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DIGITAL INPUT/OUTPUT CONTROLLER

PROGRAMMING MANUAL

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Table of Contents

APPENDICES

TABLES

DIGITAL INPUT/OUTPUT CONTROLLER (DIO) PROGRAMMING MANUAL

INTRODUCTION

This document provides programming information for the INTERDATA Digital I/O Controller. It assumes that the reader is familar with the I/O programming structure of INTERDATA Processors.

For information about INTERDATA programming, refer to the following:

INTERDATA 32-Bit Series Reference Manual, Publication Number 29-365
Model 7/32 Reference Manual, Publication Number 29-399
Model 8/32 Processor User's Manual, Publication Number 29-428
16-Bit Series Reference Manual, Publication Number 29-398

This manual describes the Digital Input/Output Controller and summarizes all of the information necessary to program the system. The Digital I/O (DIO) controller provides a standard interface between the Multiplexor Bus and the external peripheral device.

CONFIGURATION

The DIO Controller may be used with any Model 7/16, Model 7/32 or equivalent Processor.

DATA FORMAT

The DIO system is a halfword-oriented device. It consists of a 16-Bit output register and 16 input data lines. The 16 controller input bits represent external inputs to the system. The 16 bits of digital output data represent outputs from the processor. Since the DIO Controller includes two independent data paths, a bi-directional flow of information is possible between the processor and the peripheral device. Input operations command the external device to acquire and transfer 16 bits of information to the computer. Output operations enable the computer to output 16 bits of data to the external device (see Section entitled Device Numbers).

PROGRAMMING INSTRUCTIONS

Processor Instructions

The following Processor I/O Instructions are used to control and communicate with the Digital I/O Controller:

Sense Status (SS or SSR)

The Sense-Status instruction is used to determine whether the peripheral device is ready for data transfer operations.

Output Command (OC or OCR)

The Output Command instruction is used to enable, disable or disarm DIO Controller interrupts.

Write Halfword (WH or WHR)

The Write Halfword instruction is used to output 16 bits of data to the controller output register.

Read Halfword (RH or RHR)

The Read Halfword instruction is used to read 16 bits of data from the controller input data lines.

Acknowledge Interrupt (AI, AIR, ACK, and ACKR)

The Acknowledge Interrupt instruction (applicable to INTERDATA 16-Bit Processors only) is used to service interrupts. Execution of this instruction returns the address and status of the interrupting device.

Read Data/Write Data (RD,RDR,WD,WDR)

Since the DIO Controller is a halfword oriented device, the use of these instructions is not recommended. However, if used, the low order byte of data will be transferred to the device as a halfword with the 8 high order bits *undefined.*

STATUS AND COMMAND BYTES

Table 1 summarizes the DIO status and command byte data formats.

TABLE 1. DIO STATUS AND COMMAND BYTE FORMATS

Bit Number	0	1	2	3	4	5	6	7
Status Byte					BUSY			
Command Byte	Disable	Enable						

DISARM

*BUSY — The resetting of this bit, signals the computer that a halfword of data is available in the controller. If enabled, an interrupt is generated. The program can then read a halfword of data. When the read operation is complete, BUSY sets.

OUTPUT OPERATION:

The resetting of this bit signals the computer that the interface output register is ready to receive a halfword of data from the computer. If enable, an interrupt is generated. The program must then write a halfword of data. At the completion of the Write operation, BUSY sets.

COMMAND

ENABLE — When this bit is set and DISABLE is reset, interrupts are passed to the Processor as they occur.

DISABLE — When this bit is set and ENABLE is reset, interrupts are not passed to the Processor as they occur but are queued by the interface.

DISARM — When both ENABLE and DISABLE are set, interrupts are not passed to the Processor as they occur, and are not queued by the interface. All pending interrupts are cleared.

NOTES

1. A Controller option enables the user to unconditionally inhibit the setting of the BUSY bit.
2. When the INIT switch is depressed on the Processor console, BUSY is set. Furthermore, when power is turned on, BUSY is set.
3. There is no Controller Output command to set or reset the BUSY status. In order to set the BUSY bit under program control, a "dummy" Read and Write operation must be performed (see section entitled "PROGRAMMING SEQUENCES").

PROGRAMMING SEQUENCES

Asynchronous Data Transfers (Appendices 2 and 3)

Data may be transferred to or from the device asynchronously by issuing a Write Halfword to the output address (N), or a Read Halfword instruction from the input address (N+1). The first programming example in Appendices 2 and 3 illustrates the use of a simple subroutine designed to transfer data in this manner. Interrupts from the controller should be disarmed and the BUSY status is not used to signal the processor when data transfers should be initiated.

Sense-Status Operation (Appendices 2 and 3)

Appendices 2 and 3 illustrate a subroutine to transfer data by sensing BUSY status. In addition, to initiate an input operation:

1. Disarm the controller interrupt system (see section entitled INTERRUPTS).
2. The BUSY status bit must be set to initiate the operation. If the state of the BUSY bit is unknown, a "dummy" Read Halfword instruction must be issued to set the BUSY bit. This signals the controller to initiate an input operation. The data read from the input data register by this "dummy" read, is undefined.
3. A Sense-Status instruction is used to sense the controller status. When BUSY resets, the program can read one halfword of data.

To initiate an output operation:

1. Disarm the Controller interrupts (see section entitled INTERRUPTS).
2. The BUSY status bit must be set to initiate the operation. If the state of the BUSY bit is unknown, a "dummy" Write Halfword instruction must be issued to set the BUSY bit. This signals the Controller to initiate an output operation.
3. A Sense-Status instruction is used to sense the status. When BUSY resets, the program can write one halfword of data.

Interrupt Driver Operation

Appendix 2 outlines a program to execute interrupt driven data transfers. To initiate an input operation:

1. Output a command to the input address assigned to the interface to enable interrupts.
2. Repeat Step 2 of Sense-Status Operation.*
3. When BUSY resets, the Controller generates an interrupt indicating that the input data is available in the DIO Controller. The program can then read 1 halfword of data.

To initiate an output operation:

1. Output a command to the output address assigned to the interface to enable interrupts.
2. Repeat Step 2 of the Sense-Status operation.**
3. When BUSY resets, the Controller generates an interrupt indicating that the computer should send data to the device by issuing a Write-Halfword to the output address.

Auto Drive Channel Operation

Appendix 3 illustrates an example of using the Series 32 Processor Auto-Drive channel to execute DIO data transfers. For further information concerning Auto-Driver Channel programming, refer to the *32 Bit Series Reference Manual,* Publication Number 29-365.

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*If the Controller is wired to inhibit the setting of the BUSY status bit, this step should be ignored. An external interrupt occurs when data is available in the Controller.

**If the Controller is wired to inhibit the setting of the BUSY status bit, this step should be ignored. An external interrupt occurs when the device is ready to receive data.

INTERRUPTS

If enabled, an interrupt is generated by the DIO Controller when data is available in the interface, or when the output data register is requesting a halfword of data from the computer. This interrupt occurs if the BUSY bit is operational or not.

INITIALIZATION

Initialization disarms all system interrupts, clears the digital input and output registers and sets the BUSY status (bit 4), if operational.

DEVICE NUMBERS

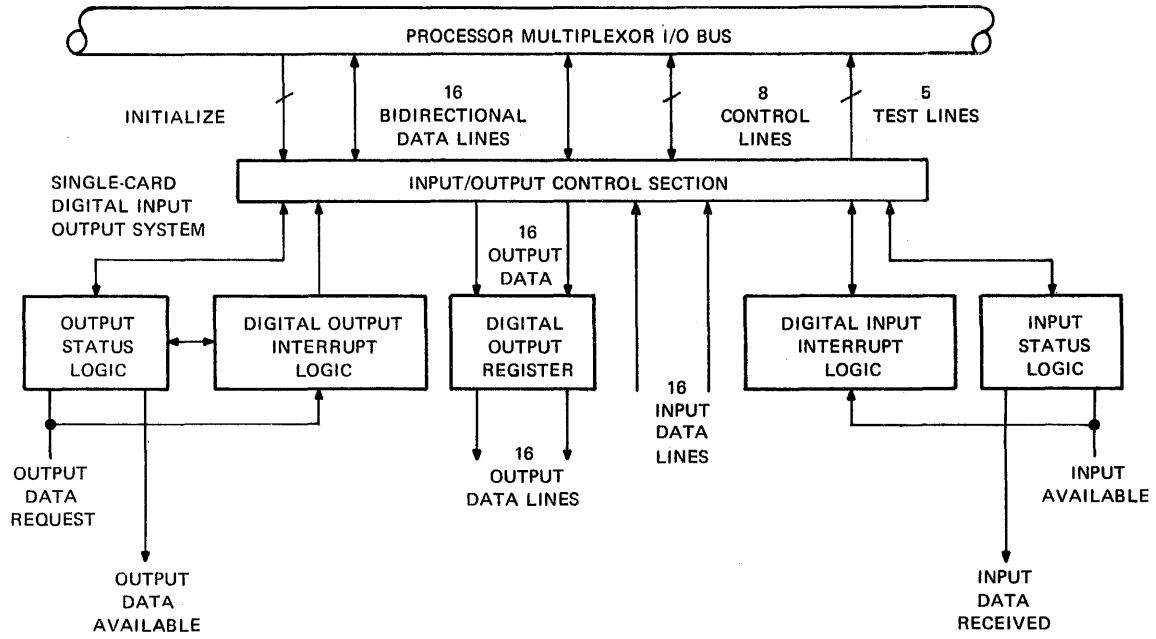
The Digital I/O Controller communicates with the processor via two device numbers. I/O instructions used in output operations must address a device number N as selected by two hexadecimal switches located on the controller board. This setting must be even, i.e., the least significant switch setting must be 0, 2, 4, 6, 8, A, C, or E. I/O instructions used in input operations must address on odd device number equal to N + 1.

SAMPLE PROGRAMS

Appendices 2 and 3 contain sample programs illustrating various methods of DIO data transfer.

APPENDIX 1

DIGITAL INPUT/OUTPUT (DIO) SYSTEM BLOCK DIAGRAM



INTERFACING SIGNALS (REQUEST/RESPONSE)

SIGNAL	DESCRIPTION	FUNCTION	INTERRUPT	STATUS
OUTPUT DATA REQUEST	1 μSEC PULSE	PERIPHERAL DEVICE REQUESTING DATA	GENERATE PROCESSOR INTERRUPT	RESET BUSY=0
OUTPUT DATA AVAILABLE	1 μSEC PULSE	PROCESSOR DATA SETTLED ON LINES AND READY FOR PERIPHERAL	NO INTERRUPT GENERATED	SET BUSY=1
INPUT AVAILABLE	1 μSEC PULSE	PERIPHERAL DEVICE REQUESTING TO INPUT DATA TO PROCESSOR	GENERATE PROCESSOR INTERRUPT	RESET BUSY=0
INPUT DATA RECEIVED	1 μSEC PULSE	PROCESSOR ACKNOWLEDGES DATA ACCEPTED	NO INTERRUPT GENERATED	SET BUSY=1

PROG= *NONE* ASSEMBLED BY CAL 03-066R04-01 (32-BIT)

```
                                1          SCRAT                                                                DI000000
                                2          TARGT  32                                                            AOC00010
0000R                           3          NLSTC                                                                DI000020
                                4          NORX3                                                                DI000030
0000R                           5          SQCHK                                                                DI000031
0000R                           6          IFZ    ADC-2                                                         DI000040
                                9          ENDC                                                                 DI000080
                               10          WIDTH  120                                                           DI000090
0000R                          11          SQUEZ                                                                DI000100
                               12          CROSS                                                                DI000110
                               13  * COPYRIGHT INTERDATA MAY 1975                                               DI000120
                               14  *                                                                            DI000130
                               15  * THE PROGRAMMING SEQUENCES THAT FOLLOW DEMONSTRATE THE VARIOUS METHODS      DI000140
                               16  * OF DATA TRANSFER USING THE DIGITAL I/O CONTROLLER. THE FLOW-               DI000150
                               17  * CHARTS IN APPENDIX 2 OUTLINE THE METHODS IMPLEMENTED BELOW.IN THE          DI000160
                               18  * FIRST EXAMPLE,DATA IS TRANSFERRED TO AND FROM THE SYSTEM WITHOUT THE      DI000170
                               19  * USE OF HANDSHAKING OR INTERRUPT LOGIC.STATUS FROM THE INPUT AND           DI000180
                               20  * OUTPUT SUBSYSTEMS IS IGNORED AND SYSTEM INTERRUPTS ARE DISARMED. THE      DI000190
                               21  * SUBROUTINE DIGITIO IS CALLED TO EXECUTE DATA TRANSFERS.THE CALLING         DI000200
                               22  * ARGUMENTS INCLUDE AN INPUT/OUTPUT OPERATION IDENTIFIER AND A POINTER      DI000210
                               23  * TO MEMORY SPECIFYING WHERE DATA IS TO RETRIEVED OR STORED.                DI000220
                               24  * ALL PROGRAMMING EXAMPLES RUN WITH THE TEST CABLE REFERENCED IN            DI000230
                               25  * APPENDIX 6 OF DOCUMENT 06-188A15.                                         DI000240
                               26  * ALL PROGRAMMING EXAMPLES ARE WRITTEN IN CAL COMMON CODE.                  DI000250
                               27  *                                                                           DI000260
                               28  * EQUATES AND REGISTER ALLOCATIONS                                          DI000270
        0000 000D              29  STAT     EQU    13              STATUS REGISTER                              DI000280
        0000 0004              30  OUTDEV   EQU    4               OUTPUT DEVICE ADDRESS                        DI000290
        0000 0005              31  INDEV    EQU    5               INPUT DEVICE ADDRESS                         DI000300
        0000 0006              32  IOIND    EQU    6               INPUT-OUTPUT IDENTIFIER                      DI000310
        0000 0007              33  DTAPTR   EQU    7               POINTER TO INPUT/OUTPUT BUFFER               DI000320
        0000 0008              34  BSY      EQU    8               BUSY STATUS FROM DIO CONTROLLER              DI000330
        0000 000C              35  DTAPTR1  EQU    12              INPUT BUFFER POINTER FOR INTERRUPTS          DI000340
        0000 0008              36  IONTCMP  EQU    8               I/O NOT COMPLETE FLAG                        DI000350
        0000 0009              37  WK1      EQU    9               WORK REGISTER- GENERAL PURPOSE               DI000360
        0000 000A              38  RETRY    EQU    10              ADDRESS FOR ERROR RETRY                      DI000370
        0000 000B              39  INTDEV   EQU    11              INTERRUPTING DEVICE ADDRESS                  DI000380
        0000 000F              40  RETN     EQU    15              SUBROUTINE RETURN ADDRESS                    DI000390
        0000 0040              41  OLDPSWST EQU    X'40'           OLD PSW SAVE AREA 16 BIT ONLY                DI000400
        0000 0044              42  NEWPSWST EQU    X'44'           NEW PSW STAT ON EXT INT 16 BIT ONLY          DI000410
        0000 0046              43  NEWPSWLC EQU    X'46'           NEW PSW LOC EXT INT 16 BIT ONLY              DI000420
        0000 0003              44  RST03    EQU    3               EXECUTIVE REGISTER SET 0 R3                  DI000430
        0000 0002              45  RST02    EQU    2               EXECUTIVE REGISTER SET 0 R2                  DI000440
        0000 0001              46  RST01    EQU    1               EXECUTIVE REGISTER SET 0 R1                  DI000450
        0000 0000              47  RST00    EQU    0               EXECUTIVE REGISTER SET 0 R0                  DI000460
        0000 0000              48  RSTF0    EQU    0               REGISTER SET F-REGISTER SET 0                DI000470
        0000 0007              49  DTAPTR0  EQU    7               OUTPUT BUFFR POINTR -REGISTER SET 0          DI000480
        0000 0004              50  OUTDEV0  EQU    4               OUTPUT DEVICE ADDRESS- REG. SET 0            DI000490
        0000 0005              51  INDEV0   EQU    5               REGISTER SET 0 INPUT DEVICE ADDR             DI000500
        0000 000C              52  DTAPTR10 EQU    12              REGISTER SET 0 INPUT BUFFER POINTER          DI000510
        0000 000E              53  WK2      EQU    14              WORK REGISTER 2                              DI000520
        0000 0002              54  BUFFLMST EQU    2               BUFFER LIMIT STATUS                          DI000530
0000R   C890 00F0              55  DIOENTR  LDAI   WK1,X'F0'       SELECT REGISTER SET X'F'                     DI000540
0004R   95A9                   56          EPSR   RETRY,WK1        EXCHANGE PROGRAM STATUS                      DI000541
```

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APPENDIX 2 16 BIT DIGITAL I/O PROGRAMMING EXAMPLES       PAGE   2   15:06:16  07/26/77

0006R  4840 010AR          57            LH     OUTDEV,DEVADR1     GET THE OUTPUT DEVICE ADDRESS          DI000542
000AR  DE40 0112R          58            OC     OUTDEV,DISARM      DISARM OUTPUT DEVICE LOGIC.            DI000550
000ER  4850 010CR          59            LH     INDEV,DEVADR2      GET THE INPUT DEVICE ADDRESS           DI000560
0012R  DE50 0112R          60            OC     INDEV,DISARM       DISARM INPUT DEVICE INTERRUPTS         DI000580
0016R  2461                61            LIS    IOIND,1            SET THE I/O INDICATOR FOR DIO OUTPUT   DI000590
0018R  C870 010ER          62            LDAI   DTAPTR,OUTBUFFR    GET THE POINTER TO THE OUTPUT DATA     DI000600
001CR  41F0 002ER          63            BAL    RETN,DIGITIO       CALL THE SUBROUTINE TO WRITE DATA.     DI000610
0020R  0766                64            XAR    IOIND,IOIND        RESET THE IO INDICATOR FOR INPUT OP    DI000620
0022R  C870 0110R          65            LDAI   DTAPTR,INBUFFR     GET POINTER FOR INPUT DATA             DI000630
0026R  41F0 002ER          66            BAL    RETN,DIGITIO       GO READ THE INPUT DATA                 DI000640
002AR  C200 0120R          67            LPSW   WAIT               HALT THE MACHINE                       DI000650
                           68  *                                                                           DI000660
                           69  * SUBROUTINE DIGITIO TRANSFERS 16 BITS OF PARALLEL BINARY DATA EITHER      DI000670
                           70  * TO THE DIGITAL I/O SYSTEM OR FROM THE DIGITAL I/O SYSTEM. STATUS LOG-    DI000680
                           71  * IC FROM THE CONTROLLER IS IGNORED. AMONG THE CALLING ARGUMENTS ARE AN     DI000690
                           72  * INPUT/OUTPUT INDICATOR FLAG,PHYSICAL DEVICE ADDRESS AND A POINTER TO     DI000700
                           73  * THE RESPECTIVE INPUT OR OUTPUT DATA BUFFER.                               DI000710
                           74  *                                                                           DI000720
                           75  * CALLING SEQUENCE: BAL RETN,DIGITIO                                       DI000730
                           76  * INPUT REGISTERS: OUTDEV= OUTPUT DEVICE ADDRESS(EVEN DEVICE ADDR.)        DI000740
                           77  *                  INDEV= INPUT DEVICE ADDRESS (ODD DEVICE ADDRESS)        DI000750
                           78  *                  IOIND= INPUT OUTPUT IDENTIFIER                          DI000760
                           79  *                  DTAPTR= POINTER TO INPUT OR OUTPUT BUFFER               DI000770
                           80  * REGISTERS DESTROYED:NONE                                                 DI000780
                           81  * SUBROUTINE OUTPUT DATA STORED IN MEMORY LOCATION SPECIFIED BY POINTER     DI000790
                           82  * DTAPTR.IF IOIND=0 OPERATION IS A READ OTHERWISE IT IS A WRITE            DI000800
                           83  *                                                                           DI000810
002ER  0866                84  DIGITIO  LDAR   IOIND,IOIND       CHECK THE I/O INDICATOR FLAG           DI000820
*  0030R  2334             85           BZ     READIN             BRANCH TO READ OPERATION               DI000830
0032R  D847 0000           86           WH     OUTDEV,0(DTAPTR)   WRITE A HALFWORD FROM OUTBUFFER        DI000840
*  0036R  2303             87           B      RETURN                                                    DI000850
0038R  D957 0000           88  READIN   RH     INDEV,0(DTAPTR)    READ A HALFWORD INTO INPUT BUFFER      DI000860
003CR  030F                89  RETURN   BR     RETN               RETURN TO THE USER.                    DI000870
                           90  *                                                                         DI000880
```

SENSE-STATUS PROGRAMMING EXAMPLES

```
                                92  * IN THIS EXAMPLE THE DATA TRANSFERS ARE SYNCHRONIZED WITH THE CONTROL-   DIO00900
                                93  * LER THROUGH THE USE OF HANDSHAKING SIGNALS ASSOCIATED WITH THE DEVICE  DIO00910
                                94  * A COMPLETE DESCRIPTION OF THE BUSY STATUS IS INCLUDED IN SECTION 4      DIO00920
                                95  *                                                                        DIO00930
                                96  *                                                                        DIO00940
 003ER  C890 00F0               97  DIOENTR1 LDAI   WK1,X'F0'          SELECT REGISTER SET X'F'              DIO00950
 0042R  95A9                    98           EPSR   RETRY,WK1          EXCHANGE PROGRAM STATUS               DIO00951
 0044R  4840 010AR              99           LH     OUTDEV,DEVADR1     GET THE OUTPUT DEVICE ADDRESS         DIO00952
 0048R  DE40 0112R             100           OC     OUTDEV,DISARM      DISARM SYSTEM INTERRUPTS              DIO00960
 004CR  4850 010CR             101           LH     INDEV,DEVADR2      GET THE INPUT SYSTEM DEVICE ADDRESS   DIO00970
 0050R  DE50 0112R             102           OC     INDEV,DISARM       DISARM INPUT DEVICE INTERRUPTS        DIO00990
 0054R  2461                   103           LIS    IOIND,1            SET THE I/O IND FOR OUTPUT OP         DIO01000
 0056R  9959                   104           RHR    INDEV,WK1          EXECUTE A READ OPERATION TO INITIA-   DIO01010
                               105  * LIZE THE DIGITAL I/O STATUS                                            DIO01020
 0058R  C870 010ER             106  CONT     LDAI   DTAPTR,OUTBUFFR    GET THE DATA POINTER TO OUTPUT BUFFR  DIO01030
 005CR  41F0 0070R             107           BAL    RETN,DIGITI01      GO TO DIGITAL I/O ROUTINE FOR OUTPUT  DIO01040
 0060R  C8A0 0058R             108           LDAI   RETRY,CONT         GO CHECK IF OP WAS COMPLETED          DIO01050
 0064R  41F0 00A0R             109           BAL    RETN,CHECK         GO TO DIGITAL I/O ROUTINE FOR INPUT   DIO01060
 0068R  41F0 0070R             110           BAL    RETN,DIGITI01      HALT THE PROCESSOR                    DIO01070
 006CR  C200 0120R             111           LPSW   WAIT                                                     DIO01080
                               112  * SUBROUTINE DIGITI01 FIRST CHECKS TO INSURE THAT BUSY STATUS FROM THE   DIO01090
                               113  * DESIRED SUBSYSTEM IS ZERO, IF IT IS NOT,THEN THE PERIPHERAL DEVICE     DIO01100
                               114  * IS NOT READY FOR DATA TRANSFER AND THE SUBROUTINE RETURNS TO THE USER  DIO01110
                               115  * WITH THE IONTCMP FLAG SET=1,OTHERWISE,THE SUBROUTINE WILL EXECUTE THE  DIO01120
                               116  * APPROPRIATE READ OR WRITE OPERATION AND INSURE THAT THE BUSY STATUS     DIO01130
                               117  * WAS SET=1 FOLLOWING THE I/O OPERATION.                                  DIO01140
                               118  *                                                                        DIO01150
                               119  * CALLING SEQUENCE: BAL RETN,DIGITI01                                    DIO01160
                               120  * INPUT REGISTERS:                                                       DIO01170
                               121  *                   OUTDEV=OUTPUT DEVICE ADDRESS(EVEN DEVICE ADDRESS)  DIO01180
                               122  *                   INDEV=INPUT DEVICE ADDRESS (ODD DEVICE ADDRESS)    DIO01190
                               123  *                   IOIND= INPUT/OUTPUT IDENTIFIER                     DIO01200
                               124  *                   DTAPTR= POINTER TO INPUT OR OUTPUT BUFFER          DIO01210
                               125  * REGISTERS DESTROYED: R8=IONTCMP,WK1=R9                                 DIO01220
                               126  *                                                                        DIO01230
                               127  *                                                                        DIO01240
 0070R  0866                   128  DIGITI01 LDAR   IOIND,IOIND        GET THE INPUT/OUTPUT OP IDENTIFIER    DIO01250
*0072R  213D                   129           BN2    WRITEOP            IF ITS SET, ITS A WRITE OPERATION.    DIO01260
 0074R  4850 010CR             130           LH     INDEV,DEVADR2      OTHERWISE,GET THE INPUT DEV.ADDRESS   DIO01270
 0078R  9D5D                   131           SSR    INDEV,STAT         GET THE STATUS OF THE DEVICE          DIO01290
*007AR  2383                   132           BFC    BSY,CONT1          IF ITS ZERO,DO THE READ OPERATION     DIO01300
 007CR  4300 009CR             133           B      EXITINCP           OTHERWISE, SET THE I/O NOT COMPLETE   DIO01310
                               134  *                                 FLAG AND RETURN TO THE USER           DIO01320
 0080R  D957 0000              135  CONT1    RH     INDEV,0(DTAPTR)    READ A HALFWORD OF DIGITAL DATA AND   DIO01330
 0084R  9D5D                   136           SSR    INDEV,STAT         CHECK INPUT STATUS BUSY SHOULD SET.   DIO01340
 0086R  4380 0106R             137           BFC    BSY,ERROR          IF IT DIDN'T,THE DEVICE IS IN ERROR.  DIO01350
*008AR  230A                   138           B      RETURN1            RETURN TO THE USER.                   DIO01360
 008CR  9D4D                   139  WRITEOP  SSR    OUTDEV,STAT        SENSE DEVICE STATUS.                  DIO01370
*008ER  2187                   140           BTC    BSY,EXITINCP       IF THE BUSY BIT IS SET,SET I/O NOT    DIO01380
                               141  *                                 COMPLETE AND RETURN.                  DIO01390
 0090R  D847 0000              142  CONT2    WH     OUTDEV,0(DTAPTR)   DO THE WRITE OPERATION.              DIO01400
 0094R  9D4D                   143           SSR    OUTDEV,STAT        SENSE DEVICE STATUS                   DIO01410
 0096R  4380 0106R             144           BFC    BSY,ERROR          BUSY BIT SHOULD BE SET                DIO01420
*009AR  2302                   145           B      RETURN1            RETURN TO THE USER                    DIO01430
```

SENSE-STATUS PROGRAMMING EXAMPLES

```
009CR  2481                146  EXITINCP LIS    IONTCMP,1          SET THE I/O INCOMPLETE FLAG          DI001440
009ER  030F                147  RETURN1  BR     RETN                                                    DI001450
                           148  *                                                                       DI001460
                           149  *                                                                       DI001470
                           150  *                                                                       DI001480
                           151  *                                                                       DI001490
                           152  * SUBROUTINE CHECK INSURES THAT THE I/O OPERATION WAS COMPLETED         DI001500
                           153  * SUCCESSFULLY.IF IT WAS NOT IT WILL RESET THE IONTCMP FLAG AND RETRY   DI001510
                           154  * THE OPERATION. IF IT WAS A SUCCESSFUL OPERATION, THE SUBROUTINE WILL  DI001520
                           155  * INITIALIZE ALL PARAMETERS FOR SUBSEQUENT OPERATIONS                   DI001530
                           156  *                                                                       DI001540
                           157  * CALLING SEQUENCE: BAL RETN,CHECK                                      DI001550
                           158  * INPUT REGISTERS: IONTCMP=IONTCMPLETED INDICATOR                       DI001560
                           159  *                  IOIND=I/O INDICATOR FLAG                           DI001570
                           160  *                  DTAPTR=DATA POINTER TO INPUT OR OUTPUT BUFFER       DI001580
                           161  *                  RETRY= RETRY ADDRESS                               DI001590
                           162  *                                                                       DI001600
                           163  * REGISTERS DESTROYED:                                                 DI001610
                           164  * IONTCMP= I/O OPERATION NOT COMPLETED FLAG                            DI001620
                           165  * DTAPTR= POINTER TO MEMORY BUFFER                                     DI001630
                           166  * IOIND= I/O INDICATOR                                                DI001640
00A0R  0888                167  CHECK    LDAR   IONTCMP,IONTCMP    TEST THE IO NOT COMPLETED FLAG       DI001650
00A2R  2333                168           BZ     REINIT             IF IT ZERO,THE PREVIOUS OPERATION    DI001660
00A4R  0788                169           XAR    IONTCMP,IONTCMP    WAS SUCCESSFUL, OTHERWISE RESET THE   DI001670
00A6R  030A                170           BR     RETRY              COMPLETED FLAG TRY AGAIN.            DI001680
00A8R  C870 0110R          171  REINIT   LDAI   DTAPTR,INBUFFR     REINITIALIZE THE OUTPUT DATA POINTER DI001690
00ACR  0766                172           XAR    IOIND,IOIND        RESET I/O FLAG FOR A READ OPERATION  DI001700
00AER  0788                173           XAR    IONTCMP,IONTCMP    RESET I/O NOT COMPLETE FLAG          DI001710
00B0R  030F                174           BR     RETN                                                    DI001720
00B2R                      175           IFZ    ADC-2                                                   DI001730
```

INTERRUPT DRIVEN OPERATION-16 BIT PROCESSORS

```
                                177  * THE FOLLOWING EXAMPLE DEMONSTRATES THE USE OF INTERRUPTS IN SYNCHRON-   DIO01750
                                178  * IZING DATA TRANSFERS.WHEN THE PERIPHERAL DEVICE REQUIRES SERVICING      DIO01760
                                179  * AN EXTERNAL INTERRUPT IS GENERATED.INTERRUPTS GENERATED BY THE COMMON   DIO01770
                                180  * DIGITAL I/O CONTROLLER CAN BE ENABLED/DISABLED OR DISARMED.THIS PROC-   DIO01780
                                181  * ESS IS DESCRIBED IN DETAIL IN SECTION 4 OF THIS DOCUMENT                 DIO01790
                                182  *                                                                         DIO01800
                                183  *                                                                         DIO01810
                                184  *                                                                         DIO01820
  00B2R  4840 010AR             185  DIOENTR2 LH     OUTDEV,DEVADR1     GET THE OUTPUT DEVICE ADDRESS        DIO01830
  00B6R  4850 010CR             186           LH     INDEV,DEVADR2      GET THE INPUT DEVICE ADDRESS         DIO01840
  00BAR  2651                   187           AIS    INDEV,1            ADD 1 TO MAKE IT AN ODD ADDRESS      DIO01850
  00BCR  0799                   188           XAR    WK1,WK1            SET UP LOCORE TO PROCESS             DIO01860
  00BER  4090 0044              189           STH    WK1,NEWPSWST       EXTERNAL INTERRUPTS                  DIO01870
  00C2R  C890 00E2R             190           LDAI   WK1,EXTINT                                              DIO01880
  00C6R  4090 0046              191           STH    WK1,NEWPSWLC                                            DIO01890
  00CAR  DE40 0113R             192           OC     OUTDEV,ENABLE      ENABLE OUTPUT AND INPUT EXTERNAL     DIO01900
  00CER  DE50 0113R             193           OC     INDEV,ENABLE       DEVICE INTERRUPTS                    DIO01910
  00D2R  C870 010ER             194           LDAI   DTAPTR,OUTBUFFR    LOAD THE MEMORY BUFFER POINTERS      DIO01920
  00D6R  C8C0 0110R             195           LDAI   DTAPTR1,INBUFFR                                         DIO01930
  00DAR  D847 0000              196           WH     OUTDEV,0(DTAPTR)   ONCE THE WRITE HALFWORD IS EXECUTED  DIO01940
                                197  * A READ SERVICE INTERRUPT IS GENERATED AND THE PROGRAM WILL              DIO01950
                                198  * CONTINUE PROCESSING INTERRUPTS UNTIL MANUALLY HALTED                    DIO01960
  00DER  C200 0120R             199           LPSW   WAIT               EXECUTED A WRITE SERVICE INTERRUPT   DIO01970
                                200  * EXTERNAL INTERRUPTS ENTER HERE- WHEN THE PERIPHERAL DEVICE REQUESTS     DIO01980
                                201  * DATA FROM THE PROCESSOR,THE INTERRUPT IS VECTORED TO WRITEINT. WHEN     DIO01990
                                202  * THE PERIPHERAL DEVICE IS READY TO SEND DATA TO THE PROCESSOR THE        DIO02000
                                203  * INTERRUPT IS VECTORED TO READINT WHICH EXECUTES A READ HALFWORD         DIO02010
                                204  * OPERATION FROM THE DIO INPUT SUBSYSTEM                                  DIO02020
                                205  *                                                                         DIO02030
  00E2R  9F9D                   206  EXTINT   ACKR   WK1,STAT           ACKNOWLEDGE THE INTERRUPT            DIO02040
  00E4R  0595                   207           CLHR   WK1,INDEV          INPUT DEVICE REQUESTING SERVICE?     DIO02050
* 00E6R  233A                   208           BE     READINT            IF YES GO SERVICE IT WITH A READ INT DIO02060
  00E8R  0594                   209           CLHR   WK1,OUTDEV         IS THE OUTPUT DEVICE REQUESTING SERV DIO02070
* 00EAR  2332                   210           BE     WRITEINT           YES GO SERVICE IT WITH A WRITE       DIO02080
* 00ECR  230D                   211           B      ERROR              OTHERWISE ERROR                      DIO02090
                                212  *                                                                         DIO02100
                                213  * REQUESTS TO WRITE TO DIGITAL I/O CONTROLLER ENTER HERE                  DIO02110
  00EER  08DD                   214  WRITEINT LDAR   STAT,STAT          TEST THE RETURNED STATUS             DIO02120
* 00F0R  213B                   215           BNZ    ERROR              BUSY STATUS NON-ZERO SIGNIFIES ERROR. DIO02130
  00F2R  D847 0000              216           WH     OUTDEV,0(DTAPTR)   WRITE DATA TO THE DIO OUTPUT SUBSYS  DIO02140
  00F6R  C200 0040              217           LPSW   OLDPSWST           RETURN TO THE USING PROGRAM          DIO02150
                                218  * REQUESTS TO READ DATA FROM THE PERIPHERAL DEVICE ENTER HERE             DIO02160
  00FAR  08DD                   219  READINT  LDAR   STAT,STAT          IF THE STATUS IS                     DIO02170
* 00FCR  2135                   220           BNZ    ERROR              NON-ZERO THATS AN ERROR CONDITION    DIO02180
  00FER  D95C 0000              221           RH     INDEV,0(DTAPTR1)   READ DATA INTO INPUT BUFFER          DIO02190
  0102R  C200 0040              222           LPSW   OLDPSWST                                                DIO02200
                                265           ENDC                                                           DIO02640
```

INTERRUPT DRIVEN OPERATION-16 BIT PROCESSORS

```
                          267  * ERRORS CAUSE THE MACHINE TO HALT IN THE WAIT STATE WITH                DIO02660
                          268  * INTERRUPTS DISABLED                                                    DIO02670
0106R  C200 0118R         269  ERROR    LPSW   ERR              ON AN ERROR HALT THE MACHINE WITH LOC  DIO02680
                          270  *                            POINTING TO ERR                           DIO02690
                          327          ELSE                                                            DIO03300
010AR                     328          ENDC                                                            DIO03310
                          329  * MEMORY CONSTANTS,BUFFER AREAS AND COMMANDS                             DIO03320
010AR  0000               330  DEVADR1  DC     X'0'             OUTPUT DEVICE ADDRESS                 DIO03330
010CR  0000               331  DEVADR2  DC     X'0'             INPUT DEVICE ADDRESS                  DIO03340
010ER  0000               332  OUTBUFFR DC     X'0'             OUTPUT BUFFER                         DIO03350
0110R  0000               333  INBUFFR  DC     X'0'             INPUT BUFFER                          DIO03360
0112R  C040               334  DISARM   DC     X'C040'          DISARM INTERRUPTS (DIO CONTROLLER)    DIO03370
       0000 0113R         335  ENABLE   EQU    *-1              ENABLE DIO INTERRUPTS                 DIO03380
0118R                     336          ALIGN  8                                                       DIO03390
       0000 0118R         337  ERR      EQU    *                                                     DIO03400
0118R                     338          IFZ    ADC-2                                                  DIO03410
0118R  8000               339          DC     X'8000'          16 BIT PSW STATUS WAIT STATE          DIO03420
011AR  0118R              340          DC     A(ERR)           16 BIT PSW LOC ON ERROR HALT          DIO03430
                          344          ENDC                                                           DIO03470
0120R                     345          ALIGN  8                                                       DIO03480
       0000 0120R         346  WAIT     EQU    *                                                     DIO03490
0120R                     347          IFZ    ADC-2                                                  DIO03500
0120R  C000               348          DC     X'C000'          16 BIT PSW STATUS WAIT STATE          DIO03510
0122R  0120R              349          DC     A(WAIT)          INTERRUPTS ENABLED LOC=WAIT           DIO03520
                          353          ENDC                                                           DIO03560
0124R                     354          ALIGN  4                                                       DIO03570
                          387          ELSE                                                           DIO03900
0124R                     388          ENDC                                                           DIO03910
0124R                     389          END                                                            DIO03920
```

INTERRUPT DRIVEN OPERATION-16 BIT PROCESSORS

NO ERRORS 3 SQUEZ PASSES

CAL 04-01

```
  ABSTOP          0000
  ADC             0002    6  175  271  338  347  355
  BSY             0008  132  137  140  144
  BUFFLMST        0002
  CHECK           00A0R 109
  CONT            0058R 108
  CONT1           0080R 132
  CONT2           0090R
  DEVADR1         010AR  57   99  185
  DEVADR2         010CR  59  101  130  186
  DIGITI01        0070R 107  110
  DIGITIO         002ER  63   66
  DIOENTR         0000R
  DIOENTR1        003ER
  DIOENTR2        00B2R
  DISARM          0112R  58   60  100  102
  DTAPTR          0007   62   65   86   88  106  135  142  171  194  196  216
  DTAPTR0         0007
  DTAPTR1         000C  195  221
  DTAPTR10        000C
  ENABLE          0113R 192  193
  ERR             0118R 269  340
  ERROR           0106R 137  144  211  215  220
  EXITINCP        009CR 133  140
  EXTINT          00E2R 190
  IMPTOP          0124R
  INBUFFR         0110R  65  171  195
  INDEV           0005   59   60   88  101  102  104  130  131  135  136  186  187  193
                         207  221
  INDEV0          0005
  INTDEV          0008
  IOIND           0006   61   64   64   84   84  103  128  128  172  172
  IONTCMP         0008  146  167  167  169  169  173  173
  LADC            0001
  NEWPSWLC        0046  191
  NEWPSWST        0044  189
  OLDPSWST        0040  217  222
  OUTBUFFR        010ER  62  106  194
  OUTDEV          0004   57   58   86   99  100  139  142  143  185  192  196  209  216
  OUTDEV0         0004
  PURETOP         0000R
  READIN          0038R  85
  READINT         00FAR 208
  REINIT          00A8R 168
  RETN            000F   63   66   89  107  109  110  147  174
  RETRY           000A   56   98  108  170
  RETURN          003CR  87
  RETURN1         009ER 138  145
  RST00           0000
  RST01           0001
```

INTERRUPT DRIVEN OPERATION-16 BIT PROCESSORS

PROG= *NONE* ASSEMBLED BY CAL 03-066R04-01 (32-BIT)

```
                                    1          SCRAT                                                                DI000000
                                    2          TARGT  32                                                            AOC00010
0000001I                            3          NLSTC                                                                DI000020
                                    4          NORX3                                                                DI000030
0000001I                            5          SQCHK                                                                DI00031
                                    8          ELSE                                                                 DI000060
0000001I                            9          ENDC                                                                 DI000080
                                   10          WIDTH  120                                                           DI000090
0000001I                           11          SQUEZ                                                                DI000100
                                   12          CROSS                                                                DI000110
                                   13  * COPYRIGHT INTERDATA MAY 1975                                               DI000120
                                   14  *                                                                            DI000130
                                   15  * THE PROGRAMMING SEQUENCES THAT FOLLOW DEMONSTRATE THE VARIOUS METHODS      DI000140
                                   16  * OF DATA TRANSFER USING THE DIGITAL I/O CONTROLLER. THE FLOW-               DI000150
                                   17  * CHARTS IN APPENDIX 2 OUTLINE THE METHODS IMPLEMENTED BELOW.IN THE          DI000160
                                   18  * FIRST EXAMPLE,DATA IS TRANSFERRED TO AND FROM THE SYSTEM WITHOUT THE      DI000170
                                   19  * USE OF HANDSHAKING OR INTERRUPT LOGIC.STATUS FROM THE INPUT AND           DI000180
                                   20  * OUTPUT SUBSYSTEMS IS IGNORED AND SYSTEM INTERRUPTS ARE DISARMED, THE     DI000190
                                   21  * SUBROUTINE DIGITIO IS CALLED TO EXECUTE DATA TRANSFERS.THE CALLING        DI000200
                                   22  * ARGUMENTS INCLUDE AN INPUT/OUTPUT OPERATION IDENTIFIER AND A POINTER      DI000210
                                   23  * TO MEMORY SPECIFYING WHERE DATA IS TO RETRIEVED OR STORED.                DI000220
                                   24  * ALL PROGRAMMING EXAMPLES RUN WITH THE TEST CABLE REFERENCED IN            DI000230
                                   25  * APPENDIX 6 OF DOCUMENT 06-188A15.                                         DI000240
                                   26  * ALL PROGRAMMING EXAMPLES ARE WRITTEN IN CAL COMMON CODE.                  DI000250
                                   27  *                                                                           DI000260
                                   28  * EQUATES AND REGISTER ALLOCATIONS                                          DI000270
     0000 000D                     29  STAT     EQU    13                STATUS REGISTER                           DI000280
     0000 0004                     30  OUTDEV   EQU    4                 OUTPUT DEVICE ADDRESS                     DI000290
     0000 0005                     31  INDEV    EQU    5                 INPUT DEVICE ADDRESS                      DI000300
     0000 0006                     32  IOIND    EQU    6                 INPUT-OUTPUT IDENTIFIER                   DI000310
     0000 0007                     33  DTAPTR   EQU    7                 POINTER TO INPUT/OUTPUT BUFFER            DI000320
     0000 0008                     34  BSY      EQU    8                 BUSY STATUS FROM DIO CONTROLLER           DI000330
     0000 000C                     35  DTAPTR1  EQU    12                INPUT BUFFER POINTER FOR INTERRUPTS       DI000340
     0000 0008                     36  IONTCMP  EQU    8                 I/O NOT COMPLETE FLAG                     DI000350
     0000 0009                     37  WK1      EQU    9                 WORK REGISTER- GENERAL PURPOSE            DI000360
     0000 000A                     38  RETRY    EQU    10                ADDRESS FOR ERROR RETRY                   DI000370
     0000 000B                     39  INTDEV   EQU    11                INTERRUPTING DEVICE ADDRESS               DI000380
     0000 000F                     40  RETN     EQU    15                SUBROUTINE RETURN ADDRESS                 DI000390
     0000 0040                     41  OLDPSWST EQU    X'40'             OLD PSW SAVE AREA 16 BIT ONLY             DI000400
     0000 0044                     42  NEWPSWST EQU    X'44'             NEW PSW STAT ON EXT INT 16 BIT ONLY       DI000410
     0000 0046                     43  NEWPSWLC EQU    X'46'             NEW PSW LOC EXT INT 16 BIT ONLY           DI000420
     0000 0003                     44  RST03    EQU    3                 EXECUTIVE REGISTER SET 0 R3               DI000430
     0000 0002                     45  RST02    EQU    2                 EXECUTIVE REGISTER SET 0 R2               DI000440
     0000 0001                     46  RST01    EQU    1                 EXECUTIVE REGISTER SET 0 R1               DI000450
     0000 0000                     47  RST00    EQU    0                 EXECUTIVE REGISTER SET 0 R0               DI000460
     0000 0000                     48  RSTF0    EQU    0                 REGISTER SET F-REGISTER SET 0             DI000470
     0000 0007                     49  DTAPTR0  EQU    7                 OUTPUT BUFFR POINTR -REGISTER SET 0       DI000480
     0000 0004                     50  OUTDEV0  EQU    4                 OUTPUT DEVICE ADDRESS. REG. SET 0         DI000490
     0000 0005                     51  INDEV0   EQU    5                 REGISTER SET 0 INPUT DEVICE ADDR          DI000500
     0000 000C                     52  DTAPTR10 EQU    12                REGISTER SET 0 INPUT BUFFER POINTER       DI000510
     0000 000E                     53  WK2      EQU    14                WORK REGISTER 2                           DI000520
     0000 0002                     54  BUFFLMST EQU    2                 BUFFER LIMIT STATUS                       DI000530
0000001I E690 00F0                 55  DIOENTR  LDAI   WK1,X'F0'          SELECT REGISTER SET X'F'                  DI000540
0000041I 95A9                      56          EPSR   RETRY,WK1          EXCHANGE PROGRAM STATUS                   DI000541
```

```
0000061  4840 8198          57           LH     OUTDEV,DEVADR1     GET THE OUTPUT DEVICE ADDRESS          DI000542
00000AI  DE40 819C          58           OC     OUTDEV,DISARM      DISARM OUTPUT DEVICE LOGIC.            DI000550
00000EI  4850 8192          59           LH     INDEV,DEVADR2      GET THE INPUT DEVICE ADDRESS           DI000560
0000121  DE50 8194          60           OC     INDEV,DISARM       DISARM INPUT DEVICE INTERRUPTS         DI000580
0000161  2461               61           LIS    IOIND,1            SET THE I/O INDICATOR FOR DIO OUTPUT   DI000590
000018I  E670 818A          62           LDAI   DTAPTR,OUTBUFFR    GET THE POINTER TO THE OUTPUT DATA     DI000600
00001CI  41F0 800E          63           BAL    RETN,DIGITIO       CALL THE SUBROUTINE TO WRITE DATA.     DI000610
0000201  0766               64           XAR    IOIND,IOIND        RESET THE IO INDICATOR FOR INPUT OP    DI000620
0000221  E670 8182          65           LDAI   DTAPTR,INBUFFR     GET POINTER FOR INPUT DATA             DI000630
0000261  41F0 8004          66           BAL    RETN,DIGITIO       GO READ THE INPUT DATA                 DI000640
00002AI  C200 816A          67           LPSW   WAIT               HALT THE MACHINE                       DI000650
                            68  *                                                                         DI000660
                            69  * SUBROUTINE DIGITIO TRANSFERS 16 BITS OF PARALLEL BINARY DATA EITHER     DI000670
                            70  * TO THE DIGITAL I/O SYSTEM OR FROM THE DIGITAL I/O SYSTEM. STATUS LOG-   DI000680
                            71  * IC FROM THE CONTROLLER IS IGNORED. AMONG THE CALLING ARGUMENTS ARE AN    DI000690
                            72  * INPUT/OUTPUT INDICATOR FLAG,PHYSICAL DEVICE ADDRESS AND A POINTER TO    DI000700
                            73  * THE RESPECTIVE INPUT OR OUTPUT DATA BUFFER.                             DI000710
                            74  *                                                                         DI000720
                            75  * CALLING SEQUENCE: BAL RETN,DIGITIO                                      DI000730
                            76  * INPUT REGISTERS: OUTDEV= OUTPUT DEVICE ADDRESS(EVEN DEVICE ADDR.)       DI000740
                            77  *                  INDEV= INPUT DEVICE ADDRESS (ODD DEVICE ADDRESS)       DI000750
                            78  *                  IOIND= INPUT OUTPUT IDENTIFIER                         DI000760
                            79  *                  DTAPTR= POINTER TO INPUT OR OUTPUT BUFFER              DI000770
                            80  * REGISTERS DESTROYED:NONE                                                DI000780
                            81  * SUBROUTINE OUTPUT DATA STORED IN MEMORY LOCATION SPECIFIED BY POINTER   DI000790
                            82  * DTAPTR.IF IOIND=0 OPERATION IS A READ OTHERWISE IT IS A WRITE           DI000800
                            83  *                                                                         DI000810
00002EI  0866               84  DIGITIO LDAR   IOIND,IOIND        CHECK THE I/O INDICATOR FLAG           DI000820
*000030I  2334               85           BZ     READIN             BRANCH TO READ OPERATION               DI000830
0000321  D847 0000          86           WH     OUTDEV,0(DTAPTR)   WRITE A HALFWORD FROM OUTBUFFER        DI000840
*000036I  2303               87           B      RETURN                                                    DI000850
0000381  D957 0000          88  READIN  RH     INDEV,0(DTAPTR)    READ A HALFWORD INTO INPUT BUFFER      DI000860
00003CI  030F               89  RETURN  BR     RETN               RETURN TO THE USER.                    DI000870
                            90  *                                                                         DI000880
```

SENSE-STATUS PROGRAMMING EXAMPLES

```
                                92  * IN THIS EXAMPLE THE DATA TRANSFERS ARE SYNCHRONIZED WITH THE CONTROL-   DIO00900
                                93  * LER THROUGH THE USE OF HANDSHAKING SIGNALS ASSOCIATED WITH THE DEVICE  DIO00910
                                94  * A COMPLETE DESCRIPTION OF THE BUSY STATUS IS INCLUDED IN SECTION 4      DIO00920
                                95  *                                                                        DIO00930
                                96  *                                                                        DIO00940
00003E1  E690 00F0              97  DIOENTR1 LDAI   WK1,X'F0'          SELECT REGISTER SET X'F'              DIO00950
0000421  95A9                   98           EPSR   RETRY,WK1          EXCHANGE PROGRAM STATUS               DIO00951
0000441  4840 815A              99           LH     OUTDEV,DEVADR1     GET THE OUTPUT DEVICE ADDRESS         DIO00952
0000481  0E40 815E             100           OC     OUTDEV,DISARM      DISARM SYSTEM INTERRUPTS              DIO00960
00004C1  4850 8154             101           LH     INDEV,DEVADR2      GET THE INPUT SYSTEM DEVICE ADDRESS   DIO00970
00005001 0E50 8156             102           OC     INDEV,DISARM       DISARM INPUT DEVICE INTERRUPTS        DIO00990
0000541  2461                 103           LIS    IOIND,1            SET THE I/O IND FOR OUTPUT OP         DIO01000
0000561  9959                 104           RHR    INDEV,WK1          EXECUTE A READ OPERATION TO INITIA-   DIO01010
                               105  * LIZE THE DIGITAL I/O STATUS                                           DIO01020
0000581  E670 814A             106  CONT     LDAI   DTAPTR,OUTBUFFR    GET THE DATA POINTER TO OUTPUT BUFFR  DIO01030
00005C1  41F0 8010             107           BAL    RETN,DIGITI01      GO TO DIGITAL I/O ROUTINE FOR OUTPUT  DIO01040
00006001 E6A0 FFF4             108           LDAI   RETRY,CONT         GO CHECK IF OP WAS COMPLETED          DIO01050
0000641  41F0 8038             109           BAL    RETN,CHECK         GO TO DIGITAL I/O ROUTINE FOR INPUT   DIO01060
0000681  41F0 8004             110           BAL    RETN,DIGITI01      HALT THE PROCESSOR                    DIO01070
00006C1  C200 8148             111           LPSW   WAIT                                                     DIO01080
                               112  * SUBROUTINE DIGITI01 FIRST CHECKS TO INSURE THAT BUSY STATUS FROM THE   DIO01090
                               113  * DESIRED SUBSYSTEM IS ZERO. IF IT IS NOT,THEN THE PERIPHERAL DEVICE     DIO01100
                               114  * IS NOT READY FOR DATA TRANSFER AND THE SUBROUTINE RETURNS TO THE USER  DIO01110
                               115  * WITH THE IONTCMP FLAG SET=1.OTHERWISE,THE SUBROUTINE WILL EXECUTE THE  DIO01120
                               116  * APPROPRIATE READ OR WRITE OPERATION AND INSURE THAT THE BUSY STATUS    DIO01130
                               117  * WAS SET=1 FOLLOWING THE I/O OPERATION.                                 DIO01140
                               118  *                                                                        DIO01150
                               119  * CALLING SEQUENCE: BAL RETN,DIGITI01                                    DIO01160
                               120  * INPUT REGISTERS:                                                       DIO01170
                               121  *                  OUTDEV=OUTPUT DEVICE ADDRESS(EVEN DEVICE ADDRESS)     DIO01180
                               122  *                  INDEV=INPUT DEVICE ADDRESS (ODD DEVICE ADDRESS)       DIO01190
                               123  *                  IOIND= INPUT/OUTPUT IDENTIFIER                        DIO01200
                               124  *                  DTAPTR= POINTER TO INPUT OR OUTPUT BUFFER             DIO01210
                               125  * REGISTERS DESTROYED: R8=IONTCMP,WK1=R9                                  DIO01220
                               126  *                                                                        DIO01230
                               127  *                                                                        DIO01240
0000701  0866                 128  DIGITI01 LDAR   IOIND,IOIND        GET THE INPUT/OUTPUT OP IDENTIFIER    DIO01250
*0000721  213D                 129           BNZ    WRITEOP            IF ITS SET, ITS A WRITE OPERATION.    DIO01260
0000741  4850 812C             130           LH     INDEV,DEVADR2      OTHERWISE,GET THE INPUT DEV.ADDRESS   DIO01270
0000781  9D5D                  131           SSR    INDEV,STAT         GET THE STATUS OF THE DEVICE          DIO01290
*00007A1  2383                 132           BFC    BSY,CONT1          IF ITS ZERO,DO THE READ OPERATION     DIO01300
 00007C1  4300 801C            133           B      EXITINCP           OTHERWISE, SET THE I/O NOT COMPLETE   DIO01310
                               134  *                                 FLAG AND RETURN TO THE USER           DIO01320
 0000801  D957 0000            135  CONT1    RH     INDEV,0(DTAPTR)    READ A HALFWORD OF DIGITAL DATA AND   DIO01330
0000841  9D5D                  136           SSR    INDEV,STAT         CHECK INPUT STATUS BUSY SHOULD SET.   DIO01340
0000861  4380 8086             137           BFC    BSY,ERROR          IF IT DION'T,THE DEVICE IS IN ERROR.  DIO01350
*00008A1  230A                 138           B      RETURN1            RETURN TO THE USER.                   DIO01360
 00008C1  9D4D                 139  WRITEOP  SSR    OUTDEV,STAT        SENSE DEVICE STATUS.                  DIO01370
*00008E1  2187                 140           BTC    BSY,EXITINCP       IF THE BUSY BIT IS SET,SET I/O NOT    DIO01380
                               141  *                                 COMPLETE AND RETURN.                  DIO01390
 0000901  D847 0000            142  CONT2    WH     OUTDEV,0(DTAPTR)   DO THE WRITE OPERATION.               DIO01400
0000941  9D4D                  143           SSR    OUTDEV,STAT        SENSE DEVICE STATUS                   DIO01410
0000961  4380 8076             144           BFC    BSY,ERROR          BUSY BIT SHOULD BE SET                DIO01420
*00009A1  2302                 145           B      RETURN1            RETURN TO THE USER                    DIO01430
```

INTERRUPT DRIVEN OPERATION-32 BIT PROCESSORS

```
                                225  *                                                                        DI002230
                                226  * THE FOLLOWING EXAMPLE DEMONSTRATES THE USE OF INTERRUPTS IN SYNCHRON-  DI002240
                                227  * IZING DATA TRANSFERS, USING THE INTERRUPT STRUCTURE OF THE SERIES 32   DI002250
                                228  * PROCESSORS.WHEN THE PERIPHERAL DEVICE REQUIRES SERVICING, AN EXTERNAL  DI002260
                                229  * INTERRUPT IS GENERATED.THE INTERRUPTS GENERATED BY THE DIO CONTROLLER   DI002270
                                230  * CAN BE DISABLED/ENABLED OR DISARMED BY THE APPROPRIATE PROCESSOR        DI002280
                                231  * OUTPUT COMMAND. THIS PROCESS IS DESCRIBED IN DETAIL                    DI002290
                                232  * IN THE SECTION ENTITLED COMMAND AND STATUS BYTES.                      DI002300
                                233  *                                                                        DI002310
0000B2I  E690 00F0              234  DIOENTR2 LDAI   WK1,X'F0'          SELECT REGISTER SET X'F'             DI002320
0000B6I  95A9                   235           EPSR   RETRY,WK1          EXCHANGE PROGRAM STATUS              DI002321
0000B8I  4840 80E6              236           LH     OUTDEV,DEVADR1     GET THE OUTPUT DEVICE ADDRESS        DI002322
0000BCI  4850 80E4              237           LH     INDEV,DEVADR2      GET THE INPUT DEVICE ADDRESS         DI002330
0000C0I  0894                   238           LDAR   WK1,OUTDEV         GET THE OUTPUT DEVICE ADDRESS        DI002350
0000C2I  1191                   239           SLLS   WK1,1              MULTIPLY IT BY 2 FOR INDEXING INTO   DI002360
0000C4I  E6E0 802C              240           LDAI   WK2,WRITEINT       LOCORE,GET INT. SERVICE ROUTINE ADDR DI002370
0000C8I  40E9 00D0              241           STH    WK2,X'D0'(WK1)     STORE INTERRUPT HANDLER ADDRESS      DI002380
0000CCI  0895                   242           LDAR   WK1,INDEV          GET INPUT DEVICE ADDRESS             DI002390
0000CEI  1191                   243           SLLS   WK1,1              MULTIPLY IT BY TWO FOR INDEXING      DI002400
0000D0I  E6E0 802E              244           LDAI   WK2,READINT        IN LOCORE, AFTER STORING THE ADDRESS  DI002410
0000D4I  40E9 00D0              245           STH    WK2,X'D0'(WK1)     OF THE INTERRUPT HANDLER ENABLE DIO  DI002420
0000D8I  DE40 80CF              246           OC     OUTDEV,ENABLE      INPUT AND OUTPUT INTERRUPTS          DI002430
0000DCI  DE50 80CB              247           OC     INDEV,ENABLE                                            DI002440
0000E0I  E670 80C2              248           LDAI   DTAPTR,OUTBUFFR    INITIALIZE THE POINTERS TO THE       DI002450
0000E4I  E6C0 80C0              249           LDAI   DTAPTR1,INBUFFR    INPUT AND OUTPUT DATA BUFFERS.       DI002460
0000E8I  D040 8144              250           STM    OUTDEV,RSAVE       STORE REG. SET X'F'                  DI002470
0000ECI  D847 0000              251           WH     OUTDEV,0(DTAPTR)                                        DI002520
0000F0I  C200 80C4              252           LPSW   WAIT               WAIT WITH INTERRUPTS ENABLED         DI002530
                                253  * WRITE SERVICE REQUESTS ENTER HERE:                                    DI002540
0000F4I  0833                   254  WRITEINT LDAR   RST03,RST03        TEST THE INTERRUPTING STATUS         DI002550
*0000F6I 213D                   255           BNZ    ERROR              A NON-ZERO STATUS IS AN ERROR COND.  DI002560
0000F8I  D847 0000              256           WH     OUTDEV0,0(DTAPTR0) WRITE DATA TO THE DIO CONTROLLER     DI002570
0000FCI  D140 8130              257           LM     OUTDEV,RSAVE       LOAD REG. SET 0: REG.4-REG X'F'      DI002571
0001001  1800                   258           LPSWR  RST00              RETURN TO USER                       DI002580
                                259  * READ SERVICE INTERRUPTS ENTER HERE:                                   DI002590
0001021  0833                   260  READINT  LDAR   RST03,RST03        TEST THE INTERRUPTING STATUS         DI002600
*0001041 2136                   261           BNZ    ERROR              A NON-ZERO STATUS IS AN ERROR COND.  DI002610
0001061  D95C 0000              262           RH     INDEV0,0(DTAPTR10) READ DATA FROM THE DIO CONTROLLER    DI002620
00010AI  D140 8122              263           LM     OUTDEV,RSAVE       LOAD REG. SET 0: REG.4-REG X'F'      DI002621
00010EI  1800                   264           LPSWR  RST00              RETURN TO USER                       DI002630
0001101                         265           ENDC                                                           DI002640
```

INTERRUPT DRIVEN OPERATION-32 BIT PROCESSORS

```
                                267  * ERRORS CAUSE THE MACHINE TO HALT IN THE WAIT STATE WITH                DI002660
                                268  * INTERRUPTS DISABLED                                                    DI002670
000110I  C200 809C              269  ERROR    LPSW   ERR              ON AN ERROR HALT THE MACHINE WITH LOC  DI002680
                                270  *                            POINTING TO ERR                           DI002690
000114I                         271           IFNZ   ADC-2                                                    DI002700
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                                273  *                                                                    DI002720
                                274  * THE FOLLOWING EXAMPLE DEMONSTRATES THE USE OF THE SERIES 32 AUTO-DR-  DI002730
                                275  * IVER CHANNEL IN EXECUTING DIGITAL INPUT-OUTPUT SYSTEM DATA TRANSFERS.  DI002740
                                276  * TWO CHANNEL COMMAND BLOCKS ARE ESTABLISHED TO CONTROL WRITE OPERATION  DI002750
                                277  * AND READ OPERATION RESPECTIVELY. THE LOW CORE INTERRUPT SERVICE POINT  DI002760
                                278  * ER TABLE IS SET UP WITH THE ADDRESS OF THE CHANNEL CONTROL BLOCKS+1     DI002770
                                279  * CHANNEL CONTROL BLOCKS ARE SET UP PRIOR TO AUTO-DRIVER SERVICING.      DI002780
000114I  E690 00F0              280  DIOENTR3 LDAI   WK1,X'F0'          SELECT REG. SET X'F'                 DI002790
000118I  95A9                   281           EPSR   RETRY,WK1          EXCHANGE PROGRAM STATUS              DI002791
00011AI  4840 8084              282           LH     OUTDEV,DEVADR1     GET THE OUTPUT DEVICE ADDRESS        DI002792
00011EI  4850 8082              283           LH     INDEV,DEVADR2      GET THE INPUT DEVICE ADDRESS         DI002800
000122I  0894                   284           LDAR   WK1,OUTDEV         GET THE OUTPUT DEVICE ADDRESS        DI002820
000124I  1191                   285           SLLS   WK1,1              MULTIPLY IT BY TWO FOR INDEXING      DI002830
000126I  E6E0 8096              286           LDAI   WK2,CCB1           GET THE WRITE CHANNEL CONTROL BLOCK  DI002840
00012AI  26E1                   287           AIS    WK2,1              MAKE IT ODD                          DI002850
00012CI  40E9 00D0              288           STH    WK2,X'D0'(WK1)     STORE IT IN THE INTERRUPT SERVICE    DI002860
                                289  *                                 TABLE                                DI002870
000130I  0895                   290           LDAR   WK1,INDEV          SIMILIARLY SET UP LOW CORE TO        DI002880
000132I  1191                   291           SLLS   WK1,1              SERVICE READ OR INPUT SERVICE INTRPT  DI002890
000134I  E6E0 80A0              292           LDAI   WK2,CCB2           GET THE WRITE CHANNEL CONTROL BLOCK  DI002900
000138I  26E1                   293           AIS    WK2,1              MAKE IT ODD                          DI002910
00013AI  40E9 00D0              294           STH    WK2,X'D0'(WK1)     AND STORE IT IN LOW CORE             DI002920
                                295  *                                                                      DI002930
00013EI  E690 8054              296           LDAI   WK1,WRITERM        LOAD ADDRESS OF WRITE TERMINAL       DI002940
000142I  4090 808E              297           STH    WK1,SUBADR         SUBROUTINE IN THE WRITE CHANNEL      DI002950
000146I  E690 4000 FF85         298           LDAI   WK1,X'FF85'        CONTROL BLOCK- STORE WRITE CHANNEL   DI002960
00014CI  4090 8070              299           STH    WK1,CCB1           COMMAND WORD IN THE WRITE CHANNEL    DI002970
000150I  E690 809C              300           LDAI   WK1,OTBFFRS        CONTROL BLOCK.                       DI002980
000154I  E6E0 80B7              301           LDAI   WK2,OTBFFRE        GET THE OUTPUT BUFFER END ADDRESS    DI002990
000158I  50E0 8068              302           ST     WK2,BUFEND         STORE IT IN THE WRITE CONTROL BLOCK  DI003000
00015CI  0B9E                   303           SR     WK1,WK2            CALCULATE THE BUFFER BYTE COUNT      DI003010
00015EI  4090 8060              304           STH    WK1,BUFCOUNT       STORE RESULT IN THE CONTROL BLOCK.   DI003020
000162I  E690 8036              305           LDAI   WK1,READTERM       LOAD ADDRESS OF THE READ TERMINAL    DI003030
000166I  4090 8082              306           STH    WK1,SUBADR1        SUBROUTINE AND STORE IT IN THE READ  DI003040
                                307  *                                 CONTROL BLOCK.                       DI003050
00016AI  E690 4000 FF81         308           LDAI   WK1,X'FF81'        LOAD THE CHANNEL COMMAND WORD.       DI003060
000170I  4090 8064              309           STH    WK1,CCB2           STORE IT IN THE READ CONTROL BLOCK.  DI003070
000174I  E690 8098              310           LDAI   WK1,INBUFFRS       GET THE INPUT BUFFER START ADDRESS   DI003080
000178I  E6E0 80B3              311           LDAI   WK2,INBUFFRE       GET THE INPUT BUFFER END ADDRESS     DI003090
00017CI  50E0 805C              312           ST     WK2,BUFEND1        STORE IT IN THE CONTROL BLOCK        DI003100
000180I  0B9E                   313           SR     WK1,WK2            CALCULATE THE BYTE COUNT             DI003110
000182I  4090 8054              314           STH    WK1,BUFCONT1       STORE IT IN THE CONTROL BLOCK.       DI003120
000186I  DE40 8021              315           OC     OUTDEV,ENABLE      ENABLE OUTPUT INTERRUPTS             DI003130
00018AI  DE50 801D              316           OC     INDEV,ENABLE       ENABLE INPUT INTERRUPTS              DI003140
00018EI  D95C 0000              317           RH     INDEV,0(DTAPTR1)   PERFORM READ OP TO GEN FIRST INTRPT  DI003200
000192I  C200 8022              318           LPSW   WAIT               WAIT WITH INTERRUPTS ENABLED         DI003210
                                319  * WRITE TERMINAL SUBROUTINE ADDRESS                                    DI003220
                                320  *                                 SENSE STATUS ON OUTPUT DEVICE        DI003230
000196I  4320 FF76              321  WRITERM  BFC    BUFFLMST,ERROR     IF NOT BUFF LIMIT STATUS ERROR       DI003240
000198I  1800                   322           LPSWR  RST00              RETURN TO THE USER                   DI003250
                                323  * READ TERMINAL SUBROUTINE                                            DI003260
                                324  *                                                                      DI003270
00019CI  4320 FF70              325  READTERM BFC    BUFFLMST,ERROR     IF NOT BUFFER LIMIT STATUS           DI003280
0001A0I  1800                   326           LPSWR  RST00              ITS IN ERROR                         DI003290
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SERIES 32 AUTO-DRIVER CHANNEL-DIGITAL I/O OPERATION

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                                328          ENDC                                                    DI003310
                                329  * MEMORY CONSTANTS,BUFFER AREAS AND COMMANDS                    DI003320
0001A2I  0000                   330  DEVADR1  DC      X'0'            OUTPUT DEVICE ADDRESS          DI003330
0001A4I  0000                   331  DEVADR2  DC      X'0'            INPUT DEVICE ADDRESS           DI003340
0001A6I  0000                   332  OUTBUFFR DC      X'0'            OUTPUT BUFFER                  DI003350
0001A8I  0000                   333  INBUFFR  DC      X'0'            INPUT BUFFER                   DI003360
0001AAI  C040                   334  DISARM   DC      X'C040'         DISARM INTERRUPTS (DIO CONTROLLER) DI003370
         0000 01ABI             335  ENABLE   EQU     *-1             ENABLE DIO INTERRUPTS          DI003380
0001B0I                         336          ALIGN   8                                              DI003390
         0000 01B0I             337  ERR      EQU     *                                              DI003400
                                341          ELSE                                                   DI003440
0001B0I  0000 80F0              342          DC      Y'80F0'         32 BIT PSW STATUS WAIT STATE   DI003450
0001B4I  0000 01B0I             343          DC      A(ERR)          32 BIT PSW LOC ON ERROR HALT   DI003460
0001B8I                         344          ENDC                                                   DI003470
0001B8I                         345          ALIGN   8                                              DI003480
         0000 01B8I             346  WAIT     EQU     *                                              DI003490
                                350          ELSE                                                   DI003530
0001B8I  0000 C0F0              351          DC      Y'C0F0'         32 BIT PSW STATUS WAIT STATE   DI003540
0001BCI  0000 01B8I             352          DC      A(WAIT)         INTERRUPTS ENABLED LOC=WAIT    DI003550
0001C0I                         353          ENDC                                                   DI003560
0001C0I                         354          ALIGN   4                                              DI003570
0001C0I                         355          IFNZ    ADC-2                                          DI003580
                                356  * THE FOLLOWING CHANNEL COMMAND BLOCKS CONTROL THE DIO INPUT OR OUTPUT DI003590
                                357  * REQUESTS AND PROVIDE THE USER WITH AN EXAMPLE OF ESTABLISHING THE DI003600
                                358  * CONTROL PARAMETERS                                            DI003610
0001C0I  0000                   359  CCB1     DC      H'0'            CCW WORD- WRITEIN THE FAST MODE DI003620
0001C2I  0000                   360  BUFCOUNT DC      H'0'            WRITE OUTPUT BUFFER COUNT      DI003630
0001C4I  0000 0000              361  BUFEND   DC      F'0'            END ADDRESS OF BUFFER          DI003640
0001C8I  0000                   362  CHECK1   DC      H'0'            CHECK BYTE                     DI003650
0001CAI  0000                   363  BUF1CNT  DC      H'0'            BUFFER 1 COUNT                 DI003660
0001CCI  0000 0000              364  BUF1END  DC      F'0'            BUFFER 1 END ADDRESS           DI003670
0001D0I  0000 0000              365  TABLE    DC      F'0'            ADDRESS OF TRANSLATION TABLE   DI003680
0001D4I  0000                   366  SUBADR   DC      H'0'            ADDRESS OF TERMINATION SUBROUTINE DI003690
                                367  *                                                              DI003700
                                368  *                                                              DI003710
                                369  *                                                              DI003720
0001D8I                         370          ALIGN   4                                              DI003730
0001D8I  0000                   371  CCB2     DC      H'0'            CCW WORD- READ IN THE FAST MODE DI003740
0001DAI  0000                   372  BUFCONT1 DC      H'0'            READ INPUT BUFFER COUNT        DI003750
0001DCI  0000 0000              373  BUFEND1  DC      F'0'            END ADDRESS OF READ BUFFER     DI003760
0001E0I  0000                   374  CHECK2   DC      H'0'            CHECK BYTE                     DI003770
0001E2I  0000                   375  BUF1CNT1 DC      H'0'            BUFFER1 COUNT                  DI003780
0001E4I  0000 0000              376  BUF1END1 DC      F'0'            BUFFER1 END ADDRESS            DI003790
0001E8I  0000 0000              377  TABLE1   DC      F'0'            ADDRESS OF TRANSLATION TABLE   DI003800
0001ECI  0000                   378  SUBADR1  DC      H'0'            ADDRESS OF TERMINATION SUBROUTINE DI003810
0001F0I                         379          ALIGN   4                                              DI003820
0001F0I                         380  OTBFFRS  DSH     16              16 HALFWORDS OF DIGITAL OUTPUT DATA DI003830
         0000 020FI             381  OTBFFRE  EQU     *-1             BUFFER END ADDRESS             DI003840
000210I                         382  INBUFFRS DSH     16              16 HALFWORDS OF DIGITAL INPUT DATA DI003850
         0000 022FI             383  INBUFFRE EQU     *-1             BUFFER END ADDRESS             DI003860
000230I                         384          ALIGN   4                                              DI003870
000230I                         385  RSAVE    DSF     16              REGISTER SAVE AREA FOR INTERRUPT DI003880
                                386  * SUBROUTINE AND AUTO-DRIVER CHANNEL SUBROUTINE                DI003890
                                388          ENDC                                                   DI003910
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0002701                 389         END                                 DI003920
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SERIES 32 AUTO-DRIVER CHANNEL-DIGITAL I/O OPERATION

NO ERRORS 3 SQUEZ PASSES

CAL 04-01

```
ABSTOP    0000 0000
ADC       0000 0004      6   175   271   338   347   355
BSY       0000 0006    132   137   140   144
BUF1CNT   0000 01CAI
BUF1CNT1  0000 01E2I
BUF1END   0000 01CCI
BUF1END1  0000 01E4I
BUFCONT1  0000 01DAI   314
BUFCOUNT  0000 01C2I   304
BUFEND    0000 01C4I   302
BUFEND1   0000 01DCI   312
BUFFLMST  0000 0002    321   325
CCB1      0000 01C0I   286   299
CCB2      0000 01D8I   292   309
CHECK     0000 00A0I   109
CHECK1    0000 01C8I
CHECK2    0000 01E0I
CONT      0000 0058I   108
CONT1     0000 0080I   132
CONT2     0000 0090I
DEVADR1   0000 01A2I    57    99   236   282
DEVADR2   0000 01A4I    59   101   130   237   283
DIGITI01  0000 0070I   107   110
DIGITIO   0000 002EI    63    66
DIOENTR   0000 0000I
DIOENTR1  0000 003EI
DIOENTR2  0000 00B2I
DIOENTR3  0000 0114I
DISARM    0000 01AAI    58    60   100   102
DTAPTR    0000 0007     62    65    86    88   106   135   142   171   248   251
DTAPTR0   0000 0007    256
DTAPTR1   0000 000C    249   317
DTAPTR10  0000 000C    262
ENABLE    0000 01ABI   246   247   315   316
ERR       0000 01B0I   269   343
ERROR     0000 0110I   137   144   255   261   321   325
EXITINCP  0000 009CI   133   140
IMPTOP    0000 0270I
INBUFFR   0000 01A8I    65   171   249
INBUFFRE  0000 022FI   311
INBUFFRS  0000 0210I   310
INDEV     0000 0005     59    60    88   101   102   104   130   131   135   136   237   242   247
                       283   290   316   317
INDEV0    0000 0005    262
INTDEV    0000 000B
IOIND     0000 0006     61    64    64    84    84   103   128   128   172   172
IONTCMP   0000 000B    146   167   167   169   169   173   173
LADC      0000 0002
NEWPSWLC  0000 0046
NEWPSWST  0000 0044
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