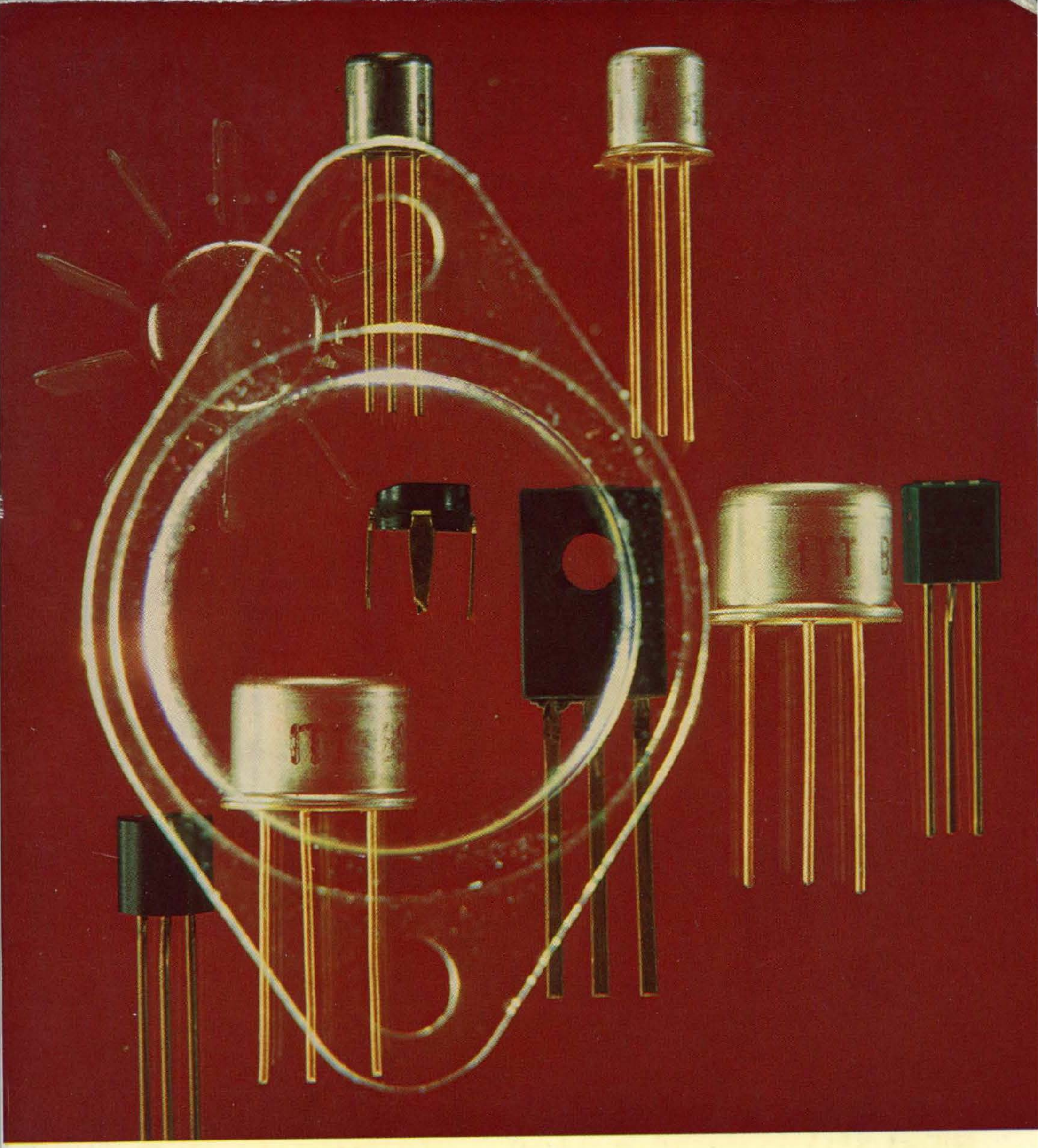
ITT

Transistors

1972/73



Transistors 1972/73

semiconductors ITT

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Transistors

Manual 1972/73

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Index of Symbols

b	Imaginary part of y-parameters
b_f	Imaginary part of forward transconductance y_f
b_i	Imaginary part of input admittance y_i
b_o	Imaginary part of output admittance y_o
b_r	Imaginary part of reverse transconductance y_r
B	Base connection
B_G	Imaginary part of generator (source) impedance
C	Capacitance; junction capacitance; collector connection
C_i	input capacitance ($b_i/2\pi f$)
C_o	Output capacitance ($b_o/2\pi f$)
C_{CB0}	Collector base capacitance (open emitter)
C_{EB0}	Emitter base capacitance (open collector)
C_r	Feedback capacitance ($b_r/2\pi f$)
E	Emitter connection
f	Frequency
f_T	Gain bandwidth product
F	Noise figure
g	Real part of y-parameters
g_f	Real part of forward transconductance y_f
g_i	Real part of input admittance y_i
g_o	Real part of output admittance y_o
g_r	Real part of reverse transconductance y_r
G_C	Current gain
G_P	Power gain
$G_{P\,av}$	Available power gain
$G_{P\,max}$	Max. available power gain
G_V	Voltage gain
h	Parameters of h- (hybrid) matrix
h_f	Small signal current gain
h_i	Input impedance
h_o	Output admittance
h_r	Reverse voltage transfer ratio
h_{FE}	DC current gain, common emitter
I_B	Base current
I_{BM}	Peak base current
I_{B1}	Turn-on current
I_{B2}	Turn-off current
I_C	Collector current

I_{CAV}	Average collector current
I_{CBO}	Collector base cutoff current (open emitter)
I_{CEO}	Collector emitter cutoff current (open base)
I_{CER}	Collector emitter cutoff current (specified resistance between base and emitter)
I_{CES}	Collector emitter cutoff current (base short-circuited to emitter)
I_{CEV}	Collector emitter cutoff current (specified voltage between base and emitter)
I_{CM}	Peak collector current
I_E	Emitter current
I_{EBO}	Emitter base cutoff current (open collector)
K_V	Thermal resistance correction factor
P_{tot}	Power dissipation
P_D	Continuous power dissipation
P_I	Pulse power dissipation
$r_{b'} \cdot C_c$	Collector base time constant
r_{thA}	Pulse thermal resistance junction to ambient air
r_{thC}	Pulse thermal resistance junction to case
R	Resistance; resistor
R_{BE}	Resistance between base and emitter
R_G	Generator impedance; source impedance
$R_{G\,opt}$	Optimum (matched) generator resistance
R_L	Load resistance
$R_{L\,opt}$	Optimum (matched) load resistance
R_S	Series resistance
R_{th}	Thermal resistance
R_{thA}	Thermal resistance junction to ambient air
R_{thC}	Thermal resistance junction to case resp. mounting base
$R_{thC/S}$	Thermal resistance case or mounting base to heat sink
R_{thS}	Thermal resistance heat sink to ambient air
t	Time
t_d	Delay time
t_f	Fall time
t_{off}	Turn-off time $(t_s + t_f)$
t_{on}	Turn-on time $(t_d + t_r)$
t_p	Pulse time
t_r	Rise time
t_s	Storage time
t_{total}	Total switching time $(t_{on} + t_{off})$

T	Temperature; duration of one period
T_{amb}	Ambient temperature
T_C	Case temperature
T_j	Junction temperature
T_S	Storage temperature
V	Voltage
V_{BB}	Base supply voltage
V_{BE}	Base emitter voltage
$V_{BE\,sat}$	Base emitter saturation voltage
$V_{(BR)CBO}$	Collector base breakdown voltage (open emitter)
$V_{(BR)CEO}$	Collector emitter breakdown voltage (open base)
$V_{(BR)CES}$	Collector emitter breakdown voltage (emitter short-circuited to base)
$V_{(BR)EBO}$	Emitter base breakdown voltage (open collector)
V_{CB}	Collector base voltage
V_{CBO}	Collector base voltage (open emitter)
V_{CC}	Collector supply voltage
V_{CE}	Collector emitter voltage
V_{CEO}	Collector emitter voltage (open base)
V_{CER}	Collector emitter voltage (specified resistance between base and emitter)
V_{CES}	Collector emitter voltage (emitter short-circuited to base)
$V_{CE\,sat}$	Collector emitter saturation voltage
V_{CEV}	Collector emitter voltage (specified voltage between base and emitter)
V_{EBO}	Emitter base voltage (open collector)
V_{EE}	Emitter supply voltage
y	Parameters of y- (admittance) matrix
y_f	Forward transconductance
y_i	Input admittance
y_o	Output admittance
y_r	Reverse transconductance
Z_1	Input impedance
Z_2	Output impedance
φ	Phase angle of y-parameters
τ_s	Storage time constant
ν	Duty factor (t_p/T)

Characteristics and Maximum Ratings

The electrical performance of a semiconductor device is usually expressed in terms of its characteristics and maximum ratings.

Characteristics are those which can be measured by use of suitable measuring instruments and circuits, and provide information on the performance of the device under specified operating conditions (at a given bias, for example). Depending on requirements, they are quoted either as typical values or guaranteed values.

Typical values are expressed as figures or as one or more curves, and are subject to spreads.

Guaranteed values are preceded either by the symbol $>$ (greater than) or $<$ (less than); sometimes the guaranteed spread limits are indicated by the numbers with three dots between them. Occasionally a typical curve is accompanied by another curve, this being a 95 %, or, in a few cases, a maximum spread limit curve.

Maximum Ratings give the values which cannot be exceeded without risk of damage to the device. Changes in supply voltage and in the tolerances of other components in the circuit must also be taken into consideration. No single maximum rating should ever be exceeded, even when the device is operated well within the other maximum ratings. The inclusion of the word "admissible" in a title means that the associated curve defines the maximum ratings.

An exception to this rule are data on collector current. The collector current, quoted as one of the critical transistor values, is a maximum value recommended by the manufacturer which should be noted in connection with the other characteristics valid for this collector current (e. g. collector and saturation voltages, current gain etc.) when selecting a transistor. In certain cases, the quoted collector current may be exceeded without the transistor being destroyed. The absolute limit for the collector current is determined by the maximum admissible power dissipation of the transistor.

Assembly and Soldering Instructions

To prevent transistors from being damaged during mounting, observe the following points:

The leads must under no circumstances be bent immediately adjacent to the glass seals. Material stresses set up in this way may produce cracks in the glass, often only after a certain delay, and may lead to the destruction of the component. The point at which leads are bent should not be less than 2 mm away from the glass seal.

All semiconductor devices are extremely sensitive to their maximum admissible junction temperature being exceeded. When planning the layout of the equipment, the distance between heat sources and semiconductor elements should be sufficiently large.

Semiconductor elements may be mounted in any desired position.

From the experience gained in soldering semiconductor elements the following rules have emerged:

When bit-soldering at copper bit temperatures from 230 ... 250 °C, the soldering time should not exceed 5 s. The distance between soldered joint and glass seal should be at least 5 mm. For leads shorter than 5 mm additional heat dissipation must be provided, for example, by means of a cooling clip.

When dip-soldering printed circuits, the temperature of the soldering bath should not exceed 240 °C. If the distance between soldered joint and mounting surface or glass seal is at least 5 mm the maximum dipping time is 10 s. For leads of 3 mm length, the maximum dipping time is restricted to 5 s.

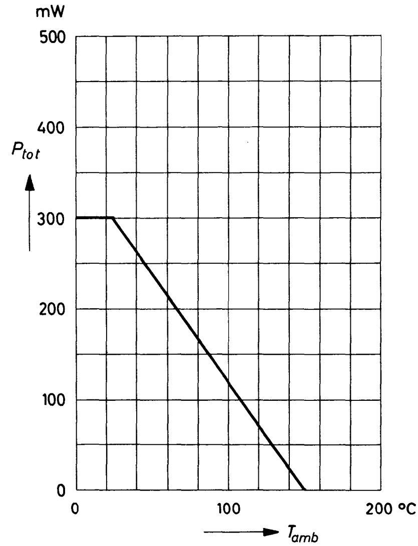
For transistors in plastic cases the maximum soldering time ist 8 s, at soldering temperatures between 230 and 260 °C. Here, the distance between soldered joint and case should be at least 4 mm. During soldering, the leads should not be subjected to mechanical stress. Types BF 121 ... BF 127 in the 50 B 4 plastic package may be mounted on printed circuits in such a way that the plastic case rests on the circuit board.

Admissible Power Dissipation

The indicated maximum admissible junction temperature must not be exceeded because this could damage or cause the destruction of the transistor crystal. Since the user cannot measure this temperature, data sheets also reveal the maximum admissible power dissipation P_{tot} usually in the form of a derating curve (see diagram).

If power dissipation is kept within these limits the maximum junction temperature will not be exceeded. This can easily be checked by using the equation

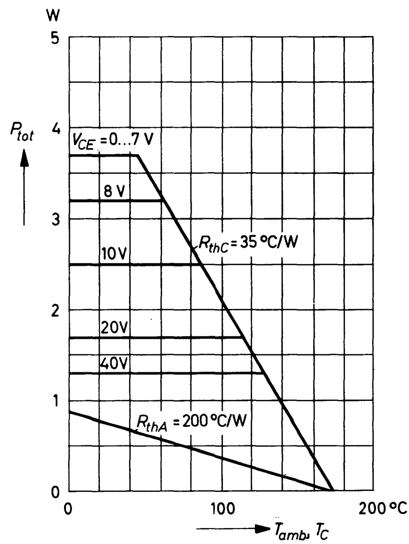
$$T_j = T_{amb} + P_{tot} \cdot R_{th}$$



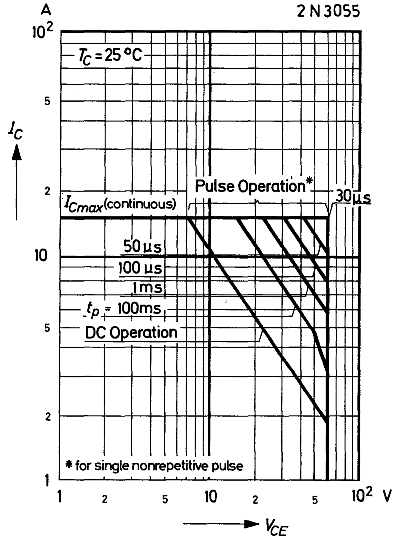
For the thermal resistance R_{th} the junction to ambient thermal resistance R_{thA} is usually substituted in the case of small transistors (in the TO-18, TO-39 or TO-92 package). In the case of power transistors (in the TO-3, SOT-9 or similar packages) which are usually mounted on a cooling fin or heat sink for the purpose of heat dissipation, the sum of the junction to case thermal resistance R_{thC} plus the heat sink to ambient thermal resistance R_{thS} plus – for more accurate calculations – the mounting surface to heat sink thermal resistance is substituted for the thermal resistance in this equation. In order to keep the mounting surface to heat sink thermal resistance low, a heat conducting compound (silicone grease) is to be applied to the mounting surface before the transistor is screwed on. If a mica insulation is used, the thermal resistance of the mica washer must be added which amounts to about 0.5 °C/W.

Directions for determining the thermal resistance R_{thS} for cooling fins can be found on page 20.

Since the distribution of heat in the transistor crystal is not uniform and depends on voltage and current, some transistors are accompanied by derating curves showing P_{tot} as a function of T_C and T_{amb} with the collector voltage V_{CE} as parameter (see diagram).



For some power transistors the data sheets also contain a diagram giving "admissible collector current" or "permissible operating range" which gives further information on admissible power dissipation. One example is illustrated in the diagram.



These diagrams are based on continuous power dissipation. However, pulse power dissipation may usually exceed continuous power dissipation. To ascertain maximum admissible pulse power dissipation P_I, reference is made to the pulse junction to case thermal resistance r_{thC} or the pulse junction to ambient thermal resistance r_{thA} whose value can be derived from the $r_{th} = f(t_p)$ diagram as illustrated below.

Use the equation

$$T_j = T_{amb} + P_I \cdot r_{thA}$$

or, if the continuous power dissipation P_D is to be taken into consideration:

$$T_j = T_{amb} + P_D \cdot R_{thA} + P_I \cdot r_{thA}$$

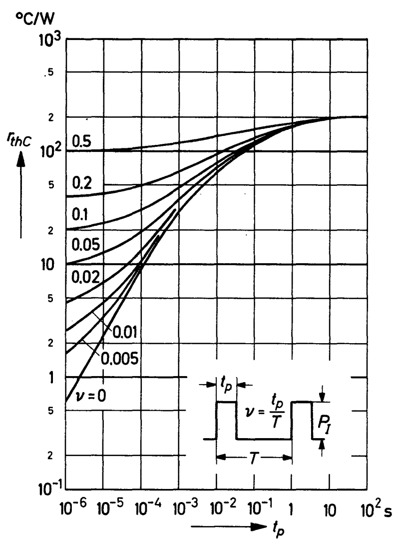
If the transistor is mounted on a cooling fin then the equation becomes:

$$T_j = T_{amb} + P_{tot} \cdot R_{thS} + P_I \cdot r_{thC}$$

wherein P_{tot} is the mean value of the pulse power dissipation P_I. Where continuous power dissipation must be considered in addition, the equation is expanded accordingly:

$$T_j = T_{amb} + P_{tot} \cdot R_{thS} + P_D \cdot R_{thC} + P_I \cdot r_{thC}$$

wherein P_{tot} is the mean value of the total power dissipation.



The thermal resistance and pulse thermal resistance values derived from the data sheets apply without limitation only to small collector emitter voltages V_{CE}, between about 5 and 10 V. For higher voltages these thermal resistance values have to be multiplied by a correction factor K_V which has to be calculated from the previously mentioned derating curves. The admissible power dissipation $P_{tot\ max}$, applicable to low collector voltages, must be divided by the admissible power dissipation $P_{tot\ V}$ for the higher collector voltage V:

$$K_V = \frac{P_{tot\ max}}{P_{tot\ V}}$$

The complete equation for T_j then reads:

$$T_j = T_{amb} + P_{tot} \cdot R_{thS} + P_D \cdot K_V \cdot R_{thC} + P_I \cdot K_V \cdot r_{thC}$$

Heat Removal from Transistors

The operation of any semiconductor device involves the dissipation of power with a consequent rise in junction temperature. Because the maximum admissible junction temperature must not be exceeded, careful circuit design with due regard not only to the electrical, but also the thermal performance of a semiconductor circuit, is essential.

If the dissipated power is low, then sufficient heat is radiated from the surface of the case; if the dissipation is high, however, additional steps may have to be taken to promote this process by reducing the thermal resistance between the junction and the ambient air. This can be achieved either by pushing a star- or flag-shaped heat dissipator over the case, or by bolting the semiconductor device to a heat sink.

P, the power to be dissipated, T_j the junction temperature, and T_{amb}, the ambient temperature are related by the formula

$$P = \frac{T_j - T_{amb}}{R_{thA}} = \frac{T_j - T_{amb}}{R_{thC} + R_{thS}},$$

where R_{thA} is the total thermal resistance between junction and ambient air. The total thermal resistance in turn comprises an internal thermal resistance R_{thC} between the junction and the mounting base, and an outer thermal resistance R_{thS} between the case and the surrounding air (or any other cooling medium). It should be noted that only the outer thermal resistance is affected by the design of the heat sink. To determine the size of the heat sink required to meet given operating conditions, proceed as follows: First calculate the outer thermal resistance by use of the formula

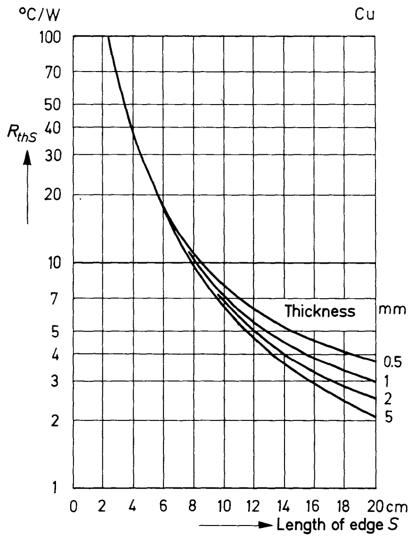
$$R_{thS} < \frac{T_j - T_{amb}}{P} - R_{thC}$$

and then, by use of the diagrams shown on next page, determine the size of the heat sink which provides the calculated R_{thS}-value. To determine the maximum admissible device dissipation and ambient temperature limit for a given heat sink, proceed in the reverse order to that described above.

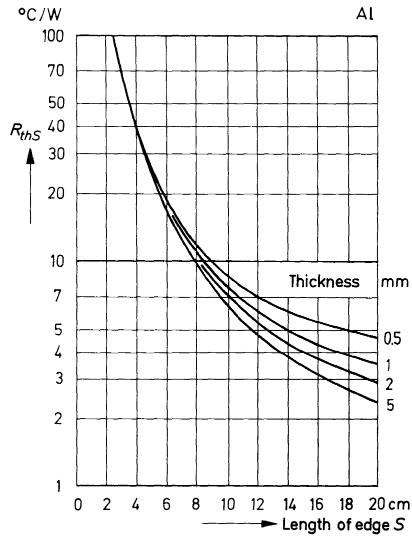
The calculations are based on the following assumptions: Use of a squareshaped heat sink without any finish, mounted in a vertical position; semiconductor device located in the centre of the sink; heat sink operated in still air and not subjected to any additional heat radiation. The calculated area should be increased by a fator of 1.3 if the sink is mounted horizontally, and can be reduced by a factor of approximately 0.7 if a black finish is used.

The curves on the following page give the thermal to ambient resistance of square vertical heat sinks as a function of side length. It is assumed that the heat is applied at the centre of the square.

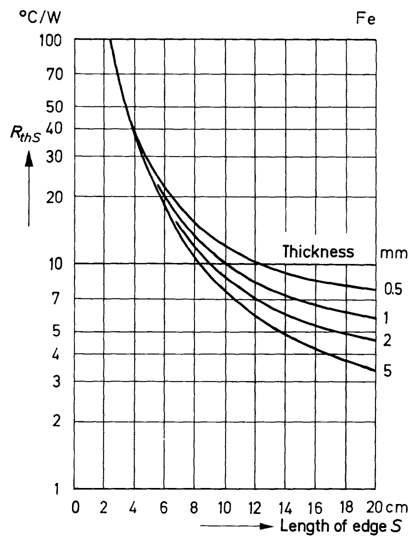
Copper Cooling Fin



Aluminium Cooling Fin

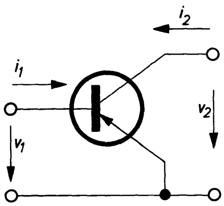


Steel Cooling Fin

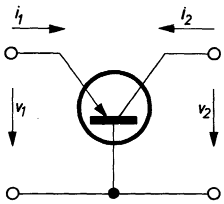


Basic Circuits

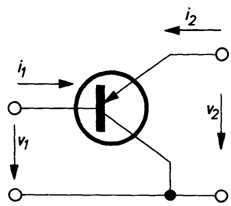
There are three basic transistor circuits. They are called according to that electrode (emitter, base, collector) which is common to both input and output circuit.



Common Emitter



Common Base



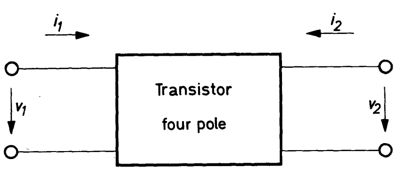
Common Collector

Properties of the three basic circuits:

	Common Emitter	Common Base	Common Collector
Input impedance	medium	small	high
Output impedance	medium	high	small
Current gain	high	less than 1	high
Upper frequency limit	low	high	low

Four-Pole Symbols of *h*-Matrix

A transistor can be considered as an active four-pole network. When driven with small low-frequency signals its properties can be described by the four characteristic values of the *h*- (hybrid) matrix, which are assumed to be real.



$$v_1 = h_i \cdot i_1 + h_r \cdot v_2$$
$$i_2 = h_f \cdot i_1 + h_o \cdot v_2$$

If expressed this in matrix form we obtain:

$$\begin{pmatrix} v_1 \\ i_2 \end{pmatrix} = (h) \begin{pmatrix} i_1 \\ v_2 \end{pmatrix} \qquad (h) = \begin{pmatrix} h_i & h_r \\ h_f & h_o \end{pmatrix}$$

Explanation of *h*-Parameters

Input impedance (shorted output) ($v_2 = 0$): $h_i = \frac{v_1}{i_1}$

Reverse voltage transfer ratio (open input) ($i_1 = 0$): $h_r = \frac{v_1}{v_2}$

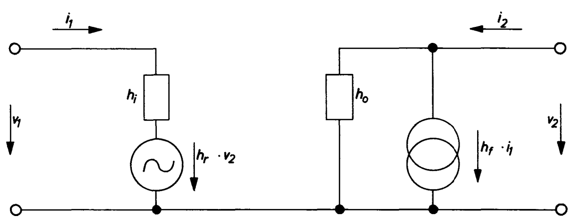
Small signal current gain (shorted output) ($v_2 = 0$): $h_f = \frac{i_2}{i_1}$

Output admittance (open input) ($i_1 = 0$): $h_o = \frac{i_2}{v_2}$

A frequently used abbreviation is the determinant:

$\Delta h = h_i \cdot h_o - h_r \cdot h_f$

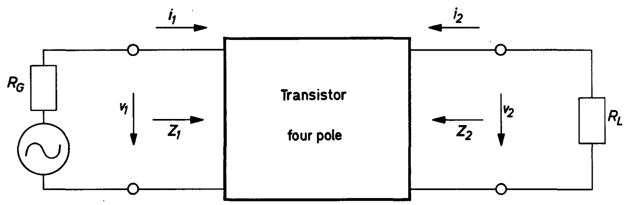
For all three basic circuit configurations the circuit illustrated below represents the equivalent four-pole circuit using *h*-parameters.



In the transistor data sheets the *h*-parameters are usually quoted for the common emitter configuration and for a given operating point (bias). The latter is determined by the collector voltage, the emitter or collector current and by the ambient temperature. For different operating points, correction factors are needed which can be gathered from the relevant curves. For common base or common collector transistor stage calculations, the appropriate *h*-parameters are ascertained from those of the common emitter configuration by using the following conversion formulas.

	Common Emitter	Common Base	Common Collector
Input impedance	h_{ie}	$h_{ib} = \frac{h_{ie}}{1 + h_{fe}}$	$h_{ic} = h_{ie}$
Reverse voltage transfer ratio	h_{re}	$h_{rb} = \frac{h_{ie} \cdot h_{oe}}{1 + h_{fe}} - h_{re}$	$h_{rc} = 1 - h_{re}$
Small signal current gain	h_{fe}	$h_{fb} = -\frac{h_{fe}}{1 + h_{fe}}$	$-h_{fc} = 1 + h_{fe}$
Output admittance	h_{oe}	$h_{ob} = \frac{h_{oe}}{1 + h_{fe}}$	$h_{oc} = h_{oe}$

Calculation of a Transistor Stage



Input impedance $$Z_1 = \frac{v_1}{i_1} = \frac{h_i + R_L \cdot \Delta h}{1 + h_o \cdot R_L}$$

Output impedance $$Z_2 = \frac{v_2}{i_2} = \frac{h_i + R_G}{\Delta h + h_o \cdot R_G}$$

Current gain $$G_C = \frac{i_2}{i_1} = \frac{h_f}{1 + h_o \cdot R_L}$$

Voltage gain $$G_V = \frac{v_2}{v_1} = \frac{-h_f \cdot R_L}{h_i + R_L \cdot \Delta_h}$$

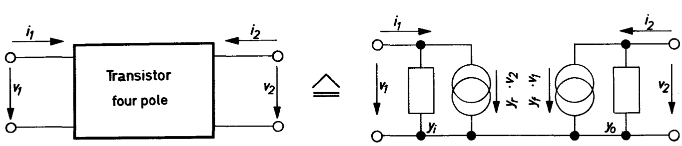
Power gain $$G_P = \frac{v_2 \cdot i_2}{v_1 \cdot i_1} = \frac{h_f^2 \cdot R_L}{(1 + h_o \cdot R_L)\,(h_i + R_L \cdot \Delta h)}$$

Max. available power gain input and output matched with $R_{G\,opt}$ resp. $R_{L\,opt}$ $$G_{p\,max} = \left(\frac{h_f}{\sqrt{\Delta h} + \sqrt{h_i \cdot h_o}}\right)^2$$

$$R_{G\,opt} = \sqrt{\frac{h_i \cdot \Delta h}{h_o}} \qquad R_{L\,opt} = \sqrt{\frac{h_i}{h_o \cdot \Delta h}}$$

Four-Pole Symbols of *y*-Matrix

Whereas the network behaviour of low-frequency transistors could be described by using the *h*- (hybrid) matrix, the *y*- (admittance) matrix is usually employed for high frequency transistors.



$$i_1 = y_i \cdot v_1 + y_r \cdot v_2$$
$$i_2 = y_f \cdot v_1 + y_o \cdot v_2$$

In matrix form we obtain:

$$\begin{pmatrix} i_2 \\ i_1 \end{pmatrix} = (y) \begin{pmatrix} v_1 \\ v_2 \end{pmatrix} \qquad (y) = \begin{pmatrix} y_i & y_r \\ y_f & y_o \end{pmatrix}$$

The y-parameters are complex values which can be expressed as

$$y_{ik} = g_{ik} + jb_{ik} \quad \text{with} \quad b_{ik} = \omega C_{ik} \quad \text{or with} \quad b_{ik} = -\frac{1}{\omega L_{ik}}$$

Often, the following notation is expedient:

$$y_{ik} = |y_{ik}| \exp j\varphi_{ik}$$

By adding the suffix e, b or c it is possible to indicate to which of the three basic circuit configurations the parameters are valid.

Explanation of y-Parameters

Input admittance (shorted output) $(v_2 = 0)$ $\qquad y_i = \frac{i_1}{v_1}$

Reverse transconductance (shorted input) $(v_1 = 0)$ $\qquad y_r = \frac{i_1}{v_2}$

Forward transconductance (shorted output) $(v_2 = 0)$ $\qquad y_f = \frac{i_2}{v_1}$

Output admittance (shorted input) $(v_1 = 0)$ $\qquad y_o = \frac{i_2}{v_2}$

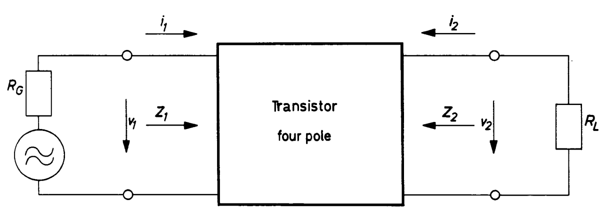
The determinant reads $\Delta y = y_i \cdot y_o - y_r \cdot y_f$

Conversion from y-Parameters to h-Parameters

$$h_i = \frac{1}{y_i} \qquad h_r = -\frac{y_r}{y_i} \qquad \Delta h = \frac{y_o}{y_i}$$

$$h_f = \frac{y_f}{y_i} \qquad h_o = \frac{\Delta y}{y_i}$$

Calculation of a Transistor Stage



Input impedance $Z_1 = \frac{v_1}{i_1} = \frac{1 + y_o \cdot R_L}{y_i + \Delta y \cdot R_L}$

Output impedance

$$Z_2 = \frac{v_2}{i_2} = \frac{1 + y_i \cdot R_G}{y_o + \Delta y \cdot R_G}$$

Current gain

$$G_C = \frac{i_2}{i_1} = \frac{y_f}{y_i + \Delta y \cdot R_L}$$

Voltage gain

$$G_V = \frac{v_2}{v_1} = \frac{-y_f \cdot R_L}{1 + y_o \cdot R_L}$$

Power gain

$$G_P = \frac{v_2 \cdot i_2}{v_1 \cdot i_1} = \frac{|y_f|^2 \cdot R_L}{(1 + y_o \cdot R_L)\ (y_i + \Delta y \cdot R_L)}$$

Available power gain
input matched
with $R_{G\ opt}$

$$G_{P\ av} = \frac{4 \cdot y_f^2 \cdot R_G \cdot R_L}{[(y_i + \Delta y \cdot R_L) \cdot R_G + 1 + y_o \cdot R_L]^2}$$

Max. available power gain
input and output matched
with $R_{G\ opt}$ resp. $R_{L\ opt}$

$$G_{P\ max} = \left(\frac{y_f}{\sqrt{\Delta y} + \sqrt{y_i \cdot y_o}}\right)^2$$

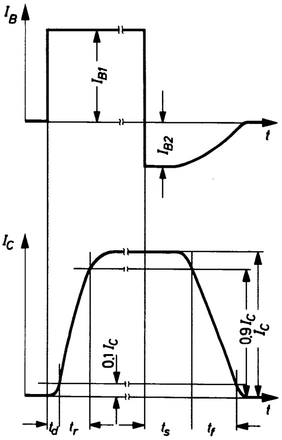
Max. available power gain will be attained if input and output are matched, where:

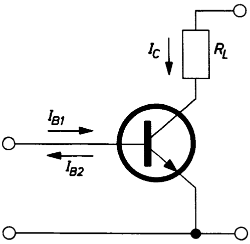
$$R_{L\ opt} = \sqrt{\frac{y_o}{y_i} \cdot \frac{1}{\Delta y}}$$

$$R_{G\ opt} = \sqrt{\frac{y_i}{y_o} \cdot \frac{1}{\Delta y}}$$

Switching Times

Definitions for the various times which make up the total switching time can be gathered from the diagram below in which the switching characteristic of a transistor in common-emitter configuration is illustrated.



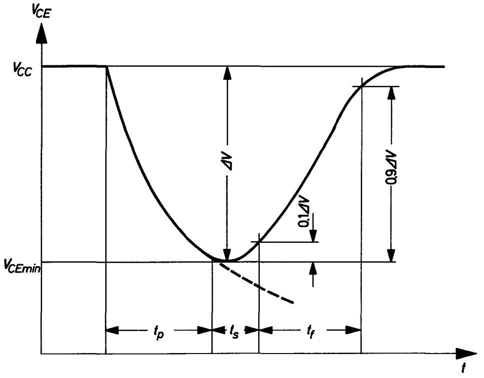


t_d	Delay time
t_r	Rise time
t_s	Storage time
t_f	Fall time
$t_{on} = t_d + t_r$	Turn-on time
$t_{off} = t_s + t_f$	Turn-off time

The duration of the switching times depends upon the transistor type and very much on the circuit arrangement.

With increasing saturation of the transistor the turn-on time decreases and the turn-off time increases. An increase of the turn-off current I_{B2} shortens the turn-off time.

The switching times depend on the duration of the turn-on pulse. It is only when the duration of this pulse is a multiple of the switching times that the latter remain constant. If the pulse is shorter, especially the storage time decreases. With a pulse duration in the region of the turn-on time the transistor is no longer fully saturated. The collector voltage then exhibits a characteristic such as is qualitatively represented in the diagram below.



DIN Standards (German)

The information contained in this book conforms, in the main, to the following German DIN Standards.

DIN 41785 Sheet 1 (10. 69)	Semiconductor devices, letter symbols on data sheets, general
DIN 41785 Sheet 2 (10. 69)	Semiconductor devices, letter symbols on data sheets for semiconductor devices for telecommunication
DIN 41791 Sheet 1 (9. 71)	Semiconductors for telecommunication, recommendations for data sheets, general
DIN 41791 Sheet 4 (E 10. 71)	Semiconductor devices for telecommunication, recommendations for data sheets, low power signal transistors
DIN 41791 Sheet 5 (7. 66)	Semiconductor devices for telecommunication, recommendations for data sheets, AF power transistors
DIN 41791 Sheet 6 (E 6. 71)	Semiconductor devices for telecommunication, recommendations for data sheets, switching transistors
DIN 41854 (11. 67)	Transistors, terms and definitions
DIN 41855 (8. 67)	Semiconductor devices, kinds of semiconductor devices, terms and definitions
DIN 41867 (E 9. 70)	Cases 50 B 3 and 50 B 4 for semiconductor devices, main dimensions
DIN 41868 (E 10. 70)	Cases 10 A 3 and 10 B 3 (JEDEC TO-92) for semiconductor devices, main dimensions
DIN 41869 Sheet 4 (E 7. 71)	Case 12 A 3 (SOT-32) for semiconductor devices, main dimensions
DIN 41870 Sheet 1 (4. 69)	Cases for semiconductor devices and integrated circuits, short designations
DIN 41870 Sheet 2 (7. 69)	Cases for semiconductor devices and integrated circuits, survey
DIN 41872 (11. 64)	Cases 3 A 2 (JEDEC TO-3) etc. for semiconductor devices, main dimensions
DIN 41873 (E 2. 70)	Cases 5 C 3 (JEDEC TO-39 $\approx$ TO-5) etc. for semiconductor devices, main dimensions
DIN 41875 (11. 64)	Cases 9 A 2 (SOT-9) etc. for semiconductor devices, main dimensions
DIN 41876 (E 2. 70)	Cases 18 A 3 (JEDEC TO-18) etc. for semiconductor devices, main dimensions

Specifications for Quality

1. General

The quality of components is determined by statistical methods, and is quoted as a maximum permissible percentage of defectives (AQL value). AQL values are based on maximum ratings and guaranteed characteristics of electrical and mechanical parameters.

2. Defectives

A device is considered defective if any one parameter does not correspond with the value specified in the data sheet. If an item has more than one defect, then this is counted as one defect only, i. e. a batch is assessed on the number of defective items and not on the number of defects.

Defects are classified according to type and extent.

Types of defects:

a) Case or lead defects
b) Electrical defects

Extent of defects:

a) Total defects are those which preclude any use of the item
b) Partial defects are those which allow restricted use of the item

3. AQL (Acceptable Quality Level) Values

The AQL values applicable to INTERMETALL semiconductor devices are summarized in the table below. The AQL values stated apply to the sum of all defectives.

Defectives		
Case and leads:		
	Total defectives	0.25 %
	Partial defectives	2.50 %
Electrical properties:		
	Total defectives	0.25 %
	Partial defectives	0.65 %

4. Incoming Inspection

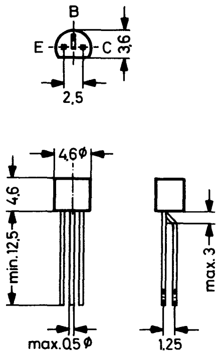
The tests carried out by the manufacturer are designed so as to obviate the need for any incoming inspection by the user. If, however, a user wishes to carry out an incoming inspection, then this should be done on a sample basis, as laid down in the internationally accepted MIL-STD 105 D specifications.

NPN Silicon Transistors

BC 107..., BC 171..., BC 237...

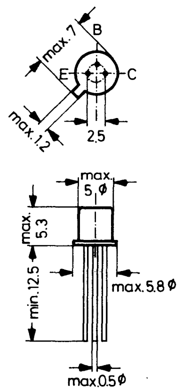
NPN Silicon Epitaxial Planar Transistors
for switching and amplifier applications

The transistors are subdivided into three groups A, B and C according to their current gain. Types BC 107, BC 190, BC 171, BC 174 and BC 237 are available in groups A and B, types BC 108, BC 172 and BC 238 in groups A, B and C, and types BC 109, BC 173 and BC 239 in groups B and C.
BC 109, BC 173 and BC 239 are low noise types.



BC 171, BC 172, BC 173, BC 174
BC 237, BC 238, BC 239

Black plastic package ≈ TO-92,
TO-18 compatible.
The case is impervious to light.
Weight approximately 0.18 g
Dimensions in mm



BC 107, BC 108, BC 109, BC 190

Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings

		BC 107 BC 171 BC 237	BC 108 BC 109 BC 172 BC 173 BC 238 BC 239	BC 190 BC 174	
Collector emitter voltage	V_{CES}	50	30	70	V
Collector emitter voltage	V_{CEO}	45	25	64	V
Emitter base voltage	V_{EBO}	6	5	5	V
Collector current	I_C	100	100	100	mA
Peak collector current	I_{CM}	200	200	200	mA
Base current	I_B	50	50	50	mA

		TO-92	TO-18	
Power dissipation at T_{amb} = 25 °C	P_{tot}	300[1]	300	mW
Junction temperature	T_j	150	175	°C
Storage temperature range	T_S	– 55 ... + 150	– 55 ... + 175	°C

[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

Characteristics at $T_{amb} = 25\ °C$		**Current Gain Group**			
h-Parameters at $V_{CE} = 5$ V, $I_C = 2$ mA, $f = 1$ kHz		**A**	**B**	**C**	
Small signal current gain	h_{fe}	220 (125..260)	330 (240..500)	600 (450..900)	
Input impedance	h_{ie}	2.7 (1.6..4.5)	4.5 (3.2..8.5)	8.7 (6...15)	kΩ
Output admittance	h_{oe}	18 (< 30)	30 (< 60)	60 (< 110)	μmho
Reverse voltage transfer ratio	h_{re}	$1.5 \cdot 10^{-4}$	$2 \cdot 10^{-4}$	$3 \cdot 10^{-4}$	
DC current gain					
at $V_{CE} = 5$ V, $I_C = 0.01$ mA	h_{FE}	90	150	270	
at $V_{CE} = 5$ V, $I_C = 2$ mA	h_{FE}	170	290	500	
at $V_{CE} = 5$ V, $I_C = 100$ mA	h_{FE}	120[1]	200[1]	400[1]	
Collector saturation voltage					
at $I_C = 10$ mA, $I_B = 0.5$ mA	V_{CEsat}		0.07 (< 0.2)		V
at $I_C = 100$ mA, $I_B = 5$ mA	V_{CEsat}		0.2 (< 0.6)[1]		V
Base saturation voltage					
at $I_C = 10$ mA, $I_B = 0.5$ mA	V_{BEsat}		0.73 (< 0.83)		V
at $I_C = 100$ mA, $I_B = 5$ mA	V_{BEsat}		0.87 (< 1.05)[1]		V
Base emitter voltage					
at $V_{CE} = 5$ V, $I_C = 0.1$ mA	V_{BE}		0.55		V
at $V_{CE} = 5$ V, $I_C = 2$ mA	V_{BE}		0.62 (0.55...0.7)		V
at $V_{CE} = 5$ V, $I_C = 100$ mA	V_{BE}		0.83[1]		V

		BC 107 **BC 171** **BC 237**	**BC 108** **BC 109** **BC 172** **BC 173** **BC 238** **BC 239**	**BC 190** **BC 174**	
Collector cutoff current					
at $V_{CE} = 60$ V	I_{CES}	–	–	0.2 (< 15)	nA
at $V_{CE} = 50$ V	I_{CES}	0.2 (< 15)	–	–	nA
at $V_{CE} = 30$ V	I_{CES}	–	0.2 (< 15)	–	nA
at $V_{CE} = 60$ V, $T_{amb} = 125\ °C$	I_{CES}	–	–	0.2 (< 4)	μA
at $V_{CE} = 50$ V, $T_{amb} = 125\ °C$	I_{CES}	0.2 (< 4)	–	–	μA
at $V_{CE} = 30$ V, $T_{amb} = 125\ °C$	I_{CES}	–	0.2 (< 4)	–	μA
Collector emitter breakdown voltage at $I_C = 2$ mA	$V_{(BR)CEO}$	> 45	> 25	> 64	V
Emitter base breakdown voltage at $I_E = 1$ μA	$V_{(BR)EBO}$	> 6	> 5	> 5	V

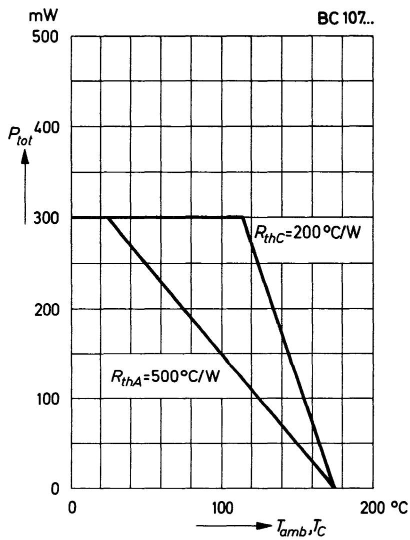
[1] not valid for BC 109, BC 173 and BC 239

Gain bandwidth product				
at $V_{CE} = 3$ V, $I_C = 0.5$ mA		f_T	85	MHz
at $V_{CE} = 5$ V, $I_C = 10$ mA		f_T	250 (> 150)	MHz
$f = 100$ MHz				
Collector base capacitance at $V_{CBO} = 10$ V, $f = 1$ MHz		C_{CBO}	3.5 (< 6)	pF
Emitter base capacitance at $V_{EBO} = 0.5$ V, $f = 1$ MHz		C_{EBO}	8	pF
BC 107, BC 108, BC 171, BC 172 BC 174, BC 190, BC 237, BC 238: Noise figure at $V_{CE} = 5$ V, $I_C = 0.2$ mA, $R_G = 2$ kΩ, $f = 1$ kHz		F	2 (< 10)	dB
BC 109, BC 173 and BC 239: Noise figure at $V_{CE} = 5$ V, $I_C = 0.2$ mA, $R_G = 2$ kΩ, $f = 1$ kHz		F	< 4	dB
Noise figure at $V_{CE} = 5$ V, $I_C = 0.2$ mA, $R_G = 2$ kΩ, $f = 30$ Hz ... 15 kHz		F	< 4	dB

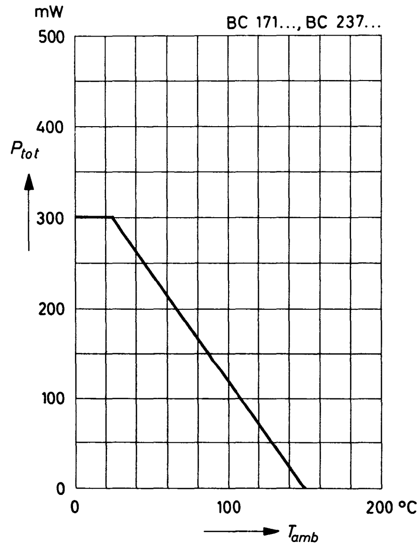
		TO-92	**TO-18**	
Thermal resistance				
Junction to case	R_{thC}	–	< 200	°C/W
Junction to ambient air	R_{thA}	< 420[1]	< 500	°C/W

[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

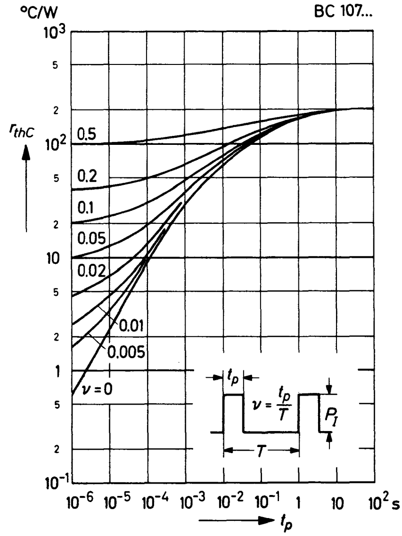
Admissible power dissipation versus temperature



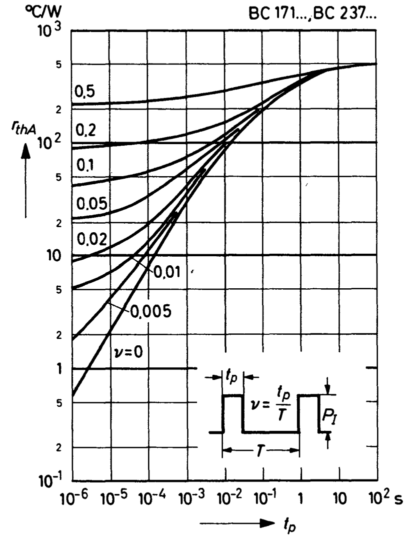
Admissible power dissipation versus ambient temperature
(see note on page 34)



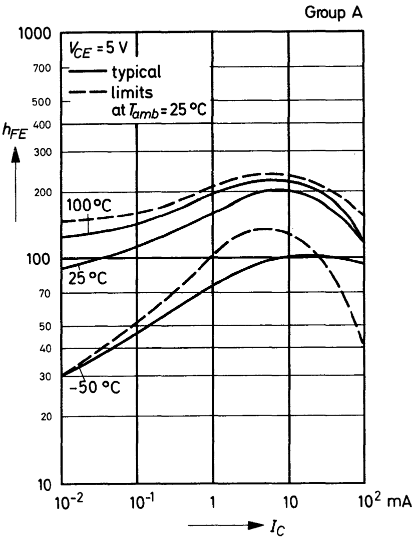
Pulse thermal resistance versus pulse duration



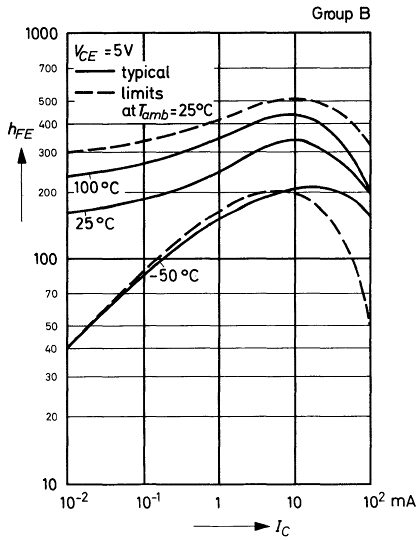
Pulse thermal resistance versus pulse duration



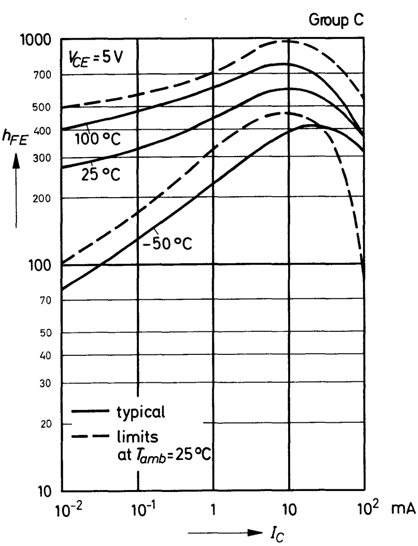
DC current gain versus collector current



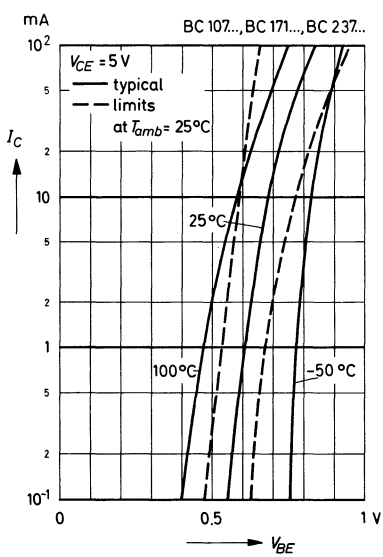
DC current gain versus collector current



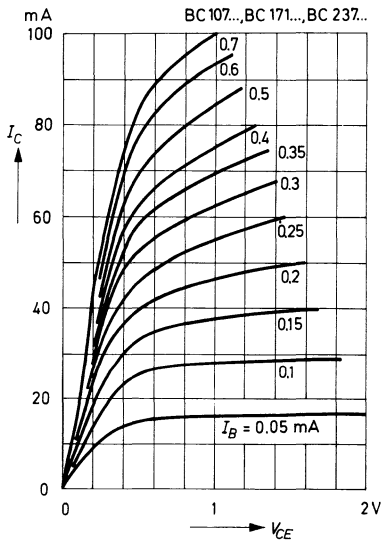
DC current gain versus collector current



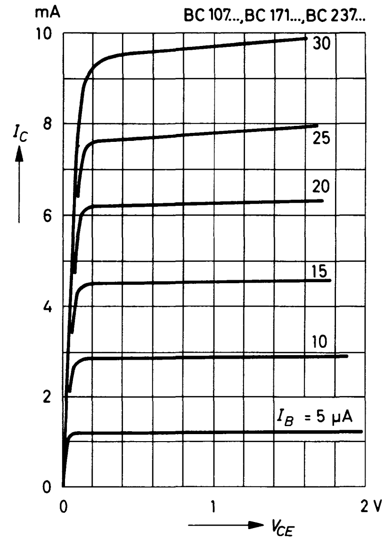
Collector current versus base emitter voltage



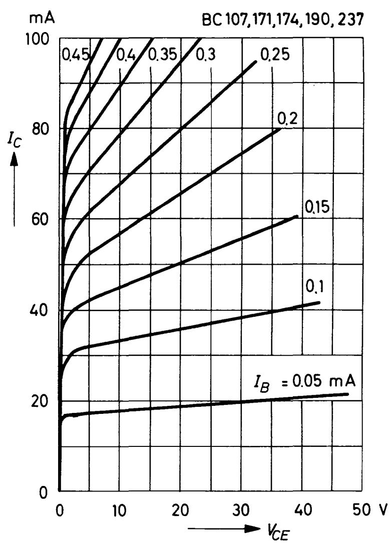
Common emitter collector characteristics



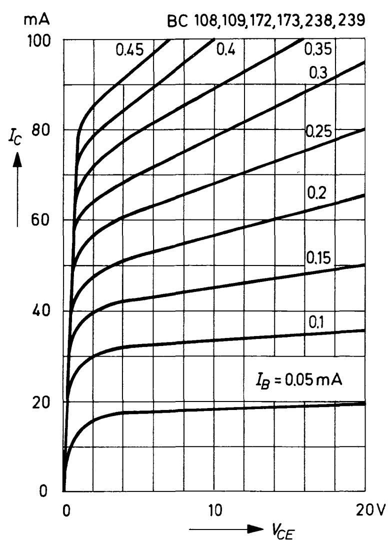
Common emitter collector characteristics



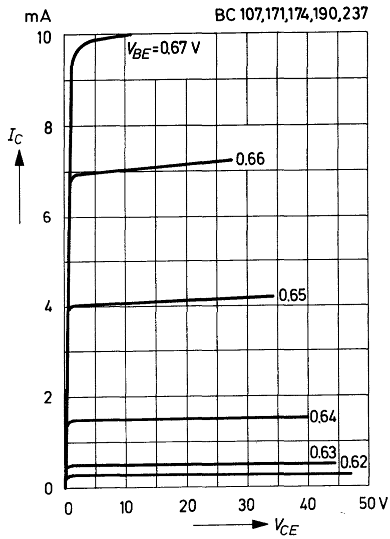
Common emitter collector characteristics



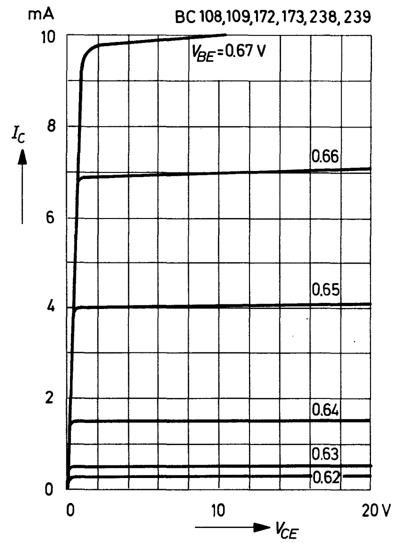
Common emitter collector characteristics



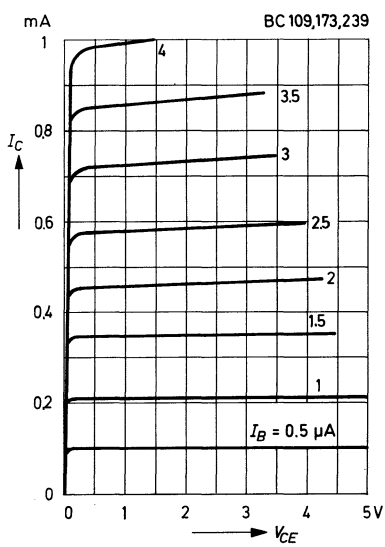
Common emitter collector characteristics



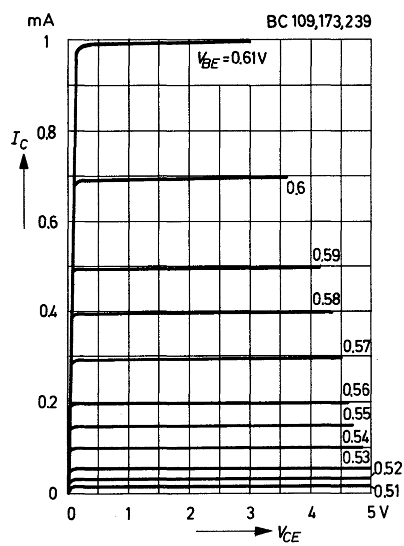
Common emitter collector characteristics



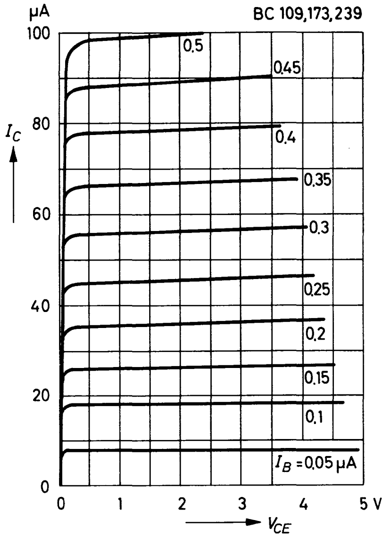
Common emitter collector characteristics



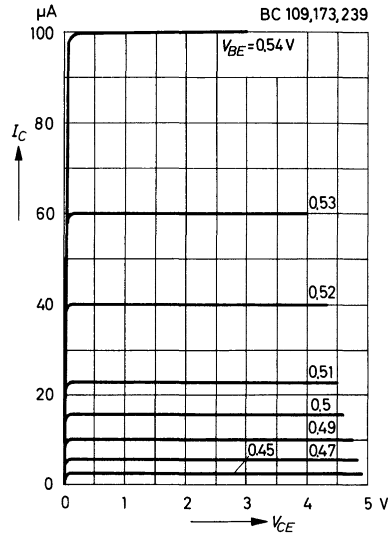
Common emitter collector characteristics



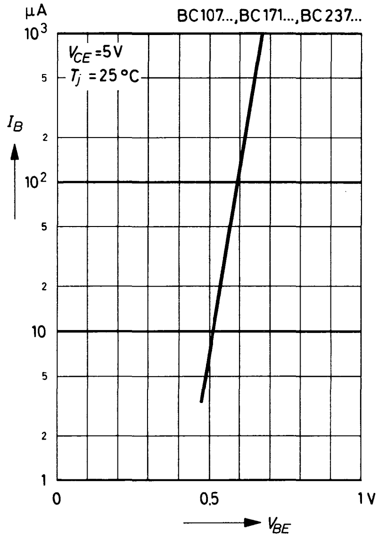
Common emitter collector characteristics



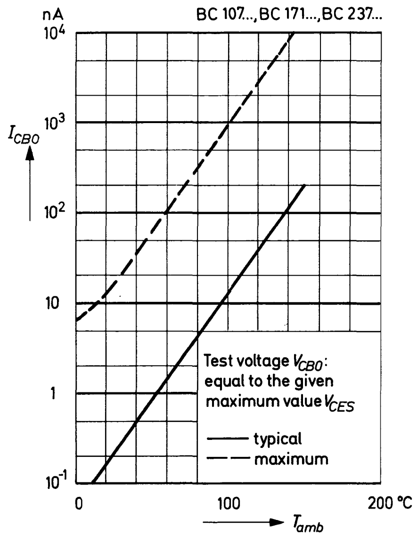
Common emitter collector characteristics



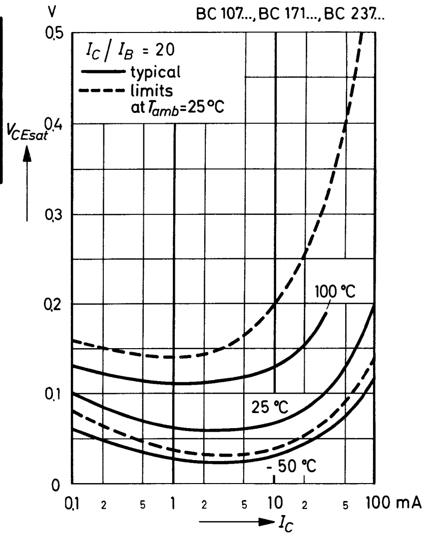
Common emitter input characteristic



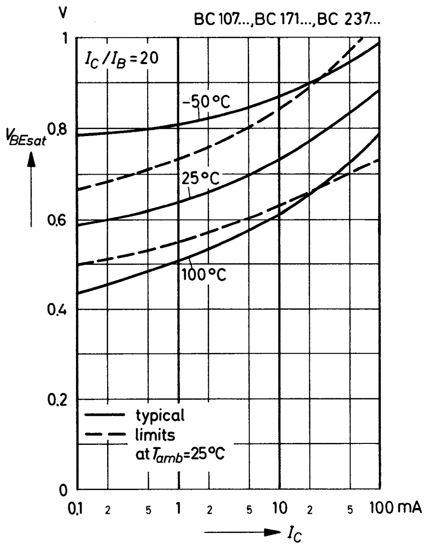
Collector cutoff current versus ambient temperature



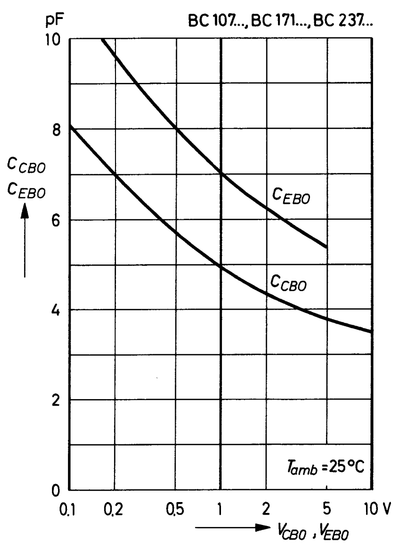
Collector saturation voltage versus collector current



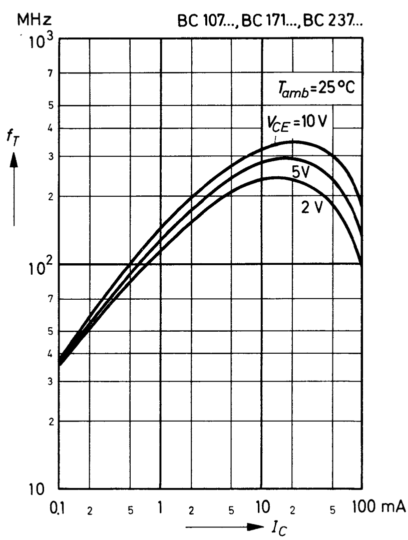
Base saturation voltage versus collector current



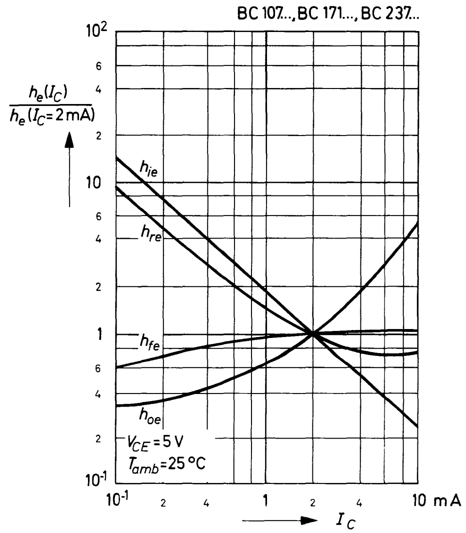
Collector base capacitance, Emitter base capacitance versus reverse bias voltage



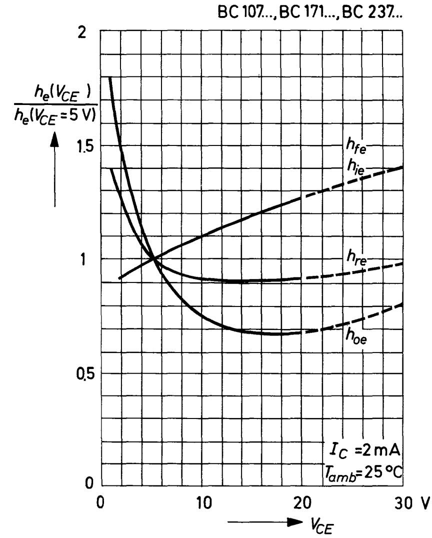
Gain bandwidth product versus collector current



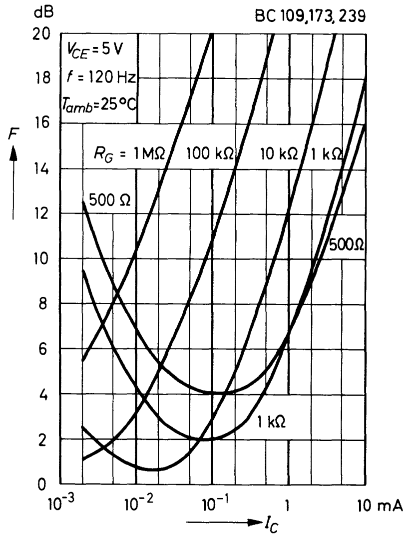
Relative *h*-parameters versus collector current



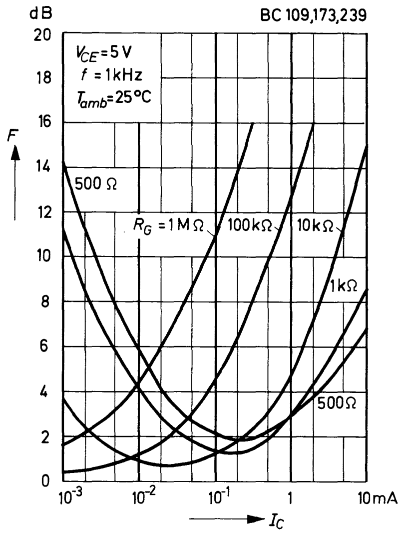
Relative *h*-parameters versus collector emitter voltage



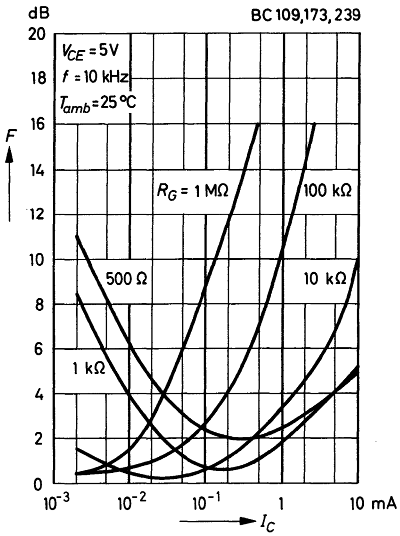
Noise figure versus collector current



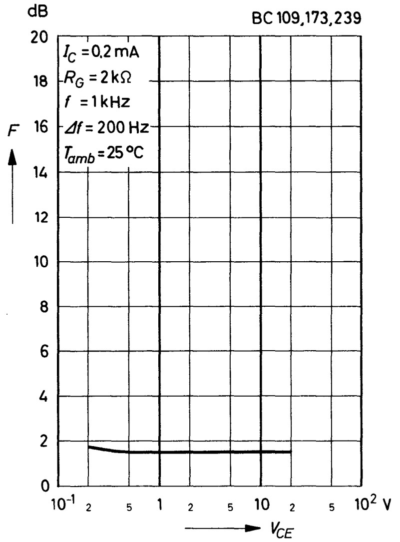
Noise figure versus collector current



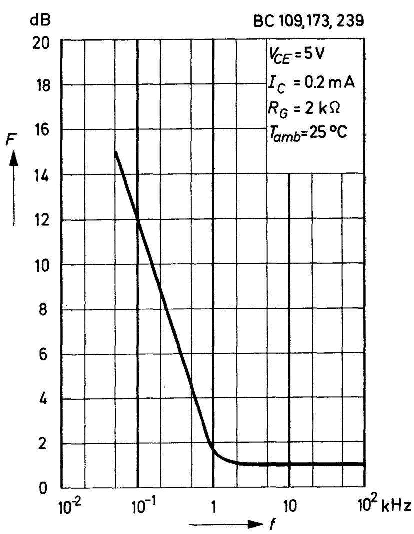
Noise figure versus collector curent



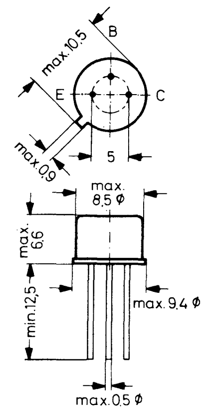
Noise figure versus collector emitter voltage



Noise figure versus frequency



NPN Silicon Epitaxial Planar Transistors
for switching and amplifier applications
These types are subdivided into three groups –6, –10 and –16, according to their DC current gain.
These transistors are available either as matched pairs or as complementary pairs BC 140/BC 160 or BC 141/BC 161 resp.
Matching condition: The ratio of the DC current gains of a matched pair at $|V_{CE}| = 1$ V, $|I_C| = 100$ mA is less than 1.25.



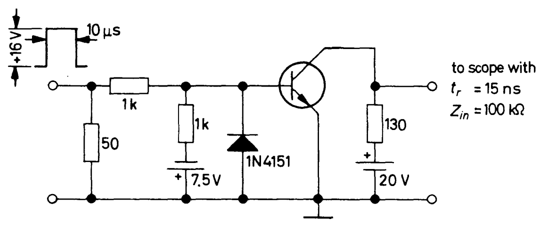
Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1 g
Dimensions in mm

Maximum Ratings		**BC 140**	**BC 141**	
Collector base voltage	V_{CBO}	80	100	V
Collector emitter voltage	V_{CEO}	40	60	V
Emitter base voltage	V_{EBO}	7	7	V
Collector current	I_C	1		A
Base current	I_B	0.1		A
Power dissipation				
at $T_{amb} = 25$ °C	P_{tot}	0.75		W
at $T_C = 45$ °C	P_{tot}	3.7		W
Junction temperature	T_j	175		°C
Storage temperature range	T_S	–55 . . . +175		°C

Characteristics at $T_j = 25$ °C		**BC 140-6** **BC 141-6**	**BC 140-10** **BC 141-10**	**BC 140-16** **BC 141-16**	
DC current gain					
at $V_{CE} = 1$ V, $I_C = 0.1$ mA	h_{FE}	28	40	90	
at $V_{CE} = 1$ V, $I_C = 100$ mA	h_{FE}	63 (40 . . . 100)	100 (63 . . . 160)	160 (100 . . . 250)	
at $V_{CE} = 1$ V, $I_C = 1$ A	h_{FE}	15	20	30	
Collector saturation voltage at $I_C = 1$ A, $I_B = 100$ mA	$V_{CE\,sat}$	0.6 (< 1)			V
Base emitter voltage at $V_{CE} = 1$ V, $I_C = 1$ A	V_{BE}	1.2 (< 1.8)			V

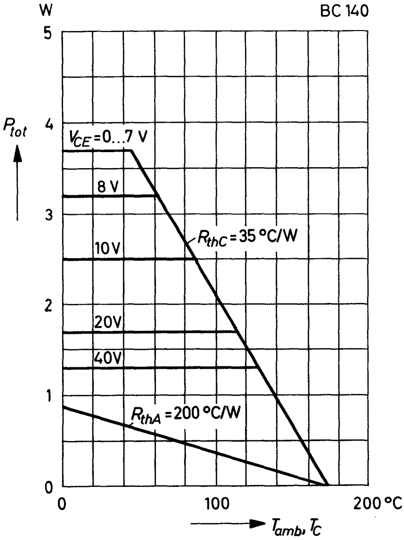
		BC 140	BC 141	
Collector cutoff current				
at V_{CE} = 40 V	I_{CES}	10 (< 100)	–	nA
at V_{CE} = 60 V	I_{CES}	–	10 (< 100)	nA
at V_{CE} = 40 V, T_j = 150 °C	I_{CES}	10 (< 100)	–	µA
at V_{CE} = 60 V, T_j = 150 °C	I_{CES}	–	10 (< 100)	µA
Collector emitter breakdown voltage				
at I_C = 0.1 mA	$V_{(BR)CES}$	> 80	> 100	V
at I_C = 30 mA (pulsed 200 µs, 1 %)	$V_{(BR)CEO}$	> 40	> 60	V
Emitter base breakdown voltage at I_E = 0.1 mA	$V_{(BR)EBO}$	> 7	–	V
Gain bandwidth product at V_{CE} = 10 V, I_C = 50 mA, f = 20 MHz	f_T	> 50		MHz
Collector base capacitance at V_{CBO} = 10 V, f = 1 MHz	C_{CBO}	< 25		pF
Emitter base capacitance at V_{EBO} = 0.5 V, f = 1 MHz	C_{EBO}	< 80		pF
Thermal resistance				
Junction to case	$R_{th\,C}$	< 35		°C/W
Junction to ambient air	$R_{th\,A}$	< 200		°C/W
Switching Times at I_C = 100 mA, $I_{B1} \approx -I_{B2} \approx$ 5 mA				
Turn-on time	t_{on}	< 250		ns
Turn-off time	t_{off}	< 850		ns

Test Circuit for Switching Times

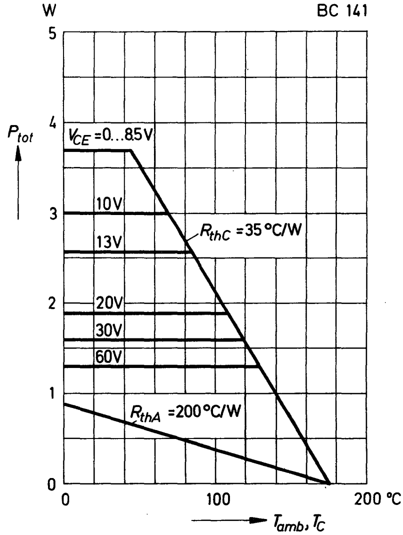


Rise time and fall time of input voltage < 15 ns, generator impedance 50 Ω

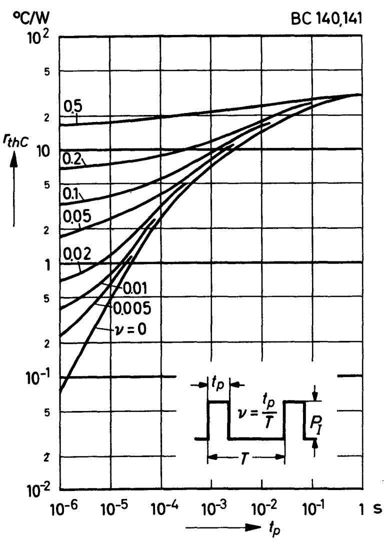
Admissible power dissipation versus temperature



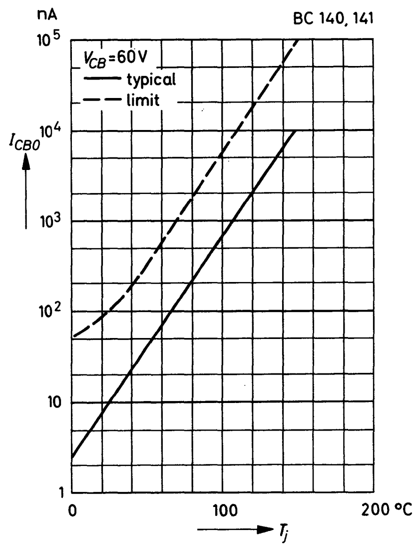
Admissible power dissipation versus temperature



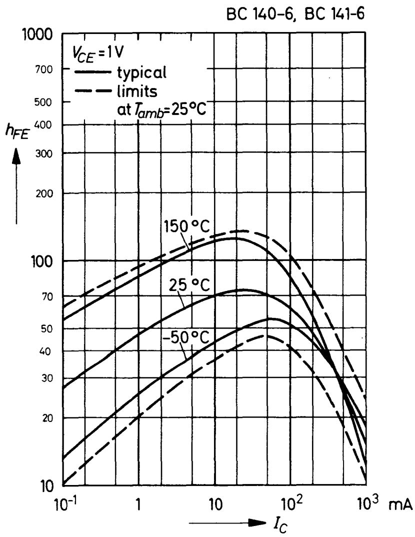
Pulse thermal resistance versus pulse duration



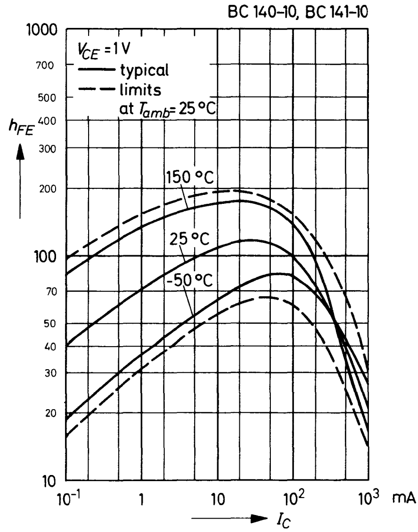
Collector cutoff current versus junction temperature



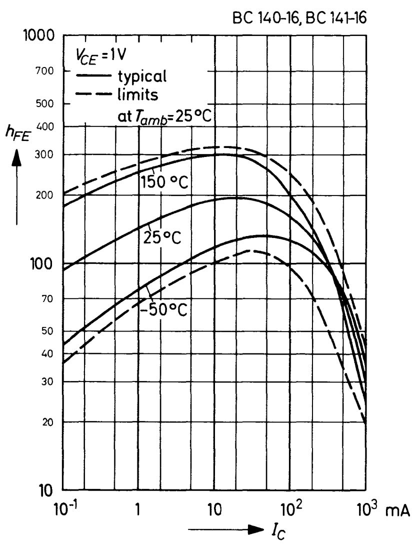
DC current gain versus collector current



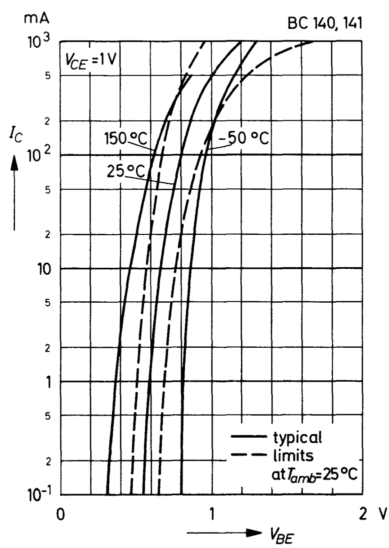
DC current gain versus collector current



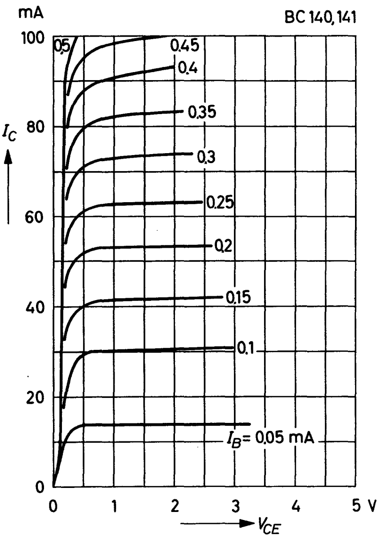
DC current gain versus collector current



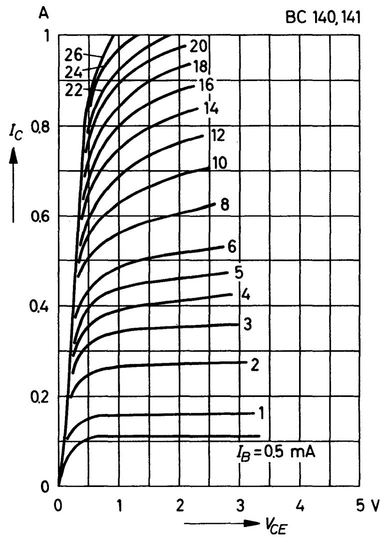
Collector current versus base emitter voltage



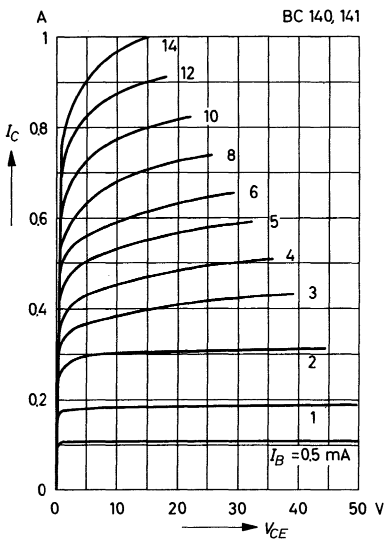
Common emitter collector characteristics



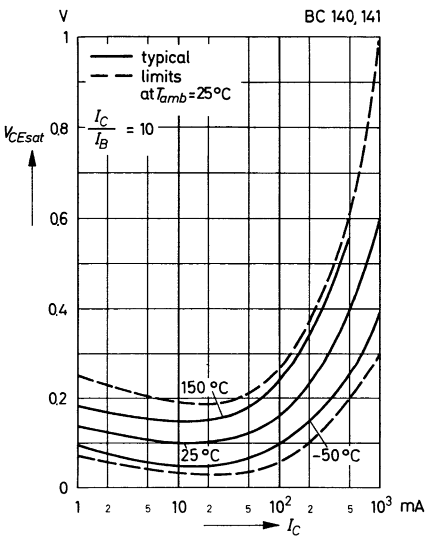
Common emitter collector characteristics



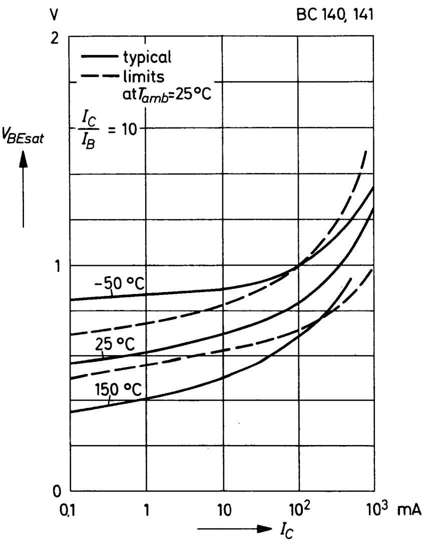
Common emitter collector characteristics



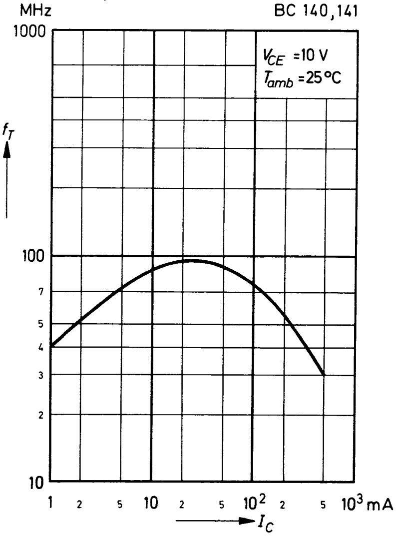
Collector saturation voltage versus collector current



Base saturation voltage versus collector current



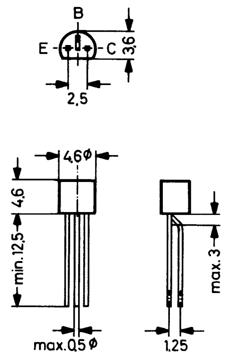
Gain bandwidth product versus collector current



BC 170

NPN Silicon Planar Transistor
for switching and amplifier applications

The transistors are subdivided into three groups, A, B and C, according to their DC current gain.



Black plastic package ≈ TO-92,
TO-18 compatible.
The case is impervious to light.
Weight approximately 0.18 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	20	V
Collector emitter voltage	V_{CEO}	20	V
Emitter base voltage	V_{EBO}	5	V
Collector current	I_C	100	mA
Power dissipation at $T_{amb} = 25\ °C$	P_{tot}	300 [1]	mW
Junction temperature	T_j	150	°C
Storage temperature range	T_S	– 55 . . . + 150	°C

Characteristics at $T_{amb} = 25\ °C$

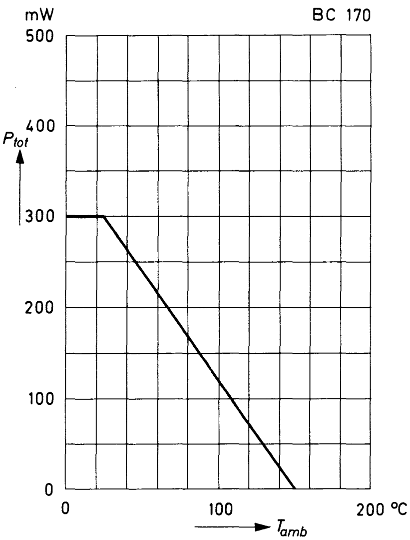
		BC 170 A	BC 170 B	BC 170 C
DC current gain				
at $V_{CE} = 1$ V, $I_C = 1$ mA	h_{FE}	35 . . . 100	80 . . . 250	200 . . . 600
at $V_{CE} = 1$ V, $I_C = 30$ mA	h_{FE}	> 30	> 60	> 150

Collector saturation voltage			
at $I_C = 1$ mA, $I_B = 0.1$ mA	$V_{CE\,sat}$	< 0.25	V
at $I_C = 30$ mA, $I_B = 3$ mA	$V_{CE\,sat}$	< 0.4	V
Base saturation voltage at $I_C = 1$ mA, $I_B = 0.1$ mA	$V_{BE\,sat}$	< 0.7	V
Collector cutoff current at $V_{CB} = 15$ V	I_{CBO}	< 0.1	µA

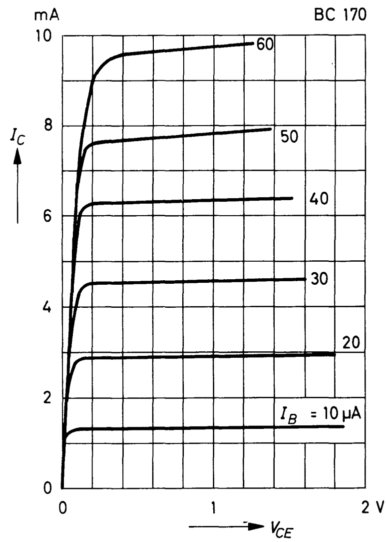
[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

Emitter cutoff current at $V_{EB} = 4$ V	I_{EBO}	< 0.1	μA
Thermal resistance Junction to ambient air	R_{thA}	< 420 [1]	°C/W
Collector base capacitance at $V_{CBO} = 10$ V, $f = 1$ MHz	C_{CBO}	4	pF
Emitter base capacitance at $V_{EBO} = 0.5$ V, $f = 1$ MHz	C_{EBO}	12	pF
Gain bandwidth product at $V_{CE} = 5$ V, $I_C = 10$ mA, $f = 50$ MHz	f_T	100	MHz
Noise figure at $V_{CE} = 5$ V, $I_C = 0.2$ mA, $R_G = 2$ kΩ, $f = 1$ kHz, $\Delta f = 200$ Hz	F	< 10	dB

Admissible power dissipation versus ambient temperature [1]



Common emitter collector characteristics



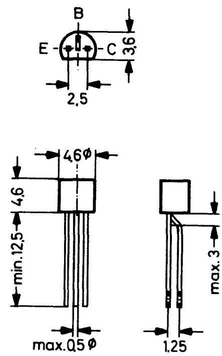
[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

BC 337, BC 338

NPN Silicon Epitaxial Planar Transistors
for switching and amplifier applications. Especially suitable for AF-driver stages and low power output stages.

These types are subdivided into three groups -16, -25 and -40, according to their DC current gain.

These transistors are available as complementary pairs BC 327/BC 337 or BC 328/BC 338. Matching conditions: The ratio of the DC current gains of a matched pair at $|V_{CE}| = 1$ V, $|I_C| = 100$ mA is less than 1.41.



Black plastic package ≈ TO-92,
TO-18 compatible.
The case is impervious to light.
Weight approximately 0.18 g
Dimensions in mm

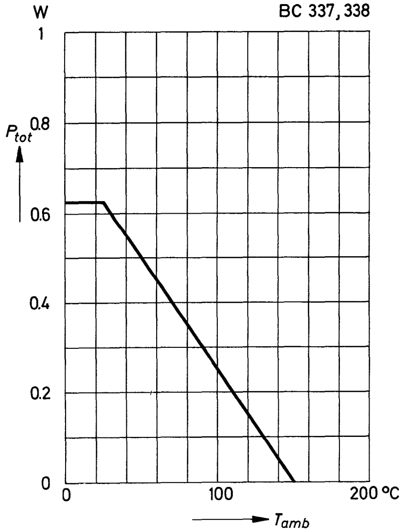
Maximum Ratings		**BC 337**	**BC 338**	
Collector emitter voltage	V_{CES}	50	30	V
Collector emitter voltage	V_{CEO}	45	25	V
Emitter base voltage	V_{EBO}	5		V
Collector current	I_C	800		mA
Peak collector current	I_{CM}	1		A
Base current	I_B	100		mA
Power dissipation at $T_{amb} = 25$ °C	P_{tot}	625 [1]		mW
Junction temperature	T_j	150		°C
Storage temperature range	T_S	– 55...+ 150		°C

Characteristics at $T_{amb} = 25$ °C		**BC 337-16** **BC 338-16**	**BC 337-25** **BC 338-25**	**BC 337-40** **BC 338-40**
DC current gain at $V_{CE} = 1$ V, $I_C = 100$ mA	h_{FE}	160 (100...250)	250 (160...400)	400 (250...630)
at $V_{CE} = 1$ V, $I_C = 300$ mA	h_{FE}	130	200	320
Thermal resistance Junction to ambient air	R_{thA}		< 200 [1]	°C/W

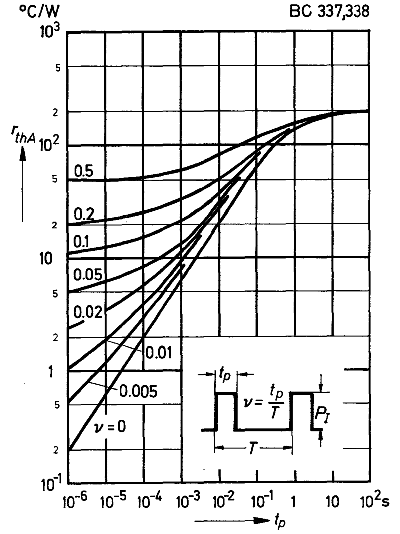
[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

		BC 337	BC 338	
Collector cutoff current				
at $V_{CE} = 25$ V	I_{CES}	–	2 (< 100)	nA
at $V_{CE} = 45$ V	I_{CES}	2 (< 100)	–	nA
at $V_{CE} = 25$ V, $T_{amb} = 125$ °C	I_{CES}	–	< 10	μA
at $V_{CE} = 45$ V, $T_{amb} = 125$ °C	I_{CES}	< 10	–	μA
Collector emitter breakdown voltage at $I_C = 10$ mA	$V_{(BR)CEO}$	> 45	> 20	V
Collector emitter breakdown voltage at $I_C = 0.1$ mA	$V_{(BR)CES}$	> 50	> 30	V
Emitter base breakdown voltage at $I_E = 0.1$ mA	$V_{(BR)EBO}$	> 5		V
Collector saturation voltage at $I_C = 500$ mA, $I_B = 50$ mA	$V_{CE\,sat}$	< 0,7		V
Base emitter voltage at $V_{CE} = 1$ V, $I_C = 300$ mA	V_{BE}	< 1,2		V
Gain bandwidth product at $V_{CE} = 5$ V, $I_C = 10$ mA, $f = 50$ MHz	f_T	100		MHz
Collector base capacitance at $V_{CB} = 10$ V, $f = 1$ MHz	C_{CBO}	12		pF

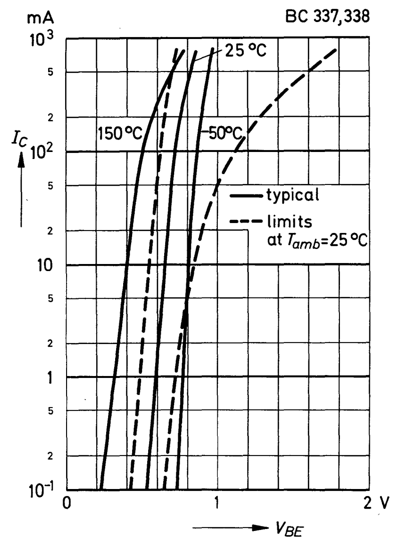
Admissible power dissipation versus ambient temperature
(see note on page 54)



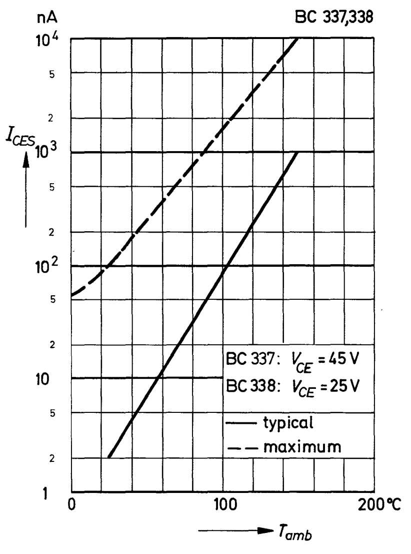
Pulse thermal resistance versus pulse duration



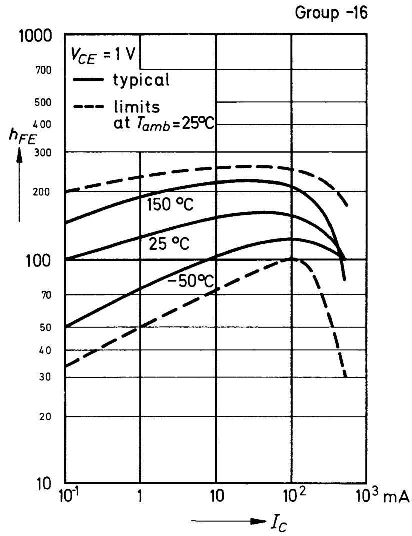
Collector current versus base emitter voltage



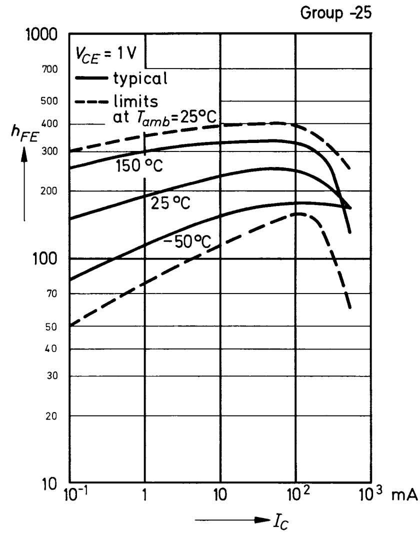
Collector cutoff current versus ambient temperature



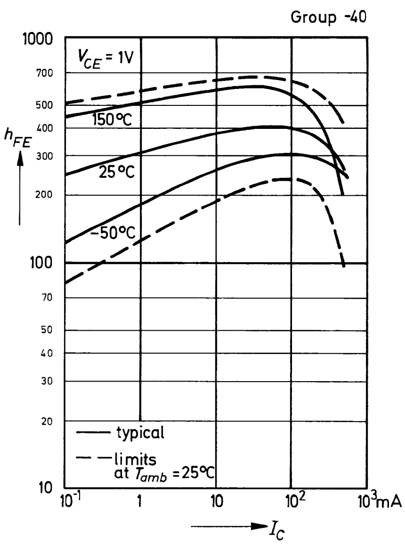
DC current gain versus collector current



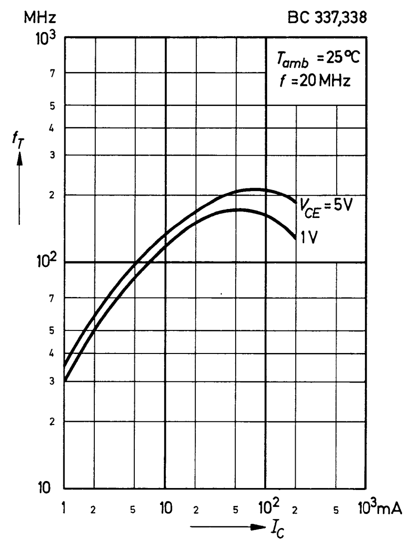
DC current gain versus collector current



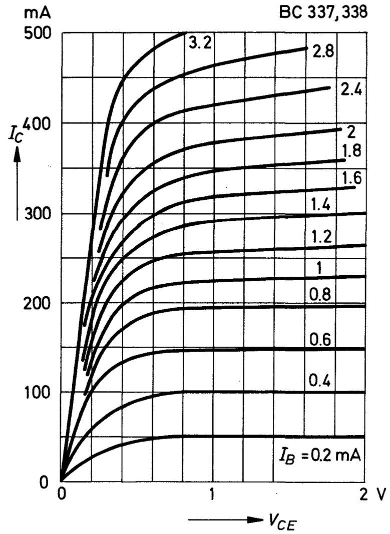
DC current gain versus collector current



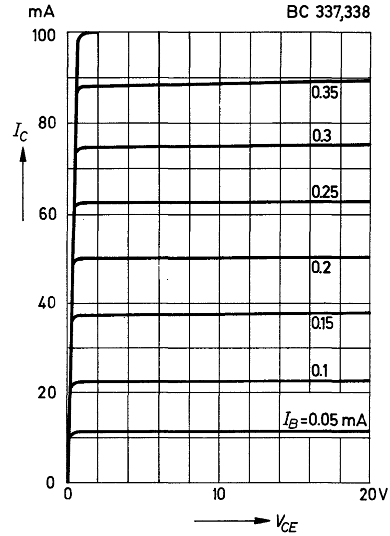
Gain bandwidth product versus collector current



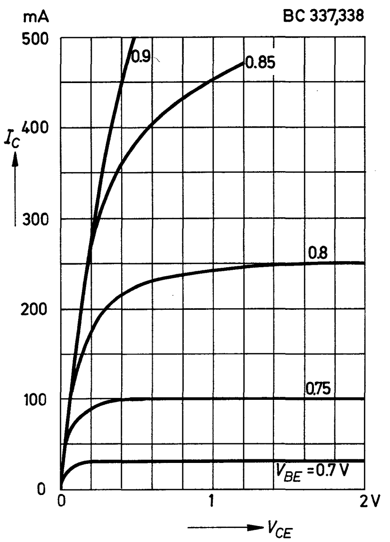
Common emitter collector characteristics



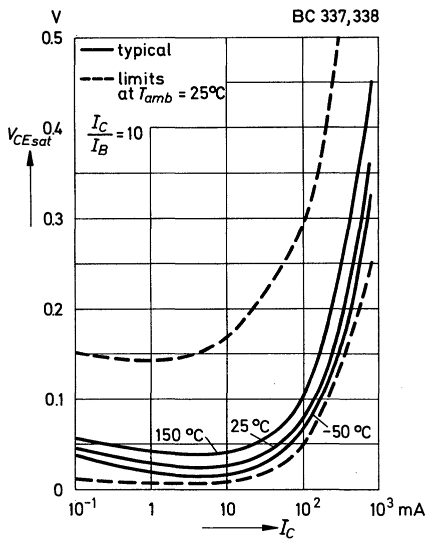
Common emitter collector characteristics



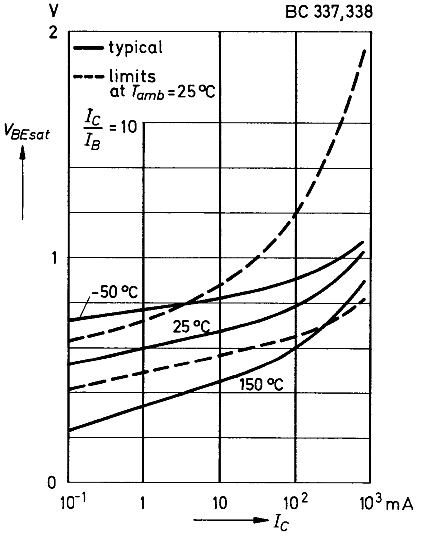
Common emitter collector characteristics



Collector saturation voltage versus collector current



Base saturation voltage versus collector current

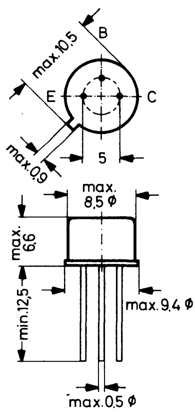


NPN Silicon Epitaxial Planar Transistors

for switching and amplifier applications

The type BC 340 is subdivided into three groups, -6, -10 and -16, the type BC 341 into two groups, -6 and -10, according to the DC current gain.

These transistors are available either as matched pairs or as complementary pairs BC 340/BC 360 or BC 341/BC 361 resp. Matching condition: The ratio of the DC current gains of a matched pair at $|V_{CE}| = 5$ V, $|I_C| = 50$ mA is less than 1.25.



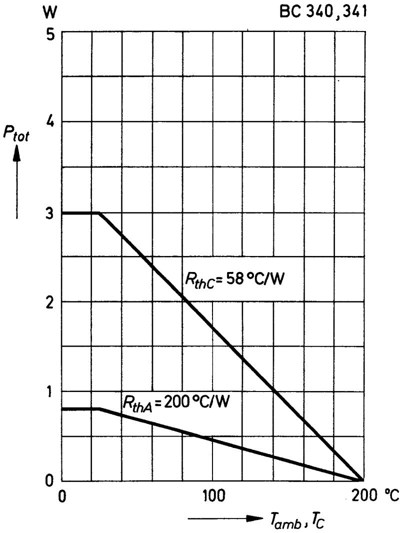
Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1 g
Dimensions in mm

Maximum Ratings		**BC 340**	**BC 341**	
Collector base voltage	V_{CBO}	40	60	V
Collector emitter voltage	V_{CEO}	40	60	V
Emitter base voltage	V_{EBO}	5	5	V
Collector current	I_C	500		mA
Base current	I_B	50		mA
Power dissipation at $T_{amb} = 25$ °C	P_{tot}	0.8		W
at $T_C = 25°$ C	P_{tot}	3		W
Junction temperature	T_j	200		°C
Storage temperature range	T_S	$-55 \ldots +200$		°C

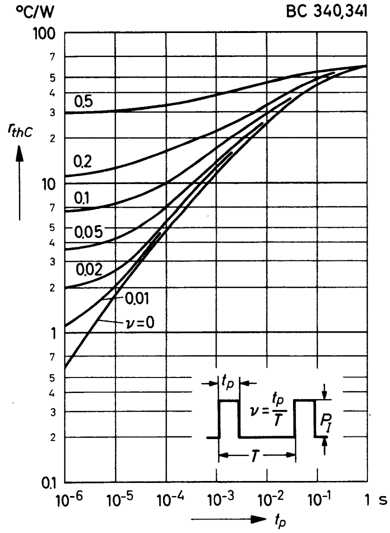
Characteristics at $T_j = 25$ °C		**BC 340-6** **BC 341-6**	**BC 340-10** **BC 341-10**	**BC 340-16**	
DC current gain at $V_{CE} = 5$ V, $I_C = 0.1$ mA	h_{FE}	27	43	70	
at $V_{CE} = 5$ V, $I_C = 50$ mA	h_{FE}	63 (40 . . . 100)	100 (63 . . . 160)	160 (100 . . . 250)	
at $V_{CE} = 5$ V, $I_C = 500$ mA	h_{FE}	13	20	32	
Collector saturation voltage at $I_C = 150$ mA, $I_B = 15$ mA	$V_{CE\,sat}$		< 0.4		V
Base saturation voltage at $I_C = 150$ mA, $I_B = 15$ mA	$V_{BE\,sat}$		0.95 (< 1.2)		V

		BC 340	BC 341	
Collector cutoff current				
at $V_{CE} = 40$ V	I_{CES}	10 (< 100)	–	nA
at $V_{CE} = 60$ V	I_{CES}	–	10 (< 100)	nA
at $V_{CE} = 40$ V, $T_j = 150$ °C	I_{CES}	10 (< 100)	–	μA
at $V_{CE} = 60$ V, $T_j = 150$ °C	I_{CES}	–	10 (< 100)	μA
Collector emitter breakdown voltage				
at $I_C = 0.1$ mA	$V_{(BR)CES}$	> 40	> 60	V
at $I_C = 30$ mA (pulsed 200 µs, 1 %)	$V_{(BR)CEO}$	> 40	> 60	V
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	100		MHz
Collector base capacitance at $V_{CB0} = 10$ V, $f = 1$ MHz	C_{CB0}	6.5		pF
Emitter base capacitance at $V_{EB0} = 0.5$ V, $f = 1$ MHz	C_{EB0}	25		pF
Thermal resistance				
Junction to ambient air	R_{thA}	< 220		°C/W
Junction to case	R_{thC}	< 58		°C/W

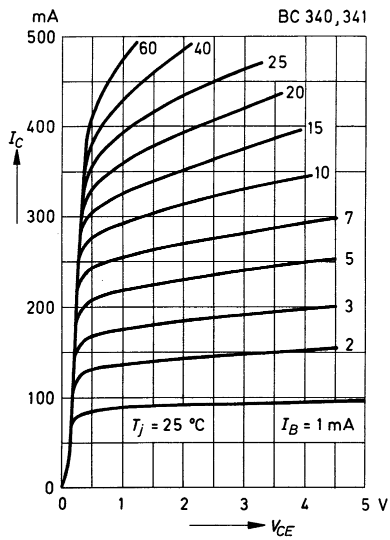
Admissible power dissipation versus temperature



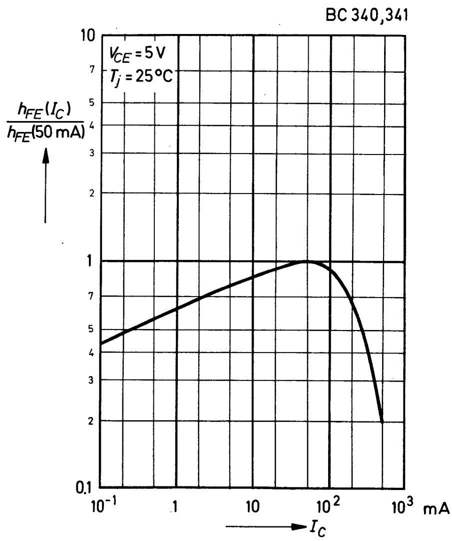
Pulse thermal resistance versus pulse duration



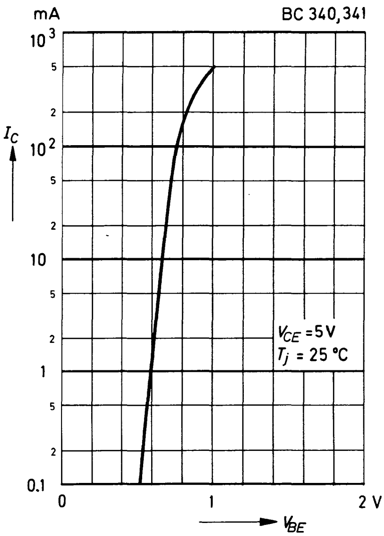
Common emitter collector characteristics



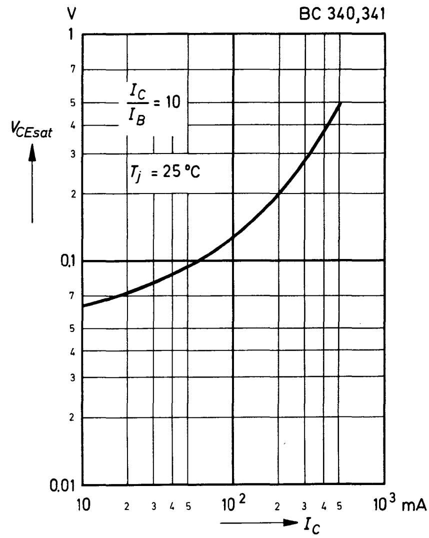
Relative DC current gain versus collector current



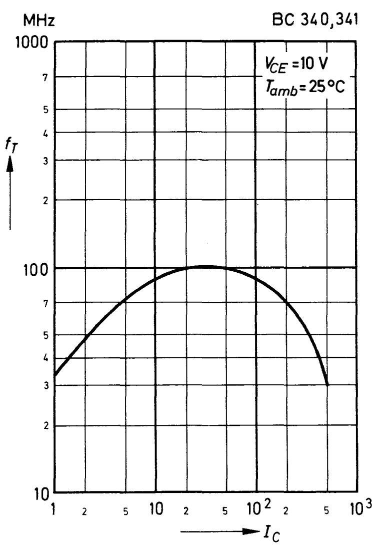
Collector current versus base emitter voltage



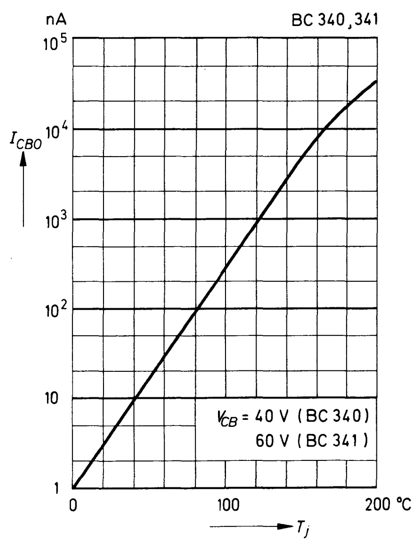
Collector saturation voltage versus collector current



Gain bandwidth product versus collector current



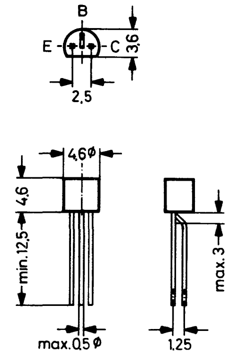
Collector cutoff current versus junction temperature



BC 413, BC 414

NPN Silicon Epitaxial Planar Transistors
for use in high-quality, low-noise AF and DC amplifiers. Complementary types are the PNP transistors BC 415 and BC 416.

These types are subdivided into two groups B and C according to their current gain.



Black plastic package ≈ TO-92, TO-18 compatible.
The case is impervious to light.
Weight approximately 0.18 g
Dimensions in mm

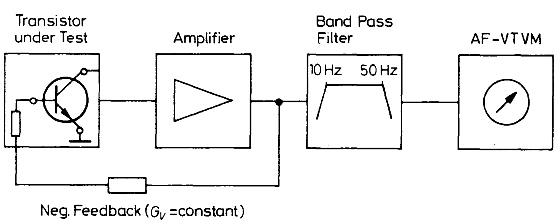
Maximum Ratings		**BC 413**	**BC 414**	
Collector base voltage	V_{CBO}	45	50	V
Collector emitter voltage	V_{CEO}	30	45	V
Emitter base voltage	V_{EBO}	5		V
Collector current	I_C	100		mA
Base current	I_B	20		mA
Power dissipation at $T_{amb} = 25\ °C$	P_{tot}	300 [1]		mW
Junction temperature	T_j	150		°C
Storage temperature range	T_S	−65 ... +150		°C

Characteristics at $T_{amb} = 25\ °C$

		Current gain group		
h-Parameters at $V_{CE} = 5$ V, $I_C = 2$ mA, $f = 1$ kHz		**B**	**C**	
Small signal current gain	h_{fe}	330 (240 ... 500)	600 (450 ... 900)	
Input impedance	h_{ie}	4.5 (3.2 ... 8.5)	8.7 (6 ... 15)	kΩ
Output admittance	h_{oe}	30 (< 60)	60 (< 110)	μmho
Reverse voltage transfer ratio	h_{re}	$2 \cdot 10^{-4}$	$3 \cdot 10^{-4}$	
DC current gain				
at $V_{CE} = 5$ V, $I_C = 0.01$ mA	h_{FE}	150 (> 100)	270 (> 100)	
at $V_{CE} = 5$ V, $I_C = 2$ mA	h_{FE}	290 (180 ... 460)	500 (380 ... 800)	
Thermal resistance Junction to ambient air	R_{thA}	420 [1]		°C/W

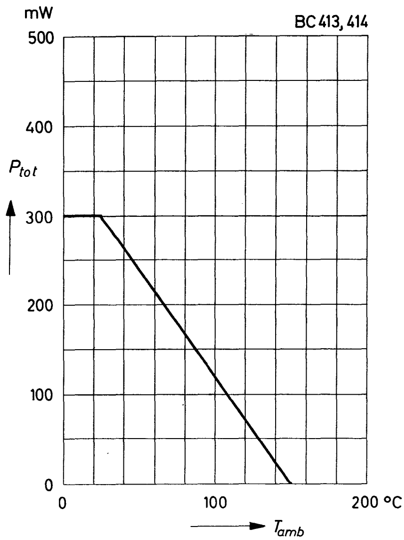
[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case

Collector saturation voltage				
at I_C = 10 mA, I_B = 0,5 mA	$V_{CE\,sat}$	0.075 (< 0.25)		V
at I_C = 100 mA, I_B = 5 mA	$V_{CE\,sat}$	0.25 (< 0.6)		V
Base saturation voltage at I_C = 100 mA, I_B = 5 mA	$V_{BE\,sat}$	0.9		V
Base emitter voltage				
at V_{CE} = 5 V, I_C = 0.01 mA	V_{BE}	0.52		V
at V_{CE} = 5 V, I_C = 0.1 mA	V_{BE}	0.55		V
at V_{CE} = 5 V, I_C = 2 mA	V_{BE}	6.62 (0.55 ... 0.75)		V
Collector cutoff current				
at V_{CB} = 30 V	I_{CBO}	< 15		nA
at V_{CB} = 30 V, T_{amb} = 150 °C	I_{CBO}	< 5		μA
Emitter cutoff current at V_{EB} = 4 V	I_{EBO}	< 15		nA
		BC 413	**BC 414**	
Collector emitter breakdown voltage at I_C = 10 mA	$V_{(BR)CEO}$	> 30	> 45	V
Collector base breakdown voltage at I_C = 10 μA	$V_{(BR)CBO}$	> 45	> 50	V
Emitter base breakdown voltage at I_E = 10 μA	$V_{(BR)EBO}$	> 5	> 5	V
Gain bandwidth product at V_{CE} = 5 V, I_C = 10 mA, f = 100 MHz	f_T	250		MHz
Collector base capacitance at V_{CBO} = 10 V, f = 1 MHz	C_{CBO}	2.5		pF
Noise figure at V_{CE} = 5 V, I_C = 0.2 mA, R_G = 2 kΩ, f = 30 Hz ... 15 kHz	F	< 2.5		dB
Equivalent noise EMF (referred to base) at V_{CE} = 5 V, I_C = 0.2 mA, R_G = 2 kΩ, f = 10 ... 50 Hz	v_r	< 0.135		μV

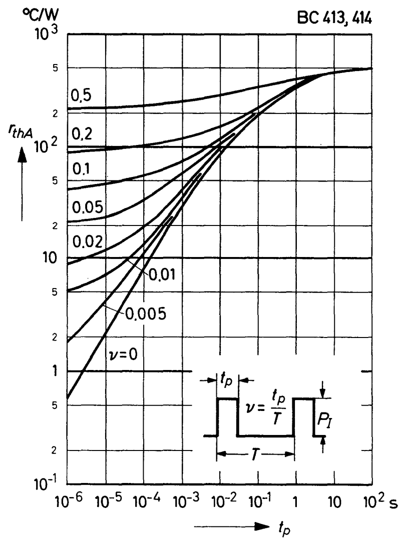


Test circuit for equivalent noise EMF

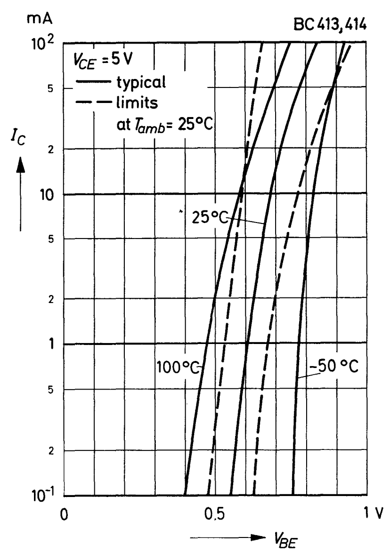
Admissible power dissipation versus ambient temperature
(see note on page 64)



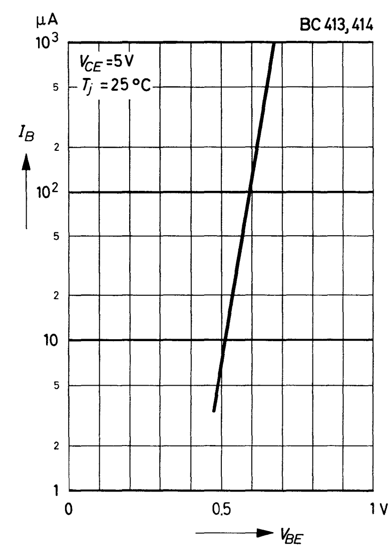
Pulse thermal resistance versus pulse duration



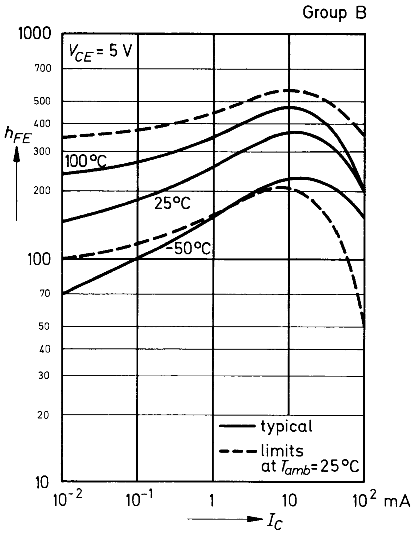
Collector current versus base emitter voltage



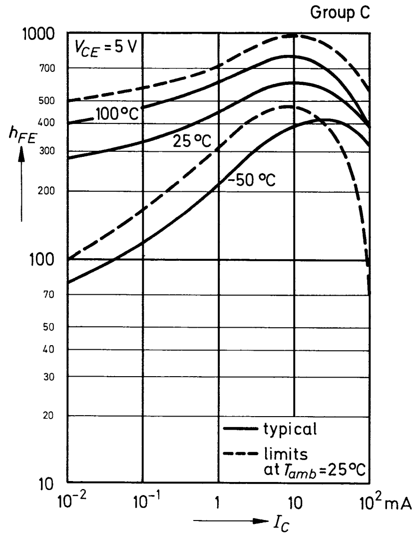
Common emitter input characteristic



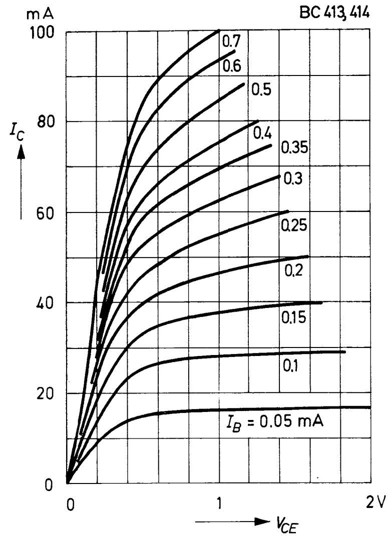
DC current gain versus collector current



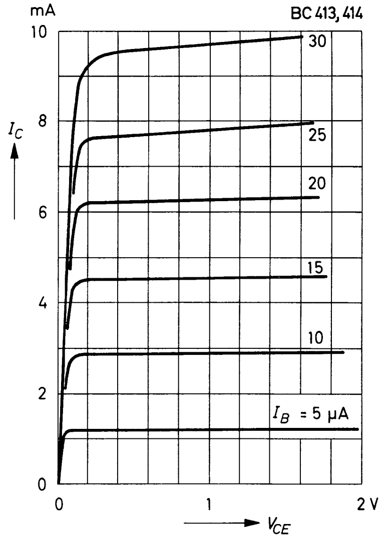
DC current gain versus collector current



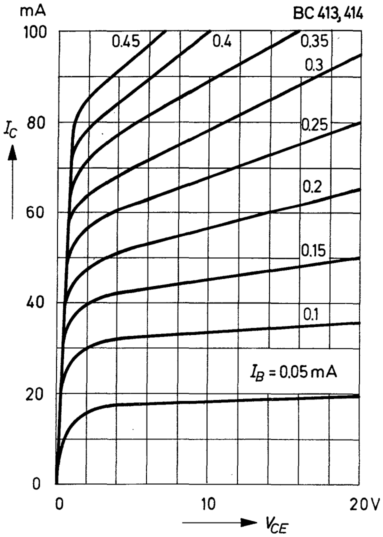
Common emitter collector characteristics



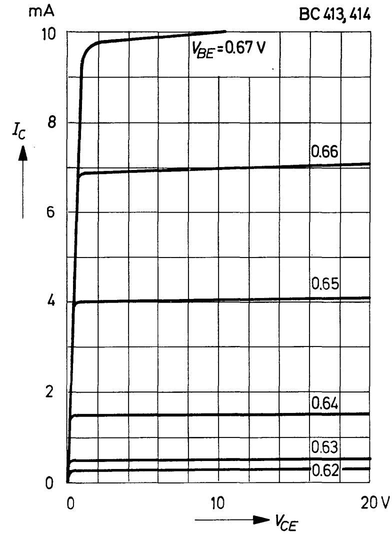
Common emitter collector characteristics



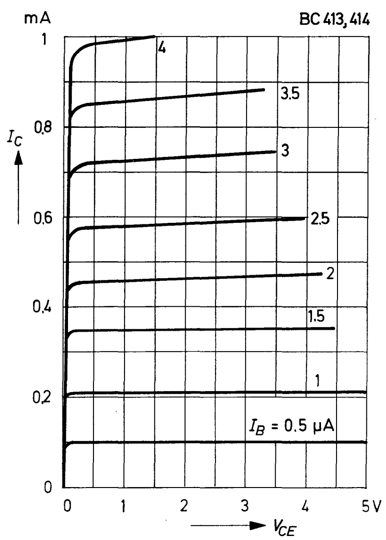
Common emitter collector characteristics



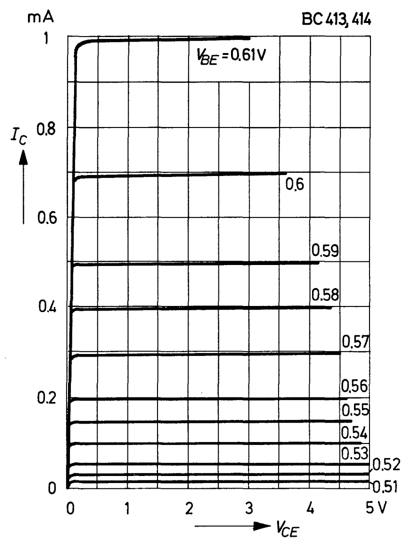
Common emitter collector characteristics



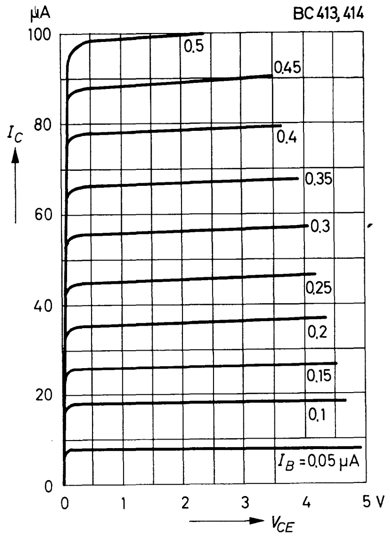
Common emitter collector characteristics



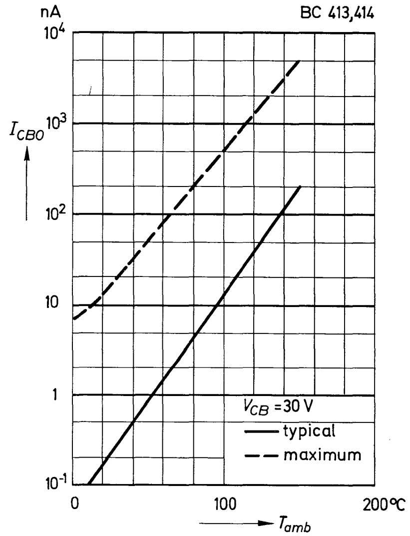
Common emitter collector characteristics



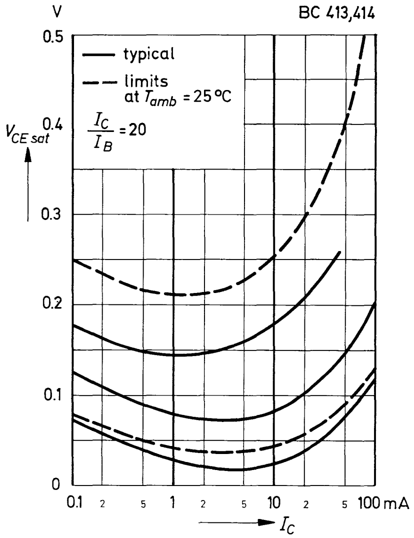
Common emitter collector characteristics



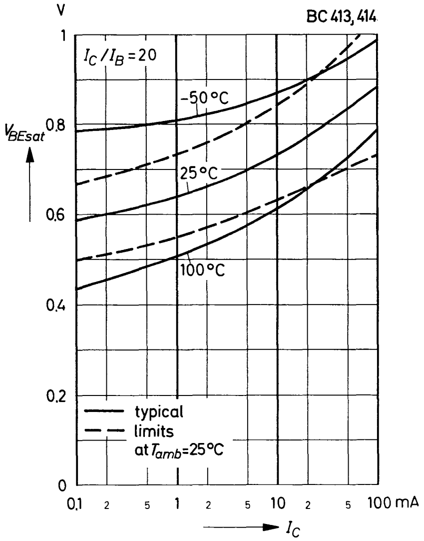
Collector cutoff current versus ambient temperature



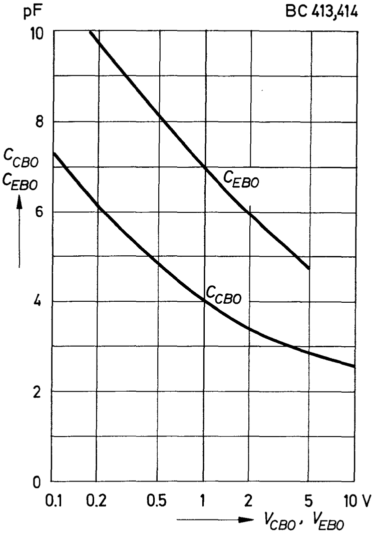
Collector saturation voltage versus collector current



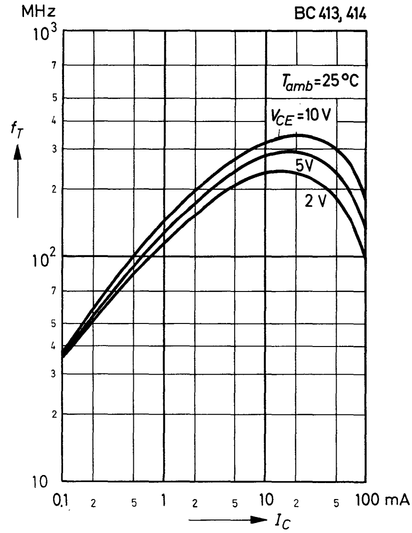
Base saturation voltage versus collector current



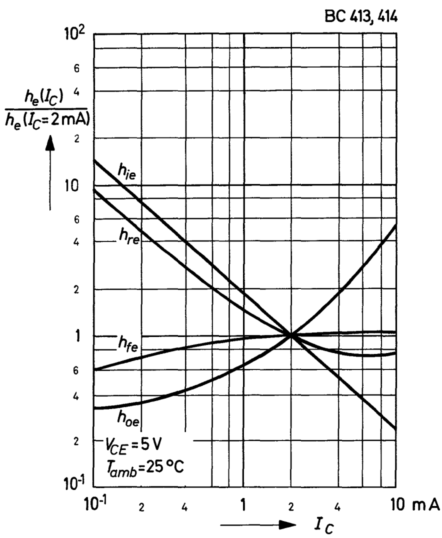
Collector base capacitance, Emitter base capacitance versus reverse bias voltage



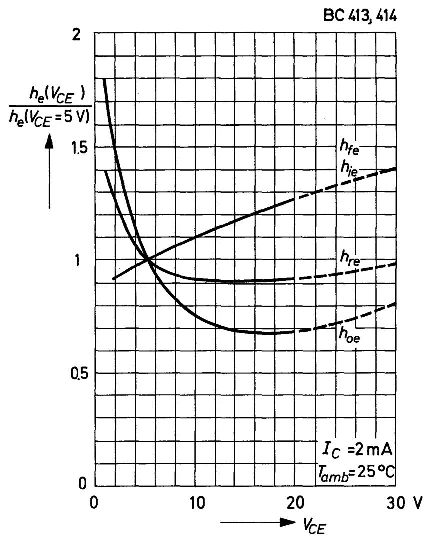
Gain bandwidth product versus collector current



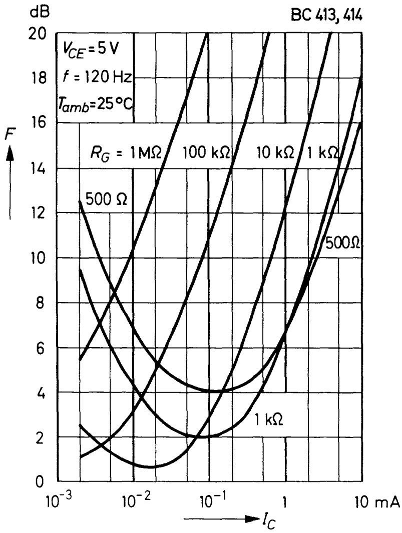
Relative *h*-parameters versus collector current



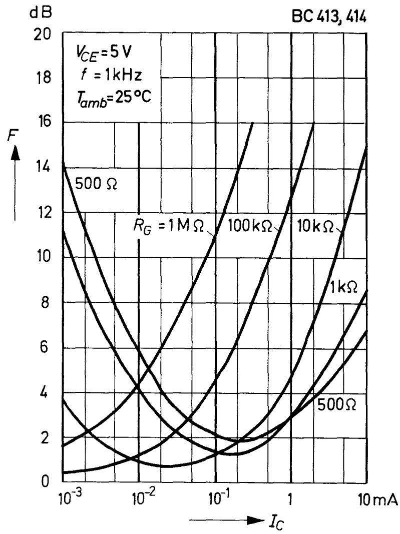
Relative *h*-parameters versus collector emitter voltage



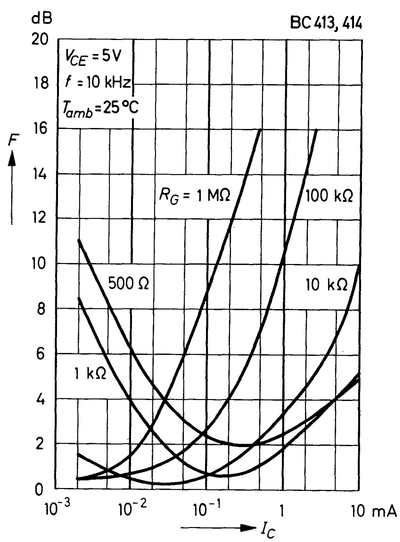
Noise figure versus collector current



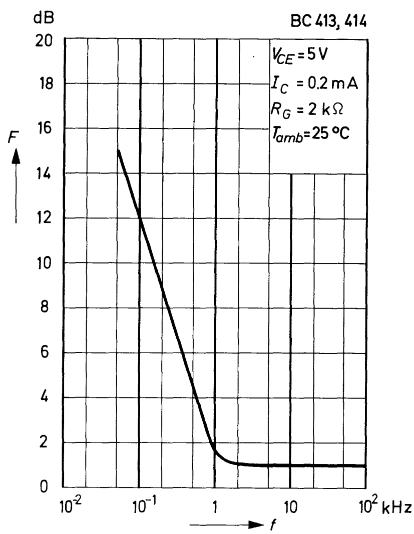
Noise figure versus collector current



Noise figure versus collector current



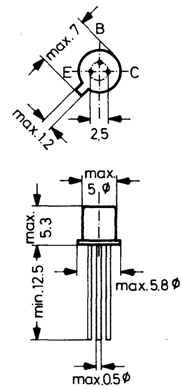
Noise figure versus frequency



BCY 58, BCY 59

NPN Silicon Epitaxial Planar Transistors
for switching and amplifier applications
in commercial electronic design

The transistors are subdivided into four groups A, B, C and D according to their current gain.



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings		**BCY 58**	**BCY 59**	
Collector emitter voltage	V_{CES}	32	45	V
Collector emitter voltage	V_{CEO}	32	45	V
Emitter base voltage	V_{EBO}	7	7	V
Collector current	I_C	200		mA
Base current	I_B	50		mA
Power dissipation at $T_{amb} = 25$ °C	P_{tot}	390		mW
at $T_C = 45$ °C	P_{tot}	1		W
Junction temperature	T_j	200		°C
Storage temperature range	T_S	−65 . . . +200		°C

Characteristics at $T_{amb} = 25$ °C — **Current Gain Group**

h-Parameter at $V_{CE} = 5$ V, $I_C = 2$ mA, $f = 1$ kHz		**A**	**B**	**C**	**D**	
Small signal current gain	h_{fe}	200 (125 . . . 250)	260 (175 . . . 350)	330 (250 . . . 500)	520 (350 . . . 700)	
Input impedance	h_{ie}	2.7 (1.6 . . . 4.5)	3.6 (2.5 . . . 6)	4.5 (3.2 . . . 8.5)	7.5 (4.5 . . . 12)	kΩ
Output admittance	h_{oe}	18 (< 30)	24 (< 50)	30 (< 60)	50 (< 100)	μmho
Reverse voltage transfer ratio	h_{re}	$1.5 \cdot 10^{-4}$	$2 \cdot 10^{-4}$	$2 \cdot 10^{-4}$	$3 \cdot 10^{-4}$	

		Current Gain Group			
		A	B	C	D
DC current gain					
at $V_{CE} = 5$ V, $I_C = 10$ µA	h_{FE}	78	145 (> 20)	220 (> 40)	300 (> 100)
at $V_{CE} = 5$ V, $I_C = 2$ mA	h_{FE}	170 (120...220)	250 (180...310)	350 (250...460)	500 (380...630)
at $V_{CE} = 1$ V, $I_C = 10$ mA	h_{FE}	190 (> 80)	260 (120...400)	380 (160...630)	550 (240...1000)
at $V_{CE} = 1$ V, $I_C = 100$ mA	h_{FE}	> 40	> 45	> 60	> 60

Base emitter voltage			
at $V_{CE} = 5$ V, $I_C = 10$ µA	V_{BE}	0.5	V
at $V_{CE} = 5$ V, $I_C = 2$ mA	V_{BE}	0.62 (0.55 ... 0.7)	V
at $V_{CE} = 1$ V, $I_C = 10$ mA	V_{BE}	0.7	V
at $V_{CE} = 1$ V, $I_C = 100$ mA	V_{BE}	0.76	V
Collector saturation voltage			
at $I_C = 10$ mA, $I_B = 0.25$ mA	$V_{CE\,sat}$	0.12 (0.05 ... 0.35)	V
at $I_C = 100$ mA, $I_B = 2.5$ mA	$V_{CE\,sat}$	0.3 (0.15 ... 0.7)	V
Base saturation voltage			
at $I_C = 10$ mA, $I_B = 0.25$ mA	$V_{BE\,sat}$	0.7 (0.6 ... 0.85)	V
at $I_C = 100$ mA, $I_B = 2.5$ mA	$V_{BE\,sat}$	0.9 (0.75 ... 1.2)	V

		BCY 58	BCY 59	
Collector cutoff current				
at $V_{CE} = 32$ V	I_{CES}	0.2 (< 10)	–	nA
at $V_{CE} = 45$ V	I_{CES}	–	0.2 (< 10)	nA
at $V_{CE} = 32$ V, $T_{amb} = 150$ °C	I_{CES}	0.2 (< 10)	–	µA
at $V_{CE} = 45$ V, $T_{amb} = 150$ °C	I_{CES}	–	0.2 (< 10)	µA
at $V_{CE} = 32$ V, $V_{BE} = 0.2$ V, $T_{amb} = 100$ °C	I_{CEV}	< 20	–	µA
at $V_{CE} = 45$ V, $V_{BE} = 0.2$ V, $T_{amb} = 100$ °C	I_{CEV}	–	< 20	µA
Emitter cutoff current at $V_{EB} = 5$ V	I_{EBO}	< 10	< 10	nA
Collector emitter breakdown voltage at $I_C = 2$ mA	$V_{(BR)CEO}$	> 32	> 45	V
Emitter base breakdown voltage at $I_E = 1$ µA	$V_{(BR)EBO}$	> 7	> 7	V
Gain bandwidth product at $V_{CE} = 5$ V, $I_C = 10$ mA, $f = 100$ MHz	f_T	250 (> 125)		MHz
Collector base capacitance at $V_{CBO} = 10$ V, $f = 1$ MHz	C_{EBO}	8 (< 15)		pF
Emitter base capacitance at $V_{EBO} = 0.5$ V, $f = 1$ MHz	C_{CBO}	3.5 (< 6)		pF

Noise figure at $V_{CE} = 5$ V, $I_C = 0.2$ mA, $R_G = 2$ kΩ, $f = 1$ kHz, $\Delta f = 200$ Hz	F	2 (< 6)	dB
Thermal resistance Junction to ambient air Junction to case	$R_{th\,A}$ $R_{th\,C}$	< 450 < 150	°C/W °C/W

Switching Times

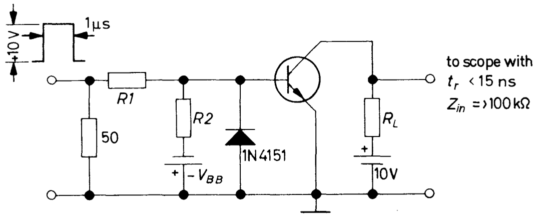
Test conditions:
$I_C : I_{B1} : -I_{B2} \sim 10:1:1$ mA, $R_1 = 5$ kΩ, $R_2 = 5$ kΩ, $R_L = 990$ Ω, $-V_{BB} = 3.6$ V

Delay time	t_d	35	ns
Rise time	t_r	50	ns
Turn-on time	t_{on}	85 (< 150)	ns
Storage time	t_s	400	ns
Fall time	t_f	80	ns
Turn-off time	t_{off}	480 (< 800)	ns

Test conditions:
$I_C : I_{B1} : -I_{B2} \sim 100:10:10$ mA, $R_1 = 500$ Ω, $R_2 = 700$ Ω, $R_L = 98$ Ω, $-V_{BB} = 5$ V

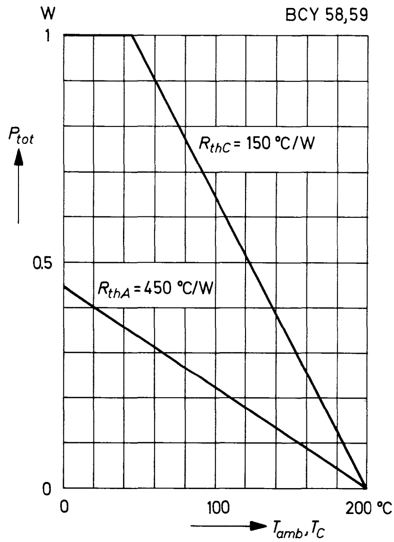
Delay time	t_d	5	ns
Rise time	t_r	50	ns
Turn-on time	t_{on}	55 (< 150)	ns
Storage time	t_s	250	ns
Fall time	t_f	200	ns
Turn-off time	t_{off}	450 (< 800)	ns

Test Circuit for Switching Times

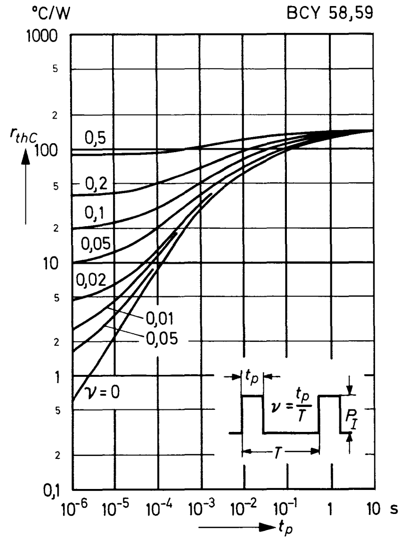


Rise time of input voltage 5 ns, pulse duty factor < 1 %, generator impedance 50 Ω

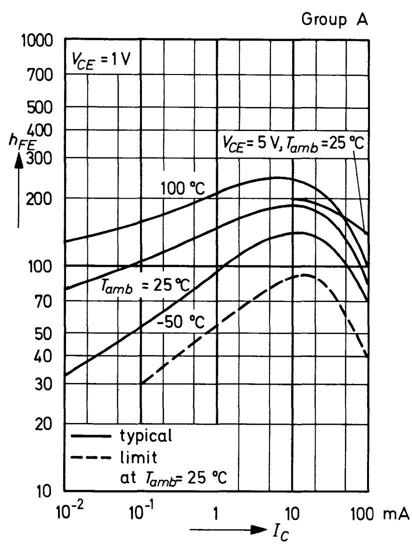
Admissible power dissipation versus temperature



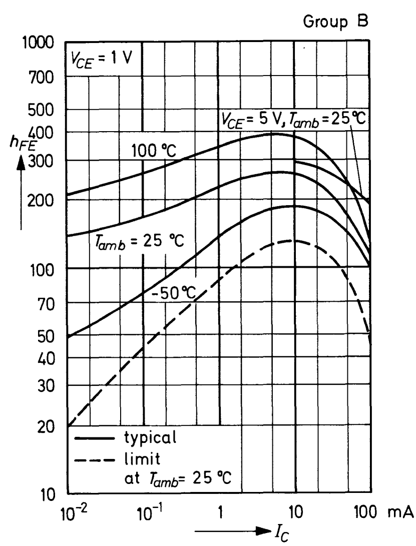
Pulse thermal resistance versus pulse duration



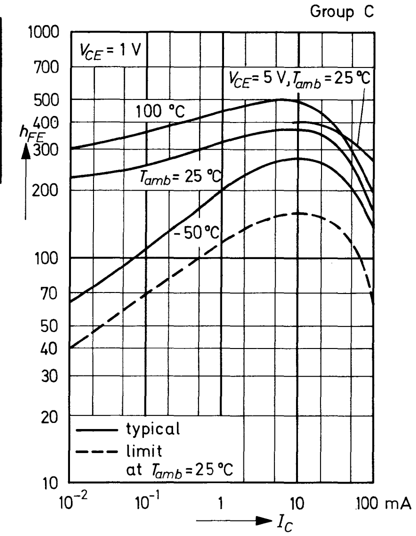
DC current gain versus collector current



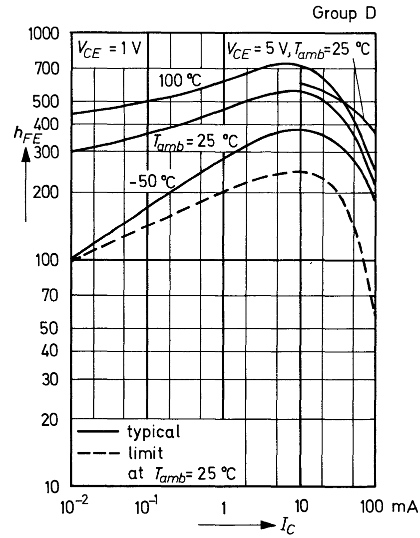
DC current gain versus collector current



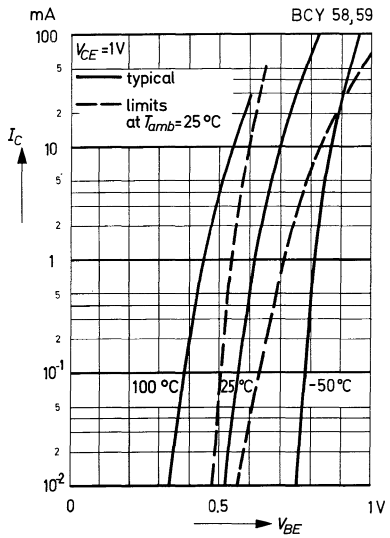
DC current gain versus collector current



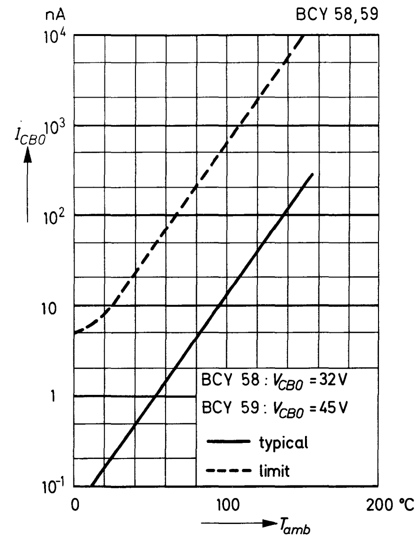
DC current gain versus collector current



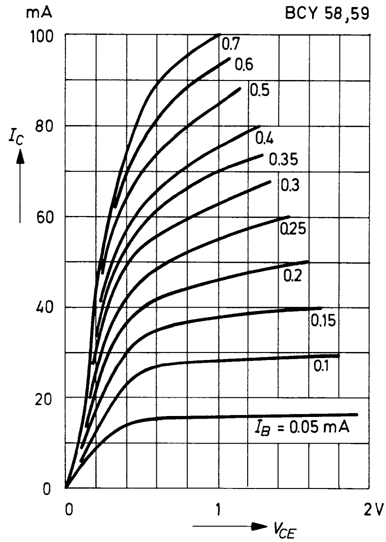
Collector current versus base emitter voltage



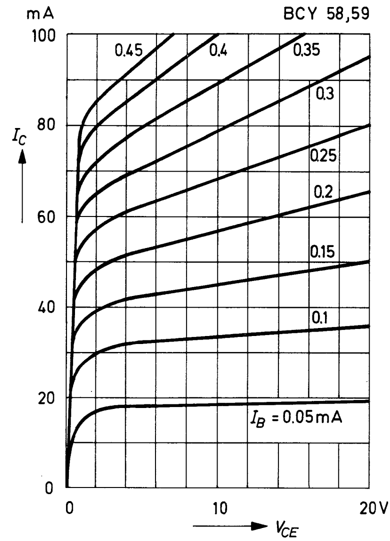
Collector cutoff current versus ambient temperature



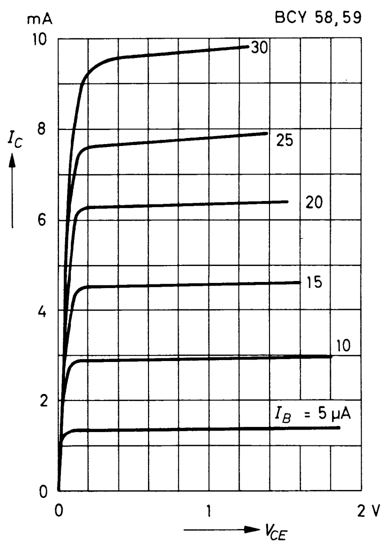
Common emitter collector characteristics



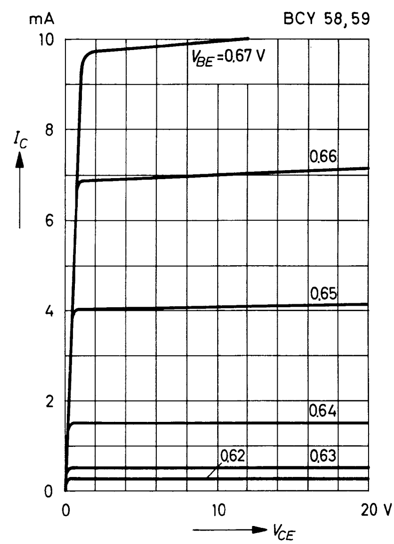
Common emitter collector characteristics



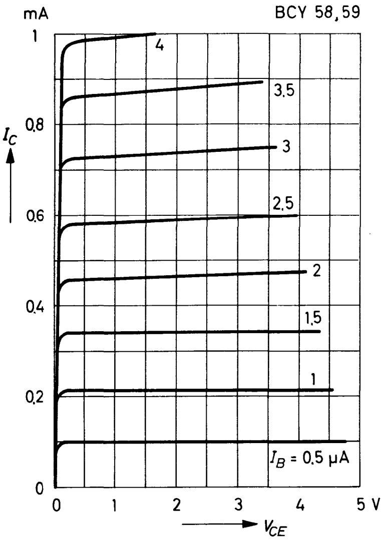
Common emitter collector characteristics



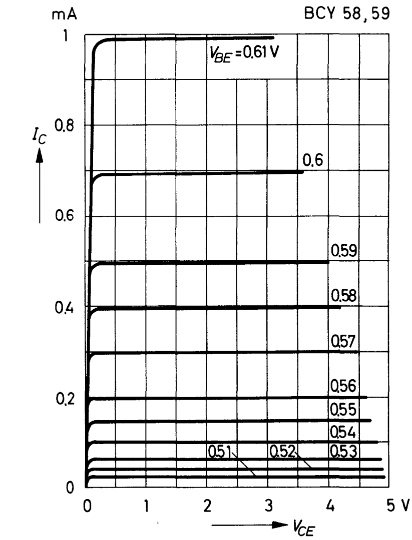
Common emitter collector characteristics



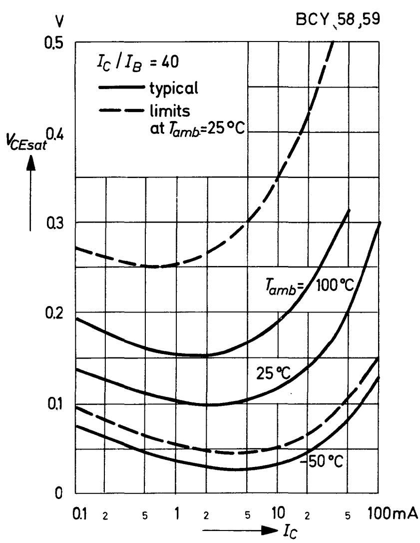
Common emitter collector characteristics



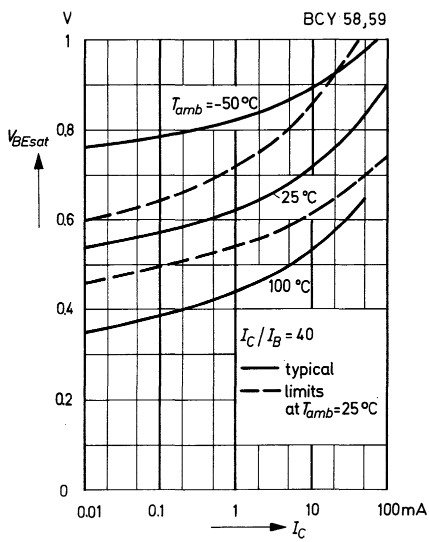
Common emitter collector characteristics



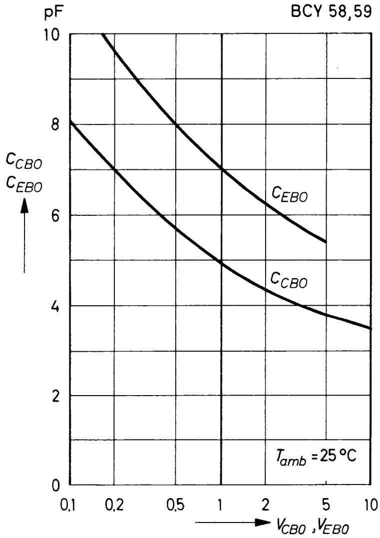
Collector saturation voltage versus collector current



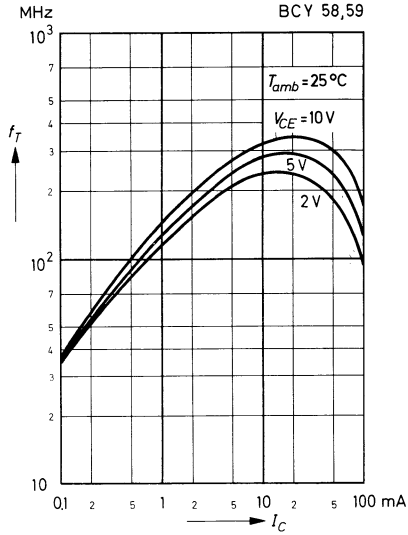
Base saturation voltage versus collector current



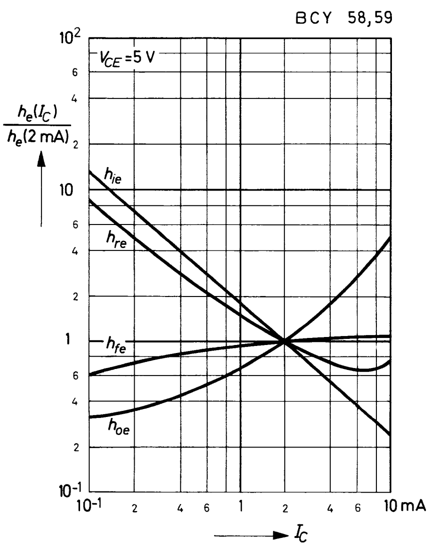
Collector base capacitance, Emitter base capacitance versus reverse bias voltage



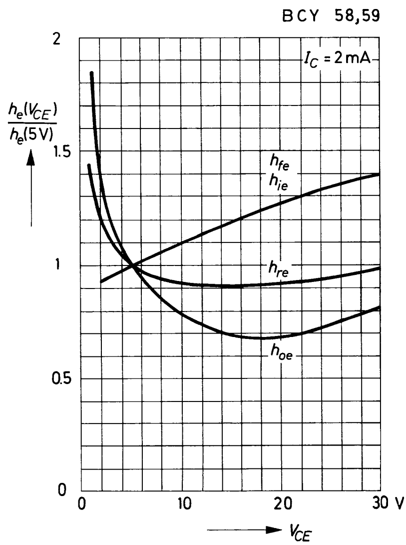
Gain bandwidth product versus collector current



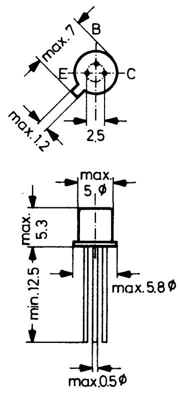
Relative *h*-parameters versus collector current



Relative *h*-parameters versus collector emitter voltage



NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications
(not recommended for new designs)



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings

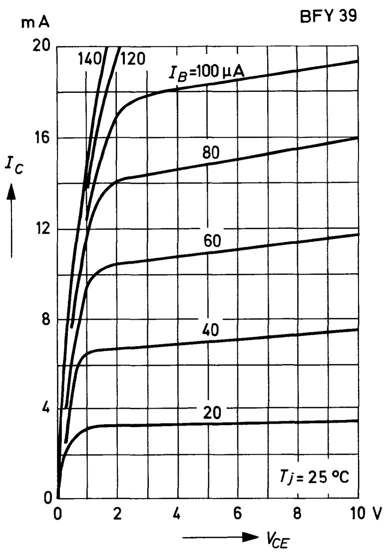
Collector base voltage	V_{CBO}	45	V
Collector emitter voltage	V_{CEO}	25	V
Emitter base voltage	V_{EBO}	5	V
Collector current	I_C	100	mA
Power dissipation			
at $T_{amb} = 25\ °C$	P_{tot}	0.3	W
at $T_C = 25\ °C$	P_{tot}	1	W
Junction temperature	T_j	175	°C
Storage temperature range	T_S	−55 ... + 175	°C

Static Characteristics at $T_j = 25\ °C$		**BFY 39-1**	**BFY 39-2**	**BFY 39-3**
DC current gain at $V_{CE} = 10\ V$, $I_C = 10\ mA$	h_{FE}	35 ... 110	100 ... 200	180 ... 400
Collector saturation voltage at $I_C = 10\ mA$, $I_B = 1\ mA$	$V_{CE\,sat}$		< 1	V
Base saturation voltage at $I_C = 10\ mA$, $I_B = 1\ mA$	$V_{BE\,sat}$		< 1	V
Collector cutoff current at $V_{CB} = 30\ V$	I_{CBO}		< 50	nA
Thermal resistance				
Junction to ambient air	R_{thA}		< 500	°C/W
Junction to case	R_{thC}		< 150	°C/W

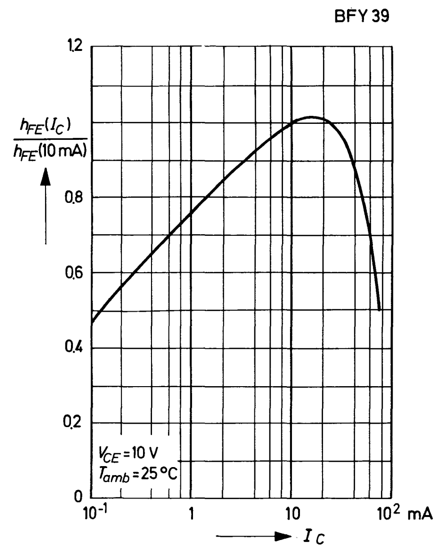
Dynamic Characteristics at $T_{amb} = 25\ °C$

Collector base capacitance at $V_{CB} = 5\ V$	C_{CB0}	5	pF
Gain bandwidth product at $V_{CE} = 10\ V$, $I_C = 10\ mA$	f_T	150	MHz
h-Parameters at $V_{CE} = 5\ V$, $I_C = 1\ mA$, $f = 1\ kHz$			
Input impedance	h_{ie}	3,2	kΩ
Reverse voltage transfer ratio	h_{re}	$3 \cdot 10^{-5}$	
Small signal current gain	h_{fe}	120	
Output admittance	h_{oe}	8	μmho

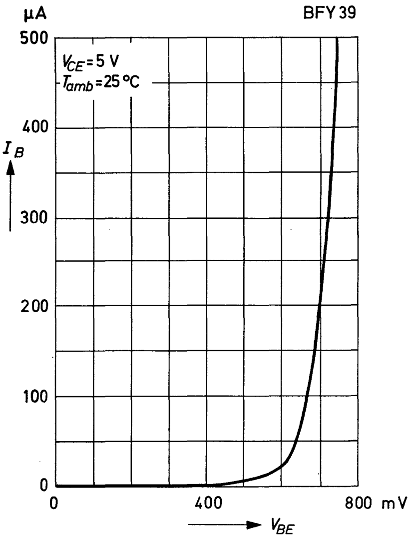
Common emitter collector characteristics



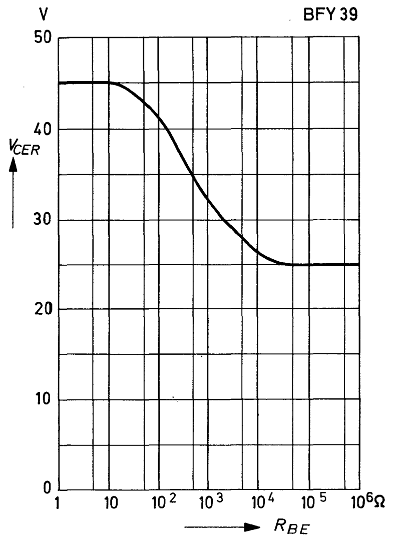
Relative DC current gain versus collector current



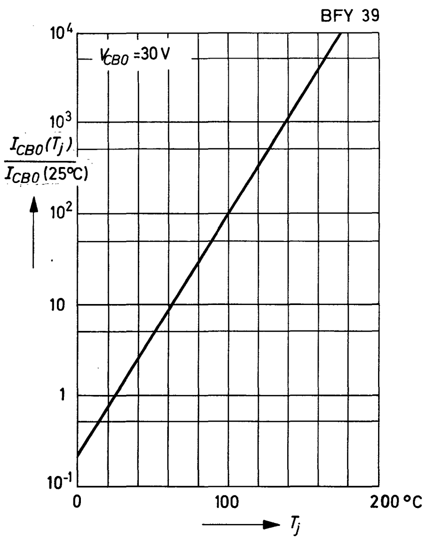
Common emitter input characteristic



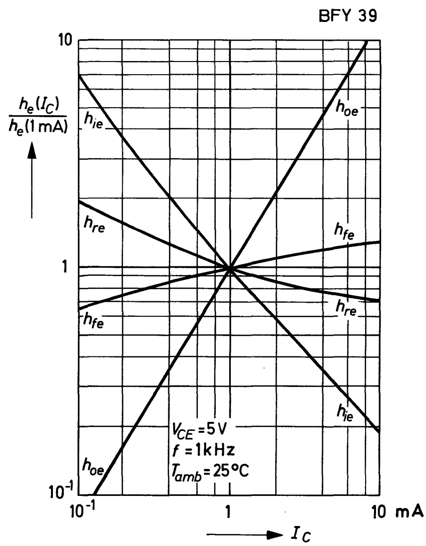
Admissible collector emitter voltage versus base emitter restistance



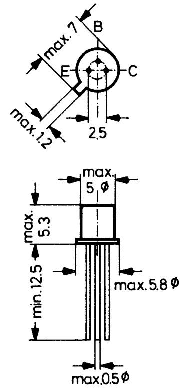
Relative collector cutoff current versus junction temperature



Relative *h*-parameters versus collector current



NPN Silicon Epitaxial Planar Transistors
with high cutoff frequency, for high speed switching



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

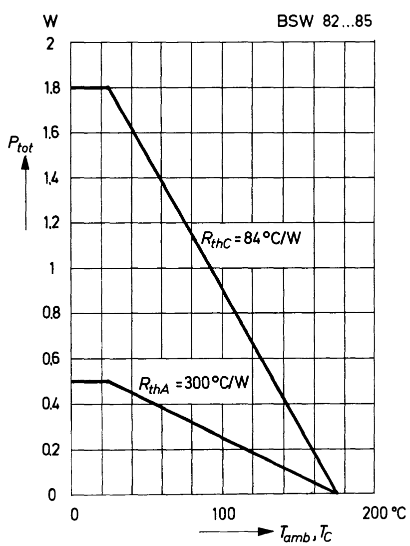
Maximum Ratings		**BSW 82** **BSW 83**	**BSW 84** **BSW 85**	
Collector base voltage	V_{CBO}	40	75	V
Collector emitter voltage	V_{CEO}	25	40	V
Emitter base voltage	V_{EBO}	5	5	V
Peak collector current	I_{CM}	500		mA
Power dissipation at $T_{amb} = 25\ °C$	P_{tot}	500		mW
at $T_C = 25\ °C$	P_{tot}	1.8		W
Junction temperature	T_j	175		°C
Storage temperature range	T_S	−50 ... + 175		°C

Characteristics at $T_j = 25\ °C$		**BSW 82**	**BSW 83**	**BSW 84**	**BSW 85**	
DC current gain at $V_{CE} = 10$ V,						
$I_C = 10$ mA	h_{FE}	> 30	> 70	> 35	> 75	
$I_C = 150$ mA	h_{FE}	40 ... 120	100 ... 300	40 ... 120	100 ... 300	
$I_C = 500$ mA	h_{FE}	–	–	> 20	> 40	
Collector saturation voltage at $I_C = 150$ mA, $I_B = 15$ mA	$V_{CE\,sat}$	< 0.6	< 0.6	< 0.4	< 0.4	V
at $I_C = 500$ mA, $I_B = 50$ mA	$V_{CE\,sat}$	–	–	< 1.6	< 1.6	V
Base saturation voltage at $I_C = 150$ mA, $I_B = 15$ mA	$V_{BE\,sat}$	< 1.3	< 1.3	< 1.3	< 1.3	V
at $I_C = 500$ mA, $I_B = 50$ mA	$V_{BE\,sat}$	–	–	< 2.6	< 2.6	V

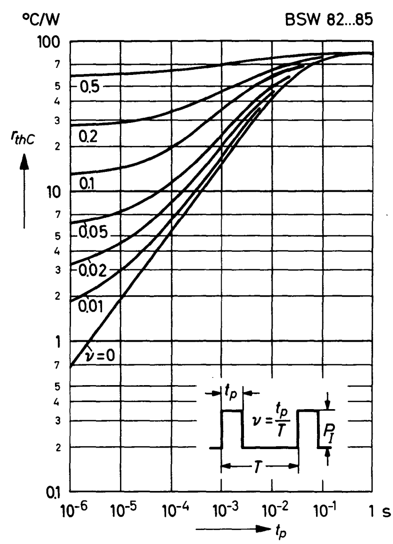
		BSW 82	BSW 83	BSW 84	BSW 85	
Collector cutoff current						
at V_{CB} = 30 V	I_{CBO}	< 100	< 100	–	–	nA
at V_{CB} = 50 V	I_{CBO}	–	–	< 10	< 10	nA
at V_{CB} = 30 V, T_j = 125 °C	I_{CBO}	< 100	< 100	–	–	μA
at V_{CB} = 50 V, T_j = 125 °C	I_{CBO}	–	–	< 10	< 10	μA

Emitter cutoff current at V_{EB} = 3 V	I_{EBO}	< 100	nA
Gain bandwidth product at V_{CE} = 20 V, I_C = 20 mA, f = 100 MHz	f_T	> 200	MHz
Collector base capacitance at V_{CBO} = 10 V, f = 100 kHz	C_{CBO}	< 8	pF
Thermal resistance			
Junction to ambient air	R_{thA}	< 300	°C/W
Junction to case	R_{thC}	< 84	°C/W

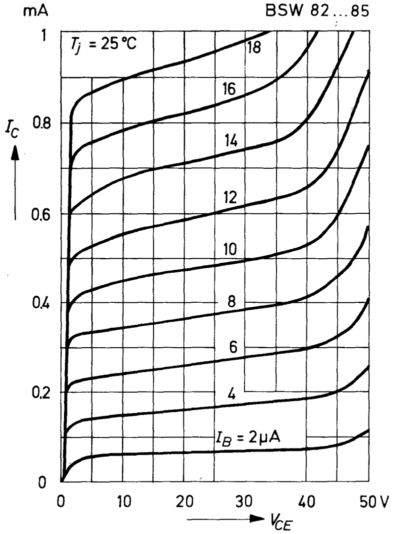
Admissible power dissipation versus temperature



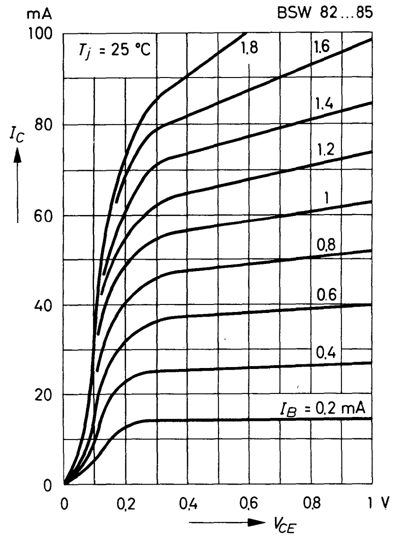
Pulse thermal resistance versus pulse duration



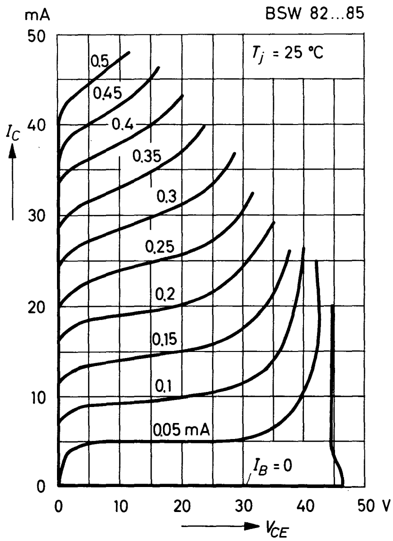
Common emitter collector characteristics



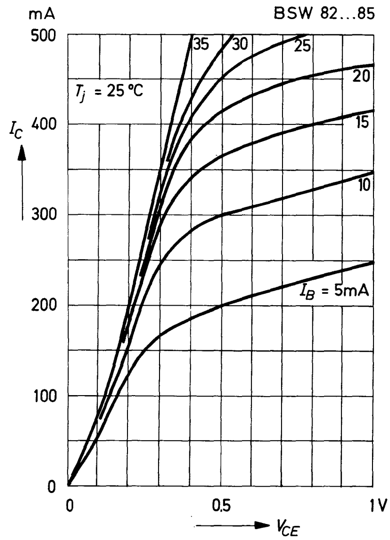
Common emitter collector characteristics



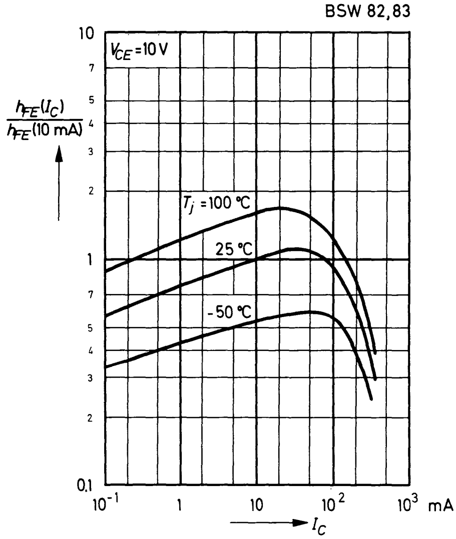
Common emitter collector characteristics



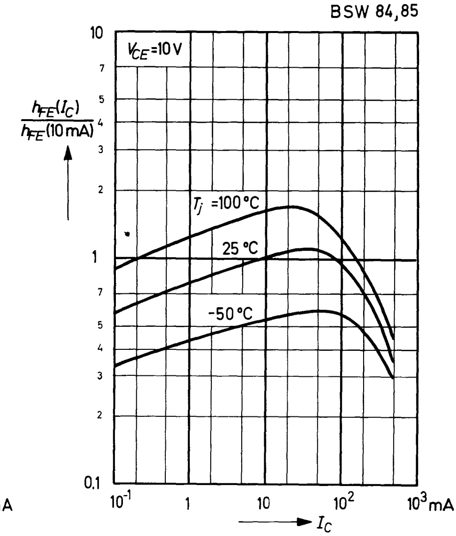
Common emitter collector characteristics



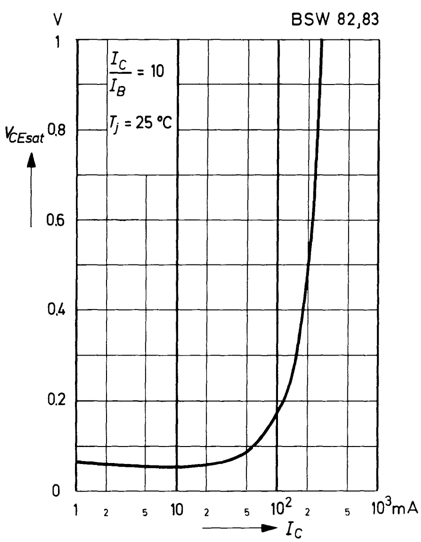
Relative DC current gain versus collector current



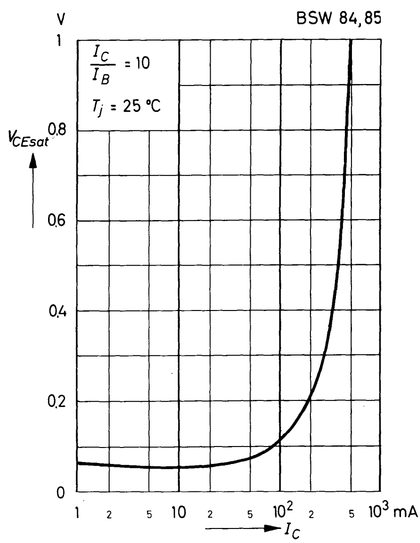
Relative DC current gain versus collector current



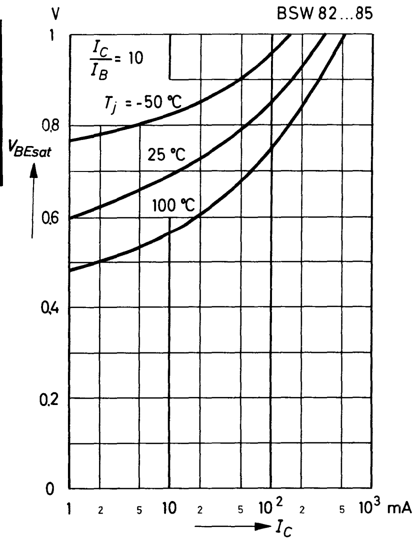
Collector saturation voltage versus collector current



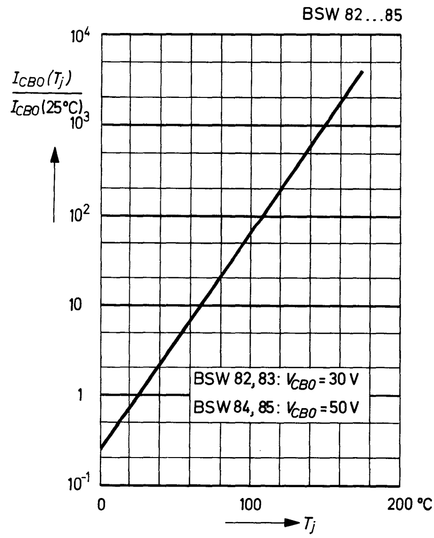
Collector saturation voltage versus collector current



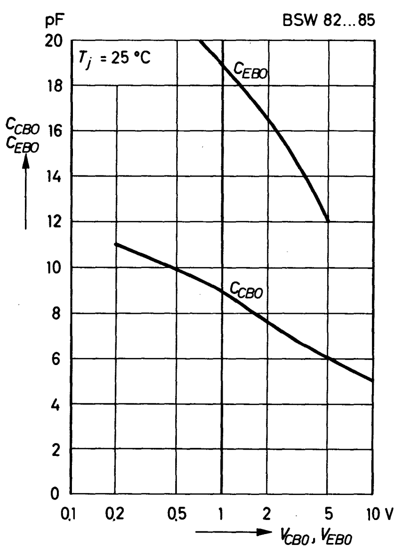
Base saturation voltage versus collector current



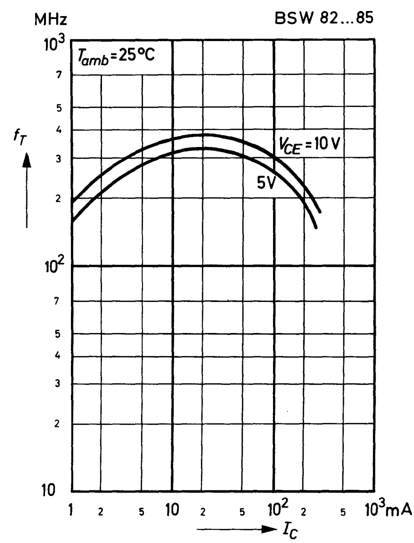
Collector cutoff current versus junction temperature



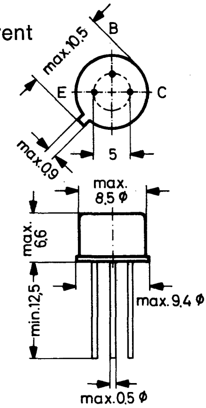
Collector base capacitance, Emitter base capacitance versus reverse bias voltage



Gain bandwidth product versus collector current



NPN Silicon Epitaxial Planar Transistors
for switching and amplifier applications at high collector current



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.3 g
Dimensions in mm

Maximum Ratings		**BSX 22**	**BSX 23**	
Collector base voltage	V_{CBO}	40	90	V
Collector emitter voltage	V_{CEO}	32	65	V
Emitter base voltage	V_{EBO}	5		V
Collector current	I_C	1.5		A
Power dissipation				
at $T_{amb} = 25$ °C	P_{tot}	0.8		W
at $T_C = 25$ °C	P_{tot}	6		W
Junction temperature	T_j	175		°C
Storage temperature range	T_S	−55 . . . + 175		°C

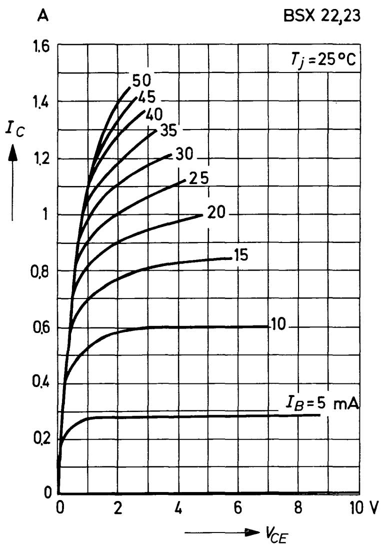
Static Characteristics at $T_j = 25$ °C

DC current gain at $V_{CE} = 2$ V, $I_C = 500$ mA	h_{FE}	> 35		
Collector saturation voltage at $I_C = 1$ A, $I_B = 100$ mA	$V_{CE\,sat}$	< 1		V
		BSX 22	**BSX 23**	
Collector cutoff current				
at $V_{CE} = 10$ V	I_{CEO}	< 1	–	μA
at $V_{CE} = 30$ V	I_{CEO}	–	< 1	μA
Thermal resistance				
Junction to ambient air	R_{thA}	< 190		°C/W
Junction to case	R_{thC}	< 25		°C/W

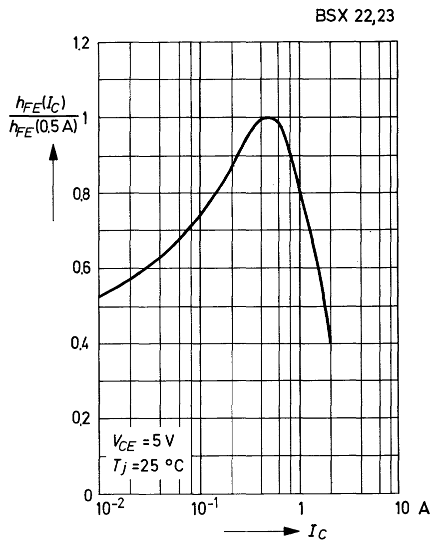
Dynamic Characteristics at $T_{amb} = 25\ °C$

Gain bandwidth product at $V_{CE} = 5\ V$, $I_C = 100\ mA$	f_T	100	MHz
Collector base capacitance at $V_{CB} = 5\ V$	C_{CB0}	20	pF

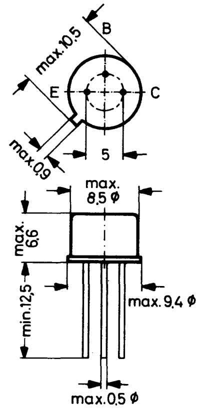
Common emitter collector characteristics



Relative DC current gain versus collector current



NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	60	V
Collector emitter voltage	V_{CEO}	25	V
Emitter base voltage	V_{EBO}	5	V
Collector current	I_C	500	mA
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.8	W
at T_C = 100 °C	P_{tot}	1.7	W
at T_C = 25 °C	P_{tot}	3	W
Junction temperature	T_j	200	°C

Static Characteristics at T_j = 25 °C

DC current gain			
at V_{CE} = 10 V, I_C = 1 mA	h_{FE}	50	
at V_{CE} = 10 V, I_C = 10 mA	h_{FE}	75 (> 30)	
at V_{CE} = 10 V, I_C = 150 mA	h_{FE}	40 . . . 120	
at V_{CE} = 10 V, I_C = 500 mA	h_{FE}	15	
Collector saturation voltage at I_C = 150 mA, I_B = 15 mA	$V_{CE\,sat}$	0.15 (< 0.8)	V
Base saturation voltage at I_C = 150 mA, I_B = 15 mA	$V_{BE\,sat}$	0.95 (< 1.2)	V
Collector cutoff current			
at V_{CB} = 30 V	I_{CBO}	3 (< 100)	nA
at V_{CB} = 30 V, T_{amb} = 150 °C	I_{CBO}	4 (< 100)	µA
Emitter cutoff current at V_{EB} = 3 V	I_{EBO}	1 (< 50)	nA
Collector base capacitance at V_{CBO} = 10 V	C_{CBO}	7.5 (< 10)	pF
Emitter base capacitance at V_{EBO} = 0.5 V	C_{EBO}	23 (< 33)	pF

Thermal resistance			
Junction to ambient air	$R_{th\,A}$	< 220	°C/W
Junction to case	$R_{th\,C}$	< 58	°C/W

Small Signal Characteristics at $T_{amb} = 25$ °C and $f = 1$ kHz

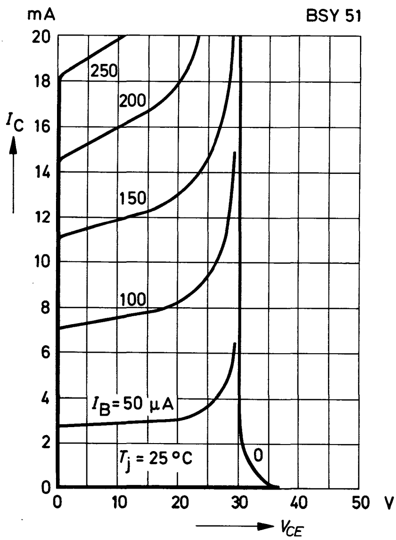
Test conditions: $V_{CE} = 5$ V, $I_C = 1$ mA, grounded emitter

Input impedance	h_{ie}	1.5 (0.8 . . . 4.5)	kΩ
Reverse voltage transfer ratio	h_{re}	$0.8\ (< 3) \cdot 10^{-4}$	
Small signal current gain	h_{fe}	55 (30 . . . 100)	
Output admittance	h_{oe}	8 (3.5 . . . 13)	μmho
Noise figure at $V_{CE} = 10$ V, $I_C = 0.3$ mA, $R_G = 1.5$ kΩ, Bandwidth 30 Hz . . . 15 kHz	F	6	dB
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	100	MHz

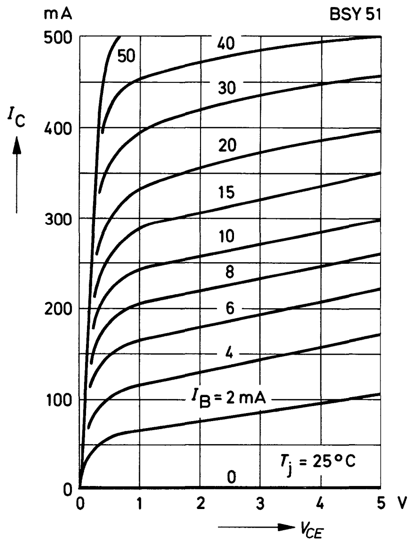
Switching Times

See diagrams and test circuits on the following pages.

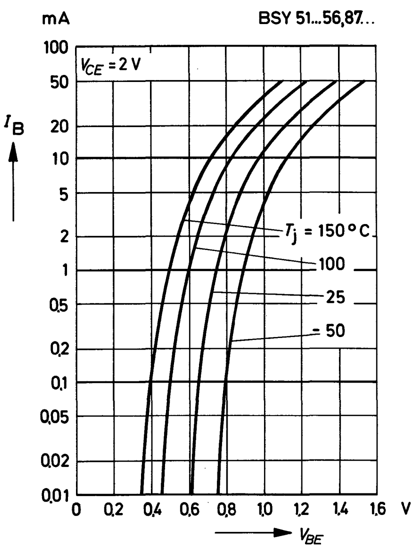
Common emitter collector characteristics



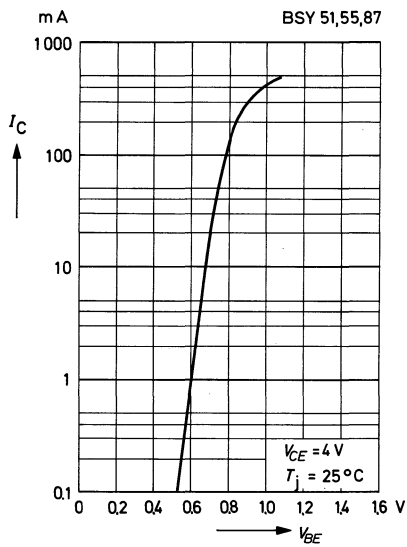
Common emitter collector characteristics



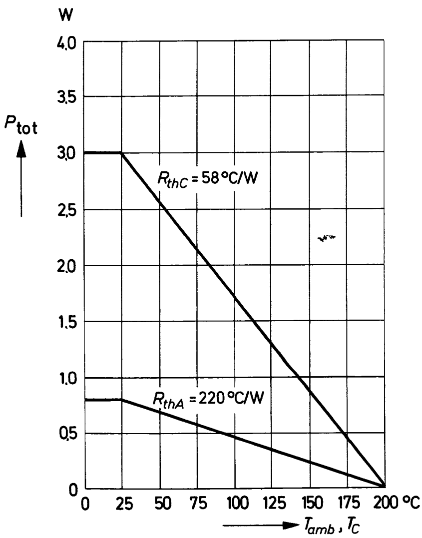
Common emitter input characteristics



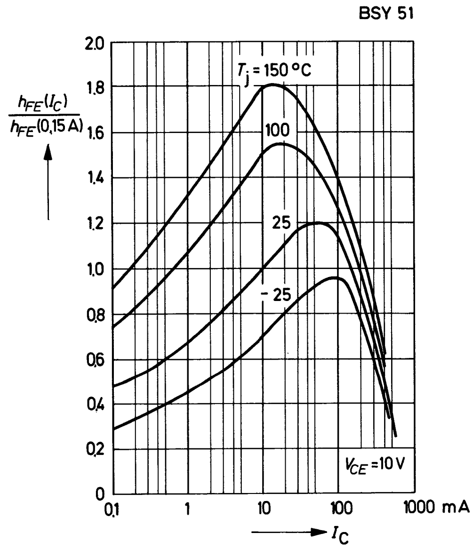
Collector current versus base emitter voltage



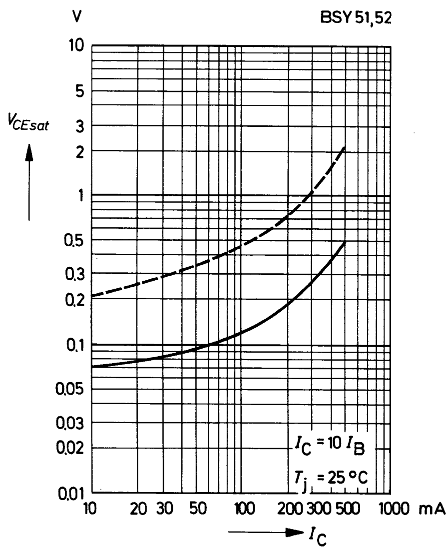
Admissible power dissipation versus temperature



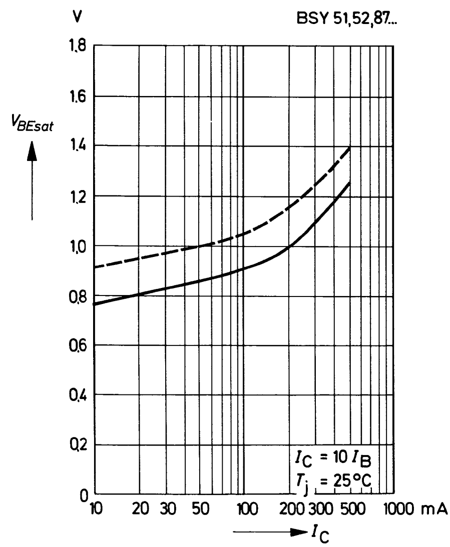
Relative DC current gain versus collector current



Collector saturation voltage versus collector current

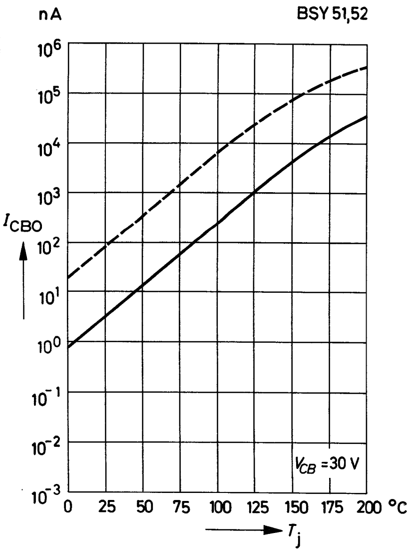


Base saturation voltage versus collector current

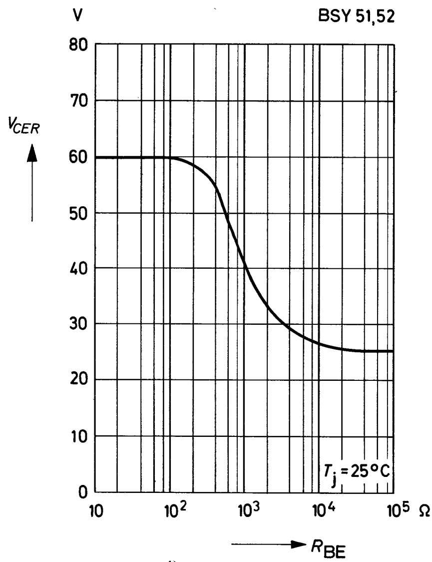


– – – – upper limit, valid for 95 % of a lot

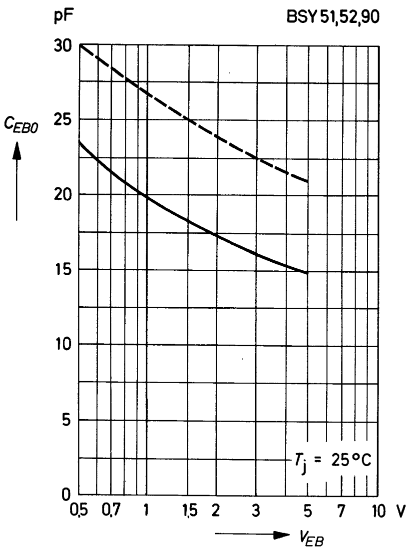
Collector cutoff current versus junction temperature



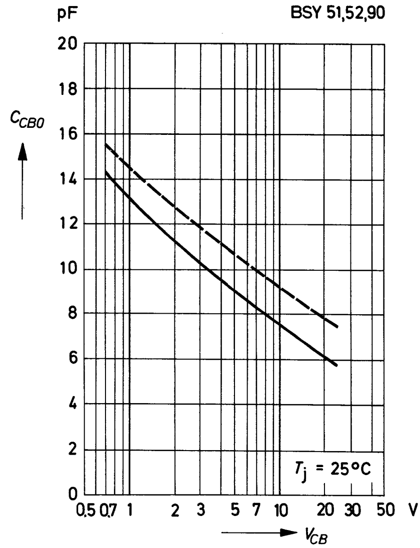
Admissible collector emitter voltage versus base emitter resistance



Emitter base capacitance versus emitter base voltage

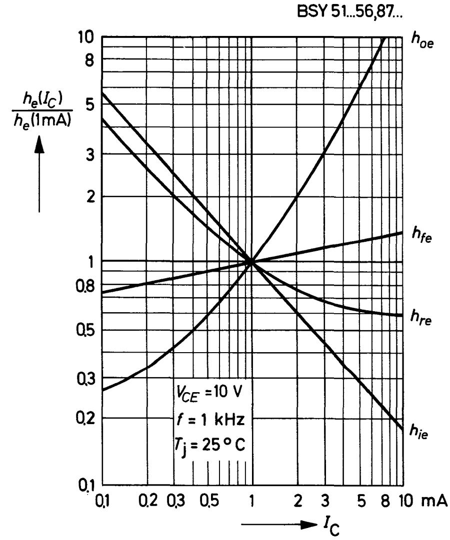


Collector base capacitance versus collector base voltage

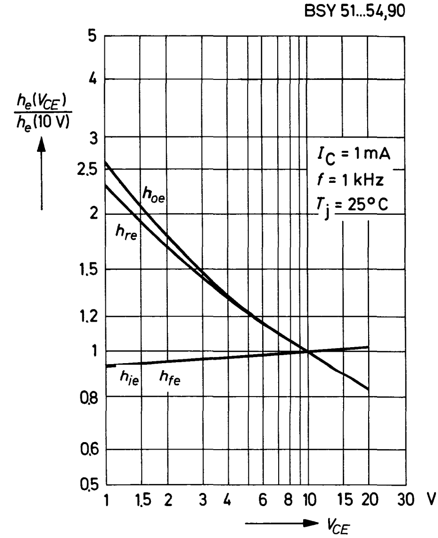


– – – – upper limit, valid for 95 % of a lot

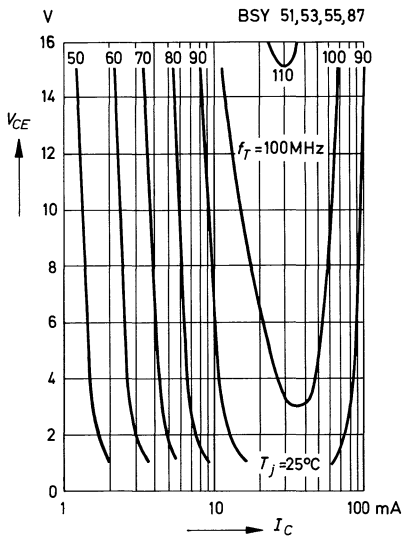
Relative *h*-parameters versus collector current



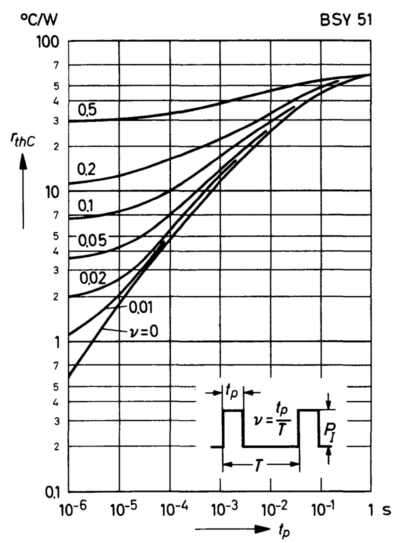
Relative *h*-parameters versus collector emitter voltage



Contours of constant gain bandwidth product

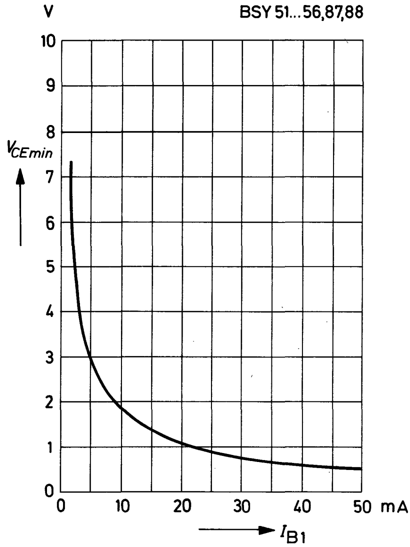


Pulse thermal resistance versus pulse duration

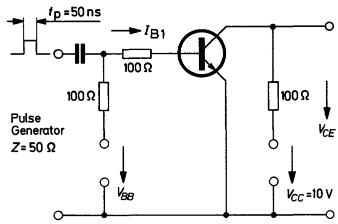


Switching characteristics, I_C = 100 mA[1], t_p = 50 ns

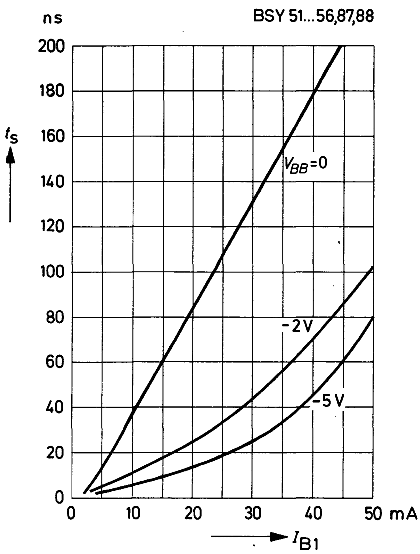
Residual collector emitter voltage versus base current



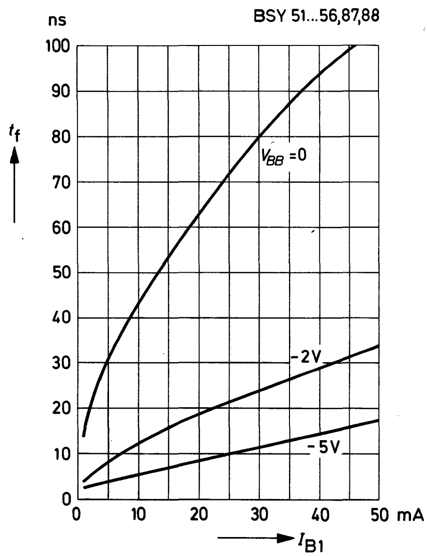
Test circuit



Storage time versus base current



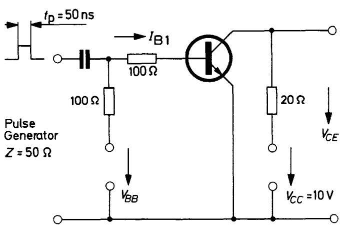
Fall time versus base current



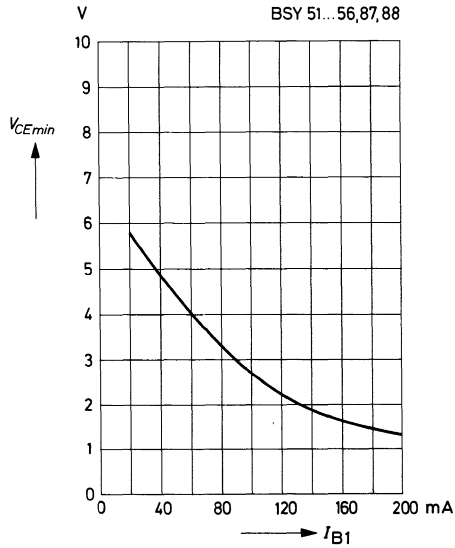
[1] 100 mA is that theoretical collector current which results from the supply voltage V_{CC} = 10 V and the operating resistor R_{CC} = 100 Ω.

Switching characteristics, I_C = 500 mA[1], t_p = 50 ns

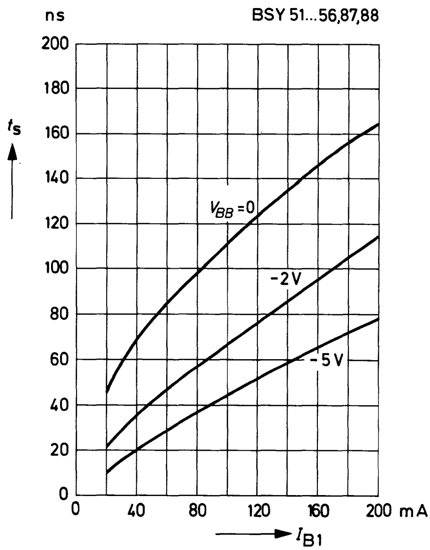
Test circuit



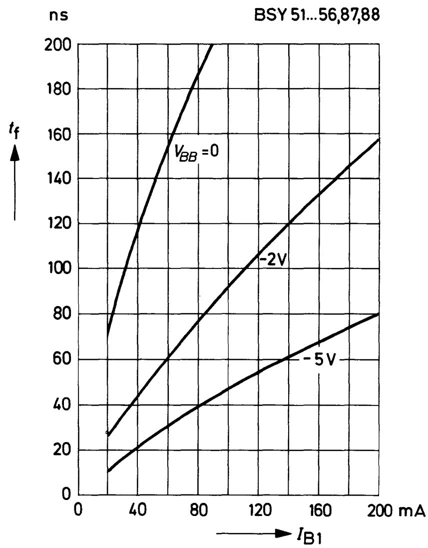
Residual collector emitter voltage versus base current



Storage time versus base current



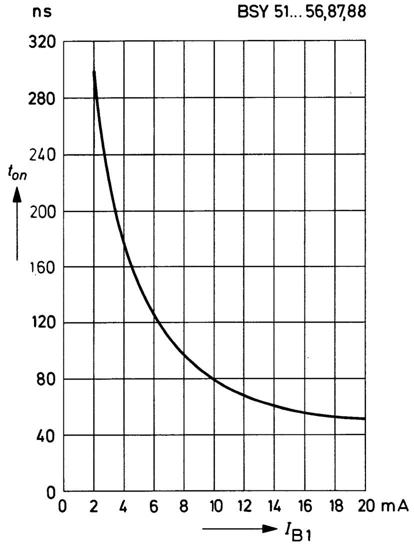
Fall time versus base current



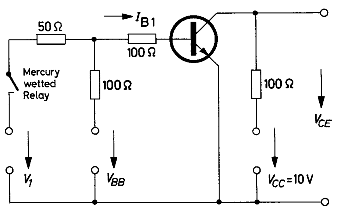
[1] 500 mA is that theoretical collector current which results from the supply voltage V_{CC} = 10 V and the operating resistor R_{CC} = 20 Ω.

Switching characteristics, I_C = 100 mA, t_p > 10 μs

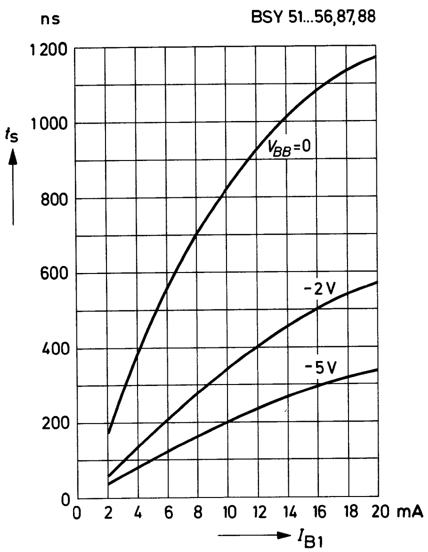
Turn-on time versus base current



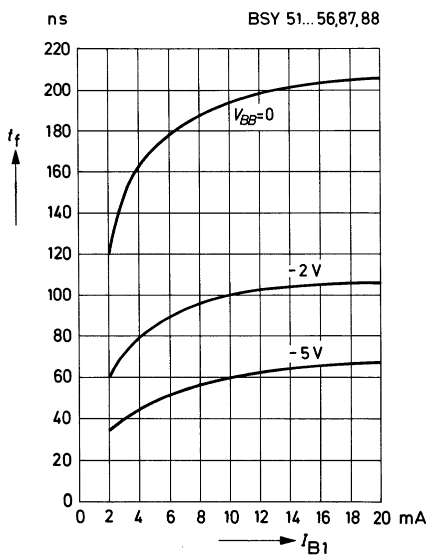
Test circuit



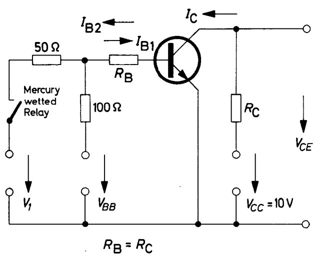
Storage time versus base current



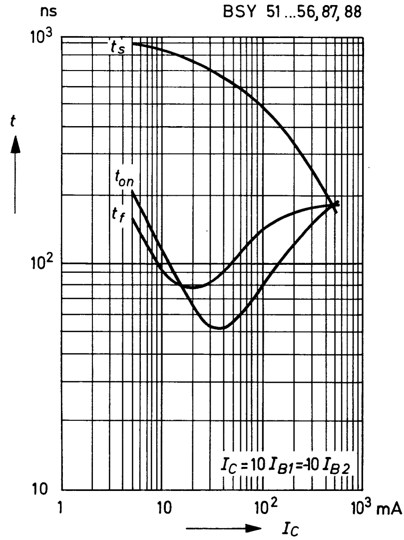
Fall time versus base current



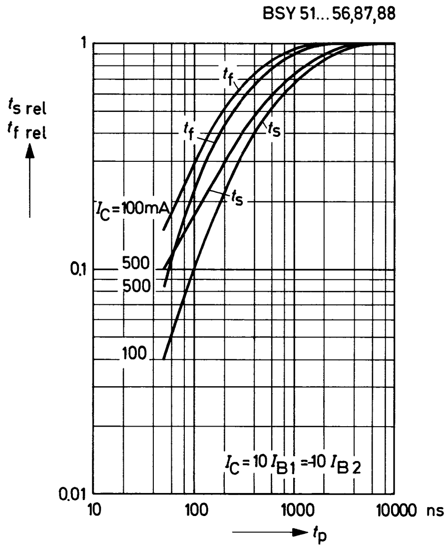
Test circuit
for graph on the right



Switching characteristics versus collector current
($t_p > 10$ µs)

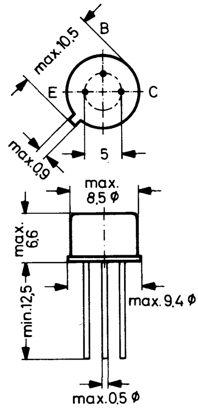


Relative storage time and fall time versus pulse duration



BSY 52 ≈ 2 N 1420

NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	60	V
Collector emitter voltage	V_{CEO}	25	V
Emitter base voltage	V_{EBO}	5	V
Collector current	I_C	500	mA
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.8	W
at T_C = 100 °C	P_{tot}	1.7	W
at T_C = 25 °C	P_{tot}	3	W
Junction temperature	T_j	200	°C

Static Characteristics at T_j = 25 °C

DC current gain			
at V_{CE} = 10 V, I_C = 1 mA	h_{FE}	100	
at V_{CE} = 10 V, I_C = 10 mA	h_{FE}	135 (> 70)	
at V_{CE} = 10 V, I_C = 150 mA	h_{FE}	100 . . . 300	
at V_{CE} = 10 V, I_C = 500 mA	h_{FE}	25	
Collector saturation voltage at I_C = 150 mA, I_B = 15 mA	$V_{CE\,sat}$	0.15 (< 0.8)	V
Base saturation voltage at I_C = 150 mA, I_B = 15 mA	$V_{BE\,sat}$	0.95 (< 1.2)	V
Collector cutoff current			
at V_{CB} = 30 V	I_{CBO}	3 (< 100)	nA
at V_{CB} = 30 V, T_{amb} = 150 °C	I_{CBO}	4 (< 100)	µA
Emitter cutoff current at V_{EB} = 3 V	I_{EBO}	1 (< 50)	nA
Collector base capacitance at V_{CBO} = 5 V	C_{CBO}	7.5 (< 10)	pF

Emitter base capacitance at $V_{EBO} = 0.5$ V	C_{EBO}	23 (< 33)	pF
Thermal resistance			
Junction to ambient air	$R_{th\,A}$	< 220	°C/W
Junction to case	$R_{th\,C}$	< 58	°C/W

Small Signal Characteristics at $T_{amb} = 25$ °C and $f = 1$ kHz

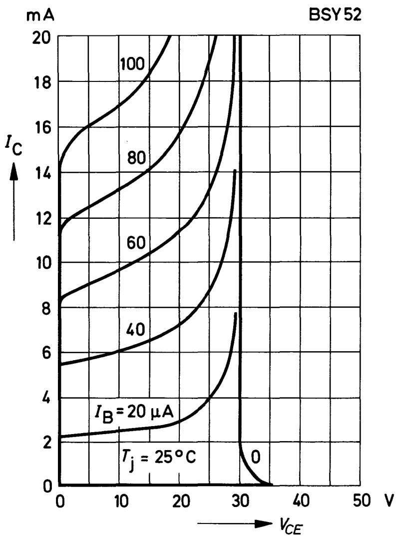
Test conditions: $V_{CE} = 5$ V, $I_C = 1$ mA, grounded emitter

Input impedance	h_{ie}	3 (1 . . . 8)	kΩ
Reverse voltage transfer ratio	h_{re}	0.8 (< 3) · 10^{-4}	
Small signal current gain	h_{fe}	100 (50 . . . 200)	
Output admittance	h_{oe}	9 (4.5 . . . 15)	µmho
Noise figure at $V_{CE} = 10$ V, $I_C = 0.3$ mA, $R_G = 1.5$ kΩ Bandwidth 30 Hz . . . 15 kHz	F	6	dB
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	130	MHz

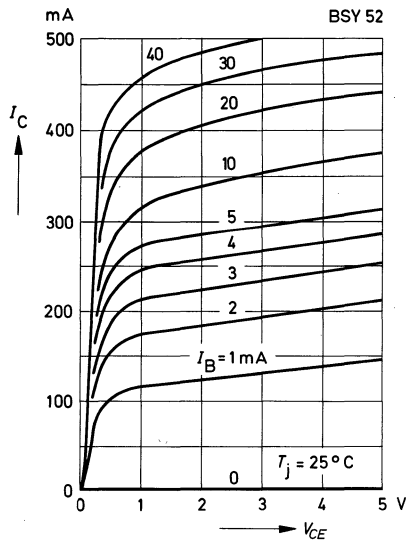
Switching Times

Specifications for switching times of type BSY 51 apply to this type.

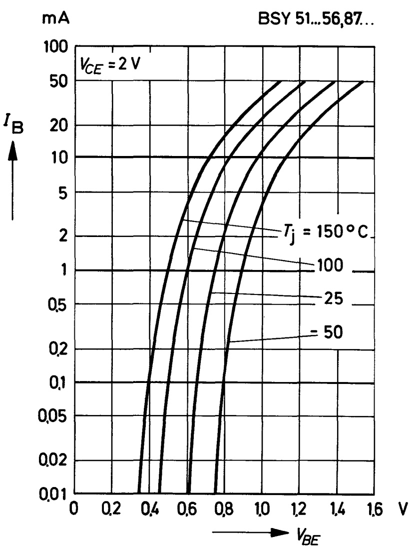
Common emitter collector characteristics



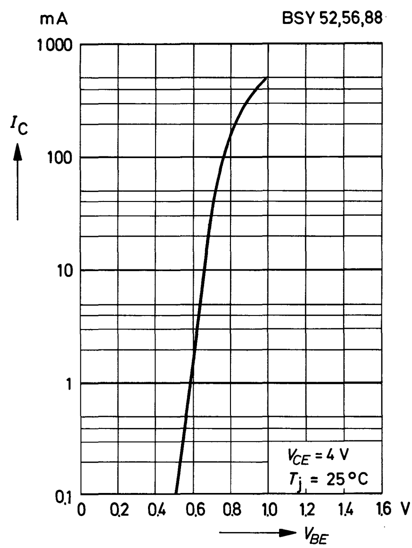
Common emitter collector characteristics



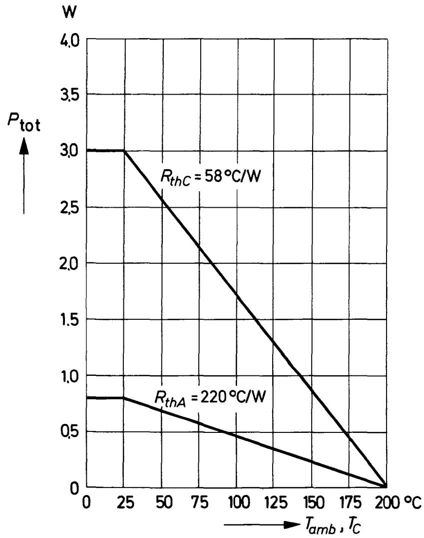
Common emitter input characteristics



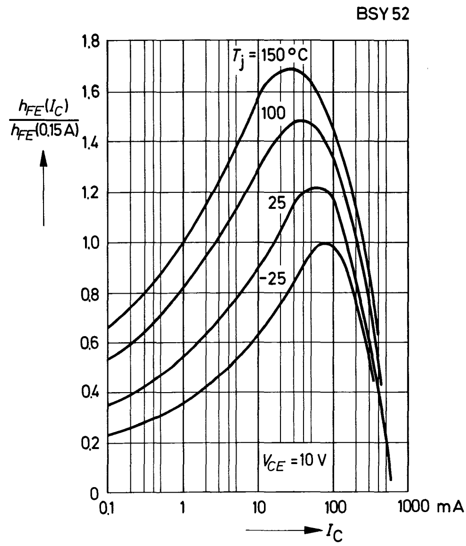
Collector current versus base emitter voltage



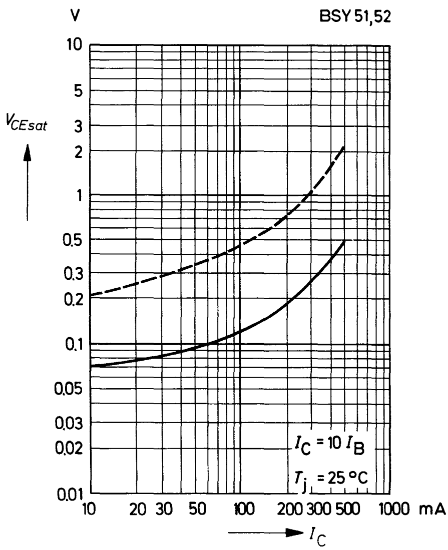
Admissible power dissipation versus temperature



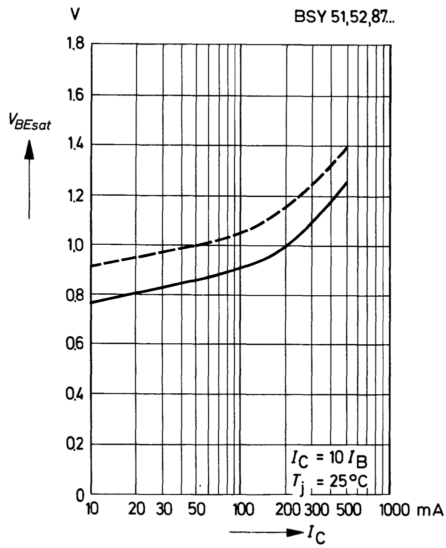
Relative DC current gain versus collector current



Collector saturation voltage versus collector current

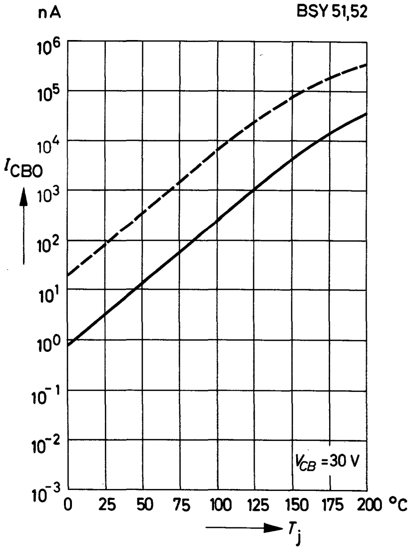


Base saturation voltage versus collector current

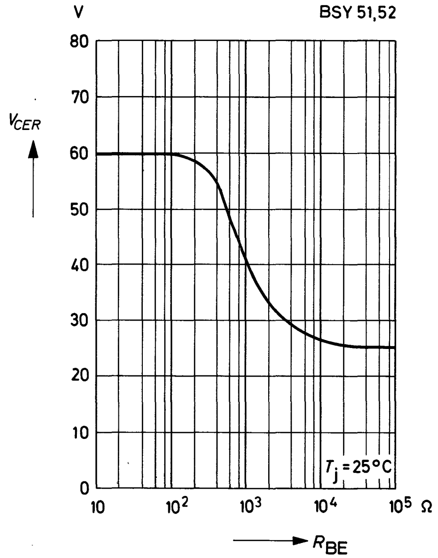


– – – – upper limit, valid for 95 % of a lot

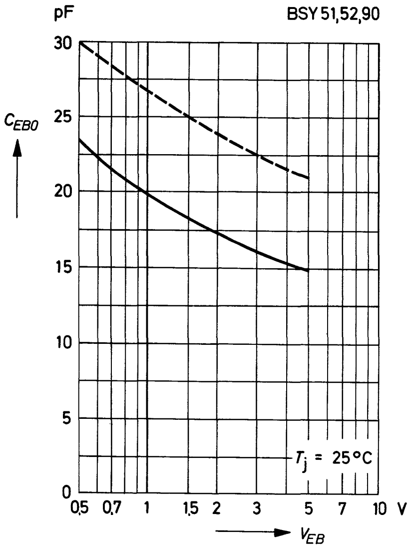
Collector cutoff current versus junction temperature



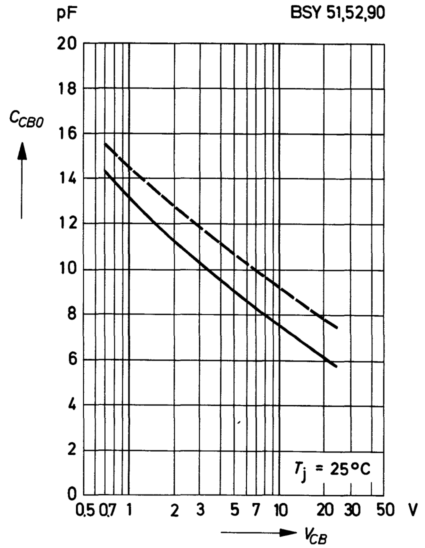
Admissible collector emitter voltage versus base emitter resistance



Emitter base capacitance versus emitter base voltage

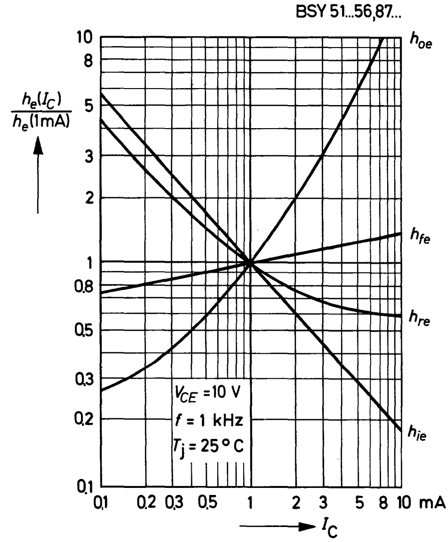


Collector base capacitance versus collector base voltage

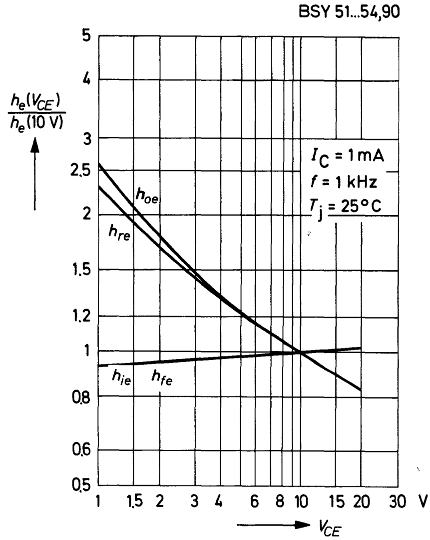


– – – – upper limit, valid for 95 % of a lot

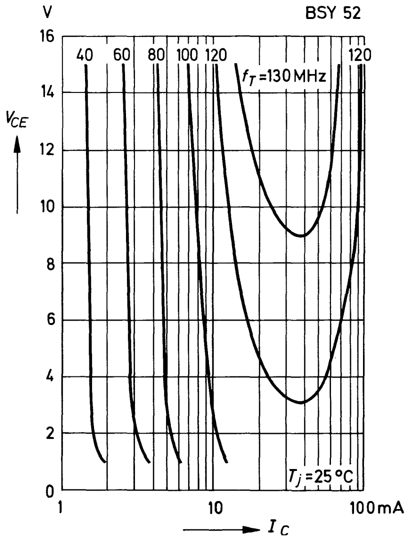
Relative *h*-parameters versus collector current



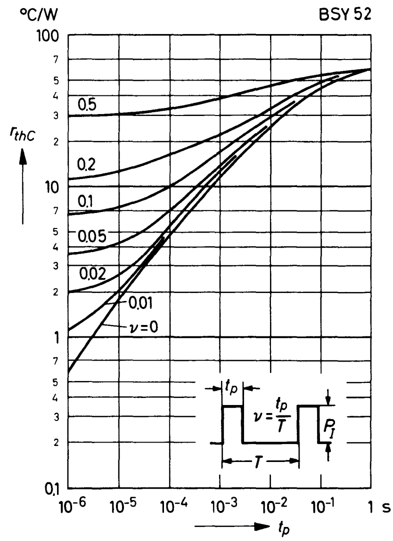
Relative *h*-parameters versus collector emitter voltage



Contours of constant gain bandwidth product

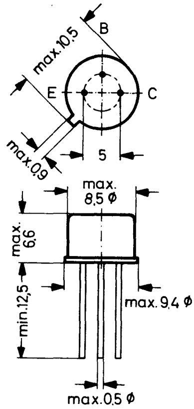


Pulse thermal resistance versus pulse duration



BSY 53 ≈ 2 N 1613

NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	75	V
Collector emitter voltage	V_{CEO}	30	V
Emitter base voltage	V_{EBO}	7	V
Collector current	I_C	750	mA
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.8	W
at T_C = 100 °C	P_{tot}	1.7	W
at T_C = 25 °C	P_{tot}	3	W
Junction temperature	T_j	200	°C

Static Characteristics at T_j = 25 °C

DC current gain			
at V_{CE} = 10 V, I_C = 0.1 mA	h_{FE}	40 (> 20)	
at V_{CE} = 10 V, I_C = 1 mA	h_{FE}	50	
at V_{CE} = 10 V, I_C = 10 mA	h_{FE}	65 (> 35)	
at V_{CE} = 10 V, I_C = 150 mA	h_{FE}	40 . . . 120	
at V_{CE} = 10 V, I_C = 500 mA	h_{FE}	35 (> 20)	
Collector saturation voltage			
at I_C = 150 mA, I_B = 15 mA	$V_{CE\,sat}$	0.15 (< 0.6)	V
at I_C = 500 mA, I_B = 50 mA	$V_{CE\,sat}$	0.5 (< 1.2)	V
Base saturation voltage at I_C = 150 mA, I_B = 15 mA	$V_{BE\,sat}$	0.95 (< 1.2)	V
Collector cutoff current			
at V_{CB} = 60 V	I_{CBO}	0.5 (< 10)	nA
at V_{CB} = 60 V, T_{amb} = 150 °C	I_{CBO}	0.4 (< 10)	µA
Emitter cutoff current at V_{EB} = 5 V	I_{EBO}	1 (< 10)	nA

Collector base capacitance at $V_{CBO} = 10$ V	C_{CBO}	6.5 (< 10)	pF
Emitter base capacitance at $V_{EBO} = 0.5$ V	C_{EBO}	23 (< 33)	pF
Thermal resistance			
Junction to ambient air	$R_{th\,A}$	< 220	°C/W
Junction to case	$R_{th\,C}$	< 58	°C/W

Small Signal Characteristics at $T_{amb} = 25$ °C and $f = 1$ kHz

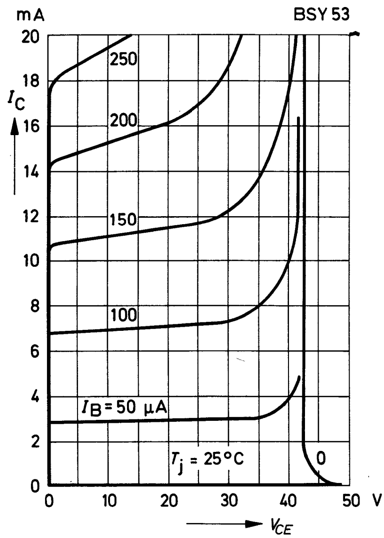
Test conditions: $V_{CE} = 5$ V, $I_C = 1$ mA, grounded emitter

Input impedance	h_{ie}	1.5 (0.8 . . . 4.5)	kΩ
Reverse voltage transfer ratio	h_{re}	0.8 (< 3) $\cdot 10^{-4}$	
Small signal current gain	h_{fe}	55 (30 . . . 100)	
Output admittance	h_{oe}	7 (3.5 . . . 10)	μmho
Noise figure at $V_{CE} = 10$ V, $I_C = 0.3$ mA, $R_G = 1.5$ kΩ, Bandwidth 30 Hz . . . 15 kHz	F	6	dB
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	100	MHz

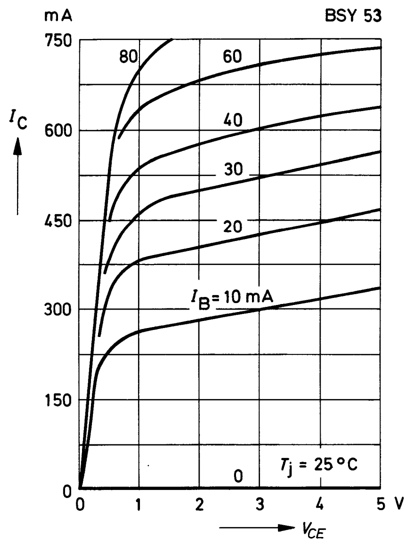
Switching Times

Specifications for switching times of type BSY 51 apply to this type.

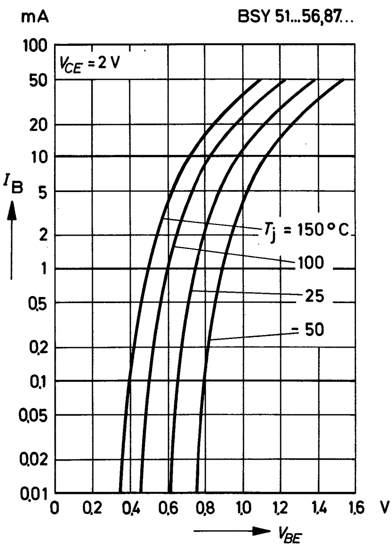
Common emitter collector characteristics



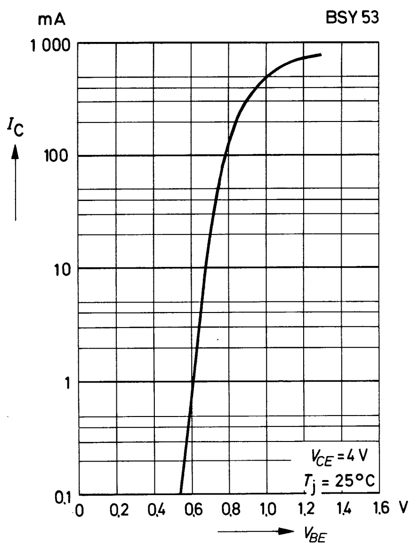
Common emitter collector characteristics



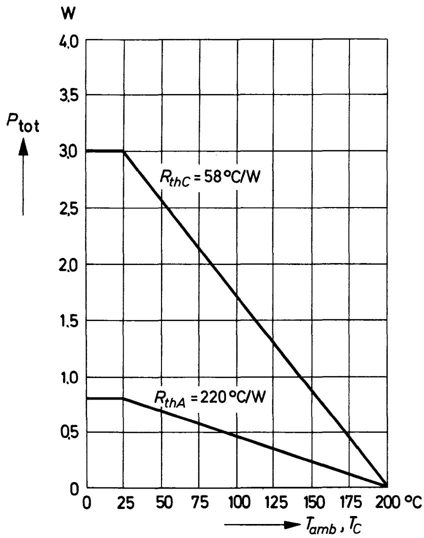
Common emitter input characteristics



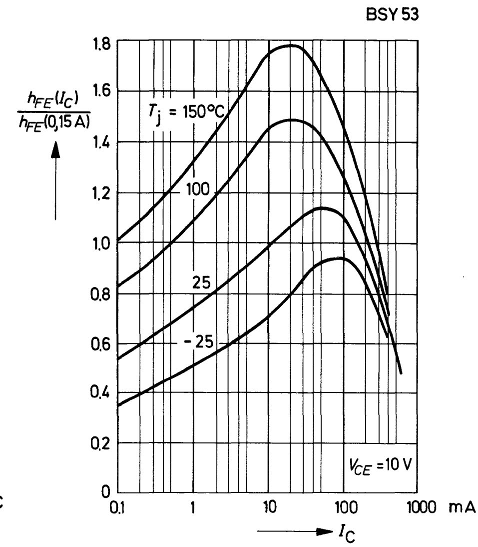
Collector current versus base emitter voltage



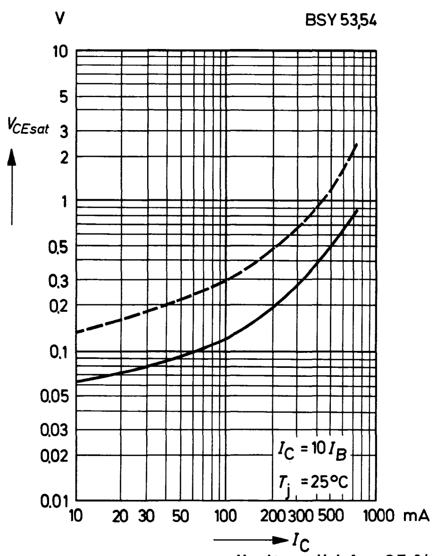
Admissible power dissipation versus temperature



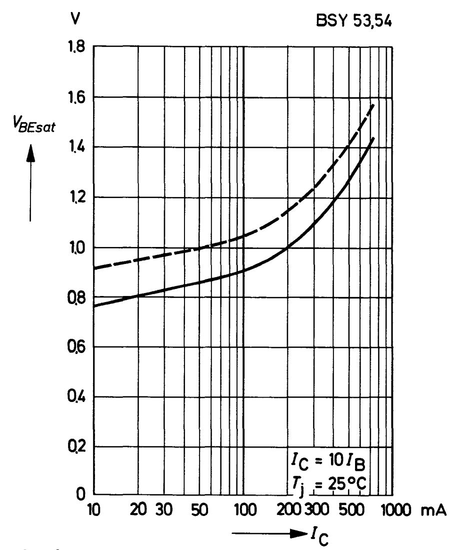
Relative DC current gain versus collector current



Collector saturation voltage versus collector current

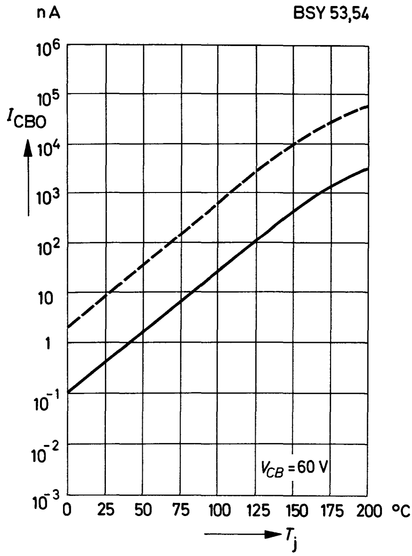


Base saturation voltage versus collector current

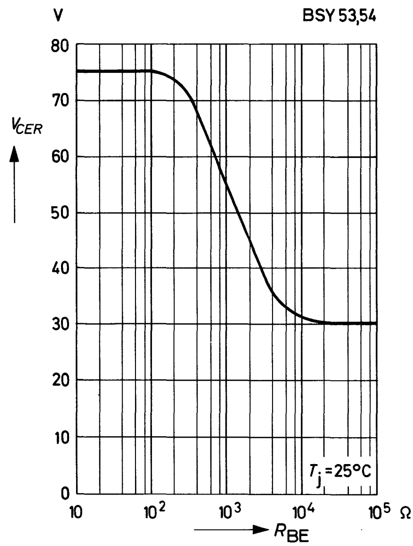


– – – – upper limit, valid for 95 % of a lot

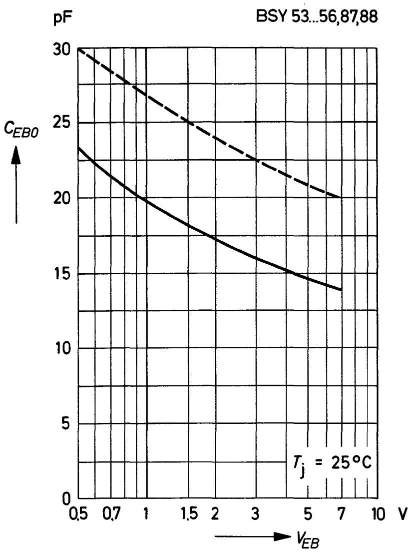
Collector cutoff current versus junction temperature



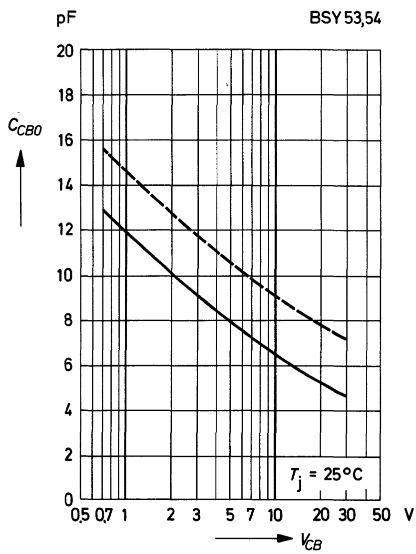
Admissible collector emitter voltage versus base emitter resistance



Emitter base capacitance versus emitter base voltage

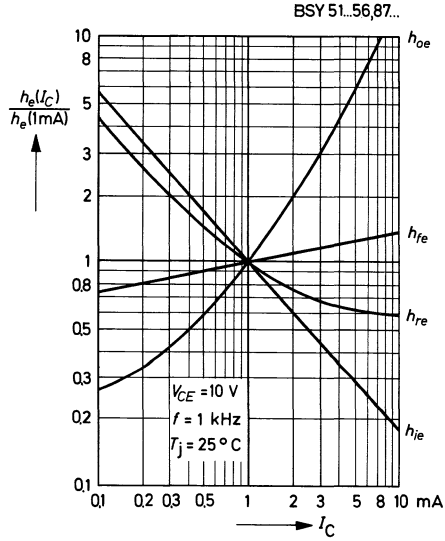


Collector base capacitance versus collector base voltage

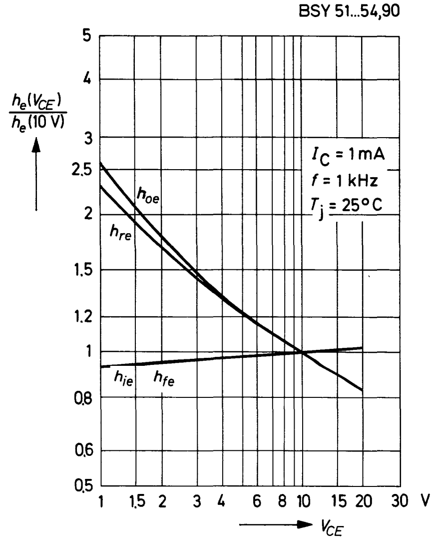


– – – – upper limit, valid for 95 % of a lot

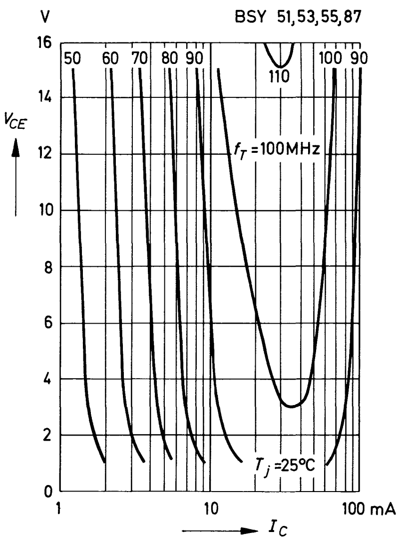
Relative *h*-parameters versus collector current



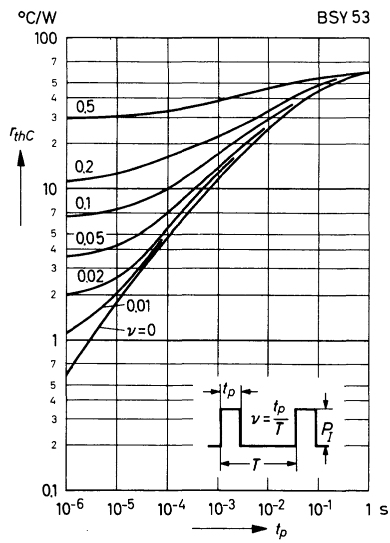
Relative *h*-parameters versus collector emitter voltage



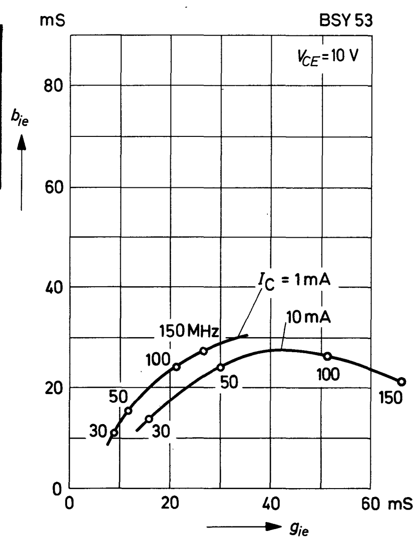
Contours of constant gain bandwidth product



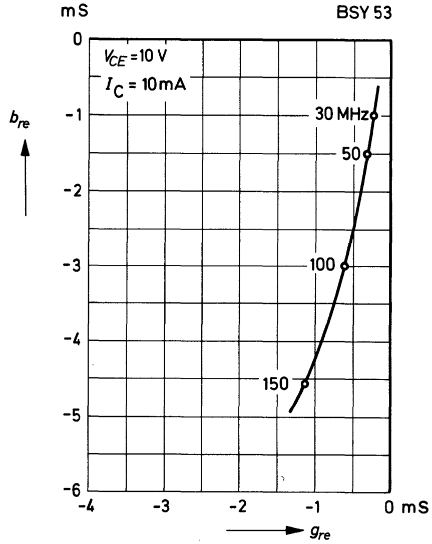
Pulse thermal resistance versus pulse duration



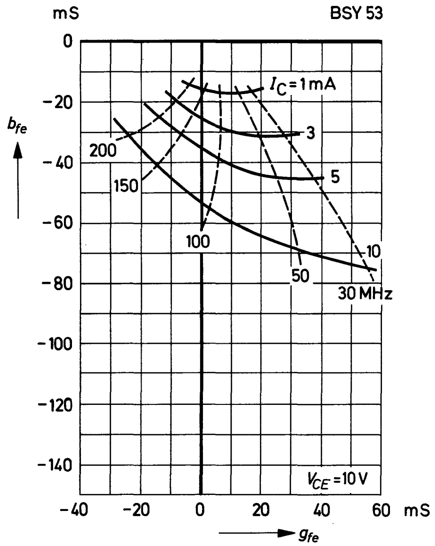
Common emitter input admittance



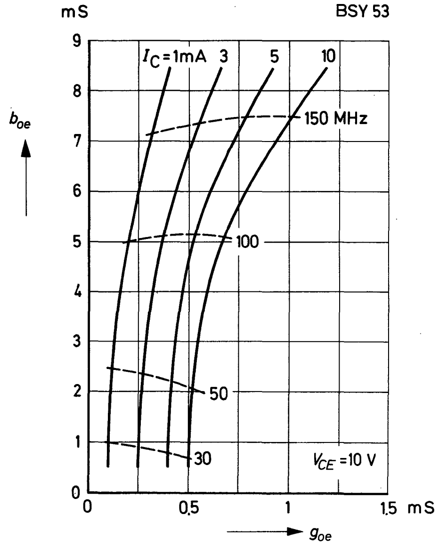
Common emitter reverse transconductance



Common emitter forward transconductance

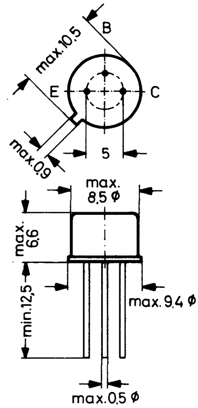


Common emitter output admittance



BSY 54 ≈ 2 N 1711

NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	75	V
Collector emitter voltage	V_{CEO}	30	V
Emitter base voltage	V_{EBO}	7	V
Collector current	I_C	750	mA
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.8	W
at T_C = 100 °C	P_{tot}	1.7	W
at T_C = 25 °C	P_{tot}	3	W
Junction temperature	T_j	200	°C

Static Characteristics at T_j = 25 °C

DC current gain			
at V_{CE} = 10 V, I_C = 0.01 mA	h_{FE}	55 (> 20)	
at V_{CE} = 10 V, I_C = 0.1 mA	h_{FE}	80 (> 35)	
at V_{CE} = 10 V, I_C = 1 mA	h_{FE}	100	
at V_{CE} = 10 V, I_C = 10 mA	h_{FE}	135 (> 80)	
at V_{CE} = 10 V, I_C = 150 mA	h_{FE}	100 ... 300	
at V_{CE} = 10 V, I_C = 500 mA	h_{FE}	60 (> 40)	
Collector saturation voltage			
at I_C = 150 mA, I_B = 15 mA	$V_{CE\,sat}$	0.15 (< 0.6)	V
at I_C = 500 mA, I_B = 50 mA	$V_{CE\,sat}$	0.5 (< 1.2)	V
Base saturation voltage at I_C = 150 mA, I_B = 15 mA	$V_{BE\,sat}$	0.95 (< 1.2)	V
Collector cutoff current			
at V_{CB} = 60 V	I_{CBO}	0.5 (< 10)	nA
at V_{CB} = 60 V, T_{amb} = 150 °C	I_{CBO}	0.4 (< 10)	µA
Emitter cutoff current at V_{EB} = 5 V	I_{EBO}	1 (< 10)	nA

Collector base capacitance at $V_{CBO} = 10$ V	C_{CBO}	6.5 (< 10)	pF
Emitter base capacitance at $V_{EBO} = 0.5$ V	C_{EBO}	23 (< 33)	pF
Thermal resistance			
Junction to ambient air	$R_{th\,A}$	< 220	°C/W
Junction to case	$R_{th\,C}$	< 58	°C/W

Small Signal Characteristics at $T_{amb} = 25$ °C and $f = 1$ kHz

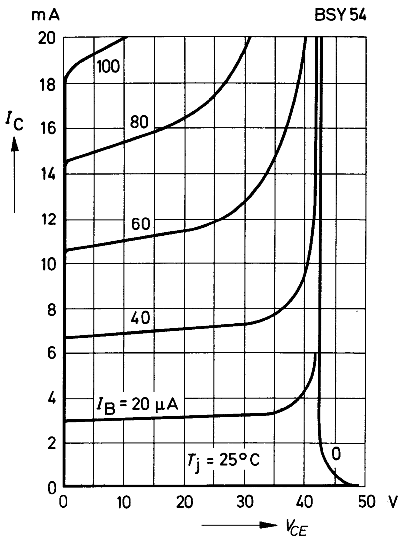
Test conditions: $V_{CE} = 5$ V, $I_C = 1$ mA, grounded emitter

Input impedance	h_{ie}	3 (1.6 . . . 9)	kΩ
Reverse voltage transfer ratio	h_{re}	0.8 (< 3) · 10^{-4}	
Small signal current gain	h_{fe}	100 (50 . . . 250)	
Output admittance	h_{oe}	8 (4.5 . . . 12.5)	μmho
Noise figure at $V_{CE} = 10$ V, $I_C = 0.3$ mA, $R_G = 1.5$ kΩ, Bandwidth 30 Hz . . . 15 kHz	F	3 (< 8)	dB
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	145	MHz

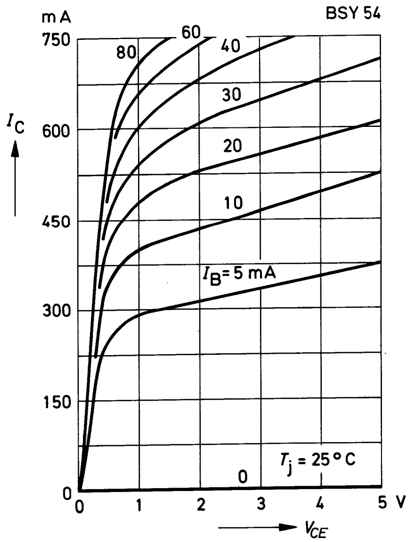
Switching Times

Specifications for switching times of type BSY 51 apply to this type.

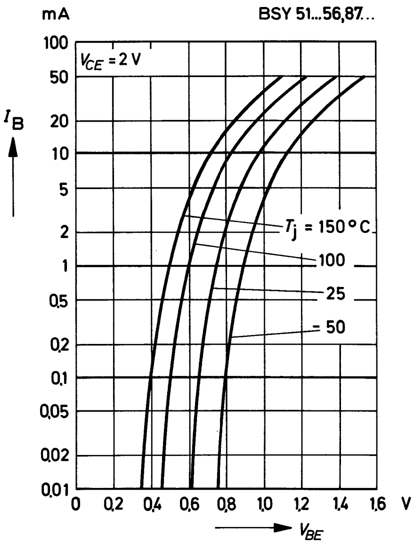
Common emitter collector characteristics



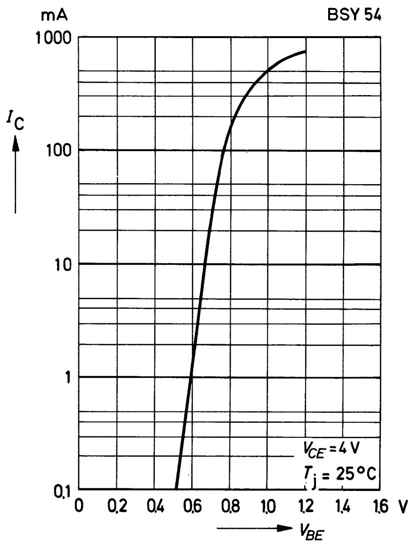
Common emitter collector characteristics



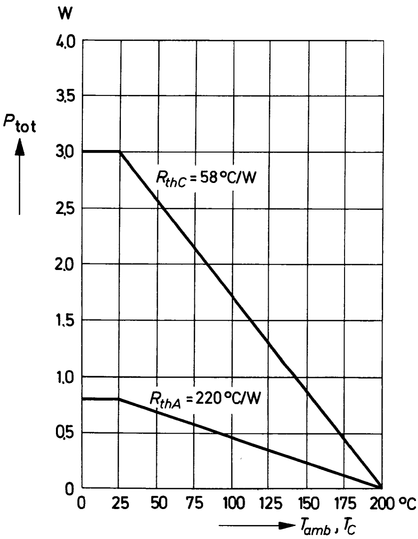
Common emitter input characteristics



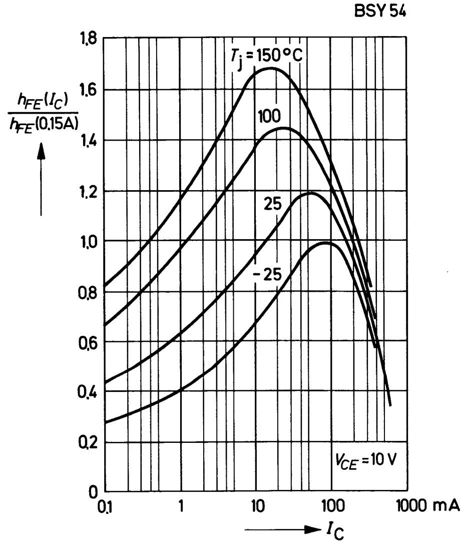
Collector current versus base emitter voltage



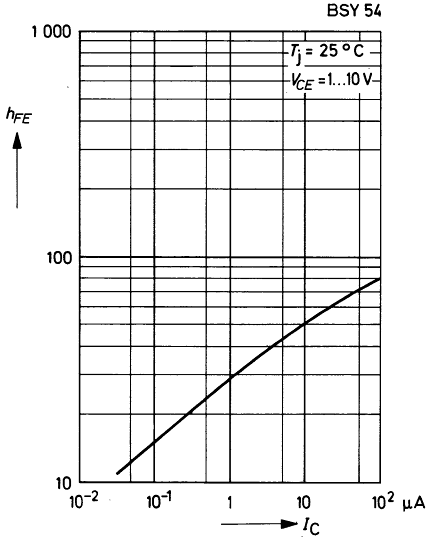
Admissible power dissipation versus temperature



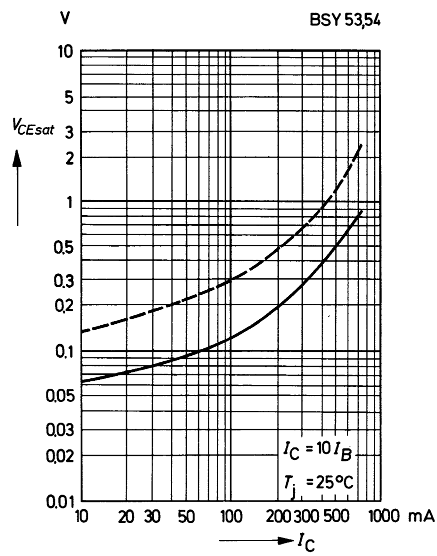
Relative DC current gain versus collector current



DC current gain versus small collector current

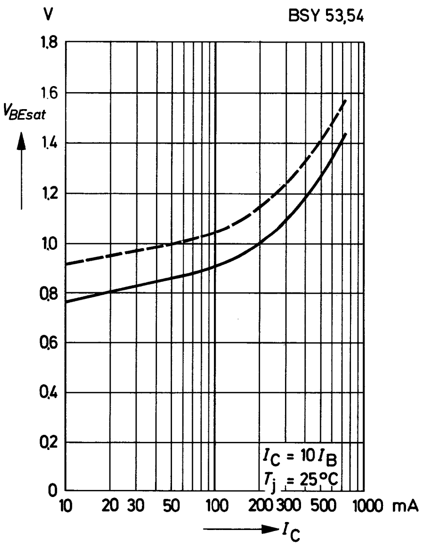


Collector saturation voltage versus collector current

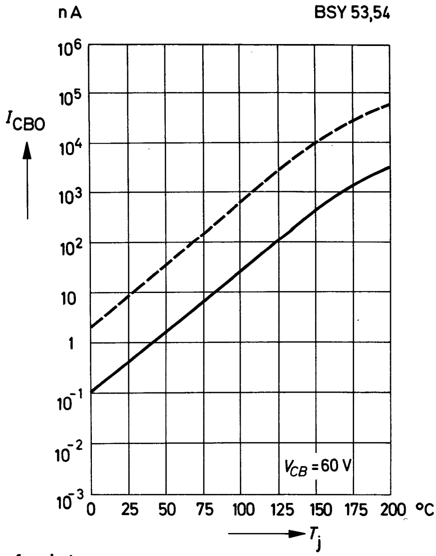


– – – – upper limit, valid for 95 % of a lot

Base saturation voltage versus collector current

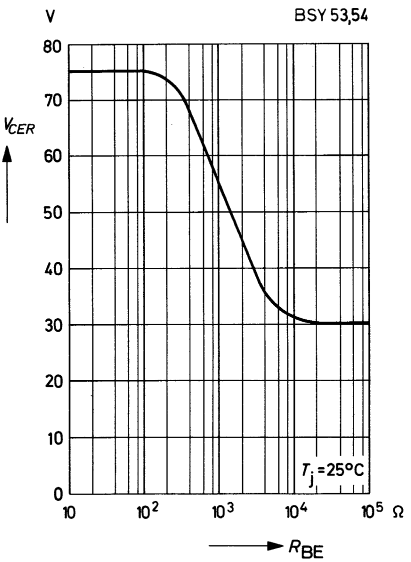


Collector cutoff current versus junction temperature

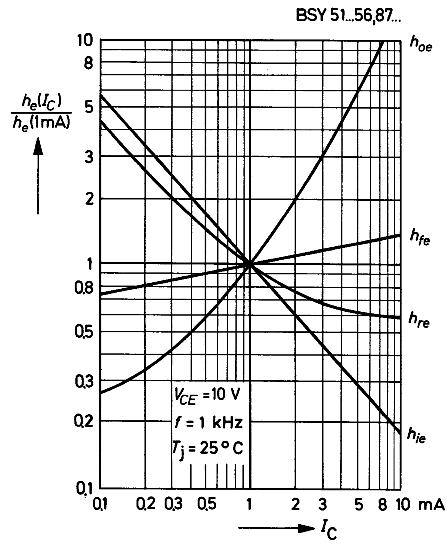


– – – – upper limit, valid for 95 % of a lot

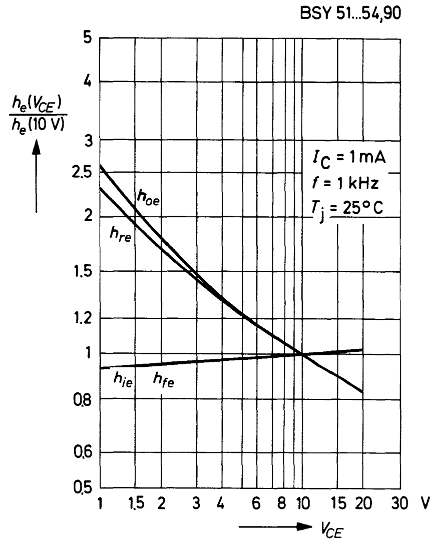
Admissible collector emitter voltage versus base emitter resistance



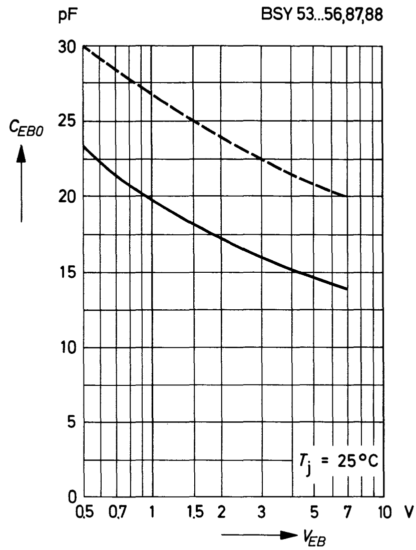
Relative *h*-parameters versus collector current



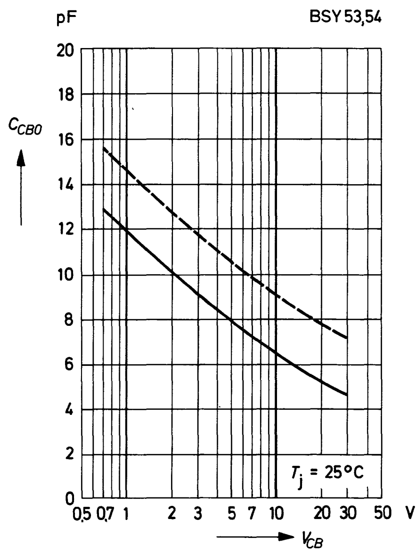
Relative *h*-parameters versus collector emitter voltage



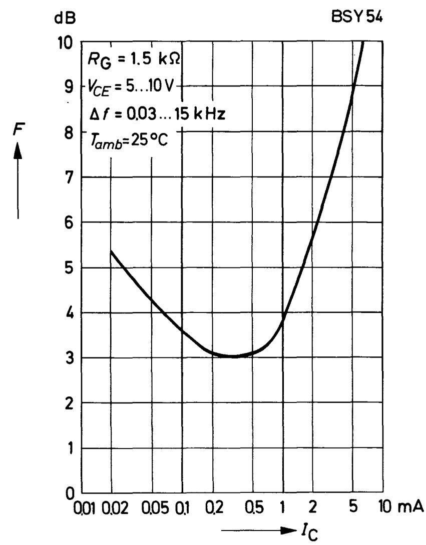
Emitter base capacitance versus emitter base voltage



Collector base capacitance versus collector base voltage

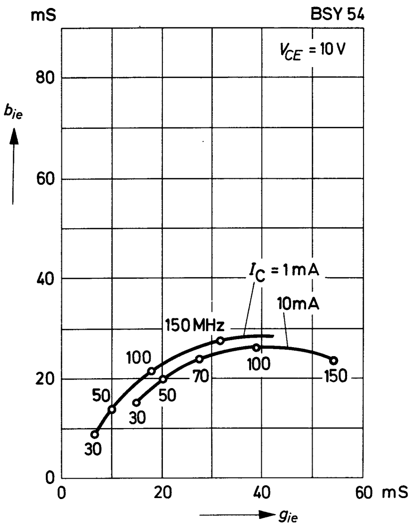


Noise figure versus collector current

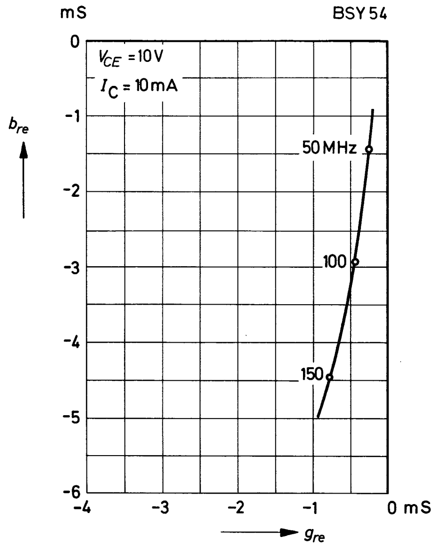


– – – – upper limit, valid for 95 % of a lot

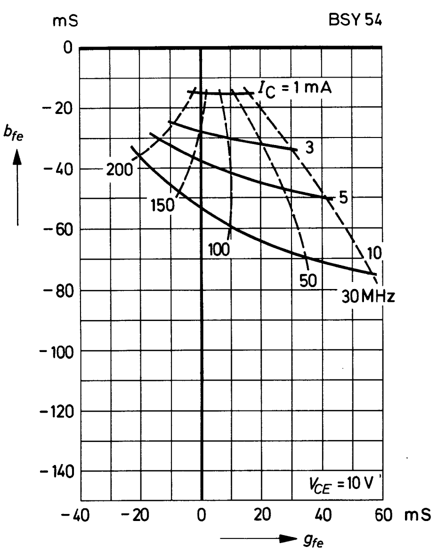
Common emitter input admittance



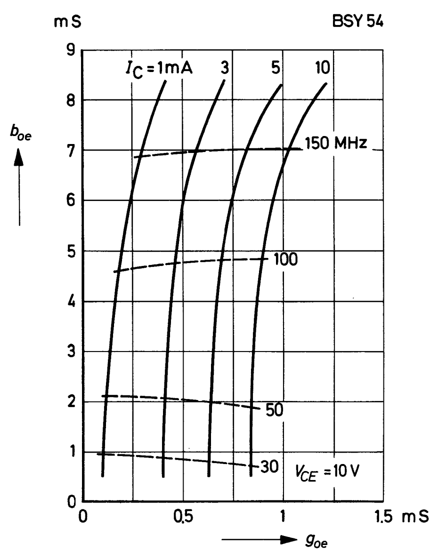
Common emitter reverse transconductance



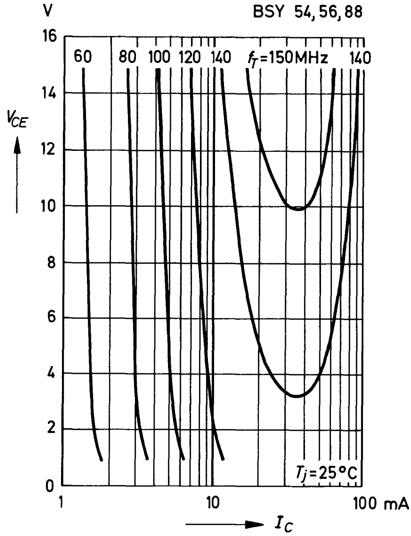
Common emitter forward transconductance



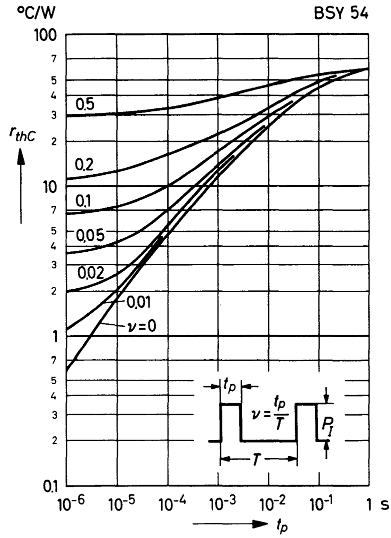
Common emitter output admittance



Contours of constant gain bandwidth product



Pulse thermal resistance versus pulse duration



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NPN Silicon Epitaxial Planar Transistor
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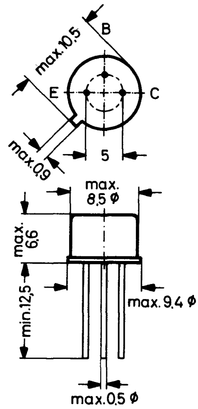


Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	120	V
Collector emitter voltage	V_{CEO}	80	V
Emitter base voltage	V_{EBO}	7	V
Collector current	I_C	500	mA
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.8	W
at T_C = 100 °C	P_{tot}	1.7	W
at T_C = 25 °C	P_{tot}	3	W
Junction temperature	T_j	200	°C

Static Characteristics at $T_j = 25$ °C

DC current gain			
at V_{CE} = 10 V, I_C = 0.1 mA	h_{FE}	50 (> 20)	
at V_{CE} = 10 V, I_C = 1 mA	h_{FE}	60	
at V_{CE} = 10 V, I_C = 10 mA	h_{FE}	65 (> 35)	
at V_{CE} = 10 V, I_C = 150 mA	h_{FE}	40 . . . 120	
at V_{CE} = 10 V, I_C = 500 mA	h_{FE}	20	
Collector saturation voltage at I_C = 150 mA, I_B = 15 mA	$V_{CE\,sat}$	0.2 (< 0.6)	V
Base saturation voltage at I_C = 150 mA, I_B = 15 mA	$V_{BE\,sat}$	1 (< 1.3)	V
Collector cutoff current			
at V_{CB} = 90 V	I_{CBO}	0.5 (< 10)	nA
at V_{CB} = 90 V, T_{amb} = 150 °C	I_{CBO}	0.4 (< 10)	µA
Emitter cutoff current at V_{EB} = 5 V	I_{EBO}	1 (< 10)	nA
Collector base capacitance at V_{CBO} = 10 V	C_{CBO}	6 (< 10)	pF

Emitter base capacitance at $V_{EBO} = 0.5$ V	C_{EBO}	23 (< 33)	pF
Thermal resistance			
Junction to ambient air	$R_{th\,A}$	< 220	°C/W
Junction to case	$R_{th\,C}$	< 58	°C/W

Small Signal Characteristics at $T_{amb} = 25$ °C and $f = 1$ kHz

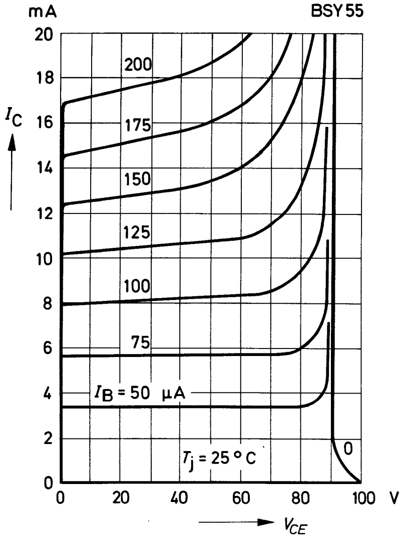
Test conditions: $V_{CE} = 5$ V, $I_C = 1$ mA, grounded emitter

Input impedance	h_{ie}	1.6 (0.8 . . . 5)	kΩ
Reverse voltage transfer ratio	h_{re}	0.6 (< 3) · 10^{-4}	
Small signal current gain	h_{fe}	75 (30 . . . 150)	
Output admittance	h_{oe}	4 (2 . . . 7)	μmho
Noise figure at $V_{CE} = 10$ V, $I_C = 0.3$ mA, $R_G = 1.5$ kΩ, Bandwidth 30 Hz . . . 15 kHz	F	6	dB
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	100	MHz

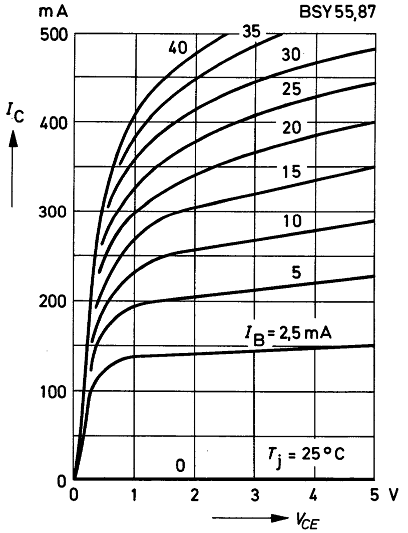
Switching Times

Specifications for switching times of type BSY 51 apply to this type.

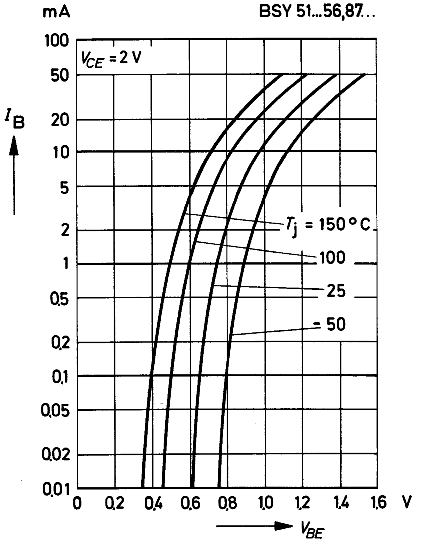
Common emitter collector characteristics



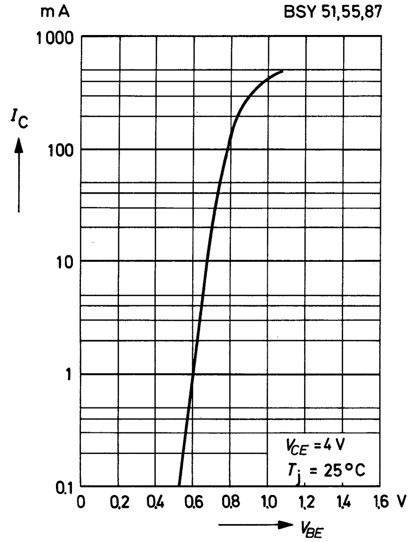
Common emitter collector characteristics



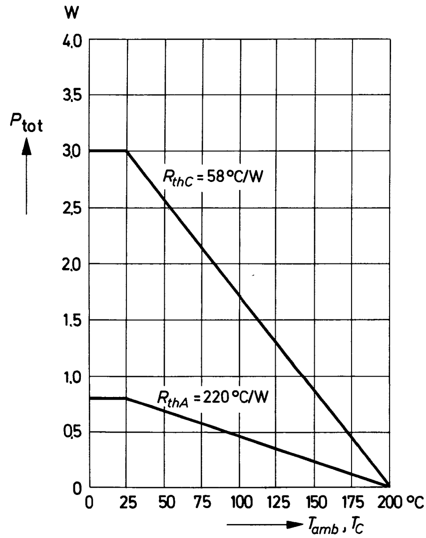
Common emitter input characteristics



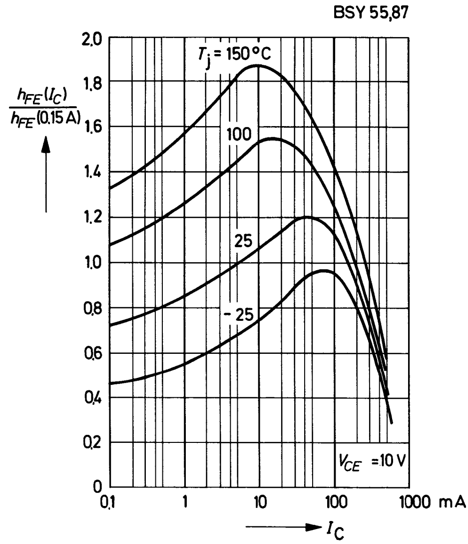
Collector current versus base emitter voltage



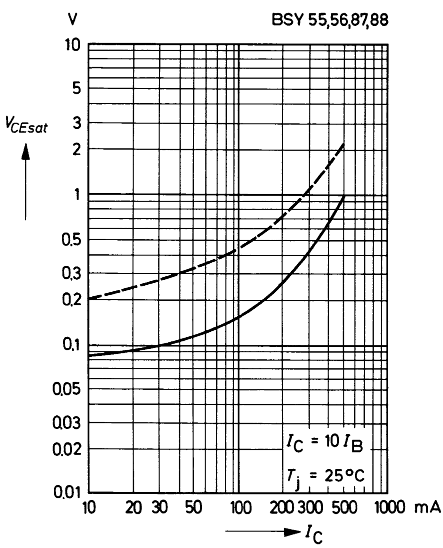
Admissible power dissipation versus temperature



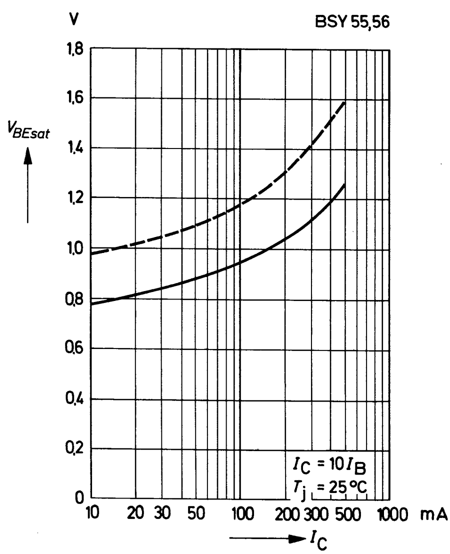
Relative DC current gain versus collector current



Collector saturation voltage versus collector current

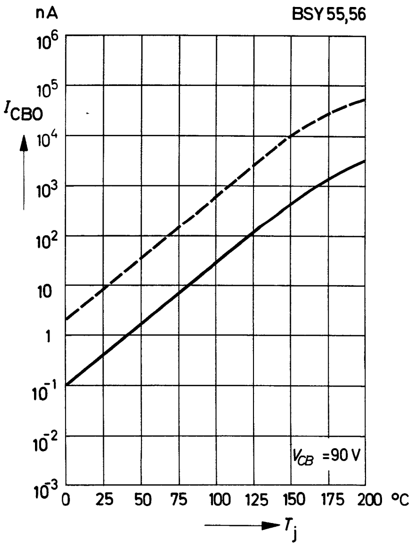


Base saturation voltage versus collector current

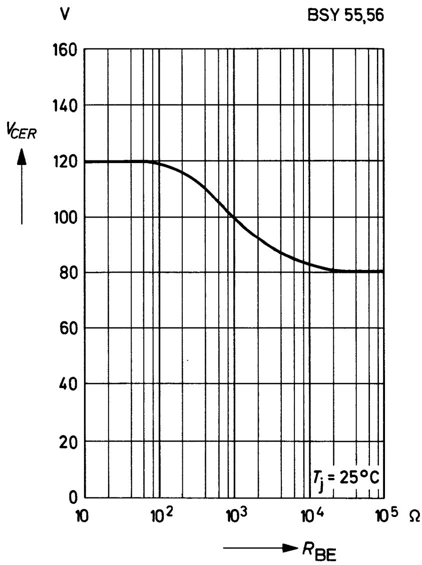


– – – – upper limit, valid for 95 % of a lot

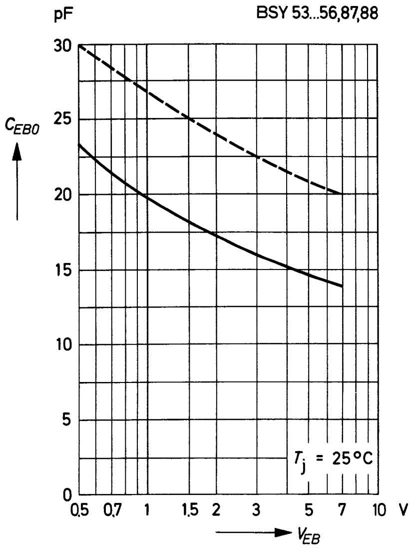
Collector cutoff current versus junction temperature



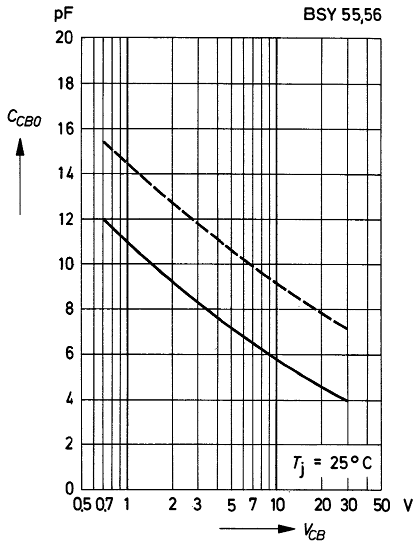
Admissible collector emitter voltage versus base emitter resistance



Emitter base capacitance versus emitter base voltage

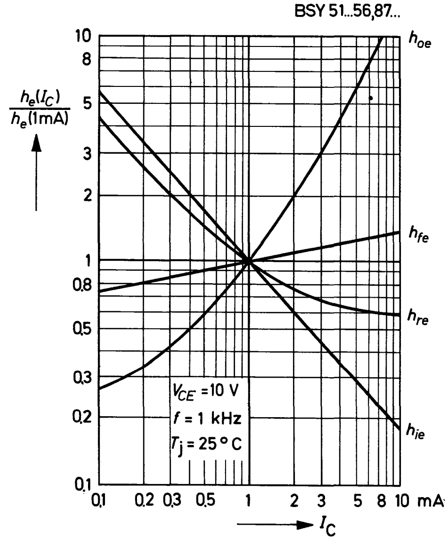


Collector base capacitance versus collector base voltage

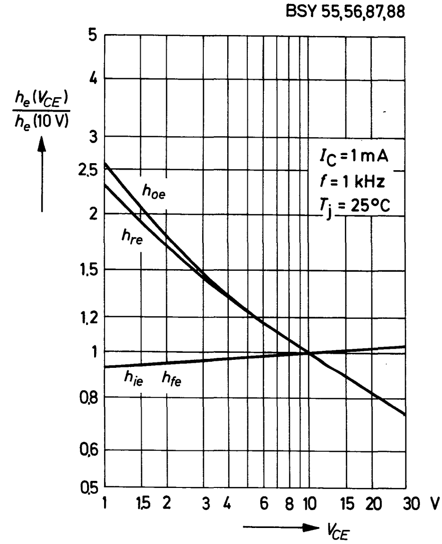


– – – – upper limit, valid for 95 % of a lot

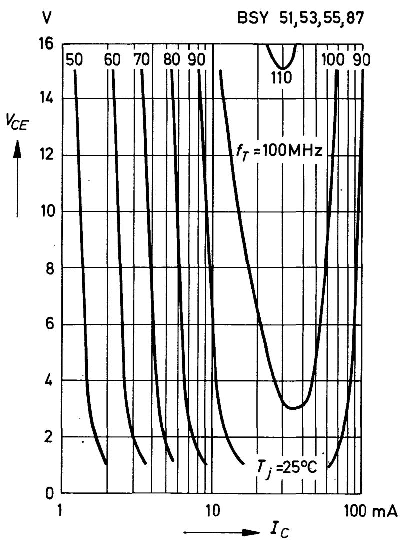
Relative *h*-parameters versus collector current



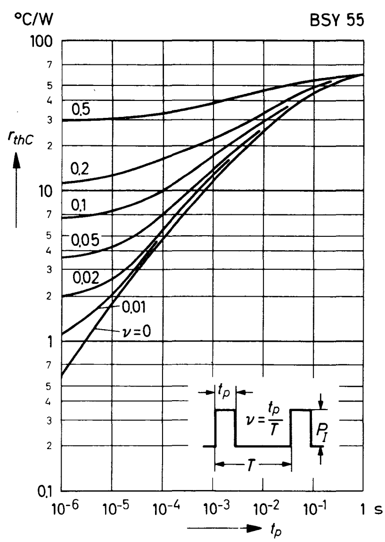
Relative *h*-parameters versus collector emitter voltage



Contours of constant gain bandwidth product

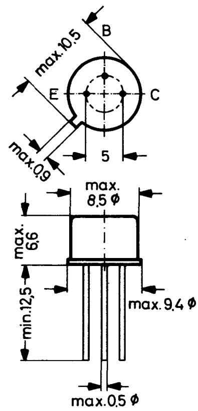


Pulse thermal resistance versus pulse duration



BSY 56

NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	120	V
Collector emitter voltage	V_{CEO}	80	V
Emitter base voltage	V_{EBO}	7	V
Collector current	I_C	500	mA
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.8	W
at T_C = 100 °C	P_{tot}	1.7	W
at T_C = 25 °C	P_{tot}	3	W
Junction temperature	T_j	200	°C

Static Characteristics at $T_j = 25$ °C

DC current gain			
at $V_{CE} = 10$ V, $I_C = 0.1$ mA	h_{FE}	100 (> 35)	
at $V_{CE} = 10$ V, $I_C = 1$ mA	h_{FE}	125	
at $V_{CE} = 10$ V, $I_C = 10$ mA	h_{FE}	180 (> 75)	
at $V_{CE} = 10$ V, $I_C = 150$ mA	h_{FE}	100 . . . 300	
at $V_{CE} = 10$ V, $I_C = 500$ mA	h_{FE}	35	
Collector saturation voltage at $I_C = 150$ mA, $I_B = 15$ mA	$V_{CE\,sat}$	0.2 (< 0.6)	V
Base saturation voltage at $I_C = 150$ mA, $I_B = 15$ mA	$V_{BE\,sat}$	1 (< 1.3)	V
Collector cutoff current			
at $V_{CB} = 90$ V	I_{CBO}	0.5 (< 10)	nA
at $V_{CB} = 90$ V, $T_{amb} = 150$ °C	I_{CBO}	0.4 (< 10)	µA
Emitter cutoff current at $V_{EB} = 5$ V	I_{EBO}	1 (< 10)	nA
Collector base capacitance at $V_{CBO} = 10$ V	C_{CBO}	6 (< 10)	pF

Emitter base capacitance at $V_{EBO} = 0.5$ V	C_{EBO}	23 (< 33)	pF
Thermal resistance			
Junction to ambient air	$R_{th\,A}$	< 220	°C/W
Junction to case	$R_{th\,C}$	< 58	°C/W

Small Signal Characteristics at $T_{amb} = 25$ °C and $f = 1$ kHz

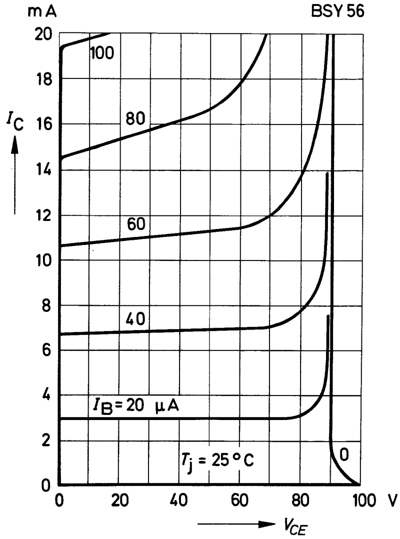
Test conditions: $V_{CE} = 5$ V, $I_C = 1$ mA, grounded emitter

Input impedance	h_{ie}	3 (1.6 . . . 9)	kΩ
Reverse voltage transfer ratio	h_{re}	0.6 (< 3) · 10^{-4}	
Small signal current gain	h_{fe}	120 (60 . . . 280)	
Output admittance	h_{oe}	6 (3 . . . 10)	μmho
Noise figure at $V_{CE} = 10$ V, $I_C = 0.3$ mA, $R_G = 1.5$ kΩ, Bandwidth 30 Hz . . . 15 kHz	F	6	dB
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	145	MHz

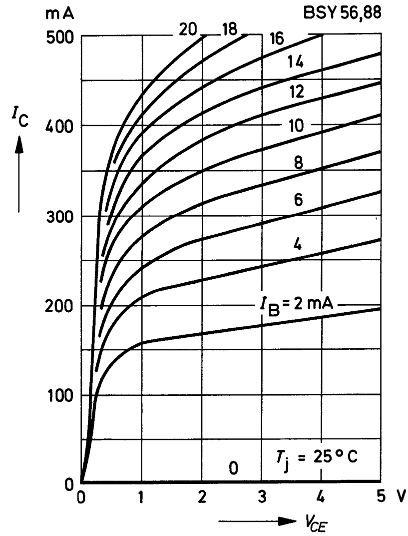
Switching Times

Specifications for switching times of type BSY 51 apply to this type.

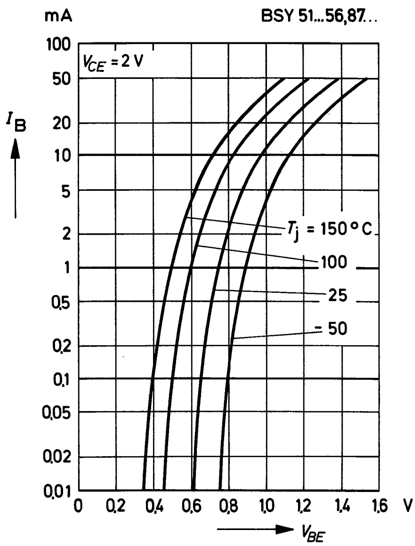
Common emitter collector characteristics



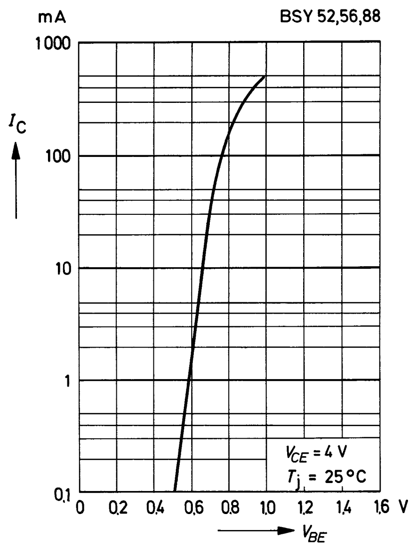
Common emitter collector characteristics



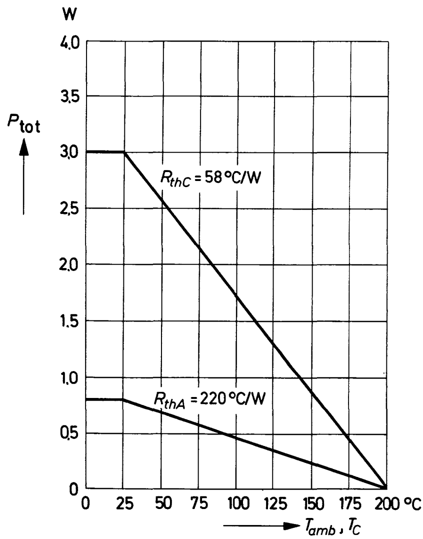
Common emitter input characteristics



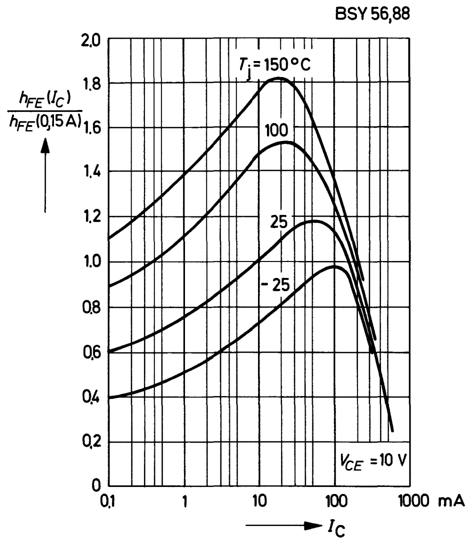
Collector current versus base emitter voltage



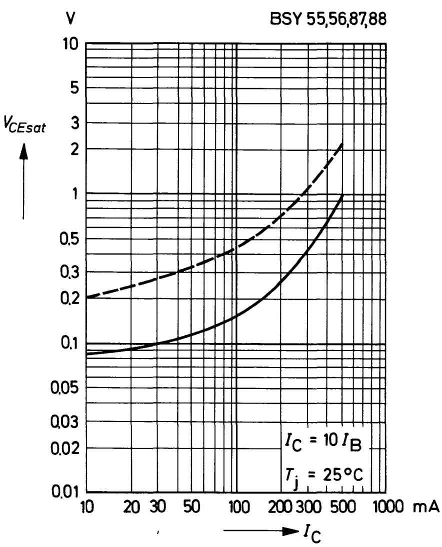
Admissible power dissipation versus temperature



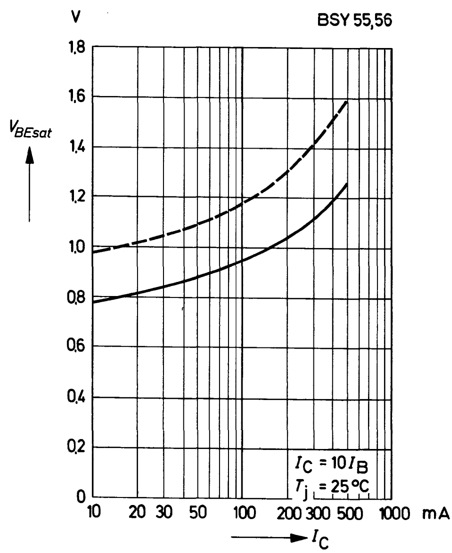
Relative DC current gain versus collector current



Collector saturation voltage versus collector current

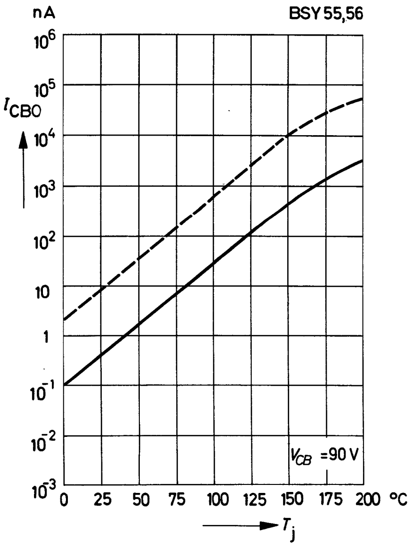


Base saturation voltage versus collector current

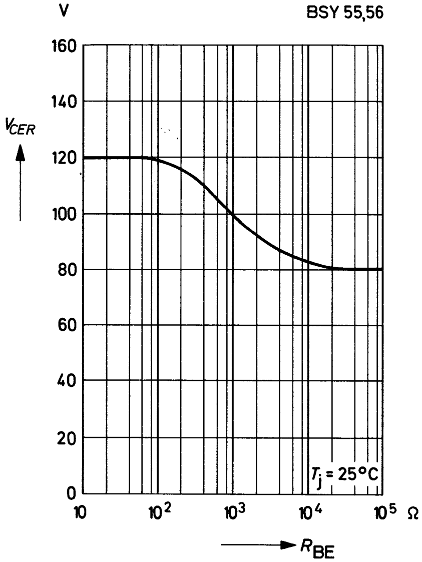


– – – – upper limit, valid for 95 % of a lot

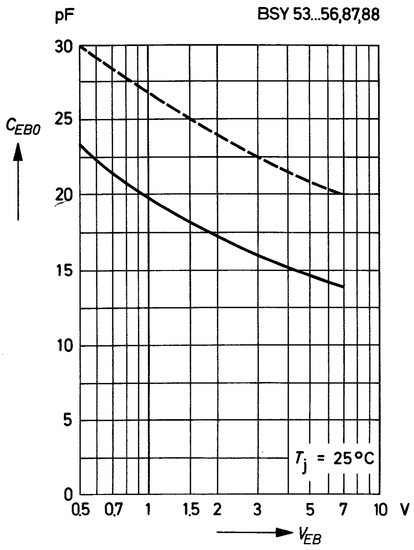
Collector cutoff current versus junction temperature



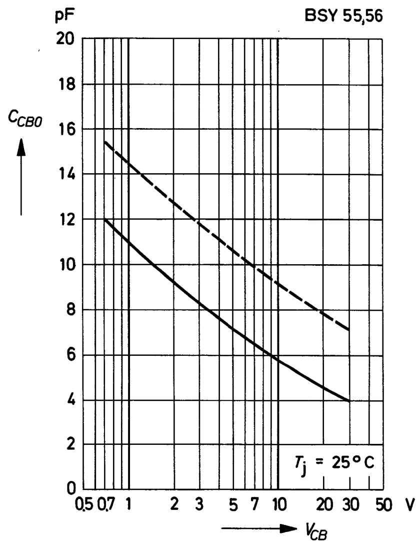
Admissible collector emitter voltage versus base emitter resistance



Emitter base capacitance versus emitter base voltage

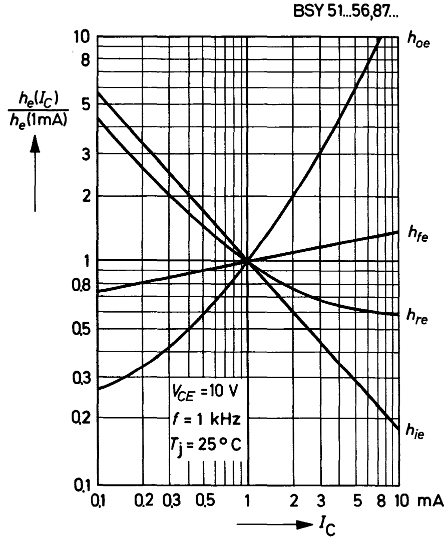


Collector base capacitance versus collector base voltage

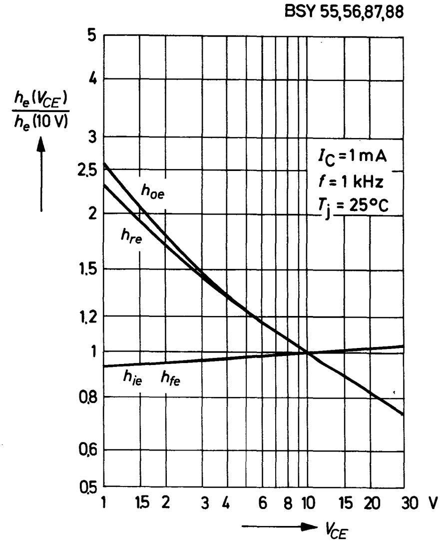


– – – – upper limit, valid for 95 % of a lot

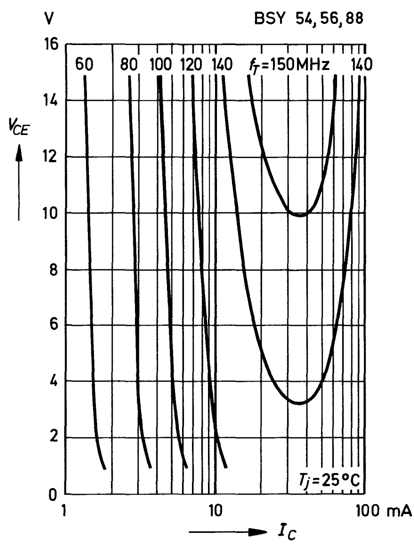
Relative *h*-parameters versus collector current



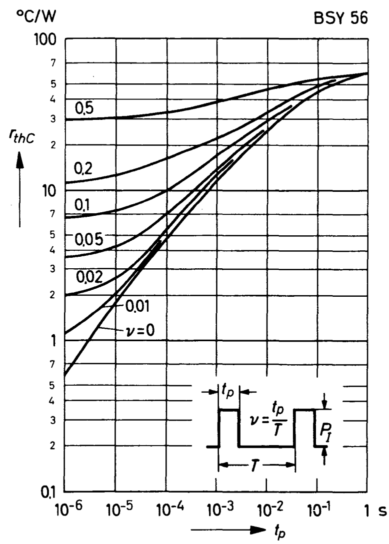
Relative *h*-parameters versus collector emitter voltage



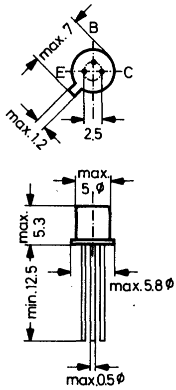
Contours of constant gain bandwidth product



Pulse thermal resistance versus pulse duration



NPN Silicon Epitaxial Planar Transistor
with high collector emitter voltage for use as driver for numerical indicator tubes (Nixie driver)



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

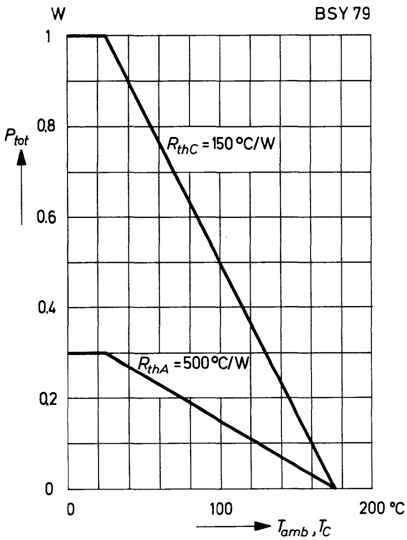
Maximum Ratings

Collector base voltage	V_{CBO}	120	V
Collector emitter voltage at $V_{EB} = 1$ V	V_{CEV}	120	V
Emitter base voltage	V_{EBO}	5	V
Collector current	I_C	30	mA
Power dissipation			
at $T_{amb} = 25$ °C	P_{tot}	300	mW
at $T_C = 25$ °C	P_{tot}	1	W
Junction temperature	T_j	175	°C

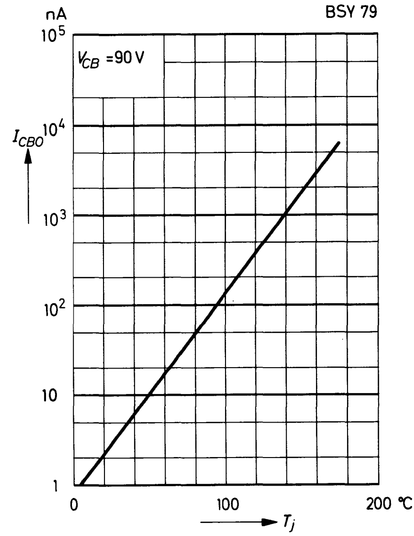
Characteristics at $T_j = 25$ °C

DC current gain at $V_{CE} = 1$ V, $I_C = 1$ mA	h_{FE}	60 (> 30)	
Collector saturation voltage at $I_C = 2$ mA, $I_B = 0.2$ mA	$V_{CE\,sat}$	0.3 (< 0.5)	V
Base saturation voltage at $I_C = 2$ mA, $I_B = 0.2$ mA	$V_{BE\,sat}$	< 1	V
Collector cutoff current			
at $V_{CB} = 90$ V	I_{CBO}	3 (< 50)	nA
at $V_{CB} = 90$ V, $T_{amb} = 150$ °C	I_{CBO}	< 10	μA
Emitter cutoff current at $V_{EB} = 4$ V	I_{EBO}	2 (< 50)	nA
Collector base capacitance at $V_{CBO} = 10$ V	C_{CBO}	4	pF
Emitter base capacitance at $V_{EB} = 0.5$ V	C_{EBO}	17	pF
Thermal resistance			
Junction to ambient air	R_{thA}	< 500	°C/W
Junction to case	R_{thC}	< 150	°C/W
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 10$ mA, $f = 50$ MHz	f_T	100	MHz

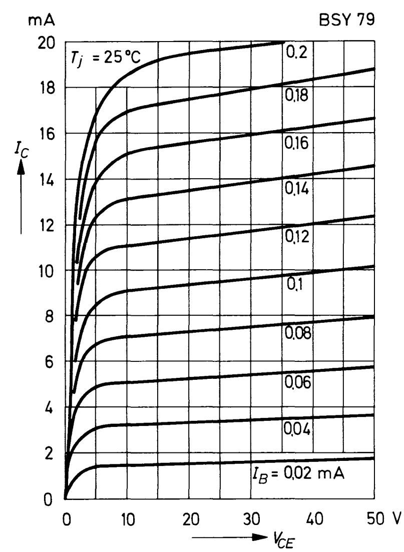
Admissible power dissipation versus temperature



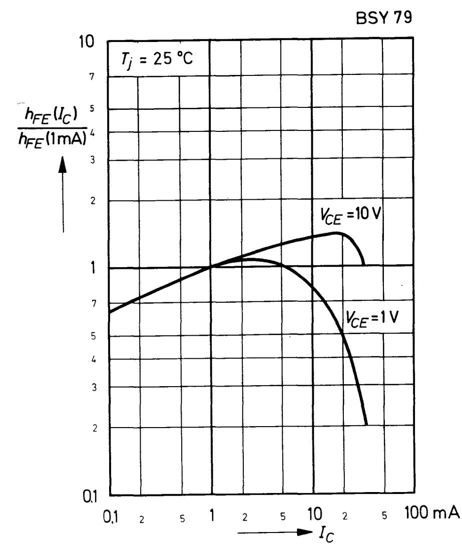
Collector cutoff current versus junction temperature



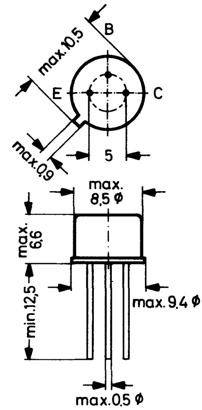
Common emitter collector characteristics



Relative DC current gain versus collector current



NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications
at higher collector current



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.3 g
Dimensions in mm

Maximum Ratings

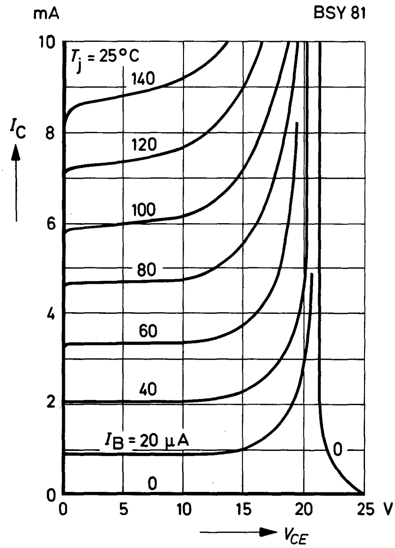
Collector base voltage	V_{CBO}	40	V
Collector emitter voltage	V_{CEO}	18	V
Emitter base voltage	V_{EBO}	5	V
Collector current	I_C	1	A
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.9	W
at T_C = 100 °C	P_{tot}	2.8	W
at T_C = 25 °C	P_{tot}	5	W
Junction temperature	T_j	200	°C

Characteristics at T_j = 25 °C

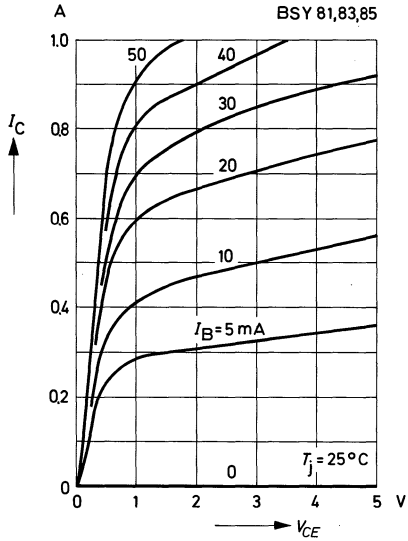
DC current gain			
at V_{CE} = 10 V, I_C = 0.1 mA	h_{FE}	30 (> 20)	
at V_{CE} = 10 V, I_C = 10 mA	h_{FE}	65 (> 35)	
at V_{CE} = 10 V, I_C = 150 mA	h_{FE}	85 (40 . . . 120)	
at V_{CE} = 10 V, I_C = 500 mA	h_{FE}	60 (> 30)	
at V_{CE} = 10 V, I_C = 1000 mA	h_{FE}	30 (> 15)	
Collector saturation voltage			
at I_C = 0.15 A, I_B = 0.015 A	$V_{CE\,sat}$	< 0.25	V
at I_C = 0.5 A, I_B = 0.05 A	$V_{CE\,sat}$	< 0.6	V
at I_C = 1 A, I_B = 0.1 A	$V_{CE\,sat}$	< 1.2	V
Base saturation voltage at I_C = 1 A, I_B = 0.1 A	$V_{BE\,sat}$	< 1.8	V
Collector cutoff current			
at V_{CB} = 30 V	I_{CBO}	2 (< 100)	nA
at V_{CB} = 30 V, T_{amb} = 150 °C	I_{CBO}	0.6 (< 25)	µA

Emitter cutoff current at $V_{EB} = 3$ V	I_{EBO}	3 (< 10)	nA
Collector base capacitance at $V_{CBO} = 10$ V	C_{CBO}	8.5 (< 15)	pF
Emitter base capacitance at $V_{EBO} = 0.5$ V	C_{EBO}	50 (< 60)	pF
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	100	MHz
Thermal resistance			
Junction to ambient air	R_{thA}	< 194	°C/W
Junction to case	R_{thC}	< 35	°C/W

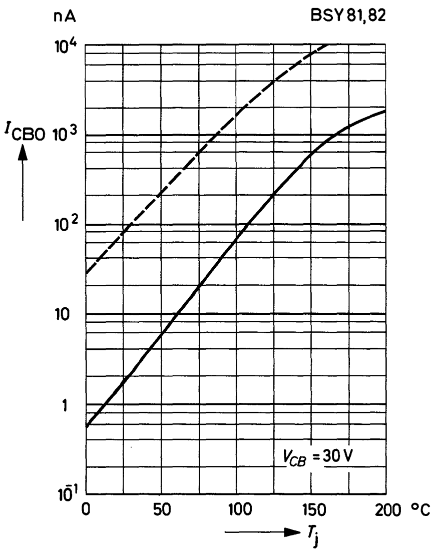
Common emitter collector characteristics



Common emitter collector characteristics

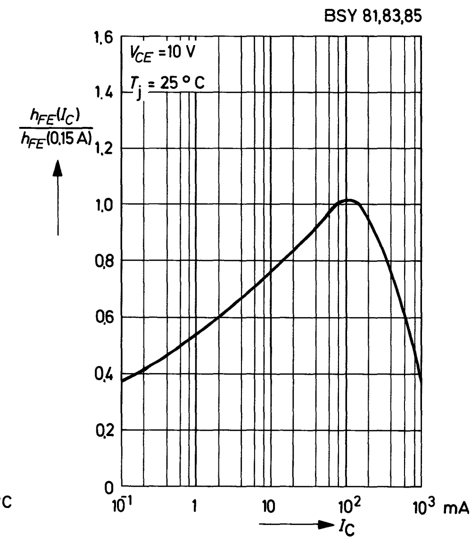


Collector cutoff current versus junction temperature

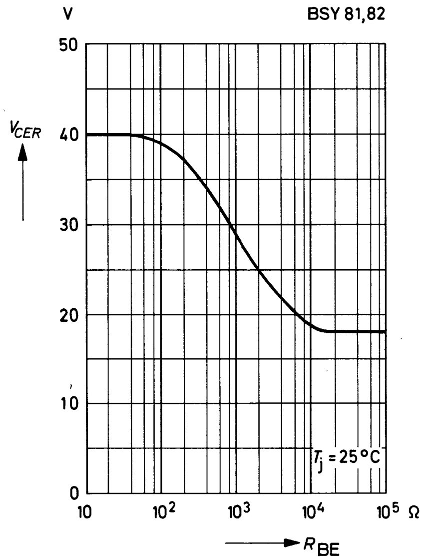


– – – – upper limit, valid for 95 % of a lot

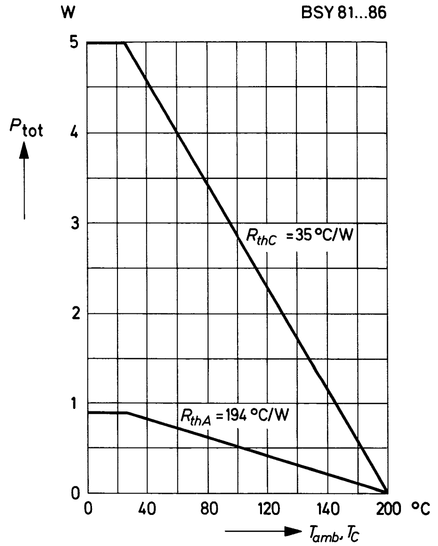
Relative DC current gain versus collector current



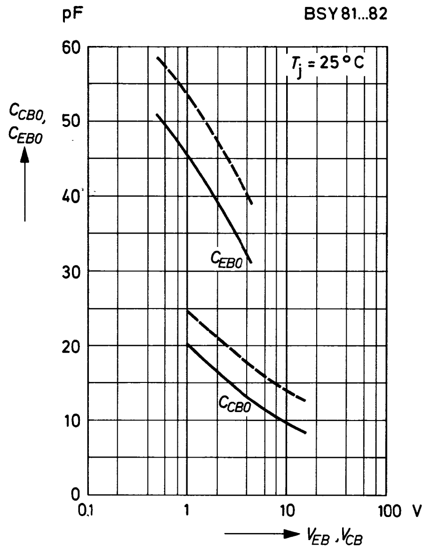
Admissible collector emitter voltage versus base emitter resistance



Admissible power dissipation versus temperature

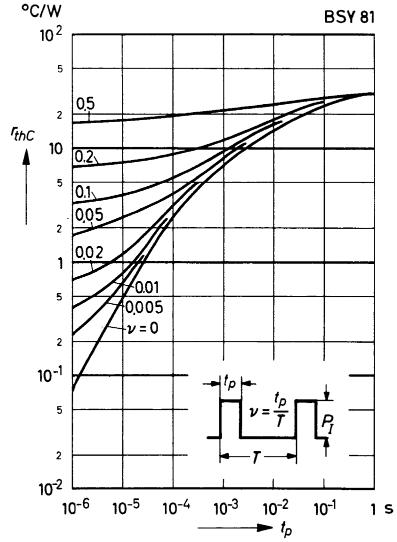


Collector base capacitance, Emitter base capacitance versus reverse bias voltage

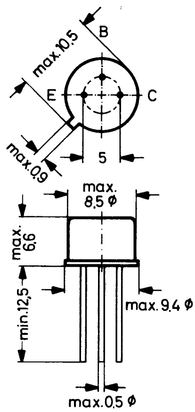


– – – – upper limit, valid for 95 % of a lot

Pulse thermal resistance versus pulse duration



NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications
at higher collector current



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.3 g
Dimensions in mm

Maximum Ratings

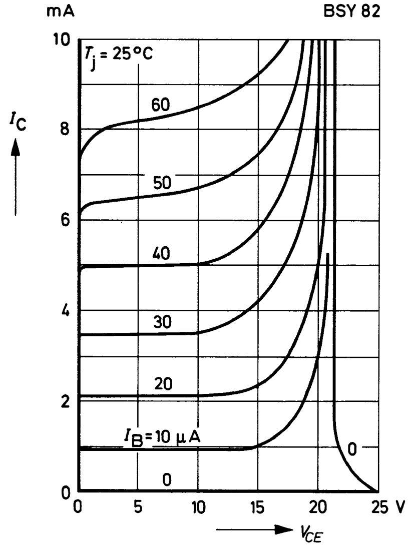
Collector base voltage	V_{CBO}	40	V
Collector emitter voltage	V_{CEO}	18	V
Emitter base voltage	V_{EBO}	5	V
Collector current	I_C	1	A
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.9	W
at T_C = 100 °C	P_{tot}	2.8	W
at T_C = 25 °C	P_{tot}	5	W
Junction temperature	T_j	200	°C

Characteristics at T_j = 25 °C

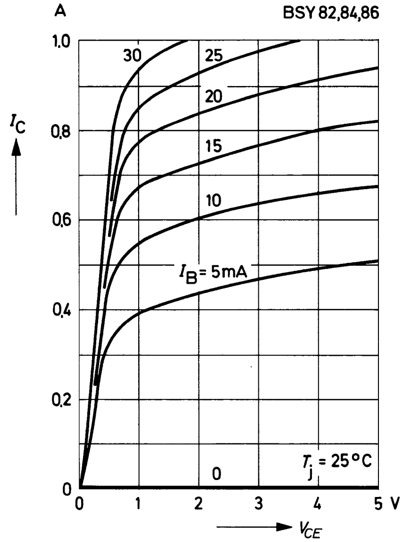
DC current gain			
at V_{CE} = 10 V, I_C = 0.1 mA	h_{FE}	60 (> 35)	
at V_{CE} = 10 V, I_C = 10 mA	h_{FE}	140 (> 75)	
at V_{CE} = 10 V, I_C = 150 mA	h_{FE}	190 (100 . . . 300)	
at V_{CE} = 10 V, I_C = 500 mA	h_{FE}	120 (> 40)	
at V_{CE} = 10 V, I_C = 1000 mA	h_{FE}	50 (> 20)	
Collector saturation voltage			
at I_C = 0.15 A, I_B = 0.015 A	$V_{CE\,sat}$	< 0.25	V
at I_C = 0.5 A, I_B = 0.05 A	$V_{CE\,sat}$	< 0.6	V
at I_C = 1 A, I_B = 0.1 A	$V_{CE\,sat}$	< 1.2	V
Base saturation voltage at I_C = 1 A, I_B = 0.1 A	$V_{BE\,sat}$	< 1.8	V
Collector cutoff current			
at V_{CB} = 30 V	I_{CBO}	2 (< 100)	nA
at V_{CB} = 30 V, T_{amb} = 150 °C	I_{CBO}	0.6 (< 25)	µA

Emitter cutoff current at $V_{EB} = 3$ V	I_{EBO}	3 (< 10)	nA
Collector base capacitance at $V_{CBO} = 10$ V	C_{CBO}	8.5 (< 15)	pF
Emitter base capacitance at $V_{EBO} = 0.5$ V	C_{EBO}	50 (< 60)	pF
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	120	MHz
Thermal resistance			
Junction to ambient air	R_{thA}	< 194	°C/W
Junction to case	R_{thC}	< 35	°C/W

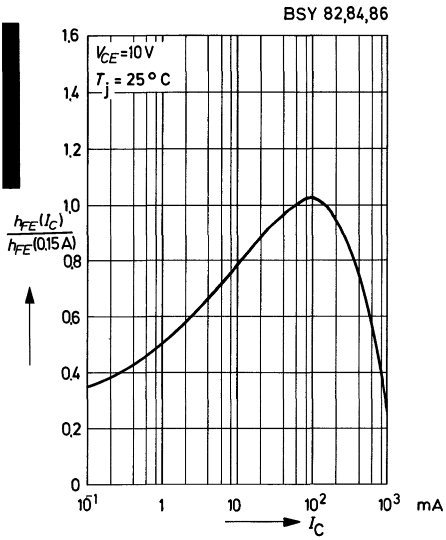
Common emitter collector characteristics



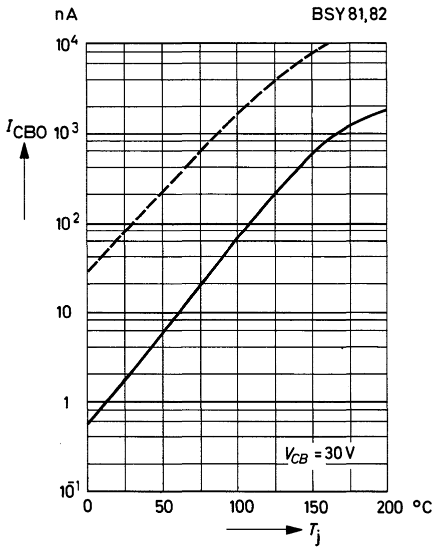
Common emitter collector characteristics



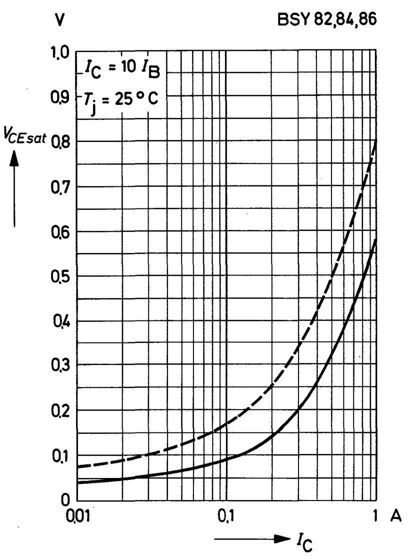
Relative DC current gain versus collector current



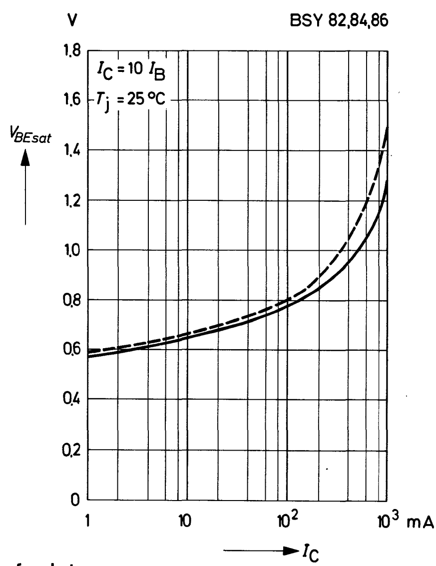
Collector cutoff current versus junction temperature



Collector saturation voltage versus collector current

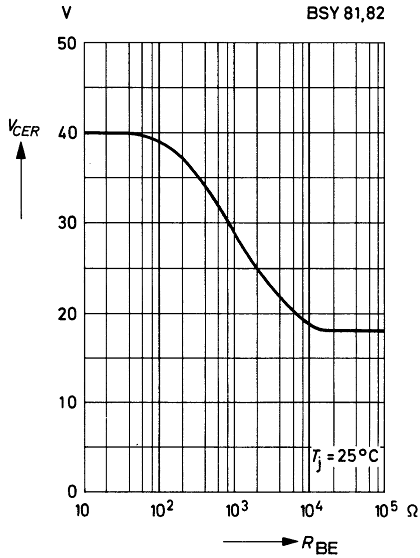


Base saturation voltage versus collector current

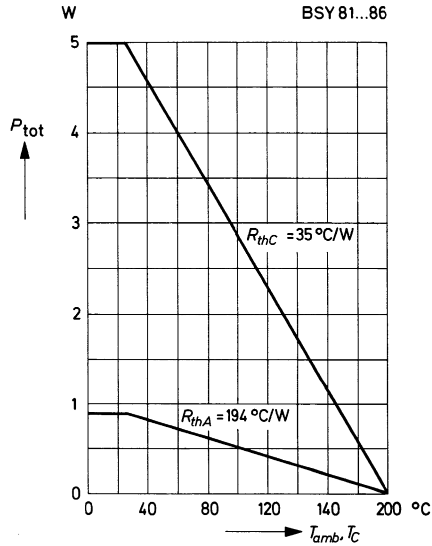


– – – – upper limit, valid for 95 % of a lot

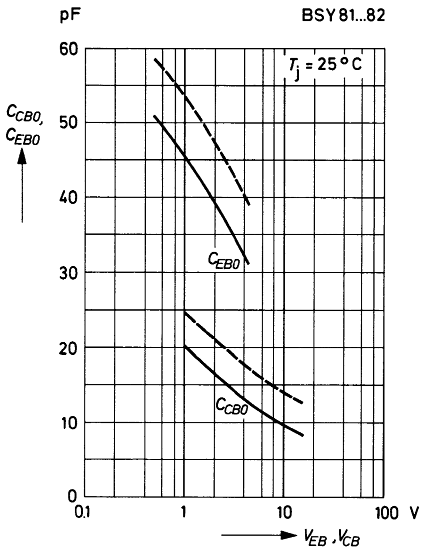
Admissible collector emitter voltage versus base emitter resistance



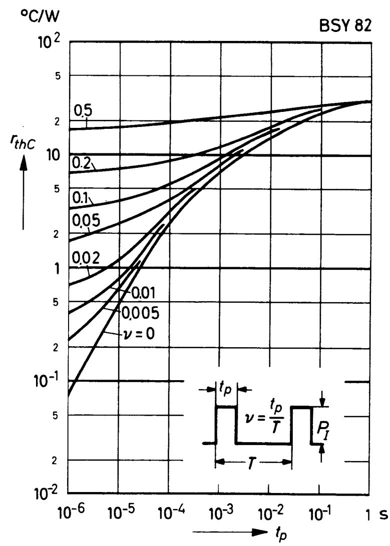
Admissible power dissipation versus temperature



Collector base capacitance, Emitter base capacitance versus reverse bias voltage



Pulse thermal resistance versus pulse duration



– – – – upper limit, valid for 95 % of a lot

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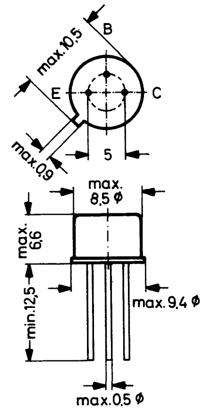
NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications
at higher collector current



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.3 g
Dimensions in mm

Maximum Ratings

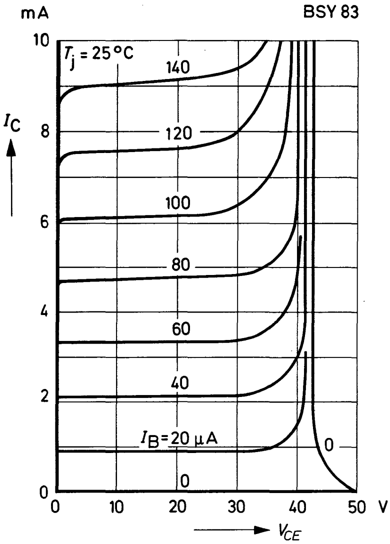
Collector base voltage	V_{CBO}	80	V
Collector emitter voltage	V_{CEO}	35	V
Emitter base voltage	V_{EBO}	7	V
Collector current	I_C	1	A
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.9	W
at T_C = 100 °C	P_{tot}	2.8	W
at T_C = 25 °C	P_{tot}	5	W
Junction temperature	T_j	200	°C

Characteristics at T_j = 25 °C

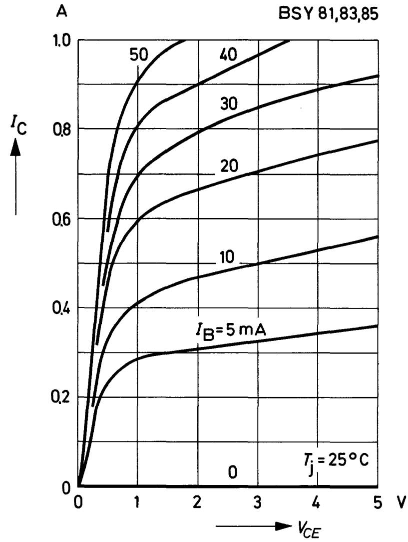
DC current gain			
at V_{CE} = 10 V, I_C = 0.1 mA	h_{FE}	30 (> 20)	
at V_{CE} = 10 V, I_C = 10 mA	h_{FE}	65 (> 35)	
at V_{CE} = 10 V, I_C = 150 mA	h_{FE}	85 (40 . . . 120)	
at V_{CE} = 10 V, I_C = 500 mA	h_{FE}	60 (> 30)	
at V_{CE} = 10 V, I_C = 1000 mA	h_{FE}	30 (> 15)	
Collector saturation voltage			
at I_C = 0.15 A, I_B = 0.015 A	$V_{CE\,sat}$	< 0.25	V
at I_C = 0.5 A, I_B = 0.05 A	$V_{CE\,sat}$	< 0.6	V
at I_C = 1 A, I_B = 0.1 A	$V_{CE\,sat}$	< 1	V
Base saturation voltage at I_C = 1 A, I_B = 0.1 A	$V_{BE\,sat}$	< 1.8	V
Collector cutoff current			
at V_{CB} = 60 V	I_{CBO}	0.6 (< 10)	nA
at V_{CB} = 60 V, T_{amb} = 150 °C	I_{CBO}	0.3 (< 10)	µA

Emitter cutoff current at $V_{EB} = 3$ V	I_{EBO}	5 (< 10)	nA
Collector base capacitance at $V_{CBO} = 10$ V	C_{CBO}	8.5 (< 15)	pF
Emitter base capacitance at $V_{EBO} = 0.5$ V	C_{EBO}	50 (< 60)	pF
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	100	MHz
Thermal resistance			
Junction to ambient air	R_{thA}	< 194	°C/W
Junction to case	R_{thC}	< 35	°C/W

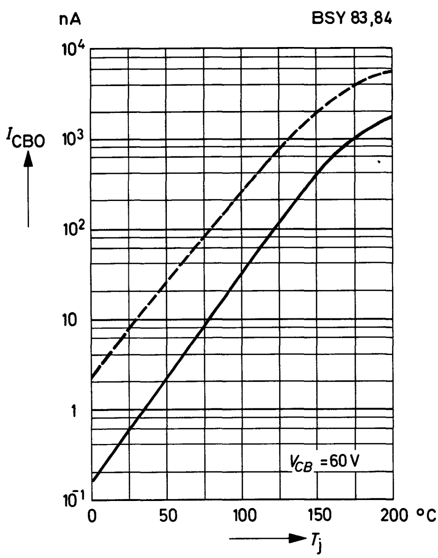
Common emitter collector characteristics



Common emitter collector characteristics

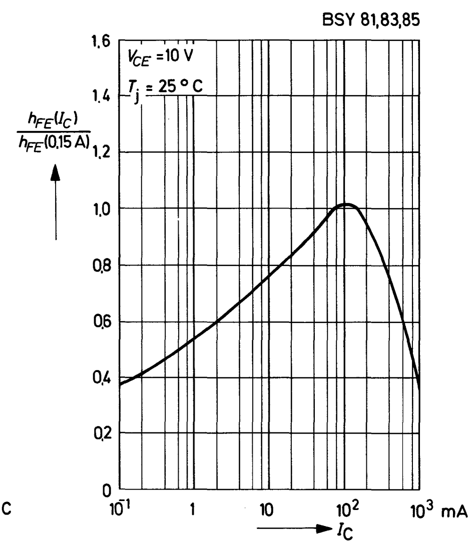


Collector cutoff current versus junction temperature

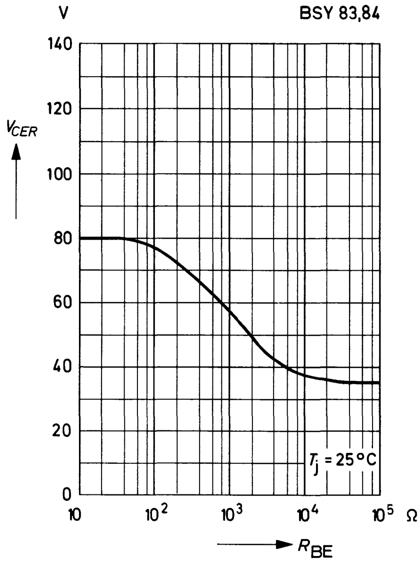


– – – – upper limit, valid for 95 % of a lot

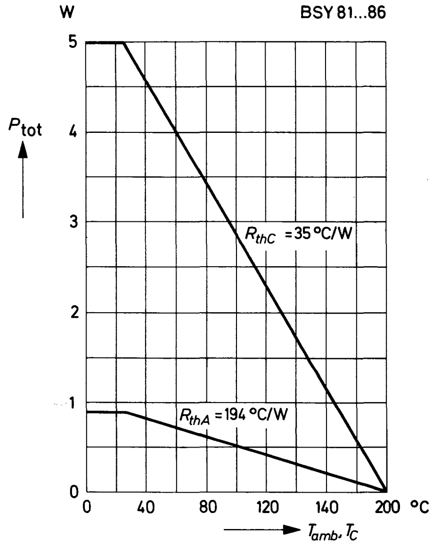
Relative DC current gain versus collector current



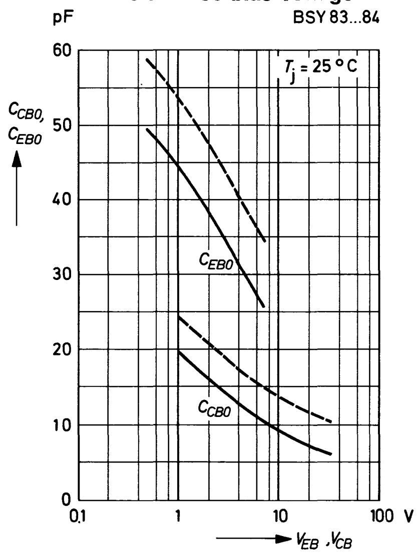
Admissible collector emitter voltage versus base emitter resistance



Admissible power dissipation versus temperature

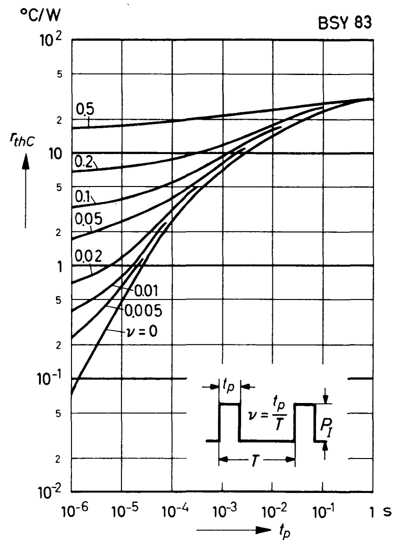


Collector emitter capacitance, Emitter base capacitance versus reverse bias voltage



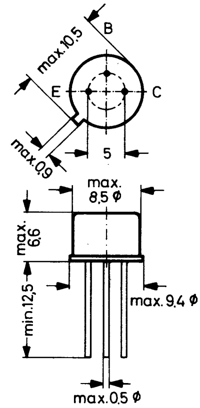
– – – – upper limit, valid for 95 % of a lot

Pulse thermal resistance versus pulse duration



BSY 84

NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications
at higher collector current



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.3 g
Dimensions in mm

Maximum Ratings

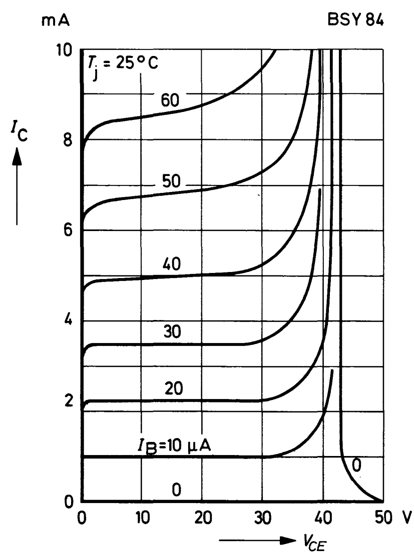
Collector base voltage	V_{CBO}	80	V
Collector emitter voltage	V_{CEO}	35	V
Emitter base voltage	V_{EBO}	7	V
Collector current	I_C	1	A
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.9	W
at T_C = 100 °C	P_{tot}	2.8	W
at T_C = 25 °C	P_{tot}	5	W
Junction temperature	T_j	200	°C

Characteristics at T_j = 25 °C

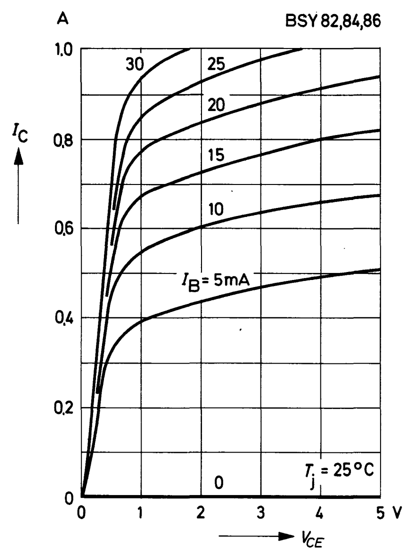
DC current gain			
at V_{CE} = 10 V, I_C = 0.1 mA	h_{FE}	60 (> 35)	
at V_{CE} = 10 V, I_C = 10 mA	h_{FE}	140 (> 75)	
at V_{CE} = 10 V, I_C = 150 mA	h_{FE}	190 (100 . . . 300)	
at V_{CE} = 10 V, I_C = 500 mA	h_{FE}	120 (> 40)	
at V_{CE} = 10 V, I_C = 1000 mA	h_{FE}	50 (> 20)	
Collector saturation voltage			
at I_C = 0.15 A, I_B = 0.015 A	$V_{CE\,sat}$	< 0.25	V
at I_C = 0.5 A, I_B = 0.05 A	$V_{CE\,sat}$	< 0.6	V
at I_C = 1 A, I_B = 0.1 A	$V_{CE\,sat}$	< 1	V
Base saturation voltage at I_C = 1 A, I_B = 0.1 A	$V_{BE\,sat}$	< 1.8	V
Collector cutoff current			
at V_{CB} = 60 V	I_{CBO}	0.6 (< 10)	nA
at V_{CB} = 60 V, T_{amb} = 150 °C	I_{CBO}	0.3 (< 10)	µA

Emitter cutoff current at $V_{EB} = 3$ V	I_{EBO}	5 (< 10)	nA
Collector base capacitance at $V_{CBO} = 10$ V	C_{CBO}	8.5 (< 15)	pF
Emitter base capacitance at $V_{EBO} = 0.5$ V	C_{EBO}	50 (< 60)	pF
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	120	MHz
Thermal resistance Junction to ambient air Junction to case	 $R_{th\,A}$ $R_{th\,C}$	 < 194 < 35	 °C/W °C/W

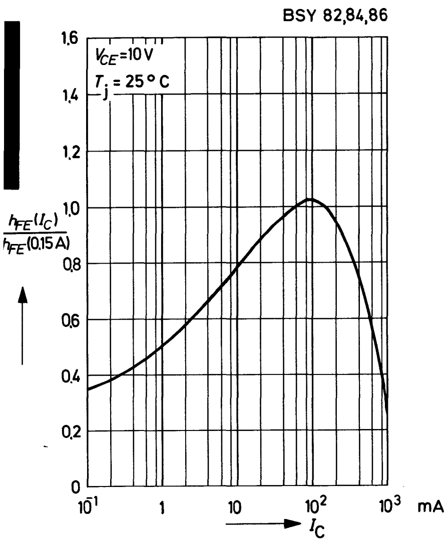
Common emitter collector characteristics



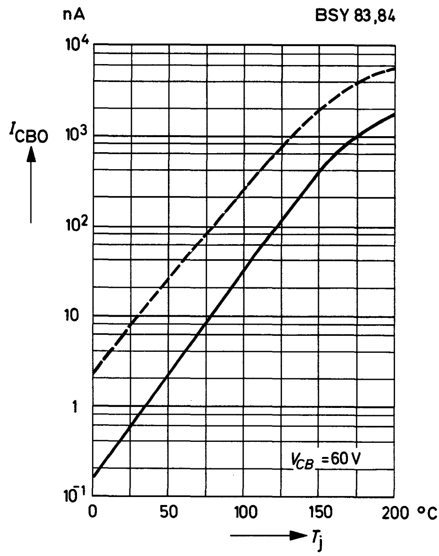
Common emitter collector characteristics



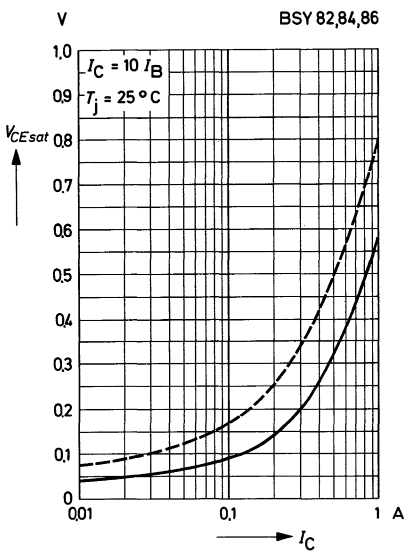
Relative DC current gain versus collector current



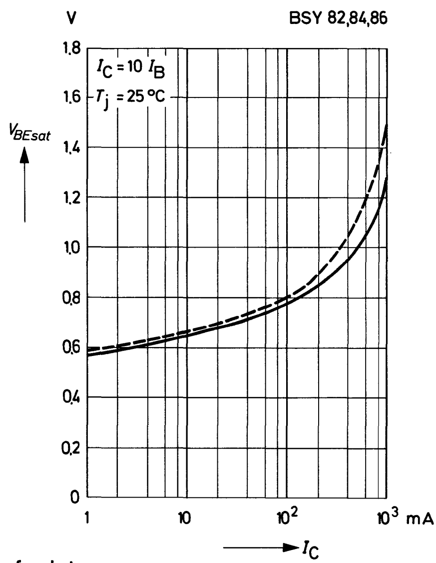
Collector cutoff current versus junction temperature



Collector saturation voltage versus collector current

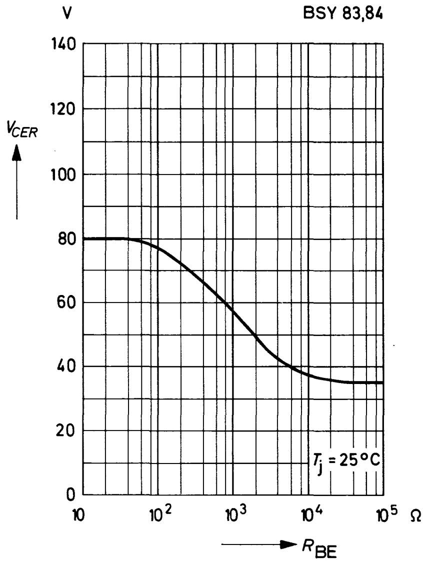


Base saturation voltage versus collector current

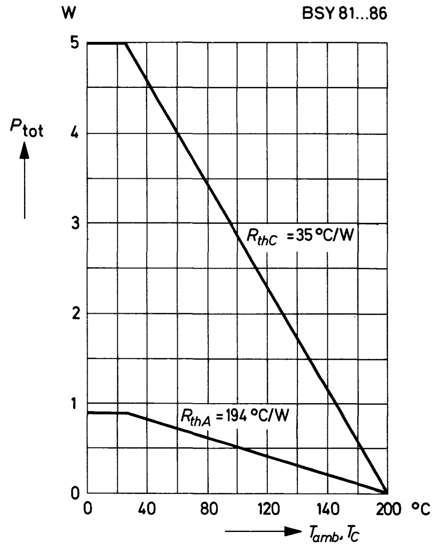


– – – – upper limit, valid for 95 % of a lot

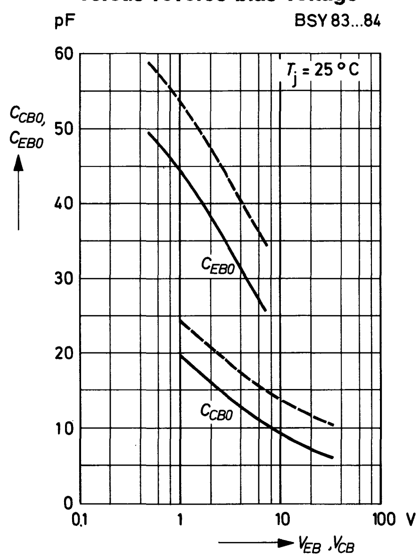
Admissible collector emitter voltage versus base emitter resistance



Admissible power dissipation versus temperature

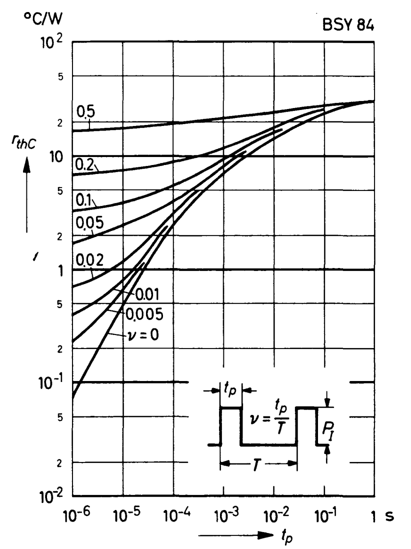


Collector base capacitance, Emitter base capacitance versus reverse bias voltage



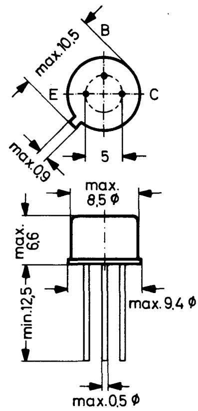
– – – – upper limit, valid for 95 % of a lot

Pulse thermal resistance versus pulse duration



BSY 85 ≈ 2 N 2193 A

NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications
at higher collector current



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.3 g
Dimensions in mm

Maximum Ratings

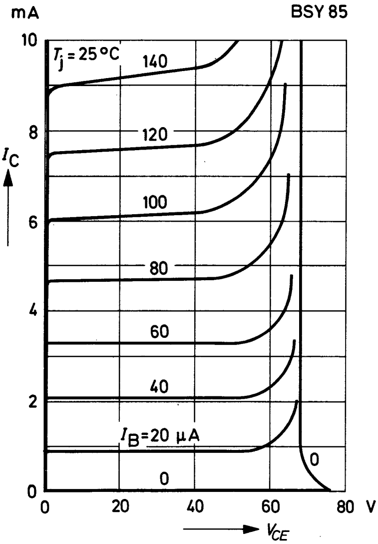
Collector base voltage	V_{CBO}	120	V
Collector emitter voltage	V_{CEO}	64	V
Emitter base voltage	V_{EBO}	7	V
Collector current	I_C	1	A
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.9	W
at T_C = 100 °C	P_{tot}	2.8	W
at T_C = 25 °C	P_{tot}	5	W
Junction temperature	T_j	200	°C

Characteristics at $T_j = 25$ °C

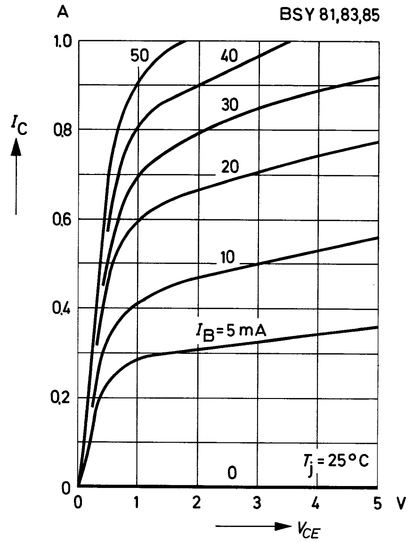
DC current gain			
at V_{CE} = 10 V, I_C = 0.1 mA	h_{FE}	30 (> 20)	
at V_{CE} = 10 V, I_C = 10 mA	h_{FE}	65 (> 35)	
at V_{CE} = 10 V, I_C = 150 mA	h_{FE}	85 (40 . . . 120)	
at V_{CE} = 10 V, I_C = 500 mA	h_{FE}	60 (> 30)	
at V_{CE} = 10 V, I_C = 1000 mA	h_{FE}	30 (> 15)	
Collector saturation voltage			
at I_C = 0.15 A, I_B = 0.015 A	$V_{CE\,sat}$	< 0.25	V
at I_C = 0.5 A, I_B = 0.05 A	$V_{CE\,sat}$	< 0.6	V
at I_C = 1 A, I_B = 0.1 A	$V_{CE\,sat}$	< 1	V
Base saturation voltage at I_C = 1 A, I_B = 0.1 A	$V_{BE\,sat}$	< 1.8	V
Collector cutoff current			
at V_{CB} = 90 V	I_{CBO}	0.6 (< 10)	nA
at V_{CB} = 90 V, T_{amb} = 150 °C	I_{CBO}	0.3 (< 10)	µA

Emitter cutoff current at $V_{EB} = 3$ V	I_{EBO}	5 (< 10)	nA
Collector base capacitance at $V_{CBO} = 10$ V	C_{CBO}	8.5 (< 15)	pF
Emitter base capacitance at $V_{EBO} = 0.5$ V	C_{EBO}	50 (< 60)	pF
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	110	MHz
Thermal resistance			
Junction to ambient air	$R_{th\,A}$	< 194	°C/W
Junction to case	$R_{th\,C}$	< 35	°C/W

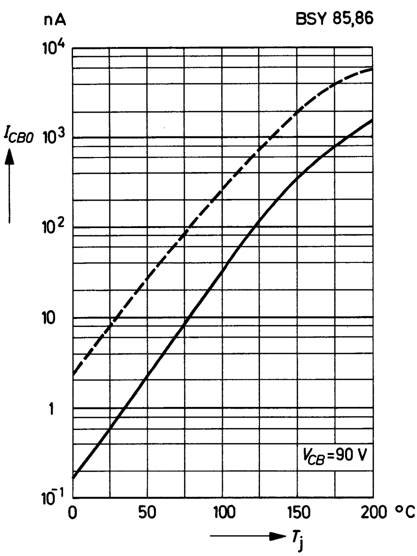
Common emitter collector characteristics



Common emitter collector characteristics

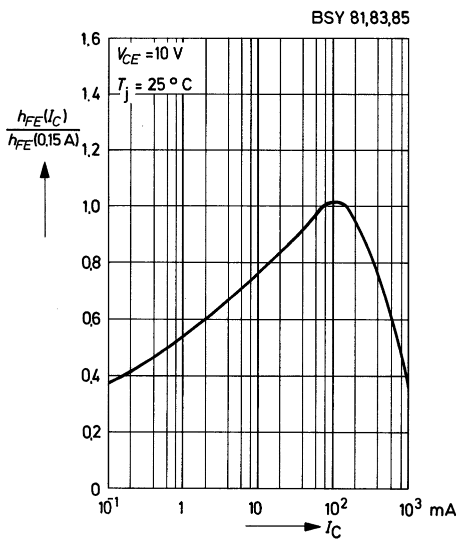


Collector cutoff current versus junction temperature

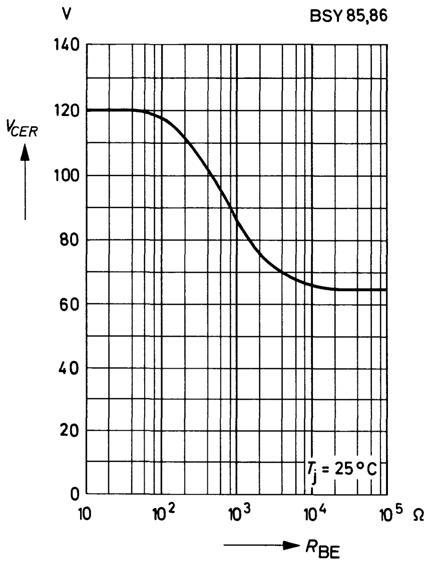


– – – – upper limit, valid for 95 % of a lot

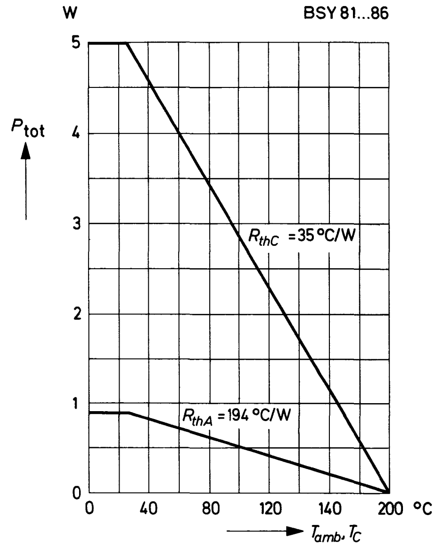
Relative DC current gain versus collector current



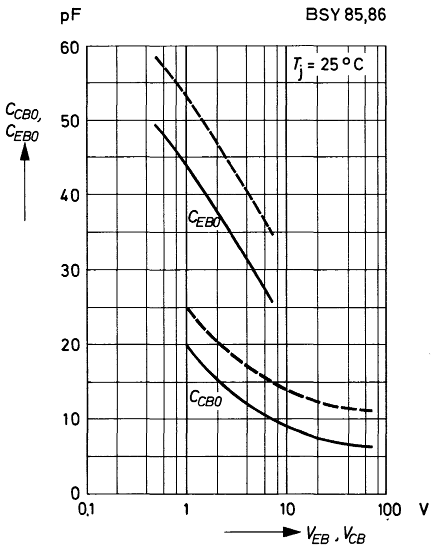
Admissible collector emitter voltage versus base emitter resistance



Admissible power dissipation versus temperature

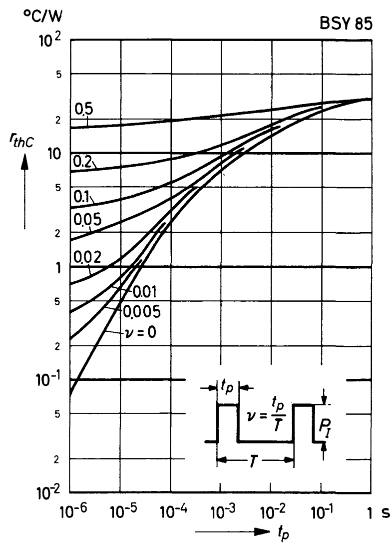


Collector base capacitance, Emitter base capacitance versus reverse bias voltage



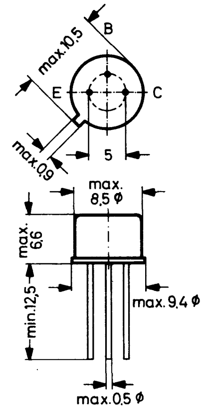
– – – – upper limit, valid for 95 % of a lot

Pulse thermal resistance versus pulse duration



BSY 86

NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications
at higher collector current



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.3 g
Dimensions in mm

Maximum Ratings

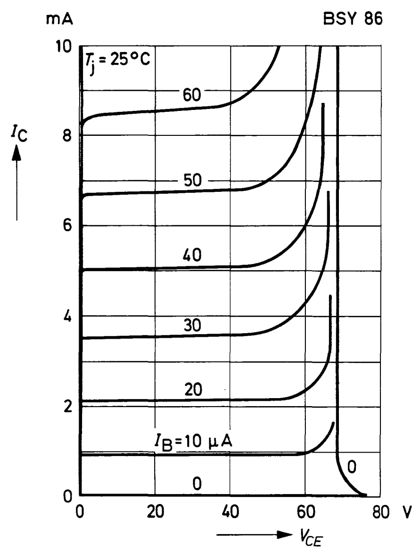
Collector base voltage	V_{CBO}	120	V
Collector emitter voltage	V_{CEO}	64	V
Emitter base voltage	V_{EBO}	7	V
Collector current	I_C	1	A
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.9	W
at T_C = 100 °C	P_{tot}	2.8	W
at T_C = 25 °C	P_{tot}	5	W
Junction temperature	T_j	200	°C

Characteristics at T_j = 25 °C

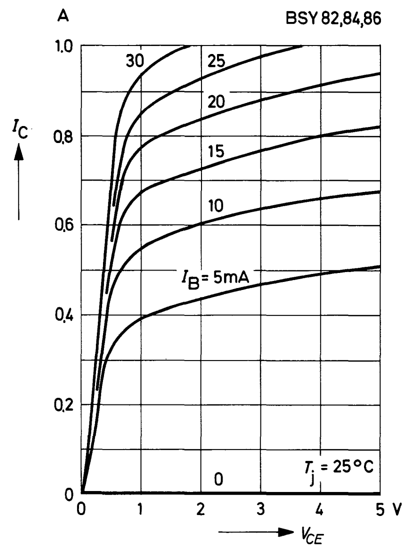
DC current gain			
at V_{CE} = 10 V, I_C = 0.1 mA	h_{FE}	60 (> 35)	
at V_{CE} = 10 V, I_C = 10 mA	h_{FE}	140 (> 75)	
at V_{CE} = 10 V, I_C = 150 mA	h_{FE}	190 (100 . . . 300)	
at V_{CE} = 10 V, I_C = 500 mA	h_{FE}	120 (> 40)	
at V_{CE} = 10 V, I_C = 1000 mA	h_{FE}	50 (> 20)	
Collector saturation voltage			
at I_C = 0.15 A, I_B = 0.015 A	$V_{CE\,sat}$	< 0.25	V
at I_C = 0.5 A, I_B = 0.05 A	$V_{CE\,sat}$	< 0.6	V
at I_C = 1 A, I_B = 0.1 A	$V_{CE\,sat}$	< 1	V
Base saturation voltage	$V_{BE\,sat}$	< 1.8	V
at I_C = 1 A, I_B = 0.1 A			
Collector cutoff current			
at V_{CB} = 90 V	I_{CBO}	0.6 (< 10)	nA
at V_{CB} = 90 V, T_{amb} = 150 °C	I_{CBO}	0.3 (< 10)	µA

Emitter cutoff current at $V_{EB} = 3$ V	I_{EBO}	5 (< 10)	nA
Collector base capacitance at $V_{CBO} = 10$ V	C_{CBO}	8.5 (< 15)	pF
Emitter base capacitance at $V_{EBO} = 0.5$ V	C_{EBO}	50 (< 60)	pF
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	130	MHz
Thermal resistance Junction to ambient air Junction to case	 R_{thA} R_{thC}	 < 194 < 35	 °C/W °C/W

Common emitter collector characteristics

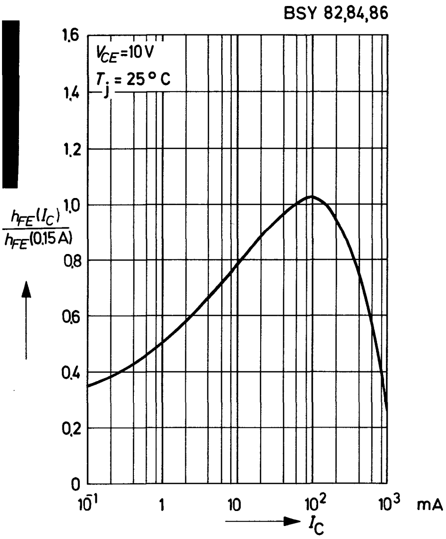


Common emitter collector characteristics

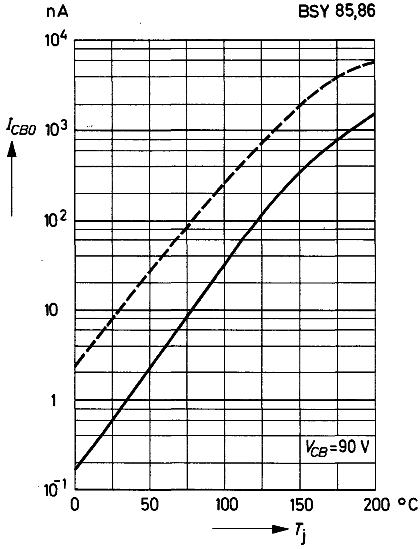


BSY 86

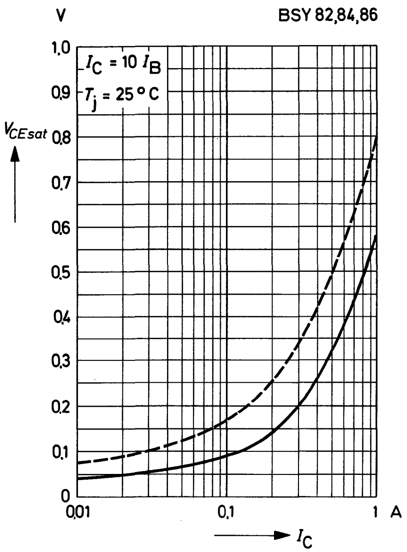
Relative DC current gain versus collector current



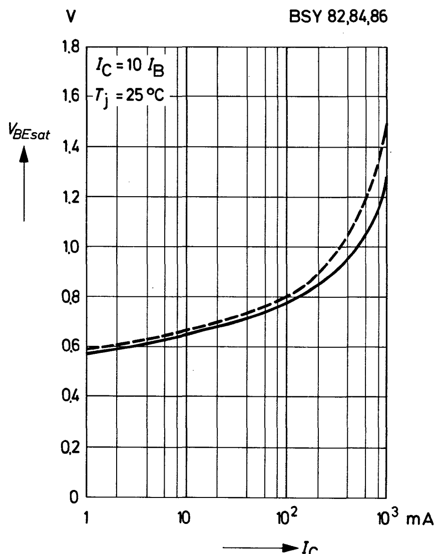
Collector cutoff current versus junction temperature



Collector saturation voltage versus collector current

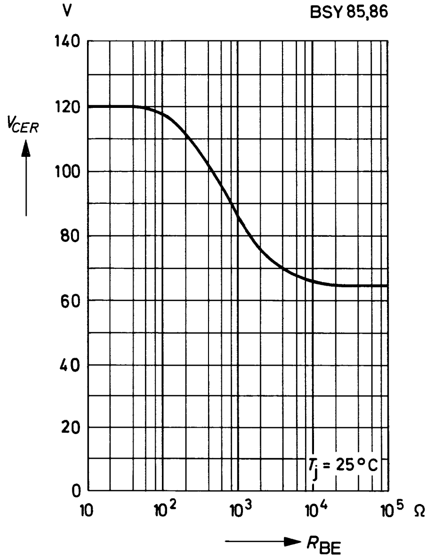


Base saturation voltage versus collector current

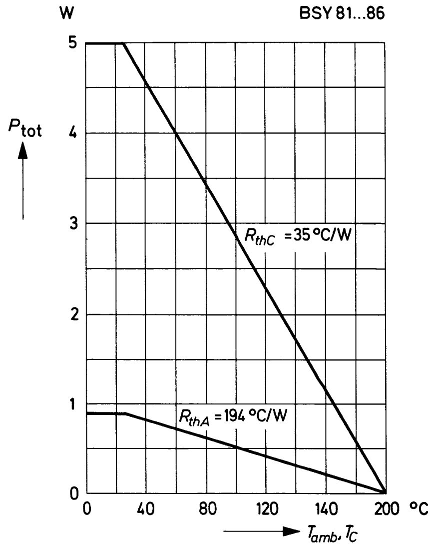


– – – – upper limit, valid for 95 % of a lot

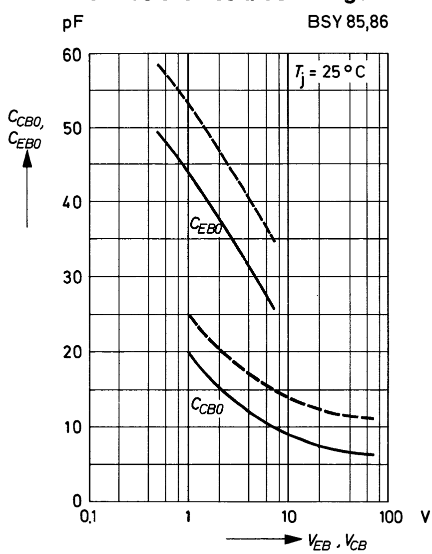
Admissible collector emitter voltage versus base emitter resistance



Admissible power dissipation versus temperature

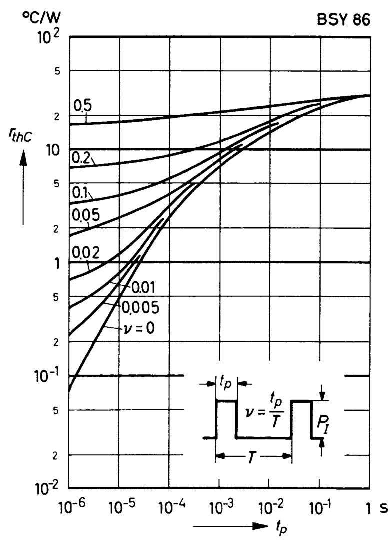


Collector base capacitance, Emitter base capacitance versus reverse bias voltage



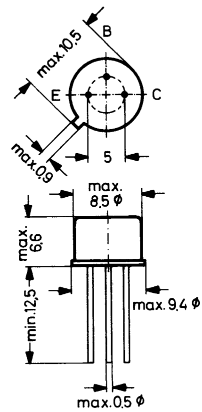
– – – – upper limit, valid for 95 % of a lot

Pulse thermal resistance versus pulse duration



BSY 87 ≈ 2 N 1889

NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CB0}	100	V
Collector emitter voltage	V_{CE0}	60	V
Emitter base voltage	V_{EB0}	7	V
Collector current	I_C	500	mA
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.8	W
at T_C = 100 °C	P_{tot}	1.7	W
at T_C = 25 °C	P_{tot}	3	W
Junction temperature	T_j	200	°C

Characteristics at $T_j = 25$ °C

DC current gain			
at $V_{CE} = 10$ V, $I_C = 0.1$ mA	h_{FE}	50 (> 20)	
at $V_{CE} = 10$ V, $I_C = 1$ mA	h_{FE}	60	
at $V_{CE} = 10$ V, $I_C = 10$ mA	h_{FE}	65 (> 35)	
at $V_{CE} = 10$ V, $I_C = 150$ mA	h_{FE}	40 . . . 120	
at $V_{CE} = 10$ V, $I_C = 500$ mA	h_{FE}	20	
Collector saturation voltage at $I_C = 150$ mA, $I_B = 15$ mA	$V_{CE\,sat}$	0.2 (< 0.6)	V
Base saturation voltage at $I_C = 150$ mA, $I_B = 15$ mA	$V_{BE\,sat}$	0.95 (< 1.2)	V
Collector cutoff current			
at $V_{CB} = 75$ V	I_{CB0}	0.5 (< 10)	nA
at $V_{CB} = 75$ V, $T_{amb} = 150$ °C	I_{CB0}	0.4 (< 10)	µA
Emitter cutoff current at $V_{EB} = 5$ V	I_{EB0}	1 (< 10)	nA

Collector base capacitance at $V_{CB0} = 10$ V	C_{CB0}	5.5 (< 10)	pF
Emitter base capacitance at $V_{EB0} = 0.5$ V	C_{EB0}	23 (< 33)	pF
Thermal resistance			
Junction to ambient air	R_{thA}	< 220	°C/W
Junction to case	R_{thC}	< 58	°C/W

Small Signal Characteristics at $T_{amb} = 25$ °C and $f = 1$ kHz

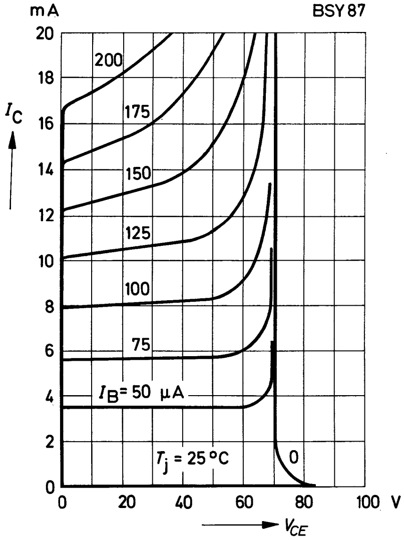
Test conditions: $V_{CE} = 5$ V, $I_C = 1$ mA, grounded emitter

Input impedance	h_{ie}	1.8 (0.8 . . . 5)	kΩ
Reserve voltage transfer ratio	h_{re}	$0.7\ (< 3) \cdot 10^{-4}$	
Small signal current gain	h_{fe}	75 (30 . . . 150)	
Output admittance	h_{oe}	6 (3 . . . 10)	µmho
Noise figure at $V_{CE} = 10$ V, $I_C = 0.3$ mA, $R_G = 1.5$ kΩ, Bandwidth 30 Hz . . . 15 kHz	F	6	dB
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	100	MHz

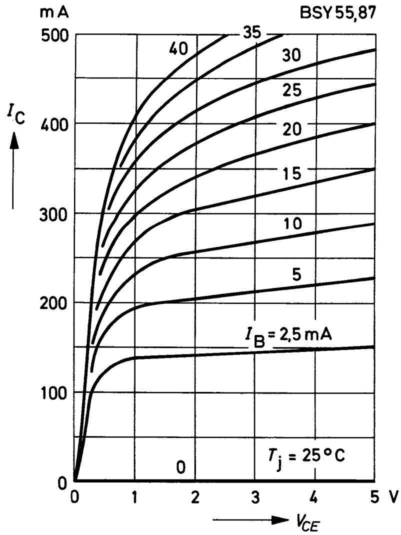
Switching Times

Specifications for switching times of type BSY 51 apply to this type.

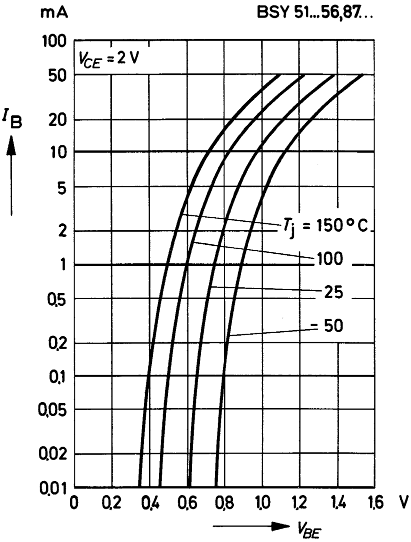
Common emitter collector characteristics



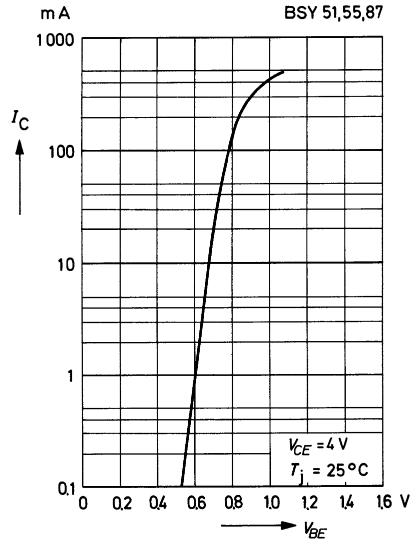
Common emitter collector characteristics



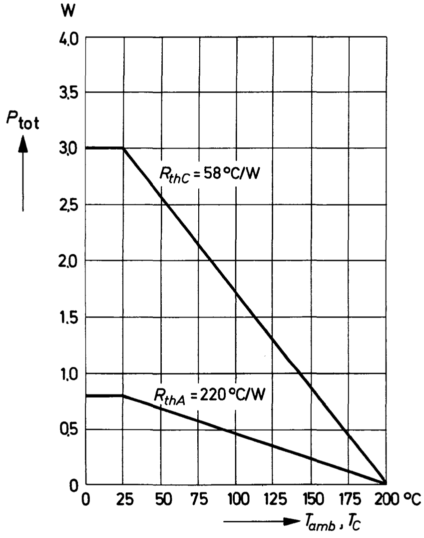
Common emitter input characteristics



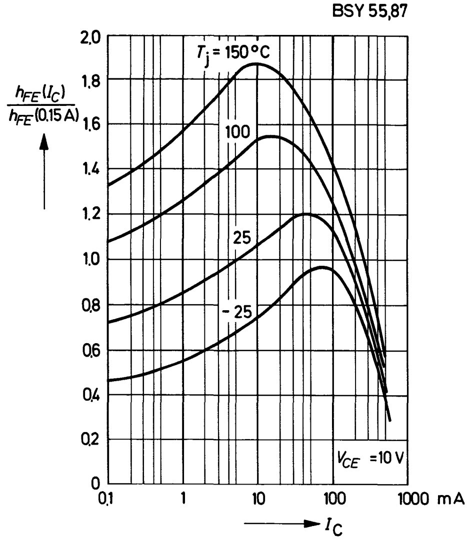
Collector current versus base emitter voltage



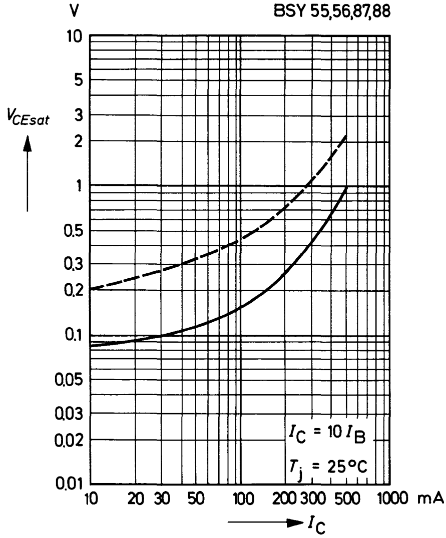
Admissible power dissipation versus temperature



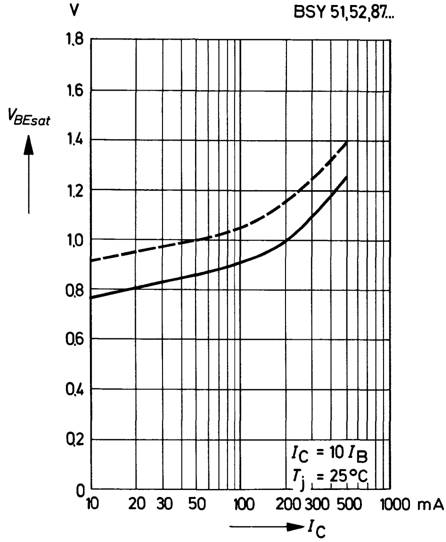
Relative DC current gain versus collector current



Collector saturation voltage versus collector current

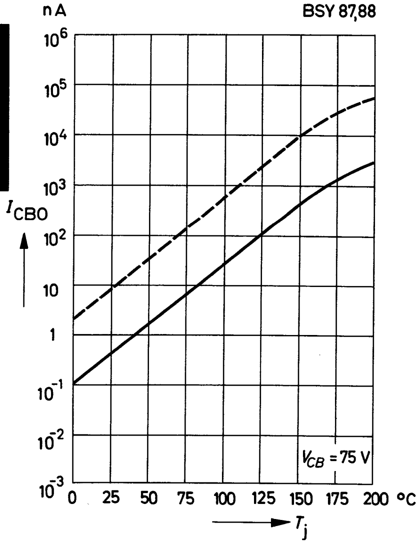


Base saturation voltage versus collector current

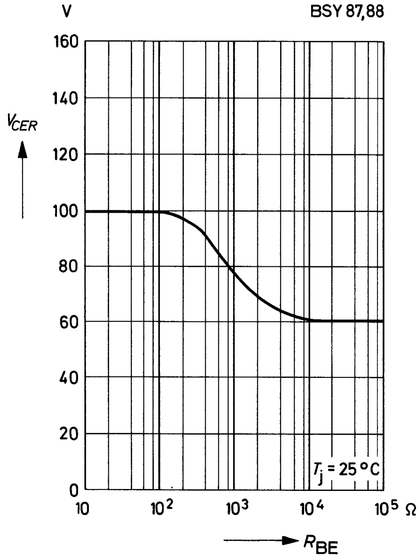


– – – – upper limit, valid for 95 % of a lot

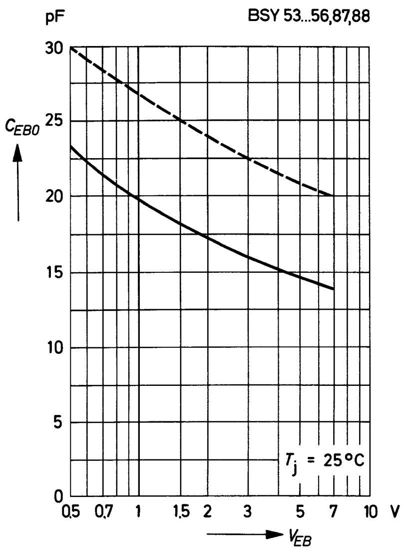
Collector cutoff current versus junction temperature



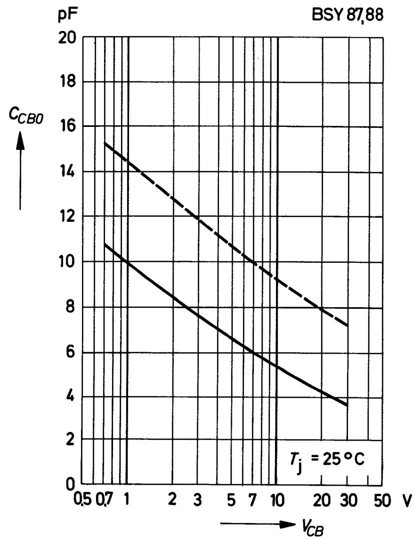
Admissible collector emitter voltage versus base emitter resistance



Emitter base capacitance versus emitter base voltage

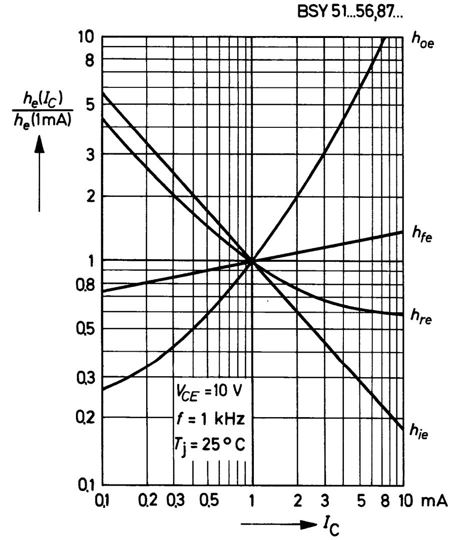


Collector base capacitance versus collector base voltage

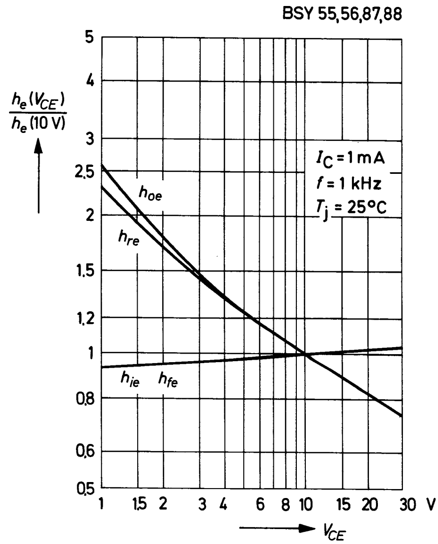


– – – – upper limit, valid for 95 % of a lot

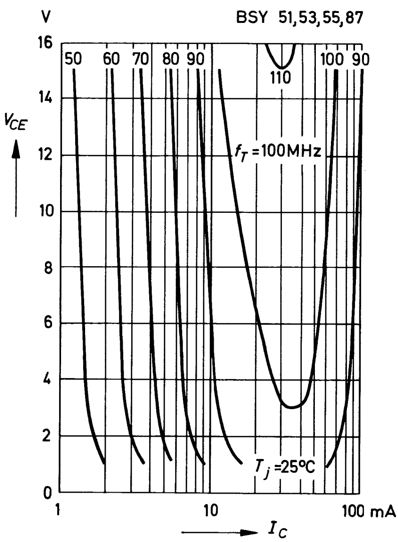
Relative h-parameters versus collector current



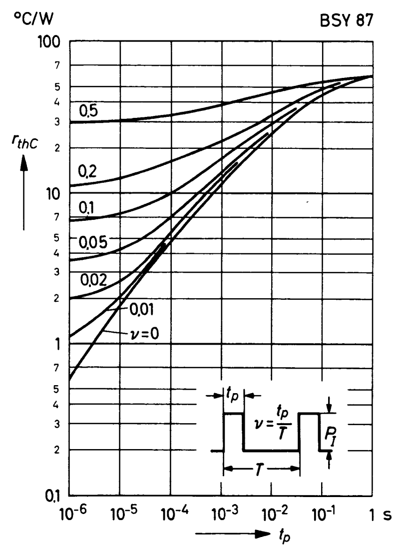
Relative h-parameters versus collector emitter voltage



Contours of constant gain bandwidth product

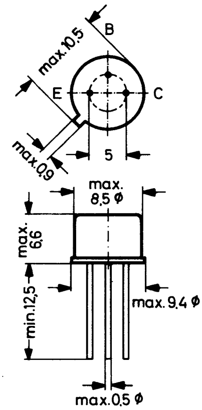


Pulse thermal resistance versus pulse duration



BSY 88 ≈ 2 N 1890

NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	100	V
Collector emitter voltage	V_{CEO}	60	V
Emitter base voltage	V_{EBO}	7	V
Collector current	I_C	500	mA
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.8	W
at T_C = 100 °C	P_{tot}	1.7	W
at T_C = 25 °C	P_{tot}	3	W
Junction temperature	T_j	200	°C

Characteristics at T_j = 25 °C

DC current gain			
at V_{CE} = 10 V, I_C = 0.1 mA	h_{FE}	100 (> 35)	
at V_{CE} = 10 V, I_C = 1 mA	h_{FE}	125	
at V_{CE} = 10 V, I_C = 10 mA	h_{FE}	180 (> 75)	
at V_{CE} = 10 V, I_C = 150 mA	h_{FE}	100 ... 300	
at V_{CE} = 10 V, I_C = 500 mA	h_{FE}	35	
Collector saturation voltage at I_C = 150 mA, I_B = 15 mA	$V_{CE\,sat}$	0.2 (< 0.6)	V
Base saturation voltage at I_C = 150 mA, I_B = 15 mA	$V_{BE\,sat}$	0.95 (< 1.2)	V
Collector cutoff current			
at V_{CB} = 75 V	I_{CBO}	0.5 (< 10)	nA
at V_{CB} = 75 V, T_{amb} = 150 °C	I_{CBO}	0.4 (< 10)	µA
Emitter cutoff current at V_{EB} = 5 V	I_{EBO}	1 (< 10)	nA

Collector base capacitance at $V_{CBO} = 10$ V	C_{CBO}	5.5 (< 10)	pF
Emitter base capacitance at $V_{EBO} = 0.5$ V	C_{EBO}	23 (< 33)	pF
Thermal resistance Junction to ambient air Junction to case	 R_{thA} R_{thC}	 < 220 < 58	 °C/W °C/W

Small Signal Characteristics at $T_{amb} = 25$ °C and $f = 1$ kHz

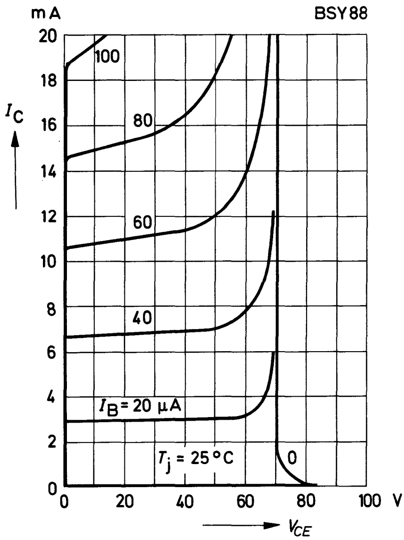
Test conditions: $V_{CE} = 5$ V, $I_C = 1$ mA, grounded emitter

Input impedance	h_{ie}	3.5 (2 . . . 9.5)	kΩ
Reverse voltage transfer ratio	h_{re}	$0.7 (< 3) \cdot 10^{-4}$	
Small signal current gain	h_{fe}	150 (60 . . . 280)	
Output admittance	h_{oe}	6 (3 . . . 10)	μmho
Noise figure at $V_{CE} = 10$ V, $I_C = 0.3$ mA, $R_G = 1.5$ kΩ, Bandwidth 30 Hz . . . 15 kHz	F	6	dB
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA, $f = 50$ MHz	f_T	145	MHz

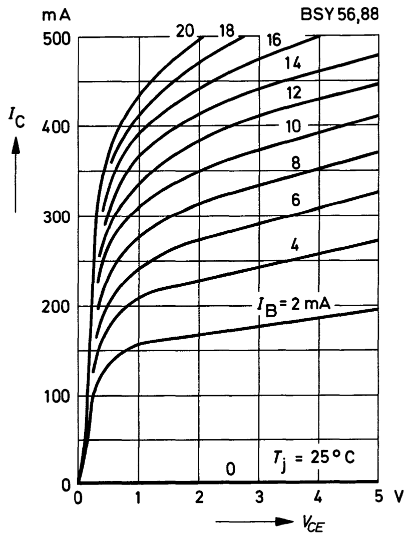
Switching Times

Specifications for switching times of type BSY 51 apply to this type.

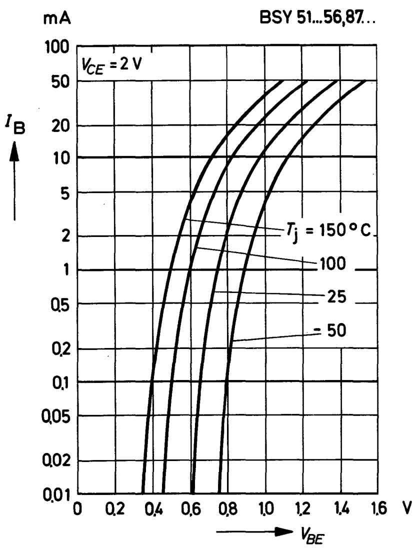
Common emitter collector characteristics



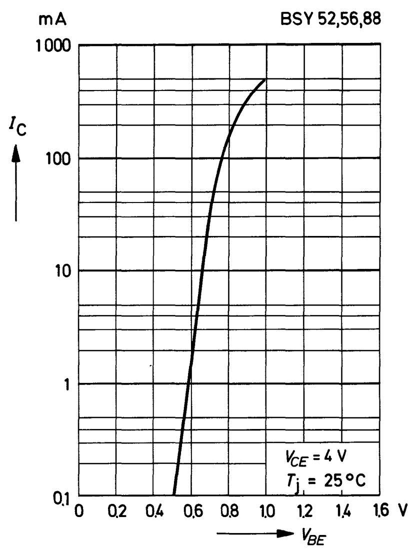
Common emitter collector characteristics



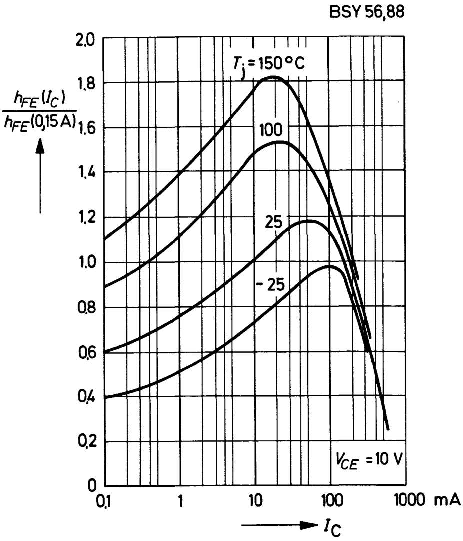
Common emitter input characteristics



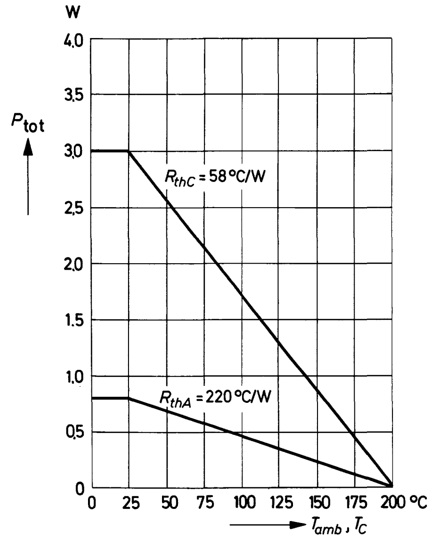
Collector current versus base emitter voltage



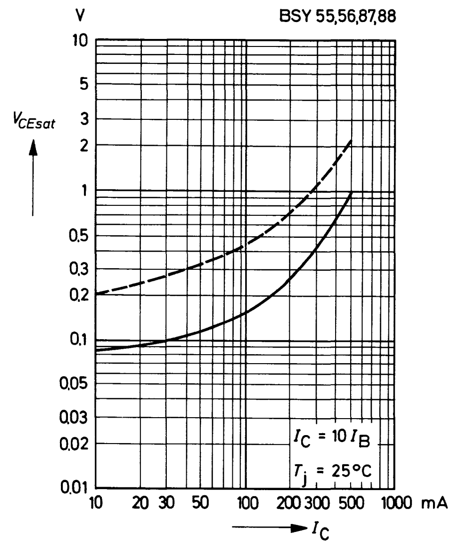
Relative DC current gain versus collector current



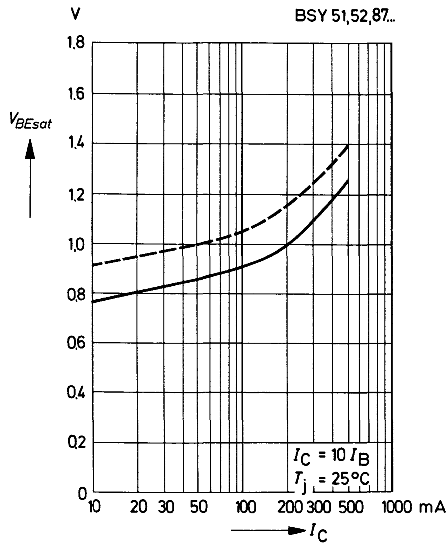
Admissible power dissipation versus temperature



Collector saturation voltage versus collector current

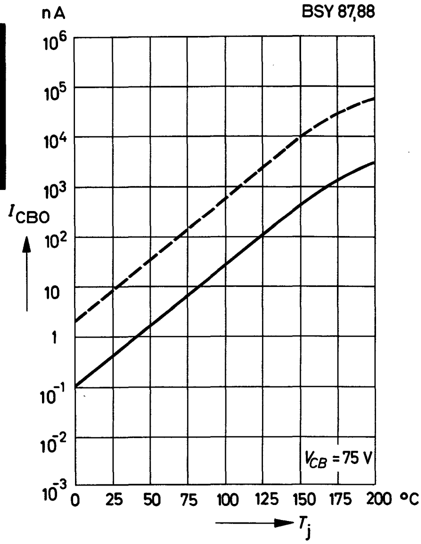


Base saturation voltage versus collector current

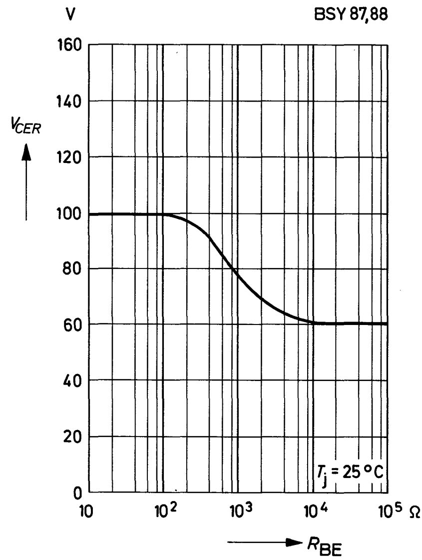


– – – – upper limit, valid for 95 % of a lot

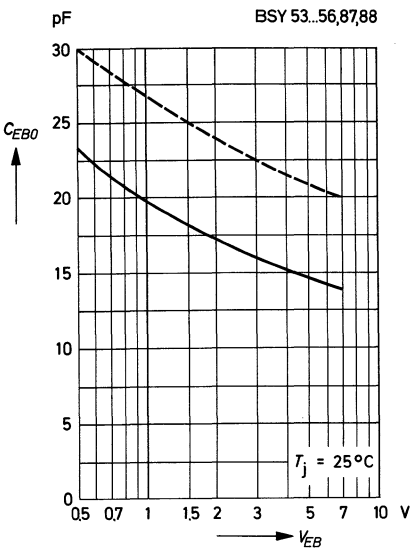
Collector cutoff current versus junction temperature



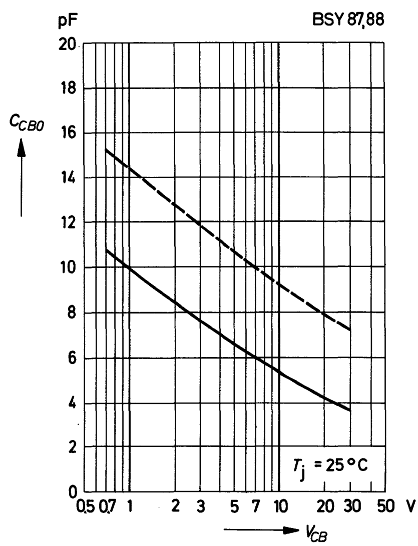
Admissible collector emitter voltage versus base emitter resistor



Emitter base capacitance versus emitter base voltage

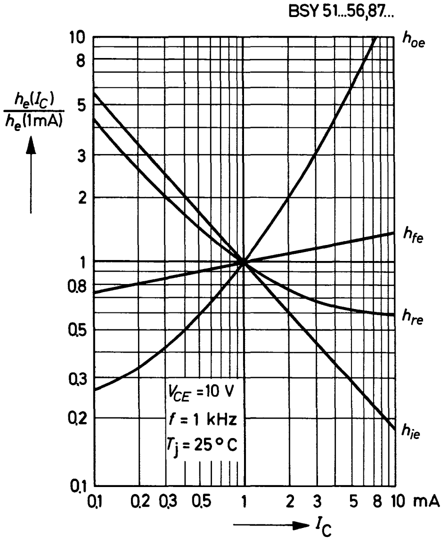


Collector base capacitance versus collector base voltage

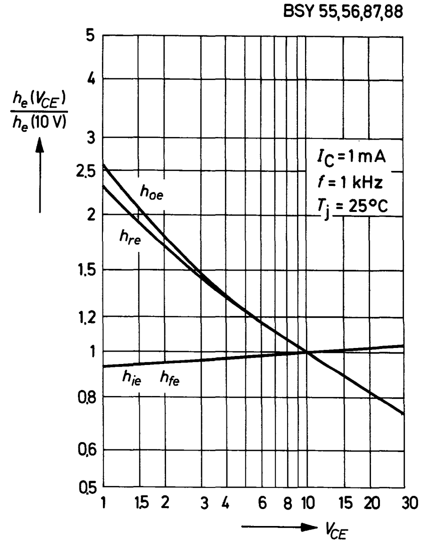


– – – – upper limit, valid for 95 % of a lot

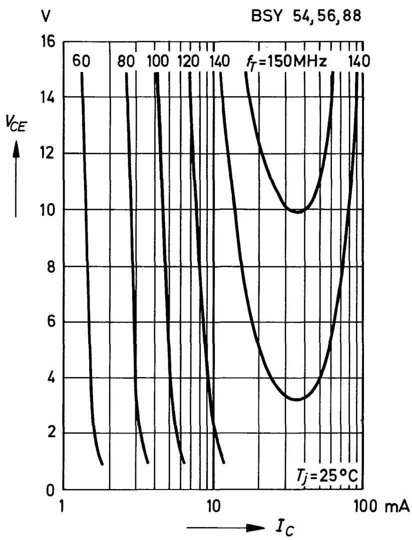
Relative *h*-parameters versus collector current



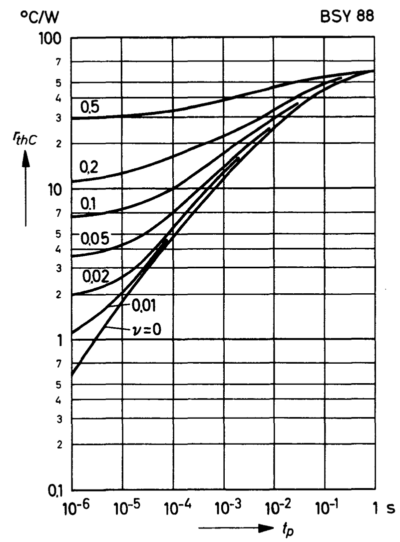
Relative *h*-parameters versus collector emitter voltage



Contours of constant gain bandwidth product

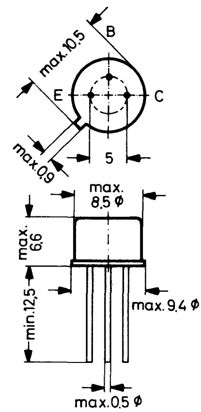


Pulse thermal resistance versus pulse duration



BSY 90

NPN Silicon Epitaxial Transistor
for switching and amplifier applications



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	60	V
Collector emitter voltage	V_{CEO}	25	V
Emitter base voltage	V_{EBO}	5	V
Collector current	I_C	500	mA
Power dissipation			
at $T_{amb} = 25\ °C$	P_{tot}	0.8	W
at $T_C = 100\ °C$	P_{tot}	1.7	W
at $T_C = 25\ °C$	P_{tot}	3	W
Junction temperature	T_j	200	°C

Characteristics at $T_j = 25\ °C$

DC current gain			
at $V_{CE} = 10$ V, $I_C = 0.01$ mA	h_{FE}	125	
at $V_{CE} = 10$ V, $I_C = 0.1$ mA	h_{FE}	200 (> 100)	
at $V_{CE} = 10$ V, $I_C = 1$ mA	h_{FE}	300	
at $V_{CE} = 10$ V, $I_C = 10$ mA	h_{FE}	425 (> 140)	
at $V_{CE} = 10$ V, $I_C = 150$ mA	h_{FE}	375 (> 250)	
Collector saturation voltage at $I_C = 150$ mA, $I_B = 15$ mA	$V_{CE\,sat}$	0.14 (< 0.8)	V
Base saturation voltage at $I_C = 150$ mA, $I_B = 15$ mA	$V_{BE\,sat}$	0.95 (< 1.2)	V
Collector cutoff current			
at $V_{CB} = 30$ V	I_{CBO}	0.5 (< 10)	nA
at $V_{CB} = 30$ V, $T_{amb} = 150\ °C$	I_{CBO}	0.4 (< 10)	µA
Emitter cutoff current at $V_{EB} = 3$ V	I_{EBO}	1 (< 50)	nA

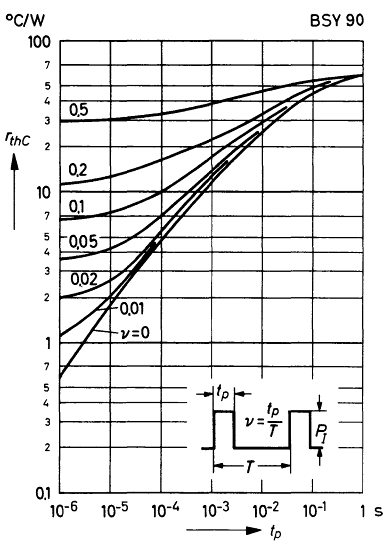
Collector base capacitance at V_{CBO} = 10 V	C_{CBO}	7.5 (< 10)	pF
Emitter base capacitance at V_{EBO} = 0.5 V	C_{EBO}	23 (< 33)	pF
Thermal resistance Junction to ambient air Junction to case	 R_{thA} R_{thC}	 < 220 < 58	 °C/W °C/W

Small Signal Characteristics at T_{amb} = 25 °C and f = 1 kHz

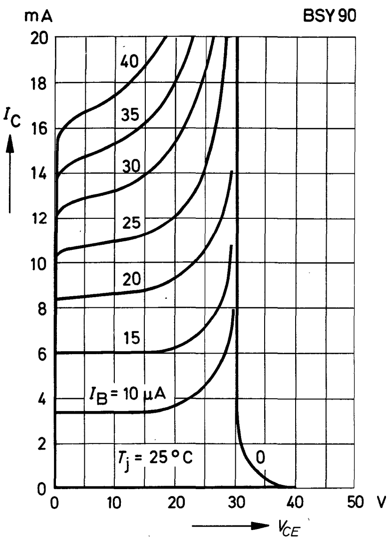
Test conditions: V_{CE} = 5 V, I_C = 1 mA, grounded emitter

Input impedance	h_{ie}	8 (4 . . . 15)	kΩ
Reverse voltage transfer ratio	h_{re}	1.5 (< 5) · 10^{-4}	
Small signal current gain	h_{fe}	350 (200 . . . 550)	
Output admittance	h_{oe}	10 (5 . . . 25)	µmho
Noise figure at V_{CE} = 10 V, I_C = 0.3 mA, R_G = 1.5 kΩ, Bandwidth 30 Hz . . . 15 kHz	F	2.5 (< 8)	dB
Gain bandwidth product at V_{CE} = 10 V, I_C = 50 mA, f = 50 MHz	f_T	170	MHz

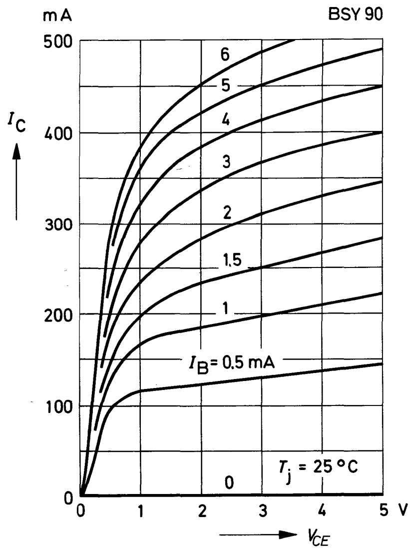
Pulse thermal resistance versus pulse duration



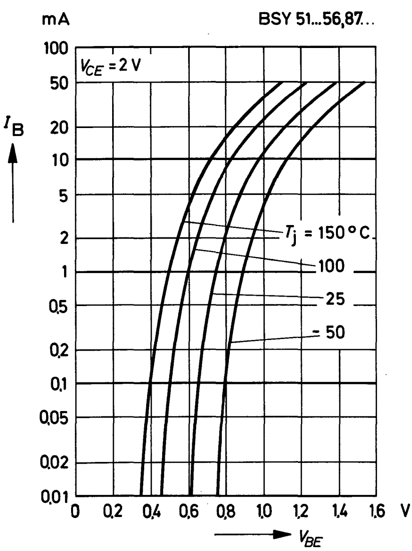
Common emitter collector characteristics



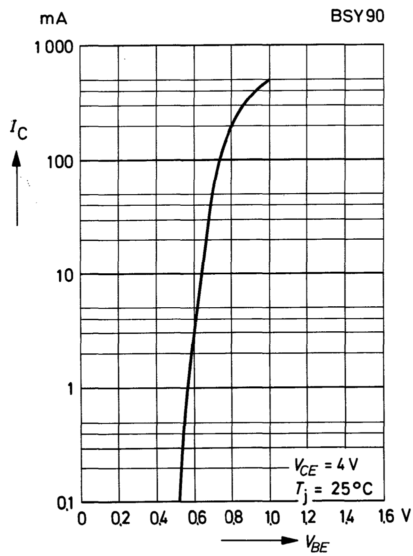
Common emitter collector characteristics



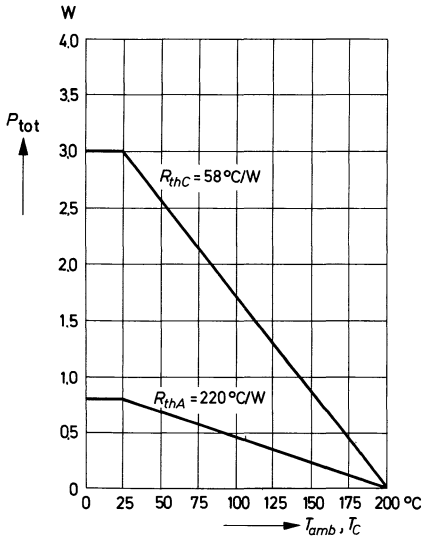
Common emitter input characteristics



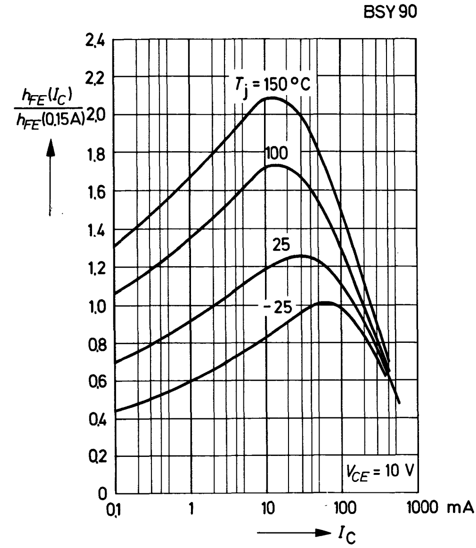
Collector current versus base emitter voltage



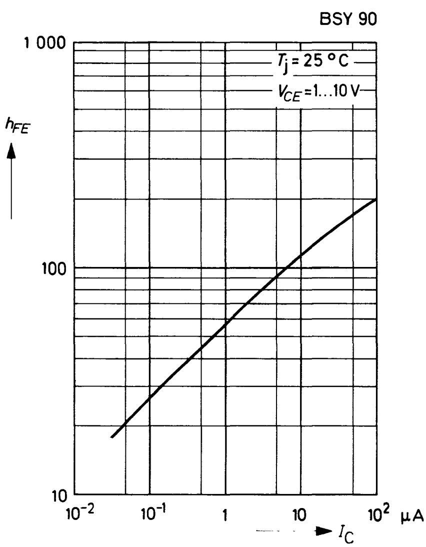
Admissible power dissipation versus temperature



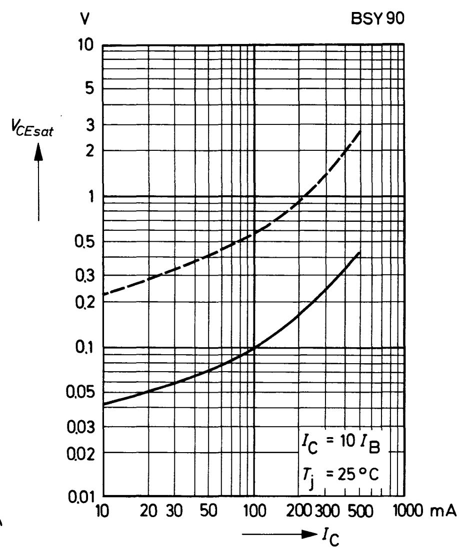
Relative DC current gain versus collector current



DC current gain versus small collector current

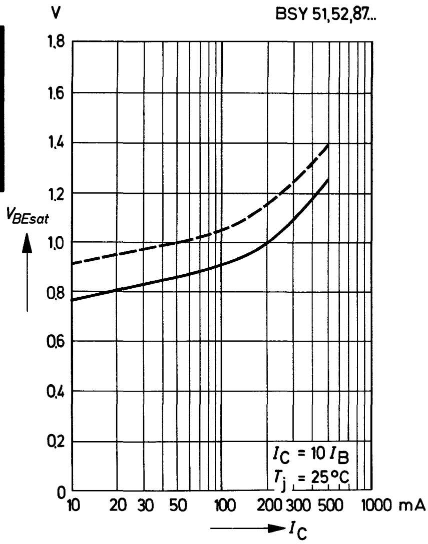


Collector saturation voltage versus collector current

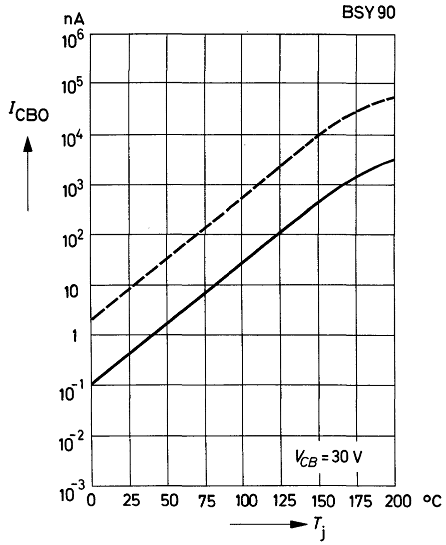


– – – – upper limit, valid for 95 % of a lot

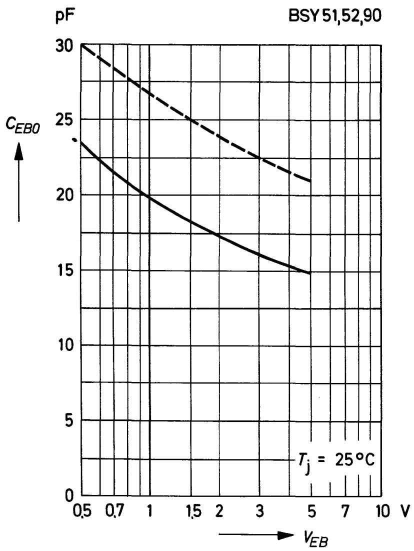
Base saturation voltage versus collector current



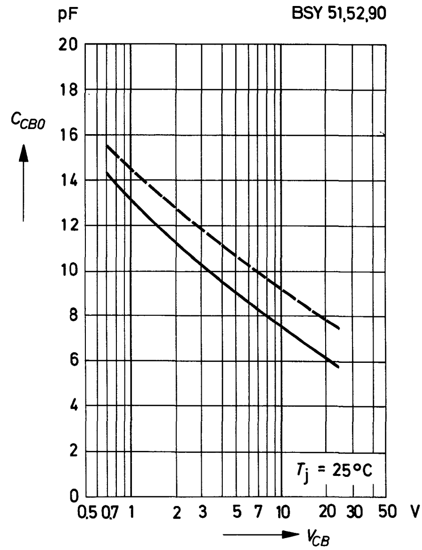
Collector cutoff current versus junction temperature



Emitter base capacitance versus emitter base voltage

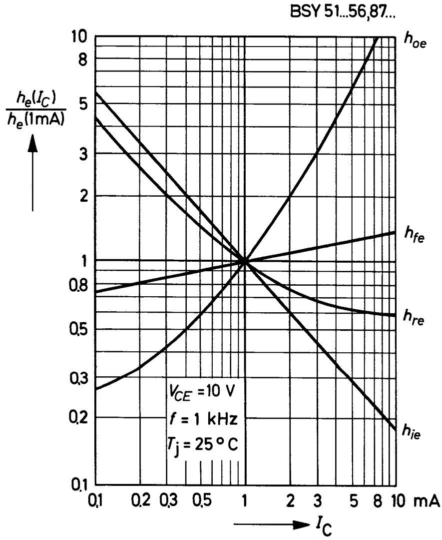


Collector base capacitance versus collector base voltage

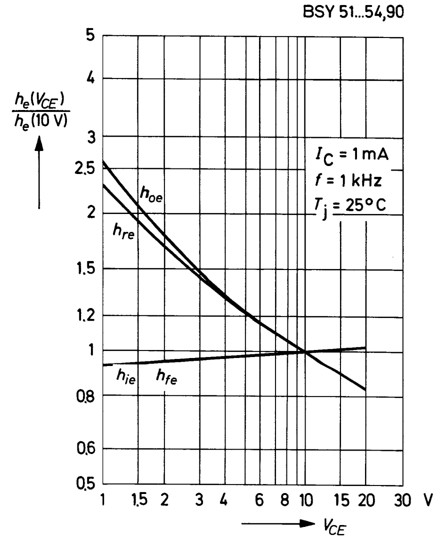


– – – – upper limit, valid for 95 % of a lot

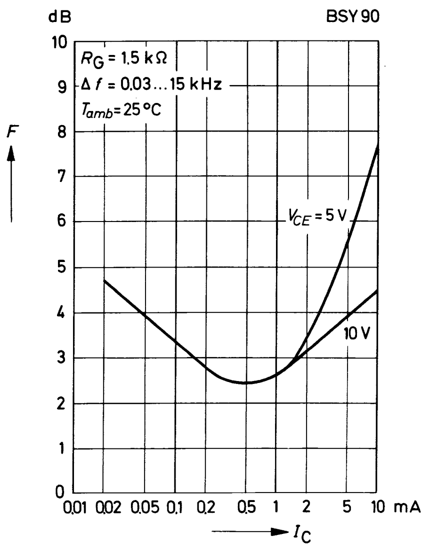
Relative *h*-parameters versus collector current



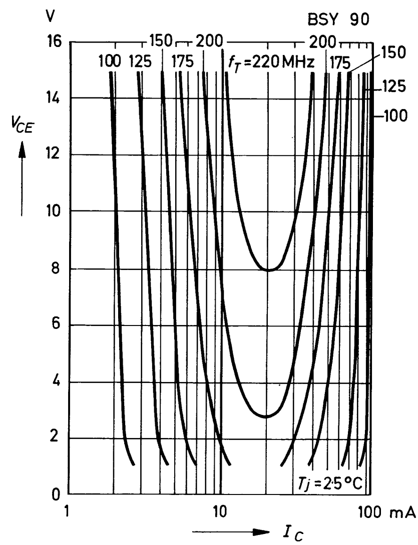
Relative *h*-parameters versus collector emitter voltage



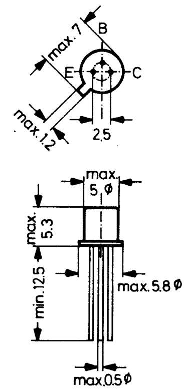
Noise figure versus collector current



Contours of constant gain bandwidth product



NPN Silicon Planar Transistor
for use in high-performance, low-level, low-noise amplifier circuits from audio through high frequency ranges



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	45	V
Collector emitter voltage	V_{CEO}	45	V
Emitter base voltage	V_{EBO}	5	V
Collector current	I_C	30	mA
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.3	W
at T_C = 25 °C	P_{tot}	0.6	W
Junction temperature	T_j	175	°C
Storage temperature range	T_S	– 65 ... + 300	°C

Static characteristics at $T_j = 25$ °C

DC current gain			
at $V_{CE} = 5$ V, $I_C = 10$ µA	h_{FE}	40 ... 120	
at $V_{CE} = 5$ V, $I_C = 0.5$ mA	h_{FE}	> 60	
at $V_{CE} = 5$ V, $I_C = 10$ mA	h_{FE}	< 350	
at $V_{CE} = 5$ V, $I_C = 10$ µA, $T_j = -55$ °C	h_{FE}	> 10	
Collector saturation voltage at $I_C = 10$ mA, $I_B = 0.5$ mA	$V_{CE\,sat}$	< 1	V
Base saturation voltage at $I_C = 10$ mA, $I_B = 0.5$ mA	$V_{BE\,sat}$	0.6 ... 1	V
Collector cutoff current			
at $V_{CB} = 45$ V	I_{CBO}	< 10	nA
at $V_{CE} = 5$ V	I_{CEO}	< 2	nA
at $V_{CE} = 45$ V, $V_{BE} = 0$	I_{CES}	< 10	nA

Emitter cutoff current at $V_{EB} = 5$ V	I_{EBO}	< 10	nA
Thermal resistance			
Junction to ambient air	R_{thA}	< 500	°C/W
Junction to case	R_{thC}	< 250	°C/W

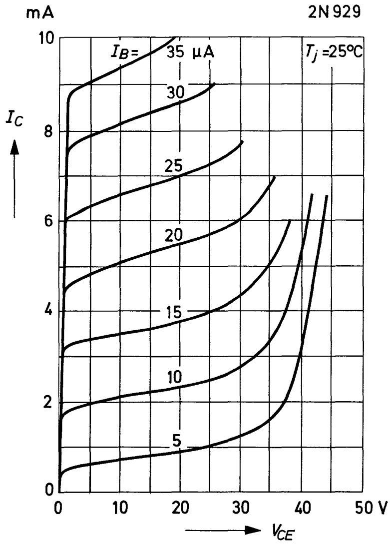
Dynamic characteristics at $T_{amb} = 25$ °C

Collector base capacitance at $V_{CB} = 5$ V, $f = 1$ MHz	C_{CBO}	< 8	pF
Gain bandwidth product at $V_{CE} = 5$ V, $I_C = 0.5$ mA	f_T	> 30	MHz

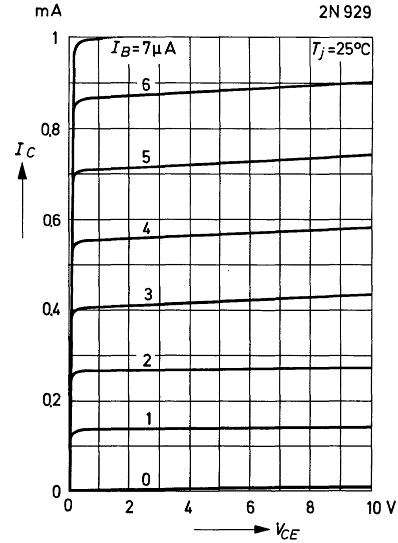
h-parameters, grounded base
Test conditions: $V_{CB} = 5$ V, $-I_E = 1$ mA, $f = 1$ kHz

Input impedance	h_{ib}	25 . . . 32	Ω
Reverse voltage transfer ratio	h_{rb}	$< 6 \cdot 10^{-4}$	
Output admittance	h_{ob}	< 1	µmho
Small signal current gain at $V_{CE} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz, grounded emitter	h_{fe}	60 . . . 350	
Noise figure at $V_{CE} = 5$ V, $I_C = 10$ µA, $R_G = 10$ kΩ, $f = 10$ Hz . . . 15 kHz	F	< 4	dB

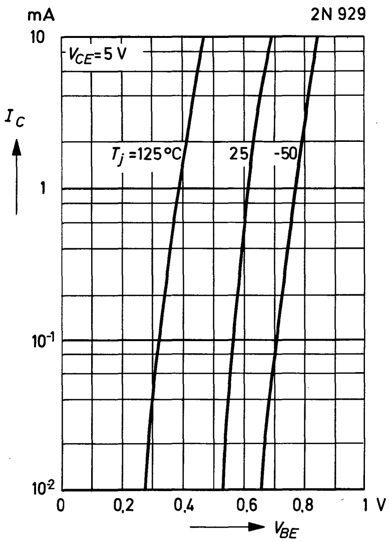
Common emitter collector characteristics



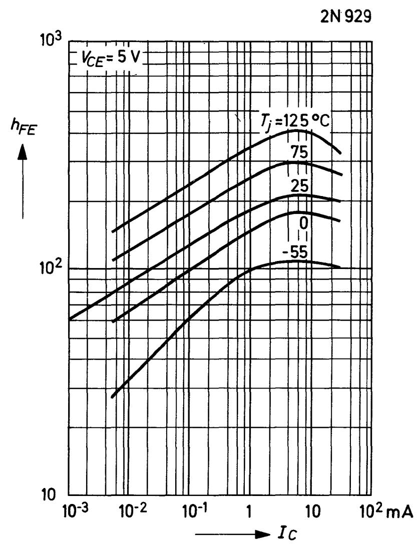
Common emitter collector characteristics



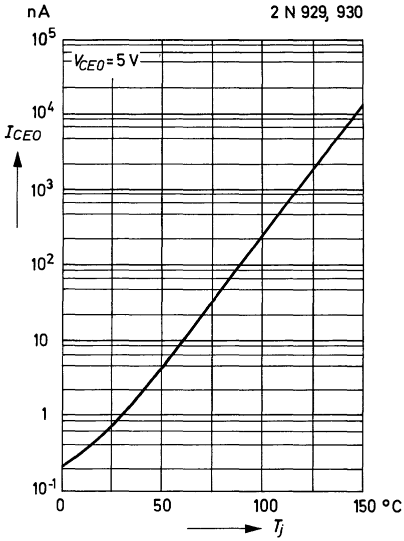
Collector current versus base emitter voltage



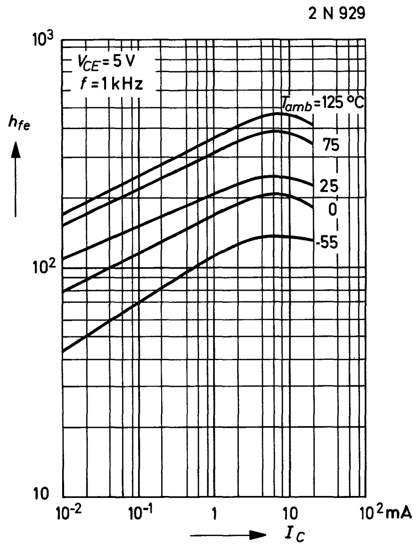
DC current gain versus collector current



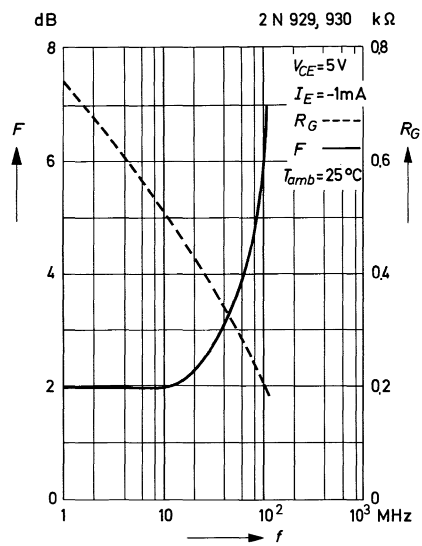
Collector cutoff current versus junction temperature



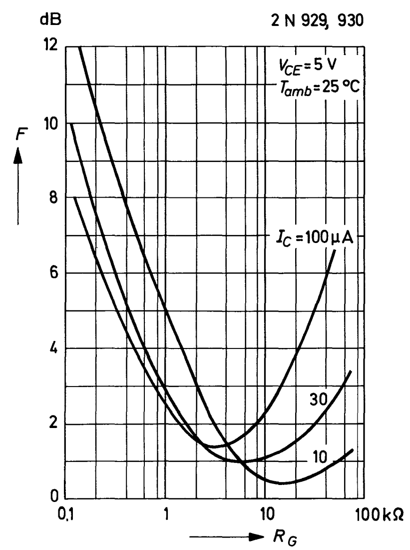
Small signal current gain versus collector current



Noise figure versus frequency

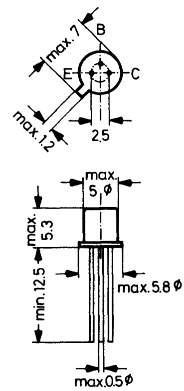


Noise figure versus generator resistance



2 N 930

NPN Silicon Planar Transistor
for use in high-performance, low-level, low-noise amplifier circuits from audio through high frequency ranges



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	45	V
Collector emitter voltage	V_{CEO}	45	V
Emitter base voltage	V_{EBO}	5	V
Collector current	I_C	30	mA
Power dissipation			
at $T_{amb} = 25\ °C$	P_{tot}	0.3	W
at $T_C = 25\ °C$	P_{tot}	0.6	W
Junction temperature	T_j	175	°C
Storage temperature range	T_S	– 65 . . . + 300	°C

Static characteristics at $T_j = 25\ °C$

DC current gain			
at $V_{CE} = 5$ V, $I_C = 10\ \mu A$	h_{FE}	100 . . . 300	
at $V_{CE} = 5$ V, $I_C = 0.5$ mA	h_{FE}	> 150	
at $V_{CE} = 5$ V, $I_C = 10$ mA	h_{FE}	< 600	
at $V_{CE} = 5$ V, $I_C = 10\ \mu A$, $T_j = -55\ °C$	h_{FE}	> 20	
Collector saturation voltage at $I_C = 10$ mA, $I_B = 0.5$ mA	$V_{CE\,sat}$	< 1	V
Base saturation voltage at $I_C = 10$ mA, $I_B = 0.5$ mA	$V_{BE\,sat}$	0.6 . . . 1	V
Collector cutoff current			
at $V_{CB} = 45$ V	I_{CBO}	< 10	nA
at $V_{CE} = 5$ V	I_{CEO}	< 2	nA
at $V_{CE} = 45$ V, $V_{BE} = 0$	I_{CES}	< 10	nA

Emitter cutoff current at $V_{EB} = 5$ V	I_{EBO}	< 10	nA
Thermal resistance Junction to ambient air Junction to case	 R_{thA} R_{thC}	 < 500 < 250	 °C/W °C/W

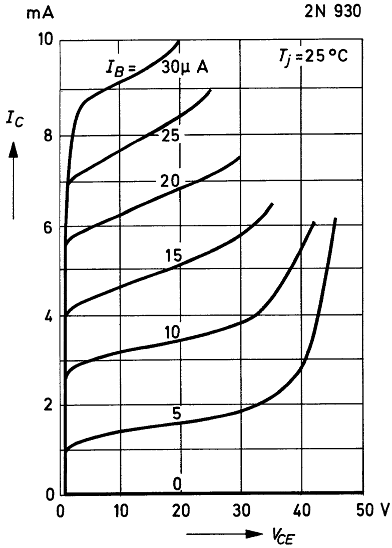
Dynamic characteristics at $T_{amb} = 25$ °C

Collector base capacitance at $V_{CB} = 5$ V, $f = 1$ MHz	C_{CBO}	< 8	pF
Gain bandwidth product at $V_{CE} = 5$ V, $I_C = 0.5$ mA	f_T	> 30	MHz

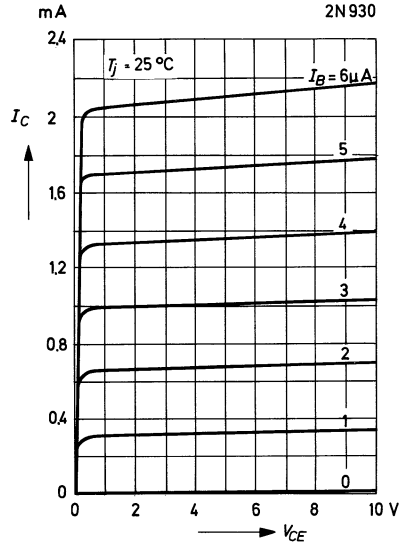
h-parameters, grounded base
Test conditions: $V_{CB} = 5$ V, $-I_E = 1$ mA, $f = 1$ kHz

Input impedance	h_{ib}	25 . . . 32	Ω
Reverse voltage transfer ratio	h_{rb}	$< 6 \cdot 10^{-4}$	
Output admittance	h_{ob}	< 1	µmho
Small signal current gain at $V_{CE} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz, grounded emitter	h_{fe}	150 . . . 600	
Noise figure at $V_{CE} = 5$ V, $I_C = 10$ µA, $R_G = 10$ kΩ, $f = 10$ Hz . . . 15 kHz	F	< 3	dB

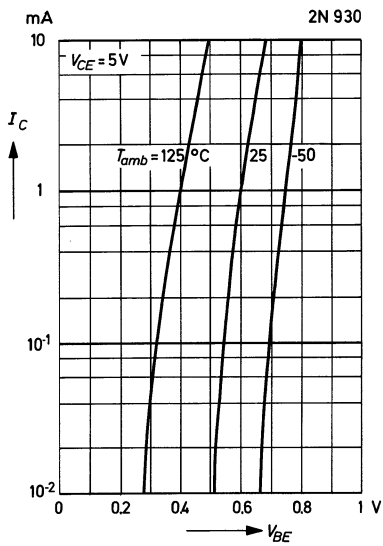
Common emitter collector characteristics



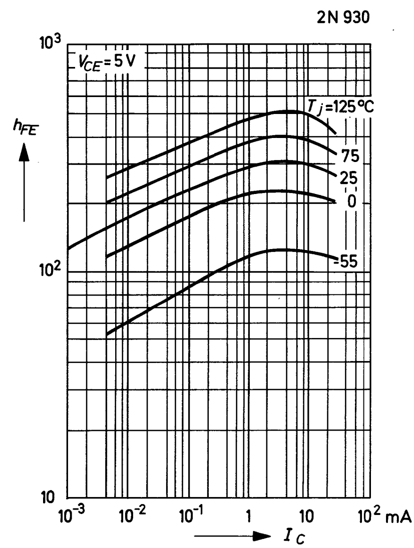
Common emitter collector characteristics



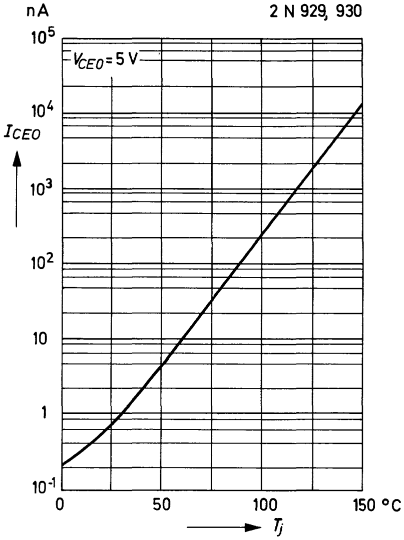
Collector current versus base emitter voltage



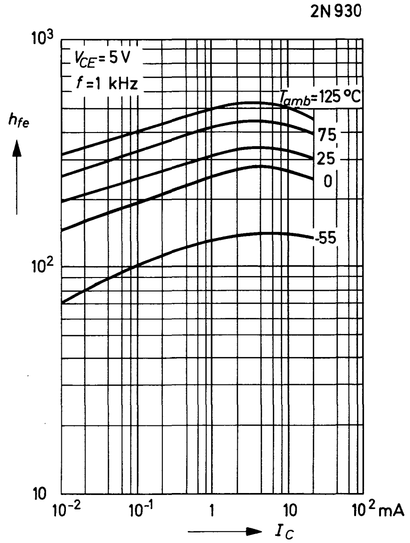
DC current gain versus collector current



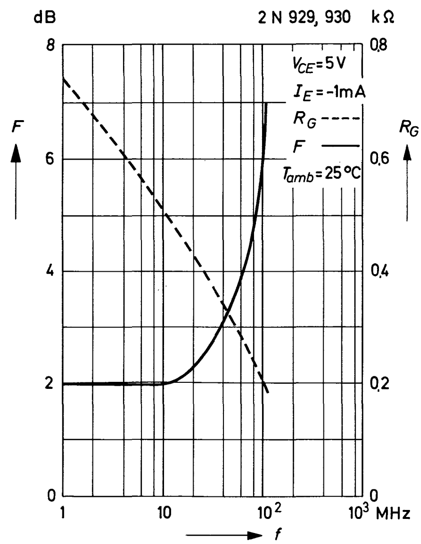
Collector cutoff current versus junction temperature



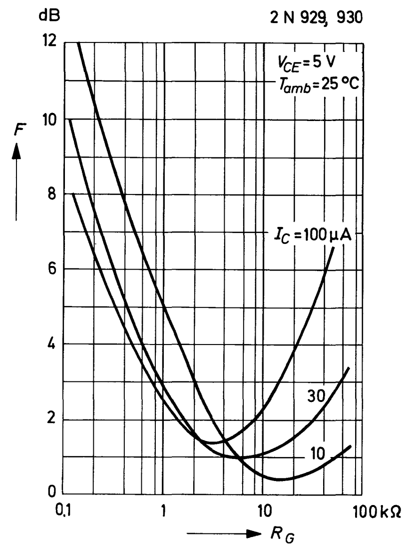
Small signal current gain versus collector current



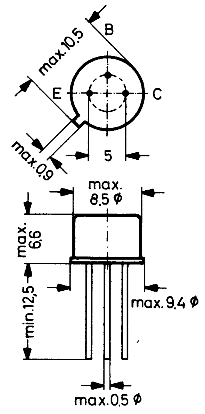
Noise figure versus frequency



Noise figure versus generator resistance



NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	75	V
Collector emitter voltage at $R_{BE} < 10\ \Omega$	V_{CER}	50	V
Emitter base voltage	V_{EBO}	7	V
Collector current	I_C	500	mA
Power dissipation			
at $T_{amb} = 25\ °C$	P_{tot}	0.8	W
at $T_C = 25\ °C$	P_{tot}	3	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	– 65 ... + 300	°C

Static characteristics at $T_j = 25\ °C$

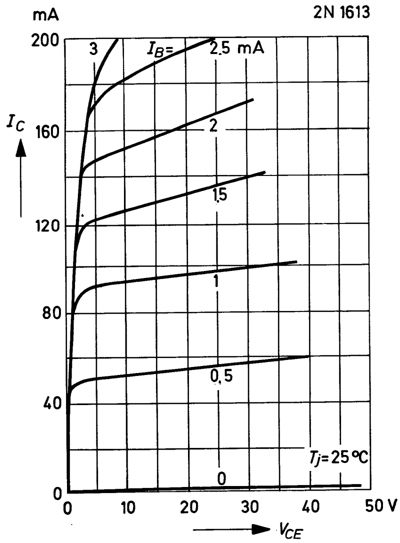
DC current gain			
at $V_{CE} = 10\ V$, $I_C = 10\ \mu A$	h_{FE}	35	
at $V_{CE} = 10\ V$, $I_C = 100\ \mu A$	h_{FE}	50 (> 20)	
at $V_{CE} = 10\ V$, $I_C = 10\ mA$	h_{FE}	80 (> 35)	
at $V_{CE} = 10\ V$, $I_C = 150\ mA$	h_{FE}	40 ... 120	
at $V_{CE} = 10\ V$, $I_C = 500\ mA$	h_{FE}	55 (> 20)	
at $V_{CE} = 10\ V$, $I_C = 10\ mA$, $T_j = -55\ °C$	h_{FE}	35 (> 20)	
Collector saturation voltage at $I_C = 150\ mA$, $I_B = 15\ mA$	$V_{CE\ sat}$	0.6 (< 1.5)	V
Base saturation voltage at $I_C = 150\ mA$, $I_B = 15\ mA$	$V_{BE\ sat}$	0.95 (< 1.3)	V
Collector cutoff current			
at $V_{CB} = 60\ V$	I_{CBO}	0.3 (< 10)	nA
at $V_{CB} = 60\ V$, $T_j = 150\ °C$	I_{CBO}	0.4 (< 10)	μA

Emitter cutoff current at $V_{EB} = 5$ V	I_{EB0}	0.05 (< 10)	nA
Thermal resistance			
Junction to ambient air	R_{thA}	< 220	°C/W
Junction to case	R_{thC}	< 58	°C/W

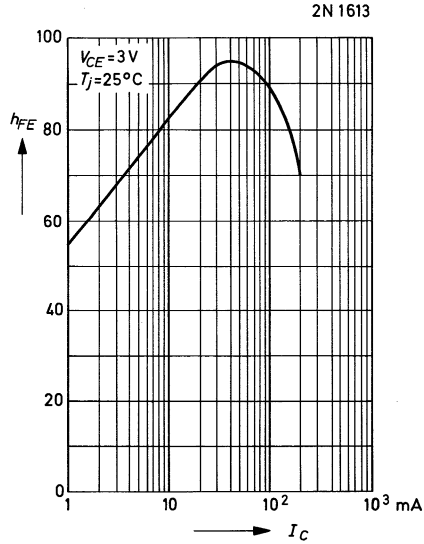
Dynamic characteristics at $T_{amb} = 25$ °C

Collector base capacitance at $V_{CB} = 10$ V, $I_E = 0$	C_{CB0}	18 (< 25)	pF
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA	f_T	80 (> 60)	MHz
h-parameters, grounded emitter Test conditions: $V_{CE} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz			
Input impedance			
Reverse voltage transfer ratio	h_{ie}	2.2	kΩ
Small signal current gain	h_{re}	$3.6 \cdot 10^{-4}$	
Output admittance	h_{fe}	30 . . . 100	
h-parameters at $f = 1$ kHz, grounded base	h_{oe}	12.5	μmho
Input impedance at $V_{CB} = 5$ V, $-I_E = 1$ mA at $V_{CB} = 10$ V, $-I_E = 5$ mA			
	h_{ib}	24 . . . 34	Ω
Reverse voltage transfer ratio	h_{ib}	4 . . . 8	Ω
at $V_{CB} = 5$ V, $-I_E = 1$ mA at $V_{CB} = 10$ V, $-I_E = 5$ mA			
	h_{rb}	$0.7\ (< 3) \cdot 10^{-4}$	
Output admittance	h_{rb}	$0.8\ (< 3) \cdot 10^{-4}$	
at $V_{CB} = 5$ V, $-I_E = 1$ mA at $V_{CB} = 10$ V, $-I_E = 5$ mA			
	h_{ob}	0.1 . . . 0.5	μmho
Noise figure	h_{ob}	0.1 . . . 1	μmho
at $V_{CE} = 10$ V, $I_C = 0.3$ mA, $R_G = 500\ \Omega$, $f = 1$ kHz	F	6 (< 12)	dB

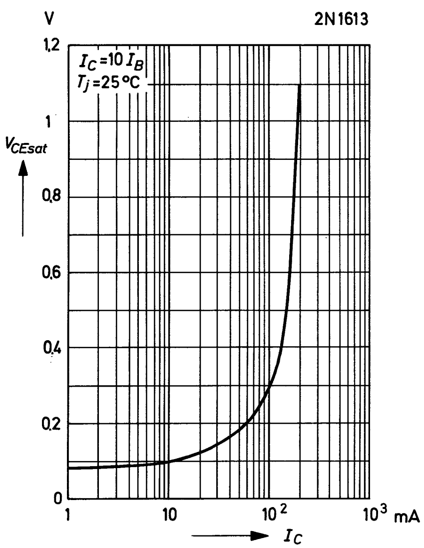
Common emitter collector characteristics



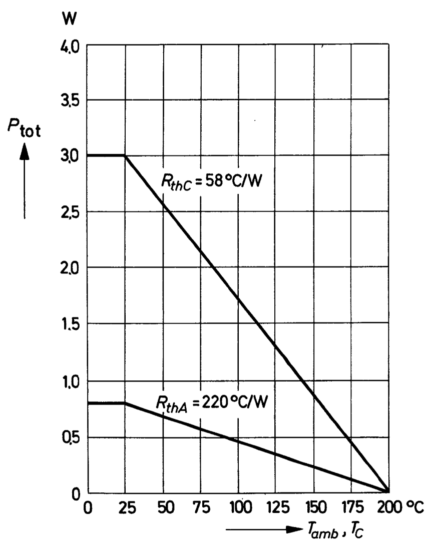
DC current gain versus collector current



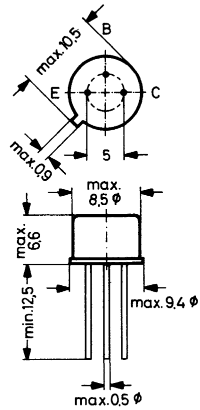
Collector saturation voltage versus collector current



Admissible power dissipation versus temperature



NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	75	V
Collector emitter voltage at $R_{BE} < 10\ \Omega$	V_{CER}	50	V
Emitter base voltage	V_{EBO}	7	V
Collector current	I_C	500	mA
Power dissipation			
at $T_{amb} = 25\ °C$	P_{tot}	0.8	W
at $T_C = 25\ °C$	P_{tot}	3	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	– 65 ... + 300	°C

Static characteristics at $T_j = 25\ °C$

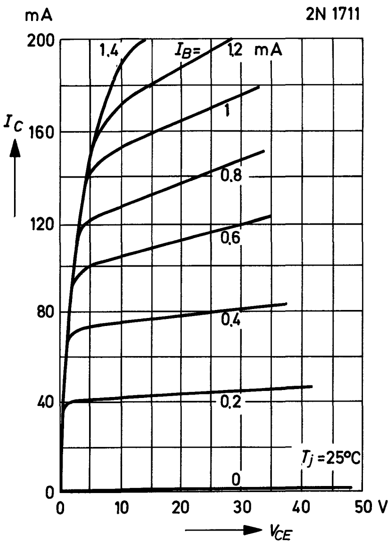
DC current gain			
at $V_{CE} = 10$ V, $I_C = 10\ \mu A$	h_{FE}	60 (> 20)	
at $V_{CE} = 10$ V, $I_C = 100\ \mu A$	h_{FE}	80 (> 35)	
at $V_{CE} = 10$ V, $I_C = 10$ mA	h_{FE}	130 (> 75)	
at $V_{CE} = 10$ V, $I_C = 150$ mA	h_{FE}	100 ... 300	
at $V_{CE} = 10$ V, $I_C = 500$ mA	h_{FE}	75 (> 40)	
at $V_{CE} = 10$ V, $I_C = 10$ mA, $T_j = -55\ °C$	h_{FE}	65 (> 35)	
Collector saturation voltage at $I_C = 150$ mA, $I_B = 15$ mA	$V_{CE\,sat}$	0.5 (< 1.5)	V
Base saturation voltage at $I_C = 150$ mA, $I_B = 15$ mA	$V_{BE\,sat}$	0.95 (< 1.3)	V
Collector cutoff current			
at $V_{CB} = 60$ V	I_{CBO}	0.3 (< 10)	nA
at $V_{CB} = 60$ V, $T_j = 150\ °C$	I_{CBO}	0.4 (< 10)	µA

Emitter cutoff current at $V_{EB} = 5$ V	I_{EB0}	0.05 (< 5)	nA
Thermal resistance Junction to ambient air Junction to case	 R_{thA} R_{thC}	 < 220 < 58	 °C/W °C/W

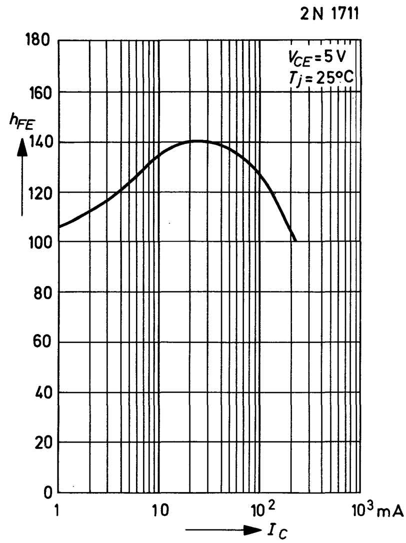
Dynamic characteristics at $T_{amb} = 25$ °C

Collector base capacitance at $V_{CB} = 10$ V, $I_E = 0$	C_{CB0}	18 (< 25)	pF
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA	f_T	100 (> 70)	MHz
h-parameters, grounded emitter Test conditions: $V_{CE} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz			
Input impedance	h_{ie}	4.4	kΩ
Reverse voltage transfer ratio	h_{re}	$7.3 \cdot 10^{-4}$	
Small signal current gain	h_{fe}	50 . . . 200	
Output admittance	h_{oe}	23.8	µmho
h-parameters at $f = 1$ kHz, grounded base			
Input impedance at $V_{CB} = 5$ V, $-I_E = 1$ mA at $V_{CB} = 10$ V, $-I_E = 5$ mA	 h_{ib} h_{ib}	 24 . . . 34 4 . . . 8	 Ω Ω
Reverse voltage transfer ratio at $V_{CB} = 5$ V, $-I_E = 1$ mA at $V_{CB} = 10$ V, $-I_E = 5$ mA	 h_{rb} h_{rb}	 $1.2\ (< 5) \cdot 10^{-4}$ $1.2\ (< 5) \cdot 10^{-4}$	
Output admittance at $V_{CB} = 5$ V, $-I_E = 1$ mA at $V_{CB} = 10$ V, $-I_E = 5$ mA	 h_{ob} h_{ob}	 0.1 . . . 0.5 0.1 . . . 1	 µmho µmho
Noise figure at $V_{CE} = 10$ V, $I_C = 0.3$ mA, $R_G = 500$ Ω, $f = 1$ kHz	F	3.5 (< 8)	dB

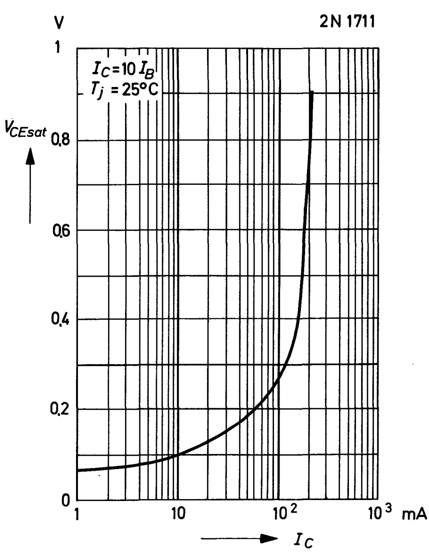
Common emitter collector characteristics



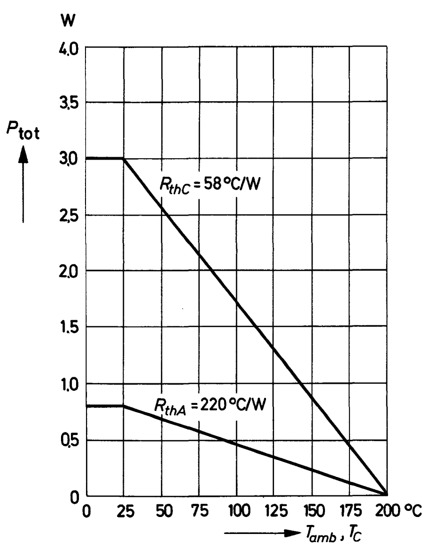
DC current gain versus collector current



Collector saturation voltage versus collector current

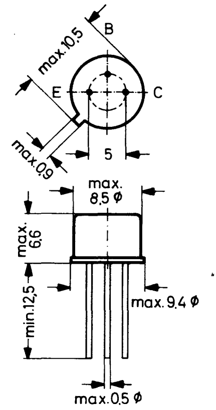


Admissible power dissipation versus temperature



2 N 1893

NPN Silicon Epitaxial Planar Transistor
for switching and amplifier applications



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	120	V
Collector emitter voltage			
at $I_B = 0$	V_{CEO}	80	V
at $R_{BE} < 10\ \Omega$	V_{CER}	100	V
Emitter base voltage	V_{EBO}	7	V
Collector current	I_C	500	mA
Power dissipation			
at $T_{amb} = 25\ °C$	P_{tot}	0.8	W
at $T_C = 25\ °C$	P_{tot}	3	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	– 65 . . . + 300	°C

Static Characteristics at $T_j = 25\ °C$

DC current gain			
at $V_{CE} = 10$ V, $I_C = 0.1$ mA	h_{FE}	50 (> 20)	
at $V_{CE} = 10$ V, $I_C = 10$ mA	h_{FE}	80 (> 35)	
at $V_{CE} = 10$ V, $I_C = 150$ mA	h_{FE}	40 . . . 120	
at $V_{CE} = 10$ V, $I_C = 10$ mA, $T_j = -55\ °C$	h_{FE}	40 (> 20)	
Collector saturation voltage			
at $I_C = 150$ mA, $I_B = 15$ mA	$V_{CE\,sat}$	2 (< 5)	V
at $I_C = 50$ mA, $I_B = 5$ mA	$V_{CE\,sat}$	0.5 (< 1.2)	V
Base saturation voltage			
at $I_C = 150$ mA, $I_B = 15$ mA	$V_{BE\,sat}$	0.96 (< 1.3)	V
at $I_C = 50$ mA, $I_B = 5$ mA	$V_{BE\,sat}$	0.82 (< 0.9)	V

Collector cutoff current			
at $V_{CB} = 90$ V	I_{CBO}	0.3 (< 10)	nA
at $V_{CB} = 90$ V, $T_j = 150$ °C	I_{CBO}	1.5 (< 15)	μA
Emitter cutoff current at $V_{EB} = 5$ V	I_{EBO}	< 10	nA
Thermal resistance			
Junction to ambient air	R_{thA}	< 220	°C/W
Junction to case	R_{thC}	< 58	°C/W

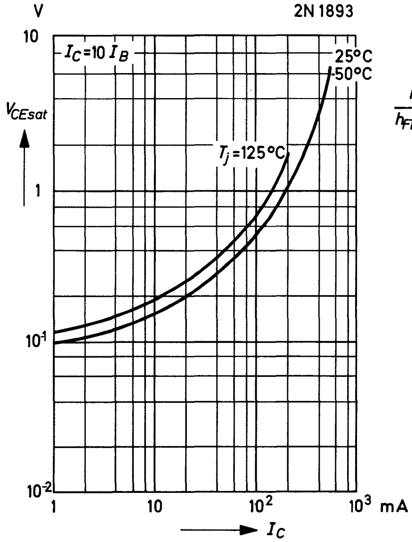
Dynamic characteristics at $T_C = 25$ °C

Collector base capacitance at $V_{CB} = 10$ V	C_{CBO}	< 15	pF
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 50$ mA	f_T	70 (> 50)	MHz
Small signal current gain at $V_{CE} = 10$ V, $I_C = 5$ mA, $f = 1$ kHz	h_{fe}	> 45	

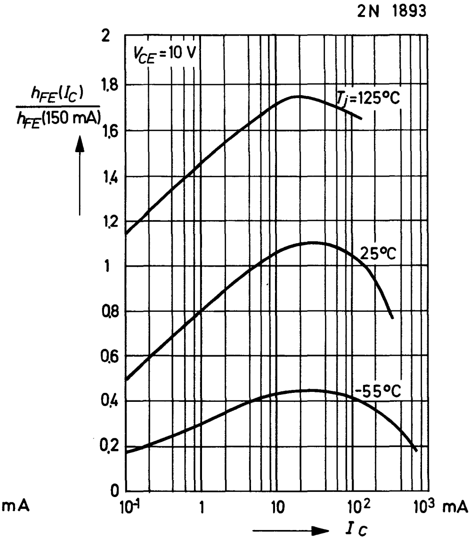
h-parameters, grounded base
Test conditions: $V_{CE} = 5$ V, $-I_E = 1$ mA, $f = 1$ kHz

Input impedance	h_{ib}	20 . . . 30	Ω
Reverse voltage transfer ratio	h_{rb}	$< 1.25 \cdot 10^{-4}$	
Output admittance	h_{ob}	< 0.5	μmho

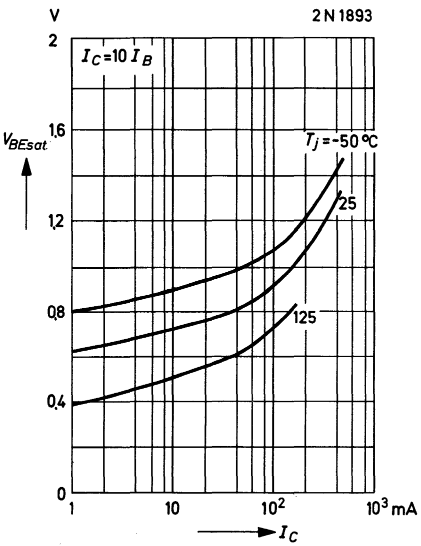
Collector saturation voltage versus collector current



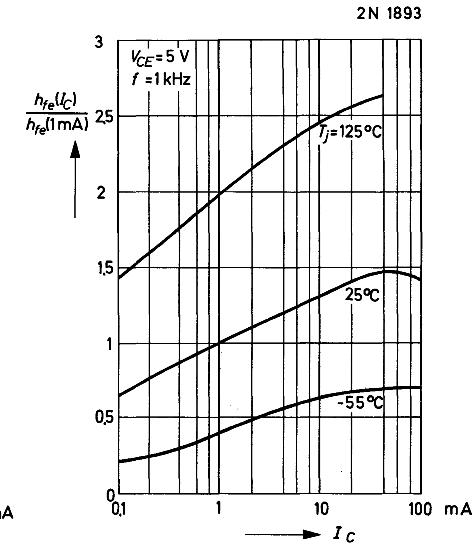
Relative DC current gain versus collector current



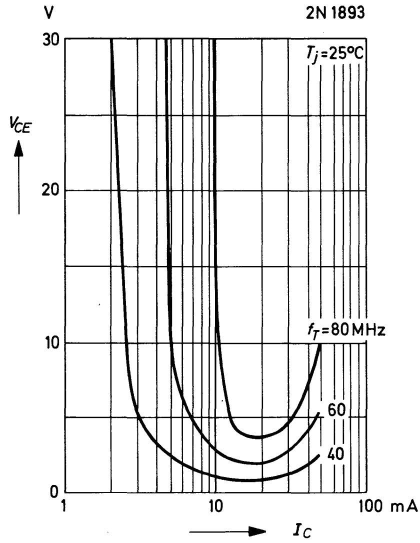
Base saturation voltage versus collector current



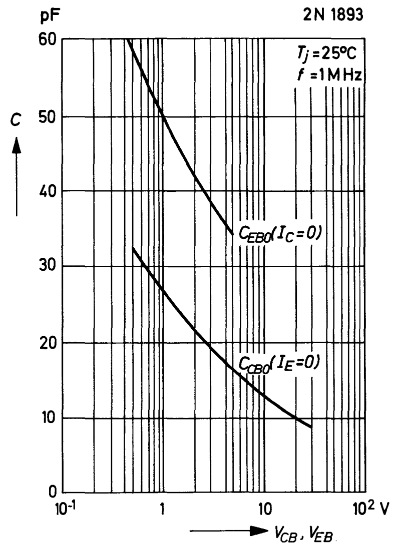
Relative small signal current gain versus collector current



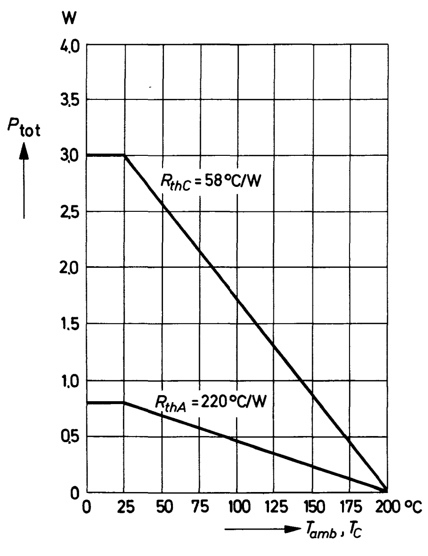
Contours of constant gain bandwidth product



Collector base capacitance, Emitter base capacitance versus reverse bias voltage

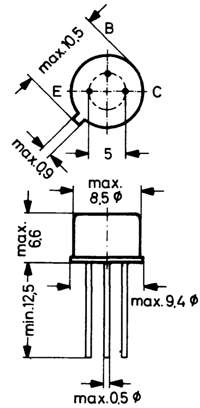


Admissible power dissipation versus temperature



2 N 2218, 2 N 2219

NPN Silicon Epitaxial Planar Transistors
with high cutoff frequency, for high speed switching



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	60	V
Collector emitter voltage	V_{CEO}	30	V
Emitter base voltage	V_{EBO}	5	V
Collector current	I_C	0.8	A
Power dissipation			
at $T_{amb} = 25\ °C$	P_{tot}	0.8	W
at $T_C = 25\ °C$	P_{tot}	3	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	−65 ... +200	°C

Characteristics at $T_j = 25\ °C$

		2 N 2218	2 N 2219	
DC current gain				
at $V_{CE} = 10$ V, $I_C = 0.1$ mA	h_{FE}	> 20	> 35	
at $V_{CE} = 10$ V, $I_C = 1$ mA	h_{FE}	> 25	> 50	
at $V_{CE} = 10$ V, $I_C = 10$ mA	h_{FE}	> 35	> 75	
at $V_{CE} = 10$ V, $I_C = 150$ mA	h_{FE}	40 ... 120	100 ... 300	
at $V_{CE} = 10$ V, $I_C = 0.5$ A	h_{FE}	> 20	> 30	
at $V_{CE} = 1$ V, $I_C = 150$ mA	h_{FE}	> 20	> 50	
Collector saturation voltage				
at $I_C = 150$ mA, $I_B = 15$ mA	$V_{CE\,sat}$	< 0.4		V
at $I_C = 500$ mA, $I_B = 50$ mA	$V_{CE\,sat}$	< 1.6		V
Base saturation voltage				
at $I_C = 150$ mA, $I_B = 15$ mA	$V_{BE\,sat}$	< 1.3		V
at $I_C = 500$ mA, $I_B = 50$ mA	$V_{BE\,sat}$	< 2.6		V

Collector cutoff current at $V_{CB} = 50$ V at $V_{CB} = 50$ V, $T_{amb} = 150$ °C	 I_{CBO} I_{CBO}	 < 10 < 10	 nA µA
Collector base breakdown voltage at $I_C = 10$ µA	$V_{(RR)CBO}$	> 60	V
Collector emitter breakdown voltage at $I_C = 10$ mA	$V_{(BR)CEO}$	> 30	V
Emitter base breakdown voltage at $I_E = 10$ µA	$V_{(BR)EBO}$	> 5	V
Gain bandwidth product at $V_{CE} = 20$ V, $I_C = 20$ mA, $f = 100$ MHz	f_T	> 250	MHz
Collector base capacitance at $V_{CBO} = 10$ V, $f = 100$ kHz	C_{CBO}	< 8	pF
Emitter base capacitance at $V_{EBO} = 0.5$ V, $f = 100$ kHz	C_{EBO}	< 30	pF
Thermal resistance Junction to ambient air Junction to case	 R_{thA} R_{thC}	 < 300 < 84	 °C/W °C/W
Turn-on time (see Fig. 1)	t_{on}	26	ns
Turn-off time (see Fig. 2)	t_{off}	70	ns
Total switching time (see Fig. 3)	t_{total}	12	ns

Curves and characteristics of types BSW 82...85 are valid analogously for types 2 N 2221 and 2 N 2222.

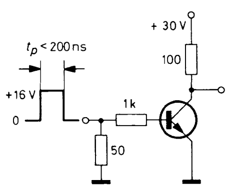


Fig. 1: Test circuit for turn-on time, saturated operation

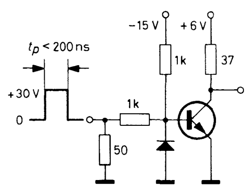


Fig. 2: Test circuit for turn-off time, saturated operation

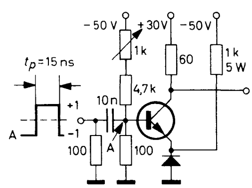
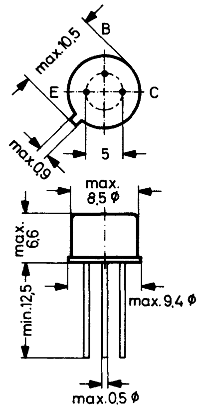


Fig. 3: Test circuit for non-saturated operation

2 N 2218 A, 2 N 2219 A

NPN Silicon Epitaxial Planar Transistors
with high cutoff frequency, for high speed switching



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	75	V
Collector emitter voltage	V_{CEO}	40	V
Emitter base voltage	V_{EBO}	6	V
Collector current	I_C	0.8	A
Power dissipation			
at $T_{amb} = 25\ °C$	P_{tot}	0.8	W
at $T_C = 25\ °C$	P_{tot}	3	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	−65...+200	°C

Characteristics at $T_j = 25\ °C$

		2 N 2218 A	2 N 2219 A
DC current gain			
at $V_{CE} = 10$ V, $I_C = 0.1$ mA	h_{FE}	> 20	> 35
at $V_{CE} = 10$ V, $I_C = 1$ mA	h_{FE}	> 25	> 50
at $V_{CE} = 10$ V, $I_C = 10$ mA	h_{FE}	> 35	> 75
at $V_{CE} = 10$ V, $I_C = 150$ mA	h_{FE}	40...120	100...300
at $V_{CE} = 10$ V, $I_C = 0.5$ A	h_{FE}	> 25	> 40
at $V_{CE} = 10$ V, $I_C = 10$ mA, $T_j = -55\ °C$	h_{FE}	> 15	> 35
at $V_{CE} = 1$ V, $I_C = 150$ mA	h_{FE}	> 20	> 50

Collector saturation voltage			
at $I_C = 150$ mA, $I_B = 15$ mA	$V_{CE\,sat}$	< 0.3	V
at $I_C = 500$ mA, $I_B = 50$ mA	$V_{CE\,sat}$	< 1	V
Base saturation voltage			
at $I_C = 150$ mA, $I_B = 15$ mA		< 1.2	V
at $I_C = 500$ mA, $I_B = 50$ mA	$V_{BE\,sat}$	< 2	V

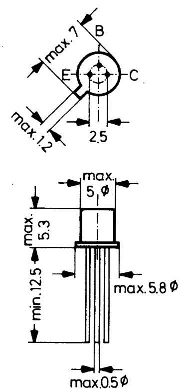
Collector cutoff current			
at V_{CB} = 60 V	I_{CBO}	< 10	nA
at V_{CB} = 60 V, T_{amb} = 150 °C	I_{CBO}	< 10	μA
at V_{CE} = 60 V, V_{EB} = 3 V	I_{CEV}	< 10	nA
Emitter cutoff current at V_{EB} = 3 V	I_{EBO}	< 10	nA
Base cutoff current at V_{CE} = 60 V, V_{EB} = 3 V	I_{EBV}	< 20	nA
Collector base breakdown voltage at I_C = 10 μA	$V_{(BR)CBO}$	> 75	V
Collector emitter breakdown voltage at I_C = 10 mA	$V_{(BR)CEO}$	> 40	V
Emitter base breakdown voltage at I_E = 10 μA	$V_{(BR)EBO}$	> 6	V

h-parameters at *f* = 1 kHz

		2 N 2218 A	**2 N 2219 A**	
Input impedance				
at V_{CE} = 10 V, I_C = 1 mA	h_{ie}	1 . . . 3.5	2 . . . 8	kΩ
at V_{CE} = 10 V, I_C = 10 mA	h_{ie}	0.2 . . . 1	0.25 . . . 1.25	kΩ
Reverse voltage transfer ratio				
at V_{CE} = 10 V, I_C = 1 mA	h_{re}	$< 5 \cdot 10^{-4}$	$< 8 \cdot 10^{-4}$	
at V_{CE} = 10 V, I_C = 10 mA	h_{re}	$< 2.5 \cdot 10^{-4}$	$< 4 \cdot 10^{-4}$	
Small signal current gain				
at V_{CE} = 10 V, I_C = 1 mA	h_{fe}	30 . . . 150	50 . . . 300	
at V_{CE} = 10 V, I_C = 10 mA	h_{fe}	50 . . . 300	75 . . . 375	
Output admittance				
at V_{CE} = 10 V, I_C = 1 mA	h_{oe}	3 . . . 15	5 . . . 35	μmho
at V_{CE} = 10 V, I_C = 10 mA	h_{oe}	10 . . . 100	25 . . . 200	μmho
Collector base time constant at V_{CE} = 20 V, I_C = 20 mA, *f* = 31.8 MHz	$r_{b'} C_c$	< 150	< 150	ps
Noise figure at V_{CE} = 10 V, I_C = 0.1 mA, R_G = 1 kΩ, *f* = 1 kHz	*F*	–	< 4	dB
Thermal resistance				
Junction to ambient air	R_{thA}	< 220		°C/W
Junction to case	R_{thC}	< 58		°C/W

Curves and characteristics of types BSW 82 . . . 85 are valid analogously for types 2 N 2218 and 2 N 2219.

NPN Silicon Epitaxial Planar Transistors
with high cutoff frequency, for high speed switching



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CB0}	60	V
Collector emitter voltage	V_{CE0}	30	V
Emitter base voltage	V_{EB0}	5	V
Collector current	I_C	0.8	A
Power dissipation			
at $T_{amb} = 25$ °C	P_{tot}	0.5	W
at $T_C = 25$ °C	P_{tot}	1.8	W
Junction temperature	T_j	175	°C
Storage temperature range	T_S	−65 ... + 200	°C

Characteristics at $T_j = 25$ °C

		2 N 2221	2 N 2222	
DC current gain				
at $V_{CE} = 10$ V, $I_C = 0.1$ mA	h_{FE}	> 20	> 35	
at $V_{CE} = 10$ V, $I_C = 1$ mA	h_{FE}	> 25	> 50	
at $V_{CE} = 10$ V, $I_C = 10$ mA	h_{FE}	> 35	> 75	
at $V_{CE} = 10$ V, $I_C = 150$ mA	h_{FE}	40 ... 120	100 ... 300	
at $V_{CE} = 10$ V, $I_C = 0.5$ A	h_{FE}	> 20	> 30	
Collector saturation voltage				
at $I_C = 150$ mA, $I_B = 15$ mA	$V_{CE\,sat}$	< 0.4		V
at $I_C = 500$ mA, $I_B = 50$ mA	$V_{CE\,sat}$	< 1.6		V
Base saturation voltage				
at $I_C = 150$ mA, $I_B = 15$ mA	$V_{BE\,sat}$	< 1.3		V
at $I_C = 500$ mA, $I_B = 50$ mA	$V_{BE\,sat}$	< 2.6		V

Collector cutoff current			
at $V_{CB} = 50$ V	I_{CBO}	< 10	nA
at $V_{CB} = 50$ V, $T_{amb} = 150$ °C	I_{CBO}	< 10	µA
Collector base breakdown voltage at $I_C = 10$ µA	$V_{(BR)CBO}$	> 60	V
Collector emitter breakdown voltage at $I_C = 10$ mA	$V_{(BR)CEO}$	> 30	V
Emitter base breakdown voltage at $I_E = 10$ µA	$V_{(BR)EBO}$	> 5	V
Gain bandwidth product at $V_{CE} = 20$ V, $I_C = 20$ mA, $f = 100$ MHz	f_T	> 250	MHz
Collector base capacitance at $V_{CBO} = 10$ V, $f = 100$ kHz	C_{CBO}	< 8	pF
Emitter base capacitance at $V_{EBO} = 0.5$ V, $f = 100$ kHz	C_{EBO}	< 30	pF
Thermal resistance			
Junction to ambient air	R_{thA}	< 220	°C/W
Junction to case	R_{thC}	< 58	°C/W
Turn-on time (see Fig. 1)	t_{on}	26	ns
Turn-off time (see Fig. 2)	t_{off}	70	ns
Total switching time (see Fig. 3)	t_{total}	12	ns

Curves and characteristics of types BSW 82 . . . 85 are valid analogously for types 2 N 2218 and 2 N 2219.

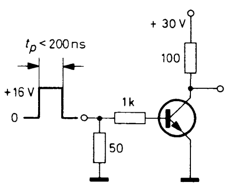


Fig. 1: Test circuit for turn-on time, saturated operation

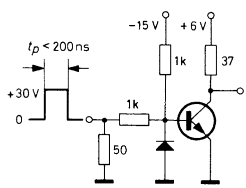


Fig. 2: Test circuit for turn-off time, saturated operation

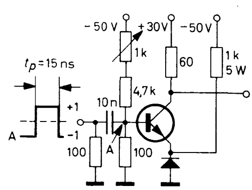
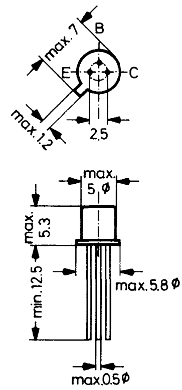


Fig. 3: Test circuit for non-saturated operation

2 N 2221 A, 2 N 2222 A

NPN Silicon Epitaxial Planar Transistors
with high cutoff frequency, for high speed switching



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	75	V
Collector emitter voltage	V_{CEO}	40	V
Emitter base voltage	V_{EBO}	6	V
Collector current	I_C	0.8	A
Power dissipation			
at $T_{amb} = 25$ °C	P_{tot}	0.5	W
at $T_C = 25$ °C	P_{tot}	1.8	W
Junction temperature	T_j	175	°C
Storage temperature range	T_S	– 65 . . . +200	°C

Characteristics at $T_j = 25$ °C

		2 N 2221 A	2 N 2222 A
DC current gain			
at $V_{CE} = 10$ V, $I_C = 0.1$ mA	h_{FE}	> 20	> 35
at $V_{CE} = 10$ V, $I_C = 1$ mA	h_{FE}	> 25	> 50
at $V_{CE} = 10$ V, $I_C = 10$ mA	h_{FE}	> 35	> 75
at $V_{CE} = 10$ V, $I_C = 150$ mA	h_{FE}	40 . . . 120	100 . . . 300
at $V_{CE} = 10$ V, $I_C = 0.5$ A	h_{FE}	> 25	> 40
at $V_{CE} = 10$ V, $I_C = 10$ mA, $T_j = -55$ °C	h_{FE}	> 15	> 35
at $V_{CE} = 1$ V, $I_C = 150$ mA	h_{FE}	> 20	> 50

Collector saturation voltage			
at $I_C = 150$ mA, $I_B = 15$ mA	$V_{CE\,sat}$	< 0.3	V
at $I_C = 500$ mA, $I_B = 50$ mA	$V_{CE\,sat}$	< 1	V
Base saturation voltage			
at $I_C = 150$ mA, $I_B = 15$ mA	$V_{BE\,sat}$	< 1.2	V
at $I_C = 500$ mA, $I_B = 50$ mA	$V_{BE\,sat}$	< 2	V

Collector cutoff current			
at $V_{CB} = 60$ V	I_{CBO}	< 10	nA
at $V_{CB} = 60$ V, $T_{amb} = 150$ °C	I_{CBO}	< 10	μA
at $V_{CE} = 60$ V, $V_{EB} = 3$ V	I_{CEV}	< 10	nA
Emitter cutoff current at $V_{EB} = 3$ V	I_{EBO}	< 10	nA
Base cutoff current at $V_{CE} = 60$ V, $V_{EB} = 3$ V	I_{EBV}	< 20	nA
Collector base breakdown voltage at $I_C = 10$ μA	$V_{(BR)CBO}$	> 75	V
Collector emitter breakdown voltage at $I_C = 10$ mA	$V_{(BR)CEO}$	> 6	V
Emitter base breakdown voltage at $I_E = 10$ μA	$V_{(BR)EBO}$	> 40	V

h-parameters at $f = 1$ kHz

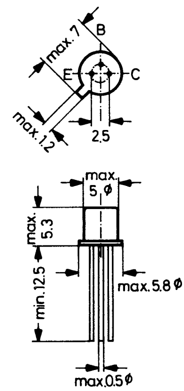
		2 N 2221 A	2 N 2222 A	
Input impedance				
at $V_{CE} = 10$ V, $I_C = 1$ mA	h_{ie}	1 . . . 3.5	2 . . . 8	kΩ
at $V_{CE} = 10$ V, $I_C = 10$ mA	h_{ie}	0.2 . . . 1	0.25 . . . 1.25	kΩ
Reverse voltage transfer ratio				
at $V_{CE} = 10$ V, $I_C = 1$ mA	h_{re}	$< 5 \cdot 10^{-4}$	$< 8 \cdot 10^{-4}$	
at $V_{CE} = 10$ V, $I_C = 10$ mA	h_{re}	$< 2.5 \cdot 10^{-4}$	$< 4 \cdot 10^{-4}$	
Small signal current gain				
at $V_{CE} = 10$ V, $I_C = 1$ mA	h_{fe}	30 . . . 150	50 . . . 300	
at $V_{CE} = 10$ V, $I_C = 10$ mA	h_{fe}	50 . . . 300	75 . . . 375	
Output admittance				
at $V_{CE} = 10$ V, $I_C = 1$ mA	h_{oe}	3 . . . 15	5 . . . 35	μmho
at $V_{CE} = 10$ V, $I_C = 10$ mA	h_{oe}	10 . . . 100	25 . . . 200	μmho
Collector base time constant at $V_{CE} = 20$ V, $I_C = 20$ mA, $f = 31.8$ MHz	$r_{b'} C_c$	< 150	< 150	ps
Noise figure at $V_{CE} = 10$ V, $I_C = 0.1$ mA, $R_G = 1$ kΩ, $f = 1$ kHz	F	–	< 4	dB

Thermal resistance			
Junction to ambient air	R_{thA}	< 300	°C/W
Junction to case	R_{thC}	< 84	°C/W

Curves and characteristics of types BSW 82 . . . 85 are valid analogously for types 2 N 2221 A and 2 N 2222 A.

NPN Silicon Epitaxial Planar Transistor
for switching applications at switching frequencies up to 50 . . . 100 MHz and collector currents from 0.1 to 100 mA.

This type is approved to MIL-S-19500.



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings

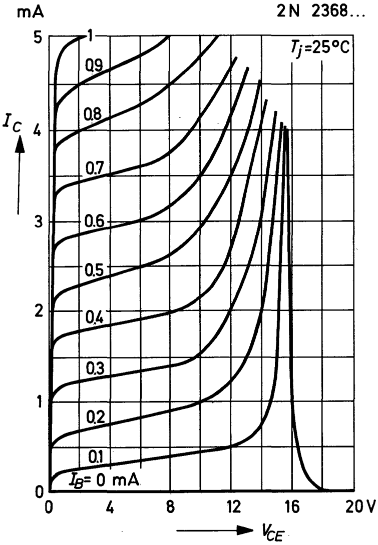
Collector base voltage	V_{CBO}	40	V
Collector emitter voltage			
at $V_{BE} = 0$	V_{CES}	40	V
at $I_B = 0$	V_{CEO}	15	V
Emitter base voltage	V_{EBO}	4.5	V
Collector current	I_C	200	mA
Collector current, pulsed $t_p = 10$ µs duration	I_C	500	mA
Power dissipation			
at $T_{amb} = 25$ °C	P_{tot}	0.36	W
at $T_C = 25$ °C	P_{tot}	1.2	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	– 65 . . . + 200	°C

Characteristics at $T_j = 25$ °C

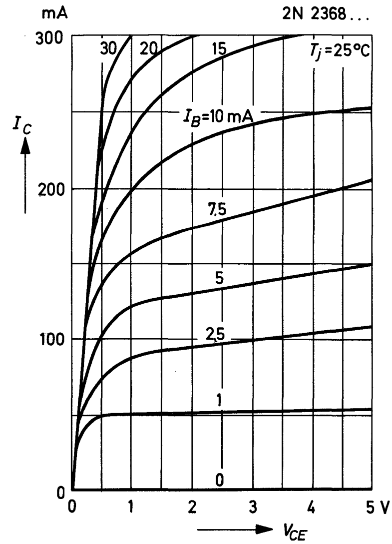
DC current gain		
at $V_{CE} = 1$ V, $I_C = 10$ mA	h_{FE}	20 . . . 60
at $V_{CE} = 1$ V, $I_C = 10$ mA, $T_j = -55$ °C	h_{FE}	> 10
at $V_{CE} = 2$ V, $I_C = 100$ mA	h_{FE}	> 10

Collector saturation voltage at $I_C = 10$ mA, $I_B = 1$ mA	$V_{CE\,sat}$	0.2 (< 0.25)	V
Base saturation voltage at $I_C = 10$ mA, $I_B = 1$ mA	$V_{BE\,sat}$	0.7 ... 0.85	V
Collector cutoff current			
at $V_{CB} = 20$ V	I_{CB0}	< 0.4	μA
at $V_{CB} = 20$ V, $T_j = 150$ °C	I_{CB0}	< 30	μA
Collector base capacitance at $V_{CB0} = 5$ V	C_{CB0}	2.5 (< 4)	pF
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 10$ mA	f_T	> 400	MHz
Storage time constant at $I_C = I_{B1} = -I_{B2} = 10$ mA	τ_s	< 10	ns
Turn-on time at $I_C = 10$ mA, $I_{B1} = 3$ mA	t_{on}	< 12	ns
Turn-off time at $I_C = 10$ mA, $I_{B1} = 3$ mA, $-I_{B2} = 1.5$ mA	t_{off}	< 15	ns
Thermal resistance			
Junction to ambient air	R_{thA}	< 480	°C/W
Junction to case	R_{thC}	< 150	°C/W

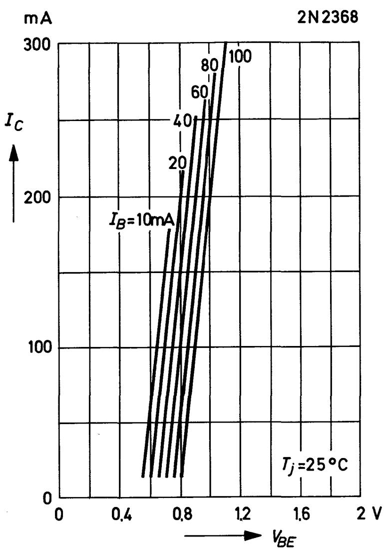
Common emitter collector characteristics



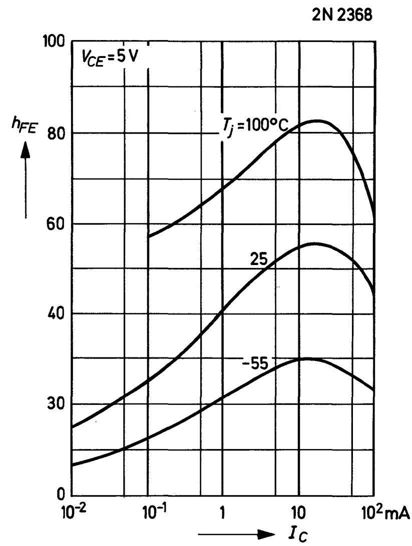
Common emitter collector characteristics



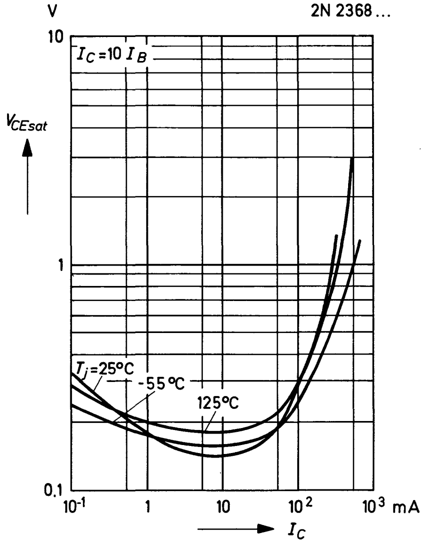
Collector current versus base emitter voltage



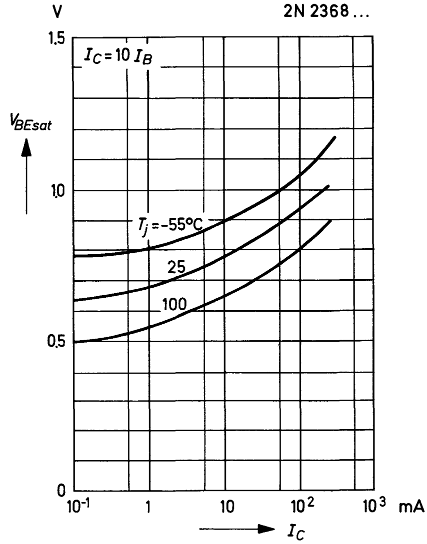
DC current gain versus collector current



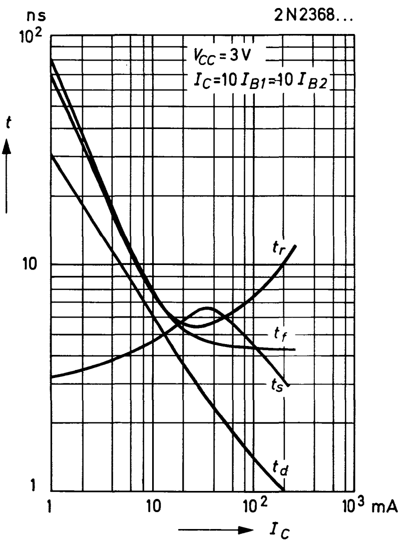
Collector saturation voltage versus collector current



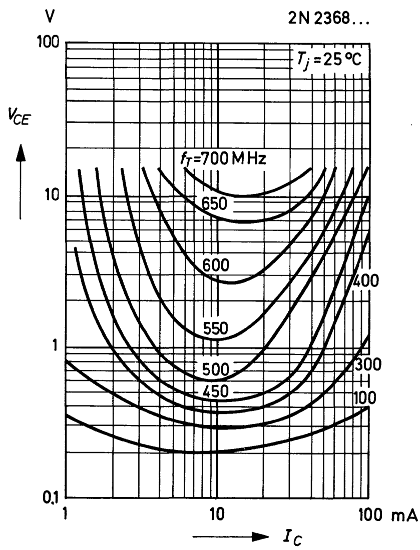
Base saturation voltage versus collector current



Switching times versus collector current

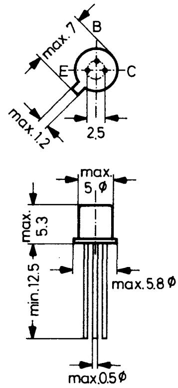


Contours of constant gain bandwidth product



NPN Silicon Epitaxial Planar Transistor
for switching applications at switching frequencies up to 50 ... 100 MHz and collector currents from 0.1 to 100 mA.

This type is approved to MIL-S-19500.



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	40	V
Collector emitter voltage			
at $V_{BE} = 0$	V_{CES}	40	V
at $I_B = 0$	V_{CEO}	15	V
Emitter base voltage	V_{EBO}	4.5	V
Collector current	I_C	200	mA
Collector current, pulsed $t_p = 10\ \mu s$ duration	I_C	500	mA
Power dissipation			
at $T_{amb} = 25\ °C$	P_{tot}	0.36	W
at $T_C = 25°\ C$	P_{tot}	1.2	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	–65...+200	°C

Characteristics at $T_j = 25\ °C$

DC current gain		
at $V_{CE} = 1$ V, $I_C = 10$ mA	h_{FE}	40 ... 120
at $V_{CE} = 1$ V, $I_C = 10$ mA, $T_j = -55\ °C$	h_{FE}	> 20
at $V_{CE} = 2$ V, $I_C = 100$ mA	h_{FE}	> 20

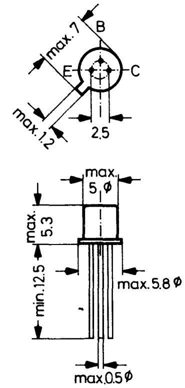
Collector saturation voltage at $I_C = 10$ mA, $I_B = 1$ mA	$V_{CE\,sat}$	0.2 (< 0.25)	V
Base saturation voltage at $I_C = 10$ mA, $I_B = 1$ mA	$V_{BE\,sat}$	0.7 . . . 0.85	V
Collector cutoff current			
at $V_{CB} = 20$ V	I_{CBO}	< 0.4	µA
at $V_{CB} = 20$ V, $T_j = 150$ °C	I_{CBO}	< 30	µA
Collector base capacitance at $V_{CBO} = 5$ V	C_{CBO}	2.5 (< 4)	pF
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 10$ mA	f_T	> 500	MHz
Storage time constant at $I_C = I_{B1} = -I_{B2} = 10$ mA	τ_s	< 13	ns
Turn-on time at $I_C = 10$ mA, $I_{B1} = 3$ mA	t_{on}	< 12	ns
Turn-off time at $I_C = 10$ mA, $I_{B1} = 3$ mA, $-I_{B2} = 1.5$ mA	t_{off}	< 18	ns
Thermal resistance			
Junction to ambient air	R_{thA}	< 480	°C/W
Junction to case	R_{thC}	< 150	°C/W

Curves and characteristics of type 2 N 2368 are valid analogously for type 2 N 2369.

2 N 2369 A

NPN Silicon Epitaxial Planar Transistor
for switching applications at switching frequencies up to 50 ... 100 MHz and collector currents from 0.1 to 100 mA.

This type is approved to MIL-S-19500.



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	40	V
Collector emitter voltage			
at $V_{BE} = 0$	V_{CES}	40	V
at $I_B = 0$	V_{CEO}	15	V
Emitter base voltage	V_{EBO}	4.5	V
Collector current	I_C	200	mA
Collector current, pulsed $t_p = 10$ µs duration	I_C	500	mA
Power dissipation			
at $T_{amb} = 25$ °C	P_{tot}	0.36	W
at $T_C = 25$° C	P_{tot}	1.2	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	– 65 ... + 200	°C

Characteristics at $T_j = 25$ °C

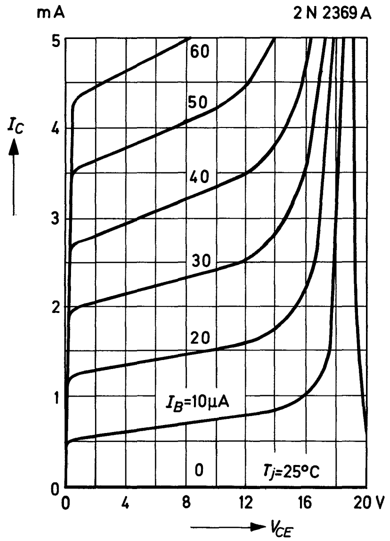
DC current gain		
at $V_{CE} = 1$ V, $I_C = 10$ mA	h_{FE}	40 ... 120 (66)
at $V_{CE} = 0.35$ V, $I_C = 10$ mA	h_{FE}	40 ... 120 (63)
at $V_{CE} = 0.4$ V, $I_C = 30$ mA	h_{FE}	70 (> 30)
at $V_{CE} = 1$ V, $I_C = 100$ mA	h_{FE}	> 20
at $V_{CE} = 0.35$ V, $I_C = 10$ mA, $T_j = -55$ °C	h_{FE}	50 (> 20)

Collector saturation voltage			
at $I_C = 10$ mA, $I_B = 1$ mA	$V_{CE\,sat}$	0.14 (< 0.2)	V
at $I_C = 30$ mA, $I_B = 3$ mA	$V_{CE\,sat}$	0.17 (< 0.25)	V
at $I_C = 100$ mA, $I_B = 10$ mA	$V_{CE\,sat}$	0.28 (< 0.5)	V
at $I_C = 10$ mA, $I_B = 1$ mA, $T_j = 125$ °C	$V_{CE\,sat}$	0.19 (< 0.3)	V
Base saturation voltage			
at $I_C = 10$ mA, $I_B = 1$ mA	$V_{BE\,sat}$	0.7 ... 0.85	V
at $I_C = 30$ mA, $I_B = 3$ mA	$V_{BE\,sat}$	0.9 (< 1.15)	V
at $I_C = 100$ mA, $I_B = 10$ mA	$V_{BE\,sat}$	1.1 (< 1.6)	V
Collector cutoff current			
at $V_{CB0} = 20$ V, $T_j = 150$ °C	I_{CB0}	10 (< 30)	µA
at $V_{CE} = 20$ V	I_{CES}	50 (< 400)	nA
Thermal resistance			
Junction to ambient air	R_{thA}	< 480	°C/W
Junction to case	R_{thC}	< 150	°C/W

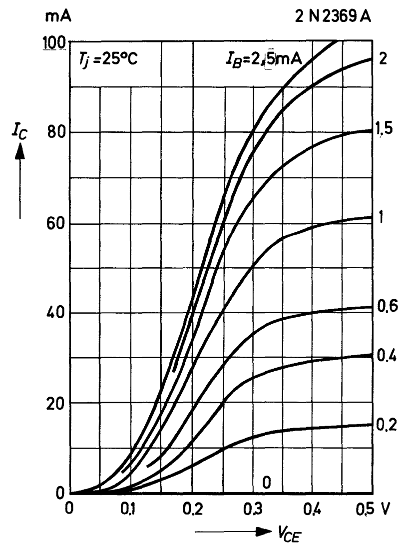
Dynamic characteristics at $T_{amb} = 25$ °C

Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 10$ mA, $f = 100$ MHz	f_T	675 (> 500)	MHz
Collector base capacitance at $V_{CB0} = 5$ V	C_{CB0}	2.3 (< 4)	pF
Storage time constant at $I_C = I_{B1} = -I_{B2} = 10$ mA	τ_s	6 (< 13)	ns
Turn-on time at $I_C = 10$ mA, $I_{B1} = 3$ mA	t_{on}	9 (< 12)	ns
Turn-off time at $I_C = 10$ mA, $I_{B1} = 3$ mA, $-I_{B2} = 1.5$ mA	t_{off}	13 (< 18)	ns

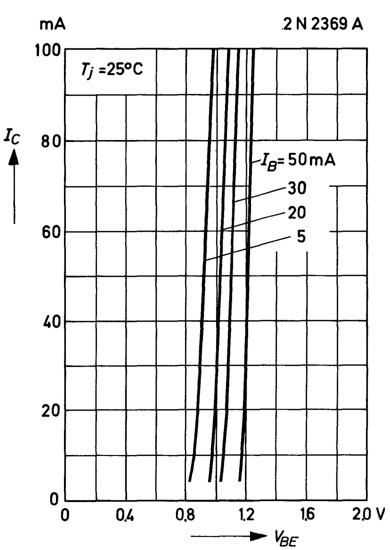
Common emitter collector characteristics



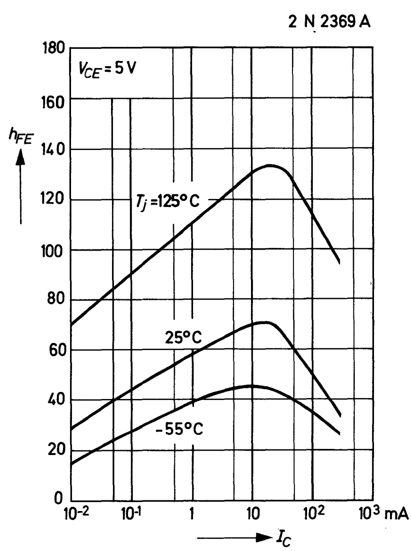
Common emitter collector characteristics



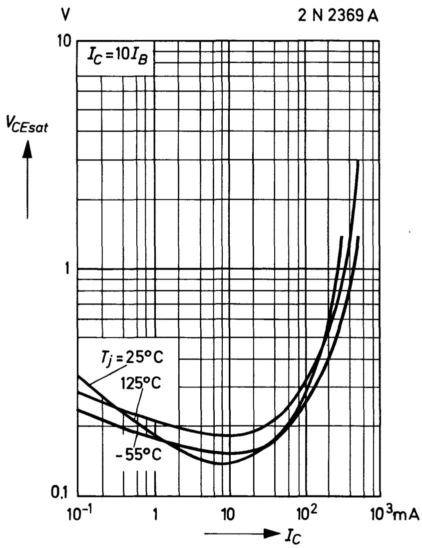
Collector current versus base emitter voltage



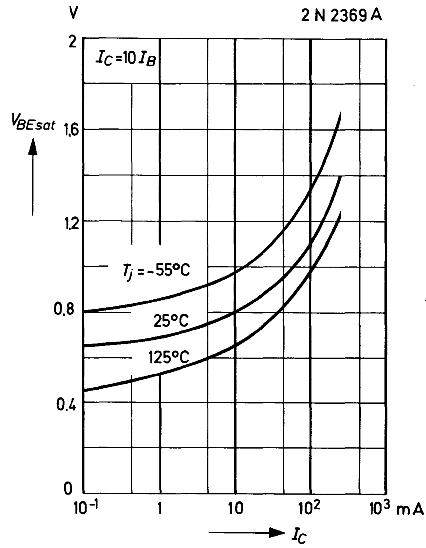
DC current gain versus collector current



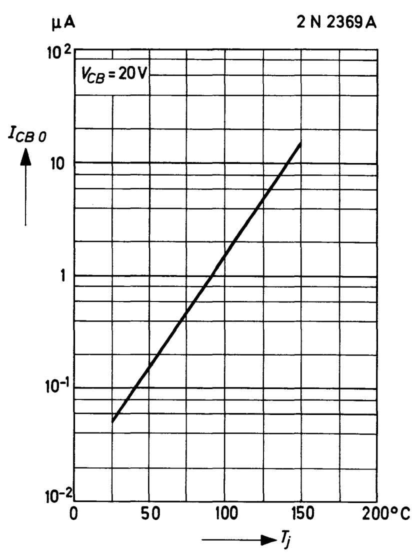
Collector saturation voltage versus collector current



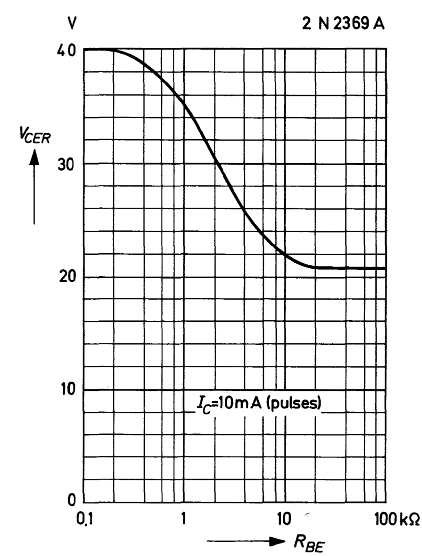
Base saturation voltage versus collector current



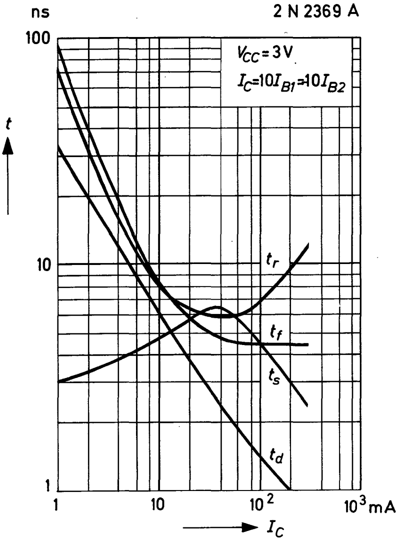
Collector cutoff current versus junction temperature



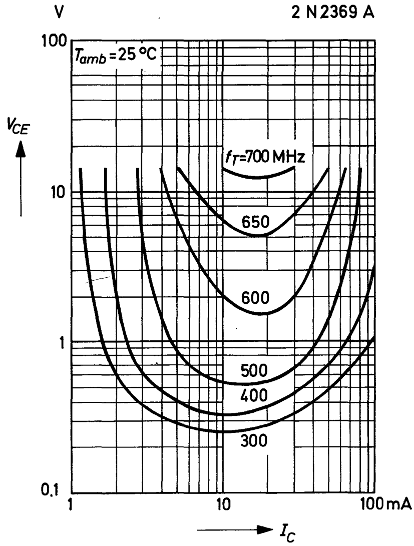
Admissible collector emitter voltage versus base emitter resistance



Switching times versus collector current

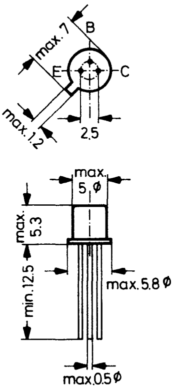


Contours of constant gain bandwidth product



NPN Silicon High Frequency Transistors

NPN Silicon Epitaxial Planar Transistor
with high collector emitter voltage, intended for use as interstage amplifier between the line frequency integrated circuit TAA 790 and the line output tube in TV sets.



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

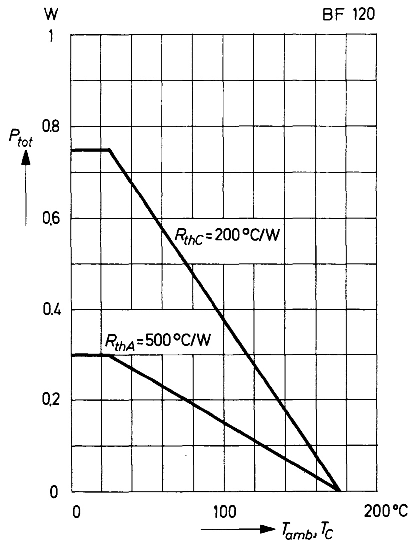
Maximum Ratings

Collector emitter voltage	V_{CEO}	220	V
Emitter base voltage	V_{EBO}	5	V
Collector current	I_C	50	mA
Power dissipation			
at $T_{amb} = 25\ °C$	P_{tot}	300	mW
at $T_C = 25°\ C$	P_{tot}	750	mW
Junction temperature	T_j	175	°C
Storage temperature range	T_S	−55 ... + 175°C	

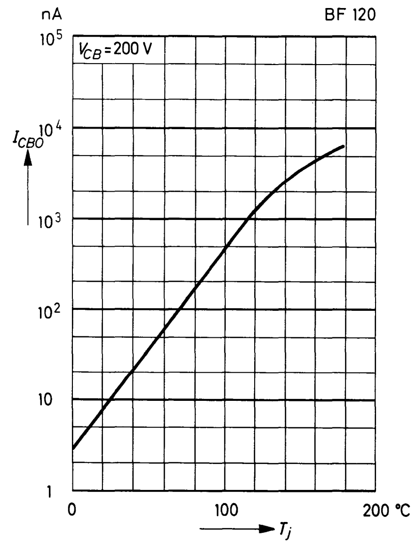
Characteristics at $T_j = 25\ °C$

DC current gain at $V_{CE} = 10\ V$, $I_C = 10\ mA$	h_{FE}	> 20	
Collector cutoff current at $V_{CB} = 200\ V$	I_{CBO}	10 (< 200)	nA
Collector saturation voltage at $I_C = 10\ mA$, $I_B = 2\ mA$	V_{CEsat}	< 2	V
Thermal resistance			
Junction to ambient air	R_{thA}	< 500	°C/W
Junction to case	R_{thC}	< 200	°C/W

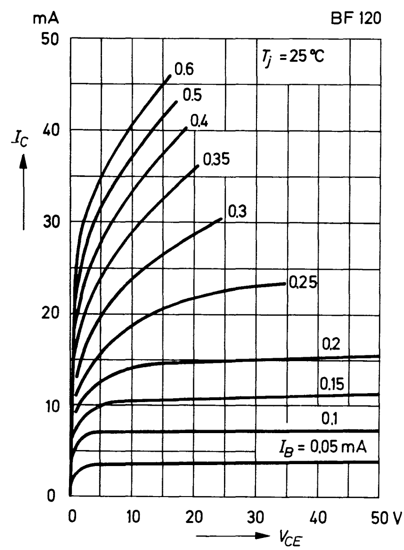
Admissible power dissipation versus temperature



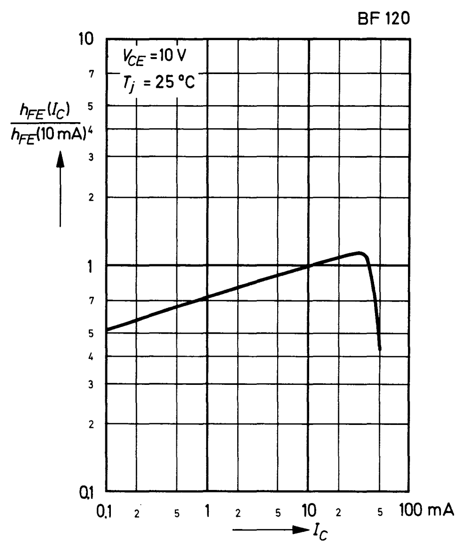
Collector cutoff current versus junction temperature



Common emitter collector characteristics

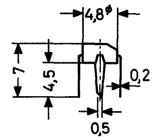


Relative DC current gain versus collector current

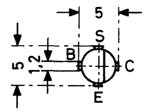


BF 121

NPN Silicon Planar Transistor
for RF applications up to 100 MHz in grounded emitter and grounded base connection, suited for forward and reverse AGC.



Black plastic package 50 B 4
The case is impervious to light.
Weight approximately 0.1 g
Dimensions in mm



Maximum Ratings

Collector emitter voltage	V_{CEO}	30	V
Emitter base voltage	V_{EBO}	4	V
Breakdown voltage of the screen diode	V_{CS00}	40	V
Collector current	I_C	25	mA
Junction temperature	T_j	125	°C
Power dissipation at $T_{amb} = 25$ °C	P_{tot}	330[1]	mW

Static characteristics at $T_{amb} = 25$ °C

DC current gain at $V_{CE} = 10$ V, $I_C = 1$ mA	h_{FE}	72	
at $V_{CE} = 10$ V, $I_C = 4$ mA	h_{FE}	80 (> 30)	
Thermal resistance Junction to ambient air	R_{thA}	< 0.3[1]	°C/mW

[1] Valid provided the transistor is soldered onto a printed circuit board with 35 μm copper foil at a distance of $a = 1.5$ mm between copper foil and transistor. For different values of "a" see curve "Admissible power dissipation versus ambient temperature".

Dynamic characteristics at $T_{amb} = 25$ °C
Screen electrode at emitter potential, but grounded for RF

Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 4$ mA	f_T	350	MHz
Feedback capacitance at $V_{CE} = 10$ V, $I_C = 1$ mA, $f = 10.7$ MHz	$-C_{re}$	0.22	pF
Noise figure at $V_{CE} = 10$ V, $I_C = 1$ mA, $f = 1$ MHz, $R_G = 500\ \Omega$, grounded emitter	F	1.5	dB
at $V_{CE} = 10$ V, $I_C = 2$ mA, $f = 100$ MHz, $R_G = 60\ \Omega$, grounded base	F	3.5	dB

y-Parameters

Test conditions: V_{CE} = 10 V, I_C = 1 mA, f = **500 kHz, grounded emitter**

y_{ie} = (0.4 + j 0.06) mmho
C_{ie} = 19 pF
$|y_{re}|$ = 0.6 µmho, $\varphi = -90°$
$|y_{fe}|$ = 35 mmho, $\varphi = 0°$
y_{oe} = (2.5 + j 4.3) µmho
C_{oe} = 1.5 pF

Test conditions: V_{CE} = 10 V, I_C = 1 mA, f = **10.7 MHz, grounded emitter**

y_{ie} = (0.53 + j 1.25) mmho
C_{ie} = 19 pF
$|y_{re}|$ = 14 µmho, $\varphi = -92°$
$|y_{fe}|$ = 35 mmho, $\varphi = -5°$
y_{oe} = (3.9 + j 94) µmho
C_{oe} = 1.5 pF

Test conditions: V_{CE} = 10 V, I_C = 2 mA, f = **100 MHz, grounded emitter**

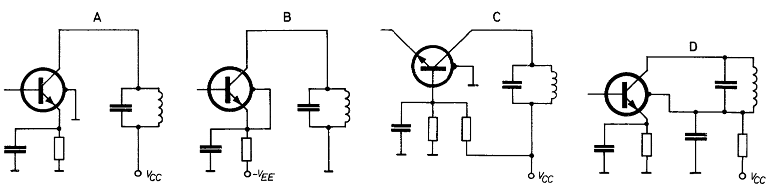
y_{ie} = (15.5 + j 14.5) mmho
C_{ie} = 23 pF
$|y_{re}|$ = 130 µmho, $\varphi = -96°$
$|y_{fe}|$ = 55 mmho, $\varphi = -34°$
y_{oe} = (46 + j 900) µmho
C_{oe} = 1.4 pF

Test conditions: V_{CE} = 10 V, I_C = 2 mA, f = **100 MHz, grounded base**

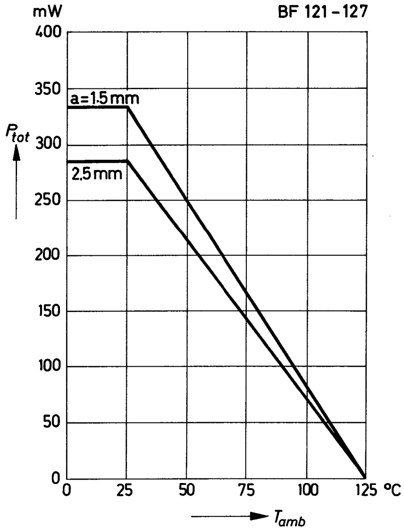
y_{ib} = (58 – j 14) mmho
$-C_{ib}$ = 22 pF
$|y_{rb}|$ = 130 µmho, $\varphi = -84°$
$|y_{fb}|$ = 55 mmho, $\varphi = 148°$
y_{ob} = (46 + j 900) µmho
C_{ob} = 1.4 pF

The screen has to be grounded for RF. Smallest output and reverse capacitances are obtained with screen connected to emitter or base potential (see Fig. A . . . C).

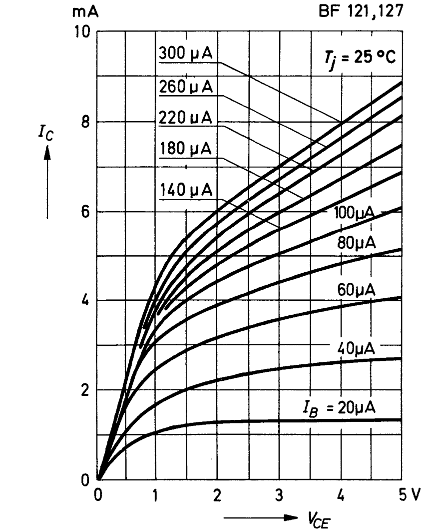
The screen diode can also be used as damper diode in parallel to the output resonant circuit of a RF stage. In this case the screen terminal has to be connected to the cold end of the output circuit (see Fig. D).



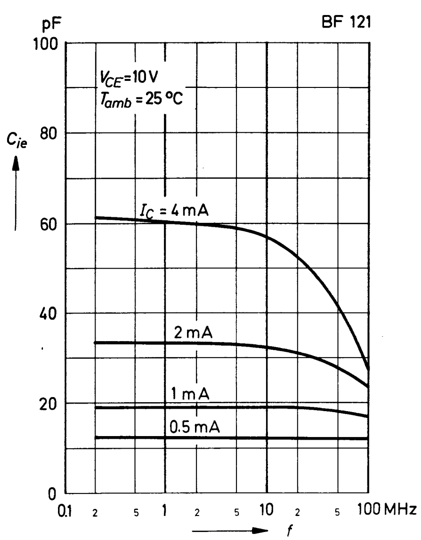
Admissible power dissipation versus ambient temperature



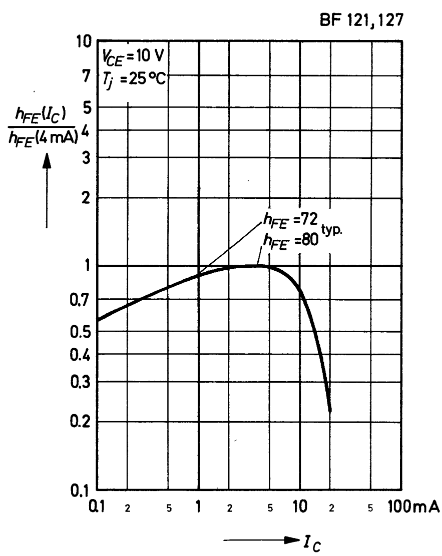
Common emitter collector characteristics



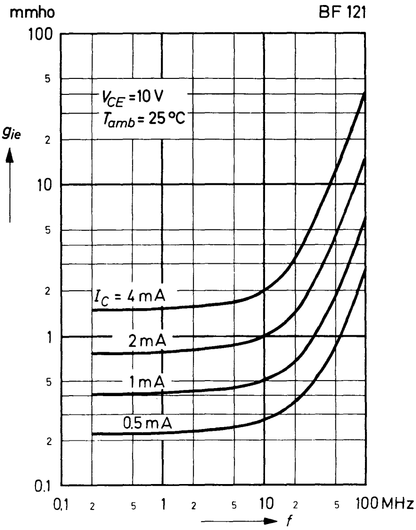
Input capacitance versus frequency



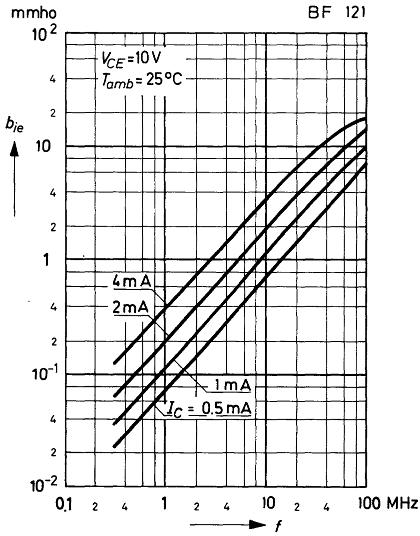
Relative DC current gain versus collector current



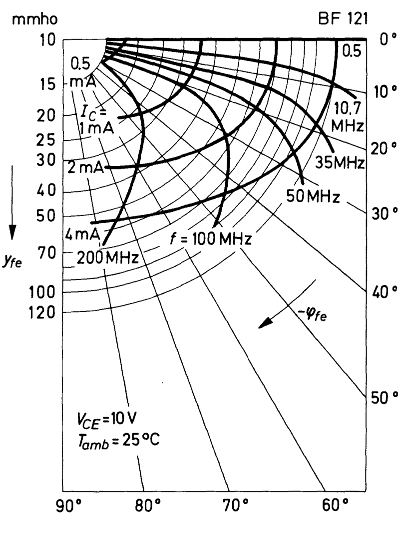
Real part of input admittance versus frequency



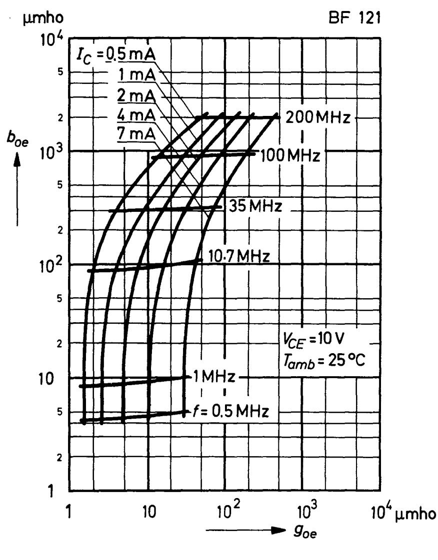
Imaginary part of input admittance versus frequency



Forward transconductance characteristics

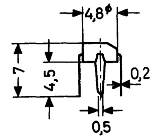


Output admittance characteristics

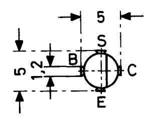


BF 123

NPN Silicon Epitaxial Planar Transistor
suited for TV IF amplifier stages without AGC,
especially for video IF output stages



Black plastic package 50 B 4
The case is impervious to light.
Weight approximately 0.1 g
Dimensions in mm



Maximum Ratings

Collector emitter voltage	V_{CEO}	30	V
Emitter base voltage	V_{EBO}	4	V
Breakdown voltage of the screen diode	V_{CS00}	40	V
Collector current	I_C	30	mA
Junction temperature	T_j	125	°C
Power dissipation at $T_{amb} = 25$ °C	P_{tot}	330[1]	mW

Static characteristics at $T_{amb} = 25$ °C

DC current gain			
at $V_{CE} = 10$ V, $I_C = 7$ mA	h_{FE}	90 ($>$ 35)	
at $V_{CE} = 2$ V, $I_C = 20$ mA	h_{FE}	$>$ 15	
Base emitter voltage at $V_{CE} = 10$ V, $I_C = 7$ mA	V_{BE}	0.74 ($<$ 0.9)	V
Thermal resistance Junction to ambient air	R_{thA}	$<$ 0.3[1]	°C/mW

[1] Valid provided the transistor is soldered onto a printed circuit board with 35 μm copper foil at a distance of $a = 1.5$ mm between copper foil and transistor. For different values of "a" see curve "Admissible power dissipation versus ambient temperature".

Dynamic characteristics at $T_{amb} = 25$ °C
Screen electrode at emitter potentional, but grounded for RF

Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 5$ mA	f_T	550	MHz
Feedback capacitance at $V_{CE} = 10$ V, $I_C = 1$ mA, $f = 10.7$ MHz	$-C_{re}$	0.3	pF
Max. available power gain at $V_{CE} = 10$ V, $I_C = 7$ mA, $f = 35$ MHz	G_{Pmax}	44.6	dB

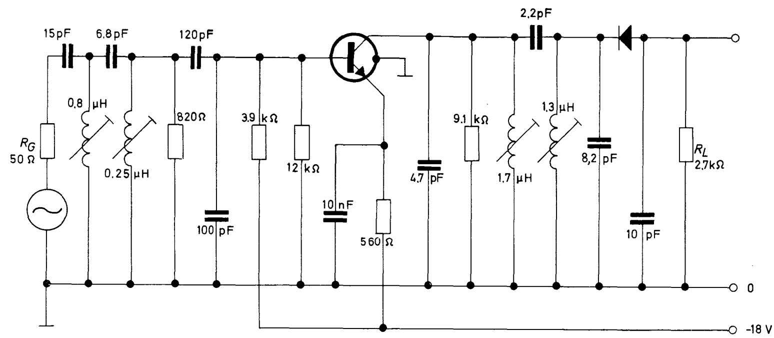
y-Parameters

Test conditions: $V_{CE} = 10$ V, $I_C = 7$ mA, $f = 35$ MHz, grounded emitter

$y_{ie} = (5.9 + j\,10)$ mmho
$C_{ie} = 45$ pF
$|y_{re}| = 65$ µmho, $\varphi = -94°$

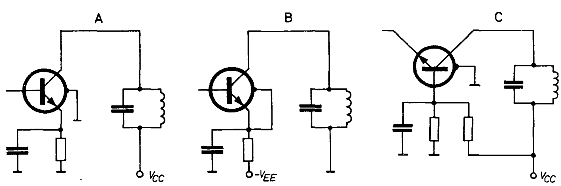
$|y_{fe}| = 185\ (> 115)$ mmho, $\varphi = -24°$
$y_{oe} = (50 + j\,395)$ µmho
$C_{oe} = 1.8$ pF

Operating Data as IF Amplifier
$f = 35$ MHz

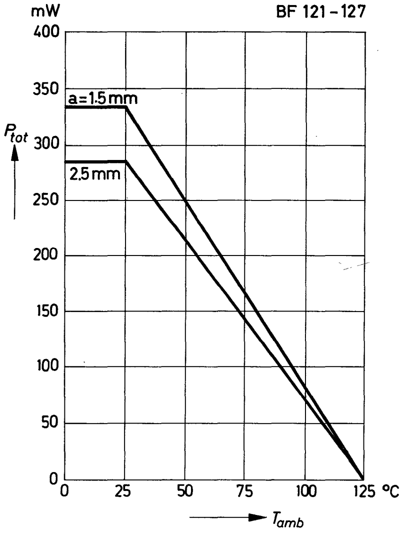


Power gain at $I_C = 7.2$ mA	G_P	26	dB

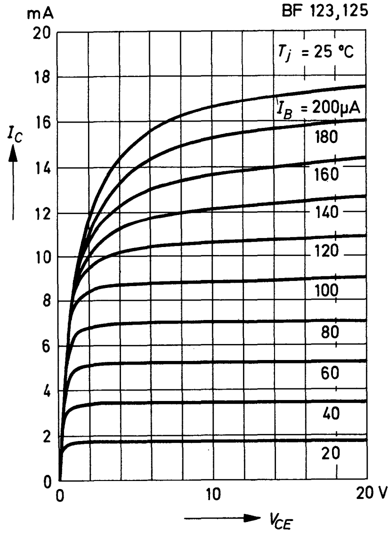
The screen has to be grounded for RF. Smallest output and reverse capacitances are obtained with screen connected to emitter or base potential (see Fig. A . . . C).



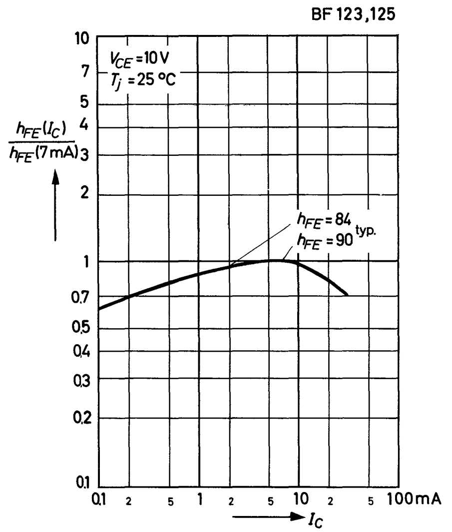
Admissible power dissipation versus ambient temperature



Common emitter collector characteristics

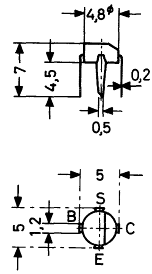


Relative DC current gain versus collector current



BF 125

NPN Silicon Epitaxial Planar Transistor
for RF amplifiers and oscillators up to 100 MHz



Black plastic package 50 B 4
The case is impervious to light
Weight approximately 0.1 g
Dimensions in mm

Maximum Ratings

Collector emitter voltage	V_{CEO}	30	V
Emitter base voltage	V_{EBO}	4	V
Breakdown voltage of the screen diode	V_{CS00}	40	V
Collector current	I_C	30	mA
Junction temperature	T_j	125	°C
Power dissipation at $T_{amb} = 25$ °C	P_{tot}	330[1]	mW

Static characteristics at $T_{amb} = 25$ °C

DC current gain			
at $V_{CE} = 10$ V, $I_C = 2$ mA	h_{FE}	84	
at $V_{CE} = 10$ V, $I_C = 7$ mA	h_{FE}	90 ($>$ 35)	
at $V_{CE} = 2$ V, $I_C = 20$ mA	h_{FE}	$>$ 15	
Thermal resistance Junction to ambient air	R_{thA}	$<$ 0.3[1]	°C/mW

[1] Valid provided the transistor is soldered onto a printed circuit board with 35 μm copper foil at a distance of $a = 1.5$ mm between copper foil and transistor. For different values of "a" see curve "Admissible power dissipation versus ambient temperature".

Dynamic characteristics at $T_{amb} = 25$ °C
Screen electrode at emitter potentional, but grounded for RF

Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 5$ mA	f_T	450	MHz
Oscillation cutoff frequency[2]	f_{max}	2.4	GHz
Feedback capacitance at $V_{CE} = 10$ V, $I_C = 1$ mA, $f = 10.7$ MHz	$-C_{re}$	0.3	pF
Noise figure at $V_{CE} = 10$ V, $I_C = 2$ mA, $f = 100$ MHz, $R_G = 60\ \Omega$, grounded base	F	3	dB

[2] $f_{max} = \sqrt{\dfrac{f_T}{8\pi \cdot r_{b'} \cdot C_c}}$

y-Parameters

Test conditions: $V_{CE} = 10$ V, $I_C = 2$ mA, $f =$ **500 kHz, grounded emitter**

$y_{ie} = (0.89 + j\,0.08)$ mmho
$C_{ie} = 25$ pF
$|y_{re}| = 0.9\ \mu$mho, $\varphi = -90°$
$|y_{fe}| = 70$ mmho, $\varphi = 0°$
$y_{oe} = (4 + j\,5.7)\ \mu$mho
$C_{oe} = 1.8$ pF

Test conditions: $V_{CE} = 10$ V, $I_C = 2$ mA, $f =$ **10.7 MHz, grounded emitter**

$y_{ie} = (1.2 + j\,1.6)$ mmho
$C_{ie} = 24$ pF
$|y_{re}| = 20\ \mu$mho, $\varphi = -92°$
$|y_{fe}| = 70$ mmho, $\varphi = -6°$
$y_{oe} = (4.5 + j\,120)\ \mu$mho
$C_{oe} = 1.8$ pF

Test conditions: $V_{CE} = 10$ V, $I_C = 2$ mA, $f =$ **100 MHz, grounded emitter**

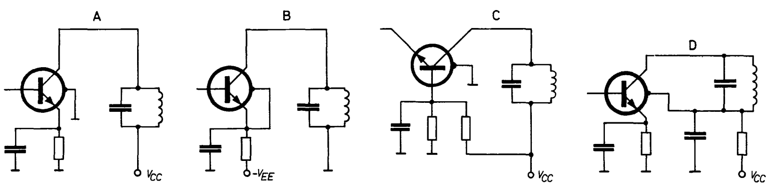
$y_{ie} = (10.8 + j\,14)$ mmho
$C_{ie} = 21$ pF
$|y_{re}| = 185\ \mu$mho, $\varphi = -95°$
$|y_{fe}| = 65$ mmho, $\varphi = -25°$
$y_{oe} = (23 + j\,1130)\ \mu$mho
$C_{oe} = 1.8$ pF

Test conditions: $V_{CE} = 10$ V, $I_C = 2$ mA, $f =$ **100 MHz, grounded base**

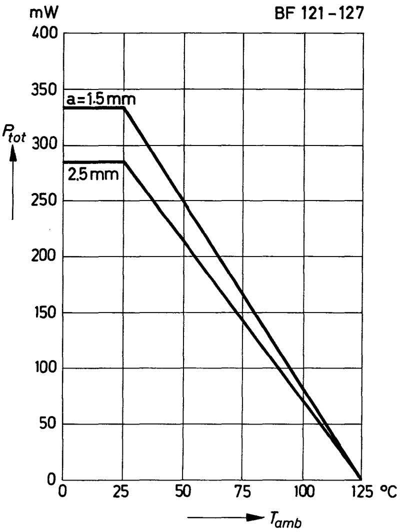
$y_{ib} = (70 - j\,12.6)$ mmho
$-C_{ib} = 21$ pF
$|y_{rb}| = 185\ \mu$mho, $\varphi = -85°$
$|y_{fb}| = 65$ mmho, $\varphi = 155°$
$y_{ob} = (23 + j\,1130)\ \mu$mho
$C_{ob} = 1.8$ pF

The screen has to be grounded for RF. Smallest output and reverse capacitances are obtained with screen connected to emitter or base potential (see Fig. A . . . C).

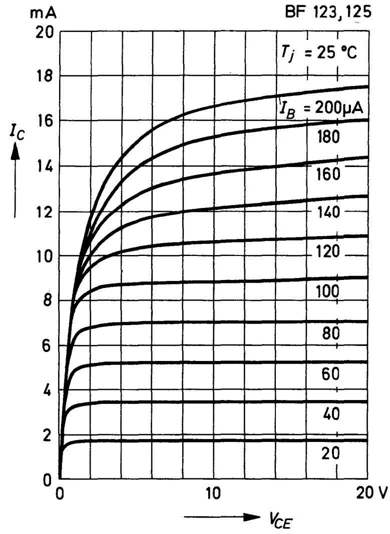
The screen diode can also be used as damper diode in parallel to the output resonant circuit of a RF stage. In this case the screen terminal has to be connected to the cold end of the output circuit (see Fig. D).



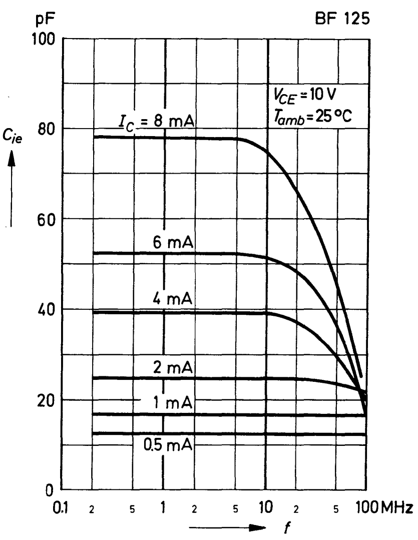
Admissible power dissipation versus ambient temperature



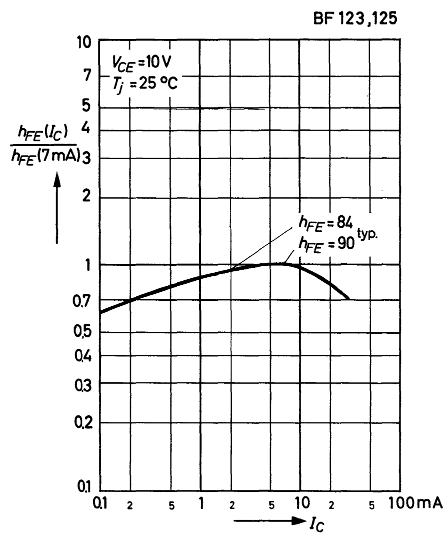
Common emitter collector characteristics



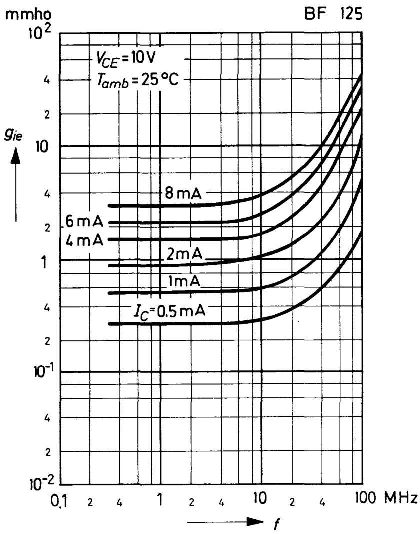
Input capacitance versus frequency



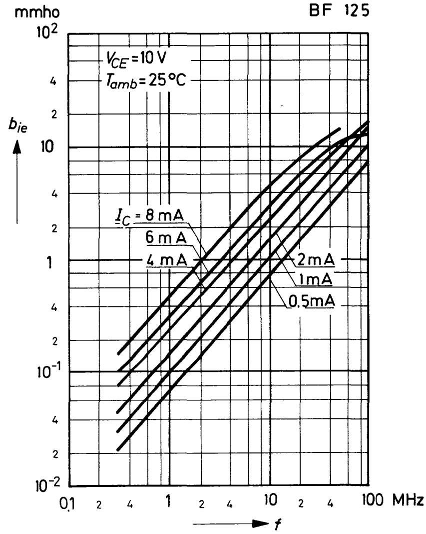
Relative DC current gain versus collector current



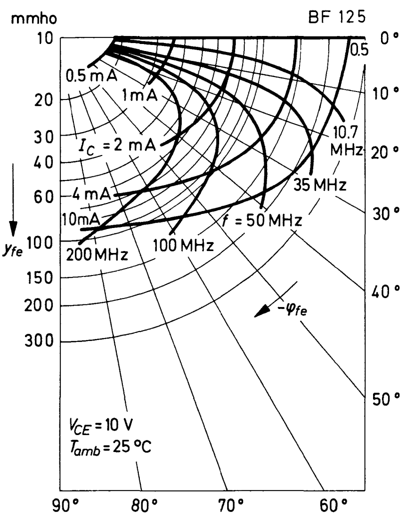
Real part of input admittance versus frequency



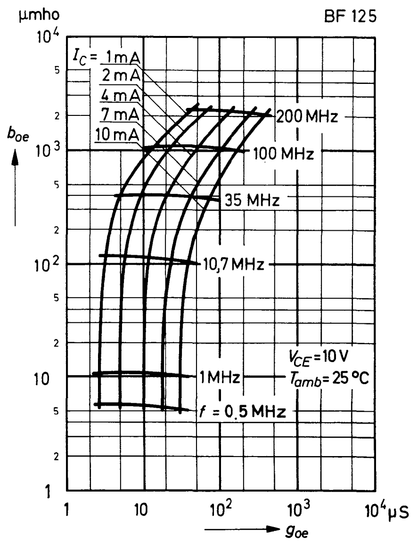
Imaginary part of input admittance versus frequency



Forward transconductance characteristics

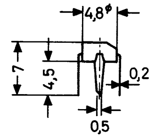


Output admittance characteristics

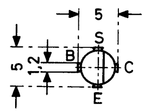


BF 127

NPN Silicon Epitaxial Planar Transistor
especially designed for use in TV IF amplifiers with forward AGC



Black plastic package 50 B 4
The case is impervious to light
Weight approximately 0.1 g
Dimensions in mm



Maximum Ratings

Collector emitter voltage	V_{CEO}	30	V
Emitter base voltage	V_{EBO}	4	V
Breakdown voltage of the screen diode	V_{CS00}	40	V
Collector current	I_C	25	mA
Junction temperature	T_j	125	°C
Power dissipation at $T_{amb} = 25$ °C	P_{tot}	330[1]	mW

Static characteristics at $T_{amb} = 25$ °C

DC current gain at $V_{CE} = 10$ V, $I_C = 4$ mA	h_{FE}	80 ($>$ 30)	
Thermal resistance Junction to ambient air	R_{thA}	$<$ 0.3[1]	°C/mW

[1] Valid provided the transistor is soldered onto a printed circuit board with 35 μm copper foil at a distance of $a = 1.5$ mm between copper foil and transistor. For different values of "a" see curve "Admissible power dissipation versus ambient temperature".

Dynamic characteristics at $T_{amb} = 25$ °C
Screen electrode at emitter potentional, but grounded for RF

Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 4$ mA	f_T	350	MHz
Feedback capacitance at $V_{CE} = 10$ V, $I_C = 1$ mA, $f = 10.7$ MHz	$-C_{re}$	0.22	pF
Max. available power gain at $V_{CE} = 10$ V, $I_C = 4$ mA, $f = 35$ MHz	G_{Pmax}	43.2	dB
Noise figure at $V_{CE} = 10$ V, $I_C = 4$ mA, $f = 35$ MHz, $R_G = 100\ \Omega$, grounded emitter	F	3	dB

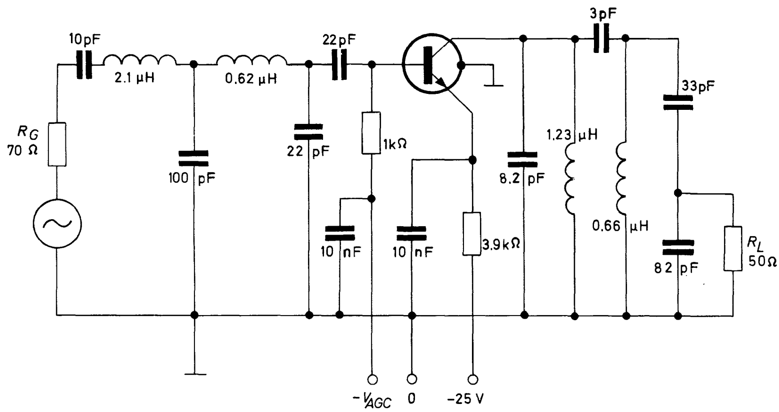
y-Parameters

Test conditions: $V_{CE} = 10$ V, $I_C = 4$ mA, $f = 35$ MHz, grounded emitter

$y_{ie} = (5.4 + j\,10)$ mmho
$C_{ie} = 45$ pF
$|y_{re}| = 48$ µmho, $\varphi = -94°$
$|y_{fe}| = 115$ (> 75) mmho, $\varphi = -21°$
$y_{oe} = (30 + j\,305)$ µmho
$C_{oe} = 1.4$ pF

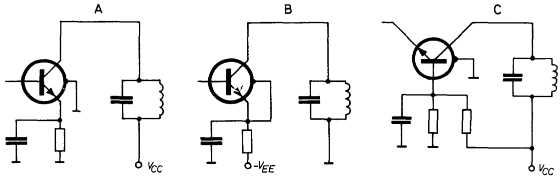
Operating Data as IF Amplifier

IF stage with AGC, $f = 35$ MHz

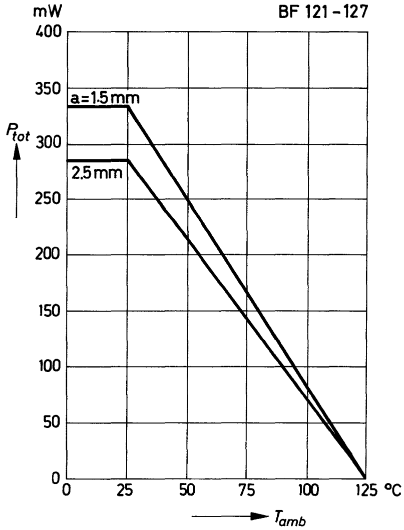


Power gain at $I_C = 4$ mA	G_P	26	dB
Gain control range	ΔG_P	60	dB

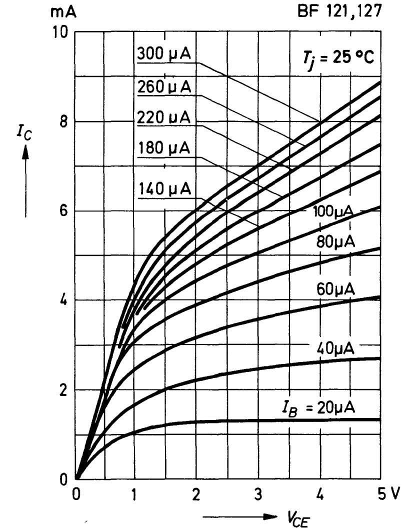
The screen has to be grounded for RF. Smallest output and reverse capacitances are obtained with screen connected to emitter or base potential (see Fig. A . . . C).



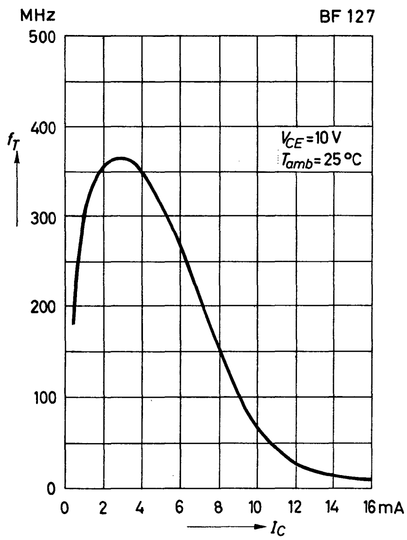
Admissible power dissipation versus ambient temperature



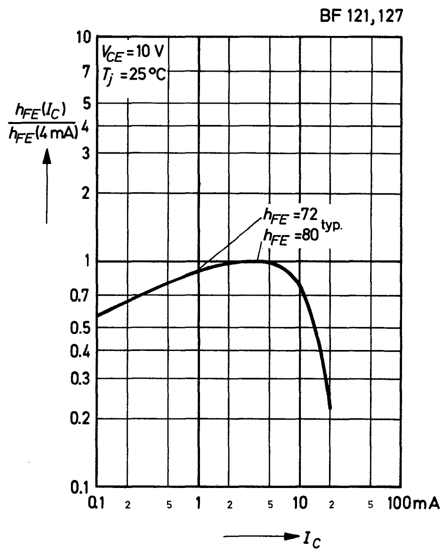
Common emitter collector characteristics



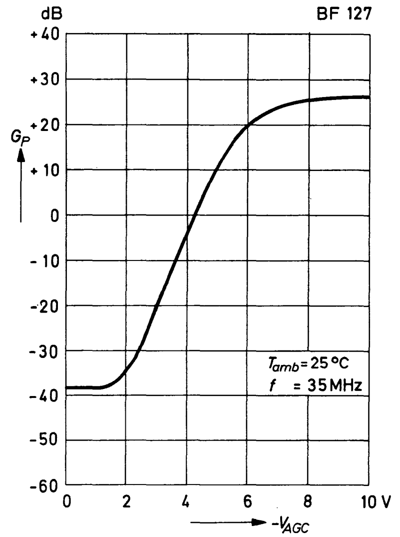
Gain bandwidth product versus collector current



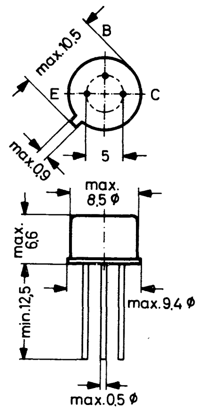
Relative DC current gain versus collector current



IF power gain versus automatic gain control voltage



NPN Silicon Epitaxial Planar Transistor
for video output stages



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1 g
Dimensions in mm

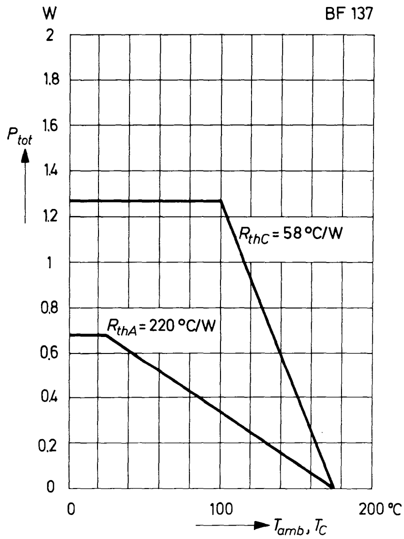
Maximum Ratings

Collector base voltage	V_{CBO}	160	V
Collector emitter voltage	V_{CEO}	160	V
Emitter base voltage	V_{EBO}	5	V
Collector current	I_C	100	mA
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	680	mW
at T_C = 100 °C	P_{tot}	1.27	W
Junction temperature	T_j	175	°C
Storage temperature range	T_S	−55 ... + 175	°C

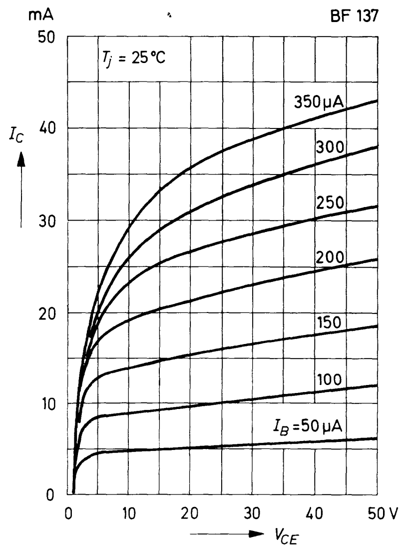
Characteristics at T_j = 25 °C

DC current gain at V_{CE} = 10 V, I_C = 30 mA	h_{FE}	> 25	
Collector saturation voltage at I_C = 30 mA, I_B = 6 mA	$V_{CE\,sat}$	< 1	V
Collector cutoff current at V_{CB} = 100 V	I_{CBO}	< 10	nA
Emitter cutoff current at V_{EB} = 4 V	I_{EBO}	< 50	nA
Collector base capacitance at V_{CBO} = 20 V, f = 500 kHz	C_{CBO}	2	pF
Gain bandwidth product at V_{CE} = 10 V, I_C = 20 mA, f = 50 MHz	f_T	95	MHz
Thermal resistance			
Junction to ambient air	R_{thA}	< 220	°C/W
Junction to case	R_{thC}	< 58	°C/W

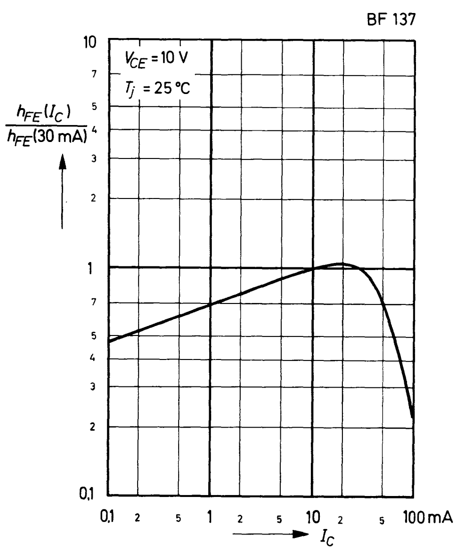
Admissible power dissipation versus temperature



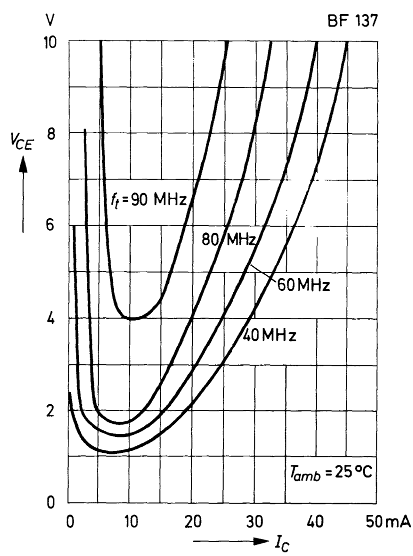
Common emitter collector characteristics



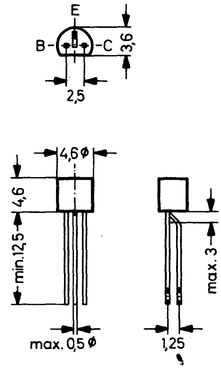
Relative DC current gain versus collector current



Contours of constant gain bandwidth product



NPN Silicon Planar Transistor
designed for RF applications; low feedback capacitance, especially suited for AGC in emitter-grounded IF stages in TV sets.



Black plastic case ≈ TO-92
TO-18 compatible.
The case is impervious to light.
Weight approximately 0.18 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	40	V
Collector emitter voltage	V_{CEO}	30	V
Emitter base voltage	V_{EBO}	4	V
Collector current	I_C	25	mA
Base current	I_B	3	mA
Power dissipation at $T_{amb} = 25\ °C$	P_{tot}	300[1]	mW
Junction temperature	T_j	150	°C
Storage temperature range	T_S	–55 ... + 150	°C

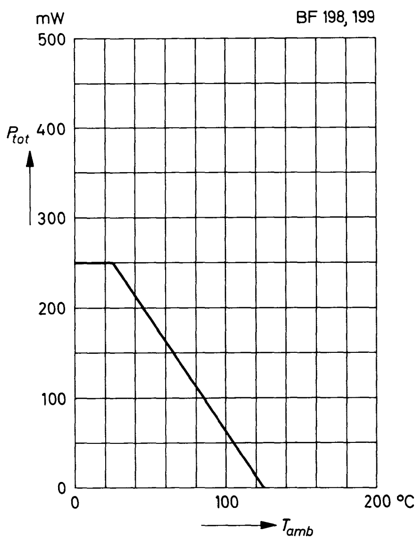
Characteristics at $T_{amb} = 25\ °C$

DC current gain at $V_{CE} = 10$ V, $I_C = 10$ mA	h_{FE}	80 (> 27)	
Base emitter voltage at $V_{CB} = 10$ V, $I_C = 4$ mA	V_{BE}	750	mV
Collector cutoff current at $V_{CB} = 40$ V	I_{CBO}	< 100	nA
Thermal resistance Junction to ambient air	R_{thA}	< 420[1]	°C/W

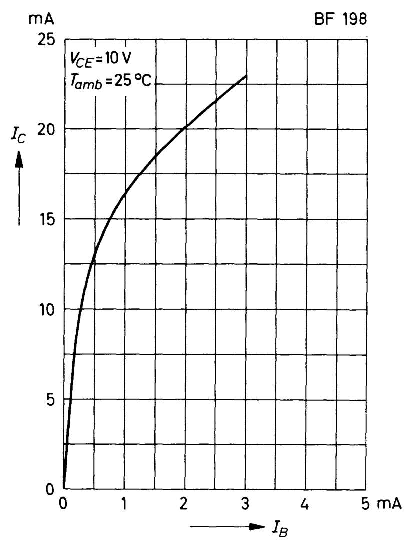
[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

Feedback capacitance at $V_{CB} = 10$ V, $I_C = 1$ mA, $f = 1$ MHz	$-C_{re}$	0.22	pF
Gain bandwidth product at $V_{CB} = 10$ V, $I_C = 4$ mA, $f = 100$ MHz	f_T	400	MHz
Noise figure at $V_{CB} = 10$ V, $I_C = 4$ mA, $f = 35$ MHz, $R_G = 100\ \Omega$	F	3	dB
y-Parameters (emitter grounded) at $f = 35$ MHz, $V_{CB} = 10$ V, $I_C = 4$ mA			
Input admittance	g_{ie}	4.5	mmho
Output admittance	g_{oe}	35	µmho
Input capacitance	C_{ie}	40	pF
Output capacitance	C_{oe}	1.3	pF
Forward transconductance	$\|y_{fe}\|$ φ_{fe}	105 −20°	mmho
Reverse transconductance	$\|y_{re}\|$ φ_{re}	45 −95°	µmho

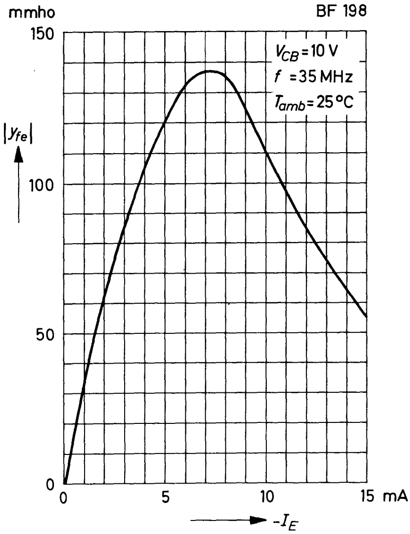
Admissible power dissipation versus ambient temperature
(see note on page 242)



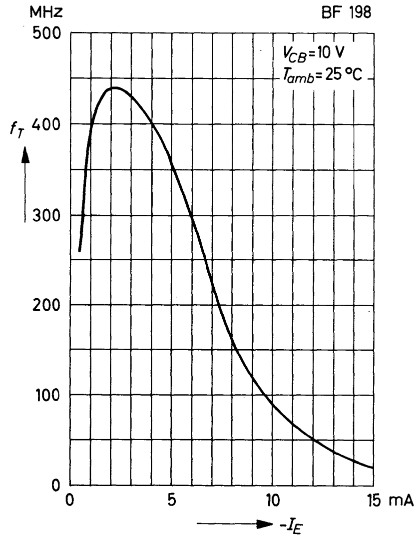
Collector current versus base current



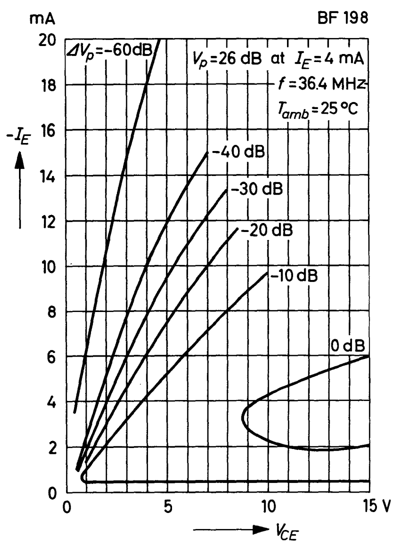
Forward transconductance versus emitter current



Gain bandwidth product versus emitter current

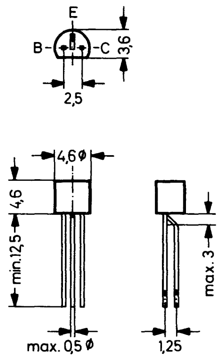


AGC characteristics



BF 199

NPN Silicon Epitaxial Planar Transistor
designed for RF applications; low feedback capacitance, especially suited for emitter-grounded IF stages in TV sets.



Black plastic case ≈ TO-92
TO-18 compatible.
The case is impervious to light.
Weight approximately 0.18 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	40	V
Collector emitter voltage	V_{CEO}	25	V
Emitter base voltage	V_{EBO}	4	V
Collector current	I_C	25	mA
Base current	I_B	2	mA
Power dissipation at $T_{amb} = 25$ °C	P_{tot}	300[1]	mW
Junction temperature	T_j	150	°C
Storage temperature range	T_S	−55 ... + 150	°C

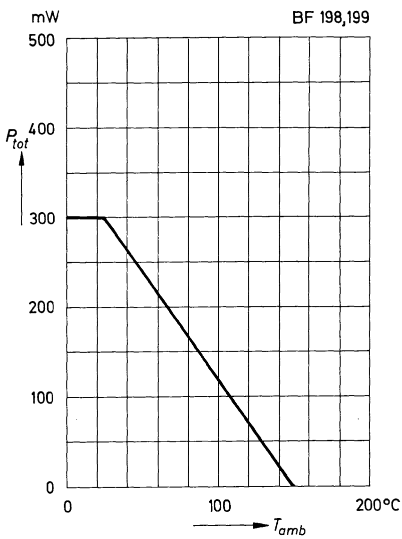
Characteristics at $T_{amb} = 25$ °C

DC current gain at $V_{CE} = 10$ V, $I_C = 7$ mA	h_{FE}	88 (> 38)	
Base emitter voltage at $V_{CB} = 10$ V, $I_C = 7$ mA	V_{BE}	750	mV
Collector cutoff current at $V_{CB} = 40$ V	I_{CBO}	< 100	nA
Thermal resistance Junction to ambient air	R_{thA}	< 420[1]	°C/W

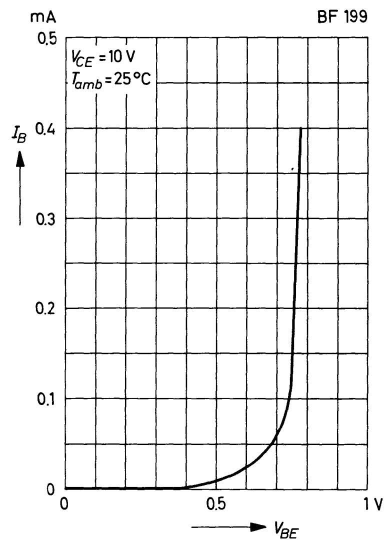
[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

Feedback capacitance at V_{CB} = 10 V, I_C = 1 mA, f = 1 MHz	$-C_{re}$	0.32	pF
Gain bandwidth product at V_{CB} = 10 V, I_C = 5 mA, f = 100 MHz	f_T	550	MHz
y-Parameters (emitter grounded) at f = 35 MHz, V_{CB} = 10 V, I_C = 7 mA			
Input admittance	g_{ie}	5	mmho
Output admittance	g_{oe}	75	µmho
Input capacitance	C_{ie}	45	pF
Output capacitance	C_{oe}	1.6	pF
Forward transconductance	$\|y_{fe}\|$ φ_{fe}	175 −25°	mmho
Reverse transconductance	$\|y_{re}\|$ φ_{re}	65 −95°	µmho

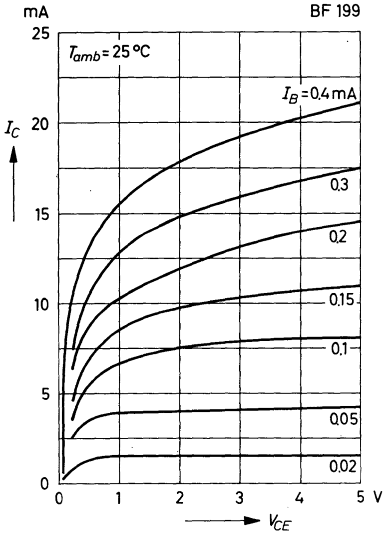
Admissible power dissipation versus ambient temperature
(see note on page 246)



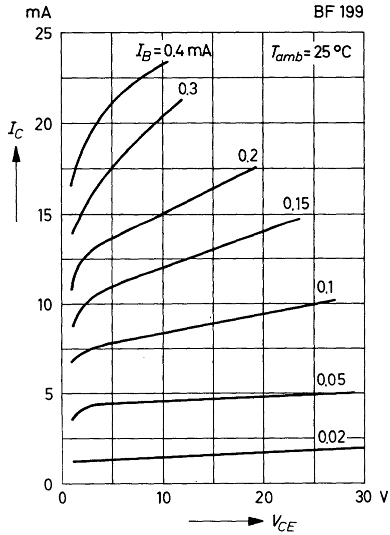
Common emitter input characteristic



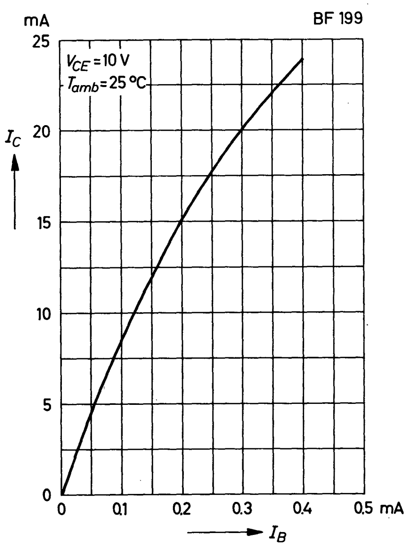
Common emitter collector characteristics



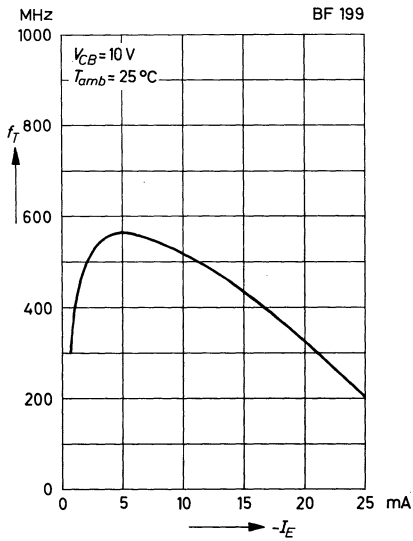
Common emitter collector characteristics



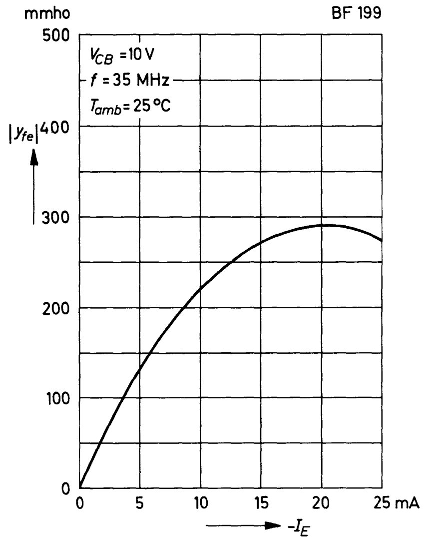
Collector current versus base current



Gain bandwidth product versus emitter current

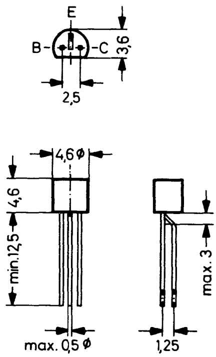


Forward transconductance versus emitter current



BF 240, BF 241

NPN Silicon Epitaxial Planar Transistors
designed for emitter-grounded AM and FM amplifier stages



Black plastic case ≈ TO-92
TO-18 compatible.
The case is impervious to light.
Weight approximately 0.18 g
Dimensions in mm

Maximum Ratings

Collector base voltage	V_{CBO}	40	V
Collector emitter voltage	V_{CEO}	40	V
Emitter base voltage	V_{EBO}	4	V
Collector current	I_C	25	mA
Base current	I_B	2	mA
Power dissipation at $T_{amb} = 25$ °C	P_{tot}	300[1]	mW
Junction temperature	T_j	150	°C
Storage temperature range	T_S	−55 ... + 150	°C

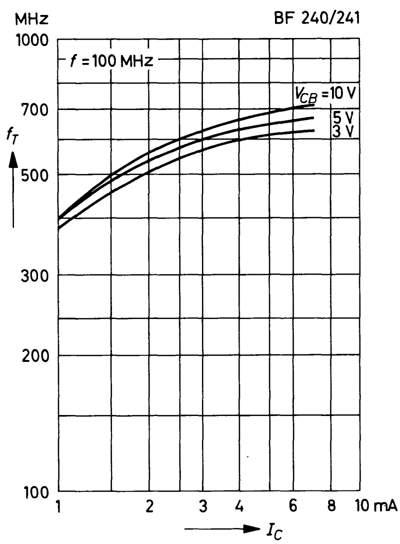
Characteristics at $T_{amb} = 25$ °C

DC current gain at $V_{CE} = 10$ V, $I_C = 1$ mA	**BF 240**	h_{FE}	67 ... 220	
	BF 241	h_{FE}	36 ... 125	
Base emitter voltage at $V_{CB} = 10$ V, $I_C = 1$ mA		V_{BE}	700 (650 ... 740)	mV
Collector cutoff current at $V_{CB} = 20$ V		I_{CBO}	< 100	nA
Thermal resistance Junction to ambient air		R_{thA}	< 420[1]	°C/W

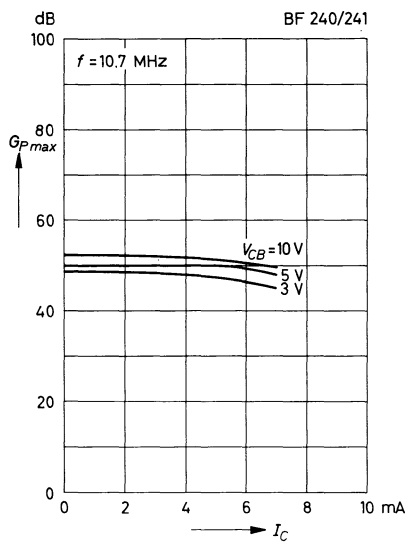
[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

Collector base breakdown voltage at $I_C = 10\ \mu A$	$V_{(BR)CBO}$	> 40		V
Collector emitter breakdown voltage at $I_C = 2$ mA	$V_{(BR)CEO}$	> 40		V
Emitter base breakdown voltage at $I_E = 10\ \mu A$	$V_{(BR)EBO}$	> 4		V
		BF 240	**BF 241**	
Gain bandwidth product at $V_{CBO} = 10$ V, $I_C = 1$ mA, $f = 100$ MHz	f_T	430	400	MHz
Feedback capacitance at $V_{CB} = 10$ V, $I_C = 1$ mA, $f = 1$ MHz	$-C_{re}$	0.27		pF
Noise figure (emitter grounded) at $V_{CB} = 10$ V, $I_C = 1$ mA				
$G_G = 5$ mmho, $f = 200$ kHz	F	1.5 (< 3.5)		dB
$Y_G = (6.6 - j\ 3.3)$ mmho, $f = 100$ MHz	F	1.6		dB
Output admittance				
at $V_{CB} = 10$ V, $I_C = 1$ mA, $f = 10.7$ MHz	g_{oe}	< 10.5		µmho
at $V_{CB} = 10$ V, $I_C = 1$ mA, $f = 470$ kHz	g_{oe}	< 8.3		µmho

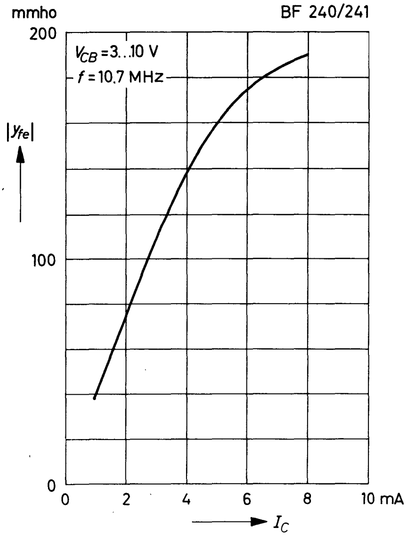
Gain bandwidth product versus collector current



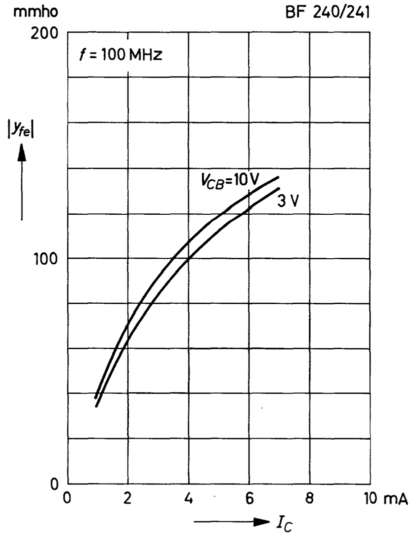
Max. available power gain versus collector current



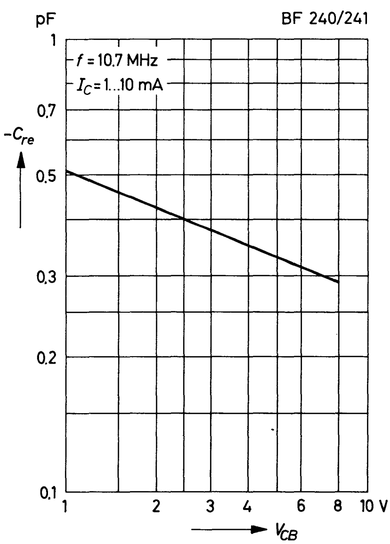
Forward transconductance at 10.7 MHz versus collector current



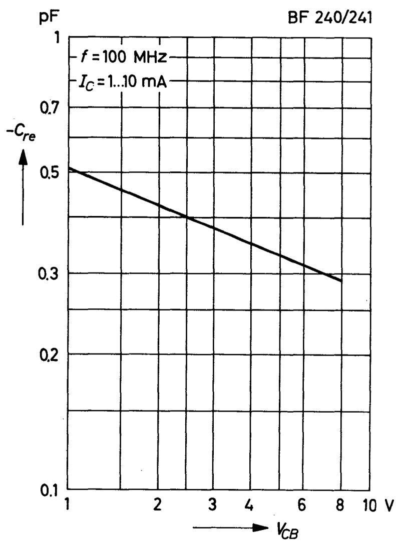
Forward transconductance at 100 MHz versus collector current



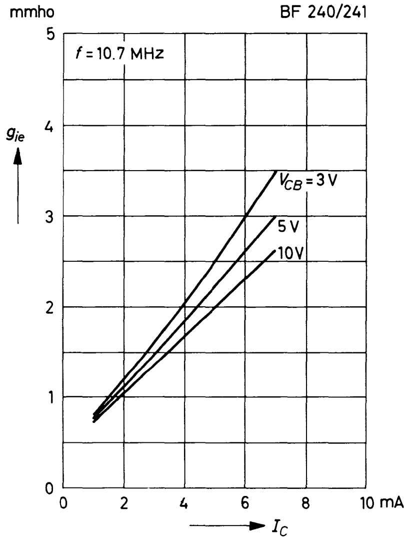
Feedback capacitance at 10.7 MHz versus collector base voltage



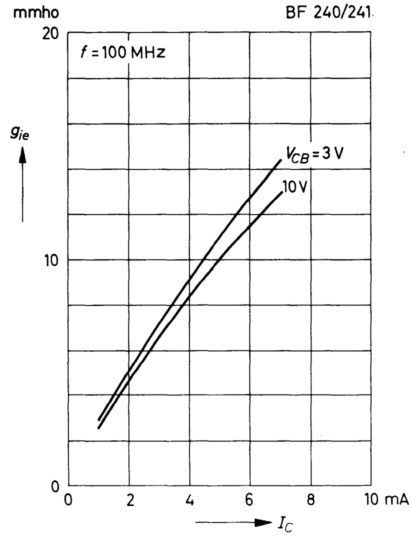
Feedback capacitance at 100 MHz versus collector base voltage



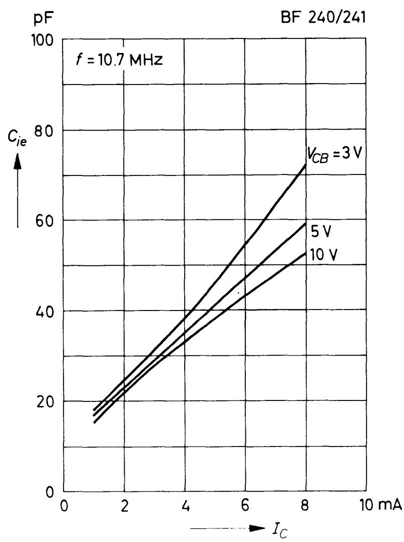
Input admittance at 10.7 MHz versus collector current



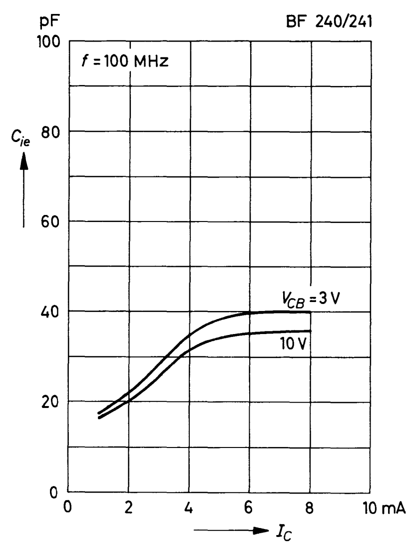
Input admittance at 100 MHz versus collector current



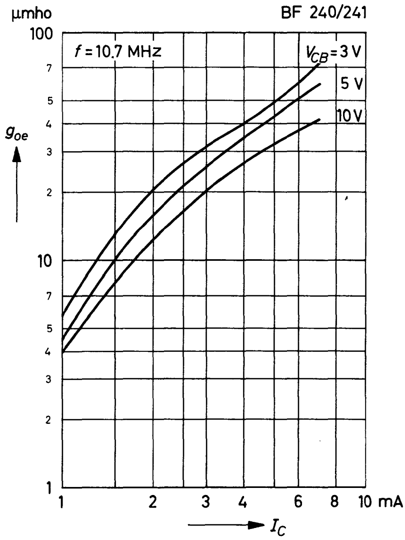
Input capacitance at 10.7 MHz versus collector current



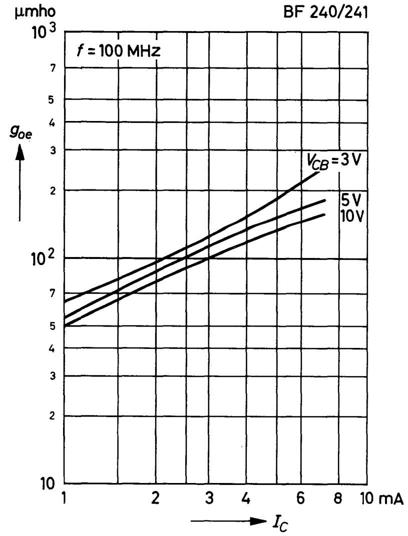
Input capacitance at 100 MHz versus collector current



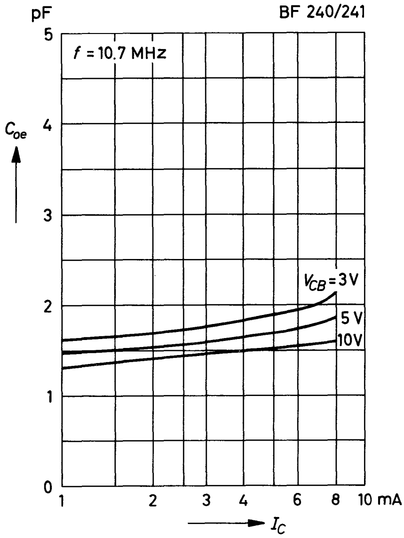
Output admittance at 10.7 MHz versus collector current



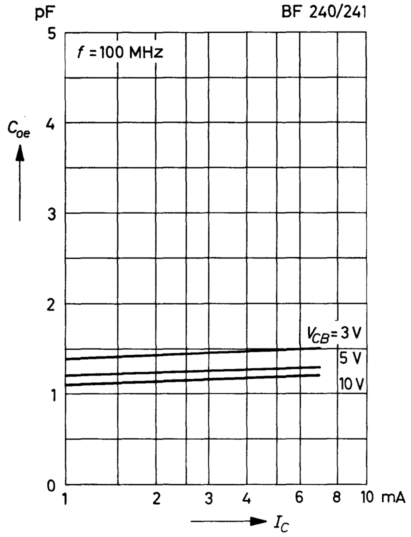
Output admittance at 100 MHz versus collector current



Output capacitance at 10.7 MHz versus collector current

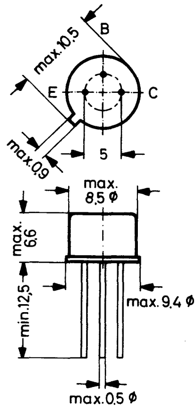


Output capacitance at 100 MHz versus collector current



BF 257, BF 258, BF 259

NPN Silicon Epitaxial Planar Transistors
for video output stages



Metal case JEDEC TO-39
Weight approximately 1 g
Collector connected to case
Dimensions in mm

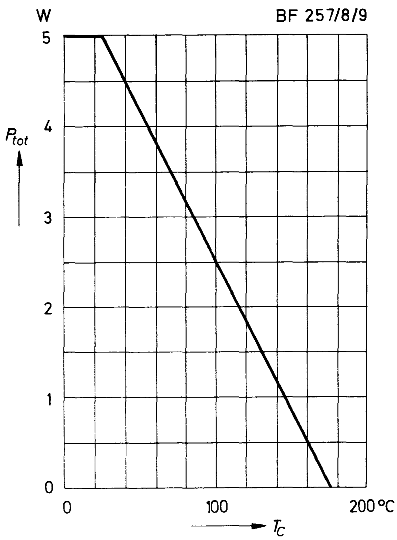
Maximum Ratings		**BF 257**	**BF 258**	**BF 259**	
Collector base voltage	V_{CBO}	160	250	300	V
Collector emitter voltage	V_{CEO}	160	250	300	V
Collector emitter voltage at $R_{BE} = 1$ kΩ	V_{CER}	160	250	300	V
Emitter base voltage	V_{EBO}	5			V
Collector current	I_C	100			mA
Power dissipation at $T_C = 25$ °C	P_{tot}	5			W
Junction temperature	T_j	175			°C

Characteristics at $T_j = 25$ °C

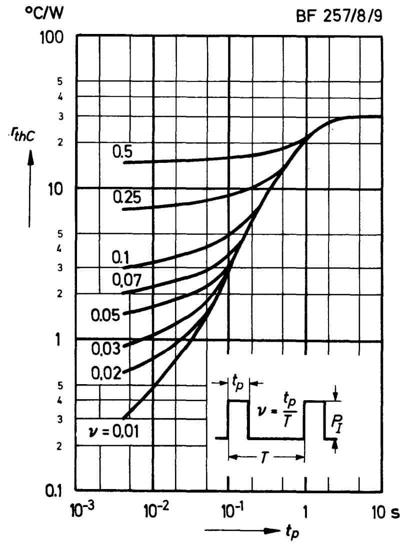
DC current gain at $V_{CE} = 10$ V, $I_C = 30$ mA	h_{FE}	> 25			
Collector saturation voltage at $I_C = 30$ mA, $I_B = 6$ mA	$V_{CE\,sat}$	< 1			V
		BF 257	**BF 258**	**BF 259**	
Collector cutoff current at $V_{CB} = 100$ V	I_{CBO}	< 50	–	–	nA
at $V_{CB} = 200$ V	I_{CBO}	–	< 50	–	nA
at $V_{CB} = 250$ V	I_{CBO}	–	–	< 50	nA
Collector base breakdown voltage at $I_C = 100$ µA	$V_{(BR)CBO}$	> 160	> 250	> 300	V
Collector emitter breakdown voltage at $I_C = 10$ mA	$V_{(BR)CEO}$	> 160	> 250	> 300	V

Emitter base breakdown voltage at $I_E = 100\ \mu A$	$V_{(BR)EBO}$	>5	V
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 15$ mA	f_T	90	MHz
Feedback capacitance at $V_{CB} = 30$ V, $f = 1$ MHz	$\|C_{re}\|$	4.2	pF
Output capacitance at $V_{CB} = 30$ V, $f = 1$ MHz	C_{oe}	5.5	pF
Thermal resistance Junction to case	R_{thC}	<30	°C/W

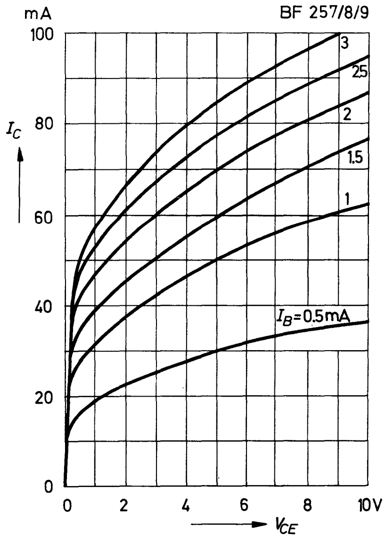
Admissible power dissipation versus case temperature



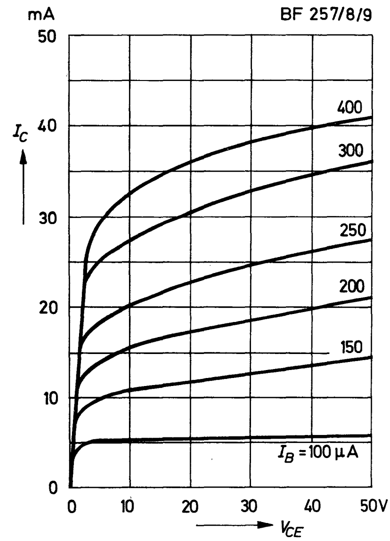
Pulse thermal resistance versus pulse duration



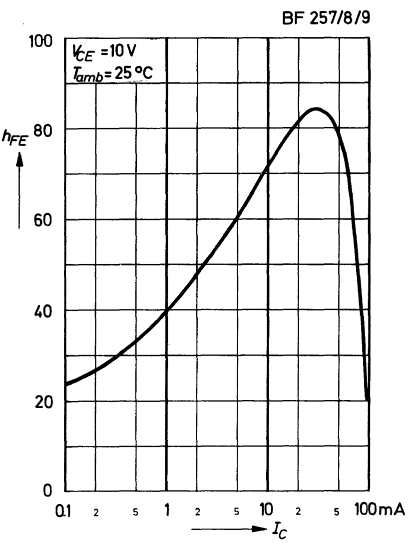
Common emitter collector characteristics



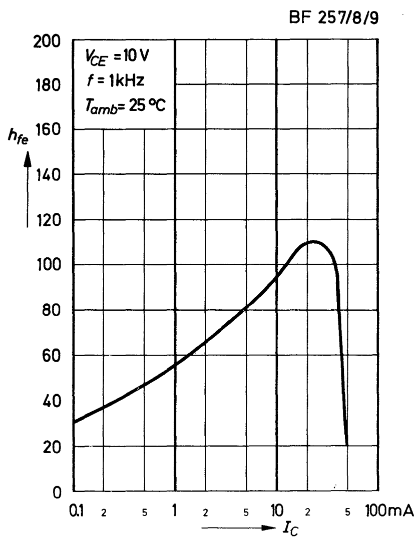
Common emitter collector characteristics



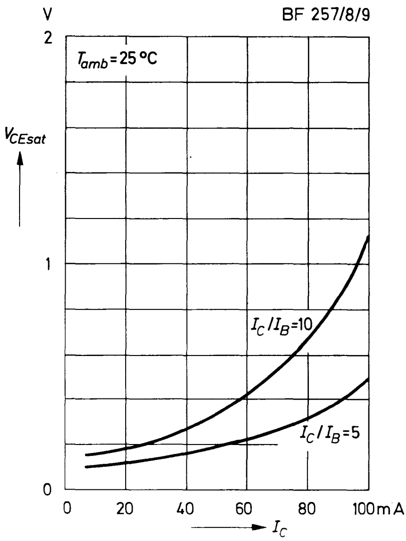
DC current gain versus collector current



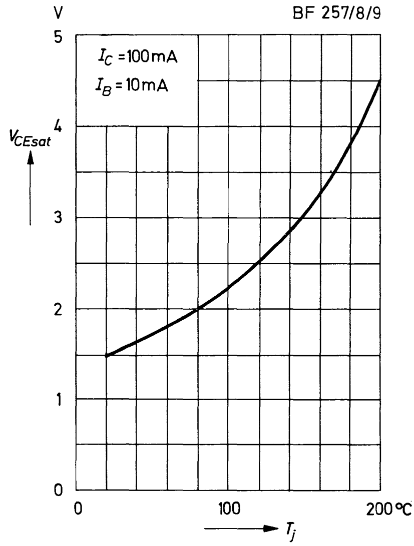
Small signal current gain versus collector current



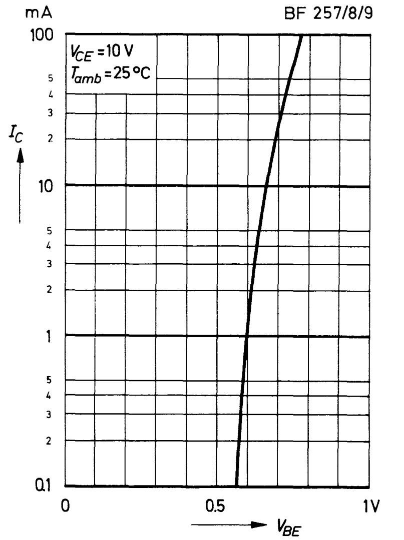
Collector saturation voltage versus collector current



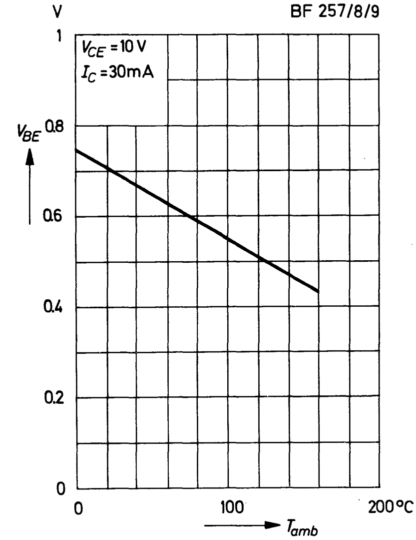
Collector saturation voltage versus junction temperature



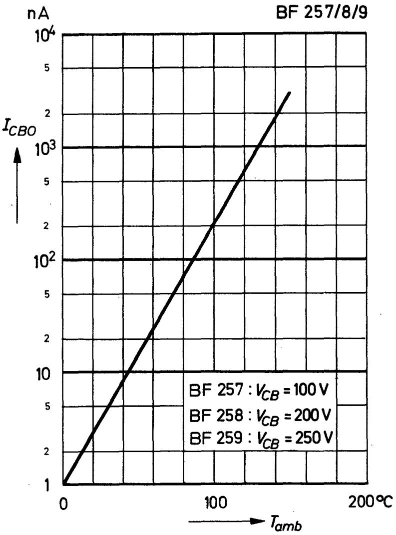
Collector current versus base emitter voltage



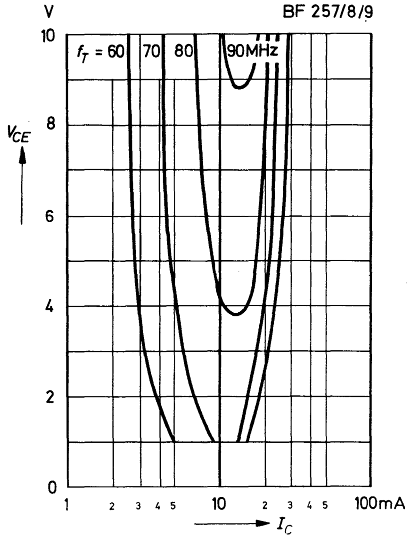
Base emitter voltage versus ambient temperature



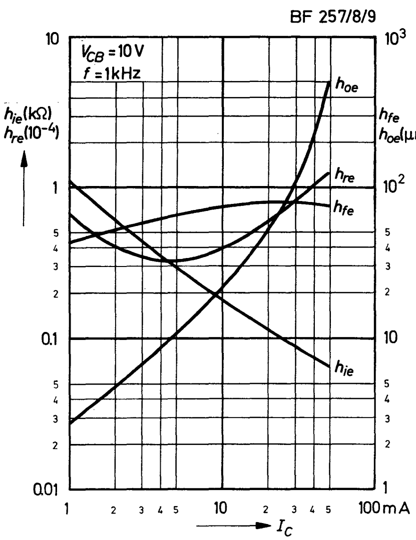
Collector cutoff current versus ambient temperature



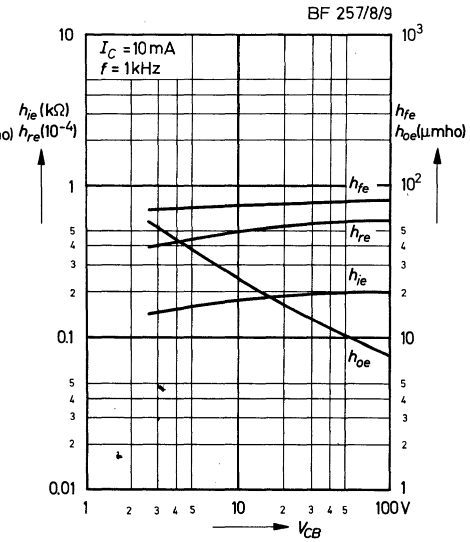
Contours of constant gain bandwidth product



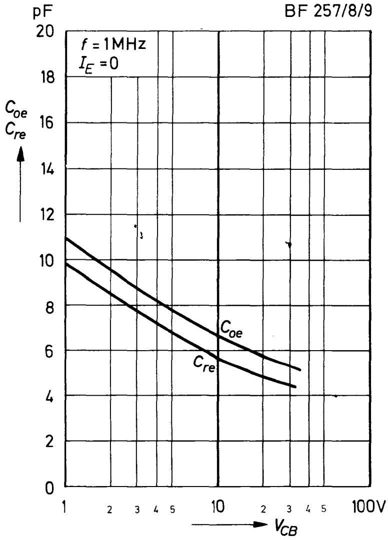
h-Parameters versus collector current



h-Parameters versus collector base voltage



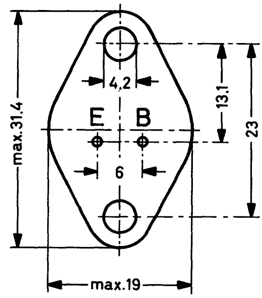
Output capacitance and feedback capacitance versus collector base voltage



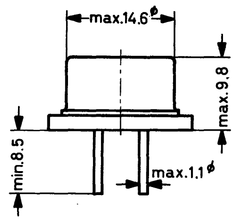
NPN Silicon Power Transistors

NPN Silicon Epitaxial Planar Power Transistors
for use in AF output stages, available matched in pairs

These transistors are subdivided into two groups A and B according to their DC current gain.

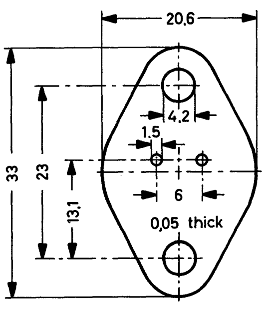


Metal case SOT-9
Collector connected to case
Weight approximately 8 g

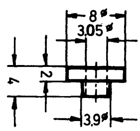


A set of accessories No. 9
will be delivered with each
transistor on request.
This set consists of:
1 insulating washer No. 02 911 mica
2 insulating bushes No. 02 321 polycarbonate

Insulating washer No. 02 911



Insulating bush No. 02 321



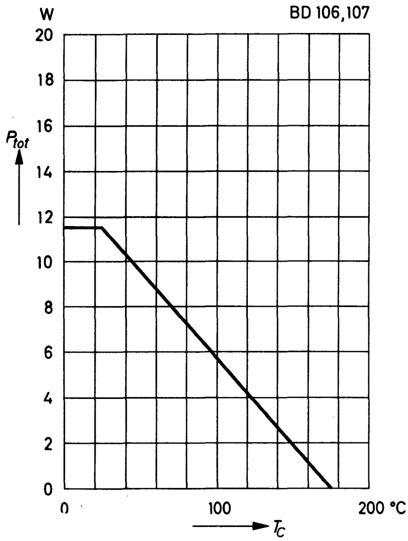
Dimensions in mm

Maximum Ratings		**BD 106**	**BD 107**	
Collector base voltage	V_{CBO}	36	64	V
Collector emitter voltage	V_{CEO}	36	64	V
Emitter base voltage	V_{EBO}	5		V
Collector current	I_C	2.5		A
Power dissipation at $T_C = 25\ °C$	P_{tot}	11.5		W
Junction temperature	T_j	175		°C
Storage temperature range	T_S	$-55 \ldots +175$		°C

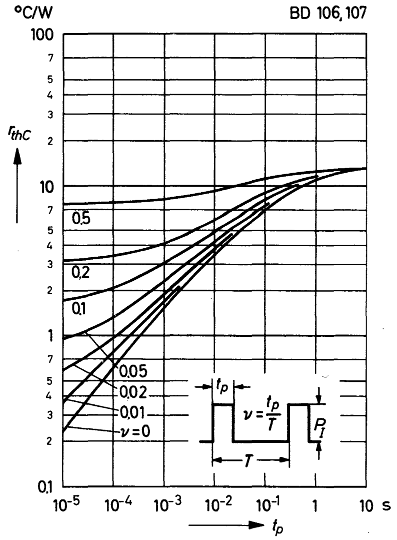
Characteristics at $T_j = 25\ °C$		**BD 106 A** **BD 107 A**	**BD 106 B** **BD 107 B**	
DC current gain				
at $V_{CE} = 2$ V, $I_C = 0.5$ A	$h_{FE\,0.5A}$	50...150	100...300	
at $V_{CE} = 2$ V, $I_C = 1.5$ A (BD 106 only)	$h_{FE\,1.5A}$	$> 0.7 \cdot h_{FE\,0.5A}$		
at $V_{CE} = 2$ V, $I_C = 1$ A (BD 107 only)	$h_{FE\,1A}$	$> 0.7 \cdot h_{FE\,0.5A}$		
Collector saturation voltage at $I_C = 2.5$ A, $I_B = 0.25$ A	$V_{CE\,sat}$	< 1		V
Collector cutoff current				
at $V_{CB} = 32$ V (BD 106)	I_{CBO}	0.01 (< 0.5)		μA
at $V_{CB} = 60$ V (BD 107)	I_{CBO}	0.01 (< 0.5)		μA
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 0.3$ A, $f = 50$ MHz	f_T	100		MHz
Collector base capacitance at $V_{CBO} = 10$ V, $f = 1$ MHz	C_{CBO}	25		pF
Thermal resistance Junction to case	R_{thC}	< 13		°C/W

The thermal resistance R_{thC} rises approximately 0.5 °C/W by insulated mounting using accessory set No. 9.

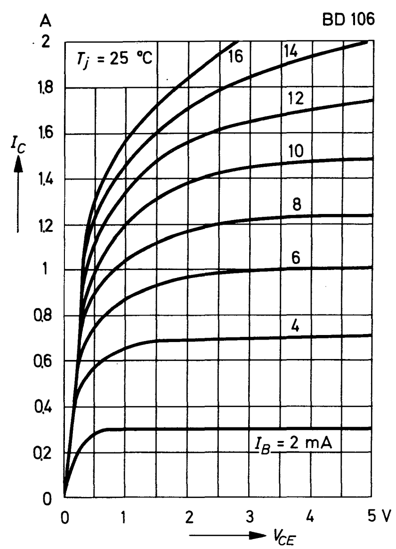
Admissible power dissipation versus case temperature



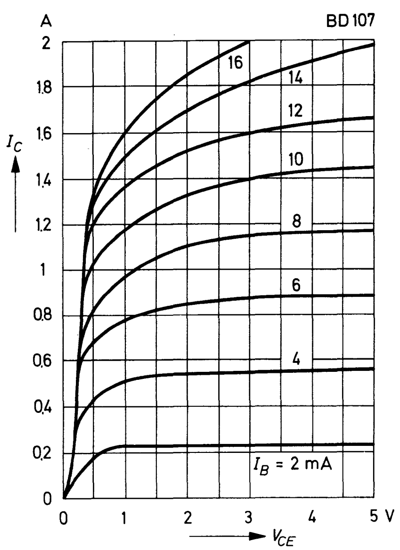
Pulse thermal resistance versus pulse duration



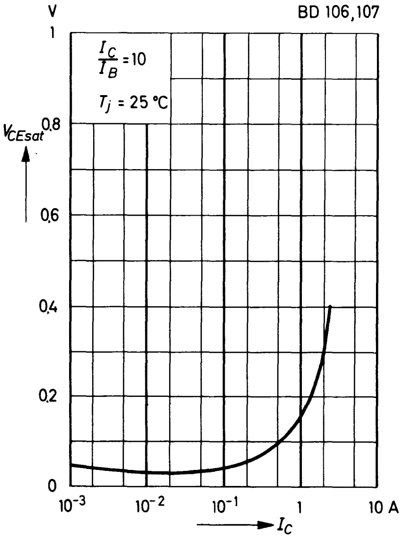
Common emitter collector characteristics



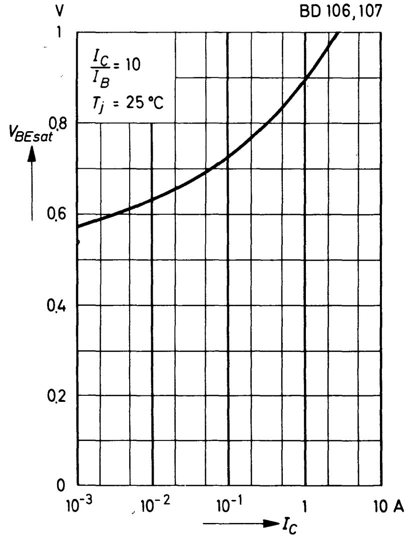
Common emitter collector characteristics



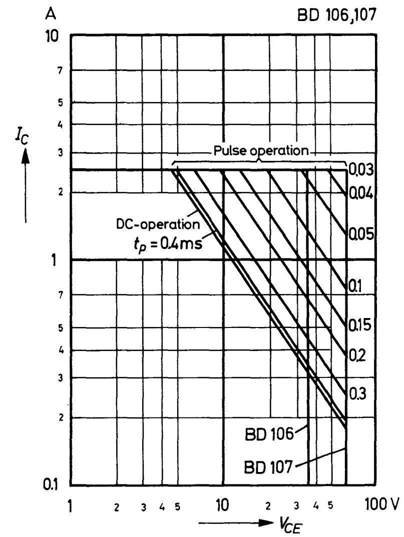
Collector saturation voltage versus collector current



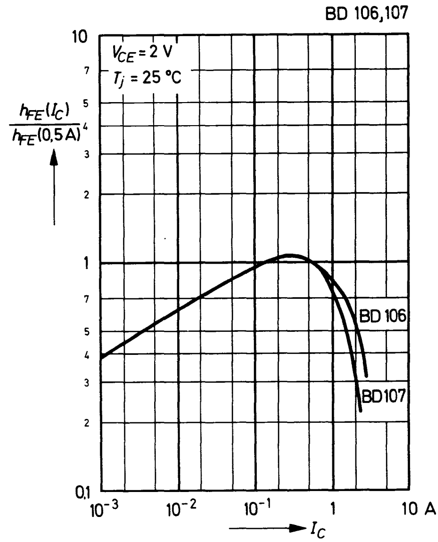
Base saturation voltage versus collector current



Admissible collector current versus collector emitter voltage



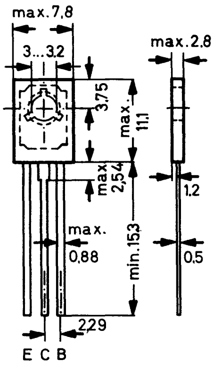
Relative DC current gain versus collector current



BD 135, BD 137

NPN Silicon Epitaxial Planar Power Transistors
for AF driver stages in hifi equipment and for push-pull output stages matched with BD 136/138 as complementary pairs.

These transistors are available either as matched pairs or as complementary pairs BD 135 / BD 136 or BD 137 / BD 138. Matching condition: The typical ratio of the DC current gain of a matched pair at $|V_{CE}| = 2$ V, $|I_C| = 150$ mA is 1.3 (max. 1.6).



Plastic case SOT-32
Collector connected to metal base
Weight approximately 1 g
Dimensions in mm

Maximum Ratings		**BD 135**	**BD 137**	
Collector base voltage	V_{CBO}	45	60	V
Collector emitter voltage	V_{CEO}	45	60	V
Emitter base voltage	V_{EBO}	5		V
Average collector current	I_{CAV}	0.5		A
Peak collector current	I_{CM}	1.5		A
Power dissipation at $T_C < 60$ °C	P_{tot}	6.5		W
Junction temperature	T_j	125		°C
Storage temperature range	T_S	$-55 \ldots +125$		°C

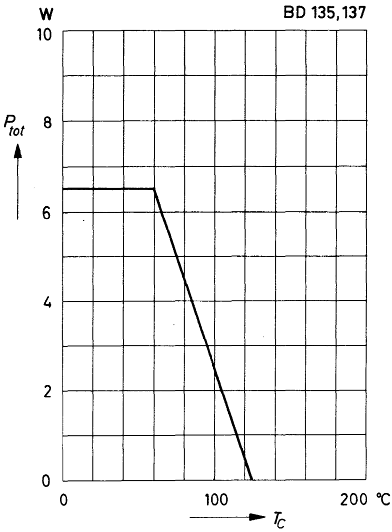
Characteristics at $T_j = 25$ °C

		BD 135	**BD 137**
DC current gain			
at $V_{CE} = 2$ V, $I_C = 5$ mA	h_{FE}	> 25	> 25
at $V_{CE} = 2$ V, $I_C = 150$ mA	h_{FE}	40 . . . 250	40 . . . 160
at $V_{CE} = 2$ V, $I_C = 500$ mA	h_{FE}	> 25	> 25

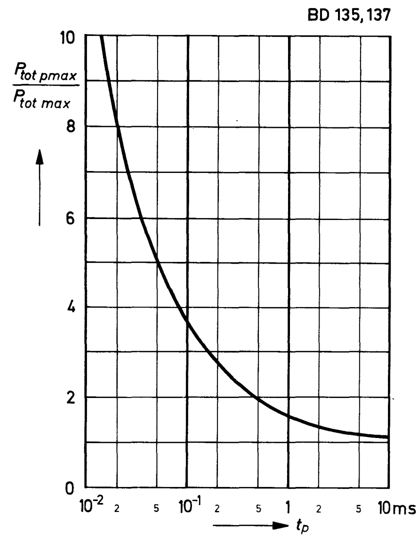
Base emitter voltage at $V_{CE} = 2$ V, $I_C = 500$ mA	V_{BE}	< 1	V
Collector saturation voltage at $I_C = 500$ mA, $I_B = 50$ mA	$V_{CE\,sat}$	< 0.5	V
Collector cutoff current at $V_{CB} = 30$ V at $V_{CB} = 30$ V, $T_j = 125$ °C	 I_{CBO} I_{CBO}	 < 100 < 10	 nA μA
Emitter cutoff current at $V_{EB} = 5$ V	I_{EBO}	< 10	μA
Gain bandwidth product at $V_{CE} = 5$ V, $I_C = 50$ mA, $f = 35$ MHz	f_T	250	MHz
Thermal resistance Junction to ambient air Junction to metal base Metal base to heat sink	 R_{thA} R_{thC} $R_{thC/S}$	 < 100 < 10 < 1	 °C/W °C/W °C/W

BD 135, BD 137

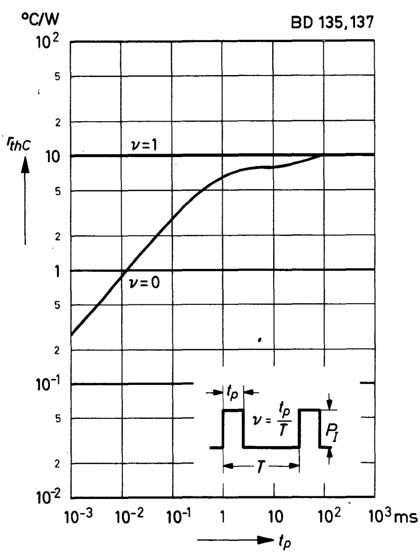
Admissible power dissipation versus metal base temperature



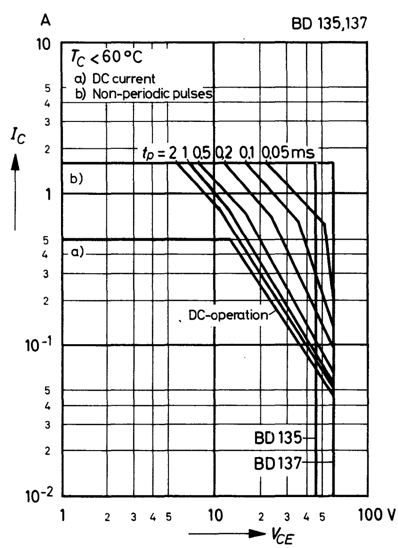
Multiplier for admiss. power dissipation for non-periodic pulses versus pulse duration



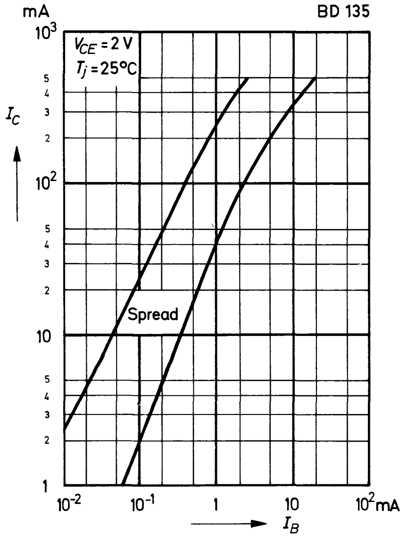
Pulse thermal resistance versus pulse duration



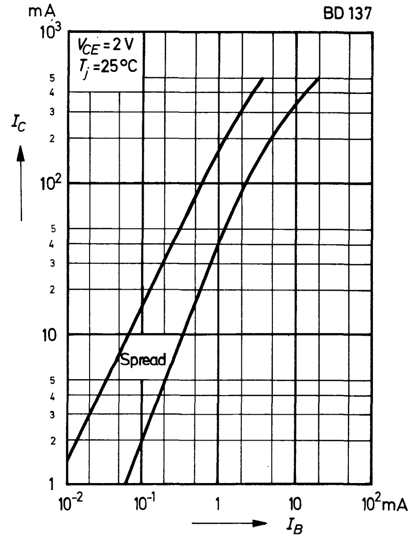
Admissible collector current versus collector emitter voltage



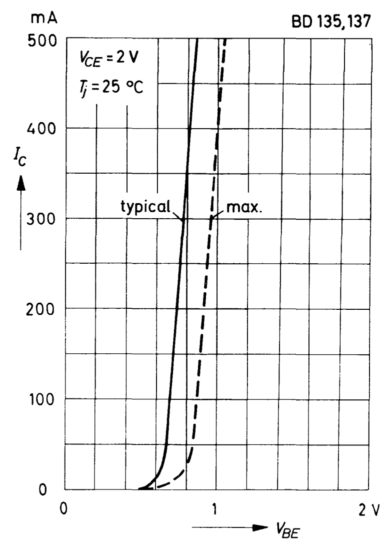
Collector current versus base current



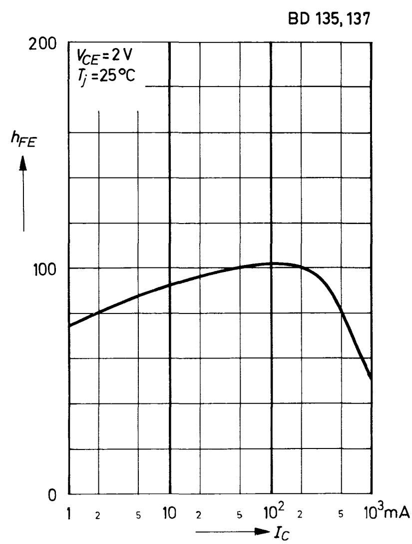
Collector current versus base current



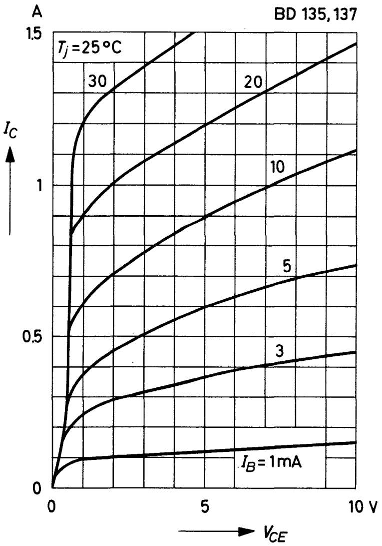
Collector current versus base emitter voltage



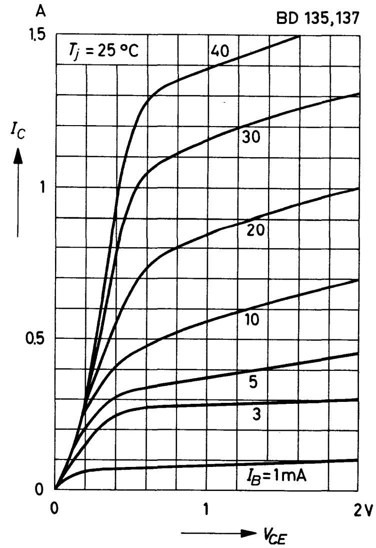
DC current gain versus collector current



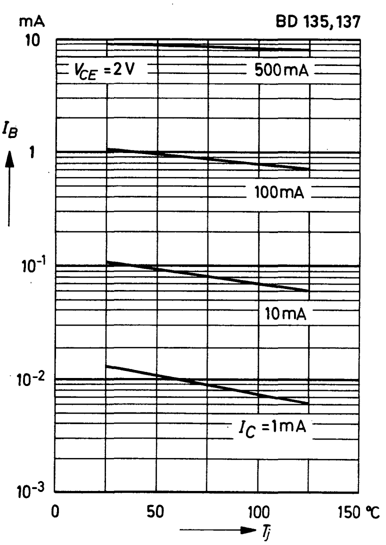
Common emitter collector characteristics



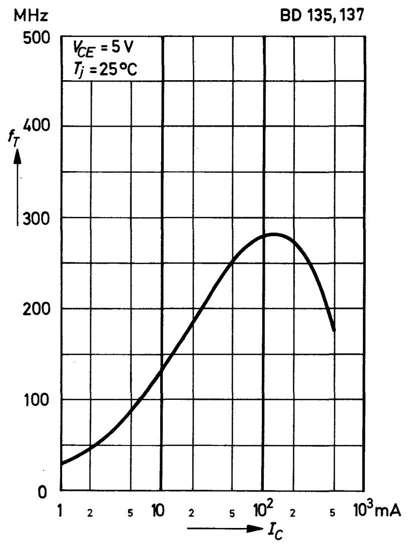
Common emitter collector characteristics



Base current versus junction temperature

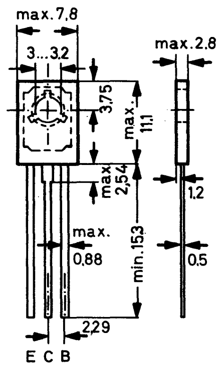


Gain bandwidth product versus collector current



NPN Silicon Epitaxial Planar Power Transistor
for AF driver stages in hifi equipment and for push-pull output stages matched with BD 140 as complementary pair.

This transistor is available either as matched pair or as complementary pair BD 139/BD 140. Matching condition: The typical ratio of the DC current gain of a matched pair at $|V_{CE}| = 2$ V, $|I_C| = 150$ mA is 1.3 (max. 1.6).



Plastic case SOT-32
Collector connected
to metal base
Weight approximately 1 g
Dimensions in mm

Maximum Ratings

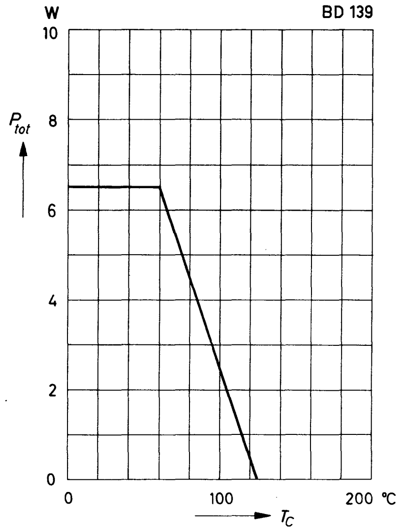
Collector emitter voltage at $R_{BE} < 1$ kΩ	V_{CER}	100	V
Collector emitter voltage	V_{CEO}	80	V
Emitter base voltage	V_{EBO}	5	V
Average collector current	I_{CAV}	0.5	A
Peak collector current	I_{CM}	1.5	A
Power dissipation at $T_C < 60$ °C	P_{tot}	6.5	W
Junction temperature	T_j	125	°C
Storage temperature range	T_S	−55 ... +125	°C

Characteristics at $T_j = 25$ °C

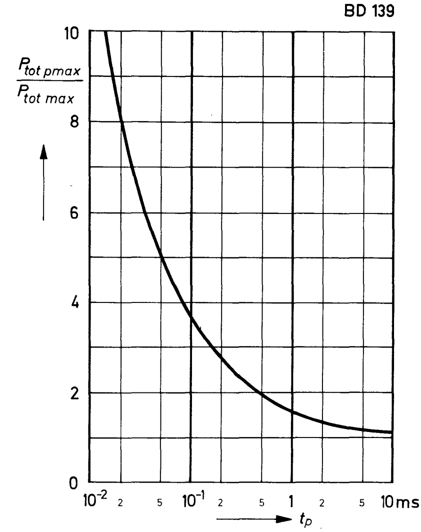
DC current gain		
at $V_{CE} = 2$ V, $I_C = 5$ mA	h_{FE}	> 25
at $V_{CE} = 2$ V, $I_C = 150$ mA	h_{FE}	40 ... 160
at $V_{CE} = 2$ V, $I_C = 500$ mA	h_{FE}	> 25

Base emitter voltage at $V_{CE} = 2$ V, $I_C = 500$ mA	V_{BE}	< 1	V
Collector saturation voltage at $I_C = 500$ mA, $I_B = 50$ mA	$V_{CE\,sat}$	< 0.5	V
Collector cutoff current			
at $V_{CB} = 30$ V	I_{CBO}	< 100	nA
at $V_{CB} = 30$ V, $T_j = 125$ °C	I_{CBO}	< 10	µA
Emitter cutoff current at $V_{EB} = 5$ V	I_{EBO}	< 10	µA
Gain bandwidth product at $V_{CE} = 5$ V, $I_C = 50$ mA, $f = 35$ MHz	f_T	250	MHz
Thermal resistance			
Junction to ambient air	R_{thA}	< 100	°C/W
Junction to metal base	R_{thC}	< 10	°C/W
Metal base to heat sink	$R_{thC/S}$	< 1	°C/W

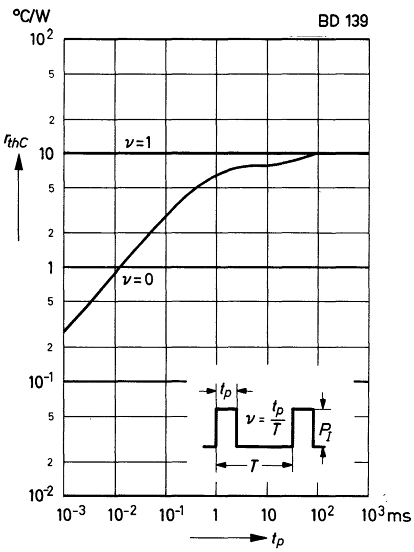
Admissible power dissipation versus metal base temperature



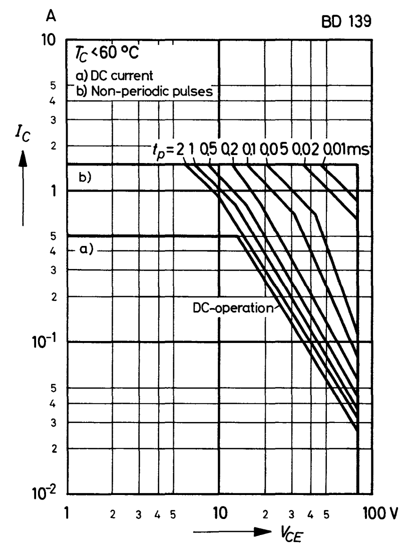
Multiplier for admiss. power dissipation for non-periodic pulses versus pulse duration



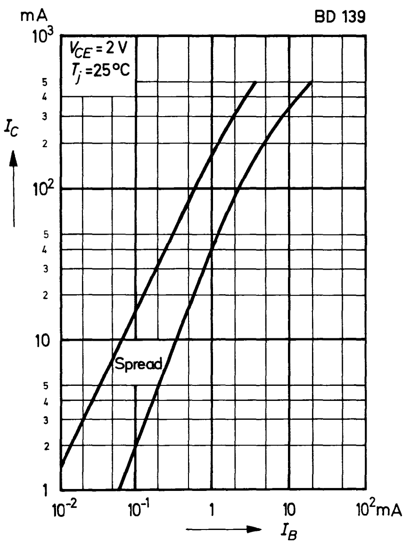
Pulse thermal resistance versus pulse duration



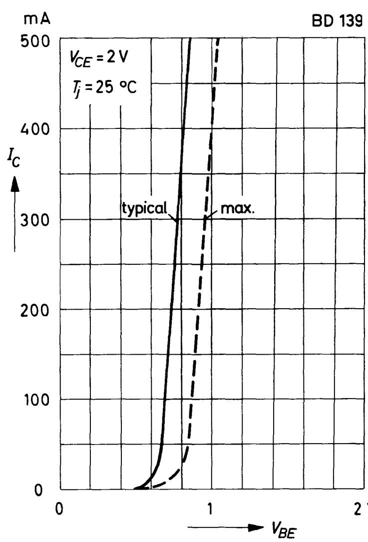
Admissible collector current versus collector emitter voltage



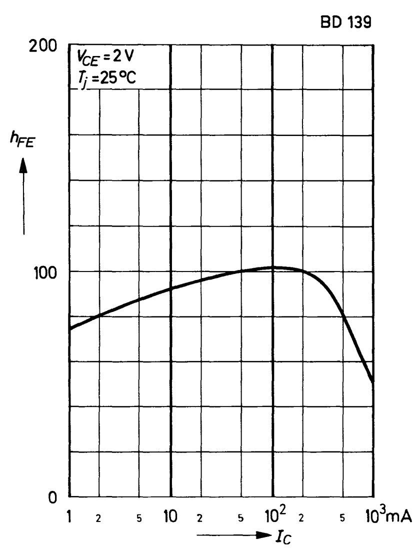
Collector current versus base current



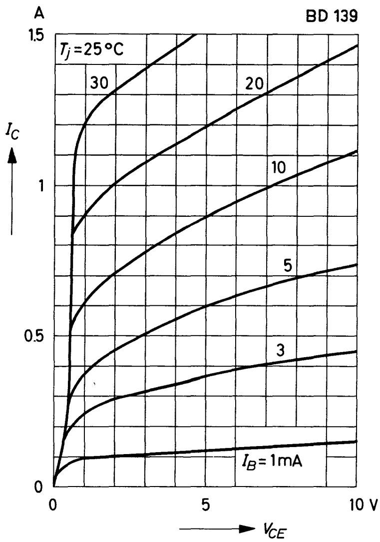
Collector current versus base emitter voltage



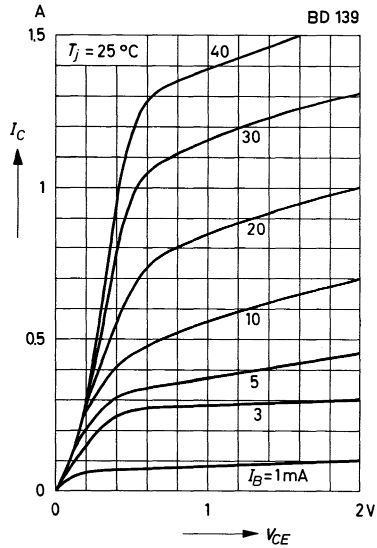
DC current gain versus collector current



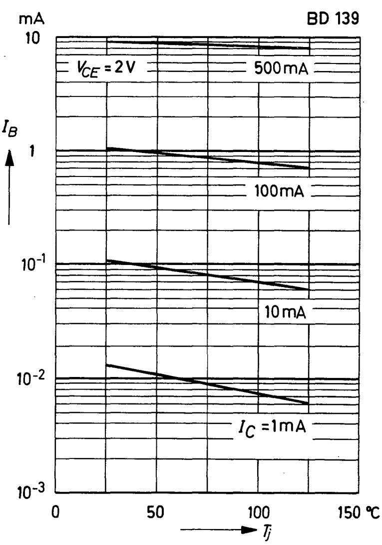
Common emitter collector characteristics



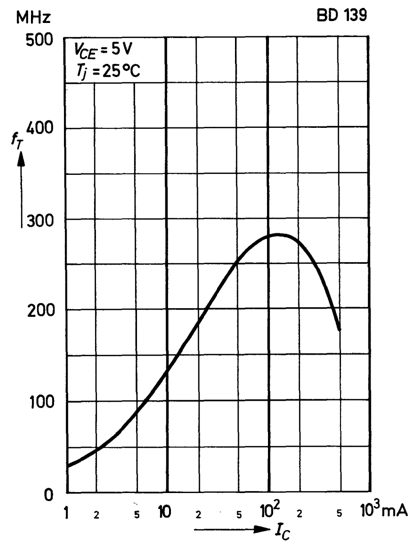
Common emitter collector characteristics



Base current versus junction temperature

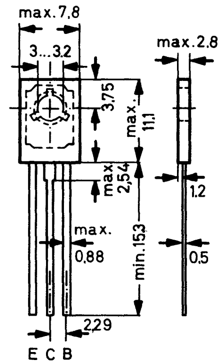


Gain bandwidth product versus collector current



NPN Silicon Epitaxial Planar Power Transistors
for use in AF output stages, available matched in pairs.

These transistors are subdivided into two groups A and B according to their DC current gain.

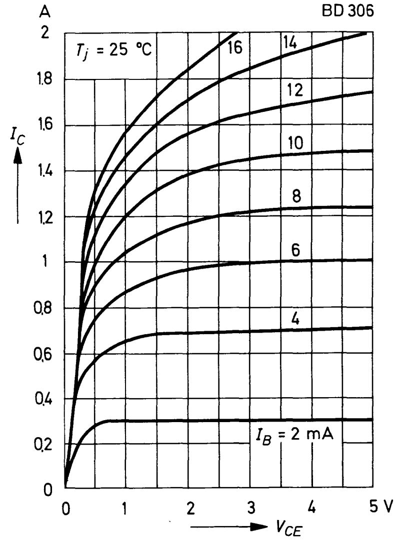


Plastic case SOT-32
Collector connected to metal base
Weight approximately 1 g
Dimensions in mm

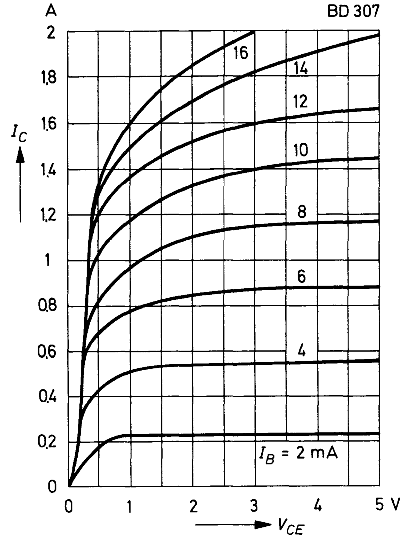
Maximum Ratings		**BD 306**	**BD 307**	
Collector base voltage	V_{CBO}	36	64	V
Collector emitter voltage	V_{CEO}	36	64	V
Emitter base voltage	V_{EBO}	5		V
Collector current	I_C	2.5		A
Power dissipation at $T_C = 25\ °C$	P_{tot}	12.5		W
Junction temperature	T_j	125		°C
Storage temperature range	T_S	–55 . . . +125		°C

Characteristics at $T_j = 25\ °C$		**BD 306 A** **BD 307 A**	**BD 306 B** **BD 307 B**	
DC current gain				
at $V_{CE} = 2$ V, $I_C = 0.5$ A	$h_{FE\ 0.5A}$	50 . . . 150	100 . . . 300	
at $V_{CE} = 2$ V, $I_C = 1.5$ A (BD 306 only)	$h_{FE\ 1.5A}$	$> 0.7 \cdot h_{FE\ 0.5A}$		
at $V_{CE} = 2$ V, $I_C = 1$ A (BD 307 only)	$h_{FE\ 1A}$	$> 0.7 \cdot h_{FE\ 0.5A}$		
Collector saturation voltage at $I_C = 2.5$ A, $I_B = 0.25$ A	$V_{CE\ sat}$	< 1		V
Collector cutoff current				
at $V_{CB} = 32$ V (BD 306)	I_{CBO}	0.01 (<0.5)		µA
at $V_{CB} = 60$ V (BD 307)	I_{CBO}	0.01 (<0.5)		µA
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 0.3$ A, $f = 50$ MHz	f_T	100		MHz
Collector base capacitance at $V_{CBO} = 10$ V, $f = 1$ MHz	C_{CBO}	25		pF
Thermal resistance Junction to metal base	R_{thC}	< 8		°C/W

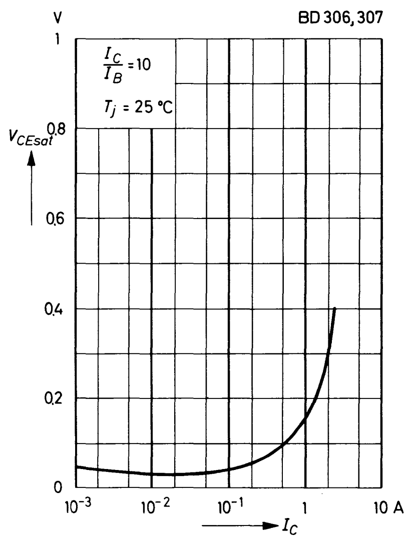
Common emitter collector characteristics



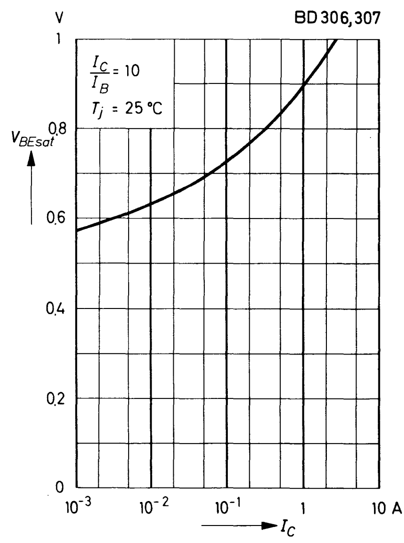
Common emitter collector characteristics



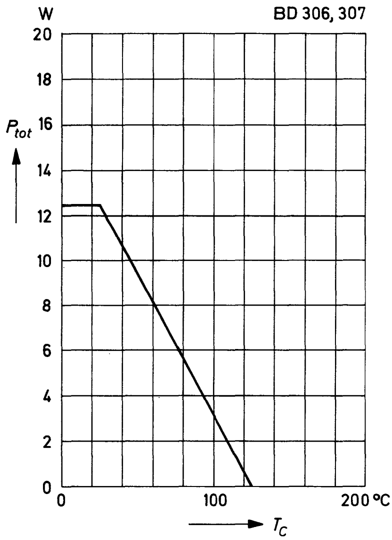
Collector saturation voltage versus collector current



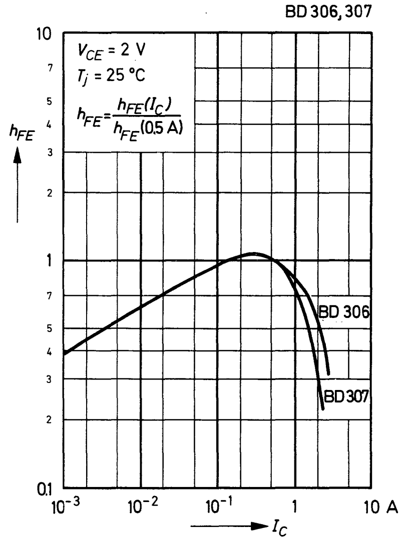
Base saturation voltage versus collector current



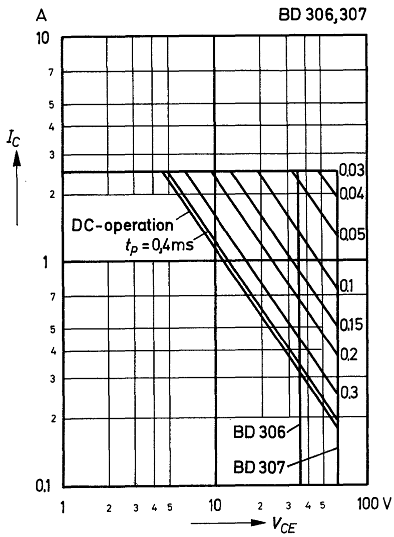
Admissible power dissipation versus metal base temperature



Relative DC current gain versus collector current

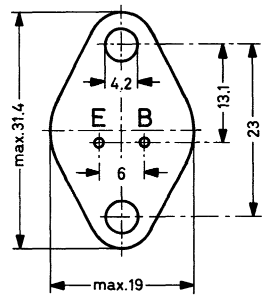


Admissible collector current versus collector emitter voltage

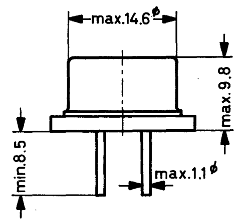


NPN Silicon Epitaxial Planar Power Transistors
for switching and amplifier applications
in commercial electronic design

These transistors are subdivided into three groups A, B and C according to their DC current gain. Type BDY 16 is available in groups A and B only.

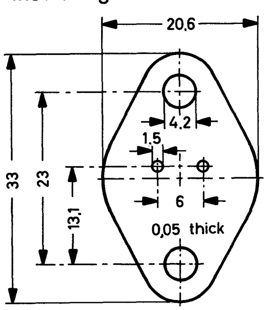


Metal case SOT-9
Collector connected to case
Weight approximately 8 g

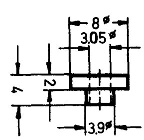


A set of accessories No. 9
will be delivered with each
transistor on request.
This set consists of:
1 insulating washer No. 02 911 mica
2 insulating bushes No. 02 321 polycarbonate

Insulating washer No. 02 911



Insulating bush No. 02 321



Dimensions in mm

Maximum Ratings

		BDY 15	BDY 16	
Collector base voltage	V_{CBO}	36	64	V
Collector emitter voltage	V_{CEO}	36	64	V
Emitter base voltage	V_{EBO}	5		V
Collector current	I_C	2.5		A
Peak collector current at $t < 100$ ms	I_{CM}	4		A
Power dissipation at $T_C = 25$ °C	P_{tot}	11.5		W
Junction temperature	T_j	175		°C
Storage temperature range	T_S	–55 ... +175		°C

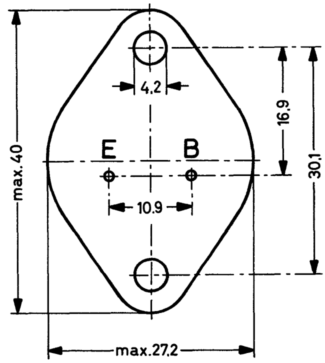
Characteristics at $T_j = 25$ °C

		BDY 15 A BDY 16 A	BDY 15 B BDY 16 B	BDY 15 C	
DC current gain at $V_{CE} = 2$ V, $I_C = 0.5$ A	h_{FE}	50...150	100...300	200...600	
at $V_{CE} = 2$ V, $I_C = 2.5$ A	h_{FE}	> 15	> 25	> 35	
Collector saturation voltage at $I_C = 2.5$ A, $I_B = 0.25$ A	$V_{CE\,sat}$	< 1			V
Collector cutoff current at $V_{CB} = 30$ V (BDY 15)	I_{CBO}	0.01 (< 0.1)			µA
at $V_{CB} = 60$ V (BDY 16)	I_{CBO}	0.01 (< 0.1)			µA
Gain bandwidth product at $V_{CE} = 10$ V, $I_C = 0.3$ A, $f = 50$ MHz	f_T	100			MHz
Collector base capacitance at $V_{CBO} = 10$ V, $f = 1$ MHz	C_{CBO}	25			pF
Thermal resistance Junction to case	R_{thC}	< 13			°C/W

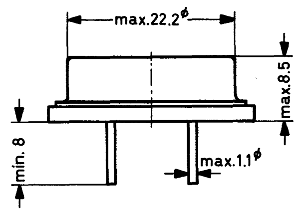
The thermal resistance R_{thC} rises approximately 0.5 °C/W by insulated mounting using accessory set No. 9.

Curves and characteristics of types BD 106 and BD 107 are valid analogously for types BDY 15 and BDY 16.

Diffused NPN Silicon AF Power Transistor
with excellent second-breakdown properties,
for AF high power output stages, stabilizer circuits and power switches

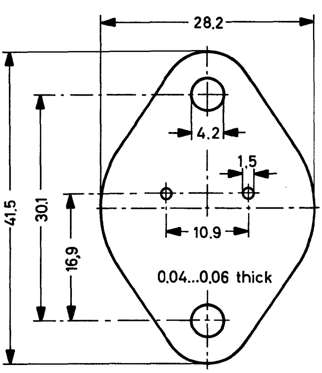


Metal Case JEDEC TO-3
Collector connected to case
Weight approximately 23 g

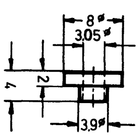


A set of accessories No. 3 will be delivered with each transistor on request.
This set consists of:
1 insulating washer No. 02 311 mica
2 insulating bushes No. 02 321 polycarbonate

Insulating washer No. 02 311



Insulating bush No. 02 321



Dimensions in mm

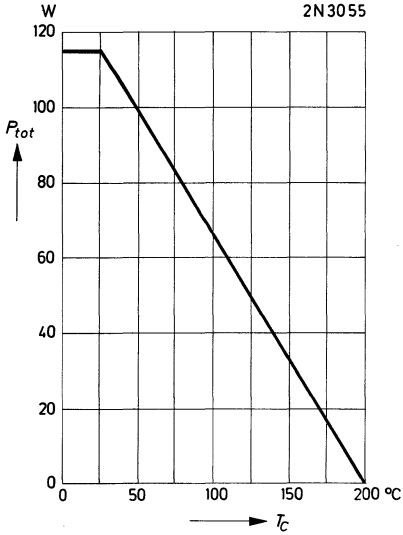
Maximum Ratings

Collector base voltage	V_{CBO}	100	V
Collector emitter voltage			
at $V_{BE} = -1.5$ V	V_{CEV}	90	V
at $R_{BE} = 100\ \Omega$	V_{CER}	70	V
at $I_B = 0$	V_{CEO}	60	V
Emitter base voltage	V_{EBO}	7	V
Collector current	I_C	15	A
Base current	I_B	7	A
Power dissipation at $T_C = 25$ °C	P_{tot}	115	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	−65 ... +200	°C
Soldering temperature at the pins for max. 10 s, at min. 1 mm distance between glass seal and joint	T_L	235	°C

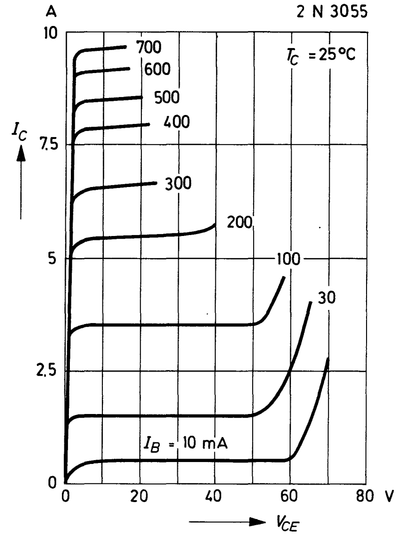
Characteristics at $T_C = 25$ °C

DC current gain			
at $V_{CE} = 4$ V, $I_C = 4$ A	h_{FE}	20 ... 70	
at $V_{CE} = 4$ V, $I_C = 10$ A	h_{FE}	> 5	
Collector saturation voltage at $I_C = 4$ A, $I_B = 0.4$ A	$V_{CE\,sat}$	< 1.1	V
Base emitter voltage at $V_{CE} = 4$ V, $I_C = 4$ A	V_{BE}	< 1.8	V
Collector cutoff current			
at $V_{CE} = 100$ V, $V_{BE} = -1.5$ V	I_{CEV}	< 5	mA
at $V_{CE} = 100$ V, $V_{BE} = -1.5$ V, $T_C = 150$ °C	I_{CEV}	< 30	mA
at $V_{CE} = 30$ V	I_{CEO}	< 0.7	mA
Emitter cutoff current at $V_{EB} = 7$ V	I_{EBO}	< 5	mA
Collector emitter breakdown voltage			
at $I_C = 200$ mA, $I_B = 0$	$V_{(BR)CEO}$	> 60	V
at $I_C = 100$ mA, $-V_{BE} = 1.5$ V	$V_{(BR)CEV}$	> 90	V
at $I_C = 200$ mA, $R_{BE} = 100\ \Omega$	$V_{(BR)CER}$	> 70	V
Small signal current gain at $V_{CE} = 4$ V, $I_C = 1$ A, $f = 1$ kHz	h_{fe}	15 ... 120	
Gain bandwidth product at $V_{CE} = 4$ V, $I_C = 1$ A	f_T	1.5 (> 0.8)	MHz
Thermal resistance Junction to case	R_{thC}	< 1.5	°C/W

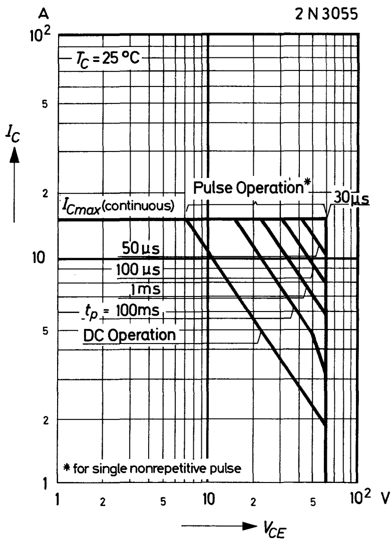
Admissible power dissipation versus case temperature



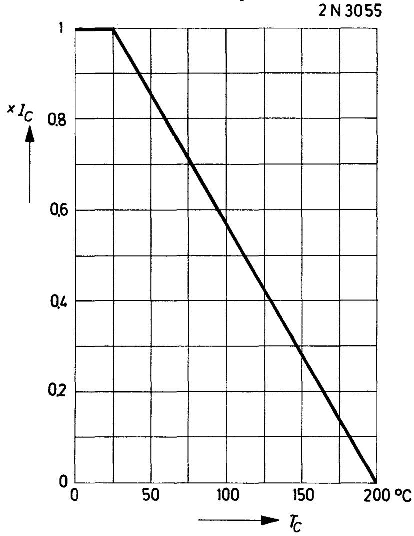
Common emitter collector characteristics



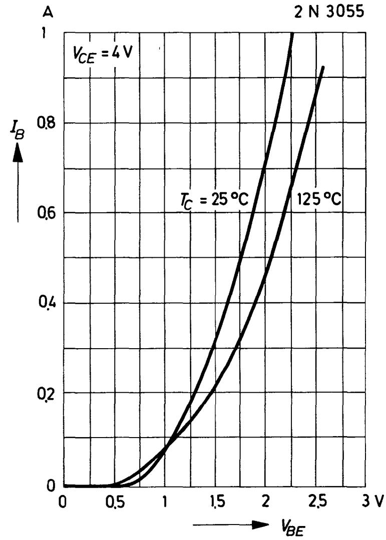
Admissible collector current versus collector emitter voltage



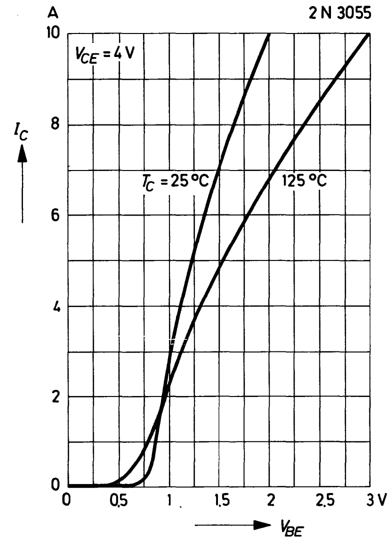
Derating factor of admissible collector currents as shown in the graph on the left versus case temperature



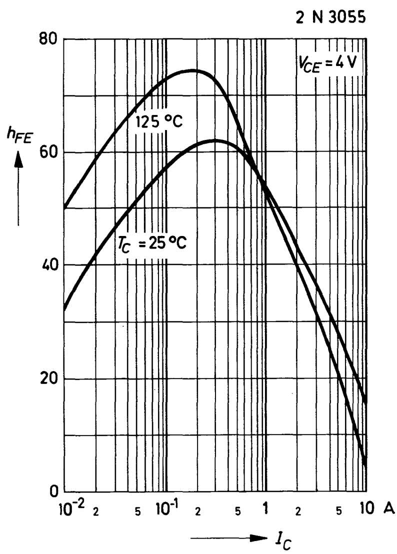
Common emitter input characteristics



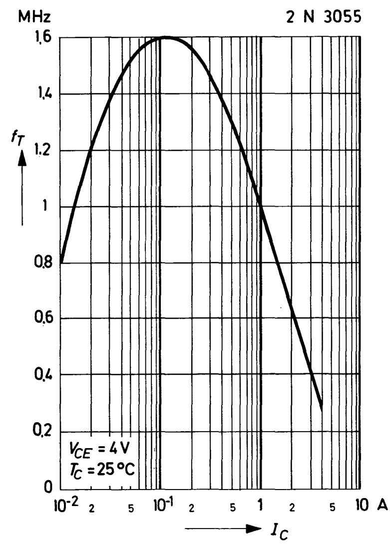
Collector current versus base emitter voltage



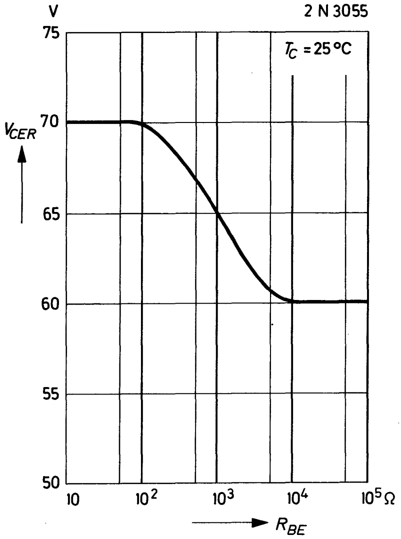
DC current gain versus collector current



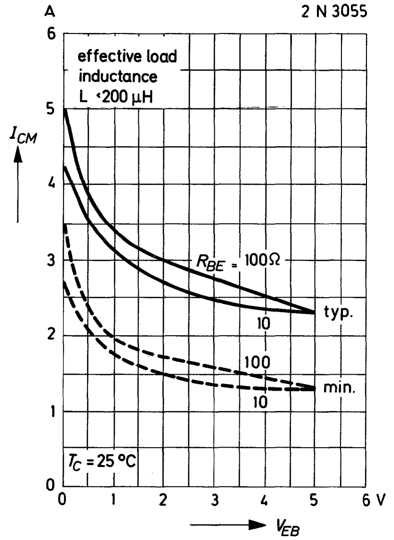
Gain bandwidth product versus collector current



Admissible collector emitter voltage versus base emitter resistance

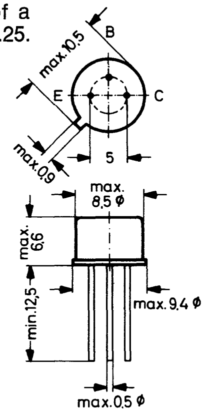


Admissible turnoff collector peak current versus emitter base voltage after turnoff



PNP Silicon Transistors

PNP Silicon Epitaxial Planar Transistors
for switching and amplifier applications
These types are subdivided into three groups, -6, -10 and -16, according to their DC current gain
These transistors are available either as matched pairs or as complementary pairs BC 140/BC 160 or BC 141/BC 161 resp.
Matching condition: The ratio of the DC current gains of a matched pair at $|V_{CE}| = 1$ V, $|I_C| = 100$ mA is less than 1.25.



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1 g
Dimensions in mm

Maximum Ratings		**BC 160**	**BC 161**	
Collector base voltage	$-V_{CBO}$	40	60	V
Collector emitter voltage	$-V_{CEO}$	40	60	V
Emitter base voltage	$-V_{EBO}$	5	5	V
Collector current	$-I_C$	1		A
Base current	$-I_B$	0.1		A
Power dissipation at $T_{amb} = 25$ °C	P_{tot}	0.75		W
at $T_C = 60$ °C, $-V_{CE} < 8$ V	P_{tot}	3.2		W
Junction temperature	T_j	175		°C
Storage temperature range	T_S	−55...+175		°C

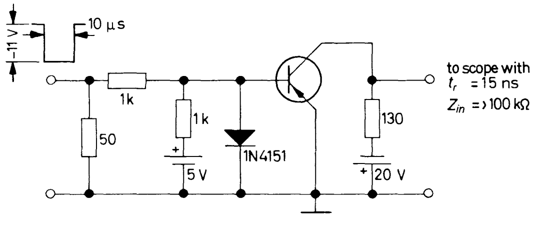
Characteristics at $T_j = 25$ °C		**BC 160-6** **BC 161-6**	**BC 160-10** **BC 161-10**	**BC 160-16** **BC 161-16**	
DC current gain at $-V_{CE} = 1$ V, $-I_C = 0.1$ mA	h_{FE}	46	80	120	
at $-V_{CE} = 1$ V, $-I_C = 100$ mA	h_{FE}	63 (40...100)	100 (63...160)	160 (100...250)	
at $-V_{CE} = 1$ V, $-I_C = 1$ A	h_{FE}	15	20	30	
Collector saturation voltage at $-I_C = 1$ A, $-I_B = 100$ mA	$-V_{CE\,sat}$	0.6 (< 1)			V
Base emitter voltage at $-V_{CE} = 1$ V, $-I_C = 1$ A	$-V_{BE}$	1.0 (< 1.7)			V

		BC 160	BC 161	
Collector cutoff current				
at $-V_{CE} = 40$ V	$-I_{CES}$	10 (< 100)	–	nA
at $-V_{CE} = 60$ V	$-I_{CES}$	–	10 (< 100)	nA
at $-V_{CE} = 40$ V, $T_j = 150$ °C	$-I_{CES}$	10 (< 100)	–	μA
at $-V_{CE} = 60$ V, $T_j = 150$ °C	$-I_{CES}$	–	10 (< 100)	μA
Collector emitter breakdown voltage				
at $-I_C = 0.1$ mA	$-V_{(BR)CES}$	> 40	> 60	V
at $-I_C = 50$ mA (pulsed 200 μs, 1%)	$-V_{(BR)CE0}$	> 40	> 60	V
Emitter base breakdown voltage at $-I_C = 0.1$ mA	$-V_{(BR)EB0}$	> 5	> 5	V
Gain bandwidth product at $-V_{CE} = 10$ V, $-I_C = 50$ mA, f = 20 MHz	f_T	> 50		MHz
Collector base capacitance at $-V_{CB0} = 10$ V, $f = 1$ MHz	C_{CB0}	< 30		pF
Emitter base capacitance at $-V_{EB0} = 0.5$ V, $f = 1$ MHz	C_{EB0}	< 180		pF
Thermal resistance				
Junction to case	R_{thC}	< 35		°C/W
Junction to ambient air	R_{thA}	< 200		°C/W

Switching Times at $-I_C = 100$ mA, $-I_{B1} \approx I_{B2} \approx 5$ mA

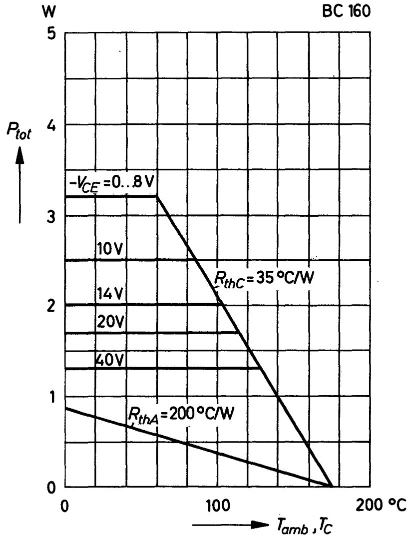
Turn-on time	t_{on}	< 500	ns
Turn-off time	t_{off}	< 650	ns

Test Circuit for Switching Times

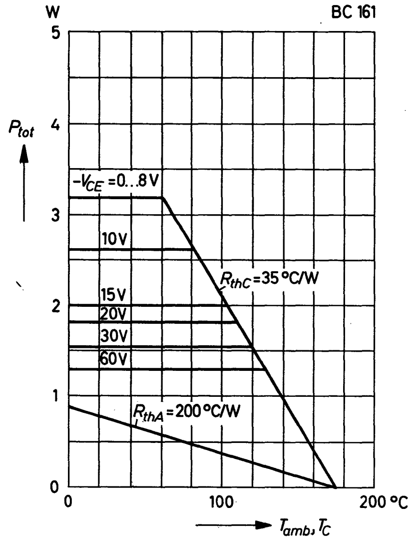


Rise time and fall time of input voltage < 15 ns, generator impedance 50 Ω.

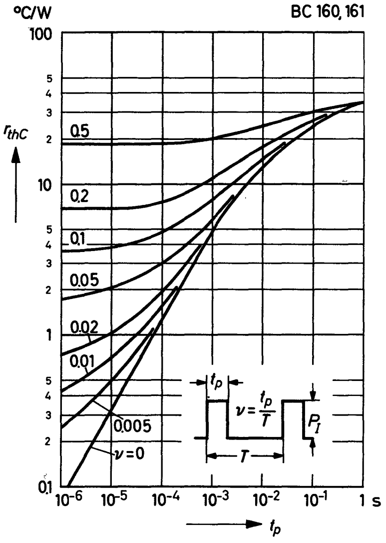
Admissible power dissipation versus temperature



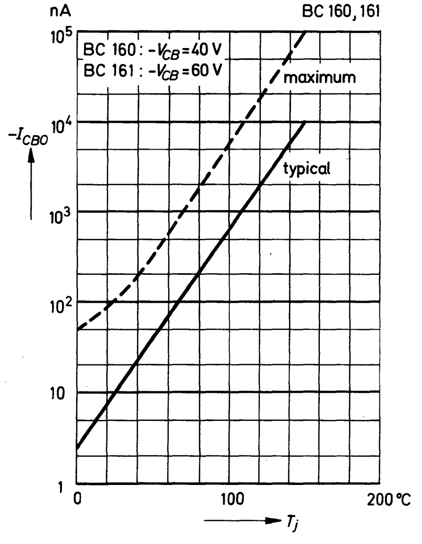
Admissible power dissipation versus temperature



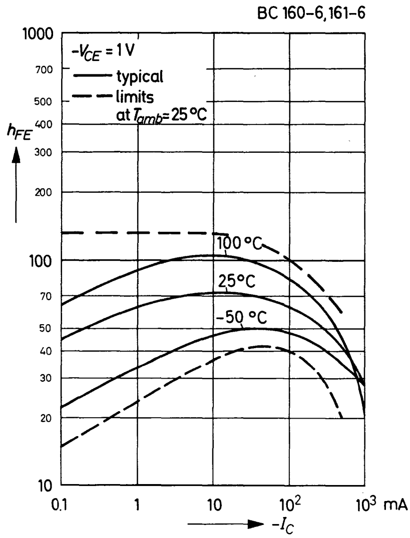
Pulse thermal resistance versus pulse duration



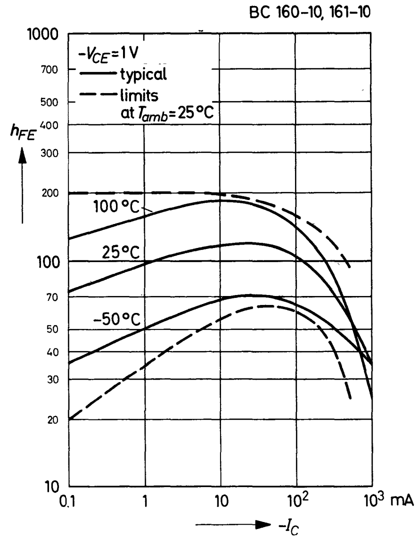
Collector cutoff current versus junction temperature



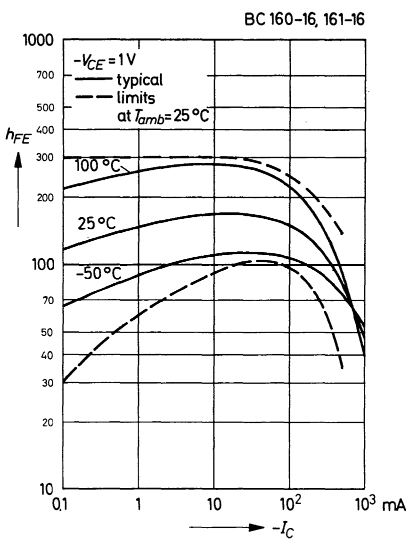
DC current gain versus collector current



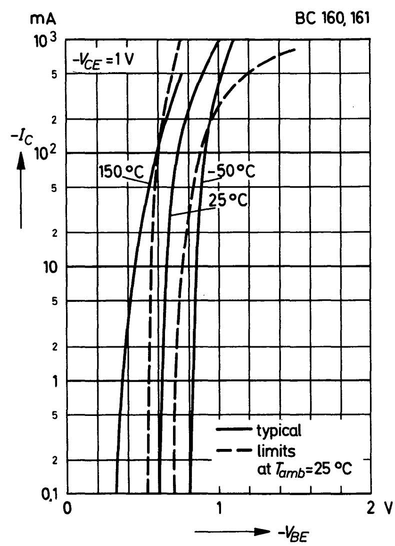
DC current gain versus collector current



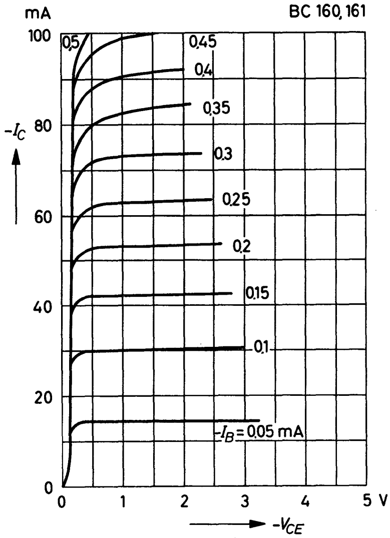
DC current gain versus collector current



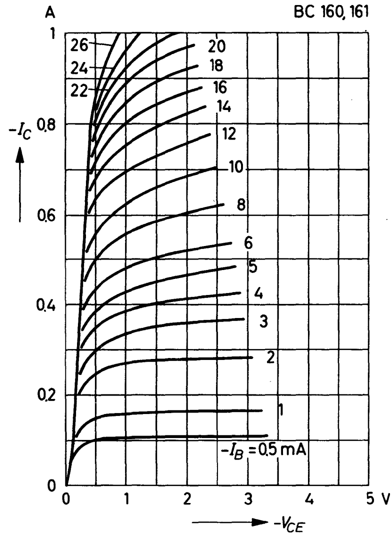
Collector current versus base emitter voltage



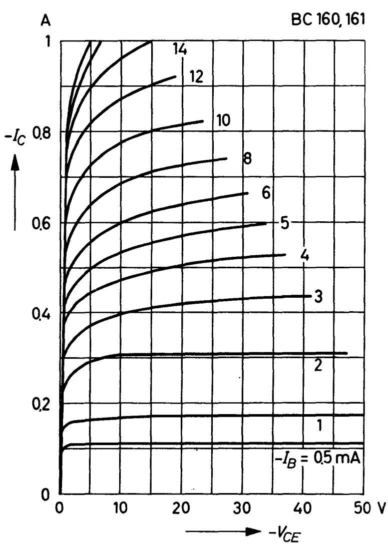
Common emitter collector characteristics



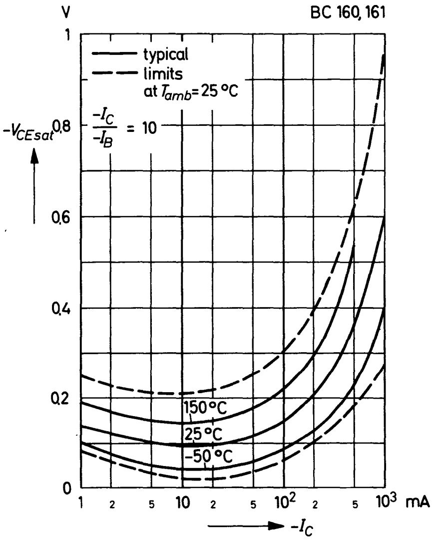
Common emitter collector characteristics



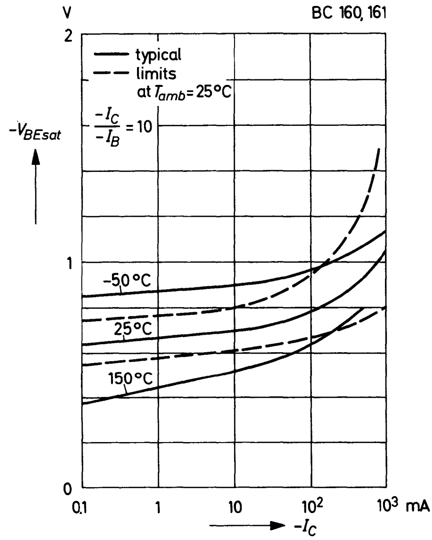
Common emitter collector characteristics



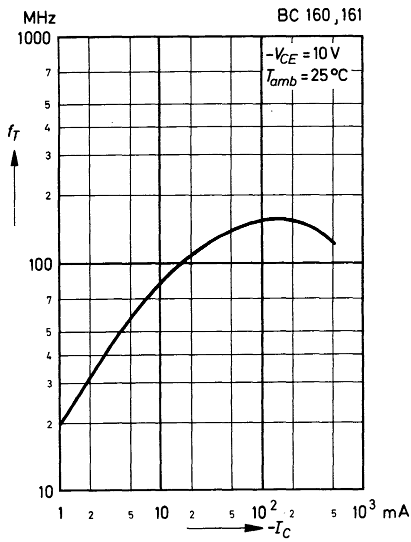
Collector saturation voltage versus collector current



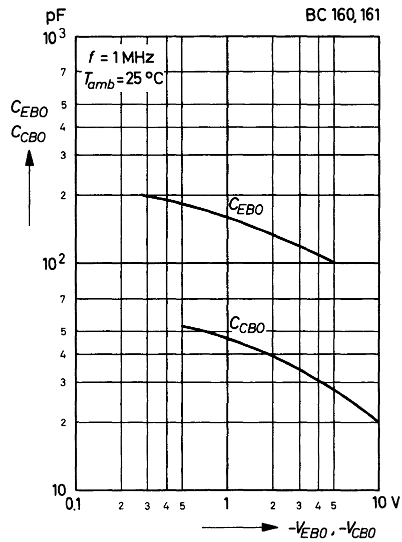
Base saturation voltage versus collector current



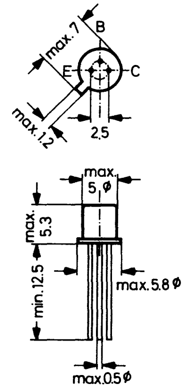
Gain bandwidth product versus collector current



Collector base capacitance, Emitter base capacitance versus reverse bias voltage



PNP Silicon Epitaxial Planar Transistor
for switching and amplifier applications



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

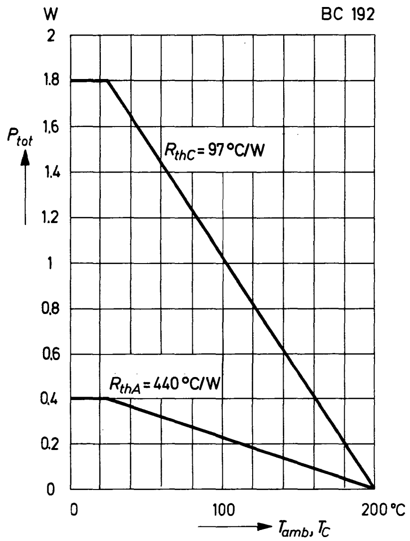
Maximum Ratings

Collector base voltage	$-V_{CBO}$	25	V
Collector emitter voltage	$-V_{CEO}$	25	V
Emitter base voltage	$-V_{EBO}$	5	V
Collector current	$-I_C$	500	mA
Base current	$-I_B$	100	mA
Power dissipation			
at $T_{amb} = 25$ °C	P_{tot}	0.4	W
at $T_C = 25$ °C	P_{tot}	1.8	W
Junction temperature	T_j	200	°C

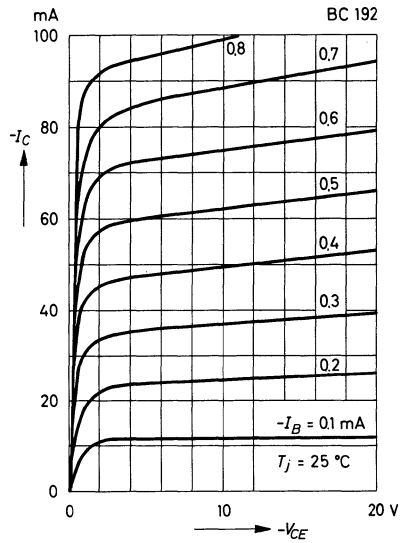
Characteristics at $T_j = 25$ °C

DC current gain at $-V_{CE} = 5$ V, $-I_C = 50$ mA	h_{FE}	60 . . . 180	
Collector saturation voltage at $-I_C = 50$ mA, $-I_B = 5$ mA	$-V_{CE\,sat}$	< 0.25	V
Collector cutoff current at $-V_{CB} = 20$ V	$-I_{CBO}$	10 (< 100)	nA
Collector base capacitance at $-V_{CBO} = 10$ V, $f = 1$ MHz	C_{CBO}	12	pF
Gain bandwidth product at $-V_{CE} = 5$ V, $-I_C = 50$ mA	f_T	> 100	MHz
Thermal resistance			
Junction to ambient air	R_{thA}	< 440	°C/W
Junction to case	R_{thC}	< 97	°C/W

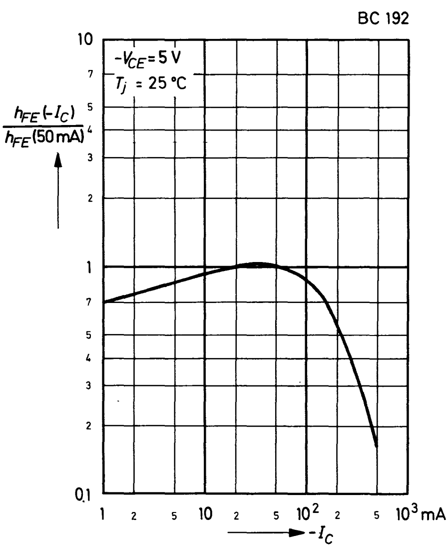
Admissible power dissipation versus temperature



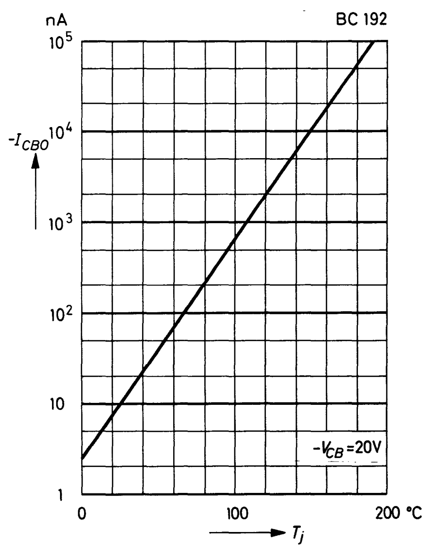
Common emitter collector characteristics



Relative DC current gain versus collector current



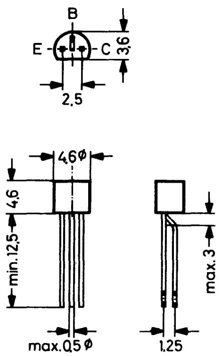
Collector cutoff current versus junction temperature

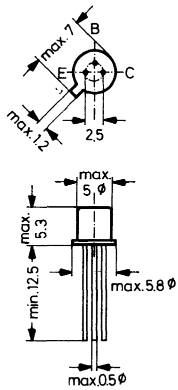


BC 250, BC 260

PNP Silicon Epitaxial Planar Transistors
for switching and amplifier applications

The transistors are subdivided into three groups A, B and C according to their DC current gain.





BC 250
Green plastic package ≈ TO-92,
TO-18 compatible.
The case is impervious to light.
Weight about 0.18 g
Dimensions in mm

BC 260
Metal case JEDEC TO-18
Collector connected to case
Weight about 0.35 g
Dimensions in mm

Maximum Ratings

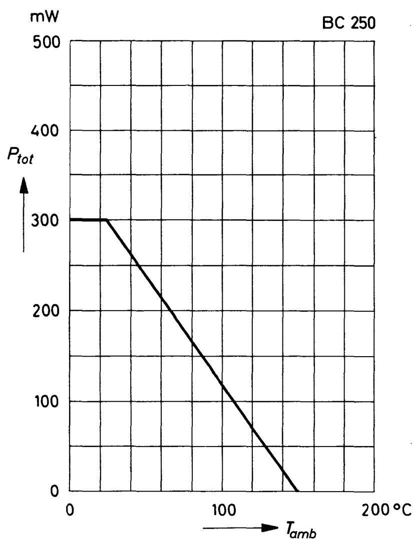
Collector base voltage	$-V_{CBO}$	20		V
Collector emitter voltage	$-V_{CEO}$	20		V
Emitter base voltage	$-U_{EBO}$	5		V
Collector current	$-I_C$	100		mA
		BC 250	**BC 260**	
Power dissipation at $T_{amb} = 25\ °C$	P_{tot}	300[1]	300	mW
Junction temperature	T_j	150	175	°C
Storage temperature range	T_S	–55...+150	–65...+175	°C

[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

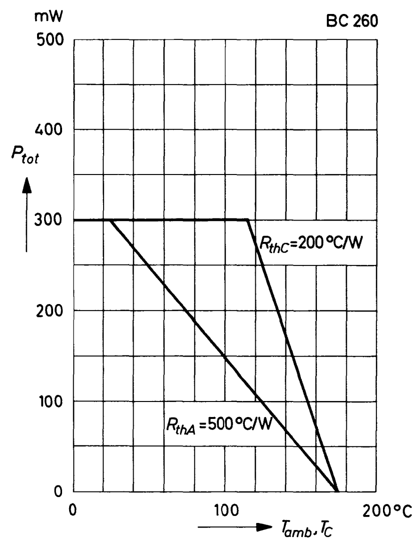
Characteristics at $T_j = 25$ °C		BC 250 A BC 260 A	BC 250 B BC 260 B	BC 250 C BC 260 C	
DC current gain at $-V_{CE} = 1$ V, $-I_C = 1$ mA	h_{FE}	35...100	80...250	200...600	
Collector saturation voltage at $-I_C = 30$ mA, $-I_B = 3$ mA	$-V_{CE\,sat}$	0.4			V
Collector cutoff current at $-V_{CB} = 15$ V	$-I_{CB0}$	< 100			nA
Emitter cutoff current at $-V_{EB} = 4$ V	$-I_{EB0}$	< 100			nA
Gain bandwidth product at $-V_{CE} = 5$ V, $-I_C = 10$ mA, $f = 100$ MHz	f_T	180			MHz
Collector base capacitance at $-V_{CB0} = 10$ V, $f = 1$ MHz	C_{CB0}	3			pF
Emitter base capacitance at $-V_{EB0} = 0.5$ V, $f = 1$ MHz	C_{EB0}	12			pF

		BC 250	BC 260	
Thermal resistance				
Junction to ambient air	R_{thA}	< 420[1]	< 500	°C/W
Junction to case	R_{thC}		< 200	°C/W

Admissible power dissipation versus ambient temperature[1]

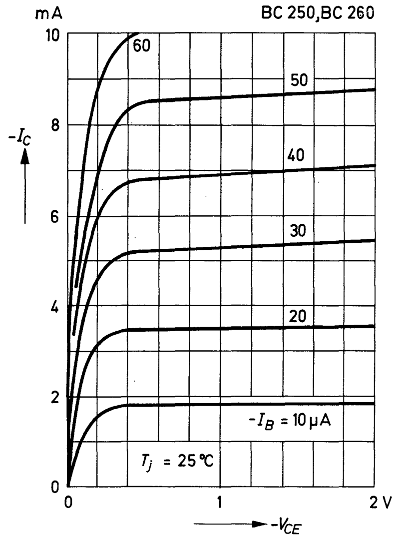


Admissible power dissipation versus temperature

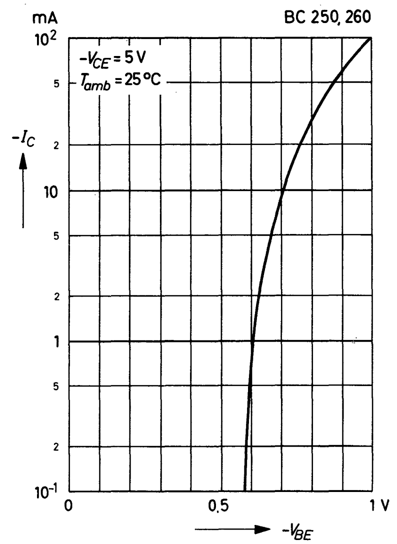


[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

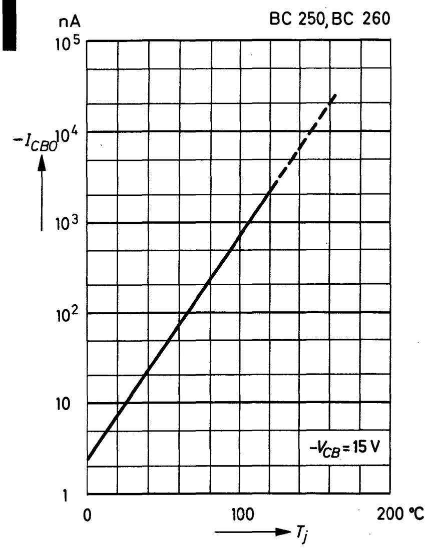
Common emitter collector characteristics



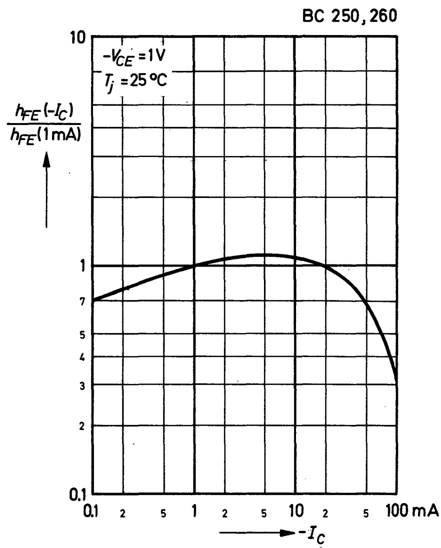
Collector current versus base emitter voltage



Collector cutoff current versus junction temperature

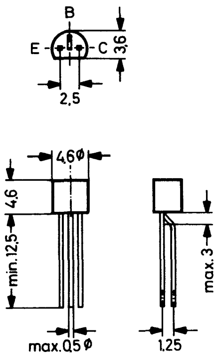


Relative DC current gain versus collector current



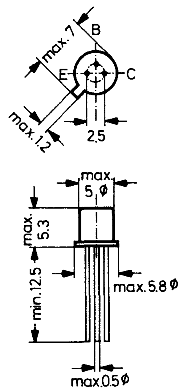
PNP Silicon Epitaxial Planar Transistors
for switching and amplifier applications

The transistors are subdivided into three groups A, B and C according to their current gain. BC 256 and BC 266 are available in groups A and B only. BC 253, BC 263 and BC 309 are low noise types.



BC 251, BC 252, BC 253, BC 256, BC 307, BC 308, BC 309

Green plastic package ≈ TO-92, TO-18 compatible.
The case is impervious to light
Weight approximately 0.18 g
Dimensions in mm



BC 261, BC 262, BC 263, BC 266

Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings

		BC 251 **BC 261** **BC 307**	**BC 252** **BC 253** **BC 262** **BC 263** **BC 308** **BC 309**	**BC 256** **BC 266**	
Collector emitter voltage	$-V_{CES}$	50	30	64	V
Collector emitter voltage	$-V_{CEO}$	45	25	64	V
Emitter base voltage	$-V_{EBO}$	5	5	5	V
Collector current	$-I_C$	100	100	100	mA
Peak collector current	$-I_{CM}$	200	200	200	mA
Base current	$-I_B$	50	50	50	mA
Base peak current	$-I_{BM}$	100	100	100	mA

		TO-92	**TO-18**	
Power dissipation at $T_{amb} = 25\ °C$	P_{tot}	300[1]	300	mW
Junction temperature	T_j	150	175	°C
Storage temperature range	T_S	–55...+150	–55...+175	°C

[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

Characteristics at $T_{amb} = 25\ °C$ h-Parameters at $-V_{CE} = 5$ V, $-I_C = 2$ mA, $f = 1$ kHz		**Current gain group** **A**	**B**	**C**	
Small signal current gain	h_{fe}	220 (125..260)	330 (240..500)	600 (450..900)	
Input impedance	h_{ie}	2.7 (1.6..4.5)	4.5 (3.2...8.5)	8.7 (6...15)	kΩ
Output admittance	h_{oe}	18 (< 30)	35 (< 60)	60 (< 110)	μmho
Reverse voltage transfer ratio	h_{re}	$1.5 \cdot 10^{-4}$	$2 \cdot 10^{-4}$	$3 \cdot 10^{-4}$	
DC current gain					
at $-V_{CE} = 5$ V, $-I_C = 0.01$ mA	h_{FE}	90	150	270	
at $-V_{CE} = 5$ V, $-I_C = 2$ mA	h_{FE}	170	290	500	
at $-V_{CE} = 5$ V, $-I_C = 100$ mA	h_{FE}	120[1]	200[1]	400[1]	
Collector saturation voltage					
at $-I_C = 10$ mA, $-I_B = 1$ mA	$-V_{CE\,sat}$		< 0.3		V
at $-I_C = 100$ mA, $-I_B = 5$ mA	$-V_{CE\,sat}$		0.5[1]		V
Base saturation voltage					
at $-I_C = 10$ mA, $-I_B = 0.5$ mA	$-V_{BE\,sat}$		0.7		V
at $-I_C = 100$ mA, $-I_B = 5$ mA	$-V_{BE\,sat}$		0.85[1]		V
Base emitter voltage at $-V_{CE} = 5$ V, $-I_C = 2$ mA	$-V_{BE}$		0.62 (0.55...0.7)		V

		BC 252 **BC 253** **BC 262** **BC 263** **BC 308** **BC 309**	**BC 251** **BC 261** **BC 307**	**BC 256** **BC 266**	
Collector cutoff current					
at $-V_{CE} = 25$ V	$-I_{CES}$	2 (< 15)	–	–	nA
at $-V_{CE} = 45$ V	$-I_{CES}$	–	2 (< 15)	–	nA
at $-V_{CE} = 64$ V	$-I_{CES}$	–	–	2 (< 15)	nA
at $-V_{CE} = 25$ V, $T_j = 125\ °C$	$-I_{CES}$	< 4	–	–	μA
at $-V_{CE} = 45$ V, $T_j = 125\ °C$	$-I_{CES}$	–	< 4	–	μA
at $-V_{CE} = 64$ V, $T_j = 125\ °C$	$-I_{CES}$	–	–	< 4	μA
Collector emitter breakdown voltage					
at $-I_{CES} = 10$ μA	$-V_{(BR)CES}$	> 30	> 50	> 64	V
at $-I_{CEO} = 2$ mA	$-V_{(BR)CEO}$	> 25	> 45	> 64	V
Emitter base breakdown voltage at $-I_{EBO} = 10$ μA	$-V_{(BR)EBO}$	> 5	> 5	> 5	V

[1] not valid for BC 253, BC 263 and BC 309

Gain bandwidth product at $-V_{CE} = 5$ V, $-I_C = 10$ mA, $f = 50$ MHz	f_T	130	MHz
Collector base capacitance at $-V_{CB0} = 10$ V, $f = 1$ MHz	C_{CB0}	< 6	pF
Emitter base capacitance at $-V_{EB0} = 0.5$ V, $f = 1$ MHz	C_{EB0}	12	pF

BC 251, BC 252, BC 256, BC 261, BC 262, BC 266, BC 307, BC 308:

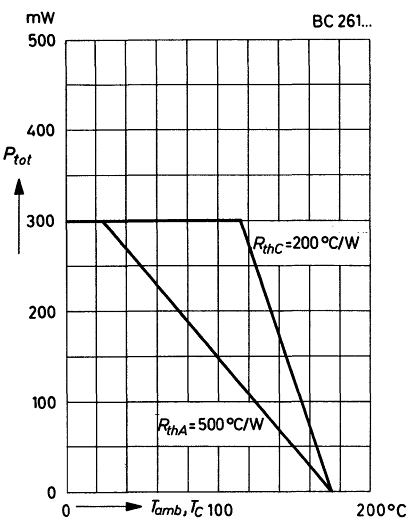
Noise figure at $-V_{CE} = 2$ V, $-I_C = 0.2$ mA, $R_G = 2$ kΩ, $f = 1$ kHz	F	< 10	dB

BC 253, BC 263 and **BC 309:**

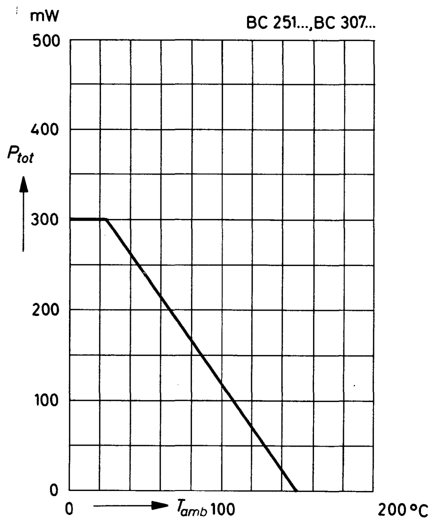
Noise figure at $-V_{CE} = 2$ V, $-I_C = 0.2$ mA, $R_G = 2$ kΩ, $f = 1$ kHz	F	< 4	dB
Noise figure at $-V_{CE} = 2$ V, $-I_C = 0.2$ mA, $R_G = 2$ kΩ, $f = 30$ Hz ... 15 kHz	F	2 (< 4)	dB

Thermal resistance		TO-92	TO-18	
Junction to case	R_{thC}	–	< 200	°C/W
Junction to ambient air	R_{thA}	< 420[1]	< 500	°C/W

Admissible power dissipation versus temperature

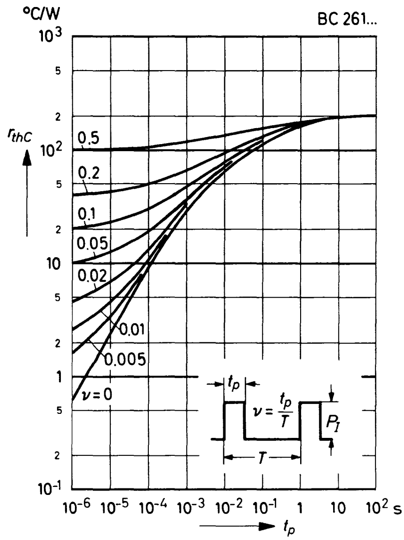


Admissible power dissipation versus ambient temperature[1]

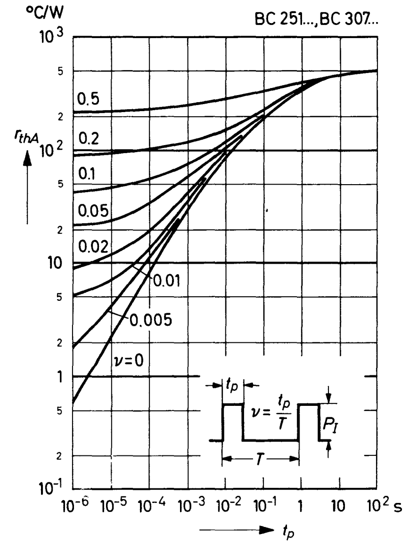


[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

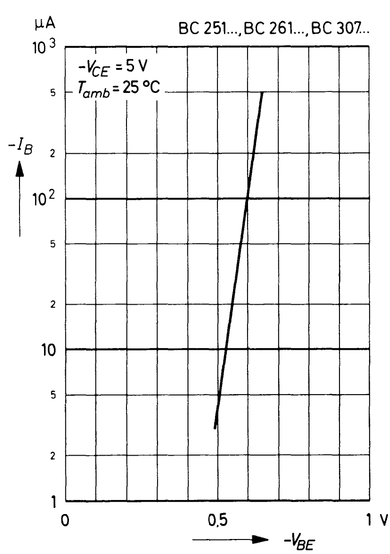
Pulse thermal resistance versus pulse duration



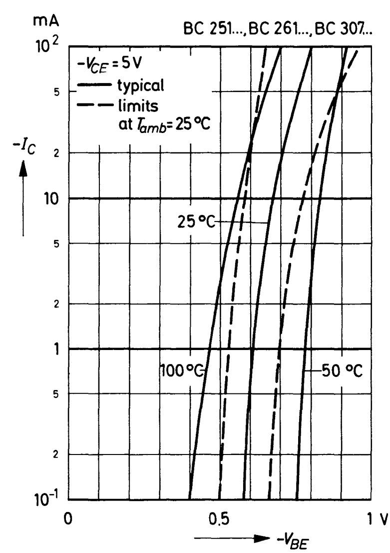
Pulse thermal resistance versus pulse duration



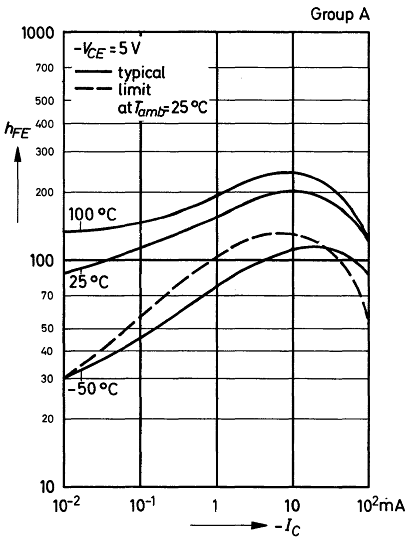
Common emitter input characteristic



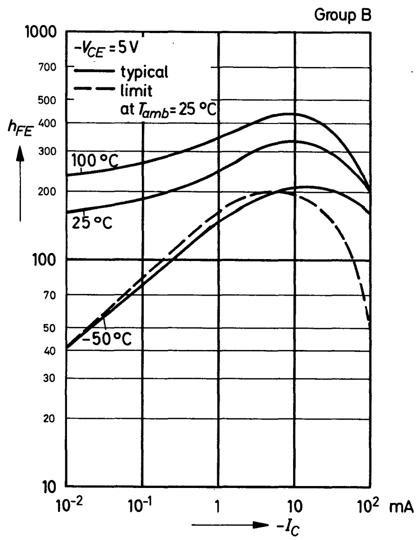
Collector current versus base emitter voltage



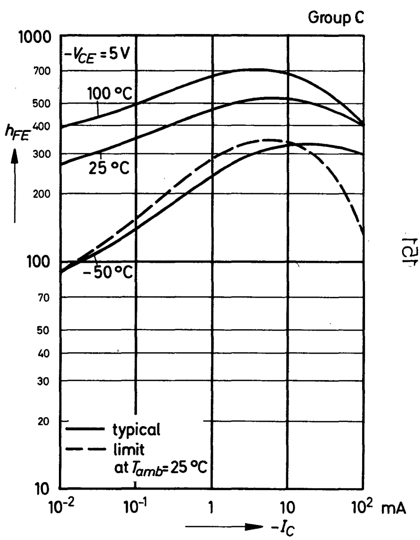
DC current gain versus collector current



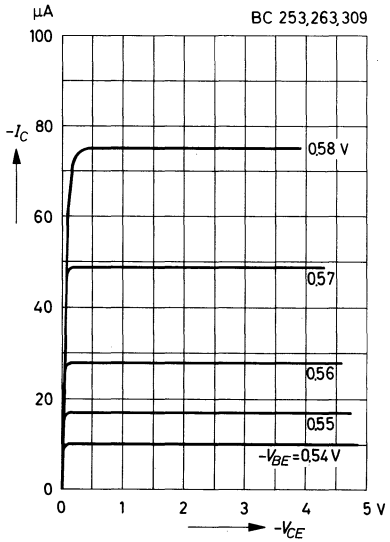
DC current gain versus collector current



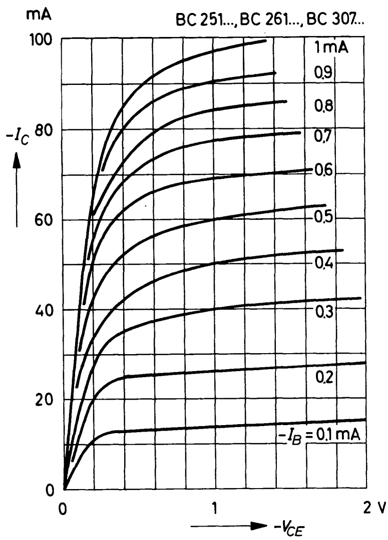
DC current gain versus collector current



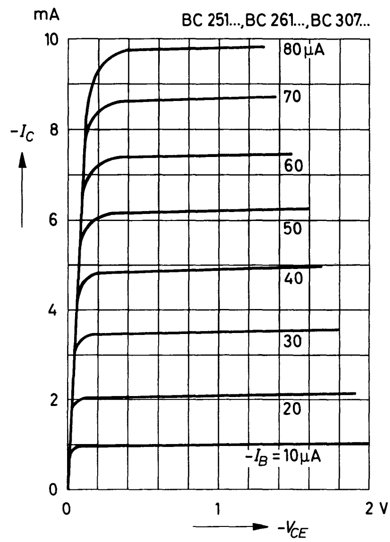
Common emitter collector characteristics



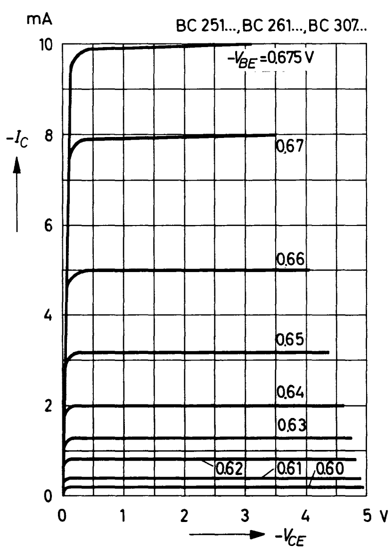
Common emitter collector characteristics



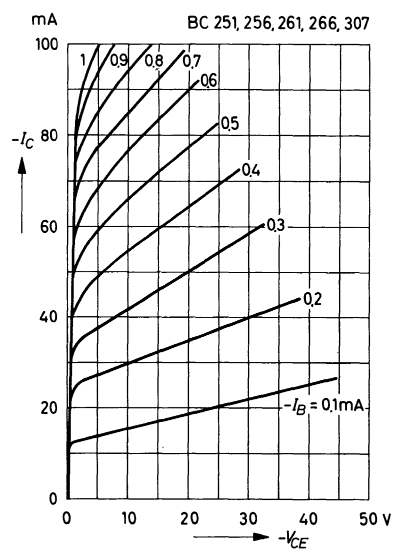
Common emitter collector characteristics



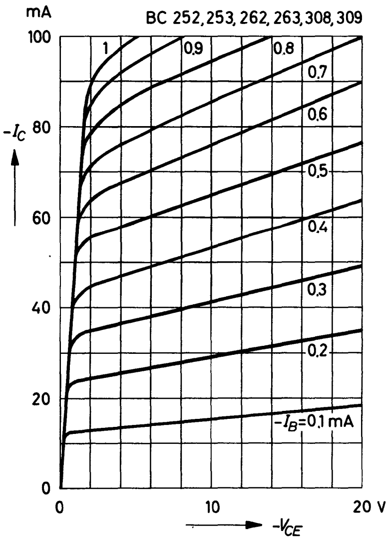
Common emitter collector characteristics



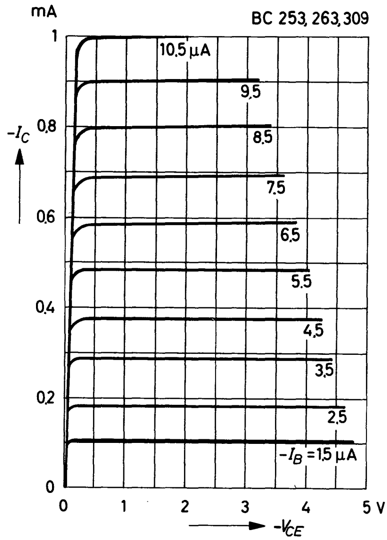
Common emitter collector characteristics



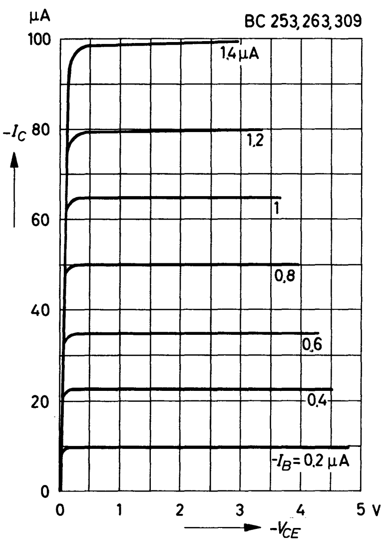
Common emitter collector characteristics



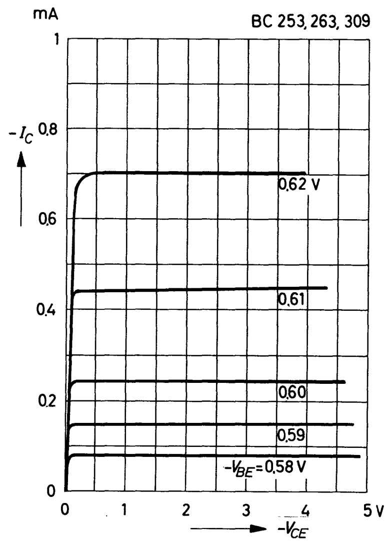
Common emitter collector characteristics



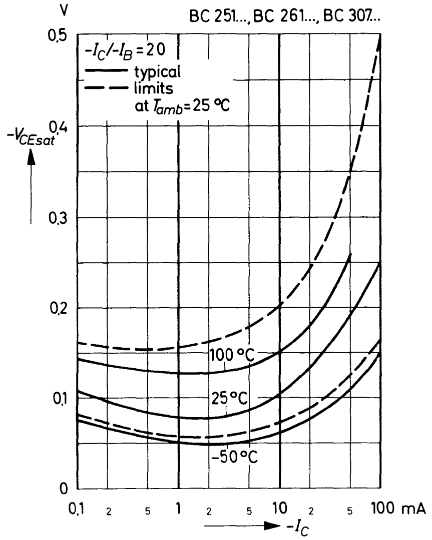
Common emitter collector characteristics



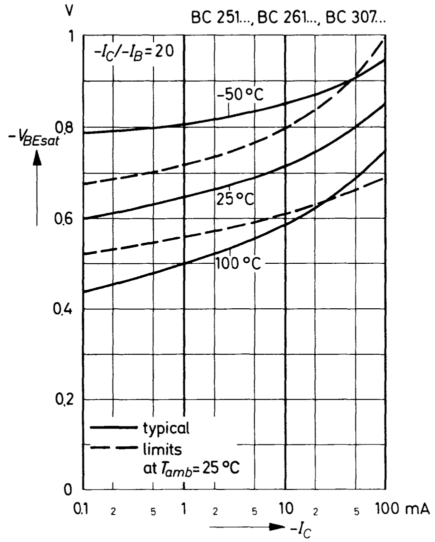
Common emitter collector characteristics



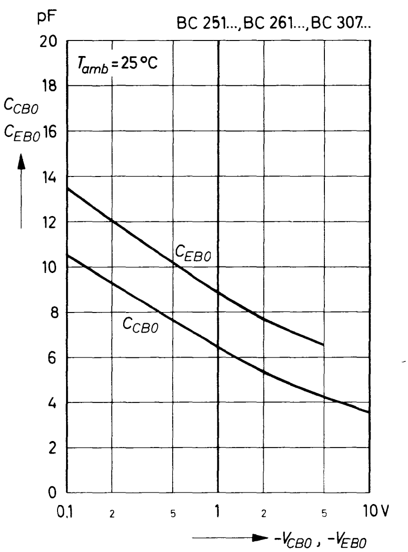
Collector saturation voltage versus collector current



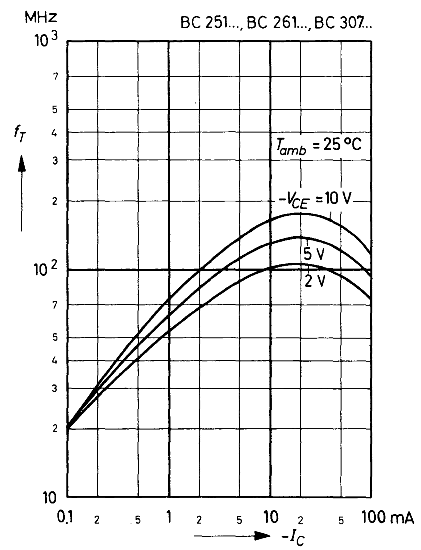
Base saturation voltage versus collector current



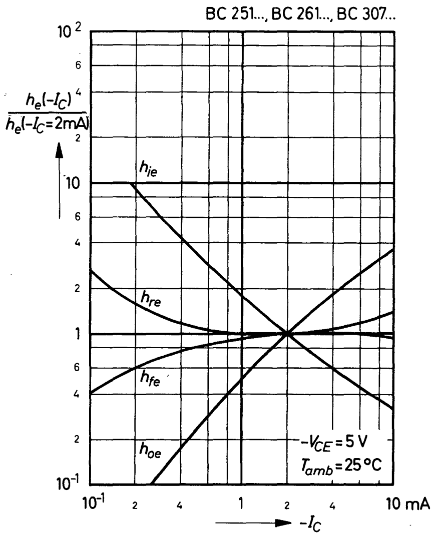
Collector base capacitance, Emitter base capacitance versus reverse bias voltage



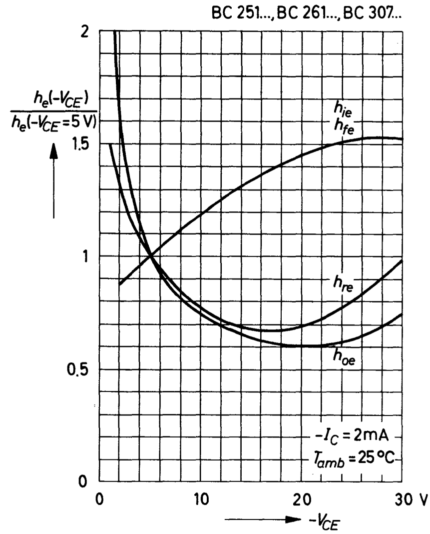
Gain bandwidth product versus collector current



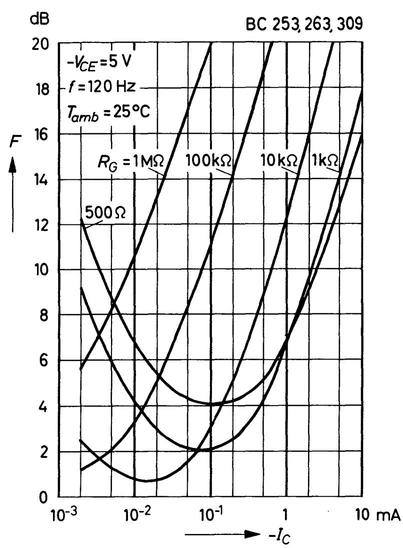
Relative *h*-parameters versus collector current



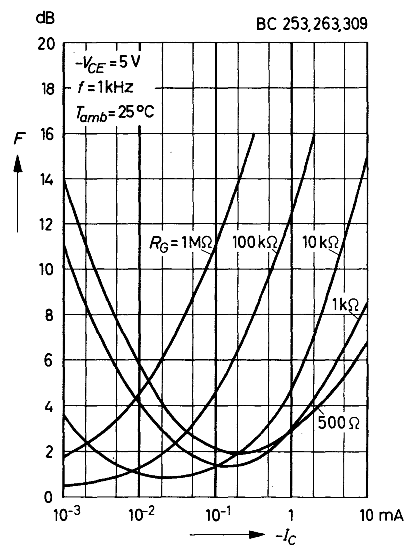
Relative *h*-parameters versus collector emitter voltage



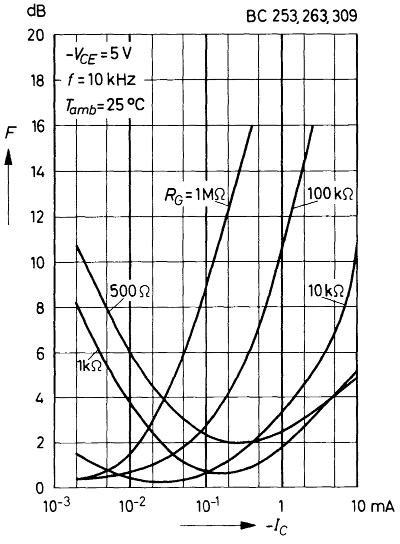
Noise figure versus collector current



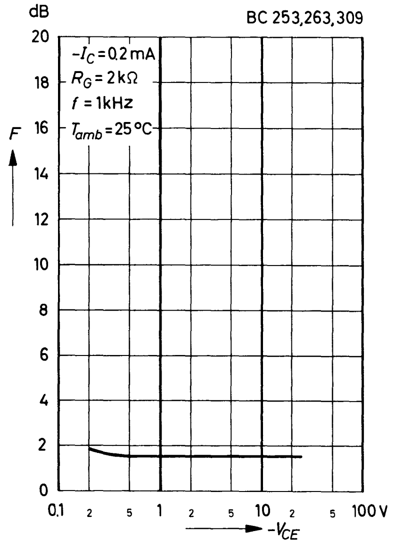
Noise figure versus collector current



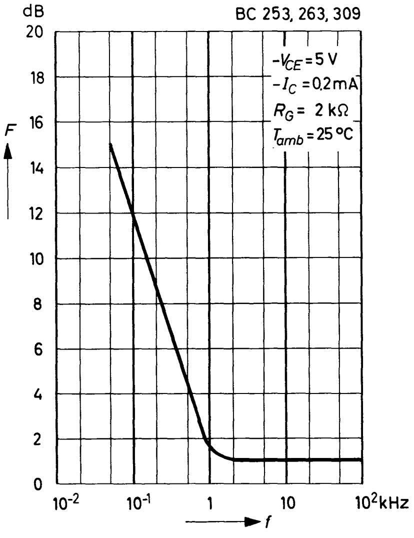
Noise figure versus collector current



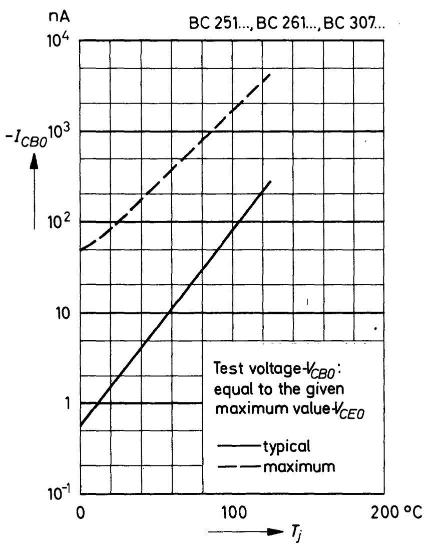
Noise figure versus collector emitter voltage



Noise figure versus frequency

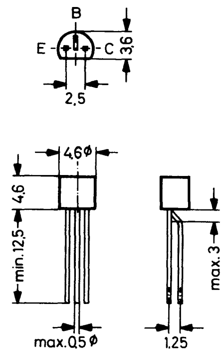


Collector cutoff current versus ambient temperature



BC 327, BC 328

PNP Silicon Epitaxial Planar Transistors
for switching and amplifier applications. Especially suitable for AF-driver stages and low power output stages.
These types are subdivided into three groups –16, –25 and –40, according to their DC current gain.
These transistors are available as complementary pairs BC 327/BC 337 or BC 328/BC 338. Matching conditions: The ratio of the DC current gains of a matched pair at $|V_{CE}| = 1$ V, $|I_C| = 100$ mA is less than 1.41.



Green plastic package ≈TO-92,
TO-18 compatible.
The case is impervious to light.
Weight approximately 0.18 g
Dimensions in mm

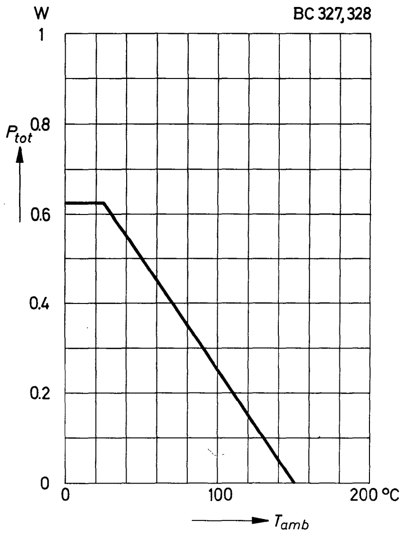
Maximum Ratings		**BC 327**	**BC 328**	
Collector emitter voltage	$-V_{CES}$	50	30	V
Collector emitter voltage	$-V_{CEO}$	45	25	V
Emitter base voltage	$-V_{EBO}$	5		V
Collector current	$-I_C$	800		mA
Peak collector current	$-I_{CM}$	1		A
Base current	$-I_B$	100		mA
Power dissipation at $T_{amb} = 25$ °C	P_{tot}	625		mW
Junction temperature	T_j	150		°C
Storage temperature range	T_S	– 55 . . . + 150		°C

Characteristics at $T_{amb} = 25$ °C		**BC 327–16** **BC 328–16**	**BC 327–25** **BC 328–25**	**BC 327–40** **BC 328–40**	
DC current gain at $-V_{CE} = 1$ V, $-I_C = 100$ mA	h_{FE}	160 (100...250)	250 (160...400)	400 (250...630)	
at $-V_{CE} = 1$ V, $-I_C = 300$ mA	h_{FE}	130	200	320	
Thermal resistance Junction to ambient air	R_{thA}	< 200			°C/W

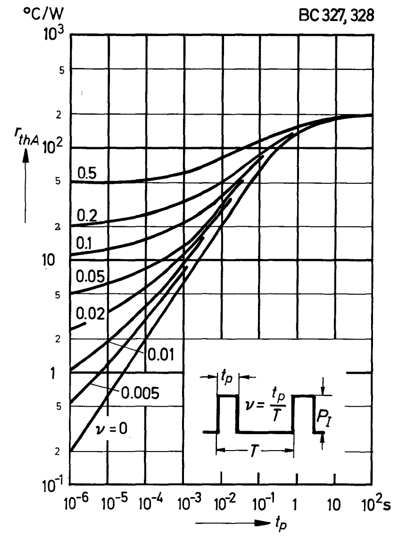
[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

		BC 327	BC 328	
Collector cutoff current				
at $-V_{CE} = 25$ V	$-I_{CES}$	–	2 (< 100)	nA
at $-V_{CE} = 45$ V	$-I_{CES}$	2 (< 100)	–	nA
at $-V_{CE} = 25$ V, $T_{amb} = 125$ °C	$-I_{CES}$	–	< 10	μA
at $-V_{CE} = 45$ V, $T_{amb} = 125$ °C	$-I_{CES}$	< 10	–	μA
Collector emitter breakdown voltage at $-I_C = 10$ mA	$-V_{(BR)CEO}$	> 45	> 25	V
Collector emitter breakdown voltage at $-I_C = 0.1$ mA	$-V_{(BR)CES}$	> 50	> 30	V
Emitter base breakdown voltage at $-I_E = 0.1$ mA	$-V_{(BR)EBO}$	> 5		V
Collector saturation voltage at $-I_C = 500$ mA, $-I_B = 50$ mA	$-V_{CE\,sat}$	< 0.7		V
Base emitter voltage at $-V_{CE} = 1$ V, $-I_C = 300$ mA	$-V_{BE}$	< 1.2		V
Gain bandwidth product at $-V_{CE} = 5$ V, $-I_C = 10$ mA $f = 50$ MHz	f_T	100		MHz
Collector base capacitance at $-V_{BC} = 10$ V, $f = 1$ MHz	C_{CBO}	12		pF

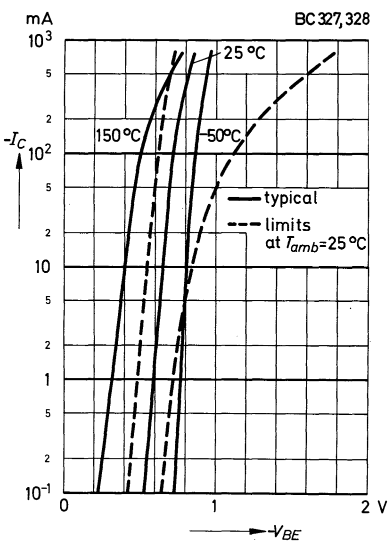
Admissible power dissipation versus ambient temperature
(see note on page 316)



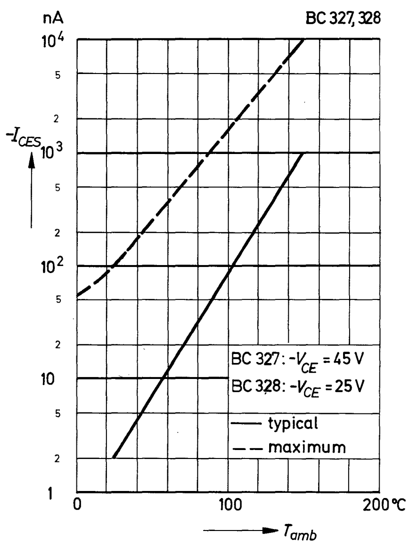
Pulse thermal resistance versus pulse duration



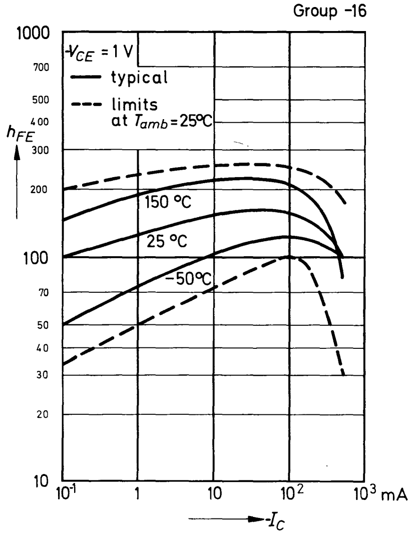
Collector current versus base emitter voltage



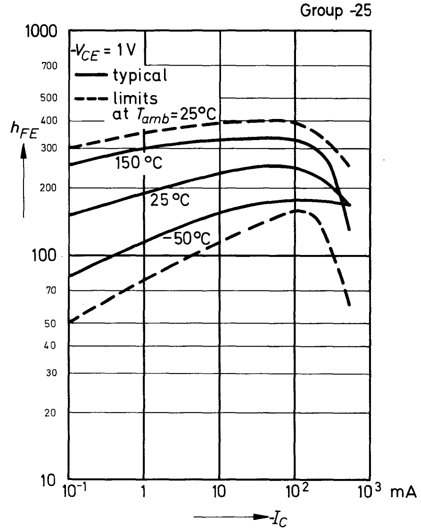
Collector cutoff current versus ambient temperature



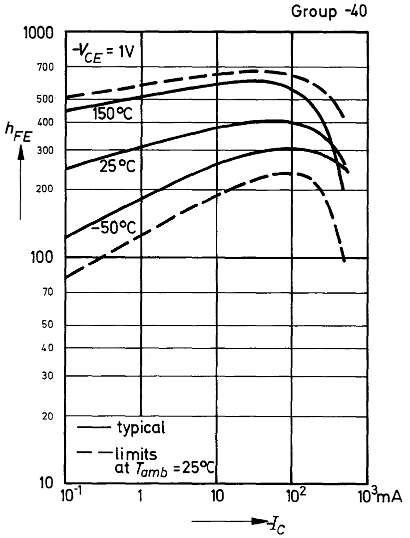
DC current gain versus collector current



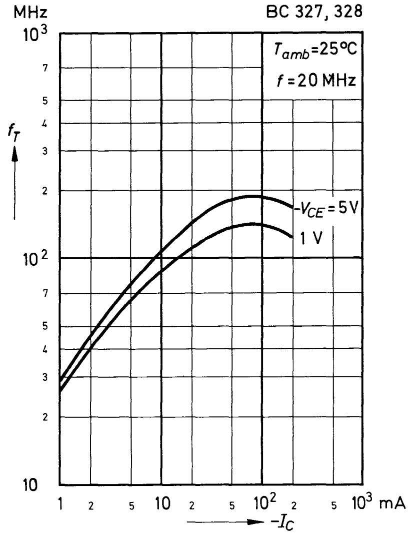
DC current gain versus collector current



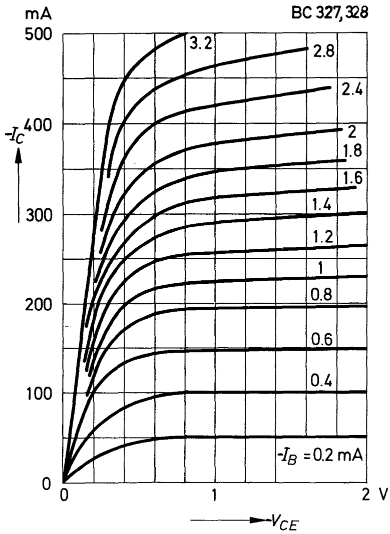
DC current gain versus collector current



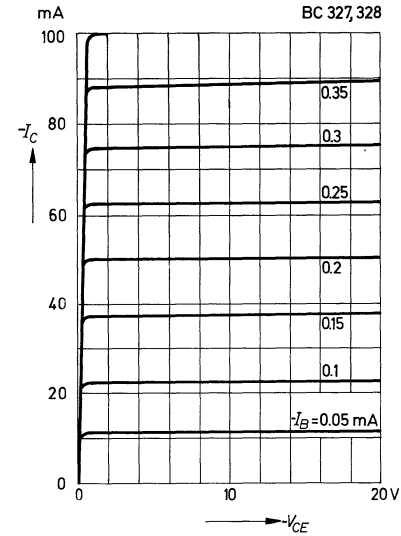
Gain bandwidth product versus collector current



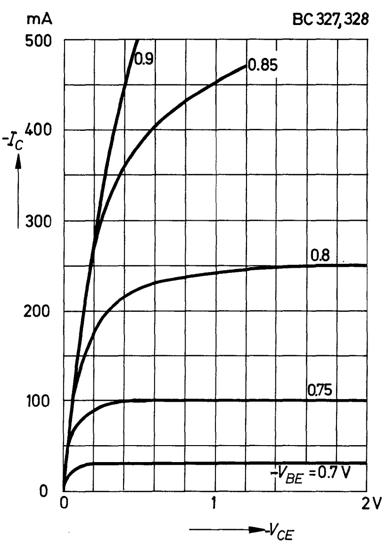
Common emitter collector characteristics



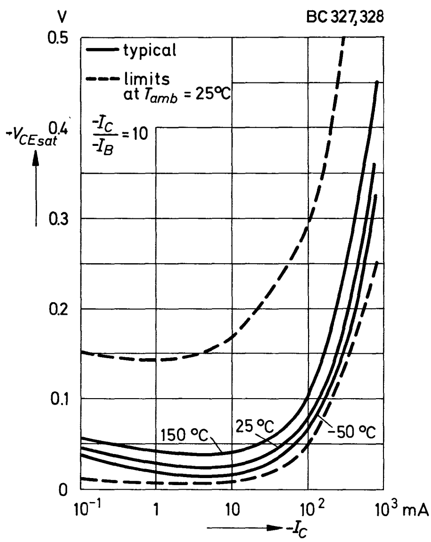
Common emitter collector characteristics



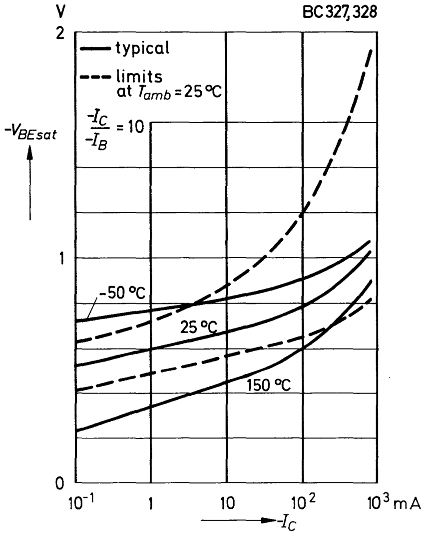
Common emitter collector characteristics



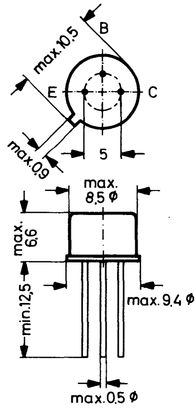
Collector saturation voltage versus collector current



Base saturation voltage versus collector current



PNP Silicon Epitaxial Planar Transistors
for switching and amplifier applications
The type BC 360 is subdivided into three groups, −6, −10 and −16, the type BC 361 into two groups, −6 and −10, according to the DC current gain.
These transistors are available either as matched pairs or as complementary pairs BC 340/BC 360 or BC 341/BC 361 resp. Matching condition: The ratio of the DC current gains of a matched pair at $|V_{CE}| = 5$ V, $|I_C| = 50$ mA is less than 1.25.



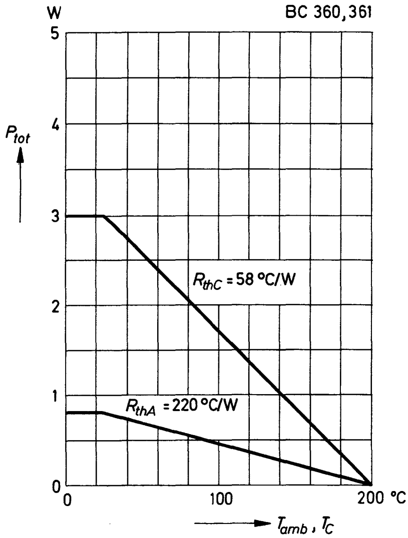
Metal case JEDEC TO-39
Collector connected to case
Weight about 1 g
Dimensions in mm

Maximum Ratings		**BC 360**	**BC 361**	
Collector base voltage	$-V_{CBO}$	40	60	V
Collector emitter voltage	$-V_{CEO}$	40	60	V
Emitter base voltage	$-V_{EBO}$	5	5	V
Collector current	$-I_C$	500		mA
Base current	$-I_B$	50		mA
Power dissipation at $T_{amb} = 25$ °C	P_{tot}	0.8		W
at $T_C = 25$ °C	P_{tot}	3		W
Junction temperature	T_j	200		°C
Storage temperature range	T_S	−55 . . . +200		°C

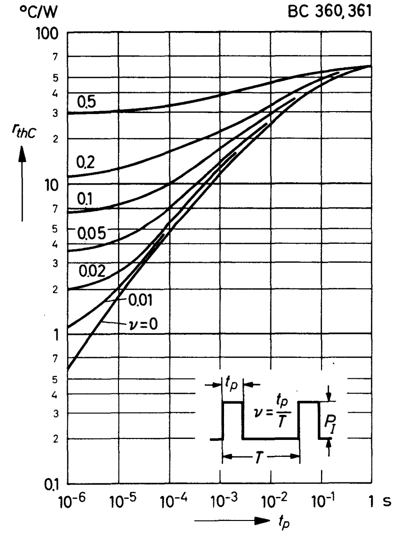
Characteristics at $T_j = 25$ °C		**BC 360-6** **BC 361-6**	**BC 360-10** **BC 361-10**	**BC 360-16**	
DC current gain at $-V_{CE} = 5$ V, $-I_C = 0.1$ mA	h_{FE}	40	65	100	
at $-V_{CE} = 5$ V, $-I_C = 50$ mA	h_{FE}	63 (40...100)	100 (63...160)	160 (100...250)	
at $-V_{CE} = 5$ V, $-I_C = 500$ mA	h_{FE}	20	30	48	
Collector saturation voltage at $-I_C = 150$ mA, $-I_B = 15$ mA	$-V_{CE\,sat}$	< 0.4			V
Base saturation voltage at $-I_C = 150$ mA, $-I_B = 15$ mA	$-V_{BE\,sat}$	0.95 (< 1.2)			V

		BC 360	BC 361	
Collector cutoff current				
at $-V_{CE} = 40$ V	$-I_{CES}$	10 (< 100)	–	nA
at $-V_{CE} = 60$ V	$-I_{CES}$	–	10 (< 100)	nA
at $-V_{CE} = 40$ V, $T_j = 150$ °C	$-I_{CES}$	10 (< 100)	–	μA
at $-V_{CE} = 60$ V, $T_j = 150$ °C	$-I_{CES}$	–	10 (< 100)	μA
Collector emitter breakdown voltage				
at $-I_C = 0.1$ mA	$-V_{(BR)CES}$	> 40	> 60	V
at $-I_C = 30$ mA (pulsed 200 μs, 1%)	$-V_{(BR)CEO}$	> 40	> 60	V
Gain bandwidth product at $-V_{CE} = 10$ V, $-I_C = 50$ mA, $f = 50$ MHz	f_T	250		MHz
Collector base capacitance at $-V_{CBO} = 10$ V, $f = 1$ MHz	C_{CBO}	6.5		pF
Emitter base capacitance at $-V_{EBO} = 0.5$ V, $f = 1$ MHz	C_{EBO}	25		pF
Thermal resistance				
Junction to ambient air	R_{thA}	< 220		°C/W
Junction to case	R_{thC}	< 58		°C/W

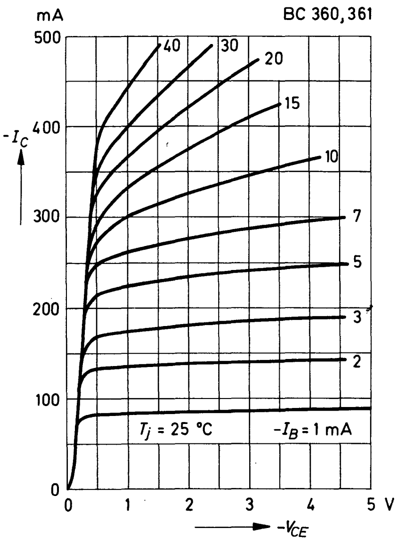
Admissible power dissipation versus temperature



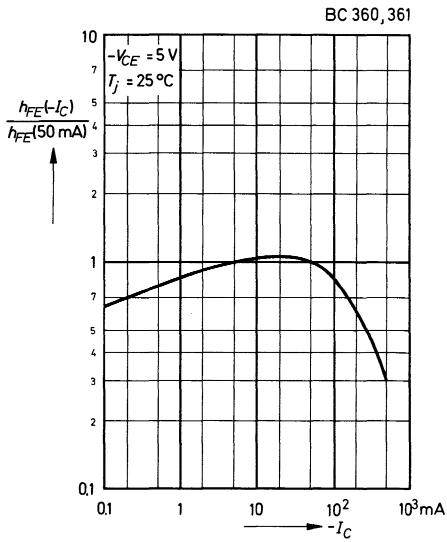
Pulse thermal resistance versus pulse duration



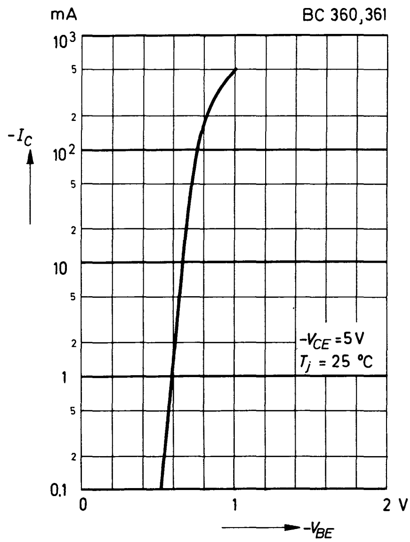
Common emitter collector characteristics



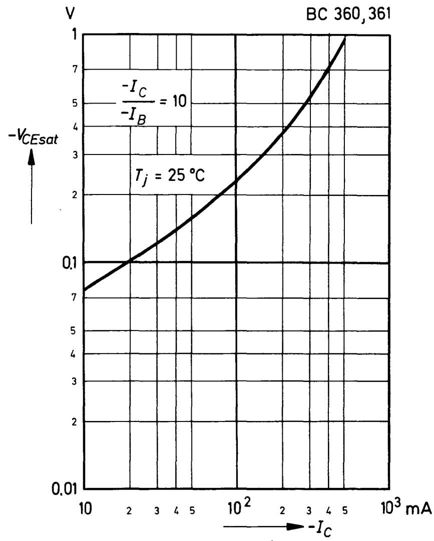
Relative DC current gain versus collector current



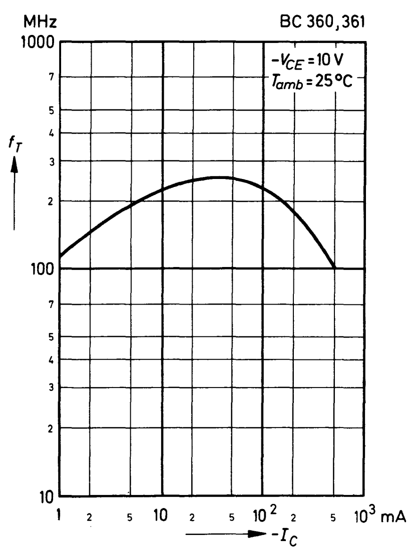
Collector current versus base emitter voltage



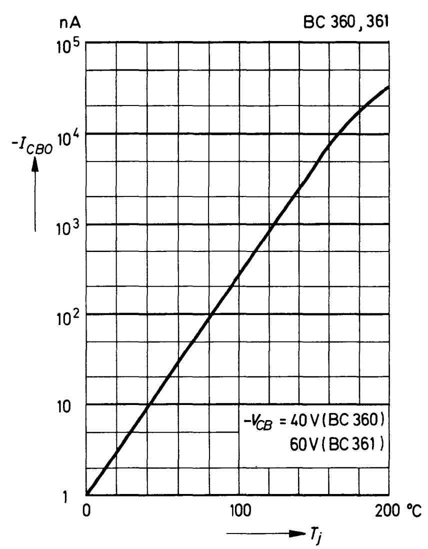
Collector saturation voltage versus collector current



Gain bandwidth product versus collector current

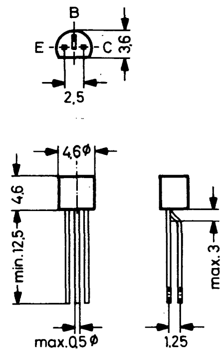


Collector cutoff current versus junction temperature



PNP Silicon Epitaxial Planar Transistors
for use in high-quality, low-noise AF and DC amplifiers. Complementary types are the NPN transistors BC 413 and BC 414.

These types are subdivided into three groups –6, –10 and –16, according to their DC current gain.



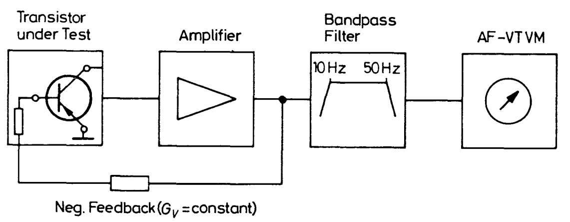
Green plastic package ≈ TO-92,
TO-18 compatible.
The case is impervious to light.
Weight approximately 0.18 g
Dimensions in mm

Maximum Ratings		**BC 415**	**BC 416**	
Collector base voltage	$-V_{CBO}$	45	50	V
Collector emitter voltage	$-V_{CEO}$	30	45	V
Emitter base voltage	$-V_{EBO}$	5		V
Collector current	$-I_C$	100		mA
Base current	$-I_B$	20		mA
Power dissipation at T_{amb} = 25 °C	P_{tot}	300[1]		mW
Junction temperature	T_j	150		°C
Storage temperature range	T_S	–65 ... +150		°C

Characteristics at T_{amb} = 25 °C h-parameters at $-V_{CE}$ = 5 V, $-I_C$ = 2 mA, f = 1 kHz		**Current gain group** **A**	 **B**	 **C**	
Small signal current gain	h_{fe}	222 (125...260)	330 (240...500)	600 (450...900)	
Input impedance	h_{ie}	2.7 (1.6...4.5)	4.5 (3.2...8.5)	8.7 (6...15)	kΩ
Output admittance	h_{oe}	18 (< 30)	30 (< 60)	60 (< 110)	µmho
Reverse voltage transfer ratio	h_{re}	$1.5 \cdot 10^{-4}$	$2 \cdot 10^{-4}$	$3 \cdot 10^{-4}$	
DC current gain at $-V_{CE}$ = 5 V, $-I_C$ = 0.01 mA	h_{FE}	90 (> 40)	150 (> 100)	270 (> 100)	
at $-V_{CE}$ = 5 V, $-I_C$ = 2 mA	h_{FE}	170 (120...220)	290 (180...460)	500 (380...800)	
Thermal resistance Junction to ambient air	R_{thA}		< 420[1]		°C/W

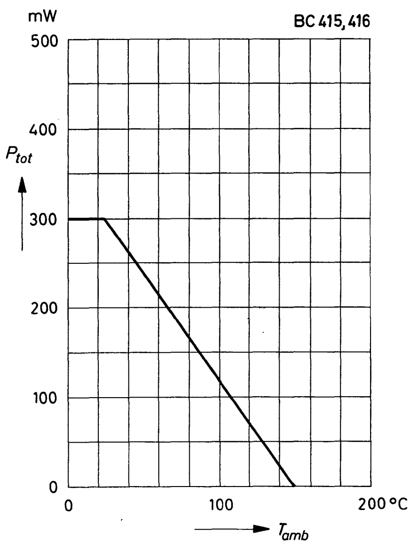
[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

Collector saturation voltage				
at $-I_C =$ 10 mA, $-I_B =$ 0.5 mA	$-V_{CE\,sat}$	0.075 (< 0.25)		V
at $-I_C =$ 100 mA, $-I_B =$ 5 mA	$-V_{CE\,sat}$	0.25 (< 0.6)		V
Base saturation voltage at $-I_C =$ 100 mA, $-I_B =$ 5 mA	$-V_{BE\,sat}$	0.9		V
Base emitter voltage				
at $-V_{CE} =$ 5 V, $-I_C =$ 0.01 mA	$-V_{BE}$	0.52		V
at $-V_{CE} =$ 5 V, $-I_C =$ 0.1 mA	$-V_{BE}$	0.55		V
at $-V_{CE} =$ 5 V, $-I_C =$ 2 mA	$-V_{BE}$	0.65 (0.55...0.75)		V
Collector cutoff current				
at $-V_{CB} =$ 30 V	$-I_{CBO}$	< 15		nA
at $-V_{CB} =$ 30 V, $T_{amb} =$ 150 °C	$-I_{CBO}$	< 5		µA
Emitter cutoff current at $-V_{EB} =$ 4 V	$-I_{EBO}$	< 15		nA
		BC 415	**BC 416**	
Collector emitter breakdown voltage at $-I_{CE} =$ 10 mA	$-V_{(BR)CEO}$	> 30	> 45	V
Collector base breakdown voltage at $-I_{CB} =$ 10 µA	$-V_{(BR)CBO}$	> 45	> 50	V
Emitter base breakdown voltage at $-I_{EB} =$ 10 µA	$-V_{(BR)EBO}$	> 5	> 5	V
Gain bandwidth product at $-V_{CE} =$ 5 V, $-I_C =$ 10 mA, $f =$ 100 MHz	f_T	200		MHz
Collector base capacitance at $-V_{CBO} =$ 10 V, $f =$ 1 MHz	C_{CBO}	4.5		pF
Noise figure at $-V_{CE} =$ 5 V, $-I_C =$ 0.2 mA, $R_G =$ 2 kΩ, $f =$ 30 Hz ... 15 kHz	F	< 2		dB
Equivalent noise EMF (referred to base) at $-V_{CE} =$ 5 V, $-I_C =$ 0.2 mA, $R_G =$ 2 kΩ, $f =$ 10 ... 50 Hz	v_r	< 0.11		µV

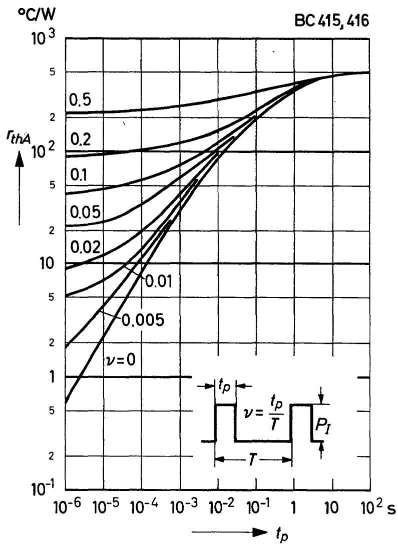


Test circuit for equivalent noise EMF

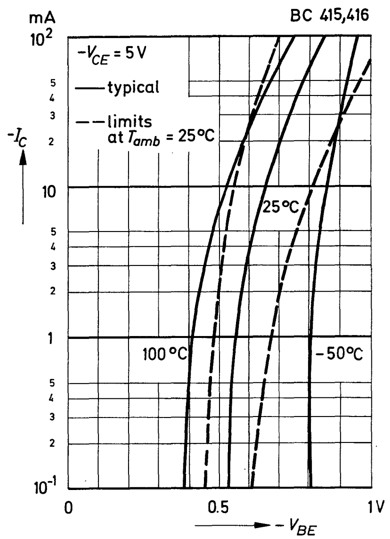
Admissible power dissipation versus ambient temperature
(see note on page 326)



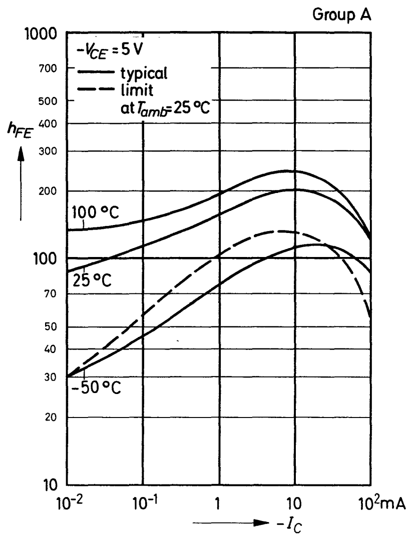
Pulse thermal resistance versus pulse duration



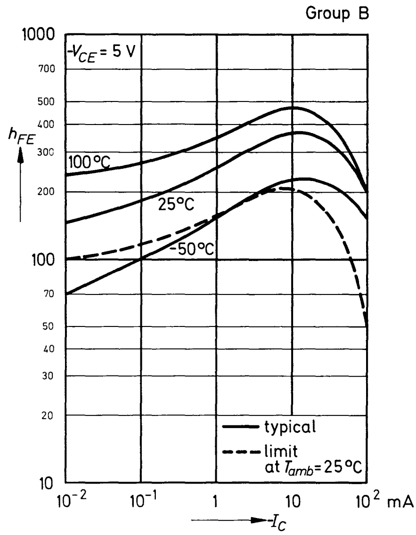
Collector current versus base emitter voltage



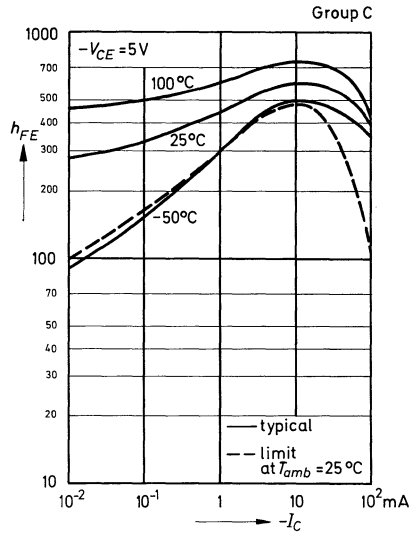
DC current gain versus collector current



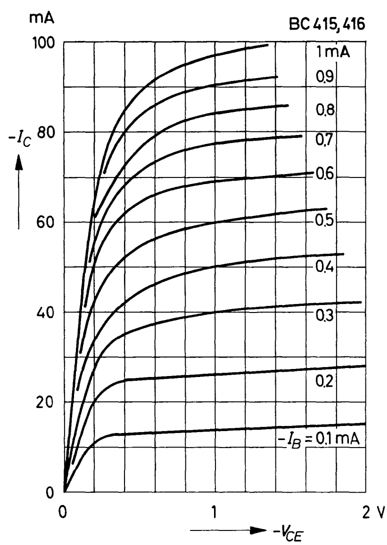
DC current gain versus collector current



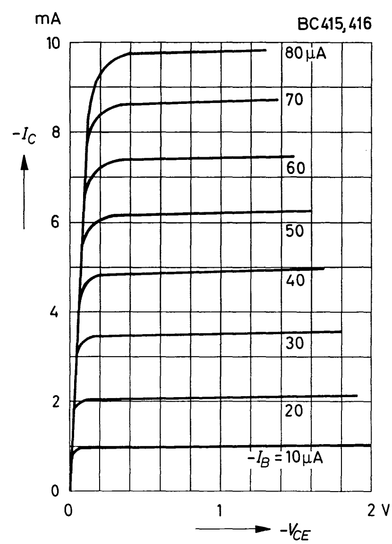
DC current gain versus collector current



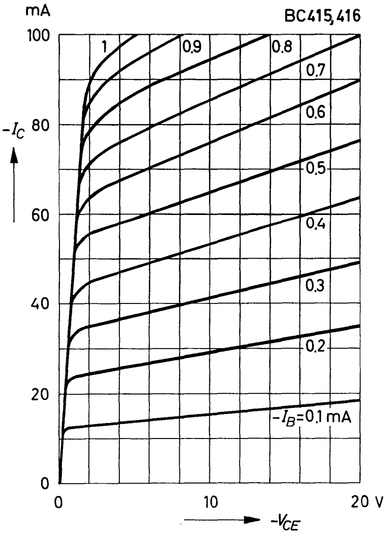
Common emitter collector characteristics



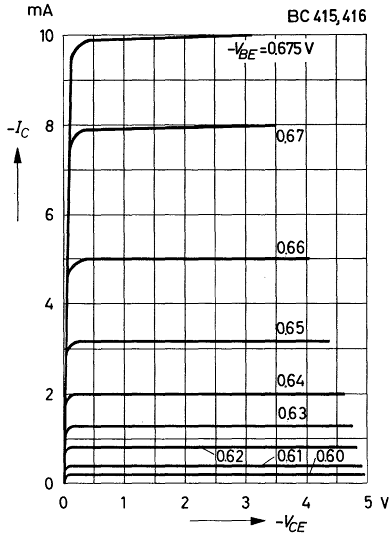
Common emitter collector characteristics



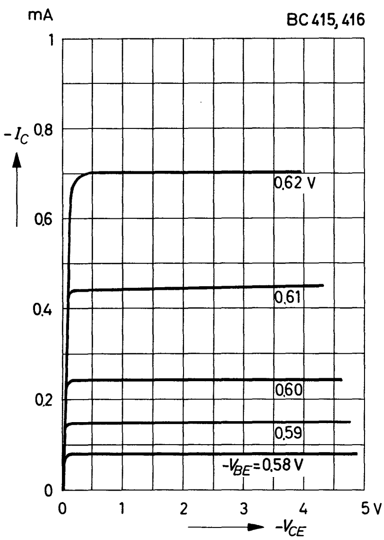
Common emitter collector characteristics



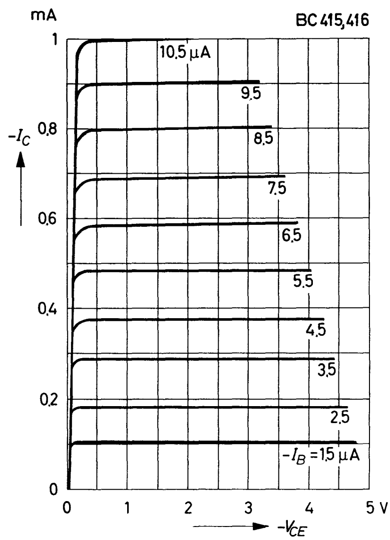
Common emitter collector characteristics



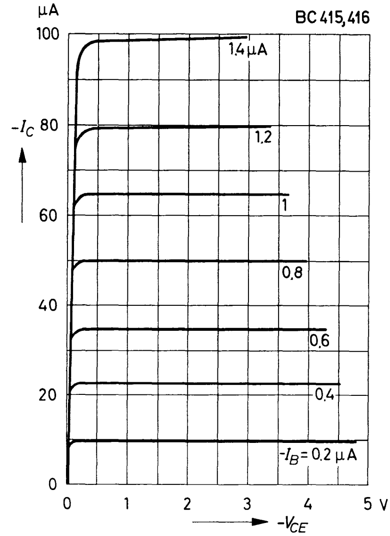
Common emitter collector characteristics



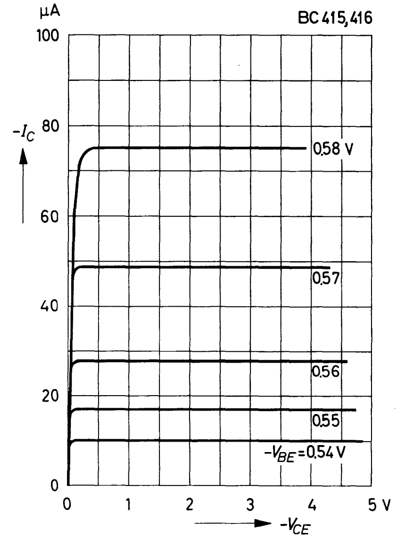
Common emitter collector characteristics



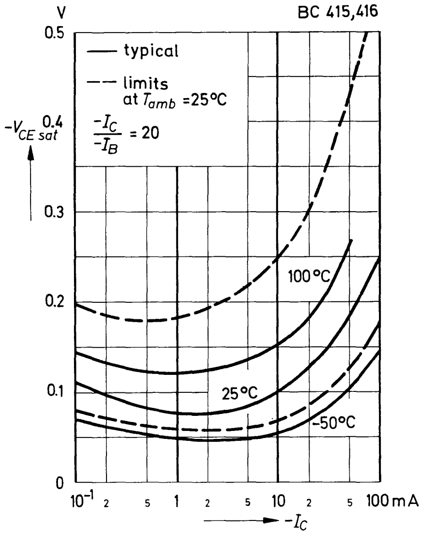
Common emitter collector characteristics



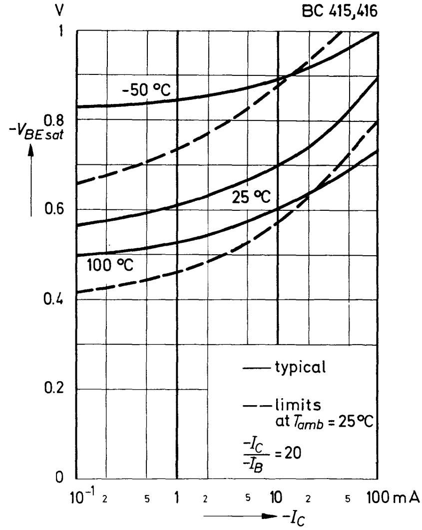
Common emitter collector characteristics



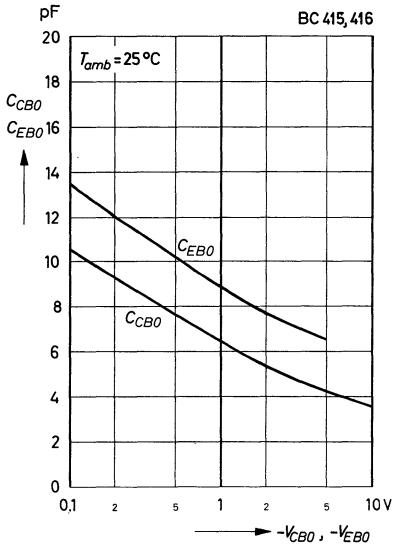
Collector saturation voltage versus collector current



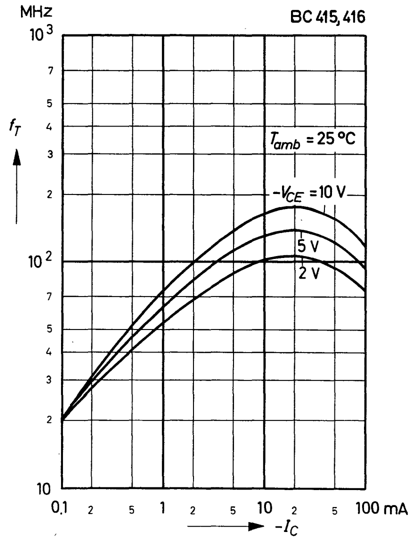
Base saturation voltage versus collector current



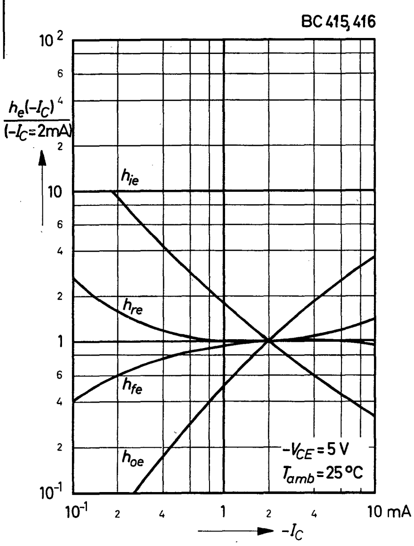
Collector base capacitance, Emitter base capacitance versus reverse bias voltage



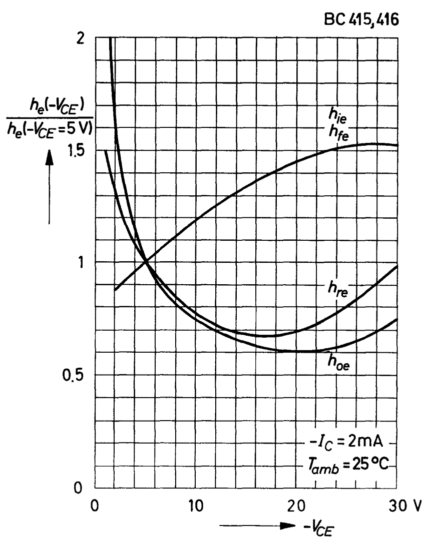
Gain bandwidth product versus collector current



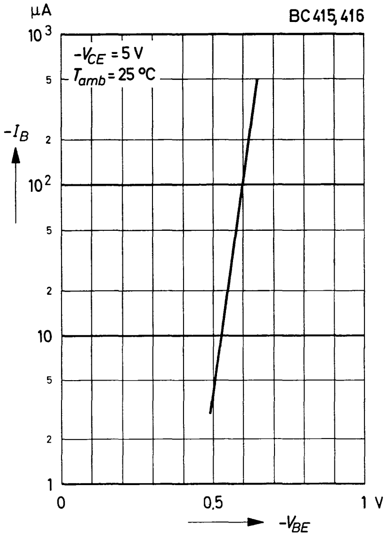
Relative *h*-parameters versus collector current



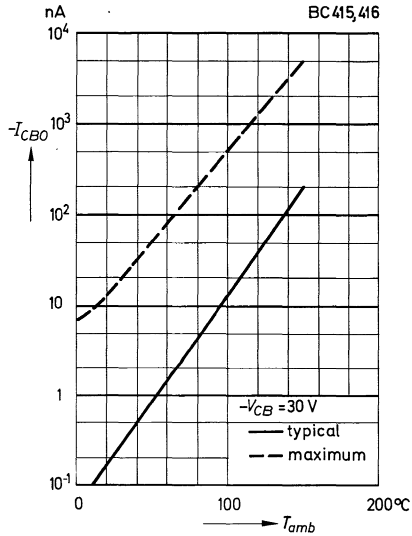
Relative *h*-parameters versus collector emitter voltage



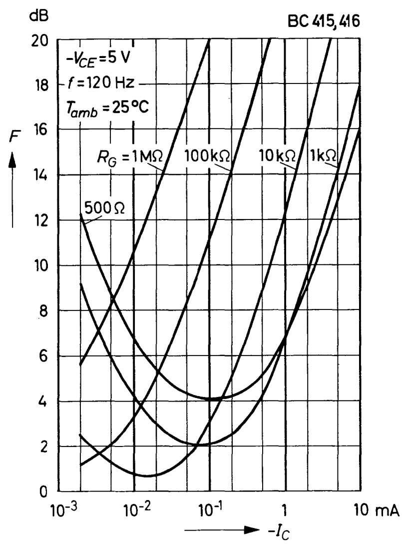
Common emitter input characteristic



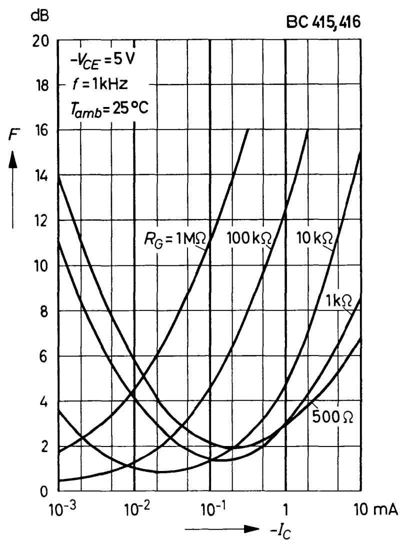
Collector cutoff current versus ambient temperature



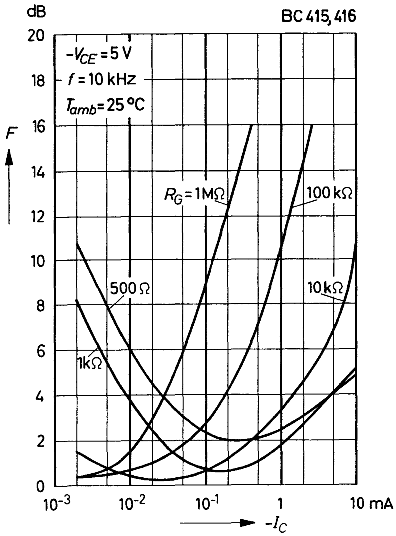
Noise figure versus collector current



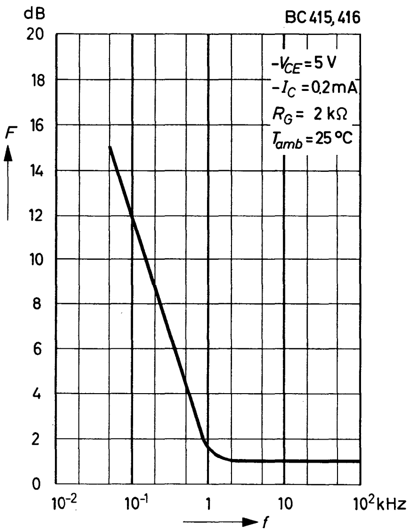
Noise figure versus collector current



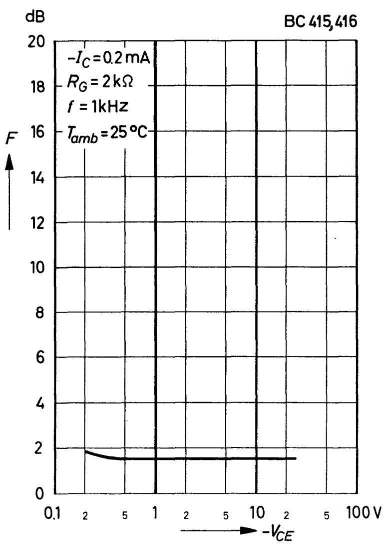
Noise figure versus collector current



Noise figure versus frequency



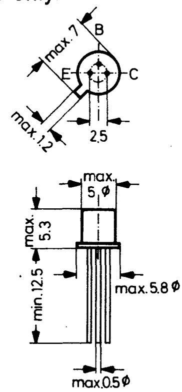
Noise figure versus collector emitter voltage



BCY 78, BCY 79

PNP Silicon Epitaxial Planar Transistors
for switching and amplifier applications in commercial electronic design

These Transistors are subdivided into four groups A, B, C and D according to their current gain. Type BCY 79 is available in groups A, B and C only.



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings		**BCY 78**	**BCY 79**	
Collector emitter voltage	$-V_{CES}$	32	45	V
Collector emitter voltage	$-V_{CEO}$	32	45	V
Emitter base voltage	$-V_{EBO}$	5		V
Collector current	$-I_C$	200		mA
Base current	$-I_B$	50		mA
Power dissipation at $T_{amb} = 25\ °C$	P_{tot}	390		mW
at $T_C = 45\ °C$	P_{tot}	1		W
Junction temperature	T_j	200		°C
Storage temperature range	T_S	−65. . . .+200		°C

Characteristics at $T_{amb} = 25\ °C$

h-parameters at $-V_{CE} = 5$ V, $-I_C = 2$ mA, $f = 1$ kHz

		Current Gain Group				
		A	**B**	**C**	**D**	
Small signal current gain	h_{fe}	200 (125...250)	260 (175...350)	330 (250...500)	520 (350...700)	
Input impedance	h_{ie}	2.7 (1.6...4.5)	3.6 (2.5...6)	4.5 (3.2...8.5)	7.5	kΩ
Output admittance	h_{oe}	18 (< 30)	24 (< 50)	30 (< 60)	50 (< 100)	μmho
Reverse voltage transfer ratio	h_{re}	$1.5 \cdot 10^{-4}$	$2 \cdot 10^{-4}$	$2 \cdot 10^{-4}$	$3 \cdot 10^{-4}$	

		Current Gain Group				
		A	B	C	D	
DC current gain at $-V_{CE} = 5$ V, $-I_C = 10$ µA	h_{FE}	140	200 (> 30)	270 (> 40)	340 (> 100)	
at $-V_{CE} = 5$ V, $-I_C = 2$ mA	h_{FE}	170 (120...220)	250 (180...310)	350 (250...460)	500 (380...630)	
at $-V_{CE} = 1$ V, $-I_C = 10$ mA	h_{FE}	180 (> 80)	260 (120...400)	360 (160...630)	500 (240...1000)	
at $-V_{CE} = 1$ V, $-I_C = 100$ mA	h_{FE}	> 40	> 45	> 60	> 60	

Base emitter voltage			
at $-V_{CE} = 5$ V, $-I_C = 10$ µA	$-V_{BE}$	0.55	V
at $-V_{CE} = 5$ V, $-I_C = 2$ mA	$-V_{BE}$	0.65 (0.6...0.75)	V
at $-V_{CE} = 1$ V, $-I_C = 10$ mA	$-V_{BE}$	0.68	V
at $-V_{CE} = 1$ V, $-I_C = 100$ mA	$-V_{BE}$	0.75	V
Collector saturation voltage			
at $-I_C =$ 10 mA, $-I_B = 0.25$ mA	$-V_{CE\,sat}$	0.12 (0.06...0.25)	V
at $-I_C = 100$ mA, $-I_B = 2.5$ mA	$-V_{CE\,sat}$	0.4 (0.2...0.8)	V
Base saturation voltage			
at $-I_C =$ 10 mA, $-I_B = 0.25$ mA	$-V_{BE\,sat}$	0.7 (0.6...0.85)	V
at $-I_C = 100$ mA, $-I_B = 2.5$ mA	$-V_{BE\,sat}$	0.85 (0.7...1.2)	V

		BCY 78	BCY 79	
Collector cutoff current				
at $-V_{CES} = 25$ V	$-I_{CES}$	2 (< 20)	–	nA
at $-V_{CES} = 35$ V	$-I_{CES}$	–	2 (< 20)	nA
at $-V_{CES} = 32$ V	$-I_{CES}$	< 100	–	nA
at $-V_{CES} = 45$ V	$-I_{CES}$	–	< 100	nA
at $-V_{CES} = 25$ V, $T_{amb} = 150$ °C	$-I_{CES}$	< 10	–	µA
at $-V_{CES} = 35$ V, $T_{amb} = 150$ °C	$-I_{CES}$	–	< 10	µA
at $-V_{CE} = 32$ V, $-V_{BE} = 0.2$ V, $T_{amb} = 100$ °C	$-I_{CEV}$	< 20	–	µA
at $-V_{CE} = 45$ V, $-V_{BE} = 0.2$ V, $T_{amb} = 100$ °C	$-I_{CEV}$	–	< 20	µA
Emitter cutoff current at $-V_{EBO} = 4$ V	$-I_{EBO}$	< 20	< 20	nA
Collector emitter breakdown voltage				
at $-I_C = 10$ µA	$-V_{(BR)CEO}$	> 32	> 45	V
at $-I_C = 10$ µA	$-V_{(BR)CES}$	> 32	> 45	V
Emitter base breakdown voltage at $-I_E = 1$ µA	$-V_{(BR)EBO}$	> 5	> 5	V

Gain bandwidth product at $-V_{CE} = 5$ V, $-I_C = 10$ mA, $f = 100$ MHz	f_T	180	MHz
Collector base capacitance at $-V_{CB0} = 10$ V, $f = 1$ MHz	C_{CB0}	4.5 (< 7)	pF
Emitter base capacitance at $-V_{EB0} = 0.5$ V, $f = 1$ MHz	C_{EB0}	11 (< 15)	pF
Noise figure at $-V_{CE} = 5$ V, $-I_C = 0.2$ mA, $R_G = 2$ kΩ, $f = 1$ kHz, $\Delta f = 200$ Hz	F	2 (< 6)	dB
Thermal resistance			
Junction to ambient air	R_{thA}	< 450	°C/W
Junction to case	R_{thC}	< 150	°C/W

Switching Times

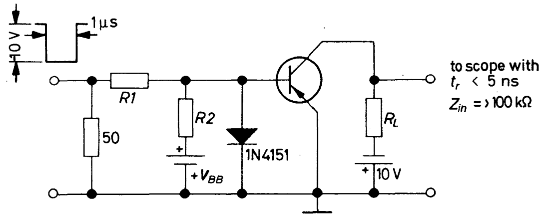
Test conditions:
$-I_C : -I_{B1} : I_{B2} \approx 10 : 1 : 1$ mA,
$R_1 = 5$ kΩ, $R_2 = 5$ kΩ, $R_L = 990$ Ω, $V_{BB} = 3.6$ V

Delay time	t_d	35	ns
Rise time	t_r	50	ns
Turn-on time	t_{on}	85 (< 150)	ns
Storage time	t_s	400	ns
Fall time	t_f	80	ns
Turn-off time	t_{off}	480 (< 800)	ns

Test conditions:
$-I_C : -I_{B1} : I_{B2} \approx 100 : 10 : 10$ mA,
$R_1 = 500$ Ω, $R_2 = 700$ Ω, $R_L = 98$ Ω, $V_{BB} = 5$ V

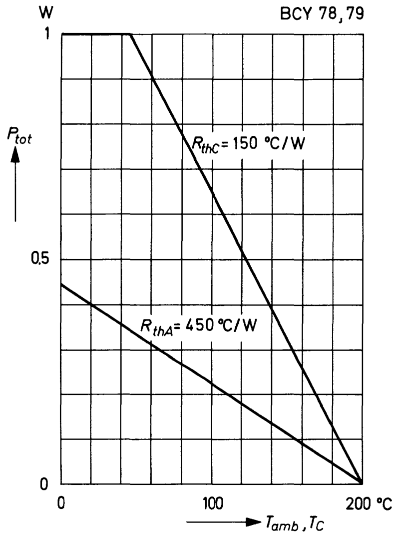
Delay time	t_d	5	ns
Rise time	t_r	50	ns
Turn-on time	t_{on}	55 (< 150)	ns
Storage time	t_s	250	ns
Fall time	t_f	200	ns
Turn-off time	t_{off}	450 (< 800)	ns

Test Circuit for Switching Times

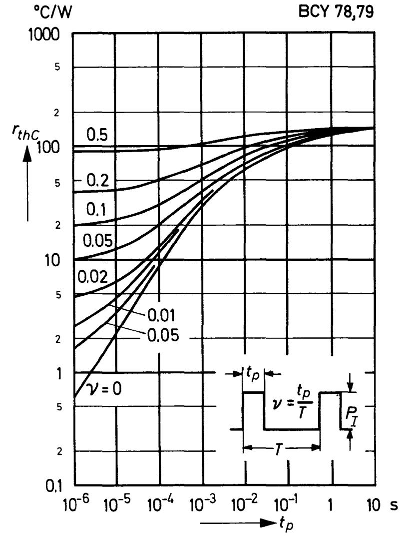


Rise time of input voltage 5 ns; pulse duty factor < 1 %,
generator impedance 50 Ω

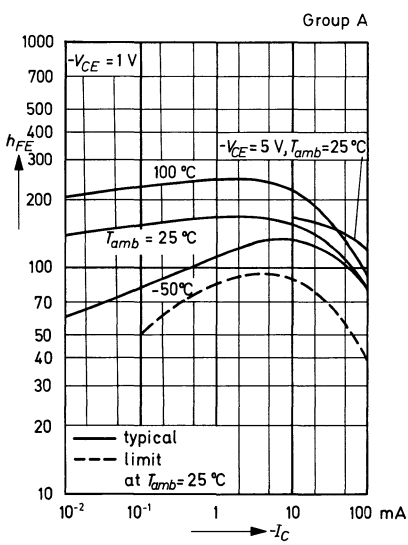
Admissible power dissipation versus temperature



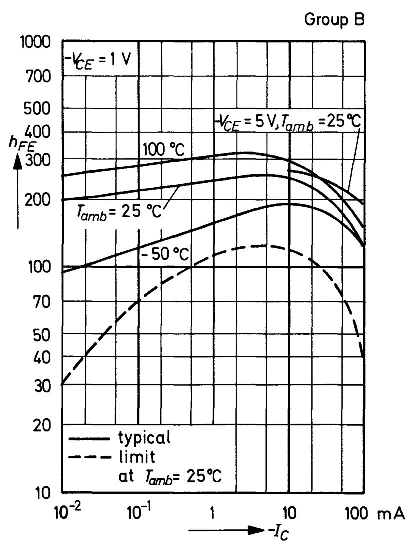
Pulse thermal resistance versus pulse duration



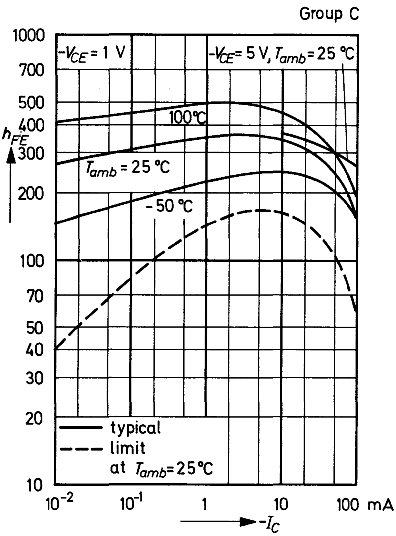
DC current gain versus collector current



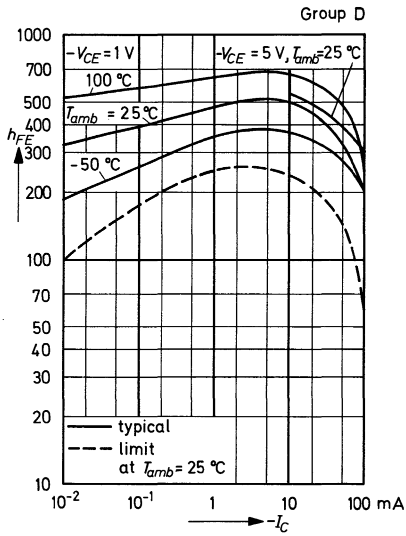
DC current gain versus collector current



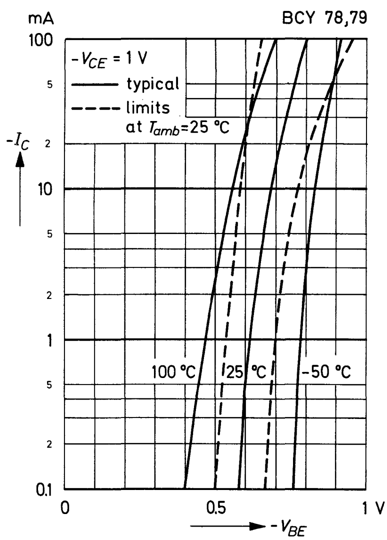
DC gurrent gain versus collector current



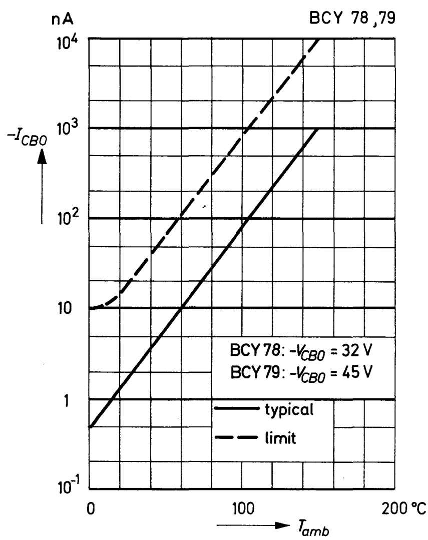
DC gurrent gain versus collector current



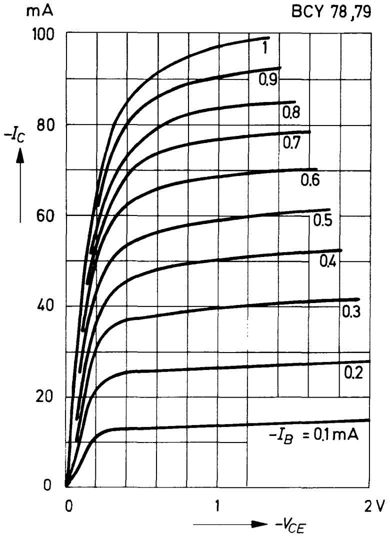
Collector current versus base emitter voltage



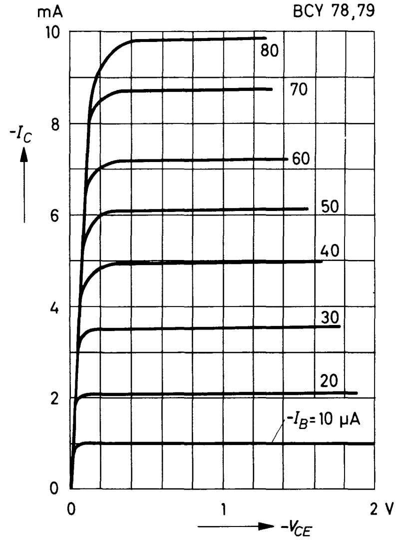
Collector cutoff current versus ambient temperature



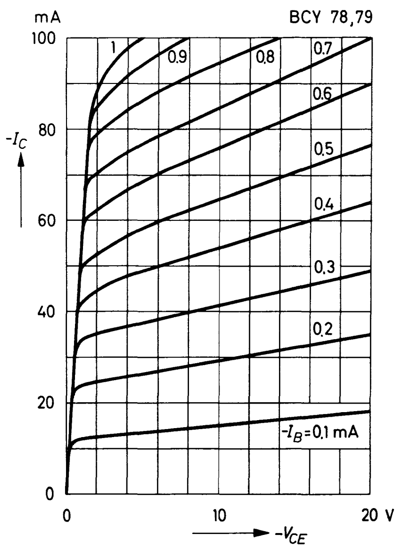
Common emitter collector characteristics



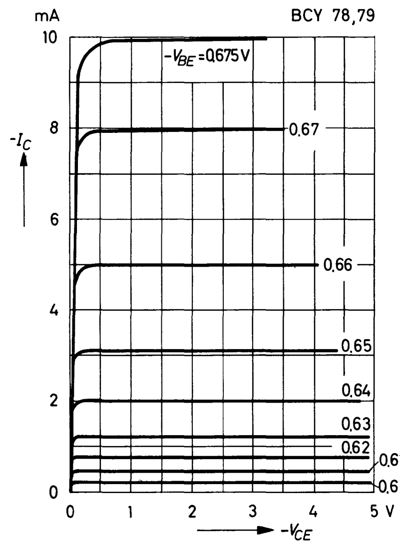
Common emitter collector characteristics



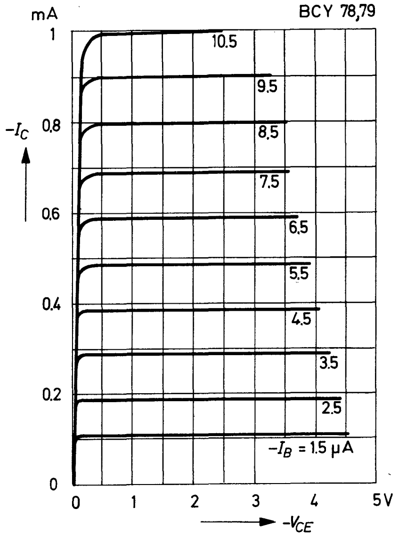
Common emitter collector characteristics



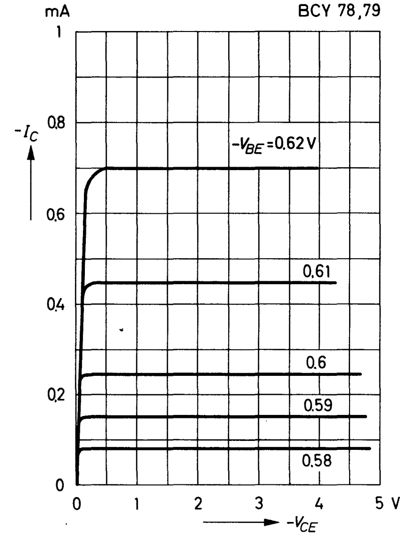
Common emitter collector characteristics



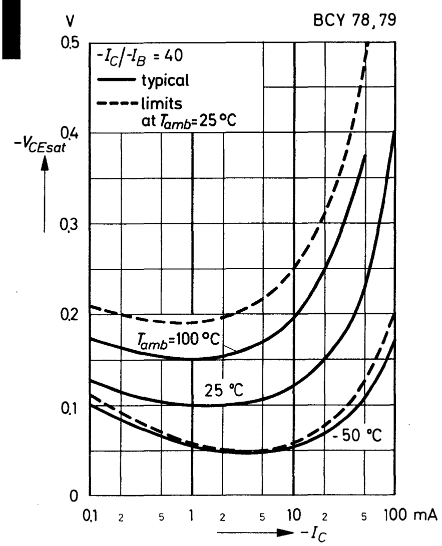
Common emitter collector characteristics



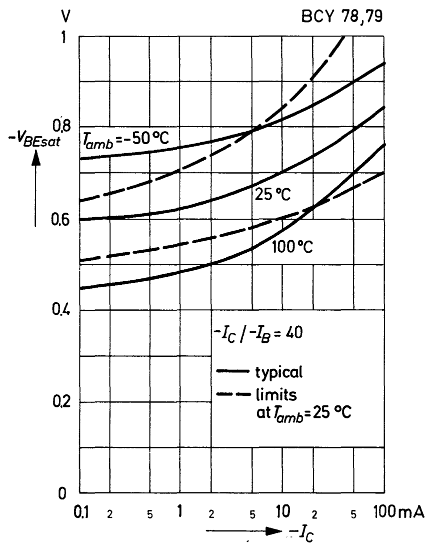
Common emitter collector characteristics



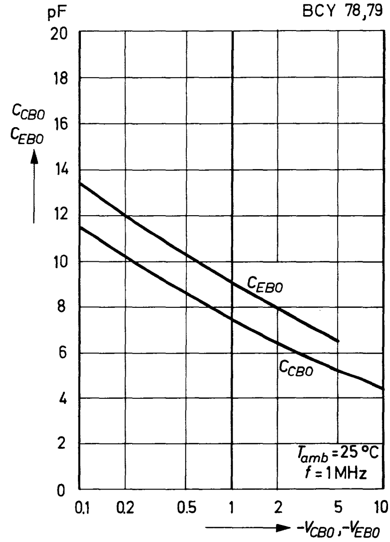
Collector saturation voltage versus collector current



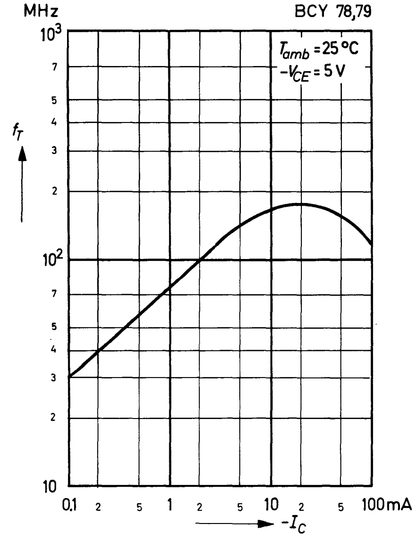
Base saturation voltage versus collector current



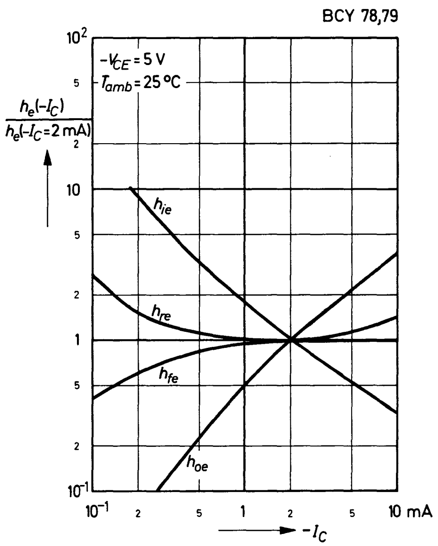
Collector base capacitance, Emitter base capacitance versus reverse bias voltage



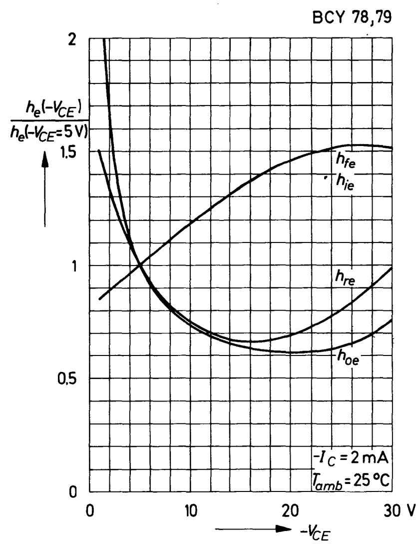
Gain bandwidth product versus collector current



Relative *h*-parameters versus collector current

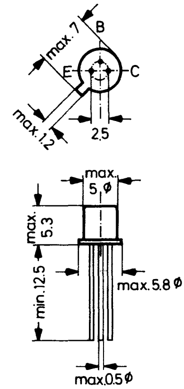


Relative *h*-parameters versus collector emitter voltage



BSW 72, BSW 73, BSW 74, BSW 75

PNP Silicon Epitaxial Planar Transistors
with high cutoff frequency, for high speed switching



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

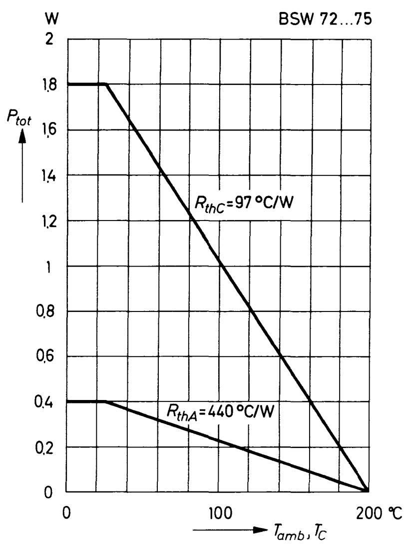
Maximum Ratings		**BSW 72** **BSW 73**	**BSW 74** **BSW 75**	
Collector base voltage	$-V_{CBO}$	40	75	V
Collector emitter voltage	$-V_{CEO}$	25	40	V
Emitter base voltage	$-V_{EBO}$	5		V
Collector peak current	$-I_{CM}$	500		mA
Power dissipation				
at $T_{amb} = 25$ °C	P_{tot}	400		mW
at $T_C = 25$ °C	P_{tot}	1.8		W
Junction temperature	T_j	200		°C
Storage temperature range	T_S	–50...+200		°C

Characteristics at $T_j = 25$ °C

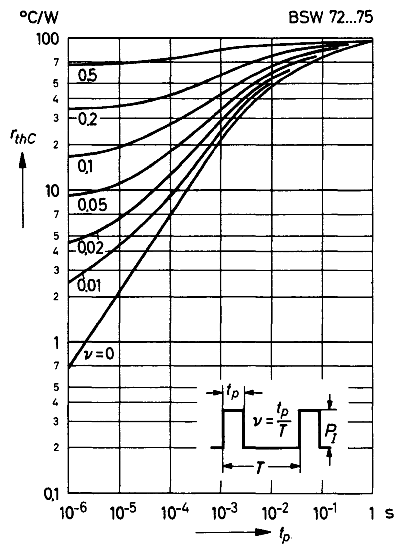
		BSW 72	**BSW 73**	**BSW 74**	**BSW 75**	
DC current gain						
at $-V_{CE} = 10$ V, $-I_C = 0.1$ mA	h_{FE}	–	–	> 20	> 35	
at $-V_{CE} = 10$ V, $-I_C = 10$ mA	h_{FE}	> 30	> 70	> 35	> 75	
at $-V_{CE} = 10$ V, $-I_C = 150$ mA	h_{FE}	40...120	100...300	40...120	100...300	
at $-V_{CE} = 10$ V, $-I_C = 500$ mA	h_{FE}	–	–	> 20	> 40	
Collector saturation voltage						
at $-I_C = 150$ mA, $-I_B = 15$ mA	$-V_{CE\,sat}$	< 0.6	< 0.6	< 0.4	< 0.4	V
at $-I_C = 500$ mA, $-I_B = 50$ mA	$-V_{CE\,sat}$	–	–	< 1.6	< 1.6	V
Base saturation voltage						
at $-I_C = 150$ mA, $-I_B = 15$ mA	$-V_{BE\,sat}$	< 1.3	< 1.3	< 1.3	< 1.3	V
at $-I_C = 500$ mA, $-I_B = 50$ mA	$-V_{BE\,sat}$	–	–	< 2.6	< 2.6	V
Collector cutoff current						
at $-V_{CB} = 30$ V	$-I_{CBO}$	< 100	< 100	–	–	nA
at $-V_{CB} = 50$ V	$-I_{CBO}$	–	–	< 10	< 10	nA
at $-V_{CB} = 30$ V, $T_j = 125$ °C	$-I_{CBO}$	< 100	< 100	–	–	µA
at $-V_{CB} = 50$ V, $T_j = 125$ °C	$-I_{CBO}$	–	–	< 10	< 10	µA

Emitter cutoff current at $-V_{EB} = 3$ V	$-I_{EBO}$	< 100	nA
Gain bandwidth product at $-V_{CE} = 20$ V, $-I_C = 50$ mA, $f = 100$ MHz	f_T	> 150	MHz
Collector base capacitance at $-V_{CBO} = 10$ V, $f = 100$ kHz	C_{CBO}	< 8	pF
Thermal resistance Junction to ambient air Junction to case	R_{thA} R_{thC}	< 440 < 97	°C/W °C/W

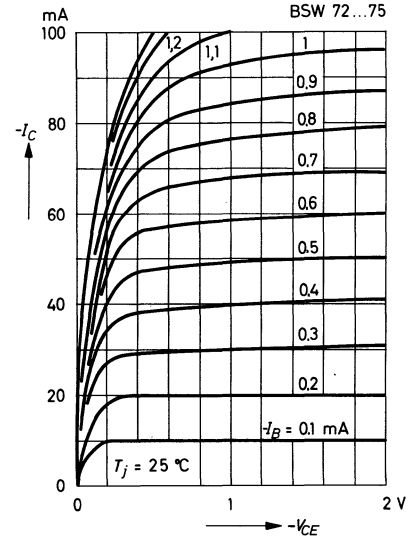
Admissible power dissipation versus temperature



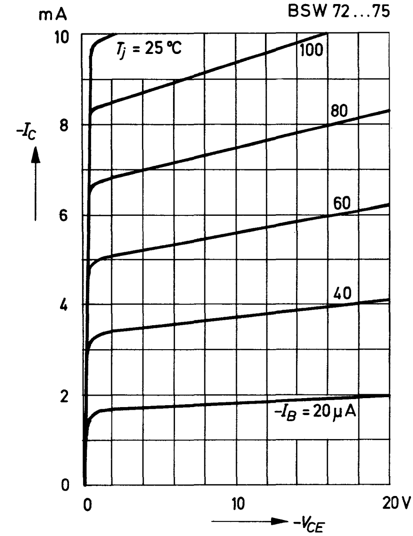
Pulse thermal resistance versus pulse duration



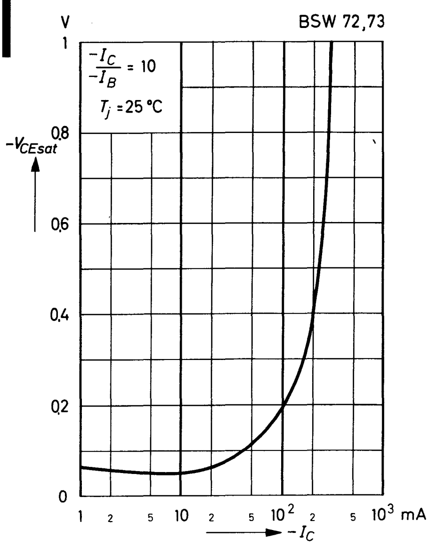
Common emitter
Collector characteristics



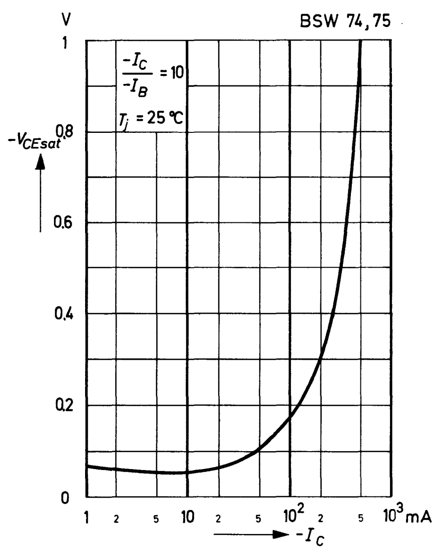
Common emitter
collector characteristics



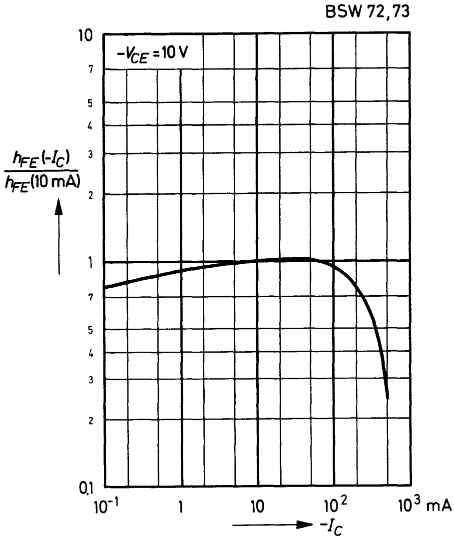
Collector saturation voltage
versus collector current



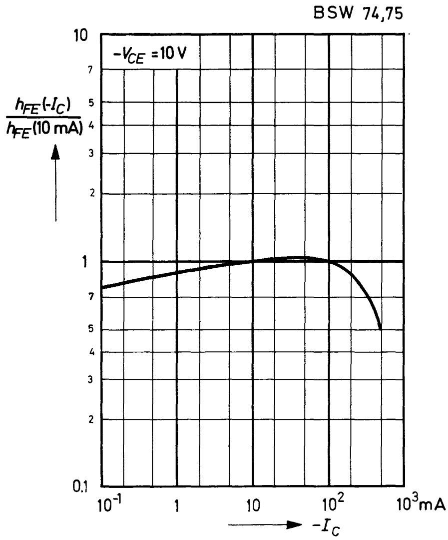
Collector saturation voltage
versus collector current



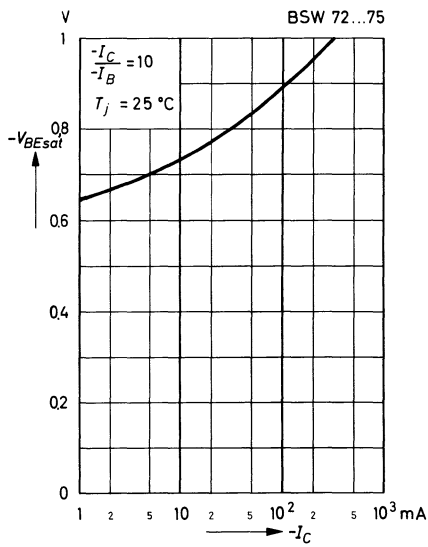
Relative DC current gain versus collector current



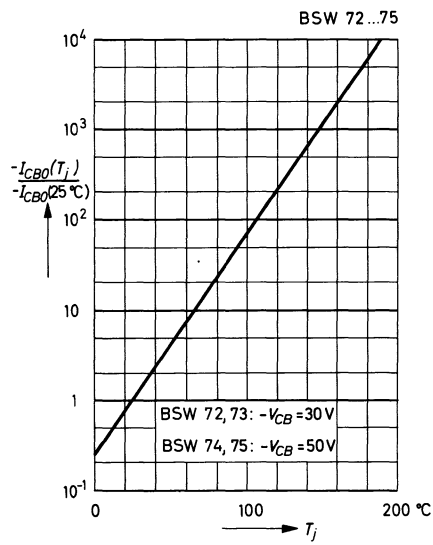
Relative DC current gain versus collector current



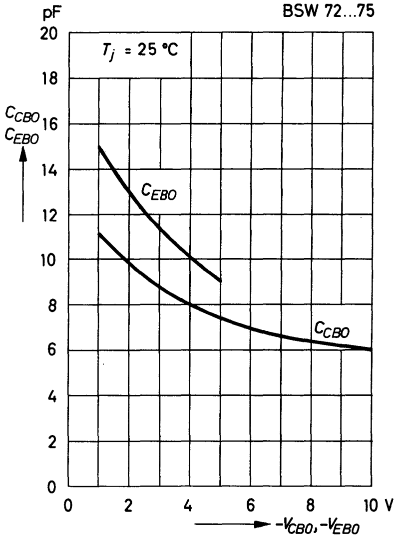
Base saturation voltage versus collector current



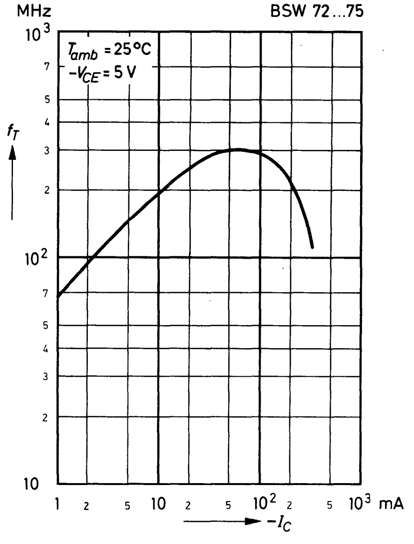
Collector cutoff current versus junction temperature



Collector base capacitance, Emitter base capacitance versus reverse bias voltage

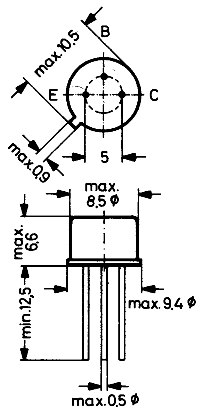


Gain bandwidth product versus collector current



2 N 2904, 2 N 2905

PNP Silicon Epitaxial Planar Transistors
with high cutoff frequency, for high speed switching



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	$-V_{CBO}$	60	V
Collector emitter voltage	$-V_{CEO}$	40	V
Emitter base voltage	$-V_{EBO}$	5	V
Collector current	$-I_C$	0.6	A
Power dissipation			
at $T_{amb} = 25\ °C$	P_{tot}	0.8	W
at $T_C = 25\ °C$	P_{tot}	3	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	−65...+200	°C

Characteristics at $T_j = 25\ °C$

		2 N 2904	2 N 2905	
DC current gain				
at $-V_{CE} = 10$ V, $-I_C = 0.1$ mA	h_{FE}	> 20	> 35	
at $-V_{CE} = 10$ V, $-I_C = 1$ mA	h_{FE}	> 25	> 50	
at $-V_{CE} = 10$ V, $-I_C = 10$ mA	h_{FE}	> 35	> 75	
at $-V_{CE} = 10$ V, $-I_C = 150$ mA	h_{FE}	40...120	100...300	
at $-V_{CE} = 10$ V, $-I_C = 0.5$ A	h_{FE}	> 20	> 30	
Collector saturation voltage				
at $-I_C = 150$ mA, $-I_B = 15$ mA	$-V_{CE\,sat}$	< 0.4		V
at $-I_C = 500$ mA, $-I_B = 50$ mA	$-V_{CE\,sat}$	< 1.6		V
Base saturation voltage				
at $-I_C = 150$ mA, $-I_B = 15$ mA	$-V_{BE\,sat}$	< 1.3		V
at $-I_C = 500$ mA, $-I_B = 50$ mA	$-V_{BE\,sat}$	< 2.6		V

Collector cutoff current			
at $-V_{CB} = 50$ V	$-I_{CBO}$	< 20	nA
at $-V_{CB} = 50$ V, $T_{amb} = 150$ °C	$-I_{CBO}$	< 20	µA
at $-V_{CE} = 30$ V, $-V_{EB} = 0.5$ V	$-I_{CEV}$	< 50	nA
Base cutoff current at $-V_{CE} = 30$ V, $-V_{EB} = 0.5$ V	$-I_{EBV}$	< 50	nA
Collector base breakdown voltage at $-I_C = 10$ µA	$-V_{(BR)CBO}$	> 60	V
Collector emitter breakdown voltage at $-I_C = 10$ mA	$-V_{(BR)CEO}$	> 40	V
Emitter base breakdown voltage at $-I_E = 10$ µA	$-V_{(BR)EBO}$	> 5	V
Gain bandwidth product at $-V_{CE} = 20$ V, $-I_C = 50$ mA, $f = 100$ MHz	f_T	> 200	MHz
Collector base capacitance at $-V_{CBO} = 10$ V, $f = 100$ kHz	C_{CBO}	< 8	pF
Emitter base capacitance at $-V_{EBO} = 2$ V, $f = 100$ kHz	C_{EBO}	< 30	pF
Thermal resistance			
Junction to ambient air	R_{thA}	< 220	°C/W
Junction to case	R_{thC}	< 58	°C/W
Delay time (see Fig. 1)	t_d	6 (< 10)	ns
Rise time (see Fig. 1)	t_r	20 (< 40)	ns
Turn-on time (see Fig. 1)	t_{on}	26 (< 45)	ns
Storage time (see Fig. 2)	t_s	50 (< 80)	ns
Fall time (see Fig. 2)	t_f	20 (< 30)	ns
Turn-off time (see Fig. 2)	t_{off}	70 (< 100)	ns
Total switching time (see Fig. 3)	t_{total}	12	ns

Curves and characteristics of types BSW 72 . . . 75 are valid analogously for types 2 N 2904 and 2 N 2905.

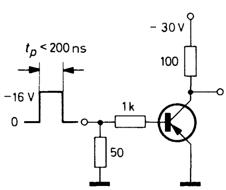


Fig. 1: Test circuit for turn-on time, saturated operation

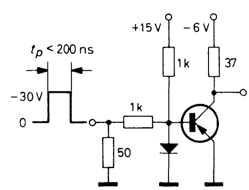


Fig. 2: Test circuit for turn-off time, saturated operation

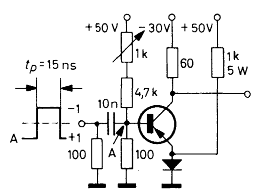
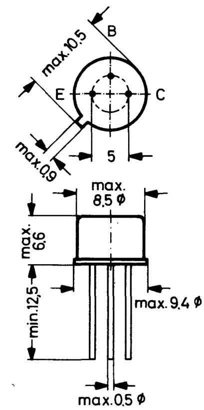


Fig. 3: Test circuit for non-saturated operation

2 N 2904 A, 2 N 2905 A

PNP Silicon Epitaxial Planar Transistors
with high cutoff frequency, for high speed switching



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1.1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	$-V_{CBO}$	60	V
Collector emitter voltage	$-V_{CEO}$	60	V
Emitter base voltage	$-V_{EBO}$	5	V
Collector current	$-I_C$	0.6	A
Power dissipation			
at $T_{amb} = 25$ °C	P_{tot}	0.8	W
at $T_C = 25$ °C	P_{tot}	3	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	−65...+200	°C

Characteristics at $T_j = 25$ °C

		2 N 2904 A	2 N 2905 A	
DC current gain				
at $-V_{CE} = 10$ V, $-I_C = 0.1$ mA	h_{FE}	> 40	> 75	
at $-V_{CE} = 10$ V, $-I_C = 1$ mA	h_{FE}	> 40	> 100	
at $-V_{CE} = 10$ V, $-I_C = 10$ mA	h_{FE}	> 40	> 100	
at $-V_{CE} = 10$ V, $-I_C = 150$ mA	h_{FE}	40...120	100...300	
at $-V_{CE} = 10$ V, $-I_C = 0.5$ A	h_{FE}	> 40	> 50	
Collector saturation voltage				
at $-I_C = 150$ mA, $-I_B = 15$ mA	$-V_{CE\,sat}$	< 0.4		V
at $-I_C = 500$ mA, $-I_B = 50$ mA	$-V_{CE\,sat}$	< 1.6		V
Base saturation voltage				
at $-I_C = 150$ mA, $-I_B = 15$ mA	$-V_{BE\,sat}$	< 1.3		V
at $-I_C = 500$ mA, $-I_B = 50$ mA	$-V_{BE\,sat}$	< 2.6		V

Collector cutoff current			
at $-V_{CB} = 50$ V	$-I_{CBO}$	< 10	nA
at $-V_{CB} = 50$ V, $T_{amb} = 150$ °C	$-I_{CBO}$	< 10	µA
at $-V_{CE} = 30$ V, $-V_{EB} = 0.5$ V	$-I_{CEV}$	< 50	nA
Base cutoff current at $-V_{CE} = 30$ V, $-V_{EB} = 0.5$ V	$-I_{EBV}$	< 50	nA
Collector base breakdown voltage at $-I_C = 10$ µA	$-V_{(BR)CBO}$	> 60	V
Collector emitter breakdown voltage at $-I_C = 10$ mA	$-V_{(BR)CEO}$	> 60	V
Emitter base breakdown voltage at $-I_E = 10$ µA	$-V_{(BR)EBO}$	> 5	V
Gain bandwidth product at $-V_{CE} = 20$ V, $-I_C = 50$ mA, $f = 100$ MHz	f_T	> 200	MHz
Collector base capacitance at $-V_{CBO} = 10$ V, $f = 100$ kHz	C_{CBO}	< 8	pF
Emitter base capacitance at $-V_{EBO} = 2$ V, $f = 100$ kHz	C_{EBO}	< 30	pF
Thermal resistance			
Junction to ambient air	R_{thA}	< 220	°C/W
Junction to case	R_{thC}	< 58	°C/W

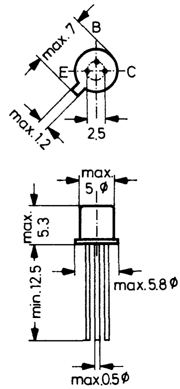
Curves and characteristics of types BSW 72 . . . 75 are valid analogously for types 2 N 2904 A and 2 N 2905 A.

Switching times

Specifications for switching times of types 2 N 2904 and 2 N 2905 resp. apply to these types.

2 N 2906, 2 N 2907

PNP Silicon Epitaxial Planar Transistors
with high cutoff frequency, for high speed switching



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings

Collector base voltage	$-V_{CBO}$	60	V
Collector emitter voltage	$-V_{CEO}$	40	V
Emitter base voltage	$-V_{EBO}$	5	V
Collector current	$-I_C$	0.6	A
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.4	W
at T_C = 25 °C	P_{tot}	1.8	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	−65...+200	°C

Characteristics at T_j = 25 °C

		2 N 2906	2 N 2907	
DC current gain				
at $-V_{CE}$ = 10 V, $-I_C$ = 0.1 mA	h_{FE}	> 20	> 35	
at $-V_{CE}$ = 10 V, $-I_C$ = 1 mA	h_{FE}	> 25	> 50	
at $-V_{CE}$ = 10 V, $-I_C$ = 10 mA	h_{FE}	> 35	> 75	
at $-V_{CE}$ = 10 V, $-I_C$ = 150 mA	h_{FE}	40...120	100...300	
at $-V_{CE}$ = 10 V, $-I_C$ = 0.5 A	h_{FE}	> 20	> 30	
Collector saturation voltage				
at $-I_C$ = 150 mA, $-I_B$ = 15 mA	$-V_{CE\,sat}$	< 0.4		V
at $-I_C$ = 500 mA, $-I_B$ = 50 mA	$-V_{CE\,sat}$	< 1.6		V
Base saturation voltage				
at $-I_C$ = 150 mA, $-I_B$ = 15 mA	$-V_{BE\,sat}$	< 1.3		V
at $-I_C$ = 500 mA, $-I_B$ = 50 mA	$-V_{BE\,sat}$	< 2.6		V

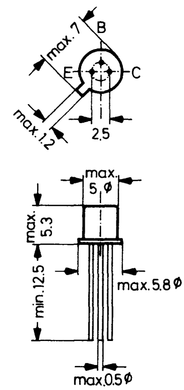
Collector cutoff curent			
at $-V_{CB} = 50$ V	$-I_{CBO}$	< 20	nA
at $-V_{CB} = 50$ V, $T_{amb} = 150$ °C	$-I_{CBO}$	< 20	µA
at $-V_{CE} = 30$ V, $-V_{EB} = 0.5$ V	$-I_{CEV}$	< 50	nA
Base cutoff current at $-V_{CE} = 30$ V, $-V_{EB} = 0.5$ V	$-I_{EBV}$	< 50	nA
Collector base breakdown voltage at $-I_C = 10$ µA	$-V_{(BR)CBO}$	> 60	V
Collector emitter breakdown voltage at $-I_C = 10$ mA	$-V_{(BR)CEO}$	> 40	V
Emitter base breakdown voltage at $-I_E = 10$ µA	$-V_{(BR)EBO}$	> 5	V
Gain bandwidth product at $-V_{CE} = 20$ V, $-I_C = 50$ mA, $f = 100$ MHz	f_T	> 200	MHz
Collector base capacitance at $-V_{CBO} = 10$ V, $f = 100$ kHz	C_{CBO}	< 8	pF
Emitter base capacitance at $-V_{EBO} = 2$ V, $f = 100$ kHz	C_{EBO}	< 30	pF
Thermal resistance			
Junction to ambient air	R_{thA}	< 440	°C/W
Junction to case	R_{thC}	< 97	°C/W

Curves and characteristics of types BSW 72 . . . 75 are valid analogously for types 2 N 2906 and 2 N 2907.

Switching Times
Specifications for switching times of types 2 N 2904 and 2 N 2905 resp. apply to these types.

2 N 2906 A, 2 N 2907 A

PNP Silicon Epitaxial Planar Transistors
with high cutoff frequency, for high speed switching



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings

Collector base voltage	$-V_{CBO}$	60	V
Collector emitter voltage	$-V_{CEO}$	60	V
Emitter base voltage	$-V_{EBO}$	5	V
Collector current	$-I_C$	0.6	A
Power dissipation			
at $T_{amb} = 25$ °C	P_{tot}	0.4	W
at $T_C = 25$ °C	P_{tot}	1.8	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	−65 . . . +200	°C

Characteristics at $T_j = 25$ °C

		2 N 2906 A	2 N 2907 A	
DC current gain				
at $-V_{CE} = 10$ V, $-I_C = 0.1$ mA	h_{FE}	> 40	> 75	
at $-V_{CE} = 10$ V, $-I_C = 1$ mA	h_{FE}	> 40	> 100	
at $-V_{CE} = 10$ V, $-I_C = 10$ mA	h_{FE}	> 40	> 100	
at $-V_{CE} = 10$ V, $-I_C = 150$ mA	h_{FE}	40 . . . 120	100 . . . 300	
at $-V_{CE} = 10$ V, $-I_C = 0.5$ A	h_{FE}	> 40	> 50	
Collector saturation voltage				
at $-I_C = 150$ mA, $-I_B = 15$ mA	$-V_{CE\,sat}$	< 0.4		V
at $-I_C = 500$ mA, $-I_B = 50$ mA	$-V_{CE\,sat}$	< 1.6		V
Base saturation voltage				
at $-I_C = 150$ mA, $-I_B = 15$ mA	$-V_{BE\,sat}$	< 1.3		V
at $-I_C = 500$ mA, $-I_B = 50$ mA	$-V_{BE\,sat}$	< 2.6		V

Collector cutoff curent			
at $-V_{CB} = 50$ V	$-I_{CBO}$	< 10	nA
at $-V_{CB} = 50$ V, $T_{amb} = 150$ °C	$-I_{CBO}$	< 10	µA
at $-V_{CE} = 30$ V, $-V_{EB} = 0.5$ V	$-I_{CEV}$	< 50	nA
Base cutoff current at $-V_{CE} = 30$ V, $-V_{EB} = 0.5$ V	$-I_{EBV}$	< 50	nA
Collector base breakdown voltage at $-I_C = 10$ µA	$-V_{(BR)CBO}$	> 60	V
Collector emitter breakdown voltage at $-I_C = 10$ mA	$-V_{(BR)CEO}$	> 60	V
Emitter base breakdown voltage at $-I_E = 10$ µA	$-V_{(BR)EBO}$	> 5	V
Gain bandwidth product at $-V_{CE} = 20$ V, $-I_C = 50$ mA, $f = 100$ MHz	f_T	> 200	MHz
Collector base capacitance at $-V_{CBO} = 10$ V, $f = 100$ kHz	C_{CBO}	< 8	pF
Emitter base capacitance at $-V_{EBO} = 2$ V, $f = 100$ kHz	C_{EBO}	< 30	pF
Thermal resistance			
Junction to ambient air	R_{thA}	< 440	°C/W
Junction to case	R_{thC}	< 97	°C/W

Curves and characteristics of types BSW 72 . . . 75 are valid analogously for types 2 N 2906 A and 2 N 2907 A.

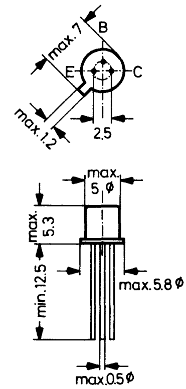
Switching Times

Specifications for switching times of types 2 N 2904 and 2 N 2905 resp. apply to these types.

2 N 3962, 2 N 3963, 2 N 3964

PNP Silicon Planar Transistors
designed for use in high-performance, low level, low noise amplifiers from audio to high frequency ranges. These units feature excellent DC current gain linearity from 1 μA to 50 mA.

Type 2 N 3964 offers extremely small low-frequency noise figures over a wide range of source impedances.



Metal case JEDEC TO-18
Collector connected to case
Weight approximately 0.35 g
Dimensions in mm

Maximum Ratings		**2 N 3962**	**2 N 3963**	**2 N 3964**	
Collector base voltage	$-V_{CBO}$	60	80	45	V
Collector emitter voltage	$-V_{CEO}$	60	80	45	V
Emitter base voltage	$-V_{EBO}$	6	6	6	V
Power dissipation at $T_{amb} = 25\ °C$	P_{tot}	0.36			W
at $T_C = 25\ °C$	P_{tot}	1.2			W
Junction temperature	T_j	200			°C
Storage temperature range	T_S	$-65 \dots +200$			°C

Static characteristics at $T_j = 25\ °C$		**2 N 3962** **2 N 3963**	**2 N 3964**	
DC current gain				
at $-V_{CE} = 5$ V, $-I_C = 1$ μA	h_{FE}	175 (> 60)	300 (> 180)	
at $-V_{CE} = 5$ V, $-I_C = 10$ μA	h_{FE}	210 (100 ... 300)	320 (250 ... 500)	
at $-V_{CE} = 5$ V, $-I_C = 100$ μA	h_{FE}	240 (> 100)	330 (> 250)	
at $-V_{CE} = 5$ V, $-I_C = 1$ mA	h_{FE}	260 (100 ... 450)	330 (250 ... 600)	
at $-V_{CE} = 5$ V, $-I_C = 10$ mA	h_{FE}	280 (> 100)	330 (> 200)	
at $-V_{CE} = 5$ V, $-I_C = 50$ mA	h_{FE}	260 (> 90)	315 (> 180)	
at $-V_{CE} = 5$ V, $-I_C = 10$ μA, $T_j = -55\ °C$	h_{FE}	90 (> 40)	160 (> 100)	
at $-V_{CE} = 5$ V, $-I_C = 50$ mA, $T_j = -55\ °C$	h_{FE}	150 (> 45)	190 (> 90)	
at $-V_{CE} = 5$ V, $-I_C = 1$ mA, $T_j = 100\ °C$	h_{FE}	375 (< 600)	400 (< 800)	
Collector saturation voltage				
at $-I_C = 10$ mA, $-I_B = 0.5$ mA	$-V_{CE\,sat}$	0.1 (< 0.25)		V
at $-I_C = 50$ mA, $-I_B = 5$ mA	$-V_{CE\,sat}$	0.16 (< 0.4)		V
Base saturation voltage				
at $-I_C = 10$ mA, $-I_B = 0.5$ mA	$-V_{BE\,sat}$	0.72 (< 0.9)		V
at $-I_C = 50$ mA, $-I_B = 5$ mA	$-V_{BE\,sat}$	0.81 (< 0.95)		V

		2 N 3962	2 N 3963	2 N 3964	
Collector cutoff current					
at $-V_{CE} = 40$ V	$-I_{CES}$	–	–	0.5 (< 10)	nA
at $-V_{CE} = 50$ V	$-I_{CES}$	0.5 (< 10)	–	–	nA
at $-V_{CE} = 70$ V	$-I_{CES}$	–	0.5 (< 10)	–	nA
at $-V_{CE} = 40$ V, $T_j = 150$ °C	$-I_{CES}$	–	–	2 (< 10)	µA
at $-V_{CE} = 50$ V, $T_j = 150$ °C	$-I_{CES}$	2 (< 10)	–	–	µA
at $-V_{CE} = 70$ V, $T_j = 150$ °C	$-I_{CES}$	–	2 (< 10)	–	µA
Emitter cutoff current at $-V_{EB} = 4$ V	$-I_{EBO}$	< 10	< 10	< 10	nA
Collector base breakdown voltage at $-I_C = 10$ µA	$-V_{(BR)CBO}$	> 60	> 80	> 45	V
Collector emitter breakdown voltage					
at $-I_C = 10$ µA	$-V_{(BR)CES}$	> 60	> 80	> 45	V
at $-I_C = 5$ mA	$-V_{(BR)CEO}$	> 60	> 80	> 45	V
Emitter base breakdown voltage at $-I_E = 10$ µA	$-V_{(BR)EBO}$	> 6	> 6	> 6	V

Thermal resistance			
Junction to ambient air	R_{thA}	< 480	°C/W
Junction to case	R_{thC}	< 150	°C/W

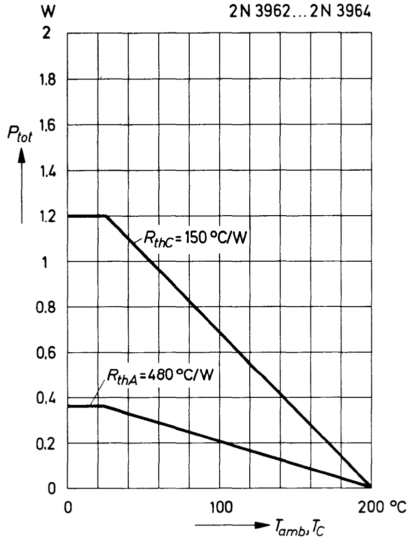
Dynamic characteristics at $T_{amb} = 25$ °C

Collector base capacitance at $-V_{CBO} = 5$ V	C_{CBO}	< 6	pF
Emitter base capacitance at $-V_{EBO} = 0.5$ V	C_{EBO}	< 15	pF
Gain bandwidth product at $-V_{CE} = 5$ V, $-I_C = 0.5$ mA, $f = 20$ MHz			
2 N 3962 and 2 N 3963	f_T	> 40	MHz
2 N 3964	f_T	> 50	MHz

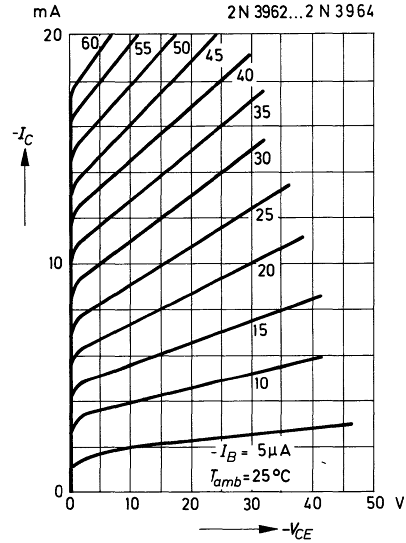
h-parameters at $-V_{CE} = 5$ V, $-I_C = 1$ mA, $f = 1$ kHz		**2 N 3962 2 N 3963**	**2 N 3964**	
Small signal current gain	h_{fe}	300 (100 ... 550)	360 (250 ... 700)	
Input impedance	h_{ie}	8 (2.5 ... 17)	10 (6 ... 20)	kΩ
Output admittance	h_{oe}	19 (5 ... 40)	25 (5 ... 50)	µmho
Reverse voltage transfer ratio	h_{re}	$< 10 \cdot 10^{-4}$	$< 10 \cdot 10^{-4}$	

		2 N 3962 2 N 3963	2 N 3964	
Noise figure				
at $-V_{CE} = 5$ V, $-I_C = 20$ μA, $R_G = 10$ kΩ				
at $\Delta f = 30$ Hz . . . 15 kHz	F	1 (< 3)	0.7 (< 2)	dB
at $f = 10$ Hz	F	–	3.5 (< 8)	dB
at $f = 120$ Hz	F	3 (< 10)	1.8 (< 4)	dB
at $f = 1$ kHz	F	0.8 (< 3)	0.5 (< 2)	dB
at $f = 10$ kHz	F	0.8 (< 3)	0.5 (< 2)	dB

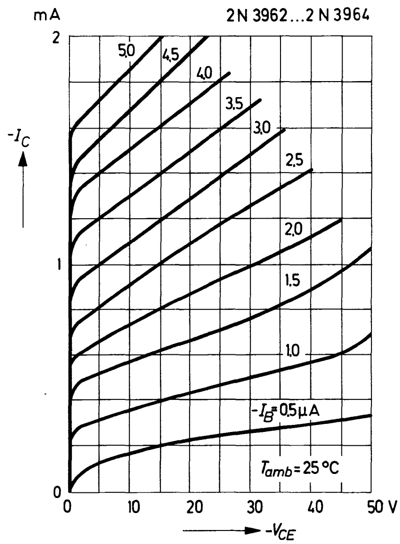
Admissible power dissipation versus temperature



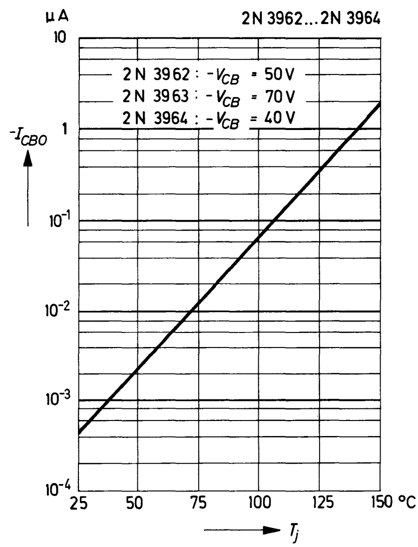
Common emitter collector characteristics



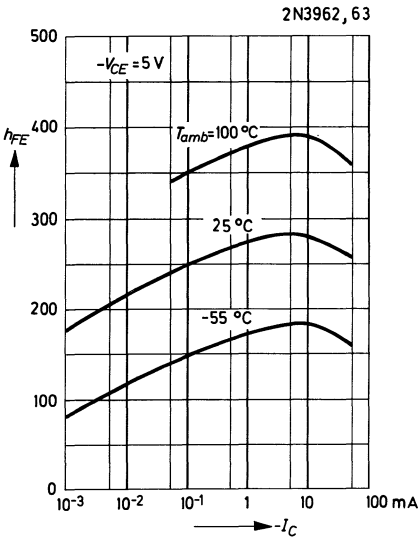
Common emitter collector characteristics



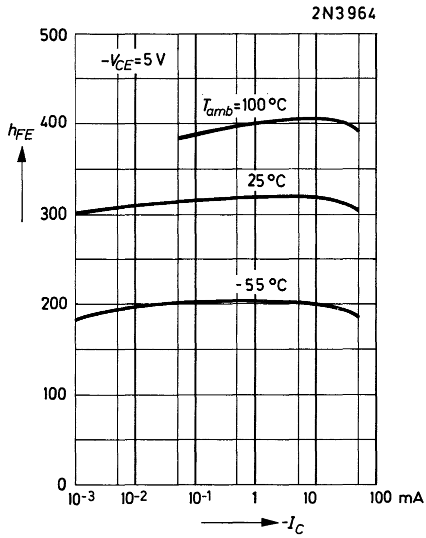
Collector cutoff current versus junction temperature



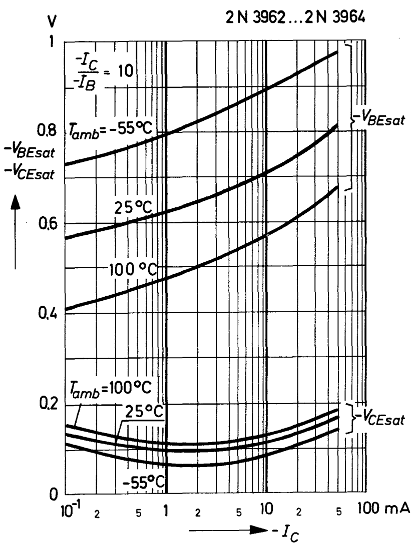
DC current gain versus collector current



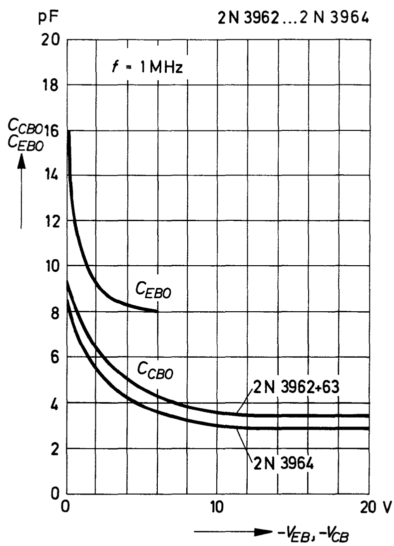
DC current gain versus collector current



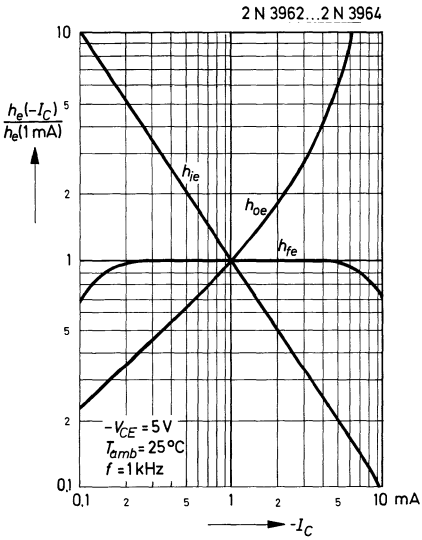
Collector saturation voltage Base saturation voltage versus collector current



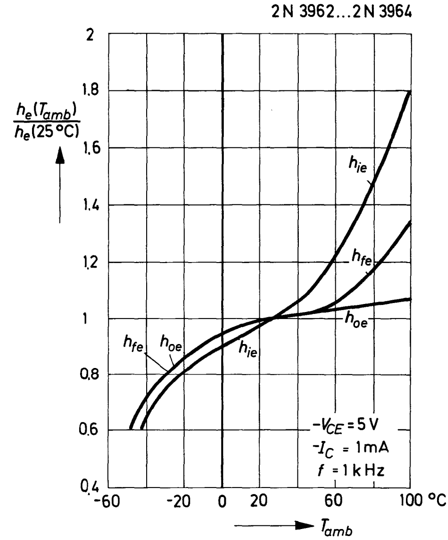
Collector base capacitance, Emitter base capacitance versus reverse bias voltage



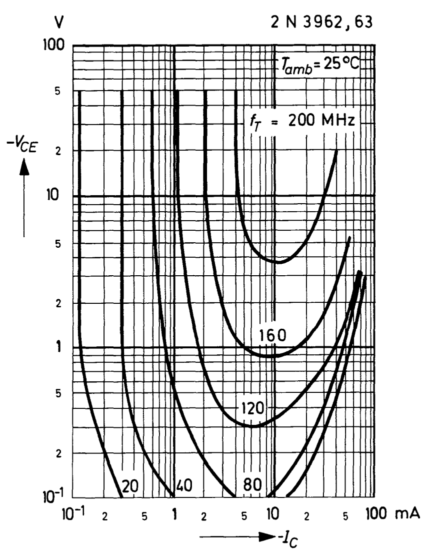
Relative *h*-parameters versus collector current



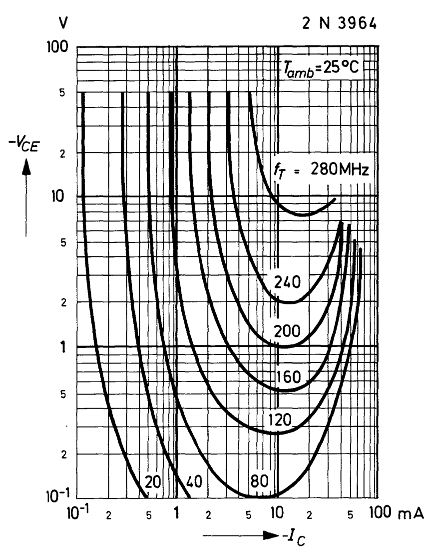
Relative *h*-parameters versus ambient temperature



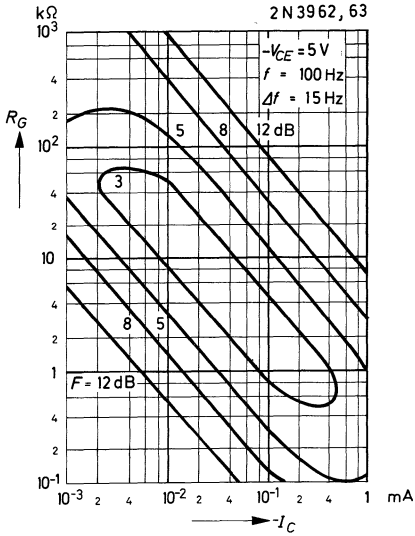
Contours of constant gain bandwidth product



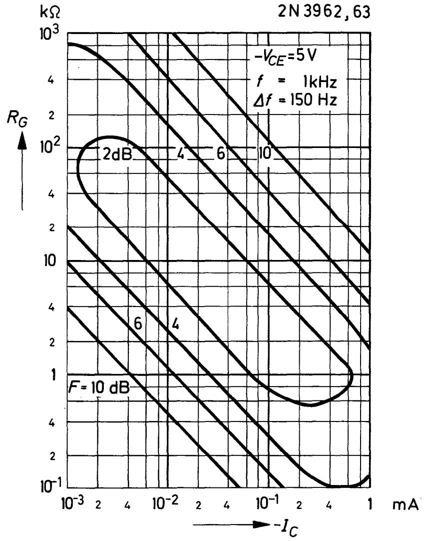
Contours of constant gain bandwidth product



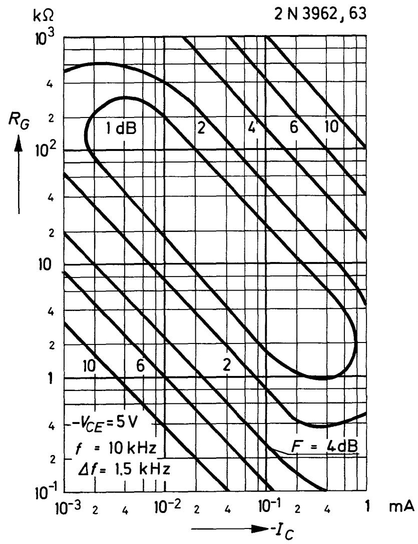
Contours of constant narrow band noise figure



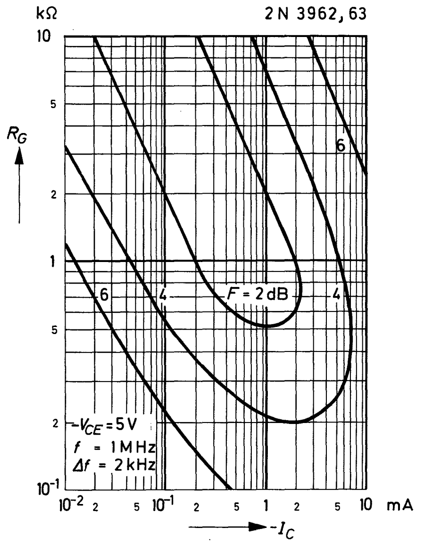
Contours of constant narrow band noise figure



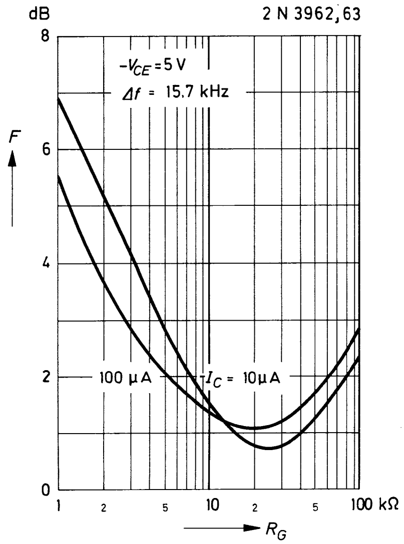
Contours of constant narrow band noise figure



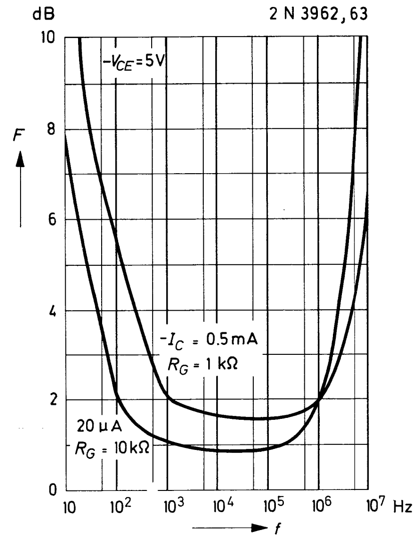
Contours of constant narrow band noise figure



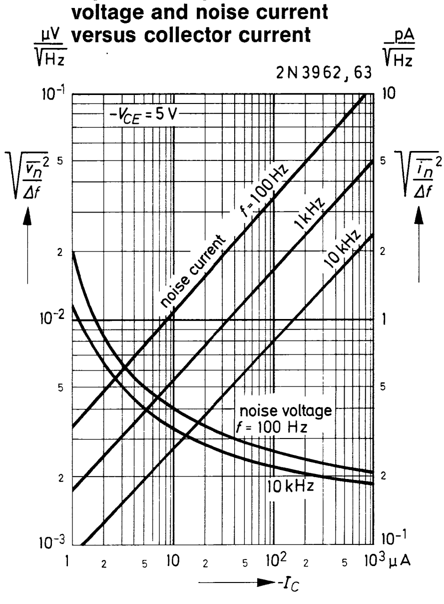
Wide band noise figure versus generator resistance



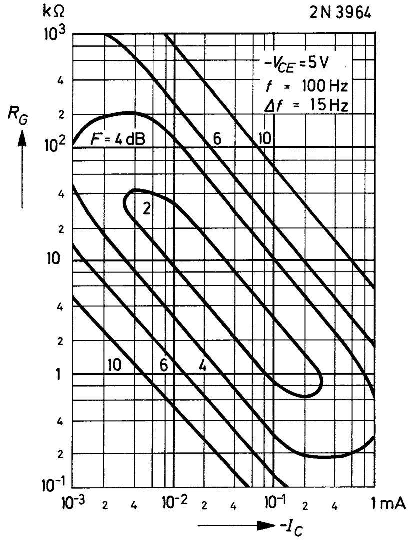
Noise figure versus frequency



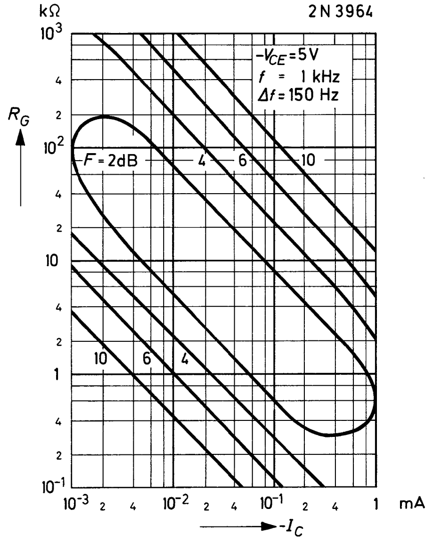
Equivalent input noise voltage and noise current versus collector current



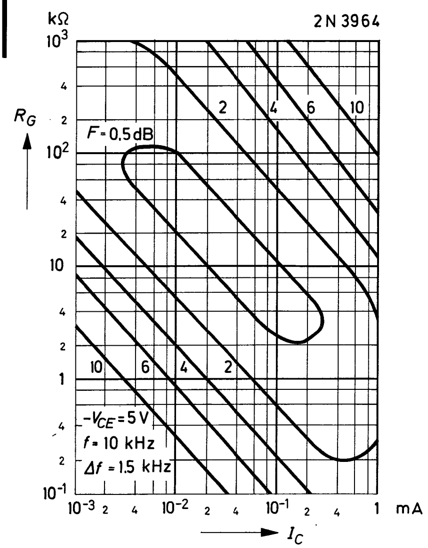
Contours of constant narrow band noise figure



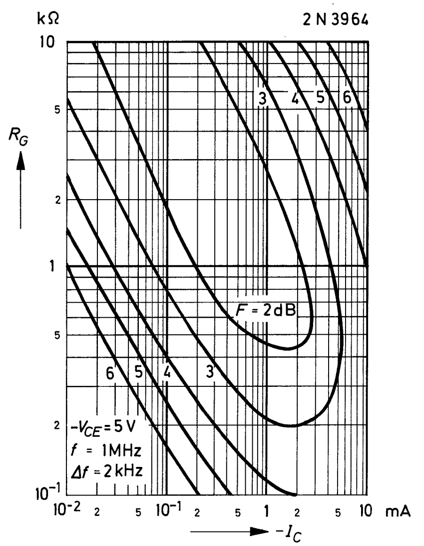
Contours of constant narrow band noise figure



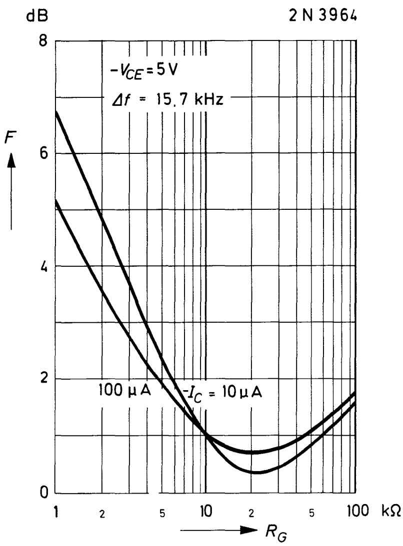
Contours of constant narrow band noise figure



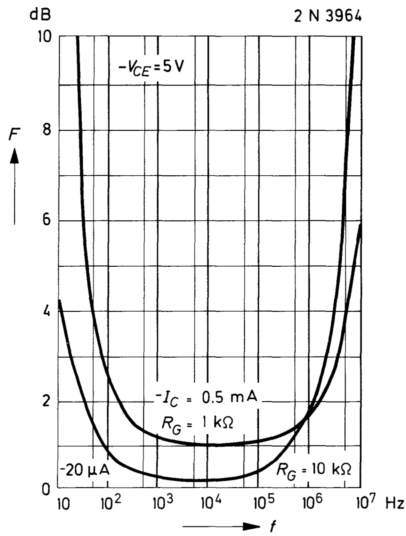
Contours of constant narrow band noise figure



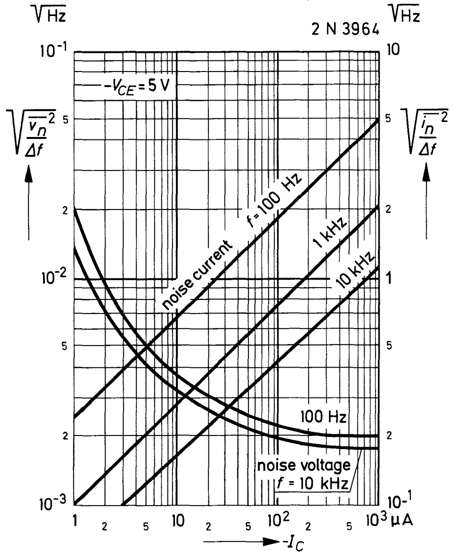
Wide band noise figure versus generator resistance



Noise figure versus frequency

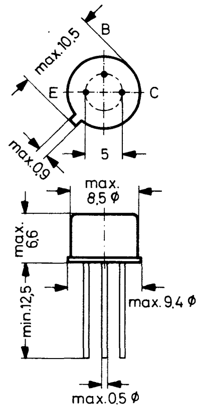


Equivalent input noise voltage and noise current versus collector current



2 N 4030, 2 N 4032

PNP Silicon Epitaxial Planar Transistors
for switching and amplifier applications from DC to RF



Metal case JEDEC TO--39
Collector connected to case
Weight approximately 1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	$-V_{CBO}$	60	V
Collector emitter voltage	$-V_{CEO}$	60	V
Emitter base voltage	$-V_{EBO}$	5	V
Collector current	$-I_C$	1	A
Power dissipation			
at T_{amb} = 25 °C	P_{tot}	0.8	W
at T_C = 25 °C	P_{tot}	4	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	–65...+200	°C

Characteristics at T_j = 25 °C

		2 N 4030	**2 N 4032**
DC current gain			
at $-V_{CE}$ = 5 V, $-I_C$ = 100 μA	h_{FE}	80 (> 30)	150 (> 75)
at $-V_{CE}$ = 5 V, $-I_C$ = 100 mA	h_{FE}	40...120	100...300
at $-V_{CE}$ = 5 V, $-I_C$ = 0.5 A	h_{FE}	60 (> 25)	110 (> 70)
at $-V_{CE}$ = 5 V, $-I_C$ = 1 mA	h_{FE}	> 15	> 40
at $-V_{CE}$ = 5 V, $-I_C$ = 100 mA, T_j = –55 °C	h_{FE}	50 (> 15)	100 (> 40)

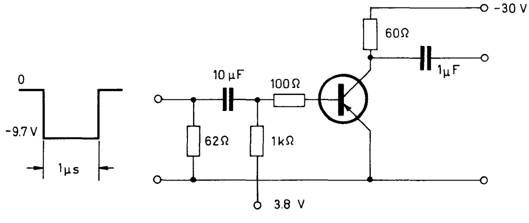
Collector saturation voltage			
at $-I_C$ = 150 mA, $-I_B$ = 15 mA	$-V_{CE\,sat}$	0.1 (< 0.15)	V
at $-I_C$ = 500 mA, $-I_B$ = 50 mA	$-V_{CE\,sat}$	0.25 (< 0.5)	V
at $-I_C$ = 1 A, $-I_B$ = 100 mA	$-V_{CE\,sat}$	0.5 (< 1)	V
Base saturation voltage			
at $-I_C$ = 150 mA, $-I_B$ = 15 mA	$-V_{BE\,sat}$	0.8 (< 0.9)	V
at $-I_C$ = 500 mA, $-I_B$ = 50 mA	$-V_{BE\,sat}$	0.95 (< 1.1)	V
at $-I_C$ = 1 A, $-I_B$ = 100 mA	$-V_{BE\,sat}$	1.05 (< 1.2)	V

Collector cutoff current at $-V_{CB} = 50$ V	$-I_{CBO}$	0.2 (< 50)	nA
at $-V_{CB} = 50$ V, $T_j = 150$ °C	$-I_{CBO}$	0.2 (< 50)	μA
Emitter cutoff current at $-V_{EB} = 5$ V	$-I_{EBO}$	< 10	μA
Collector base breakdown voltage at $-I_C = 10$ μA	$-V_{(BR)CBO}$	> 60	V
Collector emitter breakdown voltage at $-I_C = 10$ mA	$-V_{(BR)CEO}$	> 60	V
Emitter base breakdown voltage at $-I_E = 10$ μA	$-V_{(BR)EBO}$	> 5	V
Gain bandwidth product at $-V_{CE} = 10$ V, $-I_C = 50$ mA, $f = 100$ MHz	f_T	150 (> 100)	MHz
Collector base capacitance at $-V_{CBO} = 10$ V	C_{CBO}	15 (< 20)	pF
Emitter base capacitance at $-V_{EBO} = 0.5$ V	C_{EBO}	75 (< 110)	pF
Thermal resistance Junction to ambient air	R_{thA}	< 220	°C/W
Junction to case	R_{thC}	< 44	°C/W

Curves and characteristics of types BC 160 and BC 161 are valid analogously for types 2 N 4030 and 2 N 4032.

Switching Times

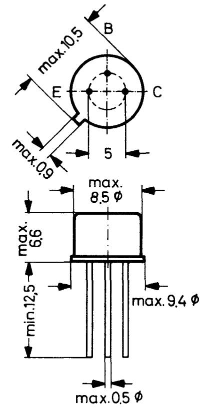
Turn-on time at $-I_C \doteq 500$ mA, $-I_{B1} = 50$ mA	t_{on}	27 (< 100)	ns
Storage time at $-I_C = 500$ mA, $-I_{B1} = 50$ mA, $I_{B2} = 50$ mA	t_s	160 (< 350)	ns
Fall time at $-I_C = 500$ mA, $-I_{B1} = 50$ mA, $I_{B2} = 50$ mA	t_f	23 (< 50)	ns



Test Circuit for Switching Times

2 N 4031, 2 N 4033

PNP Silicon Epitaxial Planar Transistors
for switching and amplifier applications from DC to RF



Metal case JEDEC TO-39
Collector connected to case
Weight approximately 1 g
Dimensions in mm

Maximum Ratings

Collector base voltage	$-V_{CBO}$	80	V
Collector emitter voltage	$-V_{CEO}$	80	V
Emitter base voltage	$-V_{EBO}$	5	V
Collector current	$-I_C$	1	A
Power dissipation			
at $T_{amb} = 25$ °C	P_{tot}	0.8	W
at $T_C = 25$ °C	P_{tot}	4	W
Junction temperature	T_j	200	°C
Storage temperature range	T_S	$-65 \ldots +200$	°C

Characteristics at $T_j = 25$ °C

		2 N 4031	2 N 4033
DC current gain			
at $-V_{CE} = 5$ V, $-I_C = 100$ µA	h_{FE}	80 (> 30)	150 (> 75)
at $-V_{CE} = 5$ V, $-I_C = 100$ mA	h_{FE}	40…120	100…300
at $-V_{CE} = 5$ V, $-I_C = 0.5$ A	h_{FE}	60 (> 25)	110 (> 70)
at $-V_{CE} = 5$ V, $-I_C = 1$ A	h_{FE}	> 15	> 40
at $-V_{CE} = 5$ V, $-I_C = 100$ mA, $T_j = -55$ °C	h_{FE}	50 (> 15)	100 (> 40)

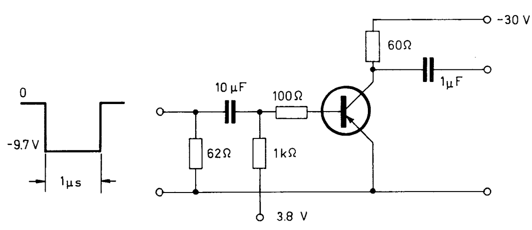
Collector saturation voltage			
at $-I_C = 150$ mA, $-I_B = 15$ mA	$-V_{CE\,sat}$	0.1 (< 0.15)	V
at $-I_C = 500$ mA, $-I_B = 50$ mA	$-V_{CE\,sat}$	0.25 (< 0.5)	V
Base saturation voltage			
at $-I_C = 150$ mA, $-I_B = 15$ mA	$-V_{BE\,sat}$	0.8 (< 0.9)	V
at $-I_C = 500$ mA, $-I_B = 50$ mA	$-V_{BE\,sat}$	0.95 (< 1.1)	V

Collector cutoff current at $-V_{CB} = 50$ V at $-V_{CB} = 50$ V, $T_j = 150$ °C	 $-I_{CBO}$ $-I_{CBO}$	 0.2 (< 50) 0.2 (< 50)	 nA μA
Emitter cutoff current at $-V_{EB} = 5$ V	$-I_{EBO}$	< 10	μA
Collector base breakdown voltage at $-I_C = 10$ μA	$-V_{(BR)CBO}$	> 80	V
Collector emitter breakdown voltage at $-I_C = 10$ mA	$-V_{(BR)CEO}$	> 80	V
Emitter base breakdown voltage at $-I_E = 10$ μA	$-V_{(BR)EBO}$	> 5	V
Gain bandwidth product at $-V_{CE} = 10$ V, $-I_C = 50$ mA, $f = 100$ MHz	f_T	150 (> 100)	MHz
Collector base capacitance at $-V_{CBO} = 10$ V	C_{CBO}	15 (< 20)	pF
Emitter base capacitance at $-V_{EBO} = 0.5$ V	C_{EBO}	75 (< 110)	pF
Thermal resistance Junction to ambient air Junction to case	 R_{thA} R_{thC}	 < 220 < 44	 °C/W °C/W

Curves and characteristics of types BC 160 and BC 161 are valid analogously for types 2 N 4031 and 2 N 4033.

Switching Times

Turn-on time at $-I_C = 500$ mA, $-I_{B1} = 50$ mA	t_{on}	27 (< 100)	ns
Storage time at $-I_C = 500$ mA, $-I_{B1} = 50$ mA, $I_{B2} = 50$ mA	t_s	160 (< 350)	ns
Fall time at $-I_C = 500$ mA, $-I_{B1} = 50$ mA, $I_{B2} = 50$ mA	t_f	23 (< 50)	ns

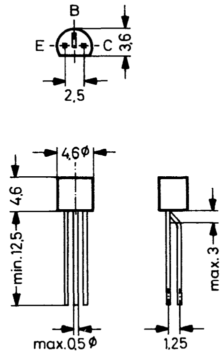


Test Circuit for Switching Times

PNP Silicon High Frequency Transistors

BF 324

PNP Silicon Epitaxial Planar Transistor
with extremely small feedback capacitance, designed for base-grounded FM RF amplifiers in the range of 100 MHz



Green plastic case ≈ TO-92
TO-18 compatible.
The case is impervious to light.
Weight approximately 0.18 g
Dimensions in mm

Maximum Ratings

Collector base voltage	$-V_{CBO}$	30	V
Collector emitter voltage	$-V_{CEO}$	30	V
Emitter base voltage	$-V_{EBO}$	4	V
Collector current	$-I_C$	25	mA
Base current	$-I_B$	5	mA
Power dissipation at $T_{amb} = 45\ °C$	P_{tot}	250 [1]	mW
Junction temperature	T_j	150	°C
Storage temperature range	T_S	−55...+150	°C

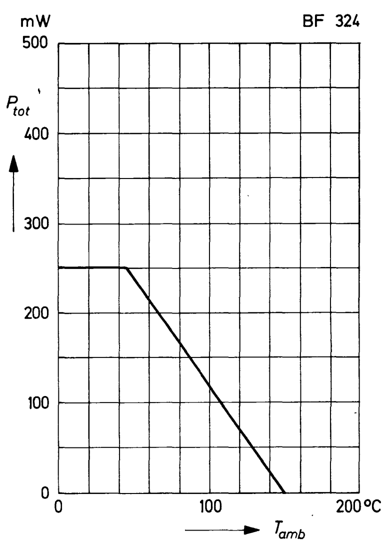
Characteristics at $T_{amb} = 25\ °C$

DC current gain at $-V_{CE} = 10$ V, $-I_C = 1$ mA	h_{FE}	45	
at $-V_{CE} = 10$ V, $-I_C = 4$ mA	h_{FE}	50 (25 . . . 160)	
Base emitter voltage at $-V_{CE} = 10$ V, $-I_C = 4$ mA	$-V_{BE}$	0.76	V
Collector emitter breakdown voltage at $-I_C = 10$ mA	$-V_{(BR)CEO}$	> 30	V
Emitter base breakdowm voltage at $-I_E = 10\ \mu A$	$-V_{(BR)EBO}$	> 4	V
Collector cutoff current at $-V_{CB} = 30$ V	$-I_{CBO}$	< 50	nA
Thermal resistance Junction to ambient air	R_{thA}	< 420 [1]	°C/W

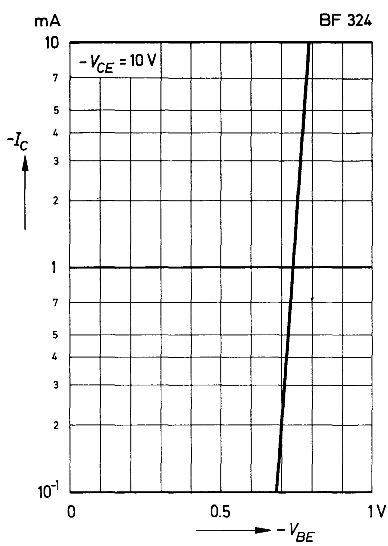
[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

Gain bandwidth product at $f = 100$ MHz			
at $-V_{CE} = 10$ V, $-I_C = 1$ mA	f_T	350	MHz
at $-V_{CE} = 10$ V, $-I_C = 4$ mA	f_T	450	MHz
at $-V_{CE} = 10$ V, $-I_C = 8$ mA	f_T	440	MHz
Feedback capacitance at $-V_{CB} = 10$ V, $V_{BE} = 0$, $f = 1$ MHz	C_{rb}	0.1	pF
Noise figure at $-V_{CE} = 10$ V, $-I_C = 2$ mA, $f = 100$ MHz, $R_G = 60\ \Omega$	F	3	dB

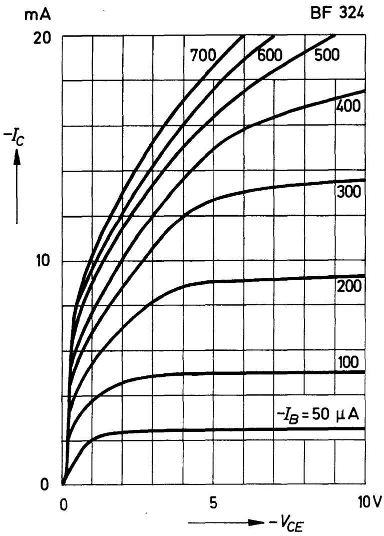
Admissible power dissipation versus ambient temperature
(see note on page 374)



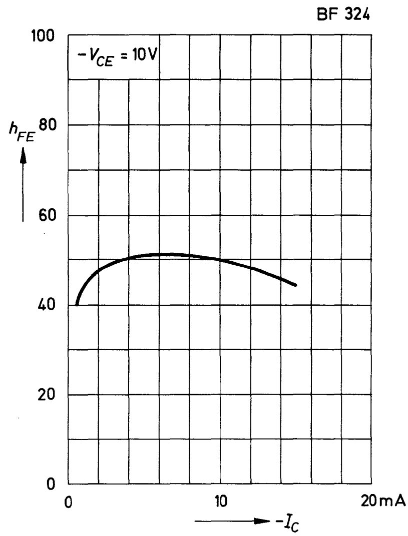
Collector current versus base emitter voltage



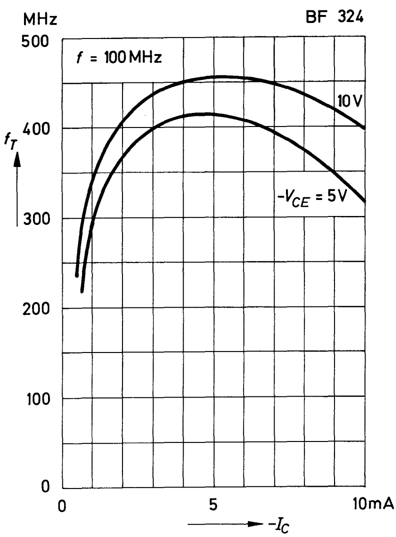
Common emitter collector characteristics



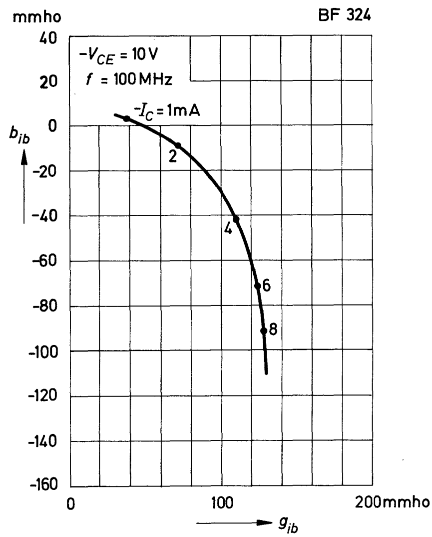
DC current gain versus collector current



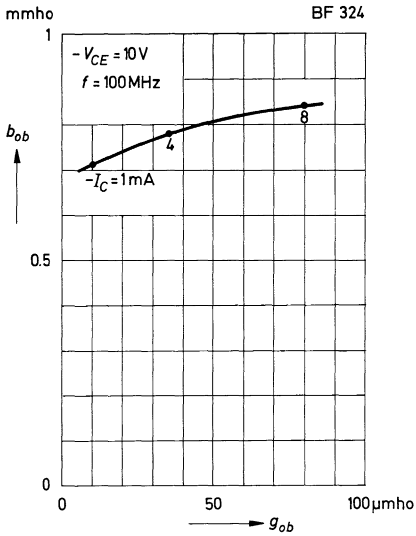
Gain bandwidth product versus collector current



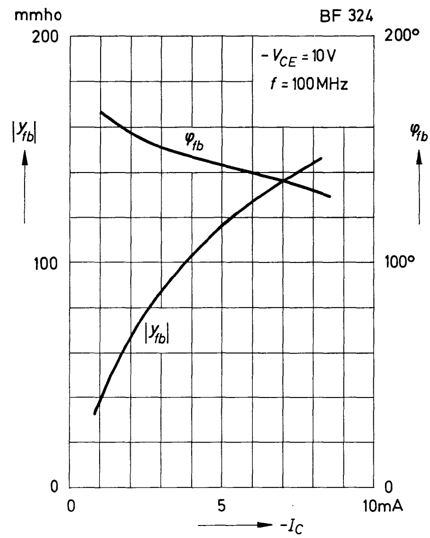
Input admittance characteristic



Output admittance characteristic



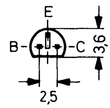
Forward transconductance versus collector current

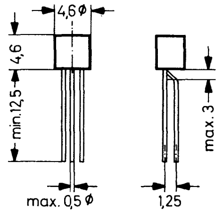


BF 450, BF 451

PNP Silicon Epitaxial Planar Transistors
designed for emitter-grounded AM and FM IF amplifier stages in which the negative pole of the supply voltage is grounded

The BF 450 is designed for stages with AGC, and the BF 451 is designed for stages without AGC.





Green plastic case ≈ TO-92
TO-18 compatible.
The case is impervious to light.
Weight approximately 0.18 g
Dimensions in mm

Maximum Ratings

Collector base voltage	$-V_{CBO}$	40	V
Collector emitter voltage	$-V_{CEO}$	40	V
Emitter base voltage	$-V_{EBO}$	4	V
Collector current	$-I_C$	25	mA
Base current	$-I_B$	5	mA
Power dissipation at $T_{amb} = 25\ ^\circ C$	P_{tot}	150 [1]	mW
Junction temperature	T_j	125	°C
Storage temperature range	T_S	−55...+150	°C

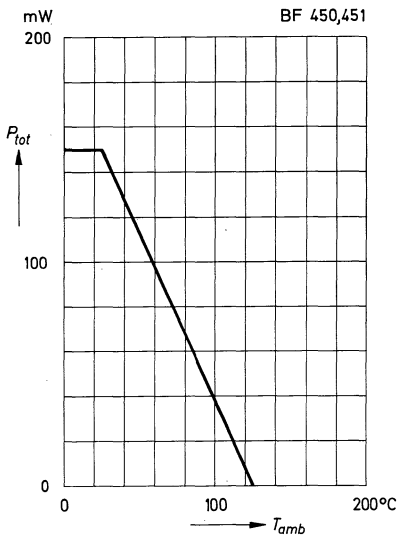
Characteristics at $T_{amb} = 25\ ^\circ C$

DC current gain at $-V_{CE} = 10$ V, $-I_C = 1$ mA	**BF 450**	h_{FE}	> 60	
	BF 451	h_{FE}	> 30	
Collector base breakdown voltage at $-I_C = 10\ \mu A$		$-V_{(BR)CBO}$	> 40	V
Collector emitter breakdown voltage at $-I_C = 2$ mA		$-V_{(BR)CEO}$	> 40	V
Collector cutoff current at $-V_{CB} = 30$ V		$-I_{CBO}$	< 50	nA
Thermal resistance Junction to ambient air		R_{thA}	< 660 [1]	°C/W

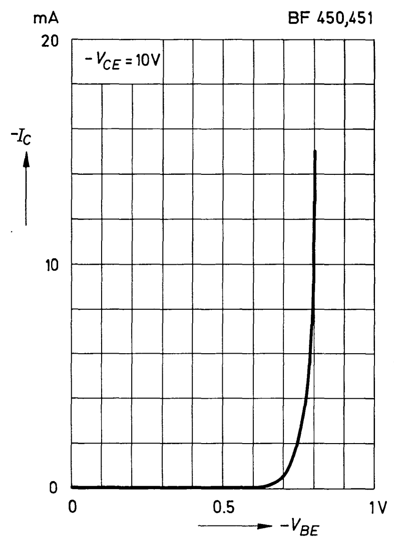
[1] Valid provided that leads are kept at ambient temperature at a distance of 2 mm from case.

Gain bandwidth product at $-V_{CE} = 10$ V, $-I_C = 1$ mA, $f = 100$ MHz	f_T	325	MHz
Feedback capacitance at $-V_{CE} = 10$ V, $-I_C = 1$ mA, $f = 1$ MHz	$-C_{re}$	0.35	pF
Real part of output admittance at $-V_{CE} = 10$ V, $-I_C = 1$ mA, $f = 0.5$ MHz	g_{oe}	< 8	µmho
Noise figure at $-V_{CE} = 10$ V, $-I_C = 1$ mA, $f = 100$ kHz, $R_G = 300\ \Omega$	F	2	dB

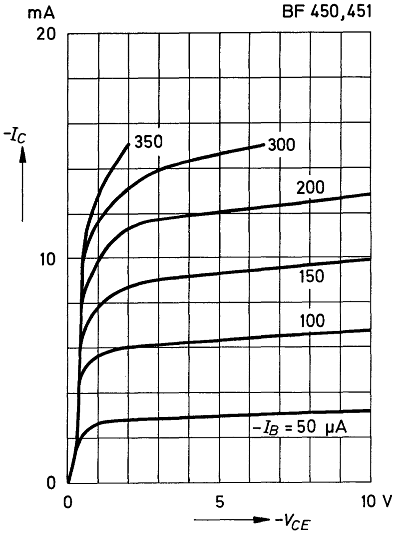
Admissible power dissipation versus ambient temperature
(see note on page 378)



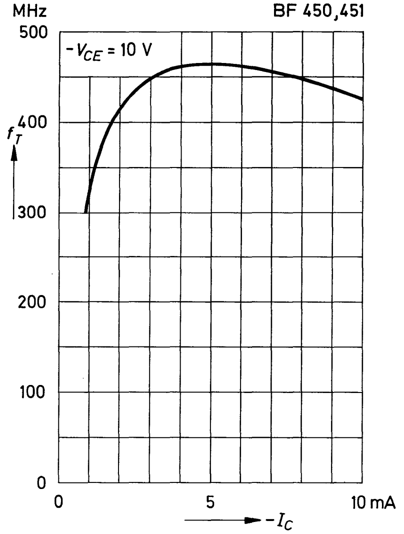
Collector current versus base emitter voltage



Common emitter collector characteristics



Gain bandwidth product versus collector current

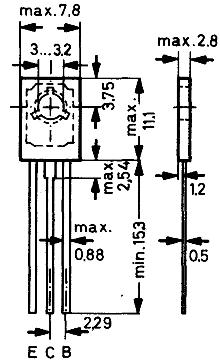


PNP Silicon
Power Transistors

BD 136, BD 138

PNP Silicon Epitaxial Planar Power Transistors
for AF driver stages in hifi equipment and for push-pull output stages matched with BD 135/137 as complementary pairs.

These transistors are available either as matched pairs or as complementary pairs BD 135/BD 136 or BD 137/BD 138. Matching condition: The typical ratio of the DC current gain of a matched pair at $|V_{CE}| = 2$ V, $|I_C| = 150$ mA is 1.3 (max. 1.6).



Plastic case SOT-32
Collector connected
to metal base
Weight approximately 1 g
Dimensions in mm

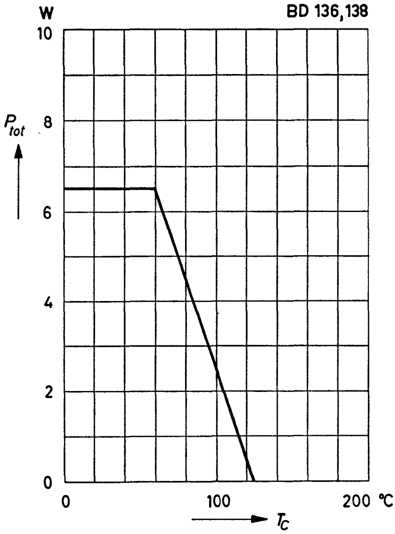
Maximum Ratings		BD 136	BD 138	
Collector base voltage	$-V_{CBO}$	45	60	V
Collector emitter voltage	$-V_{CEO}$	45	60	V
Emitter base voltage	$-V_{EBO}$	5		V
Average collector current	$-I_{CAV}$	0.5		A
Peak collector current	$-I_{CM}$	1.5		A
Power dissipation at $T_C < 60$ °C	P_{tot}	6.5		W
Junction temperature	T_j	125		°C
Storage temperature range	T_S	−55...+125		°C

Characteristics at $T_j = 25$ °C

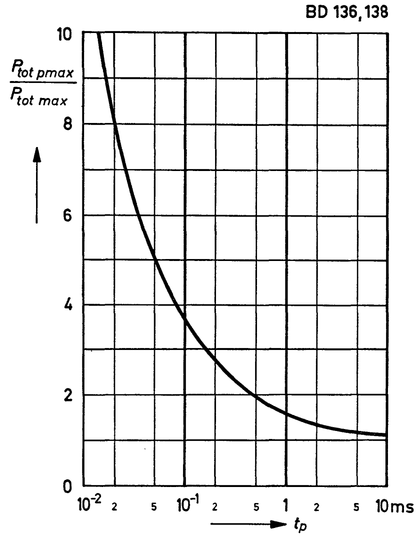
DC current gain			
at $-V_{CE} = 2$ V, $-I_C = 5$ mA	h_{FE}	> 25	> 25
at $-V_{CE} = 2$ V, $-I_C = 150$ mA	h_{FE}	40...250	40...160
at $-V_{CE} = 2$ V, $-I_C = 500$ mA	h_{FE}	> 25	> 25

Base emitter voltage at $-V_{CE} = 2$ V, $-I_C = 500$ mA	$-V_{BE}$	<1	V
Collector saturation voltage at $-I_C = 500$ mA, $-I_B = 50$ mA	$-V_{CE\,sat}$	<0.5	V
Collector cutoff current			
at $-V_{CB} = 30$ V	$-I_{CBO}$	<100	nA
at $-V_{CB} = 30$ V, $T_j = 125$ °C	$-I_{CBO}$	<10	µA
Emitter cutoff current at $-V_{EB} = 5$ V	$-I_{EBO}$	<10	µA
Gain bandwidth product at $-V_{CE} = 5$ V, $-I_C = 50$ mA $f = 35$ MHz	f_T	75	MHz
Thermal resistance			
Junction to ambient air	R_{thA}	<100	°C/W
Junction to metal base	R_{thC}	<10	°C/W
Metal base to heat sink	$R_{thC/S}$	<1	°C/W

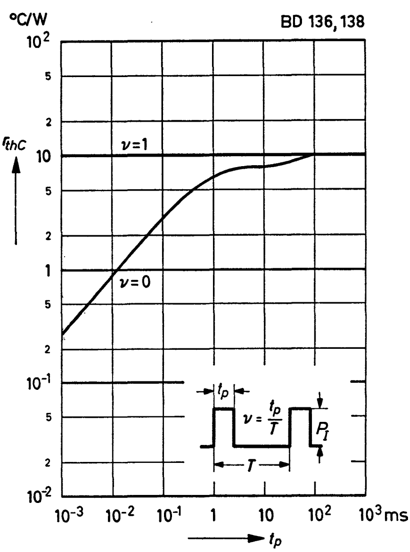
Admissible power dissipation versus metal base temperature



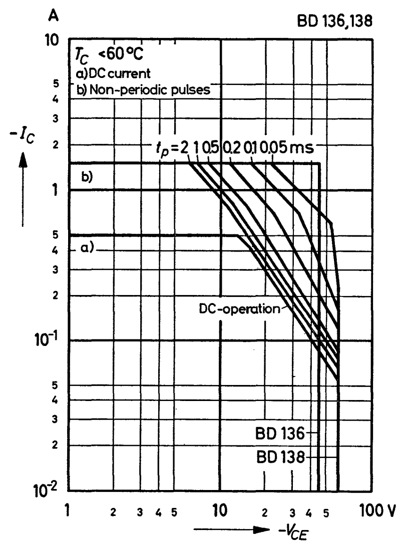
Multiplier for admiss. power dissipation for non-periodic pulses versus pulse duration



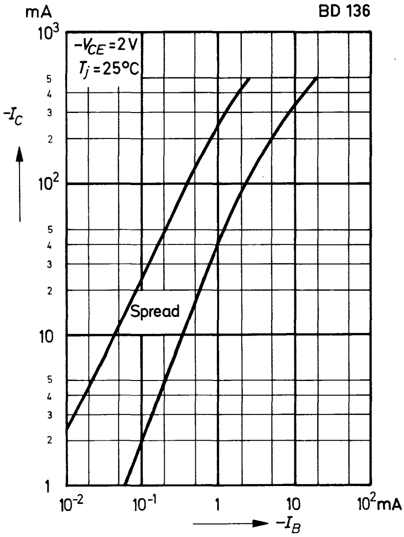
Pulse thermal resistance versus pulse duration



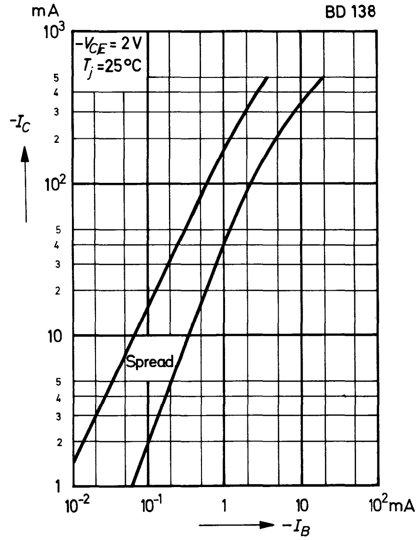
Admissible collector current versus collector emitter voltage



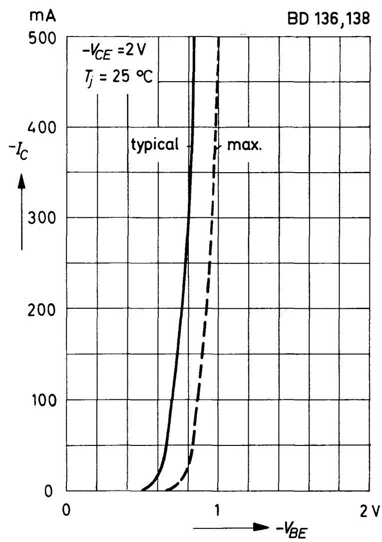
Collector current versus base current



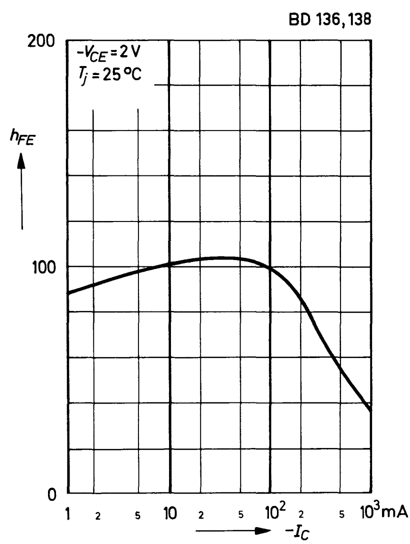
Collector current versus base current



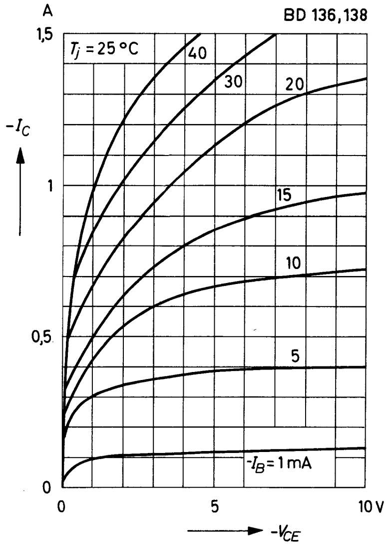
Collector current versus base emitter voltage



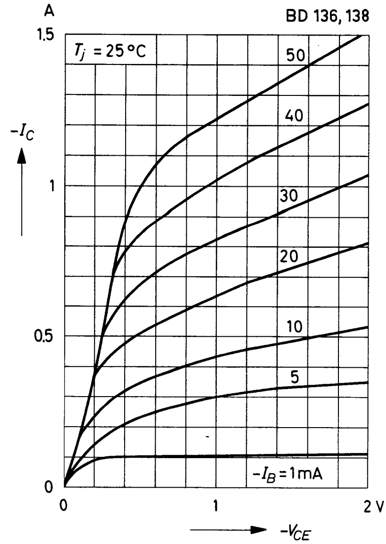
DC current gain versus collector current



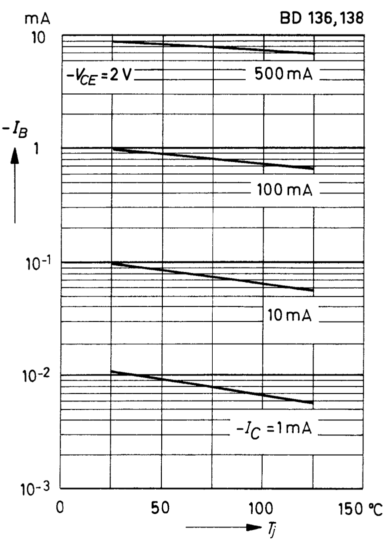
Common emitter collector characteristics



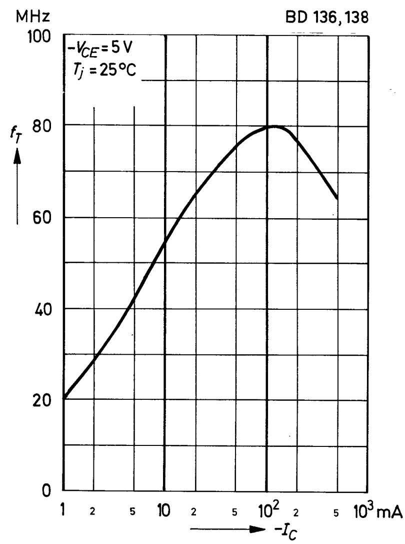
Common emitter collector characteristics



Base current versus junction temperature

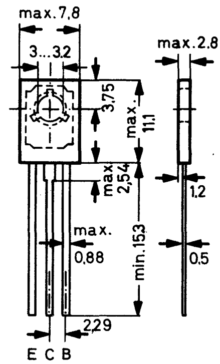


Gain bandwidth product versus collector current



PNP Silicon Epitaxial Planar Power Transistor
for AF driver stages in hifi equipment and for push-pull output stages matched with BD 139 as complementary pair.

This transistor is available either as matched pair or as complementary pair BD 139/BD 140. Matching condition: The typical ratio of the DC current gain of a matched pair at $|V_{CE}| = 2$ V, $|I_C| = 150$ mA is 1.3 (max. 1.6).



Plastic case SOT-32
Collector connected
to metal base
Weight approximately 1 g
Dimensions in mm

Maximum Ratings

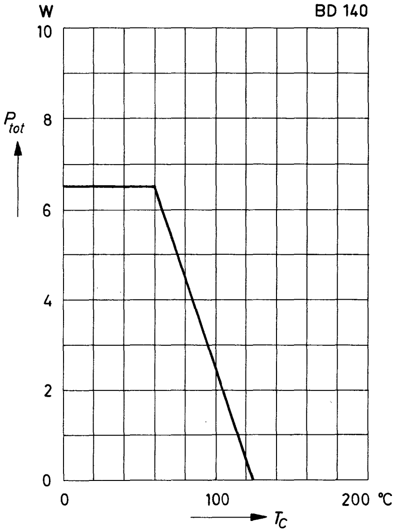
Collector emitter voltage at $R_{BE} < 1$ kΩ	$-V_{CER}$	100	V
Collector emitter voltage	$-V_{CEO}$	80	V
Emitter base voltage	$-V_{EBO}$	5	V
Average collector current	$-I_{CAV}$	0.5	A
Peak collector current	$-I_{CM}$	1.5	A
Power dissipation at $T_C < 60$ °C	P_{tot}	6.5	W
Junction temperature	T_j	125	°C
Storage temperature range	T_S	–55...+125	°C

Characteristics at $T_j = 25$ °C

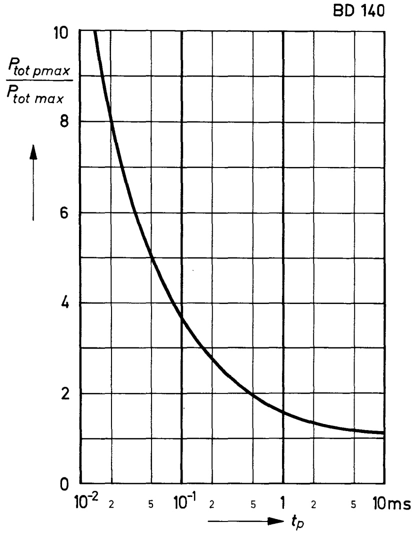
DC current gain		
at $-V_{CE} = 2$ V, $-I_C = 5$ mA	h_{FE}	> 25
at $-V_{CE} = 2$ V, $-I_C = 150$ mA	h_{FE}	40...160
at $-V_{CE} = 2$ V, $-I_C = 500$ mA	h_{FE}	> 25

Base emitter voltage at $-V_{CE} = 2$ V, $-I_C = 500$ mA	$-V_{BE}$	< 1	V
Collector saturation voltage at $-I_C = 500$ mA, $-I_B = 50$ mA	$-V_{CE\,sat}$	< 0.5	V
Collector cutoff current			
at $-V_{CB} = 30$ V	$-I_{CBO}$	< 100	nA
at $-V_{CB} = 30$ V, $T_j = 125$ °C	$-I_{CBO}$	< 10	μA
Emitter cutoff current at $-V_{EB} = 5$ V	$-I_{EBO}$	< 10	μA
Gain bandwidth product at $-V_{CE} = 5$ V, $-I_C = 50$ mA, $f = 35$ MHz	f_T	75	MHz
Thermal resistance			
Junction to ambient air	R_{thA}	< 100	°C/W
Junction to metal base	R_{thC}	< 10	°C/W
Metal base to heat sink	$R_{thC/S}$	< 1	°C/W

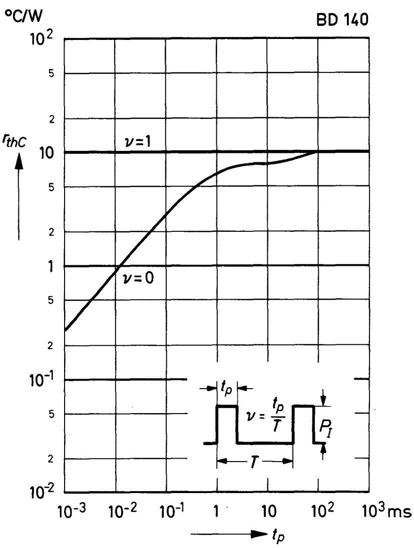
Admissible power dissipation versus metal base temperature



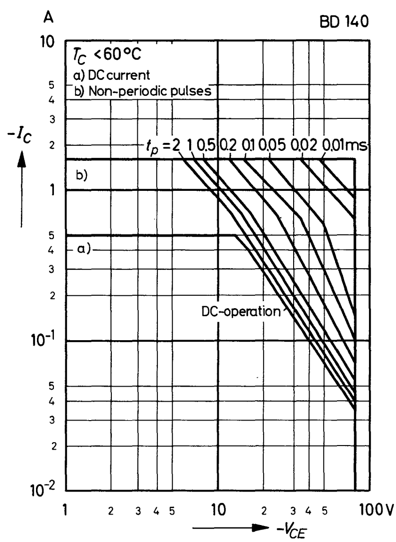
Multiplier for admiss. power dissipation for non-periodic pulses versus pulse duration



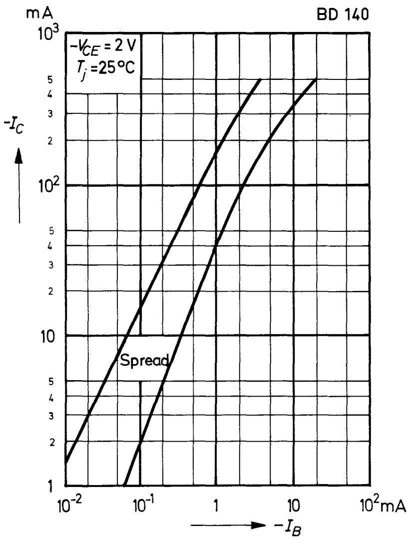
Pulse thermal resistance versus pulse duration



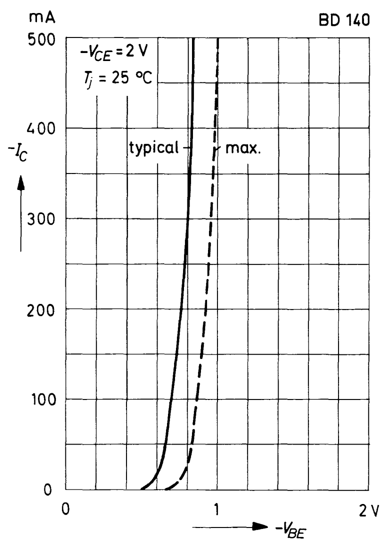
Admissible collector current versus collector emitter voltage



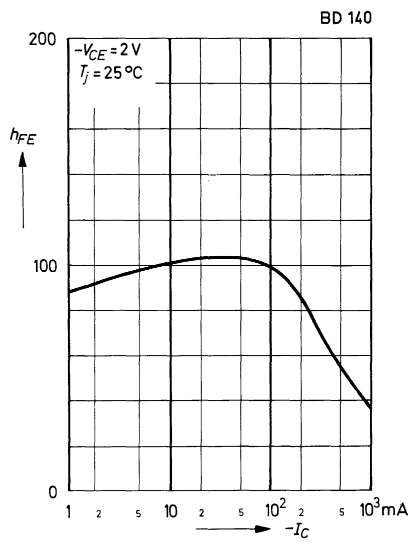
Collector current versus base current



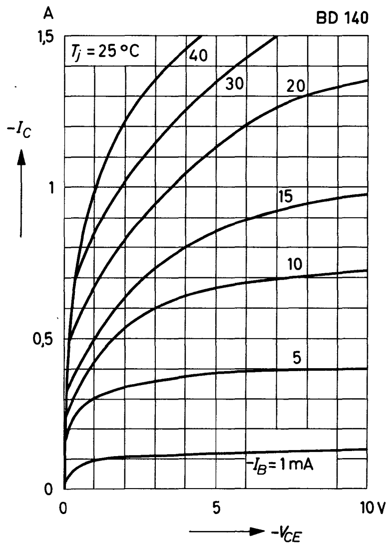
Collector current versus base emitter voltage



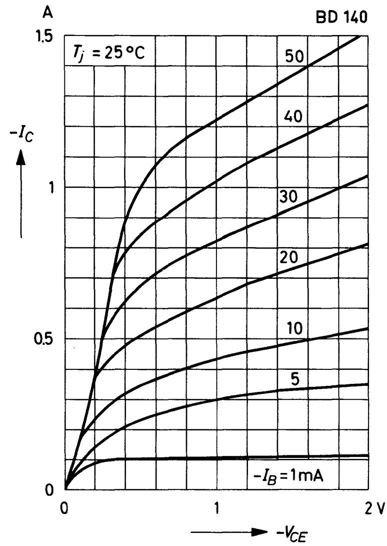
DC current gain versus collector current



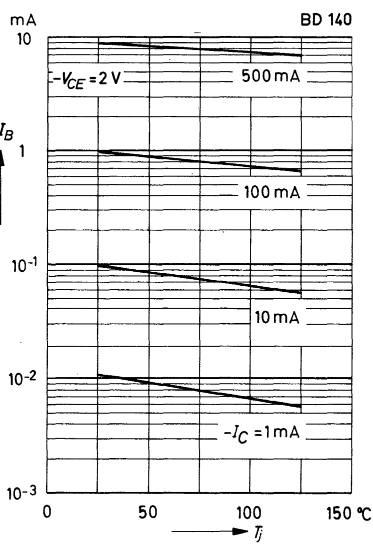
Common emitter collector characteristics



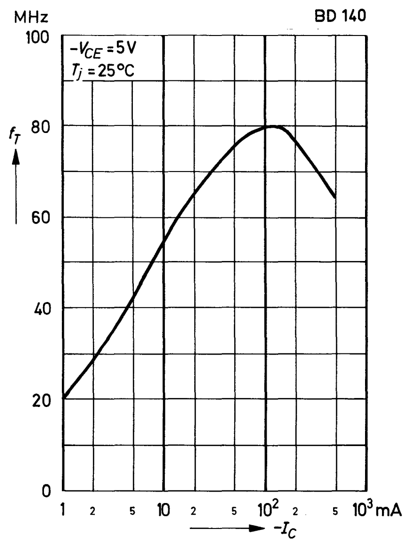
Common emitter collector characteristics



Base current versus junction temperature



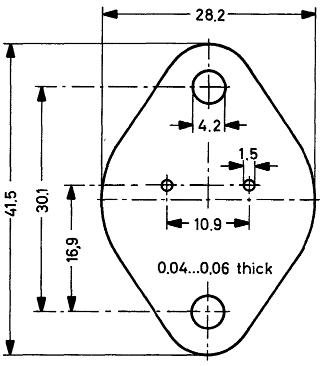
Gain bandwidth product versus collector current



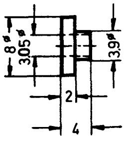
Accessories

Set of accessories No. 3

Insulating washer



Insulating bush



comprising

1 insulating washer No. 02 311 mica
2 insulating bushes No. 02 321 polycarbonate

for insulated mounting of TO-3 transistors

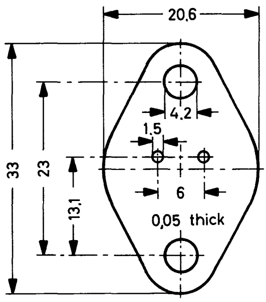
Weight of kit approx. 0.35 g

If transistors are mounted insulated a good thermal contact has to be provided, e.g. by greasing the insulating washer with silicon grease. The thermal resistance R_{thC} rises approximately 0.5 °C/W by insulated mounting using accessory set No. 3.

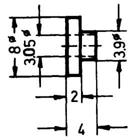
Dimensions in mm

Set of accessories No. 9

Insulating washer



Insulating bush



comprising

1 insulating washer No. 02 911 mica
2 insulating bushes No. 02 321 polycarbonate

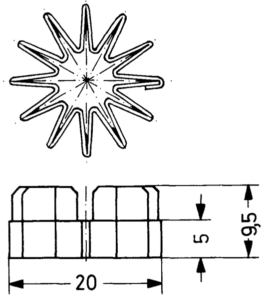
for insulated mounting of SOT-9 transistors

Weight of kit approx. 0.3 g

If transistors are mounted insulated a good thermal contact has to be provided, i.g. by greasing the insulating washer with silicon grease. The thermal resistance R_{thC} rises approximately 0.5 °C/W by insulated mounting using accessory set No. 9.

Heat sink KS 1 for TO-39 case

fitting for all transistors in TO-39 case



Material: black varnished bronze beryllium
Weight approx. 2 g

Thermal resistance in free air
R_{th} = 46 °C/W

Dimensions in mm

ITT Manufacturing

Transistors described in this manual are only parts of the ITT semiconductors manufacturing programme. A wide range of monolithic integrated circuits as well as diodes, thyristors and rectifiers of outstanding quality are at your disposal for your designs and your production.

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- Silicon Diode Switches
- Silicon Zener Diodes
- Silicon Reference Elements and Amplifiers
- Silicon Rectifiers
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- Silicon 4-Layer Components

All information given herein is subject to modification with respect to progress or errors.

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General Information

NPN Silicon Transistors

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PNP Silicon Transistors

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Accessories

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