

# DIO1

## Digital Input/Output Module

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The DIO1 Digital Input/Output Module 1 provides 32 programmable digital input/output channels at LS-TTL levels. These channels are grouped into 8-bit ports, and each port can be individually programmed for input or output by on-card DIP switches. Rapid settling times allow sampling of high-speed digital inputs. Outputs are latched to allow asynchronous reading of the output data.

I/O connections are made to on-card screw terminals, which accept 16-24 gage wire leads. In addition to the screw terminals, a jack is provided for quick connection and disconnection of inputs and outputs.

The DIO1 module can be installed in any available slot in the system; however, digital modules should generally be placed in the high-numbered slots if any analog modules are present in the system. To install the module, remove the baseboard top cover and insert the module into the desired slot with the component side facing the power supply.

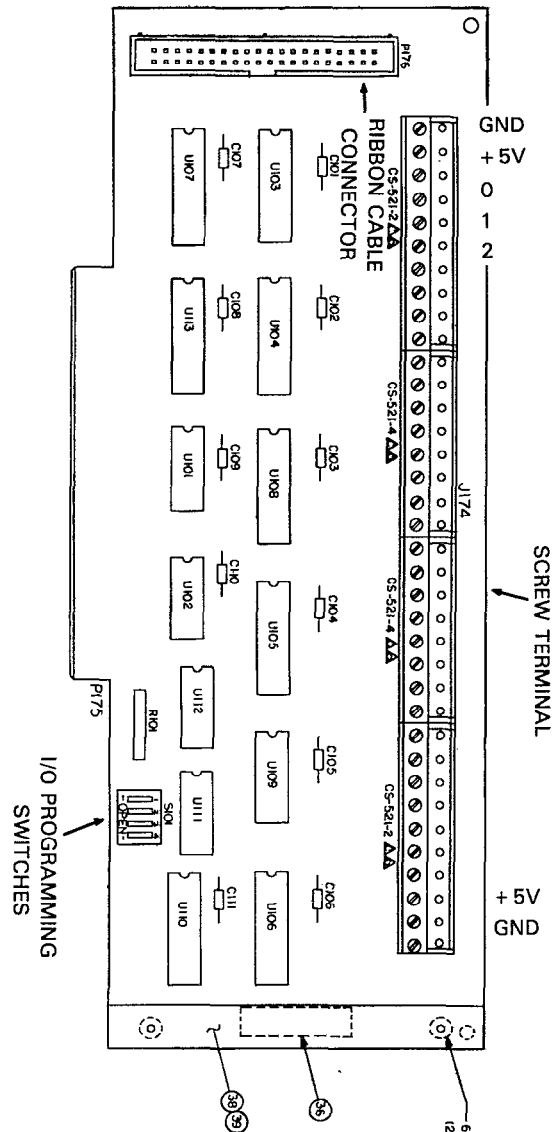
**CAUTION:** Always turn off the baseboard power before installing or removing modules. Replace the top cover and secure it with screws. To avoid the possibility of EMI radiation, never operate the system with the top cover removed.

### User-Configured Components

User-configured components for the DIO1 include the input/output connections and the I/O programming DIP switches, as listed in Table 1. Connections can be made either to screw terminals at the top of the module or to a separate on-card jack, which allows the quick connection and disconnection of I/O lines. Input/output programming of each of the four ports is performed by setting DIP switches located on S101. For the location of these components, refer to Figure 1.

Table 1. User-Configured Components

Component	Designation	Function
Screw Terminals	J174	Input Output Signal Connections
I/O Connector	P176	Quick Disconnect Signal Connections
DIP Switches	S101	Program Ports A-D for Input/Output

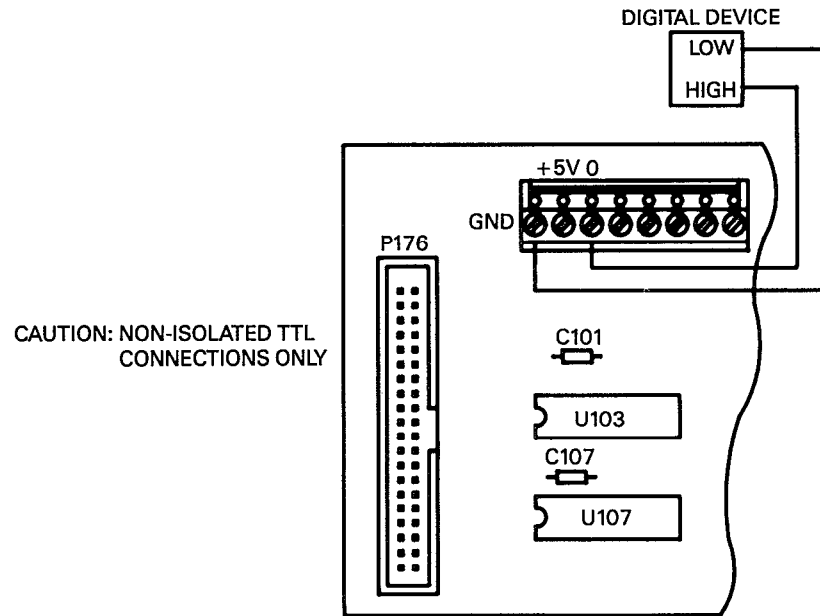


**Figure 1. DIO1 Module Configuration**

**Connections**

The screw terminals, which provide one means of making input/ output connections, are located on J174 across the top edge of the module board. The channel numbers for the 32 inputs (0-31) are marked on the board and are also shown in Figure 1. Two con-

nections each for module ground (GND) and +5V are also included on the terminal strip. The terminals are intended for 16-24 gage wire stripped to 3/16 of an inch. Typical input/output connections when using the screw terminals are shown in Figure 2.

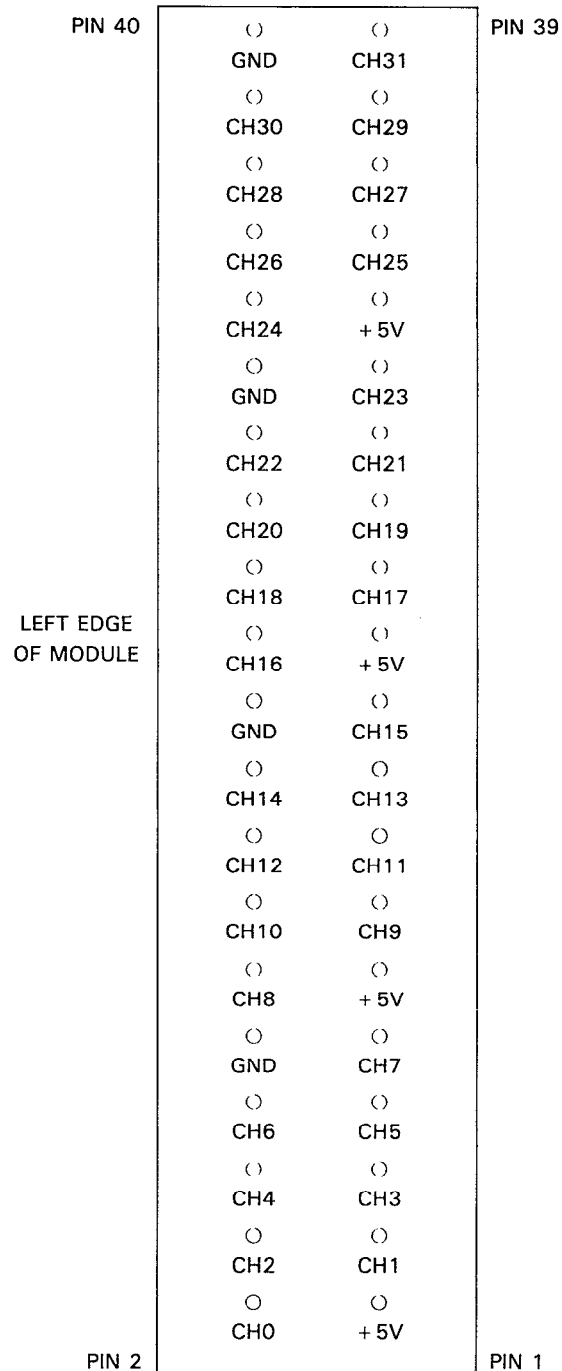


**Figure 2. Typical DIO1 Connections**

In situations requiring rapid connection or disconnection of signal lines, P176 can be used as an alternate method of signal connection. Figure 3 shows the pin diagram for the mating plug for P176, which is designed for use with a suitable ribbon cable. When connecting external circuits in this manner, the screw terminals should not be used.

If EMI radiation becomes a problem, use shielded cable for input/ output connections. Connect the shield to baseboard ground only, and leave the other end of the shield disconnected. Do not use the shield as a signal carrying lead.

**CAUTION: DIO1 inputs and outputs are non-isolated, meaning that circuit low is connected to power line ground. Any circuits connected to the module must also be referenced to power line ground and must not be floating.**



**Figure 3. Connector Terminal Configuration**

## Input/Output Programming

The 32 digital input/output channels of the DIO1 are grouped into four ports of eight bits each. Port A consists of channels 0-7, port B of 8-15, port C of 16-23, and port D of 24-31. Each port (and thus, the eight channels associated with that port) can be individually programmed as an input or an output port by setting the appropriate DIP switch on S101, as indicated in Table 2.

For a port to be programmed for output, the associated switch must be open (off); for it to be programmed for input, the switch must be closed (on). All channels associated with a particular port will be programmed for input or output simultaneously. For example, if port C is programmed as an output port, channels 16-23 will all be configured as outputs.

**Table 2. Input/Output Programming**

<u>Switch Position (S101)*</u>	<u>Port</u>	<u>Channels</u>
1	A	0-7
2	B	8-15
3	C	16-23
4	D	24-31

\*S101 switch open (off) to program port for output; closed (on) to program port for input.

## TTL Levels and Loading Considerations

When configured for input, each channel of the DIO1 represents one LS TTL load to external circuitry (20 $\mu$ A high, 0.2mA low). Logic low should be between 0V and 0.8V, and logic high should be between 2V and 5V (standard TTL levels).

When set up for output, each channel is capable of driving a maximum of 60 LS TTL or 15 standard TTL inputs (maximum output is 1.2mA high, and 24mA low). Logic low will be in the range of 0V to 0.5V, and logic high will be between 2.7V and 5V.

## Commands

DIO1 module commands include those necessary to select the input/output port and to read or write data to the selected port, as summarized in Table 3. The locations for these commands will depend on the slot in which the DIO1 is placed, as indicated in Table 4.

**Table 3. Command Used with the DIO1 Module**

<u>Command</u>	<u>Location</u>
SELECT PORT	Slot-dependent CMDB
DIGITAL I/O	Slot-dependent CMDB

**Table 4. Locations for Slot-Dependent Commands**

<b>Slot</b>	<b>SELECT PORT (CMDA)</b>	<b>DIGITAL I/O (CMDB)</b>
Slot 1	CFF80	CFF81
Slot 2	CFF82	CFF83
Slot 3	CFF84	CFF85
Slot 4	CFF86	CFF87
Slot 5	CFF88	CFF89
Slot 6	CFF8A	CFF8B
Slot 7	CFF8C	CFF8D
Slot 8	CFF8E	CFF8F
Slot 9	CFF90	CFF91
Slot 10	CFF92	CFF93

### **SELECT PORT**

Location: Slot-dependent CMDA

The SELECT PORT command is used to select which of the four ports (port A, B, C, or D) is to be used for digital I/O operations. To select the desired port, write the appropriate value (see Table 5) to the SELECT PORT location before writing or reading a specific port. From BASIC, port selection can be performed by POKEing the correct value to this location. Note that the actual memory location will depend on the slot being used (see Table 4).

Once the SELECT PORT command is given, the selected port will remain active until another port is selected by writing a new value to this location. The SELECT PORT command should always be given at least once to avoid random port selection.

**Table 5. Values Written to the SELECT PORT Location**

<b>Port</b>	<b>Channels</b>	<b>Binary</b>	<b>Hex</b>	<b>Decimal</b>
A	0-7	00	H0	0
B	8-15	01	H1	1
C	16-23	10	H2	2
D	24-31	11	H3	3

### **DIGITAL I/O**

Location: Slot-dependent CMDB

The DIGITAL I/O command is used to access data from a selected port when that port is configured for input, or to write data to a selected port if that port is set up for output. Note that each of the four ports can be individually programmed for input or output by setting on-card DIP switches, as discussed in the section on input/output programming.

When a port is configured as an input port, the DIGITAL I/O location is read to access the status of the channels associated with that port. Reading this location will return an 8-bit binary number, with the D0 through D7 lines representing the input lines for the

selected port, as indicated in Table 6. Since the inputs are not latched, the data will reflect the condition of the input channels at the time the read operation is performed. Note that the channels being read will depend on the port selected with the SELECT PORT command, as discussed previously.

**Table 6. Digital I/O Channels and Corresponding Bit Values**

<b>Bit Position</b>	<b>D7</b>	<b>D6</b>	<b>D5</b>	<b>D4</b>	<b>D3</b>	<b>D2</b>	<b>D1</b>	<b>D0</b>
Weighting	128	64	32	16	8	4	2	1
Port A	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0
Port B	Ch15	Ch14	Ch13	Ch12	Ch11	Ch10	Ch9	Ch8
Port C	Ch23	Ch22	Ch21	Ch20	Ch19	Ch18	Ch17	Ch16
Port D	Ch31	Ch30	Ch29	Ch28	Ch27	Ch26	Ch25	Ch24

If you need to know the status of a single channel, a logical AND instruction can be used from assembly language to mask off the unnecessary bit positions. The mask should contain 0's in the irrelevant bit positions, and a logic 1 in the bit positions representing the channel in question. The result will then be an 8-bit binary number where each bit is 0 except for the one bit that indicates the channel being read. For that channel, the corresponding bit will either be 0 or 1 depending on whether that channel is low or high.

When reading a DIO1 port with the BASIC PEEK statement, the returned value will be a decimal number between 0 and 255, depending on the status of the input channels. The status of a particular channel can be determined by ANDing the returned value with the decimal weighting for that particular bit position. If the value is non-zero, that channel is high (logic 1). For example, if the status of channel 6 on port A is to be determined, the returned value would be ANDed with 64. If the results were non-zero, channel 6 would be high.

If a DIO1 port is configured for output, DIGITAL I/O should only be written to, and should not be read. The value written to this location should be the equivalent of an 8-bit binary number, with the status of the eight bits (1 or 0) representing the status of the eight channels of the selected port (high or low). The channels affected will depend on the selected port, as outlined in Table 6. Data written to a port will be latched into the outputs, which will remain unchanged until the port is written to again. From BASIC, the value written to DIGITAL I/O with the POKE statement will be a decimal number in the range of 0-255.

To change the status of one output channel while leaving the others unchanged, you must know the status of all the channels. Because a port configured as an output cannot be read, a variable in the controlling program should be assigned to the current status of the output port in question. This variable should then be updated whenever channel status is changed. When the current status of all bits (channels) is known, the value of the variable can be changed to correspond to the desired status of the selected port, and this new number written to the DIGITAL I/O location.

In assembly language, this modification can be performed by using logical AND and logical OR instructions. When turning a single channel on (high), the variable representing current port status should be ORed with a number equivalent to an 8-bit binary

value, with 0's in the bit positions for the channels that are to remain unchanged, and 1's in the bit positions for the channels to be turned on.

When turning a channel off (low), the variable should be ANDed with an 8-bit number, with 1s in those bit positions representing channels that remain unchanged, and 0s in those positions to be turned off.

From BASIC, the decimal value of the bit to be turned on or off should be added to (off to on), or subtracted from (on to off), the decimal number that represents the current port status. For example, to turn channel 3 off, it would be necessary to subtract 8 from the decimal value representing the port status. To turn channel 7 on, it would be necessary to add 128 to the status.

## Theory of Operation

A schematic drawing of the DIO1 module is located in drawing number 500-436.

The DIO1 circuitry may be divided into five sections: data bus buffering circuitry, port selection circuitry, input/output selection circuitry, channel input buffers, and channel output latches. The data bus buffer circuitry is made up of U113, and the port selection circuitry consists of U101 and U102. Input/output conditioning circuitry consists of R101, S101, U111, and U112. Input buffer for the four ports are U103 through U106, while the output latches consist of U107 through U110.

Data from the baseboard data bus is applied to the data bus buffer (U113), which is an octal bus transceiver (74LS245). Bus transmission direction of the IC is controlled by the baseboard R/W line, while the CMDDB line is used to enable the device when reading or writing data to one of the four ports on the module using the DIGITAL I/O command.

The two least significant bits of the data bus (D0 and D1) are also applied to the port selection circuitry made up of U101 and U103. U101 is a dual D-type flip-flop (74LS74G) being used as a latch to store the port selection data, while U103 is a 1 of 4 decoder (74LS139). When the SELECT PORT command is used, the values on the D0 and D1 data lines are latched into U101. When CMDDB next line goes low (with the DIGITAL I/O command), the outputs of U101 are decoded by U102 such that only one of the U102 outputs goes low, selecting the port to be used. For example, if 102 is latched into U101, the Y2 output of U106 will go low when CMDDB goes low, selecting port C.

Input/output selection is performed by R101, S101, U111, and U112. Four sections of R101 are pull up resistors to apply a high logic level to the four sections of the selection switches located on S101. When a particular switch is open, that port is configured as an output port; when the switch is closed, the port is set up for input. Additional gating for the input/output selection circuitry is performed by elements U111, a quad 2-input NOR gate (74LS02), and by sections of U112, which is a hex inverter IC (74LS04).

Each port on the DIO1 has an input buffer IC. The ICs are U103 through U106 for ports A through D, respectively. Each IC is a 3-state octal buffer (74LS244). The outputs of U111 control the enabling of these input buffers. This gating signal is derived from the port selection and input/output selection circuitry.



When a port is configured for output, data is latched into the appropriate data latch when the DIGITAL I/O command is executed. U107 through U110 are the output latches for ports A through D respectively. Each IC is an octal D-type flip-flop with 3-state outputs (74LS374). Output enabling is performed both by the port selection circuitry and the input/output selection circuitry. Each latch will be enabled only when that port has been configured as an output, and when the port in question has been selected by writing the appropriate value to the SELECT PORT location.

## Troubleshooting Information

Troubleshoot the DIO1 module by using the procedure outlined in Table 7. This process is fairly straightforward because signal tracing is simply a matter of checking for the correct digital logic level throughout the module.

If a defective part is found, a replacement may be ordered from Keithley Data Acquisition and Control. Refer to the Service Section of the hardware manual for ordering details. Part numbers for the module are located on the component layout drawing (500-430).

**Table 7. DIO1 Troubleshooting Information**

Step	Item/ Component	Required Condition	Remarks
1	DIO1 Module	Install in slot 10	Turn power on
2	Channels 0-31	Apply high logic level	Apply to all inputs
3	S101	Program ports as inputs	All switches closed (on)
4	Computer	Select Port A	Use POKE statement
5	Computer	Read back 255 from Port A	Use PEEK statement
6	Ports B-D	Repeat steps 4 & 5	Use POKE to select port
7	Channels 0-31	Apply low logic level	Apply to all inputs
8	Computer	Select Port A	Use POKE statement
9	Computer	Read back 0 from Port A	Use PEEK statement
10	Ports B-D	Repeat steps 8 & 9	Use POKE to select port
11	S101	Program ports as outputs	All switches open (off)
12	Computer	Select Port A	Use POKE statement
13	Computer	Write 255 to port	A
14	Channels 0-7	All outputs high	Use logic probe or DMM
15	Ports B-D	Repeat steps 13 & 14	Use POKE to select port
16	Computer	Select Port A	Use POKE statement
17	Computer	Write 0 to Port A	Use POKE statement
18	Channels 0-7	All outputs low	Use DMM or logic probe
19	Ports B-D	Repeat steps 17 & 18	Use POKE statement

Slot 10 locations: 1. To select port: CFF92  
2. To read/write data: CFF93

## DIO1 Specifications

Channels: 32, switch-selectable in groups of 8 for input or output

Signal Connection: Quick disconnect screw terminal blocks, plus 40 pin receptacle for ribbon cable assembly

### Input Characteristics:

TTL-compatible, high true

High-level input current:  $20\mu\text{A}$

Low-level input current:  $-0.4\text{mA}$

### Output Characteristics:

TTL-compatible, high true

Drive capability:

15 standard TTL loads

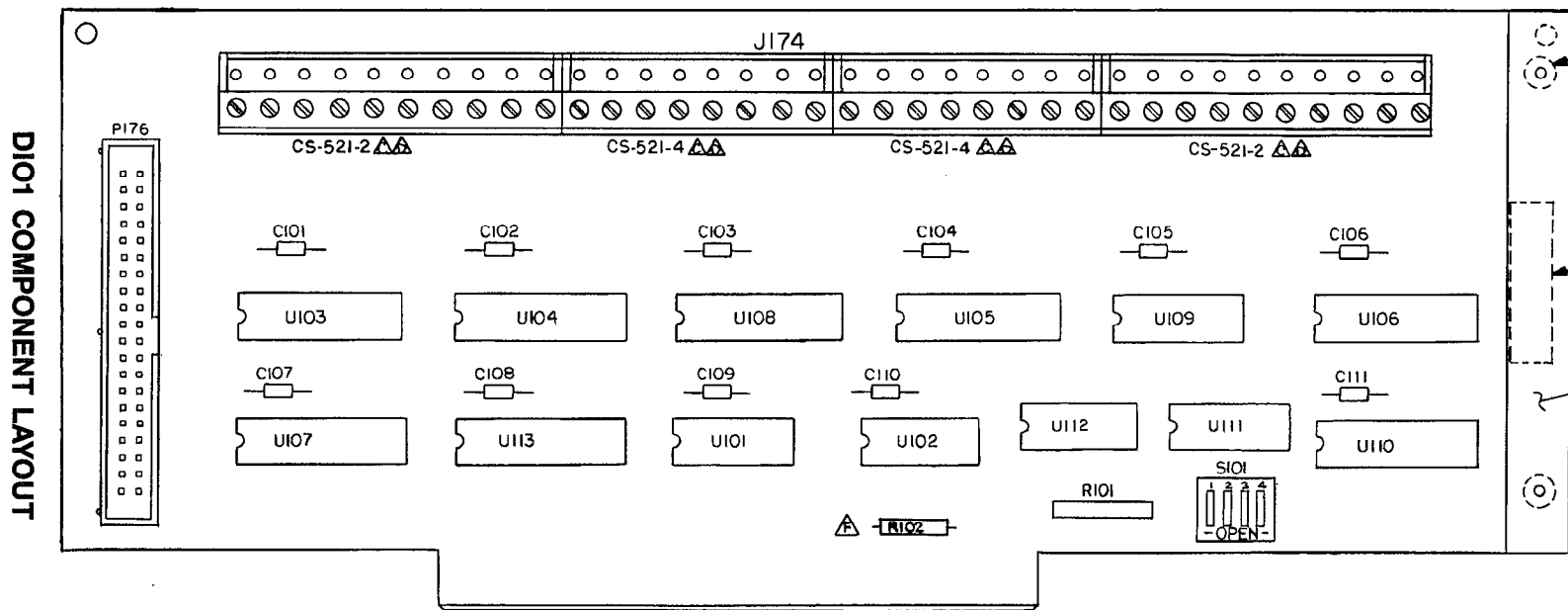
60 LS TTL loads

24mA sink at 0.5V

General: All inputs and outputs references to system ground

Accessories: Ribbons cable assembly, 6- foot, 40 conductor. One end mates with 40 pin receptacle on DIO1, other end unterminated





ZONE	LTR	ECO NO	REVISION	ENG	DATE
	A	10318	RELEASED	CS	11/8/85
	B	10469	CHG J174 FROM CS-521-1 AND -2 TO CS-521-1 AND -2.	W	2-8-85
	C	10797	CS-521-1 & 2 ONLY 1 CS-521-2. DELETED ADDED CS-521-4.	W	7-24-84
	D	10868	J174 REDRAWN	W	11-1-85
	E	11708	CHG CLAMP SCREWS WERE 6-32x7/16 IN	W	10/17/85
	F	12712	ADDED RTR 4-535	W	3-27-86



ITEM	PART NO.	SCHEM. DESIG.	ZONE
1	C-365-D.1	C101	B2
2	"	C102	C2
3	"	C103	E2
4	"	C104	D2
5	"	C105	E2
6	"	C106	E2
7	"	C107	B3
8	"	C108	C3
9	"	C109	E3
10	"	C110	D3
11	"	C111	E3
12			
13			
14	TF-17B-1	R101	D3
15	R176-4.53K	R102	D3
16			
17	SW-422	S101	E3
18			
19			
20	IC-144	U101	C3
21	IC-190	U102	D3
22	IC-230	U103	B2
23	"	U104	C2
24	"	U105	D2
25	"	U106	E2
26	IC-242	U107	B3
27	"	U108	C2
28	"	U109	E2
29	"	U110	E3
30	IC-257	U111	E3
31	IC-186	U112	D3
32	IC-356	U113	C3
33			
34			
35			

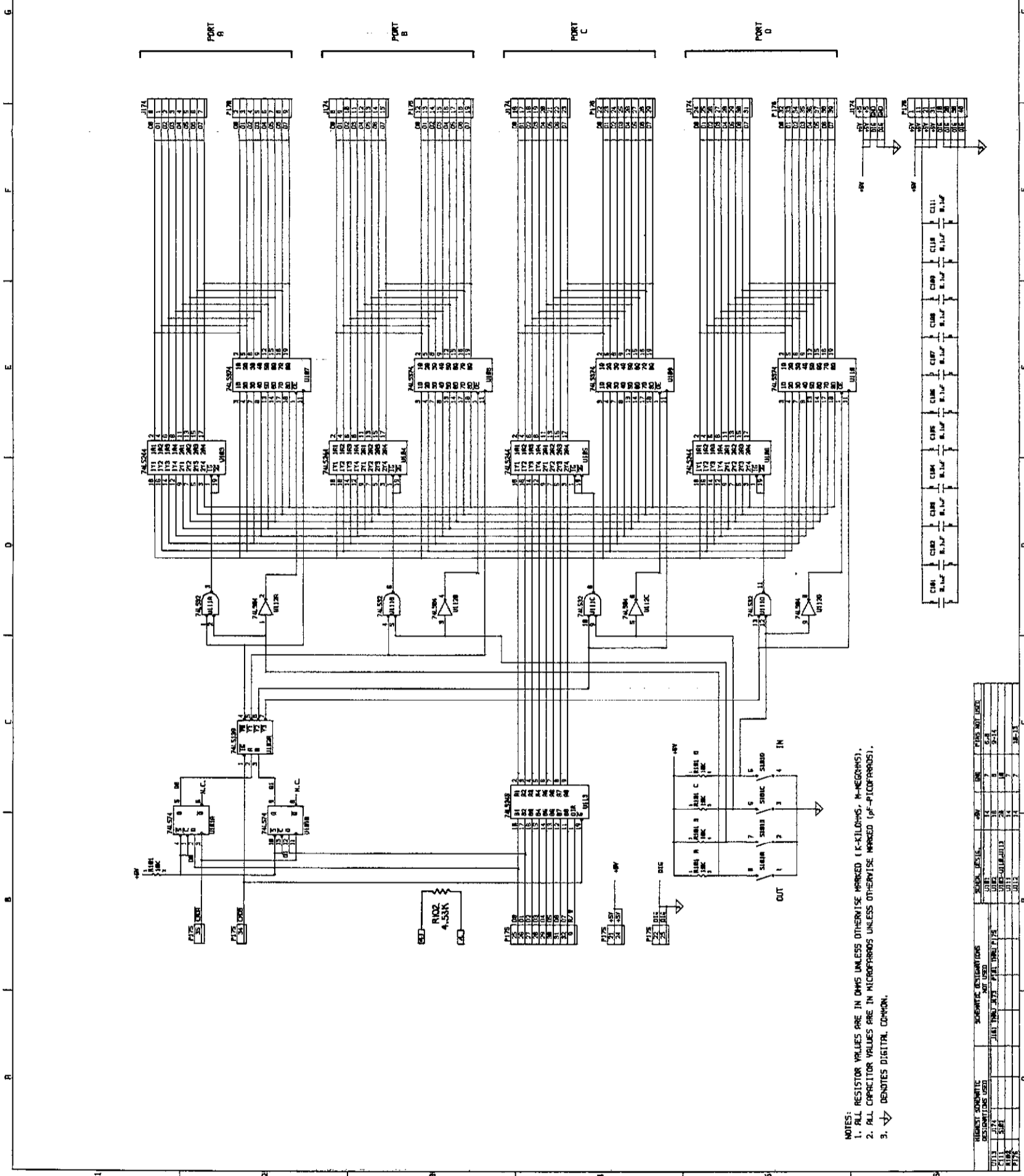
A

ITEM	PART NO.	SCHEM. DESIG.	ZONE
36	ML-285		F2
37			
38	SOD-322		F2
39	SOD-323		F2
40			
41			
42	CS-368-40	P176	B2
43	CS-521-4	J174	B1
44	CS-521-2	J174	C1, D1, E1
45			
46			
47			
48			
49			
50			
51			
52	500-432	Hole Size	E4

2 Req'd    
 2 Req'd  

PARTS LIST

DATE	BY	CHKD	APP'D
10/18/68	J.P.A.	J.P.A.	J.P.A.
10/20/68	J.P.A.	J.P.A.	J.P.A.
10/21/68	J.P.A.	J.P.A.	J.P.A.



KEITHLEY INSTRUMENTS INC.	
SCHEMATIC DIO1	
SIZE	D
DATE	JEFF
NUMBER	588-436
APP'D	J.P.A.
DATE	10/21/68
SHEET	1

REQUEST SCHEMATIC	SCHEMATIC EXTENSIONS	DATE	BY	REVISION
RESISTORS USED	NOT USED	10/18/68	J.P.A.	1
74LS125	74LS125	10/20/68	J.P.A.	2
74LS244	74LS244	10/21/68	J.P.A.	3
74LS125	74LS125	10/21/68	J.P.A.	4
74LS244	74LS244	10/21/68	J.P.A.	5

NOTES:  
 1. ALL RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE MARKED (K-KILOHMS, M-MEGOHMS).  
 2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE MARKED (pF-PICOFARADS).  
 3.  $\nabla$  DENOTES DIGITAL COMMON.