

**TRANSISTOR  
DATABOOK**

**FIELD-EFFECT/POWER/SMALL SIGNAL**

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**NATIONAL  
SEMICONDUCTOR  
CORPORATION**



**1982**

**TRANSISTOR**

**DATABOOK**

**National Semiconductor**

# TRANSISTOR DATABOOK

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# Introduction

National Semiconductor has added many new transistors and product families since publication of the last data-book. Many have already been widely acclaimed by users.

In addition to small signal and power bipolar and field effect transistors that have been the mainstay of our catalog, there is a section for multiple field effect transistors. More part numbers will be added as market needs expand.

To keep current on all new National transistors, please contact your National sales representative or franchised distributor and ask to be placed on the customer mailing list.

## HOW TO USE THIS CATALOG

### If you know the part/type number

Turn to the standard parts listing which begins on page 8 and find the desired part number. The electrical specifications page number will be shown. The list also identifies the process number from which that product is selected and the particular package code in which it is assembled. Package codes are cross-referenced to JEDEC code on page 12-14.

### If performance data is required

Turn to the process data sheet indicated in the standard parts listing. Process data sheets are indexed in their appropriate sections by numerical order and begin on page 8-1, 9-1 or 10-1.

### If you know the application

Turn to the selector guide section that begins on page 4-1 and select a potential process type. Selector guides as follows:

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FET Application .....	4-5
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NPN-RF Amplifier .....	4-15
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High Speed Switches .....	4-17
Power Transistors .....	4-18

Then refer to the applicable process sheet, which will give the process/chip performance data and a common reference part type.

Or one can also refer to the Table of Contents, which is organized by general applications.

To convert a metal can transistor to a molded epoxy type, see page 18.

To convert a TO-105/TO-106 product type to a TO-92, see page 19. To convert a TO-18/TO-5 metal can product type to a TO-92/TO-237 molded epoxy type, see page 19.

Refer to the Package Outlines section beginning on page 12-14 for complete physical dimensions.

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# Transistor Standard Parts List

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2N696	1-18	19	10	2N2712	1-25	27	94	2N3368	3-7	52	02
2N697	1-18	19	10	2N2714	1-25	27	94	2N3369	3-7	52	02
2N699	1-27	12	10	2N2857	1-6	42	25	2N3370	3-7	52	02
2N706	1-2	21	18	2N2890	1-31	34	10	2N3390	1-14	04	94
2N708	1-3	22	18	2N2891	1-32	34	10	2N3391	1-14	04	94
2N718	1-18	19	02	2N2894	2-2	64	18	2N3391A	1-14	04	94
2N718A	1-18	19	02	2N2894A	2-2	64	18	2N3392	1-14	04	94
2N722	2-8	63	02	2N2897	1-19	19	02	2N3393	1-14	04	94
2N743	1-2	21	18	2N2904	2-8	63	10	2N3394	1-25	27	94
2N744	1-2	21	18	2N2904A	2-8	63	10	2N3395	1-14	04	94
2N753	1-2	21	18	2N2905	2-8	63	10	2N3396	1-14	04	94
2N760	1-10	07	02	2N2905A	2-8	63	10	2N3397	1-14	04	94
2N760A	1-10	07	02	2N2906	2-8	63	02	2N3398	1-15	04	94
2N834	1-2	21	18	2N2906A	2-8	63	02	2N3414	1-20	19	94
2N869	2-2	64	18	2N2907	2-8	63	02	2N3415	1-15	04	94
2N869A	2-2	64	18	2N2907A	2-9	63	02	2N3416	1-15	04	94
2N915	1-23	23	02	2N2923	1-14	04	94	2N3417	1-15	04	94
2N916	1-23	23	02	2N2924	1-14	04	94	2N3440	1-32	36	10
2N917	1-7	43	25	2N2925	1-14	04	94	2N3444	1-4	25	17
2N918	1-7	43	25	2N2926	1-14	04	94	2N3451	2-3	65	18
2N929	1-10	07	02	2N3009	1-4	22	18	2N3458	3-7	52	02
2N929A	1-10	07	02	2N3011	1-2	21	18	2N3459	3-7	52	02
2N930	1-10	07	02	2N3012	2-2	64	18	2N3460	3-7	52	02
2N956	1-18	19	02	2N3013	1-4	22	18	2N3467	2-4	70	17
2N995	2-2	64	18	2N3015	1-4	25	17	2N3468	2-5	70	17
2N995A	2-2	64	18	2N3019	1-28	12	10	2N3478	1-6	42	25
2N1132	2-8	63	10	2N3020	1-28	12	10	2N3502	2-9	63	10
2N1420	1-18	19	10	2N3053	1-28	12	10	2N3503	2-10	63	10
2N1566	1-18	19	10	2N3070	3-7	52	02	2N3504	2-10	63	02
2N1613	1-27	12	10	2N3071	3-7	52	02	2N3505	2-10	63	02
2N1711	1-27	12	10	2N3072	2-9	63	10	2N3545	2-2	64	18
2N2017	1-27	12	10	2N3073	2-9	63	10	2N3546	2-3	64	18
2N2102	1-27	12	10	2N3107	1-28	12	10	2N3547	2-6	62	02
2N2192	1-27	12	10	2N3108	1-28	12	10	2N3548	2-6	62	02
2N2192A	1-27	12	10	2N3109	1-29	12	10	2N3549	2-6	62	02
2N2193	1-27	12	10	2N3110	1-29	14	10	2N3550	2-6	62	02
2N2193A	1-28	12	10	2N3115	1-20	19	02	2N3563	1-7	43	92
2N2195	1-28	12	10	2N3116	1-20	19	02	2N3564	1-7	43	92
2N2195A	1-28	12	10	2N3117	1-10	07	02	2N3565	1-11	07	92
2N2218	1-18	19	10	2N3120	2-9	63	02	2N3566	1-30	13	92
2N2218A	1-18	19	10	2N3121	2-9	63	02	2N3567	1-30	13	92
2N2219	1-19	19	10	2N3133	2-9	63	02	2N3568	1-29	12	92
2N2219A	1-19	19	10	2N3134	2-9	63	02	2N3569	1-30	13	92
2N2221	1-19	19	02	2N3135	2-9	63	02	2N3576	2-3	64	18
2N2221A	1-19	19	02	2N3136	2-9	63	02	2N3600	1-6	42	25
2N2222	1-19	19	02	2N3209	2-2	64	18	2N3605	1-2	21	94
2N2222A	1-19	19	02	2N3244	2-4	70	17	2N3606	1-2	21	94
2N2243	1-28	12	10	2N3245	2-4	70	17	2N3607	1-2	21	94
2N2243A	1-28	12	10	2N3246	1-10	07	02	2N3638	2-10	63	92
2N2270	1-28	12	10	2N3248	2-2	64	18	2N3638A	2-10	63	92
2N2369	1-2	21	18	2N3249	2-2	64	18	2N3639	2-3	65	92
2N2369A	1-2	21	18	2N3250	2-14	66	02	2N3640	2-3	65	92
2N2484	1-10	07	02	2N3251	2-14	66	02	2N3641	1-20	19	92
2N2509	1-10	07	02	2N3252	1-4	25	17	2N3642	1-20	19	92
2N2510	1-10	07	02	2N3253	1-4	25	17	2N3643	1-20	19	92
2N2511	1-10	07	02	2N3299	1-20	19	10	2N3644	2-10	63	92
2N2586	1-10	07	02	2N3300	1-20	19	10	2N3645	2-10	63	92
2N2604	2-6	62	06	2N3301	1-20	19	02	2N3646	1-4	22	92
2N2605	2-6	62	06	2N3302	1-20	19	02	2N3662	1-7	43	94
2N2608	3-15	89	11	2N3304	2-3	65	18	2N3663	1-7	43	94
2N2609	3-15	88	11	2N3329	3-15	89	23	2N3665	1-29	12	10
2N2657	1-31	34	10	2N3330	3-15	89	23	2N3666	1-29	12	10
2N2658	1-31	34	10	2N3331	3-15	89	23	2N3678	1-20	19	10
2N2696	2-8	63	02	2N3332	3-15	89	23	2N3684	3-7	52	25

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Device	Page	Process	Pkg	Device	Page	Process	Pkg	Device	Page	Process	Pkg
2N3685	3-7	52	25	2N3966	3-2	50	29	2N4258A	2-3	65	92
2N3686	3-7	52	25	2N3967	3-7	55	25	2N4259	1-6	42	25
2N3687	3-7	52	25	2N3967A	3-7	55	25	2N4274	1-2	21	92
2N3691	1-23	23	92	2N3968	3-7	55	25	2N4275	1-2	21	92
2N3692	1-23	23	92	2N3968A	3-7	55	25	2N4286	1-11	07	94
2N3693	1-25	27	92	2N3969	3-7	55	25	2N4287	1-11	07	94
2N3694	1-25	27	92	2N3969A	3-7	55	25	2N4288	2-7	62	94
2N3700	1-29	12	02	2N3970	3-2	51	02	2N4289	2-7	62	94
2N3702	2-10	63	94	2N3971	3-2	51	02	2N4290	2-10	63	94
2N3703	2-10	63	94	2N3972	3-2	51	02	2N4291	2-11	63	94
2N3704	1-16	13	94	2N4013	1-5	25	02	2N4292	1-7	43	94
2N3705	1-16	13	94	2N4014	1-5	25	02	2N4293	1-7	43	94
2N3706	1-16	13	94	2N4030	2-19	67	10	2N4294	1-2	21	94
2N3707	1-11	07	94	2N4031	2-19	67	10	2N4295	1-2	21	94
2N3708	1-11	07	94	2N4032	2-19	67	10	2N4314	2-19	67	10
2N3709	1-11	07	94	2N4033	2-19	67	10	2N4338	3-7	52	02
2N3710	1-11	07	94	2N4036	2-19	67	10	2N4339	3-7	52	02
2N3711	1-11	07	94	2N4037	2-19	67	10	2N4340	3-7	52	02
2N3721	1-25	27	94	2N4047	1-5	25	17	2N4341	3-7	52	02
2N3724	1-4	25	17	2N4058	2-6	62	94	2N4354	2-17	67	92
2N3724A	1-4	25	17	2N4059	2-6	62	94	2N4355	2-17	67	92
2N3725	1-4	25	17	2N4061	2-6	62	94	2N4356	2-17	67	92
2N3725A	1-5	25	17	2N4062	2-6	62	94	2N4381	3-15	89	11
2N3742	1-38	48	10	2N4082	3-10	83	12	2N4384	1-11	07	02
2N3794	1-16	13	94	2N4083	3-10	83	12	2N4386	1-11	07	02
2N3799	2-6	62	02	2N4084	3-10	83	12	2N4391	3-2	51	02
2N3819	3-4	50	94	2N4085	3-10	83	12	2N4392	3-2	51	02
2N3820	3-15	89	94	2N4091	3-2	51	02	2N4393	3-2, 3-5, 3-6	51	02
2N3821	3-7	55	25	2N4092	3-2	51	02	2N4400	1-16	13	92
2N3822	3-7	55	25	2N4093	3-2	51	02	2N4401	1-16	13	92
2N3823	3-4	50	29	2N4117	3-6	53	25	2N4402	2-11	63	92
2N3824	3-2	55	25	2N4117A	3-6	53	25	2N4403	2-11	63	92
2N3825	1-7	43	94	2N4118	3-6	53	25	2N4409	1-11	07	92
2N3827	1-25	27	94	2N4118A	3-6	53	25	2N4410	1-12	07	92
2N3858	1-25	27	94	2N4119	3-6	53	25	2N4416	3-4	50	29
2N3858A	1-11	07	94	2N4119A	3-6	53	25	2N4416A	3-4	50	29
2N3859	1-26	27	94	2N4121	2-15	66	92	2N4424	1-15	04	94
2N3859A	1-11	07	94	2N4122	2-15	66	92	2N4856	3-2	51	02
2N3860	1-26	27	94	2N4123	1-24	23	92	2N4856A	3-2	51	02
2N3877	1-11	07	94	2N4124	1-24	23	92	2N4857	3-2	51	02
2N3877A	1-11	07	94	2N4125	2-15	66	92	2N4857A	3-2	51	02
2N3900	1-15	04	94	2N4126	2-15	66	92	2N4858	3-2	51	02
2N3900A	1-11	07	94	2N4134	1-8	44	25	2N4858A	3-2	51	02
2N3901	1-11	07	94	2N4135	1-8	44	25	2N4859	3-2	51	02
2N3903	1-23	23	92	2N4140	1-20	19	92	2N4859A	3-2	51	02
2N3904	1-23	23	92	2N4141	1-21	19	92	2N4860	3-2	51	02
2N3905	2-14	66	92	2N4142	2-10	63	92	2N4860A	3-2	51	02
2N3906	2-15	66	92	2N4143	2-10	63	92	2N4861	3-2	51	02
2N3921	3-10	83	12	2N4208	2-3	65	18	2N4861A	3-2	51	02
2N3922	3-10	83	12	2N4209	2-3	65	18	2N4916	2-15	66	92
2N3932	1-6	42	25	2N4220	3-7	55	25	2N4917	2-15	66	92
2N3933	1-6	42	25	2N4220A	3-7	55	25	2N4918	2-26	5F	58
2N3934	3-10	83	12	2N4221	3-7	55	25	2N4919	2-26	5F	58
2N3935	3-10	83	12	2N4221A	3-7	55	25	2N4920	2-26	5F	58
2N3945	1-29	12	10	2N4222	3-7	55	25	2N4921	1-44	4H	58
2N3946	1-23	23	02	2N4222A	3-7	55	25	2N4922	1-45	4H	58
2N3947	1-24	23	02	2N4223	3-4	50	29	2N4923	1-45	4H	58
2N3954	3-10	83	12	2N4224	3-4	50	29	2N4924	1-29	12	10
2N3954A	3-10	83	12	2N4237	1-30	14	10	2N4926	1-38	48	10
2N3955	3-10	83	12	2N4248	2-6	62	92	2N4927	1-38	48	10
2N3955A	3-10	83	12	2N4249	2-6	62	92	2N4944	1-16	13	92
2N3956	3-10	83	12	2N4250	2-6	62	92	2N4945	1-29	12	92
2N3957	3-10	83	12	2N4250A	2-7	62	92	2N4946	1-16	13	92
2N3958	3-10	83	12	2N4258	2-3	65	92	2N4951	1-16	13	94

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2N4952	1-16	13	94	2N5197	3-10	83	12	2N5496	1-43	4E	57
2N4953	1-16	13	94	2N5198	3-10	83	12	2N5515	3-11	95	12
2N4954	1-16	13	94	2N5199	3-10	83	12	2N5516	3-11	95	12
2N4964	2-7	62	92	2N5209	1-12	07	92	2N5517	3-11	95	12
2N4965	2-7	62	92	2N5210	1-12	07	92	2N5518	3-11	95	12
2N4966	1-12	07	92	2N5219	1-26	27	92	2N5519	3-11	95	12
2N4967	1-12	07	92	2N5220	1-16	13	92	2N5520	3-11	95	12
2N4968	1-12	07	92	2N5221	2-11	63	92	2N5521	3-11	95	12
2N4969	1-21	19	92	2N5223	1-26	27	92	2N5522	3-11	95	12
2N4970	1-21	19	92	2N5224	1-2	21	92	2N5523	3-11	95	12
2N4971	2-11	63	92	2N5225	1-16	13	92	2N5524	3-11	95	12
2N4972	2-11	63	92	2N5226	2-11	63	92	2N5545	3-10	83	12
2N5018	3-14	88	11	2N5227	2-7	62	92	2N5546	3-10	83	12
2N5019	3-14	88	11	2N5232	1-12	07	94	2N5547	3-10	83	12
2N5020	3-15	89	11	2N5232A	1-12	07	94	2N5550	1-17	16	92
2N5021	3-15	89	11	2N5245	3-4	90	97	2N5551	1-17	16	92
2N5022	2-5	70	17	2N5246	3-4	90	97	2N5555	3-2	50	92
2N5023	2-5	70	17	2N5247	3-4	90	97	2N5556	3-8	50	29
2N5030	1-2	21	94	2N5248	3-4	50	94	2N5557	3-8	50	29
2N5045	3-10	83	12	2N5294	1-43	4E	57	2N5558	3-8	50	29
2N5046	3-10	83	12	2N5296	1-43	4E	57	2N5561	3-10	98	12
2N5047	3-10	83	12	2N5298	1-43	4E	57	2N5562	3-10	98	12
2N5056	2-3	64	18	2N5305	1-47	05	94	2N5563	3-10	98	12
2N5057	2-3	64	18	2N5306	1-47	05	94	2N5564	3-12	96	12
2N5078	3-4	50	29	2N5307	1-47	05	94	2N5565	3-12	96	12
2N5086	2-7	62	92	2N5308	1-47	05	94	2N5566	3-12	96	92
2N5087	2-7	62	92	2N5336	1-32	34	10	2N5638	3-2	51	92
2N5088	1-12	07	92	2N5338	1-32	34	10	2N5639	3-2	51	92
2N5089	1-12	07	92	2N5354	2-11	63	94	2N5640	3-2	51	92
2N5103	3-7	50	29	2N5355	2-11	63	94	2N5653	3-3	51	92
2N5104	3-7	50	29	2N5358	3-8	55	25	2N5654	3-3	51	92
2N5105	3-8	50	29	2N5359	3-8	55	25	2N5655	1-41	36	58
2N5114	3-14	88	11	2N5360	3-8	55	25	2N5656	1-41	36	58
2N5115	3-14	88	11	2N5361	3-8	55	25	2N5657	1-41	36	58
2N5116	3-14	88	11	2N5362	3-8	55	25	2N5668	3-4	50	92
2N5127	1-26	27	92	2N5363	3-8	55	25	2N5669	3-4	50	92
2N5128	1-21	19	92	2N5364	3-8	55	25	2N5670	3-4	50	92
2N5129	1-21	19	92	2N5365	2-11	63	94	2N5769	1-3	21	92
2N5130	1-7	43	92	2N5366	2-11	63	94	2N5770	1-7	43	92
2N5131	1-26	27	92	2N5397	3-4	90	29	2N5771	2-4	65	92
2N5132	1-26	27	92	2N5398	3-4	90	29	2N5772	1-3	22	92
2N5133	1-12	07	92	2N5400	2-18	74	92	2N5817	2-12	63	97
2N5134	1-2	21	92	2N5401	2-18	74	92	2N5830	1-17	16	92
2N5135	1-21	19	92	2N5432	3-2	58	07	2N5902	3-13	84	24
2N5136	1-21	19	92	2N5433	3-2	58	07	2N5903	3-13	84	24
2N5137	1-21	19	92	2N5434	3-2	58	07	2N5904	3-13	84	24
2N5138	2-15	66	92	2N5447	2-12	63	97	2N5905	3-13	84	24
2N5139	2-15	66	92	2N5448	2-17	67	97	2N5906	3-13	84	24
2N5140	2-3	65	92	2N5449	1-35	38	97	2N5907	3-13	84	24
2N5142	2-11	63	92	2N5452	3-10	83	12	2N5908	3-13	84	24
2N5143	2-11	63	92	2N5453	3-10	83	12	2N5909	3-13	84	24
2N5148	1-32	34	10	2N5454	3-10	83	12	2N5910	2-4	65	92
2N5150	1-32	34	10	2N5457	3-8	55	92	2N5911	3-12	93	24
2N5172	1-15	04	94	2N5458	3-8	55	92	2N5912	3-12	93	24
2N5179	1-6	42	25	2N5459	3-8	55	92	2N5949	3-4	50	97
2N5180	1-6	42	25	2N5460	3-15	89	91	2N5950	3-4	50	97
2N5189	1-6	25	17	2N5461	3-15	89	91	2N5951	3-4	50	97
2N5190	1-43	4E	58	2N5462	3-15	89	91	2N5952	3-4	50	97
2N5191	1-43	4E	58	2N5484	3-4	50	92	2N5953	3-4	50	97
2N5192	1-43	4E	58	2N5485	3-4	50	92	2N6034	2-30	5J	58
2N5193	2-26	5E	58	2N5486	3-4	50	92	2N6035	2-30	5J	58
2N5194	2-26	5E	58	2N5490	1-43	4E	57	2N6036	2-30	5J	58
2N5195	2-26	5E	58	2N5492	1-43	4E	57	2N6037	1-49	4J	58
2N5196	3-10	83	12	2N5494	1-43	4E	57	2N6038	1-49	4J	58



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Device	Page	Process	Pkg	Device	Page	Process	Pkg	Device	Page	Process	Pkg
2N6039	1-49	4J	58	2N6709	2-21	78	90	92PU57	2-24	79	91
2N6040	2-30	5J	57	2N6710	2-21	78	90	92PU100	1-37	39	91
2N6041	2-30	5J	57	2N6711	1-38	48	90	92PU200	2-24	79	91
2N6042	2-31	5K	57	2N6712	1-38	48	90	92PU391	1-39	48	91
2N6043	1-49	4K	57	2N6713	1-38	48	90	92PU392	1-39	48	91
2N6044	1-49	4K	57	2N6714	1-34	37	91	92PU393	1-39	48	91
2N6045	1-49	4K	57	2N6715	1-35	38	91	AM1000H	10-21	87	25
2N6076	2-18	71	94	2N6716	1-35	38	91	AM1001H	10-21	87	25
2N6099	1-42	4A	57	2N6717	1-37	39	91	AM1002H	10-21	87	25
2N6101	1-42	4A	57	2N6718	1-37	39	91	BC107*	5-2	04	02
2N6103	1-42	4A	57	2N6719	1-38	48	91	BC108*	5-2	04	02
2N6107	2-26	5E	57	2N6720	1-32	36	91	BC109*	5-2	04	02
2N6109	2-26	5E	57	2N6721	1-32	36	91	BC140*	5-2	14	10
2N6110	2-26	5E	57	2N6722	1-32	36	91	BC141*	5-2	14	10
2N6111	2-26	5E	57	2N6723	1-32	36	91	BC143	5-3	61	10
2N6121	1-43	4E	57	2N6724	1-47	05	91	BC146*	5-3	61	10
2N6122	1-43	4E	57	2N6725	1-47	05	91	BC160*	5-3	67	10
2N6123	1-43	4E	57	2N6726	2-20	77	91	BC161*	5-3	67	10
2N6124	2-26	5E	57	2N6727	2-20	77	91	BC167*	5-3	04	94
2N6125	2-26	5E	57	2N6728	2-23	79	91	BC168*	5-3	04	94
2N6126	2-26	5E	57	2N6729	2-23	79	91	BC169*	5-4	04	94
2N6129	1-43	4E	57	2N6730	2-23	79	91	BC177*	5-4	71	02
2N6130	1-43	4E	57	2N6731	1-37	39	91	BC178*	5-4	71	02
2N6131	1-43	4E	57	2N6732	2-23	79	91	BC179*	5-4	71	02
2N6132	2-26	5E	57	2N6733	1-38	48	91	BC182*	5-5	04	97
2N6133	2-26	5E	57	2N6734	1-39	48	91	BC183*	5-5	04	97
2N6134	2-26	5E	57	2N6735	1-39	48	91	BC184*	5-6	04	97
2N6288	1-43	4E	57	2N6737	1-6	25	91	BC204	5-6	71	92
2N6290	1-43	4E	57	40235	1-6	42	25	BC207	5-6	04	92
2N6292	1-43	4E	57	40236	1-6	42	25	BC212*	5-6	63	97
2N6386	1-49	4J	57	40237	1-6	42	25	BC213*	5-7	63	97
2N6387	1-49	4K	57	40238	1-6	42	25	BC214*	5-8	63	97
2N6388	1-49	4K	57	40239	1-6	42	25	BC237*	5-8	04	97
2N6426	1-47	05	92	40240	1-7	42	25	BC238*	5-9	04	97
2N6427	1-47	05	92	40242	1-7	42	25	BC239*	5-9	04	97
2N6473	1-44	4F	57	40314	1-29	12	10	BC261*	5-9	71	02
2N6474	1-44	4F	57	40319	2-19	67	10	BC262*	5-10	71	02
2N6475	2-27	5F	57	40321	1-39	48	10	BC263*	5-10	71	02
2N6476	2-27	5F	57	92PE37A	1-35	38	90	BC264*	5-37	50	97
2N6483	3-11	95	12	92PE37B	1-35	38	90	BC307*	5-10	71	97
2N6484	3-11	95	12	92PE37C	1-35	38	90	BC308*	5-10	71	97
2N6485	3-11	95	12	92PE77A	2-21	78	90	BC309*	5-11	71	97
2N6486	1-42	4A	57	92PE77B	2-21	78	90	BC317*	5-11	04	92
2N6487	1-42	4A	57	92PE77C	2-21	78	90	BC318*	5-11	04	92
2N6488	1-42	4A	57	92PE487	1-39	48	90	BC319*	5-12	04	92
2N6489	2-25	5A	57	92PE488	1-39	48	90	BC327*	5-12	67	97
2N6490	2-25	5A	57	92PE489	1-39	48	90	BC328*	5-12	67	97
2N6491	2-25	5A	57	92PU01	1-34	37	90	BC337*	5-12	38	97
2N6548	1-47	05	55	92PU01A	1-34	37	90	BC338*	5-13	38	97
2N6549	1-47	05	55	92PU05	1-37	39	90	BC415*	5-13	71	97
2N6551	1-35	38	55	92PU06	1-37	39	90	BC485*	5-13	38	97
2N6552	1-35	38	55	92PU07	1-37	39	91	BC547*	5-13	04	97
2N6553	1-37	39	55	92PU10	1-39	48	91	BC548*	5-14	04	97
2N6554	2-21	78	55	92PU36	1-33	36	91	BC549*	5-14	04	97
2N6555	2-21	78	55	92PU36A	1-33	36	91	BC550*	5-14	04	97
2N6556	2-21	78	55	92PU36B	1-33	36	91	BC557*	5-14	71	97
2N6591	1-32	36	55	92PU36C	1-33	36	91	BC558*	5-15	71	97
2N6592	1-32	36	55	92PU45	1-47	05	91	BC559*	5-15	71	97
2N6593	1-32	36	55	92PU45A	1-47	05	91	BC560*	5-15	71	97
2N6705	1-35	38	90	92PU51	2-20	77	91	BCX58*	5-16	04	97
2N6706	1-35	38	90	92PU51A	2-20	77	91	BCX59*	5-16	04	97
2N6707	1-35	38	90	92PU55	2-24	79	91	BCX78*	5-17	71	97
2N6708	2-21	78	90	92PU56	2-24	79	91	BCX79*	5-17	71	97

\*All suffixes

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Device	Page	Process	Pkg	Device	Page	Process	Pkg	Device	Page	Process	Pkg
BCY56	5-18	04	02	BD435	5-28	4F	58	BF237	5-32	47	98
BCY57	5-18	04	02	BD436	5-28	5F	58	BF238	5-32	47	98
BCY58*	5-18	04	02	BD437	5-28	4F	58	BF240	5-32	47	98
BCY59*	5-18	04	02	BD438	5-28	5F	58	BF241	5-32	47	98
BCY70	5-19	71	02	BD439	5-28	4E	58	BF244*	5-37	50	94
BCY71	5-19	71	02	BD440	5-29	5E	58	BF245*	5-37	50	97
BCY71A	5-19	71	02	BD441	5-29	4E	58	BF246*	5-37	51	94
BCY72	5-19	71	02	BD442	5-29	5E	58	BF247*	5-37	51	97
BD135*	5-19	37	58	BD533	5-29	4E	57	BF254	5-33	46	98
BD136*	5-19	77	58	BD534	5-29	5E	57	BF255	5-33	46	98
BD137*	5-19	38	58	BD535	5-29	4E	57	BF256*	5-37	50	97
BD138*	5-20	78	58	BD536	5-29	5E	57	BF257	5-33	48	10
BD139*	5-20	39	58	BD537	5-29	4E	57	BF258	5-33	48	10
BD140*	5-20	79	58	BD538	5-29	5E	57	BF259	5-33	48	10
BD157	5-20	36	58	BD633	5-29	4F	57	BF457	5-33	48	58
BD158	5-20	36	58	BD634	5-29	5F	57	BF458	5-33	48	58
BD159	5-20	36	58	BD635	5-29	4F	57	BF459	5-33	48	58
BD185	5-20	4F	58	BD636	5-30	5F	57	BFX13	5-33	66	02
BD186	5-20	5F	58	BD637	5-30	4F	57	BFX29	5-33	63	10
BD187	5-20	4F	58	BD638	5-30	5F	57	BFX30	5-33	63	10
BD188	5-20	5F	58	BD675*	5-30	4J	58	BFX37	5-33	62	02
BD189	5-20	4F	58	BD676*	5-30	5J	58	BFX65	5-33	62	02
BD190	5-20	5F	58	BD677*	5-30	4J	58	BFX84	5-34	12	10
BD201	5-20	4A	57	BD678*	5-30	5J	58	BFX85	5-34	12	10
BD202	5-20	5A	57	BD679*	5-30	4J	58	BFX86	5-34	14	10
BD203	5-21	4A	57	BD680*	5-30	5J	58	BFX87	5-34	63	10
BD204	5-21	5A	57	BD681	5-30	4J	58	BFX88	5-34	63	10
BD220	5-21	4F	57	BD682	5-30	5J	58	BFY39*	5-34	23	02
BD221	5-21	4F	57	BD733	5-30	4F	57	BFY50	5-34	14	10
BD222	5-21	4F	57	BD734	5-30	5E	57	BFY51	5-34	14	10
BD223	5-21	5F	57	BD735	5-30	4F	57	BFY52	5-34	14	10
BD224	5-21	5F	57	BD736	5-30	5E	57	BFY56	5-34	14	10
BD225	5-21	5F	57	BD737	5-30	4F	57	BFY72	5-35	19	04
BD233	5-21	4F	58	BD738	5-30	5E	57	BFY76	5-35	07	02
BD234	5-21	5F	58	BD795	5-30	4E	57	BSX21	5-35	07	02
BD235	5-21	4F	58	BD796	5-30	5E	57	BSX45*	5-35	14	10
BD236	5-21	5F	58	BD797	5-30	4E	57	BSX46*	5-35	12	10
BD237	5-21	4F	58	BD798	5-31	5E	57	BSX48	5-35	19	02
BD238	5-21	5F	58	BD799	5-31	4E	57	BSX88	5-35	21	18
BD239*	5-21	4F	57	BD800	5-31	5E	57	BSY38	5-35	21	18
BD240*	5-21	5F	57	BD801	5-31	4E	57	BSY39	5-35	21	18
BD241*	5-22	4F	57	BD802	5-31	5E	57	BSY51	5-35	19	10
BD242*	5-22	5E	57	BD895*	5-31	4K	57	BSY52	5-35	19	10
BD243*	5-22	4A	57	BD896*	5-31	5K	57	BSY53	5-35	19	10
BD244*	5-22	5A	57	BD897*	5-31	4K	57	BSY54	5-36	19	10
BD344	5-22	78	58	BD898*	5-31	5K	57	BSY95A	5-36	21	92
BD345	5-23	38	58	BD899*	5-31	4K	57	CS9011*	6-2	27	92
BD346	5-23	5A	57	BD900*	5-31	5K	57	CS9012*	6-2	68	92
BD347	5-23	4A	57	BD901	5-31	4K	57	CS9013*	6-2	09	92
BD348	5-23	79	58	BD902	5-31	5K	57	CS9014*	6-2	04	92
BD349	5-23	39	58	BDX33*	5-31	4K	57	CS9015*	6-2	71	92
BD370*	5-23	78/79	91	BDX34*	5-31	5K	57	CS9016*	6-2	46	92
BD371*	5-24	38/39	91	BF167	5-32	45	28	CS9018*	6-2	43	92
BD372*	5-24	78/79	90	BF180	5-32	41	25	D40C*	1-47	05	55
BD373*	5-25	38/39	90	BF181	5-32	41	25	D40D*	1-36	38	55
BD375*	5-26	38	58	BF194	5-32	46	98	D40E*	1-36	38	55
BD376*	5-26	78	58	BF195	5-32	46	98	D40K*	1-48	05	55
BD377*	5-27	38	58	BF196	5-32	46	98	D40N*	1-39	48	55
BD378*	5-27	78	58	BF197	5-32	47	98	D40P*	1-33	36	55
BD379*	5-27	39	58	BF198	5-32	45	98	D41D*	2-22	78	55
BD380*	5-28	79	58	BF199	5-32	47	98	D41E*	2-22	78	55
BD433	5-28	4F	58	BF200	5-32	41	25	D41K*	2-30	61	55
BD434	5-28	5F	58	BF233*	5-32	49	96	D42C*	1-34	4P	56

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D43C*	2-22, 2-27	5P	56	MJE223	1-46	4P	58	MPS706	1-3	21	92
D44C*	1-45	4P	57	MJE224	1-46	4P	58	MPS834	1-3	21	92
D44H*	1-46	4Q	57	MJE225	1-46	4P	58	MPS2369	1-3	21	92
D45C*	2-28	5P	57	MJE230	2-28	5P	58	MPS2711	1-24	23	92
D45H*	2-29	5Q	57	MJE231	2-28	5P	58	MPS2712	1-24	23	92
DH3467CD	2-5	70	40	MJE232	2-28	5P	58	MPS2713	1-3	21	92
DH3467CN	2-5	70	39	MJE233	2-28	5P	58	MPS2714	1-3	21	92
DH3468CD	2-5	70	40	MJE234	2-29	5P	58	MPS2716	1-24	23	92
DH3468CN	2-5	70	39	MJE235	2-29	5P	58	MPS2923	1-24	23	92
DH3724CD	1-5	25	40	MJE240	1-46	4P	58	MPS2924	1-24	23	92
DH3724CN	1-5	25	39	MJE241	1-46	4P	58	MPS2925	1-24	23	92
DH3725CD	1-5	25	40	MJE242	1-46	4P	58	MPS2926	1-24	23	92
DH3725CN	1-5	25	39	MJE243	1-46	4P	58	MPS3392	1-15	04	92
ED1402*	6-2	07	92	MJE244	1-46	4P	58	MPS3393	1-15	04	92
ED1502*	6-2	46	92	MJE250	2-29	5P	58	MPS3394	1-15	27	92
ED1602*	6-2	62	92	MJE251	2-29	5P	58	MPS3395	1-15	04	92
ED1702*	6-2	37	92	MJE252	2-29	5P	58	MPS3396	1-15	04	92
ED1802*	6-2	77	92	MJE253	2-29	5P	58	MPS3397	1-15	04	92
J108	3-3	58	92	MJE254	2-29	5P	58	MPS3398	1-15	04	92
J109	3-3	58	92	MJE340	1-41	36	58	MPS3563	1-7	43	92
J110	3-3	58	92	MJE341	1-41	36	58	MPS3638	2-12	63	92
J111	3-3	51	92	MJE344	1-41	36	58	MPS3638A	2-12	63	92
J112	3-3	51	92	MJE370	2-27	5F	58	MPS3639	2-4	65	92
J113	3-3	51	92	MJE371	2-26	5E	58	MPS3640	2-4	65	92
J114	3-3	90	92	MJE520	1-44	4F	58	MPS3642	1-24	19	92
J174	3-14	88	94	MJE521	1-44	4F	58	MPS3644	2-12	63	92
J175	3-14	88	94	MJE700	2-30	5J	58	MPS3645	2-12	63	92
J176	3-14	88	94	MJE701	2-30	5J	58	MPS3646	1-3	22	92
J177	3-14	88	94	MJE702	2-30	5J	58	MPS3693	1-26	27	92
J201	3-8	52	92	MJE703	2-30	5J	58	MPS3694	1-26	27	92
J202	3-8	52	92	MJE710	2-25	77	58	MPS3702	2-12	63	92
J203	3-8	52	92	MJE711	2-25	78	58	MPS3703	2-12	63	92
J210	3-8	90	92	MJE712	2-25	79	58	MPS3704	1-16	13	92
J211	3-8	90	92	MJE720	1-42	37	58	MPS3705	1-17	13	92
J212	3-8	90	92	MJE721	1-36	38	58	MPS3706	1-17	13	92
J270	3-15	88	94	MJE722	1-37	39	58	MPS3707	1-12	07	92
J271	3-15	88	94	MJE800	1-49	4J	58	MPS3708	1-12	07	92
J300	3-4	90	92	MJE801	1-49	4J	58	MPS3709	1-12	07	92
J304	3-4	90	92	MJE802	1-49	4J	58	MPS3710	1-12	07	92
J305	3-4	50	92	MJE803	1-49	4J	58	MPS3711	1-12	07	92
J308	3-4	50	92	MJE2801T	1-42	4A	57	MPS3721	1-24	23	92
J309	3-4	92	92	MJE2901T	2-25	5A	57	MPS3826	1-24	23	92
J310	3-4	92	92	MJE2955T	2-25	5A	57	MPS3827	1-24	23	92
J401	3-10	92	92	MJE3055T	1-42	4A	57	MPS3903	1-13	02	92
J402	3-10	98	60	MJE3439	1-42	36	58	MPS3904	1-14	02	92
J403	3-10	98	60	MJE3440	1-42	36	58	MPS3905	2-15	66	92
J404	3-10	98	60	MJE5190J	1-44	4E	58	MPS3906	2-15	66	92
J405	3-10	98	60	MJE5191J	1-44	4E	58	MPS4354	2-17	67	92
J406	3-10	98	60	MJE5192J	1-44	4E	58	MPS4355	2-17	67	92
J410	3-10	83	60	MPF102	3-5	50	92	MPS4356	2-17	67	92
J411	3-11	83	60	MPF103	3-8	55	92	MPS5172	1-15	04	92
J412	3-11	83	60	MPF104	3-8	55	92	MPS6507	1-7	43	92
MJE170	2-25	77	58	MPF105	3-8	55	92	MPS6511	1-8	43	92
MJE171	2-25	78	58	MPF106	3-5	50	92	MPS6512	1-24	23	92
MJE172	2-25	79	58	MPF107	3-5	50	92	MPS6513	1-24	23	92
MJE180	1-42	37	58	MPF108	3-5	55	92	MPS6514	1-24	23	92
MJE181	1-42	38	58	MPF109*	3-8	55	92	MPS6515	1-24	27	92
MJE182	1-42	39	58	MPF110	3-8	50	92	MPS6516	2-15	66	92
MJE200	1-45	4R	58	MPF111	3-8	50	92	MPS6517	2-15	66	92
MJE210	2-29	5R	58	MPF112	3-8	55	92	MPS6518	2-16	66	92
MJE220	1-45	4P	58	MPF256	3-5	90	92	MPS6520	1-15	04	92
MJE221	1-45	4P	58	MPF820	3-5	51	92	MPS6521	1-15	04	92
MJE222	1-45	4P	58	MPQ3725	1-31	25	39	MPS6522	1-17	66	92

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Device	Page	Process	Pkg	Device	Page	Process	Pkg	Device	Page	Process	Pkg
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MPS6530	1-17	13	92	MRF501	1-7	42	25	NB122E*	7-44	71	92
MPS6531	1-17	13	92	MRF502	1-7	42	25	NB122F*	7-44	71	94
MPS6532	1-17	13	92	NA01E*	7-4	09	92	NB123E*	7-44	71	92
MPS6533	2-12	63	92	NA01F*	7-4	09	94	NB123F*	7-44	71	94
MPS6534	2-12	63	92	NA02E*	7-4	68	92	NB211E*	7-48	19	92
MPS6535	2-12	63	92	NA02F*	7-4	68	94	NB211F*	7-48	19	94
MPS6539	1-7	42	96	NA11E*	7-8	09	92	NB211X*	7-48	19	91
MPS6540	1-9	49	96	NA11F*	7-8	09	94	NB211Y*	7-48	19	90
MPS6541	1-8	43	92	NA12E*	7-8	68	92	NB212E*	7-48	19	92
MPS6542	1-9	47	96	NA12F*	7-8	68	94	NB212F*	7-48	19	94
MPS6543	1-9	47	96	NA21E*	7-12	37	92	NB212X*	7-48	19	91
MPS6544	1-9	49	96	NA21F*	7-12	37	94	NB212Y*	7-48	19	90
MPS6546	1-9	47	96	NA21X*	7-12	37	91	NB213E*	7-48	19	92
MPS6547	1-9	47	96	NA21Y*	7-12	37	90	NB213F*	7-48	19	94
MPS6548	1-7	42	96	NA22E*	7-12	77	92	NB213X*	7-48	19	91
MPS6560	1-31	14	92	NA22F*	7-12	77	94	NB213Y*	7-48	19	90
MPS6561	1-31	14	92	NA22X*	7-12	77	91	NB221E*	7-48	63	92
MPS6562	2-17	67	92	NA22Y*	7-12	77	90	NB221F*	7-48	63	94
MPS6563	2-18	60	92	NA31K*	7-16	37	55	NB221X*	7-48	63	91
MPS6564	1-26	27	92	NA31M*	7-16	37	56	NB221Y*	7-48	63	90
MPS6565	1-26	27	92	NA31X*	7-16	37	91	NB222E*	7-48	63	92
MPS6566	1-26	27	92	NA31Y*	7-16	37	90	NB222F*	7-48	63	94
MPS6567	1-9	49	96	NA32K*	7-16	77	55	NB222X*	7-48	63	91
MPS6568A	1-8	44	96	NA32M*	7-16	77	56	NB222Y*	7-48	63	90
MPS6569	1-8	44	96	NA32X*	7-16	77	91	NB223E*	7-48	63	92
MPS6570	1-8	44	96	NA32Y*	7-16	77	90	NB223F*	7-48	63	94
MPS6571	1-12	07	92	NA41U*	7-20	4F	58	NB223X*	7-48	63	91
MPS6573	1-14	02	92	NA42U*	7-20	5F	58	NB223Y*	7-48	63	90
MPS6574	1-14	02	92	NA51U	7-24	4F	58	NB311E	7-52	38	92
MPS6575	1-14	02	92	NA51W	7-24	4F	57	NB311F	7-52	38	94
MPS6576	1-14	02	92	NA52U	7-24	5F	58	NB311K	7-52	38	55
MPS8098	1-18	18	92	NA52W	7-24	5F	57	NB311M	7-52	38	56
MPS8099	1-18	18	92	NA61U	7-28	4E	58	NB311X	7-52	38	91
MPSA05	1-29	12	92	NA61W	7-28	4E	57	NB311Y	7-52	38	90
MPSA06	1-29	12	92	NA62U	7-28	5E	58	NB312E	7-52	38	92
MPSA09	1-12	07	92	NA62W	7-28	5E	57	NB312F	7-52	38	94
MPSA10	1-26	27	92	NA71U	7-32	4E	58	NB312K	7-52	38	55
MPSA12	1-48	05	92	NA71W	7-32	4E	57	NB312M	7-52	38	56
MPSA13	1-48	05	92	NA72U	7-32	5E	58	NB312X	7-53	38	91
MPSA14	1-48	05	92	NA72W	7-32	5E	57	NB312Y	7-53	38	90
MPSA20	1-14	02	92	NB011E*	7-36	04	92	NB313E	7-53	38	92
MPSA42	1-39	48	92	NB011F*	7-36	04	94	NB313F	7-53	38	94
MPSA43	1-40	48	92	NB012E*	7-36	04	92	NB313K	7-53	38	55
MPSA55	2-17	67	92	NB012F*	7-36	04	94	NB313M	7-53	38	56
MPSA56	2-17	67	92	NB013E*	7-40	04	92	NB313X	7-53	38	91
MPSA62	2-30	61	92	NB013F*	7-40	04	94	NB313Y	7-53	38	90
MPSA63	2-30	61	92	NB014E*	7-40	04	92	NB321E	7-53	78	92
MPSA64	2-30	61	92	NB014F*	7-40	04	94	NB321F	7-53	78	94
MPSA65	2-30	61	92	NB021E*	7-36	62	92	NB321K	7-53	78	55
MPSA66	2-30	61	92	NB021F*	7-36	62	94	NB321M	7-53	78	56
MPSA70	2-7	62	92	NB022E*	7-36	62	92	NB321X	7-53	78	91
MPSH10	1-7	42	96	NB022F*	7-36	62	94	NB321Y	7-52	78	90
MPSH11	1-9	47	96	NB023E*	7-40	62	92	NB322E	7-52	78	92
MPSH19	1-9	47	96	NB023F*	7-40	62	94	NB322F	7-52	78	94
MPSH20	1-9	49	96	NB024E*	7-40	62	92	NB322K	7-52	78	55
MPSH24	1-9	47	96	NB111E*	7-44	04	92	NB322M	7-52	78	56
MPSH30	1-8	44	96	NB111F*	7-44	04	94	NB322X	7-52	78	91
MPSH31	1-8	44	96	NB112E*	7-44	04	92	NB322Y	7-52	78	90
MPSH32	1-8	45	96	NB112F*	7-44	04	94	NB323E	7-52	78	92
MPSH34	1-9	47	96	NB113E*	7-44	07	92	NB323F	7-52	78	94
MPSH37	1-9	49	96	NB113F*	7-44	07	94	NB323K	7-52	78	55
MPSL01	1-18	16	92	NB121E*	7-44	71	92	NB323M	7-52	78	56

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NB323Y	7-52	78	90	NSDU02	1-35	38	55	PN3644	2-13	63	92
NCBT13	1-17	13	92	NSDU05	1-37	38	55	PN3645	2-13	63	92
NCBV14	1-31	14	55	NSDU06	1-38	39	55	PN3646	1-4	22	92
NDF9406	3-12	94	12	NSDU07	1-38	39	55	PN3684	3-8	52	92
NDF9407	3-12	94	12	NSDU10	1-40	48	55	PN3685	3-8	52	92
NDF9408	3-12	94	12	NSDU45	1-48	05	55	PN3686	3-8	52	92
NDF9409	3-12	94	12	NSDU45A	1-48	05	55	PN3687	3-8	52	92
NDF9410	3-12	94	12	NSDU51	2-20	77	55	PN3691	1-25	23	92
NF5101	3-5	51	29	NSDU51A	2-20	77	55	PN3692	1-25	23	92
NF5102	3-5	51	29	NSDU52	2-21	77	55	PN3694	1-26	27	92
NF5103	3-5	51	29	NSDU55	2-23	78	55	PN4091	3-3	51	92
NF5301*	3-6	53	25	NSDU56	2-24	79	55	PN4092	3-3	51	92
NPD5564	3-12	96	67	NSDU57	2-24	79	55	PN4093	3-3	51	92
NPD5565	3-12	96	67	NSDU95	2-30	61	55	PN4117*	3-6	53	92
NPD5566	3-12	96	67	NSDU95A	2-30	61	55	PN4118*	3-6	53	92
NPD8301	3-11	83	67	NSE170	2-21	77	56	PN4119*	3-6	53	92
NPD8302	3-11	83	67	NSE171	2-23	78	56	PN4121	2-16	66	92
NPD8303	3-11	83	67	NSE180	1-35	38	56	PN4122	2-16	66	92
NR041E	7-56	04	92	NSE181	1-37	38	56	PN4140	1-22	19	92
NR421D*	7-60	42	96	NSE457	1-40	48	56	PN4141	1-22	19	92
NR421F*	7-60	42	94	NSE458	1-40	48	56	PN4142	2-13	63	92
NR431E*	7-64	43	92	NSE459	1-40	48	56	PN4143	2-13	63	92
NR431F*	7-64	43	94	NSE871	1-31	17	51	PN4220	3-9	55	92
NR461E*	7-68	46	92	NSE872	2-20	76	51	PN4221	3-9	55	92
NR461F*	7-68	46	94	P1086	3-14	88	91	PN4222	3-9	55	92
NS3762	2-5	70	17	P1087	3-14	88	91	PN4223	3-5	50	92
NS3763	2-5	70	17	PE3100	1-9	47	96	PN4224	3-5	50	92
NS3903	1-25	23	02	PE4010	1-13	07	92	PN4248	2-7	62	92
NS3904	1-25	23	02	PE5025	1-8	46	92	PN4249	2-7	62	92
NS3905	2-16	66	02	PE5029	1-9	47	96	PN4250	2-7	62	92
NS3906	2-16	66	02	PE5030B	1-9	47	96	PN4250A	2-7	62	92
NS4234	2-17	67	10	PE5031	1-9	47	96	PN4258	2-4	65	92
NSD36*	1-33	36	55	PF5101	3-6	51	92	PN4258A	2-4	65	92
NSD102	1-34	38	55	PF5102	3-6	51	92	PN4274	1-3	21	92
NSD103	1-34	38	55	PF5103	3-6	51	92	PN4275	1-3	21	92
NSD104	1-38	39	55	PF5301*	3-6	53	92	PN4302	3-9	52	92
NSD105	1-38	39	55	PN918	1-8	43	92	PN4303	3-9	52	92
NSD106	1-38	39	55	PN930	1-13	07	92	PN4304	3-9	52	92
NSD131	1-40	48	55	PN2221	1-21	19	92	PN4342	3-15	89	92
NSD132	1-40	48	55	PN2221A	1-21	19	92	PN4354	2-17	67	92
NSD133	1-40	48	55	PN2222	1-21	19	92	PN4355	2-17	67	92
NSD134	1-40	48	55	PN2222A	1-22	19	92	PN4356	2-18	67	92
NSD135	1-40	48	55	PN2369	1-3	21	92	PN4360	3-15	89	92
NSD151	1-48	05	55	PN2369A	1-3	21	92	PN4391	3-3	51	92
NSD152	1-48	05	55	PN2484	1-13	07	92	PN4392	3-3	51	92
NSD153	1-48	05	55	PN2906	2-12	63	92	PN4393	3-3, 3-6	51	92
NSD154	1-48	05	55	PN2906A	2-12	63	92	PN4416	3-5	50	92
NSD202	2-20	77	55	PN2907	2-12	63	92	PN4856	3-3	51	92
NSD203	2-20	77	55	PN2907A	2-13	63	92	PN4857	3-3	51	92
NSD204	2-24	79	55	PN3563	1-8	43	92	PN4858	3-3	51	92
NSD205	2-24	79	55	PN3564	1-8	43	92	PN4859	3-3	51	92
NSD206	2-24	79	55	PN3565	1-13	07	92	PN4860	3-3	51	92
NSD457	1-40	48	55	PN3566	1-17, 1-30	13	92	PN4861	3-3	51	92
NSD458	1-40	48	55	PN3567	1-17, 1-30	13	92	PN4916	2-16	66	92
NSD459	1-40	48	55	PN3568	1-29	12	92	PN4917	2-16	66	92
NSD3439	1-33	36	55	PN3569	1-17, 1-30	13	92	PN5019	3-14	88	94
NSD3440	1-34	36	55	PN3638	2-13	63	92	PN5033	3-15	89	92
NSD6178	1-37	38	55	PN3638A	2-13	63	92	PN5127	1-26	27	92
NSD6179	1-37	38	55	PN3639	2-4	65	92	PN5128	1-22	19	92
NSD6180	2-23	78	55	PN3640	2-4	65	92	PN5129	1-22	19	92
NSD6181	2-23	78	55	PN3641	1-22	19	92	PN5130	1-8	43	92
NSDU01	1-34	37	55	PN3642	1-22	19	92	PN5131	1-26	27	92

\*All suffixes

# Transistor Standard Parts List (Continued)

Device	Page	Process	Pkg	Device	Page	Process	Pkg	Device	Page	Process	Pkg
PN5132	1-26	27	92	TIP121	1-49	4J	57	U257	3-12	93	24
PN5133	1-13	07	92	TIP122	1-49	4J	57	U308	3-5	92	07
PN5134	1-3	21	92	TIP125	2-31	5J	57	U309	3-5	92	07
PN5135	1-22	19	92	TIP126	2-31	5J	57	U310	3-5	92	07
PN5136	1-22	19	92	TIP127	2-31	5J	57	U312	3-5	90	07
PN5137	1-22	19	92	TIP130	1-50	4K	57	U401	3-11	98	12
PN5138	2-16	66	92	TIP131	1-50	4K	57	U402	3-11	98	12
PN5139	2-16	66	92	TIP132	1-50	4K	57	U403	3-11	98	12
PN5140	2-4	65	92	TIP135	2-31	5K	57	U404	3-11	98	12
PN5142	2-14	63	92	TIP136	2-31	5K	57	U405	3-11	98	12
PN5143	2-14	63	92	TIP137	2-31	5K	57	U406	3-11	98	12
PN5163	3-9	50	92	TIS58*	3-9	50	94	U421	3-13	86	24
PN5179	1-7	42	96	TIS59	3-9	50	94	U422	3-13	86	24
PN5432	3-3	58	92	TIS73	3-3	51	97	U423	3-13	86	24
PN5433	3-3	58	92	TIS74	3-3	51	97	U424	3-13	86	24
PN5434	3-3	58	92	TIS75	3-3	51	97	U425	3-13	86	24
PN5447	2-18	67	92	TIS86	1-9	47	98	U426	3-13	86	24
PN5449	1-17	13	92	TIS87	1-9	47	98	U1897	3-3	51	92
PN5816	1-17	13	92	TIS90	1-23	19	94	U1898	3-3	51	92
PN5910	2-4	65	92	TIS91	2-14	63	94	U1899	3-3	51	92
PN7055	1-40	48	92	TIS92	1-23	19	97				
SE5020	1-8	44	25	TIS93	2-14	63	97				
SE5021	1-8	44	25	TIS97	1-15	04	97				
SE5022	1-8	44	25	TIS98	1-18	18	97				
SE5023	1-8	44	25	TIS99	1-18	18	97				
SE5024	1-8	44	25	TN1711	1-29	12	91				
SE5050	1-8	44	25	TN2017	1-30	12	91				
SE5051	1-8	44	25	TN2102	1-30	12	91				
SE5052	1-8	44	25	TN2218A	1-22	19	91				
SE5055	1-8	45	28	TN2219	1-23	19	91				
SE7055	1-40	48	10	TN2219A	1-23	19	91				
SE7056	1-41	48	10	TN2270	1-30	12	91				
SE9300	1-49	4K	57	TN2904A	2-14	63	91				
SE9301	1-50	4K	57	TN2905	2-14	63	91				
SE9302	1-50	4K	57	TN2905A	2-14	63	91				
SE9400	2-31	5K	57	TN3019	1-30	12	91				
SE9401	2-31	5K	57	TN3020	1-30	12	91				
SE9402	2-31	5K	57	TN3053	1-30	12	91				
ST3904	1-25	23	92	TN3244	2-19	70	91				
ST3906	2-16	66	92	TN3245	2-20	70	91				
ST5771	2-4	65	92	TN3252	1-31	25	91				
SV7056	1-41	48	55	TN3253	1-31	25	91				
TIP29*	1-44	4F	57	TN3440	1-34	36	91				
TIP30*	2-27	5F	57	TN3444	1-31	25	91				
TIP31*	1-44	4F	57	TN3467	2-20	70	91				
TIP32*	2-27	5F	57	TN3724	1-31	25	91				
TIP41*	1-42	4A	57	TN3725	1-31	25	91				
TIP42*	2-25	5A	57	TN3742	1-41	48	91				
TIP61*	1-44	4F	57	TN4030	2-19	67	91				
TIP62*	2-27	5F	57	TN4033	2-19	67	91				
TIP100	1-50	4K	57	TN4036	2-18	67	91				
TIP101	1-50	4K	57	TN4037	2-18	67	91				
TIP102	1-50	4K	57	TN4234	2-23	78	91				
TIP105	2-31	5K	57	TN4235	2-23	78	91				
TIP106	2-31	5K	57	TN4236	2-23	78	91				
TIP107	2-31	5K	57	TN4314	2-19	67	91				
TIP110	1-49	4J	57	TN5022	2-20	70	91				
TIP111	1-49	4J	57	TN5023	2-20	70	91				
TIP112	1-49	4J	57	U231	3-11	83	12				
TIP115	2-31	5J	57	U232	3-11	83	12				
TIP116	2-31	5J	57	U233	3-11	83	12				
TIP117	2-31	5J	57	U234	3-11	83	12				
TIP120	1-49	4J	57	U235	3-11	83	12				

\*All suffixes

## **Bipolar Transistor and FET Dice**

### **Dice**

Standard types from National's transistor families are available in unencapsulated die form for use in hybrid circuits. Contact factory for conditions of sale.

## Conversion of Bipolar Metal Can to Plastic

Metal P/N	Plastic Equivalent	Electrical Equivalency*	Process	Metal P/N	Plastic Equivalent	Electrical Equivalency*	Process
2N697	2N4400	A	13	2N2905	TN2905	E	63
2N706	MPS706	E	21	2N2905A	TN2905A	E	63
2N708	PN3646	N	22	2N2906	PN2906	E	63
2N718	2N4400	A	13	2N2906A	PN2906A	E	63
2N722	PN2906	N	63	2N2907	PN2907	E	63
2N744	PN2369	N	21	2N2907A	PN2907A	E	63
2N753	PN2369	N	21	2N3009	PN3646	N	22
2N760A	2N4409	N	07	2N3011	PN2369	N	21
2N834	MPS834	E	21	2N3012	PN3640	A	65
2N869A	PN3640	A	65	2N3013	PN3646	E	22
2N915	MPS6565	A	27	2N3019	TN3019	E	12
2N917	PN3563	E	43	2N3020	TN3020	E	12
2N918	PN918	E	43	2N3053	2N3053	E	12
2N929	2N4409	N	07	2N3117	2N5210	N	07
2N930	PN930	E	07	2N3133	MPS3703	N	63
2N956	PN2222A	N	19	2N3134	PN3645	N	63
2N995A	PN3640	A	65	2N3135	MPS3703	N	63
2N1132	PN2906	N	63	2N3136	PN3645	N	63
2N1613	PN2221A	N	19	2N3250	2N3905	A	66
2N1711	PN2222A	N	19	2N3251	2N3906	A	66
2N2218	TN2218	E	19	2N3300	2N4401	A	13
2N2218A	TN2218A	E	19	2N3301	2N4400	A	13
2N2219	TN2219	E	19	2N3302	2N4401	A	13
2N2219A	TN2219A	E	19	2N3304	PN3639	A	65
2N2221	PN2221	E	19	2N3440	TN3440	E	36
2N2221A	PN2221A	E	19	2N3724	TN3724	E	25
2N2222	PN2222	E	19	2N3725	TN3725	E	25
2N2222A	PN2222A	E	19	2N3944	2N3903	N	23
2N2369	PN2369	E	21	2N3947	2N3904	N	23
2N2369A	PN2369A	E	21	2N3962	2N5086	N	62
2N2483	2N5209	N	07	2N3964	2N5087	N	62
2N2484	2N5210	N	07	2N3965	2N5087	N	62
2N2604	2N5086	N	62	2N4033	TN4033	E	67
2N2605	2N5086	N	62	2N4036	TN4036	E	67
2N2894	PN3640	A	65	2N4037	TN4037	E	67
2N2894A	PN3639	A	65	2N4208	PN3640	N	65
2N2904	TN2904	E	63	2N4209	PN3640	N	65
2N2904A	TN2904A	E	63				

\* E = Exact electrical equivalent

N = Near electrical equivalent

A = Approximate electrical equivalent

**Note:** On "N" and "A" categories please refer to device specification section for deviation from metal can specifications.

This list is for use when an alternative to a metal can transistor is needed.

To facilitate conversions on the most popular types National is offering the "PN" series, TO-92 devices that use the same die type and are screened to same electrical specifications. The TO-92 transistors produced by National Semiconductor are the most advanced Plastic Transistors ever manufactured. They utilize epoxy B encapsulation and a copper lead frame to give a power dissipation of up to 625 mW @  $T_A = 25^\circ\text{C}$ . These transistors provide electrical performance and reliability equivalent to their metal can versions in most applications where  $T_J$  does not exceed  $150^\circ\text{C}$ .

The same situation is applicable to the "TN" series, except that the National-originated TO-237 (TO-92 +) case outline is used, which permits power dissipation of up to 1.0W @  $T_A = 25^\circ\text{C}$ .

# Conversion of TO-105/TO-106 to TO-92

National has chosen to no longer produce the TO-105/106 plastic transistor line. The decision to drop this line was based on two major factors: cost and performance.

The TO-92 is the most advanced transistor offered today. With its automated assembly, it has the lowest potential cost. By contrast, the TO-105/106 is a hand-assembled product and its cost is tied to ever-increasing labor costs.

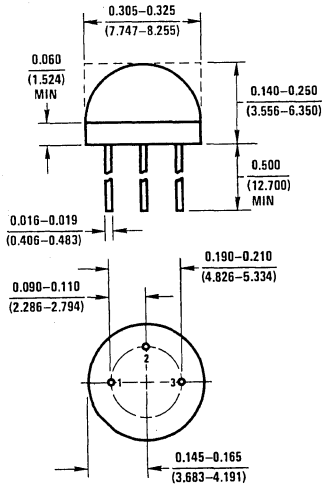
Our TO-92 is encapsulated in "Epoxy B" and has a copper lead frame. This is *the* superior TO-92 available today. As compared with TO-105/106, our TO-92 has better than twice the power dissipation of either package.

We have done several things in order to make this conversion as easy as possible. We are offering a series on "PN"

("PN and "J" in FETs) part numbers that have exactly the same number as the original part; i.e., 2N3565 becomes a PN3565. These PN types use the same chip and are screened to the same electrical specification as the original part. The original parts have a pin circle, TO-106 = TO-18 and TO-105 = TO-5, so we will supply TO-92 lead formed to the appropriate configuration at no extra charge. If you enter an order to the old part number, our computer will automatically convert it to the correct PN number *with* the correct lead form; i.e., 2N3565 becomes PN3565-18. In the case of some of the less popular types, we have converted to the nearest part type using the same chip. Please use the conversion chart on the next page as a guide.

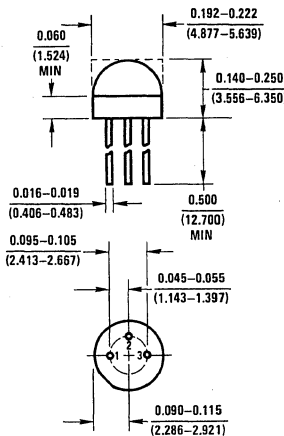
It is our intent to service our customers with the highest quality and most cost-effective product available.

TO-105



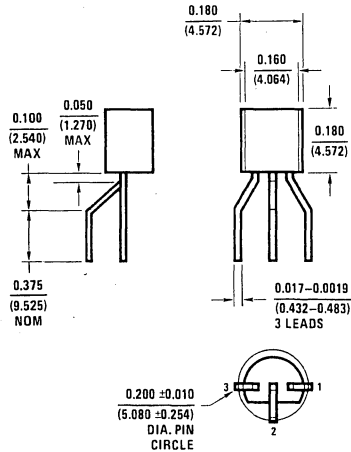
Pin	T
1	E
2	B
3	C

TO-106

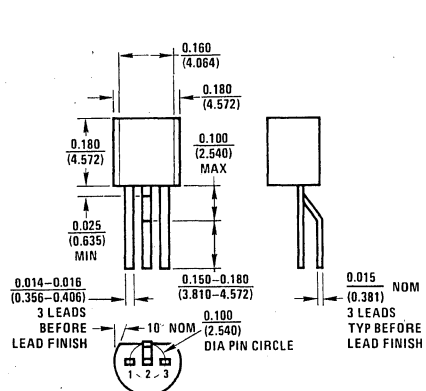


Pin	FET	T
1	S	E
2	D	B
3	G	C

TO-92 Device to TO-5 Pin Circle



TO-92 Device to TO-18 Pin Circle



## Conversion of TO-105/TO-106 to TO-92 (Continued)

### Bipolar

TO-105/106	TO-92	TO-105/106	TO-92	TO-105/106	TO-92
EN2222	PN2222-18	2N3692	PN3692-18	2N4965	2N5086-18
EN2369A	PN2369A-18	2N3693	MPS3693-18	2N4966	2N5209-18
EN2484	PN2484-18	2N3694	PN3694-18	2N4967	2N5210-18
3N2907	PN2907-18	2N4121	PN4121-18	2N4968	2N5209-18
EN918	PN918-18	2N4122	PN4122-18	2N4969	PN2221-18
EN930	PN930-18	2N4140	PN4140-18	2N4970	PN2222-18
SM3904	2N3904-18	2N4141	PN4141-18	2N4971	PN2906-18
SM3906	2N3906-18	2N4142	PN4142-18	2N4972	PN2907-18
2N3563	PN3563-18	2N4143	PN4143-18	2N5127	PN5127-18
2N3564	PN3564-18	2N4248	PN4248-18	2N5128	PN5128-5
2N3565	PN3565-18	2N4249	PN4249-18	2N5129	PN5129-18
2N3566	PN3566-5	2N4250	PN4250-18	2N5130	PN5130-18
2N3567	PN3567-5	2N4250A	PN4250A-18	2N5131	PN5131-18
2N3568	PN3568-5	2N4258	PN4258-18	2N5132	PN5132-18
2N3569	PN3569-5	2N4258A	PN4258A-18	2N5133	PN5133-18
2N3638	PN3638-5	2N4274	PN4274-18	2N5134	PN5134-18
2N3638A	PN3638A-5	2N4275	PN4275-18	2N5135	PN5135-18
2N3639	PN3639-18	2N4354	PN4354-5	2N5136	PN5136-5
2N3640	PN3640-18	2N4355	PN4355-5	2N5137	PN5137-18
2N3641	PN3641-5	2N4356	PN4356-5	2N5138	PN5138-18
2N3642	PN3642-5	2N4916	PN4916-18	2N5139	PN5139-18
2N3643	PN3643-5	2N4917	PN4917-18	2N5142	PN5142-18
2N3644	PN3644-5	2N4944	PN2222A-18	2N5143	PN5143-18
2N3645	PN3645-5	2N4945	PN2222A-18	2N5910	PN5910-18
2N3646	PN3646-18	2N4946	PN2222A-18		
2N3691	PN3691-18	2N4964	MPSA70-18		

### FETS

TO-106	TO-92	TO-106	TO-92	TO-106	TO-92
E100	J203-18	E300	J300-18	KE4393	PN4393-18
E101	J201-18	E304	J304-18	KE4416	PN4416-18
E102	J202-18	E305	J305-18	KE4857	PN4857-18
E103	J203-18	E308	J308-18	KE4858	PN4858-18
E108	J108-18	E309	J309-18	KE4859	PN4859-18
E109	J109-18	E310	J310-18	KE4860	PN4860-18
E110	J110-18	E311	J309-18	KE4861	PN4861-18
E111	J111-18	E312	J310-18	ITE4391	PN4391-18
E112	J112-18	KE3684	PN3684-18	ITE4392	PN4392-18
E113	J113-18	KE3685	PN3685-18	ITE4393	PN4393-18
E114	J114-18	KE3686	PN3686-18	P1086E	P1086-18
E174	J174-18	KE3687	PN3687-18	P1087E	P1087-18
E175	J175-18	KE4091	PN4091-18	U1897E	U1897-18
E176	J176-18	KE4092	KE4092-18	U1898E	U1898-18
E201	J201-18	KE4093	PN4093-18	U1899E	U1899-18
E202	J202-18	KE4220	PN4220-18	PN4302	PN4302-18
E203	J203-18	KE4221	PN4221-18	2N4303	PN4303-18
E210	J210-18	KE4222	PN4222-18	2N4304	PN4304-18
E211	J211-18	KE4223	PN4223-18	2N4342	PN4342-18
E212	J212-18	KE4224	PN4224-18	2N4343	PN4343-18
E270	J270-18	KE4391	PN4391-18	2N4360	PN4360-18
E271	J271-18	KE4392	PN4392-18	2N5033	PN5033-18
				2N5163	PN5163-18

# Reliability and Quality

## B+ PROGRAM

The B+ Program is a quality enhancement program intended primarily for users of transistors who either cannot or choose not to perform incoming inspection of transistors, or desire significantly better than usual incoming quality levels for their parts.

Transistor users who specify B+ processed parts will find that the program can:

- Eliminate incoming inspection
- Eliminate the need for, and thus the cost of, independent testing laboratories
- Reduce the cost of reworking assembled boards/assemblies

## RELIABILITY VIS-A-VIS QUALITY

The words "reliability" and "quality" are often used interchangeably, as though they connote identical facets of a product's merit. However, reliability and quality are different, and discrete component users must understand the essential difference between the two concepts in order to properly evaluate the various vendors' programs for product improvement that are generally available, and National's B+ program in particular.

The concept of quality gives us information about the population of faulty components among good components, and generally relates to the number of faulty components that arrive at a user's plant. Looked at in another way, quality can instead relate to the number of faulty components that escape detection at the component vendor's plant.

It is the function of a vendor's Quality Control arm to monitor the degree of success of that vendor in reducing the number of faulty components that escape detection. QC does this by testing the outgoing parts on a sampled basis. The Acceptable Quality Level (AQL) determines the stringency of the sampling. As the AQL decreases, it becomes more difficult for bad parts to escape detection, thus the quality of the shipped parts increases.

The concept of reliability, on the other hand, refers to how well a part that is initially good will withstand its environment. Reliability is measured by the percentage of parts that fail in a given period of time.

## QUALITY IMPROVEMENT

When purchasing a component or a system, it is expected that each item delivered has been thoroughly tested and will perform according to data sheet or detailed specifications. However, some test escapes do occur.

Additional screening programs can be implemented to reduce the number of escapes. To be effective, however, a screening program must not only reduce escapes but must also be tailored specifically to detect and remove the types of residual defects that are predicted by process and line monitor control data. A frequently used screening procedure consists of a short, accelerated burn-in, but this will not usually detect the primary historical failure mechanism, which is thermo-mechanical in origin.

## DOUBLE PASS + HOT SCREENING

National's double pass + hot screen flow, B+, provides a cost effective screening technique. By testing each B+ transistor at both room temperature and at +125°C, the following benefits are realized:

- Escapes caused by mishandling are reduced significantly.
- Residual thermo-mechanical defects not detected during normal room temperature testing or high temperature lot buy-off are removed.
- Anomalous high temperature parametric effects that may have been created during wafer fabrication are removed.
- An AQL of 0.05% or better is guaranteed.

## RELIABILITY THROUGH DESIGN

With increased component density in modern electronic products has come an increased concern with component failures in such products. Virtually all equipment manufacturers thoroughly exercise their products before shipment. This "system burn-in" is designed to simulate, as closely as possible, field operating conditions. A high failure rate of discrete components at the system burn-in level can dramatically increase manufacturing costs.

The most important factor affecting a component's reliability is its construction; i.e., the materials used and the method by which they are fabricated and assembled. Reliability cannot be tested in per se. Yet most transistor reliability enhancement programs utilize standardized procedures (usually MIL-STD) for either screening or lot acceptance. Frequently these standardized screening methods have only a minor influence on transistor field failure rates.

## NATIONAL'S ON-GOING RELIABILITY IMPROVEMENT PROGRAM

Transistor reliability improvement at National Semiconductor is a continuous program.

Implementation of a program for field reliability improvement requires knowledge of field environments and their influence on device performance. National's broad experience in commercial reliability programs has led to the development of an extensive in-house reliability monitoring program that permits us to monitor device performance under combinations of the following stresses:

- Thermal
- Thermo-Mechanical
- Mechanical
- Voltage
- Humidity

The data generated by these monitors is continually ranked and analyzed to determine appropriate corrective action necessary for any failure mechanisms noted. This continuous cycle of testing, analysis, and corrective action assures the continued improvement of transistor field reliability.

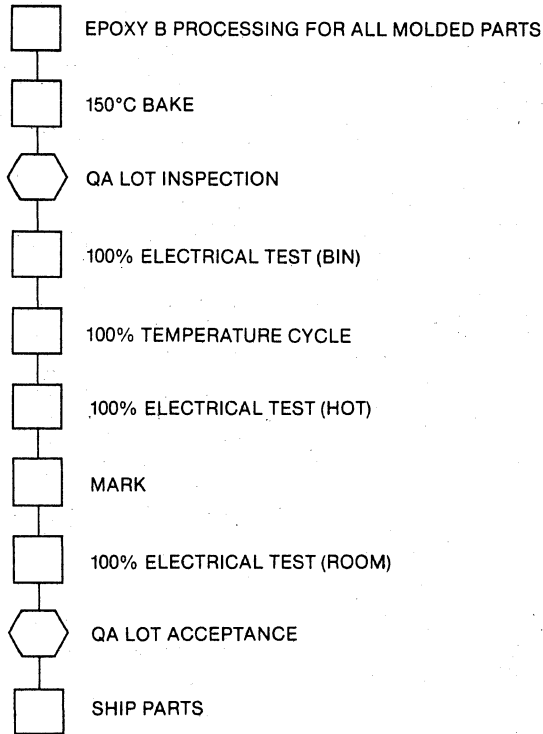


# Reliability and Quality (Continued)

## NATIONAL'S B + PROGRAM—A Logical Choice

A quality improvement program, the B + program actually combines the benefits of National's on-going reliability improvement program with the quality enhancement benefits of double pass + hot screening. The practical

benefit realized from this program is a significant reduction in rework at the device and PC board levels. The following flow chart shows how we do it, step by step:





Section 1

**NPN Transistors**





## SATURATED SWITCHES

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>(off)</sub> (ns) Max	Test Conditions	Process No.			
						Min	Max	1	Max	Min	Max		Min	Max						
2N706	TO-18	25	15	5	500	15	20	10	1	0.6	0.7	0.9	10	6	200	10	75	2	21	
2N743	TO-52		12		1 μA	20	10	100	1		0.65	0.85	10	5	300	10	24	1	21	
2N744	TO-52	20	12	5	1 μA	20	20	100	1		0.65	0.85	10	5	280	10	24	1	21	
							40	120	10											0.35
							20		1											0.25
2N753	TO-52	25	15	5	500	15	40	120	10	1	0.6	0.7	0.9	10	5	200	10	75	2	21
							20		10	0.35										
							20		1	0.25										
2N834	TO-52	40		5	500	20	25		10	1	0.25	0.9	10	4	350	10	30	2	21	
2N2369	TO-52	40	15	4.5	400	20	20	100	2	0.25	0.7	0.85	10	4	500	10	18	1	21	
2N2369A	TO-18	40	15	4.5	400*	20	20	120	100	1	0.2	0.7	0.85	10	4	500	10	18	1	21
							30	120	30	0.4										
							40	120	10	1										
							40	120	10	0.35										
2N3011	TO-52	30	12	5	400*	20	12	100	1	0.2	0.72	0.85	10	4	400	20	20	4	21	
							25	30	0.4											
							30	120	10											0.35
2N3605	TO-92 (94)		14		500	18	30	10	1	0.25		0.85	10	6	300	10	45	2	21	
2N3606	TO-92 (94)		14		500	18	30	10	1	0.25		0.85	10	6	300	10	60	2	21	
2N3607	TO-92 (94)		14		500	18	30	10	1	0.25		0.85	10	6	300	10	70	2	21	
2N4274	TO-92 (92)	Same as PN4274, see page 1-3 for explanation																21		
2N4275	TO-92 (92)	Same as PN4275, see page 1-3 for explanation																21		
2N4294	TO-92 (94)	30	12	4.5	400	20	20	100	2	0.25	0.6	0.9	10	5	400	10	20	1	21	
2N4295	TO-92 (94)	40	15	5	100	20	20	100	2	0.25	0.6	0.9	10	4	500	10	15	1	21	
							40	120	10											1
2N5030	TO-92 (94)	30	12	4	250	20	30	10	1	0.25	0.72	0.87	10	4	400	10	30	9	21	
2N5134	TO-92 (92)	Same as PN5134, see page 1-3 for explanation																21		
2N5224	TO-92 (92)	25	12	5	500	15	15	100	1	0.35		0.9	10	4	250	10	60	11	21	
							40	100	10	1										



# SATURATED SWITCHES (Continued)

Type No.	Case Style	V <sub>CE</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CE</sub> * I <sub>CB0</sub> (mA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> & V <sub>BE(SAT)</sub>			I <sub>C</sub> (mA) (I <sub>B</sub> = I <sub>C</sub> /10)	C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>(off)</sub> (ns) Max	Test Conditions	Process No.
						Min	Max	Max	Max	Min	Max			Min	Max			
2N5769	TO-92 (92)	40	15	4.5	400 20	20 30 40	100 30 120	1 0.4 0.35	0.2 0.25 0.5	0.7 1.5 1.6	0.85 30 100	10 30 100	4	500	10	18	1	21
2N5772	TO-92 (92)	40	15	5	500 20	15 25 30	300 100 120	1 0.5 0.4	0.2 0.28 0.5	0.75 1.2 1.7	0.95 100 300	30 100 300	5	350	30	28	3	21
MPS706	TO-92 (92)	15	15	3	500 15	20	10	1	0.6	0.9	10	10	6	200	10	75	11	21
MPS834	TO-92 (92)	40		5	500 20	25	10	1	0.25 0.4	0.9	10 50	10	4	350	10	30	2	21
MPS2369	TO-92 (92)	40*	15	4.5	400 20	20 40	100 120	2 1	0.25	0.7 0.85	10 10	10	4	500	10	18	7	21
MPS2713	TO-92 (92)	18	15	5	500 18	30	90	2	4.5	0.3	1.3	50						21
MPS2714	TO-92 (92)	18	15	5	500 18	75	225	2	4.5	0.3	0.6 1.3	50						21
MPS3646	TO-92 (92)	Same as PN3646, see page 1-4 for explanation																21
PN2369	TO-92 (92)	40*	15	4.5	400 20	20 40	100 120	2 1	0.25	0.7 0.85	10 10	10	4	500	10	18	1	21
PN2369A	TO-92 (92)	40*	15	4.5	30 20	20 30 40 40	100 30 120 10	1 0.4 1 0.35	0.2 0.2	0.7 1.15	0.85 30	10 30 100	4	500	10	18	1	21
PN4274	TO-92 (92)	30*	12	4.5	500 20	18 30 35	100 30 120	1 0.4 1	0.2 0.25 0.5	0.7 1.15 1.6	0.85 30 100	10 30 100	4	400	10	12	12	21
PN4275	TO-92 (92)	40*	15	4.5	500 20	18 30 35	100 30 120	1 0.4 1	0.2 0.25 0.5	0.72 1.15 1.6	0.85 30 100	10 30 100	4	400	10	12	12	21
PN5134	TO-92 (92)	20*	10	3.5	100 15	15 20	30 150	0.4 1	0.25	0.7 0.9	10	10	4	250	10	18	12	21
2N708	TO-52	40	15	5	25 20	30 15	120 10	1 0.5	1	0.4	0.72 0.8	10	6	300	10			22

### TEST CONDITIONS:

(1) V<sub>CC</sub> = 3V, I<sub>C</sub> = 10 mA, I<sub>B</sub><sup>1</sup> = 3 mA, I<sub>B</sub><sup>2</sup> = 1.5 mA. (2) V<sub>CC</sub> = 3V, I<sub>C</sub> = 10 mA, I<sub>B</sub><sup>1</sup> = 3 mA, I<sub>B</sub><sup>2</sup> = 1 mA. (3) V<sub>CC</sub> = 10V, I<sub>C</sub> = 300 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (4) V<sub>CC</sub> = 2V, I<sub>C</sub> = 30 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 3 mA. (5) V<sub>CC</sub> = 25V, I<sub>C</sub> = 300 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (6) V<sub>CC</sub> = 25V, I<sub>C</sub> = 500 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA. (7) V<sub>CC</sub> = 30V, I<sub>C</sub> = 500 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA. (8) V<sub>CC</sub> = 30V, I<sub>C</sub> = 1A, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 100 mA. (9) V<sub>CC</sub> = 3V, I<sub>C</sub> = 10 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (10) V<sub>CC</sub> = 10.7V, I<sub>C</sub> = 1A, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 100 mA. (11) V<sub>CC</sub> = 3V, I<sub>C</sub> = 10 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 3 mA. (12) V<sub>CC</sub> = 3V, I<sub>C</sub> = 10 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 3.3 mA.



# NPN Transistors



## SATURATED SWITCHES (Continued)

Type No.	Case Style	VCES* VCBO (V) Min	VCEO (V) Min	VEBO (V) Min	ICES* ICBO (nA) Max @ VCB (V)	hFE @ IC & VCE			VCE(SAT) (V) & VBE(SAT) (V)		IC (mA) (IB = IC/10)	Cob (pF) Max	fT (MHz) @ IC		t(off) (ns) Max	Test Conditions	Process No.	
						Min	Max	IC (mA)	VCE (V)	Max			Min	Max				Min
2N3009	TO-52	40	15	4	500* 20	15	300	1	0.18	0.75	0.95	30	5	350	30	25	3	22
						25	100	0.5	0.28	1.2	100							
						30	120	30	0.4	0.5	1.7	300						
2N3013	TO-52	40	15	5	300* 20	15	300	1	0.18	0.75	0.95	30	5	350	30	25	3	22
						25	100	0.5	0.28	1.2	100							
						30	120	30	0.4	0.5	1.7	300						
2N3646	Same as PN3646, see below for explanation																22	
PN3646	TO-92 (92)	40*	15	5	500* 20	15	300	1	0.2	0.75	0.95	30	5	350	30	28	3	22
						20	100	0.5	0.28	1.2	100							
						30	120	30	0.4	0.5	1.7	300						
2N3015	TO-39	60	30	5	200 30	10	300	0.7	0.4	1.2	150	8	250	50	60	5 & 6	25	
						30	120	150	10	1.0	1.6							500
2N3252	TO-39	60	30	5	500 40	25	1A	5	0.3	0.7	1.0	150	12	200	50	70	7	25
						30	90	500	1	0.5	1.3	500						
						30	150	150	1	1.0	1.8	1A						
2N3253	TO-39	75	40	5	500 60	20	750	5	0.35	0.7	1.0	150	12	175	50	70	7	25
						25	75	375	1	0.6	1.3	500						
						25	150	150	1	1.2	1.8	1A						
2N3444	TO-39	80	50	5	500 60	15	1A	5	0.35	0.7	1.0	150	12	150	50	70	7	25
						20	60	500	1	0.6	1.3	500						
						20	150	150	1	1.2	1.8	1A						
2N3724	TO-39	50	30	6	1.7 μA 40	30	1A	5	0.32	0.9	1.1	300	12	300	50	60	7	25
						25	800	2	0.42	1.2	500							
						35	500	1	0.65	1.5	800							
						40	300	1	0.75	1.7	1A							
						60	150	100	1	0.75	1.7	1A						
						30	10	1	0.75	1.7	1A							
2N3724A	TO-39	50	30	6	500 40	25	1.5A	5	0.32	0.9	1.1	300	12	300	50	50	8	25
						30	1A	5	0.42	1.2	500							
						30	800	2	0.65	1.3	800							
						35	500	1	0.75	1.7	1A							
						40	300	1	0.75	1.7	1A							
						60	150	100	1	0.75	1.7	1A						
						30	10	1	0.75	1.7	1A							
2N3725	TO-39	80	50	6	1.7 μA 60	25	1A	5	0.4	0.9	1.1	300	10	300	50	60	7	25
						20	800	2	0.52	1.2	500							
						35	500	1	0.8	1.5	800							
						40	300	1	0.95	1.7	1A							
						60	150	100	1	0.95	1.7	1A						
						30	10	1	0.95	1.7	1A							



## SATURATED SWITCHES (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EB0</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>(off)</sub> (ns) Max	Test Conditions	Process No.	
						Min	Max	I <sub>C</sub> (mA)	V <sub>CE</sub> (V)	Max	Min	Max		I <sub>C</sub> (mA)	Min				Max
2N3725A	TO-39	80	50	6	500	60	20	1.5A	5	0.4	1.1	300	10	50	50	8	25		
							25	1A	5	0.52	1.2	500							
							25	800	2	0.8	1.3	800							
							35	500	1	0.9	1.4	1A							
							40	300	1										
							60	150	100	1									
DH3724CD	Ceramic DIP (40)	50*	36	60	1.7 μA	40	30	1A	5	0.75	1.7	500	12	300	50	60	7	25	
							35	500	1	0.45	1.2	1A							
							60	150	100	1									
DH3724CN	Molded DIP (39)	Electrical same as DH3724CD															25		
DH3725CD	Ceramic DIP (40)	80*	50	6	1.7 μA	60	25	1A	5	0.95	1.7	500	10	250	50	60	7	25	
							35	500	1	0.52	1.2	1A							
							60	150	100	1									
DH3725CN	Molded DIP (39)	Electrical same as DH3725CD															25		
2N4013	TO-18	50	30	6	1.7 μA	40	30	1A	5	0.25	0.76	10	12	300	50	60	7	25	
							25	800	2	0.2	0.86	100							
							35	500	1	0.32	1.1	300							
							40	300	1	0.42	0.9	1.2							500
							60	150	100	1	0.65	1.5							800
							30	10	1	0.75	1.7	1A							
2N4014	TO-18	80	50	6	1.7 μA	60	25	1A	5	0.25	0.76	10	10	300	50	60	7	25	
							20	800	2	0.26	0.86	100							
							35	500	1	0.4	1.1	300							
							40	300	1	0.25	0.9	1.2							500
							60	150	100	1	0.8	1.5							800
							30	10	1	0.9	1.7	1A							
2N4047	TO-39	80	50	6	1.7 μA	60	15	1A	5	0.4	1.1	300	10	250	50	60	7	25	
							15	800	2										
							20	500	1	0.52	0.9	1.2							500
							30	300	1	0.8	1.5	800							
							40	150	100	1									
							20	10	1	0.95	1.7	1A							

### TEST CONDITIONS:

- (1) V<sub>CC</sub> = 3V, I<sub>C</sub> = 10 mA, I<sub>B</sub><sup>1</sup> = 3 mA, I<sub>B</sub><sup>2</sup> = 1.5 mA. (2) V<sub>CC</sub> = 3V, I<sub>C</sub> = 10 mA, I<sub>B</sub><sup>1</sup> = 3 mA, I<sub>B</sub><sup>2</sup> = 1 mA. (3) V<sub>CC</sub> = 10V, I<sub>C</sub> = 300 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (4) V<sub>CC</sub> = 2V, I<sub>C</sub> = 30 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 3 mA. (5) V<sub>CC</sub> = 25V, I<sub>C</sub> = 300 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (6) V<sub>CC</sub> = 25V, I<sub>C</sub> = 500 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA. (7) V<sub>CC</sub> = 30V, I<sub>C</sub> = 500 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA. (8) V<sub>CC</sub> = 30V, I<sub>C</sub> = 1A, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 100 mA. (9) V<sub>CC</sub> = 3V, I<sub>C</sub> = 10 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (10) V<sub>CC</sub> = 10.7V, I<sub>C</sub> = 1A, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 100 mA. (11) V<sub>CC</sub> = 3V, I<sub>C</sub> = 10 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 3 mA. (12) V<sub>CC</sub> = 3V, I<sub>C</sub> = 10 mA, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 3.3 mA.



## SATURATED SWITCHES (Continued)

Type No.	Case Style	VCES* VCBO (V) Min	VCEO (V) Min	VEBO (V) Min	ICES* ICBO (nA) Max	@ VCB (V)	hFE @ IC & VCE (V)			VCE(SAT) (V) & VBE(SAT) (V) @ IC (mA)			Cob (pF) Max	fT (MHz) @ IC (mA)		t(off) (ns) Max	Test Conditions	Process No.	
							Min	Max	1A	1	1.0	1.5		1A	Min				Max
2N5189	TO-39	60	35	5	500	30	15	1A	1	1.0	1.5	1A	12	250	50	70	10	25	
2N6737	TO-237 (EBC)	80	45	6	1.7 μA	60	35	500	1	0.52	0.8	1.1	500	10	300	50	60	7	25

### TEST CONDITIONS:

- (1)  $V_{CC} = 3V$ ,  $I_C = 10\text{ mA}$ ,  $I_{B1} = 3\text{ mA}$ ,  $I_{B2} = 1.5\text{ mA}$ . (2)  $V_{CC} = 3V$ ,  $I_C = 10\text{ mA}$ ,  $I_{B1} = 3\text{ mA}$ ,  $I_{B2} = 1\text{ mA}$ . (3)  $V_{CC} = 10V$ ,  $I_C = 300\text{ mA}$ ,  $I_{B1} = I_{B2} = 30\text{ mA}$ . (4)  $V_{CC} = 2V$ ,  $I_C = 30\text{ mA}$ ,  $I_{B1} = I_{B2} = 3\text{ mA}$ . (5)  $V_{CC} = 25V$ ,  $I_C = 300\text{ mA}$ ,  $I_{B1} = I_{B2} = 30\text{ mA}$ . (6)  $V_{CC} = 25V$ ,  $I_C = 500\text{ mA}$ ,  $I_{B1} = I_{B2} = 50\text{ mA}$ . (7)  $V_{CC} = 30V$ ,  $I_C = 500\text{ mA}$ ,  $I_{B1} = I_{B2} = 50\text{ mA}$ . (8)  $V_{CC} = 30V$ ,  $I_C = 1A$ ,  $I_{B1} = I_{B2} = 100\text{ mA}$ . (9)  $V_{CC} = 3V$ ,  $I_C = 10\text{ mA}$ ,  $I_{B1} = I_{B2} = 1\text{ mA}$ . (10)  $V_{CC} = 10.7V$ ,  $I_C = 1A$ ,  $I_{B1} = I_{B2} = 100\text{ mA}$ . (11)  $V_{CC} = 3V$ ,  $I_C = 10\text{ mA}$ ,  $I_{B1} = I_{B2} = 3\text{ mA}$ . (12)  $V_{CC} = 3V$ ,  $I_C = 10\text{ mA}$ ,  $I_{B1} = I_{B2} = 3.3\text{ mA}$ .



## RF AMPS AND OSCILLATORS

Type No.	Case Style	VCES* VCBO (V) Min	VCEO (V) Min	VEBO (V) Min	ICBO (nA) Max	@ VCB (V)	hFE @ IC & VCE (V)			VCE(SAT) (V) & VBE(SAT) (V) @ IC (mA)			Cob/Cre (pF)		fT (MHz) @ IC (mA)		NF (dB) @ Freq (MHz)		Process No.	
							Min	Max	1A	1	0.4	1.0	10	Min	Max	Min	Max	5		450
2N2857	TO-72	30	15	2.5	10	15	30	150	3	1		1	1000	1900	5	4.5	450	42		
2N3478	TO-72	30	15	2	20	1	25	150	2	8		1	750	1600	5	4.5	200	42		
2N3600	TO-72	30	15	3	10	15	20	150	3	1		1	850	1500	5	4.5	200	42		
2N3932	TO-72	30	20	2.5	10	15	40	150	2	8		0.55	750	1600	2	4.5	200	42		
2N3933	TO-72	40	30	2.5	10	15	60	200	2	8		0.55	750	1600	2	4	200	42		
2N4259	TO-72	40	30	2.5	10	15	60	250	2	8		0.55	750	1600	2	5	450	42		
2N5179	TO-72	20	12	2.5	20	15	25	250	3	1	0.4	1.0	10	1	900	2000	5	4.5	200	42
2N5180	TO-72	30	15	2	500	8	20	200	2	8		1	650	1700	2			42		
40235	TO-72	35		3	1 μA 20	35 1	40	170	1	6		0.65						42		
40236	TO-72	35		3	1 μA 20	35 1	40	275	1	6		0.65						42		
40237	TO-72	35		3	1 μA 20	35 1	27	275	1	6		0.8						42		
40238	TO-72	35		3	1 μA 20	35 1	40	170	1	6		0.65						42		
40239	TO-72	35		3	1 μA 20	35 1	27	100	1	6		0.65						42		



# RF AMPS AND OSCILLATORS (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CBO</sub> (nA) @ Max	V <sub>CB</sub> (V) 1	h <sub>FE</sub>		I <sub>C</sub> (mA) &	V <sub>CE</sub> (V) (V)	V <sub>CE(SAT)</sub> & V <sub>BE(SAT)</sub>			C <sub>ob</sub> /C <sub>re</sub>		f <sub>T</sub>			NF		Freq (MHz)	Process No.
							Min	Max			Max	Min	Max	Min	Max	Min	Max	Min	Max	Min		
40240	TO-72	35		3	1 μA 20	35 1	27	275	1	6				0.65								42
40242	TO-72	35		3	20	1	40	170	1	6				0.65								42
MPS6539	TO-92 (91)	20	20		50	15	20		4	10				0.7	500		4	4.5	100			42
MPS6548	TO-92 (91)	30	25	3	100	25	25		4	10	0.5		0.95	4	0.7	650		4				42
MPSH10	TO-92 (91)	30	25	3	100	25	60		4	10	0.5			4	0.35 0.65	650		4				42
MRF501	TO-72	25	15	3.5	50	1	30	250	1	6						600		5				42
MRF502	TO-72	35	15	3.5	20	1	40	170	1	6						800		5				42
PN5179	TO-92 (91)	20	15	2.5	2	15	25	250	3	1	0.4		1.0	10	1.0	900	2000	5	4.5	200		42
2N917	TO-72	30	15	3	1	15	20		3	1	0.5		0.87	3	3	500		4	6	60		43
2N918	TO-72	30	15	3	10	15	20		3	1	0.4		1.0	10	3	600		4	6	60		43
2N3563	TO-92 (92)	Same as PN3563, see page 1-8 for explanation																			43	
2N3564	TO-92 (92)	Same as PN3564, see page 1-8 for explanation																			43	
2N3662	TO-92 (94)	18	12	3	500	15	20		8	10				0.8 1.7	700	2100	5	6.5	60			43
2N3663	TO-92 (94)	30	12	3	500	15	20		8	10				0.8 1.7	700	2100	5	6.5	60			43
2N3825	TO-92 (94)	30	15	4	100	15	20		2	10	0.25			2	3.5	200	800	2	5.5	1		43
2N4292	TO-92 (94)	30	15	3	500	15	20		3	1	0.6			10	3.5	600		4	6	60		43
2N4293	TO-92 (94)	30	15	3	500	15	20		3	1	0.6			10	3.5	600		4	6	60		43
2N5130	TO-92 (92)	Same as PN5130, see page 1-8 for explanation																			43	
2N5770	TO-92 (92)	30	15	4.5	10	15	50 20	200	8 3	10 1	0.4		1.0	10	0.7 1.1	900	1800	8	6	60		43
MPS3563	TO-92 (92)	Same as PN3563, see page 1-8 for explanation																			43	
MPS6507	TO-92 (92)	30*	20		5	15	25		2	10					2.5	700		10				43

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NPN Transistors



# NPN Transistors



## RF AMPS AND OSCILLATORS (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CBO</sub> (nA) @ Max	V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> & V <sub>BE(SAT)</sub> @ I <sub>C</sub>			C <sub>ob</sub> /C <sub>re</sub> (pF)		f <sub>T</sub> @ I <sub>C</sub>			NF @ Freq		Process No.	
							Min	Max	(mA)	(V)	(V)	Min	Max	(mA)	Min	Max	(MHz)	(MHz)	(dB)		(MHz)
MPS6511	TO-92 (92)	30*	20		50	15	25	10	10			2.5								43	
MPS6541	TO-92 (92)	30*	20	4	50	15	25	4	10			1.7	600	1500	4					43	
PN918	TO-92 (92)	30	15	3	10	15	20	3	1	0.4	1.0	10	1.7	600	4	6	60			43	
PN3563	TO-92 (92)	30	15	2	50	15	20	200	8	10		1.7	600	1500	8					43	
PN3564	TO-92 (92)	30	15	4	50	15	20	500	15	10	0.3	0.97	20	3.5	400	1200	15			43	
PN5130	TO-92 (92)	30	12	1	50	10	15	250	8	10	0.6	1.0	10	1.7	450	8				43	
2N4134	TO-72	30	30	3	50	10	25	200	4	5		0.5	350	800	4	2.5	60			44	
2N4135	TO-72	30	30	3	50	10	25	200	4	5		0.5	425	800	4	5	450			44	
MPS6568A	TO-92 (91)	20	20	3	50	10	20	200	4	5	0.3	0.96	10	0.65	375	800	4	3.3	200	44	
MPS6569	TO-92 (91)	20	20	3	50	10	20	200	4	5	3	0.96	10	0.25	0.5	300	800	4	6	45	44
MPS6570	TO-92 (91)	20	20	3	50	10	20	200	4	5	3	0.96	10	0.25	0.5	300	800	4	6	45	44
MPSH30	TO-92 (91)	20	20	3	50	10	20	200	4	5	0.3	0.96	10	0.65	300	800	4	6	45	44	
MPSH31	TO-92 (91)	20	20	3	50	10	20	200	4	5	0.3	0.96	10	0.65	300	800	4	6	45	44	
SE5020	TO-72	20	20	3	50	10	20	200	4	5	3.0	0.96	10	0.25	0.5	375	800	4	3.3	200	44
SE5021	TO-72	20	20	3	50	10	20	200	4	5	3.0	0.96	10	0.25	0.5	375	800	4	4	200	44
SE5022	TO-72	20	20	3	50	10	20	200	4	5	3.0	0.96	10	0.25	0.5	300	800	4			44
SE5023	TO-72	20	20	3	50	10	20	200	4	5	3.0	0.96	10	0.25	0.5	300	800	4	6	45	44
SE5024	TO-72	20	20	3	50	10	20	200	4	5	3.0	0.96	10	0.25	0.5	300	800	4	6	45	44
SE5050	TO-72	20	20	3	50	10	20	200	4	5	3.0	0.96	10	0.25	0.5	300	4	4	100	44	
SE5051	TO-72	20	20	3	50	10	20	200	4	5	3.0	0.96	10	0.25	0.5	300	4			44	
SE5052	TO-72	20	20	3	50	10					3.0		10			375	4	4	200	44	
MPSH32	TO-92 (96)	30	30	4	50	10	27	200	4	5	0.3	1.2	10	0.22	300	4				45	
SE5055	TO-72	20	20	3	50	20	20	220	2	10	2.75		10	0.22	300	2	5	45		45	
PE5025	TO-92 (92)	30	30	3	50	30	20	100	10	10	0.6		20	0.6	1	300	700	10			46



# RF AMPS AND OSCILLATORS (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CBO</sub> (nA) Max	V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> & V <sub>BE(SAT)</sub> (V) & (V)			C <sub>ob</sub> /C <sub>re</sub> (pF)		f <sub>T</sub> (MHz)		NF (dB) Max	Freq (MHz)	Process No.		
							Min	Max	@ I <sub>C</sub> (mA)	Max	Min	Max	@ I <sub>C</sub> (mA)	Min	Max	Min				Max	@ I <sub>C</sub> (mA)
MPS6542	TO-92 (96)	30*	20		50	15	25		2	10				1.5	700		10			47	
MPS6543	TO-92 (96)	35	20	3	100	25	25		4	10	0.35		0.95	10	1	750		4		47	
MPS6546	TO-92 (96)	35	25	3	100	25	20		2	10	0.35			10	0.45	600		2		47	
MPS6547	TO-92 (96)	35	25	3	100	25	20		2	5	0.35			10	0.35	600		2		47	
MPSH11	TO-92 (96)	30	25	3	100	25	60		4	10	0.5			4	0.6	0.9	650	4		47	
MPSH19	TO-92 (96)	30	25	3	100	15	45		4	10				0.65	300		4			47	
MPSH24	TO-92 (96)	40	30	4	50	15	30		8	10				0.36	400		8			47	
MPSH34	TO-92 (96)	45	45	4	50	30	15 40		20 7	2 15	0.5			20	0.32	500		15		47	
PE3100	TO-92 (96)	30*	30	3	200	30	30	225	5	10				0.8	500		5			47	
PE5029	TO-92 (96)	30	30	3	200	30	30	225	5	10				0.4	500		5	6	45	47	
PE5030B	TO-92 (96)	45	40	4.5	100	30	45	150	7	15	3			20 10	0.25	0.4	600		7		47
PE5031	TO-92 (96)	40	30	4	100	30	30	180	5	10	1			10	0.4	500		5	4.5	200	47
TIS86	TO-92 (98)	30	30		100	15	40	200	4	10	0.5			15	0.45	500		4	5	200	47
TIS87	TO-92 (98)	45	45		100	15	30	150	12	12	0.5			15	0.45	500		12			47
MPS6540	TO-92 (91)	30	30	4	100	25	25		2	10	0.5			10	0.65	350		2		49	
MPS6544	TO-92 (91)	60	45	4	500	35	20		30	10	0.5			30	0.65						49
MPS6567	TO-92 (91)		40	5	500	35	25		10	5	0.5			10	0.7						49
MPSH20	TO-92 (91)	40	30	4	50	15	25		4	10			0.95	10	0.65	400		4			49
MPSH37	TO-92 (91)		40	5	500	35	25		5	10	0.5			10	0.7	300		5			49

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NPN Transistors

# NPN Transistors



## LOW LEVEL AMPS

Type No.	Case Style	V <sub>CB0</sub>	V <sub>CE0</sub>	V <sub>EB0</sub>	I <sub>CB0</sub> (nA) Max	V <sub>CB</sub> (V)	h <sub>FE</sub>			V <sub>CE</sub> (V)	V <sub>CE(SAT)</sub> & V <sub>BE(SAT)</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub>		I <sub>C</sub> (mA)	NF (dB) Max	Test Conditions	Process No.
		Min	Min	Min			Min	Max	@		I <sub>C</sub> (mA)	Max	Min		Max	@				
2N760	TO-18	45	45	8	200	30	76	300	1	5	1.0	0.6	1.1	10	8	50	1.0			07
2N760A	TO-18	60	60	8	100	30	76	333	1	5	1.0		1.1	10	8	50	1.0			07
2N929	TO-18	45	45	5	10	45	60	350	10	5	1.0	0.6	1.0	10	8	30	0.5	4	1	07
2N929A	TO-18	60	45	6	2	45	40	120	500 μA	5	0.5	0.7	0.9	10	6	45	0.5	4		07
2N930	TO-18	45	45	5	10	45	150	600	10	5	1.0	0.6	1.0	10	8	30	0.5	3	1	07
2N2484	TO-18	60	60	6	10	45	100	300	500 μA	5	0.35			1	10	15	0.05	3	1	07
2N2509	TO-18	125	80	7	5	100	25	40	10	5	1.0		0.9	5	6	45	5	7	1	07
2N2510	TO-18	100	65	7	5	80	75	150	500	10	1.0		0.9	5	6	45	5	4	2	07
2N2511	TO-18	80	50	7	5	60	80	240	750	10	1.0		0.9	5	6	45	5	4	2	07
2N2586	TO-18	60	45	6	2	45	120	150	360	500 μA	0.5	0.7	0.9	10	7	45	0.5	3.5	2	07
2N3117	TO-18	60	60	6	10	45	100	400	500	10	0.35			1	4.5	60	0.5	1	2	07
2N3246	TO-18	60	40	10	1	40	150	400	800	10	0.5	0.7	0.9	5	5	60	180	1	2	07



# LOW LEVEL AMPS (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CBO</sub> (nA) Max	V <sub>CB</sub> (V) @	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>			NF (dB) Max	Test Conditions	Process No.	
							Min	Max	(mA)	(V)	Max	Min	Max		Min	Max	Min				Max
2N3565	TO-92 (92)	Same as PN3565, see page 1-13 for explanation																		07	
2N3707	TO-92 (94)	30	30	6	100	20	100	400	100 μA	5	1.0		10				5	1	07		
2N3708	TO-92 (94)	30	30	6	100	20	45	660	1	5	1.0		10						07		
2N3709	TO-92 (94)		30		100	20	45	165	1	5	1.0		10						07		
2N3710	TO-92 (94)	30	30	6	100	20	90	330	1	5	1.0		10						07		
2N3711	TO-92 (94)	30	30	6	100	20	180	660	1	5	1.0		10						07		
2N3858A	TO-92 (94)	60	60	6	500	18	60	120	10	1				4	90	250	2		07		
2N3859A	TO-92 (94)	60	60	6	500	18	100	200	10	1				4	90	250	2		07		
2N3877	TO-92 (94)	70	70	4	500	70	20	250	2	4.5		0.5	0.9	10					07		
2N3877A	TO-92 (94)	85	85	4	500	70	20	250	2	4.5		0.5	0.9	10					07		
2N3900A	TO-92 (94)	18	18	5	100	18	250	500	2	4.5				12			5	4	07		
2N3901	TO-92 (94)	18	18	5	100	15	350	700	2	4.5							5	4	07		
2N4286	TO-92 (94)	30	25	6	50	25	150	600	1	5	0.35		0.8	1	6	40		1	07		
2N4287	TO-92 (94)	45	45	7	10	30	150	600	1	5	0.35		0.8	1	6	40		1	5	1	07
2N4384	TO-18	40	30	5	10	30	150		10	5	0.2	0.65	0.8	10	8	30	120	0.5	2	1	07
							120		1	5											
							100	500	10 μA	5											
							60		1 μA	5											
2N4386	TO-18	40	30	5	10	30	120		10	5	0.2	0.65	0.8	10	8	30	120	0.5	3	1	07
							100		1	5											
							40	500	10 μA	5											
2N4409	TO-92 (92)	80	50	5	10	60	60	400	10	1	0.2		0.8	1	12	60	300	10			07
							60		1	1											

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 10 Hz-15.7 kHz. (2) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (3) I<sub>C</sub> = 5 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (4) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 10 Hz-15.7 kHz. (5) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 10 kHz. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 5 kHz.



# NPN Transistors



## LOW LEVEL AMPS (Continued)

Type No.	Case Style	VCBO (V) Min	VCEO (V) Min	VEBO (V) Min	ICBO (nA) @ VCB (V) Max	hFE @ IC & VCE				VCE(SAT) (V) & VBE(SAT) (V) @ IC (mA)			Cob (pF) Max	fT (MHz) @ IC (mA)			NF (dB) Max	Test Conditions	Process No.
						Min	Max	Min	Max	Max	Min	Max		Min	Max	Min			
2N4410	TO-92 (92)	120	80	5	10 100	60 60	400 1	10 1	1 1	0.2	0.8	1	12	60	300	10			07
2N4966	TO-92 (92)	50	40	6	25 25	40 50	200 10	0.01 10	5 5	0.4		10	6	40		1			07
2N4967	TO-92 (92)	50	40	6	25 25	100 120	600 10	0.01 10	5 5	0.4		10	6	40		1			07
2N4968	TO-92 (92)	30	25	6	50 25	40 50	200 10	0.01 10	5 5	0.4		10	6						07
2N5088	TO-92 (92)	35	30		50 20	300 350 300		10 1 100 μA	5 5 5	0.5		10	4				3	3	07
2N5089	TO-92 (92)	30	25		50 15	400 450 400		10 1 100 μA	5 5 5	0.5		10	4				2	3	07
2N5133	TO-92 (92)	20	18	3	50 15	60 1000		1 mA	5	0.4		1	5						07
2N5209	TO-92 (92)	50	50		50 35	150 150 100		10 1 100 μA	5 5 5	0.7		10	4	30		0.5	4	5	07
2N5210	TO-92 (92)	50	50		50 35	250 250 200		10 1 100 μA	5 5 5	0.7		10	4	30		0.5	3	4	07
2N5232	TO-92 (94)		50		30 50	250 500		2	5	0.125		10	4						07
2N5232A	TO-92 (94)		50		30 50	250 500		2	5	0.125		10	4				5	2	07
MPS3707	TO-92 (92)		30		100 20	100 400		100 μA	5	1.0		10					5	4	07
MPS3708	TO-92 (92)		30		100 20	45 660		1	5	1.0		10							07
MPS3709	TO-92 (92)		30		100 20	45 165		1	5	1.0		10							07
MPS3710	TO-92 (92)		30		100 20	90 330		1	5	1.0		10							07
MPS3711	TO-92 (92)		30		100 20	180 660		1	5	1.0		10							07
MPS6571	TO-92 (92)	25	20	3	50 20	250 1000		100 μA	5	0.5		10	4.5	50		0.5			07
MPSA09	TO-92 (92)	50	50		100 25	100 600		100 μA	5	0.9		10	5	600		0.5			07



## LOW LEVEL AMPS (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CB0</sub> (nA) Max @ V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		NF (dB) Max	Test Conditions	Process No.		
						Min	Max	1	10	Max	Min	Max		1	Min				Max	
PE4010	TO-92 (92)	30	25	6	200	5	200	1000	1	10	0.35			4	20	60	0.05		07	
PN930	TO-92 (92)	45	45	5	10	45	600	10	5	1.0	0.6	1.0	10	8	30	0.5	3	1	07	
							150	500 μA	5											
							100	300	10 μA											5
PN2484	TO-92 (92)	60	60	6	10	45	800	10	5	0.35			10	6					07	
							250	1	5											
							200	500 μA	5											
							175	100 μA	5											
							100	500	10 μA											5
							30	1 μA	5											
PN3565	TO-92 (92)	30	25	6	50	25	150	600	1	10	0.35			4	40	240	1		07	
PN5133	TO-92 (92)	20	18	3	50	15	60	1000	1	5	0.4			5	40	240	1		07	

### TEST CONDITIONS:

(1) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 10 Hz-15.7 kHz. (2) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (3) I<sub>C</sub> = 5 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (4) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 10 Hz-15.7 kHz. (5) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 10 kHz. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 5 kHz.



## GENERAL PURPOSE AMPS AND SWITCHES

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CB0</sub> (nA) Max @ V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
						Min	Max	1	10	Max	Min	Max		1	Min					Max
MPS3903	TO-92 (92)	60	40	6		20	0.1	1	0.2	0.65	0.85	10	4	200	10		5	8	02	
						35	1	1												
						50	150	10												1
						30	50	1												1
						15	100	1												1
									0.3		1.0	50								

### TEST CONDITIONS:

(1) I<sub>C</sub> = 300 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (2) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (3) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (4) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 25V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (5) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 4.5V, f = 15.7 kHz. (6) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (7) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 15.7 kHz. (8) I<sub>C</sub> = 250 μA, V<sub>CE</sub> = 5V, f = 10 Hz-15.7 kHz. (9) I<sub>C</sub> = 3 mA, V<sub>CE</sub> = 10V, f = 1 MHz. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 15.7 kHz.



## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V)	V <sub>CE0</sub> (V)	V <sub>EBO</sub> (V)	I <sub>CB0</sub> (nA)	V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF)	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns)	NF (dB)	Test Conditions	Process No.		
		Min	Min	Min	Max	@	Min	Max	Max	Max	Min	Max	Max	Min	Max	Max	Max				
MPS3904	TO-92 (92)	60	40	6			40	0.1	1	0.2	0.65	0.85	10	4	200	10		5	8	02	
							70	1	1												
							100	300	10												1
							60		50												1
							30		100												1
MPS6573	TO-92 (92)		35		100	35	100	100 μA	5	0.5			10	12	100	300	10				02
							200	500	10												
MPS6574	TO-92 (92)		35		100	35	100	300	1	5	0.5		10	12	100	300	10				02
							(4 Groups)														
MPS6575	TO-92 (92)		45		100	45	100	100 μA	5	0.5			10	12	100	300	10				02
							200	500	10												
MPS6576	TO-92 (92)		45		100	45	100	300	1	5	0.5		10	12	100	300	10				02
							(4 Groups)														
MPSA20	TO-92 (92)		40	4	100	30	40	400	5	10				4	125	5					02
2N2923	TO-92 (94)	25	25	5	100	25	90	180	2	10				10							04
											(1 kHz)										
2N2924	TO-92 (94)	25	25	5	100	25	150	300	2	10				10							04
											(1 kHz)										
2N2925	TO-92 (94)	25	25	5	100	25	235	470	2	10				10							04
											(1 kHz)										
2N2926	TO-92 (94)	18	18	5	500	18	35	470	2	10				10							04
											(1 kHz)										
2N3390	TO-92 (94)	25	25	5	100	18	400	800	2	4.5				10							04
2N3391	TO-92 (94)	25	25	5	100	18	250	500	2	4.5				10				5	5		04
2N3391A	TO-92 (94)	25	25	5	100	18	250	500	2	4.5				10				5	5		04
2N3392	TO-92 (94)	25	25	5	100	18	150	300	2	4.5				10							04
2N3393	TO-92 (94)	25	25	5	100	18	90	180	2	4.5				10							04
2N3395	TO-92 (94)	25	25	5	100	18	150	500	2	4.5				10							04
2N3396	TO-92 (94)	25	25	5	100	18	90	500	2	4.5				10							04
2N3397	TO-92 (94)	25	25	5	100	18	55	500	2	4.5				10							04



## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CBO</sub> (nA) Max	V <sub>CB</sub> (V)	h <sub>FE</sub>			V <sub>CE</sub> (V)	V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V)				I <sub>C</sub> (mA)	C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	@		Max	Min	Max	@			Min	Max				
2N3398	TO-92 (94)	25	25	5	100	18	55	800	2	4.5					10						04	
2N3415	TO-92 (94)	25	25	5	100	25	180	540	2	4.5	0.3	0.6	1.3	50							04	
2N3416	TO-92 (94)	50	50	5	100	25	75	225	2	4.5	0.3	0.6	1.3	50							04	
2N3417	TO-92 (94)	50	50	5	100	25	180	540	2	4.5	0.3	0.6	1.3	50							04	
2N3900	TO-92 (94)	18	18	5	100	18	250	500	2	4.5						12					04	
2N4424	TO-92 (94)	40	40	5	100	25	180	540	2	4.5	0.3	0.6	1.3	50							04	
2N5172	TO-92 (94)	25	25	5	100	25	100	500	10	10	0.25			10	10						04	
MPS3392	TO-92 (92)	25	25	5	100	18	150	300	2	4.5					10						04	
MPS3393	TO-92 (92)		25		100	18	90	180	2	4.5					3.5						04	
MPS3394	TO-92 (92)		25		100	18	55	110	2	4.5					3.5						04	
MPS3395	TO-92 (92)		25		100	18	150	500	2	4.5					3.5						04	
MPS3396	TO-92 (92)		25		100	18	90	500	2	4.5					3.5						04	
MPS3397	TO-92 (92)		25		100	18	55	500	2	4.5					3.5						04	
MPS3398	TO-92 (92)		25		100	18	55	800	2	4.5					3.5						04	
MPS5172	TO-92 (92)	25	25	5	100	25	100	500	10	10	0.25			10	10						04	
MPS6520	TO-92 (92)		25	4	50	30	200	400	2	10	0.5			50	3.5				3	10	04	
MPS6521	TO-92 (92)		25	4	50	30	200	600	2	10	0.5			50	3.5				3	10	04	
							150			100 μA												10
TIS97	TO-92 (97)		40		10	40	250	700	0.1	5									3	7	04	

### TEST CONDITIONS:

(1) I<sub>C</sub> = 300 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (2) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (3) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (4) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 25V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (5) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 4.5V, f = 15.7 kHz. (6) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (7) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 15.7 kHz. (8) I<sub>C</sub> = 250 μA, V<sub>CE</sub> = 5V, f = 10 Hz-15.7 kHz. (9) I<sub>C</sub> = 3 mA, V<sub>CE</sub> = 10V, f = 1 MHz. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 15.7 kHz.





## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	VCBO	VCEO	VEBO	ICBO	VCB	hFE				VCE(SAT) (V) Max	VBE(SAT) (V)			Cob (pF) Max	fT (MHz)			toff (ns) Max	NF (dB) Max	Test Conditions	Process No.
		(V) Min	(V) Min	(V) Min	(nA) Max		(V)	Min	Max	@ IC (mA)		& VCE (V)	Min	Max		@ IC (mA)	Min	Max				
2N3704	TO-92 (94)	50	30	5	100	20	100	300	50	2	0.6			100	12	100	50				13	
2N3705	TO-92 (94)	50	30	5	100	20	50	150	50	2	0.8			100	12	100	50				13	
2N3706	TO-92 (94)	40	20	5	100	20	30	600	50	2	1.0			100	12	100	50				13	
2N3794	TO-92 (94)	40	20	5	500	15	100 100 35	600	100 10 1	10 10 10	0.4			10	10	100	600	10				13
2N4400	TO-92 (92)	60	40	6			20 50 40 20	150	500 150 10 1	2 1 1 1	0.4 0.75	0.75	0.95	150	6.5	200	20	255		2		13
2N4401	TO-92 (92)	60	40	6			40 100 80 40 20	300	500 150 10 1 100 $\mu$ A	2 1 1 1 1	0.4 0.75	0.75	0.95	150	6.5	250	20	255		2		13
2N4944	TO-92 (92)	80	40	5	50	40	40 40	120	150 30	1	0.25			150		60	900	50				13
2N4946	TO-92 (92)	80	40	5	50	40	100 100	300	150 30	1	0.25			150		60	900	50				13
2N4951	TO-92 (94)	60	30	5	50	40	60 40 20	200	150 10 1	10 10 10	0.3		1.3	150	8	250	20	400		2		13
2N4952	TO-92 (94)	60	30	5	50	40	100 75 50	300	150 10 1	10 10 10	0.3		1.3	150	8	250	20	400		2		13
2N4953	TO-92 (94)	60	30	5	50	40	200 150 75	600	150 10 1	10 10 10	0.3		1.3	150	8	250	20	400		2		13
2N4954	TO-92 (94)	40	30	5	50	30	60 40 20	600	150 10 1	10 10 10	0.3		1.3	150	8	250	20	400		2		13
2N5220	TO-92 (92)	15	15	3	100	10	30 25	600	50 10	10 10	0.5		1.1	150	10	100	20					13
2N5225	TO-92 (92)	25	25	4	300	15	30 25	600	50 50	10 10	0.8		1.0	100	20	50	20					13
MPS3704	TO-92 (92)	50	30	5	100	20	100	300	50	2	0.6			100	12	100	50					13



## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> (V) Min	V <sub>EB0</sub> (V) Min	I <sub>CB0</sub> (nA) Max @ V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
						Min	Max	Min	Max	Max	Min	Max		Min	Max					Min
MPS3705	TO-92 (92)	50	30	5	100 20	50	150	50	2	0.8		100	12	100	50				13	
MPS3706	TO-92 (92)	40	20	5	100 20	30	600	50	2	1.0		100	12	100	50				13	
MPS6522	TO-92 (92)		25	4	50 20	100		0.1	10	0.5		50	4						13	
MPS6530	TO-92 (92)	60	40	5	50 40	25		500	10	0.5	1.0	100	5						13	
						40	120	100	1											
						30		10	1											
MPS6531	TO-92 (92)	60	40	5	50 40	50		500	10	0.3	1.0	100	5						13	
						90	270	100	1											
						60		10	1											
MPS6532	TO-92 (92)	50	30	5	100 30	30		100	1	0.5	1.2	100	5						13	
NCBT13	TO-92 (92)	80	40	4	100 30	40		20	1	0.15		100	6	150	20				13	
PN3566	TO-92 (92)	40	30	5	50 20	80		2	10	1		100	25	40	700	30			13	
						150	600	10	10											
PN3567	TO-92 (92)	80	40	5	50 40	40	120	30	1	0.25		150	20	60	900	50			13	
						40		150	1											
PN3569	TO-92 (92)	80	40	5	50 40	100	300	150	1	0.25		150		60	900	50			13	
						100		30	1											
PN5449	TO-92 (92)	50	30	5	100 20	100	300	50	2	0.6		100		100	50				13	
PN5816	TO-92 (92)	50	40	5	100 25	100	200	2	2	0.75	1.2	500		100	50				13	
2N5550	TO-92 (92)	160	140	6	100 100	20		50	5	0.15	1.0	10	6	100	300	10		10	8	16
						60	250	10	5											
						60		1	5	0.25	1.2	50								
2N5551	TO-92 (92)	180	160	6	50 120	30		50	5	0.15	1.0	10	6	100	300	10		8	8	16
						80	250	10	5											
						80		1	5	0.2	1.0	50								
2N5830	TO-92 (92)	120	100	5	50 100	60		1	5	0.15	0.8	1		100	500	10			16	
						80	500	10	5	0.2	1	10								
						80		50	5	0.25	1	50								

### TEST CONDITIONS:

(1) I<sub>C</sub> = 300 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (2) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (3) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (4) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 25V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (5) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 4.5V, f = 15.7 kHz. (6) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (7) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 15.7 kHz. (8) I<sub>C</sub> = 250 μA, V<sub>CE</sub> = 5V, f = 10 Hz-15.7 kHz. (9) I<sub>C</sub> = 3 mA, V<sub>CE</sub> = 10V, f = 1 MHz. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 15.7 kHz.

# NPN Transistors



## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CBO</sub> (nA) @ Max	V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	@	I <sub>C</sub> (mA)	Max	Min	Max		Min	Max				
MPSL01	TO-92 (92)	140	120	6	1 μA	40	50	300	10	5	0.2	1.2	10	8	60	10				16
MPS8098	TO-92 (92)	60	0	6	100	60	100	300	1	5	0.3	1.4	100	6	150	10				18
MPS8099	TO-92 (92)	80	80	6	100	60	100	300	1	5	0.3	1.4	100	6	150	10				18
TIS98	TO-92 (97)		60		10	40	100	300	1	5	0.5	1.4	100		2	10				18
TIS99	TO-92 (97)		65		10	40	55	300	100	5	0.5	1.4	100		2	10				18
2N696	TO-5	60		5	1 μA	30	20	60	150	10	1.5	1.3	150	20	40	50				19
2N697	TO-5	60	45	5	1 μA	30	40	120	150	10	1.5	1.3	150	35	50	50				19
2N718	TO-18	60	30	5	1 μA	30	40	120	150	10	1.5	1.3	150	35	50	15				19
2N718A	TO-18	75		7	10	60	20		500	10	1.5	1.3	150	25	60	50		12	1	19
							40	120	150	10										
							35		10	10										
							20		100 μA	10										
2N956	TO-18	75	35	7	10	60	40		500	10	1.5	1.3	150	25	70	50		8	1	19
							100	300	150	10										
							75		10	10										
							35		100 μA	10										
							20		10 μA	10										
2N1420	TO-5	60	30	5	1 μA	30	100	300	150	10	1.5	1.3	150	35	50	50				19
2N1566	TO-5	80	60	5	1 μA	40	80	200	5	5	1.0	1.3	10	10	60	5				19
2N2218	TO-5	60	30	5	10	50	20		500	10	0.4	1.3	150	8	250	20				19
							20		150	1										
							40	120	150	10	1.6	2.6	500							
							35		10	10										
							25		1	10										
							20		100 μA	10										
2N2218A	TO-5	75	40	6	10	60	25		500	10	0.3	0.6	1.2	8	250	20	285		2	19
							20		150	1										
							40	120	150	10										
							35		10	10										
							25		1	10										
							20		100 μA	10										



# GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	VCBO (V) Min	VCEO (V) Min	VEBO (V) Min	ICBO (nA) Max	VCB (V) @	hFE @ IC & VCE			VCE(SAT) & VBE(SAT) @ IC			Cob (pF) Max	fT (MHz) @ IC		toff (ns) Max	NF (dB) Max	Test Conditions	Process No.				
							Min	Max	IC (mA)	VCE (V)	Max	Min		Max	IC (mA)					Min	Max		
2N2219	TO-5	60	30	5	10	50	30	500	10	0.4	1.3	150	8	250	20				19				
							50		1														
							100	300	150											10	1.6	2.6	500
							75		10														
							50		1														
2N2219A	TO-5	75	40	6	10	60	40	500	10	0.6	1.2	150	8	300	20	285		2	19				
							50		1														
							100	300	150											10	2	500	
							75		10														
							50		1														
2N2221	TO-18	60	30	5	10	50	20	500	10	0.4	1.3	150	8	250	20				19				
							20		1														
							40	120	150											10	1.6	2.6	500
							35		10														
							25		1														
2N2221A	TO-18	75	40	6	10	60	25	500	10	0.3	0.6	1.2	8	250	20	285		2	19				
							40	120	150											10			
							35		10											10	1.0	2.0	500
							25		1														
							20		100 μA											10			
2N2222	TO-18	60	30	5	10	50	30	500	10	0.4	1.3	150	8	250	20				19				
							50		1														
							100	300	150											10	1.6	2.6	500
							75		10														
							50		1														
2N2222A	TO-18	75	40	6	10	60	40	500	10	0.3	0.6	1.2	8	250	20	285	4	2/3	19				
							50		1														
							100	300	150											10	1	2	500
							75		10														
							50		1														
2N2897	TO-18	60		7	50	60	35	1	10	1	1.3	150	15						19				
							50	200	150											10			

**TEST CONDITIONS:**

(1) IC = 300 μA, VCE = 10V, f = 1 kHz. (2) IC = 150 mA, VCC = 30V, IB<sup>1</sup> = IB<sup>2</sup> = 15 mA. (3) IC = 100 μA, VCE = 10V, f = 1 kHz. (4) IC = 300 mA, VCC = 25V, IB<sup>1</sup> = IB<sup>2</sup> = 30 mA. (5) IC = 100 μA, VCE = 4.5V, f = 15.7 kHz. (6) IC = 10 mA, VCC = 3V, IB<sup>1</sup> = IB<sup>2</sup> = 1 mA. (7) IC = 100 μA, VCE = 5V, f = 15.7 kHz. (8) IC = 250 μA, VCE = 5V, f = 10 Hz-15.7 kHz. (9) IC = 3 mA, VCE = 10V, f = 1 MHz. (10) IC = 10 μA, VCE = 5V, f = 15.7 kHz.

# NPN Transistors



## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> (V) Min	V <sub>EB0</sub> (V) Min	I <sub>CB0</sub> (nA) @ Max	V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.		
							Min	Max	Min	Max	Min	Max	Min		Max	Min					Max	
2N3115	TO-18	60	20	5	25	50	40	120	150	10	0.5	1.3	150	8	250	20	500			2	19	
2N3116	TO-18	60	20	5	25	50	100	300	150	10	0.5	1.3	150	8	250	20	500			2	19	
2N3299	TO-5	60	30	5	10*	50	20		500	10	0.22	1.1	150	8	250	50	150			4	19	
							20		150	1												
							40	120	150	10												
							35		10	10												
							25		1	10												
20		100 μA	10																			
2N3300	TO-5	60	30	5	10*	50	50		500	10	0.22	1.1	150	8	250	50	150			4	19	
							50		150	1												
							100	300	150	10												
							75		10	10												
							50		1	10												
35		100 μA	10																			
2N3301	TO-18	60	30	5	10*	50	20		500	10	0.22	1.1	150	8	250	50	150			4	19	
							20		150	1												
							40	120	150	10												
							35		10	10												
							25		1	10												
20		100 μA	10																			
2N3302	TO-18	60	30	5	10*	50	50		500	10	0.22	1.1	150	8	250	50	150			4	19	
							50		150	1												
							100	300	150	10												
							75		10	10												
							50		1	10												
35		100 μA	10																			
2N3414	TO-92 (94)	25	25	5	100	25	75	225	2	4.5	0.3	0.6	1.3	50								19
2N3641	TO-92 (92)	Same as PN3641, see page 1-22 for explanation																		19		
2N3642	TO-92 (92)	Same as PN3642, see page 1-22 for explanation																		19		
2N3643	TO-92 (92)	Same as PN3643, see page 1-22 for explanation																		19		
2N3678	TO-5	75	55	6	10	60	25		500	10	0.4	0.6	1.2	150			250			2	19	
							20		150	1												
							40	120	150	10												
							35		10	10												
							25		1	10												
20		100 μA	10																			
2N4140	TO-92 (92)	Same as PN4140, see page 1-22 for explanation																		19		



## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V)	V <sub>CEO</sub> (V)	V <sub>EBO</sub> (V)	I <sub>CBO</sub> (nA)	V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>				V <sub>CE(SAT)</sub> & V <sub>BE(SAT)</sub> @ I <sub>C</sub>				C <sub>ob</sub> (pF)	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns)	NF (dB)	Test Conditions	Process No.	
		Min	Min	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max	Max			
2N4141	TO-92 (92)	Same as PN4141, see page 1-22 for explanation																				19
2N4969	TO-92 (92)	Same as PN2221, see below for explanation																				19
2N4970	TO-92 (92)	50	30	5			100	350	150	10	0.4	0.6	1.2	150	8	200	20				19	
							70		10	10												
							50		150	1												
2N5128	TO-92 (92)	Same as PN5128, see page 1-22 for explanation																				19
2N5129	TO-92 (92)	Same as PN5129, see page 1-22 for explanation																				19
2N5135	TO-92 (92)	Same as PN5135, see page 1-22 for explanation																				19
2N5136	TO-92 (92)	Same as PN5136, see page 1-22 for explanation																				19
2N5137	TO-92 (92)	Same as PN5137, see page 1-22 for explanation																				19
PN2221	TO-92 (92)	60	30	5	10	50	20		500	10	0.4		1.3	150	8	250	20				19	
							20		150	1												
							40	120	150	10	1.6		2.6	500								
							35		10	10												
							25		1	10												
							20		100 μA	10												
PN2221A	TO-92 (92)	75	40	6	10	60	25		500	10	0.3	0.6	1.2	150	8	250	20	285		2	19	
							20		150	1												
							40	120	150	10	1.0		2.0	500								
							35		10	10												
							25		1	10												
							20		100 μA	10												
PN2222	TO-92 (92)	60	30	5	10	50	30		500	10	0.4		1.3	150	8	250	20				19	
							50		150	1												
							100	300	150	10	1.6		2.6	500								
							75		10	1												
							50		1	1												
							35		100 μA	1												

### TEST CONDITIONS:

(1) I<sub>C</sub> = 300 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (2) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (3) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (4) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 25V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (5) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 4.5V, f = 15.7 kHz. (6) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (7) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 15.7 kHz. (8) I<sub>C</sub> = 250 μA, V<sub>CE</sub> = 5V, f = 10 Hz-15.7 kHz. (9) I<sub>C</sub> = 3 mA, V<sub>CE</sub> = 10V, f = 1 MHz. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 15.7 kHz.

# NPN Transistors



## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CB0</sub> (nA) Max @ V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.		
						Min	Max	Min	Max	Min	Max	Min		Max	Min					Max	
PN2222A	TO-92 (92)	75	40	6	10 60	40	500	10	0.3	0.6	1.2	150	8	300	20	285	2	19			
						50	150	1	1.0	2.0	500										
						100	300	10													
						75	10	1													
						50	1	1													
35	100 μA	1																			
PN3641	TO-92 (92)	60*	30	5	50* 50	15	500	10	0.22			150	8	250	50			19			
						40	120	10													
PN3642	TO-92 (92)	60	45	5	50* 50	15	500	10	0.22			150	8	250	50			19			
						40	120	10													
PN3643	TO-92 (92)	60	30	5	50* 50	20	500	10	0.22			150	8	250	50			19			
						100	300	10													
PN4140	TO-92 (92)	60	30	5		20	500	10	0.4		1.3	150	8	250	20	310	2	19			
						20	150	1													
						40	120	10											1.6	2.6	500
						35	10	10													
						25	1	10													
20	100 μA	10																			
PN4141	TO-92 (92)	60	30	5		30	500	10	0.4		1.3	150	8	250	20	310	2	19			
						50	150	1													
						100	300	10											1.6	2.6	500
						75	10	10													
						50	1	10													
35	100 μA	10																			
PN5128	TO-92 (92)	15	12	3	50 10	35	350	50	0.25		1.1	150	10	200	800	50			19		
						20	10	10													
PN5129	TO-92 (92)	15	12	3	50 10	35	350	50	0.25		1.1	150	10	200	800	50			19		
						20	10	10													
PN5135	TO-92 (92)	30	25	4	300 15	50	60*	10	1.0		1.0	100	25	40	500	30			19		
PN5136	TO-92 (92)	30	20	3	100 20	20	400	150	0.25		1.1	150	35	40	400	50			19		
						20	30	1													
PN5137	TO-92 (92)	30	20	3	100 20	20	400	150	0.25		1.1	150	35	40	400	50			19		
						20	30	1													
TN2218A	TO-237 (91)	75	40	6	10 60	25	500	10	0.3	0.6	1.2	150	8	250	20	285	2	19			
						20	150	1													
						40	120	10													
						35	10	10													
						25	1	10													
20	100 μA	10																			



**GENERAL PURPOSE AMPS AND SWITCHES** (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CBO</sub> (nA) @ Max	V <sub>CB</sub> (V) @ Max	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.		
							Min	Max	@ I <sub>C</sub> (mA)	Max	Min	Max		Min	Max					Min	Max
TN2219	TO-237 (91)	60	30	5	10	50	30	500	10	0.4	1.3	150	8	50	20				19		
							50	150	1												
							100	300	150	10	1.6	2.6	500								
							75	10	10												
							50	1	10												
							35	0.1	10												
TN2219A	TO-237 (91)	75	40	6	10	60	40	500	10	0.3	0.6	1.2	150	8	60	20		4	3	19	
							50	150	1												
							100	300	150	10	1.0	2.0	500								
							75	10	10												
							50	1	10												
							35	0.1	10												
TIS90	TO-92 (94)	40	40	5	100	20	100	300	50	2	0.25	0.6	1	50						19	
TIS92	TO-92 (97)	40	40	5	100	20	100	300	50	2	0.25	0.6	1	50							19
2N915	TO-18	70	50	5	10	60	50	200	10	5	1.0	0.9	10	3.5	250	10				23	
2N916	TO-18	45	25	5	10	30	50	200	10	1	0.5	0.9	10	6	300	10				23	
2N3691	TO-92 (92)	Same as PN3691, see page 1-25 for explanation																	23		
2N3692	TO-92 (92)	Same as PN3692, see page 1-25 for explanation																	23		
2N3903	TO-92 (92)	60	40	6			15	100	1	0.2	0.6	0.85	10	4	250	10	225	6	6/7	23	
							30	50	1												
							50	150	1	0.3	0.95	50									
							35	1	1												
							20	100 μA	1												
2N3904	TO-92 (92)	60	40	6		30	30	100	1	0.2	0.65	0.85	10	4	300	10	250	5	6/7	23	
							60	50	1												
							100	300	10	0.3	0.95	50									
							70	1	1												
							40	100 μA	1												
2N3946	TO-18	60	40	6			20	50	1	0.2	0.6	0.9	10	4	250	10	375	5	6/7	23	
							50	150	1												
							45	1	1	0.3	1.0	50									
							30	100 μA	1												

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 300 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (2) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (3) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (4) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 25V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (5) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 4.5V, f = 15.7 kHz. (6) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (7) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 15.7 kHz. (8) I<sub>C</sub> = 250 μA, V<sub>CE</sub> = 5V, f = 10 Hz-15.7 kHz. (9) I<sub>C</sub> = 3 mA, V<sub>CE</sub> = 10V, f = 1 MHz. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 15.7 kHz.

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## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CBO</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> & I <sub>C</sub> & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
						Min	Max	@	I <sub>C</sub> (mA)	V <sub>CE</sub> (V)	Max	Min		Max	Min					Max
2N3947	TO-18	60	40	6		40		50	1	0.2	0.6	0.9	10	4	300	10	450	5	6/7	23
						100	300	10	1											
						90		1	1											
						60		100 μA	1											
2N4123	TO-92 (92)	40	30	5	50 20	25		50	1	0.3	0.95	50	4	250	10		6	7	23	
						50	150	2	1											
2N4124	TO-92 (92)	30	25	5	50 20	60		50	1	0.3	0.95	50	4	300	10		5	7	23	
						120	360	2	1											
MPS2711	TO-92 (92)	18	18	5	500 18	30	90	2	4.5				4							23
MPS2712	TO-92 (92)	18	18	5	500 18	75	225	2	4.5				4							23
MPS2716	TO-92 (92)	18	18	5	500 18	75	225	2	4.5				3.5							23
MPS2923	TO-92 (92)	25	25	5	500 25	90	180	2	10				12							23
								(1 kHz)												
MPS2924	TO-92 (92)	25	25	5	500 25	150	300	2	10				12							23
								(1 kHz)												
MPS2925	TO-92 (92)	25	25	5	500 25	235	470	2	10				12							23
								(1 kHz)												
MPS2926	TO-92 (92)	25	25	5	500 18	35	470	2	10				3.5							23
								(1 kHz) (5 Groups)												
MPS3642	TO-92 (92)	Same as PN3642, see page 1-22 for explanation																		23
MPS3721	TO-92 (92)				500 18	60	660	2	10				3.5							23
								(1 kHz)												
MPS3826	TO-92 (92)	60	45	4	100 30	40	160	10	10				3.5	200	800	10				23
MPS3827	TO-92 (92)	60	45	4	100 30	100	400	10	10				3.5	200	800	10				23
MPS6512	TO-92 (92)	40	30	4	50 30	30		100	10	0.5		50	3.5							23
						50	100	2	10											
MPS6513	TO-92 (92)	40	30	4	50 30	60		100	10	0.5		50	3.5							23
						90	180	2	10											
MPS6514	TO-92 (92)	40	25	4	50 30	90		100	10	0.5		50	3.5							23
						150	300	2	10											
MPS6515	TO-92 (92)	40	25	4	50 30	150		100	10	0.5		50	3.5							23
						250	500	2	10											



## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CBO</sub> (nA) Max	V <sub>CB</sub> (V) @	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.					
							Min	Max	@	Max	Min	Max		@	Min					Max				
NS3903	TO-18	60	40	6			15	100	1	0.2	0.65	0.85	10	4	250	10	225		6	23				
							30	50	1															
							50	150	10												1	0.3	0.95	50
							35	1	1															
							20	100	μA												1			
NS3904	TO-18	60	40	6			30	100	1	0.2	0.65	0.85	10	4	300	10	250		6	23				
							60	50	1															
							100	300	10												1	0.3	0.95	50
							70	1	1															
							40	100	μA												1			
PN3691	TO-92 (92)	35	20	4	50	15	40	160	10	1	0.7	0.9	10	3.5	200	500	10				23			
PN3692	TO-92 (92)	35	20	4	50	15	100	400	10	1	0.7	0.9	10	3.5	200	500	10				23			
ST3904	TO-92 (92)	60	40	6			40	0.1	1	0.2	0.65	0.85	10	4	300	10		8	7	23				
							70	1	1															
							100	300	10												1	0.3	0.95	50
							60	50	1															
							30	100	1															
2N2712	TO-92 (94)	18	18	5	500	18	75	225	2	4.5				12	80	300	2				27			
2N2714	TO-92 (94)	18	18	5	500	18	75	225	2	4.5	0.3	0.6	1.2	50							27			
2N3394	TO-92 (94)	25	25	5	100	18	55	110	2	4.5				10							27			
2N3693	TO-92 (92)	Same as MPS3693, see page 1-26 for explanation																	27					
2N3694	TO-92 (92)	Same as PN3694, see page 1-26 for explanation																	27					
2N3721	TO-92 (94)	18	18	5	500	18	60	660	2	10				12							27			
2N3827	TO-92 (94)	60	45	4	100	30	100	400	10	10				3.5	200	800	10				27			
2N3858	TO-92 (94)	30	30	4	500	18	60	120	2	4.5				4	90	250	2				27			

### TEST CONDITIONS:

(1) I<sub>C</sub> = 300 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (2) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (3) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (4) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 25V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (5) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 4.5V, f = 15.7 kHz. (6) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (7) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 15.7 kHz. (8) I<sub>C</sub> = 250 μA, V<sub>CE</sub> = 5V, f = 10 Hz-15.7 kHz. (9) I<sub>C</sub> = 3 mA, V<sub>CE</sub> = 10V, f = 1 MHz. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 15.7 kHz.



## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CBO</sub> (nA) Max @ V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)			t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max	2	4.5	Max	Min	Max		10	Min	Max				
2N3859	TO-92 (94)	30	30	4	500	18	100	200	2	4.5			4	90	250	2				27
2N3860	TO-92 (94)	30	30	4	500	18	150	300	2	4.5			4	90	250	2				27
2N5127	TO-92 (92)	Same as PN5127, see below for explanation																	27	
2N5131	TO-92 (92)	Same as PN5131, see below for explanation																	27	
2N5132	TO-92 (92)	Same as PN5132, see below for explanation																	27	
2N5219	TO-92 (92)	20	15	3	100	10	35	500	2	10	0.4	1.0	10	4	150	10				27
2N5223	TO-92 (92)	25	20	3	100	10	50	800	2	10	0.7	1.2	10	4	150	10				27
MPS3693	TO-92 (92)	45	45	4	50	35	40	160	10	10			3.5	200	10		4	9		27
MPS3694	TO-92 (92)	45	45	4	50	35	100	400	10	10			3.5	200	10		4	9		27
MPS6564	TO-92 (92)		45	5	500	40	25		10	5	0.5		10	4						27
MPS6565	TO-92 (92)	60	45	4	100	30	40	160	10	10	0.4		10	3.5						27
MPS6566	TO-92 (92)	60	45	4	100	30	100	400	10	10	0.4		10	3.5	200	10				27
MPSA10	TO-92 (92)		40	4	100	30	40	400	5	10			4	50	5					27
PN3694	TO-92 (92)	45	45	4	50	30	100	400	10	1			6	200	10					27
PN5127	TO-92 (92)	20	12	3	50	10	15	300	2	10	0.3	1.0	10	3.5	150	2				27
PN5131	TO-92 (92)	20	15	3	50	10	35	500	10	1	1.0		10	6	100	10				27
PN5132	TO-92 (92)	20	20	3	50	10	30	400	10	10	2.0	0.9	10	3.5	200	10				27

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 300 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (2) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (3) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (4) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 25V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (5) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 4.5V, f = 15.7 kHz. (6) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (7) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 15.7 kHz. (8) I<sub>C</sub> = 250 μA, V<sub>CE</sub> = 5V, f = 10 Hz-15.7 kHz. (9) I<sub>C</sub> = 3 mA, V<sub>CE</sub> = 10V, f = 1 MHz. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 15.7 kHz.



# MEDIUM POWER

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CER</sub> * V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CS</sub> * I <sub>CBO</sub> (nA) @ V <sub>CB</sub> (V)		h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
					Min	Max	Min	Max	Min	Max	Min	Max	Min		Max	Min				
2N699	TO-39	120	60	5	2	60	40	120	150	10	5.0	1.3	150	20	50	50				12
2N1613	TO-5	75	35	7	10	60	20	500	10	1.5	1.3	150	25	60	50		12	1	12	
							40	120	10											
							35	10	10											
							20	100 μA	10											
2N1711	TO-5	75	35	7	10	60	40	500	10	1.5	1.3	150	25	70	50		8	1	12	
							100	300	10											
							75	10	10											
							35	100 μA	10											
							20	10 μA	10											
2N2017	TO-39	60	60	8	10 μA	30	20	10	10	2.0		200								12
							50	200	10											
							20	1A	15											
2N2102	TO-39	120	65	7	2	60	10	0.01	10	0.5	1.1	150	15	60	50					12
							20	0.1	10											
							35	10	10											
							40	120	10											
							25	500	10											
							10	1A	10											
2N2192	TO-39	60	40	5	10	30	15	0.01	10	0.35	1.3	150	10	50	50					12
							75	0.1	10											
							100	300	10											
							70	150	10											
							35	500	10											
							15	1A	10											
							2N2192A	TO-39	60											
75	0.1	10																		
100	300	10																		
70	150	10																		
35	500	10																		
15	1A	10																		
2N2193	TO-39	80	50	8	10	80	15	0.01	10	0.35	1.3	150	20	50	50					12
							30	0.1	10											
							40	120	10											
							30	150	10											
							20	500	10											
							15	1A	10											

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 100V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (2) I<sub>C</sub> = 500 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (3) I<sub>C</sub> = 500 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA. (4) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (5) I<sub>C</sub> = 100 μA, V<sub>CC</sub> = 10V, f = 1 kHz. (6) I<sub>C</sub> = 500 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA. (7) I<sub>C</sub> = 2A, V<sub>CC</sub> = 40V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 200 mA.

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# NPN Transistors



## MEDIUM POWER (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> * (V) Min	V <sub>EB0</sub> (V) Min	I <sub>CS</sub> * (nA) @ I <sub>CB0</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max	@ I <sub>C</sub> (mA)	V <sub>CE</sub> (V)	Max	Min	Max		@ I <sub>C</sub> (mA)	Min				
2N2193A	TO-39	80	50	8	10 60	15		0.1	10	0.25	1.3	150	20	50	50				12
						30		10	10										
						40	120	150	10										
						30		150	1										
						20		500	10										
15		1A	10																
2N2195	TO-39	45	25	5	100 30	10		150	1	0.35	1.3	150	20	50	50				12
						20		150	10										
2N2195A	TO-39	45	25	5	100 30	10		150	1	0.25	1.3	150	20	50	50				12
						20		150	10										
2N2243	TO-39	120	80	7	10 60	15		0.1	10	0.35	1.3	150	15	50	50				12
						30		10	10										
						40	120	150	10										
						30		150	1										
						15		500	10										
2N2243A	TO-39	120	80	7	10 60	15		0.1	10	0.25	1.3	150	15	50	50				12
						30		10	10										
						40	120	150	10										
						30		150	1										
						15		500	10										
2N2270	TO-39	60	45	7	50 60	30		1	10	0.9	1.2	150	15	100	50				12
						50	200	150	10										
2N3019	TO-39	140	80	7	10 90	50		0.1	10	0.2	1.1	150	12	100	50				12
						90		10	10										
						100	300	150	10										
						50		500	10										
						15		1A	10										
2N3020	TO-39	140	80	7	10 90	30	100	0.1	10	0.2	1.1	150	12	80	50				12
						40	120	10	10										
						40	120	150	10										
						30	100	500	10										
						15		1A	10										
2N3053	TO-39	60	40	5	250 30	25		150	2.5	1.4	1.7	150	15	100	50				12
						50	250	150	10										
2N3107	TO-39	100	60	7	10 60	35		0.1	10	0.25	1.1	150	20	70	50	1000	7	5/6 (See page 1-27)	12
						100	300	150	10										
						40		500	10										
2N3108	TO-39	100	60	7	10 60	20		0.1	10	0.25	1.1	150	20	60	50	600	7	5/6 (See page 1-27)	12
						40	120	150	10										
						25		500	10										
										1.0		1A							



### MEDIUM POWER (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CER</sub> * V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (mA) Max @ V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
						Min	Max	(mA)	(V)	Max	Min		Max	(mA)					Min
2N3109	TO-39	80	40	7	10* 60	35	100	0.1	10	0.25	1.1	150	25	70	50	1000	7	5/6 (See page 1-27)	12
2N3110	TO-39	80	40	7	10* 60	20	40	0.1	10	0.25	1.1	150	25	60	50	600	7	5/6 (See page 1-27)	12
2N3568	TO-92 (92)	Same as PN3568, see below for explanation																	12
2N3665	TO-39	120	80	10	50 60	30	40	10	10	0.5	1.2	150	12	60	50				12
2N3666	TO-39	120	80	10	50 60	70	100	10	10	0.5	1.2	150	12	60	50				12
2N3700	TO-18	140	80	7	10 90	50	90	1	10	0.2	1.1	150	12	100	200	5			12
2N3945	TO-39	70	50	8	40 60	25	40	10	10	0.5	1.2	150	12	60	50				12
2N4924	TO-39	100	100	5	100 50	25	35	1	10	0.25		10	10	10	500	20			12
2N4945	TO-92 (92)	80	60	5	50 40	40	40	120	150	0.25		150		60	900	50			12
40314	TO-39		40		250 15	70	350	50	4	1.4		150							12
MPSA05	TO-92 (92)		60	4	100 60	50	50	10	1	0.25		100		100	100				12
MPSA06	TO-92 (92)		80	4	100 80	50	50	10	1	0.25		100		100	100				12
PN3568	TO-92 (92)	80	60	5	50 40	40	40	30	1	0.25		150	20	60	600	50			12
TN1711	TO-237 (91)	75		7	10 60	20	35	0.01	10	1.5		150	25						12
						75	100	0.1	10	1.3		150							
						40	300	150	10										

# NPN Transistors



## MEDIUM POWER (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> * (V) Min	V <sub>EB0</sub> (V) Min	I <sub>CS</sub> * (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max	I <sub>C</sub> (mA)	V <sub>CE</sub> (V)	Max	Min		Max	I <sub>C</sub> (mA)				
TN2017	TO-237 (91)	60	60	8	10 μA 30	35	10	10										12
						50	200	200	10									
						20		1A	10									
TN2102	TO-237 (91)	120	65	7	10 60	10	0.01	10	0.5	1.1	150	15	60	50				12
						20	0.1	10										
						35	10	10										
						40	120	150	10									
						25	500	10										
						10	1A	10										
TN2270	TO-237 (91)	60	45	7	50 60	30	1	10	0.9	1.2	150	15	100	50				12
						50	200	150	10									
TN3019	TO-237 (91)	140	80	7	10 90	50	1	10	0.2	1.1	150	12	100	50				12
						90	10	10										
						100	300	150	10	0.5	500							
						50	500	10										
						15	1A	10										
TN3020	TO-237 (91)	140	80	7	10 90	30	100	1	0.2	1.1	150	12	80	50				12
						40	120	10										
						40	120	150	10	0.5	500							
						30	100	500	10									
						15	1A	10										
TN3053	TO-237 (91)	60	40	5	250 30	25	150	2.5	1.4	1.7	150	15	100	50				12
						50	250	150	10									
2N3566	TO-92 (92)	40	30	5	50 20	150	600	10	1.0		100	25	4	100	30			13
						80		2										
2N3567	TO-92 (92)	80	40	5	50 40	40	120	150	0.25		150	20	60	600	50			13
						40	30	1										
2N3569	TO-92 (92)	80	40	5	50 40	100	300	150	0.25		150	20	60	600	50			13
						100		30										
PN3566	TO-92 (92)	Same as 2N3566, see above for explanation															13	
PN3567	TO-92 (92)	Same as 2N3567, see above for explanation															13	
PN3569	TO-92 (92)	Same as 2N3569, see above for explanation															13	
2N4237	TO-39		40		100 μA 50	15	1A	1	0.6	1.5	1A	100	1	100				14
						30	500	4										
						30	150	250	1	0.3	500							



**MEDIUM POWER** (Continued)

Type No.	Case Style	VCBO (V) Min	VCER* VCEO (V) Min	VEBO (V) Min	ICES* ICBO (nA) @ VCB (V) Max	hFE @ IC & VCE (V)			VCE(SAT) (V) & VBE(SAT) (V) @ IC (mA)			Cob (pF) Max	fT (MHz) @ IC (mA)		toff (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max	@ IC (mA)	Max	Min	Max		@ IC (mA)	Min				
MPS6560	TO-92 (92)	25	25	5	100 20	35 50 50	10 200	1 1 1	0.5	1.2*	500	30	60	10				14
MPS6561	TO-92 (92)	20	20	5	100 20	35 50 50	10 200	1 1 1	0.5	1.2*	350	30	60	10				14
NCBV14	TO-202 (55)	60	40	4	100 30	75	50	1	0.4		500	10	125	50				14
NSE871	TO-202 (51)	300			100 200	50	25	20					60	10				17
MPO3725	TO-39		40	6	500 40	35 25	200 500	100 500	1 2	0.45	0.8 1.0	500	10	250	50			25
TN3252	TO-237 (91)	60	30		500 40	30 30 25	150 90 1A	1 1 5	0.3 0.5	1.0 1.3	150 500	12	200	50				25
TN3253	TO-237 (91)	75	40	5	500 60	25 25 20	150 75 750	1 1 5	0.35	1.0	150	12						25
TN3444	TO-237 (91)	80	50	5	500 60	20 20 15	150 60 1A	1 1 5	0.35 0.6	1.0 1.3	150 500	12	150	50				25
TN3724	TO-237 (91)	50	30	6	1.7 μA 40	30 60 40 35 25 30	10 150 300 500 800 1A	1 1 1 1 2 5	0.25	0.76	10	12			60		6 (See page 1-27)	25
TN3725	TO-237 (91)	80	50	6	1.7 μA 60	30 60 40 35 20 25	10 150 300 500 800 1A	1 1 1 1 2 5	0.25	0.76	10	10			60		6 (See page 1-27)	25
2N2657	TO-39	80	50	8	100 60	15 40	5A 120 1A	6 2	0.5 3.0	1.5 2.5	1A 5A	150	20	200	15		2 (See page 1-27)	34
2N2658	TO-39	100	80	8	100 60	15 40	5A 120 1A	6 2	0.5 3.0	1.5 2.5	1A 5A		20	200	15		2 (See page 1-27)	34
2N2890	TO-39	100	80	5	50 μA 60	25 30 20	2A 90 1A 100	5 2 2	0.5	1.2	1A	70	30	200	15		3 (See page 1-27)	34

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# NPN Transistors



## MEDIUM POWER (Continued)

Type No.	Case Style	VCBO (V) Min	VCER* VCEO (V) Min	VEBO (V) Min	ICES* ICBO (nA) Max @ VCB (V)	hFE @ IC (mA) & VCE (V)				VCE(SAT) (V) & VBE(SAT) (V) @ IC (mA)			Cob (pF) Max	fT (MHz) @ IC (mA)			toff (ns) Max	NF (dB) Max	Test Conditions	Process No.		
						Min	Max	Min	Max	Max	Min	Max		Min	Max	Min					Max	
2N2891	TO-39	100	80	5	50 $\mu$ A 60	50	300	50	10	0.5	1.2	1A	70	30	200	15		3 (See page 1-27)	34			
						36		100														
						50	150	1A	2	0.75	1.3	2A										
						40		2A	5													
2N5148	TO-39		80		1 $\mu$ A 60	20		50	5	0.46	1.2	100	70	60	200				34			
						30	90	1A	5													
						15		2A	5	0.85	1.5	200										
						5		3A	5													
2N5150	TO-39		80		1 $\mu$ A 60	60		50	5	0.46	1.2	100	70	60	200				34			
						70	200	1A	5													
						30		2A	5	5.0		3A										
						15		3A	5													
2N5336	TO-39		80		10 $\mu$ A 80	30		600	2	0.7	1.2	2A		30	500	2200		7 (See page 1-27)	34			
						30	120	2A	2													
						20		5A	2	1.2	1.8	5A										
2N5338	TO-39		100		10 $\mu$ A 100	30		600	2	0.7	1.2	2A		30	500	2200		7 (See page 1-27)	34			
						30	120	2A	2													
						20		5A	2	1.2	1.8	5A										
2N3440	TO-39		250		20 $\mu$ A* 300	40	160	20	10										36			
2N6591	TO-202 (55)	150	150	5	200 100	40	250	10	10	0.8		200								36		
						40	200	100	10													
2N6592	TO-202 (55)	200	200	5	200 150	30	250	10	10	0.8		200								36		
						40	200	100	10													
2N6593	TO-202 (55)	250	250	5	200 200	30	250	10	10	0.8		200								36		
						30	200	100	10													
2N6720	TO-237 (91)	175	150	6	1 $\mu$ A 150	25		50	10	0.5		100		30	300	50				36		
						30		100	10													
						15		250	10													
						10	50	500	10													
2N6721	TO-237 (91)	225	200	6	1 $\mu$ A 200	25		50	10	0.5		100		30	300	50				36		
						30		100	10													
						15		250	10													
						10	50	500	10													
2N6722	TO-237 (91)	275	250	6	1 $\mu$ A 250	25		50	10	0.5		100		30	300	50				36		
						30		100	10													
						15		250	10													
						10	50	500	10													
2N6723	TO-237 (91)	325	300	6	1 $\mu$ A 300	25		50	10	0.5		100		30	300	50				36		
						30		100	10													
						15		250	10													
						10	50	500	10													



**MEDIUM POWER** (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> * (V) Min	V <sub>EB0</sub> (V) Min	I <sub>CS</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max		Max	Min	Max		Min	Max				
92PU36	TO-237 (91)	175	150	6	1 μA 150	25	50	10	0.5		100							36
						30	300	100										
						15		250										
						10		500										
92PU36A	TO-237 (91)	225	200	6	1 μA 200	25	50	10	0.5		100							36
						30	300	100										
						15		250										
						10		500										
92PU36B	TO-237 (91)	275	250	6	1 μA 250	25	50	10	0.5		100							36
						30	300	100										
						15		250										
						10		500										
92PU36C	TO-237 (91)	325	300	6	1 μA 300	25	50	10	0.5		100							36
						30	300	100										
						15		250										
						10		500										
D40P1	TO-202 (55)		120		10 μA 200	20	2	10	1.0		100	15	10	80				36
						40		80										
D40P3	TO-202 (55)		180		10 μA 250	20	2	10	1.0	1.5	100	15	10	80				36
						40		80										
D40P5	TO-202 (55)		225		10 μA 300	20	2	10	1.0	1.5	100	15	10	80				36
						40		80										
NSD36	TO-202 (55)	175	150	6	1 μA 150	25	50	10	0.5			15	10	50				36
						30	300	100										
						15		250										
						10		500										
NSD36A	TO-202 (55)	225	200	6	1 μA 200	25	50	10	0.5			15	10	50				36
						30	300	100										
						15		250										
						10		500										
NSD36B	TO-202 (55)	275	250	6	1 μA 250	25	50	10	0.5			15	10	50				36
						30	300	100										
						15		250										
						10		500										
NSD36C	TO-202 (55)	325	300	6	1 μA 300	25	50	10	0.5			15	10	50				36
						30	300	100										
						15		250										
						10		500										
NSD3439	TO-202 (55)		350		20 μA 300	30	2	10	0.5	1.3	50	20	15	10				36
						40	160	20										

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# NPN Transistors



## MEDIUM POWER (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CER</sub> * V <sub>CE0</sub> (V) Min	V <sub>EB0</sub> (V) Min	I <sub>CS</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max		Max	Min	Max		Min	Max				
NSD3440	TO-202 (55)		250		500 μA 200	30	2	10	0.5	1.3	50	20	15	10				36
TN3440	TO-237 (91)		250		20 μA 250	30	2	10	0.5	1.3	50		15	10				36
2N6714	TO-237 (91)	40	30	5	100 40	55	10	1	0.5		100		50	500	50			37
92PU01	TO-237 (90)		30	5	100 40	55	10	1	0.5		1A	30	100	50				37
92PU01A	TO-237 (90)		40	5	100 50	55	10	1	0.5		1A	30	100	50				37
D42C1	TO-202 (56)		30		1 μA 30	25	200	1	0.5	1.3	1A	30						37
D42C2	TO-202 (56)		30		1 μA 30	40	120	200	0.5	1.3	1A	30						37
D42C3	TO-202 (56)		30		1 μA 30	40	200	1	0.5	1.3	1A	30						37
D42C4	TO-202 (56)		45		1 μA 45	25	200	1	0.5	1.3	1A	30						37
D42C5	TO-202 (56)		45		1 μA 45	40	120	200	0.5	1.3	1A	30						37
D42C6	TO-202 (56)		45		1 μA 45	40	200	1	0.5	1.3	1A	30						37
NSD102	TO-202 (55)	60	45	5	100 60	40	10	5	0.2	0.9	100	30	60	50				37
						50	150	100	0.4	1.2	500							
NSD103	TO-202 (55)	60	45	5	100 60	50	10	5	0.2	0.9	100	30	60	50				37
						120	360	100	0.4	1.2	500							
NSDU01	TO-202 (55)	40	30	5	100 30	55	10	1	0.5	1.2	1A	30	50	50				37
						60	100	1										
						50	1A	1										
NSDU01A	TO-202 (55)	50	40	5	100 40	55	10	1	0.5	1.2	1A	30	50	50				37
						60	100	1										
						50	1A	1										



# MEDIUM POWER (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CER</sub> * V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CB0</sub> * (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)			t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max		Max	Min	Max			Min	Max				
NSDU02	TO-202 (55)	60	40	5	100 40	60	10	10	0.4	1.3	150	20	50	20				37	
						50	300	150											10
						30		500											10
NSE180	TO-202 (55)		40		100 60	50	250	100	0.3		500		50	100				37	
						30		500											1
						12		1A											1.5
2N5449	TO-92 (97)	50	30	5	100 20	100	300	50	2	0.6		100	5	50					38
2N6551	TO-202 (55)	60	60	5	100 40	60	10	1	0.5		500							38	
						80	250	50											1
						60		250											1
						25		500											1
2N6552	TO-202 (55)	80	80	5	100 60	60	10	1	1.0		1A		75	250	100			38	
						80	250	50											1
						60		250											1
						25		500											1
2N6705	TO-237 (90)	60	45	5	100 60	40	50	2	0.5		500		50	400	200			38	
						40	250	250											2
						25		500											2
2N6706	TO-237 (90)	80	60	5	100 80	40	50	2	0.5		500		50	400	200			38	
						40	250	250											2
						25		500											2
2N6707	TO-237 (90)	100	80	5	100 100	40	50	2	0.5		500		50	400	200			38	
						40	250	250											2
						25		500											2
2N6715	TO-237 (91)	50	40	5	100 50	55	10	1	0.5		1A		50	400	50			38	
						60		100											1
						50	250	1A											1
2N6716	TO-237 (91)	60	60	5	100 40	80	50	1	0.35		250		50	500	50			38	
						50	250	250											1
						20		500											1
92PE37A	TO-237 (90)		45		100 60	25	50	2	0.5		500	30	50	200				38	
						40	250	2											
						40		500											2
92PE37B	TO-237 (90)		60		100 80	25	50	2	0.5		500	30	50	200				38	
						40	250	2											
						40		500											2
92PE37C	TO-237 (90)		80		100 100	25	50	2	0.5		500	30	50	200				38	
						40	250	2											
						40		500											2

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## MEDIUM POWER (Continued)

Type No.	Case Style	VCBO (V) Min	VCER* VCEO (V) Min	VEBO (V) Min	ICES* ICBO (nA) @ VCB (V) Max	hFE				VCE (V)	VCE(SAT) (V) & VBE(SAT) (V) @ IC (mA)			Cob (pF) Max	fT (MHz) @ IC (mA)			toff (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max	@ IC (mA)	& VCE (V)		Max	Min	Max		Min	Max	Min				
BD137-6	TO-126	60	60	5	100 30	40	100	150	2	0.5	500		50	50				38			
BD137-10	TO-126	60	60	5	100 30	63	160	150	2	0.5	500		50	50				38			
BD345	TO-126	60	60	5	500 60	60	250	50	1	0.4	200	15	50	50				38			
D40D1	TO-202 (55)		30		100* 45	50	150	100	2	0.5	500							38			
D40D2	TO-202 (55)		30		100* 45	120	360	100	2	0.5	500							38			
D40D3	TO-202 (55)		30		100* 45	290	100	100	2		500							38			
D40D4	TO-202 (55)		46		100* 60	50	150	100	2	0.5	500							38			
D40D5	TO-202 (55)		45		100* 60	120	360	100	2	0.5	500							38			
D40D6	TO-202 (55)		45		100* 60	50	150	100	2	1.0	500							38			
D40D7	TO-202 (55)		60		100* 60	50	150	100	2	1.0	500							38			
D40D8	TO-202 (55)		60		100* 75	120	360	100	2	1.0	500							38			
D40D10	TO-202 (55)		75		100* 90	50	150	100	2	1.0	500							38			
D40D11	TO-202 (55)		75		100* 90	120	360	100	2	1.0	500							38			
D40D13	TO-202 (55)		75		100* 90	50	150	100	2	1.0	500							38			
D40D14	TO-202 (55)		75		100* 90	120	360	100	2	1.0	500							38			
D40E1	TO-202 (55)		30		100* 40	50	100	100	2	1.0	1A							38			
D40E5	TO-202 (55)		60		100* 70	50	100	100	2	1.0	1A							38			
D40E7	TO-202 (55)		80		100* 90	50	100	100	2	1.0	1A							38			
MJE721	TO-126 (58)		60			40	150	150	1	1.0	1.5A							38			
						20	500	500	1	0.15	150										
						8	1A	1A	1	0.4	500										



**MEDIUM POWER** (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CER</sub> * V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (nA) @ V <sub>CB</sub> (V)		h <sub>FE</sub> Min Max		I <sub>C</sub> (mA) @ V <sub>CE</sub> (V)	V <sub>CE</sub> (SAT) (V) Max	V <sub>BE</sub> (SAT) (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
					Max	Min	Min	Max			Min	Max	Min		Max	Min				
NSD6178	TO-202 (55)		75		500 μA	80	30 40 10	250	50 500 1A	2	0.5		1.2	500						38
NSD6179	TO-202 (55)		50		500 μA	60	30 40 10	250	500 500 1A	2	0.5		1.2	500						38
NSDU05	TO-202 (55)	60	60	4	100	60	80 50 20		50 250 500	1 1 1	0.35			250	30	50	200			38
NSE181	TO-202 (56)		60		100	80	50 30 12	250	10 500 1A	1 1 1.5	0.3			500		50	100			38
2N6553	TO-202 (55)	100	100	5	100	80	60 80 60 25		10 50 250 500	1 1 1 1	1.0			1A		75	250	100		39
2N6717	TO-237 (91)	80	80	5	100	60	80 50 20	250	50 250 500	1 1 1	0.35			250		50	500	200		39
2N6718	TO-237 (91)	100	100	5	100	80	80 50 20	250	50 250 500	1 1 1	0.35			350		50	500	200		39
2N6731	TO-237 (91)	100	80	5	100	80	100 100	300	10 350	2 2	0.35			350		50	500	200		39
92PU05	TO-237 (90)		100		100	80	80 50 20		50 250 500	1 1 1	0.35			250	30	50	200			39
92PU06	TO-237 (90)		100		100	80	20 50 80	500	500 250 50	1 1 1	0.35			250	30	50	200			39
92PU07	TO-237 (91)		100		100	80	80 50 20		50 250 500	1 1 1	0.35			250	30	50	200			39
92PU100	TO-237 (91)	100	80		100	80	20 50 10	150	10 100 1A	5 5 5	0.35			350	20	50	100			39
MJE722	TO-126 (58)		80				40 20 8		150 500 1A	1 1 1	1.0 0.15 0.4		1.3	1.5A 500						39

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## MEDIUM POWER (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CER</sub> * V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (nA) @ V <sub>CB</sub> (V)		h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)			t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
					Min	Max	Min	Max	Min	Max	Min	Max		Min	Max	Min				
NSD104	TO-202 (55)	100	80	7	100	100	20		10	5	0.2		0.9	100	30	60	50			39
							50	150	100	5	0.5		1.2	500						
							10		1A	5										
NSD105	TO-202 (55)	100	80	7	100	100	10		10	5	0.2		0.9	100	30	60	50			39
							120	360	100	5	0.5		1.2	500						
							10		1A	5										
NSD106	TO-202 (55)	140	100	7	100	140	20		10	5	0.2		0.9	100	30	60	50			39
							50	150	100	5	0.5		1.2	500	50					
							25		500	5										
NSDU06	TO-202 (55)	80	80	4	100	80	80		50	1	0.35		250	30	50	200			39	
							50		250	1										
							20		500	1										
NSDU07	TO-202 (55)	100	100	4	100	100	80		50	1	0.35		250	30	50	200			39	
							50		250	1										
							20		500	1										
2N3742	TO-39	300	300	7	200	200	10		3	10	0.75		1.0	10	6	60	10			48
							15		10	10										
							20	200	30	10	1.0		1.2	30						
							20		50	20										
2N4926	TO-39	200	200	7	100	100	10		3	10				6	30	300	20			48
							15		10	10										
							20	200	30	10										
							20		50	20										
2N4927	TO-39	250	250	7	100	150	10		3	10				6	30	300	20			48
							15		10	10										
							20	200	30	10										
							30		50	20										
2N6711	TO-237 (90)	160	160	7	50	100	15		1	10					40	200	10			48
							15		10	10										
							30	200	30	10										
2N6712	TO-237 (90)	250	250	7	50	200	15		1	10					40	200	10			48
							15		10	10										
							30	200	30	10										
2N6713	TO-237 (90)	300	300	7	50	250	15		1	10					40	200	10			48
							15		10	10										
							30	200	30	10										
2N6719	TO-237 (91)	300	300	7	100	200	25		1	10					30	300	15			48
							40		10	10										
							40	200	30	10										
2N6733	TO-237 (91)	200	200	6	100	160	25		1	10	2.0		20		50	200	10			48
							40	200	10	10										



**MEDIUM POWER** (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CER</sub> * V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)				C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)			t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max			Max	Min	Max			Min	Max					
2N6734	TO-237 (91)	250	250	6	100 200	25 40	200	1 10	10 10	2.0					50 200	10				48	
2N6735	TO-237 (91)	300	300	6	100 260	25 40	200	1 10	10 10						50 200	10				48	
40321	TO-39		300		100 150	25 200	20	10	10					6	30 300	20				48	
92PE487	TO-237 (90)	160	160	7	50 100	15 15 30		1 10 10 10	10 10 10	1.0		30	3							48	
92PE488	TO-237 (90)	250	250	7	50 100	15 15 30		10 10 10 10	10 10 10	1.0		30	3							48	
92PE489	TO-237 (90)	300	300	7	50 200	15 15 30		1 10 10 10	10 10 10	1.0		30	3							48	
92PU10	TO-237 (91)		300		100 200	25 40 40		1 10 10 10	10 10 10	0.75		30	3.5							48	
92PU391	TO-237 (91)	200	200	6	100 160	25 40		1 10 10	10 10	2.0		20	2.5	50	10					48	
92PU392	TO-237 (91)	250	250	6	100 200	25 40		1 10 10	10 10	2.0		20	2.5	50	10					48	
92PU393	TO-237 (91)	300	300	6	100 260	25 40		1 10 10	10 10	2.0		20	2.5	50	10					48	
D40N1	TO-202 (55)		250		10 μA 250	20 30 20		4 20 40	10 10 10						50	20				48	
D40N2	TO-202 (55)		250		10 μA 250	30 60 30		4 20 40	10 10 10						50	20				48	
D40N3	TO-202 (55)		300		10 μA 300	20 30 20		4 20 40	10 10 10						50	20				48	
D40N4	TO-202 (55)		300		10 μA 300	30 60 30		4 20 40	10 10 10						50	20				48	
MPSA42	TO-92 (92)	300	300	6	100 200	25 40 40		1 10 10 10	10 10 10	0.5		0.9 20	3	50	10					48	

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## MEDIUM POWER (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CER</sub> * V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (mA) @ V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> & V <sub>BE(SAT)</sub> @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max	@ I <sub>C</sub> (mA)	Max	Min	Max		@ I <sub>C</sub> (mA)	Min				
MPSA43	TO-92 (92)	200	200	6	100 160	25 40 50	1 10 30	10 10 10	0.4	0.9	20	4	50	10				48
NSD131	TO-202 (55)	250	250	7	100 150	15 15 30	1 10 30	10 10 10	1.0	0.85	20	3						48
NSD132	TO-202 (55)	250	250	7	100 150	15 30 60	1 10 30	10 10 10	1.0	0.85	20	3						48
NSD133	TO-202 (55)	300	300	7	100 150	15 15 30	1 10 30	10 10 10	1.0	0.85	20	3						48
NSD134	TO-202 (55)	300	300	7	100 150	15 30 60	1 10 30	10 10 10	1.0	0.85	20	3						48
NSD135	TO-202 (55)	375	375	7	100 150	15 30 30	1 10 30	10 10 10	1.0	0.85	20	3						48
NSD457	TO-202 (55)	160	160	5	50 100	25	30	10	1.0		30							48
NSD458	TO-202 (55)	250	250	5	50 200	25	30	10	1.0		30							48
NSD459	TO-202 (55)	300	300	5	50 250	25	30	10	1.0		30							48
NSDU10	TO-202 (55)	300	300	8	200 200	25 40 40	1 10 30	15 15 10	1.5	0.8	20	3	60					48
NSE457	TO-202 (56)	160	160	5	50 100	25	30	10	1.0		30							48
NSE458	TO-202 (56)	250	250	5	50 200	25	30	10	1.0		30							48
NSE459	TO-202 (56)	300	300	5	50 250	25	30	10	1.0		30							48
PN7055	TO-92 (92)	220	220	7	100 150	20 40 40	1 10 30	20 20 20	1.0	0.85	20	3.5	50	15				48
SE7055	TO-39	220	220	7	100 150	20 40 40	1 10 30	20 20 20	1.0	0.85	20	3.5	50	15				48



### MEDIUM POWER (Continued)

Type No.	Case Style	VCBO (V) Min	VCER* VCEO (V) Min	VEBO (V) Min	ICES* ICBO (nA) Max @ VCB (V)	hFE @ IC & VCE			VCE(SAT) (V) Max & VBE(SAT) (V) Min @ IC (mA)	Cob (pF) Max	fT (MHz) @ IC (mA)		toff (ns) Max	NF (dB) Max	Test Conditions	Process No.		
						Min	Max	@ IC (mA)			Min	Max					Min	Max
SE7056	TO-39	300	300	7	100 200	20 40 40	1 10 30	20 20 20	1.0	0.85	20	3.5	50	15		48		
SV7056	TO-202 (55)	300	300	7	100 200	20 40 40	1 10 30	20 20 20	1.0	0.85	20		50	15		48		
TN3742	TO-237 (91)	300	300	7	200 200	10	3	10	0.75	1.0	10	6	30	10			48	
						15	10	10										
						20	200	30	10	1.0	1.2							30
						20		50	20									



### POWER

Type No.	Case Style	VCBO (V) Min	VCEO (V) Min	VEBO (V) Min	ICEX* ICEB† ICBO (μA) Max @ VCB (V)	hFE @ IC & VCE			VCE(SAT) (V) Max & VBE(SAT) (V) Min @ IC (A)	Cob (pF) Max	fT (MHz) @ IC (A)		Process No.		
						Min	Max	@ IC (A)			Min	Max		Min	Max
2N5655	TO-126		250		10 275	25		0.05	10	1.0	0.1		10	0.05	36
						30	250	0.1	10						
						15		0.25	10	2.5	0.25				
						5		0.5	10						
2N5656	TO-126		300		10 350	25		0.05	10	1.0	0.1	25	10	0.05	36
						30	250	0.1	10						
						15		0.25	10	2.5	0.25				
						5		0.5	10						
2N5657	TO-126		350		10 375	25		0.05	10	1.0	0.1	25	10	0.05	36
						30	250	0.1	10						
						15		0.25	10	2.5	0.25				
						5		0.5	10						
MJE340	TO-126		300		100 300	30	240	0.05	10						36
MJE341	TO-126		150		300 175	20		0.01	10	1.0	0.05	15	15	0.05	36
						25	200	0.05	10						
						20		0.15	10	2.3	0.15				
MJE344	TO-126		200		100 200	30	300	0.05	10	1.0	0.05	15	15	0.05	36

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# NPN Transistors



## POWER (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CEX</sub> * I <sub>CEB</sub> * (μA) Max	V <sub>CB</sub> (V) @	h <sub>FE</sub>				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz)		Process No.		
							Min	Max	@ I <sub>C</sub> (A)	V <sub>CE</sub> (V)	Max	Min	Max		@ I <sub>C</sub> (A)	Min		Max	@ I <sub>C</sub> (A)
MJE3439	TO-126		360		20	360	30	40	160	0.002	10	0.5	1.3	0.05	10	15	0.01	36	
MJE3440	TO-126		250		20	250	30	40	160	0.002	10	0.5	1.3	0.05	10	15	0.01	36	
MJE180	TO-126		40		0.1	60	50	30	12	0.1	1	0.3	0.9	1.5	0.5	1.5	1.5	0.05	37
MJE720	TO-126		40		100*	40	40	20	8	0.15	1	0.15	0.4	1.0	0.15	0.5	1.5		37
MJE181	TO-126		60		0.1	80	50	30	12	0.1	1	0.3	0.9	1.7	0.5	1.5	3.0	0.1	38
MJE182	TO-126 (58)		80		100	100	50	30	12	100	1	0.3	0.9	1.7	500	1.5A	3A	0.1	39
2N6099	TO-220		60		2 mA	50	20	5		80	4	2.5			10				4A
2N6101	TO-220		70		2 mA	60	20	5		80	4	2.5			10				4A
2N6103	TO-220		40		2 mA	40	15	5		60	4	2.5			16				4A
2N6486	TO-220		40		100	35	20	15		150	4	1.3	3.5		5		1		4A
2N6487	TO-220		60		100	55	20	15		150	4	1.3	3.5		5		1		4A
2N6488	TO-220		80		100	75	20	15		150	4	1.3	3.5		5		1		4A
MJE2801T	TO-220		60				25	100		3	2								4A
MJE3055T	TO-220		60		1 mA	70	20	5		70	4	1.1			4				4A
TIP41	TO-220		40		400*	40	30	15		0.3	4	1.5			6				4A
TIP41A	TO-220		60		400*	60	30	15		0.3	4	1.5			6				4A
TIP41B	TO-220		80		400*	80	30	15		0.3	4	1.5			6				4A
TIP41C	TO-220		100		400*	100	30	15		0.3	4	1.5			6				4A



**POWER** (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CEX</sub> * I <sub>CEB</sub> <sup>†</sup> I <sub>CBO</sub> (μA) Max	V <sub>CB</sub> (V) @	h <sub>FE</sub>				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz)		Process No.
							Min	Max	@ I <sub>C</sub> (A)	& V <sub>CE</sub> (V)	Max	Min	Max		@ I <sub>C</sub> (A)	Min	
2N5190	TO-126		40		100	40	25	100	1.5	2	0.6		1.5		2	1	4E
							10		4	2	1.4		4				
2N5191	TO-126		60		100	60	25	100	1.5	2	0.6		1.5		2	1	4E
									4	2	1.4		4				
2N5192	TO-126		80		100	80	20	80	1.5	2	0.6		1.5		2	1	4E
							7		4	2	1.4		4				
2N5294	TO-220		70		500 <sup>†</sup>	50 (100Ω)	30	120	0.5	4	1		0.5		2	0.2	4E
2N5296	TO-220		40		100	35	30	120	1	4	1.0		1		2	0.2	4E
2N5298	TO-220		60		500 <sup>†</sup>	50 (100Ω)	20	80	1.5	1	1.0		1.5		2	0.2	4E
2N5490	TO-220		40		5 mA*	55	20	100	2	4	2.0		0.5				4E
							5		6.5	4							
2N5492	TO-220		55		1 mA*	70	20	100	2.5	4	2.0		0.2				4E
							5		6.5	4							
2N5494	TO-220		40		1 mA*	55	20	100	3	4	2.0		0.5				4E
							5		6.5	4							
2N5496	TO-220		70		1 mA*	85	20	100	3.5	4	2.0		7				4E
							5		7	4							
2N6121	TO-220		45		100	45	25	100	1.5	2	0.6		1.5		2.5	1	4E
							10		4	2	1.4		4				
2N6122	TO-220		60		100	60	25	100	1.5	2	0.6		1.5		2.5	1	4E
							10		4	2	1.4		4				
2N6123	TO-220		80		100	80	20	80	1.5	2	0.6		1.5		2.5	1	4E
							7		4	2	1.4		4				
2N6129	TO-220		40		100	40	20	100	2.5	4	1.4		7				4E
							7		7	4							
2N6130	TO-220		60		100	60	20	100	2.5	4	1.4		7				4E
							7		7	4							
2N6131	TO-220		80		100	80	20	100	2.5	4	2.0		7				4E
							5		7	4							
2N6288	TO-220		30		100*	37.5	30	150	3	4	1.0		3	250	4	0.5	4E
							5		6.5	4	2.0		6.5				
2N6290	TO-220		50		100*	56	30	150	3	4	1.0		2.5	250	4	0.5	4E
							5		6.5	4	2.0		6.5				
2N6292	TO-220		70		100*	75	30	150	2	4	1.0		2	250	4	0.5	4E
							5		6.5	4	2.0		6.5				

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**NPN Transistors**

# NPN Transistors



POWER (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> (V) Min	V <sub>EB0</sub> (V) Min	I <sub>CEX</sub> * I <sub>CEB</sub> † I <sub>CB0</sub> (μA) Max	V <sub>CB</sub> (V)	h <sub>FE</sub>		I <sub>C</sub> (A)	V <sub>CE</sub> (V)	V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V)		I <sub>C</sub> (A)	C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz)		I <sub>C</sub> (A)	Process No.	
							Min	Max			Max	Min			Max	Min			Max
MJE5190J	TO-126		40		100	40	25 10	250	1.5 4	2 2	0.6		1.5					4E	
MJE5191J	TO-126		60		100	60	25 10	250	1.5 4	2 2	0.6		1.5					4E	
MJE5192J	TO-126		80		100	80	50 7	250	1.5 4	2 2	0.6		1.5					4E	
2N6473	TO-220		100		100*	100	15	150	1.5	4	1.2		1.5	250				4F	
2N6474	TO-220		120		100*	120	15	150	1.5	4	1.2		1.5	250				4F	
MJE520	TO-220		30		100	30	25		1	1								4F	
MJE521	TO-220		40		100	40	40		1	1								4F	
TIP29	TO-220		40		200*	40	40 15		0.2 75	4 4	0.7		1		3		0.2	4F	
TIP29A	TO-220		60		200*	60	40 15		0.2 75	4 4	0.7		1		3		0.2	4F	
TIP29B	TO-220		80		200*	80	40 15		0.2 75	4 4	0.7		1		3		0.2	4F	
TIP29C	TO-220		40		200*	40	25 10		1 50	4 4	0.7		1		3		0.2	4F	
TIP31	TO-220		40		200*	40	25 10		1 50	4 4	1.2		3		3		0.5	4F	
TIP31A	TO-220		60		200*	60	25 10		1 50	4 4	1.2		3		3		0.5	4F	
TIP31B	TO-220		80		200*	80	25 10		1 50	4 4	1.2		3		3		0.5	4F	
TIP31C	TO-220		100		200*	100	25 10		1 50	4 4	1.2		3		3		0.5	4F	
TIP61	TO-220		40		200*	40	40 15		0.05 100	4 4	0.7		0.5		3		0.05	4F	
TIP61A	TO-220		60		200*	60	40 15		0.05 100	4 4	0.7		0.5		3		0.05	4F	
TIP61B	TO-220		80		200*	80	40 15		0.05 100	4 4	0.7		0.5		3		0.05	4F	
TIP61C	TO-220		100		200*	100	40 15		0.05 100	4 4	0.7		0.5		3		0.05	4F	
2N4921	TO-220		40		100	40	40 20 10		0.05 100 1	1 1 1	0.6		1.3	1	100	300		0.25	4H



**POWER** (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CEX</sub> * I <sub>CEB</sub> † I <sub>CB0</sub> (μA) Max	V <sub>CB</sub> (V) @	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		Process No.		
							Min	Max	(A)	(V)	Max	Min	Max		(A)	Min		Max	(A)
2N4922	TO-220		60		100	60	40		0.05	1		0.6		1.3	1	100	300	0.25	4H
2N4923	TO-220		80		100	80	40	100	0.05	1		0.6		1.3	1	100	300	0.25	4H
D44C1	TO-220		30		10*	40	25		0.2	1		0.5		1.3	1	100	3	0.02	4P
D44C2	TO-220		30		10*	40	40	120	0.2	1		0.5		1.3	1	100	3	0.02	4P
D44C3	TO-220		30		10*	40	40		0.2	1		0.5		1.3	1	100	3	0.02	4P
D44C4	TO-220		45		10*	55	25		0.2	1		0.5		1.3	1	100	3	0.02	4P
D44C5	TO-220		45		100	55	40	120	0.2	1		0.5		1.3	1	100	3	0.02	4P
D44C6	TO-220		45		10*	55	40		0.2	1		0.5		1.3	1	100	3	0.02	4P
D44C7	TO-220		60		100	75	25		0.2	1		0.5		1.3	1	100	3	0.02	4P
D44C8	TO-220		60		100	70	40	120	0.2	1		0.5		1.3	1	100	3	0.02	4P
D44C9	TO-220		60		10*	70	40		0.2	1		0.5		1.3	1	100	3	0.02	4P
D44C10	TO-220		80		100	90	25		0.2	1		0.5		1.3	1	100	3	0.02	4P
D44C11	TO-220		80		10*	90	40	120	0.2	1		0.5		1.3	1	100	3	0.02	4P
D44C12	TO-220		80		10*	90	40		0.2	1		0.5		1.3	1	100	3	0.02	4P
MJE200	TO-220		25		0.1	40	70		0.5	1		0.3			0.5	80	65	0.1	4P
MJE220	TO-220		100		0.1	60	40	200	0.2	1		0.3			0.5	80	50	0.1	4P
MJE221	TO-220		40		0.1	60	40	150	0.2	1		0.3		0.5	1.0	50	50	0.1	4P
MJE222	TO-220		40		0.1	60	25		0.2	1		0.3		0.5	0.5	50	50	0.1	4P

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**NPN Transistors**

# NPN Transistors



## POWER (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CEX</sub> * I <sub>CEB</sub> † I <sub>CB0</sub> (μA) Max	V <sub>CB</sub> (V) @	h <sub>FE</sub>				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz)		I <sub>C</sub> (A) @	Process No.
							Min	Max	@	I <sub>C</sub> (A) & V <sub>CE</sub> (V)	Max	&	Min		Max	Min		
MJE223	TO-220		60		0.1	80	40	200	0.2	1	0.3		0.5	50	50		0.1	4P
							20		2	1	0.8	1.8	2					
MJE224	TO-220		60		0.1	80	40	150	0.2	1	0.3		0.5	50	50		0.1	4P
							20		1	1	0.6		1					
MJE225	TO-220		60		0.1	80	25		0.2	1	0.3		0.5	50	50		0.1	4P
							10		1	1								
MJE240	TO-220		80		0.1	80	40	200	0.2	1	0.3		0.5	50	40		0.1	4P
							15		2	1	0.8	1.8	2					
MJE241	TO-126		80		0.1	80	40	120	0.2	1	0.3		0.5	50	40		100	4P
											0.6		1					
							20		1	1	2.5	1.8	2					
MJE242	TO-126		80		0.1	80	25		0.2	1	0.3		0.5	50	40		100	4P
							10		1	1	2.5		2					
												1.8	4					
MJE243	TO-126		100		0.1	100	40	120	0.2	1	0.3		0.5	50	40		100	4P
											0.8		2					
											2.5	1.8	4					
MJE244	TO-126		100		0.1	100	25		0.2		0.3		0.5	50	40		100	4P
							10				2.5		2					
									1				4					
D44H1	TO-220		30		10	30	35		2	1	1.0		8					4Q
							20		4	1								
D44H2	TO-220		30		10	30	60		2	1	1.0		8					4Q
							40		4	1								
D44H4	TO-220		45		10	45	35		2	1	1.0		8					4Q
							20		4	1								
D44H5	TO-220		45		10	45	60		2	1	1.0		8					4Q
							40		4	1								
D44H7	TO-220		60		10	60	35		2	1	1.0		8					4Q
							20		4	1								
D44H8	TO-220		60		10	60	60		2	1	1.0		8					4Q
							40		4	1								
D44H10	TO-220		80		10	80	35		2	1	1.0		8					4Q
							20		4	1								
D44H11	TO-220		80		10	80	60		2	1	1.0		8					4Q
							40		4	1								



DARLINGTON

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (μA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub>				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		Process No.	
						Min	Max	@ I <sub>C</sub> (mA)	@ V <sub>CE</sub> (V)	Max	Min	Max		Min	Max		
2N5305	TO-92 (94)				0.1 25	2000	20,000	2	5	1.4		200	10	60	2	05	
2N5306	TO-92 (94)				0.1 25	7000	70,000	2	5	1.4		200	10	60	2	05	
2N5307	TO-92 (94)				0.1 40	2000	20,000	2	5	1.4		200	10	60	2	05	
2N5308	TO-92 (94)				0.1 40	7000	70,000	2	5	1.4		200	10	60	2	05	
2N6426	TO-92 (92)	40	40	12	0.05 30	20,000	200,000	10	5	1.2		50	7	150	10	05	
						30,000	300,000	100	5								
						20,000	300,000	500	5	1.5	2	500					
2N6427	TO-92 (92)	40	40	12	0.05 30	10,000	100,000	10	5	1.2		50	7	130	10	05	
						20,000	200,000	100	5								
						14,000	140,000	500	5	1.5	2	500					
2N6548	TO-202 (55)	50	40	12	0.1 30	25,000	150,000	200	5			7	1		200	05	
						15,000		500	5								
						5000		1A	5								
2N6549	TO-202 (55)	50	40	12	0.1 30	15,000	150,000	200	5			7	1		200	05	
						10,000		500	5								
						3000		1A	5								
2N6724	TO-126	50		12		25,000		200	5	1.0		200		1	10	200	05
						15,000		500	5								
						4000	40,000	1A	5								
2N6725	TO-126	60		12	0.1 40	25,000		200	5	1.0		200		1	10	200	05
						15,000		500	5								
						4000	40,000	1A	5								
92PU45	TO-237 (91)	50		12	0.1 30	4000		1A	5	1.5	2.0	1A		100		200	05
						15,000		500	5								
						25,000		200	5	1.0		200					
92PU45A	TO-237 (91)	60		12	0.1 40	4000		1A	5	1.5	2.0	1A		100		200	05
						15,000		500	5								
						25,000		200	5	1.0		200					
D40C1	TO-202 (55)		30		0.5* 30	10,000	60,000	200	5	1.5	2.0	500	10			05	
D40C2	TO-202 (55)		30		0.5* 30	40,000		200	5	1.5	2.0	500	10			05	
D40C3	TO-202 (55)		30		0.5* 30	90,000		200	5	1.5	2.0	500	10			05	
D40C4	TO-202 (55)		40		0.5* 40	10,000	60,000	200	5	1.5	2.0	500	10			05	

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NPN Transistors



# NPN Transistors



## DARLINGTON (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (μA) Max	@ V <sub>CB</sub> (V)	hFE			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz)		Process No.	
							Min	Max	@ I <sub>C</sub> (mA)	@ V <sub>CE</sub> (V)	Max	Min		Max	@ I <sub>C</sub> (mA)		Min
D40C5	TO-202 (55)		40		0.5*	40	40,000		200	5	1.5	2.0	500	10		05	
D40C7	TO-202 (55)		50		0.5*	50	10,000	60,000	200	5	1.5	2.0	500	10		05	
D40C8	TO-202 (55)		50		0.5*	5	40,000		200	5	1.5	2.0	500	10		05	
D40K1	TO-202 (55)		30				10,000		200	5			10			05	
							1000		1.5A	5							
							1000		1A	5							
D40K2	TO-202 (55)		-50				10,000		200	5						05	
							1000		1.5A	5							
							1000		1A	5							
D40K3	TO-202 (55)		30				10,000		200	5						05	
							1000		1.5A	5							
							1000		1A	5							
D40K4	TO-202 (55)		50				10,000		200	5						05	
							1000		1.5A	5							
							1000		1A	5							
MPSA12	TO-92 (92)	20			0.1	15	20,000		10	5	1.0		10			05	
MPSA13	TO-92 (92)	30			0.1	30	10,000		100	5	1.5		100		125	10	05
							5000		10	5							
MPSA14	TO-92 (92)	30			0.1	30	20,000		100	5	1.5		100		125	10	05
							10,000		10	5							
NSD151	TO-202 (55)		30	12			5000		10	5	1.5		100	8	5	10	05
							10,000	150,000	100	5							
NSD152	TO-202 (55)			12			5000		10	5	1.5		100	8	5	10	05
							10,000	25,000	100	5							
NSD153	TO-202 (55)			12			20,000		10	5	1.5		100	8	5	10	05
							5000		100	5							
NSD154	TO-202 (55)			12			20,000		10	5	1.5		100	8	5	10	05
							5000		100	5							
NSDU45	TO-202 (55)	50		12			25,000	150,000	200	5	1.0		200	8	1	200	05
							15,000		500	5							
							4000		1A	5							
NSDU45A	TO-202 (55)	60		12	0.1	10	25,000	150,000	200	5	1.0		200	8	1	200	05
							15,000		500	5							
							4000		1A	5							



**DARLINGTON** (Continued)

Type No.	Case Style	VCBO (V) Min	VCEO (V) Min	VEBO (V) Min	ICES* ICBO (μA) Max @ VCB (V)	hFE		IC (mA) @ VCE (V)	VCE(SAT) (V) Max & VBE(SAT) (V) Min Max @ IC (mA)	Cob (pF) Max	fT (MHz) @ IC (mA)		Process No.		
						Min	Max				Min	Max			
2N6037	TO-126		40		500 40	100		4A	3	2.0 3.0	200	25	0.75A	4J	
						750	1500	2A	3						
						500		0.5	3						
2N6038	TO-126		60		500 60	100		4A	3	2.0 3.0	200	25	0.75A	4J	
						750	1500	2A	3						
						500		0.5	3						
2N6039	TO-126		80		500 80	100		4A	3	2.0 3.0	200	25	0.75A	4J	
						750	1500	2A	3						
						500		0.5	3						
2N6386	TO-220		40		300* 40	100		8	3	2.0 3.0	200	20	1	4J	
						1000	20,000	3	3						
MJE800	TO-126		60		200 60			1.5	3						4J
MJE801	TO-126		60		200 60			2	3						4J
MJE802	TO-126		80		200 80			1.5	3						4J
MJE803	TO-126		80		200 80			2	3						4J
TIP110	TO-220		60		1 mA 60	500		2	4	2.5					4J
						1000		1	4						
TIP111	TO-220		80		1 mA 80	500		2	4	2.5					4J
						1000		1	4						
TIP112	TO-220		100		1 mA 100	500		2	4	2.5					4J
						1000		1	4						
TIP120	TO-220		60		200 60	1000		3	3	2.0 4.0					4J
						1000		0.5	3						
TIP121	TO-220		80		200 80	1000		3	3	2.0 4.0					4J
						100		0.5	3						
TIP122	TO-220		100		200 100			3	3						4J
2N6387	TO-220	60	60	5		1000	20,000	5	3	3.0	200				4K
						100		10	3						
2N6388	TO-220	80	80	5		1000	20,000	5	3	3.0	200				4K
						100		10	3						
2N6043	TO-220		60		500 60	10,000	20,000	4	4	2.0 4.0	200	4	3		4K
						100		8	4						
2N6044	TO-220		80		500 80	1000	20,000	4	4	2.0 4.0	200	4	3		4K
						100		8	4						
2N6045	TO-220		100		500 100	1000	20,000	4	4	2.0 4.0	200	4	3		4K
						100		8	4						
SE9300	TO-220		60	4		750		1	3						4K
						1000		4	3						
						100		7.5	3						

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**NPN Transistors**

# NPN Transistors



## DARLINGTON (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CS</sub> * I <sub>CBO</sub> (μA) Max	V <sub>CB</sub> (V)	h <sub>FE</sub>		I <sub>C</sub> (mA)	V <sub>CE</sub> (V)	V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V)			I <sub>C</sub> (mA)	C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz)		I <sub>C</sub> (mA)	Process No.
							Min	Max			Max	Min	Max			Min	Max		
SE9301	TO-220		80	4			750		1	3									4K
							1000		4	3									
							100		7.5	3									
SE9302	TO-220		100	4			750		1	3									4K
							1000		4	3									
							100		7.5	3									
TIP100	TO-220	60			50	40	1000	20,000	3	4	2.0		3						4K
							200		8	4	2.5		8						
TIP101	TO-220	80			50	60	1000	20,000	3	4	2.0		3						4K
							200		8	4	2.5		8						
TIP102	TO-220	100			50	80	1000	20,000	3	4	2.0		3						4K
							200		8	4	2.5		8						
TIP130	TO-220		60		200	60	1000	15,000	4	4	2.0		4						4K
							500		1	4	3.0		6						
TIP131	TO-220		80		200	60	1000	15,000	4	4	2.0		4						4K
							500		1	4	3.0		6						
TIP132	TO-220		100		200	100	1000	15,000	4	4	2.0		4						4K
							500		1	4	3.0		6						



Section 2

**PNP Transistors**





## SATURATED SWITCHES

Type No.	Case Style	V <sub>CEO</sub> (V)	V <sub>CE0</sub> (V)	V <sub>EBO</sub> (V)	I <sub>CS</sub> * I <sub>CS0</sub> (nA) @ V <sub>CB</sub> (V)		h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)				C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)			t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
		Min	Min	Min	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max		Min	Max	Min					Max
2N869	TO-52	25		5	10	15	20	120	10	5	1.0		1.0	10	9	100	10				64		
2N869A	TO-52	25	18	5	10	15	25		100	1	0.15	0.78	0.98	10	6	400	10	80		1	64		
							40	120	30	0.5													
							30		10	0.3													
							40	120	10	5	0.2	0.85	1.2	30									
2N995	TO-52	20	15	4	5	15	35	140	20	1	0.2		0.95	20	10	100	10			64			
2N995A	TO-52	20	15	4	5	15	25		100	1	0.2	0.95	20	6	100	10	90		2	64			
							25		50	1													
							25		20	1											0.5	1.7	100
							35	140	1	1													
2N2894	TO-52	12	12	4	10*	6	25		100	1	0.15	0.78	0.98	10	6	400	30	90		2	64		
							40	150	30	0.5	0.2	0.85	1.2	30									
							30		10	0.3	0.5		1.7	100									
2N2894A	TO-52	12	12	4.5	50*	10	30		100	1	0.13	0.78	0.92	10	4.5	800	30	25		3	64		
							40	120	30	0.5	0.19	0.85	1.15	30									
							30		10	0.3	0.45	1	1.5	100									
							20		1	0.5													
2N3012	TO-52	12	12	4	80*	6	20		100	1	0.15	0.78	0.98	10	6	400	30	75		2	64		
							30	120	30	0.5	0.2	0.85	1.2	30									
							25		10	0.3	0.5		1.7	100									
2N3209	TO-52	20	20	4	80*	10	15		100	1	0.15	0.78	0.98	10	5	400	30	90		2	64		
							30	120	30	0.5	0.2	0.85	1.2	30									
							20		10	3	0.6		1.7	100									
2N3248	TO-52	15	12	5			25		100	1	0.125	0.6	0.9	10	8	250	20	100		5	64		
							35		50	1													
							50		10	1	0.25	0.7	1.1	50									
							50		1	1													
							50	150	0.1	1	0.4		1.3	100									
2N3249	TO-52	15	12	5			35		100	1	0.125	0.6	0.9	10	8	300	20	100		5	64		
							75		50	1													
							100		10	1	0.25	0.7	1.1	50									
							100		1	1													
							100	300	0.1	1	0.45		1.3	100									
2N3545	TO-52	20	20	5	10	10	30		100	1	0.2	0.6	0.85	10	8	250	10	90		8	64		
							35		50	1	0.3		1.1	50									
							40	120	10	1												0.5	
							40		1	1													
							30		1	1													



# SATURATED SWITCHES (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V) Max	hFE @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE</sub> (SAT) (V) & V <sub>BE</sub> (SAT) (V) @ I <sub>C</sub> (mA)				C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)			t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max			Max	Min	Max			Min	Max					
2N3546	TO-52	15	12	4.5	10	10	15		100	1	0.15	0.7	0.9	10	6	700	10	30		9	64
							25		50	1	0.25	0.8	1.3	50							
							30	120	10	1	0.5		1.6	100							
							20		1	1											
2N3576	TO-52	20	15	5	10	15	10		100	1	0.15	0.75	0.95	10	4.5	400	10	50		5	64
							40	120	10	0.5	0.5		1.1	100							
2N5056	TO-52	15	15	4.5	50*	10	20		100	1	0.13	0.72	0.92	10	4.5	600	30	35		3	64
							30	100	30	0.5	0.19	0.8	1.15	30							
							20		10	0.3											
							12		1	0.5	0.45	0.95	1.5	100							
2N5057	TO-52	15	15	4.5	50*	10	30		100	1	0.13	0.72	0.92	10	4.5	800	30	35		3	64
							40	100	30	0.5	0.19	0.8	1.15	30							
							30		10	0.3	0.45	0.95	1.5	100							
							20		1	0.5											
2N3304	TO-52	6	6	4	10*	3	20		50	1	0.15	0.7	0.8	1	3.5	500	10	60		7	65
							30	120	10	0.3	0.16	0.8	1.0	10							
							15		1	0.5	0.5		1.5	50							
2N3451	TO-52	6	6	4	10*	3	20		50	1	0.16	0.8	1.0	10	5.5	500	10	60		7	65
							30	120	10	0.3	0.5		1.5	50							
2N3639	TO-92 (92)	Same as PN3639, see page 2-4 for explanation																		65	
2N3640	TO-92 (92)	Same as PN3640, see page 2-4 for explanation																		65	
2N4208	TO-52	12	12	4.5	10*	6	30		50	1	0.13		0.8	1	3	700	10	20		5	65
							30	120	10	0.3	0.15	0.8	0.95	10							
							15		1	0.5	0.5		1.5	50							
2N4209	TO-52	15	15	4.5	10*	8	40		50	1	0.15		0.8	1	3	850	10	20		5	65
							50	120	10	0.3	0.18	0.8	0.95	10							
							35		1	0.5	0.6		1.5	50							
2N4258	TO-92 (92)	Same as PN4258, see page 2-4 for explanation																		65	
2N4258A	TO-92 (92)	Same as PN4258A, see page 2-4 for explanation																		65	
2N5140	TO-92 (92)	Same as PN5140, see page 2-4 for explanation																		65	

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 30 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = 3 mA, I<sub>B</sub><sup>2</sup> = 1.5 mA. (2) I<sub>C</sub> = 30 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1.5 mA. (3) I<sub>C</sub> = 30 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 3 mA. (4) I<sub>C</sub> = 500 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 1.5V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (7) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 1.5V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 500 μA. (8) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 2V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (9) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (10) I<sub>C</sub> = 1A, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 100 mA.

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# PNP Transistors



## SATURATED SWITCHES (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CB0</sub> * (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.		
						Min	Max	Min	Max	Min	Max	Min		Max	Min					Max	
2N5771	TO-92 (92)	15	15	4.5	10	8	40	50	1.0	0.15	0.8	1	3	850	10	20		6	65		
							50	120	0.3	0.18	0.8	0.95								10	
							35	1	0.5	0.6	1.5	50									
2N5910	TO-92 (92)	Same as PN5910, see below for explanation																	65		
MPS3639	TO-92 (92)	Same as PN3639, see below for explanation																	65		
MPS3640	TO-92 (92)	Same as PN3640, see below for explanation																	65		
PN3639	TO-92 (92)	6	6	4	10*	3	20	50	1.0	0.16	0.8	1.0	10	3.5	300	10	60		7	65	
							30	120	0.3	0.5	1.5	50									
PN3640	TO-92 (92)	12	12	4	10*	6	20	50	1.0	0.2	0.8	1.0	10	3.5	300	10	75		7	65	
							30	120	0.3	0.6	1.5	50									
PN4258	TO-92 (92)	12	12	4.5	10*	6	30	50	1	0.15	0.7	0.95	10	3	700	10	20		6	65	
							30	120	0.3	0.5	1.5	50									
							15	1	0.5	0.5	1.5	50									
PN4258A	TO-92 (92)	12	12	4.5	10*	6	30	50	1	0.15	0.7	0.95	10	3	700	10	18		6	65	
							30	120	0.3	0.5	1.5	50									
							15	1	0.5	0.5	1.5	50									
PN5140	TO-92 (92)	5	5	4	50*	3	20	40	10	1	0.2	1.2	10	5	400	10	20		6	65	
PN5910	TO-92 (92)	20	20	4.5	10*	10	30	50	1	0.15	0.75	0.95	10	3	700	10	20		6	65	
							30	120	0.3	0.5	1.5	50									
							15	1	0.5	0.5	1.5	50									
ST5771-1	TO-92 (92)	15	15	4.5	10	8	30	150	10	0.3	0.15	0.8	1		700	10			4	70	
							30	1	0.5	0.18	0.8	0.95	10								
							20	50	1	0.6	1.5	50									
ST5771-2	TO-92 (92)	15	15	4.5	10	8	40	150	10	0.3	0.15	0.8	1		700	10			4	70	
							35	1	0.5	0.18	0.8	0.95	10								
							30	50	1	0.6	1.5	50									
2N3244	TO-39	40	40	5	50	30	25	750	5	0.3		1.1	150	25	175	50	185		4	70	
							50	150	500	1	0.5	0.75	1.5								500
							60	150	1	0.5	0.75	1.5	500								
2N3245	TO-39	50	50	5	50	50	20	1A	5	0.35		1.1	150	25	150	50	165		4	70	
							30	90	500	1	0.6	0.75	1.5								500
							35	150	1	1.2	2	1A									
2N3467	TO-39	40	40	5	100	30	40	1	5	0.3		1.0	150	25	175	50	90		4	70	
							40	120	500	1	0.5	0.8	1.2								500
							40	150	1	0.5	0.8	1.2	500								



# SATURATED SWITCHES (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ Max	V <sub>CB</sub> (V)	hFE @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.		
							Min	Max	(mA)	(V)	Max	Min		Max	(mA)					Min	Max
2N3468	TO-39	50	50	5	100	30	20	1	5	0.35	1.0	150	25	150	50	90		4	70		
							25	75	500	1											
							25		150	1	0.6	0.8								1.2	500
NS3762	TO-39	40	40	5			30	1.5A	5	0.9	1.4	1A	18	180	50	115		10	70		
							30	120	1A	1.5	0.5	1.2								500	
							35		500	1	0.22	1.0								150	
							40		150	1	0.15	0.8								10	
							35		10	1											
NS3763	TO-39	60	60	5			20	1.5A	5	0.9	1.4	1A	18	180	50	115		10	70		
							20	80	1A	1.5	0.5	1.2								500	
							35		500	1	0.22	1.0								150	
							40		150	1	0.15	0.8								10	
							35		10	1											
2N5022	TO-39	50	50	5	100*	30	25	1A	5	0.2	1.0	100	25	170	50	90		4	70		
							25	100	500	1	0.4	0.8								1.4	500
							15		100	1	0.8	1.75								1A	
2N5023	TO-39	30	30	5	100*	20	40	1A	5	0.17	1.0	100	25	200	50	90		4	70		
							40	100	500	1	0.35	0.8								1.4	500
							30		100	1	0.7	1.75								1A	
DH3467CD	Ceramic DIP (40)	40	40	5	100	30	40	1A	5	1.0	1.6	1A	25	175	50	90		4	70		
							40	120	500	1	0.5	0.8								1.2	500
							40		150	1	0.3	1.0								150	
DH3467CN	Molded DIP (39)	40	40	5	100	30	40	1A	5	1.0	1.6	1A	25	175	50	90		4	70		
							40	120	500	1	0.5	0.8								1.2	500
							40		150	1	0.3	1.0								150	
DH3468CD	Ceramic DIP (40)	50	50	5	100	30	20	1A	5	1.2	1.6	1A	25	150	50	90		4	70		
							25	75	500	1	0.6	0.8								1.2	500
							25		150	1	0.35	1.0								150	
DH3468CN	Molded DIP (39)	50	50	5	100	30	20	1A	5	1.2	1.6	1A	25	150	50	90		4	70		
							25	75	500	1	0.6	0.8								1.2	500
							25		150	1	0.36	1.0								150	

### TEST CONDITIONS:

(1) I<sub>C</sub> = 30 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = 3 mA, I<sub>B</sub><sup>2</sup> = 1.5 mA. (2) I<sub>C</sub> = 30 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1.5 mA. (3) I<sub>C</sub> = 30 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 3 mA. (4) I<sub>C</sub> = 500 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 1.5V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (7) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 1.5V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 500 μA. (8) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 2V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (9) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (10) I<sub>C</sub> = 1A, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 100 mA.



# PNP Transistors



## LOW LEVEL AMPS

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CBO</sub> (nA) @ Max	V <sub>CB</sub> (V) 45	h <sub>FE</sub> & I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
							Min	Max	@	Min	Max	@		Min	Max					Min
2N2604	TO-46	60	45	6	10	45	350	10	5	0.5	0.7	0.9	10	6	30	0.5	3	1	62	
							60	0.5	5											
							40	120	0.01	5										
2N2605	TO-46	60	45	6	10	45	600	10	5	0.5	0.7	0.9	10	6	30	0.5	3	2	62	
							150	0.5	5											
							100	300	0.01	5										
2N3547	TO-18	60	60	6	25	45	75	10	5	1.0		1.0	10	8	45	1	5	1	62	
							100	1	5											
							60	0.1	5											
2N3548	TO-18	60	45	6	10	45	600	10	5	1.0		1.0	10	8	60	150	1	4	1	62
							150	0.1	5											
							100	300	0.01	5										
2N3549	TO-18	60	60	6	10	45	800	10	5	1.0		1.0	10	8	60	150	1	4	1	62
							200	1	5											
							150	0.1	5											
							100	500	0.01	5										
2N3550	TO-18	60	45	8	1	45	800	10	5	0.5	0.7	0.9	5	8	60	150	1	4	1	62
							300	1	5											
							250	0.1	5											
							200	600	0.01	5										
							125	0.001	5											
2N3799	TO-18	60	60	5	10	50	300	0.1	5	0.25		0.8	1	4	30		0.5	2.5	3	62
							300	900	0.5	5										
							300	0.1	5	0.2		0.7	0.1							
							225	0.01	5											
							75	0.001	5											
2N4058	TO-92 (94)	30	30	6	100	20	100	400	0.1	5	0.7		10				5	3	62	
2N4059	TO-92 (94)	30	30	6	100	20	45	660	1	5	0.7		10						62	
2N4061	TO-92 (94)	30	30	6	100	20	90	330	1	5	0.7		10						62	
2N4062	TO-92 (94)	30	30	6	100	20	180	660	1	5	0.7		10						62	
2N4248	TO-92 (92)	Same as PN4248, see page 2-7 for explanation																	62	
2N4249	TO-92 (92)	Same as PN4249, see page 2-7 for explanation																	62	
2N4250	TO-92 (92)	Same as PN4250, see page 2-7 for explanation																	62	



## LOW LEVEL AMPS (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EB0</sub> (V) Min	I <sub>CBO</sub> (nA) @ Max	V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
							Min	Max	@ (mA)	Max	Max	Min		Max	Min					Max
2N4250A	TO-92 (92)	Same as PN4250A, see below for explanation																		62
2N4288	TO-92 (94)	30	25	6	50	25	75	10	5	0.35	0.8	1	8	40	1				62	
							150	600	1	5										
							100		0.1	5										
2N4289	TO-92 (94)	60	45	7	10	45	75	10	5	0.35	0.8	1	8	40	1	4	1		62	
							150	600	1	5										
							100		0.1	5										
2N4964	TO-92 (92)	Same as MPSA70, see below for explanation																		62
2N4965	TO-92 (92)	Same as 2N5086, see below for explanation																		62
2N5086	TO-92 (92)	50	50		50	35	150	10	5	0.3		10	4	40	0.5	3	4		62	
							150		1	5										
							150	500	0.1	5										
2N5087	TO-92 (92)	50	50		50	35		10	5	0.3		10	4	40	0.5	2	4		62	
								1	5											
								0.1	5											
2N5227	TO-92 (92)	30	30	3	100	10	50	700	2	10	0.4	1.0	10	5	100	10			62	
							30		0.1	10										
MPSA 70	TO-92 (92)		40	4	100	30	40	400	5	10	0.25		10	4	125	5			62	
MPS6523	TO-92 (92)		25	4	50	20	300	600	2	10	0.5		50	4					62	
							150		0.1	10										
PN4248	TO-92 (92)	40	40	5	10	40	50		0.1	5	0.25		10	6					62	
PN4249	TO-92 (92)	60	60	5	10	40	100	300	0.1	5	0.25		10	6					62	
PN4250	TO-92 (92)	40	40	5	10	40	250	700	0.1	5	0.25		10	6		2	4		62	
PN4250A	TO-92 (92)	60	60	5	10	50	250	700	0.1	5	0.25		10	6		2	4		62	

### TEST CONDITIONS:

(1) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 10 Hz–15.7 kHz. (2) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 10 kHz. (3) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 10 Hz–15.7 kHz. (4) I<sub>C</sub> = 20 μA, V<sub>CE</sub> = 5V, f = 10 Hz–15.7 kHz.



## GENERAL PURPOSE AMPS AND SWITCHES

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CS</sub> * (nA) @ V <sub>CB</sub> (V)		h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
					Min	Max	Min	Max	Min	Max	Min	Max	Min		Max	Min					Max
2N722	TO-18	50	35	5	100	30	30	90	150	10	1.5	1.3	150	45	60	50				63	
2N1132	TO-5	50	35	2	100	30	30	90	150	10	1.5	1.3	150	45	60	50				63	
2N2696	TO-18	25	25		25	10	20	300	2	0.25	1.1	50	20	100	50	170		1		63	
2N2904	TO-5	60	40	5	20	50	20	500	10	0.4	1.3	150	8	200	50	100		2		63	
							40	120	150	10	1.6	2.6									500
2N2904A	TO-5	60	60	5	10	50	40	500	10	0.4	1.3	150	8	200	50	100		2		63	
							40		150	10	1.6	2.6									500
							40		10	10											
							40	120	1	10											
2N2905	TO-5	60	40	5	20	50	30	500	10	0.4	1.3	150	8	200	50	100		2		63	
2N2905A	TO-5	60	60	5	10	50	100	300	150	10	0.4	1.3	150	8	200	50	100		2		63
							100		10	10	1.6	2.6	500								
							100		1	10											
							100		0.1	10											
							75		0.1	10											
2N2906	TO-18	60	40	5	20	50	20	500	10	0.4	1.3	150	8	200	50	100		2		63	
2N2906A	TO-18	60	60	5	10	50	40	500	10	0.4	1.3	150	8	200	50	100		2		63	
							40	120	150	10	1.6	2.6									500
							40		10	10											
							40		1	10											
							40		0.1	10											
2N2907	TO-18	60	40	5	20	50	35	500	10	0.4	1.3	150	8	200	50	100		2		63	
2N2907	TO-18	60	40	5	20	50	100	300	150	10	0.4	1.3	150	8	200	50	100		2		63
							75		10	10	1.6	2.6	500								
							50		1	10											
							35		0.1	10											



# GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.					
						Min	Max	I <sub>C</sub> (mA)	V <sub>CE</sub> (V)	Max	Min		Max	I <sub>C</sub> (mA)					Min	Max			
2N2907A	TO-18	60	60	5	10	50	300	500	10	0.4	1.3	150	8	200	50	100		2	63				
								100	10	1.6	2.6	500											
								100	10														
								100	10														
								75	0.1	10													
2N3072	TO-5	60	60	4	10*	30	15	300	2	0.25	1.2	50	10	130	50	100		3	63				
							30	130	50	1	1.0	2.0								300			
2N3073	TO-18	60	60	4	10*	30	15	300	2	0.25	1.2	50	10	130	50	100		3	63				
							30	130	50	1	1.0	2.0								300			
2N3120	TO-5	45	45	4	10*	30	15	300	2	0.25	1.2	50	10	130	50	100		4	63				
							30	130	50	1	1.0	2.0								500			
2N3121	TO-18	45	45	4	10*	30	15	300	2	0.25	1.2	50	10	130	50	100		4	63				
							30	130	50	1	1.0	2.0								500			
2N3133	TO-5	50	35	4	50	30	10	150	1	0.6	1.5	150	10	200	50	150		2	63				
							40	120	150											10			
							25		1											10			
2N3134	TO-5	50	35	4	50	30	50	150	1	0.6	1.5	150	10	200	50	150		2	63				
							100	300	150											10			
							50		1											10			
2N3135	TO-18	50	35	4	50	30	25	150	1	0.6	1.5	150	10	200	50	150		2	63				
							40	120	150											10			
							10		1											10			
2N3136	TO-18	50	35	4	50	30	25	150	1	0.6	1.5	150	10	200	50	157		2	63				
							100	300	150											10			
							50		1											10			
2N3502	TO-5	45	45	5	10	30	50	500	10	0.25	1.0	50	8	200	50	100	4	4/7	63				
							100	300	150											10			
							140		10											10	0.4	1.3	150
							135		1											10	1	2	300
							120		0.1											10			
							80		0.01											10	1.6	2	500

### TEST CONDITIONS:

(1) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (2) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (3) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 15V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (4) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 100 Hz. (7) I<sub>C</sub> = 30 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (8) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 250 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (11) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (12) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (13) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA.





## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EB0</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> & V <sub>BE(SAT)</sub> @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.						
						Min	Max	(mA)	(V)	Max	Min		Max	Min					Max	(mA)				
2N3503	TO-5	60	60	5	10 50	50	500	10	0.25	1	50	8	200	50	100	4	4/7	63						
						100	300	150											10					
						140		10											10	0.4	1.3	150		
						135		1											10	1	2	300		
						120		0.1											10					
80		0.01	10	1.6	2	500																		
2N3504	TO-18	45	45	5	10 30	50	500	10	0.25	1	50	8	200	50	100	4	4/7	63						
						100	300	150											10					
						140		10											10	0.4	1.3	150		
						135		1											10					
						120		0.1											10	1.6	2	500		
80		0.01	10																					
2N3505	TO-18	60	60	5	10 50	100	300	150	10	0.25	1	50	8	200	50	100	4	4/7	63					
						115	300	50	1															
						140		10	10											0.4	1.3	150		
						135		1	10											2	2	300		
						120		0.1	10											1.6	2	500		
2N3638	TO-92 (92)	Same as PN3638, see page 2-13 for explanation															63							
2N3638A	TO-92 (92)	Same as PN3638A, see page 2-13 for explanation															63							
2N3644	TO-92 (92)	Same as PN3644, see page 2-13 for explanation															63							
2N3645	TO-92 (92)	60	60	5		40	0.1	10	0.4	1.3	150	8	200	20					63					
						80		1												10				
						100		10												10	1	0.8	2	300
						100	300	150												10				
						20		300												2				
80	240	50	1																					
2N3702	TO-92 (94)	40	25	5	100 20	60	300	50	5	0.25		50	12	100	50				63					
2N3703	TO-92 (94)	50	30	5	100 20	30	150	50	5	0.25		50	12	100	50				63					
2N4142	TO-92 (92)	Same as PN4142, see page 2-13 for explanation															63							
2N4143	TO-92 (92)	Same as PN4143, see page 2-13 for explanation															63							
2N4290	TO-92 (94)	30	20	5	500 20	50	300	100	10	0.4	1.5	100	10	100	10				63					
						40		10	10															
						20		0.1	10															



## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CS</sub> * (nA) @ V <sub>CB</sub> (V) Min Max	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max	I <sub>C</sub> (mA)	V <sub>CE</sub> (V)	Max	Min	Max		I <sub>C</sub> (mA)	Min				
2N4291	TO-92 (94)	40	30	6	200 30	100 300	100 10	10 10	0.4	1.5	100	10	100	10					63
2N4402	TO-92 (94)	40	40	5		20 50 50 30	150 150 10 1	2 2 1 1	0.4	0.7	0.95	150	10	150	20	255		4	63
2N4403	TO-92 (92)	40	40	5		20 100 100 60 30	300 150 10 1 0.1	2 2 1 1	0.4	0.75	0.95	150	10	200	20	255		4	63
2N4971	TO-92 (92)	Same as PN2906, see page 2-12 for explanation																	63
2N4972	TO-92 (92)	Same as PN2907, see page 2-12 for explanation																	63
2N5142	TO-92 (92)	Same as PN5142, see page 2-14 for explanation																	63
2N5143	TO-92 (92)	Same as PN5143, see page 2-14 for explanation																	63
2N5221	TO-92 (92)	15	15	3	100 10	30 30	600 600	50 10	10 10	0.5	1.1	150	15	100	20				63
2N5226	TO-92 (92)	25	25	4	300 15	30 25	600 600	50 10	10 10	0.8	1.0	100	20	50	20				63
2N5354	TO-92 (94)	25	25	4	100 25	40	120	50	1	0.25		50	8					63	
2N5355	TO-92 (94)	25	25	4	100 25	100	300	50	1	0.25		50	8					63	
2N5365	TO-92 (94)	40	40	4	100 40	20 40 32	300 120 2	5 1 1	0.25	1.1	50	8						63	
2N5366	TO-92 (94)	40	40	4	100 40	40 100 80	300 300 2	5 1 1	0.25	1.1	50	8						63	

### TEST CONDITIONS:

- (1) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (2) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (3) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 15V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (4) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 100 Hz. (7) I<sub>C</sub> = 30 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (8) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 250 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (11) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (12) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (13) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA.

# PNP Transistors



## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max	(mA)	(V)	Max	Min	Max		(mA)	Min				
2N5447	TO-92 (97)	40	25	5		60	300	50	5	0.25		50	12	100	50				63
2N5817	TO-92 (97)	50	40	5	100 25	25	100	200	500 2	0.75	1.2	500	15	100	50				63
MPS3638	TO-92 (92)	Same as PN3638, see page 2-13 for explanation																	63
MPS3638A	TO-92 (92)	Same as PN3638A, see page 2-13 for explanation																	63
MPS3644	TO-92 (92)	Same as PN3644, see page 2-13 for explanation																	63
MPS3645	TO-92 (92)	Same as PN3645, see page 2-13 for explanation																	63
MPS3702	TO-92 (92)	40	25	5	100 20	60	300	50	5	0.25		50	12	100	50				63
MPS3703	TO-92 (92)	50	30	5	100 20	30	150	50	5	0.25		50	12	100	50				63
MPS6533	TO-92 (92)	40	40	4	50 30	25	40	120	500 10	0.5	1.0	100	6						63
MPS6534	TO-92 (92)	40	40	4	50 30	50	90	270	500 10	0.3	1.0	100	6						63
MPS6535	TO-92 (92)	30	30	4	100 20	30			100 1	0.5	1.2	100	6						63
PN2906	TO-92 (92)	60	40	5	20 50	20	40	120	500 10	0.4	1.3	150	8	200	50	100		2	63
						35			10 10	1.6	2.6	500							
						25			1 10										
						20			0.1 10										
PN2906A	TO-92 (92)	60	60	5	10 50	40	40	120	500 10	0.4	1.3	150	8	200	50	100		2	63
						40			150 10										
						40			10 10	1.6	2.6	500							
						40			1 10										
						40			0.1 10										
PN2907	TO-92 (92)	60	40	5	20 50	30	100	300	500 10	0.4	1.3	150	8	200	50	100		2	63
						75			10 10	1.6	2.6	500							
						50			1 10										
						35			0.1 10										



# GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CS</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.				
						Min	Max	I <sub>C</sub> (mA)	V <sub>CE</sub> (V)	Max	Min	Max		I <sub>C</sub> (mA)	Min					Max	I <sub>C</sub> (mA)		
PN2907A	TO-92 (92)	60	60	5	20	50	50		500	10	0.4	1.3	150	8	200	50	100	2	63				
							100	300	150	10													
							100		10	10										1.6	2.6	500	
							100		1	10													
							75		0.1	10													
PN3638	TO-92 (92)	25	25	4	35*	15	20		300	2	0.25	1.1	50	20	100	50	170	1	63				
							20		50	1													
							30		10	10										1.0	0.8	2.0	300
PN3638A	TO-92 (92)	25	25	4	25*	15	20		300	2	0.25	1.1	50	10	150	50	170	1	63				
							100		50	1													
							100		10	10										1.0	0.8	2.0	300
							80		1	10													
PN3644	TO-92 (92)	45	45	5	35*	30	20		300	2	0.25	1.0	50	8	200	20	100	4	63				
							100	300	150	10													
							80	240	50	1										0.4	1.3	150	
							100		10	10										1.0	0.8	2.0	300
							80		1	10													
PN3645	TO-92 (92)	60	60	5	35*	50	20		300	2	0.25	1.0	50	8	200	20	100	4	63				
							100	300	150	10													
							80	240	50	1										0.4	1.3	150	
							100		10	10										1.0	0.8	2.0	300
							80		1	10													
PN4142	TO-92 (92)	60	40	5			20		500	10	0.4	1.3	150	8	200	50	100	12	63				
							20		150	1													
							40	120	150	10										1.6	2.6	500	
							35		10	10													
							25		1	10													
							20		0.1	10													
PN4143	TO-92 (92)	60	40	5			30		500	10	0.4	1.3	150	8	200	50	100	12	63				
							50		150	1													
							100	300	150	10										1.6	2.6	500	
							75		10	10													
							50		1	10													
							35		0.1	10													

### TEST CONDITIONS:

(1) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (2) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (3) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 15V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (4) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 100 Hz. (7) I<sub>C</sub> = 30 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (8) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 250 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (11) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (12) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (13) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA.



# PNP Transistors



## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CS</sub> * I <sub>CBO</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.			
						Min	Max		Max	Min	Max		Min	Max							
PN5142	TO-92 (92)	20	20	4	50*	12	15	300	10	0.5	1.5	50	10	100	50	200		1	63		
PN5143	TO-92 (92)	20	20	4	50*	12	15	300	10	0.5	1.5	50	10	100	50	200		1	63		
TIS91	TO-92 (94)	40	40	5	100	20	100	300	50	0.25	0.6	1.0	50						63		
TIS93	TO-92 (97)	40	40	5	100	20	100	300	50	0.25	0.6	1.0	50						63		
TIS93	TO-92 (97)	40	40	5	100	20	100	300	50	0.25		50							63		
TN2904A	TO-237 (91)	60	60	5	10	50	40		0.1	10	0.4	1.3	150	8	200	50	100		2	63	
							40		1.0	10	1.6	2.6	500								
							40	120	150	10											
							40		500	10											
TN2905	TO-237 (91)	60	40	5	20	50	30		500	10	0.4	1.3	150	8	200	50	100		2	63	
							100	300	150	10											
							75		10	10	1.6	2.6	500								
							50		1	10											
							35		0.1	10											
TN2905A	TO-237 (91)	60	60	5	10	50	50		500	10	0.4	1.3	150	8	200	50	100		2	63	
							100	300	150	10											
							100		10	10	1.6	2.6	500								
							100		1	10											
							75		0.1	10											
2N3250	TO-18	50	40	5			15		50	1	0.25	0.6	0.9	10	6	250	10	225	6	5/6	66
							50	150	10	1											
							45		1	1											
							40		0.1	1	0.5	1.2	50								
2N3251	TO-18	50	40	5			30		50	1	0.25	0.6	0.9	10	6	300	20	250	6	5/6	66
							100	300	10	1											
							90		1	1											
							80		0.1	1	0.5	1.2	50								
2N3905	TO-92 (92)	40	40	5			15		100	1	0.25	0.65	0.85	10	4.5	200	10	260	5	5/8	66
							30		50	1											
							50	150	10	1	0.4	0.95	50								
							40		1	1											
							30		0.1	1											



# GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CS</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V)		h <sub>FE</sub> Max @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.		
					Min	Max	Min	Max	Min	Max	Min		Max	Min					Max	
2N3906	TO-92 (92)	40	40	5			30	100	1	0.25	0.65	0.85	10	4.5	250	10	300	4	5/8	66
							60	50	1											
							100	300	10	1	0.4		0.95	50						
							80	1	1											
60	0.1	1																		
2N4121	TO-92 (92)	Same as PN4121, see page 2-16 for explanation																	66	
2N4122	TO-92 (92)	Same as PN4122, see page 2-16 for explanation																	66	
2N4125	TO-92 (92)	30	30	4	50	20	25	50	1	0.4	0.95	50	4.5	200	10		5	8	66	
50	150	2	1																	
2N4126	TO-92 (92)	25	25	4	50	20	60	50	1	0.4	0.95	50	4.5	250	10		4	8	66	
							120	360	2											1
2N4916	TO-92 (92)	Same as PN4916, see page 2-16 for explanation																	66	
2N4917	TO-92 (92)	Same as PN4917, see page 2-16 for explanation																	66	
2N5138	TO-92 (92)	Same as PN5138, see page 2-16 for explanation																	66	
2N5139	TO-92 (92)	Same as PN5139, see page 2-16 for explanation																	66	
MPS3905	TO-92 (92)	40	40	5			30	0.1	1	0.25	0.65	0.85	10	4.5	200	10		5	8	66
							40	1	1											
							50	150	10	1										
							30	50	1											
							15	100	1		0.4		0.95	50						
60	0.1	1	0.25	0.65	0.85	10	4.5	250	10						4	8	66			
80	1	1																		
100	300	10	1																	
60	50	1																		
30	100	1		0.4		0.95	50													
30	100	2	10																	
MPS6516	TO-92 (92)	40	40	4	50	30	30	100	10	0.5		50	4							66
							50	100	2											
MPS6517	TO-92 (92)	40	40	4	50	30	60	100	10	0.5		50	4							66
							90	180	2											

### TEST CONDITIONS:

- (1) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (2) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (3) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 15V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (4) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 100 Hz. (7) I<sub>C</sub> = 30 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (8) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 250 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (11) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (12) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (13) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA.

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# PNP Transistors



## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (nA) @ V <sub>CB</sub> (V) Max	hFE @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
						Min	Max	Min	Max	Min	Max	Min		Max	Min					Max
MPS6518	TO-92 (92)		40	4	500 30	90	100	10		0.5		50	4						66	
NS3905	TO-18	40	40	5		15	100	1		0.25	0.65	0.85	10	4.5	200	10	200	5	5/8	66
						30	50	1												
						50	150	10	1	0.4		0.95	50							
						40		1	1											
						30		0.1	1											
NS3906	TO-18	40	40	5		30	100	1		0.25	0.65	0.85	10	4.5	250	10	300	4	5/8	66
						60	50	1												
						100	300	10	1	0.4		0.95	50							
						80		1	1											
						60		0.1	1											
PN4121	TO-92 (92)	40	40	5	25* 30	15	50	1		0.13		0.75	1	4.5	400	10	150	4	11/8	66
						70	200	10	1	0.14	0.7	0.9	10							
						60		1	1	0.3		1.1	50							
						40		0.1	1											
PN4122	TO-92 (92)	40	40	5	25* 30	30	50	1		0.13		0.75	1	4.5	450	10	150	4	11/8	66
						150	300	10	1											
						150		1	1	0.14	0.7	0.9	10							
						100		0.1	1	0.3		1.1	50							
PN4916	TO-92 (92)	30	30	5	25* 15	15	200	50	1	0.13		0.75	1	4.5	400	10	150	4	13/8	66
						70		10	1	0.14	0.7	0.9	10							
						60		1	1	0.3	0.75	1.1	50							
						40		0.1	1											
PN4917	TO-92 (92)	30	30	5	25* 15	30	50	1		0.13		0.75	1	4.5	450	10	150	4	13/8	66
						150	300	10	1	0.14	0.7	0.9	10							
						150		1	1	0.3	0.75	1.1	50							
						100		0.1	1											
PN5138	TO-92 (92)	30	30	5	50 20	50		10	10	0.3		1.0	10	7	30	0.5				66
						50		1	10											
						50	800	0.1	10											
PN5139	TO-92 (92)	20	20	5	50* 15	15	50	10	10	0.2	0.7	1.0	10	5	300	10	200		13	66
						40		10	1											
						40		1	10											
						30		0.1	10	0.5	0.75	1.25	50							
ST3906	TO-92 (92)	40	40	5		60		0.1	1	0.25	0.65	0.85	10	4.5	250	10				66
						80		1	1	0.4		0.95	50							
						100	300	10	1											
						60		50	1											
						30		100	1											



# GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (nA) @ V <sub>CB</sub> (V) Max		h <sub>FE</sub> Max @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA) Max		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.							
					Min	Max	Min	Max	Min	Max	Min	Max		Min	Max					Min	Max					
2N4354	TO-92 (92)	Same as PN4354, see below for explanation																	67							
2N4355	TO-92 (92)	Same as PN4355, see below for explanation																	67							
2N4356	TO-92 (92)	Same as PN4356, see page 2-18 for explanation																	67							
2N5448	TO-92 (97)	50	30	5	100	20	30	150	50	5	0.25		50	12	100	50				67						
MPSA55	TO-92 (92)		60	4	100	60	50		100	1	0.25		100		50	100				67						
MPSA56	TO-92 (92)		80	4	100	80	50		100	1	0.25		100		50	100				67						
MPS4354	TO-92 (92)	Same as PN4354, see below for explanation																	67							
MPS4355	TO-92 (92)	Same as PN4355, see below for explanation																	67							
MPS4356	TO-92 (92)	Same as PN4356, see page 2-18 for explanation																	67							
MPS6562	TO-92 (92)			5	100	20	50	200	500	1	0.5		500	30	60	10				67						
NS4234	TO-39		40		100 μA	40	40		100	1	0.6		1.5	1A	100	300	100				67					
							30	150	250	1																
							20		500	1																
							10		1A	1																
PN4354	TO-92 (92)	60	60	5	50	50	30		500	10	0.15		0.9	150	30	100	500	50	400	3	14/15	67				
							40		100	10																
							50	500	10	10													0.5		1.1	500
							40		1	10																
							25		0.1	10																
PN4355	TO-92 (92)	60	60	5	50	50	75		500	10	0.15		0.9	150	30	100	500	50	400	3	14/15	67				
							75		100	10																
							100	400	10	10													0.5		1.1	500
							75		1	10																
							60		0.1	10																

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (2) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (3) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 15V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (4) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 100 Hz. (7) I<sub>C</sub> = 30 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (8) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 250 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (11) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (12) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (13) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (14) I<sub>C</sub> = 500 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA. (15) I<sub>C</sub> = 100 μA, V<sub>CC</sub> = 10V, f = 1 kHz.





## GENERAL PURPOSE AMPS AND SWITCHES (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub>			I <sub>C</sub> (mA) & V <sub>CE</sub> (V)	V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)			t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.			
						Min	Max	@		Max	Min	Max		Min	Max	Min					Max	@	
PN4356	TO-92 (92)	80	80	5	50	50	30	500	10	0.15	0.9	150	30	100	500	50	400	3	14/15	67			
							40	100	10														
							50	250	10												0.5	1.1	500
							40	1	10														
							25	0.1	10														
PN5447	TO-92 (92)	40	25	5	100	20	60	300	50	5	0.25	50	12	100	50					67			
TN4036	TO-237 (91)	90	65	7	20	60	20	0.1	10	0.65	1.4	150	30	60	50					67			
							40	140	150												10		
							20	500	10														
TN4037	TO-237 (91)	60	40	7	250	60	15	1	10	1.4	150	30	60	200	50					67			
							50	250	150												10		
MPS6563	TO-92 (92)			5	100	20	50	200	350	1	0.5	350	30	60	10					68			
							50	100	1														
							35	10	1														
2N6076	TO-92 (94)	25	25	5	100	25	100	500	10	10	0.25	0.8	10								71		
2N5400	TO-92 (92)	130	120	5	100	100	40	50	5	0.2	1.0	10	6	100	400	10	8	9		74			
							40	180	10												5		
							30	1	5												0.5	1.0	50
2N5401	TO-92 (92)	160	150	5	50	120	50	50	5	0.2	1.0	10	6	100	300	10	8	9		74			
							60	240	10												5		
							50	1	5												0.5	1.0	50
MPSL51	TO-92 (92)	100	100	4	1 μA	50	40	250	50	5	0.25	1.2	10	8	60	10					74		
																						0.3	1.2

### TEST CONDITIONS:

(1) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (2) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (3) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 15V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (4) I<sub>C</sub> = 300 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 30 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 100 Hz. (7) I<sub>C</sub> = 30 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (8) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 250 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (11) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (12) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (13) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (14) I<sub>C</sub> = 500 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA. (15) I<sub>C</sub> = 100 μA, V<sub>CC</sub> = 10V, f = 1 kHz.



# MEDIUM POWER

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CS</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.				
						Min	Max		Max	Min	Max		Min	Max					Min	Max		
2N4030	TO-39	60	60	5	50	50	15	1A	5	1.0		1A	20	100	400	50	400		3	67		
							25	500	5	0.5		500										
							40	100	5	0.15		150										
							30	120	0.1		0.9											
2N4031	TO-39	80	80	5	50	60	10	1A	5	0.5		500	20	100	400	50	400		3	67		
							25	500	5	0.15		150										
							40	100	5													
							30	120	0.1		0.9											
2N4032	TO-39	60	60	5	50	50	40	1A	5	1.0		1A	20	150	500	50	400		3	67		
							70	500	5	0.5		500										
							100	300	100	5	0.15										150	
							75		0.1		0.9											
2N4033	TO-39	80	80	5	50	60	25	1A	5	0.5		500	20	150	500	50	400		3	67		
							70	500	5	0.15		150										
							100	300	100	5												
							75		0.1		0.9											
2N4036	TO-39	90	65	7	20	60	20	500	10	0.6		150	30	60		50	700		4	67		
							40	140	150	10												
							20		0.1	10												
2N4037	TO-39	60	40	7	250	60	50	250	150	10	1.4		150	30	60		50			67		
							15		1	10												
2N4314	TO-39	90	65		250	60	50	250	150	10	1.4		150	30	60		50			67		
							15		1	10												
40319	TO-39		40		250	15	35	200	50	4	1.4		150								67	
TN4030	TO-237 (91)	60	60	5	50	50	30	0.1	5	0.5		500	20	100	400	50				67		
							40	120	100	5	0.15										150	
							25		500	5	1.0										1A	
							15		1A	5												
TN4033	TO-237 (91)	80	80	5	50	60	75	0.1	5	0.15		150	20	150	500	50				67		
							100	300	100	5	0.5										500	
							70		500	5												
							25		1A	5												
TN4314	TO-237 (91)	90	65		250	60	15	1	10	1.4		150		60		50				67		
							50	250	150	10												
TN3244	TO-237 (91)	40	40	5	50	30	60	150	1	0.3		150	25	175		50				70		
							50	150	500	1	0.5	0.75									1.5	500
							25		750	5	1.0										2.0	750

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 100V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (2) I<sub>C</sub> = 500 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (3) I<sub>C</sub> = 500 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA. (4) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (5) I<sub>C</sub> = 100 μA, V<sub>CC</sub> = 10V, f = 1 kHz. (6) I<sub>C</sub> = 500 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA.



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# PNP Transistors



## MEDIUM POWER (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max	@	Max	Min	Max		@	Min				
TN3245	TO-237 (91)	50	50	5	50 50	35 30 20	150 500 1A	1 1 5	0.35 0.6 1.2	1.1 1.5 2.0	150 500 1A	25	150	50				70
TN3467	TO-237 (91)	40	40	5	100 30	40 40 40	150 500 1A	1 1 5	0.3 0.5 1.0	1.0 1.2 1.6	150 500 1A	25	175	50				70
TN5022	TO-237 (91)	50	50	5		15 25 25	100 500 1A	1 1 5	0.2 0.4 0.8	1.0 1.4 1.75	100 500 1A	25	170	50	90		6	70
TN5023	TO-237 (91)	30	30	5		30 40 40	100 500 1A	1 1 5	0.17 0.35 0.7	1.0 1.4 1.75	100 500 1A		200	50	90		6	70
NSE872	TO-202 (51)	300	300		100 200	50	25	20					60	10				76
2N6726	TO-237 (91)	40	30	5	100 40	55 60 50	10 100 1A	1 1 1	0.5		1A		50	50				77
2N6727	TO-237 (91)	50	40	5	100 50	55 60 50	10 100 1A	1 1 1	0.5		1A		50	500	50			77
92PU51	TO-237 (91)		30		100 40	50 60 55	1A 100 10	1 1 1	0.5		1A	30	50	50				77
92PU51A	TO-237 (91)		40		100 50	50 60 55	1A 100 10	1 1 1	0.5		1A	30	50	50				77
NSD202	TO-202 (55)	60	45	5	100 60	25 40 50 40	1A 500 100 10	5 5 5 5	0.2 0.4	0.9 1.2	100 500	30	60	50				77
NSD203	TO-202 (55)	60	45	5	100 60	30 50 120 50	1A 500 100 10	5 5 5 5	0.2 0.4	0.9 1.2	100 500	30	60	50				77
NSDU51	TO-202 (55)	40	30	5	100 30	50 60 55	1A 100 10	1 1 1	0.7		1A	30	50	50				77
NSDU51A	TO-202 (55)	50	40	5	100 40	50 60 55	1A 100 10	1 1 1	0.7		1A	30	50	50				77



**MEDIUM POWER** (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub>			I <sub>C</sub> (mA) & V <sub>CE</sub> (V)	V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max	@		Max	Min	Max		Min	Max				
NSDU52	TO-202 (55)	60	40	5	100	40	30		500	10	0.4	1.3	150	20	150	20			77
							50	300	150	10									
							50		10	10									
NSE170	TO-202 (56)		40		100	60	12		1.5A	1	0.9	1.5	1.5A		50	100			77
							30		500	1									
							50	250	100	1									
2N6554	TO-202 (55)	60	60	5	100	40	25		500	1	1.0		1A	18	75	250	100		78
							60		250	1									
							80	300	50	1									
							60		10	1									
2N6555	TO-202 (55)	60	60	5	100	60	25		500	1	1.0		1A	18	75	250	100		78
							60		250	1									
							80	300	50	1									
							60		10	1									
2N6556	TO-202 (55)	100	100	5	100	80	25		500	1	1.0		1A	18	75	250	100		78
							60		250	1									
							80	300	50	1									
							60		10	1									
2N6708	TO-237 (90)	60	45	5	100	60	40		50	2	1.0		1A		50	50			78
							40	250	250	2									
							25		500	2									
2N6709	TO-237 (90)	80	60	5	100	80	40		50	2	1.0		1A		50	50			78
							40	250	250	2									
							25		500	2									
2N6710	TO-237 (90)	100	80	5	100	100	40		50	2	1.0		1A		50	50			78
							40	250	250	2									
							25		500	2									
92PE77A	TO-237 (90)		45		100	60	25		500	2	0.5		500	30	50	200			78
							40		250	2									
							40		50	2									
92PE77B	TO-237 (90)		60		100	80	25		500	2	0.5		500	30	50	200			78
							40		250	2									
							40		50	2									
92PE77C	TO-232 (90)		80		100	100	25		500	2	0.5		500	30	50	200			78
							40		250	2									
							40		50	2									

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 100V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (2) I<sub>C</sub> = 500 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (3) I<sub>C</sub> = 500 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA. (4) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (5) I<sub>C</sub> = 100 μA, V<sub>CC</sub> = 10V, f = 1 kHz. (6) I<sub>C</sub> = 500 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA.





## MEDIUM POWER (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (nA) @ Max	V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub>		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	I <sub>C</sub> (mA)	Max	Max		Min	Max				
D41D1	TO-202 (55)		30		100*	45	10	1A	2	0.5	1.5	500						78
D41D2	TO-202 (55)		30		100*	45	20	1A	2	0.5	1.5	500						78
D41D4	TO-202 (55)		45		100*	60	10	1A	2	0.5	1.5	500						78
D41D5	TO-202 (55)		45		100*	60	20	1A	2	0.5	1.5	500						78
D41D7	TO-202 (55)		60		100*	75	10	1A	2	1.0	1.5	500						78
D41D8	TO-202 (55)		60		100*	75	20	1A	2	1.0	1.5	500						78
D41D10	TO-202 (55)		75		100*	90	10	1A	2	1.0	1.5	500						78
D41D11	TO-202 (55)		75		100*	90	20	1A	2	1.0	1.5	500						78
D41D13	TO-202 (55)		75		100*	90	50	150	100	2	1.0	1.5	500					78
D41D14	TO-202 (55)		75		100*	90	120	360	100	2	1.0	1.5	500					78
D41E1	TO-202 (55)		30		100*	40	10	1A	2	1.0	1.3	1A						78
D41E5	TO-202 (55)		60		100*	70	10	1A	2	1.0	1.3	1A						78
D41E7	TO-202 (55)		80		100*	90	10	1A	2	1.0	1.3	1A						78
D43C7	TO-202 (55)		60		1 μA*	60	10	1A	1	0.5	1.3	1A	30					78
D43C8	TO-202 (55)		60		1 μA*	60	20	1A	1	0.5	1.3	1A	30					78
D43C9	TO-202 (55)		60		1 μA*	60	40	120	200	1	0.5	1.3	1A	30				78
D43C10	TO-202 (55)		80		10 μA*	90	20	2A	1	0.5	1.3	1A	100					78
D43C11	TO-202 (55)		80		10 μA*	90	40	200	1	0.5	1.3	1A	100					78
D43C12	TO-202 (55)		80		10 μA*	90	20	2A	1	0.5	1.3	1A	100					78



**MEDIUM POWER** (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CS</sub> * I <sub>CBO</sub> (nA) @ V <sub>CB</sub> (V)		h <sub>FE</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub> (mA)		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
					Max	Min	Min	Max	Min	Max	Min	Max		Min	Max				
NSD6180	TO-202 (55)		75		500	80	10	1A	2	0.5	1.2	500	30	50	50				78
NSD6181	TO-202 (55)		50		500	60	10	1A	2	0.5	1.2	500	30	50	50				78
NSDU55	TO-202 (55)	60	60	4	100	60	20	500	1	0.35		250	30	50	200				78
NSE171	TO-202 (56)		60		100	80	12	1.5A	1	0.9	1.5	1.5A		50	100				78
TN4234	TO-237 (91)		40		0.1 mA	40	40	100	1		1.5	1A	100						78
TN4235	TO-237 (91)		60		0.1 mA	60	40	100	1		1.5	1A	100						78
TN4236	TO-237 (91)		80		0.1 mA	80	40	100	1		1.5	1A	100						78
2N6728	TO-237 (91)	60	60	5	100	40	80	50	1	0.35		250		50	50				79
2N6729	TO-237 (91)	80	80	5	100	60	80	50	1	0.35		250		50	50				79
2N6730	TO-237 (91)	100	100	5	100	80	80	50	1	0.35		250		50	50				79
2N6732	TO-237 (91)	100	80	5	100	80	100	10	2	0.35		350		50	50				79

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 100V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (2) I<sub>C</sub> = 500 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (3) I<sub>C</sub> = 500 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA. (4) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (5) I<sub>C</sub> = 100 μA, V<sub>CC</sub> = 10V, f = 1 kHz. (6) I<sub>C</sub> = 500 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA.

# PNP Transistors



## MEDIUM POWER (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CS</sub> * (nA)		h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub> (V)			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V)		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
					I <sub>CB0</sub> (nA) Min	V <sub>CB</sub> (V) Max	Min	Max	I <sub>C</sub> (mA)	V <sub>CE</sub> (V)	Max		Min	Max				
92PU55	TO-237 (91)		60		100	40	20	500	1	0.35		250	30	50	200			79
92PU56	TO-237 (91)		80		100	60	20	500	1	0.35		250	30	50	200			79
92PU57	TO-237 (91)		100		100	80	20	500	1	0.35		250	30	50	200			79
92PU200	TO-237 (91)	100	80		100	80	100	300	350	0.35		350	20	500	100			79
NSD204	TO-202 (55)	100	80	7	100	100	10	1A	5	0.2	0.9	100	30	60	50			79
NSD205	TO-202 (55)	100	80	7	100	100	10	1A	5	0.2	0.9	100	30	60	50			79
NSD206	TO-202 (55)	140	100	7	100	140	25	500	5	0.2	0.9	100	30	60	50			79
NSDU56	TO-202 (55)	80	80	4	100	80	20	500	1	0.35		250	30	50	200			79
NSDU57	TO-202 (55)	100	100	4	100	100	20	500	1	0.35		250	30	50	200			79

### TEST CONDITIONS:

(1) I<sub>C</sub> = 50 mA, V<sub>CC</sub> = 100V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (2) I<sub>C</sub> = 500 μA, V<sub>CE</sub> = 10V, f = 1 kHz. (3) I<sub>C</sub> = 500 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA. (4) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (5) I<sub>C</sub> = 100 μA, V<sub>CC</sub> = 10V, f = 1 kHz. (6) I<sub>C</sub> = 500 mA, V<sub>CC</sub> = 30V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 50 mA.



**POWER**

Type No.	Case Style	VCBO (V) Min	VCEO (V) Min	VEBO (V) Min	ICES* ICEX† (μA) Max	VCB (V) @	hFE				VCE(SAT) (V) & VBE(SAT) (V)			Cob (pF) Max	fT (MHz)			Process No.		
							Min	Max	@	IC (A) & VCE (V)	Max	&	Min		Max	@	IC (A)		Min	Max
MJE170	TO-126		40		0.1	60	12			1.5	1	1.7		2.0	3	50	50		0.1	77
							30			0.5	1	0.9		1.5	1.5					
							50	250		0.1	1	0.3			0.5					
MJE710	TO-126		40		100†	40	8			1	1	1.0		1.3	1.5					77
							20			0.5	1	0.4			0.5					
							40			0.15	1	0.15			0.15					
MJE171	TO-126		60		0.1	80	12			1.5	1	1.7		2.0	3	50	50		0.1	78
							30			0.5	1	0.9		1.5	1.5					
							50	250		0.1	1	0.3			0.5					
MJE711	TO-126		60		100†	80	8			1	1	1.0		1.3	1.5					78
							20			0.5	1	0.4			0.5					
							40			0.15	1	0.15			0.15					
MJE172	TO-126		80		0.1	100	12			1.5	1	1.7		2.0	3	50	50		0.1	79
							30			0.5	1	0.9		1.5	1.5					
							50	250		0.1	1	0.3			0.5					
MJE712	TO-126		80		100†	80	8			1	1	1.0		1.3	1.5					79
							20			0.5	1	0.4			0.5					
							40			0.15	1	0.15			0.15					
2N6489	TO-220		40		500†	45	5			15	4	1.3			5		5		1	5A
							20	150		5	4	3.5			15					
2N6490	TO-220		60		500†	65	5			15	4	1.3			5		5		1	5A
							20	150		5	4	3.5			15					
2N6491	TO-220		80		500†	85	5			15	4	1.3			5		5		1	5A
							20	150		5	4	3.5			15					
MJE2901T	TO-220		60				25	100		3	2									5A
MJE2955T	TO-220		60		1 mA	70	20	70		4	4	1.1			4					5A
							5			10	4									
TIP42	TO-220		40		400*	40	15	75		3	4	1.5			6		3		0.5	5A
							30			0.3	4									
TIP42A	TO-220		60		400*	60	15	75		3	4	1.5			6		3		0.5	5A
							30			0.3	4									
TIP42B	TO-220		80		400*	80	15	75		3	4	1.5			6		3		0.5	5A
							30			0.3	4									
TIP42C	TO-220		100		400*	100	15	75		3	4	1.5			6		3		0.5	5A
							30			0.3	4									

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# PNP Transistors



## POWER (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CEx</sub> † (μA) Max	V <sub>CB</sub> (V) @	h <sub>FE</sub>		I <sub>C</sub> (A) &	V <sub>CE</sub> (V) &	V <sub>CE(SA r)</sub> (V) Max	V <sub>BE(SAT)</sub> (V)		I <sub>C</sub> (A) @	C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz)		I <sub>C</sub> (A) @	Process No.
							Min	Max				Min	Max			Min	Max		
2N5193	TO-126		40		100	40	10 25	100	4 1.5	2 2	0.6 1.2			1.5 4		2		1	5E
2N5194	TO-126		60		100	60	10 25	100	4 1.5	2 2	0.6 1.2			1.5 4		2		1	5E
2N5195	TO-126		80		100	80	7 20	80	4 1.5	2 2	0.6 1.2			1.5 4		2		1	5E
2N6107	TO-220		70		100†	75	5 30	150	6.5 2	4 4	1.0 2.0			2 6.5	250	10		0.5	5E
2N6109	TO-220		50		100†	56	5 30	150	6.5 2.5	4 4	1.0 2.0			2.5 6.5	250	10		0.5	5E
2N6110	TO-220 Lead Form + Clip		30		100†	37.5	5 30	150	6.5 3	4 4	1.0 2.0			3 6.5	250	10		0.5	5E
2N6111	TO-220		30		100†	37.5	5 30	150	6.5 3	4 4	1.0 2.0			3 6.5	250	10		0.5	5E
2N6124	TO-220		45		100	45	10 25	100	4 1.5	2 2	0.6 1.4			1.5 4		2.5		1	5E
2N6125	TO-220		60		100	60	10 25	100	4 1.5	2 2	0.6 1.4			1.5 4		2.5		1	5E
2N6126	TO-220		80		100	80	7 20	80	4 1.5	2 2	0.6 1.4			1.5 4		2.5		1	5E
2N6132	TO-220		40		100	40	7 20	100	7 2.5	4 4	1.4			7		2.5		1	5E
2N6133	TO-220		60		100	60	7 20	100	7 2.5	4 4	1.4			7		2.5		1	5E
2N6134	TO-220		80		100	60	5 20	100	7 2.5	4 4	2.0			7		2.5		1	5E
MJE371	TO-220		40				40		1	1									5E
2N4918	TO-126		40		100	40	10 20 40	100	1 0.5 0.05	1 1 1	0.6		1.3	1	100	3		0.25	5F
2N4919	TO-126		60		100	60	10 20 40	100	1 0.5 0.05	1 1 1	0.6		1.3	1	100	3		0.25	5F
2N4920	TO-126		80		100	80	10 20 40	100	1 0.5 0.05	1 1 1	0.6		1.3	1	100	3		0.25	5F



**POWER** (Continued)

Type No.	Case Style	V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CEx</sub> † (μA) Max	V <sub>CB</sub> (V) @	h <sub>FE</sub>		I <sub>C</sub> (A) &	V <sub>CE</sub> (V) (V)	V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> (V)		I <sub>C</sub> (A) @	C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz)		I <sub>C</sub> (A) @	Process No.
							Min	Max				Min	Max			Min	Max		
2N6475	TO-220		100		100	100	15	150	1.5	4	1.2		1.5	250	10		0.5	5F	
2N6476	TO-220		120		100	120	15	150	1.5	4	1.2		1.5	250	10		0.5	5F	
MJE370	TO-220		30				25		0.2	1								5F	
TIP30	TO-220		40		200*	40	15	75	1	4	0.7		1		3		0.2	5F	
TIP30A	TO-220		60		200*	60	15	75	1	4	0.7		1		3		0.2	5F	
TIP30B	TO-220		80		200*	80	15	75	1	4	0.7		1		3		0.2	5F	
TIP30C	TO-220		100		200*	100	15	75	1	4	0.7		1		3		0.2	5F	
TIP32	TO-220		40		200*	40	10	50	3	4	1.2		3		3		0.5	5F	
TIP32A	TO-220		60		200*	60	10	50	3	4	1.2		3		3		0.5	5F	
TIP32B	TO-220		80		200*	80	10	50	3	4	1.2		3		3		0.5	5F	
TIP32C	TO-220		100		200*	100	10	50	3	4	1.2		3		3		0.5	5F	
TIP62	TO-220		40		200*	40	15	100	0.5	4	0.7		0.5		3		0.05	5F	
TIP62A	TO-220		60		200*	60	15	100	0.5	4	0.7		0.5		3		0.05	5F	
TIP62B	TO-220		80		200*	80	15	100	0.5	4	0.7		0.5		3		0.05	5F	
TIP62C	TO-220		100		200*	100	15	100	0.5	4	0.7		0.5		3		0.05	5F	
D43C1	TO-202 (56)		30		1 μA	1	10		1A	1	0.5		1.3	1A	30			5P	
D43C2	TO-202 (56)		30		1 μA	30	20		1A	1	0.5		1.3	1A	30			5P	
D43C3	TO-202 (56)		30		1 μA	30	20		1A	1	0.5		1.3	1A	30			5P	

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# PNP Transistors



## POWER (Continued)

Type No.	Case Style	V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CEX</sub> † (μA) Max	V <sub>CB</sub> (V) @	h <sub>FE</sub>				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz)		I <sub>C</sub> (A) @	Process No.		
							Min	Max	@	I <sub>C</sub> (A) & V <sub>CE</sub> (V)	Max	&	Min		Max	Min			Max	
D43C4	TO-202 (56)		45		1 μA	45	10	25		1A	1	0.5		1.3	1A	30			5P	
D43C5	TO-202 (56)		45		1 μA	45	20	40	120	1A	1	0.5		1.3	1A	30			5P	
D43C6	TO-202 (56)		45		1 μA	45	20	40		2A	1	0.5		1.3	1A	30			5P	
D45C1	TO-220		30		10*	40	10	25		1	1	0.5		1.3	1	125	3		0.02	5P
D45C2	TO-220		30		10*	40	20	40	120	1	1	0.5		1.3	1	125	3		0.02	5P
D45C3	TO-220		30		10*	40	20	40		2	1	0.5		1.3	1	125	3		0.02	5P
D45C4	TO-220		45		10*	55	10	25		1	1	0.5		1.3	1	125	3		0.02	5P
D45C5	TO-220		45		10*	55	20	40	120	1	1	0.5		1.3	1	125	3		0.02	5P
D45C6	TO-220		45		10*	55	20	40		2	1	0.5		1.3	1	125	3		0.02	5P
D45C7	TO-220		60		10*	70	10	25		1	1	0.5		1.3	1	125	3		0.02	5P
D45C8	TO-220		60		10*	70	20	40	120	1	1	0.5		1.3	1	125	3		0.02	5P
D45C9	TO-220		60		10*	70	20	40		2	1	0.5		1.3	1	125	3		0.02	5P
D45C10	TO-220		80		10*	90	10			1	1	0.5		1.3	1	125	3		0.02	5P
D45C11	TO-220		80		10*	90	20	40	120	1	1	0.5		1.3	1	125	3		0.02	5P
D45C12	TO-220		80		10*	90	20	40		2	1	0.5		1.3	1	125	3		0.02	5P
MJE230	TO-126		40				40	20	200	0.2	1	0.3			0.5	70	50		0.1	5P
MJE231	TO-126		40				40	20	200	0.2	1	0.3			0.5	70	50		0.1	5P
MJE232	TO-126		40				25	10		0.2	1	0.3			0.5	70	50		0.1	5P
MJE233	TO-126		60				40	20	200	0.2	1	0.3			0.5	70	50		0.1	5P



**POWER** (Continued)

Type No.	Case Style	VCBO (V) Min	VCEO (V) Min	VEBO (V) Min	ICES* ICEX† (μA) Max	VCB (V)	hFE				VCE(SAT) (V) Max	VBE(SAT) (V)			IC (A)	Cob (pF) Max	fT (MHz)		IC (A)	Process No.
							Min	Max	@	&		Min	Max	@			Min	Max		
MJE234	TO-126		60				40	150	0.2	1	0.3			0.5	70	50		0.1	5P	
							20			1	0.6		1.8	2						
MJE235	TO-126		60				25		0.2	1	0.3			0.5	70	50		0.1	5P	
							10			1			1.8	2						
MJE250	TO-126						40	200	0.2	1	0.3			0.5	70	40		0.1	5P	
							15			2	0.8		1.8	2						
MJE251	TO-126		80				40	120	0.2	1	0.3			0.5	70	40		0.1	5P	
							20			1	0.6		1.8	2						
MJE252	TO-126		80				25		0.2	1	0.3			0.5	70	40		0.1	5P	
							10			1			1.8	2						
MJE253	TO-126		100				40	120	0.2	1	0.3			0.5	70	40		0.1	5P	
										1	0.8		1.8	2						
MJE254	TO-126		100				25		0.2	1	0.3			0.5	70	40		0.1	5P	
							10			1			1.8	2						
D45H1	TO-220		30		10	30	20			4	1	1.0		1.5	8				5Q	
							35			2	1									
D45H2	TO-220		30		10	30	40			4	1	1.0		1.5	8				5Q	
							60			2	1									
D45H4	TO-220		45		10	45	20			4	1	1.0		1.5	8				5Q	
							35			2	1									
D45H5	TO-220		45		10	45	40			4	1	1.0		1.5	8				5Q	
							60			2	1									
D45H7	TO-220		60		10	60	20			4	1	1.0		1.5	8				5Q	
							35			2	1									
D45H8	TO-220		60		10	60	40			4	1	1.0		1.5	8				5Q	
							60			2	1									
D45H10	TO-220		80		10	80	20			4	1	1.0		1.5	8				5Q	
							35			2	1									
D45H11	TO-220		80		10	80	40			4	1	1.0		1.5	8				5Q	
							60			2	1									
MJE210	TO-126		25				70			0.5	1	0.3		0.5	120	65		0.1	5R	
							45	180		2	1	0.75		2						
							10			5	2									

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# PNP Transistors



## DARLINGTON

Type No.	Case Style	VCBO (V) Min	VCES* VCEO (V) Min	VEBO (V) Min	ICES* ICES† (μA) Max	VCB (V) @	hFE			IC (A) &	VCE (V)	VCE(SAT) (V) Max	VBE(SAT) (V) @		IC (A)	Cob (pF) Max	fT (MHz)		IC (A) @	Process No.
							Min	Max	@				Min	Max			Min	Max		
D41K1	TO-202 (55)		30*	13	0.5	30	10,000		0.2	5	1.5		2.5	1.5		100		0.02	61	
D41K2	TO-202 (55)		50*	13	0.5	50	10,000		0.2	5	1.5		2.5	1.5		100		0.02	61	
D41K3	TO-202 (55)		30*	13	0.5	30	10,000		0.2	5	1.5		2.5	1		100		0.02	61	
D41K4	TO-202 (55)		50*	13	0.5	50	10,000		0.2	5	1.5		2.5	1		100		0.02	61	
MPSA62	TO-92 (92)		20*		0.1	15	20,000		10	5	1.0			10				0.01	61	
MPSA63	TO-92 (92)		30*		0.1	30	10,000		100	5	1.5			100		125		0.01	61	
MPSA64	TO-92 (92)		30*		0.1	30	20,000		100	5	1.5			100		125		0.01	61	
MPSA65	TO-92 (92)		30*		0.1	30	50,000		0.01	5	1.5					100		0.01	61	
MPSA66	TO-92 (92)		30*		0.1	30	75,000		0.01	5	1.5					100		0.01	61	
NSDU95	TO-202 (55)	50		10			25,000		0.2	5	1.5			1		50		0.02	61	
NSDU95A	TO-202 (55)	60		10			15,000		0.5	5	1.5			1		50		0.02	61	
2N6034	TO-126		40		500	40	100		4	3	2.0			2	200	25		0.75	5J	
							750	15,000	2	3										
							500		0.05	3	3.0		4.0	4						
2N6035	TO-126		60		500	60	100		4	3	2.0			2	200	25		0.75	5J	
							750	15,000	2	3										
							500		0.5	3	3.0		4.0	4						
2N6036	TO-126		80		500	80	100		4	3	2.0			2	200	25		0.75	5J	
2N6040	TO-220		60		500†	60	1000	20,000	4	4	2.0			4	300				5J	
							100		8	4										
2N6041	TO-220		80		500†	80	1000	20,000	4	4	2.0			4	300				5J	
							100		8	4										
MJE700	TO-126		60		200	60	750		1.5	3	2.5			1.5		1		1.5	5J	
MJE701	TO-126		60		200	60	750	2	3	2.8				2		1		1.5	5J	
MJE702	TO-126		80		200	80	750		1.5	3	2.5			1.5		1		1.5	5J	
MJE703	TO-126		80		200	80	750		2	3	2.8			2		1		1.5	5J	



DARLINGTON (Continued)

Type No.	Case Style	VCBO (V) Min	V <sub>CE</sub> S* V <sub>CEO</sub> (V) Min	VEBO (V) Min	I <sub>CE</sub> S* I <sub>CE</sub> X† (μA) Max	V <sub>CB</sub> (V)	h <sub>FE</sub> @ I <sub>C</sub> (A) & V <sub>CE</sub> (V)				V <sub>CE</sub> (SAT) (V) & V <sub>BE</sub> (SAT) (V) @ I <sub>C</sub> (A)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (A)		Process No.
							Min	Max	Min	Max	Max	Min	Max		Min	Max	
TIP115	TO-220		60		1 mA	60	500 1000		2 1	4 4	2.5		2				5J
TIP116	TO-220		80		1 mA	80	500 1000		2 1	4 4	2.5		2				5J
TIP117	TO-220		100		1 mA	100	500 1000		2 1	4 4	2.5		2				5J
TIP125	TO-220		60		200	60	1000 1000		3 0.5	3 3	4.0 2.0		5 3				5J
TIP126	TO-220		80		200	80	1000 1000		3 0.5	3 3	4.0 2.0		5 3				5J
TIP127	TO-220		100		200	100	1000 1000		3 0.5	3 3	4.0 2.0		5 3				5J
2N6042	TO-220		100		500†	100	1000 100	20,000	4 8	4 4	2.0		4	300			5K
SE9400	TO-220		60				750 1000 100		1 4 7.5	3 3 3	2.0 2.5		4 7.5		1	4	5K
SE9401	TO-220		80				750 1000 100		1 4 7.5	3 3 3	2.0 2.5		4 7.5		1	4	5K
SE9402	TO-220		100				750 1000 100		1 4 7.5	3 3 3	2.0 2.5		4 7.5		1	4	5K
TIP105	TO-220		60				1000 200	20,000	3 8	4 4	2.0 2.5		3.0 8.0				5K
TIP106	TO-220		80				1000 200	20,000	3 8	4 4	2.0 2.5		3 8				5K
TIP107	TO-220		100				1000 200	20,000	3 8	4 4	2.0 2.5		3 8				5K
TIP135	TO-220		60		200	60	1000 500	15,000	4 1	4 4	3.0 2.0		6 4	200			5K
TIP136	TO-220		80		200	80	1000 500	15,000	4 1	4 4	3.0 2.0		6 4	200			5K
TIP137	TO-220		100		200	100	1000 500	15,000	4 1	4 4	3.0 2.0		6 4	200			5K

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NPN Transistors





Section 3  
**Junction Field Effect  
Transistors**



## N-Channel JFETs



### SWITCHES/CHOPPERS

Type No.	Case Style	BV <sub>GSS</sub> BV <sub>GDO</sub> (V) @ I <sub>G</sub>		I <sub>GSS</sub> * I <sub>DGO</sub> (nA) @ V <sub>DG</sub>		I <sub>D(off)</sub> (nA) @ V <sub>DS</sub> V <sub>GS</sub>			V <sub>p</sub> (V) @ V <sub>DS</sub> I <sub>D</sub>			I <sub>DSS</sub> (mA) @ V <sub>DS</sub>			r <sub>ds(on)</sub> (Ω) @ I <sub>D</sub>		C <sub>iss</sub> (pF) @ V <sub>DS</sub> V <sub>GS</sub>			C <sub>rss</sub> (pF) @ V <sub>DS</sub> V <sub>GS</sub>			t <sub>on</sub> (ns)	t <sub>off</sub> (ns)	Process No.	Pkg. No.	
		Min	Max	Min	Max	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max	Max	Max	Max	Max	Max	Max						
2N3824	TO-72	50	1	0.1	30	0.1	15	-8	8	15	0.1			250	6	15	0	3	0	-8			55	25			
2N3966	TO-72	30	1	1	20	0.1	10	-7	4	6	10	10	2	20	220	6	20	0	1.5	0	-7			50	25		
2N3970	TO-18	40	1	0.25*	20	0.25	20	-12	4	10	20	1	50	150	20	30	1	25	20	0	6	0	-12	20	30	51	02
2N3971	TO-18	40	1	0.25*	20	0.25	20	-12	2	5	20	1	25	75	20	60	1	25	20	0	6	0	-12	130	60	51	02
2N3972	TO-18	40	1	0.25*	20	0.25	20	-12	0.5	3	20	1	5	30	20	100	1	25	20	0	6	0	-12	80	100	51	02
2N4091	TO-18	40	1	0.2*	20	0.2	20	-12	5	10	20	1	30	20	30	1	16	20	0	5	0	-20	25	40	51	02	
2N4092	TO-18	40	1	0.2*	20	0.2	20	-8	2	7	20	1	15	20	50	1	16	20	0	5	0	-20	35	60	51	02	
2N4093	TO-18	40	1	0.2*	20	0.2	20	-6	1	5	20	1	8	20	80	1	16	20	0	5	0	-20	60	80	51	02	
2N4391	TO-18	40	1	0.1	20	0.1	20	-12	4	10	20	1	50	150	20	30	1	14	20	0	3.5	0	-12	20	35	51	02
2N4392	TO-18	40	1	0.1	20	0.1	20	-7	2	5	20	1	25	75	20	60	1	14	20	0	3.5	0	-7	20	55	51	02
2N4393	TO-18	40	1	0.1	20	0.1	20	-5	0.5	3	20	1	5	30	20	100	1	14	20	0	3.5	0	-5	20	80	51	02
2N4856	TO-18	40	1	0.25	20	0.25	15	-10	4	10	15	0.5	50	15	25	18	0	-10	8	0	-10	9	25	51	02		
2N4856A	TO-18	40	1	0.25	20	0.25	15	-10	4	10	15	0.5	50	15	25	10	0	-10	4	0	-10	8	20	51	02		
2N4857	TO-18	40	1	0.25	20	0.25	15	-10	2	6	15	0.5	20	100	15	40	18	0	-10	8	0	-10	10	50	51	02	
2N4857A	TO-18	40	1	0.25	20	0.25	15	-10	2	6	15	0.5	20	100	15	40	10	0	-10	3.5	0	-10	10	40	51	02	
2N4858	TO-18	40	1	0.25	20	0.25	15	-10	0.8	4	15	0.5	8	80	15	60	18	0	-10	8	0	-10	20	100	51	02	
2N4858A	TO-18	40	1	0.25	20	0.25	15	-10	0.8	4	15	0.5	8	80	15	60	10	0	-10	3.5	0	-10	16	80	51	02	
2N4859	TO-18	30	1	0.25	15	0.25	15	-10	4	10	15	0.5	50	15	25	18	0	-10	8	0	-10	9	25	51	02		
2N4859A	TO-18	30	1	0.25	15	0.25	15	-10	4	10	15	0.5	50	15	25	10	0	-10	4	0	-10	8	20	51	02		
2N4860	TO-18	30	1	0.25	15	0.25	15	-10	2	6	15	0.5	20	100	15	40	18	0	-10	8	0	-10	10	50	51	02	
2N4860A	TO-18	30	1	0.25	15	0.25	15	-10	2	6	15	0.5	20	100	15	40	10	0	-10	3.5	0	-10	10	40	51	02	
2N4861	TO-18	30	1	0.25	15	0.25	15	-10	0.8	4	15	0.5	8	80	15	60	18	0	-10	8	0	-10	20	100	51	02	
2N4861A	TO-18	30	1	0.25	15	0.25	15	-10	0.8	4	15	0.5	8	80	15	60	10	0	-10	3.5	0	-10	16	80	51	02	
2N5432	TO-52	25	1	0.2	15	0.2	5	-10	4	10	5	3	150	15	5	10	30	0	-10	15	0	-10	5	36	58	07	
2N5433	TO-52	25	1	0.2	15	0.2	5	-10	3	9	5	3	100	15	7	10	30	0	-10	15	0	-10	5	36	58	07	
2N5434	TO-52	25	1	0.2	15	0.2	5	-10	1	4	5	3	30	15	10	10	30	0	-10	15	0	-10	5	36	58	07	
2N5555	TO-92	25	10	1	15	10	12	-10	(10)				15	15	150	5	15	0	1.2	0	-10	10	25	50	92		
2N5638	TO-92	30	10	1	15	1	15	-12	(12)				50	20	30	1	10	0	-12	4	0	-12			51	92	
2N5639	TO-92	30	10	1	15	1	15	-8	(8)				25	20	60	1	10	0	-12	4	0	-8			51	92	
2N5640	TO-92	30	10	1	15	1	15	-6	(6)				5	20	100	1	10	0	-12	4	0	-6			51	92	



SWITCHES/CHOPPERS (Continued)

N-Channel JFETs

Type No.	Case Style	BV <sub>GSS</sub> BV <sub>GDO</sub> (V) @ I <sub>G</sub>		I <sub>GSS</sub> * I <sub>DGO</sub> (nA) @ V <sub>DG</sub>		I <sub>D(off)</sub> (nA) @ V <sub>DS</sub> V <sub>GS</sub>			V <sub>P</sub> (V) @ V <sub>DS</sub> I <sub>D</sub>			I <sub>DSS</sub> (mA) @ V <sub>DS</sub>			r <sub>ds(on)</sub> (Ω) @ I <sub>D</sub>		C <sub>iss</sub> (pF) @ V <sub>DS</sub> V <sub>GS</sub>			C <sub>rss</sub> (pF) @ V <sub>DS</sub> V <sub>GS</sub>			t <sub>on</sub> (ns)	t <sub>off</sub> (ns)	Process No.	Pkg. No.	
		Min	Max	Min	Max	Max	Max	Max	Min	Max	Max	Min	Max	Max	Max	Max	Max	Max	Max	Max	Max						
2N5653	TO-92	30	10	1	15	1	15	-12	(12)			40	20	50	1	10	0	-12	3.5	0	-12	9	15	51	92		
2N5654	TO-92	25	10	1	15	10	15	-8	(8)			15	20	100	1	10	0	-12	3.5	0	-8	14	30	51	92		
J108	TO-92	25	1	3	15	3	5	-10	3	10	5	1000	80	15	8	10	130	0	-10	115	0	-10	15	136	58	92	
J109	TO-92	25	1	3	15	3	5	-10	2	6	5	1000	40	15	12	10	130	0	-10	115	0	-10	15	136	58	92	
J110	TO-92	25	1	3	15	3	5	-10	0.5	4	5	1000	10	15	18	10	130	0	-10	115	0	-10	15	136	58	92	
J111	TO-92	35	1	1	15	1	5	-10	3	10	5	1000	20	15	30	1	110	0	-10	15	0	-10	113	135	51	92	
J112	TO-92	35	1	1	15	1	5	-10	1	5	5	1000	5	15	50	1	110	0	-10	15	0	-10	113	135	51	92	
J113	TO-92	35	1	1	15	1	5	-10	0.5	3	5	1000	2	15	100	1	110	0	-10	15	0	-10	113	135	51	92	
J114	TO-92	25	1	1	15	1	5	-10	3	10	5	1000	15	15	150	1	14	0	-10	12	0	-10	16	120	90	92	
PN4091	TO-92	40	1	0.2*	20	0.2	20	-12	5	10	20	1	30	20	30		16	20	0	5	20	0	25	40	51	92	
PN4092	TO-92	40	1	0.2*	20	0.2	20	-8	2	7	20	1	15	20	50		16	20	0	5	20	0	35	60	51	92	
PN4093	TO-92	40	1	0.2*	20	0.2	20	-6	1	5	20	1	8	20	80		16	20	0	5	20	0	60	80	51	92	
PN4391	TO-92	40	1	0.1	20	0.1	20	-12	4	10	20	1	50	150	20		14	20	0	3.5	0	-12	20	35	51	92	
PN4392	TO-92	40	1	0.1	20	0.1	20	-7	2	5	20	1	25	75	20		14	20	0	3.5	0	-7	40	80	51	92	
PN4393	TO-92	40	1	0.1	20	0.1	20	-5	0.5	3	20	1	5	30	20		14	20	0	3.5	0	-5	55	130	51	92	
PN4856	TO-92	40	1	0.25	20	0.25	15	-10	4	10	15	0.5	50	15	25		18	0	-10	8	0	-10	9	25	51	92	
PN4857	TO-92	40	1	0.25	20	0.25	15	-10	2	6	15	0.5	20	100	15		18	0	-10	8	0	-10	10	50	51	92	
PN4858	TO-92	40	1	0.25	20	0.25	15	-10	0.8	4	15	0.5	8	80	15		18	0	-10	8	0	-10	20	100	51	92	
PN4859	TO-92	30	1	0.25	15	0.25	15	-10	4	10	15	0.5	50	15	25		18	0	-10	8	0	-10	9	25	51	92	
PN4860	TO-92	30	1	0.25	15	0.25	15	-10	2	6	15	0.5	20	100	15		18	0	-10	8	0	-10	10	50	51	92	
PN4861	TO-92	30	1	0.25	15	0.25	15	-10	0.8	4	15	0.5	8	80	15		18	0	-10	8	0	-10	20	100	51	92	
PN5432	TO-92	25	1	0.2	15	0.2	5	-10	4	10	5	3	150	15	5	10		30	0	-10	15	0	-10	5	36	58	92
PN5433	TO-92	25	1	0.2	15	0.2	5	-10	3	9	5	3	100	15	7	10		30	0	-10	15	0	-10	5	36	58	92
PN5434	TO-92	25	1	0.2	15	0.2	5	-10	1	4	5	3	30	15	10	10		30	0	-10	15	0	-10	5	36	58	92
TIS73	TO-92	30	1	2	15	2	15	-10	4	10	15	4	50	15	25		18	0	-10	8	0	-10	9	25	51	97	
TIS74	TO-92	30	1	2	15	2	15	-10	2	6	15	4	20	100	15		18	0	-10	8	0	-10	10	50	51	97	
TIS75	TO-92	30	1	2	15	2	15	-10	0.8	4	15	4	8	80	15		18	0	-10	8	0	-10	20	100	51	97	
U1897	TO-92	40	1	0.2*	20				5	10	20	1	30	20	30	1		16	20	0	5	0	-20	25	40	51	92
U1898	TO-92	40	1	0.2*	20				2	7	20	1	15	20	50	1		16	20	0	5	0	-20	35	60	51	92
U1899	TO-92	40	1	0.2*	20				1	5	20	1	8	20	80	1		16	20	0	5	0	-20	60	80	51	92

t = typical value.



## RF, VHF, UHF AMPLIFIERS

## N-Channel JFETs

Type No.	Case Style	BV <sub>GSS</sub> (V) @ I <sub>G</sub>		I <sub>GSS</sub> (nA) @ V <sub>DG</sub>		V <sub>p</sub> (V) @ V <sub>DS</sub> I <sub>D</sub> (nA)				I <sub>DSS</sub> (mA) @ V <sub>DS</sub>			R <sub>e</sub> Y <sub>fs</sub> (mmho) @ Freq		R <sub>e</sub> (Y <sub>os</sub> ) (μmho) @ f		C <sub>iss</sub> (pF) @ V <sub>DS</sub> V <sub>GS</sub>		C <sub>rss</sub> (pF) @ V <sub>DS</sub> V <sub>GS</sub>		NF (dB) @ R <sub>G</sub> = 1k Freq		Process No.	Pkg. No.		
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min			Max	
2N3819	TO-92	25	1	2	15	8	15	2	2	20	15	1.6	100	8	15	0	-4	15	0	50	94					
2N3823	TO-72	30	1	0.5	20	8	15	0.5	4	20	15	3.2	200	200	200	6	15	0	-2	15	0	2.5	100	50	25	
2N4223	TO-72	30	10	0.25	20	0.1	8	15	0.25	3	18	15	2.7	200	200	200	6	15	0	-2	15	0	5	200	50	25
2N4224	TO-72	30	10	0.5	20	0.1	8	15	0.5	2	20	15	1.7	200	200	200	6	15	0	2	15	0			50	25
2N4416	TO-72	30	1	0.1	20	6	15	1	5	15	15	4	400	100	400	4	15	0	0.8	15	0	4	400	50	25	
2N4416A	TO-72	35	1	0.1	20	2.5	6	15	1	5	15	15	4	400	100	400	4	15	0	0.8	15	0	4	400	50	25
2N5078	TO-72	30	1	0.25	20	0.5	8	15		4	25	15	4	200	150	200	6	15	0	2	15	0	3	200	50	25
2N5245	TO-92	30	1	1	20	1	6	15	10	5	15	15	4	400	100	400	4.5	15	0	1	15	0	4	400	90	97
2N5246	TO-92	30	1	1	20	0.5	4	15	10	1.5	7	15	2.5	400	100	400	4.5	15	0	1	15	0			90	97
2N5247	TO-92	30	1	1	20	1.5	8	15	10	8	24	15	4	400	150	400	4.5	15	0	1	15	0			90	97
2N5248	TO-92	30	1	5	20	1	8	15	10	4	20	15	3	200	200	200	6	15	0	2	15	0			50	94
2N5397	TO-72	25	1	0.1	15	1	6	10	1	10	30	10	5.5	450	200	450	5	10	10 mA	1.2	10	10 mA	3.5	450	90	29
2N5398	TO-72	25	1	0.1	15	1	6	10	1	5	40	10	5.0	450	400	450	5.5	10	0	1.3	10	0	3.2	450	90	29
2N5484	TO-92	25	1	1	20	0.3	3	15	10	1	5	15	2.5	100	75	100	5	15	0	1	15	0	3	100	50	92
2N5485	TO-92	25	1	1	20	1	4	15	10	4	10	15	3	400	100	400	5	15	0	1	15	0	4	400	50	92
2N5486	TO-92	25	1	1	20	2	6	15	10	8	20	15	3.5	400	100	400	5	15	0	1	15	0	4	400	50	92
2N5668	TO-92	25	10	2	15	0.2	4	14	10	1	5	15	1	100	50	100	7	15	0	3	15	0	2.5	100	50	92
2N5669	TO-92	25	10	2	15	1	6	15	10	4	10	15	1.6	100	100	100	7	15	0	3	15	0	2.5	100	50	92
2N5670	TO-92	25	10	2	15	2	8	15	10	8	20	15	2.5	100	150	100	7	15	0	3	15	0	2.5	100	50	92
2N5949	TO-92	300	1	1	15	3	7	15	100	12	18	15	3.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5950	TO-92	30	1	1	15	2.5	6	15	100	10	15	15	3.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5951	TO-92	30	1	1	15	2	5	15	100	7	13	15	3.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5952	TO-92	30	1	1	15	1.3	3.5	15	100	4	8	15	1.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5953	TO-92	30	1	1	15	0.8	3	15	100	2.5	5	15	1.0	100	50	100	6	15	0	2	15	0	5	100	50	97
J300	TO-92	25	1	0.5	15	1	6	10	1	6	30	10	4.5	0.001	200	0.001	5.5	10	5 mA	1.7	10	5 mA	t2	100	90	92
J304	TO-92	30	1	0.1	20	2	6	15	1	5	15	15	t4.2	400	t80	100	t3	15	0	t.8	15	0	t4	400	50	92
J305	TO-92	30	1	0.1	20	0.5	3	15	1	1	8	15	t3.0	400	t80	100	t3	15	0	t.8	15	0	t4	400	50	92
J308	TO-92	25	1	1	15	1	6.5	10	1	12	60	10	8	0.001	200	0.001	7.5	0	-10	2.5	0	-10	t1.5	100	92	92
J309	TO-92	25	1	1	15	1	4.0	10	1	12	30	10	10	0.001	200	0.001	7.5	0	-10	2.5	0	-10	t1.5	100	92	92
J310	TO-92	25	1	1	15	2	6.5	10	1	24	60	10	8	0.001	200	0.001	7.5	0	-10	2.5	0	-10	t1.5	100	92	92

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## RF, VHF, UHF AMPLIFIERS (Continued)

## N-Channel JFETs

Type No.	Case Style	BV <sub>GSS</sub> (V) @ I <sub>G</sub> (μA)		I <sub>GSS</sub> (nA) @ V <sub>DG</sub> (V)		V <sub>p</sub> (V) @ V <sub>DS</sub> (V)		I <sub>D</sub> (nA)	I <sub>DSS</sub> (mA) @ V <sub>DS</sub> (V)			R <sub>e</sub>   Y <sub>fs</sub>   (mmho) @ Freq (MHz)		R <sub>e</sub> (Y <sub>os</sub> ) (μmho) @ f (MHz)		C <sub>iss</sub> (pF) @ V <sub>DS</sub> (V) V <sub>GS</sub> (V)			C <sub>rss</sub> (pF) @ V <sub>DS</sub> (V) V <sub>GS</sub> (V)			NF (dB) @ R <sub>G</sub> = 1k Freq (MHz)		Process No.	Pkg. No.	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max			
MPF102	TO-92	25	1	2	15	8	15	2	2	20	15	1.6	100	100	200	7	15	0	3	15	0	4	400	50	92	
MPF106	TO-92	25	1	1	20	0.5	4	15	0.5	4	10	15	2.5	0.001		5	15	0	2	15	0			50	92	
MPF107	TO-92	25	1	1	20	2	6	15	0.5	8	20	15	4	0.001		5	15	0	1.2	15	0	4	400	50	92	
MPF108	TO-92	25	10	1	15	0.5	8	15	10	1.5	24	15	1.6	100	200	100	6.5	15	0	2.5	15	0	3	100	50	92
MPF256	TO-92	25	10	5	15	0.5	7.5	15	200 <sub>μ</sub>	3	18	15	6	0.001								2.0	100	90	92	
MPF820	TO-92	25	10	5	15		5.0	15	200 <sub>μ</sub>	10	15		0.001									4.0	100	51	92	
PN4223	TO-92	30	1	0.25	20	0.1	8	15	1	3	18	15	2.7	200	200	200	6	15	0	2	15	0	5	200	50	92
PN4224	TO-92	30	1	0.5	20	0.1	8	15	5	2	20	15	1.7	200	200	200	6	15	0	2	15	0			50	92
PN4416	TO-92	30	1	0.1	20		6	15	1	5	15	15	4	400	100	400	4	15	0	0.8	15	0	4	400	50	92
U308	TO-52	25	1	0.15	15	1	6	10	1	12	60	10	10	0.001	150	100	5	0	10 mA	2.5	0	10 mA	13	450	92	07
U309	TO-52	25	1	0.15	15	1	4	10	1	12	30	10	10	0.001	150	100	5	0	10 mA	2.5	0	10 mA	13	450	92	07
U310	TO-52	25	1	0.15	15	2.5	6	10	1	24	60	10	10	0.001	150	100	5	10	10 mA	2.5	10	10 mA	13	450	92	07
U312	TO-52	25	1	0.1	15	1	6	10	1	10	30	10	6	0.001			3.8	10	10 mA	1.2	10	10 mA	13.5	450	90	07

t = typical value.

\*V<sub>DS</sub> = 15 Vdc, R<sub>s</sub> = 50 ohms.



## LOW FREQUENCY—LOW NOISE AMPLIFIERS

Type No.	Case Style	BV <sub>GSS</sub> (V) @ I <sub>G</sub> (μA)		I <sub>GSS</sub> (nA) @ V <sub>DG</sub> (V)		V <sub>GS(off)</sub> (V) @ V <sub>DS</sub> (V)		I <sub>D</sub> (nA)	I <sub>DSS</sub> (mA) @ V <sub>DS</sub> (V)			g <sub>fs</sub> (R <sub>e</sub>   Y <sub>fs</sub> ) (mmho) @ V <sub>DS</sub> (V)		f (MHz)	G <sub>oss</sub> (μmho) @ V <sub>DS</sub> (V)		C <sub>iss</sub> (pF) @ V <sub>DS</sub> (V) V <sub>GS</sub> (V)			C <sub>rss</sub> (pF) @ V <sub>DS</sub> (V) V <sub>GS</sub> (V)		e <sub>n</sub> (nV/√Hz) @ f (Hz)	Process No.	Pkg. No.				
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max							
2N4393	TO-18	40	1.0	0.1	20	0.5	3.0	20	1.0	5	30	20	112	20	0.001		14	20	0	3.5	5 (GS)	18	10	51	02			
2N5556	TO-72	30	10	0.1	15	0.2	4.0	15	1.0	0.5	2.5	15	1.5	6.5	15	0.001	20	15		6	15	0	3	15	35	10	50	25
2N5557	TO-72	30	10	0.1	15	0.8	5.0	15	1.0	2	5.0	15	1.5	6.5	15	0.001	20	15		6	15	0	3	15	35	10	50	25
2N5558	TO-72	30	10	0.1	15	1.5	6.0	15	1.0	4	10	15	1.5	6.5	15	0.001	20	15		6	15	0	3	15	35	10	50	25
NF5101	TO-72	40	1	0.2	15	0.5	1.1	15	1.0	1	12	15	3.5	15	0.001	25	15		112	15	0	14	15	3.5	1000	51	25	
NF5102	TO-72	40	1	0.2	15	0.7	1.6	15	1.0	4	20	15	7.5	15	0.001	25	15		112	15	0	14	15	3.5	1000	51	25	
NF5103	TO-72	40	1	0.2	15	1.2	2.7	15	1.0	10	40	15	7.5	15	0.001	25	15		112	15	0	14	15	3.5	1000	51	25	

t = typical value



## N-Channel JFETs



### LOW FREQUENCY—LOW NOISE AMPLIFIERS (Continued)

Type No.	Case Style	BV <sub>GSS</sub> (V) @ I <sub>G</sub> (μA)		IGSS (nA) @ V <sub>DG</sub> (V)		V <sub>GS(off)</sub> (V) @ V <sub>DS</sub> (V) I <sub>D</sub> (nA)				IDSS (mA) @ V <sub>DS</sub> (V)		g <sub>fs</sub> (R <sub>e</sub> /Y <sub>fs</sub> ) (mmho) @ V <sub>DS</sub> (V)		f (MHz)	G <sub>oss</sub> (μmho) @ V <sub>DS</sub> (V)		C <sub>iss</sub> (pF) @ V <sub>DS</sub> (V) V <sub>GS</sub> (V)			C <sub>rss</sub> (pF) @ V <sub>DS</sub> (V) V <sub>GS</sub> (V)		e <sub>n</sub> nV/√Hz @ f Max (Hz)	Process No.	Pkg. No.		
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max		Max	Max	Max	Max	Max	Max						
PF5101	TO-92	40	1	0.2	15	0.5	1.1	15	1.0	1	12	15	3.5	15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	92
PF5102	TO-92	40	1	0.2	15	0.7	1.6	15	1.0	4	20	15	7.5	15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	92
PF5103	TO-92	40	1	0.2	15	1.2	2.7	15	1.0	10	40	15	7.5	15	0.001	25	15	t12	15	0	t4	15	3.5	1000	51	92
PN4393	TO-92	40	1.0	0.1	20	0.5	3.0	20	1.0	5	30	20	t12	20	0.001			14	20	0	3.5	5 (GS)	t8	10	51	92

t = typical value



### ULTRA LOW INPUT CURRENT AMPS

Type No.	Case Style	BV <sub>GSS</sub> (V) @ I <sub>G</sub> (μA)		IGSS (pA) @ V <sub>DG</sub> (V)		V <sub>P</sub> (V) @ V <sub>DS</sub> (V) I <sub>D</sub> (nA)				IDSS (μA) @ V <sub>DS</sub> (V)		G <sub>fs</sub> (μmho) @ V <sub>DS</sub> (V)		G <sub>oss</sub> (μmho) @ V <sub>DS</sub> (V)		C <sub>iss</sub> (pF) @ V <sub>DS</sub> (V) V <sub>GS</sub> (V)			C <sub>rss</sub> (pF) @ V <sub>DS</sub> (V) V <sub>GS</sub> (V)		Process No.	Pkg. No.			
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max	Max	Max	Max	Max	Max						
2N4117	TO-72	40	1	10	20	0.6	1.8	10	1	30	90	10	20	210	10	3	10	3	10	0	1.5	10	0	53	25
2N4117A	TO-72	40	1	1	20	0.6	1.8	10	1	30	90	10	70	210	10	3	10	3	10	0	1.5	10	0	53	25
2N4118	TO-72	40	1	10	20	1	3	10	1	80	240	10	80	250	10	5	10	3	10	0	1.5	10	0	53	25
2N4118A	TO-72	40	1	1	20	1	3	10	1	80	240	10	80	250	10	5	10	3	10	0	1.5	10	0	53	25
2N4119	TO-72	40	1	10	20	2	6	10	1	200	600	10	100	330	10	10	10	3	10	0	1.5	10	0	53	25
2N4119A	TO-72	40	1	1	20	2	6	10	1	200	600	10	100	330	10	10	10	3	10	0	1.5	10	0	53	25
NF5301	TO-72	30	1	1	15	0.6	3	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	25
NF5301-1	TO-72	30	1	1	15	0.6	1.8	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	25
NF5301-2	TO-72	30	1	1	15	1.7	3	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	25
NF5301-3	TO-72	30	1	1	15	1.0	2.4	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	25
PF5301	TO-92	30	1	1	15	0.6	3	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	92
PF5301-1	TO-92	30	1	1	15	0.6	1.8	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	92
PF5301-2	TO-92	30	1	1	15	1.7	3	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	92
PF5301-3	TO-92	30	1	1	15	1.0	3.4	10	1	30	500	10	70	300	10			3	10	0	1.5	10	0	53	92
PN4117	TO-92	40	1	10	20	0.6	2.8	10	1	30	90	10	20	210	10	3	10	3	10	0	1.5	10	0	53	92
PN4117A	TO-92	40	1	1	20	0.6	2.8	10	1	30	90	10	70	210	10	3	10	3	10	0	1.5	10	0	53	92
PN4118	TO-92	40	1	10	20	1	3	10	1	80	240	10	80	250	10	5	10	3	10	0	1.5	10	0	53	92
PN4118A	TO-92	40	1	1	20	1	3	10	1	80	240	10	80	250	10	5	10	3	10	0	1.5	10	0	53	92
PN4119	TO-92	40	1	10	20	2	6	10	1	200	600	10	100	330	10	10	10	3	10	0	1.5	10	0	53	92
PN4119A	TO-92	40	1	1	20	2	6	10	1	200	600	10	100	330	10	10	10	3	10	0	1.5	10	0	53	92



GENERAL PURPOSE AMPS

N-Channel JFETs

Type No.	Case Style	BV <sub>GSS</sub> * BV <sub>GDO</sub> (V) @ I <sub>G</sub> (μA)		I <sub>GSS</sub> (nA) @ V <sub>DG</sub> (V)		V <sub>p</sub> (V) @ V <sub>DS</sub> (V) I <sub>D</sub> (nA)			I <sub>DSS</sub> (mA) @ V <sub>DS</sub> (V)			G <sub>fs</sub> (mmho) @ V <sub>DS</sub> (V)			G <sub>oss</sub> (μmho) @ V <sub>DS</sub> (V)			C <sub>iss</sub> (pF) @ V <sub>DS</sub> (V) V <sub>GS</sub> (V)			C <sub>rss</sub> (pF) @ V <sub>DS</sub> (V) V <sub>GS</sub> (V)			e <sub>n</sub> (NV/√Hz) @ Freq (Hz)	Process No.	Pkg. No.			
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max						
2N3369	TO-18	40	1	5	30			6.5	20	1000	0.5	2.5	30	0.6	2.5	30	30	30	20	8	0	3	30	0		52	02		
2N3370	TO-18	40	1	5	30			3.2	20	1000	0.1	0.6	30	0.3	2.5	30	15	30	20	8	0	3	30	0		52	02		
2N3458	TO-18	50	1	0.25	30			7.8	20	1000	3	15	20	2.5	10	20	35	30	18	0	-10	5	30	0	225	20	52	02	
2N3459	TO-18	50	1	0.25	30			3.4	20	1000	0.8	4	20	1.5	6	20	20	30	18	0	-6	5	30	0	155	20	52	02	
2N3460	TO-18	50	1	0.25	30			1.8	20	1000	0.2	1	20	0.8	4.5	20	5	30	18	0	-4	5	30	0	155	20	52	02	
2N3684	TO-72	50	1	0.1	30		2	5	20	1	2.5	7.5	20	2	3	20	50	20	4	20	0	1.2	20	0	150	100	52	25	
2N3685	TO-72	50	1	0.1	30		1	3.5	20	1	1	3	20	1.5	2.5	20	25	20	4	20	0	1.2	20	0	150	100	52	25	
2N3686	TO-72	50	1	0.1	30		0.6	2	20	1	0.4	1.2	20	1	2	20	10	20	4	20	0	1.2	20	0	150	100	52	25	
2N3687	TO-72	50	1	0.1	30		0.3	1.2	20	1	0.1	0.5	20	0.5	1.5	20	5	20	4	20	0	1.2	20	0	150	100	52	25	
2N3821	TO-72	50	1	0.1	30			4	15	0.5	0.5	2.5	15	1.5	4.5	15	10	15	6	15	0	3	15	0	200	10	55	25	
2N3822	TO-72	50	1	0.1	30			6	15	0.5	2	10	15	3	6.5	15	20	15	6	15	0	3	15	0	200	10	55	25	
2N3967	TO-72	30	1	0.1	20		2	5	20	1	2.5	10	20	2.5	20	20	35	20†	5	20 †	1.3	20 ■	84	100	84	100	55	25	
2N3967A	TO-72	30	1	0.1	20		2	5	20	1	2.5	10	20	2.5	20	20	35	20†	5	20 †	1.3	20 ■	160	10	160	10	55	25	
2N3968	TO-72	30	1	0.1	20			3	20	1	1	5	20	2	20	15	20**	5	20 **	1.3	20 †	84	100	84	100	55	25		
2N3968A	TO-72	30	1	0.1	20			3	20	1	1	5	20	2	20	15	20**	5	20 **	1.3	20 †	160	10	160	10	55	25		
2N3969	TO-72	30	1	0.1	20			1.7	20	1	0.4	2	20	1.3	20	5	20††	5	20 ††	1.3	20 †	84	100	84	100	55	25		
2N3969A	TO-72	30	1	0.1	20			1.7	20	1	0.4	2	20	1.3	20	5	20††	5	20 ††	1.3	20 †	160	10	160	10	55	25		
2N4220	TO-72	30	10	0.1	15			4	15	0.1	0.5	3	15	1	4	15	10	15	6	15	0	2	15	0		55	25		
2N4220A	TO-72	30	10	0.1	15			4	15	0.1	0.5	3	15	1	4	15	10	15	6	15	0	2	15	0	115	100	55	25	
2N4221	TO-72	30	10	0.1	15			6	15	0.1	2	6	15	2	5	15	20	15	6	15	0	2	15	0		55	25		
2N4221A	TO-72	30	10	0.1	15			6	15	0.1	2	6	15	2	5	15	20	15	6	15	0	2	15	0	115	100	55	25	
2N4222	TO-72	30	10	0.1	15			8	15	0.1	5	15	15	2.5	6	15	40	15	6	15	0	2	15	0		55	25		
2N4222A	TO-72	30	10	0.1	15			8	15	0.1	5	15	15	2.5	6	15	40	15	6	15	0	2	15	0	115	100	55	25	
2N4338	TO-18	50	1	0.1	30		0.3	1	15	100	0.2	0.6	15	0.6	1.8	15	5	15	7	15	0	3	15	0	68	1000	52	02	
2N4339	TO-18	50	1	0.1	30		0.6	1.8	15	100	0.5	1.5	15	0.8	2.4	15	15	15	7	15	0	3	15	0	68	1000	52	02	
2N4340	TO-18	50	1	0.1	30		1	3	15	100	1.2	3.6	15	1.3	3	15	30	15	7	15	0	3	15	0	68	1000	52	02	
2N4341	TO-18	50	1	0.1	30		2	6	15	100	3	9	15	2	4	15	60	15	7	15	0	3	15	0	68	1000	55	02	
2N5103	TO-72	25	10	0.1	15			0.5	4	15	1	8	15	2	8	15	100	15	5	15	0	1	15	0	100	10	50	25	
2N5104	TO-72	25	1	0.1	15			0.5	4	15	1	8	15	2	6	15	3.5	7.5	15	100	15	5	15	0	1	15	0	50	25

■ I<sub>D</sub> = 1 mA; † I<sub>D</sub> = 500 μA; †† I<sub>D</sub> = 40 μA; \*\* I<sub>D</sub> = 100 μA; † I<sub>D</sub> = 250 μA.  
t = typical value.

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# JFET Selection Guide

## N-Channel JFETs



### GENERAL PURPOSE AMPS (Continued)

Type No.	Case Style	BV <sub>GSS</sub> *BV <sub>GDO</sub> (V) @ I <sub>G</sub>		I <sub>GSS</sub> (nA) @ V <sub>DG</sub>		V <sub>p</sub> (V) @ V <sub>DS</sub>				I <sub>DSS</sub> (mA) @ V <sub>DS</sub>			G <sub>fs</sub> (mmho) @ V <sub>DS</sub>			G <sub>oss</sub> (μmho) @ V <sub>DS</sub>		C <sub>iss</sub> (pF) @ V <sub>DS</sub> V <sub>GS</sub>			C <sub>rss</sub> (pF) @ V <sub>DS</sub> V <sub>GS</sub>			e <sub>n</sub> ( $\frac{NV}{\sqrt{Hz}}$ ) @ Freq Max (Hz)	Process No.	Pkg. No.	
		Min	Max (μA)	Min	Max (V)	Min	Max	(V)	I <sub>D</sub> (nA)	Min	Max	(V)	Min	Max	(V)	Max	(V)	Max	(V)	Max	(V)	Max	(V)				
2N5105	TO-72	25	1	0.1	15	0.5	4	15	1	5	15	15	5	10	15	100	15	5	15	0	1	15	0		50	25	
2N5358	TO-72	40	1	0.1	20	0.5	3	15	100	0.5	1	15	1	3	15	10	15	6	15	0	2	15	0	115	100	55	25
2N5359	TO-72	40	1	0.1	20	0.8	4	15	100	0.6	1.6	15	1.2	3.6	15	10	15	6	15	0	2	15	0	115	100	55	25
2N5360	TO-72	40	1	0.1	20	0.8	4	15	100	1.5	3.0	15	1.4	4.2	15	20	15	6	15	0	2	15	0	115	100	55	25
2N5361	TO-72	40	1	0.1	20	1	6	15	100	2.5	5	15	1.5	4.5	15	20	15	6	15	0	2	15	0	115	100	55	25
2N5362	TO-72	40	1	0.1	20	2	7	15	100	4	8	15	2	5.5	15	40	15	6	15	0	2	15	0	115	100	55	25
2N5363	TO-72	40	1	0.1	20	2.5	8	15	100	7	14	15	2.5	6	15	40	15	6	15	0	2	15	0	115	100	55	25
2N5364	TO-72	40	1	0.1	20	2.5	8	15	100	9	18	15	2.7	6.5	15	60	15	6	15	0	2	15	0	115	100	55	25
2N5457	TO-92	25	1	1	15	0.5	6	15	10	1	5	15	2	5	15	50	15	7	15	0	3	15	0		55	92	
2N5458	TO-92	25	1	1	15	1	7	15	10	2	9	15	1.5	5.5	15	50	15	7	15	0	3	15	0		55	92	
2N5459	TO-92	25	1	1	15	2	8	15	10	4	16	15	2	6	15	50	15	7	15	0	3	15	0		55	92	
2N5556	TO-72	30	1	0.1	15	0.2	4	15	1	0.5	2.5	15	1.5	6.5	15	20	15	6	15	0	3	15	0	35	10	50	25
2N5557	TO-72	30	1	0.1	15	0.8	5	15	1	2	5	15	1.5	6.5	15	20	15	6	15	0	3	15	0	35	10	50	25
2N5558	TO-72	30	1	0.1	15	1.5	6	15	1	4	10	15	1.5	6.5	15	20	15	6	15	0	3	15	0	35	10	50	25
J201	TO-92	40	1	0.1	20	0.3	1.5	20	10	0.2	1	20	0.5		20	11	20	15	20	0	12	20	0	110	1000	52	92
J202	TO-92	40	1	0.1	20	0.8	4	20	10	0.9	4.5	20	1		20	13.5	20	15	20	0	12	20	0	110	1000	52	92
J203	TO-92	40	1	0.1	20	2	10	20	10	4	20	20	1.5		20	110	20	15	20	0	12	20	0	110	1000	52	92
J210	TO-92	25	1	0.1	15	1	3	15	1	2	15	15	4	12	15	150	15	15	15	0	11.5	15	0	110	1000	90	92
J211	TO-92	25	1	0.1	15	2.5	4.5	15	1	7	20	15	7	12	15	200	15	15	15	0	11.5	15	0	110	1000	90	92
J212	TO-92	25	1	0.1	15	4	6	15	1	15	40	15	7	12	15	200	15	15	15	0	11.5	15	0	110	1000	90	92
MPF103	TO-92	25	1	1	15		6	15	1	1	5	15	1	5	15	50	15	7	15	0	3	15	0		55	92	
MPF104	TO-92	25	1	1	15		7	15	1	2	9	15	1.5	5.5	15	50	15	7	15	0	3	15	0		55	92	
MPF105	TO-92	25	1	1	15		8	15	1	4	16	15	2	6	15	50	15	7	15	0	3	15	0		55	92	
MPF109	TO-92	25	10	1	15	0.2	8	15	10	0.5	24	15	0.8	6	15	75	15	7	15	0	3	15	0	115	1000	55	92
MPF110	TO-92	20	10	100	10	0.5	10	10	1	0.5	20	10	0.5		10										50	92	
MPF111	TO-92	20	10	100	10	0.5	10	10	1000	0.5	20	10	0.5		10	200	10								50	92	
MPF112	TO-92	25	10	100	10	0.5	10	10	1000	1	25	10	1	7.5	10										55	92	
PN3684	TO-92	50	1	0.1	30	2	5	20	1	2.5	7.5	20	2	3	20	50	20	4	20	0	1.2	20	0	150	20	52	92
PN3685	TO-92	50	1	0.1	30	1	3.5	20	1	1	3	20	1.5	2.5	20	25	20	4	20	0	1.2	20	0	150	20	52	92
PN3686	TO-92	50	1	0.1	30	0.6	2	20	1	0.4	1.2	20	1	2	20	10	20	4	20	0	1.2	20	0	150	20	52	92

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GENERAL PURPOSE AMPS (Continued)

N-Channel JFETs

Type No.	Case Style	BV <sub>GSS</sub> *BV <sub>GDO</sub> (V) @ I <sub>G</sub>		I <sub>GSS</sub> (nA) @ V <sub>DG</sub>		V <sub>p</sub> (V) @ V <sub>DS</sub> I <sub>D</sub>				I <sub>DSS</sub> (mA) @ V <sub>DS</sub>			G <sub>fs</sub> (mmho) @ V <sub>DS</sub>			G <sub>oss</sub> (μmho) @ V <sub>DS</sub>		C <sub>iss</sub> (pF) @ V <sub>DS</sub> V <sub>GS</sub>		C <sub>rss</sub> (pF) @ V <sub>DS</sub> V <sub>GS</sub>			e <sub>n</sub> ( $\frac{NV}{\sqrt{Hz}}$ ) @ Freq		Process No.	Pkg. No.	
		Min (μA)	Max (V)	Min	Max (V)	Min	Max	(V)	(nA)	Min	Max	(V)	Min	Max	(V)	Max	(V)	Max	(V)	Max	(V)	Max	(Hz)				
PN3687	TO-92	50	1	0.1	30	0.3	1.2	20	1	0.1	0.5	20	0.5	1.5	20	5	20	4	20	0	1.2	20	0	150	20	52	92
PN4220	TO-92	30	10	0.1	15		4	15	1	0.5	3	15	1	4	15	10	15	6	15	0	2	15	0			55	92
PN4221	TO-92	30	10	0.1	15		6	15	1	2	6	15	2	5	15	20	15	6	15	0	2	15	0			55	92
PN4222	TO-92	30	10	0.1	15		8	15	1	5	15	15	2.5	6	15	40	15	6	15	0	2	15	0			55	92
PN4302	TO-92	30	1	1	10		4	20	10	0.5	5	20	1		20	50	20	6	20	0	3	20	0	100	1000	52	92
PN4303	TO-92	30	1	1	10		6	20	10	4	10	20	2		20	50	20	6	20	0	3	20	0	100	1000	52	92
PN4304	TO-92	30	1	1	10		10	20	10	0.5	15	20	1		20	50	20	6	20	0	3	20	0	125	1000	52	92
PN5163	TO-92	25	1	10	15	0.4	8	15	1000	1	40	15	2	9	15	200	15	12	15	0	3	15	0	50	1000	50	92
TIS58	TO-92	25	1	4	15	0.5	5	15	20	2.5	8	15	1.3	4	15			6	15	2 mA	3	15	2 mA			50	94
TIS59	TO-92	25	1	4	15	1	9	15	20	6	25	15	1.3		15			6	15	2 mA	3	15	2 mA			50	94

■ I<sub>D</sub> = 1 mA; † I<sub>D</sub> = 500 μA; †† I<sub>D</sub> = 40 μA; \*\* I<sub>D</sub> = 100 μA; †† I<sub>D</sub> = 250 μA.  
t = typical value.

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# N-Channel JFETs

## GENERAL PURPOSE DUAL JFETs (Continued)

Type No.	Case Style	Operating Conditions For These Characteristics										V <sub>p</sub> (V)	I <sub>DSS</sub> (mA)	G <sub>fs</sub> (mmho)	G <sub>oss</sub> (μmho)	I <sub>GSS</sub> (pA) @ V <sub>DG</sub>	C <sub>iss</sub> (pF)	C <sub>rss</sub> (pF)	BV (V)	e <sub>n</sub> (nV/√Hz)@f	I <sub>DSS</sub> Match %	G <sub>fs</sub> Match %	G <sub>oss1-2</sub> (μmho)	I <sub>G1-1</sub> I <sub>G2</sub> 125°C (nA)	Process No.	Pkg. No.						
		Op. Char. V <sub>DG</sub> (V)	I <sub>D</sub> (μA)	V <sub>G1-2</sub> V <sub>OS</sub> (mV)	Drift (μV/°C)	I <sub>G</sub> (pA)	G <sub>fs</sub> μmhos	G <sub>oss</sub> (μmho)	CMRR (dB)	V <sub>GS</sub> (V)																						
		Max	Max	Max	Max	Max	Max	Max	Min	Max	Min																Max	Min	Max	Min	Max	Min
J411	Mini-	20	200	25	25	250	600	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	250	20	4.5	1.2	40	50	100			83	60		
J412	DIP	20	200	40	80	250	600	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	250	20	4.5	1.2	40	50	100			83	60		
NPD8301	8-Pin	20	200	5	10	100	700	1200	5	70	0.3	4	0.5	3.5	0.5	6	1	4	20	100	20	4.5	1.2	40	50	100			83	67		
NPD8302	Mini-	20	200	10	15	100	700	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	100	20	4.5	1.2	40	50	100			83	67		
NPD8303	DIP	20	200	15	25	100	700	1200	5		0.3	4	0.5	3.5	0.5	6	1	4	20	100	20	4.5	1.2	40	50	100			83	67		
U231	TO-71	20	200	5	10	50	600		10		0.3	4	See 2N3954 as an improved replacement																	83	12	
U232	TO-71	20	200	10	25	50	600		10		0.3	4	See 2N3955 as an improved replacement																		83	12
U233	TO-71	20	200	15	50	50	600		10		0.3	4	See 2N3956 as an improved replacement																		83	12
U234	TO-71	20	200	20	75	50	600		10		0.3	4	See 2N3957 as an improved replacement																		83	12
U235	TO-71	20	200	25	100	50	600		10		0.3	4	See 2N3958 as an improved replacement																		83	12
U401	TO-71	10	200	5	10	15	1000	1600	2	95	2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12	
U402	TO-71	10	200	10	10	15	1000	1600	2	95	2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12	
U403	TO-71	10	200	10	25	15	1000	1600	2	95	2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12	
U404	TO-71	10	200	15	25	15	1000	1600	2	95	2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12	
U405	TO-71	10	200	20	40	15	1000	1600	2	90	2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12	
U406	TO-71	10	200	40	80	15	1000	1600	2		2.3	0.5	2.5	0.5	10	2	7	20	25	30	8	3	50	20	10					98	12	

† I<sub>D</sub> = 100 μA for V<sub>GS</sub> for 2N5561/2/3 only.



## LOW FREQUENCY—LOW NOISE DUAL JFETs

Type No.	Case Style	Operating Conditions For These Characteristics										V <sub>p</sub> (V)	I <sub>DSS</sub> (mA)	G <sub>fs</sub> (mmho)	G <sub>oss</sub> (μmho)	I <sub>GSS</sub> (pA) @ V <sub>DG</sub>	C <sub>iss</sub> (pF)	C <sub>rss</sub> (pF)	BV (V)	e <sub>n</sub> (nV/√Hz)@f	I <sub>DSS</sub> Match %	G <sub>fs</sub> Match %	G <sub>oss1-2</sub> (μmho)	I <sub>G1-1</sub> I <sub>G2</sub> 125°C (nA)	Process No.	Pkg. No.						
		Op. Char. V <sub>DG</sub> (V)	I <sub>D</sub> (μA)	V <sub>G1-2</sub> V <sub>OS</sub> (mV)	Drift (μV/°C)	I <sub>G</sub> (pA)	G <sub>fs</sub> μmhos	G <sub>oss</sub> (μmho)	CMRR (dB)	V <sub>GS</sub> (V)																						
		Max	Max	Max	Max	Max	Max	Max	Min	Max	Min																Max	Min	Max	Min	Max	Min
2N5515	TO-71	20	200	5	5	100	500	1000	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	5	3	0.1	10	95	12
2N5516	TO-71	20	200	5	10	100	500	1000	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	5	3	0.1	10	95	12
2N5517	TO-71	20	200	10	20	100	500	1000	1	90	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	5	5	0.1	10	95	12
2N5518	TO-71	20	200	15	40	100	500	1000	1		0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	5	5	0.1	10	95	12
2N5519	TO-71	20	200	15	80	100	500	1000	1		0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	30	10	10	10	0.1	10	95	12
2N5520	TO-71	20	200	5	5	100	500	1000	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	5	3	0.1	10	95	12
2N5521	TO-71	20	200	5	10	100	500	1000	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	5	3	0.1	10	95	12
2N5522	TO-71	20	200	10	20	100	500	1000	1	90	0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	5	5	0.1	10	95	12
2N5523	TO-71	20	200	15	40	100	500	1000	1		0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	5	5	0.1	10	95	12
2N5524	TO-71	20	200	15	80	100	500	1000	1		0.2	3.8	0.7	4	0.5	7.5	1	4	10	250	30	25	5.0	40	15	10	10	10	0.1	10	95	12
2N6483	TO-71	20	200	5	5	100	500	1500	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	200	30	20	3.5	50	10	10	5	3	0.1	10	95	12
2N6484	TO-71	20	200	10	10	100	500	1500	1	100	0.2	3.8	0.7	4	0.5	7.5	1	4	10	200	30	20	3.5	50	10	10	5	3	0.1	10	95	12
2N6485	TO-71	20	200	15	25	100	500	1500	1	90	0.2	3.8	0.7	4	0.5	7.5	1	4	10	200	30	20	3.5	50	10	10	5	5	0.1	10	95	12

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## N-Channel JFETs



### WIDE BAND—LOW NOISE DUAL JFETs

Type No.	Case Style	Operating Conditions For These Characteristics											$V_p$ (V)		$I_{DSS}$ (mA)		$G_{fs}$ (mmho)		$G_{oss}$ ( $\mu$ mho)	$I_{GSS}$ (pA) @ $V_{DG}$	$C_{iss}$ (pF)	$C_{rss}$ (pF)	BV (V)	$e_n$ (nV/ $\sqrt{Hz}$ )@f	$I_{DSS}$ Match %	$G_{fs}$ Match %	$G_{oss1-2}$ ( $\mu$ mho)	$I_{G1-1}I_{G2}$ 125°C (nA)	Process No.	Pkg. No.
		Op. Char.		$ V_{GS1-2} $	Drift	$I_G$	$G_{fs}$		$G_{oss}$	CMRR	$V_{gs}$ (V)																			
		$V_{DG}$ (V)	$I_D$ ( $\mu$ A)	VOS (mV) Max	$\Delta V_{GS}$ ( $\mu$ V/°C) Max	$I_G$ (pA) Max	Min	Max	Max	Min	Min	Max	Min	Max	Min	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	
2N5564	TO-71	15	2000	5	10		7500	45			0.5	3	5	30			100	20	12	3	40	50	10	5	5			96	12	
2N5565	TO-71	15	2000	10	25		7500	45			0.5	3	5	30			100	20	12	3	40	50	10	5	10			96	12	
2N5566	TO-71	15	2000	20	50		7500	45			0.5	3	5	30			100	20	12	3	40	50	10	5	10			96	12	
2N5911	TO-78	10	5000	10	20	100	5000	10,000	100		0.3	4	1	5	7	40		100	15	5	1.2	25	20	10,000	5	5	20	20	93	24
2N5912	TO-78	10	5000	15	40	100	5000	10,000	100		0.3	4	1	5	7	40		100	15	5	1.2	25	20	10,000	5	5	20	20	93	24
NPD5564	8-Pin	15	2000	5	10		7500	45			0.5	3	5	30			100	20	12	3	40	50	10	5	5			96	67	
NPD5565	Mini-	15	2000	10	25		7500	45			0.5	3	5	30			100	20	12	3	40	50	10	5	10			96	67	
NPD5566	DIP	15	2000	20	50		7500	45			0.5	3	5	30			100	20	12	3	40	50	10	5	10			96	67	
U257	TO-78	10	5000	100			5000	10,000	150			1	5	5	40			100	15	5	1.2	25	30	10,000	15	15	20		93	24

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### LOW LEAKAGE—HIGH CMRR—WIDE BAND DUAL JFETs

Type No.	Case Style	Operating Conditions For These Characteristics											$V_p$ (V)		$I_{DSS}$ (mA)		$G_{fs}$ (mmho)		$G_{oss}$ ( $\mu$ mho)	$I_{GSS}$ (pA) @ $V_{DG}$	$C_{iss}$ (pF)	$C_{rss}$ (pF)	BV (V)	$e_n$ (nV/ $\sqrt{Hz}$ )@f	$I_{DSS}$ Match %	$G_{fs}$ Match %	$G_{oss1-2}$ ( $\mu$ mho)	$I_{G1-1}I_{G2}$ 125°C (nA)	Process No.	Pkg. No.
		Op. Char.		$ V_{GS1-2} $	Drift	$I_G$	$G_{fs}$		$G_{oss}$	CMRR	$V_{gs}$ (V)																			
		$V_{DG}$ (V)	$I_D$ ( $\mu$ A)	VOS (mV) Max	$\Delta V_{GS}$ ( $\mu$ V/°C) Max	$I_G$ (pA) @ 35V Max	Min	Max	Max	Min	Min	Max	Min	Max	Min	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max
NDF9406	TO-71	20	200	5	5	5	700	1800	1	120	0.1	4	0.5	4	0.5	10		50	30	5	0.02	50	30	10	5	3	0.1	1	94	12
NDF9407	TO-71	20	200	5	10	5	700	1800	1	120	0.1	4	0.5	4	0.5	10		50	30	5	0.02	50	30	10	5	3	0.1	1	94	12
NDF9408	TO-71	20	200	10	10	5	700	1800	1	110	0.1	4	0.5	4	0.5	10		50	30	5	0.02	50	30	10	5	5	0.1	1	94	12
NDF9409	TO-71	20	200	15	10	5	700	1800	1	110	0.1	4	0.5	4	0.5	10		50	30	5	0.02	50	30	10	5	5	0.1	1	94	12
NDF9410	TO-71	20	200	25	25	5	700	1800	1	100	0.1	4	0.5	4	0.5	10		50	30	5	0.02	50	30	10	10	10	0.1	1	94	12



ULTRA LOW LEAKAGE DUALS

N-Channel JFETs

Type No.	Case Style	Operating Conditions For These Characteristics									V <sub>p</sub> (V)		I <sub>DSS</sub> (mA)		G <sub>fs</sub> (mmho)		G <sub>oss</sub> (μmho)		I <sub>GSS</sub> (pA) @ V <sub>GS</sub>		C <sub>iss</sub> (pF)		C <sub>rss</sub> (pF)		BV <sub>GSS</sub> (V)		I <sub>G1-I</sub> G <sub>2</sub> @ 125°C (nA)		Process No.	Pkg. No.
		V <sub>DG</sub> (V)	I <sub>D</sub> (μA)	V <sub>GS1-2</sub> V <sub>OS</sub> (mV)	ΔV <sub>GS</sub> Drift (μV/°C)	I <sub>G</sub> (pA)	G <sub>fs</sub> (mmho)	G <sub>oss</sub> (μmho)	V <sub>GS</sub> (V)																					
2N5902	TO-78	10	30	5	5	3	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	5	5	20	3	1.5	40	2	84	24						
2N5903	TO-78	10	30	5	10	3	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	5	5	20	3	1.5	40	2	84	24						
2N5904	TO-78	10	30	10	20	3	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	5	5	20	3	1.5	40	2	84	24						
2N5905	TO-78	10	30	15	40	3	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	4	5	20	3	1.5	40	2	84	24						
2N5906	TO-78	10	30	5	5	1	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	5	2	20	3	1.5	40	0.2	84	24						
2N5907	TO-78	10	30	5	10	1	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	5	2	20	3	1.5	40	0.2	84	24						
2N5908	TO-78	10	30	10	20	1	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	5	2	20	3	1.5	40	0.2	84	24						
2N5909	TO-78	10	30	15	40	1	50 μ	1	4	0.6	4.5	30 μ	0.5	70 μ	0.25	5	2	20	3	1.5	40	0.2	84	24						
U421	TO-78	Process In Development																			86	24								
U422	TO-78																				86	24								
U423	TO-78																				86	24								
U424	TO-78																				86	24								
U425	TO-78																				86	24								
U426	TO-78																				86	24								

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## SWITCHES

## P-Channel JFETs

Type No.	Case Style	BV <sub>GSS</sub> BV <sub>GDO</sub> (V) @ I <sub>G</sub>		I <sub>GSS</sub> (nA)@V <sub>DG</sub>		I <sub>D(off)</sub> (nA)@V <sub>DS</sub> V <sub>GS</sub>			V <sub>p</sub> (V) @ V <sub>DS</sub> I <sub>D</sub>			I <sub>DSS</sub> (mA) @ V <sub>DS</sub>		r <sub>ds</sub> (Ω) @ I <sub>D</sub>		C <sub>iss</sub> (pF)@V <sub>DS</sub> V <sub>GS</sub>			C <sub>rss</sub> (pF)@V <sub>DS</sub> V <sub>GS</sub>			t <sub>on</sub> (ns)	t <sub>off</sub> (ns)	Process No.	Pkg. No.		
		Min	Max	Max	Max	Max	Max	Min	Max	Max	Min	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max
2N5018	TO-18	30	1	2	15	10	-15	12	10	-15	1	10	20	75	45	-15	0	10	0	12	35	65	88	11			
2N5019	TO-18	30	1	2	15	10	-15	7	5	-15	1	5	20	150	45	-15	0	10	0	7	90	125	88	11			
2N5114	TO-18	30	1	0.5	20	0.5	-15	12	5	10	-15	0.001	30	90	18	75	1	25	-15	0	7	0	12	16	21	88	11
2N5115	TO-18	30	1	0.5	20	0.5	-15	7	3	6	-15	0.001	16	60	15	100	1	25	-15	0	7	0	7	30	38	88	11
2N5116	TO-18	30	1	0.5	20	0.5	-15	5	1	4	-15	0.001	5	25	15	150	1	25	-15	0	7	0	5	42	60	88	11
J174	TO-92	30	1	1	20	1	-15	10	5	10	-15	0.01	20	100	15	85	1	11	0	10	5.5	0	10	2	5	88	94
J175	TO-92	30	1	1	20	1	-15	10	3	6	-15	0.01	7	60	15	125	0.5	11	0	10	5.5	0	10	5	10	88	94
J176	TO-92	30	1	1	20	1	-15	10	1	4	-15	0.01	2	25	15	250	0.25	11	0	10	5.5	0	10	15	15	88	94
J177	TO-92	30	1	1	20	1	-15	10	0.8	2.25	-15	0.01	1.5	20	15	300	0.1	11	0	10	5.5	0	10	20	20	88	94
P1086	TO-92	30	1	2	15	10	-15	12	10	-15	1	10	20	75	1	45	-15	0	10	0	12	35	65	88	92		
P1087	TO-92	30	1	2	15	10	-15	7	5	-15	1	5	20	150	1	45	-15	0	10	0	7	90	125	88	92		



# AMPLIFIERS

# P-Channel JFETs

Type No.	Case Style	BV <sub>GSS</sub> BV <sub>GDO</sub> (V) @ I <sub>G</sub>		I <sub>GSS</sub> (nA) @ V <sub>DG</sub>		V <sub>p</sub> (V) @ V <sub>DS</sub> I <sub>D</sub>				I <sub>DSS</sub> (mA) @ V <sub>DS</sub>			G <sub>fs</sub> (mmho) @ V <sub>DS</sub>			G <sub>oss</sub> (μmho) V <sub>DS</sub>		C <sub>iss</sub> (pF) V <sub>DS</sub> V <sub>GS</sub>			C <sub>rss</sub> (pF) V <sub>DS</sub> V <sub>GS</sub>			e <sub>n</sub> ( $\frac{NV}{\sqrt{Hz}}$ ) @ Freq		Process No.	Pkg. No.
		Min	Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max	Max				
2N2608	TO-18	30	1	10	30	1	4	-5	1	0.9	4.5	5	1	5			17	-5	1				125	1000	89	11	
2N2609	TO-18	30	1	30	30	1	4	-5	1	2	10	5	2.5	5			30	-5	1			125	1000	88	11		
2N3329	TO-72	20	10	10	10		5	-15	10	1	3	10	1	2	10/1 mA	20	10	20	-10	1		125	1000	89	23		
2N3330	TO-72	20	10	10	10		6	-15	10	2	6	10	1.5	3	10/2 mA	40	10	20	-10	1		125	1000	89	23		
2N3331	TO-72	20	10	10	10		8	-15	10	5	15	10	2	4	10/5 mA	100	10	20	-10	1		155	1000	89	23		
2N3332	TO-72	20	10	10	10		6	-15	10	1	6	10	1	2.2	10/1 mA	20	10	20	-10	1		65	1000	89	23		
2N3820	TO-92	20	10	20	10		8.0	-10	10	0.3	15	10	0.8	5	10	200	10	32	-10	0	16	-10	0		89	94	
2N4381	TO-18	25	1	1	15	1	5	-15	1	3	12	15	2	6	15	75	15	20	-15	0	5	-15	0	20	1000	89	11
2N5020	TO-18	25	1	1	15	0.3	1.5	-15	1	0.3	1.2	15	1	3.5	15	20	15	25	-15	0	7	-15	0	30	1000	89	11
2N5021	TO-18	25	1	1	15	0.5	2.5	-15	1	1	3.5	15	1.5	6	15	20	15	25	-15	0	7	-15	0	30	1000	89	11
2N5460	TO-92	40	10	5	20	0.75	6	-15	1	1	5	15	1	4	15	50	15	7	-15	0	2	-15	0	115	100	89	92
2N5461	TO-92	40	10	5	20	1	7.5	-15	1	2	9	15	1.5	5	15	50	15	7	-15	0	2	-15	0	115	100	89	92
2N5462	TO-92	40	10	5	20	1.8	9	-15	1	4	16	15	2	6	15	50	15	7	-15	0	2	-15	0	115	100	89	92
J270	TO-92	30	1	0.2	20	0.5	2.0	-15	0.001	2	15	15	6.0	15	15	200	15	120	-15	0	15	-15	0	110	1000	88	94
J271	TO-92	30	1	0.2	20	1.5	4.5	-15	0.001	6	50	15	8.0	18		500	15	120	-15	0	15	-15	0	110	1000	88	94
PN4342	TO-92	25	10	10	15		5.5	-10	1	4	12	10	2	6	10	75	10	20	-10	0	5	-10	0	80	100	89	92
PN4360	TO-92	20	10	10	15	0.7	10	-10	1	3	30	10	2	8	10	100	10	20	-10	0	5	-10	0	190	100	89	92
PN5033	TO-92	20	10	10	15	0.3	2.5	-10	1	0.3	3.5	10	1	5	10	20	10	25	-10	0	7	-10	0	100	1000	89	92

t = typical value.

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Section 4

**Selection Guides**

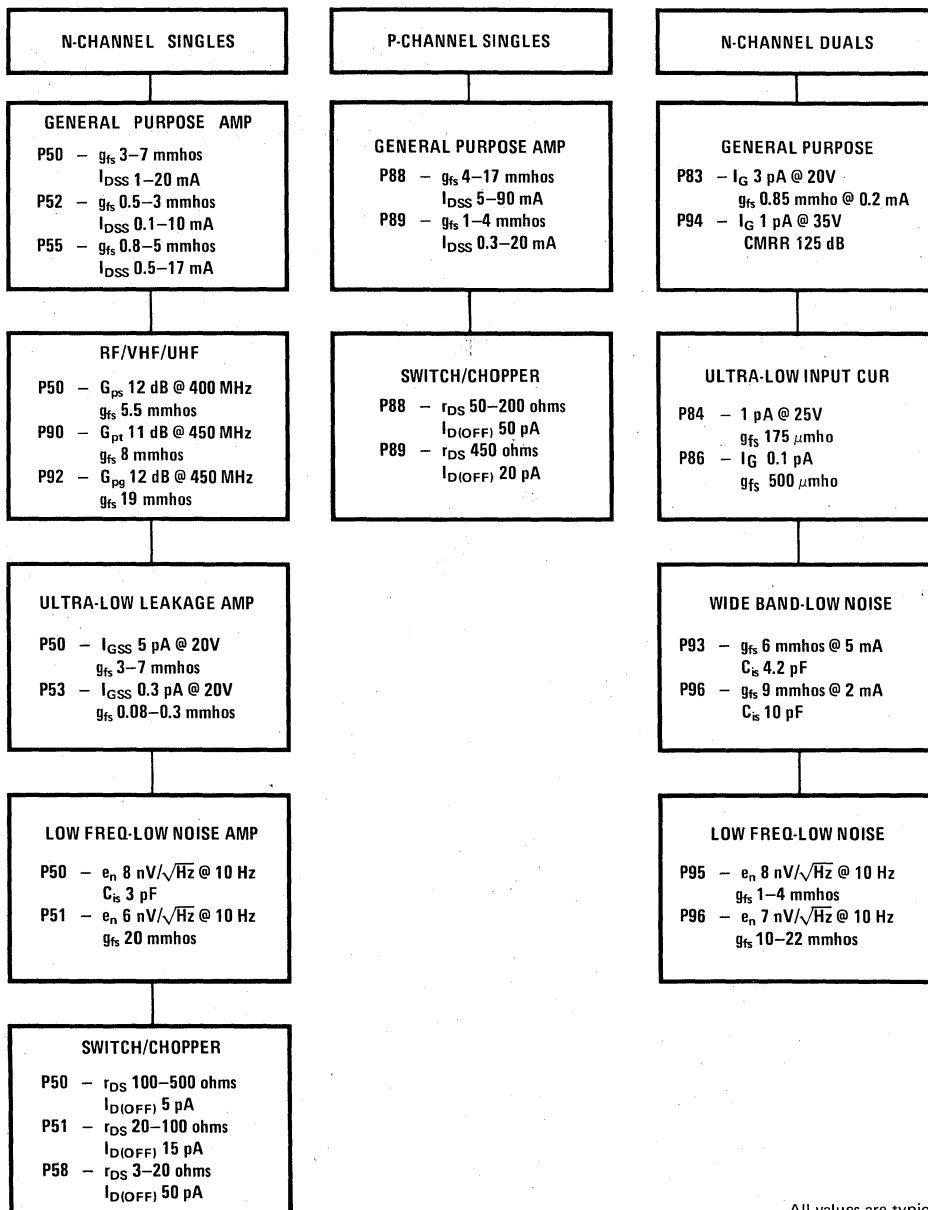


## Choose The Proper FET

National Semiconductor utilizes 17 different FET geometries to cover, without compromise, the full spectrum of applications. Detailed data on each process, along with a list of all part numbers manufactured from each process, is to be found in Section 9.

To further simplify the selection procedure, the FET Family Tree is included for quick identification. After narrowing down the process types, it is suggested that the process sheets and specific part number characteristics be consulted.

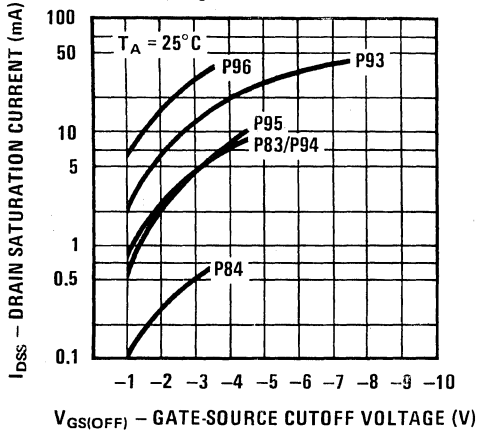
### FET FAMILY TREE



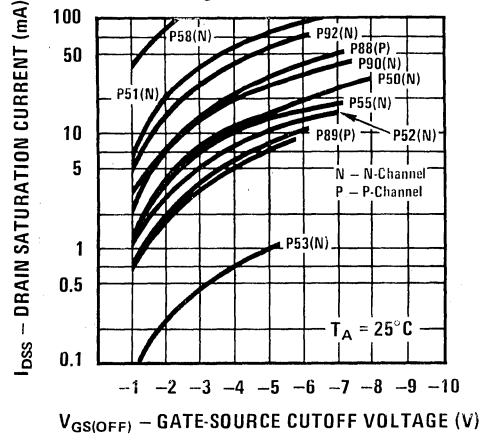
All values are typical

# FET Process Comparison Curves

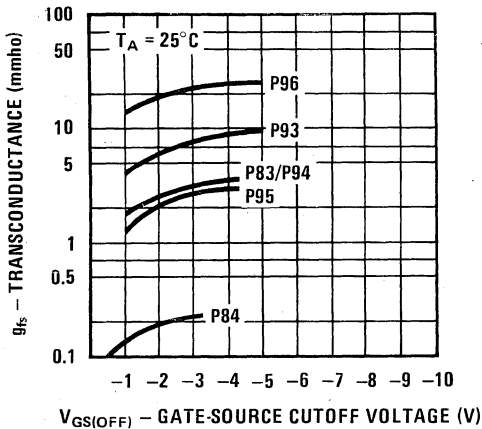
Dual FET Drain Saturation Current vs Cutoff Voltage



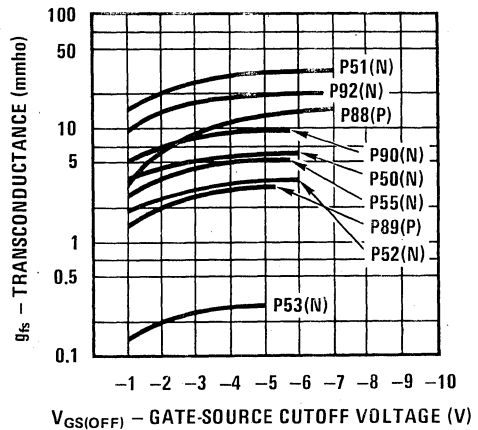
Single FET Drain Saturation Current vs Cutoff Voltage



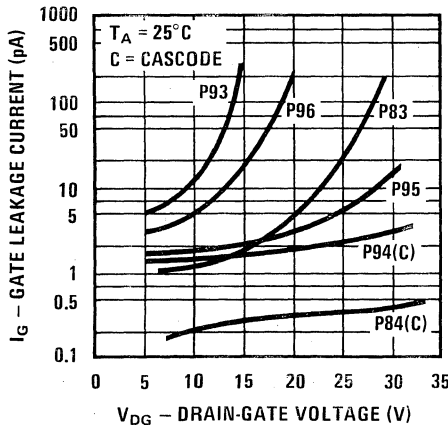
Dual FET Transconductance vs Cutoff Voltage



Single FET Transconductance vs Cutoff Voltage

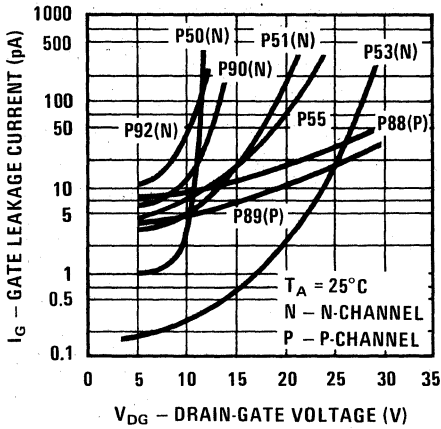


Dual FET Gate Leakage Current vs Drain-Gate Voltage

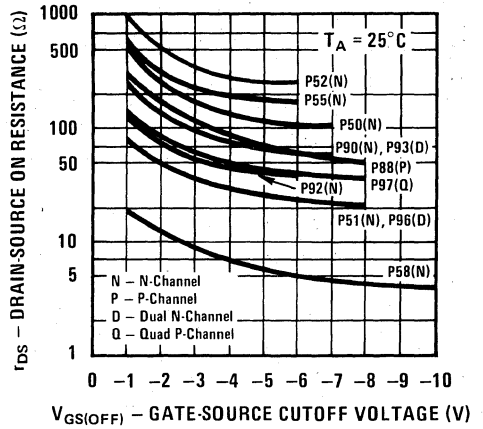


# FET Process Comparison Curves (Continued)

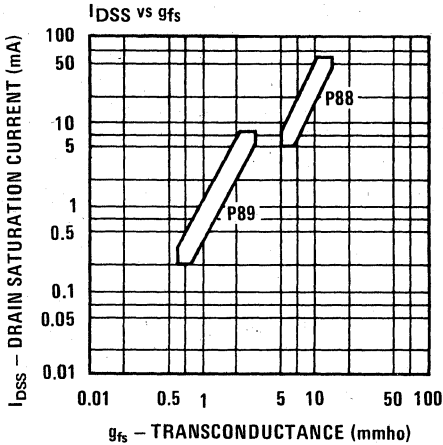
Single FET Gate Leakage Current vs Drain-Gate Voltage



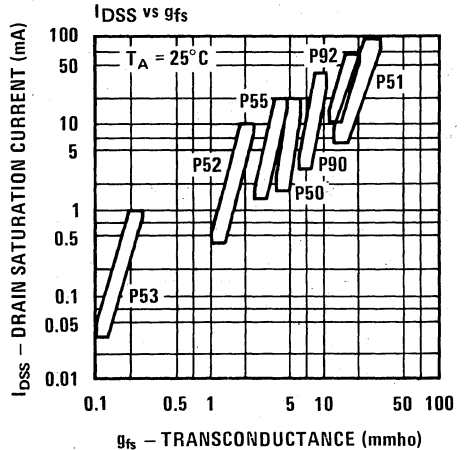
ON Resistance vs Cutoff Voltage



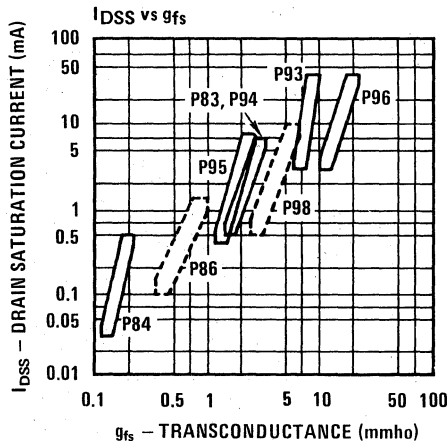
Single P-Channel FET Process Distribution



Single N-Channel FET Process Distribution



Monolithic Dual FET Process Distribution



# FET Application Guide

National Semiconductor manufactures a broad line of silicon Junction Field Effect Transistors (JFETs). National's JFETs provide excellent performance in many areas such as RF amplifiers, analog switching, low input current amplifiers, low noise high impedance amplifiers and outstanding matched duals for operational amplifiers input applications.

The following FET guides enable the user to determine when to use FETs and where to look for the best choice.

POPULAR PRODUCT TYPES	2N4416, 2N5485, 6 PN4416, PN4302-4	2N4856-61, 2N4391-3 PN4856-61, PN4391-3	2N4338-41, 2N3684-7	2N4117-9, 2N3452-4 2N4117A-19A	2N3821-2, 2N4221-2 2N5457-9	2N5432-4	2N5196-9, 2N5545-7 2N3954-8	2N5902-9	U421-U426	2N5018-21, P1086-7E 2N5114-6	2N2608-9, 2N5460-62	2N5397, J300	U308-10, J308-10	2N5911-12	NDF9401-10	2N5515-24, 2N6483-5	2N5564-6	2N5561-63	
PROCESS DESIGNATION	50	51	52	53	55	58	83	84	86	88	89	90	92	93	94	95	96	98	
Low Current Amplifier			S	P	S			P	P	P						P	P		P
Low Freq Ampli ≤ 100 Hz			S		S			P		S	S					P	P		P
High Freq Ampli > 100 MHz	P											P	P	P					P
General Purpose Amplifier	P		P		P						P								
Low Noise Amp (10 Hz $\bar{e}_n$ )	S	S			S	S	P								P	P	P	P	P
Low Noise Amp > 50 MHz	P				S								P	P	P				P
High Frequency Mixer	P												P	P					
Dual Diff Pair							P	P	P						P	P	S	P	P
AGC Amplifier	P				P														
Electrometer Preamp				P				P	P							P			S
Microvolt Amplifier				P				P	P							P			P
Low Leakage Diode				P															
Diff/Angle Ended Inp. Stag.							P	P	P						P	P		P	P
Active Filter	P		S		P								S						
Oscillator	P		S		P							S	P	P					
Voltage Variable Resistor	P	P	S		P					P	P								P
Hybrid Chips	P	P		P	P		P	P	P	P	P					P			
Analog/Digital Switch		P				P				P								S	S
Multiplexing	P	P			S	S				P									
Choppers		P				P				P									P
Nixie Drivers																			
Reed Relay Replacement						P													
Sub pA Dual Diff Pair									P	P									
Sample-Hold	P	P			S				S	P									P
Buffer Interface to CMOS										P	P								
Matched Switch							S							S	S			P	P
HF ≥ 400 MHz Prime												P	P						
Current Limiter		P								P									
Current Source			P	S	P						S								

P - Prime Choice    S - Secondary (Alternate) Choice



# FET Application Guide (Continued)

## ADVANTAGES OF USING FIELD-EFFECT TRANSISTORS

APPLICATION	ADVANTAGES	FINAL ASSEMBLY WHERE USED
DC Amplifiers	High $Z_{in}$ Low drift duals Low noise	Transducers, military guidance systems, control systems, temp indicators, multimeters
Low frequency amplifiers	Small coupling capacitors Low noise, distortion High input impedance	Sound detection, microphones, inductive transducers, hearing aids, high impedance transducers
Operational amplifiers	Summing point essentially zero. Low device noise. Less loading of transducers	Control systems, potted op amps, test equipment, medical electronics
Medium and high frequency amplifiers	Low cross modulation Low device noise	FM tuners, communication received scope inputs, most instrumentation equipment, high impedance inputs
Mixers — 100 MHz and up	Low mixing noise Low cross modulation	FM tuners, communication receivers
Oscillators	Low drift	Transmitters, receivers, organ
Logic gates	Virtually infinite fan in Simplified circuitry Zero storage time Symmetrical	Guidance controls, computer market mini military teaching aids, traffic control, telemetry
Choppers	Zero offset Low leakage currents Simplified circuitry Eliminates input transformers	Op amp modules guidance controls instrumentation equipment
AD Converters Multiplex switching (arrays) and sample hold	Improved isolation of input and output. Zero offset. Symmetrical. Low resistance Simplified circuitry	Control system, DVM's and any read-out equipment, medical electronics
Relay contact replacement	Solid state reliability Zero offset, High isolation Symmetrical No inductive spring No contact bounce High repetition rate	Test equipment, airborne equipment instrumentation market
Voltage variable resistor	Symmetrical Solid state reliability Functions as variable resistor. Low noise. High isolation Improved resolution	Organ, tone controls, control ckts to input operational amplifiers
Current limiters Sources	Two lead simplicity Wide selection range Low voltage operation	Hybrid circuits, amplifiers, power supply protection, timing ckts, voltage regulators

# Important Parameters by Application

LISTED IN APPROXIMATE ORDER OF IMPORTANCE

Low Frequency Amplifier	Source Follower	Electrometer Amplifier	Low Drift Amplifier	Low Noise Amplifier	High Frequency Amplifier	Oscillator	Differential Amplifier	Analog and Digital Switch
$Y_{fs}$	$Y_{fs}$	$I_G$	$I_{DZ}$	$e_n$	$Re(Y_{fs})$	$Y_{fs}$	$ V_{GS1}-V_{GS2} $	$R_{DS(ON)}$
$I_{DSS}$	$I_G$	$Y_{fs}$	$Y_{fs} @ I_{DZ}$	$I_G$	$Re(Y_{is})$	$I_{DSS}$	$\frac{\Delta V_{GS1}-V_{GS2} }{\Delta T}$	$I_{D(off)}$
$V_{GS(off)}$	$C_{rss}$	$I_{DZ}$	$V_{GS} @ I_{DZ}$	$i_n$	NF	$C_{rss}$	$  G1-I_G2 $	$C_{iss}$
$C_{iss}$	$C_{iss}$	$e_n$	$I_G$	$Y_{fs}$	$C_{rss}$	$C_{iss}$	$I_G$	$C_{rss}$
$C_{rss}$	$I_{DSS}$	$g_{os}$	BVGSS	$I_{DSS}$	$Re(Y_{os})$	$V_{GS(off)}$	$Y_{fs}$	$V_{GS(off)}$
$e_n$	$V_{GS(off)}$			$V_{GS(off)}$	$I_{DSS}$	BVGSS	$Y_{fs1}/Y_{fs2}$	BVGSS
BVGSS	BVGSS				$V_{GS(off)}$		$ Y_{os1}-Y_{os2} $	
							CMRR	
							$V_{GS(off)}$	

# JFET Cross Reference Guide

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type	Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
2N2386-5	P	TO-5		2N5462-5	8971	TO-92	2N3966	N	TO-72	2N3966		5029	TO-72
2N2386A	P	TO-5		2N5462-5	8971	TO-92	2N3967	N	TO-72	2N3967		5225	TO-72
2N2497	P	TO-5		2N3329-5	8923	TO-72	2N3967A	N	TO-72	2N3967A		5525	TO-72
2N2498	P	TO-5		2N3330-5	8923	TO-72	2N3968	N	TO-72	2N3968		5525	TO-72
2N2499	P	TO-5		2N3331-5	8923	TO-72	2N3968A	N	TO-72	2N3968A		5525	TO-72
2N2500	P	TO-5		2N3332-5	8923	TO-72	2N3969	N	TO-72	2N3969		5525	TO-72
2N2606	P	TO-18		2N5020	8911	TO-18	2N3969A	N	TO-72	2N3969A		5525	TO-72
2N2607	P	TO-18		2N5020	8911	TO-18	2N3970	N	TO-18	2N3970		5102	TO-18
2N2608	P	TO-18	2N2608	2N5020	8911	TO-18	2N3971	N	TO-18	2N3971		5102	TO-18
2N2609	P	TO-18	2N2609		8911	TO-18	2N3972	N	TO-18	2N3972		5102	TO-18
2N2843	P	TO-18		2N5020	8911	TO-18	2N3993	P	TO-72		2N5116	8811	TO-72
2N2844	P	TO-18		2N5020	8911	TO-18	2N3993A	P	TO-72		2N5116	8811	TO-72
2N3066	N	TO-18		2N4340	5202	TO-18	2N3994	P	TO-72		2N5116	8811	TO-72
2N3067	N	TO-18		2N4338	5202	TO-18	2N3994A	P	TO-72			8811	TO-72
2N3068	N	TO-18		2N4338	5202	TO-18	2N4084	N	TO-71	2N4084		8312	TO-71
2N3069	N	TO-18	2N3069		5202	TO-18	2N4085	N	TO-71	2N4085		8312	TO-71
2N3070	N	TO-18	2N3071		5202	TO-18	2N4091	N	TO-18	2N4091		5102	TO-18
2N3071	N	TO-18	2N3071		5202	TO-18	2N4092	N	TO-18	2N4092		5102	TO-18
2N3084	N	TO-5		2N4340-5	5202	TO-18	2N4093	N	TO-18	2N4093		5102	TO-18
2N3085	N	TO-18		2N4340	5202	TO-18	2N4117	N	TO-72	2N4117		5325	TO-72
2N3086	N	TO-5		2N4340	5202	TO-18	2N4117A	N	TO-72	2N4117A		5325	TO-72
2N3087	N	TO-18		2N4340	5202	TO-18	2N4118	N	TO-72	2N4118		5325	TO-72
2N3088	N	TO-5		2N4339-5	5202	TO-18	2N4118A	N	TO-72	2N4118A		5325	TO-72
2N3088A	N	TO-5		2N4339-5	5202	TO-18	2N4119	N	TO-72	2N4119		5325	TO-72
2N3089	N	TO-18		2N4339	5202	TO-18	2N4119A	N	TO-72	2N4119A		5325	TO-72
2N3089A	N	TO-18		2N4339	5202	TO-18	2N4139	N	TO-18		2N5363	5525	TO-72
2N3329	P	TO-72	2N3329		8923	TO-72	2N4220	N	TO-72	2N4220		5525	TO-72
2N3330	P	TO-72	2N3330		8923	TO-72	2N4220A	N	TO-72	2N4220A		5525	TO-72
2N3331	P	TO-72	2N3331		8923	TO-72	2N4221	N	TO-72	2N4221		5525	TO-72
2N3332	P	TO-72	2N3332		8923	TO-72	2N4221A	N	TO-72	2N4221A		5525	TO-72
2N3365	N	TO-18		2N4340	5202	TO-18	2N4222	N	TO-72	2N4222		5525	TO-72
2N3368	N	TO-18	2N3368		5202	TO-18	2N4222A	N	TO-72	2N4222A		5525	TO-72
2N3369	N	TO-18	2N3369		5202	TO-18	2N4223	N	TO-72	2N4223		5025	TO-72
2N3370	N	TO-18	2N3370		5202	TO-18	2N4224	N	TO-72	2N4224		5025	TO-72
2N3376	P	TO-72		2N3329	8923	TO-72	2N4302	N	TO-106	PN4302-18		5272	TO-92
2N3378	P	TO-72		2N3330	8923	TO-72	2N4303	N	TO-106	PN4303-18		5272	TO-92
2N3380	P	TO-72		2N3331	8923	TO-72	2N4304	N	TO-106	PN4304-18		5272	TO-92
2N3382	P	TO-72		2N5116	8811	TO-72	2N4338	N	TO-18	2N4338		5202	TO-18
2N3384	P	TO-72		2N5115	8811	TO-72	2N4339	N	TO-18	2N4339		5202	TO-18
2N3386	P	TO-72		2N5114	8811	TO-72	2N4340	N	TO-18	2N4340		5202	TO-18
2N3436	N	TO-18		2N4222	5525	TO-72	2N4341	N	TO-18	2N4341		5202	TO-18
2N3437	N	TO-18		2N3968	5525	TO-72	2N4342	P	TO-106	PN4342-18		8971	TO-92
2N3438	N	TO-18		2N5358	5525	TO-72	2N4360	P	TO-106	PN4360-18		8971	TO-92
2N3453	N	TO-72		2N4119	5325	TO-72	2N4381	P	TO-18	2N4381		8971	TO-92
2N3454	N	TO-72		2N4117	5325	TO-72	2N4382	P	TO-18	2N5115		8811	TO-18
2N3457	N	TO-72		2N4117	5325	TO-72	2N4391	N	TO-18	2N4391		5102	TO-18
2N3458	N	TO-18	2N3458		5202	TO-18	2N4392	N	TO-18	2N4392		5102	TO-18
2N3459	N	TO-18	2N3459		5202	TO-18	2N4393	N	TO-18	2N4393		5102	TO-18
2N3460	N	TO-18	2N3460		5202	TO-18	2N4416	N	TO-72	2N4416		5025	TO-72
2N3578	P	TO-18		2N2608	8911	TO-18	2N4416A	N	TO-72	2N4416A		5025	TO-72
2N3684	N	TO-72	2N3684		5225	TO-72	2N4445	N	TO-18		2N5432	5807	TO-52
2N3684A	N	TO-72		2N3684	5225	TO-72	2N4446	N	TO-18		2N5433	5807	TO-52
2N3685	N	TO-72	2N3685		5225	TO-72	2N4447	N	TO-18		2N5432	5807	TO-52
2N3685A	N	TO-72		2N3685	5225	TO-72	2N4448	N	TO-18		2N5433	5807	TO-52
2N3686	N	TO-72	2N3686		5225	TO-72	2N4856	N	TO-18	2N4856		5102	TO-18
2N3686A	N	TO-72		2N3686A	5225	TO-72	2N4856A	N	TO-18	2N4856A		5102	TO-18
2N3687	N	TO-72	2N3687		5225	TO-72	2N4857	N	TO-18	2N4857		5102	TO-18
2N3687A	N	TO-72		2N3687	5225	TO-72	2N4857A	N	TO-18	2N4857A		5102	TO-18
2N3819	N	TO-92	2N3819		5074	TO-92	2N4858	N	TO-18	2N4858		5102	TO-18
2N3820	P	TO-92	2N3820		8974	TO-92	2N4858A	N	TO-18	2N4858A		5102	TO-18
2N3821	N	TO-72	2N3821		5525	TO-72	2N4859	N	TO-18	2N4859		5102	TO-18
2N3822	N	TO-72	2N3822		5525	TO-72	2N4859A	N	TO-18	2N4859A		5102	TO-18
2N3823	N	TO-72	2N3823		5025	TO-72	2N4860	N	TO-18	2N4860		5102	TO-18
2N3824	N	TO-72	2N3824		5525	TO-72	2N4860A	N	TO-18	2N4860A		5102	TO-18
2N3909	P	TO-72		2N3820	8974	TO-92	2N4861	N	TO-18	2N4861		5102	TO-18
2N3909A	P	TO-72		2N5462	8971	TO-92	2N4861A	N	TO-18	2N4861A		5102	TO-18
2N3921	N	TO-71		2N3921	8312	TO-71	2N4867	N	TO-72		2N4339	5202	TO-18
2N3922	N	TO-71	2N3922		8312	TO-71	2N4868	N	TO-72		2N3459	5202	TO-18
2N3954	N	TO-71	2N3954		8312	TO-71	2N4869	N	TO-72		2N4341	5702	TO-18
2N3955	N	TO-71	2N3955		8312	TO-71	2N4977	N	TO-18		2N5432	5807	TO-52
2N3955A	N	TO-71	2N3955A		8312	TO-71	2N4978	N	TO-18		2N5433	5807	TO-52
2N3956	N	TO-71	2N3956		8312	TO-71	2N4979	N	TO-18		2N5434	5807	TO-52
2N3957	N	TO-71	2N3957		8312	TO-71	2N5018	P	TO-18	2N5018		8811	TO-18
2N3958	N	TO-71	2N3958		8312	TO-71	2N5019	P	TO-18	2N5019		8811	TO-18

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type	Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
2N5020	P	TO-18	2N5020		8811	TO-18	2N5668	N	TO-92	2N5668		5072	TO-92
2N5021	P	TO-18	2N5021		8971	TO-92	2N5669	N	TO-92	2N5669		5072	TO-92
2N5033	P	TO-106	PN5033-18		8971	TO-92	2N5670	N	TO-92	2N5670		5072	TO-92
2N5045	N	TO-71	2N5045		8312	TO-71	2N5717	N	TO-92		PN3686	5272	TO-92
2N5046	N	TO-71	2N5046		8312	TO-71	2N5718	N	TO-92		PN4302	5272	TO-92
2N5047	N	TO-71	2N5047		8312	TO-71	2N5801	N	TO-92		J212	9072	TO-92
2N5078	N	TO-72	2N5078		5025	TO-72	2N5802	N	TO-92			9072	TO-92
2N5103	N	TO-72	2N5103		5025	TO-72	2N5902	N	TO-78	2N5902		8424	TO-78
2N5104	N	TO-72	2N5104		5025	TO-72	2N5903	N	TO-78	2N5903		8424	TO-78
2N5105	N	TO-72	2N5105		5025	TO-72	2N5904	N	TO-78	2N5904		8424	TO-78
2N5114	P	TO-18	2N5114		8811	TO-18	2N5905	N	TO-78	2N5905		8424	TO-78
2N5115	P	TO-18	2N5115		8811	TO-18	2N5906	N	TO-78	2N5906		8424	TO-78
2N5116	P	TO-18	2N5116		8811	TO-18	2N5907	N	TO-78	2N5907		8424	TO-78
2N5158	N	TO-18		2N5433	8807	TO-52	2N5908	N	TO-78	2N5908		8424	TO-78
2N5159	N	TO-18		2N5432	5807	TO-52	2N5909	N	TO-78	2N5908		8424	TO-78
2N5163	N	TO-106	PN5163-18		5072	TO-18	2N5911	N	TO-78	2N5911		9324	TO-78
2N5196	N	TO-71	2N5196		8312	TO-18	2N5912	N	TO-78	2N5912		9324	TO-78
2N5197	N	TO-71	2N5197		8312	TO-18	2N5949	N	TO-106	2N5949-18		5077	TO-92
2N5198	N	TO-71	2N5198		8312	TO-18	2N5950	N	TO-106	2N5950-18		5077	TO-92
2N5199	N	TO-71	2N5199		8312	TO-18	2N5951	N	TO-106	2N5951-18		5077	TO-92
2N5245	N	TO-106	2N5245-18		9077	TO-92	2N5952	N	TO-106	2N5952-18		5077	TO-92
2N5246	N	TO-106	2N5246-18		9077	TO-92	2N5953	N	TO-106	2N5953-18		5077	TO-92
2N5247	N	TO-106	2N5247-18		9077	TO-92	2N6483	N	TO-71	2N6483		9512	TO-71
2N5248	N	TO-92	2N5248		5074	TO-92	2N6484	N	TO-71	2N6484		9512	TO-71
2N5358	N	TO-72	2N5358		5525	TO-72	2N6485	N	TO-71	2N6485		9512	TO-71
2N5359	N	TO-72	2N5359		5525	TO-72	2SK11	N	TO-72		2N3459	5202	TO-18
2N5360	N	TO-72	2N5360		5525	TO-72	2SK12	N	TO-72		2N4340	5202	TO-18
2N5361	N	TO-72	2N5361		5525	TO-72	2SK13	N	TO-72		2N4340	5202	TO-18
2N5362	N	TO-72	2N5362		5525	TO-72	2SK15	N	TO-72		2N4340	5202	TO-18
2N5363	N	TO-72	2N5363		5525	TO-72	2SK19	N	TO-106		2N5485-18	5072	TO-92
2N5364	N	TO-72	2N5364		5525	TO-72	2SK30	N	TO-92		PN4304	5272	TO-92
2N5397	N	TO-72	2N5397		9025	TO-72	2SK37	N	B-69		2N5484	5072	TO-92
2N5398	N	TO-72	2N5398		9025	TO-72	2SK48	N	TO-72		2N3686	5225	TO-72
2N5432	N	TO-18	2N5432		5807	TO-72	2SK68	N	TO-92		PF5101	5172	TO-92
2N5433	N	TO-18	2N5433		5807	TO-72	3SK22	N	TO-72		2N5078	5025	TO-72
2N5434	N	TO-18	2N5434		5807	TO-72	3SK23	N	TO-72		2N5397	9025	TO-72
2N5452	N	TO-71	2N5452		8312	TO-71	3SK28	N	TO-72		2N5078	5025	TO-72
2N5453	N	TO-71	2N5453		8312	TO-71	A5T3821	N	TO-92	2N3821		5525	TO-72
2N5454	N	TO-71	2N5454		8312	TO-71	A5T3822	N	TO-92	2N3822		5525	TO-72
2N5457	N	TO-92	2N5457		5572	TO-92	A5T3823	N	TO-92	2N3823		5029	TO-72
2N5458	N	TO-92	2N5458		5572	TO-92	A5T3824	N	TO-92	2N3824		5525	TO-72
2N5459	N	TO-92	2N5459		5572	TO-92	A5T5460	P	TO-92	2N5460		8971	TO-92
2N5460	P	TO-92	2N5460		8971	TO-92	A5T5461	P	TO-92	2N5461		8971	TO-92
2N5461	P	TO-92	2N5461		8971	TO-92	A5T5462	P	TO-92	2N5462		8971	TO-92
2N5462	P	TO-92	2N5462		8971	TO-92	BC264A	N	TO-92	BC264A		5077	TO-92
2N5471	P	TO-72		2N5020	8911	TO-18	BC264B	N	TO-92	BC264B		5077	TO-92
2N5472	P	TO-72		2N5020	8911	TO-18	BC264C	N	TO-92	BC264C		5077	TO-92
2N5473	P	TO-72		2N5020	8911	TO-18	BC264D	N	TO-92	BC264D		5077	TO-92
2N5474	P	TO-72		2N5020	8911	TO-18	BF244A	N	TO-92	BF244A		5074	TO-92
2N5475	P	TO-72		2N5020	8911	TO-18	BF244B	N	TO-92	BF244B		5074	TO-92
2N5476	P	TO-72		2N5020	8911	TO-18	BF244C	N	TO-92	BF244C		5074	TO-92
2N5484	N	TO-92	2N5484		5072	TO-92	BF245A	N	TO-92	BF245A		5077	TO-92
2N5485	N	TO-92	2N5485		5072	TO-92	BF245B	N	TO-92	BF245B		5077	TO-92
2N5486	N	TO-92	2N5486		5072	TO-92	BF245C	N	TO-92	BF245C		5077	TO-92
2N5515	N	TO-71	2N5515		9512	TO-71	BF246A	N	TO-92	BF246A		5174	TO-92
2N5516	N	TO-71	2N5516		9512	TO-71	BF246B	N	TO-92	BF246B		5174	TO-92
2N5517	N	TO-71	2N5517		9512	TO-71	BF246C	N	TO-92	BF246C		5174	TO-92
2N5518	N	TO-71	2N5518		9512	TO-71	BF247A	N	TO-92	BF247A		5177	TO-92
2N5519	N	TO-71	2N5519		9512	TO-71	BF247B	N	TO-92	BF247B		5177	TO-92
2N5520	N	TO-71	2N5520		9512	TO-71	BF247C	N	TO-92	BF247C		5177	TO-92
2N5521	N	TO-71	2N5521		9512	TO-71	BF256A	N	TO-92	BF256A		5077	TO-92
2N5522	N	TO-71	2N5522		9512	TO-71	BF256B	N	TO-92	BF256B		5077	TO-92
2N5523	N	TO-71	2N5523		9512	TO-71	BF256C	N	TO-92	BF256C		5077	TO-92
2N5524	N	TO-71	2N5524		9512	TO-71	BFW10	N	TO-72		2N4224	5025	TO-72
2N5545	N	TO-71	2N5545		8312	TO-71	BFW11	N	TO-72		2N5558	5025	TO-72
2N5546	N	TO-71	2N5546		8312	TO-71	BFW61	N	TO-72		2N4224	5025	TO-72
2N5547	N	TO-71	2N5547		8312	TO-71	BSV78	N	TO-18		2N4856	5102	TO-18
2N5549	N	TO-72		2N5397	9025	TO-72	BSV79	N	TO-18		2N4857	5102	TO-18
2N5555	N	TO-92	2N5555		5072	TO-92	BSV80	N	TO-18		2N4858	5102	TO-18
2N5556	N	TO-72	2N5556		5025	TO-72	E101	N	TO-106	J201-18		5272	TO-92
2N5557	N	TO-72	2N5557		5025	TO-72	E102	N	TO-106	J202-18		5272	TO-92
2N5558	N	TO-72	2N5558		5025	TO-72	E103	N	TO-106	J203-18		5272	TO-92
2N5561	N	TO-71	2N5561		9812	TO-71	E106	N	TO-106		J108-18	5872	TO-92
2N5562	N	TO-71	2N5562		9812	TO-71	E107	N	TO-106		J108-18	5872	TO-92
2N5563	N	TO-71	2N5563		9812	TO-71	E108	N	TO-106	J108-18		5872	TO-92
2N5564	N	TO-71	2N5564		9612	TO-71	E109	N	TO-106	J109-18		5872	TO-92
2N5565	N	TO-71	2N5565		9612	TO-71	E110	N	TO-106	J110-18		5872	TO-92
2N5566	N	TO-71	2N5566		9612	TO-71	E111	N	TO-106	J111-18		5172	TO-92
2N5592	N	TO-72		PN5163-18	5072	TO-92	E112	N	TO-106	J112-18		5172	TO-92
2N5593	N	TO-72		PN5163-18	5072	TO-92	E113	N	TO-106	J113-18		5172	TO-92
2N5594	N	TO-72		PN5163-18	5072	TO-92	E114	N	TO-106	J114-18		9072	TO-92
2N5638	N	TO-92	2N5638		5172	TO-92	E174	N	TO-106	J174-18		8874	TO-92
2N5639	N	TO-92	2N5639		5172	TO-92	E175	N	TO-106	J175-18		8874	TO-92
2N5640	N	TO-92	2N5640		5172	TO-92	E176	N	TO-106	J176-18		8874	TO-92
2N5653	N	TO-92	2N5653		5172	TO-92	E177	N	TO-106	J177-18		8874	TO-92
2N5654	N	TO-92	2N5654		5172	TO-92	E201	N	TO-106	J201-18		5272	TO-92

# JFET Cross Reference Guide

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type	Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
E202	N	TO-106	J202-18		5272	TO-92	J309	N	TO-92	J309		9272	TO-92
E203	N	TO-106	J203-18		5272	TO-92	J310	N	TO-92	J310		9272	TO-92
E204	N	TO-106		PN4220-18	5572	TO-92	J3970	N	TO-92		PN4391	5172	TO-92
E210	N	TO-106	J210-18		9072	TO-92	J3971	N	TO-92		PN4392	5172	TO-92
E211	N	TO-106	J211-18		9072	TO-92	J3972	N	TO-92		PN4393	5172	TO-92
E212	N	TO-106	J212-18		9072	TO-92	J401	N	MiniDip	J401		9860	MiniDip
E230	N	TO-106		PN3821-18	5272	TO-92	J402	N	MiniDip	J402		9860	MiniDip
E231	N	TO-106		PN3684-18	5272	TO-92	J403	N	MiniDip	J403		9860	MiniDip
E232	N	TO-106		J203-18	5272	TO-92	J404	N	MiniDip	J404		9860	MiniDip
E270	P	TO-106	J270-18		8874	TO-92	J405	N	MiniDip	J405		9860	MiniDip
E271	P	TO-106	J271-18		8874	TO-92	J406	N	MiniDip	J406		9860	MiniDip
E300	N	TO-106	J300-18		9072	TO-92	J410	N	MiniDip	J410		8360	MiniDip
E304	N	TO-106	J304-18		5072	TO-92	J411	N	MiniDip	J411		8360	MiniDip
E305	N	TO-106	J305-18		5072	TO-92	J412	N	MiniDip	J412		8360	MiniDip
E308	N	TO-106	J308-18		9272	TO-92	J4091	N	TO-92	PN4091		5172	TO-92
E309	N	TO-106	J309-18		9272	TO-92	J4092	N	TO-92	PN4092		5172	TO-92
E310	N	TO-106	J310-18		9272	TO-92	J4093	N	TO-92	PN4093		5172	TO-92
E311	N	TO-106	J309		9272	TO-92	J4220	N	TO-92	PN4220		5572	TO-92
E312	N	TO-106		J310-18	9272	TO-92	J4221	N	TO-92	PN4221		5572	TO-92
E430	N	TO-71		2N5566	9612	TO-71	J4222	N	TO-92	PN4222		5572	TO-92
ESM4091	N	FO-18	2N4091		5102	TO-18	J4223	N	TO-92	PN4223		5072	TO-92
ESM4093	N	FO-18	2N4091		5102	TO-18	J4224	N	TO-92	PN4224		5072	TO-92
ESM4302	N	FO-18	PN4302-18		5272	TO-92	J4302	N	TO-92	PN4302		5272	TO-92
ESM4303	N	FO-18	PN4303-18		5272	TO-92	J4303	N	TO-92	PN4303		5272	TO-92
ESM4304	N	FO-18	PN4304-18		5272	TO-92	J4304	N	TO-92	PN4304		5272	TO-92
FT0654A	N			2N3824	5525	TO-72	J4338	N	TO-92		PN3687	5272	TO-92
FT0654B	N			2N3824	5525	TO-72	J4339	N	TO-92		PN3686	5272	TO-92
FT0654C	N			2N4221	5202	TO-18	J4391	N	TO-92	PN4391		5172	TO-92
FT3920	P	TO-18	2N3820-18		8974	TO-92	J4392	N	TO-92	PN4392		5172	TO-92
GE15457	N		2N5457		5572	TO-92	J4393	N	TO-92	PN4393		5172	TO-92
GET5458	N		2N5458		5572	TO-92	J4416	N	TO-92	PN4416		5072	TO-92
GET5459	N		2N5459		5572	TO-92	J4856	N	TO-92	PN4856		5172	TO-92
IMF3954	N	TO-71		2N3954	8312	TO-71	J4857	N	TO-92	PN4857		5172	TO-92
IMF3954A	N	TO-71		2N3954A	8312	TO-71	J4858	N	TO-92	PN4858		5172	TO-92
IMF3955	N	TO-71		2N3955	8312	TO-71	J4859	N	TO-92	PN4859		5172	TO-92
IMF3956	N	TO-71		2N3956	8312	TO-71	J4860	N	TO-92	PN4860		5172	TO-92
IMF3957	N	TO-71		2N3957	8312	TO-71	J4861	N	TO-92	PN4861		5172	TO-92
IMF3958	N	TO-71		2N3758	8312	TO-71	J5103	N	TO-92		J305	5072	TO-92
IMF6485	N	TO-71		2N6485	9512	TO-71	J5104	N	TO-92		J305	5072	TO-92
IT101	P	TO-18		2N5114	8811	TO-18	J5105	N	TO-92		J304	5072	TO-92
IT108	N			2N5486	5072	TO-92	K114-18	N			J114	9072	TO-92
ITE3066	N	TO-106		2N4340	5202	TO-18	K210-18	N		J210-18		9072	TO-92
ITE3067	N	TO-106		2N4338	5202	TO-18	K211-18	N		J211-18		9072	TO-92
ITE3068	N	TO-106		2N4338	5202	TO-18	K212-18	N		J212-18		9072	TO-92
ITE4117	N	TO-106	PN4117-18		5372	TO-92	K300-18	N		J300-18		9072	TO-92
ITE4118	N	TO-106	PN4118-18		5372	TO-92	K304-18	N		J304-18		5072	TO-92
ITE4119	N	TO-106	PN4119-18		5372	TO-92	K305-18	N		J305-18		5072	TO-92
ITE4338	N	TO-106		2N4338	5202	TO-18	K308-18	N		J308-18		9272	TO-92
ITE4339	N	TO-106		2N4339	5202	TO-18	K309-18	N		J308-18		9272	TO-92
ITE4340	N	TO-106		2N4340	5202	TO-18	K310-18	N		J310-18		9272	TO-92
ITE4341	N	TO-106		2N4391	5202	TO-18	KE510	N	TO-106		J111	5172	TO-92
ITE4391	N	TO-106	PN4391-18		5172	TO-92	KE511	N	TO-106		J111	5172	TO-92
ITE4392	N	TO-106	PN4392-18		5172	TO-92	KE3684	N	TO-106	PN3684-18		5272	TO-92
ITE4393	N	TO-106	PN4393-18		5172	TO-92	KE3685	N	TO-106	PN3685-18		5272	TO-92
ITE4416	N	TO-106	PN4416-18		5072	TO-92	KE3686	N	TO-106	PN3686-18		5272	TO-92
ITE4867	N	TO-106		PN3686-18	5272	TO-92	KE3687	N	TO-106	PN3687-18		5272	TO-92
ITE4868	N	TO-106		PN3685-18	5272	TO-92	KE3823	N	TO-106		PN4224-18	5072	TO-92
J108	N	TO-92	J108		5872	TO-92	KE3970	N	TO-106	PN4391-18		5172	TO-92
J109	N	TO-92	J109		5872	TO-92	KE3971	N	TO-106	PN4392-18		5172	TO-92
J110	N	TO-92	J110		5872	TO-92	KE3972	N	TO-106	PN4393-18		5172	TO-92
J111	N	TO-92	J111		5172	TO-92	KE4091	N	TO-106	PN4091-18		5172	TO-92
J111A	N	TO-92		PN4091	5172	TO-92	KE4092	N	TO-106	PN4092-18		5172	TO-92
J112	N	TO-92	J112		5172	TO-92	KE4093	N	TO-106	PN4093-18		5172	TO-92
J112A	N	TO-92		PN4092	5172	TO-92	KE4220	N	TO-106	PN4220-18		5572	TO-92
J113	N	TO-92	J113		5172	TO-92	KE4221	N	TO-106	PN4221-18		5572	TO-92
J113A	N	TO-92		PN4093	5172	TO-92	KE4222	N	TO-106	PN4222-18		5572	TO-92
J114	N	TO-92	J114		9072	TO-92	KE4223	N	TO-106	PN4223-18		5072	TO-92
J174	N	TO-92	J174		8874	TO-92	KE4224	N	TO-106	PN4224-18		5072	TO-92
J175	P	TO-92	J175		8874	TO-92	KE4391	N	TO-106	PN4391-18		5172	TO-92
J176	P	TO-92	J176		8874	TO-92	KE4392	N	TO-106	PN4392-18		5172	TO-92
J177	P	TO-92	J177		8874	TO-92	KE4393	N	TO-106	PN4393-18		5172	TO-92
J201	N	TO-92	J201		5272	TO-92	KE4416	N	TO-106	PN4416-18		5072	TO-92
J202	N	TO-92	J202		5274	TO-92	KE4856	N	TO-106	PN4856-18		5172	TO-92
J203	N	TO-92	J203		5272	TO-92	KE4857	N	TO-106	PN4857-18		5172	TO-92
J210	N	TO-92	J210		9072	TO-92	KE4858	N	TO-106	PN4858-18		5172	TO-92
J211	N	TO-92	J211		9072	TO-92	KE4859	N	TO-106	PN4859-18		5172	TO-92
J212	N	TO-92	J212		9072	TO-92	KE4860	N	TO-106	PN4860-18		5172	TO-92
J230	N	TO-92		J202	5272	TO-92	KE4861	N	TO-106	PN4861-18		5172	TO-92
J231	N	TO-92		J202	5272	TO-92	KE5103	N	TO-106		J305-18	5072	TO-92
J232	N	TO-92		J203	5272	TO-92	KE5104	N	TO-106		J305-18	5072	TO-92
J270	P	TO-92	J270		8874	TO-92	KE5105	N	TO-106		J304-18	5072	TO-92
J271	P	TO-92	J271		8874	TO-92	KK4416-18	N		PN4416-18		5072	TO-92
J300	N	TO-92	J300		9072	TO-92	MFE2000	N	TO-72		2N4416	5025	TO-72
J304	N	TO-92	J304		5072	TO-92	MFE2001	N	TO-72		2N4416	5025	TO-72
J305	N	TO-92	J305		5072	TO-92	MFE2004	N	TO-18		2N4093	5102	TO-18
J308	N	TO-92	J308		9272	TO-92	MFE2005	N	TO-18		2N4092	5102	TO-18

Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type	Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
MFE2006	N	TO-18		2N4091	5102	TO-18	PN3685	N	TO-92	PN3685		5272	TO-92
MFE2007	N	TO-18		2N4857	5102	TO-18	PN3686	N	TO-92	PN3686		5272	TO-92
MFE2008	N	TO-18		2N4391	5102	TO-18	PN3667	N	TO-92	PN3667		5272	TO-92
MFE2009	N	TO-18		2N4856	5102	TO-18	PN4091	N	TO-92	PN4091		5172	TO-92
MFE2010	N	TO-18		2N4856	5102	TO-18	PN4092	N	TO-92	PN4092		5172	TO-92
MFE2011	N	TO-18		2N5433	5807	TO-52	PN4093	N	TO-92	PN4093		5172	TO-92
MFE2012	N	TO-18		2N5433	5807	TO-52	PN4220	N	TO-92	PN4220		5572	TO-92
MFE4007	P	TO-72		2N5020	8911	TO-18	PN4221	N	TO-92	PN4221		5572	TO-92
MFE4008	P	TO-72		2N2608	8911	TO-18	PN4222	N	TO-92	PN4222		5572	TO-92
MFE4009	P	TO-72		2N3329	8923	TO-72	PN4223	N	TO-92	PN4223		5072	TO-92
MFE4010	P	TO-72		2N3330	8923	TO-72	PN4224	N	TO-92	PN4224		5072	TO-92
MFE4011	P	TO-72		2N3331	8923	TO-72	PN4302	N	TO-92	PN4302		5272	TO-92
MPF102	N	TO-92	MPF102		5072	TO-92	PN4303	N	TO-92	PN4303		5272	TO-92
MPF103	N	TO-92	MPF103		5572	TO-92	PN4304	N	TO-92	PN4304		5272	TO-92
MPF104	N	TO-92	MPF104		5072	TO-92	PN4342	N	TO-92	PN4342		8971	TO-92
MPF105	N	TO-92	MPF105		5572	TO-92	PN4360	N	TO-92	PN4360		8971	TO-92
MPF106	N	TO-92	MPF106		5072	TO-92	PN4391	N	TO-92	PN4391		5172	TO-92
MPF107	N	TO-92	MPF107		5072	TO-92	PN4392	N	TO-92	PN4392		5172	TO-92
MPF108	N	TO-92	MPF108		5072	TO-92	PN4393	N	TO-92	PN4393		5172	TO-92
MPF109	N	TO-92	MPF109		5572	TO-92	PN4416	N	TO-92	PN4416		5072	TO-92
MPF110	N	TO-92	MPF110		5072	TO-92	PN4856	N	TO-92	PN4856		5172	TO-92
MPF111	N	TO-92	MPF111		5072	TO-92	PN4857	N	TO-92	PN4857		5172	TO-92
MPF112	N	TO-92	MPF112		5072	TO-92	PN4858	N	TO-92	PN4858		5172	TO-92
MPF161	P	TO-92		2N5461	8971	TO-92	PN4859	N	TO-92	PN4859		5172	TO-92
MPF256	N	TO-92	MPF256		9072	TO-92	PN4860	N	TO-92	PN4860		5172	TO-92
MPF820	N	TO-92	MPF820		9272	TO-92	PN4861	N	TO-92	PN4861		5172	TO-92
MPF970	P	TO-92		P1066	8871	TO-92	PN5033	N	TO-92	PN5033		8971	TO-92
MPF971	P	TO-92		P1087	8871	TO-92	PN5163	N	TO-92	PN5163		5072	TO-92
MPF4391	N	TO-92	PN4391		5172	TO-92	SU2000	N	TO-71		2N3822	5525	TO-72
MPF4392	N	TO-92	PN4392		5172	TO-92	SU2020	N	TO-71		2N5196	8312	TO-71
MPF4393	N	TO-92	PN4393		5172	TO-92	SU2021	N	TO-71		2N5196	8312	TO-71
NDF9401	N	TO-78		NDF9406	9412	TO-71	SU2022	N	TO-71		2N5196	8312	TO-71
NDF9402	N	TO-78		NDF9407	9412	TO-71	SU2023	N	TO-71		2N5196	8312	TO-71
NDF9403	N	TO-78		NDF9408	9412	TO-71	SU2024	N	TO-71		2N5196	8312	TO-71
NDF9404	N	TO-78		NDF9409	9412	TO-71	SU2025	N	TO-71		2N5196	8312	TO-71
NDF9405	N	TO-78		NDF9410	9412	TO-71	SU2026	N	TO-71		2N5196	8312	TO-71
NDF9406	N	TO-71	NDF9406		9412	TO-71	SU2027	N	TO-71		2N5196	8312	TO-71
NDF9407	N	TO-71	NDF9407		9412	TO-71	SU2028	N	TO-71		2N5196	8312	TO-71
NDF9408	N	TO-71	NDF9408		9412	TO-71	SU2029	N	TO-71		2N5196	8312	TO-71
NDF9409	N	TO-71	NDF9409		9412	TO-71	SU2030	N	TO-71		2N4082	8312	TO-71
NDF9410	N	TO-71	NDF9410		9412	TO-71	SU2033	N	TO-71		2N5561	8312	TO-71
NF500	N	TO-72		2N4224	5025	TO-72	SU2034	N	TO-71		2N5561	8312	TO-71
NF501	N	TO-72		2N4224	5025	TO-72	SU2035	N	TO-71		2N5561	8312	TO-71
NF506	N	TO-72		2N3823	5025	TO-72	SU2076	N	TO-71		2N5561	8312	TO-71
NF510	N	TO-18		2N4092	5102	TO-18	SU2077	N	TO-71		2N5561	8312	TO-71
NF511	N	TO-18		2N4092	5102	TO-18	SU2078	N	TO-71		2N3955	8312	TO-71
NF520	N	TO-72		2N4224	5025	TO-72	SU2079	N	TO-71		2N3956	8312	TO-71
NF521	N	TO-72		2N4220	5525	TO-72	SU2080	N	TO-71		U404	9812	TO-71
NF522	N	TO-72		2N4224	5025	TO-72	SU2081	N	TO-71		U404	9812	TO-71
NF523	N	TO-72		2N4220	5525	TO-72	SU2098	N	TO-71		2N3954	8312	TO-71
NF530	N	TO-18		2N3822	5525	TO-72	SU2098A	N	TO-71		2N3954	8312	TO-71
NF531	N	TO-18		2N3821	5525	TO-72	SU2098B	N	TO-71		2N3954A	8312	TO-71
NF532	N	TO-18		2N3822	5525	TO-72	SU2099	N	TO-71		2N3955A	8312	TO-71
NF533	N	TO-18		2N3821	5525	TO-72	SU2099A	N	TO-71		2N3955A	8312	TO-71
NF3819	N	TO-18	2N3819-18		5074	TO-92	SU2365	N	TO-71		U401	9812	TO-71
NF4302	N	TO-18	PN4302-18		5272	TO-92	SU2365A	N	TO-71		U401	9812	TO-71
NF4303	N	TO-18	PN4303-18		5272	TO-92	SU2366	N	TO-71		U402	9812	TO-71
NF4304	N	TO-18	PN4304-18		5272	TO-92	SU2366A	N	TO-71		U402	9812	TO-71
NF4445	N	TO-18		2N5432	5807	TO-52	SU2367	N	TO-71		U403	9812	TO-71
NF4446	N	TO-18		2N5433	5807	TO-52	SU2367A	N	TO-71		U403	9812	TO-71
NF4447	N	TO-18		2N5432	5807	TO-52	SU2368	N	TO-71		U404	9812	TO-71
NF4448	N	TO-18		2N4856	5807	TO-52	SU2368A	N	TO-71		U404	9812	TO-71
NF5101	N	TO-72	NF5101		5125	TO-72	SU2369	N	TO-71		U405	9812	TO-71
NF5102	N	TO-72	NF5102		5125	TO-72	SU2369A	N	TO-71		U405	9812	TO-71
NF5103	N	TO-72	NF5103		5125	TO-72	SU2652M	N	MiniDip		J401	9860	MiniDip
NF5163	N	TO-18	PN5163-18		5072	TO-72	SU2653M	N	MiniDip		J401	9860	MiniDip
NF5457	N	TO-18	2N5457-18		5572	TO-92	SU2654M	N	MiniDip		J401	9860	MiniDip
NF5458	N	TO-18	2N5458-18		5572	TO-92	SU2655M	N	MiniDip		J402	9860	MiniDip
NF5459	N	TO-18	2N5459-18		5572	TO-92	SU2656M	N	MiniDip		J404	9860	MiniDip
NF5484	N	TO-18	2N5484-18		5072	TO-92	TD5452	N	TO-18/8		2N5452	8312	TO-71
NF5485	N	TO-18	2N5485-18		5072	TO-92	TD5453	N	TO-18/8		2N5453	8312	TO-71
NF5486	N	TO-18	2N5486-18		5072	TO-92	TD5454	N	TO-18/8		2N5454	8312	TO-71
NF5555	N	TO-72	2N5555-18		5072	TO-92	TD5902	N	TO-18/8	2N5902		8424	TO-78
NF5638	N	TO-18	2N5638-18		5172	TO-92	TD5902A	N	TO-18/8		2N5902	8424	TO-78
NF5639	N	TO-18	2N5639-18		5172	TO-92	TD5903	N	TO-18/8	2N5903		8424	TO-78
NF5640	N	TO-18	2N5640-18		5172	TO-92	TD5903A	N	TO-18/8		2N5903	8424	TO-78
NF5653	N	TO-18	2N5653-18		5172	TO-92	TD5904	N	TO-18/8	2N5904		8424	TO-78
NF5654	N	TO-18	2N5654-18		5172	TO-92	TD5904A	N	TO-18/8		2N5904	8424	TO-78
P1086E	P	TO-106	P1086-18		8871	TO-92	TD5905	N	TO-18/8	2N5905		8424	TO-78
P1087E	P	TO-106	P1087-18		8871	TO-92	TD5905A	N	TO-18/8		2N5905	8424	TO-78
PF510	P	TO-18		PN4392-18	5172	TO-92	TD5906	N	TO-18/8	2N5906		8424	TO-78
PF511	P	TO-18		PN4392-18	5172	TO-92	TD5906A	N	TO-18/8		2N5906	8424	TO-78
PF5101	N	TO-92	PF5101		5172	TO-92	TD5907	N	TO-18/8	2N5907		8424	TO-78
PF5102	N	TO-92	PF5102		5172	TO-92	TD5907A	N	TO-18/8		2N5907	8424	TO-78
PF5103	N	TO-92	PF5103		5172	TO-92	TD5908	N	TO-18/8	2N5908		8424	TO-78
PN3684	N	TO-92	PN3684		5272	TO-92	TD5908A	N	TO-18/8		2N5908	8424	TO-78

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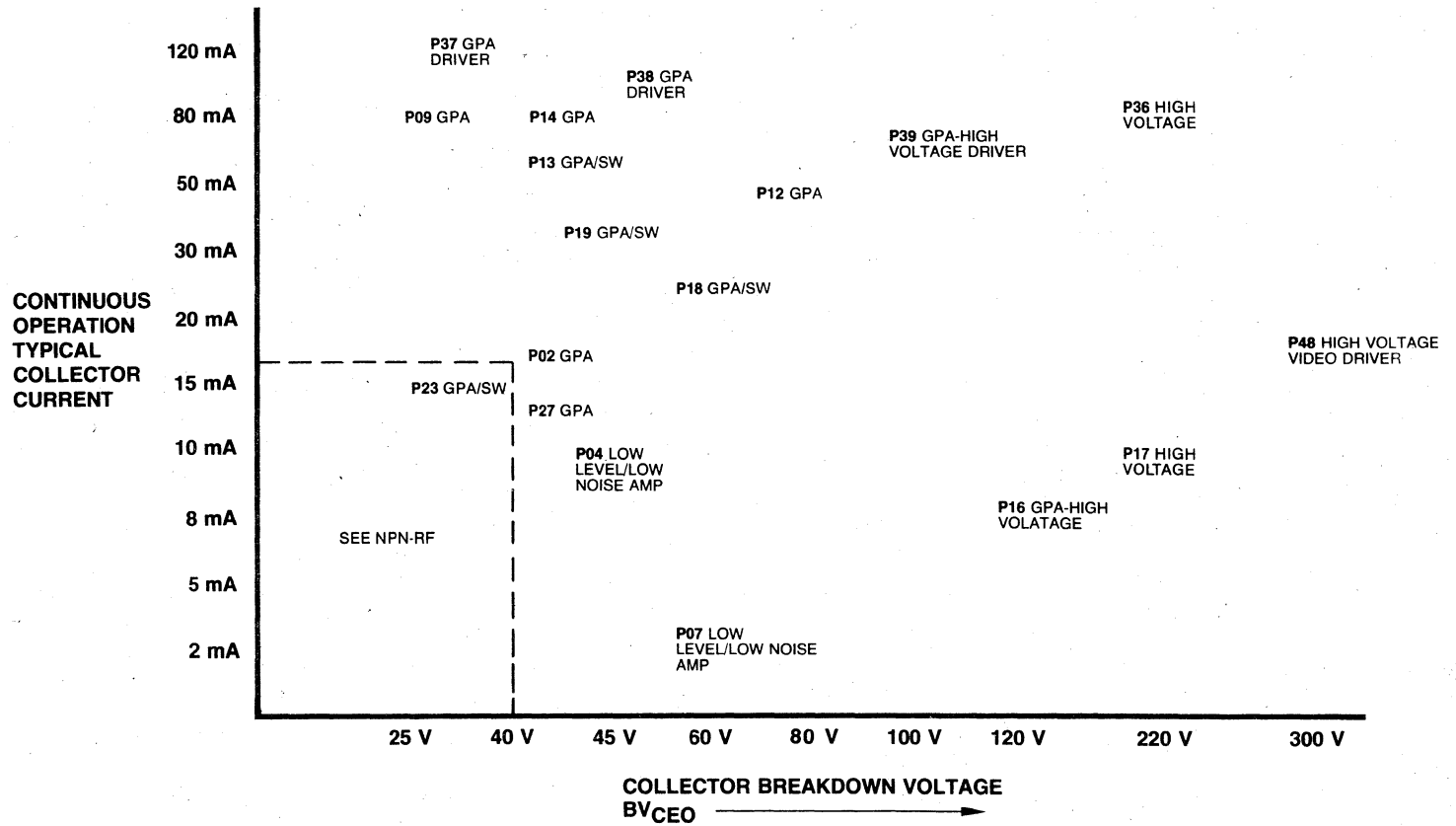
Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type	Industry P/N	Polarity	Package	Direct Replacement	Closest Equivalent Replacement	Process Package	Package Type
TD5909	N	TO-18/8	2N5909		8424	TO-78	U312	N	TO-18	U312		9007	TO-52
TD5909A	N	TO-18/8		2N5909	8424	TO-78	U316	N	B-69	U309		9207	TO-52
TD5910	N	TO-18/8	2N5910		8424	TO-78	U317	N	B-69	U310		9207	TO-52
TD5910A	N	TO-18/8		2N5910	8424	TO-78	U320	N	TO-5		2N5433	5807	TO-52
TD5911	N	TO-18/8	2N5911		9324	TO-78	U321	N	TO-5		2N5433	5807	TO-52
TD5911A	N	TO-18/8		2N5911	9324	TO-78	U322	N	TO-5		2N5432	5807	TO-52
TD5912	N	TO-18/8	2N5912		9324	TO-78	U401	N	TO-71	U401		9812	TO-71
TD5912A	N	TO-18/8		2N5912	9324	TO-78	U402	N	TO-71	U402		9812	TO-71
TIS25	N	TO-5/6		U401	9812	TO-71	U403	N	TO-71	U403		9812	TO-71
TIS26	N	TO-5/6		U402	9812	TO-71	U404	N	TO-71	U404		9812	TO-71
TIS27	N	TO-5/6		U403	9812	TO-71	U405	N	TO-71	U405		9812	TO-71
TIS34	N	TO-92		2N5486	5072	TO-92	U406	N	TO-71	U406		9812	TO-71
TIS41	N	TO-18		2N4859	5172	TO-92	U440	N	TO-71		2N5911	9324	TO-78
TIS42	N	TO-92		PN4392	5172	TO-92	U441	N	TO-71		2N5912	9324	TO-78
TIS58	N	TO-92	TIS58		5074	TO-92	U1837E	N	TO-106		2N5486-18	5072	TO-92
TIS59	N	TO-92	TIS59		5074	TO-92	U1897	N	TO-106	U1897		5172	TO-92
TIS73	N	TO-18	TIS73		5177	TO-92	U1897E	N	TO-106		U1897-18	5172	TO-92
TIS74	N	TO-18	TIS74		5177	TO-92	U1898	N	TO-106	U1898		5172	TO-92
TIS75	N	TO-18	TIS75		5177	TO-92	U1898E	N	TO-106		U1898-18	5172	TO-92
TIS88A	N	TO-18		2N5486	5072	TO-92	U1899	N	TO-106	U1899		5172	TO-92
TP5114	P	TO-18	2N5114		8811	TO-18	U1899E	N	TO-106		U1899-18	5172	TO-92
TP5115	P	TO-18	2N5115		8811	TO-18	U1994	N	TO-106		PN4416-18	5072	TO-92
TP5116	P	TO-18	2N5116		8811	TO-18	U1994E	N	TO-106		PN4416-18	5072	TO-92
U110	P	TO-18		2N5020	8911	TO-18	U2047	N	TO-92		PN4416	5072	TO-92
U112	P	TO-18		2N4318	8911	TO-18	U2047E	N	TO-106		PN4416-18	5072	TO-92
U146	P	TO-18		2N5020	8911	TO-18	UC155	N	TO-72		2N4416	5025	TO-72
U147	P	TO-18		2N5020	8911	TO-18	UC200	N	TO-72		2N4393	5102	TO-18
U148	P	TO-18		2N2608	8911	TO-18	UC201	N	TO-72		2N4416	5025	TO-72
U149	P	TO-18		2N2609	8811	TO-18	UC210	N	TO-72		2N3822	5525	TO-72
U183	N	TO-72		2N3823	5025	TO-72	UC220	N	TO-72		2N4220	5525	TO-72
U184	N	TO-72		2N4416	5025	TO-72	UC241	N	TO-72		2N3822	5525	TO-72
U197	N	TO-18		2N4338	5202	TO-18	UC250	N	TO-18		2N4391	5102	TO-18
U198	N	TO-18		2N4340	5202	TO-18	UC251	N	TO-18		2N4392	5102	TO-18
U199	N	TO-18		2N4341	5202	TO-18	UC400	P	TO-72		2N2609	8811	TO-18
U200	N	TO-18		2N4393	5102	TO-18	UC401	P	TO-72		2N5019	8811	TO-18
U201	N	TO-18		2N4392	5102	TO-18	UC410	P	TO-72		2N2609	8811	TO-18
U202	N	TO-18		2N4391	5102	TO-18	UC420	P	TO-72		2N3329	8923	TO-72
U231	N	TO-71	U231		8312	TO-71	UC588	N	TO-106		PN4416-18	5072	TO-92
U232	N	TO-71	U232		8312	TO-71	UC703	N	TO-72		2N3822	5525	TO-72
U233	N	TO-71	U233		8312	TO-71	UC705	N	TO-72		2N3824	5525	TO-72
U234	N	TO-71	U234		8312	TO-71	UC707	N	TO-18		2N4391	5102	TO-18
U235	N	TO-71	U235		8312	TO-71	UC714	N	TO-72		2N4416	5025	TO-72
U257	N	TO-78	U257		9324	TO-78	UC734	N	TO-72		2N4416	5025	TO-72
U300	P	TO-18		2N5114	8811	TO-18	UC734E	N	TO-106		PN4416-18	5072	TO-92
U301	P	TO-18		2N5145	8811	TO-18	UC755	N	TO-18		2N4391	5102	TO-18
U304	P	TO-18		2N5114	8811	TO-18	UC756	N	TO-18		2N4224	5025	TO-72
U305	P	TO-18		2N5116	8811	TO-18	UC805	P	TO-72		2N3331	8923	TO-72
U308	N	TO-52	U308		9207	TO-52	UC807	P	TO-72		2N4861	5102	TO-18
U309	N	TO-52	U309		9207	TO-52	UC814	P	TO-72		2N3331	8923	TO-72
U310	N	TO-52	U310		9207	TO-52	UC851	P	TO-18		2N2608	8911	TO-18

# RF Selector Guide

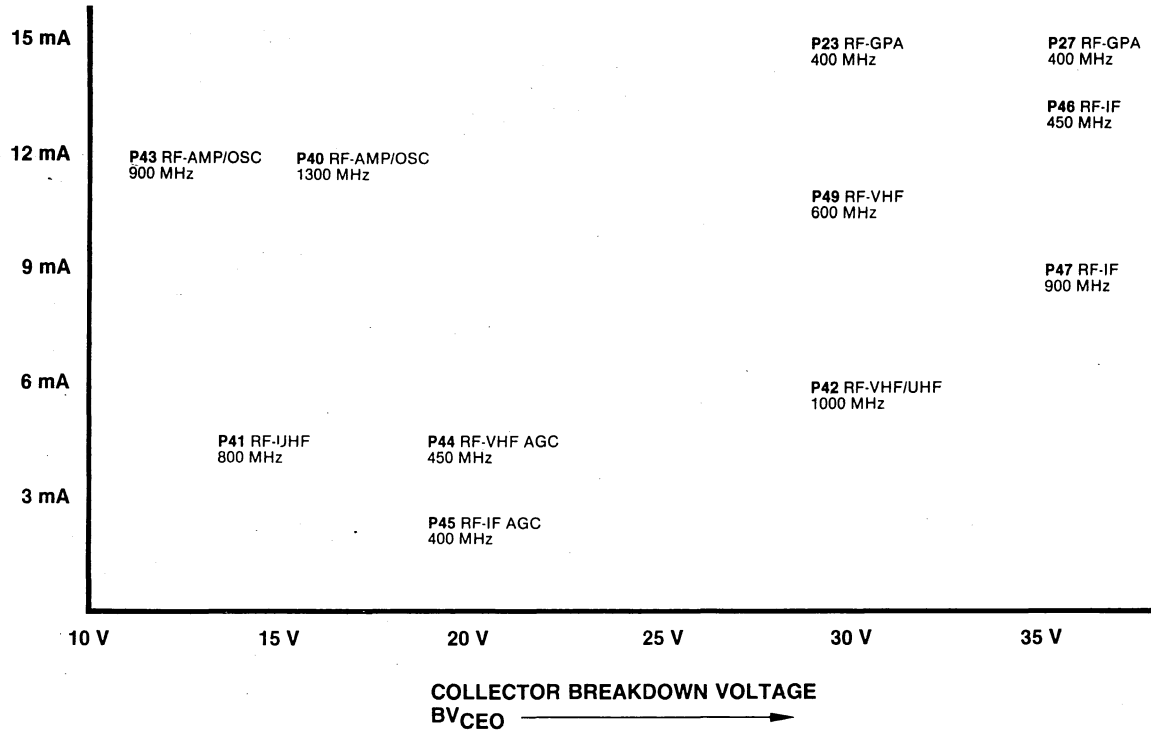
	BIPOLARS									JFETs		
	40	41	42	43	44	45	46	47	49	50	90	92
<b>Preamplifiers</b>												
> 500 MHz		•										
> 500 MHz with AGC	•	•								•		•
200–500 MHz			•									
200–500 MHz with AGC					•							
50–250 MHz			•		•			•		•	•	•
50–250 MHz with AGC					•							
20–120 MHz					•	•			•	•	•	
<b>Mixers</b>												
Input > 500 MHz		•										
Input 200–500 MHz	•		•					•		•	•	•
Input 50–250 MHz	•		•		•			•	•	•	•	
Input 20–120 MHz							•	•	•	•	•	
<b>Loc Osc</b>												
> 500 MHz Mech. Tuned			•	•								
> 500 MHz Varactor	•		•									
200–500 MHz Mech. Tuned				•				•				
200–500 MHz Varactor	•		•					•				
50–250 MHz				•				•				
20–120 MHz				•				•				
<b>IF Amps</b>												
< 75 MHz			•			•	•	•	•	•	•	
< 15 MHz				•			•	•		•		
< 75 MHz with AGC					•	•		•				
< 15 MHz with AGC					•			•				
< 75 MHz Last Stage							•	•	•			
< 15 MHz Last Stage							•		•	•		
<b>Special Uses</b>												
200–500 MHz < 1.0 mA Bias	•		•									
50–250 MHz < 1.0 mA Bias	•		•									
200–500 MHz 5–15 mA Linear IF	•											
50–250 MHz 5–15 mA Linear IF								•				•
< 120 MHz/15 mA Wideband RF								•				•
VHF Freq. Generator and/or Multiplier to 75 mW Levels	•			•								



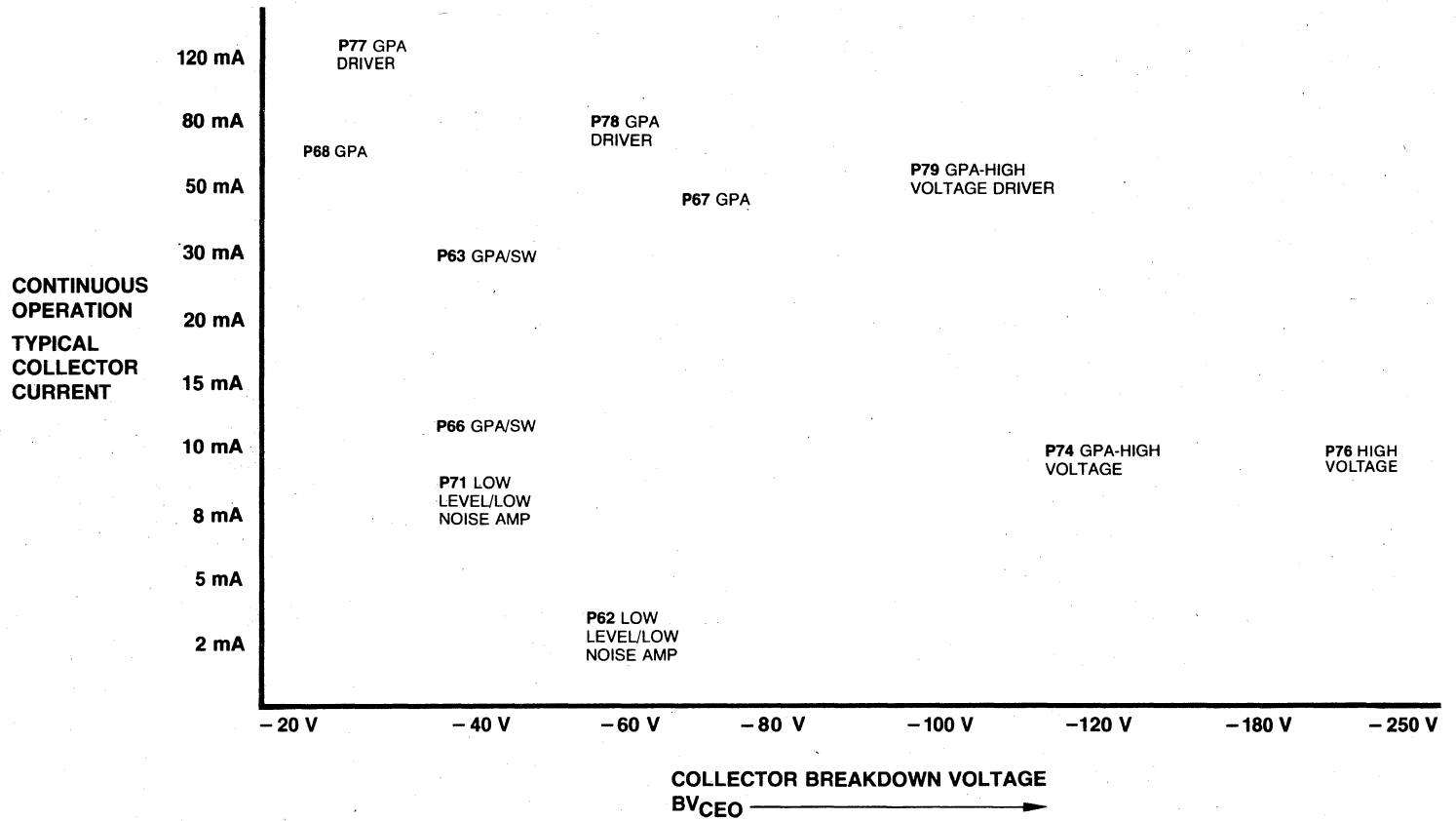
# Transistors NPN GPA Devices



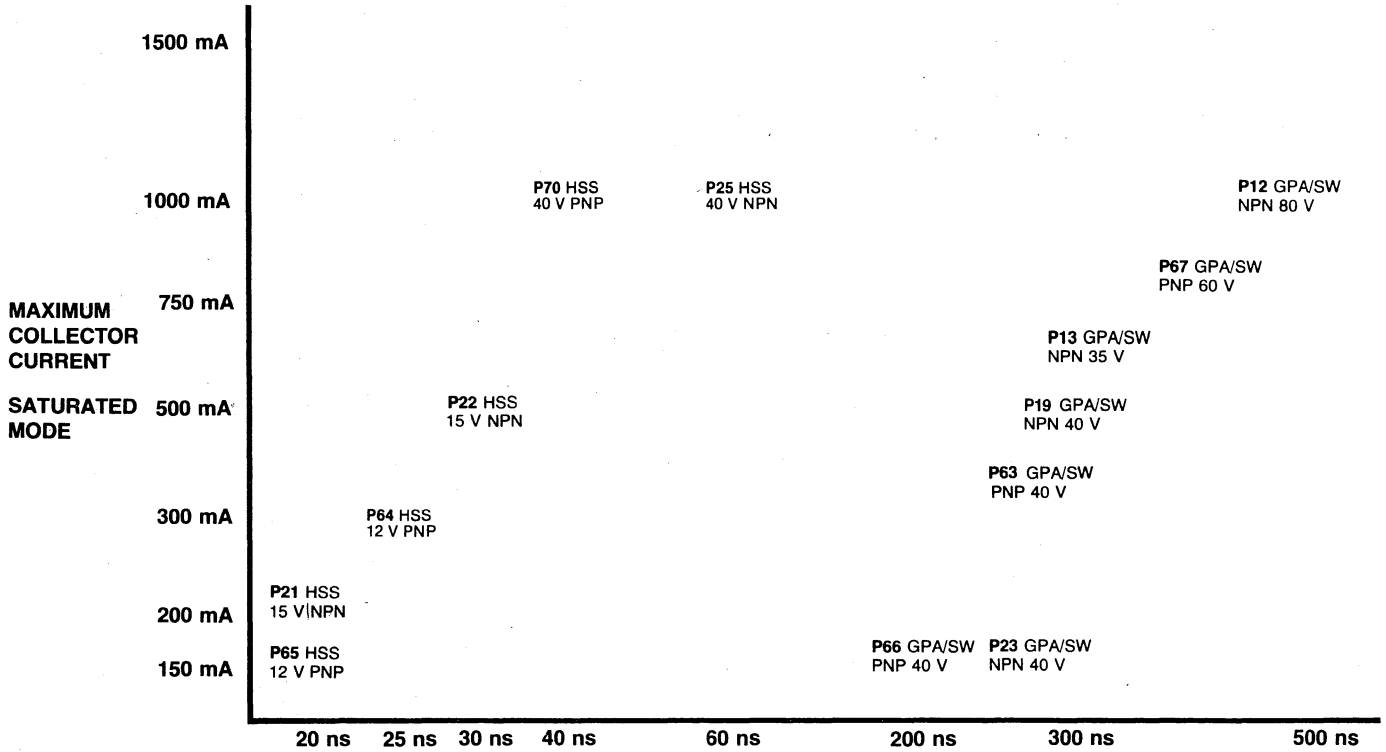
CONTINUOUS  
OPERATION  
TYPICAL  
COLLECTOR  
CURRENT



# Transistors PNP GPA Devices



4-17



GPA/SW – General Purpose Amplifier/Switch  
 HSS – High Speed Switch

**MAXIMUM T<sub>OFF</sub>** →  
 SEE DATA BOOK FOR CIRCUIT CONDITIONS

## TO-237 Type Power Transistor Selection Guide

Part Number		I <sub>C</sub> (A)	V <sub>CEO</sub> (V)	h <sub>FE</sub>		@		Max V <sub>CE(SAT)</sub>		P <sub>D</sub> (W)	f <sub>T</sub> (MHz)	Process (NPN/PNP)
NPN	PNP			Min	Max	I <sub>C</sub> (mA)	V <sub>CE</sub> (V)	(V)	@ I <sub>C</sub> (mA)			
92PE869	92PE870	0.1	250	50		25	20			*	60	17/76
92PE871	92PE872	0.1	300	50		25	20				60	17/76
2N6711/ 92PE487		0.1	160	30		30	10	1	30	*	50	48
2N6733/ 92PU391		0.1	200	40		10	10	2	20		50	48
2N6712/ 92PE488		0.1	250	30		30	10	1	30		50	48
2N6734/ 92PU392		0.1	250	40		10	10	2	20		50	48
2N6773/ 92PE489		0.1	300	30		30	10	1	30	*	50	48
2N6735/ 92PU393		0.1	300	40		10	10	2	20		50	48
2N6719/ 92PU10		0.1	300	40		30	10	0.75	30		50	48
TN2219		0.5	30	100	300	150	10	0.4	150	*	250	19
TN2218A		0.5	40	40	120	150	10	0.3	150		250	19
TN2219A	TN2905	0.5	40	100	300	150	10	0.3/ 0.4	150		300	19/63
	TN2904A	0.5	60	40	120	150	10	0.4	150		200	63
	TN2905A	0.5	60	100	300	150	10	0.4	150		200	63
TN3053	TN4037	1	40	50	250	150	10	1.4	150	*	100	12/63
2N6737		1	45	60	150	100	1	0.4	300		300	25
TN3726		1	50	60	150	100	1	0.4	300		300	25
TN2102	TN4036	1	65	40	120	150	10	0.5/ 0.65	150	*	60	12/67
TN3019		1	80	100	300	150	10	0.2	150		100	12
TN3020		1	80	40	120	150	10	0.2	150		100	12
	TN4033	1	80	100	300	100	5	0.15	150		150	67
2N6720/ 92PU36		1	150	30	300	100	10	0.5	100	*	10	36
2N6721/ 92PU36A		1	200	0		00	10	0.5	00		10	36
2N6722/ 92PU36B		1	250								10	36
2N6723/ 92PU36C		1	300								10	36
TN3724		1.5	30	60	150	100	1	0.2	100		300	25
				40		300	1	0.32	300			

\*All TO-237: 850 mW, free air (T<sub>A</sub> = 25°C)  
 2.0W, collector lead at 25°C  
 1W-1.2W mounted flush in PC board

# TO-237 Type Power Transistor Selection Guide (Continued)

Part Number		I <sub>C</sub> (A)	V <sub>CEO</sub> (V)	h <sub>FE</sub>		@		Max V <sub>CE</sub> (SAT)		P <sub>D</sub> (W)	f <sub>T</sub> (MHz)	Process (NPN/PNP)
NPN	PNP			Min	Max	I <sub>C</sub> (mA)	V <sub>CE</sub> (V)	(V)	@ I <sub>C</sub> (mA)			
2N6714/ 92PU01	2N6726/ 92PU51	2	30	60	55	100	1	0.5	1000		50	37/77
2N6715/ 92PU01A	2N6727/ 92PU51A			100		1	0.5	1000				
2N6724/ 92PU45		2	40	25k	4k	200	5	1	200	*	100	05
2N6705/ 92PE37A	2N6708/ 92PE77A			500		5	1.5	1000				
2N6725 92PU45A		2	50	25k	4k	200	5	1	200		100	05
				25k	4k	1000	5	1.5	1000			
2N6706/ 92PE37B	2N6709/ 92PE77B	2	60	40		500	2	0.5	500		50	38/78
2N6716/ 92PU05	2N6728/ 92PU55	2	60	20		500	1	0.35	250		50	38/78
2N6731/ 92PU100	2N6732/ 92PU200	2	80	100	300	350	2	0.35	350	*	50	39/79
2N6707/ 92PE37C	2N6710/ 92PE77C	2	80	40		500	2	0.5	500		50	39/79
2N6717/ 92PU06	2N6720/ 92PU56	2	80	20		500	1	0.35	250		50	39/79

Pinout: 92PE      ECB  
 92PU, TN      EBC

\*All TO-237: 850 mW, free air (T<sub>A</sub> = 25°C)  
 2.0W, collector lead at 25°C  
 1W-1.2W mounted flush in PC board

## TO-202 Type Power Transistor Selection Guide

Part Number		I <sub>C</sub> (A)	V <sub>CE0</sub> (V)	h <sub>FE</sub>		@		Max V <sub>CE</sub> (SAT)		P <sub>D</sub> (W)	f <sub>T</sub> (MHz)	Process (NPN/PNP)
NPN	PNP			Min	Max	I <sub>C</sub> (A)	V <sub>CE</sub> (V)	(V)	@ I <sub>C</sub> (A)			
NSD457		0.1	160	25		0.03	10	1	0.03	1.75	50	48
NSE457		0.1	160	25		0.03	10	1	0.03	1.75	50	48
NSD458		0.1	250	25		0.03	10	1	0.03	1.75	50	48
NSE458		0.1	250	25		0.03	10	1	0.03	1.75	50	48
D40N1		0.1	250	30	90	0.02	10			1.67	50	48
D40N2		0.1	250	60	180	0.02	10			1.67	50	48
NSD131		0.1	250	30	90	0.03	10	1	0.02	1.75		48
NSD132		0.1	250	60	180	0.03	10	1	0.02	1.75		48
NSE869	NSE870	0.1	250	50		25m	20			1.8	60	17/76
NSD871	NSE872	0.1	300	50		25m	20			1.8	60	17/76
D40N3		0.1	300	30	90	0.02	10			1.67	50	48
D40N4		0.1	300	60	180	0.02	10			1.67	50	48
NSD133		0.1	300	30	90	0.03	10	1	0.02	1.75	50	48
NSD134		0.1	300	60	180	0.03	10	1	0.02	1.75	50	48
NSD459		0.1	300	25		0.03	10	1	0.03	1.75	50	48
NSE459		0.1	300	25		0.03	10	1	0.03	1.75	50	48
NSDU10		0.1	300	40		0.03	10	1.5	0.02	1.75	60	48
D40N5		0.1	375	20		0.02	10			1.67	50	48
NSD135		0.1	375	30	90	0.03	10	1	0.02	1.75	50	48
D40C1		0.5	30	10k	60k	0.2	5	1.5	0.5	1.33	75	05
D40C2		0.5	30	40k		0.2	5	1.5	0.5	1.33	75	05
D40C3		0.5	30	90k		0.2	5	1.5	0.5	1.33	75	05
D40C4		0.5	40	10k	60k	0.2	5	1.5	0.5	1.33	75	05
D40C5		0.5	40	40k		0.2	5	1.5	0.5	1.33	75	05
D40C7		0.5	50	10k	60k	0.2	5	1.5	0.5	1.33	75	05
D40C8		0.5	50	40k		0.2	5	1.5	0.5	1.33	75	05
D40P1		0.5	120	40		0.08	10	1	0.1	1.67	50	36
D40P3		0.5	180	40		0.08	10	1	0.1	1.67	50	36
D40P5		0.5	225	40		0.08	10	1	0.1	1.67	50	36
D40D1	D41D1	1	30	50	150	0.1	2	0.5	0.5	1.67	200	38/78
D40D2	D41D2	1	30	120	300	0.1	2	0.5	0.5	1.67	200	38/78
D40D3		1	30	290		0.1	2			1.67	200	38
D40D4	D41D4	1	45	50	150	0.1	2	0.5	0.5	1.67	200	38/78
D40D5	D41D5	1	45	120	360	0.1	2	0.5	0.5	1.67	200	38/78
NSD102	NSD202	1	45	50	150	0.1	5	0.2	0.1	1.75	60	38/78
NSD103	NSD203	1	45	120	360	0.1	5	0.2	0.1	1.75	60	38/78
D40D7	D41D7	1	60	50	150	0.1	2	1	0.5	1.67	200	38/78
D40D8	D41D8	1	60	120	360	0.1	2	1	0.5	1.67	200	38/78
2N6551	2N6554	1	60	80	250	0.05	1	0.5	0.25	2.0	75	38/78
D40D10	D41D10	1	75	50	150	0.1	2	1	0.5	1.67	200	38/78
D40D11	D41D11	1	75	120	360	0.1	2	1	0.5	1.67	200	38/78
D40D13	D41D13	1	75	50	150	0.1	2	1	0.5	1.67	200	38/78
D40D14	D41D14	1	75	120	360	0.1	2	1	0.5	1.67	200	38/78
2N6552	2N6555	1	80	80	250	0.05	1	0.5	0.25		75	39/79
NSD104	NSD204	1	80	50	150	0.1	5	0.2	0.1	1.75	60	39/79
NSD105	NSD205	1	80	120	360	0.1	5	0.2	0.1	1.75	60	39/79
NSD106	NSD206	1	100	50	150	0.1	5	0.2	0.1	1.75	60	39/79
2N6553	2N6556	1	100	80	250	0.05	1	0.5	0.25		75	39/79
NSD36		1	150	30	300	0.1	10	0.5	0.1	1.75	10	36
NSD36A		1	200	30	300	0.1	10	0.5	0.1	1.75	10	36
NSD36B		1	250	30	300	0.1	10	0.5	0.1	1.75	10	36
NSD36C		1	300	30	300	0.1	10	0.5	0.1	1.75	10	36

# TO-202 Type Power Transistor Selection Guide (Continued)

Part Number		I <sub>c</sub> (A)	V <sub>CEO</sub> (V)	h <sub>FE</sub>		@		Max V <sub>CE(SAT)</sub>		P <sub>D</sub> (W)	f <sub>T</sub> (MHz)	Process (NPN/PNP)
NPN	PNP			Min	Max	I <sub>c</sub> (A)	V <sub>CE</sub> (V)	(V)	@ I <sub>c</sub> (A)			
NSDU01	NSDU51	2	30	60		0.1	1	0.5	1	1.75	50	37/77
NSD151		2	30	10k	250k	0.1	5	1.5	0.1	1.75	100	05
NSD153		2	30	5k		0.1	5	1.5	0.1	1.75	100	05
D40E1	D41E1	2	30	50		0.1	2	1	1	1.3		37/77
D40K1	D41K1	2	30	10k		0.2	5	1.5	1.5	1.67	75	05/61
D40K3	D41K3	2	30	10k		0.2	5	1.5	1.0	1.67	75	05/61
NSDU01A	NSDU51A	2	40	60		0.1	1	0.5	1	1.75	50	37/77
NSDU02	NSDU52	2	40	50	300	0.15	10	0.4	0.15	1.75	50	37/77
2N6548		2	40	15k		0.2	5	1.5	1	1.75	100	05
2N6549		2	40	25k		0.2	5	1.5	1	1.75	100	05
NSDU45		2	40	25k	150k	0.2	5	1	0.2	1.75	100	05
NSD152		2	40	10k	250k	0.1	5	1.5	1	1.75	100	05
NSD154		2	40	5k		0.1	5	1.5	1	1.75	100	05
D40K2	D41K2	2	50	10k		0.2	5	1.5	1.5	1.67	75	05/61
D40K4	D41K4	2	50	10k		0.2	5	1.5	1.0	1.67	75	05/61
NSDU45A		2	50	25k	150k	0.2	5	1	0.2	1.75	100	05
NSDU05	NSDU55	2	60	80		0.05	1	0.5	0.25	1.75	50	38/78
D40E5	D41E5	2	60	50		0.1	2	1	1	1.3		38/78
NSDU06	NSDU56	2	80	80		0.05	1	0.5	0.25	1.75	50	39/79
D40E7	D41E7	2	80	50		0.1	2	1	1	1.3		38/78
NSDU07	NDSU57	2	100	80		0.05	1	0.5	0.25	1.75	50	39/79
D42C1	D43C1	3	30	25		0.2	1	0.5	1	2.1	50	4P/5P
D42C2	D43C2	3	30	100	220	0.2	1	0.5	1	2.1	50	4P/5P
D42C3	D43C3	3	30	40	120	0.2	1	0.5	1	2.1	50	4P/5P
D42C4	D43C4	3	45	25		0.2	1	0.5	1	2.1	50	4P/5P
D42C5	D43C5	3	45	100	220	0.2	1	0.5	1	2.1	50	4P/5P
D42C6	D43C6	3	45	40	120	0.2	1	0.5	1	2.1	50	4P/5P
D42C7	D43C7	3	60	25		0.2	1	0.5	1	2.1	50	4P/5P
D42C8	D43C8	3	60	100	220	0.2	1	0.5	1	2.1	50	4P/5P
D42C9	D43C9	3	60	40	120	0.2	1	0.5	1	2.1	50	4P/5P
D42C10	D43C10	3	80	25		0.2	1	0.5	1	2.1	50	4P/5P
D42C11	D43C11	3	80	100	220	0.2	1	0.5	1	2.1	50	4P/5P
D42C12	D43C12	3	80	40	120	0.2	1	0.5	1	2.1	50	4P/5P

Pinout: EBC, NSDU, NSD, D40, D41  
BCE, NSE, D42, D43



## TO-126 Type Power Transistor Selection Guide

Part Number		I <sub>C</sub> (A)	V <sub>CEO</sub> (V)	h <sub>FE</sub>		@		Max V <sub>CE</sub> (SAT)		P <sub>D</sub> (W)	f <sub>T</sub> (MHz)	Process (NPN/PNP)
NPN	PNP			Min	Max	I <sub>C</sub> (A)	V <sub>CE</sub> (V)	(V)	@ I <sub>C</sub> (A)			
MJE3440		0.3	250	40	160	0.02	10	0.5	0.05	15	15	36
MJE3439		0.3	350	40	160	0.02	10	0.5	0.05	15	15	36
MJE341		0.5	150	25	200	0.05	10	1	0.05	20	15	36
MJE344		0.5	200	30	300	0.05	10	1	0.05	30	15	36
2N5655		0.5	250	30	250	0.1	10	1	0.1	20	10	36
MJE340		0.5	300	30	240	0.05	10			20		36
2N5656		0.5	300	30	250	0.1	10	1	0.1	20	10	36
2N5657		0.5	350	30	250	0.1	10	1	0.1	20	10	36
2N4921	2N4918	1	40	20	100	0.5	1	0.6	1	30	3	4H/5F
2N4922	2N4919	1	60	20	100	0.5	1	0.6	1	30	3	4H/5F
2N4923	2N4920	1	80	20	100	0.5	1	0.6	1	30	3	4H/5F
MJE720	MJE710	1.5	40	40		0.15	1	0.15	0.15	20		37/77
BD345	BD344	1.5	60	40	250	0.2	1	0.4	0.2	20	50	38/78
MJE721	MJE711	1.5	60	40		0.15	1	0.15	0.15	20		38/78
BD349	BD348	1.5	80	50	250	0.25	1	0.5	0.25	20	50	39/79
MJE722	MJE712	1.5	80	40		0.15	1	0.15	0.15	20		39/79
MJE520	MJE370	3	30	25		1	1			25		4F/5F
MJE180	MJE170	3	40	50	250	0.1	1	0.3	0.5	12.5	50	37/77
MJE181	MJE171	3	60	50	250	0.1	1	0.3	0.5	12.5	50	38/78
MJE182	MJE172	3	80	50	250	0.1	1	0.3	0.5	12.5	50	39/79
MJE220	MJE230	4	40	20		2	1	0.8	2	15	50	4P/5P
MJE221	MJE231	4	40	20		1	1	0.6	1	15	50	4P/5P
MJE222	MJE232	4	40	25		1	1	0.3	0.5	15	50	4P/5P
MJE521	MJE371	4	40	40		0.1	1			40		4F/5F
2N5190	2N5193	4	40	25	100	1.5	2	0.6	1.5	40	2	4E/5E
2N6037	2N6034	4	40	750	15k	2	3	2	2	40		4J/5J
2N5191	2N5194	4	60	25	100	1.5	2	0.6	1.5	40	2	4E/5E
MJE223	MJE233	4	60	20		2	1	0.8	2	15	50	4P/5P
MJE224	MJE234	4	60	20		1	1	0.6	1	15	50	4P/5P
MJE225	MJE235	4	60	25		1	1	0.3	0.5	15	50	4P/5P
MJE800	MJE700	4	60	750		1.5	3	2.5	1.5	40		4J/5J
MJE801	MJE701	4	60	750		2	3	2.8	2	40		4J/5J
2N6038	2N6035	4	60	750	15k	2	3	2	2	40		4J/5J
MJE240	MJE250	4	80	15		2	1	0.8	2	15	40	4P/5P
MJE241	MJE251	4	80	20		1	1	0.6	1	15	40	4P/5P
MJE242	MJE252	4	80	10		1	1	0.3	0.5	15	40	4P/5P
MJE802	MJE702	4	80	750		1.5	3	2.5	1.5	40		4J/5J
MJE803	MJE703	4	80	750		2	3	2.8	2	40		4J/5J
2N5192	2N5195	4	80	20	80	1.5	2	0.6	1.5	40	2	4E/5E
2N6039	2N6036	4	80	750	15k	2	3	2	2	40		4J/5J
MJE243	MJE253	4	100	20		1	1	0.6	1	15	40	4P/5P
MJE244	MJE254	4	100	10		1	1	0.3	0.5	15	40	4P/5P
MJE200	MJE210	5	25	45	180	2	1	0.75	2	15	65	4R/5R

Pinout: ECB

# TO-220 Type Power Transistor Selection Guide

Part Number		I <sub>C</sub> (A)	V <sub>CE0</sub> (V)	h <sub>FE</sub>		@		Max V <sub>CE</sub> (SAT)		P <sub>D</sub> (W)	f <sub>T</sub> (MHz)	Process (NPN/PNP)
NPN	PNP			Min	Max	I <sub>C</sub> (A)	V <sub>CE</sub> (V)	(V)	@ I <sub>C</sub> (A)			
TIP61	TIP62	0.5	40	15	100	0.5	4	0.7	0.5	20	3	4F/5F
TIP61A	TIP62A	0.5	60	15	100	0.5	4	0.7	0.5	20	3	4F/5F
TIP61B	TIP62B	0.5	80	15	100	0.5	4	0.7	0.5	20	3	4F/5F
TIP61C	TIP62C	0.5	100	15	100	0.5	4	0.7	0.5	20	3	4F/5F
TIP29	TIP30	1	40	15	75	1	4	0.7	1	30	3	4F/5F
TIP29A	TIP30A	1	60	15	75	1	4	0.7	1	30	3	4F/5F
TIP29B	TIP30B	1	80	15	75	1	4	0.7	1	30	3	4F/5F
TIP29C	TIP30C	1	100	15	75	1	4	0.7	1	30	3	4F/5F
TIP110	TIP115	2	60	1000		1	4	2.5	2	50	1	4J/5J
TIP111	TIP116	2	80	1000		1	4	2.5	2	50	1	4J/5J
TIP112	TIP117	2	100	1000		1	4	2.5	2	50	1	4J/5J
TIP31	TIP32	3	40	10	50	3	4	1.2	3	40	3	4F/5F
TIP31A	TIP32A	3	60	10	50	3	4	1.2	3	40	3	4F/5F
TIP31B	TIP32B	3	80	10	50	3	4	1.2	3	40	3	4F/5F
TIP31C	TIP32C	3	100	10	50	3	4	0.2	3	40	3	4F/5F
D44C1	D45C1	3	30	25		0.2	1	0.5	1	30	50	4P/5P
D44C2	D45C2	3	30	40	120	0.2	1	0.5	1	30	50	4P/5P
D44C3	D45C3	3	30	40	120	0.2	1	0.5	1	30	50	4P/5P
2N5296		4	40	30	120	1	4	1	1	36	2	4E
D44C4	D45C4	3	45	25		0.2	1	0.5	1	30	50	4P/5P
D44C5	D45C5	3	45	40	120	0.2	1	0.5	1	30	50	4P/5P
D44C6	D45C6	3	45	40	120	0.2	1	0.5	1	30	50	4P/5P
2N6121	2N6124	4	45	25	100	1.5	2	0.6	1.5	40	2.5	4E/5E
D44C7	D45C7	3	60	25		0.2	1	0.5	1	30	50	4P/5P
D44C8	D45C8	3	60	40	120	0.2	1	0.5	1	30	50	4P/5P
D44C9	D45C9	3	60	40	120	0.2	1	0.5	1	30	50	4P/5P
2N5298		4	60	20	80	1.5	4	1	1.5	36	2	4E
2N6122	2N6125	4	60	25	100	1.5	2	0.6	1.5	40	2.5	4E/5E
2N5294		4	70	30	120	0.5	4	1	0.5	36	2	4E
D44C10	D45C10	3	80	25		0.2	1	0.5	1	30	50	4P/5P
D44C11	D45C11	3	80	100	220	0.2	1	0.5	1	30	50	4P/5P
D44C12	D45C12	3	80	40	120	0.2	1	0.5	1	30	50	4P/5P
2N6123	2N6126	4	80	20	80	1.5	2	0.6	1.5	40	2.5	4E/5E
MJE105T	MJE205T	5	50	25	100	2	2			65		4A/5A
TIP120	TIP125	5	60	1000		3	3	2	3	65	1	4J/5K
TIP121	TIP126	5	80	1000		3	3	2	3	65	1	4K/5K
TIP122	TIP127	5	100	1000		3	3	2	3	65	1	4K/5K
TIP41	TIP42	6	40	15	75	3	4	1.5	6	65	3	4A/5A
TIP41A	TIP42A	6	60	15	75	3	4	1.5	6	65	3	4A/5A
TIP130	TIP135	6	60	1000	15,000	4	4	2	4	65	1	4K/5K
TIP41B	TIP42B	6	80	15	75	3	4	1.5	6	65	3	4A/5A
TIP131	TIP136	6	80	1000	15,000	4	4	2	4	65	1	4K/5K
TIP41C	TIP42C	6	100	15	75	3	4	1.5	6	65	3	4A/5A
TIP132	TIP137	6	100	1000	15,000	4	4	2	4	65	1	4K/5K
2N6288	2N6111	7	30	30	150	3	4	1	3	40	4	4E/5E
2N5494		7	40	20	100	2	4	1	0.2	50	0.8	4E
2N5494		7	40	20	100	3	4	1	0.3	50	0.8	4E
2N6129	2N6132	7	40	20	100	2.5	4	1.4	7	50	2.5	4E/5E
2N6290	2N6109	7	50	30	150	2.5	4	1	2.5	40	4	4E/5E
2N5492		7	55	20	100	2.5	4	1	0.25	50	0.8	4E

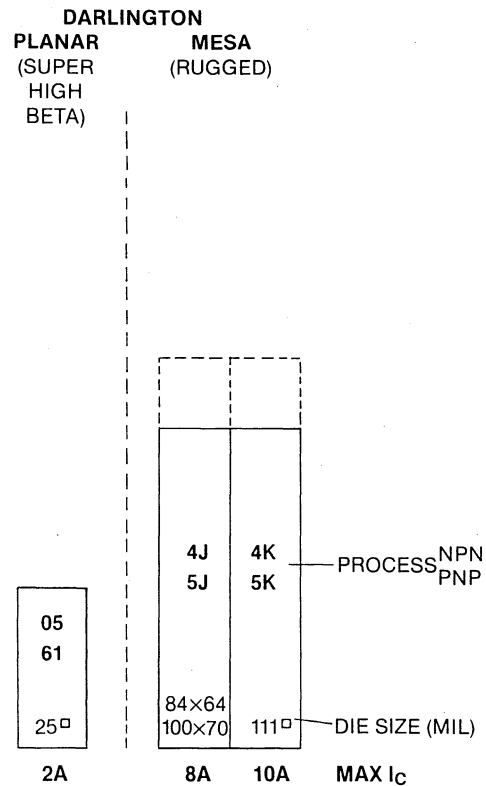
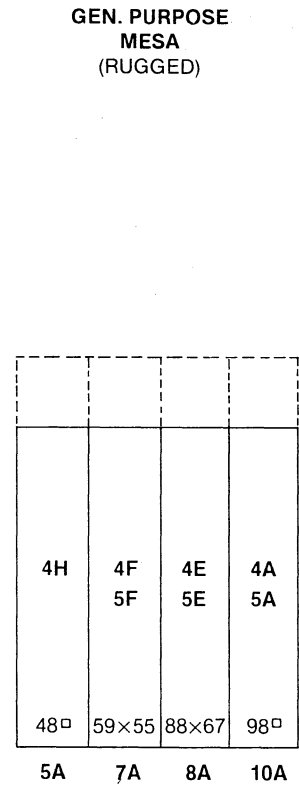
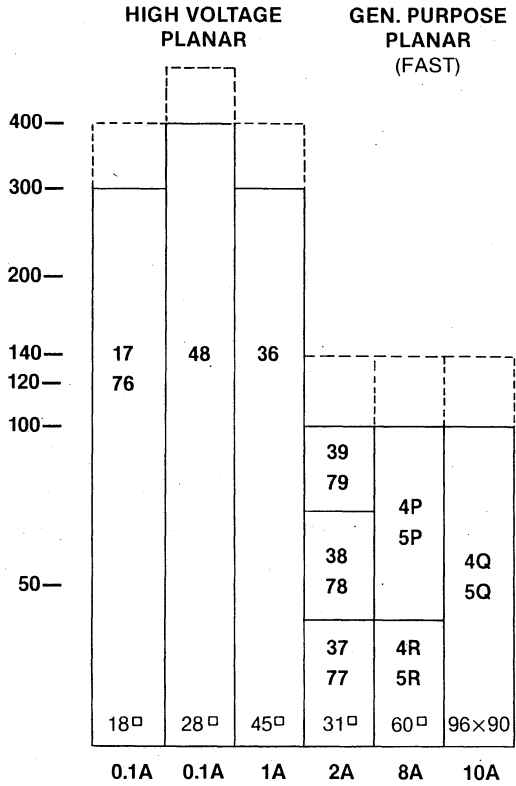
## TO-220 Type Power Transistor Selection Guide (Continued)

Part Number		I <sub>C</sub> (A)	V <sub>CEO</sub> (V)	h <sub>FE</sub>		@		Max V <sub>CE</sub> (SAT)		P <sub>D</sub> (W)	f <sub>T</sub> (MHz)	Process (NPN/PNP)
NPN	PNP			Min	Max	I <sub>C</sub> (A)	V <sub>CE</sub> (V)	(V)	@ I <sub>C</sub> (A)			
2N6130	2N6133	7	60	20	100	2.5	4	1.4	7	50	2.4	4E/5E
2N5496		7	70	20	100	3.5	4	1	0.35	50	0.8	4E
2N6292	2N6107	7	70	30	150	2	4	1	2	40	4	4E/5E
2N6131	2N6134	7	80	20	100	2.5	4	2	7	50	2.5	4E/5E
2N6386		8	40	1000	20,000	3	3	2	3	40	20	4J
BD347	BD346	8	60	40	140	2	2.5	0.6	4	60	4	4A/5A
D44H1	D45H1	10	30	35		2	1	1	8	50	50	4Q/5Q
D44H2	D45H2	10	30	60		2	1	1	8	50	50	4Q/5Q
D44H4	D45H4	10	45	35		2	1	1	8	50	50	4Q/5Q
D44H5	D45H5	10	45	60		2	1	1	8	50	50	4Q/5Q
2N6099		10	60	20	80	4	4	2.5	10	75	0.8	4A
D44H7	D45H7	10	60	35		2	1	1	8	50	50	4Q/5Q
D44H8	D45H8	10	60	60		2	1	1	8	50	50	4Q/5Q
SE9300	SE9400	10	60	1000		4	3	2	4	70	1	4K/5K
2N6101		10	70	20	80	5	4	2.5	10	75	0.8	4A
D44H10	D45H10	10	80	35		2	1	1	8	50	50	4Q/5Q
D44H11	D45H11	10	80	60		2	1	1	8	50	50	4Q/5Q
MJE2801T	MJE2901T	10	60	25	100	3	2			60		4A/5A
MJE3055T	MJE2955T	10	60	20	70	4	4	1.1	4	60	2	4A/5A
TIP100	TIP105	10	60	1000		3	4	2	3	60		4K/5K
TIP101	TIP106	10	80	1000		3	4	2	3	60		4K/5K
TIP102	TIP107	10	100	1000		3	4	2	3	60		4K/5K
SE9301	SE9401	10	80	1000		4	3	2	4	70	1	4K/5K
SE9302	SE9402	10	100	1000		4	3	2	4	70	1	4K/5K
2N6486	2N6489	15	40	20	150	5	4	1.3	5	75	5	4A/5A
2N6487	2N6490	15	60	20	150	5	4	1.3	5	75	5	4A/5A
2N6488	2N6491	15	80	20	150	5	4	1.3	5	75	5	4A/5A

Pinout: BCE

BV<sub>CEO</sub>—VOLTS

4-25



DISSIPATION (WATTS)

Package

- TO-92 (Note 1)
- TO-237 (Note 2)
- TO-202 (Note 3)
- TO-126 (Note 3)
- TO-220 (Note 3)

	0.6		0.6	
2	2	2	2	
8	10	15	10	15
		25	15	30
			40	60

30	30	40
	40	50
		60

0.6
2
10

40	60
50	

Notes: 1) T<sub>A</sub> = 25°C 2) T<sub>COLL LEAD</sub> = 25°C, will do 1-1.2 W in PC board 3) T<sub>C</sub> = 25°C

**Substitution Guide for Non-Listed Power Part Types**

## Substitution Guide for Non-Listed Power Part Types

Industry Part No.	Package	NSC Part No.	Package	Industry Part No.	Package	NSC Part No.	Package
2N2102	TO-39	TN2102	TO-237	2N6411	TO-126 (rev)	MJE210	TO-126
2N2218A	TO-18	TN2218A	TO-237	2N6412	TO-126 (rev)	MJE180	TO-126
2N2219A	TO-18	TN2219A	TO-237	2N6413	TO-126 (rev)	MJE181	TO-126
2N2905	TO-18	TN2905	TO-237	2N6414	TO-126 (rev)	MJE170	TO-126
2N3019	TO-39	TN3019	TO-237	2N6415	TO-126 (rev)	MJE171	TO-126
2N3020	TO-39	TN3020	TO-237	2N6416	TO-126 (rev)	MJE241	TO-126
2N3053	TO-39	TN3053	TO-237	2N6417	TO-126 (rev)	MJE243	TO-126
2N3054	TO-66	NSP3054	TO-220	2N6418	TO-126 (rev)	MJE251	TO-126
2N3724	TO-39	TN3724	TO-237	2N6419	TO-126 (rev)	MJE253	TO-126
2N3725	TO-39	TN3725	TO-237	2N6465	TO-66	TIP41C	TO-220
2N3735	TO-39	TN3735	TO-237	2N6530	TO-220	TIP101	TO-220
2N3740	TO-66	NSP3740	TO-220	2N6531	TO-220	TIP102	TO-220
2N3741	TO-66	NSP3741	TO-220	BD575	Mot Case 199	NSP575	TO-220
2N4033	TO-39	TN4033	TO-237	BD576	Mot Case 199	NSP576	TO-220
2N4037	TO-39	TN4037	TO-237	BD577	Mot Case 199	NSP577	TO-220
2N4063	TO-37	MJE3439	TO-126	BD578	Mot Case 199	NSP578	TO-220
2N4064	TO-37	MJE3440	TO-126	BD579	Mot Case 199	NSP579	TO-220
2N5974	TO-127	NSP5974	TO-220	BD579	Mot Case 199	NSP578	TO-220
2N5975	TO-127	NSP5975	TO-220	BD580	Mot Case 199	NSP580	TO-220
2N5976	TO-127	NSP5976	TO-220	BD581	Mot Case 199	NSP581	TO-220
2N5977	TO-127	NSP5977	TO-220	BD582	Mot Case 199	NSP582	TO-220
2N5978	TO-127	NSP5978	TO-220	BD585	Mot Case 199	NSP585	TO-220
2N5979	TO-127	NSP5979	TO-220	BD586	Mot Case 199	NSP586	TO-220
2N5980	Mot Case 90	2N6489	TO-220	BD587	Mot Case 199	NSP587	TO-220
2N5981	Mot Case 90	MJE2955T	TO-220	BD588	Mot Case 199	NSP588	TO-220
2N5982	Mot Case 90	2N6491	TO-220	BD589	Mot Case 199	NSP589	TO-220
2N5983	Mot Case 90	MJE3055T	TO-220	BD590	Mot Case 199	NSP590	TO-220
2N5984	Mot Case 90	MJE3055T	TO-220	BD595	Mot Case 199	NSP595	TO-220
2N5985	Mot Case 90	2N6488	TO-220	BD596	Mot Case 199	NSP596	TO-220
2N6021	TO-220	2N6126	TO-220	BD597	Mot Case 199	NSP597	TO-220
2N6022	TO-220	2N6124	TO-220	BD601	Mot Case 199	NSP601	TO-220
2N6023	TO-220	2N6124	TO-220	BD602	Mot Case 199	NSP602	TO-220
2N6024	TO-220	2N6124	TO-220	BD603	Mot Case 199	NSP603	TO-220
2N6025	TO-220	2N6125	TO-220	BD604	Mot Case 199	NSP604	TO-220
2N6026	TO-220	2N6125	TO-220	BD605	Mot Case 199	NSP605	TO-220
2N6040	Mot Case 199	TIP125	TO-220	BD606	Mot Case 199	NSP606	TO-220
2N6041	Mot Case 199	TIP126	TO-220	BD607	Mot Case 199	NSP607	TO-220
2N6042	Mot Case 199	TIP127	TO-220	BD608	Mot Case 199	NSP608	TO-220
2N6043	Mot Case 199	TIP120	TO-220	BD609	Mot Case 199	NSP609	TO-220
2N6044	Mot Case 199	TIP121	TO-220	BD610	Mot Case 199	NSP610	TO-220
2N6045	Mot Case 199	TIP122	TO-220	BD695	Mot Case 199	NSP695	TO-220
2N6098	TO-220	2N6099	TO-220	BD695A	Mot Case 199	NSP695A	TO-220
2N6100	TO-220	2N6101	TO-220	BD700	Mot Case 199	NSP700	TO-220
2N6101	TO-220	2N6101	TO-220	BD700A	Mot Case 199	NSP700A	TO-220
2N6102	TO-220	2N6102	TO-220	BD701	Mot Case 199	NSP701	TO-220
2N6103	TO-220	2N6103	TO-220	BD702	Mot Case 199	NSP702	TO-220
2N6106	TO-220	2N6107	TO-220	D45E1	TO-220	TIP125	TO-220
2N6108	TO-220	2N6109	TO-220	D45E2	TO-220	TIP125	TO-220
2N6109	TO-220	2N6109	TO-220	D45E3	TO-220	TIP126	TO-220
2N6110	TO-220	2N6111	TO-220	FT2955	TO-220	MJE2955T	TO-220
2N6111	TO-220	2N6111	TO-220	FT3055	TO-220	MJE3055T	TO-220
2N6175	Plastic TO-5	2N5656	TO-126	MJE29	Mot Case 199	TIP29	TO-220
2N6176	Plastic TO-5	2N5656	TO-126	MJE29A	Mot Case 199	TIP29A	TO-220
2N6177	Plastic TO-5	2N5657	TO-126	MJE29B	Mot Case 199	TIP29B	TO-220
2N6178	Plastic TO-5	MJE182	TO-126	MJE29C	Mot Case 199	TIP29C	TO-220
2N6179	Plastic TO-5	MJE181	TO-126	MJE30	Mot Case 199	TIP30	TO-220
2N6180	Plastic TO-5	MJE172	TO-126	MJE30A	Mot Case 199	TIP30A	TO-220
2N6181	Plastic TO-5	MJE171	TO-126	MJE30B	Mot Case 199	TIP30B	TO-220
2N6406	TO-126 (rev)	MJE171	TO-126	MJE30C	Mot Case 199	TIP30C	TO-220
2N6407	TO-126 (rev)	MJE172	TO-126	MJE33	Mot Case 199	TIP41	TO-220
2N6408	TO-126 (rev)	MJE181	TO-126	MJE33A	Mot Case 199	TIP41A	TO-220
2N6409	TO-126 (rev)	MJE182	TO-126	MJE33B	Mot Case 199	TIP41B	TO-220
2N6410	TO-126 (rev)	MJE200	TO-126	MJE33C	Mot Case 199	TIP41C	TO-220

# Substitution Guide for Non-Listed Power Part Types (Continued)

Industry Part No.	Package	NSC Part No.	Package	Industry Part No.	Package	NSC Part No.	Package
MJE34	Mot Case 199	TIP42	TO-220	MJE3371	TO-126 (rev)	MJE371	TO-126
MJE34A	Mot Case 199	TIP42A	TO-220	MJE3520	TO-126 (rev)	MJE520	TO-126
MJE34B	Mot Case 199	TIP42B	TO-220	MJE3521	TO-126 (rev)	MJE521	TO-126
MJE34C	Mot Case 199	TIP42C	TO-220	MJE4918		TIP30	
MJE41	Mot Case 199	TIP41	TO-220	MJE4919		TIP30A	
MJE41A	Mot Case 199	TIP41A	TO-220	MJE4920		TIP30B	
MJE41B	Mot Case 199	TIP41B	TO-220	MJE4921		TIP29	
MJE41C	Mot Case 199	TIP41C	TO-220	MJE4922		TIP29A	
MJE42	Mot Case 199	TIP42	TO-220	MJE4923		TIP29B	
MJE42A	Mot Case 199	TIP42A	TO-220	MJE5190		2N6121	
MJE42B	Mot Case 199	TIP42B	TO-220	MJE5191		2N6122	
MJE42C	Mot Case 199	TIP42C	TO-220	MJE5192		2N6123	
MJE105K	Mot Case 199	TIP42A	TO-220	MJE5193		2N6124	
MJE105	Mot Case 199	MJE105T	TO-220	MJE5194		2N6125	
MJE170	TO-126	MJE170	TO-126	MJE5195		2N6126	
MJE171	TO-126	MJE171	TO-126	MJE5974	Mot Case 199	NSP5974	TO-220
MJE172	TO-126	MJE172	TO-126	MJE5975	Mot Case 199	NSP5975	TO-220
MJE180	TO-126	MJE180	TO-126	MJE5976	Mot Case 199	NSP5976	TO-220
MJE181	TO-126	MJE181	TO-126	MJE5977	Mot Case 199	NSP5977	TO-220
MJE182	TO-126	MJE182	TO-126	MJE5978	Mot Case 199	NSP5978	TO-220
MJE200	TO-126	MJE200	TO-126	MJE5979	Mot Case 199	NSP5979	TO-220
MJE205	Mot Case 199	MJE205T	TO-220	MJE5980	Mot Case 199	NSP5980	TO-220
MJE205K	Mot Case 199	TIP41A	TO-220	MJE5981	Mot Case 199	NSP5981	TO-220
MJE345	TO-126	MJE3439	TO-126	MJE5982	Mot Case 199	NSP5982	TO-220
MJE370K	Mot Case 199	NSP370	TO-220	MJE5983	Mot Case 199	NSP5983	TO-220
MJE371K	Mot Case 199	NSP371	TO-220	MJE5984	Mot Case 199	NSP5984	TO-220
MJE482	TO-126	2N5190	TO-126	MJE5985	Mot Case 199	NSP5985	TO-220
MJE483	TO-126	2N5191	TO-126	MPSU01	Mot 152	NSDU01	TO-202
MJE484	TO-126	2N5192	TO-126	MPSU01	Mot 152	92PU01	TO-237
MJE492	TO-126	2N5193	TO-126	MPSU01A	Mot 152	NSDU01A	TO-202
MJE493	TO-126	2N5194	TO-126	MPSU01A	Mot 152	92PU01A	TO-237
MJE494	TO-126	2N5195	TO-126	MPSU02	Mot 152	NSDU02	TO-202
MJE520K	Mot Case 199	TIP31	TO-220	MPSU02	Mot 152	TN2219A	TO-237
MJE521K	Mot Case 199	TIP31	TO-220	MPSU03	Mot 152	92PU391	TO-237
MJE2010	Mot Case 199	NSP2010	TO-220	MPSU04	Mot 152	92PU319	TO-237
MJE2011	Mot Case 199	NSP2011	TO-220	MPSU05	Mot 152	NSDU05	TO-202
MJE2020	Mot Case 199	NSP2020	TO-220	MPSU05	Mot 152	92PU05	TO-237
MJE2021	Mot Case 199	NSP2021	TO-220	MPSU06	Mot 152	NSDU06	TO-202
MJE2090	Mot Case 199	NSP2090	TO-220	MPSU06	Mot 152	92PU06	TO-237
MJE2091	Mot Case 199	NSP2091	TO-220	MPSU07	Mot 152	NSDU07	TO-202
MJE2092	Mot Case 199	NSP2092	TO-220	MPSU07	Mot 152	92PU07	TO-237
MJE2093	Mot Case 199	NSP2093	TO-220	MPSU10	Mot 152	NSDU10	TO-202
MJE2100	Mot Case 199	NSP2100	TO-220	MPSU10	Mot 152	92PU10	TO-237
MJE2101	Mot Case 199	NSP2101	TO-220	MPSU31	Mot 152	TN2102	TO-237
MJE2102	Mot Case 199	NSP2102	TO-220	MPSU45	Mot 152	NSDU45	TO-202
MJE2103	Mot Case 199	NSP2103	TO-220	MPSU45	Mot 152	92PU45	TO-237
MJE2150	TO-126 (rev)	MJE210	TO-126	MPSU45A	Mot 152	NSDU45A	TO-202
MJE2370	Mot Case 199	NSP2370	TO-220	MPSU45A	Mot 152	92PU45A	TO-237
MJE2371	Mot Case 199	TIP32A	TO-220	MPSU51	Mot 152	NSDU51	TO-202
MJE2480	Mot Case 199	TIP31	TO-220	MPSU51	Mot 152	92PU51	TO-237
MJE2481	Mot Case 199	TIP32A	TO-220	MPSU51A	Mot 152	NSDU51A	TO-202
MJE2482	Mot Case 199	TIP41	TO-220	MPSU52	Mot 152	NSPU52	TO-202
MJE2483	Mot Case 199	TIP41A	TO-220	MPSU52	Mot 152	92PU51A	TO-237
MJE2490	Mot Case 199	NSP2490	TO-220	MPSU55	Mot 152	NSDU55	TO-202
MJE2491	Mot Case 199	NSP2491	TO-220	MPSU55	Mot 152	92PU55	TO-237
MJE2520	Mot Case 199	NSP2520	TO-220	MPSU56	Mot 152	NSDU56	TO-202
MJE2801K	Mot Case 199	NSP2801T	TO-220	MPSU56	Mot 152	92PU56	TO-237
MJE2901K	Mot Case 199	MJE2901T	TO-220	MPSU57	Mot 152	NSDU57	TO-202
MJE2955K	Mot Case 199	MJE2955T	TO-220	MPSU57	Mot 152	92PU57	TO-237
MJE2955	Mot Case 90	MJE2955T	TO-220	RCA1C05	TO-220	2N6130	TO-220
MJE3055K	Mot Case 199	MJE3055T	TO-220	RCA1C06	TO-220	2N6133	TO-220
MJE3055	Mot Case 90	MJE3055T	TO-220	RCA1C07	TO-220	MJE3055T	TO-220
MJE3370	TO-126 (rev)	MJE370	TO-126	RCA1C08	TO-220	MJE2955T	TO-220

## Substitution Guide for Non-Listed Power Part Types (Continued)

Industry Part No.	Package	NSC Part No.	Package	Industry Part No.	Package	NSC Part No.	Package
RCA1C09	TO-220	MJE3055T	TO-220	RCP704B	TO-202	2N6554	TO-202
RCA1C10	TO-220	2N6292	TO-220	RCP705	TO-202	2N6551	TO-202
RCA1C11	TO-220	2N6107	TO-220	RCP705B	TO-202	2N6551	TO-202
RCA1C14	TO-220	2N6290	TO-220	RCP706	TO-202	2N6554	TO-202
RCA1C15	TO-220	2N6388	TO-220	RCP706B	TO-202	2N6554	TO-202
RCA29	TO-220	TIP29	TO-220	RCP707	TO-202	2N6551	TO-202
RCA29A	TO-220	TIP29A	TO-220	RCP707B	TO-202	2N6551	TO-202
RCA29B	TO-220	TIP29B	TO-220	TIP33	TO-220	TIP41	TO-220
RCA29C	TO-220	TIP29C	TO-220	TIP33A	TO-220	TIP41A	TO-220
RCA30	TO-220	TIP30	TO-220	TIP33B	TO-220	TIP41B	TO-220
RCA30A	TO-220	TIP30A	TO-220	TIP33C	TO-220	TIP41C	TO-220
RCA30B	TO-220	TIP30B	TO-220	TIP34	TO-220	TIP42	TO-220
RCA30C	TO-220	TIP30C	TO-220	TIP34A	TO-220	TIP42A	TO-220
RCA31	TO-220	TIP31	TO-220	TIP34B	TO-220	TIP42B	TO-220
RCA31A	TO-220	TIP31A	TO-220	TIP34C	TO-220	TIP42C	TO-220
RCA31B	TO-220	TIP31B	TO-220	TIP73	TO-220	2N6486	TO-220
RCA31C	TO-220	TIP31C	TO-220	TIP73A	TO-220	2N6487	TO-220
RCA32	TO-220	TIP32	TO-220	TIP73B	TO-220	2N6488	TO-220
RCA32A	TO-220	TIP32A	TO-220	TIP74	TO-220	2N6489	TO-220
RCA32B	TO-220	TIP32B	TO-220	TIP74A	TO-220	2N6490	TO-220
RCA32C	TO-220	TIP32C	TO-220	TIP74B	TO-220	2N6491	TO-220
RCA41	TO-220	TIP41	TO-220	TIP2955	TO-220	MJE2955T	TO-220
RCA41A	TO-220	TIP41A	TO-220	TIP3055	TO-220	MJE3055T	TO-220
RCA41B	TO-220	TIP41B	TO-220	40513	TO-220	MJE3055T	TO-220
RCA41C	TO-220	TIP41C	TO-220	40514	TO-220	MJE3055T	TO-220
RCA42	TO-220	TIP42	TO-220	40613	TO-220	TIP31	TO-220
RCA42A	TO-220	TIP42A	TO-220	40618	TO-220	TIP31	TO-220
RCA42B	TO-220	TIP42B	TO-220	40621	TO-220	TIP31	TO-220
RCA42C	TO-220	TIP42C	TO-220	40622	TO-220	TIP31	TO-220
RCA120	TO-220	TIP120	TO-220	40624	TO-220	TIP41A	TO-220
RCA121	TO-220	TIP121	TO-220	40627	TO-220	TIP41A	TO-220
RCA122	TO-220	TIP122	TO-220	40629	TO-220	TIP31	TO-220
RCA125	TO-220	TIP125	TO-220	40630	TO-220	TIP31	TO-220
RCA126	TO-220	TIP126	TO-220	40631	TO-220	TIP31A	TO-220
RCA3054	TO-220	2N6122	TO-220	40632	TO-220	TIP41A	TO-220
RCA3055	TO-220	2N6487	TO-220	40871	TO-220	TIP41C	TO-220
RCP115	TO-202	2N6591	TO-202	40872	TO-220	TIP42C	TO-220
RCP117	TO-202	2N6591	TO-202	40873	TO-220	TIP41B	TO-220
RCP131A	TO-202	2N6592	TO-202	40874	TO-220	TIP41B	TO-220
RCP131B	TO-202	2N6593	TO-202	40875	TO-220	TIP41C	TO-220
RCP133A	TO-202	2N6592	TO-202	40876	TO-220	TIP41A	TO-220
RCP133B	TO-202	2N6593	TO-202	41500	TO-220	TIP29	TO-220
RCP135	TO-202	2N6553	TO-202	41501	TO-220	TIP30	TO-220
RCP137	TO-202	2N6553	TO-202	41504	TO-220	TIP31	TO-220
RCP700A	TO-202	2N6554	TO-202	2SA496	TO-126	2N4918	TO-126
RCP700B	TO-202	2N6554	TO-202	2SA505	TO-126	2N4919	TO-126
RCP700C	TO-202	2N6555	TO-202	2SA623	TO-202	D41E1	TO-202
RCP700D	TO-202	2N6556	TO-202	2SA624	TO-202	D41E5	TO-202
RCP701A	TO-202	2N6551	TO-202	2SA633	TO-202	D41E1	TO-202
RCP701B	TO-202	2N6551	TO-202	2SA634	TO-202	D41E5	TO-202
RCP701C	TO-202	2N6552	TO-202	2SA635	TO-202	D41D7	TO-202
RCP701D	TO-202	2N6553	TO-202	2SA636	TO-202	2N6556	TO-202
RCP702A	TO-202	2N6554	TO-202	2SA645	TO-202	D41D10	TO-202
RCP702B	TO-202	2N6554	TO-202	2SA646	TO-202	2N6556	TO-202
RCP702C	TO-202	2N6555	TO-202	2SA647	TO-202	2N6556	TO-202
RCP702D	TO-202	2N6556	TO-202	2SA681	TO-126	MJE253	TO-126
RCP703A	TO-202	2N6551	TO-202	2SA682	TO-126	MJE253	TO-126
RCP703B	TO-202	2N6551	TO-202	2SA699	TO-202	D41E5	TO-202
RCP703C	TO-202	2N6552	TO-202	2SA700	TO-220	TIP30	TO-220
RCP703D	TO-202	2N6553	TO-202	2SA703	TO-220	D41E1	TO-202
RCP704	TO-202	2N6554	TO-202				



Section 5

**Pro Electron Series**







## PRO ELECTRON SERIES (Bipolar—see page 5-37 for JFET)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EB0</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V) Max	H <sub>FE</sub> h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> & V <sub>BE(ON)</sub> * @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max	Min	Max	Max	Min	Max		Min	Max				
BC107	TO-18	50	45	6	15*	50	40 125 40	0.01 500* 0.01	5 5 5	0.6 0.2		100 10 2	4.5	150	10		10	1	04
BC107A	TO-18	50	45	6	15*	50	125	260*	2 5	0.6 0.2		100 10 2	4.5	150	10		10	1	04
BC107B	TO-18	50	45	6	15*	50	40 240	0.01 500*	5 2 5	0.6 0.2		100 10 2	4.5	150	10		10	1	04
BC108	TO-18	30	20	5	15*	30	40 125	0.01 900*	5 2 5	0.6 0.2		100 10 2	4.5	150	10		10	1	04
BC108A	TO-18	30	20	5	15*	30	40 125	0.01 260*	5 2 5	0.6 0.2		100 100 2	4.5	150	10		10	1	04
BC108B	TO-18	30	20	5	15*	30	40 240	0.01 500*	5 2 5	0.6 0.2		100 10 2	4.5	150	10		10	1	04
BC108C	TO-18	30	20	5	15*	30	40 450	0.01 900*	5 2 5	0.6 0.2		100 10 2	4.5	150	10		10	1	04
BC109	TO-18	30	20	5	15*	30	100 240	0.01 900*	5 2 5	0.6 0.2		100 10 2	4.5	150	10		4	1	04
BC109B	TO-18	30	20	5	15*	30	100 240	0.01 500*	5 2 5	0.6 0.2		100 10 2	4.5	150	10		4	1	04
BC109C	TO-18	30	20	5	15*	30	100 450	0.01 900*	5 2 5	0.6 0.2		100 10 2	4.5	150	10		4	1	04
BC140	TO-39	80*	40	7	100*	60	40	250	100 1	1.0	1.8*	1A	25	50	50	850		2	14
BC140-6	TO-39	80*	40	7	100*	60	40	100	100 1	1.0	1.8*	1A	25	50	50	850		2	14
BC140-10	TO-39	80*	40	7	100*	60	63	160	100 1	1.0	1.8*	1A	25	50	50	850		2	14
BC140-16	TO-39	80*	40	7	100*	60	100	250	100 1	1.0	1.8*	1A	25	50	50	850		2	14
BC141	TO-39	100*	60	7	100*	60	40	250	100 1	1.0	1.8*	1A	25	50	50	850		2	14
BC141-6	TO-39	100*	60	7	100*	60	40	100	100 1	1.0	1.8*	1A	25	50	50	850		2	14
BC141-10	TO-39	100*	60	7	100*	60	63	160	100 1	1.0	1.8*	1A	25	50	50	850		2	14



**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	V <sub>CES</sub> *	V <sub>CEO</sub>	V <sub>EBO</sub>	I <sub>CES</sub> *	V <sub>CB</sub>	H <sub>FE</sub>			V <sub>CE(SAT)</sub>	V <sub>BE(SAT)</sub>		C <sub>ob</sub> (pF) Max	f <sub>T</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
		V <sub>CB0</sub> (V) Min	(V) Min	(V) Min	I <sub>CB0</sub> (nA) Max	(V)	h <sub>FE</sub> 1 kHz*	@ I <sub>C</sub> (mA)	& V <sub>CE</sub> (V)	(V) Max	Min	Max		(MHz) @ I <sub>C</sub> (mA)	Min					Max
BC143	TO-5	60	60	5	50	40	20		200	2	1.5	1.5	500 200	20	60	50			63	
BC146-1	TO-92 (94)	20	20	4	50	40	100 80	2	200	1	1.5	1.5	500 200	20	60	50			04	
BC146-2	TO-92 (94)	20	20	4	50	40	140 140	2	350	1	1.5	1.5	500 200	20	60	50			04	
BC146-3	TO-92 (94)	20	20	4	50	40	280 280	2	550	1	1.5	1.5	500 200	20	60	50			04	
BC160	TO-39	40*	5	40	100	40	40	250	100	1	1.0	1.7*	1A	30	50	50	650		2	67
BC160-6	TO-39	40*	5	40	100	40	40	100	100	1	1.0	1.7*	1A	30	50	50	650		2	67
BC160-10	TO-39	40*	5	40	100	40	63	160	100	1	1.0	1.7*	1A	30	50	50	650		2	67
BC160-16	TO-39	40*	5	40	100	40	100	250	100	1	1.0	1.7*	1A	30	50	50	650		2	67
BC161	TO-39	60*	5	60	100	60	40	250	100	1	1.0	1.7*	1A	30	50	50	650		2	67
BC161-6	TO-39	60*	5	60	100	60	40	100	100	1	1.0	1.7*	1A	30	50	50	650		2	67
BC161-10	TO-39	60*	5	60	100	60	63	160	100	1	1.0	1.7*	1A	30	50	50	650		2	67
BC161-16	TO-39	60*	5	60	100	60	100	250	100	1	1.0	1.7*	1A	30	50	50	650		2	67
BC167	TO-92 (94)	60*	45	6	15*	50	110 125	2	500*	5	0.2 0.6		10 100	4.5	150	10		10	1	04
											0.55	0.7*	2							
BC167A	TO-92 (94)	60*	45	6	15*	50	110 125	260*	2	5	0.2 0.6		10 100	4.5	150	10		10	1	04
											0.55	0.7*	2							
BC167B	TO-92 (94)	60*	45	6	15*	50	110 240	500*	2	5	0.2 0.6		10 100	4.5	150	10		10	1	04
											0.55	0.7*	2							
BC168	TO-92 (94)		20	5	15*	30	110 125	2	900*	5	0.2 0.6		10 100	4.5	150	10		10	1	04
											0.55	0.70*	2							
BC168A	TO-92 (94)		20	5	15*	30	110 125	2	260*	5	0.2 0.6		10 100	4.5	150	10		10	1	04
											0.55	0.70*	2							
BC168B	TO-92 (94)		20	5	15*	30	110 240	2	500*	5	0.2 0.6		10 100	4.5	150	10		10	1	04
											0.55	0.70*	2							

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 mA, V<sub>CE</sub> = 5V, f = WB.





PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ Max	V <sub>CB</sub> (V)	H <sub>FE</sub> h <sub>fe</sub> 1 kHz* @ I <sub>C</sub> & V <sub>CE</sub>				V <sub>CE(SAT)</sub> (V) Max			V <sub>BE(SAT)</sub> V <sub>BE(ON)*</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	2	5	Max	Min	Max	2	Min	Max		2					
BC168C	TO-92 (94)		20	5	15*	30	110 450	2 900*	2 2	5 5	0.2 0.6		0.55	0.70*	10 100 2	4.5	150	10		10	1	04	
BC169	TO-92 (94)		20	5	15*	30	110 240	2 900*	2 2	5 5	0.2 0.6		0.55	0.70*	10 100 2	4.5	150	10		4	1	04	
BC169B	TO-92 (94)		20	5	15*	30	110 240	2 500*	2 2	5 5	0.2 0.6		0.55	0.70*	10 100 2	4.5	150	10		4	1	04	
BC169C	TO-92 (94)		20	5	15*	30	110 450	2 900*	2 2	5 5	0.2 0.6		0.55	0.70*	10 100 2	4.5	150	10		4	1	04	
BC177	TO-18	50	45	5	100	20	110 125	2 500*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150	10		10	1	71		
BC177A	TO-18	50	45	5	100	20	110 125	2 260*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150	10		10	1	71		
BC177B	TO-18	50	45	5	100	20	110 240	2 500*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150	10		10	1	71		
BC177V1	TO-18	50	45	5	100	20	110 75	2 150*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150	10		10	1	71		
BC178	TO-18	30	25	5	100	20	110 125	2 900*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150	10		10	1	71		
BC178A	TO-18	30	25	5	100	20	110 125	2 260*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150	10		10	1	71		
BC178B	TO-18	30	25	5	100	20	110 240	2 500*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150	10		10	1	71		
BC179	TO-18	25	20	5	100	20	110 125	2 900*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150	10		4	1	71		
BC179A	TO-18	25	20	5	100	20	110 125	2 260*	2 2	5 5	0.18		0.78 0.75* 1.0*	10 2 100	4.5	150	10		4	1	71		

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**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	$V_{CES}^*$	$V_{CEO}$	$V_{EBO}$	$I_{CES}^*$	$V_{CB}$ (V)	$H_{FE}$ $h_{fe}$ 1 kHz*			$V_{CE(SAT)}$ (V) & $V_{BE(SAT)}$ & $V_{BE(ON)}^*$ (V) @			$I_C$ (mA)	$C_{ob}$ (pF) Max	$f_T$ (MHz) @ $I_C$ (mA)		$t_{off}$ (ns) Max	NF (dB) Max	Test Conditions	Process No.
		(V) Min	(V) Min	(V) Min	(nA) @ Max		Min	Max	@ $I_C$ (mA) & $V_{CE}$ (V)	Max	Min	Max			Min	Max				
BC179B	TO-18	25	20	5	100	20	110	2	5	0.18	0.78	10	4.5	150	10		4	1	71	
							240	500*	2		0.75*	2								
											1.0*	100								
BC182	TO-92 (97)	60	50	5	15	50	40	0.01	5	0.6	1.2	100	5	150	10		10	1	04	
							80	100	5	0.25		10								
							125	500*	2	0.55	0.70*	2								
BC182A	TO-92 (97)	60	50	5	15	50	40	0.01	5	0.6	1.2	100	5	150	10		10	1	04	
							80	100	5	0.25		10								
							125	260*	2	0.55	0.70*	2								
BC182B	TO-92 (97)	60	50	5	15	50	40	0.01	5	0.6	1.2	100	5	150	10		10	1	04	
							80	100	5	0.25		10								
							240	500*	2	0.55	0.70*	2								
BC182L	TO-92 (94)	60	50	5	15	50	40	0.01	5	0.6	1.2	100	5	150	10		10	1	04	
							80	100	5	0.25		10								
							125	500*	2	0.55	0.70*	2								
BC182LA	TO-92 (94)	60	50	5	15	50	40	0.01	5	0.6	1.2	100	5	150	10		10	1	04	
							80	100	5	0.25		10								
							125	260*	2	0.55	0.70*	2								
BC182LB	TO-92 (94)	60	50	5	15	50	40	0.01	5	0.6	1.2	100	5	150	10		10	1	04	
							80	100	5	0.25		10								
							240	500*	2	0.55	0.70*	2								
BC183	TO-92 (97)	45	30	5	15	30	40	0.01	5	0.6	1.2	100	5	150	10		10	1	04	
							80	100	5	0.25		10								
							125	900*	2	0.55	0.70*	2								
BC183A	TO-92 (97)	45	30	5	15	30	40	0.01	5	0.6	1.2	100	5	150	10		10	1	04	
							80	100	5	0.25		10								
							125	260*	2	0.55	0.70*	2								
BC183B	TO-92 (97)	45	30	5	15	30	40	0.01	5	0.6	1.2	100	5	150	10		10	1	04	
							80	100	5	0.25		10								
							240	500*	2	0.55	0.70*	2								
BC183C	TO-92 (97)	45	30	5	15	30	40	0.01	5	0.6	1.2	100	5	150	10		10	1	04	
							80	100	5	0.25		10								
							450	900*	2	0.55	0.70*	2								

**TEST CONDITIONS:**

(1)  $I_C = 200 \mu A$ ,  $V_{CE} = 5V$ ,  $f = 1 \text{ kHz}$ . (2)  $I_C = 100 \text{ mA}$ ,  $V_{CC} = 20V$ ,  $I_B^1 = I_B^2 = 5 \text{ mA}$ . (3)  $I_C = 200 \mu A$ ,  $V_{CE} = 2V$ ,  $f = 1 \text{ kHz}$ . (4)  $I_C = 100 \text{ mA}$ ,  $V_{CC} = 10V$ ,  $I_B^1 = I_B^2 = 10 \text{ mA}$ . (5)  $I_C = 10 \text{ mA}$ ,  $V_{CC} = 3V$ ,  $I_B^1 = I_B^2 = 1 \text{ mA}$ . (6)  $I_C = 100 \mu A$ ,  $V_{CE} = 5V$ ,  $f = 1 \text{ kHz}$ . (7)  $I_C = 1 \text{ mA}$ ,  $V_{CE} = 10V$ ,  $f = 200 \text{ kHz}$ . (8)  $I_C = 1 \text{ mA}$ ,  $V_{CE} = 5V$ ,  $f = 1 \text{ kHz}$ . (9)  $I_C = 150 \text{ mA}$ ,  $V_{CC} = 6V$ ,  $I_B^1 = I_B^2 = 15 \text{ mA}$ . (10)  $I_C = 10 \mu A$ ,  $V_{CE} = 5V$ ,  $f = \text{WB}$ .



PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> @ (nA) Max	V <sub>CB</sub> (V)	H <sub>FE</sub> h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> & V <sub>BE(SAT)</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
							Min	Max	5	Max	Min	Max		100	Min					Max
BC183L	TO-92 (94)	45	30	5	15	30	40 80 125	0.01 100 2	5 5 5	0.6 0.25	1.2 0.70*	100 10 2	5	150	10		10	1	04	
BC183LA	TO-92 (94)	45	30	5	15	30	40 80 125	0.01 100 2	5 5 5	0.6 0.25	1.2 0.70*	100 10 2	5	150	10		10	1	04	
BC183LB	TO-92 (94)	45	30	5	15	30	40 80 240	0.01 100 2	5 5 5	0.6 0.25	1.2 0.70*	100 10 2	5	150	10		10	1	04	
BC183LC	TO-92 (94)	45	30	5	15	30	40 80 450	0.01 100 2	5 5 5	0.6 0.25	1.2 0.70*	100 10 2	5	150	10		10	1	04	
BC184	TO-92 (97)	45	30	5	15	30	100 130 240	0.01 100 2	5 5 5	0.6 0.25	1.2 0.70*	100 10 2	5	150	10		4	1	04	
BC184B	TO-92 (97)	45	30	5	15	30	100 130 240	0.01 100 2	5 5 5	0.6 0.25	1.2 0.70*	100 10 2	5	150	10		4	1	04	
BC184C	TO-92 (97)	45	30	50	15	30	100 130 450	0.01 100 2	5 5 5	0.6 0.25	1.2 0.70*	100 10 2	5	150	10		4	1	04	
BC184L	TO-92 (94)	45	30	50	15	30	100 130 240	0.01 100 2	5 5 5	0.6 0.25	1.2 0.70*	100 10 2	5	150	10		4	1	04	
BC184LB	TO-92 (94)	45	30	50	15	30	100 130 240	0.01 100 2	5 5 5	0.6 0.25	1.2 0.70*	100 10 2	5	150	10		4	1	04	
BC184LC	TO-92 (94)	45	30	50	15	30	100 130 450	0.01 100 2	5 5 5	0.6 0.25	1.2 0.70*	100 10 2	5	150	10		4	1	04	
BC204	TO-92 (92)	50	45	5	50	45	50	450	2	5	0.3		10				10	1	71	
BC207	TO-92 (92)	50	45	5	15	40	110	450	2	5	0.25 0.6		10 100	6			10	1	04	
BC212	TO-92 (97)	60	50	5	15	30	60	400*	2	5	0.6 0.25	1.1 0.72*	100 10 2	10	200	10		10	1	63



**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	V <sub>CE</sub> * V <sub>CB0</sub> (V) Min	V <sub>CE0</sub> (V) Min	V <sub>EB0</sub> (V) Min	I <sub>CE</sub> * I <sub>CB0</sub> (nA) @ Max	V <sub>CB</sub> (V) @	H <sub>FE</sub> h <sub>FE</sub> 1 kHz* @ I <sub>C</sub> & V <sub>CE</sub> (mA) & (V)				V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)</sub> * (V) @ I <sub>C</sub> (mA)		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	Min	Max		Min	Max		Min	Max				
BC212A	TO-92 (97)	60	50	5	15	30					0.6 0.25	1.1 0.72*	100 10 2	10	200	10		10	1	63
BC212B	TO-92 (97)	60	50	5	15	30					0.6 0.25	1.1 0.72*	100 10 2	10	200	10		10	1	63
BC212L	TO-92 (94)	60	50	5	15	30	40 60 60*		0.01 2 2	5 5 5	0.6 0.25	1.1 0.72*	100 10 2	10	200	10		10	1	63
BC212LA	TO-92 (94)	60	50	5	15	30	40 60 100		0.01 2 2	5 5 5	0.6 0.25	1.1 0.72*	100 10 2	10	200	10		10	1	63
BC212LB	TO-92 (94)	60	50	5	15	30	40 60 200		0.01 2 2	5 5 5	0.6 0.25	1.1 0.72*	100 10 2	10	200	10		10	1	63
BC213	TO-92 (97)	45	30	5	15	30	40 60 80		0.01 2 2	5 5 5	0.6 0.25	1.1 0.72*	100 10 2	10	200	10		10	1	63
BC213A	TO-92 (97)	45	30	5	15	30	40 60 100		0.01 2 2	5 5 5	0.6 0.25	1.1 0.72*	100 10 2	10	200	10		10	1	63
BC213B	TO-92 (97)	45	30	5	15	30	40 60 200		0.01 2 2	5 5 5	0.6 0.25	1.1 0.72*	100 10 2	10	200	10		10	1	63
BC213C	TO-92 (97)	45	30	5	15	30	40 60 350		0.01 2 2	5 5 5	0.6 0.25	1.1 0.72*	100 10 2	10	200	10		10	1	63
BC213L	TO-92 (94)	45	30	5	15	30	40 80 80*		0.01 2 2	5 5 5	0.6 0.25	1.1 0.72*	100 10 2	10	200	10		10	1	63
BC213LA	TO-92 (94)	45	30	5	15	30	40 80 100		0.01 2 2	5 5 5	0.6 0.25	1.1 0.72*	100 10 2	10	200	10		10	1	63

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = WB.

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## PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V) Max	H <sub>FE</sub> h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> & V <sub>BE(SAT)</sub> (V) & V <sub>BE(ON)*</sub> @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.		
						Min	Max	5	Max	Min	Max		10	Min					Max	
BC213LB	TO-92 (94)	45	30	5	15	30	40	0.01	5	0.6	1.1	100	10	200	10		10	1	63	
							80	2	5	0.25		10								
							200	400*	2	5	0.6	0.72*								2
BC213LC	TO-92 (94)	45	30	5	15	30	40	0.01	5	0.6	1.1	100	10	200	10		10	1	63	
							80	2	5	0.25		10								
							350	600*	2	5	0.6	0.72*								2
BC214	TO-92 (97)	45	30	5	15	30	40	0.01	5	0.6	1.1	100	10	200	10		2	1	63	
							80	2	5	0.25		10								
							140	600*	2	5	0.6	0.72*								2
BC214A	TO-92 (97)	45	30	5	15	30	40	0.01	5	0.6	1.1	100	10	200	10		2	1	63	
							80	2	5	0.25		10								
							100	300*	2	5	0.6	0.72*								2
BC214B	TO-92 (97)	45	30	5	15	30	40	0.01	5	0.6	1.1	100	10	200	10		2	1	63	
							80	2	5	0.25		10								
							200	400*	2	5	0.6	0.72*								2
BC214C	TO-92 (97)	45	30	5	15	30	40	0.01	5	0.6	1.1	100	10	200	10		2	1	63	
							80	2	5	0.25		10								
							350	600*	2	5	0.6	0.72*								2
BC214L	TO-92 (94)	45	30	5	15	30	100	0.01	5	0.6	1.1	100	10	200	10		2	1	63	
							140	400	2	5	0.25									10
							120	100	5		0.6	0.72*								2
							140*	2	5											
BC214LB	TO-92 (94)	45	30	5	15	30	100	0.01	5	0.6	1.1	100	10	200	10		2	1	63	
							140	2	5	0.25		10								
							120	100	5		0.6	0.72*								2
							200	400*	2	5										
BC214LC	TO-92 (94)	45	30	5	15	30	100	0.01	5	0.6	1.1	100	10	200	10		2	1	63	
							140	2	5	0.25		10								
							120	100	5		0.6	0.72*								2
							350	600*	2	5										
BC237-92	TO-92 (97)	50	45	6	50	20	100	0.01	5	0.25	0.77*	10	4.5				10	1	04	
							140	2	5		0.6	100								
							120	100	5											
							125	500*	2	5	0.55	0.70*								2
BC237A-92	TO-92 (97)	50	45	6	50	20	100	0.01	5	0.25	0.77*	10	4.5				10	1	04	
							140	2	5		0.6	100								
							120	100	5											
							125	500*	2	5	0.55	0.70*								2



**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	V <sub>CE(S)</sub> V <sub>CB(O)</sub> (V) Min	V <sub>CE(O)</sub> (V) Min	V <sub>EB(O)</sub> (V) Min	I <sub>CE(S)</sub> I <sub>CB(O)</sub> (nA) @ Max	V <sub>CB</sub> (V)	h <sub>FE</sub> @ 1 kHz*			I <sub>C</sub> (mA) & V <sub>CE</sub> (V)	V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)</sub> * (V) @		I <sub>C</sub> (mA)	C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.					
							Min	Max	Min			Max	Min			Max	Min					Max				
BC237B-92	TO-92 (97)	50	45	6	50	20	100	0.01	5	0.25	0.77*	10	4.5													
							140	2	5													0.55	0.70*	2		
							120	100	5																	
							240	500*	2																5	
BC238-92	TO-92 (97)	30	20	5	50	20	100	0.01	5	0.25	0.77*	10	4.5													
							140	2	5														0.55	0.70*	2	
							120	100	5																	
							125	900*	2																	5
BC238A-92	TO-92 (97)	30	20	5	50	20	100	0.01	5	0.25	0.77*	10	4.5													
							140	2	5															0.55	0.70*	2
							120	100	5																	
							125	260*	2																	
BC238B-92	TO-92 (97)	30	20	5	50	20	100	0.01	5	0.25	0.77*	10	4.5													
							140	2	5															0.55	0.70*	2
							120	100	5																	
							240	500*	2																	
BC238C-92	TO-92 (97)	30	20	5	50	20	100	0.01	5	0.25	0.77*	10	4.5													
							140	2	5															0.55	0.70*	2
							120	100	5																	
							450	900*	2																	
BC239-92	TO-92 (97)	30	20	5	50	20	100	0.01	5	0.25	0.77*	10	4.5													
							140	2	5															0.55	0.70	2
							120	100	5																	
							240	900*	2																	
BC239B-92	TO-92 (97)	30	20	5	50	20	100	0.01	5	0.25	0.77*	10	4.5													
							140	2	5															0.55	0.70	2
							120	100	5																	
							240	500*	2																	
BC239C-92	TO-92 (97)	30	20	5	50	20	100	0.01	5	0.25	0.77*	10	4.5													
							140	2	5															0.55	0.70	2
							120	100	5																	
							450	900*	2																	
BC261A	TO-18		45		50	45	100	0.01	5	0.25	0.9	10	4.5													
							140	2	5															0.55	0.70	2
							120	100	5																	
							125	260*	2																	

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = WB.

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## PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (nA) @ Max	V <sub>CB</sub> (V)	H <sub>FE</sub> h <sub>FE</sub> 1 kHz*				V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)</sub> * (V) @		I <sub>C</sub> (mA)	C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @		I <sub>C</sub> (mA)	t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	I <sub>C</sub> (mA)	V <sub>CE</sub> (V)		Min	Max			Min	Max					
BC261B	TO-18		45		50	45	100	0.01	5	0.25	0.9	10										
							140	2	5	0.6		100										
							120	100	5													
							240	500*	2	5												
BC262A	TO-18		20	5	50	20	100	0.01	5	0.25	0.9	10										
							140	2	5													
							120	100	5													
							125	260*	2	5	0.6	100										
BC262B	TO-18		20	5	50	20	100	0.01	5	0.25	0.9	10										
							140	2	5													
							120	100	5													
							240	500*	2	5	0.6	100										
BC263A	TO-18		20	5	50	20	100	0.01	5	0.25	0.9	10										
							140	2	5													
							120	100	5													
							125	260*	2	5	0.6	100										
BC263B	TO-18		20	5	50	20	100	0.01	5	0.25	0.9	10										
							140	2	5													
							120	100	5													
							240	500*	2	5	0.6	100										
BC307-92	TO-92 (97)	50	45	5	100	20	100	0.01	5	0.18	0.78	10										
							140	2	5		1.0*	100										
							120	100	5													
							75	500*	2	5		0.75*										
BC307A-92	TO-92 (97)	50	45	5	100	20	100	0.01	5	0.18	0.78	10										
							140	2	5		1.0*	100										
							120	100	5													
							125	260*	2	5		0.75*										
BC307B-92	TO-92 (97)	50	45	5	100	20	100	0.01	5	0.18	0.78	10										
							140	2	5		1.0*	100										
							120	100	5													
							240	500*	2	5		0.75*										
BC308-92	TO-92 (97)	30	25	5	100	20	100	0.01	5	0.18	0.78	10										
							140	2	5		1.0*	100										
							120	100	5													
							125	900*	2	5		0.75*										
BC308A-92	TO-92 (97)	30	25	5	100	20	100	0.01	5	0.18	0.78	10										
							140	2	5		1.0*	100										
							120	100	5													
							125	260*	2	5		0.75*										



**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (nA) @ Max	V <sub>CB</sub> (V)	H <sub>FE</sub>				V <sub>CE(SAT)</sub> (V) Max			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)			t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.				
							Min	Max	h <sub>fe</sub> 1 kHz*	@ I <sub>C</sub> (mA)	V <sub>CE</sub> (V)	Max	Min		Max	Min	Max					Min	Max		
BC308B-92	TO-92 (97)	30	25	5	100	20	100		0.01	5	0.18	0.78	10												
							140	400	2	5											1.0*	100			
							120		100	5															
							240	500*	2	5													0.75*	2	
BC308C-92	TO-92 (97)	30	25	5	100	20	100		0.01	5	0.18	0.78	10												
							140	400	2	5												1.0*	100		
							120		100	5															
							450	900*	2	5														0.75*	2
BC309-92	TO-92 (97)	25	20	5	100	20	100		0.01	5	0.18	0.78	10												
							140	400	2	5													1.0	100	
							120		100	5															
							125	900*	2	5															0.75
BC309B-92	TO-92 (97)	25	20	5	100	20	100		0.01	5	0.18	0.78	10												
							140		2	5														1.0	100
							120		100	5															
							240	500*	2	5															
BC309C-92	TO-92 (97)	25	20	5	100	20	100		0.01	5	0.8	0.78	10												
							140	400	2	5														1.0	100
							120		100	5															
							450	900*	2	5															
BC317	TO-92 (92)	50	45	6	30	20	110	450	2	5	0.2	0.77*	10	4											
							125	500*	2	5														0.5	100
BC317A	TO-92 (92)	50	45	6	30	20	110	220	2	5	0.2	0.77*	10	4											
							125	260*	2	5														0.5	100
BC317B	TO-92 (92)	50	45	6	30	20	200	450	2	5	0.2	0.77*	10	4											
							240	500*	2	5														0.5	100
BC318	TO-92 (92)	30	20	5	30	20	110	800	2	5	0.2	0.77*	10	4											
							125	900*	2	5														0.5	100
BC318A	TO-92 (92)	30	20	5	30	20	110	220	2	5	0.2	0.77*	10	4											
							125	260*	2	5														0.5	100
											0.57	0.72*	2												

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = WB.

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PRO ELECTRON SERIES (Continued)

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Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (mA) @ Max	V <sub>CB</sub> (V)	H <sub>FE</sub> h <sub>fe</sub> 1 kHz*				I <sub>C</sub> (mA)	V <sub>CE</sub> (V)	V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)*</sub> (V) @		I <sub>C</sub> (mA)	C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @		I <sub>C</sub> (mA)	t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	2	5				2	5			Min	Max					
BC318B	TO-92 (92)	30	20	5	30	20	200 240	450 500*	2 2	5 5		0.2 0.5	0.77* 0.57	10 2	100	4					6	1	04	
BC318C	TO-92 (92)	30	20	5	30	20	100 450 450	800 900*	2 2	5 5	0.01	0.2* 0.5	0.77* 0.72*	10 2	100	4					6	1	04	
BC319	TO-92 (92)	30	20	5	30	20	40 200 240	800 900*	2 2	5 5	0.01	0.2 0.5	0.77* 0.72*	10 2	100	4					4	1	04	
BC319B	TO-92 (92)	30	20	5	30	20	200 240	450 500*	2 2	5 5		0.2 0.5	0.77* 0.72*	10 2	100	4					4	1	04	
BC319C	TO-92 (92)	30	20	5	30	20	100 420 450	800 900*	2 2	5 5	0.01	0.2 0.5	0.77* 0.72*	10 2	100	4					4	1	04	
BC327	TO-92 (97)	50 <sup>†</sup>	45	5	100 <sup>†</sup>	45	40 100	300 600	1 100	1		0.7		500 300	4						4	1	67	
BC327-10	TO-92 (97)	50 <sup>†</sup>	45	5	100 <sup>†</sup>	45	40 63	300 160	1 100	1		0.7		500 300	4						4	1	67	
BC327-16	TO-92 (97)	50 <sup>†</sup>	45	5	100 <sup>†</sup>	45	40 100	300 250	1 100	1		0.7		500 300	4						4	1	67	
BC327-25	TO-92 (97)	50 <sup>†</sup>	45	5	100 <sup>†</sup>	45	40 160	300 400	1 100	1		0.7		500 300	4						4	1	67	
BC328	TO-92 (97)	30 <sup>†</sup>	25	5	100 <sup>†</sup>	25	40 100	300 600	1 100	1		0.7		500 300	4						4	1	67	
BC328-10	TO-92 (97)	30 <sup>†</sup>	25	5	100 <sup>†</sup>	25	40 63	300 160	1 100	1		0.7		500 300	4						4	1	67	
BC328-16	TO-92 (97)	30 <sup>†</sup>	25	5	100 <sup>†</sup>	25	40 100	300 250	1 100	1		0.7		500 300	4						4	1	67	
BC328-25	TO-92 (97)	30 <sup>†</sup>	25	5	100 <sup>†</sup>	25	40 160	300 400	1 100	1		0.7		500 300	4						4	1	67	
BC337	TO-92 (97)	50 <sup>†</sup>	45	5	100 <sup>†</sup>	45	40 100	300 600	1 100	1		0.7		500 300	4						4	1	14	
BC337-10	TO-92 (97)	50 <sup>†</sup>	45	5	100 <sup>†</sup>	45	40 63	300 160	1 100	1		0.7		500 300	4						4	1	14	
BC337-16	TO-92 (97)	50 <sup>†</sup>	45	5	100 <sup>†</sup>	45	40 100	300 250	1 100	1		0.7		500 300	4						4	1	14	
BC337-25	TO-92 (97)	50 <sup>†</sup>	45	5	100 <sup>†</sup>	45	40 160	300 400	1 100	1		0.7		500 300	4						4	1	14	



**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	VCES*	VCEO	VEBO	ICES*	VCB	HFE		IC	& VCE	VCE(SAT)	VBE(SAT)		Cob	fT		toff	NF	Test Conditions	Process No.
		VCBO (V) Min	(V) Min	(V) Min	(nA) @ Max		(V)	hfe @ 1 kHz*				(mA)	(V)		(V) Min	(V) Max				
BC338	TO-92 (97)	30†	25	5	100†	25	40 100	600	300 100	1	0.7		1.2*	4				4	1	14
BC338-10	TO-92 (97)	30†	25	5	100†	25	40 63	160	300 100	1	0.7		1.2*	4				4	1	14
BC338-16	TO-92 (97)	30†	25	5	100†	25	40 100	250	300 100	1	0.7		1.2*	4				4	1	14
BC338-25	TO-92 (97)	30†	25	5	100†	25	40 160	400	300 100	1	0.7		1.2*	4				4	1	14
BC415	TO-92 (97)	45	35	5	15	30	40 120		0.01 800	5 2	0.25 0.6							2	10	71
BC415A	TO-92 (97)	45	35	5	15	30	40 120		0.01 220	5 2	0.25 0.6							2	10	71
BC415B	TO-92 (97)	45	35	5	15	30	100 180		0.01 460	5 2	0.25 0.6							2	10	71
BC415C	TO-92 (97)	45	35	5	15	30	100 380		0.01 800	5 2	0.25 0.6							2	10	71
BC485	TO-92 (97)	45	45	5	100	30	15 40 60		1A 10 400	5 2 100	0.5		1.2 1.2*	4				4	1	14
BC485A	TO-92 (97)	45	45	5	100	30	15 40 100		1A 10 250	5 2 100	0.5		1.2 1.2*	4				4	1	14
BC485B	TO-92 (97)	45	45	5	100	30	15 40 160		1A 10 400	5 2 100	0.5		1.2 1.2*	4				4	1	14
BC485L	TO-92 (97)	45	45	5	100	30	15 40 60		1A 10 150	5 2 100	0.5		1.2 1.2*	4				4	1	14
BC547	TO-92 (97)	50	45	6	10	20					0.25 0.6		0.77* 0.70*	4.5				10	1	04
BC547A	TO-92 (97)	50	45	6	10	20					0.25 0.6		0.77* 0.70*	4.5				10	1	04

**TEST CONDITIONS:**

(1) IC = 200 μA, VCE = 5V, f = 1 kHz. (2) IC = 100 mA, VCC = 20V, IB<sup>1</sup> = IB<sup>2</sup> = 5 mA. (3) IC = 200 μA, VCE = 2V, f = 1 kHz. (4) IC = 100 mA, VCC = 10V, IB<sup>1</sup> = IB<sup>2</sup> = 10 mA. (5) IC = 10 mA, VCC = 3V, IB<sup>1</sup> = IB<sup>2</sup> = 1 mA. (6) IC = 100 μA, VCE = 5V, f = 1 kHz. (7) IC = 1 mA, VCE = 10V, f = 200 kHz. (8) IC = 1 mA, VCE = 5V, f = 1 kHz. (9) IC = 150 mA, VCC = 6V, IB<sup>1</sup> = IB<sup>2</sup> = 15 mA. (10) IC = 10 μA, VCE = 5V, f = WB.

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## PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (nA) Max	V <sub>CB</sub> (V) 20	HFE h <sub>fe</sub> @ I <sub>C</sub> & V <sub>CE</sub> 1 kHz* @ (mA) & (V)				V <sub>CE(SAT)</sub> & V <sub>BE(ON)*</sub> (V) @ I <sub>C</sub> (mA)		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	2	5	Max	Min		Max	Min				
BC547B	TO-92 (97)	50	45	6	10	20	240	500*	2	5	0.25 0.6	0.77* 0.70*	10 100 2	4.5			10	1	04
BC547C	TO-92 (97)	50	45	6	10	20	450	900*	2	5	0.25 0.6	0.77* 0.70*	10 100 2	4.5			10	1	04
BC548	TO-92 (97)	30	20	5	10	20	125	900*	2	5	0.25 0.6	0.77* 0.70*	10 100 2	4.5			10	1	04
BC548A	TO-92 (97)	30	20	5	10	20	125	260*	2	5	0.25 0.6	0.77* 0.70*	10 100 2	4.5			10	1	04
BC548B	TO-92 (97)	30	20	5	10	20	240	500*	2	5	0.25 0.6	0.77* 0.70*	10 100 2	4.5			10	1	04
BC548C	TO-92 (97)	30	20	5	10	20	450	900*	2	5	0.25 0.6	0.77* 0.70*	10 100 2	4.5			10	1	04
BC549	TO-92 (97)	30	20	5	10	20	240	900*	2	5	0.25 0.6	0.77* 0.70	10 100 2	4.5			4	1	04
BC549B	TO-92 (97)	30	20	5	10	20	240	500*	2	5	0.25 0.6	0.77* 0.70	10 100 2	4.5			4	1	04
BC549C	TO-92 (97)	30	20	5	10	20	450	900*	2	5	0.25 0.6	0.77* 0.70	10 100 2	4.5			4	1	04
BC550	TO-92 (97)	50	45	5	10	45	240	900*	2	5	0.25 0.6	0.77* 0.70	10 100 2				3	1	04
BC550B	TO-92 (97)	50	45	5	10	45	240	500*	2	5	0.25 0.6	0.77* 0.70	10 100 2				3	1	04
BC550C	TO-92 (97)	50	45	5	10	45	450	900*	2	5	0.25 0.6	0.77* 0.70	10 100 2				3	1	04
BC557	TO-92 (97)	50	45	5	100	20	75	260*	2	5	0.3 0.65	0.82* 0.75*	10 100 2				10	1	71



**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	V <sub>CE</sub> * VCBO (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EB0</sub> (V) Min	I <sub>CE</sub> * ICBO (nA) @ Max	V <sub>CB</sub> (V)	H <sub>FE</sub> h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)*</sub> @ I <sub>C</sub> (mA)		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	1 kHz*	2		5	Min		Max	Min				
BC557A	TO-92 (97)	50	45	5	100	20					0.3	0.82*	10					10	1	71
							125	260*	2	5	0.65	0.6	0.75*	2						
BC557B	TO-92 (97)	50	45	5	100	20					0.3	0.82*	10					10	1	71
							240	500*	2	5	0.65	0.6	0.75*	2						
BC558	TO-92 (97)	30	25	5	100	20					0.3	0.82*	10					10	1	71
							75	500*	2	5	0.65	0.6	0.75	2						
BC558A	TO-92 (97)	30	25	5	100	20					0.3	0.82*	10					10	1	71
							125	260*	2	5	0.65	0.6	0.75	2						
BC558B	TO-92 (97)	30	25	5	100	20					0.3	0.82*	10					10	1	71
							240	500*	2	5	0.65	0.6	0.75	2						
BC558C	TO-92 (97)	30	25	5	100	20					0.3	0.82*	10					10	1	71
							450	900*	2	5	0.65	0.6	0.75	2						
BC559	TO-92 (97)	25	20	5	100	20					0.3	0.82*	10					4	1	71
							125	500*	2	5	0.65	0.6	0.75*	2						
BC559A	TO-92 (97)	25	20	5	100	20					0.3	0.82*	10					4	1	71
							125	260*	2	5	0.65	0.6	0.75*	2						
BC559B	TO-92 (97)	25	20	5	100	20					0.3	0.82*	10					4	1	71
							240	500*	2	5	0.65	0.6	0.75*	2						
BC559C	TO-92 (97)	25	20	5	100	20					0.3	0.82*	10					4	1	71
							450	900*	2	5	0.65	0.6	0.75*	2						
BC560	TO-92 (97)	50	45	5	100	45					0.3	0.82*	10					2	1	71
							125	500*	2	5	0.65	0.6	0.75*	2						

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = WB.

5-15



## PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V <sub>CE</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CE</sub> * I <sub>CB0</sub> (nA) @ Max	V <sub>CB</sub> (V)	h <sub>FE</sub> h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub>				V <sub>CE(SAT)</sub> & V <sub>BE(SAT)</sub> (V) & V <sub>BE(ON)</sub> * @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	(mA)	(V)	Max	Min	Max		(mA)	Min				
BC560A	TO-92 (97)	50	45	5	100	45					0.3	0.82*	10					2	1	71
							125	260*	2	5	0.65	0.6	0.75*							
BC560B	TO-92 (97)	50	45	5	100	45					0.3	0.82*	10					2	1	71
							240	500*	2	5	0.65	0.6	0.75*							
BC560C	TO-92 (97)	50	45	5	100	45					0.3	0.82*	10					2	1	71
							450	900*	2	5	0.65	0.6	0.75*							
BCX58	TO-92 (97)		32	7	10	32	120	630	2	5				125	10	800	6	3/4	04	
							80	1000	10	1										
							40		100	1										
BCX58-7	TO-92 (97)		32	7	10	32	120	220	2	5				125	10	800	6	3/4	04	
							80		10	1										
							40		100	1										
BCX58-8	TO-92 (97)		32	7	10	32	20		0.01	5				125	10	800	6	3/4	04	
							180	310	2	5										
							120	400	10	1										
							45		100	1										
BCX58-9	TO-92 (97)		32	7	10	32	40		0.01	5				125	10	800	6	3/4	04	
							250	460	2	5										
							160	630	10	1										
							60		100	1										
BCX58-10	TO-92 (97)		32	7	10	32	100		0.01	5				125	10	800	6	3/4	04	
							380	630	2	5										
							240	1000	10	1										
							60		100	1										
BCX59	TO-92 (97)		45	7			120	630	2	5	0.5	1.0	100	125	10	800		5	04	
							80	1000	10	1										
							40		100	1										
BCX59-7	TO-92 (97)		45	7			120	220	2	5	0.5	1.0	100	125	10	800		5	04	
							80		10	1										
							40		100	1										
BCX59-8	TO-92 (97)		45	7			20		0.01	5	0.5	1.0	100	125	10	800		5	04	
							180	310	2	5										
							120	400	10	1										
							45		100	1										
BCX59-9	TO-92 (97)		45	7			40		0.01	5	0.5	1.0	100	125	10	800		5	04	
							250	460	2	5										
							160	630	10	1										
							60		100	1										

5-16



PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V) Max	H <sub>FE</sub> h <sub>fe</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> V <sub>BE(ON)</sub> * @ I <sub>C</sub> (mA)		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
						Min	Max	Min		Max	Min		Max	Min					Max
BCX59-10	TO-92 (97)		45	7		100	0.01	5	0.5	1.0	100		125	10	800		5	04	
						380	630	2											5
						240	1000	10											1
						60	100	100											1
BCX78	TO-92 (97)		32	5		120	630	2	0.6	1.0	100							71	
						80	1000	10											1
						40	100	100											1
BCX78-7	TO-92 (97)		32	5		120	220	2	0.6	1.0	100							71	
						80	10	1											
						40	100	100											1
BCX78-8	TO-92 (97)		32	5		30	0.01	5	0.6	1.0	100							71	
						180	310	2											5
						120	400	10											1
						45	100	100											1
BCX78-9	TO-92 (97)		32	5		40	0.01	5	0.6	1.0	100							71	
						250	460	2											5
						160	630	10											1
						60	100	100											1
BCX78-10	TO-92 (97)		32	5		100	0.01	5	0.6	1.0	100							71	
						380	630	2											5
						240	1000	10											1
						60	100	100											1
BCX79	TO-92 (97)		45	5		80	1000	10	0.6	1.0	100							71	
						40	100	1											
						120	630	2											5
BCX79-7	TO-92 (97)		45	5		120	220	2	0.6	1.0	100							71	
						45	100	1											
BCX79-8	TO-92 (97)		45	5		120	400	10	0.6	1.0	100							71	
						45	100	1											
						30	0.01	5											
						180	310	2											5
BCX79-9	TO-92 (97)		45	5		160	630	10	0.6	1.0	100							71	
						60	100	1											
						40	0.01	5											
						250	460	2											5

TEST CONDITIONS:

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = WB.

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## PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (nA) @ V <sub>CB</sub> (V) Max	h <sub>FE</sub> @ I <sub>C</sub> & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) & V <sub>BE(ON)</sub> * (V) @ I <sub>C</sub> (mA)				C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						1 kHz*	Min	Max	10 (mA)	1 (V)	Max	Min	Max		Min	Max				
BCX79-10	TO-92 (97)		45	5		240	1000	10	1	0.6		1.0	100							71
						60		100	1											
						100		0.01	5											
						380	630	2	5											
BCY56	TO-18	45	45	5	100	20	40	10	5	0.6	0.7*	2						5	1	04
							100	450	2											
							125	500*	2											
							40		0.01											
BCY57	TO-18	25	20	5	100	20	200	10	5	0.6	0.7*	2						5	1	04
							200	800	2											
							240	900*	2											
							100		0.01											
BCY58	TO-18		32	7	10 <sup>†</sup>	32	40	100	1	0.35	0.6	0.85	10	6	125	10	800	6	4/1	04
							80	1000	10	0.7	0.75	1.2	100							
							125	700*	2		0.55	0.7*	2							
BCY58-7	TO-18		32	7	10 <sup>†</sup>	32	40	100	1	0.35	0.6	0.85	10	6	125	10	800	6	4/1	04
							80	1000	10	0.7	0.75	1.2	100							
							125	250*	2		0.55	0.7*	2							
BCY58-8	TO-18		32	7	10 <sup>†</sup>	32	40	100	1	0.35	0.6	0.85	10	6	125	10	800	6	4/1	04
							80	1000	10	0.7	0.75	1.2	100							
							175	350*	2		0.55	0.7*	2							
BCY58-9	TO-18		32	7	10 <sup>†</sup>	32	40	100	1	0.35	0.6	0.85	10	6	125	10	800	6	4/1	04
							80	1000	10	0.7	0.75	1.2	100							
							250	500*	2		0.55	0.7*	2							
BCY58-10	TO-18		32	7	10 <sup>†</sup>	32	40	100	1	0.35	0.6	0.85	10	6	125	10	800	6	4/1	04
							80	1000	10	0.7	0.75	1.2	100							
							350	700*	2		0.55	0.7*	2							
BCY59	TO-18		45	7	10 <sup>†</sup>	45	40	100	1	0.35	0.6	0.85	10	6	125	10	800	6	4/1	04
							80	1000	10	0.7	0.75	1.2	100	100						
							125	700*	2		0.55	0.7*	2							
BCY59-7	TO-18		45	7	10 <sup>†</sup>	45	40	100	1	0.35	0.6	0.85	10	6	125	10	800	6	4/1	04
							80	1000	10	0.7	0.75	1.2	100							
							125	250*	2		0.55	0.7*	2							
BCY59-8	TO-18		45	7	10 <sup>†</sup>	45	40	100	1	0.35	0.6	0.85	10	6	125	10	800	6	4/1	04
							80	1000	10	0.7	0.75	1.2	100	100						
							175	350*	2		0.55	0.7*	2							
BCY59-9	TO-18		45	7	10 <sup>†</sup>	45	40	100	1	0.35	0.6	0.85	10	6	125	10	800	6	4/1	04
							80	1000	10	0.7	0.75	1.2	100							
							250	500*	2		0.55	0.7*	2							



**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (mA) @ Max	V <sub>CB</sub> (V)	H <sub>FE</sub> h <sub>fe</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> (V) & V <sub>BE(SAT)</sub> (V) & V <sub>BE(ON)</sub> * (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
							Min	Max	1 kHz*	100	1	Max		Min	Max					Min
BCY59-10	TO-18		45	7	10†	45	40	100	1	0.35	0.6	0.85	10	6	125	10	800	6	4/1	04
							80	1000	10	0.7	0.75	1.2	100							
							350	700*	2		0.55	0.7*	2							
BCY70	TO-18	50	40	5	10	40	40	0.1	1	0.25	0.6	0.9	10	6	250	10	420	6	5/6	71
							45	1	1											
							50	10	1											
							15	50	1	0.5		1.2	50							
BCY71	TO-18	45	45	5	500	45	40	0.01	1	0.25	0.6	0.9	10	6	200	10		2	6	71
							80	0.1	1											
							90	1	1											
							100	600	10	0.5		1.2	50							
BCY71A	TO-18	45	45	5	500	45	40	0.01	1	0.25	0.6	0.9	10	6	300	10	420	2	6	71
							80	0.1	1											
							90	1	1											
							100	600	10	0.5		1.2	50							
BCY72	TO-18	25	25	5	500	20	40	1	1	0.25			10	6	200	10	420	6	5/6	71
							50	10	1	0.5		1.2	50							
BD135	TO-126	45	45	5	100	30	25	500	2	0.5		1.0*	500		50	50	420	6	5/6	37
							40	250	50											
BD135-6	TO-126	45	45	5	100	30	40	100	150	0.5			500		50	50				37
							25	500	2											
BD135-10	TO-126	45	45	5	100	30	63	160	150	0.5			500		50	50				37
							25	500	2											
BD135-16	TO-126	45	45	5	100	30	100	250	150	0.5			500		50	50				37
							25	500	2											
BD136	TO-126	45	45	5	100	30	40	250	150	0.5			500		50	50				77
							25	500	2											
BD136-6	TO-126	45	45	5	100	30	40	100	150	0.5			500		50	50				77
							25	500	2											
BD136-10	TO-126	45	45	5	100	30	63	160	150	0.5			500		50	50				77
							25	500	2											
BD136-16	TO-126	45	45	5	100	30	100	250	150	0.5			500		50	50				77
							25	500	2											
BD137	TO-126	60	60	5	100	30	40	160	150	0.5			500		50	50				38
							25	500	2											

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = WB.

5-19





## PRO ELECTRON SERIES (Continued)

Type No.	Case Style	VCES*	VCEO	VEBO	ICES*	VCB	HFE			VCE(SAT)	VBE(SAT)		Cob	f <sub>T</sub>		t <sub>off</sub>	NF	Test Conditions	Process No.
		VCBO (V) Min	(V) Min	(V) Min	ICBO (nA) Max		(V)	h <sub>fe</sub> 1 kHz* @ IC (mA) & VCE (V)	Min		Max	(V) Max		VBE(ON)* @ IC (mA)	Min				
BD137-6	TO-126	60	60	5	100	30	40	100	150	2	0.5		500	50	50				38
BD137-10	TO-126	60	60	5	100	30	63	160	150	2	0.5		500	50	50				38
BD138	TO-126	60	60	5	100	30	40	160	150	2	0.5		500	50	50				78
BD138-6	TO-126	60	60	5	100	30	40	100	150	2	0.5		500	50	50				78
BD138-10	TO-126	60	60	5	100	30	63	160	150	2	0.5		500	50	50				78
BD139	TO-126	80	80	5	100	30	25	160	500	2	0.5	1.0*	500	50	50	420	6	5/6	39
BD139-6	TO-126	80	80	5	100	30	25	100	500	2	0.5	1.0*	500	50	50				39
BD139-10	TO-126	80	80	5	100	30	25	160	500	2	0.5	1.0*	500	50	50				39
BD140	TO-126	80	80	5	100	30	25	160	500	2	0.5	1.0*	500	50	50	420	6	5/6	79
BD157	TO-126		250		100 μA	275	30	240	50	10									36
BD158	TO-126		300		100 μA	325	30	240	50	10									36
BD159	TO-126		350		100 μA	325	30	240	50	10									36
BD185	TO-126		30		100 μA	40	40	15	500	2	1.0	1.2*	2A						4F
BD186	TO-126		30		100 μA	40	40	15	500	2	1.0	1.5*	2A						5F
BD187	TO-126		45		100 μA	55	40	15	500	2	1.0	1.5*	2A						4F
BD188	TO-126		45		100 μA	55	40	15	500	2	1.0	1.5*	2A						5F
BD189	TO-126		60		100 μA	70	40	15	500	2	1.0	1.5*	2A						4F
BD190	TO-126		60		100 μA	70	40	15	500	2	1.0	1.5*	2A						5F
BD201	TO-220	60	45	5	10 μA	40	30	75	3A	2	1.0	1.5*	3A	3	300	420	6	5/6	4A
BD202	TO-220	60	45	5	10 μA	40	30	75	3A	2	1.0	1.5*	3A	3	300	420	6	5/6	5A



**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	V <sub>CE(SAT)</sub> (V) Min	V <sub>CE(O)</sub> (V) Min	V <sub>BE(O)</sub> (V) Min	I <sub>CE(S)</sub> (nA) @ Max	V <sub>CB</sub> (V) (V)	H <sub>FE</sub> h <sub>FE</sub> 1 kHz* @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> & V <sub>BE(ON)</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	(mA)	(V)	Min	Max		Min	Max				
BD203	TO-220	60	60	5			30	2	2	1.0		3A		3	300				4A
BD204	TO-220	60	60	5	10 μA	40	30	2A	2	1.0	1.5*	3A							5A
BD220	TO-220		70				30	120	500	4	1.0	1.1*	500						4F
BD221	TO-220		40				30	120	1A	4	1.0	1.3*	1A						4F
BD222	TO-220		60				20	80	1.5A	4	1.0	1.5*	1.5A						4F
BD223	TO-220	70					30	120	300	4	1.0	1.1*	500						5F
BD224	TO-220		40				30	120	1A	4	1.0	1.3*	1A						5F
BD225	TO-220		60				20	80	1.5A	4	1.0	1.5*	1.5A						5F
BD233	TO-126	45	45		100 μA	45	25	1A	2	0.6	1.3*	1A	3	250	420	6	5/6		4F
BD234	TO-126	45	45		100 μA	45	25	1A	2	0.6	1.3*	1A	3	250	420	6	5/6		5F
BD235	TO-126	60	60		100 μA	60	25	1A	2	0.6	1.3*	1A	3	250	420	6	5/6		4F
BD236	TO-126	60	60		100 μA	60	25	1A	2	0.6	1.3*	1A	3	250	420	6	5/6		5F
BD237	TO-126	80	80		100 μA	80	25	1A	2	0.6	1.3*	1A	3	250	420	6	5/6		4F
BD238	TO-126		80		100 μA	80	25	1A	2	0.6	1.3*	1A	3	250	420	6	5/6		5F
BD239	TO-220		45		200 μA*	45	15	1A	4	0.7	1.3*	1A	3	200	420	6	5/6		4F
BD239A	TO-220		60		200 μA*	60	15	1A	4	0.7	1.3*	1A	3	200	420	6	5/6		4F
BD239B	TO-220		80		200 μA*	80	15	1A	4	0.7	1.3*	1A	3	200	420	6	5/6		4F
BD239C	TO-220		100		200 μA*	100	15	1A	4	0.7	1.3*	1A	3	200	420	6	5/6		4F
BD240	TO-220		45		200 μA*	45	15	1A	4	0.7	1.3*	1A	3	200	420	6	5/6		5F
BD240A	TO-220	80	60		200 μA*	60	15	1A	4	0.7	1.3*	1A	3	200	420	6	5/6		5F

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = WB.

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PRO ELECTRON SERIES (Continued)

Type No.	Case Style	VCES* VCBO (V) Min	VCEO (V) Min	VEBO (V) Min	ICES* ICBO (nA) @ Max	VCB (V)	HFE h <sub>fe</sub> @ IC & VCE			VCE(SAT) (V) & VBE(SAT) (V) & VBE(ON)* @ IC (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ IC (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	Min	Max	Min	Max		Min	Max				
BD240B	TO-220	80	80		200 μA* 80		15 40	1A 200	4 4	0.7	1.3*	1A		3	200	420	6	5/6	5F
BD240C	TO-220	80	100		200 μA* 100		15 40	1A 200	4 4	0.7	1.3*	1A		3	200	420	6	5/6	5F
BD241	TO-220	80	45		200 μA* 45		10 25	3A 1A	4 4	1.3	1.8*	3A		3	500	420	6	5/6	4F
BD241A	TO-220	80	60		200 μA* 60		10 25	3A 1A	4 4	1.3	1.8*	3A		3	500	420	6	5/6	4F
BD241B	TO-220	80	80		200 μA* 80		10 25	3A 1A	4 4	1.3	1.8*	3A		3	500	420	6	5/6	4F
BD241C	TO-220	80	100		200 μA* 100		10 25	3A 1A	4 4	1.3	1.8*	3A		3	500	420	6	5/6	4F
BD242	TO-220	80	45		200 μA* 45		10 25	3A 1A	4 4	1.2	1.8*	3A		3	500	420	6	5/6	5E
BD242A	TO-220	80	60		200 μA* 60		10 25	3A 1A	4 4	1.2	1.8*	3A		3	500	420	6	5/6	5E
BD242B	TO-220	80	80		200 μA* 80		10 25	3A 1A	4 4	1.2	1.8*	3A	3	3	500	420	6	5/6	5E
BD242C	TO-220	80	100		200 μA* 100		10 25	3A 1A	4 4	1.2	1.8*	3A		3	500	420	6	5/6	5E
BD243	TO-220		45		400 μA* 45		30 15	300 3A	4 4					3	500				4A
BD243A	TO-220		60		400 μA* 60		30 15	300 3A	4 4					3	500				4A
BD243B	TO-220		80		400 μA* 80		30 15	300 3A	4 4					3	500				4A
BD243C	TO-220		100		400 μA* 100		30 15	300 3A	4 4										4A
BD244	TO-220		45		400 μA* 45		30 15	300 3A	4 4										4A
BD244A	TO-220		60		400 μA* 60		30 15	300 3A	4 4										5A
BD244B	TO-220		80		400 μA* 80		30 15	300 3A	4 4				3	500					5A
BD244C	TO-220		100		400 μA* 100		30 15	300 3A	4 4				3	500					5A
BD344	TO-126	60	60	5	500 60		60 40	50 250 200	1 1	0.4		200	20	50	50				78



**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	V <sub>CE(S)</sub> V <sub>CB(O)</sub> (V) Min	V <sub>CE(O)</sub> (V) Min	V <sub>EB(O)</sub> (V) Min	I <sub>CE(S)</sub> I <sub>CB(O)</sub> (nA) @ V <sub>CB</sub> (V) Max	H <sub>FE</sub> h <sub>FE</sub> 1 kHz*				V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)</sub> * (V) @ I <sub>C</sub> (mA)		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max	@ (mA)	& V <sub>CE</sub> (V)		Min	Max		Min	Max				
BD345	TO-126	60	60	5	500	60	40	50	1	0.4		200	20	50	50				38
BD346	TO-220		60		10 μA	40	30	140	2A				200	4	250				5A
BD347	TO-220		60		10 μA	40	30	140	2A				200	4	250				4A
BD348	TO-126	80	80	5	500	60	50	100	1	0.5		250	17	50	50				79
BD349	TO-126		80		500	60	50	100	1	0.5	1.5*	250	15	50	50				39
BD370A	TO-237 (91)	80	45		100	25	40	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD370A-10	TO-237 (91)	80	45		100	25	63	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD370A-16	TO-237 (91)	80	45		100	25	100	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD370A-25	TO-237 (91)	80	45		100	25	160	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD370B	TO-237 (91)	80	60		100	25	40	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD370B-10	TO-237 (91)	80	60		100	25	63	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD370B-16	TO-237 (91)	80	60		100	25	100	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD370B-25	TO-237 (91)	80	60		100	25	160	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD370C	TO-237 (91)	80	80		100	25	40	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD370-6	TO-237 (91)	80	80		100	25	40	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD370C-10	TO-237 (91)	80	80		100	25	63	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD370C-16	TO-237 (91)	80	80		100	25	100	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = WB.

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## PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (mA) @ Max	V <sub>CB</sub> (V)	H <sub>FE</sub> h <sub>fe</sub> 1 kHz*		I <sub>C</sub> (mA) & V <sub>CE</sub> (V)	V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)</sub> * (V) @		I <sub>C</sub> (mA)	C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max			Min	Max			Min	Max				
BD370D	TO-237 (91)	80	100		100	80	25 40	500 400	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	79	
BD370D-6	TO-237 (91)	80	100		100	80	25 40	500 100	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	79	
BD370D-10	TO-237 (91)	80	100		100	80	25 63	500 160	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	79	
BD371A	TO-237 (91)	80	45		100	45	25 40	500 400	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	38	
BD371A-10	TO-237 (91)	80	45		100	45	25 63	500 160	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	38	
BD371A-16	TO-237 (91)	80	45		100	45	25 100	500 250	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	38	
BD371A-25	TO-237 (91)	80	45		100	45	25 180	500 400	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	38	
BD371B	TO-237 (91)	80	60		100	60	25 40	500 400	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	38	
BD371B-10	TO-237 (91)	80	60		100	60	25 63	500 160	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	38	
BD371B-16	TO-237 (91)	80	60		100	60	25 100	500 250	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	38	
BD371B-25	TO-237 (91)	80	60		100	60	25 160	500 400	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	38	
BD371C	TO-237 (91)	80	80		100	80	25 40	500 400	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	38	
BD371C-6	TO-237 (91)	80	80		100	80	25 40	500 100	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	38	
BD371C-10	TO-237 (91)	80	80		100	80	25 63	500 160	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	38	
BD371C-16	TO-237 (91)	80	80		100	80	25 100	500 250	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	38	
BD371D	TO-237 (91)	80	100		100	100	25 40	500 400	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	39	
BD371D-6	TO-327 (91)	80	100		100	100	25 40	500 100	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	39	
BD371D-10	TO-237 (91)	80	100		100	100	25 63	500 160	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	39	
BD372A	TO-237 (90)	80	45		100	45	25 40	500 400	2 1	0.7	1.2*	1A	30	50	200	420	6	5/6	78	



**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	VCES* VCBO (V) Min	VCEO (V) Min	VEBO (V) Min	ICES* ICBO (nA) @ VCB Max	HFE h <sub>fe</sub> @ I <sub>C</sub> & V <sub>CE</sub>				V <sub>CE(SAT)</sub> & V <sub>BE(SAT)</sub> (V) & V <sub>BE(ON)*</sub> @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
						Min	Max	(mA)	(V)	Max	Min	Max		Min	Max				
BD372A-10	TO-237 (90)	80	45		100	45	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD372A-16	TO-237 (90)	80	45		100	45	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD372A-25	TO-237 (90)	80	45		100	45	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD372B	TO-237 (90)	80	60		100	60	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD372B-10	TO-237 (90)	80	60		100	60	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD372B-16	TO-237 (90)	80	60		100	60	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD372B-25	TO-237 (90)	80	60		100	60	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD372C	TO-237 (90)	80	80		100	80	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD372C-6	TO-237 (90)	80	80		100	80	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD372C-10	TO-237 (90)	80	80		100	80	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD372C-16	TO-237 (90)	80	100		100	100	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	78
BD372D	TO-237 (90)	80	100		100	100	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	79
BD372D-6	TO-237 (90)	80	100		100	100	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	79
BD372D-10	TO-237 (90)	80	100		100	100	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	79
BD373A	TO-237 (90)	80	45		100	45	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	38
BD373A-10	TO-237 (90)	80	45		100	45	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	38
BD373A-16	TO-237 (90)	80	45		100	45	25	500	2	0.7	1.2*	1A	30	50	200	420	6	5/6	38

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = WB.





## PRO ELECTRON SERIES (Continued)

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Type No.	Case Style	V <sub>CES</sub> *	V <sub>CEO</sub>	V <sub>EBO</sub>	I <sub>CES</sub> *	V <sub>CB</sub>	H <sub>FE</sub>				V <sub>CE(SAT)</sub>	V <sub>BE(SAT)</sub> & V <sub>BE(ON)</sub> *			I <sub>C</sub>	C <sub>ob</sub>	f <sub>T</sub>		t <sub>off</sub>	NF	Test Conditions	Process No.
		V <sub>CBO</sub> (V) Min	(V) Min	(V) Min	I <sub>CBO</sub> (nA) Max		Min	h <sub>fe</sub> 1 kHz*	Max	I <sub>C</sub> (mA) @ V <sub>CE</sub> (V)		Max	Min	Max			(pF) Max	Min				
BD373A-25	TO-237 (90)	80	45		100	45	25	160	400	500	2	1	0.7	1.2*	1A	30	50	200	420	6	5/6	38
BD373B	TO-237 (90)	80	80		100	80	25	40	400	500	2	1	0.7	1.2*	1A	30	50	200	420	6	5/6	38
BD373B-10	TO-237 (90)	80	60		100	80	25	63	160	500	2	1	0.7	1.2*	1A	30	50	200	420	6	5/8	38
BD373B-16	TO-237 (90)	80	60		100	60	25	100	250	500	2	1	0.7	1.2*	1A	30	50	200	420	6	5/8	38
BD373B-25	TO-237 (90)	80	60		100	60	25	160	400	500	2	1	0.7	1.2*	1A	30	50	200	420	6	5/6	38
BD373C	TO-237 (90)	80	80		100	80	25	40	400	500	2	1	0.7	1.2*	1A	30	50	200	420	6	5/6	38
BD373C-6	TO-237 (90)	80	80		100	80	25	40	100	500	2	1	0.7	1.2*	1A	30	50	200	420	6	5/6	38
BD373C-10	TO-237 (90)	80	80		100	80	25	63	160	500	2	1	0.7	1.2*	1A	30	50	200	420	6	5/6	38
BD373C-16	TO-237 (90)	80	80		100	80	25	100	250	500	2	1	0.7	1.2*	1A	30	50	200	420	6	5/6	38
BD373D	TO-237 (90)	80	100		100	100	25	40	400	500	2	1	0.7	1.2*	1A	30	50	200	420	6	5/6	39
BD373D-6	TO-237 (90)	80	100		100	100	25	40	100	500	2	1	0.7	1.2*	1A	30	50	200	420	6	5/6	39
BD373D-10	TO-237 (90)	80	100		100	100	25	63	160	500	2	1	0.7	1.2*	1A	30	50	200	420	6	5/6	39
BD375	TO-126	50	45		2 μA	45	20	40		1A	2	2	1.0	1.5*	1A	30	50	200	420	6	5/6	38
BD375-6	TO-126	50	45		2 μA	45	20	40	100	1A	2	2	1.0	1.5*	1A	30	50	200	420	6	5/6	38
BD375-10	TO-126	50	45		2 μA	45	20	63	160	1A	2	2	1.0	1.5*	1A	30	50	200	420	6	5/6	38
BD375-16	TO-126	50	45		2 μA	45	20	100	250	1A	2	2	1.0	1.5*	1A	30	50	200	420	6	5/6	38
BD375-25	TO-126	50	45		2 μA	45	20	150	375	1A	2	2	1.0	1.5*	1A	30	50	200	420	6	5/6	38
BD376	TO-126	50	45		2 μA	45	20	40	375	1A	2	2	1.0	1.5*	1A	30	50	200	420	6	5/6	78
BD376-6	TO-126	50	45		2 μA	45	20	40	100	1A	2	2	1.0	1.5*	1A	30	50	200	420	6	5/6	78



**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) Max	V <sub>CB</sub> (V)	H <sub>FE</sub> h <sub>fe</sub> @ I <sub>C</sub> & V <sub>CE</sub>				V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)</sub> * @ I <sub>C</sub>		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	Min	Max		Min	Max		Min	Max				
BD376-10	TO-126	50	45		2 μA	45	20 63	160	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	78
BD376-16	TO-126	50	45		2 μA	45	20 100	200	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	78
BD376-25	TO-126	50	45		2 μA	45	20 150	375	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	78
BD377	TO-126	75	60		2 μA	60	20 40	375	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	38
BD377-6	TO-126	75	60		2 μA	60	20 40	100	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	38
BD377-10	TO-126	75	60		2 μA	60	20 63	160	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	38
BD377-16	TO-126	75	60		2 μA	60	20 100	250	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	38
BD377-25	TO-126	75	60		2 μA	60	20 150	375	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	38
BD378	TO-126	75	60		2 μA	60	20 40	375	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	78
BD378-6	TO-126	75	60		2 μA	60	20 40	100	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	78
BD378-10	TO-126	75	60		2 μA	60	20 63	160	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	78
BD378-16	TO-126	75	60		2 μA	60	20 100	250	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	78
BD378-25	TO-126	75	60		2 μA	60	20 150	375	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	78
BD379	TO-126	100	80		2 μA	80	20 40	375	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	39
BD379-6	TO-126	100	80		2 μA	80	20 40	100	1A 150	2 2	1.0	1.5*	1A	30	50	200	420	6	5/6	39

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = WB.

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## PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ V <sub>CB</sub> (V) Max.		H <sub>FE</sub> h <sub>fe</sub> @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)				V <sub>CE(SAT)</sub> (V) Max			V <sub>BE(SAT)</sub> & V <sub>BE(ON)*</sub> (V) @ I <sub>C</sub> (mA)			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
					Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max							
BD379-10	TO-126	100	80		2 μA	80	20	160	1A	2	1.0	1.5*	1A	30	50	200	420	6	5/6	39			
BD379-16	TO-126	100	80		2 μA	80	63	250	1A	2	1.0	1.5*	1A	30	50	200	420	6	5/6	39			
BD379-25	TO-126	100	80		2 μA	80	20	375	1A	2	1.0	1.5*	1A	30	50	200	420	6	5/6	39			
BD380	TO-126	100	80		2 μA	80	20	375	1A	2	1.0	1.5*	1A	30	50	200	420	6	5/6	79			
BD380-6	TO-126	100	80		2 μA	80	20	100	1A	2	1.0	1.5*	1A	30	50	200	420	6	5/6	79			
BD380-10	TO-126	100	80		2 μA	80	20	160	1A	2	1.0	1.5*	1A	30	50	200	420	6	5/6	79			
BD380-16	TO-126	100	80		2 μA	80	20	250	1A	2	1.0	1.5*	1A	30	50	200	420	6	5/6	79			
BD380-25	TO-126	100	80		2 μA	80	20	375	1A	2	1.0	1.5*	1A	30	50	200	420	6	5/6	79			
BD433	TO-126	22 <sup>†</sup>	22	5	100 μA	22	50	475	2A	1	0.5	1.1*	2A	30	3	250	420	6	5/6	4E			
BD434	TO-126	22 <sup>†</sup>	22	5	100 μA	22	40	475	2A	1	0.5	1.1*	2A	30	3	250	420	6	5/6	5E			
BD435	TO-126	32 <sup>†</sup>	32	5	100 μA	32	40	475	2A	1	0.5	1.1*	2A	30	3	250	420	6	5/6	4E			
BD436	TO-126	32 <sup>†</sup>	32	5	100 μA	32	40	475	2A	1	0.5	1.1*	2A	30	3	250	420	6	5/6	5E			
BD437	TO-126	45 <sup>†</sup>	45	5	100 μA	45	40	236	2A	1	0.6	1.2*	2A	30	3	250	420	6	5/6	4E			
BD438	TO-126	45 <sup>†</sup>	45	5	100 μA	45	40	236	2A	1	0.6	1.2*	2A	30	3	250	420	6	5/6	5E			
BD439	TO-126	60 <sup>†</sup>	60	5	100 μA	60	25	236	2A	1	0.8	1.5*	2A	30	3	250	420	6	5/6	4E			



**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) Max	V <sub>CB</sub> (V)	H <sub>FE</sub> h <sub>fe</sub> @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)</sub> * @ I <sub>C</sub>		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
							Min	Max	(mA)		(V)	Min		Max	Min					Max
BD440	TO-126	60 <sup>†</sup>	60	5	100 μA	60	25 40 20	236	2A 500 10	1 1 5	0.8	1.5*	2A	80	3	250	420	6	5/6	5E
BD441	TO-126	80 <sup>†</sup>	80	5	100 μA	80	15 40 15	236	2A 500 10	1 1 5	0.8	1.5*	2A	30	3	250	420	6	5/6	4E
BD442	TO-126	80 <sup>†</sup>	80	5	100 μA	80	15 40 15	236	2A 500 10	1 1 5	0.8	1.5*	2A	30	3	250	420	6	5/6	5E
BD533	TO-220	80 <sup>†</sup>	45	5	100 μA	45	25 40 20		2A 500 10	2 2 5	0.8	1.5*	2A	30	3	250	420	6	5/6	4E
BD534	TO-220	80 <sup>†</sup>	45	5	100 μA	45	25 40 20		2A 500 10	2 2 5	0.8	1.5*	2A	30	3	250	420	6	5/6	5E
BD535	TO-220	80 <sup>†</sup>	60	5	100 μA	60	25 40 20		2A 500 10	2 2 5	0.8	1.5*	2A	30	3	250	420	6	5/6	4E
BD536	TO-220	80 <sup>†</sup>	60	5	100 μA	60	25 40 20		2A 500 10	2 2 5	0.8	1.5*	2A	30	3	250	420	6	5/6	5E
BD537	TO-220	80 <sup>†</sup>	80	5	100 μA	80	15 40 15		2A 500 10	2 2 5	0.8	1.5*	2A	30	3	250	420	6	5/6	4E
BD538	TO-220	80 <sup>†</sup>	80	5	100 μA	80	15 40 15		2A 500 10	2 2 5	0.8	1.5*	2A	30	3	250	420	6	5/6	5E
BD633	TO-220	45	45	5	200 μA <sup>†</sup>	45	25 40		1A 25	2 2	0.6	1.3*	1A	30	3	250	420	6	5/6	4F
BD634	TO-220	45	45	5	200 μA <sup>†</sup>	45	25 40		1A 25	2 2	0.6	1.3*	1A	30	3	250	420	6	5/6	5F
BD635	TO-220	60	60	5	200 μA <sup>†</sup>	60	25 40		1A 25	2 2	0.6	1.3*	1A	30	3	250	420	6	5/6	4F

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 mA, V<sub>CE</sub> = 5V, f = WB.

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## PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CBO</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (nA) @ Max	V <sub>CB</sub> (V)	H <sub>FE</sub> h <sub>fe</sub> 1 kHz* @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)			V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)</sub> * (V) @ I <sub>C</sub> (mA)		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	Min		Max	Min		Max	Min				
BD636	TO-220	60	60	5	200 μA†	60	25 40	1A 25	2 2	0.6	1.3*	1A	30	3	250	420	6	5/6	5F
BD637	TO-220	100	80	5	200 μA†	100	25 40	1A 25	2 2	0.6	1.3*	1A	30	3	250	420	6	5/6	4F
BD638	TO-220	100	80	5	200 μA†	100	25 40	1A 25	2 2	0.6	1.3	1A	30	3	250	420	6	5/6	5F
BD675	TO-126		45		200 μA	45	750	1.5A	3	2.5	2.5*	1.5A		1	1.5A				4J
BD675A	TO-126		45		200 μA	45	750	2A	3	2.8	2.5*	2A		1	1.5A				4J
BD676	TO-126		45		200 μA	45	750	1.5A	3V	2.5	2.5*	1.5A		1	1.5A				5J
BD676A	TO-126		45		200 μA	45	750	2A	3V	2.8	2.5*	2A		1	1.5A				5J
BD677	TO-126		60		200 μA	60	750	1.5A	3V	2.5	2.5*	1.5A		1	1.5A				4J
BD677A	TO-126		60		200 μA	60	750	2A	3V	2.8	2.5*	2A		1	1.5A				4J
BD678	TO-126		60		200 μA	60	750	1.5A	3V	2.5	2.5*	1.5A		1	1.5A				5J
BD678A	TO-126		60		200 μA	60	750	2A	3V	2.8	2.5*	2A		1	1.5A				5J
BD679	TO-126		80		200 μA	80	750	1.5A	3V	2.5	2.5*	1.5A		1	1.5A				4J
BD679A	TO-126		80		200 μA	80	750	2A	3V	2.8	2.5*	2A		1	1.5A				4J
BD680	TO-126		80		200 μA	80	750	1.5A	3V	2.5	2.5*	1.5A		1	1.5A				5J
BD680A	TO-126		80		200 μA	80	750	2A	3V	2.8	2.5*	2A		1	1.5A				5J
BD681	TO-126		100		200 μA	100	750	1.5A	3V	2.5	2.5*	1.5A		1	1.5A				4J
BD682	TO-126		100		200 μA	100	750	1.5A	3V	2.5	2.5*	1.5A		1	1.5A				5J
BD733	TO-220	25	25	5	200 μA†	25	50 40	2A 20	1 4	0.6	1.1*	2A		1	1.5A				4F
BD734	TO-220	25	25	5	200 μA†	25	50 40	2A 20	1 4	0.6	1.1*	2A		1	1.5A				5E
BD735	TO-220	35	35	5	200 μA†	35	40 40	2A 20	1 4	0.6	1.1*	2A		1	1.5A				4F
BD736	TO-220	35	35	5	200 μA†	35	40 40	2A 20	1 4	0.6	1.1*	2A		1	1.5A				5E
BD737	TO-220	45	45	5	200 μA†	45	40 40	2A 20	1 4	0.8	1.1*	2A		1	1.5A				4F
BD738	TO-220	45	45	5	200 μA†	45	40 40	2A 20	1 4	0.8	1.1*	2A		1	1.5A				5E
BD795	TO-220		45		100	45	40 25	1A 3A	2 2	1.0	1.6*	3A		3	250				4E
BD796	TO-220		45		100	45	40 25	1A 3A	2 2	1.0	1.6*	2A		3	250				5E
BD797	TO-220		60		100 μA	60	40 25	1A 3A	2 2	1.0	1.6*	3A		3	250				4E

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**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ Max	V <sub>CB</sub> (V)	H <sub>FE</sub> h <sub>FE</sub> 1 kHz* @ I <sub>C</sub> (mA) & V <sub>CE</sub> (V)			V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)</sub> * (V) @ I <sub>C</sub> (mA)		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							Min	Max	Min		Max	Min		Max	Min				
BD798	TO-220		60		100 μA	60	40	1A	2	1.0	1.6*	3A		3	250				5E
BD799	TO-220		80		100 μA	80	30	1A	2	1.0	1.6*	3A		3	250				4E
BD800	TO-220		80		100 μA	80	15	3A	2	1.0	1.6*	3A		3	250				5E
BD801	TO-220		100		100 μA	100	30	1A	2	1.0	1.6*	3A		3	250				4E
BD802	TO-220		100		100 μA	100	15	3A	2	1.0	1.6*	3A		3	250				5E
BD895	TO-220		45		200 μA	45	750	3A	3		2.5*	3A		1	3A				4K
BD895A	TO-220		45		200 μA	45	750	4A	3		2.5*	4A		1	3A				4K
BD896	TO-220		45		200 μA	45	750	3A	3		2.5*	3A		1	3A				5K
BD896A	TO-220		45		200 μA	45	750	4A	3		2.5*	4A		1	3A				5K
BD897	TO-220		60		200 μA	60	750	3A	3		2.5*	3A		1	3A				4K
BD897A	TO-220		60		200 μA	60	750	4A	3		2.5*	4A		1	4A				4K
BD898	TO-220		60		200 μA	60	750	3A	3		2.5*	3A		1	3A				5K
BD898A	TO-220		60		200 μA	60	750	4A	3		2.5*	4A		1	4A				5K
BD899	TO-220		80		200 μA	80	750	3A	3		2.5*	3A		1	3A				4K
BD899A	TO-220		80		200 μA	80	750	4A	3		2.5*	4A		1	4A				4K
BD900	TO-220		80		200 μA	80	750	3A	3		2.5*	3A		1	3A				5K
BD900A	TO-220		80		200 μA	80	750	4A	3		2.5*	4A		1	4A				5K
BD901	TO-220		100		200 μA	100	750	3A	3		2.5*	3A		1	3A				4K
BD902	TO-220		100		200 μA	100	750	4A	3		2.5*	4A		1	4A				4K
BDX33	TO-220		45		1 mA	45	750	4A	3		2.5*	4A		20	1A				4K
BDX33A	TO-220		60		1 mA	60	750	4A	3		2.5*	4A		20	1A				4K
BDX33B	TO-220		80		1 mA	80	750	3A	3		2.5*	3A		20	1A				4K
BDX33C	TO-220		100		1 mA	100	750	3A	3		2.5*	3A		20	1A				4K
BDX33D	TO-220		120		1 mA	120	750	3A	3		2.5*	3A		20	1A				4K
BDX34	TO-220		45		1 mA	45	750	4A	3		2.5*	4A		20	1A				5K
BDX34A	TO-220		60		1 mA	60	750	4A	3		2.5*	4A		20	1A				5K
BDX34B	TO-220		80		1 mA	80	750	3A	3		2.5*	3A		20	1A				5K

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 mA, V<sub>CE</sub> = 5V, f = WB.





## PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CBO</sub> (mA) @ Max	V <sub>CB</sub> (V) Min	HFE			V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)</sub> * (V) @ Min Max		I <sub>C</sub> (mA) Max	C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ Min Max		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
							h <sub>fe</sub> 1 kHz*	I <sub>C</sub> (mA)	V <sub>CE</sub> (V)		Min	Max			I <sub>C</sub> (mA)	Min				
BDX34C	TO-220		100		1 mA	100	750	3A	3		2.5*	3A		20	1A					5K
BDX34D	TO-220		120		1 mA	120	750	3A	3		2.5*	3A		20	1A					5K
BF167	TO-72 (28)	40	30	4	100†	30	26	4	10		0.84*	4								45
BF180	TO-72 (25)	30	20	3	100	20	13 6	2 12	10 7											41
BF181	TO-72 (25)	30	20	3	100	20	13 6	2 12	10 7											41
BF194	TO-92 (98)	Same as BF254, see page 5-33 for explanation																		46
BF195	TO-92 (98)	Same as BF255, see page 5-33 for explanation																		46
BF196	TO-92 (98)	Same as BF198, see below for explanation																		45
BF197	TO-92 (98)	Same as BF199, see below for explanation																		47
BF198	TO-92 (98)	40	30	4	100	40	26 6	4 12	10 7		0.85*	4								45
BF199	TO-92 (98)	40	25	4	100	40	36 6	7 12	10 7					1100 typ	7					47
BF200	TO-72 (25)	30	20	3	100	40	15 6	3 12	10 7											41
BF233-2	TO-92 (96)	30	30	4	100	10	40 6	70 12	1 7	10	0.65	0.74*	1	1.0	150	1				49
BF233-3	TO-92 (96)	30	30	4	100	10	60 6	100 12	1 7	10	0.65	0.74*	1	1.0	150	1				49
BF233-4	TO-92 (96)	30	30	4	100	10	90 6	150 12	1 7	10	0.65	0.74*	1	1.0	150	1				49
BF233-5	TO-92 (96)	30	30	4	100	10	140 6	220 12	1 7	10	0.65	0.74*	1	1.0	150	1				49
BF237	TO-92 (98)	45	30	4	100	20				0.25		10								47
BF238	TO-92 (98)	45	30	4	100	20				0.25		10								47
BF240	TO-92 (98)	40	40	4	100	20	67 6	222 12	1 7	10	0.65	0.74*	1	0.34		1		3.5	7	47
BF241	TO-92 (98)	40	40	4	100	20	36 6	125 12	1 7	10	0.65	0.74*	1	0.34		1		3.5	7	47



**PRO ELECTRON SERIES** (Continued)

5-33

Type No.	Case Style	V <sub>CE(S)</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CE(S)</sub> (mA) Max	I <sub>CBO</sub> (nA) Max	V <sub>CB</sub> (V)	H <sub>FE</sub>		I <sub>C</sub> (mA) &	V <sub>CE</sub> (V)	V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)</sub> (V) Min Max		I <sub>C</sub> (mA)	C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.
								1 kHz* Min	@ Max				Min	Max			Min	Max				
BF254	TO-92 (98)	30	20	5	100	20		67 6	220 12	1 12	10 7		0.65	0.74*	1	0.34		1		3.5	7	46
BF255	TO-92 (98)	30	20	-5	100	20		36 6	125 12	1 12	10 7		0.65	0.74*	1	0.34		1		3.5	7	46
BF257	TO-39	100	100	5	50	100		25 6	30 12	10 7		1.0	0.65	0.74*	30	0.34		1		3.5	7	48
BF258	TO-39	250	250	5	50	200		25 6	30 12	10 7		1.0	0.65	0.74*	30	0.34		1		3.5	7	48
BF259	TO-39	300	300	5	50	250		25 6	30 12	10 7		1.0	0.65	0.74*	30	0.34		1		3.5	7	48
BF457	TO-126	100	100	5	50	100		25 6	30 12	10 7		1.0	0.65	0.74*	30	0.34		1		3.5	7	48
BF458	TO-126	250	200	5	50	200		25 6	30 12	10 7		1.0	0.65	0.74*	30	0.34		1		3.5	7	48
BF459	TO-126	300	300	5	50	250		25 6	30 12	10 7		1.0	0.65	0.74*	30	0.34		1		3.5	7	48
BFX13	TO-18	20	15	5	50	15		10 50 18	100 250 1	2 10 0.35 2		0.2 0.25 1.5	0.78 0.9 1.5	1 10 100	6	150	10		10	8	66	
BFX29	TO-5	20	15	5	50	50		40 50 50 40 20	150 50 10 1 0.1	10 10 10 10 10		0.4	1.3 0.9	150 30	12	100	50	150		9	63	
BFX30	TO-5	65	65	5	50	50		10 20 50 40	150 50 10 1	0.4 0.4 0.4 0.4			0.9 1.3	30 150	12		290		4	63		
BFX37	TO-18	60	60	6	20 <sup>†</sup>	50		100 100 0.85 70	10 1 0.1 300	5 5 5 0.01		0.4 0.25	1.0 0.9	50 10	6	40	0.5		3	1	62	
BFX65	TO-18	45	45	6	10*	40		100 100 100 40	10 1 0.1 0.01	5 5 5 5		0.25	0.9	10	6.5				3	1	62	

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 mA, V<sub>CE</sub> = 5V, f = WB.







## PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V <sub>CES</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EBO</sub> (V) Min	I <sub>CES</sub> * I <sub>CB0</sub> (nA) @ Max	V <sub>CB</sub> (V)	H <sub>FE</sub> h <sub>fe</sub> 1 kHz* @ I <sub>C</sub> & V <sub>CE</sub>			V <sub>CE(SAT)</sub> & V <sub>BE(SAT)</sub> (V) & V <sub>BE(ON)</sub> * (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
							Min	Max	1A	500	10	Max		Min	Max					Min
BFX84	TO-39	45	45	6	500	100	15	1A	10	0.15	1.2	10	12	50	50	360		9	14	
							20	500	10	0.35	1.3	150								
							30	150	10	1.0	1.5	500								
							20	10	10	1.6	2.0	1A								
BFX85	TO-39	45	45	6	50	80	15	1A	10	0.15	1.2	10	12	50	50	360		9	14	
							30	500	10	0.35	1.3	150								
							70	150	10	1.0	1.5	500								
							50	10	10	1.6	2.0	1A								
BFX86	TO-39	45	45	6	50	30	15	1A	10	0.15	1.2	10	12	50	50	360		9	14	
							30	500	10	0.35	1.3	150								
							70	150	10	1.0	1.5	500								
							50	10	10	1.6	2.0	1A								
BFX87	TO-5	45	50	6	50	40	25	500	10	0.4	1.3	150	12	100	50	150		9	63	
							40	150	10			0.9								30
							40	10	10											
							40	1	10											
BFX88	TO-5	45	40	6	50	30	25	500	10	0.4	1.3		150	12	100	50	150		9	
							40	150	10			0.9	30							
							40	10	10											
							40	1	10											
BFY39	TO-18	45	25	5	50	30	35	400	10	10	1.0			1.0	10		150	10		
BFY39-1	TO-18	45	25	5	50	30	35	110	10	10	1.0	1.0	10		150	10			23	
BFY39-2	TO-18	45	25	5	50	30	100	200	10	10	1.0	1.0	10		150	10			23	
BFY39-3	TO-18	45	25	5	50	30	180	400	10	10	1.0	1.0	10		150	10			23	
BFY50	TO-18	80	35	6	500	80	20	10	10	0.1	1.2	10	12	60	50	360		9	14	
							30	150	10											
							20	500	10											
							15	1A	10											
BFY51	TO-39	60	30	6	500	60	30	10	10	0.1	1.2	10	12	60	50	360		9	14	
							40	150	10											
							25	500	10											
							15	1A	10											
BFY52	TO-39	40	20	6	500	60	30	10	10	0.1	1.2	10	12	60	50	360		9	14	
							60	150	10											
							30	500	10											
							15	1A	10											
BFY56	TO-39	80	45	5	50	50	15	1	10	0.3	1.5	150	25	40	50				14	
							20	500	10											
							30	150	150			1								1.2



**PRO ELECTRON SERIES** (Continued)

Type No.	Case Style	V <sub>CE</sub> * V <sub>CB0</sub> (V) Min	V <sub>CEO</sub> (V) Min	V <sub>EB0</sub> (V) Min	I <sub>CE</sub> * I <sub>CB0</sub> (nA) Max	V <sub>CB</sub> (V) @	H <sub>FE</sub> h <sub>fe</sub> @ I <sub>C</sub> & V <sub>CE</sub> 1 kHz*			V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)*</sub> (V) @ I <sub>C</sub> (mA)		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.			
							Min	Max	Min		Max	Min		Max	Min					Max		
BFY72	TO-39	50	28	5	40*	20	15	0.1	10	0.25	1.2	150	8	50	50				19			
							20	1	10													
							30	10	10													
							40	150	150											10		
							15	500	500											10		
BFY76	TO-18	45	45	6	20	30	30	200	0.01	5	0.35	1	6									
							80	0.5	5													
							140	1	5													
BSX21	TO-18		80		500	50	20	4	3		0.9	4		60	4					07		
BSX45-6	TO-39	80*	40	7	10*	60	40	100	100	1	1.0	500 1A	20	60	50						14	
																						2.0
BSX45-10	TO-39	80*	40	7	10*	60	63	160	100	1	1.0	500 1A	20	60	50						14	
																						2.0
BSX45-16	TO-39	80*	40	7	10*	60	100	250	100	1	1.0	500 1A	20	60	50						14	
																						2.0
BSX46-6	TO-39	100*	60	7	10*	60	40	100	100	1	1.0	500 1A	25	60	50						12	
																						2.0
BSX46-10	TO-39	100*	60	7	10*	60	63	160	100	1	1.0	500 1A	25	60	50						12	
																						2.0
BSX46-16	TO-39	100*	60	7	10*	60	100	250	100	1	1.0	500 1A	25	60	50						12	
																						2.0
BSX48	TO-18	50	25	5	120	50	17	100	1	1.5	1.5	500	6	250	30						19	
BSX88	TO-18	40	15	5	25	20	15	0.5	1	0.5	0.72	0.8	6	300	10						21	
BSY38	TO-18	20	12	5	100	20	30	60	10	0.35	0.25	0.7	0.85	5	200	10	45				16	21
							15	45	100	1												
BSY39	TO-18	20	12	5	100	20	40	120	10	0.35	0.25	0.7	0.85	5	200	10	45				16	21
							20	70	100	1												
BSY51	TO-18	60	35	5	100	30	40	120	150	10	1.0	1.3	150	9	130	50					19	
BSY52	TO-18	60	25	5	100	30	100	300	150	10	1.0	1.3	150	9	130	50					19	
BSY53	TO-18	75	30	7	10	60	20	0.1	10	0.6	1.3	150	9	150	50						19	
							35	10	10													
							40	120	150													10
							20	500	500													10
							2.0	500	500													10

**TEST CONDITIONS:**

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = WB.



PRO ELECTRON SERIES (Continued)

Type No.	Case Style	V <sub>CE(S)</sub> V <sub>CB(O)</sub> (V) Min	V <sub>CE(O)</sub> (V) Min	V <sub>EB(O)</sub> (V) Min	I <sub>CE(S)</sub> I <sub>CB(O)</sub> @ (nA) @ V <sub>CB</sub> (V) Max	H <sub>FE</sub> h <sub>fe</sub> @ I <sub>C</sub> & V <sub>CE</sub> 1 kHz* (mA) (V)			V <sub>CE(SAT)</sub> (V) Max	V <sub>BE(SAT)</sub> & V <sub>BE(ON)</sub> * @ I <sub>C</sub> (V) (mA)		C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub> (mA)		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Conditions	Process No.	
						Min	Max			Min	Max		Min	Max					
BSY54	TO-18	75	30	7	10	60	35	0.1	10	0.6	1.3	150	9	150	50			19	
							75	10	10										
							100	300	150										10
							40	500	10										10
2.0		50																	
BSY95A	TO-18	20	15	5	50	16	30	1	0.35	0.35	0.67	0.87	10	6	200	10			21
							50	200	10										

TEST CONDITIONS:

(1) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (2) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 20V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 5 mA. (3) I<sub>C</sub> = 200 μA, V<sub>CE</sub> = 2V, f = 1 kHz. (4) I<sub>C</sub> = 100 mA, V<sub>CC</sub> = 10V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 10 mA. (5) I<sub>C</sub> = 10 mA, V<sub>CC</sub> = 3V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 1 mA. (6) I<sub>C</sub> = 100 μA, V<sub>CE</sub> = 5V, f = 1 kHz. (7) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 10V, f = 200 kHz. (8) I<sub>C</sub> = 1 mA, V<sub>CE</sub> = 5V, f = 1 kHz. (9) I<sub>C</sub> = 150 mA, V<sub>CC</sub> = 6V, I<sub>B</sub><sup>1</sup> = I<sub>B</sub><sup>2</sup> = 15 mA. (10) I<sub>C</sub> = 10 μA, V<sub>CE</sub> = 5V, f = WB.

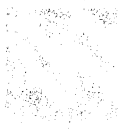


**PRO ELECTRON SERIES (JFET)**

Type No.	Case Style	BV <sub>GSS</sub> BV <sub>GDO</sub> (V) @ I <sub>G</sub> Min (μA)		I <sub>GSS</sub> I <sub>DGD</sub> (nA) @ V <sub>GD</sub> Max (V)		V <sub>P</sub> (V) @ V <sub>DS</sub> (V)		I <sub>D</sub> (nA)	V <sub>GS</sub> (V) @ V <sub>GS</sub> (V) I <sub>D</sub> (μA)				I <sub>DSS</sub> (mA) @ V <sub>DS</sub> (V)			R <sub>θ</sub> (YFS) (mmho) @ f (MHz)		C <sub>iss</sub> (pF) @ V <sub>DS</sub> Typ (V)		V <sub>GS</sub> (V)	C <sub>rss</sub> (pF) @ V <sub>DS</sub> Typ (V)		V <sub>GS</sub> (V)	NF (dB) @ R <sub>G</sub> = 1k e <sub>n</sub> * f (Hz)*		Process No.	Pkg. No.		
		Min	Max	Min	Max	Min	Max		Min	Max	Min	Max	Min	Max	Min	Max	Typ	Typ	Max		Typ								
BF244A	TO-92	30	1	5	20	.5	8	15	10	.4	2.2	15	200	2	6.5	15	3	6.5	.001	4	20	-1	1.1	20	-1	1.5	100	50	74
BF244B	TO-92	30	1	5	20	.5	8	15	10	1.6	3.8	15	200	6	15	15	3	6.5	.001	4	20	-1	1.1	20	-1	1.5	100	50	74
BF244C	TO-92	30	1	5	20	.5	8	15	10	3.2	7.5	15	200	12	25	15	3	6.5	.001	4	20	-1	1.1	20	-1	1.5	100	50	74
BF245A	TO-92	30	1	5	20	.5	8	15	10	.4	2.2	15	200	2	6.5	15	3	6.5	.001	4	20	-1	1.1	20	-1			50	77
BF245B	TO-92	30	1	5	20	.5	8	15	10	1.6	3.8	15	200	6	15	15	3	6.5	.001	4	20	-1	1.1	20	-1			50	77
BF245C	TO-92	30	1	5	20	.5	8	15	10	3.2	7.5	15	200	12	25	15	3	6.5	.001	4	20	-1	1.1	20	-1			50	77
BF246A	TO-92	25	1	5	15	.6	14.5	15	10	1.5	4.0	15	200	30	80	15	8		.001	11	15	0	3.5	15	0			51	74
BF246B	TO-92	25	1	5	15	.6	14.5	15	10	3.0	7.0	15	200	60	140	15	8		.001	11	15	0	3.5	15	0			51	74
BF246C	TO-92	25	1	5	15	.6	14.5	15	10	5.5	12	15	200	110	250	15	8		.001	11	15	0	3.5	15	0			51	74
BF247A	TO-92	25	1	5	15	.6	14.5	15	10	1.5	4.0	15	200	30	80	15	8		.001	11	15	0	3.5	15	0			51	77
BF247B	TO-92	25	1	5	15	.6	14.5	15	10	3.0	7.0	15	200	60	140	15	8		.001	11	15	0	3.5	15	0			51	77
BF247C	TO-92	25	1	5	15	.6	14.5	15	10	5.5	12	15	200	110	250	15	8		.001	11	15	0	3.5	15	0			51	77
BF256A	TO-92	30	1	5	20					.5	7.5	15	200	3	7	15	4.5		.001				.7	20	-1	7.5	800	50	77
BF256B	TO-92	30	1	5	20					.5	7.5	15	200	6	13	15	4.5		.001				.7	20	-1	7.5	800	50	77
BF256C	TO-92	30	1	5	20					.5	7.5	15	200	11	18	15	4.5		.001				.7	20	-1	7.5	800	50	77
BC264A	TO-92	30	1	10	20	.5		15	10	.2	1.2	15	1000	2	4.5	15	2.5		.001	4.0	15	-1	1.2	15	-1	40*	10*	50	77
BC264B	TO-92	30	1	10	20	.5		15	10	.4	1.4	15	1500	3.5	6.5	15	3.0		.001	4.0	15	-1	1.2	15	-1	40*	10*	50	77
BC264C	TO-92	30	1	10	20	.5		15	10	.5	1.5	15	2500	5.0	8.0	15	3.5		.001	4.0	15	-1	1.2	15	-1	40*	10*	50	77
BC264D	TO-92	30	1	10	20	.5		15	10	.6	1.6	15	3500	7.0	12.0	15	4.0		.001	4.0	15	-1	1.2	15	-1	40*	10*	50	77

5-37





1914



Section 6

**Consumer Series**





## CONSUMER SERIES

Type No.	Case Style	V <sub>CE(S)</sub> * V <sub>CB(O)</sub> (V) Min	V <sub>CE(O)</sub> (V) Min	V <sub>EB(O)</sub> (V) Min	I <sub>CE(S)</sub> * I <sub>CB(O)</sub> (nA) Max	V <sub>CB</sub> (V)	HFE h <sub>fe</sub> @ I <sub>C</sub> & V <sub>CE</sub>				V <sub>CE(SAT)</sub> & V <sub>BE(SAT)</sub> (V) & V <sub>BE(ON)*</sub> (V) @ I <sub>C</sub>			C <sub>ob</sub> (pF) Max	f <sub>T</sub> (MHz) @ I <sub>C</sub>		t <sub>off</sub> (ns) Max	NF (dB) Max	Test Condition	Process No.
							Min	Max	1 kHz*	(mA)	(V)	Max	Min		Max	Min				
CS9011	TO-92 (92)	20	18	3	50	18	28	198	1	5	1.0		1	3.5						27
CS9012	TO-92 (92)	25	25	3	500	18	64	350	50	1	1.0		250							60
CS9013	TO-92 (92)	25	25	3	500	18	64	350	50	1	1.0		250							09
CS9014	TO-92 (92)	20	18	3	50	18	60	600	1	5	0.5		1							04
CS9015	TO-92 (92)	20	18	3	50	18	60	600	1	5	0.5		1							71
CS9016	TO-92 (92)	20	20	3	50	18	28	146	1	5	3		1	10	1.6					44
CS9018	TO-92 (92)	20	12	2	50	15	28	146	1	5	0.6		10							43
ED1402	TO-92 (92)	35	30	4	10	10	110	810	2	5							10	1		07
ED1502	TO-92 (92)	25	20	4	10	10	36	210	1	10				250		5				46
ED1602	TO-92 (92)	35	30	4	10	10	70	475	2	5							10	1		62
ED1702	TO-92 (92)	30*	25	5	100*	20	40		0.5A	1	0.4		500							37
ED1802	TO-92 (92)	30*	25	5	100*	20	40	106	300	100	0.4		500							77



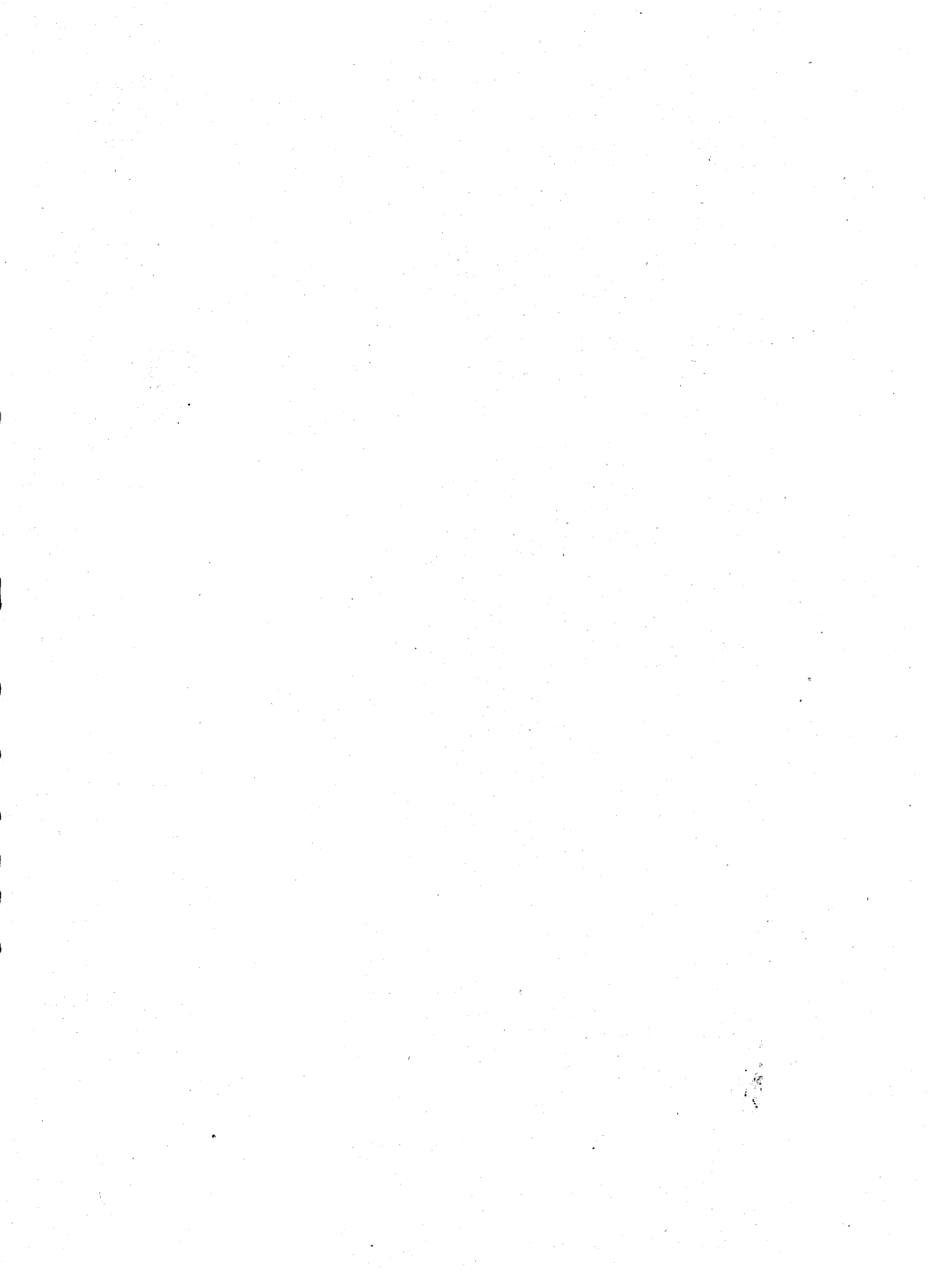
**CONSUMER SERIES** (Continued)

**HFE BINS**

	A	B	C	D	E	F	G	H	I	K	L	M	N
CS9011				28-45	39-60	54-80	72-108	97-146	132-198				
CS9012				64-91	78-112	96-135	118-166	144-202	180-350				
CS9013				64-91	78-112	96-135	118-166	144-202	180-350				
CS9014	60-150	100-300	200-600										
CS9015	60-150	100-300	200-600										
CS9016				28-45	39-60	54-80	72-108	97-146					
CS9018				28-45	39-60	54-80	72-108						
ED1402	110-165	150-225	202-318	290-450	410-810								
ED1502	36-55	48-75	66-100	84-127	105-210								
ED1602	70-105	90-140	125-190	170-260	223-475								
ED1702										106-150	132-188	170-233	213-300
ED1802										106-150	132-188	170-233	213-300

**Note:** Orders must contain at least two adjacent bins.







Section 7

**NA/NB/NR Series**





## NA/NB TRANSISTOR SERIES SELECTION GUIDE

### GENERAL DESCRIPTION

The NA series of transistors are complementary power series which provide minimum collector saturation voltages at low drive conditions and feature matched HFE, guaranteed  $V_{BE}$  (on),  $V_{BE}$  (sat),  $V_{CE}$  (sat), etc. for estimating circuit performance at limit conditions. They are ideal for use with the NB series in complementary audio power amplifier applications. In addition, the collector breakdown voltages range from 20 to 60 Volts, which allows great flexibility in other power applications, such as converters/inverters, servo amplifiers, etc. The NB series of transistors are complementary general-purpose devices which cover a wide range of applications from low-noise equalizer preamplifiers to 1.5 Amp class B drivers. This series provides low leakage, low  $V_{CE}$  (sat), high HFE and three different types of collector breakdown voltages (35, 50 and 65 Volts) for multi-purpose usage and total flexibility.

### NA — APPLICATIONS

- 0.1 to 25 Watts fully complementary audio power amplifiers
- Converters/Inverters
- Power control circuits
- Switching/linear regulators
- High current switching circuits
- Servo amplifiers

### NB — APPLICATIONS

- Low noise equalizer preamplifiers
- Class A general purpose amplifiers
- Class B drivers
- Oscillators
- Control/Switching circuits
- Display/line drivers
- Servo amplifiers

### NA SERIES — — COMPLEMENTARY POWER TRANSISTORS

#### device types and ratings

PART #		AVAILABLE PACKAGES	$V_{CE}$ (max) VOLTS	$I_C$ (max) AMPS	HFE	DESCRIPTION
NPN	PNP					
NA01	NA02	TO-92	20	0.8	Matched	0.8A complementary power transistors 1.0A complementary power transistors 1.5A complementary power transistors
NA11	NA12	TO-92	20	1.0	Matched	
NA21	NA22	TO-92, TO-92 PLUS	20	1.5	Matched	
NA31	NA32	TO-92 PLUS, TO-202	30	2.0	Matched	2.0A complementary power transistors 2.5A complementary power transistors 3.5A complementary power transistors
NA41	NA42	TO-126, TO-220	30	2.5	Guaranteed min	
NA51	NA52	TO-126, TO-220	45	3.5	Guaranteed min	
NA61	NA62	TO-126, TO-220	45	4.5	Guaranteed min	4.5A complementary power transistors 3.5A complementary power transistors
NA71	NA72	TO-126, TO-220	60	3.5	Guaranteed min	

### NB SERIES — — GENERAL PURPOSE COMPLEMENTARY TRANSISTORS

#### device types and ratings

PART #		AVAILABLE PACKAGES	$V_{CE}$ (max) VOLTS	$I_C$ (max) AMPS	$V_{CE}$ (sat)		DESCRIPTION
NPN	PNP				max	$I_C/I_b$ (mA)	
NB011	NB021	TO-92	35	0.03	0.3	10/0.5	30mA general purpose transistors 30mA general purpose transistors
NB012	NB022	TO-92	50	0.03	0.3	10/0.5	
NB013	NB023	TO-92	35	0.03	0.3	10/0.5	30mA low noise transistors 30mA low noise transistors
NB014	NB024	TO-92	50	0.03	0.3	10/0.5	
NB111	NB121	TO-92	35	0.1	0.3	40/0.8	100mA general purpose transistors 100mA general purpose transistors 100mA general purpose transistors
NB112	NB122	TO-92	50	0.1	0.3	40/0.8	
NB113	NB123	TO-92	65	0.1	0.3	40/0.8	
NB211	NB221	TO-92, TO-92 PLUS	35	0.5	0.4	100/2	500mA medium current drivers 500mA medium current drivers 500mA medium current drivers
NB212	NB222	TO-92, TO-92 PLUS	50	0.5	0.4	100/2	
NB213	NB223	TO-92, TO-92 PLUS	65	0.5	0.4	100/2	
NB311	NB321	TO-92, TO-92 PLUS, TO-202	35	1.5	0.5	300/10	1.5A complementary power drivers 1.5A complementary power drivers 1.5A complementary power drivers
NB312	NB322	TO-92, TO-92 PLUS, TO-202	50	1.5	0.5	300/10	
NB313	NB323	TO-92, TO-92 PLUS, TO-202	65	1.5	0.5	300/10	

## COMPLEMENTARY AUDIO AMPLIFIER CROSS REFERENCE CHARTS

### AUDIO OUTPUT POWER -- Battery operated "OTL" amplifiers

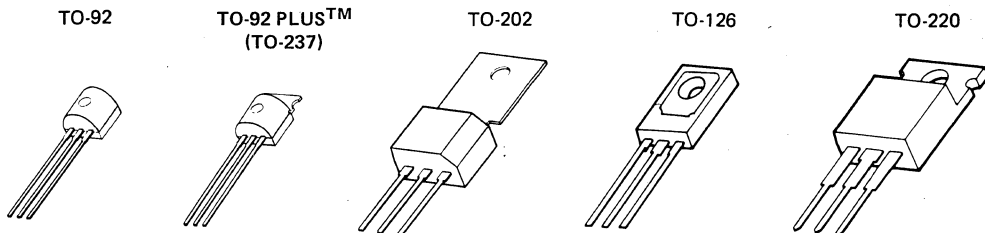
OPERATING CONDITIONS	(1) OUTPUT POWER minimum	@ 10% THD typical	RECOMMENDED OUTPUT DEVICES	RECOMMENDED DRIVER DEVICES
6 Volts/8Ω single-bootstrapping		380 mW	NA01 / NA02	NB111 / NB121
6 Volts/8Ω single-bootstrapping	380 mW	480 mW	NA11 / NA12	NB111 / NB121
6 Volts/4Ω single-bootstrapping	680 mW	850 mW	NA21 / NA22	NB111 / NB121
6 Volts/4Ω double-bootstrapping	920 mW	1.0 W	NA21 / NA22	NB111 / NB121
9 Volts/8Ω single-bootstrapping	800 mW	1.0 W	NA21 / NA22	NB111 / NB121
9 Volts/4Ω single-bootstrapping	1.4 W	1.8 W	NA21 / NA22	NB111 / NB121
9 Volts/4Ω double-bootstrapping	1.9 W	2.2 W	NA21 / NA22	NB111 / NB121
14 Volts/8Ω single-bootstrapping	2.0 W	2.3 W	NA21 / NA22	NB111 / NB121
14 Volts/4Ω single-bootstrapping	3.8 W	4.2 W	NA31 / NA32	NB211 / NB221

### AUDIO OUTPUT POWER -- AC operated "OTL" amplifiers

OUTPUT POWER (min) @ 10% THD	LOAD IMPEDEANCE	(2) REQUIRED SUPPLY VOLTAGE (min)	RECOMMENDED OUTPUT DEVICES	RECOMMENDED DRIVER DEVICES
3 Watts	8Ω	15	NA31 / NA32	NB211 / NB221
4 Watts	8Ω	17	NA31 / NA32	NB211 / NB221
6 Watts	8Ω	20	NA41 / NA42	NB211 / NB221
8 Watts	8Ω	23	NA51 / NA52	NB212 / NB222
12 Watts	8Ω	27	NA51 / NA52	NB312 / NB322
15 Watts	8Ω	32	NA71 / NA72	NB312 / NB322
18 Watts	8Ω	35	NA71 / NA72	NB313 / NB323
24 Watts	8Ω	40	NA71 / NA72	NB313 / NB323
3 Watts	4Ω	11	NA31 / NA32	NB211 / NB221
4 Watts	4Ω	13	NA31 / NA32	NB211 / NB221
6 Watts	4Ω	16	NA41 / NA42	NB211 / NB221
8 Watts	4Ω	18	NA51 / NA52	NB211 / NB221
12 Watts	4Ω	20	NA51 / NA52	NB311 / NB321
15 Watts	4Ω	23	NA61 / NA62	NB312 / NB322
18 Watts	4Ω	26	NA61 / NA62	NB312 / NB322
24 Watts	4Ω	30	NA61 / NA62	NB312 / NB322

- NOTES:** (1) Minimum Output Power levels shown are obtained by considering transistor parameter variations only, and do not include external component value tolerances.  
 (2) Voltage drops across emitter ballast resistors of the output devices are not included as part of the minimum required supply voltages; voltages specified are dc and under full load condition.  
 (3) Orders must allow for shipment of at least two adjacent HFE BIN ranges.

### PACKAGE OUTLINES





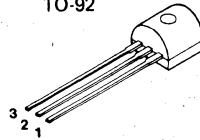
**NAO1(NPN)  
NAO2(PNP) 800mA complementary power transistors**

**features**

- 20 Volt/800 mA Amp rating
- Low  $V_{CE(sat)}$  and  $V_{BE(sat)}$  characteristics at  $I_C = 500\text{ mA}$ ,  $I_B = 50\text{ mA}$
- Guaranteed  $V_{BE(on)}$  characteristics at low current for stable biasing
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

**1 package and lead coding**

TO-92



**applications**

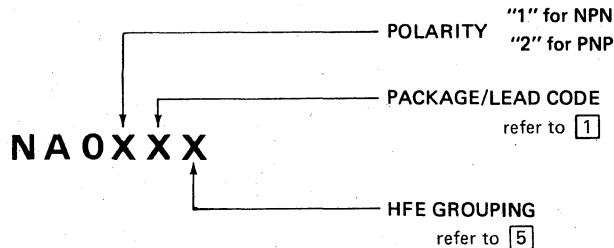
- 0.2 to 1 Watt audio power amplifiers
- Medium power switching circuits
- Converter/Inverter circuits
- Circuits for toys

PACKAGE CODE TO-92	LEAD		
	1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

**2 maximum ratings**

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	$V_{CEO}$	20	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	25	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	5.0	$V_{DC}$
Collector Current (continuous)	$I_C (max)$	800	mA
Power Dissipation ( $T_A = 25^\circ\text{C}$ )	$P_D$		
TO-92		0.6	W
Power Dissipation ( $T_C = 25^\circ\text{C}$ )	$P_D$		
TO-92		1.0	W
Thermal Resistance			
TO-92	$\theta_{JA}$	208	$^\circ\text{C/W}$
	$\theta_{JC}$	125	$^\circ\text{C/W}$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to + 150	$^\circ\text{C}$

**3 ordering information**



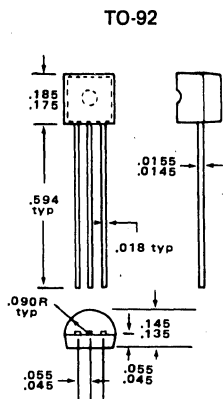
**4** electrical characteristics  $T_C = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$V_{CE0}$	Collector-Emitter Sustaining Voltage	$I_C = 1 \text{ mA}$	20			V
$V_{CB0}$	Collector-Base Breakdown Voltage	$I_C = 100\mu\text{A}$	25			V
$V_{EB0}$	Emitter-Base Breakdown Voltage	$I_E = 10\mu\text{A}$	5			V
$I_{CE0}$	Collector-Emitter Leakage Current	$V_{CE} = 15\text{V}$			100	$\mu\text{A}$
$I_{CB0}$	Collector-Base Leakage Current	$V_{CB} = 20\text{V}$			1	$\mu\text{A}$
$V_{BE}(\text{on})$	Base-Emitter Voltage	$I_C = 10 \text{ mA}, V_{CE} = 3\text{V}$	630	680	730	mV
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$		0.95	1.5	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$		0.2	0.5	V
$C_{ob}$	Collector Output Capacitance NPN types PNP types	$V_{CB} = 10\text{V}, f = 1 \text{ MHz}$		4.5 7.0		pF pF
$f_t$	Current Gain Bandwidth Product	$I_C = 100 \text{ mA}, V_{CE} = 3\text{V}$	50	200		MHz

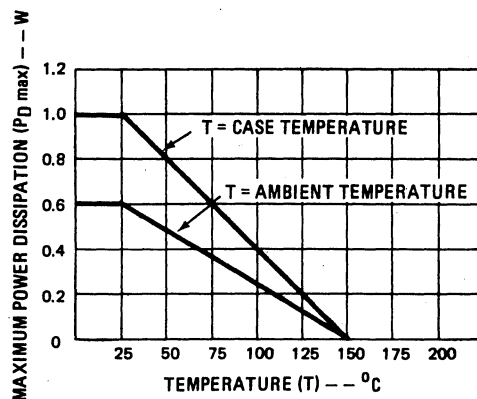
**5** HFE groupings

GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
G	DC Current Gain	$I_C = 100 \text{ mA}, V_{CE} = 3\text{V}$	68	85	110	1:1.6
H	DC Current Gain	$I_C = 100 \text{ mA}, V_{CE} = 3\text{V}$	100	127	160	1:1.6
I	DC Current Gain	$I_C = 100 \text{ mA}, V_{CE} = 3\text{V}$	140	180	240	1:1.6
J	DC Current Gain	$I_C = 100 \text{ mA}, V_{CE} = 3\text{V}$	200	260	350	1:1.6
X	DC Current Gain	$I_C = 100 \text{ mA}, V_{CE} = 3\text{V}$	30	58	110	1:3.5
Y	DC Current Gain	$I_C = 100 \text{ mA}, V_{CE} = 3\text{V}$	100	190	350	1:3.5

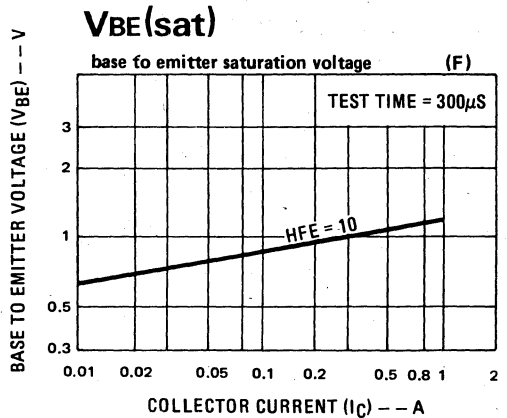
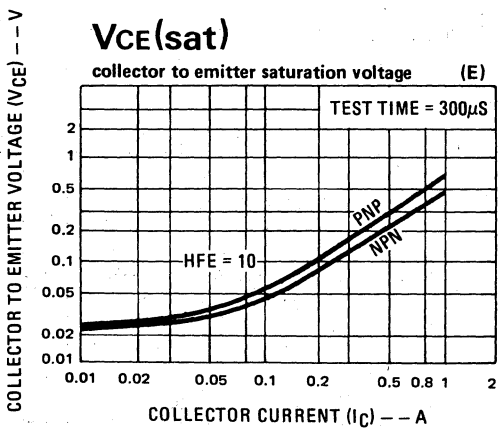
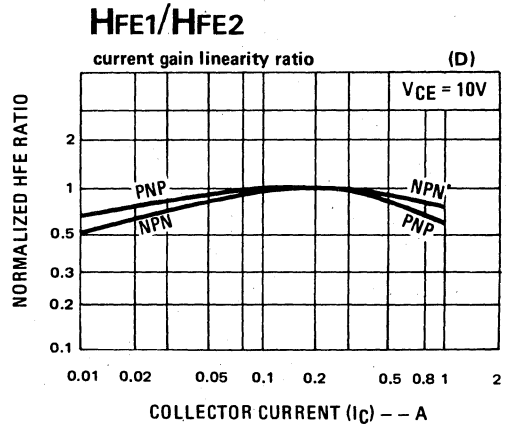
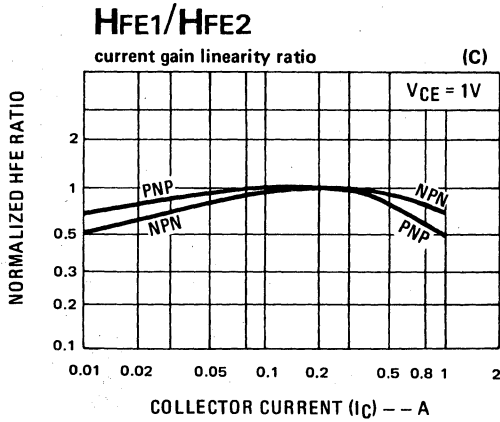
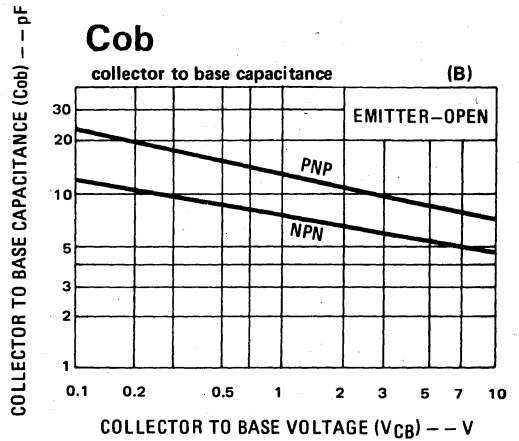
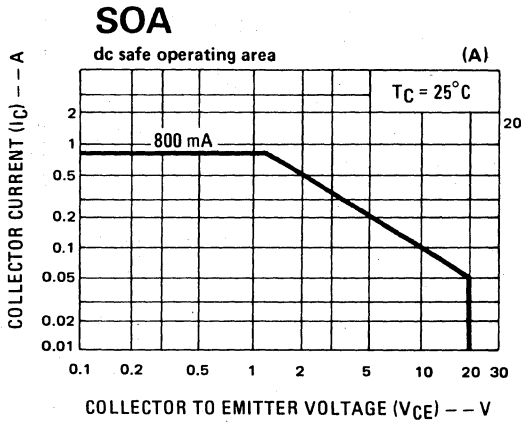
**6** physical dimensions



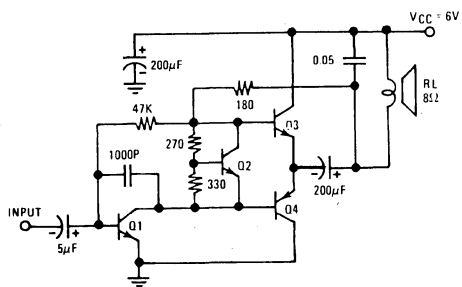
**7** max power dissipation



8 typical performance characteristics

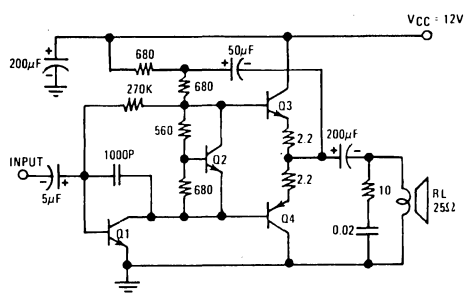


9 typical applications



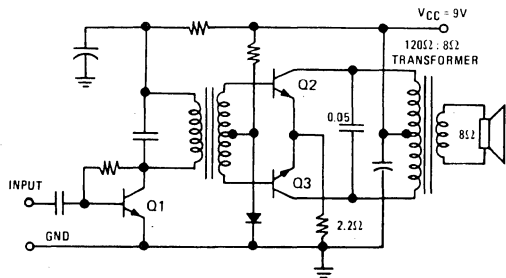
Q1 NB111EH/J Q3 NA01EG/J  
Q2 NR001E Q4 NA01EG/J

Figure A. 380mW 6V/8Ω OTL Amplifier



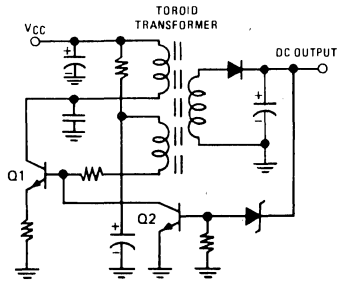
Q1 NB111EH/J Q3 NA01EG/J  
Q2 NR001E Q4 NA01EG/J

Figure B. 650mW 12V/25Ω OTL Amplifier



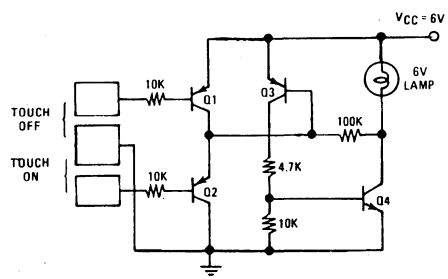
Q1 NB111EH/J Q2 NA01EG/J Q3 NA01EG/J

Figure C. 1.2W Audio Amplifier



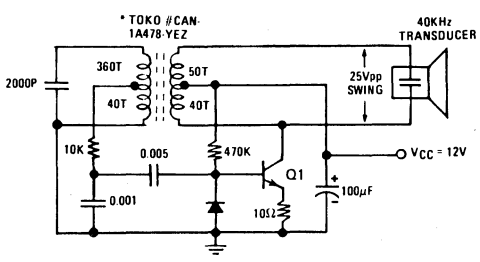
Q1 NA01EX Q2 NB111EY

Figure D. Typical Converter Circuit



Q1 NB021EY Q3 NB021EY  
Q2 NB021EY Q4 NA01EX

Figure E. Touch-on/Touch-off Electronic Switch



Q1 NA01EX

Figure F. 40KHz Ultrasonic Transmitter





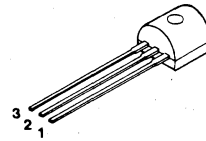
**NA11 (NPN)  
NA12 (PNP) 1 Amp complementary power transistors**

**features**

- 20 Volt/1 Amp rating
- Low  $V_{CE(sat)}$  and  $V_{BE(sat)}$  characteristics at  $I_C = 400\text{ mA}$ ,  $I_B = 10\text{ mA}$
- Guaranteed  $V_{BE(on)}$  characteristics at low current for stable biasing
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

**1 package and lead coding**

TO-92



**applications**

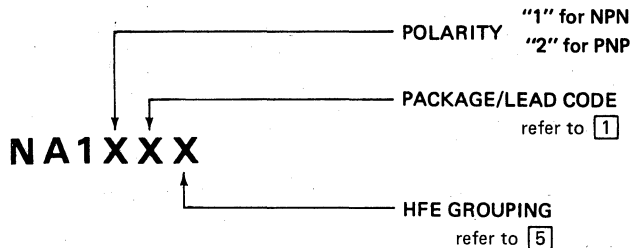
- 0.2 to 1 Watt audio power amplifiers
- Medium power switching circuits
- Converter/Inverter circuits
- Circuits for toys

PACKAGE CODE TO-92	LEAD		
	1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

**2 maximum ratings**

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	$V_{CEO}$	20	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	25	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	5.0	$V_{DC}$
Collector Current (continuous)	$I_C(\text{max})$	1.0	A
Power Dissipation ( $T_A = 25^\circ\text{C}$ )	$P_D$		
TO-92		0.6	W
Power Dissipation ( $T_C = 25^\circ\text{C}$ )	$P_D$		
TO-92		1.0	W
Thermal Resistance			
TO-92	$\theta_{JA}$	208	$^\circ\text{C/W}$
	$\theta_{JC}$	125	$^\circ\text{C/W}$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to + 150	$^\circ\text{C}$

**3 ordering information**



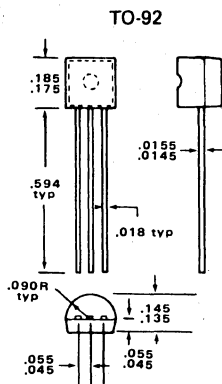
**4** electrical characteristics  $T_C = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$BV_{CEO}$	Collector-Emitter Sustaining Voltage	$I_C = 1\text{ mA}$	20			V
$BV_{CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\mu\text{A}$	25			V
$BV_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\mu\text{A}$	5			V
$I_{CEO}$	Collector-Emitter Leakage Current	$V_{CE} = 15\text{V}$			100	$\mu\text{A}$
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 20\text{V}$			1	$\mu\text{A}$
$V_{BE}(\text{on})$	Base-Emitter Voltage	$I_C = 10\text{ mA}, V_{CE} = 3\text{V}$	630	680	730	mV
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 400\text{ mA}, I_B = 10\text{ mA}$		0.9	1.0	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 400\text{ mA}, I_B = 10\text{ mA}$		0.3	0.5	V
$C_{ob}$	Collector Output Capacitance NPN types PNP types	$V_{CB} = 10\text{V}, f = 1\text{ MHz}$		4.5 7.0		pF pF
$f_t$	Current Gain Bandwidth Product	$I_C = 100\text{ mA}, V_{CE} = 3\text{V}$	50	200		MHz

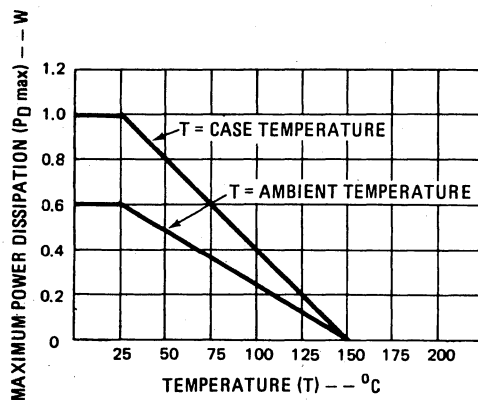
**5** HFE groupings

GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
G	DC Current Gain	$I_C = 100\text{ mA}, V_{CE} = 3\text{V}$	68	85	110	1:1.6
H	DC Current Gain	$I_C = 100\text{ mA}, V_{CE} = 3\text{V}$	100	127	160	1:1.6
I	DC Current Gain	$I_C = 100\text{ mA}, V_{CE} = 3\text{V}$	140	180	240	1:1.6
J	DC Current Gain	$I_C = 100\text{ mA}, V_{CE} = 3\text{V}$	200	260	350	1:1.6
X	DC Current Gain	$I_C = 100\text{ mA}, V_{CE} = 3\text{V}$	30	58	110	1:3.5
Y	DC Current Gain	$I_C = 100\text{ mA}, V_{CE} = 3\text{V}$	100	190	350	1:3.5

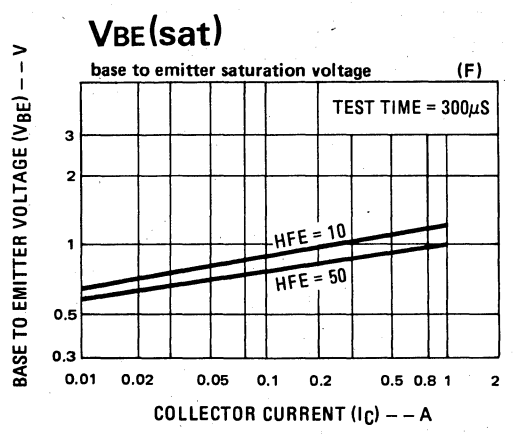
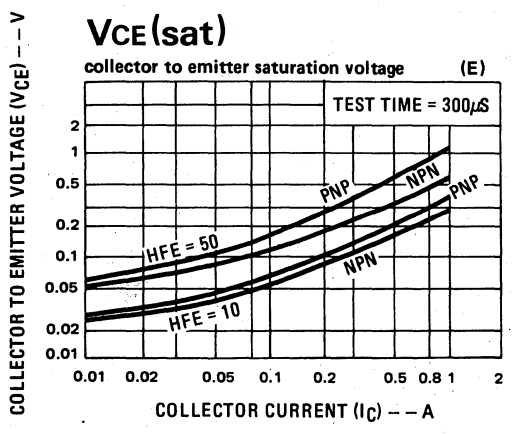
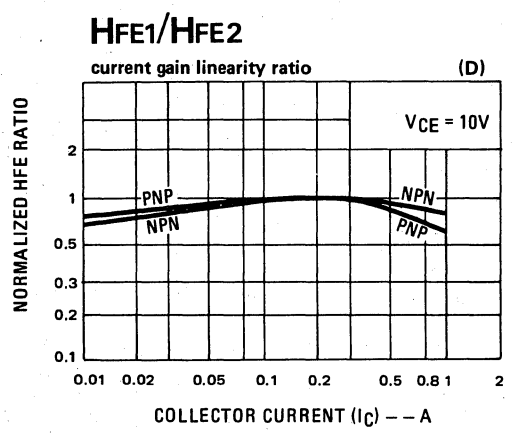
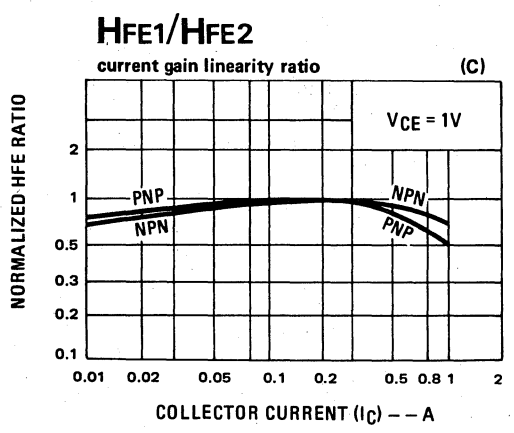
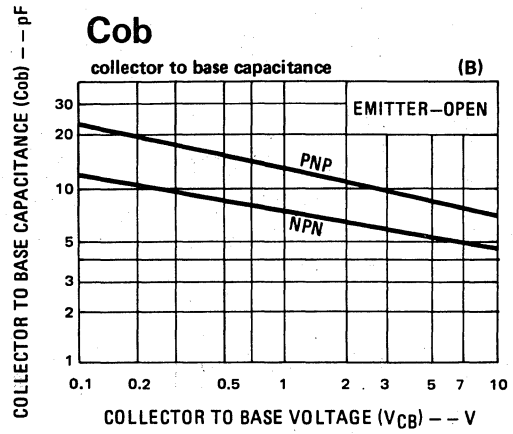
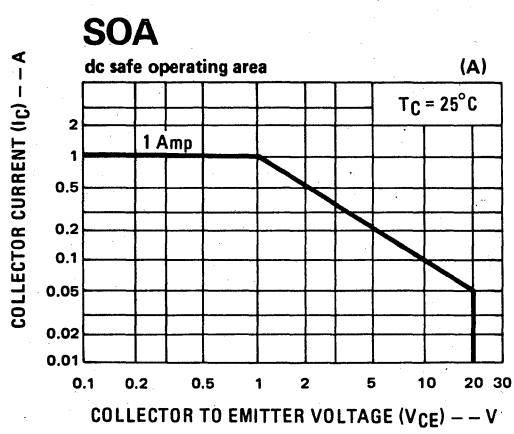
**6** physical dimensions



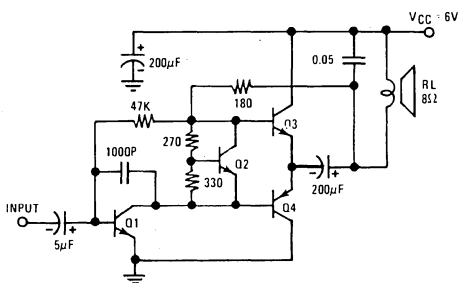
**7** max power dissipation



8 typical performance characteristics

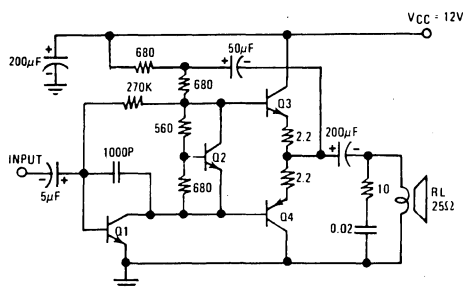


9 typical applications



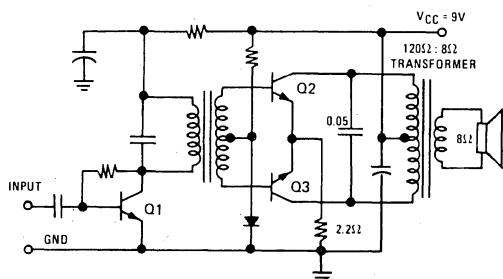
Q1 NB111EH/J      Q3 NA11EG/J  
Q2 NR001E        Q4 NA12EG/J

Figure A. 380mW 6V/8Ω OTL Amplifier



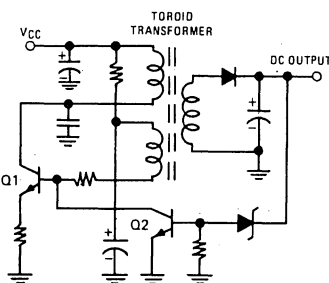
Q1 NB111EH/J      Q3 NA11EG/J  
Q2 NR001E        Q4 NA12EG/J

Figure B. 650mW 12V/25Ω OTL Amplifier



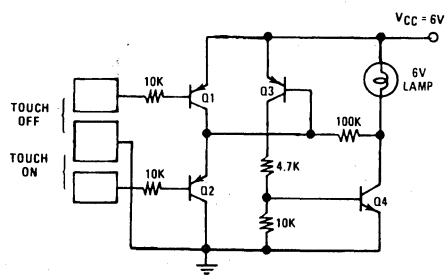
Q1 NB111EH/J    Q2 NA11EG/J    Q3 NA11EG/J

Figure C. 1.2W Audio Amplifier



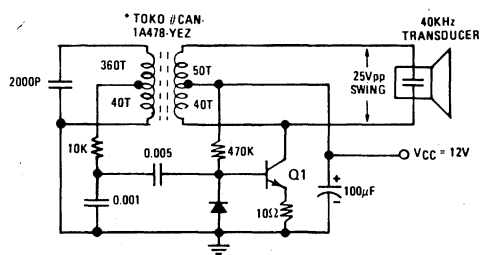
Q1 NA11EX            Q2 NB111EY

Figure D. Typical Converter Circuit



Q1 NB021EY      Q3 NB021EY  
Q2 NB021EY      Q4 NA11EX

Figure E. Touch-on/Touch-off Electronic Switch



Q1 NA11EX

Figure F. 40KHz Ultrasonic Transmitter

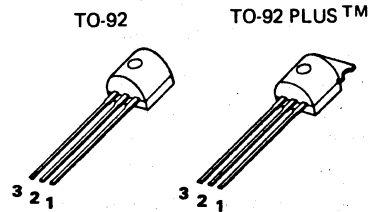


# NA21 (NPN) NA22 (PNP) 1.5 Amp complementary power transistors

## features

- 20 Volt/1.5 Amp rating
- 1.2 Watts practical power dissipation (TO-92 PLUS™)
- Low  $V_{CE(sat)}$  and  $V_{BE(sat)}$  characteristics at  $I_C = 700\text{ mA}$ ,  $I_B = 14\text{ mA}$
- Guaranteed  $V_{BE(on)}$  characteristics at small current for stable biasing
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

## 1 package and lead coding



## applications

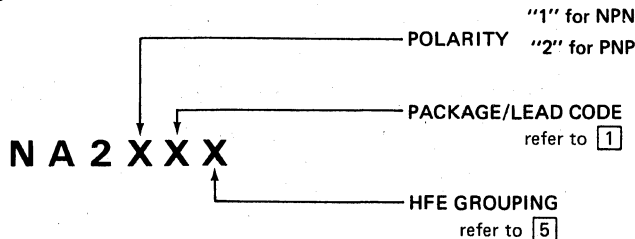
- 0.5 – 2 Watt audio power amplifiers
- Medium power switching circuits
- Converter/Inverter circuits
- Toy circuits

PACKAGE CODE		LEAD		
TO-92	TO-92 PLUS	1	2	3
E	X	E	B	C
F	Y	E	C	B
	Z	B	C	E
H		C	B	E

## 2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	$V_{CE}$	20	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	25	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	5.0	$V_{DC}$
Collector Current (continuous)	$I_C(\text{max})$	1.5	A
Power Dissipation ( $T_A = 25^\circ\text{C}$ )	$P_D$		
TO-92		0.6	W
TO-92 PLUS		0.75	W
Power Dissipation ( $T_C = 25^\circ\text{C}$ )	$P_D$		
TO-92		1.0	W
TO-92 PLUS		2.5	W
Thermal Resistance			
TO-92	$\theta_{JA} / \theta_{JC}$	208/125	$^\circ\text{C/W}$
TO-92 PLUS	$\theta_{JA} / \theta_{JC}$	167/50	$^\circ\text{C/W}$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to +150	$^\circ\text{C}$

## 3 ordering information



**4 electrical characteristics**  $T_C = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$BV_{CEO}$	Collector-Emitter Sustaining Voltage	$I_C = 1 \text{ mA}$	20			V
$BV_{CBO}$	Collector-Base Breakdown Voltage	$I_C = 100 \mu\text{A}$	25			V
$BV_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10 \mu\text{A}$	5			V
$I_{CEO}$	Collector-Emitter Leakage Current	$V_{CE} = 15\text{V}$			100	$\mu\text{A}$
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 20\text{V}$			1	$\mu\text{A}$
$V_{BE}(\text{on})$	Base-Emitter Voltage	$I_C = 10 \text{ mA}, V_{CE} = 3\text{V}$	600	670	730	mV
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 700 \text{ mA}, I_B = 14 \text{ mA}$		0.9	1.0	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 700 \text{ mA}, I_B = 14 \text{ mA}$				
	NPN types			0.35	0.5	V
	PNP types			0.65	1	V
$C_{ob}$	Collector Output Capacitance	$V_{CB} = 10\text{V}, f = 1 \text{ MHz}$		0.45		pF
	NPN types			0.7		pF
$f_t$	Current Gain Bandwidth Product	$I_C = 100 \text{ mA}, V_{CE} = 3\text{V}$	50	200		MHz

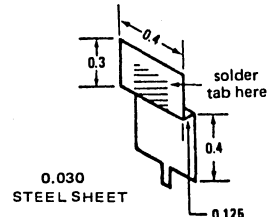
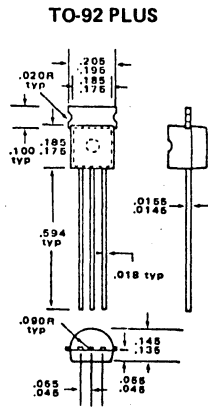
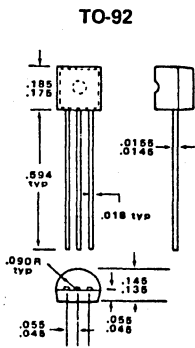
**5 HFE groupings**

GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
G	DC Current Gain	$I_C = 100 \text{ mA}, V_{CE} = 3\text{V}$	68	85	110	1:1.6
H	DC Current Gain	$I_C = 100 \text{ mA}, V_{CE} = 3\text{V}$	100	127	160	1:1.6
I	DC Current Gain	$I_C = 100 \text{ mA}, V_{CE} = 3\text{V}$	140	180	240	1:1.6
J	DC Current Gain	$I_C = 100 \text{ mA}, V_{CE} = 3\text{V}$	200	260	350	1:1.6
X	DC Current Gain	$I_C = 100 \text{ mA}, V_{CE} = 3\text{V}$	30	58	110	1:3.5
Y	DC Current Gain	$I_C = 100 \text{ mA}, V_{CE} = 3\text{V}$	100	190	350	1:3.5

**6 physical dimensions**

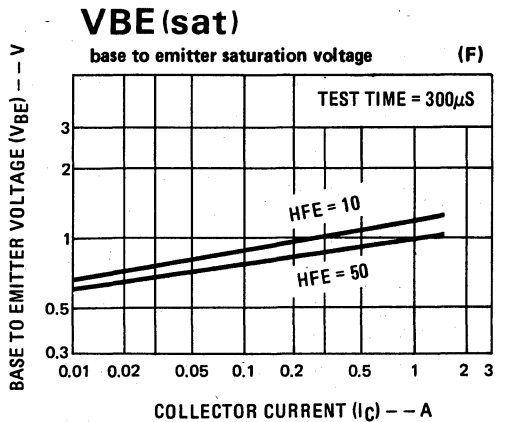
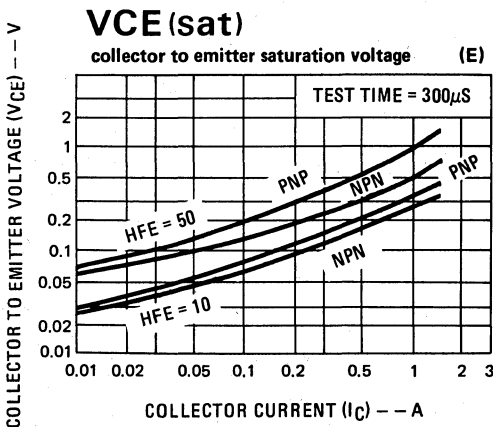
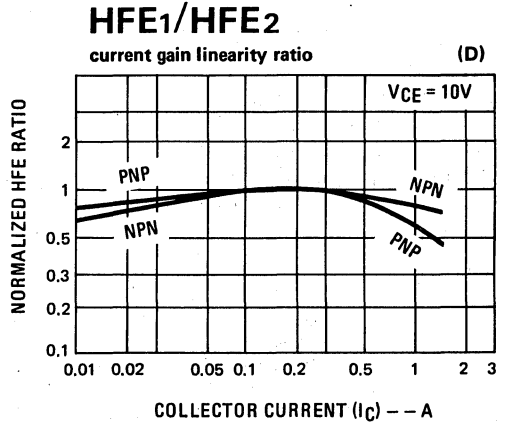
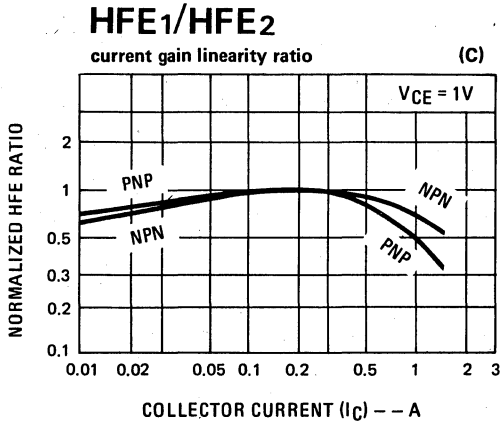
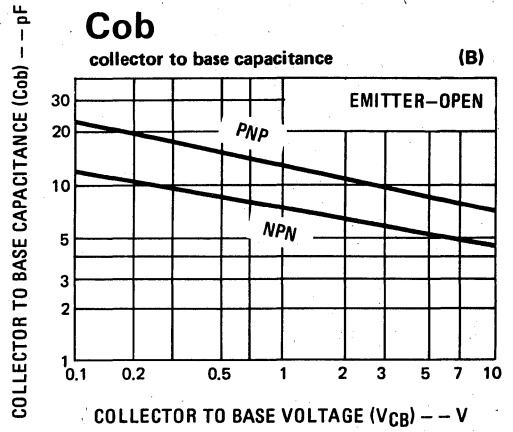
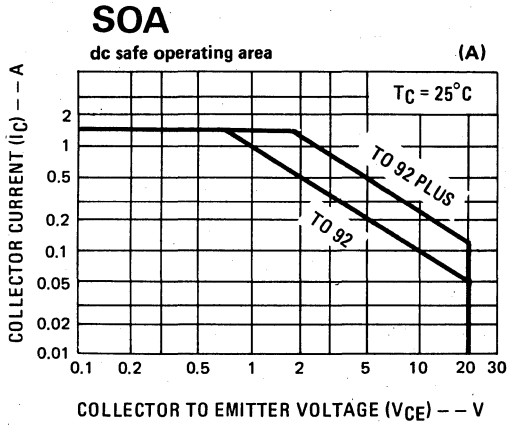
**7 heatsink information**

**7**

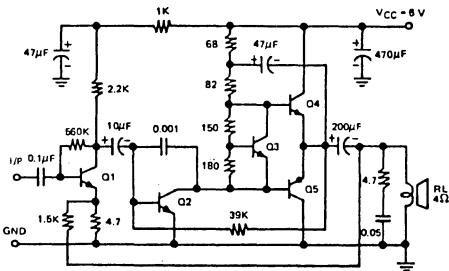


■ TO-92 PLUS package with heat-sink shown on right permits 1.6 Watts power dissipation and combined Thermal Resistance  $\theta_{JA} = 78^\circ\text{C/W}$ . If used without heatsink and PCB land area at collector lead  $> 1 \text{ sq. inch}$ ,  $P_D = 1.2\text{W}$ .

8 typical performance characteristics

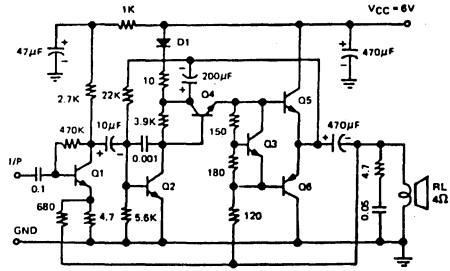


9 typical applications



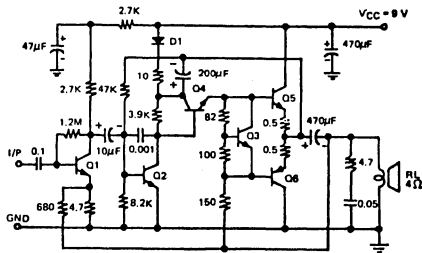
Q1 NB011EY Q3 NR001E Q5 NA22EG/J  
Q2 NB111EH/J Q4 NA21EG/J

Figure A. 700mW 6V/4Ω OTL Amplifier



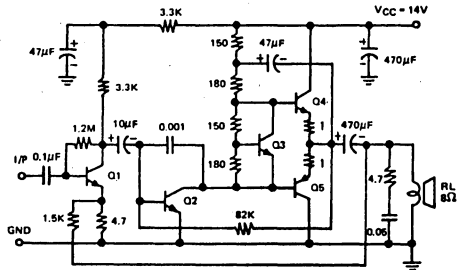
Q1 NB011EY Q3 NR001E Q5 NA21EG/J  
Q2 NB011EY Q4 NB111EY Q6 NA22EG/J

Figure B. 950mW 6V/4Ω OTL Amplifier



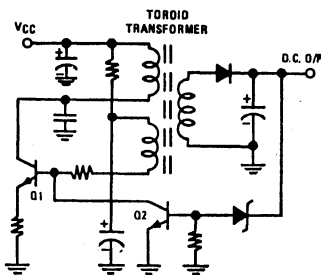
Q1 NB011EY Q3 NR001E Q5 NA21EG/J  
Q2 NB011EY Q4 NB111EY Q6 NA22EG/J

Figure C. 2W 9V/4Ω OTL Amplifier



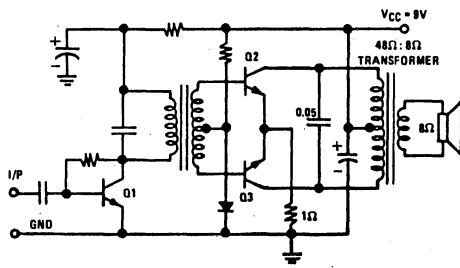
Q1 NB011EY Q3 NR001E Q5 NA22EG/J  
Q2 NB111EH/J Q4 NA21EG/J

Figure D. 2.2W 14V/8Ω OTL Amplifier



Q1 NA21EX Q2 NB111EY

Figure E. Typical Converter Circuit



Q1 NB111E Q2 NA21Y G/J Q3 NA21Y G/J

Figure F. 2W Audio Amplifier



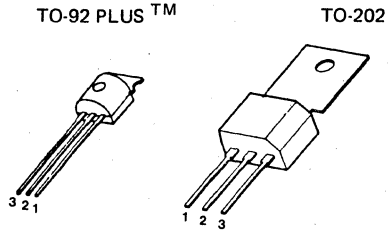


**NA31 (NPN) 2 Amp complementary power transistors**  
**NA32 (PNP)**

**features**

**1 packages and lead coding**

- 30 Volt/2 Amp rating
- 1.2 Watts practical power dissipation (TO-92 PLUS™)
- 1.75 Watts free air power dissipation (TO-202)
- Low  $V_{CE(sat)}$  and  $V_{BE(sat)}$  characteristics at  $I_C = 1.2A, I_B = 30 mA$
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability



**applications**

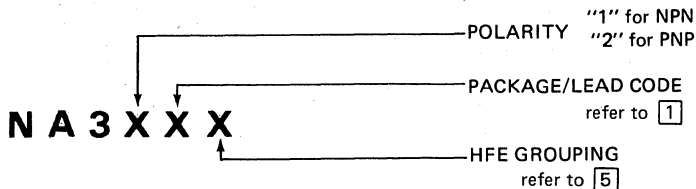
- 4-Watt audio power amplifiers
- Medium power switching circuits
- Converter/Inverter circuits
- TV receivers

PACKAGE CODE		LEAD		
TO-92 PLUS	TO-202	1	2	3
X	K	E	B	C
Y	L	E	C	B
Z	M	B	C	E

**2 maximum ratings**

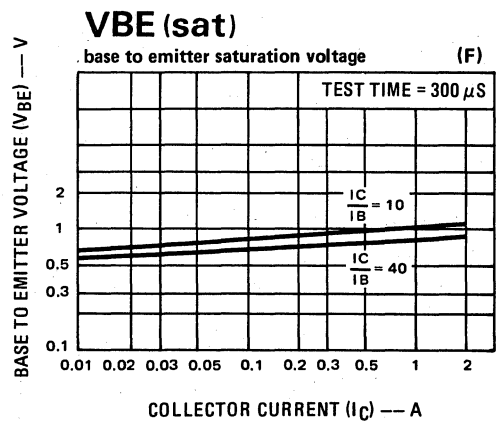
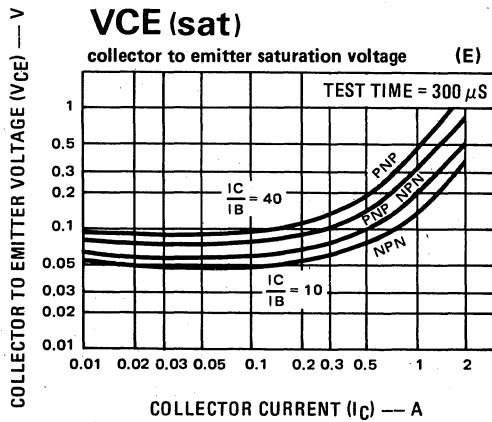
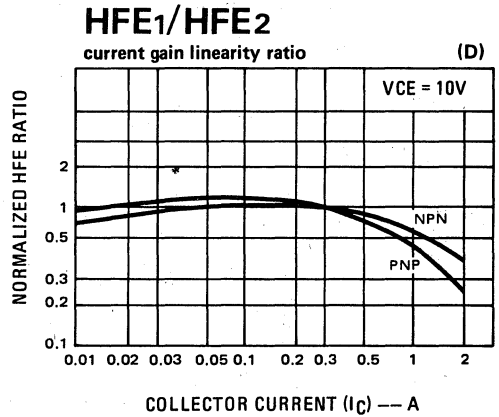
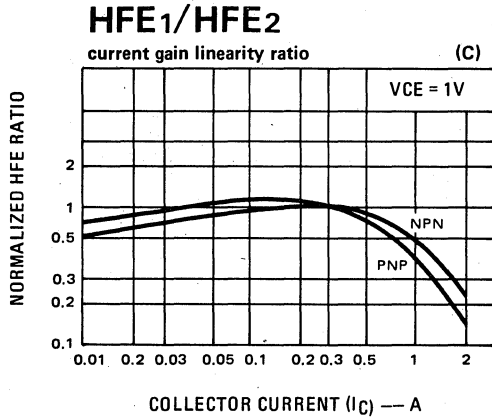
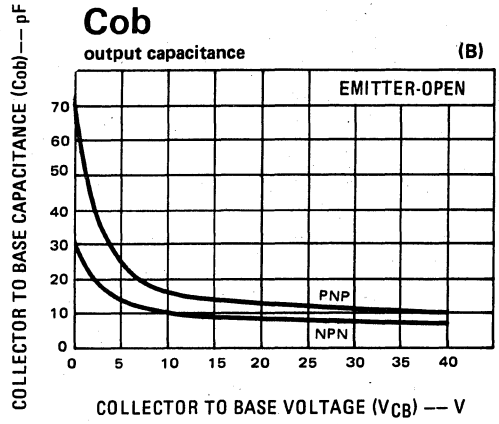
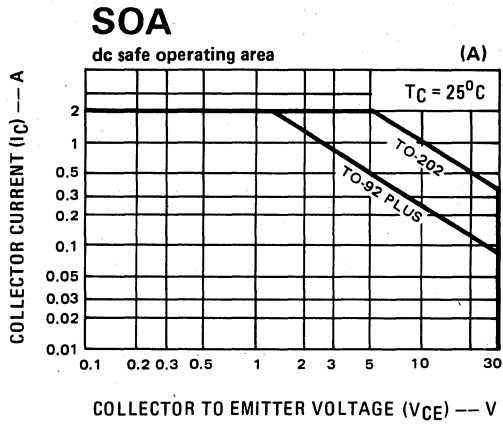
PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	$V_{CEO}$	30	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	35	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	5.0	$V_{DC}$
Collector Current (continuous)	$I_C (max)$	2.0	A
Power Dissipation ( $T_A = 25^\circ C$ )	$P_D$		
TO-92 PLUS		0.75	W
TO-202		1.75	W
Power Dissipation ( $T_C = 25^\circ C$ )	$P_D$		
TO-92 PLUS		2.5	W
TO-202		10	W
Thermal Resistance			
TO-92 PLUS	$\theta_{JA}/\theta_{JC}$	167/50	$^\circ C/W$
TO-202	$\theta_{JA}/\theta_{JC}$	72/12.5	$^\circ C/W$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to +150	$^\circ C$

**3 ordering information**

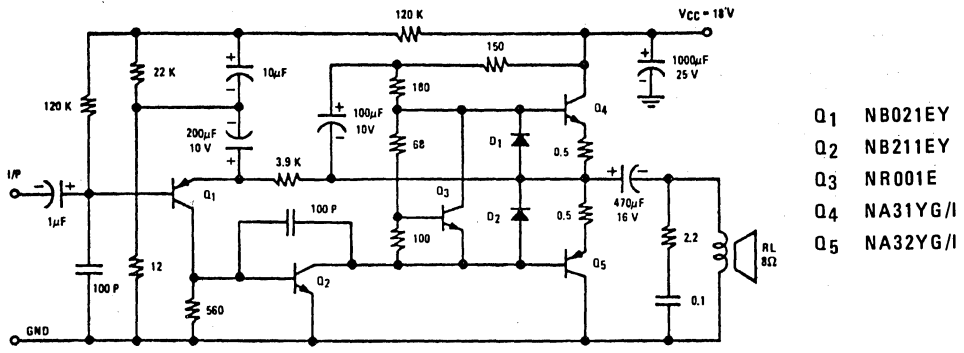




⊗ typical performance characteristics

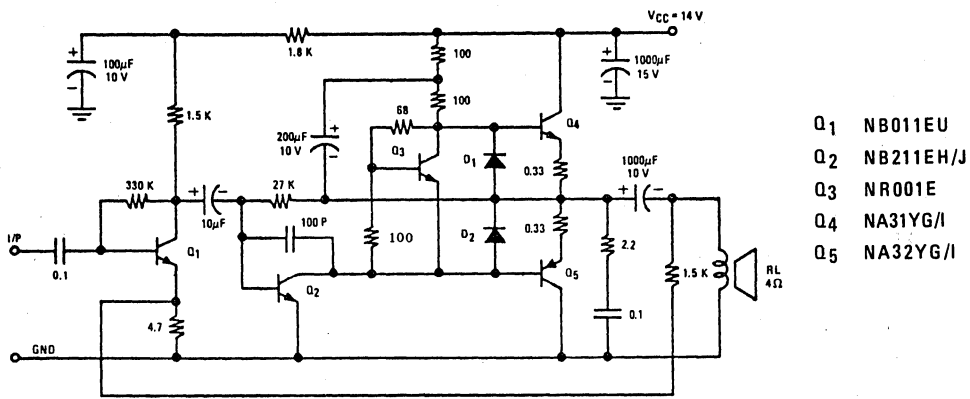


9 typical applications



- Q1 NB021EY
- Q2 NB211EY
- Q3 NR001E
- Q4 NA31YG/I
- Q5 NA32YG/I

Figure A. 4 Watt / 8 Ohm OTL Amplifier



- Q1 NB011EU
- Q2 NB211EH/J
- Q3 NR001E
- Q4 NA31YG/I
- Q5 NA32YG/I

Figure B. 4 Watt / 4 Ohm OTL Amplifier

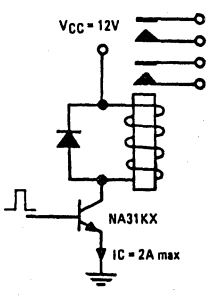


Figure C. Relay Driver

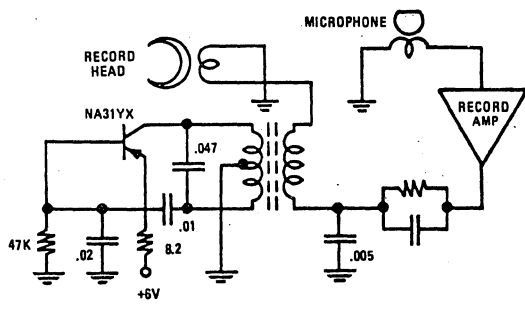


Figure D. Cassette Bias Oscillator



**NA41 (NPN)  
NA42 (PNP) 2.5 Amp complementary power transistors**

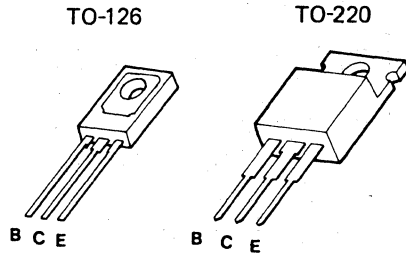
**features**

- 30 Volt/2.5 Amp rating
- Available in TO-126 and TO-220 packages
- Low  $V_{CE}$  (sat) and  $V_{BE}$  (sat) characteristics at  $I_C = 1.6$  A,  $I_B = 40$  mA
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

**applications**

- 4 to 7 Watt, 4 or 8 Ohm audio power amplifiers
- High current switching circuits
- Converter/Inverter circuits
- TV receivers

**1 packages and lead coding**

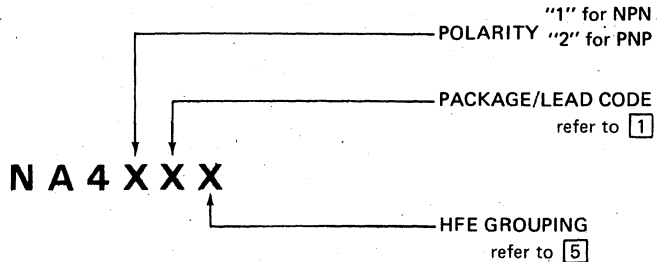


PACKAGE CODE	
TO 126	TO 220
U	W

**2 maximum ratings**

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	$V_{CE}$	30	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	35	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	4	$V_{DC}$
Collector Current (continuous)	$I_C$ (max)	2.5	A
Power Dissipation ( $T_A = 25^\circ C$ )	$P_D$		
TO-126		1.7	W
TO-220		1.8	W
Power Dissipation ( $T_C = 25^\circ C$ )	$P_D$		
TO-126		25	W
TO-220		25	W
Thermal Resistance			
TO-126	$\theta_{JA}/\theta_{JC}$	73.5/5	$^\circ C/W$
TO-220	$\theta_{JA}/\theta_{JC}$	69.4/5	$^\circ C/W$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to +150	$^\circ C$

**3 ordering information**



**4** electrical characteristics  $T_C = 25^\circ\text{C}$

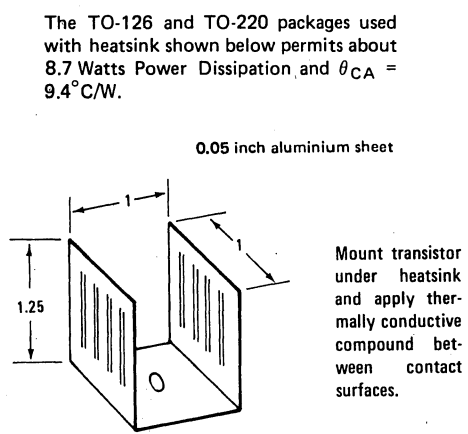
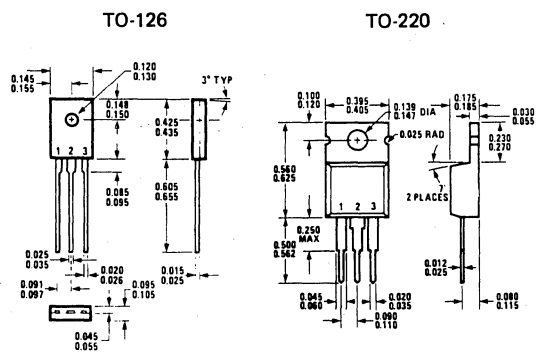
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$BV_{CER}$	Collector-Emitter Sustaining Voltage	$I_C = 10 \text{ mA}, R = 1\text{K}$	30			V
$BV_{CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\mu\text{A}$	35			V
$BV_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\mu\text{A}$	4			V
$I_{CER}$	Collector-Emitter Leakage Current	$V_{CE} = 20\text{V}, R = 1\text{K}$			500	$\mu\text{A}$
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 25\text{V}$			200	$\mu\text{A}$
$V_{BE}(\text{on})$	Base-Emitter Voltage	$I_C = 10 \text{ mA}, V_{CE} = 10\text{V}$	510	590	670	mV
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 1.6\text{A}, I_B = 40 \text{ mA}$			1.2	V
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 1.6\text{A}, I_B = 160 \text{ mA}$			1.4	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 1.6\text{A}, I_B = 40 \text{ mA}$			1.2	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 1.6\text{A}, I_B = 160 \text{ mA}$			0.6	V
$C_{ob}$	Collector Output Capacitance NPN types PNP types	$V_{CB} = 10\text{V}, f = 1 \text{ MHz}$		35 65		pF pF

**5** HFE groupings

GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
G	DC Current Gain	$I_C = 300 \text{ mA}, V_{CE} = 10\text{V}$	68	85	110	1:1.6
H	DC Current Gain	$I_C = 300 \text{ mA}, V_{CE} = 10\text{V}$	100	127	160	1:1.6
I	DC Current Gain	$I_C = 300 \text{ mA}, V_{CE} = 10\text{V}$	140	180	240	1:1.6
X	DC Current Gain	$I_C = 300 \text{ mA}, V_{CE} = 10\text{V}$	30	58	110	1:3.5
Y	DC Current Gain	$I_C = 300 \text{ mA}, V_{CE} = 10\text{V}$	100	190	350	1:3.5

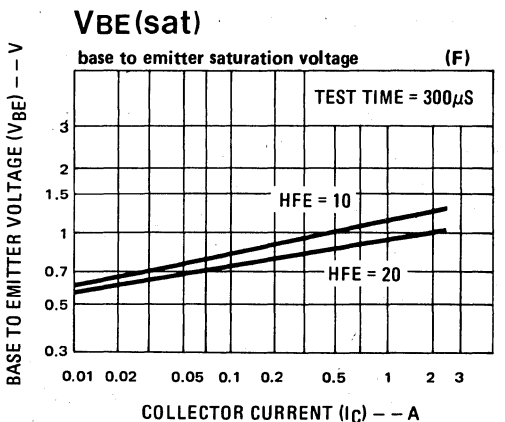
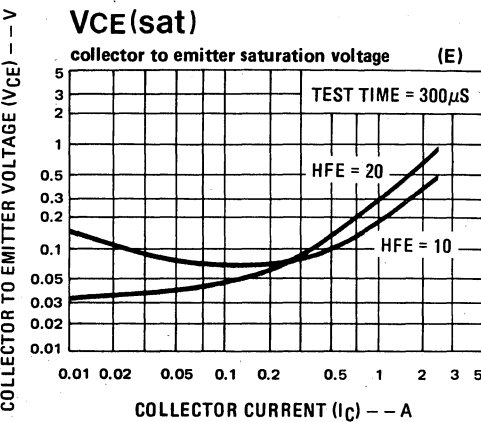
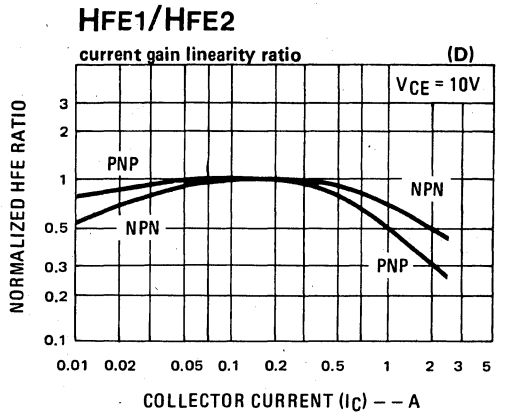
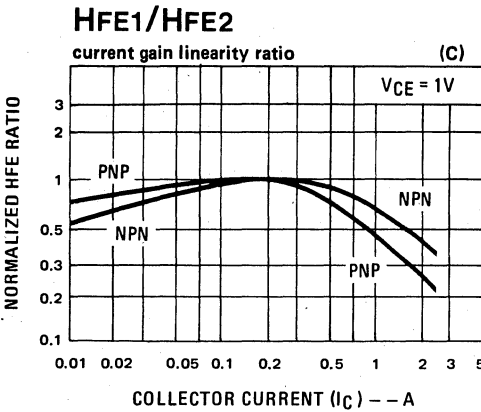
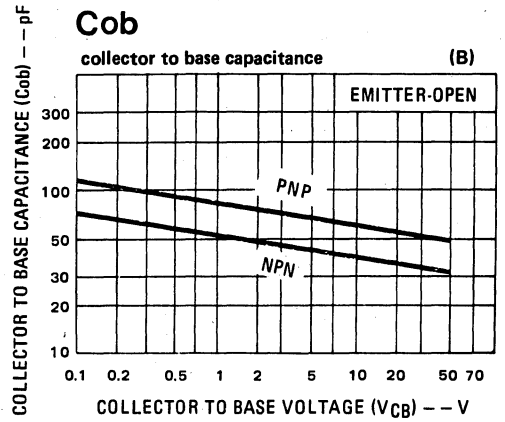
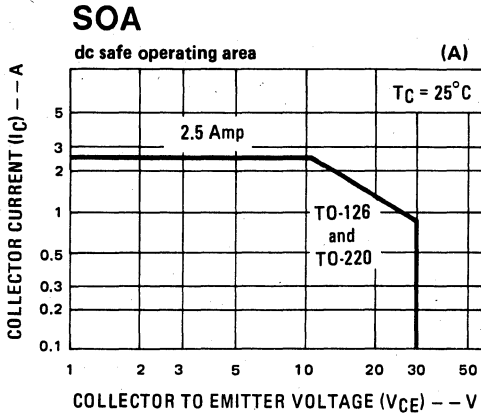
**6** physical dimensions

**7** heatsink information

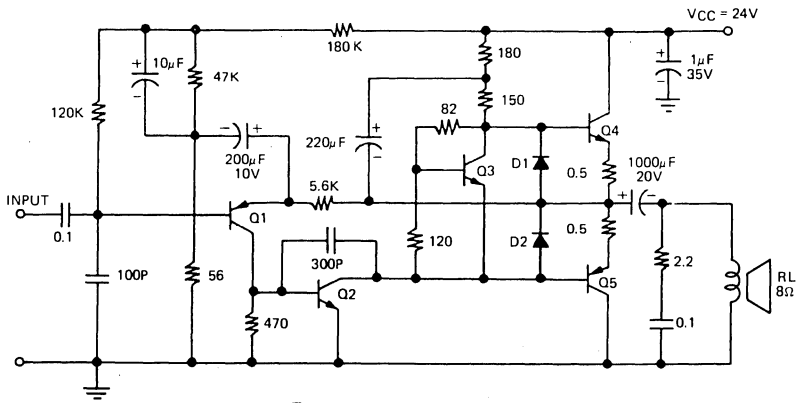


The TO-126 and TO-220 packages used with heatsink shown below permits about 8.7 Watts Power Dissipation, and  $\theta_{CA} = 9.4^\circ\text{C/W}$ .

8 typical performance characteristics

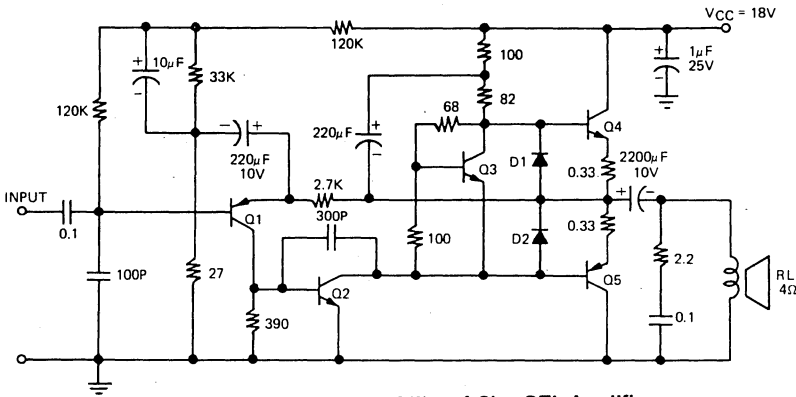


9 typical applications



- Q1 NB021EY
- Q2 NB211YY
- Q3 NR001E
- Q4 NA41U
- Q5 NA42U

Figure A. 6 Watt, 8 Ohm OTL Amplifier



- Q1 NB021EY
- Q2 NB211YY
- Q3 NR001E
- Q4 NA41U
- Q5 NA42U

Figure B. 6 Watt, 4 Ohm OTL Amplifier

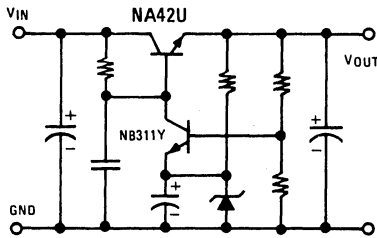


Figure C. Linear Regulator Circuit

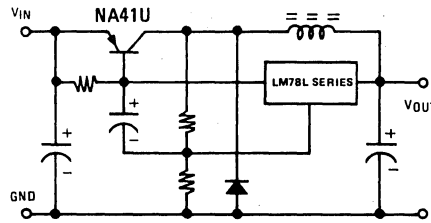


Figure D. Switching Regulator Circuit





## NA51 (NPN) NA52 (PNP) 3.5 Amp complementary power transistors

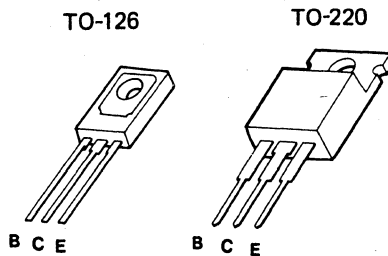
### features

- 45 Volt/3.5 Amp rating
- Available in TO-126 and TO-220 packages
- Low  $V_{CE}$  (sat) and  $V_{BE}$  (sat) characteristics at  $I_C = 2A, I_B = 80\text{ mA}$
- Guaranteed  $V_{CE}$  (sat) and  $V_{BE}$  (sat) at  $I_C = 3A, I_B = 160\text{ mA}$  for improved short-circuit protection design in audio amplifier
- "Epoxy B" packaging concept for excellent reliability

### applications

- 6 to 14 Watt, 4 or 8 Ohm audio power amplifier
- High current switching circuits
- Converter/Inverter circuits
- TV receivers

### 1 packages and lead coding

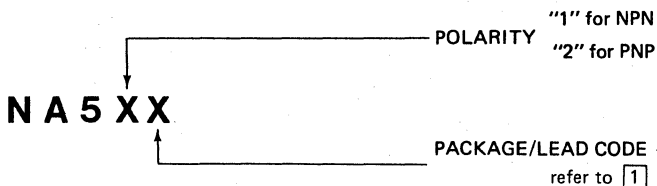


PACKAGE CODE	
TO 126	TO 220
U	W

### 2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	$V_{CE}$	45	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	50	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	4	$V_{DC}$
Collector Current (continuous)	$I_C$ (max)	3.5	A
Power Dissipation ( $T_A = 25^\circ\text{C}$ )	$P_D$		
TO-126		1.8	W
TO-220		2.0	W
Power Dissipation ( $T_C = 25^\circ\text{C}$ )	$P_D$		
TO-126		30	W
TO-220		30	W
Thermal Resistance			
TO-126	$\theta_{JA}/\theta_{JC}$	69.4/4.17	$^\circ\text{C/W}$
TO-220	$\theta_{JA}/\theta_{JC}$	62.5/4.17	$^\circ\text{C/W}$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to +150	$^\circ\text{C}$

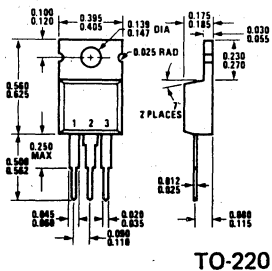
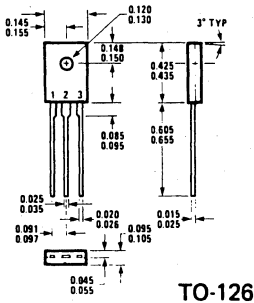
### 3 ordering information



**4** electrical characteristics  $T_C = 25^\circ\text{C}$

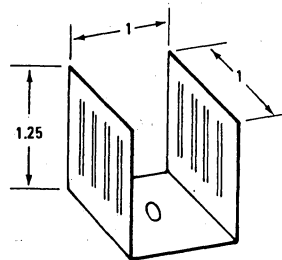
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$BV_{CER}$	Collector-Emitter Sustaining Voltage	$I_C = 10\text{ mA}, R = 1\text{K}$	45			V
$BV_{CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\mu\text{A}$	50			V
$BV_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\mu\text{A}$	4			V
$I_{CER}$	Collector-Emitter Leakage Current	$V_{CE} = 35\text{V}, R = 1\text{K}$			1	mA
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 40\text{V}$			0.5	mA
$V_{BE}(\text{on})$	Base-Emitter Voltage	$I_C = 15\text{ mA}, V_{CE} = 10\text{V}$	520	600	680	mV
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 2\text{A}, I_B = 80\text{ mA}$			1.3	V
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 3\text{A}, I_B = 160\text{ mA}$			1.6	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 2\text{A}, I_B = 80\text{ mA}$			1.5	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 3\text{A}, I_B = 160\text{ mA}$			5	V
$HFE_1$	DC Current Gain	$I_C = 500\text{ mA}, V_{CE} = 10\text{V}$	30	100		ratio
$C_{ob}$	Collector Output Capacitance NPN types PNP types	$V_{CB} = 10\text{V}, f = 1\text{ MHz}$		35 65		pF pF

**5** physical dimensions



**6** heatsink information

The TO-126 and TO-220 packages used with heatsink shown below permits about 9.2 Watts power dissipation and  $\theta_{CA} = 9.4^\circ\text{C/W}$ .



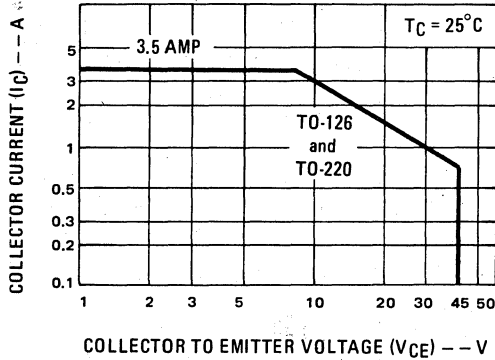
0.05 inch aluminium sheet

Mount transistor under heatsink and apply thermally conductive compound between contact surfaces.

7 typical performance characteristics

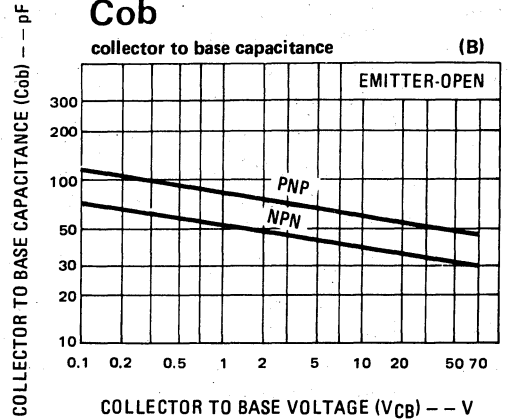
SOA

dc safe operating area (A)



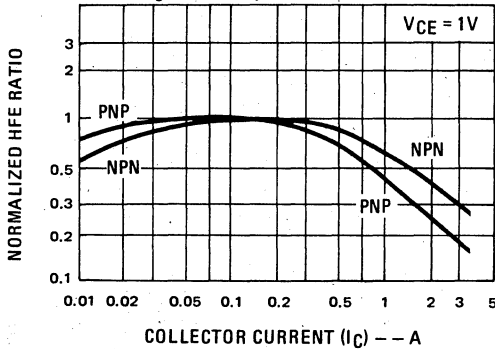
Cob

collector to base capacitance (B)



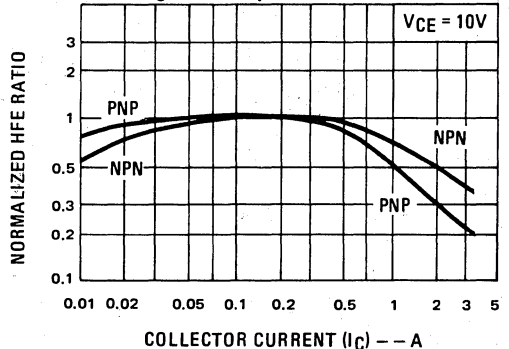
HFE1/HFE2

current gain linearity ratio (C)



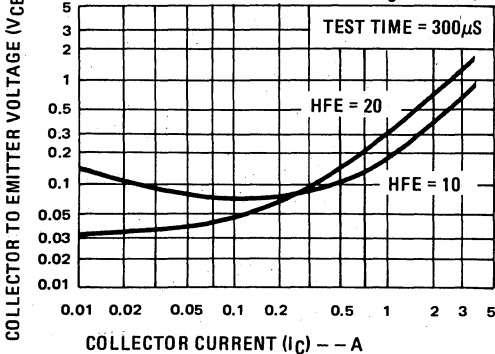
HFE1/HFE2

current gain linearity ratio (D)



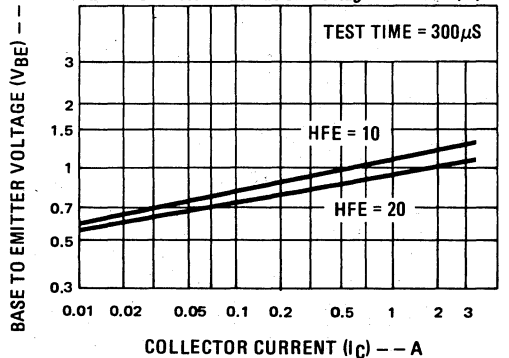
VCE(sat)

collector to emitter saturation voltage (E)

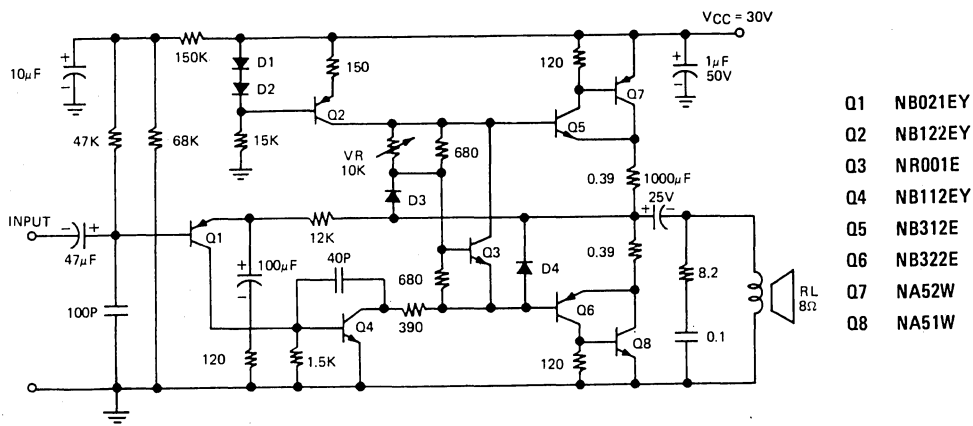


VBE(sat)

base to emitter saturation voltage (F)

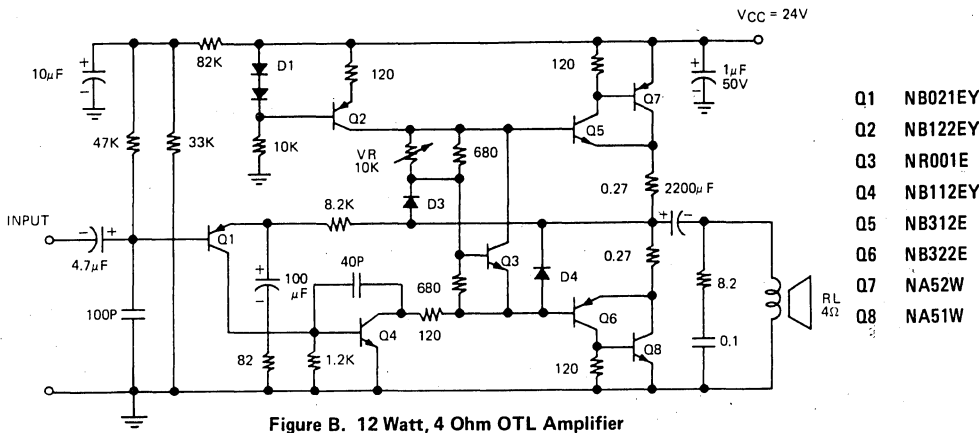


**8** typical applications



- Q1 NB021EY
- Q2 NB122EY
- Q3 NR001E
- Q4 NB112EY
- Q5 NB312E
- Q6 NB322E
- Q7 NA52W
- Q8 NA51W

Figure A. 12 Watt, 8 Ohm OTL Amplifier



- Q1 NB021EY
- Q2 NB122EY
- Q3 NR001E
- Q4 NB112EY
- Q5 NB312E
- Q6 NB322E
- Q7 NA52W
- Q8 NA51W

Figure B. 12 Watt, 4 Ohm OTL Amplifier

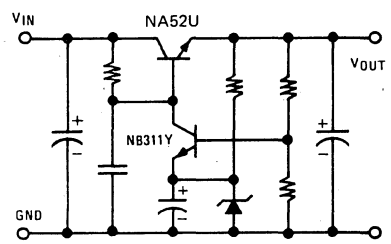


Figure C. Linear Regulator Circuit

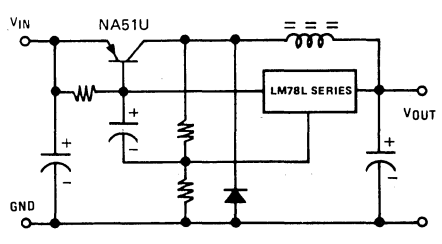


Figure D. Switching Regulator Circuit



## NA61 (NPN) NA62 (PNP) 4.5 Amp complementary power transistors

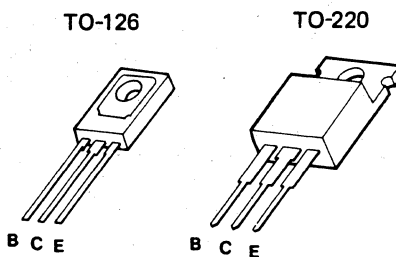
### features

- 45 Volt/4.5 Amp rating
- Available in TO-126 and TO-220 packages
- Low  $V_{CE(sat)}$  and  $V_{BE(sat)}$  characteristics at  $I_C = 3A, I_B = 150 mA$
- Guaranteed  $V_{CE(sat)}$  and  $V_{BE(sat)}$  at  $I_C = 4.5A, I_B = 300 mA$  for improved short-circuit protection design in audio amplifiers
- "Epoxy B" packaging concept for excellent reliability

### applications

- 10 to 25 Watt, 4 Ohm audio power amplifiers
- High current switching circuits
- Converter/Inverter circuits
- TV receivers

### 1 packages and lead coding

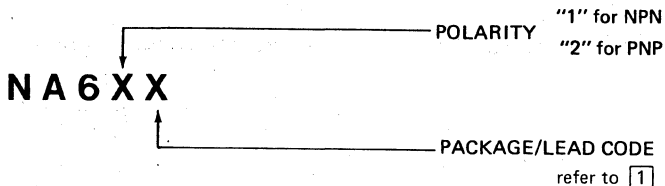


PACKAGE CODE	
TO 126	TO 220
U	W

### 2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	$V_{CE}$	45	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	50	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	4	$V_{DC}$
Collector Current (continuous)	$I_C (max)$	4.5	A
Power Dissipation ( $T_A = 25^\circ C$ )	$P_D$		
TO-126		1.8	W
TO-220		2.0	W
Power Dissipation ( $T_C = 25^\circ C$ )	$P_D$		
TO-126		40	W
TO-220		40	W
Thermal Resistance			
TO-126	$\theta_{JA}/\theta_{JC}$	69.4/3.125	$^\circ C/W$
TO-220	$\theta_{JA}/\theta_{JC}$	62.5/3.125	$^\circ C/W$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to + 150	$^\circ C$

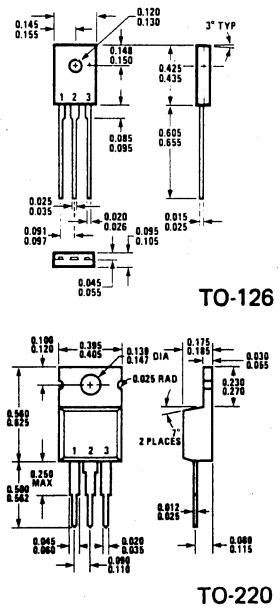
### 3 ordering information



**4** electrical characteristics  $T_C = 25^\circ\text{C}$

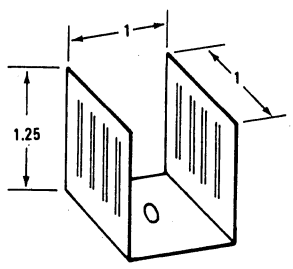
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$BV_{CER}$	Collector-Emitter Sustaining Voltage	$I_C = 10 \text{ mA}, R = 1\text{K}$	45			V
$BV_{CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\mu\text{A}$	50			V
$BV_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\mu\text{A}$	4			V
$I_{CER}$	Collector-Emitter Leakage Current	$V_{CE} = 35\text{V}, R = 1\text{K}$			2	mA
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 40\text{V}$			1	mA
$V_{BE}(\text{on})$	Base-Emitter Voltage	$I_C = 20 \text{ mA}, V_{CE} = 10\text{V}$	520	600	680	mV
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 3\text{A}, I_B = 150 \text{ mA}$			1.5	V
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 4.5\text{A}, I_B = 300 \text{ mA}$			2	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 3\text{A}, I_B = 150 \text{ mA}$			2	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 4.5\text{A}, I_B = 300 \text{ mA}$			5	V
$HFE_1$	DC Current Gain	$I_C = 500 \text{ mA}, V_{CE} = 10\text{V}$	30	100		ratio
$C_{ob}$	Collector Output Capacitance	$V_{CB} = 10\text{V}, f = 1 \text{ MHz}$		40 70		pF pF
	NPN types					
	PNP types					

**5** physical dimensions



**6** heatsink information

The TO-126 and TO-220 packages used with heatsink shown below permits about 10 Watts power dissipation and  $\theta_{CA} = 9.4^\circ\text{C/W}$ .



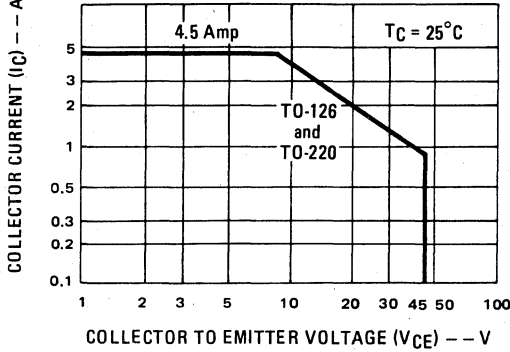
Mount transistor under heatsink and apply thermally conductive compound between contact surfaces.

7 typical performance characteristics

SOA

dc safe operating area

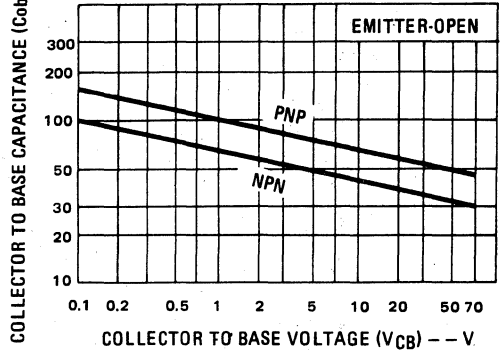
(A)



Cob

collector to base capacitance

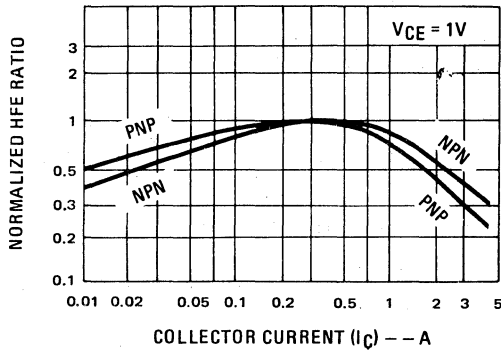
(B)



HFE1/HFE2

current gain linearity ratio

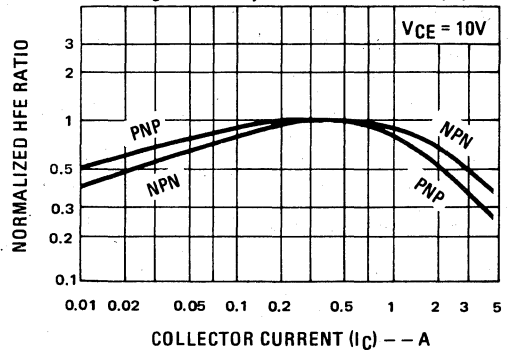
(C)



HFE1/HFE2

current gain linearity ratio

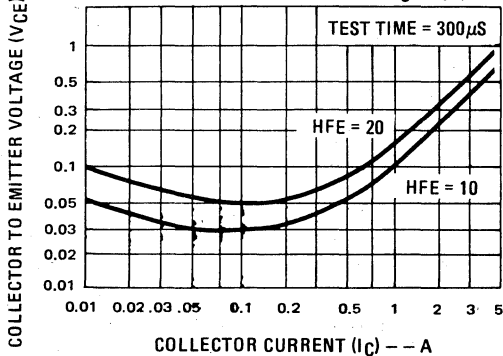
(D)



VCE(sat)

collector to emitter saturation voltage

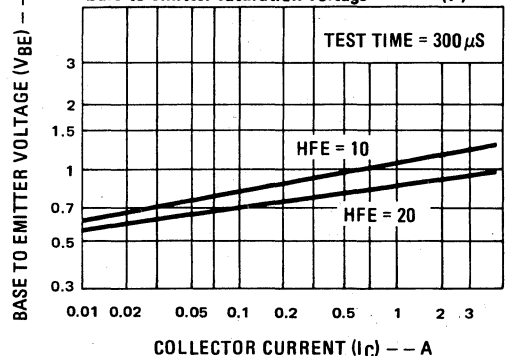
(E)



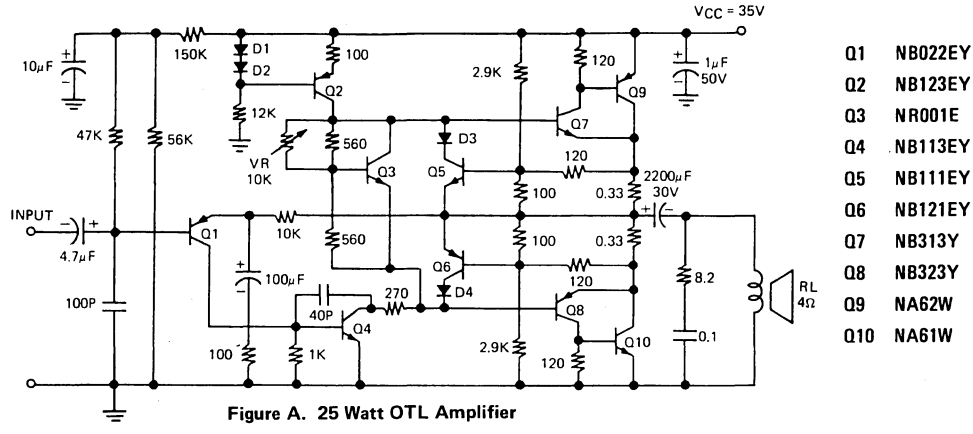
VBE(sat)

base to emitter saturation voltage

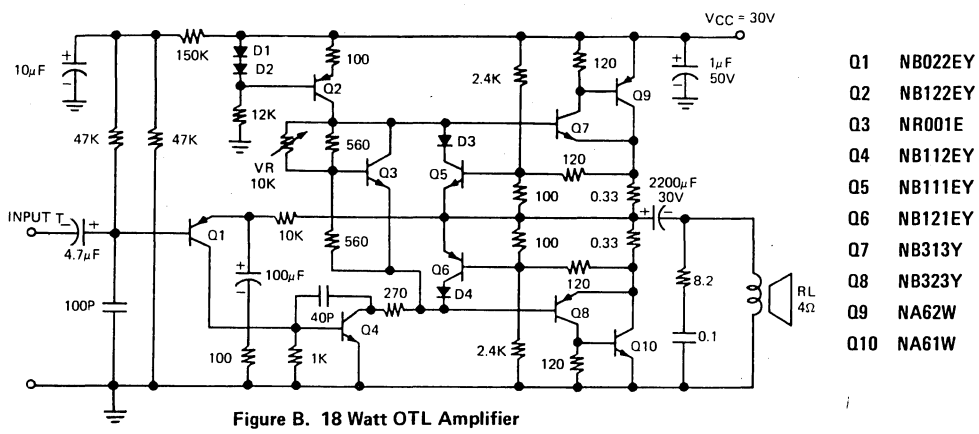
(F)



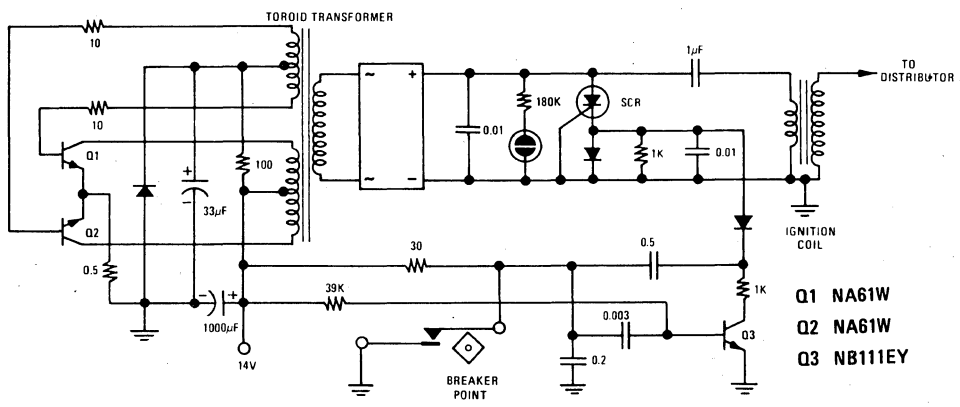
**8** typical applications



- Q1 NB022EY
- Q2 NB123EY
- Q3 NR001E
- Q4 NB113EY
- Q5 NB111EY
- Q6 NB121EY
- Q7 NB313Y
- Q8 NB323Y
- Q9 NA62W
- Q10 NA61W



- Q1 NB022EY
- Q2 NB122EY
- Q3 NR001E
- Q4 NB112EY
- Q5 NB111EY
- Q6 NB121EY
- Q7 NB313Y
- Q8 NB323Y
- Q9 NA62W
- Q10 NA61W



- Q1 NA61W
- Q2 NA61W
- Q3 NB111EY





**NA71 (NPN)  
NA72 (PNP) 3.5 Amp complementary power transistors**

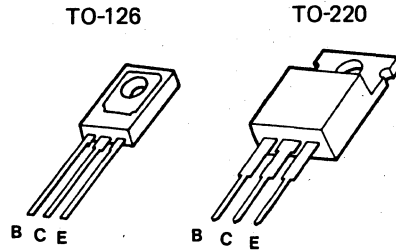
**features**

- 60 Volt/3.5 Amp rating
- Available in TO-126 and TO-220 packages
- Low  $V_{CE(sat)}$  and  $V_{BE(sat)}$  characteristics at  $I_C = 2\text{ A}$ ,  $I_B = 100\text{ mA}$
- Guaranteed  $V_{CE(sat)}$  and  $V_{BE(sat)}$  at  $I_C = 3\text{ A}$ ,  $I_B = 200\text{ mA}$  for improved short circuited protection design in audio amplifiers
- "Epoxy B" packaging concept for excellent reliability

**applications**

- 10–25 Watt 8 Ohm audio power amplifiers
- High current switching circuits
- Converter/Inverter circuits
- TV receivers

**1 packages and lead coding**

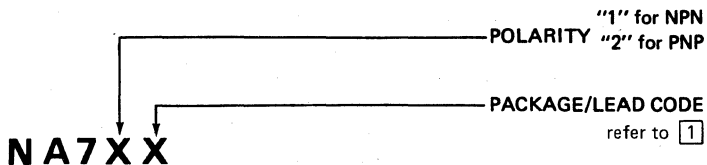


PACKAGE CODE	
TO 126	TO 220
U	W

**2 maximum ratings**

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	$V_{CE}$	60	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	65	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	4	$V_{DC}$
Collector Current (continuous)	$I_C(\text{max})$	3.5	A
Power Dissipation ( $T_A = 25^\circ\text{C}$ )	$P_D$		
TO-126		1.8	W
TO-220		2.0	W
Power Dissipation ( $T_C = 25^\circ\text{C}$ )	$P_D$		
TO-126		40	W
TO-220		40	W
Thermal Resistance			
TO-126	$\theta_{JA}/\theta_{JC}$	69.4/3.125	$^\circ\text{C/W}$
TO-220	$\theta_{JA}/\theta_{JC}$	62.5/3.125	$^\circ\text{C/W}$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to +150	$^\circ\text{C}$

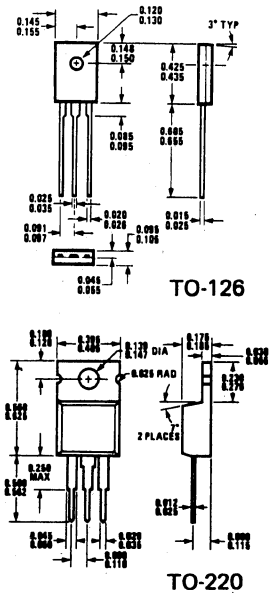
**3 ordering information**



**4** electrical characteristics  $T_C = 25^\circ\text{C}$

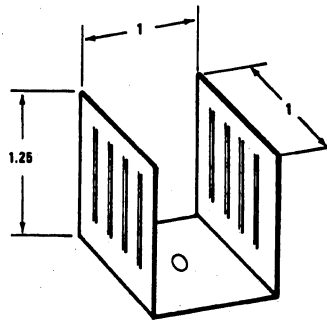
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$BV_{CER}$	Collector-Emitter Sustaining Voltage	$I_C = 10\text{ mA}, R = 1\text{K}$	60			V
$BV_{CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu\text{A}$	65			V
$BV_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu\text{A}$	4			V
$I_{CER}$	Collector-Emitter Leakage Current	$V_{CE} = 50\text{V}, R = 1\text{K}$			2	mA
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 55\text{V}$			1	mA
$V_{BE}(\text{on})$	Base-Emitter Voltage	$I_C = 20\text{ mA}, V_{CE} = 10\text{V}$	520	600	680	mV
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 2\text{A}, I_B = 100\text{ mA}$			1.5	V
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 3\text{A}, I_B = 200\text{ mA}$			2	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 2\text{A}, I_B = 100\text{ mA}$			2	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 3\text{A}, I_B = 200\text{ mA}$			5	V
$HFE_1$	DC Current Gain	$I_C = 500\text{ mA}, V_{CE} = 10\text{V}$	30	100		ratio
$C_{ob}$	Collector Output Capacitance	$V_{CB} = 10\text{V}, f = 1\text{ MHz}$		40 70		pF pF
						NPN types PNP types

**5** physical dimensions



**6** heatsink information

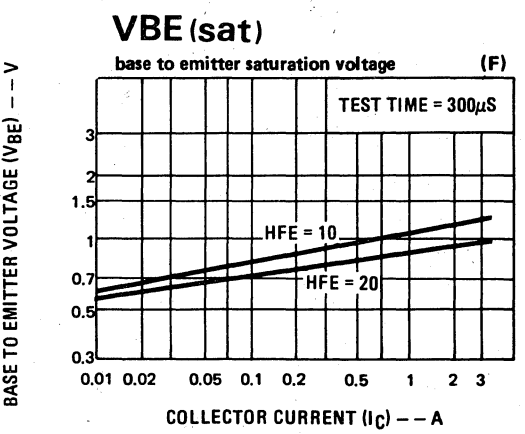
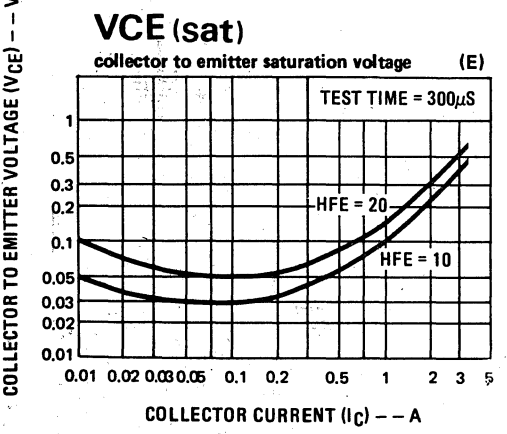
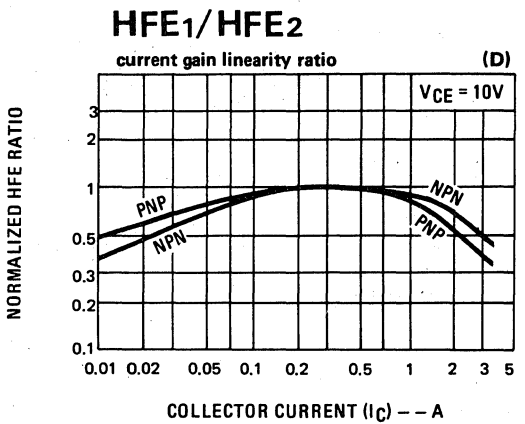
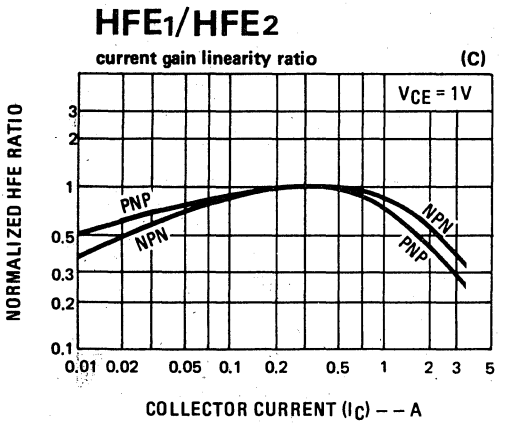
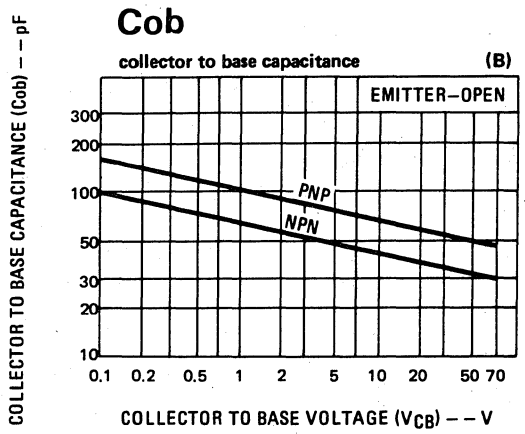
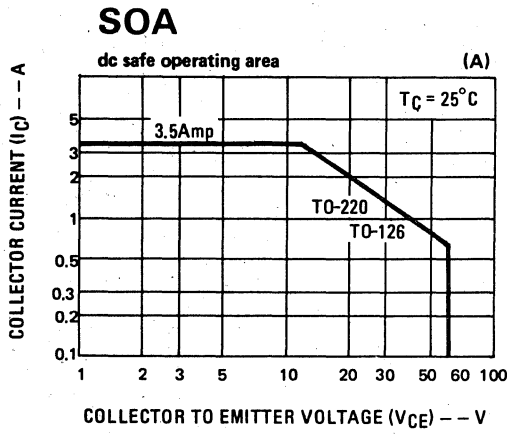
The TO-126 and TO-220 packages used with heatsink shown below permits about 10 Watts power dissipation and  $\theta_{CA} = 9.4^\circ\text{C/W}$ .



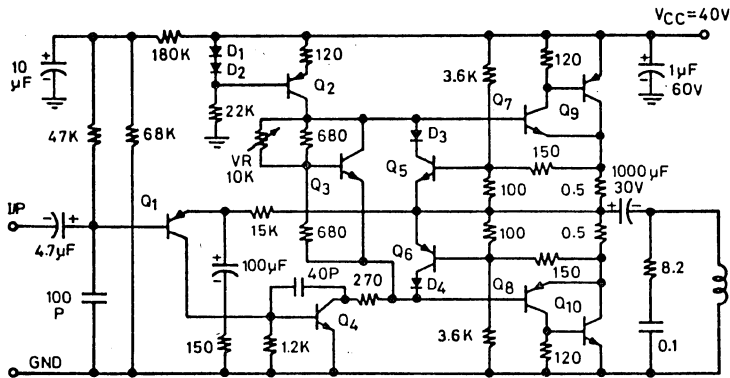
0.05 inch aluminium sheet

Mount transistor under heatsink and apply thermally conductive compound between contact surfaces.

7 typical performance characteristics

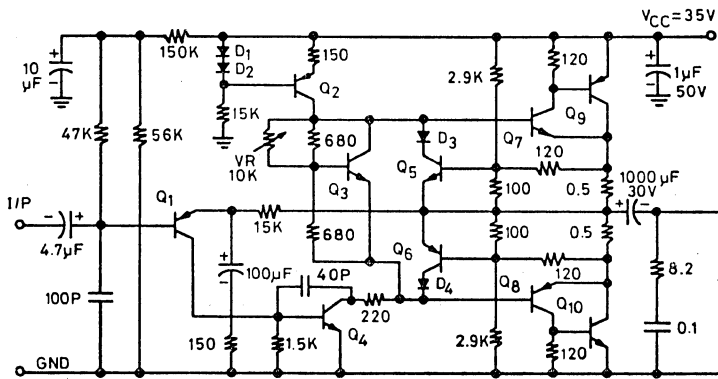


8 typical applications



- Q1 NB022EY
- Q2 NB123EY
- Q3 NR001E
- Q4 NB113EY
- Q5 NB111EY
- Q6 NB121EY
- Q7 NB313Y
- Q8 NB323Y
- Q9 NA72W
- Q10 NA71W

Figure A. 25 Watt OTL Amplifier



- Q1 NB022EY
- Q2 NB123EY
- Q3 NR001E
- Q4 NB113EY
- Q5 NB111EY
- Q6 NB121EY
- Q7 NB313Y
- Q8 NB323Y
- Q9 NA72W
- Q10 NA71W

Figure B. 18 Watt OTL Amplifier

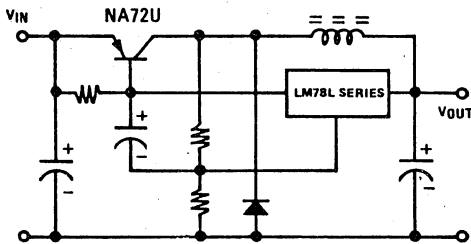


Figure C. Switching Regulator Circuit

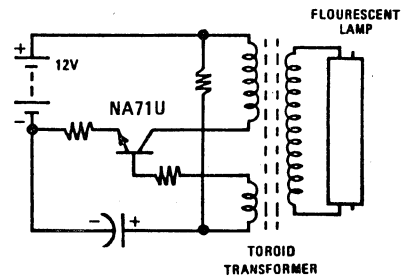


Figure D. Battery Lantern Circuit

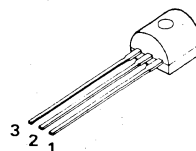


**NB011, 012 (NPN) 30mA general purpose transistors**  
**NB021, 022 (PNP)**

**features**

- 35 to 50 Volt at 30 mA collector ratings
- 300 mV guaranteed  $V_{CE}$  (sat) characteristics at  $I_C = 10$  mA and  $I_B = 0.5$  mA
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

**1 package and lead coding**



**applications**

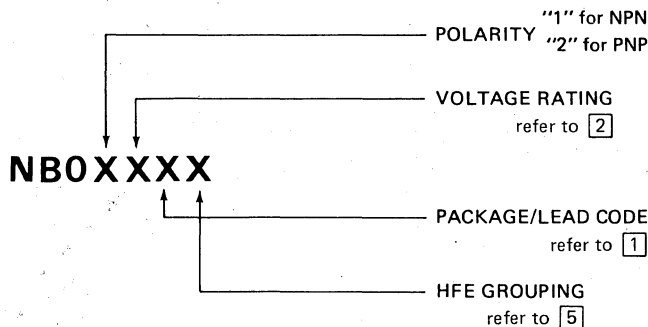
- Small signal amplifier circuits
- Equalizer preamplifiers
- Low current switching circuits
- TV receivers

PACKAGE CODE TO-92	LEAD		
	1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

**2 maximum ratings**

PARAMETER	SYMBOL	NB011 NB021	NB012 NB022	UNIT
Collector-Emitter Voltage	$V_{CEO}$	35	50	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	40	55	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	5	5	$V_{DC}$
Collector Current (continuous)	$I_C$ (max)	30	30	mA <sub>DC</sub>
Power Dissipation ( $T_A = 25^\circ\text{C}$ )	$P_D$	0.6	0.6	W
Power Dissipation ( $T_C = 25^\circ\text{C}$ )	$P_D$	1.0	1.0	W
Thermal Resistance	$\theta_{JA}$	208	208	$^\circ\text{C/W}$
	$\theta_{JC}$	125	125	$^\circ\text{C/W}$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to + 150	-55 to + 150	$^\circ\text{C}$

**3 ordering information**



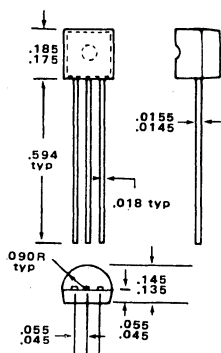
**4 electrical characteristics**  $T_C = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$BV_{CEO}$	Collector-Emitter Sustaining Voltage NB011/021 NB012/022	$I_C = 1\text{ mA}$	35 50			V V
$BV_{CBO}$	Collector-Base Breakdown Voltage NB011/021 NB012/022	$I_C = 100\mu\text{A}$	40 55			V V
$BV_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\mu\text{A}$	5			V
$I_{CEO}$	Collector-Emitter Leakage Current	$V_{CE} = 30\text{V}$ NB011 45V NB012			1 1	$\mu\text{A}$ $\mu\text{A}$
$I_{CES}$	Collector-Emitter Leakage Current	$V_{CE} = 30\text{V}$ NB021 45V NB022			0.5 0.5	$\mu\text{A}$ $\mu\text{A}$
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 35\text{V}$ NB011/021 50V NB012/022			0.1 0.1	$\mu\text{A}$ $\mu\text{A}$
$I_{EBO}$	Emitter-Base Leakage Current	$V_{EB} = 4\text{V}$			0.1	$\mu\text{A}$
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 10\text{ mA}$ , $I_B = 0.5\text{ mA}$		0.75	0.95	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 10\text{ mA}$ , $I_B = 0.5\text{ mA}$		0.1	0.3	V
$C_{ob}$	Collector Output Capacitance NPN types PNP types	$V_{CB} = 10\text{V}$ , $f = 1\text{ MHz}$		2 3		pF pF
$f_t$	Current Gain Bandwidth Product	$I_C = 1\text{ mA}$ , $V_{CE} = 5\text{V}$	50	120		MHz

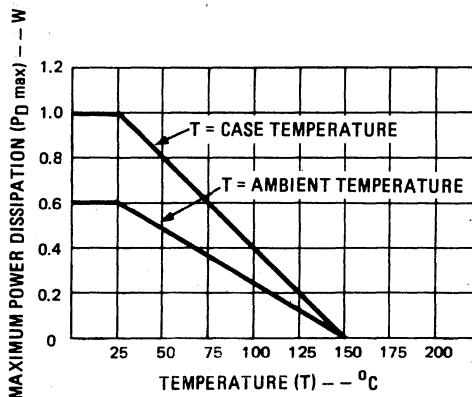
**5 HFE groupings**

GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
I	DC Current Gain	$I_C = 1\text{ mA}$ , $V_{CE} = 5\text{V}$	140	180	240	1:1.6
J	DC Current Gain	$I_C = 1\text{ mA}$ , $V_{CE} = 5\text{V}$	200	260	350	1:1.6
K	DC Current Gain	$I_C = 1\text{ mA}$ , $V_{CE} = 5\text{V}$	300	380	500	1:1.6
L	DC Current Gain	$I_C = 1\text{ mA}$ , $V_{CE} = 5\text{V}$	450	580	750	1:1.6
T	DC Current Gain	$I_C = 1\text{ mA}$ , $V_{CE} = 5\text{V}$	100	150	240	1:2.4
U	DC Current Gain	$I_C = 1\text{ mA}$ , $V_{CE} = 5\text{V}$	200	320	500	1:2.4
V	DC Current Gain	$I_C = 1\text{ mA}$ , $V_{CE} = 5\text{V}$	450	700	1100	1:2.4
Y	DC Current Gain	$I_C = 1\text{ mA}$ , $V_{CE} = 5\text{V}$	100	190	350	1:3.5
Z	DC Current Gain	$I_C = 1\text{ mA}$ , $V_{CE} = 5\text{V}$	300	580	1100	1:3.5

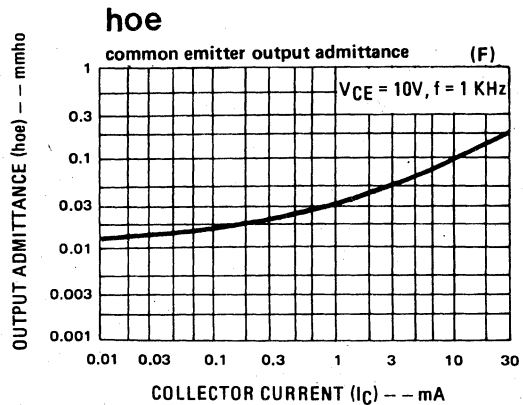
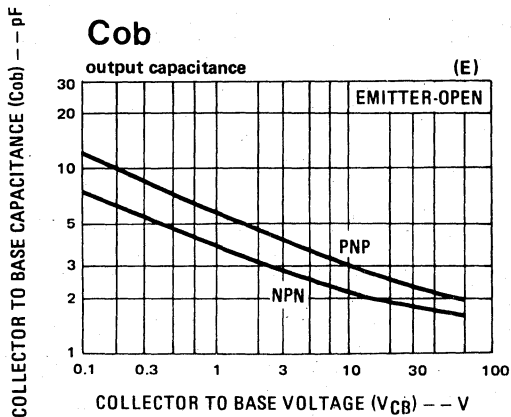
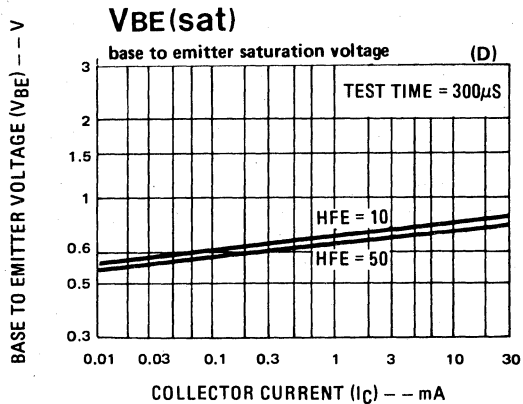
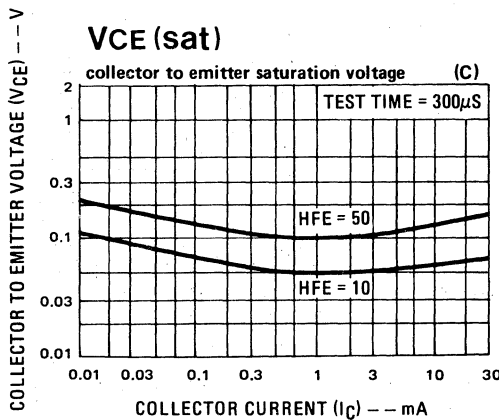
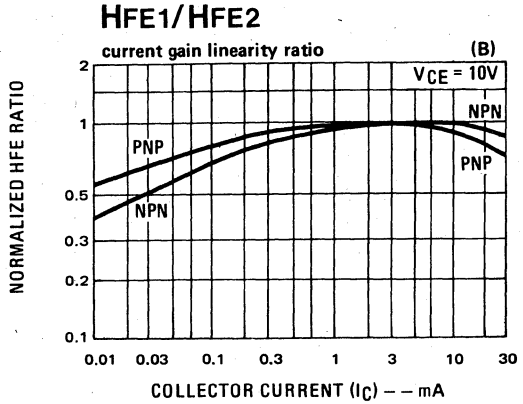
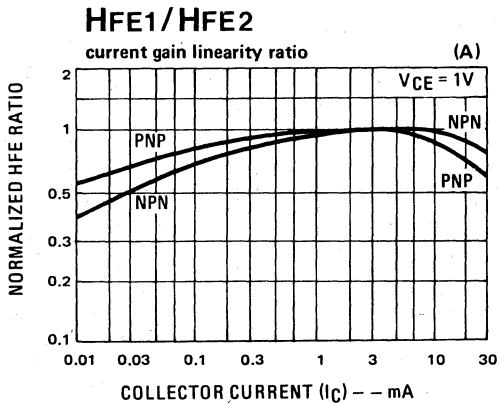
**6 physical dimensions**

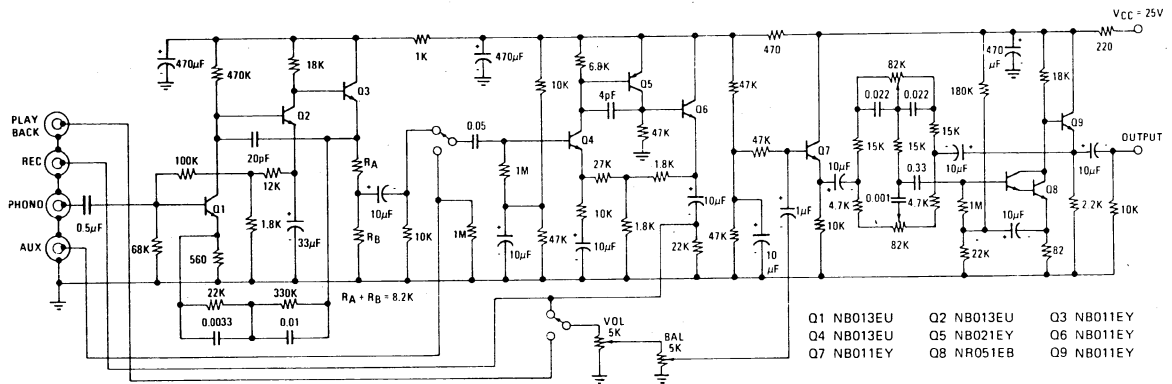


**7 max power dissipation**



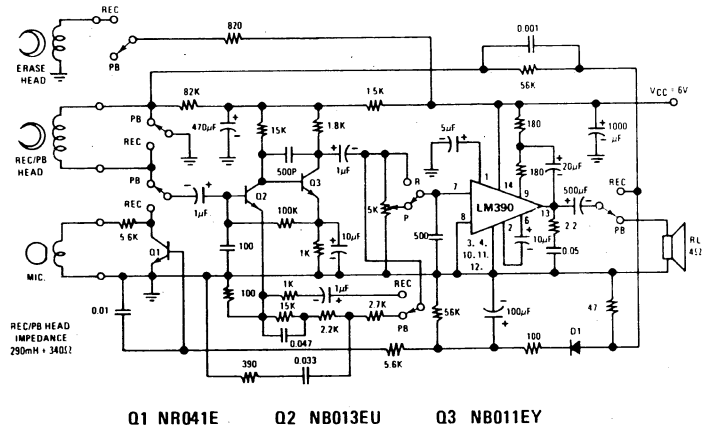
typical performance characteristics





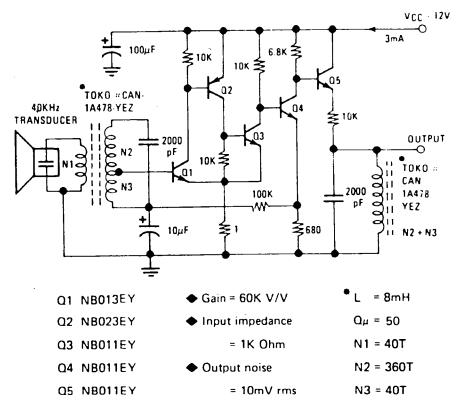
- Q1 NB013EU    Q2 NB013EU    Q3 NB011EY
- Q4 NB013EU    Q5 NB021EY    Q6 NB011EY
- Q7 NB011EY    Q8 NR051EB    Q9 NB011EY

Figure A. High Quality Preamplifier with Tone Control Circuit



- Q1 NR041E    Q2 NB013EU    Q3 NB011EY

Figure B. Battery Operated Recording/Playback Cassette Circuit



- Q1 NB013EY    ♦ Gain = 60K V/V    \* L = 8mH
- Q2 NB023EY    ♦ Input impedance    O<sub>m</sub> = 50
- Q3 NB011EY    = 1K Ohm    N1 = 40T
- Q4 NB011EY    ♦ Output noise    N2 = 360T
- Q5 NB011EY    = 10mV rms    N3 = 40T

Figure C. High Gain Ultrasonic Amplifier



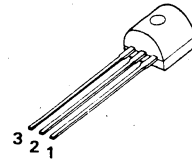


**NB013,014 (NPN) 30mA low noise transistors**  
**NB023,024 (PNP)**

**features**

- 35 to 50 Volt at 30mA collector ratings
- 300mV guaranteed  $V_{CE}$  (sat) characteristics at  $I_C = 10mA$  and  $I_B = 0.5mA$
- 1dB typical wide-band Noise Figure
- "Epoxy B" packaging concept for excellent reliability

**1 package and lead coding**



**applications**

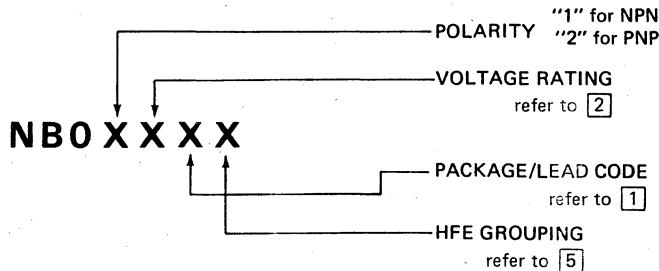
- Low noise amplifier circuits
- Equalizer, preamplifiers

PACKAGE CODE TO-92	LEAD		
	1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

**2 maximum ratings**

PARAMETER	SYMBOL	NB013 NB023	NB014 NB024	UNIT
Collector-Emitter Voltage	$V_{CEO}$	35	50	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	40	55	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	5	5	$V_{DC}$
Collector Current (continuous)	$I_C$ (max)	30	30	$mA_{DC}$
Power Dissipation ( $T_A = 25^\circ C$ )	$P_D$	0.6	0.6	W
Power Dissipation ( $T_C = 25^\circ C$ )	$P_D$	1.0	1.0	W
Thermal Resistance	$\theta_{JA}$	208	208	$^\circ C/W$
	$\theta_{JC}$	125	125	$^\circ C/W$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to +150	-55 to +150	$^\circ C$

**3 ordering information**



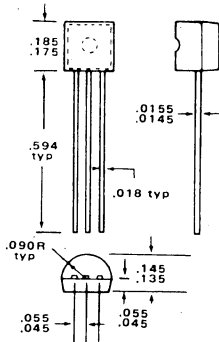
**4** electrical characteristics  $T_C = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$V_{CE0}$	Collector-Emitter Sustaining Voltage NB013/023 NB014/024	$I_C = 1 \text{ mA}$	35 50			V V
$V_{CBO}$	Collector-Base Breakdown Voltage NB013/023 NB014/024	$I_C = 100\mu\text{A}$	40 55			V V
$V_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\mu\text{A}$	5			V
$I_{CEO}$	Collector-Emitter Leakage Current	$V_{CE} = 30\text{V}$ NB013 $45\text{V}$ NB014			1 1	$\mu\text{A}$ $\mu\text{A}$
$I_{CES}$	Collector-Emitter Leakage Current	$V_{CE} = 30\text{V}$ NB023 $45\text{V}$ NB024			0.5 0.5	$\mu\text{A}$ $\mu\text{A}$
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 35\text{V}$ NB013/023 $50\text{V}$ NB014/024			50 50	nA nA
$I_{EBO}$	Emitter-Base Leakage Current	$V_{EB} = 4\text{V}$			0.1	$\mu\text{A}$
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 10 \text{ mA}$ , $I_B = 0.5 \text{ mA}$		0.75	0.95	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 10 \text{ mA}$ , $I_B = 0.5 \text{ mA}$		0.1	0.3	V
$C_{ob}$	Collector Output Capacitance NPN types PNP types	$V_{CB} = 10\text{V}$ , $f = 1 \text{ MHz}$		2 3		pF pF
$f_t$	Current Gain Bandwidth Product	$I_C = 1 \text{ mA}$ , $V_{CE} = 5\text{V}$	50	120		MHz
NF	Noise Figure	$I_C = 10\mu\text{A}$ , $V_{CE} = 5\text{V}$ $R_S = 10 \text{ K}$ , $BW = 15.7 \text{ KHz}$		1	4	dB

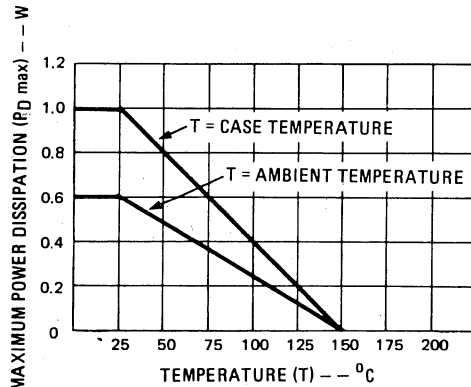
**5** HFE groupings

GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
I	DC Current Gain	$I_C = 100\mu\text{A}$ , $V_{CE} = 5\text{V}$	140	180	240	1:1.6
J	DC Current Gain	$I_C = 100\mu\text{A}$ , $V_{CE} = 5\text{V}$	200	260	350	1:1.6
K	DC Current Gain	$I_C = 100\mu\text{A}$ , $V_{CE} = 5\text{V}$	300	380	500	1:1.6
L	DC Current Gain	$I_C = 100\mu\text{A}$ , $V_{CE} = 5\text{V}$	450	580	750	1:1.6
T	DC Current Gain	$I_C = 100\mu\text{A}$ , $V_{CE} = 5\text{V}$	100	150	240	1:2.4
U	DC Current Gain	$I_C = 100\mu\text{A}$ , $V_{CE} = 5\text{V}$	200	320	500	1:2.4
V	DC Current Gain	$I_C = 100\mu\text{A}$ , $V_{CE} = 5\text{V}$	450	700	1100	1:2.4
Y	DC Current Gain	$I_C = 100\mu\text{A}$ , $V_{CE} = 5\text{V}$	100	190	350	1:3.5
Z	DC Current Gain	$I_C = 100\mu\text{A}$ , $V_{CE} = 5\text{V}$	300	580	1100	1:3.5

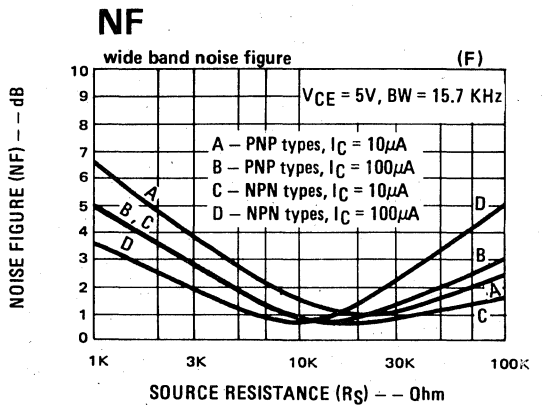
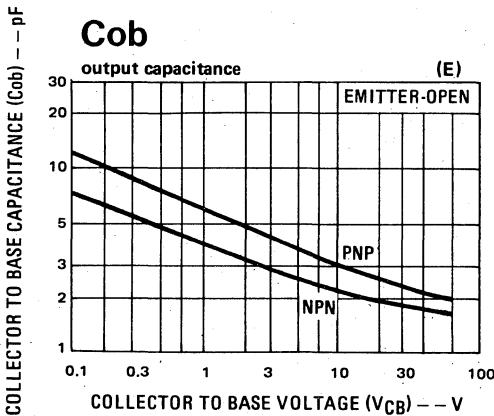
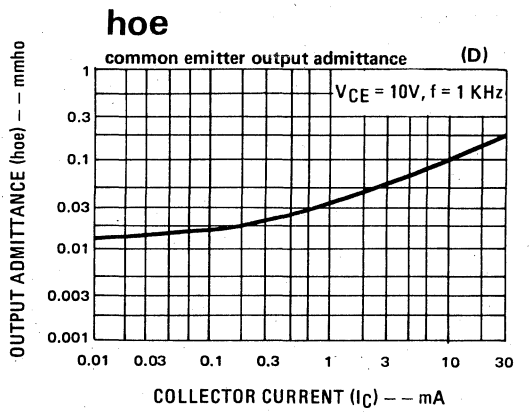
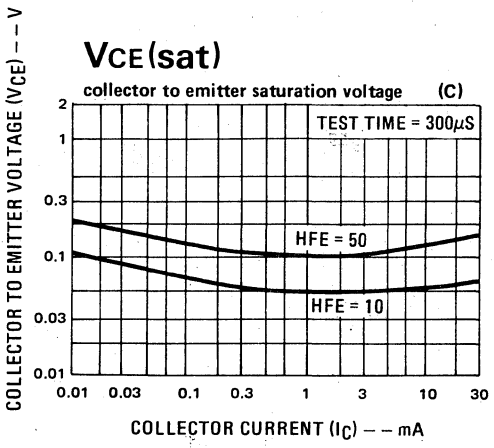
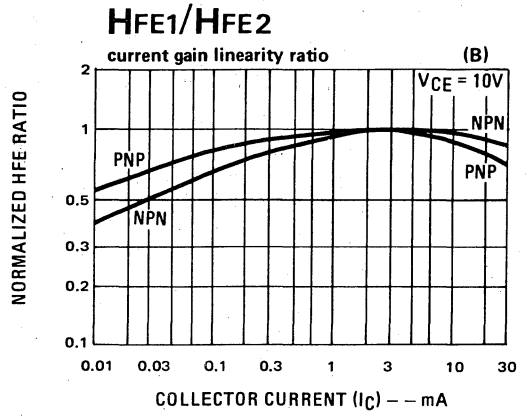
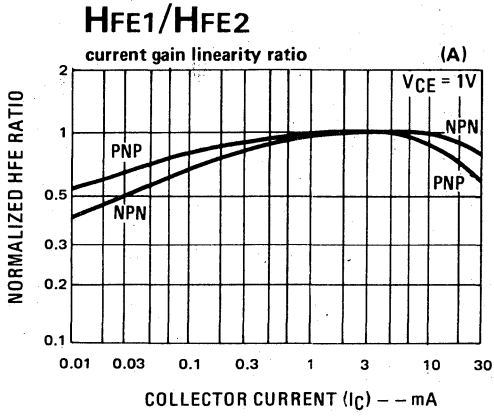
**6** physical dimensions



**7** max power dissipation



**8** typical performance characteristics



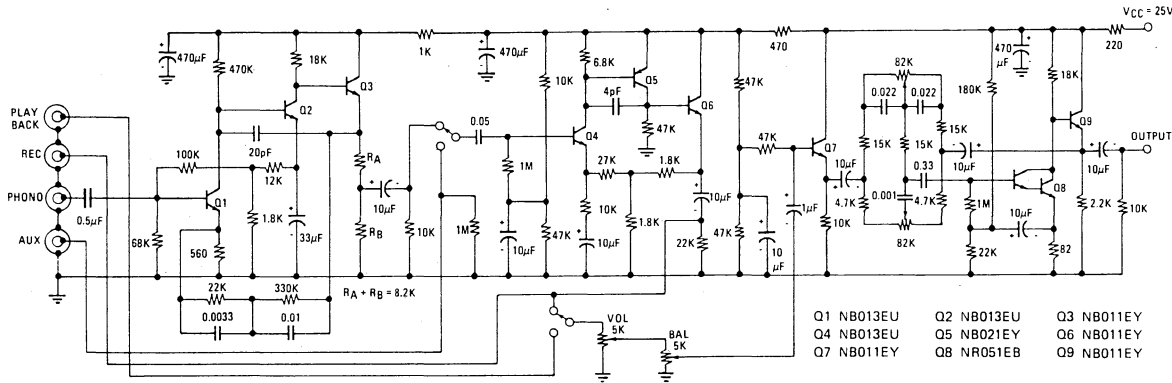


Figure A. High Quality Preamp with Tone Control Circuit

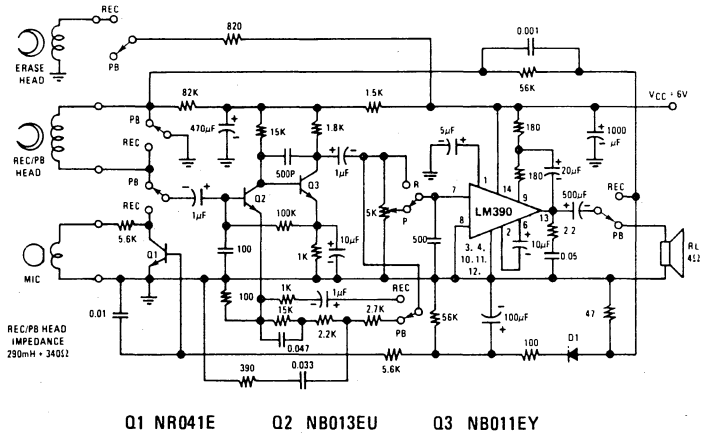
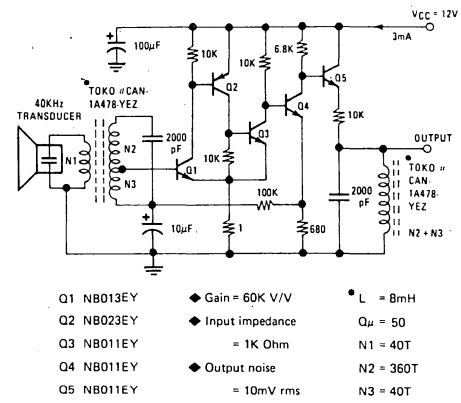


Figure B. Battery Operated Recording/Playback Cassette Circuit



- Q1 NB013EY
- Q2 NB023EY
- Q3 NB011EY
- Q4 NB011EY
- Q5 NB011EY
- Gain = 60K V/V
- Input impedance = 1K Ohm
- Output noise = 10mV rms
- L = 8mH
- Q<sub>m</sub> = 50
- N1 = 40T
- N2 = 360T
- N3 = 40T

Figure C. High Gain Ultrasonic Amplifier

NB013,014(NPN), NB023,024(PNP)



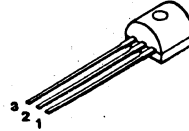
**NB111, 112, 113 (NPN) 100mA general purpose transistors**  
**NB121, 122, 123 (PNP)**

**features**

- 35 to 65 Volt at 100mA collector ratings
- 400mV guaranteed  $V_{CE}$  (sat) characteristics at  $I_C = 20mA$  and  $I_B = 0.4mA$
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

**1 package and lead coding**

TO-92



**applications**

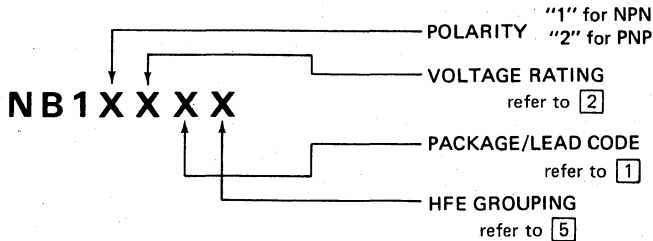
- Small signal amplifier circuits
- Medium current level switching circuits
- LED drivers
- TV receivers

PACKAGE CODE TO-92	LEAD		
	1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

**2 maximum ratings**

PARAMETER	SYMBOL	NB111 NB121	NB112 NB122	NB113 NB123	UNIT
Collector-Emitter Voltage	$V_{CEO}$	35	50	65	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	40	55	70	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	6	6	6	$V_{DC}$
Collector Current (continuous)	$I_C$ (max)	100	100	100	$mA_{DC}$
Power Dissipation ( $T_A = 25^\circ C$ )	$P_D$	0.6	0.6	0.6	W
Power Dissipation ( $T_C = 25^\circ C$ )	$P_D$	1.0	1.0	1.0	W
Thermal Resistance	$\theta_{JA}$	208	208	208	$^\circ C/W$
	$\theta_{JC}$	125	125	125	$^\circ C/W$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to + 150	-55 to + 150	-55 to + 150	$^\circ C$

**3 ordering information**



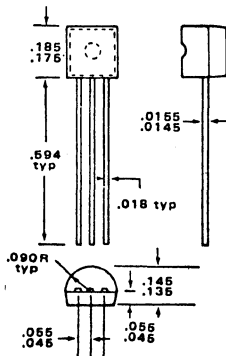
**4** electrical characteristics  $T_C = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$V_{CEO}$	Collector-Emitter Sustaining Voltage NB111/121 NB112/122 NB113/123	$I_C = 1\text{ mA}$	35 50 65			V V V
$V_{CBO}$	Collector-Base Breakdown Voltage NB111/121 NB112/122 NB113/123	$I_C = 100\mu\text{A}$	40 55 70			V V V
$V_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\mu\text{A}$	6			V
$I_{CEO}$	Collector-Emitter Leakage Current	$V_{CE} = 30\text{V NB111/121}$ $45\text{V NB112/122}$ $60\text{V NB113/123}$			2 2 2	$\mu\text{A}$ $\mu\text{A}$ $\mu\text{A}$
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 35\text{V NB111/121}$ $50\text{V NB112/122}$ $65\text{V NB113/123}$			0.1 0.1 0.1	$\mu\text{A}$ $\mu\text{A}$ $\mu\text{A}$
$I_{EBO}$	Emitter-Base Leakage Current	$V_{EB} = 5\text{V}$			0.1	$\mu\text{A}$
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	$I_C = 20\text{ mA}, I_B = 0.4\text{ mA}$		0.8	0.95	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C = 20\text{ mA}, I_B = 0.4\text{ mA}$		0.15	0.4	V
HFE1	DC Current Gain	$I_C = 100\mu\text{A}, V_{CE} = 5\text{V}$	50			ratio
$C_{ob}$	Collector Output Capacitance NPN types PNP types	$V_{CB} = 10\text{V}, f = 1\text{MHz}$		2 3		pF pF
$f_t$	Current Gain Bandwidth Product	$I_C = 15\text{ mA}, V_{CE} = 5\text{V}$	100			MHz

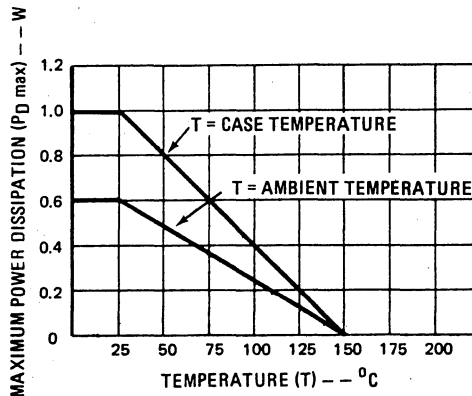
**5** HFE groupings

GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
H	DC Current Gain	$I_C = 15\text{ mA}, V_{CE} = 5\text{V}$	100	127	160	1:1.6
I	DC Current Gain	$I_C = 15\text{ mA}, V_{CE} = 5\text{V}$	140	180	240	1:1.6
J	DC Current Gain	$I_C = 15\text{ mA}, V_{CE} = 5\text{V}$	200	260	350	1:1.6
Y	DC Current Gain	$I_C = 15\text{ mA}, V_{CE} = 5\text{V}$	100	190	350	1:3.5

**6** physical dimensions

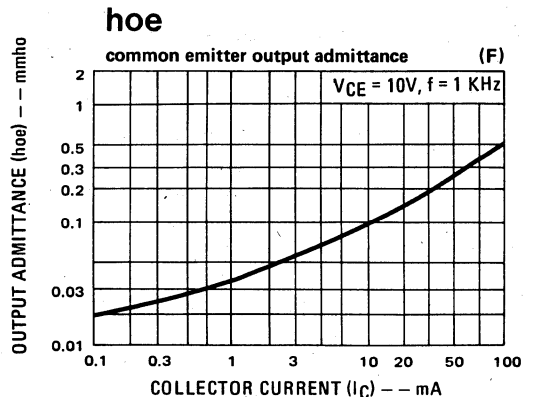
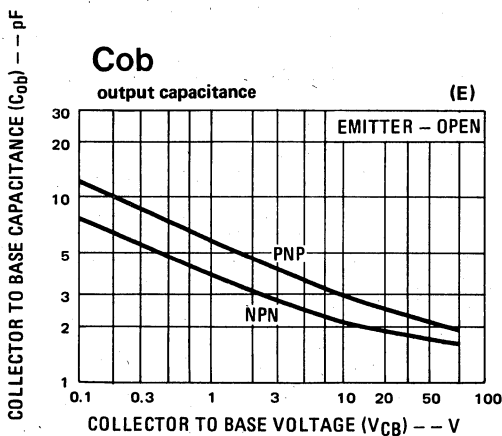
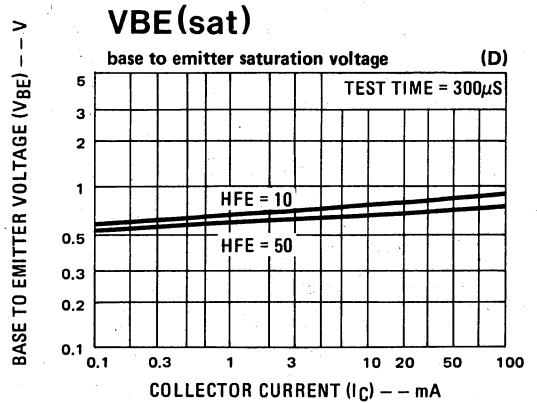
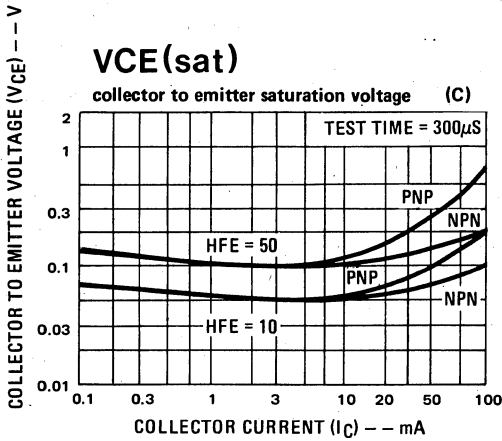
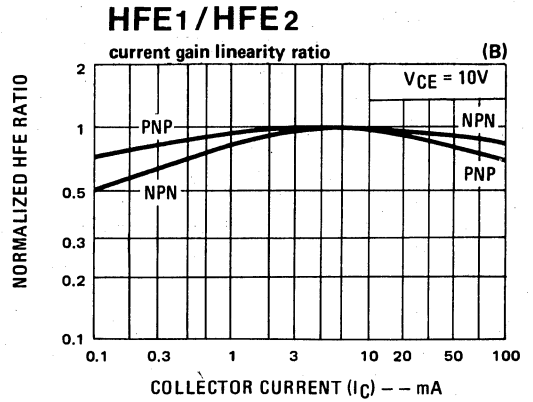
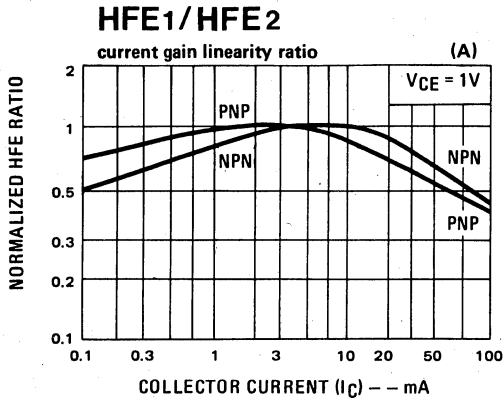


**7** max power dissipation

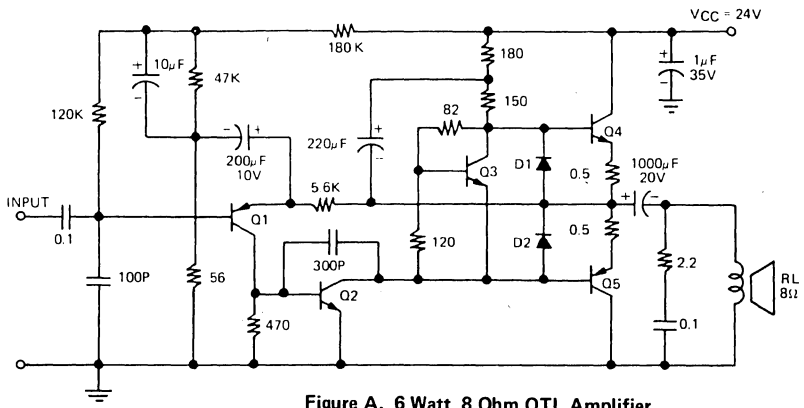


**7**

8 typical performance characteristics

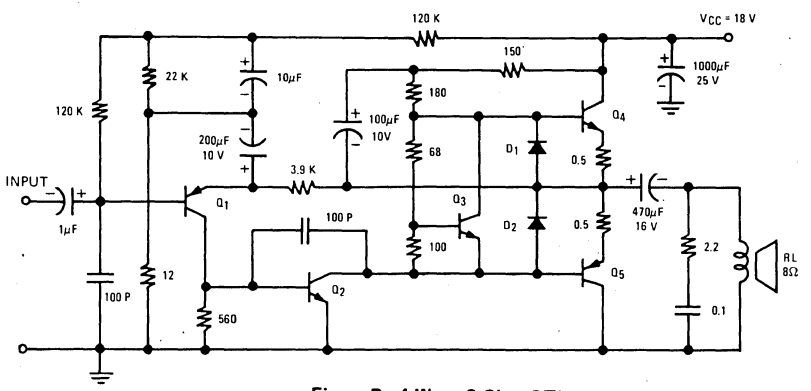


9 typical applications



- Q1 NB021EY
- Q2 NB211Y
- Q3 NR001E
- Q4 NA41U
- Q5 NA42U

Figure A. 6 Watt, 8 Ohm OTL Amplifier



- Q1 NB021EY
- Q2 NB211EY
- Q3 NR001E
- Q4 NA31YG/I
- Q5 NA32YG/I

Figure B. 4 Watt, 8 Ohm OTL Amplifier

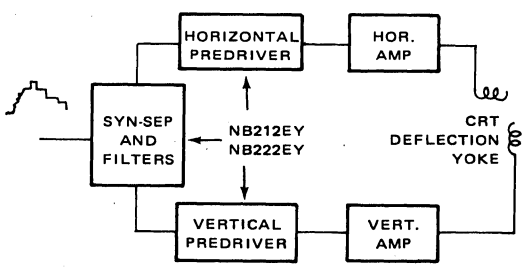


Figure C. TV processor/predriver applications

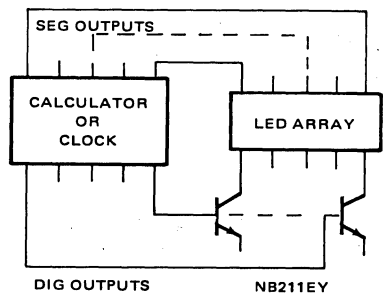


Figure D. Calculator/Clock driver application





## NB 211, 212, 213 (NPN) NB 221, 222, 223 (PNP) 500mA medium current driver transistors

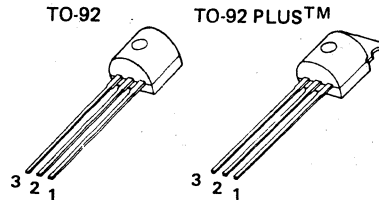
### features

- 35 to 65 Volt at 500 mA collector ratings
- 1.2 Watts practical power dissipation (TO-92 PLUSTM)
- 400 mV guaranteed  $V_{CE}$  (sat) characteristics at  $I_C = 100$  mA and  $I_B = 2$  mA
- Matched HFE groupings for complementary applications
- "Epoxy B" packaging concept for excellent reliability

### applications

- 4 to 6 Watt amplifier class A drivers
- Medium current level switching circuits
- LED drivers
- TV receivers

### 1 package and lead coding

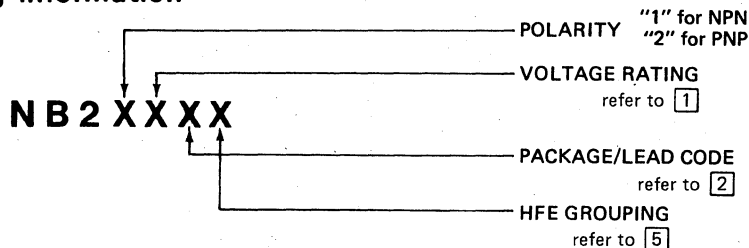


PACKAGE CODE	TO-92 PLUS	LEAD		
		1	2	3
E	X	E	B	C
F	Y	E	C	B
H	Z	B	C	E

### 2 maximum ratings

PARAMETER	SYMBOL	NB211 NB221	NB212 NB222	NB213 NB223	UNIT
Collector-Emitter Voltage	$V_{CEO}$	35	50	65	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	40	55	70	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	6.0	6.0	6.0	$V_{DC}$
Collector Current (continuous)	$I_C$ (max)	500	500	500	mA
Power Dissipation ( $T_A = 25^\circ C$ )	$P_D$				
TO-92		0.6	0.6	0.6	W
TO-92 PLUS		0.75	0.75	0.75	W
Power Dissipation ( $T_C = 25^\circ C$ )	$P_D$				
TO-92		1.0	1.0	1.0	W
TO-92 PLUS		2.5	2.5	2.5	W
Thermal Resistance					
TO-92	$\theta_{JA}/\theta_{JC}$	208/125	208/125	208/125	$^\circ C/W$
TO-92 PLUS	$\theta_{JA}/\theta_{JC}$	167/50	167/50	167/50	$^\circ C/W$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to +150	-55 to +150	-55 to +150	$^\circ C$

### 3 ordering information



**4** electrical characteristics  $T_C = 25^\circ\text{C}$

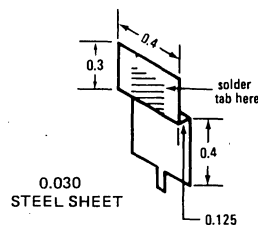
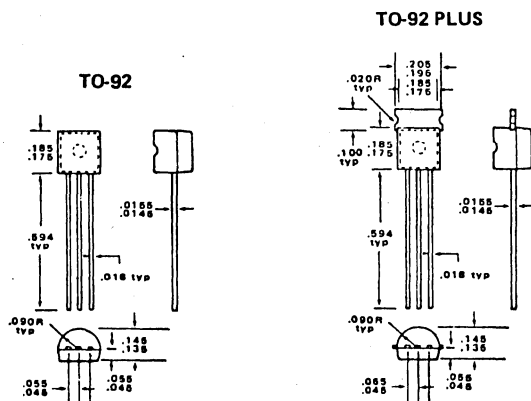
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$BV_{CEO}$	Collector-Emitter Sustaining Voltage NB211/221 NB212/222 NB213/223	$I_C = 1 \text{ mA}$	35			V
			50			V
			65			V
$BV_{CBO}$	Collector-Base Breakdown Voltage NB211/221 NB212/222 NB213/223	$I_C = 100\mu\text{A}$	40			V
			55			V
			70			V
$BV_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\mu\text{A}$	6			V
$I_{CEO}$	Collector-Emitter Leakage Current	$V_{CE} = 30\text{V NB211/221}$ $45\text{V NB212/222}$ $60\text{V NB213/223}$			10	$\mu\text{A}$
					10	$\mu\text{A}$
					10	$\mu\text{A}$
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 35\text{V NB211/221}$ $50\text{V NB212/222}$ $65\text{V NB213/223}$			0.5	$\mu\text{A}$
					0.5	$\mu\text{A}$
					0.5	$\mu\text{A}$
$I_{EBO}$	Emitter-Base Leakage Current	$V_{EB} = 5\text{V}$			0.1	$\mu\text{A}$
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 100 \text{ mA}, I_B = 2 \text{ mA}$		0.8	0.95	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 100 \text{ mA}, I_B = 2 \text{ mA}$		0.2	0.4	V
HFE1	DC Current Gain	$I_C = 1 \text{ mA}, V_{CE} = 5\text{V}$	30			ratio
$C_{ob}$	Collector Output Capacitance NPN types PNP types	$V_{CB} = 10\text{V}, f = 1 \text{ MHz}$		3.5		pF
				4.5		pF
$f_t$	Current Gain Bandwidth Product	$I_C = 20 \text{ mA}, V_{CE} = 5\text{V}$	50			MHz

**5** HFE groupings

GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
G	DC Current Gain	$I_C = 30 \text{ mA}, V_{CE} = 5\text{V}$	68	85	110	1:1.6
H	DC Current Gain	$I_C = 30 \text{ mA}, V_{CE} = 5\text{V}$	100	127	160	1:1.6
I	DC Current Gain	$I_C = 30 \text{ mA}, V_{CE} = 5\text{V}$	140	180	240	1:1.6
J	DC Current Gain	$I_C = 30 \text{ mA}, V_{CE} = 5\text{V}$	200	260	350	1:1.6
X	DC Current Gain	$I_C = 30 \text{ mA}, V_{CE} = 5\text{V}$	30	58	110	1:3.5
Y	DC Current Gain	$I_C = 30 \text{ mA}, V_{CE} = 5\text{V}$	100	190	250	1:3.5

**6** physical dimensions

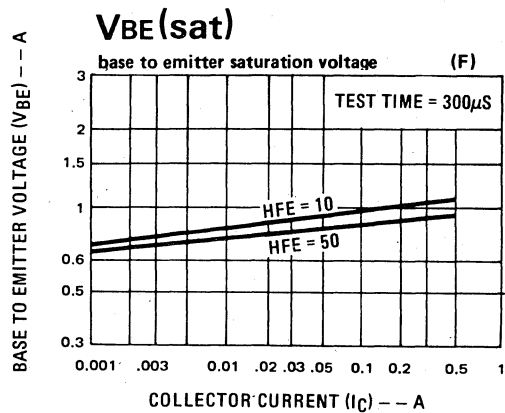
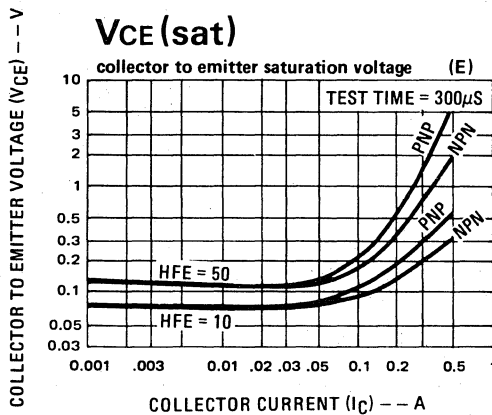
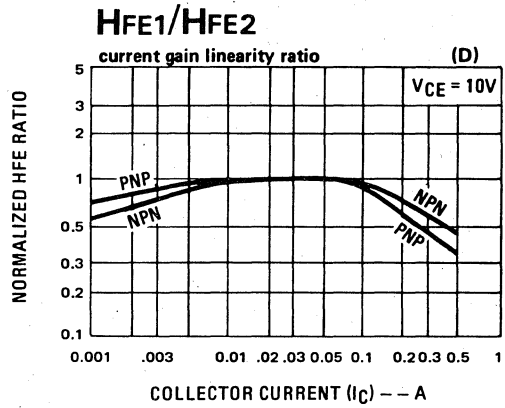
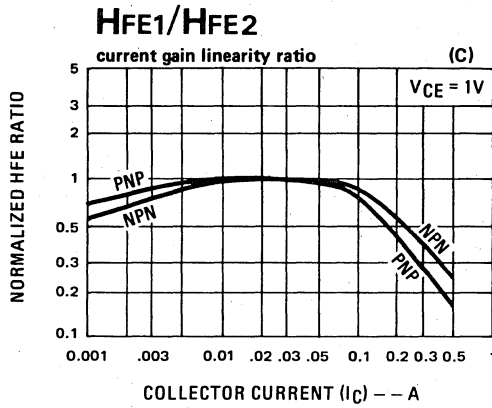
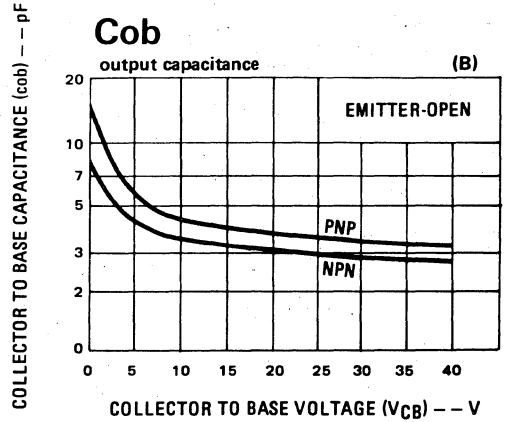
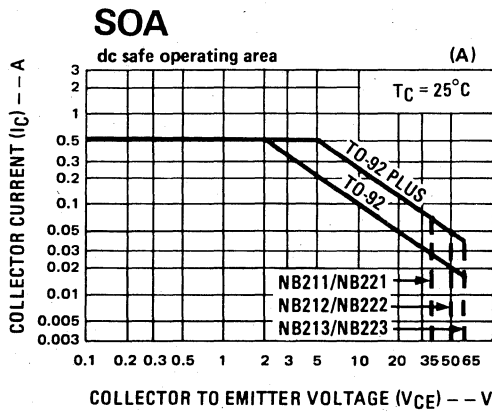
**7** heatsink information



- TO-92 PLUS package with heat-sink shown on right permits 1.6 Watts power dissipation and combined Thermal Resistance  $\theta_{JA} = 78^\circ\text{C/W}$ . If used without heatsink and PCB land area at collector lead  $> 1 \text{ sq. inch}$ ,  $P_D = 1.2\text{W}$ .

**7**

8 typical performance characteristics



9 typical applications

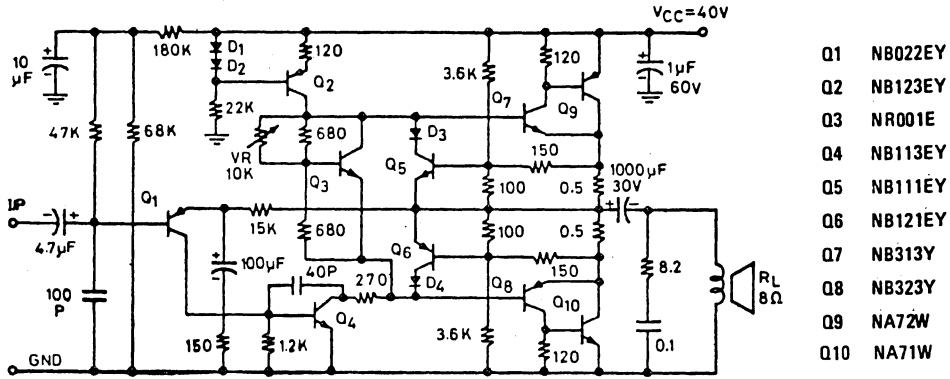


Figure A. 25 Watt OTL Amplifier

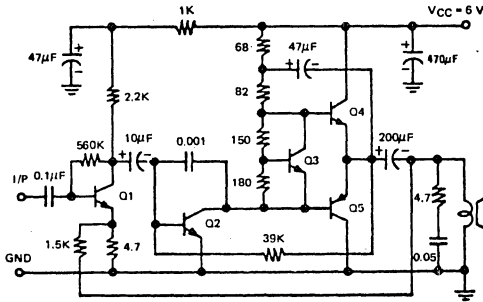


Figure B. 700mW 6V/4Ω OTL Amplifier

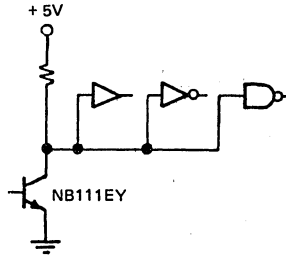


Figure C. High fan-out TTL driver

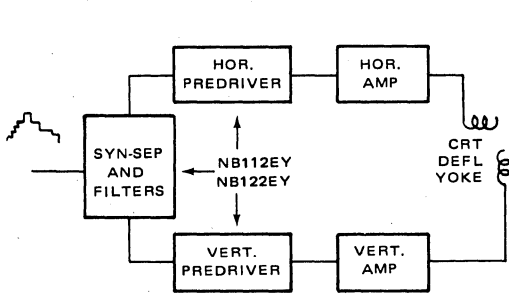


Figure D. TV processor/predriver applications

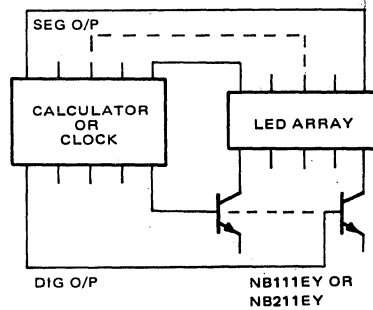


Figure E. Calculator/Clock driver application



**NB311, 312, 313 (NPN)  
NB321, 322, 323 (PNP) 1.5Amp complementary power drivers**

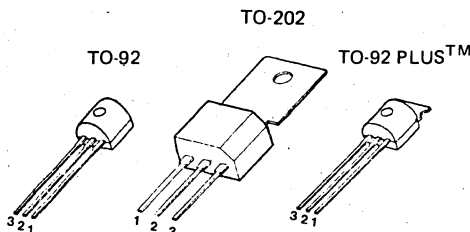
**features**

- 35 to 65 Volt at 1.5 Amp collector ratings
- Low  $V_{CE(sat)}$  and  $V_{BE(sat)}$  characteristics with  $I_C = 300\text{ mA}$  and  $I_B = 10\text{ mA}$  drive
- Available in TO-92, TO-92 PLUS™ and TO-202 packages
- "Epoxy B" packaging concept for excellent reliability

**applications**

- Driver stages in high-power audio amplifiers
- Medium-power switching circuits
- Converter/inverter circuits
- TV receivers

**1 packages and lead coding**

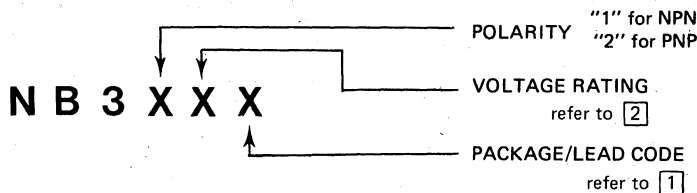


PACKAGE CODE			LEAD		
TO-92	TO-92 PLUS	TO-202	1	2	3
E	X	K	E	B	C
F	Y	L	E	C	B
H	Z	M	B	C	E
			C	B	E

**2 maximum ratings**

PARAMETER	SYMBOL	NB311 NB321	NB312 NB322	NB313 NB323	UNIT
Collector-Emitter Voltage	$V_{CEO}$	35	50	65	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	40	55	70	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	6	6	6	$V_{DC}$
Collector Current (continuous)	$I_C$	1.5	1.5	1.5	$A_{DC}$
Power Dissipation ( $T_A = 25^\circ\text{C}$ )	$P_D$				
TO-92		0.6	0.6	0.6	W
TO-92 PLUS		0.75	0.75	0.75	W
TO-202		1.75	1.75	1.75	W
Power Dissipation ( $T_C = 25^\circ\text{C}$ )	$P_D$				
TO-92		1.0	1.0	1.0	W
TO-92 PLUS		2.5	2.5	2.5	W
TO-202		10	10	10	W
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to +150	-55 to +150	-55 to +150	$^\circ\text{C}$

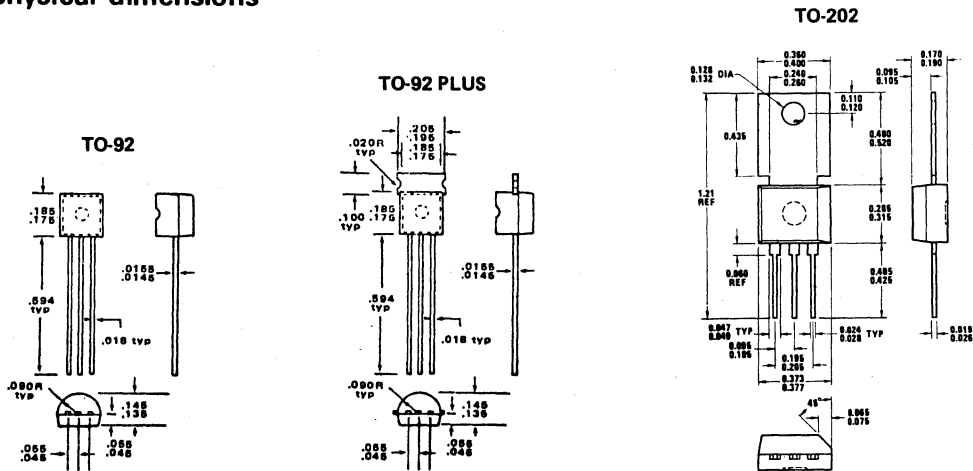
**3 ordering information**



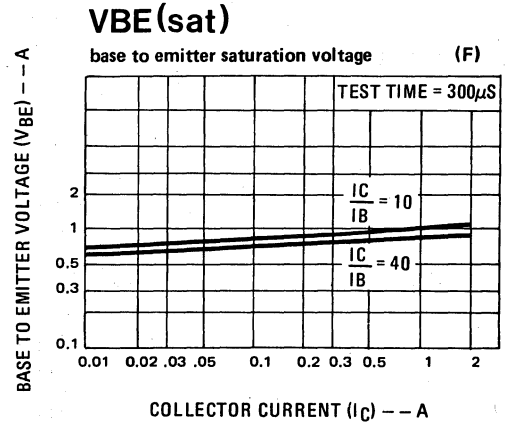
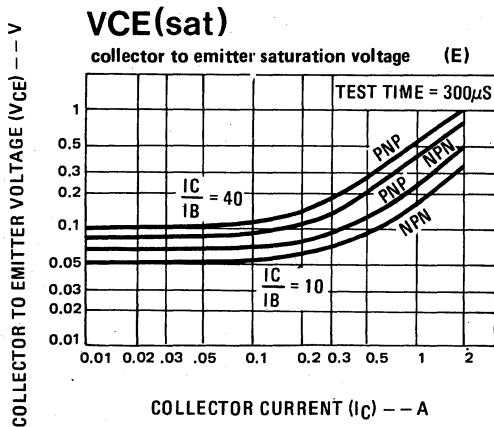
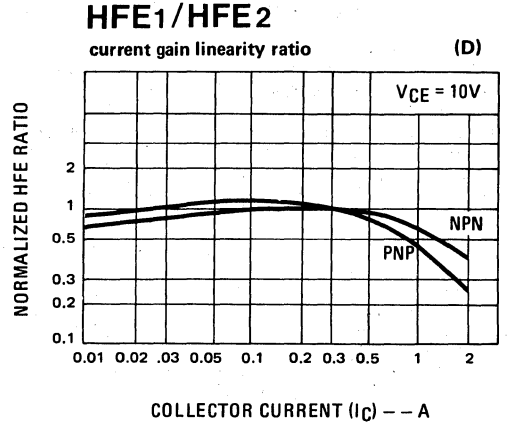
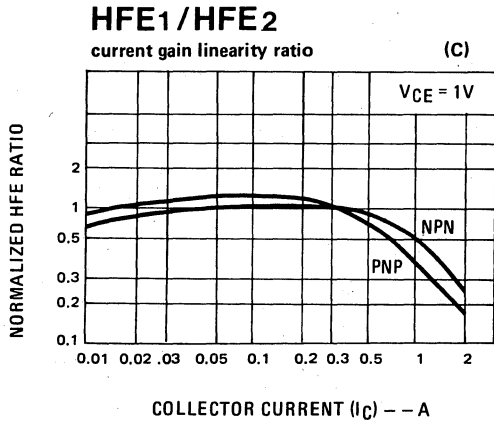
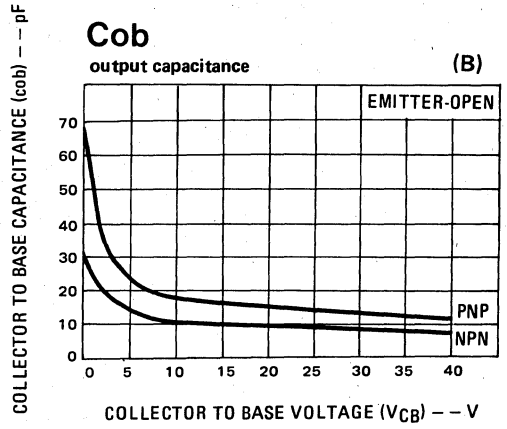
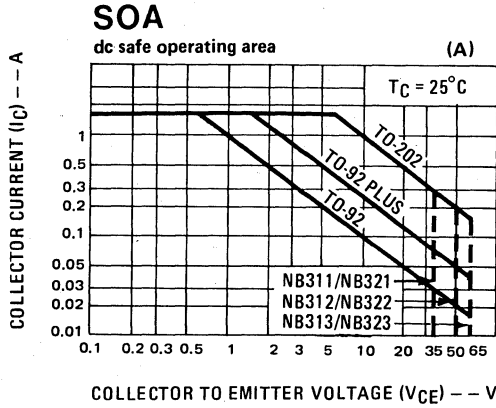
**4 electrical characteristics**  $T_C = 25^{\circ}C$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$V_{CEO}$	Collector-Emitter Sustaining Voltage NB311/321 NB312/322 NB313/323	$I_C = 1 \text{ mA}$	35 50 65			V V V
$V_{CBO}$	Collector-Base Breakdown Voltage NB311/321 NB312/322 NB313/323	$I_C = 100 \mu\text{A}$	40 55 70			V V V
$V_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10 \mu\text{A}$	6			V
$I_{CEO}$	Collector-Emitter Leakage Current	$V_{CE} = 30\text{V}$ NB311/321 45V NB312/322 60V NB313/323			50 50 50	$\mu\text{A}$ $\mu\text{A}$ $\mu\text{A}$
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 35\text{V}$ NB311/321 50V NB312/322 65V NB313/323			0.5 0.5 0.5	$\mu\text{A}$ $\mu\text{A}$ $\mu\text{A}$
$I_{EBO}$	Emitter-Base Leakage Current	$V_{EB} = 5\text{V}$			0.5	$\mu\text{A}$
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	$I_C = 300 \text{ mA}, I_B = 10 \text{ mA}$		0.9	1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C = 300 \text{ mA}, I_B = 10 \text{ mA}$		0.15	0.5	V
$HFE_1$	DC Current Gain	$I_C = 1 \text{ mA}, V_{CE} = 10\text{V}$	30			
$HFE_2$	DC Current Gain	$I_C = 100 \text{ mA}, V_{CE} = 10\text{V}$	50			
$C_{ob}$	Collector Output Capacitance NPN types PNP types	$V_{CB} = 10\text{V}, f = 1 \text{ MHz}$		10 17		pF pF
$f_t$	Current Gain Bandwidth Product	$I_C = 100 \text{ mA}, V_{CE} = 10\text{V}$	20			MHz

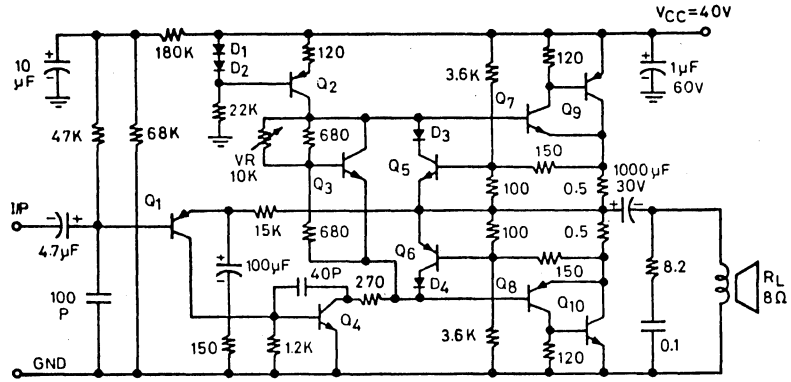
**5 physical dimensions**



6 typical performance characteristics

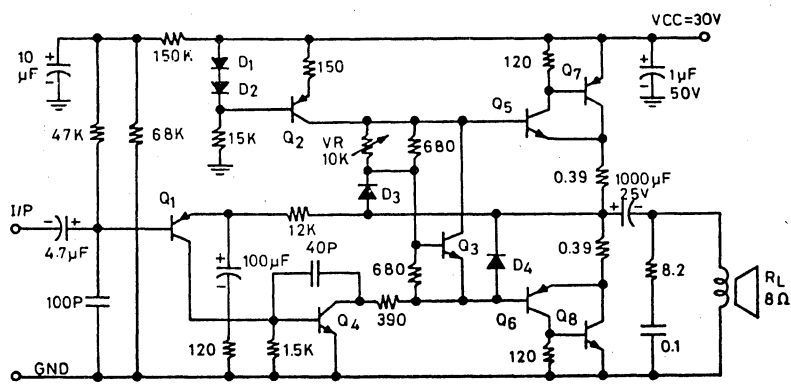


**7** typical applications



- Q1 NB022EY
- Q2 NB123EY
- Q3 NR001E
- Q4 NB113EY
- Q5 NB111EY
- Q6 NB121EY
- Q7 NB313Y
- Q8 NB323Y
- Q9 NA72W
- Q10 NA71W

Figure A. 25 Watt OTL Amplifier



- Q1 NB021EY
- Q2 NB122EY
- Q3 NR001E
- Q4 NB112EY
- Q5 NB312E
- Q6 NB322E
- Q7 NA52W
- Q8 NA51W

Figure B. 12 Watt OTL Amplifier

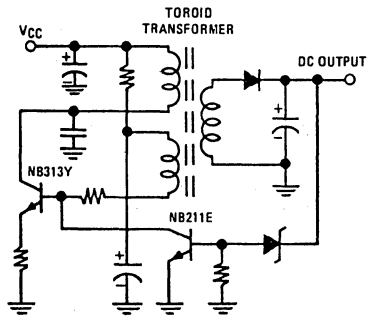


Figure C. Typical Converter Circuit

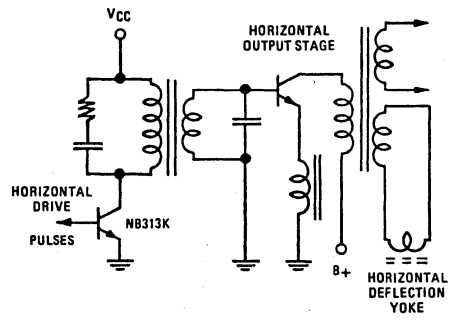


Figure D. Typical TV Horizontal Driver Application





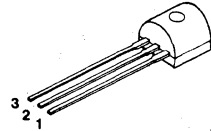
## NR041 (NPN) low-level signal switching transistor

### features

- 40mV guaranteed  $V_{CE}$  (sat) characteristics at  $I_C = 1\text{mA}$  and  $I_B = 0.1\text{mA}$
- Linear collector characteristics
- 1dB typical wide-band Noise Figure
- "Epoxy B" packaging concept for excellent reliability

### 1 package and lead coding

TO-92



### applications

- ALC device for CB microphone circuits
- Cassette circuits
- Audio signal switches
- Envelope modulators for musical equipment

PACKAGE CODE TO-92	LEAD		
	1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

### 2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	$V_{CE0}$	20	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	20	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	5	$V_{DC}$
Collector Current (continuous)	$I_C$ (max)	30	$\text{mA}_{DC}$
Power Dissipation ( $T_A = 25^\circ\text{C}$ )	$P_D$	0.6	W
Power Dissipation ( $T_C = 25^\circ\text{C}$ )	$P_D$	1.0	W
Thermal Resistance	$\theta_{JA}$	208	$^\circ\text{C/W}$
	$\theta_{JC}$	125	$^\circ\text{C/W}$
Temperature, Junction and Storage	$T_j, T_{stg}$	- 55 to +150	$^\circ\text{C}$

### 3 ordering information

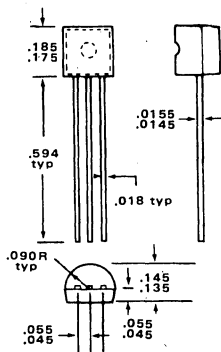
**NR041X**

PACKAGE/LEAD CODE  
refer to 1

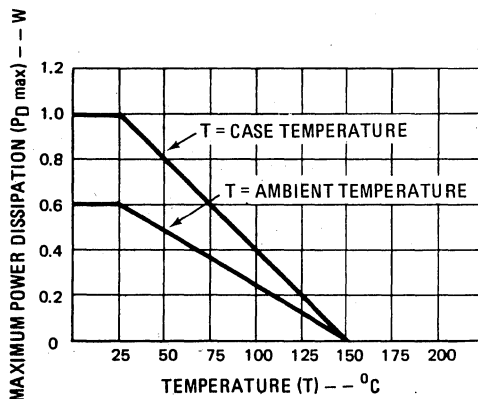
**4** electrical characteristics  $T_C = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$BV_{CEO}$	Collector-Emitter Sustaining Voltage	$I_C = 1\text{ mA}$	20			V
$BV_{CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\mu\text{A}$	20			V
$BV_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\mu\text{A}$	5			V
$I_{CEO}$	Collector-Emitter Leakage Current	$V_{CE} = 15\text{V}$			1	$\mu\text{A}$
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 15\text{V}$			50	nA
$I_{EBO}$	Emitter-Base Leakage Current	$V_{EB} = 4\text{V}$			0.1	$\mu\text{A}$
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 1\text{ mA}, I_B = 0.1\text{ mA}$		0.65	0.8	V
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 1\text{ mA}, I_B = 0.1\text{ mA}$		25	40	mV
$C_{ob}$	Collector Output Capacitance	$V_{CB} = 10\text{V}, f = 1\text{ MHz}$		2		pF
NF	Noise Figure	$I_C = 10\mu\text{A}, V_{CE} = 5\text{V}$ $R_S = 10\text{K}, \text{BW} = 15.7\text{ KHz}$		1		dB

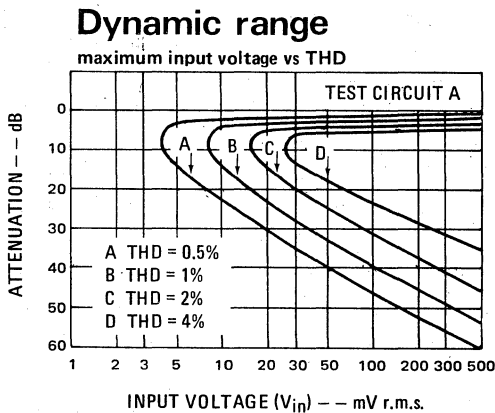
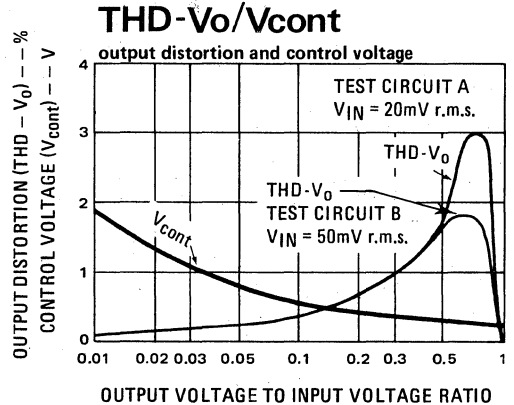
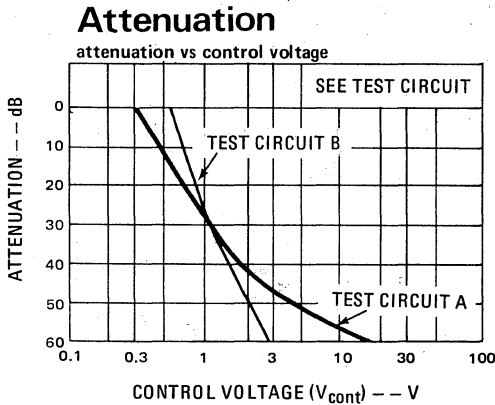
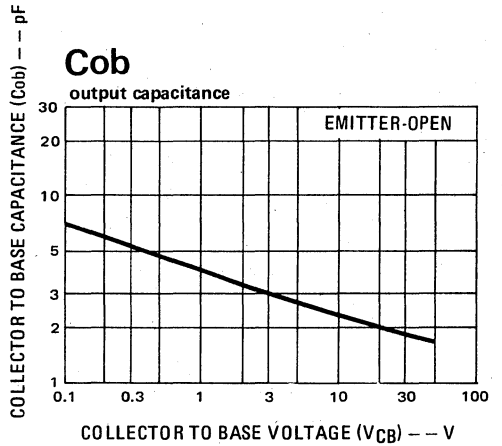
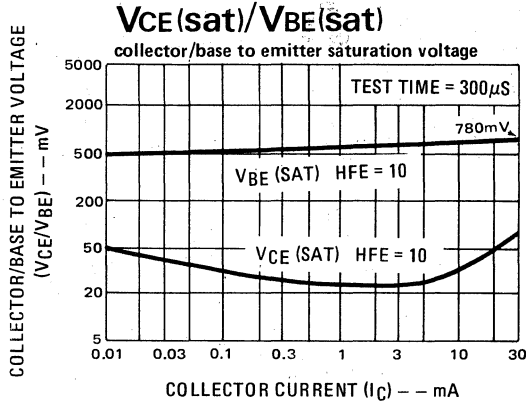
**5** physical dimensions



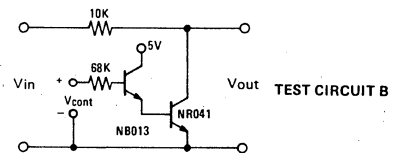
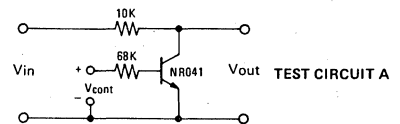
**6** max power dissipation



**7** typical performance characteristics

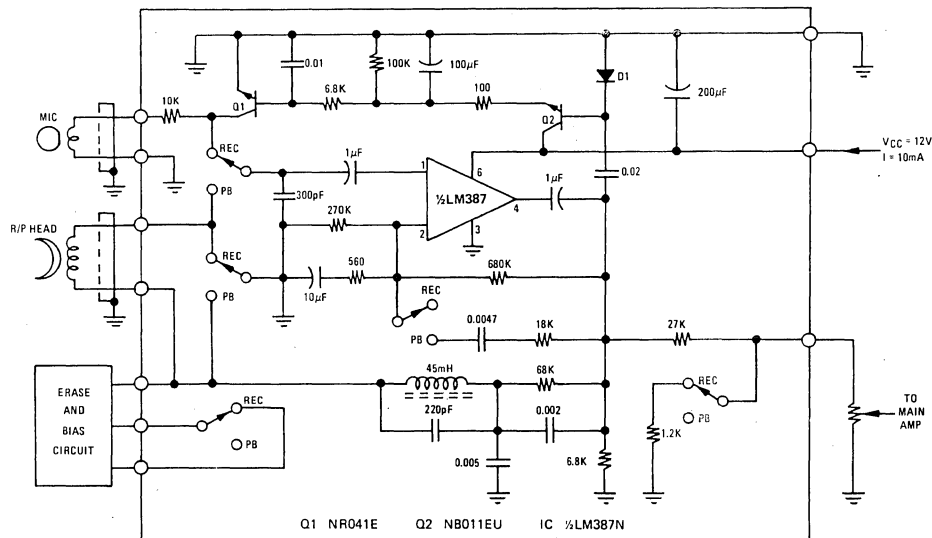


### Test circuits

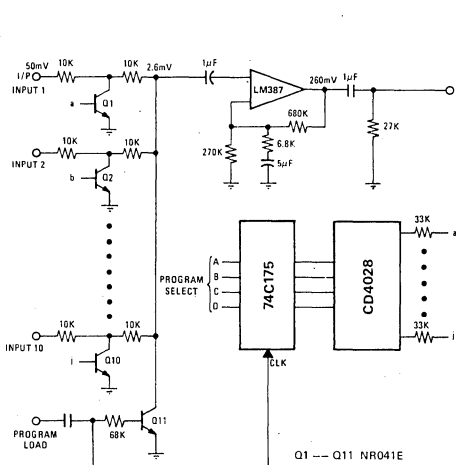


NOTE: ATTENUATION = 20 log<sub>10</sub>  $\frac{V_{out}}{V_{in}}$

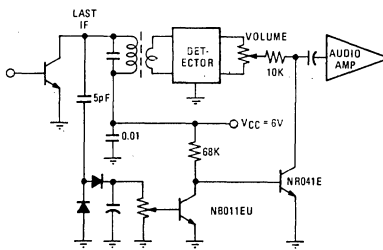
**8** typical applications



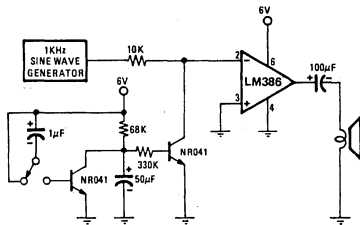
**Figure A. 60dB ALC Range Record/Playback Preamplifier**



**Figure B. 10 Channel Program Selector**



**Figure C. Squelch Circuit**



**Figure D. Ringing Tone Generator**

## NR421(NPN) VHF amplifier/FM converter transistor

### features

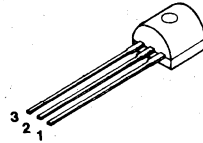
- 0.65pF typical feedback capacitance for excellent RF stability
- Guaranteed collector-base time constant and RF output resistance
- 150mV typical  $V_{CE}$  (sat) characteristics at  $I_C = 10$  mA, and  $I_B = 0.5$  mA
- 2 dB typical noise figure at 200 MHz
- "Epoxy B" packaging concept for excellent reliability

### applications

- VHF RF amplifiers/converters
- CB radios
- Low-power RF oscillators

### 1 package and lead coding

TO-92

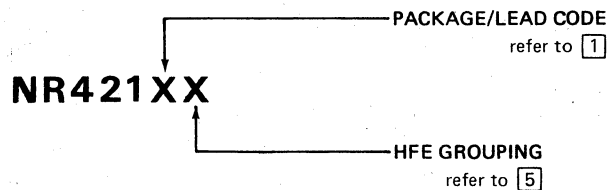


PACKAGE CODE TO-92	LEAD		
	1	2	3
D	B	E	C
F	E	C	B

### 2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	$V_{CEO}$	30	V <sub>DC</sub>
Collector-Base Voltage	$V_{CB}$	35	V <sub>DC</sub>
Emitter-Base Voltage	$V_{EB}$	3	V <sub>DC</sub>
Collector Current (continuous)	$I_C$ (max)	30	mA <sub>DC</sub>
Power Dissipation ( $T_A = 25^\circ\text{C}$ )	$P_D$	0.6	W
Power Dissipation ( $T_C = 25^\circ\text{C}$ )	$P_D$	1.0	W
Thermal Resistance	$\theta_{JA}$	208	$^\circ\text{C}/\text{W}$
	$\theta_{JC}$	125	$^\circ\text{C}/\text{W}$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to +150	$^\circ\text{C}$

### 3 ordering information



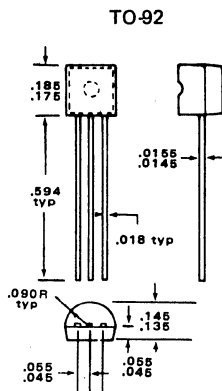
**4 electrical characteristics**  $T_C = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$V_{CE0}$	Collector-Emitter Sustaining Voltage	$I_C = 1\text{ mA}$	30			V
$V_{CB0}$	Collector-Base Breakdown Voltage	$I_C = 100\mu\text{A}$	35			V
$V_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\mu\text{A}$	3	5.5		V
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 30\text{V}$			0.1	$\mu\text{A}$
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 10\text{ mA}$ , $I_B = 0.5\text{ mA}$		830	950	mV
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 10\text{ mA}$ , $I_B = 0.5\text{ mA}$		150	300	mV
$C_{cb}$	Common Emitter Collector Feedback Capacitance	$V_{CB} = 10\text{V}$ , $f = 1\text{ MHz}$		0.65	0.9	pF
$C_{ob}$	Collector Output Capacitance	$V_{CB} = 10\text{V}$ , $f = 1\text{ MHz}$		0.9	1.3	pF
$r_b'c_c$	Collector Base Time Constant	$I_C = 2\text{ mA}$ , $V_{CE} = 5\text{V}$		8	20	pS
$R_{oep}$	Common Emitter Output Resistance	$I_C = 2\text{ mA}$ , $V_{CE} = 5\text{V}$ $f = 200\text{ MHz}$	5			KOhm
$f_t$	Current Gain Bandwidth Product	$I_C = 2\text{ mA}$ , $V_{CE} = 5\text{V}$	450	700		MHz

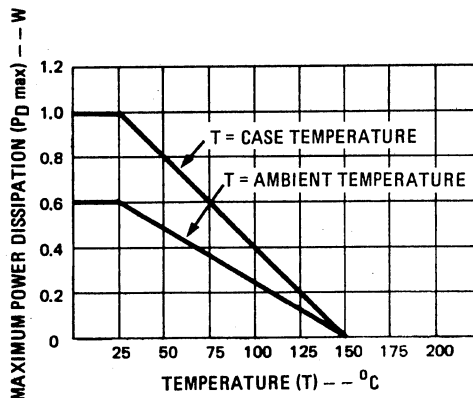
**5 HFE groupings**

GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
E	DC Current Gain	$I_C = 2\text{ mA}$ , $V_{CE} = 5\text{V}$	30	38	50	1:1.6
F	DC Current Gain	$I_C = 2\text{ mA}$ , $V_{CE} = 5\text{V}$	45	58	75	1:1.6
G	DC Current Gain	$I_C = 2\text{ mA}$ , $V_{CE} = 5\text{V}$	68	85	110	1:1.6
H	DC Current Gain	$I_C = 2\text{ mA}$ , $V_{CE} = 5\text{V}$	100	127	160	1:1.6
R	DC Current Gain	$I_C = 2\text{ mA}$ , $V_{CE} = 5\text{V}$	20	32	50	1:2.4
S	DC Current Gain	$I_C = 2\text{ mA}$ , $V_{CE} = 5\text{V}$	45	70	110	1:2.4
T	DC Current Gain	$I_C = 2\text{ mA}$ , $V_{CE} = 5\text{V}$	100	150	240	1:2.4

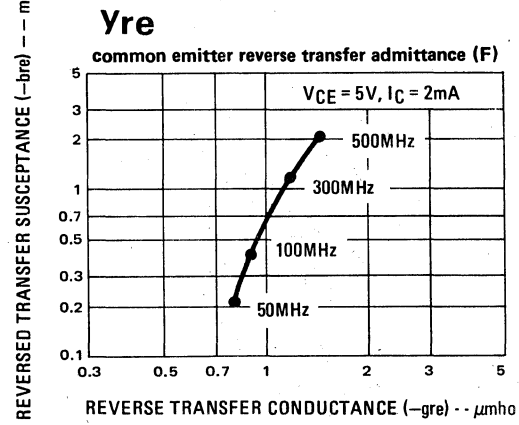
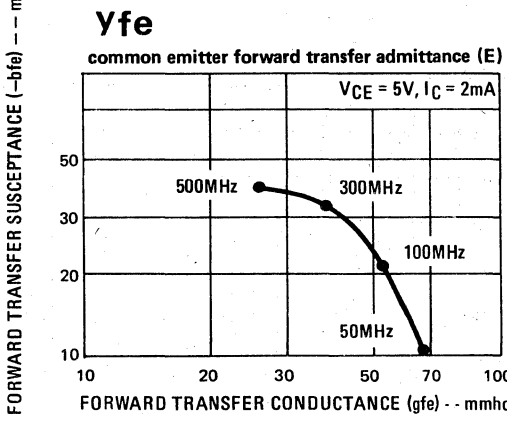
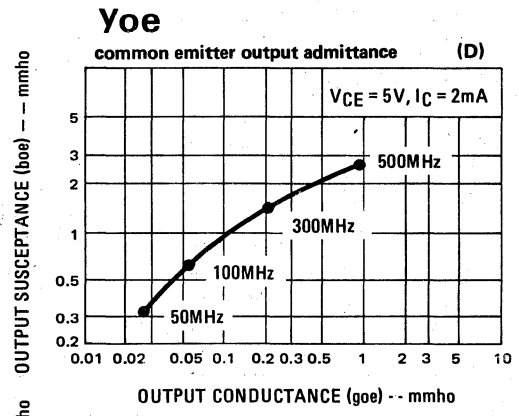
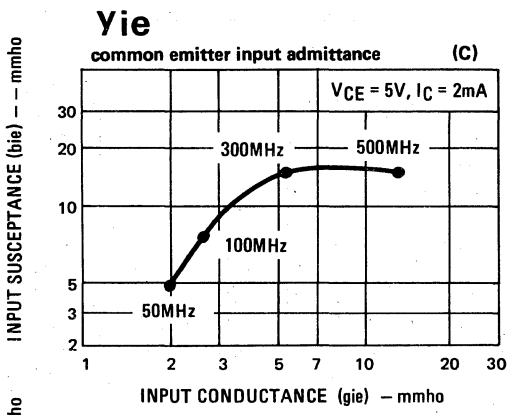
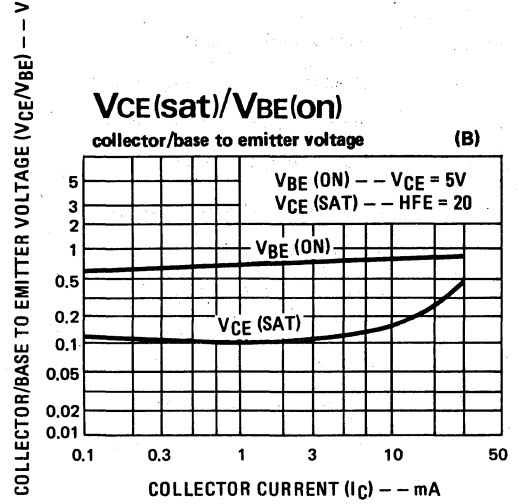
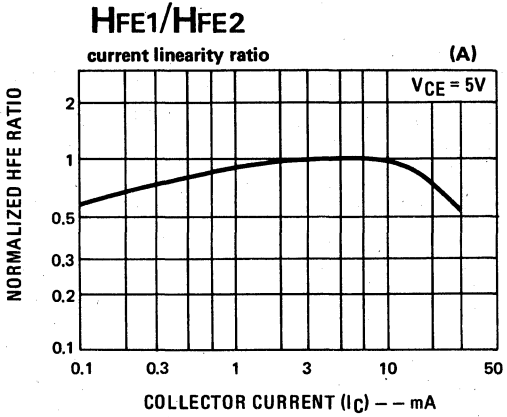
**6 physical dimensions**

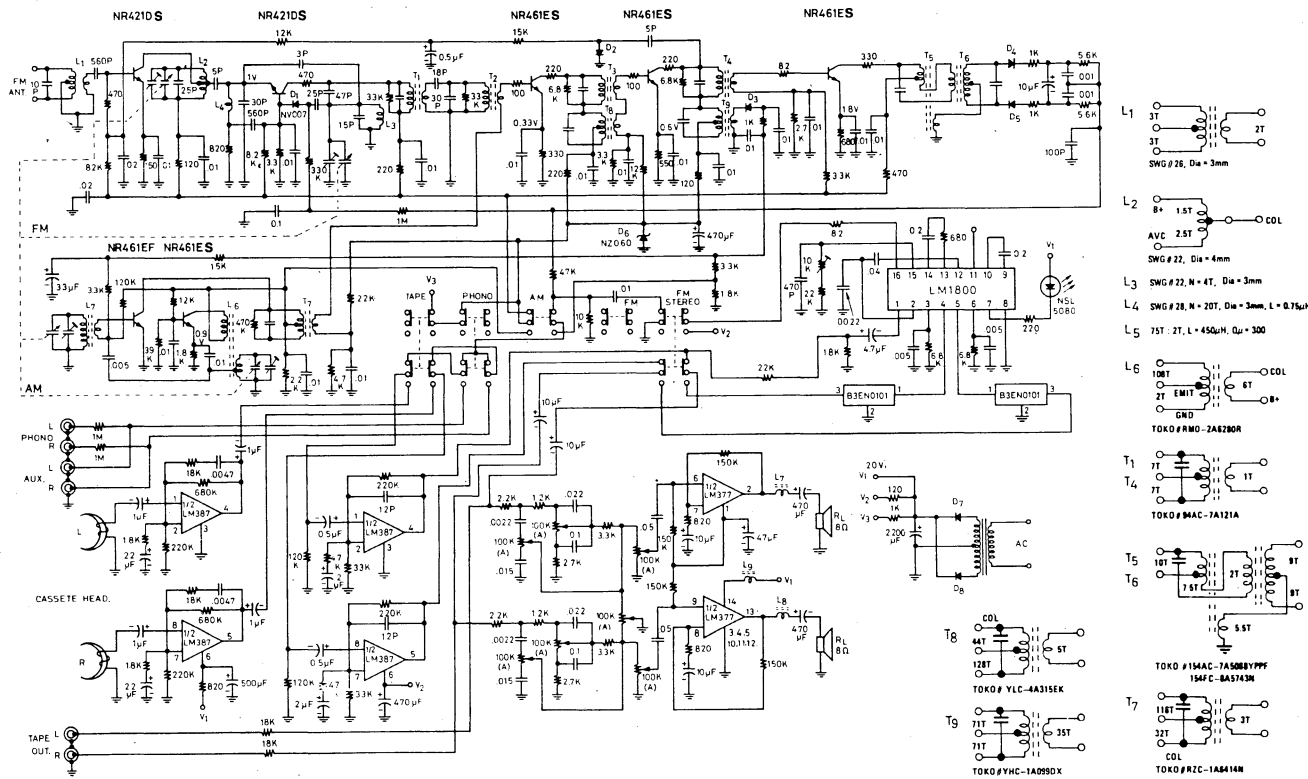


**7 max power dissipation**



8 typical performance characteristics





**FM performance (88–108 MHz)**

- 30dB quieting sensitivity: 2 $\mu$ V
- limiting sensitivity: 7 $\mu$ V
- AM rejection: 40dB
- AFC holding range: 800KHz
- stereo separation: 40dB

**AM performance (525–1650 KHz)**

- maximum sensitivity: 100 $\mu$ V/M
- 20dB quieting sensitivity: 280 $\mu$ V/M
- selectivity  $\pm$ 10KHz: -28dB
- AGC figure of merit: 52dB
- overload distortion: 3%

**AUDIO performance**

- 10% THD output power: 3W + 3W
- frequency response: 50Hz – 15KHz
- channel separation: 45dB
- tone control range:  $\pm$ 10dB
- typical system dist: 0.5%

Figure A. AM/FM/Cassette Home Stereo Circuit





## NR431(NPN) HF amplifier/FM converter transistor

### features

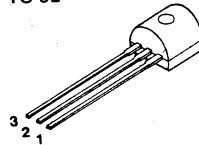
- 1.1pF typical collector feedback capacitance
- 5K Ohm minimum RF output resistance at 100 MHz
- 150mV typical  $V_{CE}$  (sat) characteristics at  $I_C = 10$  mA, and  $I_B = 0.5$  mA
- "Epoxy B" packaging concept for excellent reliability

### applications

- High frequency amplifiers/converters
- CB radios
- Low power RF oscillators

### 1 package and lead coding

TO-92

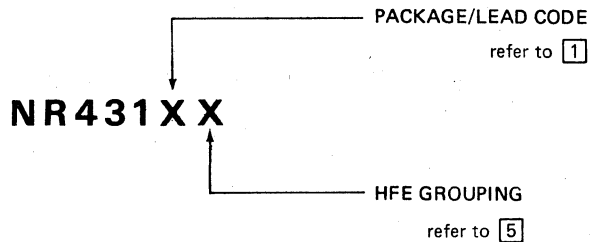


PACKAGE CODE TO-92	LEAD		
	1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

### 2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	$V_{CEO}$	15	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	18	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	3	$V_{DC}$
Collector Current (continuous)	$I_C$ (max)	30	$mA_{DC}$
Power Dissipation ( $T_A = 25^\circ C$ )	$P_D$	0.6	W
Power Dissipation ( $T_C = 25^\circ C$ )	$P_D$	1.0	W
Thermal Resistance	$\theta_{JA}$	208	$^\circ C/W$
	$\theta_{JC}$	125	$^\circ C/W$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to +150	$^\circ C$

### 3 ordering information



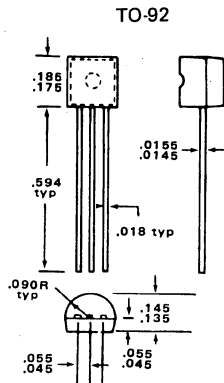
**4** electrical characteristics  $T_C = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$BV_{CEO}$	Collector-Emitter Sustaining Voltage	$I_C = 1\text{ mA}$	15			V
$BV_{CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\mu\text{A}$	18			V
$BV_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\mu\text{A}$	3	5.6		V
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 15\text{V}$			0.1	$\mu\text{A}$
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 10\text{ mA}, I_B = 0.5\text{ mA}$		830	950	mV
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 10\text{ mA}, I_B = 0.5\text{ mA}$		150	300	mV
$C_{cb}$	Common Emitter Collector Feedback Capacitance	$V_{CB} = 10\text{V}, f = 1\text{ MHz}$		1.1	1.4	pF
$C_{ob}$	Collector Output Capacitance	$V_{CB} = 10\text{V}, f = 1\text{ MHz}$		1.4	1.7	pF
$R_{oep}$	Common Emitter Output Resistance	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$ $f = 100\text{ MHz}$	5			KOhm
$f_t$	Current Gain Bandwidth Product	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$	350	600		MHz

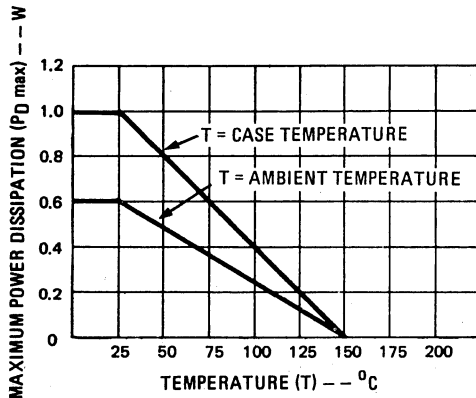
**5** HFE groupings

GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
E	DC Current Gain	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$	30	38	50	1:1.6
F	DC Current Gain	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$	45	58	75	1:1.6
G	DC Current Gain	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$	68	85	110	1:1.6
R	DC Current Gain	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$	20	32	50	1:2.4
S	DC Current Gain	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$	45	70	110	1:2.4

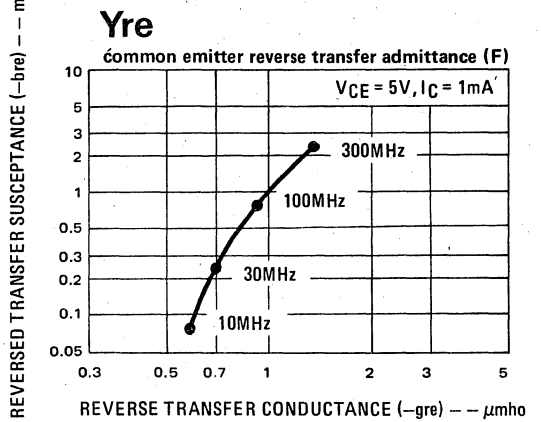
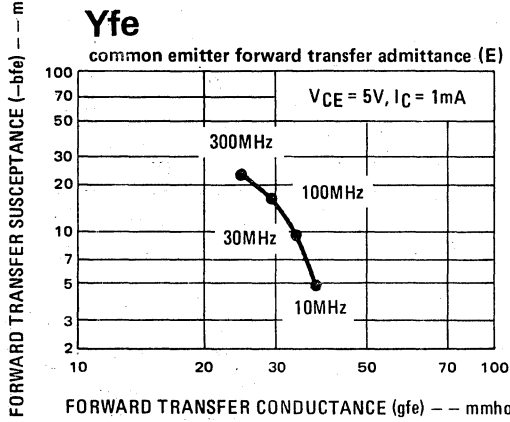
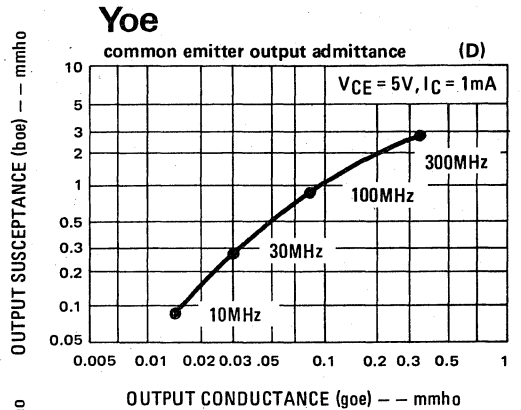
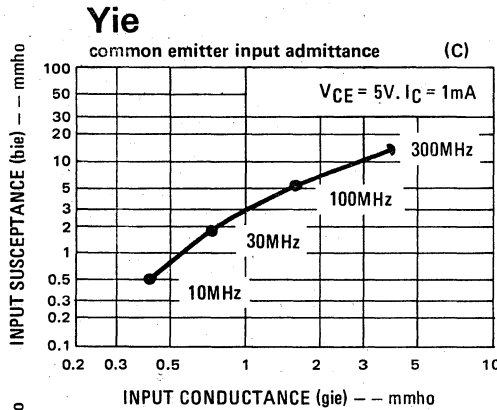
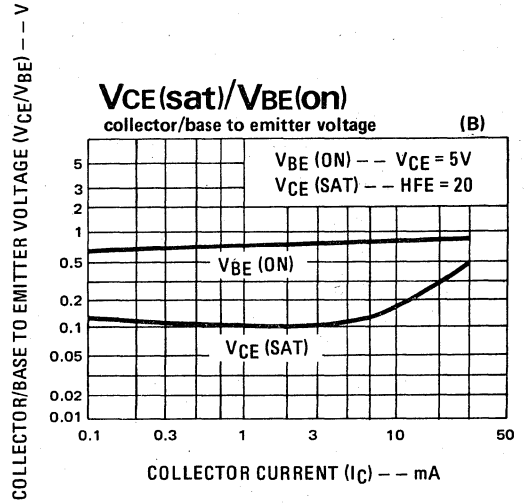
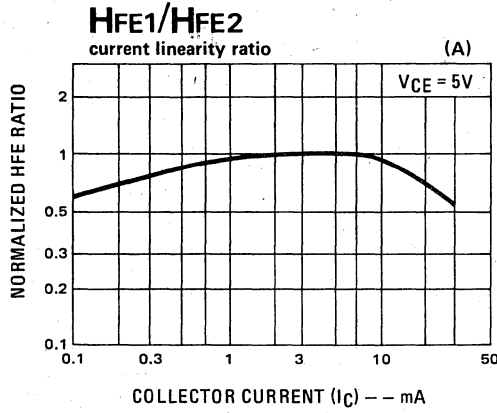
**6** physical dimensions

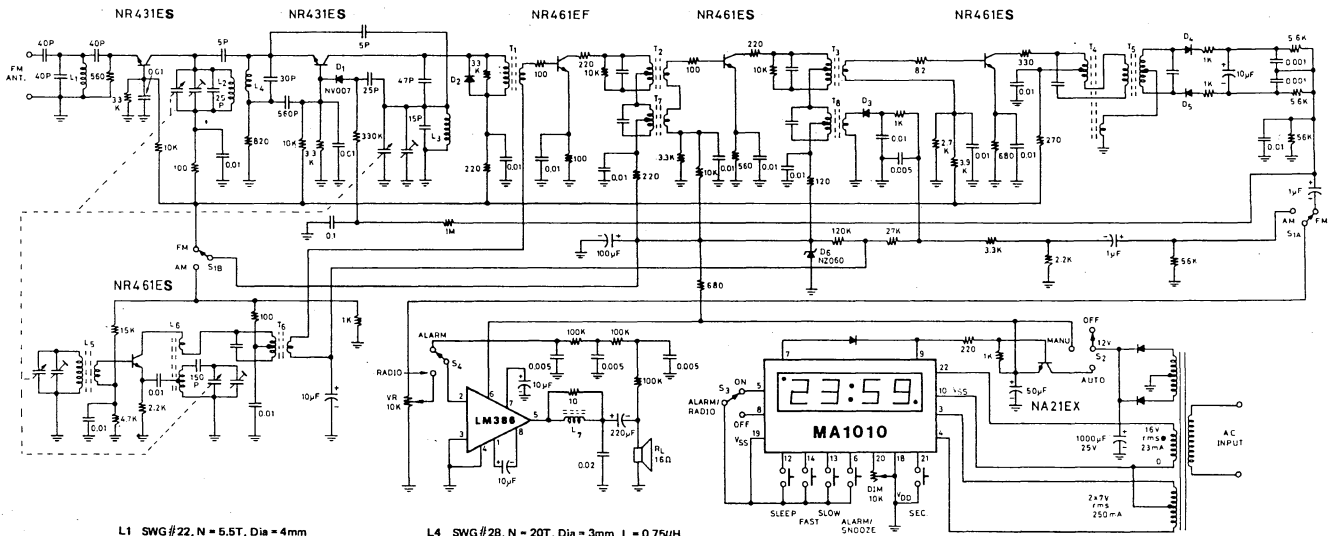


**7** max power dissipation



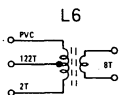
8 typical performance characteristics



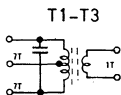


L1 SWG #22, N = 5.5T, Dia = 4mm  
 L2 SWG #22, N = 4T, Dia = 4mm  
 L3 SWG #22, N = 4T, Dia = 3mm

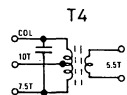
L4 SWG #28, N = 20T, Dia = 3mm L = 0.75μH  
 L5 95T - 8T, L = 600μH, Qμ = 300  
 L7 N = 1.5T, PHILIPS #4312-020-34401



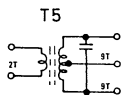
TOKO # YMO - 2A188R



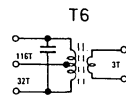
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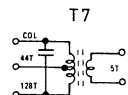
TOKO # 7A5068YFF



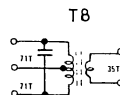
TOKO # 154FC - 8A5743N



TOKO # RZC - 1A6414N



TOKO # YCC - 4A315EK



TOKO # YHC - 1A099DX

**FM performance (88-108 MHz)**

- 30dB quieting sensitivity: 5μV
- limiting sensitivity: 20μV
- AM rejection: 40dB
- AFC holding range: 800KHz
- Bandwidth: 180KHz

**AM performance (525-1650 KHz)**

- maximum sensitivity: 100μV/M
- 20dB quieting sensitivity: 280μV/M
- selectivity ± 10KHz: -28dB
- AGC figure of merit: 40dB
- overload distortion: 6%

**AUDIO performance**

- gain at 1 KHz: 200
- 10% THD output power: 900mW
- frequency response: 70Hz - 12KHz
- typical system dist: 0.8%
- alarm tone frequency: 600Hz

Figure A. AM/FM clock radio

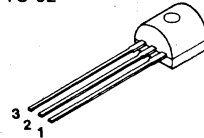
## NR461(NPN) low-noise RF/IF transistor

### features

- Low  $C_{cb}$  for excellent RF stability
- High  $R_{oep}$  for simplified RF coupling designs
- 70mV typical  $V_{CE}$  (sat) characteristics at  $I_C = 10$  mA, and  $I_B = 0.5$  mA
- 1.1 dB typical noise figure at 1 MHz
- "Epoxy B" packaging concept for excellent reliability

### 1 package and lead coding

TO-92



### applications

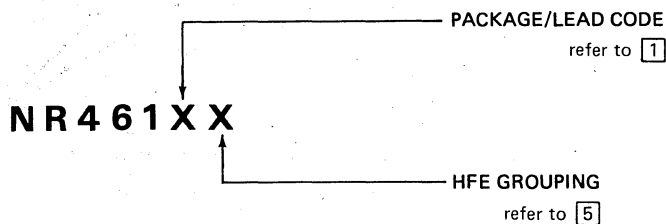
- MW/SW/CB radios
- 0.1 to 50 MHz frequency converters
- 455KHz to 10.7 MHz IF stages
- Low-power RF oscillators

PACKAGE CODE TO-92	LEAD		
	1	2	3
E	E	B	C
F	E	C	B
H	C	B	E

### 2 maximum ratings

PARAMETER	SYMBOL	RATING	UNIT
Collector-Emitter Voltage	$V_{CEO}$	30	$V_{DC}$
Collector-Base Voltage	$V_{CB}$	35	$V_{DC}$
Emitter-Base Voltage	$V_{EB}$	4	$V_{DC}$
Collector Current (continuous)	$I_C$ (max)	30	$mA_{DC}$
Power Dissipation ( $T_A = 25^\circ C$ )	$P_D$	0.6	W
Power Dissipation ( $T_C = 25^\circ C$ )	$P_D$	1.0	W
Thermal Resistance	$\theta_{JA}$	208	$^\circ C/W$
	$\theta_{JC}$	125	$^\circ C/W$
Temperature, Junction and Storage	$T_j, T_{stg}$	-55 to +150	$^\circ C$

### 3 ordering information



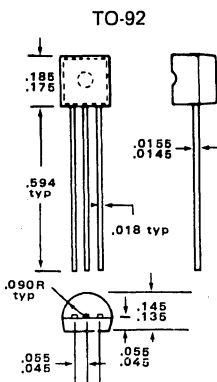
**4 electrical characteristics**  $T_C = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$BV_{CEO}$	Collector-Emitter Sustaining Voltage	$I_C = 1\text{ mA}$	30			V
$BV_{CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\mu\text{A}$	35			V
$BV_{EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\mu\text{A}$	4	5.5		V
$I_{CBO}$	Collector-Base Leakage Current	$V_{CB} = 30\text{V}$			0.1	$\mu\text{A}$
$V_{BE}(\text{sat})$	Base-Emitter Saturation Voltage	$I_C = 10\text{ mA}, I_B = 0.5\text{ mA}$		760	950	mV
$V_{CE}(\text{sat})$	Collector-Emitter Saturation Voltage	$I_C = 10\text{ mA}, I_B = 0.5\text{ mA}$		70	300	mV
$C_{cb}$	Common Emitter Collector Feedback Capacitance	$V_{CB} = 10\text{V}, f = 1\text{ MHz}$		0.9	1.1	pF
$R_{oep}$	Common Emitter Output Resistance	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$ $f = 455\text{ KHz}$ $f = 10.7\text{ MHz}$	100 20			KOhm KOhm
$f_t$	Current Gain Bandwidth Product	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$	180	300		MHz

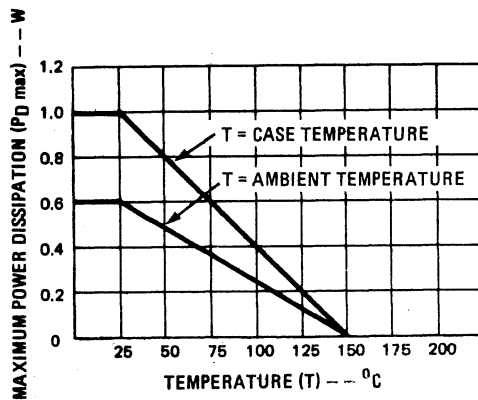
**5 HFE groupings**

GROUPING	PARAMETER	CONDITIONS	MIN	TYP	MAX	RATIO
E	DC Current Gain	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$	30	38	50	1:1.6
F	DC Current Gain	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$	45	58	75	1:1.6
G	DC Current Gain	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$	68	85	110	1:1.6
H	DC Current Gain	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$	100	127	160	1:1.6
R	DC Current Gain	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$	20	32	50	1:2.4
S	DC Current Gain	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$	45	70	110	1:2.4
T	DC Current Gain	$I_C = 1\text{ mA}, V_{CE} = 5\text{V}$	100	150	240	1:2.4

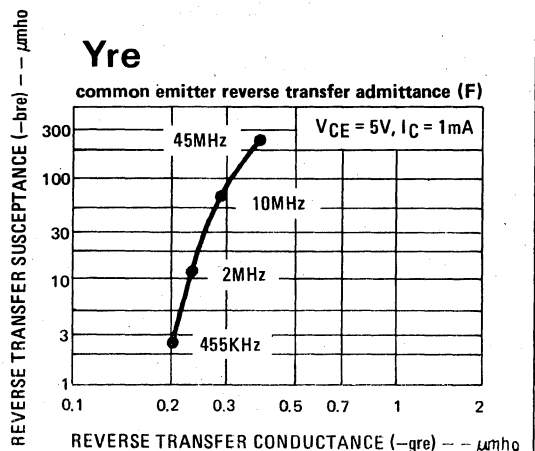
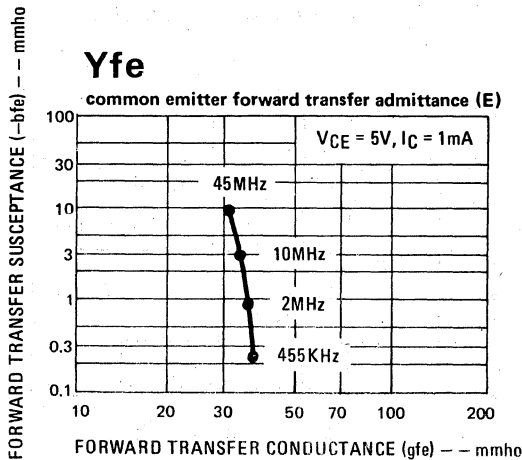
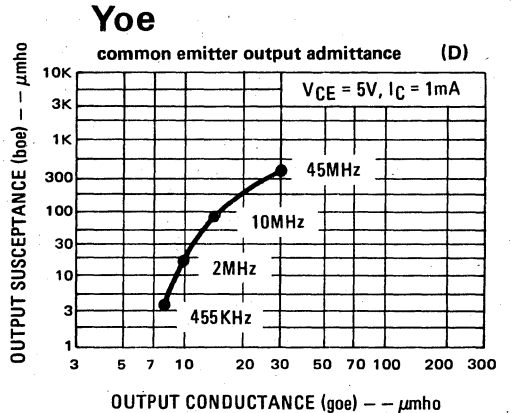
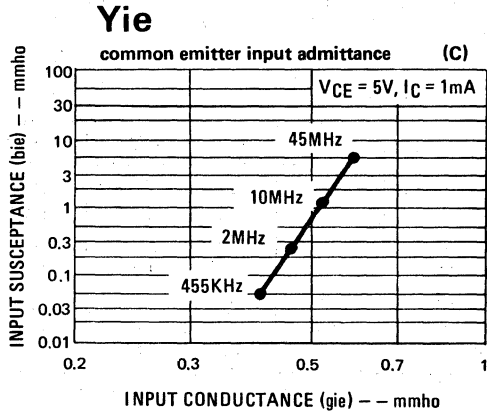
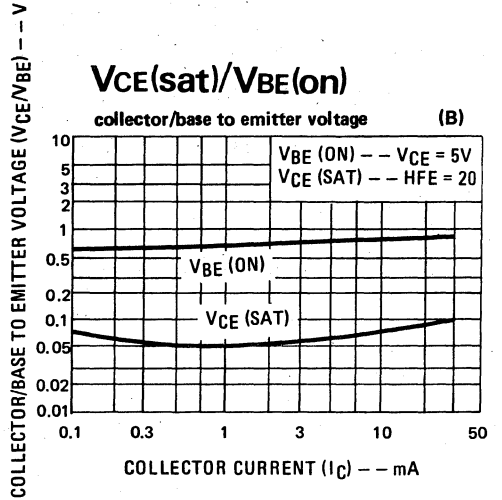
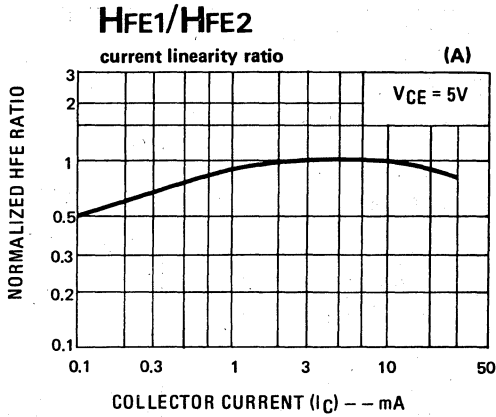
**6 physical dimensions**

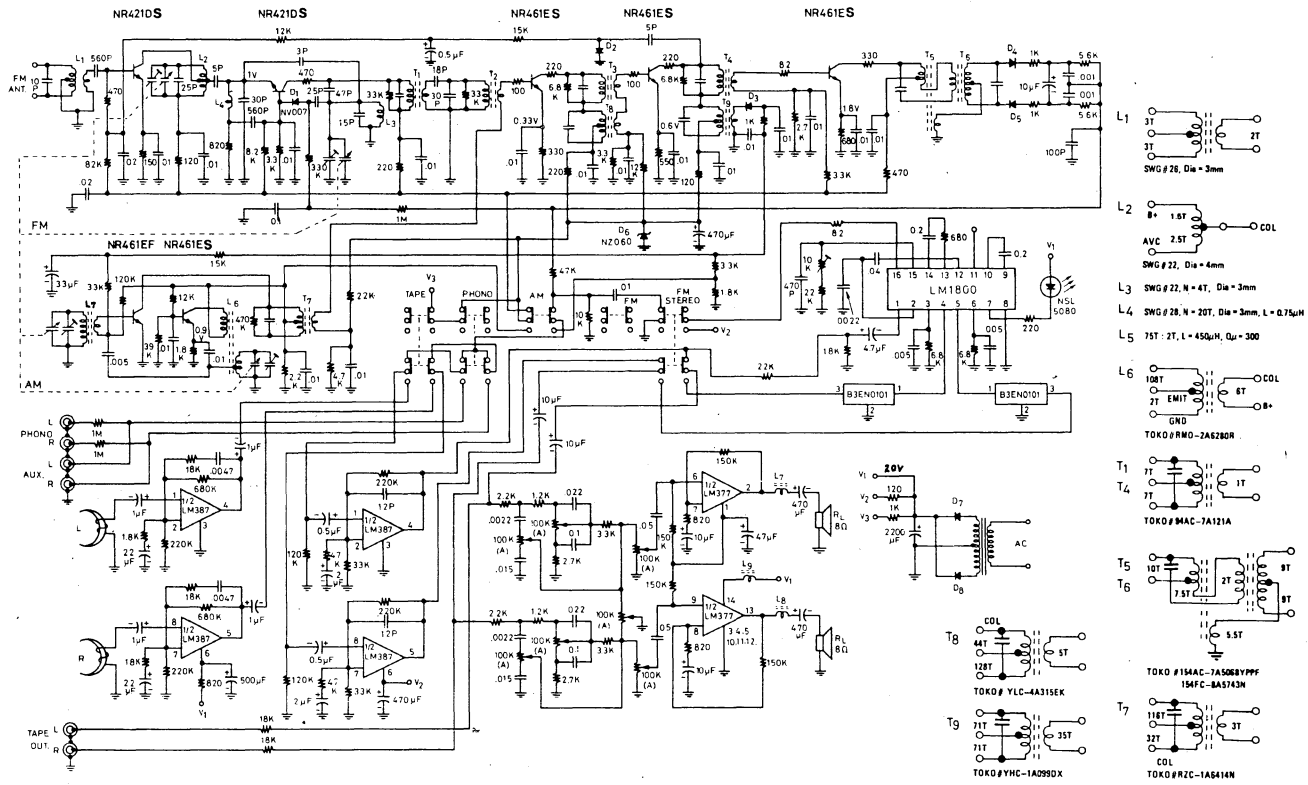


**7 max power dissipation**



8 typical performance characteristics





**FM performance (88–108 MHz)**

- 30dB quieting sensitivity: 2 $\mu$ V
- limiting sensitivity: 7 $\mu$ V
- AM rejection: 40dB
- AFC holding range: 800KHz
- stereo separation: 40dB

**AM performance (525–1650 KHz)**

- maximum sensitivity: 100 $\mu$ V/M
- 20dB quieting sensitivity: 280 $\mu$ V/M
- selectivity  $\pm$ 10KHz: -28dB
- AGC figure of merit: 52dB
- overload distortion: 3%

**AUDIO performance**

- 10% THD output power: 3W + 3W
- frequency response: 50Hz – 15KHz
- channel separation: 45dB
- tone control range:  $\pm$ 10dB
- typical system dist: 0.5%

**Figure A. AM/FM/Cassette Home Stereo Circuit**

7-71

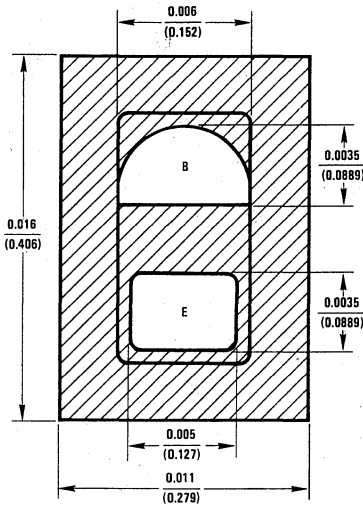






Section 8  
**Process  
Characteristics  
Double-Diffused  
Epitaxial Transistors**





**DESCRIPTION**

Process 02 is a non-overlay, double-diffused, silicon epitaxial device.

**APPLICATION**

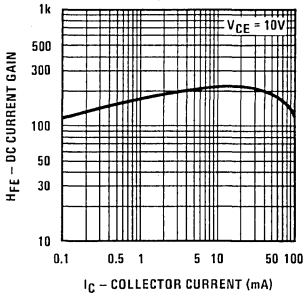
An economical device, good for all-around applications from DC to low radio frequencies. Ideal for use in general amplifier and control functions in consumer, industrial and automotive environments up to 100 mA.

**PRINCIPAL DEVICE TYPE**

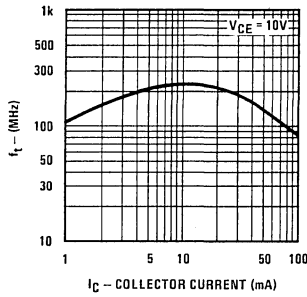
TO-92, EBC: MPS-A20

Parameter	Conditions	Min	Typ	Max	Units	Notes
$BV_{CEO}$	$I_C = 10 \text{ mA}$	40			V	
$BV_{CBO}$	$I_C = 10 \mu\text{A}$	45			V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	6.0			V	
$I_{CBO}$	$V_{CB} = 40\text{V}$			100	nA	
$I_{EBO}$	$V_{EB} = 5\text{V}$			100	nA	
$h_{FE}$	$I_C = 100 \mu\text{A}, V_{CE} = 10\text{V}$	35				
$h_{FE}$	$I_C = 5 \text{ mA}, V_{CE} = 10\text{V}$	60	180	480		
$h_{FE}$	$I_C = 100 \text{ mA}, V_{CE} = 10\text{V}$	25				
$V_{BE(ON)}$	$I_C = 5 \text{ mA}, V_{CE} = 10\text{V}$			0.85	V	
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.25	V	
$f_T$	$I_C = 5 \text{ mA}, V_{CE} = 10\text{V}, f = 100 \text{ MHz}$	125	225		MHz	
$C_{ib}$	$V_{EB} = 0.5\text{V}, f = 1 \text{ MHz}$			10	pF	
$C_{ob}$	$V_{CB} = 10\text{V}, I_E = 0, f = 1 \text{ MHz}$		2.0	4.0	pF	

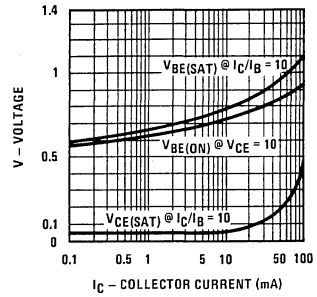
DC Current Gain vs Collector Current



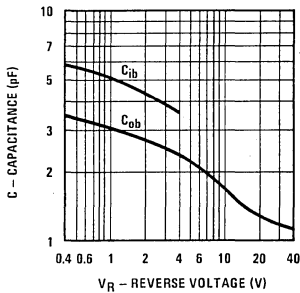
Bandwidth Product vs Collector Current



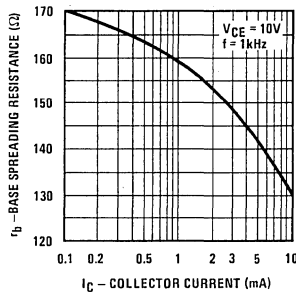
Saturation and ON Voltages vs Collector Current



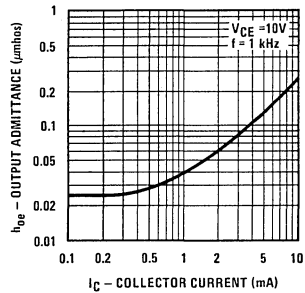
Capacitance vs Reverse Voltage



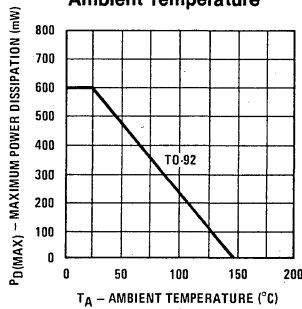
Output Admittance vs Collector Current



Base Spreading Resistance vs Collector Current

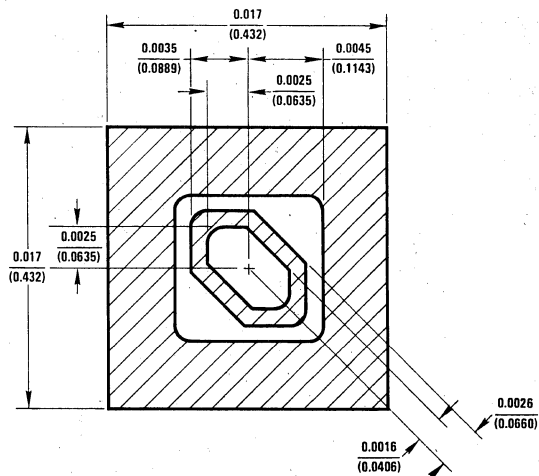


Maximum Power Dissipation vs Ambient Temperature





# Process 04 NPN Small Signal



## DESCRIPTION

Process 04 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 71.

## APPLICATION

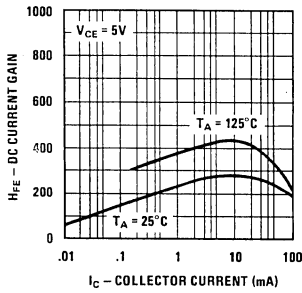
This device was designed for low noise, high gain, general purpose amplifier applications from 10  $\mu$ A to 100 mA collector current.

## PRINCIPAL DEVICE TYPES

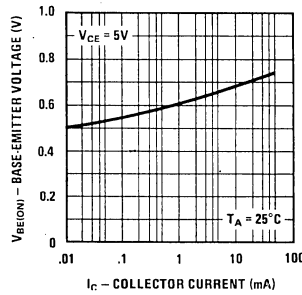
- TO-18: BC107 Series
- TO-92, ECB: 2N2923 Series  
2N5172
- TO-92, EBC: MPS2923 Series

Parameter	Conditions	Min	Typ	Max	Units	Notes
NF (spot)	$I_C = 200 \mu A, V_{CE} = 5V, f = 1 \text{ kHz}, R_S = 2k$		2.0	4.0	dB	TO-18
$C_{ob}$	$V_{CB} = 10V, f = 1 \text{ MHz}$		2.5	3.5	pF	
$C_{ib}$	$V_{EB} = 0.5V, f = 1 \text{ MHz}$			10	pF	
$f_T$	$V_{CE} = 5V, I_C = 10 \text{ mA}$	125	250		MHz	
$h_{FE}$	$V_{CE} = 5V, I_C = 100 \mu A$	50				
$h_{FE}$	$V_{CE} = 5V, I_C = 2 \text{ mA}$	75	250	600		
$h_{FE}$	$V_{CE} = 5V, I_C = 100 \text{ mA}$	40				
$h_{FE}$	$V_{CE} = 1V, I_C = 100 \text{ mA}$	25				
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.2	V	
$V_{CE(SAT)}$	$I_C = 100 \text{ mA}, I_B = 10 \text{ mA}$			0.5	V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.85	V	
$V_{BE(SAT)}$	$I_C = 100 \text{ mA}, I_B = 10 \text{ mA}$			0.95	V	
$BV_{CBO}$	$I_C = 10 \mu A$	45			V	
$BV_{CEO}$	$I_C = 10 \text{ mA}$	35			V	
$BV_{EBO}$	$I_E = 10 \mu A$	7.0			V	
$I_{CBO}$	$V_{CB} = 40V$			100	nA	
$I_{EBO}$	$V_{EB} = 6V$			100	nA	

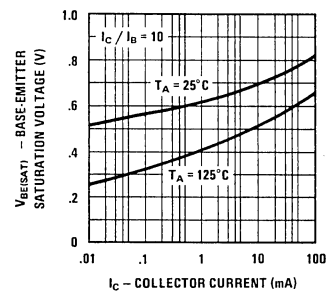
### DC Current Gain vs Collector Current



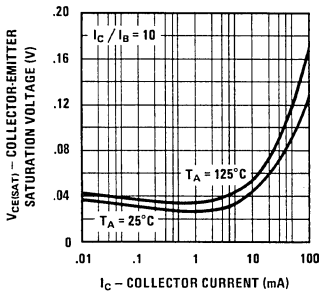
### Base-Emitter ON Voltage vs Collector Current



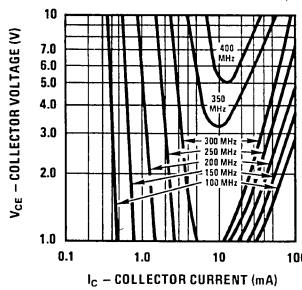
### Base-Emitter Saturation Voltage vs Collector Current



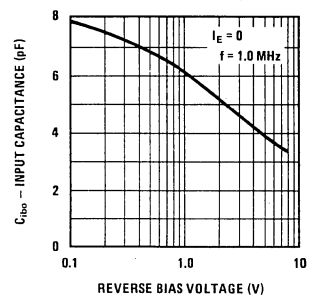
### Collector-Emitter Saturation Voltage vs Collector Current



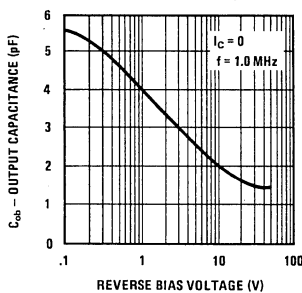
### Contours of Constant Gain Bandwidth Product (fT)



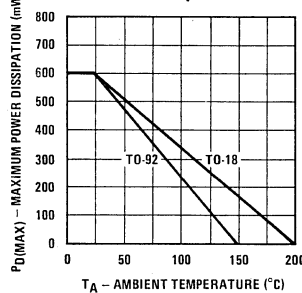
### Input Capacitance vs Reverse Bias Voltage



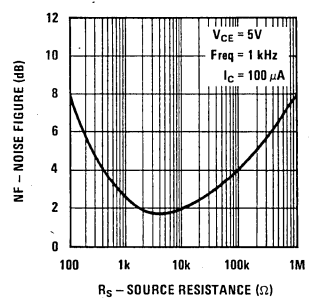
### Output Capacitance vs Reverse Bias Voltage



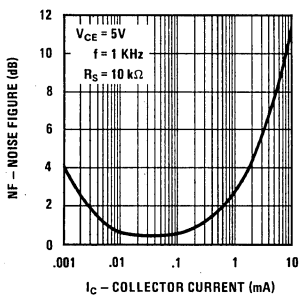
### Maximum Power Dissipation vs Ambient Temperature



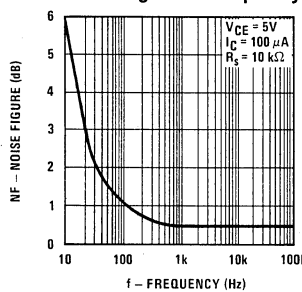
### Noise Figure vs Source Resistance



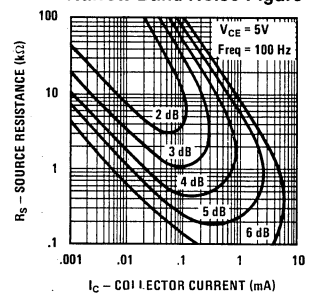
### Noise Figure vs Collector Current



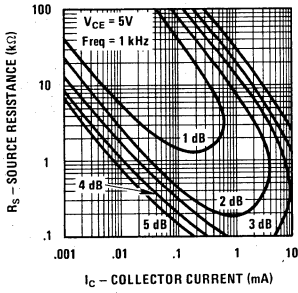
### Noise Figure vs Frequency



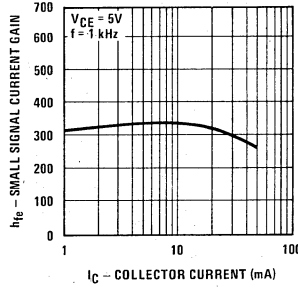
### Contours of Constant Narrow Band Noise Figure



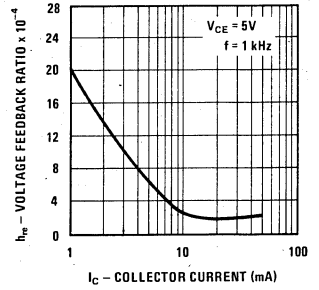
Contours of Constant Narrow Band Noise Figure



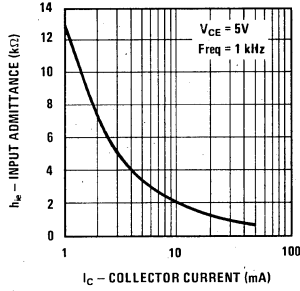
Small Signal Current Gain



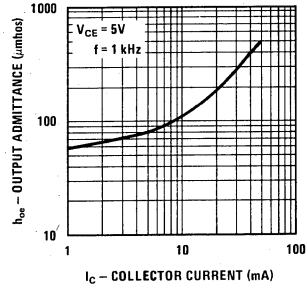
Voltage Feedback Ratio

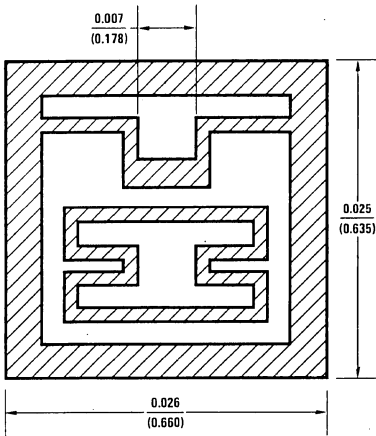


Input Admittance



Output Admittance




**DESCRIPTION**

Process 05 is a monolithic, double-diffused, silicon epitaxial Darlington. Complement to Process 61.

**APPLICATION**

This device is designed for applications requiring extremely high current gain at collector currents to 1.5A.

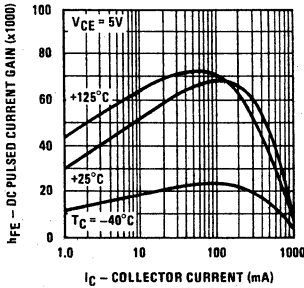
**PRINCIPAL DEVICE TYPES**

- TO-202, EBC:** D40C1-8  
D40K1-4  
NSD151-4  
NSDU45, 45A
- TO-237, EBC:** 2N6724, 5  
(92PU45, 45A)
- TO-92, EBC:** MPSA12-14
- TO-92, ECB:** 2N5305-08

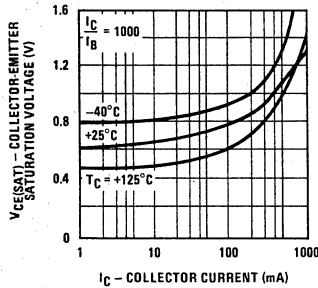
Parameter	Conditions	Min	Typ	Max	Units	Notes
NF	$I_C = 1 \text{ mA}$ , $V_{CE} = 5\text{V}$ , $R_S = 100\text{k}$ , $f = 1 \text{ kHz}$		2		dB	
$C_{CB}$	$V_{CB} = 10\text{V}$ , $I_E = 0$ , $f = 1 \text{ MHz}$		4	6	pF	
$h_{FE}$	$I_C = 10 \text{ mA}$ , $V_{CE} = 5\text{V}$	4,000				
$h_{FE}$	$I_C = 100 \text{ mA}$ , $V_{CE} = 5\text{V}$	8,000	40,000	200,000		
$h_{FE}$	$I_C = 1\text{A}$ , $V_{CE} = 5\text{V}$	3,000				
$V_{CE(SAT)}$	10 mA, 0.01 mA			1.0	V	
$V_{CE(SAT)}$	100 mA, 0.1 mA			1.5	V	
$V_{BE(ON)}$	10 mA, 5V		1.2	1.4	V	
$V_{BE(ON)}$	100 mA, 5V		1.25	1.8	V	
$h_{fe}$	$I_C = 10 \text{ mA}$ , $V_{CE} = 5.0\text{V}$ , $f = 1 \text{ kHz}$		60,000			
$BV_{CES}$	$I_C = 100 \mu\text{A}$	40			V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	12			V	
$I_{CES}$	$V_{CE} = 15\text{V}$ , $V_{BE} = 0$			100	nA	
$I_{CBO}$	$V_{CB} = 30\text{V}$ , $I_E = 0$			100	nA	
$I_{EBO}$	$V_{EB} = 10\text{V}$ , $I_C = 0$			100	nA	
$P_{D(max)}$						
TO-202	$T_C = 25^\circ\text{C}$	10			W	
	$T_A = 25^\circ\text{C}$	2				
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$	2			W	
	$T_A = 25^\circ\text{C}$	850			mW	
TO-92	$T_A = 25^\circ\text{C}$	600			mW	
$\theta_{JC}$						
TO-202	$T_C = 25^\circ\text{C}$			12.5	$^\circ\text{C/W}$	
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$	
$\theta_{JA}$						
TO-202	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$	
TO-237	$T_A = 25^\circ\text{C}$			147	$^\circ\text{C/W}$	
TO-92	$T_A = 25^\circ\text{C}$			208	$^\circ\text{C/W}$	
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$	



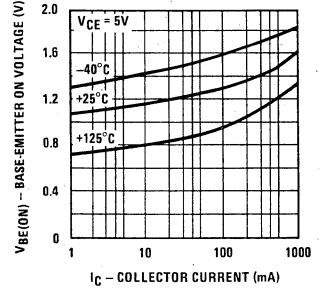
**DC Pulsed Current Gain vs Collector Current**



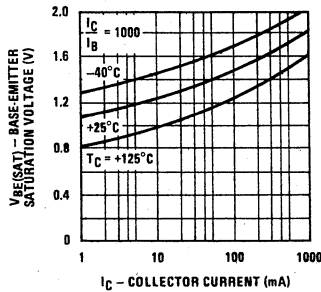
**Collector-Emitter Saturation Voltage vs Collector Current**



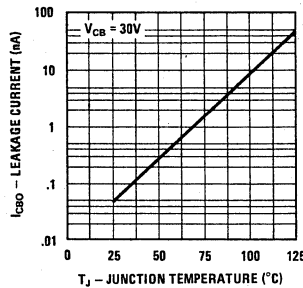
**Base-Emitter ON Voltage vs Collector Current**



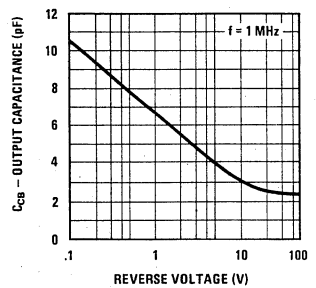
**Base-Emitter Saturation Voltage vs Collector Current**



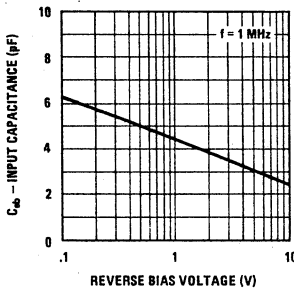
**Collector-Base Diode Reverse Current vs Temperature**



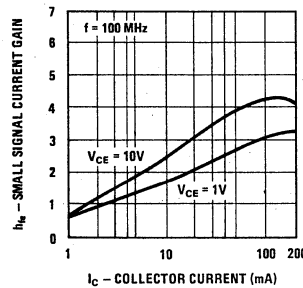
**Output Capacitance vs Reverse Bias Voltage**



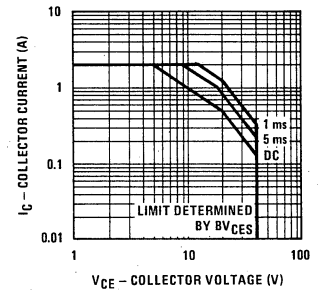
**Input Capacitance vs Reverse Bias Voltage**



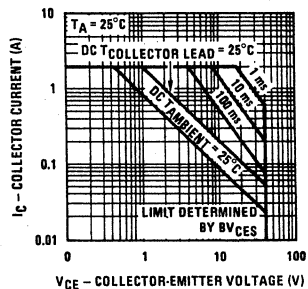
**Small Signal Current Gain vs Collector Current**



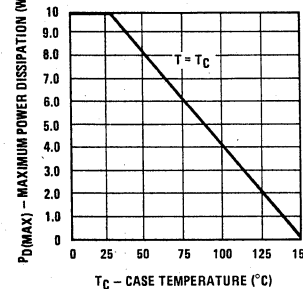
**Safe Operating Area TO-202**



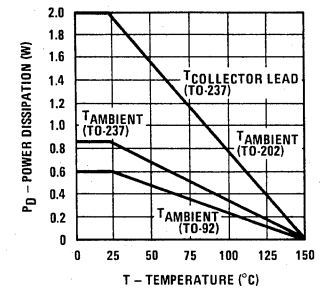
**Safe Operating Area TO-237**

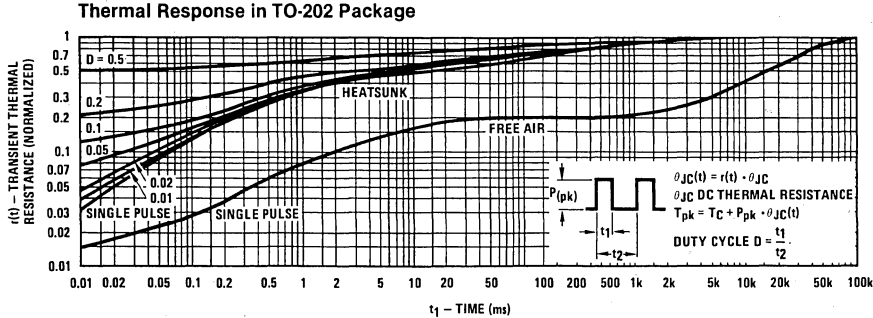


**Maximum Power Dissipation TO-202 vs Case Temperature**



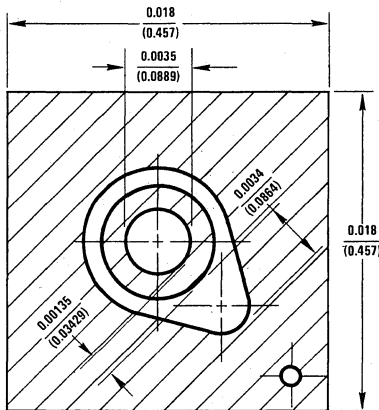
**Thermal Derating Curve**







## Process 07 NPN Small Signal



### DESCRIPTION

Process 07 a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 62.

### APPLICATION

This device was designed for low noise, high gain, general purpose amplifier applications from 1  $\mu$ A to 25 mA collector current.

### PRINCIPAL DEVICE TYPES

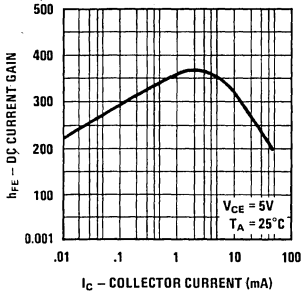
TO-18: 2N930

TO-92, EBC: 2N5088

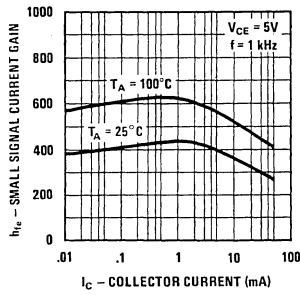
TO-92, ECB: 2N3392

Parameter	Conditions	Min	Typ	Max	Units	Notes
NF (spot)	$I_C = 10 \mu A, V_{CE} = 5V, R_S = 10k, f = 100 \text{ kHz}$		3	10	dB	TO-18
NF (spot)	$I_C = 10 \mu A, V_{CE} = 5V, R_S = 10k, f = 1 \text{ kHz}$		1	3	dB	TO-18
NF (spot)	$I_C = 10 \mu A, V_{CE} = 5V, R_S = 10k, f = 10 \text{ kHz}$		1	3	dB	TO-18
NF (wideband)	$I_C = 10 \mu A, V_{CE} = 5V, R_S = 10k, P_{BW} = 15.7 \text{ kHz}$		1	3	dB	TO-18
$h_{fe}$	$I_C = 500 \mu A, V_{CE} = 5V, f = 20 \text{ MHz}$	3	6			
$C_{ob}$	$V_{CB} = 5V, f = 1 \text{ MHz}$		1.7	3.0	pF	
$C_{eb}$	$V_{EB} = 0.50V, f = 1 \text{ MHz}$			8.0	pF	
$h_{FE}$	$I_C = 1 \mu A, V_{CE} = 5V$	35				
$h_{FE}$	$I_C = 10 \mu A, V_{CE} = 5V$	50				
$h_{FE}$	$I_C = 100 \mu A, V_{CE} = 5V$	70				
$h_{FE}$	$I_C = 500 \mu A, V_{CE} = 5V$	80				
$h_{FE}$	$I_C = 1 \text{ mA}, V_{CE} = 5V$	90	360	1,000		
$h_{FE}$	$I_C = 20 \text{ mA}, V_{CE} = 5V$	50				
$V_{CE(SAT)}$	$I_C = 1 \text{ mA}, I_B = 0.10 \text{ mA}$			0.10	V	
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.15	V	
$V_{BE(SAT)}$	$I_C = 1 \text{ mA}, I_B = 0.1 \text{ mA}$			0.75	V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.85	V	
$BV_{CEO}$	$I_C = 1 \text{ mA}$	60			V	
$BV_{CBO}$	$I_C = 10 \mu A$	60			V	
$BV_{EBO}$	$I_E = 10 \mu A$	8			V	
$I_{CBO}$	$V_{CB} = 45V$			100	nA	
$I_{EBO}$	$V_{EB} = 6V$			100	nA	

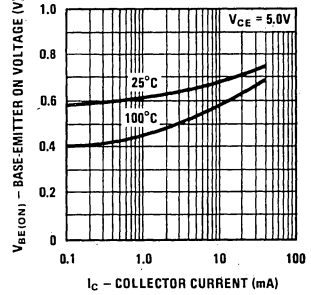
**DC Current Gain vs Collector Current**



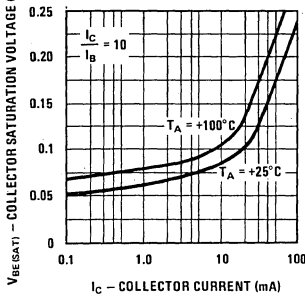
**Small Signal Current Gain vs Collector Current**



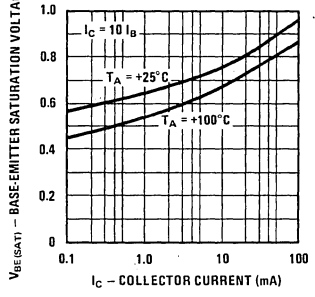
**Base-Emitter ON Voltage vs Collector Current**



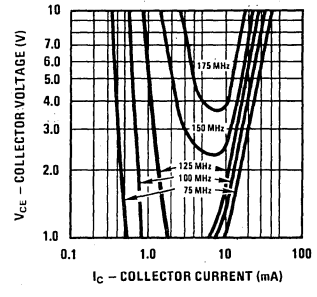
**Collector Saturation Voltage vs Collector Current**



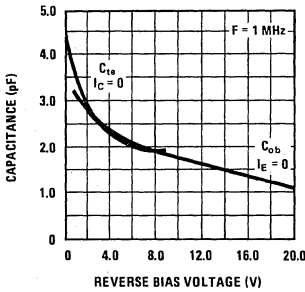
**Base-Emitter Saturation Voltage vs Collector Current**



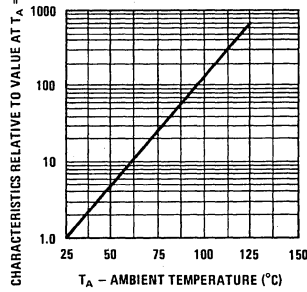
**Contours of Constant Gain Bandwidth Product (f<sub>T</sub>)**



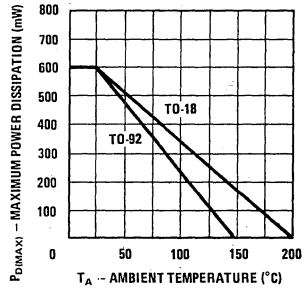
**Input and Output Capacitance vs Reverse Bias Voltage**



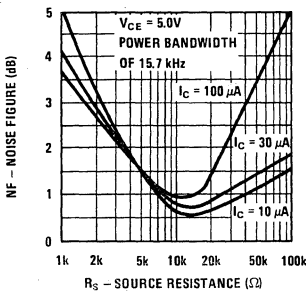
**Normalized Collector Cutoff Current vs Ambient Temperature**



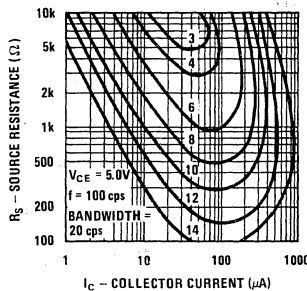
**Maximum Power Dissipation vs Ambient Temperature**



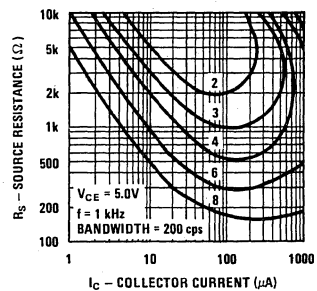
**Wideband Noise Figure vs Source Resistance**



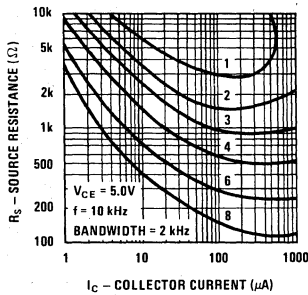
**Contours of Constant Narrow Band Noise Figure**



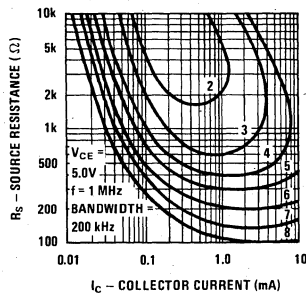
**Contours of Constant Narrow Band Noise Figure**



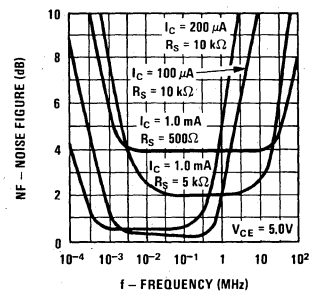
Contours of Constant Narrow Band Noise Figure



Contours of Constant Narrow Band Noise Figure



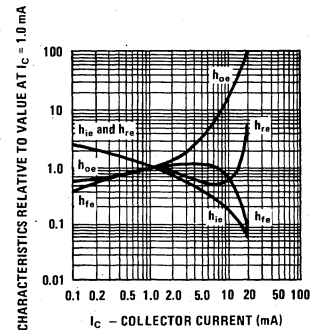
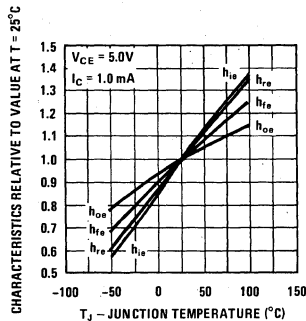
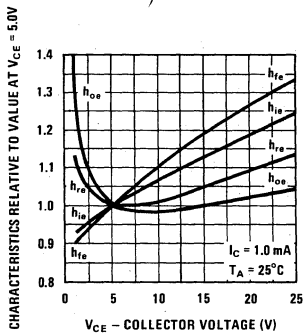
Noise Figure vs Frequency

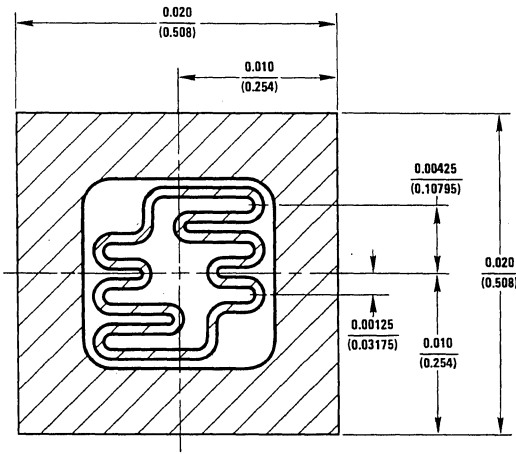


SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

Symbol	Characteristic	Typ	Units	Conditions
$h_{ie}$	Input Resistance	15	$k\Omega$	$I_C = 1.0 \text{ mA}$ , $V_{CE} = 5.0V$
$h_{oe}$	Output Conductance	15	$\mu\text{mho}$	$I_C = 1.0 \text{ mA}$ , $V_{CE} = 5.0V$
$h_{re}$	Voltage Feedback Ratio	425	$\times 10^{-6}$	$I_C = 1.0 \text{ mA}$ , $V_{CE} = 5.0V$
$h_{fe}$	Small Signal Current Gain	400		$I_C = 1.0 \text{ mA}$ , $V_{CE} = 5.0V$
$h_{ib}$	Input Resistance	27	$\Omega$	$I_C = 1.0 \text{ mA}$ , $V_{CE} = 5.0V$

TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)




**DESCRIPTION**

Process 09 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 68.

**APPLICATION**

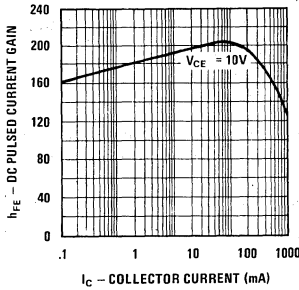
This device was designed for general purpose audio amplifier applications at collector currents to 1A.

**PRINCIPAL DEVICE TYPES**

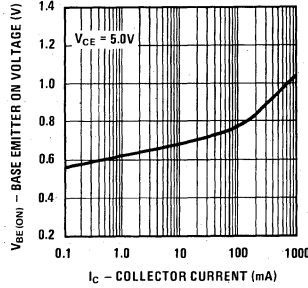
TO-92, EBC: CS9013

Parameter	Conditions	Min	Typ	Max	Units	Notes
$C_{ob}$	$V_{CB} = 10V, f = 1 \text{ MHz}$		6	8	pF	
$C_{ib}$	$V_{EB} = 0.5V, f = 1 \text{ MHz}$			35	pF	
NF	$V_{CE} = 10V, I_C = 1 \text{ mA}, R_S = 100\Omega, f = 1 \text{ kHz}$		2.0		dB	
$f_T$	$V_{CE} = 10V, I_C = 50 \text{ mA}$	200			MHz	
$h_{FE}$	$V_{CE} = 1.0V, I_C = 1 \text{ mA}$	40				
$h_{FE}$	$V_{CE} = 1.0V, I_C = 100 \text{ mA}$	60	180	360		
$h_{FE}$	$V_{CE} = 1.0V, I_C = 500 \text{ mA}$	35				
$V_{CE(SAT)}$	$I_C = 150 \text{ mA}, I_B = 15 \text{ mA}$			0.2	V	
$V_{CE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$		0.25	0.4	V	
$V_{BE(SAT)}$	$I_C = 150 \text{ mA}, I_B = 15 \text{ mA}$			1.0	V	
$V_{BE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			1.2	V	
$BV_{CBO}$	$I_C = 100 \mu A$	45				
$BV_{CEO}$	$I_C = 10 \text{ mA}$	25				
$BV_{EBO}$	$I_E = 10 \mu A$	6.0				
$I_{CBO}$	$V_{CB} = 40V$			100	nA	
$I_{EBO}$	$V_{EB} = 4.0V$			100	nA	

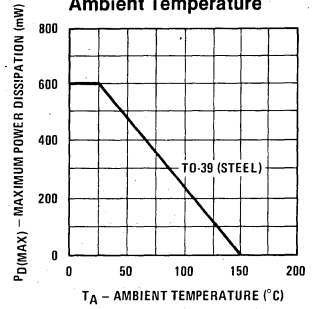
DC Pulsed Current Gain vs Collector Current



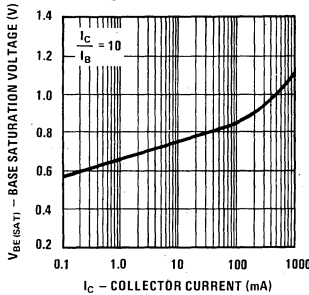
Base-Emitter ON Voltage vs Collector Current



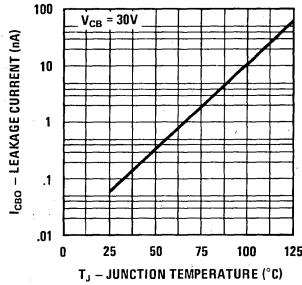
Maximum Power Dissipation vs Ambient Temperature



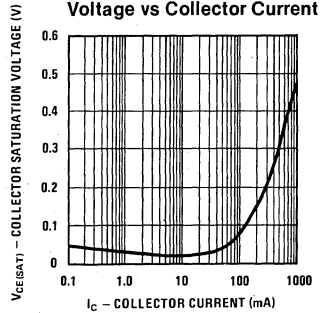
Base-Emitter Saturation Voltage vs Collector Current



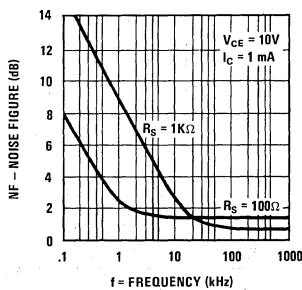
Collector-Base Diode Reverse Current vs Temperature



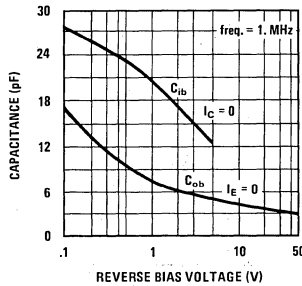
Collector-Emitter Saturation Voltage vs Collector Current



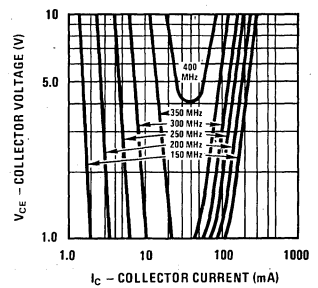
Noise Figure vs Frequency

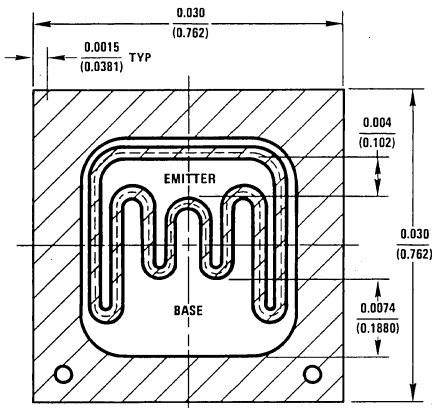


Capacitance vs Reverse Bias Voltage



Contours of Constant Gain Bandwidth Product (fT)




**DESCRIPTION**

Process 12 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 67.

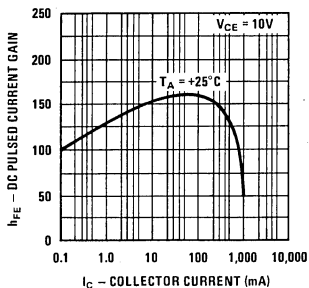
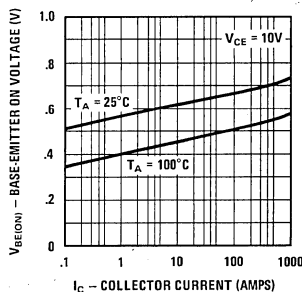
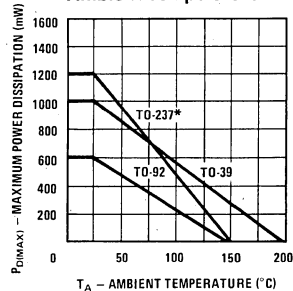
**APPLICATION**

This device was designed for general purpose medium power amplifiers and switches requiring collector currents up to 1A and collector voltages up to 80V.

**PRINCIPAL DEVICE TYPES**

TO-92, EBC: MP5A05  
 TO-39: 2N3019  
 TO-202: NSD106  
 TO-237: TN3019  
 TN3020

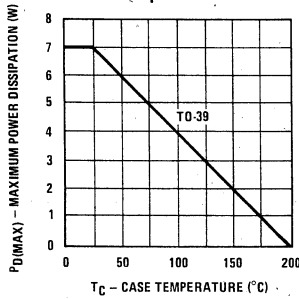
Parameter	Conditions	Min	Typ	Max	Units	Notes
$t_{ON}$	$I_C = 150 \text{ mA}$ , $I_{B1} = 15 \text{ mA}$		50		ns	Figure 1
$t_{OFF}$	$I_C = 150 \text{ mA}$ , $I_{B2} = 15 \text{ mA}$		400		ns	Figure 1
$h_{fe}$	$I_C = 50 \text{ mA}$ , $V_{CE} = 10\text{V}$ , $f = 20 \text{ MHz}$	4.0	6.5			
$C_{ob}$	$V_{CB} = 10\text{V}$ , $f = 1 \text{ MHz}$		6.5	10	pF	
$C_{eb}$	$V_{EB} = 0.5\text{V}$ , $f = 1 \text{ MHz}$			60	pF	
$h_{FE}$	$I_C = 1 \text{ mA}$ , $V_{CE} = 10\text{V}$	30				
$h_{FE}$	$I_C = 10 \text{ mA}$ , $V_{CE} = 10\text{V}$	35				
$h_{FE}$	$I_C = 150 \text{ mA}$ , $V_{CE} = 10\text{V}$	40	160	320		
$h_{FE}$	$I_C = 500 \text{ mA}$ , $V_{CE} = 10\text{V}$	30				
$V_{CE(SAT)}$	$I_C = 100 \text{ mA}$ , $I_B = 10 \text{ mA}$			0.2	V	
$V_{CE(SAT)}$	$I_C = 500 \text{ mA}$ , $I_B = 50 \text{ mA}$			0.5	V	
$V_{BE(SAT)}$	$I_C = 100 \text{ mA}$ , $I_B = 10 \text{ mA}$			0.90	V	
$V_{BE(SAT)}$	$I_C = 500 \text{ mA}$ , $I_B = 50 \text{ mA}$			1.20	V	
$BV_{CEO}$	$I_C = 10 \text{ mA}$	65			V	
$BV_{CBO}$	$I_C = 100 \mu\text{A}$	100			V	
$BV_{EBO}$	$I_C = 10 \mu\text{A}$	7			V	
$I_{CBO}$	$V_{CB} = 80\text{V}$			100	nA	
$I_{EBO}$	$V_{EB} = 6\text{V}$			100	nA	

**Pulsed DC Current Gain vs Collector Current**

**Base-Emitter ON Voltage vs Collector Current**

**Maximum Power Dissipation vs Ambient Temperature**


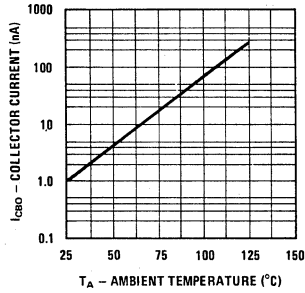
\* One square inch of copper run



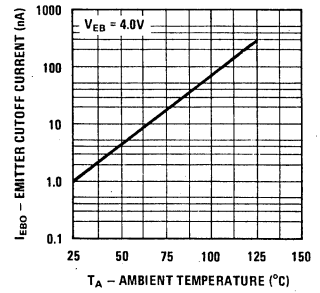
Maximum Power Dissipation vs Case Temperature



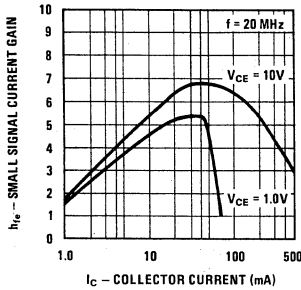
Collector Reverse Current vs Ambient Temperature



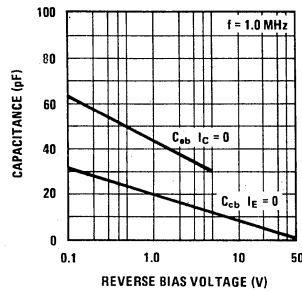
Emitter Cutoff Current vs Ambient Temperature



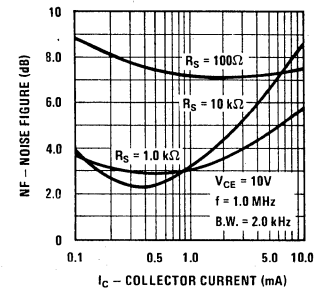
Small Signal Current Gain at 20 MHz



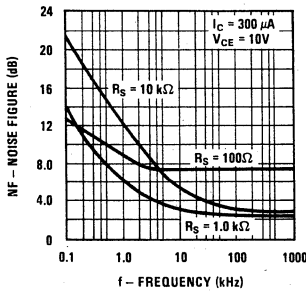
Collector-Base and Emitter-Base Capacitance vs Reverse Bias Voltage



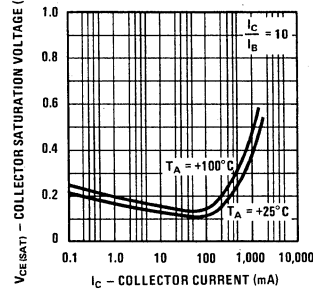
Noise Figure vs Collector Current



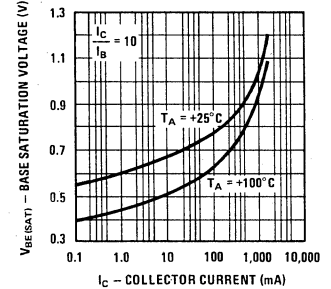
Noise Figure vs Frequency



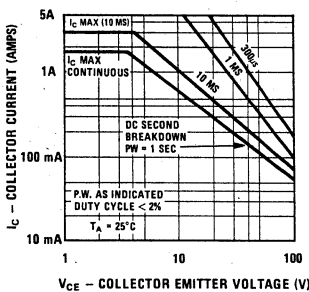
Collector Saturation Voltage vs Collector Current



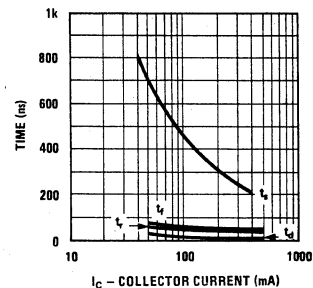
Base Saturation Voltage vs Collector Current



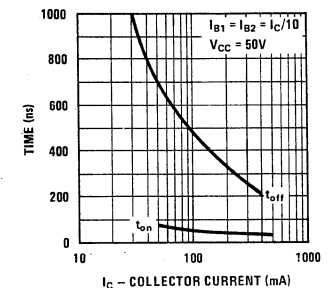
Safe Operating Area TO-39 with "Wake Field" Type 296-4 Heat Sink



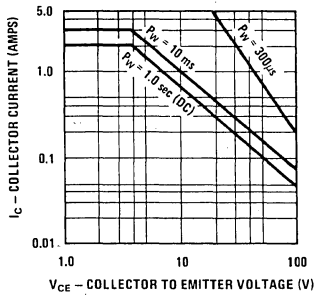
Switching Times vs Collector Current



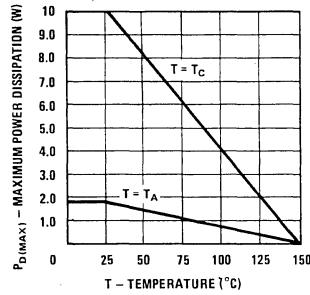
Turn On and Turn Off Times vs Collector Current



Safe Operating Area TO-202



Maximum Power Dissipation TO-202 vs Case and Ambient Temperature



$I_C$	$R_b$	$R_L$
150 mA	314Ω	330Ω
300 mA	157Ω	167Ω
500 mA	94Ω	100Ω

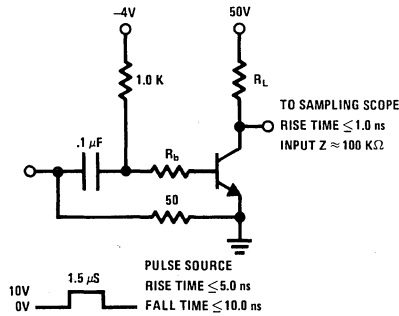
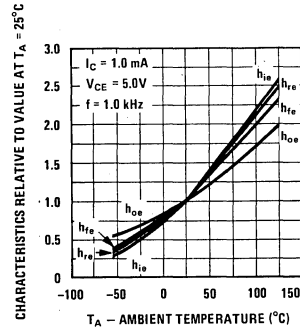
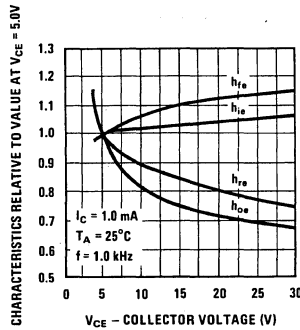
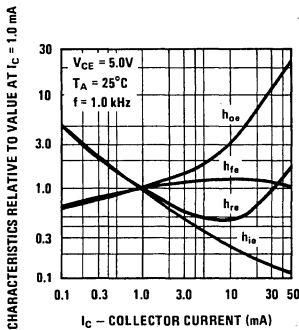


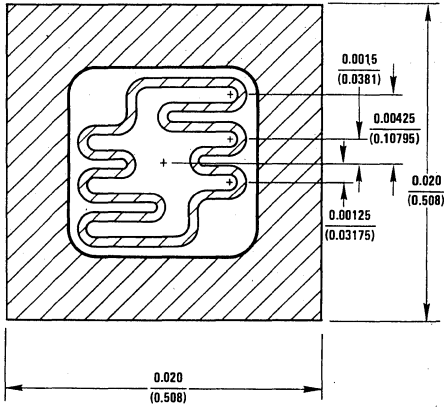
FIGURE 1.  $t_{ON}$ ,  $t_{OFF}$  Test Circuit

SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

Symbol	Characteristic	Typ	Units	Conditions
$h_{ie}$	Input Resistance	3000	Ω	$I_C = 1.0 \text{ mA}$ , $V_{CE} = 5.0 \text{ V}$
$h_{oe}$	Output Conductance	8.0	μmhos	$I_C = 1.0 \text{ mA}$ , $V_{CE} = 5.0 \text{ V}$
$h_{re}$	Voltage Feedback Ratio	2.1	$\times 10^{-4}$	$I_C = 1.0 \text{ mA}$ , $V_{CE} = 5.0 \text{ V}$
$h_{fe}$	Small Signal Current Gain	100		$I_C = 1.0 \text{ mA}$ , $V_{CE} = 5.0 \text{ V}$

TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)





### DESCRIPTION

Process 13 is a non-overlay, double-diffused, silicon epitaxial device.

### APPLICATION

This device was designed for use as medium power amplifiers and switches requiring collector currents of 100  $\mu$ A to 500 mA.

### PRINCIPAL DEVICE TYPES

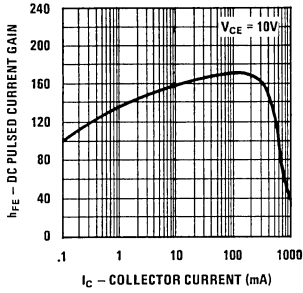
TO-92, EBC: 2N440T

TO-92, ECB: 2N3704

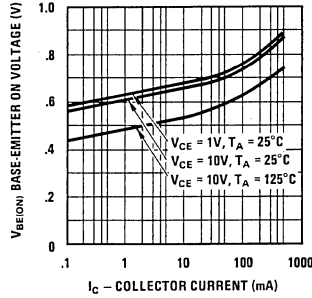
Parameter	Conditions	Min	Typ	Max	Units	Notes
$t_{ON}$	$I_C = 150 \text{ mA}$ , $I_{B1} = 15 \text{ mA}$		35		ns	
$t_{OFF}$	$I_C = 150 \text{ mA}$ , $I_{B2} = 15 \text{ mA}$		250		ns	
$h_{fe}$	$I_C = 20 \text{ mA}$ , $V_{CE} = 20\text{V}$ , $f = 100 \text{ MHz}$	2.0	3.0			
NF (spot)	$I_C = 100 \mu\text{A}$ , $V_{CE} = 10\text{V}$ , $R_S = 1 \text{ k}\Omega$ , $f = 1 \text{ kHz}$		1.2		dB	
$C_{ob}$	$V_{CB} = 10\text{V}$ , $f = 1 \text{ MHz}$		4.5	8.0	pF	
$C_{ib}$	$V_{EB} = 0.5\text{V}$ , $f = 1 \text{ MHz}$			35	pF	
$h_{FE}$	$V_{CE} = 1.0\text{V}$ , $I_C = 1.0 \text{ mA}$	30				
$h_{FE}$	$V_{CE} = 1.0\text{V}$ , $I_C = 10 \text{ mA}$	40				
$h_{FE}$	$V_{CE} = 1.0\text{V}$ , $I_C = 100 \text{ mA}$	50	150	300		
$h_{FE}$	$V_{CE} = 1.0\text{V}$ , $I_C = 500 \text{ mA}$	25				
$V_{CE(SAT)}$	$I_C = 150 \text{ mA}$ , $I_B = 15 \text{ mA}$			0.2	V	
$V_{CE(SAT)}$	$I_C = 500 \text{ mA}$ , $I_B = 50 \text{ mA}$			0.5	V	
$V_{BE(SAT)}$	$I_C = 150 \text{ mA}$ , $I_B = 15 \text{ mA}$			1.0	V	
$V_{BE(SAT)}$	$I_C = 500 \text{ mA}$ , $I_B = 50 \text{ mA}$			1.2	V	
$BV_{CBO}$	$I_C = 100 \mu\text{A}$	60			V	
$BV_{CEO}$	$I_C = 10 \text{ mA}$	35			V	
$BV_{EBO}$	$I_C = 10 \mu\text{A}$	6.0			V	
$I_{CBO}$	$V_{CB} = 40\text{V}$			100	nA	
$I_{EBO}$	$V_{EB} = 4\text{V}$			100	nA	

# Process 13

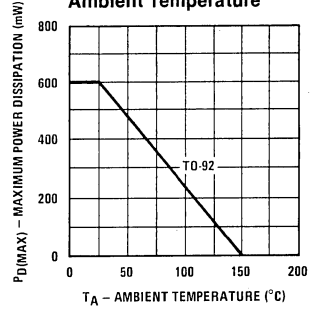
**DC Pulsed Current Gain vs Collector Current**



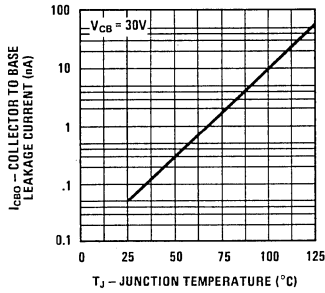
**Base-Emitter ON Voltage vs Collector Current**



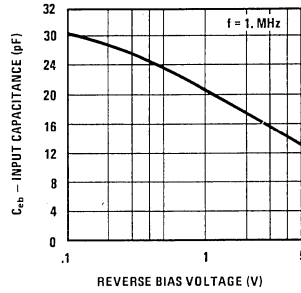
**Maximum Power Dissipation vs Ambient Temperature**



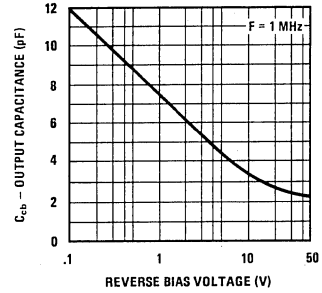
**Collector-Base Diode Reverse Current vs Temperature**



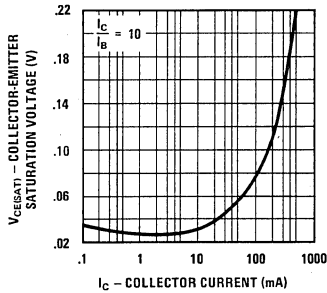
**Input Capacitance vs Reverse Bias Voltage**



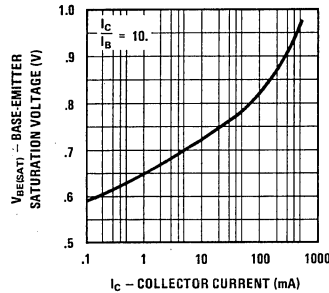
**Output Capacitance vs Reverse Bias Voltage**

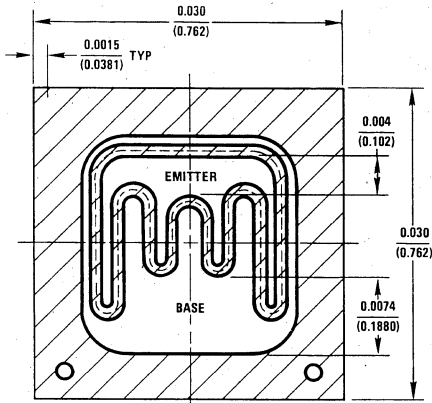


**Collector-Emitter Saturation Voltage vs Collector Current**



**Base-Emitter Saturation Voltage vs Collector Current**





**DESCRIPTION**

Process 14 is a non-overlay, double-diffused, silicon epitaxial device.

**APPLICATION**

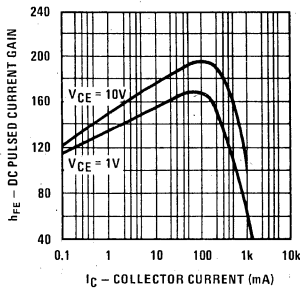
This device was designed for general purpose amplifier applications at collector currents to 1A.

**PRINCIPAL DEVICE TYPES**

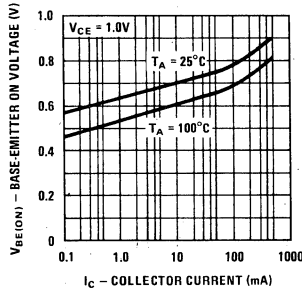
- TO-39: BFY50
- TO-92, EBC: MPS6560

Parameter	Conditions	Min	Typ	Max	Units	Notes
$C_{ob}$	$V_{CB} = 10V, f = 1 \text{ MHz}$		8	12	pF	
$C_{ib}$	$V_{EB} = 0.5V, f = 1 \text{ MHz}$			65	pF	
$h_{fe}$	$I_C = 50 \text{ mA}, V_{CE} = 10V, f = 20 \text{ MHz}$	5	10			
NF	$I_C = 100 \mu A, V_{CE} = 5V, R_S = 1 \text{ k}\Omega, f = 1 \text{ kHz}$		1.2		dB	
$h_{FE}$	$I_C = 1 \text{ mA}, V_{CE} = 1V$	40				
$h_{FE}$	$I_C = 10 \text{ mA}, V_{CE} = 1V$	50				
$h_{FE}$	$I_C = 150 \text{ mA}, V_{CE} = 1V$	60	180	360		
$h_{FE}$	$I_C = 500 \text{ mA}, V_{CE} = 1V$	30				
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.10	V	
$V_{CE(SAT)}$	$I_C = 150 \text{ mA}, I_B = 10 \text{ mA}$			0.15	V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.85	V	
$V_{BE(SAT)}$	$I_C = 150 \text{ mA}, I_B = 10 \text{ mA}$			1.0	V	
$BV_{CEO}$	$I_C = 10 \text{ mA}$	35			V	
$BV_{CBO}$	$I_C = 100 \mu A$	60			V	
$BV_{EBO}$	$I_E = 10 \mu A$	7			V	
$I_{CBO}$	$V_{CB} = 40V$			100	nA	
$I_{EBO}$	$V_{EB} = 5V$			100	nA	

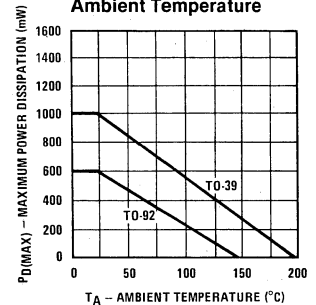
**DC Pulsed Current Gain vs Collector Current**



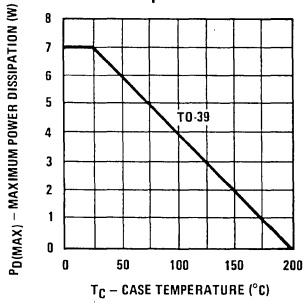
**Base-Emitter ON Voltage vs Collector Current**



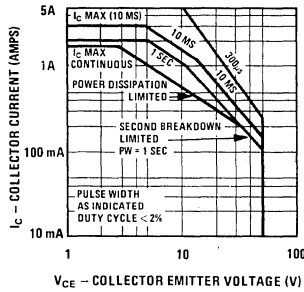
**Maximum Power Dissipation vs Ambient Temperature**



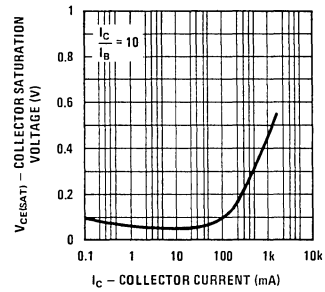
Maximum Power Dissipation vs Case Temperature



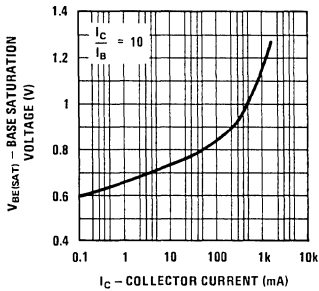
Safe Operating Area TO-39 with "Wake Field" Type 296-4 Heat Sink



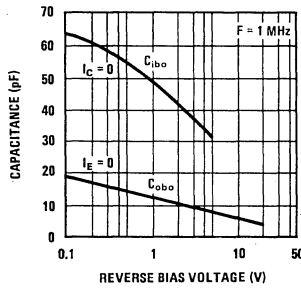
Collector-Emitter Saturation Voltage vs Collector Current



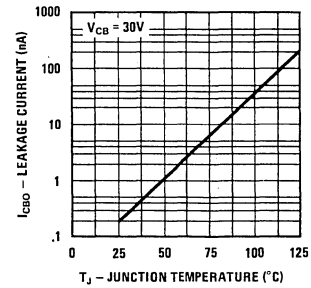
Base-Emitter Saturation Voltage vs Collector Current



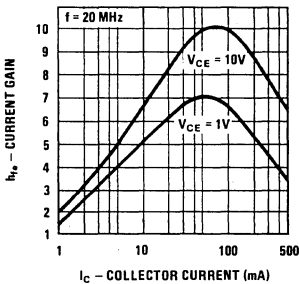
Capacitance vs Reverse Bias Voltage



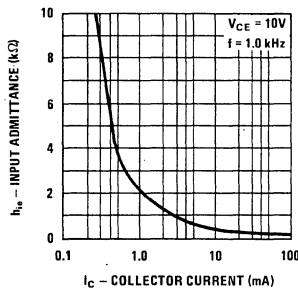
Collector-Base Diode Reverse Current vs Temperature



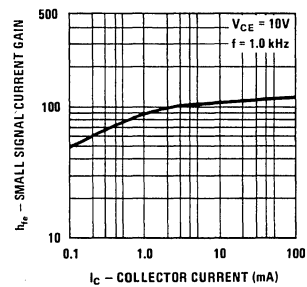
Small Signal Current Gain at 20 MHz vs Collector Current



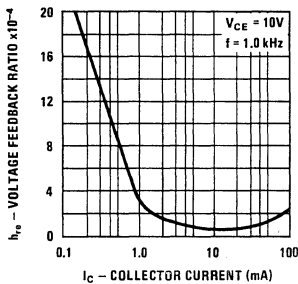
Input Admittance vs Collector Current



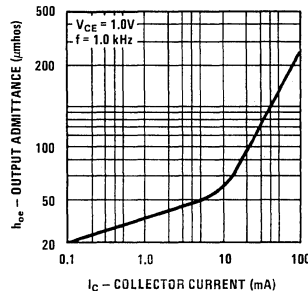
Small Signal Current Gain vs Collector Current

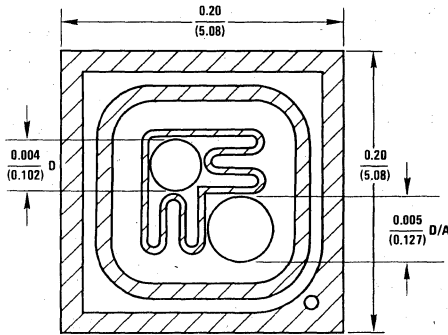


Voltage Feedback Ratio vs Collector Current



Output Admittance vs Collector Current





## DESCRIPTION

Process 16 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 74.

## APPLICATION

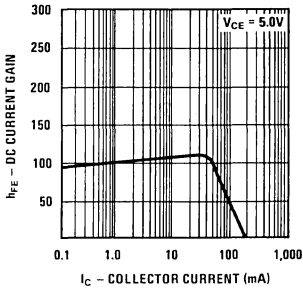
This device was designed for general purpose high voltage amplifiers and gas discharge display driving.

## PRINCIPAL DEVICE TYPES

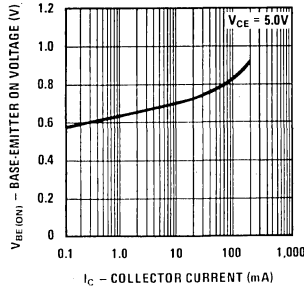
TO-92, EBC: 2N5551

Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 1.0 \text{ mA}$	120			V
$BV_{CBO}$	$I_C = 10 \mu\text{A}$	140			V
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	6			V
$I_{CBO}$	$V_{CB} = 100\text{V}$			100	nA
$I_{EBO}$	$V_{EB} = 4.0\text{V}$			100	nA
$h_{FE}$	$I_C = 1.0 \text{ mA}, V_{CE} = 5.0\text{V}$	40			
$h_{FE}$	$I_C = 10 \text{ mA}, V_{CE} = 5.0\text{V}$	50	120	300	
$h_{FE}$	$I_C = 50 \text{ mA}, V_{CE} = 5.0\text{V}$	20			
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1.0 \text{ mA}$			0.15	V
$V_{CE(SAT)}$	$I_C = 50 \text{ mA}, I_B = 5.0 \text{ mA}$			0.30	V
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1.0 \text{ mA}$			0.90	V
$V_{BE(SAT)}$	$I_C = 50 \text{ mA}, I_B = 5 \text{ mA}$			1.2	V
$f_T$	$I_C = 10 \text{ mA}, V_{CE} = 10\text{V}, f = 100 \text{ MHz}$	100	220		MHz
$C_{ob}$	$V_{CB} = 10\text{V}, f = 1 \text{ MHz}$		3.0	5.0	pF
$C_{ib}$	$V_{EB} = 0.5\text{V}, f = 1 \text{ MHz}$			30	pF

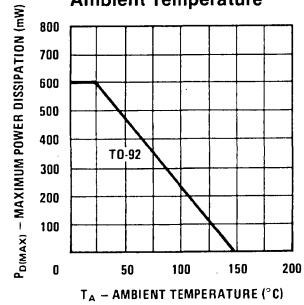
**DC Current Gain vs Collector Current**



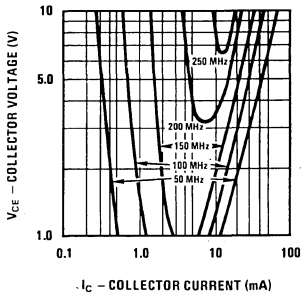
**Base-Emitter ON Voltage vs Collector Current**



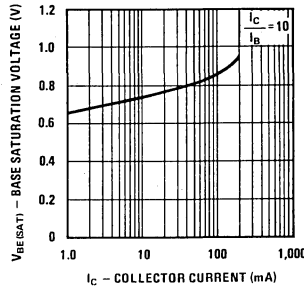
**Maximum Power Dissipation vs Ambient Temperature**



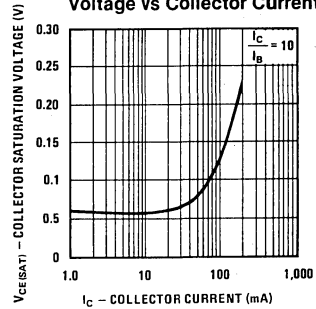
**Contours of Constant Gain Bandwidth Product ( $f_T$ )**



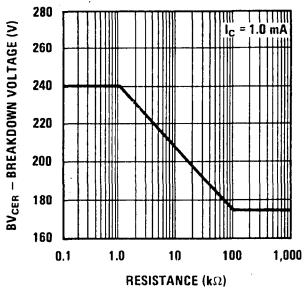
**Base-Emitter Saturation Voltage vs Collector Current**



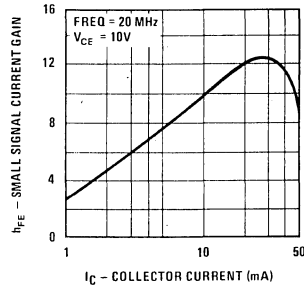
**Collector-Emitter Saturation Voltage vs Collector Current**



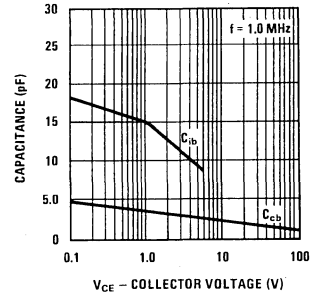
**Collector-Emitter Breakdown Voltage with Resistance Between Emitter-Base**



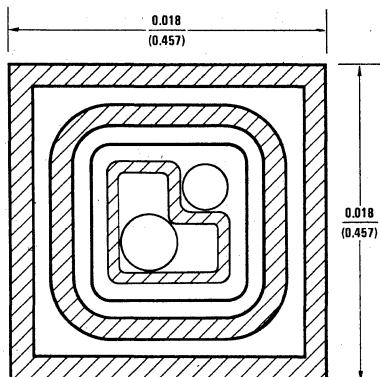
**Small Signal Current Gain vs Collector Current**



**Input and Output Capacitance vs Reverse Bias Voltage**







### DESCRIPTION

Process 17 is a non-overlay, planar epitaxial silicon transistor with a field plate.

### APPLICATION

This device was designed as video output to drive color CRT, mainly in complementary configurations. Complement to Process 76.

### PRINCIPAL DEVICE TYPES

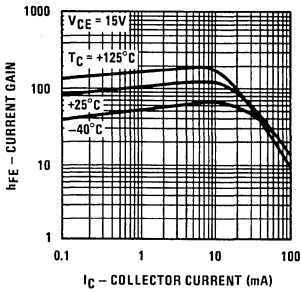
**TO-202, ECB:** NSE869  
NSE871

**TO-237, ECB:** 92PE869  
92PE871

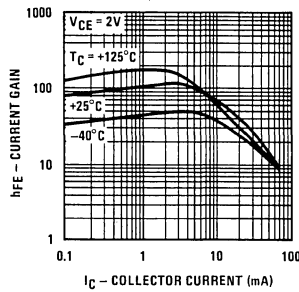
Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 1 \text{ mA}$ (Note 1)	220	280		V
$BV_{CES}$	$I_C = 100 \mu\text{A}$		400		V
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	6			V
$I_{CES}$	$V_{CE} = 150\text{V}$			200	nA
$I_{EBO}$	$V_{EB} = 5\text{V}$			100	nA
$h_{FE1}$	$V_{CE} = 15\text{V}, I_C = 0.1 \text{ mA}$		60		
$h_{FE2}$	$V_{CE} = 15\text{V}, I_C = 25 \text{ mA}$	40	80	200	
$h_{FE3}$	$V_{CE} = 15\text{V}, I_C = 50 \text{ mA}$		25		
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$		0.1	1.0	V
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$		0.7		V
$f_T$	$V_{CE} = 15\text{V}, I_C = 10 \text{ mA}, f = 20 \text{ MHz}$		90		MHz
$C_{cb}$	$V_{CB} = 10\text{V}, f = 1 \text{ MHz}$		1.6		pF
$C_{ib}$	$V_{EB} = 1\text{V}, f = 1 \text{ MHz}$		2.7		pF
$P_{D(max)}$					
TO-202	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	8	1.8		W
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	2	0.85		W
$\theta_{JC}$					
TO-202				15.6	$^\circ\text{C/W}$
TO-237				69.4	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-202				62.5	$^\circ\text{C/W}$
TO-237				147	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts			150	$^\circ\text{C}$

**Note 1:** Pulsed measurement, 300  $\mu\text{s}$  pulse width

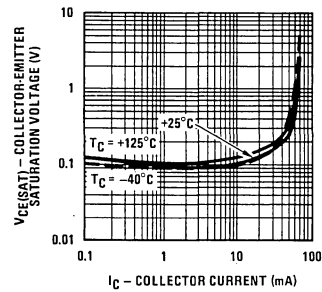
DC Current Gain vs Collector Current



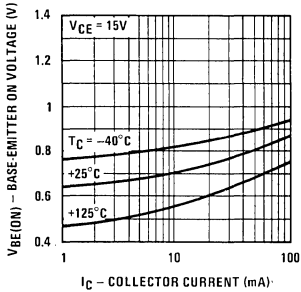
DC Current Gain vs Collector Current



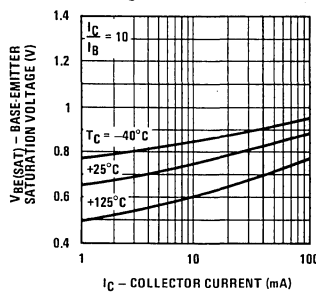
Collector-Emitter Saturation Voltage vs Collector Current



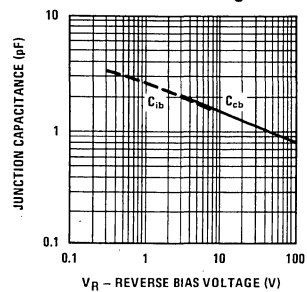
Base-Emitter ON Voltage vs Collector Current



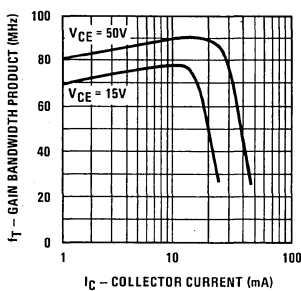
Base-Emitter Saturation Voltage vs Collector Current



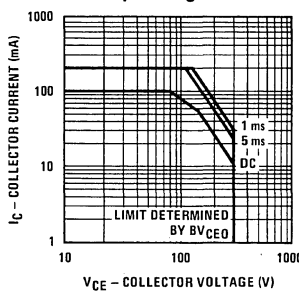
Junction Capacitance vs Reverse Bias Voltage



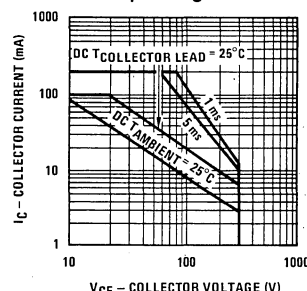
Gain Bandwidth Product vs Collector Current



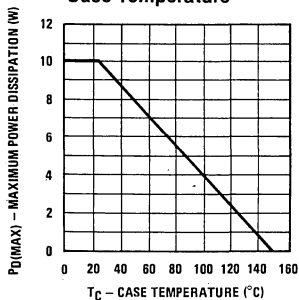
Safe Operating Area TO-202



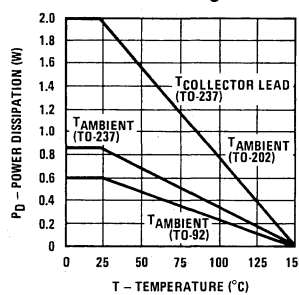
Safe Operating Area TO-237

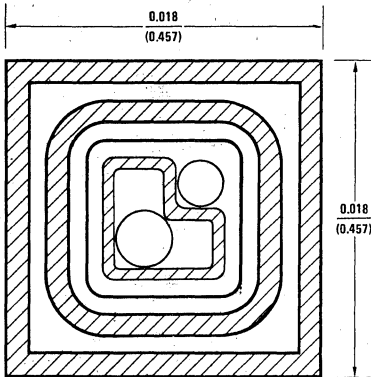


Maximum Power Dissipation vs Case Temperature



Thermal Derating Curve





### DESCRIPTION

Process 18 is a non-overlay, double-diffused, silicon epitaxial device.

### APPLICATION

This device was designed for use in general purpose amplifier and switching applications operating in the range of 100  $\mu$ A to 100 mA.

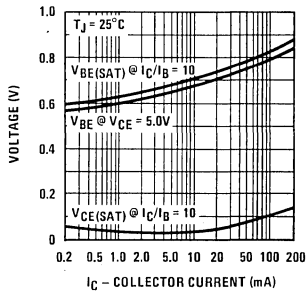
### PRINCIPAL DEVICE TYPES

**TO-92, CBE:** TIS98

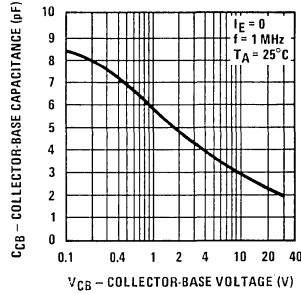
**TO-92, EBC:** MPS8098

Parameter	Conditions	Min	Typ	Max	Units
$f_T$	$I_C = 10 \text{ mA}, V_{CE} = 5\text{V}, f = 100 \text{ MHz}$	150			MHz
$C_{CB}$	$V_{CB} = 5\text{V}, f = 1 \text{ MHz}$			5.0	pF
$C_{EB}$	$V_{EB} = 0.5\text{V}, f = 1 \text{ MHz}$			20	pF
NF	$I_C = 100 \mu\text{A}, V_{CE} = 5\text{V}, R_S = 10 \text{ k}\Omega, P_{BW} = 15.7 \text{ kHz}$		2		dB
$h_{FE}$	$I_C = 100 \mu\text{A}, V_{CE} = 5\text{V}$	40			
$h_{FE}$	$I_C = 1 \text{ mA}, V_{CE} = 5\text{V}$	50			
$h_{FE}$	$I_C = 10 \text{ mA}, V_{CE} = 5\text{V}$	60	180	360	
$h_{FE}$	$I_C = 100 \text{ mA}, V_{CE} = 5\text{V}$	40			
$V_{BE(ON)}$	$I_C = 10 \text{ mA}, V_{CE} = 5\text{V}$			0.85	V
$V_{CE(SAT)}$	$I_C = 100 \text{ mA}, I_B = 10 \text{ mA}$			0.50	V
$BV_{CBO}$	$I_C = 10 \mu\text{A}$	60			V
$BV_{CEO}$	$I_C = 10 \text{ mA}$	50			V
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	5			V
$I_{CBO}$	$V_{CB} = 40\text{V}$			100	nA
$I_{EBO}$	$V_{EB} = 4\text{V}$			100	nA

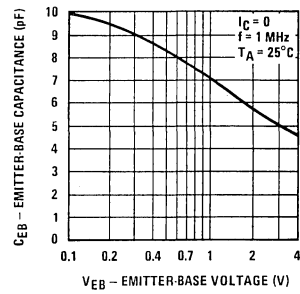
Collector-Emitter and Base-Emitter Voltage vs Collector Current



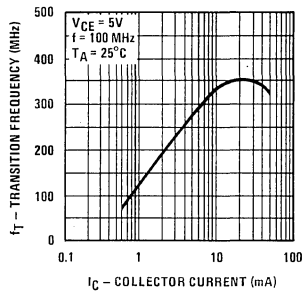
Collector-Base Capacitance vs Reverse Voltage



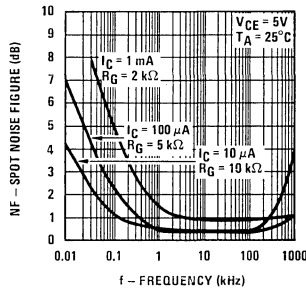
Emitter-Base Capacitance vs Reverse Voltage



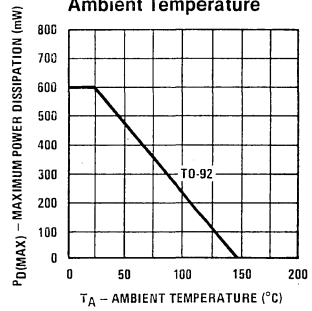
Transition Frequency vs Collector Current



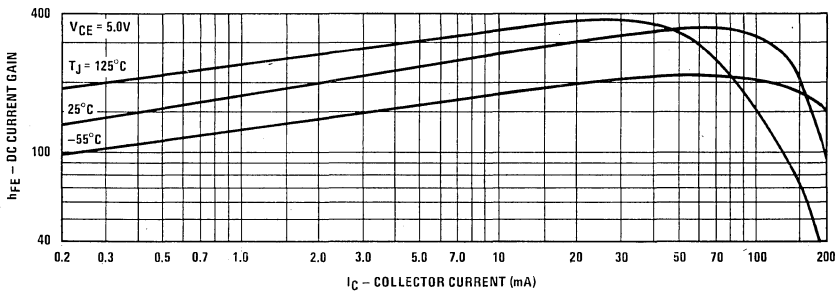
Noise Figure vs Frequency

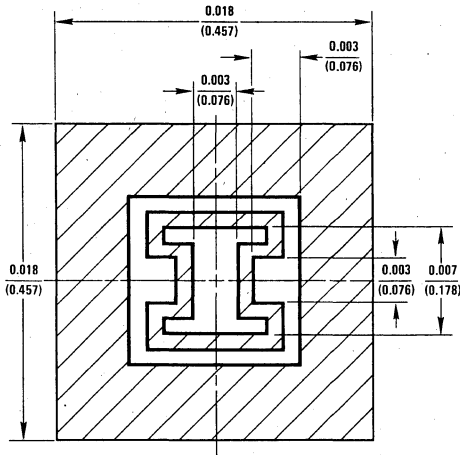


Maximum Power Dissipation vs Ambient Temperature



DC Current Gain vs Collector Current





**DESCRIPTION**

Process 19 is a non-overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 63.

**APPLICATION**

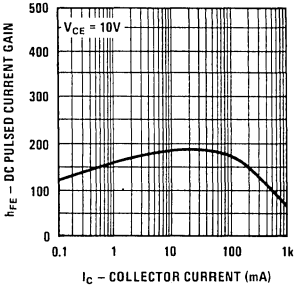
This device was designed for use as a medium power amplifier and switch requiring collector currents of 0.1 mA to 500 mA.

**PRINCIPAL DEVICE TYPES**

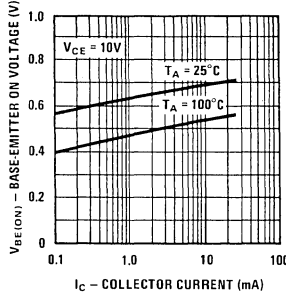
- TO-5:** 2N2219
- TO-18:** 2N2222
- TO-92, EBC:** MPS3642  
PN2222
- TO-237:** TN2219

Parameter	Conditions	Min	Typ	Max	Units	Notes
$t_{ON}$	$I_C = 150 \text{ mA}, I_{B1} = 15 \text{ mA}$		25	35	ns	
$t_{OFF}$	$I_C = 150 \text{ mA}, I_{B2} = 15 \text{ mA}$		200	285	ns	
$h_{fe}$	$I_C = 20 \text{ mA}, V_{CE} = 20\text{V}, f = 100 \text{ MHz}$	2.0	3.5			
$C_{ob}$	$V_{CB} = 10\text{V}, f = 1 \text{ MHz}$		4.0	6.0	pF	
$C_{ib}$	$V_{EB} = 0.5\text{V}, f = 1 \text{ MHz}$			25	pF	
NF (spot)	$I_C = 100 \mu\text{A}, V_{CE} = 10\text{V}, R_S = 1 \text{ k}\Omega, f = 1 \text{ kHz}$		1.2		dB	
$h_{FE}$	$I_C = 100 \mu\text{A}, V_{CE} = 10\text{V}$	30				
$h_{FE}$	$I_C = 1 \text{ mA}, V_{CE} = 10\text{V}$	40				
$h_{FE}$	$I_C = 10 \text{ mA}, V_{CE} = 10\text{V}$	50				
$h_{FE}$	$I_C = 150 \text{ mA}, V_{CE} = 10\text{V}$	60	180	420		
$h_{FE}$	$I_C = 500 \text{ mA}, V_{CE} = 10\text{V}$	30				
$V_{CE(SAT)}$	$I_C = 100 \text{ mA}, I_B = 10 \text{ mA}$			0.50	V	
$V_{CE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			1.0	V	
$V_{BE(SAT)}$	$I_C = 100 \text{ mA}, I_B = 10 \text{ mA}$			1.2	V	
$V_{BE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			1.5	V	
$BV_{CEO}$	$I_C = 10 \text{ mA}$	35			V	
$BV_{CBO}$	$I_C = 100 \mu\text{A}$	60			V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	6			V	
$I_{CBO}$	$V_{CB} = 40\text{V}$			100	nA	
$I_{EBO}$	$V_{EB} = 4\text{V}$			100	nA	

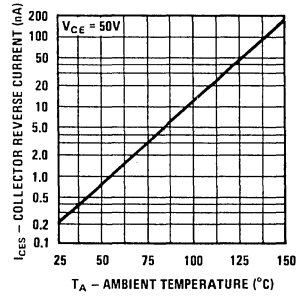
**DC Pulsed Current Gain vs Collector Current**



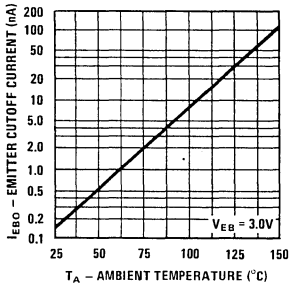
**Base-Emitter ON Voltage vs Collector Current**



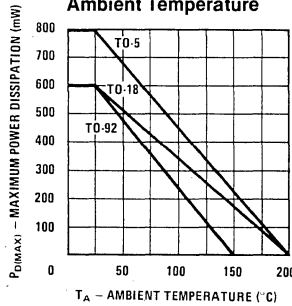
**Collector Reverse Current vs Ambient Temperature**



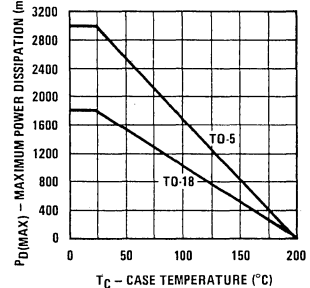
**Emitter Cutoff Current vs Ambient Temperature**



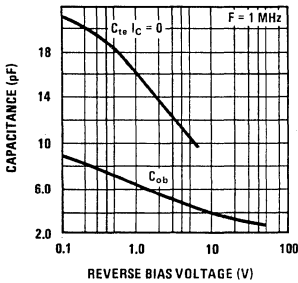
**Maximum Power Dissipation vs Ambient Temperature**



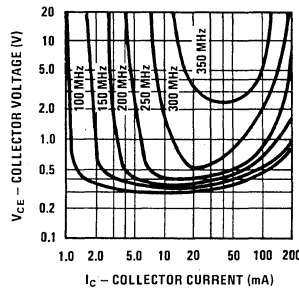
**Maximum Power Dissipation vs Case Temperature**



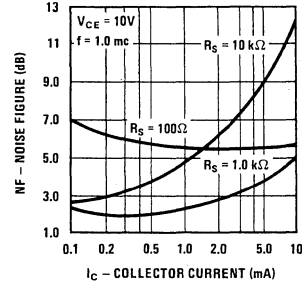
**Emitter Transition and Output Capacitance vs Reverse Bias Voltage**



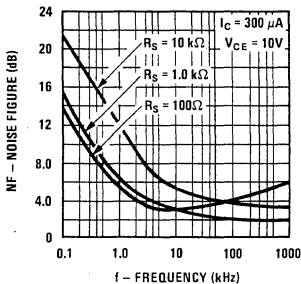
**Contours of Constant Gain Bandwidth Product (fT)**



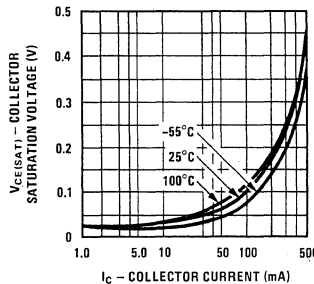
**Noise Figure vs Collector Current**



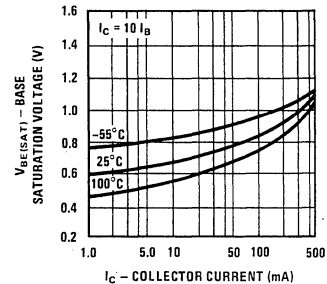
**Noise Figure vs Frequency**



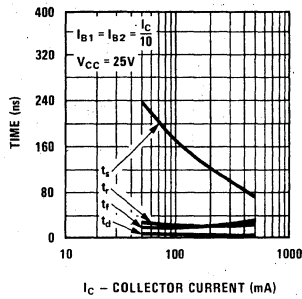
**Collector Saturation Voltage vs Collector Current**



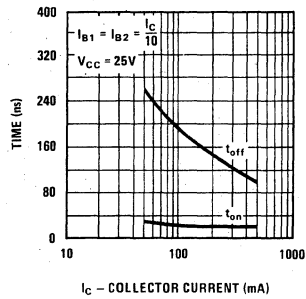
**Base Saturation Voltage vs Collector Current**



Switching Times vs Collector Current



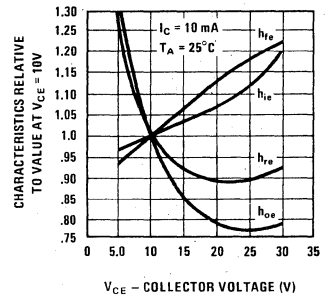
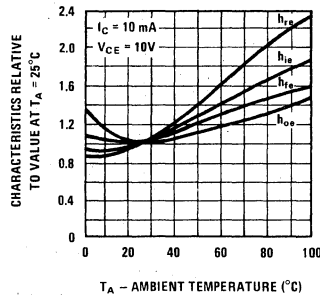
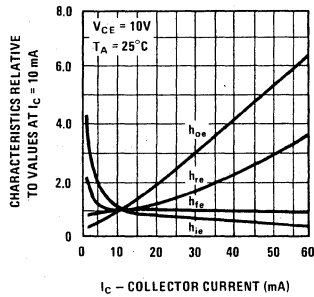
Turn On and Turn Off Times vs Collector Current

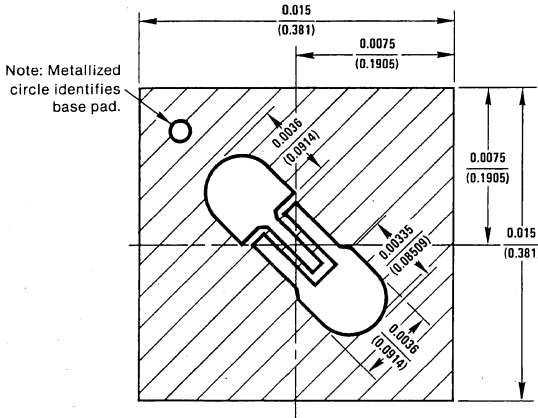


SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

Symbol	Characteristic	Typ	Units	Conditions
$h_{ie}$	Input Resistance	700	$\Omega$	$I_C = 10 \text{ mA}, V_{CE} = 10 \text{ V}$
$h_{oe}$	Output Conductance	120	$\mu\text{mhos}$	$I_C = 10 \text{ mA}, V_{CE} = 10 \text{ V}$
$h_{fe}$	Small Signal Current Gain	240		$I_C = 10 \text{ mA}, V_{CE} = 10 \text{ V}$
$h_{re}$	Voltage Feedback Ratio	460	$\times 10^{-6}$	$I_C = 10 \text{ mA}, V_{CE} = 10 \text{ V}$

TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)




**DESCRIPTION**

Process 21 is an overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 65.

**APPLICATION**

This device was designed for high speed saturated switching at collector currents of 10 mA to 100 mA.

**PRINCIPAL DEVICE TYPES**

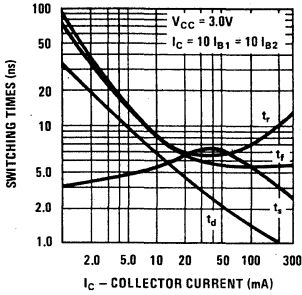
TO-18: 2N2369

TO-92, EBC: PN2369

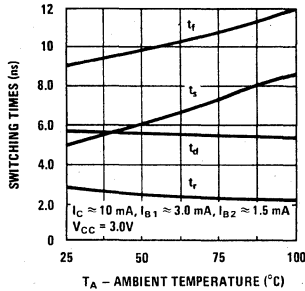
Parameter	Conditions	Min	Typ	Max	Units	Notes
$t_s$	$I_{B1} = I_{B2} = I_C = 10 \text{ mA}$		7	13	ns	Figure 1
$t_{ON}$	$I_C = 10 \text{ mA}, I_{B1} = 3 \text{ mA}$		9	12	ns	Figure 2
$t_{OFF}$	$I_C = 10 \text{ mA}, I_{B2} = 1.50 \text{ mA}$		12	20	ns	Figure 2
$h_{fe}$	$I_C = 10 \text{ mA}, V_{CE} = 10V,$ $f = 100 \text{ MHz}$	4.5	6.5			
$C_{ob}$	$V_{CB} = 5V, f = 1 \text{ MHz}$		2.0	4.0	pF	
$C_{ib}$	$V_{EB} = 0.5V, f = 1 \text{ MHz}$			5.0	pF	
$h_{FE}$	$I_C = 1 \text{ mA}, V_{CE} = 1V$	30				
$h_{FE}$	$I_C = 10 \text{ mA}, V_{CE} = 1V$	35	70	150		
$h_{FE}$	$I_C = 50 \text{ mA}, V_{CE} = 1V$	30	55	150		
$h_{FE}$	$I_C = 100 \text{ mA}, V_{CE} = 1V$	20				
$h_{FE}$	$I_C = 10 \text{ mA}, V_{CE} = 0.35V$	30				
$h_{FE}$	$I_C = 30 \text{ mA}, V_{CE} = 0.4V$	30				
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.2	V	
$V_{CE(SAT)}$	$I_C = 100 \text{ mA}, I_B = 10 \text{ mA}$			0.5	V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.85	V	
$V_{BE(SAT)}$	$I_C = 100 \text{ mA}, I_B = 10 \text{ mA}$			1.5	V	
$BV_{CEO}$	$I_C = 10 \text{ mA}$	12			V	
$BV_{CBO}$	$I_C = 10 \mu A$	30			V	
$BV_{EBO}$	$I_E = 10 \mu A$	4.5			V	
$I_{CBO}$	$V_{CB} = 20V$			100	nA	
$I_{EBO}$	$V_{EB} = 3V$			100	nA	



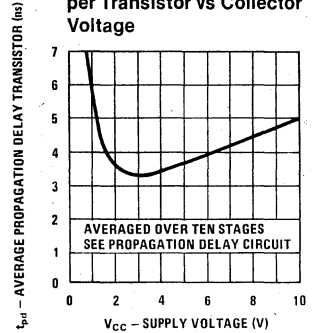
Switching Times vs Collector Current



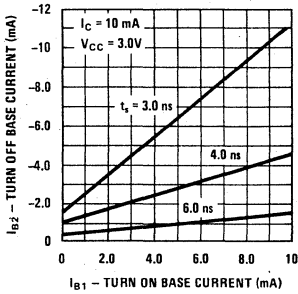
Switching Times vs Ambient Temperature



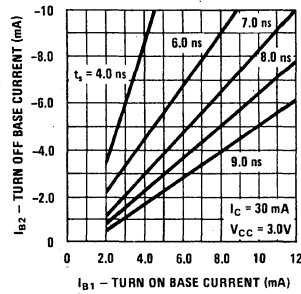
Average Propagation Delay per Transistor vs Collector Voltage



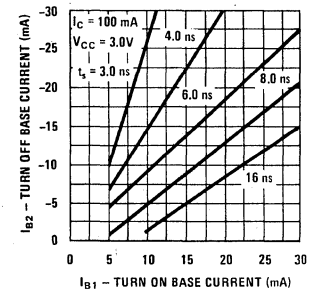
Storage Time vs Turn On and Turn Off Base Currents



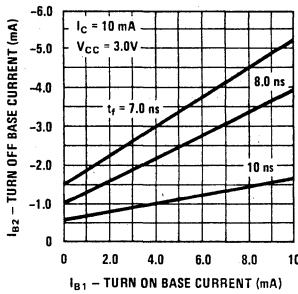
Storage Time vs Turn On and Turn Off Base Currents



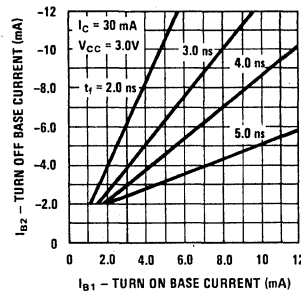
Storage Time vs Turn On and Turn Off Base Currents



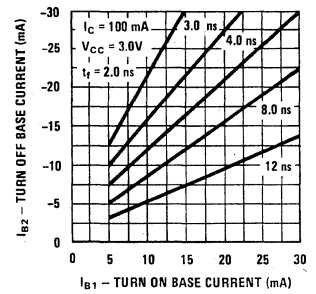
Fall Time vs Turn On and Turn Off Base Current



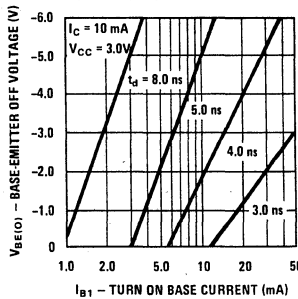
Fall Time vs Turn On and Turn Off Base Current



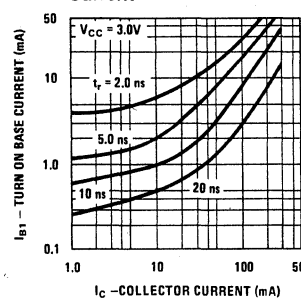
Fall Time vs Turn On and Turn Off Base Current



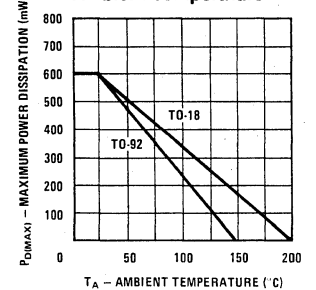
Delay Time vs Base-Emitter Off Voltage and Turn On Base Current



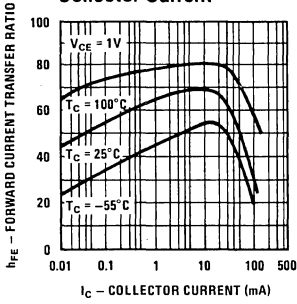
Rise Time vs Turn On Base Current and Collector Current



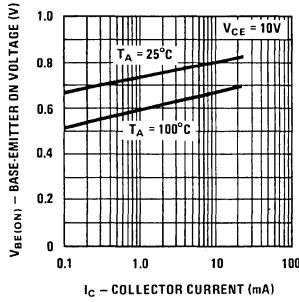
Maximum Power Dissipation vs Ambient Temperature



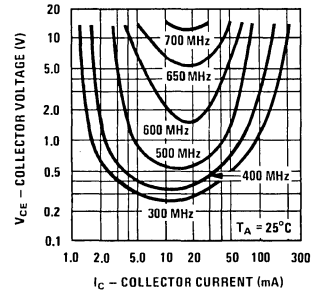
**DC Current Gain vs Collector Current**



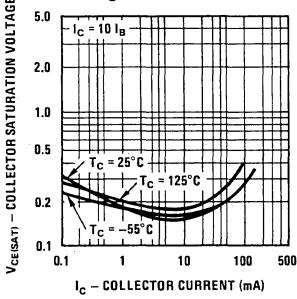
**Base-Emitter On Voltage vs Collector Current**



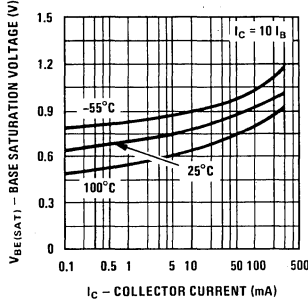
**Contours of Constant Gain Bandwidth Product ( $f_T$ )**



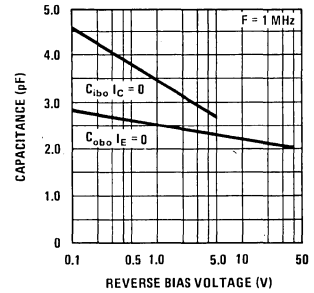
**Collector Saturation Voltage vs Collector Current**



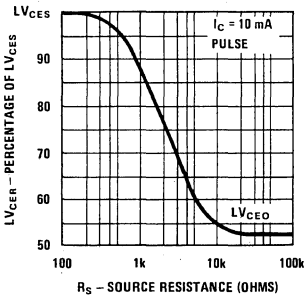
**Base Saturation Voltage vs Collector Current**



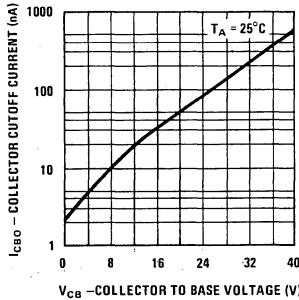
**Emitter Transition and Output Capacitances vs Reverse Bias Voltage**



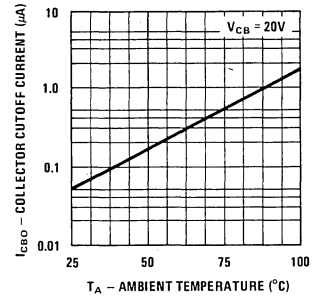
**Lower Limiting Voltage vs Source Resistance**



**Collector Cutoff Current vs Reverse Bias Voltage**



**Collector Cutoff Current vs Ambient Temperature**



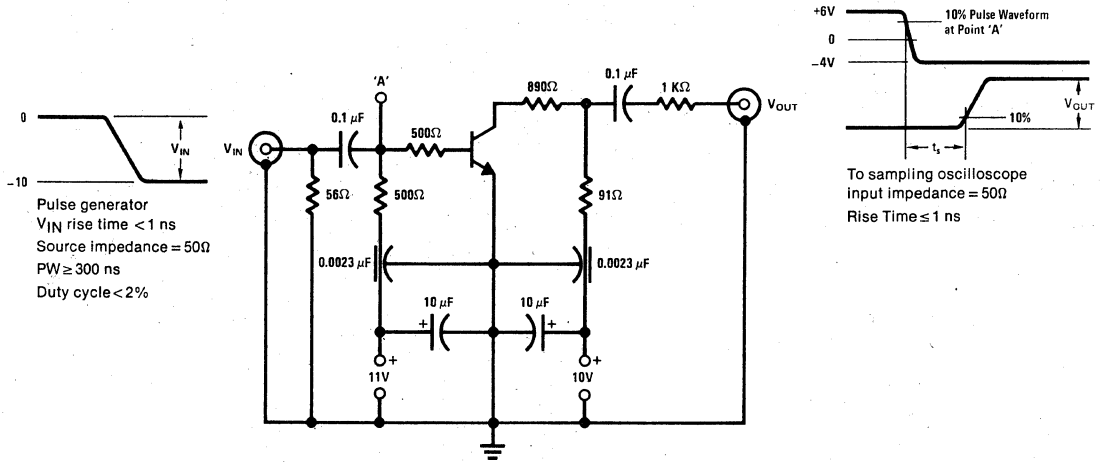


FIGURE 1. Charge Storage Time Measurement Circuit

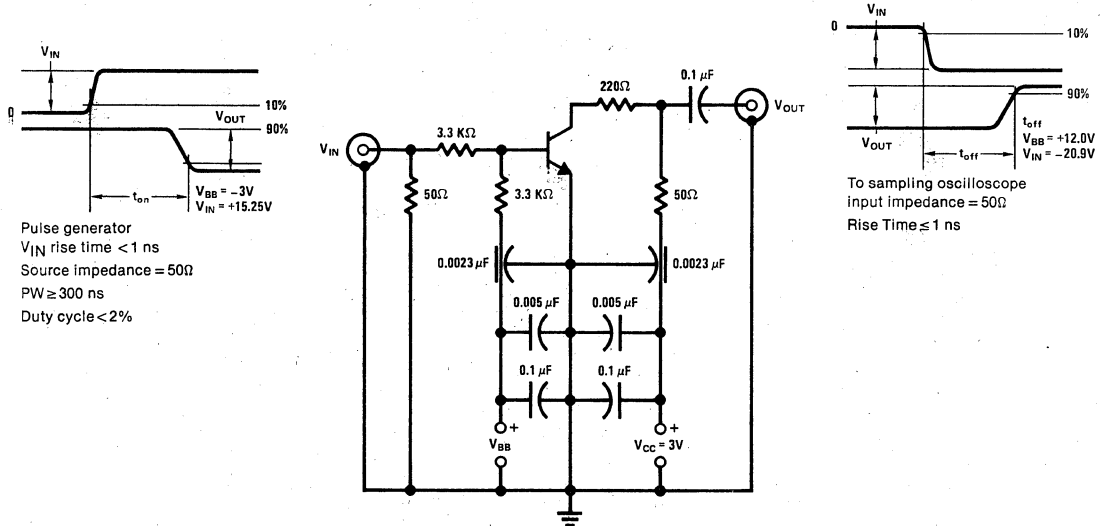


FIGURE 2.  $t_{ON}$ ,  $t_{OFF}$  Measurement Circuit

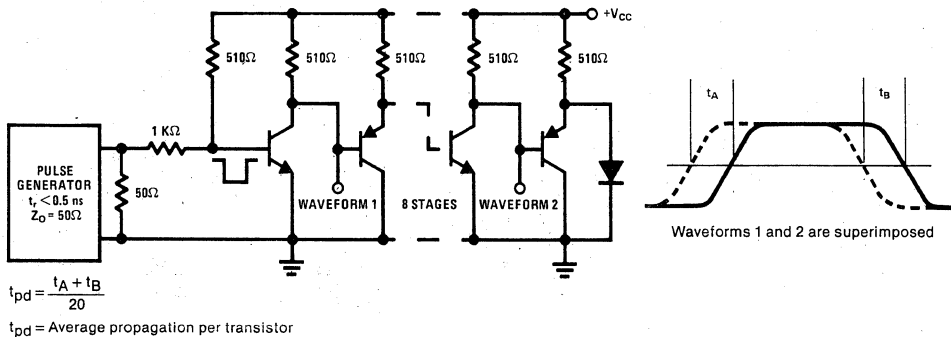
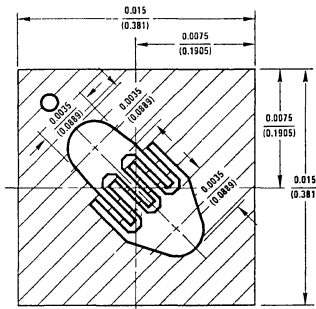


FIGURE 3. Circuit for Measurement of Propagation Delay


**DESCRIPTION**

Process 22 is an overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 64.

**APPLICATION**

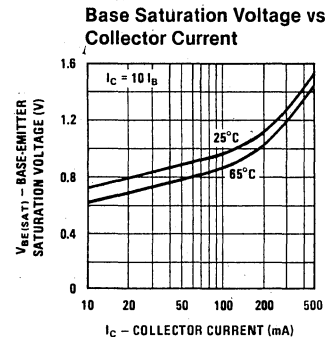
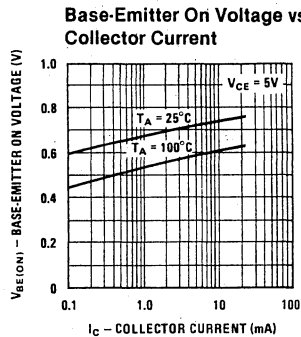
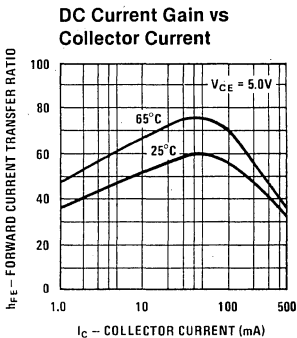
This device was designed for high speed logic and core driver applications to 300 mA.

**PRINCIPAL DEVICE TYPES**

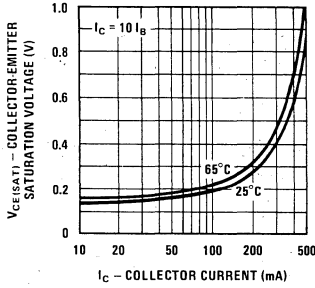
TO-52: 2N3013

TO-92, EBC: 2N5772

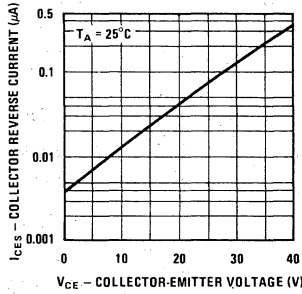
Parameter	Conditions	Min	Typ	Max	Units	Notes
$t_s$	$I_C = 10 \text{ mA}$ , $I_{B1} = I_{B2} = 10 \text{ mA}$		12	18	ns	Figure 1
$t_{ON}$	$I_C = 300 \text{ mA}$ , $I_{B1} = I_{B2} = 30 \text{ mA}$		10	18	ns	Figure 2
$t_{OFF}$	$I_C = 300 \text{ mA}$ , $I_{B1} = I_{B2} = 30 \text{ mA}$		18	30	ns	
$C_{ob}$	$V_{CB} = 5\text{V}$ , $f = 1 \text{ MHz}$		3.0	5.0	pF	
$C_{ib}$	$V_{EB} = 0.5\text{V}$ , $f = 1 \text{ MHz}$			8.0	pF	
$h_{fe}$	$I_C = 30 \text{ mA}$ , $V_{CE} = 10\text{V}$ , $f = 100 \text{ MHz}$	3.5	7.0			
$h_{FE}$	$V_{CE} = 1\text{V}$ , $10 \text{ mA}$	20				
$h_{FE}$	$V_{CE} = 1\text{V}$ , $I_C = 30 \text{ mA}$	25	60	150		
$h_{FE}$	$V_{CE} = 1\text{V}$ , $I_C = 100 \text{ mA}$	20	45	150		
$h_{FE}$	$V_{CE} = 1\text{V}$ , $I_C = 300 \text{ mA}$	15				
$h_{FE}$	$V_{CE} = 0.4\text{V}$ , $I_C = 30 \text{ mA}$	20				
$h_{FE}$	$V_{CE} = 0.5\text{V}$ , $I_C = 100 \text{ mA}$	20				
$V_{CE(SAT)}$	$I_C = 30 \text{ mA}$ , $I_B = 3 \text{ mA}$			0.20	V	
$V_{CE(SAT)}$	$I_C = 100 \text{ mA}$ , $I_B = 10 \text{ mA}$			0.30	V	
$V_{CE(SAT)}$	$I_C = 300 \text{ mA}$ , $I_B = 30 \text{ mA}$			0.50	V	
$V_{BE(SAT)}$	$I_C = 30 \text{ mA}$ , $I_B = 3 \text{ mA}$			0.95	V	
$V_{BE(SAT)}$	$I_C = 100 \text{ mA}$ , $I_B = 10 \text{ mA}$			1.2	V	
$V_{BE(SAT)}$	$I_C = 300 \text{ mA}$ , $I_B = 30 \text{ mA}$			1.7	V	
$BV_{CBO}$	$I_C = 10 \mu\text{A}$	35			V	
$BV_{CEO}$	$I_C = 10 \text{ mA}$	15			V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	5.0			V	
$I_{CBO}$	$V_{CB} = 25\text{V}$			100	nA	
$I_{EBO}$	$V_{EB} = 3\text{V}$			100	nA	



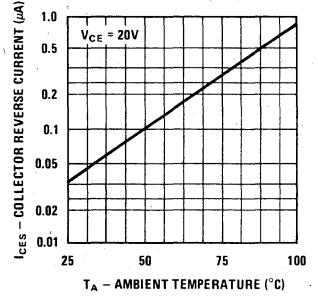
Collector Saturation Voltage vs Collector Current



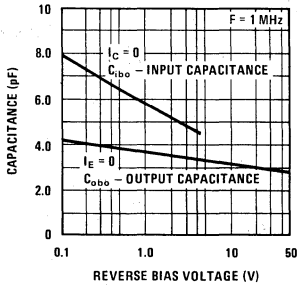
Collector Reverse Current vs Reverse Bias Voltage



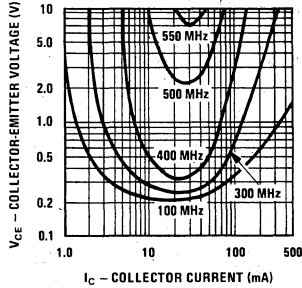
Collector Reverse Current vs Ambient Temperature



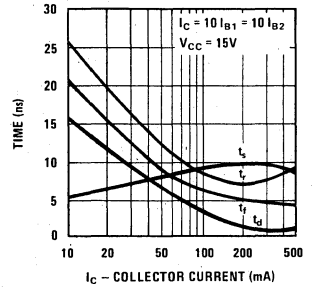
Input and Output Capacitance vs Reverse Bias Voltage



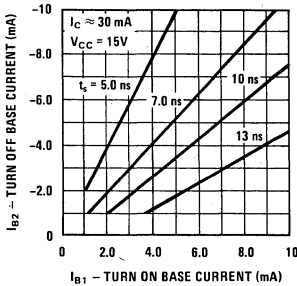
Contours of Constant Gain Bandwidth Product (f\_T)



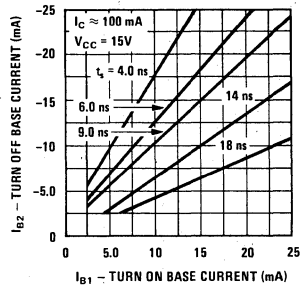
Switching Times vs Collector Current



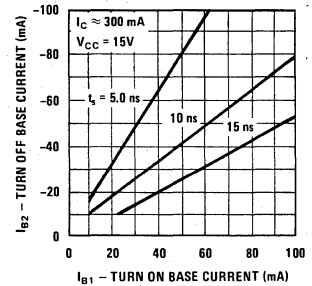
Storage Time vs Turn On and Turn Off Base Currents



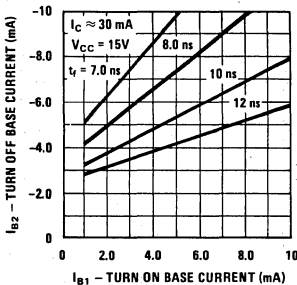
Storage Time vs Turn On and Turn Off Base Currents



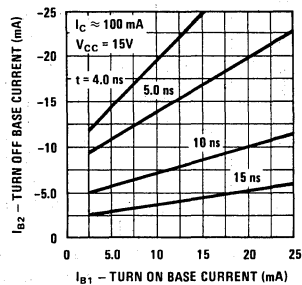
Storage Time vs Turn On and Turn Off Base Currents



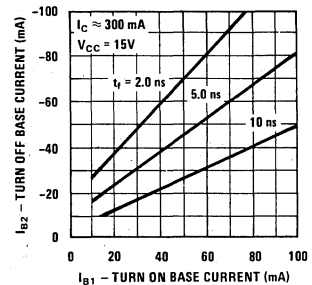
Fall Time vs Turn On and Turn Off Base Currents



Fall Time vs Turn On and Turn Off Base Currents

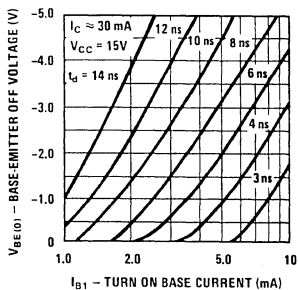


Fall Time vs Turn On and Turn Off Base Currents

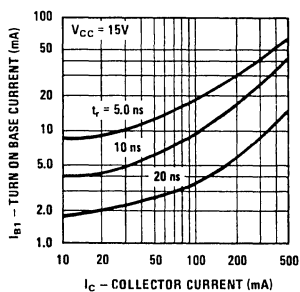


# Process 22

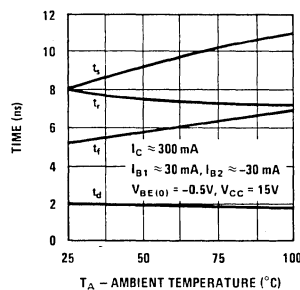
**Delay Time vs Base-Emitter Off Voltage and Turn On Base Current**



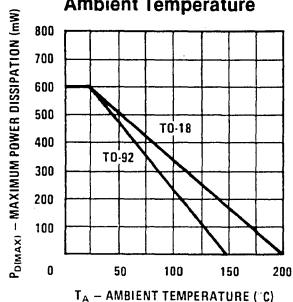
**Rise Time vs Collector and Turn On Base Currents**



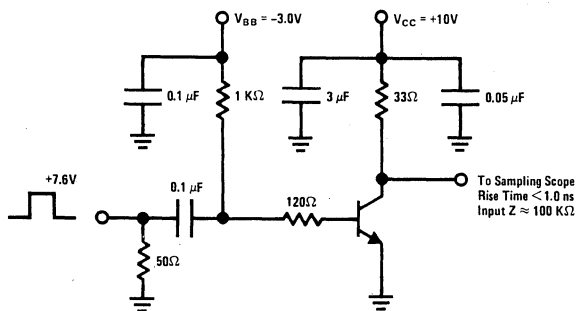
**Switching Times vs Ambient Temperature**



**Maximum Power Dissipation vs Ambient Temperature**



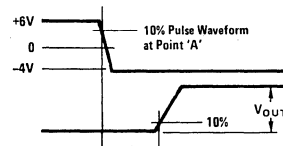
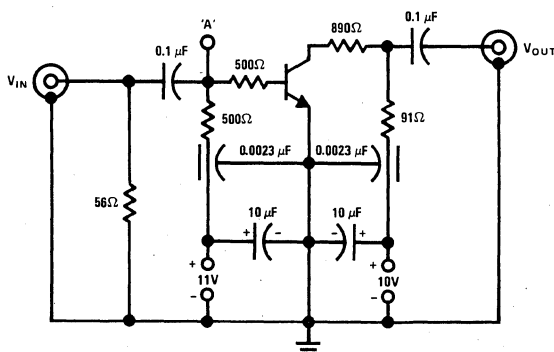
Pulse width  $\geq 240$  ns  
 $t_r, t_f = 1.0$  ns  
 $Z_{IN} = 50\Omega$



**FIGURE 1.  $t_{ON}, t_{OFF}$  Test Circuit**



Pulse generator  
 $V_{IN}$  rise time  $< 1$  ns  
 Source impedance =  $50\Omega$   
 $PW \geq 300$  ns  
 Duty cycle  $< 2\%$

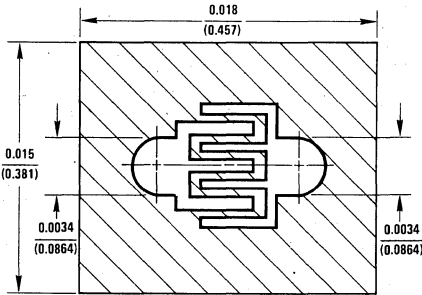


To sampling oscilloscope  
 $Z_{IN} \approx 100$  k $\Omega$   
 Rise Time  $\leq 1$  ns

**FIGURE 2. Charge Storage Time Measurement Circuit**



# Process 23 NPN Small Signal



## DESCRIPTION

Process 23 is an overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 66.

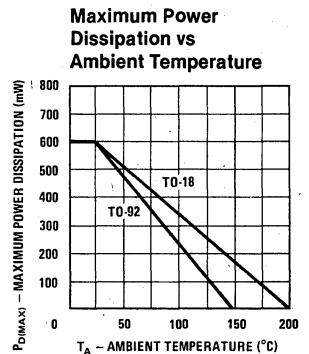
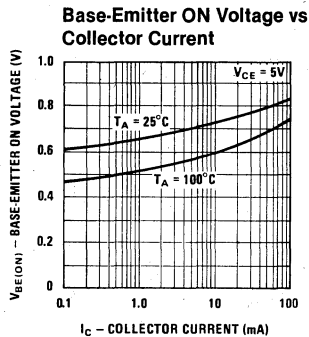
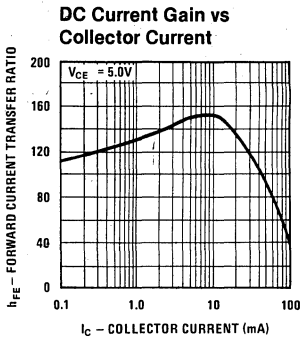
## APPLICATION

This device is designed as a general purpose amplifier and switch. The useful dynamic range extends to 100 mA as a switch and to 100 MHz as an amplifier.

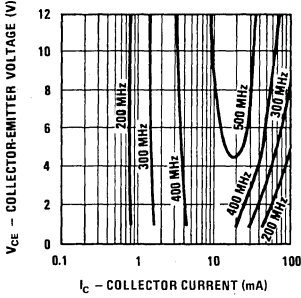
## PRINCIPAL DEVICE TYPES

- TO-18: NS3904
- TO-92, EBC: 2N3904

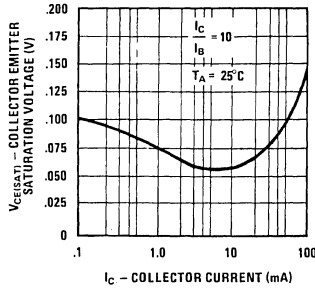
Parameter	Conditions	Min	Typ	Max	Units	Notes
$t_{ON}$	$I_C = 10 \text{ mA}, I_{B1} = 1 \text{ mA}$		30	70	ns	Figure 1
$t_{OFF}$	$I_C = 10 \text{ mA}, I_{B2} = 1 \text{ mA}$		150	250	ns	Figure 2
$C_{ob}$	$V_{CB} = 5V, f = 1 \text{ MHz}$		2.7	4.0	pF	
$C_{ib}$	$V_{EB} = 0.5V, f = 1 \text{ MHz}$			8.0	pF	
NF	$V_{CE} = 5V, I_C = 100 \mu A, R_S = 1 \text{ k}\Omega, P_{BW} = 15.7 \text{ kHz}$		2.0		dB	
$h_{fe}$	$I_C = 10 \text{ mA}, V_{CE} = 20V, f = 100 \text{ MHz}$	2.5	4.5			
$h_{FE}$	$I_C = 100 \mu A, V_{CE} = 5V$	40				
$h_{FE}$	$I_C = 1 \text{ mA}, V_{CE} = 5V$	90				
$h_{FE}$	$I_C = 10 \text{ mA}, V_{CE} = 5V$	60	150	360		
$h_{FE}$	$I_C = 50 \text{ mA}, V_{CE} = 5V$	40				
$h_{FE}$	$I_C = 100 \text{ mA}, V_{CE} = 5V$	20				
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.15	V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.80	V	
$V_{CE(SAT)}$	$I_C = 50 \text{ mA}, I_B = 5 \text{ mA}$			0.25	V	
$V_{BE(SAT)}$	$I_C = 50 \text{ mA}, I_B = 5 \text{ mA}$			0.85	V	
$BV_{CBO}$	$I_C = 10 \mu A$	60			V	
$BV_{CEO}$	$I_C = 1 \text{ mA}$	30			V	
$BV_{EBO}$	$I_E = 10 \mu A$	6.0			V	
$I_{CBO}$	$V_{CB} = 30V$			100	nA	
$I_{EBO}$	$V_{EB} = 4V$			100	nA	



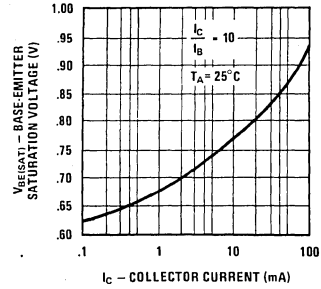
Contours of Constant Gain Bandwidth Product ( $f_T$ )



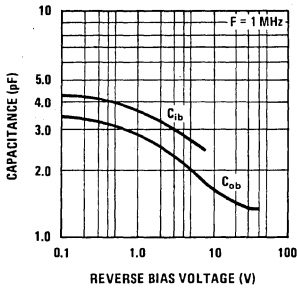
Collector Saturation Voltage vs Collector Current



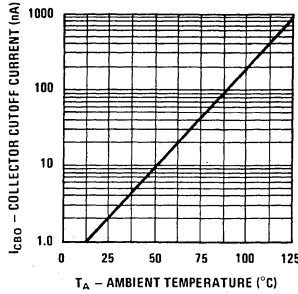
Base Saturation Voltage vs Collector Current



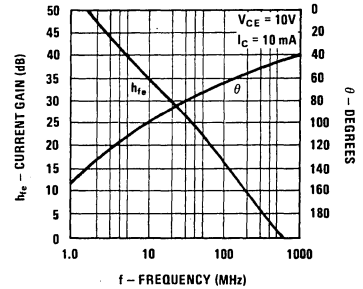
Capacitance vs Reverse Bias Voltage



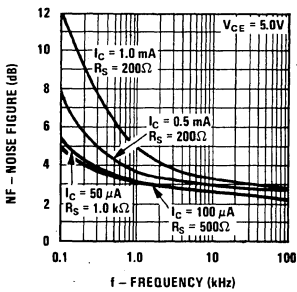
Collector Cutoff Current vs Ambient Temperature



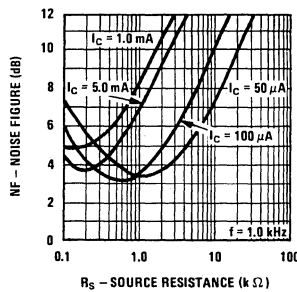
Current Gain and Phase Angle vs Frequency



Noise Figure vs Frequency

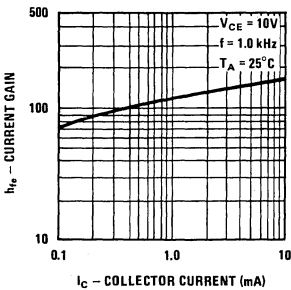


Noise Figure vs Source Resistance

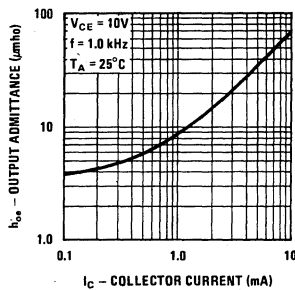


H PARAMETERS ( $V_{CE} = 10 V_{DC}$ ,  $f = 1.0 kHz$ ,  $T_A = 25^\circ C$ )

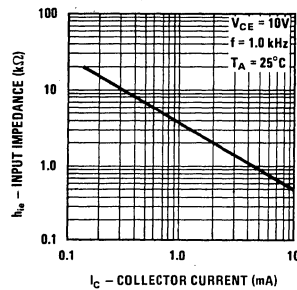
Current Gain



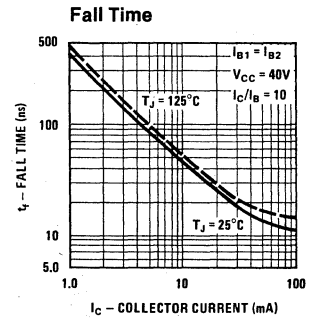
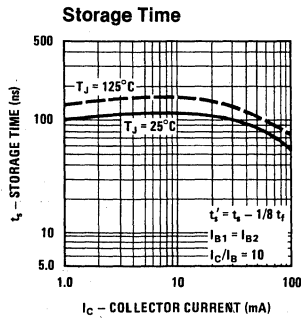
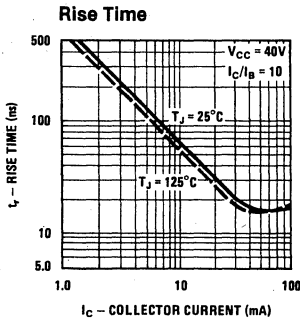
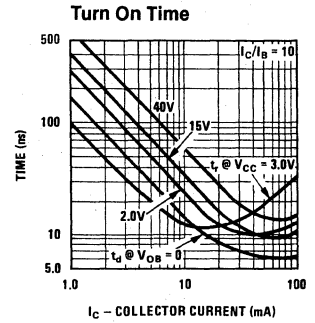
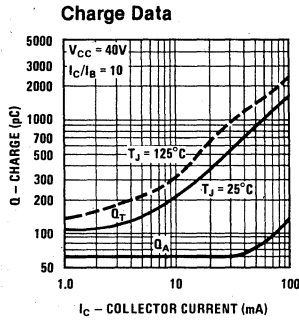
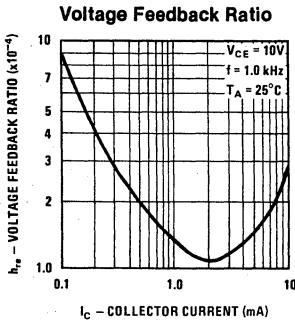
Output Admittance



Input Impedance







TRANSIENT CHARACTERISTICS ( $-T_J = 25^\circ\text{C} - T_J = 125^\circ\text{C}$ )

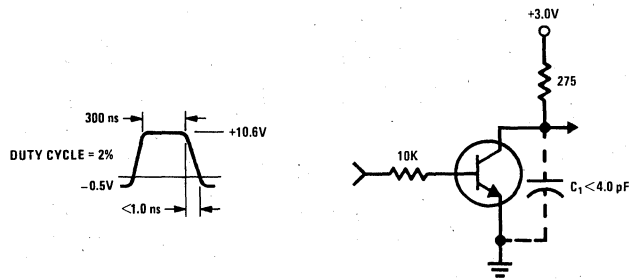


FIGURE 1. Delay and Rise Time Equivalent Test Circuit

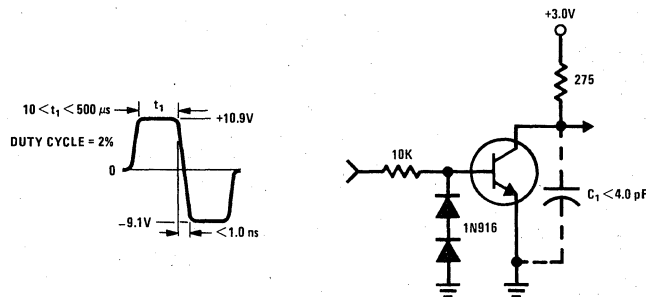


FIGURE 2. Storage and Fall Time Equivalent Test Circuit

**DESCRIPTION**

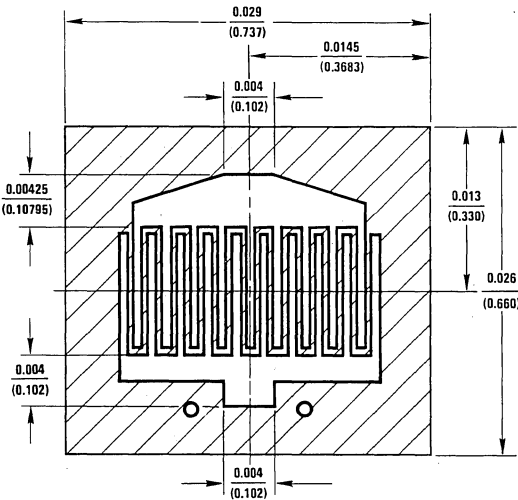
Process 25 is an overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 70.

**APPLICATION**

This device was designed for high speed core driver applications.

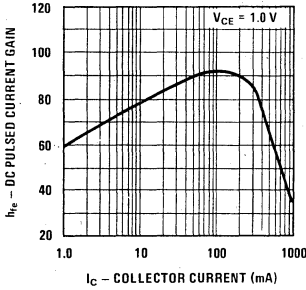
**PRINCIPAL DEVICE TYPES**
**TO-18:** 2N4014

**TO-39:** 2N3725

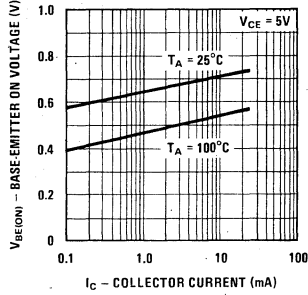
**TO-237:** TN3725


Parameter	Conditions	Min	Typ	Max	Units	Notes
$t_{ON}$	$I_C = 500 \text{ mA}$ , $I_{B1} = 50 \text{ mA}$		12	35	ns	Figure 1
$t_{OFF}$	$I_C = 500 \text{ mA}$ , $I_{B2} = 50 \text{ mA}$		50	60	ns	Figure 1
$h_{fe}$	$I_C = 50 \text{ mA}$ , $V_{CE} = 10\text{V}$ , $f = 100 \text{ MHz}$	2.5	4.25			
$C_{ob}$	$V_{CB} = 10\text{V}$ , $f = 1 \text{ MHz}$		6	8	pF	
$C_{ib}$	$V_{EB} = 0.5\text{V}$ , $f = 1 \text{ MHz}$			55	pF	
$h_{FE}$	$I_C = 10 \text{ mA}$ , $V_{CE} = 1\text{V}$	40				
$h_{FE}$	$I_C = 100 \text{ mA}$ , $V_{CE} = 1\text{V}$	45	90	150		
$h_{FE}$	$I_C = 300 \text{ mA}$ , $V_{CE} = 1\text{V}$	35				
$h_{FE}$	$I_C = 500 \text{ mA}$ , $V_{CE} = 1\text{V}$	25				
$h_{FE}$	$I_C = 800 \text{ mA}$ , $V_{CE} = 1\text{V}$	20				
$h_{FE}$	$I_C = 1\text{A}$ , $V_{CE} = 1\text{V}$	15				
$h_{FE}$	$I_C = 800 \text{ mA}$ , $V_{CE} = 2\text{V}$	25				
$h_{FE}$	$I_C = 1\text{A}$ , $V_{CE} = 5\text{V}$	25				
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}$ , $I_B = 1 \text{ mA}$			0.20	V	
$V_{CE(SAT)}$	$I_C = 100 \text{ mA}$ , $I_B = 10 \text{ mA}$			0.20	V	
$V_{CE(SAT)}$	$I_C = 300 \text{ mA}$ , $I_B = 30 \text{ mA}$			0.40	V	
$V_{CE(SAT)}$	$I_C = 500 \text{ mA}$ , $I_B = 50 \text{ mA}$			0.50	V	
$V_{CE(SAT)}$	$I_C = 800 \text{ mA}$ , $I_B = 80 \text{ mA}$			0.80	V	
$V_{CE(SAT)}$	$I_C = 1\text{A}$ , $I_B = 100 \text{ mA}$			1.20	V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}$ , $I_B = 1 \text{ mA}$			0.70	V	
$V_{BE(SAT)}$	$I_C = 100 \text{ mA}$ , $I_B = 10 \text{ mA}$			0.85	V	
$V_{BE(SAT)}$	$I_C = 300 \text{ mA}$ , $I_B = 30 \text{ mA}$			1.20	V	
$V_{BE(SAT)}$	$I_C = 500 \text{ mA}$ , $I_B = 50 \text{ mA}$			1.20	V	
$V_{BE(SAT)}$	$I_C = 800 \text{ mA}$ , $I_B = 80 \text{ mA}$			1.50	V	
$V_{BE(SAT)}$	$I_C = 1\text{A}$ , $I_B = 100 \text{ mA}$			1.70	V	
$BV_{CEO}$	$I_C = 10 \text{ mA}$	40			V	
$BV_{CBO}$	$I_C = 100 \mu\text{A}$	80			V	
$BV_{EBO}$	$I_C = 10 \mu\text{A}$	6			V	
$I_{CBO}$	$V_{CB} = 40\text{V}$			100	nA	
$I_{EBO}$	$V_{EB} = 4\text{V}$			100	nA	

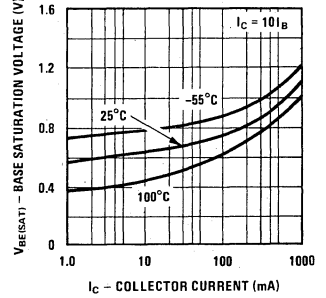
DC Pulsed Current Gain vs Collector Current



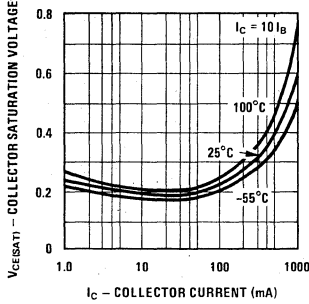
Base-Emitter ON Voltage vs Collector Current



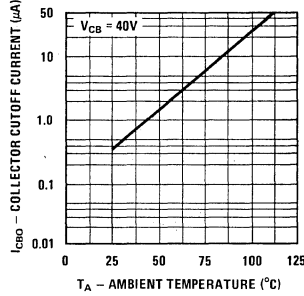
Base Saturation Voltage vs Collector Current



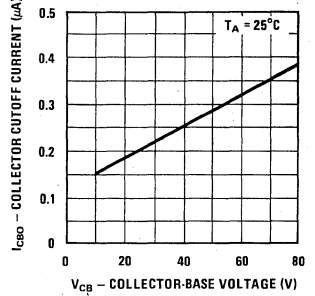
Collector Saturation Voltage vs Collector Current



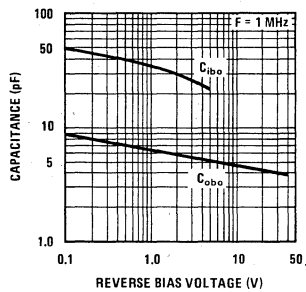
Collector Cutoff Current vs Ambient Temperature



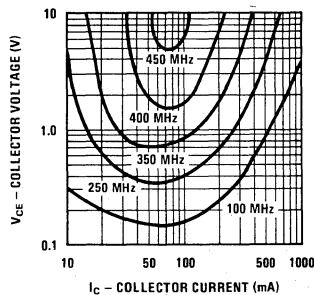
Collector Cutoff Current vs Reverse Bias Voltage



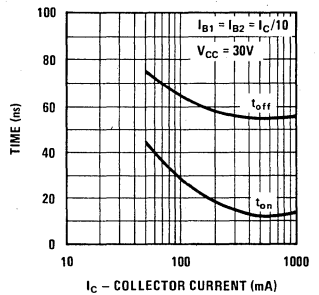
Input and Output Capacitance vs Reverse Bias



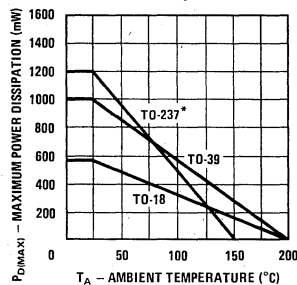
Contours of Constant Bandwidth Product (fT)



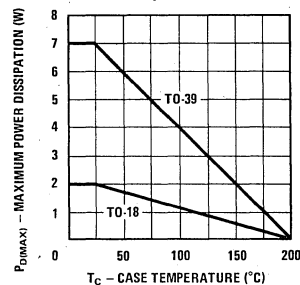
Turn On and Turn Off Times vs Collector Current



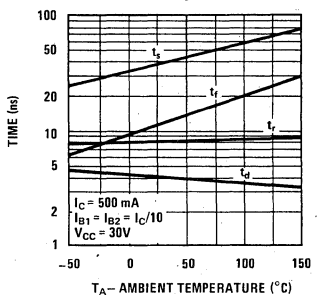
Maximum Power Dissipation vs Ambient Temperature



Maximum Power Dissipation vs Case Temperature

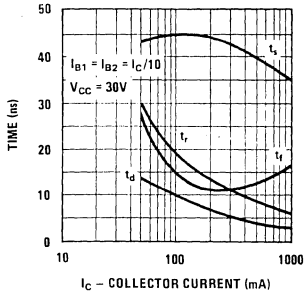


Switching Times vs Ambient Temperature

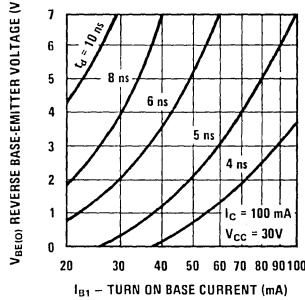


\* One square inch of copper run

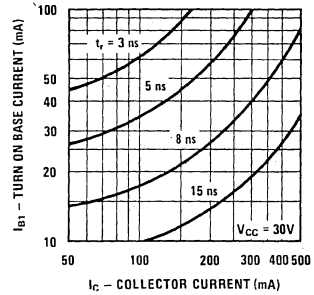
Switching Times vs Collector Current



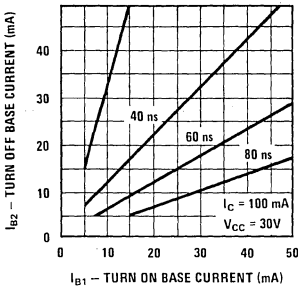
Delay Time vs Turn On Base Current and Reverse Base-Emitter Voltage



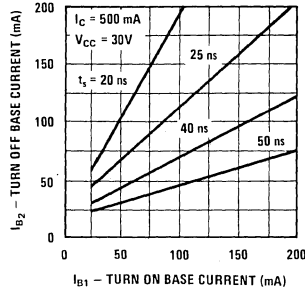
Rise Time vs Collector and Turn On Base Currents



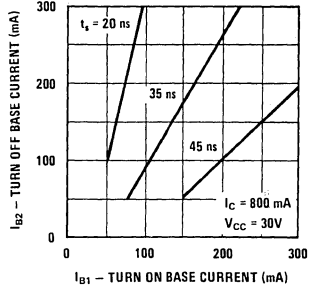
Storage Time vs Turn On and Turn Off Base Currents



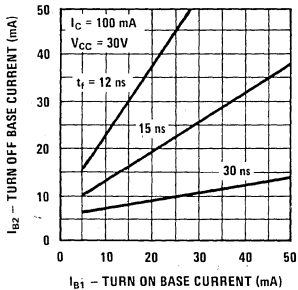
Storage Time vs Turn On and Turn Off Base Currents



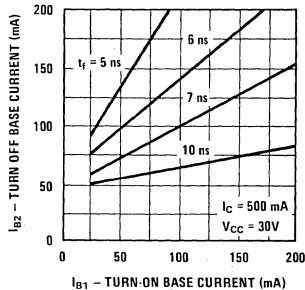
Storage Time vs Turn On and Turn Off Base Currents



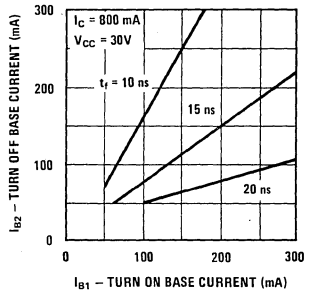
Fall Time vs Turn On and Turn Off Base Currents



Fall Time vs Turn On and Turn Off Base Currents



Fall Time vs Turn On and Turn Off Base Currents



SWITCHING TIME TEST CIRCUIT

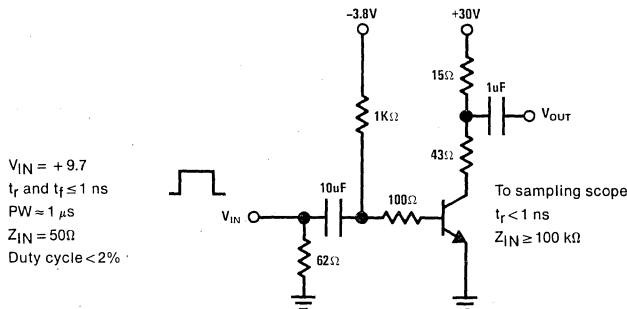
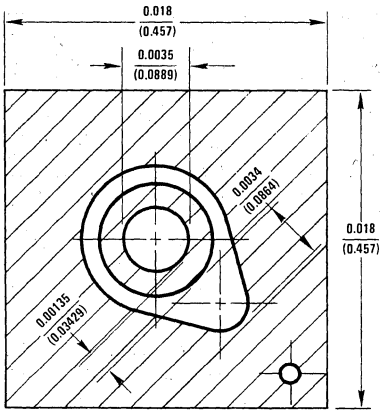


FIGURE 1.  $I_C \approx 500$  mA,  $I_{B1} \approx 50$  mA,  $I_{B2} \approx -50$  mA



## Process 27 NPN Small Signal



### DESCRIPTION

Process 27 is a non-overlay, double-diffused, silicon epitaxial device.

### APPLICATION

This device is designed for general purpose amplifier and switch applications, useful from audio to RF frequencies.

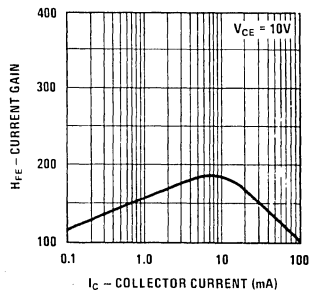
### PRINCIPAL DEVICE TYPES

TO-18: 2N915  
 TO-92, EBC: PN3694  
 TO-92, ECB: 2N3394

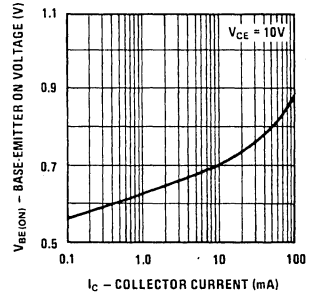
Parameter	Conditions	Min	Typ	Max	Units	Notes
NF (wideband)	$V_{CE} = 5V, I_C = 100 \mu A, P_{BW} = 15.7 \text{ kHz}$		1.5		dB	
NF (spot)	$V_{CE} = 5V, I_C = 100 \mu A, f = 1 \text{ kHz}, R_S = 1k$		1.5		dB	
$C_{ob}$	$V_{CB} = 10V, f = 1 \text{ MHz}$		2.5	3.5	pF	
$C_{ib}$	$V_{EB} = 0.50V, f = 1 \text{ MHz}$			7.0	pF	
$f_T$	$V_{CE} = 10V, I_C = 10 \text{ mA}$	250	450		MHz	
$h_{FE}$	$V_{CE} = 10V, I_C = 100 \mu A$	40				
$h_{FE}$	$V_{CE} = 10V, I_C = 1 \text{ mA}$	50				
$h_{FE}$	$V_{CE} = 10V, I_C = 10 \text{ mA}$	60	180	360		
$h_{FE}$	$V_{CE} = 10V, I_C = 50 \text{ mA}$	45				
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.20	V	
$V_{BE(SAT)}$	$I_C = 1 \text{ mA}, I_B = 1 \text{ mA}$			0.85	V	
$BV_{CBO}$	$I_C = 100 \mu A$	50			V	
$BV_{CEO}$	$I_C = 10 \text{ mA}$	35			V	
$BV_{EBO}$	$I_E = 10 \mu A$	5.0			V	
$I_{CBO}$	$V_{CB} = 40V$			100	nA	
$I_{EBO}$	$V_{EB} = 4.0V$			100	nA	

# Process 27

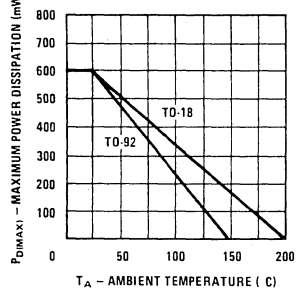
**DC Current Gain vs Collector Current**



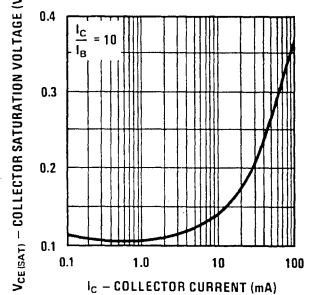
**Base-Emitter ON Voltage vs Collector Current**



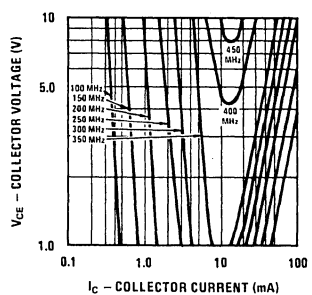
**Maximum Power Dissipation vs Ambient Temperature**



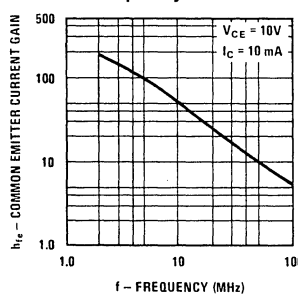
**Collector-Emitter Saturation Voltage vs Collector Current**



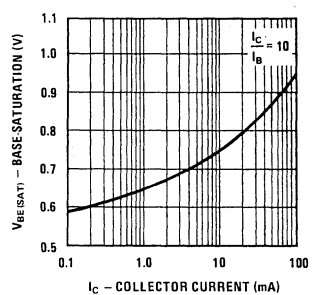
**Small Signal Current Gain vs Collector Current**



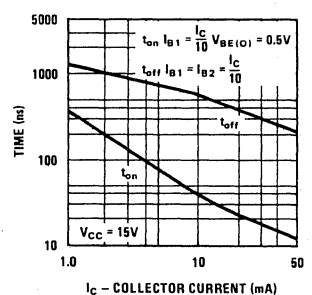
**Small Signal Current Gain vs Frequency**



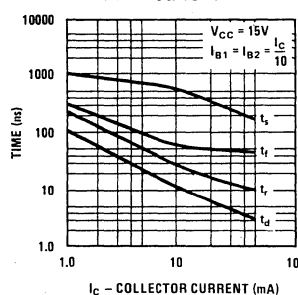
**Base Saturation Voltage vs Collector Current**



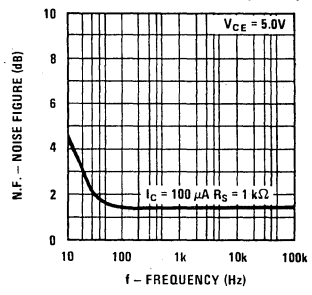
**tON and tOFF vs Collector Current**



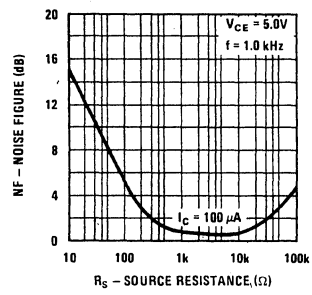
**Switching Times vs Collector Current**



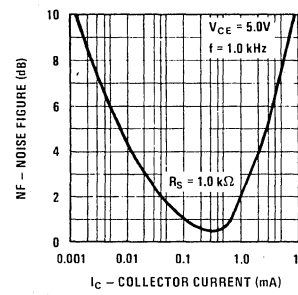
**Noise Figure vs Frequency**



**Noise Figure vs Source Resistance**

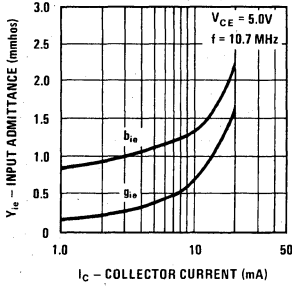


**Noise Figure vs Collector Current**

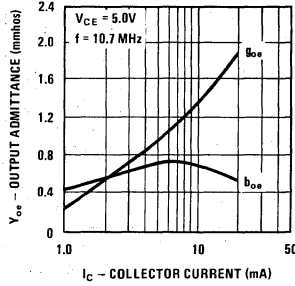


COMMON EMITTER Y PARAMETERS

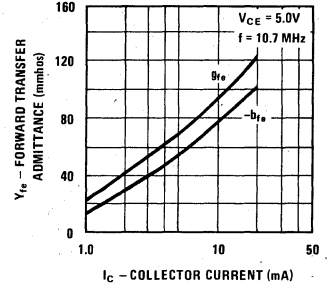
Input Admittance vs Collector Current



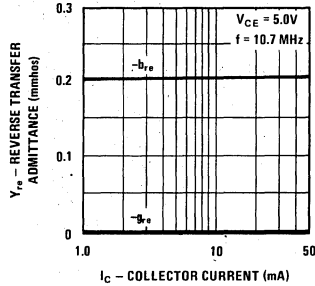
Output Admittance vs Collector Current



Forward Transfer Admittance vs Collector Current

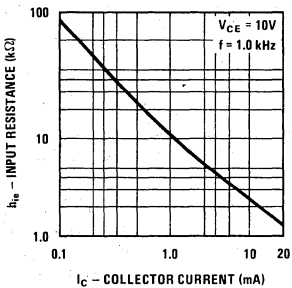


Reverse Transfer Admittance vs Collector Current

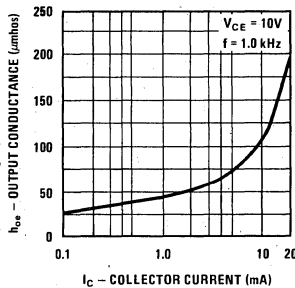


COMMON EMITTER H PARAMETERS

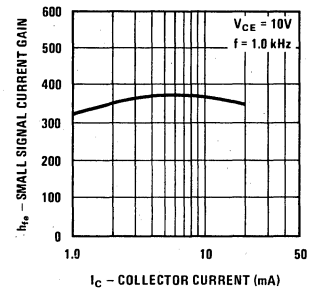
Small Signal Input Resistance vs Collector Current



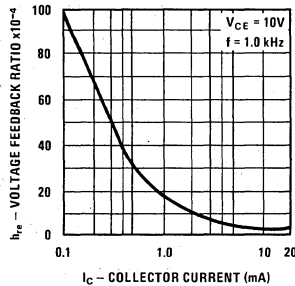
Small Signal Output Conductance vs Collector Current

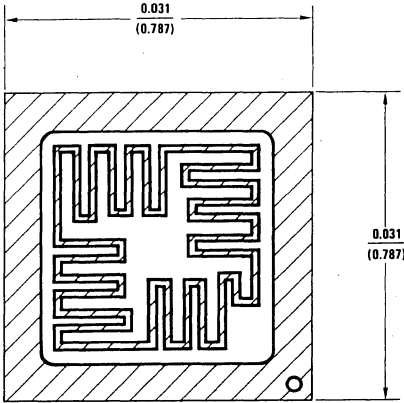


Small Signal Current Gain vs Collector Current



Small Signal Voltage Feedback Ratio vs Collector Current




**DESCRIPTION**

Process 37 is a double-diffused, silicon epitaxial planar device. Complement to Process 77.

**APPLICATION**

This device was designed for general purpose medium power amplifiers and switching circuits that require collector currents to 2A.

**PRINCIPAL DEVICE TYPES**

**TO-202, EBC:** NSD102, 103  
NSDU01, 01A  
NSDU02

**TO-202, BCE:** NSE180

**TO-237, EBC:** 2N6714, 15  
(92PU01, 01A)

**TO-237, ECB:** NA21/31 Series

**TO-126, ECB:** MJE180

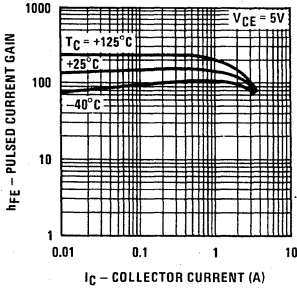
MJE720

**TO-92, EBC:** ED1702

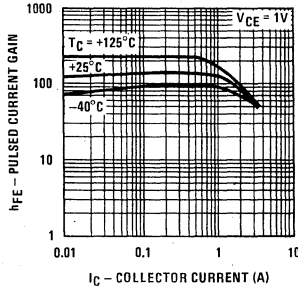
Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 10 \text{ mA}$	25			V
$BV_{CBO}$	$I_C = 100 \mu\text{A}$	40			V
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	5			V
$I_{CBO}$	$V_{CB} = 20\text{V}$			100	nA
$I_{EBO}$	$V_{EB} = 4\text{V}$			100	nA
$h_{FE}$	$I_C = 100 \text{ mA}, V_{CE} = 1\text{V}$	60	160	360	
$h_{FE}$	$I_C = 1\text{A}, V_{CE} = 1\text{V}$	40			
$V_{CE(SAT)}$	$I_C = 1\text{A}, I_B = 0.1\text{A}$			0.5	V
$V_{BE(SAT)}$	$I_C = 1\text{A}, I_B = 0.1\text{A}$			1.25	V
$f_T$	$I_C = 100 \text{ mA}, V_{CE} = 10\text{V}$	150	300		MHz
$C_{ob}$	$V_{CB} = 10\text{V}, f = 1 \text{ MHz}$		17	20	pF
$P_{D(max)}$					
TO-126	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	15 1.5			W
TO-202	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	10 2			W
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	2 850			W mW
TO-92	$T_A = 25^\circ\text{C}$	600			mW
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$				$^\circ\text{C/W}$
TO-126	$T_C = 25^\circ\text{C}$			8.33	$^\circ\text{C/W}$
TO-202	$T_C = 25^\circ\text{C}$			12.5	$^\circ\text{C/W}$
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
TO-202	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-237	$T_A = 25^\circ\text{C}$			147	$^\circ\text{C/W}$
TO-92	$T_A = 25^\circ\text{C}$			208	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$



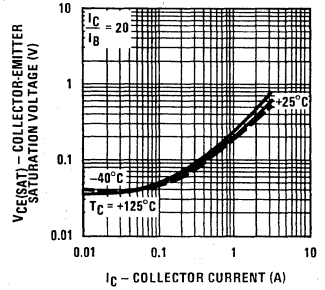
Typical Pulsed Current Gain vs Collector Current



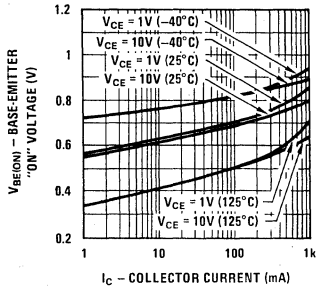
Typical Pulsed Current Gain vs Collector Current



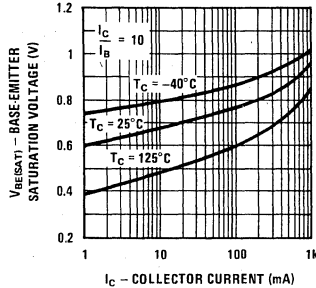
Collector-Emitter Saturation Voltage vs Collector Current



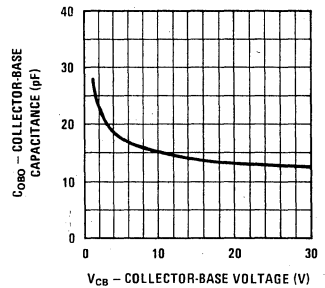
Base-Emitter ON Voltage vs Collector Current



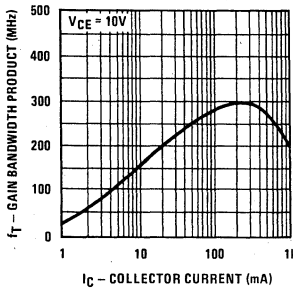
Base-Emitter Saturation Voltage vs Collector Current



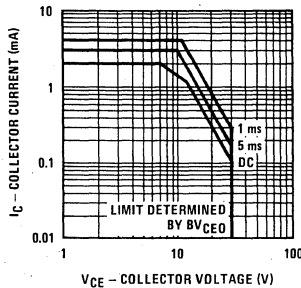
Collector-Base Capacitance vs Collector-Base Voltage



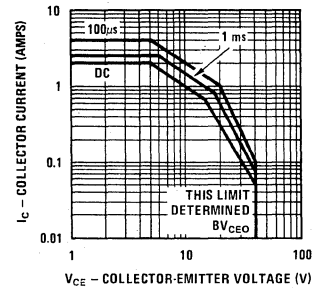
Gain Bandwidth Product vs Collector Current



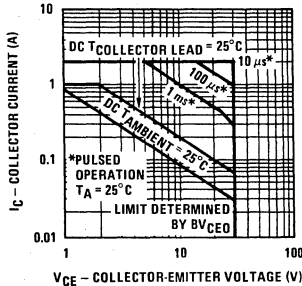
Safe Operating Area TO-126



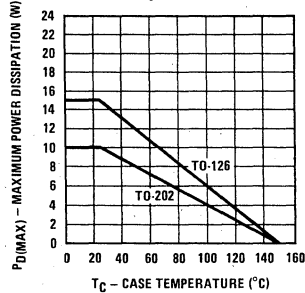
Safe Operating Area TO-202



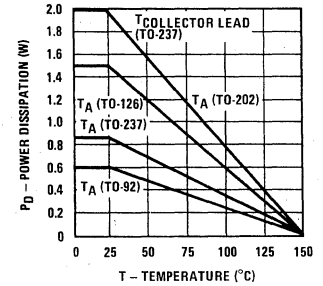
Safe Operating Area TO-237



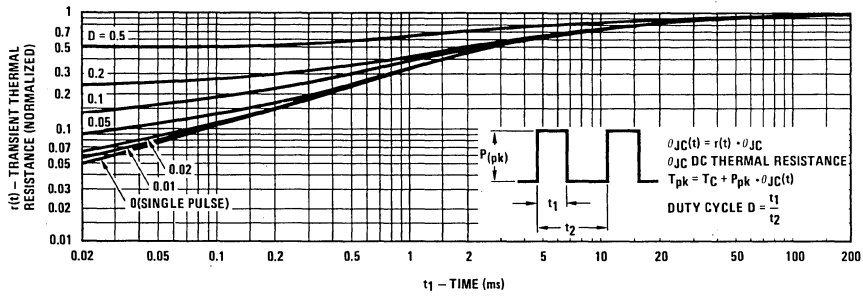
Maximum Power Dissipation vs Case Temperature



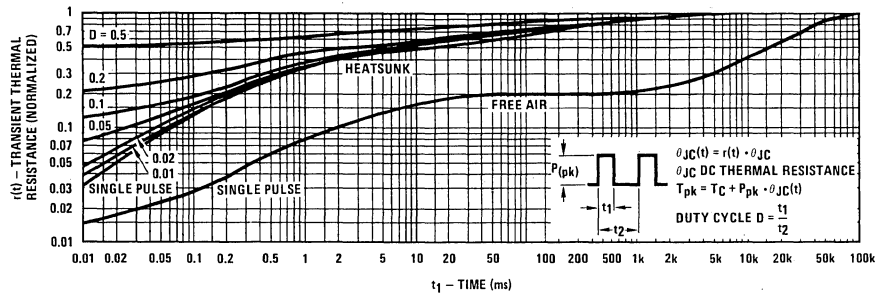
Thermal Derating Curve



Thermal Response in TO-126 Package

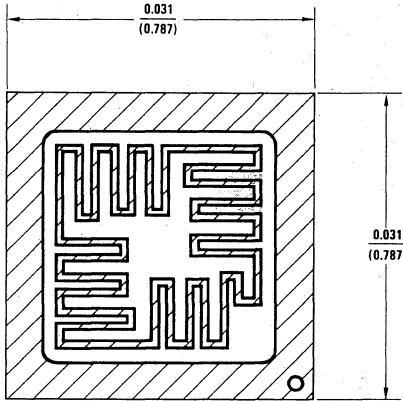


Thermal Response in TO-202 Package





## Process 38 NPN Medium Power



### DESCRIPTION

Process 38 is a double-diffused, silicon epitaxial planar device. Complement to Process 78.

### APPLICATION

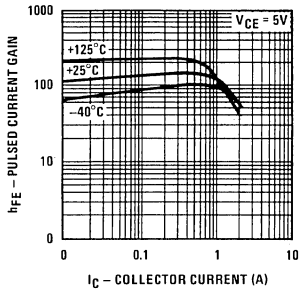
This device was designed for general purpose medium power amplifier and switching circuits that require collector currents to 1.5A.

### PRINCIPAL DEVICE TYPES

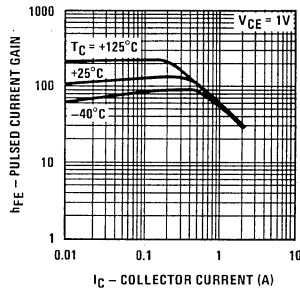
<b>TO-202, EBC:</b> 2N6551	<b>TO-237, ECB:</b> 2N6705, 6
D40D1-14	(92PE37A, B)
D40E5, 7	
<b>TO-126, ECB:</b> BDE345	
NSD102, 103	
NSDU05	MJE181
	MJE721
<b>TO-202, BCE:</b> NSE180, 181	
<b>TO-237, EBC:</b> 2N6716	
(92PU05)	

Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 10 \text{ mA}$	40			V
$BV_{CBO}$	$I_C = 100 \mu\text{A}$	65			V
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	5			V
$I_{CBO}$	$V_{CB} = 40\text{V}$			100	nA
$I_{EBO}$	$V_{EB} = 4\text{V}$			100	nA
$h_{FE}$	$I_C = 100 \text{ mA}, V_{CE} = 1\text{V}$	60	160	360	
$h_{FE}$	$I_C = 1\text{A}, V_{CE} = 1\text{V}$	20			
$V_{CE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			0.5	V
$V_{BE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			1.25	V
$f_T$	$I_C = 100 \text{ mA}, V_{CE} = 10\text{V}$	125	250		MHz
$C_{ob}$	$V_{CB} = 10\text{V}, f = 1 \text{ MHz}$		14	18	pF
$P_{D(max)}$					
TO-126	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	15 1.5			W
TO-202	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	10 2			W
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	2 850			W mW
TO-92	$T_C = 25^\circ\text{C}$	600			mW
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$				$^\circ\text{C/W}$
TO-126	$T_C = 25^\circ\text{C}$			8.33	$^\circ\text{C/W}$
TO-202	$T_C = 25^\circ\text{C}$			12.5	$^\circ\text{C/W}$
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
TO-202	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-237	$T_A = 25^\circ\text{C}$			147	$^\circ\text{C/W}$
TO-92	$T_A = 25^\circ\text{C}$			208	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$

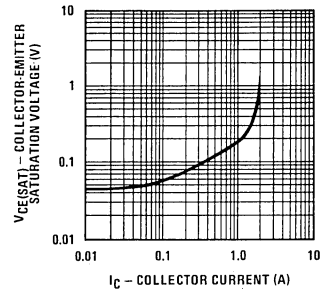
Typical Pulsed Current Gain vs Collector Current



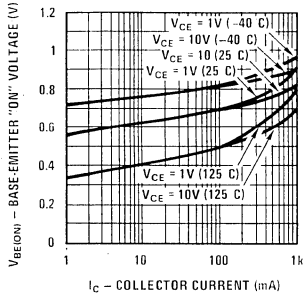
Typical Pulsed Current Gain vs Collector Current



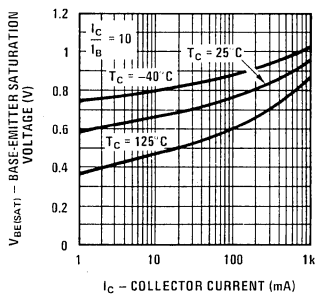
Collector-Emitter Saturation Voltage vs Collector Current



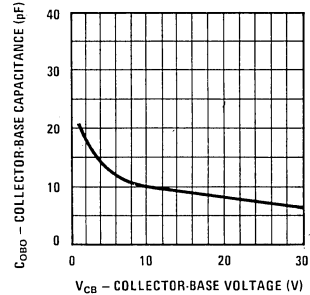
Base-Emitter ON Voltage vs Collector Current



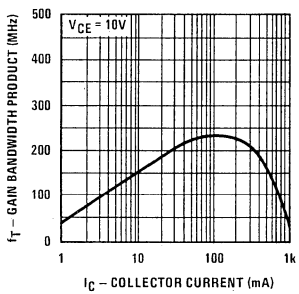
Base-Emitter Saturation Voltage vs Collector Current



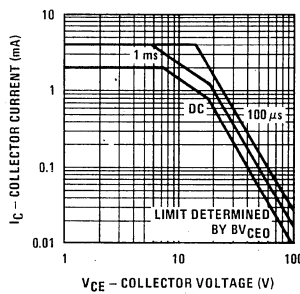
Collector-Base Capacitance vs Collector-Base Voltage



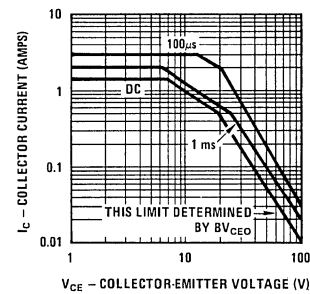
Gain Bandwidth Product vs Collector Current



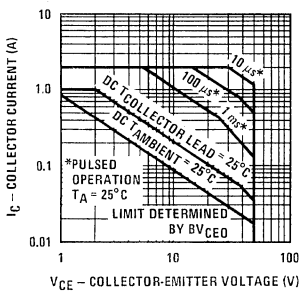
Safe Operating Area TO-126



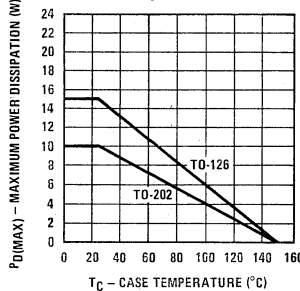
Safe Operating Area TO-202



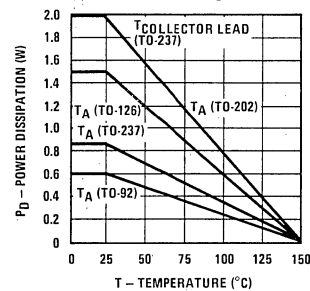
Safe Operating Area TO-237



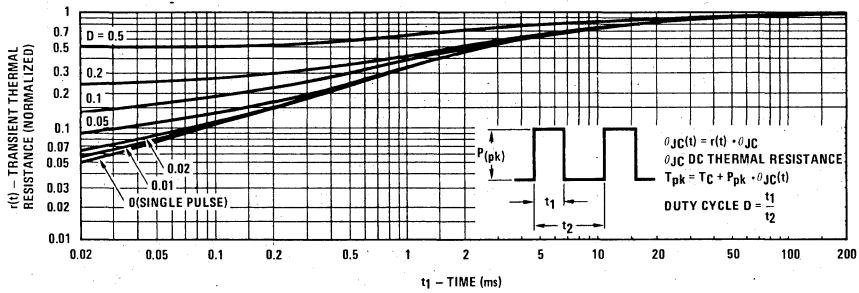
Maximum Power Dissipation vs Case Temperature



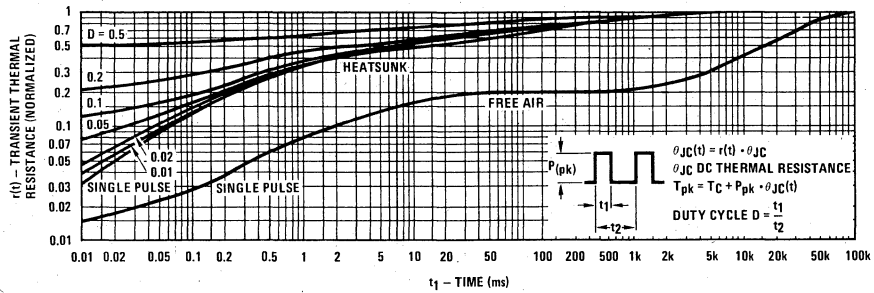
Thermal Derating Curve

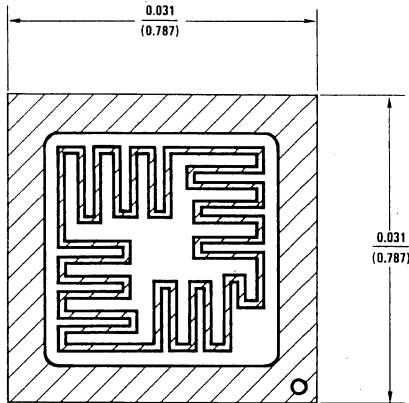


Thermal Response in TO-126 Package



Thermal Response in TO-202 Package




**DESCRIPTION**

Process 39 is a double-diffused, silicon epitaxial planar device. Complement to Process 79.

**APPLICATION**

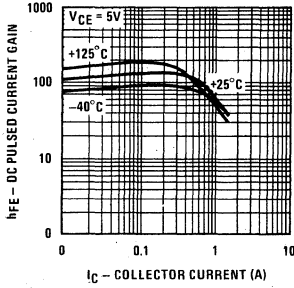
This device was designed for general purpose medium power amplifier and switching circuits that require collector currents to 1A.

**PRINCIPAL DEVICE TYPES**

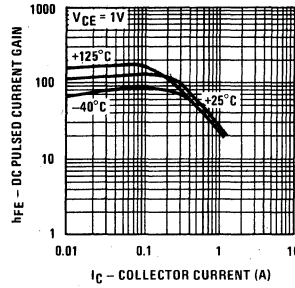
- TO-202, EBC:** 2N6552, 3  
NSD104-106  
NSDU07
- TO-237, EBC:** 2N6717, 18  
(92PU06, 07)
- TO-237, ECB:** 2N6707  
(92PE37C)

Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 10 \text{ mA}$	80			V
$BV_{CBO}$	$I_C = 100 \mu\text{A}$	100			V
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	5			V
$I_{CBO}$	$V_{CB} = 80\text{V}$			100	nA
$I_{EBO}$	$V_{EB} = 4\text{V}$			100	nA
$h_{FE}$	$I_C = 100 \text{ mA}, V_{CE} = 1\text{V}$	50		300	
$h_{FE}$	$I_C = 500 \text{ mA}, V_{CE} = 1\text{V}$	20			
$V_{CE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			0.8	V
$V_{BE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			1.3	V
$f_T$	$I_C = 100 \text{ mA}, V_{CE} = 10\text{V}$	80	150		MHz
$C_{ob}$	$V_{CB} = 10\text{V}, f = 1 \text{ MHz}$		10	15	pF
$P_{D(max)}$					
TO-126	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	15			W
TO-202	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	10			W
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	2			W
TO-92	$T_A = 25^\circ\text{C}$	850			mW
		600			mW
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$				$^\circ\text{C/W}$
TO-126	$T_C = 25^\circ\text{C}$			8.33	$^\circ\text{C/W}$
TO-202	$T_C = 25^\circ\text{C}$			12.5	$^\circ\text{C/W}$
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
TO-202	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-237	$T_A = 25^\circ\text{C}$			147	$^\circ\text{C/W}$
TO-92	$T_A = 25^\circ\text{C}$			208	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$

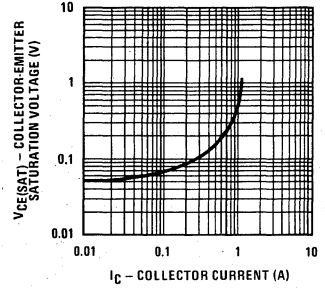
Typical Pulsed Current Gain vs Collector Current



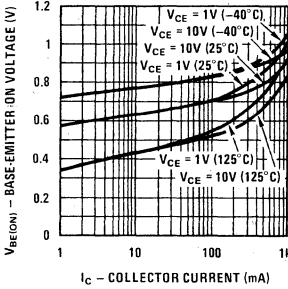
Typical Pulsed Current Gain vs Collector Current



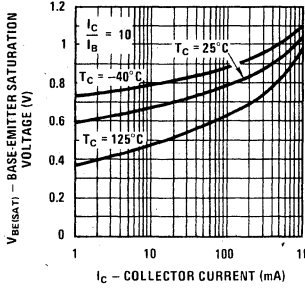
Collector-Emitter Saturation Voltage vs Collector Current



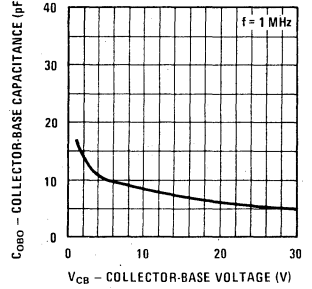
Base-Emitter ON Voltage vs Collector Current



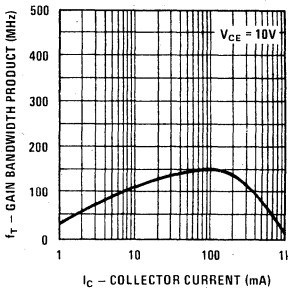
Base-Emitter Saturation Voltage vs Collector Current



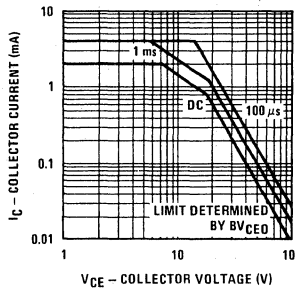
Collector-Base Capacitance vs Collector-Base Voltage



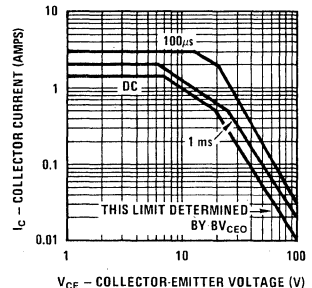
Gain Bandwidth Product vs Collector Current



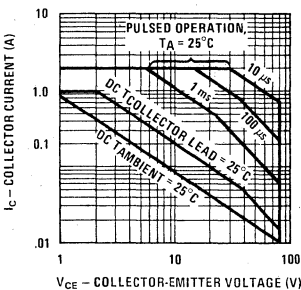
Safe Operating Area TO-126



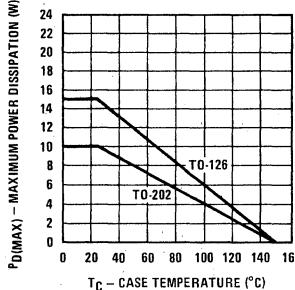
Safe Operating Area TO-202



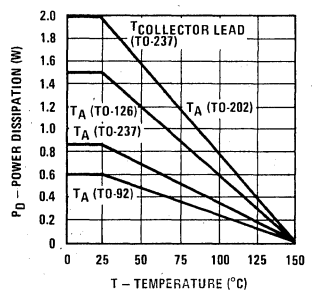
Safe Operating Area TO-237



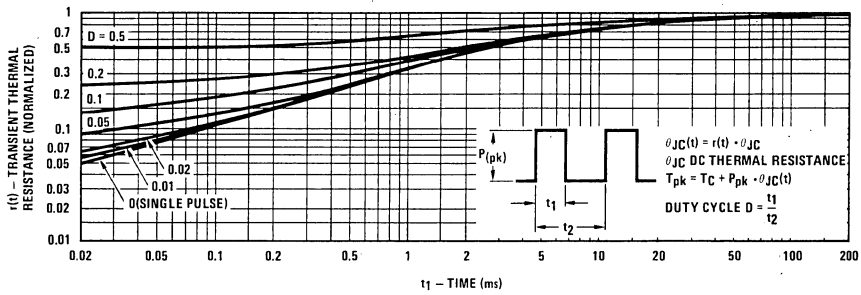
Maximum Power Dissipation vs Case Temperature



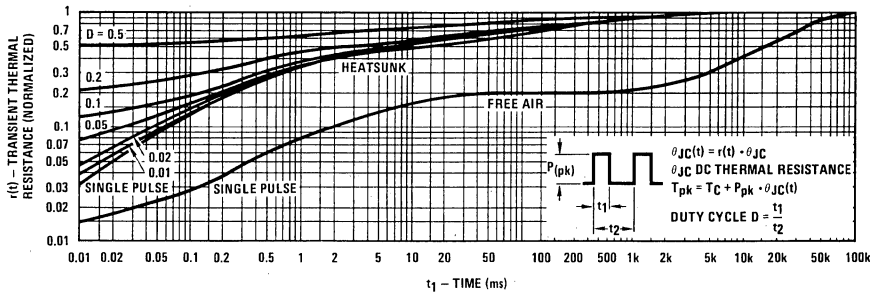
Thermal Derating Curve



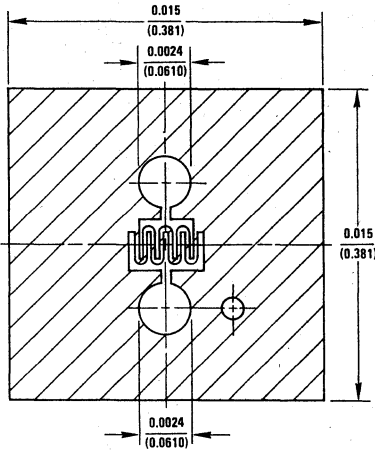
Thermal Response in TO-126 Package



Thermal Response in TO-202 Package







## DESCRIPTION

Process 40 is an overlay, double-diffused, silicon epitaxial device.

## APPLICATION

This device was designed for use in low noise UHF/VHF amplifiers with collector current in the 100  $\mu$ A to 20 mA range in common emitter or common base mode of operation, and in low frequency drift, high output UHF oscillators.

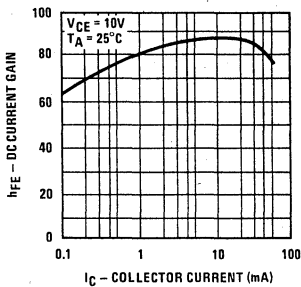
## PRINCIPAL DEVICE TYPES

TO-72

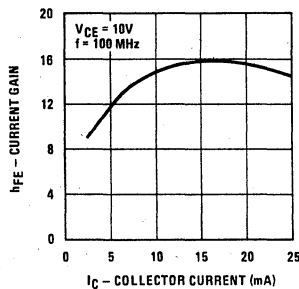
TO-92

Parameter	Conditions	Min	Typ	Max	Units	Notes
$P_G$	$f = 450 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 2 \text{ mA}$	12	16		dB	Figure 1
NF	$f = 450 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 2 \text{ mA}, R_G = 50\Omega$		3.0	5.0	dB	Figure 1
$P_{OUT}$	$f = 500 \text{ MHz}, V_{CB} = 15\text{V}, I_E = 10 \text{ mA}$	40	65		mW	TO-92 Figure 2
$h_{fe}$	$f = 100 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 10 \text{ mA}$	10	15			
$rb'_{CC}$	$f = 79.8 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 5 \text{ mA}$			10	ps	
$C_{CB}$	$f = 1.0 \text{ MHz}, V_{CB} = 10\text{V}, I_E = 0$		0.5	0.6	pF	TO-72
$C_{CE}$	$f = 1.0 \text{ MHz}, V_{CE} = 10\text{V}, I_B = 0$		0.2	0.3	pF	TO-72
$C_{EB}$	$f = 1.0 \text{ MHz}, V_{EB} = 0.5\text{V}, I_C = 0$		0.8	1.5	pF	TO-72
$h_{FE}$	$V_{CE} = 10\text{V}, I_C = 5 \text{ mA}$	40	90	200		
$h_{FE}$	$V_{CE} = 6\text{V}, I_C = 1 \text{ mA}$	30				
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 5 \text{ mA}$			0.2	V	
$BV_{CEO}$	$I_C = 1 \text{ mA}$	20			V	
$BV_{CBO}$	$I_C = 10 \mu\text{A}$	30			V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	4.0			V	
$I_{CBO}$	$V_{CB} = 20\text{V}$			100	nA	
$I_{EBO}$	$V_{EB} = 3\text{V}$			100	nA	

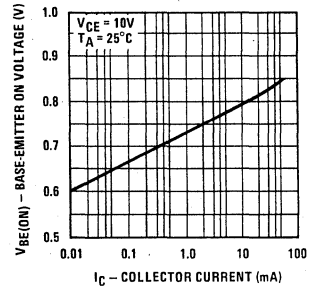
**DC Current Gain vs Collector Current**



**Current Gain at 100 MHz vs Collector Current**

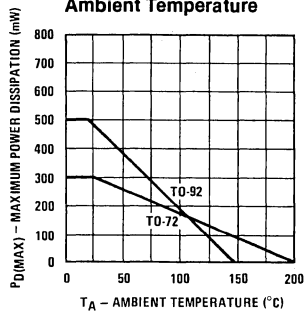


**Base-Emitter ON Voltage vs Collector Current**

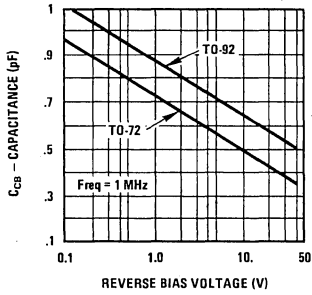


# Process 40

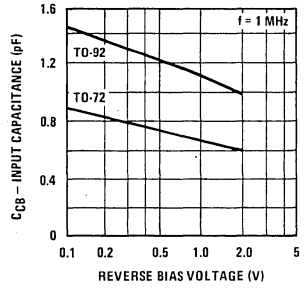
**Maximum Power Dissipation vs Ambient Temperature**



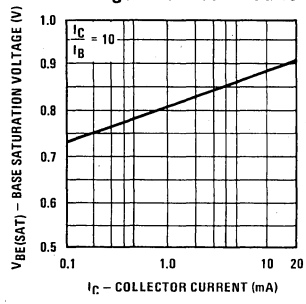
**Reverse Transfer Capacitance vs Reverse Bias Voltage**



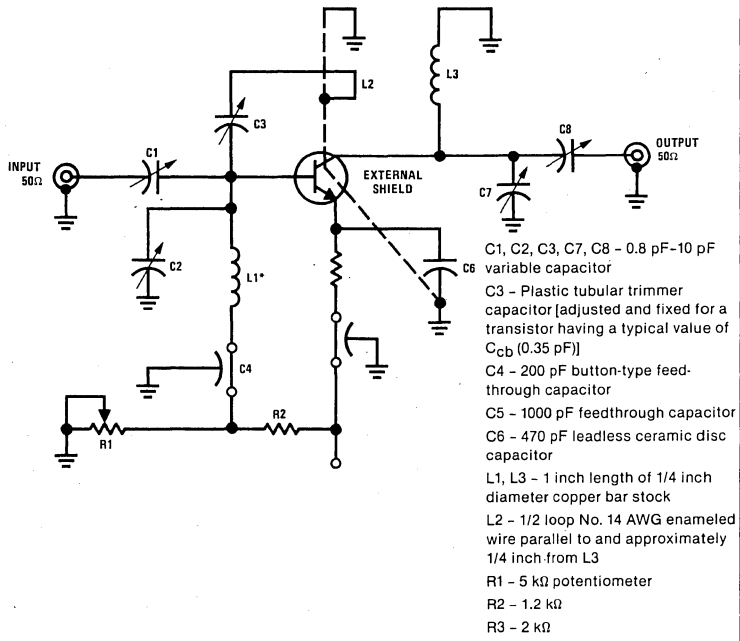
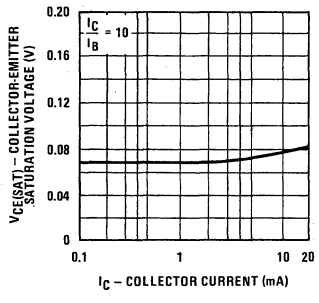
**Input Capacitance vs Reverse Bias Voltage**



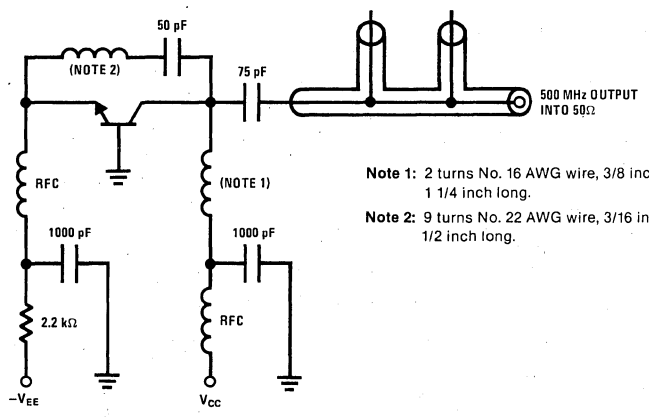
**Base-Emitter Saturation Voltage vs Collector Current**



**Collector-Emitter Saturation Voltage vs Collector Current**

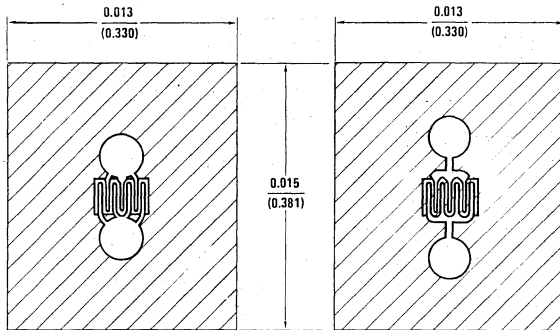


**FIGURE 1. Neutralized 450 MHz Gain and Noise Figure Circuit**



- Note 1:** 2 turns No. 16 AWG wire, 3/8 inch OD, 1 1/4 inch long.
- Note 2:** 9 turns No. 22 AWG wire, 3/16 inch OD, 1/2 inch long.

**FIGURE 2. 500 MHz Oscillator Circuit**



### DESCRIPTION

Process 41 is an overlay, double-diffused, silicon epitaxial device.

### APPLICATION

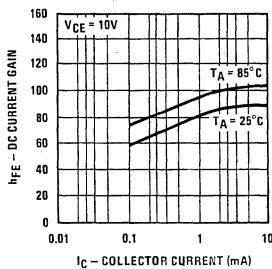
This device was designed for use in extremely low noise UHF/VHF preamplifiers operated common emitter or common base, and in UHF mixers.

### PRINCIPAL DEVICE TYPES

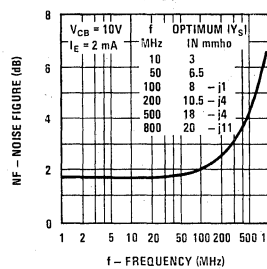
TO-72  
TO-92

Parameter	Conditions	Min	Typ	Max	Units	Notes
NF	f = 800 MHz, V <sub>CB</sub> = 10V, I <sub>C</sub> = 2 mA, Common Base,  Y <sub>S</sub>   = Optimum		5.5		dB	TO-72
NF	f = 800 MHz, V <sub>CB</sub> = 10V, I <sub>C</sub> = 2 mA, Common Base,  Y <sub>S</sub>   = 10 ± 10 mmhos		7.0	9.5	dB	TO-72
P <sub>G</sub>	f = 800 MHz, V <sub>CB</sub> = 10V, I <sub>C</sub> = 2 mA, Common Base, R <sub>L</sub> = 500Ω	7.5	9.0		dB	TO-72
NF	f = 450 MHz, V <sub>CE</sub> = 10V, I <sub>C</sub> = 2 mA, Common Emitter, R <sub>S</sub> = 75Ω		2.0		dB	TO-72
NF	f = 200 MHz, V <sub>CB</sub> = 10V, I <sub>C</sub> = 3 mA, Common Base, R <sub>S</sub> = 100Ω		2.5	3.0	dB	Figure 1
P <sub>G</sub>	f = 200 MHz, V <sub>CB</sub> = 10V, I <sub>C</sub> = 3 mA, Common Base, R <sub>L</sub> = 1 kΩ	13	16		dB	Figure 1
rb'Cc	f = 79.8 MHz, V <sub>CB</sub> = 10V, I <sub>C</sub> = 3 mA		2.5	5.0	ps	TO-72
h <sub>fe</sub>	f = 100 MHz, V <sub>CE</sub> = 10V, I <sub>C</sub> = 3 mA	7.0	8.5			
C <sub>CB</sub>	f = 1.0 MHz, V <sub>CB</sub> = 10V, I <sub>E</sub> = 0		0.28	0.35	pF	TO-72
C <sub>CE</sub>	f = 1.0 MHz, V <sub>CE</sub> = 10V, I <sub>B</sub> = 0		0.12 0.19	0.20 0.30	pF	TO-72 TO-92
h <sub>FE</sub>	V <sub>CE</sub> = 10V, I <sub>C</sub> = 3 mA	30	75	200		
BV <sub>CEO</sub>	I <sub>C</sub> = 1 mA	20			V	
BV <sub>CB0</sub>	I <sub>C</sub> = 10 μA	30			V	
BV <sub>EBO</sub>	I <sub>E</sub> = 1 μA	3.0			V	
I <sub>CBO</sub>	V <sub>CB</sub> = 20V			100	nA	
I <sub>EBO</sub>	V <sub>EB</sub> = 2V			100	nA	

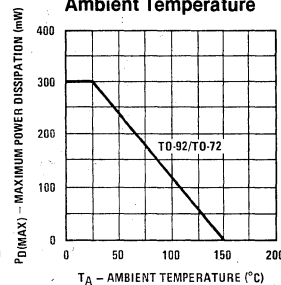
**DC Current Gain vs Collector Current**



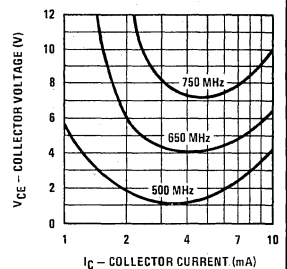
**Common Base Noise Figure vs Frequency at Optimum |Y<sub>S</sub>|**



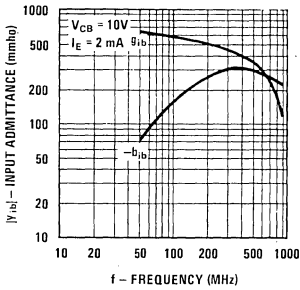
**Maximum Power Dissipation vs Ambient Temperature**



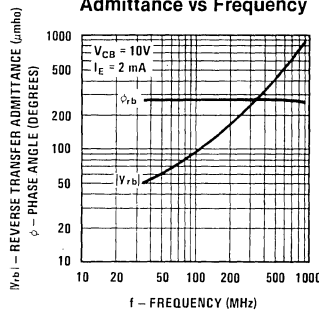
**Contours of Constant Gain Bandwidth Product (f<sub>T</sub>)**



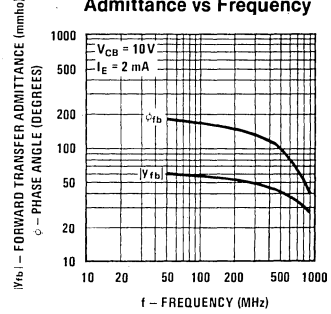
Input Admittance vs Frequency



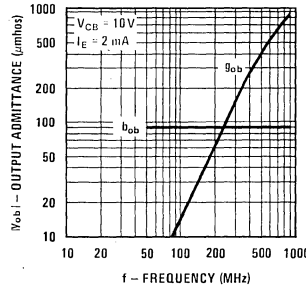
Reverse Transfer Admittance vs Frequency



Forward Transfer Admittance vs Frequency

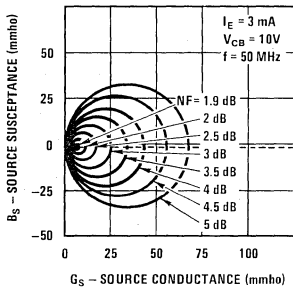


Output Admittance vs Frequency

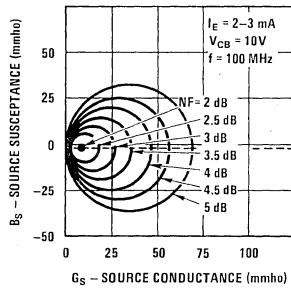


CONTOURS OF CONSTANT NOISE FIGURES

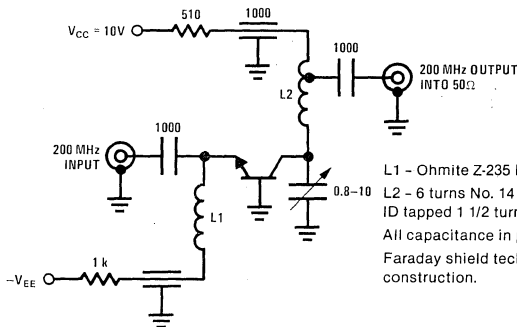
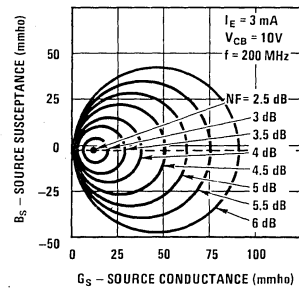
Common Base Noise Figure vs Source |Y\_S|



Common Base Noise Figure vs Source |Y\_S|

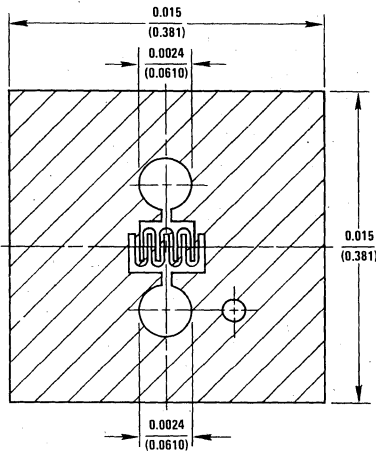


Common Base Noise Figure vs Source |Y\_S|



L1 - Ohmite Z-235 RF choke  
 L2 - 6 turns No. 14 wire, 1 inch L x 1/4 inch ID tapped 1 1/2 turns from cold side.  
 All capacitance in pF, all resistance in ohms.  
 Faraday shield techniques used in jig construction.

FIGURE 1. Common Base 200 MHz PG and NF Circuit



**DESCRIPTION**

Process 42 is an overlay, double-diffused, silicon epitaxial device.

**APPLICATION**

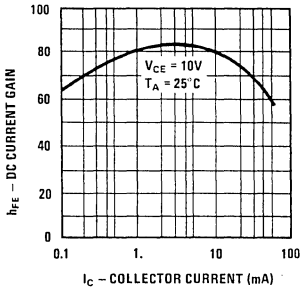
This device was designed for use in low noise UHF/VHF amplifiers with collector current in the 100  $\mu$ A to 10 mA range in common emitter or common base mode of operation, and in low frequency drift, high output UHF oscillators.

**PRINCIPAL DEVICE TYPES**

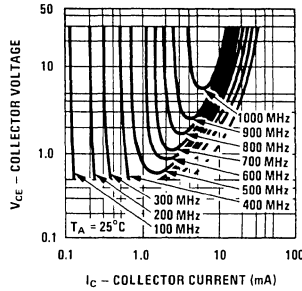
- TO-72:** 2N5179
- TO-92, ECB:** 2SC535
- TO-92, BEC:** MPS-H10

Parameter	Conditions	Min	Typ	Max	Units	Notes
$P_G$	$f = 450 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 2 \text{ mA}$	10	13		dB	Figure 1
NF	$f = 450 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 2 \text{ mA}, R_G = 50\Omega$		3.0	5.0	dB	Figure 1
$P_{OUT}$	$f = 500 \text{ MHz}, V_{CB} = 15\text{V}, I_E = 8 \text{ mA}$	30	50		mW	TO-92 Figure 3
$P_G$	$f = 200 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 2 \text{ mA}$	22	27		dB	Figure 2
NF	$f = 200 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 2 \text{ mA}, R_S = 120\Omega$		2.0	3.5	dB	Figure 2
$h_{fe}$	$f = 100 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 5 \text{ mA}$	6	10			
$rb'C_c$	$f = 79.8 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 5 \text{ mA}$			10	ps	
$C_{CB}$	$f = 1.0 \text{ MHz}, V_{CB} = 10\text{V}, I_E = 0$		0.4	0.5	pF	TO-72
$C_{CE}$	$f = 1.0 \text{ MHz}, V_{CE} = 10\text{V}, I_B = 0$		0.2	0.3	pF	TO-72
$C_{EB}$	$f = 1.0 \text{ MHz}, V_{EB} = 0.5\text{V}, I_C = 0$		0.8	1.5	pF	TO-72
$h_{FE}$	$V_{CE} = 10\text{V}, I_C = 5 \text{ mA}$	40	90	200		
$h_{FE}$	$V_{CE} = 6\text{V}, I_C = 1 \text{ mA}$	30				
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 5 \text{ mA}$			0.2	V	
$BV_{CEO}$	$I_C = 1 \text{ mA}$	30			V	
$BV_{CBO}$	$I_C = 10 \mu\text{A}$	35			V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	4			V	
$I_{CBO}$	$V_{CB} = 30\text{V}$			100	nA	
$I_{EBO}$	$V_{EB} = 3\text{V}$			100	nA	

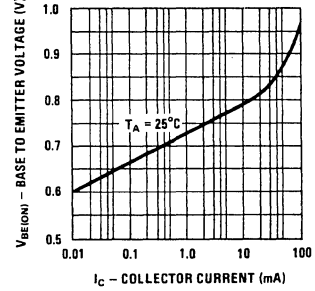
DC Current Gain vs Collector Current



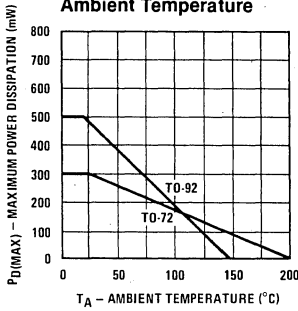
Contours of Constant Gain Bandwidth Product ( $f_T$ )



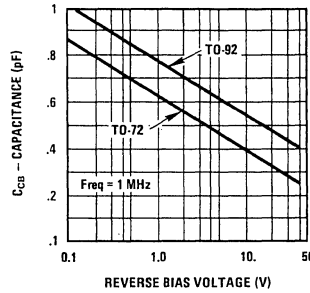
Base-Emitter ON Voltage vs Collector Current



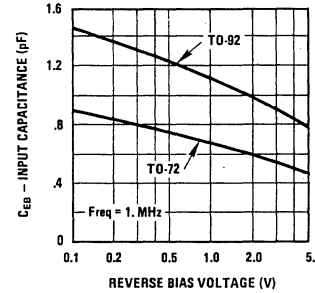
Maximum Power Dissipation vs Ambient Temperature



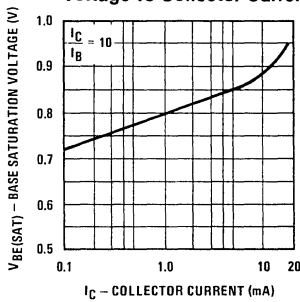
Reverse Transfer Capacitance vs Reverse Bias Voltage



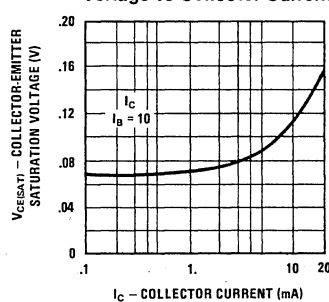
Input Capacitance vs Reverse Bias Voltage



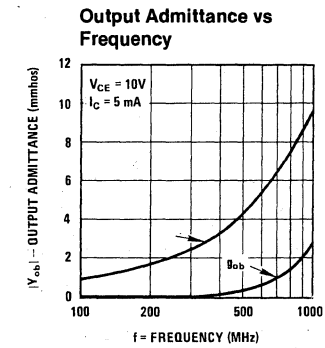
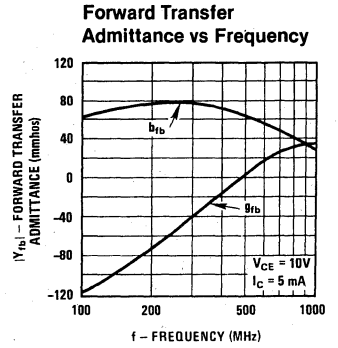
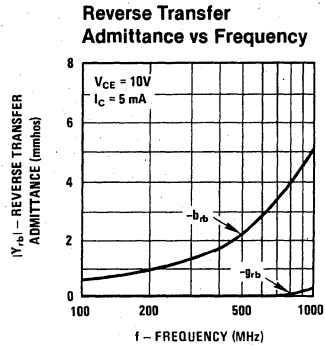
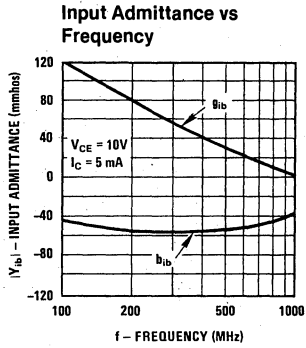
Base-Emitter Saturation Voltage vs Collector Current



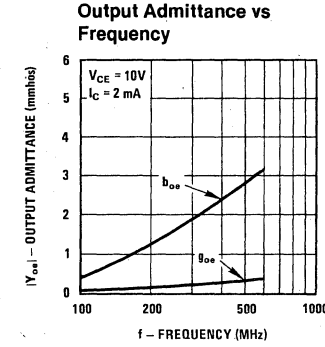
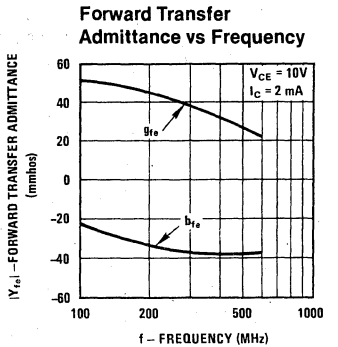
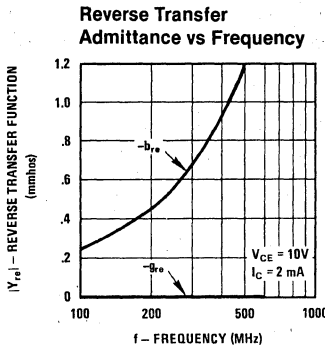
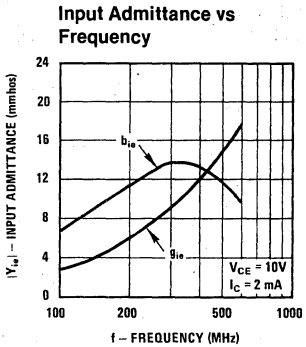
Collector-Emitter Saturation Voltage vs Collector Current

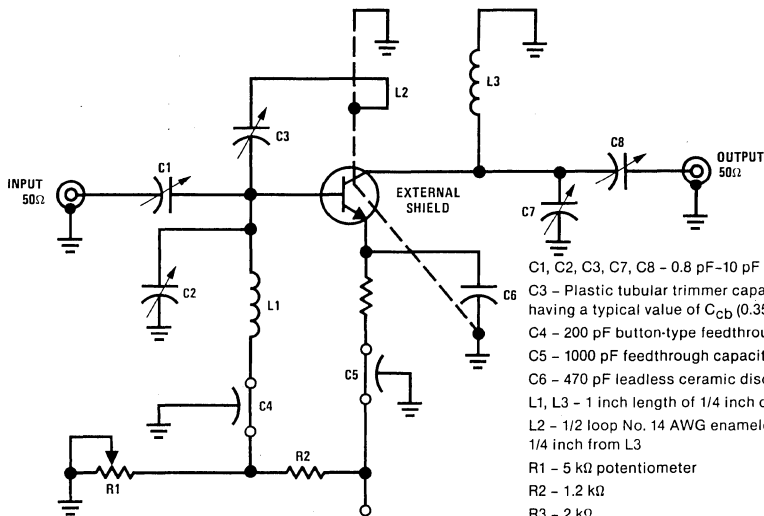


COMMON BASE Y PARAMETERS VS FREQUENCY



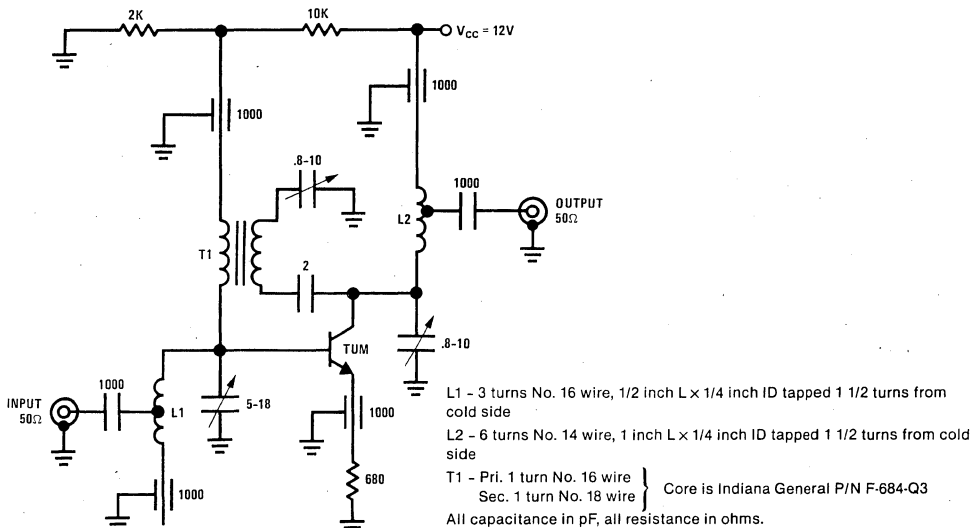
COMMON EMITTER Y PARAMETERS VS FREQUENCY





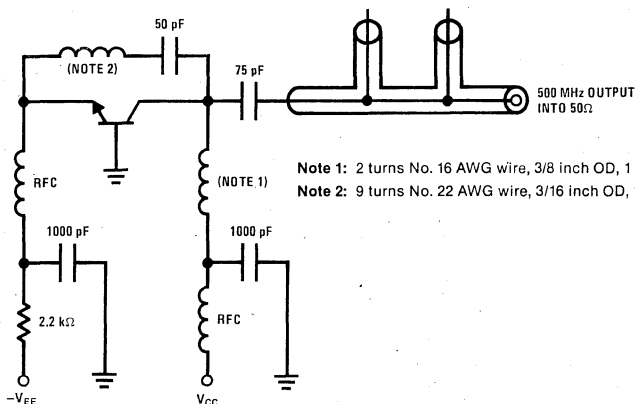
- C1, C2, C3, C7, C8 - 0.8 pF-10 pF variable capacitor
- C3 - Plastic tubular trimmer capacitor [adjusted and fixed for a transistor having a typical value of  $C_{cb}$  (0.35 pF)]
- C4 - 200 pF button-type feedthrough capacitor
- C5 - 1000 pF feedthrough capacitor
- C6 - 470 pF leadless ceramic disc capacitor
- L1, L3 - 1 inch length of 1/4 inch diameter copper bar stock
- L2 - 1/2 loop No. 14 AWG enameled wire parallel to and approximately 1/4 inch from L3
- R1 - 5 kΩ potentiometer
- R2 - 1.2 kΩ
- R3 - 2 kΩ

FIGURE 1. Neutralized 450 MHz Gain and Noise Figure Circuit



- L1 - 3 turns No. 16 wire, 1/2 inch L x 1/4 inch ID tapped 1 1/2 turns from cold side
- L2 - 6 turns No. 14 wire, 1 inch L x 1/4 inch ID tapped 1 1/2 turns from cold side
- T1 - Pri. 1 turn No. 16 wire } Core is Indiana General P/N F-684-Q3  
 Sec. 1 turn No. 18 wire }
- All capacitance in pF, all resistance in ohms.

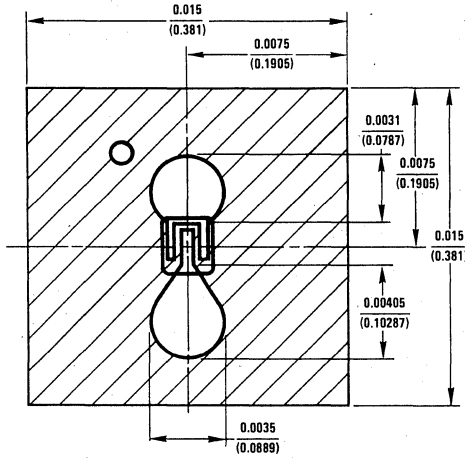
FIGURE 2. Neutralized 200 MHz PF and NF Circuit



- Note 1: 2 turns No. 16 AWG wire, 3/8 inch OD, 1 1/4 inch long.
- Note 2: 9 turns No. 22 AWG wire, 3/16 inch OD, 1/2 inch long.

FIGURE 3. 500 MHz Oscillator Circuit





**DESCRIPTION**

Process 43 is an overlay, double-diffused, silicon epitaxial device.

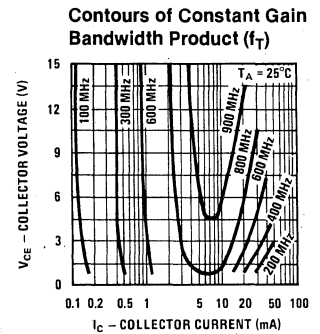
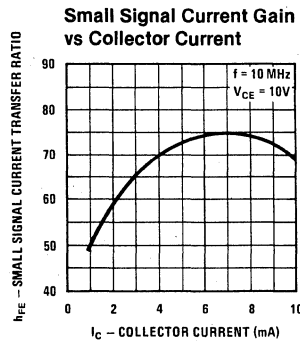
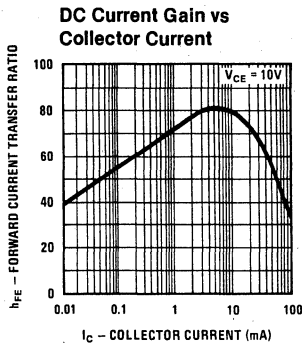
**APPLICATION**

This device was designed for use as RF amplifiers, oscillators and multipliers with collector current in the 1 mA to 2 mA range.

**PRINCIPAL DEVICE TYPES**

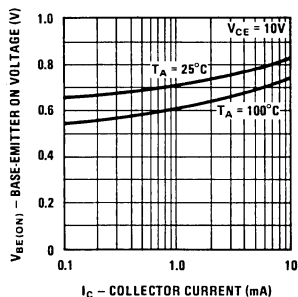
- TO-72: 2N918
- TO-92, EBC: PN3563
- PN5130
- TO-92, ECB: 2N3663

Parameter	Conditions	Min	Typ	Max	Units	Notes
$G_{PE}$	$f = 200 \text{ MHz}, I_C = 5 \text{ mA}, V_{CE} = 10 \text{ V}$	14	18		dB	Neutralized
NF	$f = 60 \text{ MHz}, I_C = 1 \text{ mA}, V_{CE} = 10 \text{ V}, R_S = 200 \Omega$		3.5	6.0	dB	
PO	$f = 500 \text{ MHz}, I_C = 8 \text{ mA}, V_{CE} = 15 \text{ V}$	20	35		mW	Figure 1
PO	$f = 900 \text{ MHz}, I_C = 8 \text{ mA}, V_{CE} = 15 \text{ V}$	3.0	8.0		mW	
$h_{fe}$	$I_C = 5 \text{ mA}, V_{CE} = 10 \text{ V}, f = 100 \text{ MHz}$	6.0	9.0			
$r_b/c_c$	$f = 79.8 \text{ MHz}, V_{CE} = 10 \text{ V}, I_E = 8 \text{ mA}$		10	25	ps	
$C_{CB}$	$V_{CB} = 10 \text{ V}, I_E = 0$		1.2	1.7	pF	
$C_{EB}$	$V_{EB} = 0.5 \text{ V}, I_C = 0$		1.4	2.0	pF	
$h_{FE}$	$I_C = 1 \text{ mA}, V_{CE} = 1 \text{ V}$	25				
$h_{FE}$	$I_C = 5 \text{ mA}, V_{CE} = 10 \text{ V}$	40	80	200		
$h_{FE}$	$I_C = 30 \text{ mA}, V_{CE} = 10 \text{ V}$	30				
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$		0.25		V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$		0.9		V	
$BV_{CEO}$	$I_C = 3 \text{ mA}$	15			V	
$BV_{CBO}$	$I_C = 10 \mu\text{A}$	30			V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	4			V	
$I_{CBO}$	$V_{CB} = 20 \text{ V}$			100	nA	
$I_{EBO}$	$V_{CB} = 3 \text{ V}$			100	nA	

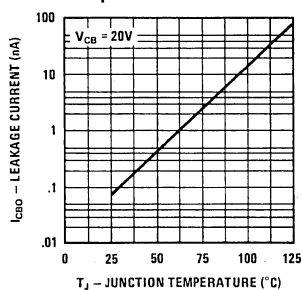


# Process 43

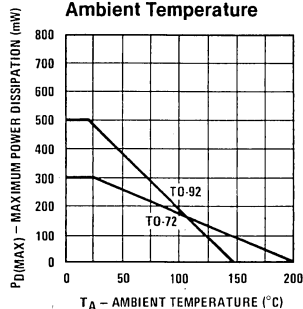
**Base-Emitter ON Voltage vs Collector Current**



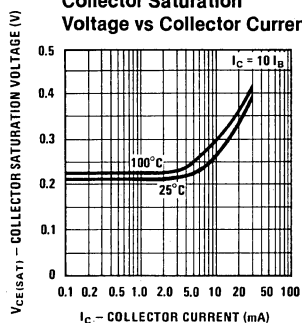
**Collector-Base Diode Reverse Current vs Temperature**



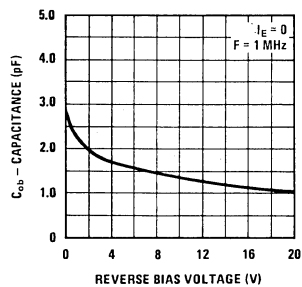
**Maximum Power Dissipation vs Ambient Temperature**



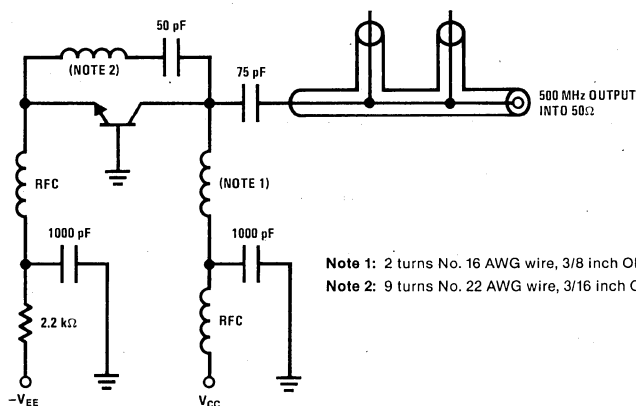
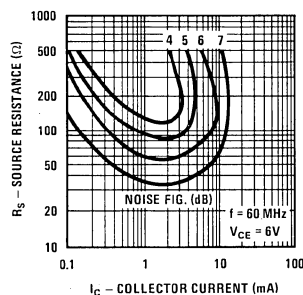
**Collector Saturation Voltage vs Collector Current**



**Output Capacitance vs Reverse Bias Voltage**



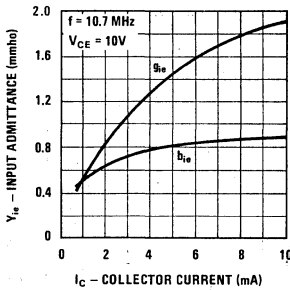
**Contours of Constant Noise Figure**



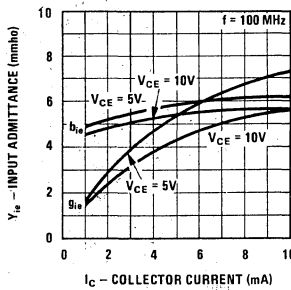
**Note 1:** 2 turns No. 16 AWG wire, 3/8 inch OD, 1 1/4 inch long.  
**Note 2:** 9 turns No. 22 AWG wire, 3/16 inch OD, 1/2 inch long.

**FIGURE 1. 500 MHz Oscillator Circuit**

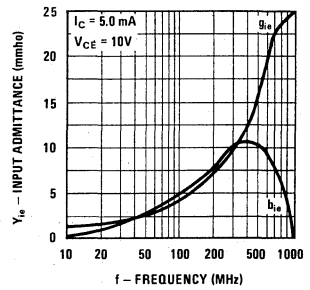
Input Admittance vs Collector Current-Output Short Circuit



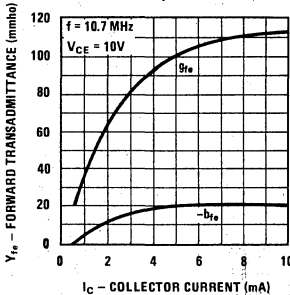
Input Admittance vs Collector Current-Output Short Circuit



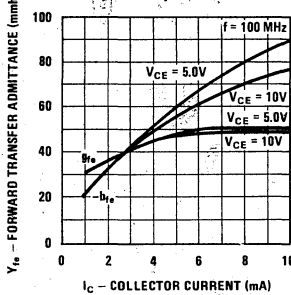
Input Admittance vs Frequency-Output Short Circuit



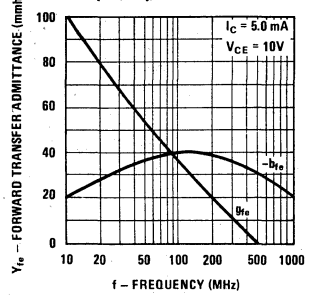
Forward Transfer Admittance vs Collector Current-Output Short Circuit



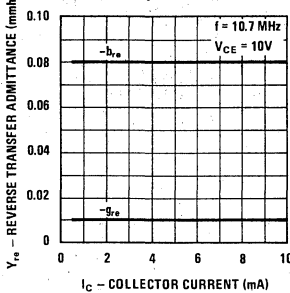
Forward Transfer Admittance vs Collector Current-Output Short Circuit



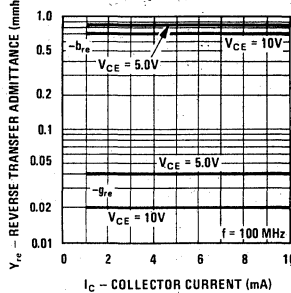
Forward Transfer Admittance vs Frequency-Output Open Circuit



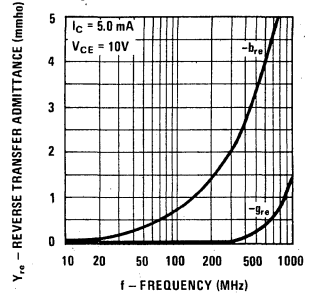
Reverse Transfer Admittance vs Collector Current-Input Short Circuit



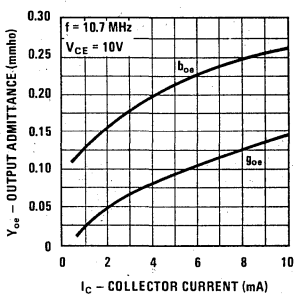
Reverse Transfer Admittance vs Collector Current-Input Short Circuit



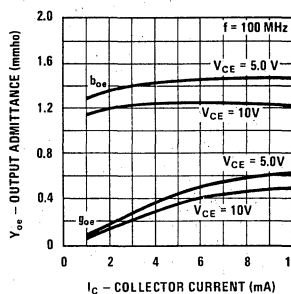
Reverse Transfer Admittance vs Frequency-Input Short Circuit



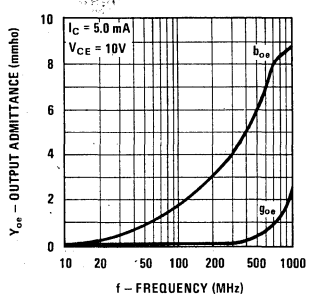
Output Admittance vs Collector Current-Input Short Circuit

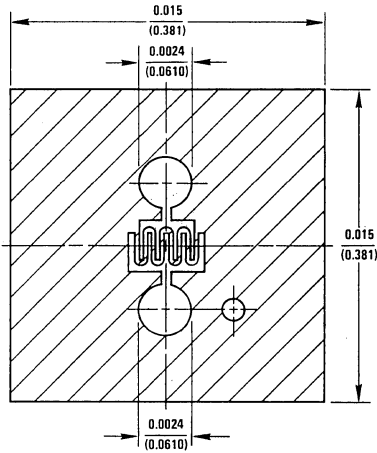


Output Admittance vs Collector Current-Input Short Circuit



Output Admittance vs Frequency-Input Short Circuit




**DESCRIPTION**

Process 44 is an overlay, double-diffused, silicon device.

**APPLICATION**

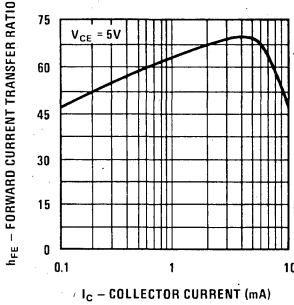
This device was designed for use as a low noise VHF amplifier with forward AGC capability.

**PRINCIPAL DEVICE TYPES**

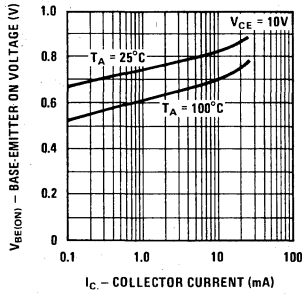
**TO-72:** SE5020  
**TO-92, BEC:** MPS6568  
 MPS-H30

Parameter	Conditions	Min	Typ	Max	Units	Notes
NF	$f = 200 \text{ MHz}$ , $I_C = 2 \text{ mA}$ , $V_{CE} = 10 \text{ V}$ , $R_S = 50 \Omega$		2.0	3.0	dB	Figure 1
$P_G$	$f = 200 \text{ MHz}$ , $I_C = 2 \text{ mA}$ , $V_{CE} = 10 \text{ V}$ , $R_S = 50 \Omega$	20	24		dB	Figure 1
NF	$f = 45 \text{ MHz}$ , $I_C = 4 \text{ mA}$ , $V_{CE} = 10 \text{ V}$ , $R_S = 50 \Omega$		3.0	5.0	dB	Figure 2
$P_G$	$f = 45 \text{ MHz}$ , $I_C = 4 \text{ mA}$ , $V_{CE} = 10 \text{ V}$ , $R_S = 50 \Omega$	23	26		dB	Figure 2
AGC	$f = 200 \text{ MHz}$ , $V_{AGC}$ at 30 dB Down	3.9	4.5	5.2	V	Figure 1
AGC	$f = 45 \text{ MHz}$ , $V_{AGC}$ at 30 dB Down	4.0	5.0	6.0	V	Figure 2
$C_{cb}$	$V_{CB} = 10 \text{ V}$ , $I_E = 0$		0.35	0.50	pF	TO-72
			0.45	0.55	pF	TO-92
$h_{fe}$	$V_{CE} = 10 \text{ V}$ , $I_C = 4 \text{ mA}$ , $f = 100 \text{ MHz}$	4.0	5.5			
$h_{FE}$	$I_C = 4 \text{ mA}$ , $V_{CE} = 5 \text{ V}$	30	70	200		
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}$ , $I_B = 5 \text{ mA}$		0.5	2.0	V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}$ , $I_B = 5 \text{ mA}$		0.85	0.95	V	
$BV_{CEO}$	$I_C = 1 \text{ mA}$	30			V	
$BV_{CBO}$	$I_C = 10 \mu\text{A}$	30			V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	4.0			V	
$I_{CBO}$	$V_{CB} = 20 \text{ V}$			100	nA	
$I_{EBO}$	$V_{EB} = 3 \text{ V}$			100	nA	

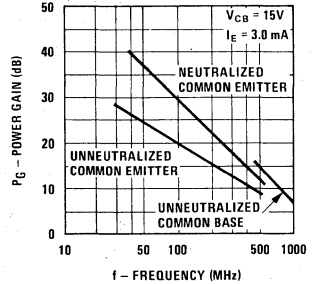
**Pulsed DC Current Gain vs Collector Current**



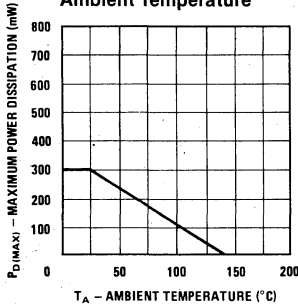
**Base-Emitter ON Voltage vs Collector Current**



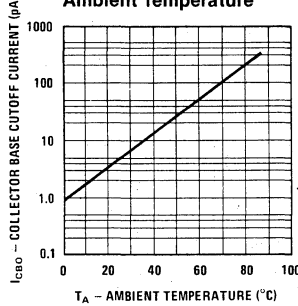
**Power Gain vs Frequency**



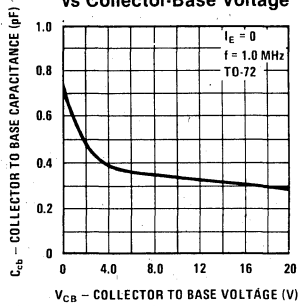
**Maximum Power Dissipation vs Ambient Temperature**



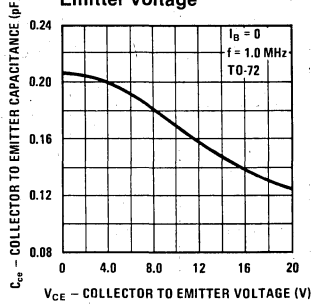
**Collector Cutoff Current vs Ambient Temperature**



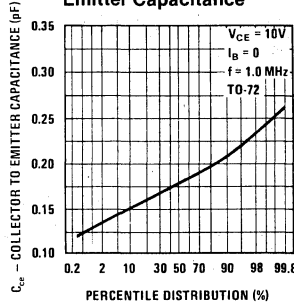
**Collector-Base Capacitance vs Collector-Base Voltage**



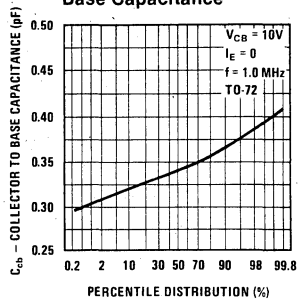
**Collector-Emitter Capacitance vs Collector-Emitter Voltage**



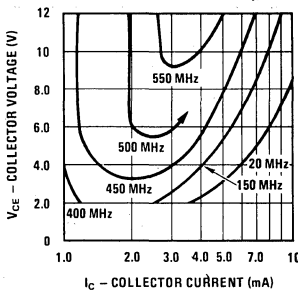
**Distribution of Collector-Emitter Capacitance**



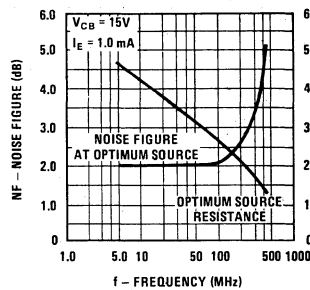
**Distribution of Collector-Base Capacitance**



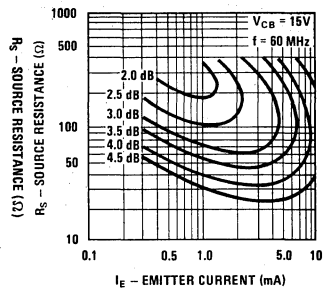
**Contours of Constant Gain Bandwidth Product (fT)**



**Noise Figure and Source Resistance vs Frequency**



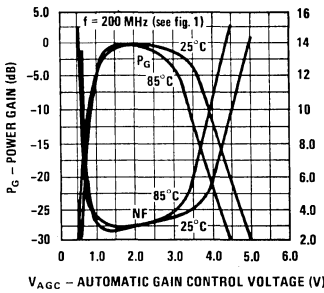
**Noise Figure vs Source Resistance and Collector Current**



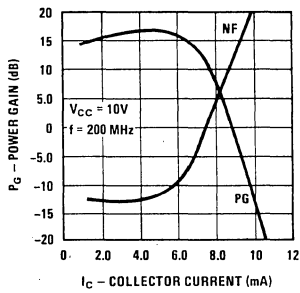
Process 44

COMMON EMITTER PERFORMANCE

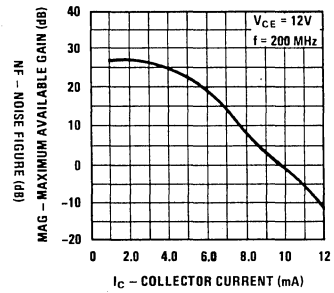
Power Gain and Noise Figure vs Automatic Gain Control Voltage



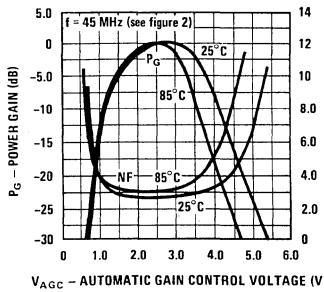
Power Gain and Noise Figure vs Collector Current



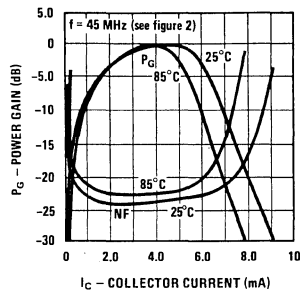
Maximum Available Gain vs Collector Current



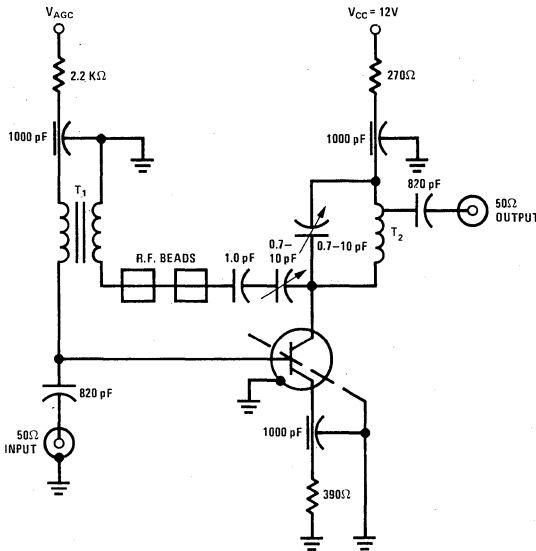
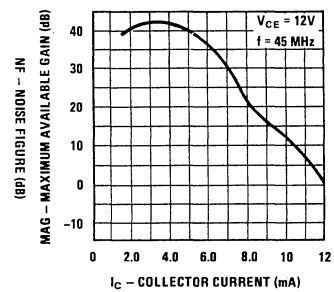
Power Gain and Noise Figure vs Automatic Gain Control Voltage



Power Gain and Noise Figure vs Collector Current

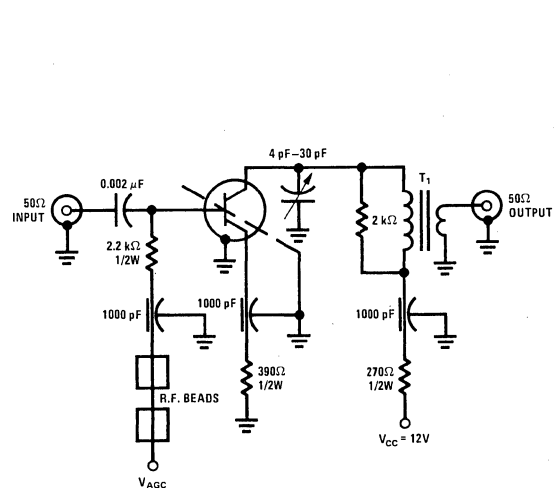


Maximum Available Gain vs Collector Current



T<sub>1</sub>-Ferrite Core Indiana Gen. Corp. F-684-Q3  
T<sub>2</sub>-6 turns No. 16 buss wire ID = 1/4 inch L = 3/4 inch

FIGURE 1. 200 MHz, AGC, Power Gain and Noise Figure Test Jig

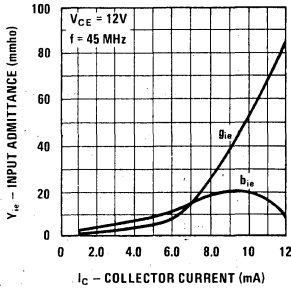


T<sub>1</sub>-Q3 Toroid 4:1 ratio  
8 turns-Pri. 2 turns-Sec. } No. 22 wire

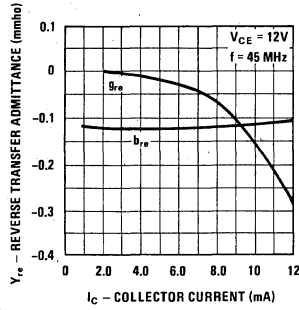
FIGURE 2. 45 MHz, AGC, Power Gain and Noise Figure Test Jig

COMMON EMITTER Y PARAMETERS VS FREQUENCY

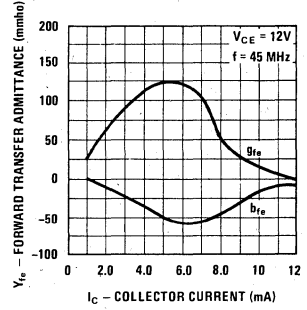
Input Admittance vs Collector Current-Output Short Circuit



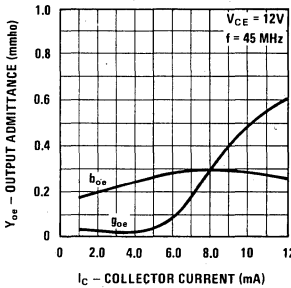
Reverse Transfer Admittance vs Collector Current-Input Short Circuit



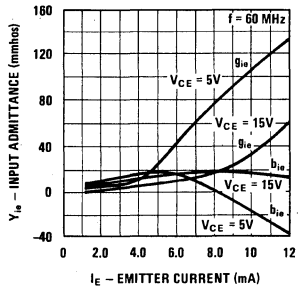
Forward Transfer Admittance vs Collector Current-Output Short Circuit



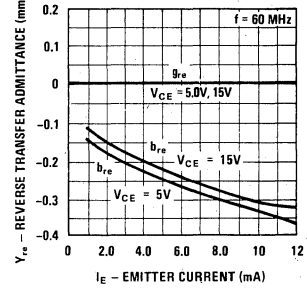
Output Admittance vs Collector Current-Input Short Circuit



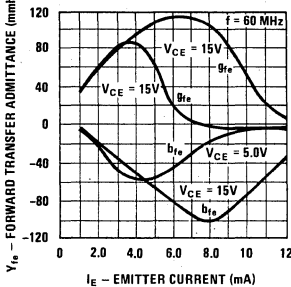
Input Admittance vs Emitter Current-Output Short Circuit



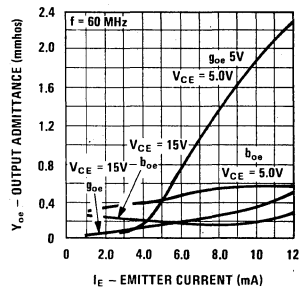
Reverse Transfer Admittance vs Emitter Current-Input Short Circuit



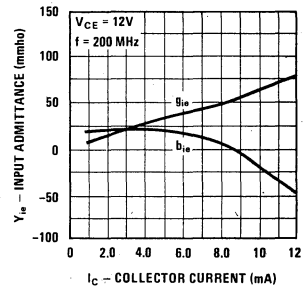
Forward Transfer Admittance vs Emitter Current-Output Short Circuit



Output Admittance vs Emitter Current-Input Short Circuit

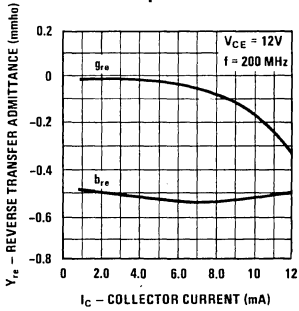


Input Admittance vs Collector Current-Output Short Circuit

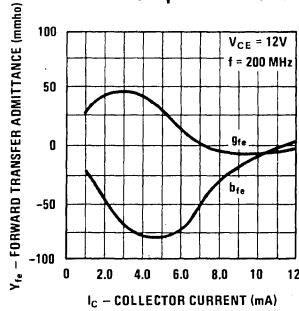


COMMON EMITTER Y PARAMETER VS FREQUENCY (Continued)

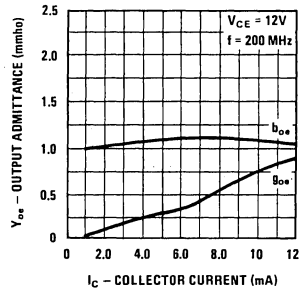
Reverse Transfer Admittance vs Collector Current-Input Short Circuit



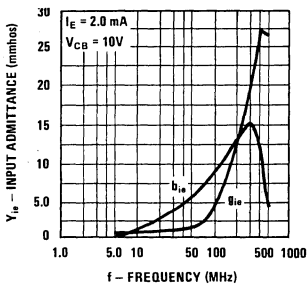
Forward Transfer Admittance vs Collector Current-Input Short Circuit



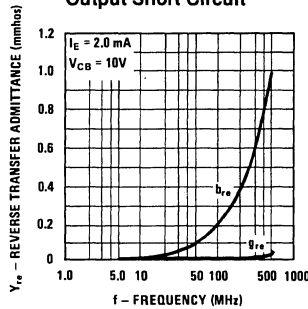
Output Admittance vs Collector Current-Input Short Circuit



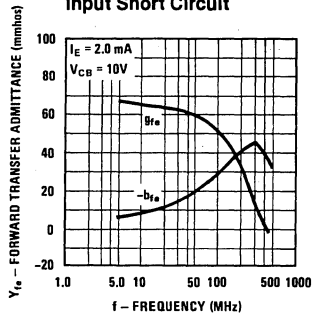
Input Admittance vs Frequency-Output Short Circuit



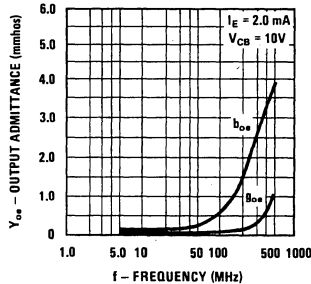
Reverse Transfer Admittance vs Frequency-Output Short Circuit



Forward Transfer Admittance vs Frequency-Input Short Circuit



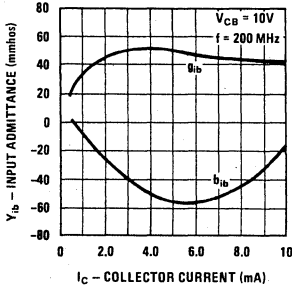
Output Admittance vs Frequency-Input Short Circuit



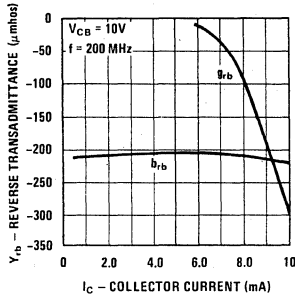


COMMON BASE Y PARAMETERS VS FREQUENCY

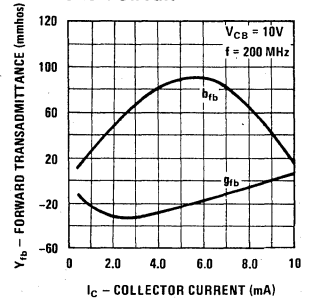
Input Admittance vs Collector Current-Output Short Circuit



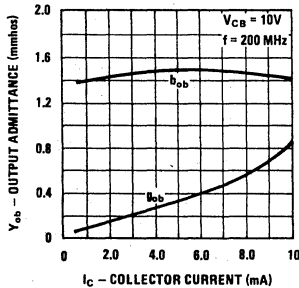
Reverse Transadmittance vs Collector Current-Input Short Circuit



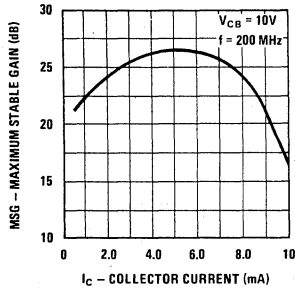
Forward Transadmittance vs Collector Current-Output Short Circuit



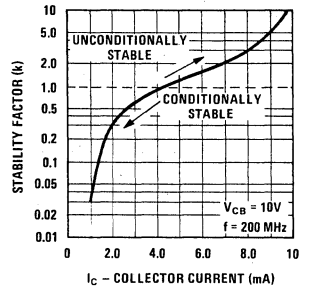
Output Admittance vs Collector Current-Input Short Circuit



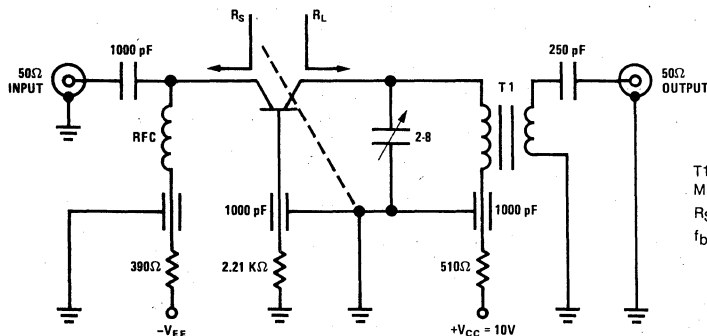
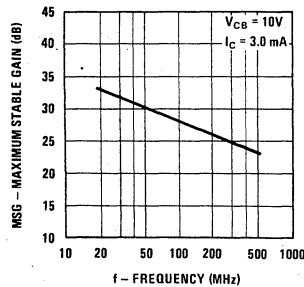
Maximum Stable Gain vs Collector Current Common Base Configuration



Common Base Configuration Stability Factor-k vs Collector Current

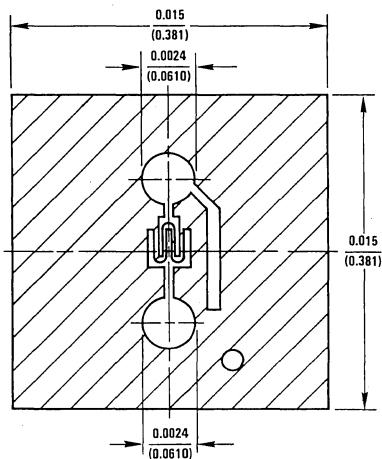


Maximum Stable Gain vs Frequency Common Base Configuration



T1 - 3:1 ratio No. 22 Bifilar on Micrometals Toroid, P/N T30-12  
 $R_S = 50\Omega$ ,  $R_L = 2.5 k\Omega$   
 $f_{bw} = 8.0 \text{ MHz}$

FIGURE 3. 200 MHz Common Base Power Gain, Noise Figure, Automatic Gain Control Test Circuit


**DESCRIPTION**

Process 45 is an overlay, double-diffused, silicon device, with a Faraday shield diffusion.

**APPLICATION**

This device was designed for use as a forward AGC amplifier in IF amplifiers without neutralization.

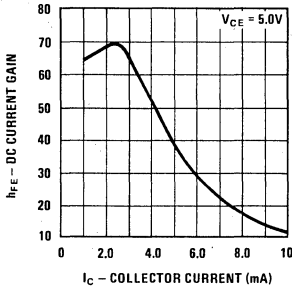
**PRINCIPAL DEVICE TYPES**

TO-72: SE5055 (pkg 28)

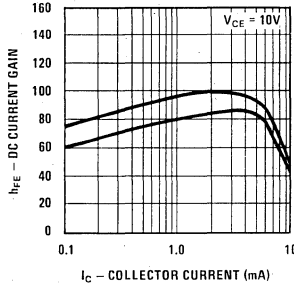
TO-92, BEC: MPS-H32

Parameter	Conditions	Min	Typ	Max	Units	Notes
$P_G$	$f = 45 \text{ MHz}$ , $V_{CE} = 10\text{V}$ , $I_C = 3 \text{ mA}$ , $R_G = 50\Omega$	27.0	30		dB	Figure 1
NF	$f = 45 \text{ MHz}$ , $V_{CE} = 10\text{V}$ , $I_C = 3 \text{ mA}$ , $R_G = 50\Omega$		2.8	5.0	dB	Figure 1
$C_{re}$	$V_{CB} = 10\text{V}$ , $I_E = 0$		0.13	0.22	pF	TO-72
$C_{re}$	$V_{CB} = 10\text{V}$ , $I_E = 0$		0.20	0.30	pF	TO-92
$V_{AGC}$	$f = 45 \text{ MHz}$ , $V_{CC} = 12\text{V}$ , 30 dB Gain Reduction	3.8	4.4	5.1	V	Figure 1
$V_{AGC}$	$f = 45 \text{ MHz}$ , $V_{CC} = 12\text{V}$ , 50 dB Gain Reduction		6.8	8.5	V	Figure 1
$h_{fe}$	$V_{CE} = 10\text{V}$ , $I_C = 2 \text{ mA}$ , $f = 100 \text{ MHz}$	3.0	5.5			
$h_{FE}$	$V_{CE} = 10\text{V}$ , $I_C = 2 \text{ mA}$	30	80	200		
$h_{FE}$	$V_{CE} = 10\text{V}$ , $I_C = 10 \text{ mA}$	18	35			
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}$ , $I_B = 5 \text{ mA}$		0.5	2.0	V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}$ , $I_B = 5 \text{ mA}$		0.92	1.0	V	
$BV_{CEO}$	$I_C = 1 \text{ mA}$	30			V	
$BV_{CBO}$	$I_C = 10 \mu\text{A}$	30			V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	4.0			V	
$I_{CBO}$	$V_{CB} = 20\text{V}$			100	nA	
$I_{EBO}$	$V_{EB} = 3\text{V}$			100	nA	

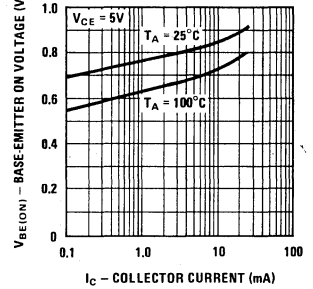
DC Current Gain vs Collector Current



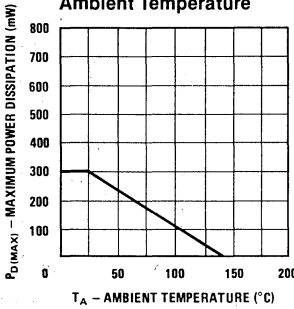
DC Current Gain vs Collector Current



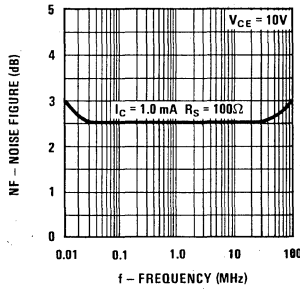
Base-Emitter ON Voltage vs Collector Current



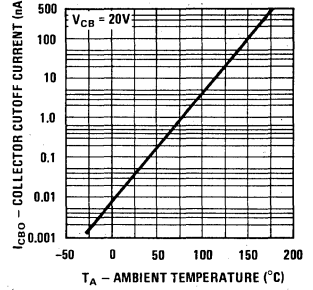
Maximum Power Dissipation vs Ambient Temperature



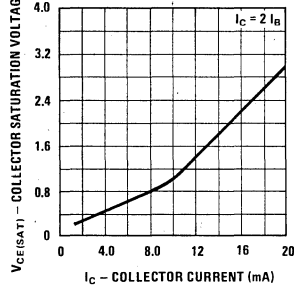
Noise Figure vs Frequency



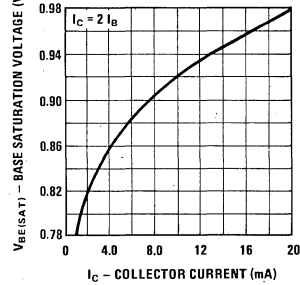
Collector Cutoff Current vs Ambient Temperature



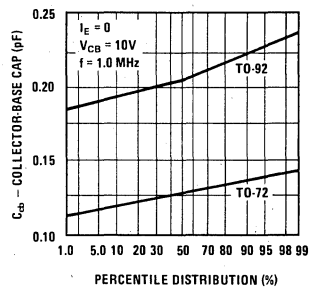
Collector Saturation Voltage vs Collector Current



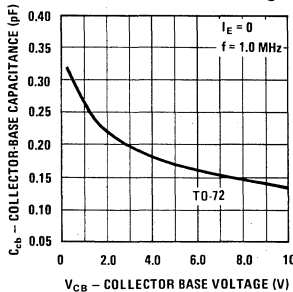
Base Saturation Voltage vs Collector Current



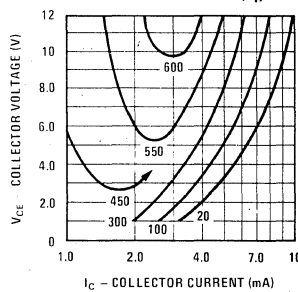
Distribution of Collector-Base Capacitance



Collector-Base Capacitance vs Collector-Base Voltage



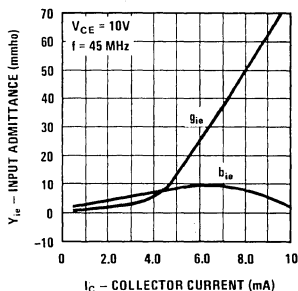
Contours of Constant Gain Bandwidth Product (fT)



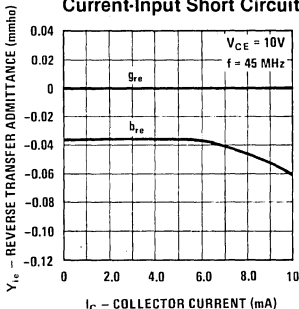
COMMON EMITTER Y PARAMETERS VS FREQUENCY

Process 45

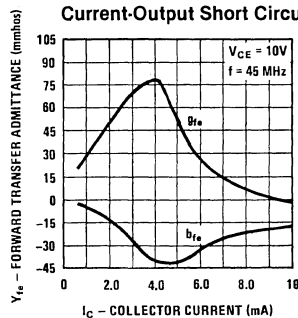
Input Admittance vs Collector Current-Output Short Circuit



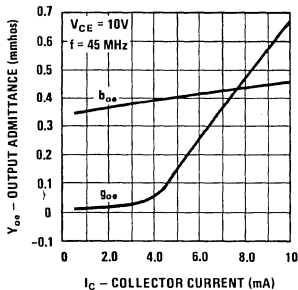
Reverse Transfer Admittance vs Collector Current-Input Short Circuit



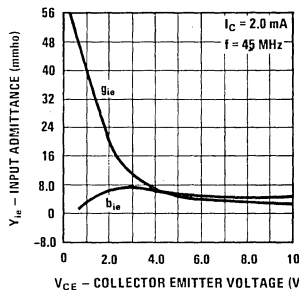
Forward Transfer Admittance vs Collector Current-Output Short Circuit



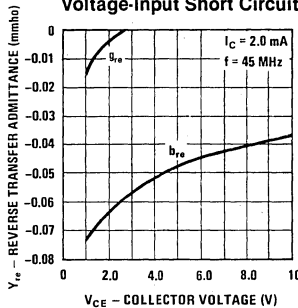
Output Admittance vs Collector Current-Input Short Circuit



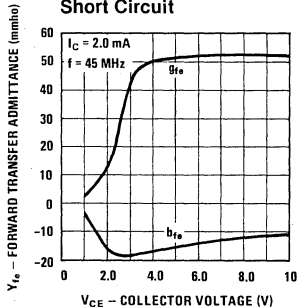
Input Admittance vs Collector Voltage-Output Short Circuit



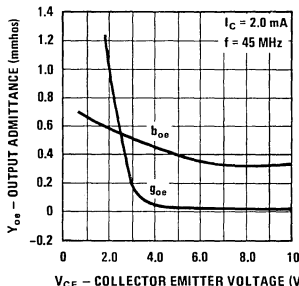
Reverse Transfer Admittance vs Collector Voltage-Input Short Circuit



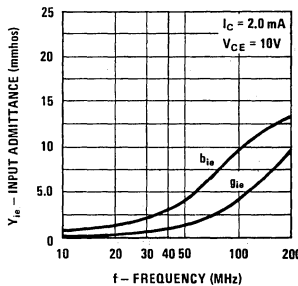
Forward Transfer Admittance vs Collector Voltage-Output Short Circuit



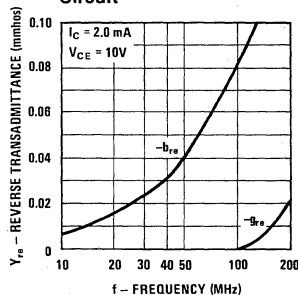
Output Admittance vs Collector Voltage-Input Short Circuit



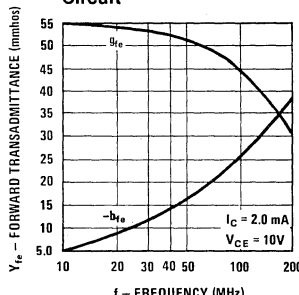
Input Admittance vs Frequency-Output Short Circuit



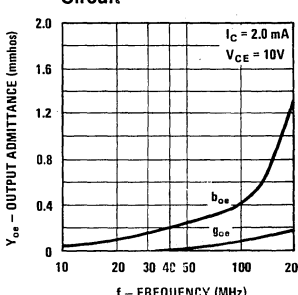
Reverse Transadmittance vs Frequency-Input Short Circuit



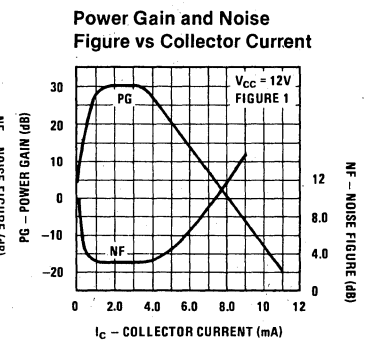
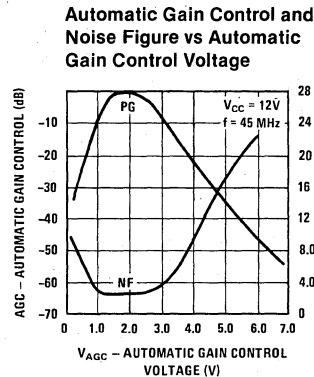
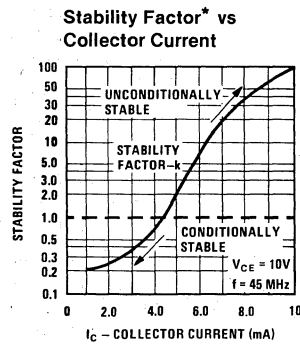
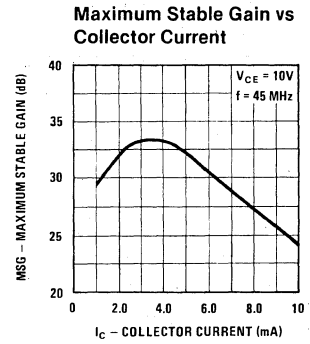
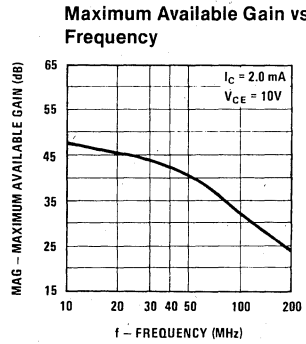
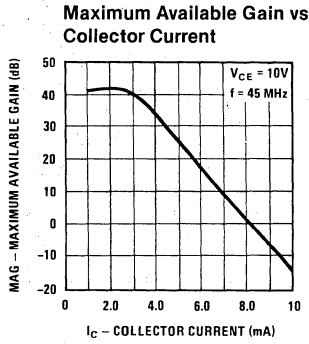
Forward Transadmittance vs Frequency-Output Short Circuit



Output Admittance vs Frequency-Input Short Circuit



COMMON EMITTER PERFORMANCE



\* Rollet stability factor "k" is defined as  $R = \frac{2g_{i0} - R_e(Y_f Y_r)}{|Y_f Y_r|}$

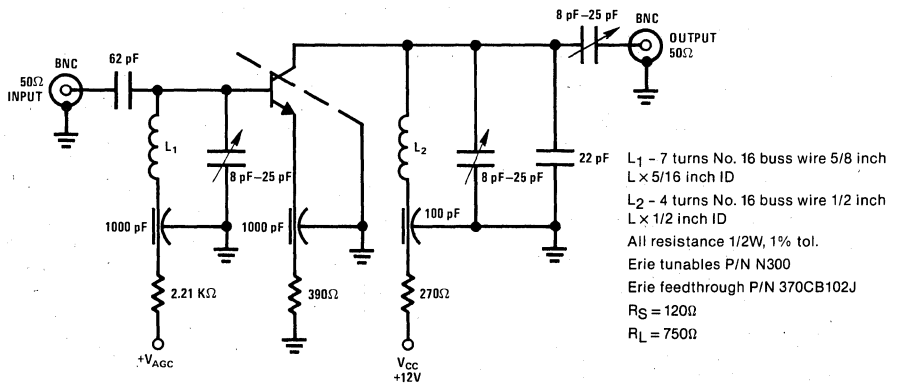
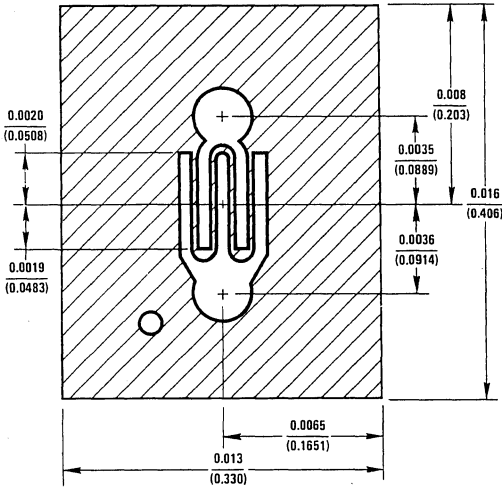


FIGURE 1. SE5055 45 MHz Gain, Noise Figure, AGC Circuit


**DESCRIPTION**

Process 46 is an overlay, double-diffused, silicon epitaxial device.

**APPLICATION**

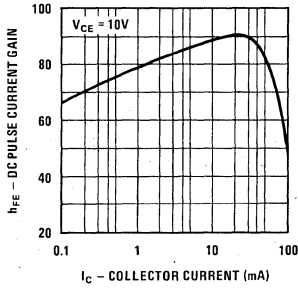
This device was designed for linear RF amplifier applications up to 100 MHz with collector current in the 1 mA to 30 mA range.

**PRINCIPAL DEVICE TYPES**

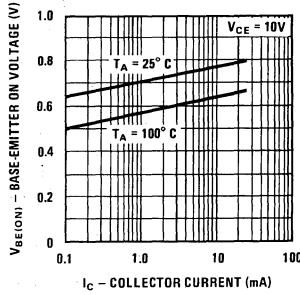
**TO-92, EBC:** CS9016  
PE5025

Parameter	Conditions	Min	Typ	Max	Units	Notes
$G_{pe}$	$f = 45 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 10 \text{ mA}$	25	28		dB	
$C_{CB}$	$V_{CB} = 10\text{V}$		0.8	1.1	pF	
$g_{oe}$	$f = 45 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 10 \text{ mA}$			200	$\mu\text{mho}$	
$h_{fe}$	$I_C = 10 \text{ mA}, V_{CE} = 10\text{V}, f = 100 \text{ MHz}$	3.0	4.5			
$h_{FE}$	$I_C = 10 \text{ mA}, V_{CE} = 10\text{V}$	30	100	250		
$V_{CE(SAT)}$	$I_C = 20 \text{ mA}, I_B = 1 \text{ mA}$		0.2	0.5	V	
$BV_{CEO}$	$I_C = 1 \text{ mA}$	35			V	
$BV_{CBO}$	$I_C = 10 \mu\text{A}$	45			V	
$BV_{EBO}$	$I_C = 10 \mu\text{A}$	4.0			V	
$I_{CBO}$	$V_{CB} = 30\text{V}$			100	nA	
$I_{EBO}$	$V_{EB} = 3\text{V}$			100	nA	

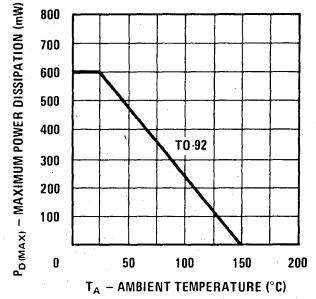
DC Current Gain vs Collector Current



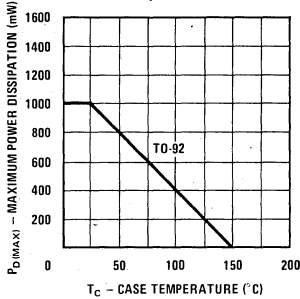
Base-Emitter ON Voltage vs Collector Current



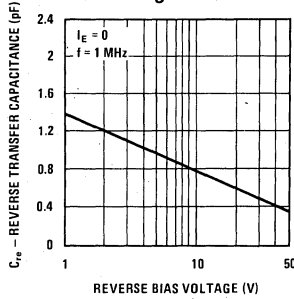
Maximum Power Dissipation vs Ambient Temperature



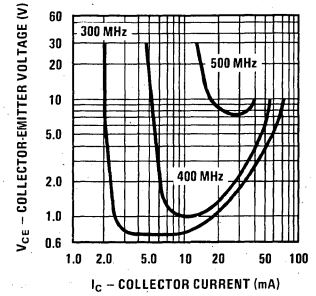
Maximum Power Dissipation vs Case Temperature



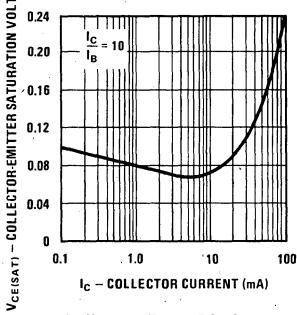
Reverse Transfer Capacitance vs Reverse Bias Voltage



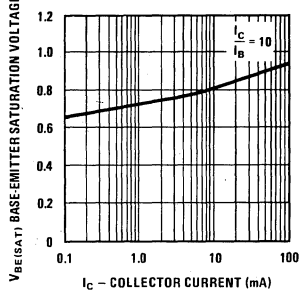
Contours of Constant Gain Bandwidth Product (fT)



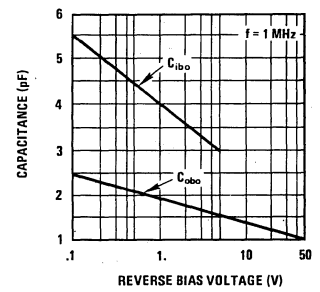
Collector-Emitter Saturation Voltage vs Collector Current



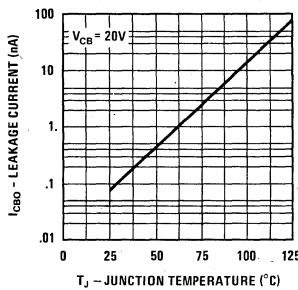
Base-Emitter Saturation Voltage vs Collector Current



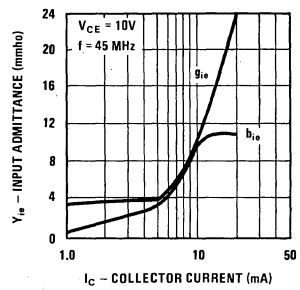
Capacitance vs Reverse Bias Voltage



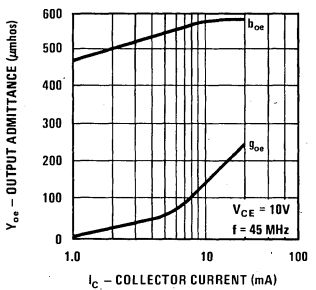
Collector-Base Diode Reverse Current vs Temperature



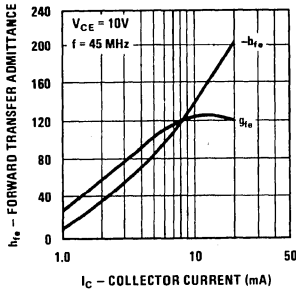
Input Admittance vs Collector Current



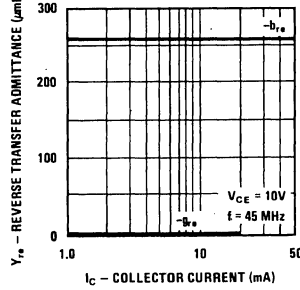
Output Admittance vs Collector Current



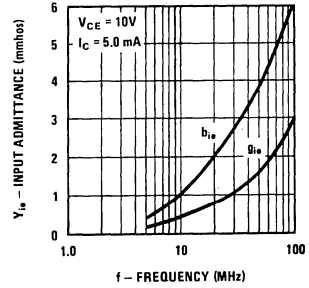
**Forward Transfer Admittance vs Collector Current**



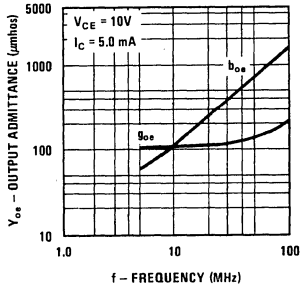
**Reverse Transfer Admittance vs Collector Current**



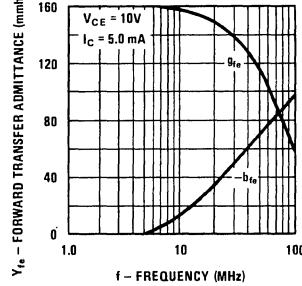
**Input Admittance vs Frequency**



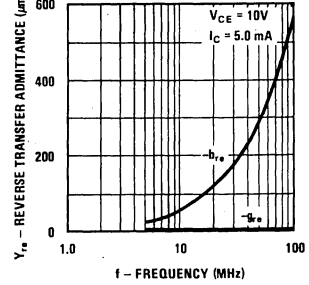
**Output Admittance vs Frequency**



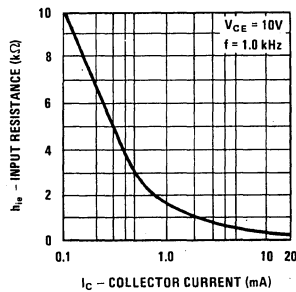
**Forward Transfer Admittance vs Frequency**



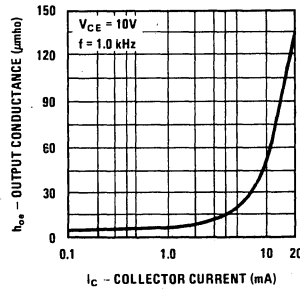
**Reverse Transfer Admittance vs Frequency**



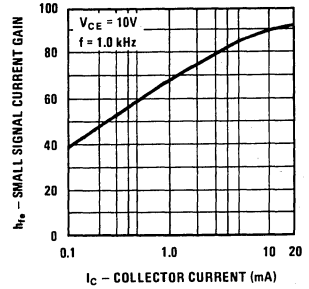
**Small Signal Input Resistance vs Collector Current**



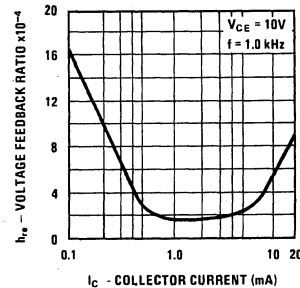
**Small Signal Output Conductance vs Collector Current**



**Small Signal Current Gain vs Collector Current**



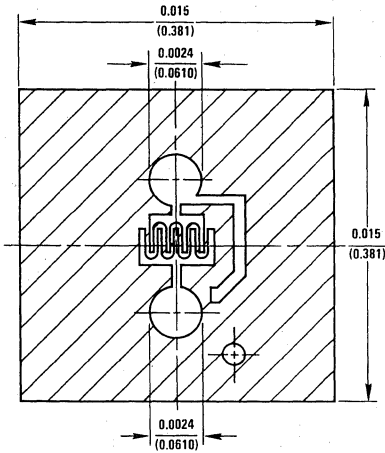
**Small Signal Voltage Feedback Ratio vs Collector Current**







# Process 47 NPN RF-IF Amp



## DESCRIPTION

Process 47 is an overlay, double-diffused, silicon epitaxial device, with a Faraday shield diffusion.

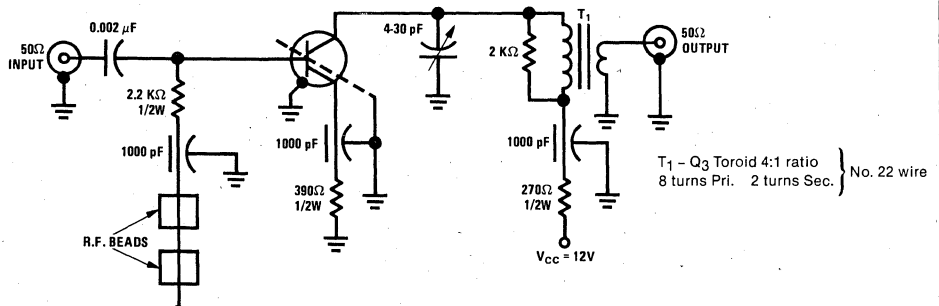
## APPLICATION

This device was designed for common-emitter low noise amplifier and mixer applications in the 100  $\mu$ A to 15 mA range to 300 MHz, and low frequency drift common-base VHF oscillator applications with high output levels for driving FET mixers.

## PRINCIPAL DEVICE TYPES

TO-92, BEC: MPSH11  
 MPSH24  
 PE5030

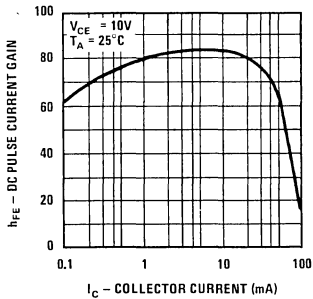
Parameter	Conditions	Min	Typ	Max	Units	Notes
$P_G$	$f = 45 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 4 \text{ mA}$	29	33		dB	Figure 1
$P_G$	$f = 200 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 2 \text{ mA}$	17	19.5		dB	Unneutralized Figure 3
NF	$f = 200 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 2 \text{ mA}, R_S = 50\Omega$		2.0	3.5	dB	Figure 3
rb/Cc	$f = 79.8 \text{ MHz}, V_{CB} = 10\text{V}, I_E = 5 \text{ mA}$			15.0	ps	
$h_{fe}$	$f = 100 \text{ MHz}, V_{CE} = 15\text{V}, I_C = 7 \text{ mA}$	6	10			
$C_{ib}$	$V_{EB} = 0.5\text{V}, I_C = 0$		2.0	3.0	pF	TO-92
$C_{CB}$	$V_{CB} = 10\text{V}, I_E = 0$		0.33	0.40	pF	TO-92
$g_{oe}$	$f = 45 \text{ MHz}, V_{CE} = 15\text{V}, I_C = 7 \text{ mA}$			125	$\mu\text{mho}$	
roep	$f = 10.7 \text{ MHz}, V_{CE} = 10\text{V}, I_C = 2 \text{ mA}$	100k			$\Omega$	
$h_{FE}$	$V_{CE} = 15\text{V}, I_C = 7 \text{ mA}$	40	100	200		
$V_{CE(SAT)}$	$I_C = 20 \text{ mA}, I_B = 1 \text{ mA}$		0.3	1.0	V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 5 \text{ mA}$			0.95	V	
$BV_{CEO}$	$I_C = 1 \text{ mA}$	35			V	
$BV_{CBO}$	$I_C = 10 \mu\text{A}$	40			V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	4.0			V	
$I_{CBO}$	$V_{CB} = 30\text{V}$			100	nA	
$I_{EBO}$	$V_{EB} = 3\text{V}$			100	nA	



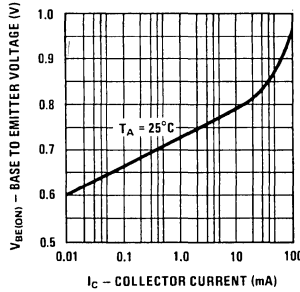
V<sub>acc</sub> FIGURE 1. 45 MHz Power Gain Circuit

# Process 47

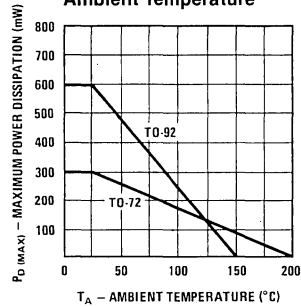
**DC Current Gain vs Collector Current**



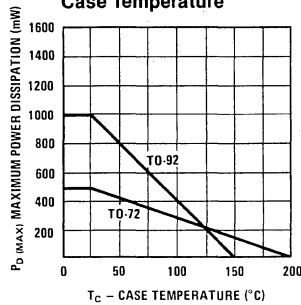
**Base-Emitter ON Voltage vs Collector Current**



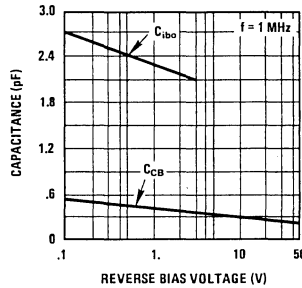
**Maximum Power Dissipation vs Ambient Temperature**



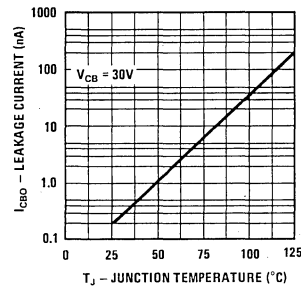
**Maximum Power Dissipation vs Case Temperature**



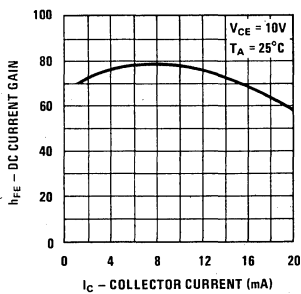
**Capacitance vs Reverse Bias Voltage**



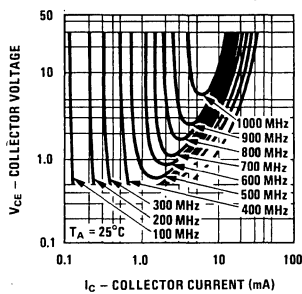
**Collector-Base Diode Reverse Current vs Temperature**



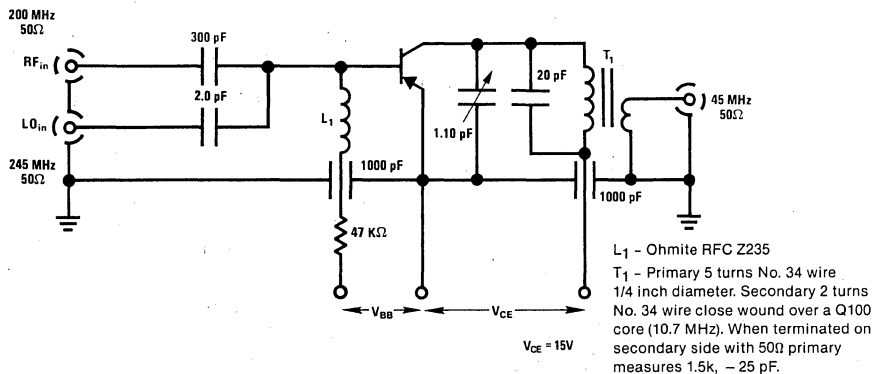
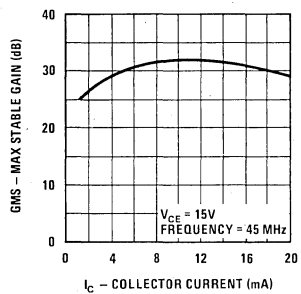
**DC Current Gain vs Collector Current**



**Contours of Constant Gain Bandwidth Product (fT)**

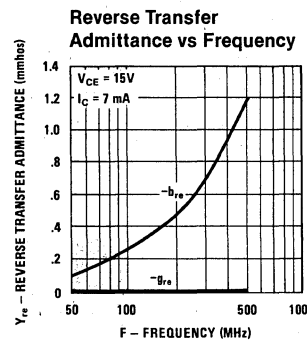
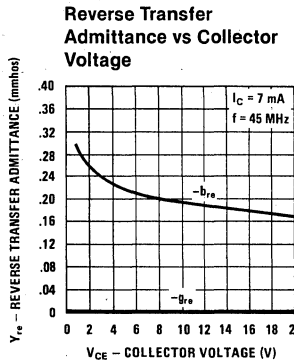
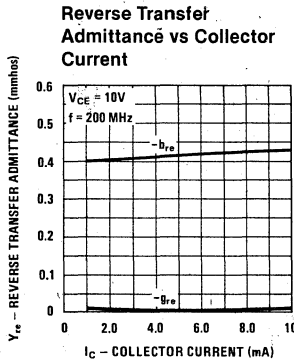
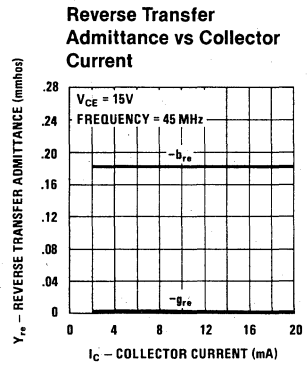
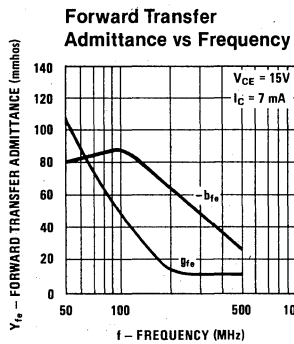
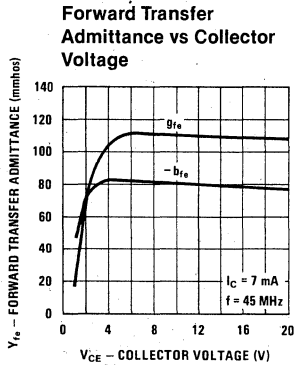
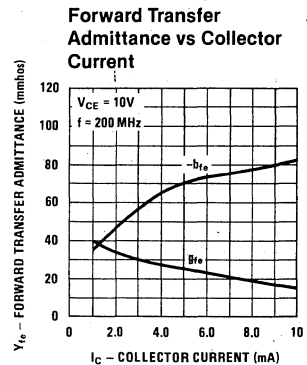
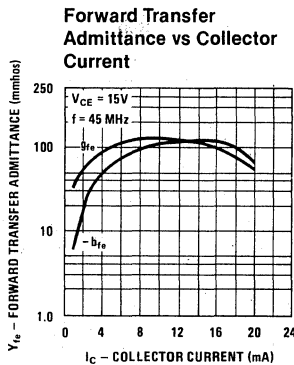
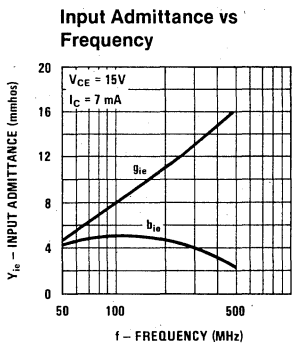
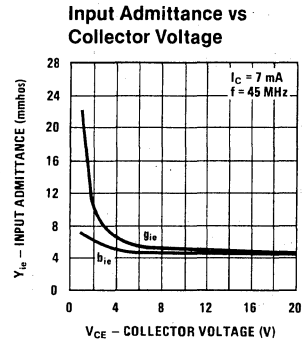
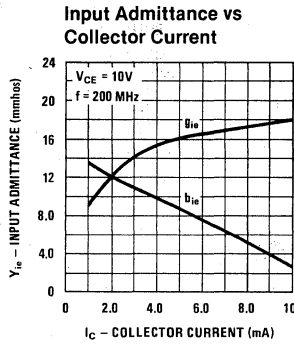
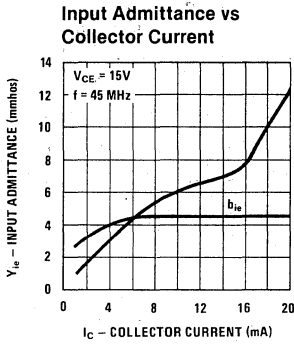


**Maximum Stable Gain vs Collector Current**



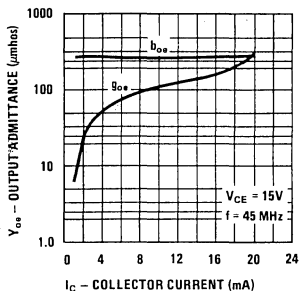
**FIGURE 2. 200 MHz Conversion Gain Test Circuit**

COMMON-EMITTER VS FREQUENCY Y PARAMETERS

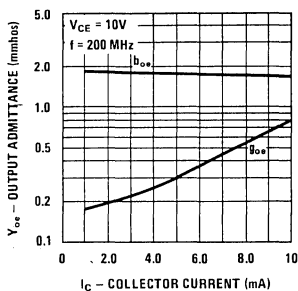


# Process 47

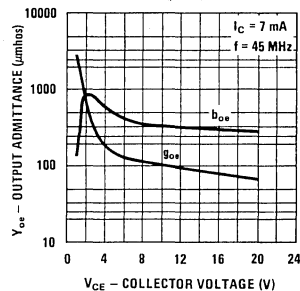
**Output Admittance vs Collector Current**



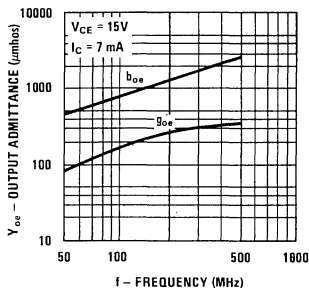
**Output Admittance vs Collector Current**



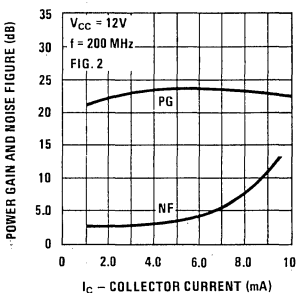
**Output Admittance vs Collector Voltage**



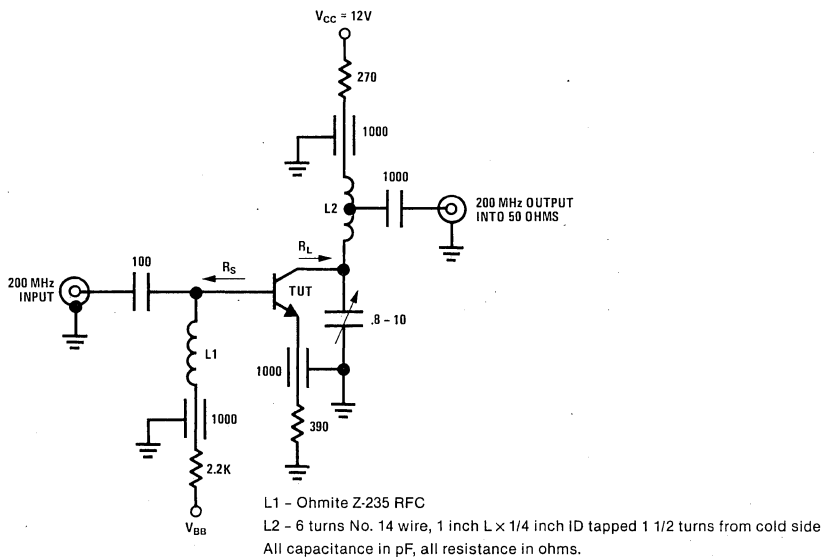
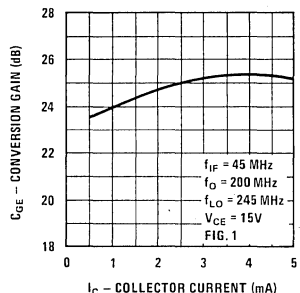
**Output Admittance vs Frequency**



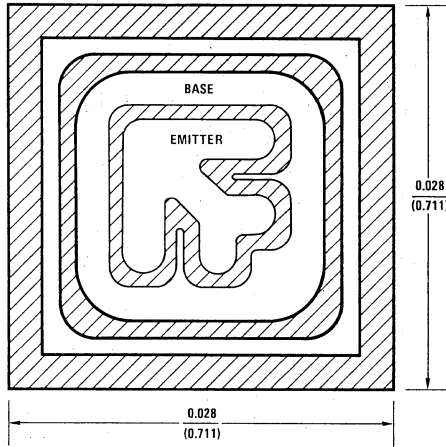
**Power Gain and Noise Figure vs Collector Current**



**Conversion Gain vs Collector Current**



**FIGURE 3. Unneutralized 200 MHz PG NF Test Circuit**



**DESCRIPTION**

Process 48 is a non-overlay, triple-diffused, silicon device with a field plate.

**APPLICATION**

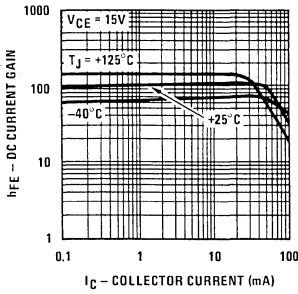
This device was designed for application as a video output to drive color CRT.

**PRINCIPAL DEVICE TYPES**

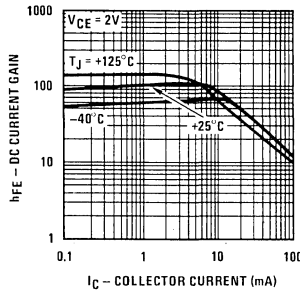
- TO-202, EBC:** D40N1-5  
NSD131-5  
NSD457-9  
NSE457-9
- TO-202, BCE:** NSE457-9
- TO-237, EBC:** 2N6733-5 (92PU391-3)
- TO-237, ECB:** 2N6711-13 (92PE487-9)  
2N6719 (92PU10)
- TO-39 (Steel):** SE7056
- TO-92:** MPSA42

Parameter	Conditions	Min	Typ	Max	Units	Notes
$BV_{CEO}$	$I_C = 1 \text{ mA}$	300	370		V	
$BV_{CBO}$	$I_C = 100 \mu\text{A}$		500		V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	7.0			V	
$I_{CES}$	$V_{CB} = 150\text{V}$			100	nA	
$I_{EBO}$	$V_{EB} = 6\text{V}$			100	nA	
$h_{FE}$	$I_C = 1 \text{ mA}, V_{CE} = 10\text{V}$	30				
$h_{FE}$	$I_C = 10 \text{ mA}, V_{CE} = 10\text{V}$	40	90	200		
$h_{FE}$	$I_C = 100 \text{ mA}, V_{CE} = 10\text{V}$		20			
$V_{CE(SAT)}$	$I_C = 20 \text{ mA}, I_B = 2 \text{ mA}$		0.25	1.0	V	
$V_{BE(SAT)}$	$I_C = 20 \text{ mA}, I_B = 2 \text{ mA}$		0.74	1.0	V	
$C_{CB}$	$V_{CB} = 20\text{V}$		1.9	3.5	pF	TO-92
$C_{ib}$	$V_{EB} = 0.5\text{V}$			70	pF	
$h_{fe}$	$I_C = 15 \text{ mA}, V_{CE} = 100\text{V},$ $I_C = 15 \text{ mA}, f = 20 \text{ MHz}$	2.5	4.0			
$P_{D(max)}$						
TO-202	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	10 2			W	
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	2 850			W mW	
TO-92	$T_A = 25^\circ\text{C}$	600			mW	
$\theta_{JC}$						
TO-202	$T_C = 25^\circ\text{C}$			12.5	$^\circ\text{C/W}$	
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$	
$\theta_{JA}$						
TO-202	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$	
TO-237	$T_A = 25^\circ\text{C}$			147	$^\circ\text{C/W}$	
TO-92	$T_A = 25^\circ\text{C}$			208	$^\circ\text{C/W}$	
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$	

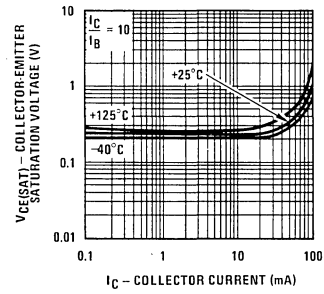
**DC Current Gain vs Collector Current**



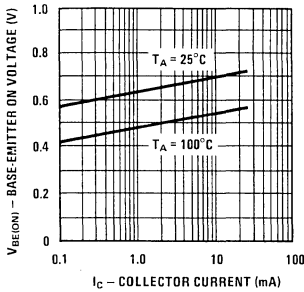
**Typical Pulsed Current Gain vs Collector Current**



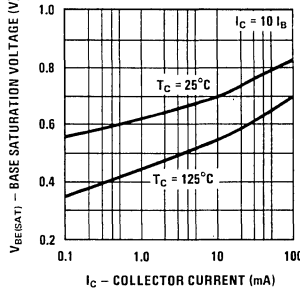
**Collector-Emitter Saturation Voltage vs Collector Current**



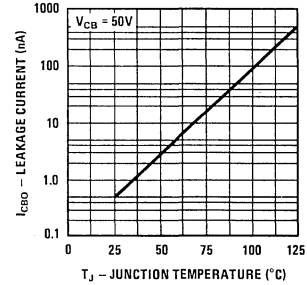
**Base-Emitter ON Voltage vs Collector Current**



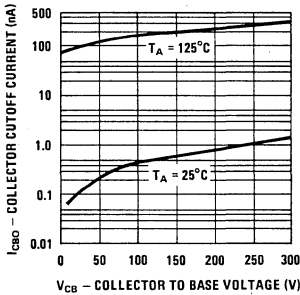
**Base Saturation Voltage vs Collector Current**



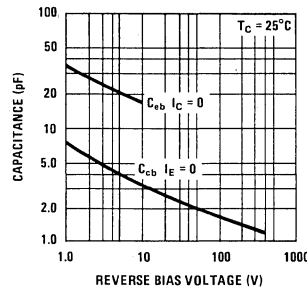
**Collector-Base Diode Reverse Current vs Temperature**



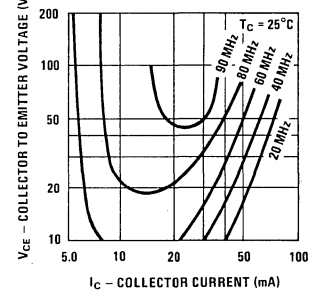
**Collector Cutoff Current vs Collector Voltage**



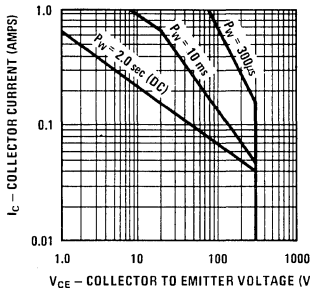
**Collector-Base and Emitter-Base Capacitance vs Reverse Bias Voltage**



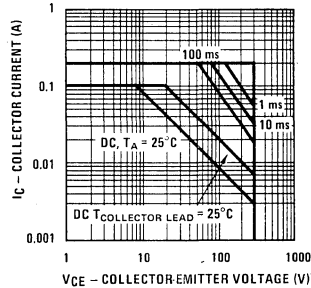
**Contours of Constant Gain Bandwidth Product**



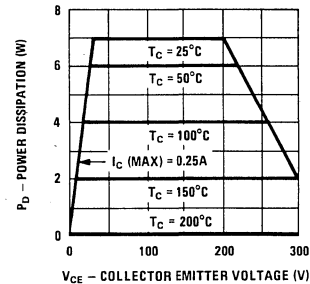
**Safe Operating Area TO-202**



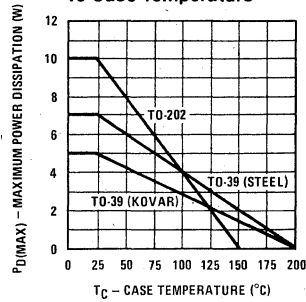
**Safe Operating Area TO-237**



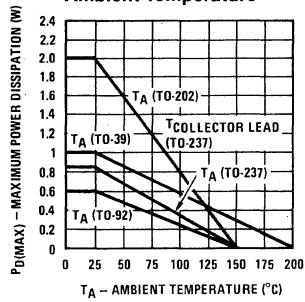
**Guaranteed Maximum DC Power Dissipation vs Collector-Emitter Voltage TO-39**



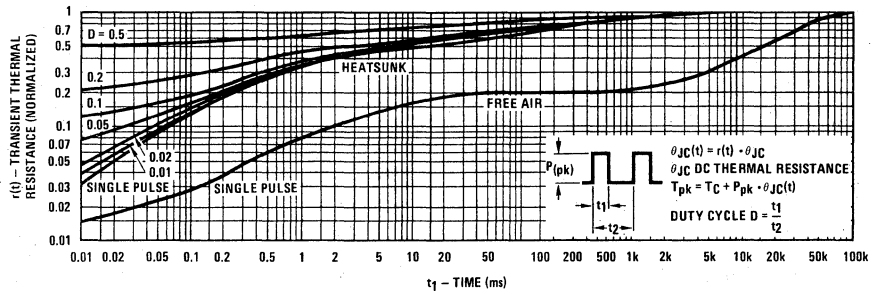
Maximum Power Dissipation vs Case Temperature

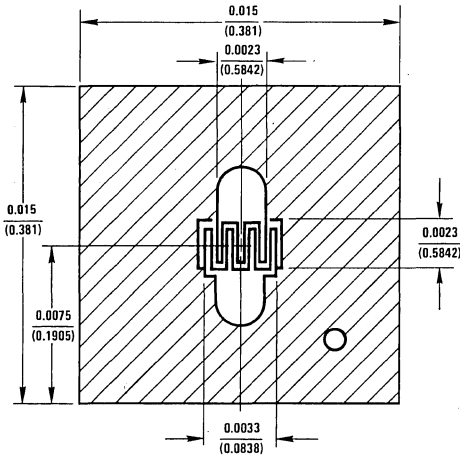


Maximum Power Dissipation vs Ambient Temperature



Thermal Response in TO-202 Package




**DESCRIPTION**

Process 49 is an overlay, double-diffused, silicon epitaxial device.

**APPLICATION**

This device was designed for general RF amplifier and mixer applications to 250 MHz with collector current in the 1 mA to 20 mA range.

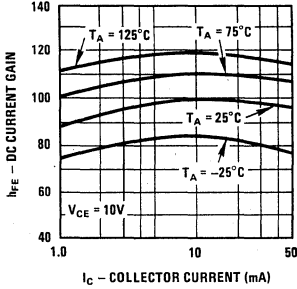
**PRINCIPAL DEVICE TYPES**

TO-92, BEC: MPS6544  
MPSH20

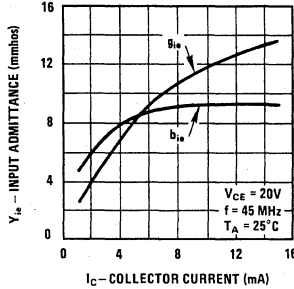
Parameter	Conditions	Min	Typ	Max	Units	Notes
$P_G$	$f = 45 \text{ MHz}$ , $V_{CE} = 10\text{V}$ , $I_C = 10 \text{ mA}$	25	30		dB	
$f_T$	$V_{CE} = 10\text{V}$ , $I_C = 10 \text{ mA}$	400	700		MHz	
$rb'Cc$	$f = 79.8 \text{ MHz}$ , $V_{CE} = 10\text{V}$ , $I_C = 8 \text{ mA}$			20.0	ps	
$C_{CB}$	$f = 1.0 \text{ MHz}$ , $V_{CB} = 10\text{V}$ , $I_E = 0$		0.55	0.65	pF	
$h_{FE}$	$V_{CE} = 10\text{V}$ , $I_C = 10 \text{ mA}$	40	100	250		
$h_{FE}$	$V_{CE} = 10\text{V}$ , $I_C = 4 \text{ mA}$	30				
$V_{BE(ON)}$	$V_{CE} = 10\text{V}$ , $I_C = 10 \text{ mA}$		0.80	0.90	V	
$V_{CE(SAT)}$	$I_C = 30 \text{ mA}$ , $I_C = 3 \text{ mA}$		0.15	0.50	V	
roep	$f = 4.5 \text{ MHz}$ , $V_{CE} = 10\text{V}$ , $I_C = 2 \text{ mA}$	80k			$\Omega$	
$BV_{CEO}$	$I_C = 1 \text{ mA}$	35			V	
$BV_{CBO}$	$I_C = 10 \mu\text{A}$	45			V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	4.0			V	
$I_{CBO}$	$V_{CB} = 30\text{V}$			100	nA	
$I_{EBO}$	$V_{EB} = 3.0\text{V}$			100	nA	



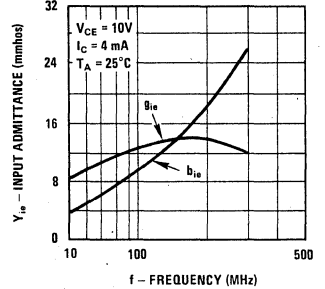
DC Current Gain vs Collector Current



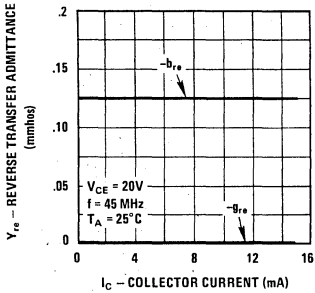
Input Admittance vs Collector Current



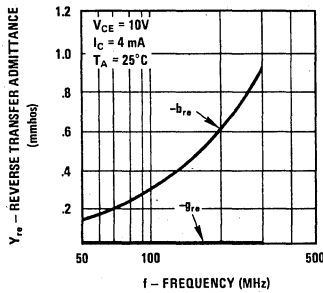
Input Admittance vs Frequency



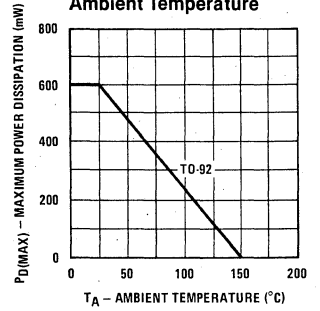
Reverse Transfer Admittance vs Collector Current



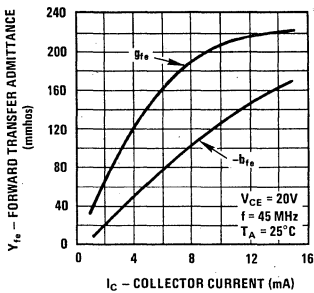
Reverse Transfer Admittance vs Frequency



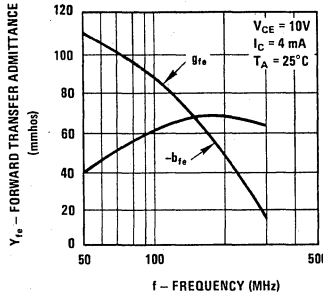
Maximum Power Dissipation vs Ambient Temperature



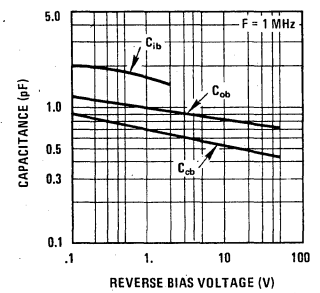
Forward Transfer Admittance vs Collector Current



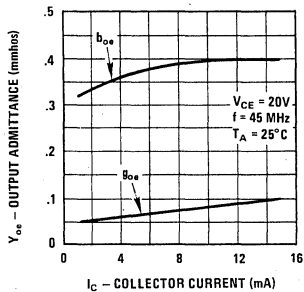
Forward Transfer Admittance vs Frequency



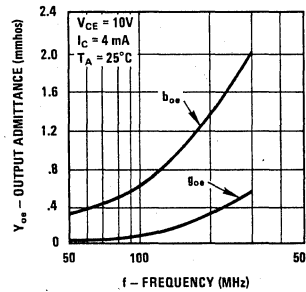
Capacitance vs Reverse Bias Voltage



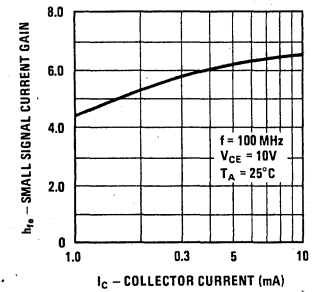
Output Admittance vs Collector Current



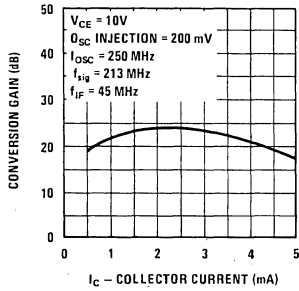
Output Admittance vs Frequency



Small Signal Current Gain vs Collector Current



Conversion Gain vs Collector Current



Conversion Gain vs Oscillator Injection Level

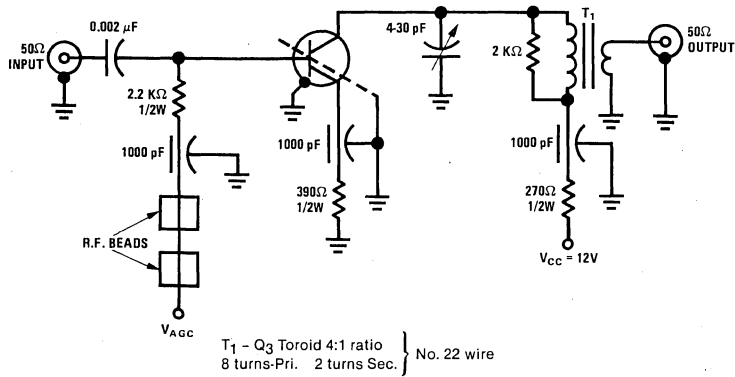
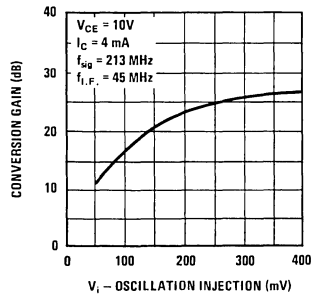


FIGURE 1. 45 MHz Power Gain Circuit

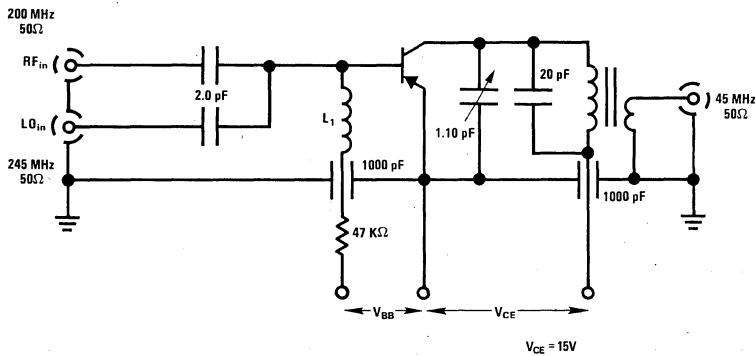


FIGURE 2. 200 MHz Conversion Gain Test Circuit

**DESCRIPTION**

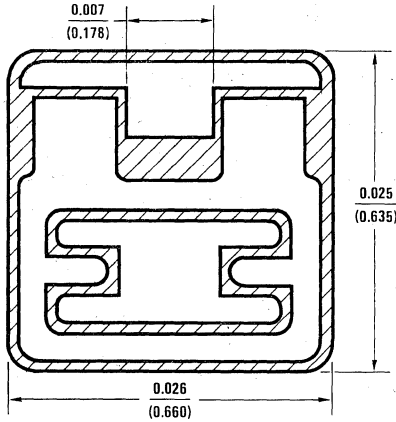
Process 61 is a monolithic, double-diffused, silicon epitaxial Darlington. Complement to Process 05.

**APPLICATION**

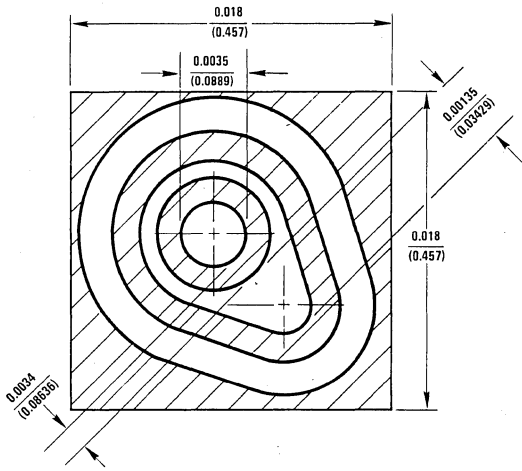
This device is designed for applications requiring extremely high current gain at collector currents to 1.5A.

**PRINCIPAL DEVICE TYPES**

- TO-202, EBC: D41K1-4  
NSDU95, 95A
- TO-237, EBC: 92PU95, 95A
- TO-92, EBC: MPSA62-66



Parameter	Conditions	Min	Typ	Max	Units	Notes
NF	$I_C = 1 \text{ mA}, V_{CE} = 5 \text{ V}, R_S = 100 \text{ k}, f = 1 \text{ kHz}$		2		dB	
$C_{CB}$	$V_{CB} = 10 \text{ V}, I_E = 0, f = 1 \text{ MHz}$		5	8	pF	
$h_{FE}$	$I_C = 10 \text{ mA}, V_{CE} = 5 \text{ V}$	5,000				
$h_{FE}$	$I_C = 100 \text{ mA}, V_{CE} = 5 \text{ V}$	5,000	40,000	200,000		
$h_{FE}$	$I_C = 1 \text{ A}, V_{CE} = 5 \text{ V}$	1500				
$V_{CE(SAT)}$	10 mA, 0.01 mA 100 mA, 0.1 mA			1.0 1.5	V	
$V_{BE(ON)}$	10 mA, 5V 100 mA, 5V		1.2 1.25	1.4 2.0	V	
$h_{fe}$	$I_C = 10 \text{ mA}, V_{CE} = 5.0 \text{ V}, f = 1 \text{ kHz}$		50,000			
$BV_{CES}$	$I_C = 100 \mu\text{A}$	40			V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	12			V	
$I_{CES}$	$V_{CE} = 15 \text{ V}, V_{BE} = 0$			100	nA	
$I_{CBO}$	$V_{CB} = 15 \text{ V}, I_E = 0$			100	nA	
$I_{EBO}$	$V_{EB} = 10 \text{ V}, I_C = 0$			100	nA	
$P_{D(max)}$						
TO-202	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	10 2			W	
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	2 850			W mW	
TO-92	$T_A = 25^\circ\text{C}$	600			mW	
$\theta_{JC}$						
TO-202	$T_C = 25^\circ\text{C}$			12.5	$^\circ\text{C/W}$	
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$	
$\theta_{JA}$						
TO-202	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$	
TO-237	$T_A = 25^\circ\text{C}$			147	$^\circ\text{C/W}$	
TO-92	$T_A = 25^\circ\text{C}$			208	$^\circ\text{C/W}$	
$T_J(max)$	All Plastic Parts	150			$^\circ\text{C}$	


**DESCRIPTION**

Process 62 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 07.

**APPLICATION**

These devices are designed for low level, high gain, low noise general purpose amplifier applications to 20 mA collector current.

**PRINCIPAL DEVICE TYPES**

**TO-18:** 2N3550

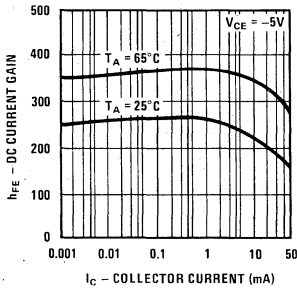
**TO-46:** 2N2605

**TO-92, ECB:** 2N4058

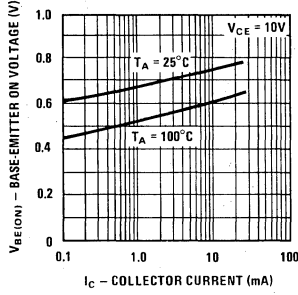
**TO-92, EBC:** 2N5086

Parameter	Conditions	Min	Typ	Max	Units	Notes
NF	$V_{CE} = 5V$ , $I_C = 10 \mu A$ , $R_S = 10 k\Omega$ , PBW = 15.70 kHz		1	3	dB	
$h_{fe}$	$V_{CE} = 5V$ , $I_C = 500 \mu A$ , $f = 20 \text{ MHz}$	3	6			
$C_{ib}$	$V_{EB} = 0.5V$			8	pF	
$C_{ob}$	$V_{CB} = 5V$		3.5	5	pF	
$h_{FE}$	$I_C = 1 \mu A$ , $V_{CE} = 5V$	45				
$h_{FE}$	$I_C = 10 \mu A$ , $V_{CE} = 5V$	60				
$h_{FE}$	$I_C = 100 \mu A$ , $V_{CE} = 5V$	75				
$h_{FE}$	$I_C = 500 \mu A$ , $V_{CE} = 5V$	90	270			
$h_{FE}$	$I_C = 1 \text{ mA}$ , $V_{CE} = 5V$	90	270	630		
$h_{FE}$	$I_C = 10 \text{ mA}$ , $V_{CE} = 5V$	75				
$V_{CE(SAT)}$	$I_C = 1 \text{ mA}$ , $I_B = 0.1 \text{ mA}$			0.10	V	
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}$ , $I_B = 1 \text{ mA}$			0.15	V	
$V_{BE(SAT)}$	$I_C = 1 \text{ mA}$ , $I_B = 0.1 \text{ mA}$			0.75	V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}$ , $I_B = 1 \text{ mA}$			0.90	V	
$BV_{CEO}$	$I_C = 1 \text{ mA}$	50			V	
$BV_{CBO}$	$I_C = 10 \mu A$	60			V	
$BV_{EBO}$	$I_E = 10 \mu A$	8			V	
$I_{CBO}$	$V_{CB} = 40V$			100	nA	
$I_{EBO}$	$V_{EB} = 6V$			100	nA	

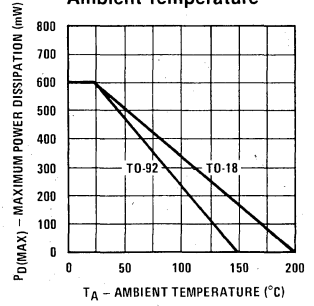
DC Current Gain vs Collector Current



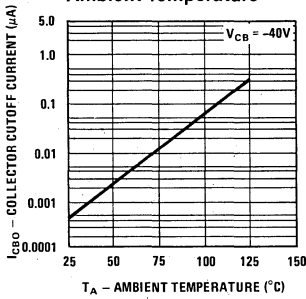
Base-Emitter ON Voltage vs Collector Current



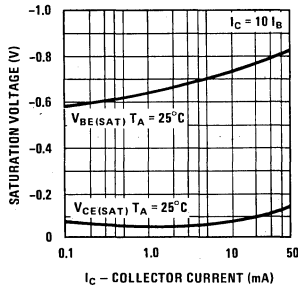
Maximum Power Dissipation vs Ambient Temperature



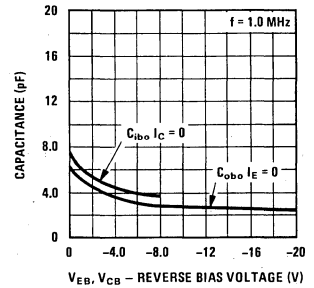
Collector Cutoff Current vs Ambient Temperature



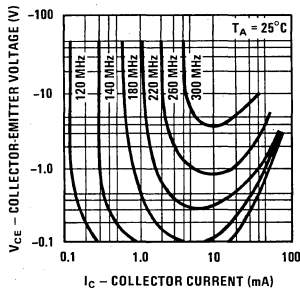
Collector and Base Saturation Voltage vs Collector Current



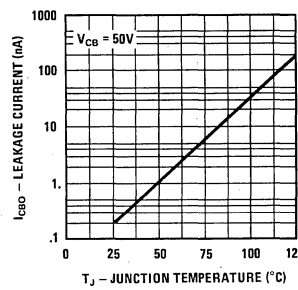
Input and Output Capacitance vs Reverse Bias Voltage



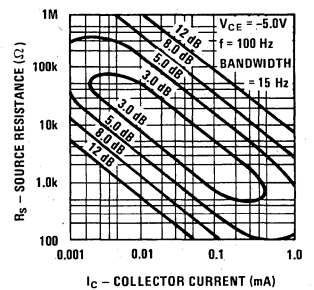
Contours of Constant Gain Bandwidth Product (fT)



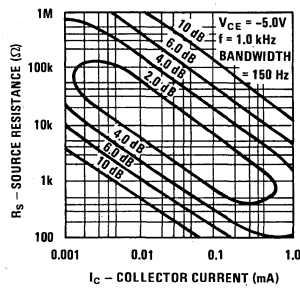
Collector-Base Diode Current vs Temperature



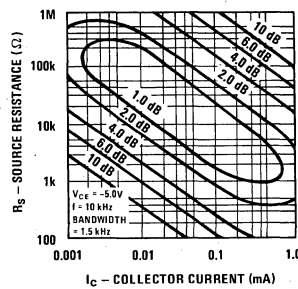
Contours of Constant Narrow Band Noise Figure



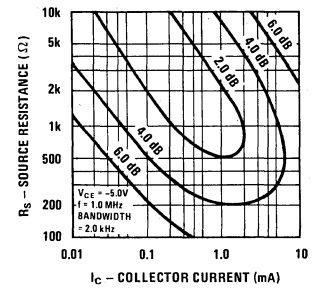
Contours of Constant Narrow Band Noise Figure



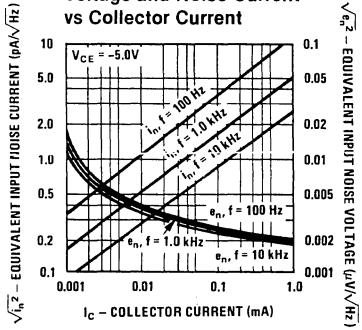
Contours of Constant Narrow Band Noise Figure



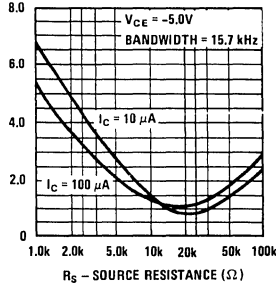
Contours of Constant Narrow Band Noise Figure



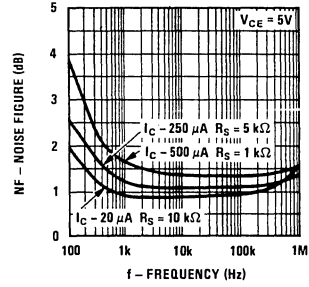
Equivalent Input Noise Voltage and Noise Current vs Collector Current



Wideband Noise Figure vs Source Resistance



Noise Figure vs Frequency

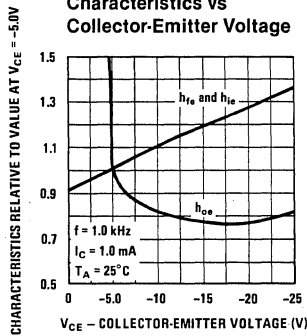


SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

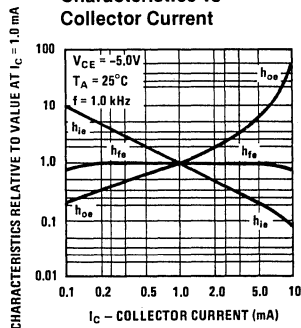
Symbol	Characteristic	Min	Typ	Max	Units	Conditions
$h_{ie}$	Input Resistance	2.5	8.0	20	k $\Omega$	$I_C = 1.0 \text{ mA}, V_{CE} = -5.0 \text{ V}$
$h_{oe}$	Output Conductance	5.0	19	50	$\mu\text{mho}$	$I_C = 1.0 \text{ mA}, V_{CE} = -5.0 \text{ V}$
$h_{re}$	Voltage Feedback Ratio			10	$\times 10^{-4}$	$I_C = 1.0 \text{ mA}, V_{CE} = -5.0 \text{ V}$
$h_{fe}$	Small Signal Current Gain	100	250	800		$I_C = 1.0 \text{ mA}, V_{CE} = -5.0 \text{ V}$

TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)

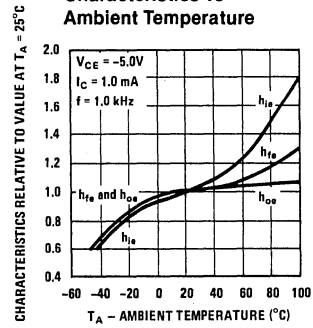
Common Emitter Characteristics vs Collector-Emitter Voltage

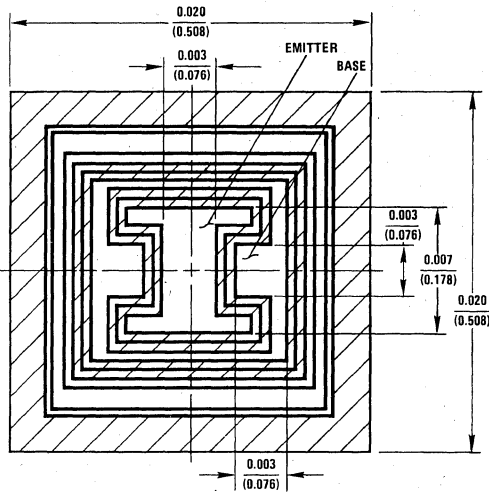


Common Emitter Characteristics vs Collector Current



Common Emitter Characteristics vs Ambient Temperature





**DESCRIPTION**

Process 63 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 19.

**APPLICATION**

This device was designed for use as general purpose amplifiers and switches requiring collector currents to 500 mA.

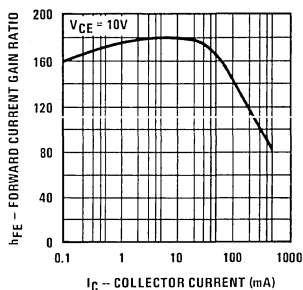
**PRINCIPAL DEVICE TYPES**

- TO-5: 2N2905
- TO-18: 2N2907
- TO-92, EBC: 2N4403
- TO-92, ECB: 2N3702
- TO-237: TN2905

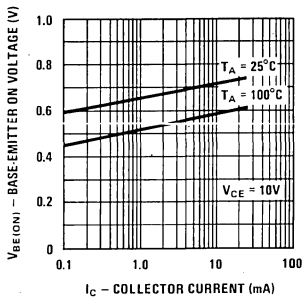
Parameter	Conditions	Min	Typ	Max	Units	Notes
$t_{ON}$	$I_C = 150 \text{ mA}, I_{B1} = 15 \text{ mA}$		30	45	ns	Figure 1
$t_{OFF}$	$I_C = 150 \text{ mA}, I_{B2} = 15 \text{ mA}$		220	290	ns	Figure 2
$C_{CB}$	$V_{CB} = 10V$		6	8	pF	
$C_{EB}$	$V_{EB} = 0.50V$			20	pF	
$h_{fe}$	$I_C = 20 \text{ mA}, V_{CE} = 20V,$ $f = 100 \text{ MHz}$	1.5	2.5			
NF (spot)	$I_C = 100 \mu A, V_{CE} = 10V, R_S = 1k$ $f = 1 \text{ kHz}$		1.5		dB	
$h_{FE}$	$I_C = 1 \text{ mA}, V_{CE} = 10V$	50				
$h_{FE}$	$I_C = 10 \text{ mA}, V_{CE} = 10V$	50				
$h_{FE}$	$I_C = 150 \text{ mA}, V_{CE} = 10V$	50	150	400		
$h_{FE}$	$I_C = 500 \text{ mA}, V_{CE} = 10V$	30				
$V_{CE(SAT)}$	$I_C = 150 \text{ mA}, I_B = 15 \text{ mA}$			0.5	V	
$V_{CE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			1.2	V	
$V_{BE(SAT)}$	$I_C = 150 \text{ mA}, I_B = 15 \text{ mA}$			1.3	V	
$V_{BE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			1.6	V	
$BV_{CEO}$	$I_C = 10 \text{ mA}$	35			V	
$BV_{CBO}$	$I_C = 100 \mu A$	50			V	
$BV_{EBO}$	$I_E = 10 \mu A$	6			V	
$I_{CBO}$	$V_{CB} = 35V$			100	nA	
$I_{EBO}$	$V_{EB} = 4V$			100	nA	

# Process 63

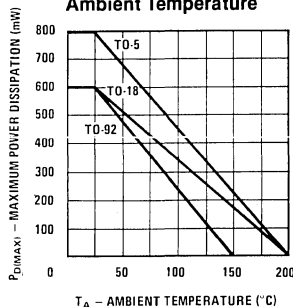
**DC Pulsed Current Gain vs Collector Current**



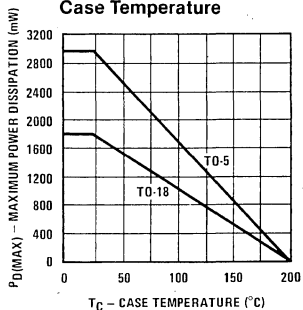
**Base-Emitter ON Voltage vs Collector Current**



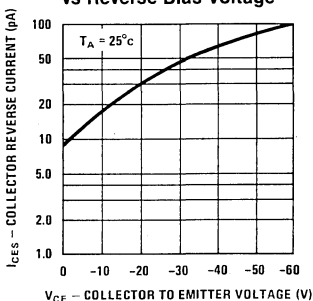
**Maximum Power Dissipation vs Ambient Temperature**



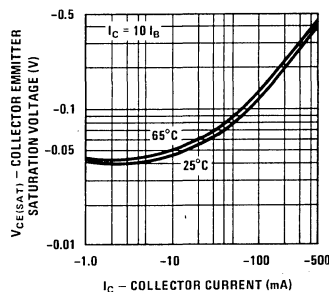
**Maximum Power Dissipation vs Case Temperature**



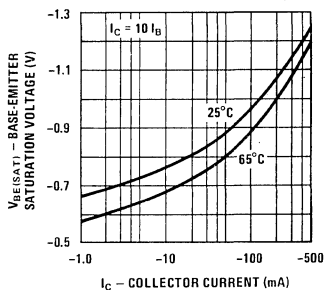
**Collector Reverse Current vs Reverse Bias Voltage**



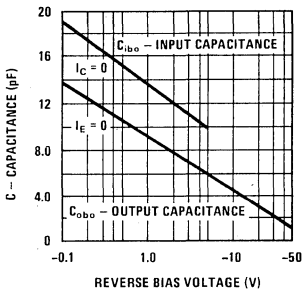
**Pulsed Collector Saturation Voltage vs Collector Current**



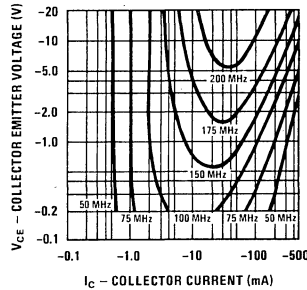
**Pulsed Base Saturation Voltage vs Collector Current**



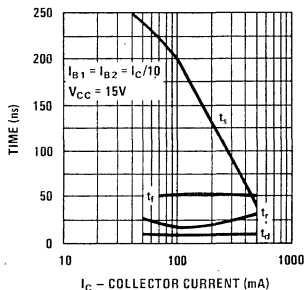
**Input and Output Capacitances vs Reverse Bias Voltage**



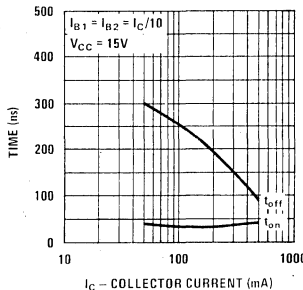
**Contours of Constant Gain Bandwidth Product (fT)**



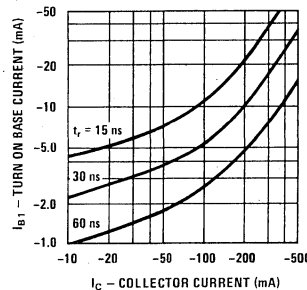
**Switching Times vs Collector Current**



**Turn On and Turn Off Times vs Collector Current**



**Rise Time vs Collector and Turn On Base Currents**





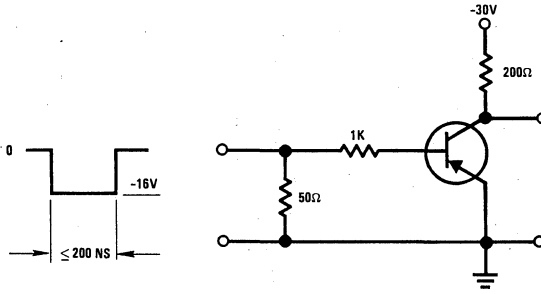


FIGURE 1. Saturated Turn On Switching Time Test Circuit

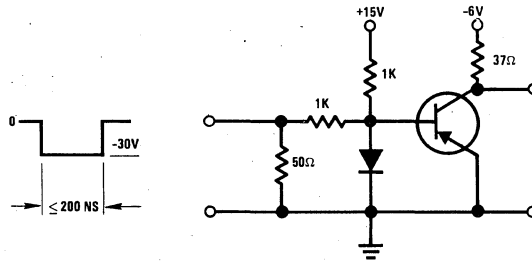
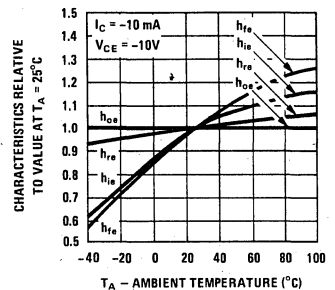
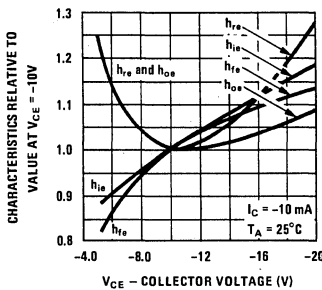
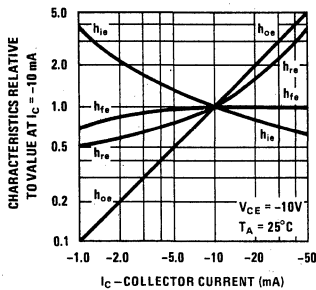


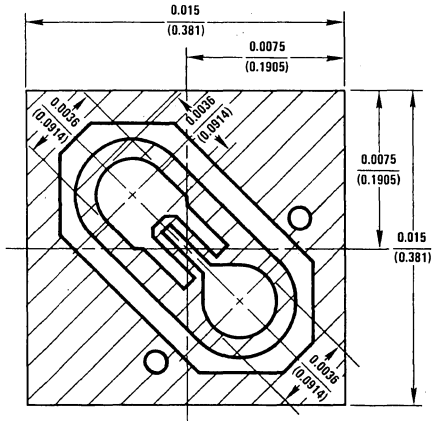
FIGURE 2. Saturated Turn Off Switching Time Test Circuit

SMALL SIGNAL CHARACTERISTICS (f = 1.0 kHz)

Symbol	Characteristic	Min	Typ	Max	Units	Conditions
$h_{ie}$	Input Resistance		480	2000	$\Omega$	$I_C = 10 \text{ mA}, V_{CE} = -10 \text{ V}$
$h_{oe}$	Output Conductance		80	1200	$\mu\text{mhos}$	$I_C = 10 \text{ mA}, V_{CE} = -10 \text{ V}$
$h_{re}$	Voltage Feedback Ratio		162	1500	$\times 10^{-6}$	$I_C = 10 \text{ mA}, V_{CE} = -10 \text{ V}$
$h_{fe}$	Small Signal Current Gain	100				$I_C = 10 \text{ mA}, V_{CE} = -10 \text{ V}$

TYPICAL COMMON EMITTER CHARACTERISTICS (f = 1.0 kHz)




**DESCRIPTION**

Process 64 is an overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 22.

**APPLICATION**

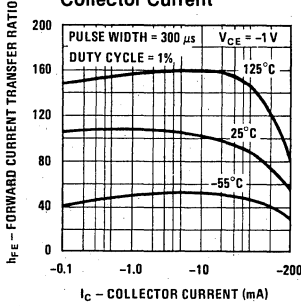
This device was designed for high speed saturated switching applications at collector currents to 200 mA.

**PRINCIPAL DEVICE TYPES**

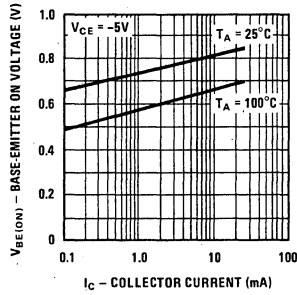
**TO-52:** 2N2894  
**TO-92, EBC:** PN4313

Parameter	Conditions	Min	Typ	Max	Units	Notes
$t_{ON}$	$I_C = 30 \text{ mA}, I_{B1} = 3 \text{ mA}$		10	20	ns	Figure 1
$t_{OFF}$	$I_C = 30 \text{ mA}, I_{B2} = 3 \text{ mA}$		21	30	ns	Figure 1
$t_s$	$I_C = I_{B1} = I_{B2} = 10 \text{ mA}$		15	20	ns	
$C_{ob}$	$V_{CE} = 5V$		3.0	4.5	pF	
$C_{ib}$	$V_{EB} = 0.5V$			6.0	pF	
$h_{fe}$	$f = 100 \text{ MHz}, I_C = 30 \text{ mA}, V_{CE} = 10V$	8	12			
$h_{FE}$	$I_C = 1 \text{ mA}, V_{CE} = 1V$	20				
$h_{FE}$	$I_C = 10 \text{ mA}, V_{CE} = 1V$	30				
$h_{FE}$	$I_C = 30 \text{ mA}, V_{CE} = 1V$	40	90	150		
$h_{FE}$	$I_C = 100 \text{ mA}, V_{CE} = 1V$	30				
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.15	V	
$V_{CE(SAT)}$	$I_C = 30 \text{ mA}, I_B = 3 \text{ mA}$			0.2	V	
$V_{CE(SAT)}$	$I_C = 100 \text{ mA}, I_B = 10 \text{ mA}$			0.5	V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.90	V	
$V_{BE(SAT)}$	$I_C = 30 \text{ mA}, I_B = 3 \text{ mA}$			1.20	V	
$V_{BE(SAT)}$	$I_C = 100 \text{ mA}, I_B = 10 \text{ mA}$			1.50	V	
$BV_{CEO}$	$I_C = 10 \text{ mA}$	12			V	
$BV_{CBO}$	$I_C = 10 \mu A$	12			V	
$BV_{EBO}$	$I_E = 10 \mu A$	4.5			V	
$I_{CBO}$	$V_{CE} = 10V$			100	nA	
$I_{EBO}$	$V_{EB} = 3V$			100	nA	

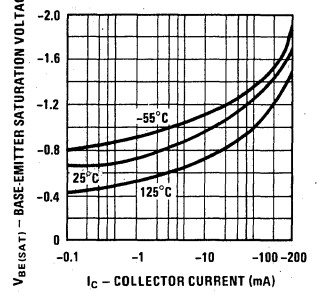
DC Current Gain vs Collector Current



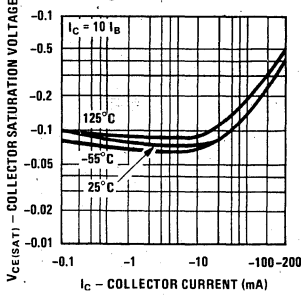
Base-Emitter ON Voltage vs Collector Current



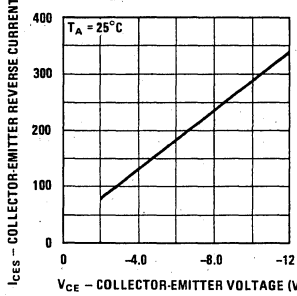
Base Saturation Voltage vs Collector Current



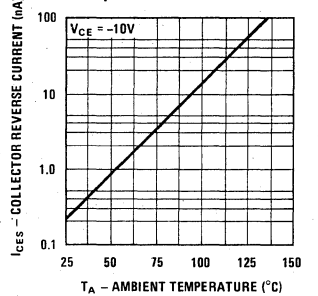
Collector Saturation Voltage vs Collector Current



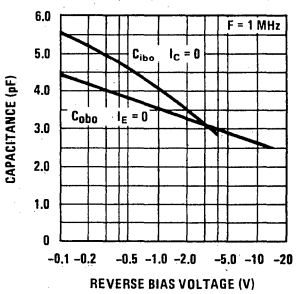
Collector-Base Reverse Current vs Reverse Bias Voltage



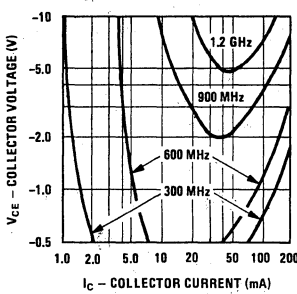
Collector-Base Diode Reverse Current vs Temperature



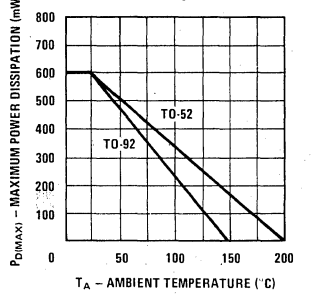
Input and Output Capacitance vs Reverse Bias Voltage



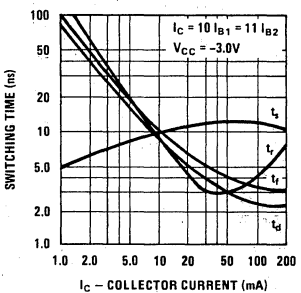
Contours of Constant Gain Bandwidth Product (fT)



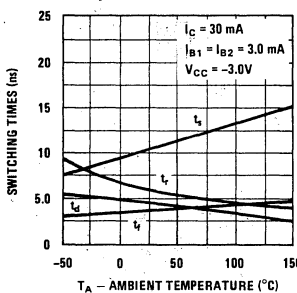
Maximum Power Dissipation vs Ambient Temperature



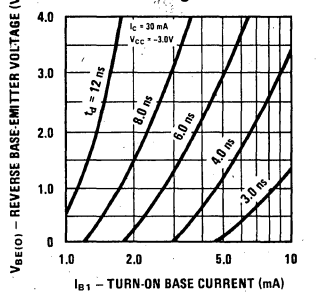
Switching Times vs Collector Current



Switching Times vs Temperature

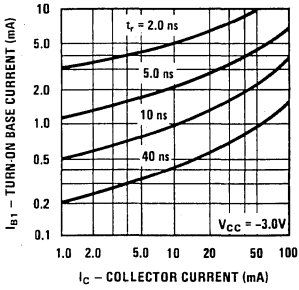


Delay Time vs Turn On Base Current and Reverse Base-Emitter Voltage

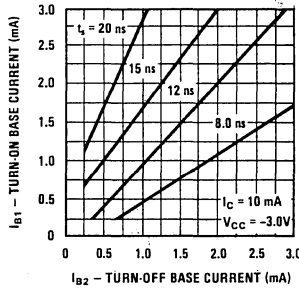


# Process 64

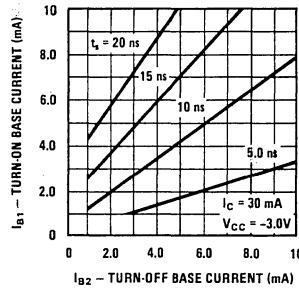
**Rise Time vs Collector and Turn On Base Currents**



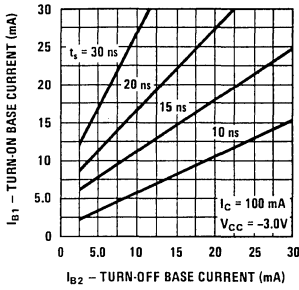
**Storage Time vs Turn On and Turn Off Base Currents**



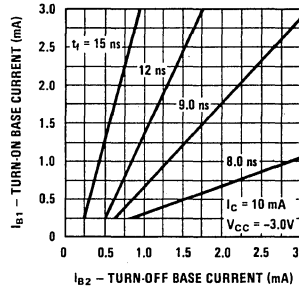
**Storage Time vs Turn On and Turn Off Base Currents**



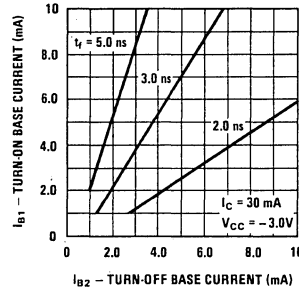
**Storage Time vs Turn On and Turn Off Base Currents**



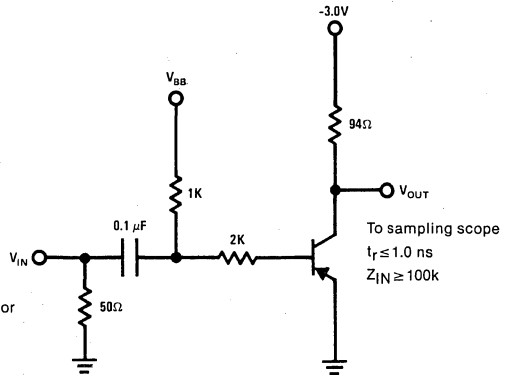
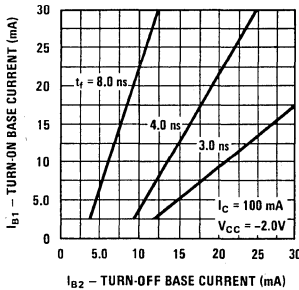
**Fall Time vs Turn On and Turn Off Base Currents**



**Fall Time vs Turn On and Turn Off Base Currents**



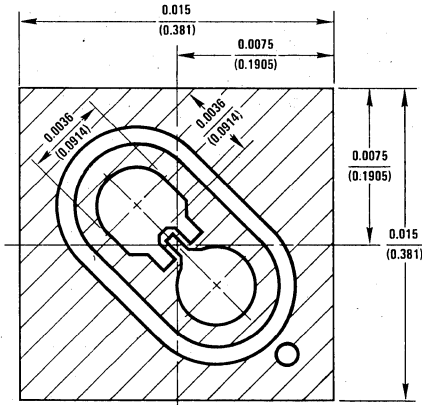
**Fall Time vs Turn On and Turn Off Base Currents**



Pulse generator  
 $t_r \approx 1.0$  ns  
 PW = 400 ns  
 PPS = 150  
 $Z_{IN} = 50\Omega$

$t_{on}$   $V_{BB} = 0, V_{IN} = -6.85V$   
 $t_{off}$   $V_{BB} = -9.85V, V_{IN} = +11.7V$

**FIGURE 1. Switching Time Test Circuit**



**DESCRIPTION**

Process 65 is an overlay, double diffused, gold doped, silicon epitaxial device. Complement to Process 21.

**APPLICATION**

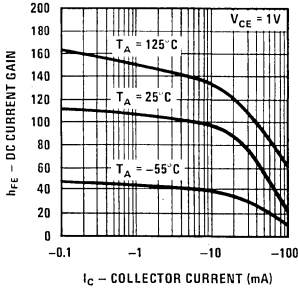
This device was designed for very high speed saturate switching at collector currents to 50 mA.

**PRINCIPAL DEVICE TYPES**

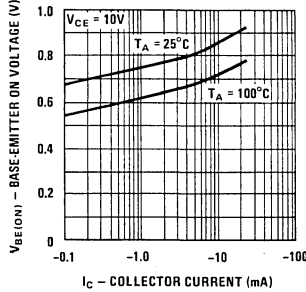
- TO-18: 2N4208
- TO-92, EBC: 2N5771
- MPS3640

Parameter	Conditions	Min	Typ	Max	Units	Notes
$t_{OFF}$	$I_C = 10 \text{ mA}, I_{B2} = 1 \text{ mA}$		18	25	ns	Figure 1
$t_{ON}$	$I_C = 10 \text{ mA}, I_{B1} = 1 \text{ mA}$		11	15	ns	Figure 1
$t_s$	$I_C = I_{B1} = I_{B2} = 10 \text{ mA}$		15	20	ns	
$C_{ob}$	$V_{CB} = 5V$		2	3	pF	
$C_{ib}$	$V_{EB} = 0.5V$			3.5	pF	
$h_{FE}$	$V_{CE} = 10V, I_C = 10 \text{ mA}, f = 100 \text{ MHz}$	6.5	9			
$h_{FE}$	$I_C = 1 \text{ mA}, V_{CE} = 1V$	20				
$h_{FE}$	$I_C = 10 \text{ mA}, V_{CE} = 1V$	30	85	150		
$h_{FE}$	$I_C = 50 \text{ mA}, V_{CE} = 1V$	25	75			
$h_{FE}$	$I_C = 100 \text{ mA}, V_{CE} = 1V$	20				
$h_{FE}$	$I_C = 1 \text{ mA}, V_{CE} = 0.5V$	20				
$h_{FE}$	$I_C = 10 \text{ mA}, V_{CE} = 0.3V$	20				
$V_{CE(SAT)}$	$I_C = 1 \text{ mA}, I_B = 0.1 \text{ mA}$			0.15	V	
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.20	V	
$V_{CE(SAT)}$	$I_C = 50 \text{ mA}, I_B = 5 \text{ mA}$			0.50	V	
$V_{BE(SAT)}$	$I_C = 1 \text{ mA}, I_B = 0.1 \text{ mA}$			0.8	V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$			0.95	V	
$V_{BE(SAT)}$	$I_C = 0 \text{ mA}, I_B = 5 \text{ mA}$			1.5	V	
$BV_{CEO}$	$I_C = 3 \text{ mA}$	12			V	
$BV_{CBO}$	$I_C = 100 \mu A$	15			V	
$BV_{EBO}$	$I_C = 10 \mu A$	4.5			V	
$I_{CBO}$	$V_{CB} = 10V$			100	nA	
$I_{EBO}$	$V_{EB} = 3V$			100	nA	

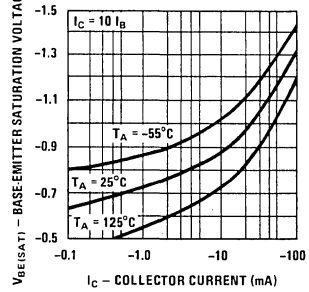
**DC Current Gain vs Collector Current**



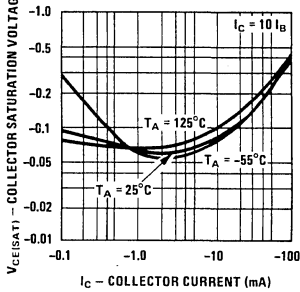
**Base-Emitter ON Voltage vs Collector Current**



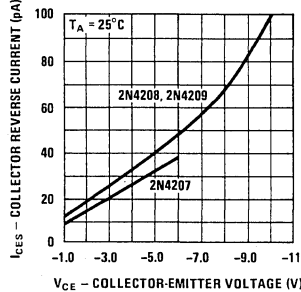
**Base Saturation Voltage vs Collector Current**



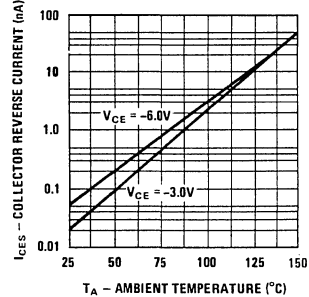
**Collector Saturation Voltage vs Collector Current**



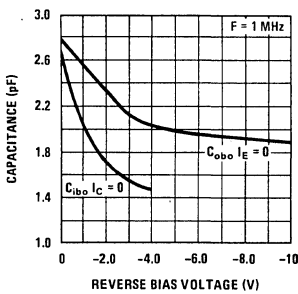
**Collector Reverse Current vs Collector-Emitter Voltage**



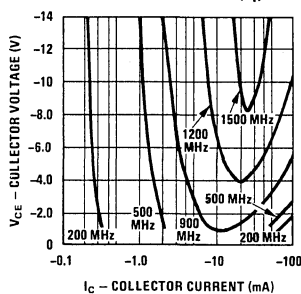
**Collector Reverse Current vs Ambient Temperature**



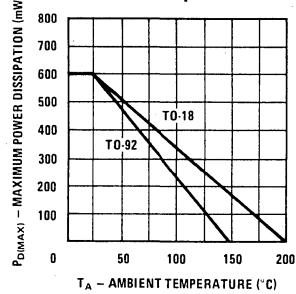
**Input and Output Capacitance vs Reverse Bias Voltage**



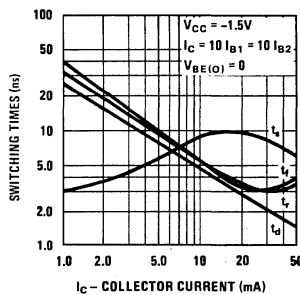
**Contours of Constant Gain Bandwidth Product (fT)**



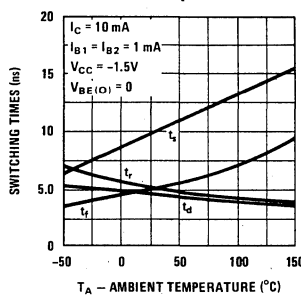
**Maximum Power Dissipation vs Ambient Temperature**



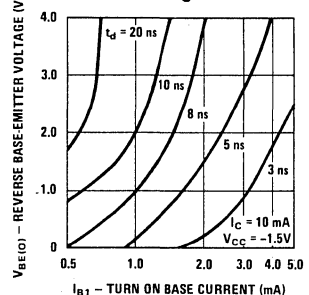
**Switching Times vs Collector Current**



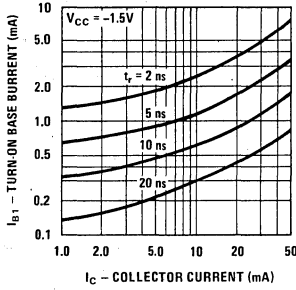
**Switching Times vs Ambient Temperature**



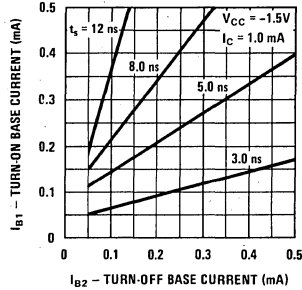
**Delay Time vs Turn On Base Current and Reverse Base-Emitter Voltage**



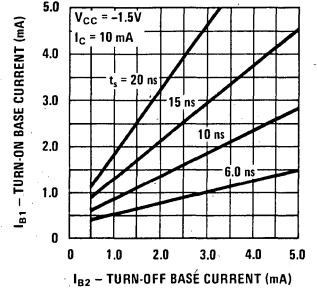
Rise Time vs Collector and Turn On Base Currents



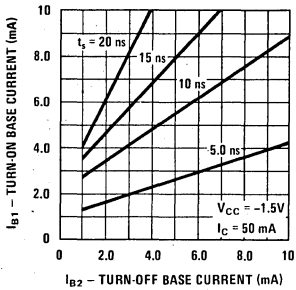
Storage Time vs Turn On and Turn Off Base Currents



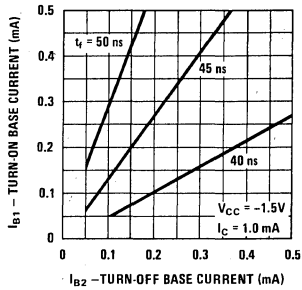
Storage Time vs Turn On and Turn Off Base Currents



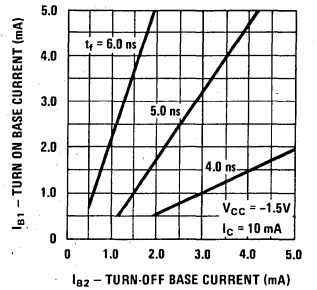
Storage Time vs Turn On and Turn Off Base Currents



Fall Time vs Turn On and Turn Off Base Currents



Fall Time vs Turn On and Turn Off Base Currents



Fall Time vs Turn On and Turn Off Base Currents

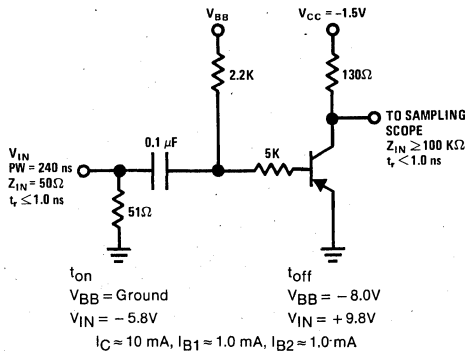
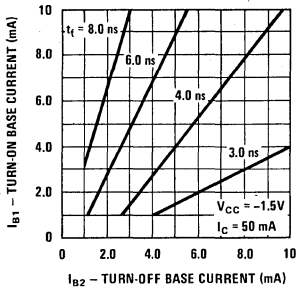
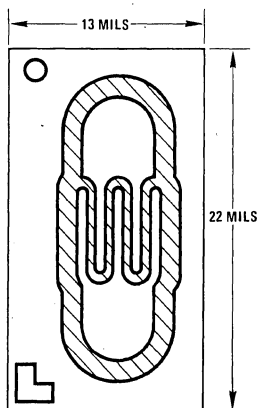


FIGURE 1.  $t_{ON}$  and  $t_{OFF}$  Test Circuit


**DESCRIPTION**

Process 66 is an overlay, double-diffused, silicon epitaxial device. Complement to Process 23.

**APPLICATION**

This device was designed for general purpose amplifier and switching applications at collector currents of 10  $\mu$ A to 100 mA.

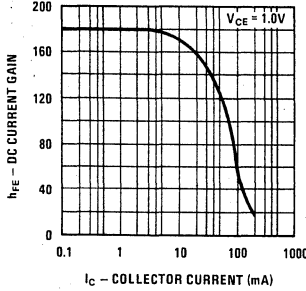
**PRINCIPAL DEVICE TYPE**

TO-92, EBC: 2N3906

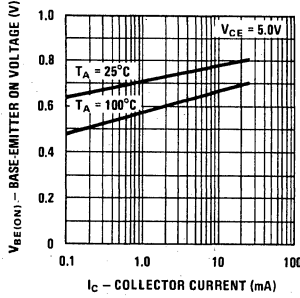
Parameter	Conditions	Min	Typ	Max	Units	Notes
$t_{OFF}$	$I_C = 10 \text{ mA}$ , $I_{B2} = 1 \text{ mA}$		150	300	ns	
$t_{ON}$	$I_C = 10 \text{ mA}$ , $I_{B1} = 1 \text{ mA}$		30	70	ns	
$C_{ob}$	$V_{CB} = 5\text{V}$		3.0	4.5	pF	
$C_{ib}$	$V_{EB} = 0.5\text{V}$			15	pF	
$h_{fe}$	$f = 100 \text{ MHz}$ , $V_{CE} = 20\text{V}$ , $I_C = 10 \text{ mA}$	2.5	4.5			
NF (wideband)	$I_C = 100 \mu\text{A}$ , $V_{CE} = 5\text{V}$ ,		2.0		dB	
		$R_S = 1 \text{ k}\Omega$				
$h_{FE}$	$I_C = 0.1 \text{ mA}$ , $V_{CE} = 1\text{V}$	40				
$h_{FE}$	$I_C = 1 \text{ mA}$ , $V_{CE} = 1\text{V}$	50				
$h_{FE}$	$I_C = 10 \text{ mA}$ , $V_{CE} = 1\text{V}$	50	150	350		
$h_{FE}$	$I_C = 50 \text{ mA}$ , $V_{CE} = 1\text{V}$	40				
$h_{FE}$	$I_C = 100 \text{ mA}$ , $V_{CE} = 1\text{V}$	20				
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}$ , $I_B = 1 \text{ mA}$			0.25	V	
$V_{CE(SAT)}$	$I_C = 50 \text{ mA}$ , $I_B = 5 \text{ mA}$			0.40	V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}$ , $I_B = 1 \text{ mA}$			0.85	V	
$V_{BE(SAT)}$	$I_C = 50 \text{ mA}$ , $I_B = 5 \text{ mA}$			0.95	V	
$BV_{CEO}$	$I_C = 1 \text{ mA}$	35			V	
$BV_{CBO}$	$I_C = 10 \mu\text{A}$	45			V	
$BV_{EBO}$	$I_C = 10 \mu\text{A}$	5.0			V	
$I_{CBO}$	$V_{CB} = 25\text{V}$			100	nA	
$I_{EBO}$	$V_{EB} = 4\text{V}$			100	nA	



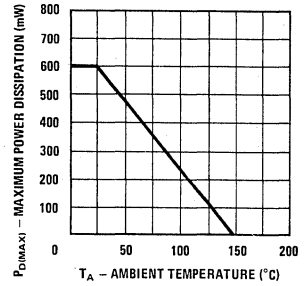
DC Current Gain vs Collector Current



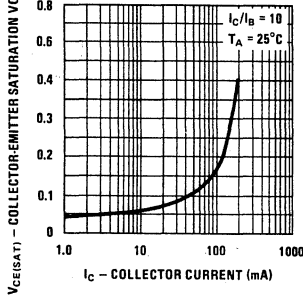
Base-Emitter ON Voltage vs Collector Current



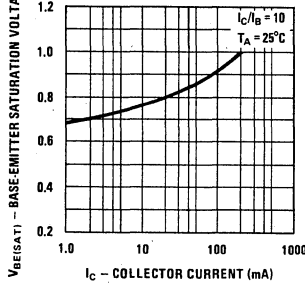
Maximum Power Dissipation vs Ambient Temperature TO-92



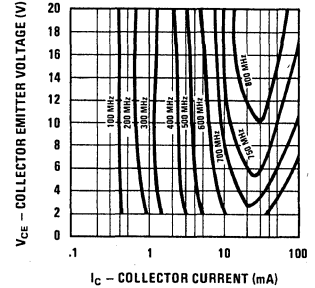
Collector-Emitter Saturation Voltage vs Collector Current



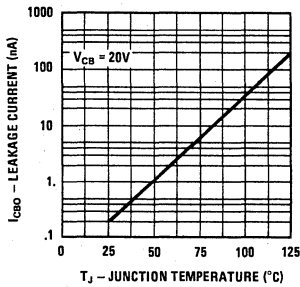
Base-Emitter Saturation Voltage vs Collector Current



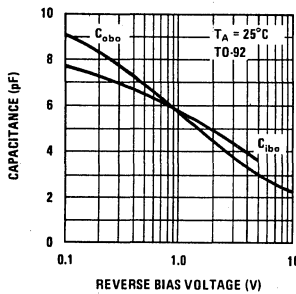
Contours of Constant Gain Bandwidth Product (fT)



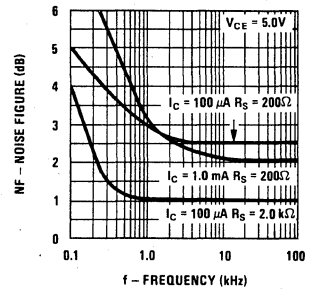
Collector-Base Diode Reverse Current vs Temperature



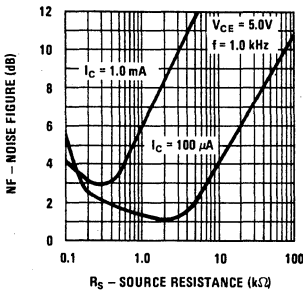
Common Base Open Circuit Input and Output Capacitance vs Reverse Bias Voltage



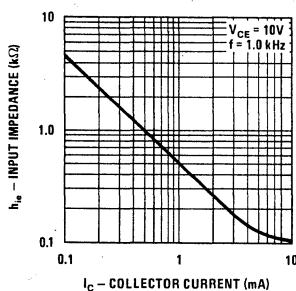
Noise Figure vs Frequency



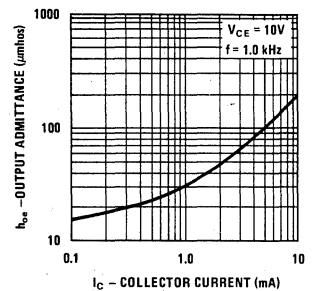
Noise Figure vs Source Resistance



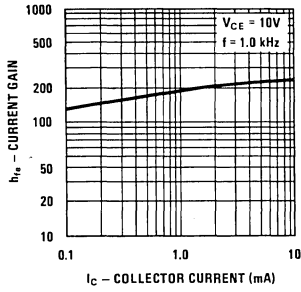
Input Impedance



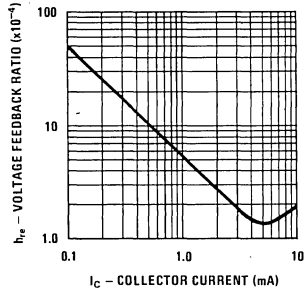
Output Admittance



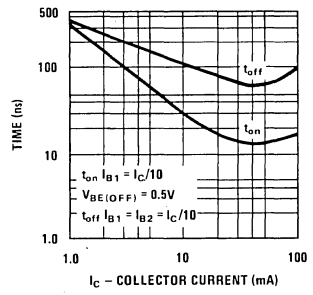
Current Gain



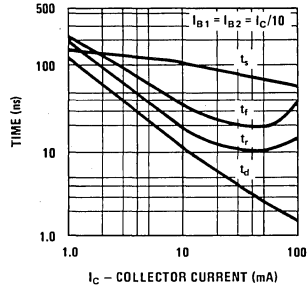
Voltage Feedback Ratio



Turn On and Turn Off Times vs Collector Current

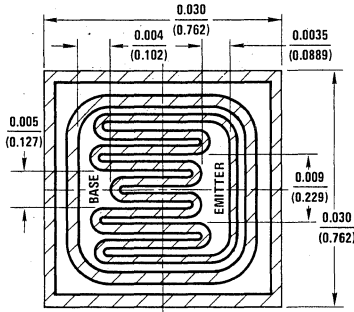


Switching Times vs Collector Current





# Process 67 PNP Medium Power



## DESCRIPTION

Process 67 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 12.

## APPLICATION

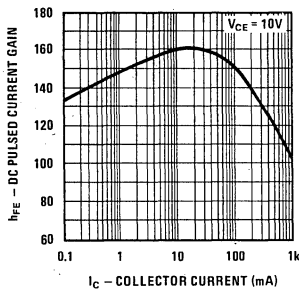
This device is designed for general purpose amplifier and switching applications at currents to 1A and collector voltages up to 70V.

## PRINCIPAL DEVICE TYPES

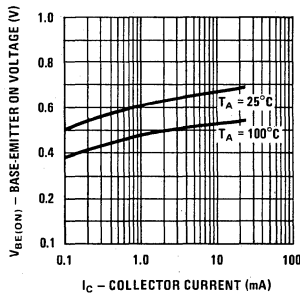
TO-39: 2N4033 TO-92: MPS4356 TO-237: TN4033  
MPSA55

Parameter	Conditions	Min	Typ	Max	Units	Notes
$t_{ON}$	$I_C = 500 \text{ mA}$ , $I_{B1} = 50 \text{ mA}$		35		ns	
$t_{OFF}$	$I_C = 500 \text{ mA}$ , $I_{B2} = 50 \text{ mA}$		250		ns	
$C_{ob}$	$V_{CB} = 10 \text{ V}$		11	15	pF	
$C_{ib}$	$V_{EB} = 0.50 \text{ V}$			90	pF	
$h_{fe}$	$V_{CE} = 10 \text{ V}$ , $I_C = 50 \text{ mA}$ , $f = 100 \text{ MHz}$	1	2			
NF (spot)	$I_C = 100 \mu\text{A}$ , $R_S = 1 \text{ k}$ , $V_{CE} = 10 \text{ V}$ , $f = 1 \text{ kHz}$		1		dB	
$h_{FE}$	$I_C = 0.10 \text{ mA}$ , $V_{CE} = 10 \text{ V}$	40				
$h_{FE}$	$I_C = 1.0 \text{ mA}$ , $V_{CE} = 10 \text{ V}$	45				
$h_{FE}$	$I_C = 10 \text{ mA}$ , $V_{CE} = 10 \text{ V}$	50				
$h_{FE}$	$I_C = 100 \text{ mA}$ , $V_{CE} = 10 \text{ V}$	50	150	350		
$h_{FE}$	$I_C = 500 \text{ mA}$ , $V_{CE} = 10 \text{ V}$	35				
$V_{CE(SAT)}$	$I_C = 150 \text{ mA}$ , $I_B = 15 \text{ mA}$			0.2	V	
$V_{CE(SAT)}$	$I_C = 500 \text{ mA}$ , $I_B = 50 \text{ mA}$			0.6	V	
$V_{BE(SAT)}$	$I_C = 150 \text{ mA}$ , $I_B = 15 \text{ mA}$			1.0	V	
$V_{BE(SAT)}$	$I_C = 500 \text{ mA}$ , $I_B = 50 \text{ mA}$			1.2	V	
$BV_{CEO}$	$I_C = 10 \text{ mA}$	60			V	
$BV_{CBO}$	$I_C = 100 \mu\text{A}$	70			V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	7			V	
$I_{CBO}$	$V_{CB} = 50 \text{ V}$			100	nA	
$I_{EBO}$	$V_{EB} = 5 \text{ V}$			100	nA	

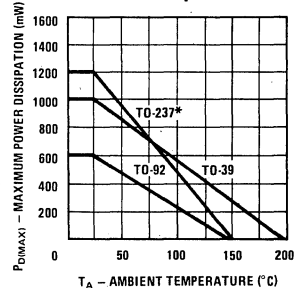
**DC Pulsed Current Gain vs Collector Current**



**Base-Emitter ON Voltage vs Collector Current**



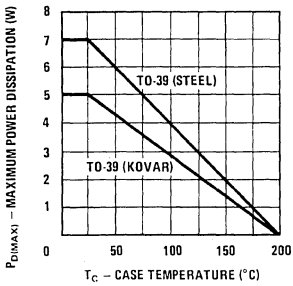
**Maximum Power Dissipation vs Ambient Temperature**



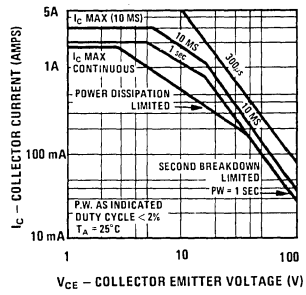
\* One square inch of copper run

# Process 67

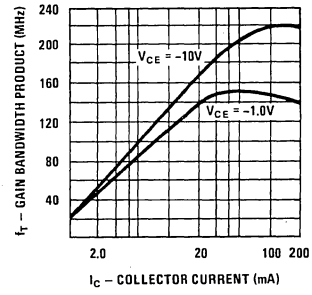
**Maximum Power Dissipation vs Case Temperature**



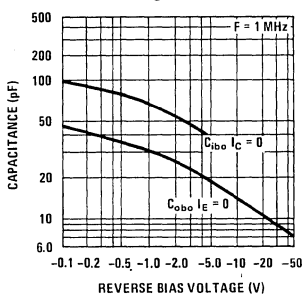
**Safe Operating Area TO-39 with "Wake Field" Type 296-4 Heat Sink**



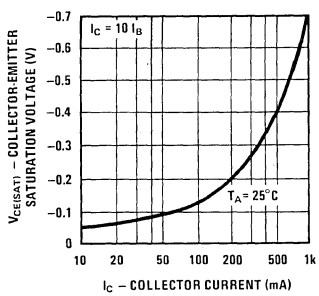
**Gain Bandwidth Product vs Collector Current**



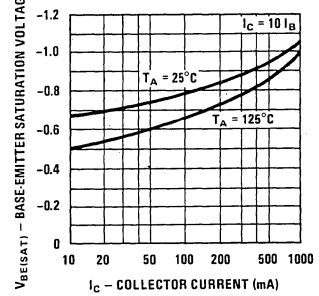
**Common Base Open Circuit Input and Output Capacitance vs Reverse Bias Voltage**



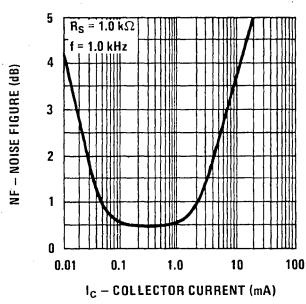
**Collector-Emitter Saturation Voltage vs Collector Current**



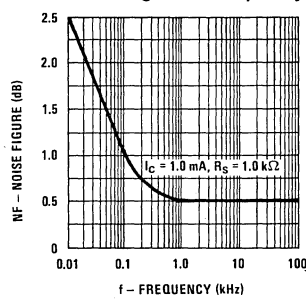
**Base-Emitter Saturation Voltage vs Collector Current**



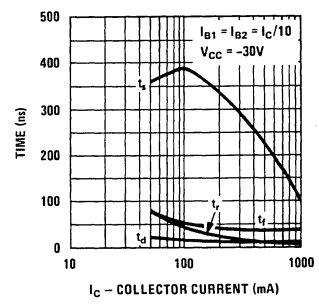
**Noise Figure vs Collector Current**



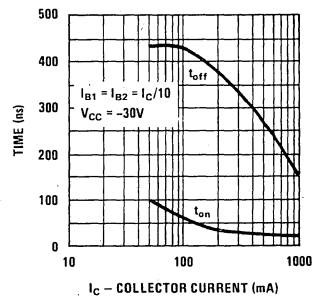
**Noise Figure vs Frequency**



**Switching Times vs Collector Current**

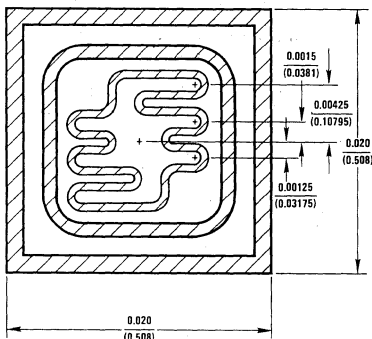


**Turn On and Turn Off Times vs Collector Current**





# Process 68 PNP Medium Power



## DESCRIPTION

Process 68 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 09.

## APPLICATION

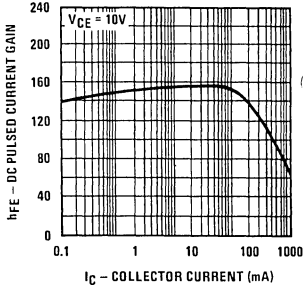
This device was designed for general purpose amplifier applications at collector currents to 1A.

## PRINCIPAL DEVICE TYPES

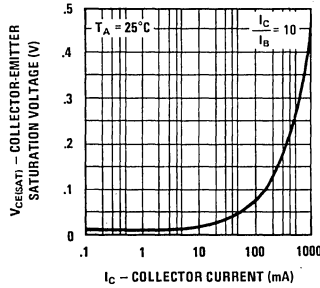
TO-92, EBC: CS9012  
MPS6563

Parameter	Conditions	Min	Typ	Max	Units	Notes
$C_{ob}$	$V_{CB} = 10V, f = 1 \text{ MHz}$		9	12	pF	
$C_{ib}$	$V_{EB} = 0.5V, f = 1 \text{ MHz}$			35	pF	
NF	$V_{CE} = 10V, I_C = 1 \text{ mA}, R_S = 100\Omega, f = 1 \text{ kHz}$		1.0		dB	
$f_T$	$V_{CE} = 10V, I_C = 50 \text{ mA}$	175			MHz	
$h_{FE}$	$V_{CE} = 1V, I_C = 1 \text{ mA}$	50				
$h_{FE}$	$V_{CE} = 1V, I_C = 100 \text{ mA}$	50	150	300		
$h_{FE}$	$V_{CE} = 1V, I_C = 500 \text{ mA}$	30				
$V_{CE(SAT)}$	$I_C = 150 \text{ mA}, I_B = 15$			0.2	V	
$V_{CE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$		0.3	0.5	V	
$V_{BE(SAT)}$	$I_C = 150 \text{ mA}, I_B = 15 \text{ mA}$			1.0	V	
$V_{BE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			1.2	V	
$I_{CBO}$	$V_{CE} = 30V$			100	nA	
$I_{EBO}$	$V_{EB} = 5V$			100	nA	
$BV_{CBO}$	$I_C = 100 \mu A$	35			V	
$BV_{EBO}$	$I_E = 10 \mu A$	7			V	
$BV_{CEO}$	$I_C = 10 \text{ mA}$	25			V	

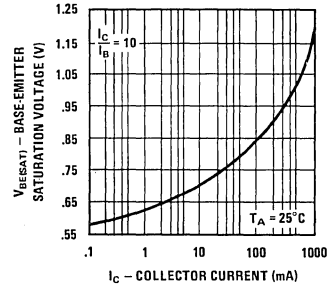
**DC Pulsed Current Gain vs Collector Current**



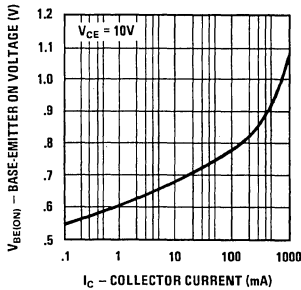
**Collector-Emitter Saturation Voltage vs Collector Current**



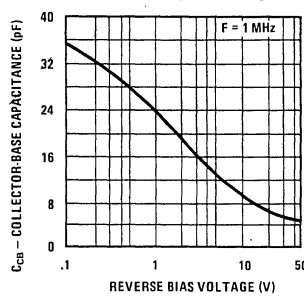
**Base-Emitter Saturation Voltage vs Collector Current**



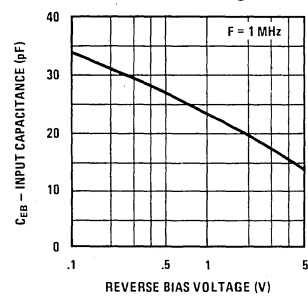
**Base-Emitter ON Voltage vs Collector Current**



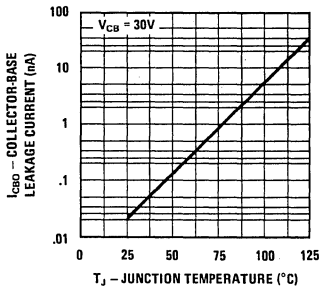
**Collector-Base Capacitance vs Reverse Bias Voltage**



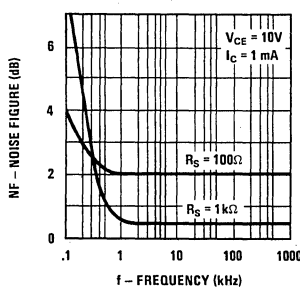
**Input Capacitance vs Reverse Bias Voltage**



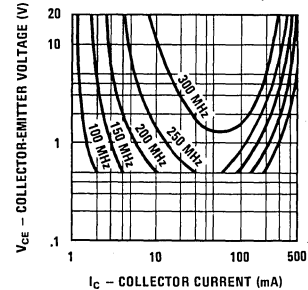
**Collector-Base Diode Reverse Current vs Temperature**



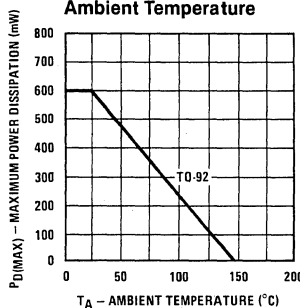
**Noise Figure vs Frequency**

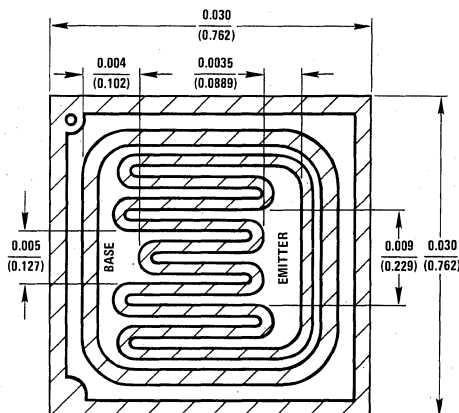


**Contours of Constant Gain Bandwidth Product (f<sub>T</sub>)**



**Maximum Power Dissipation vs Ambient Temperature**





### DESCRIPTION

Process 70 is a non-overlay, double-diffused, gold doped, silicon epitaxial device. Complement to Process 25.

### APPLICATION

This device was designed primarily for high speed saturated switching applications.

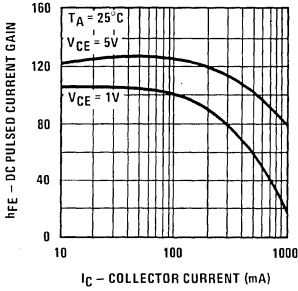
### PRINCIPAL DEVICE TYPES

TO-39: 2N3467

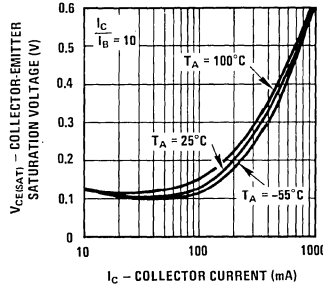
TO-237: TN3467

Parameter	Conditions	Min	Typ	Max	Units	Notes
$t_{ON}$	$I_C = 500 \text{ mA}, I_{B1} = 50 \text{ mA}$		20	40	ns	Figure 1
$t_{OFF}$	$I_C = 500 \text{ mA}, I_{B2} = 50 \text{ mA}$		60	90	ns	Figure 2
$C_{ob}$	$V_{CB} = -10V$		15	20	pF	
$C_{ib}$	$V_{EB} = -0.5V$			80	pF	
$h_{FE}$	$I_C = 100 \text{ mA}, V_{CE} = -1V$	40	100	200		
$h_{FE}$	$I_C = 500 \text{ mA}, V_{CE} = -1V$	30		120		
$h_{FE}$	$I_C = 1A, V_{CE} = -1V$	15				
$V_{CE(SAT)}$	$I_C = 150 \text{ mA}, I_B = 15 \text{ mA}$			0.3	V	
$V_{CE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			0.6	V	
$V_{CE(SAT)}$	$I_C = 1A, I_B = 100 \text{ mA}$			1.0	V	
$V_{BE(SAT)}$	$I_C = 150 \text{ mA}, I_B = 50 \text{ mA}$			1.2	V	
$V_{BE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			1.2	V	
$V_{BE(SAT)}$	$I_C = 1A, I_B = 100 \text{ mA}$			1.7	V	
$BV_{CEO}$	$I_C = 10 \text{ mA}$	40			V	
$BV_{CBO}$	$I_C = 100 \mu A$	50			V	
$BV_{EBO}$	$I_E = 10 \mu A$	6			V	
$I_{CBO}$	$V_{CB} = 30V$			100	nA	
$I_{EBO}$	$V_{EB} = 4V$			100	nA	

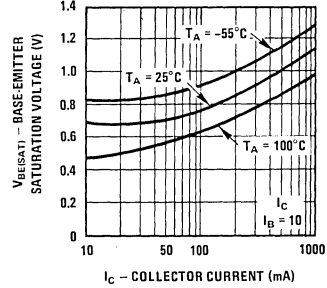
**DC Pulsed Current Gain vs Collector Current**



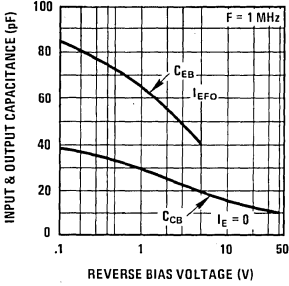
**Collector-Emitter Saturation Voltage vs Collector Current**



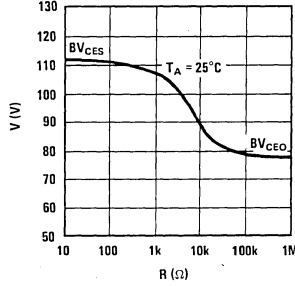
**Base-Emitter Saturation Voltage vs Collector Current**



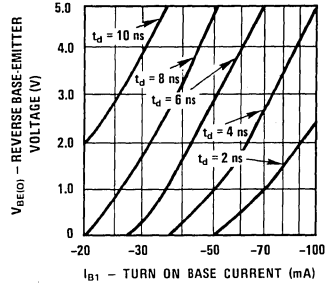
**Input and Output Capacitance vs Reverse Bias Voltage**



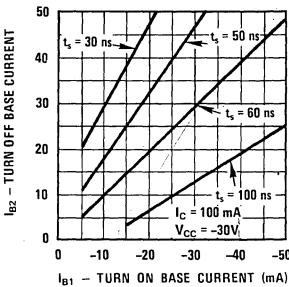
**BV<sub>CER</sub> vs R<sub>BE</sub>, I<sub>C</sub> = 10 mA**



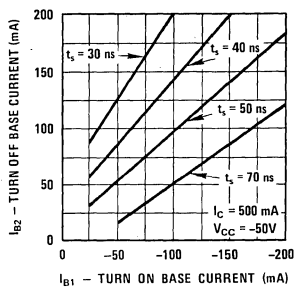
**Delay Time vs Turn On Base Current and Reverse Base-Emitter Voltage**



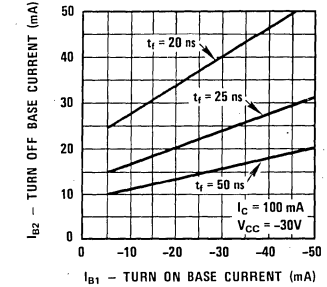
**Storage Time vs Turn On and Turn Off Base Currents**



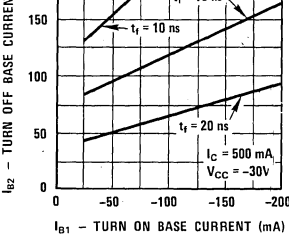
**Storage Time vs Turn On and Turn Off Base Currents**



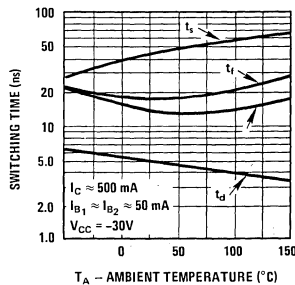
**Fall Time vs Turn On and Turn Off Base Currents**



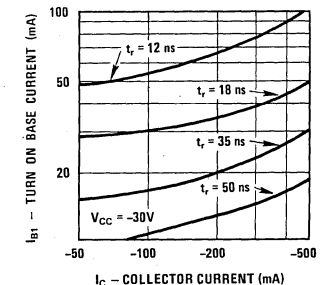
**Storage Time vs Turn On and Turn Off Base Currents**



**Switching Times vs Ambient Temperature**

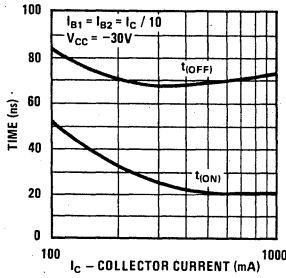


**Rise Time vs Collector Current and Turn On Base Current**

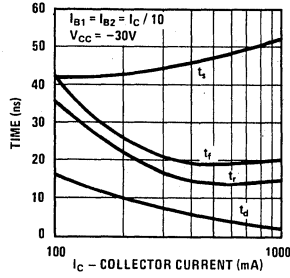




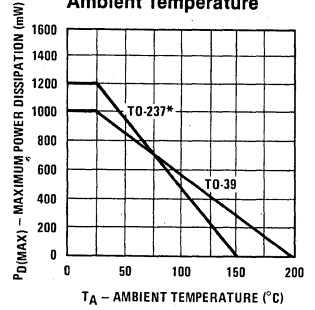
Turn On and Turn Off Times vs Collector Current



Switching Times vs Collector Current

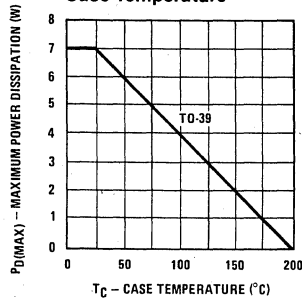


Maximum Power Dissipation vs Ambient Temperature



\* One square inch of copper run

Maximum Power Dissipation vs Case Temperature



PW = 200 ns  
Rise time ≤ 2 ns  
Duty cycle = 2%

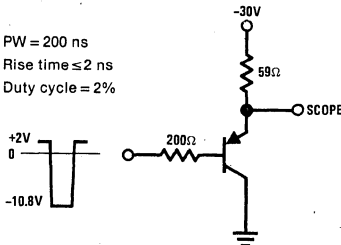


FIGURE 1.  $t_{ON}$  Equivalent Test Circuit

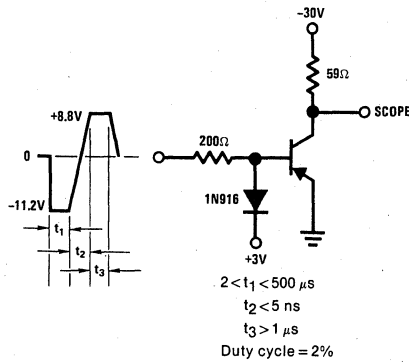
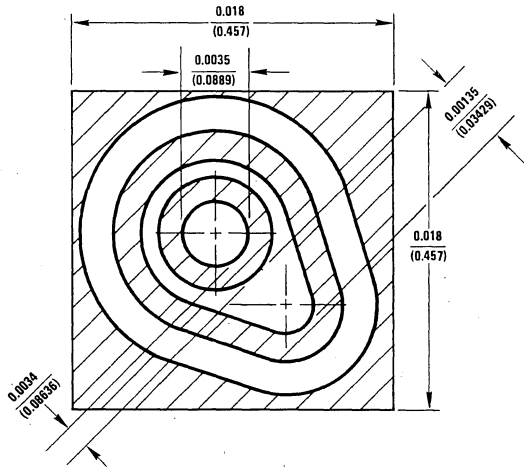


FIGURE 2.  $t_{OFF}$  Equivalent Test Circuit


**DESCRIPTION**

Process 71 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 04.

**APPLICATION**

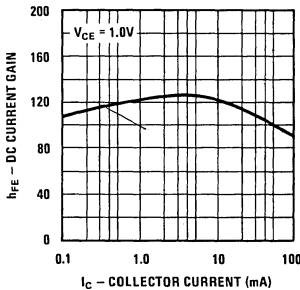
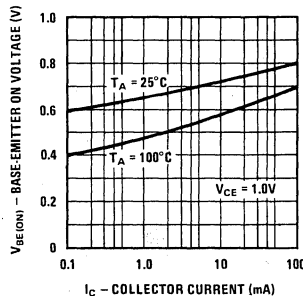
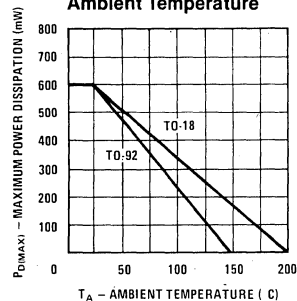
This device was designed for general purpose amplifier applications at collector currents to 50 mA.

**PRINCIPAL DEVICE TYPES**

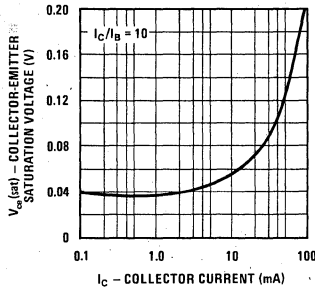
**TO-18:** BC177 Series

**TO-92, CBE:** BC560 Series

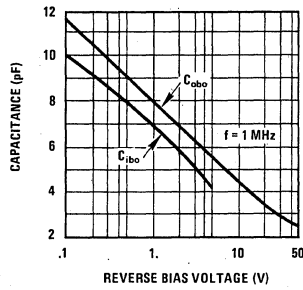
Parameter	Conditions	Min	Typ	Max	Units	Notes
NF (spot)	$I_C = 200 \mu A$ , $V_C = 5V$ , $R_S = 2k$ , $f = 1 \text{ kHz}$		1.0	4.0	dB	
$h_{fe}$	$I_C = 10 \text{ mA}$ , $V_{CE} = 5V$ , $f = 100 \text{ MHz}$	2.0	4.0			
$C_{ob}$	$V_{CB} = 10V$		4	6	pF	
$C_{ib}$	$V_{EB} = 0.50V$			12	pF	
$h_{FE}$	$I_C = 100 \mu A$ , $V_{CE} = 5V$	70				
$h_{FE}$	$I_C = 1 \text{ mA}$ , $V_{CE} = 5V$	80	200	560		
$h_{FE}$	$I_C = 10 \text{ mA}$ , $V_{CE} = 5V$	70				
$h_{FE}$	$I_C = 50 \text{ mA}$ , $V_{CE} = 5V$	50				
$V_{CE(SAT)}$	$I_C = 1 \text{ mA}$ , $I_B = 0.10 \text{ mA}$			0.10	V	
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}$ , $I_B = 1 \text{ mA}$			0.11	V	
$V_{BE(SAT)}$	$I_C = 1 \text{ mA}$ , $I_B = 0.10 \text{ mA}$			0.95	V	
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}$ , $I_B = 1 \text{ mA}$			1.0	V	
$BV_{CEO}$	$I_C = 1 \text{ mA}$	30			V	
$BV_{CBO}$	$I_C = 10 \mu A$	40			V	
$BV_{EBO}$	$I_E = 10 \mu A$	6			V	
$I_{CBO}$	$V_{CB} = 30V$			100	nA	
$I_{EBO}$	$V_{EB} = 5V$			100	nA	

**DC Current Gain vs Collector Current**

**Base-Emitter ON Voltage vs Collector Current**

**Maximum Power Dissipation vs Ambient Temperature**


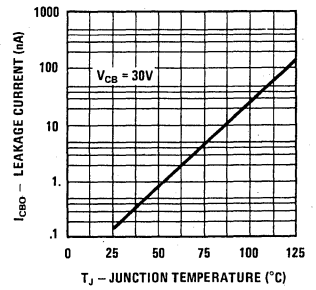
Collector-Emitter Saturation Voltage vs Collector Current



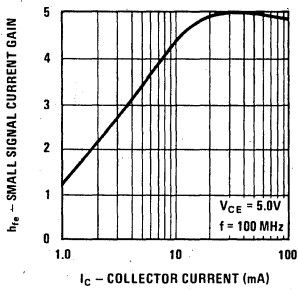
Capacitance vs Reverse Bias Voltage



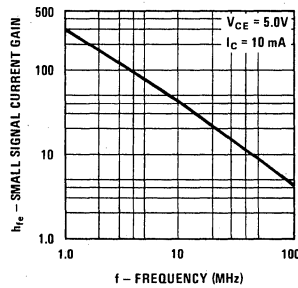
Collector-Base Diode Reverse Current vs Temperature



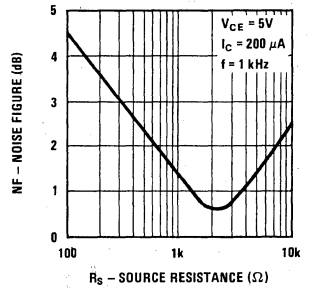
Small Signal Current Gain vs Collector Current



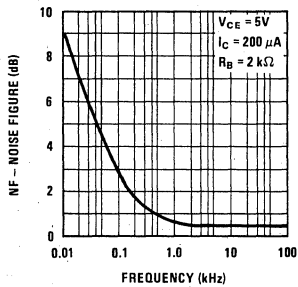
Capacitance vs Reverse Bias Voltage



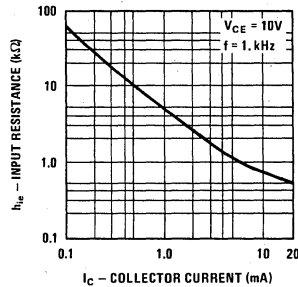
Noise Figure vs Source Resistance



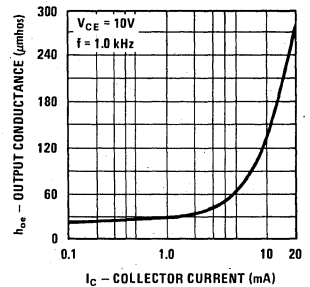
Noise Figure vs Frequency



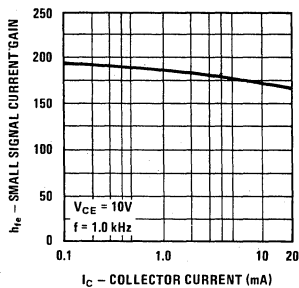
Small Signal Input Resistance vs Collector Current



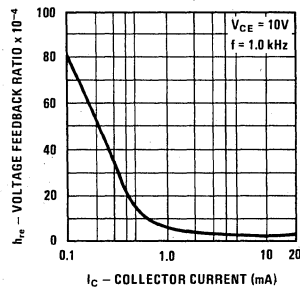
Small Signal Output Conductance vs Collector Current

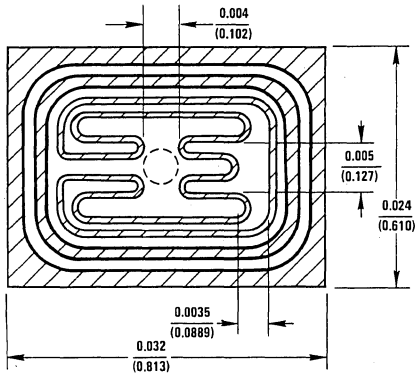


Small Signal Current Gain vs Collector Current



Small Signal Voltage Feedback Ratio vs Collector Current




**DESCRIPTION**

Process 74 is a non-overlay, double-diffused, silicon epitaxial device. Complement to Process 16.

**APPLICATION**

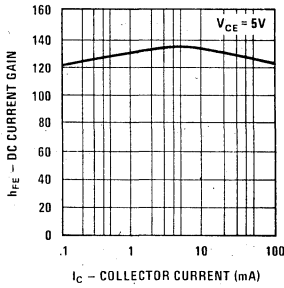
This device was designed as a general purpose amplifier and switch for applications requiring high voltages.

**PRINCIPAL DEVICE TYPES**

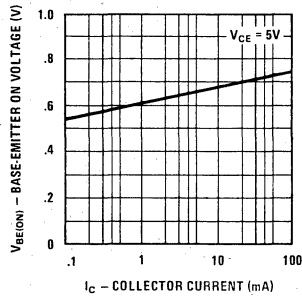
TO-92, EBC: 2N5401  
MPSL51

Parameter	Conditions	Min	Typ	Max	Units	Notes
$f_T$	$I_C = 10 \text{ mA}$ , $V_{CE} = 10 \text{ V}$ , $f = 100 \text{ MHz}$	100	160		MHz	
$C_{ob}$	$V_{CB} = 10 \text{ V}$ , $f = 1 \text{ MHz}$		8	12	pF	
$h_{FE}$	$I_C = 1 \text{ mA}$ , $V_{CE} = 5 \text{ V}$	40				
$h_{FE}$	$I_C = 10 \text{ mA}$ , $V_{CE} = 5 \text{ V}$	50	120	250		
$h_{FE}$	$I_C = 50 \text{ mA}$ , $V_{CE} = 5 \text{ V}$	20				
$V_{BE(SAT)}$	$I_C = 50 \text{ mA}$ , $I_B = 5 \text{ mA}$			0.95	V	
$V_{CE(SAT)}$	$I_C = 50 \text{ mA}$ , $I_B = 5 \text{ mA}$			0.50	V	
$BV_{CEO}$	$I_C = 1 \text{ mA}$	120			V	
$BV_{CBO}$	$I_C = 10 \mu\text{A}$	140			V	
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	6			V	
$I_{CBO}$	$V_{CB} = 100 \text{ V}$			100	nA	
$I_{EBO}$	$V_{CB} = 4 \text{ V}$			100	nA	

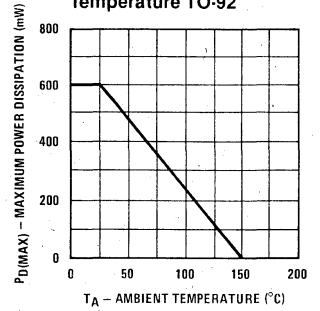
DC Current Gain vs Collector Current



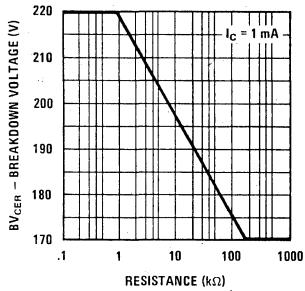
Base-Emitter ON Voltage vs Collector Current



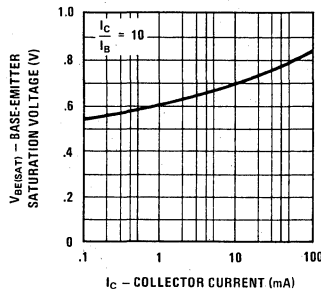
Maximum Power Dissipation vs Ambient Temperature TO-92



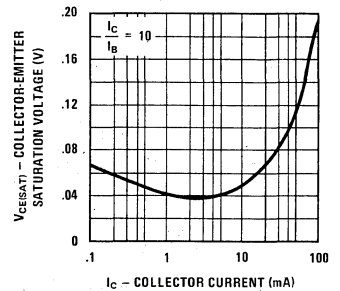
Collector-Emitter Breakdown Voltage with Resistance Between Base-Emitter



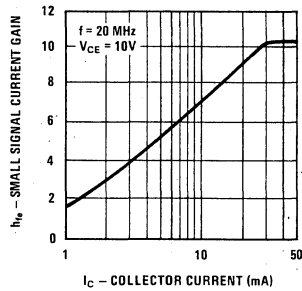
Base-Emitter Saturation Voltage vs Collector Current



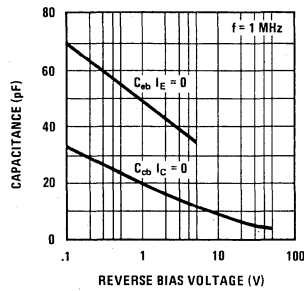
Collector-Emitter Saturation Voltage vs Collector Current

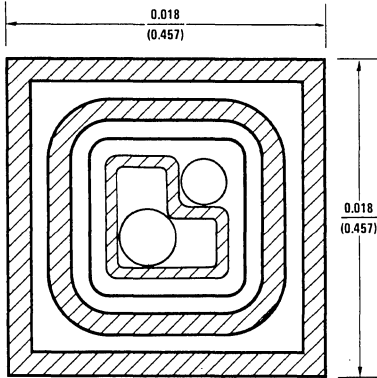


Small Signal Current Gain vs Collector Current



Input and Output Capacitance vs Reverse Bias Voltage




**DESCRIPTION**

Process 76 is a non-overlay, planar epitaxial silicon transistor with a field plate.

**APPLICATION**

This device was designed as video output to drive color CRT, mainly in complementary configuration. Complement to Process 17.

**PRINCIPAL DEVICE TYPES**

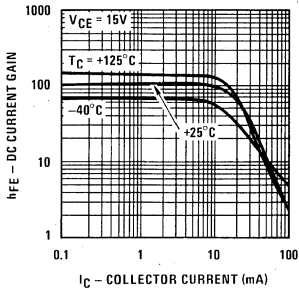
**TO-202, ECB:** NSE870  
NSE872

**TO-237, ECB:** 92PU870  
92PU872

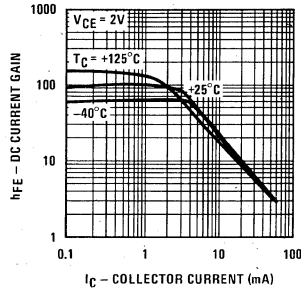
Parameter	Conditions	Min	Typ	Max	Units
$V_{CE0}$	$I_C = 1 \text{ mA}$ (Note 1)	220	300		V
$V_{CES}$	$I_C = 0.1 \text{ mA}$		350		V
$V_{EBO}$	$I_E = 0.1 \text{ mA}$	6			V
$I_{CES}$	$V_{CE} = 150\text{V}$			200	nA
$I_{EBO}$	$V_{EB} = 5\text{V}$			100	nA
$h_{FE1}$	$V_{CE} = 15\text{V}, I_C = 0.1 \text{ mA}$		70		
$h_{FE2}$	$V_{CE} = 15\text{V}, I_C = 25$	40	80	200	
$h_{FE3}$	$V_{CE} = 15\text{V}, I_C = 50$		25		
$V_{CE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$		0.3	1.0	V
$V_{BE(SAT)}$	$I_C = 10 \text{ mA}, I_B = 1 \text{ mA}$		0.8		V
$f_T$	$V_{CE} = 15\text{V}, I_C = 10 \text{ mA}, f = 20 \text{ MHz}$		0		MHz
$\omega_{ob}$	$V_{CB} = 10\text{V}, I_C = 10 \text{ mA}, f = 20 \text{ MHz}$		0		MHz
$C_{ib}$	$V_{EB} = 1\text{V}, f = 1 \text{ MHz}$		0.5		pF
$P_{D(max)}$					
TO-202	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	8 1.8			W
TO-237	$T_{COLLECTOR} = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	2 0.85			W
$\theta_{JC}$					
TO-202				15.6	$^\circ\text{C/W}$
TO-237				69.4	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-202				62.5	$^\circ\text{C/W}$
TO-237				147	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts			150	$^\circ\text{C}$

Note 1: Pulsed measurement, 300  $\mu\text{s}$  pulse width

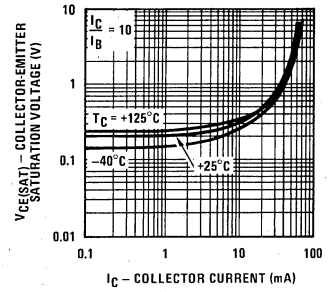
DC Current Gain vs Collector Current



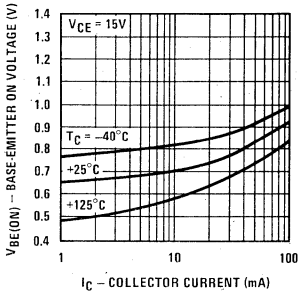
Pulsed Current Gain vs Collector Current



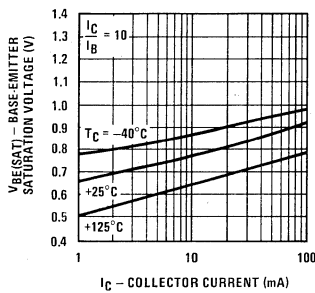
Collector-Emitter Saturation Voltage vs Collector Current



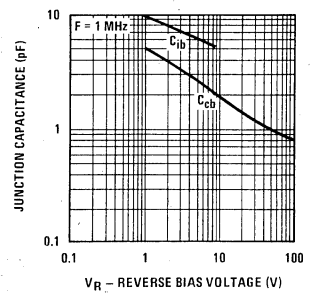
Base-Emitter ON Voltage vs Collector Current



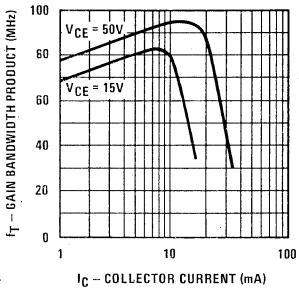
Base-Emitter Saturation Voltage vs Collector Current



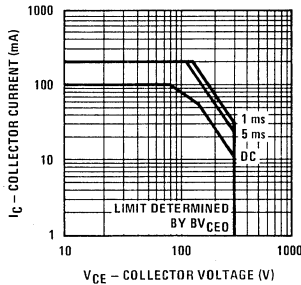
Junction Capacitance vs Reverse Bias Voltage



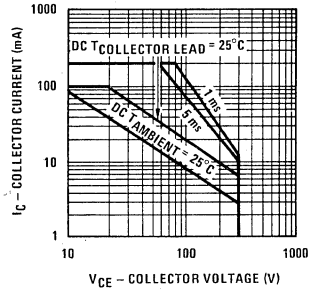
Gain Bandwidth Product vs Collector Current



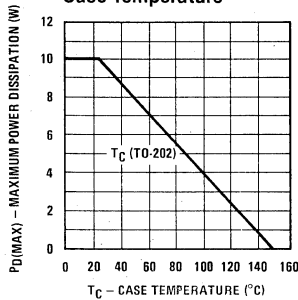
Safe Operating Area TO-202



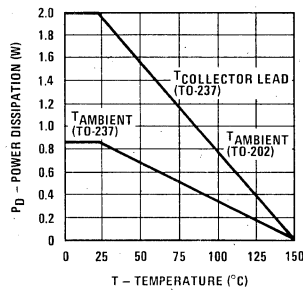
Safe Operating Area TO-237

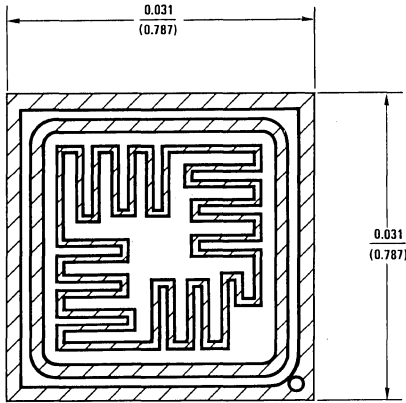


Maximum Power Dissipation vs Case Temperature



Thermal Derating Curve




**DESCRIPTION**

Process 77 is a double-diffused, silicon epitaxial planar device. Complement to Process 37.

**APPLICATION**

This device was designed for general purpose medium power amplifier and switching circuits that require collector currents to 2A.

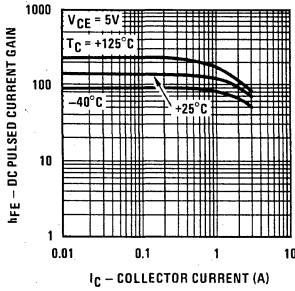
**PRINCIPAL DEVICE TYPES**

- TO-202, EBC:** D41E7  
NSDU51, -A  
NSDU52
- TO-202, BCE:** NSE170
- TO-237, EBC:** 2N6726, 7  
(92PU51, -A)
- TO-237, ECB:** NA22/32 Series
- TO-92, EBC:** ED1802
- TO-126, ECB:** MJE170  
MJE710

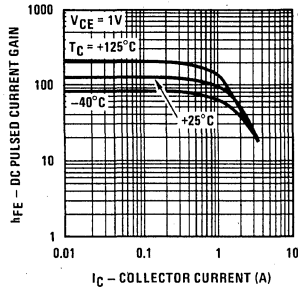
Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 10 \text{ mA}$	25			V
$BV_{CBO}$	$I_C = 100 \mu\text{A}$	35			V
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	5			V
$I_{CBO}$	$V_{CB} = 20\text{V}$			100	nA
$I_{EBO}$	$V_{EB} = 4\text{V}$		10	100	nA
$h_{FE}$	$I_C = 100 \text{ A}, V_{CE} = 1\text{V}$	50	150	300	
$h_{FE}$	$I_C = 1 \text{ mA}, V_{CE} = 1\text{V}$	35			
$V_{CE(SAT)}$	$I_C = 0.5 \text{ A}, I_B = 50 \text{ mA}$			0.5	V
$V_{BE(SAT)}$	$I_C = 0.5 \text{ A}, I_B = 50 \text{ mA}$			1.3	V
$f_T$	$I_C = 100 \text{ mA}, V_{CE} = 10\text{V}$	100	200		MHz
$C_{ob}$	$V_{CE} = 10\text{V}, f = 1 \text{ MHz}$		28	35	pF
$P_{D(max)}$					
TO-126	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	15 1.5			W
TO-202	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	10 2			W
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	2 850			W mW
TO-92	$T_A = 25^\circ\text{C}$	600			mW
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$				$^\circ\text{C/W}$
TO-126	$T_C = 25^\circ\text{C}$			8.33	$^\circ\text{C/W}$
TO-202	$T_C = 25^\circ\text{C}$			12.5	$^\circ\text{C/W}$
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
TO-202	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-237	$T_A = 25^\circ\text{C}$			147	$^\circ\text{C/W}$
TO-92	$T_A = 25^\circ\text{C}$			208	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$



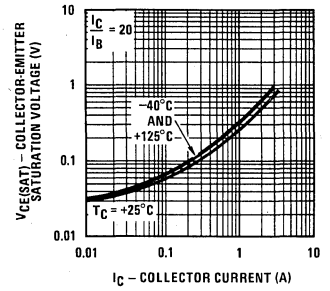
DC Pulsed Current Gain vs Collector Current



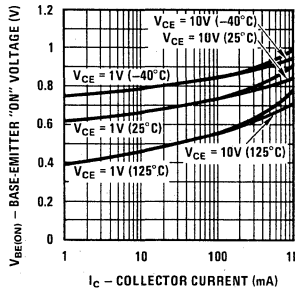
DC Pulsed Current Gain vs Collector Current



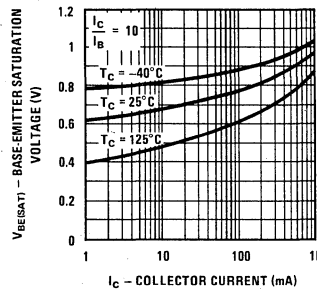
Collector-Emitter Saturation Voltage vs Collector Current



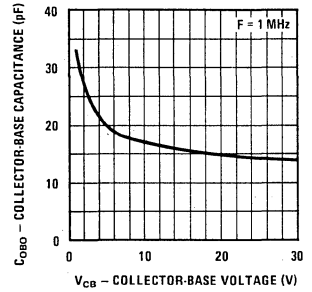
Base-Emitter ON Voltage vs Collector Current



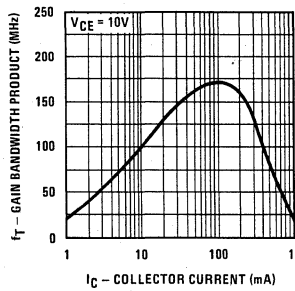
Base-Emitter Saturation Voltage vs Collector Current



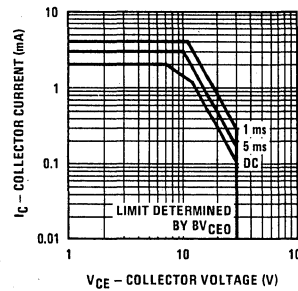
Collector-Base Capacitance vs Collector-Base Voltage



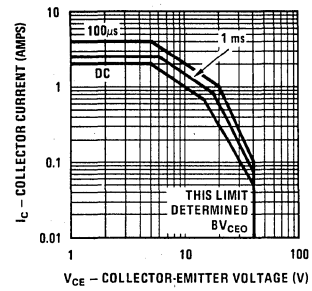
Gain Bandwidth Product vs Collector Current



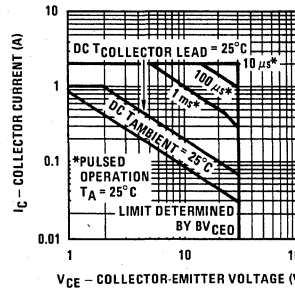
Safe Operating Area TO-126



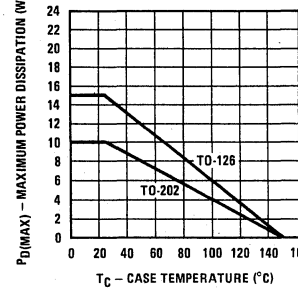
Safe Operating Area TO-202



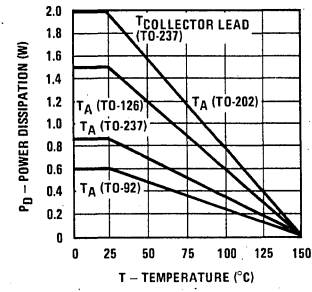
Safe Operating Area TO-237



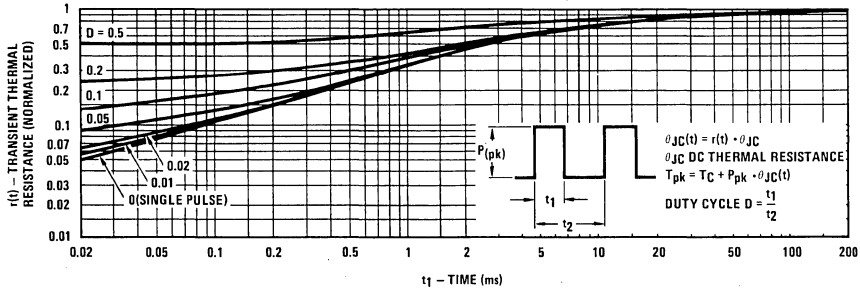
Maximum Power Dissipation vs Case Temperature



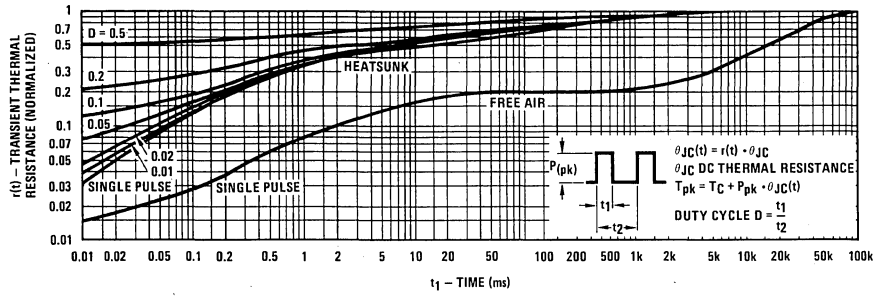
Thermal Derating Curve

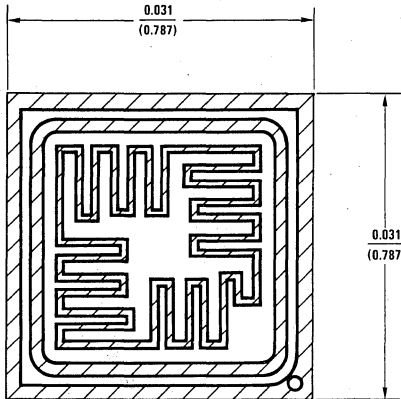


Thermal Response in TO-126 Package



Thermal Response in TO-202 Package





### DESCRIPTION

Process 78 is a double-diffused, silicon epitaxial planar device. Complement to Process 38.

### APPLICATION

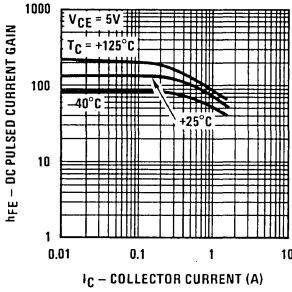
This device was designed for general purpose medium power amplifier and switching circuits that require collector currents to 1.5A.

### PRINCIPAL DEVICE TYPES

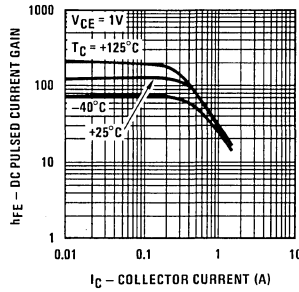
- TO-202, EBC:** 2N6554  
D41D1-14  
D41E5, 7  
NSDU55, 56
- TO-202, BCE:** NSE170, 171
- TO-237, EBC:** 2N6728 (92PU55)
- TO-237, ECB:** 2N6708, 9 (92PE77A, B)
- TO-126, ECB:** BD344  
MJE171  
MJE711

Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 10 \text{ mA}$	40			V
$BV_{CBO}$	$I_C = 100 \mu\text{A}$	50			V
$BV_{EBO}$	$I_E = 10 \mu\text{A}$	5			V
$I_{CBO}$	$V_{CB} = 40\text{V}$			100	nA
$I_{EBO}$	$V_{EB} = 4\text{V}$			100	nA
$h_{FE}$	$I_C = 100 \text{ mA}, V_{CE} = 1\text{V}$	50	150	300	
$h_{FE}$	$I_C = 500 \text{ mA}, V_{CE} = 1\text{V}$	35			
$V_{CE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			0.6	V
$V_{BE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			1.3	V
$f_T$	$I_C = 100 \text{ mA}, V_{CE} = 10\text{V}$	80	150		MHz
$C_{ob}$	$V_{CB} = 10\text{V}$		20	25	pF
$P_{D(max)}$					
TO-126	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	15 1.5			W
TO-202	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	10 2			W
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	2 850			W mW
TO-92	$T_A = 25^\circ\text{C}$	600			mW
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$				$^\circ\text{C/W}$
TO-126	$T_C = 25^\circ\text{C}$			8.33	$^\circ\text{C/W}$
TO-202	$T_C = 25^\circ\text{C}$			12.5	$^\circ\text{C/W}$
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
TO-202	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-237	$T_A = 25^\circ\text{C}$			147	$^\circ\text{C/W}$
TO-92	$T_A = 25^\circ\text{C}$			208	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$

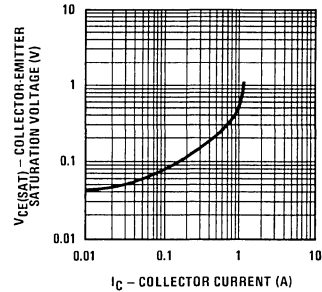
**Pulsed Current Gain vs Collector Current**



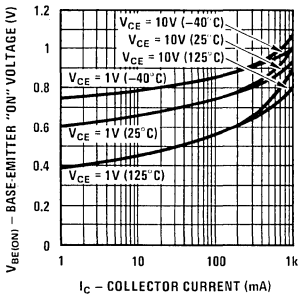
**Pulsed Current Gain vs Collector Current**



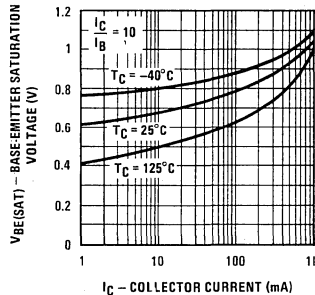
**Collector-Emitter Saturation Voltage vs Collector Current**



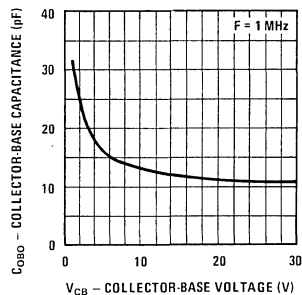
**Base-Emitter ON Voltage vs Collector Current**



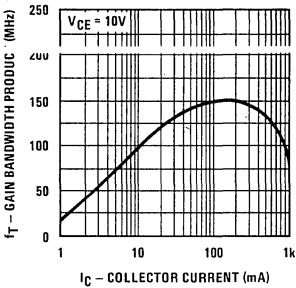
**Base-Emitter Saturation Voltage vs Collector Current**



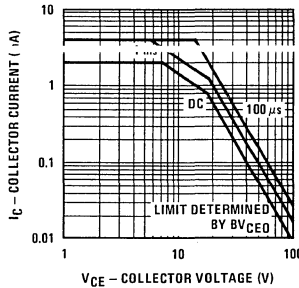
**Collector-Base Capacitance vs Collector-Base Voltage**



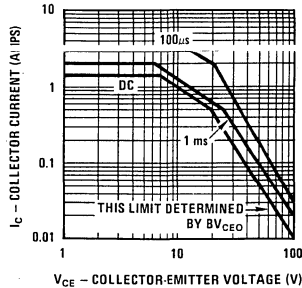
**Gain Bandwidth Product vs Collector Current**



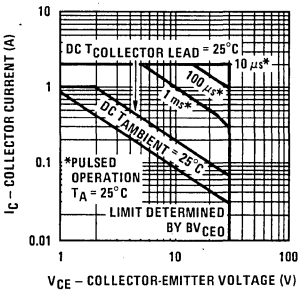
**Safe Operating Area TO-126**



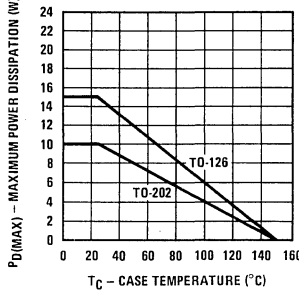
**Safe Operating Area TO-202**



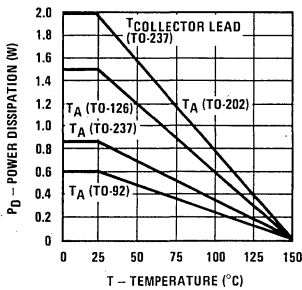
**Safe Operating Area TO-237**



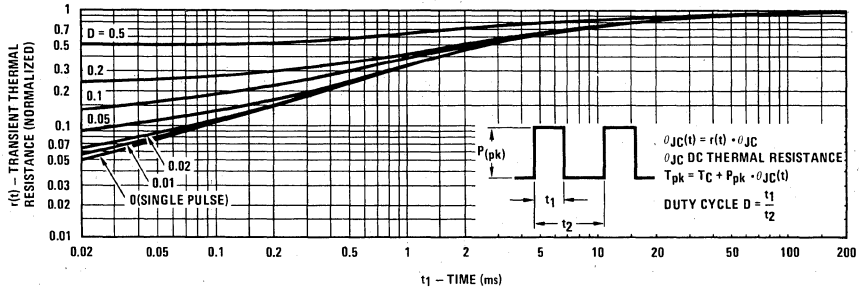
**Maximum Power Dissipation vs Case Temperature**



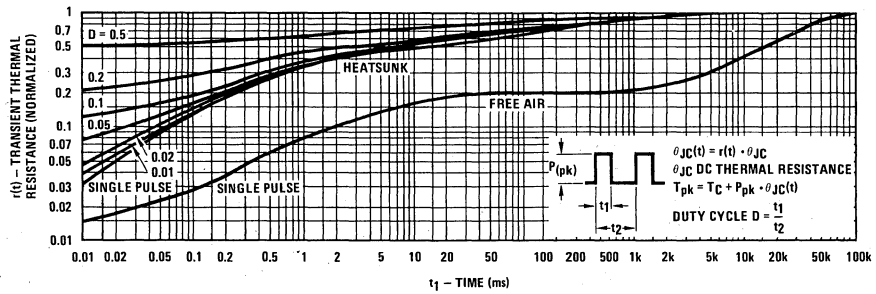
**Thermal Derating Curve**

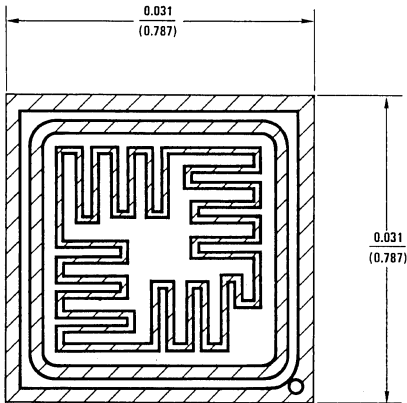


Thermal Response in TO-126 Package



Thermal Response in TO-202 Package




**DESCRIPTION**

Process 79 is a double-diffused, silicon epitaxial planar device. Complement to Process 39.

**APPLICATION**

This device was designed for general purpose medium power amplifier and switching circuits that require collector currents to 1A.

**PRINCIPAL DEVICE TYPES**

**TO-202, EBC:** 2N6555-56  
NSD204-6  
NSDU57

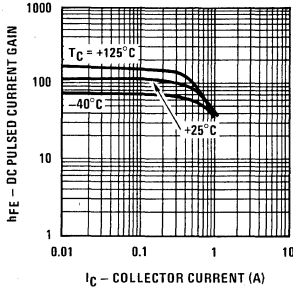
**TO-237, EBC:** 2N6729,30  
(92PU56, 57)

**TO-237, ECB:** 2N6710  
(92PE77C)

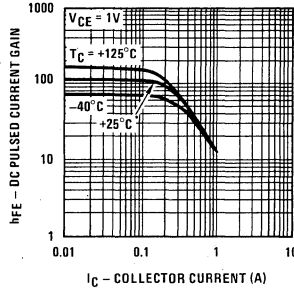
**TO-126, ECB:** BD348  
MJE172  
MJE712

Parameter	Conditions	Min	Typ	Max	Units
$V_{CE0}$	$I_C = 10 \text{ mA}$	70			V
$V_{CB0}$	$I_C = 100 \mu\text{A}$	80			V
$V_{EBO}$	$I_E = 10 \mu\text{A}$	5			V
$I_{CBO}$	$V_{CB} = 60\text{V}$			100	nA
$I_{EBO}$	$V_{EB} = 4\text{V}$			100	nA
$h_{FE}$	$I_C = 100 \text{ mA}, V_{CE} = 1\text{V}$	40	120	240	
$h_{FE}$	$I_C = 500 \text{ mA}, V_{CE} = 1\text{V}$	20			
$V_{CE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			0.8	V
$V_{BE(SAT)}$	$I_C = 500 \text{ mA}, I_B = 50 \text{ mA}$			1.4	V
$f_T$	$I_C = 100 \text{ mA}, V_{CE} = 10\text{V}$	70	125		MHz
$C_{ob}$	$V_{CB} = 10\text{V}$		14	18	pF
$P_{D(max)}$					
TO-126	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	15			W
TO-202	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	10			W
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	2			W
TO-92	$T_A = 25^\circ\text{C}$	850			mW
TO-92	$T_A = 25^\circ\text{C}$	600			mW
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$				$^\circ\text{C/W}$
TO-126	$T_C = 25^\circ\text{C}$			8.33	$^\circ\text{C/W}$
TO-202	$T_C = 25^\circ\text{C}$			12.5	$^\circ\text{C/W}$
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
TO-202	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-237	$T_A = 25^\circ\text{C}$			147	$^\circ\text{C/W}$
TO-92	$T_A = 25^\circ\text{C}$			208	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$

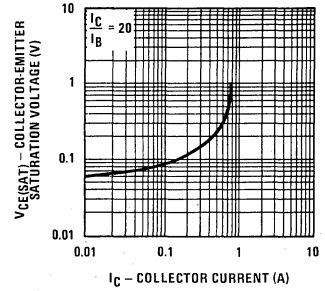
**Pulsed Current Gain vs Collector Current**



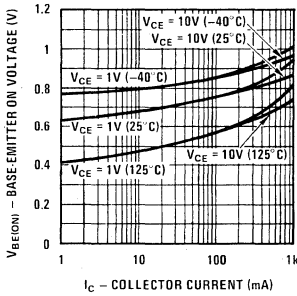
**Pulsed Current Gain vs Collector Current**



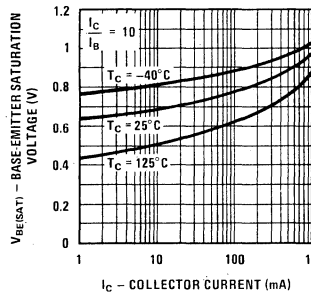
**Collector-Emitter Saturation Voltage vs Collector Current**



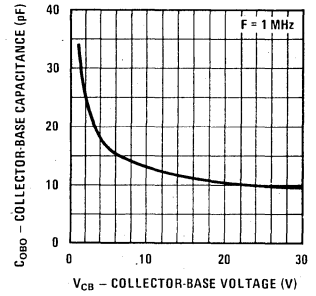
**Base-Emitter ON Voltage vs Collector Current**



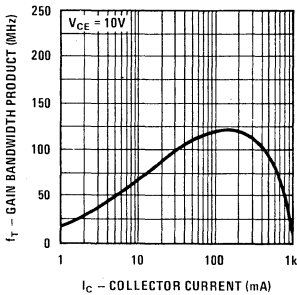
**Base-Emitter Saturation Voltage vs Collector Current**



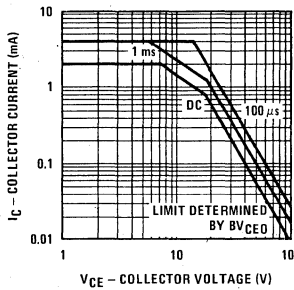
**Collector-Base Capacitance vs Collector-Base Voltage**



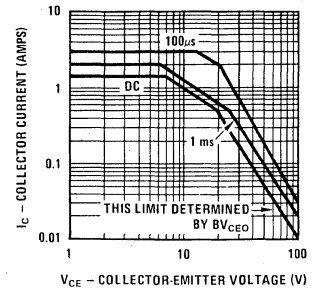
**Gain Bandwidth Product vs Collector Current**



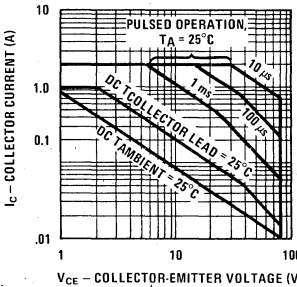
**Safe Operating Area TO-126**



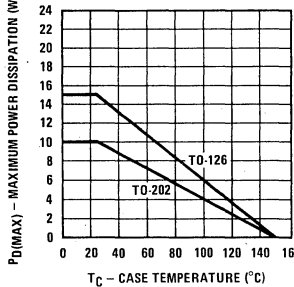
**Safe Operating Area TO-202**



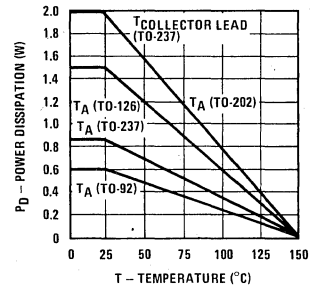
**Safe Operating Area TO-237**



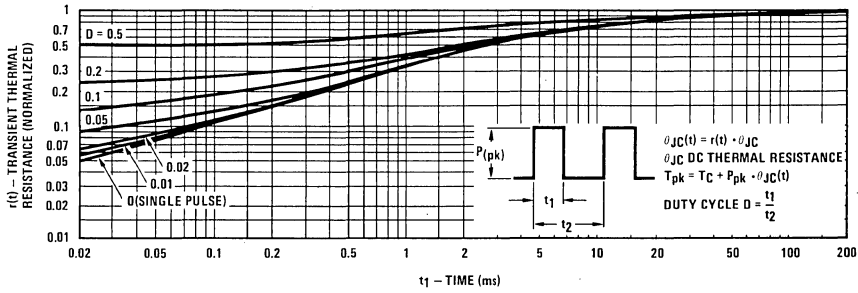
**Maximum Power Dissipation vs Case Temperature**



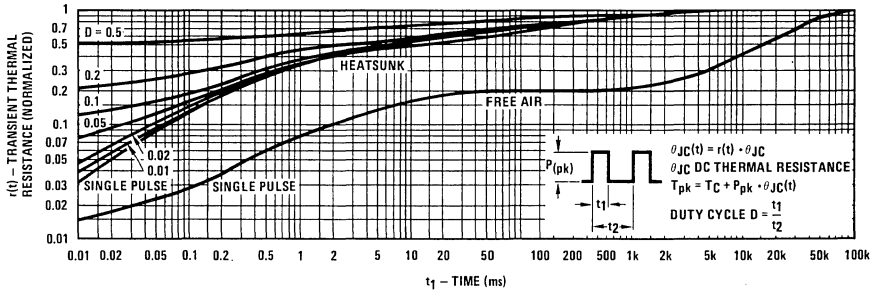
**Thermal Derating Curve**



Thermal Response in TO-126 Package



Thermal Response in TO-202 Package



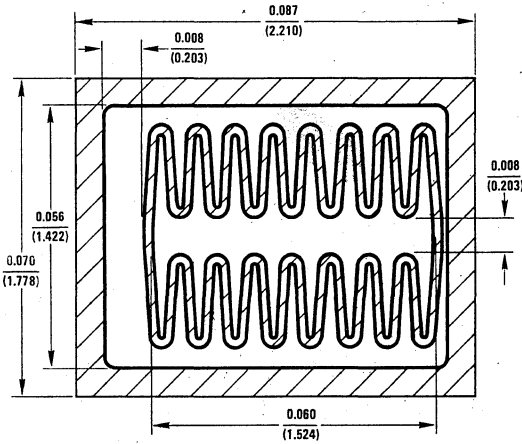






Section 9  
**Process  
Characteristics  
Power Transistors**





**DESCRIPTION**

This device is a nonoverlay double-diffused, silicon epitaxial planar transistor.

**APPLICATION**

This device was designed for general purpose amplifier applications utilizing collector currents to 5A.

**PRINCIPAL DEVICE TYPES**

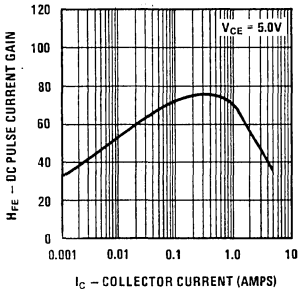
TO-39, EBC: 2N2891

TO-237, EBC: TN3440

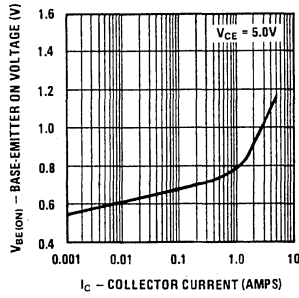
Parameter	Conditions	Min	Typ	Max	Units	Notes
$t_{ON}$	$I_C = 1\text{ A}, I_{B1} = 0.1\text{ A}$		90	120	ns	
$t_{OFF}$	$I_C = 1\text{ A}, I_{B2} = 0.1\text{ A}$		200	260	ns	
$C_{ob}$	$V_{CB} = 10\text{ V}, f = 1\text{ MHz}$		60	70	pF	
$C_{ib}$	$V_{EB} = 0.5\text{ V}, f = 1\text{ MHz}$			500	pF	
$h_{fe}$	$I_C = 200\text{ mA}, V_{CE} = 10\text{ V}, f = 20\text{ MHz}$	4.0	5.0			
$h_{FE}$	$I_C = 1\text{ mA}, V_{CE} = 5\text{ V}$	40				
$h_{FE}$	$I_C = 10\text{ mA}, V_{CE} = 5\text{ V}$	40				
$h_{FE}$	$I_C = 100\text{ mA}, V_{CE} = 5\text{ V}$	40				
$h_{FE}$	$I_C = 500\text{ mA}, V_{CE} = 5\text{ V}$	40	80	150		
$h_{FE}$	$I_C = 1\text{ A}, V_{CE} = 5\text{ V}$	20				
$h_{FE}$	$I_C = 5\text{ A}, V_{CE} = 5\text{ V}$	15				
$V_{CE(SAT)}$	$I_C = 100\text{ mA}, I_B = 10\text{ mA}$		0.05	0.10	V	TO-39
$V_{CE(SAT)}$	$I_C = 1\text{ A}, I_B = 100\text{ mA}$		0.20	0.30	V	TO-39
$V_{BE(SAT)}$	$I_C = 100\text{ mA}, I_B = 10\text{ mA}$		0.70	0.85	V	TO-39
$V_{BE(SAT)}$	$I_C = 1\text{ A}, I_B = 100\text{ mA}$		0.90	1.10	V	TO-39
$BV_{CEO}$	$I_C = 10\text{ mA}$	80				
$BV_{CBO}$	$I_C = 100\text{ }\mu\text{A}$	100				
$BV_{EBO}$	$I_E = 10\text{ }\mu\text{A}$	8				
$I_{CBO}$	$V_{CB} = 60\text{ V}$			100	nA	
$I_{EBO}$	$V_{EB} = 6\text{ V}$			100	nA	

# Process 34

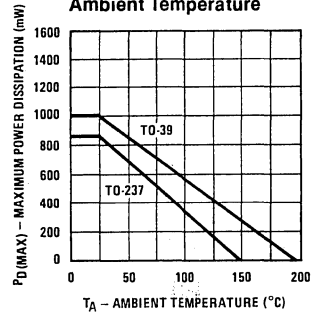
**Pulsed DC Current Gain vs Collector Current**



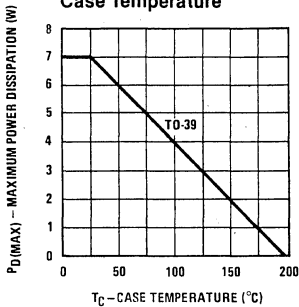
**Base-Emitter ON Voltage vs Collector Current**



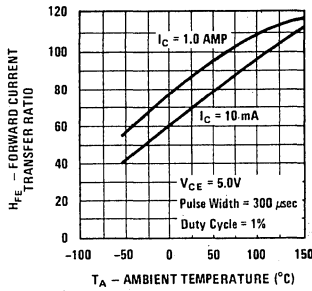
**Maximum Power Dissipation vs Ambient Temperature**



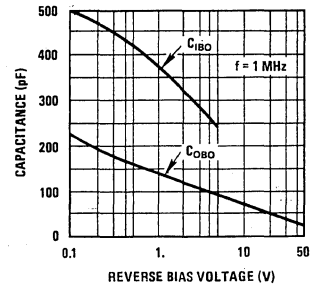
**Maximum Power Dissipation vs Case Temperature**



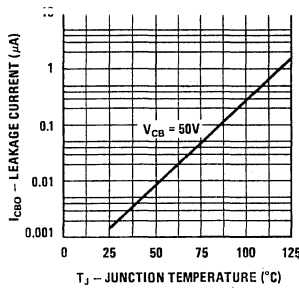
**Pulsed DC Current Gain vs Ambient Temperature**



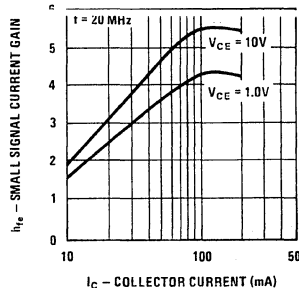
**Capacitance vs Reverse Bias Voltage**



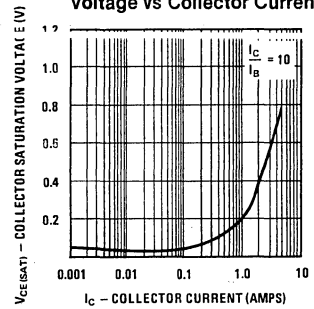
**Collector-Base Diode Reverse Current vs Temperature**



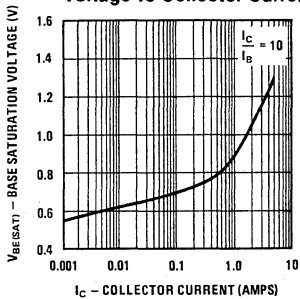
**Small Signal Current Gain vs Collector Current**



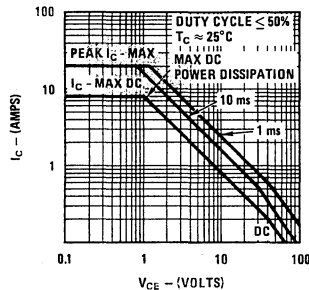
**Collector-Emitter Saturation Voltage vs Collector Current**



**Base-Emitter Saturation Voltage vs Collector Current**

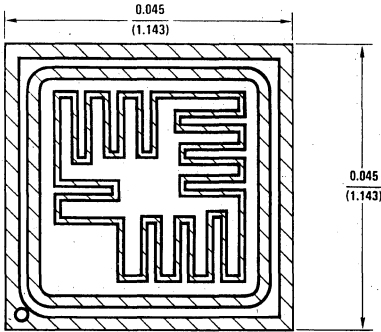


**Safe Operating Area**





# Process 36 NPN High Voltage Power



### DESCRIPTION

Process 36 is a non-overlay double-diffused silicon epitaxial planar device with a field plate.

### APPLICATION

This device is designed for use in horizontal driver, class A off-line amplifier and off-line switching applications.

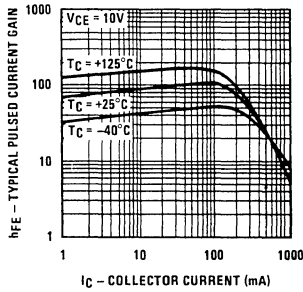
### PRINCIPAL DEVICE TYPES

TO-202, EBC: D40P1, 3, 5      TO-126, ECB: 2N5655-57  
 NSD36-36C                      MJE340-44  
 TO-237, EBC: 2N6720-23 (92PU36-36C)      MJE3439-40

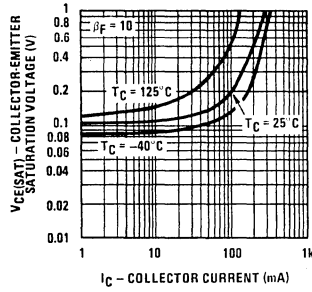
Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_{CE} = 1 \text{ mA}$ (Note 1)	200	300		V
$BV_{CBO}$	$I_{CB} = 100 \mu\text{A}$	225	325		V
$BV_{EBO}$	$I_{EB} = 10 \mu\text{A}$	6			V
$I_{CEO}$	$V_{CE} = 200\text{V}$			50	$\mu\text{A}$
$I_{CBO}$	$V_{CB} = 225\text{V}$			1	$\mu\text{A}$
$I_{EBO}$	$V_{EB} = 5\text{V}$			1	$\mu\text{A}$
$h_{FE}$	$I_C = 50 \text{ mA}$ , $V_{CE} = 10\text{V}$ (Note 1) $I_C = 100 \text{ mA}$ , $V_{CE} = 10\text{V}$ (Note 1) $I_C = 250 \text{ mA}$ , $V_{CE} = 10\text{V}$ (Note 1) $I_C = 500 \text{ mA}$ , $V_{CE} = 10\text{V}$ (Note 1)	30	110 120 60 25	300	
$V_{CE(SAT)}$	$I_C = 100 \text{ mA}$ , $I_B = 10 \text{ mA}$ (Note 1)		0.2	0.5	V
$V_{CE(SAT)}$	$I_C = 500 \text{ mA}$ , $I_B = 100 \text{ mA}$ (Note 1)		0.3	0.7	V
$V_{BE(SAT)}$	$I_C = 500 \text{ mA}$ , $I_B = 100 \text{ mA}$ (Note 1)		0.9	1.2	V
$V_{BE(ON)}$	$I_C = 100 \text{ mA}$ , $V_{CE} = 10\text{V}$ (Note 1)		0.7	1.0	V
$f_t$	$I_C = 50 \text{ mA}$ , $V_{CE} = 10\text{V}$	20	60		MHz
$C_{ob}$	$V_{CB} = 10\text{V}$ , $f = 1 \text{ MHz}$			15	pF
$C_{ib}$	$V_{BE} = 0.5\text{V}$ , $f = 1 \text{ MHz}$			125	pF
$P_{D(max)}$					
TO-126	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	25 1.5			W
TO-202	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	15 2			W
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	2 850			W mW
TO-39	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	10 1			W
$\theta_{JC}$					
TO-126	$T_C = 25^\circ\text{C}$			5.0	$^\circ\text{C/W}$
TO-202	$T_C = 25^\circ\text{C}$			8.33	$^\circ\text{C/W}$
TO-237	$T_{COLLECTOR LEAD} = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-39	$T_C = 25^\circ\text{C}$			17.5	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
TO-202	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-237	$T_A = 25^\circ\text{C}$			147	$^\circ\text{C/W}$
TO-39	$T_A = 25^\circ\text{C}$			175	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts TO-39	150 200			$^\circ\text{C}$ $^\circ\text{C}$

\* Pulse test, pulse width = 300  $\mu\text{s}$

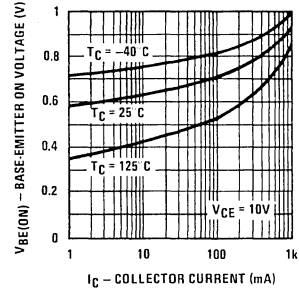
**Typical Pulsed Current Gain vs Collector Current**



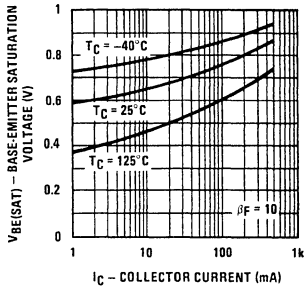
**Collector-Emitter Saturation Voltage vs Collector Current**



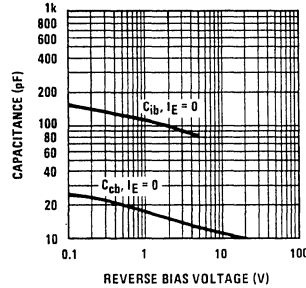
**Base-Emitter ON Voltage vs Collector Current**



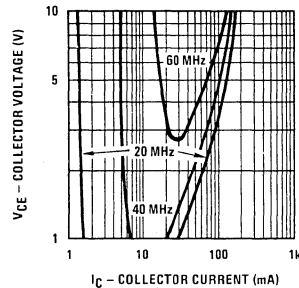
**Base-Emitter Saturation Voltage vs Collector Current**



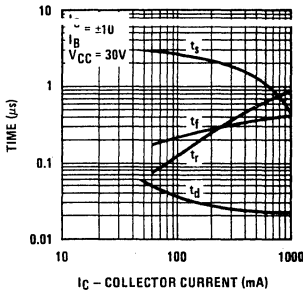
**Collector-Base and Emitter-Base Capacitance vs Reverse Bias Voltage**



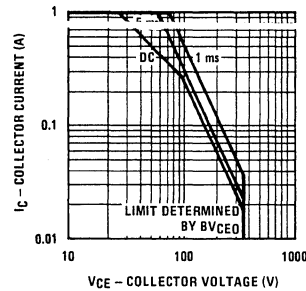
**Contours of Constant Gain Bandwidth Product (f\_t)**



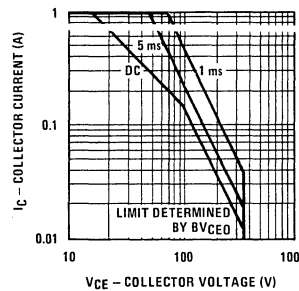
**Typical Switching Time vs Collector Current**



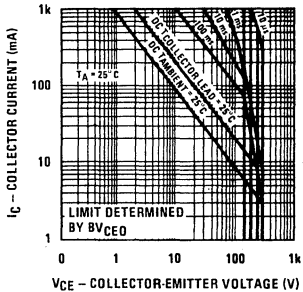
**Safe Operating Area TO-126**



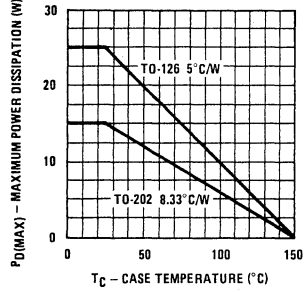
**Safe Operating Area TO-202**



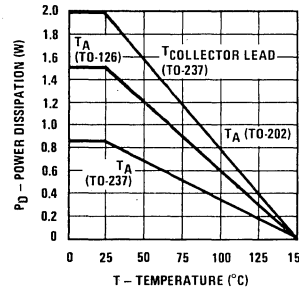
**Safe Operating Area TO-237**



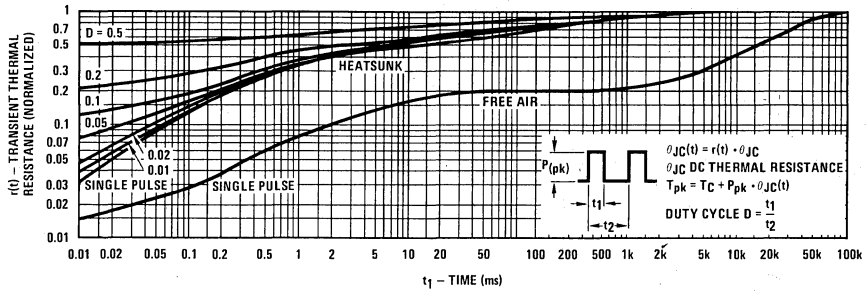
**Maximum Power Dissipation vs Case Temperature**

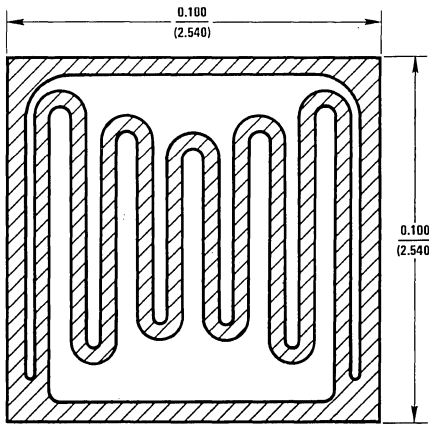


**Thermal Derating Curve**



Thermal Response in TO-202 Package




**DESCRIPTION**

Process 4A is a double epitaxial silicon NPN mesa device with diffused emitter. Complement to Process 5A.

**APPLICATION**

This device was designed for general purpose power amplifier and switching circuits where a large safe operating area is required.

**PRINCIPAL DEVICE TYPES**

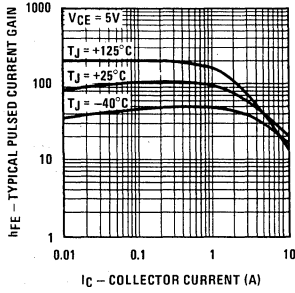
TO-220, BCE: 2N6099  
 2N6101  
 2N6486-88  
 BD347  
 MJE2801T  
 MJE3055T  
 TIP41-41C

Parameter	Conditions	Min	Typ	Max	Units
$V_{CE0}$	$I_C = 200 \text{ mA}$ (Note 1)	40		120	V
$V_{CB0}$	$I_C = 1 \text{ mA}$	60			V
$V_{EBO}$	$I_E = 1 \text{ mA}$	5	7		V
$I_{CE0}$	$V_{CE} = V_{CE0} - 10V$			200	$\mu A$
$I_{CBO}$	$V_{CB} = V_{CE0}$			20	$\mu A$
$I_{EBO}$	$V_{EB} = 5V$			500	$\mu A$
$h_{FE}$	$I_C = 2.5A, V_{CE} = 2V$ (Note 1)	20		160	
$V_{CE(SAT)}$	$I_C = 4A, I_B = 0.4A$ (Note 1)		0.4	0.6	V
$V_{BE(ON)}$	$I_C = 5A, V_{CE} = 2V$ (Note 1)		1.1	1.3	V
$f_t$	$I_C = 0.5A, V_{CE} = 5V$	2			MHz
$t_d$	$I_C = 5A, I_{B1} = I_{B2} = 0.5A, V_{CC} = 40V$		0.07		$\mu S$
$t_r$	$I_C = 5A, I_{B1} = I_{B2} = 0.5A, V_{CC} = 40V$		0.8		$\mu S$
$t_s$	$I_C = 5A, I_{B1} = I_{B2} = 0.5A, V_{CC} = 40V$		0.4		$\mu S$
$t_f$	$I_C = 5A, I_{B1} = I_{B2} = 0.5A, V_{CC} = 40V$		0.5		$\mu S$
$P_{D(max)}$ TO-220	$T_C = 25^\circ C$ $T_A = 25^\circ C$	60 2			W
$\theta_{JC}$ TO-220	$T_C = 25^\circ C$			2.08	$^\circ C/W$
$\theta_{JA}$ TO-220	$T_A = 25^\circ C$			62.5	$^\circ C/W$
$T_{J(max)}$	All Plastic Parts	150			$^\circ C$

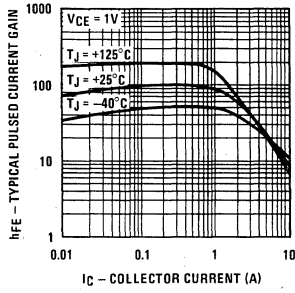
Note 1: Pulsed measurement = 300  $\mu s$  pulse width.



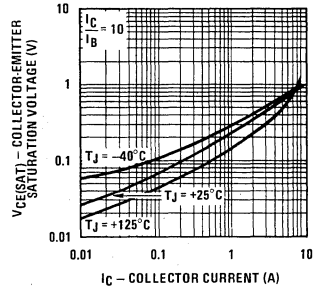
Typical Pulsed Current Gain vs Collector Current



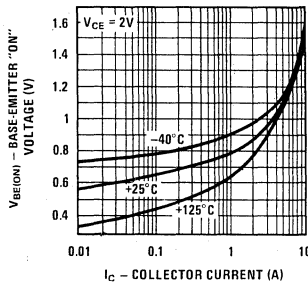
Typical Pulsed Current Gain vs Collector Current



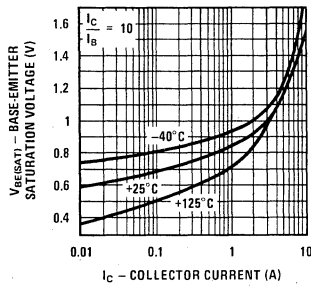
Collector-Emitter Saturation Voltage vs Collector Current



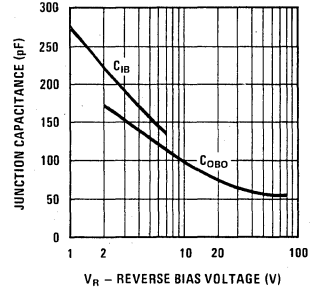
Base-Emitter ON Voltage vs Collector Current



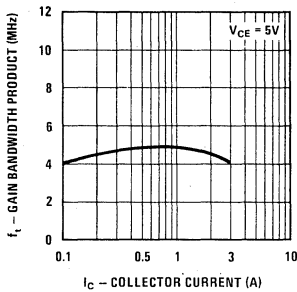
Base-Emitter Saturation Voltage vs Collector Current



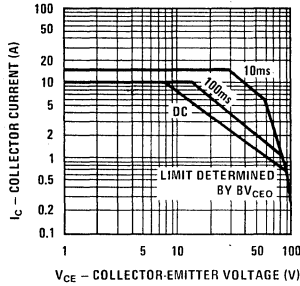
Junction Capacitance vs Reverse Bias Voltage



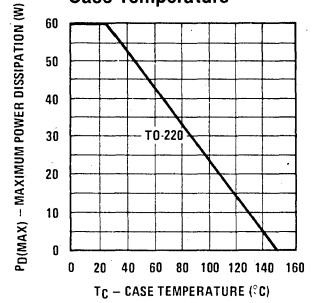
Gain Bandwidth Product vs Collector Current



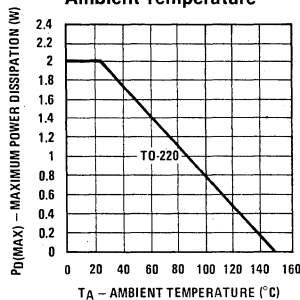
Safe Operating Area TO-220

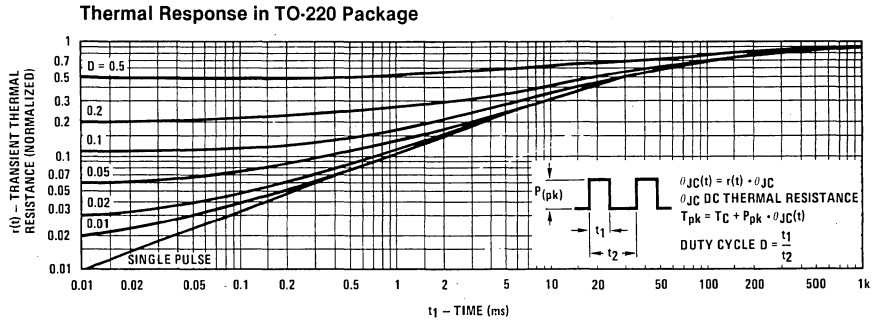


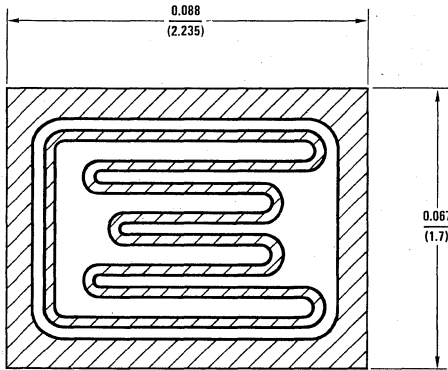
Maximum Power Dissipation vs Case Temperature



Maximum Power Dissipation vs Ambient Temperature







### DESCRIPTION

Process 4E is a double epitaxial silicon mesa device with diffused emitter. Complement to Process 5E.

### APPLICATION

This device was designed for general purpose power amplifier and switching circuits where a large safe operating area is required.

### PRINCIPAL DEVICE TYPES

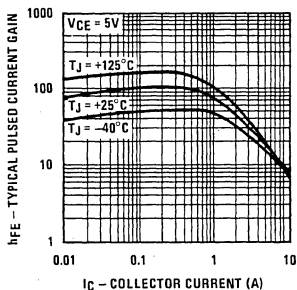
**TO-220, BCE:** 2N5294, 96, 98  
 2N5490, 92, 94, 96  
 2N6121-23  
 2N6129-31  
 2N6288, 90, 92  
**TO-126, ECB:** 2N5190-92

Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 100 \text{ mA}$ (Note 1)	30		120	V
$BV_{CBO}$	$I_C = 1 \text{ mA}$	50			V
$BV_{EBO}$	$I_E = 1 \text{ mA}$	5	8		V
$I_{CEO}$	$V_{CE} = BV_{CEO} - 10V$			300	$\mu\text{A}$
$I_{CBO}$	$V_{CB} = BV_{CEO}$			100	$\mu\text{A}$
$I_{EBO}$	$V_{EB} = 5V$			1000	$\mu\text{A}$
$h_{FE}$	$I_C = 1.5A, V_{CE} = 2.0V$ (Note 1)	20		200	
$V_{CE(SAT)}$	$I_C = 4.0A, I_B = 0.4A$ (Note 1)			1.0	V
$V_{BE(ON)}$	$I_C = 4.0A, V_{CE} = 2.0V$ (Note 1)			1.3	V
$f_t$	$I_C = 0.5A, V_{CE} = 2V$	4			MHz
$t_d$	$I_C = 1.0A, I_{B1} = 0.1A, I_{B2} = 0.1A, V_{CC} = 30V$		0.10		$\mu\text{s}$
$t_r$	$I_C = 1.0A, I_{B1} = 0.1A, I_{B2} = 0.1A, V_{CC} = 30V$		0.25		$\mu\text{s}$
$t_s$	$I_C = 1.0A, I_{B1} = 0.1A, I_{B2} = 0.1A, V_{CC} = 30V$		0.35		$\mu\text{s}$
$t_f$	$I_C = 1.0A, I_{B1} = 0.1A, I_{B2} = 0.1A, V_{CC} = 30V$		0.23		$\mu\text{s}$
$P_{D(max)}$					
TO-220	$T_C = 25^\circ\text{C}$	50			
	$T_A = 25^\circ\text{C}$	2			W
TO-126	$T_C = 25^\circ\text{C}$	40			
	$T_A = 25^\circ\text{C}$	1.5			W
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$			2.5	$^\circ\text{C/W}$
TO-126	$T_C = 25^\circ\text{C}$			3.12	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-220	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
$T_{I(max)}$	All Plastic Parts	150			$^\circ\text{C}$

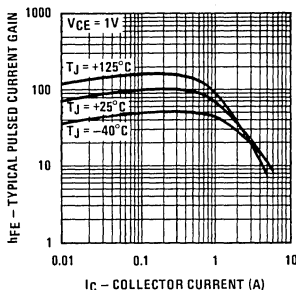
Note 1: Pulsed measurement = 300  $\mu\text{s}$  pulse width.

# Process 4E

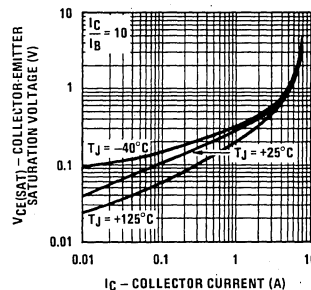
Typical Pulsed Current Gain vs Collector Current



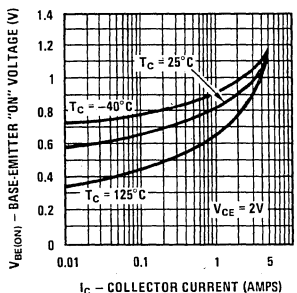
Typical Pulsed Current Gain vs Collector Current



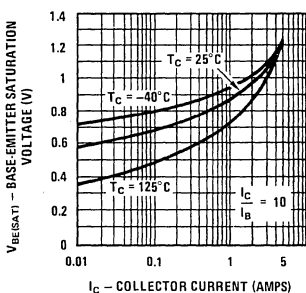
Collector-Emitter Saturation Voltage vs Collector Current



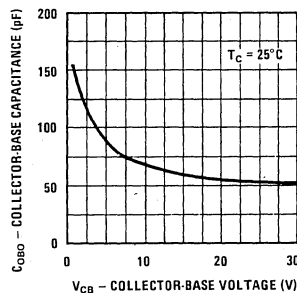
Base-Emitter ON Voltage vs Collector Current



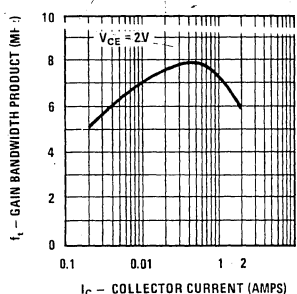
Base-Emitter Saturation Voltage vs Collector Current



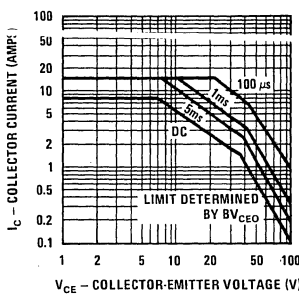
Typical Collector-Base Capacitance vs Collector-Base Voltage



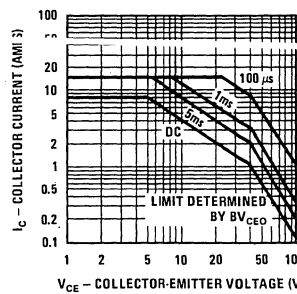
Gain Bandwidth Product vs Collector Current



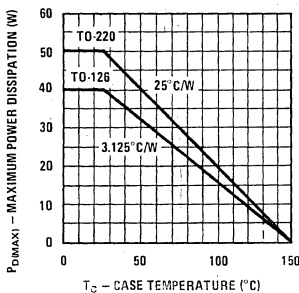
Safe Operating Area TO-220



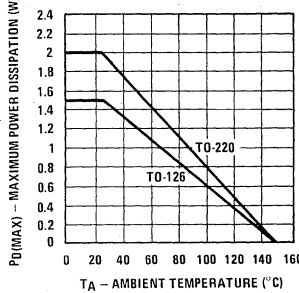
Safe Operating Area TO-126



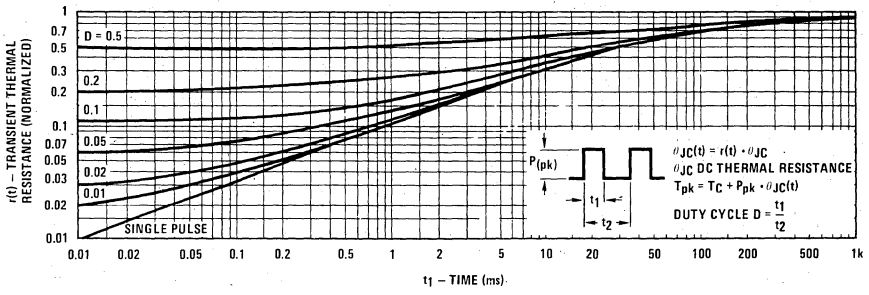
Maximum Power Dissipation vs Case Temperature



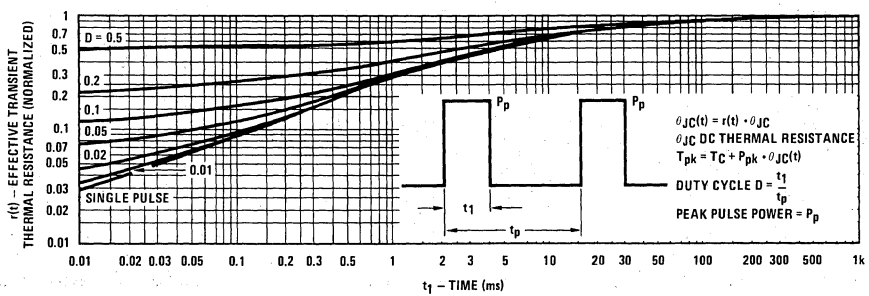
Maximum Power Dissipation vs Ambient Temperature



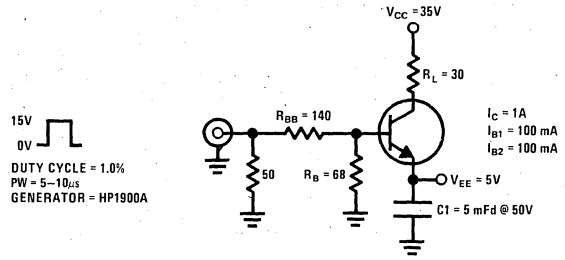
Thermal Response in TO-220 Package

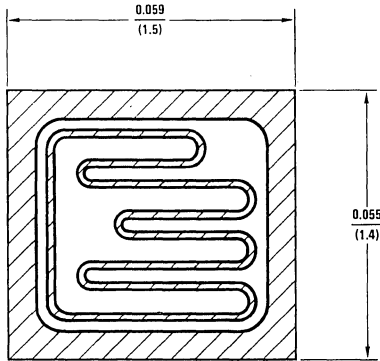


Thermal Response in TO-126 Package



Switching Circuit





### DESCRIPTION

Process 4F is a double epitaxial silicon mesa device with diffused emitter. Complement to Process 5F.

### APPLICATION

This device was designed for general purpose power amplifier and switching circuits where a large safe operating area is required.

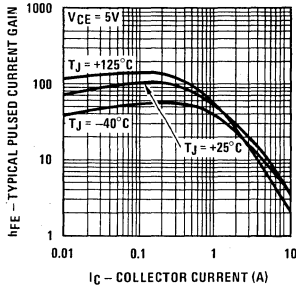
### PRINCIPAL DEVICE TYPES

**TO-220, BCE:** TIP29-29C  
TIP31-31C  
TIP61-61C  
**TO-126, ECB:** 2N4921-23  
MJE520, 21

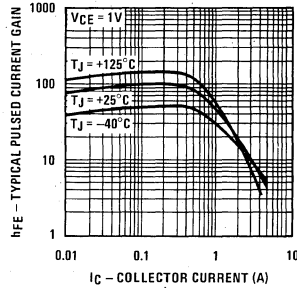
Parameter	Conditions	Min	Typ	Max	Units
$V_{CE0}$	$I_C = 100 \text{ mA}$ (Note 1)	30		120	V
$V_{CB0}$	$I_C = 1 \text{ mA}$	60		240	V
$V_{EBO}$	$I_E = 1 \text{ mA}$	5	8		V
$I_{CEO}$	$V_{CE} = V_{CE0} - 10V$			300	$\mu\text{A}$
$I_{CBO}$	$V_{CB} = V_{CE0}$			10	$\mu\text{A}$
$I_{EBO}$	$V_{EB} = 5V$			100	$\mu\text{A}$
$h_{FE}$	$I_C = 1.0A, V_{CE} = 1V$ (Note 1)	15		200	
$V_{CE(SAT)}$	$I_C = 2.0A, I_B = 0.2A$ (Note 1)			1.0	V
$V_{BE(ON)}$	$I_C = 2.0A, V_{CE} = 2.0V$ (Note 1)			1.0	V
$f_t$	$I_C = 0.5A, V_{CE} = 2V$	4			MHz
$t_d$	$I_C = 1A, I_{B1} = I_{B2} = 0.1A,$ $V_{CC} = 30V$		0.05		$\mu\text{s}$
$t_r$	$I_C = 1A, I_{B1} = I_{B2} = 0.1A,$ $V_{CC} = 30V$		0.25		$\mu\text{s}$
$t_s$	$I_C = 1A, I_{B1} = I_{B2} = 0.1A,$ $V_{CC} = 30V$		0.75		$\mu\text{s}$
$t_f$	$I_C = 1A, I_{B1} = I_{B2} = 0.1A,$ $V_{CC} = 30V$		0.25		$\mu\text{s}$
$P_{D(max)}$					
TO-220	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	40 2			W
TO-126	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	30 1.5			W
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$			3.12	$^\circ\text{C/W}$
TO-126	$T_C = 25^\circ\text{C}$			4.16	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-220	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$

Note 1: Pulsed measurement = 300  $\mu\text{s}$  pulse width.

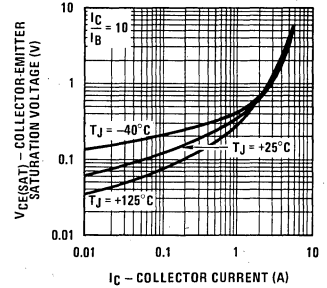
Typical Pulsed Current Gain vs Collector Current



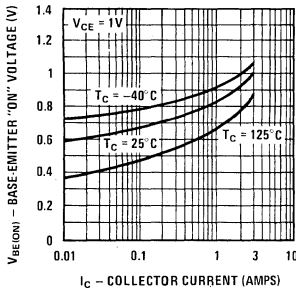
Typical Pulsed Current Gain vs Collector Current



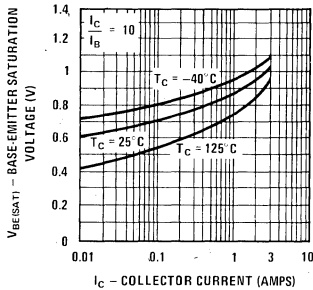
Collector-Emitter Saturation Voltage vs Collector Current



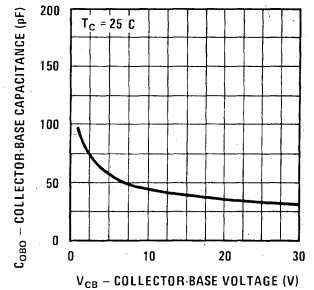
Base-Emitter ON Voltage vs Collector Current



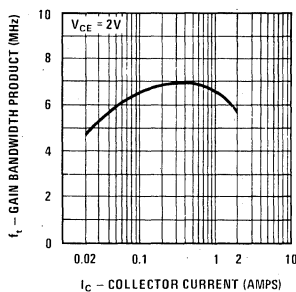
Base-Emitter Saturation Voltage vs Collector Current



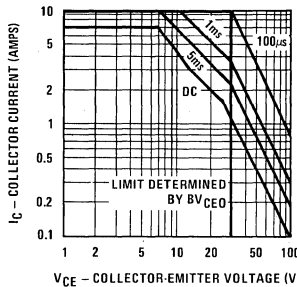
Collector-Base Capacitance vs Collector-Base Voltage



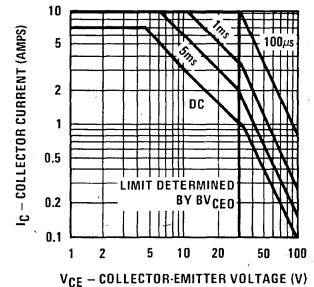
Gain Bandwidth Product vs Collector Current



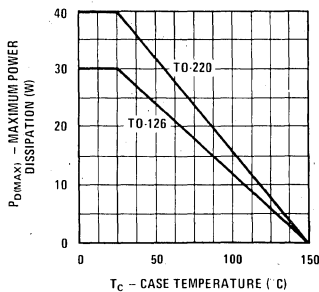
Safe Operating Area TO-220



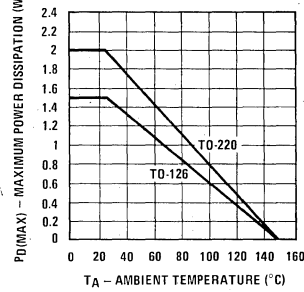
Safe Operating Area TO-126



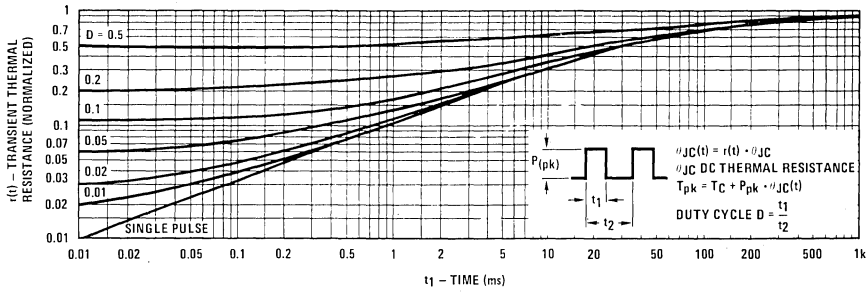
Maximum Power Dissipation vs Case Temperature



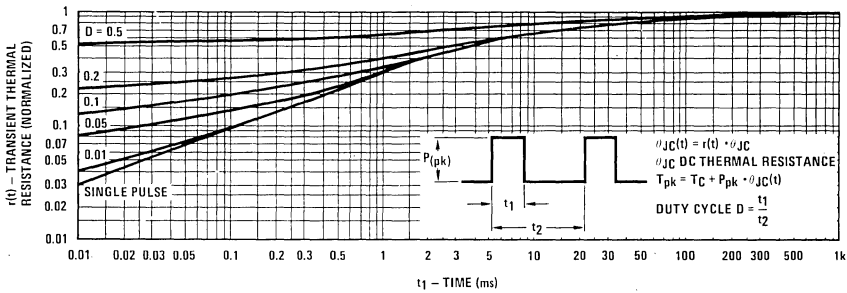
Maximum Power Dissipation vs Ambient Temperature



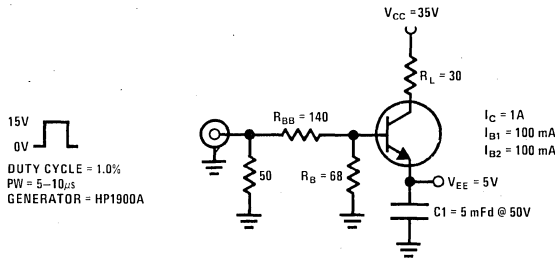
Thermal Response in TO-220 Package



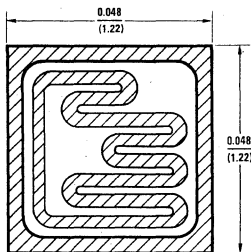
Thermal Response in TO-126 Package



Switching Circuit







### DESCRIPTION

Process 4H is a double epitaxial silicon mesa transistor with diffused emitter.

### APPLICATION

This device was designed for general purpose power amplifier and switching circuits where a large safe operating area is required.

### PRINCIPAL DEVICE TYPES

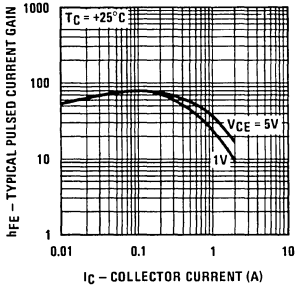
TO-126, EBC: 2N4921-3

Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 50 \text{ mA}$ (Note 1)	30		120	V
$BV_{CBO}$	$I_C = 1 \text{ mA}$	60			V
$BV_{EBO}$	$I_E = 1 \text{ mA}$	5	8		V
$I_{CEO}$	$V_{CE} = BV_{CEO} - 10V$			300	$\mu A$
$I_{CBO}$	$V_{CB} = BV_{CEO}$			10	$\mu A$
$I_{EBO}$	$V_{EB} = 5V$			100	$\mu A$
$h_{FE}$	$I_C = 100 \text{ mA}$ , $V_{CE} = 5V$	30	80	200	
$V_{CE(SAT)}$	$I_C = 0.5A$ , $I_B = 50 \text{ mA}$		0.3		V
$V_{BE(SAT)}$	$I_C = 0.5A$ , $I_B = 50 \text{ mA}$		0.86		V
$f_t$	$V_{CE} = 10V$ , $I_C = 250 \text{ mA}$	3			MHz
$C_{OB}$	$V_{CB} = 10V$		20		pF
$P_{D(max)}$					
TO-126	$T_C = 25^\circ C$	30			W
	$T_A = 25^\circ C$	1.5			
$\theta_{JC}$					
TO-126	$T_C = 25^\circ C$			4.16	$^\circ C/W$
$\theta_{JA}$					
TO-126	$T_A = 25^\circ C$			83.3	$^\circ C/W$
$T_{J(max)}$	All Plastic Parts	150			$^\circ C$

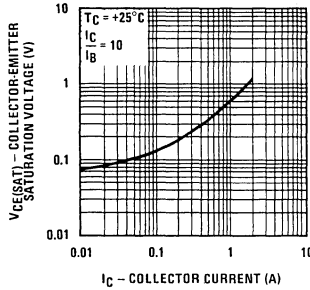
Note 1: Pulse test, pulse width = 300  $\mu s$

# Process 4H

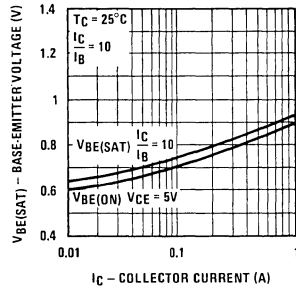
**Typical Pulsed Current Gain vs Collector Current**



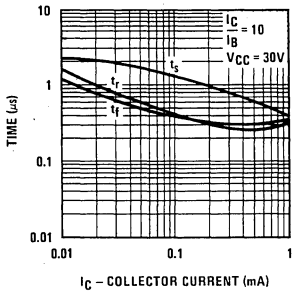
**Collector-Emitter Saturation Voltage vs Collector Current**



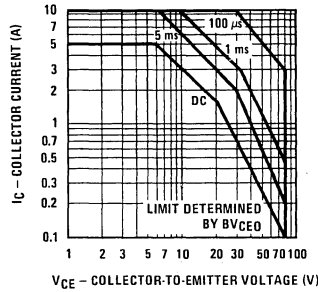
**Base-Emitter Voltage vs Collector Current**



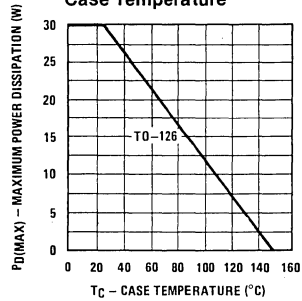
**Typical Switching Time vs Collector Current**



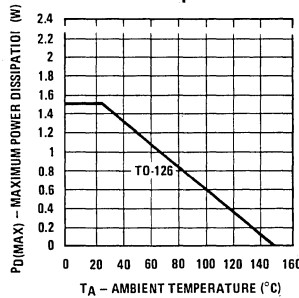
**Safe Operating Area TO-126**



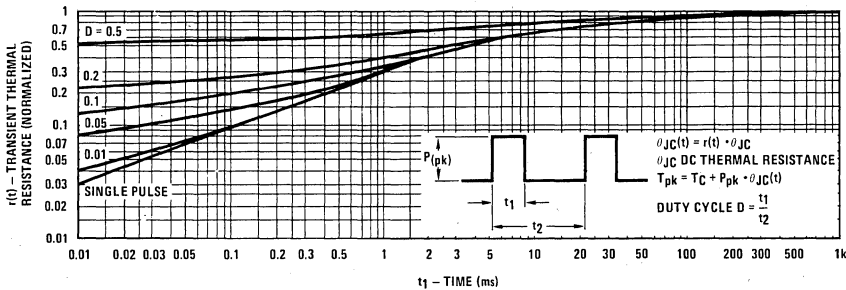
**Maximum Power Dissipation vs Case Temperature**

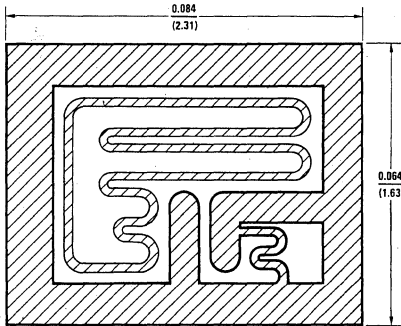


**Maximum Power Dissipation vs Ambient Temperature**



**Thermal Response in TO-126 Package**





### DESCRIPTION

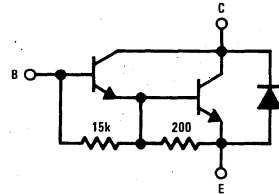
Process 4J is a double epitaxial silicon mesa device. Complement to Process 5J.

### APPLICATION

This device was designed for use in driver and output stages of complementary audio amplifier circuits. It is also well suited for solenoid driver applications.

### PRINCIPAL DEVICE TYPES

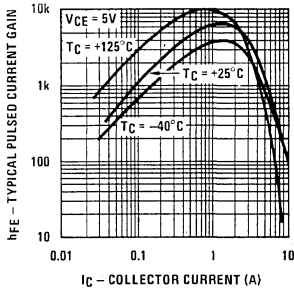
- TO-220, BCE:** 2N6386  
NSP2100-03  
TIP110-12
- TO-126, ECB:** 2N6037-39  
MJE800-03



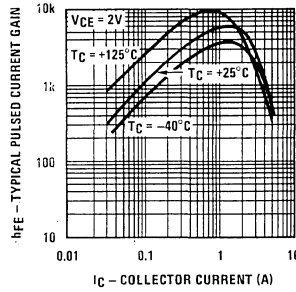
Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 100 \text{ mA}$ (Note 1)	40		120	V
$BV_{CBO}$	$I_C = 100 \mu\text{A}$	70			V
$BV_{EBO}$	$I_E = 2 \text{ mA}$	5			V
$I_{CEO}$	$V_{CE} = 1/2 BV_{CEO}$			0.5	mA
$I_{CBO}$	$V_{CB} = BV_{CEO}$			20	$\mu\text{A}$
$I_{EBO}$	$V_{EB} = 5\text{V}$			2.0	mA
$h_{FE}$	$I_C = 2\text{A}, V_{CE} = 3\text{V}$ (Note 1)	750		20,000	
$V_{CE(SAT)}$	$I_C = 5\text{A}, I_B = 20 \text{ mA}$ (Note 1)			3.0	V
$V_{BE(ON)}$	$I_C = 5\text{A}, V_{CE} = 3\text{V}$ (Note 1)			2.5	V
$C_{OBO}$	$V_{CB} = 10\text{V}$		30		pF
$ h_{fe} $	$I_C = 1\text{A}, V_{CE} = 3\text{V}, f = 1 \text{ MHz}$		9		
$t_{ON}$	$I_C = 6\text{A}, V_{CE} = 30\text{V}$		1.25		$\mu\text{s}$
$t_{OFF}$	$I_C = 6\text{A}, V_{CE} = 30\text{V}$		2.75		$\mu\text{s}$
$P_{D(max)}$					
TO-220	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	50 2			W
TO-126	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	40 1.5			W
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$			2.5	$^\circ\text{C/W}$
TO-126	$T_C = 25^\circ\text{C}$			3.12	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-220	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$

Note 1: Pulsed measurement = 300  $\mu\text{s}$  pulse width.

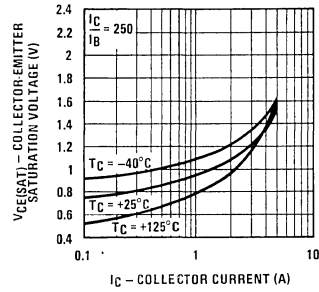
**Typical Pulsed Current Gain vs Collector Current**



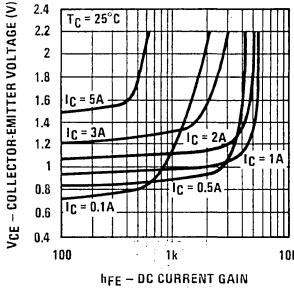
**Typical Pulsed Current Gain vs Collector Current**



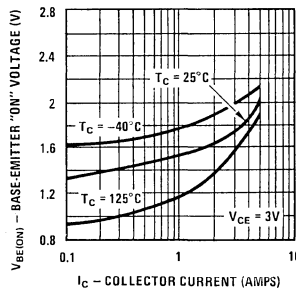
**Collector-Emitter Saturation Voltage vs Collector Current**



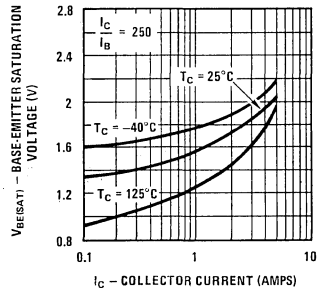
**Collector Saturation Region—Typical Values**



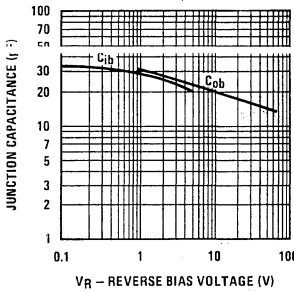
**Base-Emitter ON Voltage vs Collector Current**



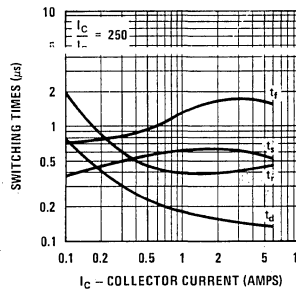
**Base-Emitter Saturation Voltage vs Collector Current**



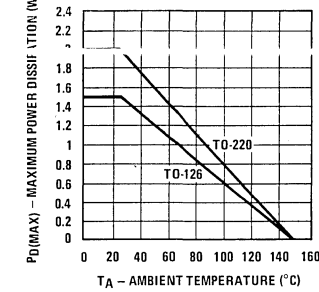
**Junction Capacitance vs Reverse Bias Voltage**



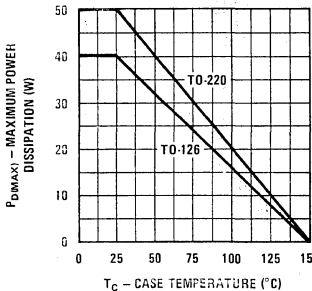
**Switching Times vs Collector Current**



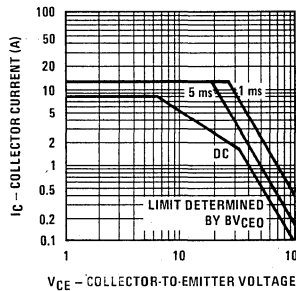
**Maximum Power Dissipation vs Ambient Temperature**



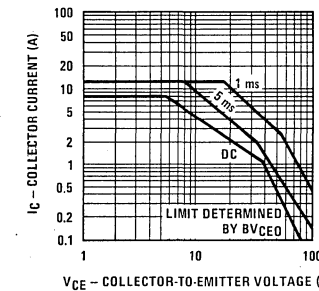
**Maximum Power Dissipation vs Case Temperature**



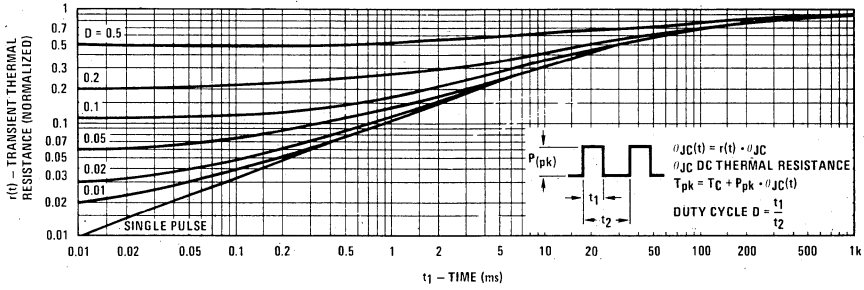
**Safe Operating Area TO-220**



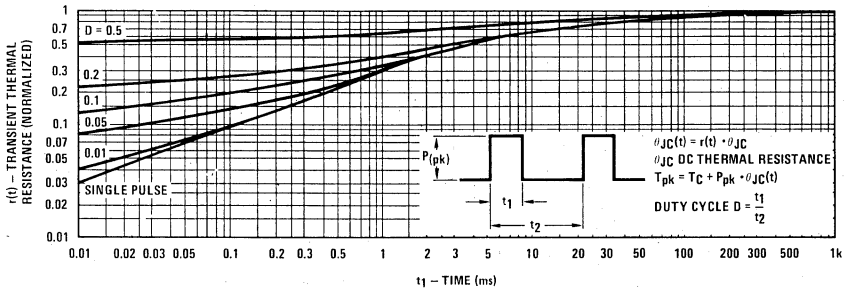
**Safe Operating Area TO-126**

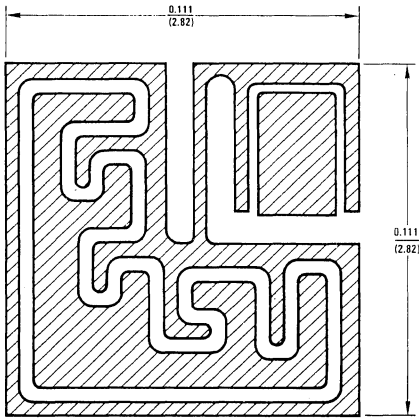


Thermal Response in TO-220 Package



Thermal Response in TO-126 Package





### DESCRIPTION

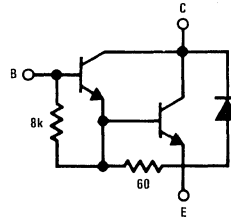
Process 4K is a double epitaxial silicon mesa Darlington transistor. Complement to Process 5K.

### APPLICATION

The 4K was designed for general purpose amplifier and low-speed switching applications.

### PRINCIPAL DEVICE TYPES

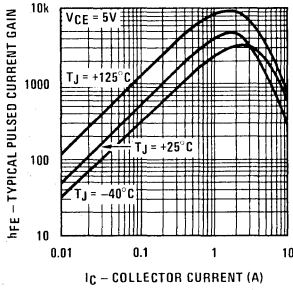
TO-220, BCE: SE9300-02  
TIP121, 22  
TIP130-32



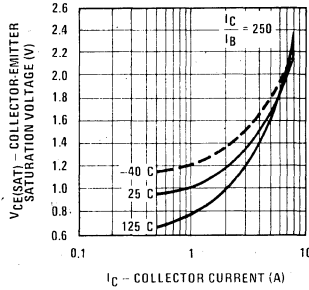
Parameter	Conditions	Min	Typ	Max	Units
$V_{CE0}$	$I_C = 100 \text{ mA}$ (Note 1)	40		120	V
$V_{CB0}$	$I_C = 200 \mu\text{A}$	70			V
$V_{EBO}$	$I_E = 5 \text{ mA}$	5			V
$I_{CE0}$	$V_{CE} = 1/2 V_{CE0}$			0.5	mA
$I_{CBO}$	$V_{CB} = 0 V_{CE0}$			100	$\mu\text{A}$
$I_{EBO}$	$V_{BE} = 5 \text{ V}$			2.0	mA
$h_{FE}$	$I_C = 4 \text{ A}, V_{CE} = 3 \text{ V}$ (Note 1)	750		18,000	
$h_{FE}$	$I_C = 8 \text{ A}, V_{CE} = 3 \text{ V}$ (Note 1)	100			
$V_{CE(SAT)}$	$I_C = 4 \text{ A}, I_B = 16 \text{ mA}$ (Note 1)			2	V
$V_{CE(SAT)}$	$I_C = 8 \text{ A}, I_B = 80 \text{ mA}$ (Note 1)			3	V
$V_{BE(SAT)}$	$I_C = 8 \text{ A}, I_B = 80 \text{ mA}$ (Note 1)			4	V
$V_{BE(ON)}$	$I_C = 4 \text{ A}, V_{CE} = 3 \text{ V}$ (Note 1)			2.8	V
$C_{OBO}$	$V_{CB} = 10 \text{ V}$			200	pF
$ h_{fe} $	$I_C = 3 \text{ A}, V_{CE} = 3 \text{ V}, f = 1 \text{ MHz}$	4			
$P_{D(max)}$					
TO-220	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	60 2			W
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$			2.08	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-220	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
$T_{U(max)}$	All Plastic Parts	150			$^\circ\text{C}$

Note 1: Pulsed measurement = 300  $\mu\text{s}$  pulse width.

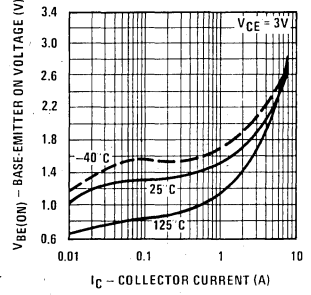
Typical Pulsed Current Gain vs Collector Current



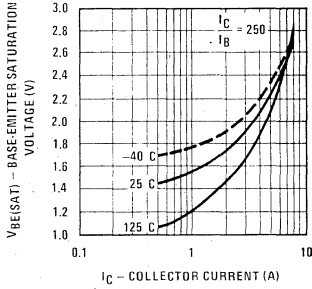
Collector-Emitter Saturation Voltage vs Collector Current



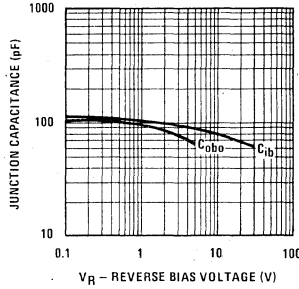
Base-Emitter ON Voltage vs Collector Current



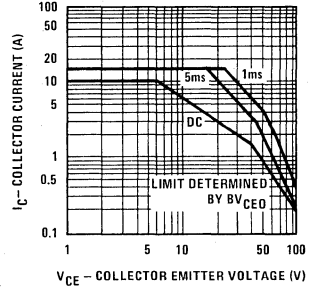
Base-Emitter Saturation Voltage vs Collector Current



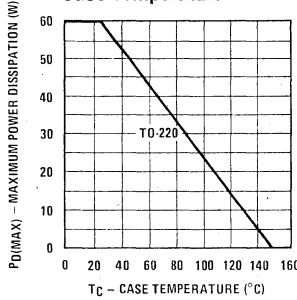
Junction Capacitance vs Reverse Bias Voltage



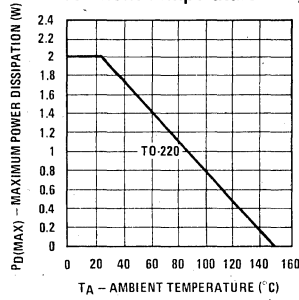
Safe Operating Area TO-220



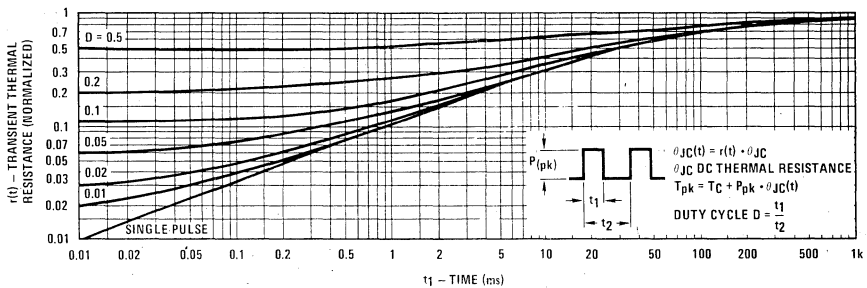
Maximum Power Dissipation vs Case Temperature

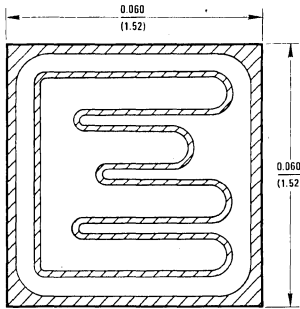


Maximum Power Dissipation vs Ambient Temperature



Thermal Response in TO-220 Package




**DESCRIPTION**

Process 4P is a double-diffused silicon epitaxial planar device. Complement to Process 5P.

**APPLICATION**

This device was designed for power amplifier, regulator and switching circuits where speed is important.

**PRINCIPAL DEVICE TYPES**

TO-220, BCE: D44C1-12

TO-126, ECB: MJE220-25

MJE240-44

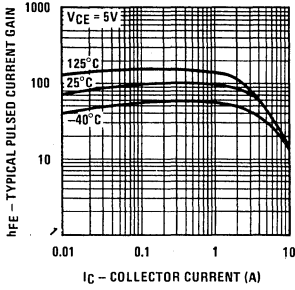
TO-202, BCE: D42C1-12

Parameter	Conditions	Min	Typ	Max	Units
$V_{CE0}$	$I_C = 100 \text{ mA}$ (Note 1)	50		120	V
$V_{CES}$	$I_C = 1 \text{ mA}$	75			V
$V_{EBO}$	$I_E = 1 \text{ mA}$	5	8		V
$I_{CES}$	$V_{CE} = 50\text{V}$			5	$\mu\text{A}$
$I_{EBO}$	$V_{EB} = 5\text{V}$			5	$\mu\text{A}$
$h_{FE}$	$V_{CE} = 5\text{V}, I_C = 20 \text{ mA}$	30			
$h_{FE}$	$V_{CE} = 5\text{V}, I_C = 0.5\text{A}$	50	80	200	
$h_{FE}$	$V_{CE} = 5\text{V}, I_C = 5\text{A}$ (Note 1)	10			
$V_{CE(SAT)}$	$I_C = 3\text{A}, I_B = 0.3\text{A}$		0.5	1	V
$V_{BE(SAT)}$	$I_C = 3\text{A}, I_B = 0.3\text{A}$		1		V
$f_t$	$V_{CE} = 5\text{V}, I_C = 0.5\text{A}$	50			MHz
$C_{CB}$	$V_{CB} = 10\text{V}$		45		pF
$C_{IB}$	$V_{EB} = 1\text{V}$		400		pF
$t_r$	$I_C = 2\text{A}, V_{CE} = 30\text{V}$ $I_{B1} = I_{B2} = 0.2\text{A}$		60		ns
$t_s$			750		ns
$t_f$			80		ns
$P_{D(max)}$					
TO-220	$T_C = 25^\circ\text{C}$	40			W
TO-126	$T_C = 25^\circ\text{C}$	30			W
TO-202	$T_C = 25^\circ\text{C}$	15			W
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$			3.2	$^\circ\text{C/W}$
TO-126	$T_C = 25^\circ\text{C}$			4.16	$^\circ\text{C/W}$
TO-202	$T_C = 25^\circ\text{C}$			8.33	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-220	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-202	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$

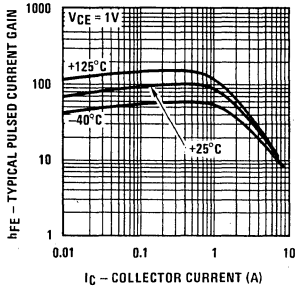
Note 1: Pulsed measurement = 300  $\mu\text{s}$  pulse width.



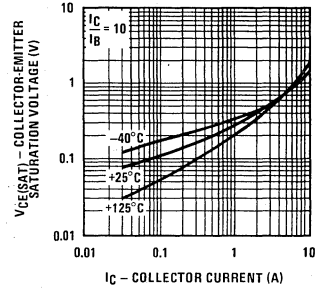
Typical Pulsed Current Gain vs Collector Current



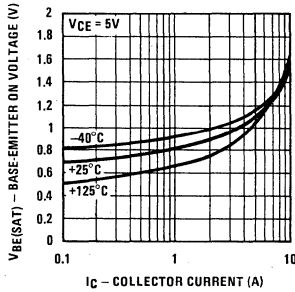
Typical Pulsed Current Gain vs Collector Current



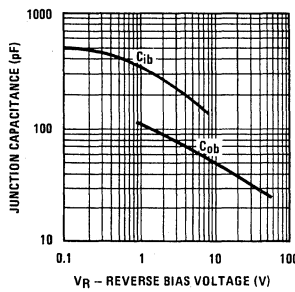
Collector-Emitter Saturation Voltage vs Collector Current



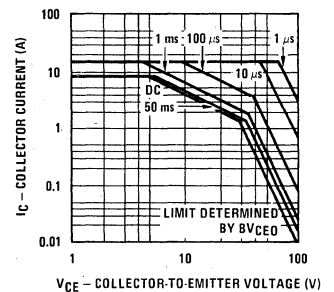
Base-Emitter ON Voltage vs Collector Current



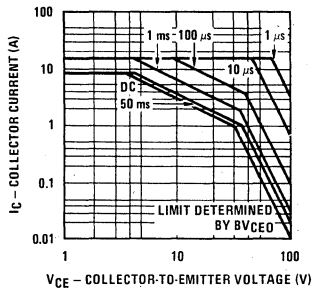
Junction Capacitance vs Reverse Bias Voltage



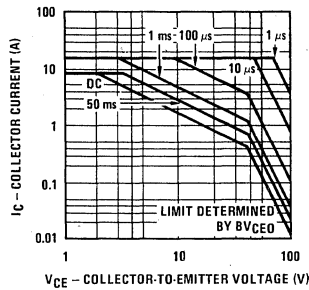
Safe Operating Area TO-220



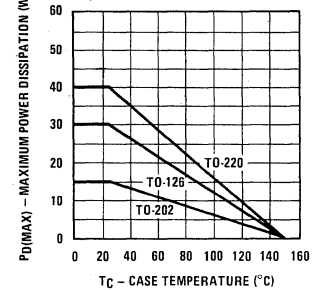
Safe Operating Area TO-126



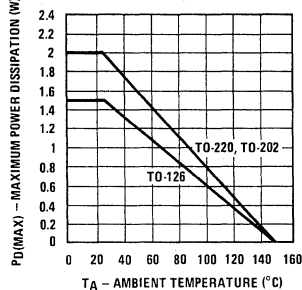
Safe Operating Area TO-202



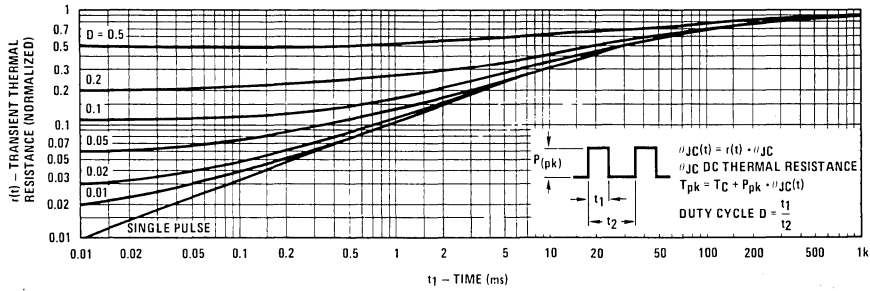
Maximum Power Dissipation vs Case Temperature



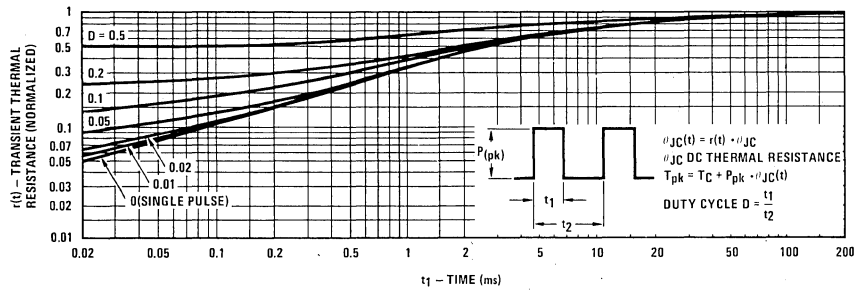
Maximum Power Dissipation vs Ambient Temperature

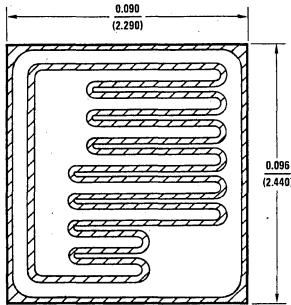


Thermal Response in TO-220 Package



Thermal Response in TO-126 Package





### DESCRIPTION

Process 4Q is a double diffused silicon epitaxial planar device. Complement to Process 5Q.

### APPLICATION

This device was designed for power amplifier, regulator and switching circuits where speed is important.

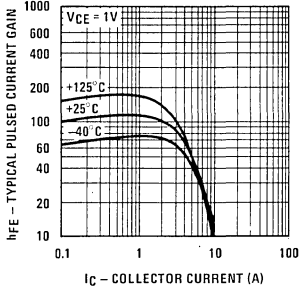
### PRINCIPAL DEVICE TYPES

**TO-220, BCE:** D44H1  
D44H2  
D44H4  
D44H5  
D44H7  
D44H8  
D44H10  
D44H11

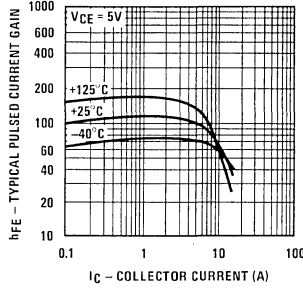
Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 100 \text{ mA}$ (Note 1)	50		120	V
$BV_{CES}$	$I_C = 1 \text{ mA}$	75			V
$BV_{EBO}$	$I_E = 1 \text{ mA}$	5	8		V
$I_{CES}$	$V_{CE} = 50\text{V}$			5	$\mu\text{A}$
$I_{EBO}$	$V_{EB} = 5\text{V}$			5	$\mu\text{A}$
$h_{FE}$	$V_{CE} = 5\text{V}, I_C = 20 \text{ mA}$	30			
$h_{FE}$	$V_{CE} = 5\text{V}, I_C = 1 \text{ A}$ (Note 1)	50	100	300	
$h_{FE}$	$V_{CE} = 5\text{V}, I_C = 8 \text{ A}$ (Note 1)	20			
$V_{CE(SAT)}$	$I_C = 8 \text{ A}, I_B = 0.8 \text{ A}$ (Note 1)		0.6	1	V
$V_{BE(SAT)}$	$I_C = 8 \text{ A}, I_B = 0.8 \text{ A}$ (Note 1)		1.2		V
$f_t$	$V_{CE} = 5\text{V}, I_C = 0.5 \text{ A}$	50			MHz
$C_{OB}$	$V_{CB} = 10\text{V}$		110		pF
$C_{IB}$	$V_{EB} = 1\text{V}$		730		pF
$t_r$	$I_C = 5 \text{ A}, V_{CE} = 30\text{V}$		30		ns
$t_s$			500		ns
$t_f$	$I_{B1} = I_{B2} = 0.5 \text{ A}$		60		ns
$P_{D(max)}$					
TO-220	$T_C = 25^\circ\text{C}$	60			W
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$			2.08	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-220	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
$T_{J(max)}$					$^\circ\text{C}$
	All Plastic Parts	150			$^\circ\text{C}$

Note 1: Pulsed measurement = 300  $\mu\text{s}$  pulse width.

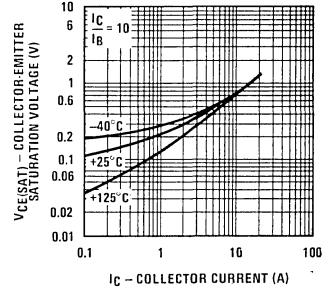
**Typical Pulsed Current Gain vs Collector Current**



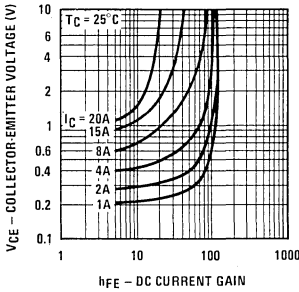
**Typical Pulsed Current Gain vs Collector Current**



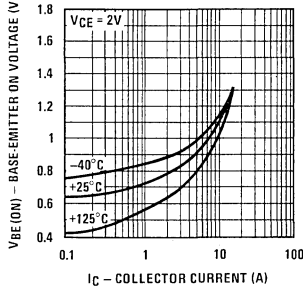
**Collector-Emitter Saturation Voltage vs Collector Current**



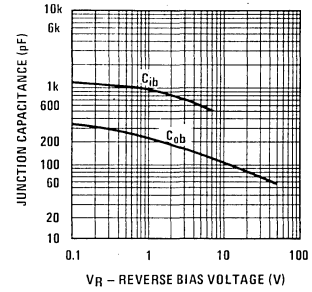
**Collector Saturation Region**



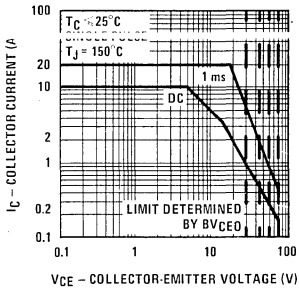
**Base-Emitter ON Voltage vs Collector Current**



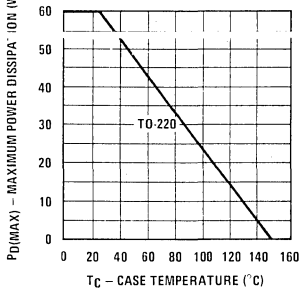
**Junction Capacitance vs Reverse Bias Voltage**



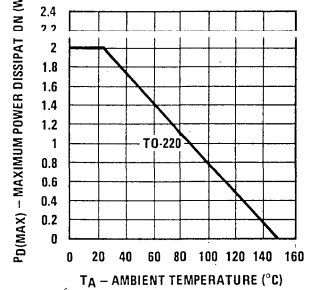
**Safe Operating Area TO-220**



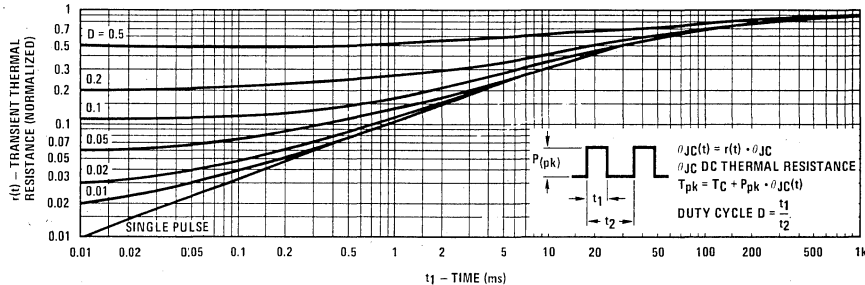
**Maximum Power Dissipation vs Case Temperature**



**Maximum Power Dissipation vs Ambient Temperature**



**Thermal Response in TO-220 Package**



### DESCRIPTION

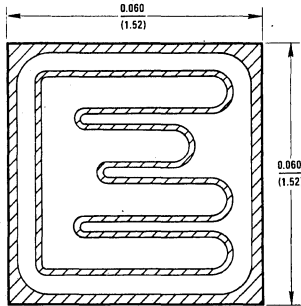
Process 4R is a double diffused silicon epitaxial planar device. Complement to Process 5R.

### APPLICATION

This device was designed for power amplifier, regulator and switching circuits where speed is important.

### PRINCIPAL DEVICE TYPES

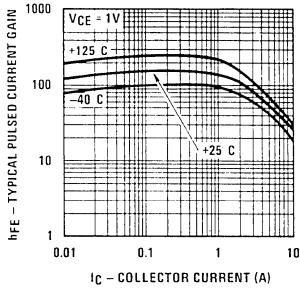
TO-126, ECB: MJE200



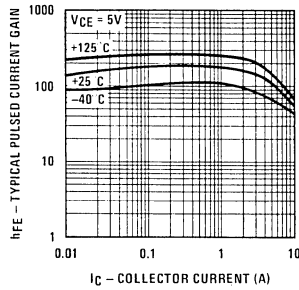
Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 100 \text{ mA}$ (Note 1)	20		40	V
$BV_{CES}$	$I_C = 1 \text{ mA}$	35			V
$BV_{EBO}$	$I_E = 1 \text{ mA}$	5	1		V
$I_{CES}$	$V_{CE} = 20\text{V}$			5	$\mu\text{A}$
$I_{EBO}$	$V_{EB} = 5\text{V}$			5	$\mu\text{A}$
$h_{FE}$	$V_{CE} = 5\text{V}, I_C = 20 \text{ mA}$	50	180		
$h_{FE}$	$V_{CE} = 5\text{V}, I_C = 0.5\text{A}$	50	180	350	
$h_{FE}$	$V_{CE} = 5\text{V}, I_C = 10\text{A}$ (Note 1)	25	50		
$V_{CE(SAT)}$	$I_C = 3\text{A}, I_B = 0.3\text{A}$		0.5	1	V
$V_{BE(SAT)}$	$I_C = 3\text{A}, I_B = 0.3\text{A}$		1		V
$f_t$	$V_{CE} = 5\text{V}, I_C = 0.5\text{A}$	50			MHz
$C_{OB}$	$V_{CB} = 10\text{V}$		63		pF
$C_{IB}$	$V_{EB} = 1\text{V}$		450		pF
$P_{D(max)}$					
TO-126	$T_C = 25^\circ\text{C}$	30			W
$\theta_{JC}$					
TO-126	$T_C = 25^\circ\text{C}$			4.16	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
$T_{J(max)}$					
	All Plastic Parts	150			$^\circ\text{C}$

Note 1: Pulsed measurement = 300  $\mu\text{s}$  pulse width.

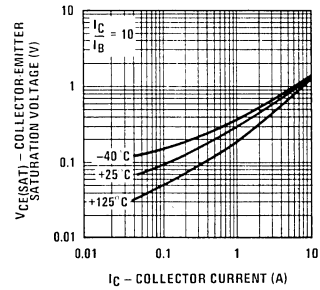
### Typical Pulsed Current Gain vs Collector Current



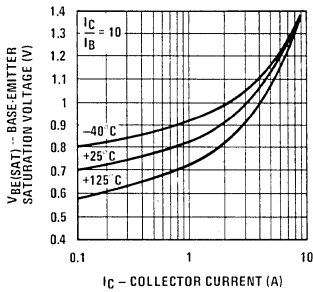
### Typical Pulsed Current Gain vs Collector Current



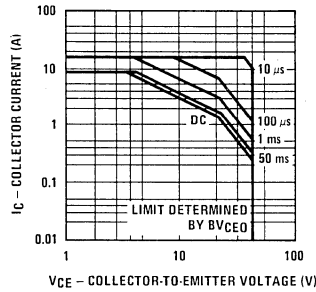
### Collector-Emitter Saturation Voltage vs Collector Current



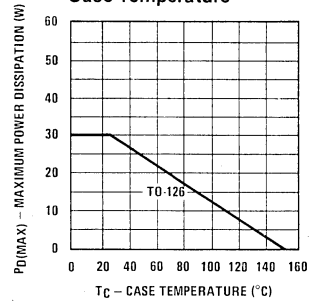
### Base-Emitter Saturation Voltage vs Collector Current



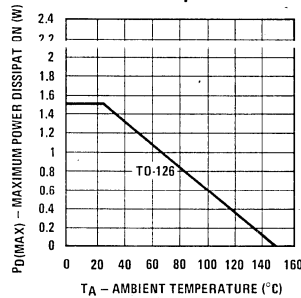
### Safe Operating Area TO-126



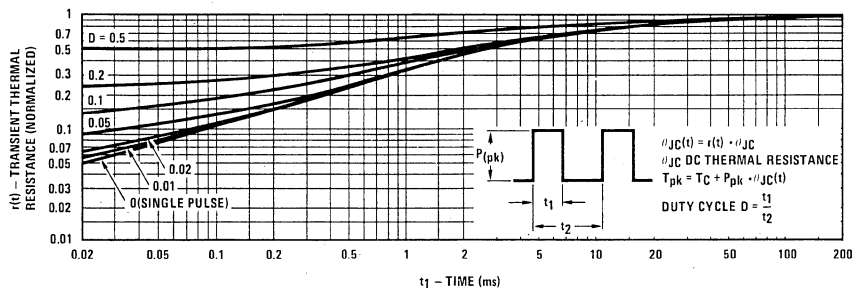
### Maximum Power Dissipation vs Case Temperature



### Maximum Power Dissipation vs Ambient Temperature



### Thermal Response in TO-126 Package





# Process 5A PNP Epitaxial Power

## DESCRIPTION

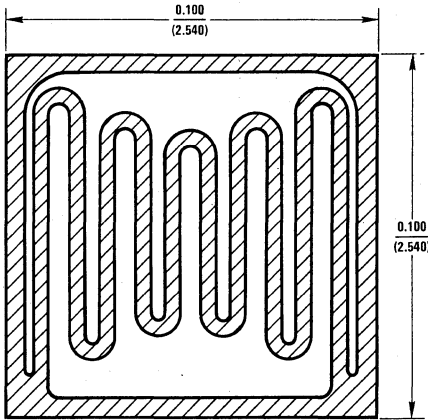
Process 5A is a double epitaxial silicon PNP mesa device with a diffused emitter. Complement to Process 4A.

## APPLICATION

This device was designed for general purpose power amplifier and switching circuits where a large safe operating area is required.

## PRINCIPAL DEVICE TYPES

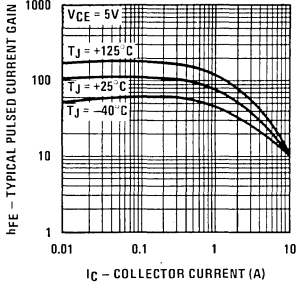
- TO-220, BCE:** 2N6489-91  
 BD346  
 MJE2901T  
 MJE2955T  
 TIP42-42C



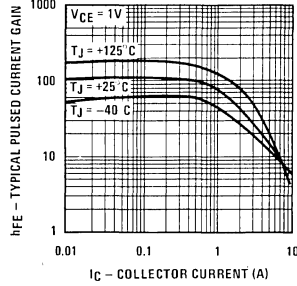
Parameter	Conditions	Min	Typ	Max	Units
$V_{CE0}$	$I_C = 200 \text{ mA}$ (Note 1)	40		120	V
$V_{CB0}$	$I_C = 1 \text{ mA}$	60			V
$V_{EBO}$	$I_E = 1 \text{ mA}$	5	7		V
$I_{CE0}$	$V_{CE} = V_{CE0} - 10V$			200	$\mu A$
$I_{CB0}$	$V_{CB} = V_{CE0}$			20	$\mu A$
$I_{EBO}$	$V_{EB} = 5V$			500	$\mu A$
$\eta_{FE}$	$I_C = 2.5A, V_{CE} = 2V$ (Note 1)	20		200	
$V_{CE(SAT)}$	$I_C = 4A, I_B = 0.4A$ (Note 1)		0.5	0.6	V
$V_{BE(ON)}$	$I_C = 5A, V_{CE} = 2V$ (Note 1)		1.2	1.3	V
$f_t$	$I_C = 0.5A, V_{CE} = 5V$	2			MHz
$t_d$	$I_C = 5A, I_{B1} = I_{B2} = 0.5A, V_{CC} = 40V$		0.03		$\mu s$
$t_r$	$I_C = 5A, I_{B1} = I_{B2} = 0.5A, V_{CC} = 40V$		0.27		$\mu s$
$t_s$	$I_C = 5A, I_{B1} = I_{B2} = 0.5A, V_{CC} = 40V$		0.3		$\mu s$
$t_f$	$I_C = 5A, I_{B1} = I_{B2} = 0.5A, V_{CC} = 40V$		0.37		$\mu s$
$P_{D(max)}$					
TO-220	$T_C = 25^\circ C$	60			W
	$T_A = 25^\circ C$	2			
$\theta_{JC}$					
TO-220	$T_C = 25^\circ C$			2.08	$^\circ C/W$
$\theta_{JA}$					
TO-220	$T_A = 25^\circ C$			62.5	$^\circ C/W$
$T_{J(max)}$	All Plastic Parts	150			$^\circ C$

Note 1: Pulsed measurement = 300  $\mu s$  pulse width.

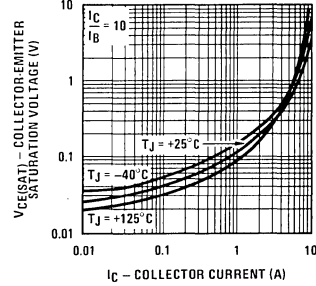
**Typical Pulsed Current Gain vs Collector Current**



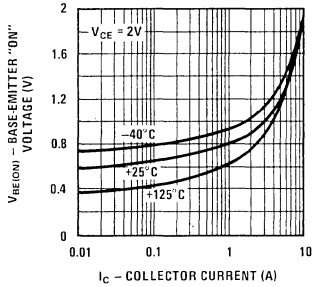
**Typical Pulsed Current Gain vs Collector Current**



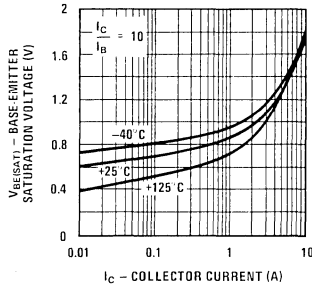
**Collector-Emitter Saturation Voltage vs Collector Current**



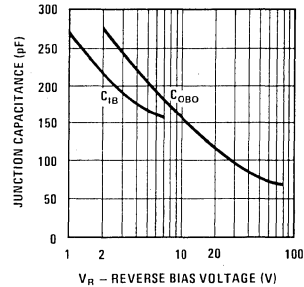
**Base-Emitter ON Voltage vs Collector Current**



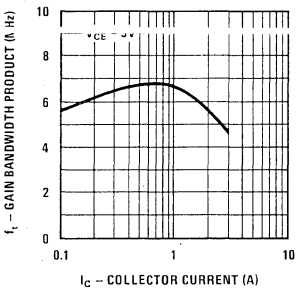
**Base-Emitter Saturation Voltage vs Collector Current**



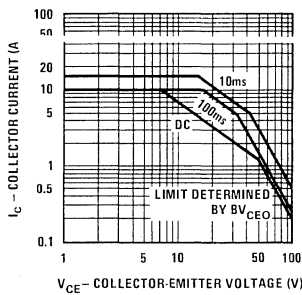
**Junction Capacitance vs Reverse Bias Voltage**



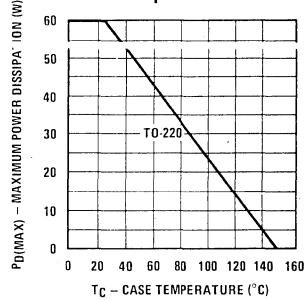
**Gain Bandwidth Product vs Collector Current**



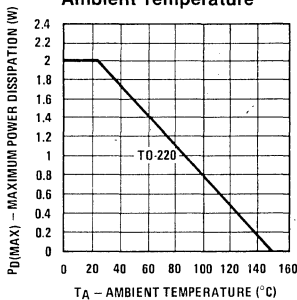
**Safe Operating Area TO-220**



**Maximum Power Dissipation vs Case Temperature**

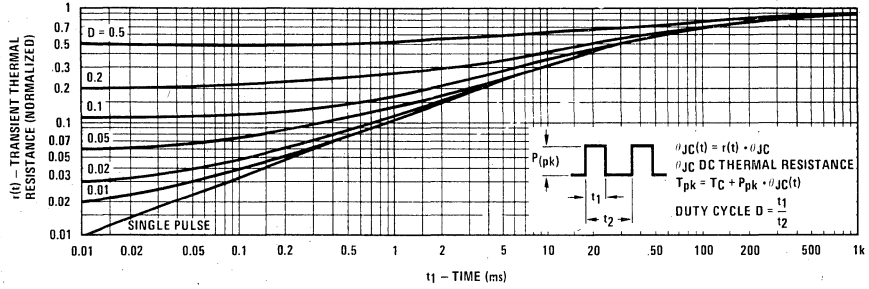


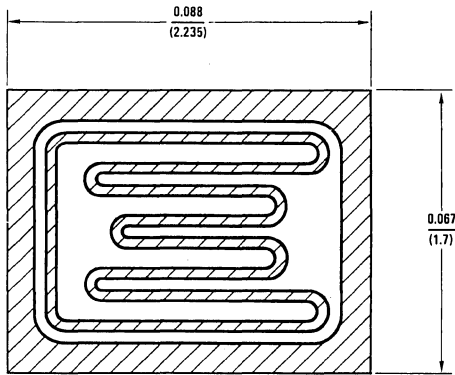
**Maximum Power Dissipation vs Ambient Temperature**





Thermal Response in TO-220 Package




**DESCRIPTION**

Process 5E is a double epitaxial silicon mesa device with diffused emitter. Complement to Process 4E.

**APPLICATION**

This device was designed for general purpose power amplifier and switching circuits where a large safe operating area is required.

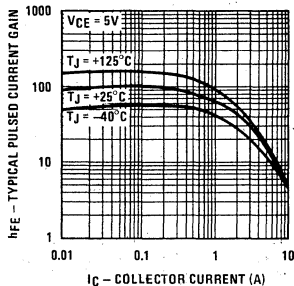
**PRINCIPAL DEVICE TYPES**

**TO-220, BCE:** 2N6107-09  
2N6124-26  
2N6132-34  
**TO-126, ECB:** 2N5193-95  
MJE371

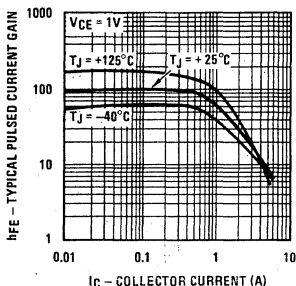
Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 100 \text{ mA}$ (Note 1)	30		120	V
$BV_{CBO}$	$I_C = 1 \text{ mA}$	40			V
$BV_{EBO}$	$I_E = 1 \text{ mA}$	5	8		V
$I_{CEO}$	$V_{CE} = BV_{CEO}$			300	$\mu\text{A}$
$I_{CBO}$	$V_{CB} = BV_{CEO}$			100	$\mu\text{A}$
$I_{EBO}$	$V_{EB} = 5\text{V}$			1000	$\mu\text{A}$
$h_{FE}$	$I_C = 1.5\text{A}$ , $V_{CE} = 2.0\text{V}$ (Note 1)	20		170	
$V_{CE(SAT)}$	$I_C = 4.0\text{A}$ , $I_B = 0.4\text{A}$ (Note 1)			1.0	V
$V_{BE(ON)}$	$I_C = 4.0\text{A}$ , $V_{CE} = 2.0\text{V}$ (Note 1)			1.3	V
$f_t$	$I_C = 0.5\text{A}$ , $V_{CE} = 2\text{V}$	4			MHz
$t_d$	$I_C = 1.0\text{A}$ , $I_{B1} = 0.1\text{A}$ , $I_{B2} = 0.1\text{A}$ , $V_{CC} = 30\text{V}$		0.10		$\mu\text{s}$
$t_r$	$I_C = 1.0\text{A}$ , $I_{B1} = 0.1\text{A}$ , $I_{B2} = 0.1\text{A}$ , $V_{CC} = 30\text{V}$		0.25		$\mu\text{s}$
$t_s$	$I_C = 1.0\text{A}$ , $I_{B1} = 0.1\text{A}$ , $I_{B2} = 0.1\text{A}$ , $V_{CC} = 30\text{V}$		0.40		$\mu\text{s}$
$t_f$	$I_C = 1.0\text{A}$ , $I_{B1} = 0.1\text{A}$ , $I_{B2} = 0.1\text{A}$ , $V_{CC} = 30\text{V}$		0.23		$\mu\text{s}$
$P_{D(max)}$					
TO-220	$T_C = 25^\circ\text{C}$	50			W
	$T_A = 25^\circ\text{C}$	2			
TO-126	$T_C = 25^\circ\text{C}$	40			W
	$T_A = 25^\circ\text{C}$	1.5			
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$			2.5	$^\circ\text{C/W}$
TO-126	$T_C = 25^\circ\text{C}$			3.12	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-220	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$

Note 1: Pulsed measurement = 300  $\mu\text{s}$  pulse width.

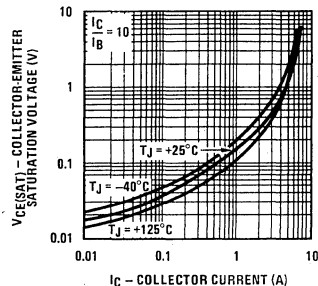
Typical Pulsed Current Gain vs Collector Current



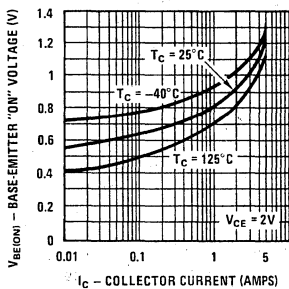
Typical Pulsed Current Gain vs Collector Current



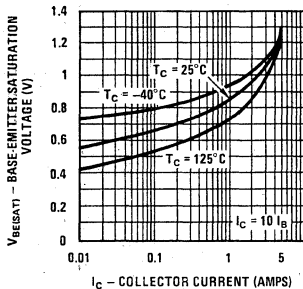
Collector-Emitter Saturation Voltage vs Collector Current



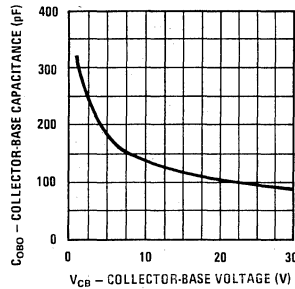
Base-Emitter ON Voltage vs Collector Current



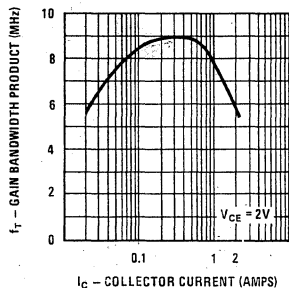
Base-Emitter Saturation Voltage vs Collector Current



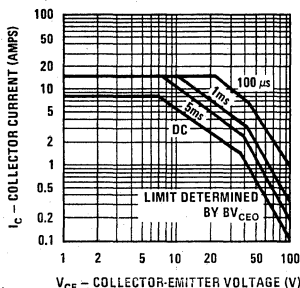
Collector-Base Capacitance vs Collector-Base Voltage



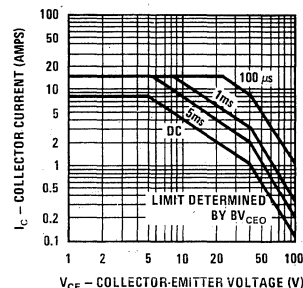
Gain Bandwidth Product vs Collector Current



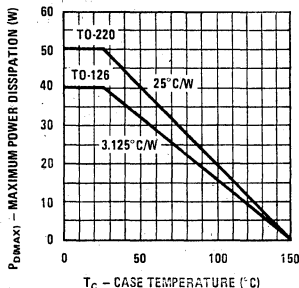
Safe Operating Area TO-220



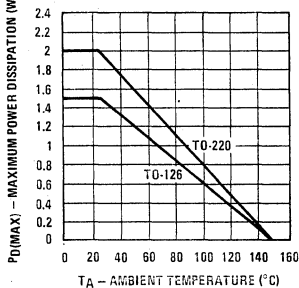
Safe Operating Area TO-126



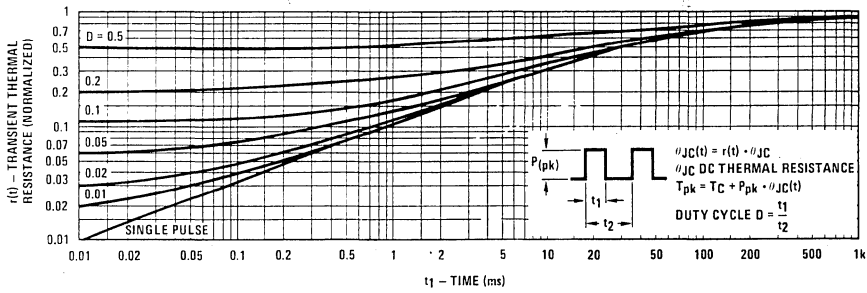
Maximum Power Dissipation vs Case Temperature



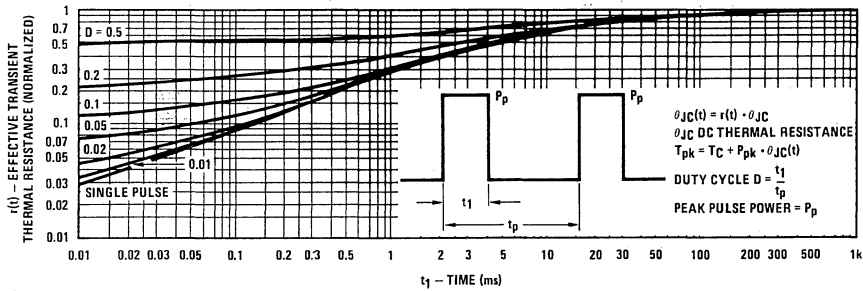
Maximum Power Dissipation vs Ambient Temperature



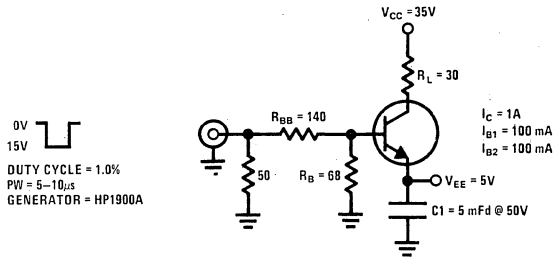
Thermal Response in TO-220 Package



Thermal Response in TO-126 Package



Switching Circuit





# Process 5F PNP Epitaxial Power

## DESCRIPTION

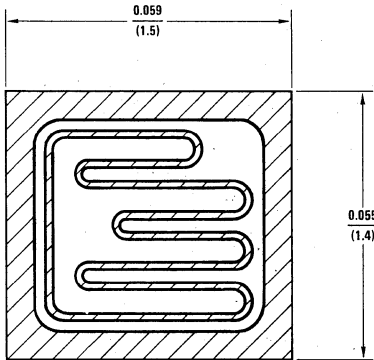
Process 5F is a double epitaxial silicon mesa device with diffused emitter. Complement to Process 4F.

## APPLICATION

This device was designed for general purpose power amplifier and switching circuits where a large safe operating area is required.

## PRINCIPAL DEVICE TYPES

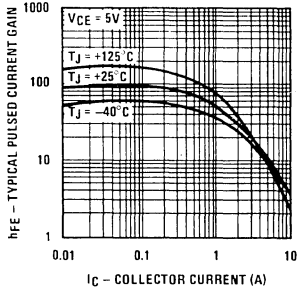
- TO-220, BCE:** TIP30-30C  
 TIP32-32C  
 TIP62-62C
- TO-126, ECB:** 2N4918-20  
 MJE370



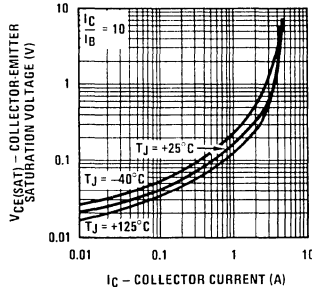
Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 100 \text{ mA}$ (Note 1)	30		120	V
$BV_{CBO}$	$I_C = 1 \text{ mA}$	50			V
$BV_{EBO}$	$I_E = 1 \text{ mA}$	5	6.5		V
$I_{CEO}$	$V_{CE} = BV_{CEO} - 10V$			300	$\mu A$
$I_{CBO}$	$V_{CB} = BV_{CEO}$			10	$\mu A$
$I_{EBO}$	$V_{EB} = 5V$			100	$\mu A$
$h_{FE}$	$I_C = 1.0A, V_{CE} = 1.0V$ (Note 1)	10		120	
$V_{CE(SAT)}$	$I_C = 2.0A, I_B = 0.2A$ (Note 1)			1.0	V
$V_{BE(ON)}$	$I_C = 2.0A, V_{CE} = 2.0V$ (Note 1)			1.1	V
$f_t$	$I_C = 0.5A, V_{CE} = 2V$	4			MHz
$t_d$			0.03		$\mu s$
$t_r$	$I_C = 1A, I_{B1} = I_{B2} = 0.1A,$		0.20		$\mu s$
$t_s$	$V_{CC} = 30V$		0.26		$\mu s$
$t_f$			0.20		$\mu s$
$P_{D(max)}$					
TO-220	$T_C = 25^\circ C$	40			W
	$T_A = 25^\circ C$	2			
TO-126	$T_C = 25^\circ C$	30			W
	$T_A = 25^\circ C$	1.5			
$\theta_{JC}$					
TO-220	$T_C = 25^\circ C$			3.12	$^\circ C/W$
TO-126	$T_C = 25^\circ C$			4.16	$^\circ C/W$
$\theta_{JA}$					
TO-220	$T_A = 25^\circ C$			62.5	$^\circ C/W$
TO-126	$T_A = 25^\circ C$			83.3	$^\circ C/W$
$T_{J(max)}$	All Plastic Parts	150			$^\circ C$

Note 1: Pulsed measurement = 300  $\mu s$  pulse width.

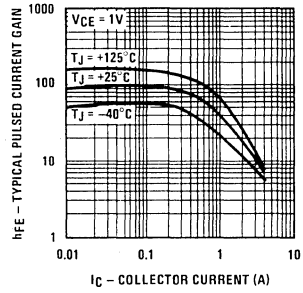
**Typical Pulsed Current Gain vs Collector Current**



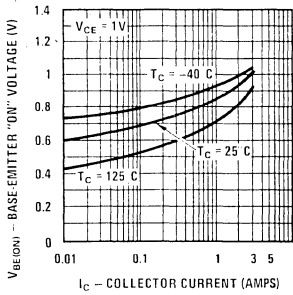
**Collector-Emitter Saturation Voltage vs Collector Current**



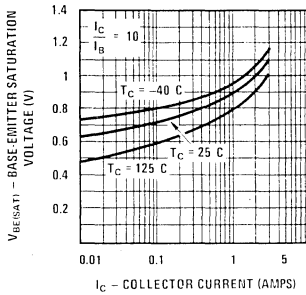
**Typical Pulsed Current Gain vs Collector Current**



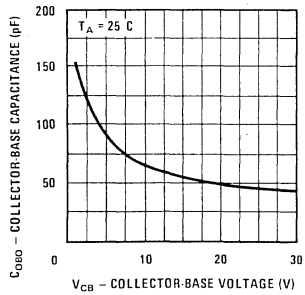
**Base-Emitter ON Voltage vs Collector Current**



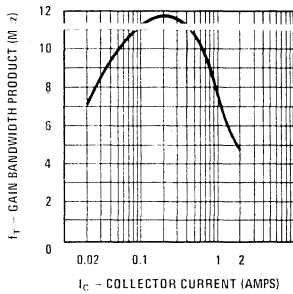
**Base-Emitter Voltage vs Collector Current**



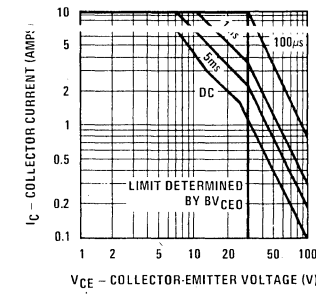
**Typical Collector Capacitance vs Collector-Base Voltage**



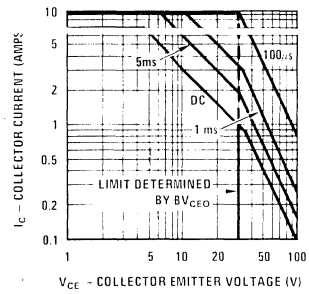
**Gain Bandwidth Product vs Collector Current**



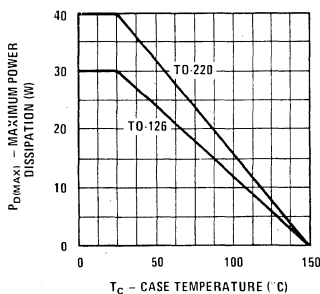
**Safe Operating Area TO-220**



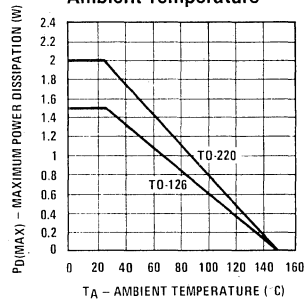
**Safe Operating Area TO-126**



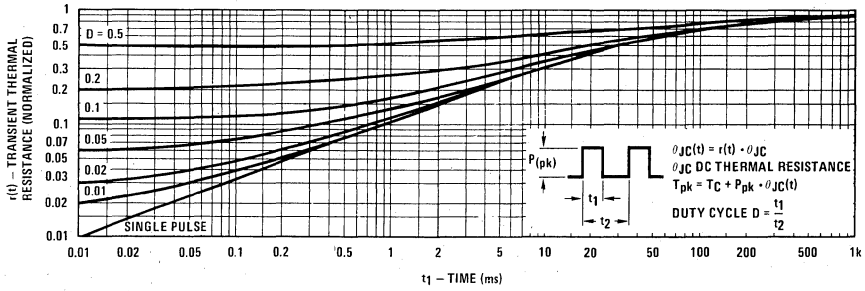
**Maximum Power Dissipation vs Case Temperature**



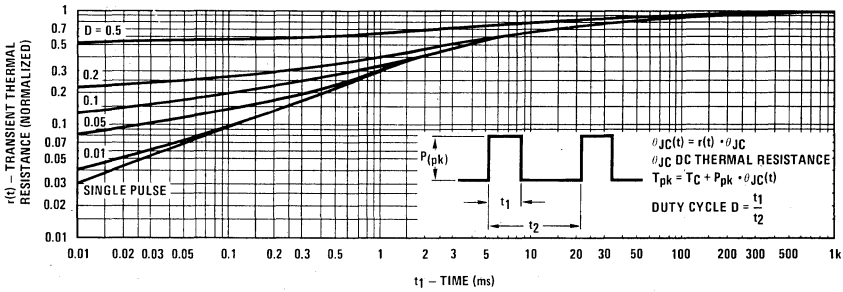
**Maximum Power Dissipation vs Ambient Temperature**



Thermal Response in TO-220 Package

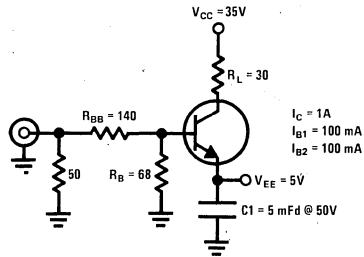


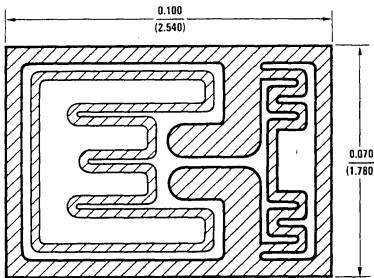
Thermal Response in TO-126 Package



Switching Circuit

0V  
15V  
DUTY CYCLE = 1.0%  
PW = 5-10µs  
GENERATOR = HP1900A




**DESCRIPTION**

Process 5J is a double epitaxial silicon mesa device. Complement to Process 4J.

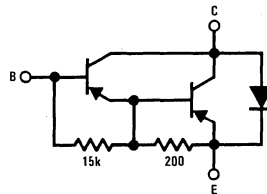
**APPLICATION**

This device was designed for use in driver and output stages of complementary audio amplifier circuits. It is also well suited for solenoid driver applications.

**PRINCIPAL DEVICE TYPES**

**TO-126, ECB:** 2N6034-36  
MJE700-03

**TO-220, BCE:** NSP2090-93  
TIP115-17

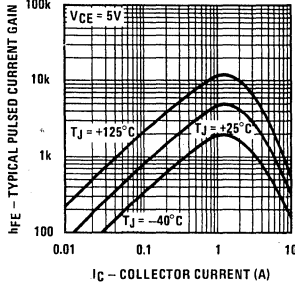


Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 100 \text{ mA}$ (Note 1)	40		120	V
$BV_{CBO}$	$I_C = 20 \mu\text{A}$	50			V
$BV_{EBO}$	$I_E = 2 \text{ mA}$	5			V
$I_{CEO}$	$V_{CE} = 1/2 BV_{CEO}$			0.5	mA
$I_{CBO}$	$V_{CE} = BV_{CEO}$			200	$\mu\text{A}$
$I_{EBO}$	$V_{EB} = 5\text{V}$			2.0	mA
$h_{FE}$	$I_C = 2\text{A}$ , $V_{CE} = 3\text{V}$ (Note 1)	750		20,000	
$V_{CE(SAT)}$	$I_C = 5\text{A}$ , $I_B = 20 \text{ mA}$ (Note 1)			3.3	V
$V_{BE(ON)}$	$I_C = 5\text{A}$ , $V_{CE} = 3\text{V}$ (Note 1)			2.8	V
$C_{OBO}$	$V_{CB} = 10\text{V}$		35		pF
$ h_{fe} $	$I_C = 1\text{A}$ , $V_{CE} = 3\text{V}$ , $f = 1 \text{ MHz}$		4		
$t_{ON}$	$I_C = 6\text{A}$ , $V_{CE} = 30\text{V}$		2.0		$\mu\text{s}$
$t_{OFF}$	$I_C = 6\text{A}$ , $V_{CE} = 30\text{V}$		2.6		$\mu\text{s}$
$P_{D(max)}$					
TO-220	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	50 2			W
TO-126	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	40 1.5			W
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$			2.5	$^\circ\text{C/W}$
TO-126	$T_C = 25^\circ\text{C}$			3.12	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-220	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$

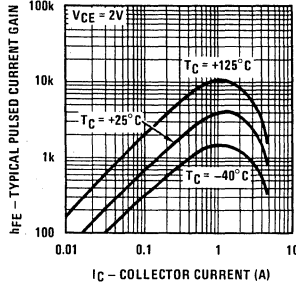
Note 1: Pulse test, pulse width = 300  $\mu\text{s}$



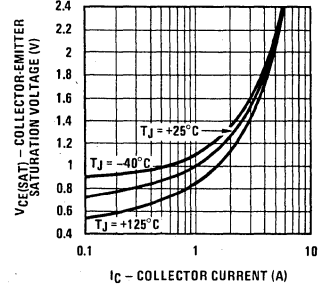
Typical Pulsed Current Gain vs Collector Current



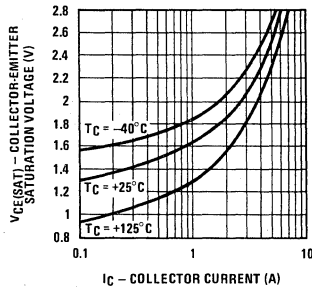
Typical Pulsed Current Gain vs Collector Current



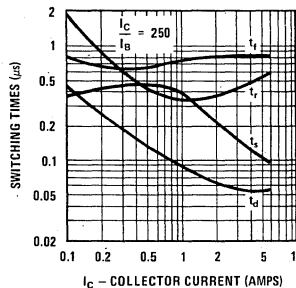
Collector-Emitter Saturation Voltage vs Collector Current



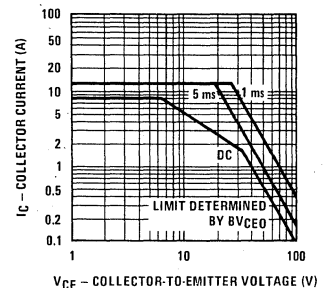
Base-Emitter Saturation Voltage vs Collector Current



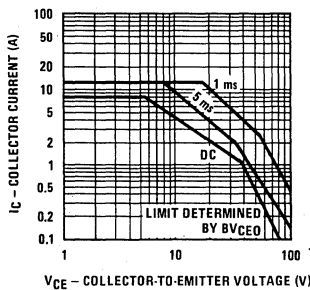
Switching Times vs Collector Current



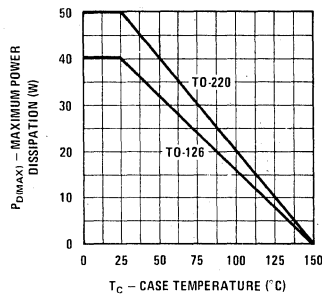
Safe Operating Area TO-220



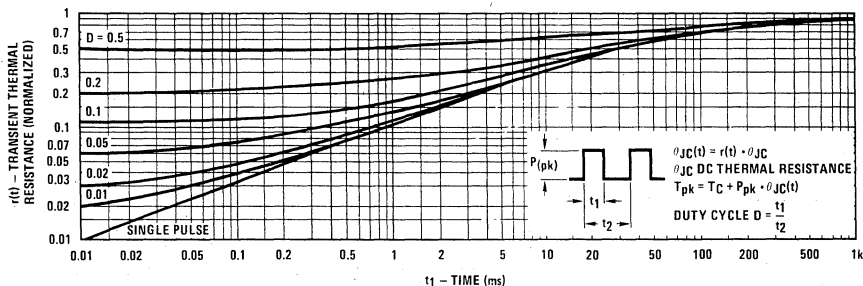
Safe Operating Area TO-126



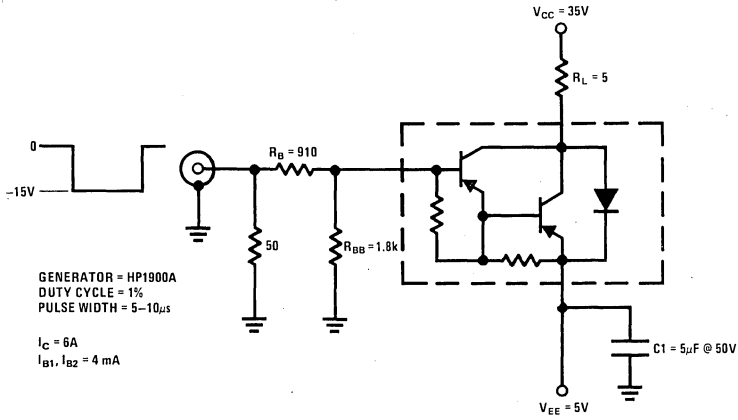
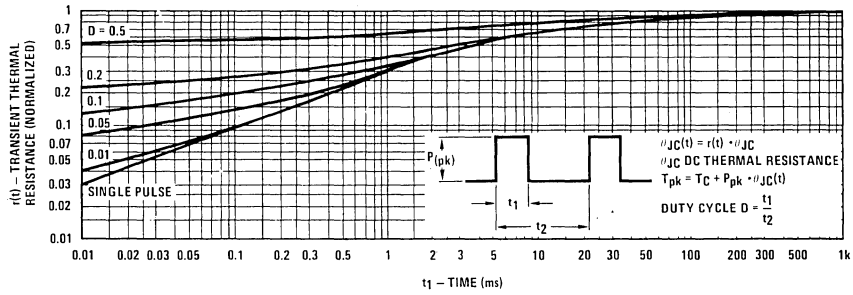
Maximum Power Dissipation vs Case Temperature



Thermal Response in TO-220 Package



Thermal Response in TO-126 Package



# Process 5K PNP Epitaxial Power Darlington

## DESCRIPTION

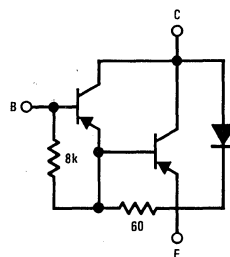
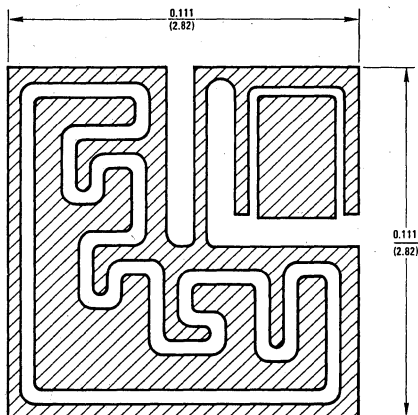
Process 5K is a double epitaxial silicon mesa Darlington transistor. Complement to Process 4K.

## APPLICATION

The 5K was designed for general purpose amplifier and low-speed switching applications.

## PRINCIPAL DEVICE TYPES

- TO-220, BCE: SE9401, 02
- TIP105-107
- TIP125-27
- TIP135-37

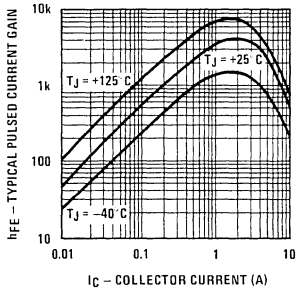


Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 100 \text{ mA}$ (Note 1)	40		120	V
$BV_{CBO}$	$I_C = 200 \mu\text{A}$	50			V
$BV_{EBO}$	$I_E = 5 \text{ mA}$	5			V
$I_{CEO}$	$V_{CE} = 1/2 BV_{CEO}$			0.5	mA
$I_{CBO}$	$V_{CB} = BV_{CEO}$			100	$\mu\text{A}$
$I_{EBO}$	$V_{BE} = 5\text{V}$			2.0	mA
$h_{FE}$	$I_C = 4\text{A}, V_{CE} = 3\text{V}$ (Note 1)	750		18,000	
$h_{FE}$	$I_C = 8\text{A}, V_{CE} = 3\text{V}$ (Note 1)	100			
$V_{CE(SAT)}$	$I_C = 4\text{A}, I_B = 16 \text{ mA}$ (Note 1)			2	V
$V_{CE(SAT)}$	$I_C = 8\text{A}, I_B = 80 \text{ mA}$ (Note 1)			3	V
$V_{BE(SAT)}$	$I_C = 8\text{A}, I_B = 80 \text{ mA}$ (Note 1)			4	V
$V_{BE(ON)}$	$I_C = 4\text{A}, V_{CE} = 3\text{V}$ (Note 1)			2.8	V
$C_{OBO}$	$V_{CB} = 10\text{V}$			300	pF
$ h_{fe} $	$I_C = 3\text{A}, V_{CE} = 3\text{V}, f = 1 \text{ MHz}$	4			
$P_{D(max)}$					
TO-220	$T_C = 25^\circ\text{C}$ $T_A = 25^\circ\text{C}$	60			W
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$			2.08	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-220	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$

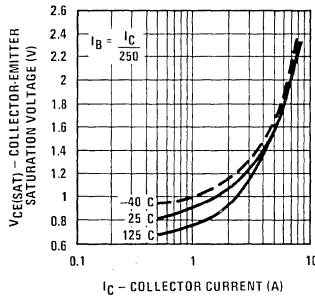
Note 1: Pulsed measurement = 300  $\mu\text{s}$  pulse width.

Process 5K

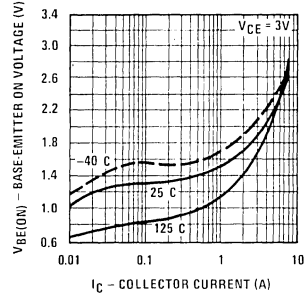
Typical Pulsed Current Gain vs Collector Current



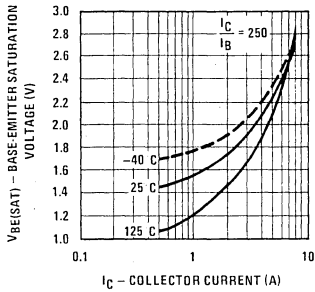
Collector-Emitter Saturation Voltage vs Collector Current



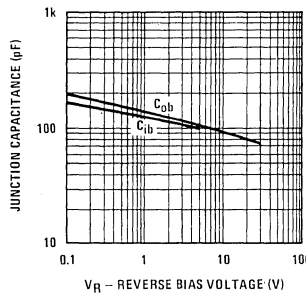
Base-Emitter ON Voltage vs Collector Current



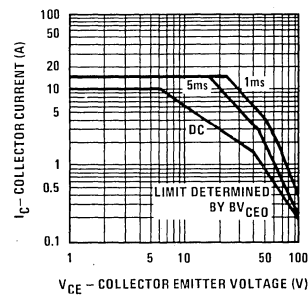
Base-Emitter Saturation Voltage vs Collector Current



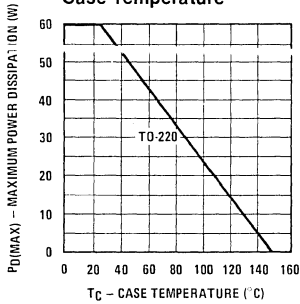
Junction Capacitance vs Reverse Bias Voltage



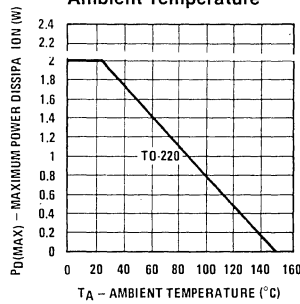
Safe Operating Area TO-220



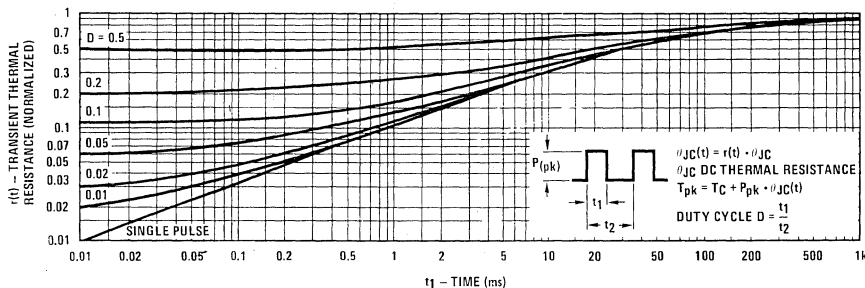
Maximum Power Dissipation vs Case Temperature



Maximum Power Dissipation vs Ambient Temperature



Thermal Response in TO-220 Package



## DESCRIPTION

Process 5P is a double diffused silicon epitaxial planar device. Complement to Process 4P.

## APPLICATION

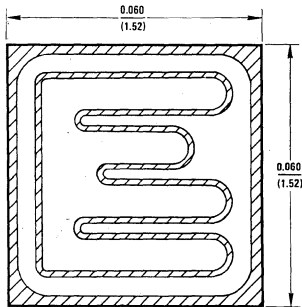
This device was designed for power amplifier, regulator and switching circuits where speed is important.

## PRINCIPAL DEVICE TYPES

**TO-220, BCE:** D45C1-12

**TO-126, ECB:** MJE230-35  
MJE250-54

**TO-202, BCE:** D43C1-12

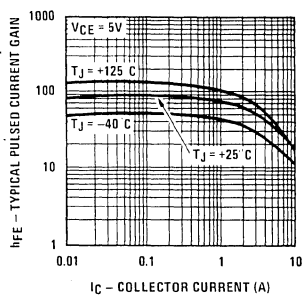


Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 100 \text{ mA}$ (Note 1)	50		120	V
$BV_{CES}$	$I_C = 1 \text{ mA}$				V
$BV_{EBO}$	$I_E = 1 \text{ mA}$	5	8		V
$I_{CES}$	$V_{CE} = 50 \text{ V}$			5	$\mu\text{A}$
$I_{EBO}$	$V_{EB} = 5 \text{ V}$			5	$\mu\text{A}$
$h_{FE}$	$V_{CE} = 5 \text{ V}, I_C = 20 \text{ mA}$	30			
$h_{FE}$	$V_{CE} = 5 \text{ V}, I_C = 0.5 \text{ A}$	50	80	200	
$h_{FE}$	$V_{CE} = 5 \text{ V}, I_C = 5 \text{ A}$ (Note 1)	10			
$V_{CE(SAT)}$	$I_C = 3 \text{ A}, I_B = 0.3 \text{ A}$		0.35	1	V
$V_{BE(SAT)}$	$I_C = 3 \text{ A}, I_B = 0.3 \text{ A}$		1.1		V
$f_t$	$V_{CE} = 5 \text{ V}, I_C = 0.5 \text{ A}$	40			MHz
$C_{OB}$	$V_{CB} = 10 \text{ V}$		75		pF
$C_{IB}$	$V_{EB} = 1 \text{ V}$		400		pF
$t_r$			60		ns
$t_s$	$I_C = 2 \text{ A}, V_{CE} = 30 \text{ V}$		500		ns
$t_f$	$I_{B1} = I_{B2} = 0.2 \text{ A}$		50		ns
$P_{D(max)}$					
TO-220	$T_C = 25^\circ\text{C}$	40			W
TO-126	$T_C = 25^\circ\text{C}$	30			W
TO-202	$T_C = 25^\circ\text{C}$	15			W
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$			3.2	$^\circ\text{C/W}$
TO-126	$T_C = 25^\circ\text{C}$			4.16	$^\circ\text{C/W}$
TO-202	$T_C = 25^\circ\text{C}$			8.33	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-220	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-202	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
TO-126	$T_A = 25^\circ\text{C}$			83.3	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$

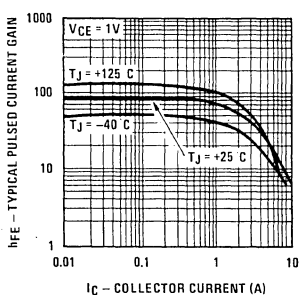
Note 1: Pulsed measurement = 300  $\mu\text{s}$  pulse width.

# Process 5P

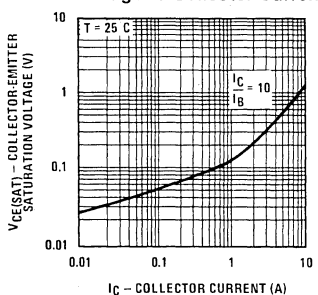
**Typical Pulsed Current Gain vs Collector Current**



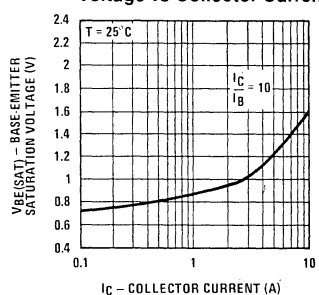
**Typical Pulsed Current Gain vs Collector Current**



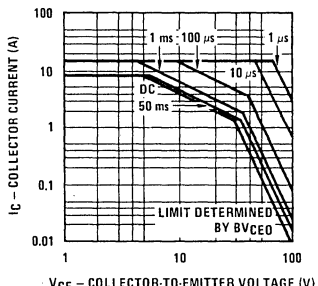
**Collector-Emitter Saturation Voltage vs Collector Current**



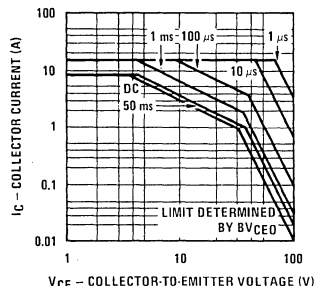
**Base-Emitter Saturation Voltage vs Collector Current**



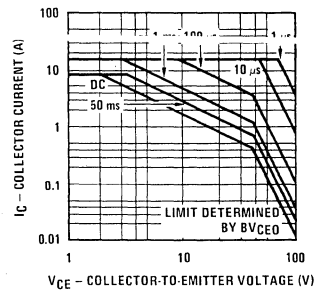
**Safe Operating Area TO-220**



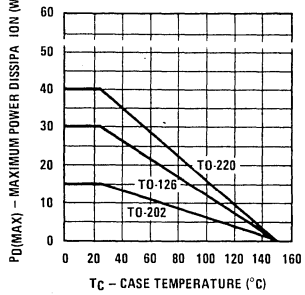
**Safe Operating Area TO-126**



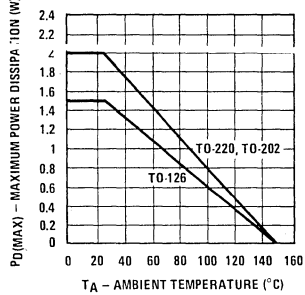
**Safe Operating Area TO-202**



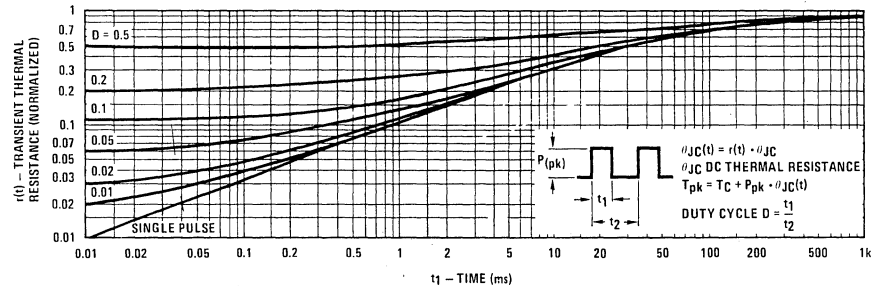
**Maximum Power Dissipation vs Case Temperature**



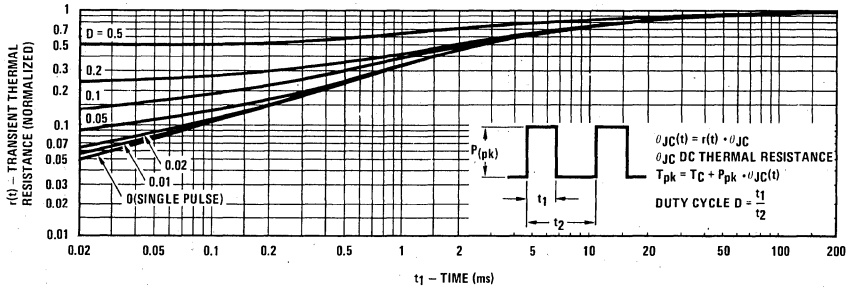
**Maximum Power Dissipation vs Ambient Temperature**

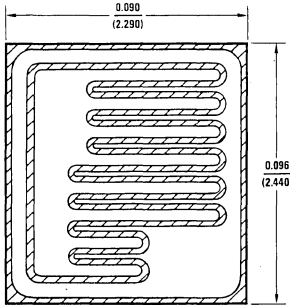


**Thermal Response in TO-220 Package**



Thermal Response in TO-126 Package




**DESCRIPTION**

Process 5Q is a double diffused silicon epitaxial planar device. Complement to Process 4Q.

**APPLICATION**

This device was designed for power amplifier, regulator and switching circuits where speed is important.

**PRINCIPAL DEVICE TYPES**

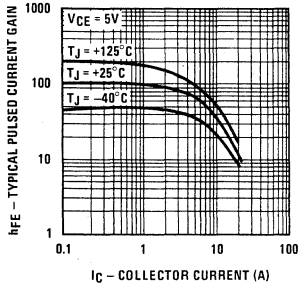
**TO-220, BCE:** D45H1  
D45H2  
D45H4  
D45H5  
D45H7  
D45H8  
D45H10  
D45H11

Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 100 \text{ mA}$ (Note 1)	50		120	V
$BV_{CES}$	$I_C = 1 \text{ mA}$	60			V
$BV_{EBO}$	$I_E = 1 \text{ mA}$	5	8		V
$I_{CES}$	$V_{CE} = 50\text{V}$			5	$\mu\text{A}$
$I_{EBO}$	$V_{EB} = 5\text{V}$			5	$\mu\text{A}$
$h_{FE}$	$V_{CE} = 5\text{V}, I_C = 20 \text{ mA}$	30			
$h_{FE}$	$V_{CE} = 5\text{V}, I_C = 1\text{A}$ (Note 1)	50	100	200	
$h_{FE}$	$V_{CE} = 5\text{V}, I_C = 8\text{A}$ (Note 1)	20			
$V_{CE(SAT)}$	$I_C = 8\text{A}, I_B = 0.8\text{A}$ (Note 1)		0.6	1	V
$V_{BE(SAT)}$	$I_C = 8\text{A}, I_B = 0.8\text{A}$ (Note 1)		1.2		V
$f_t$	$V_{CE} = 5\text{V}, I_C = 0.5\text{A}$	40			MHz
$C_{OB}$	$V_{CB} = 10\text{V}$		170		pF
$C_{IB}$	$V_{EB} = 1\text{V}$		870		pF
$t_r$			40		ns
$t_s$	$I_C = 5\text{A}, V_{CE} = 30\text{V}$		500		ns
$t_f$	$I_{B1} = I_{B2} = 0.5\text{A}$		60		ns
$P_{D(max)}$					
TO-220	$T_C = 25^\circ\text{C}$	60			W
$\theta_{JC}$					
TO-220	$T_C = 25^\circ\text{C}$			2.08	$^\circ\text{C/W}$
$\theta_{JA}$					
TO-220	$T_A = 25^\circ\text{C}$			62.5	$^\circ\text{C/W}$
$T_{J(max)}$	All Plastic Parts	150			$^\circ\text{C}$

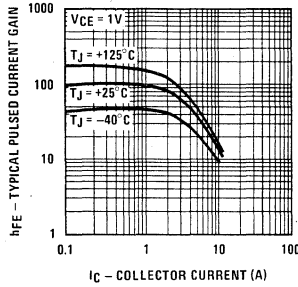
Note 1: Pulsed measurement = 300  $\mu\text{s}$  pulse width.



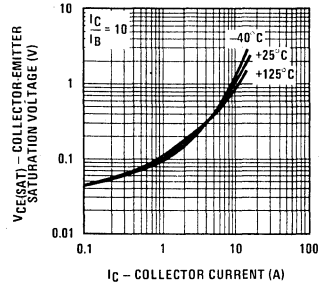
Typical Pulsed Current Gain vs Collector Current



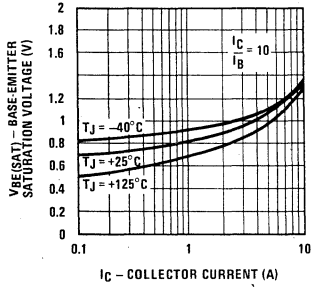
Typical Pulsed Current Gain vs Collector Current



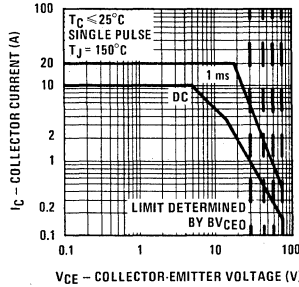
Collector-Emitter Saturation Voltage vs Collector Current



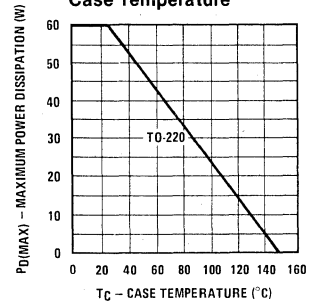
Base-Emitter Saturation Voltage vs Collector Current



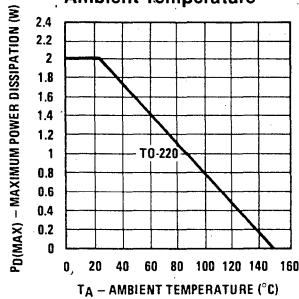
Safe Operating Area TO-220



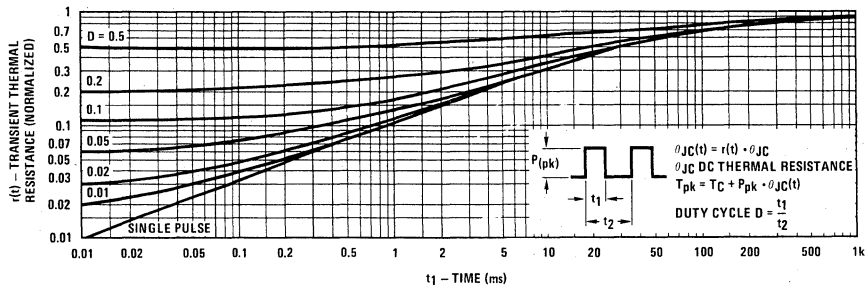
Maximum Power Dissipation vs Case Temperature



Maximum Power Dissipation vs Ambient Temperature



Thermal Response in TO-220 Package



**DESCRIPTION**

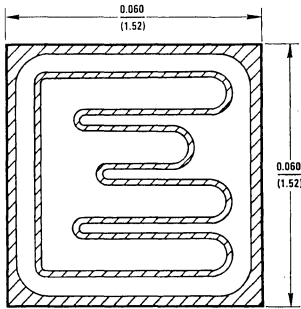
Process 5R is a double diffused silicon epitaxial planar device. Complement to Process 4R.

**APPLICATION**

This device was designed for power amplifier, regulator and switching circuits where speed is important.

**PRINCIPAL DEVICE TYPES**

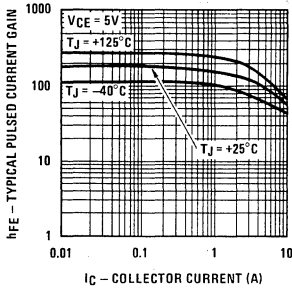
TO-126, ECB: MJE210



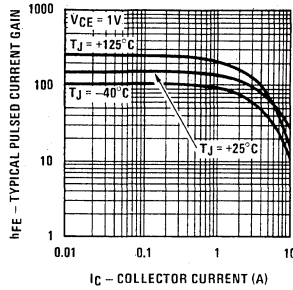
Parameter	Conditions	Min	Typ	Max	Units
$BV_{CEO}$	$I_C = 100 \text{ mA}$ (Note 1)	20		40	V
$BV_{CES}$	$I_C = 1 \text{ mA}$	25			V
$BV_{EBO}$	$I_E = 1 \text{ mA}$	5	7		V
$I_{CEC}$	$V_{CE} = 20V$			5	$\mu A$
$I_{EBO}$	$V_{EB} = 5V$			5	$\mu A$
$h_{FE}$	$V_{CE} = 5V, I_C = 20 \text{ mA}$	50	180		
$h_{FE}$	$V_{CE} = 5V, I_C = 0.5A$	50	180	350	
$h_{FE}$	$V_{CE} = 5V, I_C = 10A$ (Note 1)	25	50		
$V_{CE(SAT)}$	$I_C = 3A, I_B = 0.3A$		0.35	8	V
$V_{BE(SAT)}$	$I_C = 3A, I_B = 0.3A$		1		V
$f_t$	$V_{CE} = 5V, I_C = 0.5A$	50			MHz
$C_{OB}$	$V_{CB} = 10V$		95		pF
$C_{IB}$	$V_{EB} = 1V$		450		pF
$P_{D(max)}$					
TO-126	$T_C = 25^\circ C$	30			W
$\theta_{JC}$					
TO-126	$T_C = 25^\circ C$			4.16	$^\circ C/W$
$\theta_{JA}$					
TO-126	$T_A = 25^\circ C$			83.3	$^\circ C/W$
$T_{J(max)}$	All Plastic Parts	150			$^\circ C$

Note 1: Pulsed measurement = 300  $\mu s$  pulse width.

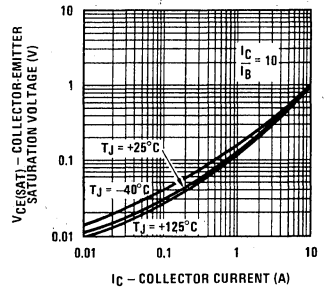
Typical Pulsed Current Gain vs Collector Current



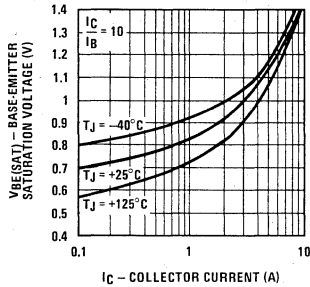
Typical Pulsed Current Gain vs Collector Current



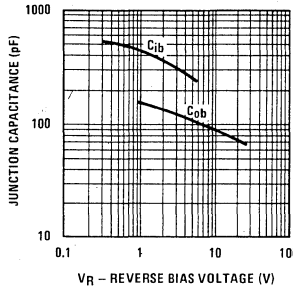
Collector-Emitter Saturation Voltage vs Collector Current



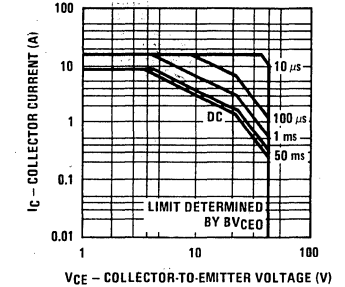
Base-Emitter Saturation Voltage vs Collector Current



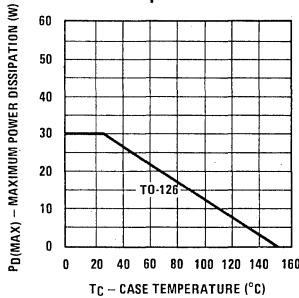
Junction Capacitance vs Reverse Bias Voltage



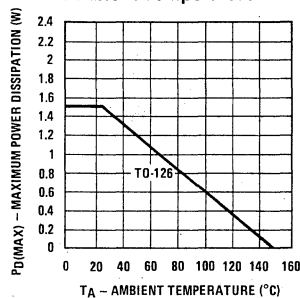
Safe Operating Area TO-126



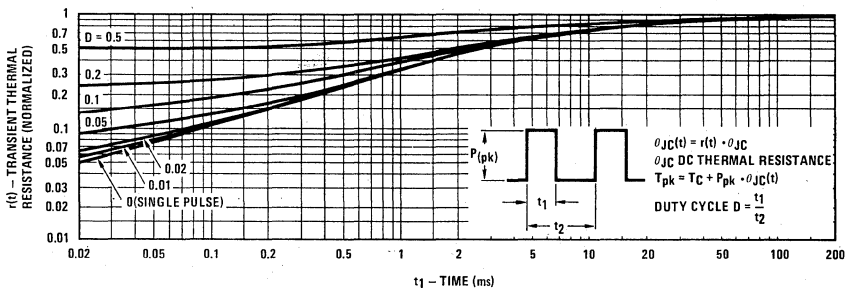
Maximum Power Dissipation vs Case Temperature



Maximum Power Dissipation vs Ambient Temperature



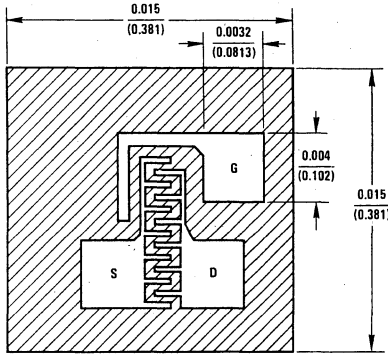
Thermal Response in TO-126 Package





Section 10  
**Process**  
**Characteristics JFETs**





GATE IS ALSO BACKSIDE CONTACT

## DESCRIPTION

Process 50 is designed primarily for RF amplifier and mixer applications. It will operate up to 450 MHz with low noise figure and good power gain. These devices offer outstanding performance at VHF aircraft and communications frequencies. Their major advantage is low crossmodulation and intermodulation, low noise figure and good power gain. The device is also a good choice for analog switching where low capacitance is very important.

CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	-25	-40		V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 15V, V_{GS} = 0V$	1.0	10	20	mA
Forward Transconductance	$g_{fs}$	$V_{DS} = 15V, V_{GS} = 0$	3.0	5.5	7.0	mmhos
Forward Transconductance	$g_{fs}$	$V_{DG} = 15V, I_D = 200 \mu A$		1.1		mmhos
Reverse Gate Leakage	$I_{GSS}$	$V_{GS} = -20V, V_{DS} = 0$		-5.0	-100	pA
"ON" Resistance	$r_{DS}$	$V_{DS} = 100 mV, V_{GS} = 0$	100	175	500	$\Omega$
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 15V, I_D = 1 nA$	-0.7	-3.5	-6.0	V
Output Conductance	$g_{os}$	$V_{DG} = 15V, I_D = 1 mA, f = 1 kHz$		10		$\mu mhos$
Feedback Capacitance	$C_{rss}$	$V_{DG} = 15V, V_{GS} = 0$		0.7	0.9	pF
Input Capacitance	$C_{iss}$	$V_{DS} = 15V, V_{GS} = 0$		3.5	4.0	pF
Noise Voltage	$e_n$	$V_{DG} = 15V, I_D = 1 mA, f = 100 Hz$		8.0		$nV/\sqrt{Hz}$
Noise Figure	NF	$V_{DG} = 15V, I_D = 5 mA, R_G = 1 k\Omega, f = 400 MHz$		2.2	4.0	dB
Power Gain	$G_{PS}$	$V_{DG} = 15V, I_D = 5 mA, f = 400 MHz$		12		dB

This process is available in the following device types. \*Denotes preferred parts.

### TO-72 (CASE 25)

*2N5486
2N3823
2N3966
2N4223
2N4224
2N4416
*2N4416A
2N5078
2N5103
2N5104
2N5105
2N5556
2N5557
2N5558

### TO-92 (CASE 92)

\*2N5484  
\*2N5485

*2N5486
2N5555
2N5668
2N5669
2N5670
*J304
*J305
PN4223
PN4224
*PN4416
PN5163
MPF102
MPF106
MPF107
MPF110
MPF111

### TO-92 (CASE 94)

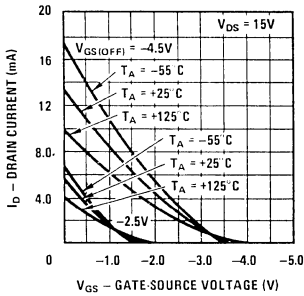
2N3819
2N5248
BF244A
BF244B
BF244C
TIS58
TIS59

### TO-92 (CASE 97)

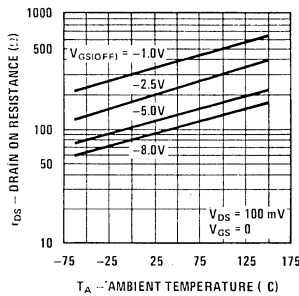
2N5949
2N5950
2N5951
2N5952
2N5953
BC264A
BC264B

BC264C
BC264D
BF245A
BF245B
BF245C
BF256A
BF256B
BF256C

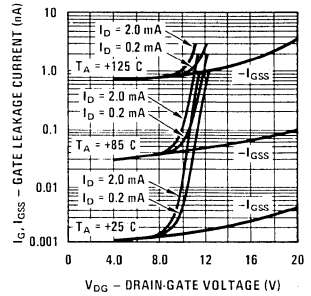
Transfer Characteristics



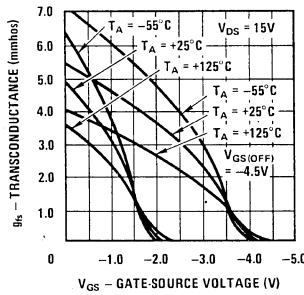
Channel Resistance vs Temperature



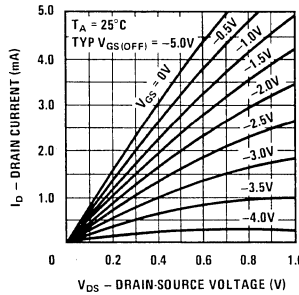
Leakage Current vs Voltage



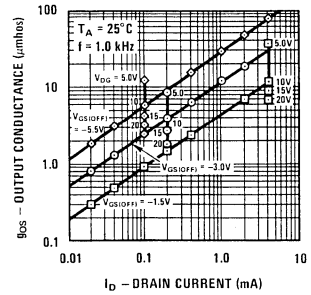
Transconductance Characteristics



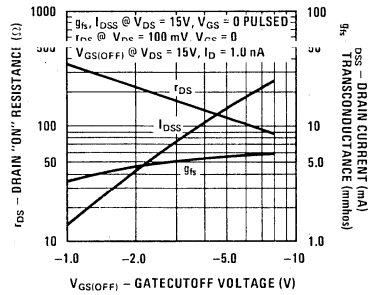
Common Drain-Source Characteristics



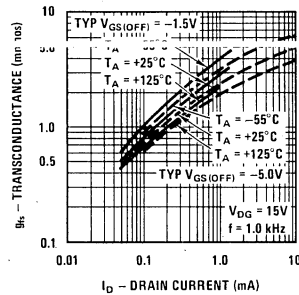
Output Conductance vs Drain Current



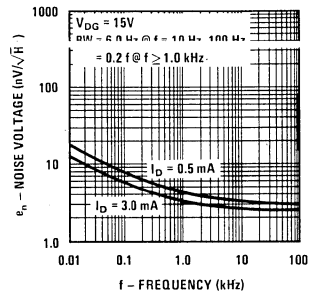
Parameter Interactions



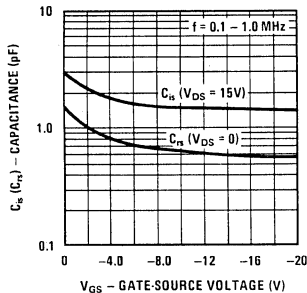
Transconductance vs Drain Current



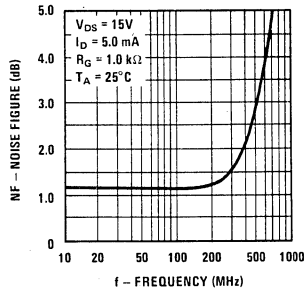
Noise Voltage vs Frequency



Capacitance vs Voltage

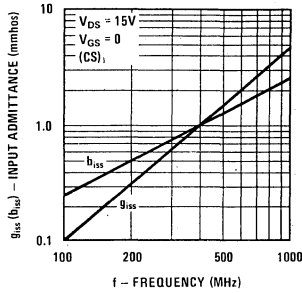


Noise Figure Frequency



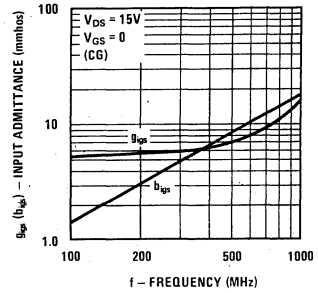
COMMON SOURCE

Input Admittance

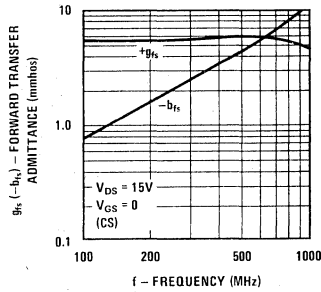


COMMON GATE

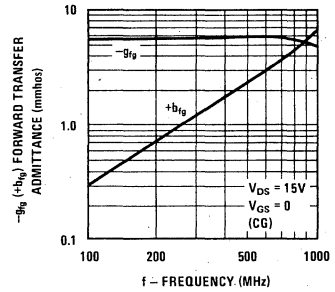
Input Admittance



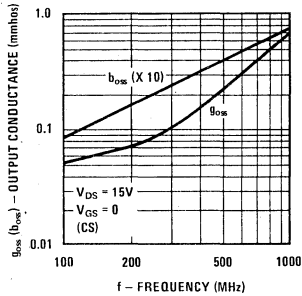
Forward Transadmittance



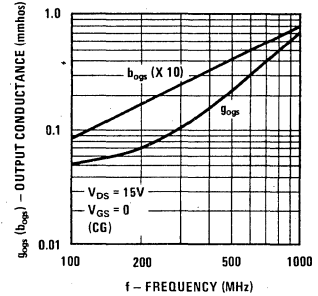
Forward Transadmittance



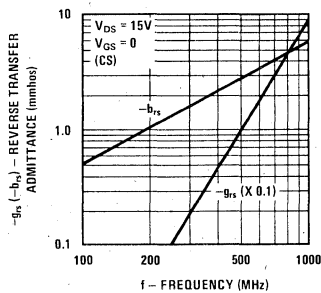
Output Admittance



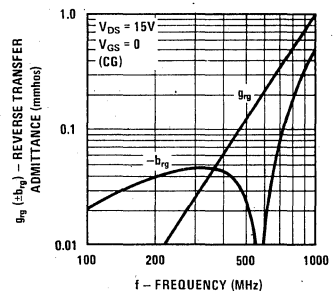
Output Admittance

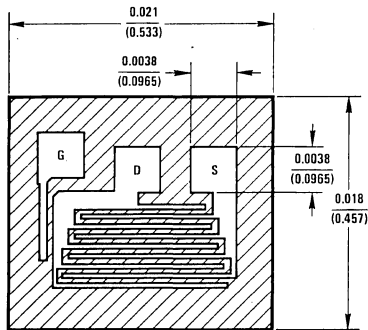


Reverse Transadmittance



Reverse Transadmittance




**GATE IS ALSO BACKSIDE CONTACT**
**DESCRIPTION**

Process 51 is designed primarily for electronic switching applications such as low ON resistance analog switching. It features excellent  $C_{iss}$   $R_{DS(ON)}$  time constant. The inherent zero offset voltage and low leakage current make these devices excellent for chopper stabilized amplifiers, sample and hold circuits, and reset switches. Low feed-through capacitance also allows them to handle video signals to 100 MHz.

Characteristic	Parameter	Test Conditions	Min	Typ	Max	Units
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	-30	-45		V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 20V, V_{GS} = 0$ Pulse Test	5.0	65	170	mA
Reverse Gate Leakage	$I_{GSS}$	$V_{GS} = -20V, V_{DS} = 0$		-15	-200	pA
ON Resistance	$r_{DS}$	$V_{DS} = 100 mV, V_{GS} = 0$	20	35	100	$\Omega$
Forward Transconductance	$g_{fs}$	$V_{DG} = 15V, I_D = 2 mA$			8.5	mmhos
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 20V, I_D = 1 nA$	-0.5	-4.5	-9.0	V
Drain OFF Current	$I_{D(OFF)}$	$V_{DS} = 20V, V_{GS} = -10V$		15	200	pA
Feedback Capacitance	$C_{rss}$	$V_{DG} = 15V, I_D = 5 mA, f = 1 MHz$		3.5	4.0	pF
Input Capacitance	$C_{iss}$	$V_{DG} = 15V, I_D = 5 mA, f = 1 MHz$		10	16	pF
Noise Voltage	$e_n$	$V_{DG} = 15V, I_D = 1 mA, f = 100 Hz$		6.0		$nV/\sqrt{Hz}$
Turn-On Time	$t_{on}$	$V_{DD} = 10V, I_D = 6.6 mA$		12	20	ns
Turn-Off Time	$t_{off}$	$V_{DD} = 10V, I_D = 6.6 mA$		40	80	ns

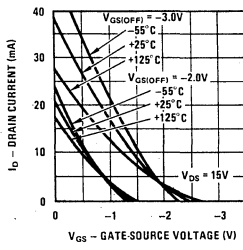
This process is available in the following device types. \*Denotes preferred parts.

TO-18 (CASE 02)	TO-72 (CASE 25)	TO-92 (CASE 92)	TO-92 (CASE 94)
2N3970	2N4860	*NF5101	*2N5638 *PN4856 BF246A
2N3971	2N4860A	*NF5102	*2N5639 *PN4857 BF246B
2N3972	2N4861	*NF5103	*2N5640 *PN4858 BF246C
*2N4091	2N4861A		2N5653 *PN4859
*2N4092			2N5654 *PN4860
*2N4093		*J111	*PN4861 BF247A
*2N4391		*J112	U1897 BF247B
*2N4392		*J113	U1898 BF247C
*2N4393		*PF5101	U1899 *TIS73
*2N4856		*PF5102	MPF820 *TIS74
2N4856A		*PF5103	*TIS75
*2N4857		*PN4091	
2N4857A		*PN4092	
*2N4858		*PN4093	
2N4858A		*PN4391	
2N4859		*PN4392	
2N4859A		*PN4393	

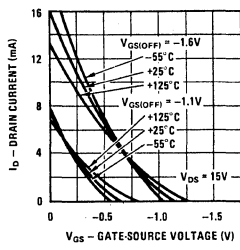


Common Drain-Source Characteristics

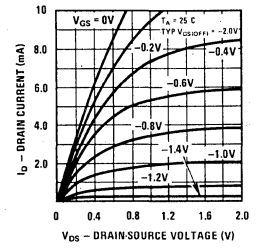
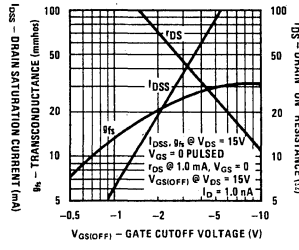
Transfer Characteristics



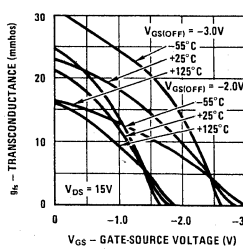
Transfer Characteristics



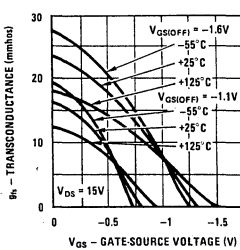
Parameter Interactions



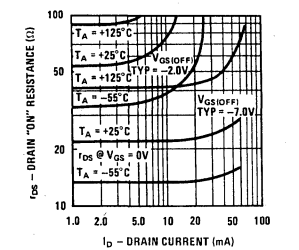
Transfer Characteristics



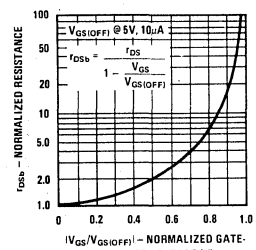
Transfer Characteristics



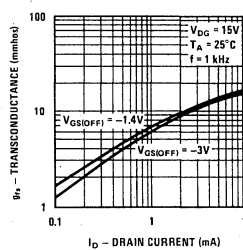
Resistance vs Drain Current



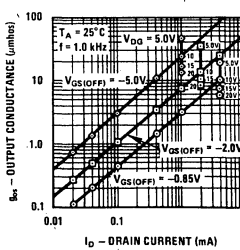
Normalized Drain Resistance vs Bias Voltage



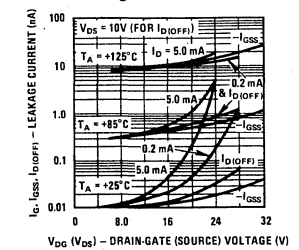
Transconductance vs Drain Current



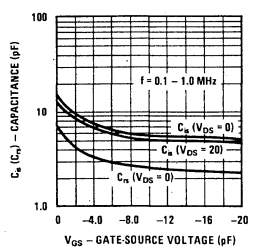
Output Conductance vs Drain Current



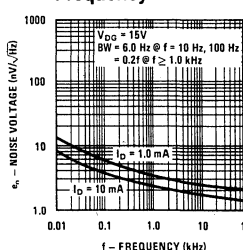
Leakage Current vs Voltage



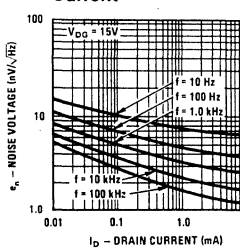
Capacitance vs Voltage



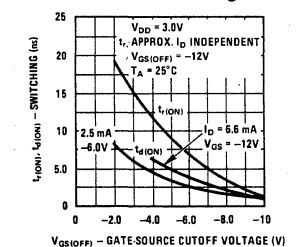
Noise Voltage vs Frequency



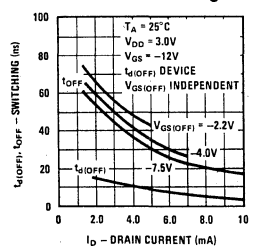
Noise Voltage vs Current

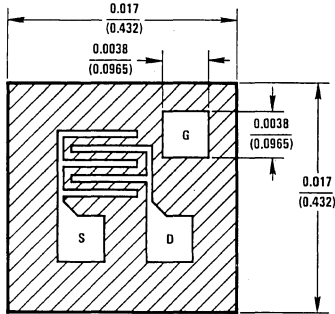


Turn-On Switching



Turn-Off Switching



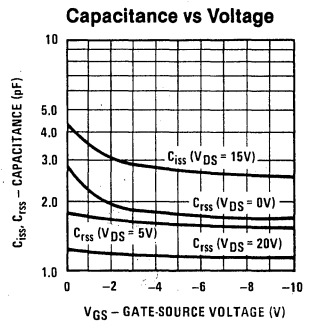
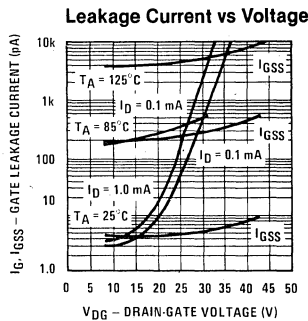
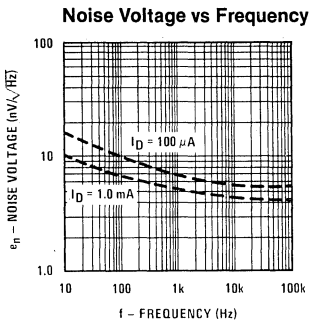
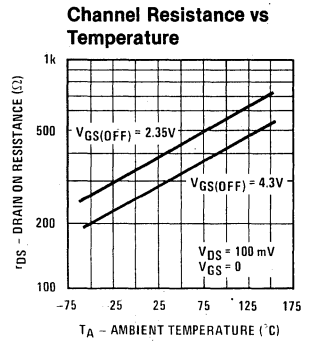
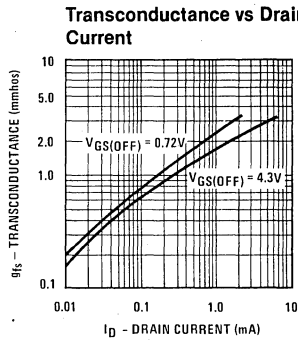
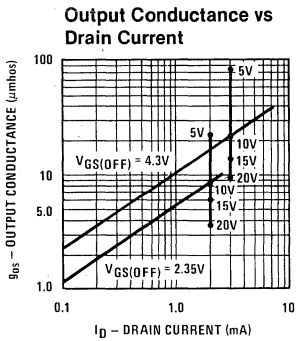
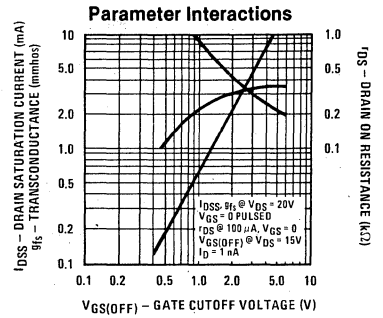
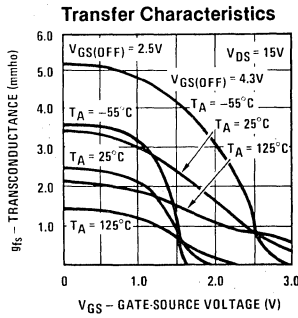
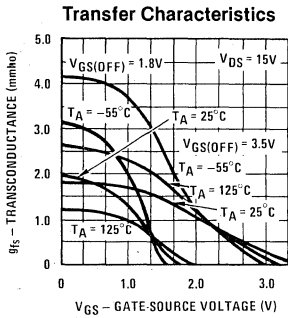
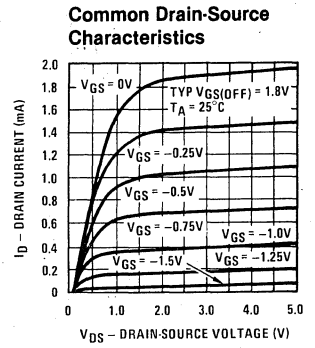
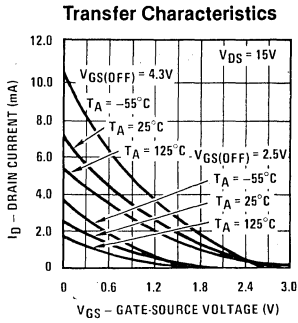
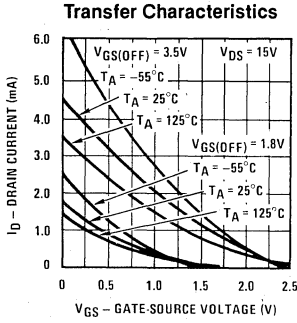

**GATE IS ALSO BACKSIDE CONTACT**
**DESCRIPTION**

Process 52 is designed primarily for low level audio and general purpose applications. These devices provide excellent performance as input stages for piezoelectric transducers or other high impedance signal sources. Their high output impedance and high voltage breakdown lend them to high gain audio and video amplifier applications. Source and drain are interchangeable.

Characteristic	Parameter	Test Conditions	Min	Typ	Max	Units
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	-40	-70		V
Drain Saturation Current	$I_{DSS}$	$V_{DS} = 20V, V_{GS} = 0V$	0.2	1.5	12	mA
Forward Transconductance	$g_{fs}$	$V_{DS} = 20V, V_{GS} = 0V$	1.0	2.5	5.0	mmho
Forward Transconductance	$g_{fs}$	$V_{DS} = 20V, I_D = 200 \mu A$		700		$\mu mho$
Reverse Gate Leakage Current	$I_{GSS}$	$V_{GS} = -30V, V_{DS} = 0V$		-10		pA
Drain ON Resistance	$r_{DS}$	$V_{DS} = 100 mV, V_{GS} = 0V$	250	400	2000	$\Omega$
Gate Cutoff Voltage	$V_{GS(OFF)}$	$V_{DS} = 15V, I_D = 1 nA$	-0.3	1.0	-8.0	V
Output Conductance	$g_{OS}$	$V_{DG} = 15V, I_D = 200 \mu A$		2.0		$\mu mho$
Feedback Capacitance	$C_{rss}$	$V_{DG} = 15V, V_{GS} = 0V, f = 1 MHz$		1.3	1.8	pF
Input Capacitance	$C_{iss}$	$V_{DG} = 15V, V_{GS} = 0V, f = 1 MHz$		5	6	pF
Noise Voltage	$e_n$	$V_{DG} = 15V, I_D = 200 \mu A, f = 100 Hz$		10		$nV/\sqrt{Hz}$

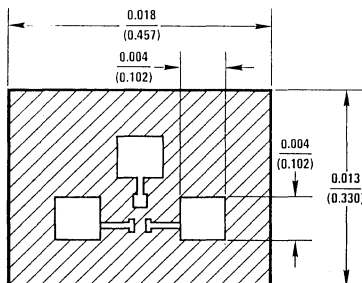
This process is available in the following device types. \*Denotes preferred parts.

TO-18 (CASE 02)	TO-72 (CASE 25)	TO-92 (CASE 92)
2N3069	*2N3684	*J201
2N3070	*2N3685	*J202
2N3071	*2N3686	*J203
2N3368	*2N3687	*PN3684
2N3369		*PN3685
2N3370		*PN3686
2N3458		*PN3687
2N3459		*PN4302
2N3460		*PN4303
*2N4338		*PN4304
*2N4339		
*2N4340		
*2N4341		



**DESCRIPTION**

Process 53 is designed primarily for low current DC and audio applications. These devices provide excellent performance as input stages for sub pico-amp instrumentation or any high impedance signal sources.



GATE IS ALSO BACKSIDE CONTACT

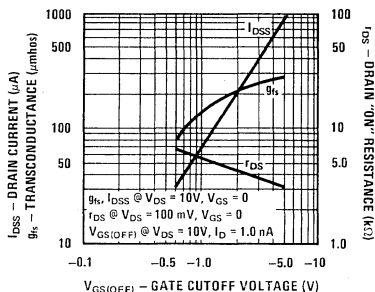
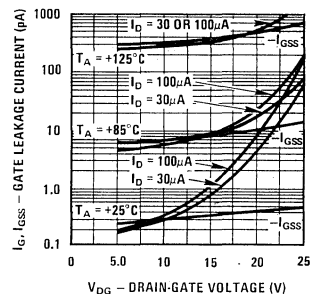
CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	-40	-60		V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 10V, V_{GS} = 0$	0.02	0.25	1.0	mA
Forward Transconductance	$g_{fs}$	$V_{DS} = 10V, V_{GS} = 0$	80	250	350	$\mu mho$
Forward Transconductance	$g_{fs}$	$V_{DG} = 15V, I_D = 50 \mu A$		120		$\mu mho$
Reverse Gate Leakage	$I_{GSS}$	$V_{GS} = 20V, V_{DS} = 0$		0.5	10	$\mu A$
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 10V, I_D = 1 nA$	-0.5	-2.2	-6.0	V
Feedback Capacitance	$C_{rss}$	$V_{DG} = 15V, V_{GS} = 0, f = 1 MHz$		0.85	1.0	pF
Input Capacitance	$C_{iss}$	$V_{DS} = 15V, V_{GS} = 0, f = 1 MHz$		2.0	2.5	pF
Output Conductance	$g_{os}$	$V_{DG} = 10V, I_D = 50 \mu A$		0.9	5.0	$\mu mhos$
Noise Voltage	$e_n$	$V_{DG} = 10V, I_D = 50 \mu A, f = 100 Hz$		45	150	$nV/\sqrt{Hz}$

This process is available in the following device types.

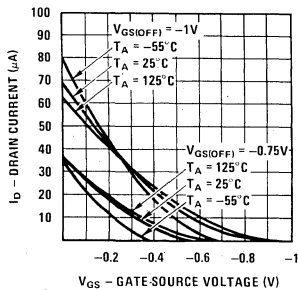
\*Denotes preferred parts.

**TO-72 (CASE 25) TO-92 (CASE 92)**

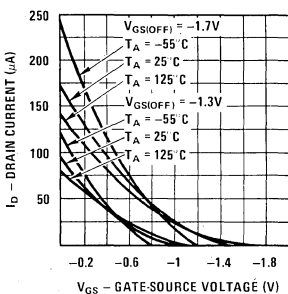
2N4117	PN4117
*2N4117A	PN4117A
2N4118	PN4118
*2N4118A	PN4118A
2N4119	PN4119
*2N4119A	PN4119A
*NF5301	PF5301
NF5301-1	PF5301-1
NF5301-2	PF5301-2
NF5301-3	PF5301-3

**Parameter Interactions**

**Leakage Current vs Voltage**


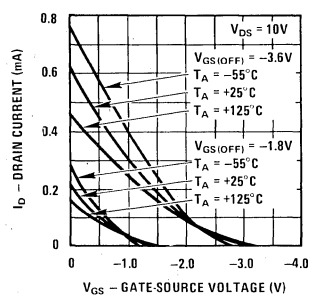
Transfer Characteristics



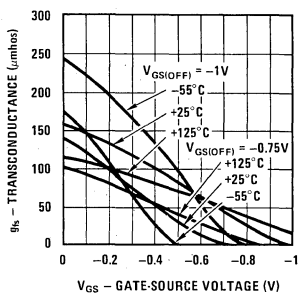
Transfer Characteristics



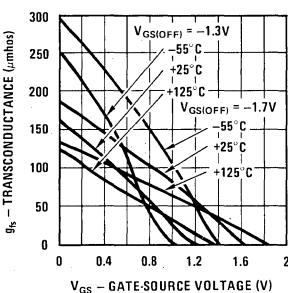
Transfer Characteristics



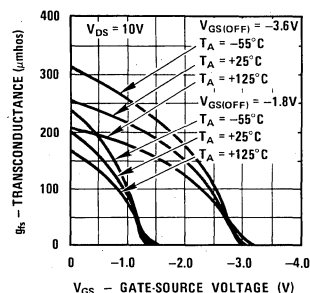
Transfer Characteristics



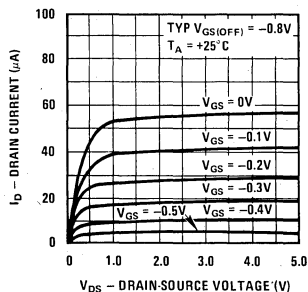
Transfer Characteristics



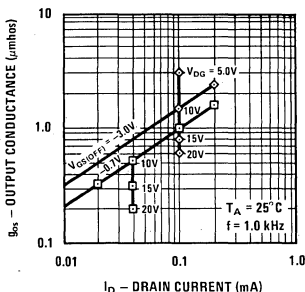
Transfer Characteristics



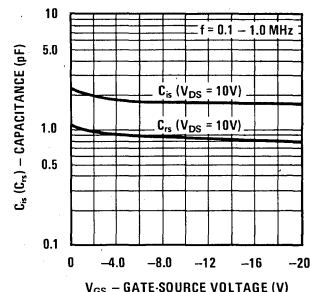
Common Drain-Source Characteristics



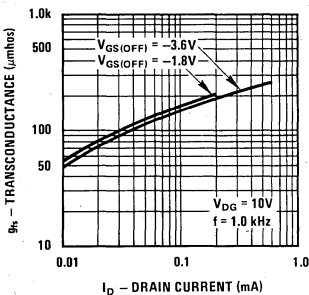
Output Conductance vs Drain Current



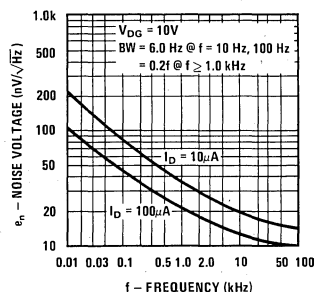
Capacitance vs Voltage

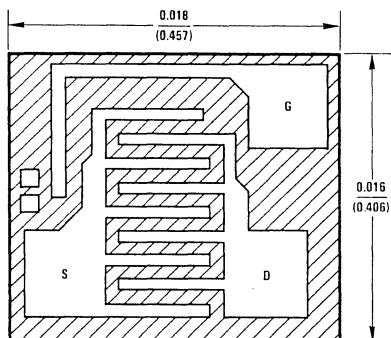


Transconductance vs Drain Current



Noise Voltage vs Frequency





GATE IS ALSO BACKSIDE CONTACT

**DESCRIPTION**

Process 55 is a general purpose low level audio amplifier and switching transistor. Wafer processing is similar to process 52 but process 55 uses a larger geometry. This results in higher  $Y_{fs}$ ,  $I_{DSS}$ , and capacitance and lower  $R_{DS(ON)}$ . It is useful for audio and video frequency amplifiers and RF amplifiers under 50 MHz. It may also be used for analog switching applications.

CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	-40	-70		V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 20V, V_{GS} = 0$	0.5	5.0	20	mA
Forward Transconductance	$g_{fs}$	$V_{DS} = 20V, V_{GS} = 0$	2.0	4.5	7.0	mmho
Forward Transconductance	$g_{fs}$	$V_{DG} = 15V, I_D = 200 \mu A$		1200		$\mu mhos$
Reverse Gate Leakage	$I_{GSS}$	$V_{GS} = -30V, V_{DS} = 0$		-10	-100	$\mu A$
"ON" Resistance	$r_{DS}$	$V_{DS} = 100 mV, V_{GS} = 0$	140	250	600	$\Omega$
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 20V, I_D = 1 nA$	-0.5	-2.0	-8.0	V
Feedback Capacitance	$C_{iss}$	$V_{DG} = 15V, V_{GS} = 0, f = 1 MHz$		1.5	2.0	$\mu F$
Input Capacitance	$C_{iss}$	$V_{DS} = 15V, V_{GS} = 0, f = 1 MHz$		6.0	7.0	pF
Output Conductance	$g_{os}$	$V_{DG} = 15V, I_D = 200 \mu A$		2		$\mu mhos$
Noise Voltage	$e_n$	$V_{DG} = 15V, I_D = 200 \mu A, f = 100 Hz$		10		$nV/\sqrt{Hz}$

This process is available in the following device types. \*Denotes preferred parts.

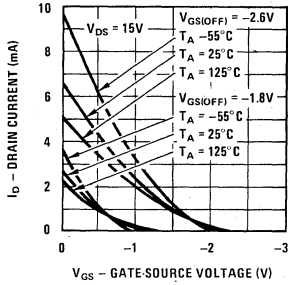
**TO-72 (CASE 25)**

\*2N5360  
2N3821 \*2N5361  
2N3822 \*2N5362  
2N3824 \*2N5363  
2N3967 \*2N5364

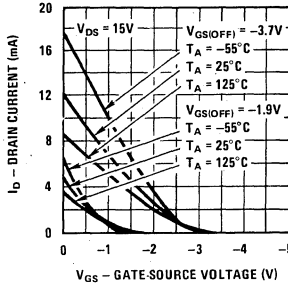
**TO-92 (CASE 92)**

2N3967A  
2N3968 \*2N5457  
2N3968A \*2N5458  
2N3969 \*2N5459  
2N3969A  
2N4220 MPF 103  
2N4220A MPF 104  
2N4221 MPF 105  
2N4221A MPF 108  
2N4222 MPF 109  
2N4222A MPF 112  
\*2N5358 PN4220  
\*2N5359 PN4221  
PN4222

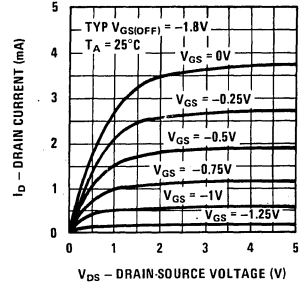
Transfer Characteristics



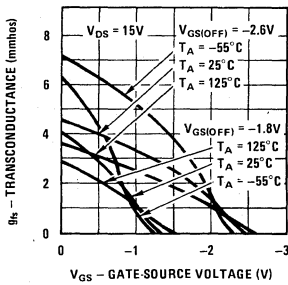
Transfer Characteristics



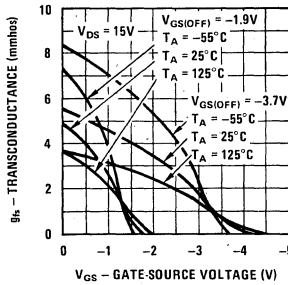
Common Drain-Source Characteristics



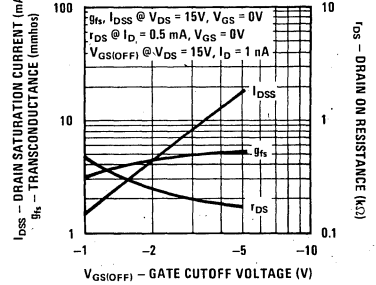
Transfer Characteristics



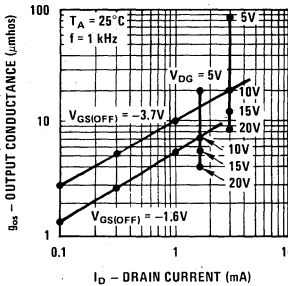
Transfer Characteristics



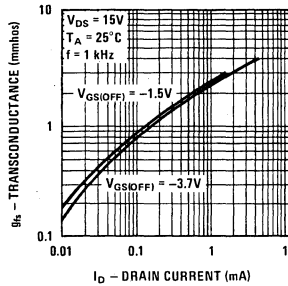
Parameter Interaction



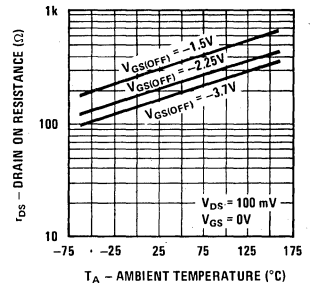
Output Conductance vs Drain Current



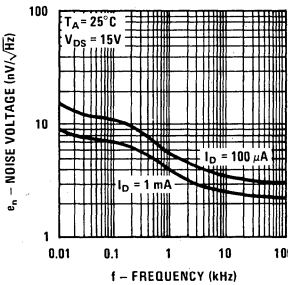
Transconductance vs Drain Current



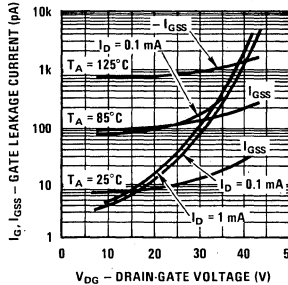
Channel Resistance vs Temperature



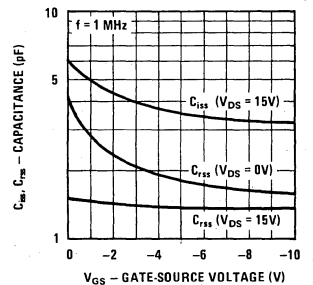
Noise Voltage vs Frequency



Leakage Current vs Voltage

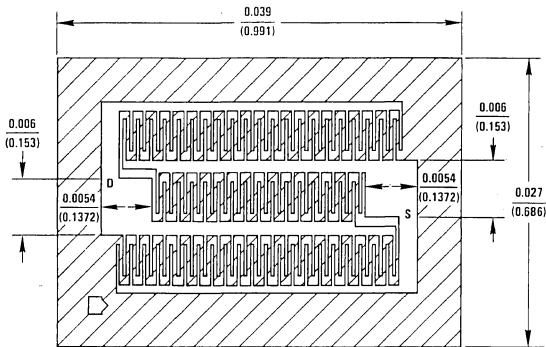


Capacitance vs Voltage



**DESCRIPTION**

Process 58 was developed for analog or digital switching applications where very low  $r_{DS(ON)}$  is mandatory. Switching times are very fast and  $R_{DS(ON)} C_{iss}$  time constant is low. The  $6\Omega$  typical on resistance is very useful in precision multiplex systems where switch resistance must be held to an absolute minimum. With  $r_{DS}$  increasing only  $0.7\%/^{\circ}\text{C}$ , accuracy is retained over a wide temperature excursion.



GATE IS ALSO BACKSIDE CONTACT

CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	-25	-30		V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 5V, V_{GS} = 0$ Pulse Test	100	400	1000	mA
Reverse Gate Leakage	$I_{GSS}$	$V_{GS} = -15V, V_{DS} = 0$		-50	-500	pA
"ON" Resistance	$r_{DS}$	$V_{DS} = 100 \text{ mV}, V_{GS} = 0$	3.0	6.0	20	$\Omega$
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 5V, I_D = 3 \text{ nA}$	-0.5	-5.0	-12	V
Drain "OFF" Current	$I_{D(OFF)}$	$V_{DS} = 5V, V_{GS} = -10V$		0.05	20	nA
Feedback Capacitance	$C_{rss}$	$V_{DS} = 15V, I_D = 2 \text{ mA}, f = 1 \text{ MHz}$		12	25	pF
Input Capacitance	$C_{iss}$	$V_{DG} = 15V, I_D = 2 \text{ mA}, f = 1 \text{ MHz}$		25	50	pF
Forward Transconductance	$g_{fs}$	$V_{DG} = 10V, I_D = 2 \text{ mA}$		10		mmhos
Output Conductance	$g_{os}$	$V_{DG} = 10V, I_D = 2 \text{ mA}$		100		$\mu\text{mhos}$
Noise Voltage	$e_n$	$V_{DG} = 15V, I_D = 2 \text{ mA}, f = 100 \text{ Hz}$		6.0		$\text{nV}/\sqrt{\text{Hz}}$

This process is available in the following device types. \* Denotes preferred parts.

**TO-52 (CASE 07)**

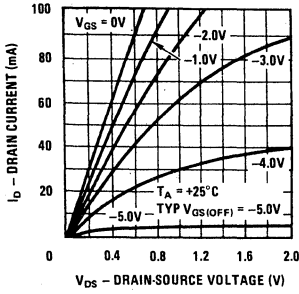
\*2N5432  
\*2N5433  
\*2N5434

**TO-92 (CASE 92)**

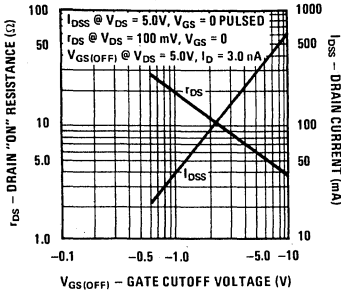
\*J108  
\*J109  
\*J110  
PN5432  
PN5433  
PN5434



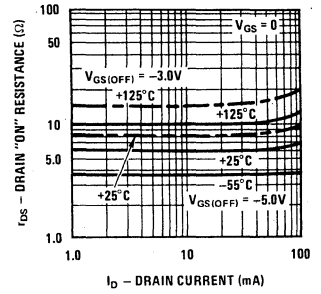
Common Drain-Source Characteristics



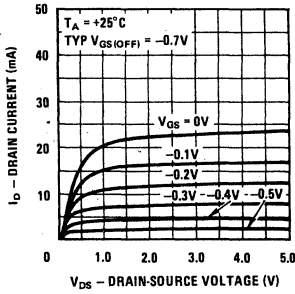
Parameter Interactions



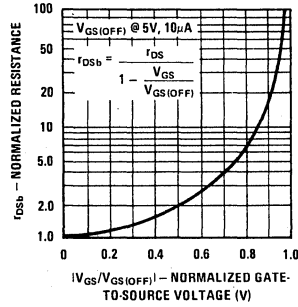
"ON" Resistance vs Drain Current



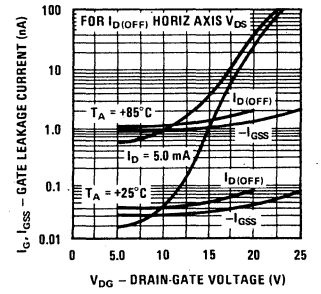
Common Drain-Source Characteristics



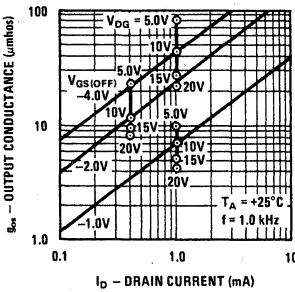
Normalized Drain Resistance vs Bias Voltage



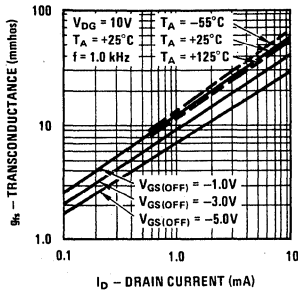
Leakage Current vs Voltage



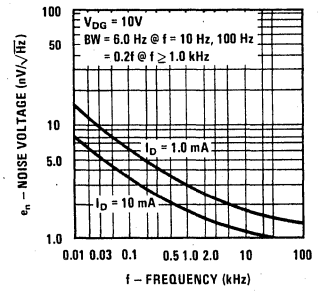
Output Conductance vs Drain Current



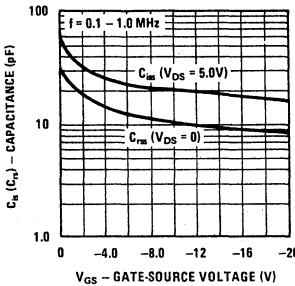
Transconductance vs Drain Current



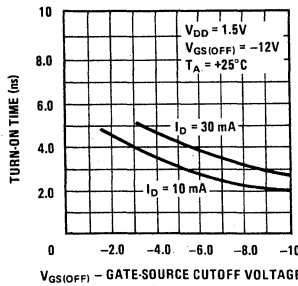
Noise Voltage vs Frequency



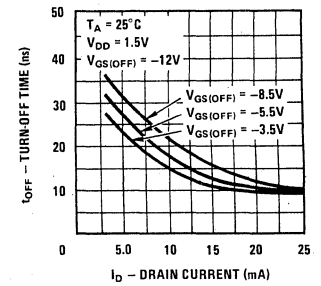
Capacitance vs Voltage

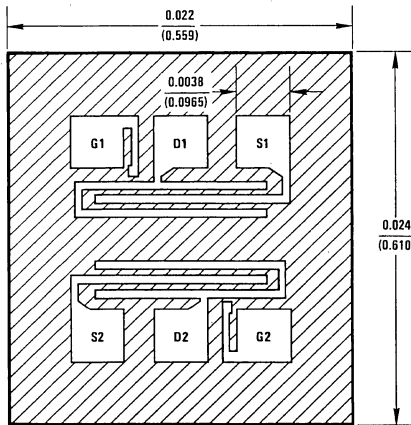


Switching Turn-On vs Gate-Source Voltage



Switching Turn-On Time vs Drain Current




**DESCRIPTION**

Process 83 is a monolithic dual JFET with a diode isolated substrate. It is intended for operational amplifier input buffer applications. Processing results in low input bias current and virtually unmeasurable offset current. Likewise matching characteristics are virtually independent of operating current and voltage, providing design flexibility. Most GP 2N types are sorted from this family.

Characteristic	Parameter	Test Conditions	Min	Typ	Max	Units
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	-50	-70		V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 15V, V_{GS} = 0$	0.5	2.5	8.0	mA
Forward Transconductance	$g_{fs}$	$V_{DS} = 15V, V_{GS} = 0$	1.0	2.5	5.0	mmho
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 15V, I_D = 1 nA$	-0.5	-2.0	-4.5	V
Gate Current	$I_G$	$V_{DG} = 20V, I_D = 0.2 mA$		3.0	50	pA
Forward Transconductance	$g_{fs}$	$V_{DG} = 15V, I_D = 0.2 mA$	600	950		mmhos
Output Conductance	$g_{os}$	$V_{DG} = 15V, I_D = 0.2 mA$		1.0	5.0	$\mu mhos$
ON Resistance	$r_{DS}$	$V_{DS} = 100 mV, V_{GS} = 0$		450		$\Omega$
Noise Voltage	$e_n$	$V_{DG} = 15V, I_D = 0.2 mA, f = 100 Hz$		10	50	$nV/\sqrt{Hz}$
Differential Match	$ V_{GS1} - V_{GS2} $	$V_{DG} = 15V, I_D = 0.2 mA$		7.0	25	mV
Differential Match	$\Delta V_{GS1-2}$	$V_{DG} = 15V, I_D = 0.2 mA$		10	50	$\mu V/^\circ C$
Common-Mode Rejection	CMRR	$V_{DG} = 15V, I_D = 0.2 mA$	80	95		dB
Feedback Capacitance	$C_{rs}$	$V_{DG} = 15V, I_D = 0.2 mA, f = 1 MHz$		1.0	1.2	pF
Input Capacitance	$C_{is}$	$V_{DG} = 15V, I_D = 0.2 mA, f = 1 MHz$		3.4	4.0	pF

This process is available in the following device types. \* Denotes preferred parts.

**TO-71 (CASE 12)**

2N3921	2N4085	2N5454
2N3922	2N5045	*2N5545
*2N3954	2N5046	*2N5546
*2N3954A	2N5047	*2N5547
*2N3955	*2N5196	U231
*2N3955A	*2N5197	U232
*2N3956	*2N5198	U233
*2N3957	*2N5199	U234
*2N3958	2N5452	U235
2N4084	2N5453	

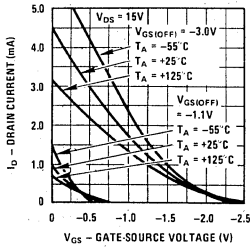
**8-Pin MiniDIP (CASE 60)**

J410
J411
J412

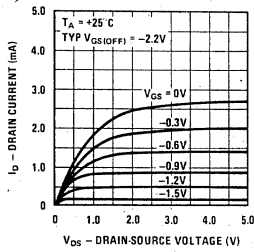
**8-Pin MiniDIP (CASE 67)**

*NPD8301
*NPD8302
*NPD8303

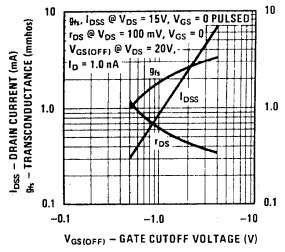
Transfer Characteristics



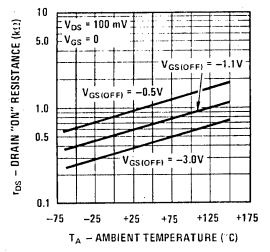
Common Drain-Source Characteristics



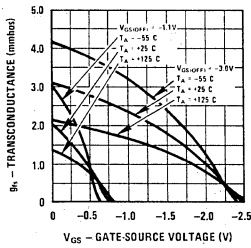
Parameter Interactions



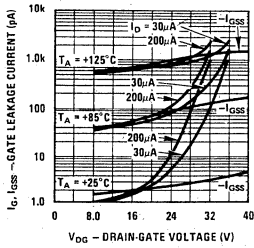
Channel Resistance vs Temperature



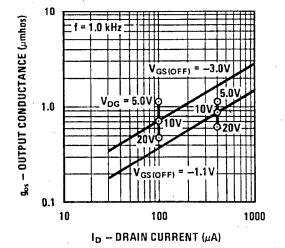
Transfer Characteristics



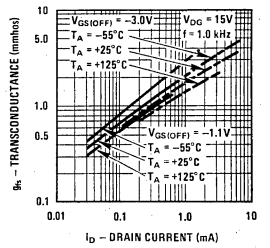
Leakage Current vs Voltage



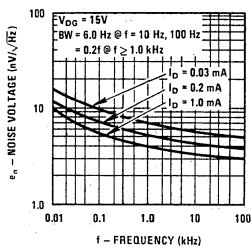
Output Conductance vs Drain Current



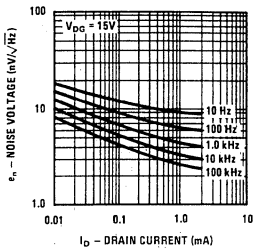
Transconductance vs Drain Current



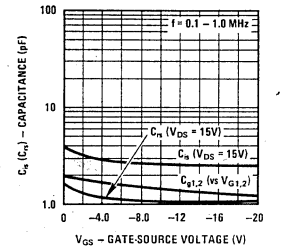
Noise Voltage vs Frequency



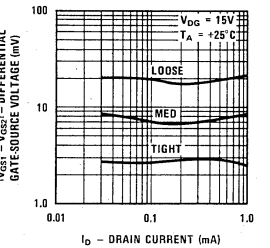
Noise Voltage vs Current



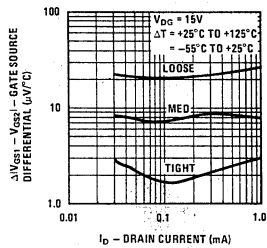
Capacitance vs Voltage



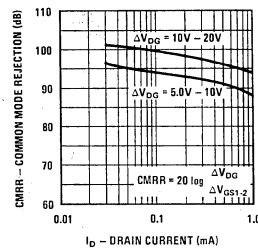
Differential Offset

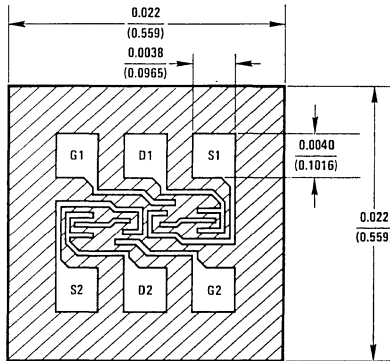


Differential Drift



CMRR vs Drain Current




**DESCRIPTION**

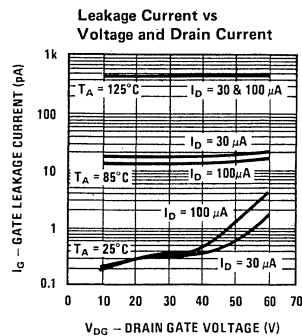
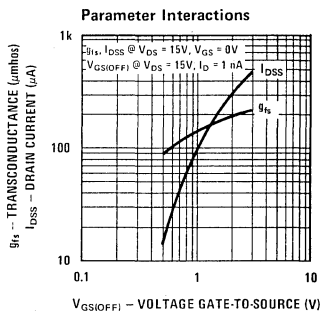
Process 84 is a monolithic dual JFET with a diode isolated substrate. It is designed for the most critical operational amplifier input stages or electrometer single ended preamp. Ideal for medical applications and instrumentation inputs where subpicoamp inputs are important. Device design considered high CMRR, subpicoamp leakage over wide input swings, low capacitance, and tight match over wide current range.

CHARACTERISTIC	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	-40	-60		V
Drain Saturation Current	$I_{DSS}$	$V_{DS} = 15V, V_{GS} = 0V$	20	300	1000	$\mu A$
Forward Transconductance	$g_{fs}$	$V_{DS} = 15V, V_{GS} = 0V$	90	180	300	$\mu mhos$
Forward Transconductance	$g_{fs}$	$V_{DS} = 15V, I_D = 30 \mu A$	50	120	150	$\mu mhos$
Gate Cutoff Voltage	$V_{GS(OFF)}$	$V_{DS} = 15V, I_D = 1 nA$	0.5	2	4.5	V
Reverse Gate Leakage Current	$I_{GSS}$	$V_{DS} = 0V, V_{GS} = -20V$		1	5	$\mu A$
Gate Leakage Current	$I_G$	$V_{DG} = 10V, I_D = 30 \mu A$		0.5	3	$\mu A$
Feedback Capacitance	$C_{rss}$	$V_{DS} = 15V, V_{GS} = 0, f = 1 MHz$		0.3	0.4	pF
Input Capacitance	$C_{iss}$	$V_{DS} = 15V, V_{GS} = 0, f = 1 MHz$		2	3	pF
Noise Voltage	$e_n$	$V_{DS} = 15V, I_D = 30 \mu A, f = 1 kHz$		30	50	$nV/\sqrt{Hz}$
Noise Voltage	$e_n$	$V_{DS} = 15V, I_D = 30 \mu A, f = 10 Hz$		180		$nV/\sqrt{Hz}$
Output Conductance	$g_{os}$	$V_{DS} = 10V, I_D = 30 \mu A$		0.01	0.1	$\mu mhos$
Differential Gate-Source Voltage	$ V_{GS1} - V_{GS2} $	$V_{DS} = 10V, I_D = 30 \mu A$		10	50	mV
Differential Gate-Source Voltage Drift	$\Delta V_{GS1-2}$	$V_{DS} = 10V, I_D = 30 \mu A$		10	50	$\mu V/^\circ C$
Common-Mode Rejection Ratio	CMRR	$V_{DS} = 10V, I_D = 30 \mu A$		112		dB

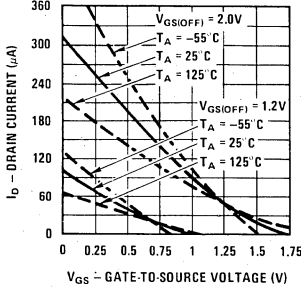
This process is available in the following device types. \*Denotes preferred parts.

**TO-78 (CASE 24)**

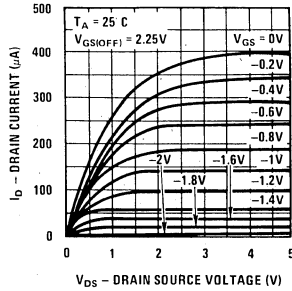
2N5902	*2N5906
2N5903	*2N5907
2N5904	*2N5908
2N5905	*2N5909



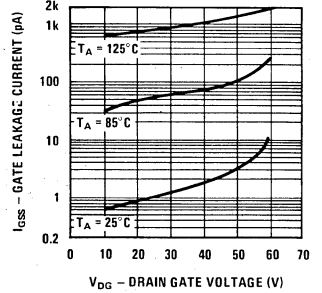
Transfer Characteristics



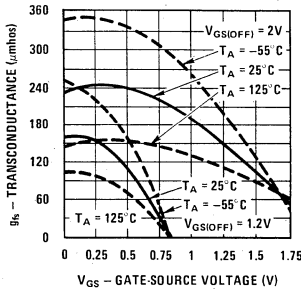
Common Drain-Source Characteristics



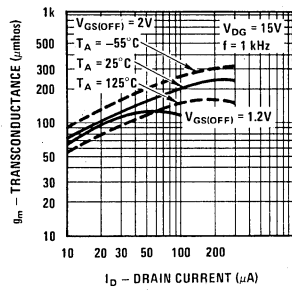
Leakage Current vs Voltage



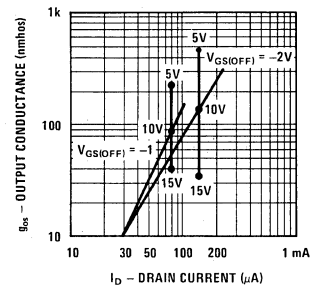
Transfer Characteristics



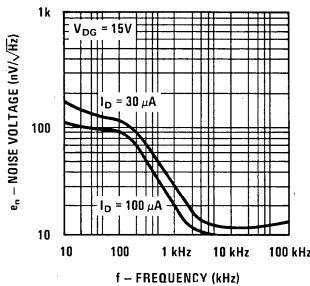
Transconductance vs Drain Current



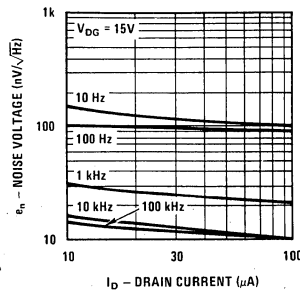
Output Conductance vs Drain Current



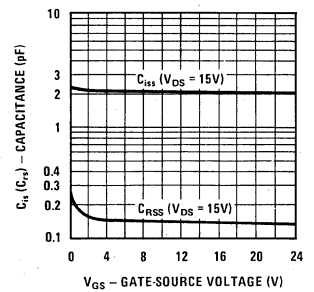
Noise Voltage vs Frequency



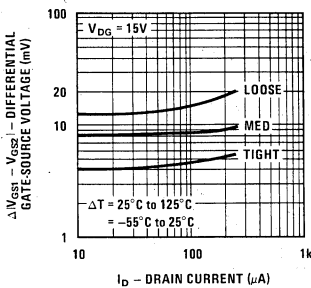
Noise Voltage vs Current



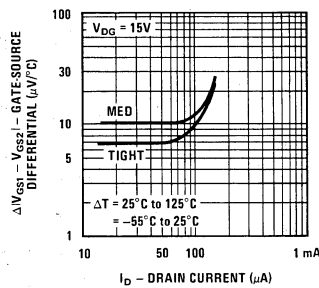
Capacitance vs Voltage



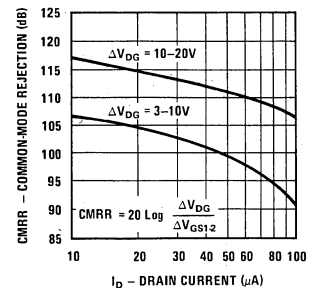
Differential Offset

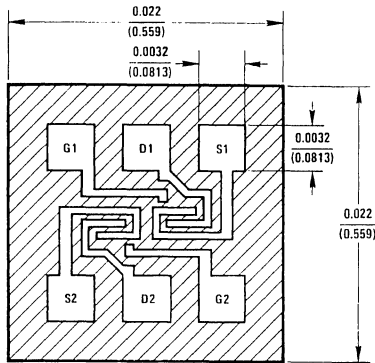


Differential Drift



CMRR vs Drain Current





**DESCRIPTION**

Process 86 is a monolithic dual JFET with a diode isolated substrate. It is intended for critical amplifier input stages requiring low noise, sub picoamp bias currents and high gain. Exacting process control results in consistent parameter distribution with tight match and low drift.

This process is available in the following device types.  
\* Denotes preferred parts.

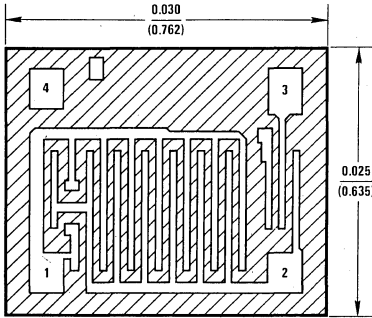
**TO-78 (CASE 24)**

- U421
- U422
- U423
- U424
- U425
- U426

**PROCESS IN DEVELOPMENT**



# Process 87 Analog Switches



Note: Pin 4 is also backside gate

## DESCRIPTION

The AM1000 series are junction FET integrated circuit analog switches. These devices commute faster and with less voltage spiking than any other analog switch presently available. By comparison, discrete JFET switches require elaborate drive circuits to obtain reasonable performance for high toggle rates. Encapsulated in a four pin TO-72 package, these units require a

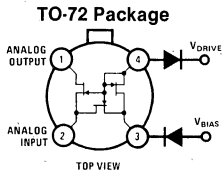
minimum of circuit board area. Switching transients are greatly reduced by a monolithic integrated circuit process. The resulting analog switch device provides the following features:

- Low ON Resistance 30Ω
- High Analog Signal Frequency 100 MHz
- High Toggle Rate 4 MHz
- Low Leakage Current 250 pA
- Large Analog Signal Swing ± 15V
- Break Before Make Action

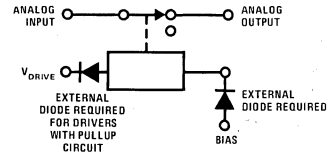
The AM1000 series of analog switches are particularly suitable for the following applications:

- High Speed Commutators
- Multiplexers
- Sample and Hold Circuits
- Reset Switching
- Video Switching

## SCHEMATIC AND CONNECTION DIAGRAM

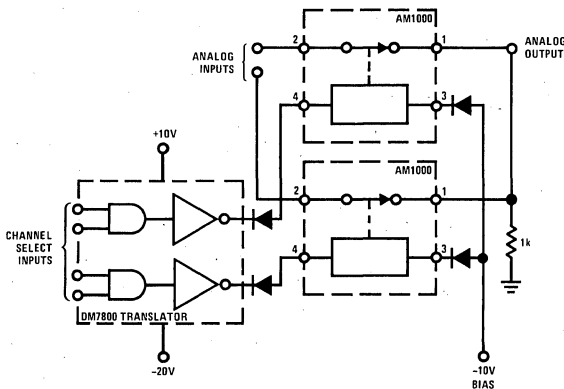


## EQUIVALENT CIRCUIT

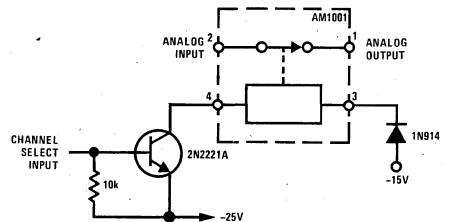


## TYPICAL APPLICATIONS

### ± 10 Volt Swing Analog Switch 0.5% Accuracy



### ± 15 Volt Swing Analog Switch



## TO-18 (CASE 25)

- AM1000
- AM1001
- AM1002

# Process 87

## ABSOLUTE MAXIMUM RATINGS

			Power Dissipation @ $T_A = 25^\circ\text{C}$	300 mW
			Linear Derating Factor	1.7 mW/ $^\circ\text{C}$
			Power Dissipation @ $T_C = 125^\circ\text{C}$	150 mW
			Linear Derating Factor	6 mW/ $^\circ\text{C}$
			Maximum Junction Operating Temperature	$-55^\circ\text{C}$ to $+150^\circ\text{C}$
			Storage Temperature	$200^\circ\text{C}$
			Lead Temperature (Soldering, 10 seconds)	$300^\circ\text{C}$
$V_{IN}$ (Note 1)	AM1001	AM1000 AM1002		
$V_{OUT}$ (Note 1)	50V	40V		
$V_{DRIVE}$ (Note 1)	50V	40V		
$V_{BIAS}$ (Note 1)	-50V	-40V		
	50V	40V		

## ELECTRICAL CHARACTERISTICS

### ON CHARACTERISTICS (Note 2)

Parameter	Conditions		Min	Typ	Max	Units
$R_{ON}$	$V_{DRIVE} = 15\text{V}$ , $V_{BIAS} = -15\text{V}$ $I_{IN} = 1\text{ mA}$ , $V_{OUT} = 0\text{V}$	AM1001	15	40	50	$\Omega$
$R_{ON}$	$V_{DRIVE} = 10\text{V}$ , $V_{BIAS} = -10\text{V}$ $I_{IN} = 1\text{ mA}$ , $V_{OUT} = 0\text{V}$	AM1000	15	25	30	$\Omega$
		AM1002	15	50	100	$\Omega$

### OFF CHARACTERISTICS

Parameter	Conditions	AM1000, AM1001			AM1002			Units
		Min	Typ	Max	Min	Typ	Max	
$I_{OUT(OFF)}$	$V_{DRIVE} = -20\text{V}$ , $V_{BIAS} = -10\text{V}$ $V_{IN} = 10\text{V}$ , $V_{OUT} = 10\text{V}$ $T_A = 25^\circ\text{C}$ $T_A = 125^\circ\text{C}$		0.05	0.25		0.5	1	nA
			0.025	0.25		0.2	1	$\mu\text{A}$
$I_{OUT(OFF)}$	$V_{DRIVE} = -20\text{V}$ , $V_{BIAS} = -10\text{V}$ $V_{IN} = 10\text{V}$ , $V_{OUT} = -10\text{V}$ $T_A = 25^\circ\text{C}$ $T_A = 125^\circ\text{C}$		0.05	0.25		0.5	1	nA
			0.05	0.25		0.2	1	$\mu\text{A}$

### DRIVE CHARACTERISTICS (Note 3)

Parameter	Conditions	Min	Typ	Max	Units
$I_{DRIVE}$ (Switch OFF)	$V_{DRIVE} = -20\text{V}$ , $V_{BIAS} = -10\text{V}$ $V_{IN} = \pm 10\text{V}$ , $V_{OUT} = \pm 10\text{V}$	AM1000, AM1001, AM1002	5	10	mA

### SWITCHING CHARACTERISTICS

Parameter	Conditions	AM1000 Max	AM1001 Max	AM1002 Max	Units
$t_{ON}$	See Switching Time Test Circuit	100	150	200	ns
$t_{OFF}$	See Switching Time Test Circuit	100	100	100	ns

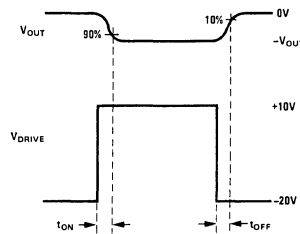
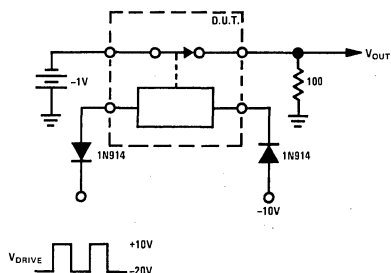
**Note 1:** The maximum voltage ratings may be applied between any pin or pins simultaneously. Power dissipation may be exceeded in some modes if the voltage pulse exceeds 10 ms. Normal operation will not cause excessive power dissipation even in a DC switching application.

**Note 2:** All parameters are measured with external silicon diodes. See electrical connection diagram for proper diode placement.

**Note 3:**  $I_{BIAS}$  (Switch OFF) is equal to  $I_{DRIVE}$  (Switch OFF).  $I_{BIAS}$  (Switch ON), is equal to external diode leakage.

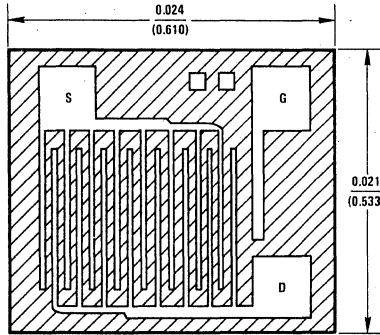
**Note 4:** Rise and fall times of  $V_{DRIVE}$  shall be 15 ns maximum for switching time testing.

### SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



10





GATE IS ALSO BACKSIDE CONTACT

## DESCRIPTION

Process 88 is designed primarily for electronic switching applications where a P channel device is desirable. Inherent zero offset voltage, low leakage and low  $R_{DS(ON)}$   $C_{iss}$  time constant make this device excellent for low level analog switching, sample and hold circuits and chopper stabilized amplifiers. This device is the complement to Process 51.

CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = 1 \mu A$	30	40		V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = -15V, V_{GS} = 0$	-5.0	-30	-90	mA
Forward Transconductance	$g_{fs}$	$V_{DS} = -15V, V_{GS} = 0$	4.0	13	17	mmhos
Forward Transconductance	$g_{fs}$	$V_{DG} = -15V, I_D = -2 mA$		3.5		mmhos
Gate Leakage	$I_{GSS}$	$V_{GS} = 20V, V_{DS} = 0$		0.05	1.0	nA
"ON" Resistance	$r_{DS}$	$V_{DS} = -100 mV, V_{GS} = 0$	50	80	200	$\Omega$
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = -15V, I_D = -1 nA$	0.5	5.0	10	V
Drain "OFF" Current	$I_{D(OFF)}$	$V_{DS} = -15V, V_{GS} = 10V$		-0.05	-10	nA
Feedback Capacitance	$C_{rss}$	$V_{DG} = -15V, I_D = -2 mA, f = 1 MHz$		4.0	5.0	pF
Input Capacitance	$C_{iss}$	$V_{DS} = -15V, I_D = -2 mA, f = 1 MHz$		14	15	pF
Output Conductance	$g_{os}$	$V_{DG} = -15V, I_D = -2 mA$		100	300	$\mu mhos$
Noise Voltage	$e_n$	$V_{DG} = -15V, I_D = -2 mA, f = 100 Hz$		20		$nV/\sqrt{Hz}$

This process is available in the following device types. \*Denotes preferred parts.

### TO-18 (CASE 11)

2N2609  
2N5018  
2N5019  
\*2N5114  
\*2N5115  
\*2N5116

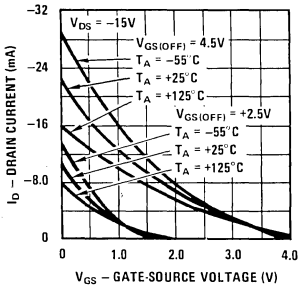
### TO-92 (CASE 94)

\*J174  
\*J175  
\*J176  
\*J177  
\*J270  
\*J271

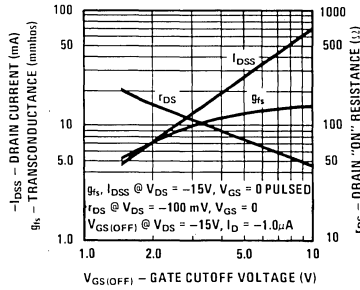
### TO-92 (CASE 92)

\*P1086  
\*P1087

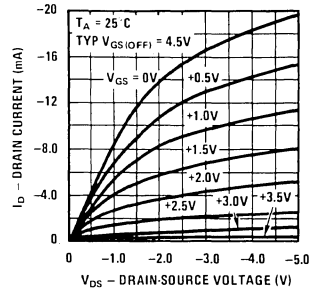
Transfer Characteristics



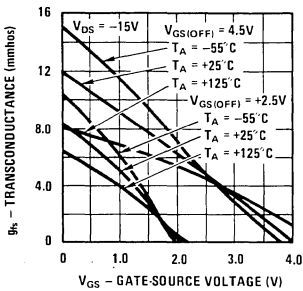
Parameter Interactions



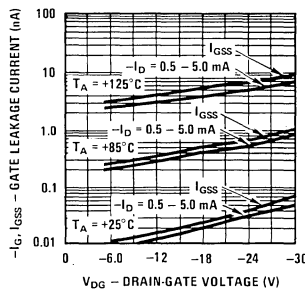
Common Drain-Source Characteristics



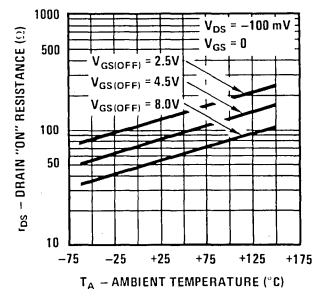
Transfer Characteristics



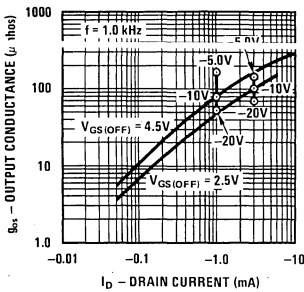
Leakage Current vs Voltage



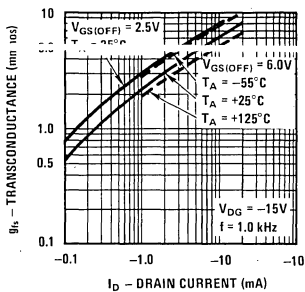
Channel Resistance vs Temperature



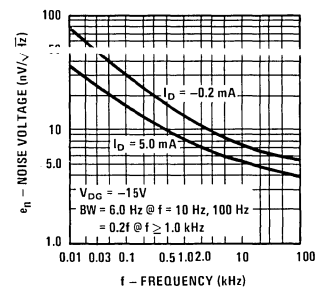
Output Conductance vs Drain Current



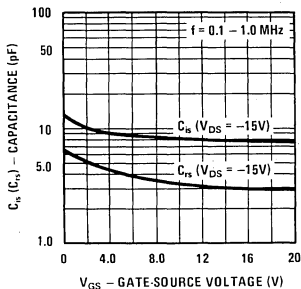
Transconductance vs Drain Current



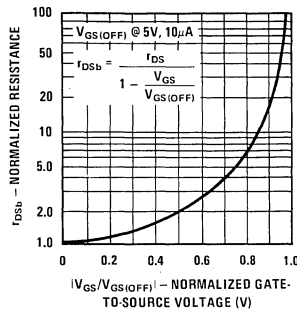
Noise Voltage vs Frequency

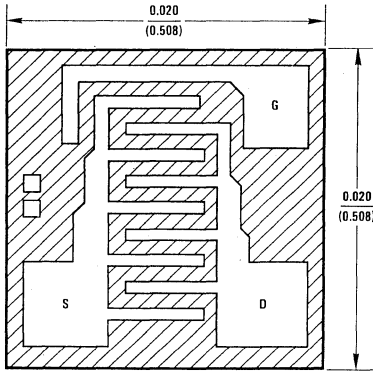


Capacitance vs Voltage



Normalized Drain Resistance vs Bias Voltage





## DESCRIPTION

Process 89 is designed primarily for low level amplifier applications. This device is the complement to Process 52. Commonly used in voltage variable resistor applications.

CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = 1 \mu A$	20	40		V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = -15V, V_{GS} = 0$	-0.3	-4.0	-20	mA
Forward Transconductance	$g_{fs}$	$V_{DS} = -15V, V_{GS} = 0$	1.0	2.5	4.0	mmhos
Forward Transconductance	$g_{fs}$	$V_{DG} = -15V, I_D = -0.2 mA$		700		$\mu mhos$
Gate Leakage	$I_{GSS}$	$V_{GS} = 20V, V_{DS} = 0$		0.02	1.0	nA
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = -15V, I_D = -1 nA$	0.5	3.0	9.0	V
Feedback Capacitance	$C_{rss}$	$V_{DG} = -15V, V_{GS} = 0, f = 1 MHz$		2.0	2.5	pF
Input Capacitance	$C_{is}$	$V_{DS} = -15V, I_D = -2 mA, f = 1 MHz$		7.0	8.5	pF
"ON" Resistance	$r_{DS}$	$V_{DS} = -100 mV, V_{GS} = 0$		450		$\Omega$
Output Conductance	$g_{os}$	$V_{DG} = -15V, I_D = -0.2 mA$		5.0	15	$\mu mhos$
Noise Voltage	$e_n$	$V_{DG} = -15V, I_D = -0.2 mA, f = 100 Hz$		30		$nV/\sqrt{Hz}$

This process is available in the following device types. \* Denotes preferred parts.

### TO-18 (CASE 11)

2N2608  
2N4381  
2N5020  
2N5021

### TO-92 (CASE 92)

\*2N5460  
\*2N5461  
\*2N5462  
PN4342  
PN4360  
PN5033

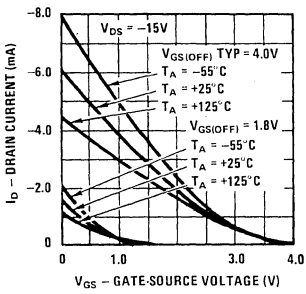
### TO-92 (CASE 94)

2N3820

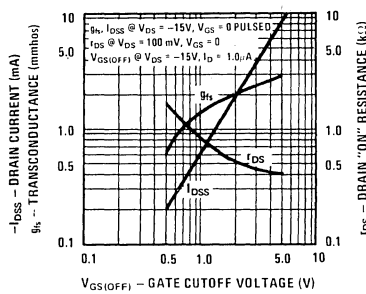
### TO-72 (CASE 23)

2N3329  
2N3330  
2N3331  
2N3332

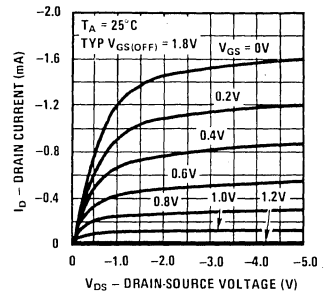
Transfer Characteristics



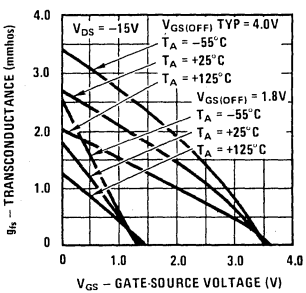
Parameter Interactions



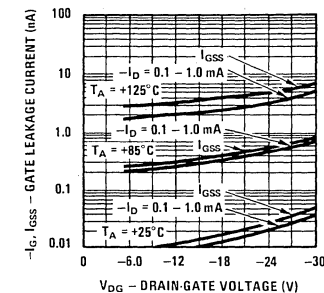
Common Drain-Source Characteristics



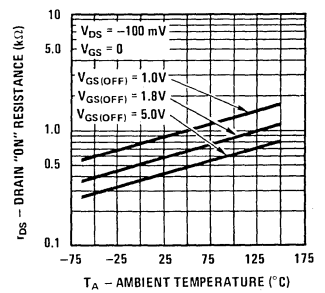
Transfer Characteristics



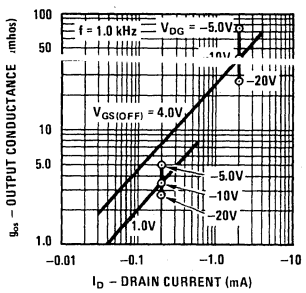
Leakage Current vs Voltage



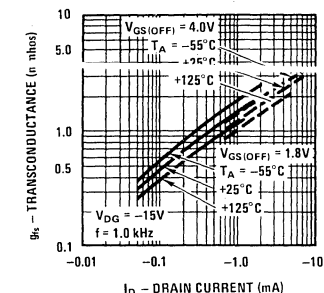
Channel Resistance vs Temperature



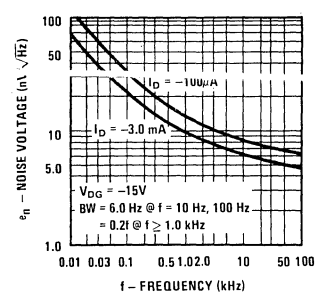
Output Conductance vs Drain Current



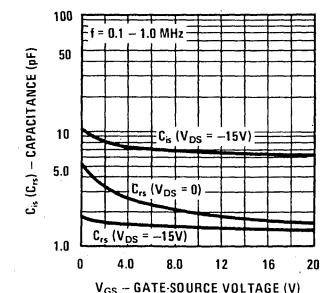
Transconductance vs Drain Current

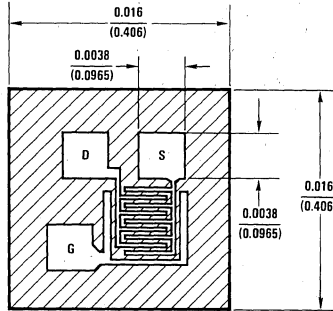


Noise Voltage vs Frequency



Capacitance vs Voltage





GATE IS ALSO BACKSIDE CONTACT

## DESCRIPTION

Process 90 is designed for VHF/UHF mixer/amplifier and applications where Process 50 is not adequate. Has sufficient gain and low noise, common gate configuration at 450 MHz, for sensitive receivers. The high transconductance and square law characteristics insures low crossmodulation and intermodulation distortions. Common-gate operation simplifies circuitry. Consider Process 92 for even higher performance.

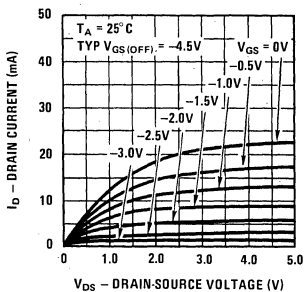
CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	-20	-30		V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 10V, V_{GS} = 0$	3	18	40	mA
Forward Transconductance	$g_{fs}$	$V_{DS} = 10V, V_{GS} = 0$	5.5	8.0	10	mmhos
Forward Transconductance	$g_{fs}$	$V_{DS} = 10V, I_D = 5 mA$	4.5	5.8		mmhos
Reverse Gate Current	$I_{GSS}$	$V_{GS} = -15V, V_{DS} = 0$		-5.0	-100	pA
"ON" Resistance	$r_{DS}$	$V_{DS} = 100 mV, V_{GS} = 0$		90		$\Omega$
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 10V, I_D = 1 nA$	-1.5	-3.5	-6.0	V
Output Conductance	$g_{os}$	$V_{DG} = 10V, I_D = 5 mA$		45	100	$\mu mhos$
Feedback Capacitance	$C_{rs}$	$V_{DG} = 10V, I_D = 5 mA$		1.0	1.2	pF
Input Capacitance	$C_{is}$	$V_{DG} = 10V, I_D = 5 mA$		4.0	5.0	pF
Noise Voltage	$e_n$	$V_{DG} = 10V, I_D = 5 mA, f = 100 Hz$		13		$nV/\sqrt{Hz}$
Noise Figure	NF	$V_{DG} = 10V, I_D = 5 mA, f = 450 MHz$		3.0		dB
Power Gain	$G_{pg} (CG)$	$V_{DG} = 10V, I_D = 5 mA, f = 450 MHz$		11		dB

This process is available in the following device types. \*Denotes preferred parts.

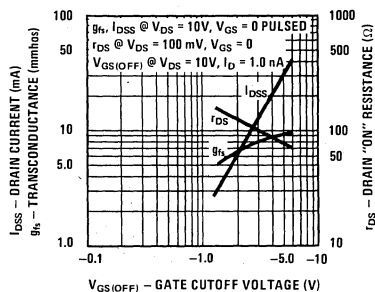
TO-52 (CASE 07)	TO-72 (CASE 29)	TO-92 (CASE 92)	TO-92 (CASE 97)
U312	*2N5397 2N5398	J114 *J210 *J211 *J212 *J300	*2N5245 *2N5246 *2N5247

MPF256

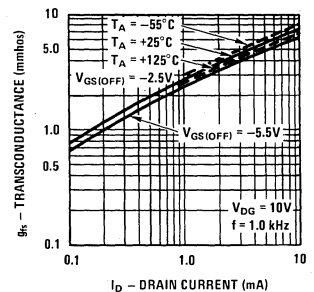
Common Drain-Source Characteristics



Parameter Interactions



Transconductance vs Drain Current

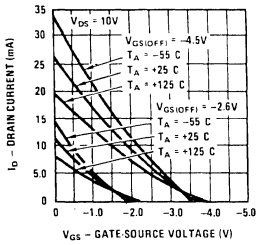


Process 90

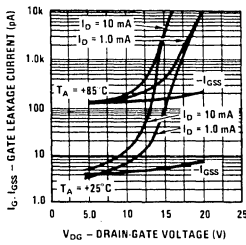
COMMON SOURCE

COMMON GATE

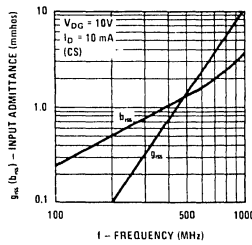
Transfer Characteristics



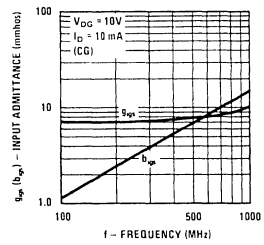
Leakage Current vs Voltage



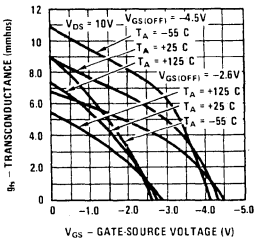
Input Admittance



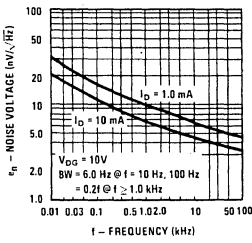
Input Admittance



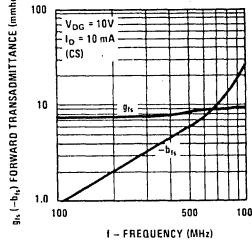
Transfer Characteristics



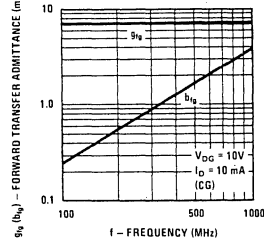
Noise Voltage vs Frequency



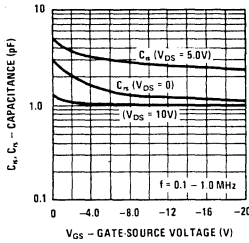
Forward Transadmittance



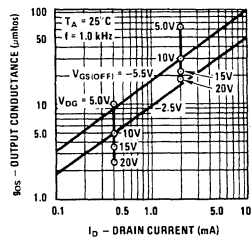
Forward Transadmittance



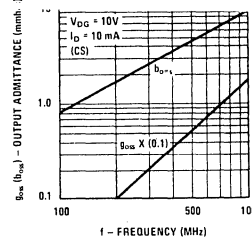
Capacitance vs Voltage



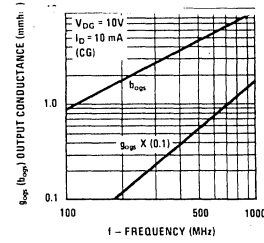
Output Conductance vs Drain Current



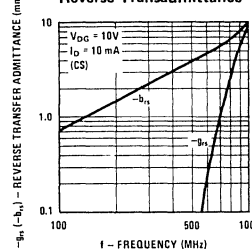
Output Admittance



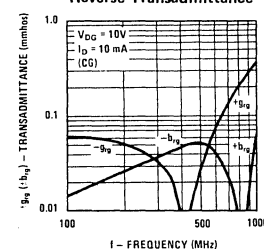
Output Admittance



Reverse Transadmittance

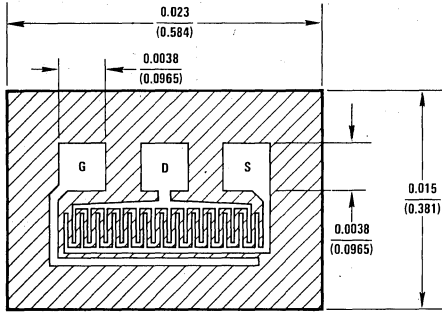


Reverse Transadmittance





# Process 92 N-Channel JFET



GATE IS ALSO BACKSIDE CONTACT

## DESCRIPTION

Process 92 is designed for VHF/UHF amplifier, oscillator, and mixer applications. As a common gate amplifier, 16 dB at 100 MHz and 12 dB at 450 MHz can be realized. Worst case 75 ohm input impedance provides ideal input match.

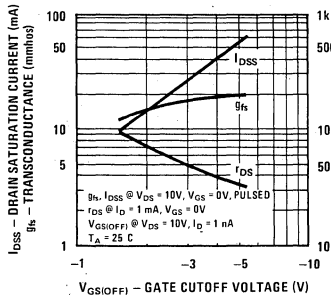
Characteristic	Parameter	Test Conditions	Min	Typ	Max	Units
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	-20	-30		V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 10V, V_{GS} = 0, \text{ Pulsed}$	10	38	80	mA
Forward Transconductance	$g_{fs}$	$V_{DS} = 10V, V_{GS} = 0, \text{ Pulsed}$		19		mmhos
Forward Transconductance	$g_{fs}$	$V_{DG} = 10V, I_D = 10 \text{ mA}$	10	13	18	mmhos
Reverse Gate Current	$I_{GSS}$	$V_{GS} = -15V, V_{DS} = 0$		-15	-100	pA
ON Resistance	$r_{DS}$	$V_{DS} = 100 \text{ mV}, V_{GS} = 0$	35	45	80	$\Omega$
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 10V, I_D = 1 \text{ nA}$	-1.5	-4.0	-6.5	V
Output Conductance	$g_{os}$	$V_{DG} = 10V, I_D = 10 \text{ mA}$		160	250	$\mu\text{mhos}$
Feedback Capacitance	$C_{gd}$	$V_{DG} = 10V, I_D = 10 \text{ mA}, f = 1 \text{ MHz}$		2.0	2.5	pF
Input Capacitance	$C_{gs}$	$V_{DG} = 10V, I_D = 10 \text{ mA}, f = 1 \text{ MHz}$		4.1	5.0	pF
Noise Voltage	$e_n$	$V_{DG} = 10V, I_D = 10 \text{ mA}, f = 100 \text{ Hz}$		6.0		$nV/\sqrt{\text{Hz}}$
Noise Figure	NF	$V_{DG} = 10V, I_D = 10 \text{ mA}, f = 450 \text{ MHz}$		3.0		dB
Power Gain	$G_{pg}$	$V_{DG} = 10V, I_D = 10 \text{ mA}, f = 450 \text{ MHz}$		12		dB

This process is available in the following device types. \*Denotes preferred parts.

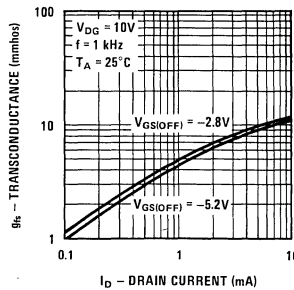
**TO-52 (CASE 07)      TO-92 (CASE 92)**

- U308                      J308
- \*U309                    \*J309
- \*U310                    \*J310

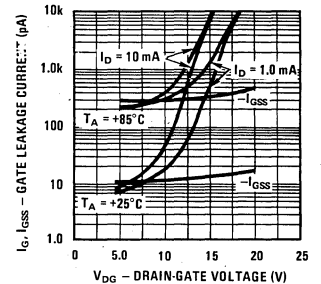
**Parameter Interactions**



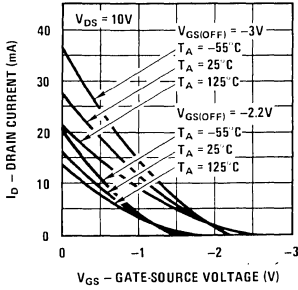
**Transconductance vs Drain Current**



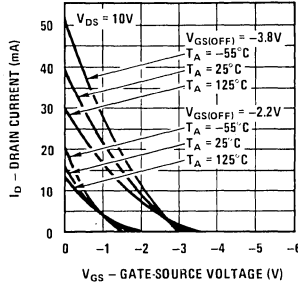
**Leakage Current vs Voltage**



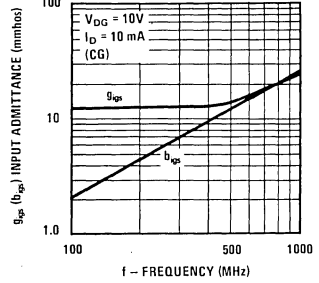
Transfer Characteristics



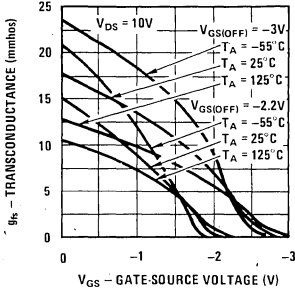
Transfer Characteristics



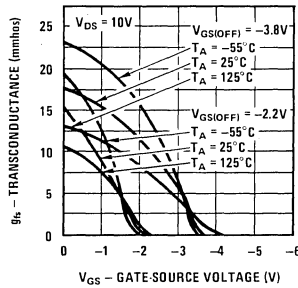
Input Admittance



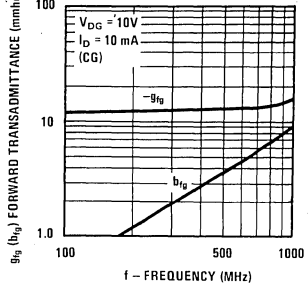
Transfer Characteristics



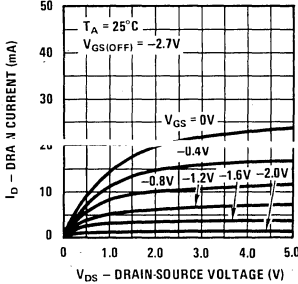
Transfer Characteristics



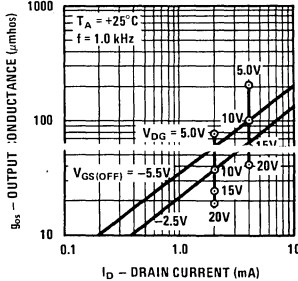
Forward Transadmittance



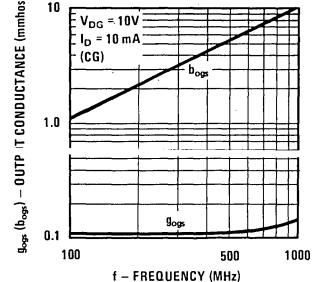
Common Drain-Source Characteristics



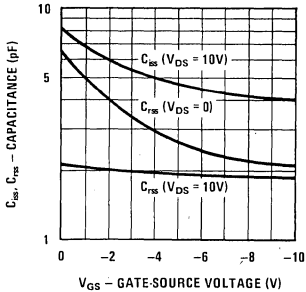
Output Conductance vs Drain Current



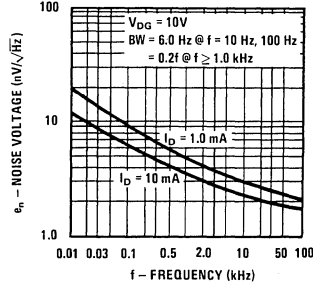
Output Admittance



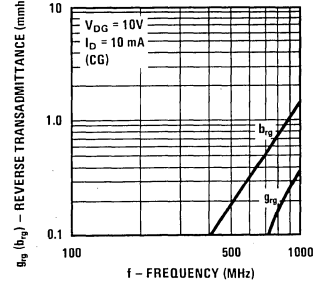
Capacitance vs Voltage



Noise Voltage vs Frequency



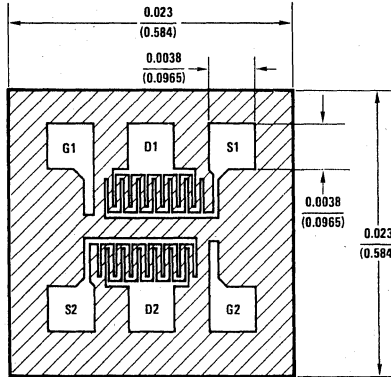
Reverse Transadmittance







# Process 93 N-Channel Monolithic Dual JFET



## DESCRIPTION

Process 93 is a monolithic dual JFET with a diode isolated substrate. It is intended for wide band, low noise, single ended video amplifier input stages, and high slew rate op amps. Monolithic structure eliminates thermal transient errors, and provides freedom to pick operating current and voltage.

CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	-25	-30		V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 10V, V_{GS} = 0, \text{ Pulsed}$	3.0	18	40	mA
Forward Transconductance	$g_{fs}$	$V_{DS} = 10V, V_{GS} = 0, \text{ Pulsed}$		8.0		mmhos
Forward Transconductance	$g_{fs}$	$V_{DG} = 10V, I_D = 5 \text{ mA}$	5.0	6.0	10	mmhos
Output Conductance	$g_{os}$	$V_{DG} = 10V, I_D = 5 \text{ mA}$		50	100	$\mu\text{mhos}$
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 10V, I_D = 1 \text{ nA}$	-1.5	-3.5	-6.0	V
"ON" Resistance	$r_{DS}$	$V_{DS} = 100 \text{ mV}, V_{GS} = 0$		100		$\Omega$
Gate Current	$I_G$	$V_{DG} = 10V, I_D = 5 \text{ mA}$		10	100	pA
Noise Voltage	$e_n$	$V_{DG} = 10V, I_D = 5 \text{ mA}, f = 100 \text{ Hz}$		9.0	30	$\text{nV}/\sqrt{\text{Hz}}$
Differential Match	$ V_{GS1} - V_{GS2} $	$V_{DG} = 10V, I_D = 5 \text{ mA}$		9.0	30	mV
Differential Match	$\Delta V_{GS1-2}$	$V_{DG} = 10V, I_D = 5 \text{ mA}$		15	40	$\mu\text{V}/^\circ\text{C}$
Common Mode Rejection	CMRR	$V_{DG} = 10V, I_D = 5 \text{ mA}$		90		dB
Feedback Capacitance	$C_{fs}$	$V_{DG} = 10V, I_D = 5 \text{ mA}, f = 1 \text{ MHz}$		1.0	1.2	pF
Input Capacitance	$C_{is}$	$V_{DG} = 10V, I_D = 5 \text{ mA}, f = 1 \text{ MHz}$		4.2	5.0	pF

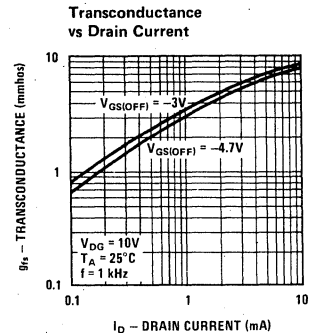
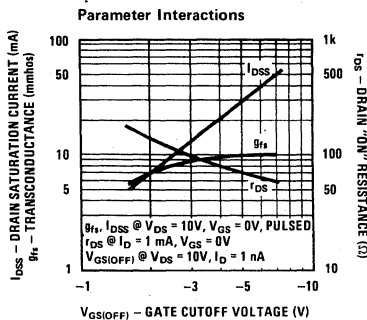
This process is available in the following device types. \*Denotes preferred parts.

TO-78 (CASE 24)

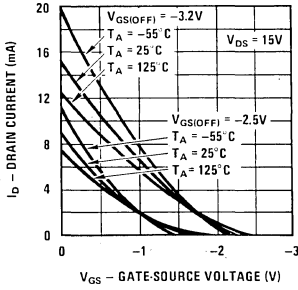
\*2N5911

\*2N5912

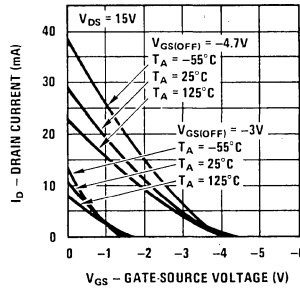
U257



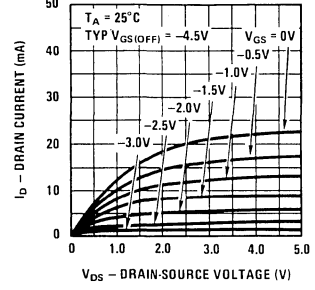
Transfer Characteristics



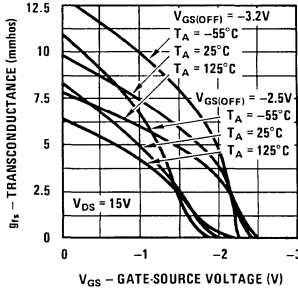
Transfer Characteristics



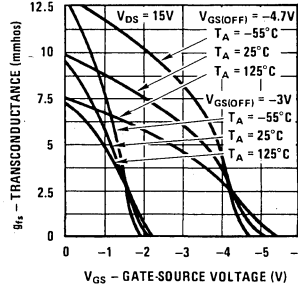
Common Drain-Source Characteristics



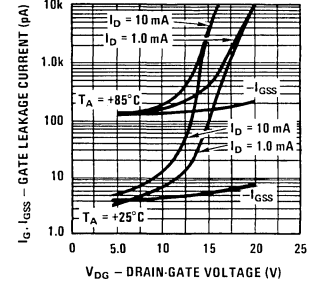
Transfer Characteristics



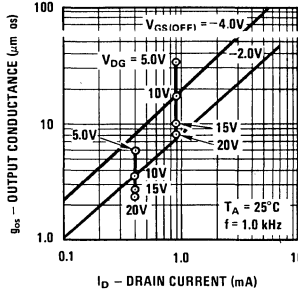
Transfer Characteristics



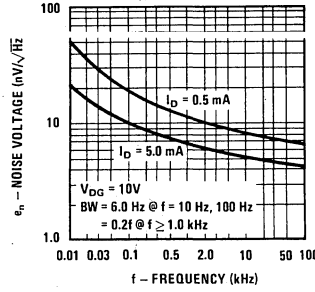
Leakage Current vs Voltage



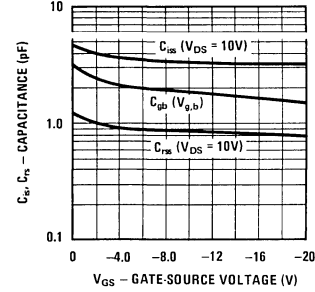
Output Conductance vs Drain Current



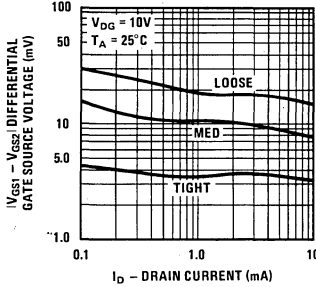
Noise Voltage vs Frequency



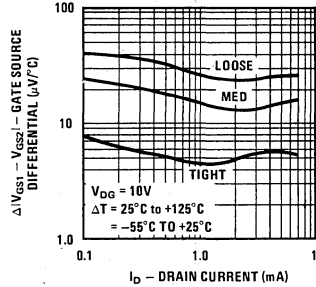
Capacitance vs Voltage



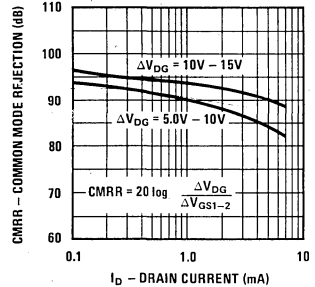
Differential Offset

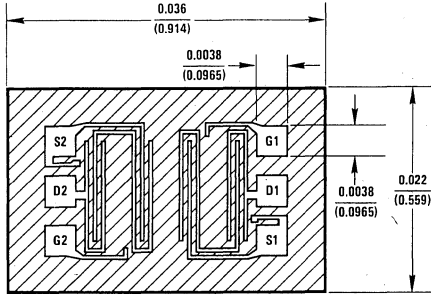


Differential Drift



CMRR vs Drain Current





## DESCRIPTION

Process 94 is a monolithic dual JFET. It is strictly intended for operational amplifier input buffer applications. Special processing results in extremely low input bias current and virtually unmeasurable offset current. It is important to note that the <5 pico ampere bias current is measured at 35 volts. Typical CMRR is 125 dB. Performance superior to electrometer tubes can be readily achieved with low offset voltage and almost zero long term drift.

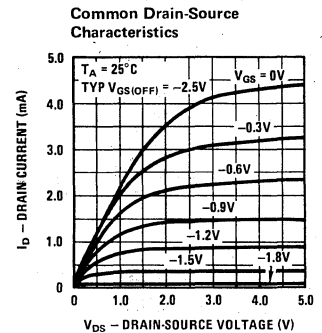
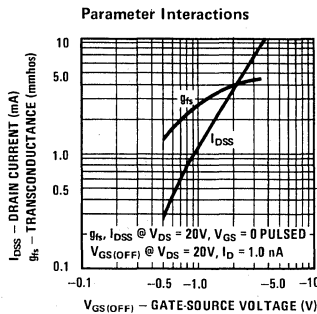
CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	-40	-70		V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 15V, V_{GS} = 0$	0.5	3.0	10	mA
Forward Transconductance	$g_{fs}$	$V_{DS} = 15V, V_{GS} = 0$	1.5	3.5	7.0	mmho
Forward Transconductance	$g_{fs}$	$V_{DG} = 15V, I_D = 0.2 \text{ mA}$	0.7	1.2	1.8	mmhos
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 15V, I_D = 1 \text{ nA}$	-0.5	-2.0	-6.0	V
Gate Current	$I_G$	$V_{DG} = 35V, I_D = 0.20 \text{ mA}$		2.0	15	pA
Feedback Capacitance	$C_{rss}$	$V_{DS} = 15V, V_{GS} = 0, f = 1 \text{ MHz}$		0.01	0.02	pF
Input Capacitance	$C_{iss}$	$V_{DS} = 15V, V_{GS} = 0, f = 1 \text{ MHz}$		4.0	5.0	pF
Noise Voltage	$e_n$	$V_{DG} = 15V, I_D = 0.2 \text{ mA}, f = 10 \text{ Hz}$		12	50	nV/ $\sqrt{\text{Hz}}$
Output Conductance	$g_{os}$	$V_{DG} = 15V, I_D = 0.2 \text{ mA}$		<0.1		$\mu\text{mhos}$
Differential Match	$ V_{GS1} - V_{GS2} $	$V_{DG} = 15V, I_D = 0.2 \text{ mA}$		5.0	25	mV
Differential Match	$\Delta V_{GS1-2}$	$V_{DG} = 15V, I_D = 0.2 \text{ mA}$		6.0	50	$\mu\text{V}/^\circ\text{C}$
Common Mode Rejection	CMRR	$V_{DG} = 15V, I_D = 0.2 \text{ mA}$		125		dB

This process is available in the following device types.

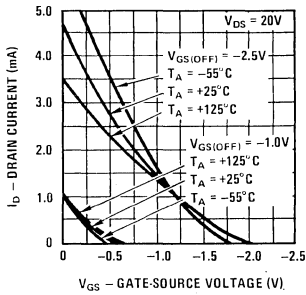
\* Denotes preferred parts.

### TO-71 (CASE 12)

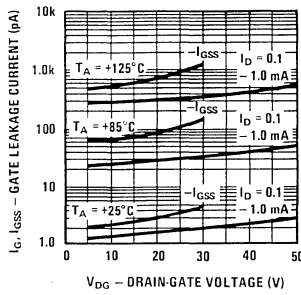
- \*NDF9406
- \*NDF9407
- \*NDF9408
- \*NDF9409
- \*NDF9410



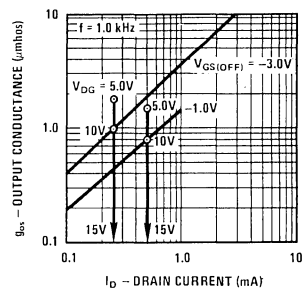
Transfer Characteristics



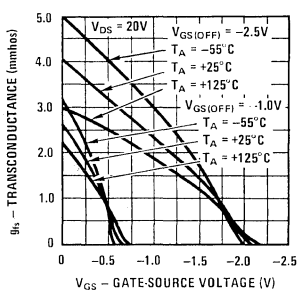
Leakage Current vs Voltage



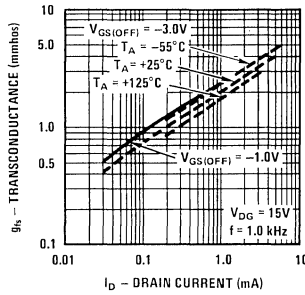
Output Conductance vs Drain Current



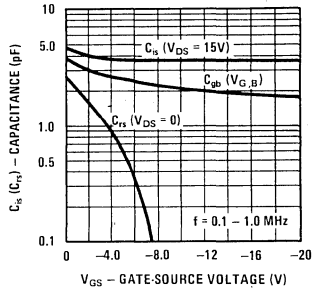
Transfer Characteristics



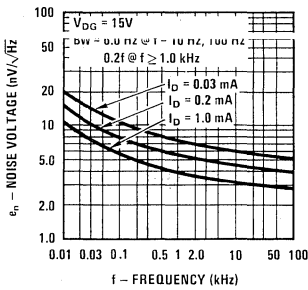
Transconductance vs Drain Current



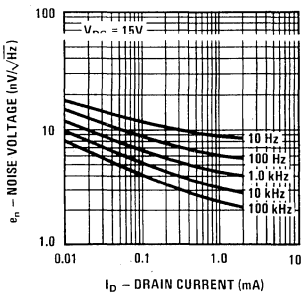
Capacitance vs Voltage



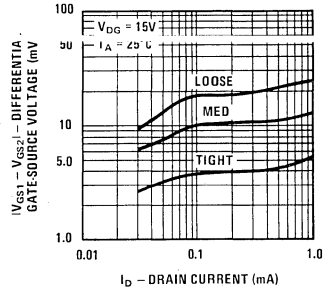
Noise Voltage vs Frequency



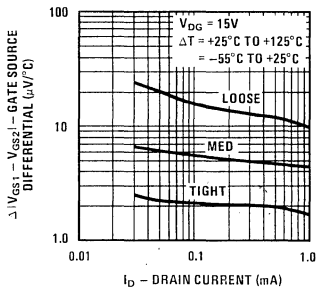
Noise Voltage vs Current



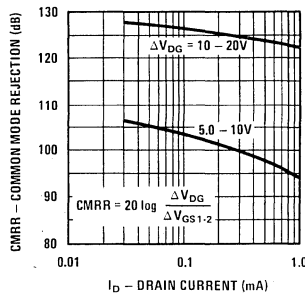
Differential Offset



Differential Drift

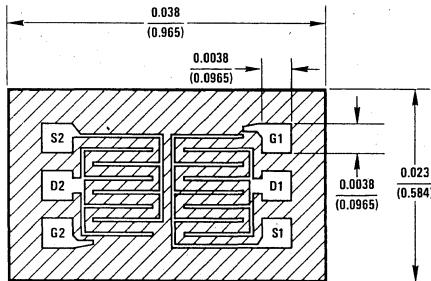


CMRR vs Drain Current



## DESCRIPTION

Process 95 is a monolithic dual JFET with a diode isolated substrate. It is intended for operational amplifier input buffer applications. Processing results in low input bias current and virtually unmeasurable offset current. Low noise voltage and high CMRR for critical 1/f applications.



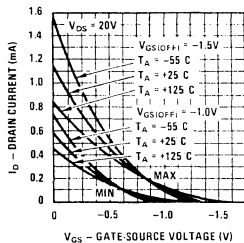
CHARACTERISTIC	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	-40	-70		V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 15V, V_{GS} = 0$	0.5	3.0	8.0	mA
Forward Transconductance	$g_{fs}$	$V_{DS} = 15V, V_{GS} = 0$	1.0	2.5	4.0	mmhos
Forward Transconductance	$g_{fs}$	$V_{DG} = 15V, I_D = 0.2 mA$	0.5	0.7		mmhos
Gate Leakage	$I_{GSS}$	$V_{GS} = -20V, V_{DS} = 0$		-5.0	-100	pA
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 15V, I_D = 1 nA$	-0.5	-2.5	-4.0	V
Input Capacitance	$C_{iss}$	$V_{DS} = 15V, V_{GS} = 0, f = 1 MHz$		10	14	pF
Noise Voltage	$e_n$	$V_{DS} = 15V, I_D = 0.2 mA, f = 10 Hz$		8.0	30	$nV/\sqrt{Hz}$
Noise Voltage	$e_n$	$V_{DS} = 15V, I_D = 0.2 mA, f = 100 Hz$		6.0	10	$nV/\sqrt{Hz}$
Output Conductance	$g_{os}$	$V_{DG} = 15V, I_D = 0.2 mA$		0.3	1.0	$\mu mhos$
Feedback Capacitance	$C_{rss}$	$V_{DS} = 15V, V_{GS} = 0, f = 1 MHz$		3.5	5.0	pF
Differential Match	$ V_{GS1} - V_{GS2} $	$V_{DG} = 20V, I_D = 0.2 mA$		6.0	25	mV
Differential Match	$\Delta V_{GS1-2}$	$V_{DG} = 20V, I_D = 0.2 mA$		9.0	60	$\mu V/^\circ C$
Common Mode Rejection	CMRR	$V_{DG} = 20V, I_D = 0.2 mA$	86	115		dB

This process is available in the following device types. \*Denotes preferred parts.

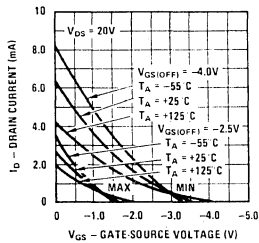
### TO-71 (CASE 12)

2N5515	*2N5522
2N5516	*2N5523
2N5517	*2N5524
2N5518	*2N6483
2N5519	*2N6484
*2N5520	*2N6485
*2N5521	

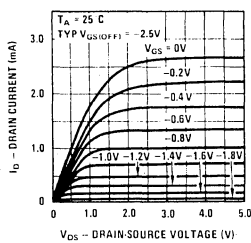
Transfer Characteristics



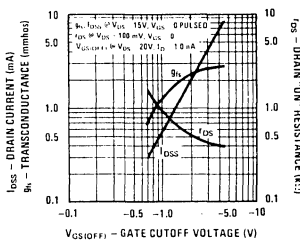
Transfer Characteristics



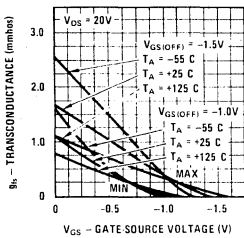
Common Drain-Source Characteristics



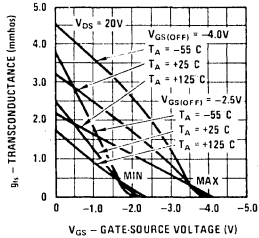
Parameter Interactions



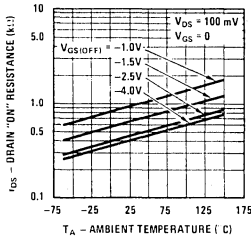
Transconductance Characteristics



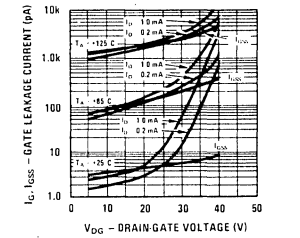
Transconductance Characteristics



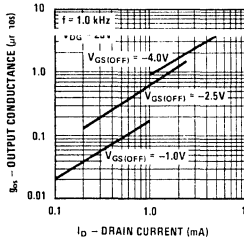
Channel Resistance vs Temperature



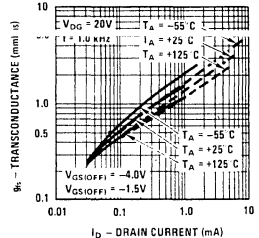
Leakage Current vs Voltage



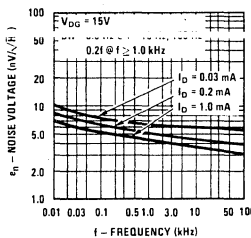
Output Conductance vs Drain Current



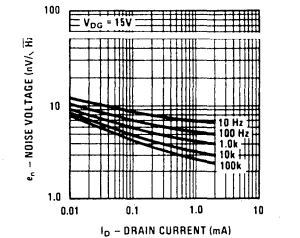
Transconductance vs Drain Current



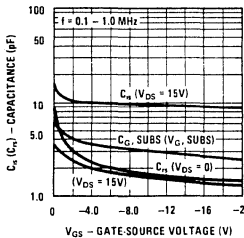
Noise Voltage vs Frequency



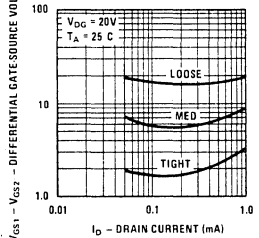
Noise Voltage vs Current



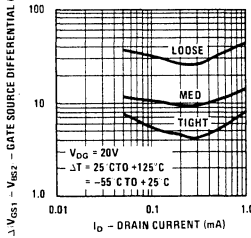
Capacitance vs Voltage



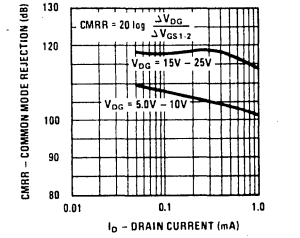
Differential Offset

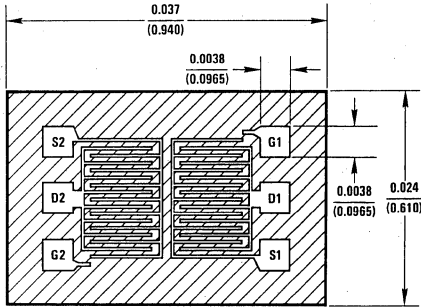


Differential Drift



CMRR vs Drain Current





### DESCRIPTION

Process 96 is a monolithic dual JFET with a diode isolated substrate. It is intended for wide band, low noise, single ended video amplifier input stages. Also ideal for matched voltage variable resistor applications over 60 dB tracking range.

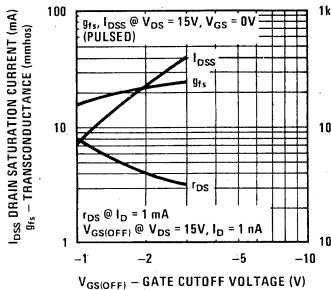
Characteristic	Parameter	Test Conditions	Min	Typ	Max	Units
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	-40	-55		V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 15V, V_{GS} = 0$	5.0	15	30	mA
Forward Transconductance	$g_{fs}$	$V_{DS} = 15V, V_{GS} = 0$	9.0	18	30	mmhos
Forward Transconductance	$g_{fs}$	$V_{DG} = 15V, I_D = 2 mA$	7.5	9.0		mmhos
Output Conductance	$g_{os}$	$V_{DG} = 15V, I_D = 2 mA$		15	45	$\mu mhos$
Pinch Off Voltage	$V_{GS(OFF)}$	$V_{DS} = 15V, I_D = 1 nA$	-0.5	-1.8	-3.0	V
ON Resistance	$r_{DS}$	$V_{DS} = 100 mV, V_{GS} = 0$	35	70	120	$\Omega$
Gate Current	$I_{GSS}$	$V_{GS} = -20V, V_{DS} = 0$		-8.0	-100	$\mu A$
Gate Current	$I_G$	$V_{DG} = 15V, I_D = 2 mA$		15	200	$\mu A$
Noise Voltage	$e_n$	$V_{DG} = 15V, I_D = 2 mA, f = 100 Hz$		4.5	10	$nV/\sqrt{Hz}$
Feedback Capacitance	$C_{rs}$	$V_{DG} = 15V, I_D = 2 mA, f = 1 MHz$		2.5	3.0	pF
Input Capacitance	$C_{is}$	$V_{DG} = 15V, I_D = 2 mA, f = 1 MHz$		10	12	pF
Differential Voltage	$ V_{GS1} - V_{GS2} $	$V_{DG} = 15V, I_D = 2 mA$		8.0	25	mV
Differential Voltage	$\Delta V_{GS}$	$V_{DG} = 15V, I_D = 2 mA$		9.0	50	$\mu V/^\circ C$
Common-Mode Rejection	CMRR	$V_{DG} = 15V, I_D = 2 mA$	76	95		dB

This process is available in the following device types. \* Denotes preferred parts.

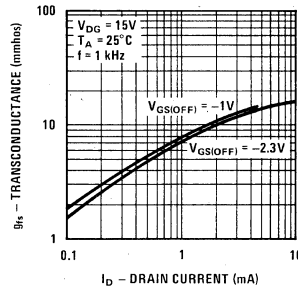
#### T0-71 (CASE 12)      8-Pin DIP (CASE 67)

- \*2N5564                      \*NPD5564
- \*2N5565                      \*NPD5565
- \*2N5566                      \*NPD5566

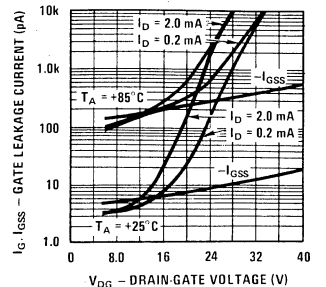
#### Parameter Interactions



#### Transconductance vs Drain Current

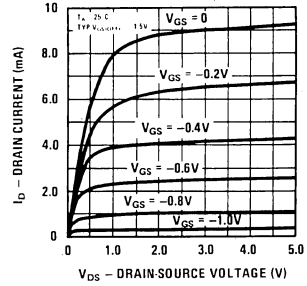


#### Leakage Current vs Voltage

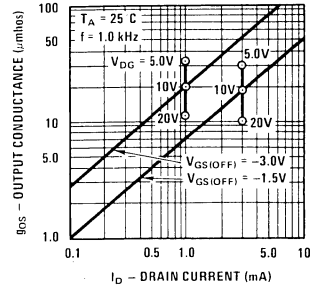


# Process 96

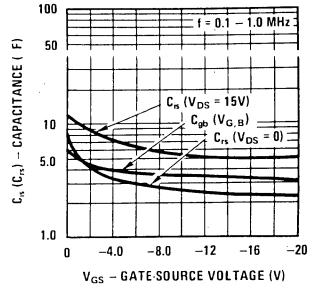
## Common Drain-Source Characteristics



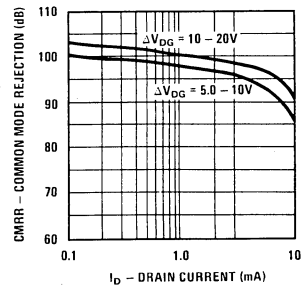
## Output Conductance vs Drain Current



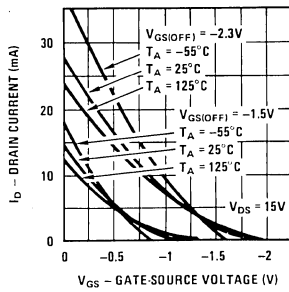
## Capacitance vs Voltage



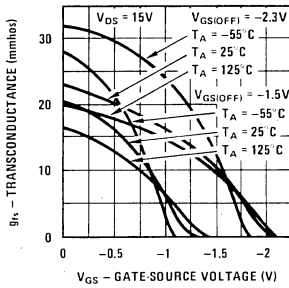
## CMRR vs Drain Current



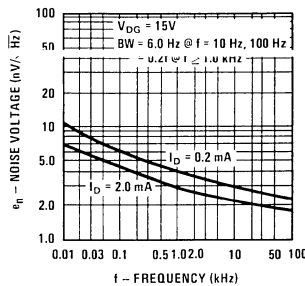
## Transfer Characteristics



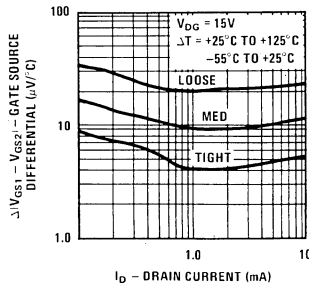
## Transfer Characteristics



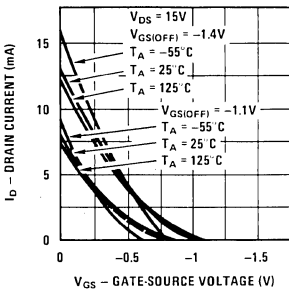
## Noise Voltage vs Frequency



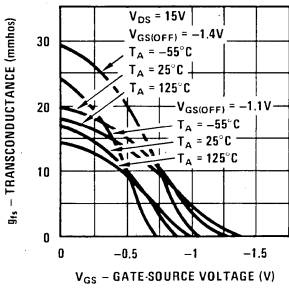
## Differential Drift



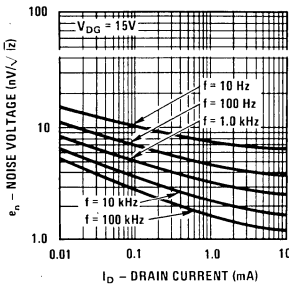
## Transfer Characteristics



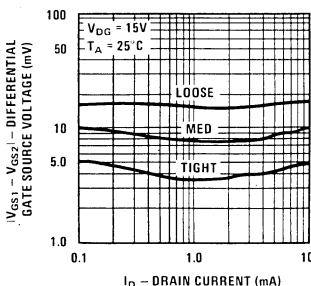
## Transfer Characteristics



## Noise Voltage vs Current



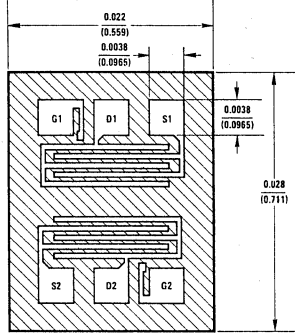
## Differential Offset







# Process 98 N-Channel JFET



## DESCRIPTION

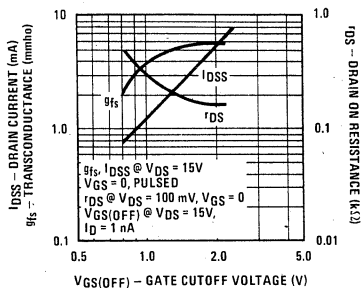
Process 98 is a high gain, general purpose, monolithic dual JFET with a diode isolated substrate. It is intended for amplifier input stages requiring high gain, low noise and low offset drift over temperature. Strict processing controls result in low input bias currents and virtually immeasurable offset currents. Matching characteristics are essentially independent of operating current and voltage.

Characteristic	Parameter	Test Conditions	Min	Typ	Max	Units
Gate-Source Breakdown Voltage	$BV_{GSS}$	$V_{DS} = 0V, I_G = -1 \mu A$	50	75		V
Gate Leakage Current	$I_{GSS}$	$V_{GS} = -30V, V_{DS} = 0V$		2.0	100	pA
Pinch-off Voltage	$V_{GS(OFF)}$	$V_{DS} = 15V, I_D = 1 nA$	0.5	1.3	3.0	V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 10V, V_{GS} = 0$	0.5	1.8	10	mA
Forward Transconductance	$g_{fs}$	$V_{DS} = 10V, V_{GS} = 0$	2.0	4.5	7.0	mmhos
Output Conductance	$g_{os}$	$V_{DS} = 10V, V_{GS} = 0$		8.0	20	$\mu$ mhos
Forward Transconductance	$g_{fs}$	$V_{DG} = 15V, I_D = 200 \mu A$	1.0	1.4	1.8	mmhos
Output Conductance	$g_{os}$	$V_{DG} = 15V, I_D = 200 \mu A$		1.3	2.0	$\mu$ mhos
Differential Offset Voltage	$V_{OS}$	$V_{DG} = 10V, I_D = 200 \mu A$		10	40	mV
Feedback Capacitance	$C_{rss}$	$V_{DG} = 15V, I_D = 200 \mu A, f = 1 MHz$		1.7	3.0	pF
Input Capacitance	$C_{iss}$	$V_{DG} = 15V, I_D = 200 \mu A, f = 1 MHz$		6.0	8.0	pF
Noise Voltage	$e_n$	$V_{DS} = 15V, I_D = 200 \mu A, f = 10 Hz$		8.0	50	$nV\sqrt{Hz}$
Common Mode Rejection Ratio	CMRR	$V_{DG} = 5V-10V, I_D = 200 \mu A$	90	108		dB

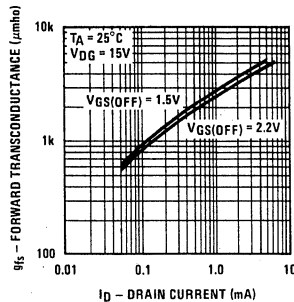
This process is available in the following device types.

TO-71 (CASE 12)			8-PIN DIP (CASE 60)	
2N5561	U401	U404	J401	J404
2N5562	U402	U405	J402	J405
2N5563	U403	U406	J403	J406

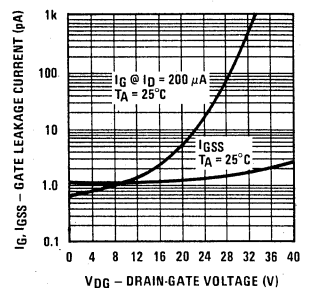
Parameter Interactions



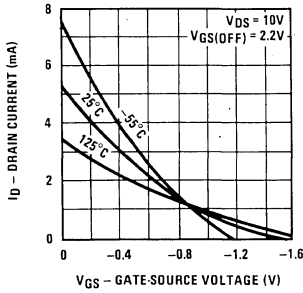
Forward Transconductance vs Drain Current



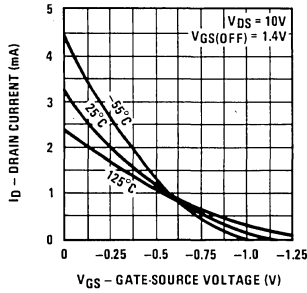
Gate Leakage Current vs Voltage



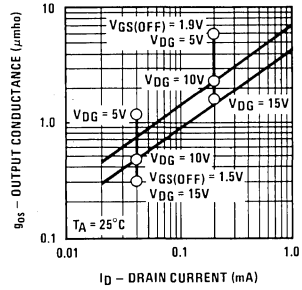
**Transfer Characteristics**



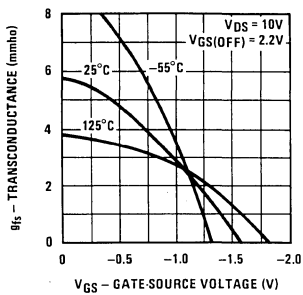
**Transfer Characteristics**



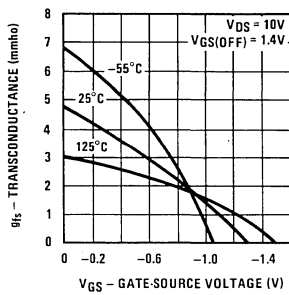
**Output Conductance vs Drain Current**



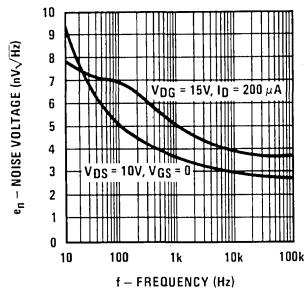
**Transconductance vs Gate Source Voltage**



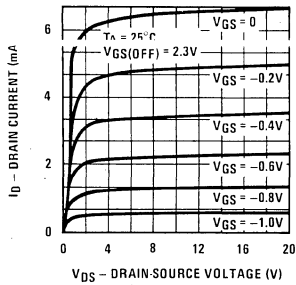
**Transconductance vs Gate Source Voltage**



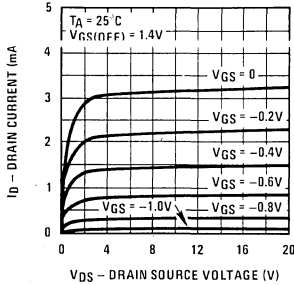
**Noise Voltage vs Frequency**



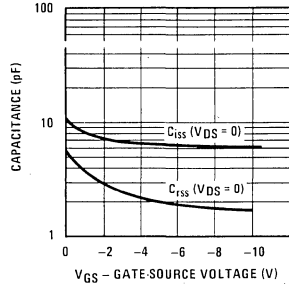
**Common Drain Source Characteristics**



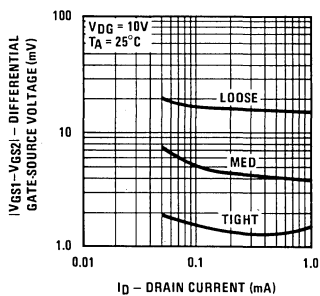
**Common Drain Source Characteristics**



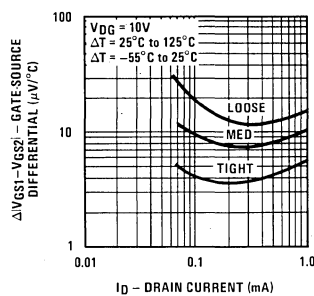
**Capacitance vs Gate Source Voltage**



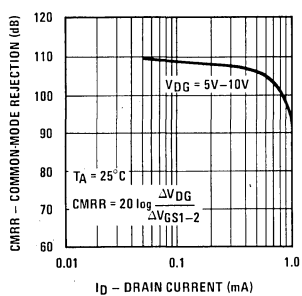
**Differential Offset**



**Differential Drift**



**CMRR vs Drain Current**







Section 11  
**JFET**  
**Applications Notes**



# FET Application Guide

National Semiconductor manufactures a broad line of silicon Junction Field Effect Transistors (JFETs). National's JFETs provide excellent performance in many areas such as RF amplifiers, analog switching, low input current amplifiers, ultra low noise amplifiers and outstanding matched duals for operational amplifiers input applications.

The following chart is a guide to enable the user to determine what parameters are important in each application.

## APPLICATIONS AND THEIR PARAMETERS LISTED IN APPROXIMATE ORDER OF IMPORTANCE

LOW FREQUENCY AMPLIFIER	SOURCE FOLLOWER	ELECTROMETER AMPLIFIERS	LOW DRIFT AMPLIFIER	LOW NOISE AMPLIFIER	HIGH FREQUENCY AMPLIFIER	OSCILLATOR	DIFFERENTIAL AMPLIFIER	ANALOG AND DIGITAL SWITCHING
$Y_{fs}$ $I_{DSS}$	$Y_{fs}$ $I_G$	$I_G$ $Y_{fs}$	$I_{DZ}$ $Y_{fs} @ I_{DZ}$	$e_n$ $I_G, i_n$	$Re(Y_{fs})$ $Re(Y_{fs})$	$Y_{fs}$ $I_{DSS}$	$ V_{GS1}-V_{GS2} $ $\frac{\Delta V_{GS1}-V_{GS2} }{\Delta T}$	$r_{DS(ON)}$ $I_{D(OFF)}$
$V_{GS(OFF)}$ $C_{iss}$ $C_{rss}$ $e_n$ $BVGSS$	$C_{rss}$ $C_{iss}$ $I_{DSS}$ $V_{GS(OFF)}$ $BVGSS$	$I_{DZ}$ $e_n$ $g_{os}$	$V_{GS} @ I_{DZ}$ $I_G$ $BVGSS$	$Y_{fs}$ $I_{DSS}$ $V_{GS(OFF)}$	NF $C_{rss}$ $Re(Y_{os})$ $I_{DSS}$ $V_{GS(OFF)}$	$C_{rss}$ $C_{iss}$ $V_{GS(OFF)}$ $BVGSS$	$ I_{G1}-I_{G2} $ $I_G$ $Y_{fs}$ $Y_{fs1}/Y_{fs2}$ $ Y_{os1}-Y_{os2} $ CMRR $V_{GS(OFF)}$	$C_{iss}$ $C_{rss}$ $V_{GS(OFF)}$ $BVGSS$

## JFET Parameter Relationships

$I_D = I_{DSS} \left(1 - \frac{V_{GS}}{V_{GS(OFF)}}\right)^2$  Variation of drain current with gate bias. Square low transfer characteristic.

$V_{GS(OFF)} = \frac{2 I_{DSS}}{g_{fs0}}$  Gate-source cutoff voltage in terms of  $I_{DSS}$  and  $g_{fs0}$ .

$V_{GS} = V_{GS(OFF)} \left(1 - \left(\frac{I_D}{I_{DSS}}\right)^{1/2}\right)$  Gate-source voltage in terms of operating current  $I_D$ ,  $I_{DSS}$ , and  $V_{GS(OFF)}$ .

$g_{fs0} = K \frac{I_{DSS}}{V_{GS(OFF)}}$  Transconductance at zero gate voltage in terms of  $I_{DSS}$  and  $V_{GS(OFF)}$ .  $K = 1.1$  to  $2.5$ . Typically 2 for N-channel JFETs.

$g_{fs} = g_{fs0} \left(1 - \frac{V_{GS}}{V_{GS(OFF)}}\right)$  Variation in transconductance with gate bias.

$g_{fs} = g_{fs0} \sqrt{I_D/I_{DSS}}$  Variation in transconductance with drain current.

$r_{DS} \approx \frac{1}{g_{fs}}$  Relationship between  $r_{DS}$  and  $g_{fs}$  in the triode region (i.e.,  $V_{DS} < V_{GS(OFF)}$ ).

$r_{DS} \approx \frac{r_{DS(0)}}{1 - \frac{V_{GS}}{V_{GS(OFF)}}}$  Variation of drain resistance with gate bias in terms zero bias resistance ( $r_{DS0}$ ) and  $V_{GS(OFF)}$ .

$r_{DS} \approx \frac{K V_{GS(OFF)}^2}{I_{DSS}(V_{GS(OFF)} - V_{GS})}$  Variation of drain resistance in terms of  $V_{GS}$ , and  $V_{GS(OFF)}$   
 $K = 0.5 - 0.9$   
 $I_{DSS}$ .

$r_{DST} \approx r_{DS @ 25^\circ C} (1 + 0.007 (\Delta T))$  Variation of ON resistance as a function of temperature.

# Monolithic Dual FETs vs 2-Chip Dual FETs

National Semiconductor  
February 1977



Monolithic Dual FETs vs 2-Chip Dual FETs

## INTRODUCTION

Recent development of a monolithic dual field effect transistor offers distinct cost and design advantages to the dual FET user. In this article, we have pointed out these advantages on the basis of a comparison that was made between this monolithic structure and the 2-chip dual. Finally, a typical application for this FET is presented and evaluated.

## GENERAL

Most dual junction field effect transistors that are available today are the 2-chip variety. These devices are costly to manufacture since 2 FET dice must be found whose electrical characteristics match under a certain set of bias conditions. Finding the matched pair is accomplished by collecting data on a large number of dice and, with the help of a computer, selecting 2 devices with identical characteristics. The result is a device that exhibits excellent end point temperature characteristics as long as the device is operated at the manufacturer specified bias conditions. If the device is operated at bias levels that deviate too much from the specified conditions, the user runs the risk of poor temperature performance. In addition, even if the device is biased at the specific drain current operating point, there still is no guarantee that the device will be well behaved between the temperature end points.

The dual FET manufacturer and user alike would like to have a device that exhibits none of the above shortcomings. They are:

1. High price because of the device selection process.
2. Poor temperature tracking characteristics at currents other than those specified by the manufacturer.

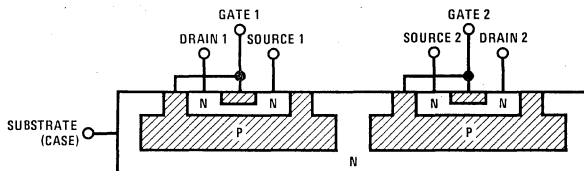


FIGURE 1a. Typical National Monolithic Dual FET Cross-Section (Processes 83, 84, 93, 94, 95 and 96)

3. Non-linear temperature tracking performance between the manufacturer specified end point temperatures.

Recent development by National of a complete family of dual monolithic junction FETs has virtually eliminated these shortcomings. National's family of duals include general purpose dual process 83 (2N3954 family, etc.), ultra low leakage dual process 84 (2N5902 family), wideband RF dual process 93 (2N5911 family) instrumentation dual cascode process 94 (NDF9400 family), low noise dual process 95 (2N5515 family), and wideband chopper switch dual process 96 (2N5564 family). While some other companies now manufacture a monolithic dual g.p. FET similar to process 83, National is the only "all monolithic" dual manufacturer. These devices (illustrated in Figures 1a and 1b) consist of 2 diffused isolated junction FETs.

Since these devices are a monolithic structure, no dice matching is required. The FETs that make up the chip either match or they don't. Units that do not match are eliminated at the wafer sorting stage. Units that do match and exhibit good temperature tracking characteristics at a specified drain current also exhibit good temperature tracking characteristics at other current levels. These devices display a linear differential gate-source voltage relationship to temperature. This is very important to the operational amplifier manufacturer since it allows him to temperature compensate the dual FET or his entire amplifier circuit for that matter such that temperature coefficient approaching  $0 \mu V/^{\circ}C$  can be achieved. Since the 2 FETs that constitute the monolithic structure are isolated by a diffusion, they can be operated at different potentials without device interaction.

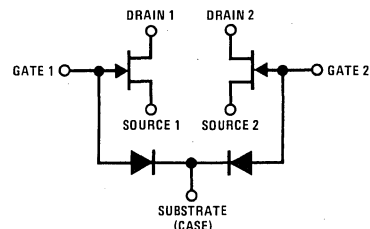


FIGURE 1b. Process 83 Equivalent Schematic

**FET TEMPERATURE CHARACTERISTICS**

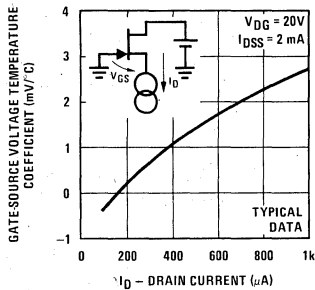
Figure 2 illustrates the gate-source voltage temperature dependence of the 2N3954 (process 83) monolithic FET for various values of drain current. All junction FETs, whether they are monolithic or single unit construction, display similar characteristics. It becomes evident, upon examination of this curve, that a very slight change in drain current results in a substantial change in the gate to source voltage ( $V_{GS}$ ) temperature coefficient.

Figure 3 illustrates just exactly how dependent  $V_{GS}$  is to an  $I_D$  change. For example, suppose a device is biased at a 200  $\mu A$  drain current level. The curve in Figure 4, tells us that a drain current change of 1  $\mu A$  will change the  $V_{GS}$  temperature coefficient 4.8  $\mu V/^\circ C$ . The fact the  $V_{GS}$  temperature coefficient can be predictably changed by slight variation in the drain current implies that the differential gate-source voltage temperature coefficient can be adjusted to 0  $\mu V/^\circ C$  by a change in drain current. A 2-chip dual FET can also be temperature compensated in this same manner provided the differential  $V_{GS}$  temperature coefficient is constant at all temperatures. The temperature coefficient of the 2-chip system, however, is generally not constant over the specified operating temperature range, therefore

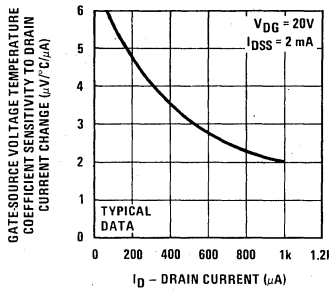
making this type compensation difficult. To illustrate the difference in temperature tracking characteristics of the 2-chip FET and the monolithic structure, a 2-chip 10  $\mu V/^\circ C$  device was compared to a monolithic 10  $\mu V/^\circ C$  unit.

Figure 4 illustrates how the differential gate-source voltage of the monolithic 2N3954 varies as a function temperature. When both sides of the dual FET are biased at the specified 200  $\mu A \pm 0.01\%$  level, the temperature coefficient is constant and equal to 6  $\mu V/^\circ C$ . Also, note that the  $\Delta V_{GS}$  temperature coefficient can be adjusted to about 0  $\mu V/^\circ C$  by increasing the drain current in Q2 to 201  $\mu A$ . The  $\Delta V_{GS}$  temperature characteristics for the 2-chip 2N3954 dual FET are shown in Figure 5. Note that if one employs the definition of temperature coefficient set forth in Note 1, the  $\Delta V_{GS}$  temperature coefficient of the 2-chip dual is about 8  $\mu V/^\circ C$ . It would be impossible, however, to achieve a temperature coefficient much better than 8  $\mu V/^\circ C$  (by adjusting the drain current), because the  $\Delta V_{GS}$  temperature curve is non-linear.

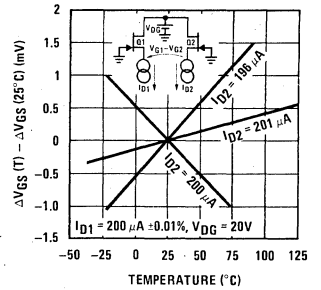
The  $\Delta V_{GS}$  temperature characteristics of the 2-chip dual and the monolithic dual were then measured at 500  $\mu A$  of drain current. The results are illustrated in Figures 6 and 7.



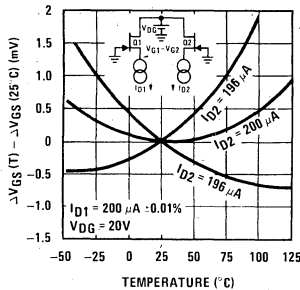
**FIGURE 2.** Gate-Source Voltage Temperature Coefficient vs Drain Current (Single Device)



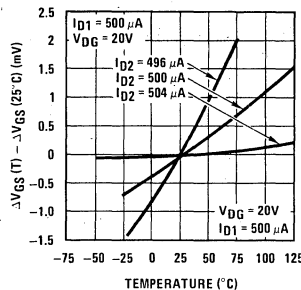
**FIGURE 3.** Gate-Source Voltage Temperature Coefficient Sensitivity to Drain Current Change vs Drain Current (Single Device)



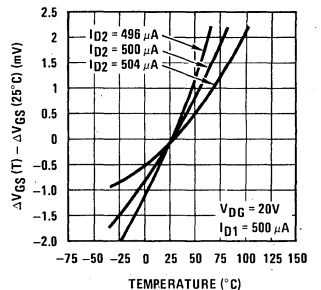
**FIGURE 4.** Differential Gate-Source Voltage vs Temperature for a Typical Monolithic Dual JFET



**FIGURE 5.** Differential Gate-Source Voltage vs Temperature for a Typical 2-Chip Dual JFET (10  $\mu V/^\circ C$  Unit)



**FIGURE 6.** Differential Gate-Source Voltage vs Temperature for the Same Monolithic JFET in Figure 4, Only the Drain Current has been Changed to 500  $\mu A$ .



**FIGURE 7.** Differential Gate-Source Voltage vs Temperature for the Same 2-Chip Dual FET in Figure 5, Only the Drain Current is 500  $\mu A$

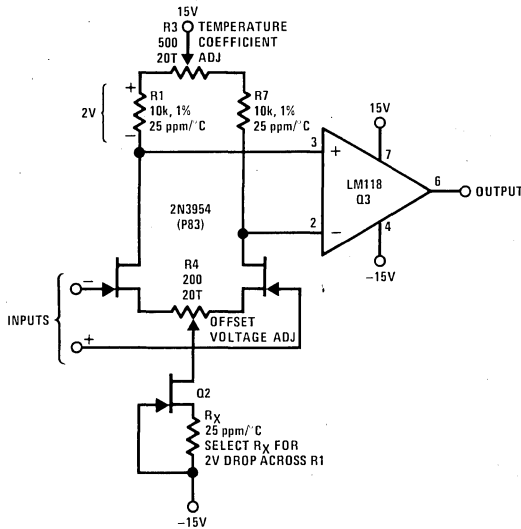
Note that the monolithic dual exhibits good  $\Delta V_{GS}$  temperature characteristics ( $TC \approx 15 \mu V/^{\circ}C$ ) while the 2-chip dual has a temperature coefficient greater than  $50 \mu V/^{\circ}C$ . The data displayed in Figures 4-7 is for 2 specific devices; however, it is representative of the data accumulated on a number of process 83 and 2-chip dual FETs.

Another point that warrants discussion is the fast thermal transient response of the monolithic dual FET. This type device is generally employed as the input stage for an operational amplifier; therefore, it may be subjected to electrical overload such as input voltage transients. This condition causes 1 side of the dual FET to dissipate more power than the other, which in turn results in a temperature differential between the 2 sides

of the device. The  $\Delta V_{GS}$  error will disappear once the devices are again in thermal equilibrium. The time for the 2-chip dual FET to reach thermal equilibrium, after a thermal transient, is considerable since the FET chips making up the 2-chip dual are located some distance apart. On the other hand, the monolithic structure recovers from thermal transients very rapidly because the 2 FETs, constituting the chip, are in intimate contact.

**APPLICATIONS**

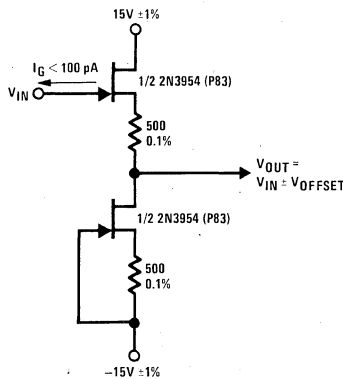
A typical operational amplifier application is illustrated in Figure 8. This circuit employs the 2N3954 monolithic dual FET as the input device. The drain current level is set by FET Q2 and resistor  $R_X$ . FET Q2 is a 2N5457. This device exhibits a 0 TC drain current operating point



**Note 1:** The temperature coefficient can typically be adjusted (by R3 and R4) to less than  $5 \mu V/^{\circ}C$  from  $-25^{\circ}C$  to  $+85^{\circ}C$ .

**Note 2:** The common-mode rejection ratio is typically greater than 100 dB for input voltage swings of 5V.

**FIGURE 8. Low Temperature Coefficient Operational Amplifier**



**FIGURE 9**



at about 400  $\mu\text{A}$ . In addition, the Q2-R $\chi$  combination exhibits an output impedance typically greater than 10 M $\Omega$ . This characteristic, coupled with the high output impedance of the 2N3954, contribute to a CMRR of greater than 100 dB for this amplifier. Input offset voltage can be adjusted to 0 with R4. This control exhibits sensitivity of 2 mV/turn. The temperature coefficient can be compensated by R3 with an approximate sensitivity of 5  $\mu\text{V}/^\circ\text{C}$ /turn. The temperature performance of a typical amplifier of this type is illustrated in Figure 10.

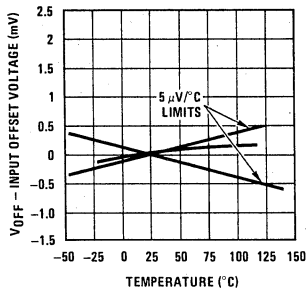


FIGURE 10. Input Offset Voltage vs Temperature

## CONCLUSION

The junction isolated dual monolithic junction FET does exhibit a more linear  $\Delta\text{V}_{\text{GS}}$  temperature relationship than does the 2-chip dual FET. In addition, the monolithic structure exhibits good temperature tracking

characteristics at drain currents other than the specified  $I_{\text{D}}$ . This is generally not the case for the 2-chip system. Since all National duals are monolithic structures, the cumbersome process of matching individual dice is not required.

This, of course, makes the monolithic dual less expensive than its 2-chip counterpart. And finally, the monolithic dual FET maintains excellent tracking characteristics when the device is subjected to thermal transients or momentary voltage overloads. This is not the case with the 2-chip dual since these devices are thermally isolated from one another.

## Note 1:

Definition of temperature coefficient:

$$(TC)_L = \frac{|\Delta\text{V}_{\text{GS}}(T_O) - \Delta\text{V}_{\text{GS}}(T_L)|}{T_O - T_L} \times 10^6 \mu\text{V}/^\circ\text{C}$$

$$(TC)_H = \frac{|\Delta\text{V}_{\text{GS}}(T_H) - \Delta\text{V}_{\text{GS}}(T_O)|}{T_H - T_O} \times 10^6 \mu\text{V}/^\circ\text{C}$$

Where  $T_O = 25^\circ\text{C}$

$T_H$  - High temperature limit ( $T_H = 85$  or  $125^\circ\text{C}$ )

$T_L$  - Low temperature limit

$\Delta\text{V}_{\text{GS}}(T_O)$  - Differential gate-source offset voltage at  $T_O$  (volts)

$\Delta\text{V}_{\text{GS}}(T_H)$  - Differential gate-source offset voltage at  $T_H$

$\Delta\text{V}_{\text{GS}}(T_L)$  - Differential gate-source offset voltage at  $T_L$

# Why Use Cascode Dual FETs?

National Semiconductor  
FET Brief 2  
Mike Turner  
March 1977



Why Use Cascode Dual FETs?

National Semiconductor's cascode dual JFET is a unique structure in which each half of a monolithic dual is actually 2 FETs connected in cascode. *Figure 1a and 1b* show the comparison. The advantages of a cascode structure are low dynamic leakage ( $I_G$ ) and greatly improved common-mode rejection ratio. National's processes 84 and 94 use the cascode configuration.

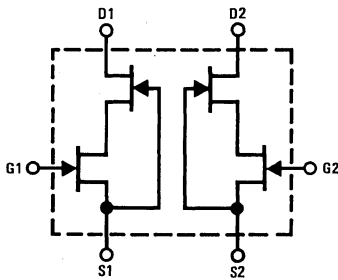


FIGURE 1a. Cascode Configuration

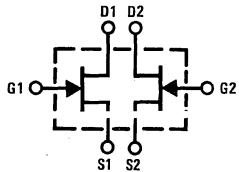


FIGURE 1b. Triode Configuration

The cascode FET device offers a significant improvement in gain/input current ratio when compared to standard FET triodes. Specifically, the NDF9406 series devices are specified at  $I_G < 5 \text{ pA}$  under operating conditions, and they exhibit operating  $g_{fs}$  of 1200  $\mu\text{mho}$  typical. This compares favorably with non-cascode duals exhibiting 3–10 times the  $I_G$ .

Furthermore, the NDF9406 series will maintain this low input current over a common-mode input range of up to  $\pm 15\text{V}$ , while triode devices are limited to approximately  $\pm 5\text{V}$  for the same performance.

Table I compares popular junction dual devices available in the marketplace.

It is important to remember that  $I_G$  is a dynamic characteristic. The data supplied by major FET suppliers clearly shows the effect of operating voltage and current on  $I_G$  and the considerable difference between  $I_G$  and the static parameter  $I_{GSS}$ .

*Figure 2* explores the differences between cascode devices such as NDF9406–NDF9409 and a triode configured 2N5196. It is easily seen that severe gate current modulation will result in triode devices with even relatively small change in  $V_{DG}$ . Gate current variations will cause variations in offset bias currents, offset voltage and common-mode rejection. This is especially true in high impedance circuits where gate impedances are not matched.

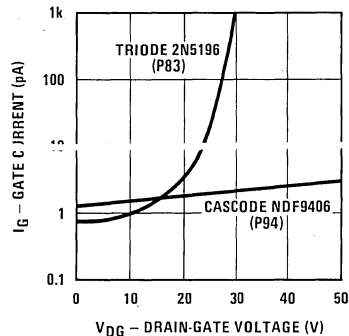


FIGURE 2. Typical Gate Current vs Drain-Gate Voltage @  $I_D = 200 \mu\text{A}$

The second major advantage of the cascode configuration is improved common-mode rejection ratio. The input FETs are effectively shielded from large changes in operating point by the drain load FETs.

TABLE I

DEVICE SERIES	BV	$I_G V_{DG}/I_D$	$g_{fs} I_D$
2N3954–2N3958	>50V	<50 pA @ 20V/200 $\mu\text{A}$	1000 @ 200 $\mu\text{A}$ *
2N5196–2N5199	>50V	<15 pA @ 20V/200 $\mu\text{A}$	>700 @ 200 $\mu\text{A}$
NDF9406–NDF9409	>50V	<5 pA @ 35V/200 $\mu\text{A}$	>950 @ 200 $\mu\text{A}$

\* Limits not specified on the published data sheet.

# Why Use Cascode Dual FETs?

The inherent matching of all devices because of monolithic construction further reduces the effects of common-mode signals.

Figure 3 compares CMRR of a monolithic triode dual FET (National P83) with a cascode structure (National P94).

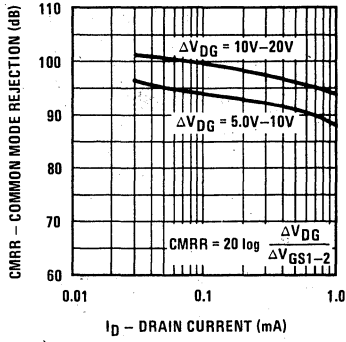


FIGURE 3a. Triode Construction

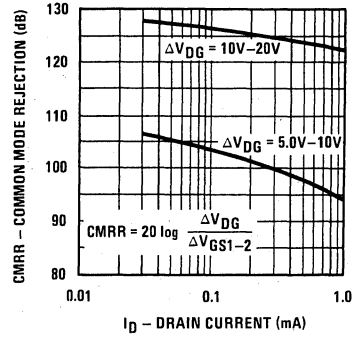


FIGURE 3b. Cascode Construction

# Simple VHF Analog Switches

National Semiconductor  
FET Brief 1  
Mike Turner  
February 1977



Simple JFET switches like those in *Figure 1* will toggle at rates to about 10 MHz and switch analog signals with frequencies to above 100 MHz. They accomplish this by resolving in the gate-driver design the contradictory performance goals that even the best switching transistors cannot meet.

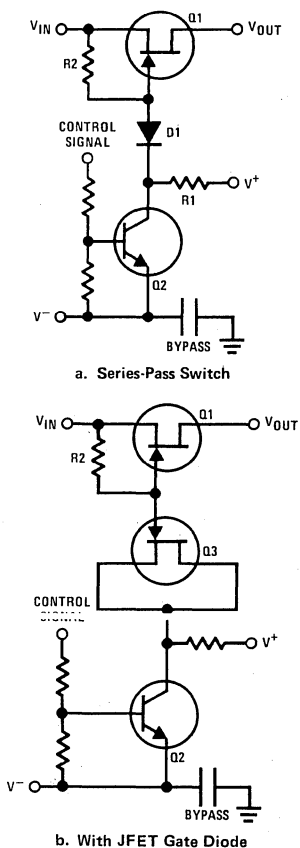


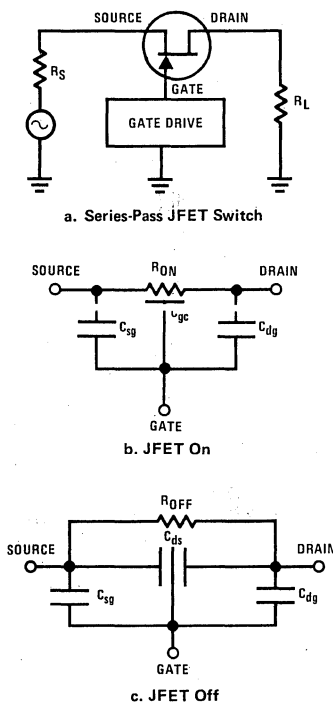
FIGURE 1. High-Frequency JFET Switching Circuits

To switch high-frequency signals, the JFET should have low ON impedance,  $r_{ds(on)}$  or  $R_{ON}$ , and low input capacitance,  $C_{iss}$ . The switch's RC time constant is established by these 2 parameters, and they also indicate the bandwidth capability. JFETs have been developed that come close to being ideal, but unfortunately the real-world nature of semiconductor devices makes it impossible to achieve optimum values of both parameters in the same device. Low  $R_{ON}$  calls for a physically large JFET. On the other hand, the very low capacitance needed for fast toggle rates implies small size.

At a casual glance, gate drive impedance does not appear very important. However, the JFET device conflict between  $R_{ON}$  and  $C_{iss}$  may be overcome by using the

proper gate driver. The drive circuit should have a low impedance when the JFET is turned OFF and a high impedance when the JFET is turned ON. The low-impedance path is needed to prevent analog-signal feedthrough and the high impedance to minimize signal attenuation through the driver while the JFET is conducting. A well-designed driver can do both.

The relationships among JFET and driver characteristics can be sorted out with the help of *Figure 2*, which shows a typical series-pass switch and the equivalent circuits of the JFET in its ON and OFF conditions. A JFET operates best as a series-pass switch when the ON condition allows  $R_{ON}$  and shunt capacitance to be low, and series-pass capacitance to be high. But in the OFF condition, it should exhibit low series-pass capacitance and high series-pass resistance ( $R_{OFF}$ ). The JFET will have these characteristics when properly matched to the driver.



- $C_{dg}$  = drain-gate capacitance
- $C_{gc}$  = gate-channel distributed capacitance
- $C_{sg}$  = source-gate capacitance
- $C_{ds}$  = drain-source capacitance
- $R_{ON}$  = ON impedance
- $R_{OFF}$  = OFF impedance

FIGURE 2. Series-Pass Switch and JFET Equivalent Circuits

Getting down to a low  $R_{ON}$  when the gate is turned ON is no problem. A JFET such as the 2N4391 has a maximum  $R_{ON}$  of  $30\Omega$  (see  $r_{ds(on)}$  in Table I). However, the parallel capacitance in the signal path can become fairly high—about 15 pF when drain, source and gate have the same potential ( $V_{DS} = V_{GS} = 0$ ). The simple answer to this dilemma is to drive the gate with a high AC impedance when the switch is closed. The shunt capacitance will be in series with a high impedance. Virtually all of the signal will then go through the JFET, the path of least resistance, rather than through the gate-to-ground connection.

Next problem. When the switch is OFF, high-frequency attenuation is the name of the game. It is depended upon to prevent the signal at the input from reaching the output. The JFET channel is, for all practical purposes, an open circuit because  $R_{OFF}$  of a quality JFET is over  $10^{12}\Omega$  although this decreases as frequency goes up. However, capacitive feedthrough is the most significant route across the switch. From *Figure 2c*,

$$C_{FEEDTHROUGH} = C_{ds} + \frac{C_{sg}C_{dg}}{C_{sg} + C_{dg}}$$

Feedthrough capacitance can be significant if the gate is not operated at AC ground. Minimizing the right-hand term by operating the gate at AC ground allows  $C_{ds}$  to become the pacing factor. If the gate is grounded,  $C_{ds}$  will be approximately 0.2 pF. In other words, the effective  $R_{OFF}$  of the switch depends directly on circuit design, not the JFET.

Now to put these principles to work. The best high-frequency switch is an N-channel JFET. Its gate should be biased positive from a high-impedance source for turn-on and biased negative through a low-impedance path for turn-off. Driving the switch ON through an RF choke sounds tempting, but it would be difficult to avoid resonances and oscillation bursts during some switching conditions. DC resistances could be increased to equal

or exceed  $R_S$  in parallel with  $R_L$ , but then the toggle rate would be kept down by the very high drive impedance.

We prefer the circuits in *Figure 1*, which are fairly fast and not tricky. When NPN transistor Q2 is in saturation, Q1 is biased OFF through a low-impedance path. The diode is slightly forward-biased and exhibits high capacitance. When Q2 turns OFF, D1's cathode is driven positive by R1. Now the diode is reverse-biased and exhibits high impedance and low capacitance. The charge that was stored on D1 discharges into the gate of Q1, allowing the JFET to be turned ON. Because there is no good discharge path available to the charge stored on Q1's gate, the gate will "follow" any signal swing in the analog input voltage. Adding R2 will ensure that the gate follows the signal even during DC conditions. Remember, however, that the  $R2/C_{sg}$  time constant will effect switching time and gate-source signal tracking.

Don't expect just any diode to work well; D1's capacitance is critical and should match that of the JFET ( $C_{D1} = C_{Q1}$ ). One good way of making sure that the JFET and the diode are well mated is to use the same type of JFET for both. The gate lead is 1 electrode of the diode and the drain and source leads are simply tied together to form the other electrode. The circuit in *Figure 1b* was optimized in this way.

Excellent high-frequency series switches can be made with 2N4091, 2N4092 and 2N4093 JFETs. RC time constants are short because of their low  $r_{ds(on)}$  and capacitance, and leakage is low. The 2N4391, 2N4392 and 2N4393 series is even better, having only 100 pA leakage and lower  $C_{iss}$ . Even though the 2N4416 is classed as an RF amplifier, it is also listed in Table I to illustrate that many of our other JFETs can solve special switching problems. This one does well in circuits requiring very low capacitance and leakage. Although the  $R_{ON}$  of an RF transistor is not specified, it can be estimated as  $r_{ds(on)} \cong 0.85/Y_{fs}$ , which is typically  $170\Omega$  for the 2N4416.

TABLE I. JFETs for High-Frequency Analog Signal Switching

TYPE NO.	BV <sub>GSS</sub> OR BV <sub>DGO</sub> (MAX)	I <sub>GSS</sub> (MAX)	C <sub>iss</sub> (MAX)	C <sub>rss</sub> OR C <sub>DGO</sub> (MAX)	r <sub>ds(on)</sub> (MAX)	t <sub>on</sub> (MAX)	t <sub>off</sub> (MAX)
2N4091	40V	0.2 nA	16 pF	5 pF	30Ω	25 ns	40 ns
2N4092	40V	0.2 nA	16 pF	5 pF	50Ω	35 ns	60 ns
2N4093	40V	0.2 nA	16 pF	5 pF	80Ω	60 ns	80 ns
2N4391	40V	0.1 nA	14 pF	3.5 pF	30Ω	15 ns	20 ns
2N4392	40V	0.1 nA	14 pF	3.5 pF	60Ω	15 ns	35 ns
2N4393	40V	0.1 nA	14 pF	3.5 pF	100Ω	15 ns	50 ns
2N4416	30V	0.1 nA	4 pF	0.8 pF	170Ω*		
2N4416A	35V	0.1 nA	4 pF	0.8 pF	170Ω*		

\*This value is not specified in RF amplifier JFETs; 170Ω is typical

# Noise of Sources

National Semiconductor  
John Maxwell  
February 1977



## INTRODUCTION

The elimination or minimization of noise is one of the most perplexing problems facing engineers today. Many preamplifiers and components come with outstanding noise specifications, only to disappoint the user. The problem is the difference between specification and application, as the amplifiers are specified under ideal conditions not the real conditions, (i.e., a transducer connected to the input). Many times the transducer noise is as large or even greater than the amplifier noise, degrading the signal to noise ratio. Before amplifier or component noise can be considered, familiarity with the source noise is essential.

## REVIEW OF NOISE BASICS

There are 3 types of transducers: resistive, capacitive and inductive. The noise of a passive network is thermal noise, generated by the real part of the complex impedance, as given by Nyquist's relation:

$$\overline{V_n^2} = 4kTR\text{Re}(Z) \Delta f \quad (1)$$

$$\overline{V_n^2} = \text{Mean square noise voltage (V}^2\text{)}$$

- k = Boltzmann's constant ( $1.38 \times 10^{-23}$  VAS/°K)
- T = Absolute temperature (°K)
- Re(Z) = Real part of complex impedance ( $\Omega$ )
- $\Delta f$  = Noise bandwidth (Hz)

The noise may be represented as a spectral density ( $V^2/\text{Hz}$ ) or more commonly in  $\mu V/\sqrt{\text{Hz}}$  or  $nV/\sqrt{\text{Hz}}$  and is given by:

$$e_n^2 = \frac{\overline{V_n^2}}{\Delta f} \quad (2)$$

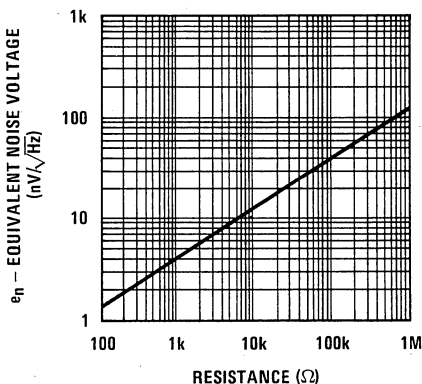


FIGURE 1. Thermal Noise Voltage vs Resistance

The total noise voltage in a frequency band can be readily calculated if it is white noise (i.e., Re(Z) is frequency independent). This is not the case for capacitive or inductive sources or most real world noise problems.

Rapidly changing network impedance and amplifier gain equalization combine to complicate the issue. The total source noise in a non-ideal case can be calculated by breaking the noise spectrum into several small bands where the noise (Re(Z)) is nearly white and calculating the noise of each band. The total source noise is the RMS sum of the noise in each of the bands  $N_1-N_n$ .

$$V_{\text{NOISE}} = (V_{N_1}^2 + V_{N_2}^2 + \dots + V_{N_n}^2)^{1/2} \quad (3)$$

The expression does not take amplifier gain equalization (like RIAA) into account, which will change the character of the noise at the amplifier output. By reflecting the gain equalization to the amplifier input and normalizing the gain to 0 dB at 1 kHz, the equalized source noise may then be calculated.

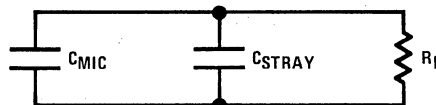
$$V_{\text{EQ}} = (|A_1|^2 V_{N_1}^2 + |A_2|^2 V_{N_2}^2 + \dots + |A_n|^2 V_{N_n}^2)^{1/2} \quad (4)$$

Where  $V_{\text{EQ}}$  = equalized source noise ( $\mu V$ ) and  $|A_n|$  = magnitude of the equalized gain at the center of each noise band (V/V).

## SOURCE NOISE

Models are needed for capacitive and inductive systems such that noise calculations can be made. Namely, the real part of the impedance needs to be determined.

A lumped model of a capacitive source, such as condenser or electret microphone, consists of the microphone and stray capacitance shunted by a load resistance.



$$Z = \text{Re}(Z) + j\text{Im}(Z) \quad (5)$$

$$\text{Re}(Z) = \frac{R}{1 + \omega^2 R^2 C^2}$$

$$|Z| = \left( \frac{R^2}{1 + \omega^2 R^2 C^2} \right)^{1/2}$$

FIGURE 2. Lumped Model of a Capacitive Microphone

It should be noted that for any particular microphone, the noise of the network ( $(C_m + C_s) // R_L$ ) is reduced by increasing  $R_L$  because Re(Z) (the real part of the impedance) is inversely proportional to  $R_L$  (see equation 5).

The inductive source (phono cartridges and tape heads) is more complex to analyze because it has a much more complex model. The simplified lumped model of a phono cartridge or tape head consists of a series inductance and resistance shunted by a small capacitor. Each phono cartridge or tape head has a recommended load con-

sisting of a specified shunt resistance and capacitance. A model for the inductive source and preamp input network is shown in *Figure 3*.

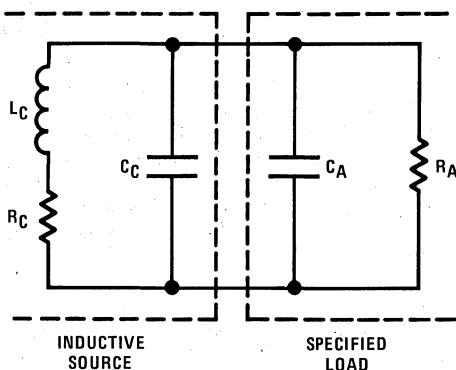
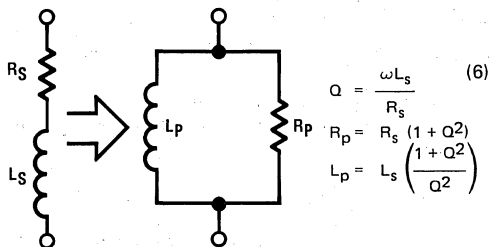


FIGURE 3. Phono Cartridge or Tape Head and Preamp Input Network

This circuit is quite formidable to analyze and needs further simplification. Through the use of Q equations, a series L-R is transformed to a parallel L-R.



Simplifying the input network to:

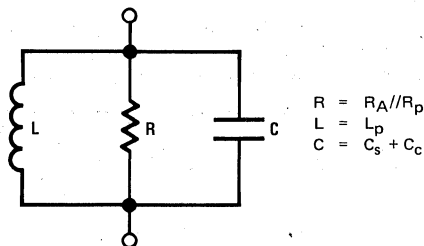


FIGURE 4. Simplified Inductive Source Network

$$\text{Re}(Z) = \frac{R X_L^2 X_C^2}{(R X_L - R X_C)^2 + X_L^2 X_C^2} \quad (7)$$

$$Z = \frac{R X_L X_C}{((R X_L - R X_C)^2 + X_L^2 X_C^2)^{1/2}}$$

$$X_L = \omega L$$

$$X_C = 1/\omega C$$

The tools are now available to calculate the noise of a variety of transducers and see how this unspecified noise affects amplifier (S/N) performance.

## EXAMPLES

Calculations of electret microphone noise with various loads and RIAA equalized phono cartridge noise is done using equations (1)–(7). Center frequencies and frequency bands must be chosen first. Values of the lumped circuit components calculated and noise calculated for each band, then summed for the total noise. Octave bandwidths starting at 25 Hz will be adequate for approximating the noise.

In this example, the microphone capacitance is 10 pF loaded with 5 pF of amplifier and stray capacitance. Two resistive loads will be used to illustrate the effect  $R_L$  has on the microphone noise.  $R_{L1} = 1G\Omega$  ( $10^9$ ),  $R_{L2} = 10G\Omega$  ( $10^{10}$ ). It is assumed that there is no gain equalization in the amplifiers that follow. The noise calculations are summarized in Table I.

The electret or condenser microphone noise ( $\text{Re}(Z)$ ) is reduced when the load resistance is increased. This is one of the cases when a larger resistance means lower noise, not more noise.

The second example is the calculation of the RIAA equalized noise of an ADC 27 phono cartridge loaded with  $C_A = 250$  pF and  $R_A = 47k$ . The cartridge constants are  $R_S = 1.13k$  and  $L_S = 0.75H$  ( $C_C$  may be neglected). The noise calculations are summarized in Table II for this example.

The RIAA equalized noise of the ADC 27 phono cartridge and preamp input network was  $0.73 \mu V$  for the audio band. Typical high quality preamps have noise voltages less than  $1 \mu V$ , resulting in a 3 dB or more loss in system S/N ratio when the cartridge noise is added to the preamp noise (in an RMS fashion).

## CONCLUSIONS

Zero noise sources and amplifiers do not exist. Specifying amplifier noise under ideal conditions will only lead to ideal specifications, not a measure of actual performance. Methods of S/N ratio measurement should be used that reflect the true performance instead of hollow specifications.

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TABLE I Summary of Electret Microphone Calculations

	25-50	50-100	100-200	200-400	400-800	800-1600	1600-3200	3200-6400	9600-12.8k	12.8k-20k
f Range (Hz)	25-50	50-100	100-200	200-400	400-800	800-1600	1600-3200	3200-6400	9600-12.8k	12.8k-20k
f Center (Hz)	37.5	75	150	300	600	1200	2400	4800	9600	16,400
fBw (Hz)	25	50	100	200	400	800	1600	3200	6400	7,200
for $R_L = 1G\Omega$										
Re(Z) ( $\Omega$ )	74.2M	19.6M	4.98M	1.25M	0.31M	78k	19k	4.9k	1.22k	420
Z  ( $\Omega$ )	272M	140M	70.6M	35.4M	17.7M	8.8M	4.4M	2.2M	1.1M	650
$e_{nz}$ (nV/ $\sqrt{Hz}$ )	1100	560	280	140	71	36	18	9	4.5	2.8
$V_{nz}$ ( $\mu V$ )	5.5	3.96	2.8	1.98	1.42	1.02	0.72	0.51	0.36	0.24
$V_{nz}^2$ ( $\mu V^2$ )	30.2	15.7	7.84	3.92	2.0	1.04	0.52	0.26	0.13	0.06
$(\Sigma V_{nz}^2)^{1/2} \approx 7.9 \mu V$										
$R_L = 10G\Omega$										
Re(Z) ( $\Omega$ )	8M	2M	0.5M	125k	31.3k	7.8k	2k	500	122	42
Z  ( $\Omega$ )	283M	141M	70.8M	35.4M	17.7M	8.8M	4.4M	2.2M	1.1M	650k
$e_{nz}$ (nV/ $\sqrt{Hz}$ )	320	180	90	45	23	11.4	5.8	2.9	1.4	0.84
$V_{nz}$ ( $\mu V$ )	1.6	1.3	0.9	0.64	0.46	0.32	0.232	0.16	0.112	0.07
$V_{nz}^2$ ( $\mu V^2$ )	2.56	1.62	0.81	0.41	0.21	0.103	0.054	0.025	0.013	0.005
$(\Sigma V_{nz}^2)^{1/2} \approx 2.4 \mu V$										

TABLE II. Summary of Phono Cartridge Calculations

	25-50	50-100	100-200	200-400	400-800	800-1.6k	1.6k-3.2k	3.2k-6.4k	6.4k-12.8k	12.8k-20k
f Range (Hz)	25-50	50-100	100-200	200-400	400-800	800-1.6k	1.6k-3.2k	3.2k-6.4k	6.4k-12.8k	12.8k-20k
f Center (Hz)	37.5	75	150	300	600	1200	2400	4800	9600	16.4k
fBw (Hz)	25	50	100	200	400	800	1600	3200	6400	7.2k
Q = ( $\omega L_s/R_s$ )	0.156	0.313	0.625	1.25	2.5	5	10	20	40	68.4
Q2	0.0244	0.098	0.391	1.56	6.25	25	100	400	1600	4678.6
1 + Q2	1.0244	1.098	1.391	2.56	7.25	26	101	401	1601	4679.6
1 + Q2/Q2	42	11.24	3.56	1.64	1.16	1.04	1.01	1.0	1.0	1.0
$R_p$ ( $\Omega$ )	1.16k	1.24k	1.57k	2.9k	8.2k	29.4k	114k	454k	1.8M	5.29M
$L_p$ (H)	31.5	8.43	2.67	1.23	0.87	0.78	0.76	0.75	0.75	0.75
$R_p/R$ ( $\Omega$ )	1.13k	1.21k	1.52k	2.74k	7k	18.1k	32.9k	42.6k	45.8k	46.6k
$X_L$ ( $\Omega$ )	7.42k	3.97k	2.52k	2.32k	3.28k	5.88k	11.45k	22.6k	45.2k	77.2k
$X_c$ ( $\Omega$ )	17M	8.48M	4.24M	2.12M	1.06M	0.53M	0.265M	0.133M	66.3k	38.8k
Re(Z) ( $\Omega$ )	1.11k	1.11k	1.11k	1.15k	1.26k	1.73k	3.86k	12.4k	41.5k	34k
Z  ( $\Omega$ )	1.12k	1.15k	1.3k	1.77k	2.97k	5.59k	11.7k	24.4k	43.6k	40.1k
$e_{nz}$ (nV/ $\sqrt{Hz}$ )	4.24	4.24	4.24	4.31	4.51	5.29	7.9	14.2	26	23.5
$V_N$ (nV)	21.2	30	42.4	61	90.2	149.6	316	803	2080	1994
$V_N^2$ (nV <sup>2</sup> )	449.4	900	1798	3721	8136	22.4k	99.9k	645k	4.33M	3.98M
$A^2$	63.0	29.5	10.7	3.85	1.66	0.85	0.49	0.154	0.043	0.019
$A^2 V_N^2$ (nV <sup>2</sup> )	28.3k	26.6k	19.2k	13.2k	13.5k	19k	48.9k	99.3k	186k	76k

$(\Sigma V_n^2)^{1/2} = 3 \mu V$  unequalized noise

$(\Sigma 1A_n 12V_n^2)^{1/2} = 0.73 \mu V$  RIAA equalized noise



# The Noise Figure Fallacy

National Semiconductor  
John Maxwell  
February 1977



Noise Figure (NF) can be one of the most misleading specifications confronting the engineer today. Noise Figure is defined as the ratio of total output noise power to the output noise power of the source.

$$NF = 10 \text{ Log } \frac{\text{Total output noise power}}{\text{Output noise power of the source}} \quad (1)$$

A minimum NF exists for any amplifier, but is usually far removed from the actual operating conditions. This is where the problem begins. Lowering the NF doesn't always lower the noise which is what the engineer is really interested in. NF only gives the designer insight into the ratio of the amplifier noise to the source noise, not the input noise of the amplifier or the signal to noise ratio.

Amplifier noise performance is adequately described by modeling the noise sources as a series voltage generator and a shunt current generator with a series voltage generator for the source resistance noise.

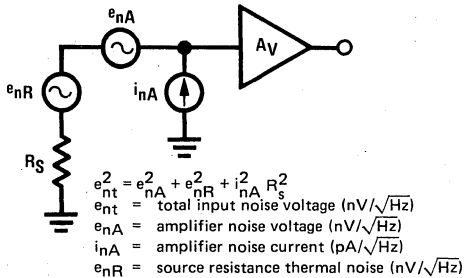


FIGURE 1. Simplified Amplifier Noise Model

The amplifier noise data is found on vendor data sheets in the form of  $e_n$  and  $i_n$  vs frequency for bipolar transistors and  $e_n$  vs frequency for FETs and FET amplifiers.

Current noise depends on amplifier input bias current which is only a few picoamps for FETs and is therefore negligible. However, bipolar transistor amplifiers have bias currents into the microamp range where current noise is significant.

The thermal noise of the source resistance is given by Nyquist's relation.

$$\overline{V_R^2} = 4kTR\Delta f \quad (2)$$

$\overline{V_R^2}$  = mean square noise voltage ( $V^2$ )  
 $k$  = Boltzmann constant ( $1.38 \times 10^{-23}$  VAS/ $^\circ\text{K}$ )  
 $T$  = absolute temperature ( $^\circ\text{K}$ )  
 $R$  = resistance ( $\Omega$ )  
 $\Delta f$  = noise bandwidth (Hz)

with the spectral density given by  $e_n^2$

$$e_{nR} = (\overline{V_R^2} / \Delta f)^{1/2} \quad (3)$$

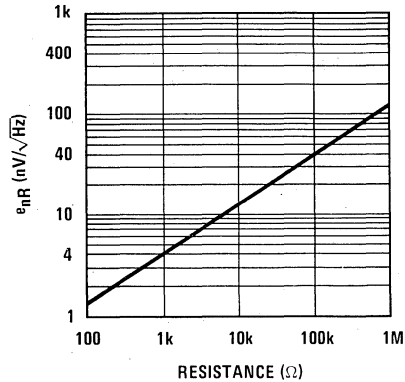


FIGURE 2. Thermal Noise vs Resistance

Using the model of Figure 1, an expression of noise figure in terms of the noise generators can be developed.

The noise power of the source can be found by using Nyquist's relation.

$$\text{Source Noise Power} = \frac{\overline{V_R^2}}{R^2} = \frac{e_{nR}^2 \Delta f}{R^2} \quad (4)$$

with the total output noise power at the input of the amplifier of:

$$\text{Total noise power} = \frac{e_{nR}^2 \Delta f}{R^2} + \frac{e_{nA}^2 \Delta f}{R^2} + i_{nA}^2 R^2 \Delta f \quad (5)$$

Yielding

$$NF = 10 \text{ Log } \left[ 1 + \frac{e_{nA}^2 + i_{nA}^2 R^2}{e_{nR}^2} \right] \quad (6)$$

Noise figure has a minimum that occurs at an optimum source resistance  $R_{opt}$ .

$$R_{opt} = \frac{e_{nA}}{i_{nA}} \quad (7)$$

Artificially changing the source resistance for minimum NF will generally increase the circuit noise as demonstrated by the following example.

Example:

An amplifier is needed to boost the signal from a resistive transducer.

Amplifier requirements

$A_v = 100$   
 $f = 10 \text{ Hz to } 10 \text{ kHz}$   
 Transducer =  $10 \text{ k}\Omega$

Amplifier—LF356  
 Noise data,  $e_n = 12 \text{ nV}/\sqrt{\text{Hz}}$  @ 1 kHz  
 $i_n = 0.01 \text{ pA}/\sqrt{\text{Hz}}$  @ 1 kHz

The optimum source resistance for the amplifier is found to be 12M (using equation (7)). Using Figure 2, the noise of the transducer is  $12 \text{ nV}/\sqrt{\text{Hz}}$  and the noise of the optimum source resistance is  $140 \text{ nV}/\sqrt{\text{Hz}}$ .

Using the non-inverting amplifier configuration, we'll view the effect of  $R_{opt}$ . In one case, resistance will be added to the source to equal the amplifier optimum

source resistance (not affecting gain). The other case will only have the transducer connected to the input.

We will neglect the noise of the feedback resistors and determine the input noise and NF for both configurations using equations (1)–(6).

Case A, minimum NF

$$\text{Total input noise } V_n = e_{nt}(\Delta f)^{1/2} = 14 \mu\text{V}$$

$$\text{NF} = 0.06 \text{ dB}$$

Case B, minimum noise

$$V_n = 1.7 \mu\text{V}$$

$$\text{NF} = 3 \text{ dB}$$

Noise figure is only a measurement of the amplifier noise relative to the source noise. The example used was radical, but it illustrated a very important point. Resistance should never be added in series with the source to improve the NF. The NF will improve but the input noise will suffer, degrading performance. Total input noise should always be considered allowing problem sources to be identified and minimized to meet the system's specific noise requirements.

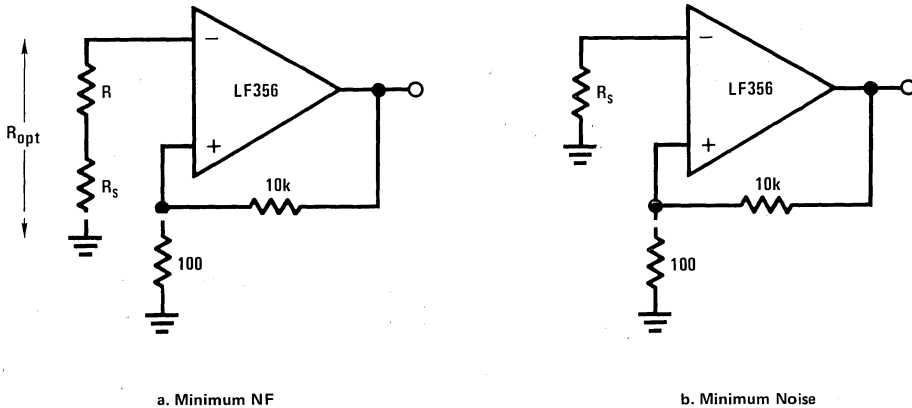


FIGURE 3. 2 Amplifier Solutions

# Low Noise FET Amplifiers

National Semiconductor  
John Maxwell  
March 1977



## INTRODUCTION

Discrete JFETs reign supreme as low noise amplifiers. JFETs are virtually free from the problems of current noise, popcorn noise and limited bandwidth which plague bipolar transistors and bipolar input op amps.

Unfortunately, JFETs are cumbersome to use because of low gain and the need of extensive biasing networks. However, monolithic op amps are cheap and easy to use but suffer from poor noise performance. By combining JFETs with an op amp yields single and differential input amplifiers that have the best of both worlds; low noise, high gain and ease of use.

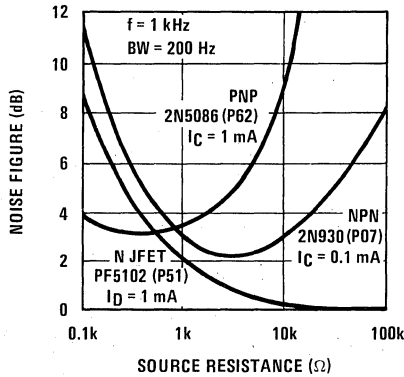


FIGURE 1. Bipolar and JFET Transistor Noise Comparison

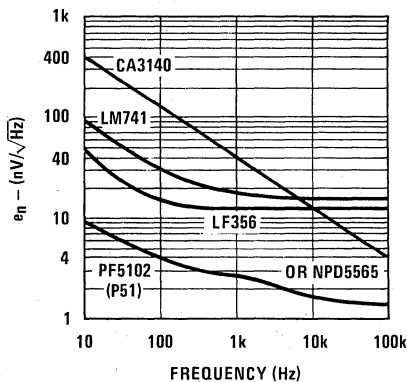


FIGURE 2. Discrete JFET and Op Amp Noise Comparison

The main problem with JFETs is that the voltage gain is limited by the size of the load resistance which is limited by the power supply voltage and the FET operating current. The voltage gain can be increased by combining the JFET (a transconductance amplifier) with an op amp

current to voltage (I/V) amplifier, circumventing the limited load resistor.

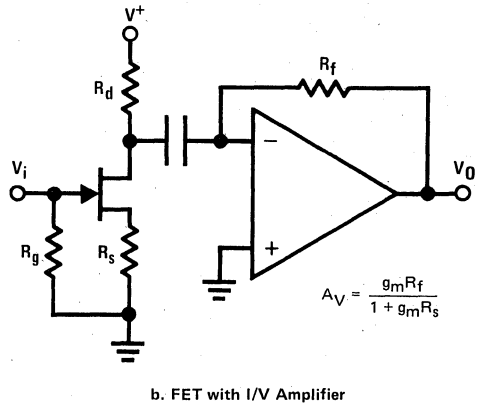
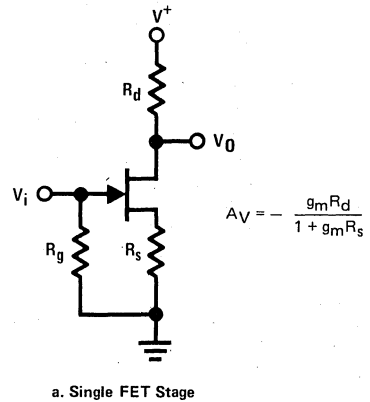


FIGURE 3. FET Gain Stages

In the FET/op amp configuration, the FET AC drain current is shunted to the op amp virtual ground and through its feedback resistor, bypassing the FET drain resistor,  $R_d$ . The drain resistor is used to bias the FET in a linear region with the feedback resistor,  $R_f$ , used to set the gain.

Biasing problems associated with lot and device to device parameter variations are minimized by biasing the source through a large resistor to the negative supply of the op amp. A portion of the source resistor should be unby-passed to minimize gain variations between FETs.

From a design standpoint, the maximum AC drain current should be 1/10 of the FET quiescent current for low distortion. The unbypassed portion of the source resistor should be limited to 220Ω for minimum noise and to increase the op amp feedback resistor (decreased AC current).

Expressions for the single and differential amplifier configurations are needed for optimizing the noise to meet system noise requirements.

Amplifier noise performance is adequately described by modeling the noise sources as a series voltage generator

and a shunt current generator with a series voltage generator for the source resistance thermal noise. The thermal noise of a resistor is given by Nyquist's relation and has a spectral density given by  $e_{nR}^2$ .

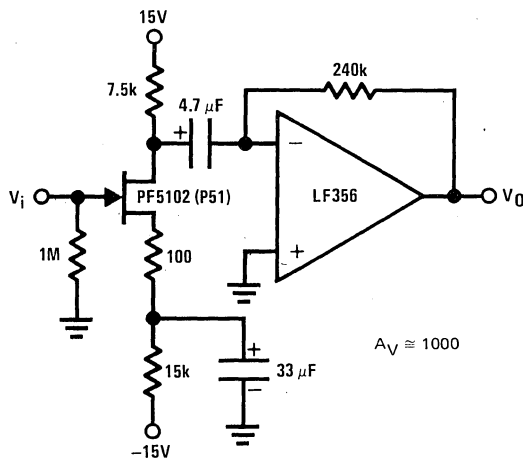
$$e_{nR}^2 = 4kTR \tag{1}$$

$e_{nR}^2$  = mean square noise voltage per unit bandwidth ( $nV^2/Hz$ )

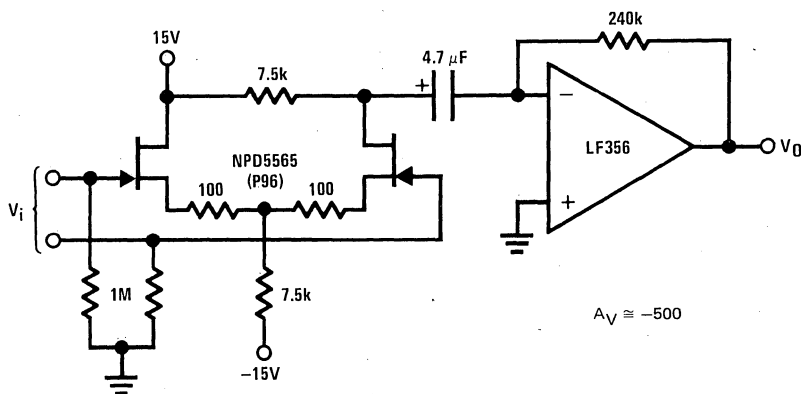
k = Boltzmann constant ( $1.38 \times 10^{-23} \text{VAS}/^\circ\text{K}$ )

T = absolute temperature ( $^\circ\text{K}$ )

R = resistance ( $\Omega$ )



a. Single-Ended



b. Differential Input

FIGURE 4. High Gain FET/Op Amp AC Amplifiers

The single ended and differential input amplifier input noise (FET noise current is negligible) is given by the RMS sum of the noise generators.

Single-Ended:

$$e_{nt}^2 = e_{nf}^2 + e_{ns}^2 + \left( \frac{1 + g_m R_s}{g_m R_d} \right)^2 (e_{nA}^2 + e_{nR}^2 + i_{nA}^2 R^2)$$

Differential Input:

$$e_{nt}^2 = 2(e_{nf}^2 + e_{ns}^2) + 4 \left( \frac{1 + g_m R_s}{g_m R_d} \right)^2 (e_{nA}^2 + e_{nR}^2 + i_{nA}^2 R^2)$$

with

- $e_{nt}$  = total input noise voltage (nV/ $\sqrt{\text{Hz}}$ )
- $e_{nf}$  = FET noise voltage (nV/ $\sqrt{\text{Hz}}$ )
- $e_{nA}$  = op amp noise voltage (nV/ $\sqrt{\text{Hz}}$ )
- $i_{nA}$  = op amp noise current (pA/ $\sqrt{\text{Hz}}$ )
- $e_{ns}$  = source resistor thermal noise (nV/ $\sqrt{\text{Hz}}$ )
- $e_{nR}$  = drain and feedback ( $R_d//R_f$ ) resistor thermal noise (nV/ $\sqrt{\text{Hz}}$ )
- $g_m$  = FET transconductance at the FET operating current (mmho)
- $R$  = parallel resistance of  $R_d$  and  $R_f$  ( $\Omega$ )

The differential configuration has higher noise and lower gain than the single-ended version, but is useful when

low distortion or balanced inputs are of paramount importance.

The noise of the op amp and the FET drain resistor is reduced by the gain of the FET portion of the amplifier  $\frac{g_m R_d}{1 + g_m R_s}$ . The noise of the feedback resistor has little effect on the noise but in conjunction with the drain resistor, it can have a dramatic effect on the total circuit noise. The drain resistor is the input leg of an inverting amplifier with the op amp and the feedback resistor. This amplifier has a gain of  $-R_f/R_d$  which boosts the op amp noise, limiting the size of  $R_f$  to about 390k.

Practical low noise, high gain AC amplifiers can be built using a low noise JFET and just about any op amp. The op amp needs to meet the slew rate and bandwidth requirements of the circuit, eliminating selected low noise op amps or complex discrete amplifiers.

A note of caution is in order for the op amp noise. Virtually any JFET input or bipolar input op amp can be used without trouble, but MOSFET input op amps should be avoided. MOSFET 1/f noise is one or more orders of magnitude greater than discrete JFETs, JFET op amps or bipolar input op amps. MOSFETs have 1/f corner frequencies (where the noise power rises as 1/f) starting as high as 100 kHz. The other forms of amplifiers have 1/f corner frequencies of 1 kHz and less. Quite a difference.

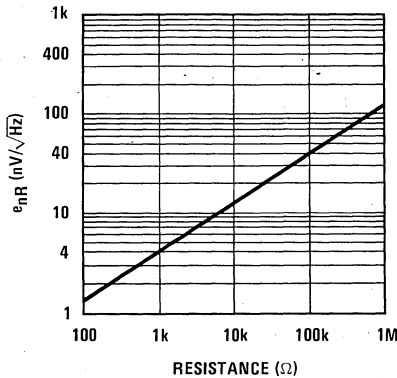


FIGURE 5. Thermal Noise vs Resistance

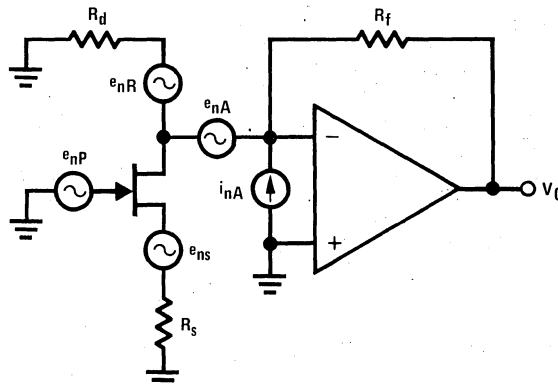


FIGURE 6. Single-Ended Noise Model

# The Low Noise JFET— The Noise Problem Solver

National Semiconductor  
Application Note 151  
John Maxwell  
January 1976



The most versatile low noise active device available to the designer today is the Junction Field-Effect Transistor (JFET). JFETs are virtually free of the problems which have plagued bipolar transistors—limited bandwidth, popcorn noise, a complex design procedure to optimize noise performance. In addition, JFETs offer low distortion and very high dynamic range.

Most designers think of JFETs for very high source impedances. However, modern devices offer the designer performance improvements over bipolar transistors in NF for all but lowest impedance (<500Ω) sources and even then may provide improved performance if popcorn noise, bandwidth or circuit component noise is a consideration (see Figure 1).

Therefore, the purpose of this article is to review low noise design procedures and indicate the simplicity of designing high performance low noise amplifiers with low cost JFETs.

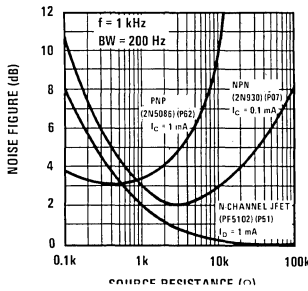


FIGURE 1. Bipolar and JFET Transistor Noise Comparison

## REVIEW OF BASICS

Before guidelines are established for designing low noise JFET amplifiers, a method of noise characterization must be chosen. Designers are confronted with a multitude of different noise parameters such as Noise Figure (NF), noise voltage and current densities, noise temperature, noise resistance, etc. Designers are primarily concerned with signal to noise (S/N) ratios preferring noise voltage, ( $e_n$ ) and current ( $i_n$ ) density.

Noise generally manifests itself in three forms: thermal noise, shot noise and flicker or "1/f" noise. Thermal noise arises from thermal agitation of electrons in a conductor and is given by Nyquist's relation:

$$\overline{V_R^2} = 4k TR \Delta f \quad (1)$$



- $\overline{V_R^2}$  = mean square noise voltage
- k = Boltzmann constant  
( $1.38 \times 10^{-23}$  VAS/°K)
- T = Absolute temperature (°K)
- R = Resistance in ohms
- $\Delta f$  = Noise bandwidth (Hz)

The noise of a resistor may be represented as a spectral density ( $V^2/Hz$ ) or more commonly in  $\mu V/\sqrt{Hz}$  or  $nV/\sqrt{Hz}$  and is given by:

$$e_{nR} = (\overline{V_R^2}/\Delta f)^{1/2} \quad (2)$$

It is sometimes more convenient to represent thermal noise as noise current instead of a noise voltage. One needs only to consider the Norton equivalent yielding a noise current density.

$$i_{nR} = \frac{e_{nR}}{R} = \left(\frac{4kT}{R}\right)^{1/2} \quad (3)$$

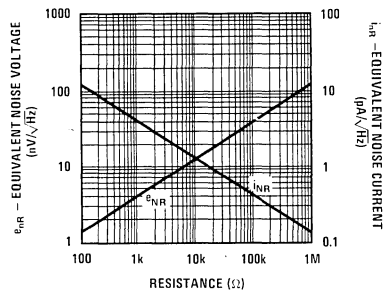


FIGURE 2. Thermal Noise Voltage and Current Densities vs. Resistance.

The second basic form of noise, shot noise, is due to the randomness of current flow (discrete charge particles) in semiconductor P-N junctions.

$$\overline{i^2} = 2qI_{DC}\Delta f \quad (4)$$

$\overline{i^2}$  = Mean square noise current

q = Charge of an electron ( $1.6 \times 10^{-19}$  AS)

$I_{DC}$  = dc current flowing through the junction (A)

$\Delta f$  = Noise bandwidth (Hz)

As with thermal noise, shot noise may be represented as a current density ( $A^2/Hz$ ) or  $pA/\sqrt{Hz}$ .

$$i_n = (\overline{i^2}/\Delta f)^{1/2} \quad (5)$$

It should be noted that both thermal noise and shot noise are "white" noise sources, i.e., frequency independent.

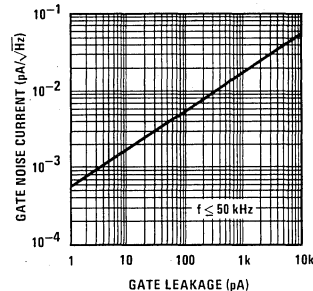


FIGURE 3. Current Noise vs. Gate Leakage Current

The third basic noise source confronting designers is flicker or "1/f" noise whose density is roughly inversely proportional to frequency starting at about 1 kHz in both JFETs and bipolar transistors and increasing as frequency is decreased. Through careful processing, flicker noise in JFETs has been reduced to levels nearly insignificant to the designer. Flicker noise in JFETs is primarily a noise voltage and is source independent. Flicker noise in bipolar transistors is a function of base and leakage currents increasing with increased source impedance or operating currents.

A simple noise model of a JFET or any amplifying device may be constructed using a thermal and shot noise source which would adequately describe its noise performance allowing signal to noise ratios to be calculated directly.

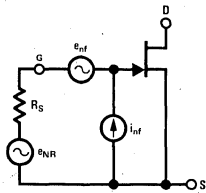


FIGURE 4. Simple JFET Noise Model

The input noise per unit bandwidth at some frequency may be calculated from the mean square sum of the noise sources (assuming the JFET noise sources are uncorrelated or independent of one another).

$$e_{nt}^2 = e_{nR}^2 + e_{nf}^2 + i_{nf}^2 R_s^2 \quad (6)$$

The total noise in the same bandwidth  $\Delta f$ , where the noise sources are independent of frequency, is simply:

$$V_{NOISE} = (e_{nt}^2 \Delta f)^{1/2} \quad (7)$$

Practically, noise sources are not frequency independent except resistor noise with no dc bias. The total input noise for the nonideal case may be calculated by breaking the spectrum up into several small bands and calculating the noise in each band where the noise sources are nearly frequency independent. The total input noise would then be the RMS sum of the noise in each of the bands  $N_1 \dots N_n$ .

$$V_{NOISE} = (V_{N1}^2 + V_{N2}^2 + \dots + V_{Nn}^2)^{1/2} \quad (8)$$

### THE DESIGN PROCESS

The final circuit configuration and suitable JFET will be determined by the external circuit constraints.

- 1) Minimum signal to noise ratio (maximum amplifier noise)
- 2) Type and magnitude of source impedance (resistive or reactive)
- 3) Amplifier input impedance requirements
- 4) Bandwidth and maximum frequency of interest
- 5) Maximum operating temperature

- 6) Stage gain
- 7) Power supply voltage and current limitations
- 8) Circuit configuration, single or dual device

The design procedure is dependent on the type of source and each case must be considered separately. Resistive sources will be considered first because they are the least restrictive for the preamplifier.

### Resistive Sources

Preamplifiers for resistive sources are typically voltage amplifiers requiring a fixed input resistance and capacitance consistent with the maximum frequency of interest and source resistance. In most cases a resistor of the desired value connected between the gate and ground will satisfy the input resistance requirement leaving the maximum input capacitance as the major concern.

The maximum amplifier input capacitance is a function of the JFET source resistor, input resistance, source capacitance and maximum frequency. The maximum allowable input capacitance will be used in eliminating unsuitable JFET geometrics and optimizing the circuit configuration. Sometimes the JFET geometry (or type) with the lowest noise may also have an input capacitance that makes it unsuitable. The JFET input capacitance should be considered before noise in high source resistance, wideband amplifier designs.

$$C_{in} \cong C_{rs} \left( 1 + \frac{gm R_D}{1 + gm R_s} \right) + \frac{C_{gs}^*}{1 + gm R_s} \quad (9)$$

$$*C_{gs} = C_{is} - C_{rs}$$

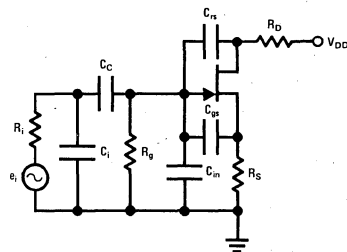


FIGURE 5. A Typical Resistive Source JFET Amplifier

If low input capacitance is required, a cascode configuration minimizes input capacitance and still allows high gain within a device type. The cascode configuration can also be used to reduce the voltage across a device, reducing device heating (for high current operation) and gate leakage currents when source impedances are very high.

Once the basic circuit configuration has been decided upon or dictated by gain, bandwidth and power supply limitations, the final JFET selection will be on noise. Redrawing the amplifier in Figure 4 with all of the noise sources, the total amplifier noise per unit bandwidth can be found.

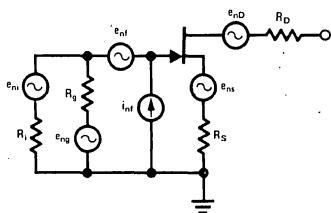


FIGURE 6. A Typical Resistive Source JFET Amplifier with Noise Sources

$$e_{nt} = \left[ e_{nig}^2 + e_{nf}^2 + e_{ns}^2 + \frac{e_{nd}^2}{A_v^2} + i_n^2 (R_i // R_g)^2 \right]^{1/2} \quad (10)$$

- where:  $e_{nig}^2$  = The noise of the parallel connection of  $R_i$  and  $R_g$   
 $e_{nf}^2$  = The noise voltage of the JFET  
 $e_{ns}^2$  = The noise of the source resistor  $R_s$   
 $\frac{e_{nd}^2}{A_v^2}$  = The noise at the drain (thermal noise of the load plus the second stage noise)  
 $i_n^2 (R_i // R_g)^2$  = The current noise contribution of the JFET

When the amplifier is operated at room temperature and moderate drain voltages, the current noise term is usually negligible with source resistances as high as 10 MΩ. Depending on the voltage gain of the stage, the drain circuit noise may be negligible, simplifying the input noise expression.

$$e_{nt} = (e_{nig}^2 + e_{nf}^2 + e_{ns}^2)^{1/2} \quad (11)$$

The final JFET selection will be based on the noise requirements from the maximum allowable noise  $V_{MAX}$ .

$$V_{MAX} = (e_{nf}^2 + e_{ns}^2)^{1/2} \quad (12)$$

Depending on  $V_{MAX}$  and  $e_{nf}^2$  the source resistor may have to be bypassed to ground to eliminate noise of the bias resistor.

### Capacitive Sources

Preamplifiers for capacitive sources are primarily current amplifiers requiring very high input resistance and controlled input capacitance to match the source capacitance.

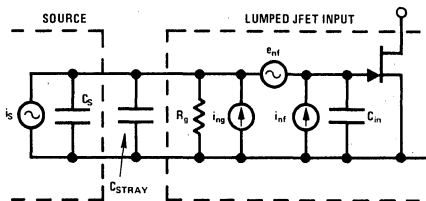


FIGURE 7. JFET Preamplifier with a Capacitive Source

The source capacitance should equal the sum of the preamplifier input capacitance and the stray capacitance for maximum frequency response and power transfer

from the signal source. Assuming the gate resistor,  $R_g$ , is so large as to not load the capacitive source, the input noise voltage is:

$$e_{nt} \cong \left[ e_{nf}^2 + (i_{nf}^2 + i_{ng}^2) \left( \frac{R_g^2}{(1 + \omega^2 R_g^2 C^2)} \right) \right]^{1/2} \quad (13)$$

where  $C = C_s + C_{in}$

with an input signal of

$$e_s \cong i_s \left( \frac{R_g^2}{1 + \omega^2 R_g^2 C^2} \right)^{1/2} \quad (14)$$

When the source and input capacitance are matched, the final JFET geometry will be selected on two criteria: the noise voltage,  $e_n$ , and the current noise from the gate leakage,  $I_{G(ON)}$ , to optimize the signal to noise ratio. As in the resistive source case, the circuit configuration and JFET selection is an iterative process using all of the external circuit constraints and device parameters and limitations.

### Inductive Sources

Amplifiers designed for inductive sources (including transformers) require fixed input resistances (as in the resistive source case) and controlled input capacitance (as in the capacitive source case). The input noise per unit bandwidth will rise with increasing frequency to a maximum value at resonance of the inductive source and the input capacitance or when the shunt resistance of the inductor is larger than the input resistance of the amplifier.

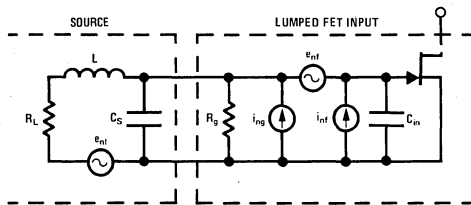


FIGURE 8. JFET Amplifier with an Inductive Source

The inductive source amplifier is the most difficult to analyze due to the complex input impedance. The input noise per unit bandwidth is given by:

$$e_{nt}^2 = e_{nf}^2 + (i_{nf}^2) (|Z_{in}|^2) + 4 kT (R_e (Z_{in})) \quad (15)$$

where  $Z = X_{CIN} // R_g$

and  $Z_{in} = Z // (Z_L + R_L)$

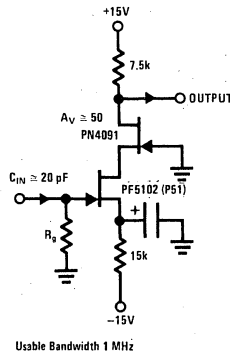
Usually the current noise of the JFET is negligible, simplifying the expression a little, but not much. The optimization process for inductive sources is very complex and it will require the spectrum to be broken up into several small bands to arrive at a final design. Generally, a JFET with a minimum noise voltage will be the proper choice.



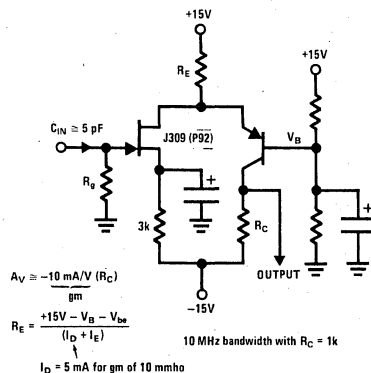
Transformers may be used with JFET amplifiers to minimize noise with very low source impedances. Transformers have both drawbacks and advantages and both must be examined before a transformer design is chosen. Poor frequency response, susceptibility to mechanical and magnetic pickup and thermal noise head the list of disadvantages to be weighed against two very important advantages. First, the noise voltage is transformed by the turns ratio  $N$ ; second, the resistance is transformed by  $N^2$ . These can be used to advantage by matching very low values of source resistance to a relatively noisy amplifier and still maintaining a good signal to noise ratio, i.e., the total noise at the source assuming an ideal transformer is

$$e_{nt}^2 = e_{nRs}^2 + \frac{e_{nAmp}^2}{N^2} \quad (16)$$

**SOME PRACTICAL LOW NOISE JFET INPUT CIRCUITS**



**a) Wide Band, Low Input Capacitance, Very Low Noise Preamplifier**



**b) Low Noise, Very Low Input Capacitance Video Amplifier**

**SUMMARY**

Low noise amplifier design concepts have been introduced for the three basic types of sources. Basic parameters ( $C_{in}$ ,  $e_n$ ,  $g_m$ ) were discussed that affect both circuit configuration and JFET type. There is no universal low noise JFET or circuit configuration that solves all problems. Each low noise amplifier design is different and must be considered within its own framework of performance requirements.

**REFERENCES**

A. Van der Ziel, "Noise," Prentice-Hall, 1954.  
 Richard S.C. Cobbold, "Theory and Applications of Field-Effect Transistors," John Wiley & Sons, 1970.  
 C.D. Motchenbacher and F.C. Fitchen, "Low Noise Electronic Design," John Wiley & Sons, 1973.

APPENDIX A

Important National JFET Process Parameter Guide

Test Conditions  $V_{DS} = 15V, I_D = 1\text{ mA} (V_{GS} = 0V)^*$

PROCESS	$e_n @ 10\text{ Hz}$ ( $nV/\sqrt{\text{Hz}}$ )	$e_n @ 1\text{ kHz}$ ( $nV/\sqrt{\text{Hz}}$ )	$e_n @ 100\text{ kHz}$ ( $nV/\sqrt{\text{Hz}}$ )	$g_{fs}$ (mmho)	$I_{G(ON)}$ ( $\mu A$ )	$C_{GD}$ (pF)	$C_{GS}$ (pF)
50	15	5	2.5	3	5V 2 $\mu A$ 10V 10 $\mu A$ 15V 1 nA	0.7	2.5
51	5	3	1.3	7	30	3	9
55	10	4	2.5	2.4	5	2	4
92	10	4	1.5	4.5	10V 20 $\mu A$ 15V 1 nA	2	4
83	10	5	2.5	2	5	1	2.5
84*	50	15	9	0.2	0.1	0.01	2
94	10	5	2.5	2	1-2	0.01	4
95	10	4	2.5	1.5	15	3.5	15
96	5	3	1.3	7	30	3	9
93	15	7	2	3.5	10V 20 $\mu A$ 15V 1 nA	1	3.2

National JFET Process Low Noise Amplifier Guide

PROCESS	50	51	55	92	83	84	93	94	95	96
Low Noise Application	Single JFET				Dual JFET					
Resistive Ultra-Low $e_n < 5\text{ nV}/\sqrt{\text{Hz}}$ @ 10 Hz		X								X
Resistive Low Freq < 20 kHz		X	X		X			X	X	X
Resistive Wideband < 10 MHz	X	X		X	X		X	X	X	X
Resistive Wide Band > 10 MHz	X			X			X			
Resistive Very High $R_S > 10\text{ M}\Omega$	X					X		X		
Capacitive Low C < 10 pF	X		X	X	X	X	X	X		
Capacitive High C > 20 pF		X	X						X	X
Inductive	X	X	X	X	X	X	X	X	X	X

APPENDIX B

NOISE PARAMETER CONVERSION

Noise Figure (NF) to an Effective  $e_n$

It is more convenient to present noise data for bipolar transistors in the form of contours of constant noise figure at a fixed frequency or plots of noise figure versus frequency at a fixed source resistance due to large values of noise current ( $i_n$ ). Noise figure must be converted to an effective noise voltage ( $e_{nE}$ ) for comparisons to be made between a BJT and a JFET or for signal to raise ratio calculations.

By definition:

$$NF = 10 \log \frac{\text{Total Output Noise Power}}{\text{Output Noise Power of the Source}} \quad (B1)$$

From equations 1 and 2, one finds the source noise power to be

$$\text{Source Noise Power} = \frac{e_{nR}^2 \Delta f}{R_S} \quad (B2)$$

for some source resistance  $R_S$ .

Referring to *Figure 4*, the total output noise power at the input of the amplifier would be:

$$\text{Total Output Noise Power} = \frac{e_{nR}^2 \Delta f}{R_S} + \frac{e_{nf}^2 \Delta f}{R_S} + i_{nf}^2 R_S^2 \Delta f \quad (B3)$$

The noise figure (NF) can now be expressed in terms of the noise source generators,  $e_{nR}$ ,  $e_{nf}$  and  $i_{nf}$  allowing an expression to convert noise figure (NF) to an effective noise voltage ( $e_{nE}$ ).

$$NF = 10 \log \left( 1 + \frac{e_{nf}^2 + i_{nf}^2 R_S^2}{e_{nR}^2} \right) \quad (B4)$$

yielding

$$e_{nf}^2 + i_{nf}^2 R_S^2 = e_{nE}^2 = (10^{NF/10} - 1) e_{nR}^2 \quad (B5)$$

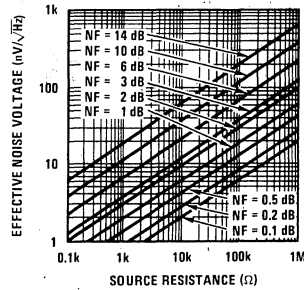


FIGURE B1. Effective Noise Voltage ( $e_{nE}$ ) vs Noise Figure and Source Resistance ( $R_S$ )

Noise Resistance

The effective noise voltage density ( $e_n$ ) and noise current density ( $i_n$ ) are found directly by referring to *Figure 1*, and reading the values for the corresponding resistances.

$$e_{nR} = (4 KTR)^{1/2} \quad (1)$$

$$i_{nR} = \left( \frac{4 KT}{R} \right)^{1/2} \quad (3)$$

APPENDIX C

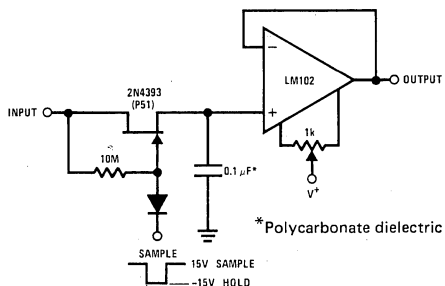
JFET Current Noise

At low frequencies the current noise and voltage noise sources are uncorrelated in JFETs with the current noise being pure shot noise due to gate leakage currents. As frequency is increased, the current noise also increases starting at frequencies as low as 50 kHz in some high capacitance device types.

It has been suggested and experimentally verified that the noise current at high frequencies is due to increased gate input conductance.

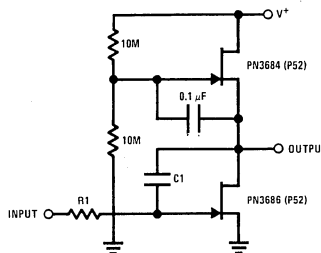
$$i_n^2 = 4 KT [\text{Re} (Y_{11})]^{-1} \quad (C1)$$

$\text{Re} (Y_{11})$  is available on high frequency JFET data sheet as the real portion of the common source input admittance parameters. In effect the channel noise is coupling to the gate circuit through the source-gate and drain gate capacitances. Hence low capacitance devices exhibit lower values of noise current at high frequencies than do high capacitance devices.



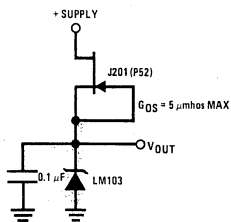
Sample and Hold With Offset Adjustment

The 2N4393 JFET was selected because of its low  $I_{GSS}$  ( $<100$  pA), very low  $I_{D(OFF)}$  ( $<100$  pA) and low pinchoff voltage. Leakages of this level put the burden of circuit performance on clean, solder-resin free, low leakage circuit layout.



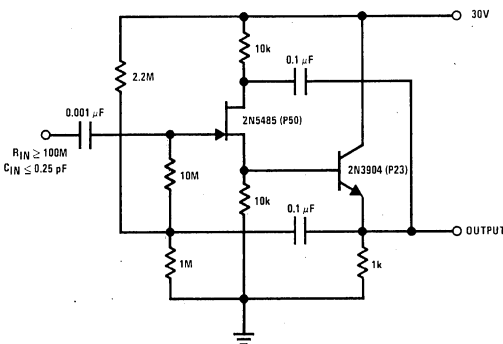
JFET AC Coupled Integrator

This circuit utilizes the "μ-amp" technique to achieve very high voltage gain. Using C1 in the circuit as a Miller integrator, or capacitance multiplier, allows this simple circuit to handle very long time constants.



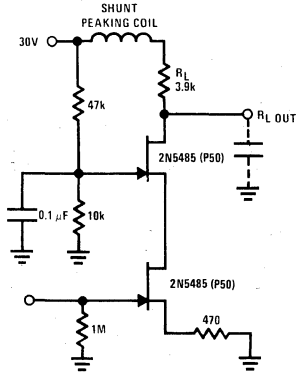
Low Power Regulator Reference

This simple reference circuit provides a stable voltage reference almost totally free of supply voltage hash. Typical power supply rejection exceeds 100 dB.



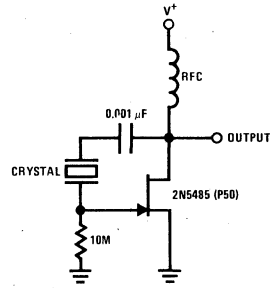
Ultra-High  $Z_{IN}$  AC Unity Gain Amplifier

Nothing is left to chance in reducing input capacitance. The 2N5485, which has low capacitance in the first place, is operated as a source follower with bootstrapped gate bias resistor and drain.



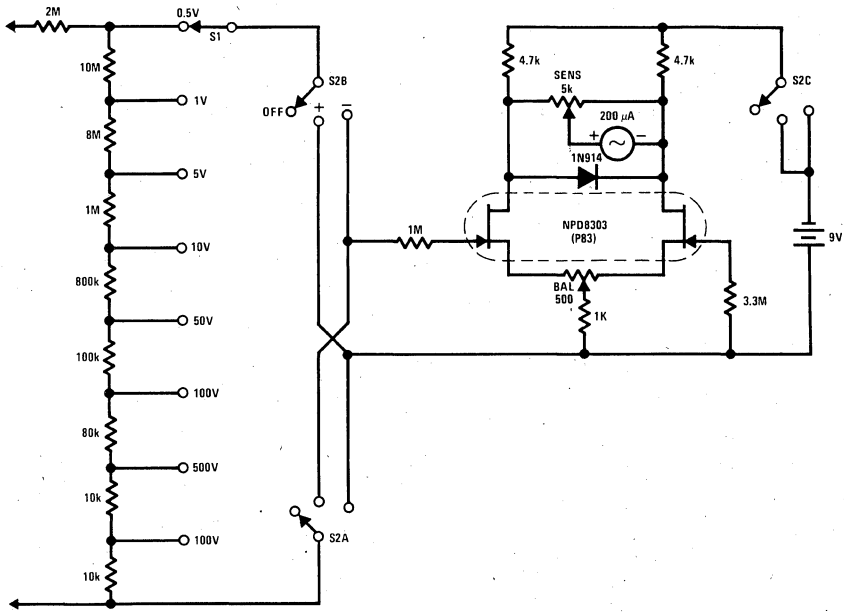
FET Cascode Video Amplifier

The FET cascode video amplifier features very low input loading and reduction of feedback to almost zero. The 2N5485 is used because of its low capacitance and high  $Y_{fs}$ . Bandwidth of this amplifier is limited by  $R_L$  and load capacitance.



JFET Pierce Crystal Oscillator

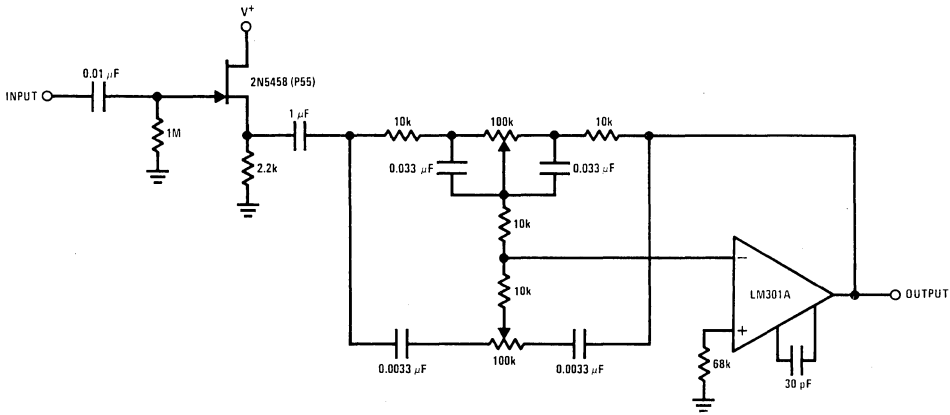
The JFET Pierce crystal oscillator allows a wide frequency range of crystals to be used without circuit modification. Since the JFET gate does not load the crystal, good  $Q$  is maintained, thus insuring good frequency stability.



FETVM-FET Voltmeter

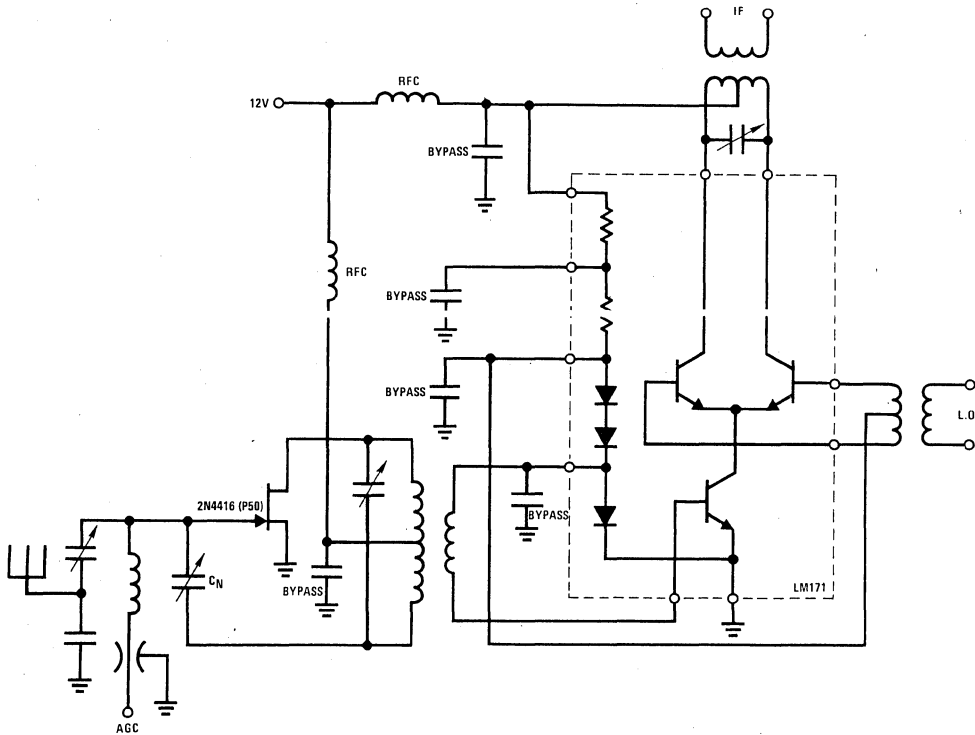
This FETVM replaces the function of the VTVM while at the same time ridding the instrument of the usual line cord. In addition, drift rates are far superior to vacuum tube circuits allowing a 0.5V full-scale range

which is impractical with most vacuum tubes. The low leakage, low noise NPD8303 is an ideal device for this application.



HI-FI Tone Control Circuit (High Z Input)

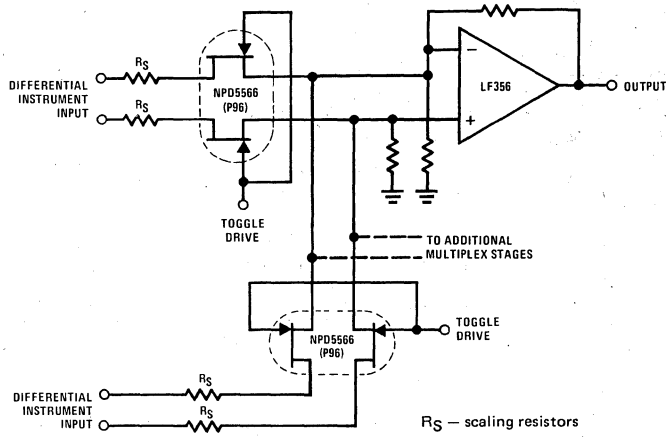
The 2N5458 JFET provides the function of a high input impedance and low noise characteristics to buffer an op-amp-operated feedback type tone control circuit.



100 MHz Converter

The 2N4416 JFET will provide noise figures of less than 3 dB and power gain of greater than 20 dB. The JFET's outstanding low crossmodulation and low intermodulation distortion provides an ideal characteristic for an

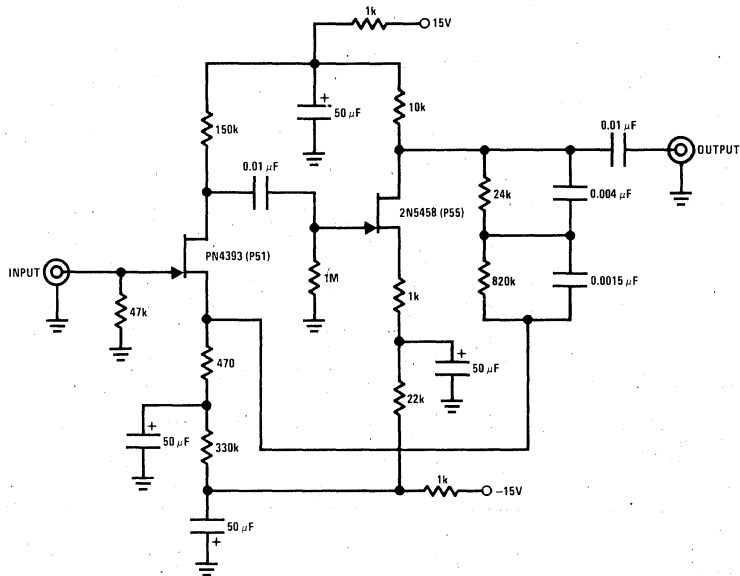
input stage. The output feeds into an LM171 used as a balanced mixer. This configuration greatly reduces L.O. radiation both into the antenna and into the IF strip and also reduces RF signal feedthrough.



Differential Analog Switch

The NPD566 monolithic dual is used in a differential multiplexer application where  $R_{DS(ON)}$  should be closely matched. Since  $R_{DS(ON)}$  for the monolithic dual tracks at better than  $\pm 1\%$  over wide temperature

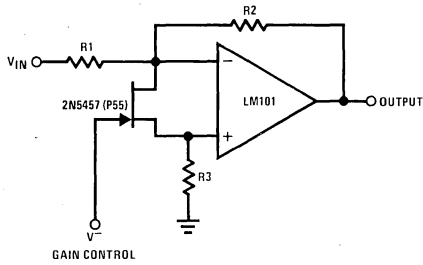
ranges ( $-25^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ), this makes it an unusual but ideal choice for an accurate multiplexer. This close tracking greatly reduces errors due to common-mode signals.



Magnetic Pickup Phono Preamp

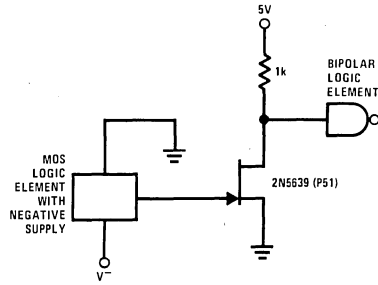
This preamplifier provides proper loading to a reluctance phono cartridge. It provides approximately 35 dB of gain at 1 kHz (2.2 mV input for 100 mV output), it features S + N/N ratio of better than  $-70$  dB (referenced

to 10 mV input at 1 kHz) and has a dynamic range of 84 dB (referenced to 1 kHz). The feedback provides for RIAA equalization.



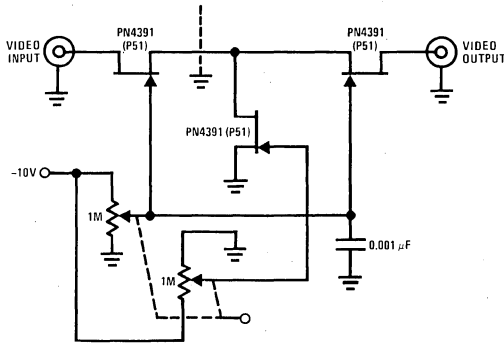
**Voltage Controlled Variable Gain Amplifier**

The 2N5457 acts as a voltage variable resistor with an  $R_{DS(ON)}$  of  $800\Omega$  max. Since the differential voltage on the LM101 is in the low mV range, the 2N5457 JFET will have linear resistance over several decades of resistance providing an excellent electronic gain control.



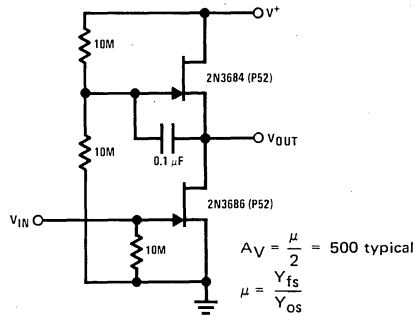
**Negative to Positive Supply Logic Level Shifter**

This simple circuit provides for level shifting from any logic function (such as MOS) operating from minus to ground supply to any logic level (such as TTL) operating from a plus to ground supply. The 2N5639 provides a low  $r_{ds(ON)}$  and fast switching times.



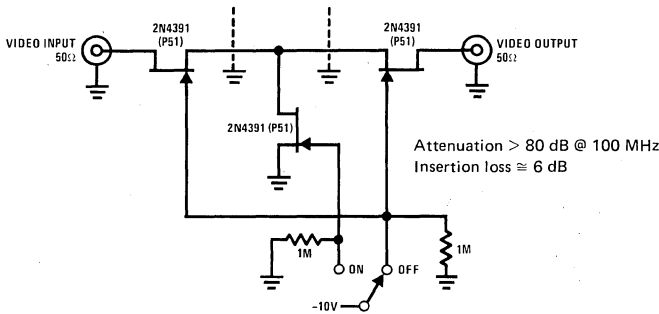
**Variable Attenuator**

The PN4391 provides a low  $R_{DS(ON)}$  (less than  $300\Omega$ ). The tee attenuator provides for optimum dynamic linear range for attenuation and if complete turn-off is desired, attenuation of greater than 100 dB can be obtained at 10 MHz providing proper RF construction techniques are employed.



**Ultra-High Gain Audio Amplifier**

Sometimes called the JFET  $\mu$ -amp, this circuit provides a very low power, high gain amplifying function. Since  $\mu$  of a JFET increases as drain current decreases, the lower drain current is, the more gain you get. You do sacrifice input dynamic range with increasing gain, however.



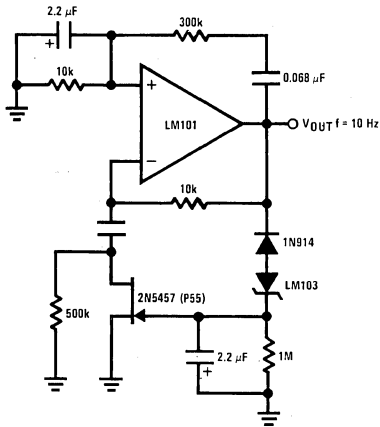
**High Frequency Switch**

The 2N4391 provides a low ON resistance of  $30\Omega$  and a high OFF impedance ( $<0.2$  pF) when OFF. With proper

layout and an "ideal" switch, the performance stated above can be readily achieved.



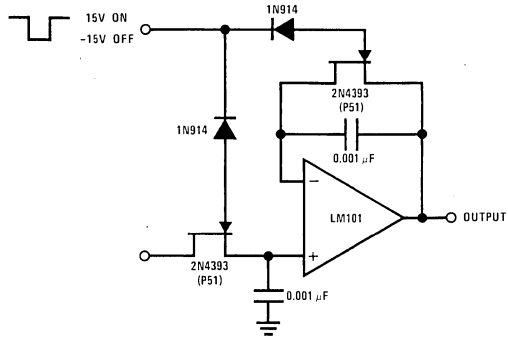




Peak output voltage  
 $V_p \cong V_z + 1V$

Wien Bridge Sine Wave Oscillator

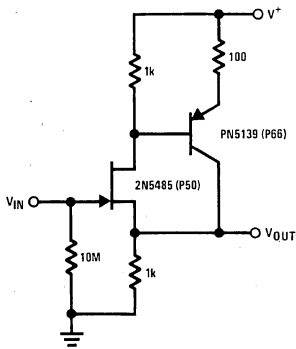
The major problem in producing a low distortion, constant amplitude sine wave is getting the amplifier loop gain just right. By using the 2N5457 JFET as a voltage variable resistor in the amplifier feedback loop, this can be easily achieved. The LM103 zener diode provides the voltage reference for the peak sine wave amplitude; this is rectified and fed to the gate of the



JFET Sample and Hold Circuit

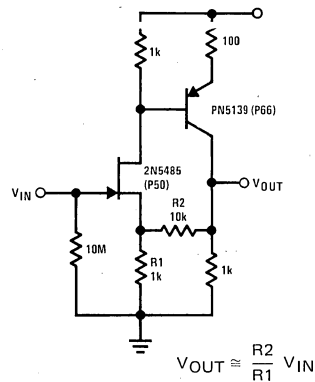
2N5457, thus varying its channel resistance and, hence, loop gain.

The logic voltage is applied simultaneously to the sample and hold JFETs. By matching input impedance and feedback resistance and capacitance, errors due to  $r_{ds(ON)}$  of the JFETs is minimized.



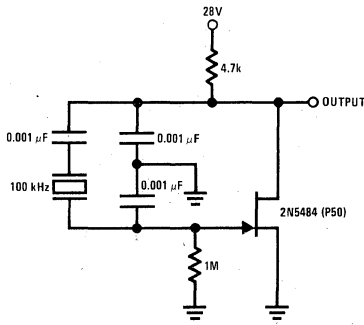
High Impedance Low Capacitance Wideband Buffer

The 2N5485 features low input capacitance which makes this compound series-feedback buffer a wide-band unity gain amplifier.



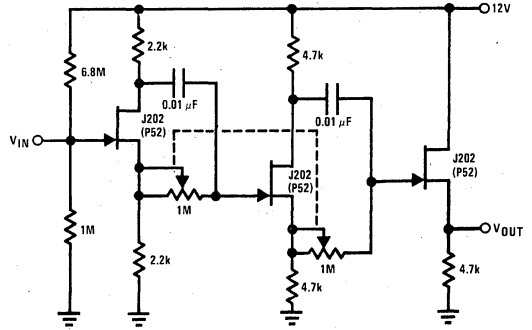
High Impedance Low Capacitance Amplifier

This compound series-feedback circuit provides high input impedance and stable, wide-band gain for general purpose video amplifier applications.



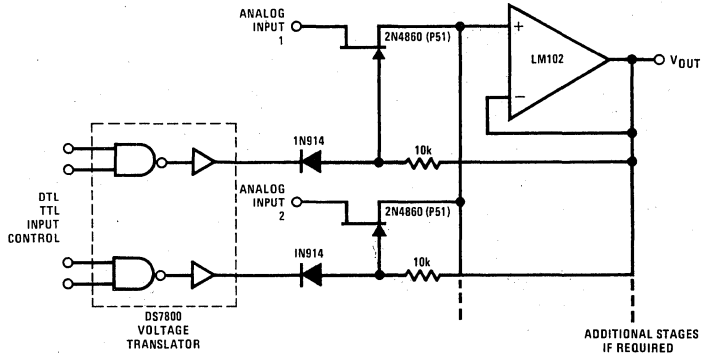
Stable Low Frequency Crystal Oscillator

This Colpitts-Crystal oscillator is ideal for low frequency crystal oscillator circuits. Excellent stability is assured because the 2N5484 JFET circuit loading does not vary with temperature.



0 to 360° Phase Shifter

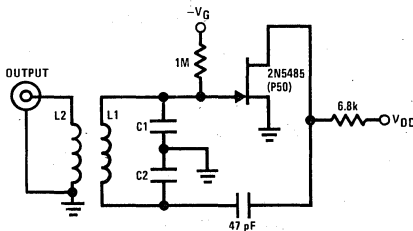
Each stage provides 0° to 180° phase shift. By ganging the 2 stages, 0° to 360° phase shift is achieved. The J202 JFETs are ideal since they do not load the phase shift networks.



DTL-TTL Controlled Buffered Analog Switch

This analog switch uses the 2N4860 JFET for its 25Ω RON and low leakage. The LM102 serves as a voltage buffer. This circuit can be adapted to a dual trace oscil-

loscope chopper. The DS7800 monolithic IC provides adequate switch drive controlled by DTL/TTL logic levels.



Low Distortion Oscillator

The 2N5485 JFET is capable of oscillating in a circuit where harmonic distortion is very low. The JFET

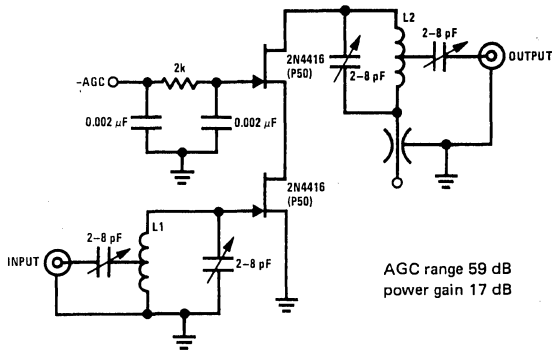
local oscillator is excellent when a low harmonic content is required for a good mixer circuit.

20 MHz oscillator values

- C1 ≈ 700 pF    L1 = 1.3 μH
- C2 = 75 pF    L2 = 10T 3/8" dia 3/4" long
- VDD = 16V    ID = 1 mA

20 MHz oscillator performance

- Low distortion 20 MHz osc
- 2nd harmonic - 60 dB
- 3rd harmonic > -70 dB

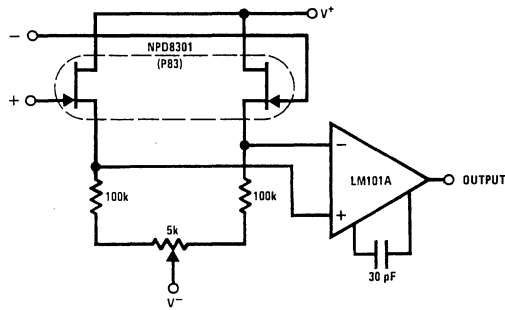


L1 = 0.07 μHy center tap  
L2 = 0.07 μHy tap 1/4 up from ground

200 MHz Cascode Amplifier

This 200 MHz JFET cascode circuit features low cross-modulation, large signal handling ability, no neutralization, and AGC controlled by biasing the upper cascode

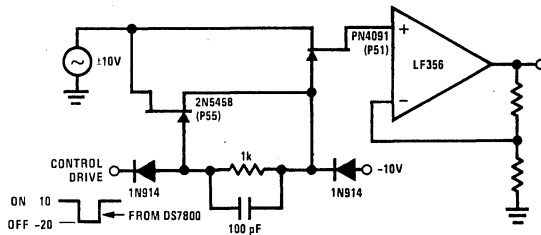
JFET. The only special requirement of this circuit is that  $I_{DSS}$  of the upper unit must be greater than that of the lower unit.



FET Op Amp

The NPD8301 monolithic-dual provides an ideal low offset, low drift buffer function for the LM101A op amp. The excellent matching characteristics of the

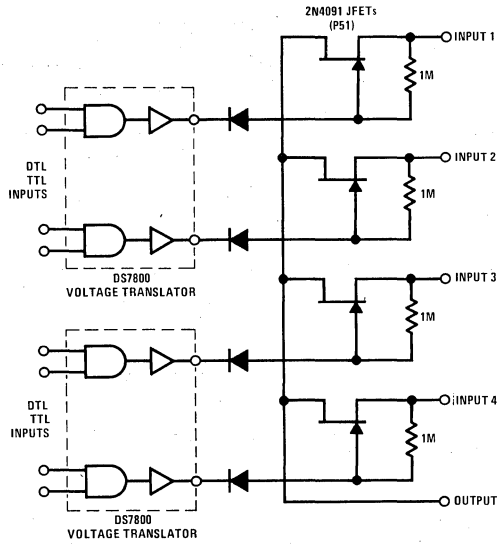
NPD8301 track well over its bias current range, thus improving common-mode rejection.



High Toggle Rate High Frequency Analog Switch

This commutator circuit provides low impedance gate drive to the PN4091 analog switch for both ON and OFF drive conditions. This circuit also approaches the ideal gate drive conditions for high frequency signal

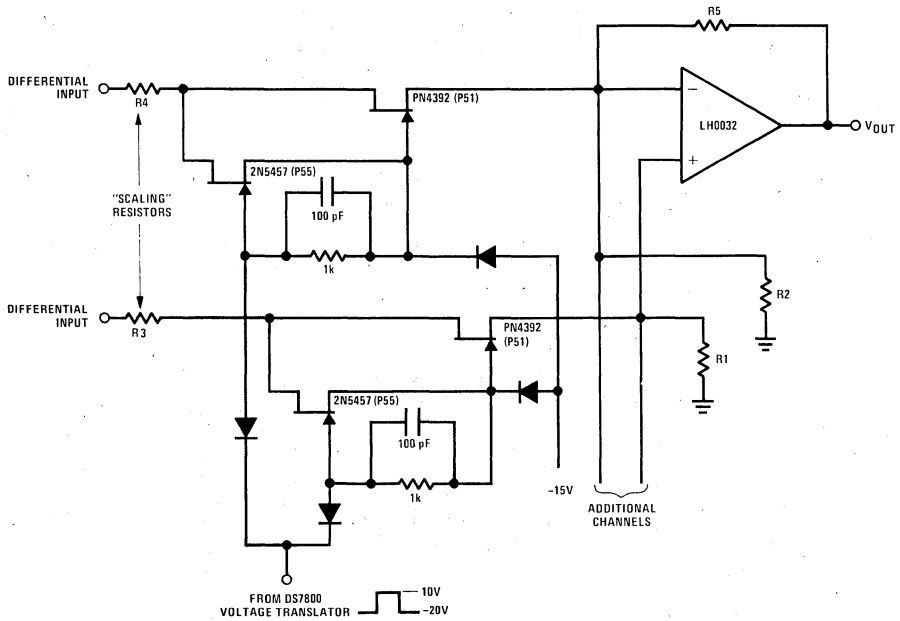
handling by providing a low AC impedance for OFF drive and high AC impedance for ON drive to the PN4091.



4-Channel Commutator

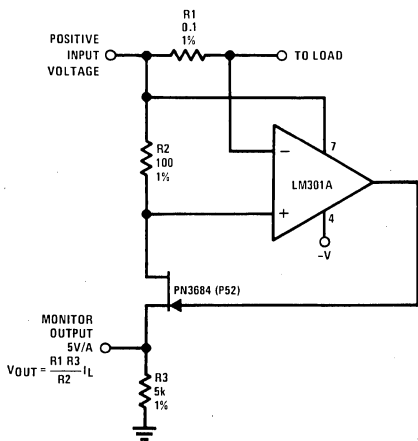
This 4-channel commutator uses the 2N4091 to achieve low channel ON resistance ( $<30\Omega$ ) and low OFF current leakage. The DS7800 voltage translator is a monolithic

device which provides from 10V to  $-20V$  gate drive to the JFETs while at the same time providing DTL/TTL logic compatibility.



Wide Band Differential Multiplexer

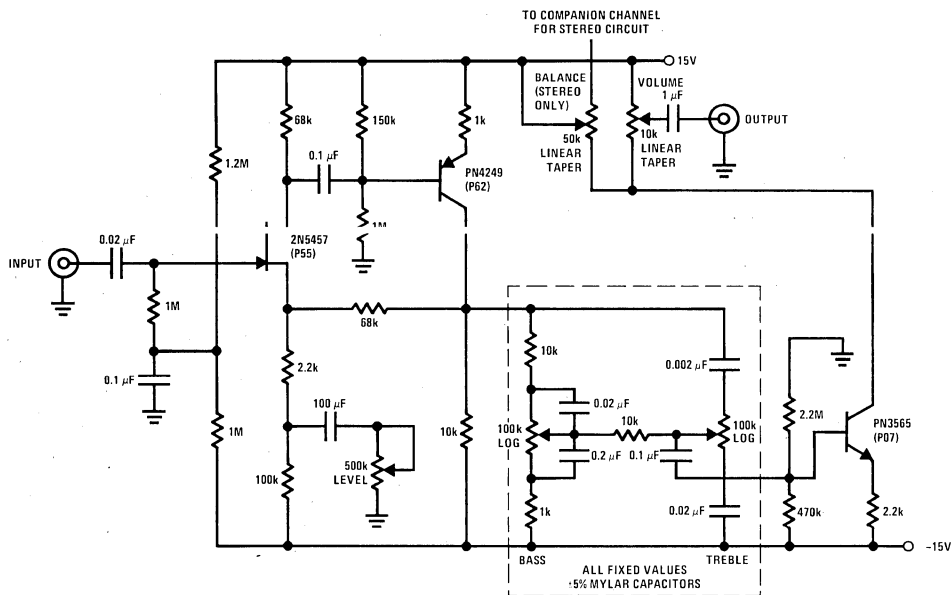
This design allows high frequency signal handling and high toggle rates simultaneously. Toggle rates up to 1 MHz and MHz signals are possible with this circuit.



Current Monitor

R1 senses current flow of a power supply. The JFET is used as a buffer because  $I_D = I_S$ , therefore the output

monitor voltage accurately reflects the power supply current flow.



Low Cost High Level Preamp and Tone Control Circuit

This preamp and tone control uses the JFET to its best advantage; as a low noise high input impedance device. All device parameters are non-critical, yet the circuit achieves harmonic distortion levels of less than

0.05% with an S/N ratio of over 85 dB. The tone controls allow 18 dB of cut and boost; the amplifier has a 1V output for 100 mV input at maximum level.



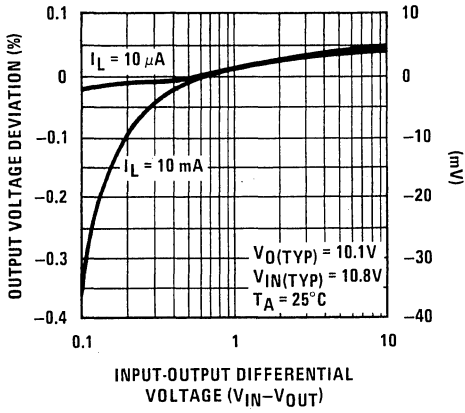


FIGURE 2. Line Regulation vs Input-Output Differential

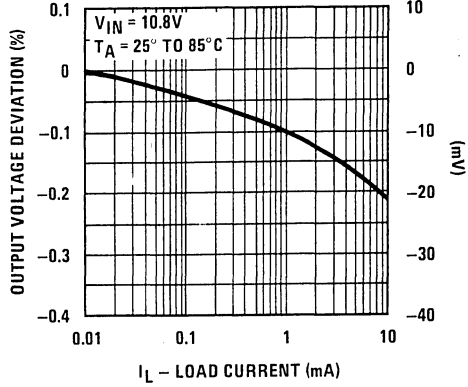


FIGURE 3. Load Regulation

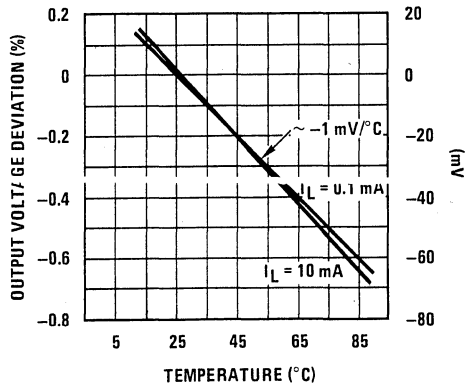


FIGURE 4. Temperature Stability



# A Linear Multiple Gain-Controlled Amplifier

National Semiconductor  
Application Note 129  
Jim Sherwin  
August 1975



## INTRODUCTION

A linear control function over three decades of gain can be achieved with a FET in the feedback path of a non-inverting amplifier. Besides the ultimate simplicity of the circuit, multiple tracking gain control circuits can be constructed with dual op amps and monolithic dual FET's or quad op amps and monolithic quad FET's. Such circuits could even be integrated with ion-implanted FET's on single or multiple monolithic op amp chips. The gain control range may be designed for less than 2 to 1 or higher than 1000:1, but input voltage levels are limited by acceptable levels of distortion. Bandwidth is dependent on maximum gain and unity gain bandwidth of the op amp used. The gain control circuit is especially suitable for volume expansion applications.

## GAIN CONTROL WITH FETS

The FET has long been used as a voltage controlled resistor (VCR), often as the shunt arm in the series-shunt attenuator of *Figure 1*. Advantages of the FET as a VCR are that:

1. The control signal is almost perfectly isolated from the controlled signal path, and
2. The resistance can be made to vary over an almost infinite max/min ratio.

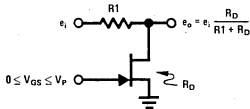


FIGURE 1. Voltage Controlled FET Attenuator

Disadvantages are that:

1. The FET behaves as a linear resistance only for small values of source-drain voltage  $V_{DS}$ .
2. Non-linearity (of resistance) increases as the control voltage  $V_{GS}$  approaches cut-off voltage  $V_P$  when the resistance is maximum,
3. The relationship of resistance  $r_d$  to  $V_{GS}$  is reciprocal rather than direct linear,
4. VCR multiples with matched resistance characteristics over their full control range have been extremely difficult to obtain at any kind of reasonable price, and
5. Production spread in  $V_P$  requires separate bias set and gain set on each circuit.

Examination of the FET drain characteristics in *Figure 2* will reveal the essential non-linearity of  $r_d$  at high signal levels, especially as  $V_{GS}$  approaches  $V_P$ . This non-linear region must be avoided in order to achieve tolerable distortion levels. One obvious way is to limit  $V_{DS}$  to small values when  $r_d$  is high as suggested by *Figures 2c and 2d*, another is to utilize FET's with high  $V_P$  as suggested by reference to *Figures 2b and 2d*.

The reciprocal relationship of  $r_d$  and  $V_{GS}$  is an advantage, as it is precisely that which allows the linear control of gain in the circuit to be described. The availability of matched monolithic dual FET's such as the NSC 2N3958 (watch out for the matched pairs as their resistance match close to  $V_P$  may not be as good as that of the monolithic versions) make available low cost duals with very closely matched resistance characteristics over the full control range. There are even some monolithic quads available (such as the AM9709 series). The final problem of the production range of  $V_P$  can be much improved with ion-implant diffusion techniques whereby lot variation in  $V_P$  may be held to within a few tenths of one volt.

The gain control circuit is that of an ordinary non-inverting op amp with feedback. The usual circuit is modified in *Figure 3a* to include a FET as controlled resistor. The gain function is normal except that  $r_d$  replaces  $R_2$  in the usual form.

$$A_V = 1 + \frac{R_1}{r_d} \quad (1)$$

Now  $r_d$  can be equated to a control voltage  $V_C$  as follows:

$$r_d = r_o \frac{V_P}{V_P - V_{GS}} \quad (2)$$

Where:

$$\begin{aligned} r_o &= r_d \Big|_{V_{GS} = 0} \\ r_d &= r_o \frac{V_P}{V_C} \end{aligned} \quad (3)$$

Where:

$$V_C = V_P - V_{GS}$$

The gain function is thus seen to be linear with  $V_C$ .

$$A_V = 1 + \frac{R_1}{r_o} \frac{V_C}{V_P} \quad (4)$$

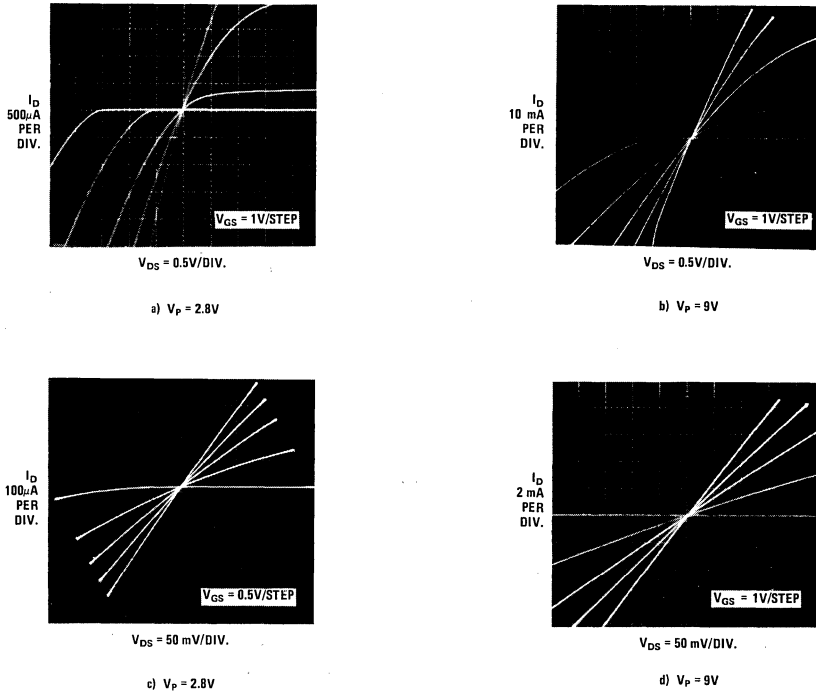


FIGURE 2. AC Output Characteristics of FET

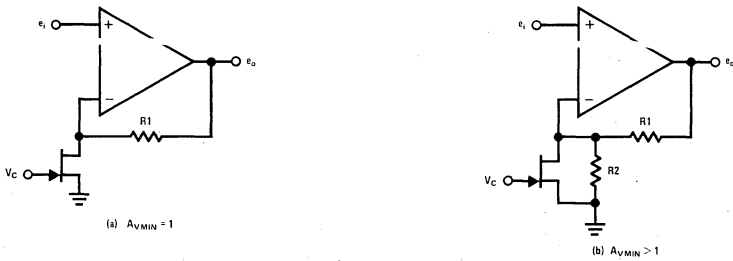


FIGURE 3. FET/Op Amp Gain Control Circuit

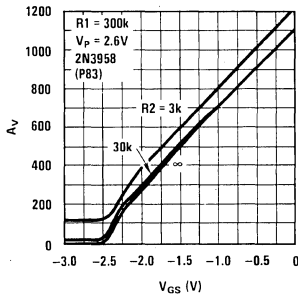


FIGURE 4. Gain vs Control Voltage For Short Channel FET

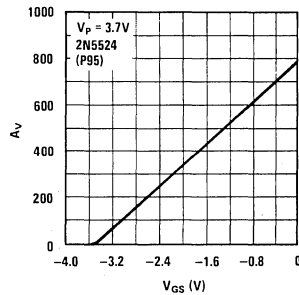


FIGURE 5. Gain vs Control Voltage For Long Channel FET

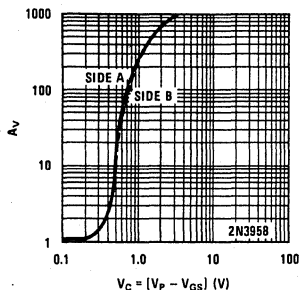


FIGURE 6. Control-Gain Match For Dual FET

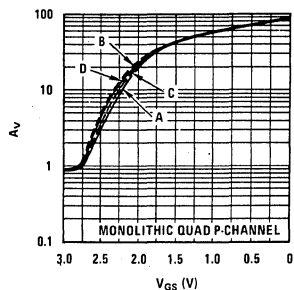


FIGURE 7. Monolithic Quad Gain Control Tracking

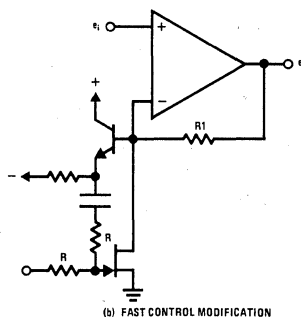
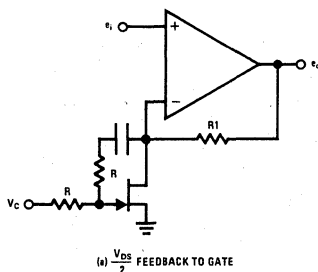


FIGURE 8. Circuit to Reduce Distortion

At  $V_C = 0$ , the gain reduces to unity; and at  $V_C = V_P$ , the gain increases to  $1 + R1/r_o$  which may be as high as 1000 or so. If it is desired to limit the minimum gain to some value greater than unity, another resistor  $R2$  may be added as in *Figure 3b*. Then the gain equation becomes:

$$A_V = 1 + \frac{R1}{\frac{R2 r_o (V_P/V_C)}{R2 + r_o (V_P/V_C)}}$$

$$= 1 + \frac{R1 [R2 + r_o (V_P/V_C)]}{R2 r_o (V_P/V_C)}$$

$$A_V = 1 + \frac{R1}{R2} + \frac{R1 V_C}{r_o V_P} \quad (5)$$

In either case, the gain function is linear with  $V_C$ .

The circuits of *Figure 3* do indeed show a linear gain versus control voltage as plotted in *Figure 4* for several values of minimum gain. There is some non-linearity near minimum gain which appears in all curves. This is certainly due to a non-ideal characteristic of the FET caused by finite contact and bulk resistance at source and drain. *Figure 5* shows a similar control curve for a FET with longer channel in which the controlled channel resistance is a greater part of the total resistance than that of the short channel device of *Figure 4*. For those applications requiring a more precisely linear control of gain, the long channel devices will be preferable.

Several variable-gain circuits can be made to track when monolithic multiple FET's are used as the control elements with matched feedback resistors. A monolithic FET dual (NSC 2N3958) used in two identical control circuits shows remarkable tracking over the entire control range, even when  $V_{GS}$  is near  $V_P$  where variations would be expected to be most apparent. The plots appear in *Figure 6*. Similar performance for a quad gain control using a monolithic P-channel quad FET (AH5009) is shown in *Figure 7*.

### DISTORTION

Reference to *Figure 2* will show that the FET acts as a linear resistance only for relatively small values of drain-source voltage, in either polarity. This is particularly apparent for positive  $V_{DS}$  (for N-channel FET) and  $V_{GS}$  approaching  $V_P$ . The difference between *Figures 2c* and *2d* indicates that the maximum allowed applied signal will be greater for high  $V_P$  as compared with low  $V_P$ .

It is possible to improve the linearity characteristics somewhat by applying a part of the  $V_{DS}$  in series with the control voltage applied as  $V_{GS}$ . The circuit to accomplish this is that shown in *Figure 8*. It happens that about half of  $V_{DS}$  applied to the gate provides the greatest improvement for small signals. The addition of two resistors and one capacitor as in *Figure 8a* is all that is required. The capacitor simply blocks the control voltage from the FET drain and the op amp input. *Figure 8b* shows the addition of an emitter follower to

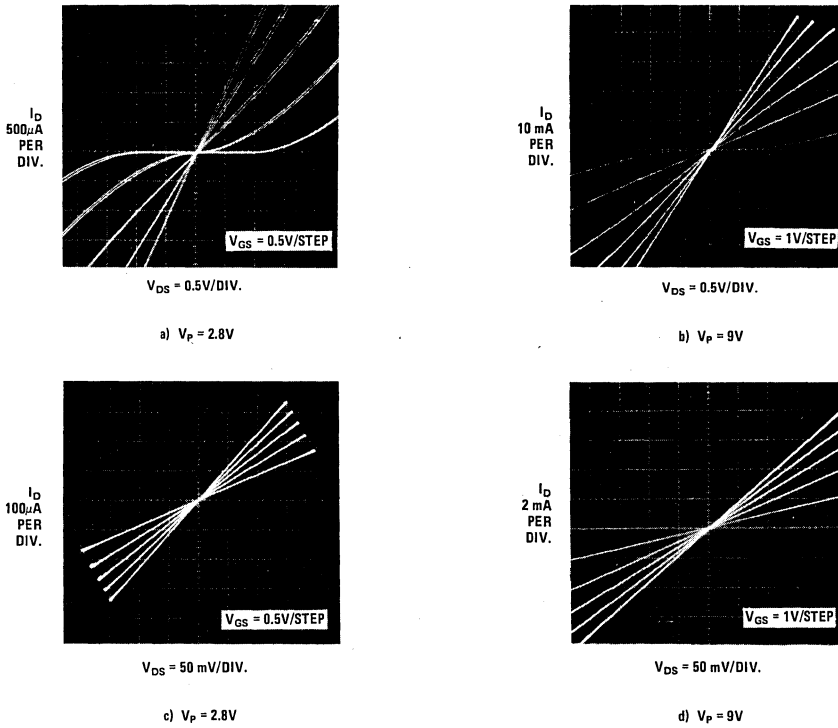


FIGURE 9. AC Output Characteristics of FET with Feedback Linearization

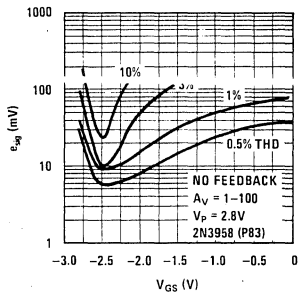


FIGURE 10. Distortion With  $V_p = 2.8V$

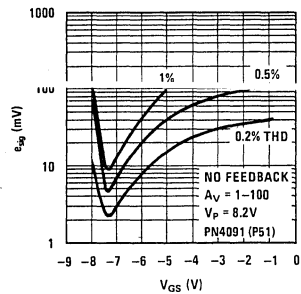


FIGURE 11. Distortion With  $V_p = 8.2V$

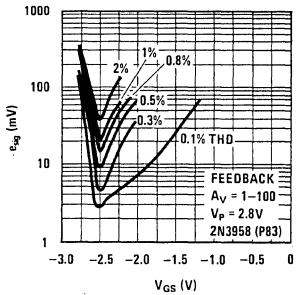


FIGURE 12. Distortion With  $V_p = 2.8V$ , With Linearization

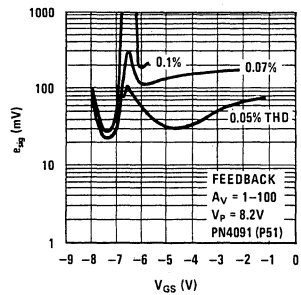


FIGURE 13. Distortion With  $V_p = 8.2V$ , With Linearization

prevent abrupt changes in  $V_C$  from coupling to the op amp. *Figure 9* shows the improved linearity of the drain characteristics as compared to *Figure 2*. The improvement is also seen in the distortion versus input signal plots of *Figures 10–13*. Note particularly that the distortion at any value of  $V_C$  is primarily a function of input signal (which equals the feedback signal applied to the FET drain at the inverting input). Some modification is made to this direct relationship if an  $R_2$  is shunted across the FET as in *Figure 3b*. Measured distortion at low signal level is the result of noise rather than of signal distortion. Maximum gain is limited to about 100 in these plots so as to avoid the region of lower S/N. The noise is that of the op amp input stage and the signal source resistance plus the contribution of the FET which is essentially the thermal noise of  $r_{d1}$ .

**BANDWIDTH AND CONTROL TIME CONSTANT**

The circuit bandwidth is the closed loop bandwidth of the op amp used at the (instantaneous) set gain. The gain control time constant is that of the input circuit to the FET (dependent on the value of  $R$  in *Figure 8*) limited by the slew rate of the op amp. The FET itself reacts practically instantly, producing a step change in feedback ratio. Control time constant is thus a few microseconds at most.

**APPLICATIONS**

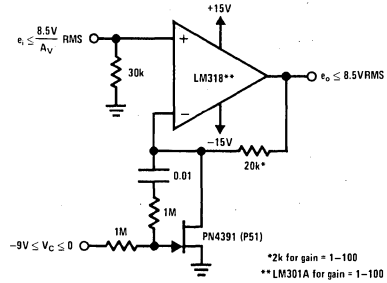
Three obvious applications present themselves; they are:

1. Remote or multichannel gain control
2. Volume expansion
3. Volume compression/limiting

To this short list might be added a number of others, including applications in noise reduction and quad sound techniques.

The gain-controlled amplifier of *Figure 14* has a gain range of 1–1000, a maximum output level of 8.5 Vrms, and a bandwidth of better than 20 kHz at maximum gain. The FET used has high  $V_P$  for maximum freedom from distortion. *Figures 15 and 16* show the gain function and constant distortion contour lines. Note that the gain control curve is non-linear near unity gain because the PN4091 is a short channel FET. Distortion

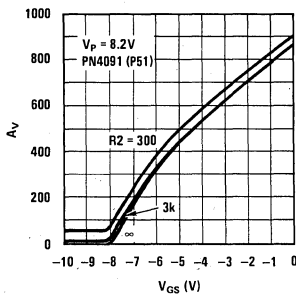
is quite low except as limited by maximum output voltage. Note that the maximum  $e_{in}$  is restricted by output saturation. The LM318 is used in the example only to achieve wideband response at maximum gain. The amplifier input voltage must be restricted to about 8 mVrms at maximum gain when the S/N will be about 60 dB over a 10 kHz bandwidth.



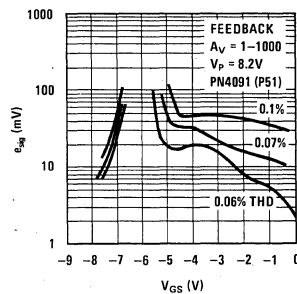
**FIGURE 14. Amplifier With Gain Range = 1–1000**

A more practical circuit might employ a gain range of 1–100. Then the amplifier could be a LM301A and still achieve a 10 kHz bandpass at maximum gain. The input signal could, accordingly, be increased to 80 mVrms for a S/N of 80 dB. This performance can be extended to dual and quad control circuits with tracking gain functions, but watch the bandwidth as required at maximum gain. Any of the several dual op amps could be used with the 2N3958 (monolithic dual from NSC), or the LM324 quad op amp can be used in limited gain times bandwidth applications with a quad monolithic FET. *Figure 17* shows all details of an ac coupled tracking quad gain control with 40 dB range. Gain varies over 1–100 range, bandwidth is 10 kHz minimum, S/N is better than 70 dB with 4.3 Vrms maximum output. *Figure 7* shows the gain curve and matching characteristics.

Noise considerations could be important in this method of gain control, as the signal is amplified rather than attenuated. To realize the function of a 40 dB variable attenuator, it is necessary to install a fixed attenuator at the amplifier input and perhaps also at the output. This will reduce the minimum signal level to millivolts, thus a low noise amplifier is desirable. The LM381 dual low-noise ac coupled amplifier could be used in a 40 dB



**FIGURE 15. Gain For Circuit of Figure 14**



**FIGURE 16. Distortion For Circuit of Figure 14**

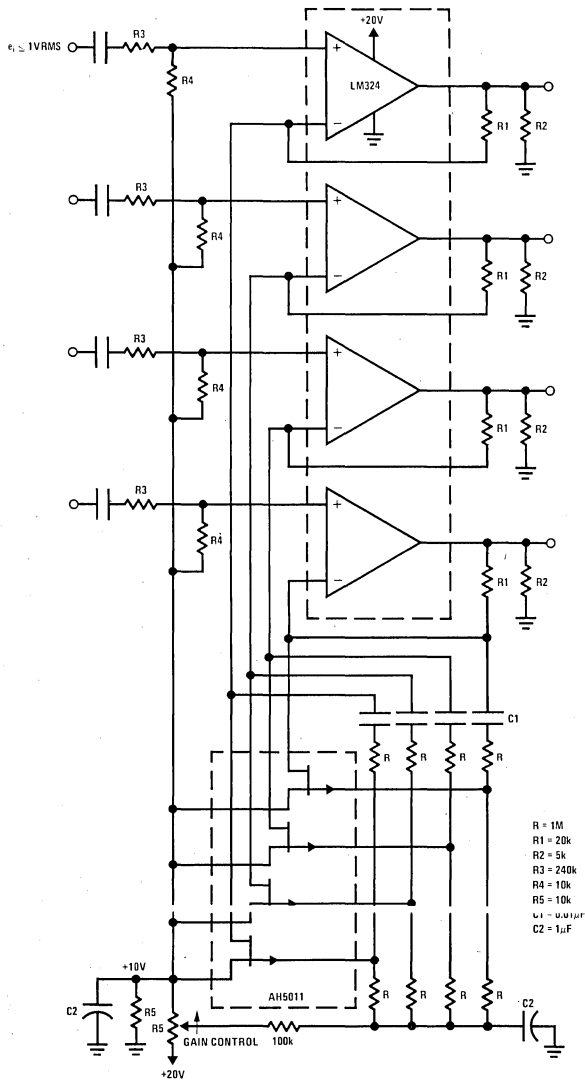


FIGURE 17. Quad Gain Control

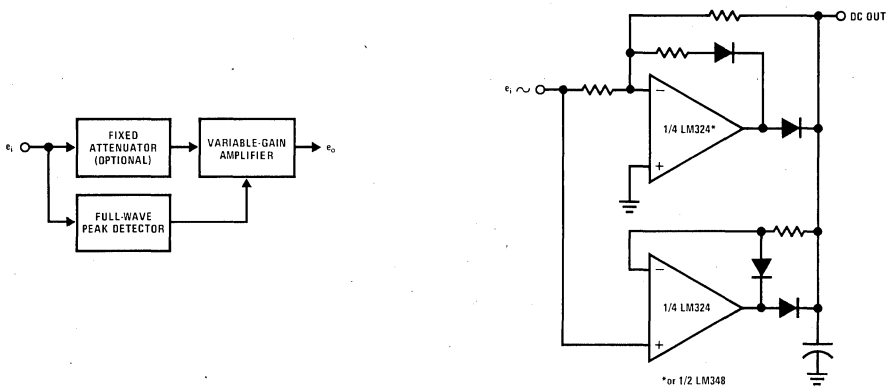


FIGURE 18. Volume Expander/Compressor Block Diagram

FIGURE 19. Full Wave Linear Precision Peak Detector

audio attenuator to realize S/N about 100 dB or in a 60 dB attenuator to realize 80 dB S/N. Improvements in S/N can be made by reducing system bandwidth in fixed or low frequency operation. Minimum noise is also achieved by using the minimum practical amplifier source resistance. Values as low as 1 k $\Omega$  are advantageous.

The effect of temperature will be to change the gain according to the temperature sensitivity of the FET. This effect can be reduced by using a silicon resistor for the feedback resistor, R1. If the FET were to be integrated onto the op amp chip, an attempt should be made to include R1 on the chip as well.

The application to a volume expander circuit is of interest as the control is linear, the required control range is only about 1:4, and the input signal is small for the low gain condition when distortion would otherwise be most apparent. The elements of a volume expander are indicated in *Figure 18*. The gain controlled amplifier need only exhibit a 12 dB variation in gain, being lowest for small signals. The slope of gain versus control should be linear, more specifically the slope of (log) gain in dB versus (log) signal in dB should be linear. A practical range is 12 dB gain change over a 30 dB input signal range. The peak detector should be linear down to very small signals, exhibit a fast attack or charge time of a millisecond or less, a discharge time constant of about 2 seconds, and operate on the first

half cycle (full-wave detector). The detector should, therefore, be a full-wave precision linear peak detector with low internal impedance; the requirements can be met with the circuit of *Figure 19*.

The expander circuit shown in *Figure 20* will perform as desired. The gain control function is plotted in *Figure 21*; distortion is below 0.1% at all levels. Resistors R3 and R4 are added in order to modify the linear control curve to the desired log curve. Note that the input signal is attenuated prior to amplification in order to reduce distortion and maintain an overall gain of approximately 0 dB at midrange of expansion. The noise with the LM124 over a 20 kHz bandwidth is, of course, a function of signal; but the maximum signal to noise ratio is 80 dB. The circuit could be adapted to stereo or quad sound as in *Figures 22–23*. Questions for individual design concern the method of control. Whether to expand all channels together, and whether to derive the control signals individually from each channel, a summation from 2 to 4 channels, or from a single channel (assuming that high level from any channel indicates high levels from all channels). Note that the FET is biased OFF (minimum gain) for low signals, and increasing signals progressively bias the FET ON (maximum gain).

The volume compression circuit is a logical mate to the expander. The only difference would be that the FET is initially biased ON (maximum gain) for low signals, and

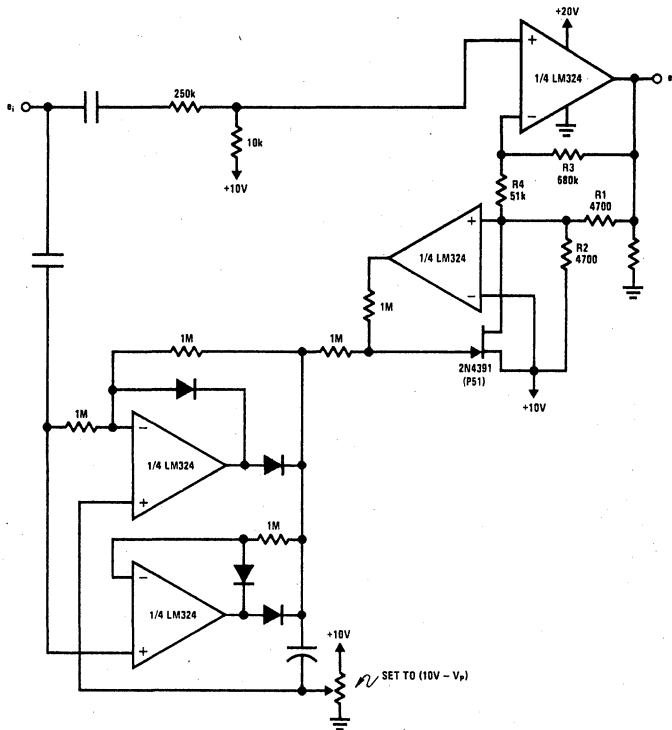


FIGURE 20. Volume Expander Circuit

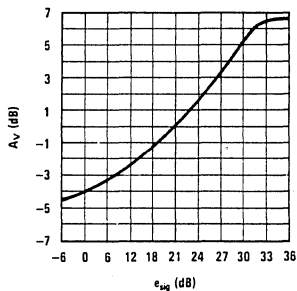


FIGURE 21. Expander Gain Characteristic

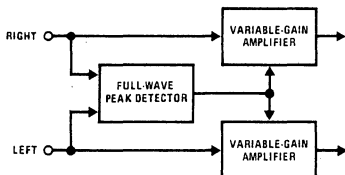


FIGURE 22. Stereo Expander Block

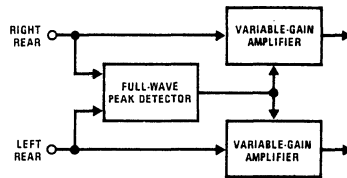
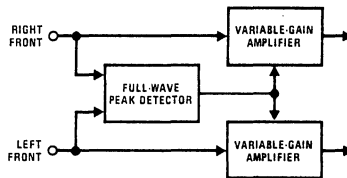


FIGURE 23. Four-Channel Expander Block

increasing signals progressively bias the FET OFF (minimum gain). A disadvantage is that the circuit produces greatest distortion in the low gain condition when signals are highest. Maximum S/N is degraded by 24 dB over that of the expander, minimum S/N is the same.

### CONCLUSION

The combination of FET and op amp provides a linear dc (voltage) control of gain over a range to 60 dB. As the circuit realizes positive gain, rather than being a controlled attenuator, the input signal is limited. Input

signal is further limited to several hundred millivolts by the non-linearity of the FET (which sees the full input signal). Because input signals will generally be in the 10–300 mV range, noise performance of the selected op amp will be important. Even so, S/N of 60–100 dB is obtainable with standard amplifiers. Tracking pair or quad gain-control amplifiers are realizable with existing monolithic dual or quad FET's, and the combination of FET and op amp lends itself to simple integration. The circuit is well-suited to remote and multiple linear gain control and to volume expander/compressors. The volume expander is especially interesting as the signal level and gain conditions result in extremely low distortion and more than adequate signal-to-noise ratio.



# Binary/BCD Gain Programmed Amplifiers

National Semiconductor  
John Maxwell  
February 1977



Many systems require logic controlled gain programmable amplifiers (GPA) for signal preconditioning, level control and dynamic range expansion. The system sets GPA requirements for accuracy, speed and signal handling capability, limiting the type used. Conventional CMOS analog switches limit signal handling to  $\pm 7.5V$  and accuracy to 1%. High voltage CMOS or JFET analog switches increase both accuracy and signal handling ( $\pm 10V$  to  $\pm 15V$ ) but at a greater cost. Programmable amplifiers using current mode analog switches have the highest signal handling capability ( $\pm 25V$ ) with high accuracy, speed and low cost.

In reality, the logic controlled GPA is a multiplying digital-to-analog converter (multiplying D/A). The D/A input is the reference node which is multiplied by the digital input. Multiplying D/A converters have been available for some time in module, hybrid and monolithic form but suffer from high cost and poor signal handling capability ( $\pm 10V$  maximum).

Large signal handling ( $\pm 25V$ ), moderate cost multiplying D/A converters can be built using monolithic current mode analog switches, an op amp and a few resistors.

Unlike conventional analog switches, only signal current is switched at the virtual ground of an op amp with current mode analog switches. Limiting the voltage across the switch to a few hundred millivolts, power supplies, logic interface and level translator circuits are eliminated allowing the JFET switches to be driven directly by standard logic.

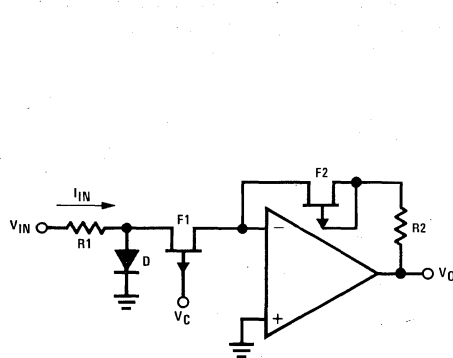


FIGURE 1. Current Mode Analog Switch

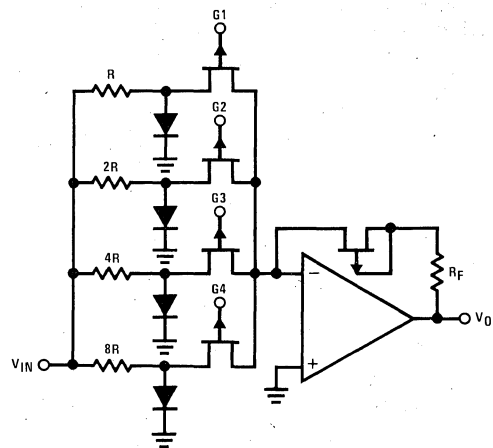
A logic "0" turns the switch ON with a logic "1" shutting the switch OFF by pinching the FET OFF. The diode is used to clamp the source to drain voltage to about 0.7V in the switch OFF state. The series FET in the feedback path is used to compensate for the ON resistance of the switch FET.

Current through the switch is determined by the input resistor, R1, the switch ON resistance and the input voltage,  $V_{IN}$ . Scaling of the output voltage is accomplished with the feedback resistor, setting the gain of the amplifier.

$$A_V = -\frac{R_2 + R_{ON2}}{R_1 + R_{ON1}} \quad (1)$$

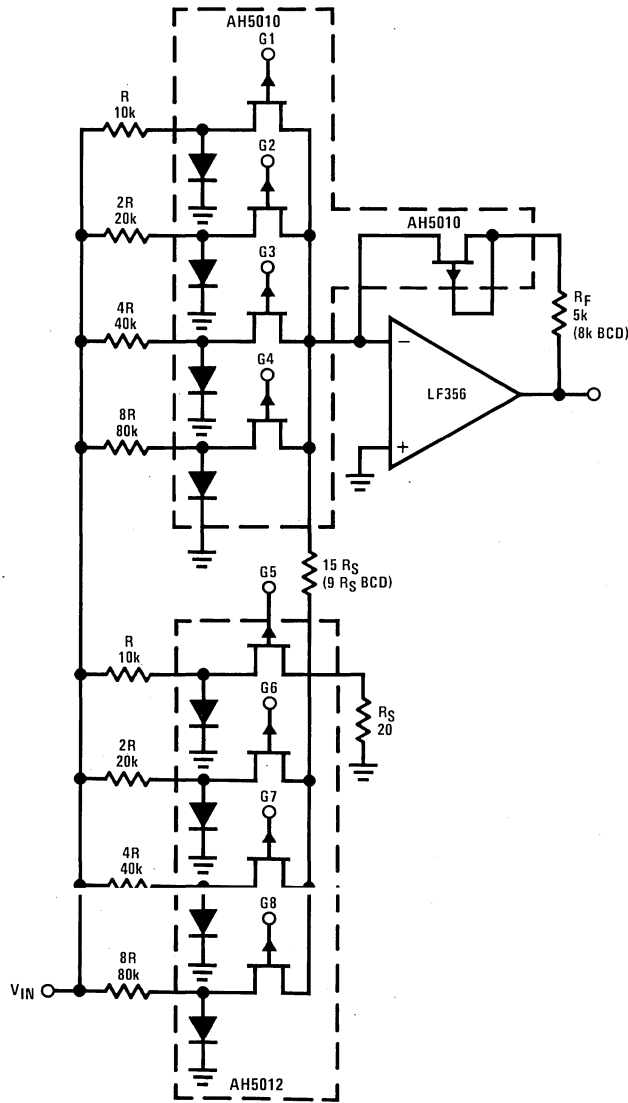
A 4-bit multiplying D/A converter can be built using a quad current mode switch, 4 binary weighted resistors (R, 2R, 4R, 8R) and an op amp. The output voltage will be a function of the feedback resistor, input resistors and the logic state of the FET gates,  $G_N$ .

The number of bits is expanded by cascading another quad current switch and resistor array to the first. Instead of continuing the binary progression of the input resistors, (16R, 32R, etc), current splitting resistors are used such that the same resistor array (R, 2R, 4R, 8R) is used for the additional bits, minimizing the number of resistor values required for higher order converters.



$$V_O = -V_{IN} \frac{R_F}{R} (\bar{G}_1 2^0 + \bar{G}_2 2^{-1} + \bar{G}_3 2^{-2} + \bar{G}_4 2^{-3})$$

FIGURE 2. 4-Bit Multiplying D/A Converter



$$V_O = -V_{IN} \frac{R_F}{R} [\bar{G}_1 2^0 + \bar{G}_2 2^{-1} + \bar{G}_3 2^{-2} + \bar{G}_4 2^{-3} + \frac{1}{16} (\bar{G}_5 2^0 + \bar{G}_6 2^{-1} + \bar{G}_7 2^{-2} + \bar{G}_8 2^{-3})]$$

(1/10 for BCD)

FIGURE 3. 8-Bit Multiplying D/A Using Cascaded 4-Bit Sections

Binary weighting requires a 1/16 current split for the second switch quad while BCD weighting requires a 1/10 split.

There are 2 basic switch configurations available that are optimized for a variety of logic drives: TTL or CMOS Multiple independent switches (4 by SPST) and a 4-channel multiplex version with a series compensation FET.

Practical limitations in using monolithic current mode analog switches need consideration. Resistor values and tolerance impacted by switch resistance is minimized by increasing resistor values without regard, but limits bandwidth and creates leakage errors at elevated temperatures. Using resistors that are too small, increase switch resistance errors. Current saturation (increased switch resistance) occurs when the switch current approaches the FET saturation current,  $I_{DSS}$ . High currents also

cause  $I_{G(ON)}$ , current lost through the gate, as the diode and FET source to gate diode become forward biased. An input resistor value of 10k limits the switch current to less than 2 mA minimizing both leakage and switch resistance problems. For example, the gain accuracy at unity gain using the compensation FET is less than 0.05% with  $R = R_F = 10k$ .

The current shunt resistor used in cascading switches should be kept small to minimize the voltage drop, keeping the FET drains near ground. Values of  $R_S$  should be less than  $100\Omega$  (20 typ).

Resistor tolerance will be determined by converter resolution, i.e., the number of bits (N). For example, an 8-bit binary D/A converter will have  $2^N - 1$  or 255 steps (99 for BCD) or different gains. The resolution or smallest step is (least significant bit)  $1/2^N$  of the full-scale value (0.0039). Typical accuracy specifications for D/A converters are stated as 1 LSB or  $\pm 1/2$  LSB.

This works out to be  $\pm 0.2\%$  for the 8-bit binary unit. Errors in the feedback resistor directly affect the output of the converter. The most significant resistor, R, contributes  $1/2$  full-scale, reducing its error contribution by a factor of 2. The same is true for the rest of the resistors with contributions of  $1/4$ ,  $1/8$ , etc. Using a resistor tolerance of 0.1% for the feedback resistor, 0.2% for the 2 most significant resistors (R, 2R), 0.5% for the 3rd and 1% for the 4th and 5th switches allows 5% resistors to be used in the 6th, 7th and 8th switch positions.

Using the above information, 4-bit or more binary/BCD gain programmable amplifiers can be built with large signal handling capability, few parts and easily adjustable gain or attenuation. Figure 3 shows a practical 8-bit binary/BCD GPA with gains of 0.996 (binary) with  $R_F = 5k$  and 0.99 (BCD) with  $R_F = 8k$ . For other gains, only the feedback resistor need be changed.

$$\begin{aligned} \% \text{ error} &= \left[ \epsilon_f^2 + \left(\frac{\epsilon_R}{2}\right)^2 + \left(\frac{\epsilon_{2R}}{2^2}\right)^2 + \dots + \left(\frac{\epsilon_{nR}}{2^n}\right)^2 \right]^{1/2} \\ \text{or} & \\ \% \text{ error} &= \left[ (0.1)^2 + \left(\frac{0.2}{2}\right)^2 + \left(\frac{0.2}{4}\right)^2 + \dots + \left(\frac{5}{256}\right)^2 \right]^{1/2} = \pm 0.198\% \end{aligned} \tag{2}$$

- $\epsilon_f$  = tolerance of feedback resistor
- $\epsilon_R$  = tolerance of most significant resistor
- $\epsilon_{nR}$  = tolerance of Nth resistor

# FET Curve Tracer

National Semiconductor  
John Maxwell  
February 1977



Junction field-effect transistors (JFETs), unlike bipolar transistors, do not easily lend themselves to analytic solutions of bias networks. By their very nature, JFETs are voltage controlled devices. Gate to source voltage (control voltage  $V_{GS}$ ) variations of several volts can exist within a given part type at the same operating conditions, causing the problem. Multiple suppliers and inadequate or non-existent data sheet curves compound the problem further, requiring data from the suppliers or the use of a curve tracer.

A simple curve tracer, used with any oscilloscope, can be built using a quad op amp and a handful of parts. The circuit displays drain current versus gate voltage for both P and N-channel JFETs at a constant drain voltage.

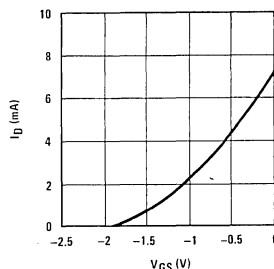


FIGURE 1. Typical N-Channel FET Transfer Curve

The circuit consists of an op amp current to voltage (I/V) amplifier with a positive or negative gate sweep

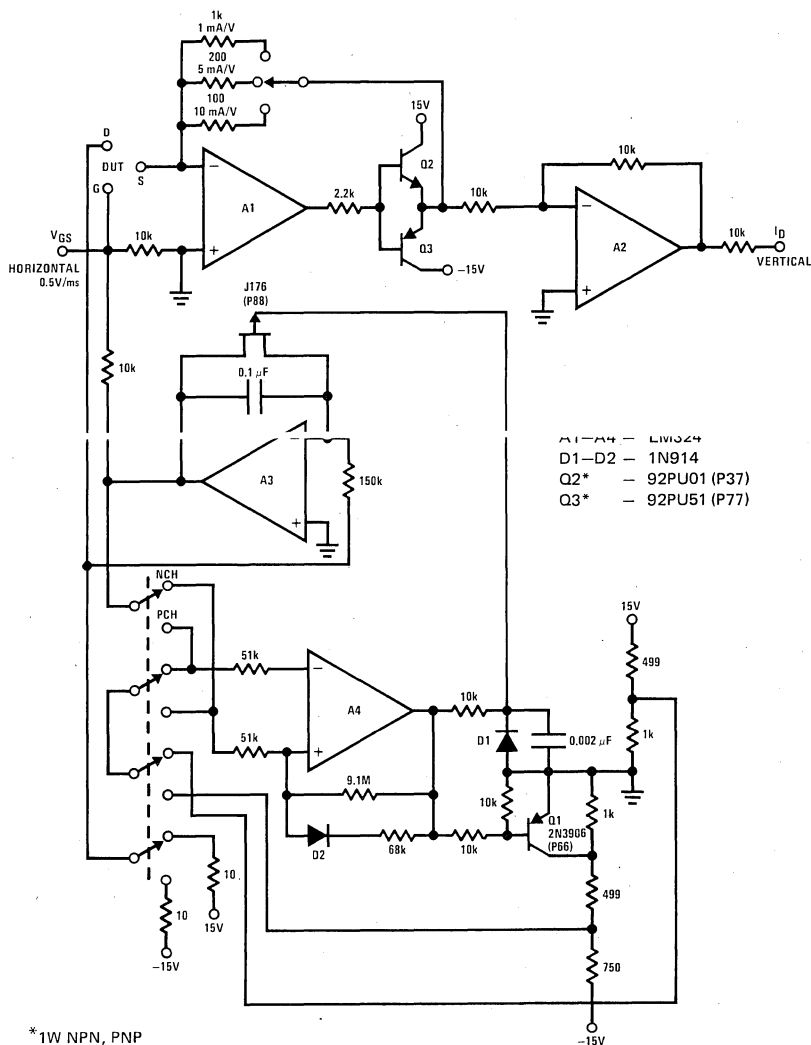


FIGURE 2. FET Curve Tracer

voltage. The I/V amplifier uses 1/4 of the quad op amp and 3 switchable feedback resistors for drain current scaling: 1k for 1 mA/V, 200Ω for 5 mA/V and 100Ω for 10 mA/V. An NPN-PNP emitter-follower buffer is used with the I/V amplifier to handle high FET currents (to 100 mA). A unity gain inverting amplifier is used for proper drain current polarity.

The gate sweep generator consists of 2 parts, a linear ramp generator with a reset and a window comparator. The ramp generator is an op amp with a capacitor in its feedback loop. The sweep rate is set by a constant current supplied to the capacitor through a resistor tied to either the plus or minus voltage supply.

The positive (P-channel) ramp mode uses the positive reference on the plus input of the comparator with the ramp connected to the minus input. The comparator output stays high (15V) pinching the FET OFF until the input exceeds the reference (10V). At that point, the output snaps to the negative supply, turning the FET switch ON, discharging the capacitor. The reference voltage at the plus input is set near ground using the 51k input resistor, D2 and 68k feedback resistor when the comparator output is in the low state. When the capacitor is discharged, the comparator resets, restarting the ramp.

A negative sweep is more difficult to generate using the same comparator. The reference (-10V) is on the minus input with the ramp connected to the plus input. As with the positive sweep, the comparator output is high until the negative sweep exceeds the reference. The difference is that the reference cannot be set to ground for the reset sweep but to a negative voltage such that when the ramp is at 0V the comparator resets. The function of Q2 is to short R1, changing the reference voltage from -10V to -6V.

In both cases, the sweep time is 10 ms. The resistor attenuator on the FET gate terminal divides the voltage in half, yielding a sweep rate of 0.5V/ms with a maximum gate voltage of ±5V. This should be adequate for most FETs used as amplifiers but if additional gate voltage is required, the attenuator can be switched out.

The circuit is limited to displaying only the FET transfer characteristic  $I_D$  vs  $V_{GS}$ , but this is the curve most needed by designers. It gives insight into parameter variations of bias circuits and it can be used to observe temperature effects on the FET. The oscilloscope vertical input is used for the drain current and the

horizontal input is used for the gate voltage. The horizontal sweep can be used if no horizontal input is available where a sweep rate of 0.5 ms/cm corresponds to 0.5V/ms, allowing the curve tracer to be used with an oscilloscope.

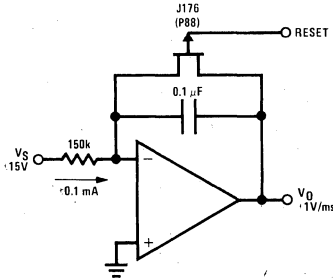


FIGURE 3. Linear Ramp Generator

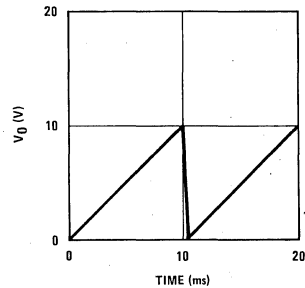


FIGURE 4. Positive Sweep

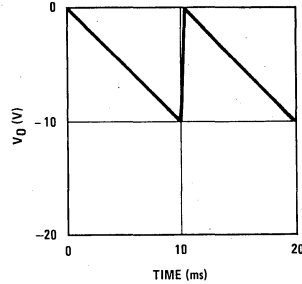


FIGURE 5. Negative Sweep



Section 12

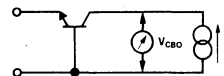
**Appendices**

**12**

**DC PARAMETERS**

**$BV_{CBO}$**       **Collector-Base Breakdown Voltage with Emitter Open-Circuited**

The breakdown voltage of the collector-base junction, measured at a specified current, with the emitter open-circuited.



**$BV_{CEO}$**       **Collector-Emitter Breakdown Voltage with the Base Open-Circuited**

The collector-emitter breakdown voltage, measured at a specified collector current, with the base open-circuited.

**$BV_{CER}$**       **Collector-Emitter Breakdown Voltage with Resistance between Emitter and Base**

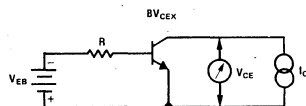
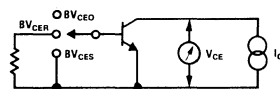
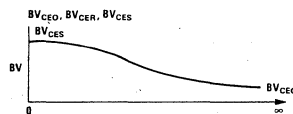
The collector-emitter breakdown voltage measured at a specified current with a specified resistance R connected between the base and the emitter.

**$BV_{CES}$**       **Collector-Emitter Breakdown Voltage with Base Shorted to Emitter**

The collector-emitter breakdown, measured at a specified current, with the base shorted to the emitter.

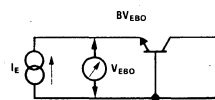
**$BV_{CEX}$**       **Collector-Emitter Breakdown Voltage at a Specified Condition**

The collector-emitter breakdown voltage measured at a specified current with the base-emitter junction forward or reverse biased by a specified voltage or current.



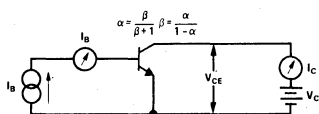
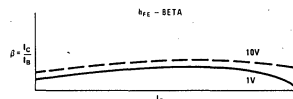
**$BV_{EBO}$**       **Emitter-Base Breakdown Voltage with Collector Open-Circuited**

The emitter-base breakdown voltage, measured at a specified current, with the collector open-circuited.



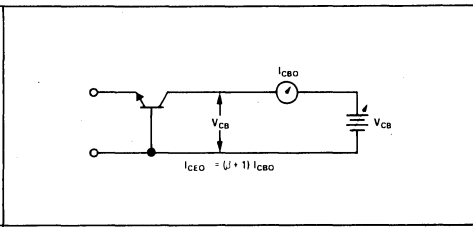
**$h_{FE}$**       **Common-Emitter DC Current Gain**

The ratio of DC collector current to DC base current measured at a specified collector-emitter voltage and a specified collector current.



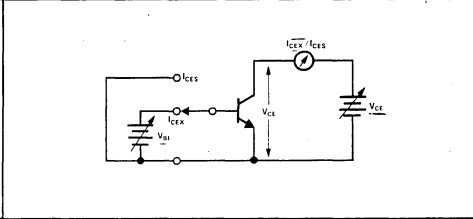
**$I_{CBO}$**       **Inverse Collector-Base Current**

The collector-base current with the junction reverse biased by a specified voltage, with the emitter open-circuited.



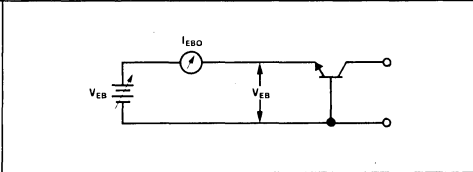
**$I_{CEX}$** ,  
 **$I_{CES}$**       **Inverse Collector-Emitter Current at a Specified Condition**

The collector-emitter current measured at a specified collector-emitter voltage with the base forward or reverse biased by a specified voltage or current, or with the base shorted to the emitter.



**$I_{EBO}$**       **Inverse Emitter-Base Current**

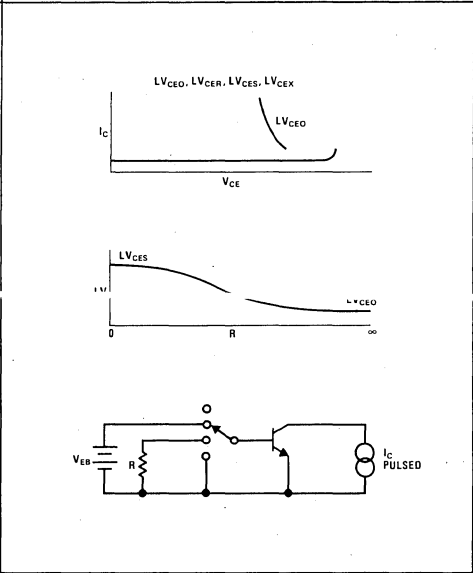
The emitter-base current with the junction reverse biased by a specified voltage with the collector open-circuited.



**$LV_{CEO}$** ,  
 **$LV_{CER}$** ,  
 **$LV_{CES}$** ,  
 **$LV_{CEX}$** , or,  
 **$V_{CEO}(sust)$** ,  
 **$V_{CER}(sust)$** ,  
 **$V_{CES}(sust)$** ,  
 **$V_{CEX}(sust)$**

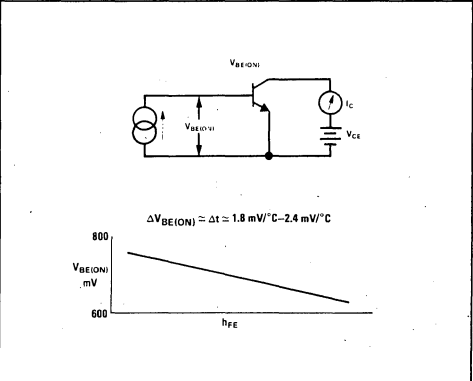
**Pulsed Limiting Breakdown Voltages**

These are similar to the corresponding, above defined, BV parameters but are measured at a specified high current point where collector-emitter voltage is lowest. The duration of the pulse and its duty cycle must be specified. The letter L indicates LIMITING Value and is measured outside the negative resistance zone of the reverse characteristic.

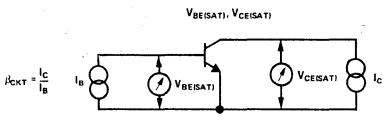
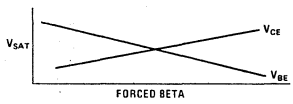
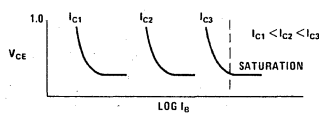
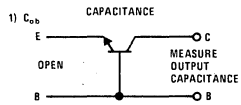
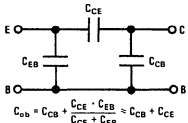


**$V_{BE(ON)}$**       **Unsaturated Base-Emitter Voltage**

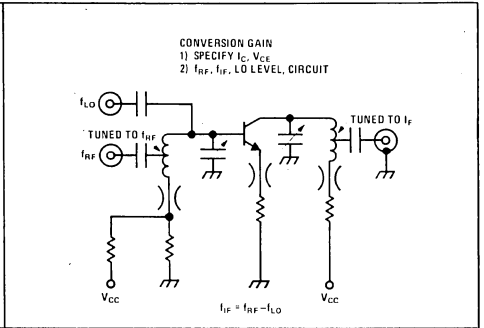
The base-emitter voltage measured in the common-emitter connection at a specified collector to emitter voltage and specified collector current.



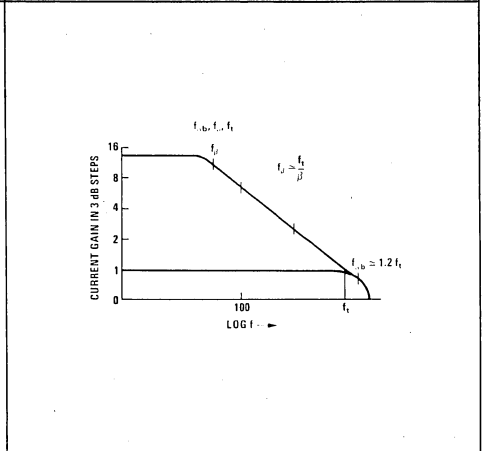


<p><math>V_{BE(SAT)}</math>      <b>Base-Emitter Saturation Voltage</b></p> <p>The base-emitter voltage measured in the common-emitter connection at a specified collector and base saturation currents.</p> <p><math>V_{CE(SAT)}</math>      <b>Collector-Emitter Saturation Voltage</b></p> <p>The collector-emitter voltage measured in the common-emitter connection at specified collector and base saturation currents.</p>	 <p style="text-align: center;"><math>\beta_{FORCED} = \frac{I_C}{I_B}</math></p>  
<p><math>V_{RT}</math>      <b>Reach Through Voltage</b></p> <p><math>V_{PT}</math>      <b>Punch Through Voltage</b></p> <p>The collector-base voltage above which an increase of applied voltage can be measured in the emitter-base open circuit.</p>	
<p><b>SMALL SIGNAL PARAMETERS</b></p>	
<p><math>C_{ob}</math>      <b>Common-Base Output Capacitance</b></p> <p>The common-base output capacitance with input ac open.</p>	
<p><math>C_{re}</math>      <b>Common-Emitter Reverse Transfer Capacitance</b></p> <p>This parameter is the imaginary part of <math>y_{re}</math>. When <math>I_C = 0</math>, <math>C_{re}</math> is identical to <math>C_{CB}</math>.</p>	
<p><math>C_{te}</math>, <math>C_{ib}</math>, <math>C_{EB}</math> <math>C_{CB}</math></p> <p><b>Base-Emitter Capacitance</b></p> <p>The capacity of the base-emitter junction at a specified inverse voltage with the collector open.</p> <p><b>Collector-Base Capacitance</b></p> <p>Collector-base capacitance measured at some specified collector-base voltage.</p>	 <p>2) <math>C_{CB}</math></p> <p style="text-align: center;"><math>C_{CB} = C_{ob}</math> (WITH EMITTER GUARDED)</p>

<p><b>CG<sub>e</sub>, CG<sub>b</sub></b></p>	<p><b>Conversion Gain, Common-Emitter or Common-Base</b></p> <p>The ratio of the output power of a mixer, at one specified frequency, to its input power, at another specified frequency. This parameter is a function of oscillator injection voltage and the mixer operating point.</p>
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<p><b>f<sub>αb</sub>, f<sub>hfb</sub></b></p>	<p><b>Common-Base Cut Off Frequency</b></p> <p>The frequency at which the h<sub>fb</sub> (α) is reduced to 0.707 of its low frequency value.</p>
<p><b>f<sub>β</sub>, f<sub>hfe</sub></b></p>	<p><b>Common-Emitter Cut Off Frequency</b></p> <p>The frequency at which the h<sub>fe</sub> (β) is reduced to 0.707 of its low frequency value.</p>
	<p><b>Gain Band-Width Product</b></p> <p>The common-emitter current gain band-width product in the frequency range where the current gain is falling at approximately 6 db/octave.</p>
<p><b>f<sub>t</sub></b></p>	<p><b>Transition Frequency</b></p> <p>The frequency at which the h<sub>fe</sub> (β) is equal to 1.0. This is a device figure of merit that is often specified at a V<sub>CE</sub> and I<sub>C</sub>.</p>

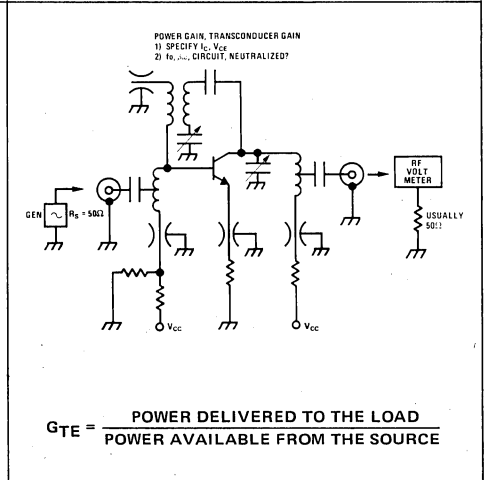


<p><b>f<sub>MAX</sub></b></p>	<p><b>Maximum Frequency of Oscillation</b></p> <p>This parameter is a device figure of merit that is calculated from f<sub>t</sub> and r<sub>b</sub>'C<sub>c</sub>.</p>
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**f<sub>MAX</sub> = MAX FREQUENCY OF OSCILLATION FREQUENCY AT WHICH MAG = 1**

$$f_{MAX} = \sqrt{\frac{f_t}{8\pi r_b C_c}} = f \sqrt{PG}$$

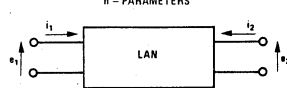
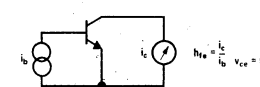
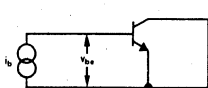
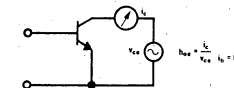
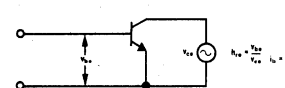
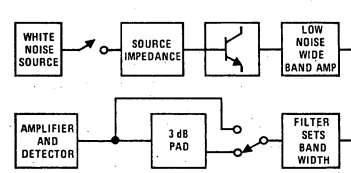
<p><b>GP<sub>e</sub></b></p>	<p><b>Common-Emitter Power Gain</b></p>
<p><b>PG</b></p>	<p><b>Power Gain</b></p> <p>Can be common-emitter or common-base.</p> <p>Usually stability-limited gains involved, thus are effectively a transducer gain measurement.</p>
<p><b>G<sub>TE</sub></b></p>	<p><b>Common-Emitter Transducer Gain</b></p> <p>A test fixture must be specified.</p>



<p><b>GMA</b></p>	<p><b>Stability Limited Gain or Gain Maximum Available</b></p> <p>This parameter is a device figure of merit and must be calculated from the two port "y" parameters.</p>
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$$GMA = 10 \text{ LOG } \left[ \frac{|Y_{fe}|}{|Y_{re}|} (K - \sqrt{K^2 - 1}) \right]$$

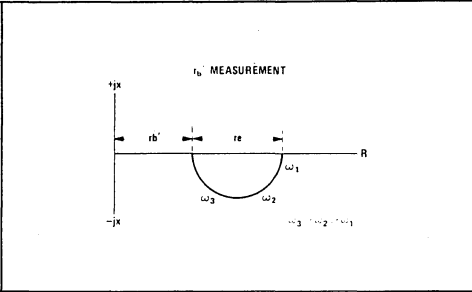
NOT DEFINED FOR K < 1

<p><b>h Parameters</b></p>	<p style="text-align: center;">h - PARAMETERS</p>  <p>WHERE <math>e_1, i_1, e_2, i_2</math> ARE SMALL SIGNAL VOLTAGES AND CURRENTS          THE h - (HYBRID) PARAMETERS ARE DEFINED BY  <math display="block">e_1 = h_{11} i_1 + h_{12} e_2</math> <math display="block">i_2 = h_{21} i_1 + h_{22} e_2</math>         AND FOR COMMON EMITTER OPERATION THESE EQ BECOME  <math display="block">e_1 = h_{ie} i_1 + h_{re} e_2</math> <math display="block">i_2 = h_{fe} i_1 + h_{oe} e_2</math></p>
<p><b><math>h_{fe}</math></b></p> <p><b>Common-Emitter Current Gain</b></p> <p>The common-emitter forward current transfer ratio with output ac shorted. This is a complex quantity.</p>	<p style="text-align: center;">h - PARAMETERS-COMMON EMITTER</p>  <p><math>h_{fe} = \frac{i_2}{i_1} \quad v_{ce} = 0</math></p>
<p><b><math>h_{ie}</math></b></p> <p><b>Common-Emitter Input Impedance</b></p> <p>The common-emitter input impedance with the output ac shorted. This is a complex quantity.</p>	 <p><math>h_{ie} = \frac{v_{be}}{i_b} \quad v_{ce} = 0</math></p>
<p><b><math>h_{oe}</math></b></p> <p><b>Common-Emitter Output Admittance</b></p> <p>The common-emitter output admittance with the input ac open. This is a complex quantity.</p>	 <p><math>h_{oe} = \frac{i_c}{v_{ce}} \quad i_b = 0</math></p>
<p><b><math>h_{re}</math></b></p> <p><b>Common-Emitter Reverse Voltage Transfer Ratio</b></p> <p>The common-emitter reverse voltage transfer ratio with input ac open. This is a complex quantity.</p>	 <p><math>h_{re} = \frac{v_{be}}{v_{ce}} \quad i_b = 0</math></p>
<p><b>MAG</b></p> <p><b>Maximum Available Gain</b></p> <p>Device figure of merit that must be calculated from the two port "y" parameters.</p>	$MAG = 10 \text{ LOG } \frac{ Y_{21} ^2}{4 \text{ Re } (Y_{11}) \text{ Re } (Y_{22})}$
<p><b>MSG</b></p> <p><b>Maximum Stable Gain</b></p> <p>This parameter is a device figure of merit that is calculated from the two port "y" parameters.</p>	$MSG = 10 \text{ LOG } \frac{ y_{fe} }{ y_{re} }$
<p><b>NF</b></p> <p><b>Noise Figure</b></p> <p>Noise figure = <math>10 \log_{10} F</math>, where F is the ratio of total output noise power to the output power due solely to the thermal noise of the source impedance.</p>	<p style="text-align: center;">NOISE FIGURE MUST SPECIFY          1) <math>V_{ce}, I_c</math>          2) <math>R_s, f_o, \text{PBW}</math></p> 

$r_{bb'}, r_b'$

**Base << Spreading >> Resistance**

Equivalent to the real part of  $h_{ie}$  at some specified very high frequency.



$r_b' C_c$

**Collector Base Time Constant**

This parameter is a device figure of merit and is measured in a specified test circuit.

$r_b' C_c =$  COLLECTOR BASE TIME CONSTANT  
SPECIFY -  $I_C, V_{CE},$  FREQUENCY

**Common-Emitter Switching Parameters**

In the following, drive circuit conditions and collector circuit conditions must be specified. The transition times of the input must be negligible compared to the measured times.

$t_d$  }  $t_{ON}$

**Delay Time**

The time interval during turn-on from the point when the input pulse at the base reaches 10% of its full amplitude to the point when the collector pulse changes from 0 to 10% of its maximum amplitude.

$t_r$  }

**Rise Time**

The time interval during turn-on in which the collector pulse changes from 10% to 90% of its maximum amplitude.

$t_s$  }  $t_{OFF}$

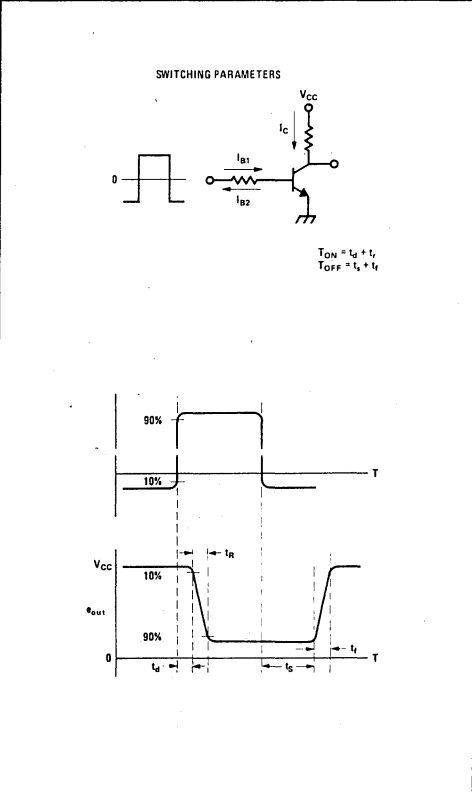
**Storage Time**

The time interval during turn-off from the point when the turn-off pulse at the base changes from 100% to 90% of its full amplitude to the time when the collector current has changed from 100% to 90% of its maximum amplitude.

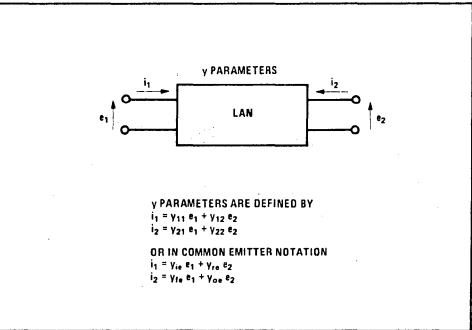
$t_f$  }

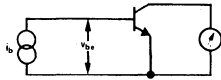
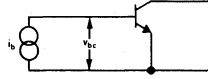
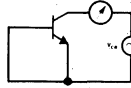
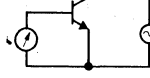

**Fall Time**

The time interval during turn-off in which the collector pulse decreases from 90% to 10% of its maximum amplitude.



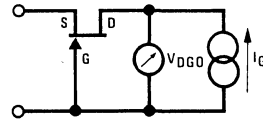
**Y Parameters**



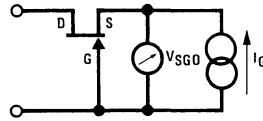
<p><math>Y_{fe}</math></p>	<p><b>Common-Emitter Forward Transfer Admittance</b></p> <p>The common-emitter forward transfer admittance with output ac shorted. This is a complex quantity (<math>g_{fe} + jb_{fe}</math>).</p>	 <p><math>Y_{fe} = \frac{i_c}{v_{be}} \Big _{v_{ce} = 0}</math></p>
<p><math>Y_{ie}</math></p>	<p><b>Common-Emitter Input Admittance</b></p> <p>The common-emitter input admittance with output ac shorted. This is a complex quantity (<math>g_{ie} + jb_{ie}</math>).</p>	<p>Y PARAMETERS-COMMON EMITTER</p>  <p><math>Y_{ie} = \frac{i_b}{v_{be}} \Big _{v_{ce} = 0}</math></p>
<p><math>Y_{oe}</math></p>	<p><b>Common-Emitter Output Admittance</b></p> <p>The common-emitter output admittance with input ac open. This is a complex quantity (<math>g_{oe} + jb_{oe}</math>).</p>	 <p><math>Y_{oe} = \frac{i_c}{v_{ce}} \Big _{v_{be} = 0}</math></p>
<p><math>Y_{re}</math></p>	<p><b>Common-Emitter Reverse Transfer Admittance</b></p> <p>The common-emitter reverse transfer admittance with input ac shorted. This is a complex quantity (<math>g_{re} + jb_{re}</math>).</p>	 <p><math>Y_{re} = \frac{i_b}{v_{ce}} \Big _{v_{be} = 0}</math></p>
<p><b>LARGE SIGNAL PARAMETERS</b></p>		
<p><math>\eta</math></p>	<p><b>Collector Efficiency</b></p> <p>This parameter applies to oscillators and class C amplifiers, predominantly. It is defined as the ratio of RF Power Out/DC Power In.</p>	<p><math>\eta</math> - COLLECTOR EFFICIENCY</p> $\eta = \frac{P_o \text{ (RF)}}{P_{in} \text{ (DC)}} = \frac{v_i}{I_C \times V_{CE}}$
<p><math>P_o</math></p>	<p><b>Power Out</b></p> <p>This parameter applies to oscillators. The units are watts and a test circuit must be specified.</p>	 <p>SPECIFY - <math>I_C, V_{CE}</math> UNDER QUIESCENT CONDITIONS - <math>I_o, P_{LOAD}</math></p>
<p><b>THERMAL PARAMETERS</b></p>		
<p><math>R_{TH}</math></p>	<p><b>Internal Junction-to Case Thermal Resistance</b></p> <p>The rated increase of junction temperature with respect to the case temperature per unit of dissipated power. It is also called Thermal Resistance with infinite heat sink.</p>	
<p><math>\theta_{JC}</math></p>	<p><b>Junction-to Case Thermal Rating</b></p>	
<p><math>\theta_{JA}</math></p>	<p><b>Junction-to Ambient Thermal Rating</b></p>	

**DC PARAMETERS**
 **$BV_{DGO}$  (V)  
or  $BV_{GDO}$** 
**Drain-Gate Breakdown Voltage with Source Open-Circuited**

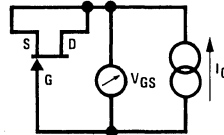
The breakdown voltage of the drain-gate junction, measured at a specified current with the source open-circuited.


 **$BV_{SGO}$  (V)  
or  $BV_{GSO}$** 
**Source-Gate Breakdown Voltage with Drain Open-Circuited**

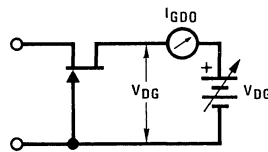
The breakdown voltage of the source-gate junction, measured at a specified current, with the drain open-circuited.


 **$BV_{GSS}$  (V)  
or  $BV, V_{(BR)GSS}$** 
**Source-Gate Breakdown Voltage with Drain-Source Shorted**

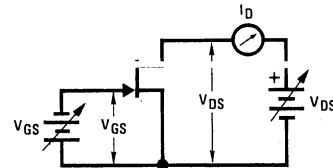
The breakdown voltage of the source-gate and drain-gate junctions, measured at a specified current with the drain-source shorted.


 **$I_{DGO}$  (pA)  
or  $I_{GDO}$** 
**Drain-Gate Leakage Current, Source Open-Circuited**

The leakage current of the drain-gate junction, measured at a specified voltage, with the source open-circuited.


 **$I_D$  (μA)  
or  $I_{D(ON)}$** 
**Drain ON Current**

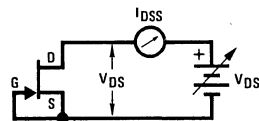
The drain current, measured at a specified drain-source voltage and gate-source voltage.


 **$I_{D(OFF)}$  (pA)**
**Drain Cutoff Current**

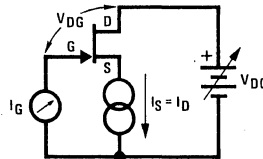
The drain cutoff current, measured at a specified drain-source voltage and gate-source voltage.


 **$I_{DSS}$  (mA)**
**Drain Saturation Current**

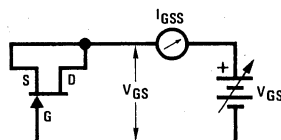
The drain current, measured at a specified drain-source voltage with the source shorted to the gate ( $V_{GS} = 0$ )

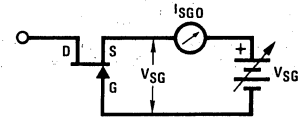
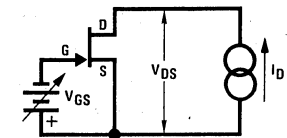
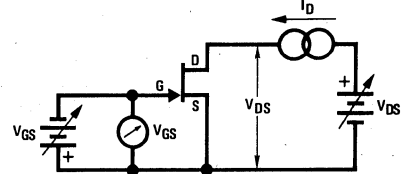
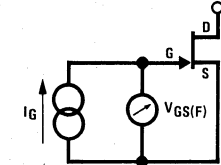
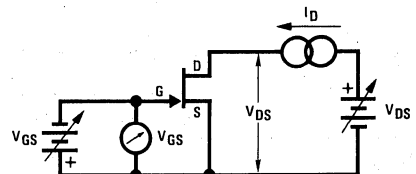
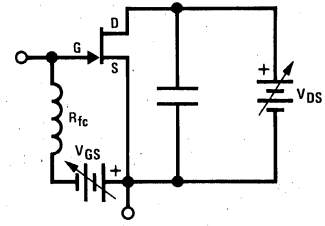
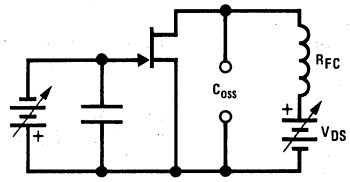

 **$I_G$  (pA)  
or  $I_{G(ON)}$** 
**Gate Leakage Current with Drain Current Flowing**

The gate leakage current, measured at a specified drain current and drain-gate voltage.


 **$I_{GSS}$  (pA)**
**Gate-Source Reverse Leakage Current with Drain-Source Shorted**

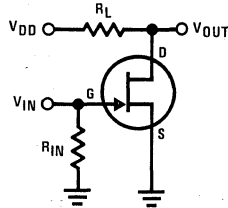
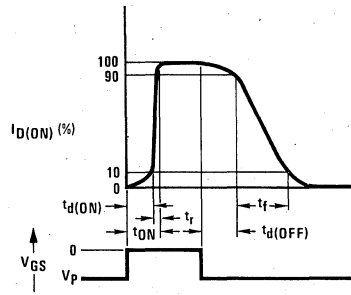
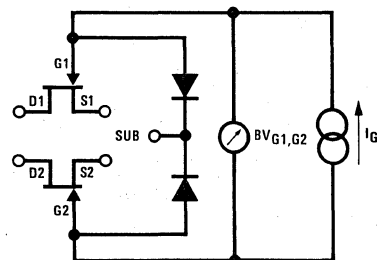
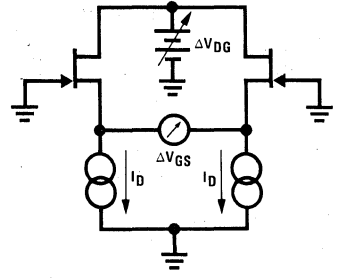
The gate-source reverse leakage current measured at a specified gate-source voltage.



<p><math>I_{SGO}</math> (pA) or <math>I_{GSO}</math></p>	<p><b>Source-Gate Reverse Leakage Current with Drain Open-Circuited</b></p> <p>The leakage current of the source-gate junction, measured at a specified voltage, with the drain open-circuited.</p>	
<p><math>r_{DS}</math> (<math>\Omega</math>) or <math>r_{ds}</math>, <math>R_{DS}</math>, <math>r_{DS(ON)}</math></p>	<p><b>Drain-Source ON Resistance</b></p> <p>The drain-source ON resistance, measured at a specified gate-source voltage and drain current.</p>	
<p><math>V_{DS(ON)}</math> (mV)</p>	<p><b>Drain-Source ON Voltage</b></p> <p>The drain-source ON voltage, measured at a specified gate-source voltage and drain current.</p>	<p style="text-align: center;"><math>r_{DS} = \frac{V_{DS}}{I_D}</math></p>
<p><math>V_{GS}</math> (V) or <math>V_{GS(ON)}</math>, <math>V_G</math></p>	<p><b>Operating Gate-Source Voltage</b></p> <p>The gate-source voltage, measured at a specified drain current and drain-source voltage.</p>	
<p><math>V_{GS(F)}</math> (V)</p>	<p><b>Forward Gate-Source Voltage</b></p> <p>The forward gate-source voltage, measured at specified current.</p>	
<p><math>V_{GS(OFF)}</math> (V) or <math>V_p</math></p>	<p><b>Gate-Source Cutoff (Pinch-Off) Voltage</b></p> <p>The gate-source cutoff voltage, measured at a specified drain current and drain-source voltage.</p>	
<b>SMALL SIGNAL PARAMETERS</b>		
<p><math>C_{iss}</math> (pF) or <math>C_{iss}</math>, <math>C_{gss}</math></p>	<p><b>Common-Source Input Capacitance</b></p> <p>The common-source input capacitance measured between the gate and source with the drain A-C shorted to the source at specified drain-source and gate-source voltages.</p>	
<p><math>C_{oss}</math> (pF) or <math>C_{os}</math>, <math>C_{dss}</math></p>	<p><b>Common-Source Output Capacitance</b></p> <p>The common-source output capacitance, measured between the drain and source with the source A-C shorted to the gate at specified drain-source and gate-source voltages.</p>	

<p><math>C_{rss}</math> (pF) or <math>C_{rs}, C_{dg}</math></p>	<p><b>Common-Source Reverse Transfer Capacitance</b></p> <p>The common-source reverse transfer capacitance, measured between the drain and gate at specified drain-source and gate source voltages.</p>	
<p><math>e_n</math> (nV/<math>\sqrt{Hz}</math>) or <math>e_n, V_n, E_n</math></p>	<p><b>Equivalent Input Noise Voltage</b></p> <p>The equivalent input noise voltage per unit bandwidth, measured with the input A-C shorted to the source at a specified operating condition.</p>	
<p><math>g_{fg}</math> (mV) (m<math>\Omega</math>) or <math>y_{fg}</math></p>	<p><b>Common-Gate Forward Transconductance</b></p> <p>The common-gate forward transconductance with the output A-C shorted. This is a complex quantity (<math>g_{fg} + jbf_{g}</math>).</p>	$Y_{fg} = \frac{I_D}{V_{GS}} \Big _{V_{DS} = 0}$
<p><math>g_{fs}</math> (mV) (m<math>\Omega</math>) or <math>g_m, Y_{fs},</math> <math>Re Y_{fs} </math></p>	<p><b>Common-Source Forward Transconductance</b></p> <p>The common source forward transconductance with the output A-C shorted. This is a complex quantity (<math>g_{fs} + jbf_{s}</math>).</p>	$Y_{fs} = \frac{I_D}{V_{GS}} \Big _{V_{DS} = 0}$
<p><math>g_{is}</math> (<math>\mu V</math>) (<math>\mu\Omega</math>) or <math>Y_{is}</math></p>	<p><b>Common-Source Input Conductance</b></p> <p>The common-source input conductance with the output A-C shorted. This is a complex quantity (<math>g_{is} + jbf_{is}</math>).</p>	$Y_{is} = \frac{I_G}{V_{GS}} \Big _{V_{DS} = 0}$
<p><math>g_{os}</math> (<math>\mu V</math>) (<math>\mu\Omega</math>) or <math>Y_{os}</math></p>	<p><b>Common-Source Output Conductance</b></p> <p>The common source output conductance with the input A-C shorted. This is a complex quantity (<math>g_{os} + jbf_{os}</math>).</p>	$Y_{os} = \frac{I_D}{V_{DS}} \Big _{V_{GS} = 0}$
<p><math>G_{pg}</math> (dB)</p>	<p><b>Common-Gate Power Gain</b></p> <p>The common-gate power gain is the ratio of output power to input power.</p>	$G_p = 10 \log_{10} \frac{P_o}{P_i}$
<p><math>G_{ps}</math> (dB)</p>	<p><b>Common-Source Power Gain</b></p> <p>The common-source power gain is the ratio of output power to input power.</p>	$G_p = 10 \log_{10} \frac{P_o}{P_i}$
<p><math>i_n</math> (pA/<math>\sqrt{Hz}</math>)</p>	<p><b>Equivalent Input Noise Current</b></p> <p>The equivalent input noise current measured with the input open-circuited under specified operating conditions.</p>	



<p>NF (dB)</p>	<p><b>Spot Noise Figure</b></p> <p>Noise figure = <math>10 \log_{10} F</math> where F is noise factor which is the ratio of the total output noise power to the output noise power of the source. Measured at specified operating conditions and source resistance.</p>	$F = \frac{\text{Total Output Noise Power}}{\text{Source Output Noise Power}}$
<p><b>COMMON-SOURCE SWITCHING PARAMETERS</b></p>		
<p><math>t_d(\text{ON})</math></p>	<p><b>Turn-On Delay Time</b></p> <p>The time interval during turn-on from the point when the input pulse at the gate reaches 10% of its full amplitude to the point when the drain pulse changes from 0 to 10% of its maximum amplitude.</p>	
<p><math>t_r</math></p>	<p><b>Rise Time</b></p> <p>The time interval during turn-on in which the drain current pulse changes from 10% to 90% of its maximum amplitude.</p>	$I_{D(\text{ON})} = \frac{V_{DD} - V_{DS(\text{ON})}}{R_L}$
<p><math>t_d(\text{OFF})</math></p>	<p><b>Turn-Off Delay Time</b></p> <p>The time interval during turn-off from the point when the turn-off pulse at the gate changes from 100% to 90% of its full amplitude to the time when the drain current has changed from 100% to 90% of its maximum amplitude.</p>	
<p><math>t_f</math></p>	<p><b>Fall Time</b></p> <p>The time interval during turn-off in which the drain current pulse decreases from 90% to 10% of its maximum amplitude.</p>	
<p><b>DUAL FET PARAMETERS</b></p>		
<p><math>BV_{G1, G2} (V)</math> or <math>BV_{G1-2}</math></p>	<p><b>Gate to Gate Breakdown Voltage</b></p> <p>The breakdown voltage of the gate to gate junctions, measured at a specified current.</p>	
<p><b>CMRR (dB)</b> or <b>CMR</b></p>	<p><b>Common-Mode Rejection Ratio</b></p> <p>The common-mode rejection ratio is the ratio of the change in differential gate voltage with a change in the drain to gate voltage.</p> $CMRR = 20 \log_{10} \frac{\Delta V_{DG}}{\Delta V_{OS}}$	

<p><math>g_{fs1-2}</math> (%) or <math>g_{fs1}/g_{fs2}</math></p>	<p><b>Common-Source Forward Transconductance Ratio (Match)</b></p> <p>The transconductance ratio = <math>g_{fs1}/g_{fs2} \times 100</math> (%) measured at specified drain-gate voltage and drain current.</p>	
<p><math>g_{os1-2}</math> (<math>\mu V</math>) or <math>g_{os1-2}</math></p>	<p><b>Common-Source Output Conductance (Match)</b></p> <p>Output conductance match = <math> g_{os1}-g_{os2} </math> measured at specified drain-gate voltage and drain current.</p>	
<p><math>I_{DSS1-2}</math> (%) or <math>I_{DS1-2}</math>, <math>I_{DSS1}/I_{DSS2}</math></p>	<p><b>Drain Saturation Current Ratio (Match)</b></p> <p>The drain saturation current ratio = <math>I_{DSS1}/I_{DSS2} \times 100\%</math> measured at specified drain-source voltages.</p>	
<p><math>I_{G1-2}</math> (pA)</p>	<p><b>Differential Gate Leakage Current</b></p> <p>Differential gate leakage current = <math> I_{G1}-I_{G2} </math> measured at specified drain-gate voltage and drain current.</p>	
<p><math>I_{G1, G2}</math> (pA)</p>	<p><b>Gate to Gate Reverse Leakage Current</b></p> <p>The gate to gate reverse leakage measured at a specified voltage monolithic dual with diode isolation shown.</p>	
<p><math>V_{GS1-2}</math> (mV) or <math>\Delta V_{GS}</math>, <math>V_{os}</math>, <math> V_{GS1}-V_{GS2} </math></p>	<p><b>Differential Gate-Source Voltage</b></p> <p>The differential gate-source voltage, measured at a specified drain-gate voltage and drain current.</p>	
<p><math>\Delta V_{GS1-2}</math> (<math>\mu V/^{\circ}C</math>) or <math>\Delta V_{GS1}-V_{GS2} /\Delta T</math> <math>\Delta V_{os}/\Delta T</math></p>	<p><b>Differential Gate-Source Voltage Drift</b></p> <p>The differential gate-source voltage drift is the change in the differential gate-source voltage with a change in device temperature at a specified operating condition.</p> $\frac{\Delta V_{os}}{\Delta T} = \frac{ (V_{GS1}-V_{GS2}) _{T1} - (V_{GS1}-V_{GS2}) _{T2}}{T1-T2}$	

**PACKAGES**
**Dual-In-Line Packages**

- (N) Devices ordered with "N" suffix are supplied in plastic molded dual-in-line package. Molding material is a highly reliable compound suitable for military as well as commercial temperature range applications. Lead material is copper or alloy 42 with a hot solder dipped surface to allow ease of solderability.
- (J) Devices ordered with the "J" suffix are supplied in a cer-dip package (ceramic lid and base sealed with high temperature vitreous glass). Lead material is solder dipped alloy 42.
- (D) Devices ordered with the "D" suffix are supplied in side braze, multi-layer ceramic dual-in-line packages. The leads are Kovar or alloy 42 and either tin-plated, gold-plated, or solder-plated.
- (Q) Devices ordered with the "Q" suffix are supplied in either a "D" or "J" package, but with a U.V. window.

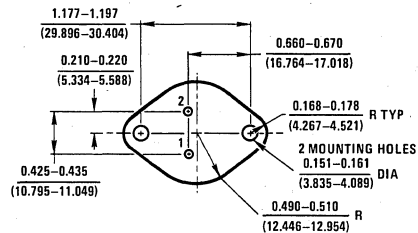
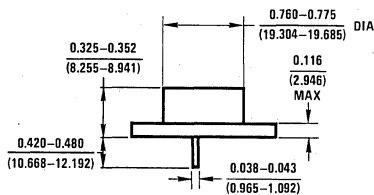
**Metal Can Packages**

- (H) Devices ordered with the "H" suffix are supplied in a metal can package. The cap is nickel finish and the leads are gold-plated Kovar. Gold free construction using epoxy D/A is also available, with a tin-plated finish.

**Flat Packages**

- (F) Devices ordered with the "F" suffix are supplied in a multi-layer ceramic bottom brazed flat package. The lid is plated alloy 42, and leads are gold-plated, tin-plated, or solder-plated alloy 42 or Kovar.

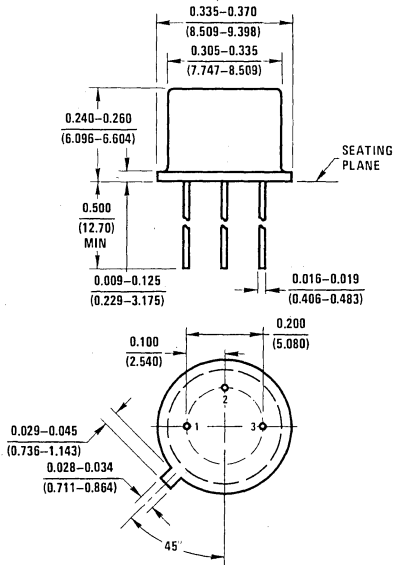
NS PACKAGE CODE	JEDEC CODE	NS PACKAGE CODE	JEDEC CODE
02	TO-18 Glass	39	TO-116 14-Lead Molded DIP (CN)
04	TO-5 Glass	40	TO-116 14-Lead Ceramic DIP (CD)
05	TO-71 Glass Diff. Amp. TO-18	41	TO-116 14-Lead Molded Array
06	TO-46 Solid	42	TO-3
07	TO-52 Solid	51	TO-202
09	TO-39 Solid Kovar	55	TO-202
10	TO-39 Solid Steel	56	TO-202
11	TO-18 Glass	57	TO-220
12	TO-71 Glass TO-18 Diff. Amp.	58	TO-126
17	TO-39 Solid Steel Low Profile	60	8-Lead Molded DIP (CN)
18	TO-52 Glass	67	8-Lead Molded DIP (CN)
19	TO-18 Solid	92	TO-92
23	TO-72 Glass (4-Lead TO-18)	94	TO-92
24	TO-78 Glass TO-5 Diff. Amp.	96	TO-92 Faraday Shield
25	TO-72 Glass (4-Lead TO-18)	97	TO-92
27	TO-78 Diff. Amp. TO-5	98	TO-92 Faraday Shield
28	TO-72 Glass (4-Lead TO-18)	90	TO-237
29	TO-72 Glass (4-Lead TO-18)	91	TO-237
30	TO-78 Glass Diff. Amp. TO-5		

**TO-3 (42)**


Pin 1 — Base  
 Pin 2 — Emitter  
 Case — Collector

TO-5 (04)

PIN	T
1	E
2	B
3	C

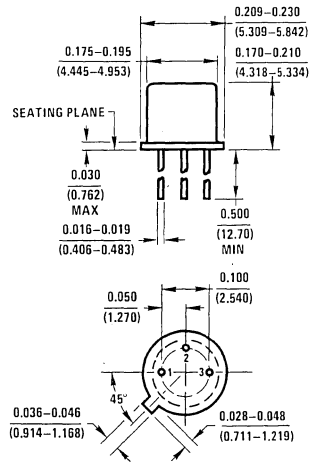


TO-18 (02, 11, 19)

PIN	T (02), (19)
1	E
2	B
3	C

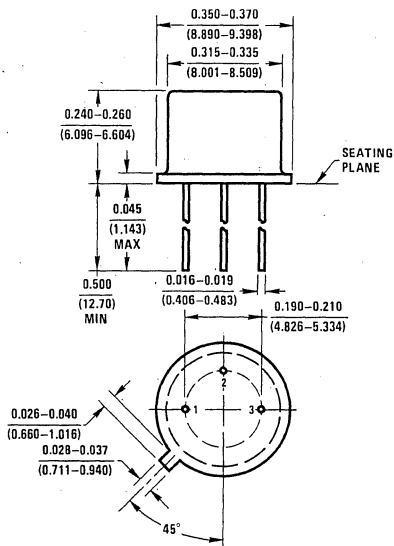
PIN	FET N (02)
1	S
2	D
3	G

PIN	FET P (11)
1	S
2	G
3	D



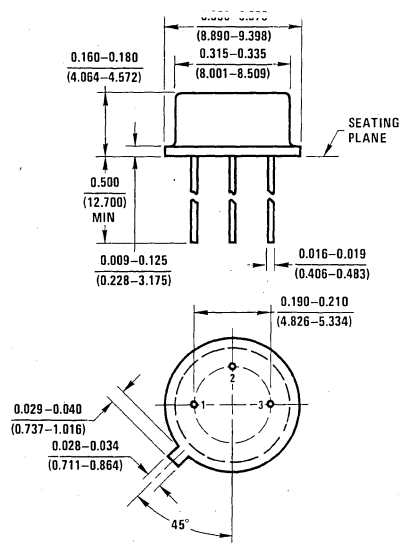
TO-39 (09, 10)

PIN	T
1	E
2	B
3	C



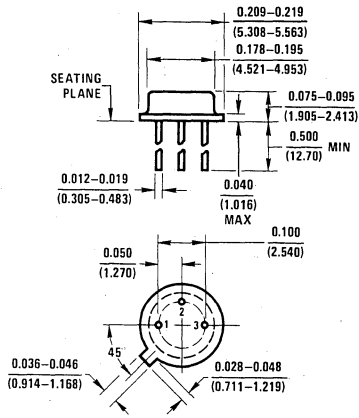
TO-39 (17) LO-PROFILE

PIN	T
1	E
2	B
3	C



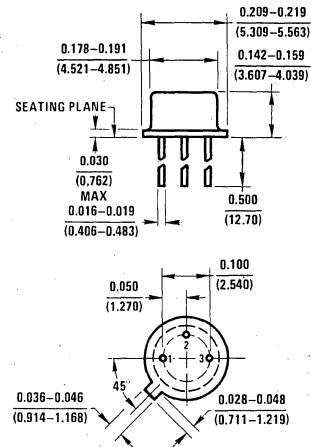
TO-46 (06)

PIN	T
1	E
2	B
3	C



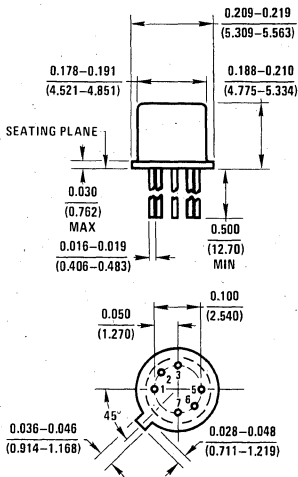
TO-52 (07, 18)

PIN	T (18)	FET (07)
1	E	S
2	B	D
3	C	G



TO-71 (08, 12)

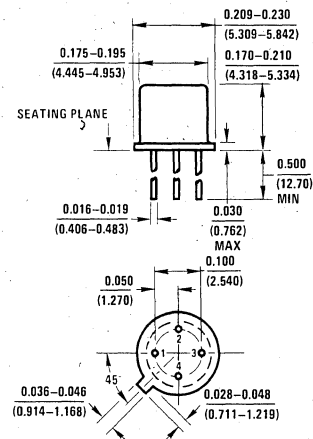
PIN	FET (12)
1	S1
2	D1
3	G1
5	S2
6	D2
7	G2



TO-72 (23, 25, 28, 29)

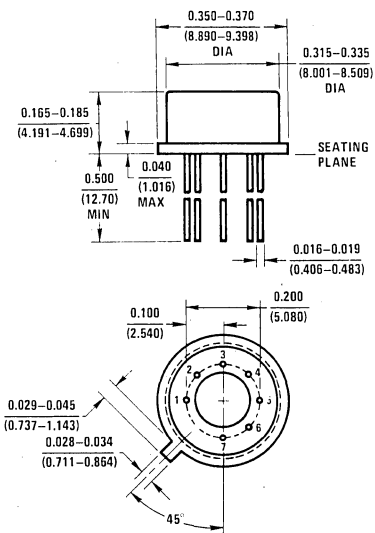
PIN	T (25)	FET N (25, 29)
1	E	S
2	B	D
3	C	G
4	GND	CASE

PIN	T (28)	FET P (23)
1	B	S
2	E	G
3	C	D
4	GND	CASE



TO-78 (24, 30)

PIN	T (30)	FET (24)
1	E1	S1
2	B1	D1
3	C1	G1
5	E2	S2
6	B2	D2
7	C2	G2



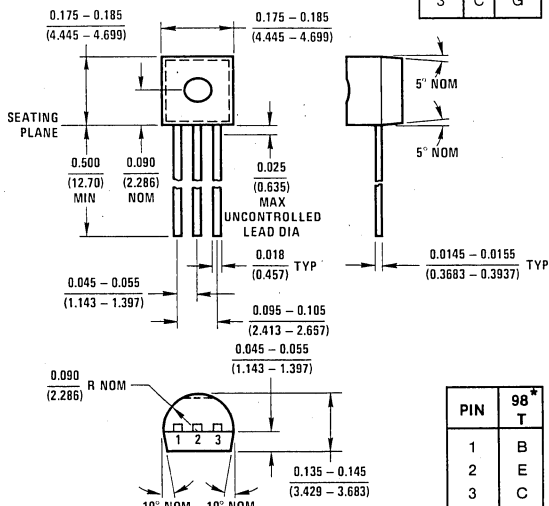
TO-92 (92, 94, 96, 97, 98)

PIN	92 (STD)		96	
	T	FET	T	FET
1	C	G	1	C
2	B	S	2	E
3	E	D	3	B

PIN	94	
	T	FET
1	B	S
2	C	G
3	E	D

Drain-source interchangeable on most JFET devices

PIN	97*	
	T	FET
1	E	D
2	B	S
3	C	G

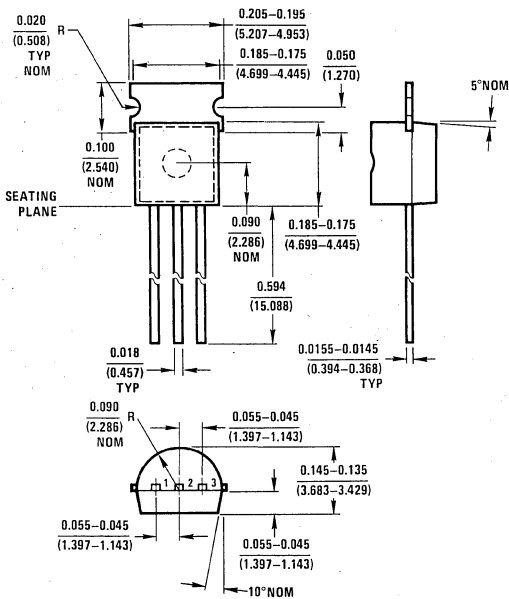


PIN	98*	
	T	FET
1	B	S
2	E	D
3	C	G

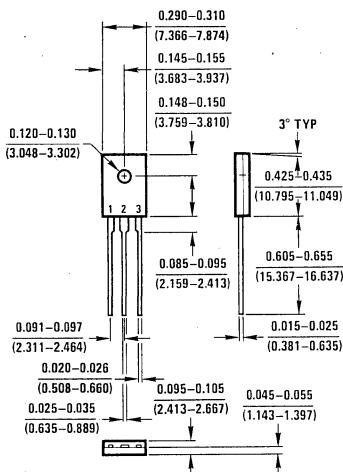
\* See note regarding leadform on 12-19

TO-237 (90, 91)

PIN	PACKAGE 90	PACKAGE 91
1	Base	Collector
2	Collector	Base
3	Emitter	Emitter



TO-126 (58)

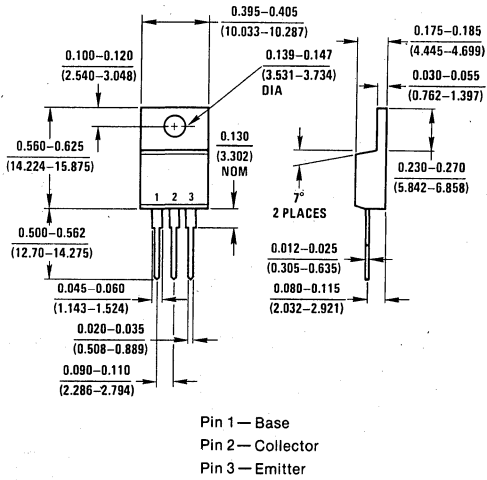


- Pin 1 — Emitter
- Pin 2 — Collector
- Pin 3 — Base

When mounting the device, torque not to exceed 6.0 in lb.

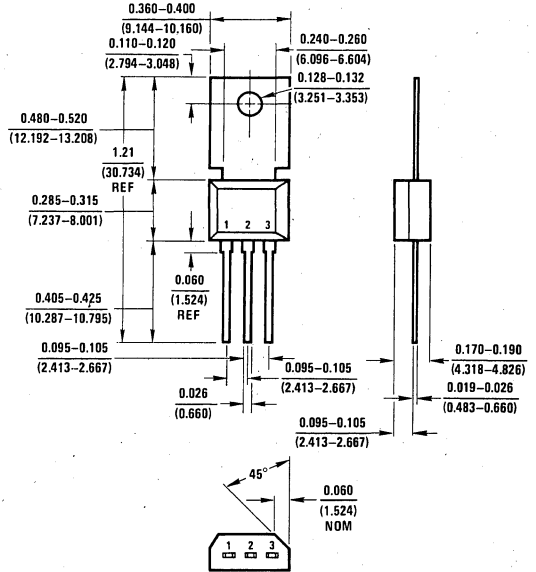
If lead bending is required, use suitable clamp or other supports between transistor case and point of bend.

TO-220 (57)



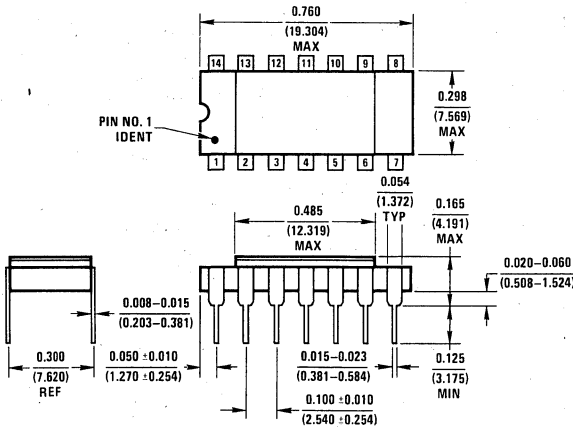
TO-202 (51, 55, 56)

PIN	PACKAGE 51 T	PACKAGE 55 T	PACKAGE 56 T
1	Emitter	Emitter	Base
2	Collector	Base	Collector
3	Base	Collector	Emitter



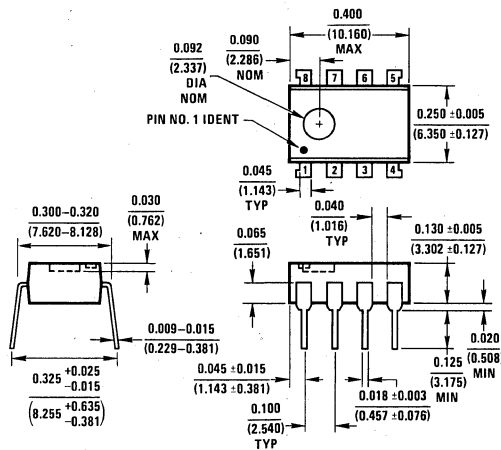
CAVITY DUAL-IN-LINE PACKAGE D (40)

PIN	T	PIN	T
1	C1	8	C3
2	B1	9	B3
3	E1	10	E3
4	NC	11	NC
5	E2	12	E4
6	B2	13	B4
7	C2	14	C4



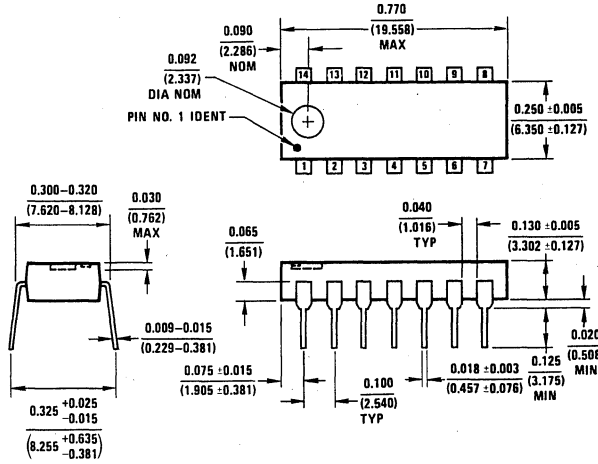
MOLDED MINI-DIP (60, 67)

PIN	60	67
1	NC	S1
2	S1	D1
3	D1	NC
4	G1	G1
5	S2	S2
6	D2	D2
7	G2	NC
8	NC	G2

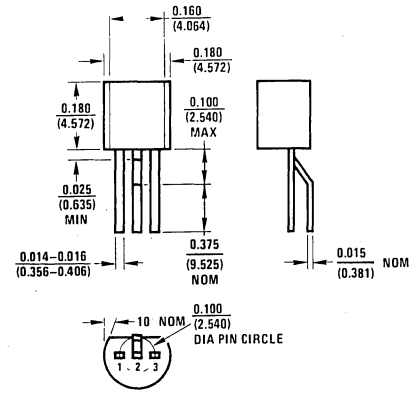


**MOLDED DUAL-IN-LINE PACKAGE N (39)**

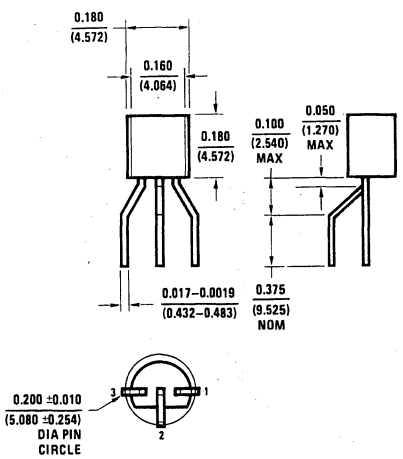
PIN	T	PIN	T
1	C1	8	C3
2	B1	9	B3
3	E1	10	E3
4	NC	11	NC
5	E2	12	E4
6	B2	13	B4
7	C2	14	C4



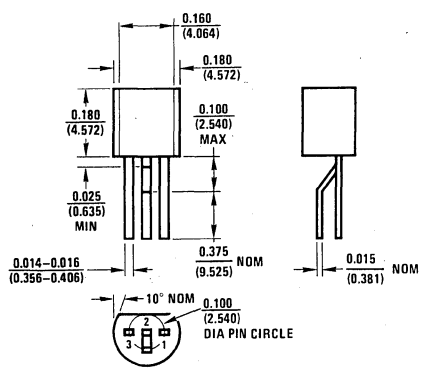
**TO-92 (92, 94, 96)  
TO-18 LEAD FORM -18 OPTION**



**TO-92 (92, 94, 96)  
TO-5 LEAD FORM -5 OPTION**



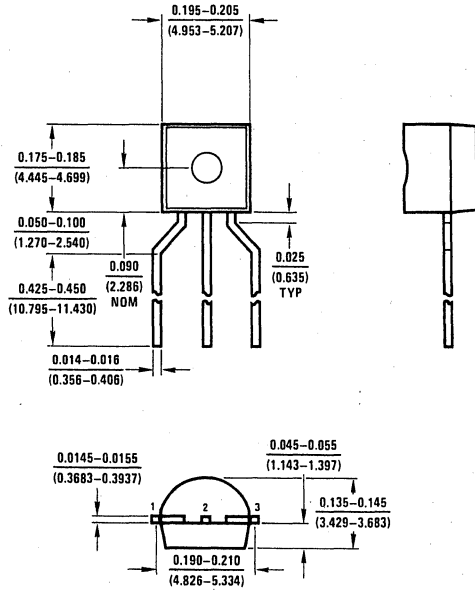
**TO-92 (97, 98)  
TO-18 LEAD FORM STD  
FOR IN-LINE LEADS L34Z OPTION**



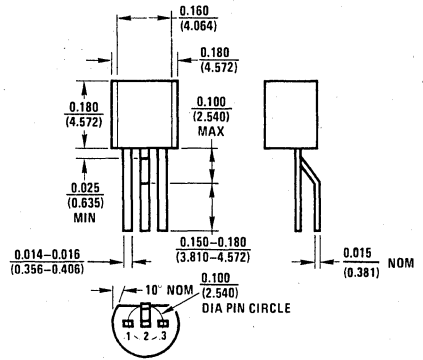
\* Note: All package 97 or 98 transistors are leadformed to this configuration prior to shipment.



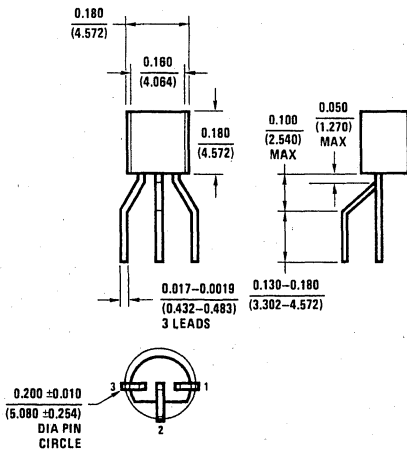
TO-92 (92, 94, 96)  
0.100" SPACING LEAD FORM J61Z OPTION



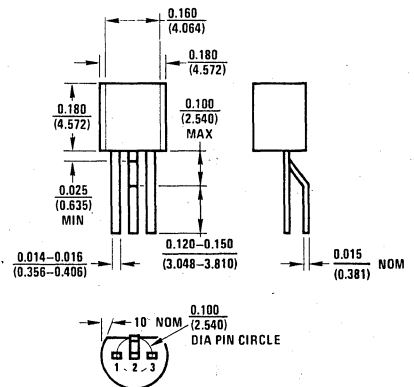
TO-92 (92, 94, 96)  
TO-18 LEAD FORM AND CROP J14Z OPTION



TO-92 (92, 94, 96)  
TO-5 LEAD FORM AND CROP J25Z OPTION

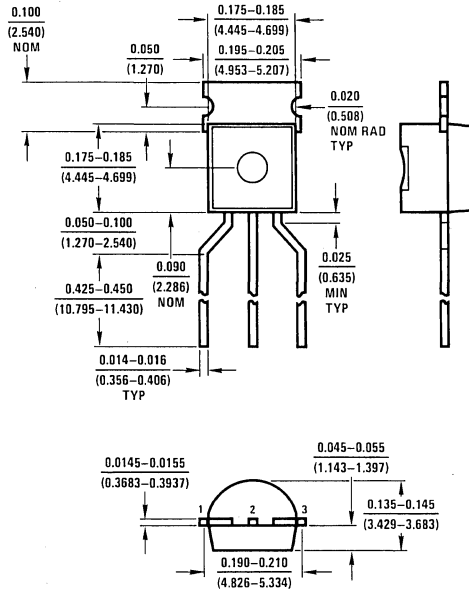


TO-92 (92, 94, 96)  
TO-18 LEAD FORM AND CROP J22Z OPTION



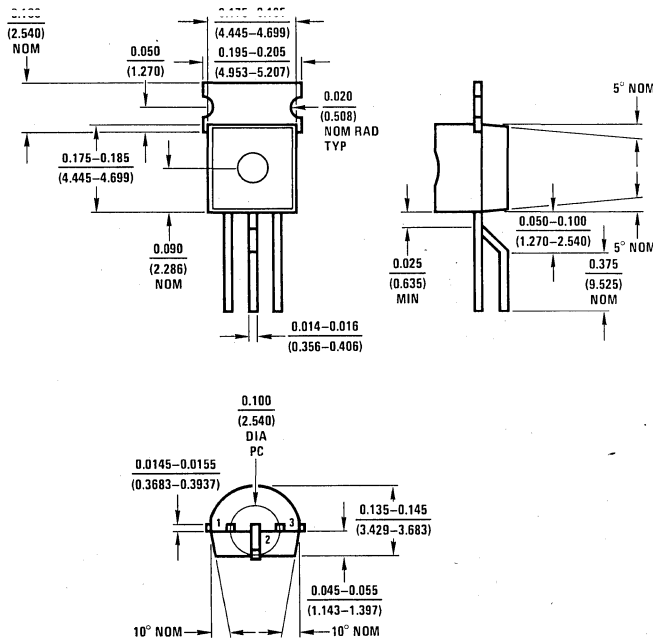
TO-237 (90, 91)  
0.100" SPACING LEAD FORM

J61Z OPTION

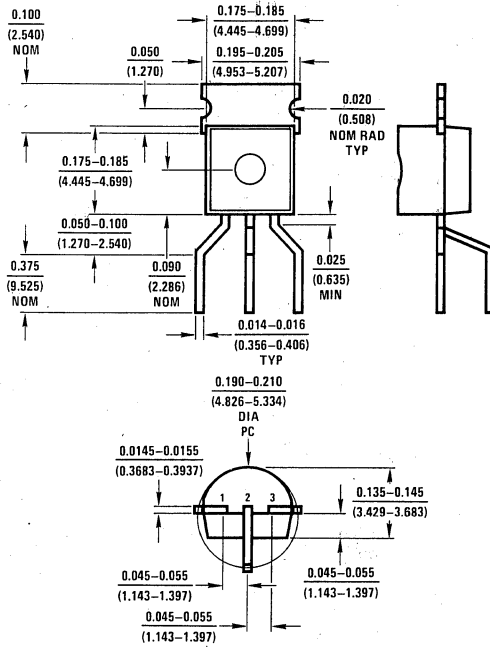


TO-237 (90, 91)  
TO-18 LEAD FORM

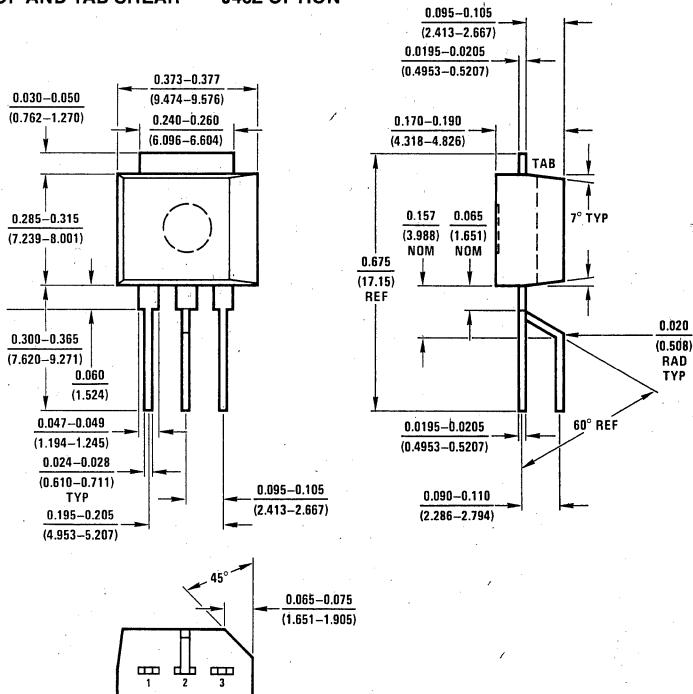
-18 OPTION



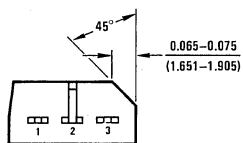
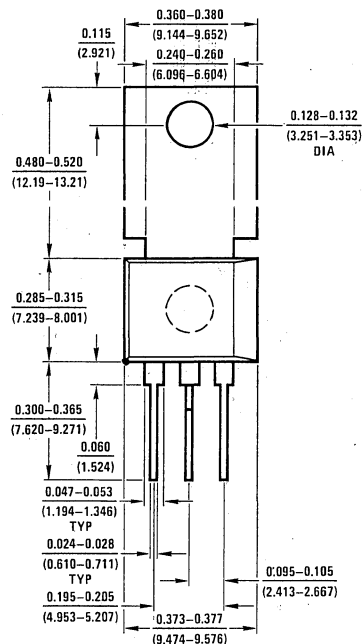
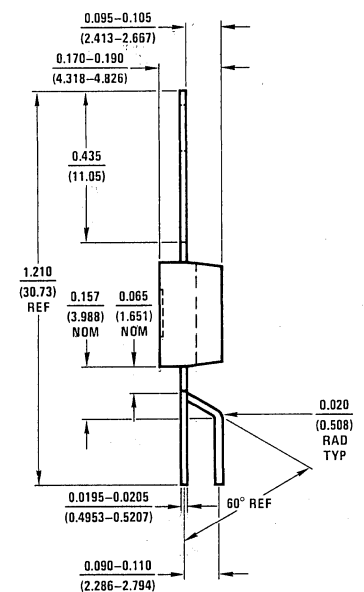
TO-237 (90, 91)  
TO-5 LEAD FORM -5 OPTION



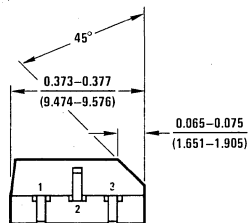
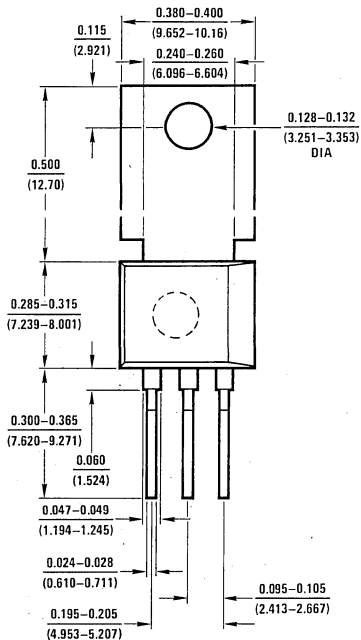
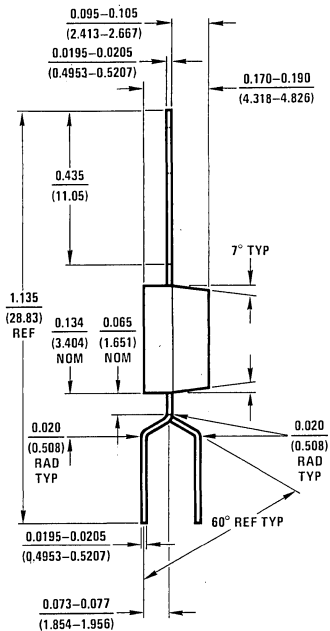
TO-202 (51, 55, 56)  
TO-5 LEAD FORM, CROP AND TAB SHEAR J46Z OPTION



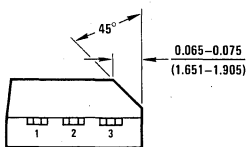
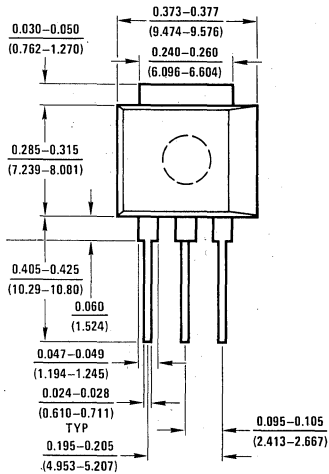
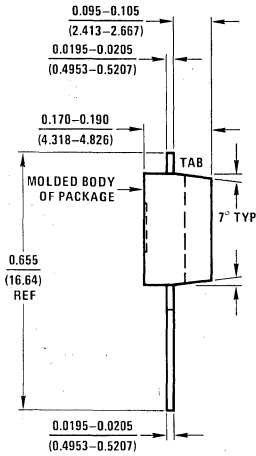
TO-202 (51, 55, 56)  
TO-5 LEAD FORM AND CROP J41Z OPTION



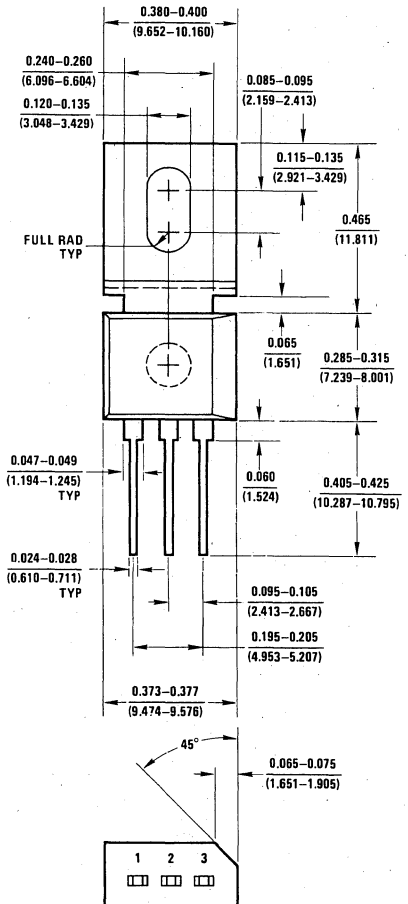
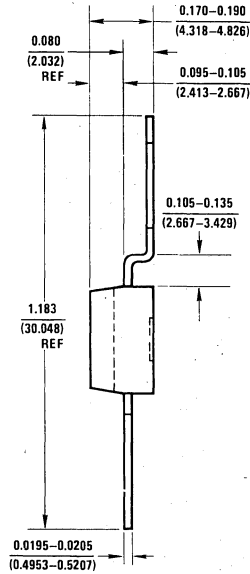
TO-202 (51, 55, 56)  
LEAD FORM J52Z OPTION



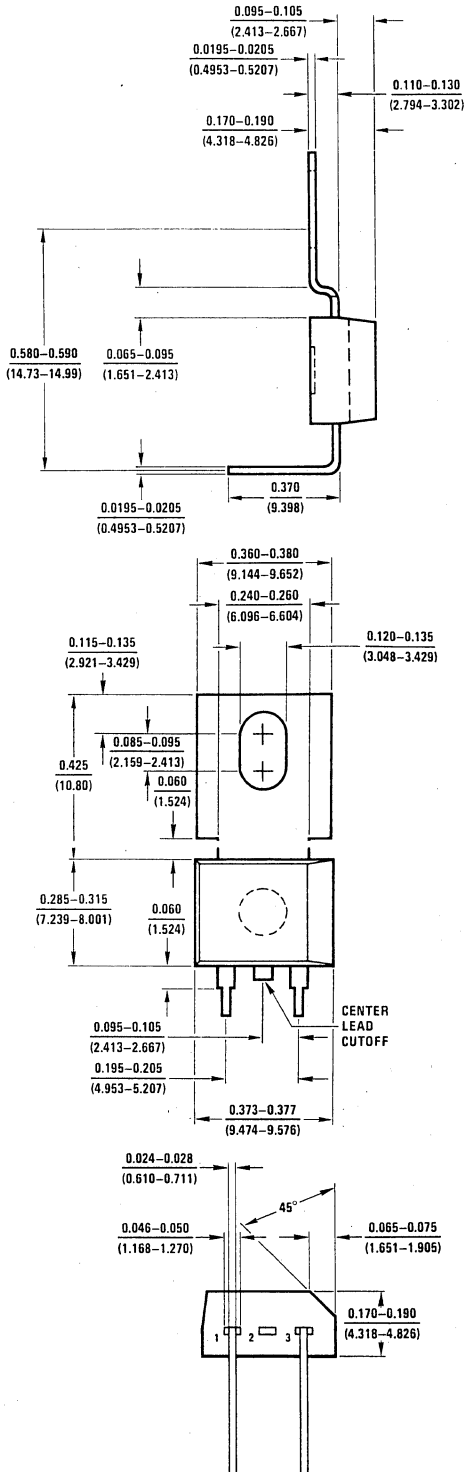
TO-202 (51, 55, 56)  
TAB SHEAR L43Z OPTION



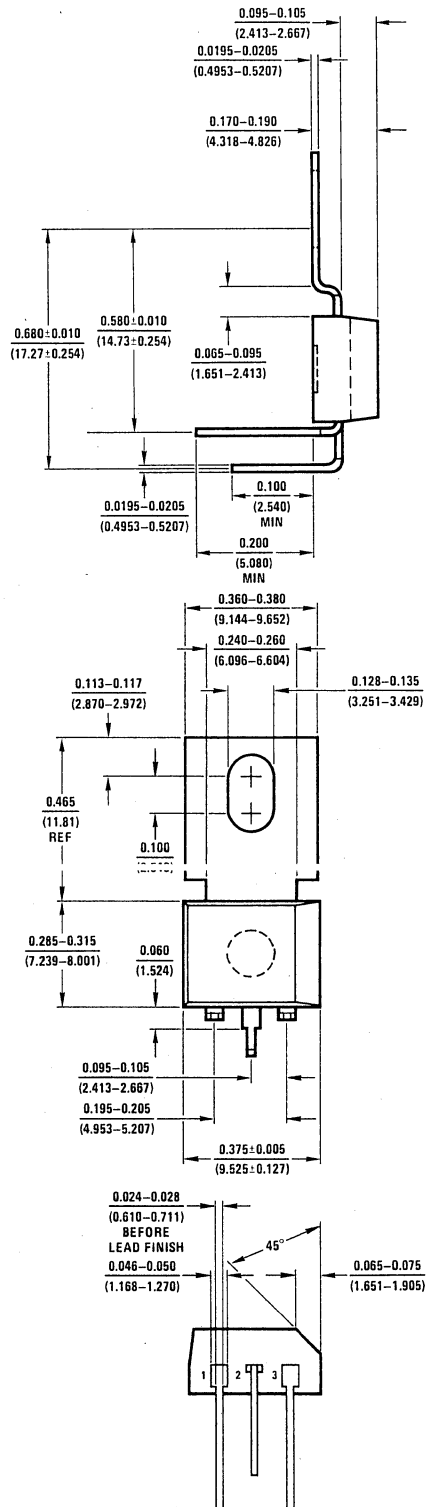
TO-202 (51, 55, 56)  
TAB FORM L42Z OPTION



TO-202 (51, 55, 56)  
TO-66 LEAD FORM, CROP AND TAB FORM  
J45Z OPTION



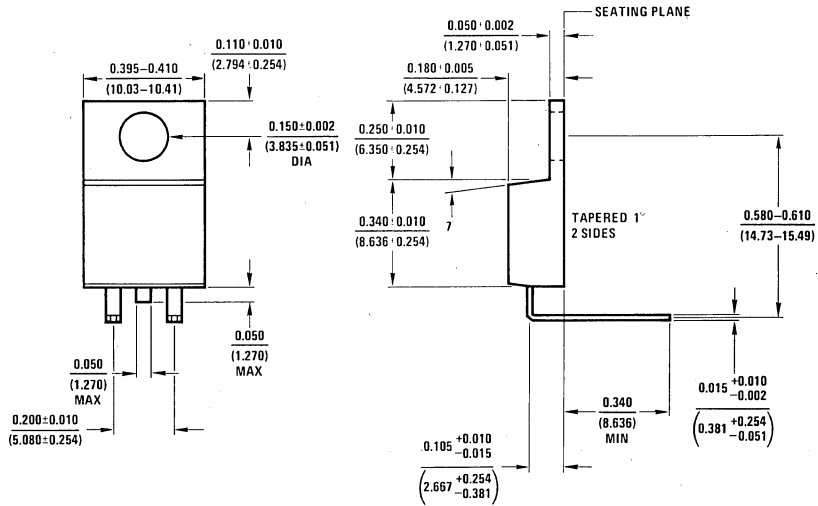
TO-202 (51, 55, 56)  
TO-5 LEAD FORM FOR FLUSH MOUNT J68Z OPTION



Package Outlines



TO-220 (57)  
 TO-66 LEAD FORM AND CROP J48Z OPTION







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