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HELIOS PLUS

2287A DATA ACQUISITION FRONT END

Service Manual

P/N 865324
P/N 873794 (Text Only)
MARCH 1990

FLUKE

WARRANTY

John Fluke Mfg. Co., Inc. (Fluke) warrants this instrument to be free from defects in material and workmanship under normal use and service for a period of 1 year from date of shipment. Software is warranted to operate in accordance with its programmed instructions on appropriate Fluke instruments. It is not warranted to be error free. This warranty extends only to the original purchaser and shall not apply to fuses, computer media, batteries or any instrument which, in Fluke's sole opinion, has been subject to misuse, alteration, abuse or abnormal conditions of operation or handling.

Fluke's obligation under this warranty is limited to repair or replacement of an instrument which is returned to an authorized service center within the warranty period and is determined, upon examination by Fluke, to be defective. If Fluke determines that the defect or malfunction has been caused by misuse, alteration, abuse, or abnormal conditions of operation or handling, Fluke will repair the instrument and bill the purchaser for the reasonable cost of repair. If the instrument is not covered by this warranty, Fluke will, if requested by purchaser, submit an estimate of the repair costs before work is started.

To obtain repair service under this warranty purchaser must forward the instrument, (transportation prepaid) and a description of the malfunction to the nearest Fluke Service Center. The instrument shall be repaired at the Service Center or at the factory, at Fluke's option, and returned to purchaser, transportation prepaid. FLUKE ASSUMES NO RISK FOR IN-TRANSIT DAMAGE.

THE FOREGOING WARRANTY IS PURCHASER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, OR FITNESS FOR ANY PARTICULAR PURPOSE OR USE. FLUKE SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OR LOSS WHETHER IN CONTRACT, TORT, OR OTHERWISE.

CLAIMS

Immediately upon arrival, purchaser shall check the packing container against the enclosed packing list and shall, within thirty (30) days of arrival, give Fluke notice of shortages or any nonconformity with the terms of the order. If purchaser fails to give notice, the delivery shall be deemed to conform with the terms of the order.

The purchaser assumes all risk of loss or damage to instruments upon delivery by Fluke to the carrier. If an instrument is damaged in transit, PURCHASER MUST FILE ALL CLAIMS FOR DAMAGE WITH THE CARRIER to obtain compensation. Upon request by purchaser, Fluke will submit an estimate of the cost to repair shipment damage.

Fluke will be happy to answer all questions to enhance the use of this instrument. Please address your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. BOX C9090, EVERETT, WA 98206, ATTENTION: Sales Department. For European Customers: Fluke (Holland) B.V., P.O. Box 2269, 5600 CG, Eindhoven, The Netherlands.

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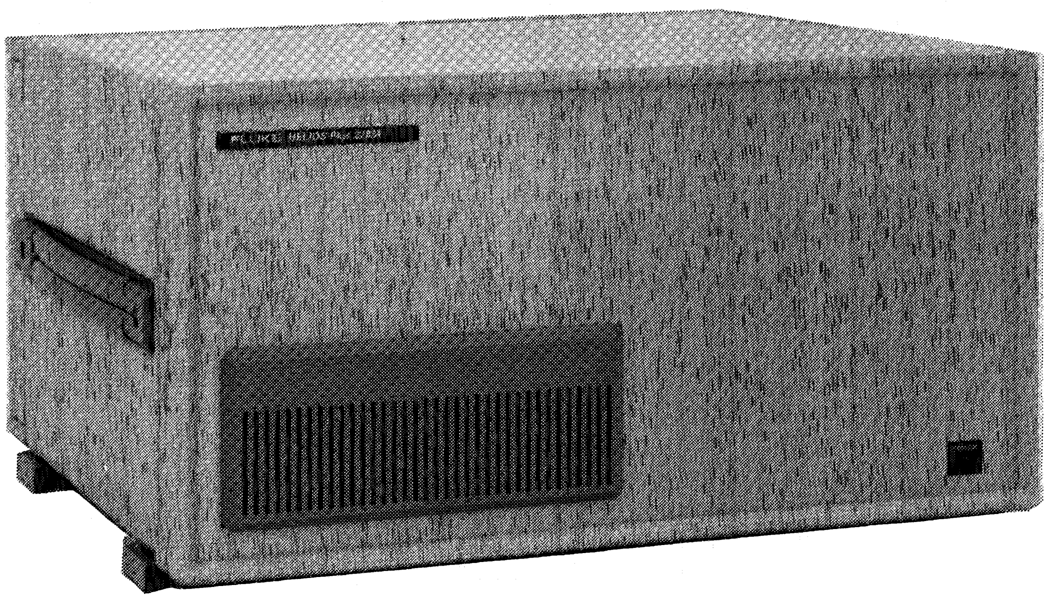


Frontispiece. Helios Plus Data Acquisition Front End

SECTION 1
HOW TO USE THIS MANUAL

CONTENTS

INTRODUCTION

WARNING

SERVICING DESCRIBED IN THIS MANUAL IS TO BE PERFORMED BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK OR DAMAGE TO THE INSTRUMENT, PERFORM ONLY THE SERVICING EXPLICITLY DESCRIBED IN THIS MANUAL.

The Helios Plus Service Manual is a service and maintenance guide (including replacement parts lists) to the Data Acquisition Front End. The Service Manual complements the two-volume Helios Plus System Manual, which provides installation, operating, performance testing, and system configuration information.

The Service Manual covers standard mainframe and option assemblies, and provides general maintenance, cleaning, performance testing, calibration, and board-level troubleshooting procedures. The Helios Plus Service Manual is to be used by technicians and maintenance personnel who need detailed, technical information about the electronics of the Front End.

Information needed to maintain the Front End and to isolate problems to circuit board level is given in this manual. Theories of operation and schematics for the mainframe and options are provided to aid those qualified by experience and/or training to troubleshoot beyond the circuit board level.

When the defective assembly has been identified, returning the Front End to service can frequently be expedited by using our Module Exchange Program (MEP). Because MEP cannot be performed in some countries, we recommend that you contact your local authorized Fluke Service Facility (listed in Section 6) to obtain instructions for replacement or repair.

ORGANIZATION

Section 1 — How to Use This Manual

Describes the organization and use of the Service Manual.

Section 2 — General Information

Describes the Front End and its available accessories and options. Required test equipment, shipping, and factory service information are included here.

Section 3 — Theory of Operation

Covers the theory of operation for the Front End mainframe. Option assembly theory is contained in the individual option subsections of Sections 8 and 9.

Section 4 Maintenance

General maintenance of the instrument, cleaning instructions and procedures to gain access to and remove mainframe assemblies are included here.

Section 5 Testing and Troubleshooting

Consists of mainframe performance tests and troubleshooting procedures designed to isolate a malfunction to the circuit board level. Component level troubleshooting may be performed using the Theory of Operation (Section 3) and Schematic Diagrams (Section 7).

Section 6 List of Replaceable Parts

Contains parts lists for the Front End mainframe and gives parts ordering information. Lists of Federal Supply Codes for Manufacturers and Technical Service Centers are also provided. Option assembly parts lists are provided in the individual subsections of Sections 8 and 9.

Section 7 Schematic Diagrams

Presents Front End mainframe schematics on foldout pages. Schematics for option assemblies are located in the individual option subsections.

Section 8 Options -160 Through -169

Covers Options -160 through -169 in subsections ordered numerically by option number. Includes theory of operation, performance test procedures, calibration instructions (where applicable), schematics, and a replacement parts list.

Section 9 Options -170 Through -179

Covers Options -170 through -179 in subsections ordered numerically by option number. Includes theory of operation, performance test procedures, calibration instructions (where applicable), schematics, and a replacement parts list.

Section 10 Appendices

A Specifications

HOW TO USE THE MANUAL SET

The Helios Plus Data Acquisition Front End is supported by a manual set consisting of two manuals, the System Manual (a two-volume set) and the Service Manual.

System Manual

The Helios Plus Data Acquisition Front End System Manual describes Helios Plus installation and operation. It provides information necessary to define required functions, identify system requirements, make the necessary hardware connections, and verify correct operation. A user who is unacquainted with the system may need all this information to install the Front End and make it operational. A user who is already familiar with the instrument may only need to refer to this information occasionally. In either case, each element of the installation process is easily accessible and fully referenced.

Service Manual

The Helios Plus Data Acquisition Front End Service Manual is the maintenance guide to the Front End. It contains general maintenance, cleaning, performance testing, calibration, and board-level troubleshooting procedures. The Service Manual also includes theory of operation, parts lists, and schematic diagrams for mainframe and option assemblies.

CONVENTIONS

- Reference to the Instrument

  The Helios Plus Data Acquisition Front End will generally be referred to as the "Front End". The terms "Helios Plus" or "Data Acquisition Front End" will also be used.

- Printed Circuit Assembly

  A Printed Circuit Assembly (PCA) is a printed circuit board with components mounted on it.

- Logic Polarity of Signals

  Logic signals whose names are followed by "(L)" are asserted or active low. On the schematic the same signal can be represented as "SIGNAL(L)" or SIGNAL overscored by a vinculum.

  When a signal is followed by "(H)" or has no parenthetical postscript, it is active or asserted high.

- o Address Notations

Hexadecimal representation of memory addresses takes the form

    0x0000

Memory addresses ranges, where specified, are inclusive.

For example, address range

    0x0000 to 0x2000

includes addresses "0000" and "2000".

- o Keystroke Notations

The following conventions are used to identify syntax keystrokes and differentiate them from surrounding text:

(xxx) When associated with a keyword, a lower case word in parentheses indicates an input required by the user.

For example, the command

    DEF.CHAN(channel[s]) = DCIN <CR>

means that the user must specify "channel[s]" to be defined as direct current input channel[s] to have a valid command.

XXX Indicates a literal keyword to be entered by the user.

For example,

    TIME

means that you enter the literal word "TIME" or "time".

The Front End is case insensitive and will accept any combination of uppercase or lower case letters. However, all Front End keywords in this manual which are not part of actual computer programs will appear in uppercase letters to distinguish them from surrounding text.

<XXX> Angle brackets around all uppercase letters means press the <XXX> key.

For example,

    <CR>

means press CARRIAGE RETURN, RETURN, or ENTER (according to your keyboard.

.. "Double Periods" designate an inclusive range.

For example,

```
CHAN(0..99) = 1 <CR>
```

assigns logic "1" to channels 0 through 99.

SECTION 2
GENERAL INFORMATION

CONTENTS

DESCRIPTION

The Fluke Helios Plus Data Acquisition Front End is is a high speed, smart intermediary between a computer and a real world measurement application. It is a highly accurate, easy-to-use data acquisition and control subsystem that can be used with any kind of personal or mainframe computer.

Capacity of the Front End ranges from a minimum configuration of a single channel, up to 1000 channels. Fast A/D Converters and High Performance A/D Converters can be used separately or in combination. The Front End can be adapted to a wide array of applications.

The Front End gathers data and generates control or stimulus signals through a standard computer interface. It combines a full range of measurement capabilities and is easy to program. The Front End's chassis includes:

- An RS-232-C and an RS-422 host computer port.
- A Serial printer port.
- A microcomputer with ROM and RAM to provide local intelligence.
- Six option slots that accept any of a range of measurement and control modules. This family of options supports a variety of both analog and digital inputs and outputs.

An expansion chassis can be added to accommodate more input/output channels, up to a maximum of 1000. A combination of A/D converter types can be used.

Power Requirements

The Front End operates on either of two ac line voltage ranges: 90 to 132V ac, or 180 to 264V ac. Line frequency for either range may be from 47 through 440 Hz. If you need to verify or change either setting, refer to Section 4, Maintenance, for details.

CAUTION

Incorrect voltage selection may damage the Computer Interface Module and void your warranty. If the voltage is not set for the correct operating voltage, the unit will either fail to operate, or will be severely damaged.

External Features and Connectors

The features and connectors located on the front and rear panels of the Front End are shown in Figure 2-1 and described Table 2-1. Six horizontal slots are available for installing scanners, A/D Converters, and other measurement and control options.

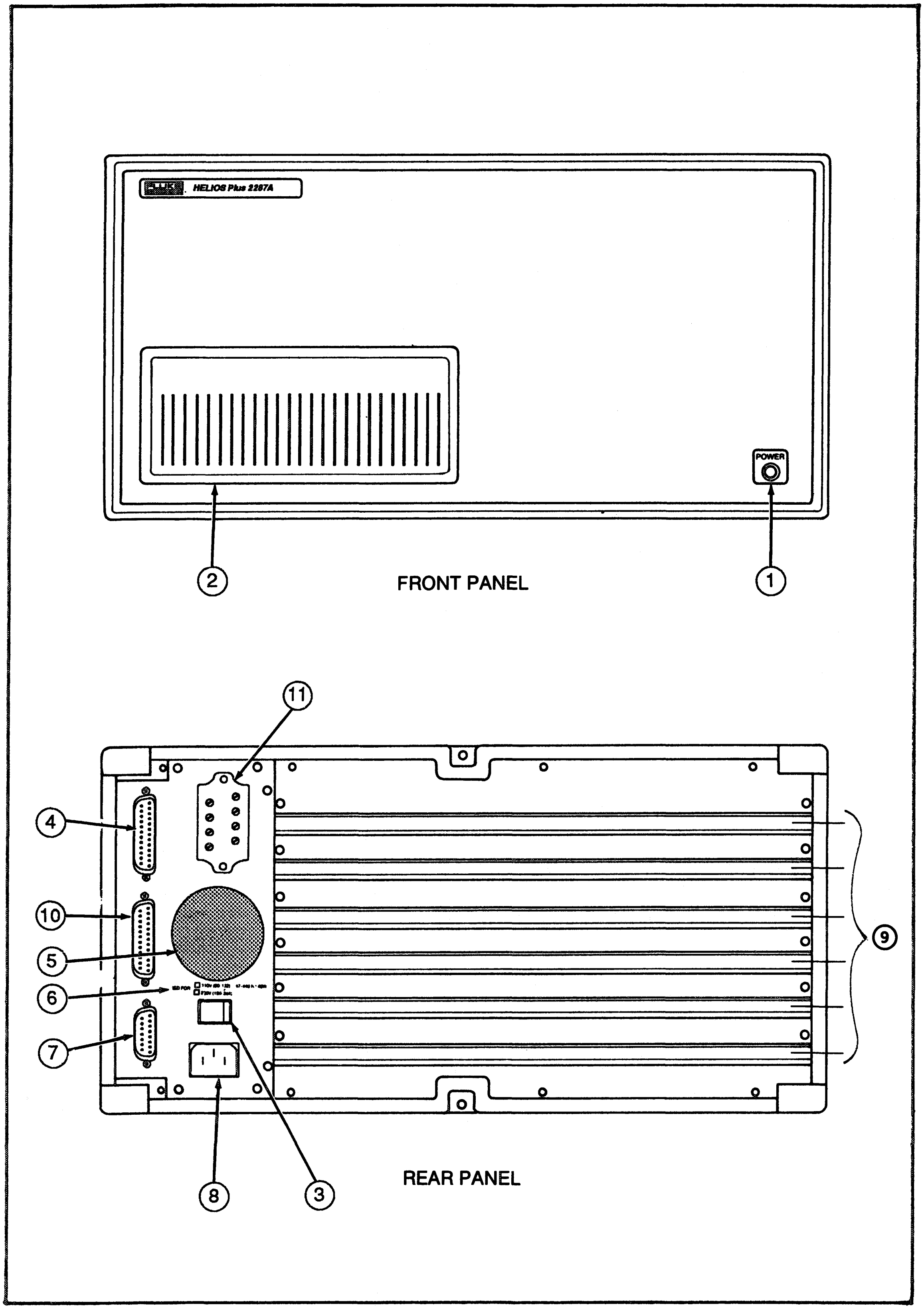


Figure 2-1. Front and Rear Panels

Table 2-1. Front and Rear Panel Features

ITEM	FEATURE	DESCRIPTION
1	Power Indicator	Green LED. Lit when power is ON
2	Grill	Ventilation grill
3	Switch	ON/OFF switch for ac line power
4	25-Pin Connector	RS-232-C/RS-422 connector to host
5	Filter	Washable, removable fan filter
6	Voltage/Frequency	Silk screened annotation of line voltage selection and frequency
7	15-Pin Connector	Connector to 2281 extension chassis
8	AC Input	Standard three-prong socket
9	Slots	Six slots for Front End options
10	Printer Port	RS-232-C connector to printer
11	Alarm Annunciator Connection	Connector to external alarm indicator hardware

The Front End's external dimensions are shown in Figure 2-2.

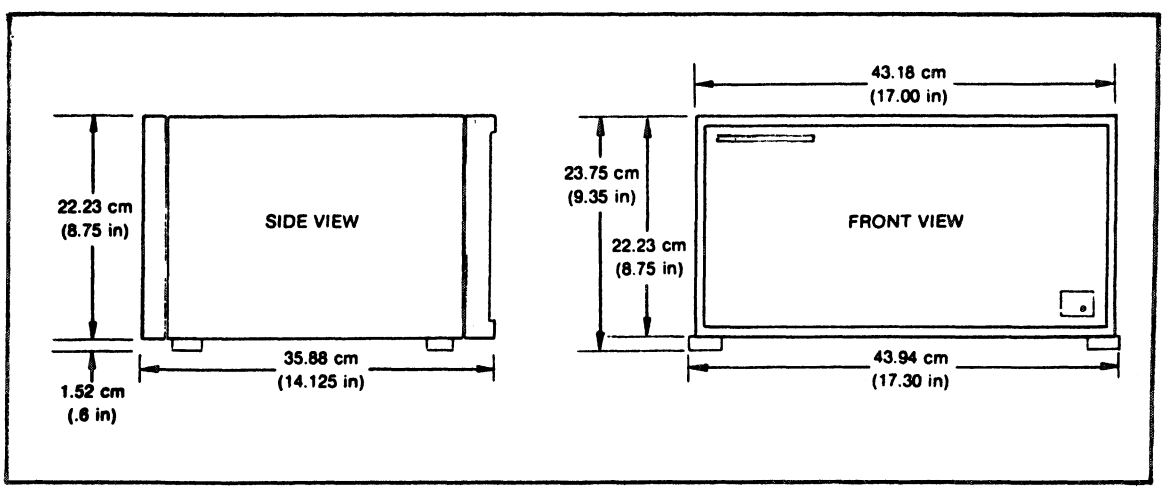


Figure 2-2. External Dimensions

REQUIRED TEST EQUIPMENT

Table 2-2 lists the equipment required for all Front End performance tests and calibration procedures. For your convenience, the test equipment is listed again in each section or subsection.

Table 2-2. Summary of Required Test Equipment

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Voltage Calibrator	+31.3 mV ±20 uV +2.048V ±50 uV -2.048V ±2 uV of +2.048 500 mV ±20 uV 6.2V ±155 uV 6.8V ±0.1V 5.0V ±100 uV 7.9V ±200 uV 63V ±800 uV 1.008V ±40 uV	Fluke Model 343
Digital Multimeter DMM	Capable of measuring +12V dc	Fluke 77 or equivalent
Meter Calibrator	10.0V ±0.01V	Fluke 5100B
Power Supply	Capable of sourcing +12V dc	Appropriate lab type
100:1 Divider	±0.005%	Fluke Accessory Y2022
DC Voltmeter	+10V ±0.06V 50.0 mV ±0.001 mV 500.0 mV ±0.005 mV	Fluke Model 8505A
Resistance Calibrator	NA	Fluke Model 5450A
Resistor (4 each)	100 ohm 0.01% 5ppm/°C	Fluke Part No. 491720
Resistor (2 each)	100 ohm 0.1%	Fluke Part No. 357400

Table 2-2. Summary of Required Test Equipment (cont.)

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
Resistor	499 ohms 1% MF	Fluke Part No. 289256
Resistor (2 each)	220 ohms, 1W	Fluke Part No. 109462
Resistor	1 kilohm ±5%, 1/2W	Fluke Part No. 108597
Resistor	3 kilohm ±5%, 1/2W	Fluke Part No. 109090
Resistor	10 kilohm ±5%, 1/2W	Fluke Part No. 109165
Resistor	8 ohm ±0.25%, 1/2W	Fluke Part No. 641449
Thermocouple	Type J or K	Fluke P-20J or P-20K
Oil or Water Bath	NA	
Mercury Thermometer	0.02 °C resolution	Princo ASTM-56C
Calibration Extender/Fixture	NA	Fluke Accessory Fluke Part No. 648741 (no substitute)
Digital Extender Assembly	NA	2400A-4021 Fluke Part No. 486910
Toggle Switch	Single-pole, double-throw	Fluke Part No. 493825
Fast A/D Extender Fixture		2287A-7697 Fluke Part No. 886031

OPTIONS, ACCESSORIES, AND OTHER RELATED EQUIPMENT

The tables in this section list the options, accessories, and other related equipment for the Front End.

Table 2-3 lists all options currently available for the Front End. Refer to Sections 8 and 9 of this manual for further information on options.

Table 2-3. Options

NUMBER	NAME	FUNCTION
-160	AC Voltage Input Connector	AC to dc conversion, voltage division, screw-terminal connections (for use with -162).
-161	High Performance A/D A/D Converter	Analog-to-digital converter, dual slope integration.
-162	Thermocouple/DC Volts Scanner	Scans 20 channels, 1 microvolt, 3 poles/channel (for use with Options -160, -161, -171, -175, or -176).
-163	RTD/Resistance Scanner	Scans 20 channels, 4 poles per channel, 1 pole/decade, precision current source excitation (for use with Options -161, -177).
-164	Transducer Excitation Module	Contains one precision 2V or 4V source and five precision 1 mA current sources (for use with Options -162, -174, -175, -176 and 10 dc channels of -160).
-165	Fast A/D Converter	Analog-to-Digital Converter. High-speed, high-accuracy.
-167	Counter/Totalizer	Measures frequency or counts events on six channels.

Table 2-3. Options (cont.)

NUMBER	NAME	FUNCTION
-168	Digital I/O Assembly	Provides 20 single-bit channels for alarm or status input or output or for BCD or binary input (for use with -169 or -179).
-169	Status Output Connector	Provides 20 screw-terminal connections for external digital devices (for use with -168).
-170	Analog Output Assembly	Four-channel current (4 to 20 mA) or voltage (0V to 10V or -5V to +5V) outputs, 12 bits.
-171	Current Input Connector	Provides 20 current input connections each with a shunt resistor (for use with options -162).
-174	Transducer Excitation Connector	Provides screw-terminal connections for voltage and current sources (for use with -164).
-175	Isothermal Input Connector	Provides screw-terminal connections for 20 thermocouple input channels (for use with options -162 or -165).
-176	Voltage Input Connector	Provides screw-terminal connections for 20 voltage input scanner channels (for use with options -162 or -165).
-177	RTD/Resistance Input Connector	Provides screw-terminal connections for 20 channels of 3- or 4-wire RTD or resistance measurement (for use with -163).
-179	Digital/Status Input Connector	Provides screw-terminal connections for binary or status digital input signals (for use with -168).

Table 2-4 lists the requirements for each of the options of the Front End.

Table 2-4. Option Requirements

FUNCTION	OPTION A/D	CARDS SCANNER or EXCITATION	CONN	CHAN/ ASSY	ASSY/ UNIT	CHAN/ UNIT
TEMPERATURE						
Thermocouple	-161	-162	-175	20	5	100
	-165		-175	20	6	120
RTD						
Config. A	-161	-163	-177	20	5	100
Config. B		-164	-174	20	2	40
	-161	-162	-175/176			
Config. C		-164	-174	20	3	60
	-165		-175/176			
Thermistor	-161	-163	-177	20	5	100
VOLTAGE						
AC	-161	-162	-160	10 ac/ 10 dc	5	50 ac/ 50 dc
DC	-161	-162	-175/176	20	5	100
	-165		-175/176	20/40	6	120/240
CURRENT						
	-161	-162	-171	20	5	100
	-165		-176**	20	6	120

Table 2-4. Option Requirements (cont.)

FUNCTION	OPTION A/D	CARDS SCANNER or EXCITATION	CONN	CHAN/ ASSY	ASSY/ UNIT	CHAN/ UNIT
RESISTANCE						
Config. A	-161	-163	-177	20	5	100
Config. B		-164	-174	20	2	40
	-161		-175/176			
Config. C		-164	-174	20	3	60
	-165		-175/176			
STRAIN	-164		-174			
	-161	-162	-175/176	20	2	40
FREQUENCY	-167		included	6	5	30*
TOTALIZING	-167		included	6	5	30*
DATA INPUT (Binary/BCD)	-168		-179	1	6	6
STATUS INPUT	-168		-179	20	6	120
STATUS OUTPUT	-168		-169	20	6	120
ANALOG OUTPUT	-170		included	4	5	20*

* Due to power requirements, do not use the sixth position.

** With shunt resistors mounted on screw terminals

Table 2-5 lists all accessories available for the Data Acquisition Front End.

Table 2-5. Accessories

ACCESSORY	DESCRIPTION
Y2044 Rack Slide Kit	Slide kit for mounting the Front End or the 2281A Extender Chassis in a 19-inch-wide, 24-inch-deep equipment rack.
Y2045 Rack Mount Kit	Mounting flanges for installing the Front End or the 2281A Extender Chassis in a 19-inch-wide, 24-inch-deep equipment rack.
Y1060 Serial Link Multi-Connector	Interconnection unit for connecting multiple 2281A Extender Chassis to the Front End.
Y2055 Serial Link Multi-Connector	Three-way connector assembly used in a multipoint serial link network.
Digital Extender PCA Fluke Part No. 486910	Allows the Computer Interface Module to be extended out from the mainframe for troubleshooting.
Calibration Extender/ Fixture Fluke Part No. 648741	Allows the horizontal PCAs to be extended out from the mainframe for calibration or troubleshooting.
Fast A/D Extender Fixture Fluke Part No. 886031	Allows the -165 Fast A/D Converter to be extended out from the mainframe for troubleshooting.

Table 2-6 lists other equipment that can be used with the Front End.

Table 2-6. Other Related Equipment

ITEM	DESCRIPTION
Fluke Model 2281A Extender Chassis	Allows adding extra channels by housing additional option assemblies.
Fluke 2281A-402 Extender Chassis Cable	Cable to connect a Front End to a 2281A Extender Chassis or to link two 2281A Extender Chassis. Ordered in lengths from 1 to 1000 meters.
Fluke 2281A-403 Connectors for Extender Chassis Cable	Connectors for each end of a 2281A-402 Cable. Installed onto the cable at the factory.
Fluke 2281A-431 Power Supply for the 2281A Extender Chassis	Optional power supply for the 2281A Extender Chassis. Used for remote operation in some cases.
Fluke Accessories Y1702 (2m), Y1703 (4m), and Y1705 (0.3m) Null Modem Cables	Used to direct connect the Front End with the host computer.
Fluke Accessories Y1707 (2m) and Y1708 (10m) RS-232-C Cables	Used to connect the Front End to another RS-232-C device.

SHIPPING INFORMATION

When you receive the instrument, inspect the shipping container for any signs of shipping damage. Special instructions for inspection and claims are included on the shipping container.

If it is necessary to reship the instrument, use the original container. If the original container is not available, a new one can be obtained from the John Fluke Manufacturing Co., Inc. upon request.

SERVICE INFORMATION

The Front End is warranted for a period of one year upon delivery to the original purchaser. The warranty is located in the front of this manual, after the title page.

Factory calibration and service for each Fluke product is available at various locations worldwide. Refer to Section 10 for a complete list of these service centers.

If you request it, we will provide you with a repair estimate before beginning work on an instrument whose warranty has expired.

Maintenance plans are available to maintain the Front End at your site, to supplement the normal warranty period, or to do both. For specific information, contact your nearest Fluke Technical Service Center or Sales Representative.

CONTENTS

INTRODUCTION

Section 3 provides the theory of operation for the Helios Plus Data Acquisition Front End mainframe. The theory of operation is complemented by block diagrams, simplified schematics, and tables, which aid in clarifying concepts.

Refer to Section 7 for full schematic diagrams for the chassis Motherboard, Computer Interface Assembly, Alarm Annunciator Assembly, and Power Supply. When unfolded, a schematic diagram remains fully visible while the manual is open to any preceding page. This arrangement is useful when simultaneously reading the theory of operation and viewing related areas of the schematic diagram.

Section 3 covers only the theory of operation. Installation, operating, and configuration instructions for the Front End are located in the Helios Plus System Manual.

Many optional modules and connectors are available to provide the Front End with specific measurement and control functions. Refer to the appropriate subsection of Section 8 or Section 9 for the theory of operation and schematic diagram for each optional assembly and connector.

OVERALL FUNCTIONAL DESCRIPTION

To help clarify the relationship of the Front End's major functional blocks, refer to Figure 3-1 (a simplified block diagram of the Front End) while reading the overall functional description.

Blocks that are drawn in dashed lines represent optional assemblies; these assemblies are not required. However, any useful system will contain at least one data acquisition or control option, hereafter collectively referred to as serial link devices. These options may include the A/D Converter, digital I/O, and analog I/O.

The serial link allows the CPU of the Front End mainframe to communicate with all measurement and control options in the system. The serial link can be extended outside the Front End Chassis to an Extender Chassis that also contains serial link device options. To communicate with the optional assemblies, the serial link uses RS-422 signals that are sent and received through two pairs of conductors. Through one pair, the computer interface transmits while the options listen. Through the other pair, the selected option can transmit only to the computer interface.

The following summary breaks down the Front End into its four major circuit blocks and briefly describes the function of each. The circuit analysis explains in detail how these blocks operate.

- Chassis Motherboard

  The chassis Motherboard provides the interconnection between the Computer Interface Assembly and the serial link devices. It also, provides interconnection between A/D options and scanner options that are associated with the A/D.

- Computer Interface Assembly

  At the heart of the Front End is the Computer Interface Assembly. The Computer Interface Assembly is centered on the TMS-9995 microprocessor. This assembly provides the interface between the host computer and the measurement and control options. Commands from the host computer are interpreted and the appropriate responses are executed by the Computer Interface Assembly.

- Alarm Annunciator Assembly

  The Alarm Annunciator Assembly provides the drive signals necessary to control user-supplied external audible and visual alarm indicators. It also provides connections for an external alarm acknowledgement switch.

- Power Supply

  The power supply converts ac power into three regulated dc output voltages that provide power to all assemblies within the Front End and for serial link options installed in an Extender Chassis. The number of serial link options that can receive power from the mainframe power supply is limited. Further information on supplying power to these options is contained in Section 3, "Installation and Setup," of the Helios Plus Data Acquisition Front End System Manual.

More complete discussions of each of these major circuit blocks follow.

CHASSIS MOTHERBOARD

The Motherboard interconnects to the Computer Interface Assembly and the serial link devices installed in the mainframe or extender chassis by way of PCA card-edge connectors that are mounted on one side of the Motherboard.

The Motherboard is designed to be used in other Fluke instruments, and there are mountings for additional connectors that are not used by the Front End. The schematic diagram for the Motherboard includes information about all card-edge connectors, whether they are installed for this instrument or not. Therefore, there are several signal names that can be ignored. Also J12, which connects to the Computer Interface Assembly, uses only the following connections: RX+ (43), RX- (41), TX+ (44), TX- (42), GND1 (17, 18, 19, 20), GND3 (25, 26, 27, 28) and +12V (22,23). The +24V line (shown on the Motherboard schematic) accepts from 10 to 25V dc to supply serial link devices; 12V dc is used with Helios Plus.

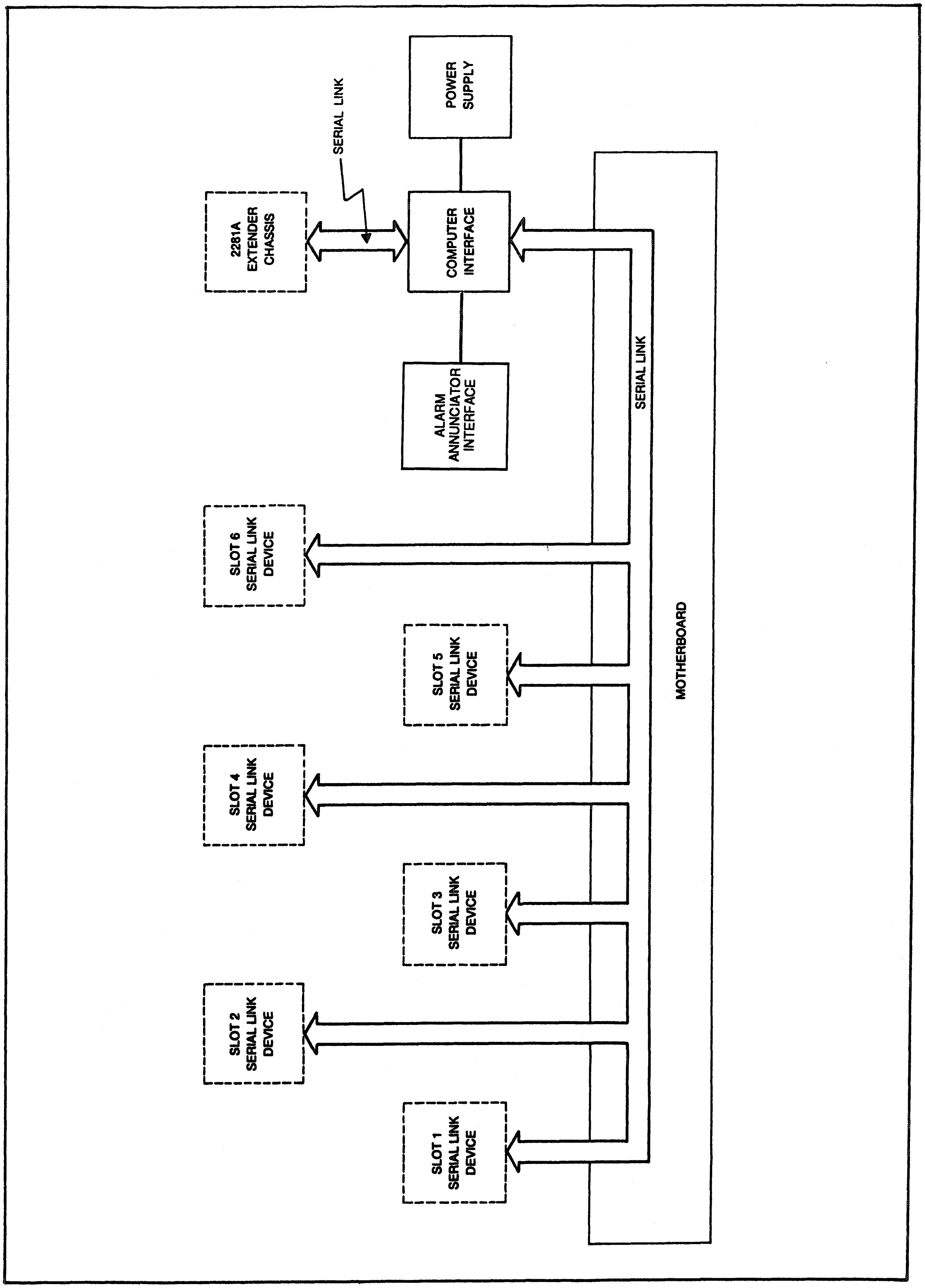


Figure 3-1. Mainframe Assemblies Block Diagram

COMPUTER INTERFACE ASSEMBLY

The discussion of the Computer Interface Assembly includes theory of operation and functional block diagrams. Figure 3-2 illustrates the 17 functional circuit blocks that make up the Computer Interface Assembly.

The discussion of the Computer Interface assembly begins with an overall functional description of the assembly, followed by discussion of each of the functional blocks.

Functional Overview

The CPU controls operations on the assembly and interfaces with ROM and RAM and with various I/O devices through a communications register unit (CRU) and the address lines.

At power-up, the reset circuit initializes various circuit elements and keeps the CPU from operating until the supply voltage is within operational limits. When reset is released, the CPU begins execution as directed by the ROM.

The CPU initializes the system based on: 1) configuration switch settings, 2) data that remains in the non-volatile RAM during the power-down state, and 3) information about serial link devices that are detected through the serial link communication interface.

After initialization is complete, the host communication interface is ready to accept commands from the host and pass them on to the CPU for interpretation and execution. Commands from the host can result in placing data into RAM, reading and returning data from RAM, setting or reading the clock data, or performing a measurement or control function on a serial link device.

Power ON/OFF Reset Circuit

The power ON/OFF reset circuit monitors the +5V power supply and asserts RESET(L) when the voltage is below an acceptable level. There is hysteresis in the circuit, so the threshold voltage depends on whether the voltage is rising or falling. When the power supply is turning ON, the voltage must rise above 4.85V for RESET (L) to clear. When the power supply is turning OFF, RESET (L) is asserted when the voltage falls below 4.7V. U16 is powered from the +5B supply, which is backed up by the battery if the power is OFF, and is used by the memory chip selector block to ensure that the RAMs remain deselected while power is below 4.85V.

R24 and R26 form a voltage divider off the +5V supply. The output of the voltage divider is compared by U16 (a dual-voltage comparator) to 1.23V, which is produced by R27 and VR2 (a band-gap reference diode). The hysteresis described in the previous paragraph, is provided by the 2M ohm resistor from pin 1 to pin 3 of U16. On power-up, when the +5V supply reaches 4.85V, U16 pin 1 releases C14 and allows the current from R28 to begin charging C14.

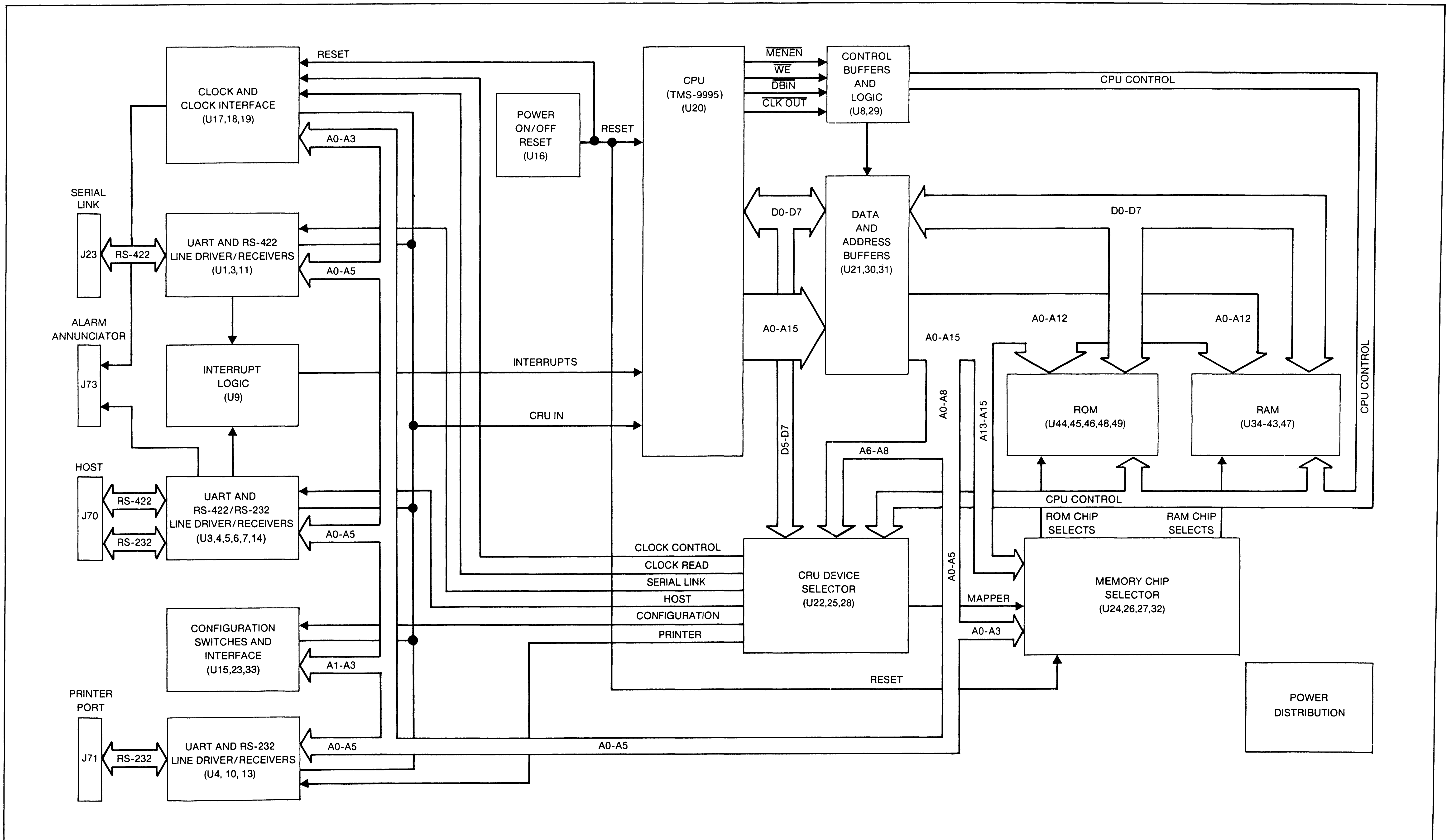


Figure 3-2. Computer Interface Assembly Block Diagram

When the voltage across C14 reaches approximately 1.26V, U16 releases the active pull-down on pin 7, and RESET(L) is pulled to the +5V supply by R25. The 100k ohm resistor between C14 and U16, pin 5 works with the 20M ohm resistor from U16 pin 5 to pin 7 to provide hysteresis so that the comparator doesn't oscillate while the voltage on C14 is near 1.23V. The .001uF capacitor C53 (on pin 7 of U16) filters noise created by other signals, which could cause a false RESET (L).

Central Processor Unit (CPU)

The CPU is implemented by U20, a TMS-9995 16-bit microprocessor. The TMS-9995 onboard clock generator uses Y1, an 11.9808 MHz crystal, to determine the frequency of the clock. C18 and C19 are used to ensure proper capacitive loading for the onboard amplifiers.

Pull-up resistor, R32, de-asserts the HOLD(L) input on the TMS-9995 since this feature is not implemented.

Pull-up resistor, R33, asserts the READY input on the TMS-9995. When RESET(L) makes a low-to-high transition at power-on with READY asserted, the automatic first wait state generation feature of the TMS-9995 is selected. This causes one wait state to be added to every memory access cycle.

Data and Address Buffers

The 8-bit data bus is buffered by U30, an octal bus transceiver. The direction of data transfer is determined by the CPU control signal DBIN(L). This buffer, which is required due to the large number of memory ICs used in the Front End, is enabled only when DBIN(L) and MEMEN(L) are asserted.

The 16-bit address bus is buffered by octal buffers U21 and U31. These buffers are required due to the large number of memory ICs and CRU devices used in the Front End.

CPU Control Buffers and Logic

The CPU control signals MEMEN(L), WE(L)/CRUCLK(L), DBIN(L), and CLKOUT are buffered by U29, an octal buffer. This buffer is required due to the large number of memory ICs and CRU devices used in the Front End.

A buffered MEMEN(L) from U29, pin 9 is used on U30, pin 19 to enable the data bus buffer.

One of the inverters of U8 is used to generate the complement of WE(L)/CRUCLK(L) as required by some of the CRU devices.

Communication Register Unit (CRU) Device Selector Circuit

Figure 3-3 shows a schematic diagram of the CRU device selector circuit. This circuit detects a CRU device input or output cycle by the CPU and selects the device based on the address bits A6 through A8.

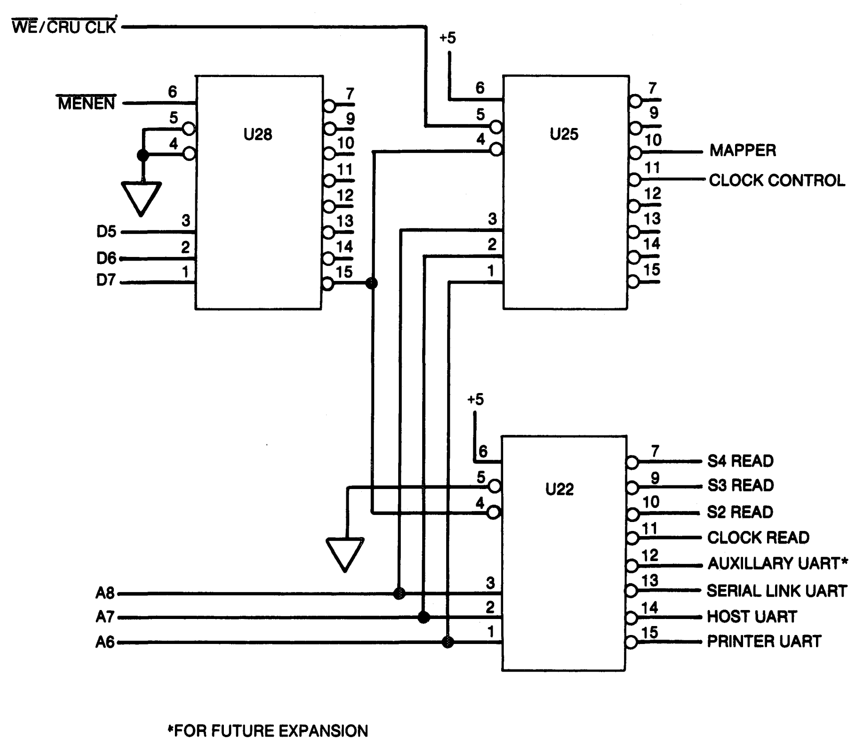


Figure 3-3. CRU Device Selector Circuit

When the data bits D5 through D7 are low and the control signal MEMEN(L) is high, U28, pin 15 is low. Since the enable inputs on U22, pins 4, 5, and 6 are all asserted, the U22 output corresponding to the address bits A6 through A8 are low. When the CRUCLK(L) control signal is low, all the enable inputs on U25, pins 4, 5, and 6 are asserted and the output corresponding to the address bits A6 through A8 are low. In other words, when the CPU is requesting communication with a CRU device, one output of U22 is low and one output of U25 follows CRUCLK(L).

Table 3-1 shows the base address, the CRU device that is selected, and the type of transaction.

Of the four ports that can be selected, the Front End uses only the host, printer, and serial link ports.

The CRU device selector circuit can select multiple CRUs simultaneously. However, pins 10 and 11 on U22 enable CRU devices that are for input only, and pins 10 and 11 on U25 enable CRU devices that are for output only. When an output device is receiving data from the CPU and the CRUCLK(L) signal is toggling, the input-only device of the same address that is enabled by U22 is inactive since DBIN(L) is high. When an input device is sending data to the CPU, the CRUCLK(L) signal is high and none of the outputs of U25 are asserted.

Table 3-1. CRU Device Selection

ADDRESS	INPUT	OUTPUT
0x0000	Printer Port	Printer Port
0x0040	Host Port	Host Port
0x0080	Serial Link	Serial Link
0x00C0	Auxiliary Port	Auxiliary Port
0x0100	Clock & Misc.	Clock & Alarm
0x0140	Switch 2	Mapper & Misc.
0x0180	Switch 3	Host Port
0x01C0	Switch 4	Printer Port

Memory Chip Selector Circuit

The memory chip selector circuit decodes the address bus and other inputs from the CPU via a CRU device to select one of 16 memory ICs for data transfer.

The CPU has the ability to address directly 64K bytes of memory with the 16-bit address bus. This address space contains EPROM (Erasable Programmable Read-Only Memory) and RAM (Random-Access Memory). Since the Scan Alarm requires more memory than can be accommodated by the 64K-byte address space, part of the memory is multiplied by using banks and pages. Banks denote selection between memory devices, and pages denote selection within a single memory device. Figure 3-4 shows how the memory is organized.

```
0xFFFF  +-----------+
        |   RAM     |
        |           |
0xE000  +-----------+-----------+-----------+-----------+-----------+
        |           |           |           |           |           |
        |  bank 0   |  bank 1   |  bank 2   |  bank 3   |  bank 4   |
        |           |           |           |           |P0 P1 P2 P3|
0xA000  +-----------+-----------+-----------+-----------+-----------+
        |  EPROM    |
        |P0 P1 P2 P3|
0x6000  +-----------+
        |  EPROM    |
        |           |
0x0000  +-----------+
```

Figure 3-4. Memory Organization

U32, a 3-to-8 line decoder/multiplexer, asserts the output that corresponds to address bits A13 through A15 when the CPU control signal MEMEN(L) is asserted low.

Table 3-2 shows the relationship between the address bits and the chip that is selected.

Table 3-2 Address Bits and Chip Selection

ADDRESS RANGE	U32 PIN ASSERTED	CHIP SELECTED
0x0000-0x1FFF	15	U46 (EPROM)
0x2000-0x3FFF	14	U49 (EPROM)
0x4000-0x5FFF	13	U45 (EPROM)
0x6000-0x7FFF	12	U48 (EPROM)
0x8000-0x9FFF	11	U44 (EPROM)
0xA000-0xBFFF	10	U27 (Bank selector)
0xC000-0xDFFF	9	U24 (Bank selector)
0xE000-0xFFFF	7	U47 (RAM)

When selected by U32, the 3-to-8 line decoder/multiplexers, U24 or U27 asserts the output that corresponds to the signals on the input pins 1, 2, and 3. These inputs are supplied as signals MM0 through MM2 from U26, an 8-bit addressable latch, which is used as a CRU output device. The CPU selects the proper bank for the data transaction and sets the bits into the appropriate outputs of U26 prior to accessing the RAM.

Table 3-3 shows the relationship between the mapper bits MM0 through MM2 and the RAM chip that is selected.

Table 3-3. Mapper Bits and RAM Chip Selection

MM2	MM1	MM0	U24 OR U27 PIN ASSERTED	RAM SELECTED IF U24 ENABLED	RAM SELECTED IF U27 ENABLED
0	0	0	15	U36	U38
0	0	1	14	U41	U43
0	1	0	13	U35	U37
0	1	1	12	U40	U42
1	0	0	11	U39	U34

U24 and U27 are CMOS ICs and have power applied from the +5B supply when Front End power is OFF. The enable input on pin 6 of U24 and U27 is connected to the power ON/OFF reset circuit. When the +5V supply is below 4.6V, the RESET(L) signal is asserted low, which deselects U24 and U27, which in turn deselect all the banked RAMs. This ensures non-volatile memory retention of parameters and data. The inputs of U24 and U27 are pulled to the +5V supply by resistors in network Z6, since the drive signals originate from TTL-LS ICs.

Outputs on U26, pins 11 and 12 are used to provide inputs from the CPU to the host communication interface circuitry. The output on U26, pin 10 is used to reset the alarm annunciator card.

The CPU sets the outputs of U26 with a CRU output cycle. The RESET(L) signal asserted at power up on U26, pin 15 (CLEAR) causes all outputs to be set low. The address of the latch to be written to is from address bits A1 through A3, and the state of the latch is defined by address bit A0. The CRU device selector circuit supplies the enable input on U26, pin 14 as discussed above.

Read-Only Memory (ROM)

The ROM that supplies the firmware for the CPU consists of three 8K-byte by 8-bit EPROMs (U45, U46, and U49) and two 64K-byte by 8-bit EPROMs (U44 and U48).

The data in these EPROMs is retrieved by a CPU read cycle. Address bits A0 through A12 are decoded by each EPROM to determine the byte being fetched. The memory chip selector circuit discussed previously uses the remaining address bits A13 through A15 to provide the chip-select signal to pin 20 on one of the five EPROMs. In addition, signals MMA, MMB, and MMC from U18, pins 4, 5, and 6 are used to select the appropriate page within memory chips U44 and U48. This selection is made prior to accessing the memory devices with a read cycle. The selected EPROM outputs data to the data bus when OE(L) is asserted low; OE(L) is the same as DBIN(L).

Capacitors C29, C30, C31, C38, and C39 are power supply bypass capacitors that reduce noise coupling through the power distribution circuit.

Wire jumpers W1, W2, W3, W5, and W6 are hardwired on the Computer Interface PCA as shown on the schematic diagram. These jumpers are provided for future modification and can be ignored.

Jumper W10, W11, and W12 must be connected to signals MMB, MMA, and MMC respectively (as shown on the schematic diagram).

Random-Access Memory (RAM)

The RAM used by the CPU consists of ten 32K-byte by 8-bit CMOS static RAMs (U34 through U43) and one 8K-byte by 8-bit CMOS static RAMs (U47).

These RAMs are powered by the +5B (battery backed up) power supply so that the data is non-volatile when the power is OFF. The power ON/OFF reset circuit and the memory selector circuit ensure that the chip select input pin 20 is de-asserted high when the +5V supply is below 4.6V.

Data is written into these RAMs by a CPU write cycle. Address bits A0 through A12 are decoded by each RAM to determine the byte being written to. The memory chip selector circuit discussed previously uses the remaining address bits A13 through A15 and the memory mapper, U26, bits MM0 through MM2 to provide the chip select signal to pin 20 on one of the ten RAMs. In addition, MM3 and MM4 are used to select one of four 8K-byte pages within U34 and U39. This selection, like the bank selection, must be made prior to the memory access cycle. The data on the data bus is written into the selected byte of the selected RAM when WE(L) is asserted low.

The data in these RAMs is retrieved by a CPU read cycle. Address bits A0 through A12 are decoded by each RAM to determine the byte being fetched. The memory chip selector circuit discussed previously uses the remaining address bits A13 through A15 and the memory mapper, U26, bits MM0 through MM2 to provide the chip select signal to pin 20 on one of ten RAMs. The selected RAM outputs data to the data bus when OE(L) is asserted low: OE(L) is the same as DBIN(L).

Capacitors C21, C22, C23, C25, C27, C32, and C33 through C37 are power supply bypass capacitors that reduce noise coupling through the power distribution circuit.

Wire jumper W7 must be connected to MM4. Wire jumper W4 on the Computer Interface PCA is as shown on the schematic diagram. This jumper is provided for future modification and can be ignored.

Configuration Switches and Interface Circuit

The circuit block containing the configuration switches and interface circuit consists of CRU devices and DIP switches for the input of configuration information to the CPU. There are three identical circuits in this block and each operates the same; however the data obtained is for different use by the CPU. Switch pack S2, pull-up resistor network Z1, and data selector/multiplexer U15 are used to provide information about the host computer communication port. Switch pack S3, pull-up resister network Z2, and data selector/multiplexer U23 are used to provide information about the host computer protocol and local line frequency. Switch pack S4, pull-up resistor network Z3, and data selector/multiplexer U33 are used to provide information about the printer communication port.

When the CRU device selector circuit detects that the CPU is accessing this circuit, the appropriate output of U22 asserts the strobe input, pin 7, of the data selector/multiplexer U15, U23, or U33. Address bits A1 through A3 are used to address each switch that is connected with a pull-up resistor to each input of U15, U23, or U33.

If the selected switch is closed, a low is output on pin 5 of the enabled data selector/multiplexer. If the selected switch is open, a high is output on pin 5 of the enabled data selector/multiplexer. These pin 5 outputs are the CRUIN signal for the CPU and are input while DBIN(L) is asserted low.

The function of each switch is shown on the decal located on the rear bezel of the Front End.

This circuit is only used at power-up. Therefore, if the configuration is changed, the power to the Front End must be cycled for the CPU to be reconfigured.

Clock and Clock Interface Circuit

The clock and clock interface circuit provides the Front End with a non-volatile system clock and calendar. U19 is a CMOS calendar/clock IC that is powered from the +5B (battery backed up) power supply. Interface to the CPU is provided by CRU devices for control and reading of the clock.

The CRU device that allows the CPU to output control signals and data to U19, is U18, an 8-bit addressable latch. The CPU sets the outputs of U18 with a CRU output cycle. The RESET(L) signal asserted at power-up on U18, pin 15 (CLEAR) causes all outputs to be set low. The address of the latch to be written to is from address bits A1 through A3 and the state of the latch is defined by address bit A0. The CRU device selector circuit supplies the enable input on U18, pin 14 as discussed above.

When the CRU device selector circuit detects that the CPU is accessing this circuit to read data, the output of U22, pin 11 is asserted low and provides the strobe input, pin 7 of U17, a data selector/multiplexer.

Table 3-4 defines the signals used for control and setting of U19.

Table 3-4. U19 Control Signals

CRU ADDRESS	U18 PIN	U19 PIN	SIGNAL
0x0100	4	3	Address 0
0x0101	5	2	Address 1
0x0102	6	1	Address 2
0x0103	7	5	Device Select
0x0104	9	4	Command Strobe
0x0105	10	8	Shift Clock
0x0106	11	6	Clock Data Input
0x0107	12		Alarm Signal

The control inputs on U19 are set by the CPU through U18 so that a bit of data from the clock is present on U19, pin 9 that is input to the CPU via U17, pin 4 by a CRU input cycle that addresses this input.

U17 is also used to input data from the communication interface circuit blocks.

Clock frequency is controlled by Y2, a 32.768 kHz crystal. Capacitors C15 and C16 are required to maintain oscillator operation and stability. Resistor R31 is a pull-up resistor for the clock data output on U19, pin 9, since this output is open drain.

Host Communication Circuit

The host communication circuit provides the interface between the CPU and the serial, asynchronous, communication channel with the host computer. The line driver and receiver portion of the circuit can be switch selected to EIA voltage levels with RS-232-C protocol or RS-422 differential voltage levels.

Data exchange with the CPU is done with a TMS-9902A asynchronous communications controller (ACC), using the CRU interface hardware.

The ACC, U14, is enabled at pin 17 when the output of U22, pin 14 is asserted low, which happens when the CPU is sending data to or receiving data from the ACC. The CPU sends control information and data to the ACC on a CRU output cycle. The CPU receives control information and data from the ACC on a CRU input cycle. The identification of each bit of data transferred is determined by addresses A1 through A5 with the state of the data for the ACC defined by address bit A0, and the state of the data for the CPU defined on pin 4 of the ACC.

The connection between the Front End and the host computer is made through connector J70. A six-position DIP switch, S1, is used to select between EIA RS-232-C and RS-422 communication types.

RS-232-C COMMUNICATION

When RS-232-C communication is used, the host sends characters to J70, pin 3. The EIA voltage-level signal is converted to TTL signal levels by U6, a quad line receiver, and passed to U14, pin 3. When the ACC detects that a character has been received, the CPU is notified with an interrupt and inputs the character from the ACC. The Clear to Send (CTS) and Data Set Ready (DSR) signals from the host computer are level shifted by U6 and passed to U14 on pins 7 and 6, respectively. When the ACC has a character to send to the host computer, the signal is output with the configuration switch-selected characteristics on pin 2 of U14, the ACC. This TTL-level signal is converted to EIA voltage levels by U5, a quad line driver, and passed to J70, pin 2 for reception by the host computer. The Request to Send (RTS) signal from U14, pin 5 is level shifted by U5 and passed to J70, pin 4. This communication takes place provided all of the RS-232-C control signals are asserted properly. If a "three wire connection" is used to the host, U6 is biased to interpret these open inputs as asserted and provides the appropriate control inputs to U14, the ACC. Capacitors C3, C7 and C8 along with resistors in resistor networks Z4 and Z5 provide noise filtering at U6.

RS-422 COMMUNICATION

When RS-422 communication is used, the host sends characters to J70, pins 14 and 15. The differential voltage input is converted to TTL signal levels by U3, a dual differential line receiver, and passed to U14, pin 3. The response of U14 from this point is the same as for RS-232-C. An output character from the ACC, is converted from TTL levels to a differential voltage level by U7, a dual differential line driver, and passed to J70, pins 9 and 10. Line drive is improved by using both drivers of U7 in parallel and resistively coupling their outputs with R16 through R19 to allow for a non-fatal driver failure. Resisters R20 and R21 provide current limit protection. Resistors R13 and R15 provide line termination for receive inputs. Resistors R12 and R14 provide a defined input for U3 when the inputs are left open.

PRINTER COMMUNICATION

The RS-232-C printer port is used to log data to a local display (CRT terminal) or recording (printer) device. The actual data to be sent can be controlled by configuration information entered by the user when the application is being set up.

When this port is used, the microprocessor (U20) sends transmitted data, in order, to U13 (UART), U10, and connector J71, pin 2. U10 accepts the TTL logic levels from the UART and outputs EIA RS-232-compatible voltage levels. Modem control line RTS(L) follows a similar path from UART through U10 to J71, pin 4.

The received data line reaches receiver U2 through J71, pin 3. U2 converts EIA RS-232 voltage levels to TTL-compatible levels, which are applied first to UART U13 and then to the microprocessor (U20).

The printer port receive line can be used to implement X-ON/X-OFF flow control by the receiving device if there is danger of losing data. However, this technique is not normally desirable since it may delay performance of other, more important, Helios tasks.

Modem control lines DSR(L) and CTS(L) are routed from the external device to receiver U4 through J71, pins 6 and 5, respectively. U4 converts EIA RS-232 voltage levels to the TTL-compatible levels that are applied to UART U13.

Modem control lines (DSR(L), CTS(L) and RTS(L)) may be used by the receiving device to implement flow control, but the same drawbacks as described for X-ON/X-OFF flow control apply.

NOTE

Due to its transmit-only nature, the printer port should not be used with a standard modem. A null-modem cable is permissible for the printer port.

Serial Link Communication Circuit

The serial link communication circuit provides the interface between the CPU and the RS-422 serial communication channel with its associated measurement and control options (referred to as serial link devices). Data exchange with the CPU is accomplished with a TMS-9902A asynchronous communications controller (ACC), using the CRU interface hardware.

The ACC, U11, is enabled at pin 17 when the output of U22, pin 13 is asserted low, which happens when the CPU is sending data to or receiving data from the ACC. The CPU sends control information and data to the ACC on a CRU output cycle. The CPU receives control information and data from the ACC on a CRU input cycle. The identification of each bit of data transferred is determined by addresses A1 through A5 with the state of the data for the ACC defined by address bit A0, and the state of the data for the CPU defined on pin 4 of the ACC.

The interconnection of the Computer Interface Assembly and serial link devices installed in the Front End is made through P12 (via the Motherboard PCA). The interconnection of the Computer Interface Assembly and serial link devices installed in Extender Chassis is made through J23 (via appropriate cabling).

A character for output on the serial link that has been transferred to U11, the ACC, is serially output by U11 on pin 2 and converted from TTL levels to RS-422 differential voltage levels by U1, a dual differential line driver. Line drive is improved by using both drivers of U1 in parallel and resistively coupling their outputs with R4 through R7 to allow for a non-fatal driver failure. CR4 through CR7 provide voltage protection for U1, and R2 and R3 provide current limit protection.

A character for input from a serial link device is converted from differential voltage levels to TTL-levels by U3, a dual differential line receiver, and passed to U11, pin 3. When U11 detects that a character has been received, the CPU is notified with an interrupt and inputs the character from the ACC. Resistors R8 through R11 provide line termination for the receive inputs. Diodes CR8 through CR11 provide voltage protection for U3.

Interrupt Control Logic

The serial link ACC operates at 25K baud, so the interrupt on pin 1 is connected directly to the INT1(L) input of U20, pin 15.

The host computer ACC interrupt on pin 1 of U14 is low OR-ed with other possible ACC interrupts to produce a composite interrupt on U9, pin 12. This composite interrupt is connected to the INT4(L) input of U20, pin 14. U12, reserved for future expansion, is not installed; pull-up resistor R23 keeps its line from floating. U13 is used for the printer port. The INT1(L) input on U20 has a higher priority than the INT4(L) input.

Alarm Annunciator Interface

The Alarm Annunciator PCA is controlled by signals on J73, pins 6 and 3. Pin 6 carries the alarm signal that is driven by U18, pin 12. Refer to the related circuit description under "Clock Interface Circuit." Pin 6 is asserted high when an alarm is detected. It must execute a low-to-high transition each time a new alarm is detected. When all alarms are cleared, pin 6 is asserted low.

Pin 3 is used to clear the alarm annunciator card by asserting a low-to-high transition. This pin is driven by U26, pin 10. Refer to the "Memory Chip Selector" circuit description. Pin 3 is left high during normal operation of the unit.

Power Distribution

Power is delivered to the Computer Interface Assembly from the mainframe power supply by an 8-conductor cable that connects at J75. TP1 through TP4 are provided to monitor the +5V, +12V, and -12V power sources at the Computer Interface Assembly. VR1, a 6V Zener diode, provides protection against voltage transients.

When Front End power is ON, and W9 (the battery power disconnect jumper) connects the negative terminal of the battery to ground, the +5V supply provides +5B through CR1 and charges BT1 through R1 and CR3. When Front End power is OFF, the battery (BT1), supplies +5B through CR2.

ALARM ANNUNCIATOR PCA

State Machine

The state machine consists of two flip-flops within U5 and the gates in U3 and U4. Table 3-5 shows the logic states.

Table 3-5. Alarm States

STATE	U5 PIN 9	U5 PIN 6	DESCRIPTION
0	Low	High	No Alarms
1	High	High	Unacknowledged Alarm
2	High	Low	Acknowledged Alarm
3	Low	Low	Alarm Cleared
4	Low	High	No Alarms

Computer Interface Assembly software initializes the state machine to state 0 by holding J77, pin 6 low while forcing a low-to-high transition on J77, pin 3. State 0 is maintained until J77, pin 6 goes high, which causes the transition to state 1. The state machine then remains at state 1 until an alarm condition is acknowledged. Once an alarm is acknowledged, the state machine advances to state 2. State 2 is maintained until J77, pin 6 goes low, which advances the state machine first to state 3 and then automatically back to state 0. Note that state 3 is only a transition state, used to prevent accidental transition from state 2 to state 1.

The two outputs from the state machine control the alarm relays as shown in Table 3-6.

Table 3-6. Alarm Outputs

STATE	AUDIBLE ALARM	VISUAL ALARM
0	OFF	OFF
1	On Steady	ON and OFF
2	OFF	On Steady
3	OFF	OFF

Relay Drivers

The relay drivers consist of U6, part of U3, and protection diodes CR2 and CR3. The gate used in U3 controls the clock signal input from U1. Inputs from U5, pins 6 and 9 control the drivers as defined in Table 3-5.

Relays

The two output relays are mounted in sockets on the Alarm Annunciator PCA. The relays are rated at 10,000,000 operations at either 0.6A for 120V ac or 1A for 30V dc.

Clock

The clock, consisting of CMOS oscillator U1, capacitors C1 and C3, and timing resistor R5, outputs a signal to the relay drivers of approximately 1.2 Hz. The clock uses separate ground and voltage supply lines along with noise-suppression capacitors C4 and C6 to protect against noise propagation from the oscillator.

Alarm Acknowledge Circuit

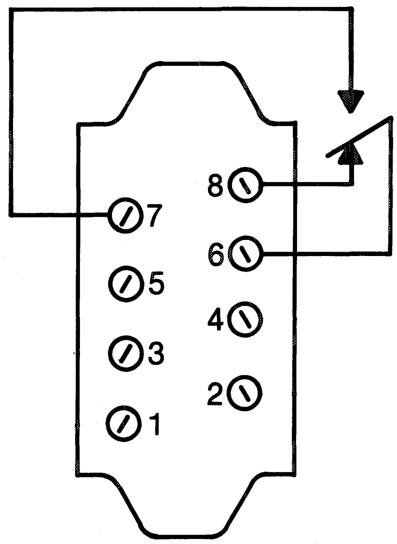
CAUTION

An SPDT switch must be used for the alarm acknowledge pushbutton. This arrangement requires that an alarm be acknowledged, which can be a very important safety consideration. The acknowledge pushbutton must not be hard wired closed.

Alarm acknowledgment requires a single-pole, double-throw switch (SPDT) allowing for the following sequence:

1. Connection of pin 6 to pin 8.
2. Disconnection of pin 6 from pin 8.
3. Connection of pin 6 to pin 7.
4. Disconnection of pin 6 from pin 7.
5. Reconnection of pin 6 to pin 8.

This switch arrangement prevents permanent wiring of alarm acknowledge contacts in the acknowledged position. See Figure 3-5.



WARNING

TO AVOID ELECTRICAL SHOCK, DISCONNECT ALL EXTERNAL POWER SOURCES BEFORE MAKING ANY ALARM CONNECTIONS.

Figure 3-5. Alarm Acknowledge Switch Connections

The alarm acknowledge pushbutton interface is formed by two flip-flops in U2. The first must be set and then cleared to generate the low-to-high signal used as the input to the second flip-flop. If the state machine is in state 1 or state 2 at this time, a high is clocked into the second U2 flip-flop, in turn causing U2, pin 9 to go high. If the state machine was in state 1, this action causes the state machine to advance to state 2, acknowledging the alarm. The pushbutton inputs use pullup resistors R1 and R2. Resistor R3 is used to bias the unused U2, pin 10 high.

POWER SUPPLY

The power supply is a switch-mode supply that operates at either 90 to 132V ac or 180 to 264V ac (depending on a jumper setting), at a frequency range between 47 through 440 Hz.

The serial link devices operate at voltages that can range from +10 to +25V dc. The ac mains voltage is regulated to +5V, +12V and -12V dc. The power supply connector pinouts are shown in Table 3-7.

Table 3-7. Power Supply Connector Pinouts

J1 (INPUT)		J2, J3, & J4 (OUTPUT)	
PIN	SIGNAL	PIN	SIGNAL
1	AC Neutral	1	-12V
2	AC Line	2	+12V
E3	AC Ground	3	Return
		4	+5V

SERIAL LINK COMMUNICATION

Hardware

The serial link connects the Computer Interface Assembly with data acquisition and control options in the system.

NOTE

In this discussion, the data acquisition and control options are collectively called "devices."

The serial link controller (i.e., Computer Interface Assembly) translates TTL-level signals from the CPU into RS-422 signals for communication with the devices. The RS-422 signals are sent and received over two twisted pairs of conductors. On one pair, the controller transmits while all devices listen. On the other pair, a device selected by the controller can transmit responses to the controller, but never to other devices.

Devices on the serial link may be physically located inside the Front End or in an Extender Chassis. The serial link is routed through each device in such a way that if power is removed from any of them, communication through the link remains unbroken.

General Protocol

This description deals only with the elements of the serial link protocol that are device independent. Because of the diversity of devices, only the most basic protocol can be covered.

Information is sent over the serial link in the form of ASCII characters at a rate of 25000 baud. Each character consists of the following:

1 Start Bit
8 Information Bits
1 Odd Parity Bit
1 Stop Bit

When the controller sends a message, the addressed device replies with either an acknowledgement or a response message (depending on the message type). A device never initiates an exchange.

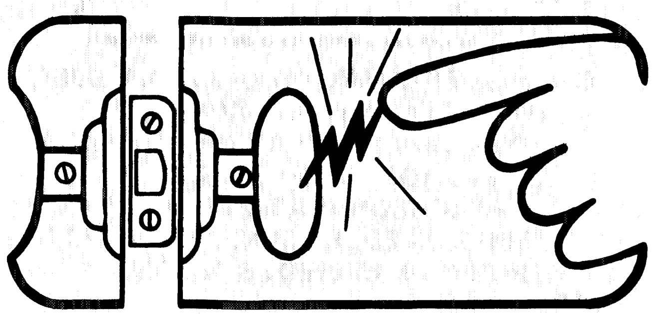
A message is sent in one or more groups. The group is the basic protocol unit and consists of three information characters followed by a check character. Some controller messages require the device to reply with an acknowledgement, which is a single character and can have one of only two values: ready (0x3C), and not ready (0xC3).

The serial link is protected against occasional errors in transmission by character parity and longitudinal parity. The protocol recovers by repeating the transmission.

static awareness

A Message From

John Fluke Mfg. Co., Inc.

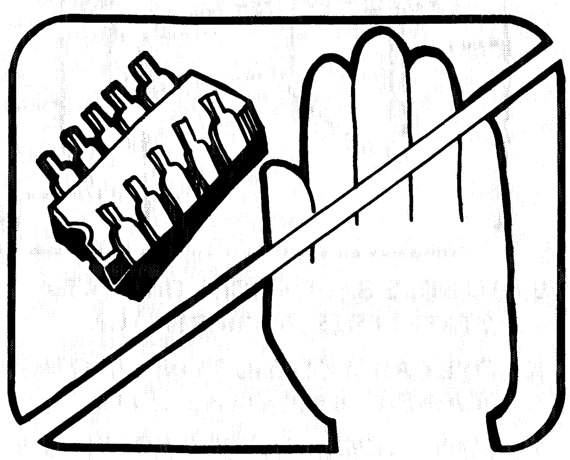


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

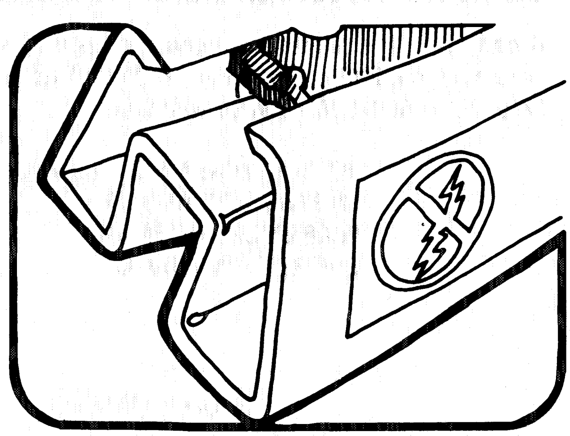
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol "⊗"

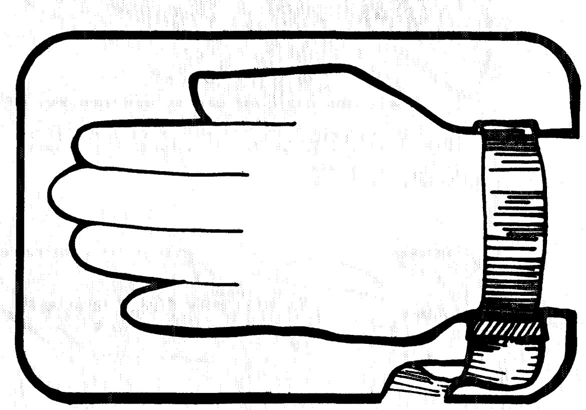
The following practices should be followed to minimize damage to S.S. devices.



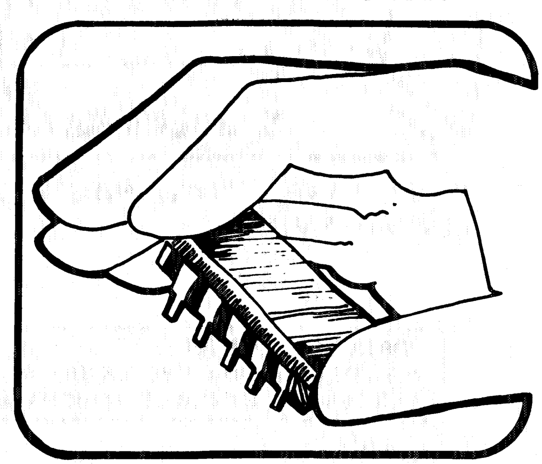
1. MINIMIZE HANDLING



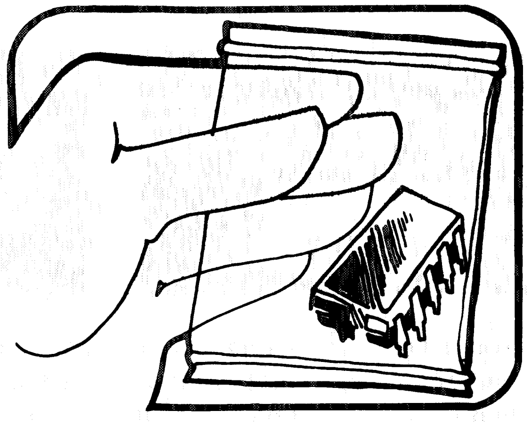
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



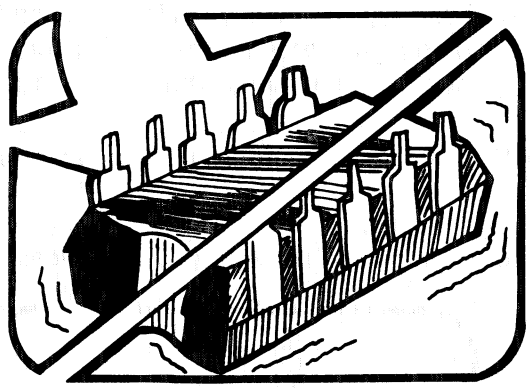
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



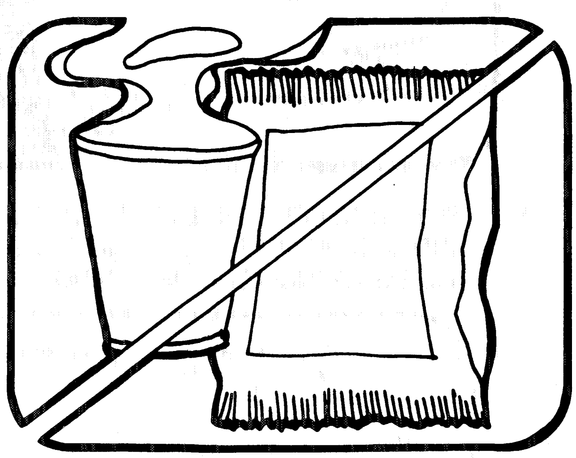
4. HANDLE S.S. DEVICES BY THE BODY



5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT

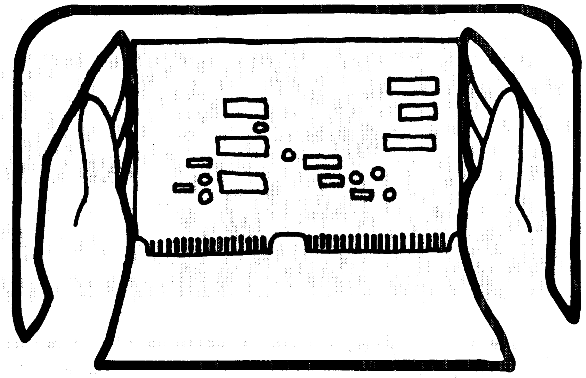


6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE

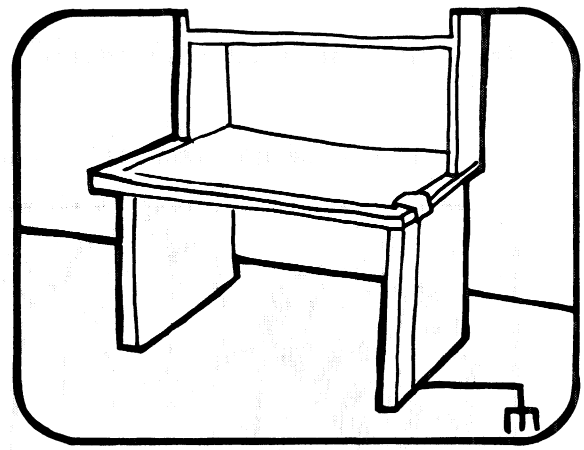


7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA

PORTIONS REPRINTED WITH PERMISSION FROM TEKTRONIX, INC. AND GENERAL DYNAMICS, POMONA DIV.



8. WHEN REMOVING PLUG-IN ASSEMBLIES, HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR HELPS TO PROTECT INSTALLED SS DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION

10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

A complete line of static shielding bags and accessories is available from Fluke Parts Department, Telephone 800-526-4731 or write to:

JOHN FLUKE MFG. CO., INC.
PARTS DEPT. M/S 86
9028 EVERGREEN WAY
EVERETT, WA 98204

® Dow Chemical

J0089D-07U8604/SE EN Litho in U.S.A.
Rev. 1 MAR 86

SECTION 4
MAINTENANCE

CONTENTS

GENERAL MAINTENANCE

Section 4 contains procedures for performing general maintenance on the Helios Plus Front End. Accessing and cleaning all major assemblies of the mainframe are also provided in this section.

Line Voltage Selection

WARNING

THE FOLLOWING PROCEDURE REQUIRES ACCESS TO THE INTERIOR OF THE FRONT END. DO NOT PERFORM THIS PROCEDURE UNLESS YOU ARE QUALIFIED TO DO SO. LETHAL VOLTAGES MAY EXIST WITHIN THE UNIT.

The power input setting (110V or 220V) is normally marked on the support panel of the Computer Interface Module, just above the power input connector. If there is no mark in either box, or if the box is marked for a voltage other than the one you will be using, use the following procedure to gain access to the internal setting.

1. Turn the Computer Front End power switch to OFF.

2. Remove the ac input line cord from the power source and from the Computer Front End.

3. Remove the four Phillips-head screws indicated in Figure 4-1.

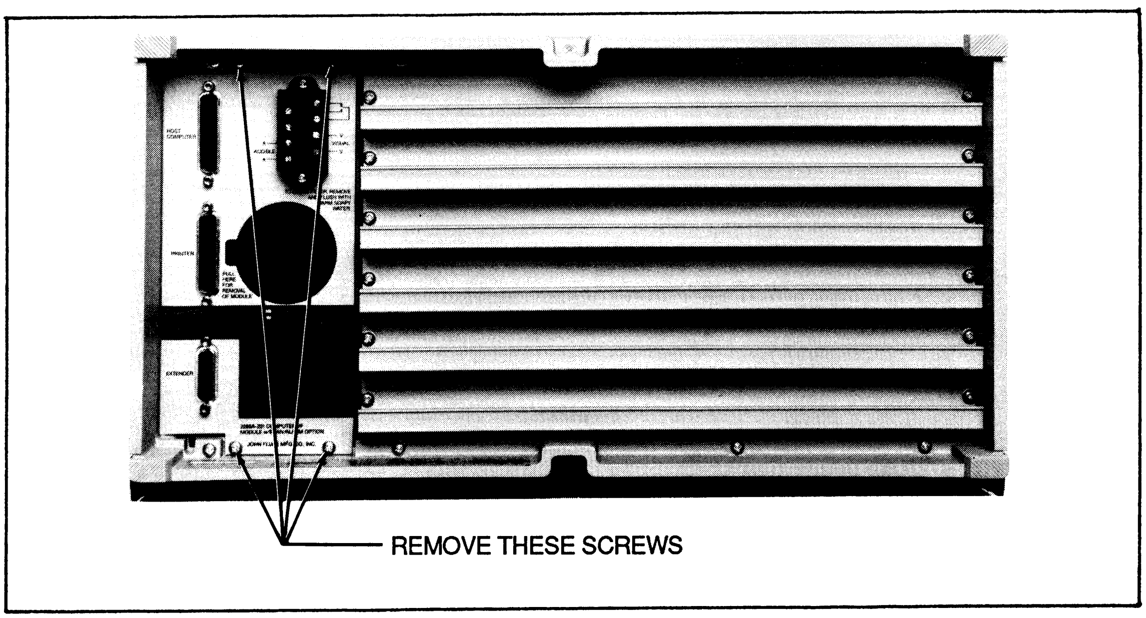


Figure 4-1. Removing The Attaching Screws

4. Remove the Computer Interface Module from the chassis by grasping the finger indentation in the fan filter hole and sliding the module straight back and out.

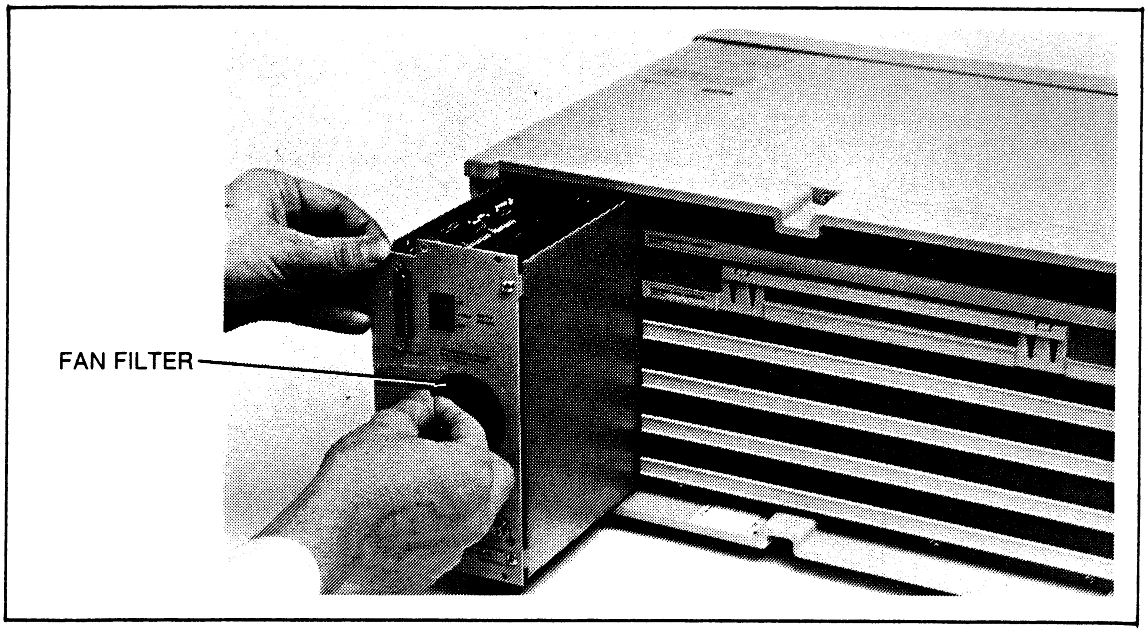


Figure 4-2. Removing the Computer Interface Module

5. Locate the Line Power Voltage Pins on the Power Supply PCA (Figure 4-3). To select 180-264V operation, connect the wire to the pin marked 220V. For 90-132 operation, place the wire on the pin labeled 110V. It is not necessary to change the power input fuse

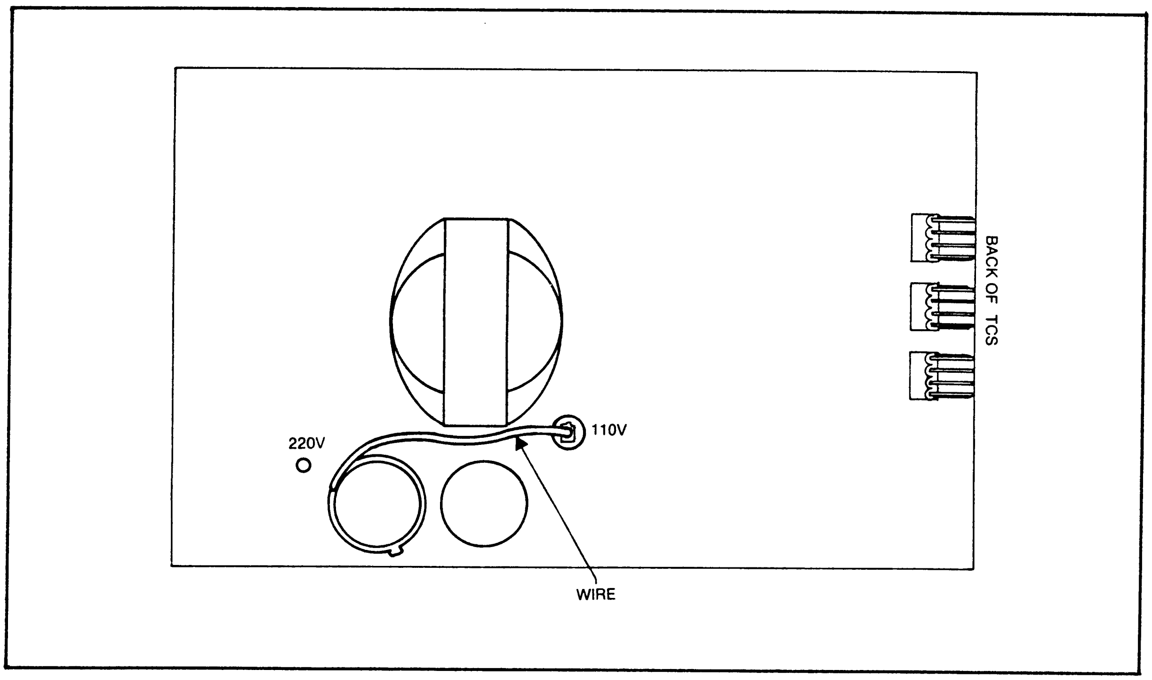


Figure 4-3. Line Power Voltage Pins

6. While the Computer Interface Module is out, locate the Line Frequency Selection Switch, S3-8, (see Figure 4-4) to ensure it is set to the local line frequency.

   If the switch is not set to the local line frequency, set it properly before continuing. For 50-Hz operation, place S3-8 in the ON position (up). For 60-Hz operation, place the switch in the OFF (down) position.

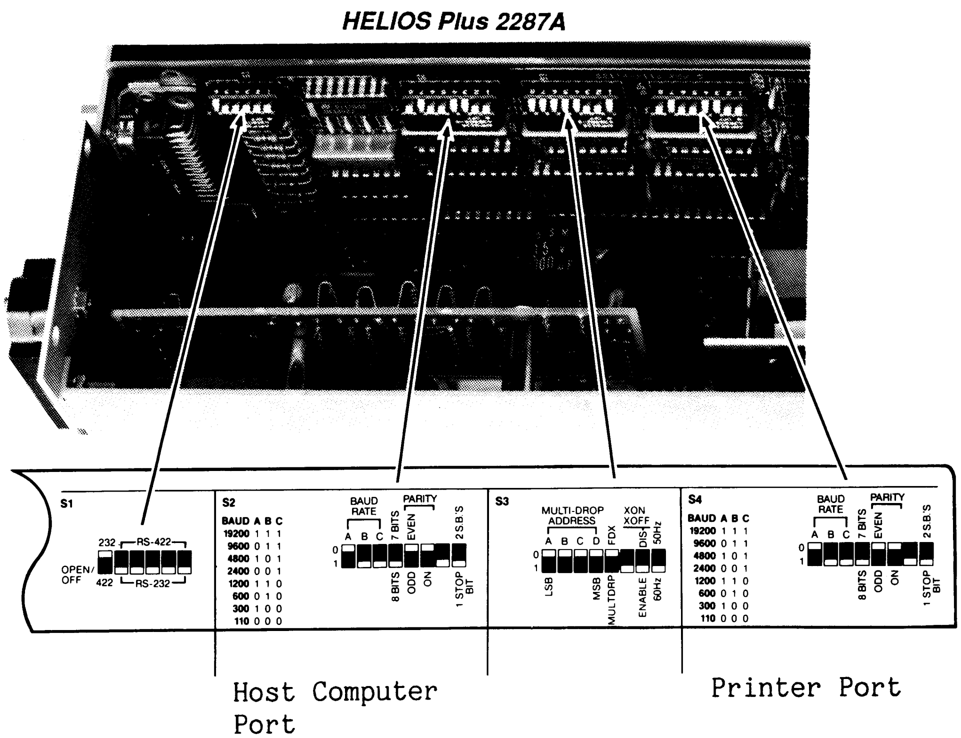


Figure 4-4. Communication Parameter Selection Switches

7. After changing the line power voltage, mark the appropriate power setting on the support panel of the module, (above the ac input socket).

8. Slide the Computer Interface Module back into the Front End, and reinstall the Phillips-head screws.

Fuse Replacement

The fuse is located on a clip-type holder on the power supply assembly, in the corner to the right of the 110V voltage selection pin. When replacing the fuse, use the same value (2.0A, 250V). To check or replace the fuse, perform the following:

1. Switch OFF power to the Front End and disconnect the ac line cord and other high voltage input.
2. Remove the Computer Interface Module as described in steps 3 and 4 of the Line Voltage Selection procedure (above).
3. Use a slotted screwdriver or adjustment tool to remove the fuse.
4. After checking or replacing the fuse, reinstall the Computer Interface Module in the Front End chassis and test its operation.

NOTE

If the fuse is bad, it is probable that the power supply is also bad. Remember that the Power Supply is a replaceable, but not repairable, item. If a replacement fuse fails, contact a Fluke Service Center.

Power Supply Adjustments

The power supply voltage levels do not normally require calibration, although some minor service adjustments may occasionally be necessary. Refer to Section 5 for power supply adjustment procedures.

General Cleaning

CAUTION

Before cleaning or servicing the Computer Interface Assembly, disconnect back-up battery power by moving the W9 jumper as shown in Figure 4-5.

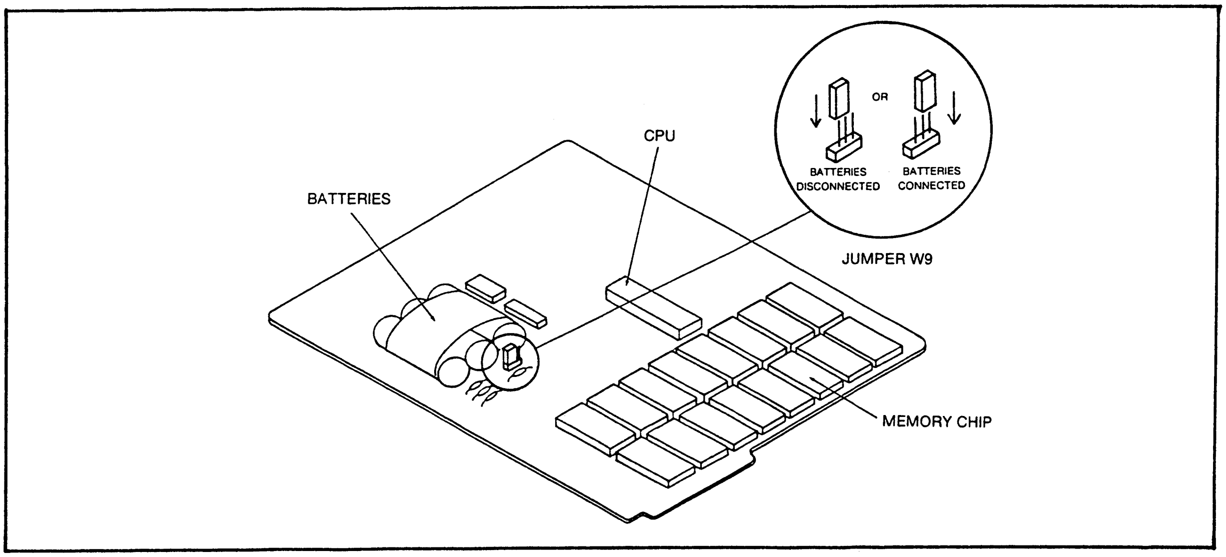


Figure 4-5. W9 Battery Power Jumper

CAUTION

Do not use aromatic hydrocarbons (such as naphthalene) or chlorinated solvents (such as carbon tetrachloride) for cleaning. They may damage plastic materials used in the instrument.

Wipe the Computer Front End periodically to remove dust, grease, and other contamination. The Front End chassis may be wiped using a soft cloth dampened with a mild solution of detergent and water. Dry the case thoroughly after cleaning.

Do not apply fluids or detergents directly to the chassis.

Observe the following precautions when cleaning the Front End:

- Handle a pca by its edges rather than by its connector pins.

  Oils from your skin can contaminate the board and degrade measurement accuracy of the system.

- Improper handling can also cause instantaneous or delayed electrostatic discharge damage.

  The yellow "Static Awareness" sheet preceding this section explains some of the hazards of static electricity to sensitive components.

- Do not use a static-inducing vacuum brush to clean assemblies. Possible electrostatic discharge can damage sensitive components.

PCA Cleaning

Unless dirt, dust or other contamination is visible on its surface, a pca does not normally require cleaning.

When significant dirt or contamination is visible, clean the board(s) with low pressure air (less than 20 psi). If air cleaning is not possible, clean the board with water-based cleaning equipment.

If commercial water-based cleaning equipment is not available, clean the board by holding it under warm, running water.

The Motherboard may be cleaned by removing it (as explained in Section 4, below) and using a FREON degreaser or warm water. Thoroughly dry the Motherboard (use only forced air, not heat) before reassembly.

Observe the following precautions when using water-based cleaning equipment:

1. Read and observe all precautions listed previously under General Cleaning.

2. Remove all board shielding covers, and separate any relay piggy-back assemblies.

3. In areas with exceptionally hard water, use either deionized or distilled water for a final wash to remove ions left by the hard water wash.

4. Dry all boards thoroughly. Use a low-temperature drying chamber or an infrared drying rack with a temperature range between 100 and 120 ^{o}F (38 to 46 ^{o}C) if available.

5. If a drying chamber or infrared drying rack is not available, air dry the board at room temperature for a minimum of 48 hours before reassembling.

6. Use a mixture of 70% isopropyl alcohol and 30% water and a lint-free cloth to clean edge-connector contacts. Never use an eraser to clean connector contacts; it might generate static or abrade the gold plating on the contacts.

Fan Filter Cleaning

Clean the fan filter (shown in Figure 4-2) any time it is visibly contaminated. If the Front End is operated too long with a dirty air filter, heat buildup inside could damage sensitive electronic components.

To remove the filter, pinch the center and pull directly out. Clean the filter with warm soapy water and rinse it thoroughly before replacing.

ACCESS, REMOVAL AND REINSTALLATION PROCEDURES

The following procedures provide step-by-step instructions for gaining access to, removing, and reinstalling major assemblies of the Data Acquisition Front End Mainframe. Refer to Figure 6-1 for the location of the major assemblies on the Front End chassis.

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING ANY OF THE FOLLOWING ACCESS PROCEDURES.

Access to Options

Front End module and connector options are accessible from the rear of the instrument.

An option board or connector may be removed by loosening the two retaining screws, one on each side, and sliding out the pca.

Removing and Reinstalling the Top and/or Bottom Cover

Use the following procedure to remove the top and/or bottom cover:

1. Disconnect all power cables and remove any connectors from the serial link options.

2. Remove the carrying straps from the sides of the instrument by removing the two Phillips-head screws at the ends of the handles.

3. Remove the three Phillips-head screws located in the handle indent groove of the cover on each side of the Front End.

4. From the rear of the Front End, remove the top or bottom counter-sunk Phillips-head screw located in the top recess of the rear bezel, and remove the desired cover.

Reverse the previous steps to reinstall the top and/or bottom cover(s).

Removing and Reinstalling the Front Panel

Use the following procedure to remove the front panel from the Front End:

1. Disconnect all power to the Front End.

2. Remove the carrying straps from the sides of the instrument by unfastening the two Phillips screws at the ends of the handles.

3. On each side, remove the three Phillips screws in the handle indent groove of the cover.

4. Remove the FLUKE decals on each side of the front panel, which are held in place by an adhesive. To remove a decal, use a pointed implement to carefully pry up a corner of the decal, then gently pull the decal out of its setting.

5. Remove the Phillips-head screws holding the front bezel to the chassis.

6. Pull off the plastic front bezel.

7. Pry off the front panel, being careful not to overextend the wire connected to the front panel LED.

8. From behind the front panel, gently push the LED forward 1/4 inch.

9. From behind the front panel, pull the snap ring off the snap coller of the LED.

10. If the LED needs to be removed, pull it out of the front panel.

Reverse the previous steps to reinstall the front panel.

Removing and Reinstalling the Motherboard

Use the following procedure to remove the Motherboard from the Front End chassis and gain access to the front panel LED:

1. Remove the top and bottom covers as described under Removing and Reinstalling the Top and/or Bottom Cover (above).

2. Remove the front panel as described under Removing and Reinstalling the Front Panel (above).

3. Carefully remove the brass gasket from the rear of the unit.

4. Remove the six Phillips-head screws along the outside edge of the unit, and remove the top part of the chassis.

5. Remove the four screws (with star washers) retaining the black serial link device card guide (two on the top and bottom sides) and remove the card guide.

6. Slide the Motherboard out towards the top of the instrument.

Reverse the previous steps when reinstalling the Motherboard.

To ensure that the Motherboard is reinstalled properly, without damaging it or the Front End chassis, remember to:

- o Reinstall the Motherboard with the P12 connector in the lower left corner as you face the Front End from the rear.
- o Reinstall the device guide with its Motherboard-locating peg in the corresponding hole.
- o Reinstall the LED before installing the front panel.

Removing and Reinstalling the Power Supply

WARNING

THERE ARE LETHAL VOLTAGES AT VARIOUS POINTS ON THE POWER SUPPLY. EXERCISE EXTREME CAUTION WHEN SERVICING. DISCONNECT THE FRONT END FROM LINE POWER AND DISCHARGE ALL CAPACITORS AS SOON AS THEY ARE ACCESSIBLE.

The Power Supply PCA is mounted on the Computer Interface Module (Figure 4-6). To access the Power Supply PCA, use the following procedure:

1. Switch OFF power to the Front End, and disconnect the ac line cord from the support panel input connector.
2. Remove the four Phillips-head screws (shown in Figure 4-1) that secure the Computer Interface Module to the mainframe chassis.
3. Remove the Computer Interface Module from the chassis by grasping the finger indentation in the fan filter hole and sliding the module straight back and out.

WARNING

THERE MAY BE DANGEROUS VOLTAGES ROUTED THROUGH THE ALARM ANNUNCIATOR CONNECTOR. DISCONNECT EXTERNAL POWER FROM THESE ANNUNCIATOR CONNECTIONS BEFORE PROCEEDING.

4. Remove the two Phillips-head screws securing the alarm annunciator connector to the panel. Then pull the connector out, disconnecting it from the Alarm Annunciator PCA.
5. Disconnect the wires leading from the Alarm Annunciator PCA to the Computer Interface PCA.

6. The Power Supply PCA is secured to the right panel of the Computer Interface Module by four Phillips-head screws.

   Rotate this panel down from the support panel of the Computer Interface Module by first removing the upper nut (on the back of the support panel) and then loosening the lower nut.

7. Disconnect all leads connecting the power supply to the Computer Interface Assembly, power switch and fan assembly.

8. To detach the power supply from the panel, remove four Phillips-head screws, one in each corner of the power supply.

Reverse the previous steps to reinstall the Power Supply.

Removing and Reinstalling the Computer Interface Assembly

CAUTION

Handle the Computer Interface Assembly with care, or some semiconductors and ICs can be damaged by electrostatic discharge during handling. Refer to the static awareness information at the beginning of Section 4 for proper handling precautions.

The Computer Interface Assembly is mounted on the Computer Interface Module (see Figure 4-6). Use the following procedure to access the Computer Interface Assembly:

1. Perform steps 1 through 3 of the Removing and Reinstalling the Power Supply procedure.

2. Disconnect all leads to the Computer Interface Assembly.

3. Place jumper W9, shown in Figure 4-6, in the "batteries disconnected" position.

4. The Computer Interface Assembly is secured to the left panel of the Computer Interface Module by six hex-head screws above and below the HOST COMPUTER, PRINTER, and EXTENDER chassis connectors.

   Remove the hex-head screws to detach the Computer Interface Assembly from the side panel.

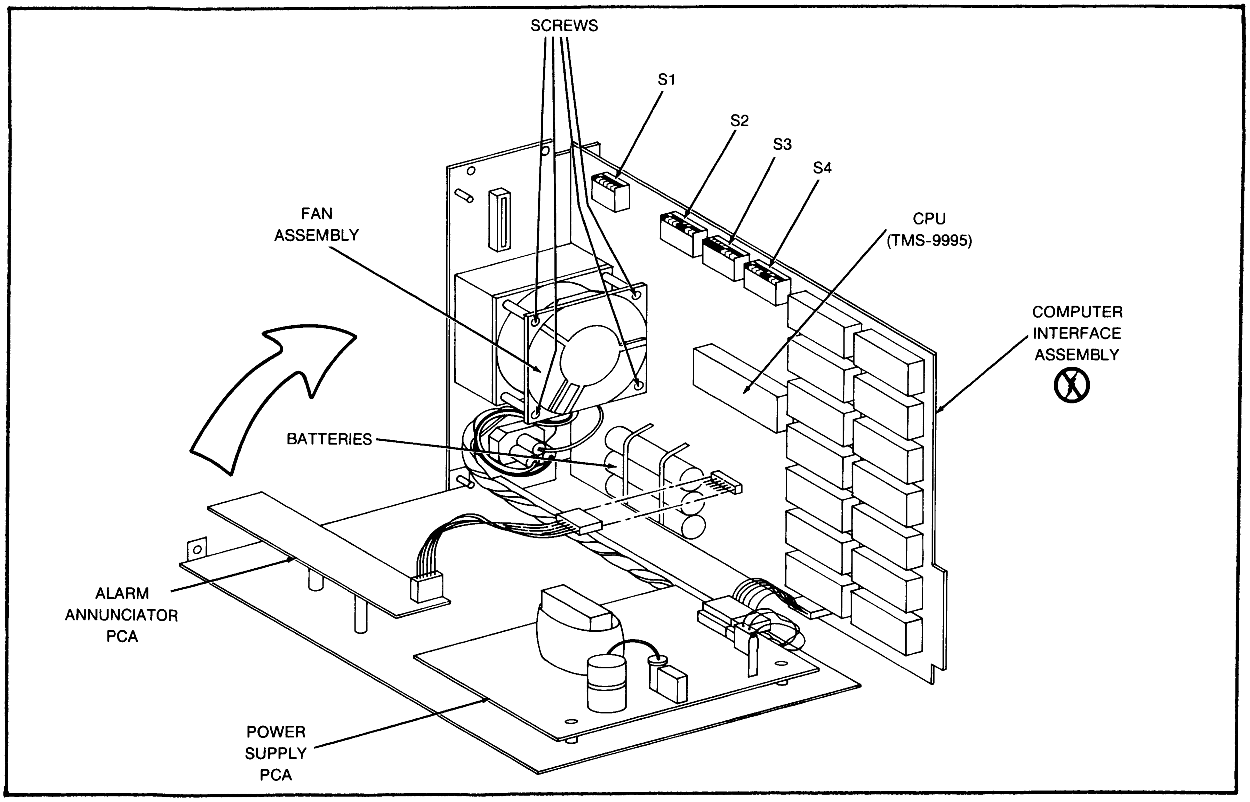


Figure 4-6. Computer Interface Module (Interior)

NOTE

The Computer Interface Assembly should be stored and transported in an anti-static bag.

Reinstall the Computer Interface Assembly by reversing these steps.

Removing and Reinstalling the Fan Assembly

To remove the fan assembly (shown in Figure 4-6), perform the following procedure:

1. Perform steps 1 through 6 of the Removing and Reinstalling the Power Supply procedure.

2. Disconnect the red and blue leads between the power supply and fan assembly if this has not already been done.

3. To detach the fan assembly (and the fan filter housing) from the support panel of the Computer Interface Module, remove the four screws (shown in Figure 4-6) that secure the fan assembly and filter housing to the panel.

To reinstall the fan assembly reverse the previous steps.

Removing and Reinstalling the Alarm Annunciator Assembly

Complete steps 1 through 6 of the "Removing and Reinstalling the Power Supply" procedure. Then remove the two screws securing the Alarm Annunciator PCA to the right panel.

SECTION 5
TESTING AND TROUBLESHOOTING

CONTENTS

INTRODUCTION

Section 5 contains performance testing and troubleshooting information for the Helios Plus Data Acquisition Front End mainframe. Performance testing of the Front End options is covered in Sections 8 (Options -160 through -169) and 9 (Options -170 through -179).

Mainframe performance testing consists of two procedures: the Mainframe Test and the System Selftest. These tests, which can also serve as initial acceptance tests, verify correct operation of the interface (RS-232-C/RS-422), interface hardware (ROM, RAM, UART), Alarm Annunciator hardware, and Printer Port.

The troubleshooting procedures assist service personnel in tracing a malfunction to the printed circuit assembly (pca) level. If a defective pca is identified, we recommend that repair be accomplished using the Fluke Module Exchange Program. For additional information, refer to the Introduction in Section 1.

Although the mainframe theory of operation (Section 3) and schematics (Section 7) can be used by qualified personnel to troubleshoot the Front End circuit assemblies to the component level, it is advisable to first contact a Fluke Service Representative.

PERFORMANCE TESTING

Table 5-1 lists the required test equipment to use when performing the following test procedures.

Table 5-1. Required Test Equipment

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Calibrator	3 to 4.2V dc $\pm$0.001V	Fluke 343
Digital Multimeter (DMM)	Resistance Measurement	Fluke 77 or equivalent
A/D Converter	na	Fluke Option -161 or Fluke Option -165
Thermocouple DC Volts Scanner	na	Fluke Option -162 (only required with -161 A/D Converter)
Input Connector	na	Fluke Option -175 or -176
Printer or Display Monitor	RS232 Compatible	most brands
Switch	Single Pole, Double Throw	Fluke PN 493825

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES WHICH CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

Mainframe Testing

To verify that the Front End mainframe has been correctly installed and is operating properly, perform the following:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.
2. Ensure that communication parameters (i.e., transmission mode, baud rate, parity, number of data bits, number of stop bits) on the Front End and the host (terminal or computer) are properly configured to send and receive serial data. Follow the instructions under the heading "Setting the Communication Switches" in Section 3A of the Helios Plus System Manual. If the Computer Interface Assembly was removed to check (or set) the communication parameters, reinstall it at this time.
3. Remove all installed options from the Front End.
4. Directly connect the host (computer or terminal) to the Front End using equipment and cables appropriate to the type of electrical interface (RS-232-C or RS-422). Check to make sure connections are tight.
5. Reconnect the ac line cord to the Front End and switch the power ON.
6. Switch ON power to the host computer.
7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

Use "PROCEDURE A" for Terminal Mode or "PROCEDURE B" for Computer Mode.

PROCEDURE A. TERMINAL MODE (Mainframe Testing)

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>
SEND VERSION$ <CR>
```

The response from the Front End to the host should be:

Helios Plus Version x.y Software by John Fluke Mfg. Inc.

(x.y is the version number of the installed firmware.)

If this response is not returned a malfunction has occurred.

PROCEDURE B. COMPUTER MODE (Mainframe Testing)

The following sample BASIC programs cause the Front End to respond with its installed version number. One program was written for an IBM* PC and one for a Fluke 1722A Instrument Controller. These programs assume that the Front End has been configured for 9600 baud, no parity, 8 data bits, and 1 stop bit.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10 CLOSE 1
20 CLS
30 REM open communication port, empty Front End buffer
40 OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50 PRINT #1,CHR$(3);
60 REM set up Front End
70 PRINT #1,"mode=comp"
80 GOSUB 300
90 REM request message and read in response
100 PRINT #1,"send version$"
110 LINE INPUT #1,M$
120 PRINT M$
130 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

* IBM is a trademark of International Business Machines Corporation.

Program for 1722A:

```
10 CLOSE 1,2
20 PRINT CHR$(27);"[2J";
30 REM open communication port and empty Front End buffer
40 OPEN "KB1:"AS NEW FILE 1%
50 OPEN "KB1:"AS OLD FILE 2%
60 PRINT #1,CHR$(3);
70 REM set up Front End
80 PRINT #1,"mode=comp"
90 GOSUB 300
100 REM request message and read in response
110 PRINT #1,"send version$"
120 INPUT #2,M$
130 PRINT M$
140 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

The response from the Front End to the host should be:

Helios Plus Version x.y Software by John Fluke Mfg. Inc.

(where x.y is the version number of the installed firmware.)

If this response is not returned a malfunction has occurred.

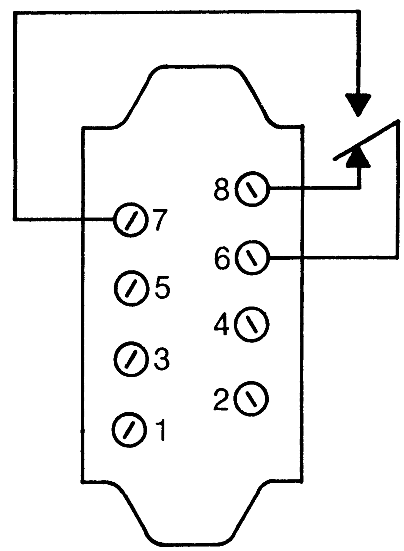
8. This completes the Mainframe Interface Test.

If the Front End fails this test, check all connections and perform the test again. If the system fails this second test, determine if the host interface is functioning properly by testing it using another system or device. If the host interface is not at fault, contact your nearest Fluke Service Representative (see Section 10, Appendices).

Alarm Annunciator Test

The Alarm Annunciator test verifies that the Alarm Annunciator Assembly is functioning properly. Because this test is dependent on voltage readings, the accuracy verification test of either the -162 Thermocouple/DC Volts Scanner or -165 Fast A/D Converter (whichever option is being used) should be performed if voltage readings are suspect.

9. Wire an Alarm Acknowledgement Switch (single pole, double throw) to the Alarm Annunciator Terminal Strip as shown in Figure 5-1.



WARNING

TO AVOID ELECTRICAL SHOCK, DISCONNECT ALL EXTERNAL POWER SOURCES BEFORE MAKING ANY ALARM CONNECTIONS.

Figure 5-1. Alarm Annunciator Terminal Strip

10. The following steps can be accomplished using either the -161 A/D Converter or the -165 Fast A/D Converter. Perform the appropriate step below:

    o -161 High Performance A/D Converter

    Set the -161 A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End. Install the -162 Thermocouple/DC Volts Scanner in the option slot immediately below.

    o -165 Fast A/D Converter

    Set the -165 Fast A/D Converter address switches to "00" and install into the top option slot of the Front End.

11. Remove all other installed options to eliminate addressing conflict.

12. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or a -175 Isothermal Input Connector. If the -161 High Performance A/D Converter is being used, install the connector on the -162 Thermocouple/DC Volts Scanner. Otherwise, install the connector directly on the -165 Fast A/D Converter.

13. On the Front End, reconnect ac line cord and switch the power ON. Connect the calibrator output to the input connector test leads.

14. Set the calibrator output to 3.0000 volts dc.

NOTE

Prior to performing steps 15 and 16, check that the terminal screws are tight to ensure good continuity.

15. With the DMM set to a resistance function, measure for an OPEN across terminals 1 and 3 (audible contacts) of the Alarm Annunciator Terminal Strip.

16. Move the DMM test leads across terminals 2 and 4 (visual contacts) of the Alarm Annunciator Terminal Strip. Check that an OPEN is measured.

17. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host. Use PROCEDURE A for Terminal Mode or PROCEDURE B for Computer Mode.

PROCEDURE A. TERMINAL MODE (Alarm Annunciator Test)

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>
DEF CHAN(0)=DVIN,MAX=5,HI=4,LO=2,HYST=5 <CR>
FORMAT=XASCII <CR>
SEND CHAN(0) <CR>
```

The accuracy in the value returned for channel(000) is dependent on the type of A/D Converter used:

- -161 High Performance A/D Converter. A -161/-162 system should return 3.00000E+00 +/- 0.0012 V.

- -165 Fast A/D Converter. A -165 system should return 3.00000E+00 +/- 0.0021 V.

Repeat steps 16 and 17, checking that relay contacts remained OPEN.

A1. Set the calibrator to output 4.2000 Volts dc.

A2. Again send the command:

```
SEND CHAN(0) <CR>
```

The response for channel 0 should be approximately 4.20000E+00 with the text "hi alarm" appended.

A3. Using the DMM as an ohmmeter, measure a contact closure across terminals 1 and 3 (audible contacts) of the Alarm Annunciator Terminal Strip.

A4. Move the DMM test leads to measure across terminals 2 and 4 (visual contacts). The DMM should indicate closure and opening of the contacts at approximately an 800 millisecond rate.

A5. Acknowledge the alarm by switching the Alarm Acknowledgement Switch so that its normally open (N/O) contact makes continuity with common, then switch back to the normally closed (N/C) position.

A6. With the DMM, check that an OPEN is measured across the audible contacts (terminals 1 and 3).

A7. Move the DMM test leads to measure across the visual contacts (terminals 2 and 4). They should now be shorted (closed).

A8. Set the calibrator to output 3.8000 Volts dc.

A9. Command the Front End to take another measurement on channel 0 by issuing the following command:

```
SEND CHAN(0) <CR>
```

Verify the response is approximately 3.80000E+00 without any alarm message.

A10. Check that both the audible (terminals 1 and 3) and the visual (terminals 2 and 4) contacts measure OPEN.

PROCEDURE B. COMPUTER MODE (Alarm Annunciator Test)

The following sample BASIC programs cause the Front End to take a DC voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A enter a program that will run on your host.

Program for IBM PC:

```
10 CLOSE 1
20 CLS
30 REM open communication port, empty Front End buffer
40 OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50 PRINT #1,CHR$(3);
60 REM set up Front End
70 PRINT #1,"mode=comp"
80 GOSUB 300
90 PRINT #1,"count=off"
100 GOSUB 300
120 PRINT #1,"def chan(0)=dvin,max=5,hi=4.0,lo=2.0,hyst=5"
130 GOSUB 300
140 PRINT #1,"format=xascii"
```

```
150 GOSUB 300
160 REM make measurement and read in response
170 PRINT #1,"send chan(0)"
180 INPUT #1,M$
190 L$=LEFT(M$,9)
200 X$=MID(M$,10,13)
210 R$=RIGHT(M$,11)
220 PRINT L$;
230 PRINT USING "##.######";VAL(X$);
240 PRINT R$
250 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program FOR 1722A:

```
10 CLOSE 1,2
20 PRINT CHR$(27);"[2J";
30 REM open communication port and empty Front End buffer
40 OPEN "KB1:"AS NEW FILE 1%
50 OPEN "KB1:"AS OLD FILE 2%
60 PRINT #1,CHR$(3);
70 REM set up Front End
80 PRINT #1,"mode=comp"
90 GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1,"def chan(0)=dvin,max=5.0,hi=4.0,lo=2.0,hyst=5"
130 GOSUB 300
140 PRINT #1,"format=xascii"
150 GOSUB 300
160 REM make measurement and read in response
170 PRINT #1,"send chan(0)"
180 INPUT #2,M$
190 L$=LEFT(M$,9%)
200 X$=MID(M$,10%,12%)
210 R$=RIGHT(M$,24%)
220 PRINT L$;
230 PRINT USING "S##.######",VAL(X$);"Volts dc ";
240 PRINT R$
250 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

The accuracy in the value returned for channel(000) is dependent on the type A/D Converter used:

- -161 High Performance A/D Converter

  A -161/-162 system should return 3 volts +/- 0.0012V.

- -165 Fast A/D Converter

  A -165 system should return 3 volts +/- 0.0021V.

B1. Set the calibrator to output 4.2000V dc.

B2. Take another measurement by RUNing the program again. The response should show the measured value plus "hi alarm".

B3. Perform steps A3 through A7.

B4. Set the calibrator to output 3.8000V dc.

B5. Run the program and check that the measured value is 3.8V. No alarm message should now be returned.

B6. Check that both the audible (terminals 1 and 3) and the visual (terminals 2 and 4) contacts measure OPEN.

Printer Output Test

1. The following Printer Output Test verifies that the Printer Port is functioning properly.

NOTE

> Switch S4 on the Computer Interface Assembly must be configured to match the communication parameters of the printer or display monitor.

2. Using an RS232 null modem cable (Y1702 or equivalent) connect an RS232 printer or display monitor to the printer port of the Helios Plus Computer Interface Module. Check that power to the device is turned ON.

3. Program the Front End using either a terminal or a computer (you can also run a terminal emulation program to use a computer behaving as a terminal). For ease of testing, a terminal is the recommended host.

Use PROCEDURE A for Terminal Mode or PROCEDURE B for Computer Mode.

PROCEDURE A. TERMINAL MODE (Printer Output Test)

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>
COUNT=OFF <CR>
FORMAT=XASCII <CR>
DEF CHAN(0)=DVIN,MAX=5,HI=4,LO=2,HYST=5 <CR>
DEF SCAN(0)=CHAN(0) <CR>
START SCAN(0),OUTPUT=PRINTER,INTERVAL=10 <CR>
```

A1. Check that the Printer Port outputs SCAN(0) information at a ten second interval. SCAN information will include: Date, Time, Scan(#), Chan(#), Measured Value, and Status (if an error or alarm occurs).

A2. Send the command:

```
STOP SCAN(0) <CR>
```

Printer port output should now cease.

PROCEDURE B. COMPUTER MODE (Printer Output Test)

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s) and output the scan data to the Printer Port. One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A enter a program that will run on your host.

Program for IBM PC:

```
10 CLOSE 1
20 CLS
30 REM open communication port, empty Front End buffer
40 OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50 PRINT #1,CHR$(3);
60 REM set up Front End
70 PRINT #1,"mode=comp"
80 GOSUB 300
90 PRINT #1,"count=off"
100 GOSUB 300
120 PRINT #1,"def chan(0)=dvin,max=5,hi=4.0,lo=2.0,hyst=5"
130 GOSUB 300
140 PRINT #1,"format=xascii"
150 GOSUB 300
160 PRINT #1,"def scan(0)=chan(0)"
```

```
170 GOSUB 300
180 REM Scan channel 0 and send response to printer port
190 PRINT #1,"start scan(0),output=printer,interval=10"
200 SOUND 32767,920
210 PRINT #1,"stop scan(0)"
220 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program FOR 1722A:

```
10 CLOSE 1,2
20 PRINT CHR$(27);"[2J";
30 REM open communication port and empty Front End buffer
40 OPEN "KB1:"AS NEW FILE 1%
50 OPEN "KB1:"AS OLD FILE 2%
60 PRINT #1,CHR$(3);
70 REM set up Front End
80 PRINT #1,"mode=comp"
90 GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1, "def chan(0)=dvin,max=5.0,hi=4.0,lo=2.0,hyst=5"
130 GOSUB 300
140 PRINT #1,"format=xascii"
150 GOSUB 300
160 PRINT #1,"def scan(0)=chan(0)"
170 GOSUB 300
180 REM scan channel 0 and send response to printer port
190 PRINT #1,"start scan(0),output=printer,interval=10"
200 WAIT 50000
210 PRINT #1,"stop scan(0)"
220 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

B1. Verify that the Printer Port outputs SCAN(0) information. Scan information includes: Date, Time, Scan(x), Chan(x), Measured Value, and Status (if an error or an alarm has occurred).

4. This completes the Printer Output Test.

System Self Test

The system-wide self test determines if the read only memory (ROM), random-access memory (RAM), and the serial link universal asynchronous receiver-transmitter (UART) are operating properly.

1. Perform the preceding Mainframe Performance Test.

2. Perform a system self test using PROCEDURE A (Terminal Mode) or PROCEDURE B (Computer Mode).

PROCEDURE A. TERMINAL MODE

If Terminal Mode is being used, send the following command to the Front End:

```
MODE=TERM <CR>
TEST <CR>
```

If a malfunction is detected, an error message will be returned.

If the Front End passes the self test routine, the normal Terminal Mode prompt

```
HCLI>
```

is returned.

PROCEDURE B. COMPUTER MODE

If Computer Mode is being used, modify the program entered in PROCEDURE B of the Mainframe Test (above) to send the TEST command to the Front End and read its response. Make this modification by changing line 100 of the IBM program or line 110 of the 1722A program to:

```
PRINT #1,"test"
```

3. Run the modified program.

If a malfunction is detected, the test failure will be reported in the format:

```
?<error code>
```

The number, <error code>, will be one of three numbers shown in the table below, which corresponds to one of the messages returned in the Terminal Mode.

ERROR CODE	ERROR MESSAGE	FAULT CONDITION
?20	?ROM failed	First priority failure. A bad ROM or faulty ROM control circuit was detected.
?21	?RAM failed	Second priority failure. A bad RAM or faulty RAM control circuit was detected.
?22	?SL UART failed	Third priority failure. A problem with the serial link UART was detected.

If more than one failure is detected, only the error code or message for the highest priority failure is returned.

NOTE

The Front End will operate after a self test error has been reported. However, measurements may be unreliable.

4. The System Self Test is complete.

INTERNAL ERRORS

Internal errors are serious errors detected by Helios Plus firmware that normally won't occur during operation. The Helios Plus automatically enters HDT (Hex Debugging Tool) when an internal error is detected to allow limited troubleshooting by the factory. Again, it should be stressed that these errors are added precautions taken in the firmware to guard against theoretically impossible conditions. If one of these errors does occur, notify the factory.

74 "INTERNAL ERROR 74 - Automatically entering HDT!"

This error indicates that the internal "NOT_EXTD" symbolic error value failed to be properly trapped and has become visible as an externally reported error.

75 "INTERNAL ERROR 75 - Automatically entering HDT!"

This error indicates that the internal "INVALID" symbolic error value failed to be properly trapped and has become visible as an externally reported error.

76 "INTERNAL ERROR 76 - Automatically entering HDT!"

This error indicates that a fault has occurred in the dynamic memory system and that a piece of allocated memory is being freed that already appears to be on the free list. This may indicate that the memory allocation system previously allocated a piece of memory from the free list, but failed to remove it from the list.

This error could be a symptom of a faulty RAM memory device. The only way to recover from this error is to turn off power and "drain" (discharge) the contents of RAM device U47.

77 "INTERNAL ERROR 77 - Automatically entering HDT!"

This error indicates that one of several internal CPU traps have been activated. These traps catch events that theoretically should never occur, such as NMI (non-maskable interrupt), XOP (extended operations), MID (macro-instruction detected), and a return from the C function "main()".

78 "INTERNAL ERROR 78 - Automatically entering HDT!"

This error indicates that the non-volatile memory has been corrupted since power was last applied to Helios-Plus. It does not indicate a problem with battery backup of memory since memory was corrupted while power was turned on.

79 "INTERNAL ERROR 79 - Automatically entering HDT!"

This error indicates that an imbalance has been detected in alarm processing conditions. Specifically, an attempt has been made in the firmware to clear one more alarm condition that was thought to exist. A count of alarm conditions is maintained that is incremented upon a new alarm and decremented when an alarm condition ends. This count should never go negative, but was about to, which is what triggered this error.

With the exception of internal error 76, operation of the Helios Plus may be restored by cycling power. However, the detection of one of the above errors indicates that there may be a serious problem with the unit or its firmware. It is recommended that you contact the factory for further troubleshooting and testing when HDT is entered.

TROUBLESHOOTING

System Troubleshooting

Troubleshooting a Data Acquisition Front End system requires a general understanding of system operation. Before troubleshooting, review the system-level block diagram (in Figure 3-1) and the system theory of operation (in Section 3) to familiarize yourself with the various assemblies of the Fron End, and their interrelationship.

The mainframe theory of operation (Section 3) and schematics (Section 7) can be used by qualified personnel to troubleshoot the Front End pcas to the component level. Before troubleshooting to the component level however, it is advised that you contact a Fluke Service Representative.

Figure 5-1 provides a system troubleshooting tree. This tree will aid you in troubleshooting a Front End system to the assembly level by isolating a specific, malfunctioning assembly.

Keep the following considerations in mind when using the troubleshooting tree:

- It is assumed that Helios-to-host communication parameters have been properly set and that external interconnections between them have been properly established.

  Therefore, before starting to troubleshoot, ensure that the communication parameters (i.e., baud rate, number of bits, parity etc.) on the Front End and host are properly configured to send and receive serial data, and that the host transmit and receive signals are connected to the proper pins on the host connecter, J70, of the Front End.

- The troubleshooting tree covers only the most common sources of system malfunction. It does not cover all possible problems that may occur.

- The troubleshooting tree isolates the assembly that is most likely the source of the problem. Other problem sources may also exist.

- The troubleshooting tree can be used with any Front End system configuration and combination of options. Skip over blocks that are not pertinent to your system.

Power Supply Troubleshooting

WARNING

THERE ARE LETHAL VOLTAGES AT VARIOUS POINTS ON THE POWER SUPPLY. EXERCISE EXTREME CAUTION WHEN SERVICING. DISCONNECT THE FRONT END FROM LINE POWER AND DISCHARGE ALL CAPACITORS AS SOON AS THEY ARE ACCESSIBLE.

CAUTION

Running the power supply without a load may damage the power supply. While servicing the power supply, a 0.5A load on 5V should be provided.

Begin troubleshooting the power supply by checking the 250V 2A fast-blow fuse. In most cases, if the fuse is blown, the power supply should be replaced. In rare instances, replacing the fuse will correct the problem.

If the fuse is good, but problems traceable to the power supply are evident, minor adjustments to the power supply may be required. Use the following procedure to adjust the power supply.

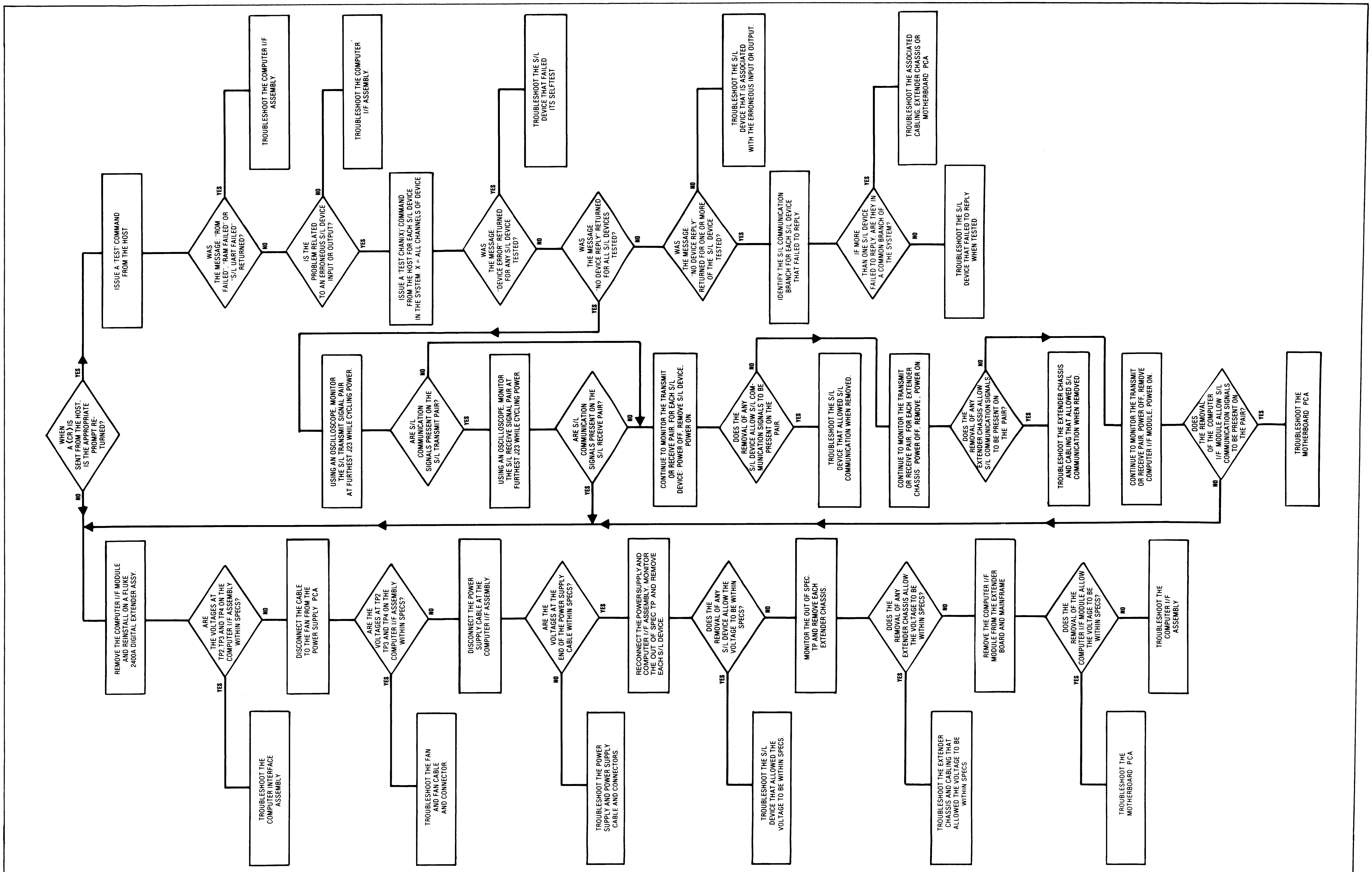


Figure 5-1. System Troubleshooting Tree

POWER SUPPLY ADJUSTMENTS

WARNING

CERTAIN COMPONENTS ON THE POWER SUPPLY HAVE BEEN SELECTED FOR ELECTRICAL CHARACTERISTICS NOT SPECIFIED ON THE COMPONENT. THEREFORE, THE POWER SUPPLY MAY FAIL EVEN IF THESE COMPONENTS ARE REPLACED WITH COMPONENTS OF THE SAME VALUE AND TOLERANCES. CONTACT THE POWER SUPPLY MANUFACTURER FOR THE PROPER COMPONENTS.

NOTE

Use a plastic screwdriver to adjust the power supply. A metal non-insulated screwdriver may cause a short if it comes in contact with metal on the chassis. After adjustment, a penetrating adhesive, such as Loctite*, should be used to hold the potentiometer in position.

Make service adjustments to the power supply as follows:

1. Use a DMM to measure the output from the power supply with respect to ground.

   If measuring at the power supply, see Table 3-7 for pin locations.

   If measuring at the Computer Interface Assembly see the schematic in Section 7 of this manual to locate the test points (TPs).

2. Probe the 5V pin.

   If the output is not within the specified 5.0V to 5.1V range, adjust the potentiometer to 5.1V, or adjust for 5.05V at TP4 on the Computer Interface Assembly.

3. Probe the +12V and -12V pins.

   If the 5V pin is within specifications, but the 12V pin is not within +/-5%, and the -12V pin is not within +/-10% (or the minor adjustments do not achieve the desired results), replace the power supply or suspect a short circuit in Front End or its option assemblies.

   Refer to "Power Supply Access" for instructions on removing and installing the power supply.

If it is necessary to troubleshoot the power supply to component level, refer to the power supply schematic in Section 7.

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* Loctite is a registered trademark of the Loctite Corporation.

TABLE OF CONTENTS

INTRODUCTION

Section 6 provides an illustrated parts list for the Helios Plus Data Acquisition Front End mainframe. A parts list for each option is included in the appropriate subsection of Section 8 (Options -160 through -169) and Section 9 (Options -170 through -179).

Components are listed alphanumerically by assembly. Both electrical and mechanical components are listed by reference designation. Each listed part is shown in an accompanying illustration.

The parts lists contain the following information:

- Reference Designator
- Description
- Fluke Stock Number
- Federal Supply Code for Manufacturers (MFRS SPLY CODE)
- Manufacturer's Part Number
- Total Quantity of Components per Assembly (TOT QTY)

HOW TO OBTAIN PARTS

Components may be ordered directly from the manufacturer's part number (a list of Federal Supply Codes for Manufacturers is provided at the end of this section), or from the John Fluke Manufacturing. Co., Inc., or an authorized representative by using the Fluke Stock Number. In the event the part ordered has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions if necessary.

A Recommended Spare Parts Kit (Fluke Part No. 878822) is available. This kit contains spare parts to maintain 1 to 2 Front End mainframes for 5 years or 3 to 5 mainframes for 3 years. Spare parts for any installed options must be ordered separately.

To ensure prompt and efficient handling of your order, please include the following information:

- Quantity
- Fluke Stock Number
- Description
- Reference Designation
- Printed Circuit Assembly (PCA) number and revision letter
- Instrument Model Number and Serial Number

Parts price information is available from the John Fluke Manufacturing Co., Inc. or its representative. Prices are also found in the Fluke Replacement Parts Catalog, which is available on request.

CAUTION

An asterisk (*) in the "S" (static) column indicates a device or component subject to damage by static discharge.

MANUAL STATUS INFORMATION

The following Manual Status Information Table defines assembly revision levels documented in this manual. To identify the configuration of the pca's used in your instrument, refer to the revision letter (marked in ink) on the component side of the pca.

NEWER INSTRUMENTS

Changes and improvements made to the instrument are identified by incrementing the revision letter marked on the affected pca. These changes are documented on a supplemental change/errata sheet which, when applicable, is inserted at the front of this manual.

TECHNICAL SERVICE CENTERS

A list of Fluke Service Centers is included at the end of this section.

Manual Status Information Table

REF OR OPTION NO.	ASSEMBLY NAME	FLUKE PART NO.	X = The PCA revision levels documented in this manual.																			
			–	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P			
A1	Motherboard PCA	799163						X														
A2	Computer I/F PCA	865311	X																			
A3	Alarm Annunciator PCA	822924				X																

Table 6-1. 2287A Final Assembly
(See Figure 6-1.)

REFERENCE DESIGNATOR -A>	-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE -E-
A	1		MOTHERBOARD PCA	799163	89536	799163	1	
A	2	*	COMPUTER INTERFACE PCA	865311	89536	865311	1	
A	3	*	ALARM ANNUNCIATOR PCA	822924	89536	822924	1	
BT	1		POWER SUP,40W,+5@3.5A,+12@2A,-12@1A	794214	89536	794214	1	
DS	1		LED,GREEN,DIFFUSED,LUM INT=1.8MCD	649673	28480	HLMP-3502	1	
E	1		STRAP,GROUNDING	578989	89536	578989	1	
H	1		FILTER,AIR	793596	5Y482	793596	1	
H	2		CONN ACC,D-SUB,JACK SCREW,4-40	448092	08718	D-20418-2	6	
H	3		SCREW,MACH,PH,P,STL,4-40X0.750	115063	COMMERCIAL		2	
H	4		SCREW,MACH,FH,P,STL,6-32X0.375	114363	COMMERCIAL		2	
H	5, 19		SCREW,MACH,PH,P,STL,6-32X0.375	152165	COMMERCIAL		6	
H	6		SCREW,MACH,PH,P,STL,6-32,.500	152173	COMMERCIAL		4	
H	7, 18		SCREW,MACH,PH,P,STL,6-32X0.750	114223	COMMERCIAL		8	
H	8		SCREW,MACH,RH,SL,STL,6-32X2.250	114421	COMMERCIAL		4	
H	9		SCREW,MACH,FH,P,STL,8-32X0.500	114355	COMMERCIAL		6	
H	10		SCREW,MACH,FH,P,STL,8-32,.875	650119	COMMERCIAL		10	
H	11		WASHER,LOCK,SPLIT,STEEL,#6	110692	COMMERCIAL		4	
H	12		WASHER,LOCK,INTRNL,STEEL,#4	110403	COMMERCIAL		2	
H	13		WASHER,FLAT,BRASS,#4,0.025	110775	COMMERCIAL		2	
H	14		NUT,SPRING,FLAT,STEEL,6-32	832345	COMMERCIAL		12	
H	15		NUT,MINI,HEX,SS,6-32	110569	COMMERCIAL		4	
H	16		NUT,MACH,HEX,STL,4-40	110635	COMMERCIAL		2	
H	17		HOLDER,CLIP,SPEED,U-TYPE,0.085-0.095	782896	78553	C25612-012-4	4	
J	76		CONN,PWB EDGE,REC,TBLK,.156CTR,8 POS	820803	2E738	PCB2B08A	1	
J	80		PWR PLUG PART,HOUSING	474668	27264	15-04-0703	1	
MP	1		BRACKET,CARD GUIDE	578948	89536	578948	1	
MP	2		HANDLE RETAINER	579052	89536	579052	4	
MP	3		BRACKET,HANDLE SUPPORT	632414	89536	632414	4	
MP	4		GASKET, REAR	712067	89536	712067	1	
MP	5		COVER, TOP	712232	89536	712232	1	
MP	6		COVER, BOTTOM	716043	89536	716043	1	
MP	7		FRONT BEZEL, PAINTED	660878	89536	660878	1	
MP	8		HANDLE,STRAP	646851	89536	646851	2	
MP	9		CHASSIS SIDE MODIFIED	581942	89536	581942	2	
MP	10		CHASSIS BASE MODIFIED	581959	89536	581959	2	
MP	11		HANDLE,SIDE MODIFIED	646638	89536	646638	2	
MP	12		FRONT PANEL	864657	89536	864657	1	
MP	13		REAR PANEL, I/F MODULE	864660	89536	864660	1	
MP	14		SHIELD, CARD GUIDE	793448	89536	793448	1	
MP	15		SHROUD, FAN	793570	89536	793570	1	
MP	16		RETAINER, FILTER	793588	89536	793588	1	
MP	17		COVER, CONN. SCAN/ALARM	822908	89536	822908	1	
MP	18		DECAL,2289A REAR BEZEL (USA)	794693	22670	794693	1	
MP	19		GRILL, FRONT PANEL	793604	1Y683	793604	1	
MP	20		FOOT, SINGLE BAIL TYPE (DARK UMBER)	653923	89536	653923	4	
MP	21		LABEL COPYRIGHT	846365	9H491	846365	5	
MP	22		SPACER,RND,AL,.156IDX.750	100966	55566	1132-6-A-22	4	
MP	23		CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	06383	SST-1M	4	
MP	24		REAR BEZEL,FINISHED	749812	89536	749812	1	
MP	25		DECAL,CORNER	605691	89536	605691	2	
MP	26		NAMEPLATE, SERIAL -REAR PANEL-	472795	89536	472795	1	
MP	27		OPTION COVER MODIFIED	633255	89536	633255	3	
MP	28		DECAL, FLUKE-PHILIPS, WHITE,SMALL	835280	89536	835280	1	
MP	29		CAP,REAR END	686212	89536	686212	2	
S	1		SWITCH,ROCKER,DPST	615054	55224	JWZ2120-0301	1	
TM	1		MANUAL, 2287A SYSTEM	865295	89536	865295	1	
W	1		CABLE, POWER SUPPLY	793612	89536	793612	1	
W	2		CABLE ASSY. ALARM ANNUNCIATOR	819193	89536	819193	1	
W	3		ASSY, FAN, CABLE & CONNECTOR	794636	89536	794636	1	
W	4		HARNESS, COMPUTER I/F MODULE	877795	89536	877795	1	
W	7, 9- 12		JUMPER,REC,2 POS,.100CTR,.025 SQ POST	530253	00779	530153-2	5	
W	8		CORD,LINE,5-15/IEC,3-18AWG,SVT	343723	70903	17237	1	

An * in 'S' column indicates a static-sensitive part.

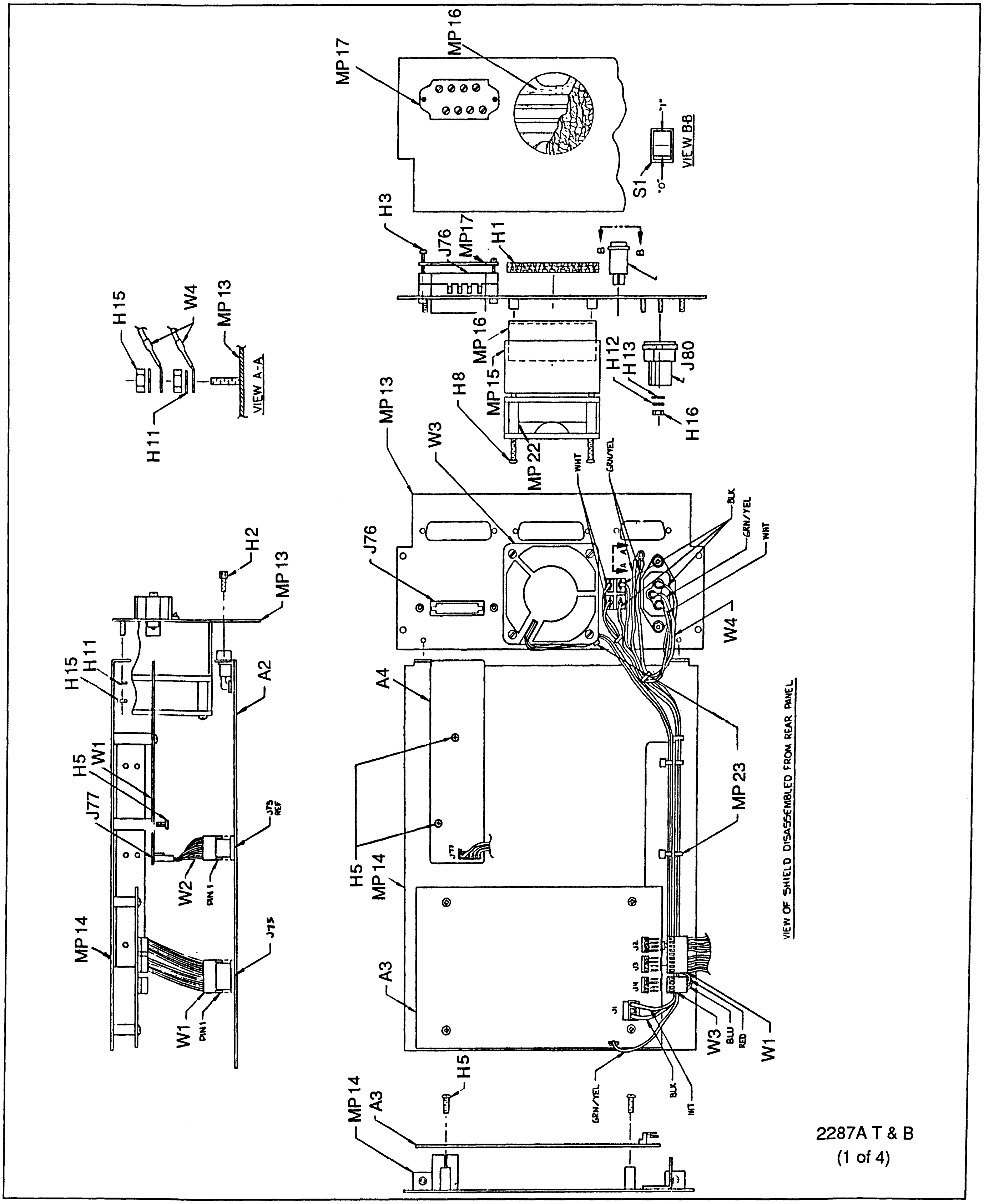

Figure 6-1. 2287A Final Assembly

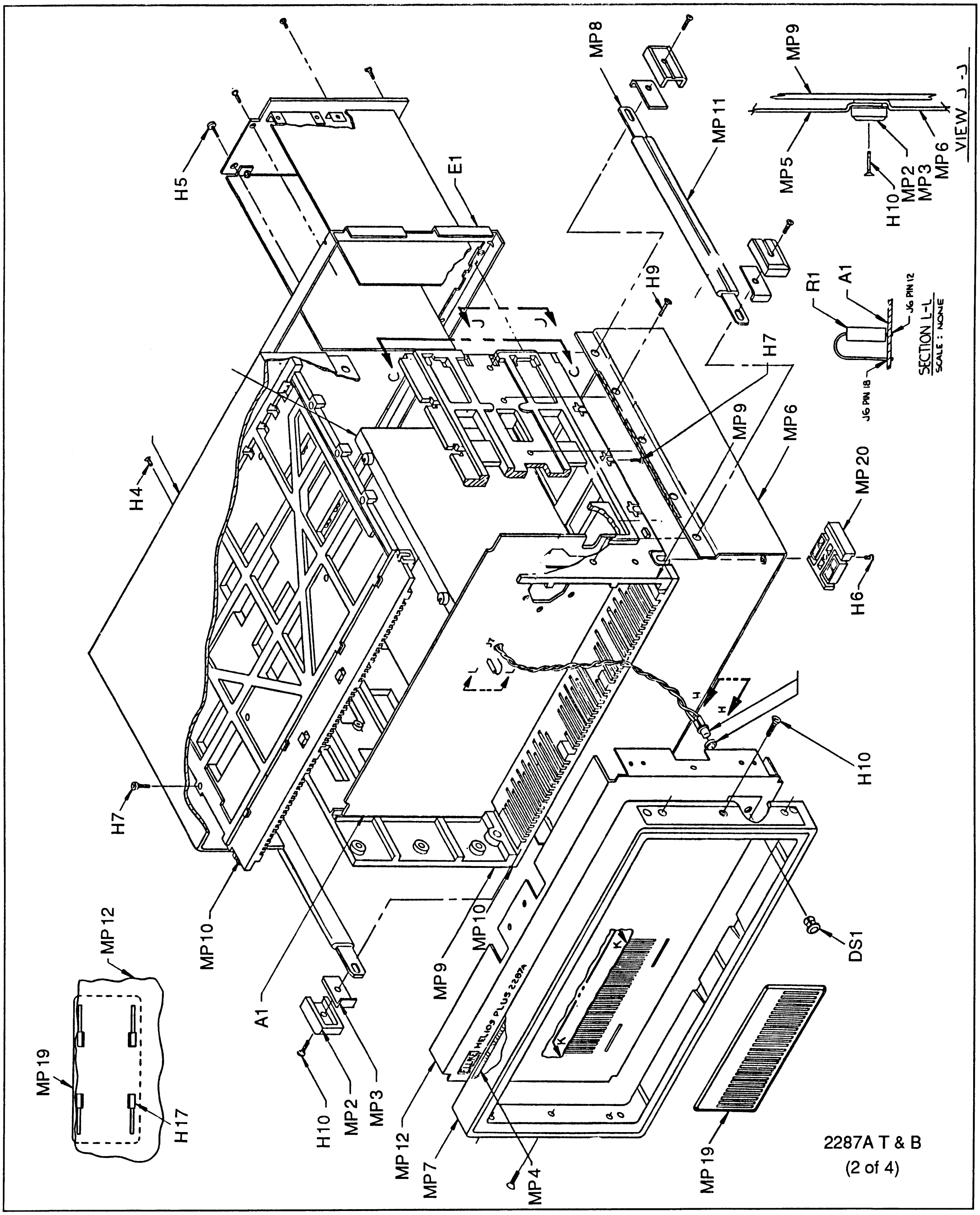

Figure 6-1. 2287A Final Assembly (cont.)

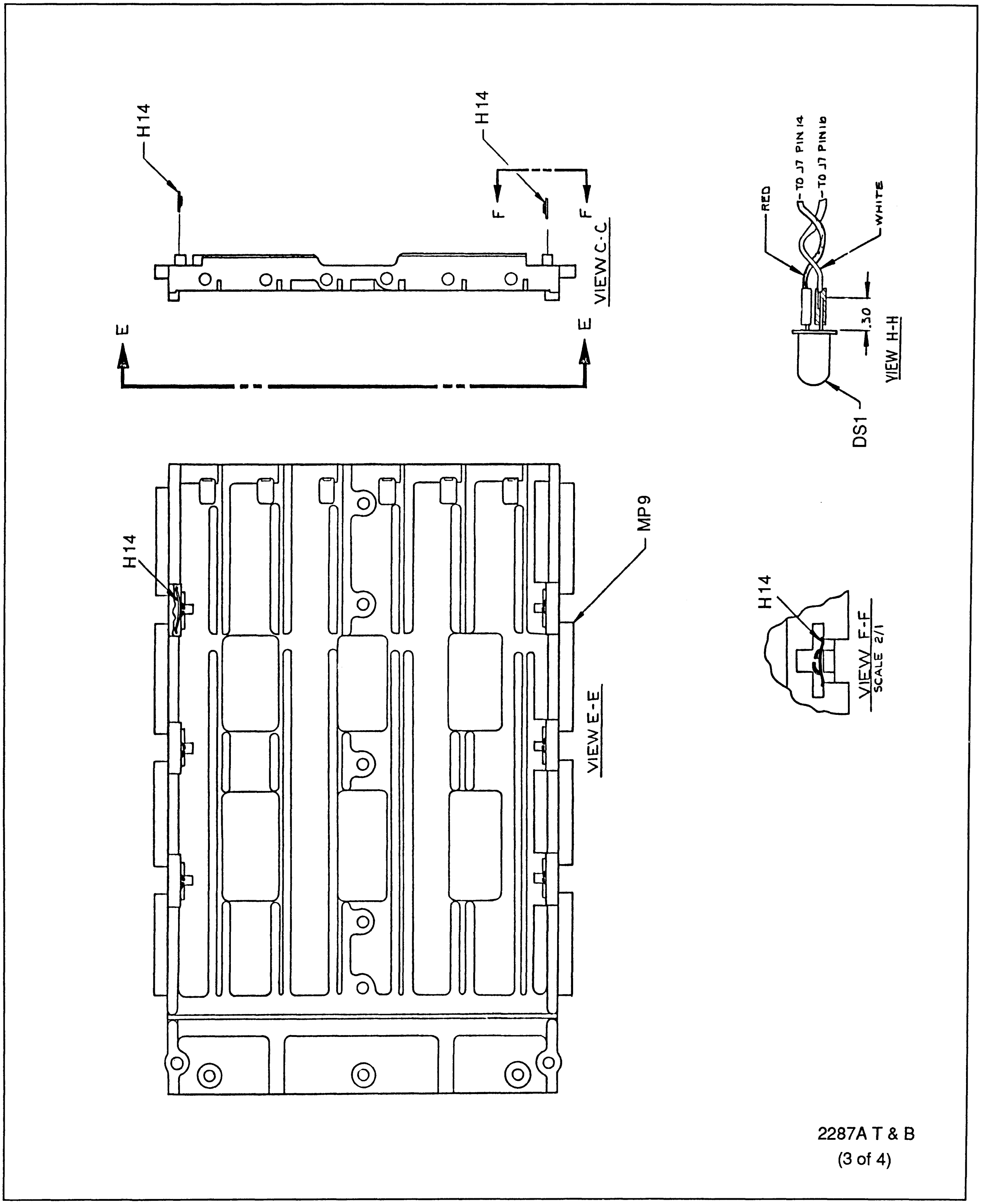

Figure 6-1. 2287A Final Assembly (cont.)

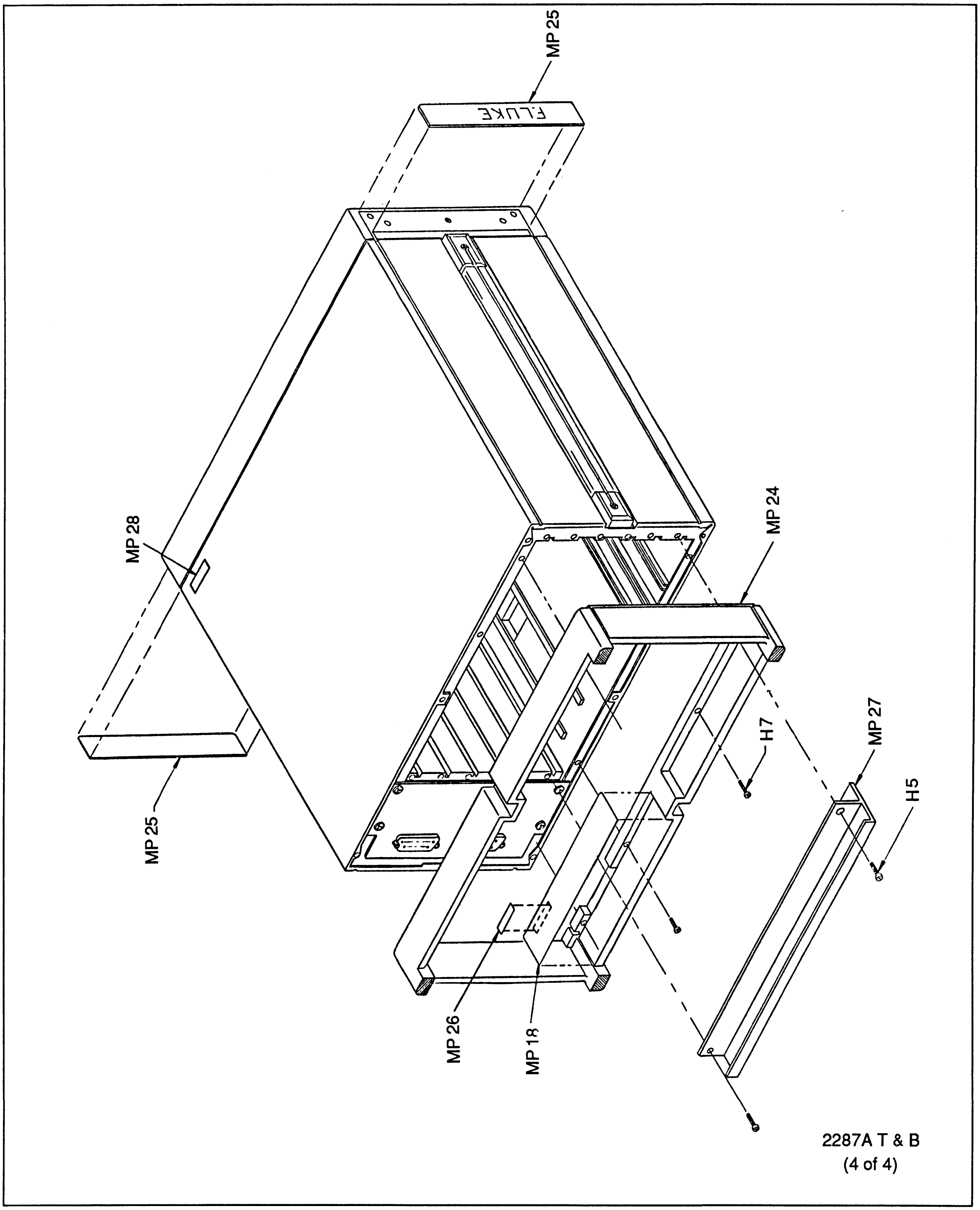

Figure 6-1. 2287A Final Assembly (cont.)

Table 6-2. A1 Motherboard PCA
(See Figure 6-2.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
J 1A-F		CONN,PWB EDGE,REC,.100CTR,72 POS	520155	01295	H421021-36	6	
J 2A-F		CONN,PWB EDGE,REC,.100CTR,20 POS	520189	00779	4-530843-9	6	
J 12		CONN,PWB EDGE,REC,.100CTR,44 POS	520148	01295	H421021-22	1	
MP 1		DECAL,PART NUMBER	648758	89536	648758	1	
R 1		RES,CC,1.2K,+-10%,0.5W	108803	01121	EB1121	1	

An * in 'S' column indicates a static-sensitive part.

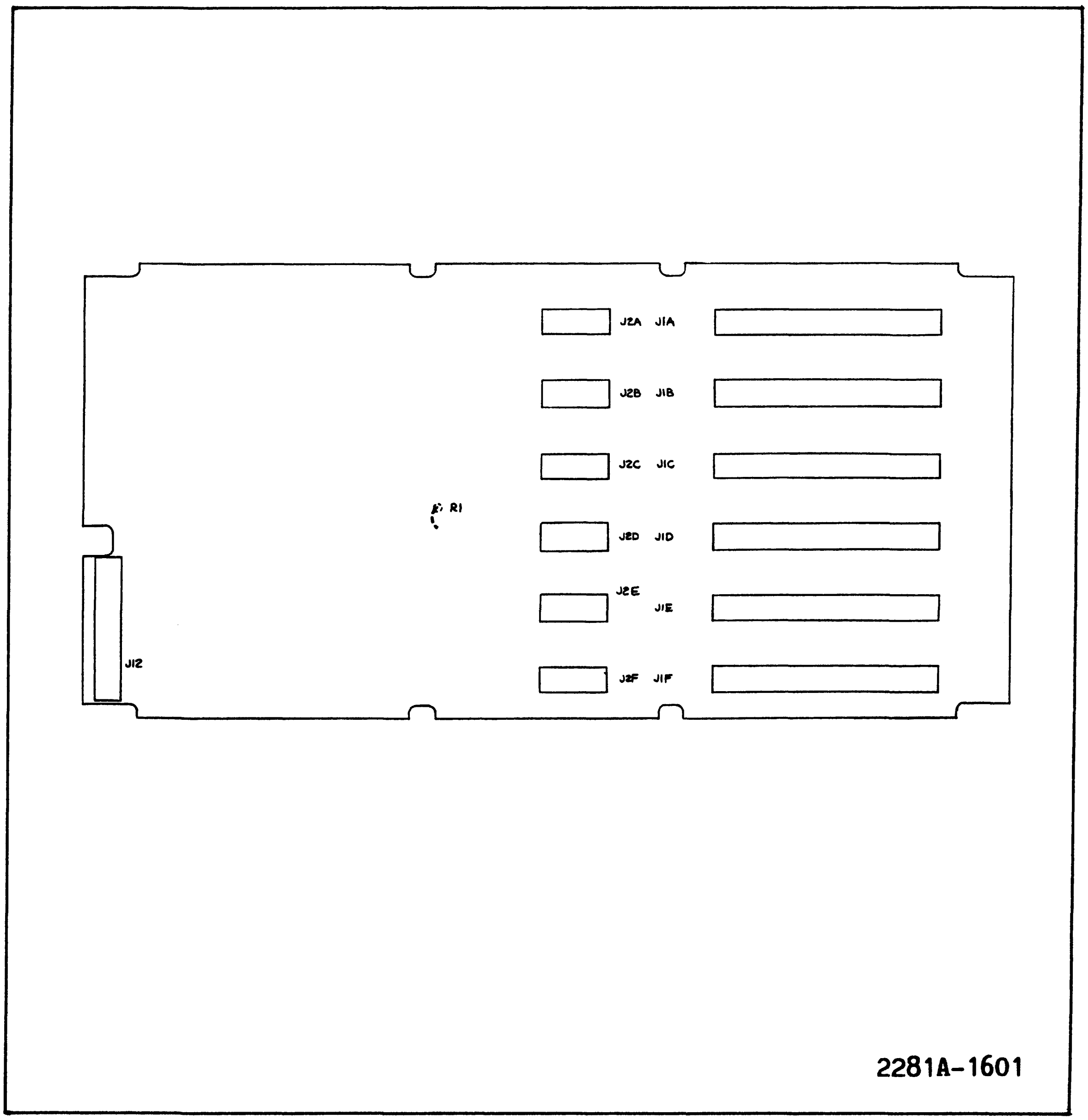

Figure 6-2. A1 Motherboard PCA

Table 6-3. A2 Computer Interface PCA
(See Figure 6-3.)

REFERENCE DESIGNATOR -A-	NUMERICS	S	DESCRIPTION	FLUKE STOCK NO	MFRS SPLY CODE	MANUFACTURERS PART NUMBER OR GENERIC TYPE	TOT QTY	NOTE
BT	1		BATTERY,NI-CAD,3.6V,0.45AH	615476	57053	41B020AD01501	1	
C	1- 8, 10-		CAP,CER,330PF,+-5%,100V,C0G	528620	05397	C320C331J1G5EA	12	
C	13			528620				
C	9, 17, 20-		CAP,CER,0.22UF,+-20%,50V,Z5U	519157	04222	SR205E224MAT	34	
C	39, 41- 42			519157				
C	14		CAP,CER,0.01UF,+-20%,100V,X7R	407361	04222	3419-1000-103M	1	
C	15		CAP,CER,10PF,+-5%,100V,C0G	566042	04222	SR155A100JAT	1	
C	16		CAP,CER,39PF,+-2%,100V,C0G	512962	05397	C315C390G1G5EA	1	
C	18, 19		CAP,CER,18PF,+-2%,100V,C0G	512335	51406	RPE110NPO18RG100	2	
C	40		CAP,ALUM,1000UF,+-50-10%,10V	289132	62643	SM10T-1000	1	
C	53		CAP,CER,.001UF,+-5%,50V,C0G	528539	04222	SR215A102JAT	1	
CR	1- 3	*	DIODE,SI,SCHOTTKY BARRIER,SMALL SIGNL	523738	28480	5082-2835	3	
CR	4- 11		DIODE,SI,50 PIV,1.0 AMP	379412	04713	1N4933	8	
H	1		WASHER,FLAT,BRASS,#4,0.025	110775	COMMERCIAL		6	
H	2		WASHER,LOCK,SPLIT,STEEL,#4	110395	COMMERCIAL		6	
H	3		NUT,MACH,HEX,STL,4-40	184044	COMMERCIAL		6	
H	4		INSERT,STUD,BROACH,PHOS BR,4-40X0.375	603894	24347	KFH-440-6	6	
J	23		CONN,D-SUB,PWB,RT ANG,15 SCKT	707034	00779	747021-5	1	
J	70, 71		CONN,D-SUB,PWB,RT ANG,25 PIN	706218	00779	747022-5	2	
J	73		HEADER,1 ROW,.100CTR,6 PIN	758003	00779	641126-6	1	
J	75		HEADER,1 ROW,.100CTR,8 PIN	800169	00779	643756-8	1	
MP	1		CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	06383	SST-1M	1	
MP	2		CABLE TIE,8"L,0.091"W,2.0 DIA	331157	06383	PLT2M	2	
MP	3		SHUNT BAR,PWB,3 INCH	453613	28213	5020	1	
R	1		RES,CF,100,+-5%,0.25W	348771	59124	CF1-4101J	1	
R	2, 3, 20,		RES,CF,33,+-5%,0.25W	414524	59124	CF1-4330JB	4	
R	21			414524				
R	4- 7, 16-		RES,CF,51,+-5%,0.25W	414540	59124	CF1-4510JB	8	
R	19			414540				
R	8, 11		RES,CF,5.1K,+-5%,0.25W	368712	59124	CF1-4512J	2	
R	9, 10, 13,		RES,CF,270,+-5%,0.25W	348789	59124	CF1-4271J	4	
R	15			348789				
R	12, 14		RES,CF,47K,+-5%,0.25W	348896	59124	CF1-4473J	2	
R	22, 23, 30-		RES,CF,10K,+-5%,0.25W	348839	59124	CF1-4102JB	1	
R	33, 35			348839				
R	24		RES,MF,102K,+-0.1%,0.125W,50PPM	293522	91637	CMF551023B T-2	1	
R	25		RES,CF,4.7K,+-5%,0.25W	348821	59124	CF1-4472JB	1	
R	26		RES,MF,37.01K,+-0.1%,0.125W,50PPM	386425	91637	CMF553701B T-2	1	
R	27		RES,CF,180K,+-5%,0.25W	348946	59124	CF1-4184J	1	
R	28, 37		RES,CF,100K,+-5%,0.25W	348920	59124	CF1-4104J	2	
R	34		RES,CC,2.2K,+-5%,0.5W	108506	01121	EB2225	1	
R	36, 38		RES,CF,2M,+-5%,0.25W	442582	59124	CF1-4205JB	2	
S	1		SWITCH,DIP,DPST,PIANO,6 POS	800037	00779	1-435802-7	1	
S	2- 4		SWITCH,DIP,SPST,PIANO,SEALED,8 POS	658567	81073	76YY21230S	3	
TP	1- 4		TERM,UNINSUL,FEEDTHRU,HOLE,TURRET	179283	88245	2010B-5	4	
U	1, 7	*	IC,BPLR,DUAL DIFF LINE DRVR W/3-STATE	586081	12040	DS1692J	2	
U	2, 4, 6	*	IC,TTL,QUAD RS232C LINE RECEIVER	524850	04713	MC1489AN	3	
U	3	*	IC,LSTTL,QUAD RS422 LINE RCVR,3-STATE	525303	04713	MC3486P	1	
U	5, 10	*	IC,TTL,QUAD RS232C LINE DRIVER	414052	04713	MC1488P	2	
U	8	*	IC,LSTTL,HEX INVERTER	393058	04713	SN74LS04N	1	
U	9	*	IC,LSTTL,TRIPLE 3 INPUT AND GATE	393082	04713	SN74LS11N	1	
U	11, 13, 14	*	IC,NMOS,ASYNC COMMUNICATION CONTROLLR	483552	01295	TMS9902ANL	3	
U	15, 17, 23,	*	IC,LSTTL,8-1 MUX W/3-STATE OUTPUTS	407577	04713	SN74LS251N	4	
U	33	*		407577				
U	16	*	IC,COMPARATOR,DUAL,LO-POWER,8 PIN DIP	783662	01295	TLC372CP	1	
U	18, 26	*	IC,LSTTL,8BIT ADDRSABLE LATCH,W/CLR	419242	04713	SN74LS259N	2	
U	19	*	IC,CMOS,SERIAL I/O CALENDER & CLOCK	586412	51984	UPD4990AC	1	
U	20	*	IC,NMOS,16 BIT MICROCOMPUTER	640417	01295	TMS9995NL-12	1	
U	21, 29, 31	*	IC,LSTTL,OCTL LINE DRVR W/3-STATE OUT	429035	04713	SN74LS244N	3	
U	22, 25, 28,	*	IC,LSTTL,3-8 LINE DCDR W/ENABLE	407585	01295	SN74LS138N	4	
U	32	*		407585				
U	24, 27	*	IC,CMOS,3-8 LINE DCDR W/ENABLE	773036	04713	MC74HC138N	2	
U	30	*	IC,LSTTL,OCTL BUS TRNSCVR W/3-ST OUT	477406	01295	SN74LS245N	1	
U	34- 43	*	IC,CMOS,32K X 8 STATIC RAM,120 NSEC	800995	12581	HM62256LP-12	10	
U	44- 46, 48	*	PROG PROM SET, COMP I/F, HELIOS PLUS	873786	89536	873786	5	
U	49			873786				
U	47	*	IC,CMOS,8KX8 STAT RAM, 200 NSEC	754259	33297	UPD4464C-20	1	
VR	1	*	ZENER,UNCOMP,6.0V TRANSIENT SUPPRESSO	508655	11961	1N5908	1	
VR	2	*	IC, 1.23V,150 PPM T.C.,BANDGAP V. REF	634451	12040	LM385Z-1.2D26Z	1	
W	7, 9- 12		HEADER,1 ROW,.100CTR,6 PIN	478669	22526	65500-106	3	1
XU	20		SOCKET,IC,40 PIN	429282	00779	2-640379-1	1	
XU	34- 49		SOCKET,IC,28 PIN	448217	91506	228-AG39D	16	
Y	1		CRYSTAL,11.9808MHZ,+-0.01%,HC-18/U	642777	5W664	NDK-119	1	
Y	2		CRYSTAL,32.768KHZ,+-0.003%	501817	87516	861-T-32.768	1	
Z	1- 3		RES,CERM,SIP,10 PIN,9 RES,47K,+-2%	485193	91637	CSC10A01473G	3	
Z	4		RES,CERM,SIP,10 PIN,9 RES,4.7K,+-2%	484063	91637	CSC10B01472G	1	
Z	5		RES,CERM,SIP,8 PIN,7 RES,47K,+-2%	413286	91637	CSC08A01473G	1	
Z	6		RES,CERM,SIP,6 PIN,5 RES,4.7K,+-2%	494690	91637	CSC06B01472G	1	

An * in 'S' column indicates a static-sensitive part.

NOTES:

NOTE 1 = Cut p/n 478669 into six 3 pin pieces for W7, W9, W10, W11 & W12.

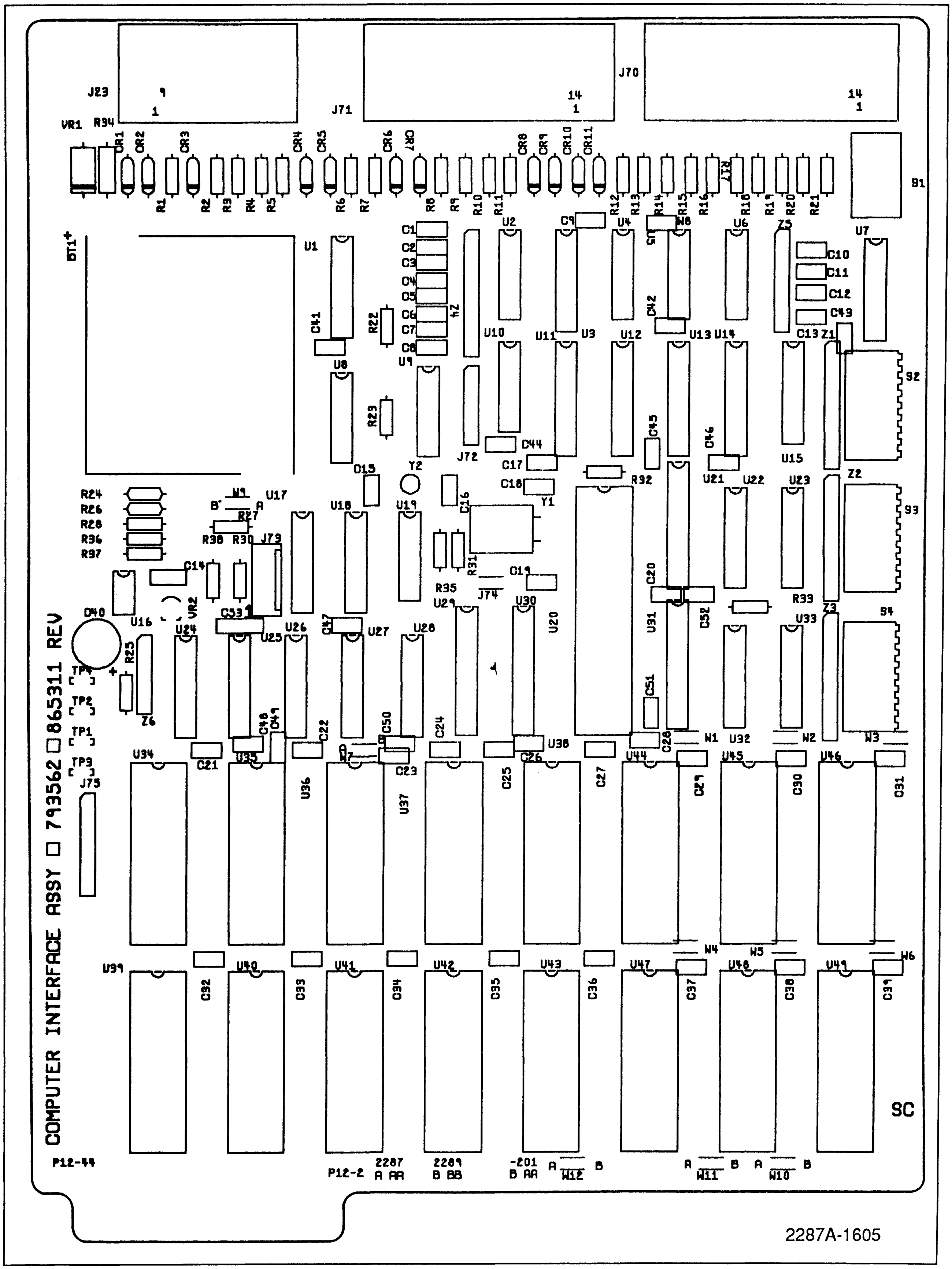

Figure 6-3. A2 Computer Interface PCA

Table 6-4. A3 Alarm Annunciator PCA
(See Figure 6-4.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	N O T -E-
C 1		CAP,TA,10UF,+-20%,20V	330662	56289	199D106X0020CA2	1	
C 3, 7- 11		CAP,CER,0.22UF,+-20%,50V,Z5U	519157	04222	SR205E224MAT	6	
C 4		CAP,AL,1000UF,+50-20%,35V	641217	62643	SM35VB-1000	1	
C 5		CAP,CER,0.01UF,+80-20%,25V,Y5U	335786	60705	563C0C0CK250EC103Z	1	
C 6		CAP,TA,47UF,+-20%,20V	348516	56289	199D476X0020EA2	1	
CR 2, 3	*	DIODE,SI,BV= 50.0V,IO=150MA,SELCTD VF	234468	07263	FDN9274	2	
J 77		HEADER,1 ROW,.100CTR,6 PIN	758003	00779	641126-6	1	
K 1, 2		RELAY,ARMATURE,2 FORM C,5V	733063	61529	DS2E-S-DC5V	2	
R 1- 3		RES,MF,10K,+-1%,0.125W,100PPM	168260	91637	CMF551002F T-1	3	
R 5		RES,MF,56.2K,+-1%,0.125W,100PPM	271346	91637	MFF1-85622F	1	
U 1	*	IC,CMOS,TIMER	742254	01295	TLC555CP	1	
U 2, 5	*	IC,LSTTL,DUAL D F/F,+EDG TRG,W/CLR	393124	04713	SN74LS74AN	2	
U 3	*	IC,LSTTL,QUAD 2 INPUT NAND GATE	393033	04713	SN74LSOON	1	
U 4	*	IC,LSTTL,TRIPLE 3 INPUT NAND GATE	393074	04713	SN74LS10N	1	
U 6	*	IC,TTL,DUAL NAND DRVR W/OPEN COLLECT	329706	01295	SN75452BP	1	

An * in 'S' column indicates a static-sensitive part.

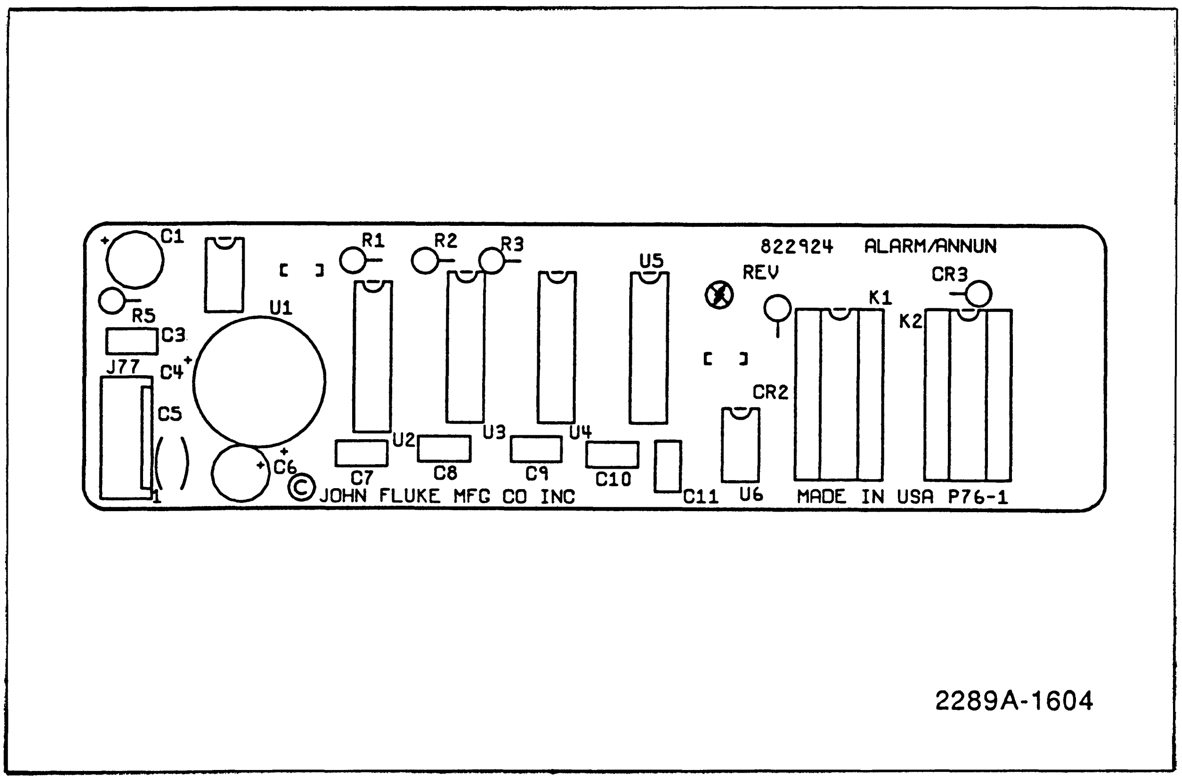

Figure 6-4. A3 Alarm Annunciator PCA

MANUFACTURER'S FEDERAL SUPPLY CODES

00779
AMP, Inc.
Harrisburg, PA

01121
Allen Bradley Co.
Milwaukee, WI

01295
Texas Instruments Inc.
Semiconductor Group
Dallas, TX

04222
AVX Corporation
AVX Ceramics Div.
Myrtle Beach, SC

04713
Motorola Inc.
Semiconductor Group
Phoenix, AZ

05397
Union Carbide Corporation
Material Systems Division
Cleveland, OH

06383
Panduit Corporation
Tinley Park, IL

07263
Fairchild Semiconductor
North American Sales
Ridgeview, CT

08718
ITT Cannon Electric
Phoenix Division
Phoenix, AZ

1Y683
Design Plastics Co.
Louisville, KY

11961
Semicon Inc.
Burlington, MA

12040
National Semiconductor
Corporation
Danbury, CT

12581
Hitachi Metals Int. Ltd.
Hitachi Magna-Lock Div.
Big Rapids, MO

2E738
Buchanan Electric
Products Corporation
Baltimore, MD

22526
DuPont, El DeNemours
& Co., Inc.
DuPont Connector Systems
Advanced Products Div.
New Cumberland, PA

22670
GM Nameplate
Seattle, WA

24347
Penn Engineering Co.
South El Monte, CA

27264
Molex Inc.
Lisle, IL

28213
MN Mining & Mfg. Co.
Consumer Products Div.
3M Center
Saint Paul, MN

28478
Deltrol Corporation
Deltrol Controls Div.
Milwaukee, WI

28480
Hewlett Packard Co.
Corporate HQ
Palo Alto, CA

33297
NEC Electronics USA Inc.
Electronic Arrays Div.
Mountain View, CA

5W664
NDK
Div. of Nihon Dempa Kogyo
Lynchburg, VA

5Y482
Thor Gasket Inc.
Seattle, WA

51406
Murata Erie
North America Inc.
Symrna, GA

51984
NEC America Inc.
Falls Church, VA

55224
SMK Electronics Corp.
Placentia, CA

55566
RAF Electronic Hardware Inc.
Seymour, CT

56289
Sprague Electric Co.
North Adams, MA

57053
Gates Energy Products
Denver, CO

59124
KOA-Speer Electronics Inc.
Bradford, PA

60705
Cera-Mite Corporation
(formerly Sprague)
Grafton, WI

61394
SEEQ Technology Inc.
San Jose, CA

61529
Aromat Corporation
New Providence, NJ

61852
Boschert, Inc.
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62643
United Chemicon
Rosemont, IL

70903
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Geneva, IL

78553
Eaton Corporation
Engineered Fastener Div.
Cleveland, OH

81073
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87516
Standard Crystal
Kansas City, KS

88245
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9H491
Radar Electric Co.
Seattle, WA

91506
Augat Alcoswitch
North Andover, MA

91637
Dale Electronics Inc.
Columbus, NE

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South African Philips (Pty) Ltd.
Service Department
195 Main Rd
Martindale, Johannesburg 2092
Tel: 27 11 470-5255

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Depto. Tecnico Instrumentacion
c/Martinez Villergas 2
28027 Madrid
Tel: 34 1 4042200

Sweden
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I&E Technical Customer Support
Borgarfjordsgatan 16
S 164 93 Kista
Tel: 46-8-703-1000

Switzerland
Philips A.G.
Technischer Kundendienst
Postfach 670
Allmendstrasse 140
CH-8027 Zurich
Tel: 41 1 482211

Taiwan, R.O.C.
Schmidt Electronics Corp.
5th Floor, Cathay Min Sheng Commercial Building,
344 Min Sheng East Road
Taipei
Tel: 886 2 501-3468

Thailand
Measuretronix Ltd.
2102/31 Ramkamhaeng Rd.
Bangkok 10240
Tel: 66 2 375-2733, 375-2734

Turkey
Turk Philips Ticaret A.S.
Inonu Caddesi 78/80
Posta Kutusu 504-Beyoglu
Istanbul
Tel: 90 1 1435891

Uruguay
Coasin Uruguaya S.A
Casilla de Correo 1400
Libertad 2525
Montevideo
Tel: 598-2-789015

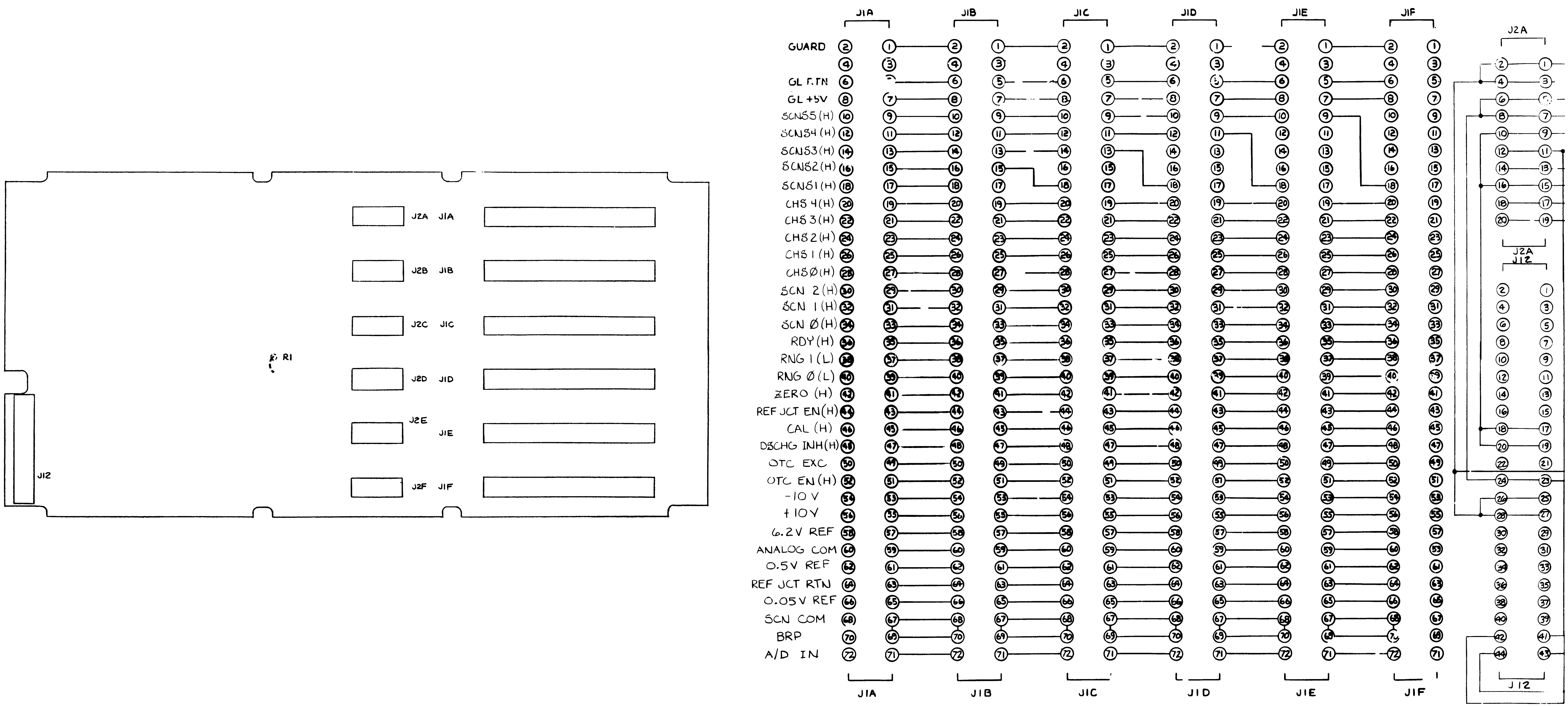
Venezuela
Coasin C.A.
Calle 9 Con Calle 4, Edif. Edinurbi
Apartado de Correos Nr-70-136
Los Ruices
Caracas 1070-A
Tel: 58 2 241-0309, 241-1248

West Germany
Philips GmbH
Service VSF
Unternehmensbereich Elektronik fur Wissenschaft und Industrie
Oskar-Messter-Strasse 18
8045 Ismaning
Tel: 49-89-9605-260

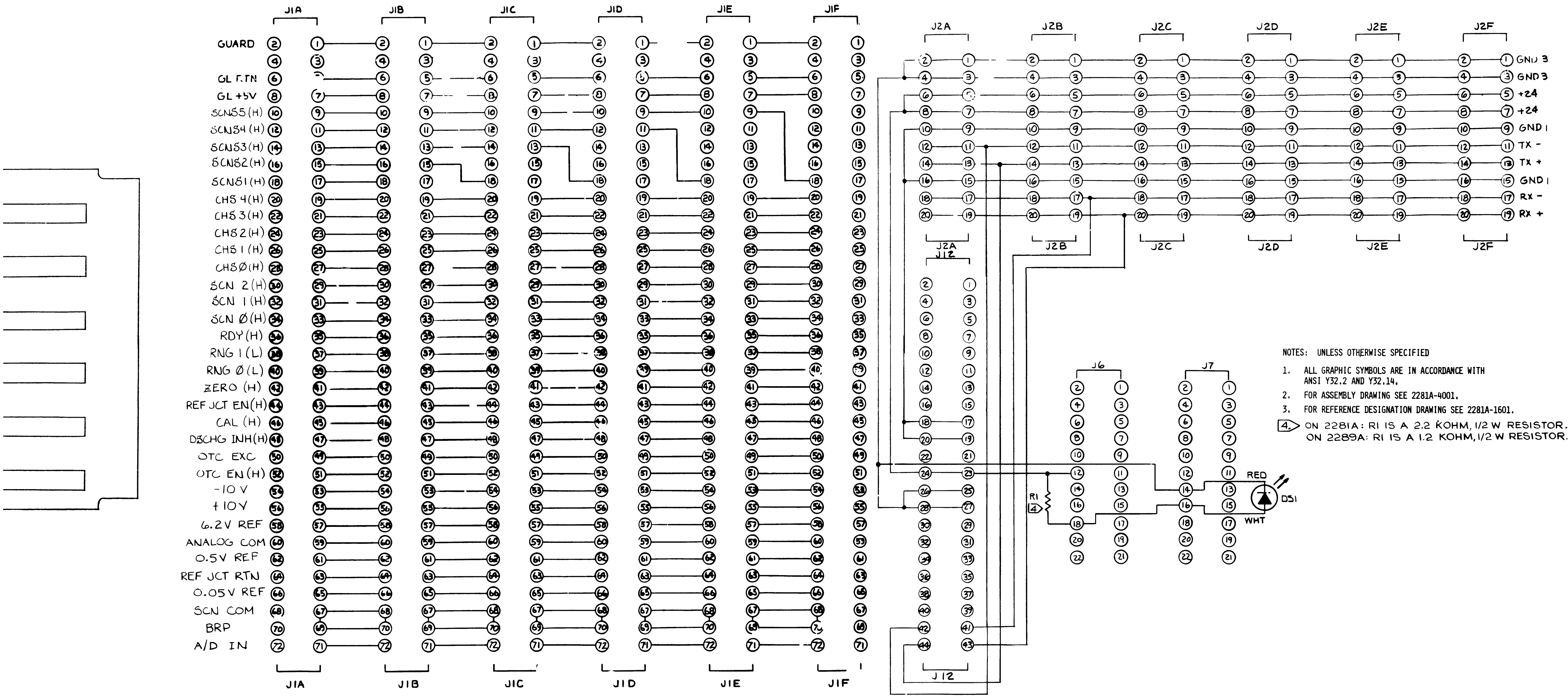
SECTION 7
MAINFRAME SCHEMATIC DIAGRAMS

TABLE OF CONTENTS

NOTES


J2A J1A
J2B J1B
J2C J1C
J2D J1D
J2E J1E
J2F J1F
J12
R1
GUARD
GL RTN
GL +5V
SCNS5 (H)
SCNS4 (H)
SCNS3 (H)
SCNS2 (H)
SCNS1 (H)
CHS 4 (H)
CHS 3 (H)
CHS 2 (H)
CHS 1 (H)
CHS Ø (H)
SCN 2 (H)
SCN 1 (H)
SCN Ø (H)
RDY (H)
RNG 1 (L)
RNG Ø (L)
ZERO (H)
REF JCT EN (H)
CAL (H)
DSCHG INH (H)
OTC EXC
OTC EN (H)
-10 V
+10 V
6.2 V REF
ANALOG COM
0.5 V REF
REF JCT RTN
0.05 V REF
SCN COM
BRP
A/D IN

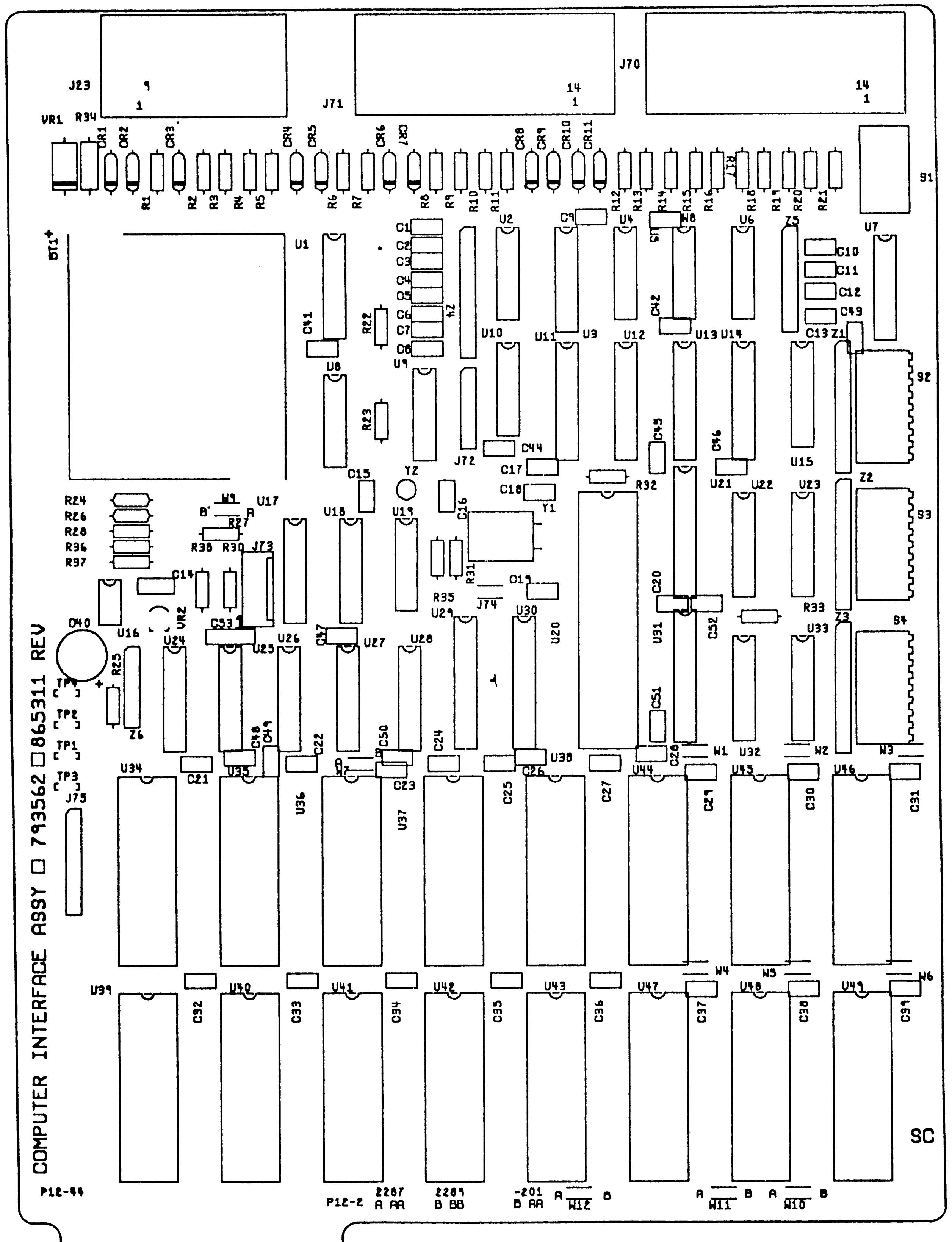
2281A-1601



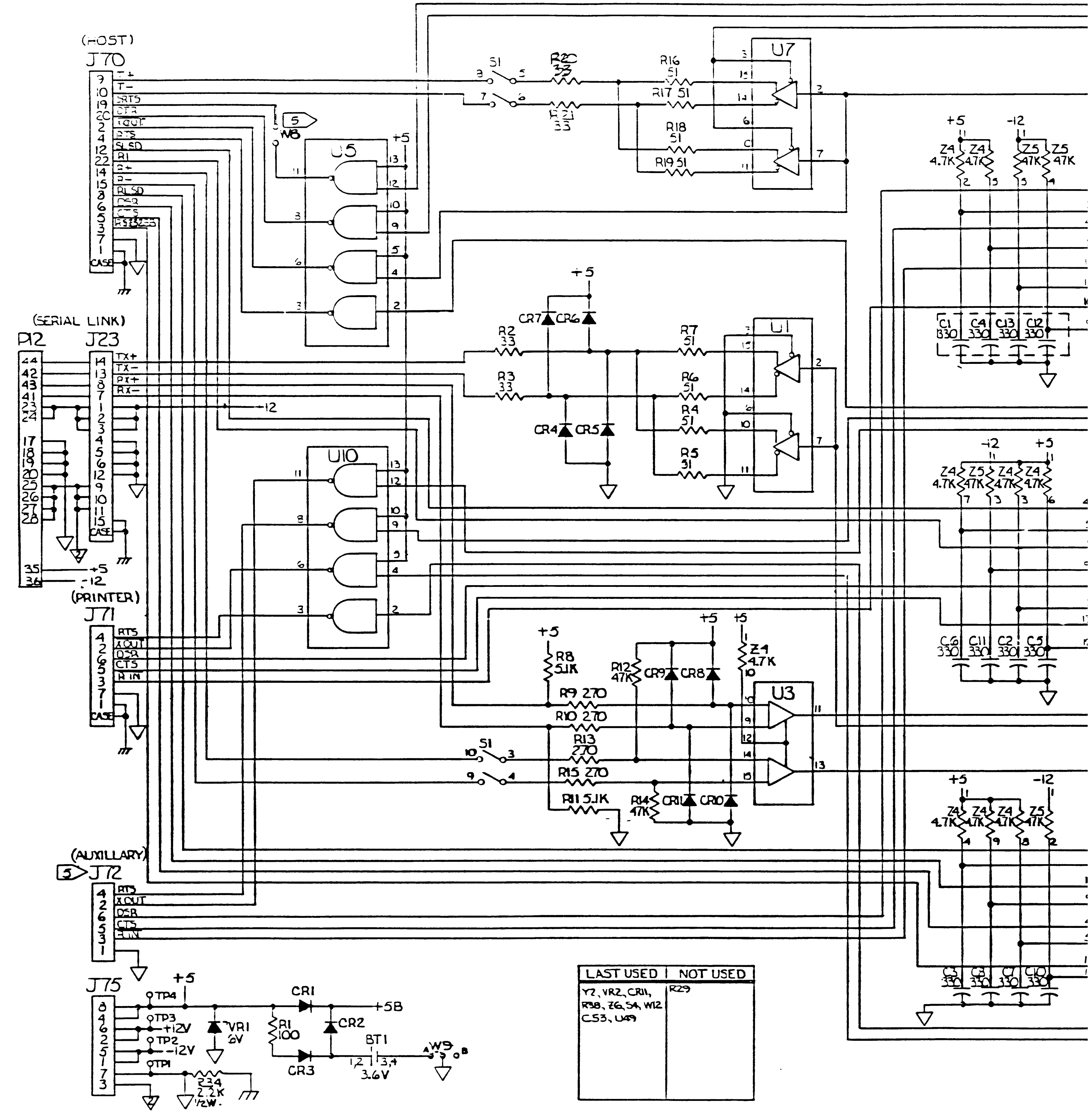
2281A-1601

2281A-1001

Figure 7-1. A1 Motherboard PCA


COMPUTER INTERFACE ASSY □ 793562 □ 865311 REV
J23
J71
J70
SC
P12-44
P12-2

2287A-1605


(HOST)
J70
(SERIAL LINK)
P12
J23
(PRINTER)
J71
(AUXILIARY)
J72
J75
U7
U5
U1
U10
U3
LAST USED
NOT USED
Y2, VR2, CR11, R38, Z6, S4, W12 C53, U49
R29

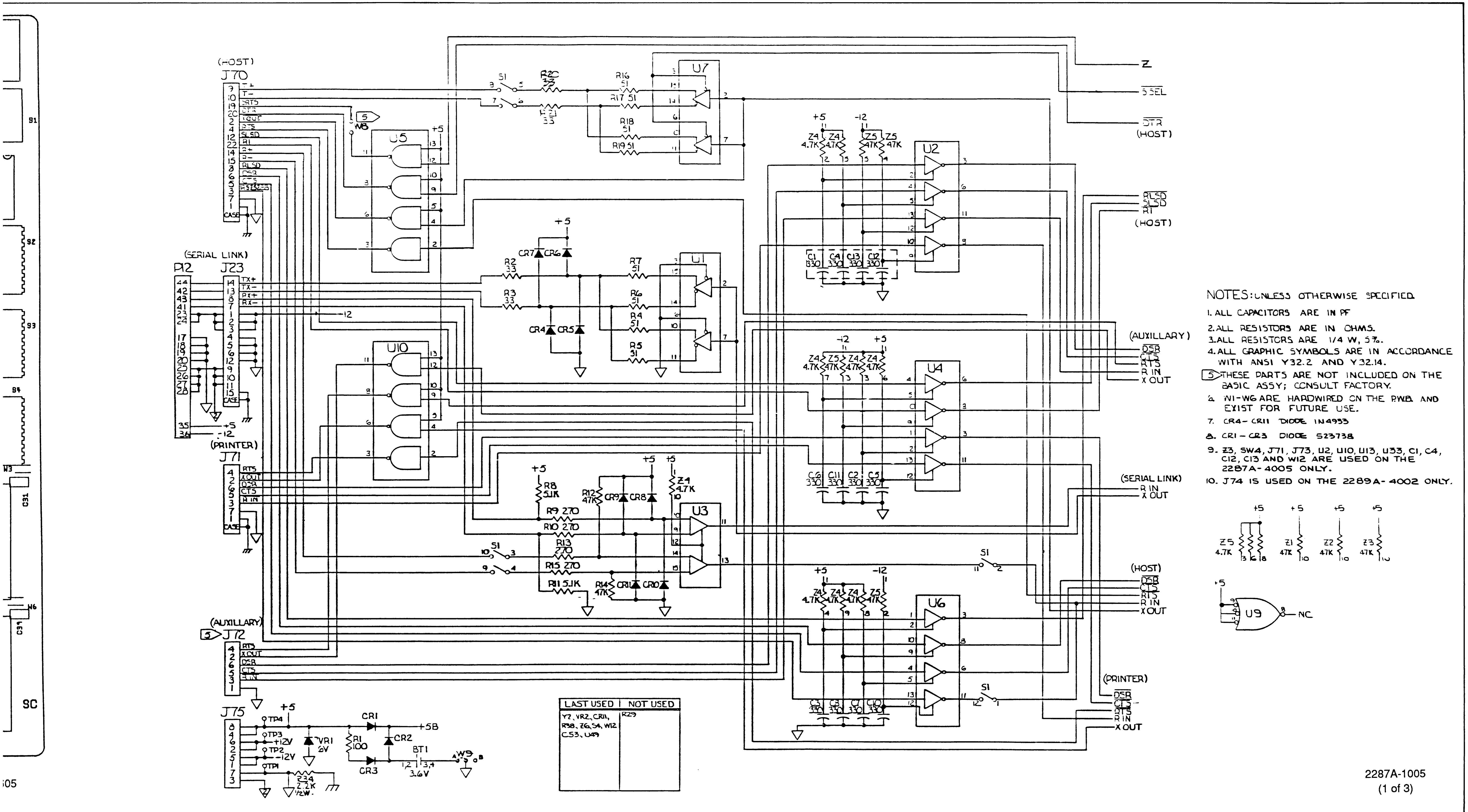
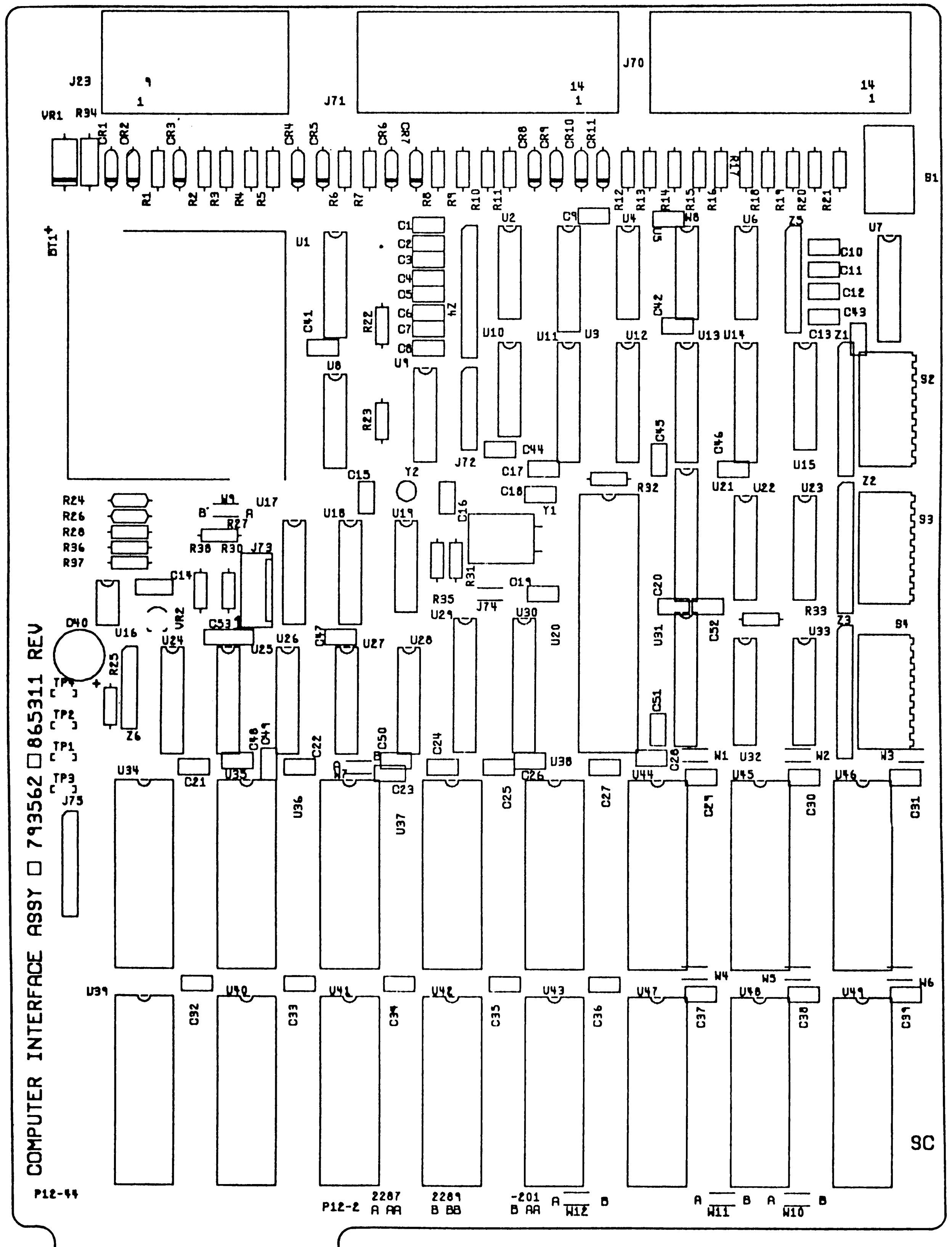
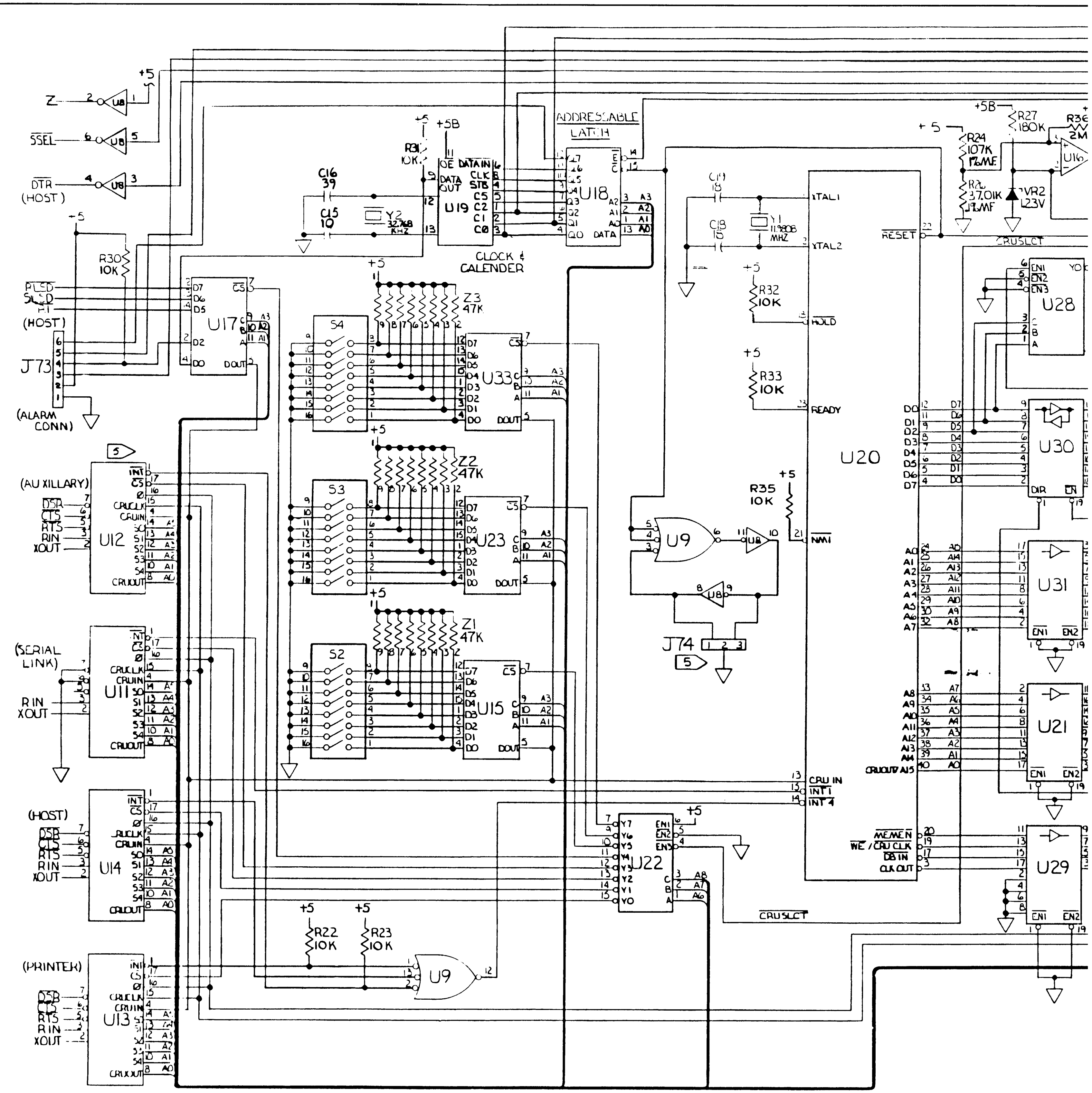
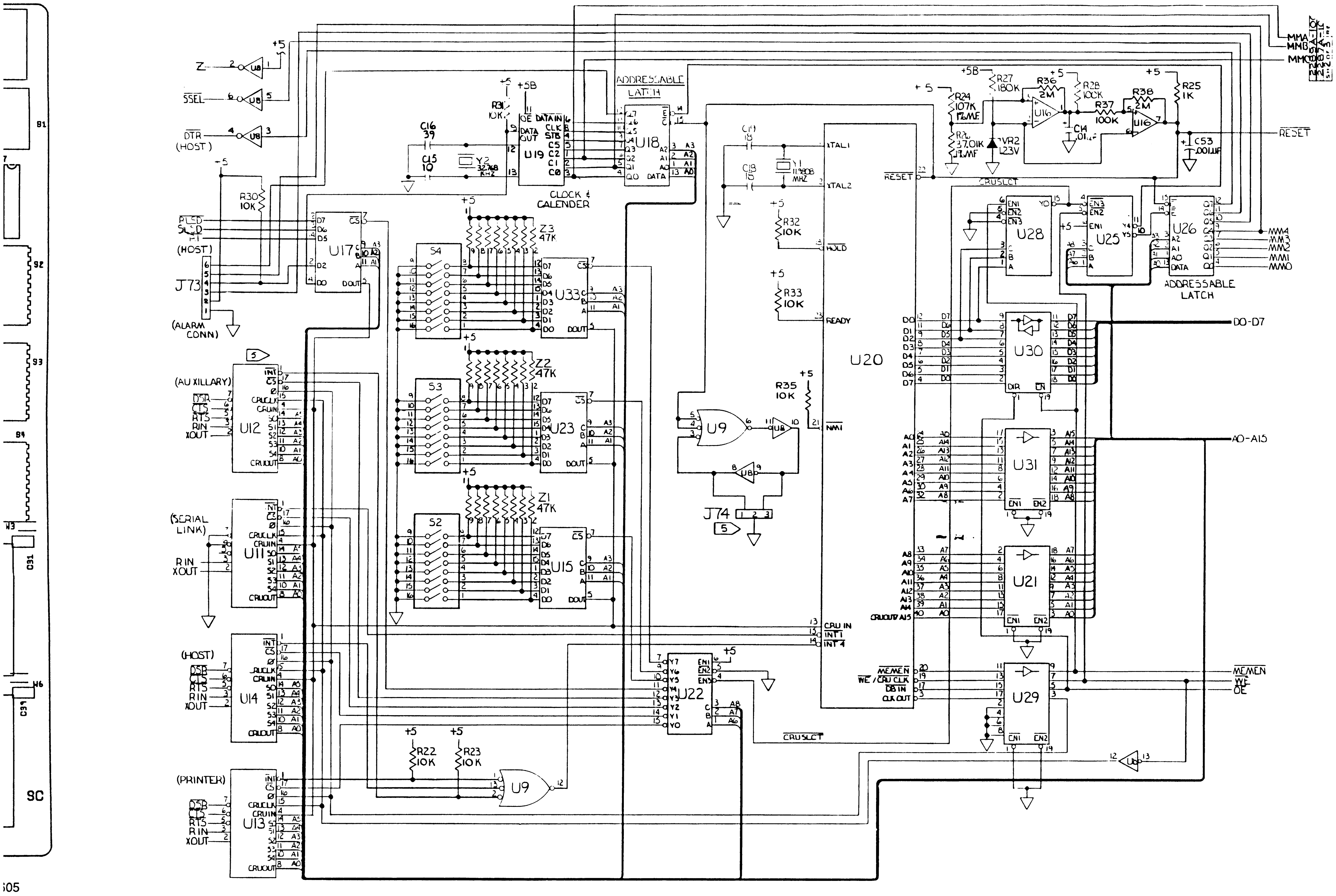


Figure 7-2. A2 Computer Interface PCA


COMPUTER INTERFACE ASSY □ 793562 □ 865311 REV
J23
J71
J70
J72
J73
J74
J75
BT1
SC
P12-44
P12-2

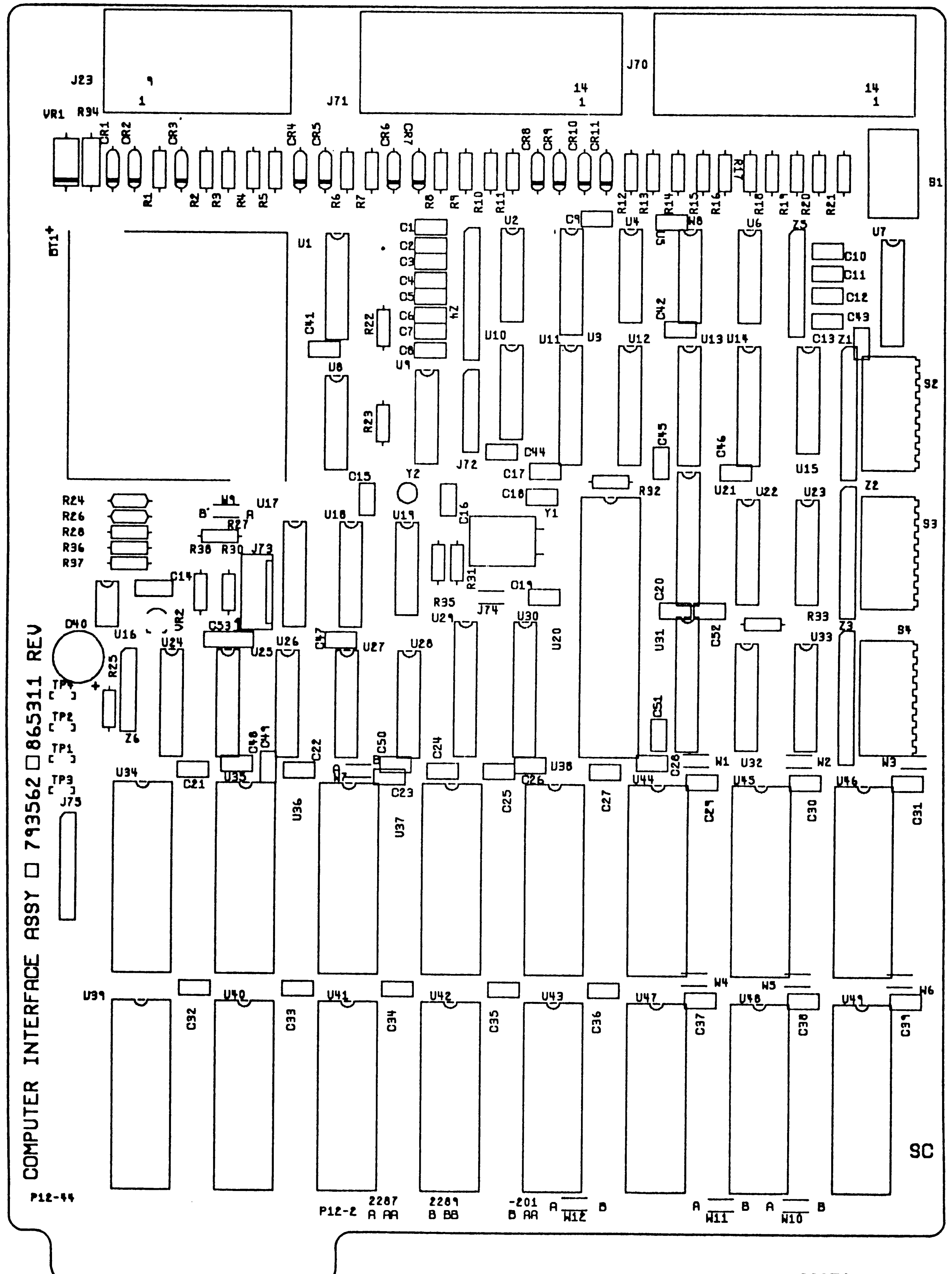
2287A-1605


ADDRESSABLE LATCH
CLOCK & CALENDER
(HOST)
(ALARM CONN)
(AUXILLARY)
(SERIAL LINK)
(PRINTER)
U20
U22
U17
U18
U19
U33
U23
U15
U12
U11
U14
U13
U9
U28
U30
U31
U21
U29

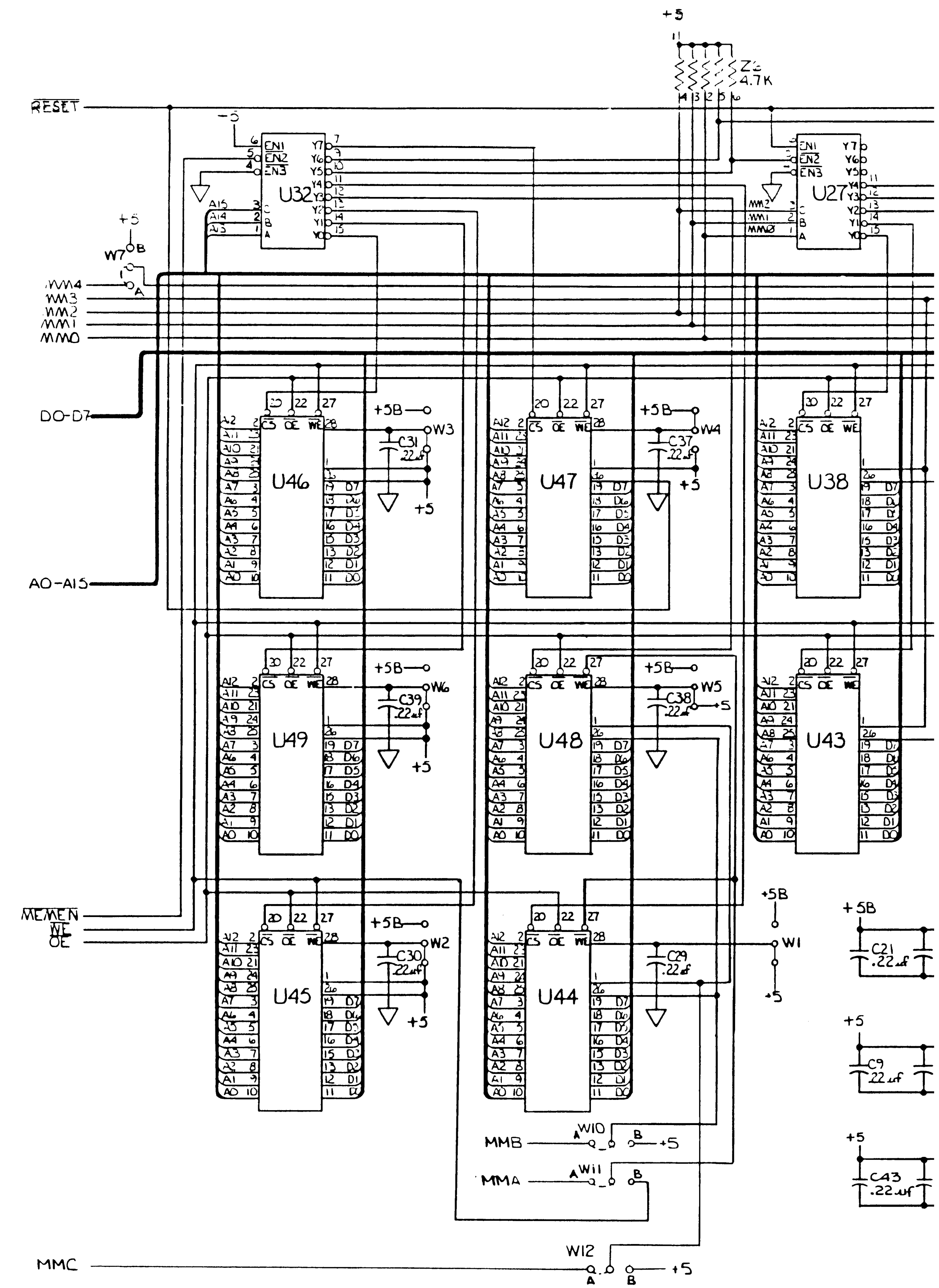


	DEVICE #	+5	+5B	+12	−12	▽
U1	DS 1692	1				4, 5, 8
U2	MC 1489	14				7
U3	MC 3486	16				8
4	MC 1489	14				7
U5	MC 1488			14	1	7
U6	MC 1489	14				7
U7	DS 1692	1				4, 5, 8
U8	LS 04	14				7
U9	LS 11	14				7
U10	MC 1488			14	1	7
U11	TMS 9902	18				9
U12	TMS 9902	18				9
U13	TMS 9902	18				9
U14	TMS9902	18				9
U15	LS 251	16				8
U16	TLC 372		8			4
U17	LS 251	16				8
U18	LS 259	16				8
U19	μPD4990A		14			7
U20	TMS9995	10				31
U21	LS 244	20				10
U22	LS 138	16				8
U23	LS 251	16				8
U24	HC 138		16			8
U25	LS 138	16				8
U26	LS 259	16				8
U27	HC 138		16			8
U28	LS 138	16				8
U29	LS 244	20				10
U30	LS 245	20				10
U31	LS 244	20				10
U32	LS 138	16				8
U33	LS 251	16				8
U34	62256-12		28			14
U35	62256-12		28			14
U36	62256-12		28			14
U37	62256-12		28			14
U38	62256-12		28			14
U39	62256-12		28			14
U40	62256-12		28			14
U41	62256-12		28			14
U42	62256-12		28			14
U43	62256-12		28			14
U44	27C512					14
U45	2764-2					14
U46	2764-2					14
U47	μPD4464					14
U48	27C512					14
U49	2764-2					14

Figure 7-2. A2 Computer Interface PCA (cont.)


COMPUTER INTERFACE ASSY 793562 865311 REV
SC
P12-44
P12-2

2287A-1605


RESET
DO-D7
AO-A15
MEMEN
WE
OE
MMC
MMB
MMA
U32
U27
U46
U47
U38
U49
U48
U43
U45
U44
Z6 4.7K

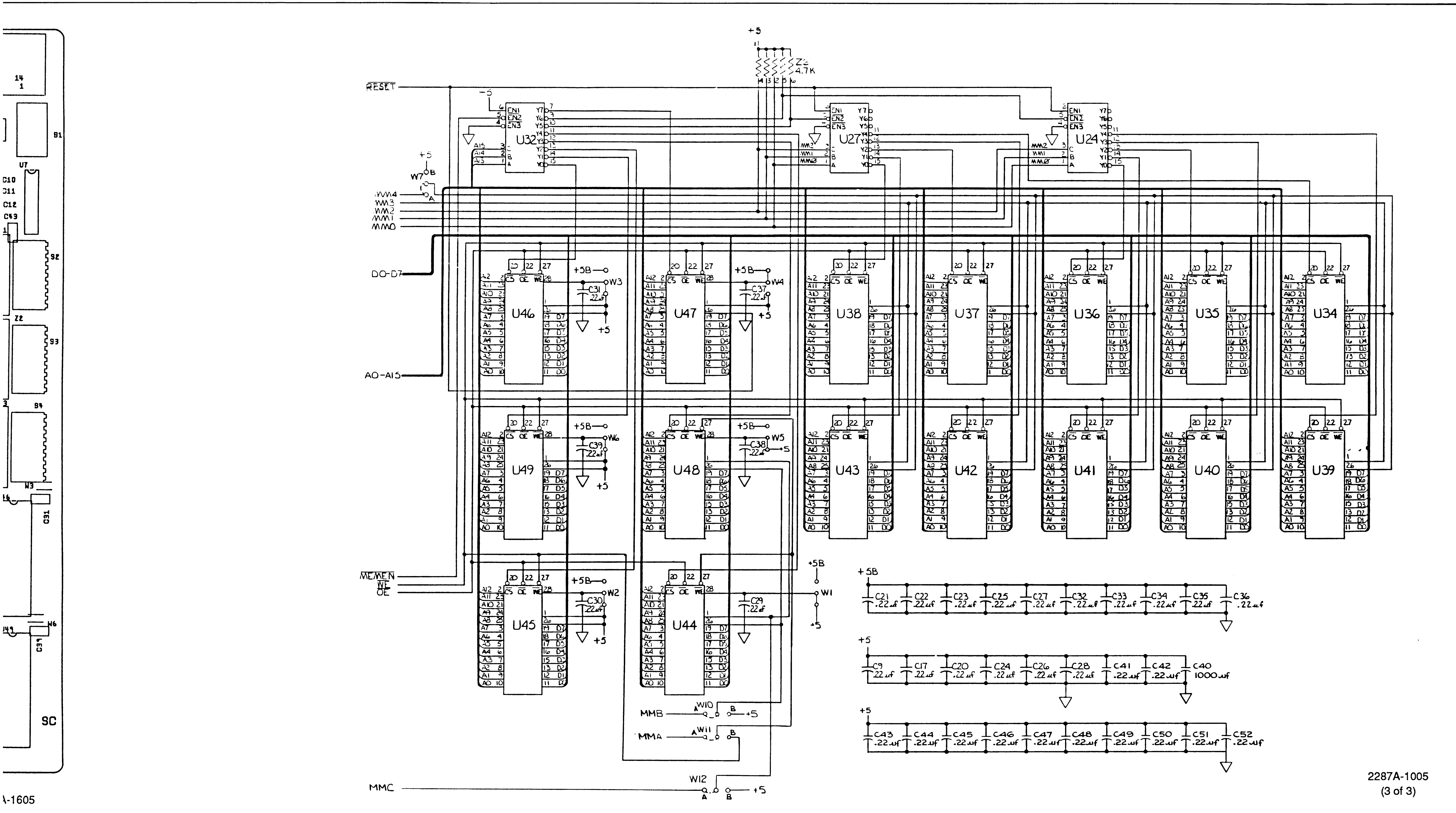
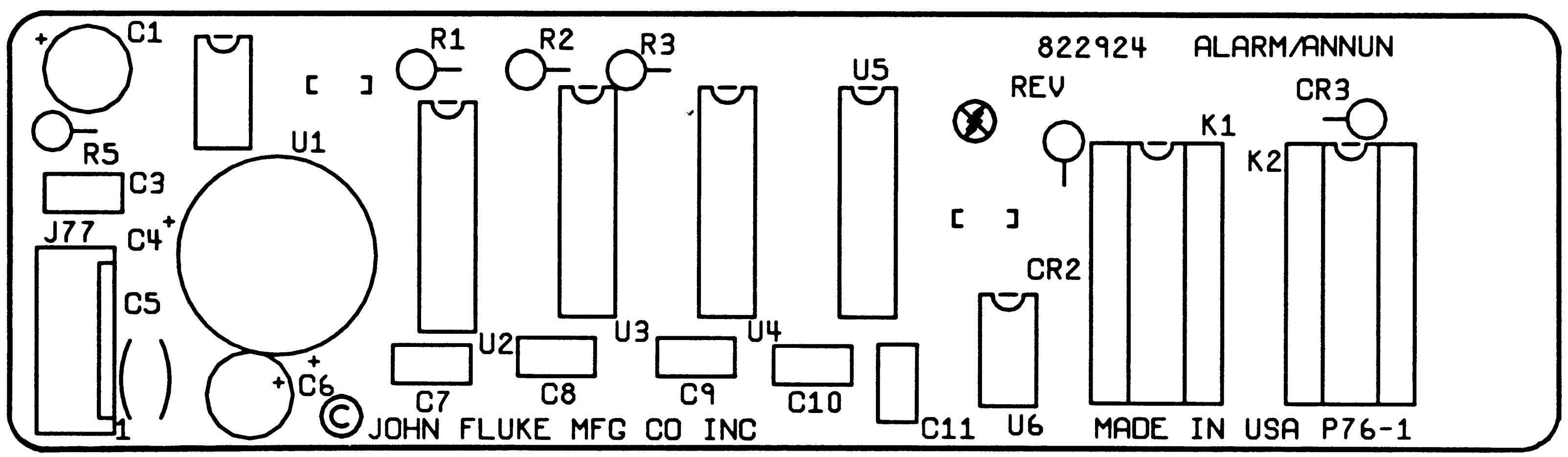
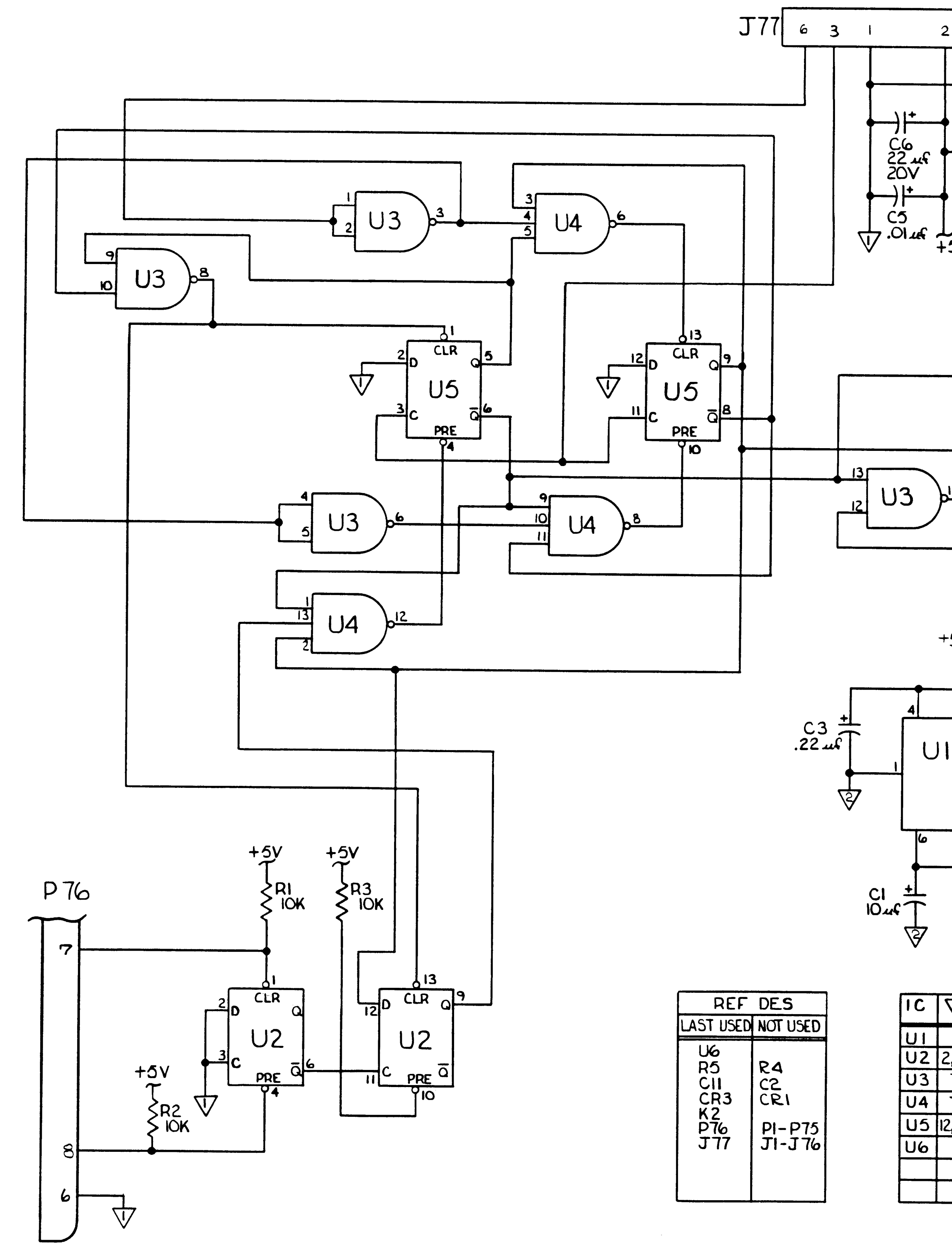


Figure 7-2. A2 Computer Interface PCA (cont.)

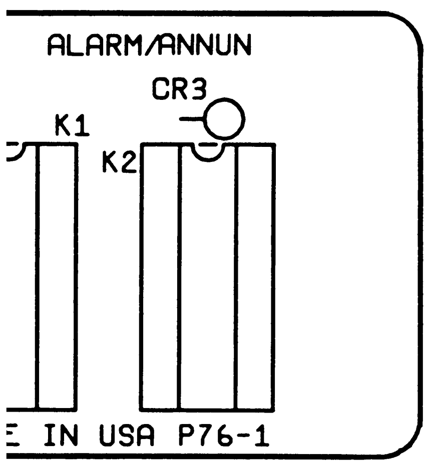


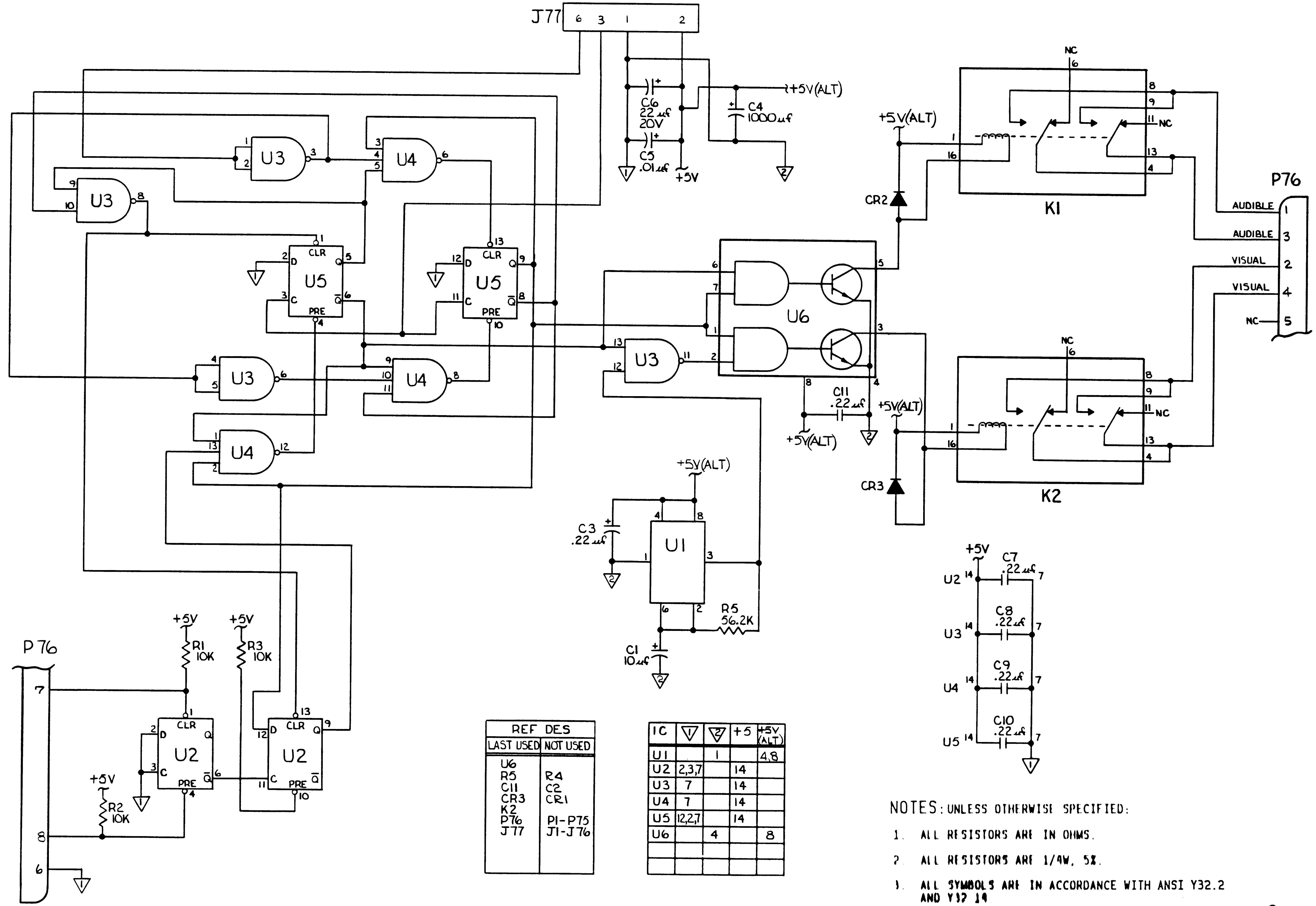


REF DES	
LAST USED	NOT USED
U6	
R5	R4
C11	C2
CR3	CR1
K2	
P76	P1-P75
J77	J1-J76

IC	▽
U1	
U2	2,3,7
U3	7
U4	7
U5	12,2,7
U6	

2289A-1604





REF DES	
LAST USED	NOT USED
U6 R5 C11 CR3 K2 P76 J77	R4 C2 CR1 P1-P75 J1-J76

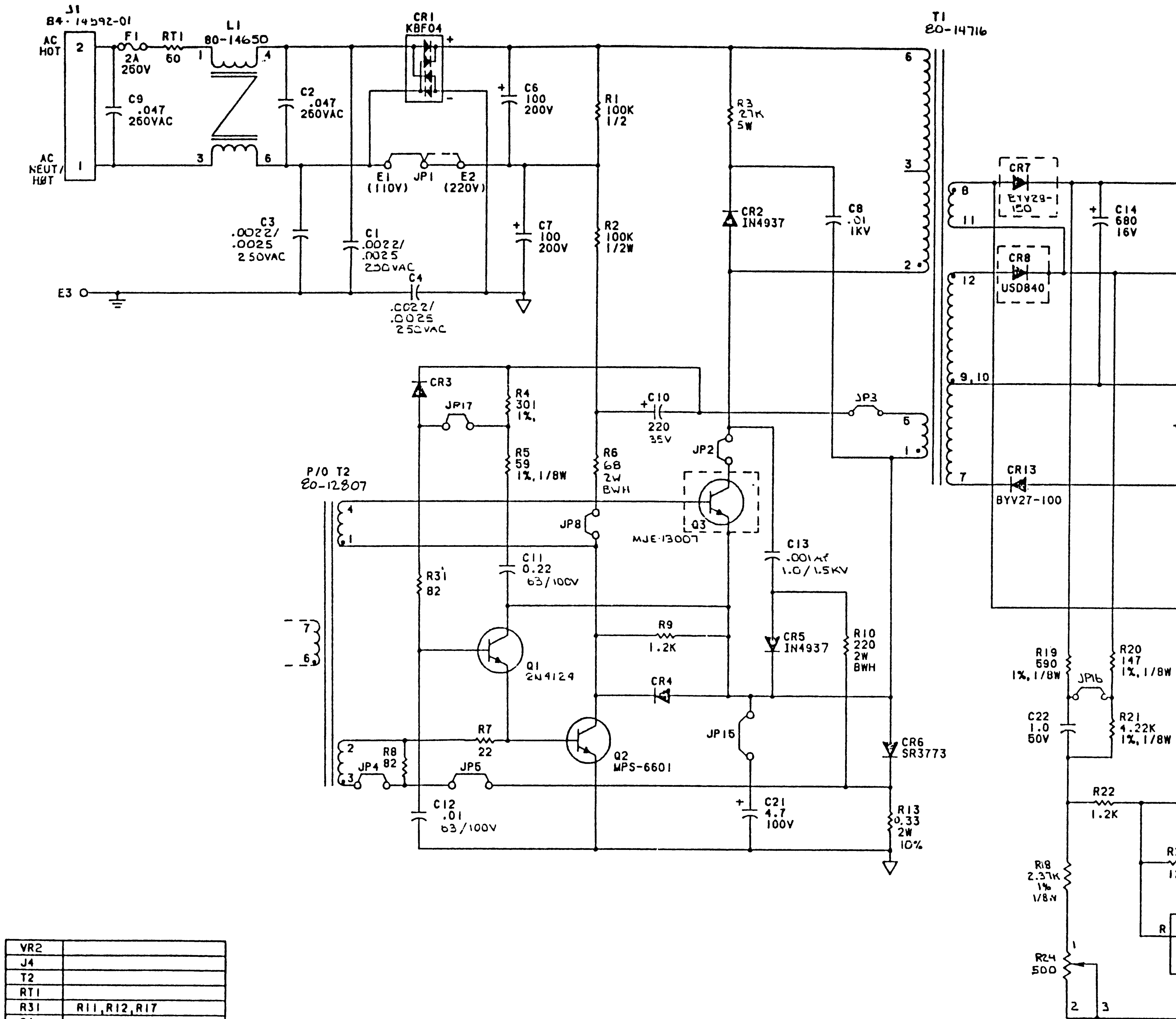
IC	▽1	▽2	+5	+5V (ALT)
U1		1		4,8
U2	2,3,7		14	
U3	7		14	
U4	7		14	
U5	12,2,7		14	
U6		4		8

NOTES: UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTORS ARE IN OHMS.
2. ALL RESISTORS ARE 1/4W, 5%.
3. ALL SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14

2289A-1004

Figure 7-2. A2 Computer Interface PCA

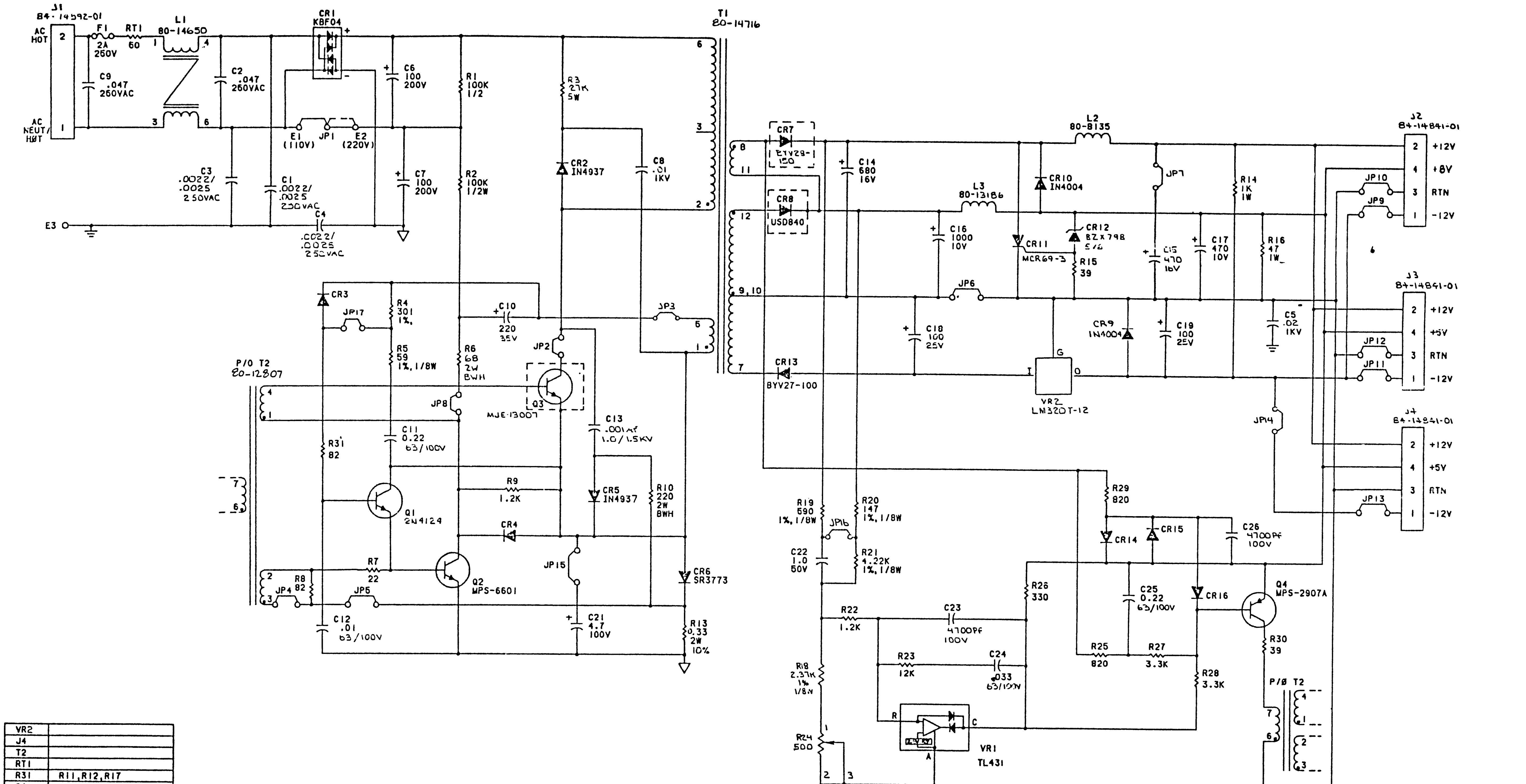


VR2	
J4	
T2	
RT1	
R31	R11, R12, R17
Q4	
L4	
JP17	
F1	
E7	E4
CR16	
C26	C20
LAST USED	NOT USED

REFERENCE DESIGNATORS

2. FOR 110V OPERATION CONNECT JP1 TO E1
   FOR 220V OPERATION CONNECT JP1 TO E2
1. VOLTAGE RATINGS ARE IN DC
   RESISTORS ARE IN OHMS, 1/4W, 5%
   DIODES ARE IN4448
   CAPACITANCE IS IN MICROFARADS

NOTES: UNLESS OTHERWISE SPECIFIED



REFERENCE DESIGNATORS	
VR2	
J4	
T2	
RT1	
R31	R11, R12, R17
Q4	
L4	
JP17	
F1	
E7	E4
CR16	
C26	C20
LAST USED	NOT USED

2. FØR 110V ØPERATIØN CØNNECT JP1 TØ E1
FØR 220V ØPERATIØN CØNNECT JP1 TØ E2

1. VØLTAGE RATINGS ARE IN DC
RESISTØRS ARE IN ØHMS, 1/4W, 5%
DIØDES ARE 1N4448
CAPACITANCE IS IN MICRØFARADS

NØTES: UNLESS ØTHERWISE SPECIFIED

Figure 7-2. A2 Computer Interface PCA (cont.)

CONTENTS

DESCRIPTION

The -160 AC Volts Input Connector (shown in Figure 160-1) mates with the Thermocouple/DC Volts Scanner and converts ac input voltages to dc for input to the scanner.

Ten ac-voltage input and ten dc-voltage input channels are provided on the connector. The input connector mates with the Thermocouple/DC Volts Scanner through a card-edge connector. The entire assembly is enclosed in a plastic housing that provides strain relief for the external wiring to the connector terminals.

Two screw terminals labeled HI and LO are provided for each channel. Channels 0 through 9 are ac voltage input channels and channels 10 through 19 are dc voltage input channels. Channels 0 through 9 accept and convert ac voltages between 5V ac rms and 250V ac rms to dc voltages to be read by the Front End using the -161 High Performance A/D Converter and the -162 Thermocouple/DC Volts Scanner. Channels 10 through 19 can be used to measure dc voltages to 64V.

The LO input terminal and a shield are connected together within the assembly so that system guard and the LO input are at the same potential. This helps minimize common mode voltage errors in the measurement.

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: AC Voltage Input Connector theory of operation, performance tests, a parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are in the Helios Plus System Manual. Option specifications are located in the appendices to this manual and in the System Manual.

Test equipment required to perform the procedures in this subsection is listed in Table 160-1. Table 2-2 in Section 2 of this manual lists the test equipment required for all procedures in this manual.

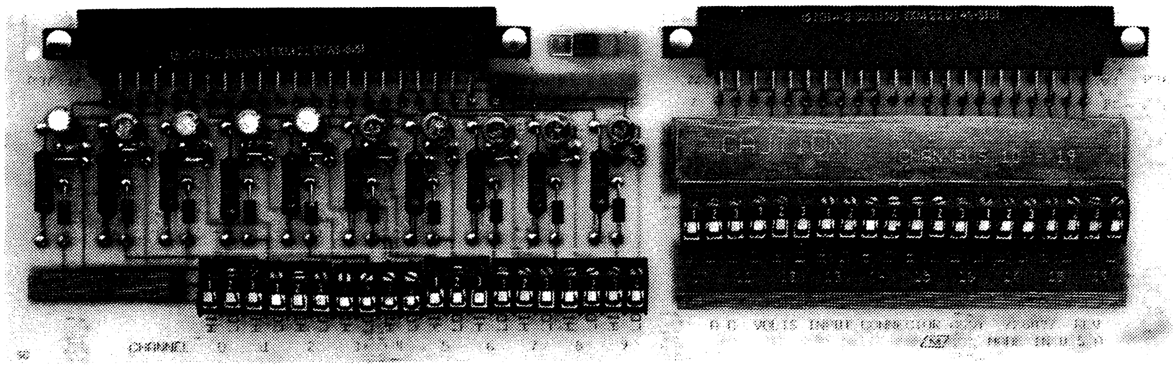


Figure 160-1. AC Voltage Input Connector

Table 160-1. Required Test Equipment for -160

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
AC Voltage Source	10.0V +/- 0.01V	Fluke 5100B
DC Voltage Source	6.2V +/- 155 uV	Fluke 343
Thermocouple/DC Volts Scanner	NA	Fluke Option -162 (no substitute)
High Performance A/D Converter	NA	Fluke Option -161 (no substitute)

THEORY OF OPERATION

The theory of operation for the AC Voltage Input Connector begins with a functional description, followed by a detailed circuit analysis. A schematic diagram of the AC Voltage Input Connector is at the end of this subsection.

Overall Functional Description

The ac-to-dc conversion circuitry for channels 0 through 9 consists of a half-wave rectifier, voltage divider, and a low-pass filter for each of the ten channels. The converter is average responding and calibrated to indicate the rms value of a sine wave. The conversion process converts a sinusoidal ac voltage to its rms value, minus 0.32 volts, divided by 1000.

Detailed Circuit Description

The following description uses the component designations for channel 0 although it applies to all channels. Only the component designations change from channel to channel. Diode CR1 rectifies the ac voltage to be measured. This voltage is then divided and filtered by a network consisting of R1, R11, R21, and C1. The dc output voltage equals the rms value of a sinusoidal input from 45 Hz to 450 Hz, minus 0.32V, divided by 1000. Overall ripple rejection is from the combination of this low-pass filter and the input filter on the -161 High Performance A/D Converter.

GENERAL MAINTENANCE

The AC Voltage Input Connector normally requires no cleaning unless dirt, dust, or other contamination is visible on the surface. Cleaning instructions are found in Section 4 of this manual.

PERFORMANCE TESTS

The following test verifies that the AC VOLTAGE INPUT CONNECTOR is fully functional and within specifications. This procedure can be used as an initial acceptance test or as a troubleshooting aid.

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Remove all addressable options from the Front End so that no address conflict occurs.

3. Set the -161 A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End. Install the -162 Thermocouple/DC Volts Scanner in the option slot immediately below.

4. Connect test leads to the HI and LO terminals for channel 0 on the AC Volt Input Connector. Install the connector on the scanner.

5. Reconnect the Front End's ac line cord, and switch the power ON.

6. Connect the AC calibrator output to the HI and LO test leads of the AC Voltage Input Connector installed on the scanner.

7. Set the calibrator output to 10.00V, 60 Hz.

8. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0..9)=AVIN <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0) <CR>
```

The value returned for the selected channel should be 10.00V +/- 0.2V (1.00000E+01).

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs will cause the Front End to take an ac voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

The following programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for an IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
110  PRINT #1,"def chan(0..9)=avin"
120  GOSUB 300
```

```
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  REM make measurement and read in response
160  PRINT #1,"send chan(0..9)"
170  FOR I=0 TO 9
180  INPUT #1,M$
190  PRINT "chan";I;"=";
200  PRINT USING "###.##";VAL(M$);
210  PRINT " Volts AC"
220  NEXT I
230  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for a 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1
50   OPEN "KB1:"AS OLD FILE 2
60   PRINT #1,CHR$(3);
70   REM set up Computer Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0..9)=avin"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  REM make measurement and read in response
170  PRINT #1,"send chan(0..9)"
180  FOR I=0 TO 9
190  INPUT #2,M$
200  PRINT "chan";I;"=";
210  PRINT USING "S###.##",VAL(M$);
220  PRINT " Volts AC"
230  NEXT I
240  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The value returned for the selected channel should be 10.00V +/- 0.2V. Ignore readings for the unselected channels.

9. Set the calibrator output to 0. Move the AC Voltage Input Connector test leads to the terminals for the next channel to be tested.

10. Repeat steps 7 through 9 for each remaining ac input channel (1 through 9), substituting the appropriate channel number in the SEND CHAN command if Terminal Mode is being used.

11. The ac portion of the AC Voltage Input Connector performance test is complete.

12. To test the dc voltage input channels (channels 10 through 19), perform the 176 Voltage Input Connector performance test provided in Section 9.

CALIBRATION

The AC Voltage Input Connector requires no calibration.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the AC Voltage Input Connector is given in Table 160-2. For parts ordering information, see Section 6 of this manual.

Figure 160-2 is a schematic diagram of the -160 AC Voltage Input Connector.

TABLE 160-2 AC VOLTAGE INPUT CONNECTOR
(SEE FIGURE 160-2.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
C 1- 10		CAP,AL,47UF,+-20%,10V	613984	89536	613984	10		
CR 1- 10	*	DIODE,SI, 1K PIV, 1.0 AMP	453399	04713	1N4007	10		
H 1		STEEL,CAD.PLATED,.125X .500	276493	89536	276493	4		
H 2		WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	4		
MP 1		CONNECTOR HOUSING, TOP	578971	89536	578971	1		
MP 2		CONNECTOR HOUSING, BOTTOM	656876	89536	656876	1		
MP 3		DECAL,AC VOLTAGE INPUT CONNECTOR	722975	89536	722975	1		
MP 4		DECAL, OPTION -160	722983	89536	722983	1		
P 36, 37		CONN,PWB EDGE,REC,90,0.156 CTR,44 POS	614313	89536	614313	2		
R 1- 10		RES,MF,1M,+-0.1%,0.5W,25PPM	266114	89536	266114	10		
R 11- 20		RES,MF,150K,+-1%,0.125W,25PPM	257444	89536	257444	10		
R 21- 30		RES,MF,2.26K,+-0.1%,0.125W,25PPM	501320	89536	501320	10		
TB 1		TERM STRIP,PWB,ANGL ENTRY,10 CONTACTS	501403	89536	501403	4	2	

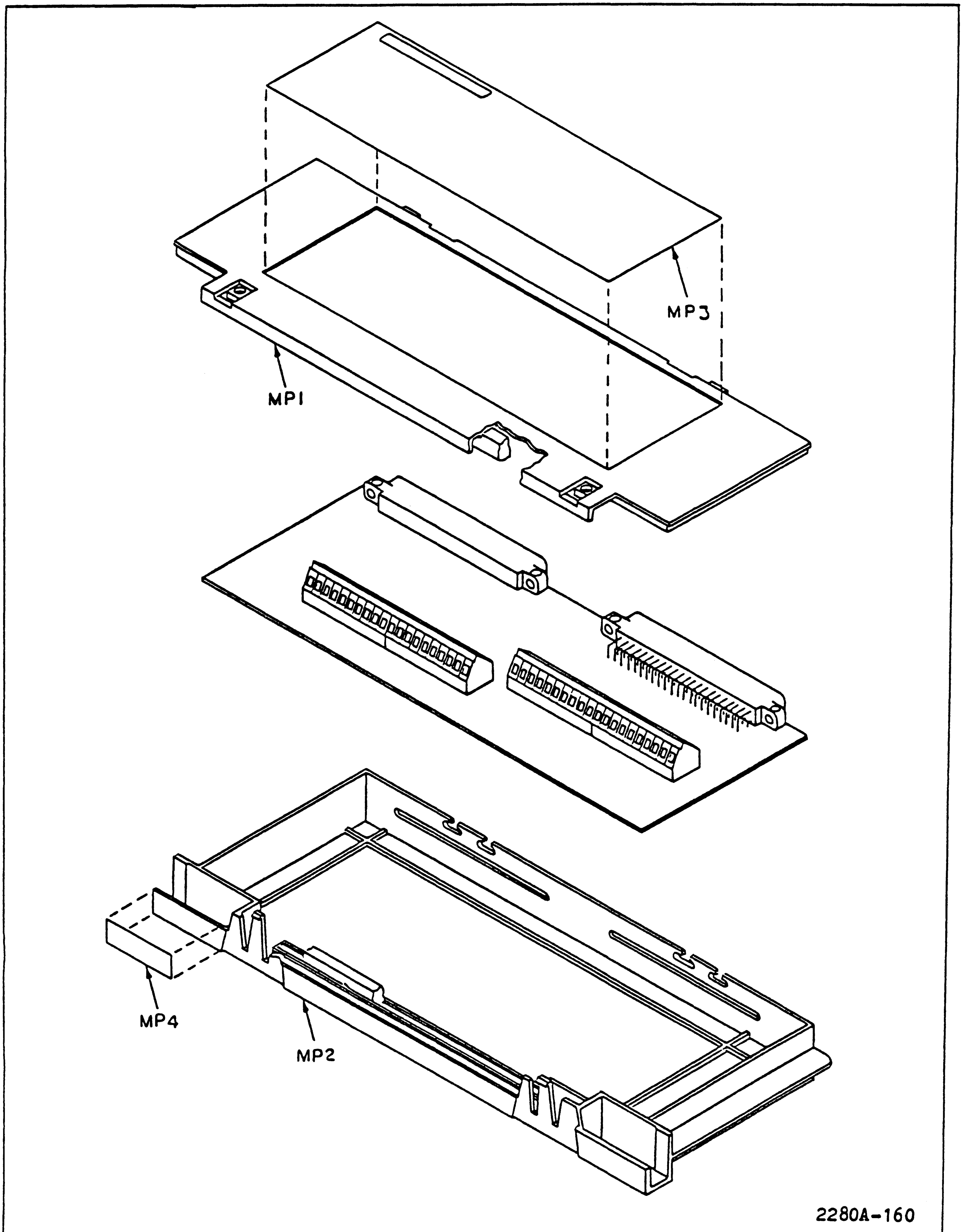
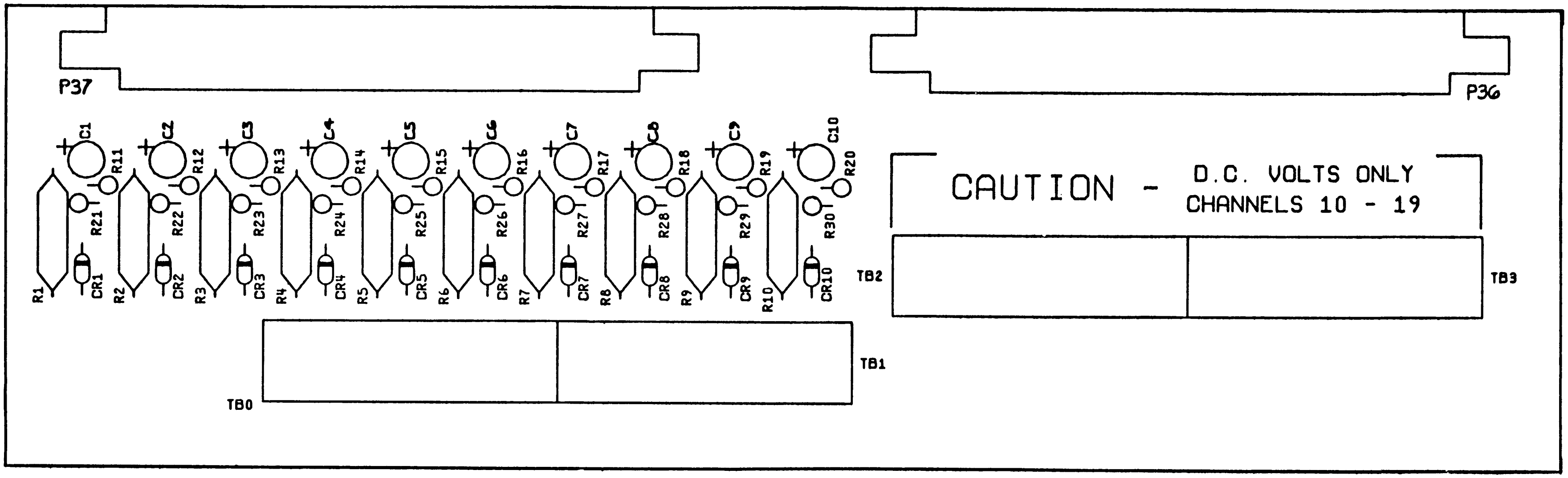


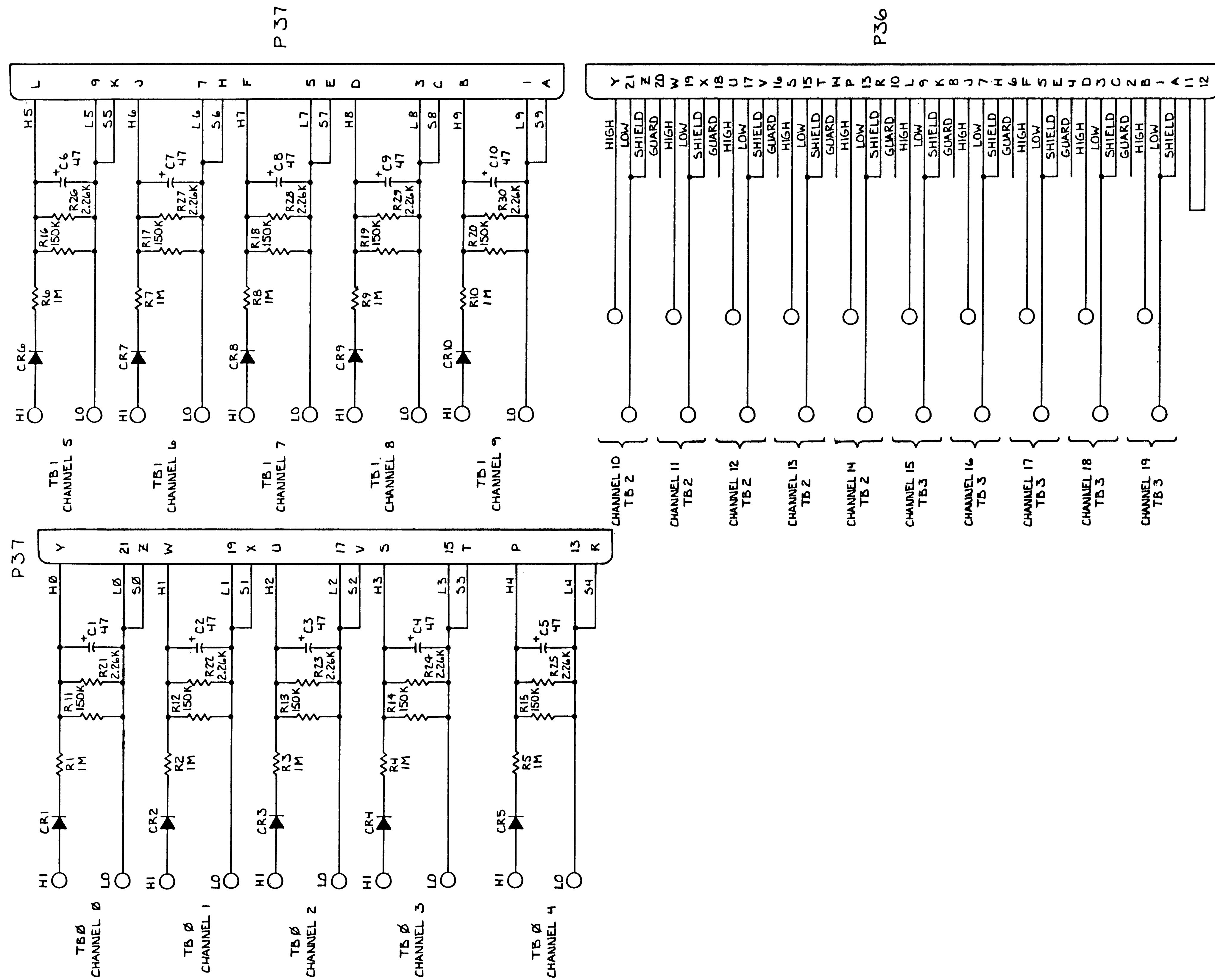
Figure 160-2. -160 AC Voltage Input Connector



NOTES: UNLESS OTHERWISE SPECIFIED.

1. FOR SCHEMATIC DIAGRAM SEE 2280A-1060
2. FOR ASSEMBLY DRAWING SEE 2280A-4060

2280A-1660



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCE IS IN OHMS.
2. ALL CAPACITANCE IS IN MICROFARRADS.
3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.

2280A-1660

2280A-1060

Figure 160-2. AC Voltage Input Connector Schematic Diagram

DESCRIPTION

The -161 High Performance A/D Converter (shown in Figure 161-1), is an analog-to-digital converter for measuring scanner input voltages. These dc voltages can represent a variety of phenomena, depending on the input connector and scanner options installed with the A/D Converter.

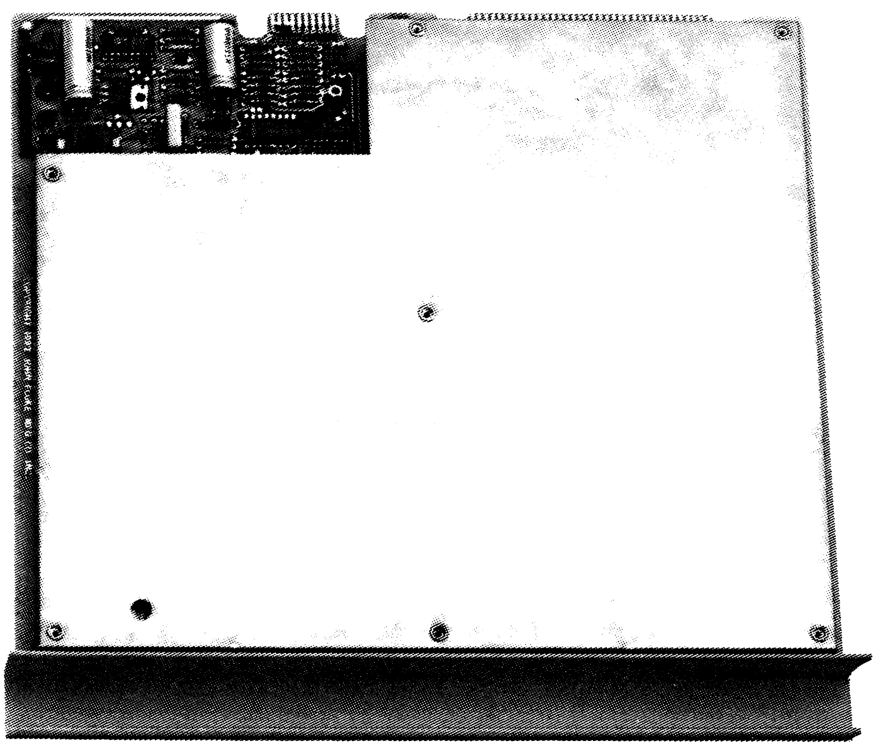


Figure 161-1. High Performance A/D Converter

Operating parameters of the A/D Converter are established through the Front End command structure. With one A/D Converter installed, the Front End reads up to 16 input channels per second. If a reading rate higher than 16 channels per second is desired, the rate can be increased by installing one or two additional A/D Converters in the mainframe. Each additional A/D Converter increases the reading rate by varying amounts depending on the system configuration, but reduces the maximum number of mainframe channels by 20 since another slot has been occupied.

Each A/D Converter supports a maximum of five, 20-channel Thermocouple/DC Volts Scanners (-162) or RTD/Resistance Scanners (-163), thereby providing up to 100 channels. A total of 15 A/D Converters may be installed in a Front End system when 2281A Extender Chassis are used. Like the Front End mainframe, each 2281A Extender Chassis supports a maximum of 100 channels.

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: A/D Converter theory of operation, performance tests, calibration procedures, the parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are provided in the Helios Plus System Manual. Option specifications are located in the appendices to this manual and the System Manual.

The test equipment required to perform the procedures in this subsection is listed in Table 161-1.

A summary of test equipment required to perform all procedures in this manual is given in Table 2-2 in Section 2 of this manual.

THEORY OF OPERATION

The A/D Converter theory of operation begins with a functional description of the A/D Converter, followed by a block diagram analysis that describes the operation of each major circuit block on the A/D Converter assembly. The theory of operation ends with a circuit analysis of each block in the block diagram.

Where necessary, block diagrams and simplified schematics are included with the text. The schematic diagrams for the A/D Converter are located at the end of this option subsection.

Overall Functional Description

The -161 High Performance A/D Converter measures dc voltages received from scanner option channels and sends the measurement results to the Front End controller in digital form over the serial link bus.

At least one scanner and input connector option must be used with the A/D Converter if the Front End is to acquire measurement data.

Table 161-1. Required Test Equipment for -161

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Calibrator	+/- 31.3 mV +/- 20 uV +2.048V +/- 50 uV -2.048V +/- 2 uV of +2.048 500 mV +/- 20 uV 6.2V +/- 155 uV 6.8V +/- 0.1V 5.0V +/- 100 uV 7.9V +/- 200 uV *63V +/- 800 uV 1.008V +/- 40 uV	Fluke 343
100:1 Divider	+/- 0.005%	Fluke Y2022
Digital Multi-meter (DMM)	+/- 10V +/- 0.06V 50.0 mV +/- 0.001 mV 500.0 mV +/- 0.005 mV	Fluke 8505A
Resistor	1 kilohm +/- 5%	Fluke Part No. 108597
Resistor	10 kilohm +/- 5%	Fluke Part No. 109165
Thermocouple/DC Volts Scanner	NA	Fluke Option -162 (no substitute)
Isothermal Input Connector	NA	Fluke Option -175 (no substitute)
Voltage Input Connector	NA	Fluke Option -176 (no substitute)
Calibration/ Extender Fixture	NA	Fluke Accessory Part No. 648741 (no substitute)

* 63V output is used for only one optional test.

Block Diagram Analysis

Figure 161-2 illustrates the A/D Converter in block diagram form. The following paragraphs discuss the function of each of the blocks in the diagram.

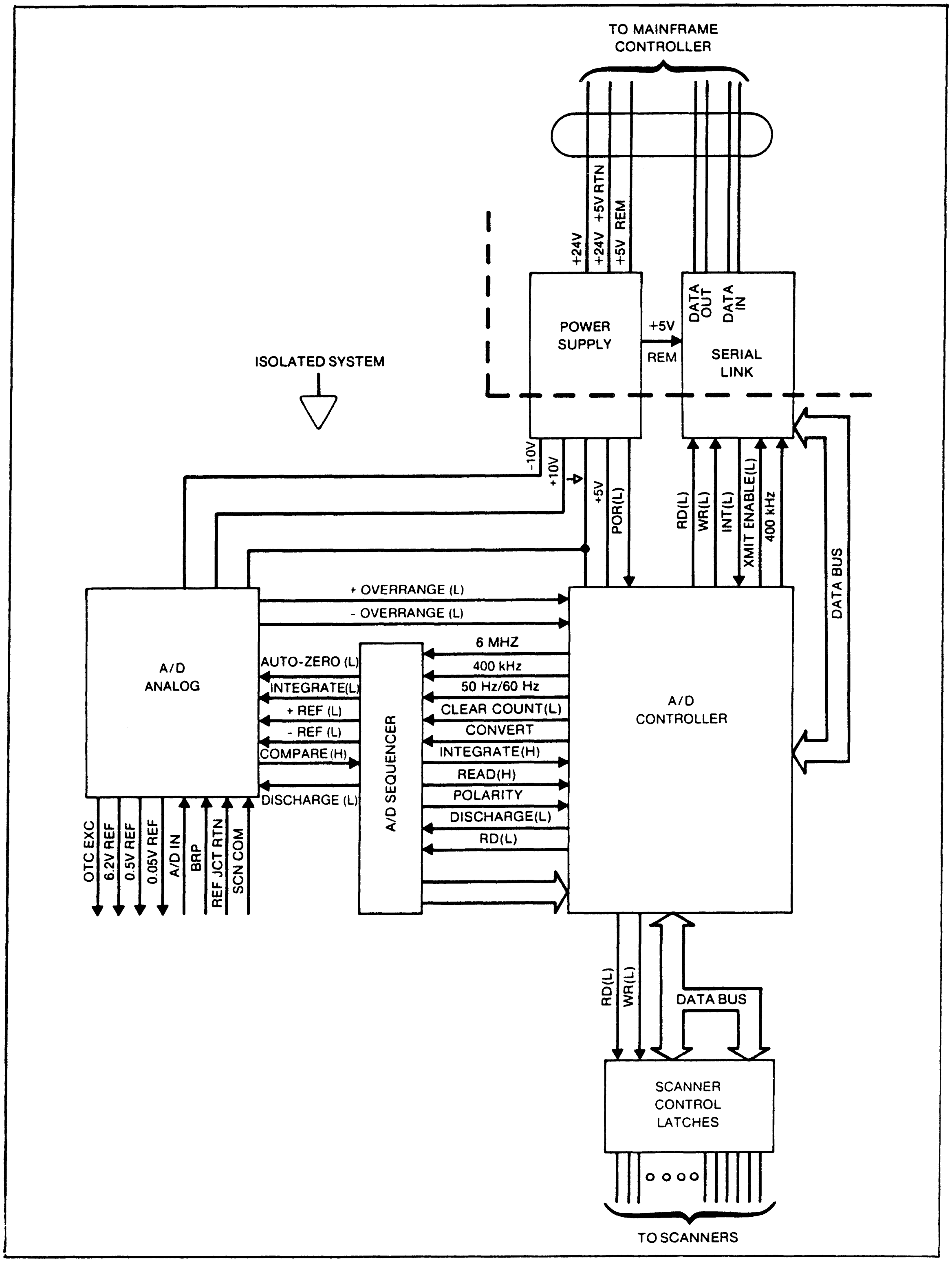


Figure 161-2. A/D Converter Block Diagram

POWER SUPPLY

The Power Supply converts incoming dc power from the serial link into isolated +10V, -10V, and +5V dc for the scanners and the measurement circuitry, as well as +5V dc for the serial link.

A reset signal is transmitted by the Power Supply to the A/D Controller upon power-up. Reference voltages produced by the A/D Analog block are used by the Power Supply to regulate the +10 and -10 output voltages.

SERIAL LINK

The Serial Link allows the A/D Controller to exchange commands and measurement data with the Front End mainframe controller.

The bidirectional serial transmissions are electrically isolated, buffered, and converted to signals that the A/D Controller can use. The serial link circuitry sends an interrupt signal and data to the controller while the controller returns data and a transmitter enable signal.

A/D CONTROLLER

The A/D Controller performs the tasks of maintaining the communication link, selecting scanner modes and channels, and invoking A/D conversions. The controller supplies 6-MHz and 400-kHz clocks, line frequency data, and conversion commands to the A/D Sequencer, and in return, it monitors the progress of conversions through the incoming integrate, read, and polarity lines. The controller is advised of impending overrange measurements by two additional lines that come from the A/D Analog block. By writing into the Scanner Control Latches, the controller manipulates many control lines that direct the scanners.

A/D SEQUENCER

The A/D Sequencer responds to a conversion command from the controller and generates the timed control signals that the A/D Analog block needs to perform a dual-slope analog-to-digital conversion. The read interval of the conversion cycle is timed by this block.

A/D ANALOG

The A/D Analog block accepts dc input voltages from the scanners and converts these inputs to a time interval that is proportional to their magnitude. Here, stable reference voltages are also generated for the Power Supply section and the scanners.

SCANNER CONTROL LATCHES

The scanner control latches are controlled by the A/D Controller, thereby enabling readings on the individual scanner channels.

Detailed Circuit Description

POWER SUPPLY

DC-to-DC Converter

Isolation of the A/D circuitry is provided by T1 (which is also the core of the dc-dc converter) where T1, U1, U34, U49, Q1, and Q2 comprise a flyback type of switching regulator converter. Incoming dc power is applied to the primary of T1 for an interval generated by U1, causing the primary current to ramp up to approximately 1-ampere peak before Q1 and Q2 are turned off. The energy stored in T1 is then released through CR10, CR11, CR12, and CR13 into C5, C17, C18, and C19. The 5.4V (nominal) on C18 is sampled by R82 and R11 and a feedback error signal is generated by U49, which is relayed to U1 through isolator U34. The duty cycle of Q1 and Q2 is then adjusted by U1 to maintain C18 at 5.4V despite load changes and variations in the serial link supply voltage. Typical waveforms are shown in Figure 161-3.

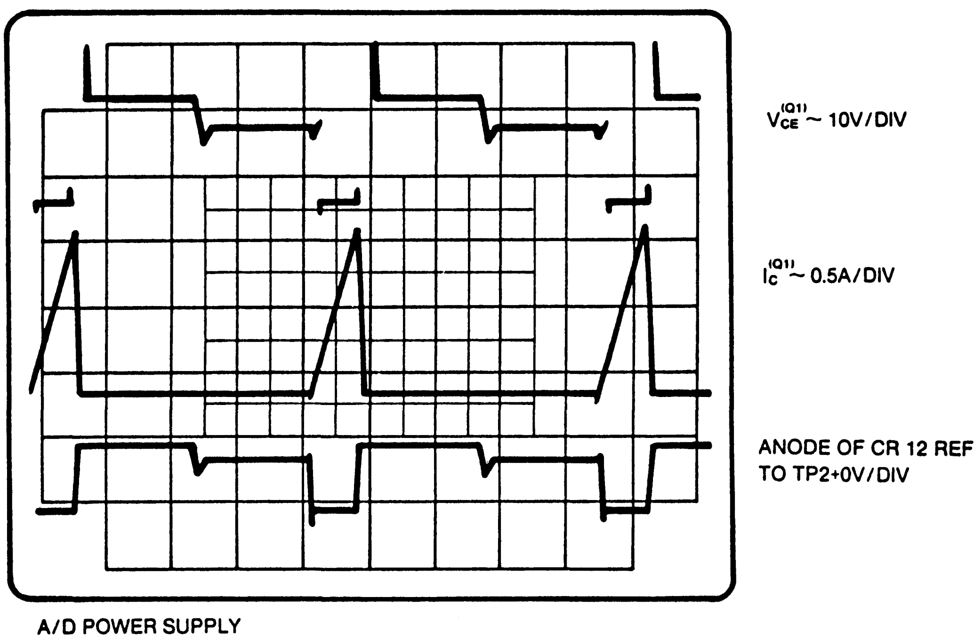


Figure 161-3. DC-DC Converter Typical Waveforms

The voltage on C17, C18 and C19 is regulated further by U33, U49, Q5, Q9, Q10, Q11, Q24, and Q25 to obtain precise +10V, -10V, and +5V dc voltages to power the A/D Converter and scanners. The +10V supply is referenced to zener diode VR5 within the A/D Analog block. The -10V supply is referenced to the +10V supply. The +5V supply is derived from U35, a 2.5V reference, which is also the reference for the switching regulator loop.

The voltage on C5 (5V nominal) is used to power the serial link interface circuits and is only regulated by its coupling to the switching regulator loop through T1.

Reset Generator

When power is first applied to the A/D Converter, Q6 is turned on by R53, and the Power-On Reset Line to the controller is held low. U15 compares the voltage on C46 to a 1.22V reference to determine whether the +5V supply is within tolerance. Once the supply voltage has stabilized, C46 is allowed to charge through R48 and R56, generating a delay of approximately 50 ms before C46 charges to 1.22V causing U15 to remove the drive to Q6, and allowing the Power-On Reset line to be pulled high by R51. At this point Q7 is turned on to light the POWER indicator DS1. For test purposes, this reset sequence can be triggered by momentarily grounding Test Point 44 to TP 2.

SERIAL LINK

Differential line drivers U2 and receiver U3 transmit and receive information through transient suppression networks consisting of resistors R12, R13, R14, R15, R18, R19, R20 and R21 and diodes CR1 through CR8 in conjunction with VR2.

Incoming data from the mainframe controller assembly, which can be monitored at Test Point 30, is fed into UART U17 through optocoupler U5. Upon receipt of a data byte, U17 interrupts microprocessor U10 in the A/D Controller block.

Data destined for the mainframe controller from the A/D is clocked out of the UART through isolator U4 to the line drivers in U2. This data to be transmitted can be observed at Test Point 32. The drivers are enabled by a Xmit Enable signal from the A/D Controller that must also pass through U4. The driver outputs remain in a high-impedance state when not enabled.

A/D CONTROLLER

The A/D Control circuitry consists of an 8-bit microprocessor, U10, that executes firmware stored in a PROM, U26. The lower eight bits of the PROM address is captured in an octal latch, U36, on the rising edge of the address latch enable (ALE(L)) signal from the microprocessor. The clock for the microprocessor is derived from a 6.0 MHz crystal, Y1, in conjunction with U18.

U27 and U28 are CMOS RAMs used to store the calibration constants of the scanners associated with the A/D Converter. Data is read from or written to the RAMs by the microprocessor by using the RD(L), WR(L), and P1-1 (pin 28 of U10).

A/D SEQUENCER

The A/D Sequencer consists of three functional blocks: the integrate timer, the read timer, and the autozero flip-flop. The integrate timer generates the integrate control signal of 16.666 or 20.000 ms duration. The read timer asserts the appropriate polarity reference signal and measures the interval to which it is applied. The autozero flip-flop places the converter into the autozero mode when not performing a conversion.

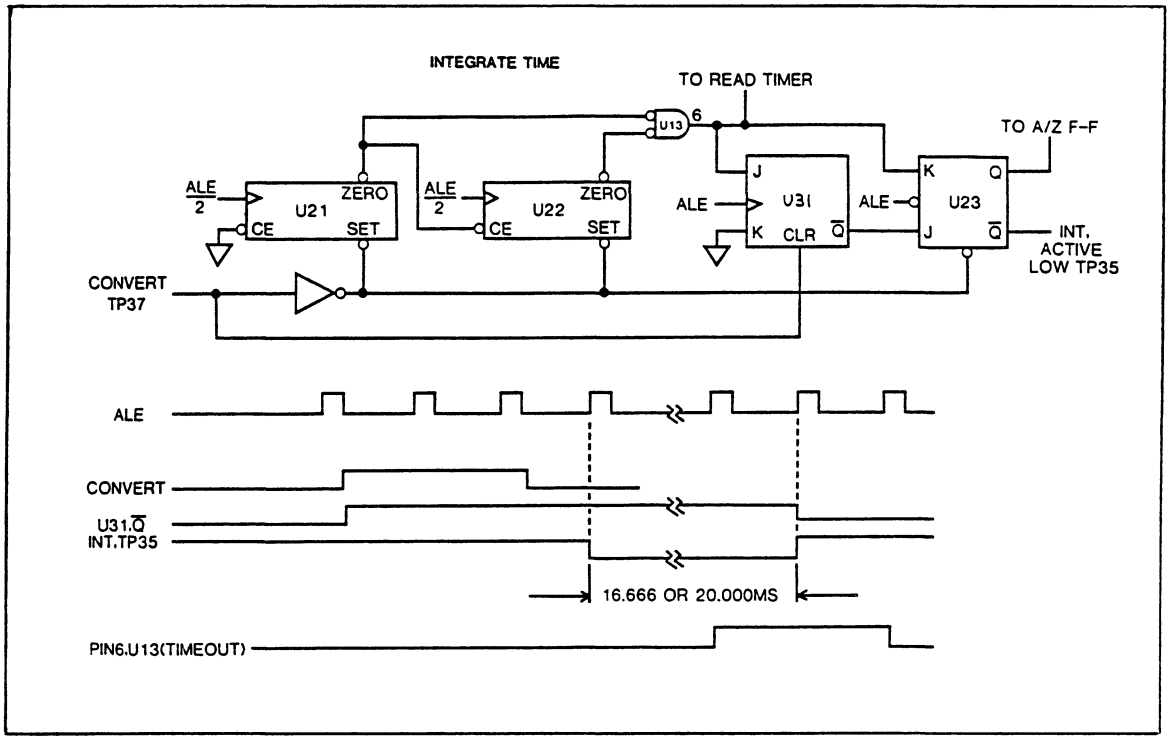


Figure 161-4. Integrate Timer Simplified Schematic and Timing Diagram

- Integrate Timer

  Refer to Figure 161-4 for a simplified schematic and timing diagram of the integrate timer. In response to a convert command from the A/D controller, J-K flip-flops U31 and U23 are reset, and counters U21 and U22 are loaded. The next ALE pulse sets U23, asserting the INTG(L) signal. Subsequent ALE pulses decrement the counters until both reach zero, causing U13 to output a timeout signal. The next ALE pulse toggles U23 to terminate the INTG(L) signal and sets U31 to prevent spurious integrate commands.

- Read Timer

  Refer to Figure 161-5 for a simplified schematic and timing diagram of the read timer. The timeout signal from the integrate timer latches the state of the COMP(H) into U12. U12 selects which reference control line (+REF or -REF) is to be asserted during the read interval. The timeout signal is gated through U40 and U13 to U23 allowing the same ALE pulse that terminates the integrate signal to set U23 and commence the read interval. The READ(H) signal (TP 34) enables U19 and U30 to count the 6-MHz system clock and thereby measure the duration of the read period. U13 and U18 detect the eventual change in comparator state and reset U23 when COMP(H) changes, ending the read interval. U32 and U20 prevent switching glitches from appearing as a comparator transition signal by preventing U23 from being reset until 20 microseconds into the read period. The eventual reset to U23 by COMP also resets U31, inhibiting read timer activity until a subsequent integrate cycle is initiated.

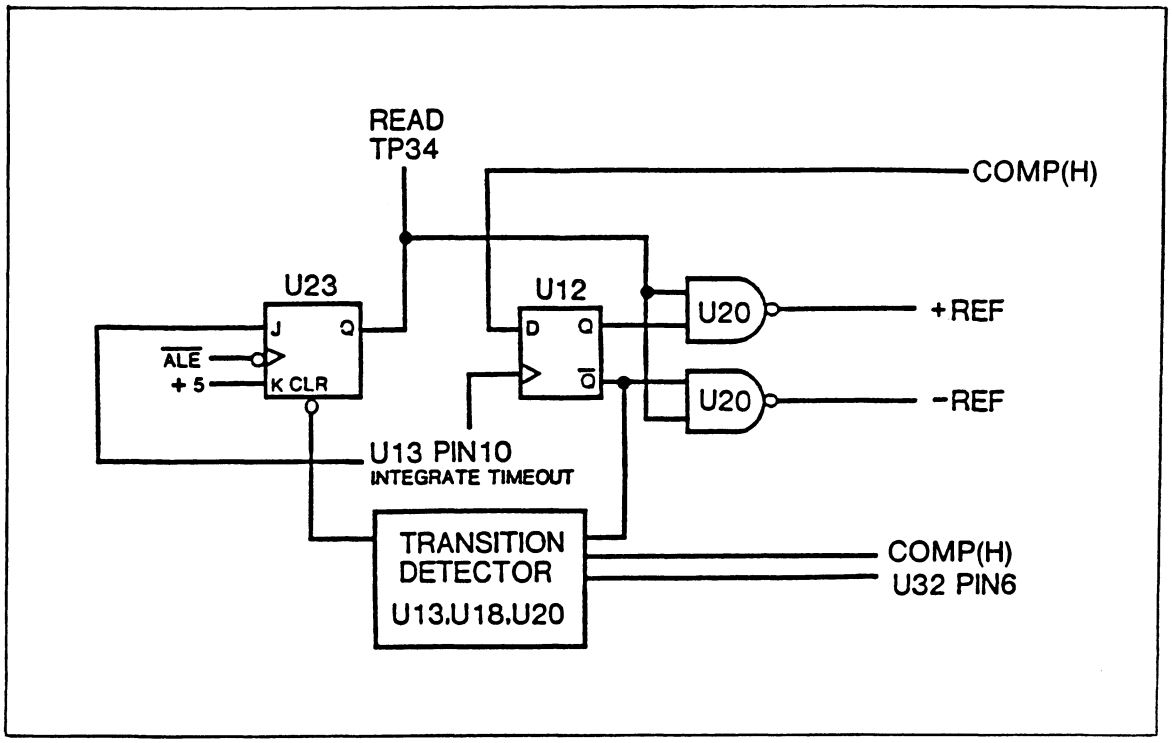


Figure 161-5. Read Timer Simplified Schematic and Timing Diagram

o Autozero Flip-Flop

When the conversion cycle ends, U12 is clocked, and the Auto-Zero control signal, AZ(L), is asserted low. The system remains in this state until another integrate cycle is entered when the integrate signal resets the autozero flip-flop causing AZ(L) to go high.

A/D ANALOG

Figure 161-6 shows the major components of the dual-slope converter that dominates this circuit block as well as the timing relationships of the control signals and the circuit waveforms as they appear during typical conversion cycles.

A conversion cycle begins with integrate when Q20 turns on and applies the scanner output voltage to the amplifier consisting of Q16 and U44. The amplifier output is integrated by the stage composed of Q13, U43, R77, and C38 as long as the integrate signal is asserted. The integration of the dc input appears as a ramp waveform that can be observed at Test Point 48.

At the end of the integrate period, Q20 is turned off and either Q17 or Q18 is turned on. This applies a stable reference voltage to the integrator with a polarity opposite to the input previously integrated. The integrator in turn ramps back toward zero. The integrator output is amplified by a stage consisting of U43, R87, and R90 before reaching the comparator U42. The amplifier increases the slope of the integrator ramp that is applied to the comparator to facilitate an accurate zero crossing detection by the comparator.

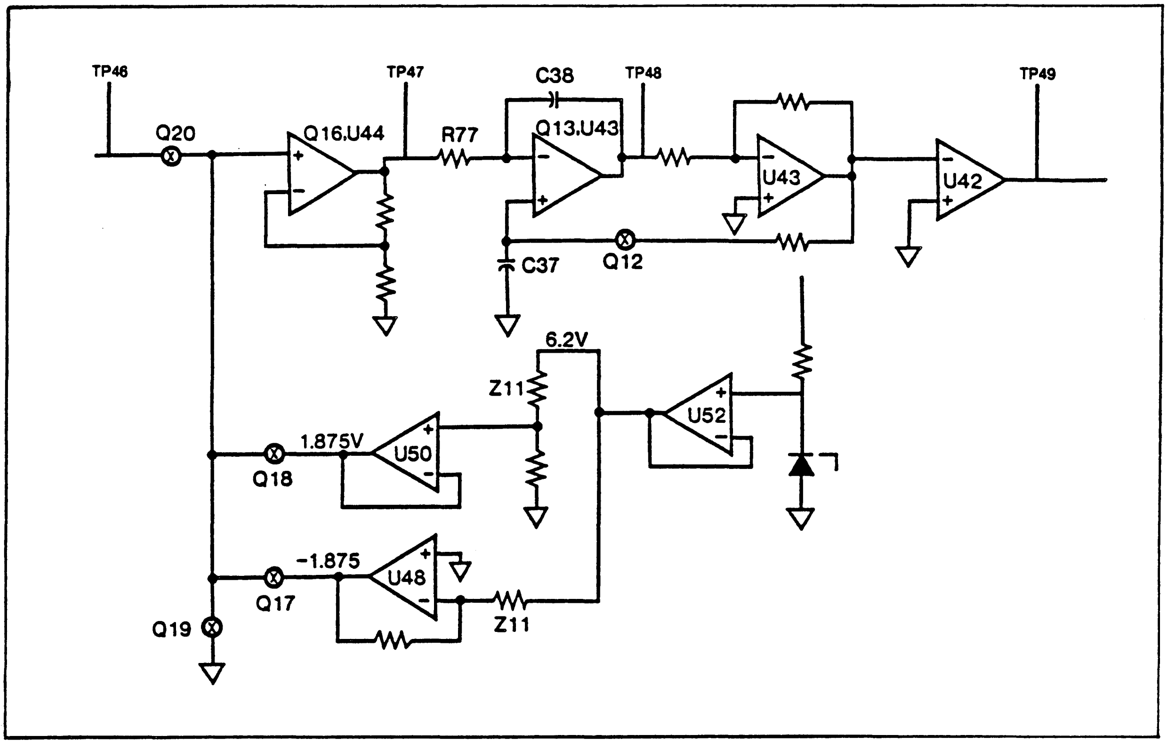


Figure 161-6. A/D Dual-Slope Converter

Once the comparator changes state, the reference is removed from the integrator by turning off Q17 or Q18 and turning on Q19, Q12, and Q14 and placing the converter in the autozero mode. During autozero, amplifier offsets are stored on C37 for use in negating the integrate and read errors that would otherwise occur.

Offscale or overvoltage inputs are detected by comparator U47. Should an out-of-range voltage appear at the A/D input, Q21 is turned on to ensure that the input filter capacitor C59 is not adversely affected. At the same time, an overload bit is pulled low to flag the A/D controller so that a measurement will not be made.

SCANNER CONTROL LATCHES

The A/D Converter generates 21 control signals to select measurement channels and ranges on the connected scanners. The binary representations of the scanner address and channel address to be measured are latched into U6 and U7 by U10 and U37. The scanner address is further decoded by U11 into one of five scanner select lines SCNS[1:5](H) and a sixth signal that is used by the A/D ANALOG block to discharge its input filter DISCHG(H).

U9 and U14 accept the binary representations of the ranging bits RNG0(L) and RNG1(L) in addition to the bits that determine the scanner mode: Zero (ZERO(H)), calibrate (CAL(H)), discharge inhibit (DISCHG INH(H)), and reference junction enable (REF JCT EN(H)). U14 also stores the line frequency bit that determines the integration period of the Intergrate Timer.

U8 gates the scanner type bits SCN[0:2](H) onto the data bus. U25 gates the setting of the A/D Address switch S1 onto the bus as well as the status of the RDY(H) line that is returned from the scanners.

A/D Operation

The A/D Converter does not initiate tasks independently, but responds to commands from the Front End mainframe controller. Six commands (listed and described in the following bulleted paragraphs) direct the A/D Converter through all of the jobs demanded of it.

o Reset Command

This command initializes the A/D Controller and its RAM. The reset command elicits no response from the A/D Converter.

o Configuration Request

The A/D Converter responds to this command by sending the type identifier of each associated scanner. One type identifier is sent for each block or decade of channels. Thus, an A/D Converter with three adjoining DC Volts Scanners would respond with six different block addresses during a system-wide configuration check.

o Calibrate Command

The A/D Converter measures the offsets and gains of each range of the DC Volts and RTD/Ohms Scanner connected to it. From these measurements the A/D Converter computes and stores correction constants for use in adjusting subsequent measurements. The calibrate command contains line frequency information that the A/D Converter uses to determine the integration period. Calibration is commanded on approximately ten-minute intervals and at power-on. The A/D Converter does not send a response to the calibration command.

o Measurement Command

The A/D Converter performs measurements on desired scanner channels in the ranges identified within the command. Normally the A/D Converter responds to a measurement request with an acknowledgement that the command was understood. If the A/D Converter is in an uncalibrated state, as might happen if serial link power had been interrupted, the A/D Converter does not send a response.

o Status Request

The A/D responds to a status request command with a Ready or a Not Ready response, indicating whether or not it has completed the measurement task previously commanded.

- o Measurement Results Request

  The A/D Converter responds by sending back the results of the measurements most recently performed. If the A/D Converter does not have readings to transmit, it does not send a response.

GENERAL MAINTENANCE

The A/D Converter normally does not require cleaning, unless dirt, dust, or other contamination is visible on the surface of the Converter. Follow cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

There are four performance tests for the -161 A/D Converter. All four tests may be performed in sequence to verify overall operation of the A/D Converter, or the tests may be run independently.

The four performance tests are:

- o Address Response Test
- o Accuracy Verification Test
- o Overrange Indication Test
- o Open Thermocouple Response Test

These performance tests verify that the A/D Converter performs properly and that it meets all specified accuracy tolerances. If calibration of the assembly is required, refer to the Calibration procedures that follow the performance tests in this subsection.

Address Response Performance Test

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES WHICH CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

The Address Response performance Test checks to see if the Front End mainframe controller can communicate properly with the A/D Converter address switch set to a variety of positions that exercise all address switch lines. (Address switch settings and channel ranges for the A/D Converter are shown on Table 161-2.)

Table 161-2. A/D Address Switch Settings and Channel Ranges

ADDRESS SWITCH SETTING	CHANNEL RANGE
0	0 through 99
1	100 through 199
2	200 through 299
3	300 through 399
4	400 through 499
5	500 through 599
6	600 through 699
7	700 through 799
8	800 through 899
9	900 through 999
10	Not Used
11	Not Used
12	Not Used
13	Not Used
14	Not Used
15	Not Used

To conduct the Address Response Performance Test, perform the following procedure:

1. Switch OFF power to the Front End.

2. Disconnect the ac line power cord and all other high voltage inputs.

3. Set the A/D Converter address switch to "0" and install the A/D Converter in the Front End option slot second from the bottom. Install the Thermocouple/DC Volts Scanner in the option slot immediately below.

4. Remove all other installed options to eliminate addressing conflict.

5. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or a -175 Isothermal Input Connector.

   Install the connector on the scanner.

6. Reconnect power to the Front End and switch power ON.

7. Connect the calibrator output to the input connector test leads.

8. Set the calibrator output to 7.9000V dc.

9. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM  <CR>

DEF CHAN(0)=DVIN,MAX=7.9  <CR>

FORMAT=DECIMAL  <CR>

SEND CHAN(0)  <CR>
```

The value returned for the selected channel should be approximately 7.9V.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
```

```
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
120  PRINT #1,"def chan(0)=dvin,max=7.9"
125  GOSUB 300
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  REM make measurement and read in response
160  PRINT #1,"send chan(0)"
170  INPUT #1,M$
180  PRINT USING "##.###";VAL(M$);
190  PRINT " Volts DC"
200  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1%
50   OPEN "KB1:"AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Computer Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0)=dvin,max=7.9"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  REM make measurement and read in response
170  PRINT #1,"send chan(0)"
180  INPUT #2,M$
190  PRINT USING "S##.###",VAL(M$);
200  PRINT " Volts DC"
210  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The value returned for the selected channel should be approximately 7.9V.

10. Switch Front End power OFF.

11. Using a common screwdriver, set the address switch on the A/D Converter to "1". Switch power to the Front End ON.

12. Program the Front End to take a measurement on channel 100 by substituting channel "100" for "0" in both the DEF CHAN and SEND CHAN commands of step 9.

13. Repeat steps 10 through 12 for channel 200 (A/D address set to 2), 400 (A/D address set to 4), 800 (address set to 8), and 1400 (address set to 14). The measurement on each channel should be approximately 7.9V.

14. This completes the Address Response Test.

Continue with the Accuracy Verification Test if you are conducting a complete performance test of the -161 High Performance A/D Converter.

Accuracy Verification Test

All voltage readings taken by the Front End depend on the accuracy of the A/D Converter. The Accuracy Verification Test checks the A/D Converter to see if its voltage measurement accuracy is within specifications.

To conduct the Accuracy Verification Test, perform the following procedure:

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Remove all addressable options from the Front End so that no address conflict occurs.

3. Set the A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End. Install the Thermocouple/DC Volt Scanner in the option slot immediately below.

4. Connect test leads to the HI and LO terminals for channel 0 on either the -176 Voltage Input Connector or the -175 Isothermal Input Connector. Install the connector on the scanner.

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Connect the calibrator output to the input of the 100:1 divider. Connect the divider output to the input connector test leads.

7. Set the calibrator output to 6.2000V (62 mV out of the divider).

8. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

MODE=TERM <CR>

DEF CHAN(0)=DVIN, MAX=0.062 <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0) <CR>

The returned value for channel 0 should be 62 mV +/- 0.014 mV.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port, empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50  PRINT #1,CHR$(3);
60  REM Set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
90  PRINT #1,"count=off"
100 GOSUB 300
```

```
120 PRINT #1,"def chan(0)=dvin,max=0.062"
125 GOSUB 300
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 REM make measurement and read in response
160 PRINT #1,"send chan(0)"
170 INPUT #1,M$
180 PRINT "chan 0 = ";
190 PRINT USING "##.######";VAL(M$)
200 PRINT " Volts DC"
210 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:"AS NEW FILE 1%
50  OPEN "KB1:"AS OLD FILE 2%
60  PRINT #1,CHR$(3);
70  REM set up Front End
80  PRINT #1,"mode=comp"
90  GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1,"def chan(0)=dvin,max=0.062"
125 GOSUB 300
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 REM make measurement and read in response
160 PRINT #1,"send chan(0)"
170 INPUT #2,M$
180 PRINT "chan 0 = ";
190 PRINT USING "S##.######",VAL(M$);
200 PRINT " Volts DC"
210 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

The returned value for channel 0 should be 62 mV +/- 0.014 mV.

9. Change to the 512 mV voltage range by redefining channel 0.

   To do this in the Terminal Mode, send the following command:

   DEF CHAN(0)=DVIN, MAX=0.5 <CR>

   To do this in the Computer Mode, change the BASIC statement in line 120 to:

   PRINT #1,"def chan(0)=dvin, max=0.5"

10. Set the calibrator to 0. Remove the 100:1 divider and connect the calibrator output directly to the connector test leads on channel 0.

11. Set the calibrator to output 500 mV.

12. Request a measurement and verify that channel 0 returns a value of 500 mV +/- 0.1 mV.

    If you are in Terminal Mode, take the measurement by sending the following command:

    SEND CHAN(0) <CR>

    If you are in the Computer Mode, run the program as modified in step 9.

13. Change to the 8V range by redefining channel 0.

    To do this in the Terminal Mode, send the following command:

    DEF CHAN(0)=DVIN, MAX=7.9

    To do this in the Computer Mode, change the BASIC program statement in line 120 to send this command.

14. Set the calibrator output to 7.9000V.

15. Request another measurement as in step 12.

    Verify that the returned value is within 7.9V +/- 0.002V.

16. Change to the 64V range by redefining channel 0.

    To do this in the Terminal Mode, send the following command:

    DEF CHAN(0)=DVIN, MAX=63 <CR>

    If you are in the Computer Mode, change the BASIC program statement in line 120 to send this command.

17. Set the calibrator output to 63.000V.

18. Request another channel 0 measurement.

The returned value should be 63V +/- 0.02V.

19. The Accuracy Verification Test is now complete.

Continue with the Overrange Indication Test if you are conducting a complete performance test of the -161 High Performance A/D Converter.

Overrange Indication Test

The Overrange Indication Test determines if the A/D Converter can detect and communicate a channel overrange condition to the mainframe controller.

To conduct the Overrange Indication Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Remove all addressable options from the Front End so that no address conflict occurs.

3. Set the A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End.

   Install the Thermocouple/DC Volts Scanner in the option slot immediately below.

4. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or a -175 Isothermal Input Connector.

   Install the connector on the scanner.

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Connect the calibrator output to the input of the 100:1 divider.

   Connect the divider output to the input connector test leads.

7. Set the calibrator output to 6.8V (68 mV out of the divider).

8. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End:

```
MODE=TERM <CR>

DEF CHAN(0)=DVIN,MAX=0.062 <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0) <CR>
```

The value displayed for channel 0 should be 9.99999E+37.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port, empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
90  PRINT #1,"count=off"
100 GOSUB 300
110 PRINT #1,"def chan(0)=dvin,max=0.062"
120 GOSUB 300
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 REM make measurement and read in response
160 PRINT #1,"send chan(0)"
170 INPUT #1,M$
180 PRINT M$
190 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:"AS NEW FILE 1%
50  OPEN "KB1:"AS OLD FILE 2%
60  PRINT #1,CHR$(3);
70  REM set up Front End
80  PRINT #1,"mode=comp"
90  GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1,"def chan(0)=dvin,max=0.062"
130 GOSUB 300
140 PRINT #1,"format=decimal"
150 GOSUB 300
160 REM make measurement and read in response
170 PRINT #1,"send chan(0)"
180 INPUT #2,M$
190 PRINT M$
200 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

The value displayed for channel 0 should be 9.99999E+37.

9. Perform PROCEDURE 9A or PROCEDURE 9B as appropriate.

PROCEDURE 9A. TERMINAL MODE

Send the following command to inspect the fault condition:

LIST ERROR <CR>

The following error message should be displayed:

Chan(0)-Out of range

PROCEDURE 9B. COMPUTER MODE

Run one of the following BASIC programs (or a similar one appropriate to your host).

Program for IBM PC:

```
10  CLS
20  REM send the fault condition
30  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
40  PRINT #1,"list error"
50  INPUT #1,N
60  PRINT N
70  IF N=0 THEN 120
80  FOR I=1 TO N
90  LINE INPUT #1,E$
100 PRINT E$
110 NEXT I
120 END
```

Program for 1722A:

```
10  PRINT CHR$(27);"[2J";
20  REM send the fault condition
30  PRINT #1,"list error"
40  INPUT #2,N
50  PRINT N
60  IF N=0 THEN 110
70  FOR I=1 TO N
80  INPUT LINE #2,E$
90  PRINT E$
100 NEXT I
110 END
```

The displayed response should be:

```
  1
0,15
```

The top number, "1", indicates that one error was logged. The lower set of numbers, "0,15", indicates that error 15 was logged on channel 0. Error 15 is an "Out of range" condition.

10. The Overrange Test is complete.

Continue with the Open Thermocouple Response Test if you are conducting a complete performance test of the -161 High Performance A/D Converter and you have not already performed the test in the Thermocouple/DC Volt Scanner performance test section.

Open Thermocouple Response Test

The Open Thermocouple Response Test determines if the A/D Converter can detect and communicate an open thermocouple condition on a channel to the mainframe controller.

NOTE

The Open Thermocouple Response Test is part of the performance test for the -162 Thermocouple/DC Volts Scanner. The test is repeated here because each assembly contains part of the circuitry that checks for an open thermocouple. If both the A/D Converter and the Thermocouple/DC Volts Scanner are being tested, the open thermocouple test need only be performed once.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Remove all addressable options from the Front End so that no address conflict occurs.

3. Set the A/D Converter address switch to "0" and install the A/D Converter in the top option slot of the Front End. Install the Thermocouple/DC Volts Scanner in the option slot immediately below.

4. Connect test leads to the HI and LO terminals for channel 0 on the -175 Isothermal Input Connector. Install the connector on the scanner.

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Connect the test leads from the Isothermal Input Connector to a 1-kilohm resistor.

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0)=TC,TYPE=JNBS <CR>

FORMAT=DECIMAL <CR>

TUNIT=CELSIUS <CR>

SEND CHAN(0) <CR>
```

Verify the value displayed for channel 0 equals the ambient temperature +/- 2 ^{o}C.

PROCEDURE B. COMPUTER MODE

The following BASIC programming examples will cause the Front End to take a thermocouple measurement on channel 0. One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port and empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
90  PRINT #1,"count=off"
100 GOSUB 300
110 PRINT #1,"def chan(0)=tc,type=jnbs"
120 GOSUB 300
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 PRINT #1,"tunit=celsius"
160 GOSUB 300
```

```
170 REM make measurement and read in response
180 PRINT #1,"send chan(0)"
190 INPUT #1,M$
200 PRINT M$
210 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:"AS NEW FILE 1%
50  OPEN "KB1:"AS OLD FILE 2%
60  PRINT #1,CHR$(3);
70  REM set up computer Front End
80  PRINT #1,"mode=comp"
90  GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1,"def chan(0)=tc,type=jnbs"
130 GOSUB 300
140 PRINT #1,"format=decimal"
150 GOSUB 300
160 PRINT #1,"tunit=celsius"
170 GOSUB 300
180 REM make measurement and read in response
190 PRINT #1,"send chan(0)"
200 INPUT #2,M$
210 PRINT M$
220 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

The value displayed for channel 0 should equal the ambient temperature +/- 2 degrees Celsius.

8. Replace the 1-kilohm resistor with a 10-kilohm resistor to simulate a high resistance or open thermocouple.

9. Request a measurement and verify that the returned value is:

   9.99999E+37

10. Perform PROCEDURE 10A or PROCEDURE 10B as appropriate.

PROCEDURE 10A. TERMINAL MODE

Send the following command to inspect the fault condition:

LIST ERROR <CR>

The following error message should be displayed:

chan(0)-open tc

PROCEDURE 10B. COMPUTER MODE

Run one of the following BASIC programs (or a similar one appropriate to your host).

Program for IBM PC:

```
10  CLS
20  REM send the fault condition
30  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
40  PRINT #1,"list error"
50  INPUT #1,N
60  PRINT N
70  IF N=0 THEN 120
80  FOR I=1 TO N
90  LINE INPUT #1,E$
100 PRINT E$
110 NEXT I
120 END
```

Program for 1722A:

```
10  PRINT CHR$(27);"[2J";
20  REM send the fault condition
30  PRINT #1,"list error"
40  INPUT #2,N
50  PRINT N
60  IF N=0 THEN 110
70  FOR I=1 TO N
80  INPUT LINE #2,E$
90  PRINT E$
100 NEXT I
110 END
```

The displayed response should be:

```
 1
0,16
```

The top number, "1", indicates that one error was logged. The lower set of numbers, "0,16", indicate that error number 16 was logged on channel 0. Error 16 is an Open thermocouple.

11. Disconnect the 10-kilohm resistor and the test leads from the Isothermal Input Connector.

12. Performance testing of the -161 High Performance A/D Converter is complete.

CALIBRATION

Perform the following procedures to calibrate the -161 High Performance A/D Converter.

NOTE

Calibrate the -161 A/D Converter only if it fails the Accuracy Verification Tests.

The 161 A/D Converter is calibrated in two stages: first, verify that power supply voltages are within specifications; second, calibrate the zero, full-scale, and reference for the A/D Converter.

WARNING

THE COMPUTER FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE COMPUTER FRONT END AND REMOVE ALL POWER SOURCES BEFORE STARTING THE FOLLOWING PROCEDURE.

Power Supply Verification Procedure

To verify that power supply voltages are within specification, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line cord and all other high voltage inputs.

2. Set the address switch on the A/D Converter to "0" and install the A/D Converter in the second option slot from the bottom of the Front End, leaving one slot open below it.

3. To eliminate addressing conflict, remove any other installed options.

4. Install the Calibration Extender/Fixture/ (Fluke Part No. 648741) in the bottom slot, just below the A/D Converter. Set the slide switch on the Calibration Fixture to the CAL position.

NOTE

Do not install a scanner at this time.

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Set the DMM to read +5V with 1 mV resolution.

7. Connect the DMM to the +5V and LOGIC COMMON test points on the Calibration Fixture, observing correct polarity.

8. Verify a DMM reading of +5.000V +/- 0.125V.

9. Set the DMM to read 10V with 1 mV resolution. Move the DMM positive lead to the +10V test point on the Calibration Fixture.

10. Verify a DMM reading of +10.067V +/- 0.140V.

11. Move the DMM positive lead to the -10V test point on the Calibration Fixture.

12. Verify a DMM reading of -10.067V +/- 0.360V.

13. This completes the Power Supply Verification Test.

14. If all voltages are within tolerance, proceed to Zero, Full-Scale, and Reference Calibration below. If the power supply voltages are not within the stated tolerances, the A/D Converter must be repaired.

Zero and Full-Scale Reference Calibration

Perform the following procedure for Zero, Full-Scale, and Reference Calibration:

1. Perform steps 1 through 5 of the Power Supply Verification Procedure.

2. Remove the DMM test leads from the Calibration Fixture.

3. Before proceeding further, be sure that the A/D Converter has been ON and its temperature stabilized for at least 30 minutes.

4. Install a 100:1 voltage divider (Fluke Y2022) on the calibrator.

5. Set the calibrator for an output of +31.3 mV dc (providing +313 uV at the voltage divider output).

   Connect the voltage divider pos (+) volts terminal to the A/D Converter INPUT test point on the Calibration Fixture with a test lead. Connect the voltage divider neg (-) volts terminal to the ANALOG COMMON test point on the Calibration Fixture with another test lead.

6. Turn the A/D Converter ZERO WIDTH potentiometer fully clockwise.

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

Use either PROCEDURE A or PROCEDURE B, depending on whether calibration will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

MODE=TERM <CR>

DEF CHAN(0)=CAL <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0) <CR>

Set the A/D zero level as follows:

NOTE

The zero level adjustment procedure will require polarity reversal of the test leads and issuance of SEND CHAN(0) commands until equal magnitudes are obtained. In the Terminal Mode, repetitive measurements on a selected channel can easily be taken by the sending the repeat command

! <CR>

to the Front End each time you want to repeat the measurement.

A1. Note the value returned and displayed on the terminal.

A2. Reverse the test leads. Wait about a minute for the connections and leads to thermally stabilize. Then command the Front End to take another measurement by sending another SEND CHAN(0) command. Again note the value returned.

A3. Adjust the ZERO LEVEL potentiometer on the A/D Converter so that the positive and negative readings are of equal magnitude.

A4. Adjust the ZERO WIDTH potentiometer on the A/D Converter until the magnitude returned is between 7.40000E+01 and 8.60000E+01 (80 +/- 6 counts).

A5. Connect a Fluke 8505A or equivalent DMM as follows:

A. Connect the LO terminal on the DMM to the ANALOG COMMON test point on the Calibration Fixture.

B. Connect the HI terminal on the DMM to the 6.2V test point on the Calibration Fixture.

A6. Adjust the 6.2V potentiometer on the A/D Converter for a DMM reading between 6.19995V and 6.20005V.

A7. Disconnect the DMM from the Calibration Fixture.

A8. Remove the divider from the calibrator.

A. Connect the pos (+) terminal of the calibrator to the A/D Converter INPUT test point on the Calibration Fixture.

B. Connect the neg (-) terminal of the calibrator to the ANALOG COMMON test point on the Calibration Fixture.

A9. Set the calibrator output to +2.0000V.

A10. Request a measurement by sending the Front End a SEND CHAN(0) command.

A11. Adjust the A/D Converter -1.875V REF potentiometer for a Front End reading of +512,000 +/- 6 counts.

The value displayed on the terminal should be between 5.11994E+05 and 5.12006E+05.

A12. Repeating the measurement for adjustment purposes is required.

Take measurements and adjust the potentiometer until the value displayed is between 5.11994E+05 and 5.12006E+05.

A13. By reversing the two connections made on the Calibration Fixture in step A8, apply -2.000V to the A/D INPUT.

A14. Adjust the A/D Converter +1.875V REF potentiometer for a Front End reading of -512,000 +/- 6 counts.

The terminal should display a value between -5.11994E+05 and -5.12006E+05.

PROCEDURE B. COMPUTER MODE

The following BASIC programming examples will request the A/D to return its measurement in counts. Math is then performed to display a value for the required resolution. One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
120  PRINT #1,"def chan(0)=cal"
125  GOSUB 300
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  REM make measurement and read in response
160  PRINT #1,"send chan(0)"
170  INPUT #1,M
180  C=(M/4)+0.5
190  PRINT INT(C);" counts"
200  GOTO 160
210  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1%
50   OPEN "KB1:"AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Computer Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0)=cal"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  REM make measurement and read in response
170  PRINT #1,"send chan(0)"
```

```
180  INPUT #2,M
190  C=(M/4)+0.5
200  PRINT INT(C);" counts"
210  GOTO 170
220  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Set the A/D Converter zero level as follows:

B1. Note the value displayed on the computer.

NOTE

The zero level adjustment procedures require polarity reversal of the test leads until equal magnitudes are obtained.

B2. Reverse the test leads. Wait about a minute for the connections and leads to thermally stabilize.

Note the value returned.

B3. Adjust the ZERO LEVEL potentiometer on the A/D Converter so that the positive and negative readings are of equal magnitude.

Repeat step B2 as often as necessary while this adjustment is being made.

B4. Adjust the ZERO WIDTH potentiometer on the A/D Converter until the magnitude returned is 20 +/- 1 count.

B5. Connect a Fluke 8505A or equivalent DMM as follows:

A. Connect the LO terminal on the DMM to the ANALOG COMMON test point on the Calibration Fixture.

B. Connect the HI terminal on the DMM to the 6.2V test point on the Calibration Fixture.

B6. Adjust the 6.2V potentiometer on the A/D Converter for a DMM reading between 6.19995 and 6.20005V.

B7. Disconnect the DMM from the Calibration Fixture.

B8. Remove the divider from the calibrator.

A. Connect the pos (+) terminal of the calibrator to the A/D INPUT test point on the Calibration Fixture.

B. Connect the neg (-) terminal of the calibrator to the ANALOG COMMON test point on the Calibration Fixture.

B9. Set the calibrator output to +2.0000V.

B10. Stop execution of the program and modify it as follows:

For the IBM PC program, change line 180 to:

```
C=((M/4)+0.5)-128000
```

For the Fluke 1722A program, change line 190 to:

```
C=((M/4)+0.5)-128000
```

B11. Run the modified program.

B12. Adjust the A/D Converter -1.875V REF potentiometer for a Front End reading of 0 +/- 1 count.

B13. By reversing the two connections made on the Calibration Fixture in step B8, apply -2.000V to the A/D Converter INPUT.

B14. Stop execution of the program and modify it as follows:

For the IBM PC program, change line 180 to:

```
C=((M/4)+0.5)+128000
```

For the Fluke 1722A program, change line 190 to:

```
C=((M/4)+0.5)+128000
```

B15. Run the modified program.

B16. Adjust the A/D Converter +1.875V REF potentiometer for a Front End reading of 0 +/- 1 count.

B17. Stop execution of the program.

8. Disconnect the calibrator from the Calibration Fixture, and connect the DMM as follows:

A. Connect the LO terminal of the DMM to the ANALOG COMMON test point on the Calibration Fixture.

B. Connect the HI terminal of the DMM to the 50 mV REF test point on the Calibration Fixture.

9. Set the DMM to a range having 1 uV resolution.

Wait one minute for the connection and leads to stabilize thermally before continuing.

10. Adjust the 0.05V potentiometer on the A/D converter for a DMM reading of 50.000 mV within a tolerance of +/- 0.001 mV.

11. Move the DMM HI terminal connection to the 500 mV REF test point on the Calibration Fixture.

12. Adjust the 0.5V potentiometer on the A/D Converter for a DMM reading of 500.000 mV within a tolerance of +/- 0.005 mV.

13. Calibration is now complete.

14. Power down the Front End then turn it back ON to cause the new calibration constants to be measured and stored by the A/D Converter. Now perform the A/D Converter accuracy verification performance test provided earlier in this subsection.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the -161 High Performance A/D Converter is given in Table 161-3.

For parts ordering information, see Section 6 of this manual.

Figure 161-7 is a schematic diagram of the High Performance A/D Converter.

TABLE 161-3. -161 HIGH PERFORMANCE A/D CONVERTER PCA
(SEE FIGURE 161-7.)

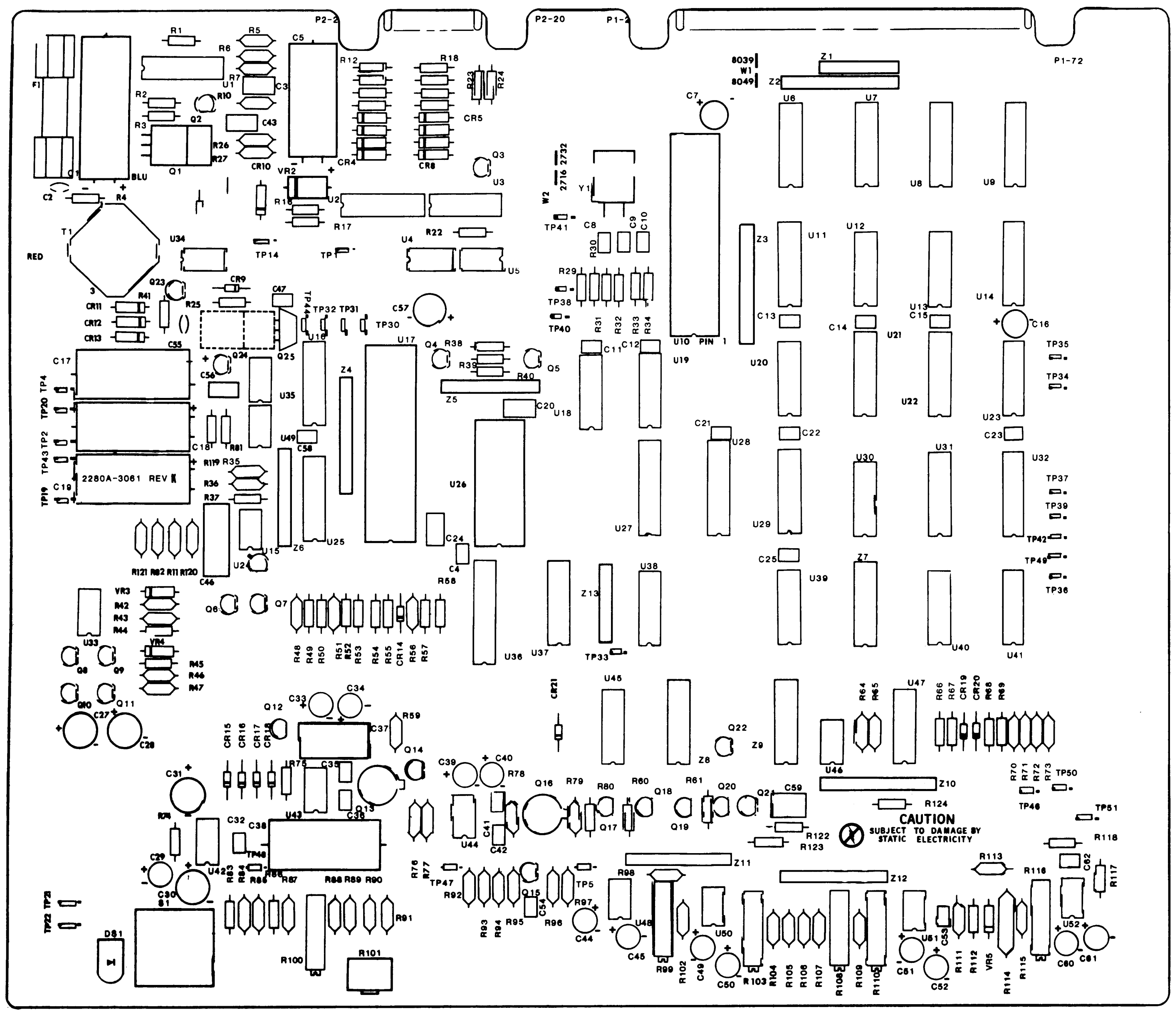
REFERENCE DESIGNATOR	A->NUMERICS--->	S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	NOTE
C	1		CAP,AL,330UF,+100-10%,25V	614404	89536	614404	1	
C	2		CAP,CER,1000PF,+-10%,500V,X5S	357806	56289	C016B102G102K	1	
C	3		CAP,CER,1000PF,+-5%,50V,COG	528539	51406	RPE113	1	
C	4, 10- 15,		CAP,CER,0.22UF,+-20%,50V,Z5U	519157	51406	RPE111Z5U224M50V	14	
C	21- 23, 25,			519157				
C	47, 54, 58			519157				
C	5, 17, 19		CAP,AL,270UF,+100-10%,20V	602656	89536	602656	3	
C	7, 16		CAP,TA,39UF,+-20%,6V	163915	56289	196D394X0020KA1	2	
C	8		CAP,CER,100PF,+-2%,100V,COG	512848	51406	RPE121	1	
C	9		CAP,CER,47PF,+-2%,100V,COG	512368	89536	512368	1	
C	18		CAP,AL,470UF,+100-10%,12V	602649	89536	602649	1	
C	20, 24, 56		CAP,CER,1.0UF,+-20%,50V,Z5U	436782	72982	8131-050-601-105M	3	
C	27, 28, 30,		CAP,AL,47UF,+-20%,16V	643304	89536	643304	5	
C	31, 57			643304				
C	29, 33, 34,		CAP,AL,10UF,+-20%,35V	643296	74840	RLR-PX	13	
C	39, 40, 44,			643296				
C	45, 49, 50,			643296				
C	51, 52, 60,			643296				
C	61			643296				
C	32, 35, 36		CAP,CER,150PF,+-2%,100V,COG	512988	89536	512988	3	
C	37		CAP,POLYPR,0.47UF,+-10%,100V	446807	89536	446807	1	
C	38		CAP,POLYPR,0.47UF,+-5%,50V	364042	84411	JF788	1	
C	41, 42		CAP,CER,68PF,+-2%,100V,COG	362756	89536	362756	2	
C	43		CAP,POLYES,0.1UF,+-10%,50V	696484	89536	696484	1	
C	46		CAP,POLYES,0.47UF,+-10%,100V	369124	89536	369124	1	
C	53, 62		CAP,CER,0.01UF,+-20%,100V,X7R	407361	72982	8121-A100-W5R-103M	2	
C	55		CAP,CER,0.0012UF,+-10%,500V,Z5R	106732	71590	CF122	1	
C	59		CAP,POLYPR,1500PF,+-5%,50V	706572	89536	706572	1	
CR	1- 8, 11,	*	DIODE,SI, 50 PIV, 1.0 AMP	379412	04713	1N4933	10	
CR	13	*		379412				
CR	9, 14- 21	*	DIODE,SI,BV= 75.0V,IO=150MA,500 MW	203323	07910	1N4448	9	
CR	10, 12	*	DIODE,SI, 20 PIV, 1.0 AMP	507731	83003	VSK120	2	
DS	1	*	LED,RED,90 LEAD PREP,LUM INT=2MCD	604884	89536	604884	1	
E	1		HEADER,1 ROW,0.100CTR,4 PIN	417329	89536	417329	2	
E	1, 2, 4,		TERM,FASTON,TAB,SOLDR,0.110 WIDE	512889	02660	62395	30	
E	5, 14, 19-			512889				
E	22, 30- 44,			512889				
E	46- 49, 50,			512889				
E	51			512889				
F	1		FUSE,1/4 X 1-1/4,SLOW,0.5A,250V	109322	71400	MDL1-2	1	
H	1		SCREW,MACH,FHP,STL,4-40X5/8	241349	89536	241349	3	
H	1		NYLON, STEM:OD=.093", L=.115"	658450	89536	658450	2	
H	2		SCREW,MACH,PHP,S.STL,4-40X5/8	413062	89536	413062	4	
H	3		WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	4	
H	4		WASHER,LOCK,SPLIT,STEEL,#4	110395	89536	110395	4	
MP	1		CABLE TIE,4"L,0.100"W,0.75 DIA	172080	89536	172080	1	
MP	2		SPACER,MOUNT,NYLON,	175125	89536	175125	1	
MP	2		BAG,SHIELDING,TRANSPARENT,12"X16"	680983	89536	680983	1	
MP	3	*	BOTTOM SHIELD,ASSY	655506	89536	655506	1	
MP	4		SHIELD A/D TOP	579037	89536	579037	1	
MP	5		HANDLE HI PERFORMANCE A/D,MODIFIED	633263	89536	633263	1	
MP	6		DECAL, OPTION-161	634469	89536	634469	1	
MP	7		DECAL,A/D CALIBRATION ADJUST	650341	89536	650341	1	
Q	1	*	SILICON, NPN, FAST SWITCHING D44H11	535542	89536	535542	1	
Q	2 .	*	TRANSISTOR,SI,NPN,HI-VOLTAGE	370684	04713	MPS A 42	1	
Q	3- 5, 9,	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	64713	2N3906	5	
Q	23	*		195974				
Q	6- 8, 22,	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	5	
Q	24	*		218396				
Q	10	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	340026	04713	MPS6563	1	
Q	11	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	330803	07263	MPS6560	1	
Q	12, 14, 17-	*	TRANSISTOR,SI,N-JFET,REMOTE CUTOFF	429977	89536	429977	7	
Q	21	*		429977				
Q	13, 16	*	TRANSISTOR,SI,N-JFET,DUAL,TO-71	419283	89536	419283	2	
Q	15	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	242065	04713	2N5089	1	
Q	25	*	TRANSISTOR,SI,BV=100V,10W	495689	04713	MPSU56	1	
R	1		RES,CF,1.8K,+-5%,0.25W	441444	80031	CR251-4-5P1K8	1	
R	2		RES,CF,1.5K,+-5%,0.25W	343418	80031	CR251-4-5P1K5	1	
R	3, 41, 50		RES,CF,330,+-5%,0.25W	368720	80031	CR251-4-5P330E	3	
R	4, 44, 45		RES,CF,510,+-5%,0.25W	441600	80031	CR251-4-5P510E	3	
R	5, 6, 26,		RES,MF,10K,+-1%,0.125W,100PPM	168260	91637	CMF551002F	10	
R	35, 42, 46,			168260				
R	47, 95,120,			168260				
R	121			168260				
R	7		RES,MF,15.8K,+-1%,0.125W,100PPM	293688	91637	CMF551582F	1	
R	10		RES,MF,39.2K,+-1%,0.125W,100PPM	236414	91637	CMF553922F	1	
R	11		RES,MF,40.2K,+-1%,0.125W,100PPM	235333	91637	CMF554022F	1	
R	12, 13, 18,		RES,CF,51,+-5%,0.25W	414540	80031	CR251-4-5P51E	4	
R	19			414540				
R	14, 15, 22,		RES,CF,270,+-5%,0.25W	348789	80031	CR251-4-5P270E	5	
R	38, 39			348789				
R	16, 17, 23,		RES,CF,5.6K,+-5%,0.25W	442350	80031	CR251-4-5P5K6	4	
R	40			442350				
R	20, 21		RES,CF,30,+-5%,0.25W	442228	80031	CR251-4-5P30E	2	

TABLE 161-3. -161 HIGH PERFORMANCE A/D CONVERTER PCA
(SEE FIGURE 161-7.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	NOTE
R 24, 49, 53,		RES,CF,10K,+-5%,0.25W	348839	80031	CR251-4-5P10K	8	
R 55, 57, 58,			348839				
R 122,124			348839				
R 25,112,118,		RES,CF,100,+-5%,0.25W	348771	80031	CR251-4-5P100E	4	
R 119			348771				
R 27		RES,MF,9.53K,+-1%,0.125W,100PPM	288563	91637	CMF559530F	1	
R 29, 30, 34,		RES,CF,1.1K,+-5%,0.25W	348797	89536	348797	4	
R 74			348797				
R 31		RES,CF,820,+-5%,0.25W	442327	80031	CR251-4-5P820E	1	
R 32, 33		RES,CF,2.2K,+-5%,0.25W	343400	80031	CR251-4-5P2K2	2	
R 36, 59		RES,MF,28.7K,+-1%,0.125W,100PPM	235176	91637	CMF552872F	2	
R 37, 54, 67,		RES,CF,1M,+-5%,0.25W	348987	80031	CR251-4-5P1M	4	
R 69			348987				
R 43		RES,MF,16.2K,+-1%,0.125W,100PPM	226233	89536	226233	1	
R 48		RES,MF,154K,+-1%,0.125W,100PPM	289447	91637	CMF551543F	1	
R 51, 90		RES,MF,1K,+-1%,0.125W,100PPM	168229	91637	CMF551001F	2	
R 52		RES,CF,8.2K,+-5%,0.25W	441675	80031	CR251-4-5P8K2	1	
R 56		RES,MF,332K,+-1%,0.125W,100PPM	289504	91637	CMF553323F	1	
R 60		RES,CF,9.1K,+-5%,0.25W	441691	80031	CR251-4-5P9K1	1	
R 61, 80		RES,CF,47K,+-5%,0.25W	348896	80031	CR251-4-5P47K	2	
R 64		RES,MF,604K,+-1%,0.125W,100PPM	235374	89536	235374	1	
R 65		RES,MF,301K,+-1%,0.125W,100PPM	289488	91637	CMF5530102F	1	
R 66		RES,CF,18K,+-5%,0.25W	348862	80031	CR251-4-5P18K	1	
R 68		RES,CF,5.1K,+-5%,0.25W	368712	80031	CR251-4-5P5K1	1	
R 70, 73, 87		RES,MF,75K,+-1%,0.125W,100PPM	291443	91637	CMF557502F	3	
R 71, 72		RES,MF,23.7K,+-1%,0.125W,100PPM	188367	91637	MFF2372F	2	
R 75		RES,CF,39K,+-5%,0.25W	442400	80031	CR251-4-5P39K	1	
R 76, 85		RES,MF,2K,+-1%,0.125W,100PPM	235226	91637	CMF552001F	2	
R 77		RES,MF,42.2K,+-1%,0.125W,100PPM	221655	91637	CMF554222F	1	
R 78		RES,MF,43.2K,+-1%,0.125W,100PPM	272153	89536	272153	1	
R 79, 88, 89		RES,MF,30.1K,+-1%,0.125W,100PPM	168286	91637	MFF1-83012F	3	
R 81,113		RES,MF,61.9K,+-1%,0.125W,100PPM	237230	91637	CMF556192F	2	
R 82		RES,MF,46.4K,+-1%,0.125W,100PPM	188375	89536	188375	1	
R 83		RES,CC,6.2M,+-5%,0.25W	221960	01121	CB6255	1	
R 84		RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF551003F	1	
R 86		RES,CF,2K,+-5%,0.25W	441469	80031	CR251-4-5P2K	1	
R 91		RES,MF,619K,+-1%,0.125W,100PPM	288639	89536	288639	1	
R 92		RES,MF,6.81K,+-1%,0.125W,100PPM	268417	91637	CMF556813F	1	
R 93, 94		RES,MF,6.04K,+-0.1%,0.125W,25PPM	512301	89536	512301	2	
R 96, 97		RES,MF,49.9K,+-1%,0.125W,100PPM	268821	91637	CMF554992F	2	
R 98,109		RES,MF,10,+-1%,0.125W,100PPM	268789	91637	CMF5510R0F	2	
R 99,103,110		RES,VAR,CERM,1K,+-20%,0.5W	267856	11236	190PC102B	3	
R 100,108		RES,VAR,CERM,20K,+-20%,0.5W	267898	11236	190PC203B	2	
R 101		RES,VAR,CERM,100K,+-10%,0.5W	288308	89536	288308	1	
R 102,104		RES,MF,24.9,+-1%,0.125W,100PPM	296657	91637	CMF5524R9F	2	
R 105,107		RES,MF,36.5K,+-1%,0.125W,100PPM	235309	91637	CMF553652F	2	
R 106		RES,MF,348K,+-1%,0.125W,100PPM	289512	89536	289512	1	
R 111		RES,MF,2.8K,+-1%,0.125W,100PPM	325670	91637	CMF552801F	1	
R 114,115	*	ZENER REFERENCE SET	646539	89536	646539	1	
R 5	*		646539				
R 116		RES,VAR,CERM,500,+-20%,0.5W	267849	11236	190PC501B	1	
R 117,123		RES,CF,1K,+-5%,0.25W	343426	80031	CR251-4-5P1K	2	
S 1		SWITCH,ROTARY,1 POLE,16 POS,1 THUMB	615096	97527	1A-21-60-33-G-F	1	
T 1		INVERTER TRANSFORMER	580407	89536	580407	1	
U 1	*	IC,REGULATING PULSE WIDTH MODULATOR	454678	01295	SG3524N	1	
U 2	*	IC,BPLR,DUAL DIFF LINE DRVR W/3-STATE	586081	12040	DS1692J	1	
U 3	*	IC,BPLR,DIFFERENTIAL LINE RECEIVER	586073	01295	SN55182J	1	
U 4	*	ISOLATOR,OPTO,HI-SPEED,DUAL	429894	28480	5082-4355	1	
U 5, 34	*	ISOLATOR,OPTO,HI-SPEED,8 PIN DIP	354746	89536	354746	2	
U 6, 7, 9,	*	IC,CMOS,QUAD D LATCH,+EDG TRG,W/RESET	412742	12040	MM74C173N	4	
U 14	*		412742				
U 8, 16, 25,	*	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	408773	12040	MM80C95N	5	
U 29, 37	*		408773				
U 10	*	IC,NMOS,8 BIT MICROCOMPUTER	685529	89536	685529	1	
U 11	*	IC,CMOS,BCD-DEC & BIN-OCTAL DCDR	473769	04713	MC14028B	1	
U 12	*	IC,CMOS,DUAL D F/F,+EDG TRG W/SET&RST	536433	04713	MC4013BCP	1	
U 13	*	IC,CMOS,QUAD 2 INPUT NOR GATE	355172	02735	CD4001AE	1	
U 15	*	IC,COMPARATOR,DUAL,LO-PWR,8 PIN DIP	478354	12040	LM393N	1	
U 17	*	IC,CMOS,UNIV ASYNC RECEIVR/TRANSMITER	453464	32293	IM6402CPL	1	
U 18	*	IC,LSTTL,QUAD 2 INPUT XOR GATE	605626	01295	SN54LS86J	1	
U 19, 23	*	IC,LSTTL,DUAL JK F/F,+EDG TRG,W/CLR	605634	01295	SN54LS107AJ	2	
U 20	*	IC,LSTTL,QUAD 2 INPUT NAND GATE	605600	01295	SN54LS00J	1	
U 21, 22	*	IC,CMOS,8STAGE SYNC PRSET DWN BIN CNT	508689	02735	CD40103BE	2	
U 24	*	IC, 1.22V,100 PPM T.C.,BANDGAP REF	452771	89536	452771	1	
U 26		IC, 2K X 8 EPROM, PROGRAMMED	655555	89536	655555	1	
U 27, 28	*	IC,256 X 4 STAT RAM	605238	34371	HM1-6561-9	2	
U 30	*	IC,CMOS,7STAGE RIPPLE CARRY BIN CNTR	412965	86684	CD4024AE	1	
U 31	*	IC,CMOS,DUAL JK F/F,+EDG TRIG	355230	02735	CD4027AE	1	
U 32	*	IC,CMOS,DUAL SYNC BINRY UP CNTR	355164	04713	MC14520BCP	1	
U 33, 49	*	IC,OP AMP,DUAL,INDUSTRIAL TEMP RANGE	605550	01295	LM258JG	2	
U 35	*	IC, 2.5 V,40 PPM T.C.,BANDGAP REF	472845	04713	MC1403V	1	
U 36	*	IC,LSTTL,OCTAL D F/F,+EDG TRG	473223	01295	SN74LS374N	1	
U 38, 48	*	IC,CMOS,HEX INVERTER	404681	02735	CD4069BE	2	
U 39	*	IC,LSTTL,QUAD 2 INPUT OR GATE	605618	01295	SN54LS32J	1	
U 41	*	IC,CMOS,QUAD 2 INPUT AND GATE	408401	02735	CD4081BE	1	
U 42	*	IC,COMPARATOR,CERAMIC,8 PIN DIP	605592	89536	605592	1	
U 43, 44	*	IC,OP AMP,DUAL,JFET INPUT,8 PIN DIP	605576	89536	605576	2	
U 45, 47	*	IC,COMPARATOR,QUAD,CERAMIC,14 PIN DIP	605584	89536	605584	2	
U 46	*	IC,OP AMP,JFET INPUT,8 PIN DIP	605568	89536	605568	1	
U 40, 50- 52	*	IC,OP AMP,LO-OFFSET VOLTAGE,LO-NOISE	605980	06665	OP-07DP	4	
VR 2	*	ZENER,UNCOMP,6V TRANSIENT SUPPRESSOR	508655	24444	1N5908	1	
VR 3, 4	*	ZENER,UNCOMP, 6.2V, 5%, 20.0MA. 0.4W	325811	07910	1N753A	2	

TABLE 161-3. -161 HIGH PERFORMANCE A/D CONVERTER PCA
(SEE FIGURE 161-7.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	NOTE
W 1, 2		JUMPER,REC,2 POS,.100CTR,.025 SQ POST	530253	00079	530153-2	2	
XF 1		HLDR,FUSE,1/4,PWB MT	485219	91833	3529	2	
XU 10, 17		SOCKET,IC,40 PIN	429282	09922	DILB40P-108	2	
XU 26		SOCKET,IC,24 PIN	376236	91506	324-AG39D	1	
XU 27, 28		SOCKET,IC,18 PIN	418228	91506	318-AG39D	2	
XZ 7		SOCKET,IC,16 PIN	276535	91506	316-AG39D	1	
Y 1	*	CRYSTAL,6MHZ,+-0.01%,HC-18/U	461665	89536	461665	1	
Z 1, 13		RES,NET,SIP,6 PIN,5 RES,10K,+-2%	500876	80031	95081002CL	2	
Z 2, 10		RES,NET,SIP,10 PIN,5 RES,10K,+-2%	529990	89536	529990	2	
Z 3, 4		RES,NET,SIP,10 PIN,9 RES,10K,+-2%	414003	80031	95081002CL	2	
Z 5		RES,NET,SIP,8 PIN,4 RES,10K,+-2%	513309	89536	513309	1	
Z 6		RES,NET,SIP,8 PIN,7 RES,10K,+-2%	412924	80031	95081002CL	1	
Z 7		RES,NET,DIP,16 PIN,8 RES,33,+-5%	413575	01121	314	1	
Z 8		RES,NET,DIP,16 PIN,8 RES,47K,+-5%	381996	89536	381996	1	
Z 9		RES,NET,DIP,16 PIN,8 RES,100K,+-5%	380618	89536	380618	1	
Z 11	*	RES NET ASSY TESTED	705509	89536	705509	1	
Z 12	*	RES NET ASSY TESTED	705558	89536	705558	1	



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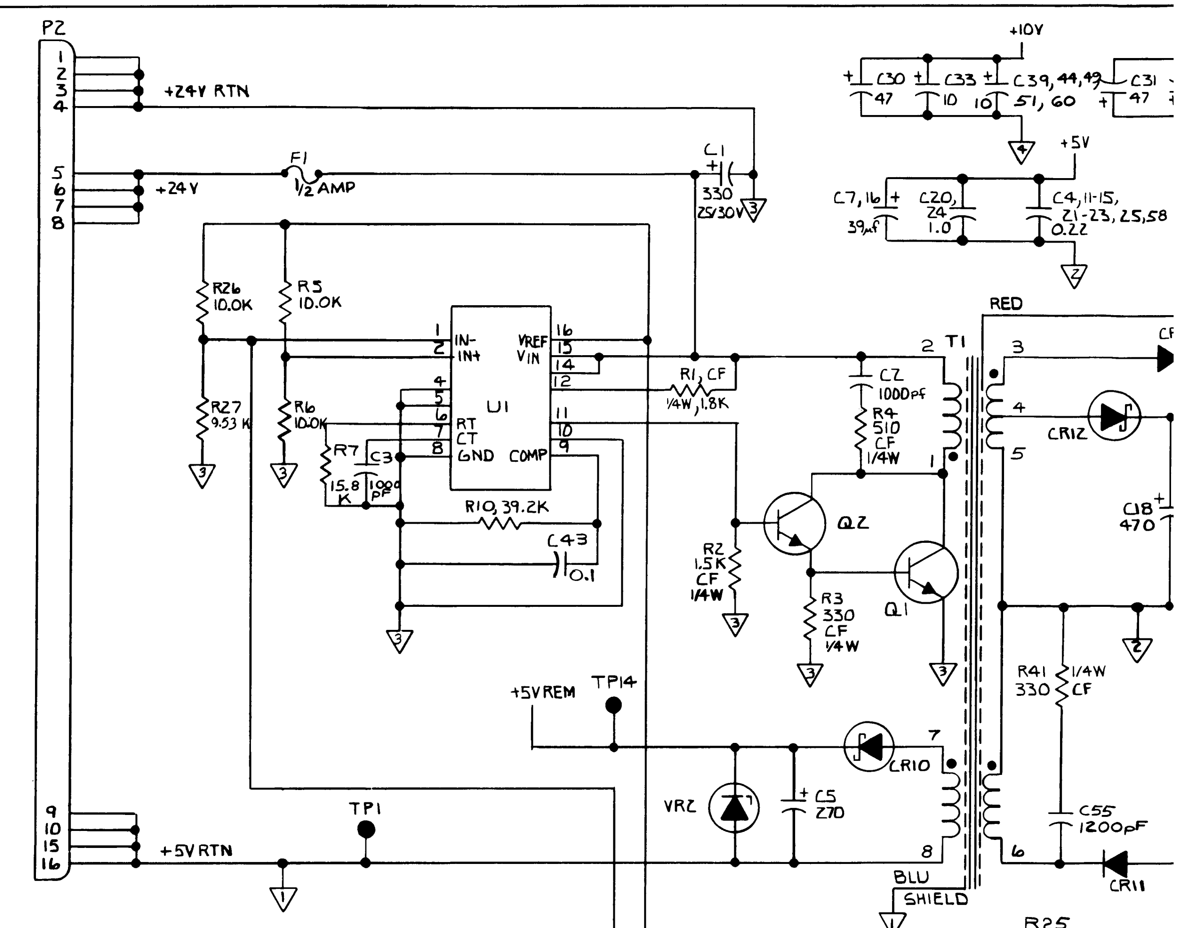
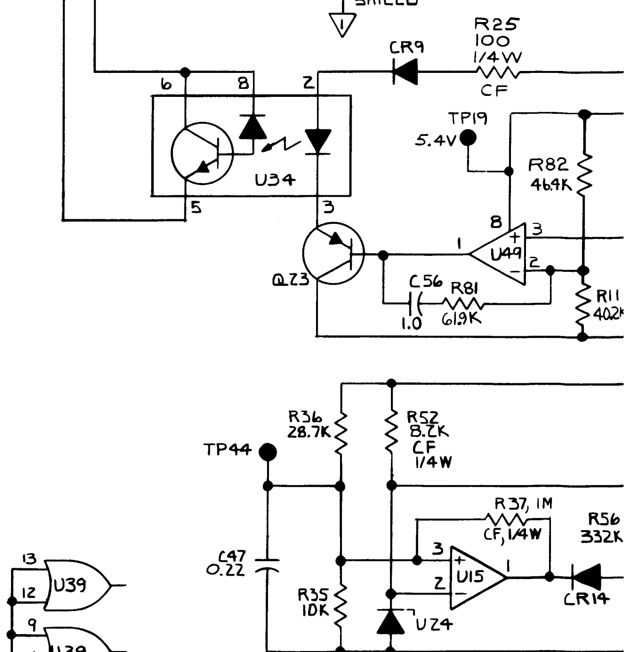
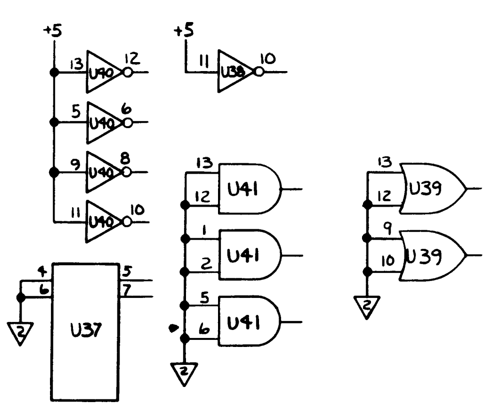


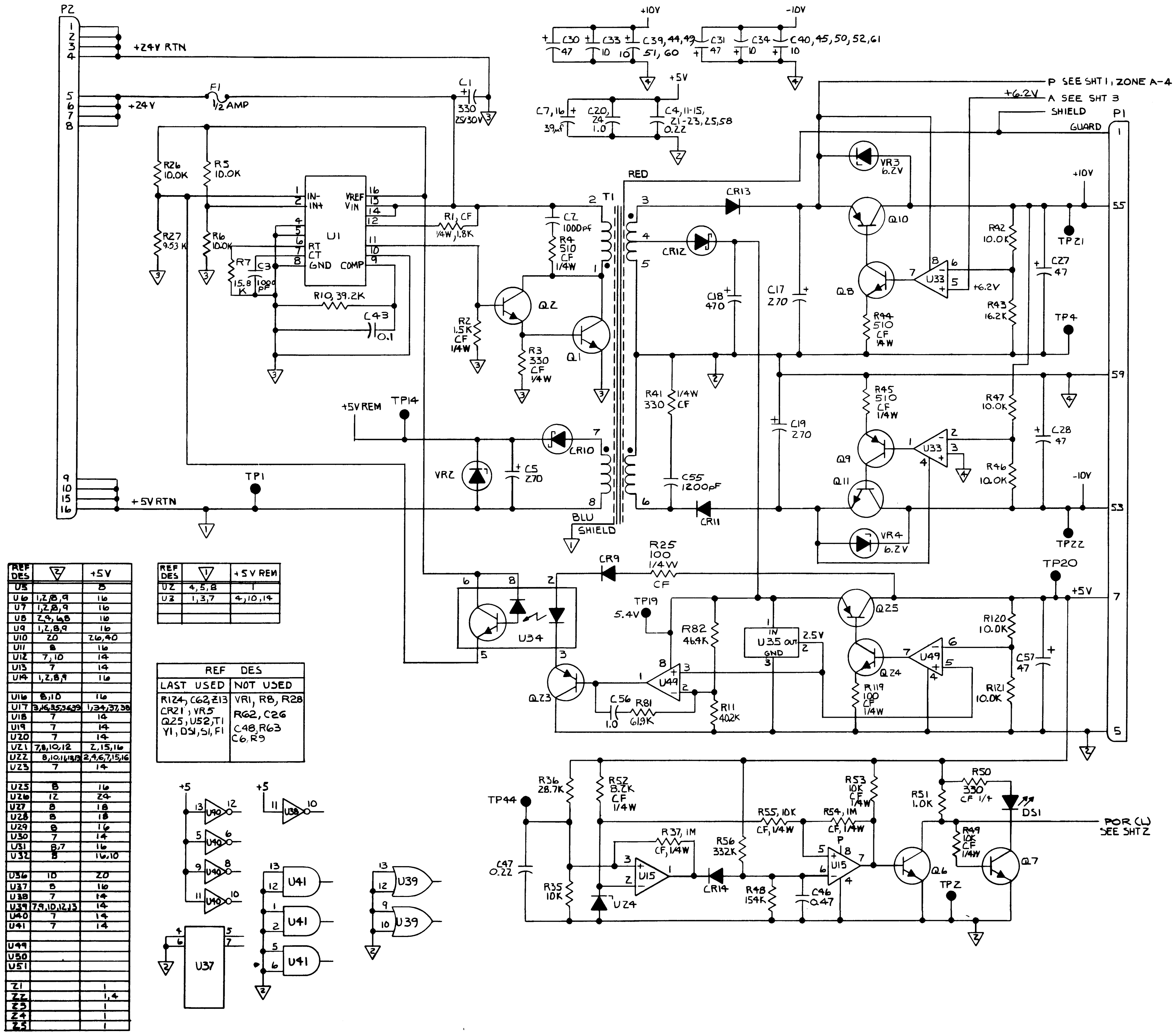
REF DES	▽2	+5V
U5		8
U6	1,2,8,9	16
U7	1,2,8,9	16
U8	2,4,6,8	16
U9	1,2,8,9	16
U10	20	26,40
U11	8	16
U12	7,10	14
U13	7	14
U14	1,2,8,9	16
U16	8,10	16
U17	3,16,35,36,39	1,34,37,38
U18	7	14
U19	7	14
U20	7	14
U21	7,8,10,12	2,15,16
U22	8,10,11,12,13	2,4,6,7,15,16
U23	7	14
U25	8	16
U26	12	24
U27	8	18
U28	8	18
U29	8	16
U30	7	14
U31	8,7	16
U32	8	16,10
U36	10	20
U37	8	16
U38	7	14
U39	7,9,10,12,13	14
U40	7	14
U41	7	14
U49		
U50		
U51		
Z1		1
Z2		1,4
Z3		1
Z4		1
Z5		1

REF DES	▽1	+5V REM
U2	4,5,8	1
U3	1,3,7	4,10,14

REF DES	
LAST USED	NOT USED
R124, C62, Z13 CR21, VR5 Q25, U52, T1 Y1, DS1, S1, F1	VR1, R8, R28 R62, C26 C48, R63 C6, R9







REF DES	▽2	+5V
U5		8
U6	1,2,8,9	16
U7	1,2,8,9	16
U8	2,4,6,8	16
U9	1,2,8,9	16
U10	20	26,40
U11	8	16
U12	7,10	14
U13	7	14
U14	1,2,8,9	16
U16	8,10	16
U17	3,16,35,36,39	1,34,37,38
U18	7	14
U19	7	14
U20	7	14
U21	7,8,10,12	2,15,16
U22	8,10,11,13,13	2,4,6,7,15,16
U23	7	14
U25	8	16
U26	12	24
U27	8	18
U28	8	18
U29	8	16
U30	7	14
U31	8,7	16
U32	8	16,10
U36	10	20
U37	8	16
U38	7	14
U39	7,9,10,12,13	14
U40	7	14
U41	7	14
U49		
U50		
U51		
Z1		1
Z2		1,4
Z3		1
Z4		1
Z5		1

REF DES	▽1	+5V REM
U2	4,5,8	1
U3	1,3,7	4,10,14

REF DES	
LAST USED	NOT USED
R124, C62, Z13 CR21, VR5 Q25, U52, T1 Y1, DS1, S1, F1	VR1, R8, R28 R62, C26 C48, R63 C6, R9

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCES ARE IN OHMS,
2. ALL RESISTORS ARE 1/8W, MF, 1%.
3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.
6. ALL CAPACITANCE IS IN MICROFARADS.
7. R114, R115, and VR5 ARE A MATCHED SET.

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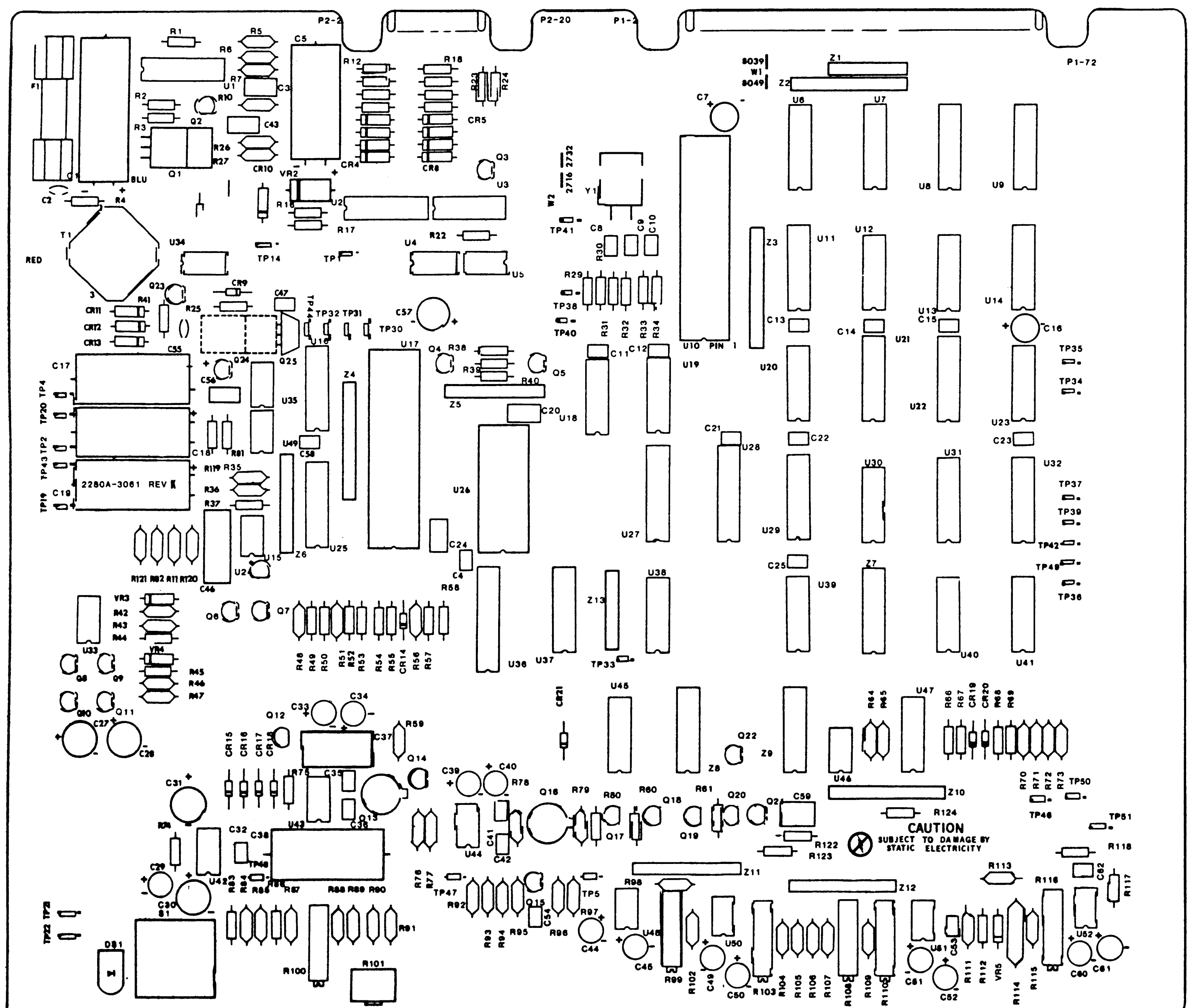
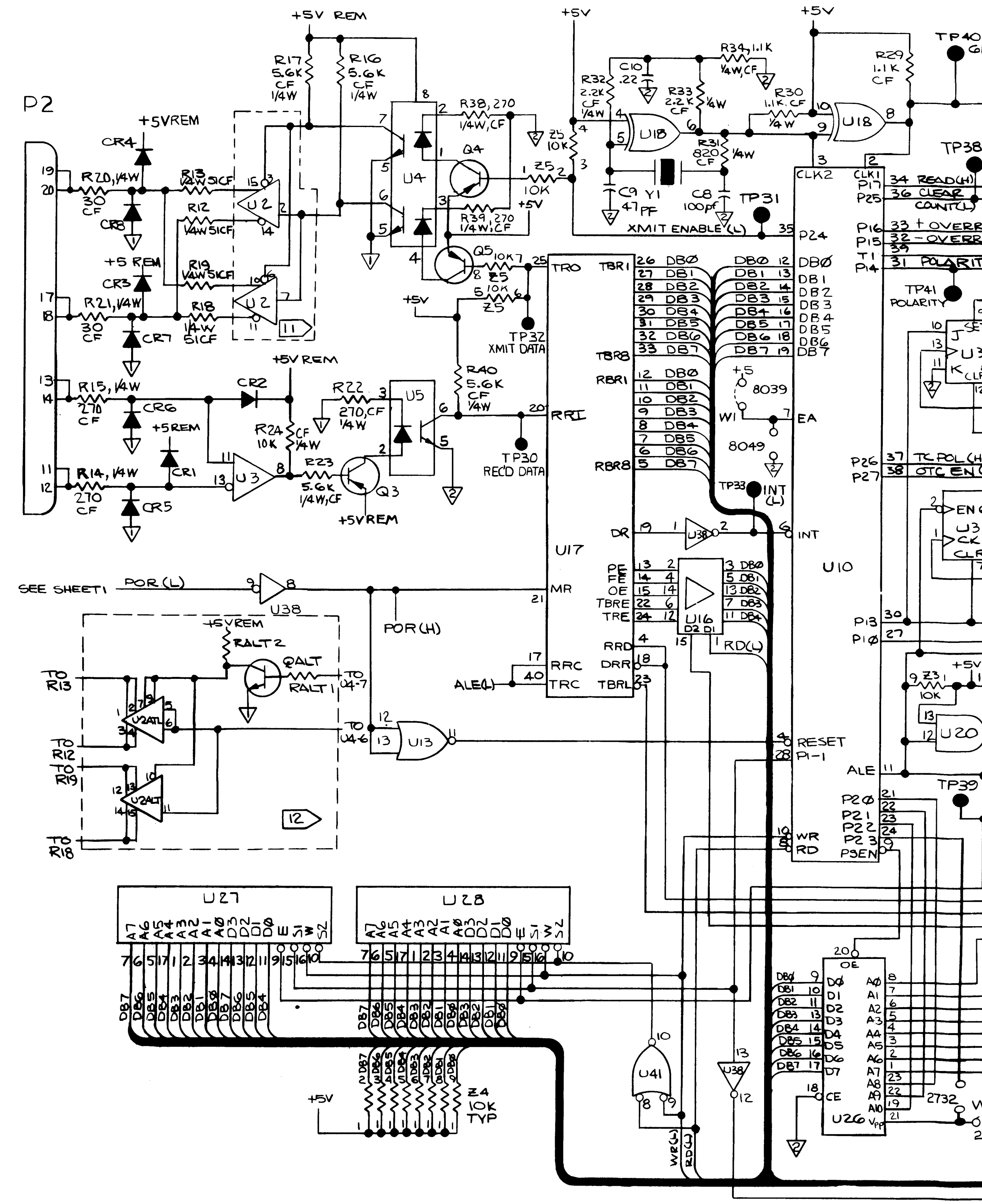
Figure 161-7. High Performance A/D Converter Schematic Diagram


2280A-3061 REV
CAUTION
SUBJECT TO DAMAGE BY STATIC ELECTRICITY

2280A-1661


P2
+5V REM
+5VREM
U17
U10
U27
U28
U38
U13
U16
U41
U26
XMIT ENABLE (L)
XMIT DATA
RECD DATA
SEE SHEET1
POR (L)
POR (H)
ALE(L)
Z4
10K
TYP

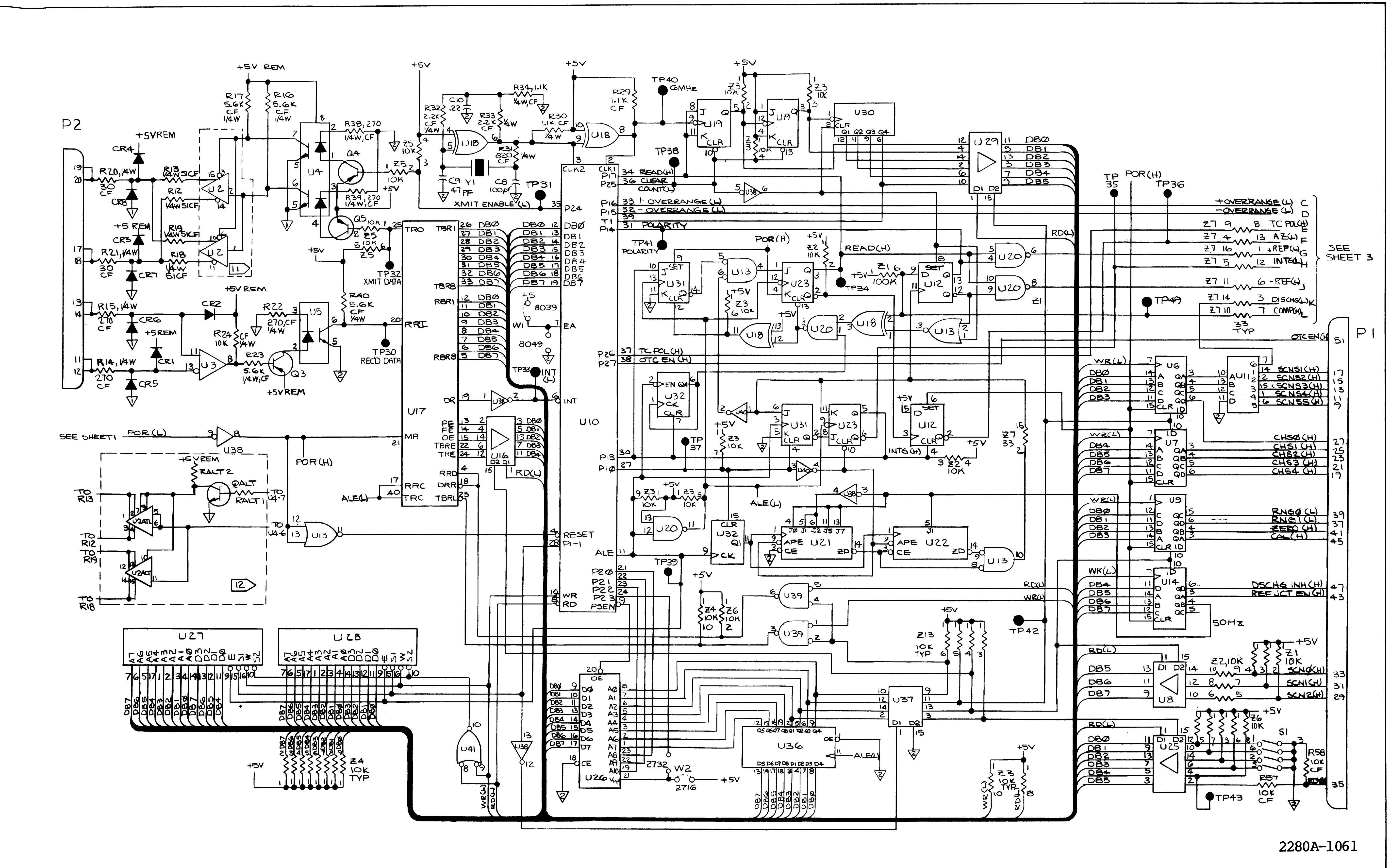
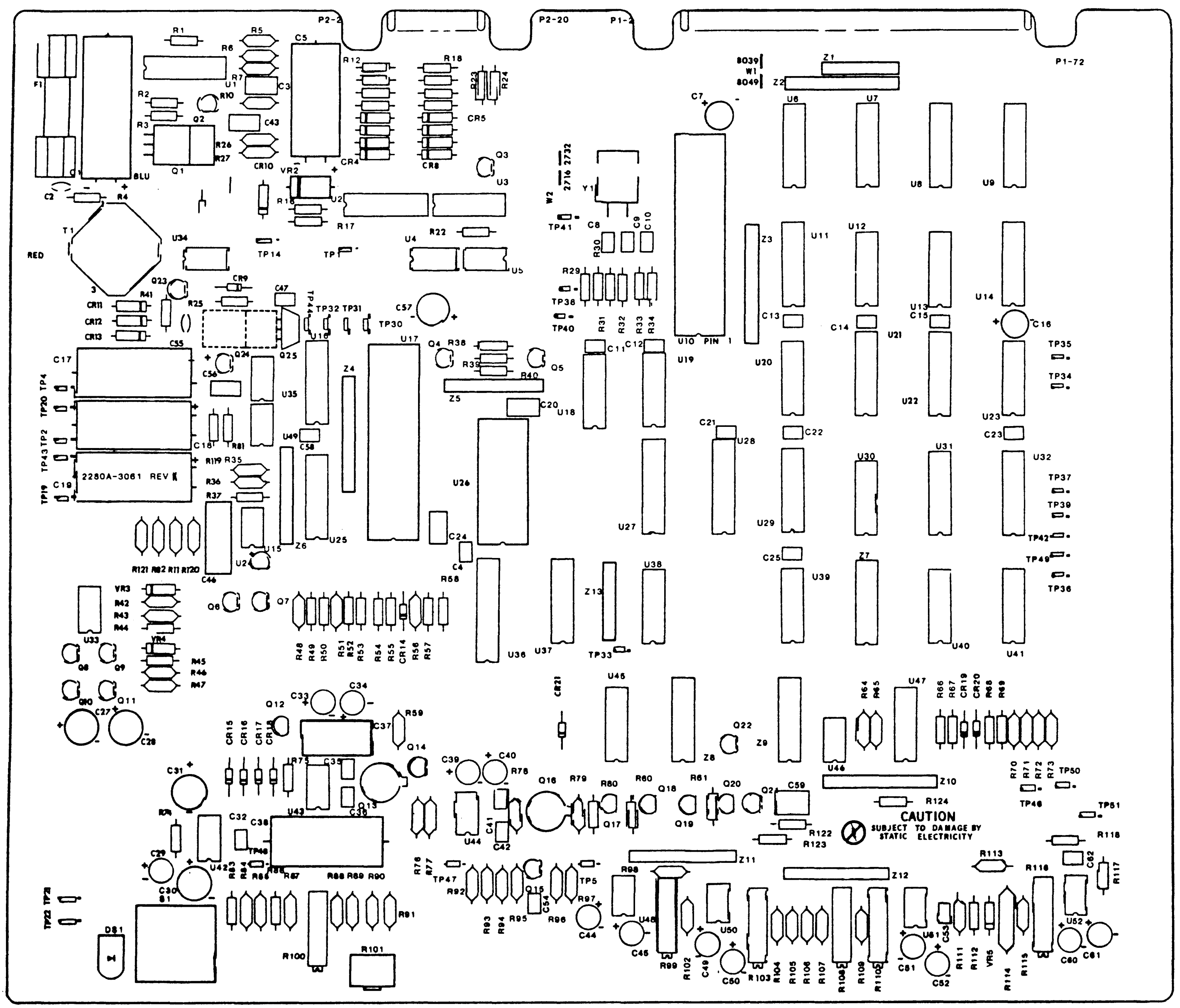
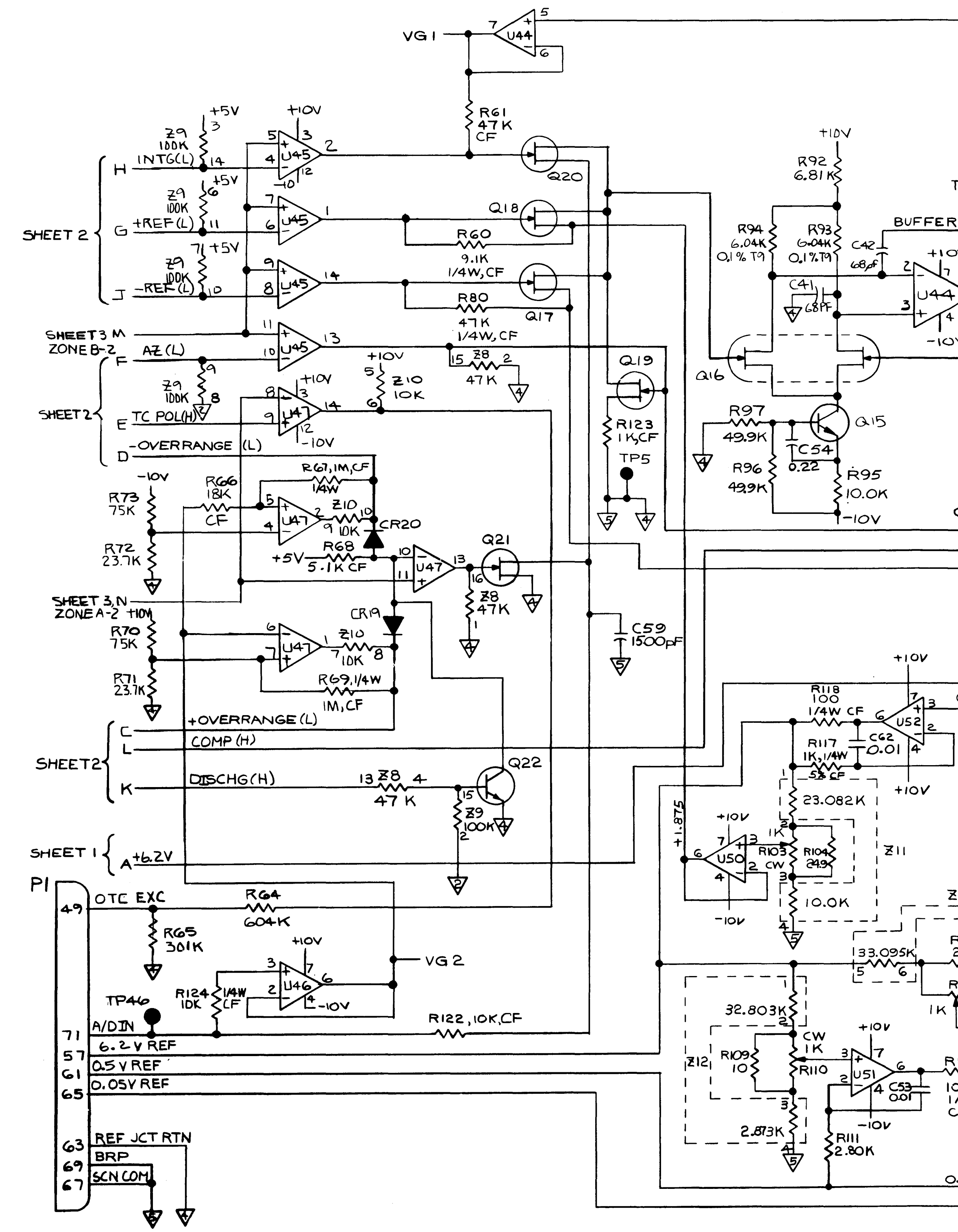


Figure 161-7. High Performance A/D Converter Schematic Diagram (cont.)


CAUTION
SUBJECT TO DAMAGE BY STATIC ELECTRICITY
2280A-3061 REV

2280A-1661


VG1
SHEET 2
H INTGC(L)
G +REF(L)
J -REF(L)
SHEET3 M ZONE B-2
AZ(L)
F
SHEET 2
E TC POL(H)
D -OVERRANGE (L)
SHEET 3, N ZONE A-2
+OVERRANGE (L)
SHEET2
C COMP(H)
L
K DISCHG(H)
SHEET 1
A +6.2V
P1
OTC EXC
VG 2
TP46
A/DIN
6.2V REF
0.5V REF
0.05V REF
REF JCT RTN
BRP
SCN COM
BUFFER
TP5

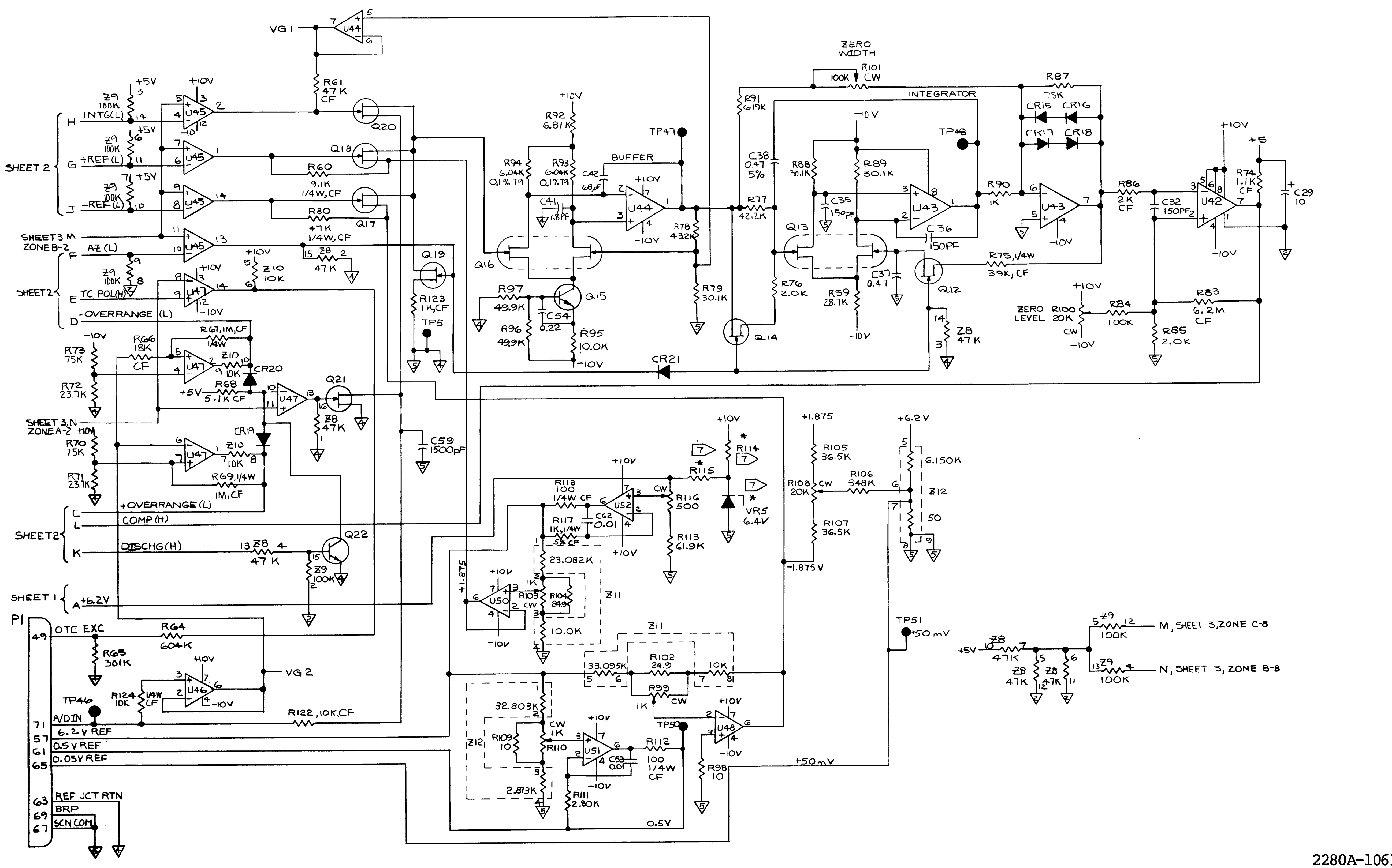


Figure 161-7. High Performance A/D Converter Schematic Diagram (cont.)

DESCRIPTION

The -162 Thermocouple/DC Volts Scanner (shown in Figure 162-1) is a plug-in, 1 uV, 20-channel dry-reed relay scanner.

This scanner operates as a self-calibrating analog data multiplexer, linking the A/D Converter to external measurement points. One to five scanners may be installed with each A/D Converter installed in a Computer Front End system.

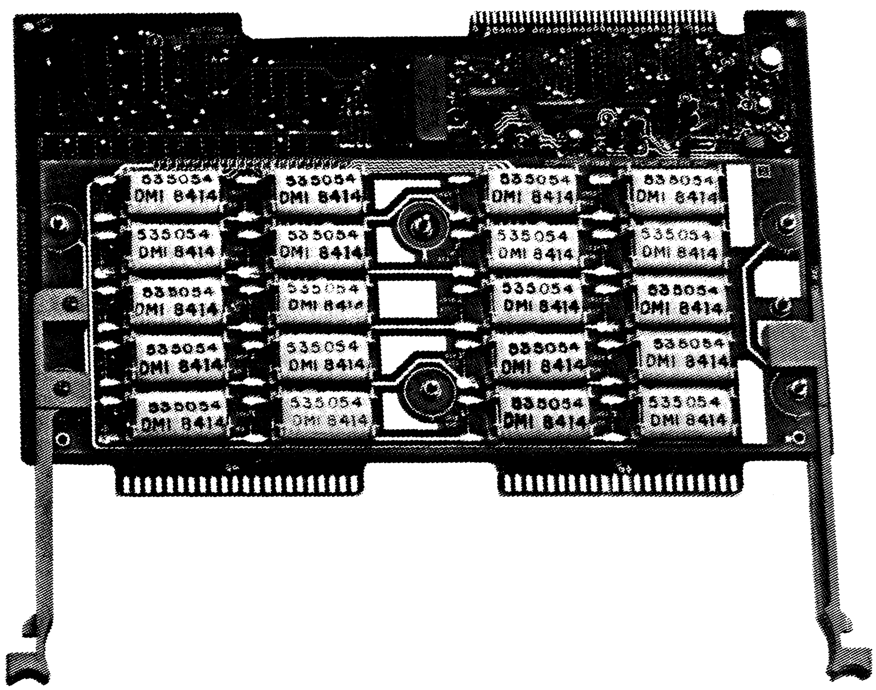


Figure 162-1. Thermocouple/DC Volts Scanner

Each channel of the scanner provides a High, a Low, and a Shield input which can be accessed through a connector option plugged onto the scanner's two 44-pin card-edge connectors. The scanner accepts only dc voltage inputs, but several different connector options are available to convert various analog measurements into dc voltages. The following connector options are available connector.

- -160 AC Voltage Input Connector
- -171 Current Input Connector
- -175 Isothermal Input Connector
- -176 Voltage Input Connector

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Thermocouple/DC Volts Scanner theory of operation, performance tests, parts list, and schematic diagrams.

Installation, operating, and system configuration instructions are located in the Helios Plus System Manual. Option specifications are located in the appendices to this manual and the System Manual.

The test equipment required to perform the procedures in this subsection is listed in Table 162-1.

An overall summary of test equipment is given in Table 2-2 in Section 2 of this manual.

THEORY OF OPERATION

The Thermocouple/DC Volts Scanner theory of operation includes a functional description of the Thermocouple/DC Volts Scanner, a block diagram analysis (which describes how each major circuit block on the assembly works), and a circuit analysis of each block.

Block diagrams and simplified schematics are included with the text. A parts lists and a schematic diagram for the Thermocouple/DC Volts Scanner can be found at the end of this option subsection.

Overall Functional Description

The Thermocouple/DC Volts Scanner is a reed-relay multiplexer and programmable gain amplifier that allows the A/D Converter access to 20 dc volt or thermocouple input measurement channels.

Gain and zero adjustments need not be made to the scanner amplifier. The A/D directly measures the offset and true gain of each scanner and compensates for those errors during measurements of user inputs.

Table 162-1. Required Test Equipment for -162

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Calibrator	+/- 31.3 mV +/- 20 uV +2.048V +/- 50 uV -2.048V +/- 2 uV of +2.048 500 mV +/- 20 uV 6.2V +/- 155 uV 6.8V +/- 0.1V 5.0V +/- 100 uV 7.9V +/- 200 uV *63V +/- 800 uV 1.008V +/- 40 uV	Fluke 343 *63V output used only for one optional test.
100:1 Divider	+/- 0.005%	Fluke Y2022
Resistor	1 kilohm +/- 5%	Fluke Part No. 108597
Resistor	10 kilohm +/- 5%	Fluke Part No. 109165
High Performance A/D Converter	NA	Fluke Option -161 (no substitute)
Isothermal Input Connector	NA	Fluke Option -175 (no substitute)
Voltage Input Connector	NA	Fluke Option -176 (no substitute)

Various operating modes of the scanner are listed in Table 162-2. The A/D measures the scanner output for all modes but Discharge, Open Thermocouple Test, and De-Select modes. The user's measurement inputs, channels 0 to 19, are accessed during the Measure modes. The remaining scanner modes are used for the zero and gain correction functions which are transparent to the user.

Table 162-2. Scanner Operating Modes

MODE	OPERATION
De-Select	De-energizes the reed switches of the input channel previously measured, and waits for them to open.
Discharge	Shorts the input filter capacitor to ground in preparation for the next measurement.
Open T/C Test	Bleeds a small current into the input filter capacitor and changes the range to 512 mV. The A/D determines whether the connected thermocouple circuit has low enough resistance.
64 mV Zero	The A/D measures the scanner offset with the input to the scanner buffer amplifier grounded through a 39 kilohm resistor on the 64-mV range.
8V Zero	The A/D measures the scanner offset with the input grounded through a 78 kilohm resistor on the 8V range.
50 mV Cal	The A/D measures the scanner output when a 50-mV input supplied by the A/D Converter is applied on the 64-mV range.
500 mV Cal	The A/D measures the scanner output when a 500-mV input supplied by the A/D Converter is applied on the 512-mV range.
6.2V Cal	The A/D measures the scanner output with an A/D supplied 6.2V input on the 8V range.

Table 162-2. Scanner Operating Modes (cont.)

MODE	OPERATION
64 mV Measure	The A/D measures the scanner output with an input channel selected on the 64-mV range. Channel reeds are closed.
512 mV Measure	The A/D measures the scanner output with the scanner on the 512-mV range with an input channel selected. Channel reeds are closed.
8V Measure	The A/D measures an input channel on the 8V scanner range. Selected channel reeds are closed.
64V Measure	The A/D measures the scanner output with an input channel selected on the 64-mV range. Channel reeds are closed.
Ref Junction	The A/D measures the output voltage of the semiconductor sensor embedded in the isothermal input connector (when one is used) with the scanner on the 512mV range. This measurement is required for thermocouple temperature measurements.

Scanner operation can be divided into two measurement sequences: calibration and scanning. Calibration is performed every ten minutes at the direction of the mainframe and involves measuring the gains of the scanner amplifier on three ranges. Scanning, the normal mode of operation, occurs when the A/D Converter is instructed to measure user input channels. Both sequences are controlled by the A/D Converter through the scanner control lines: Scanner Selects (SCNS[1:5](H)), Channel Selects (CHS[0:4]), Range Selects (RNG[0:1](L)), Calibrate (CAL(H)), Discharge Inhibit (DSCHG INH(H)), Reference Junction Enable, Open Thermocouple Test (OTC EN(H)), and Zero (ZERO(H)).

Detailed Circuit Description

The amplifier composed of U11, Q14, Q15, Q16, CR28, R19, and R20 has gains of 4 and 32. Amplifier gain is selected by U10 under control of signal RNGO(L). Components Z5, Q3, Q4, and K20 work as a switchable high-impedance, 125-to-1 ratio, voltage divider. The divider is enabled by the RNG1(L) control signal. To remove high-frequency noise, input signals are filtered by C15 in conjunction with R10 or the output resistance of Z5, depending on the state of the RNG1(L) signal.

The full-scale output of the amplifier is bipolar 2.048V. The two amplifier gains in combination with the high-impedance divider yields four dc volt ranges: 64 mV, 512 mV, 8V, and 64V full scale.

Decoders U2 and U8, gating in U3, and comparators U7, U9, and U10 select one of several inputs to the amplifier. The A/D Converter selects an input.

Reed switches provide high voltage isolation from channel to channel and scanner to scanner. Each input channel is connected to the scanner amplifier circuitry by three reed switches closed by a single drive coil (K0 through K19). One of the 20 channels is selected when decoder U2 is presented with an input from 0 through 9 (decimal) via signals CHS[0:3](H) and SCNS1(H) is true. The selected channel is in the lower group (K0 through K9) if CHS4 is low and in the higher group (K10 through K19) if CHS4 is high. Decoder U2 does not activate any outputs (and, therefore, no channels are selected) when its inputs are outside the 0 through 9 range (decimal).

Components U3 and U4 identify the presence of the scanner and its type to the A/D Converter. If the scanner select control line SCNS1 is asserted, the Thermocouple/DC Volt scanner pulls SCN[0:2](H) lines low when a -175 Isothermal Input Connector is installed on the scanner and pulls only SCN0(H) and SCN1(H) low if a -176 Voltage Input Connector or -171 Current Input Connector or no input connector is installed.

GENERAL MAINTENANCE

The Thermocouple/DC Volts Scanner normally does not require cleaning unless dirt, dust, or other contamination is visible on its surface.

If cleaning is necessary, follow the cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

Three performance tests, which can be performed separately or together, verify that the Thermocouple/DC Volts Scanner is operational and meets its accuracy specifications.

NOTE

> Since the Thermocouple/DC Volts Scanner must be used with the -161 A/D Converter, the A/D Converter must be tested and calibrated first.

The three performance tests are:

- Channel Integrity Test

- Accuracy Verification Test:
- Open Thermocouple Response Test:

These performance tests verify that the Thermocouple/DC Volts Scanner meets specified accuracy tolerances on all channels. If the scanner fails one of the tests, it must be repaired or replaced since there are no calibration adjustments on the scanner.

WARNING

THE COMPUTER FRONT END CONTAINS HIGH VOLTAGES WHICH CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE COMPUTER FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

Channel Integrity Test

The Channel Integrity Test verifies that each scanner channel is functional. Use the following procedure to perform this test:

1. Switch OFF power to the Front End. Disconnect the ac line cord and all other high voltage inputs.

2. Remove all addressable options from the Front End so that no address conflict occurs.

3. Set the address switch on an -161 A/D Converter to 0, and install it in the top option slot of the Front End. Install the Thermocouple/DC Volts Scanner to be tested in the option slot just below the A/D Converter.

4. Connect a pair of test leads to the HI and LO terminals of Channel 0 of a -175 or -176 input connector. Install the input connector on the scanner.

5. Reconnect the ac line cord to the Front End, and switch the power ON.

6. Connect the calibrator output to the input connector test leads.

7. Set the calibrator output to 7.9000V dc.

8. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM  <CR>

DEF CHAN(0..19)=DVIN,MAX=7.9  <CR>

FORMAT=DECIMAL  <CR>

SEND CHAN(0)  <CR>
```

The value returned for the selected channel should be 7.9V +/- 0.002V.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
120  PRINT #1,"def chan(0..19)=dvin,max=7.9"
125  GOSUB 300
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  REM make measurement and read in response
160  PRINT #1,"send chan(0..19)"
170  FOR I=0 TO 19
180  INPUT #1,M$
190  PRINT "chan";I;"=";
```

```
200  PRINT USING "###.###";VAL(M$);
210  PRINT " Volts DC"
220  NEXT I
230  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for a 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1
50   OPEN "KB1:"AS OLD FILE 2
60   PRINT #1,CHR$(3);
70   REM set up Computer Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0..19)=dvin,max=7.9"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  REM make measurement and read in response
170  I=0
180  FOR R=1 TO 10
190  FOR C=0 TO 1
200  PRINT #1,"send chan(";I;")"
210  INPUT #2,M$
220  PRINT TAB(35*C);"chan";I;"=";
230  PRINT USING "S###.###",VAL(M$);
240  PRINT " Volts DC"
250  I=I+1
260  NEXT C
270  NEXT R
280  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The value returned for the selected channel should be 7.9V +/- 0.002V.

9. Set the calibrator output to zero. Move the input connector test leads to the terminals for the next channel to be tested.

10. Repeat steps 7 through 9 for each remaining voltage input channel (1 through 19).

    If the Terminal Mode is being used, do so by substituting the appropriate channel number in the SEND CHAN command.

11. This completes the Channel Integrity Test.

Continue with the Accuracy Verification Test if you are performing a complete verification of the scanner and you have not already performed the test as part of the performance testing of the A/D Converter.

Accuracy Verification Test

The Accuracy Verification Test checks scanner accuracy against specifications. Because all voltage readings returned by the Front End are dependent upon the accuracy of the A/D Converter, the A/D Converter must be calibrated before performing this test.

Use the following procedure to perform the Accuracy Verification Test:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Remove all addressable options from the Front End so that no address conflict occurs.

3. Set the A/D Converter address switch to 0, and install the A/D Converter in the top option slot of the Front End.

    Install a scanner in the slot just below the A/D Converter.

4. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or on a -175 Isothermal Input Connector.

    Install the connector on the scanner.

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Connect the calibrator output to the input of the 100:1 Voltage Divider. Connect the output of the divider to the scanner input connector test leads.

7. Set the calibrator to output 6.2000V (62 mV out of the divider).

8. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

    Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0)=DVIN, MAX=0.062

FORMAT=DECIMAL <CR>

SEND CHAN(0) <CR>
```

The returned value for channel 0 should be 62 mV +/- 0.014 mV.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a DC voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port, empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50  PRINT #1,CHR$(3);
60  REM Set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
90  PRINT #1,"count=off"
100 GOSUB 300
120 PRINT #1,"def chan(0)=dvin,max=0.062"
125 GOSUB 300
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 REM make measurement and read in response
160 PRINT #1,"send chan(0)"
170 INPUT #1,M$
180 PRINT "chan 0 = ";
190 PRINT USING "##.######";VAL(M$)
200 PRINT " Volts DC"
210 END
```

```
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for a 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:"AS NEW FILE 1
50  OPEN "KB1:"AS OLD FILE 2
60  PRINT #1,CHR$(3);
70  REM set up Front End
80  PRINT #1,"mode=comp"
90  GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1,"def chan(0)=dvin,max=0.062"
125 GOSUB 300
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 REM make measurement and read in response
160 PRINT #1,"send chan(0)"
170 INPUT #2,M$
180 PRINT "chan 0 = ";
190 PRINT USING "S##.######",VAL(M$);
200 PRINT " Volts DC"
210 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

The returned value for channel 0 should be 62 mV +/- 0.014 mV.

9. Change to the 512 mV voltage range by redefining channel 0.

   To redefine channel 0 in the Terminal Mode, send the command:

   DEF CHAN(0)=DVIN, MAX=0.5 <CR>

   If you are using Computer Mode, do so by changing the BASIC statement in line 120 to:

   PRINT #1,"def chan(0)=dvin, max=0.5"

10. Set the calibrator to 0. Remove the 100:1 divider, and connect the calibrator output directly to the connector test leads on channel 0.

11. Set the calibrator to output 500 mV.

12. Take a measurement on channel 0. It should return a value of 500 mV +/- 0.1 mV.

    In the Terminal Mode, the measurement can be taken by sending the following command:

    SEND CHAN(0) <CR>

    In Computer Mode, run the program as modified in step 9.

13. Change to the 8V range by redefining channel 0.

    In the Terminal Mode, send the command:

    DEF CHAN(0)=DVIN, MAX=7.9 <CR>

    In the Computer Mode, change the BASIC program statement in line 120 appropriately.

14. Set the calibrator output to 7.9000V.

15. Take another measurement as described in step 12. Verify that the returned value is 7.9V +/- 0.002V.

16. Change to the 64V range by redefining channel 0.

    To redefine channel 0 in the Terminal Mode, send the command:

    DEF CHAN(0)=DVIN, MAX=63 <CR>

    In the Computer Mode, change the BASIC program statement in line 120 appropriately.

17. Set the calibrator output to 63.000V.

18. Take a measurement on channel 0.

    The returned value should be 63V +/- 0.02V.

19. The Accuracy Verification Test is now complete.

Continue with the Open Thermocouple Response Test if you are performing a complete verification test of the scanner and you have not already performed the test in the A/D Converter performance test section.

Open Thermocouple Response Test

The Open Thermocouple Response Test checks whether the A/D Converter and scanner respond with an open thermocouple indication when presented with an open thermocouple channel input.

NOTE

> This test is also one of the A/D Converter performance tests. It is repeated here because both the scanner and the A/D contain the circuitry which senses open thermocouple conditions. The test need not be repeated if it was performed previously.

Use the following procedure to perform the Open Thermocouple Response Test:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Remove all addressable options from the Front End so that no address conflict occurs.

3. Set the A/D Converter address switch to "0" and install the A/D in the top option slot of the Computer Front End. Install the Thermocouple/DC Volts Scanner in the option slot immediately below.

4. Connect test leads to the HI and LO terminals for channel 0 on the -175 Isothermal Input Connector. Install the connector on the scanner.

5. Reconnect the ac line cord to the Front End and switch power ON.

6. Connect the test leads from the Isothermal Input Connector to a 1 kilohm resistor.

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

   PROCEDURE A. TERMINAL MODE

   If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

   MODE=TERM <CR>

   DEF CHAN(0)=TC,TYPE=JNBS <CR>

   TUNIT=CELSIUS <CR>

   FORMAT=DECIMAL <CR>

   SEND CHAN(0) <CR>

The value returned for channel 0 should be equal to the ambient temperature +/- 2 degrees Celsius.

PROCEDURE B. COMPUTER MODE

The following BASIC programming examples will cause the Front End to take a thermocouple measurement on channel 0. One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port and empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
90  PRINT #1,"count=off"
100 GOSUB 300
110 PRINT #1,"def chan(0)=tc,type=jnbs"
120 GOSUB 300
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 PRINT #1,"tunit=celsius"
160 GOSUB 300
170 REM make measurement and read in response
180 PRINT #1,"send chan(0)"
190 INPUT #1,M$
200 PRINT M$
210 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:"AS NEW FILE 1
50  OPEN "KB1:"AS OLD FILE 2
60  PRINT #1,CHR$(3);
70  REM set up computer Front End
```

```
80  PRINT #1,"mode=comp"
90  GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1,"def chan(0)=tc,type=jnbs"
130 GOSUB 300
140 PRINT #1,"format=decimal"
150 GOSUB 300
160 PRINT #1,"tunit=celsius"
170 GOSUB 300
180 REM make measurement and read in response
190 PRINT #1,"send chan(0)"
200 INPUT #2,M$
210 PRINT M$
220 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

The value returned for channel 0 should be equal to the ambient temperature +/- 2 degrees Celsius.

8. Replace the 1-kilohm resistor with a 10-kilohm resistor to simulate a high resistance or open thermocouple.

9. Request a measurement and verify that the returned value is:

   9.99999E+37

10. Perform PROCEDURE 10A or PROCEDURE 10B as appropriate.

PROCEDURE 10A. TERMINAL MODE

Send the following command to inspect the fault condition:

LIST ERROR <CR>

The following error message should be displayed

chan(0)-open tc

meaning that a temperature measurement was attempted with a damaged or improperly connected thermocouple.

PROCEDURE 10B. COMPUTER MODE

Run one of the following BASIC programs (or a similar one appropriate to your host).

Program for an IBM PC:

```
10  CLS
20  REM send the fault condition
30  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
40  PRINT #1,"list error"
50  INPUT #1,N
60  PRINT N
70  IF N=0 THEN 120
80  FOR I=1 TO N
90  LINE INPUT #1,E$
100 PRINT E$
110 NEXT I
120 END
```

Program for a 1722A:

```
10  PRINT CHR$(27);"[2J";
20  REM send the fault condition
30  PRINT #1,"list error"
40  INPUT #2,N
50  PRINT N
60  IF N=0 THEN 110
70  FOR I=1 TO N
80  INPUT LINE #2,E$
90  PRINT E$
100 NEXT I
110 END
```

The displayed response should be:

```
   1
0,16
```

The top number, "1", indicates that one error was logged. The lower set of numbers, "0,16", indicates that error 16 was logged on channel 0.

Error number 16, "?Open TC," means that a temperature measurement was attempted with a damaged or improperly connected thermocouple.

11. Disconnect the 10-kilohm resistor and the test leads from the Isothermal Input Connector.

    Performance testing of the Thermocouple/DC Volts Scanner is complete.

CALIBRATION

No calibration is required for the Thermocouple/DC Volts Scanner.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

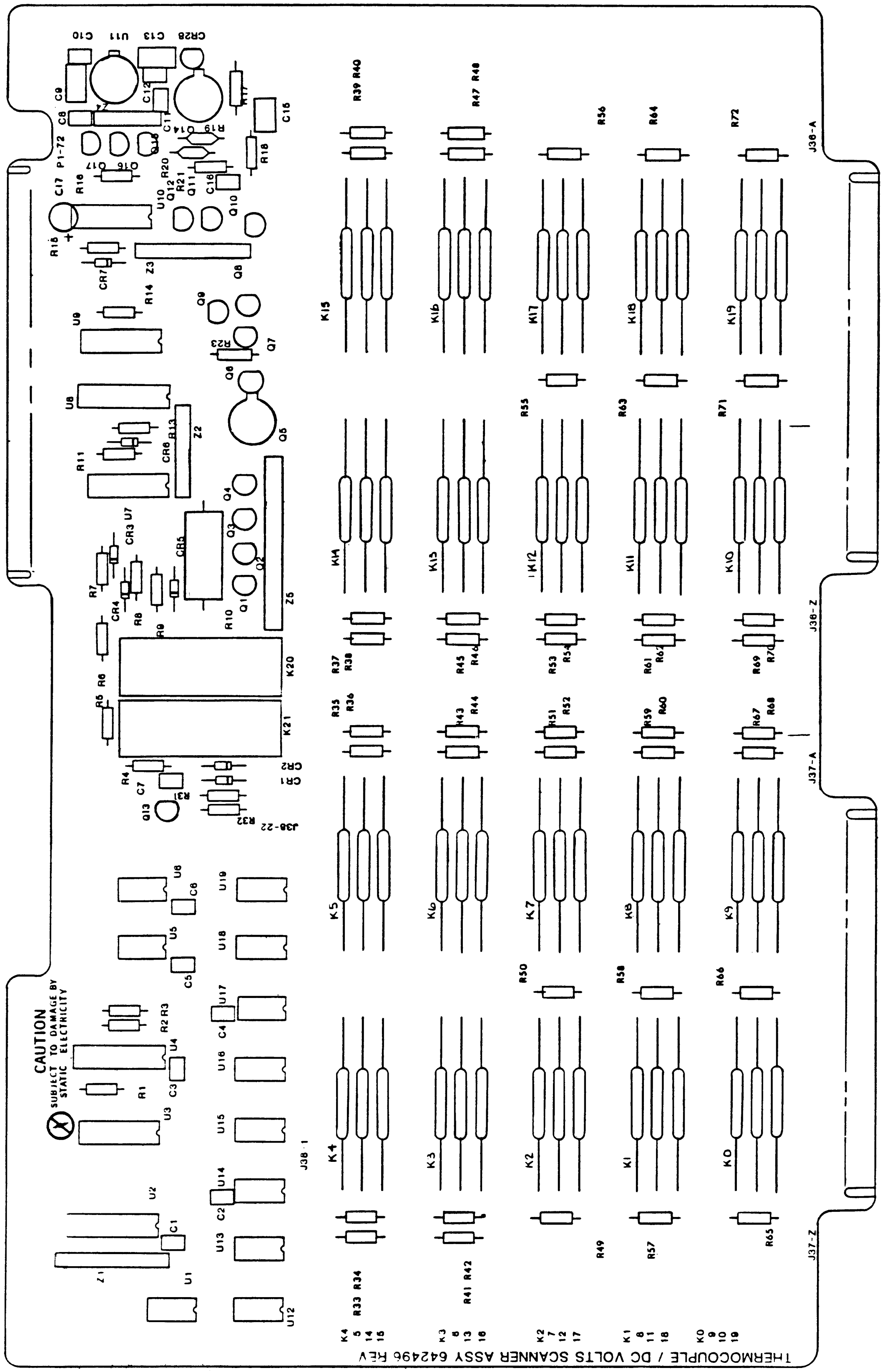
An illustrated parts list for the -162 Thermocouple/DC Volts Scanner is given in Table 162-3.

For parts ordering information, see Section 6 of this manual.

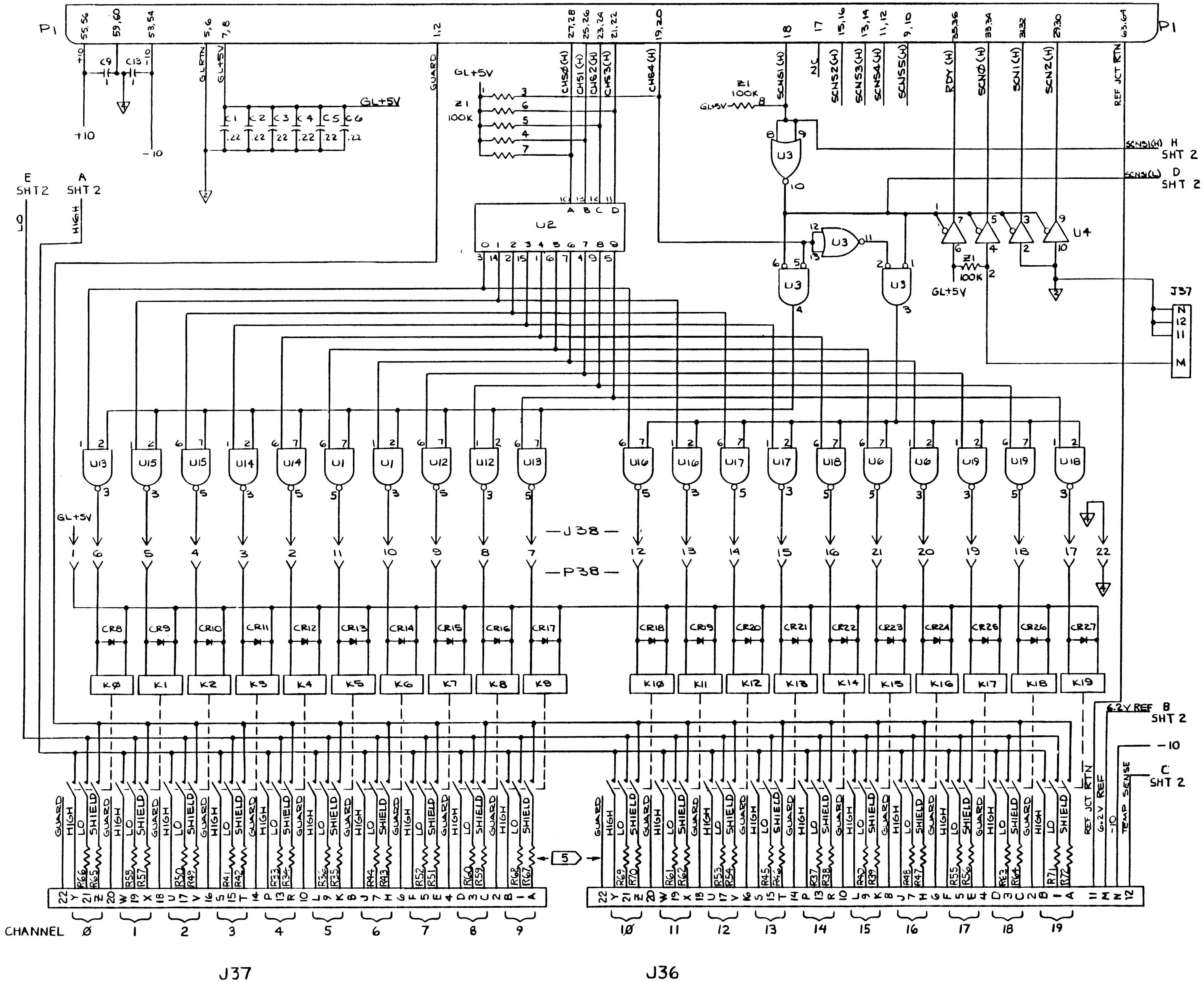
Figure 162-2 is a schematic diagram of the Thermocouple/DC Volts Scanner.

TABLE 162-3. -162 THERMOCOUPLE/DC VOLTS SCANNER PCA
(SEE FIGURE 162-2.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	N O T -E
C 1- 8, 16		CAP,CER,0.22UF,+-20%,50V,Z5U	519157	51406	RPE111Z5U224M50V	9	
C 9, 13		CAP,CER,1.0UF,+-20%,50V,Z5U	436782	72982	8131-050-601-105M	2	
C 10		CAP,CER,33PF,+-2%,100V,COG	513226	51406	RPE121	1	
C 11, 12		CAP,CER,1800PF,+-5%,50V,COG	528547	89536	528547	2	
C 15		CAP,POLYPR,6800PF,+-5%,50V	706564	89536	706564	1	
C 17		CAP,TA,10UF,+-20%,15V	193623	56289	196D106X0015A1	1	
CR 1- 6, 8-	*	DIODE,SI,BV= 75.0V,IO=150MA,500 MW	203323	07910	1N4448	26	
CR 27	*		203323				
CR 7	*	DIODE,SI,2 PELLET,BV= 20.0V,400 MW	375477	09214	MPD200	1	
H 1		WASHER,FLAT S STEEL,#4,0.032 THK	146225	89536	146225	1	
H 2		SCREW,MACH,PHP,S STL,4-40X3/4	681973	89536	681973	1	
H 3		NUT,HEX,S.STL,4-40	147611	89536	147611	1	
J 1- 22		SOCKET,SINGLE,PWB,FOR 0.025 PIN	267476	00779	85861-2	22	
J 1- 22		PIN,SINGLE,PWB,0.025 SQ	649681	00779	3-87022-2	22	
K 0- 19		RELAY COIL ASSY	777623	89536	777623	20	
K 20		RELAY,REED,1 FORM A,5VDC	404061	71707	CR-3201-5-710	1	
K 21		RELAY,REED,1 FORM A,5VDC	520247	71707	UF-40115	1	
MP 1		SPACER,REED	617415	89536	617415	1	
MP 2		BAG,SHIELDING,TRANSPARENT,12"X16"	680983	89536	680983	1	
MP 3		PCB,GUARD,TOP	583294	89536	583294	1	
MP 4		SPACER,SWAGED,RND,BRASS,0.125IDX0.187	436675	89536	436675	5	
MP 5		SPACER,SWGD,RND,BRASS,0.150IDX0.125	335075	89536	335075	1	
MP 6		PCB COIL	580647	89536	580647	1	
Q 1- 4, 6-	*	TRANSISTOR,SI,N-JFET,TO-92	376475	15818	U2810J	13	
Q 12, 15, 16	*		376475				
Q 5	*	TRANSISTOR,SI,N-JFET,DUAL,TO-71	419283	89536	419283	1	
Q 13	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	418707	04713	MPS56562	1	
Q 14	*	TRANSISTOR,SI,N-JFET,DUAL,TO-71	461772	17856	DN1675	1	
Q 17	*	TRANSISTOR,SI,N-JFET,REMOTE CUTOFF	429977	89536	429977	1	
Q 28	*	DIODE,SI,N-JFET,CURRENT REG,IF=0.43MA	393454	89536	393454	1	
R 1, 2		RES,CF,20K,+-5%,0.25W	441477	80031	CR251-4-5P20K	2	
R 3, 6- 9,		RES,CF,100K,+-5%,0.25W	348920	80031	CR251-4-5P100K	7	
R 14, 16			348920				
R 4, 21		RES,CF,100,+-5%,0.25W	348771	80031	CR251-4-5P100E	2	
R 5, 33, 36,		RES,CC,150,+-5%,0.25W	147934	01121	CB1515	21	
R 37, 40, 41,			147934				
R 44, 45, 48,			147934				
R 50, 52, 53,			147934				
R 55, 58, 60,			147934				
R 61, 63, 66,			147934				
R 68, 69, 71			147934				
R 10		RESISTOR,TINOX,39K,+-5%,2W	615435	89536	615435	1	
R 11, 13, 15,		RES,CF,10K,+-5%,0.25W	348839	80031	CR251-4-5P10K	4	
R 32			348839				
R 17		RES,CF,470,+-5%,0.25W	343434	80031	CR251-4-5P470E	1	
R 18, 23		RES,CF,39K,+-5%,0.25W	442400	80031	CR251-4-5P39K	2	
R 19, 20		RES,MF,15.4K,+-0.1%,0.125W,25PPM	340604	91637	CMF551542F	2	
R 31		RES,CF,1K,+-5%,0.25W	343426	80031	CR251-4-5P1K	1	
R 34, 35, 38,		RES,CC,470,+-5%,0.25W	147983	01121	CB4715	20	
R 39, 42, 43,			147983				
R 46, 47, 49,			147983				
R 51, 54, 56,			147983				
R 57, 59, 62,			147983				
R 64, 65, 67,			147983				
R 70, 72			147983				
S 1- 60		SWITCH,REED,1 FORM A,10VA,36AT	647578	89536	647578	60	
U 1, 5, 6,	*	IC,CMOS,DUAL 2 IN NAND DRVR W/OPN DRN	604207	02735	CD40107BE	11	
U 12- 19	*		604207				
U 2	*	IC,CMOS,BCD-DEC & BINRY-OCTAL DECODER	650689	89536	650689	1	
U 3	*	IC,CMOS,QUAD 2 INPUT NOR GATE	355172	02735	CD4001AE	1	
U 4	*	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	12040	MM80C97N	1	
U 7, 9, 10	*	IC,COMPARATOR,QUAD,CERAMIC,14 PIN DIP	605584	89536	605584	3	
U 8	*	IC,CMOS,DUAL 1 OF 4 DECODER	584987	04713	MC14555BP	1	
U 11	*	IC,OP AMP,GENERAL PURPOSE,TO-78 CASE	418368	89536	418368	1	
Z 1, 3		RES,NET,SIP,8 PIN,7 RES,100K,+-2%	412908	89536	412908	2	
Z 2		RES,NET,SIP,6 PIN,5 RES,100K,+-2%	412726	89536	412726	1	
Z 4	*	GAIN RES NET ASSY TESTED-2280A	611186	89536	611186	1	
Z 5	*	INPUT DIVIDER RESNET ASSY TESTED2280A	616011	89536	616011	1	


THERMOCOUPLE / DC VOLTS SCANNER ASSY 642496 REV
CAUTION
SUBJECT TO DAMAGE BY STATIC ELECTRICITY

2280A-1662



NOTES: UNLESS OTHERWISE SPECIFIED

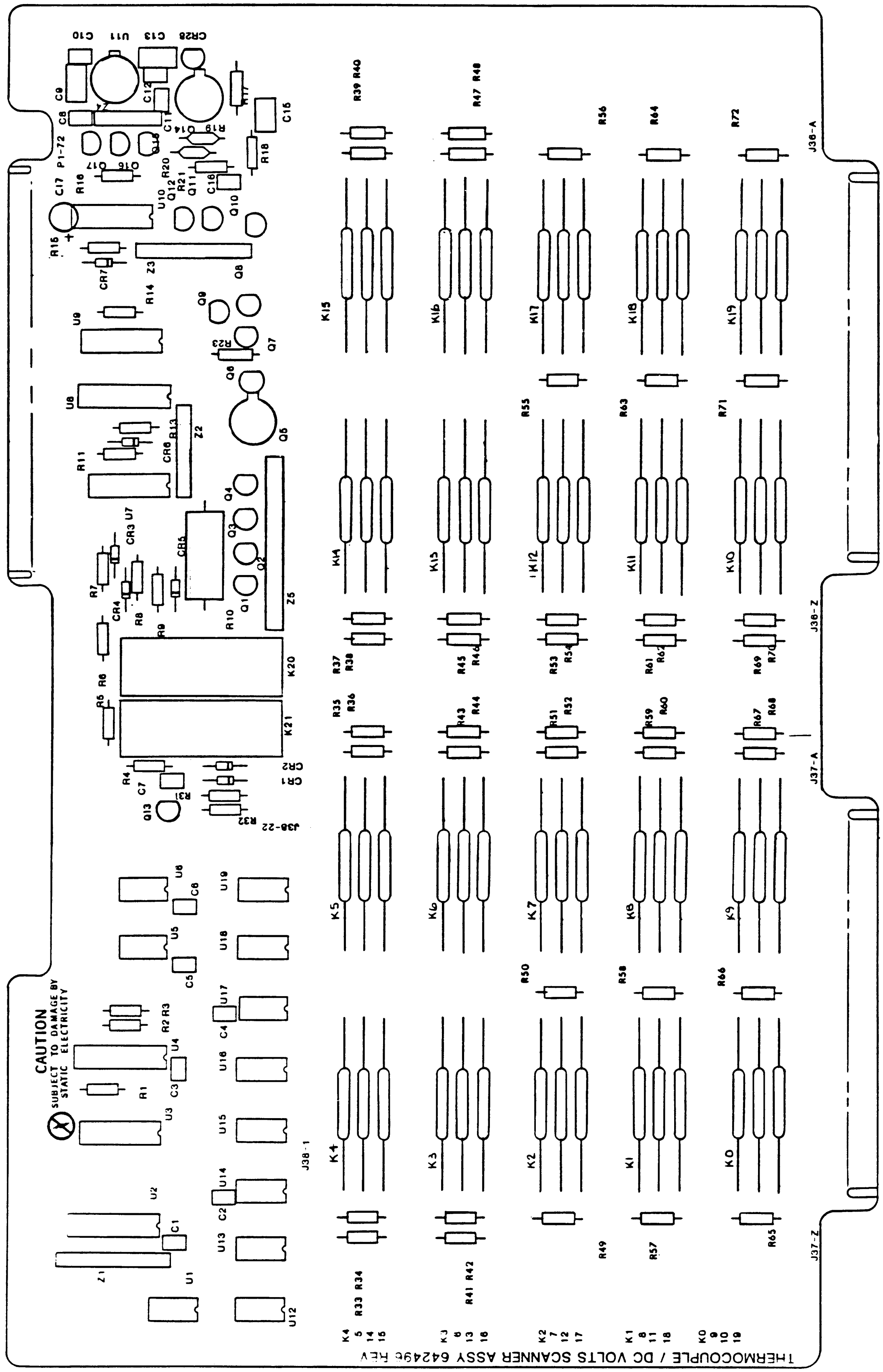
1. RESISTANCE IS IN OHMS. CAPACITANCE IS IN MICROFARADS.
2. ALL RESISTORS ARE 1/4W, 5%.
3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.

5. R33 - R72; ALL RESISTORS CONNECTED TO LO ARE 150Ω, ALL RESISTORS CONNECTED TO SHIELD ARE 470Ω.

IC POWER AND GROUND					
REF DES	▽2	GL+5V	+10V	-10V	VG
U1,5, 6,12 -19	4	8			
U2	8	16			
U3	7	14			
U4	2,8,10,14	6,12,16			
U7			3	10-13	
U8	8	16			
U9,10			3	12	
U11			7	4	
Z2,3					1

2280A-1062

Figure 162-2. Thermocouple/DC Volts Scanner Schematic Diagram


CAUTION
SUBJECT TO DAMAGE BY STATIC ELECTRICITY
THERMOCOUPLE / DC VOLTS SCANNER ASSY

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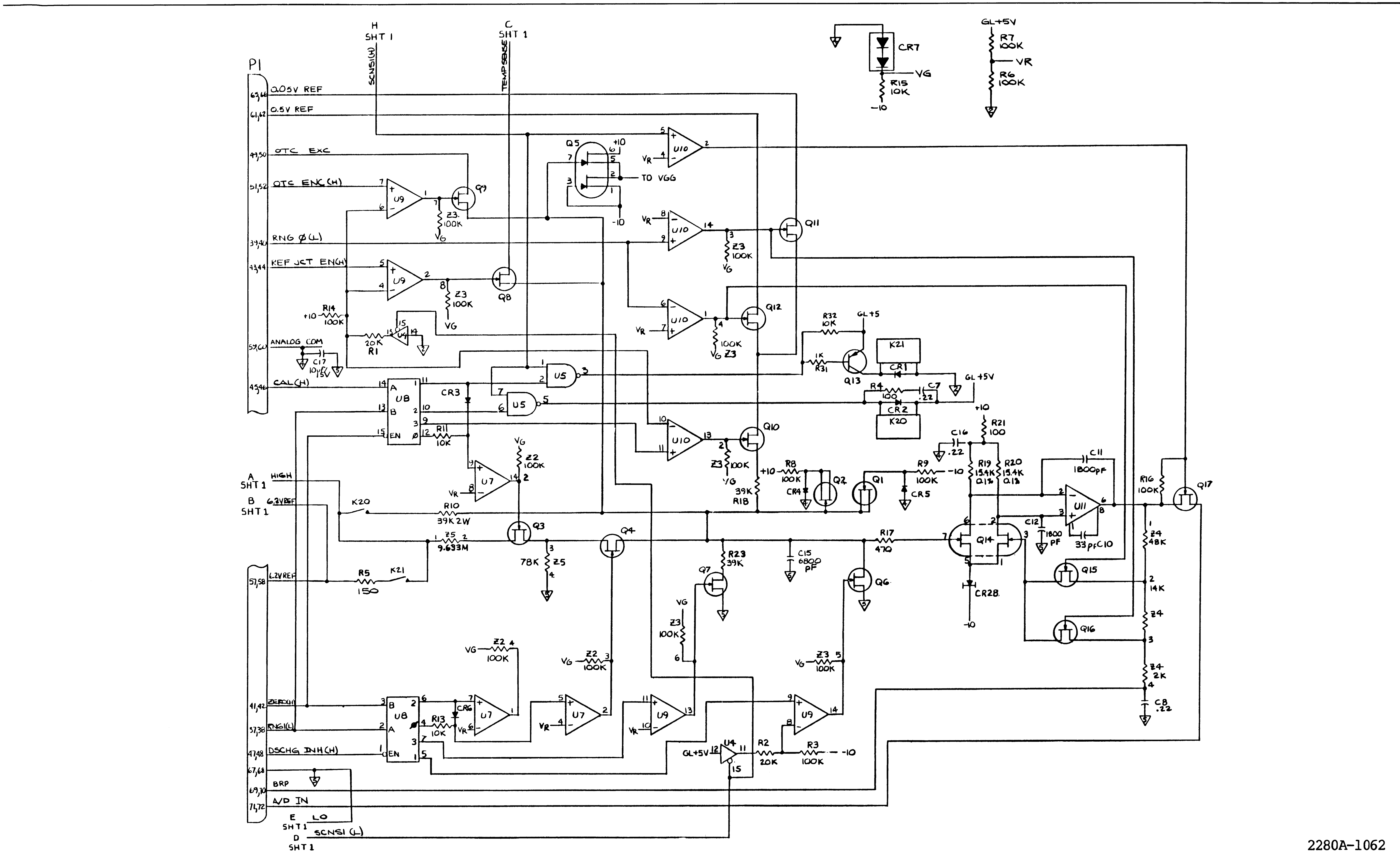


Figure 162-2. Thermocouple/DC Volts Scanner Schematic Diagram (cont.)

DESCRIPTION

The -163 RTD/Resistance Scanner (shown in Figure 163-1) multiplexes 20 input channels, with 3 or 4 poles per channel, and makes each channel available in sequence to the A/D Converter.

The -177 RTD/Resistance Input Connector is used with the RTD/Resistance Scanner to provide connection terminals for the external wiring.

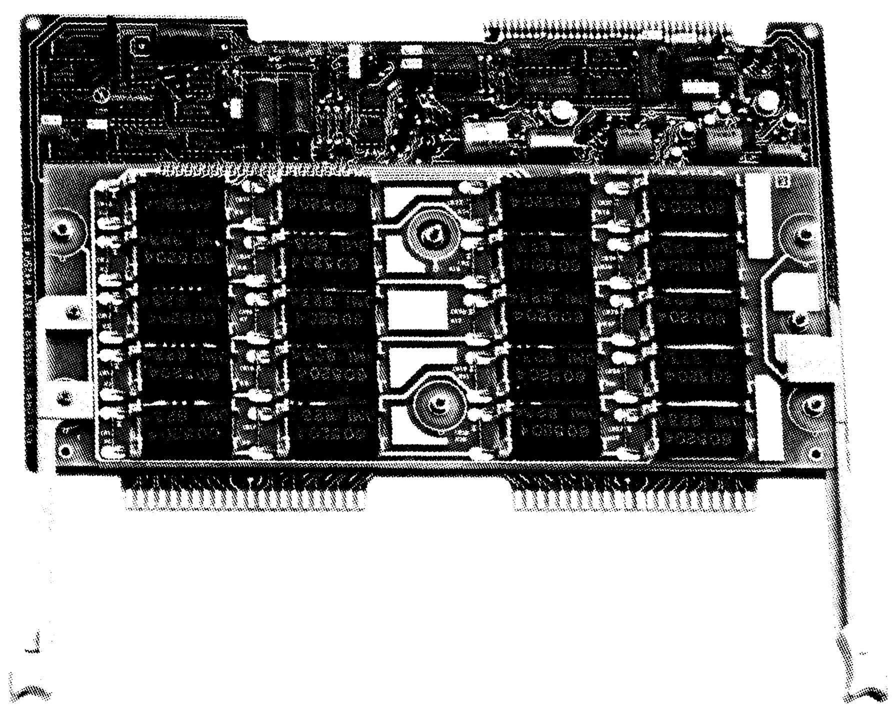


Figure 163-1. The RTD/Resistance Scanner

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: RTD/Resistance Scanner theory of operation, performance tests, a parts list, and schematic diagrams.

Installation, operating, and system configuration instructions are in the Helios Plus System Manual. Option specifications are in the appendices to this manual and the System Manual.

Test equipment required for the procedures in this subsection is listed in Table 163-1. See Table 2-2 for an overall summary of test equipment.

Table 163-1. Required Test Equipment for -163

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
A/D Converter	NA	Fluke Option -161 rev E-2, F-1, G-1, H-1, or newer (no substitute)
RTD/Ohms Input Connector	NA	Fluke Option -177 (no substitute)
Resistors R1 through R3	100 ohm, 0.01%, 5 ppm/C hermetically sealed wirewound	Fluke Part No. 491720
Resistors R4, R5	100 ohm, 0.1%, T9 metal film	Fluke Part No. 357400
Toggle Switch	Single-pole, double-throw (SPDT)	Fluke Part No. 493825

THEORY OF OPERATION

The RTD/Resistance Scanner theory of operation includes: a functional description of the RTD/Resistance Scanner, a block diagram (Figure 163-2) analysis, and a detailed circuit circuit analysis of each block on the RTD/Resistance Scanner assembly.

Where necessary, block diagrams and simplified schematics are included with the text. Schematic diagrams for the RTD/Resistance Scanner are at the end of this option subsection.

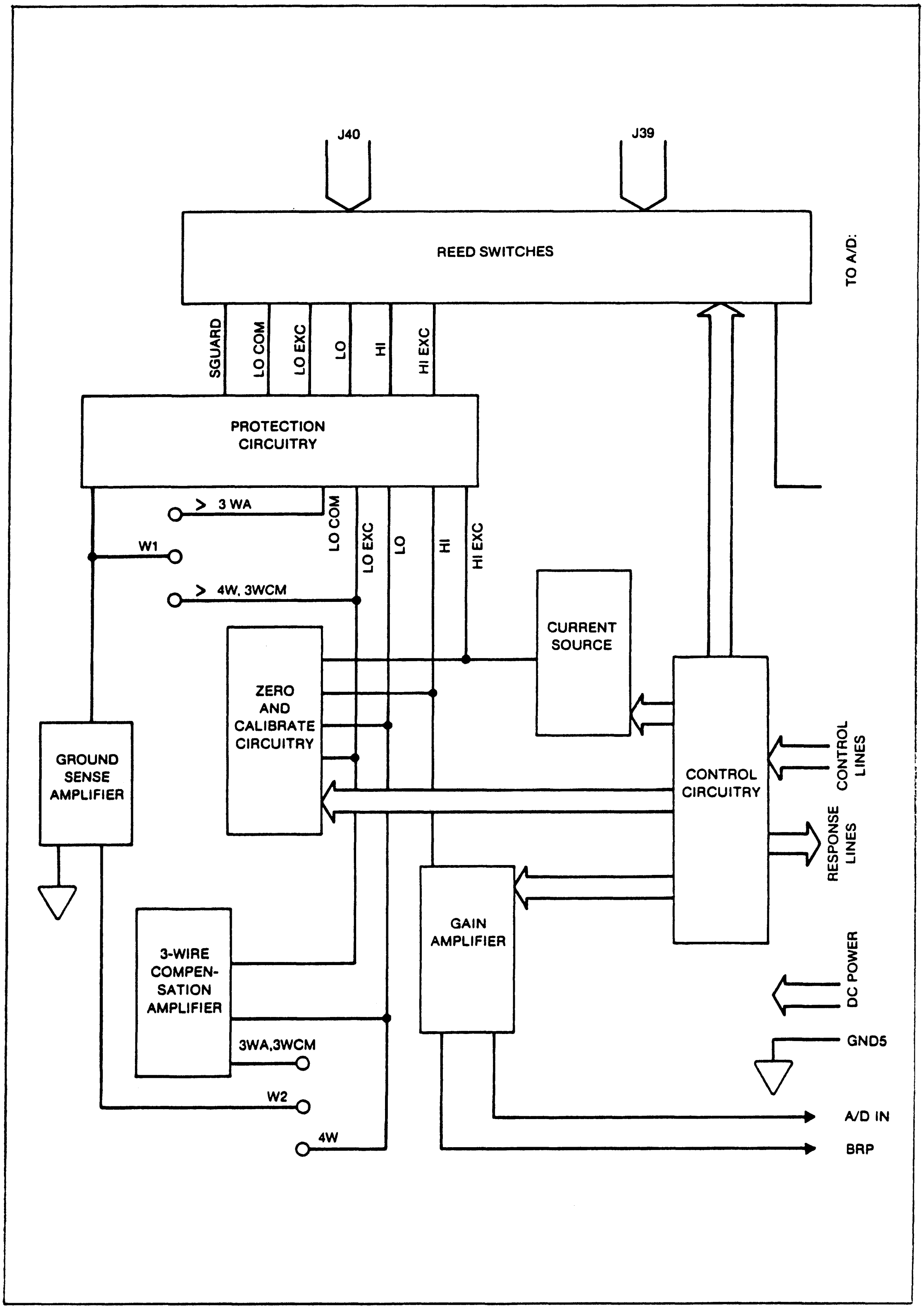


Figure 163-2. RTD/Resistance Scanner Block Diagram

Overall Functional Description

The RTD/Resistance Scanner and the -177 RTD/Resistance Input Connector work with a -161 A/D Converter to measure resistance inputs with high accuracy and stability. Power for the scanner is supplied as +/- 10V and + 5V from the A/D Converter.

When instructed by the Controller, the RTD/Resistance Scanner selects and conditions one of 20 channels. A resistance to be measured is selected by reed relays and excited by one of two current levels, and one of two amplifier gains is chosen to condition the resulting voltage in preparation for conversion by the A/D Converter.

Compensation is provided for the two 3-wire modes of operation: 3-Wire Accurate (3WA) and 3-Wire with Common Mode (3WCM). Reed resistance errors are eliminated in the 4-Wire (4W) and 3WA modes. Auto-zero and auto-calibration features are incorporated for use by the A/D Converter.

Three measurement ranges, 256 ohms, 2048 ohms, and 64 kilohms full scale are included in the RTD/Ohms Scanner. One operation mode is selected by two jumpers for all 20 channels on each scanner. Ranges for each channel are selected by the user.

Detailed Circuit Description

REED SWITCHES

Reed switches provide high voltage isolation from channel to channel and scanner to scanner.

Each input channel is connected to scanner circuitry by four reed switches driven by a single drive coil. An additional individual reed relay, K21 or K22, pulls in to provide a common current-return path for the decade of channels in which the channel selected resides, eliminating reed resistance errors in the (3WA) mode of operation. One more individual reed relay, K20, connects the A/D Converter guard to a LO line whenever the scanner is selected by the A/D Converter.

Figure 163-3 shows one channel of reed switches, with the components used in other channels listed in parentheses. The reeds for one channel, Sxx-A,B,C,D, are pulled in by the corresponding drive coil Kxx, while K21 or K22 is pulled in at the same time to provide the LO COM return for a decade of channels in the 3WA mode of operation. Relay K20 is pulled in whenever the scanner is selected by the A/D Converter, connecting the A/D guard to LO of the resistance being measured through K20 and the LO COM or LO EXC reed switches.

PROTECTION CIRCUITRY

To protect scanner and A/D circuitry, channel inputs are isolated, energy limited, and diode clamped.

Figure 163-4 shows a schematic diagram of the protection circuitry.

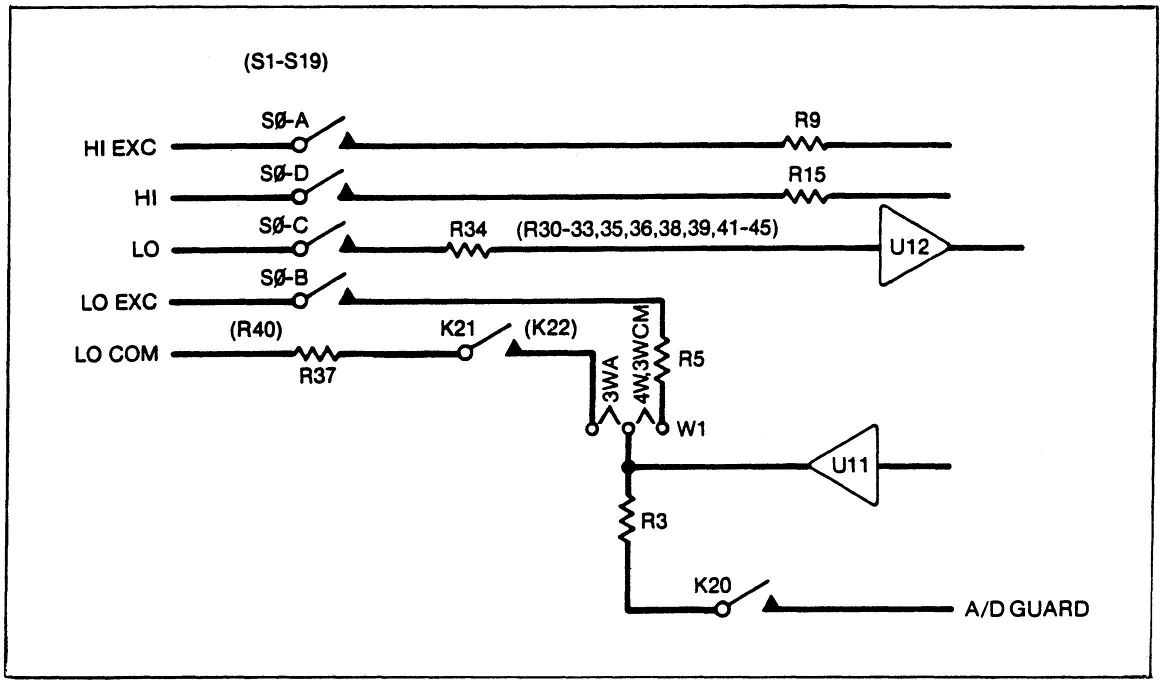


Figure 163-3. One Reed-Switch Channel

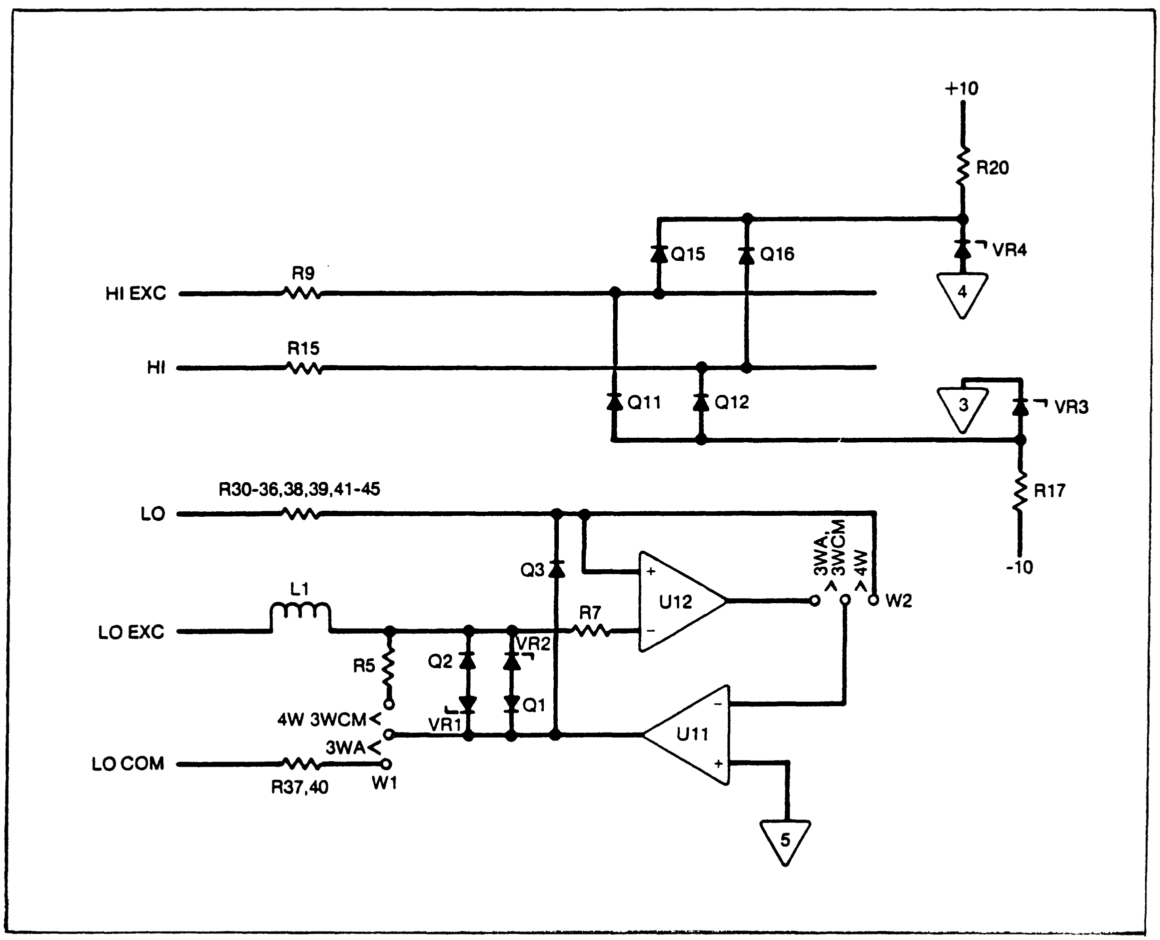


Figure 163-4. Protection Circuitry

In Figure 163-4, input terminals are clamped to defined voltages through series resistances. A positive clamp voltage of approximately 3 to 5V is provided by VR4, which is biased by R20, while a negative voltage is provided by VR3, which is biased by R17. R9 dissipates overvoltages to the HI EXC terminal in combination with Q15 and VR4 or Q11 and VR3. Both Q15 and Q11 are reverse biased in normal operation. R15 dissipates overvoltages to HI, passing current through Q16 or Q12, which are reverse biased in normal operation. LO terminals are protected by series resistors R30 through 36, R38, R39, and R41 through 45, and by the input protection diodes of U11 and U12, and Q3. L1 slows down fast transient voltages entering LO EXC terminals, while VR1, VR2, Q1, and Q2 clamp LO EXC to LO COM through W1 in the 3WA mode of operation, with R37 and R40 limiting current and dissipating power. R7 also serves to limit LO EXC current into the input of U12.

GAIN AMPLIFIER

The gain amplifier circuit filters and amplifies the signal on the HI terminal. The gain is set to 8 for the 250-ohm range, and unity is set for the other two ranges. One input filter is used with the high ohms range, while the other is used with the 256-ohm and 2048-ohm ranges. The scanner output is enabled whenever the scanner is selected by the A/D Converter.

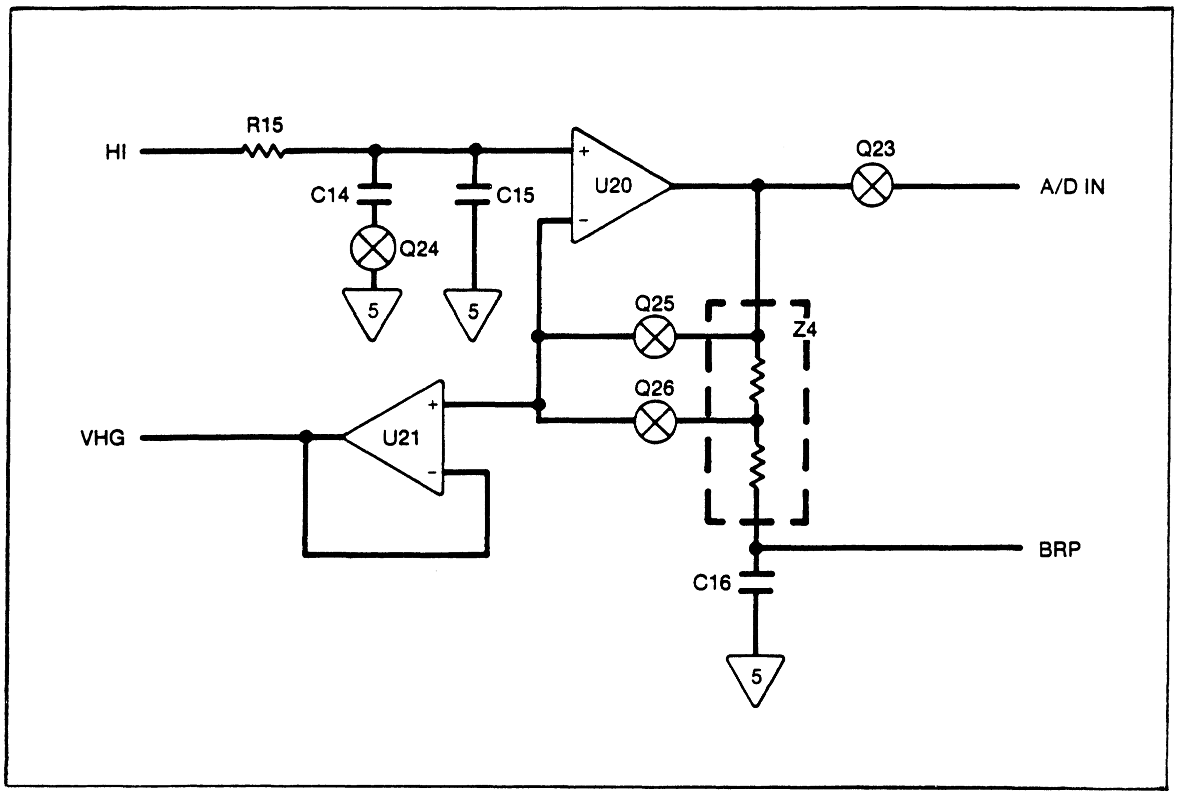


Figure 163-5. Gain Amplifier

Figure 163-5 is a schematic diagram of the gain amplifier. Two voltage gains are provided by U20 and associated components, with the output to the A/D Converter enabled by turning on Q23. Q25 sets the gain at unity, while Q26 and Z4 set the gain at 8.00. BRP, which stands for beta return path, returns currents flowing through Z4 to the A/D Converter, and C16 shunts ac signals on BRP to Ground 5. The resistance being measured plus R15 and C15 provide noise filtering of the HI input for the 64-kilohm range, with C14 switched in parallel with C15 by Q24 for the two lower resistance ranges. The VHG amplifier, U21, drives guard traces surrounding all HI circuit traces to prevent leakage under high humidity conditions.

CURRENT SOURCE

Two zener-referenced current outputs can be set by the current source circuitry, with one of the two selected at all times. The 256-ohm and 2048-ohm ranges use the 1.0 mA output, and the 64-kilohm range uses the 32-uA output. The 32-uA output can be set to another value by changing a precision resistor if a larger full scale value than 64-kilohms is desired.

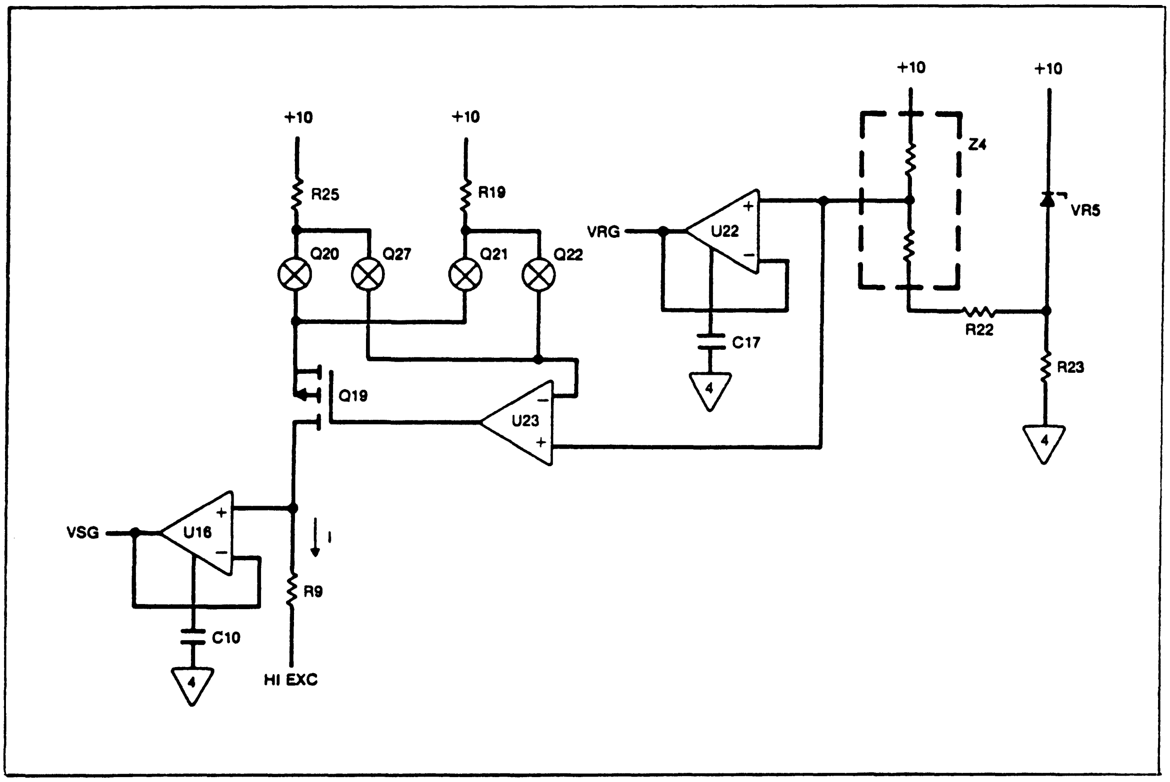


Figure 163-6. Current Source

A simplified schematic of the current source is shown in Figure 163-6. As can be seen in the schematic, the current source is centered around a stable voltage reference and precision resistances. A potential 6.2V below the +10V rail is generated by the zener reference set composed of VR5, R23, and R22, and this is then divided down to 5.00V below the rail by Z4. Range selection is provided by Q20 and Q27 (which select R25 for a 1 mA current) and Q21 and Q22, which select R19 for a 32 uA (standard) current. U23 compares the voltage across R25 or R19 to the 5V reference and enhances the gate of Q19 by the necessary amount to bring equilibrium to the circuit. Q19 then passes the current through R9 to the HI EXC reed switches. The VRG amplifier, U22, provides guard drive to traces that prevent leakage out of or into the circuit nodes that sit at the +5V potential. The VSG amplifier, U16, provides guard drive to traces which prevent leakage out of the circuitry at the potential of the drain of Q19. Capacitors C10 and C17 stabilize U16 and U22 respectively in their unity-gain configuration.

GROUND SENSE AMPLIFIER

The ground sense amplifier sets LO to a potential that allows the A/D Converter to make readings of HI with respect to ground. In 4-wire mode, tha amplifier compares LO to the analog ground 5, and in 3WA and 3WCM modes it compares the output of the 3-wire compensation amplifier to analog ground. To set LO at the desired voltage level, the amplifier pulls the necessary current through LO EXC in 4-wire and 3WCM modes, or LO COM in the 3WA mode.

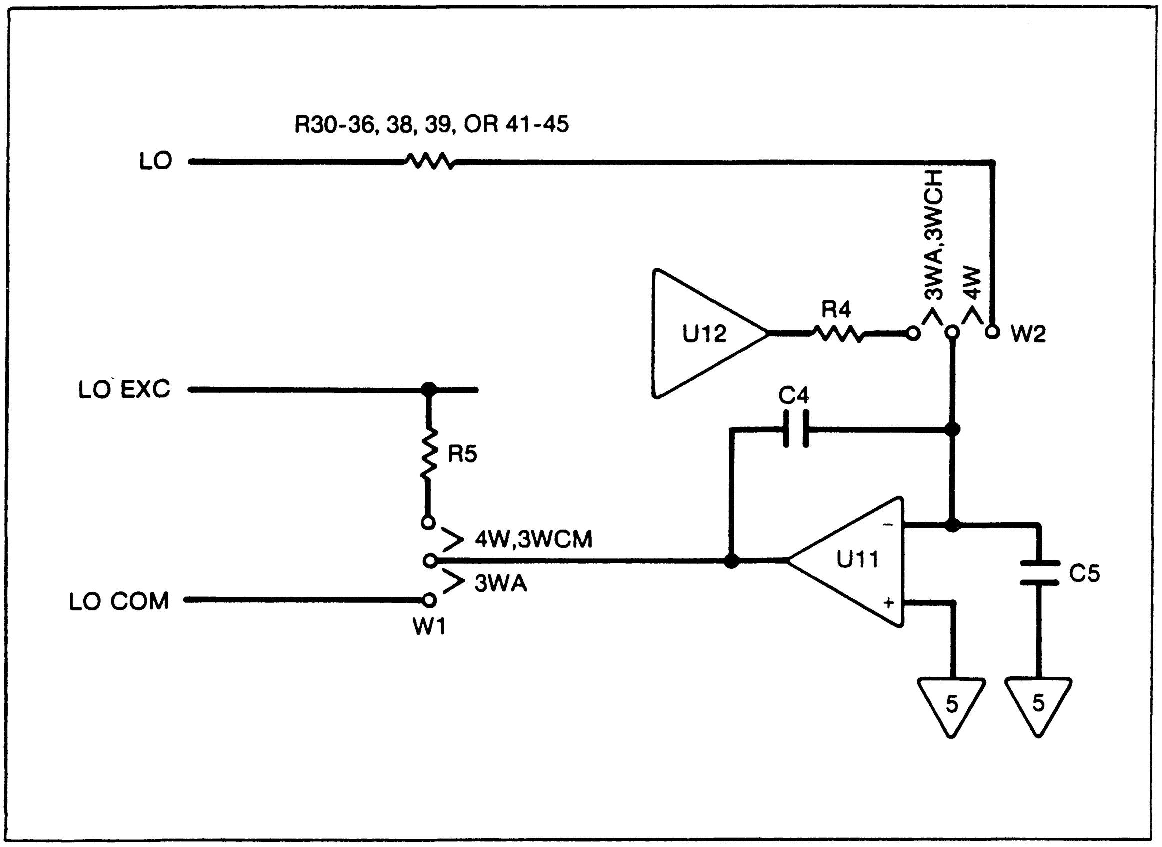


Figure 163-7. Ground Sense Amplifier

Refer to the simplified schematic of teh ground sense amplifier shown in Figure 163-7. The ground sense amplifier, as part of the measurement circuit, senses the potential at LO, or the output of U12, and sets it to analog ground 5 potential, thereby allowing the A/D Converter, which does not have a differential input, to make measurements with respect to ground. U11, in response to the inputs, pulls current through R5 and LO EXC or LO COM, depending on the setting of W1. Capacitor C4 in combination with R4 or R30 through 36, R38, R39, or R41 through 45 roll off the gain of U11 to reduce out-of-band noise, and C5 reduces the noise sensitivity of U11.

3-WIRE COMPENSATION AMPLIFIER

The output of the 3-wire compensation amplifier is selected when W2 is set to the 3WA and 3WCM position. The voltage difference between LO and LO EXC is measured to determine the lead wire voltage drop, and the output of the compensation amplifier is set to that one lead wire drop above the LO potential. The ground sense amplifier sets the output of the compensation amplifier to ground potential, setting LO to one lead wire voltage drop below ground, and thereby compensating for the HI lead wire drop.

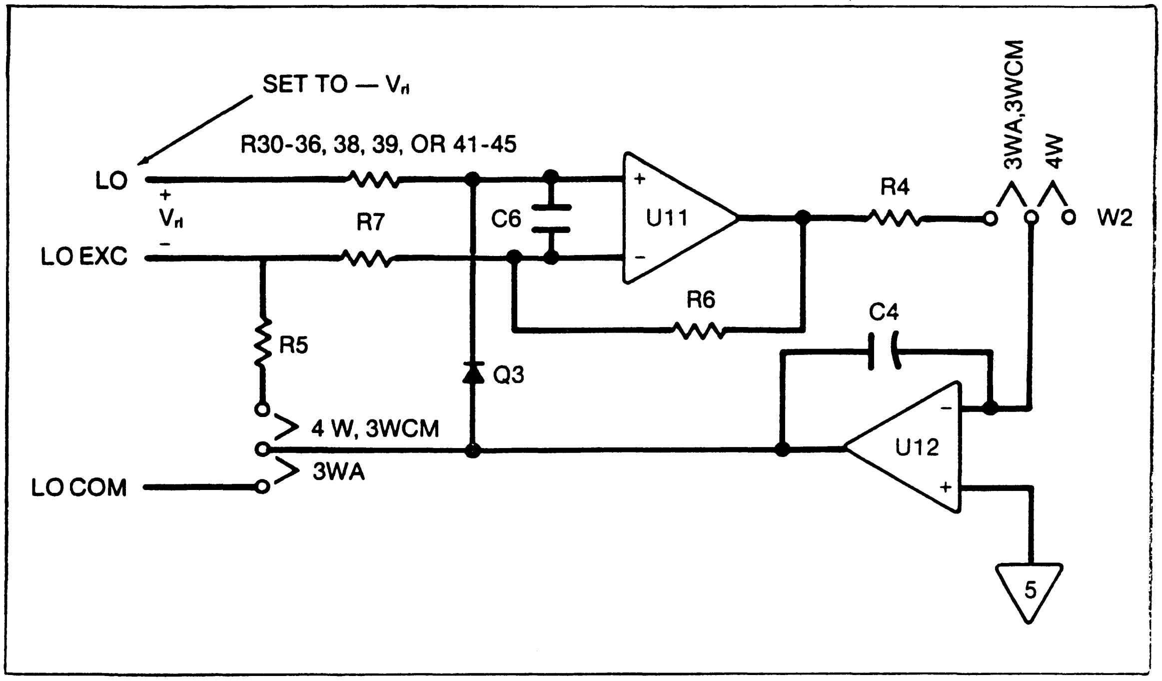


Figure 163-8. 3-Wire Compensation Amplifier

Refer to Figure 163-8, a simplified schematic of the 3-wire compensation amplifier, for the following discussion. In the two 3-wire modes of operation, U12 measures the lead wire voltage drop between LO and LO EXC (Vrl), with R7 and R6 setting the gain at -1, so that the U12 output is +Vrl, or one lead wire drop, above LO. U11 senses this output, and pulls current through LO COM or LO EXC until the U12 output is set at ground potential, thereby setting LO at -Vrl or one lead wire drop below ground to compensate for the lead wire drop in the HI lead. R4 and C4 stabilize the compensation amplifier loop and roll off the gain for frequencies that are not of interest, and the resistors in the LO path plus C6 and R7 reduce the noise sensitivity of U12.

ZERO CIRCUITRY

The zero circuitry, which is enabled by the A/D Converter, configures the scanner so that readings can be made which will allow the A/D Converter to subtract zero errors from all channel measurements. The circuitry is enabled at the start of each scan, giving direct readings of voltage and current offsets on the 256-ohm and 64-kilohm ranges. The 2048-ohm range zero reading is calculated by dividing the 256-ohm range zero reading by 8.

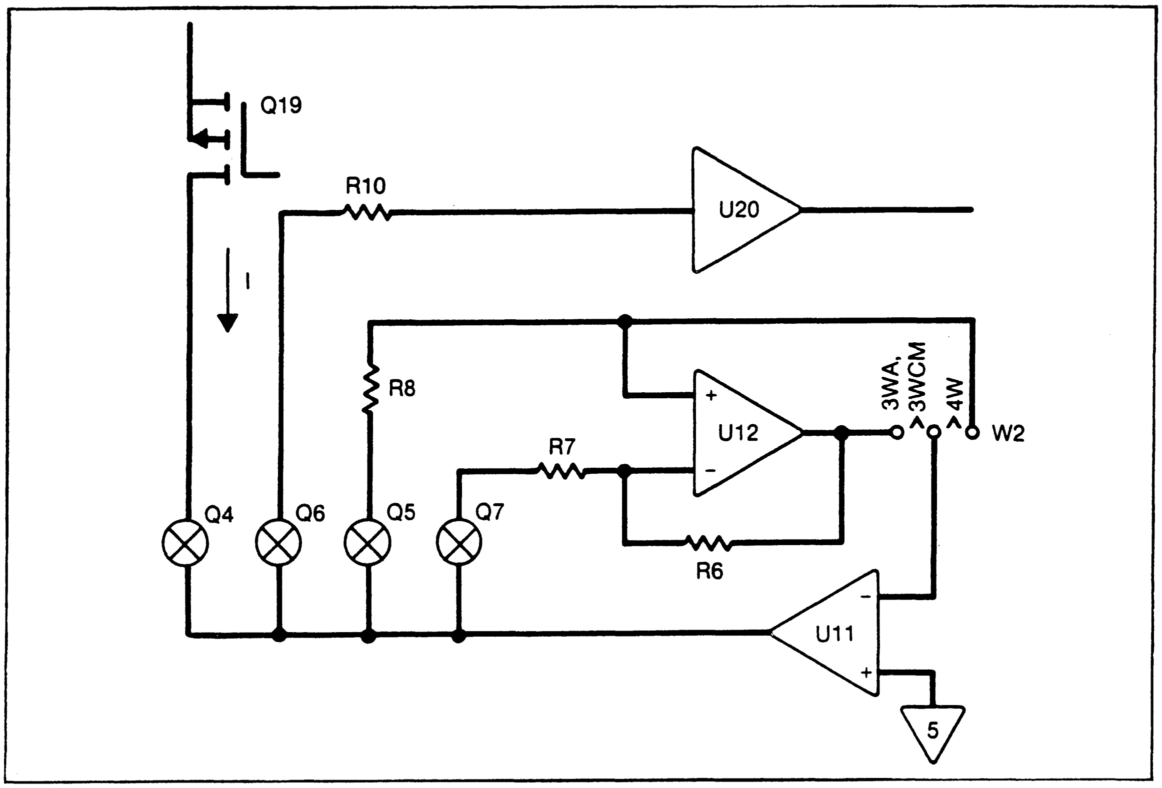


Figure 163-9. Zero Circuitry

Refer to Figure 163-9, a simplified schematic of the zero circuitry, for the following discussion.

To allow the A/D Converter to make zero readings, Q5 and Q7 close the loop around U11 and U12 so that voltage errors appear at the output of U11, and Q6 then connects the U11 output to the gain amplifier, U20. Q4 is turned on to connect the current source to U11 and keep the zero measurements consistent with channel measurements. The resistances of R8 and R10 add to the "on" resistances of Q5 and Q6 to cancel bias current shifts generated by the series resistances present in the HI and LO input lines when making channel readings.

CALIBRATE CIRCUITRY

The calibrate circuitry is enabled by the A/D Converter once every ten minutes (or on command) and the subsequent calibrate readings are used to calculate gain correction factors used by the A/D Converter when making channel readings.

Three precision resistors located on the scanner are measured and used as references for the three ranges. The voltages expected by the 2.048-volt full scale A/D Converter during calibrate are: 1.600V on the 256-ohm range, 2.000V on the 2048-ohm range, and 1.5872V on the 64-kilohm range. If a larger full scale than 64-kilohms is desired, one of the precision reference resistors must be changed.

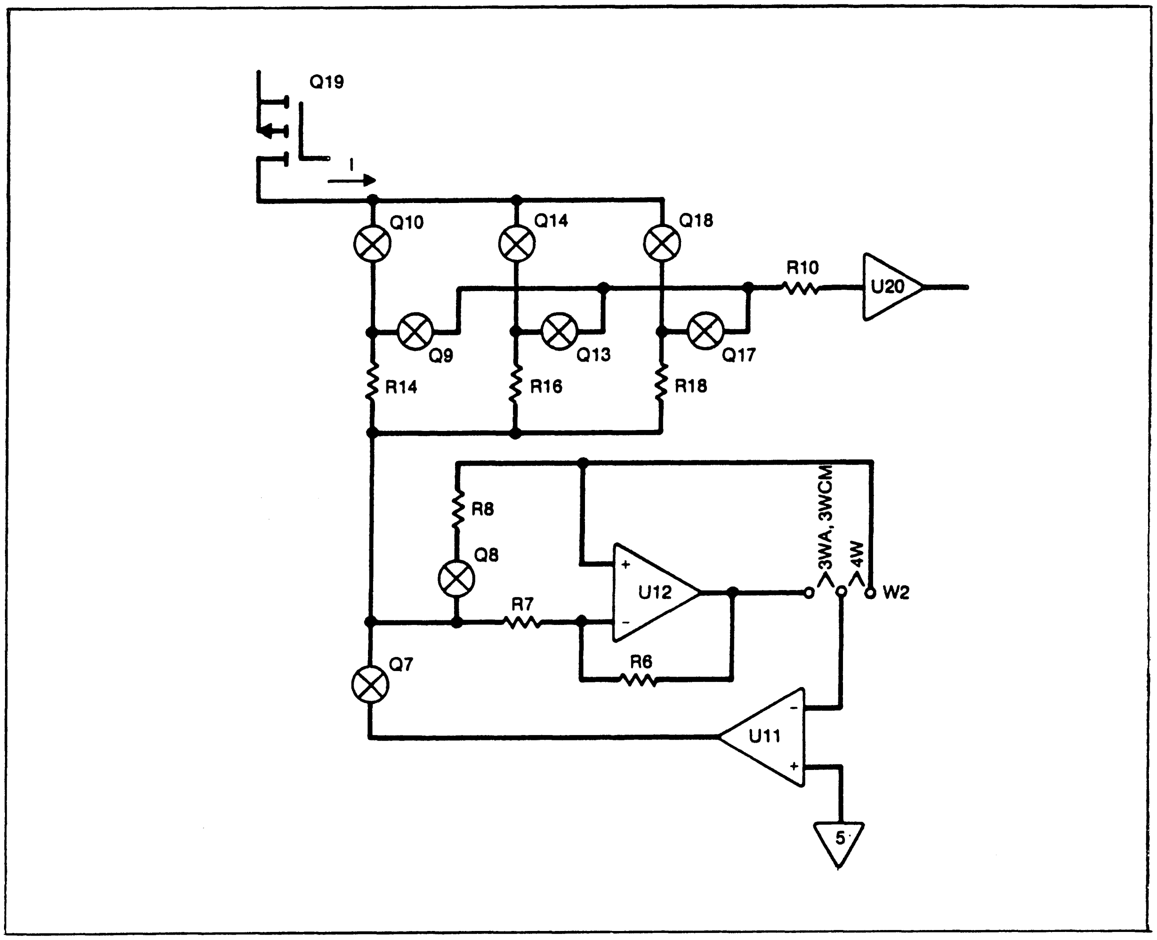


Figure 163-10. Calibrate Circuitry

Figure 163-10 is a simplified schematic of the calibrate circuitry. To close the loop around U11 and U12 in a way that bias current and offset voltage errors are included in the calibrate readings, Q7 and Q8 are turned on. U11 pulls current through Q7, setting the lower ends of R14, R16, and R18 at the proper potential near ground. During a 256-ohm range calibrate, Q10 supplies current to reference resistor R14, and Q9 switches in the gain amplifier, U20, to make a measurement. During a 2048-ohm range calibrate, Q14 supplies current to R16, and Q13 switches in U20, and during a 64-kohm range calibrate, Q18 supplies R18, with Q17 switching in U20. Resistors R8 and R10 are included to cancel the primary shifts in readings made by U11, U12, and U20 bias currents.

CONTROL CIRCUITRY

The control circuitry is a CMOS and open-collector comparator circuitry that decodes the A/D Converter control signals and controls scanner operation. The control circuitry selects and drives the reed coils, turns on zero and calibrate circuitry, sets the gain of the gain amplifier, and sets the output of the current source when directed by the A/D Converter. The control circuitry also sends the proper configuration code back to the A/D Converter, asserts RDY (ready), and turns on the scanner output when the scanner is selected.

Figure 163-11 shows a simplified schematic of the scanner control circuitry.

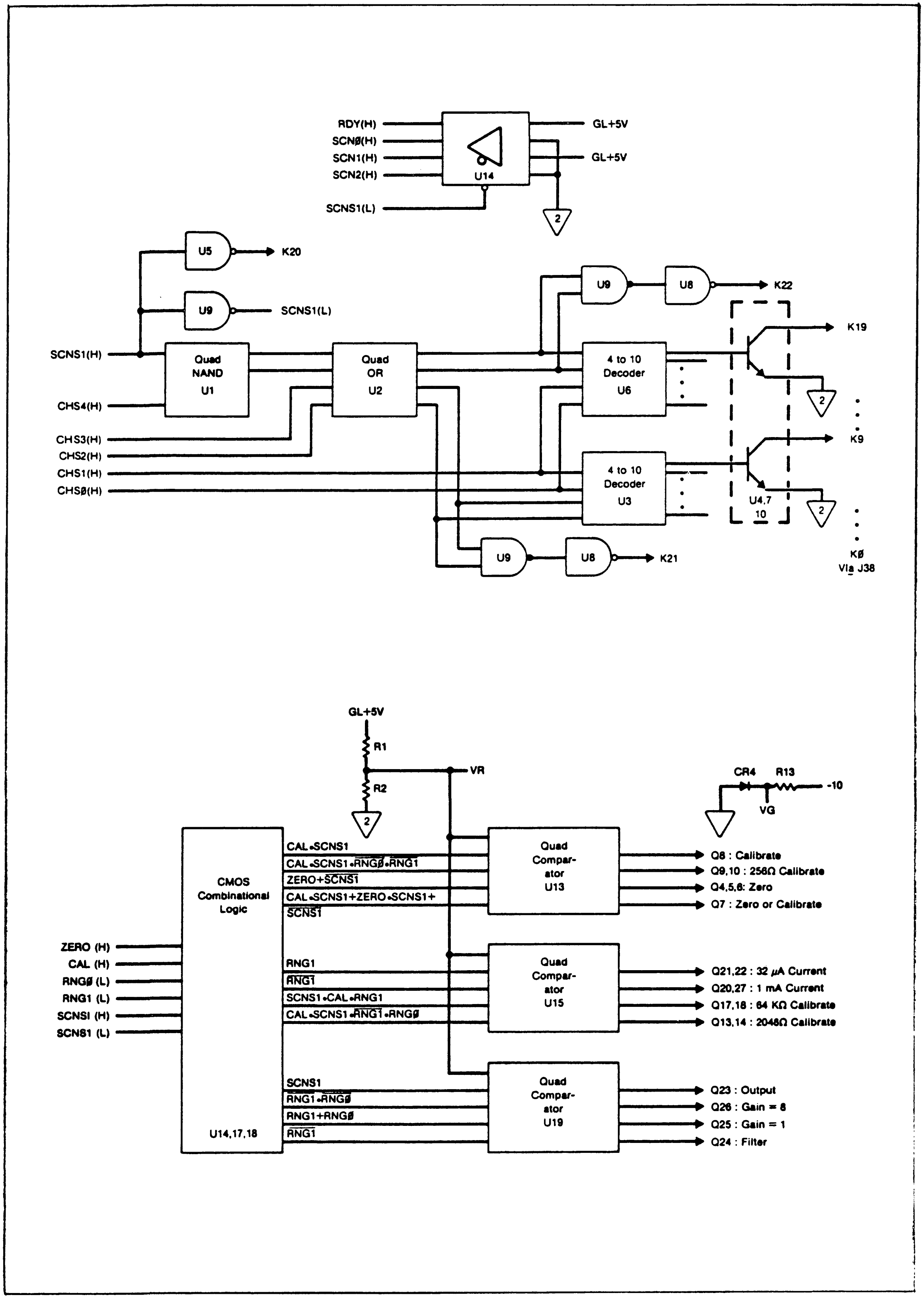


Figure 163-11. Control Circuitry

The first section of control circuitry asserts the RDY(H) and SCN[0:2](H) lines with U14 whenever SCNS1 is asserted by the A/D Converter. This indicates to the A/D Converter that the scanner is ready to make readings and that it is an RTD/Resistance Scanner.

A second section of control circuitry decodes and provides reed relay coil drive. U5 turns on K20 to connect the A/D Guard whenever the scanner is selected by SCNS1. U1 selects the 4-to-10 decoder needed to match the CHS4 line, and locks out the other decoder by asserting the two high bits of the unneeded one. When the scanner is not selected by SCNS1, the two high bits of both U3 and U6 are asserted, preventing both decoders from enabling any of their output lines. U2 passes either the lockout control lines, or the CHS2 and CHS3 channel select lines to U3 and U6. When U3 is selected, one gate of U9 instructs U8 to pull K21 in, completing the LO COM path for channels 0 through 9, while when U6 is selected, U9 has U8 pull K22 in, completing the LO COM path for channels 10 through 19. When a channel is selected by the SCNS1 and CHS[0:4] lines, U3 or U6 drive the base of an NPN transistor residing in arrays U4, U7, or U10, which switches on, driving the proper reed relay coil, and closing the four (A through D) channel reeds.

The third block of scanner control circuitry enables FET transistor switches to select the scanner functions and configurations. Logic ICs U14, U17, and U18 decode five control lines from the A/D; ZERO(H), CAL(H), RNGO(L), RNG1(L), and SCNS1(H), plus SCNS1(L) generated by U9. When SCNS1 is de-asserted and the scanner is not selected, zero mode is configured, while the current source range is set by the RNG1 line. Outputs of the logic gates are sent to comparators U13, U15, and U19 where they are compared to a 2.5V reference generated by R1 and R2. The Boolean expressions are written above each control line leading to the comparators. The comparator outputs then drive the gates of the FET transistors and perform the specific functions listed. All N-channel JFET transistors are pulled up to VG, a voltage set by CR4 and R13, through 100 kilohm pull-up resistors, which are not shown. For example, asserting CAL and SCNS1 causes U13 to turn on Q8, helping to place the scanner in a calibrate configuration.

GENERAL MAINTENANCE

The -163 RTD/Resistance Scanner normally does not require cleaning unless dirt, dust, or other contamination is visible on its surface. If cleaning is necessary, follow the cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

Six tests are conducted to verify that the RTD/Resistance Scanner is operating properly and meets specifications in all modes and operating ranges. These tests can be used as an initial acceptance test or as a troubleshooting aid. Equipment required to perform the following tests is listed in Table 163-1.

WARNING

THE COMPUTER FRONT END CONTAINS DANGEROUS HIGH VOLTAGES THAT CAN BE FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE COMPUTER FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

Performance Test Preparation

Perform the following procedure to prepare for performance testing:

1. Wire a -177 RTD/Resistance Input Connector as shown in Figure 163-12, with all connections to R1, R2, and R3 made to the resistor leads. (See Table 163-1 for resistor specifications.)

2. Switch OFF power to the Front End and disconnect the ac line cord and all other high voltage inputs.

```
   to all HI EXCs <---------------------|
                                        |--------+
                               S1  o 3W          |
   to all HIs <-------------o                    R1
                                   o 4W          |
                                   |---R4---+
                                                 |
                                                 R2
                                                 |
   to all LOs <------------------R5---+
                                                 |
                                                 R3
                                                 |
  to CH0 LO EXC <-----------------------+
  to CH1 LO EXC <-----------------------+
        .                 .             |
        .                 .             |
  to CH19 LO EXC <----------------------+
                                        |
  to CH4 LO COM <-----------------------+
  to CH14 LO COM <----------------------
```

Figure 163-12. Test Input Connector Schematic

3. Remove all addressable options from the Front End so that no address conflict occurs.

4. Set the -161 High Performance A/D Converter address switch to "0" and install the A/D Converter in the top Computer Front End option slot.

5. Set jumpers W1 and W2 of the RTD/Resistance Scanner for 4W operation, and install the scanner in the option slot immediately below the A/D Converter. See Figure 163-13.

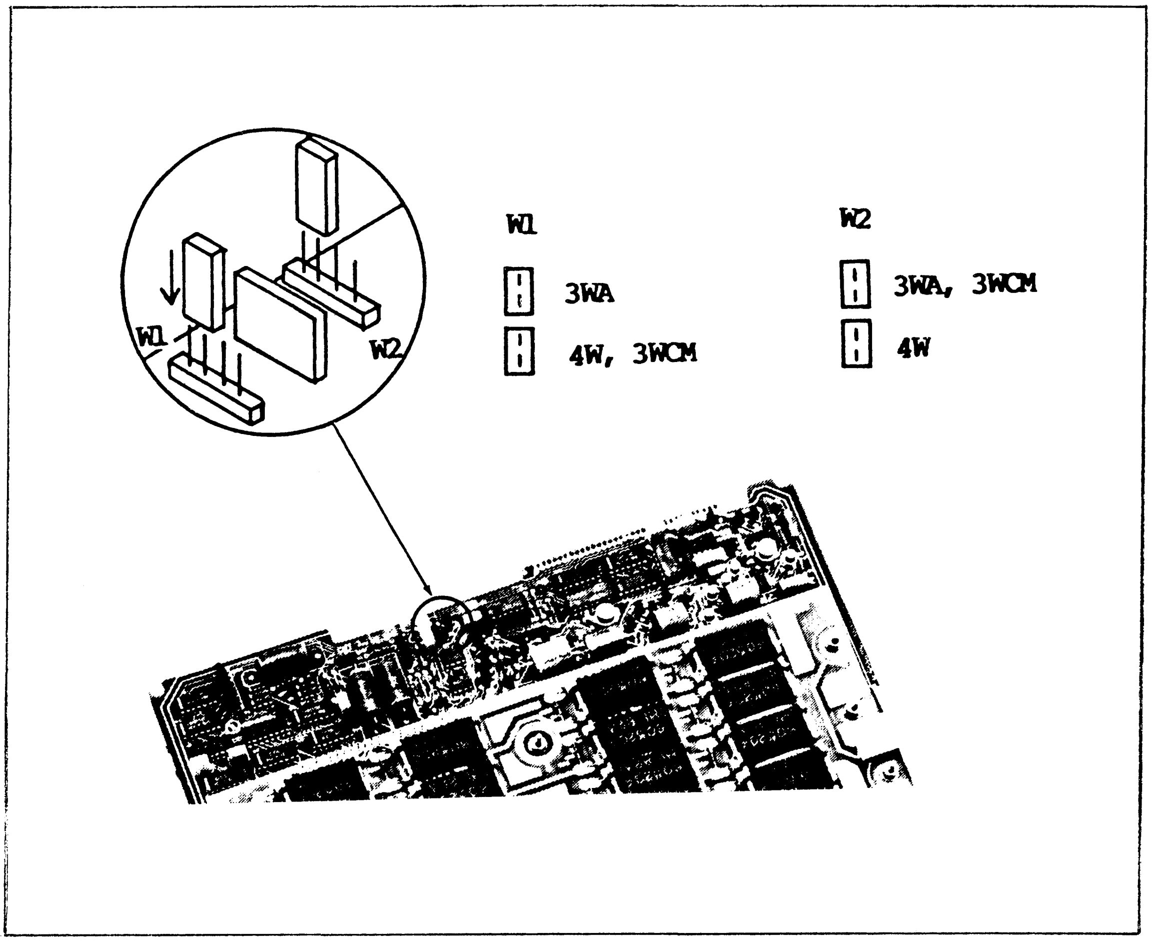


Figure 163-13. W1 and W2 Jumper Settings

6. Set S1 of the Test Input Connector to the 4W position, and install the connector on the RTD/Resistance Scanner.

7. Reconnect the ac line cord to the Front End and switch the power ON.

Performance Test Procedures

The following six tests will be performed:

- Serial Link Communication Test
- 256-Ohm Range, 4-Wire Mode Test
- 2048-Ohm Range, 4-Wire Mode Test
- 64-Kilohm Range, 4-Wire Mode Test
- 256-Ohm Range, 3WA Mode Test
- 256-Ohm Range, 3WCM Test

To conduct these tests, the Front End must be programmed using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

Use either PROCEDURE A (Terminal Mode) or PROCEDURE B (Computer Mode), depending on whether the six performance tests will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, conduct the six performance tests as follows:

SERIAL LINK COMMUNICATION TEST

1. Send the following commands to the Front End:

   MODE=TERM <CR>

   RESET CHAN(0..19) <CR>

   LIST CHAN(0..19) <CR>

2. A listing for each of the 20 designated channels should be returned as follows:

   aichan(0)=R, def=off
   .
   .
   .
   aichan(19)=R, def=off

250-OHM RANGE, 4-WIRE MODE TEST

1. Ensure the RTD/Resistance Scanner's W1 and W2 jumpers are set for 4W operation. See Figure 163-13.

2. Ensure that the Test Input Connector switch S1 is set to 4W.

3. Send the following commands to the Front End:

   FORMAT=DECIMAL <CR>

   DEF CHAN(0..19)=RESIST, MAX=100 <CR>

   SEND CHAN(0..19) <CR>

   The returned channel readings should be between 99.964 and 100.036 ohms.

2048-OHM RANGE, 4-WIRE MODE TEST

1. Send the following commands to the Front End:

   DEF CHAN(0..19)=RESIST, MAX=2000 <CR>

   SEND CHAN(0..19) <CR>

2. The returned channel readings should be between 99.930 and 100.070 ohms.

64K-OHM RANGE, 4-WIRE MODE TEST

1. Send the following commands to the Front End:

   DEF CHAN(0..19)=RESIST, MAX=6000 <CR>

   SEND CHAN(0..19) <CR>

2. The readings should now be between 98.700 and 101.300 ohms.

256-OHM RANGE, 3WA MODE TEST

1. Switch OFF power to the Front End and remove the RTD/Resistance Scanner and Test Input Connector.

2. Set the W1 and W2 jumpers of the scanner for 3WA operation. See Figure 163-13.

3. Set S1 of the Test Input Connector to the 3W position.

4. Reinstall both the RTD/Resistance Scanner and Test Input Connector in below the A/D Converter. Switch the power ON.

5. Send the following commands to the Front End:

   DEF CHAN(0..19)=RESIST, MAX=100 <CR>

   SEND CHAN(0..19) <CR>

   The readings should be between 99.743 and 100.257 ohms.

256-OHM RANGE, 3WCM TEST

1. Switch OFF power to the Front End, and remove the RTD/Resistance Scanner and Test Input Connector.

2. Set the W1 and W2 jumpers of the scanner for 3WCM operation. See Figure 163-13.

3. Ensure that S1 of the Test Input Connector is in the 3W position.

256-OHM RANGE, 4-WIRE MODE TEST

1. Ensure the RTD/Resistance Scanner's W1 and W2 jumpers are set for 4W operation. (See Figure 163-13).

2. Ensure that the Test Input Connector switch S1 is set to 4W.

3. The following are sample BASIC programs for the IBM PC and 1722A. Enter and run one of these programs "as is" or make the modifications necessary to run on your host.

Program for IBM PC

```
10  CLOSE 1
20  CLS
30  REM open communication port, empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
90  PRINT #1"count=off"
100 GOSUB 300
120 PRINT #1,"def chan(0..19)=resist,max=100"
125 GOSUB 300
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 REM make measurement and read in response
160 PRINT #1,"send chan(0..19)"
170 FOR I=0 TO 19
180 INPUT #1,M$
190 PRINT "chan";I;"=";
200 PRINT USING "###.###";VAL(M$);
210 PRINT " ohms"
220 NEXT I
230 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:"AS NEW FILE 1%
50  OPEN "KB1:"AS OLD FILE 2%
60  PRINT #1,CHR$(3);
70  REM set up Computer Front End
```

```
80  PRINT #1,"mode=comp"
90  GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1,"def chan(0..19)=resist,max=100"
130 GOSUB 300
140 PRINT #1,"format=decimal"
150 GOSUB 300
160 REM make measurement and read in response
170 DIM M$(20)
180 PRINT #1,"send chan(0..19)"
190 FOR I%=0 TO 19\INPUT #2,M$(I%)\NEXT I%
200 X%=0\I%=0
210 FOR C%=0 TO 1
220 PRINT TAB(35*C%);"chan";I%;"=";
230 PRINT USING "S###.###",VAL(M$(X%));\PRINT" ohms";
240 X%=X%+1\I%=I%+1\IF X%>19 THEN 270
250 NEXT C%
260 GOTO 210
270 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

The returned readings should be between 99.964 and 100.036 ohms.

2048-OHM RANGE, 4-WIRE MODE TEST

1. Change the MAX parameter of the DEF CHAN command in the previous program (for the 256-Ohm Range, 4-Wire Mode Test) to 2000.

   The BASIC statement in line 120 should now read:

   ```
   PRINT #1,"def chan(0..19)=resist,max=2000"
   ```

2. Run the modified program.

   The returned readings should be between 99.930 and 100.070 ohms.

64K-OHM RANGE, 4-WIRE MODE TEST

1. Change the MAX parameter in the DEF CHAN command in the previous program (for the 256-Ohm Range, 4-Wire Mode Test) to 6000.

   The BASIC statement in line 120 should now read:

   ```
   PRINT #1,"def chan(0..19)=resist,max=6000"
   ```

2. Run the modified program.

   The returned readings should be between 98.700 and 101.300 ohms.

256-OHM RANGE, 3WA MODE TEST

1. Switch OFF power to the Front End and remove the RTD/Resistance Scanner and Test Input Connector.

2. Set the W1 and W2 jumpers of the scanner for 3WA operation. See Figure 163-13.

3. Set S1 of the Test Input Connector to the 3W position.

4. Reinstall both the RTD/Resistance Scanner and the Test Input Connector below the A/D. Switch the power ON.

5. Change the MAX parameter of the DEF CHAN command in the previous program (for the 256-Ohm Range, 4-Wire Mode Test) to 100.

   The BASIC statement in line 120 should now read:

   ```
   PRINT #1,"def chan(0..19)=resist,max=100"
   ```

6. Run the modified program.

   The readings should be between 99.743 and 100.257 ohms.

256-OHM RANGE, 3WCM TEST

1. Switch OFF power to the Front End and remove the RTD/Resistance Scanner and Test Input Connector.

2. Set the W1 and W2 jumpers of the scanner for 3WCM operation. (See Figure 163-13).

3. Ensure that S1 of the Test Input Connector is in the 3W position.

4. Reinstall both the RTD/Resistance Scanner and the Test Input Connector below the A/D Converter. Switch the power ON.

5. Run the program that was run for the 256-Ohm Range, 3WA Mode Test.

   The readings returned should be between 99.150 and 100.850 ohms.

This completes performance testing in the Computer Mode.

CALIBRATION

RTD/Resistance Scanner does not require calibration adjustments.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the RTD/Resistance Scanner is given in Table 163-2.

For parts ordering information, see Section 6 of this manual.

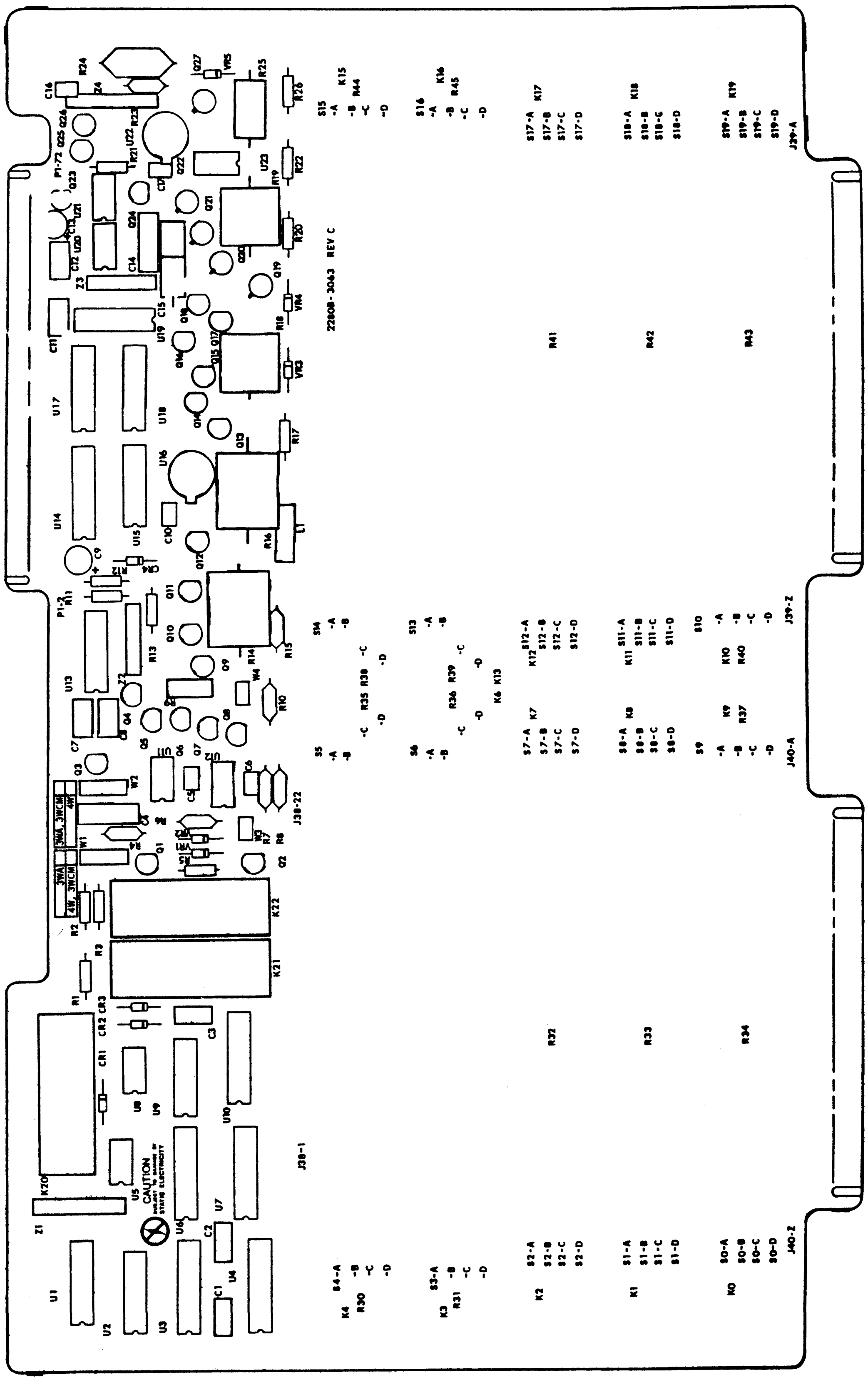
Figure 163-14 is a schematic diagram of the RTD/Resistance Scanner.

TABLE 163-2'. RTD/RESISTANCE SCANNER PCA
(SEE FIGURE 16:14:3.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	---------DESCRIPTION---------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	NOTE
C 1- 3, 7,		CAP,POLYES,0.22UF,+-10%,50V	696492	89536	696492	7	
C 8, 11, 12			696492				
C 4, 14		CAP,POLYPR,0.047UF,+-10%,100V	446773	89536	446773	2	
C 5, 16		CAP,CER,0.22UF,+-20%,50V,Z5U	519157	51406	RPE111Z5U224M50V	2	
C 6		CAP,CER,0.001UF,+-20%,100V,X7R	402966	72982	8121-A100-W5R-102M	1	
C 9, 13		CAP,TA,10UF,+-20%,15V	193623	56289	196D106X0015A1	2	
C 10, 17		CAP,CER,100PF,+-2%,100V,COG	512848	51406	RPE121	2	
C 15		CAP,POLYPR,470PF,+-5%,50V	740464	89536	740464	1	
CR 1- 4, 8-	*	DIODE,SI,BV= 75.0V,IO=150MA,500 MW	203323	07910	1N4448	24	
CR 27	*		203323				
H 1		SCREW,MACH,PHP,S STL,4-40X3/4	681973	89536	681973	1	
H 2		NUT,HEX,S.STL,4-40	147611	89536	147611	1	
H 3		WASHER	147603	89536	147603	6	
H 4		WASHER	195354	89536	195354	6	
H 5		WASHER	146225	89536	146225	6	
J 38		CONN,POST,PWB,.025SQ,NON-INSUL,GOLD30	513861	00779	1-87022-7	22	
K 0- 19		RELAY COIL ASSY	777631	89536	777631	20	
K 20- 22		RELAY,REED,1 FORM A,5VDC	520247	71707	UF-40115	3	
L 1		INDUCTOR,0.15 UH,+/-10%,400MHZ,SHLDED	256297	24759	MR0.15	1	
MP 2		SPACER,REED	617415	89536	617415	1	
MP 3		SPACER,SWAGED,RND,BRASS,0.125IDX0.187	436675	89536	436675	5	
MP 4		SPACER,SWGD,RND,BRASS,0.150IDX0.125	335075	89536	335075	1	
MP 5		BAG,SHIELDING,TRANSPARENT,12"X16"	680983	89536	680983	1	
MP 6		BOTTOM GUARD	579151	89536	579151	1	
MP 7		PCB RETAINER	579078	89536	579078	2	
MP 8		INSULATOR, BOTTOM	579102	89536	579102	1	
P 38		CONN,PWB,REC,BOARD MOUNT,1/16 THICK	267476	00779	85861-2	22	
Q 1- 18, 23-	*	TRANSISTOR,SI,N-JFET,TO-92	376475	15818	U2810J	22	
Q 26	*		376475				
Q 19- 22, 27	*	TRANSISTOR,SI,P-MOS,ENHANCEMENT,TO-72	741058	89536	741058	5	
R 1, 2, 17,		RES,CF,100K,+-5%,0.25W	348920	80031	CR251-4-5P100K	5	
R 21, 25			348920				
R 3		RES,CC,330,+-5%,0.25W	147967	01121	CB3315	1	
R 4, 15, 30-		RES,MF,4.99K,+-1%,0.125W,100PPM	168252	91637	MFF1-84991	16	
R 36, 38, 39,			168252				
R 41- 45			168252				
R 5		RES,CC,100,+-5%,0.25W	147926	01121	CB1015	1	
R 6, 7		RES,MF,10K,+-0.1%,0.125W,25PPM	435065	89536	435065	2	
R 8, 10		RES,MF,4.75K,+-1%,0.125W,100PPM	260679	91637	CMF554751F	2	
R 9		RES,CC,910,+-5%,0.5W	170704	89536	170704	1	
R 11- 13		RES,CF,10K,+-5%,0.25W	348839	80031	CR251-4-5P10K	3	
R 14		RESISTOR,WW 200(	653287	89536	653287	1	
R 16		W W RESISTOR	730903	89536	730903	1	
R 18		W W RESISTOR 49.6K	743625	89536	743625	1	
R 19		W W RESISTOR 156K	743617	89536	743617	1	
R 20		RES,CF,20K,+-5%,0.25W	441477	80031	CR251-4-5P20K	1	
R 24		RES,5.0K(+-.05% 0+-5PPM TC 1/4W BOBB	288647	89536	288647	1	
R 37, 40		RES,CC,510,+-5%,0.25W	218032	01121	CB5115	2	
S 10- 79		SWITCH,REED,1 FORM A,10VA,36AT	647578	89536	647578	80	
U 1, 9, 17	*	IC,CMOS,QUAD 2 INPUT NAND GATE	453241	02735	CD4011BE	3	
U 2	*	IC,CMOS,QUAD 2 INPUT OR GATE	408393	02735	CD4071BE	1	
U 3, 6	*	IC,CMOS,BCD-DEC & BINRY-OCTAL DECODER	650689	89536	650689	2	
U 4, 7, 10	*	IC,ARRAY,7 TRANS,NPN,COMMOM EMITTER	407866	49671	CA3081	3	
U 5, 8	*	IC,CMOS,DUAL 2 IN NAND DRVR W/OPN DRN	604207	02735	CD40107BE	2	
U 11, 12, 20,	*	IC,OP AMP,LO-OFFSET VOLTAGE,LO-NOISE	605980	06665	OP-07DP	4	
U 23	*		605980				
U 13, 15, 19	*	IC,COMPARATOR,QUAD,CERAMIC,14 PIN DIP	605584	89536	605584	3	
U 14	*	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	12040	MM80C97N	1	
U 16, 22	*	IC,OP AMP,GENERAL PURPOSE,TO-78 CASE	418368	89536	418368	2	
U 18	*	IC,CMOS,QUAD 2 INPUT NOR GATE	355172	02735	CD4001AE	1	
U 21	*	IC,OP AMP,JFET INPUT,8 PIN DIP	605568	89536	605568	1	
VR 1, 2	*	ZENER,UNCOMP, 18.0V, 5%, 7.0MA, 0.4W	327973	04713	1N967B	2	
VR 3	*	ZENER,UNCOMP, 5.1V, 5%, 20.0MA, 0.4W	159798	04713	1N751A	1	
VR 4	*	ZENER,UNCOMP, 4.7V, 5%, 20.0MA, 0.4W	524058	14552	1N751	1	
VR 5	*	ZENER REFERENCE SET	646539	89536	646539	1	

TABLE 163-2. RTD/RESISTANCE SCANNER PCA
(SEE FIGURE 163-14.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	---------DESCRIPTION---------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	NOTE
VR 22, 23	*		646539				
W 1, 2		CONN,PWB,HEADER,SIP,0.100,4 PIN	417329	89536	417329	2	
W 3, 4		CONN,PWB,HEADER,SIP,0.100,2 PIN	643916	28213	3469/20	2	
W 5, 6		JUMPER, RECEPTACLE	530253	00079	530153-2	2	
Z 1		RES,NET,SIP,8 PIN,7 RES,100K,+-2%	412908	89536	412908	1	
Z 2, 3		RES,NET,SIP,6 PIN,5 RES,100K,+-2%	412726	89536	412726	2	
Z 4	*	REF DIVIDER RNET ASSY TESTED 2280A	731018	89536	731018	1	



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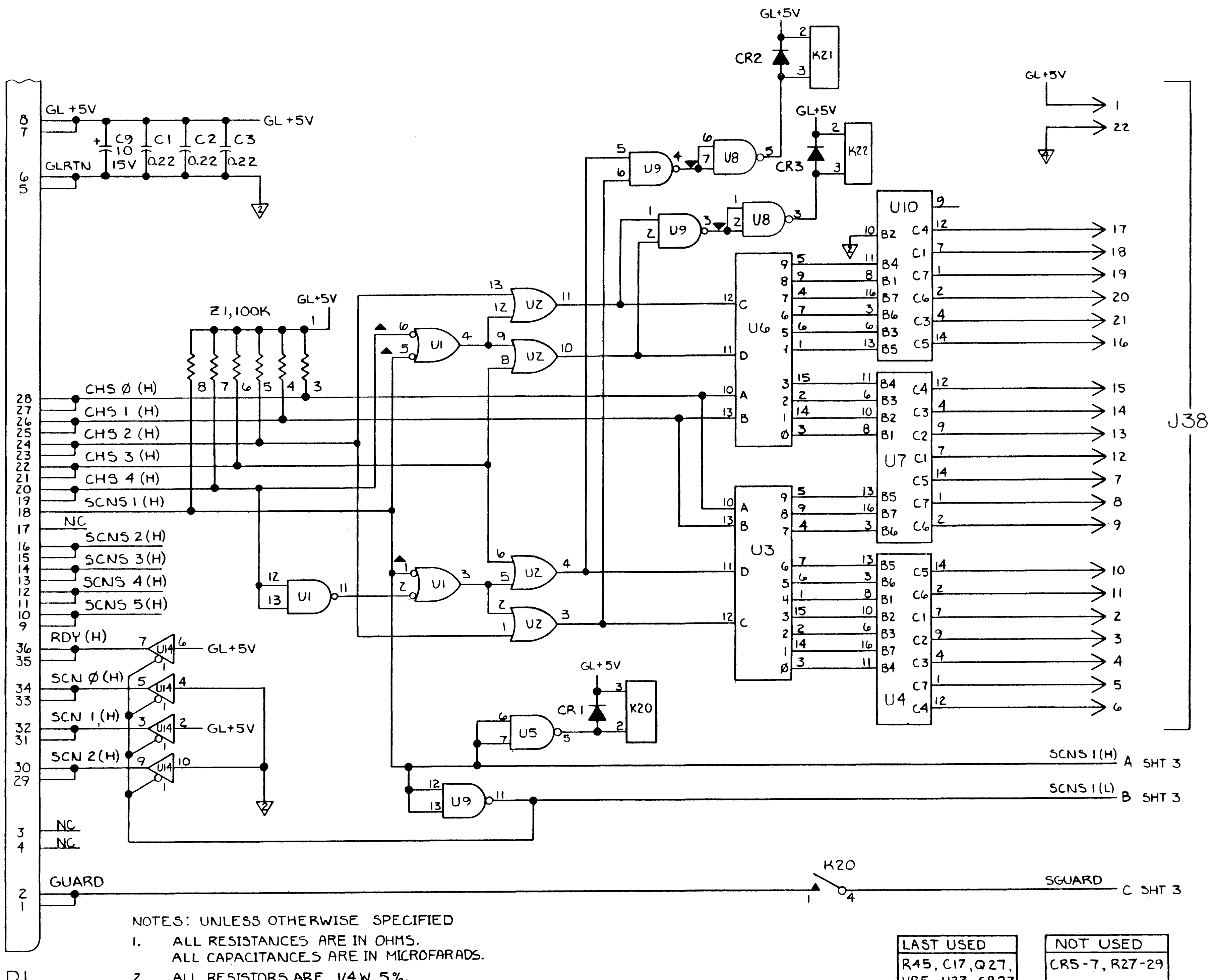
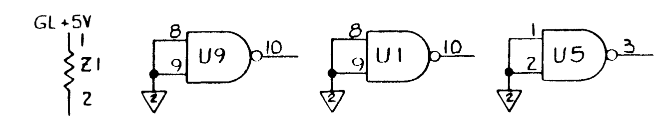


NOT USED



I.C. POWER AND GROUND						
REF. DES.	GL+5V	▽2	+10	-10	VG	DEVICE NAME
U1	14	7				4Ø11 B
U2	14	7				4Ø71 B
U3	16	8				CD 4Ø28 B
U4		5,15				CA 3Ø81
U5	8	4				4Ø1Ø7
U6	16	8				CD 4Ø28 B
U7		5,15				CA 3Ø81
U8	8	4				4Ø1Ø7
U9	14	7				4Ø11 B
U10		5,15				CA 3Ø81
U11			7	4		OP-Ø7
U12			7	4		OP-Ø7
U13			3	12		LM 239
U14	16	8				8ØC97
U15			3	12		LM 239
U16			7	4		LM2Ø8
U17	14	7				4Ø11 B
U18	14	7				4ØØ1 B
U19			3	12		LM 239
U20			7	4		OP-Ø7
U21			7	4		TLØ81 IJG
U22			7	4		LM2Ø8
U23			7	4		OP-Ø7
Z1	1					—
Z2					1	—
Z3					1	—

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCES ARE IN OHMS.
   ALL CAPACITANCES ARE IN MICROFARADS.
2. ALL RESISTORS ARE 1/4 W, 5%.
3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 & Y32.14.
4. CR8-27, KØ-19, P38 ARE SHOWN ON SHEET 2 FOR REFERENCE ONLY.

LAST USED
R45, C17, Q27, VR5, U23, CR27, Z4, K22, L1, W4

NOT USED
CR5-7, R27-29

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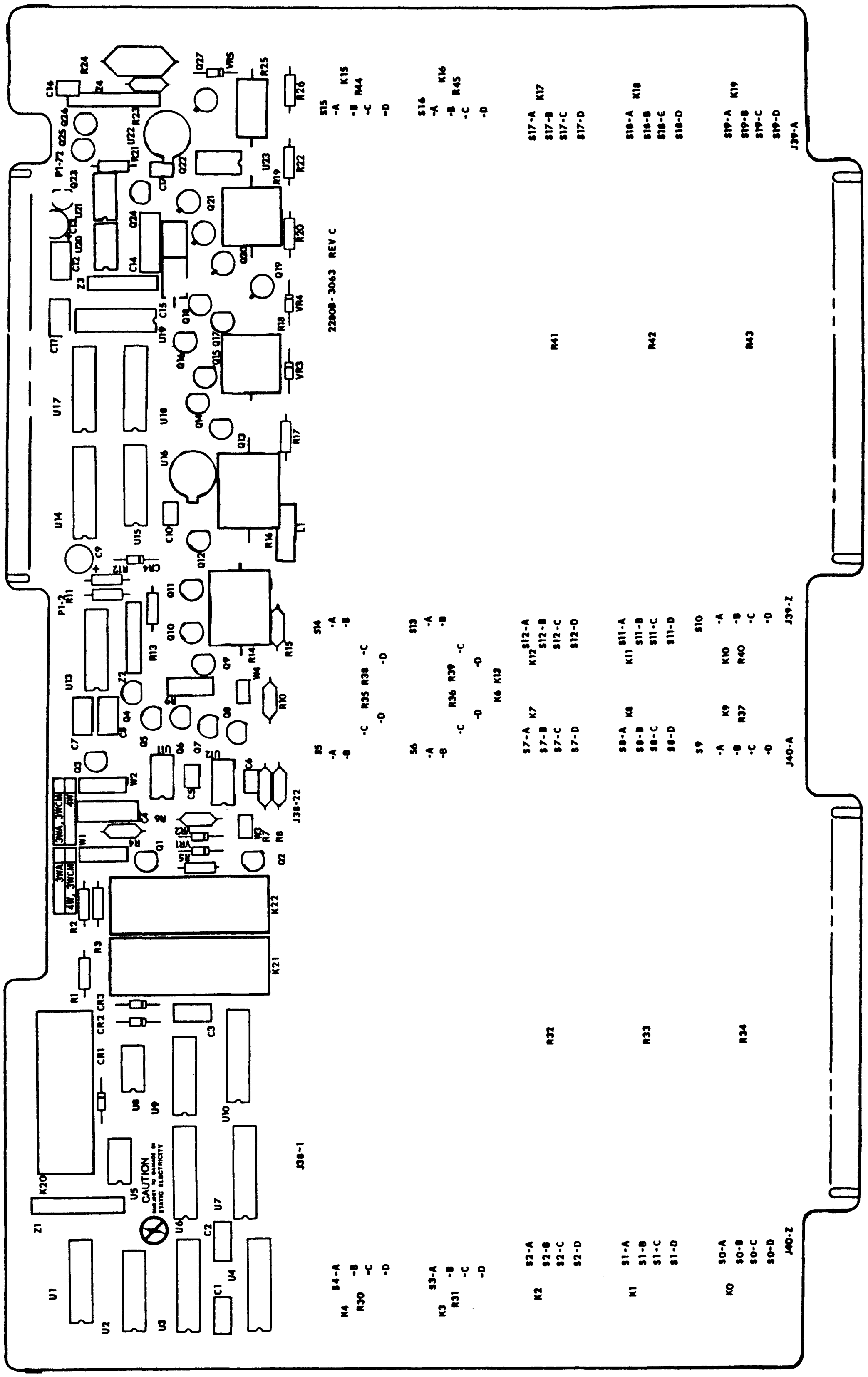
(Sheet 1 of 3)

Figure 163-14. RTD-Resistance Scanner Schematic



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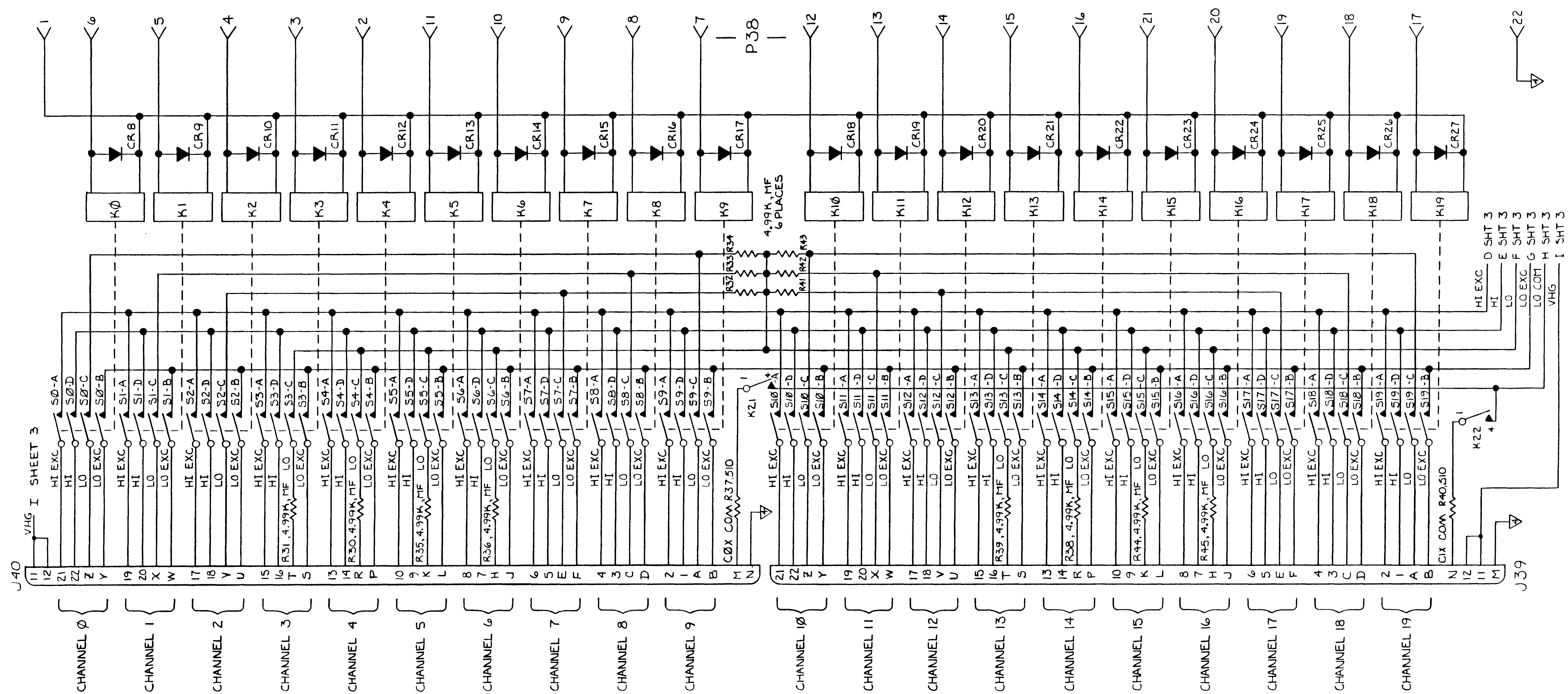

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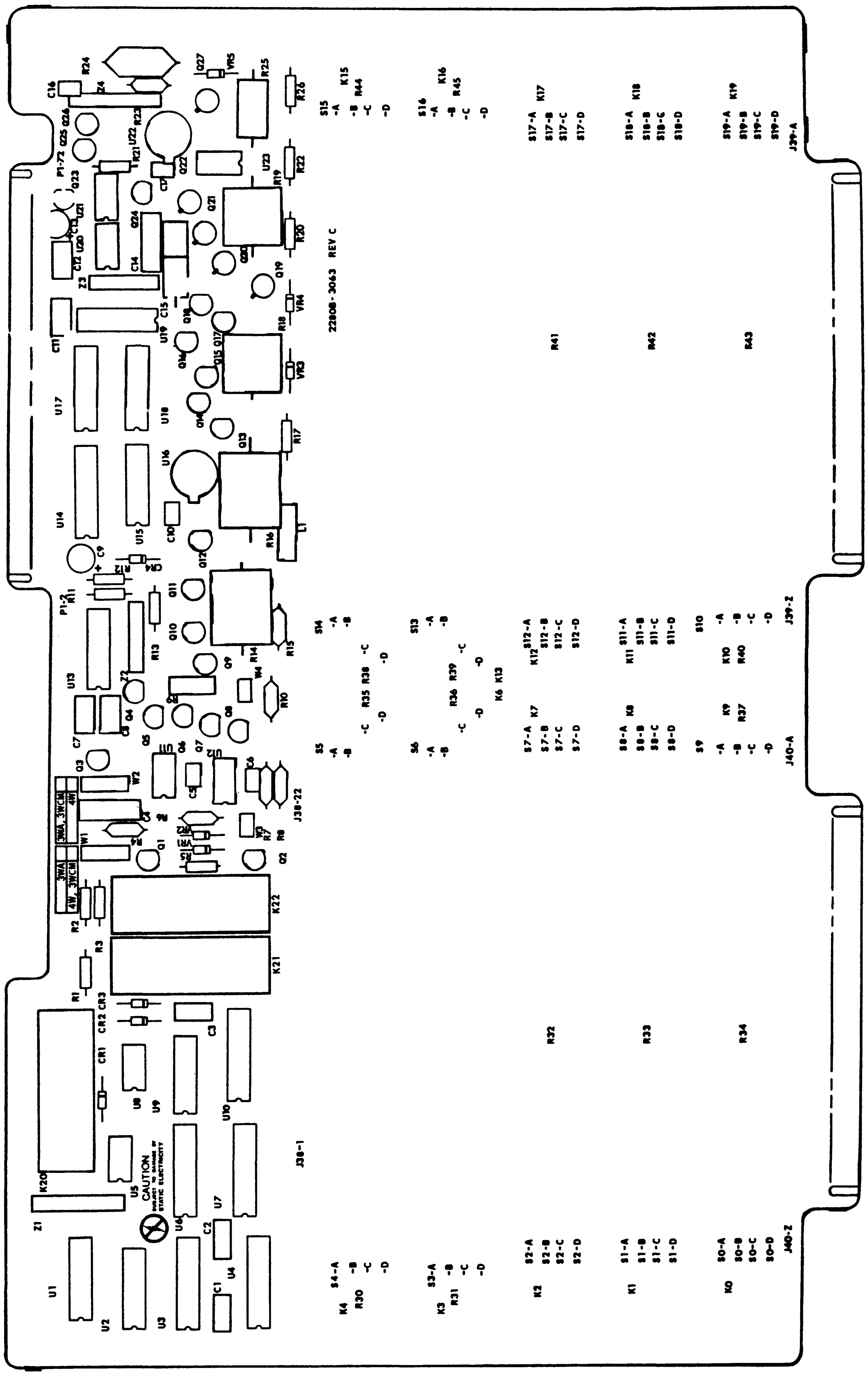
(Sheet 2 of 3)

Figure 163-14. RTD-Resistance Scanner Schematic (cont.)



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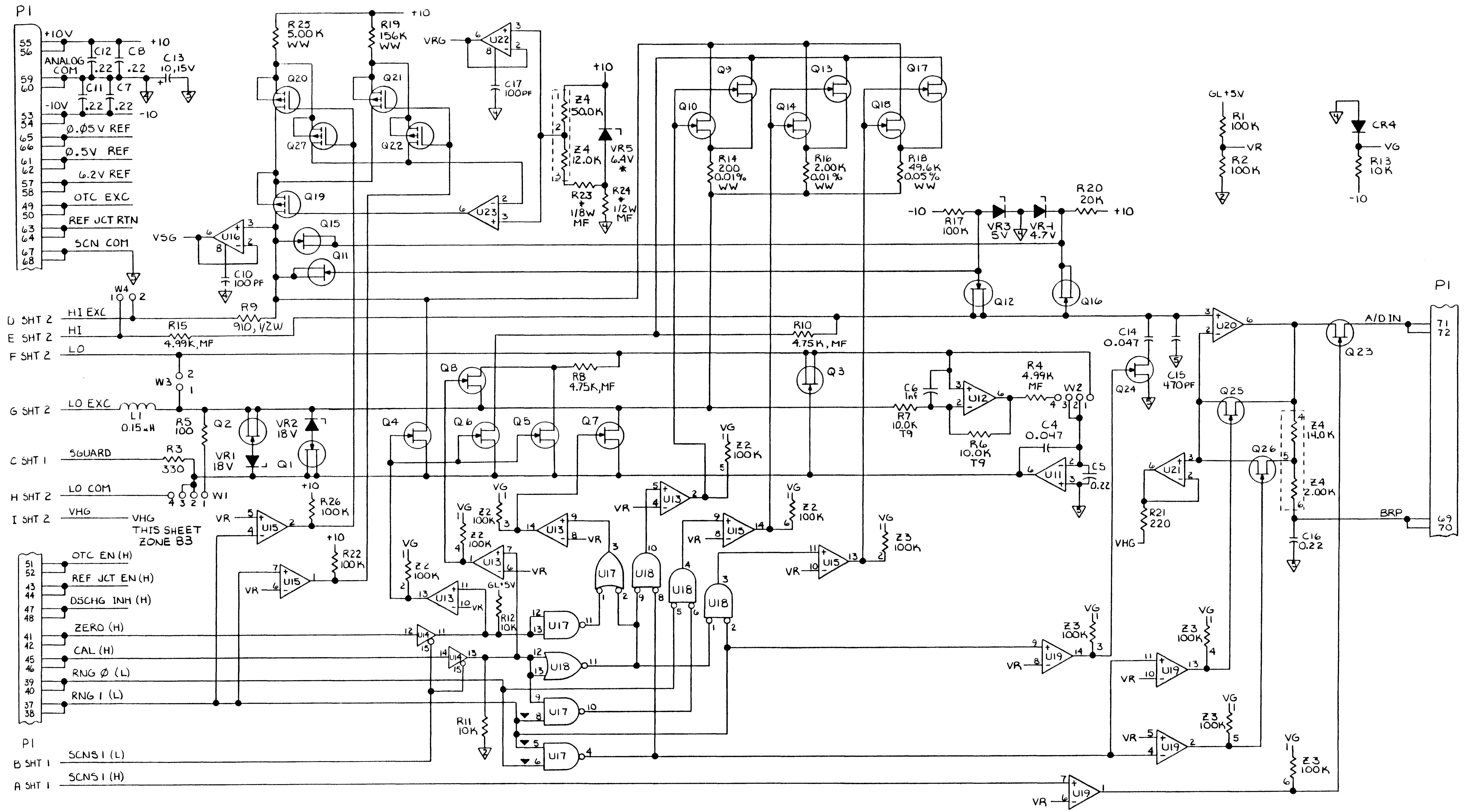

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(Sheet 3 of 3)

Figure 163-14. RTD-Resistance Scanner Schematic (cont.)

DESCRIPTION

The -164 Transducer Excitation Module (shown in Figure 164-1) provides excitation conditioning for measuring RTDs, low resistances, strain gauges, and strain-gauge-based transducers. Five precision current sources and one precision voltage source are available.

The -161 High Performance A/D Converter (or the -165 Fast A/D Converter), the -162 Thermocouple/DC Voltage Scanner, and the -176 Voltage Input Connector are needed to measure the transducer's response to the applied excitation. Excitation currents or voltages are connected to the transducer's excitation field wiring on the -174 Transducer Excitation Connector. Terminals are also provided on this connector to terminate the transducer sense wiring and to connect its signals to the Voltage Input Connector.

Excitation is provided for up to 20 measurements. The choice of voltage or current excitation is made in groups of five channels using a jumper on the Excitation Connector.

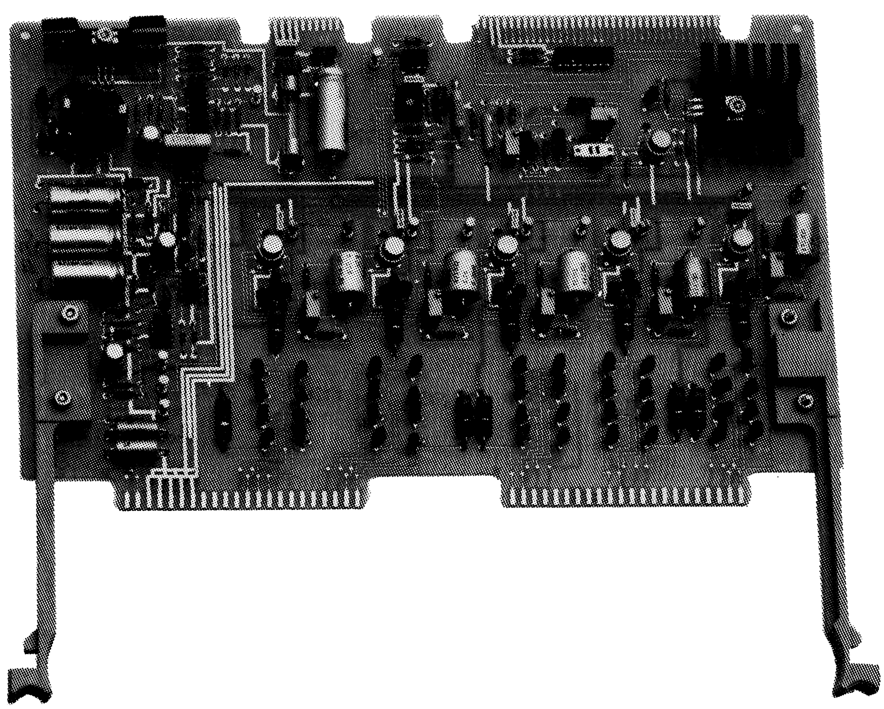


Figure 164-1. Transducer Excitation

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains the -164 Transducer Excitation Module theory of operation, performance tests, calibration procedure, a parts list, and a schematic diagram.

Installation, operating and system configuration instructions are located in the System Manual. Option specifications can be found in the appendices to this manual and the System Manual.

The test equipment required to procedures in this subsection's is listed in Table 164-1. A summary of test equipment required to perform all procedures in this manual is given in Table 2-2 in Section 2 of this manual.

Table 164-1. Required Test Equipment for -164

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
Digital Multi-meter (DMM)	NA	Fluke 8505A
Resistance Calibrator	NA	Fluke 5450A
High Performance A/D Converter	NA	Fluke Option -161
and		and
Thermocouple/DC Volts Scanner	NA	Fluke Option -162
or		
Fast A/D Converter		Fluke Option -165
Voltage or Iso-Thermal Input Connector	NA	Fluke Option -175 or -176 (no substitute)
Transducer Excitation Connector	NA	Fluke Option -174 (no substitute)
Calibration/ Extender Fixture	NA	Fluke Accessory Y2056 Fluke Part No. 648741 (no substitute)
Resistor	499 ohms +/- 1% MF	Fluke Part No. 289256

THEORY OF OPERATION

The -164 Transducer Excitation Module theory of operation includes a functional description of the module and a detailed circuit description of each major circuit block. The schematic diagrams for the Transducer Excitation Module are located at the end of this option subsection.

Overall Functional Description

The Transducer Excitation Module obtains 24V dc power from the serial link and generates stable current and voltage outputs which are made available through the -174 Transducer Excitation Connector. Voltage or current excitation is provided for 20 channels, divided into five groups of four channels. One jumper, located on the Transducer Excitation Connector for each group of channels determines whether the four channels are to have voltage or current excitation.

Detailed Circuit Description

POWER SUPPLY

A switching power supply generates the voltages required and provides isolation for the voltage and current output sections of the Transducer Excitation Module. The power supply is a flyback type composed of T1, U1, one half of U2, U3, and U4. Incoming voltage is applied across the primary winding of T1 for an interval determined by U1, causing the primary current to ramp up to a peak of 1A (when the duty cycle is at a maximum of 50%). Q1 and Q2 are then turned off and the energy stored in T1 is released through CR6, CR7, CR8, and CR10 into C5, C9, C10, and C11. The cycle is repeated at a 32-kHz rate.

The 5.4V nominal voltage on C9 is compared, using U2, with a 2.5V reference voltage from U4. The resulting error signal is relayed to U1 through isolator U3. U1 uses this error information to control the amount of time that Q1 and Q2 are on, thereby maintaining 5.4V across C9 regardless of load or line changes.

The 10V supply is regulated by the linear regulator composed of one half of U2, Q4, and Q3. The 2.5V reference from U4 is compared to the divided-down 10V output by U2, which then uses Q4 to modulate the base current of Q3 and control the output voltage.

VOLTAGE OUTPUT

The voltage output is derived from a precision voltage reference and is driven by a unity-gain buffer amplifier. One of two output values, 2V or 4V, is selected by switch S1 by connecting one of these reference voltages to the input of the buffer amplifier. The buffer amplifier is a high-current, low-output-impedance driver suitable to drive various strain gauge and other transducers.
The buffer amplifier is composed of U5, Q5, and Q6. Transistor Q5 is an n-channel MOSFET used as the series pass element. Transistor Q6 senses

the current output and decreases the gate voltage to Q5 if the current exceeds 350 mA, thereby reducing the voltage output to limit the current. The buffer amplifier output voltage is divided in half by a pair of precision wire-wound resistors (R35 and R36). This voltage is made available on the connector for use in bridge completion.

CURRENT SOURCES

Five current sources (set at the factory to output 1 mA) are provided by the Transducer Excitation Module. Each current source is designed so that it can provide current for four series-connected RTDs, giving a total of 20 excitation points. If desired, the excitation current can be reduced by placing a resistor in series with the standard current-sense resistors, replacing JR1 (typical).

To provide fail-safe operation, a pair of diode-connected transistors are connected across each RTD or resistance being excited. If a point in the series string of four opens or is left open, the diodes conduct to ensure that the current continues to flow through the other points in the string.

Each current source is composed of an amplifier (U6 typical), a precision voltage reference (VR2), a current-sense resistor (series parallel combination of R45, R50, R55, and R60 typical), and a p-channel JFET (Q8 typical). The reference is shared by all five current sources. For each source, the amplifier maintains a constant voltage across a current sense resistor by controlling the on resistance of a p-channel JFET. Each current source is protected against transient voltage damage by two series resistors (R65 and R70 typical), which limit current flow, and two JFETs connected as diodes (Q13 and Q18 typical) which clamp any transient voltages.

COMMUNICATION

The Transducer Excitation Module can be installed in any serial link slot in the Front End. In practice, however, the module is usually installed below the scanner used to measure the transducer response to the excitation. When the A/D Converter selects the slot by setting BLCT SCT2 high, the Transducer Excitation Module answers with its type code of 5. Integrated circuit U12 detects the request and responds by turning on its outputs.

GENERAL MAINTENANCE

The Transducer Excitation Module normally does not require cleaning unless dirt, dust, or other contamination is visible on its surface. If cleaning is necessary, follow the instruction provided in Section 4 of this manual.

PERFORMANCE TEST

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING THE FOLLOWING PROCEDURE.

The following performance tests will verify that the Transducer Excitation Module and Transducer Excitation Connector are operating properly within specified tolerance.

These tests can be performed using either one of two types of a/d converter: the -161 High Performance A/D Converter or the -165 Fast A/D Converter. The higher reading rates realized with the -165 Fast A/D Converter yield somewhat lower resolution and accuracy than with the -161 High Performance A/D Converter.

The following two tests are required to verify the proper operation of the assembly:

- o Current Excitation Test
- o Voltage Excitation Test

The procedures for conducting these tests follow.

Current Excitation Performance Test

To test current excitation, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line cord and all other high voltage inputs.
2. Install either a -161 High Performance A/D Converter or a -165 Fast A/D Converter in the uppermost option slot of the Front End. Set the address switch on the appropriate A/D Converter to zero.
3. To avoid addressing conflict, remove all other installed options.
4. Now, referring to the A/D Converter-specific instructions below, install the -164 Transducer Excitation Module.
   - o -161 High Performance A/D Converter
     - A. Install a -162 Thermocouple/DC Volts Scanner in the slot directly below the A/D Converter.
     - B. Install the -164 Transducer Excitation Module in the slot directly below the -162 scanner.
     - C. Channels 0 through 19 are addressable with this configuration.

- o -165 Fast A/D Converter

    A. Ensure the External Trigger Jumper (W1) on the Fast A/D Converter is positioned for normal measurement inputs on Channel 0 and 20.

    B. Install the -164 Transducer Excitation Module in the slot directly below the Fast A/D Converter.

    C. Channels 0 through 39 are addressable with this configuration.

5. On the Transducer Excitation Module, set the voltage excitation switch (S1) to the 4V position.

6. Install the five jumpers on a Transducer Excitation Connector in the current excitation position.

7. Wire the Transducer Excitation Connector to an Isothermal Input or Voltage Input Connector according to the diagram in Figure 164-2.

8. Install the -174 Transducer Excitation Connector on the -164 Transducer Excitation Module.

9. Install either the -175 Isothermal Input Connector or the -176 Voltage Input Connector on the scanner or A/D Converter, determined by the A/D Converter in use:

    - o -161: install either connector on the -162 Thermocouple/DC Volts Scanner.

    - o -165: install either connector directly on the Fast A/D Converter.

10. Reconnect the ac line cord to the Front End, and switch power ON.

```
VOLTAGE INPUT CONNECTOR                TRANSDUCER EXCITATION CONNECTOR
        or
ISOTHERMAL INPUT CONNECTOR

Channel 0  HI Terminal  0------------0  Channel 1  A Terminal
        0  LO           0---+--------0          2  D
        0  SH           0---+

Channel 4  HI Terminal  0------------0  Channel 5  A Terminal
        4  LO           0---+--------0          6  D
        4  SH           0---+

Channel 8  HI Terminal  0------------0  Channel 9  A Terminal
        8  LO           0---+--------0          10 D
        8  SH           0---+

Channel 12 HI Terminal  0------------0  Channel 13 A Terminal
        12 LO           0---+--------0          14 D
        12 SH           0---+

Channel 16 HI Terminal  0------------0  Channel 17 A Terminal
        16 LO           0---+--------0          18 D
        16 SH           0---+
```

Figure 164-2. Current Excitation Test Wiring Diagram 1

11. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

    Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0..19)=DVIN,MAX=7.9 <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0,4,8,12,16) <CR>
```

The measurement returned on each channel (0, 4, 8, 12,and 16) should be between 5.2V and 5.6V.

If the measurement is outside this range, one of the shunt diodes located on the Transducer Excitation Module may be shorted or open.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
120  PRINT #1,"def chan(0..19)=dvin,max=7.9"
125  GOSUB 300
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  REM make measurement and read in response
160  PRINT #1,"send chan(0,4,8,12,16)"
170  FOR I=0 TO 16 STEP 4
180  INPUT #1,M$
190  PRINT "chan";I;"=";
200  PRINT USING "##.#####";VAL(M$);
210  PRINT " Volts DC"
220  NEXT I
230  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1%
50   OPEN "KB1:"AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Computer Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0..19)=dvin,max=7.9"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  REM make measurement and read in response
170  PRINT #1,"send chan(0,4,8,12,16)"
180  FOR I=0 TO 16 STEP 4
190  INPUT #2,M$
200  PRINT "chan";I;"=";
210  PRINT USING "S##.#####",VAL(M$);
220  PRINT " Volts DC"
230  NEXT I
240  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The measurement returned on each channel (0, 4, 8, 12,and 16) should be between 5.2 and 5.6 volts.

If the measurement is outside this range, one of the shunt diodes located on the Transducer Excitation Module may be either shorted or open.

12. Switch OFF power to the Front End and remove the previously wired connectors.

    Rewire for channels 0, 4, 8, 12 and 16 as shown for channel 0 in Figure 164-3.

NOTE

> A 499-ohm +/- 1% resistor must be installed between terminals A and D on channels 0, 4, 8, 12, and 16 of the connector.

13. Install the rewired Transducer Excitation Connector on the Transducer Excitation Module, and install the rewired Voltage or Isothermal Input Connector onto either the Thermocouple/DC Volts Scanner or the Fast A/D Converter.

```
VOLTAGE INPUT CONNECTOR                      TRANSDUCER EXCITATION
      or                                     CONNECTOR
ISOTHERMAL INPUT CONNECTOR

  Channel #    Terminal                       Channel #    Terminal

      0           HI  ----------------------- 0            A ---|
                                                                \  499 ohm
                                                                / resistor
      0           LO  ----------------------- 0            D ---|
```

Figure 164-3. Current Excitation Test Wiring Diagram 2

14. Switch power to the Front End ON.

15. Redefine channels 0 through 19 to measure a dc voltage on the 512 mV range.

    To redefine the channels in the Terminal Mode, send the following command:

    ```
    DEF CHAN(0..19)=DVIN, MAX=0.5  <CR>
    ```

    To redefine the channels in the Computer Mode, change the BASIC statement in line 120 to:

    ```
    PRINT #1,"def chan(0..19)=dvin, max=0.5"
    ```

16. Request a measurement on channels 0, 4, 8, 12, and 16.

    The returned readings should be 499 mV, +/- 5.1 mV. This is the voltage drop across the 499-ohm resistor due to the 1 mA excitation. If a more accurate measurement of this current is desired, a digital multimeter (DMM) can be used to measure it directly.

17. This completes the Current Excitation Test.

Voltage Excitation Performance Test

To test voltage excitation, perform the following procedure:

1. Perform the Current Excitation Performance Test if you have not already done so.

2. Switch OFF power to the Front End and remove both the connectors.

3. Move the five jumpers on the Transducer Excitation Connector to the voltage excitation position.

   Rewire as shown in the Figure 164-4. Connect as shown for channel 0, 4, 8, 12, and 16.

VOLTAGE INPUT CONNECTOR or ISOTHERMAL INPUT CONNECTOR			TRANSDUCER INPUT CONNECTOR	
Channel #	Terminal		Channel #	Terminal
0	HI	--------------------	0	A
0	LO	--------------------	0	D
4	HI	--------------------	4	A
4	LO	--------------------	4	D

Figure 164-4. Voltage Excitation Test Wiring Diagram

4. Install the rewired Transducer Excitation Connector on the Transducer Excitation Module and install the rewired Voltage or Isothermal Input Connector onto either the Thermocouple/DC Volts Scanner or the Fast A/D Converter.

5. Switch ON power to the Front End.

6. Program the Front End to measure channels 0, 4, 8, 12, and 16 on the 8V range by performing step 9 of the Current Excitation Test.

   The measured value for each channel should be 4.0V +/- 0.004V.

7. This completes the Voltage Excitation Performance Test.

CALIBRATION

Perform the following procedures to calibrate the precision voltage and current sources on the Transducer Excitation Module.

Voltage Excitation Calibration

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Install a Calibration/Extender Fixture (Part No. 648741) in any option position. Set the fixture switch to the EXTEND position.

3. Install the Transducer Excitation Module on the Fixture. Put slide switch S1 into the 4V position.

4. Reconnect the ac line cord to the Front End and turn the power ON.

5. After the Transducer Excitation Module has warmed up for at least 30 minutes, connect the positive lead of the DMM to test point TP100 and connect the negative lead to test point TP4.

6. Set the DMM to measure 4V with a resolution of 0.00001V (10 uV).

7. Adjust R23 for a DMM reading of 4.00000V within a tolerance of 0.00001V (10 uV).

8. Put slide switch S1 in the 2V position. Set the DMM to measure 2V with a resolution of 0.000001V (1 uV).

9. Adjust R31 for a DMM reading of 2.000000V within a tolerance of 0.000001V (1 uV).

10. Put slide switch S1 in the proper position for your application.

This completes the voltage excitation calibration.

Current Excitation Calibration

NOTE

> If a precision resistor of known value is not available, the 8505A may be used with a stable resistor of 250 ohms. Using the DMM in 4-wire mode, measure the resistor on the 100-ohm range. Use the resulting value when performing the calibration procedure provided below.

1. Perform the setup steps 1 through 4 from the voltage excitation calibration procedure given previously.

2. Again, make sure the Transducer Excitation Module has warmed up for at least 30 minutes, then connect the DMM high lead to test point TP21 and connect the low lead to test point TP101.

3. Set the DMM to measure on the 10V range with a resolution of 0.0001V (100 uV).

4. Adjust R42 for 6.2000V within a tolerance of 0.0002V (200 uV).

5. Power down the Front End and install a -174 Transducer Excitation Connector assembly on the Transducer Excitation Module. Put the programming jumpers on the Transducer Excitation Connector in the current output position.

6. Connect the DMM, the Resistance Calibrator, and the Transducer Excitation as follows, where Terminal A and D on the Transducer Excitation Connector are those of channel 0.

```
8505A              5450A                          Option -174

                   SENSE    OUTPUT
HI                 HI       HI
0------------------0        0-------------------0 Terminal A

LO                 LO       LO
0------------------0        0-------------------0 Terminal D
```

7. Set the Resistance Calibrator to 190 ohms nominal.

8. Set the DMM to measure on the 1V range with 1 uV resolution, with the average mode enabled. The DMM must have been calibrated within 90 days and also have been software calibrated within the last 24 hours.

9. Switch ON power to the Front End.

10. To calibrate the current source for channels 0, 1, 2, and 3, adjust R55, so that the reading on the DMM equals the displayed value of the resistance output on the Resistance Calibrator.

11. Repeat the current calibration procedure for the current source for channels 4, 5, 6, and 7 by moving the Terminal A and D connections from channel 0 to channel 4 and adjusting R56 so that the reading on the DMM equals the displayed value of the resistance output on the Resistance Calibrator.

12. Repeat the current calibration procedure for the current source for channels 8, 9, 10, and 11 by moving the Terminal A and D connections from channel 4 to channel 8 and adjusting R57 so that the reading on the DMM equals the displayed value of the resistance output on the Resistance Calibrator.

13. Repeat the current calibration procedure for the current source for channels 12, 13, 14, and 15 by moving the Terminal A and D connections from channel 8 to channel 12 and adjusting R58 so that the reading on the DMM equals the displayed value of the resistance output on the Resistance Calibrator.

14. Repeat the current calibration procedure for the current source for channels 16, 17, 18, and 19 by moving the Terminal A and D connections from channel 12 to channel 16 and adjusting R59 so that the reading on the DMM equals the displayed value of the resistance output on the Resistance Calibrator.

15. Switch power to the Front End OFF.

16. Remove the Transducer Excitation Module from the Calibration/Extender Fixture.

17. Remove the Fixture from the Front End.

18. Install the Transducer Excitation Module in the Front End (or Extension Chassis) for normal operation.

19. The calibration of the Transducer Excitation Module is complete.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Transducer Excitation Module is given in Table 164-2.

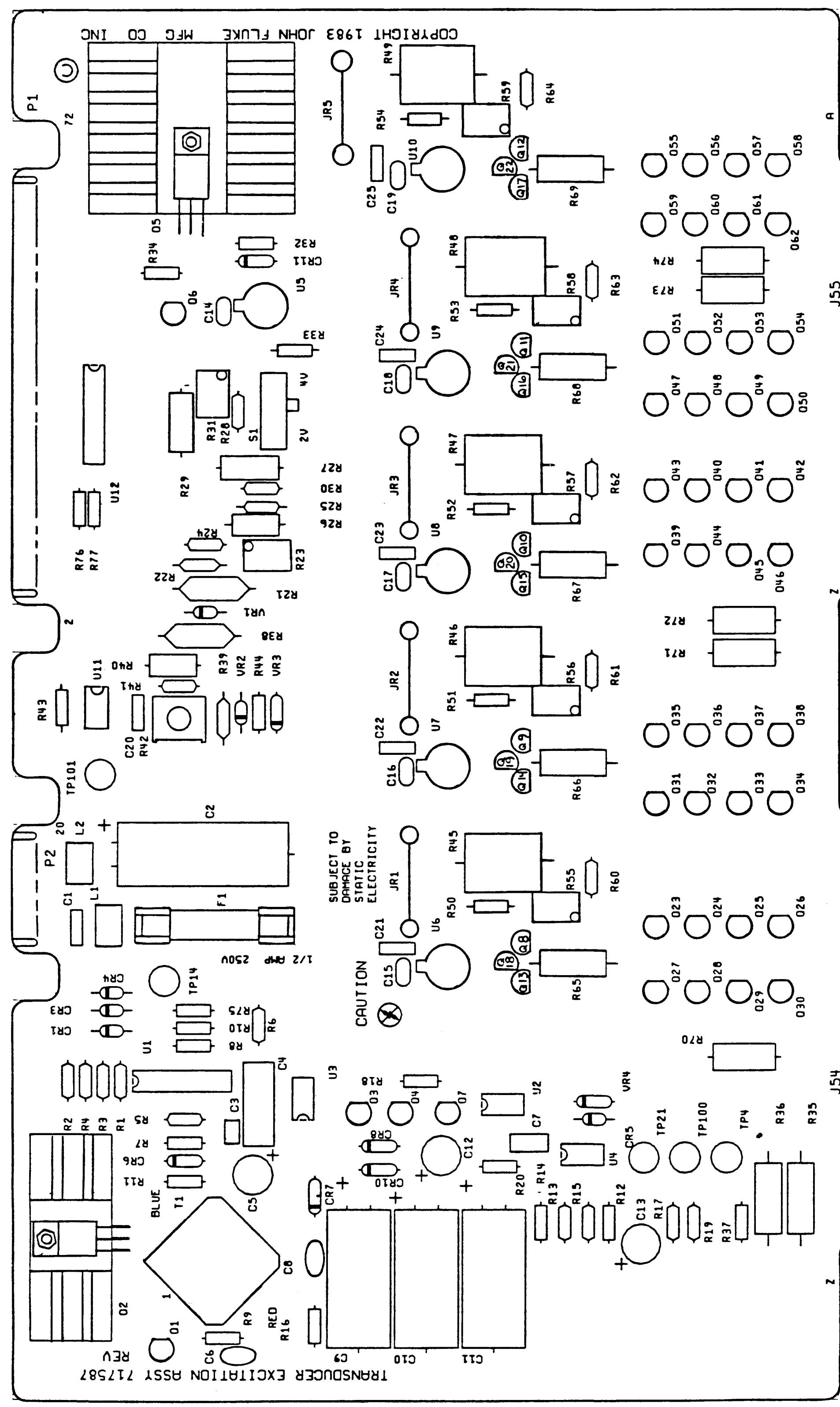
For parts ordering information, see Section 6 of this manual.

Figure 164-5 is a schematic diagram of the Transducer Excitation Module.

TABLE 164-2. -164 TRANSDUCER EXCITATION PCA
(SEE FIGURE 164-5.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	NOTE
C 1, 20- 25		CAP,POLYES,0.1UF,+-10%,50V	696484	89536	696484	7	
C 2		CAP,AL,330UF,+100-10%,25V	614404	89536	614404	1	
C 3		CAP,CER,1000PF,+-5%,50V,COG	528539	51406	RPE113	1	
C 4		CAP,POLYES,0.022UF,+-10%,50V	715268	89536	715268	1	
C 5, 12, 13		CAP,AL,47UF,+-20%,16V	643304	89536	643304	3	
C 6		CAP,CER,1000PF,+-10%,500V,X5S	357806	56289	C016B102G102K	1	
C 7		CAP,POLYES,1.0UF,+-10%,50V	733089	89536	733089	1	
C 8		CAP,CER,0.0012UF,+-10%,500V,Z5R	106732	71590	CF122	1	
C 9		CAP,AL,470UF,+100-10%,12V	602649	89536	602649	1	
C 10, 11		CAP,AL,270UF,+100-10%,20V	602656	89536	602656	2	
C 14- 19		CAP,CER,33PF,+-2%,100V,COG	513226	51406	RPE121	6	
CR 3, 5, 6,	*	DIODE,SI,BV= 75.0V,IO=150MA,500 MW	203323	07910	1N4448	4	
CR 11	*		203323				
CR 7	*	DIODE,SI, 20 PIV, 1.0 AMP	507731	83003	VSK120	1	
CR 8, 10	*	DIODE,SI, 50 PIV, 1.0 AMP	379412	04713	1N4933	2	
E 13- 17		TERM,INSUL,FEEDTHRU,MULTILEAD,BLUE	529297	98291	011-6812-00-0-206	5	
F 1		FUSE,1/4 X 1-1/4,FAST,0.5A,250V	153858	71400	AGC1-2	1	
H 1		WASHER,LOCK,SPLIT,STEEL,#4	110395	89536	110395	4	
H 1		INSERT,STUD,BROACHING,PHOSPHOR BRONZE	494682	89536	494682	2	
H 2		NUT,MACH,HEX,STL,4-40	110635	89536	110635	4	
H 2		INSERT,STUD,BROACHING,PHOSPHOR BRONZE	614636	89536	614636	2	
H 3		WASHER,FLAT,BRASS,#4,0.025	110775	89536	110775	4	
H 4		SCREW,MACH,PHP,STL,6-32X3/8	152165	89536	152165	2	
H 5		WASHER,FLAT,BRASS,#6,0.012 THK	111054	89536	111054	2	
H 6		WASHER,LOCK,SPLIT,STEEL,#6	110692	89536	110692	2	
H 7		NUT,HEX,MINI,S.STL,6-32	110569	89536	110569	2	
JR 1- 5		TERM,UNINSUL,STANDOFF,TURRET,SWAGE	100586	89536	100586	15	1
L 1, 2		CHOKE,6TURN	320911	89536	320911	2	
MP 1		RETAINER,P.C.B.	579078	89536	579078	2	
MP 2		HEAT SINK, XISTOR THERMALLOY 6072B	473686	89536	473686	1	
MP 3		HLDR,FUSE,1/4,PWB MT	485219	91833	3529	2	
MP 4		SPACER,RND,ALUM,0.156IDX0.250	153155	89536	153155	2	
MP 5		BAG,SHIELDING,TRANSPARENT,12"X16"	680983	89536	680983	1	
MP 6		HEATSINK, INNER, U1	473660	13103	6070B	1	
Q 1	*	TRANSISTOR,SI,NPN,HI-VOLTAGE	370684	04713	MPS A 42	1	
Q 2	*	SILICON, NPN, FAST SWITCHING D44H11	535542	89536	535542	1	
Q 3, 7	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	340026	04713	MPS6563	2	
Q 4, 23- 62	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	41	
Q 5	*	TRANSISTOR,SI,NMOS,75W,TO-220	586107	89536	586107	1	
Q 6	*	TRANSISTOR,SI,NPN,SELECTD,TEMP SENSOR	640862	89536	640862	1	
Q 8- 17	*	TRANSISTOR,SI,P-JFET,TO-92	413690	89536	413690	10	
Q 18- 22	*	TRANSISTOR,SI,N-JFET,REMOTE CUTOFF	429977	89536	429977	5	
R 1, 2, 4		RES,MF,4.99K,+-1%,0.125W,100PPM	168252	91637	MFF1-84991	3	
R 3		RES,MF,4.75K,+-1%,0.125W,100PPM	260679	91637	CMF554751F	1	
R 5		RES,MF,15.8K,+-1%,0.125W,100PPM	293688	91637	CMF551582F	1	
R 6		RES,MF,39.2K,+-1%,0.125W,100PPM	236414	91637	CMF553922F	1	
R 8		RES,CF,1.8K,+-5%,0.25W	441444	80031	CR251-4-5P1K8	1	
R 9, 18		RES,CF,510,+-5%,0.25W	441600	80031	CR251-4-5P510E	2	
R 10		RES,CF,1.5K,+-5%,0.25W	343418	80031	CR251-4-5P1K5	1	
R 11, 16		RES,CF,330,+-5%,0.25W	368720	80031	CR251-4-5P330E	2	
R 12		RES,CF,100,+-5%,0.25W	348771	80031	CR251-4-5P100E	1	
R 13, 14		RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF551003F	2	
R 15		RES,MF,82.5K,+-1%,0.125W,100PPM	246223	91637	CMF558252F	1	
R 17		RES,MF,10.7K,+-1%,0.125W,25PPM	423681	91637	CMF551072F	1	
R 19		RES,MF,3.57K,+-1%,0.125W,25PPM	376905	89536	376905	1	
R 20		RES,CF,51,+-5%,0.25W	414540	80031	CR251-4-5P51E	1	
R 23, 31, 55-		RES,VAR,CERM,1K,+-10%,0.5W	393728	32997	3299W-CR2-102	7	
R 59			393728				
R 24		RES,MF,3.92K,+-1%,0.125W,100PPM	294801	91637	CMF553921F	1	
R 25		RES,MF,7.5K,+-1%,0.125W,25PPM	484881	89536	484881	1	
R 26		RES,WW,23.7K,+-0.1%,0.15W	385609	89536	385609	1	
R 27, 29		RES,WW,20K,+-0.1%,0.125W	271395	89536	271395	2	
R 28		RES,MF,53.6,+-1%,0.125W,100PPM	339861	91637	CMF5553R6F	1	
R 30		RES,MF,287K,+-1%,0.125W,25PPM	257543	89536	257543	1	
R 32, 37, 43,		RES,CF,10K,+-5%,0.25W	348839	80031	CR251-4-5P10K	5	
R 44, 77			348839				
R 33		RES,CF,13K,+-5%,0.25W	441402	80031	CR251-4-5P13K	1	
R 34		RES,CF,1.5,+-5%,0.25W	442020	89536	442020	1	
R 35, 36		W W RESISTOR	719377	89536	719377	2	
R 40		RES,WW,60.75K,+-0.1%,0.15W	385625	89536	385625	1	
R 41		RES,MF,750,+-1%,0.125W,25PPM	448035	89536	448035	1	
R 42		RES,VAR,CERM,500,+-10%,0.5W	325613	89536	325613	1	
R 45- 49		W W RESISTOR	719344	89536	719344	5	
R 50- 54		RES,CF,5.6M,+-5%,0.25W	543371	80031	CR251-4-5P5M6	5	
R 60- 64		RES,MF,10.5,+-1%,0.125W,100PPM	494492	89536	494492	5	
R 65- 74		RES,WW,FUSIBLE,1K,+-10%,2W	474080	89536	474080	10	
R 75		RES,CF,160,+-5%,0.25W	441410	80031	CR251-4-5P160E	1	
R 76		RES,CF,100K,+-5%,0.25W	348920	80031	CR251-4-5P100K	1	
R 78		RES,CF,220,+-5%,0.25W	342626	80031	CR251-4-5P220E	1	
S 1		SWITCH,SLIDE,SPDT	453365	34828	G1-116-0001-G20-52	1	
T 1		INVERTER TRANSFORMER	580407	89536	580407	1	
U 1	*	IC,REGULATING PULSE WIDTH MODULATOR	454678	01295	SG3524N	1	
U 2	*	IC,OP AMP,DUAL,INDUSTRIAL TEMP RANGE	605550	01295	LM258JG	1	
U 3	*	ISOLATOR,OPTO,HI-SPEED,8 PIN DIP	354746	89536	354746	1	
U 4	*	IC, 2.5 V,40 PPM T.C.,BANDGAP REF	472845	04713	MC1403V	1	
U 5- 10	*	IC,OP AMP,GENERAL PURPOSE,TO-78 CASE	418368	89536	418368	6	
U 11	*	IC,OP AMP,MOSFET INPUT,8 PIN DIP	507426	89536	507426	1	
U 12	*	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	12040	MM80C97N	1	
VR 1, 2	*	ZENER REFERENCE SET	646539	89536	646539	2	
VR 21, 22, 38,	*		646539				
VR 39	*		646539				
VR 3	*	ZENER,UNCOMP, 10.0V, 5%, 25.0MA, 1.0W	340695	12969	UZ8710	1	
VR 5	*	ZENER,UNCOMP, 3.3V,10%, 20.0MA, 0.4W	309799	04713	1N746	1	

NOTE 1 = ALSO INCLUDES TP4,14,21,100,101.	579441		579441
	580969		580969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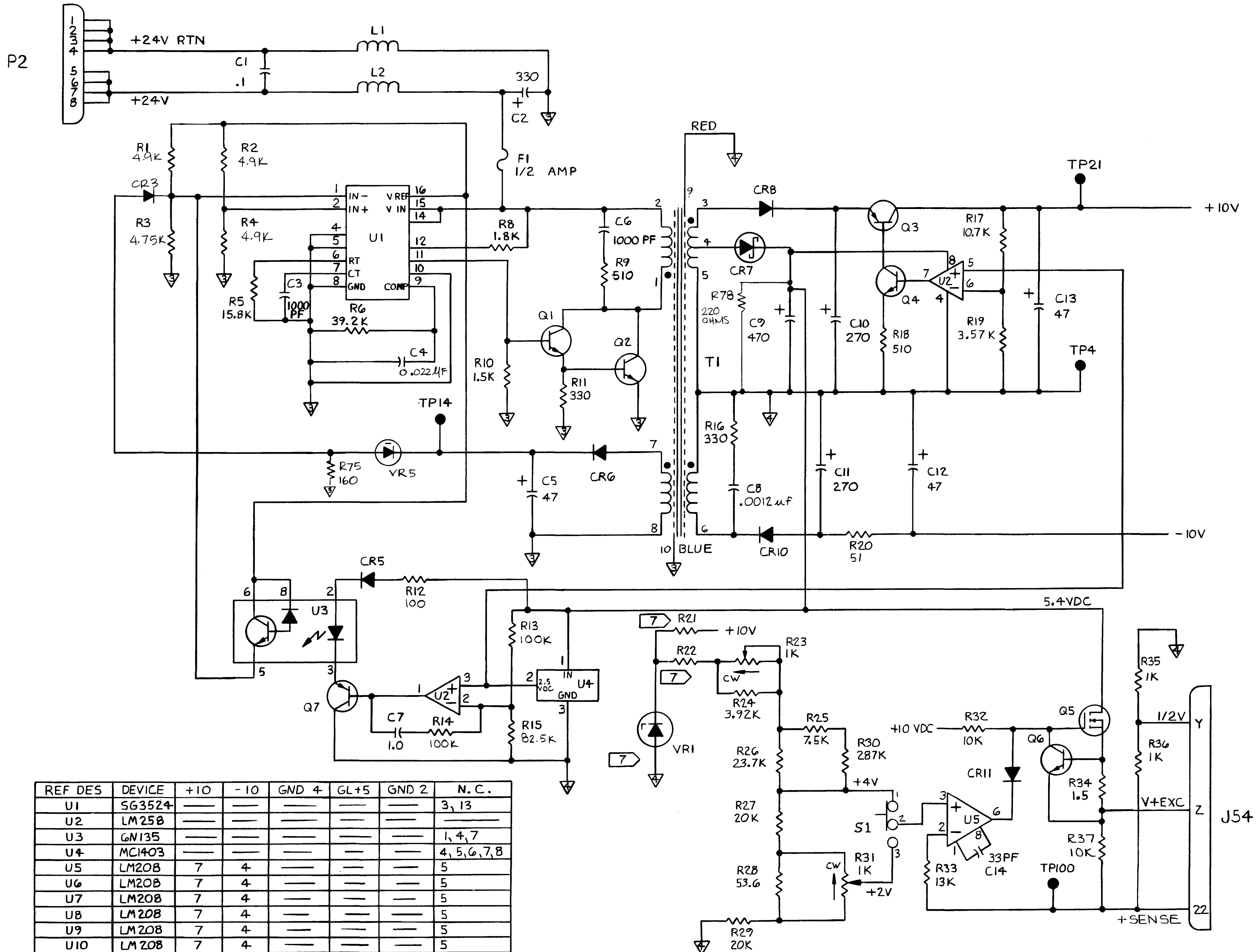
1/2 AMP 250V

2280A-1664



REF DES	DEVICE	+10	-10	GND 4	GL+5	GND 2	N.C.
U1	SG3524	—	—	—	—	—	3, 13
U2	LM258	—	—	—	—	—	—
U3	6N135	—	—	—	—	—	1, 4, 7
U4	MC1403	—	—	—	—	—	4, 5, 6, 7, 8
U5	LM208	7	4	—	—	—	5
U6	LM208	7	4	—	—	—	5
U7	LM208	7	4	—	—	—	5
U8	LM208	7	4	—	—	—	5
U9	LM208	7	4	—	—	—	5
U10	LM208	7	4	—	—	—	5
U11	3140E	7	—	4	—	—	1, 5, 8
U12	80C97	—	—	—	16	8	

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCE IS IN OHMS.
2. ALL CAPACITANCE IS IN MICROFARADS.
3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.

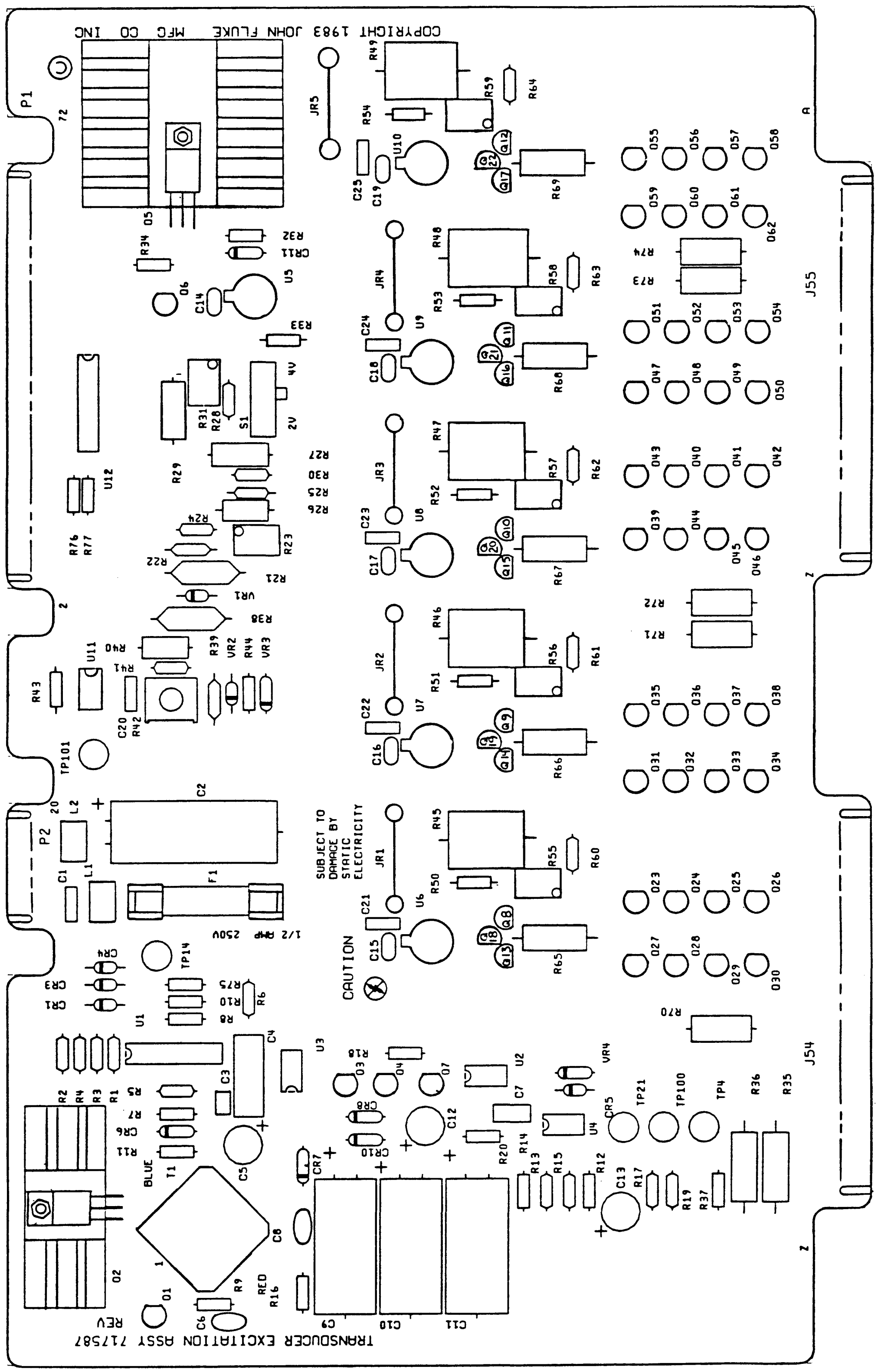
6. R38, R39, AND VR2 IS A MATCHED REFERENCE SET.

7. R21, R22, AND VR1 IS A MATCHED REFERENCE SET.

REF DES	
LAST USED	NOT USED
R78 Q62 U12 C25 CR11 VR4 T1 JR5 L2	CR2,9

2280A-1064

Figure 164-5. Transducer Excitation Module Schematic Diagram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1/2 AMP 250V
J54
J55
P1
P2

2280A-1664

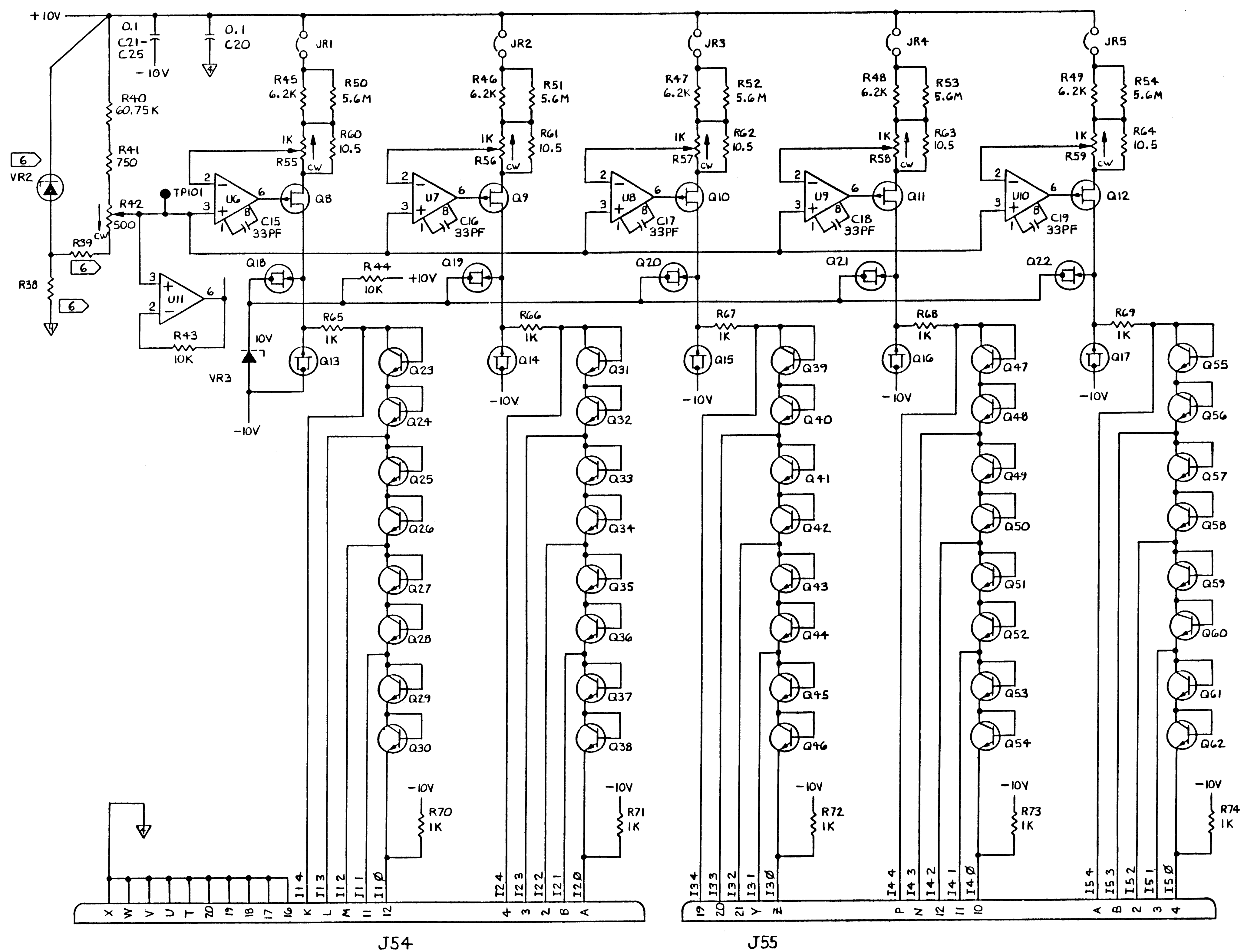

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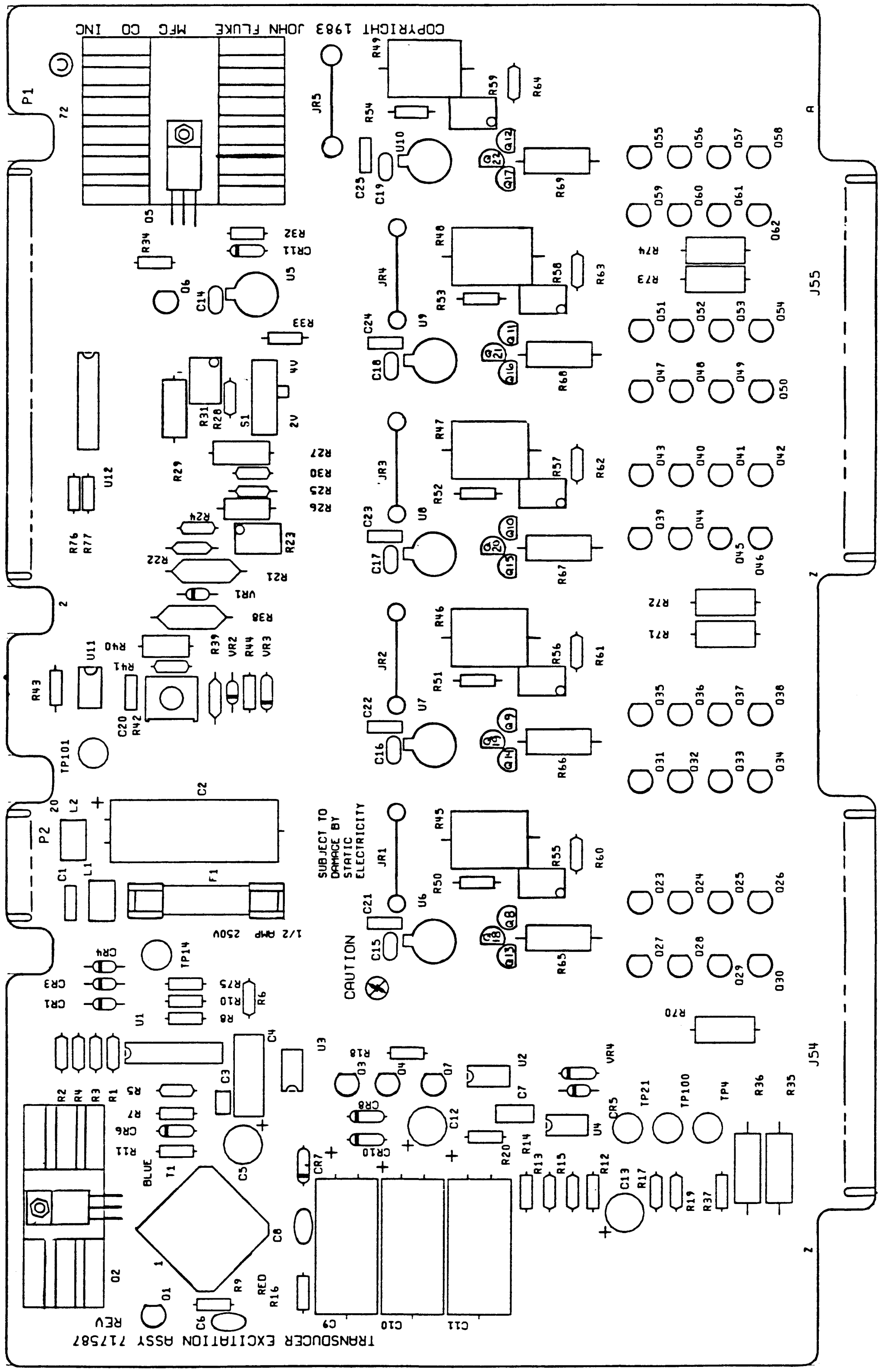
Figure 164-5. Transducer Excitation Module Schematic Diagram (cont.)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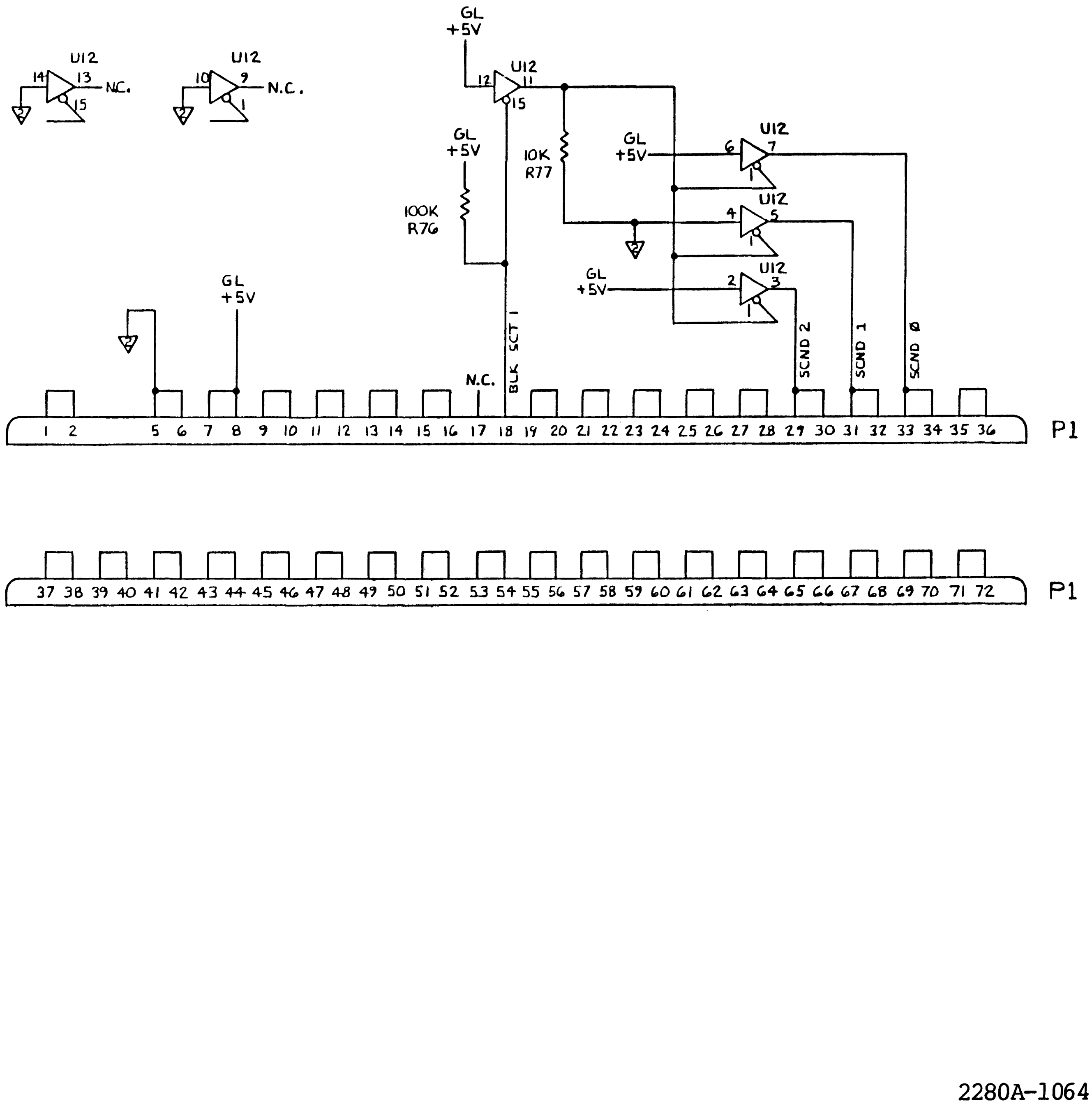


Figure 164-5. Transducer Excitation Module Schematic Diagram (cont.)

DESCRIPTION

The -165 Fast A/D Converter (refer to Figure 165-1), is an A/D (analog-to-digital) converter with programmable buffer amplifier and input multiplexers. The converter measures dc voltages, accepting a maximum of 20 differential or 40 single-ended input signals. Input signals are connected to the -165 converter through a -175 Isothermal Input Connector or a -176 Voltage Input Connector. These dc voltages can represent a variety of phenomena, depending on the input connector and/or external signal conditioning used.

Operating parameters of the Fast A/D Converter are established through the Front End command structure. The number of inputs can be expanded by adding Fast A/D Converters. Fast A/D Converters can be used in combination with -161 High Performance A/D Converters in the same system.

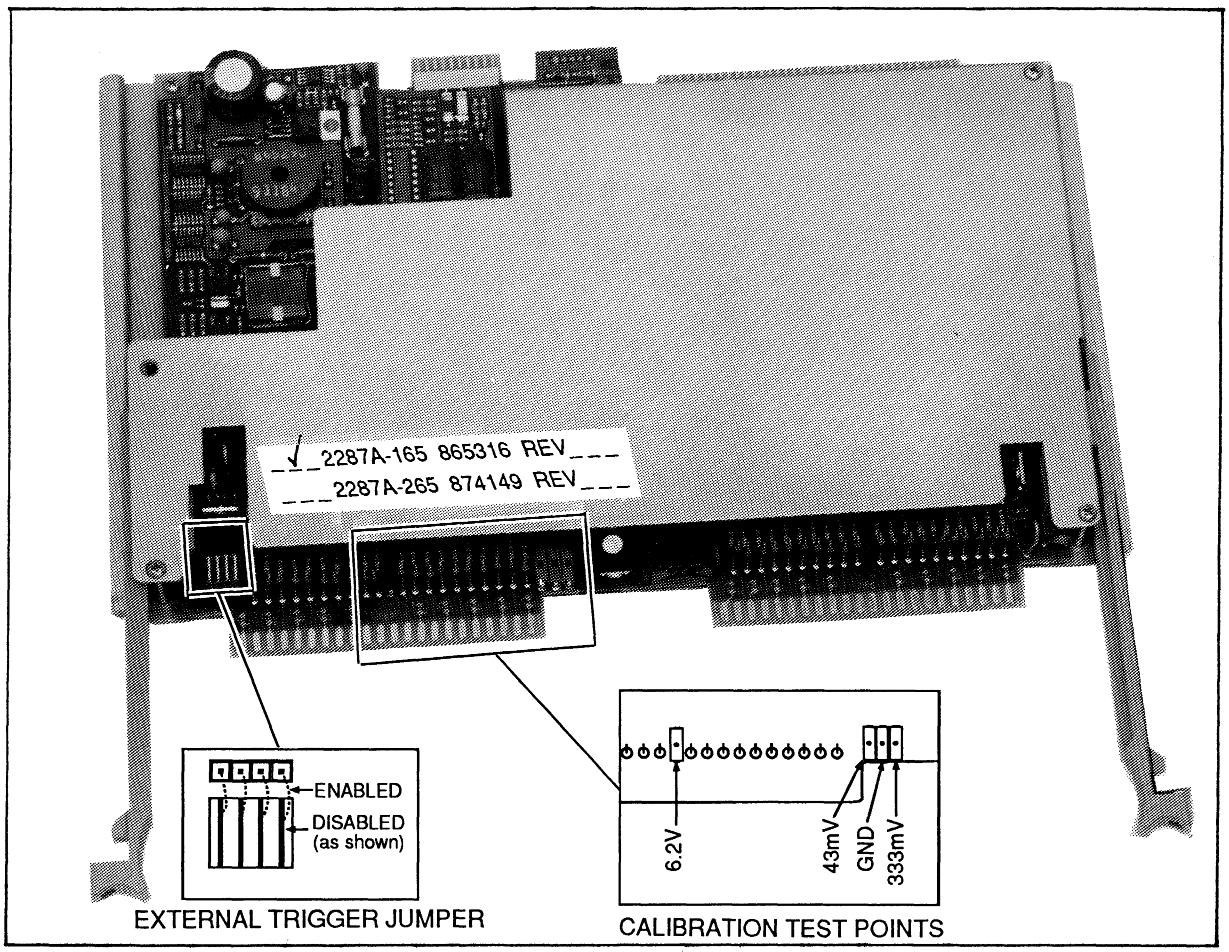


Figure 165-1. Fast A/D Converter

A maximum of 6 Fast A/D Converters can be installed in a Helios Plus mainframe. The maximum number of Fast A/D Converters that can be installed in a 2281A Extender Chassis is determined by system power restrictions and can be determined by consulting the Helios Plus System Manual and the 2281A Instruction Manual.

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains the Fast A/D Converter theory of operation, performance tests, calibration procedures, self-test error descriptions, parts list, and schematic diagram.

Installation, operating, and system configuration instructions are provided in the Helios Plus System Manual. Option specifications are located in the appendices to this manual and the System Manual.

The test equipment required to perform the procedures in this subsection is listed in Table 165-1.

A summary of test equipment required to perform all procedures in this manual is given in Table 2-2 in Section 2 of this manual.

Table 165-1. Required Test Equipment for -165

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Calibrator	62 mV ±40 uV 500 mV ±200 uV 7.9V ±1 mV 9V ±2 mV	Fluke 343
100:1 Divider	+/- 0.005%	Fluke Y2022
Digital Multi-meter (DMM)	6.2V ±0.0600V 333 mV ±4 mV 43 mV ±500 uV	Fluke 8842A
Resistor	1 kilohm +/- 5%	Fluke Part No. 108597
Resistor	3 kilohm +/- 5%	Fluke Part No. 109090
Isothermal Input Connector	NA	Fluke Option -175 (no substitute)
Voltage Input Connector	NA	Fluke Option -176 (no substitute)

THEORY OF OPERATION

Theory of operation descriptions are provided on three levels: the overall functional description deals with general operating principles; a block diagram analysis describes operation of each major circuit block on the A/D Converter assembly; and the detailed circuit analysis provides component-level descriptions of each block.

Overall Functional Description

The -165 Fast A/D Converter measures a maximum of 20 differential or 40 single-ended dc voltages, and sends the measurement results to the Helios Plus mainframe controller in digital form over the serial link bus.

Two scanning modes are available:

o Continuous Scan Mode

The a/d converter filters line frequency noise out of the readings, which are made available continuously to the mainframe controller at speeds up to 70 dc voltage (DVIN) readings per second.

o Burst Scan Mode

The a/d converter scans readings into its FIFO (first-in, first-out) buffer until a trigger event causes scanning to stop, at which point data is frozen in the buffer for later analysis.

Burst scanning takes place at 1000 readings per second without any noise filtering. The trigger event can be either a channel alarm or a change of state on the external trigger hardware input of the a/d converter. A jumper block on the Fast A/D Converter is used to select external triggering.

Either the -175 Isothermal Input Connector or the -176 Voltage Input Connector is required for the Fast A/D Converter to acquire measurement data.

Block Diagram Analysis

Figure 165-2 illustrates the A/D Converter in block diagram form. The following paragraphs discuss functions of these blocks.

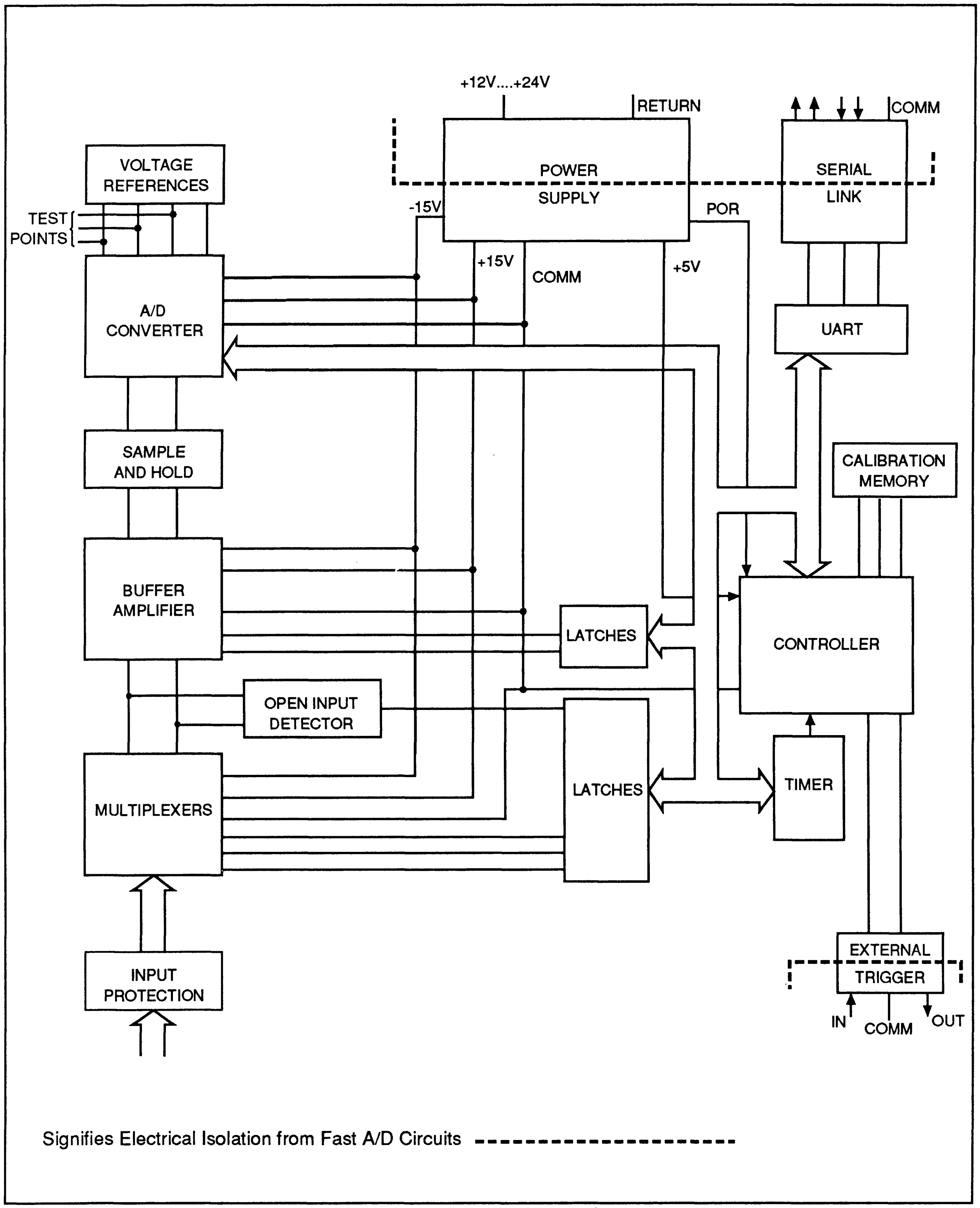


Figure 165-2. Fast A/D Converter Block Diagram

POWER SUPPLY

The power supply converts incoming dc power from the serial link into:

- o Isolated +15V, -15V and +5V for the A/D converter
- o +5V dc for the serial link
- o +5V dc (isolated) for the external trigger circuitry

INPUT PROTECTION

Input protection consists of voltage clamp diodes and fusible resistors that protect the FET multiplexers from input over-voltage conditions. At moderate overloads, the excess voltage is dropped across the fusible resistor without damage. At higher voltages, the fusible resistors open, interrupting the overload. If multiple inputs overload, the input clamp voltage goes to approximately +/-0.5 volts, protecting the protection circuitry, but affecting readings on all channels, including those not overloading.

MULTIPLEXER

The multiplexer selects any of 40 input signal lines for the A/D Converter to measure. With differential channels, the multiplexer selects a pair of input lines.

The multiplexer selects the voltage references for periodic drift correction calculations, zero (used for automatic zero drift correction), and the reference junction temperature sensor reading (used for thermocouple measurements.) The controller uses a set of latches to direct multiplexer activity from the data bus.

BUFFER AMPLIFIER

The buffer amplifier boosts the input voltage selected by the multiplexer to a level compatible with the input voltage range of the A/D Converter. The buffer amplifier also converts differential input signals to single-ended signals, which the A/D Converter can then digitize. The controller uses a set of latches to specify buffer amplifier gain from the data bus.

A/D CONVERTER

The A/D Converter is a conventional successive approximation converter, consisting of a digital-to-analog converter (DAC), a comparator, and a 16-bit successive approximation register (SAR). At the end of a conversion, the controller reads the contents of the SAR via a pair of tri-state buffers connecting the SAR to the data bus.

A/D CONTROLLER

The A/D Controller maintains the communication link, selects input channels, controls the buffer amplifier gain setting, zeros the buffer offsets, triggers the sample-and-hold circuit, and triggers A/D conversions. Timing of these events is determined by the timer. The controller directs most of this sequence via software.

SAMPLE-AND-HOLD

This circuit first tracks the output from the buffer amplifier long enough for the signal to settle. Once settling has occurred, the Sample-and-Hold circuit switches into hold mode to provide a steady signal for the A/D Converter to digitize. Sample and hold switching is controlled by the timer hardware and is as accurate as the system crystal oscillator.

CALIBRATION MEMORY

Calibration memory consists of an EEPROM that stores the precise values of the calibration reference voltages. At power-up, the microprocessor reads the contents of the calibration memory into RAM. Using the reference voltages, the A/D Controller periodically calculates calibration correction coefficients, which are used to correct all A/D readings for gain and drift errors.

SERIAL LINK

The serial link allows the A/D Controller to receive commands from and return measurement data to the Helios-Plus main controller.

Bidirectional serial transmissions are electrically isolated, buffered, and converted to signals usable by the A/D Controller. One half of the dual UART is used by the controller for serial link interfacing.

TEST CONNECTOR

All pins necessary to control the -165 digital circuitry are available at a test connector. With a test adapter, it is possible to troubleshoot the logic on the board with a Fluke Model 9010 or 9100 microprocessor tester and a 68000 pod.

Detailed Circuit Analysis

POWER SUPPLY

Overview

The power supply of the Fast A/D Converter consists of the following blocks of circuitry:

- The Switching Regulator which takes power from the serial link at 12V dc to 24V dc and regulates it down to 5.6V dc. Flyback windings on the inductor in the switching regulator provide isolated power for the serial link hardware and the external trigger circuitry.

- The Isolated DC-to-DC converter, takes power from the regulated 5.6V dc supply, chops it through an isolation transformer at 50 kHz, then rectifies and filters it to provide isolated +5V dc and +/-15V dc power to the A/D circuitry.

- The Post-Regulators are linear regulator circuits that provide tight regulation and additional noise filtering for the +/-15V dc power supplies to the analog circuits in the A/D Converter.

- The Power-on-Reset (POR) circuit senses whether the +5V dc power supply is above 4.8V. If the supply is below 4.8V, the POR circuit holds the digital circuitry in a reset state. When power is above 4.8V, the POR circuit waits roughly 100 msec before releasing the reset line, which allows the digital circuitry to start operation.

Switching Regulator

The main components in the switching regulator are U7, T2, C8, C14, C15, and CR4.

U7 is a pulse-width-controlled switching regulator IC with a built-in oscillator that runs at 40 kHz. U7 regulates the output voltage by varying the ON time of its switching transistor. Note that U7 sits on top of the regulated output voltage and operates off the difference between the input voltage and the output voltage.

While the switching transistor in U7 is turned ON, the current through winding 7-8 of transformer T2 rises as a linear ramp. The voltage across that winding is roughly constant and equal to the input voltage minus the output voltage. This current flows directly to the output of the regulator (U7) to satisfy its load requirements.

Also during this time that U7 is ON, winding 9-10 of T2 generates a negative voltage, reverse biasing rectifier CR4, and charging capacitor C8.

When the switching transistor in U7 is turned OFF, both windings 7-8 and 9-10 of T2 fly back to positive voltages making current available to the load through C8 and CR4. This load voltage is filtered by capacitor C14 and C15.

Amplifier U10 acts as a level shifter to shift the 5.6V output voltage up to the 6.82V level needed on the feedback pin of U7.

Isolated DC-to-DC Converter

FET's Q4 and Q5 act as a push-pull inverter to drive the primary of transformer T1, which draws its power from the regulated output of the switching regulator (U7). Q4 and Q5 receive their gate drive signals from the combination of U2, U3 and U4.

U4 consists of an oscillator and a counter string. The values of inductor L1 and capacitor C2 set the frequency of the oscillator to 3.2 MHz. The counter string divides the oscillator output by 64, creating a 50 kHz square wave output. Flip-flop U3 is clocked by the rising edge of the 3.2 MHz oscillator while the counter in U4 is clocked by the falling edge of the oscillator. Therefore, the outputs of U3 change state roughly 150 nanoseconds after the output of counter U4 changes state. U2 gates these signals together to generate gate drive waveforms that are approximately square waves but have 150 nanoseconds of dead time between them. This allows 150 nanoseconds for the transistors and diodes in the circuit to turn off before the circuit is driven opposite in polarity.

The rectifiers and filter capacitors on the outputs of T1 are conventional full wave types that use very fast diodes for the +/-17V dc outputs and Schottky rectifiers for the +5V dc output.

Post-Regulators

The post-regulators regulate the +/-17V outputs to +/-15V. During normal operation these post-regulators derive their reference voltage from the buffered 6.2V A/D reference source. When the power supply is under test, a removable DIP-jumper pack (W2) disconnects all the outputs from their loads. When W2 is removed, the post-regulators use the 2.5V reference from the POR circuit instead of the 6.2V.

Power-On-Reset (POR)

The Power-On-Reset circuit consists mainly of U12, which contains a voltage reference and two comparators. When the 5V dc output of the inverter is lower than 4.8V, the first comparator holds the voltage on timing capacitor C36 low, causing the second comparator to hold the reset output low. When the voltage rises above 4.8V, the first comparator releases C36. The voltage rises as C36 charges. After about 100 milliseconds, the voltage across C36 is greater than the 2.5V reference voltage and the second comparator releases the reset output line.

MULTIPLEXERS

Input signal multiplexers U8, U11, U16, U20, U41, and U44 select and route pairs of input lines to the buffer amplifier input.

Two banks of multiplexers can be controlled either together for differential measurements, or separately for single ended measurements. The first bank consists of U11, U20, and U41, which select the signal supplied to the + input of the buffer. The other bank consists of U8, U16, and U44, which select the signal supplied to the - input of the buffer. Any of 40 input lines can be selected. Four reference voltages, including analog commons, are also selectable.

The microprocessor writes multiplexer control information into latches U40 and U45. This information controls multiplexer selection. Tri-state buffers U39 and U46 are included for test verification of the data written to latches U40 and U46.

BUFFER AMPLIFIER

The buffer amplifier consists of instrumentation amplifier U57 and associated gain selection components (analog switches, resistors, and control circuitry).

Signals from the multiplexers are applied to the + and - inputs of amplifier U57 which forms a differential input stage with a gain of 20 times the ratio of R159 to the net resistance across the RG+ and RG- inputs.

Multiple resistor values on the inputs of U57 allow a selection of gains as listed in Table 165-2.

Table 165-2. Buffer Gain Selections

INPUT RANGE	GAIN U57	SIGNAL INTO A/D
+/-0.064V	154.80	+/-10V
+/-0.512V	19.10	+/-10V
+/-8.0V	1.22	+/-10V
+/-10.5V	.93	+/-10V

The input range is limited by the maximum guaranteed range of the buffer amplifier to +/-10.5V.

A/D CONVERTER AND VOLTAGE REFERENCES

The A/D Converter consists of digital-to-analog converter (DAC) U30, comparator U34, and successive approximation registers (SAR) U27 and U26. These components operate as a conventional successive approximation converter.

With all DAC bits initially set to zero, the SAR sets the most significant bit (MSB) to 1, then waits a few microseconds for the DAC to settle. Next, the SAR samples the output of the comparator to determine if the comparator input is greater than or less than the MSB of the DAC. If the input is greater, the MSB is left at 1, and the next bit is tested. If the input is less than the MSB, the MSB is reset to 0, and the next bit is tested. This process is continued until all 16 bits of the DAC are set.

Inverting buffers U31 and U32 are used to interface the SAR to the digital inputs of the DAC. Buffers U36 and U37 place the digital value on the data bus of the controller when it is read by the microprocessor.

Voltage reference VR6 is buffered by amplifier U17 to provide a very stable reference voltage of approximately 6.2V. This reference is divided by resistor network Z1 to provide additional reference voltages of 333 mV and 43 mV. These reference voltages are measured by selecting the appropriate multiplexer inputs.

The microprocessor periodically initiates reference voltage measurements for comparison with values stored in calibration memory. The ratio of the two readings represents drift in the buffer and A/D Converter and is used to correct readings taken on the inputs.

DIGITAL KERNEL

The kernel consists of 16-bit microprocessor U35, RAMs U51 and U54, ROMs U43 and U47, address decoders U29 and U38, and timer U21.

A/D OPERATION AND TIMING

The A/D Converter executes the following two types of reading cycles:

- Normal readings
- Open thermocouple tests

See Figure 165-3 for timing differences between the two reading cycle types. The reading and its timing are controlled by timer U21, which interrupts the microprocessor at the end of each critical timing interval.

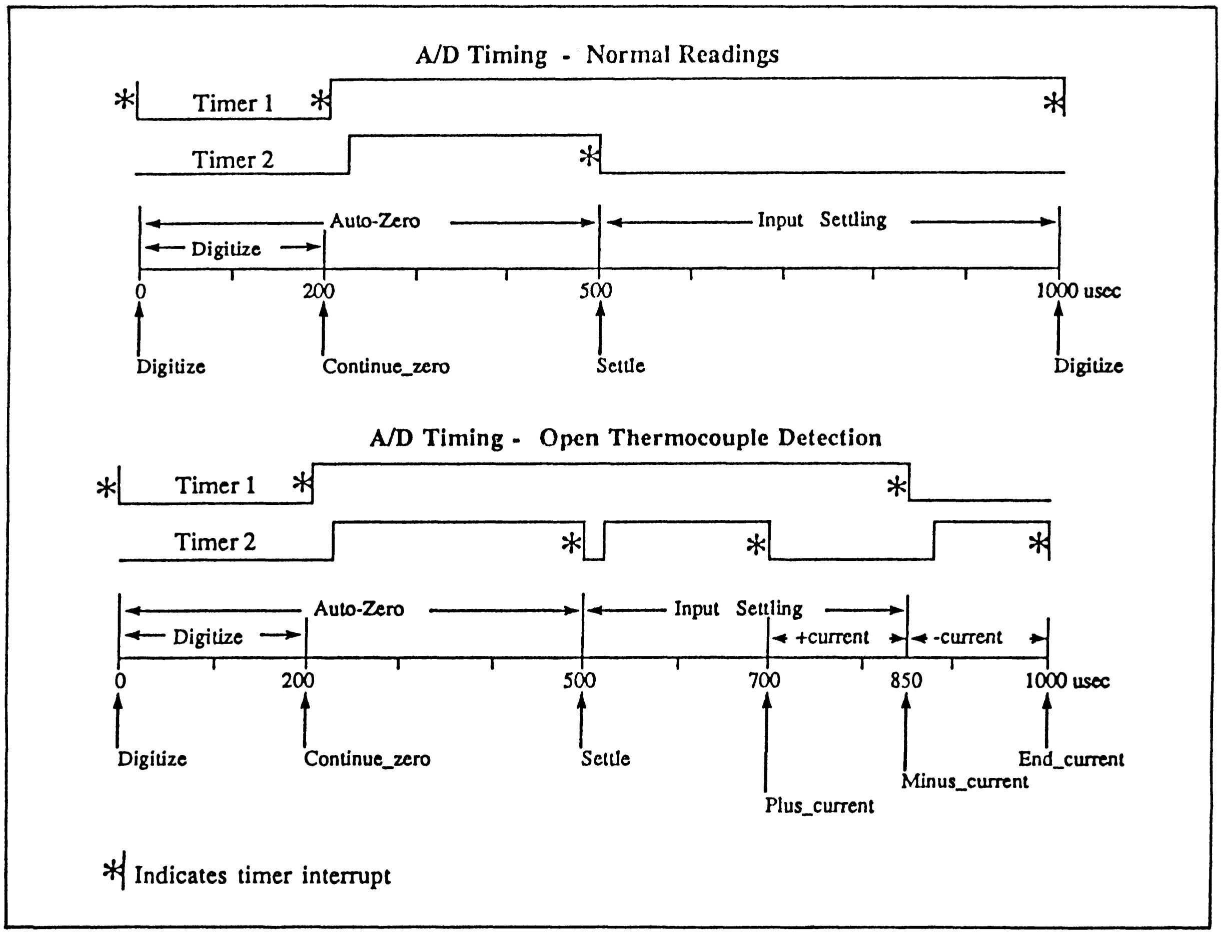


Figure 165-3. Fast A/D Timing Diagram

Normal Reading

Note the two digitize points on the timing diagram above. The first point digitizes the previous reading while the track-and-hold circuit is in the hold mode. During this period, the successive approximation register (SAR), the DAC, and the comparator work together to digitize the comparator output. Autozero can also be performed on the buffer amplifier at this time.

Autozero is performed for each measurement. This technique corrects for any amplified offset voltage from the buffer amplifier. The buffer gain is set to the desired range, the multiplexers are used to connect buffer inputs to analog common, and the amplified offset voltage is stored on auto zero capacitor C91. This capacitor tracks the offset during the auto zero period.

At the end of the auto zero period, C91 is switched to hold the offset voltage; the buffer is now ready to amplify the next input signal with virtually no offset error at the sample and hold input.

The following list details normal reading cycle sequencing:

Time 0:

- Track-and-hold switches to hold.
- The SAR, DAC, and comparator start digitizing the voltage from the track-and-hold.
- The multiplexer disconnects the previous channel and switches the inputs to analog common.
- As needed, the buffer gain is changed for the next channel.
- Auto zero is started for this channel.

Time 200 microseconds:

- The value of the previous channel is taken from the SAR.
- Auto zero continues.
- Track-and-hold enabled to discharge T/H capacitor.
- Q17 enabled to charge auto-zero capacitor C91.

Time 500 microseconds:

- The auto zero capacitor switched into hold mode by turning Q17 off.
- Multiplexer switched from analog common to next input channel.

Time 1000 microseconds:

- Time 0 steps repeated, with the next channel.

Open Thermocouple Reading

A different timing scheme is used for an open thermocouple reading. To detect open thermocouples, the Fast A/D Converter takes a voltage reading while forcing a 0.5 mA current through the thermocouple for 100 us. An open thermocouple is assumed if the measured voltage implies a thermocouple resistance greater than approximately 1600 ohms.

Since this +0.5 mA current could cause an error in the reading of any other instrument measuring the same sensor, the Fast A/D Converter follows each +0.5 mA pulse with a -0.5 mA pulse. Each pulse lasts 100 microseconds. The input filter for the other instrument measuring the same sensor can average the self-cancelling pulses.

The timing for an open input reading is the same as a normal cycle up through Time 500 microseconds. Additional timing is as follows:

Time 800 microseconds:

- The +0.5 mA current is applied to the input.

Time 900 microseconds:

- o Track-and-hold is switched to hold.
- o The +0.5 mA current pulse is removed.
- o The -0.5 mA current pulse is applied.

Time 1000 microseconds:

- o The -0.5 mA current pulse is removed.
- o The SAR, DAC, and comparator start digitizing this channel.
- o All Time 0 steps take place for the next channel.

SAMPLE-AND-HOLD

The Sample-and-Hold circuit operates as a track-and-hold circuit. It receives its input from the output of the buffer. It tracks the output of the buffer until it is put into the hold state. When in the hold state, it provides a steady signal to the A/D Controller to digitize.

CALIBRATION MEMORY

Calibration Memory uses EEPROM U23 to store the exact values of the reference voltages. The contents of U23 are accessed and transferred into RAM during power-up initialization of the Fast A/D Converter. This RAM-stored version is then used to derive correction factors for each range, based on readings of the reference voltages. UART U25 is used for serial mode access to U23.

SERIAL LINK

Differential line drivers U15 and receiver U19 transmit and receive information through transient suppression networks consisting of resistors R61, R62, R74, R75, R76, R80, R65, and R66 and diodes CR42, CR43, CR36 and CR37.

Incoming data from the mainframe controller assembly is fed into UART U25 through optocoupler U18. Upon receipt of a data byte, U25 interrupts microprocessor U35.

Data destined for the mainframe controller from the A/D Converter is driven out of the UART, through isolator U14 to the U15 line drivers. These drivers are enabled by a signal applied through isolator U14. The driver outputs remain in the high impedance state when not enabled, preventing interference with other devices transmitting on the serial link.

EXTERNAL TRIGGER

Both an external trigger input and output are provided. The external trigger input can be used to create a trigger event when the A/D Converter is operating in Burst Scan Mode. The external trigger output can be used to pass the trigger event along to other A/D converters. The external trigger circuitry is electrically isolated from the rest of the Fast A/D Converter.

The external trigger input is routed through protection circuitry (R5 and CR2.) The input is then applied to comparator U1, which is set for a threshold of approximately 2.5V and a hysteresis of 0.9V. The output of U1 is passed through transistor Q3 and isolator U5 to the controller. The external trigger input can be driven either by any of the common IC logic families or by a contact closure.

The external trigger output originates at the controller and is connected through isolator U6 directly to the output. It is capable of driving any of the common low power IC logic families or the external trigger input of another A/D converter.

GENERAL MAINTENANCE

Normally the Fast A/D Converter does not require cleaning unless dirt, dust, or other contamination is visible on the surface of the pca. Follow cleaning instructions in Section 4, Maintenance.

PERFORMANCE TESTS

There are four performance tests for the -165 Fast A/D Converter. The tests may be run independently, or all four tests may be performed in sequence to verify overall operation of the Fast A/D Converter.

The four performance tests are:

- Address Response Test
- Accuracy Verification Test
- Overrange Indication Test
- Open Thermocouple Response Test

These performance tests verify that the Fast A/D Converter performs properly and that it meets all specified accuracy tolerances. If calibration of the assembly is required, refer to the Calibration procedures that follow the performance tests in this subsection.

If the following performance tests fail to return the expected readings, refer to the self-test error description section in this subsection.

Address Response Performance Test

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES WHICH CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

The Address Response performance test checks to see if the Front End mainframe controller can communicate properly with the Fast A/D Converter address switch. The switch is then set to a variety of positions to exercise all address switch lines. Table 165-3 lists address switch settings and channel ranges for the Fast A/D Converter.

Table 165-3. Fast A/D Address Switch Settings and Channel Ranges

ADDRESS SWITCH SETTING	CHANNEL RANGE
00	0 through 39
05	50 through 89
10	100 through 139
15	150 through 189
20	200 through 239
25	250 through 289
30	300 through 339
35	350 through 389
40	400 through 439
45	450 through 489
50	500 through 539
55	550 through 589
60	600 through 639
65	650 through 689
70	700 through 739
75	750 through 789
80	800 through 839
85	850 through 889
90	900 through 939
95	950 through 989

To conduct the Address Response Performance Test, perform the following procedure:

1. Switch OFF power to the Front End.

2. Disconnect the ac line power cord and all other high voltage inputs.

3. Ensure that the External Trigger Jumper (W1) on the Fast A/D Converter is installed in the external trigger disabled position. See Figure 165-1.

4. Set the Fast A/D Converter address switch to "00", and install the Fast A/D Converter in the bottom option slot.

5. Remove all other installed options to eliminate addressing conflict.

6. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or a -175 Isothermal Input Connector. Connect the LO terminal to the adjacent common input terminal.

7. Install the connector on the -165 Fast A/D Converter.

8. Reconnect power to the Front End and switch power ON.

9. Connect the calibrator output to the input connector test leads.

10. Set the calibrator output to 7.9000V dc.

11. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to make a computer behave like a terminal.) For ease of testing, a terminal is the recommended host.

    Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM  <CR>
DEF CHAN(0)=DVIN,MAX=7.9  <CR>
FORMAT=DECIMAL  <CR>
SEND CHAN(0)  <CR>
```

The value returned for the selected channel should be approximately 7.9V.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
120  PRINT #1,"def chan(0)=dvin,max=7.9"
125  GOSUB 300
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  REM make measurement and read in response
160  PRINT #1,"send chan(0)"
170  INPUT #1,M$
180  PRINT USING "##.###";VAL(M$);
190  PRINT " Volts DC"
200  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1%
50   OPEN "KB1:"AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Computer Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0)=dvin,max=7.9"
130  GOSUB 300
140  PRINT #1,"format=decimal"
```

```
150  GOSUB 300
160  REM make measurement and read in response
170  PRINT #1,"send chan(0)"
180  INPUT #2,M$
190  PRINT USING "S##.###",VAL(M$);
200  PRINT " Volts DC"
210  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The value returned for the selected channel should be approximately 7.9V.

12. Switch the Front End power OFF.

13. Use a screwdriver to set the address switch on the Fast A/D Converter to "05". Switch power to the Front End ON.

14. Program the Front End to take a measurement on channel 50 by substituting channel "50" for "0" in both the DEF CHAN and SEND CHAN commands of step 11.

15. Repeat steps 12 through 14 for the following channels:

100	(address set to 10)
200	(address set to 20)
400	(address set to 40)
600	(address set to 60)
950	(address set to 95).

The measurement on each channel should be approximately 7.9V. This procedures verifies proper operation under most addressing situations.

16. This completes the Address Response Test.

Continue with the Accuracy Verification Test if you are conducting a complete performance test of the -165 Fast A/D Converter.

Accuracy Verification Test

All voltage readings taken by the Front End depend on the accuracy of the Fast A/D Converter. The Accuracy Verification Test checks the Fast A/D Converter to confirm its voltage measurement accuracy is within specifications.

To conduct the Accuracy Verification Test, perform the following procedure:

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Remove all addressable options from the Front End so that no address conflict occurs.

3. Set the Fast A/D Converter address switch to "00" and install the Fast A/D Converter in the top option slot of the Front End.

4. Connect test leads to the HI and LO terminals for channel 0 on either the -176 Voltage Input Connector or the -175 Isothermal Input Connector. Also connect the LO terminal to the adjacent common terminal. Install the connector on the Fast A/D Converter.

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Connect the calibrator output to the input of the 100:1 divider. Connect the divider output to the input connector test leads.

7. Set the calibrator output to 6.2000V (62 mV out of the divider).

8. Program the Front End using either a terminal or a computer. (You can run a terminal emulation program to make a computer behave like a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0)=DVIN, MAX=0.062 <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0) <CR>
```

The returned value for channel 0 should be 62 mV +/- 0.044 mV.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port, empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50  PRINT #1,CHR$(3);
60  REM Set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
90  PRINT #1,"count=off"
100 GOSUB 300
120 PRINT #1,"def chan(0)=dvin,max=0.062"
125 GOSUB 300
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 REM make measurement and read in response
160 PRINT #1,"send chan(0)"
170 INPUT #1,M$
180 PRINT "chan 0 = ";
190 PRINT USING "##.######";VAL(M$)
200 PRINT " Volts DC"
210 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:"AS NEW FILE 1%
50  OPEN "KB1:"AS OLD FILE 2%
60  PRINT #1,CHR$(3);
70  REM set up Front End
80  PRINT #1,"mode=comp"
```

```
90  GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1,"def chan(0)=dvin,max=0.062"
125 GOSUB 300
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 REM make measurement and read in response
160 PRINT #1,"send chan(0)"
170 INPUT #2,M$
180 PRINT "chan 0 = ";
190 PRINT USING "S##.######",VAL(M$);
200 PRINT " Volts DC"
210 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

The returned value for channel 0 should be 62 mV +/- 0.044 mV.

9. Change to the 512 mV voltage range by redefining channel 0.

   To do this in the Terminal Mode, send the following command:

   ```
   DEF CHAN(0)=DVIN, MAX=0.5 <CR>
   ```

   To do this in the Computer Mode, change the BASIC statement in line 120 to:

   ```
   PRINT #1,"def chan(0)=dvin, max=0.5"
   ```

10. Set the calibrator to 0. Remove the 100:1 divider and connect the calibrator output directly to the connector test leads on channel 0.

11. Set the calibrator to output 500 mV.

12. Request a measurement and verify that channel 0 returns a value of 500 mV +/- 0.25 mV.

    If you are in Terminal Mode, take the measurement by sending the following command:

    ```
    SEND CHAN(0) <CR>
    ```

    If you are in the Computer Mode, run the program in step 9.

13. Change to the 8V range by redefining channel 0. To do this in the Terminal Mode, send the following command:

    ```
    DEF CHAN(0)=DVIN, MAX=7.9
    ```

    To do this in the Computer Mode, change the BASIC program statement in line 120 to send this command.

14. Set the calibrator output to 7.9000V.

15. Request another measurement as in step 12.

    Verify that the returned value is 7.9V +/- 0.004V.

16. Change to the 10V range by redefining channel 0. To do this in the Terminal Mode, send the following command:

    ```
    DEF CHAN(0)=DVIN, MAX=9 <CR>
    ```

    If you are in the Computer Mode, change the BASIC program statement in line 120 to send this command.

17. Set the calibrator output to 9.000V.

18. Request another channel 0 measurement. The returned value should be 9V +/- 0.005V.

19. The Accuracy Verification Test is now complete.

Continue with the Overrange Indication Test if you are conducting a complete performance test of the -165 Fast A/D Converter.

Overrange Indication Test

The Overrange Indication Test determines if the Fast A/D Converter can detect and communicate a channel overrange condition to the mainframe controller.

To conduct the Overrange Indication Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Remove all addressable options from the Front End so that no address conflict occurs.

3. Set the Fast A/D Converter address switch to "00" and install the Fast A/D Converter in the top option slot of the Front End.

4. Connect test leads to the HI and LO terminals for channel 0 on either a -176 Voltage Input Connector or a -175 Isothermal Input Connector. Also connect the LO terminal to the adjacent common terminal. Install the connector on the -165 Fast A/D Converter.

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Connect the calibrator output to the input of the 100:1 divider. Connect the divider output to the input connector test leads.

7. Set the calibrator output to 6.8V (68 mV on the output of the 100:1 divider).

8. Program the Front End using either a terminal or a computer. (You can run a terminal emulation program to make a computer behave like a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End:

```
MODE=TERM <CR>

DEF CHAN(0)=DVIN,MAX=0.062 <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0) <CR>
```

The value displayed for channel 0 should be 9.99999E+37.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs instruct the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port, empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
90  PRINT #1,"count=off"
```

```
100 GOSUB 300
110 PRINT #1,"def chan(0)=dvin,max=0.062"
120 GOSUB 300
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 REM make measurement and read in response
160 PRINT #1,"send chan(0)"
170 INPUT #1,M$
180 PRINT M$
190 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:"AS NEW FILE 1%
50  OPEN "KB1:"AS OLD FILE 2%
60  PRINT #1,CHR$(3);
70  REM set up Front End
80  PRINT #1,"mode=comp"
90  GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1,"def chan(0)=dvin,max=0.062"
130 GOSUB 300
140 PRINT #1,"format=decimal"
150 GOSUB 300
160 REM make measurement and read in response
170 PRINT #1,"send chan(0)"
180 INPUT #2,M$
190 PRINT M$
200 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

The value displayed for channel 0 should be 9.99999E+37.

9. Perform PROCEDURE 9A or PROCEDURE 9B as appropriate.

PROCEDURE 9A. TERMINAL MODE

Send the following command to inspect the fault condition:

```
LIST ERROR <CR>
```

The following error message should be displayed:

Chan(0)-Out of range

PROCEDURE 9B. COMPUTER MODE

Run one of the following BASIC programs (or a similar one appropriate to your host).

Program for IBM PC:

```
10  CLS
20  REM send the fault condition
30  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
40  PRINT #1,"list error"
50  INPUT #1,N
60  PRINT N
70  IF N=0 THEN 120
80  FOR I=1 TO N
90  LINE INPUT #1,E$
100 PRINT E$
110 NEXT I
120 END
```

Program for 1722A:

```
10  PRINT CHR$(27);"[2J";
20  REM send the fault condition
30  PRINT #1,"list error"
40  INPUT #2,N
50  PRINT N
60  IF N=0 THEN 110
70  FOR I=1 TO N
80  INPUT LINE #2,E$
90  PRINT E$
100 NEXT I
110 END
```

The displayed response should be:

```
1
0,15
```

The top number, "1", indicates that one error was logged. The lower set of numbers, "0,15", indicates that error 15 was logged on channel 0. Error 15 is an "Out of range" condition.

10. The Overrange Test is complete.

Continue with the Open Thermocouple Response Test if you are conducting a complete performance test of the -165 Fast A/D Converter.

Open Thermocouple Response Test

The Open Thermocouple Response Test determines if the Fast A/D Converter can detect and communicate an open thermocouple condition on a channel to the mainframe controller.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Remove all addressable options from the Front End so that no address conflict occurs.

3. Set the Fast A/D Converter address switch to "00" and install the Fast A/D Converter in the top option slot of the Front End.

4. Connect test leads to the HI and LO terminals for channel 0 on the -175 Isothermal Input Connector. Install the connector on the -165 Fast A/D Converter.

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Connect the test leads from the Isothermal Input Connector to a 1-kilohm resistor.

7. Program the Front End using either a terminal or a computer. (You can run a terminal emulation program to make a computer behave like a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0)=TC,TYPE=JNBS <CR>

FORMAT=DECIMAL <CR>

TUNIT=CELSIUS <CR>

SEND CHAN(0) <CR>
```

The value displayed for channel 0 should equal the ambient temperature +/- 2 degrees Celsius.

PROCEDURE B. COMPUTER MODE

The following BASIC programming examples will cause the Front End to make a thermocouple measurement on channel 0. One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port and empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
90  PRINT #1,"count=off"
100 GOSUB 300
110 PRINT #1,"def chan(0)=tc,type=jnbs"
120 GOSUB 300
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 PRINT #1,"tunit=celsius"
160 GOSUB 300
170 REM make measurement and read in response
180 PRINT #1,"send chan(0)"
190 INPUT #1,M$
200 PRINT M$
210 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:"AS NEW FILE 1%
50  OPEN "KB1:"AS OLD FILE 2%
60  PRINT #1,CHR$(3);
70  REM set up computer Front End
80  PRINT #1,"mode=comp"
90  GOSUB 300
100 PRINT #1,"count=off"
```

```
110 GOSUB 300
120 PRINT #1,"def chan(0)=tc,type=jnbs"
130 GOSUB 300
140 PRINT #1,"format=decimal"
150 GOSUB 300
160 PRINT #1,"tunit=celsius"
170 GOSUB 300
180 REM make measurement and read in response
190 PRINT #1,"send chan(0)"
200 INPUT #2,M$
210 PRINT M$
220 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

The value displayed for channel 0 should equal the ambient temperature +/- 2 degrees Celsius.

8. Replace the 1-kilohm resistor with a 3-kilohm resistor to simulate a high resistance or open thermocouple.

9. Request a measurement and verify that the returned value is:

   9.99999E+37

10. Perform PROCEDURE 10A or PROCEDURE 10B as appropriate.

PROCEDURE 10A. TERMINAL MODE

Send the following command to inspect the fault condition:

LIST ERROR <CR>

The following error message should be displayed:

chan(0)-open tc

PROCEDURE 10B. COMPUTER MODE

Run one of the following BASIC programs (or a similar one appropriate to your host).

Program for IBM PC:

```
10  CLS
20  REM send the fault condition
30  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
40  PRINT #1,"list error"
50  INPUT #1,N
60  PRINT N
70  IF N=0 THEN 120
80  FOR I=1 TO N
90  LINE INPUT #1,E$
100 PRINT E$
110 NEXT I
120 END
```

Program for 1722A:

```
10  PRINT CHR$(27);"[2J";
20  REM send the fault condition
30  PRINT #1,"list error"
40  INPUT #2,N
50  PRINT N
60  IF N=0 THEN 110
70  FOR I=1 TO N
80  INPUT LINE #2,E$
90  PRINT E$
100 NEXT I
110 END
```

The displayed response should be:

```
 1
0,16
```

The top number, "1", indicates that one error was logged. The lower set of numbers, "0,16", indicate that error number 16 was logged on channel 0. Error 16 is an Open thermocouple.

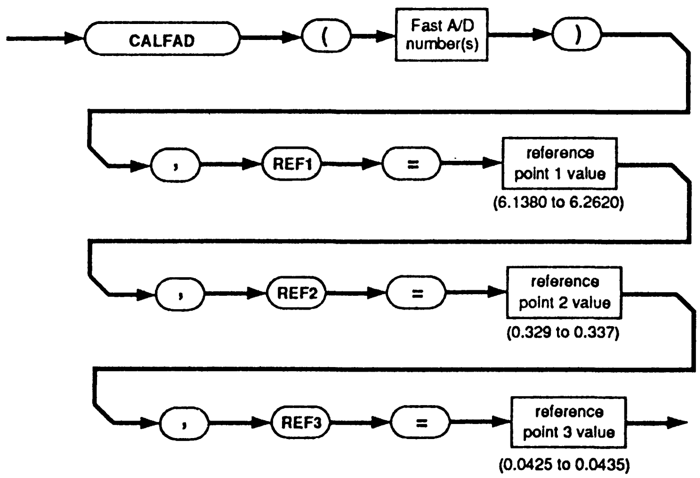
11. Disconnect the 3-kilohm resistor and the test leads from the Isothermal Input Connector.

12. Performance testing of the -165 Fast A/D Converter is complete.

Format

```
CALFAD(<Fast A/D Converter number>)
     [,REF1 = <reference point 1 value>]
     [,REF2 = <reference point 2 value>]
     [,REF3 = <reference point 3 value>]
```

Syntax Diagram



Example

The following example calibrates Fast A/D Converter 75:

```
CALFAD(75), REF1 = 6.1965, REF2 = .33427, REF3 = .04318
```

Calibration Procedure

The following procedure describes how to calibrate the -165 Fast A/D Converter:

NOTE

Calibrate the -165 only if it fails the Accuracy Verification Tests given in the preceding Performance Tests, or if it is due for normal periodic recalibration.

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE STARTING THE FOLLOWING PROCEDURE.

1. Switch OFF power to the Helios Plus Front End. Disconnect the ac line cord and all other high voltage inputs.

2. To eliminate addressing conflict, remove all other installed options.

3. Set the address switches on the Fast A/D Converter to "00" and install the Fast A/D into the bottom option slot of the Helios Plus.

4. Reconnect the ac line cord to the Helios Plus and switch power ON.

5. Send the following command to the Helios Plus:

   SEND DATE$ <CR>

   Ensure that the returned response is the current date. If the returned date is not the current calendar date, set the Helios Plus date by issuing the following command:

   DATE$=<Day>-<Month>-<Year> <CR>

   Where <Day> is a two digit number, <Month> is a three letter month keyword, and <Year> a two digit number.

   Example: DATE$=08-NOV-89

6. Ensure that the temperature has stabilized by having power applied to the Fast A/D Converter for at least 30 minutes before proceeding.

7. Send the following command to the Helios Plus:

   STOPFAD(0) <CR>

8. Set the DMM to a range which will measure 6.2V dc with a resolution of 100 microvolts. Connect the DMM to the Fast A/D Converter 6.2V and GND test points. (Refer to Figure 165-1 for the locations of the test points.) Record this reading as REF1. Acceptable values for REF1 range from +6.1380 to +6.2620V dc. Values outside this range indicate that the Fast A/D Converter is faulty.

9. Set the DMM to a range which will measure 333 mV dc with a resolution of 10 microvolts. Connect the DMM to the Fast A/D Converter 333 mV and GND test points. Wait one minute to allow thermal stabilization of connection and test leads. Record this reading as REF2. REF2 should read between +0.32900 and +0.33700V dc. The Fast A/D Converter is faulty if readings outside this range are obtained.

10. Set the DMM to a range which will measure 43 mV dc with a resolution of 1 microvolts. Connect the DMM to the Fast A/D Converter 43 mV and GND test points. Wait one minute and record this reading as REF3. REF3 should read between +0.042500 and +0.043500V dc. The Fast A/D Converter requires repair if readings outside this range are obtained.

11. Disconnect the DMM.

12. Send the following command to the Helios Plus:

    CALFAD(00),REF1=<Ref1 value>,REF2=<Ref2 value>,REF3=<Ref3 value> <CR>

    <Ref values> are in units of volts.

    Example:

    CALFAD(00),REF1=6.2023,REF2=.33170,REF3=.043217 <CR>

13. After REF values have been entered, perform the Accuracy Verification Test again. Pay particular attention to the accuracy specification for the 64 mV range. Use the following procedure if this specification is out of range:

    A. Record the reading obtained for the 64 mV range.

    NOTE

    The DMM must have high input impedance on the ranges used for 333-mV and 43-mV measurements.

    B. Divide 0.062000 by the above recorded reading. The result should be a number close to 1, with resolution to 6 decimal places (e.g., 0.995000).

C. Multiply the number calculated in step b above by the REF3 value sent in step 11. Record this result as the new REF3 value.

D. Send the following command to the Helios Plus:

CALFAD(00),REF3=<new REF3 value>

Where <new REF3 value> is the number calculated and recorded in step C above.

E. Repeat the Accuracy Verification Test for the 64 mV range.

14. Calibration is complete.

SELF-TEST ERROR DESCRIPTIONS

The following procedure can be used to determine if the Fast A/D Converter has malfunctioned and if so, what type of error occurred.

If the Helios Plus host receives the following message in response to a RESET or TEST CHAN(x) command:

In Terminal Mode:

?CHAN(X) - DEVICE SELF TEST ERROR YYY

Where x is a channel number corresponding to a channel assigned to a Fast A/D Converter and yyy the self-test error number.

Or if your system is running in the Computer Mode the message is:

?71

The message indicates the Fast A/D Converter has detected an internal fault. To determine the specific self-test error, the Helios Plus must be placed in Terminal Mode.

Use a terminal or a computer running a terminal emulation program, to send the following commands to the Helios Plus:

```
MODE=TERM    <CR>
RESET        <CR>
```

The Helios Plus will return a self-test error number.

The first message returned will be the Helios Plus Terminal Mode prompt "HCLI>". The second message returned will be the self-test error number.

The Fast A/D Converter self-test error number will be a 1 to 3 digit value which encodes one or more error conditions into one decimal number. To decode, you must convert the decimal error number to its binary equivalent and extract the true (1) bit(s) corresponding to the detected error(s).

For example, to decode an error = 192, use the following procedure:

1. Is the error number > 128? Yes. Therefore bit 7 = 1.
2. Since the number > 128, subtract 128 from it. Go to step 3.
3. Is the remainder > or = 64? Yes. Therefore bit 6 = 1.
4. Since the number > or = 64, subtract 64 from it. Go to step 5.
5. Since the remainder = 0, all other bits = 0.

If you are not familiar with decimal-to-binary conversion, Table 165-4 will help you determine which bits are true.

Table 165-4. Conversion Table

RESULT OR ERROR NUMBER > or =	SUBTRACT
128, error bit 7 is true	128
64, error bit 6 is true	64
32, error bit 5 is true	32
16, error bit 4 is true	16
8, error bit 3 is true	8
4, error bit 2 is true	4
2, error bit 1 is true	2
1, error bit 0 is true	0

Error Bit Summary:

Bit	Description of Error
0(lsb)	ROM Checksum Incorrect. One or more of the bits of ROM U43 or U47 are incorrect. Replace U43 and U47.
1	RAM read/write test failure. One or more of the bits of RAM U51 and/or U54 is either "stuck" high or low, or is unreliable. Test U51/U54 with a microprocessor system exerciser to isolate the faulty part, or replace both.
2	Calibration Data Checksum Incorrect. Incorrect/corrupted data was read from EEPROM U23, which contains self-calibration information. Recalibrate the A/D Converter (see calibration procedure in this section). If the error persists, either U23, or the device that drives it, U25, is not working properly.
3	Analog Control Latch Failure. Data read via U39/U46 does not match data written to latches U45/U40. Indicates problem with one of these four devices, or with address decoder U38.

4 Calibration Out of Limits. A large offset (>40 mV at the sample/hold output) or gain error (>10%) in the analog circuitry has been detected. Check the 43 mV, 333 mV, and 6.2V references. If these are within tolerance (1%), then either the multiplexers are not switching the reference voltages correctly, the input amplifier/filter/ sample/hold are operating with the incorrect gain or large offsets on one or more ranges, or the A/D conversion circuitry has failed.

5 Open Thermocouple Detect Circuit Failure. Indicates a failure in U49 or its associated circuitry, or a possible problem with the input multiplexers (one or more channels stuck "on").

6 Unused bit.

7 Software or System Timing Error. Indicates that the A/D Converter software has detected a condition which violates the timing or internal consistency requirements needed to guarantee error-free software operation. Check the system 4-MHz clock (test point TP16) for accuracy. May also indicate a problem with timer U21 or a problem with the core microprocessor circuitry which causes exception processing to occur (undefined op-code, bus error, addressing error, etc.). This error occurring on more than one Fast A/D Converter may indicate an a/d firmware error.

Refer to the theory of operation portion of the manual for detailed circuit descriptions.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the -165 Fast A/D Converter is given in Table 165-5 and Figure 165-4.

For parts ordering information, see Section 6 of this manual.

Figure 165-5 is a schematic diagram of the Fast A/D Converter.

Table 165-5. Fast A/D Converter
(See Figure 165-5.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	--------------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
C 1, 3, 4,		CAP,CER,0.1UF,+-10%,25V,X7R,1206	747287	04222	12063C104KAT060R	26	
C 20, 22, 47-			747287				
C 50, 52, 55,			747287				
C 57, 58, 60-			747287				
C 62, 67, 71,			747287				
C 72, 75, 79,			747287				
C 81, 85, 88,			747287				
C 92, 95			747287				
C 2, 82		CAP,CER,22PF,+-10%,50V,C0G,1206	740563	04222	12065A220KAT050R	2	
C 5, 7, 28,		CAP,TA,10UF,+-20%,25V	714774	56289	199D106X0025CG2	8	
C 29, 32, 34-			714774				
C 36			714774				
C 6, 27		CAP,TA,47UF,+-20%,10V	733246	56289	199D476X0010DG2	2	
C 8		CAP,AL,820UF,+-20%,35V,SOLV PROOF	866947	62643	SXE35VB821M18X15MC	1	
C 9, 13, 19,		CAP,TA,2.2UF,+-20%,25V	697425	56289	199D225X0025AG2	8	
C 31, 63, 97,			697425				
C 99,100			697425				
C 10- 12, 16-		CAP,CER,1000PF,+-10%,50V,C0G,1206	747378	04222	12065A1001KAT050R	40	
C 18, 21, 23,			747378				
C 24, 30, 33,			747378				
C 37- 41, 43-			747378				
C 46, 64- 66,			747378				
C 68, 70, 73,			747378				
C 74, 77, 78,			747378				
C 80, 83, 84,			747378				
C 86, 87, 89,			747378				
C 90, 93, 94,			747378				
C 96, 98			747378				
C 14, 15, 25,		CAP,AL,120UF,+-20%,35V,SOLV PROOF	866954	62643	SXF35VB121M8X12FT	4	
C 26			866954				
C 42, 59		CAP,CER,0.01UF,+-10%,50V,X7R,1206	747261	04222	12065C103KAT060R	2	
C 51		CAP,CER,0.047UF,+-20%,50V,X7R,1206	782615	04222	12065C473MAT060R	1	
C 53, 54		CAP,TA,10UF,+-20%,25V	782672	56289	199D106X0025CA2	2	
C 56, 69		CAP,TA,1UF,+-20%,35V,3528	866970	56289	293D105X0035B2W	2	
C 76		CAP,CER,10PF,+-10%,50V,C0G,1206	747311	04222	12065A100KAT060R	1	
C 91		CAP,POLYPR,0.068UF,+-20%,100V	852132	37942	171ED3680AAM	1	
C 101		CAP,POLYPR,1000PF,+-1%,100V	844816	40402	KP1830102011%	1	
C 102		CAP,POLYPR,0.033UF,+-10%,63V	721050	68919	MKP20-336-K-63V	1	
C 103		CAP,CER,500PF,+-10%,1000V,X5R	105692	60705	562CX5FCK102EE501K	1	
CR 1, 5, 6	*	DIODE,SI,BV=70.0V,IO=50MA,DUAL,SOT23	742544	25088	BAW56	3	
CR 2, 13, 24,	*	DIODE,SI,BV=100,IO=100MA,SOT23	821116	04713	MMBD7000T1	10	
CR 27, 36, 37,	*		821116				
CR 42, 43, 56,	*		821116				
CR 89	*		821116				
CR 3, 98		DIODE,SI,50 PIV,2.0 AMP	347559	14936	P-300A-031	2	
CR 4, 16, 17		DIODE,SI,20 PIV,1.0 AMP	559708	04713	1N5817	3	
CR 7- 12, 14,	*	DIODE,SI,BV=200V,IO=200MA,350MW,SOT23	867072	12040	FDSO1501SA	80	
CR 15, 18- 23,	*		867072				
CR 25, 26, 28-	*		867072				
CR 35, 38- 41,	*		867072				
CR 44- 55, 57-	*		867072				
CR 85	*		867072				
CR 99,100	*	DIODE,SI, 30 PIV, 1.0 AMP	567396	04713	1N5818	2	
F 1		FUSE,5X20MM,.500A,250V,FAST	838151	71400	GDA-500MA	1	
H 1		RIVET,PUSH,RH,NYL,.125,.182	101469	COMMERCIAL		1	
H 2		SCREW,MACH,PH,P,SS,4-40X.312	335141	COMMERCIAL		12	
H 3		FASTENER,BUTTON,PUSH-IN,NYL,.093,.115	658450	0HFJ2	27PIF0039	1	
L 1		INDUCTOR,100UH,+-5%,12MHZ,SHLD	174755	24759	MR-100	1	
MP 1		LABEL,BAR-CODE,9.4 CPI,0.245X1.25	807099	9R216	807099	1	
MP 2		LABEL COPYRIGHT	846365	9H491	846365	2	
MP 3		JUMPER,REC,2 POS,.100CTR,.025 SQ POST	757294	00779	850108-1	1	
MP 4		RETAINER,P.C.B.	579078	89536	579078	2	
MP 5		SHIELD, BOTTOM	871541	89536	871541	1	
MP 6		SHIELD, TOP	871546	89536	871546	1	
MP 7		INSULATOR	871553	89536	871553	1	
MP 8		STRAP, GROUNDING	873823	89536	873823	1	
Q 1, 6, 9,	*	TRANSISTOR,SI,NPN,SMALL SIGNAL,SOT23	742676	04713	MMBT3904T1	5	
Q 11, 12	*		742676				
Q 2	*	TRANSISTOR, SI, BV=60V, 65W, TO-220	559989	04713	TIP125	1	

An * in 'S' column indicates a static-sensitive part.

Table 165-5. Fast A/D Converter (cont)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	---DESCRIPTION---	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
Q 3, 7, 8,	*	TRANSISTOR,SI,PNP,SMALL SIGNAL,SOT23	742684	04713	MMBT3906T1	7	
Q 10, 14, 21,	*		742684				
Q 23	*		742684				
Q 4, 5	*	TRANSISTOR,SI,N-DMOS,50W,DPAK	866827	61752	IRLR024TR	2	
Q 15- 17, 19	*	TRANSISTOR,SI,N-JFET,TO-92	723734	17856	J27138TR	4	
Q 18	*	TRANSISTOR,SI,N-JFET,TO-92	867312	17856	J2970-206	1	
Q 20	*	TRANSISTOR,SI,BV= 60V, 65W,TO-220	386128	04713	TIP120T	1	
Q 22	*	TRANSISTOR,SI,N-DMOS,50W,IPAK	875211	61752	IRLU024	1	
R 1- 3, 19,	*	RES,CERM,10K,+-1%,.125W,100PPM,1206	769794	59124	RK73H2BF103B	11	
R 56, 82, 84,	*		769794				
R 107,115,159,	*		769794				
R 167	*		769794				
R 4, 5, 14,	*	RES,CERM,47K,+-5%,.125W,200PPM,1206	746685	59124	RM73B-2BJ473B	25	
R 15, 88, 97,	*		746685				
R 99-101,103-	*		746685				
R 106,108,109,	*		746685				
R 111,140,147-	*		746685				
R 149,151,153,	*		746685				
R 160,163,169	*		746685				
R 6	*	RES,CERM,220K,+-5%,.125W,200PPM,1206	746750	91637	CRCW-1206-2203JB02	1	
R 7, 8, 13,	*	RES,CERM,30.1K,+-1%,.125W,100PPM,1206	801258	59124	RK73H-2B-F3012KB	10	
R 135,136,139,	*		801258				
R 143,144,164,	*		801258				
R 168	*		801258				
R 9, 17, 34,	*	RES,CERM,1K,+-1%,.125W,100PPM,1206	783241	59124	RK73H-2B-F1001KB	21	
R 42, 46, 89-	*		783241				
R 96,102,110,	*		783241				
R 112-114,123,	*		783241				
R 128,145	*		783241				
R 10, 11, 61,	*	RES,CERM,51,+-5%,.125W,200PPM,1206	746271	59124	RM73B-2BJ510B	6	
R 62, 75, 76	*		746271				
R 12,165		RES,CF,7.5,+-5%,0.25W	854559	59124	CF1-4VT7R5J	2	
R 16, 41, 47,	*	RES,CERM,270,+-5%,.125W,200PPM,1206	746354	59124	RM73B-2BJ271B	6	
R 65, 66, 81	*		746354				
R 18, 21		RES,CC,100M,+-10%,0.5W	190520	01121	EB1071	2	
R 20, 22, 25-		RES,MF,1K,+-5%,250PPM,FLMPRF,FUSIBLE	866921	23237	FA8225-1K-5%	40	
R 27, 32, 33,			866921				
R 35, 44, 49,			866921				
R 50, 57, 63,			866921				
R 64, 69, 73,			866921				
R 78, 83, 85,			866921				
R 87,119,121,			866921				
R 122,124-127,			866921				
R 129-131,134,			866921				
R 137,141,142,			866921				
R 146,150,152,			866921				
R 154,161,162			866921				
R 23, 68, 70,	*	RES,CERM,243,+-1%,.125W,100PPM,1206	810606	91637	CRCW-1206-2430FB02	4	
R 71	*		810606				
R 24, 59, 60,	*	RES,CERM,5.6K,+-5%,.125W,200PPM,1206	746578	91637	CRCW-1206-5601JB02	7	
R 77, 86, 98,	*		746578				
R 138	*		746578				
R 28, 43	*	RES,CERM,10,+-5%,.125W,200PPM,1206	746214	09969	CRCW-1206-100JB02	2	
R 29, 30,118,	*	RES,CERM,33,+-5%,.125W,200PPM,1206	746248	09969	CRCW-1206-330JB02	4	
R 120	*		746248				
R 31	*	RES,CERM,100,+-5%,.125W,200PPM,1206	746297	59124	RM73B2BJ101B	1	
R 36, 48, 52,	*	RES,CERM,61.9K,+-1%,.125W,100PPM,1206	821330	59124	RK73H2BF6192KB	5	
R 55, 72	*		821330				
R 37	*	RES,CERM,34K,+-1%,.125W,100PPM,1206	821314	91637	CRCW-1206-343FB02	1	
R 38, 45	*	RES,CERM,14K,+-1%,.125W,100PPM,1206	816033	59124	RK73H-2B-F1402KB	2	
R 39	*	RES,CERM,9.76K,+-1%,.125W,100PPM,1206	867358	91637	CRCW-1206-9761FB02	1	
R 40, 51		ZENER REFERENCE SET	377283	89536	377283	3	
R 53	*	RES,CERM,180,+-5%,.125W,200PPM,1206	746321	59124	RM73B-2BJ181B	1	
R 54	*	RES,CERM,5.11K,+-1%,.125W,100PPM,1206	810663	91637	CRCW-1206-5111FB02	1	
R 74, 80	*	RES,CERM,33,+-5%,1W,200PPM,2512	838045	3V925	MC2512-330HM-5%T	2	
R 116,117,166,	*	RES,CERM,147K,+-1%,.125W,100PPM,1206	866926	91637	CRCW-1206-1473FB02	4	
R 170	*		866926				
R 132	*	RES,CERM,2K,+-5%,.125W,200PPM,1206	746461	59124	RM73B-2BJ202J	1	
R 133	*	RES,CERM,10M,+-5%,.125W,200PPM,1206	783274	59124	RM73B-2BJ1005B	1	
R 155	*	RES,CERM,215K,+-1%,.125W,100PPM,1206	836643	59124	RK73H2B215KB	1	
R 156	*	RES,CERM,1.30K,+-1%,.125W,100PPM,1206	780999	91637	CRCW-1206-132FB02	1	

An * in 'S' column indicates a static-sensitive part.

Table 165-5. Fast A/D Converter (cont)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	--------------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE -E-
R 157	*	RES,CERM,11K,+-1%,.125W,100PPM,1206	867291	91637	CRCW-1206-113FB02	1	
R 158	*	RES,CERM,698K,+-1%,.125W,100PPM,1206	867296	91637	CRCW-1206-6983FB02	1	
SW 1		SWITCH,ROTARY,1 POLE,16 POS,1 THUMB	867044	97525	276033M	1	
SW 2		SWITCH,ROTARY,2 POLE,REPEAT 0&5,THUMB	867036	97525	517673	1	
T 1		TRANSFORMER, HIGH FREQUENCY	865287	89536	865287	1	
T 2		TRANSFORMER, FLYBACK	865290	89536	865290	1	
TP 1- 7, 12-		JUMPER,WIRE,NONINSUL,0.200CTR	816090	91984	150T1	23	
TP 27			816090				
TP 8, 9, 11		SOCKET,SINGLE,PWB,FOR 0.080 PIN	170480	74970	105-752	3	
TP 10		SOCKET,SINGLE,PWB,FOR 0.080 PIN	149112	74970	105-0753	1	
U 1, 34, 50	*	IC,COMPARATOR,DUAL,LOW PWR,SOIC	837211	27014	LM393M FLOW-63	3	
U 2	*	IC,CMOS,QUAD INPUT NOR GATE,SOIC	830711	04713	MC74HC02DTR	1	
U 3	*	IC,CMOS,DUAL D F/F,+EDG TRG,SOIC	837922	54590	CD74AC74M	1	
U 4	*	IC,CMOS,14 STAGE BINARY COUNTER,SOIC	831081	04713	MC74HC4060DR1	1	
U 5, 6	*	ISOLATOR,OPTO,LED TO TRANSISTOR	504977	04713	ODL-340	2	
U 7	*	IC,VOLT REG,ADJ,SWITCHING REGULATOR	867119	64135	LT1072CT-FLOW30	1	
U 8, 11, 16,	*	IC,CMOS,8-1 LINE MUX/DEMUX ANALOG SW	867015	24355	ADG508AK	6	
U 20, 41, 44	*		867015				
U 9, 10	*	IC,OP AMP,SELECTED DIFF OUT VOLT=2MV	473777	27014	SL62516	2	
U 12	*	IC,VOLT SUPERVISOR,5V SENSE,SOIC	780502	01295	TL7705ACDR	1	
U 14	*	ISOLATOR,OPTO,HI-SPEED,DUAL	429894	28480	HCPL-2531	1	
U 15	*	IC,BPLR,DUAL DIFF LINE DRVR W/3-STATE	586081	12040	DS1692J	1	
U 17	*	IC,OP AMP,ULTRA-LOW-NOISE,SOIC	783001	01295	OP07CDR	1	
U 18	*	ISOLATOR,OPTO,HI-SPEED,8 PIN DIP	354746	47379	6N135	1	
U 19	*	IC,BPLR,DIFFERENTIAL LINE RECEIVER	586073	01295	SN55182J	1	
U 21	*	IC,CMOS,TRIPLE PROGRAMMABLE TIMER	866991	12581	293D105XHD63A40RP	1	
U 22, 36, 37,	*	IC,CMOS,OCTL LINE DRVR,SOIC	801043	04713	MC74HC244AD	5	
U 39, 46	*		801043				
U 23		IC,NMOS,16 X 16 BIT EEPROM,SOIC	742833	12040	NMC9306M	1	
U 24	*	IC,CMOS,QUAD BUFFER W/3-ST,SOIC	852090	18324	74HC126DT	1	
U 25	*	IC,CMOS,DUAL CHANNEL UART,PLCC	866785	52063	XR68C681CJ	1	
U 26	*	IC,CMOS,SUCCESS APPROX REG,SOIC	867010	04713	MC14549BDW	1	
U 27	*	IC,CMOS,SUCCESSIVE APPROX REG,SOIC	867002	04713	MC14559BCDWR	1	
U 28	*	IC,CMOS,QUAD BUS BUFFER W/3-ST,SOIC	866801	04713	MC74HC125DR1	1	
U 29	*	PROGRAMMED PAL, FAST A/D ADRS DECODE	872606	89536	872606	1	
U 30	*	IC,BIP,16BIT DAC,15BIT ACCUR,CUR OUT	866996	13919	DAC702KP	1	
U 31, 32	*	IC,CMOS,OCTL INV LINE DRVR,SOIC	782938	01295	SN74HC240DWR	2	
U 33	*	IC,CMOS,QUAD 2 INPUT OR GATE,SOIC	838276	54590	CD74AC32M	1	
U 35	*	IC,CMOS,16 BIT MPU,10 MHZ,PLCC	866777	04713	MC68HC000FN10	1	
U 38	*	IC,CMOS,3-8 LINE DCDR W/ENABLE,SOIC	866793	12040	74AC138SCT	1	
U 40, 45, 53	*	IC,CMOS,OCTAL D F/F,+EDG TRG,SOIC	866798	01295	SN74HC374DWR	3	
U 42	*	IC,CMOS,DUAL DIV BY 2, 5 COUNTER	867171	18324	74HC390DT	1	
U 43, 47		PROGRAMMED PROM SET, FAST A/D	872676	89536	872676	2	
U 48	*	IC,CMOS,HEX INVERTER,UNBUFFERED,SOIC	806893	18324	74HCU04DT	1	
U 49	*	IC,CMOS,QUAD BILATERAL SWITCH	867023	24355	ADG212AKN	1	
U 51, 54	*	IC,CMOS,32K X 8 STATIC RAM,120 NSEC	800250	33297	D43256C12L	2	
U 52	*	IC,COMPARATOR,QUAD,14 PIN,SOIC	741561	18324	LM339DT	1	
U 55	*	IC,OP AMP,DUAL,JFET INPUT,8 PIN DIP	495119	12040	LF353BN	1	
U 56	*	IC,LINEAR,BIPOLAR 398. SAMPLE/HOLD	723692	18324	LF398N	1	
U 57	*	IC,BPLR,INSTRUMENTATION AMPLIFIER	867304	06665	AMP01-FX	1	
VR 1- 3, 7,	*	ZENER,UNCOMP,12.1V,5%,5MA,0.2W,SOT23	866822	04713	BZX84C12T1	5	
VR 8	*		866822				
VR 4, 5	*	ZENER,UNCOMP,5.1V,5%,20MA,350MW,SOT23	837179	04713	MMBZ5231T1	2	
W 1		JUMPER,DIP,.300CTR,PROGRAM,4POS	530006	51167	8-675-191CT2E	1	
W 2		JUMPER,DIP,0.300CTR,PROGRAM, 8 POS	783183	51167	16-680-191T	1	
W 3		HEADER,1 ROW,.100CTR,2 PIN	643916	22526	65500-102	1	
W 4, 5		HEADER,1 ROW,.100CTR,6 PIN	478669	22526	65500-106	2	
XF 1		HOLDER,FUSE,5X20MM,PCB	772475	75915	111501	2	
XU 8, 11, 16,		SOCKET,IC,16 PIN	572347	00779	2-640358-1	8	
XU 20, 41, 44,			572347				
XU 49			572347				
XU 30		SOCKET,IC,24 PIN	376236	00779	2-640361-1	1	
XU 43, 47		SOCKET,IC,28 PIN,DUAL WIPE,BEAM TYPE	756353	00779	2-641605-1	2	
XU 51, 54		SOCKET,IC,32 PIN	807156	00779	2-644018-3	2	
XU 57		SOCKET,IC,18 PIN	418228	91506	218-AG39D	1	
XW 1		SOCKET,1 ROW,PWB,0.100CTR,4 POS	417311	30035	SS-109-1-04	1	
Y 1		CRYSTAL,20.00MHZ,+-30PPM,HC-49M	867051	5W664	AT51 EXTENDED TEMP	1	
Z 1	*	RES NET ASSY TESTED	872184	89536	872184	1	

An * in 'S' column indicates a static-sensitive part.

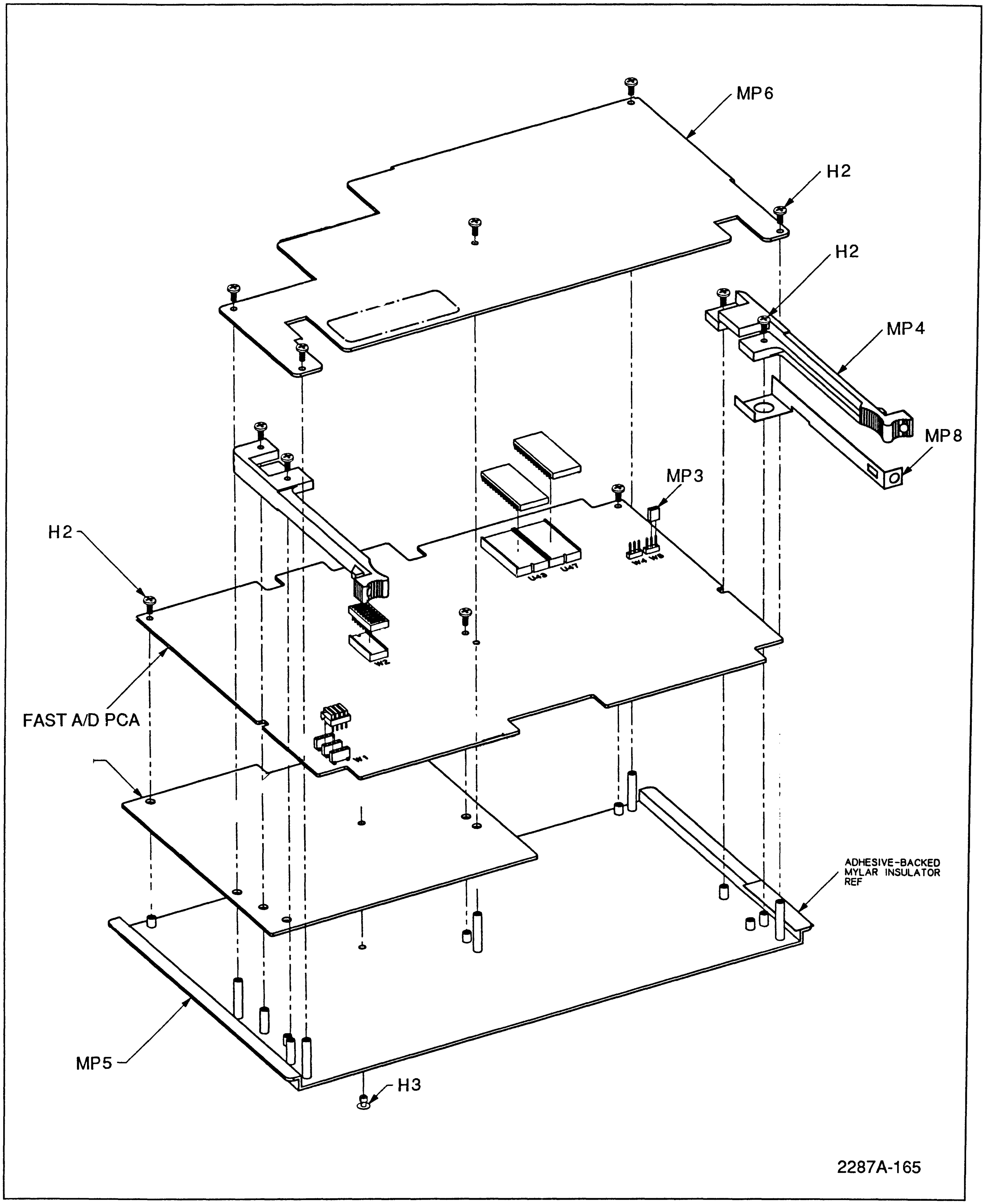
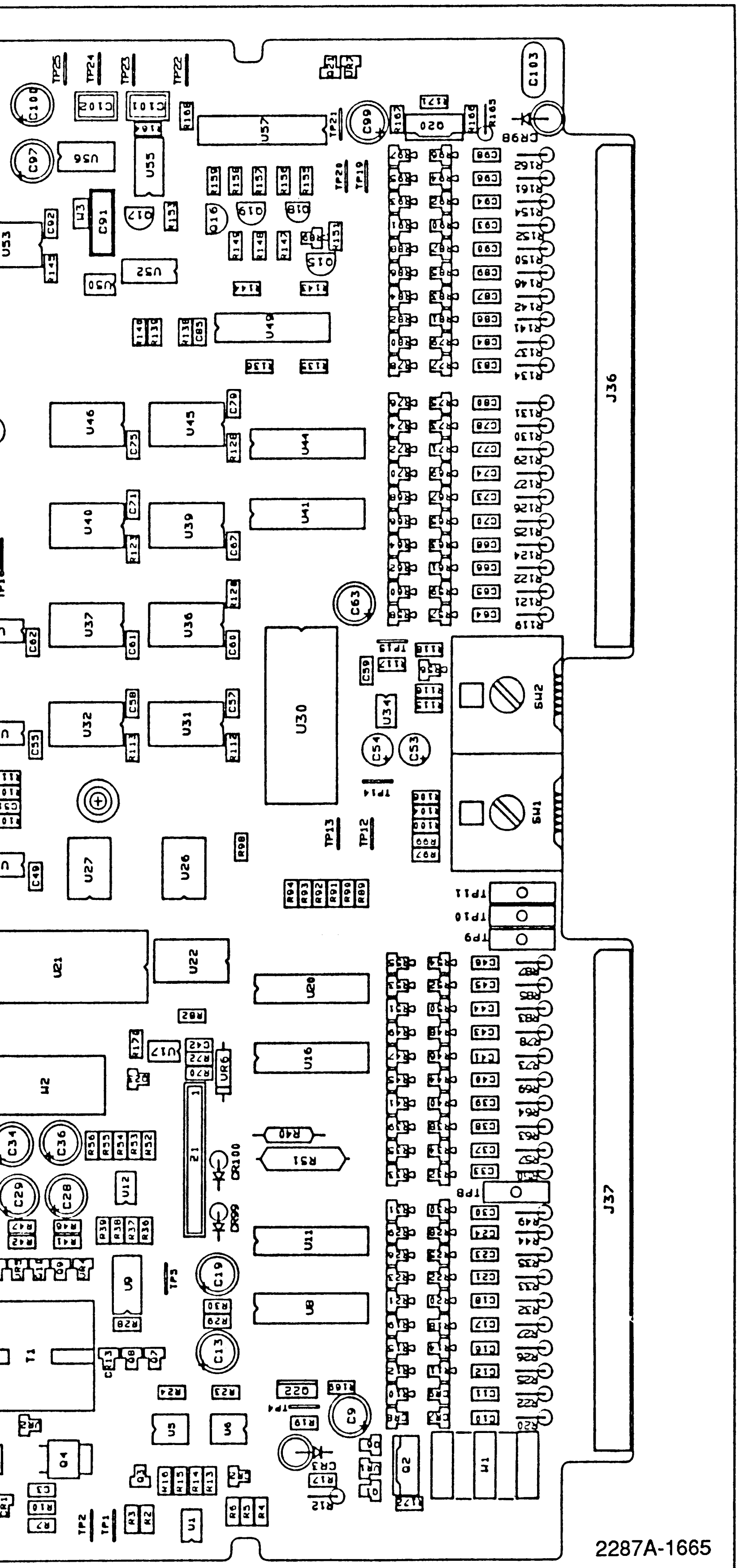


Figure 165-4. Fast A/D Converter



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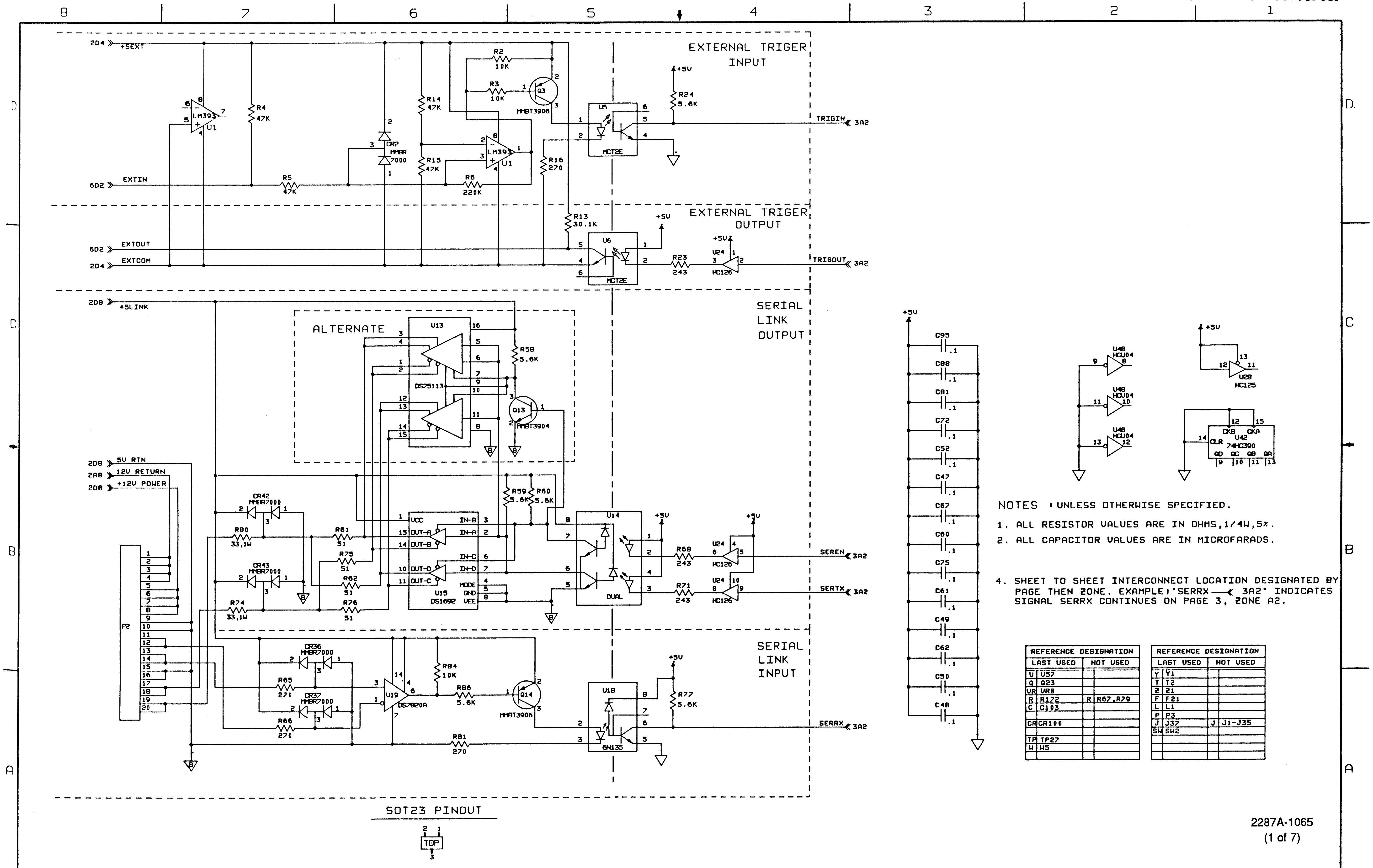


NOTES : UNLESS OTHERWISE SPECIFIED.

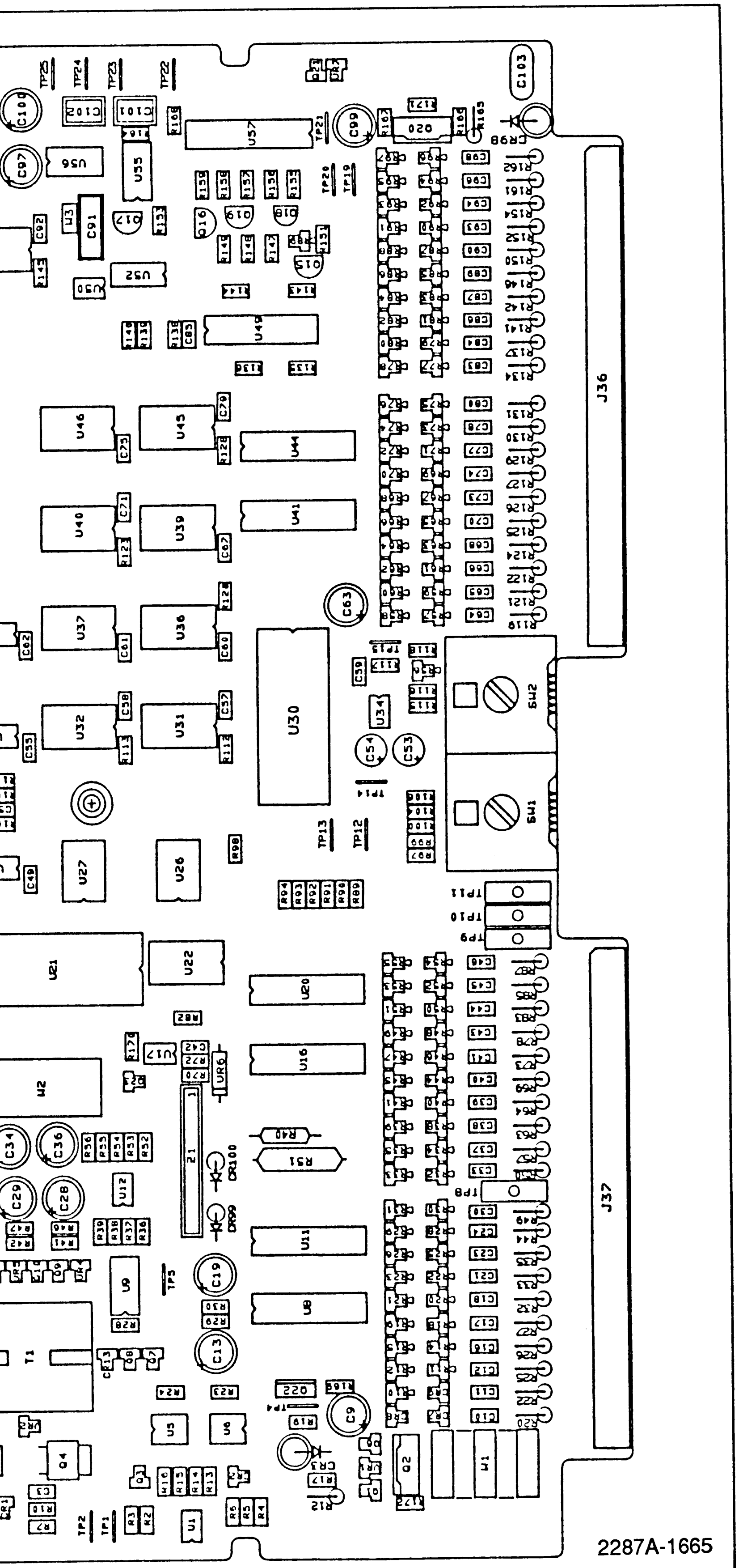
1. ALL RESISTOR VALUES ARE IN OHMS,1/4W,5%.
2. ALL CAPACITOR VALUES ARE IN MICROFARADS.

4. SHEET TO SHEET INTERCONNECT LOCATION DESIGNATED BY PAGE THEN ZONE. EXAMPLE: "SERRX ⟵ 3A2" INDICATES SIGNAL SERRX CONTINUES ON PAGE 3, ZONE A2.

REFERENCE DESIGNATION			
LAST USED		NOT USED	
U	U57		
Q	Q23		
VR	VR8		
R	R172	R	R67,R79
C	C103		
CR	CR100		
TP	TP27		
W	W5		

REFERENCE DESIGNATION			
LAST USED		NOT USED	
Y	Y1		
T	T2		
Z	Z1		
F	F21		
L	L1		
P	P3		
J	J37	J	J1-J35
SW	SW2		

Figure 165-5. Fast A/D Converter PCA



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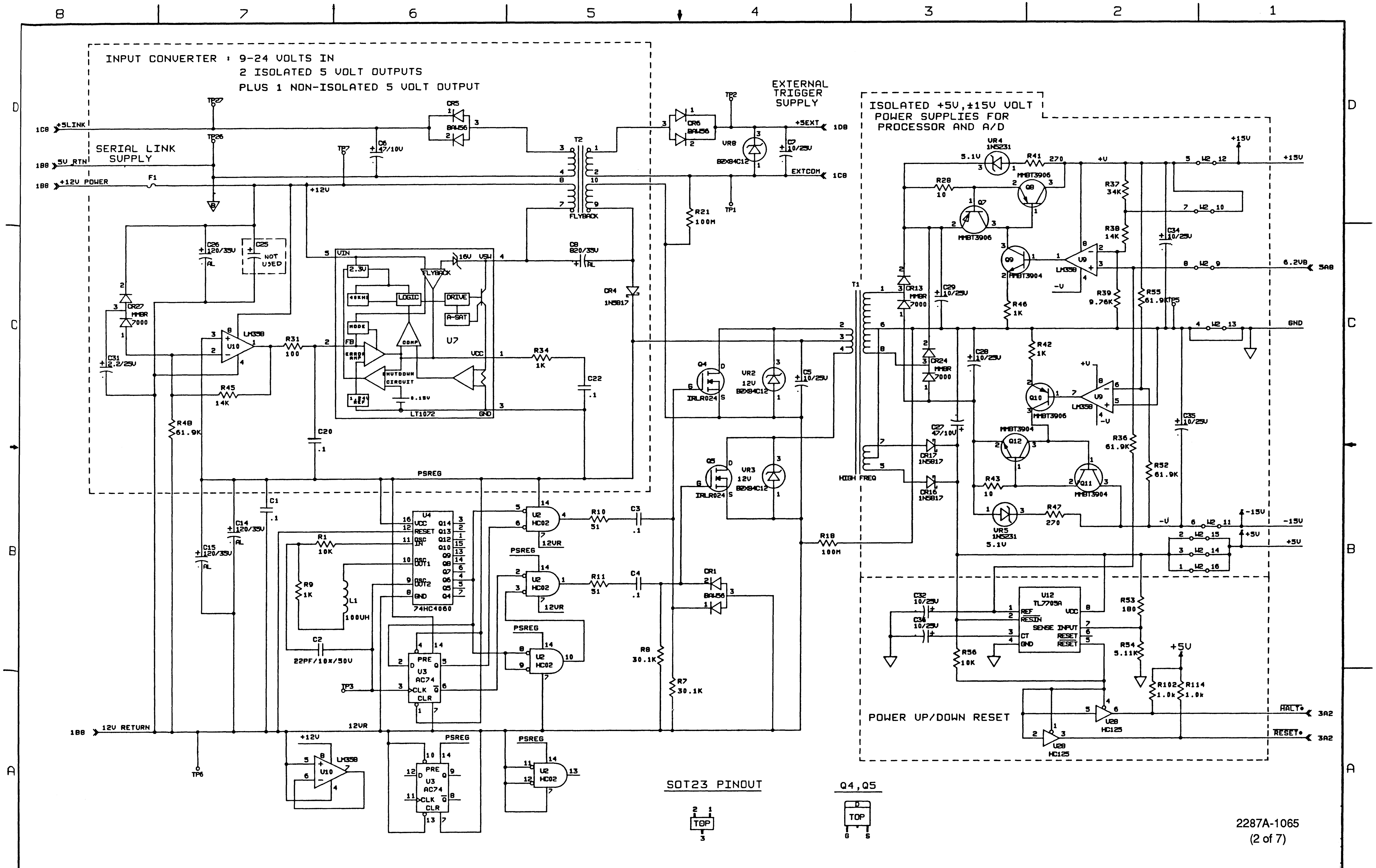
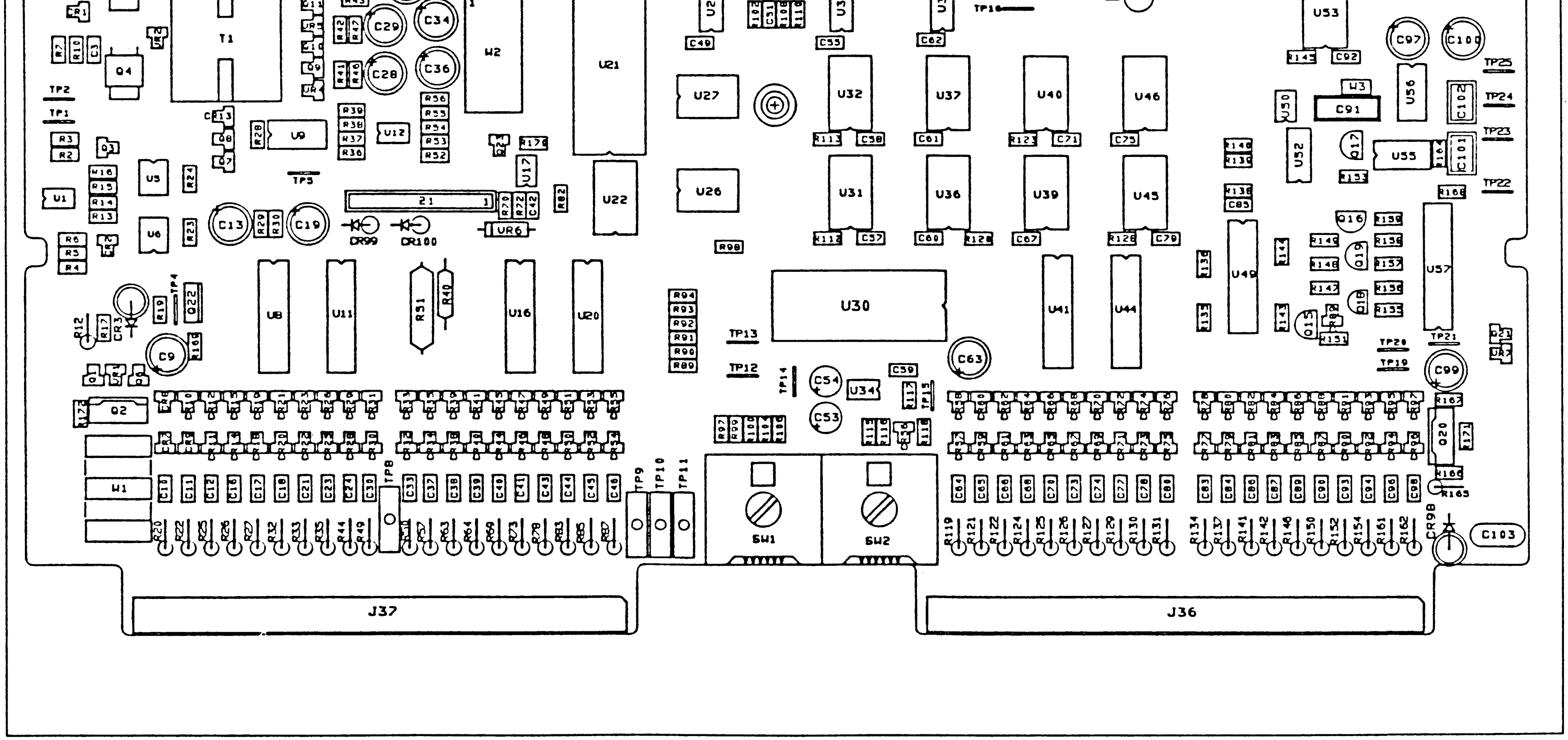


Figure 165-5. Fast A/D Converter PCA (cont.)


J37
J36
SW1
SW2
U30
U21
U22
U27
U26
U32
U31
U37
U36
U40
U39
U46
U45
U41
U44
U49
U57
U53
U55
U56
U52
U8
U11
U16
U20
U9
U12
U5
U6
U1
T1
W1
W2
Q2
Q4
C9
C13
C19
C28
C29
C34
C36
C54
C53
C63
C91
C97
C99
C100
C103

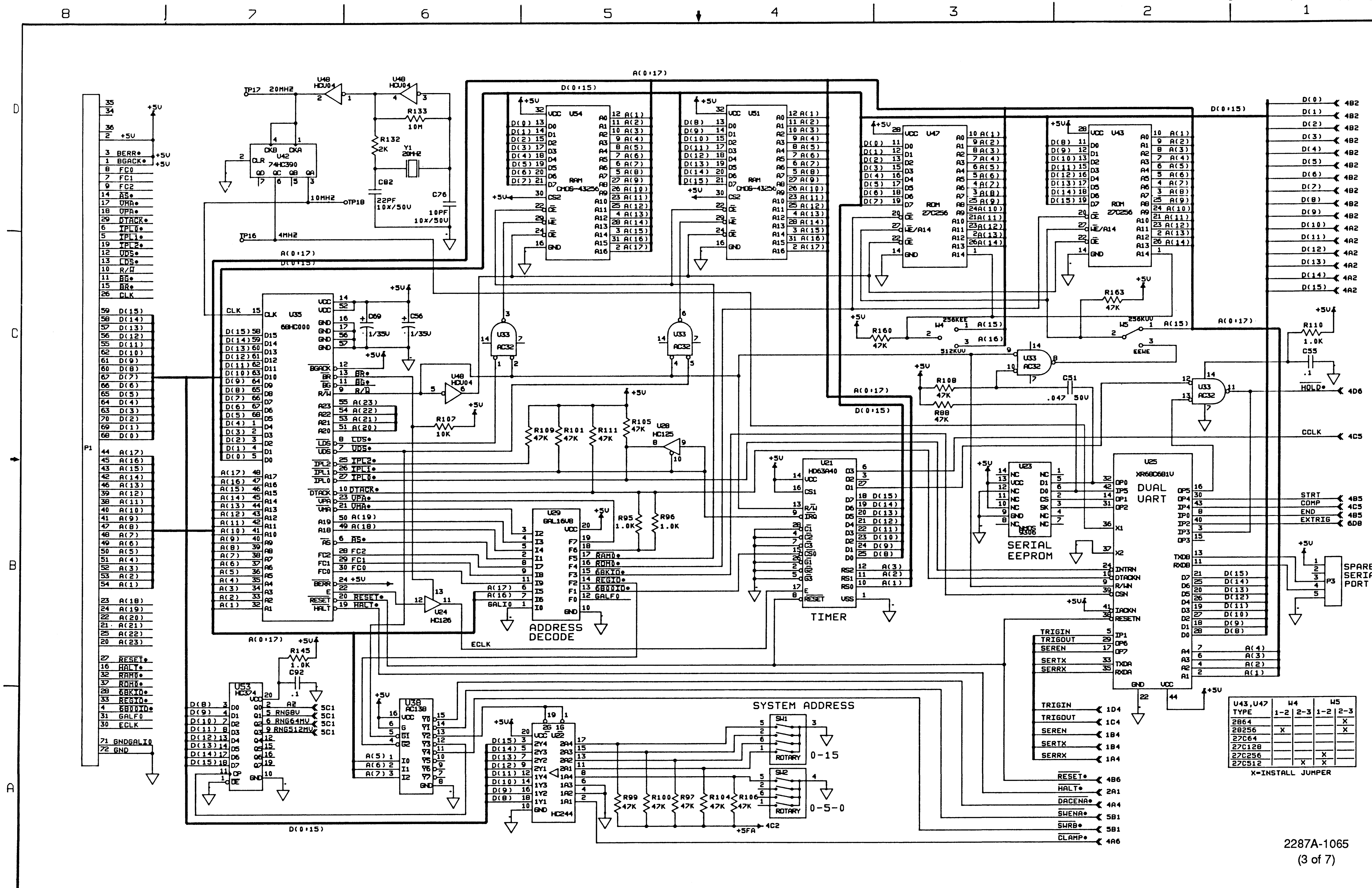
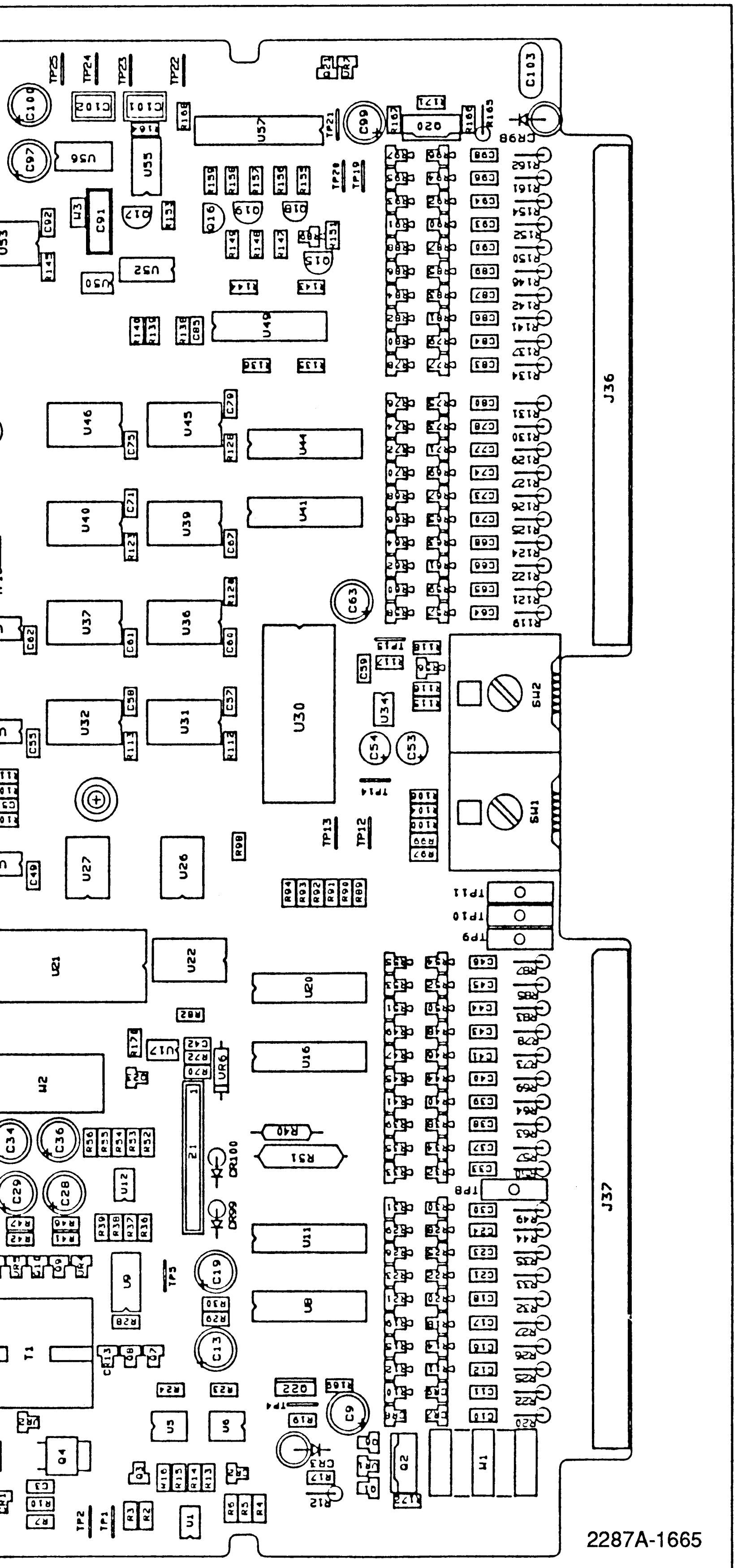


Figure 165-5. Fast A/D Converter PCA (cont.)


J36
J37
U30
U21
W2
W1
T1
SW1
SW2
U57
U56
U55
U53
U52
U49
U46
U45
U44
U41
U40
U39
U37
U36
U34
U32
U31
U27
U26
U22
U20
U16
U12
U11
U8
U5
U1
Q2
Q4
C103
C100
C99
C97
C91
C63
C54
C53
C36
C34
C29
C28
C19
C13
C9
R51
R40
VR6
TP1
TP2
TP5
TP8
TP9
TP10
TP11
TP12
TP13
TP14
TP19
TP20
TP21
TP22
TP23
TP24
TP25

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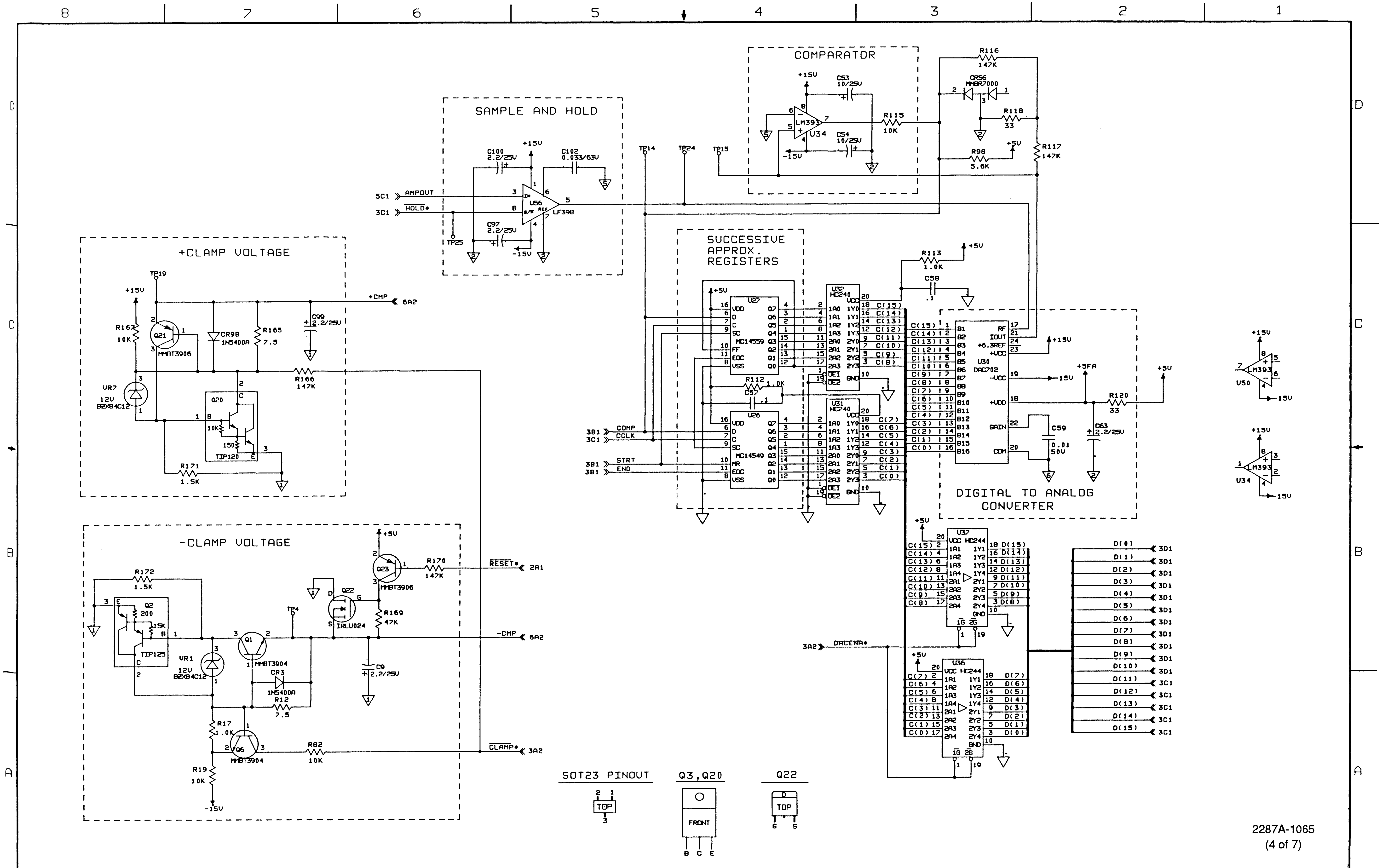
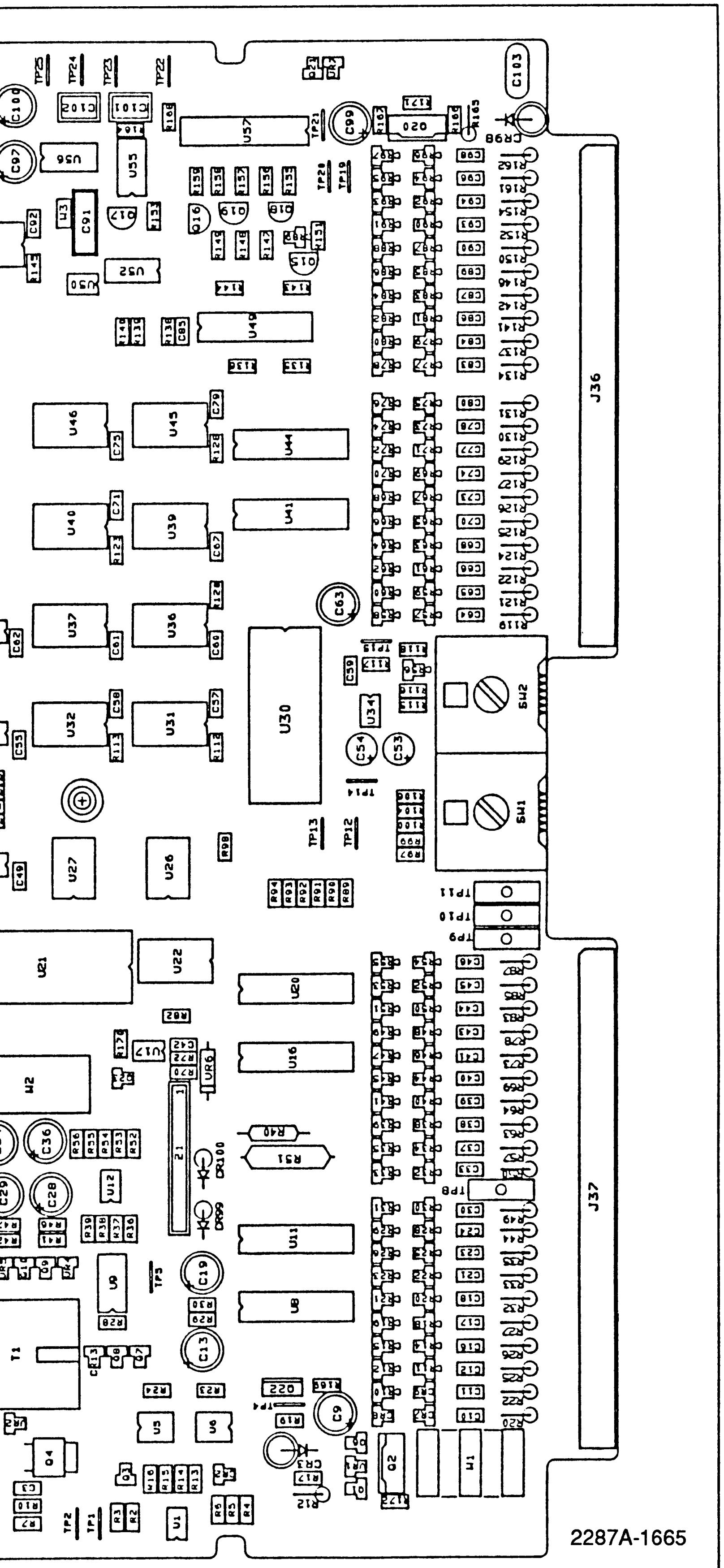


Figure 165-5. Fast A/D Converter PCA (cont.)



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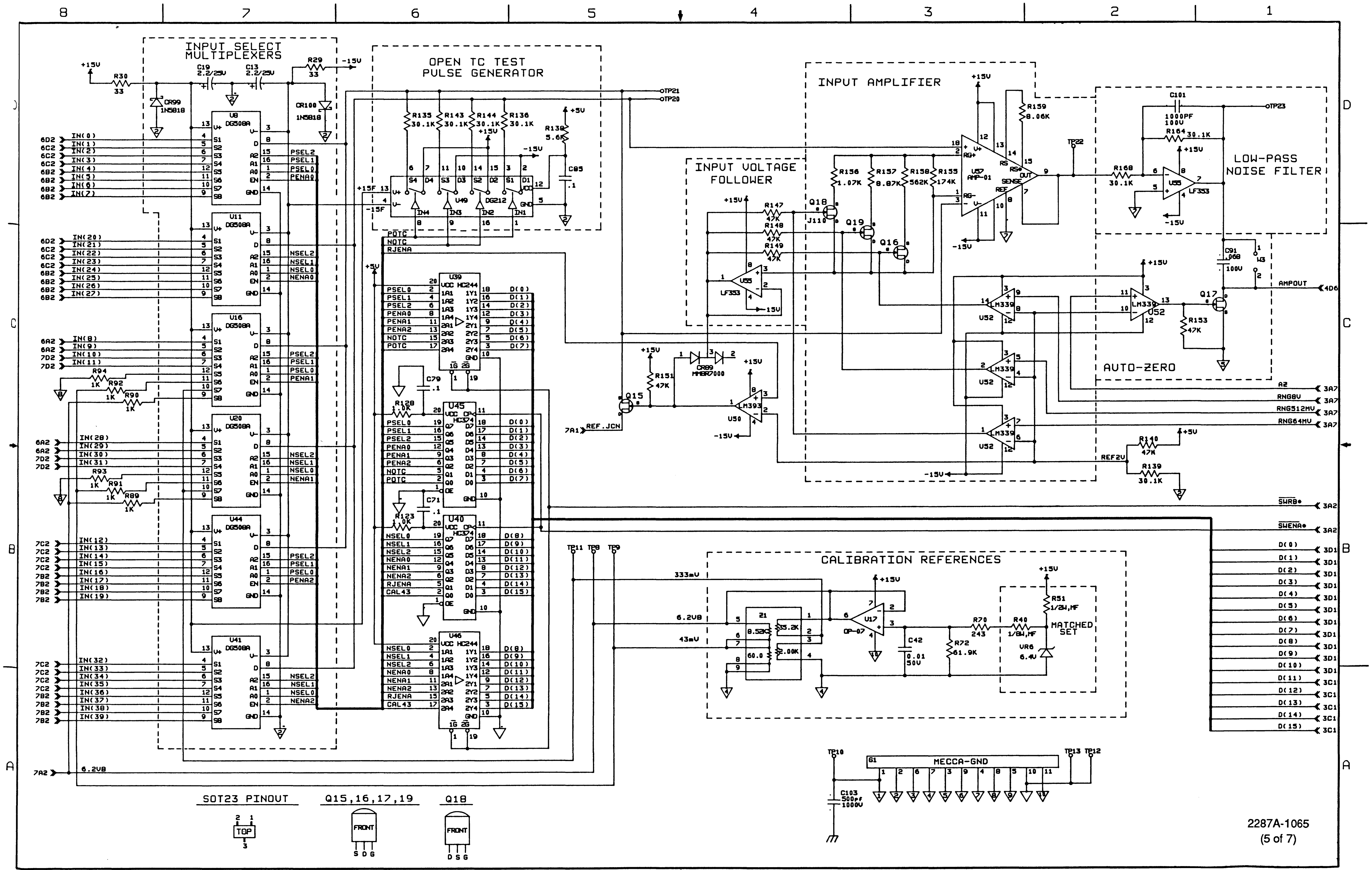
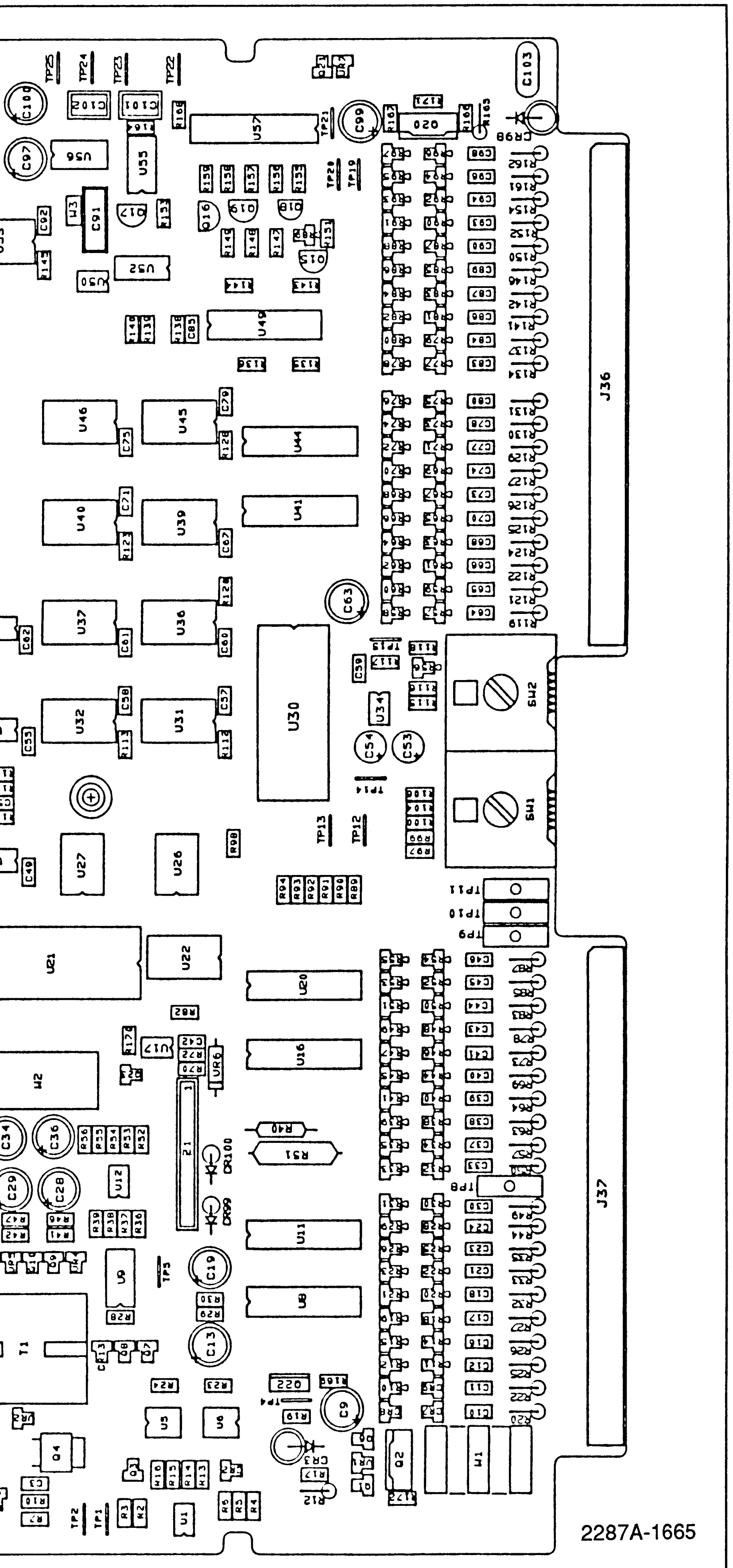


Figure 165-5. Fast A/D Converter PCA (cont.)



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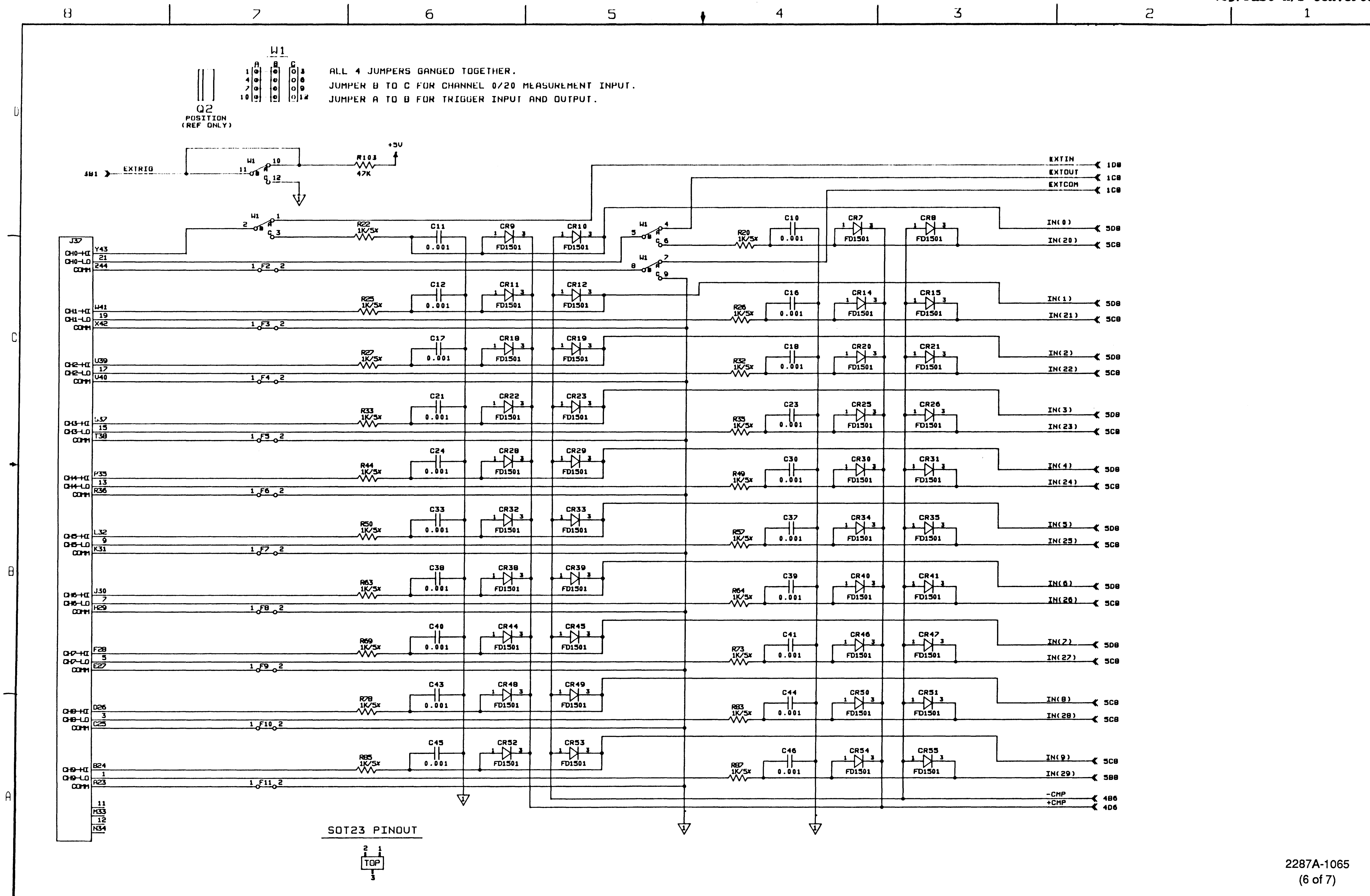

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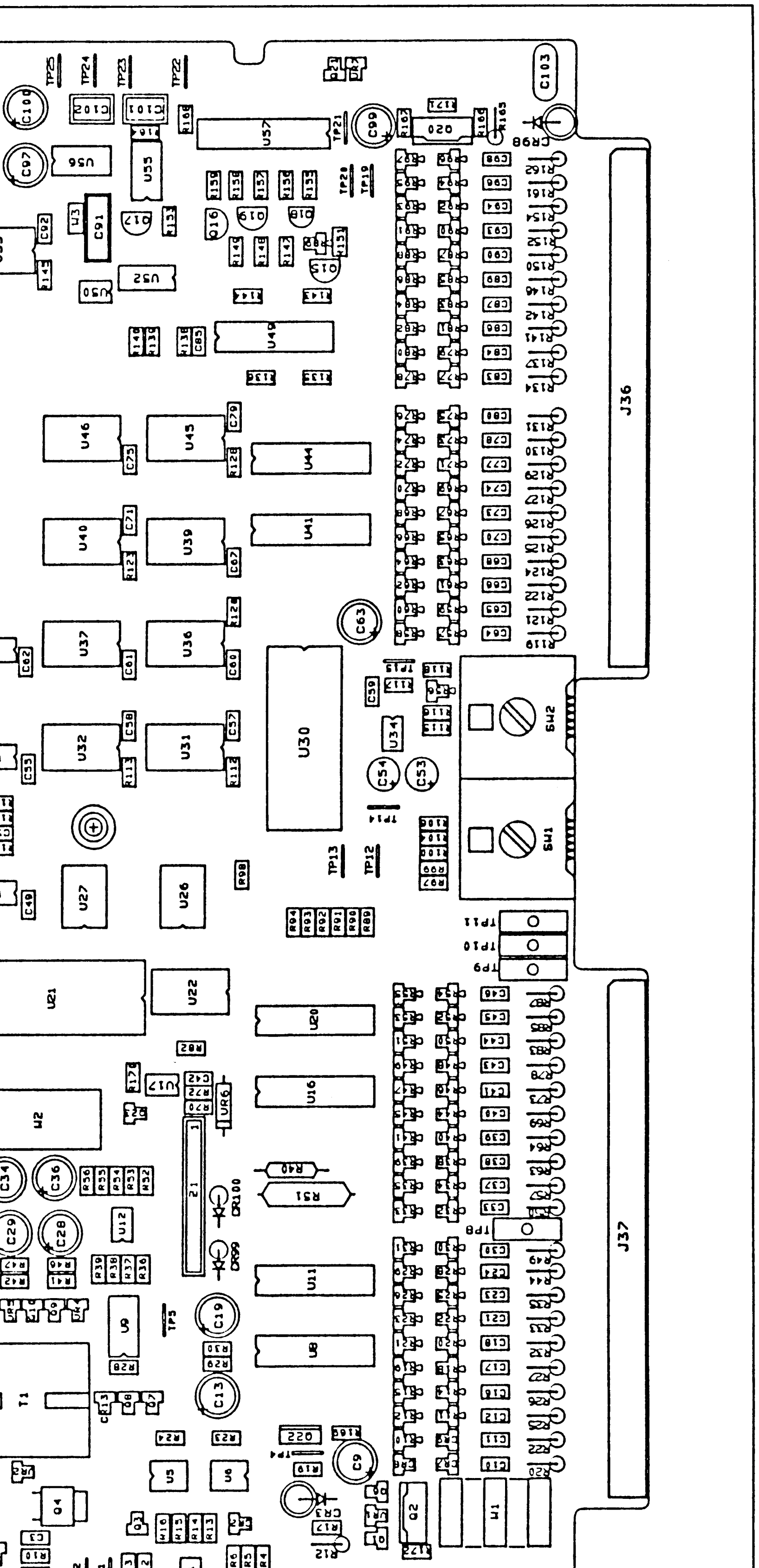
Figure 165-5. Fast A/D Converter PCA (cont.)



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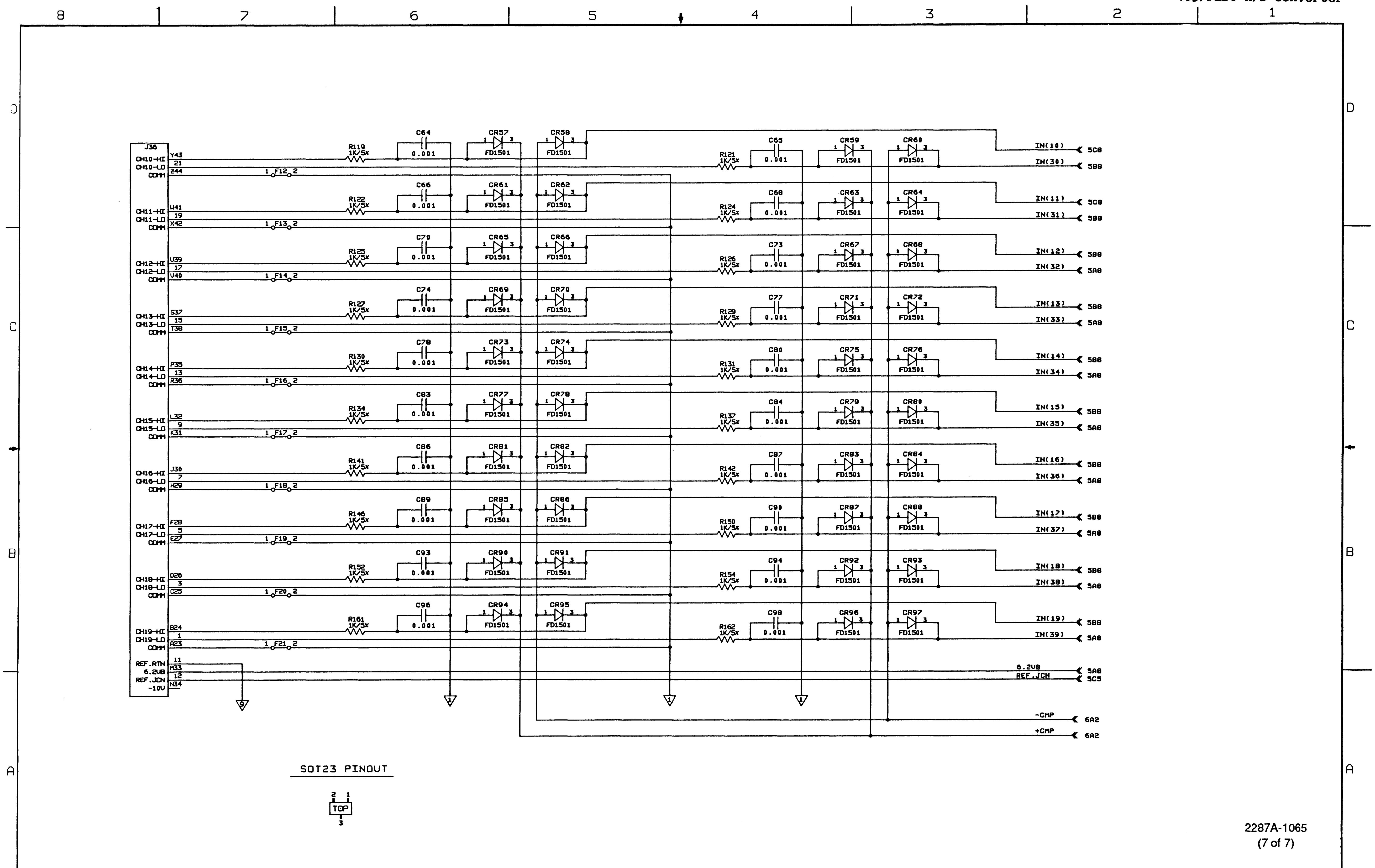


Figure 165-5. Fast A/D Converter PCA (cont.)

DESCRIPTION

The -167 Counter/Totalizer (shown in Figure 167-1) is a six-channel option that supports event counting and frequency measurement.

Switches on the Counter/Totalizer assembly determine the function of each channel. The channels are grouped in pairs. There are three pairs of channels: channels 0 and 1, channels 2 and 3, and channels 4 and 5. Both channels in a pair must have the same function.

The Counter/Totalizer has adjustments that allow it to measure a variety of signal types. The reference voltage and input deadband are adjustable. These adjustments define the high and low voltage thresholds of the input. Debouncers and input pull-ups allow the Counter/Totalizer to count contact closures.

Physically, the Counter/Totalizer consists of a single printed circuit board assembly, a rear panel, and a 22-pin screw terminal connector. The assembly slides into the back of the Front End or 2281A chassis and is secured by rear panel screws.

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: the Counter/Totalizer theory of operation, performance tests, parts list, and schematic diagrams.

Installation, operating, and system configuration instructions are found in the Helios Plus System Manual. Option specifications are included in the appendices of this manual and in the System Manual.

The equipment required to perform the procedures in this subsection is listed in Table 167-1. A summary of test equipment required for all procedures in this manual is given in Table 2-2 in Section 2.

Table 167-1. Required Test Equipment for -167

INSTRUMENT	RECOMMENDED MODEL
Digital Multimeter (DMM)	Fluke 77 or equivalent
Calibration/ Extender Fixture (Optional)	Fluke Accessory Part No. 648741

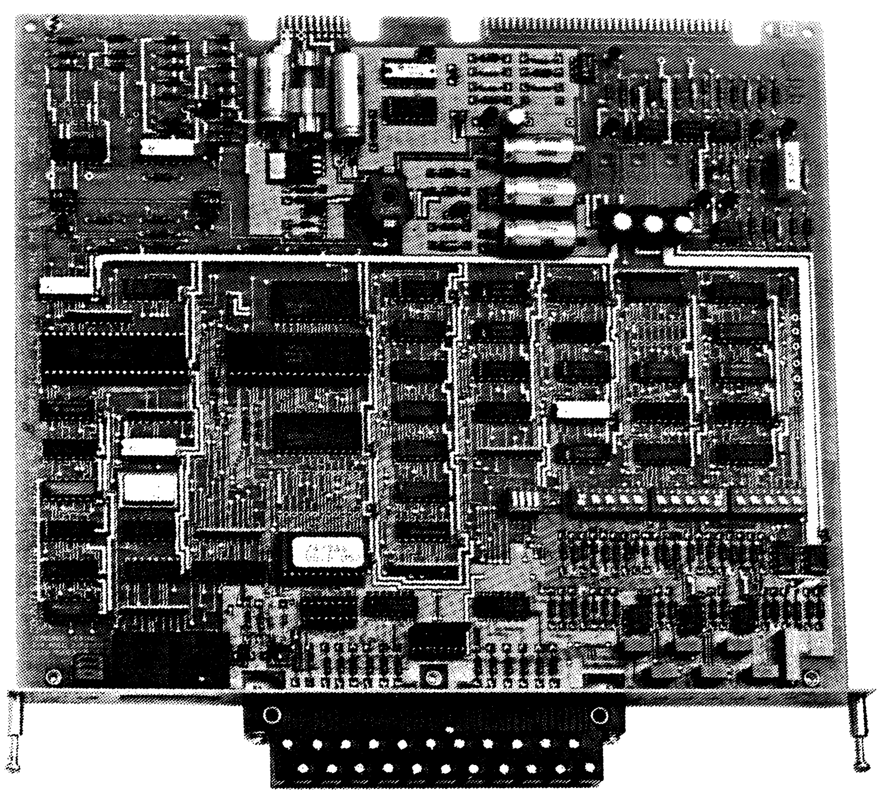


Figure 167-1. Counter/Totalizer

THEORY OF OPERATION

The -167 Counter/Totalizer monitors the signals on each of its six input channels. Depending on the function selected for each channel, the Counter/Totalizer either measures the frequency of the input signal or counts the number of high-to-low voltage transitions that occur. On command from the Front End controller, the Counter/Totalizer returns the measurements that it has obtained.

Measurement Techniques

To take totalizing and frequency measurements, each channel of the Counter/Totalizer uses a 23-bit binary counter. The counters are used differently, depending on the type of measurement to be made.

EVENT COUNTING

On an event-counting channel, each reading indicates the number of events that have occurred since the channel was last scanned. The event counter is reset to zero at the start of scanning. After each scan reading, the counter is reset again.

To ensure that no counts are lost during scanning, the counter must run continuously. The reset is performed in software by the Counter/Totalizer. Each time an event-counting channel is scanned, the Counter/Totalizer reads the running counter and stores the value. When the next scan occurs, the Counter/Totalizer reads a new counter value and computes the measurement by taking the difference between the previously stored value and the new one. The new counter value is stored away so that the process can be repeated.

The maximum number of events that can be counted between scans is 8,388,607. If more events than this occur, the reading is declared overrange. Monitoring an event channel does not reset the counter. This ensures that the monitoring and scanning operations do not interfere with each other.

FREQUENCY

To measure frequency, the Counter/Totalizer uses two counters. One counter is driven by an internal reference clock; the other is driven by the input signal. To take the measurement, the Counter/Totalizer resets both counters, then starts both counters on an input trigger. After the sample time has elapsed, the Counter/Totalizer stops both counters on the next input trigger.

In this way, the Counter/Totalizer always samples a whole number of input cycles. The measurement resolution is independent of input frequency, depending instead on the reference clock frequency and the sample time. An underrange frequency is detected if no input trigger occurs during the sample time.

To minimize circuitry, the Counter/Totalizer shares counters between a pair of channels. The three channel pairs are channels 0 and 1, channels 2 and 3, and channels 4 and 5. When the Counter/Totalizer measures frequency on an even-numbered channel, the even-numbered counter counts external triggers, while the odd-numbered counter accumulates reference counts. When the Counter/Totalizer measures on an odd-numbered channel, the counter roles are reversed.

Block Diagram Description

The major circuit blocks of the Counter/Totalizer are shown in Figure 167-2.

POWER SUPPLY AND REFERENCE VOLTAGES

The power supply converts incoming dc power from the serial link into isolated +14V, -15V, and +5V dc for the measurement circuitry as well as +5VREM for the serial link circuitry. The power supply also generates a reset signal that starts the microcomputer at power-up.

The reference voltage circuitry supplies threshold levels for the input conditioners. There is a fixed reference voltage, which is selectable for 0V or 1.4V (TTL level). There is also a variable reference, that is adjustable from -10 to +10V.

SERIAL LINK INTERFACE

The serial link allows the Counter/Totalizer to receive commands from the Front End controller and to send responses back. The serial link interface connects the 8-bit microcomputer data bus to the 25,000 baud transmit and receive lines.

MICROCOMPUTER AND STATUS/CONTROL REGISTERS

The microcomputer communicates with the Front End controller through the serial link. Through the status and control registers, the microcomputer controls the measurements on all six channels and gathers the results.

CLOCK GENERATOR

The clock generator section produces clock signals used by the microcomputer, the serial link, the input conditioners, and the measurement control section.

COUNTERS AND MEASUREMENT CONTROL SECTION

The measurement control section routes the input signals and the frequency reference clock into the six counters under direction of the microcomputer. This section also controls the counter gates that start or stop the counters. Status signals from the measurement control section allow the microcomputer to check measurement progress. The microcomputer can load or read the counters as necessary.

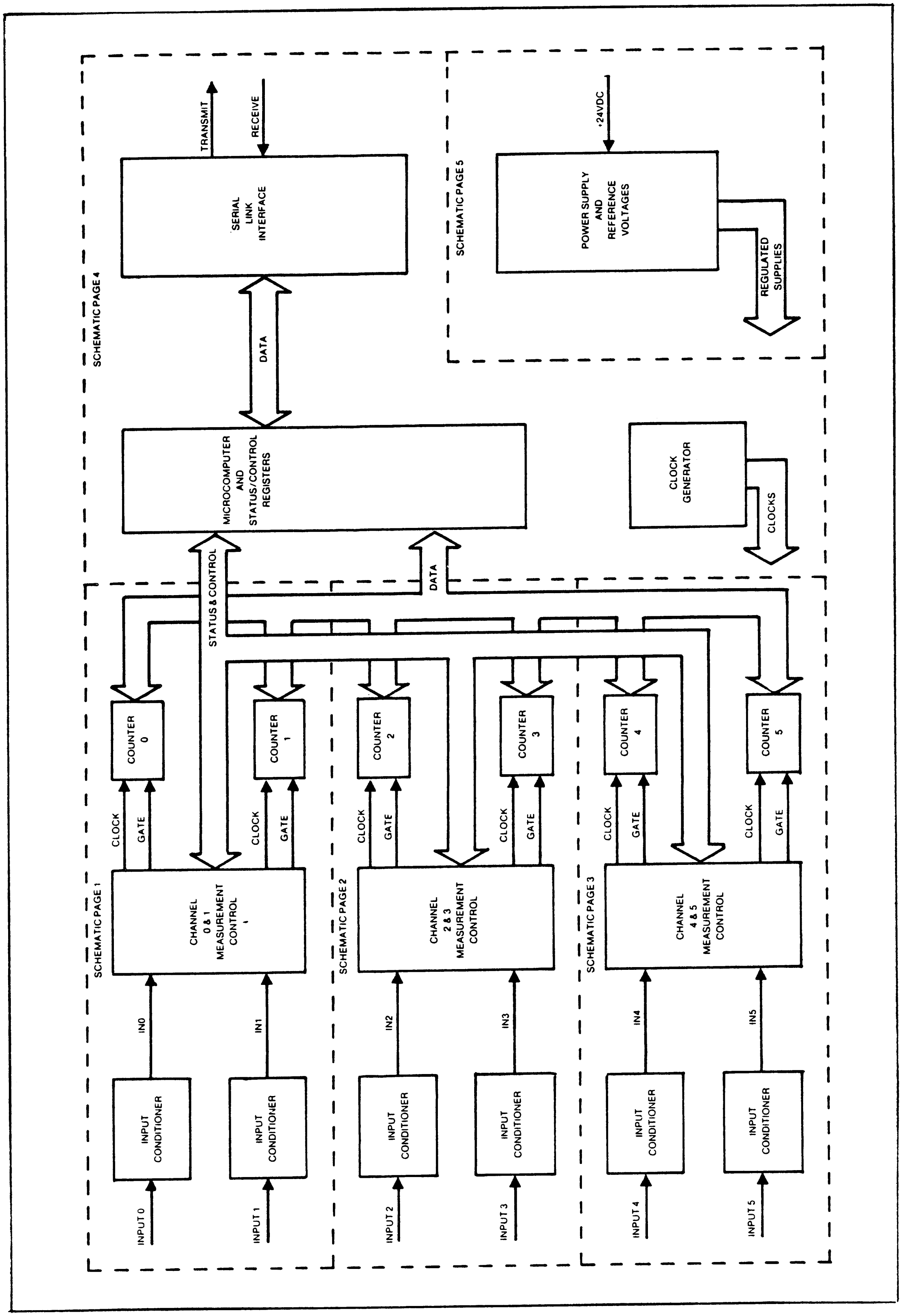


Figure 167-2. Counter/Totalizer Block Diagram

INPUT CONDITIONERS

The input conditioners convert the input waveforms into clean signals for triggering the counters. The input conditioners allow the Counter/Totalizer to sample waveforms of widely varying threshold levels.

Each input conditioner can use either the fixed or variable reference voltage. The input deadband for each channel can be adjusted from 0 to 3 volts. The reference voltage and deadband define the high and low input voltage thresholds. Each input conditioner includes a debouncer for accurate counting of contact closures.

Detailed Circuit Description

Many of the important signals on the Counter/Totalizer assembly are accessible at test point socket X1. These signals are described in the paragraphs that follow and are marked on the schematic diagram by solid black squares.

POWER SUPPLY AND REFERENCE VOLTAGES

DC-to-DC Converter

The power supply is a flyback converter that accepts 10 to 25V from the serial link. See Figure 167-3 for a simplified schematic.

Transformer T1 provides electrical isolation. When transistor Q4 is turned on, rectifier diodes CR12, CR13, and CR14 turn off, and the primary current in T1 ramps up. Turning Q4 off causes the energy stored in T1 to be released through the secondaries and the diodes. The voltage on C15 is sampled by level sensor U10, and an error signal is transmitted through the optocoupler back to the control circuitry.

The control circuitry of U6, U7, and U8 varies the duty cycle of Q4 (the percentage of time Q4 is on) to control the output voltage. If the voltage on C15 is too low, the control circuit increases the duty cycle. If the voltage is too high, the duty cycle is decreased. In this way, the secondary voltages are maintained despite variations in load current and serial link supply voltage. Proper operation of U6 can be verified by observing a 1 to 3.5V sawtooth with a period of about 18 microseconds on pin 7.

Linear regulators convert the secondary voltages to the +5V, +14V, and -15V levels needed by the measurement and control circuitry. The serial link drivers and receivers are powered by the +5VREM voltage from C1.

Power-On Reset

The power-on reset circuit withdraws the POR reset signal 50 ms after +5V power has been established. It asserts the reset signal immediately if the supply falls out of regulation.

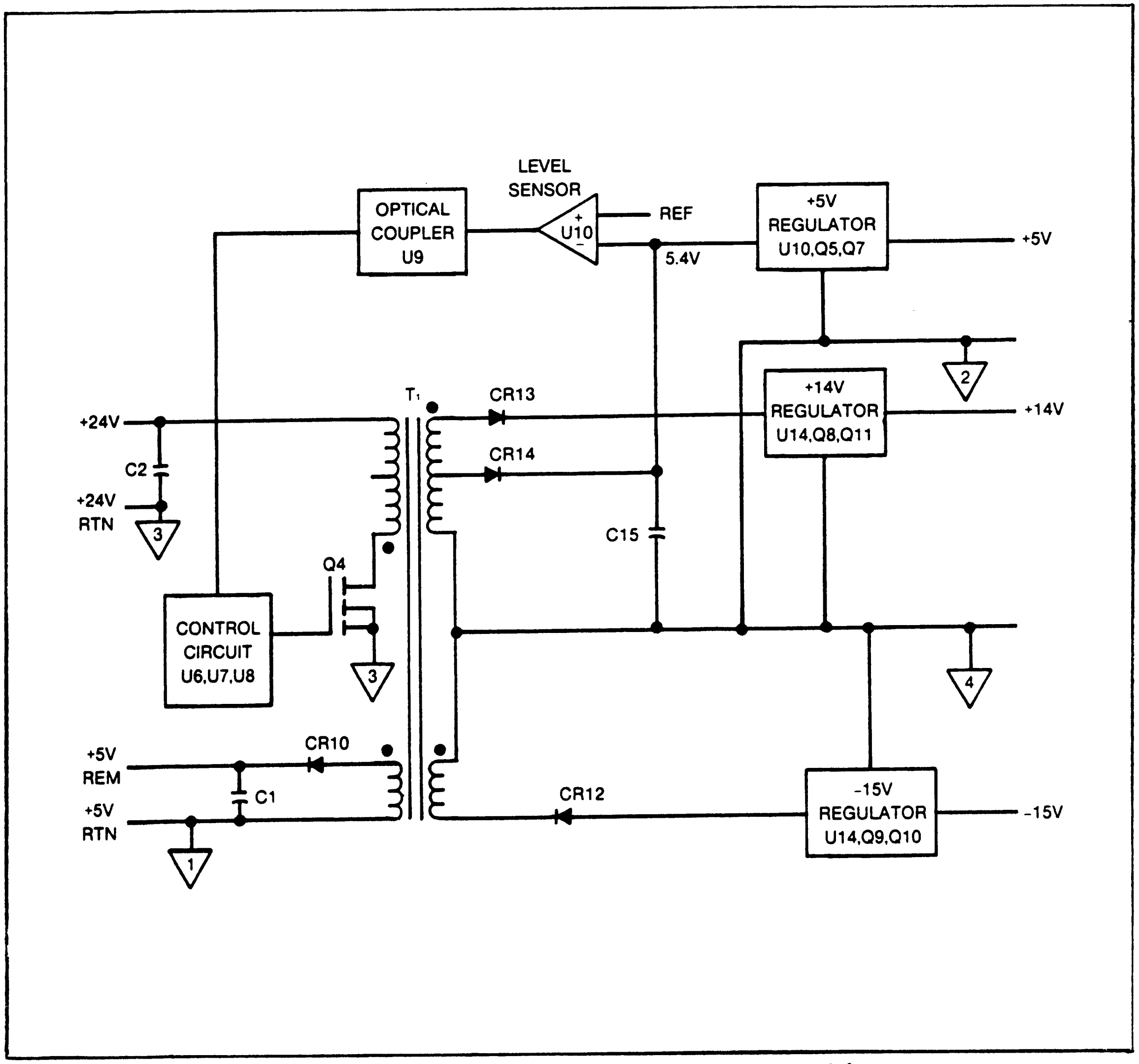


Figure 167-3. Power Supply Simplified Schematic

The circuit has two comparator stages. The first stage senses whether the +5V supply voltage is within tolerance. The second stage, because of capacitor C10, causes a time delay. When the supply voltage rises to a satisfactory level, the first stage allows C10 to charge slowly, eventually tripping the second comparator and withdrawing the reset signal. When the supply voltage falls, however, the first comparator discharges C10 quickly, causing the reset signal to be asserted without delay.

Reference Voltages

The input conditioner reference voltages are derived from the +14V and -15V power supplies through resistive voltage dividers. Voltage followers U58 and U65 buffer the reference voltages from variations in load current. Switch S2 connects the fixed reference line to either a 0-volt or 1.4-volt (TTL) level. Potentiometer R116 allows the variable reference voltage to be adjusted from -10 to +10V.

SERIAL LINK INTERFACE

Serial data is transferred between the Front End controller and the Counter/Totalizer via differential driver U2 and differential receiver U3.

A control line from the microcomputer places the serial link driver in a high-impedance state between data transmissions. Optical couplers U4 and U5 isolate the serial link driver and receiver electrically from the rest of the Counter/Totalizer circuitry.

Universal Asynchronous Receiver/Transmitter (UART) U29 converts data from the 8-bit parallel format of the microcomputer to the bit serial format of the serial link. The UART transmits and receives data at 25,000 baud. When the UART receives a character from the serial link, it drives the Data Ready (DR) line to a logical 1 to interrupt the microcomputer. When the microcomputer reads the character from the UART, the DR line returns to a logical 0.

The following paragraphs describe how the microcomputer reads data from and writes data to devices on the Counter/Totalizer assembly.

MICROCOMPUTER AND STATUS/CONTROL REGISTERS

The Counter/Totalizer microcomputer U28 executes a program stored in one or both of the read-only memories (EPROMs), U49 and U57.

Measurement results and control information are stored in the microcomputer's internal memory (RAM). Figure 167-4 shows a block diagram of this section of the Counter/Totalizer circuitry.

Before reading or writing data, the microcomputer drives a 12-bit address onto the data bus and the lower bits of port 2. The lower eight address bits are captured in latch U56 on the falling edge of the ALE signal. The port 2 address bits need not be latched. Decoder U53 uses four of the address bits to select one of the status or control registers on the assembly.

To read from the UART, counters, or status registers, the microcomputer drives the RD signal low. To write to the UART, counters, or control registers, the microcomputer drives the WR signal low.

To read from the EPROM, the microcomputer drives the PSEN signal low. Table 167-2 lists the registers that can be addressed by the microcomputer. The addresses are in hexadecimal. Non-specific (don't care) addresses are indicated by an X.

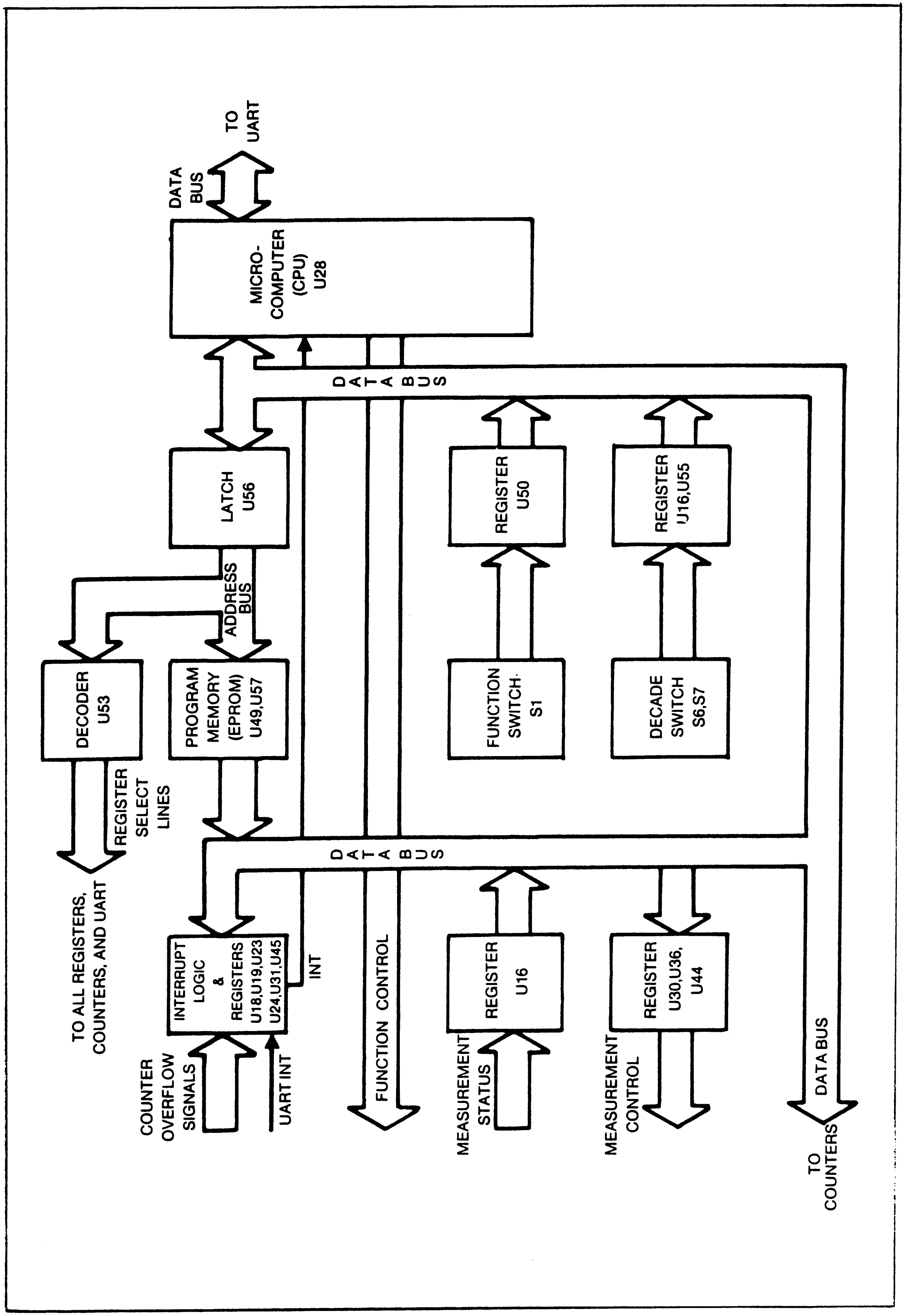


Figure 167-4. Microcomputer and Status/Control Registers Block Diagram

Table 167-2. Microcomputer U28 External Registers

ADDRESS	INPUT REGISTER	OUTPUT REGISTER
00	Counter 0	Counter 0
01	Counter 1	Counter 1
02	Counter 2	Counter 2
03	Unused	Counter 0-2 control
10	Counter 3	Counter 3
11	Counter 4	Counter 4
12	Counter 5	Counter 5
13	Unused	Counter 3-5 control
2X	Interrupt status	Interrupt clear
4X	Measurement status	Channel 0-1 measurement control
5X	Decade switch	Channel 2-3 measurement control
6X	Function switch	Channel 4-5 measurement control
7X	UART receive register	UART transmit register

The two input/output ports of the microcomputer are used for additional status and control lines. These signals are listed in Table 167-3.

Table 167-3. Microcomputer U28 Port Signals

BIT	PORT 1 SIGNAL (ACTIVE STATE)	PORT 2 SIGNAL (ACTIVE STATE)
0	UART error (H)	Unused
1	UART TRE (H)	Unused
2	UART TBRE (H)	Unused
3	UART interrupt enable (L)	Unused
4	Serial link driver enable (L)	Function control 0-1 (H = Frequency)
5	Unused	Function control 2-3 (H = Frequency)
6	Unused	Function control 4-5 (H = Frequency)
7	Unused	Unused

CLOCK GENERATOR

The clock generator section, shown in Figure 167-5, uses a chain of counters to divide the 10-MHz clock from oscillator Y1 into the other clocks needed on the assembly. The debounce period switch selects the frequency for the debouncer clock and for the test clock available at terminal 1 on the rear panel connector.

COUNTERS AND MEASUREMENT CONTROL SECTION

A simplified schematic of the counters and measurement control section is shown in Figure 167-6. The measurement control circuitry for each pair of channels is identical.

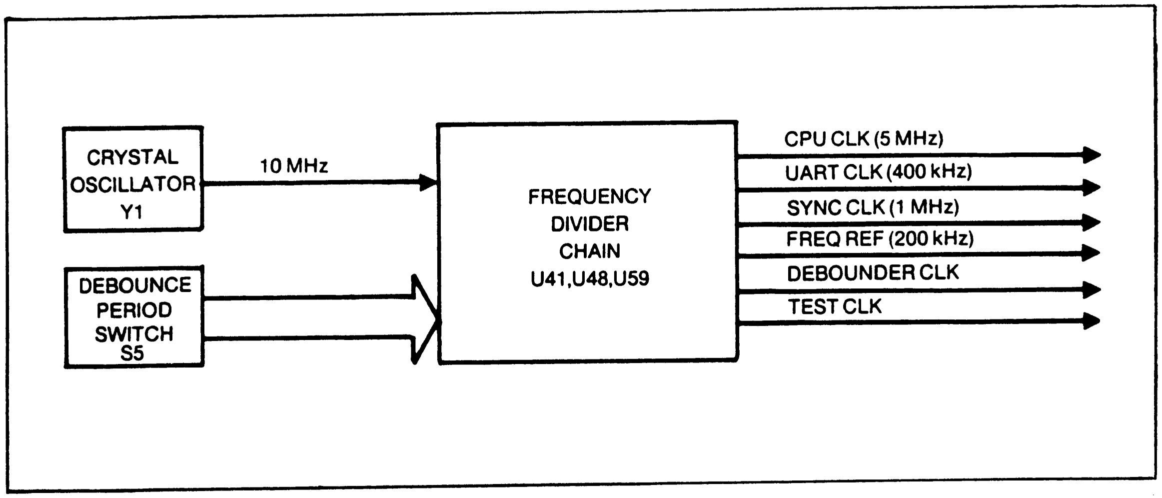


Figure 167-5. Clock Generator Block Diagram

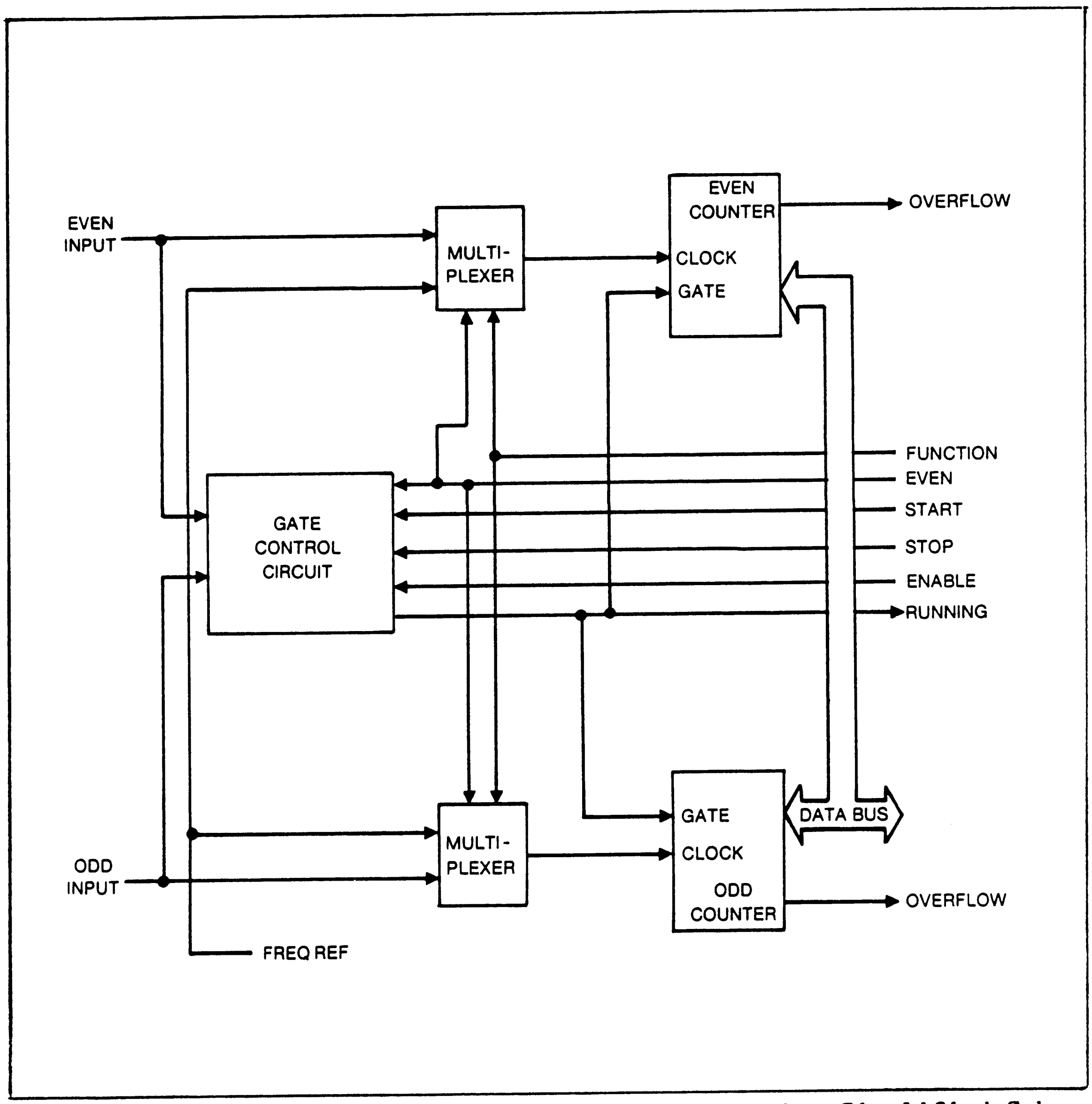


Figure 167-6. Measurement Control for a Pair of Channels, Simplified Schematic

The microcomputer uses five signals to control this section. The FUNCTION line determines whether an event counting or frequency measurement will occur. The EVEN line selects the channel, either even or odd, for frequency measurement. The START signal forces the counter gates open, allowing the counters to run. The STOP signal forces the counter gates closed. The ENABLE line allows, but does not force, the gates to open or close. Once enabled, the gates will open or close on the next input signal trigger.

Three signals are used to monitor this section. The RUNNING signal controls the counter gates and informs the microcomputer that the counters are running. The two OVERFLOW signals cause interrupts to the microcomputer when the counters overflow.

For event counting, the microcomputer selects the count function and forces the counters to start. With the even channel selected, the even and odd counters are driven by their respective input signals. With the odd channel selected, both counters are driven by the frequency reference clock. This mode is not used in normal operation.

For frequency measurements, the microcomputer selects the frequency function and enables the counters to start. With the even channel selected, the even counter counts triggers of the even input and the odd channel counts reference clocks. With the odd channel selected, the odd counter counts triggers of the odd input and the even channel counts reference clocks. The counters start running on the next trigger of the selected input signal. After the sample time (about 2/3 second), the microcomputer toggles the ENABLE signal. The counters stop running on the next input trigger. After completing a measurement on one channel, the microcomputer selects the other channel in the pair and repeats the process.

INPUT CONDITIONERS

Figure 167-7 shows a simplified schematic of the input conditioners. As shown in Figure 167-8, each input conditioner consists of several stages. The first stage clamps the input voltage to prevent damage to the Counter/Totalizer circuitry. Any input signal exceeding about 12 volts will be clamped. The comparator stage detects input voltage transitions and rejects noise. The comparator thresholds are determined by the reference voltage and deadband adjustments. The level converter shifts the comparator output signal to CMOS logic levels.

Figure 167-9 illustrates debouncer operation. When the debouncer is switched in, the input signal must remain stable longer than the debounce period before a new input level will be recognized. Three debounce times are available: 4 ms, 20 ms, and 80 ms. They are selected by the debounce period switch.

The final input conditioner stage is the synchronizer. This stage synchronizes the input signals to the Counter/Totalizer clocks to guarantee that the counter setup and hold times are satisfied.

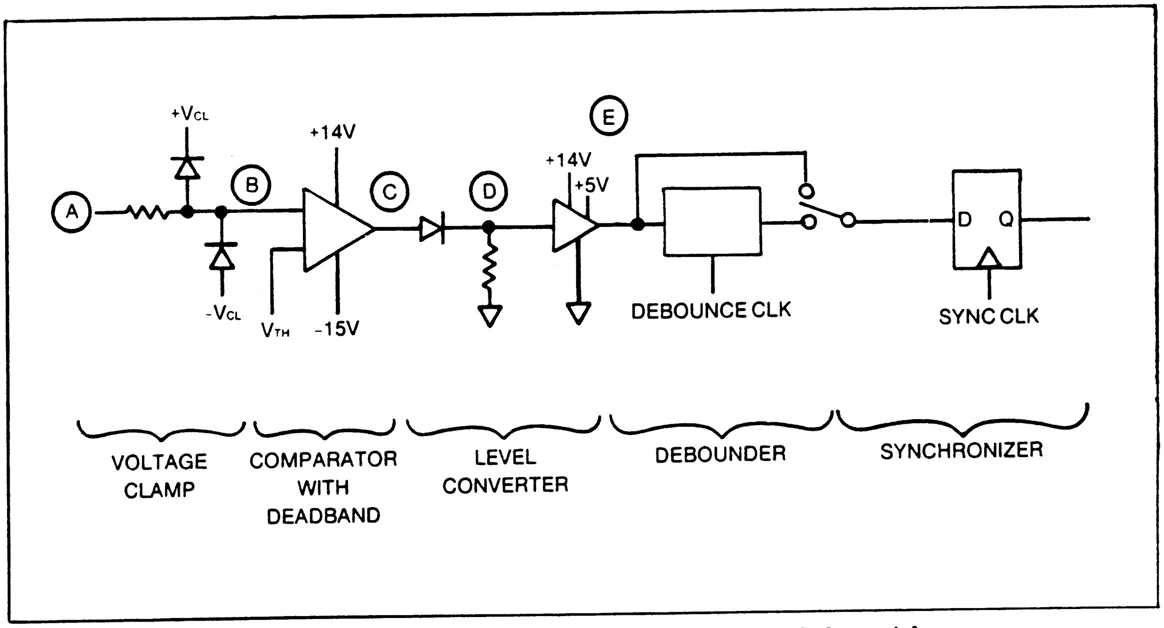


Figure 167-7. Input Conditioner, Simplified Schematic

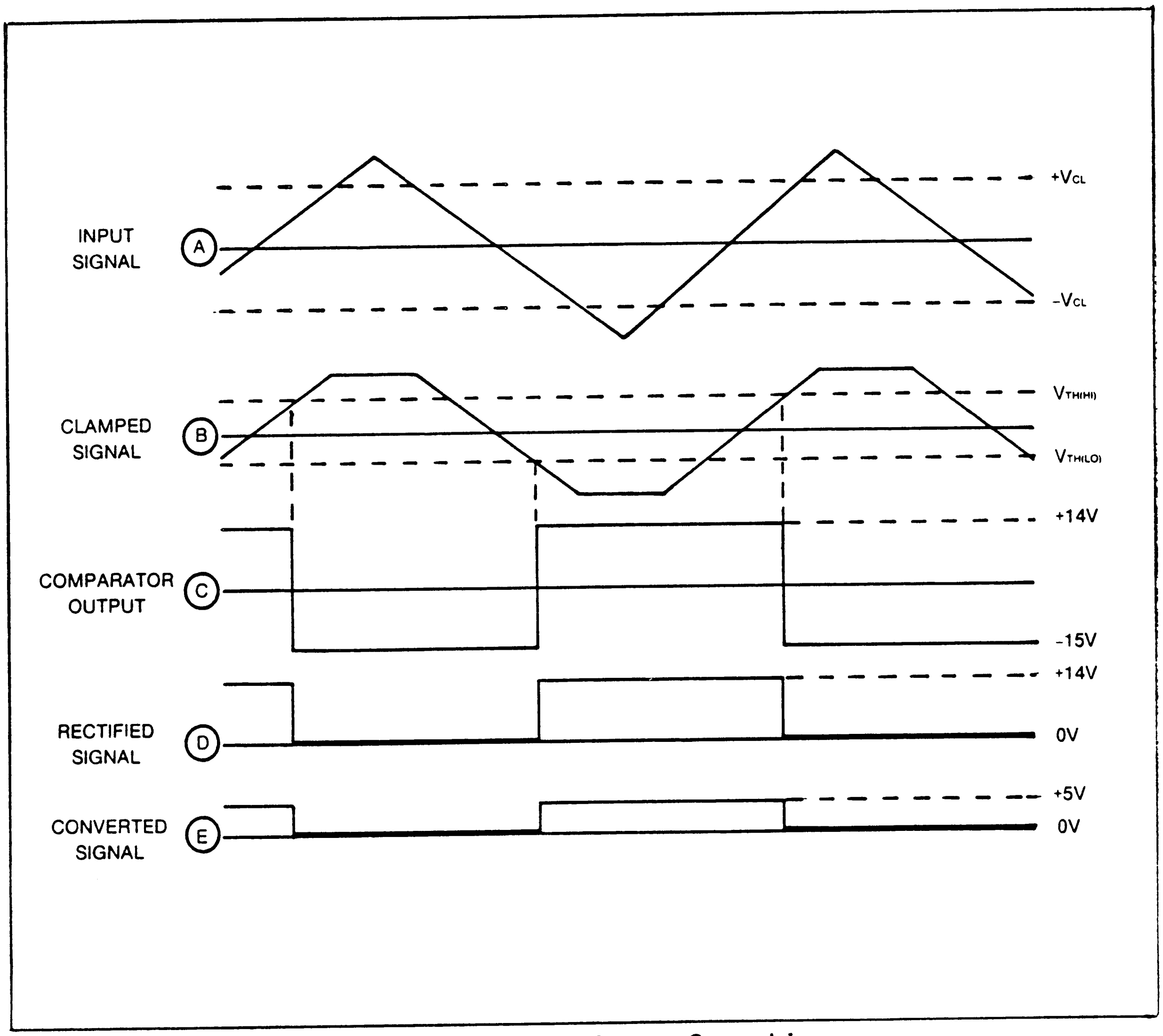


Figure 167-8. Input Conditioner Operation

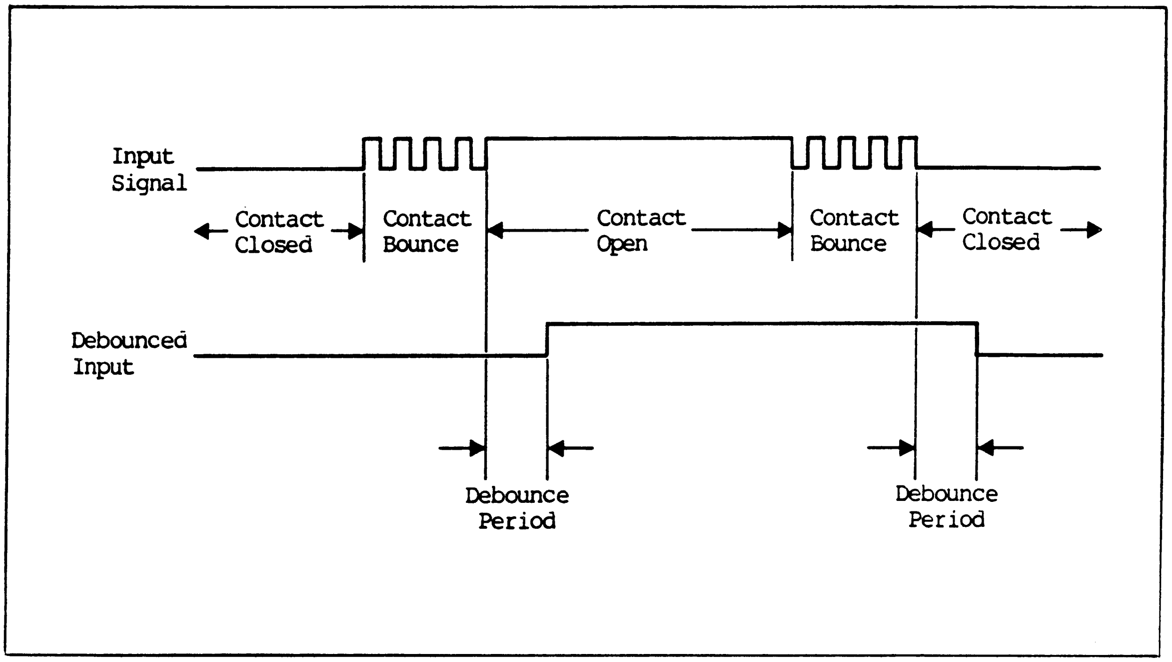


Figure 167-9. Debouncer Operation

GENERAL MAINTENANCE

The Counter/Totalizer assembly should be cleaned if dirt, dust, or other contamination is visible on the surface. Follow the cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THIS EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING THE FOLLOWING PROCEDURE.

Five performance tests are used to verify that the Counter/Totalizer assembly is operating properly. These tests, listed below, can be performed individually, for a partial performance evaluation, or in sequence for a complete test:

- Channel Selection Test
- Reference Voltage Test
- Deadband Adjustment Test
- Frequency Test
- Event Counting Test

ACCESSING COUNTER/TOTALIZER SWITCHES

To perform these tests, it is necessary to set switches on the Counter/Totalizer that are not accessible through the rear panel. These switches can be made accessible in three ways:

Alternative 1

Install a Calibration/Extender Fixture (Fluke P/N 648741) in a Front End option slot, and install the Counter/Totalizer assembly on the fixture. Ensure that the switch on the fixture is set to EXTEND position.

With this method, the switches on the Counter/Totalizer assembly are accessible at all times.

Alternative 2

If a Calibration/Extender Fixture is not available, remove all other option assemblies from the Front End and install the Counter/Totalizer assembly in the bottom slot.

In this configuration, the switches can be reached without using an extender.

Alternative 3

If neither of the previous alternatives is feasible, disconnect power and slide the Counter/Totalizer assembly out of the Front End to reach the switches. Reinstall the assembly and reconnect power to continue testing.

NOTE

The Counter/Totalizer's operating program resides in an EPROM. This EPROM may be either a 2716 installed in U57 or a 2732 installed in U49. Ensure that switch S2-1 is set to the position appropriate for the EPROM installed at the factory.

The locations of Counter/Totalizer switches and adjustments are shown in Figure 167-10.

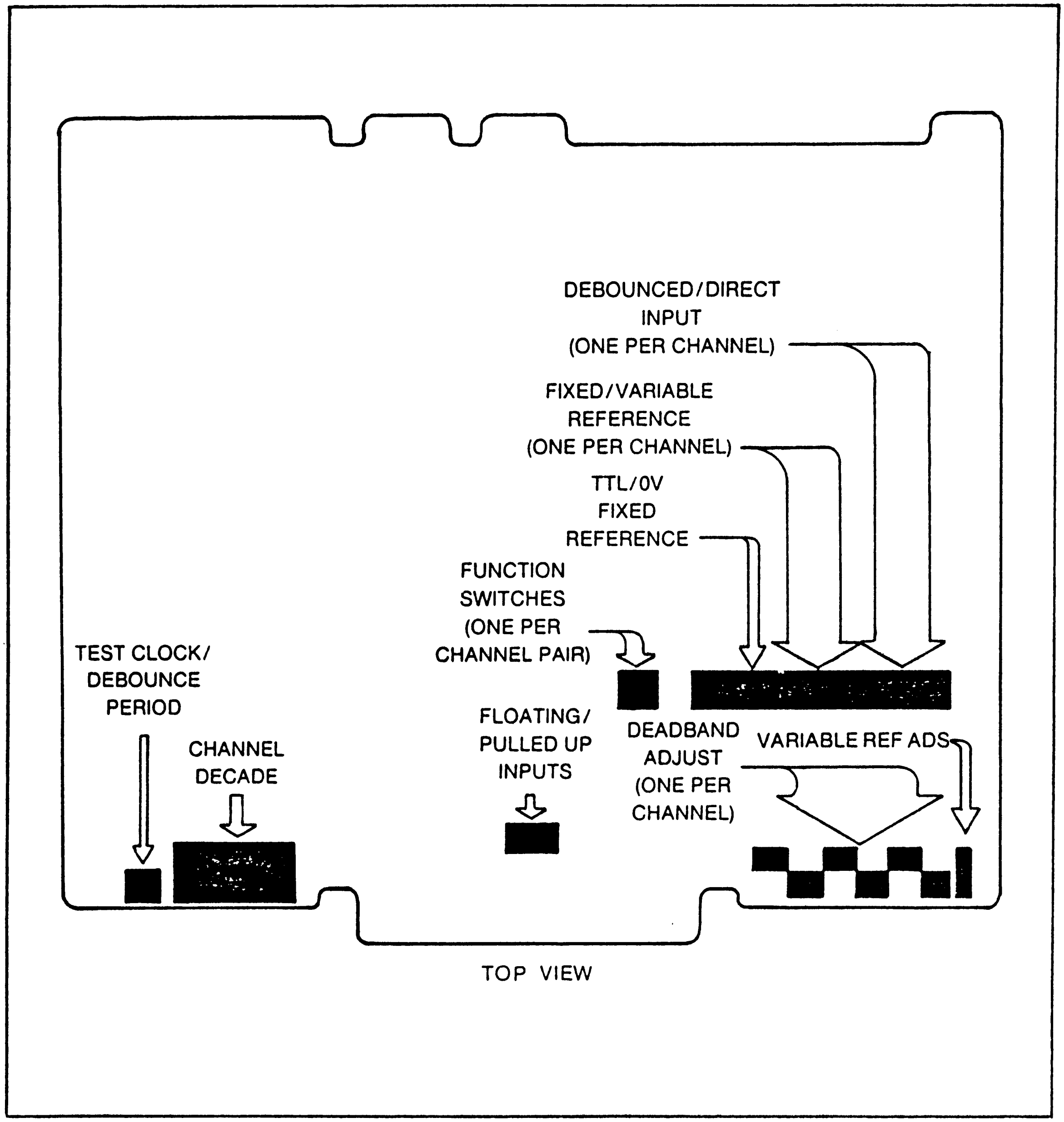


Figure 167-10. Counter/Totalizer Switches and Adjustments

Channel Selection Test

The Channel Selection Test verifies that the Counter/Totalizer channel decade is selectable. To conduct the Channel Selection Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Remove all other installed options to eliminate addressing conflict.

3. Note the setting of the function switches on the Counter/Totalizer assembly. Install the assembly in the Front End.

4. Set the Counter/Totalizer channel decade switches to position 00.

5. Reconnect the ac line cord to the Front End, and switch the power ON.

6. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>
RESET CHAN(0..5) <CR>
LIST CHAN(0..5) <CR>
```

Verify that a listing for all designated channels is returned. The response should be either:

```
ctchan(channel number)=total
```

or

```
ctchan(channel number)=freq
```

The type function, (TOTAL or FREQ) should agree with the setting of the function switch for the specified pair of channels.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to perform the required tests on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"reset chan(0..5)"
100  GOSUB 300
110  REM obtain hardware configuration
120  PRINT #1,"list chan(0..5)"
130  FOR I=0 TO 6
140  LINE INPUT #1,M$
150  PRINT M$;
160  NEXT I
200  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1%
50   OPEN "KB1:"AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Computer Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"reset chan(0..5)"
110  GOSUB 300
120  REM obtain hardware configuration
130  DIM L$(7)
140  PRINT #1,"list chan(0..5)"
150  FOR I%=0 TO 6\INPUT LINE #2,L$(I%)\NEXT I%
160  X%=0
170  PRINT L$(X%)
180  X%=1
190  PRINT L$(X%)\X%=X%+1
200  IF X%>6 THEN 220
210  GOTO 190
220  END
300  REM wait for message accepted prompt
```

```
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

A listing of the definitions for all six channels should be returned. The top line returned will be a number indicating the number of channel definitions to follow. The response should be:

```
6
0,4,0,0,0,0
    .
    .
    .
5,4,0,0,0,0
```

NOTE

The number in field 3 may be either 0 (for COUNT function) or 1 (FREQ), depending on the function switch setting.

7. Switch OFF power to the Front End. Set channel decade switches on the the Counter/Totalizer to 01. Switch power ON.

8. Program the Front End to list its hardware configuration for channels 10 through 15.

   To do this, substitute channels 10 through 15 for channels 0 through 5 in both the RESET CHAN and LIST CHAN commands of step 6.

9. Repeat steps 7 and 8 for switch settings 02 (channels 20 through 25), 04 (channels 40 through 45), 08 (channels 80 through 85), 10 (channel 100 through 105), 20 (channels 200 through 205), 40 (channels 400 through 405) and 80 (channels 800 through 805).

10. This completes the Channel Selection Test.

Reference Voltage Test

This Reference Voltage Test verifies that the 0V and TTL fixed reference voltages are within tolerance, that the variable reference is fully adjustable, and that both the fixed and variable reference voltages can be selected for each channel.

To conduct the Reference Voltage Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Install the Counter/Totalizer assembly in the Front End. To avoid addressing conflict, remove all other installed options.

3. Reconnect the ac line cord to the Front End, and switch the power ON.

4. Connect digital multimeter (DMM) test leads to the variable reference terminal and to one of the return terminals on the Counter/Totalizer input connector.

5. Using a small screwdriver, turn the variable reference adjustment screw counterclockwise until the DMM displays negative 10.00V +/- 0.10V. Then turn the screw clockwise until the DMM displays positive 10.00 +/- 0.10V.

6. Turn the deadband adjustment screw for each channel counterclockwise until it stops. Move the fixed/variable reference switch for each channel to the VARIABLE REFERENCE position.

7. By connecting the DMM test leads to the appropriate threshold output and return terminals on the Counter/Totalizer input connector, verify that the threshold voltage for each channel is between 9.80 and 10.20V.

8. Move the fixed/variable reference switch for each channel to the FIXED REFERENCE position. Move the 0V/TTL fixed reference switch to the 0V position.

9. By connecting the DMM test leads to the appropriate threshold output and return terminals, verify that the threshold voltage for each channel is between -0.10V and 0.10V.

10. Move the 0V/TTL fixed reference switch to the TTL position.

11. By connecting the DMM test leads to the appropriate threshold output and return terminals, verify that the threshold voltage for each channel is between 1.30 and 1.50V.

12. This completes the Reference Voltage Test.

Deadband Adjustment Test

The Deadband Adjustment Test verifies that the deadband is fully adjustable for each channel.

To conduct the Deadband Adjustment Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Install the Counter/Totalizer assembly in the Front End. To avoid addressing conflict, remove all other installed options.

3. Reconnect the ac line cord to the Front End. Switch the power ON.

4. Using a jumper wire, connect the test clock output terminal on the Counter/Totalizer connector to each of the six input terminals. Install the connector on the Counter/Totalizer assembly.

5. Using a small screwdriver, move the test clock switch to position 0 (+14V output).

6. Move the fixed/variable reference switch for each channel to the FIXED REFERENCE position. Move the 0V/TTL fixed reference switch to the 0V position.

7. Using a small screwdriver, turn the deadband adjustment screw for each channel counter-clockwise until it stops.

8. Connect the DMM test leads to the appropriate threshold output and return terminals on the Counter/Totalizer input connector, and verify that the threshold voltage for each channel is between -0.04V and 0.04V.

9. For each channel, turn the deadband adjustment clockwise until it stops.

10. By connecting the DMM test leads to the appropriate threshold output and return terminals, verify that the threshold voltage for each channel is between -1.20V and -1.80V.

11. This completes the Deadband Adjustment Test.

Frequency Test

The Frequency Test checks the frequency measurement function for each channel. Measurement accuracy and underrange detection are tested.

To conduct the Frequency Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs. To avoid addressing conflicts, remove all other installed options.

2. Move all of the function switches on the Counter/Totalizer assembly to the FREQ position. Move all of the debounced/direct input switches to the DIRECT INPUT position. Install the assembly in the Front End.

3. Set the channel decade switches to 00.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Using a small screwdriver, move the test clock switch to position 2 (100 KHz).

6. Using a jumper wire, connect the test clock output terminal on the Counter/Totalizer connector to each of the six input terminals. Install the connector on the Counter/Totalizer assembly.

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0..5)=FREQ <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0..5) <CR>
```

The returned channel readings should be 1.00000E+05 Hz (100 kHz) within a tolerance of 10 Hz.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a frequency measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port and empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
90  PRINT #1,"count=off"
100 GOSUB 300
120 PRINT #1,"def chan(0..5)=freq"
```

```
130 GOSUB 300
140 PRINT #1,"format=decimal"
150 GOSUB 300
160 REM make measurement and read in response
170 PRINT #1,"send chan(0..5)"
180 FOR I=0 TO 5
190 INPUT #1,M$
200 PRINT "chan";I;"=";
210 PRINT M$;
220 PRINT " hertz"
230 NEXT I
240 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:" AS NEW FILE 1%
50  OPEN "KB1:"AS OLD FILE 2%
60  PRINT #1,CHR$(3);
70  REM set up Computer Front End
80  PRINT #1,"mode=comp"
90  GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1,"def chan(0..5)=freq"
130 GOSUB 300
140 PRINT #1,"format=decimal"
150 GOSUB 300
160 REM make measurement and read in response
170 PRINT #1,"send chan(0..5)"
180 FOR I%=0 TO 5
190 INPUT #2,M$
200 PRINT "chan";I%;"=";
210 PRINT M$;
220 PRINT " hertz"
230 NEXT I%
250 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

The returned channel readings should be 1.00000E+05 Hz (100 kHz) within a tolerance of 10 Hz.

8. Move the test clock switch to position 1 (-15 VDC output) and take another measurement from channels 0 through 5.

   If you are in the Terminal Mode, take these measurements by entering:

   SEND CHAN(0..5) <CR>

   If you are in the Computer Mode, run the program entered in step 7.

   Verify that 9.999999E+37 (a fault indication reading) is returned for each channel.

9. Perform PROCEDURE 9A or PROCEDURE 9B as appropriate.

PROCEDURE 9A. TERMINAL MODE

Send the following command to inspect the fault condition:

LIST ERROR <CR>

The error displayed for the selected channels should show:

Out of range

PROCEDURE 9B. COMPUTER MODE

The following are BASIC programs for the IBM PC and 1722A, respectively. Run one of these programs "as is" or make the modifications necessary to run on your host.

Program for IBM PC:

```
10  CLS
20  REM send the fault condition
30  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
40  PRINT #1,"list error"
50  INPUT #1,N
60  PRINT N
70  IF N=0 THEN 120
80  FOR I=1 TO N
90  LINE INPUT #1,E$
100 PRINT E$
110 NEXT I
120 END
```

Program for 1722A:

```
10  PRINT CHR$(27);"[2J";
20  REM send the fault condition
30  PRINT #1,"list error"
```

```
40  INPUT #2,N
50  PRINT N
60  IF N=0 THEN 110
70  FOR I=1 TO N
80  INPUT LINE #2,E$
90  PRINT E$
100 NEXT I
110 END
```

The displayed response should be:

```
6
0,15
1,15
2,15
3,15
4,15
5,15
```

The number "6" on the first line indicates that six errors were logged. The pairs of numbers that follow indicate, first, the channel number, then, the error number. Error 15 is: "?Out of Range".

10. This completes the Frequency Test.

Event Counting Test

The Event Counting Test checks the event counting function for each channel. Measurement accuracy and overrange detection are tested.

To conduct the Event Counting Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs. To avoid addressing conflict, remove all other installed options.

2. Move all of the function switches on the Counter/Totalizer assembly to the COUNT position.

3. Move all of the debounced/direct input switches to the DIRECT INPUT position.

4. Install the Counter/Totalizer in the Front End. Be sure that the channel decade switches are set to "00".

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Using a small screwdriver, move the test clock switch to position 3 (50 Hz W/BOUNCE).

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

   PROCEDURE A. TERMINAL MODE

   If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

   ```
   MODE=TERM <CR>

   DEF CHAN(0..5)=TOTAL <CR>

   FORMAT=DECIMAL <CR>

   SEND CHAN(0..5) <CR>
   ```

   Ignore the initial measurement response. As close as possible to 20 seconds after the first SEND CHAN command is executed, send another

   ```
   SEND CHAN(0..5) <CR>
   ```

   command to the Front End.

   A count of approximately 9000 (9.00000E+03) +/- 100 should be returned.

   NOTE

   > The second SEND CHAN command returns the count accumulated since the first SEND CHAN command. Each additional SEND CHAN command returns only the counts since the previous SEND CHAN command. Timing is critical in performance of this test.

   PROCEDURE B. COMPUTER MODE

   The following sample BASIC programs cause the Front End to take a totalizing measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

   NOTE

   > These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10  CLOSE 1
20  PLAY "mf"
30  CLS
40  REM open communication port and empty Front End buffer
50  OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
60  PRINT #1,CHR$(3);
70  REM set up Front End
80  PRINT #1,"mode=comp"
90  GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1,"def chan(0..5)=total"
130 GOSUB 300
140 PRINT #1,"format=decimal"
150 GOSUB 300
160 REM make measurement and read in response
170 PRINT "1,"send chan(0..5)"
175 FOR I=0 TO 5
180 INPUT #1,M$
190 PRINT "chan";I;"=";
200 PRINT M$;
210 PRINT " events"
220 NEXT I
230 SOUND 32767,364
240 PRINT TIME$
250 GOTO 170
260 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:" AS NEW FILE 1%
50  OPEN "KB1:" AS OLD FILE 2%
60  PRINT #1,CHR$(3);
70  REM set up Front End
80  PRINT #1,"mode=comp"
90  GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1,"def chan(0..5)=total"
130 GOSUB 300
140 PRINT #1,"format=decimal"
```

```
150 GOSUB 300
160 REM make measurement and read in response
170 PRINT #1,"send chan(0..5)"
180 T=TIME
190 FOR I=0 TO 5
200 INPUT #2,M$
210 PRINT "chan";I;"=";
220 PRINT M$;
230 PRINT " events"
240 NEXT I
250 WAIT 19770
260 T=TIME-T
270 PRINT\PRINT T/1000;" second interval"
280 GOTO 170
290 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Ignore the first set of readings. Each additional set of readings (taken every 20 seconds) should respond with a count of 9000 (9.00000E+03) +/- 100 counts.

NOTE

The second SEND CHAN command will return the count accumulated since the first SEND CHAN command. Each additional SEND CHAN command returns only the counts since the previous SEND CHAN command. Timing is critical in performance of this test.

8. Move all of the debounced/direct input switches to the DEBOUNCED INPUT position. Repeat step 7 to take more measurements.

   Ignore the first set of readings. Each additional measurement should respond with a count of 1000 (1.00000E+03) +/- 25 on channels 0 through 5.

9. This completes the Event Counting Test.

CALIBRATION

The Counter/Totalizer needs no special calibration, but it must be properly configured and adjusted before making measurements.

The setup procedures for the Counter/Totalizer are determined by the type of measurement to be taken. Refer to the Helios Plus System Manual for frequency (Section 6d) and totalizing (Section 6k) measurement setup instructions.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

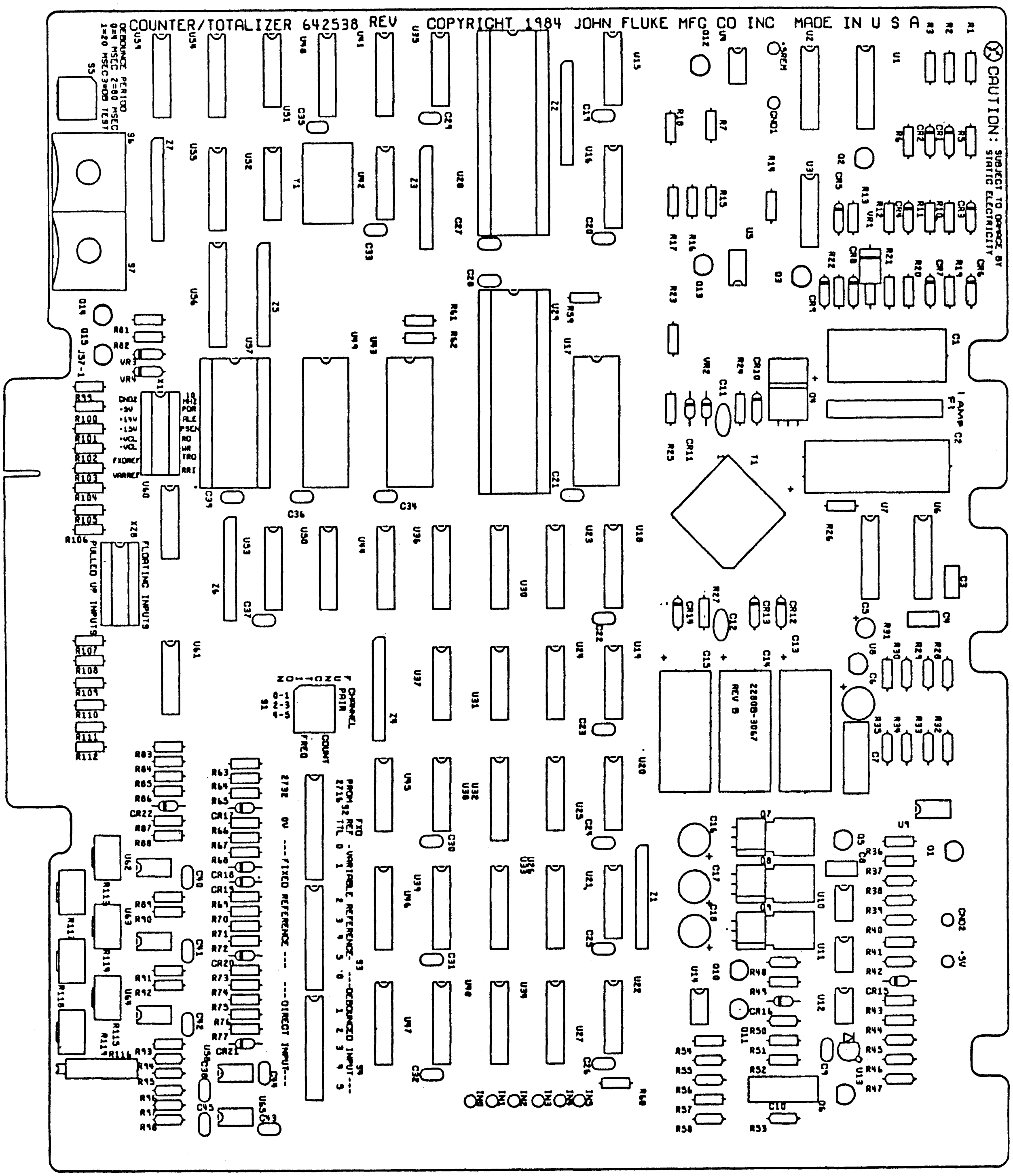
See Table 167-4 for an illustrated parts list. For parts ordering information, see Section 6. Figure 167-11 is a schematic diagram of the Counter/Totalizer.

TABLE 167-7. 2280B-167 COUNTER/TOTALIZER PCA
(SEE FIGURE 167-11.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	---DESCRIPTION---	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	NOTE
		2280B-167 COUNTER/TOTALIZER	580506	89536	580506	1	
C 1, 13- 15		CAP,AL,270UF,+100-10%,20V	602656	89536	602656	4	
C 2		CAP,AL,330UF,+100-10%,25V	614404	89536	614404	1	
C 3		CAP,CER,5600PF,+-5%,50V,COG	528596	89536	528596	1	
C 4		CAP,CER,1000PF,+-5%,50V,COG	528539	51406	RPE113	1	
C 5		CAP,TA,1UF,+-10%,35V	161919	56289	196D010X0035G	1	
C 6		CAP,AL,22UF,+-20%,35V	655084	74840	RLR-PX	1	
C 8		CAP,CER,1.0UF,+-20%,50V,Z5U	436782	72982	8131-050-601-105M	1	
C 9, 19- 37,		CAP,CER,0.22UF,+-20%,50V,Z5U	519157	51406	RPE111Z5U224M50V	26	
C 39- 44			519157				
C 10		CAP,POLYES,0.47UF,+-10%,100V	369124	89536	369124	1	
C 11		CAP,CER,1000PF,+-10%,500V,X5S	357806	56289	C016B102G102K	1	
C 12		CAP,CER,0.0012UF,+-10%,500V,Z5R	106732	71590	CF122	1	
C 16- 18		CAP,AL,47UF,+-20%,16V	643304	89536	643304	3	
C 38, 45		CAP,CER,2200PF,+-20%,100V,X7R	358291	89536	358291	2	
CR 1- 9, 12,	*	DIODE,SI, 50 PIV, 1.0 AMP	379412	04713	1N4933	11	
CR 13	*		379412				
CR 10, 14	*	DIODE,SI, 20 PIV, 1.0 AMP	507731	83003	VSK120	2	
CR 11, 15- 22	*	DIODE,SI,BV= 75.0V,IO=150MA,500 MW	203323	07910	1N4448	9	
F 1		FUSE,1/4 X 1-1/4,FAST,1.0A,250V	369819	71400	AGC1	1	
H 1		NYLON, STEM:OD=.093", L=.115"	658450	89536	658450	4	
H 2		SCREW,MACH,FHUP,S.STL,6-32X1/4	320093	89536	320093	3	
MP 1		REAR PANEL,COUNTER/TOTALIZER	737346	89536	737346	1	
MP 2		HLDR,FUSE,1/4,PWB MT	485219	91833	3529	2	
MP 3		BAG,SHIELDING,TRANSPARENT,12"X16"	680983	89536	680983	1	
MP 4		SPACER,SWAGED,RND,BRASS,6-32X0.250	446351	89536	446351	3	
Q 1, 3, 10,	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	64713	2N3906	6	
Q 12- 14	*		195974				
Q 4	*	TRANSISTOR,SI,N-MOS,POWER,TO-220AB	586107	89536	586107	1	
Q 5, 6, 11,	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	4	
Q 15	*		218396				
Q 7, 8	*	TRANSISTOR,SI,BV= 80V,100W,TO-202	495689	04713	MPSU56	2	
Q 9	*	TRANSISTOR,SI,BV= 80V, 10W,TO-202	495697	04713	MPS-U06	1	
R 1., 2, 10,		RES,CF,51,+-5%,0.25W	414540	80031	CR251-4-5P51E	4	
R 11			414540				
R 3, 13, 16,		RES,CF,5.6K,+-5%,0.25W	442350	80031	CR251-4-5P5K6	4	
R 20			442350				
R 5, 19		RES,CF,30,+-5%,0.25W	442228	80031	CR251-4-5P30E	2	
R 7, 12, 14,		RES,CF,270,+-5%,0.25W	348789	80031	CR251-4-5P270E	7	
R 15, 22, 99,			348789				
R 100			348789				
R 17, 18, 21,		RES,CF,10K,+-5%,0.25W	348839	80031	CR251-4-5P10K	8	
R 23, 25, 31,			348839				
R 44, 51			348839				
R 24, 63, 68,		RES,CF,510,+-5%,0.25W	441600	80031	CR251-4-5P510E	7	
R 71, 74, 77,			441600				
R 87			441600				
R 26, 36, 41		RES,CF,100,+-5%,0.25W	348771	80031	CR251-4-5P100E	3	
R 27		RES,CF,330,+-5%,0.25W	368720	80031	CR251-4-5P330E	1	
R 28		RES,MF,9.53K,+-1%,0.125W,100PPM	288563	91637	CMF559530F	1	
R 29, 30, 32,		RES,MF,10K,+-1%,0.125W,100PPM	168260	91637	CMF551002F	6	
R 40, 42, 50			168260				
R 33		RES,MF,39.2K,+-1%,0.125W,100PPM	236414	91637	CMF553922F	1	
R 34		RES,MF,14.3K,+-1%,0.125W,100PPM	291617	91637	CMF551432F	1	
R 37		RES,CF,100K,+-5%,0.25W	348920	80031	CR251-4-5P100K	1	
R 38		RES,MF,46.4K,+-1%,0.125W,100PPM	188375	89536	188375	1	
R 39		RES,MF,40.2K,+-1%,0.125W,100PPM	235333	91637	CMF554022F	1	
R 43		RES,CF,8.2K,+-5%,0.25W	441675	80031	CR251-4-5P8K2	1	
R 45		RES,MF,332K,+-1%,0.125W,100PPM	289504	91637	CMF553323F	1	
R 46		RES,MF,28.7K,+-1%,0.125W,100PPM	235176	91637	CMF552872F	1	
R 47, 59- 62		RES,CF,1K,+-5%,0.25W	343426	80031	CR251-4-5P1K	5	
R 48		RES,MF,154K,+-1%,0.125W,100PPM	289447	91637	CMF551543F	1	
R 49, 52		RES,CF,1M,+-5%,0.25W	348987	80031	CR251-4-5P1M	2	
R 53, 56		RES,MF,2.49K,+-1%,0.125W,100PPM	226209	91637	CMF552491F	2	
R 54, 57		RES,CF,680,+-5%,0.25W	368779	80031	CR251-4-5P200E	2	
R 55		RES,MF,11.5K,+-1%,0.125W,100PPM	267138	91637	CMF551152F	1	

TABLE 167-7. COUNTER/TOTALIZER PCA
(SEE FIGURE 167-11.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	NOTE
R 58		RES,MF,15K,+-1%,0.125W,100PPM	285296	91637	CMF551502F	1	
R 64, 66, 69,		RES,CF,51K,+-5%,0.25W	376434	80031	CR251-4-5P51K	6	
R 72, 75, 86			376434				
R 65, 67, 70,		RES,CF,6.2K,+-5%,0.25W	442368	80031	CR251-4-5P6K2	6	
R 73, 76, 85			442368				
R 81, 82		RES,CF,5.1K,+-5%,0.25W	368712	80031	CR251-4-5P5K1	2	
R 83,101-112		RES,CF,2K,+-5%,0.25W	441469	80031	CR251-4-5P2K	13	
R 84		RES,CF,180,+-5%,0.25W	441436	80031	CR251-4-5P180E	1	
R 88- 93		RES,CF,150K,+-5%,0.25W	348938	80031	CR251-4-5P150K	6	
R 94		RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF551003F	1	
R 95		RES,MF,32.4K,+-1%,0.125W,100PPM	182956	91637	CMF553242F	1	
R 96		RES,MF,1.4K,+-1%,0.125W,100PPM	344333	91637	CMF551401F	1	
R 97		RES,MF,12.7K,+-1%,0.125W,100PPM	217448	91637	CMF551272F	1	
R 98		RES,MF,866,+-1%,0.125W,100PPM	248641	89536	248641	1	
R 113-115,117-		RES,VAR,CERM,20K,+-10%,0.5W	291609	89536	291609	6	
R 119			291609				
R 116		RES,VAR,CERM,25K,+-20%,0.5W	285213	11236	190PC253B	1	
S 1		SWITCH,MODULE,SPST,DIP,4 POS	408559	00779	435166-2	1	
S 2- 4		SWITCH,MODULE,SPDT,DIP,5 POS	417766	00779	435470-4	3	
S 5		SWITCH,MODULE,BCD,DIP,10 POS	643585	89536	643585	1	
S 6		SWITCH,ROTARY,1 POLE,16 POS,1 THUMB	615096	97527	1A-21-60-33-G-F	1	
S 7		SWITCH,ROTARY,1 POLE,10 POS,1 THUMB	602888	97527	1A-21-60-02-G-F	1	
T 1		INVERTER,TRANSFORMER	716209	89536	716209	1	
TM 1		TECHNICAL DATA SHEET # 80127	530303	89536	530303	1	
U 2	*	IC,BPLR,DUAL DIFF LINE DRVR W/3-STATE	586081	12040	DS1692J	1	
U 3	*	IC,BPLR,DIFFERENTIAL LINE RECEIVER	586073	01295	SN55182J	1	
U 4	*	ISOLATOR,OPTO,HI-SPEED,DUAL	429894	28480	5082-4355	1	
U 5, 9	*	ISOLATOR,OPTO,HI-SPEED,8 PIN DIP	354746	89536	354746	2	
U 6	*	IC,REGULATING PULSE WIDTH MODULATOR	454678	01295	SG3524N	1	
U 7	*	IC,CMOS,HEX INVERTER	381848	02735	CD4049AE	1	
U 8	*	IC,VOLT REG,FIXED,+15 VOLTS,0.1 AMPS	453035	04713	MC78L15ACG	1	
U 10, 14	*	IC,OP AMP,DUAL,INDUSTRIAL TEMP RANGE	605550	01295	LM258JG	2	
U 11	*	IC, 2.5 V,40 PPM T.C.,BANDGAP REF	472845	04713	MC1403V	1	
U 12, 62- 64	*	IC,COMPARATOR,DUAL,INDUSTRIAL TEMP	741785	89536	741785	4	
U 13	*	IC, 1.22V,100 PPM T.C.,BANDGAP REF	452771	89536	452771	1	
U 15, 38, 42	*	IC,LSTTL,QUAD 2 INPUT OR GATE	605618	01295	SN54LS32J	3	
U 16, 23, 50,	*	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	12040	MM80C97N	4	
U 55	*		407759				
U 17, 43	*	IC,CMOS,PROGRAMMABLE INTERVAL TIMER	723643	89536	723643	2	
U 18	*	IC,CMOS,HEX D F/F,+EDG TRG,W/RESET	404509	12040	MM74C174N	1	
U 19, 24, 45	*	IC,CMOS,DUAL D F/F,+EDG TRG W/SET&RST	536433	04713	MC4013BCP	3	
U 20, 22	*	IC,CMOS,HEX SCHMITT TRIGGER	723320	89536	723320	2	
U 21, 25	*	IC,FTTL,DUAL D F/F,+EDG TRG,W/CL&SET	659508	07263	74F74PC	2	
U 27	*	IC,CMOS,TRIPLE 2-1 LINE MUX/DEMUX	375808	02735	CD4053BE	1	
U 28		IC, NMOS, 8 BIT MICROCOMPUTER	685529	89536	685529	1	
U 29		IC, CMOS, UNIV ASYNC RECEIVR/TRANSMIT	453464	32293	IM6402CPL	1	
U 30, 36, 44	*	IC,CMOS,QUAD D LATCH,+EDG TRG,W/RESET	412742	12040	MM74C173N	3	
U 31	*	IC,CMOS,TRIPLE 3 INPUT AND GATE	408807	02735	CD4073BE	1	
U 32- 34, 54	*	IC,CMOS,DUAL 4-1 LINE MUX/DMUX ANL SW	429886	02735	CD4052BE	4	
U 35	*	IC,LSTTL,HEX INVERTER	393058	01295	SN74LS04N	1	
U 37	*	IC,CMOS,TRIPLE 3 INPUT OR GATE	408575	02735	CD4075BE	1	
U 39, 40	*	IC,LSTTL,HEX D F/F,+EDG TRG,W/CLEAR	393207	01295	SN74LS174N	2	
U 41	*	IC,LSTTL,DUAL DIV BY 2,DIV BY 5 CNTR	483594	01295	SN74LS390N	1	
U 46	*	IC,CMOS,HEX BUFFER	355412	02735	CD4010AE	1	
U 47	*	IC,CMOS,HEX CONTACT BOUNCE ELIMINATOR	536557	04713	MC14490VP	1	
U 48, 59	*	IC,CMOS,DUAL BCD UP COUNTER	386227	04713	MC14518BCP	2	
U 51	*	IC,CMOS,QUAD XOR GATE	586727	04713	MC14077BCP	1	
U 52	*	IC,TTL,QUAD 2 INPUT AND GATE	393066	01295	SN74LS08N	1	
U 53	*	IC,LSTTL,BCD-DECIMAL 4-10 LINE DCDR	408716	01295	SN74LS42N	1	
U 56	*	IC,LSTTL,OCTAL D F/F,+EDG TRG,W/CLEAR	454892	01295	SN74LS273N	1	
U 57		IC, 2K X 8 EPROM, PROGRAMMED	747964	89536	747964	1	
U 58, 65	*	IC,OP AMP,JFET INPUT,8 PIN DIP	472779	12040	LF386N	2	
U 60, 61	*	IC,ARRAY,16 DIODE,8 COM CATH,8 COM AN	536235	89536	536235	2	
VR 1	*	ZENER,UNCOMP,6V TRANSIENT SUPPRESSOR	508655	24444	1N5908	1	
VR 2	*	ZENER,UNCOMP, 20.0V, 5%, 12.5MA, 1.0W	291575	12969	UZ8720	1	
VR 3, 4	*	ZENER,UNCOMP, 12.0V, 5%, 10.5MA, 0.4W	249052	04713	1N963B	2	
XU 28, 29		SOCKET,IC,40 PIN	429282	09922	DILB40P-108	2	
XU 57		SOCKET,IC,24 PIN	376236	91506	324-AG39D	1	
XZ 1, 8		SOCKET,IC,16 PIN	276535	91506	316-AG39D	2	
Y 1		OSCILLATOR,10.0MHZ,TTL CLOCK	723767	89536	723767	1	
Z 1- 7		RES,NET,SIP,10 PIN,9 RES,10K,+-2%	414003	80031	95081002CL	7	
Z 8		RES,NET,SIP,8 PIN,7 RES,10K,+-2%	412924	80031	95081002CL	1	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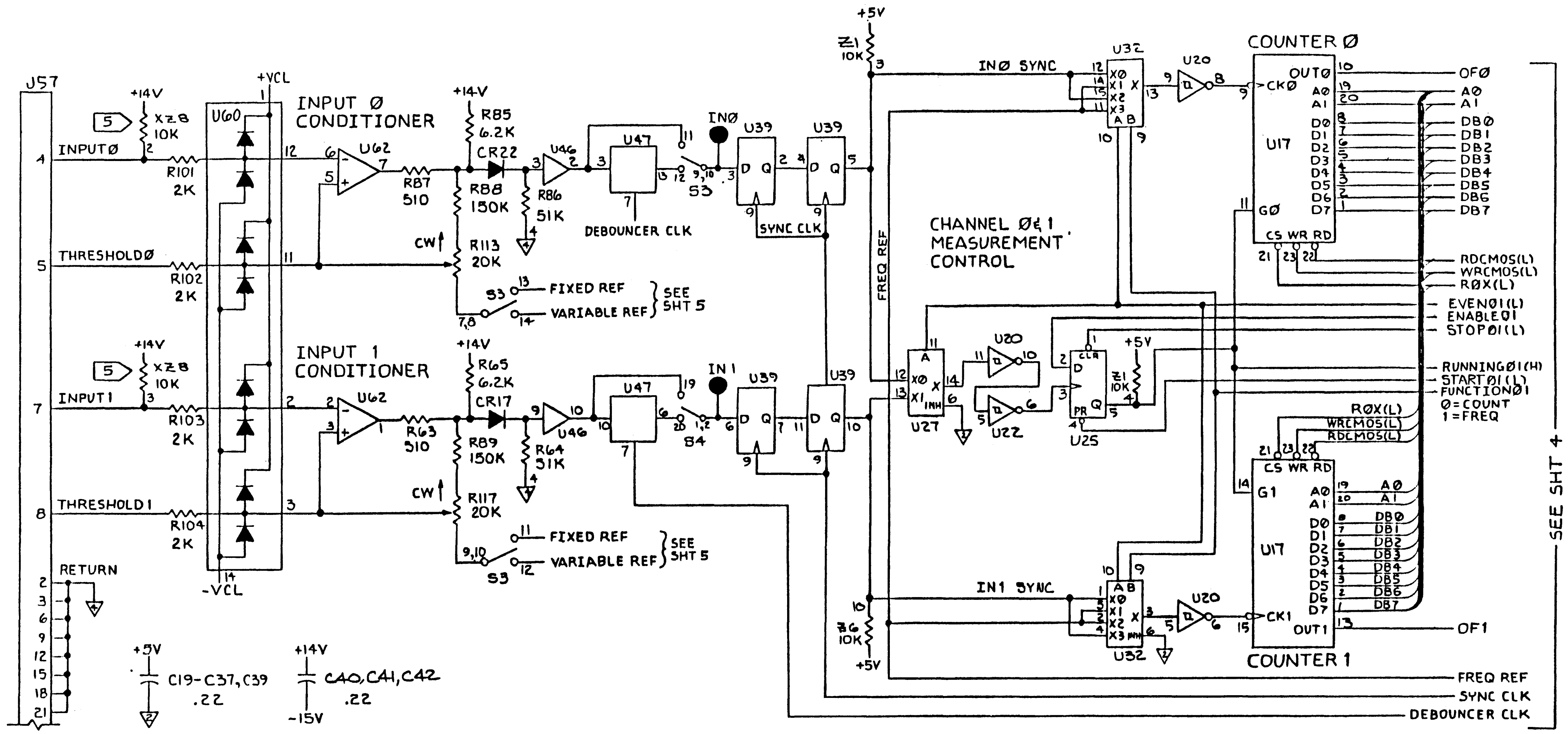

REF DES	▽1	▽2	+5VREM	+5V	+14V	-15V
U1	8		16			
U2	4,5,8		1			
U3	7		14			
U4			8			
U5				8		
U6						
U7						
U8						
U9						
U10						
U11						
U12						
U13						
U14						
U15		7		14		
U16		8		16		
U17		12		24		
U18		8		16		
U19		7		14		
U20		7		14		
U21		7		14		
U22		7		14		
U23		8		16		
U24		7		14		
U25		7		14		

REF DES	▽1	▽2	+5VREM	+5V	+14V	-15V
U26		8		16		
U27		7,8		16		
U28		20		26,40		
U29		3		1		
U30		8		16		
U31		7		14		
U32		7,8		16		
U33		7,8		16		
U34		7,8		16		
U35		7		14		
U36		8		16		
U37		7		14		
U38		7		14		
U39		8		16		
U40		8		16		
U41		8		16		
U42		7		14		
U43		12		24		
U44		8		16		
U45		7		14		
U46		8		1	16	
U47		8		16		
U48		8		16		
U49		12		24		
U50		8		16		

REF DES	▽1	▽2	▽4	+5V	+14V	-15V
U51		7		14		
U52		7		14		
U53		8		16		
U54		7,8		16		
U55		8		16		
U56		10		20		
U57		12		24		
U58						
U59		8.		16		
U60						
U61						
U62					8	4
U63					8	4
U64					8	4
Z1-7						
XZ8					1,8	

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCES ARE IN OHMS AND ALL CAPACITANCES ARE IN MICROFARADS.
2. ALL RESISTORS ARE 1/4 W 5%.
3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.

4. LAYOUT PROVISIONS HAVE BEEN MADE FOR REPLACEMENT OF U2 (SHEET 4, ZONE D2) WITH THE COMPONENTS SHOWN IN DETAIL A (SHEET 5, ZONE D2). REFER TO THE SOLE SOURCE PLAN FOR U2 (JF/PN 586081).

5. RESISTOR Z8 IS INSTALLED IN A SOCKET. THIS PART CAN BE REMOVED.

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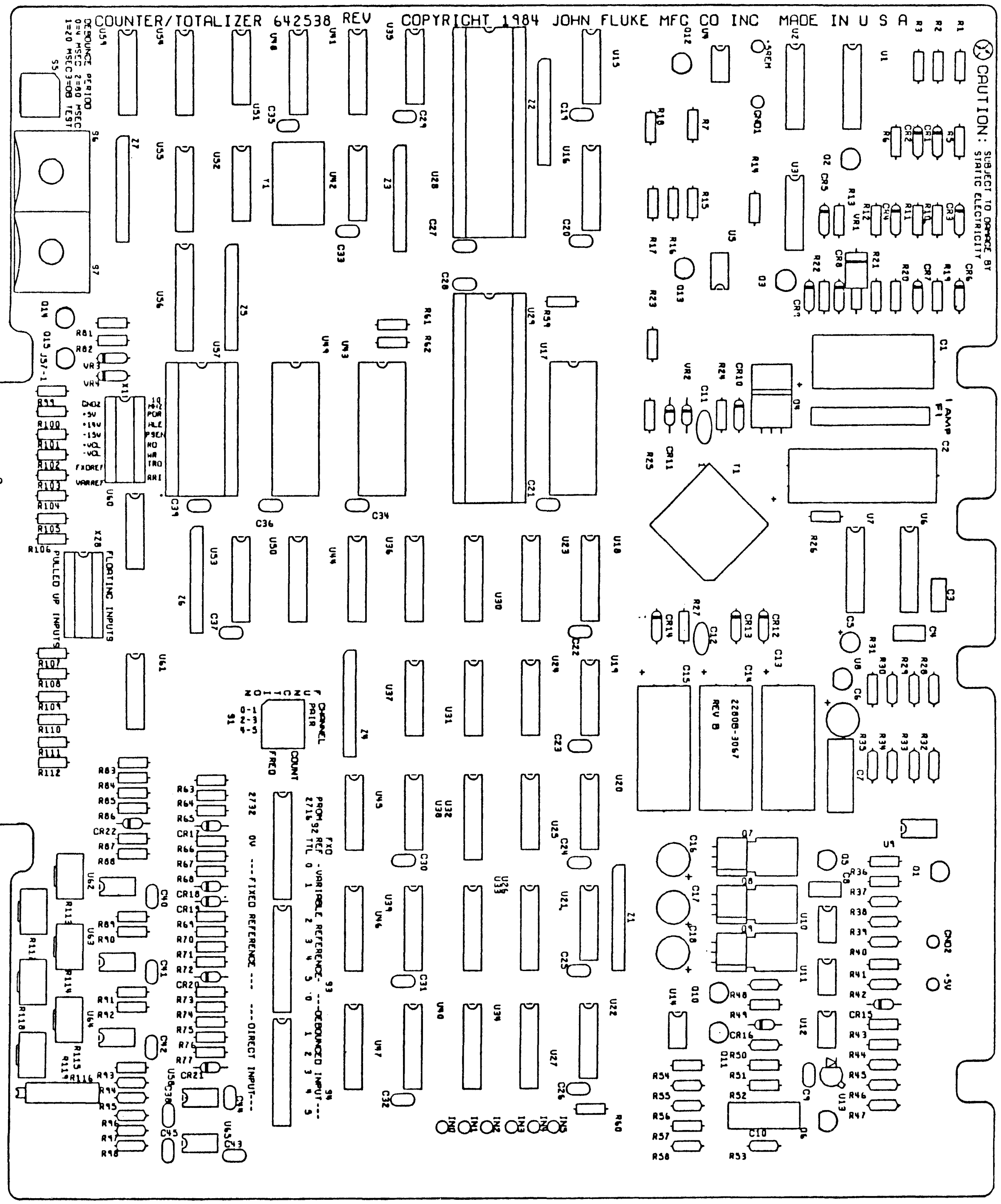
(Sheet 1 of 5)

Figure 167-11. Counter/Totalizer Assembly Schematic Diagram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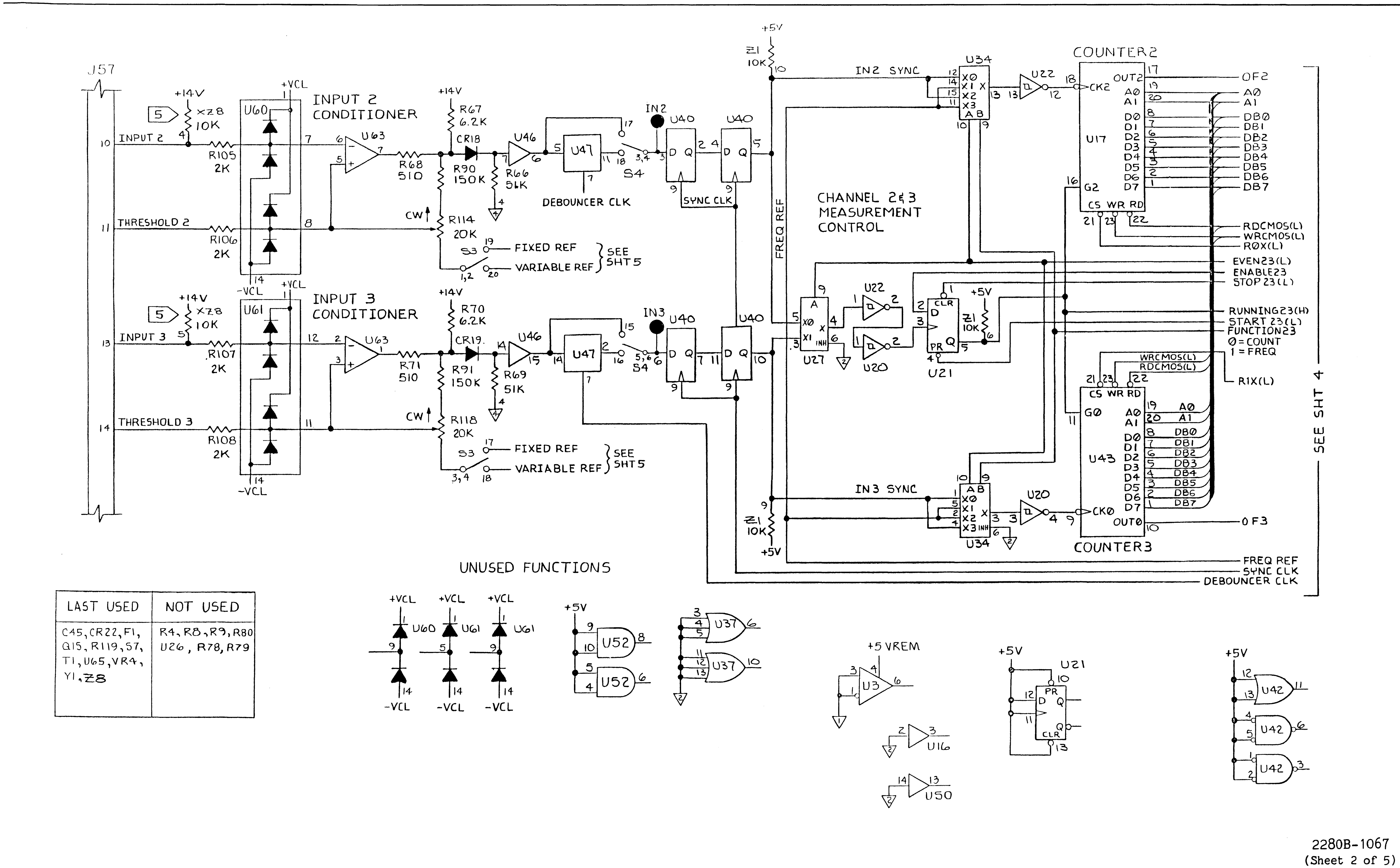
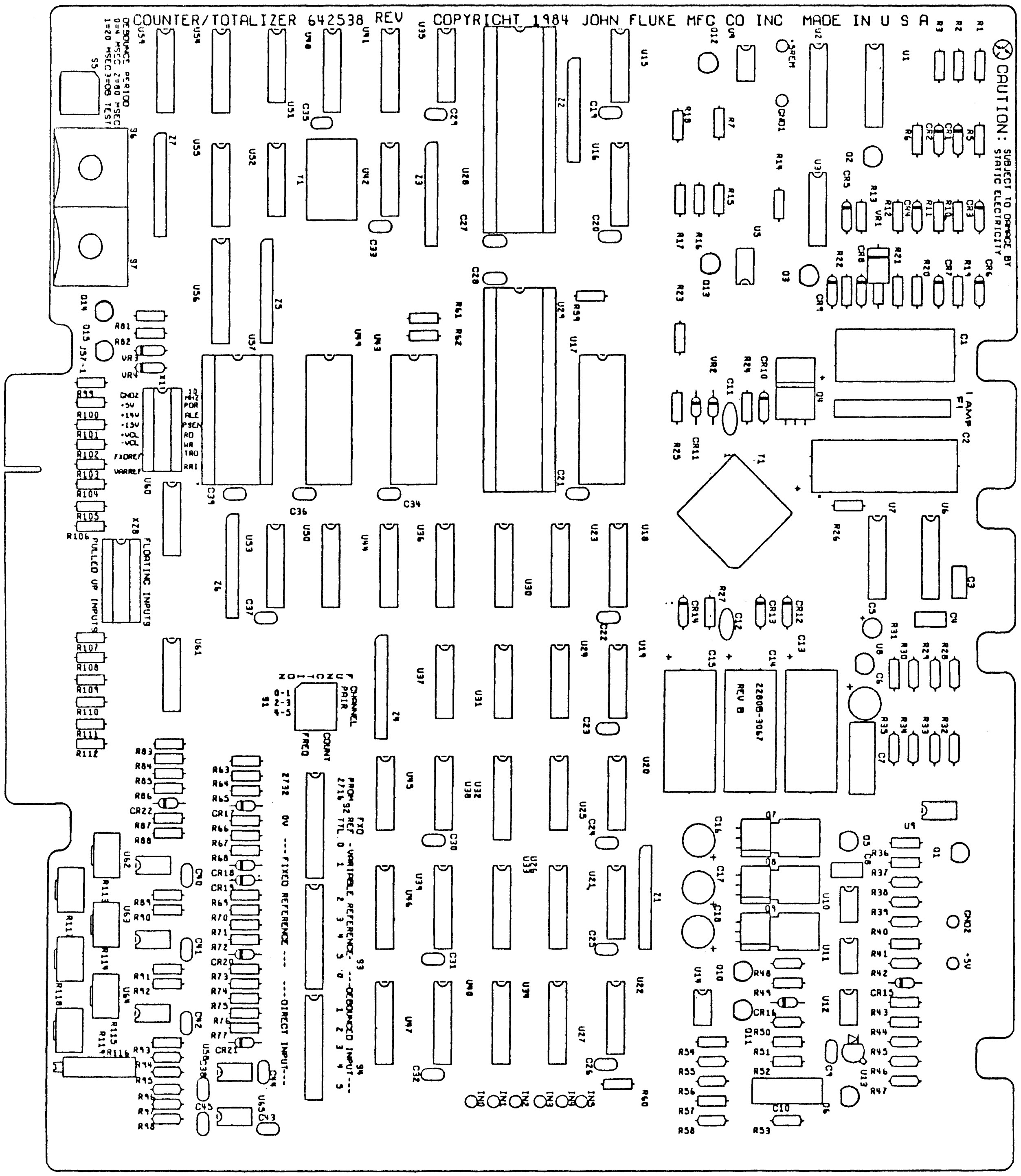
FLOATING INPUTS
PULLED UP INPUTS
CHANNEL PAIR
---FIXED REFERENCE--- ---DIRECT INPUT---
REV B
2280B-3067

2280B-1667



LAST USED	NOT USED
C45, CR22, F1, Q15, R119, S7, T1, U65, VR4, Y1, Z8	R4, R8, R9, R80, U26, R78, R79

Figure 167-11. Counter/Totalizer Assembly Schematic Diagram (cont)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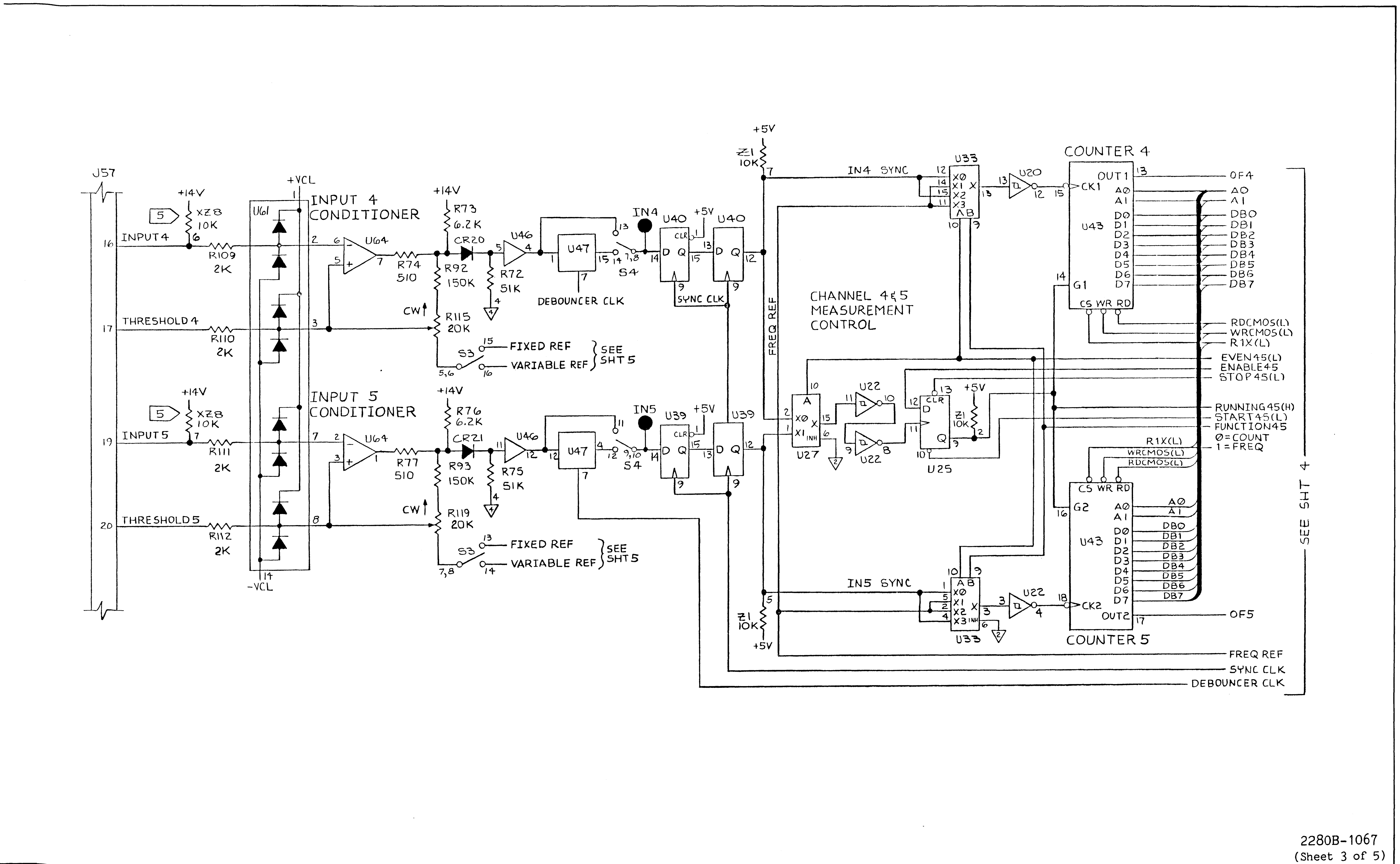
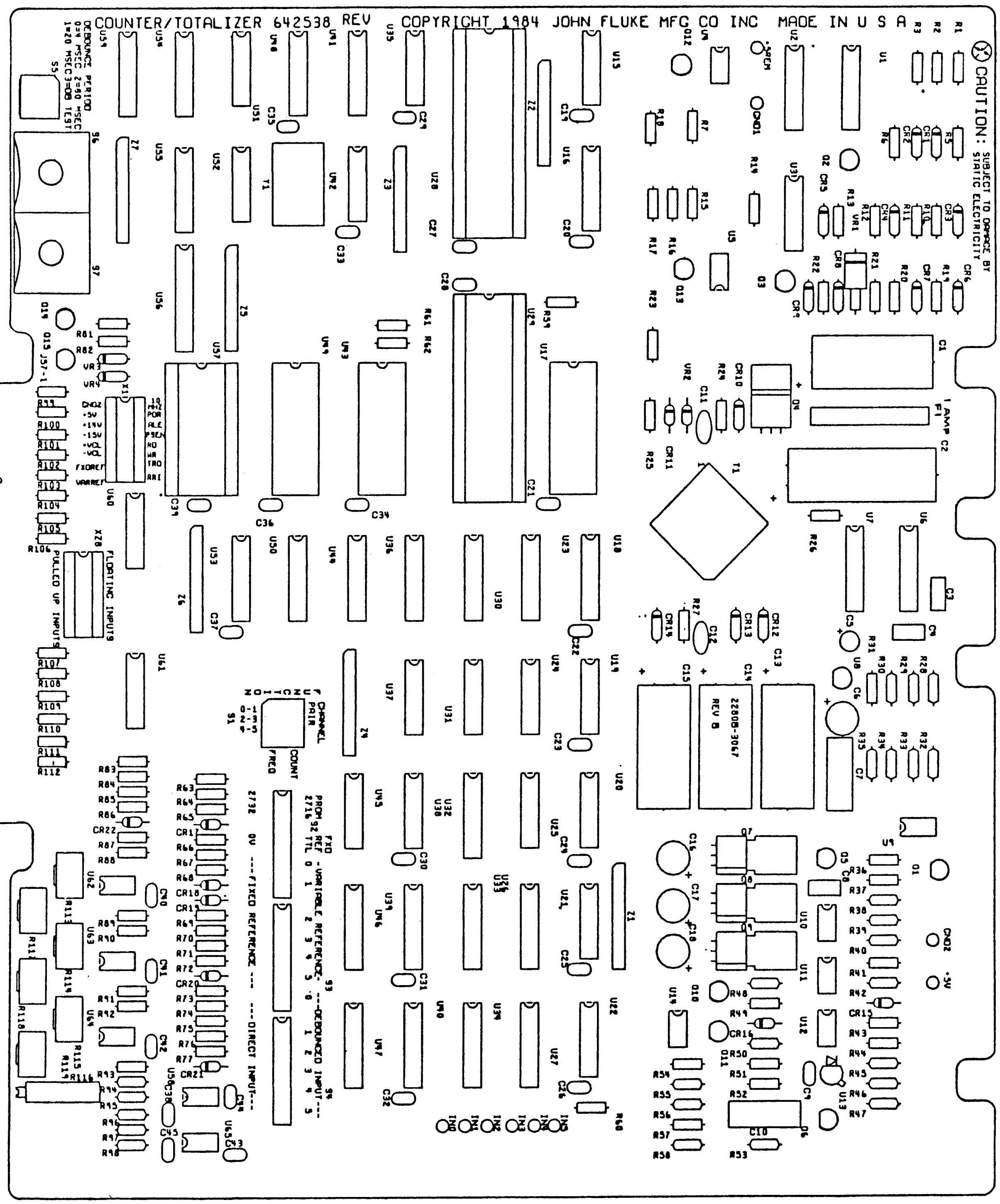


Figure 167-11. Counter/Totalizer Assembly Schematic Diagram (cont)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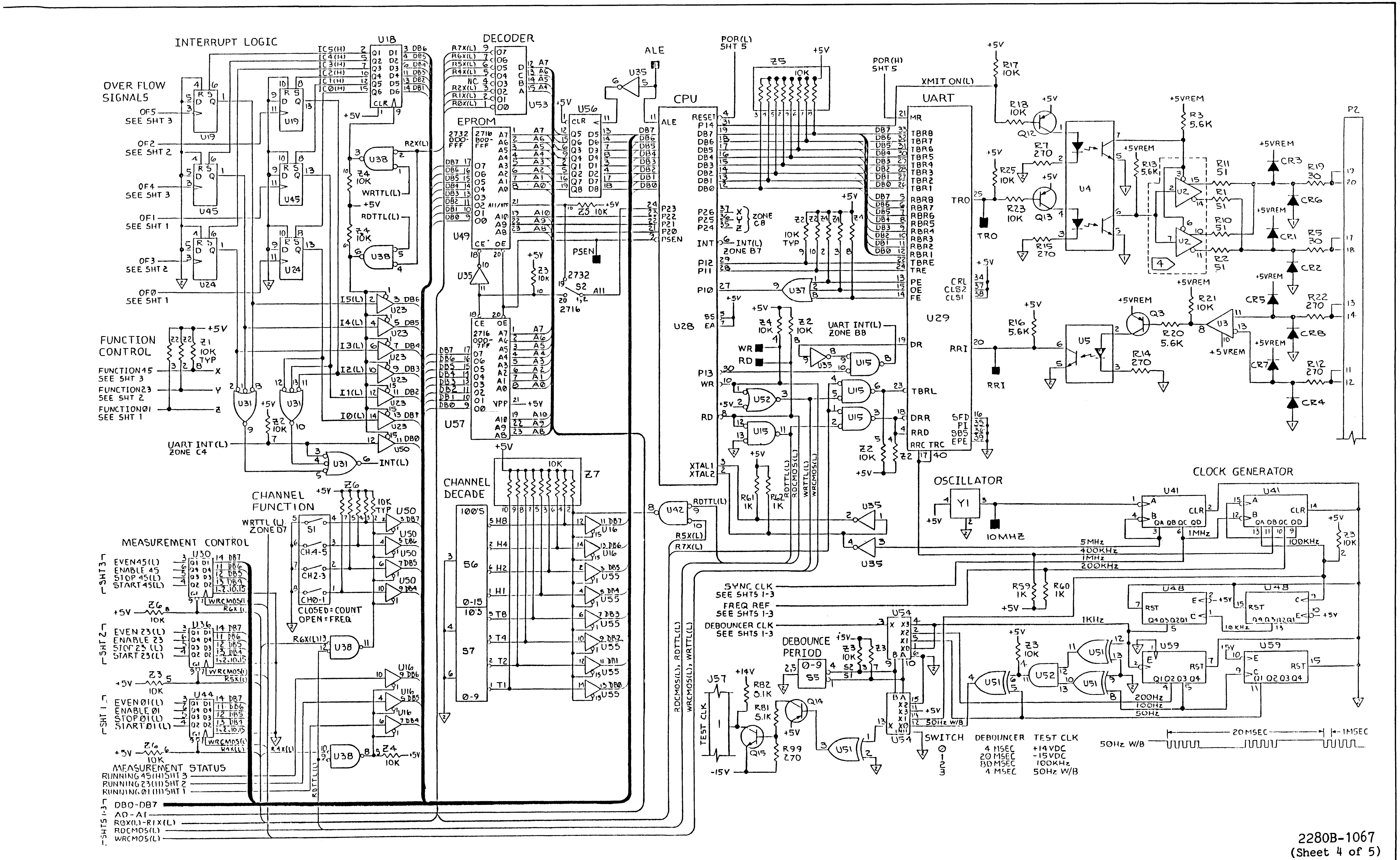
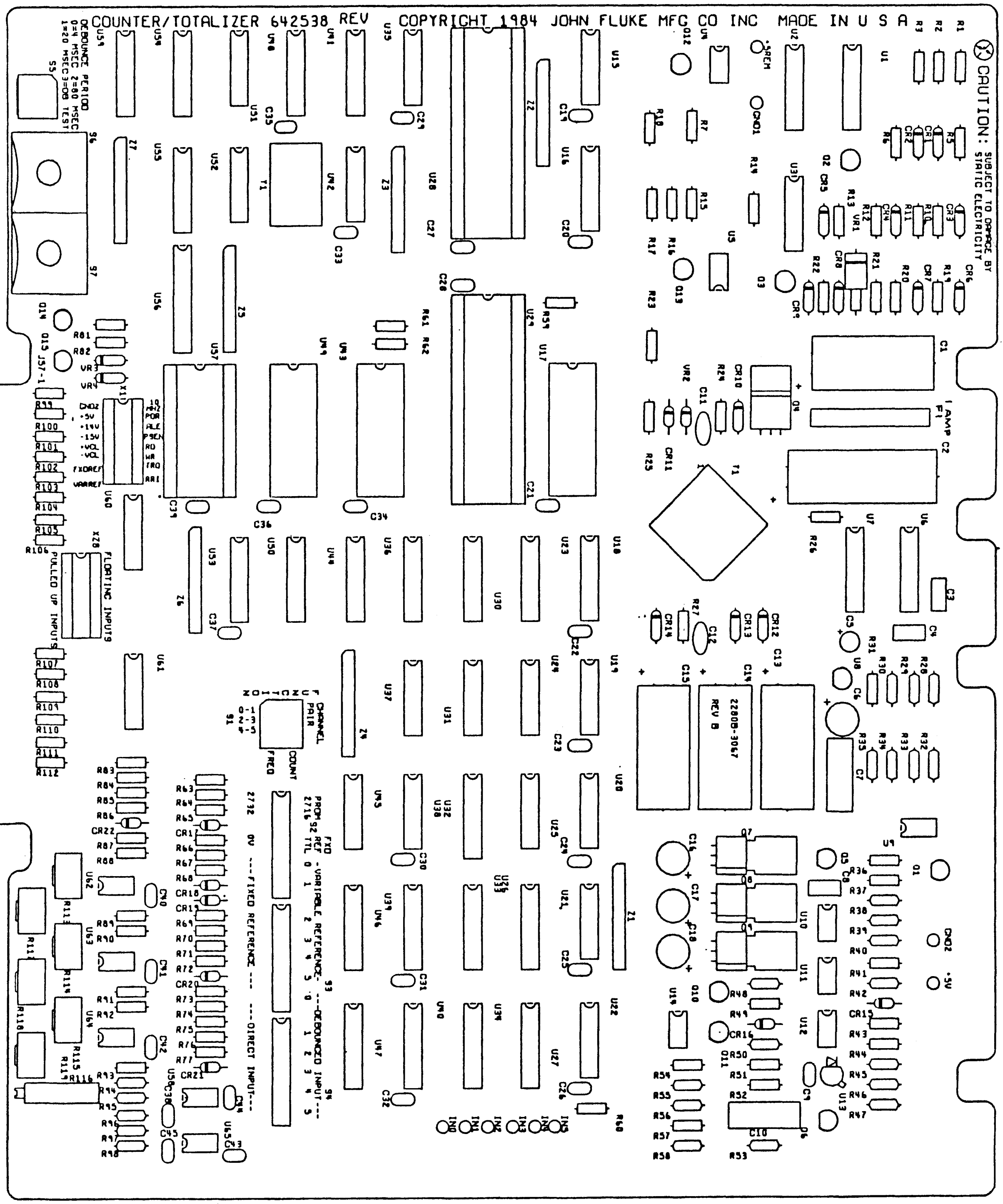


Figure 167-11. Counter/Totalizer Assembly Schematic Diagram (cont)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2280B-3067 REV B

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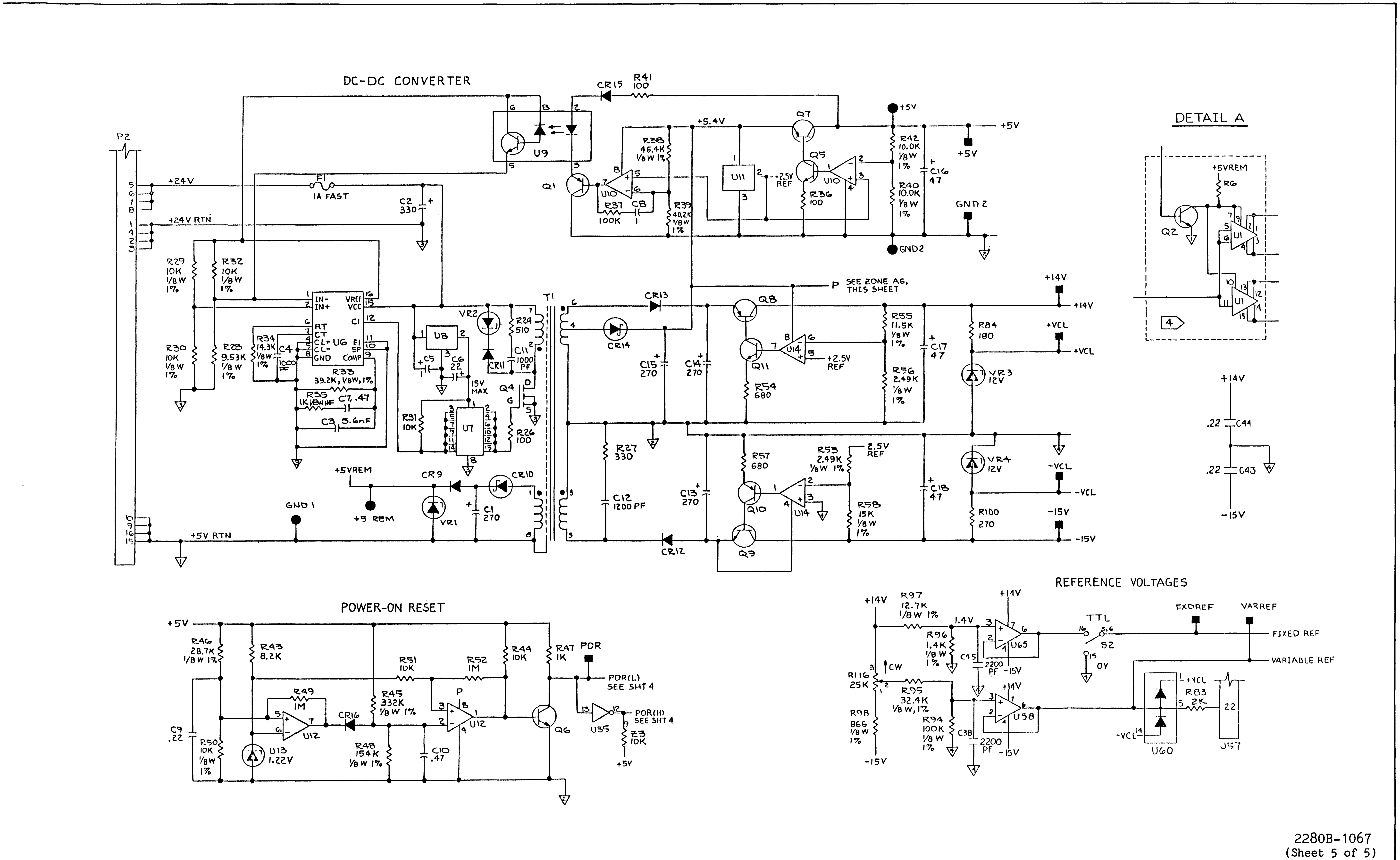


Figure 167-11. Counter/Totalizer Assembly Schematic Diagram (cont)

DESCRIPTION

The -168 Digital I/O Assembly (shown in Figure 168-1) allows the Front End to receive and transmit digital information.

The input connector used and the way the connector is wired determine whether the assembly is used by the Front End to transmit or receive information. When used for output, a single channel (or single bit) can be changed at a time. When used for input, the Front End can read a single bit at a time or parallel words in a binary or binary-coded-decimal (bcd) format.

Two connector options are available with the Digital I/O Assembly: the -169 Status Output Connector for output and the -179 Digital/Status Input Connector for input. Signals originating on the connector inform the Digital I/O Assembly whether it is being used for input or output. The Digital I/O Assembly supports 20 input or output channels.

If the Digital I/O Assembly is used to input data to the Front End, two additional input lines are used to determine which information type (bcd, binary, or status) the assembly is to measure. Refer to the appropriate connector option section in the Helios Plus System Manual for configuration instructions.

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Digital I/O Assembly theory of operation, performance tests, a parts list, and schematic diagrams.

Installation, operating, and system configuration instructions are found in the Helios Plus System Manual.

Option specifications are found in the appendices of this manual and in the System Manual.

Equipment required for the procedures in this subsection is listed in Table 168-1. A summary of test equipment required for all procedures in this manual is given in Table 2-2 in Section 2 of this manual.

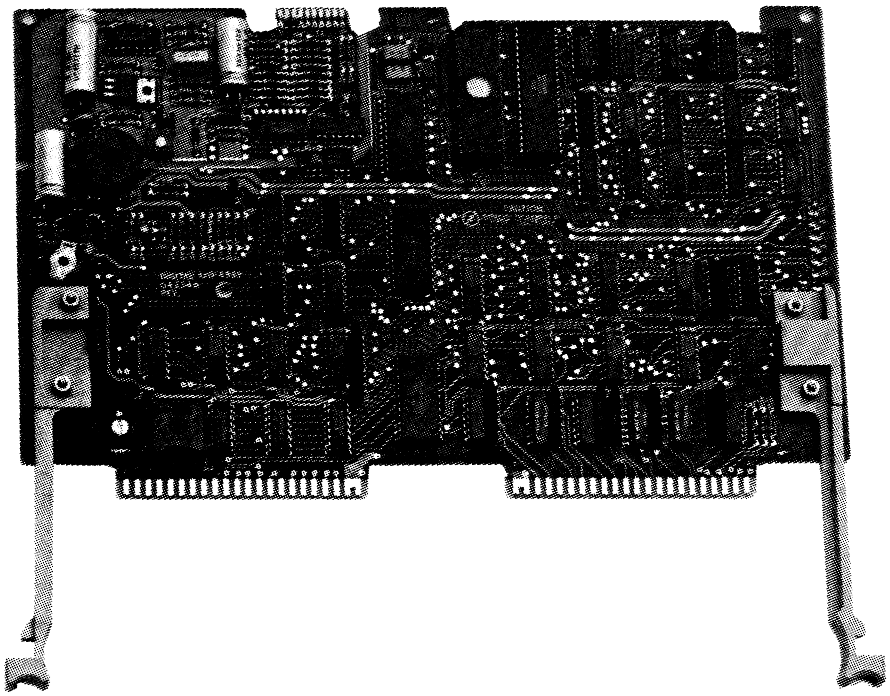


Figure 168-1. Digital I/O Assembly

Table 168-1. Required Test Equipment for -168

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DMM	Capable of measuring +12V	Fluke 77
Calibration/ Extender Fixture	NA	Fluke Accessory Part No. 648741 (no substitute)
Digital/Status Input Connector	NA	Fluke Option -179 (no substitute)
Status Output Connector	NA	Fluke Option -169 (no substitute)
Power Supply	Capable of sourcing +12V dc	Appropriate lab type
Resistor, 2ea.	220 ohms, 1W	Fluke Part No. 109462

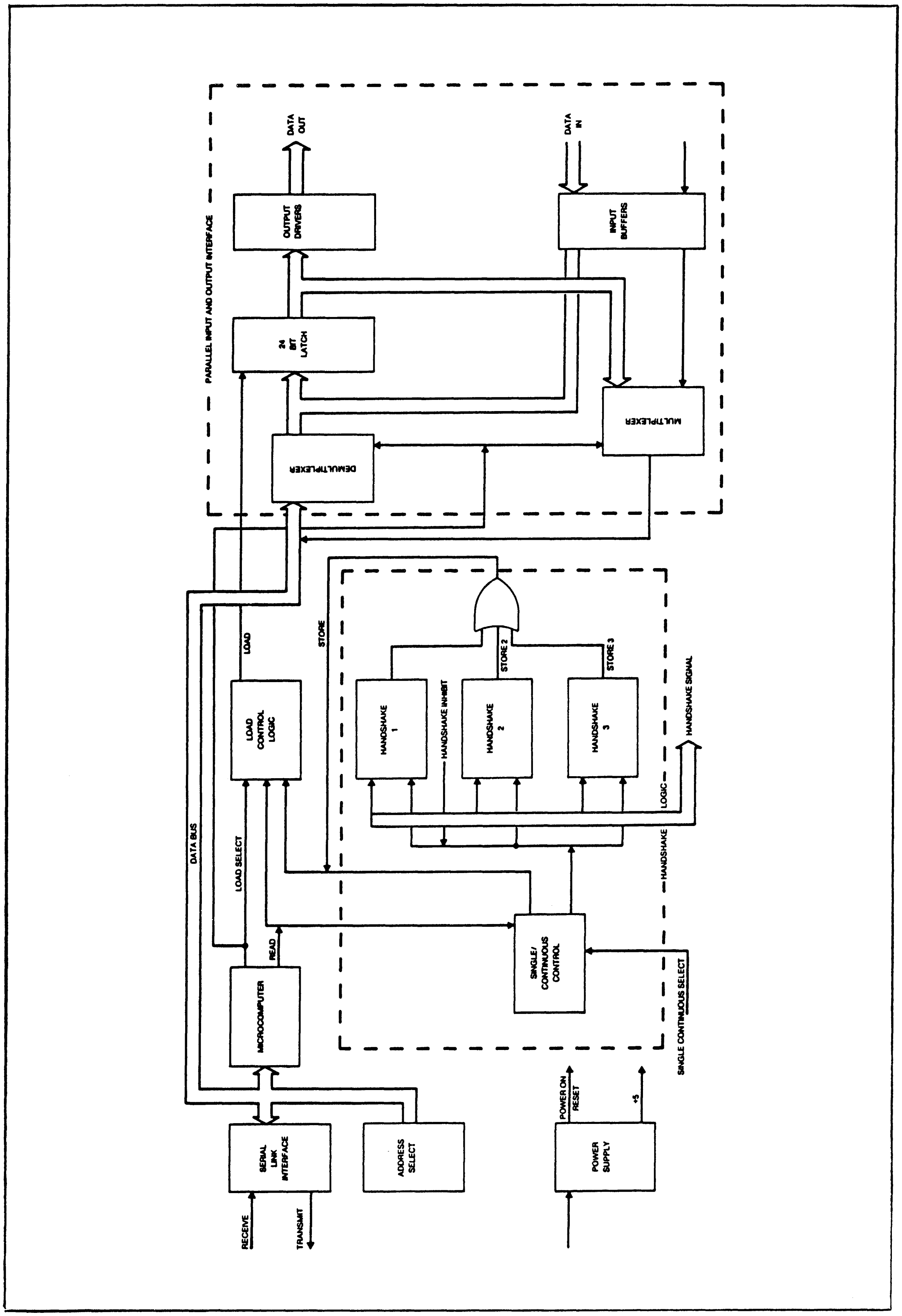


Figure 168-2. Digital I/O Assembly Block Diagram

THEORY OF OPERATION

The theory of operation for the Digital I/O Assembly includes: a functional description, a block diagram analysis (which describes how each major circuit block on the Digital I/O Assembly works), and an analysis of each circuit block.

Where necessary, block diagrams and simplified schematics are included with the text. Schematic diagrams for the Digital I/O Assembly are at the end of this option subsection.

Overall Functional Description

The Digital I/O Assembly allows the Front End to output single-bit alarm or status information and the ability to input information in any of three formats: single-bit alarm or status, bcd-formatted digital, and binary-formatted digital information.

Block Diagram Analysis

The Digital I/O Assembly contains six major circuit blocks (shown in Figure 168-2): the power supply, address select, the serial link interface, the microcomputer, the handshake logic, and the parallel input and output interfaces. The following paragraphs discuss the function of each of these circuit blocks.

POWER SUPPLY

The power supply converts incoming dc power from the serial link into isolated +5V dc for the Digital I/O circuitry and +5V dc for the serial link. The power supply circuitry also generates a reset signal that is used to start up the the microcomputer and the handshake logic properly.

SERIAL LINK

The Serial Link allows the Digital I/O Assembly to exchange commands and measurement data with the Front End mainframe controller. In this block, the bi-directional serial transmissions are electrically isolated, buffered, and converted to signals that the microcomputer can use. The serial link circuitry sends an interrupt signal and data to the microcomputer while the microcomputer returns data and a transmitter enable signal.

ADDRESS SELECT

Two thumbwheel switches on the Digital I/O Assembly are used to select the channel range for the assembly. The switches select the starting channel number of a block of 20 contiguous channels for the assembly. The switch that selects the most significant digit has a valid range of 0 to 14 (position 15 not used), and the switch that selects the second-most significant digit has a range of 0 to 9.

MICROCOMPUTER

The Digital I/O Assembly uses an NMOS 8748, 8-bit microcomputer to control all interaction between the Front End mainframe controller and the input/output interface.

HANDSHAKE LOGIC

When the Digital I/O board is used to read parallel words in either a bcd or binary format, the user may select one of three different handshake schemes through which the data may be entered. In addition, the user may select either noninverted or inverted polarity for each of the handshakes and may choose between a single or continuous update mode.

In the continuous update mode, data may be continuously loaded between transfers to the mainframe controller, thereby ensuring that only the most recent data is measured. In the single update mode, the data may be loaded only once between transfers; any further loads are inhibited until the data has been retrieved by the mainframe controller.

PARALLEL INPUT AND OUTPUT INTERFACE

This circuit block consists of data storage latches, tri-state buffers to read from and write to the latches, and input and output buffers. The latches are used to store the data output when the Digital I/O is used for status output, and they are used to store the parallel bcd or binary input data when used as a digital input.

Detailed Circuit Description

POWER SUPPLY

Dc-to-Dc Converter

Isolation of the Digital I/O circuitry is provided by T1 which is also the core of the dc-dc converter. In the dc-dc converter, T1, U1, Q1, and Q2 comprise a "flyback" type of switching regulator converter. Incoming dc power from 10V dc to 25V dc is applied to the primary of T1 for an interval generated by U1, causing the primary current to ramp up to approximately 1 ampere peak before Q1 and Q2 are turned off. The energy stored in T1 is then released through CR10 and CR12, into C5 and C20 respectively. The voltage on C5 is sampled by R9, R10, and R11, and a feedback error signal is generated and relayed to U1. The duty cycle of Q1 and Q2 is then adjusted by U1 to maintain C5 at 5.0V despite load changes.

The voltage on C20 is used to supply all isolated circuitry on the assembly. The voltage on C5 is used to power the serial link interface circuits.

Adjustment potentiometer R11 is used to set the isolated 5V dc supply voltage (GL +5) to 5V. This can be measured between test points TP2 and TP20.

Reset Generator

When power is first applied to the Digital I/O, Q6 is turned on by R36, and the power-on reset signal (POR(L)) to the controller is held low. U24 compares the voltage on C22 to a 1.22V reference provided through VR3 to determine whether the +5V supply is within tolerance. Once the supply voltage has stabilized, C21 is allowed to charge through R28 and R33, generating a delay of approximately 50 ms before C21 charges to 1.22V. This causes U24 to remove the drive to Q6, allowing POR(L) to be pulled high by R37.

SERIAL LINK

There are three major components in the serial link interface: a Universal Asynchronous Receiver/Transmitter (U8), a bidirectional optical interface (U4 and U5), and a differential driver (U2) and receiver (U3).

To improve the operation of the system in an electrically noisy environment, differential line drivers in U2 and receivers in U3 transmit and receive information through transient suppression networks consisting of resistors R12, R13, R14, R15, R18, R19, R20, and R21 and diodes CR1 through CR8 in conjunction with VR2.

When data is transmitted from the Digital I/O Assembly to the system controller, the processor places the eight-bit word on the Digital I/O Assembly internal data bus accompanied by a WRITE STROBE. The UART accepts each of the parallel eight-bit words from the processor and converts them to a serial data stream. The serialized data is then sent through the optical coupler (U4, pins 3, 4, 5, and 6) and driver (U2) onto the serial link. Because there may be a number of different devices on the link, the drivers are placed in a high-impedance state when they are not actively involved in transferring data. Driver tri-stating is accomplished by the signal from microcomputer port 1, bit 5, which is transferred through an optical coupler (U4, pins 1, 2, 5, and 7).

Incoming data from the Front End mainframe controller assembly is fed into the UART (U8) through optical coupler U5. Upon receipt of a data byte, the UART interrupts the microcomputer (U7).

The clock for the UART is provided by the Address Latch Enable (ALE(H)) signal from the microprocessor. Clock frequency is 16 times the 25,000 baud bit rate of the serial link.

ADDRESS SELECT

Two thumbwheel switches, S1 and S2, on the Digital I/O Assembly are used to select the address range for that assembly. The microcomputer reads the current switch settings through buffers in U27 and U28 when they are enabled by setting port 1 bit 6 low.

Each time a command is received from the mainframe controller, the state of the address switches is checked. If the address within the command falls within the address block selected through the switches, the remainder of the message is decoded and executed. If the address does not match, the command from the mainframe controller is ignored.

MICROCOMPUTER

The microcomputer on the Digital I/O Assembly (U7) has 1024 bytes of internal EPROM memory and 64 bytes of internal RAM. There is no external memory on the Digital I/O Assembly. A 6-MHz crystal (Y1) provides the frequency reference for the clock generated within the microcomputer. The microcomputer, in turn, generates the 400K Address Latch Enable (ALE(H)) signal used as the clock for the remainder of the subsystem.

The microcomputer has two 4-bit input/output ports, which are used to develop a number of control signals throughout the Digital I/O board. In addition, there is an 8-bit data bus used for data transfer within the Digital I/O Assembly.

HANDSHAKE LOGIC

Five subcircuits comprise the handshake logic: the three handshake circuits, the single/continuous control circuit, and the load control circuit. Handshake logic provides three alternate means by which data may be entered. In response to an external load signal, the selected handshake circuit generates the appropriate acknowledge and a store signal to the load control circuit.

The three independent handshake circuits are discussed in the following paragraphs. All signals in the accompanying illustrations are shown in the noninverted polarity.

Handshake Type One Circuit

Counter U34, flip-flops U20 (labeled F and G), and gates U12, U13, U15, U16, and U18 comprise the type one handshake circuit. Refer to Figure 168-3. Immediately following power on, the circuit is in its initial state with both flip-flops reset. One clock pulse after the counter output (P) transitions to a logical one, flip-flop G sets, generating the leading edge of the ACK1 output pulse. Approximately 32 microseconds later, P returns to the logical zero state, then flop-flop F is set and the trailing edge of ACK1 is generated.

After the ACK1 output pulse is generated, the circuit is ready to accept the LOAD 1 input pulse from the user's circuitry. When LOAD 1 transitions to a logic 0, the G flip-flop resets and the leading edge of the STORE command is sent to the Load Control circuit. The incoming data is stored. When the LOAD 1 command returns to the logic 1 state, flip-flop F resets and the sequence is complete.

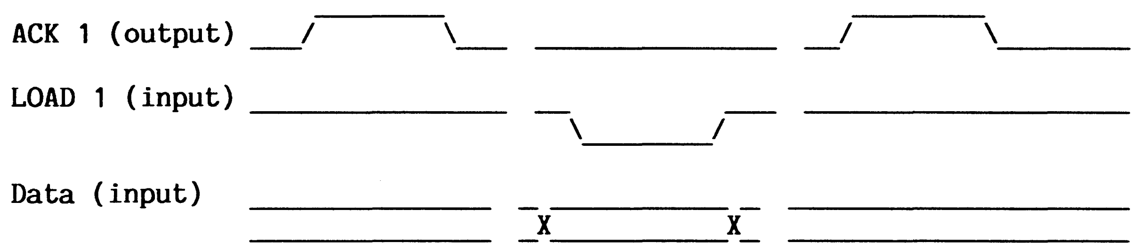


Figure 168-3. Handshake Type One Timing Diagram

Handshake Type Two Circuit

Flip-flops U21 (labeled D and E) and gates U12, U13, and U16 implement the circuit for the type two handshake. Refer to Figure 168-4. Immediately following power up, flip-flops D and E are in the reset state, from which flip-flop E transitions to the logic 1 state to generate the leading edge of the ACK 2 output signal. The external device may now generate the leading edge of the LOAD 2 input signal. In response to the LOAD 2 zero-to-one transition, the external data is stored and flip-flop E is reset, thus, generating the trailing edge of the ACK 2 signal. When LOAD 2 returns to the logic 0 state, ending the handshake, flip-flop D is reset.

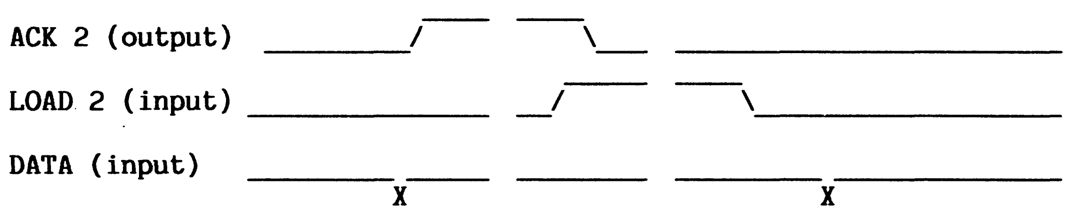


Figure 168-4. Handshake Type Two Timing Diagram

Handshake Type Three Circuit

The final handshake circuit consists of gates U12 and U15. Data may be loaded into the data storage register using this method any time that the BUSY output is in the logic zero state. The LOAD 3 input command is accepted by the Digital I/O Assembly and is passed on immediately to the Load Control circuit. Refer to Figure 168-5.

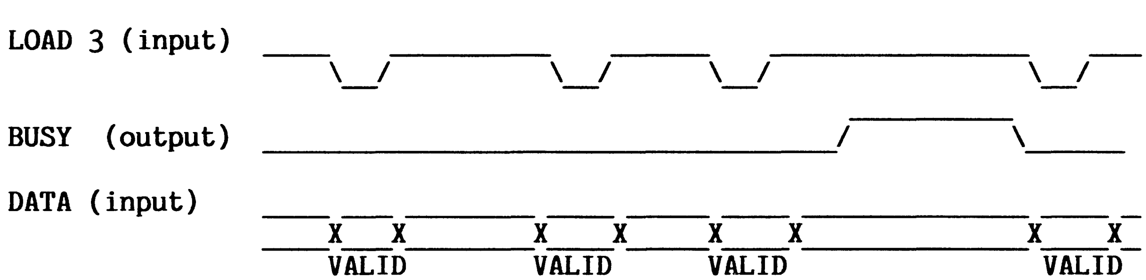


Figure 168-5. Handshake Three Timing Diagram

Load Control Logic

The load control circuit accepts the STORE signal from any of the three handshake circuits and develops a LOAD pulse to the data storage register to strobe in the external data. The load control circuit also prevents loading during a read cycle.

Three flip-flops within U22, and gates U16 and U17 comprise the load control logic. The load control logic is a sequential circuit that accepts a STORE signal from the handshake circuits and a READ signal from the microcomputer and generates a LOAD signal to the data storage register.

Upon initialization, flip-flops A, B, and C are in the reset state. One clock pulse later, C becomes set and arms gate U16 in anticipation of a STORE command. When the STORE command occurs, flip-flops A and B are set, and they remain set until the command is terminated. The Q outputs of flip-flops A and B are ANDed through U17 which, in turn, forms the D input to flip-flop C and generates the leading edge of the load strobe to the data storage register. Flip-flop C, with its D input at a logic zero, is reset on the clock pulse and therefore generates the trailing edge of the load strobe.

When the LOAD command terminates, the sequential machine returns to the quiescent state where it waits for the next command. When the READ signal is received, flip-flops A and B are prevented from changing state; therefore, a load strobe cannot be generated.

Single/Continuous Control Circuit

The single/continuous control circuit determines whether data is loaded continuously or only once between reads by the system controller. The single/continuous logic consists of flip-flop U25 and several gates in U14 and U23. If the board is in the continuous mode, the flip-flop is held in the reset state and does not affect the board operation.

If, however, the single mode has been selected, the flip-flop is set upon receipt of the first load command from an external device. When the flip-flop is set, the signal HANDSHAKE ENABLE becomes false, and the three handshake circuits are held in the reset state until the latched data is read. Following the read, the flip-flop is reset and the process may repeat.

PARALLEL INPUT AND OUTPUT INTERFACE

A temporary data storage register comprised of three 8-bit latches (U6, U29, and U40) is the focal point for all parallel data transfer between the Digital I/O Assembly and external devices. Since parallel data transfer operations are different for each of the operating modes (status input, status output, and digital input), the interface circuit will be discussed in terms of the operating mode selected.

Because the Digital I/O Assembly may be user-configured to perform three different functions, the microcomputer must determine which function has been selected.

Upon power-up, or when the system controller requests configuration, microcomputer port 2, bit 6, goes to logic 0 which gates the three most significant bits of the parallel input word onto the internal data bus. A READ strobe is then issued to accept the data, and port 2, bit 6, returns to the logic 1 state.

If the Digital I/O Assembly is used for status input (with a -179 Digital/Status Input connector), it must fetch the user input data when commanded. The first step is to gate the external data, buffered through U41, U42, U43, and U44, to the inputs of the set of latches, U6, U29, and U40. Gating is accomplished by placing port 2, bit 6, in the logic 0 state to place the input data on the inputs of the three latches. Next, port 2, bit 7, is pulsed from high to low and back to high to strobe the data into the latches. Port 2, bits 0 through 2, are then sequentially placed in the logic 0 state and returned to the logic 1 state. At the same time, a READ strobe is issued and the data is brought into the processor through buffers U36, U37, U38, and U39.

If the Digital I/O Assembly is used for status output (with a -179 Status Output Connector), operation is directly analogous to the status input configuration. In the status output configuration, port 2, bits 6 and 7, are placed in the logic 1 state and port 2, bits 0 through 2, are sequentially placed in the logic 0 state, then returned to the logic 1 state. While each port bit is in the logic 0 state, a WRITE strobe is issued to clock the output data from the processor into the appropriate latch through buffers U30, U31, U32, and U33.

The digital input configuration operates exactly like the status input configuration except that there is no need to store the data in the on-board latches since it has already been stored there through the action of the handshake sequence.

Outputs from the Digital I/O assembly are buffered to the external circuitry though buffers U46, U47, and U48. Data inputs to the assembly are buffered through U41, U42, U43, and U44.

GENERAL MAINTENANCE

The Digital I/O Assembly normally requires no cleaning unless dirt, dust, or other contamination is visible on its surface.

If cleaning is necessary, follow the cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT ARE DANGEROUS AND CAN BE FATAL. ONLY QUALIFIED PRESONNEL SHOULD ATTEMPT TO SERVICE THIS EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING THE FOLLOWING PROCEDURES.

Two performance tests are necessary to verify the Digital I/O Assembly's output and input capability, one for each of the two possible input connectors that may be used with the Assembly. Although both tests (with both connectors) are necessary to fully test the Digital I/O Assembly under all conditions, either test may be performed independently for a partial performance evaluation.

To perform these tests, it is necessary to gain access to the terminals of the connector being used. There are two ways of doing this:

Alternative 1.

Install a Calibration/Extender Fixture (Fluke P/N 648741) in one of the Front End option slots and install the Digital I/O Assembly and the connector on the fixture. Be sure the switch on the fixture is set to the EXTEND position.

Using this method, the connector's terminals are accessible at all times.

Alternative 2.

If a Calibration/Extender Fixture is not available, remove all other options from the Front End and install the Digital I/O Assembly in the bottom slot. Remove the connector's cover and install the connector on the Digital I/O Assembly.

In this configuration, the terminals can be reached without using an extender.

Output Test

The Output Test verifies operation of the Digital I/O Assembly's output capability. This test requires use of the -169 Status Output Connector.

To conduct the Output Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Install a Calibration/Extender Fixture in the uppermost option slot of the Front End. Set the fixture switch to the EXTEND position.

3. Set the Digital I/O channel decade switches to 00, then install the Digital I/O Assembly on the Calibration/Extender Fixture.

4. Install the -169 Status Output Connector on the Digital I/O Assembly.

5. Reconnect the ac line cord to the Front End and switch the power ON.

6. Testing the output drive capability of each channel requires an external voltage source, a current limiting/pull-up resistor, and a DMM, interconnected as shown in Figure 168-6 and described below:

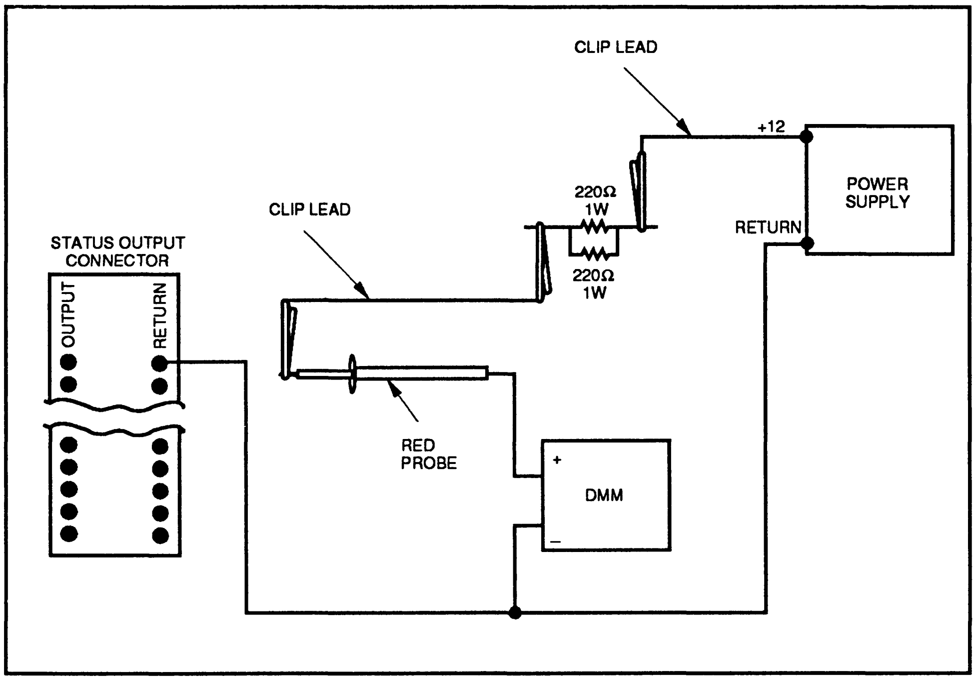


Figure 168-6. Interconnecting Output Test Equipment

A. Using clip leads, connect a +12V lab type power supply to one side of two 220 ohm, 1W carbon resistors wired in parallel.

B. Connect the power supply RETURN (-) terminal to the RETURN terminal of the -169 Status Output Connector.

C. Using clip leads, connect the other side of the resistor to the probe of the DMM's volt/ohm input (red) test lead.

D. Connect the DMM's common lead (black) to RETURN on the Status Output connector.

E. Set the DMM to measure a full scale voltage of +12V, turn the power supply ON, and ensure that the DMM reads approximately 12V.

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0..19)=STATOUT <CR>

CHAN(0..19)=0 <CR>
```

A1. Use the red probe of the DMM to touch the OUTPUT terminal of channel 0 on the Status Output Connector.

The DMM should continue to read +12V, indicating that the status output for channel 0 HAS NOT been turned ON.

A2. Repeat step A1 for each of the remaining OUTPUT terminals on the Status Output Connector (channels 1 through 19).

A3. Send the following commands to the Front End:

```
CHAN(0..19)=1 <CR>
```

A4. Use the red probe of the DMM to touch the OUTPUT terminal of channel 0 on the Status Output Connector.

The DMM should read 1V or less, indicating that the status output for that channel HAS been turned ON, and that it is able to sink a minimum of 100 mA.

A5. Repeat step A4 for each of the remaining OUTPUT terminals on the Status Output Connector (channels 1 through 19).

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs will cause the Front End to perform the required tests on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for an IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port and empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 200
90  PRINT #1,"def chan(0..19)=statout"
100 GOSUB 200
120 PRINT #1,"chan(0..19)=0"
130 GOSUB 200
140 END
200 REM wait for message accepted prompt
210 INPUT #1,A$
220 IF A$<>"!" THEN GOTO 210
230 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:" AS NEW FILE 1%
50  OPEN "KB1:" AS OLD FILE 2%
60  PRINT #1,CHR$(3);
70  REM set up Computer Front End
80  PRINT #1,"mode=comp"
90  GOSUB 200
100 PRINT #1,"def chan(0..19)=statout"
110 GOSUB 200
120 PRINT #1,"chan(0..19)=0"
130 GOSUB 200
140 END
200 REM wait for message accepted prompt
210 INPUT #2,A$
220 IF A$<>"!" THEN GOTO 210
230 RETURN
```

B1. Use the red probe of the DMM to touch the OUTPUT terminal of channel 0 on the Status Output Connector.

The DMM should continue to read +12V, indicating that the status output for channel 0 HAS NOT been turned ON.

B2. Repeat step B1 for each of the remaining OUTPUT terminals on the Status Output Connector (channels 1 through 19).

B3. Change line 120 in the above program to:

```
PRINT #1,"chan(0..19)=1"
```

Run the modified program.

B4. Use the red probe of the DMM to touch the OUTPUT terminal of channel 0 on the Status Output Connector.

The DMM should read 1V or less, indicating that the status output for that channel HAS been turned ON, and that it is able to sink a minimum of 100 mA.

B5. Repeat step B4 for each of the remaining OUTPUT terminals on the Status Output Connector (channels 1 through 19).

8. This completes the Output Test for the Digital I/O Assembly.

Input Test

The Input Test verifies operation of the Digital I/O Assembly's input capability. This test requires use of the -179 Digital/Status Input Connector.

To conduct the Input Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Install a Calibration/Extender Fixture in the uppermost option slot of the Front End. Set the fixture switch to the EXTEND position.

3. Set the Digital I/O channel decade switches to 00, then install the Digital I/O Assembly on the Calibration/Extender Fixture.

4. Using a small jumper wire, short SIGNAL to RETURN on terminal 21 of the Digital/Status Input Connector.

   Remove all other connections. Install the input connector on the Digital I/O Assembly.

5. Reconnect ac line power to the Front End and switch the power ON.

6. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

MODE=TERM <CR>

DEF CHAN(0..19)=STATIN <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0..19) <CR>

A1. Verify status input responses.

Because all status channel inputs (0..19) are open, the measurement should be returned as a 1 (1.00000E+00).

A2. Short the SIGNAL to RETURN terminals for channel inputs 0 through 19.

A3. To take new readings, send the Front End the following command:

SEND CHAN(0..19) <CR>

A4. The returned readings for all 20 channels should be 0 (0.00000E+00).

PROCEDURE B. COMPUTER MODE:

The following sample BASIC programs will cause the Front End to take a status reading on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

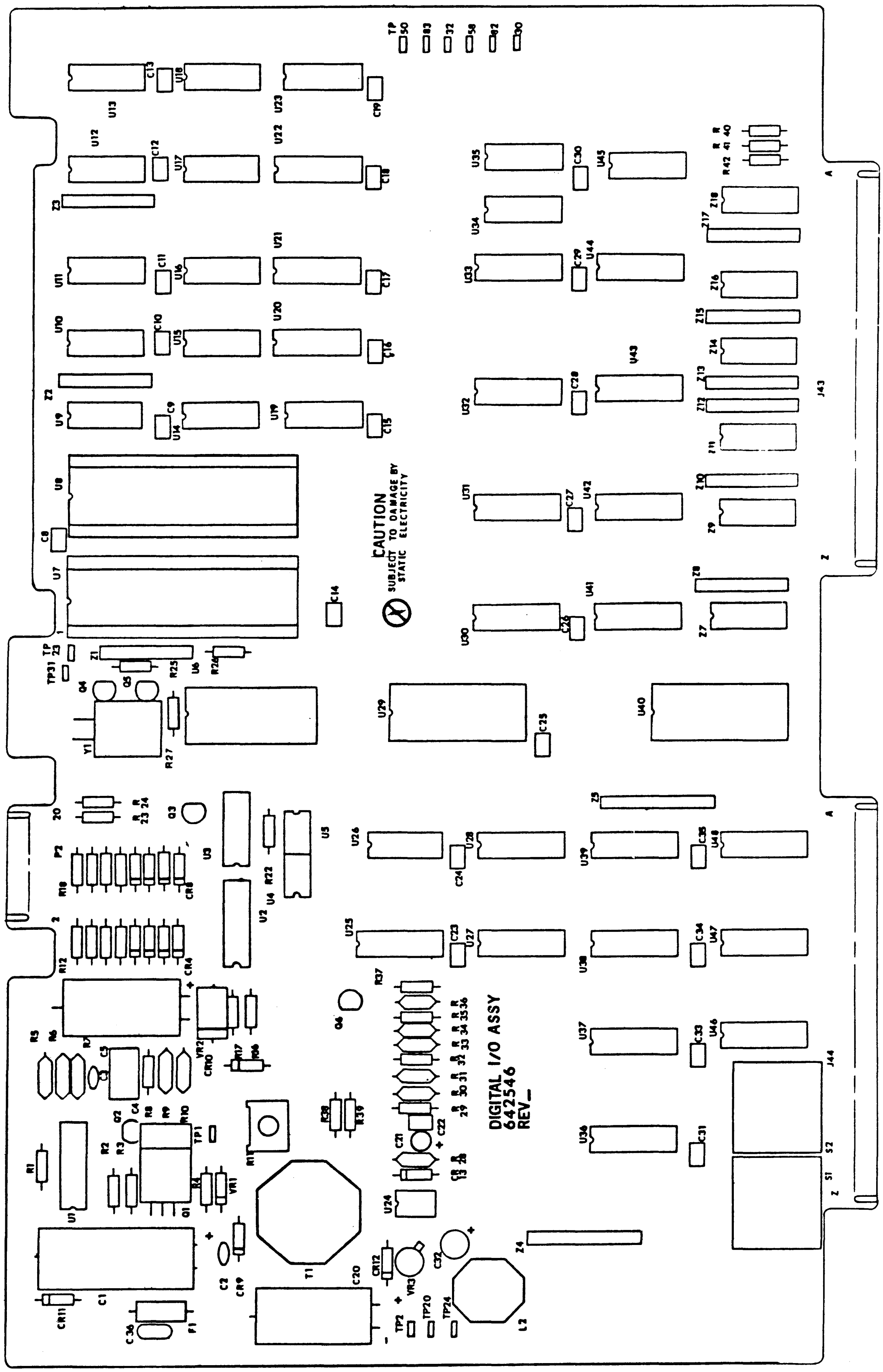
Program for an IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port and empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
```

```
80  GOSUB 300
90  PRINT #1,"count=off"
100 GOSUB 300
120 PRINT #1,"def chan(0..19)=statin"
130 GOSUB 300
140 PRINT #1,"format=decimal"
150 GOSUB 300
160 REM make measurement and read in response
170 PRINT #1,"send chan(0..19)"
180 FOR I=0 TO 19
190 INPUT #1,M$
200 PRINT "chan";I;"=";
210 PRINT M$
220 NEXT I
230 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:" AS NEW FILE 1%
50  OPEN "KB1:" AS OLD FILE 2%
60  PRINT #1,CHR$(3);
70  REM set up Front End
80  PRINT #1,"mode=comp"
90  GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1,"def chan(0..19)=statin"
130 GOSUB 300
140 PRINT #1,"format=decimal"
150 GOSUB 300
160 REM make measurement and read in response
170 DIM M$(20)
180 PRINT #1,"send chan(0..19)"
190 FOR I%=0 TO 19\INPUT #2,M$(I%)\NEXT I%
200 X%=0\I%=0
210 FOR C%=0 TO 1
220 PRINT TAB (35*C%);"chan";I%;"=";
230 PRINT M$(X%);
240 X%=X%+1\I%=I%+1\IF X%>19 THEN 270
250 NEXT C%
260 GOTO 210
270 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```


CAUTION
SUBJECT TO DAMAGE BY STATIC ELECTRICITY
DIGITAL I/O ASSY
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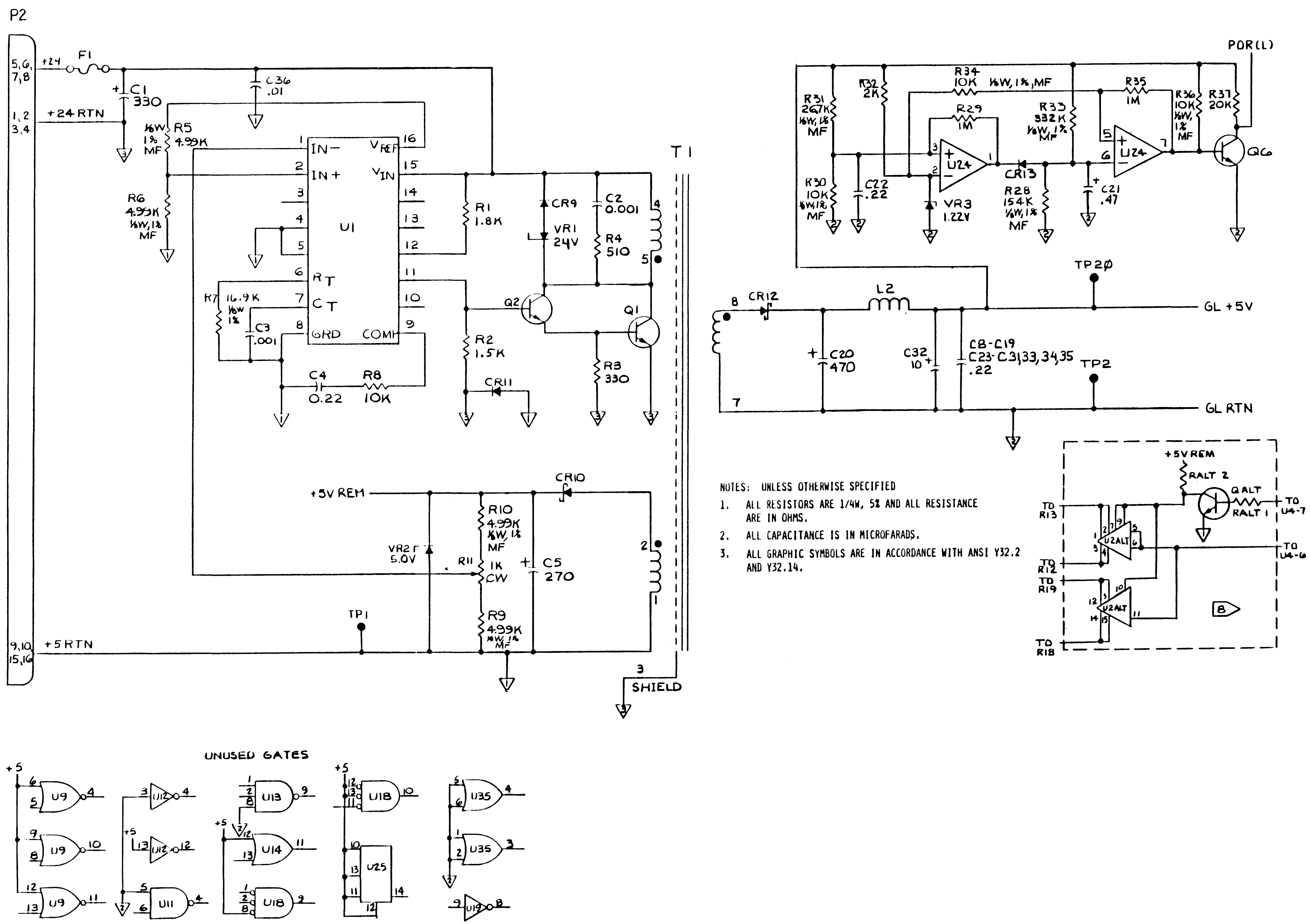

PWR & GND				
I.C.	GL +5V	▽1	▽2	+5V REM
U1		8,4,5		
U2		8,4,5		1
U3		1,3,7,		14,4,10
U4		5		8
U5	8		5	
U6	24		3,12,15	
U7	26,40		20,7	
U8	37,38,34,1		⟨6⟩	
U9	14,6,9,12		7	
U10	14		7,4	
U11	14		7,5	
U12	13,14		3,7	
U13	14		7,8	
U14	12,14		7	
U15	14		7	
U16	14		7	
U17	14		7	
U18	12,13,14,6		7	
U19	9,14		7	
U20	16		7,8,9	
U21	16		7,8,9	
U22	16		8	
U23	14		7	
U24	8		4	
U25	10,11,12,13,16		7,8	
U26	14		7	
U27	16		8,10	
U28	10,12,16		8,2	
U29	24		3,12,15	
U30	16		2,4,6,8	
U31	16		8	
U32	16		8	
U33	16		8	
U34	14		7	
U35	14		1,4,5,6,7	
U36	6,16		8	
U37	16		8	
U38	16		8	
U39	16		8	
U40	24		3,12,15	
U41	16		8	
U42	16		8	
U43	16		8	
U44	16		8	
U45	14		7	
U46			1,8	
U47			8	
U48			8	
U49	16			

3

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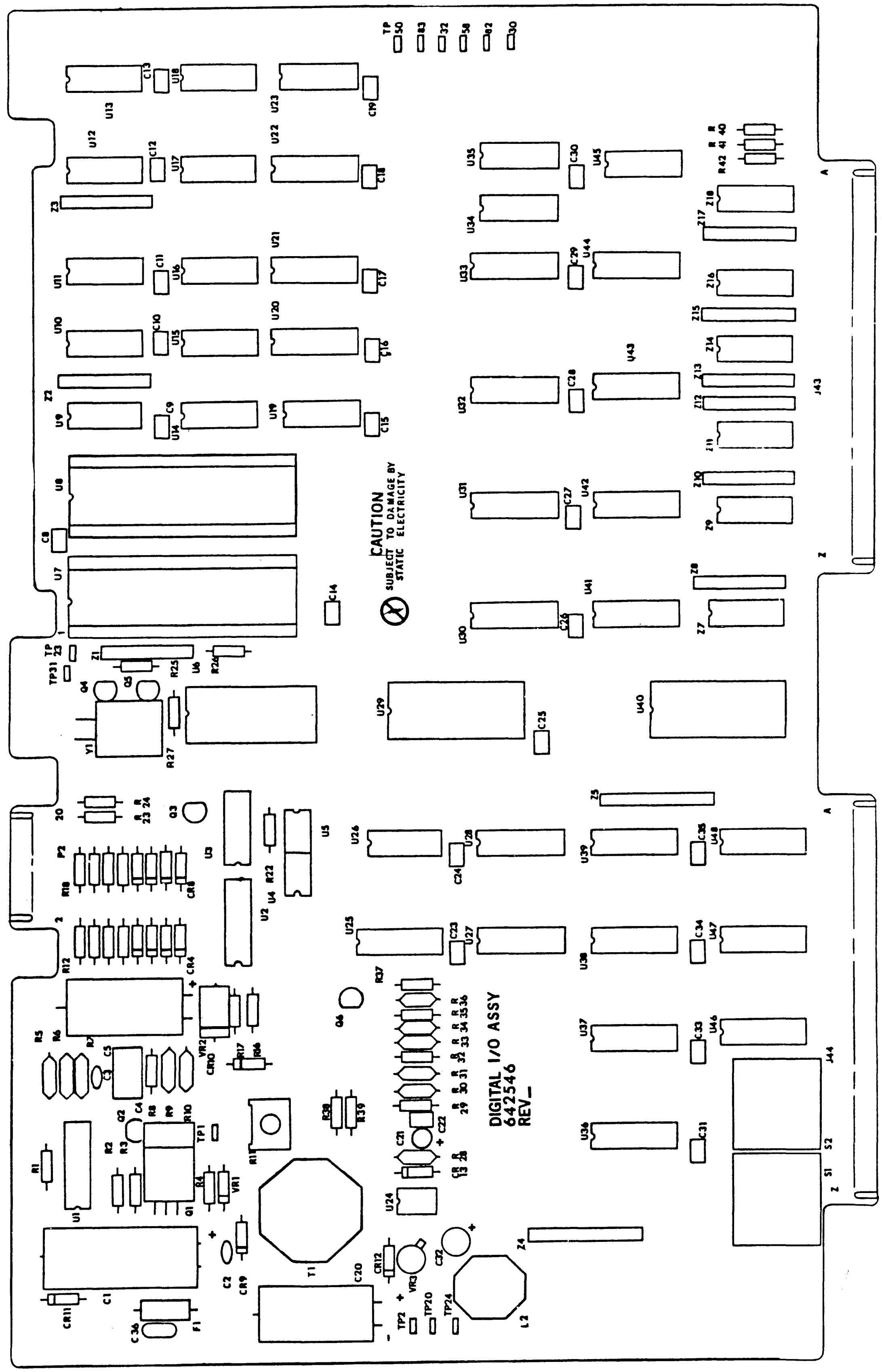
Figure 168-6. Digital I/O Assembly Schematic Diagram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STATIC ELECTRICITY
DIGITAL I/O ASSY
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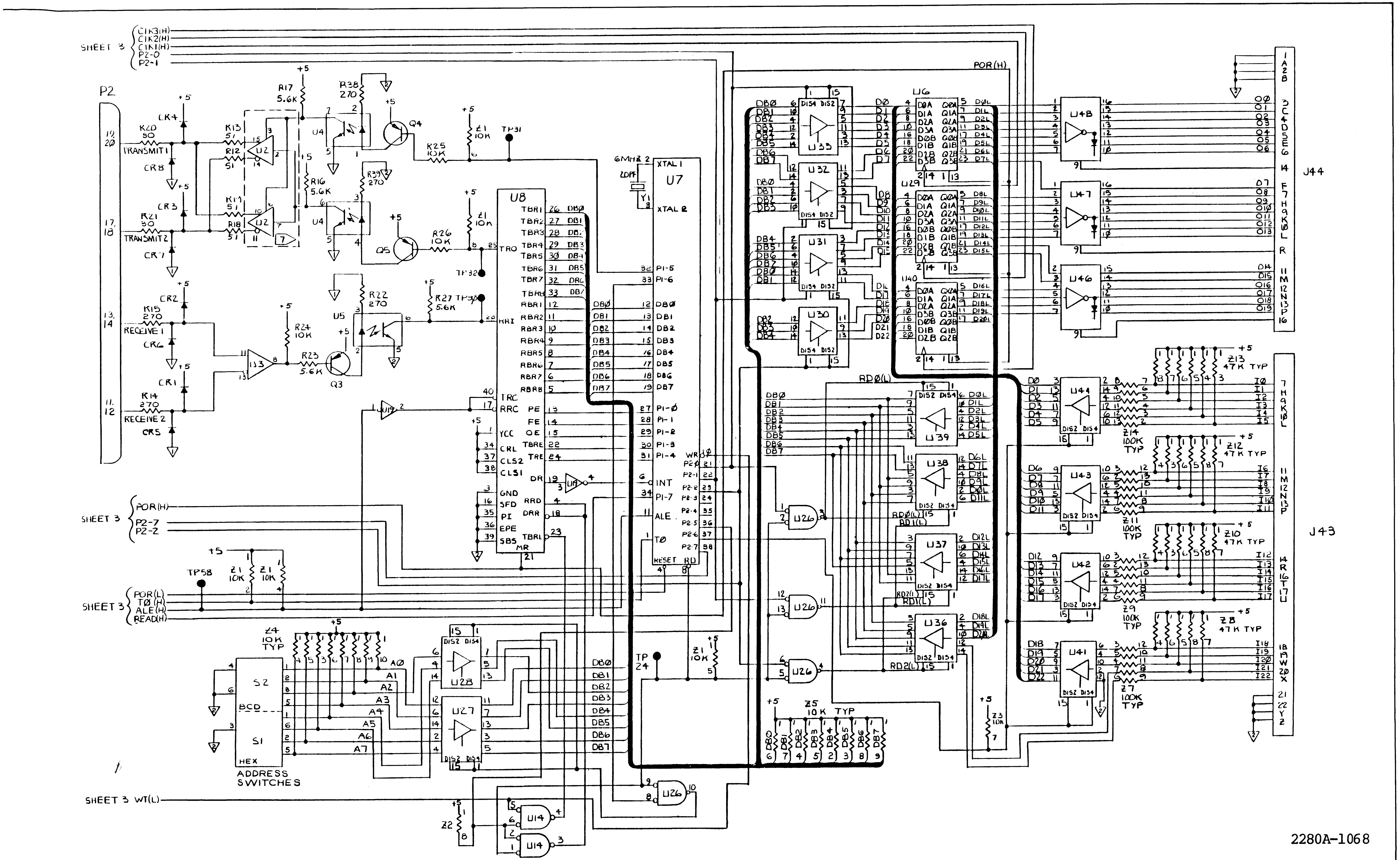
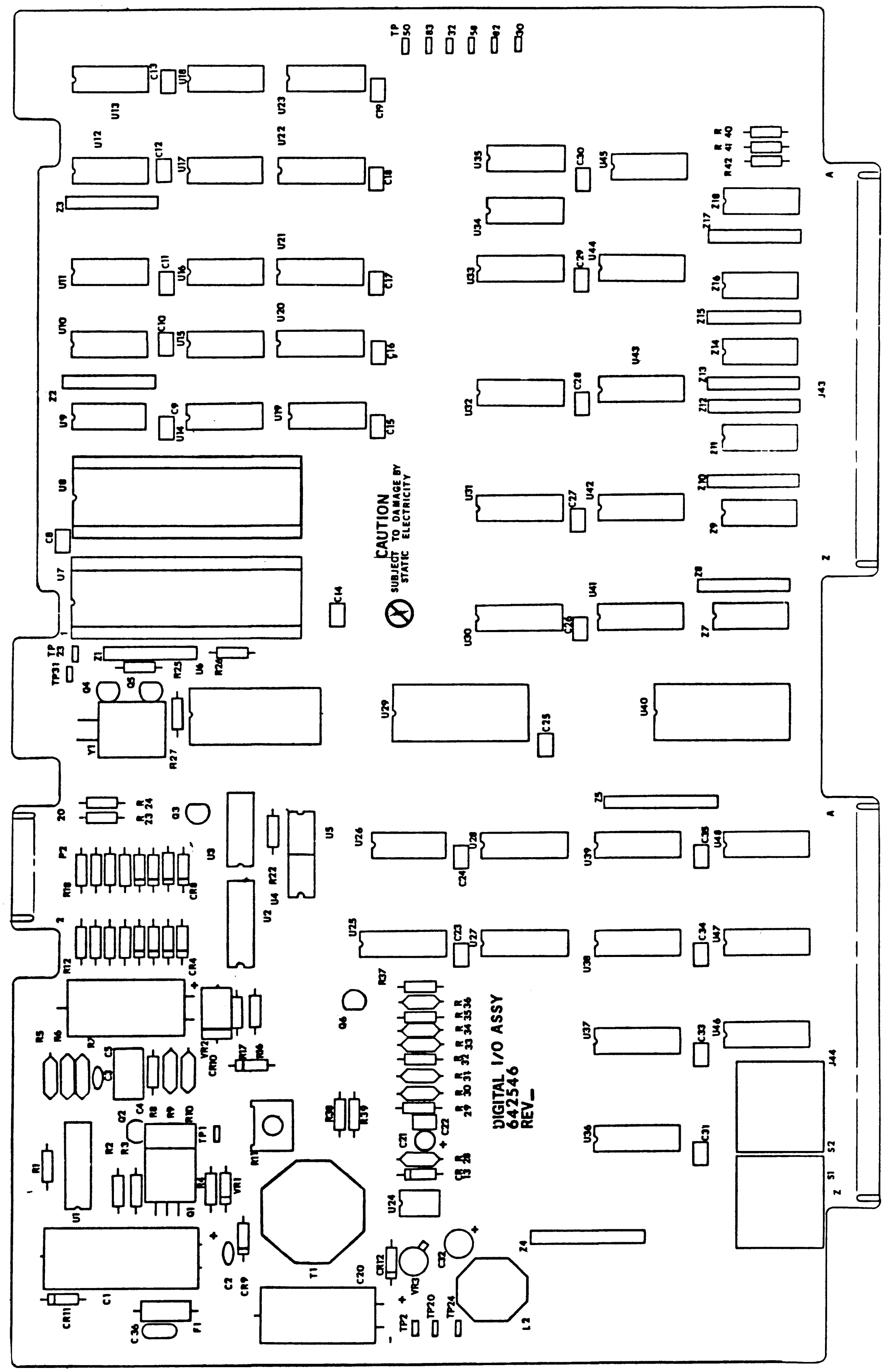


Figure 168-6. Digital I/O Assembly Schematic Diagram (cont.)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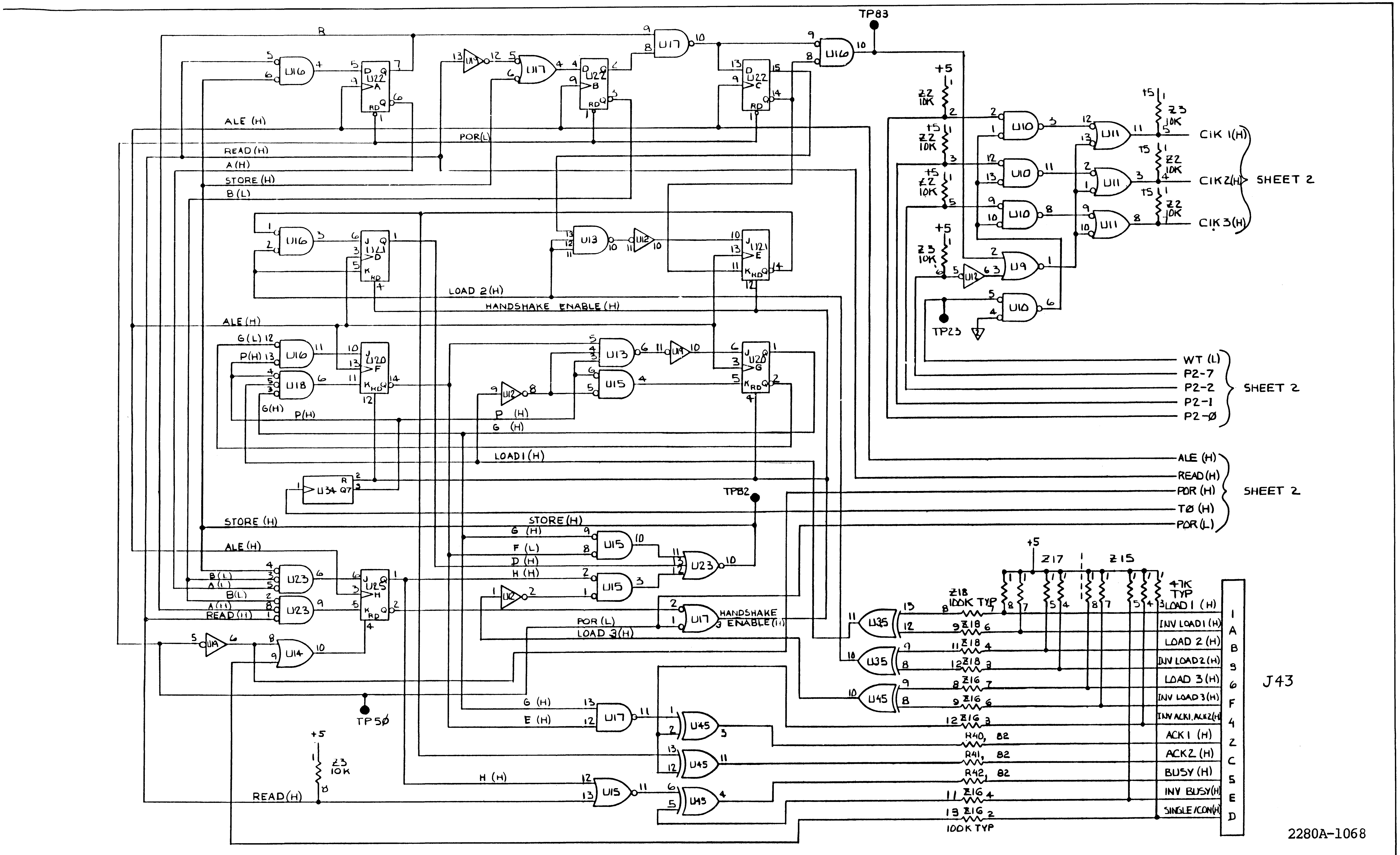


Figure 168-6. Digital I/O Assembly Schematic Diagram (cont.)

DESCRIPTION

The Status Output Connector (shown in Figure 169-1) connects 20 single-bit output signals from the Digital I/O Assembly (-168) to external points.

Each output channel is individually selectable by the Front End and can be used to drive lamps or relays, or to change logic levels.

The Status Output Connector plugs onto the 44-pin card-edge connector on the left side of the rear edge of the Digital I/O Assembly. The connector assembly is enclosed in a plastic housing that protects the terminals and provides strain relief for the external wiring. Retaining screws on each side of the housing fasten the connector assembly to the rear of the Computer Front End.

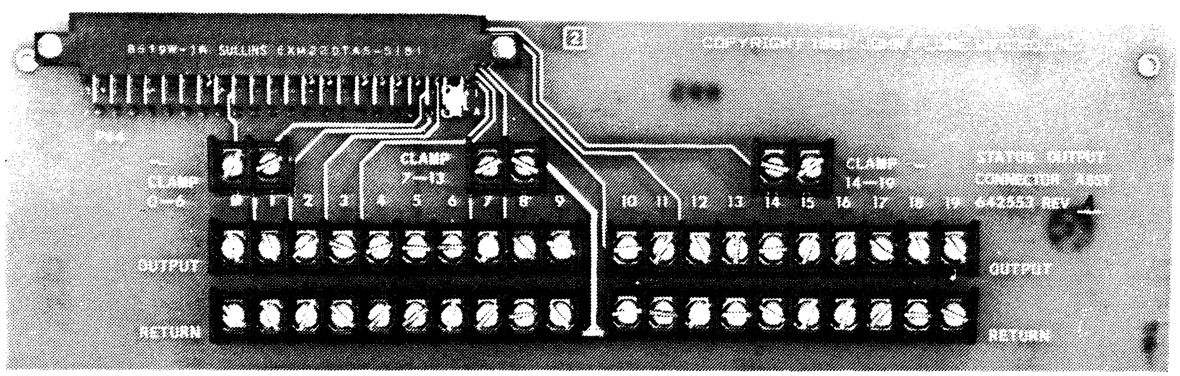


Figure 169-1. Status Output Connector

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Status Output Connector theory of operation, performance test material, a replacement parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are located in the Helios Plus System Manual.

THEORY OF OPERATION

The Status Output Connector theory of operation consists of a short functional description of the Status Output Connector. Refer to the schematic diagram at the end of this subsection for details of the circuit.

Overall Functional Description

The connector provides terminals for connecting wiring to equipment that is to be controlled by Front End status outputs. Output, return, and flyback diode clamp terminals are provided on the connector.

GENERAL MAINTENANCE

The -169 Status Output Connector normally does not require cleaning unless dirt, dust, or other contamination is visible on the surface. If cleaning is necessary, follow the instructions in Section 4 of this manual.

PERFORMANCE TEST

There is no separate performance test for the -169 Status Output Connector.

The connector is tested during output mode performance test of the -168 Digital I/O Assembly performance test. Refer to the -168 Digital I/O Assembly subsection of Section 8.

CALIBRATION

The Status Output Connector does not require calibration adjustment.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Status Output Connector is given in Table 169-1.

For parts ordering information, see Section 6 of this manual.

Figure 169-2 is a schematic diagram of the Status Output Connector.

TABLE 169-1. -169 STATUS OUTPUT CONNECTOR
(SEE FIGURE 169-2.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	NOTE
H 1		STEEL,CAD.PLATED,.125X .500	276493	89536	276493	2	
H 2		WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	2	
MP 1		CONNECTOR HOUSING TOP	578971	89536	578971	1	
MP 2		CONNECTOR HOUSING BOTTOM	656876	89536	656876	1	
MP 3		DECAL, STATUS OUTPUT CONNECTOR	634568	89536	634568	1	
MP 4		DECAL, OPTION -169	634485	89536	634485	1	
MP 5		TAPE, FOAM, PVC, 1/4W 3/8 THK	603134	89536	603134	1	
P 44		CONN,PWB EDGE,REC,90,0.156 CTR,44 POS	614313	89536	614313	1	
TB 1- 4		SINGLE ROW, .325 CENTERS, 10 POSITION	615328	89536	615328	4	
TB 5- 7		SINGLE ROW, .325 CENT., PCB MOUNT,	643858	89536	643858	3	

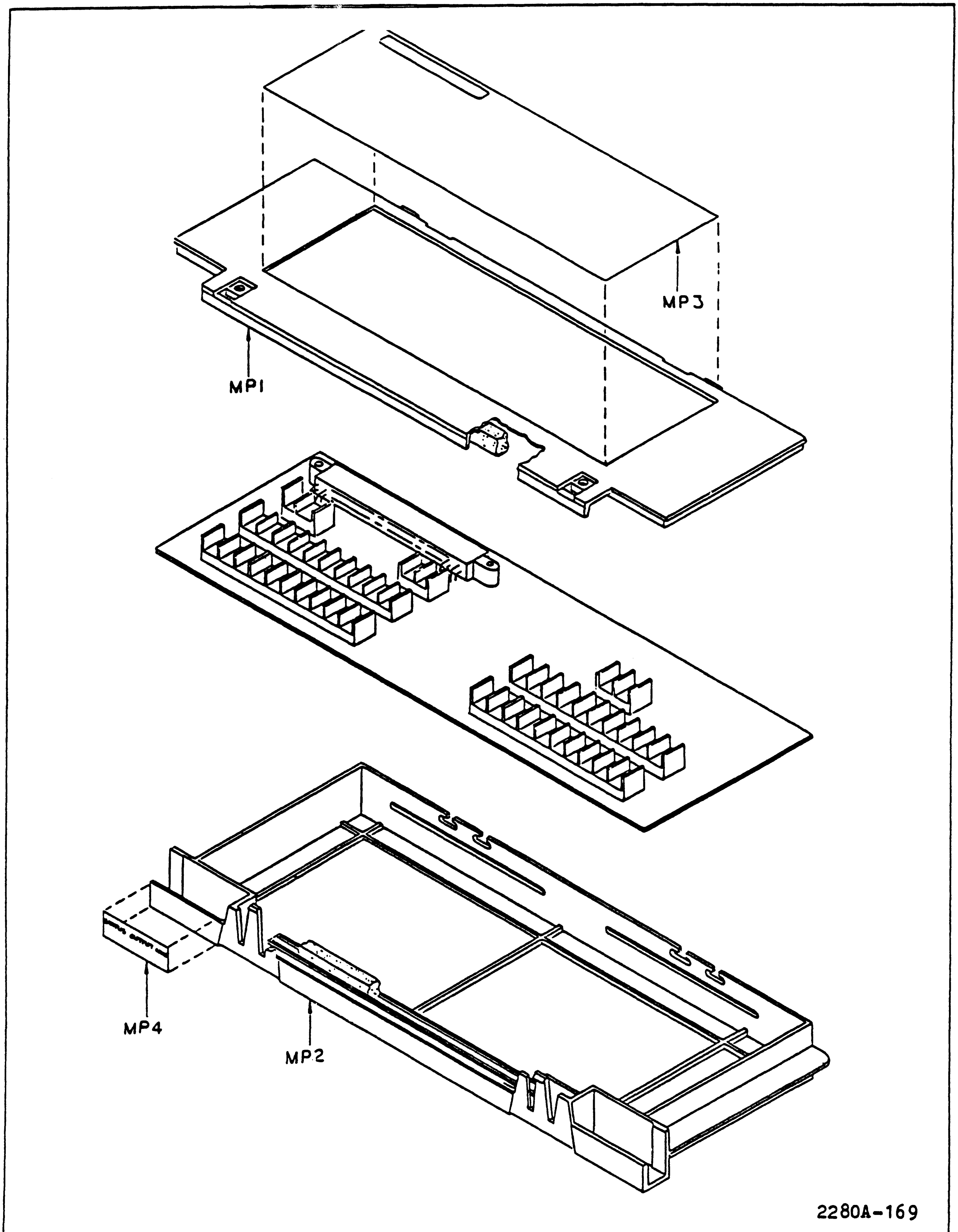
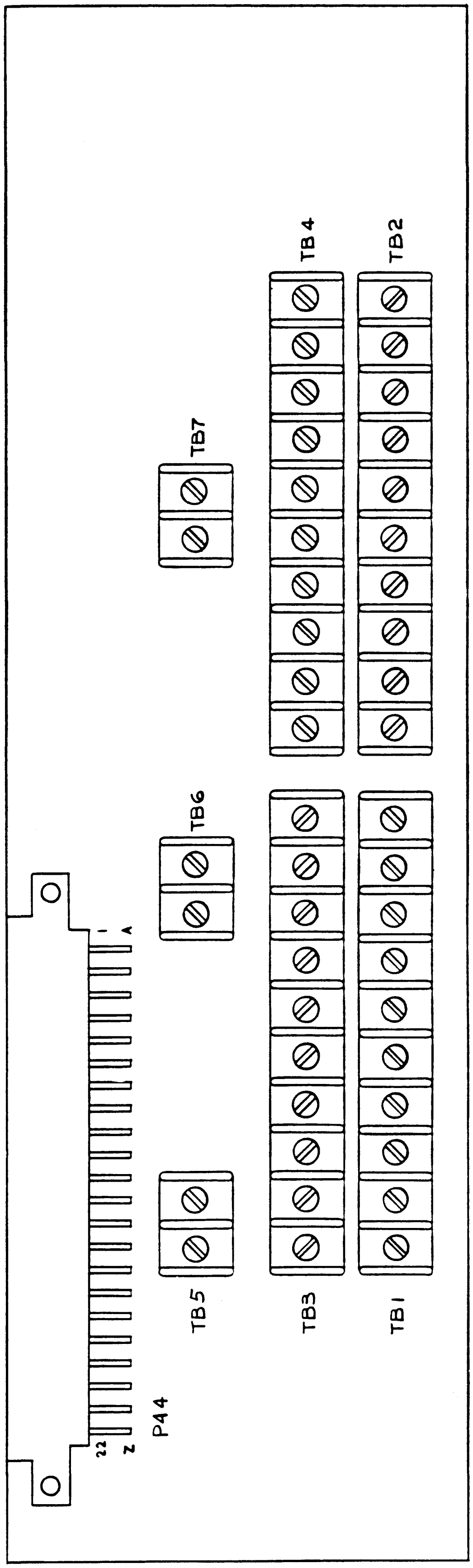


Figure 169-2. -169 Status Output Connector



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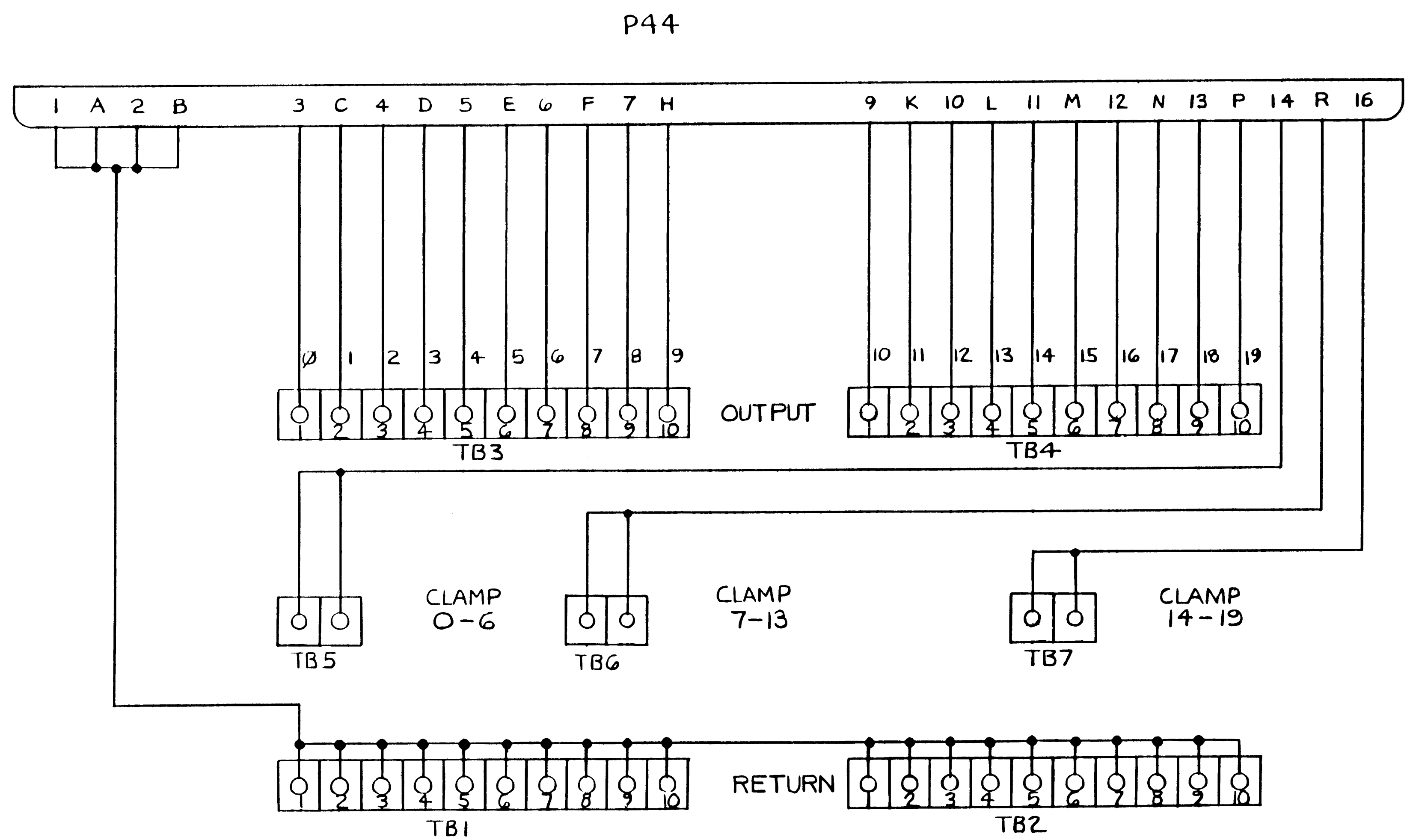


Figure 169-2. Status Output Connector Schematic Diagram

CONTENTS

DESCRIPTION

Analog outputs are available from the mainframe through the -170 Analog Output Assembly, shown in Figure 170-1.

The analog outputs provide voltage and current signals for applications that require an analog input. There are four output channels on each board. All four output channels are electrically isolated from chassis ground, but not from each other. The four outputs share common returns and voltage references. Each channel will supply 0 to +10V, -5 to +5V, and 4 to 20 mA. Only one type of output is allowed per channel at a given time.

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Analog Output theory of operation, performance tests, calibration procedures, a replacement parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are given in the Helios Plus System Manual.

Test equipment required to perform the procedures in this subsection is listed in Table 170-1. A summary of test equipment required to perform all procedures in this manual is given in Table 2-2 in Section 2 of this manual.

THEORY OF OPERATION

The Analog Output theory of operation includes a functional description, a block diagram description, and a detailed circuit description. The schematic diagram for this assembly is given at the end of this subsection.

Functional Description

The analog output consists of four primary sections; a power supply, serial link communication, digital control, and digital to analog conversion

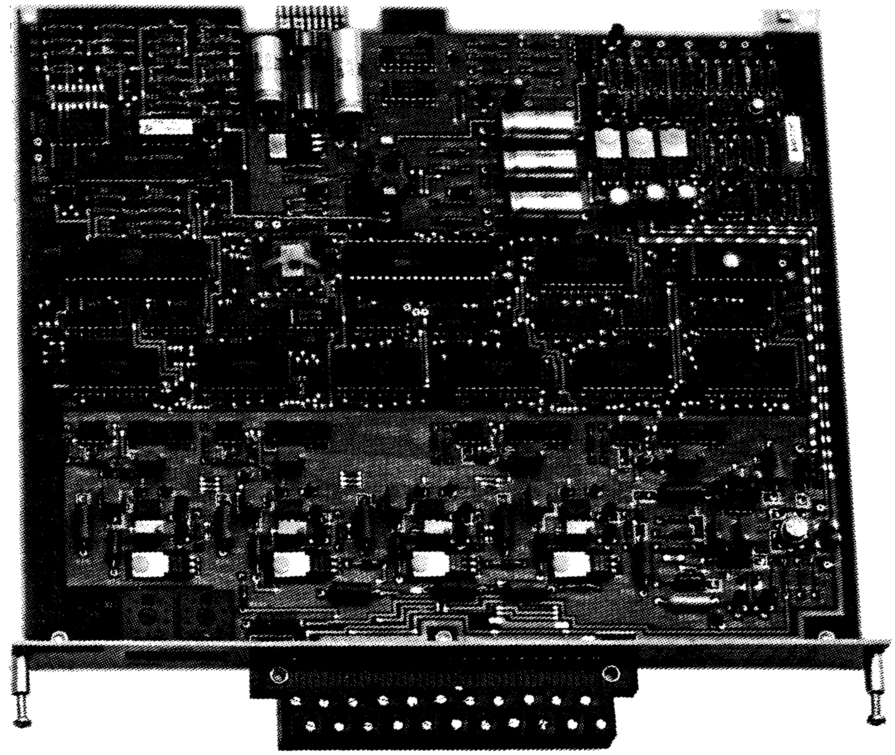


Figure 170-1. Analog Output

Table 170-1. Required Test Equipment for -170

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
Digital Multi-meter (DMM)	+/- 10V +/- 0.0001V	Fluke 8505A
Calibration/ Extender Fixture	NA	Fluke Accessory Part No. 648741 (no subsitute)

circuitry. Figure 170-2 is a block diagram showing the interrelationship between these sections. The communication circuitry is responsible for receiving and transmitting information to the mainframe via the serial link. The digital control circuitry directs the serial link communications and delivers a 12-bit data word received from the mainframe to the selected analog output circuitry. The analog circuitry converts this digital word to its corresponding voltage and current output.

Block Diagram Description

Communication circuitry includes: a serial link driver and receiver, three optical couplers, and a UART.

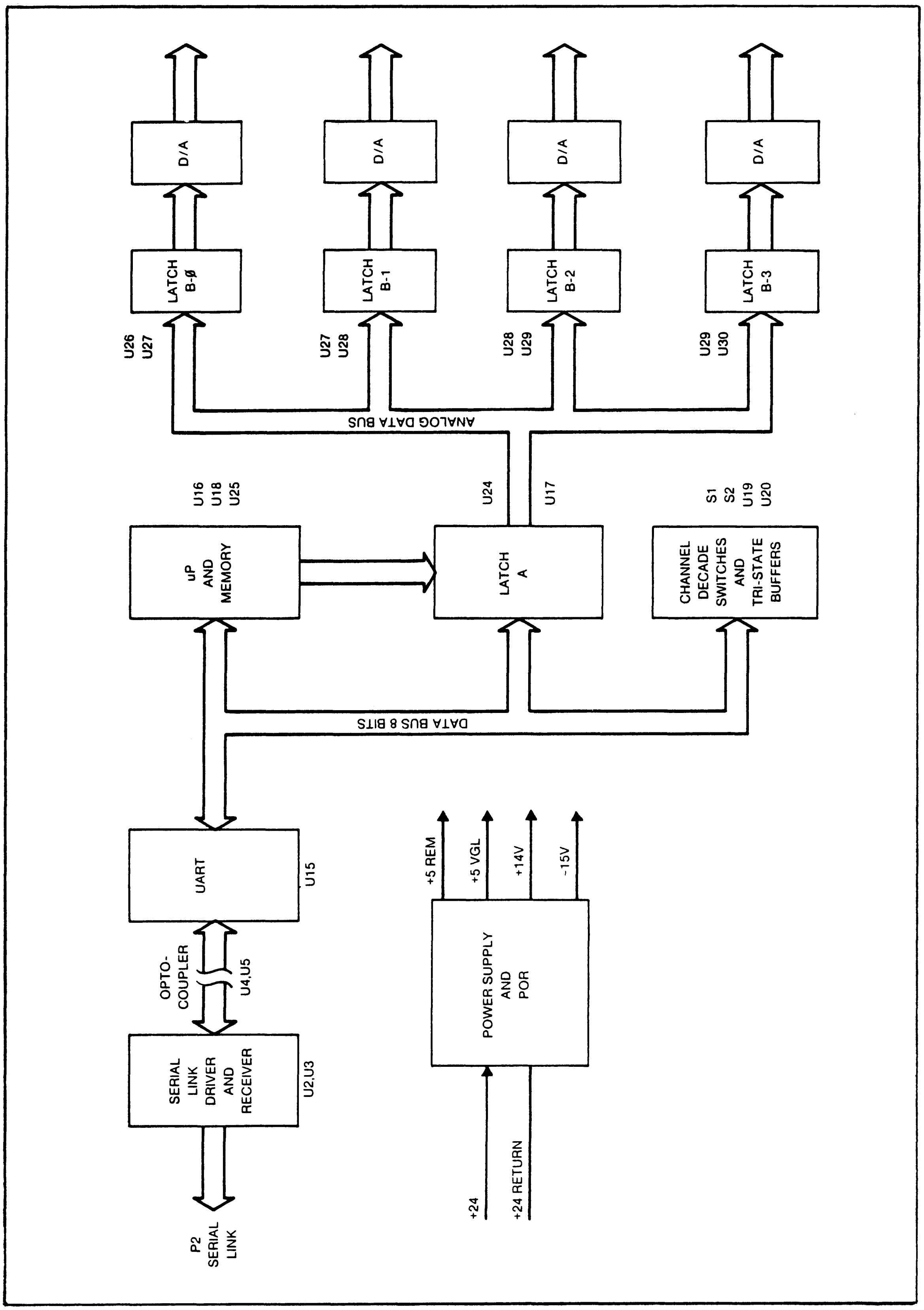


Figure 170-2. Analog Output Block Diagram

A receiver chip receives information from the serial link. The information is then transferred, using optical coupler isolation, to the UART in serial form. The UART converts the serial data to 8-bit data words to be read by the microprocessor. When a data word is ready, the UART interrupts the microprocessor. The microprocessor then reads the data supplied by the UART from the data bus, while checking for errors. To transmit data, the microprocessor loads information from the data bus into the UART and enables the transmit circuitry. When the transmit circuitry is enabled, the data is transferred, through an optical coupler, to the driver and onto the serial link.

Digital control circuitry consists of a microprocessor, decade switches with tri-state buffers, and latches to assemble and hold the 12-bit word for the digital-to-analog converters (DAC). The microprocessor directs the activities of the control circuitry. It oversees the UART communications with the mainframe controller assembly. Addresses received over the serial link are compared with the address selected through the decade switches to determine if the data is intended for this Analog Output assembly. The 12-bit data word for an output is loaded into intermediate latches and then passed to the latch associated with the intended output channel.

The digital-to-analog section consists of a 0 to +10V output, a 5V offset, and a voltage to current converter. The 5V offset, when used with the 0 to +10V output, provides a bipolar output of -5V to +5V. The voltage-to-current converter uses the 0 to +10V output to provide 4 to 20 mA.

Detailed Circuit Description

POWER SUPPLY

The power supply is a flyback converter. It will accept an input of 10 to 25V from the serial link. Voltages supplied by the converter are the 5V REM for remote serial link, 5VGL for the digital circuitry, and +14/-15V for the analog circuitry. The 5VGL, +14V, and -15V supplies have post linear regulators to provide additional regulation.

Inverter Section

A simplified schematic of the power supply is shown in Figure 170-3. Isolation is provided by T1. When the transistor, Q4, is turned on, the rectifying diodes are off, allowing the current in the primary of T1 to ramp up. Q4 is then turned off, causing the energy stored in T1 to be released into the secondaries through the diodes. The voltage on C15 is sampled by U10 and its supporting circuitry. If the voltage is above or below the nominal 5.4V, an error signal is generated. This error signal is relayed through the optical coupler to the control circuitry. The control circuitry varies the ratio of the time Q4 is on to the time Q4 is off to control the output voltage. The ratio of the on time to the off time is called the duty cycle. If the voltage sampled on C15 is lower than 5.4V, the control circuitry increases the duty cycle. If the sampled voltage is greater than 5.4V, the duty cycle is decreased. The voltages on C13, C14, and C15 are further regulated by post-linear regulators.

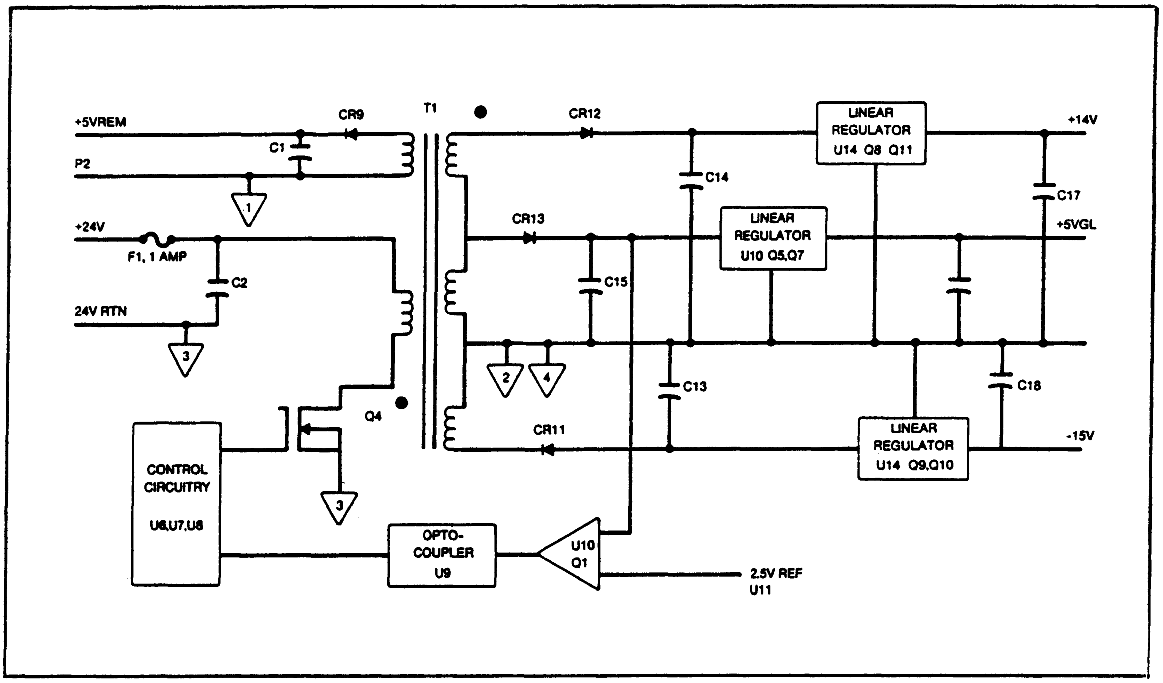


Figure 170-3. Simplified Power Supply Schematic

Control Section

The control section directs the overall activities of the analog output card. It controls the UART in serial link communications, retrieves the card address from the decade switches, and delivers the binary number to the DACs. The major components of the control section are a microprocessor (U16), a ROM (U18) that contains the program for the microprocessor, a crystal (Y1) to drive the microprocessor's clock, and a latch (U25). The address to the ROM consists of eight bits from the latch (U25) and three bits directly from the microprocessor. The latch is gated by the address latch enable (ALE) signal from the microprocessor.

Power-On Reset Circuit

The power-on reset circuit enables the digital circuitry 50 ms or more after power has been established. It also disables the microprocessor immediately if the 5VGL decreases below operating level.

The power-on reset circuit is shown in Figure 170-4. Stage 1 of the power-on reset circuit is the sensing circuit, used to determine if the output voltage is sufficient for operation. During turn-on, the sensing circuit releases the RC circuit in the second stage when the power supply is within tolerance, allowing the RC to charge slowly. If the voltage across the RC circuit is sufficient, it trips the comparator in stage 2. When the comparator trips, the POR(L) signal goes high. If on the other hand, the voltage dips, the output of the comparator in stage 1 goes low, pulling the voltage across the RC circuit low very quickly. Low voltage across the RC circuit causes the comparator to set the POR(L) reset signal low.

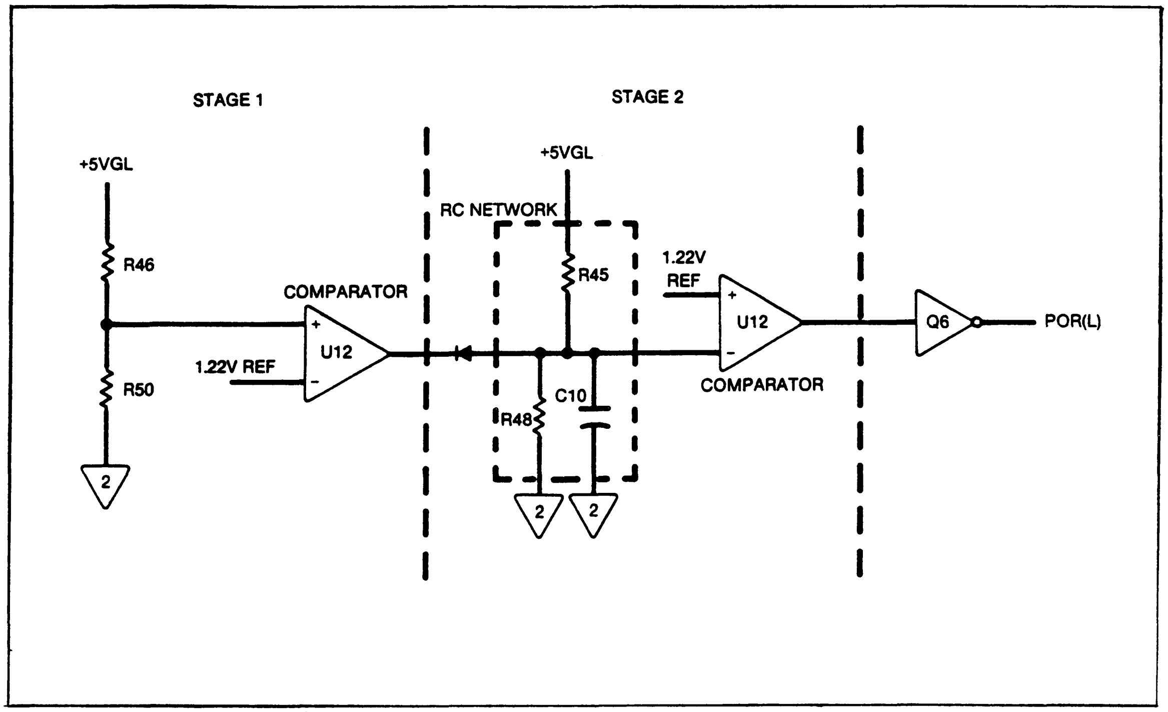


Figure 170-4. Power-On-Reset Simplified Schematic

Communication Circuitry

The communication circuitry is shown in Figure 170-5. Information is received from the serial link by U3, the serial link receiver, and transmitted onto the serial link by U2, the serial link driver. When a data word is received by the UART the DR (data ready) is set, interrupting the microprocessor. The microprocessor reads the UART by enabling the RD signal with port 1, bit 1. By checking port 1, bit 0, the microprocessor checks for three different kinds of errors: overrun error, frame error, and parity errors.

To transmit, the serial link driver is enabled by port 1, bit 3. The microprocessor loads a data word to be transmitted over the serial link by enabling the WR (write) signal to the TBRL (transmit buffer register load). The UART then serially transmits the 8-bit word just loaded from the data bus. The serial link driver is then disabled to allow other boards to use the serial link.

Decade Switches

The analog output address is determined by the position of the decade switches. The decade switches are located on the left-hand side of the board. The value of the decade switch is enabled onto the data bus by the tri-state buffers U19 and U20. The tri-state buffers are controlled by the RD signal from the microprocessor. The RD signal to the buffers

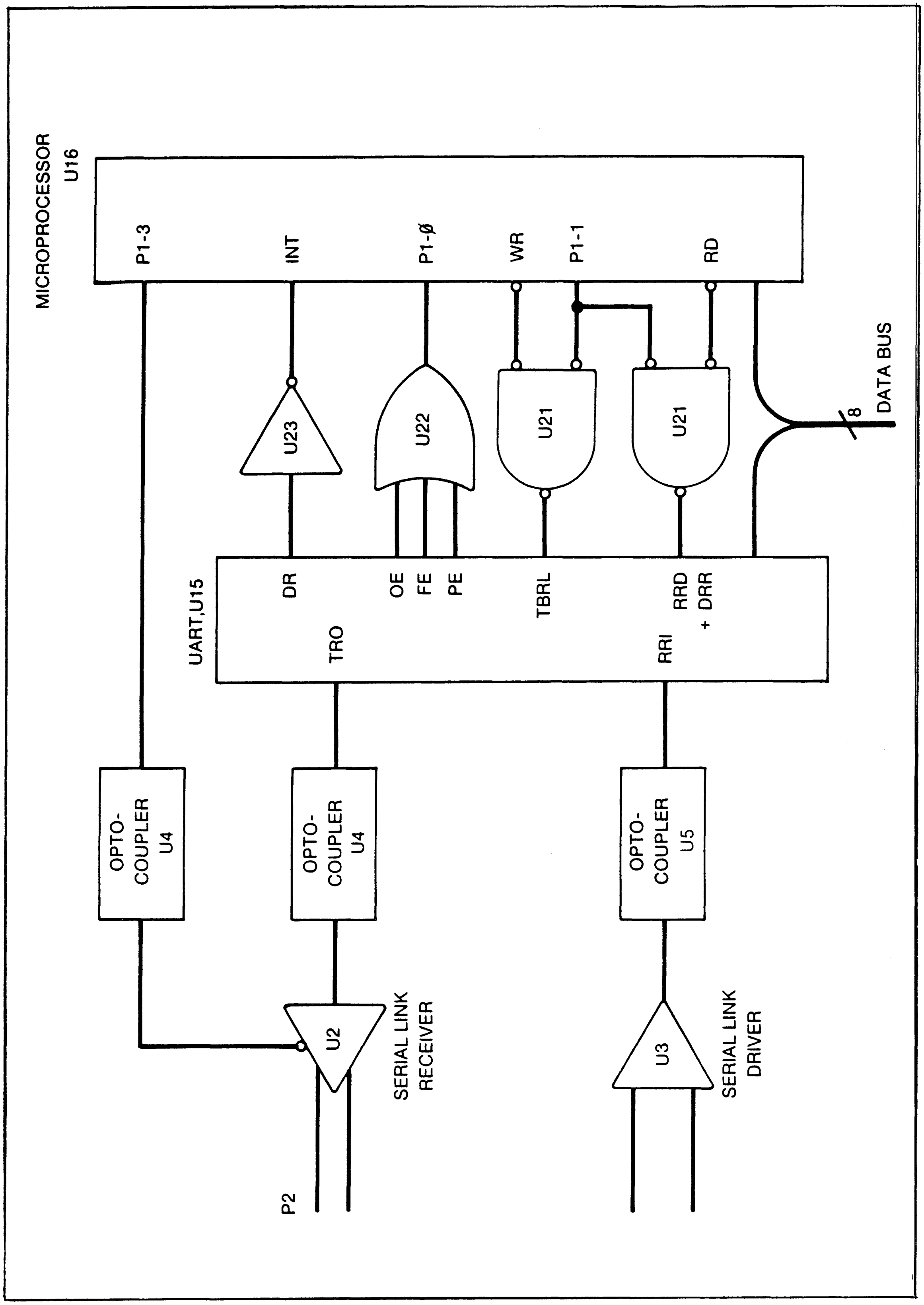


Figure 170-5. Communication Circuitry

is enabled by setting port 1, bit 5, low. Figure 170-6 is a simplified schematic of the interface between the microprocessor and the decade switch. The address read from the decade switch is compared to the address received over the serial link.

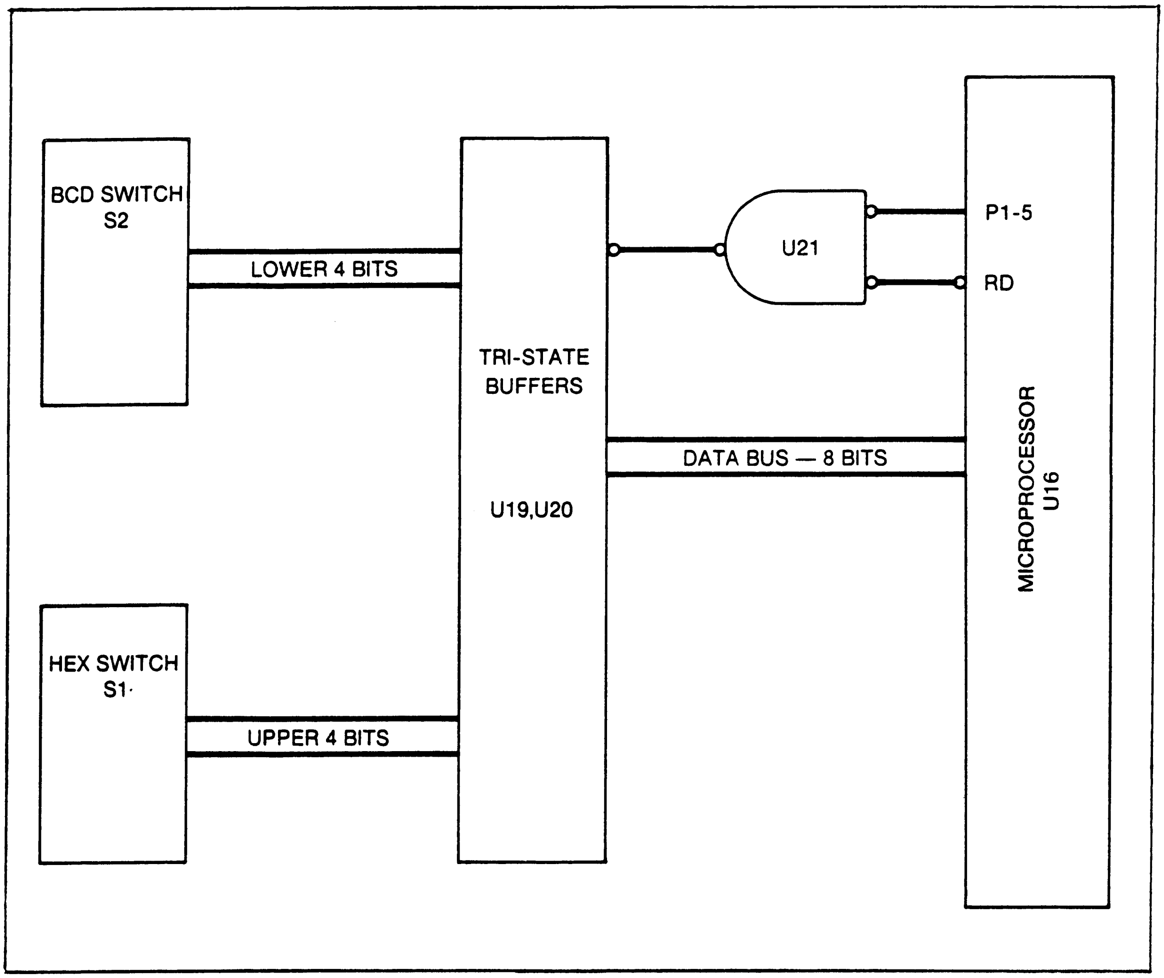


Figure 170-6. Decade Switches To Microprocessor Interface

Note that when checking the address lines for the correct signals, a value of 1 (true) is indicated by a low voltage on the corresponding line.

Latch Control

The digital-to-analog converters (DACs) convert a 12-bit digital word to an analog output. The 12-bit word is built in two steps using latch A, shown in Figure 170-7. First, an 8-bit data word is latched into U17 from the data bus. Then 4 bits are latched into U24 from the lower 4 bits of port 2. This 12-bit word is then presented to the output channel selected by port 2, bits 4 through 7, which clock the 12-bit data word into the appropriate B latch. Table 170-2 lists the port bit that is used for each channel.

Table 170-2. Channel Port Pins

PORT	BIT	PIN	CHANNEL
2	7	38	0
2	6	37	1
2	5	36	2
2	4	35	3

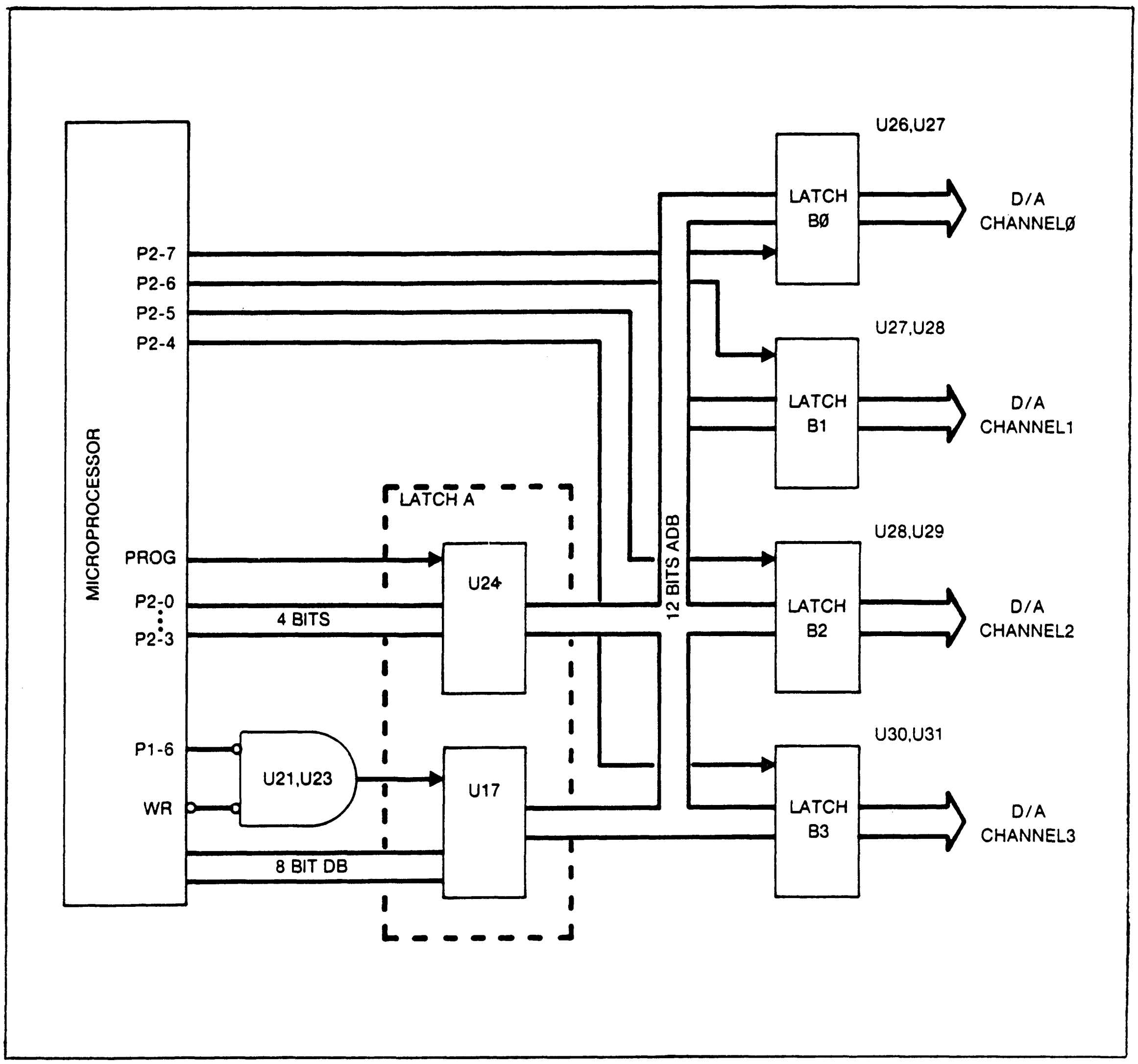


Figure 170-7. Control Circuitry

The output of all four channels is reset to 0% of full scale when port 2, bit 7, is set high. Port 2, bit 7, is high initially when the Analog Output is powered on. This control line is also used to reset the outputs when an initialize or reset command is received from the mainframe.

ANALOG SECTION

The core of the analog section is a voltage reference and DAC with an amplifier. This circuitry is all that is needed for the 0 to 10V output. The bipolar output +5V to -5V is achieved with the addition of a 5V offset. The current source converts the 0 to 10V output and -10V reference to establish the 4- to 20-mA output. The digital-to-analog circuitry is shown in Figure 170-8.

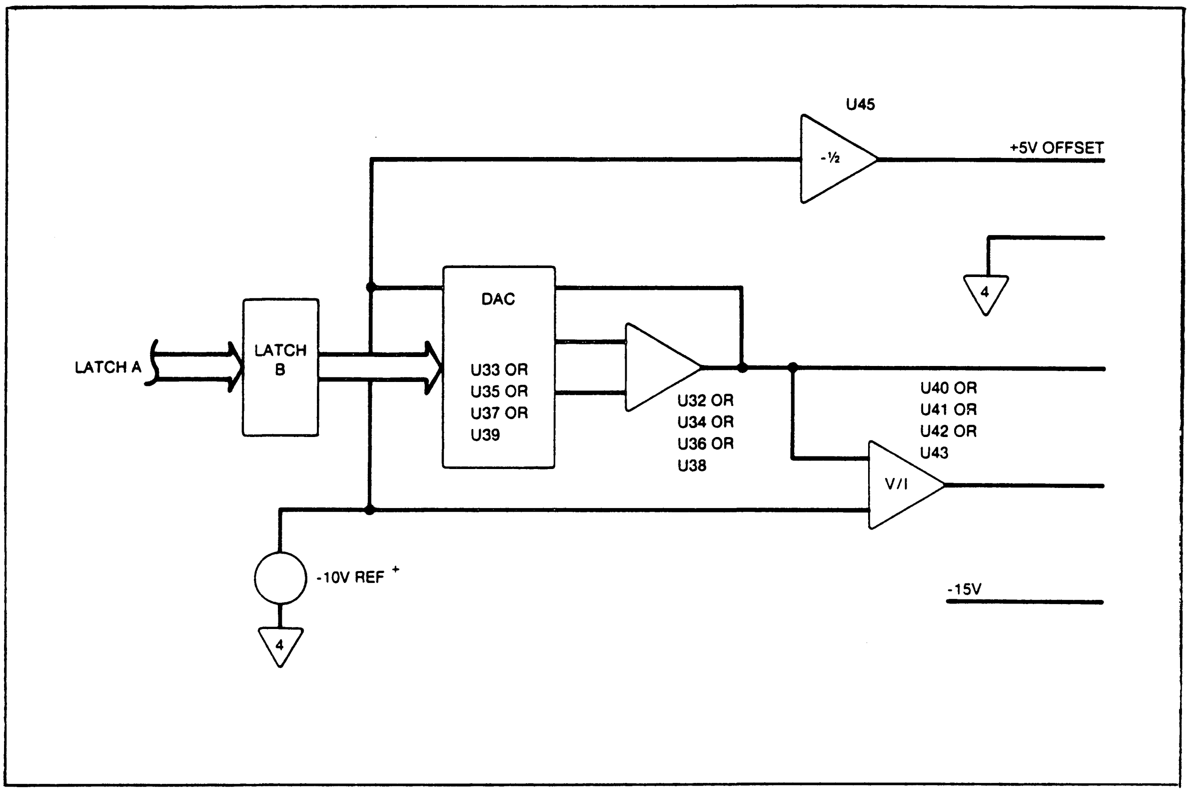


Figure 170-8. Digital-to-Analog Circuitry

-10V Reference

The -10V reference is the main reference for the analog output. The primary components are VR3 and U44. The zener diode is part of a selected set containing VR3, R98, and R106. The resistors are chosen so the voltage on pin 3 of U44 is between -6.2V and -6.45V. This voltage is amplified to -10V by U44, which is configured in a non-inverting mode with a nominal gain of 1.61. Potentiometer R99 adjusts the gain (the -10 volt reference).

5V Offset

The 5V offset is used as the return for the voltage source when the bipolar, -5V to +5V, is desired. The 5V is common to all four channels.

The primary active components are U45, Q27, and Q26. The -10 volt reference is used to drive an inverting amplifier with a gain of -0.5. Q27 and Q26 provide the additional drive necessary to support all four outputs. The potentiometer R100 adjusts the 5V offset.

DAC and Amplifier

The DAC and its amplifier for each channel are shown in Table 170-3. The potentiometer shown adjusts the voltage output of the channel.

Table 170-3. DAC Amplifier Potentiometers

CHANNEL	DAC	AMPLIFIER	POTENTIOMETER
0	U33	U32	R61
1	U35	U34	R64
2	U37	U36	R67
3	U39	U38	R70

Current Source

Figure 170-9 shows the current source. Output current flows through the 100-ohm resistor and the drive transistors to the load. The voltage drop across the 100-ohm sense resistor, and hence, the output current, is set by the output voltage of the operational amplifier. The potential at the inverting node of the amplifier is the result of the 0 to 10V output and the voltage drop across the 100-ohm sense resistor. The amplifier output voltage is set so that the voltage at the non-inverting node is equal to the voltage at the inverting node. This node is offset from ground by the offset circuitry to create the drive for the 4 mA offset.

In normal operation, Q14 (Q17, Q20, Q23) is turned off. The voltage drop is a few millivolts across the 2-kilohm resistor located between the base of the drive transistors and the output of the amplifier. When the load resistance is such that the voltage drop across the load exceeds the compliance range (10V) of the current source, the current flowing from the base of the drive transistors becomes excessive, which causes a voltage drop that approaches one volt. The voltage drop creates enough drive to turn on Q14 (Q17, Q20, Q23), thus connecting the output of the operational amplifier to the inverting node. The voltage output of the amplifier is forced to the offset voltage on the non-inverting node of the amplifier.

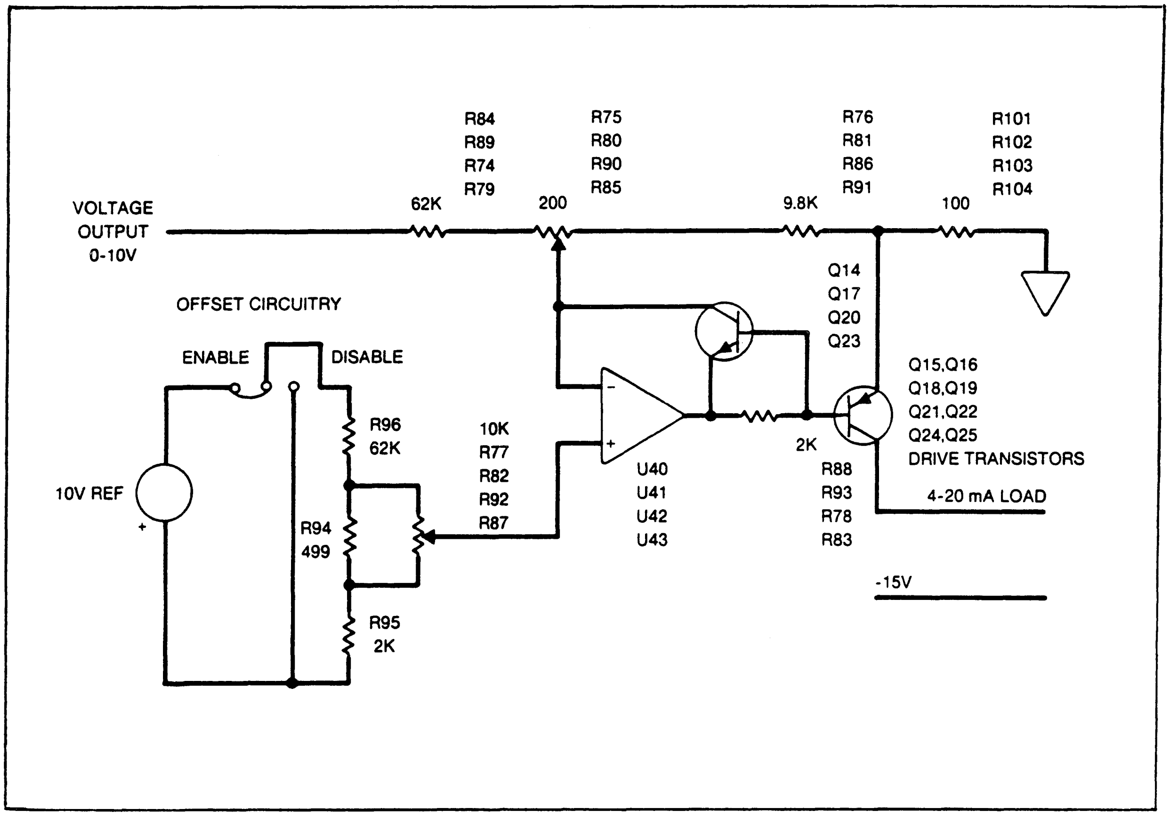


Figure 170-9. The Current Source

GENERAL MAINTENANCE

The -170 Analog Output Assembly normally does not require cleaning unless dirt, dust, or other contamination is visible on the surface of the Analog Output.

If cleaning is necessary, follow the cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

Two performance tests are required to verify that the Analog Output Assembly operates properly and meets its accuracy specifications.

These tests are:

- o Address Response Test
- o Accuracy Verification Test

Address Response Test

The Address Response Test verifies that the mainframe controller assembly can communicate properly with the Analog Output. All address switch signals are tested.

To conduct the Address Response Test, perform the following procedure:

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING THE FOLLOWING PROCEDURE.

1. Switch OFF power to the Front End. Disconnect the ac line cord and all other high voltage inputs.

2. To eliminate addressing conflict, remove all other installed options.

3. Set the channel decade switches of the Analog Output Assembly to 00, and install the assembly in the uppermost option slot of the Front End.

4. Reconnect the ac line cord and switch Front End power ON.

5. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

RESET CHAN(0..3) <CR>

LIST CHAN(0..3) <CR>
```

A channel definition listing in the following form should be returned for each of four channels (0 through 3).

```
aochan(channel number)=unipolv
```

where "(channel number)" indicates the number of the channel definition listed.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs will cause the Front End to perform the required Analog Output tests on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"reset chan(0..3)"
100  GOSUB 300
110  REM obtain hardware configuration
120  PRINT #1,"list chan(0..3)"
130  FOR I=0 TO 4
140  LINE INPUT #1,M$
150  PRINT M$;
160  NEXT I
200  END
300  REM wait for message accepted promt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1%
50   OPEN "KB1:"AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Computer Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"reset chan(0..3)"
110  GOSUB 300
120  REM obtain hardware configuration
130  DIM L$(5)
140  PRINT #1,"list chan(0..3)"
150  FOR I%=0 TO 4\INPUT LINE #2,L$(I%)\NEXT I%
160  X%=0
170  PRINT L$(X%)
```

```
180  X%=1
190  PRINT L$(X%)\X%=X%+1
200  IF X%>4 THEN 220
210  GOTO 190
220  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

A channel definition listing should be returned for each of four channels (0 through 3). The number on the top line indicates the number of channel definitions listed. The returned response should be:

```
4
0,3,0,0,0,0
    .
    .
    .
3,3,0,0,0,0
```

The number "3" in the second field of each channel definition listing confirms that the channel is an analog output channel.

6. Switch OFF power to the Front End. Set the analog output channel decade switches to position 01. Switch power ON.

7. Program the Front End to list its hardware configuration for channels 10 through 13 by substituting channels 10 through 13 for channels 0 through 3 in both the RESET CHAN and LIST CHAN statements of step 5.

8. Repeat steps 6 and 7 for switch settings 02 (channels 20 through 23), 04 (channels 40 through 43), 08 (channels 80 through 83), 10 (channels 100 through 103), 20 (channels 200 through 203), 40 (channels 400 through 403), and 80 (channels 800 through 803).

9. This completes the Address Response Test.

Continue with the Accuracy Verification Test if you are conducting a complete performance test of the -170 Analog Output Assembly.

Accuracy Verification Test

The Accuracy Verification Test ensures that all analog outputs from the assembly are within specifications.

If the -170 Analog Output Assembly fails the Accuracy Verification Test, calibration is normally required. A calibration procedure immediately follows the performance tests in this subsection.

To conduct the Accuracy Verification Test, perform the following procedure:

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING THE FOLLOWING PROCEDURE.

1. Switch OFF power to the Front End. Disconnect the ac line cord and all other high voltage inputs.

2. Set the channel decade switches of the Analog Output Assembly to 00, and install the assembly in the uppermost option slot of the Front End. To avoid addressing conflict, remove all other installed options.

3. Reconnect the ac line cord to the Front End and switch the power ON.

4. Allow the Front End a warm-up period of about 30 minutes before proceeding.

5. Using a digital multimeter (DMM), verify that the outputs of the Analog Output are within tolerance of their zero percent output values as given in Table 170-4.

CAUTION

The exposed screws on top of the Analog Output connector block can be probed only if they are screwed down tightly. Otherwise, contact is not made with the output from the -170 Assembly.

Table 170-4. Output Values and Tolerances for Zero Percent Outputs

OUTPUT SIGNAL	OUTPUT VALUE	TOLERANCE	TERMINAL PAIR FOR EACH CHANNEL 0+	0-	1+	1-	2+	2-	3+	3-
0 to 10V	0.000V	+/- 0.010V	1	2	6	7	11	12	16	17
-5 to +5V	-4.997V	+/- 0.010V	1	3	6	8	11	13	16	18
4 to 20mA	4.000mA	+/- 0.020mA	4	5	9	10	14	15	19	20

6. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.)

For ease of testing, a terminal is the recommended host.

Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0..3)=UNIPOLV <CR>

FORMAT=DECIMAL <CR>

CHAN(0..3)=10 <CR>
```

A1. Using a DMM, verify that the outputs of the Analog Output are within tolerance of their full scale output values as given below:

OUTPUT VALUE AND TOLERANCE FOR UNIPOLAR FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel 0+	0-	1+	1-	2+	2-	3+	3-
9.997V	+/- 0.010V	1	2	6	7	11	12	16	17

A2. Program the Front End to provide a full scale bipolar voltage source of +5V by sending the following commands:

```
DEF CHAN(0..3)=BIPOLV  <CR>

CHAN(0..3)=5  <CR>
```

A3. Using a DMM, verify that the bipolar voltage outputs are within the below stated tolerances:

OUTPUT VALUE AND TOLERANCE FOR BIPLOAR FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel 0+	0-	1+	1-	2+	2-	3+	3-
4.997V	+/- 0.010V	1	3	6	8	11	13	16	18

A4. To provide a full scale direct current output of 20 milliamps send the Front End the following commands:

DEF CHAN(0..3)=DCOUT <CR>

CHAN(0..3)=0.02 <CR>

A5. Use a DMM to verify that the direct current outputs are within the below stated tolerances:

OUTPUT VALUE AND TOLERANCE FOR DC CURRENT FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel							
		0+	0-	1+	1-	2+	2-	3+	3-
19.996mA	+/- 0.020mA	4	5	9	10	14	15	19	20

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs will cause the Front End to perform the required Analog Output tests on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for an IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port and empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
100 PRINT #1,"def chan(0..3)=unipolv"
110 GOSUB 300
120 PRINT #1,"chan(0..3)=10"
130 GOSUB 300
140 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:" AS NEW FILE 1%
50  OPEN "KB1:" AS OLD FILE 2%
60  PRINT #1,CHR$(3);
70  REM set up Computer Front End
80  PRINT #1,"mode=comp"
90  GOSUB 300
100 PRINT #1,"def chan(0..3)=unipolv"
110 GOSUB 300
120 PRINT #1,"chan(0..3)=10"
130 GOSUB 300
140 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

B1. Using a DMM, verify that the channel outputs are within the tolerances below:

OUTPUT VALUE AND TOLERANCE FOR UNIPOLAR FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel							
		0+	0-	1+	1-	2+	2-	3+	3-
9.997V	+/- 0.010V	1	2	6	7	11	12	16	17

B2. Modify the above program by changing the BASIC statements in lines 100 and 120 to:

```
100 PRINT #1,"def chan(0..3)=bipolv"

120 PRINT #1,"chan(0..3)=5"
```

B3. Run the modified program and verify that the channel outputs are within the tolerances below:

OUTPUT VALUE AND TOLERANCE FOR BIPLOAR FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel							
		0+	0-	1+	1-	2+	2-	3+	3-
4.997V	+/- 0.010V	1	3	6	8	11	13	16	18

B4. To verify dc output, again modify the program by changing the BASIC statements in lines 100 and 120 to:

```
100 PRINT #1,"def chan(0..3)=dcout"

120 PRINT #1,"chan(0..3)=0.02"
```

B5. Run the modified program and verify that the channel outputs are within the tolerances below:

OUTPUT VALUE AND TOLERANCE FOR DC CURRENT FULL SCALE OUTPUTS

Output Value	Tolerance	Terminal Pair for Each Channel 0+	0-	1+	1-	2+	2-	3+	3-
19.996 mA	+/- 0.020 mA	4	5	9	10	14	15	19	20

7. The Accuracy Verification Test for the Analog Output Assembly is complete.

If the -170 Analog Output Assembly fails the Accuracy Verification Test, it should be calibrated.

CALIBRATION

Perform the following procedure to calibrate the -170 Analog Output Assembly.

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING ANY OF THE PROCEDURES IN THIS SECTION.

1. Switch OFF power to the Front End. Disconnect the ac line cord and all other high voltage inputs.

2. Remove all option modules from the Front End.

3. Install the Calibration/Extender Fixture (Fluke P/N 648741) in the Front End, and mount the Analog Output Assembly on the Calibration/Extender Fixture.

   Be sure to set the Calibration/Extender switch to the EXTEND position.

4. Set the channel decade switch on the rear panel of the Analog Output to 00.

5. Reconnect the Front End ac line cord and switch the power ON.

6. Set the DMM to read +10V with 0.0001V resolution.

7. Connect the positive test lead of the DMM to terminal 21 on the Analog Output connector and connect the negative lead to terminal 2.

8. Calibrate the -10V reference by adjusting R99 such that the voltage measured between connector terminals 2 and 21 is -10.0000V within a tolerance of +/- 0.0005V.

9. Connect the positive test lead of the DMM to terminal 3 on the connector and the negative lead to terminal 2.

10. Calibrate the 5V reference by adjusting R100 so that the voltage measured between connector terminals 2 and 3 is +5.0000V +/- 0.0005V.

11. Set the outputs on channels 0, 1, 2, and 3 to their full scale values. Do so by performing Procedure A through step A1 (Terminal Mode) or Procedure B through B1 (Computer Mode) in Step 6 of the accuracy verification performance test.

12. Calibrate the full scale outputs for channels 0, 1, 2, and 3 by adjusting the appropriate pot for each channel so that the voltage measured is 9.9976V +/- 0.0005V. Refer to Table 170-5 for terminal and adjustment pot identification.

Table 170-5. Full Scale Voltage Calibration Adjustments

CHANNEL	POSITIVE TERMINAL	NEGATIVE TERMINAL	ADJUSTMENT POT
0	1	2	R61
1	6	7	R64
2	11	12	R67
3	16	17	R70

The voltage outputs are now calibrated. If the 4 to 20 mA current outputs are not going to be used, you may skip the current output calibration and proceed with step 19.

13. Power down the Front End, and install the jumper on the Analog Output at W1 (see Figure 170-10) so that pins 3 and 4 are connected. This disables the 4 mA offset.

14. Power up the Front End.

    If using the Terminal Mode, send the command

        MODE=TERM <CR>

    Then perform A4 of step 6 of the Accuracy Verification Test.

    If using the Computer Mode, perform B4 and B5 of step 6 of the accuracy verification performance test.

15. Calibrate the current outputs for channels 0, 1, 2, and 3 by adjusting the appropriate pot for each channel so that the current measured is 15.996 mA +/- 0.001 mA. Refer to Table 170-6 for terminal and adjustment pot identification.

Table 170-6. Full Scale Current Calibration Adjustments (Without Offset)

CHANNEL	POSITIVE TERMINAL	NEGATIVE TERMINAL	ADJUSTMENT POT
0	4	5	R75
1	9	10	R80
2	14	15	R85
3	19	20	R90

16. Power down the Front End return jumper W1 (see Figure 170-10) so that pins 1 and 2 are connected. This enables the 4 mA offset.

17. Power up the Front End.

If using the Terminal Mode, send the command

MODE=TERM <CR>

Then perform A4 of step 6 of the accuracy verification performance test.

If using the Computer Mode, perform B4 and B5 of step 6 of the accuracy verification performance test.

18. Calibrate the current outputs for channels 0, 1, 2, and 3 by adjusting the appropriate pot for each channel so that the current measured is 19.996 mA +/- 0.001 mA. Refer to Table 170-7 for terminal and adjustment pot identification.

Table 170-7. Full Scale Current Calibration Adjustments (With Offset)

CHANNEL	POSITIVE TERMINAL	NEGATIVE TERMINAL	ADJUSTMENT POT
0	4	5	R77
1	9	10	R82
2	14	15	R87
3	19	20	R92

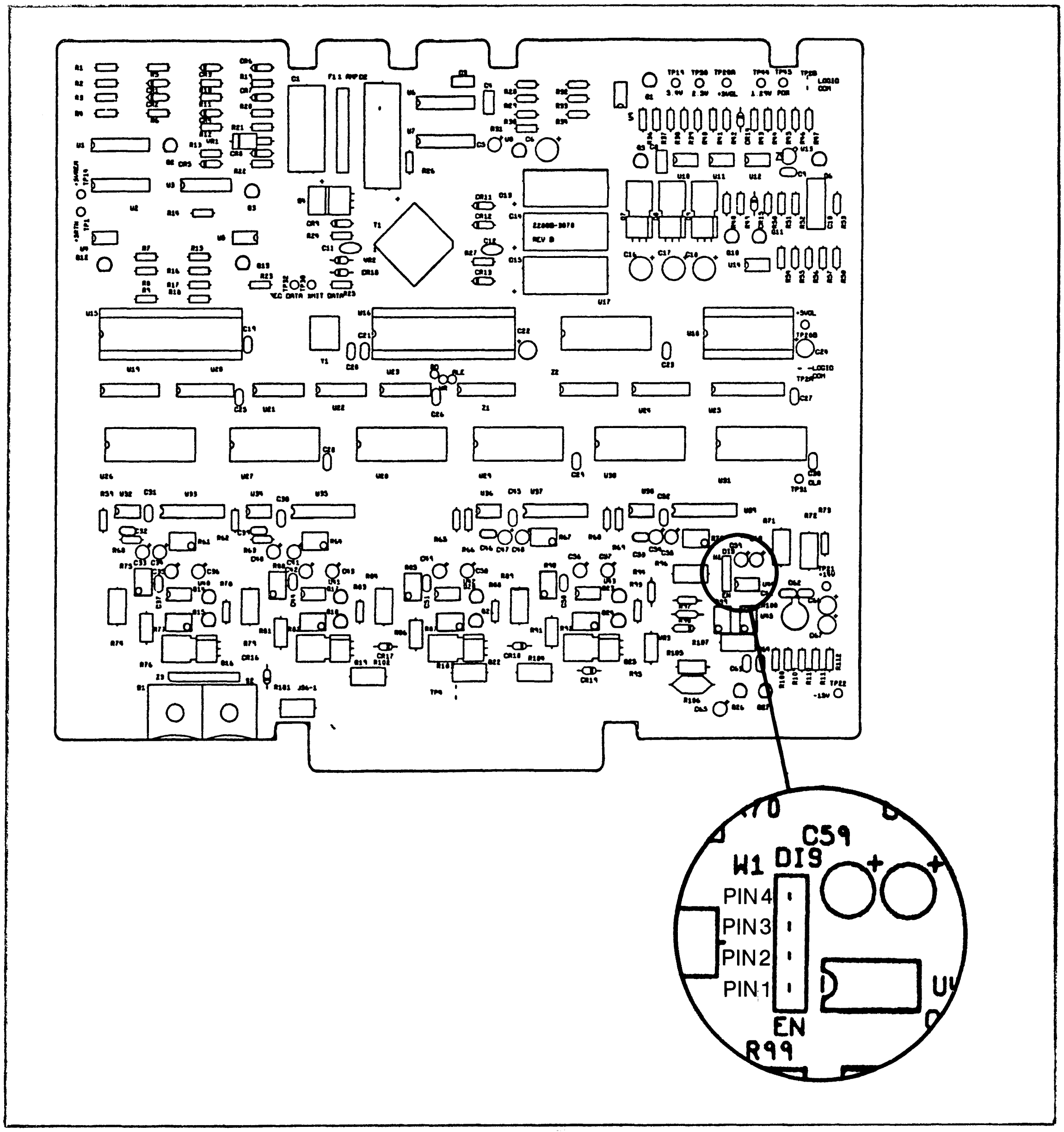


Figure 170-10. W1 Jumper and Pins

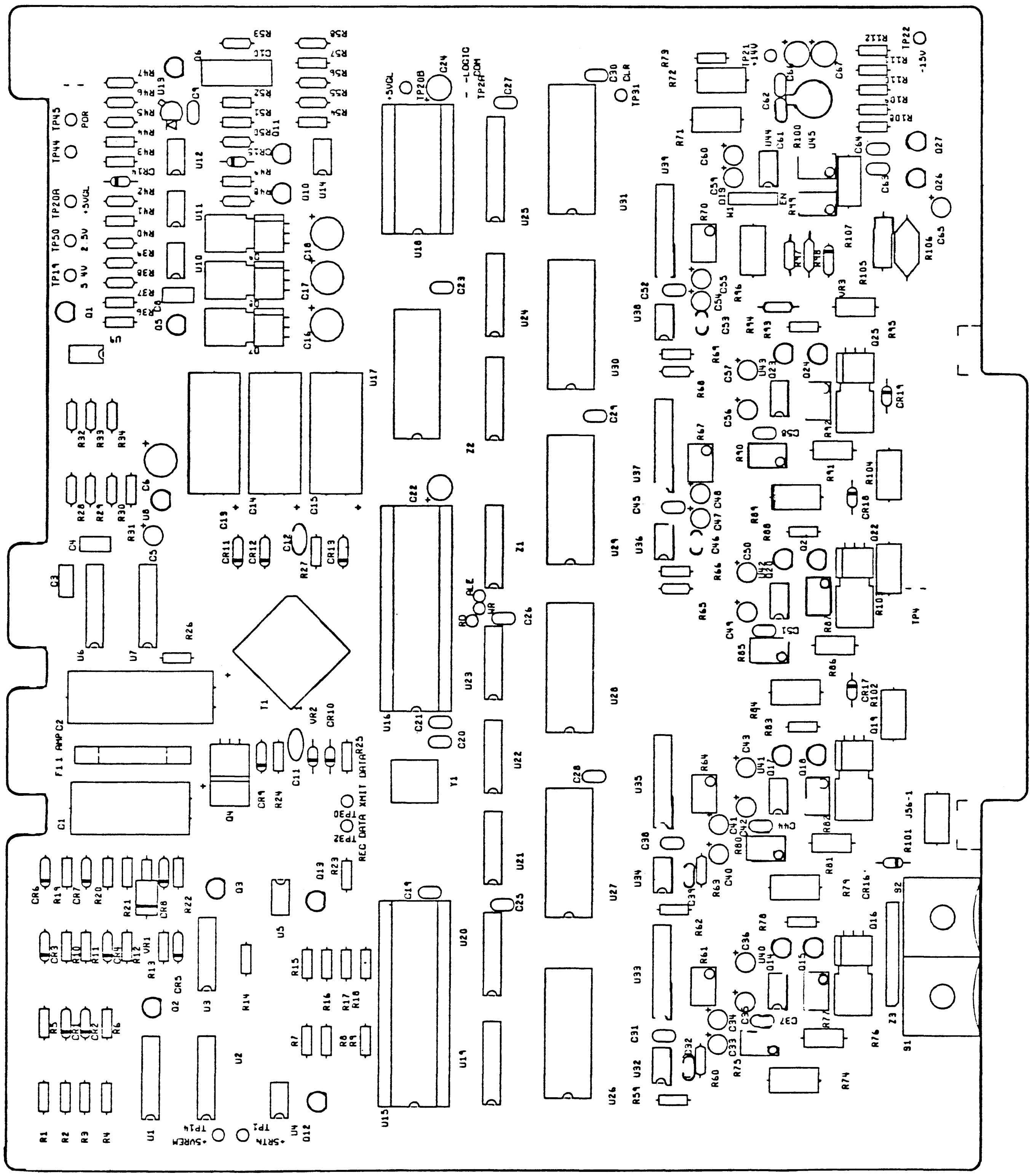
19. The calibration of the Analog Output Option is now complete.

20. Power down the Front End.

    A. Remove the Analog Output from the Calibration/Extender Fixture.

    B. Remove the Calibration/Extender Fixture from the Front End.

21. Install the Analog Output in the Front End or 2281 Extension Chassis, and set the channel decade switch as required by your application.



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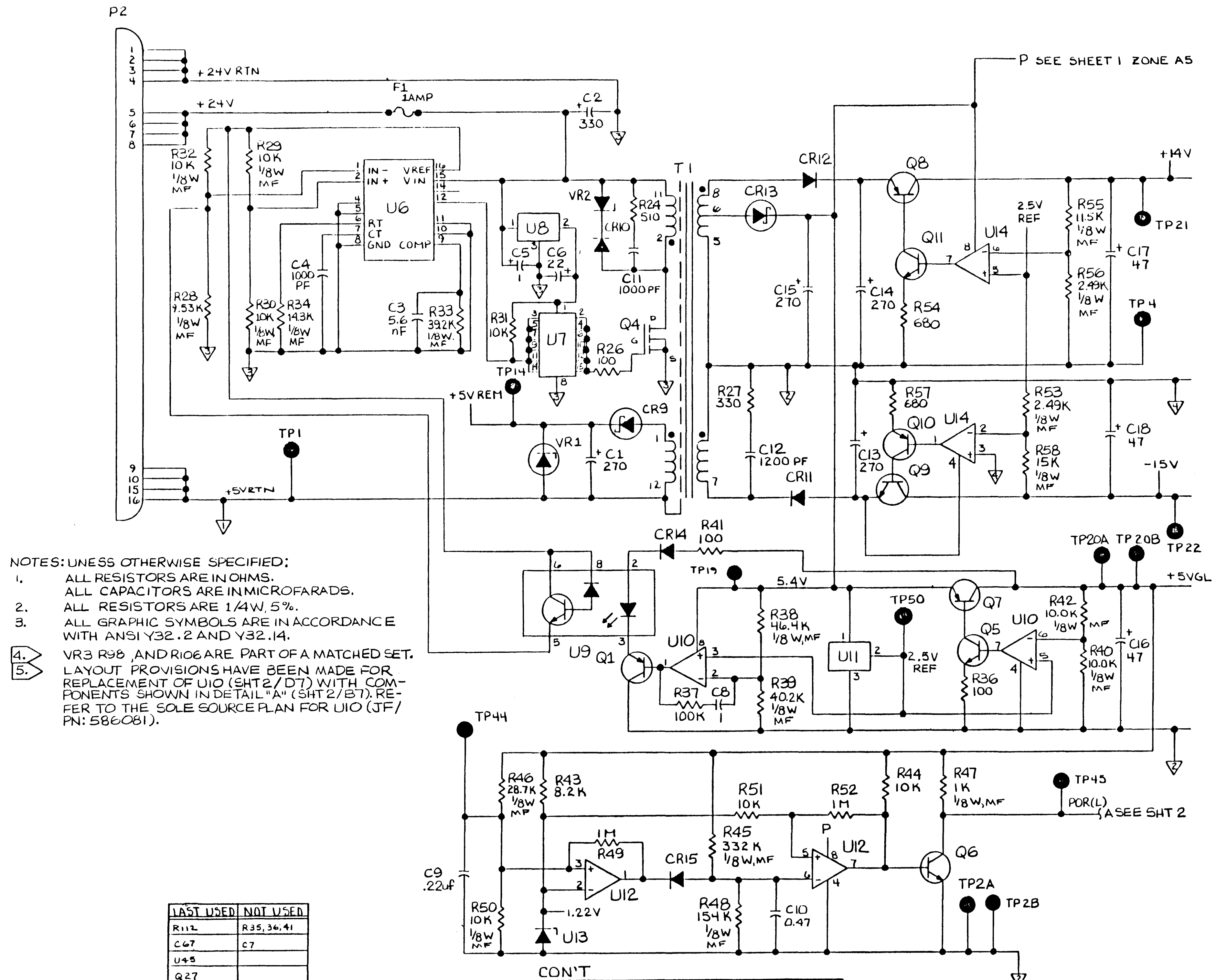

NOTES: UNESS OTHERWISE SPECIFIED:

1. ALL RESISTORS ARE IN OHMS. ALL CAPACITORS ARE IN MICROFARADS.
2. ALL RESISTORS ARE 1/4W, 5%.
3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.
4. VR3 R98, AND R106 ARE PART OF A MATCHED SET.
5. LAYOUT PROVISIONS HAVE BEEN MADE FOR REPLACEMENT OF U10 (SHT 2/D7) WITH COMPONENTS SHOWN IN DETAIL "A" (SHT 2/B7). REFER TO THE SOLE SOURCE PLAN FOR U10 (JF/PN: 586081).

REF DES.	▽1	▽2	▽3	2.5V REM	+5V REM	+5VGL	+15V	-15V
U1	8				16			
U2	4,5,8				1			
U3	1,3,7				4,10,14			
U4	5				8			
U5		5				8		
U6			4,5,8,10,11					
U7			8					
U8			3					
U9								
U10		4						
U11		3						
U12		4						
U13								
U14				5				
U15		3,16, 35,36,39				1,34, 37,38		
U16		20				1,26,40		
U17		3,12,15				24		
U18		12,18				21,24		
U19		8,14				15,16		
U20		8				15,16		
U21		7				14		
U22		3,4,5,7, 11,12,13				14		
U23		7				13,14		
U24		6,8				16		
U25		10				1,20		
U26		3,12,15				24		
U27		3,12,15				24		
U28		3,12,15				24		
U29		3,12,15				24		
U30		3,12,15				24		
U31		3,12,15				24		
U32							7	4
U33							16	
U34							7	4
U35							16	
U36							7	4
U37							16	
U38							7	4
U39							16	
U40							7	4
U41							7	4
U42							7	4
U43							7	4
U44							7	4

LAST USED	NOT USED
R112	R35, 36, 41
C67	C7
U45	
Q27	
CR19	
VR3	
Z3	
S2	
T1	
Y1	
F1	

CON'T

REF. DES.	▽1	▽2	▽3	2.5V REM	+5V REM	+5VGL	+15V	-15V	DEVICE NAME
U45							7	4	288A

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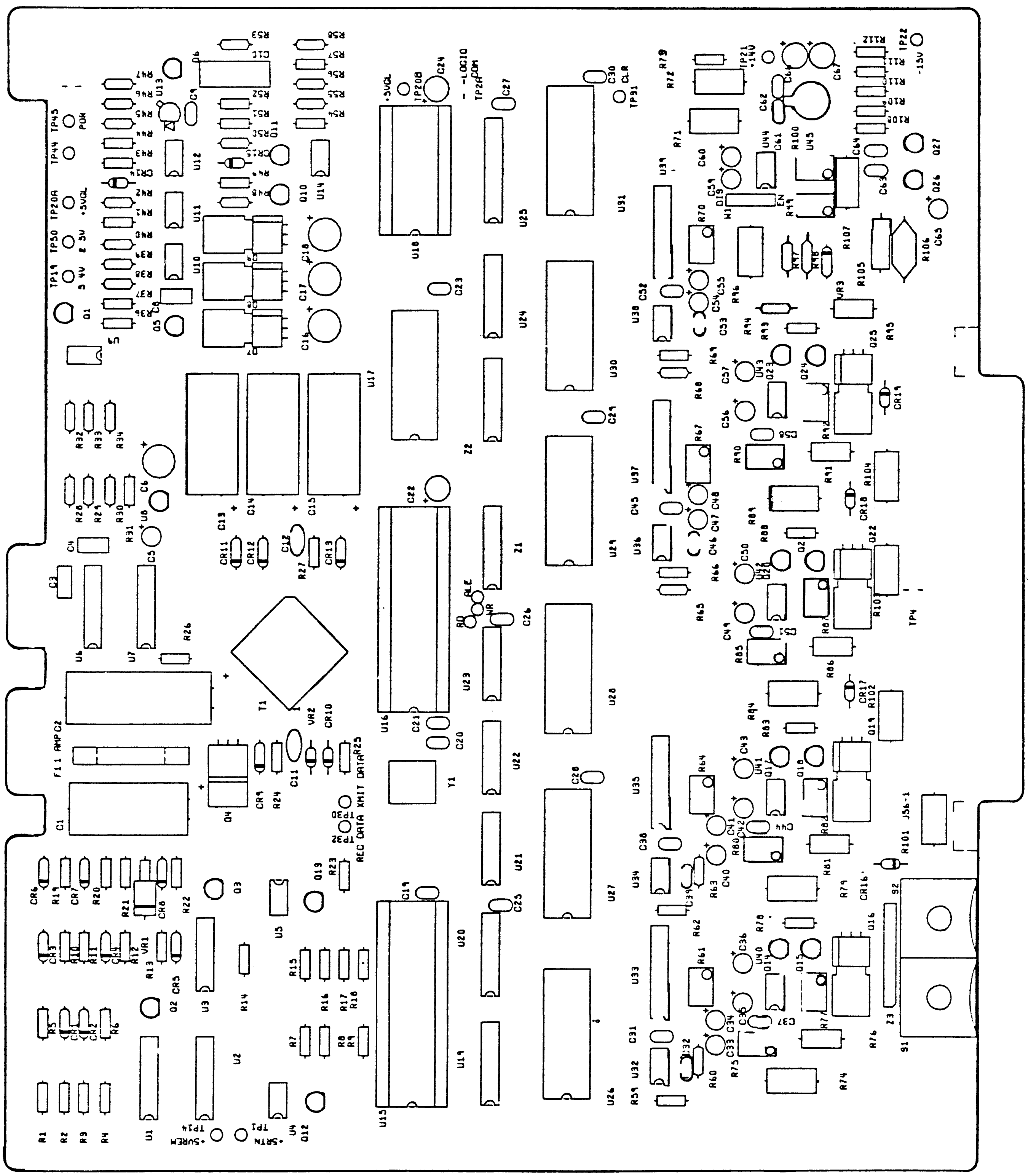
Figure 170-10. Analog Output Option Schematic Diagram



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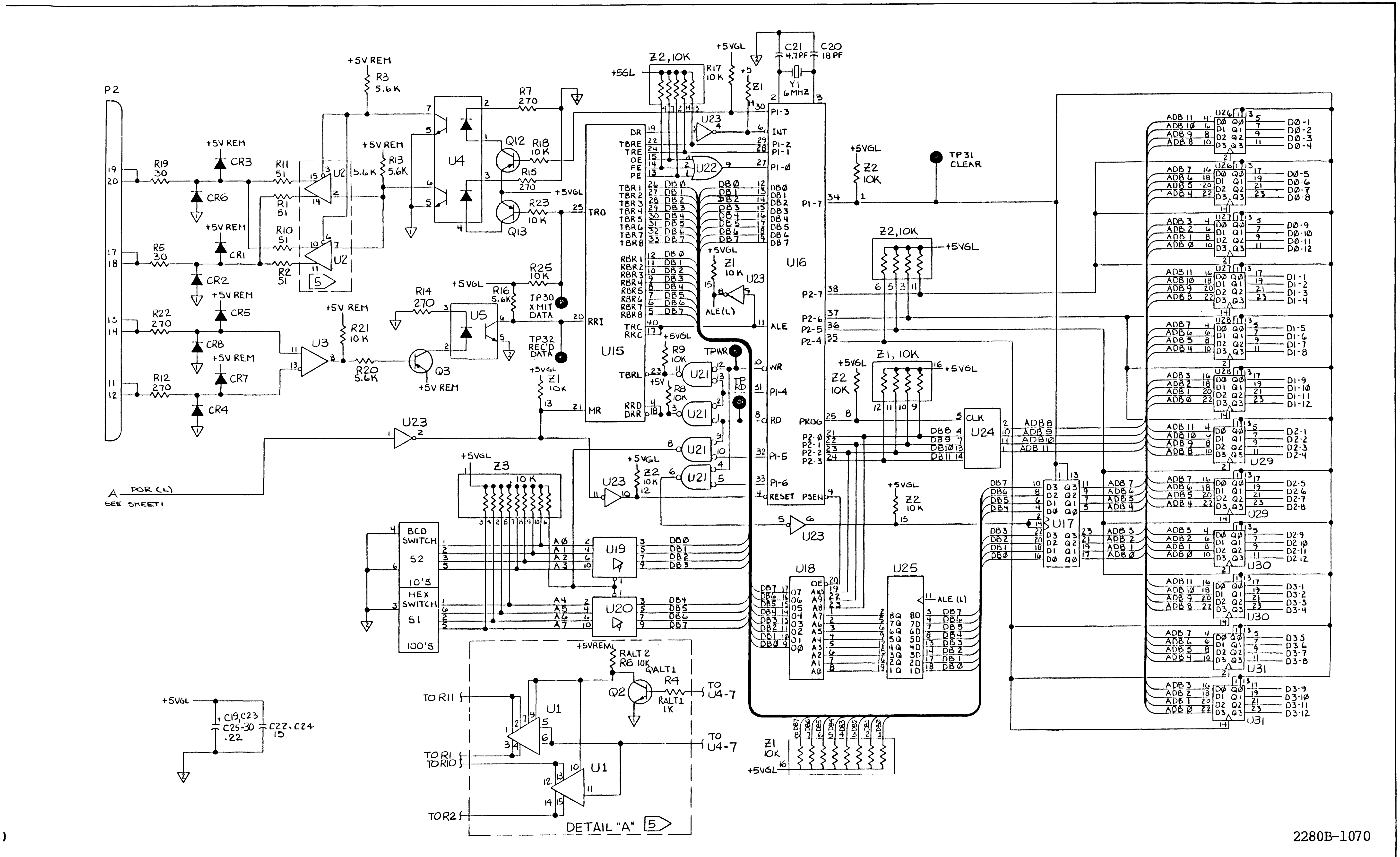

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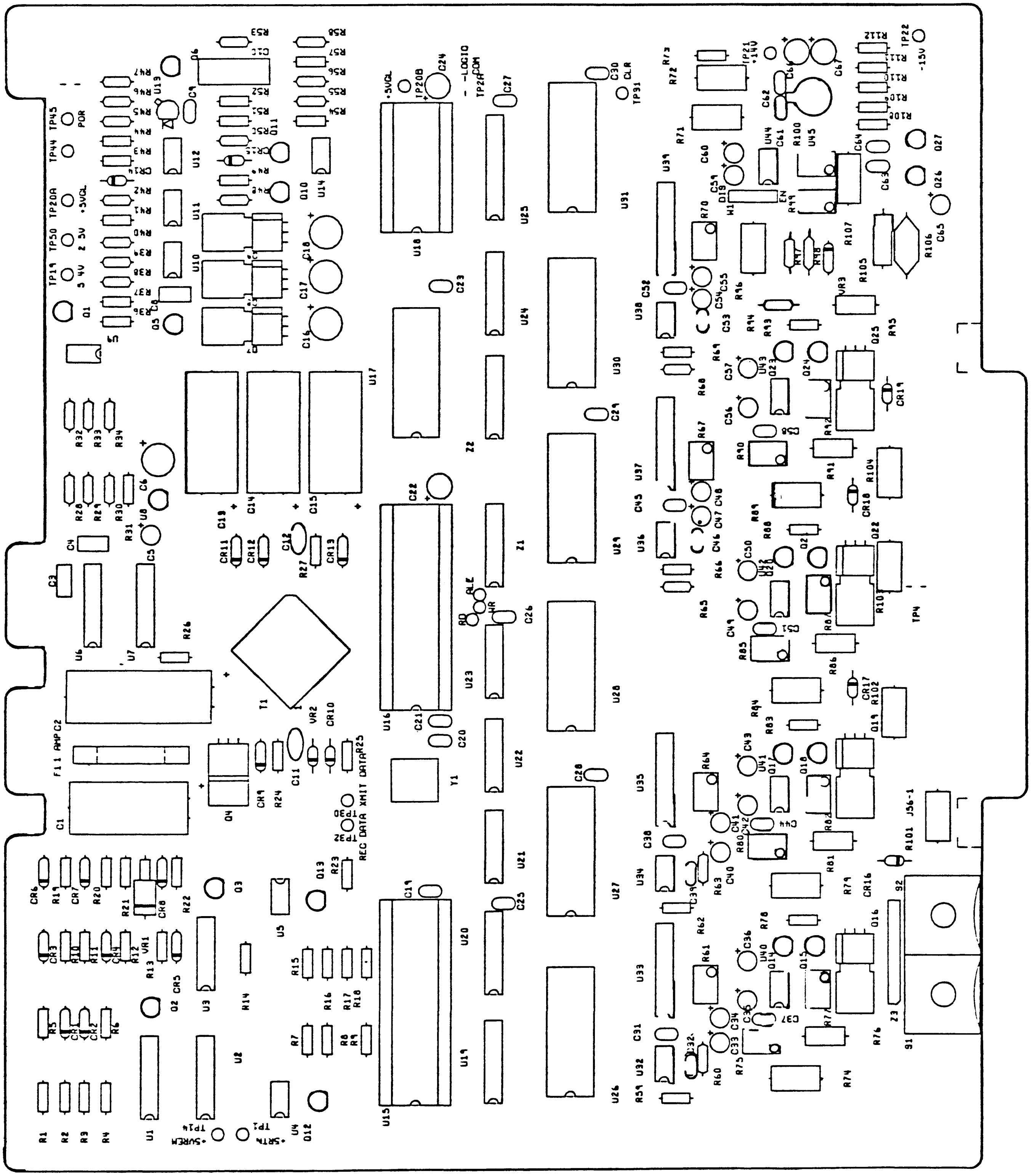
Figure 170-10. Analog Output Option Schematic Diagram (cont.)



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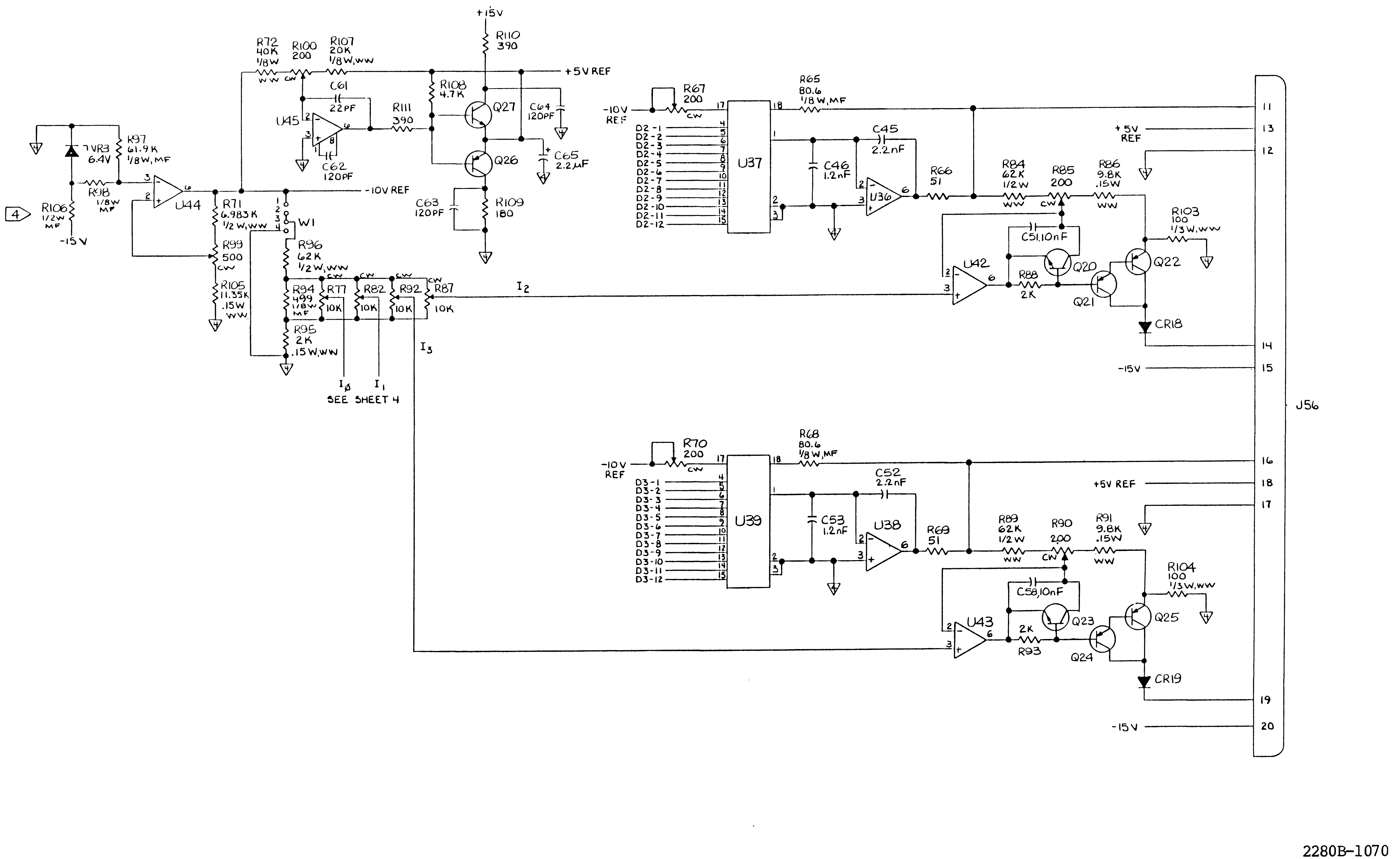


Figure 170-10. Analog Output Option Schematic Diagram (cont.)

DESCRIPTION

The -171 Current Input Connector (shown in Figure 171-1) is a screw-terminal assembly that mates with the -162 Thermocouple/DC Volts Scanner through a card-edge connector. Up to 20 channels of current inputs may be connected to the Current Input Connector.

The Current Input Connector converts current to proportional voltages to be measured by the A/D Converter in the Front End. The Current Input Connector connects to the scanner through two 44-pin, card-edge connectors. The entire connector assembly is enclosed in a plastic housing that provides protection for the terminal connections and strain relief for external wiring. When the connector is installed, the protective housing is attached to the Front End chassis with two retaining screws on each end of the assembly.

Each Input Connector channel has a precision shunt resistor and two screw terminals labeled HIGH and LOW (see Figure 171-1). Unlike the Isothermal and Voltage input connectors, there is no screw terminal for shield. The shield is internally connected to the LOW screw terminal.

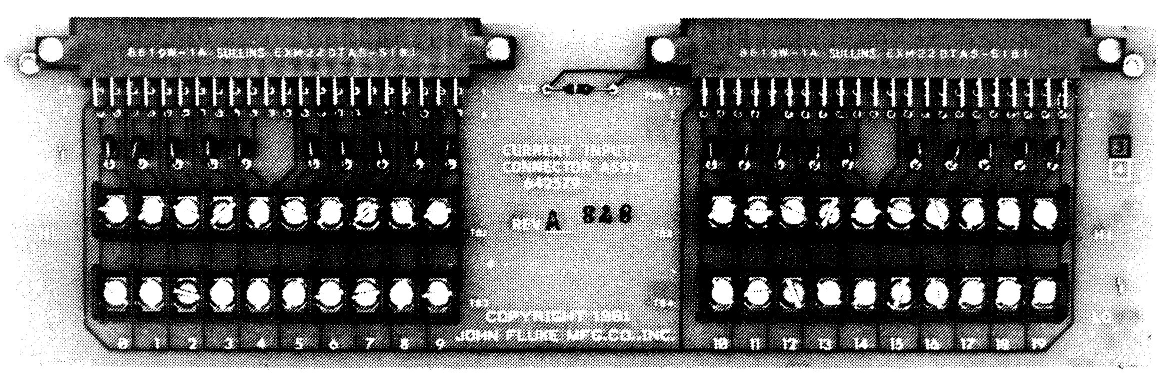


Figure 171-1. Current Input Connector

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Current Input Connector theory of operation, performance tests, a parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are found in the Helios Plus System Manual.

Test equipment required to perform the procedures in this subsection is listed in Table 171-1. A summary of test equipment required to perform all procedures in this manual is given in Table 2-2 in Section 2 of this manual.

Table 171-1. Required Test Equipment for -171

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Calibrator	64 mA +/- 0.25%	Fluke 5100B
Digital Multi-meter (DMM)	Capable of measuring resistance in four wire configuration	Fluke 8840A
High Performance A/D Converter	NA	Fluke Option -161
Thermocouple/DC Volts Scanner	NA	Fluke Option -162

THEORY OF OPERATION

The Current Input Connector theory of operation includes a functional description and a circuit analysis. A schematic diagram is at the end of this subsection.

Functional Description

The Current Input Connector receives dc currents through screw terminals and passes them through precision shunt resistors to produce dc voltages proportional to the current inputs. The dc voltages are routed through the Thermocouple/DC Volts Scanner to the A/D Converter, where they are digitized.

Circuit Analysis

Up to 20 dc current sources can be attached to the -171 Current Input Connector through two screw terminals per channel: HI and LO. DC current flows into the HI screw terminal, through an 8-ohm, .7W, 0.25% tolerance shunt resistor, and out the LO screw terminal. On command from the Front end, the resulting dc voltage that appears across the resistor is applied, through the Thermocouple/DC Volts Scanner to the A/D Converter, where the voltage is converted to a digital value.

GENERAL MAINTENANCE

The -171 Current Input Connector normally does not require cleaning unless dirt, dust, or other contamination is visible on its surface. If cleaning is necessary, follow the instructions in Section 4 of this manual.

PERFORMANCE TEST

The following test verifies that the -171 Current Input Connector is fully operational. This procedure can be used as an initial acceptance test or as a troubleshooting aid.

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Set the A/D Converter address switch to 0, and install the A/D Converter in the top option slot of the Front End. Install the Thermocouple/DC Volts Scanner in the option slot immediately below the A/D Converter. To avoid addressing conflicts, remove all other addressable options from the Front End.

3. Connect test leads to the HI and LO terminals for channel 0 on the Current Input Connector. Install the Current Input Connector on the Thermocouple/DC Volts Scanner.

4. Reconnect the ac line cord to the Front End and switch the power ON.

5. Connect the test lead from the Current Input Connector HI terminal to the calibrator HI output. Connect the calibrator LO terminal to the Current Input Connector LO test lead.

6. Set the calibrator output to 63.000 mA dc.

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0..19)=DCIN <CR>

FORMAT=DECIMAL <CR>

SEND CHAN(0) <CR>
```

Verify that the value returned for the selected channel is between 6.28000E-02 and 6.32000E-02 (63 +/- 0.2 mA).

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc current measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
110  PRINT #1,"def chan(0..19)=dcin"
120  GOSUB 300
```

```
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  REM make measurement and read in response
160  PRINT #1,"send chan(0..19)"
170  FOR I=0 TO 19
180  INPUT #1,M$
190  PRINT "chan";I;"=";
200  PRINT USING "###.##";VAL(M$)*1000;
210  PRINT " milliamps"
220  NEXT I
230  END
300  REM wait for message accepted promt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1
50   OPEN "KB1:"AS OLD FILE 2
60   PRINT #1,CHR$(3);
70   REM set up Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0..19)=dcin"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  REM make measurement and read in response
170  DIM M$(20)
180  PRINT #1,"send chan(0..19)"
190  FOR I%=0 TO 19\INPUT #2,M$(I%)\NEXT I%
200  X%=0\I%=0
210  FOR C%=0 TO 1
220  PRINT TAB(35*C%);"chan";I%;"=";
230  PRINT USING "S###.##",VAL(M$(X%))*1000;\PRINT " milliamps";
240  X%=X%+1\I%=I%+1\IF X%>19 THEN 270
250  NEXT C%
260  GOTO 210
270  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The value returned for the selected channel should be 63 +/- 0.2 mA.

8. Set the calibrator output to 0. Move the test leads of the Current Input Connector to the terminals for the next channel to be tested.

9. Repeat steps 6 through 8 for each remaining current input channel (1 through 19), substituting the appropriate channel number in the SEND CHAN command if Terminal Mode is being used.

10. Performance testing of the Current Input Connector is complete.

CALIBRATION

The Current Input Connector requires no calibration.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Current Input Connector is given in Table 171-2.

For parts ordering information, see Section 6 of this manual.

Figure 171-2 is a schematic diagram of the Current Input Connector.

TABLE 171-2. CURRENT INPUT CONNECTOR
(SEE FIGURE 171-2.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	NOTE
H 1		STEEL,CAD.PLATED,.125X .500	276493	89536	276493	4	
H 2		WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	4	
MP 1		CONNECTOR HOUSING, TOP	578971	89536	578971	1	
MP 2		CONNECTOR HOUSING, BOTTOM	656876	89536	656876	1	
MP 3		DECAL, CURRENT INPUT CONNECTOR	634576	89536	634576	1	
MP 4		DECAL, OPTION -171	634501	89536	634501	1	
MP 5		TAPE,FOAM,PVC,1/4W, 3/8 THK	601134	89536	601134	2	
P 36, 37		CONN,PWB EDGE,REC,90,0.156 CTR.44 POS	614313	89536	614313	2	
R 1- 19		RES,WW,8,+-0.25%,0.7W	641449	89536	641449	20	
R 20		RES,CF,3.9K,+-5%,0.25W	342600	80031	CR251-4-5P3K9	1	
TB 1- 4		SINGLE ROW, .325 CENTERS, 10 POSITION	615328	89536	615328	4	

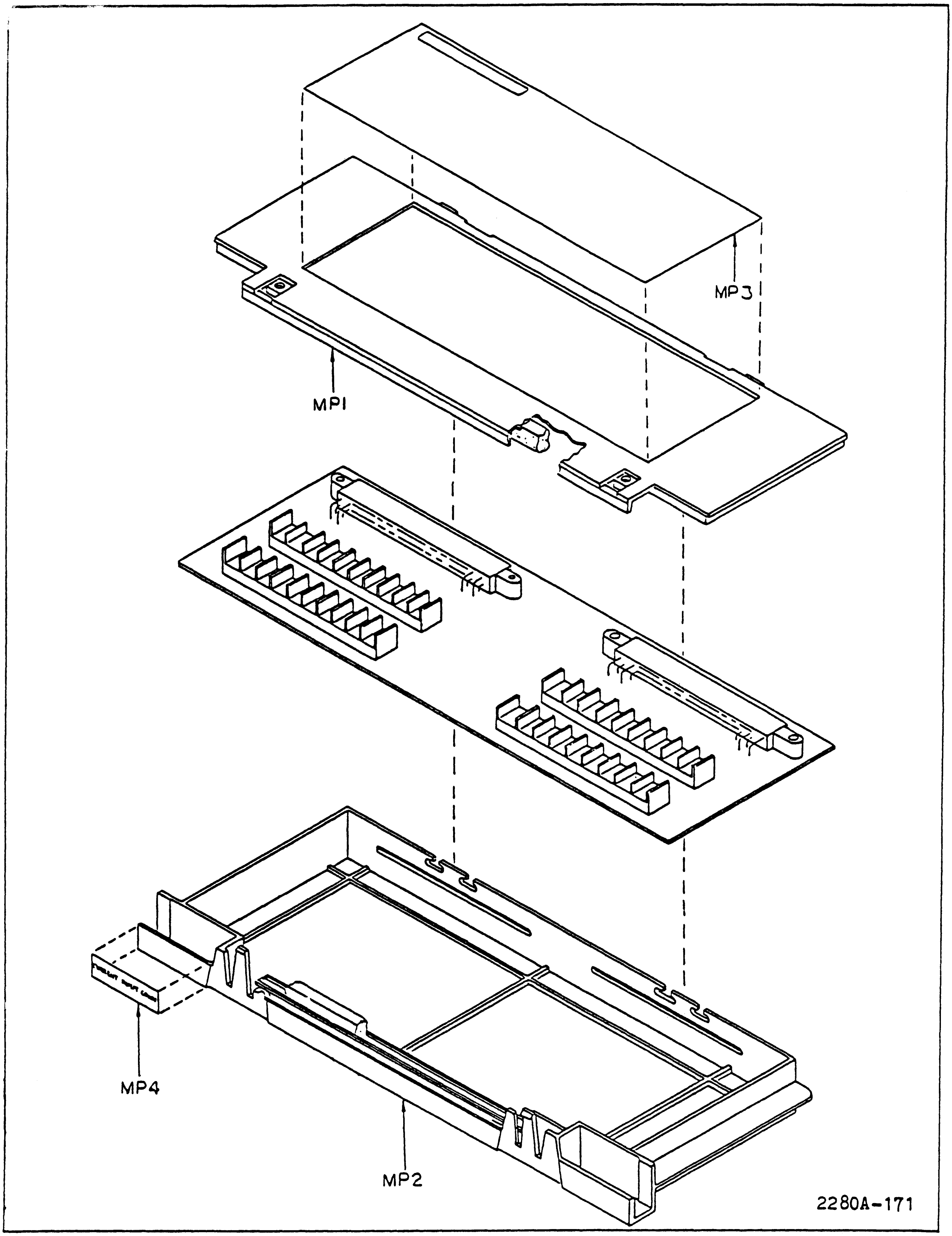
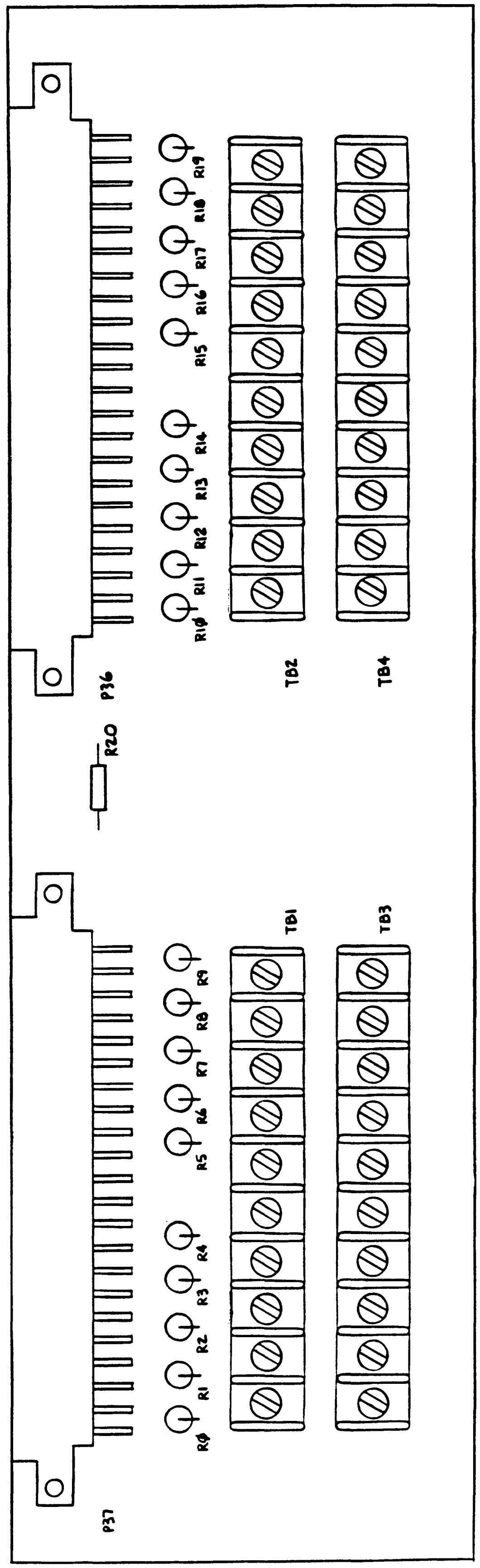


Figure 171-2. -171 Current Input Connector



P36
P37
R20
TB1
TB2
TB3
TB4
RØ
R1
R2
R3
R4
R5
R6
R7
R8
R9
R1Ø
R11
R12
R13
R14
R15
R16
R17
R18
R19

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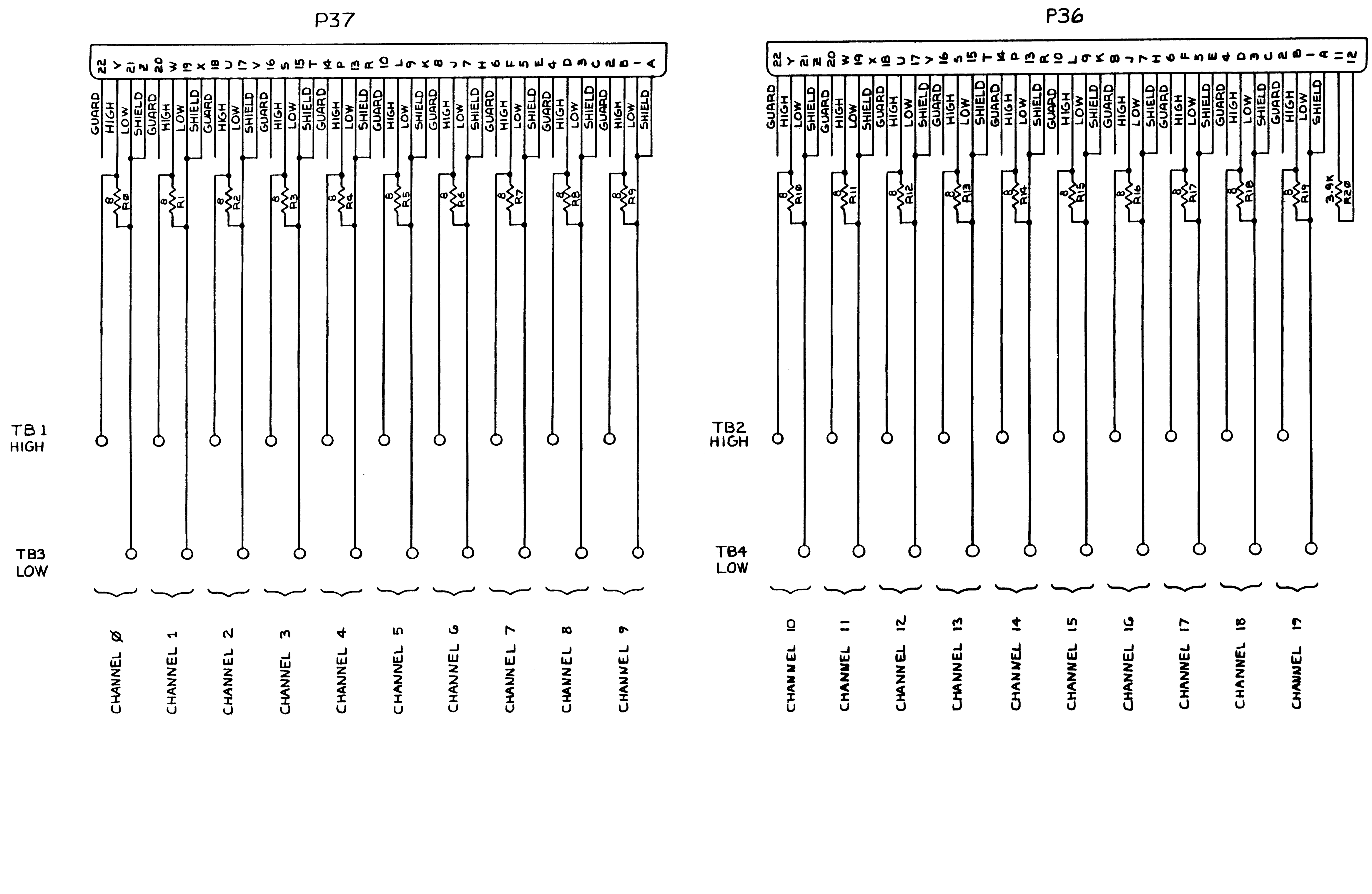


Figure 171-2. Current Input Connector Schematic Diagram

DESCRIPTION

The -174 Transducer Excitation Connector (shown in Figure 174-1), mounts on the Transducer Excitation Module (-164) and provides it with screw-terminal connections for voltage and current sources.

The combination of the -164 and -174 options allows the Front End to make RTD temperature measurements, strain gauge measurements, strain-based transducer measurements, and low resistance transducer measurements.

Five connecting terminals are available for each channel, and twenty sets of these terminals are provided on each input connector. Wiring for each set of terminals is defined by the mode (4-Wire, 3-Wire Accurate, or 3-Wire Common) selected for the Transducer Excitation Scanner. Refer to Section 3B of the Helios Plus System Manual for wiring instructions.

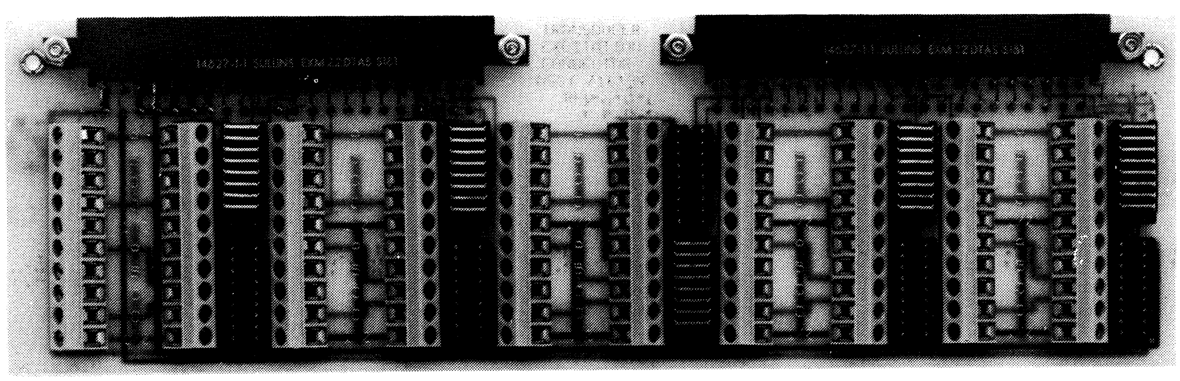


Figure 174-1. Transducer Excitation Connector

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Transducer Excitation Connector theory of operation, a replacement parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are found in the Helios I System Manual. Option specifications are found in the appendices to this manual and in the System Manual.

THEORY OF OPERATION

The Transducer Excitation Connector provides a path from screw terminals on the connector to the card-edge connector pins on the -164 Transducer Excitation Module.

Jumpers on the connector select either current or voltage excitation mode. The jumpers are set to current excitation when the connector is shipped from the factory. Section 3B of the Helios I System Manual contains instructions for connector configuration.

GENERAL MAINTENANCE

The Transducer Excitation Connector normally does not require cleaning unless dirt, dust, or other contamination is visible on the surface. If cleaning is necessary, follow the cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

There is no separate performance test for the Transducer Excitation Connector.

The connector is tested during the performance testing of the Transducer Excitation Module. Refer to the -164 Transducer Excitation Module subsection earlier in Section 8.

CALIBRATION

There are no calibration adjustments for the Transducer Excitation Connector.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Transducer Excitation Connector is given in Table 174-1.

For parts ordering information, see Section 6 of this manual.

Figure 174-2 is a schematic diagram of the Transducer Excitation Connector.

TABLE 174-1 TRANSDUCER EXCITATION CONNECTOR
(SEE FIGURE 174-2.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	NOTE
H 1		WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	4	
H 2		STEEL,CAD.PLATED,.125X .500	276493	89536	276493	4	
JR 1I 2I 3I		HEADER,DIP,PROGRAMMED,18 PIN	715227	89536	715227	5	
JR 4I 5I			715227				
MP 1		CONNECTOR HOUSING, TOP	578971	89536	578971	1	
MP 2		CONNECTOR HOUSING, BOTTOM	656876	89536	656876	1	
MP 3		DECAL, TRANSDUCER EXCITATION CONN	722041	89536	722041	1	
MP 4		DECAL, OPTION -174	722058	89536	722058	1	
MP 5		TAPE,FOAM,PVC,1/4W,3/8 THK	603134	89536	603134	2	
P 54, 55		CONN,PWB EDGE,REC,90,0.156 CTR,44 POS	614313	89536	614313	2	
TB 1- 10		TERM STRIP,PWB,ANGL ENTRY,10 CONTACTS	501403	89536	501403	10	
XJR 1- 5		SOCKET,DIP,0.100 CTR,18 PIN	418228	91506	318-AG39D	10	

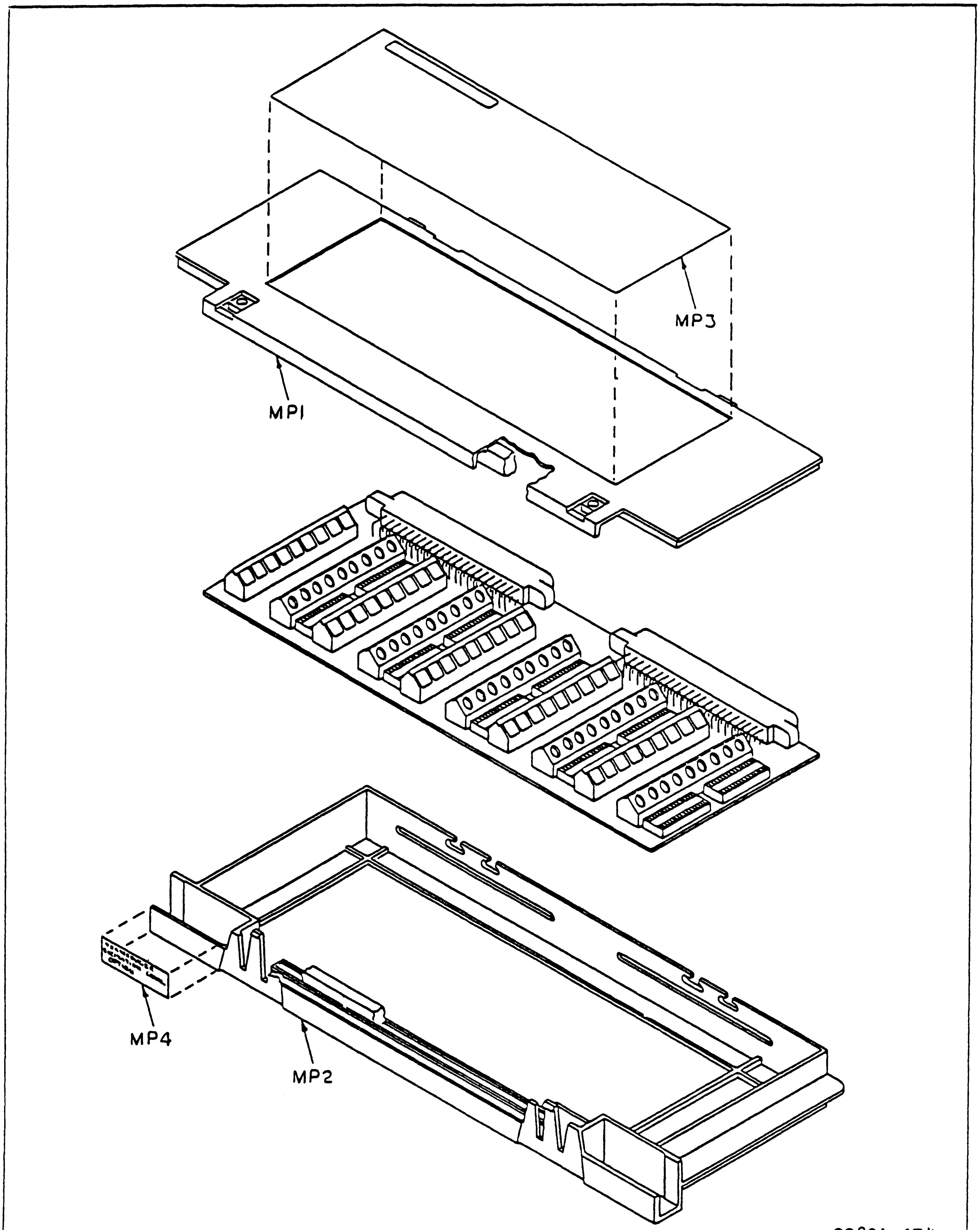
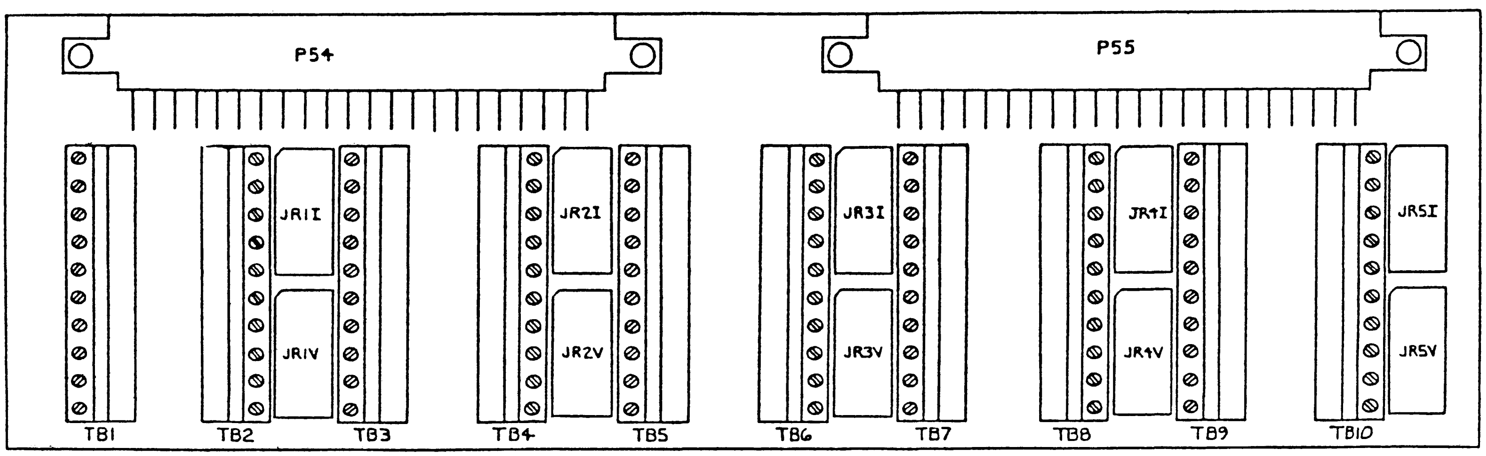


Figure 174-2. -174 Transducer Excitation Connector


P54
P55
JR1I
JR1V
JR2I
JR2V
JR3I
JR3V
JR4I
JR4V
JR5I
JR5V
TB1
TB2
TB3
TB4
TB5
TB6
TB7
TB8
TB9
TB10

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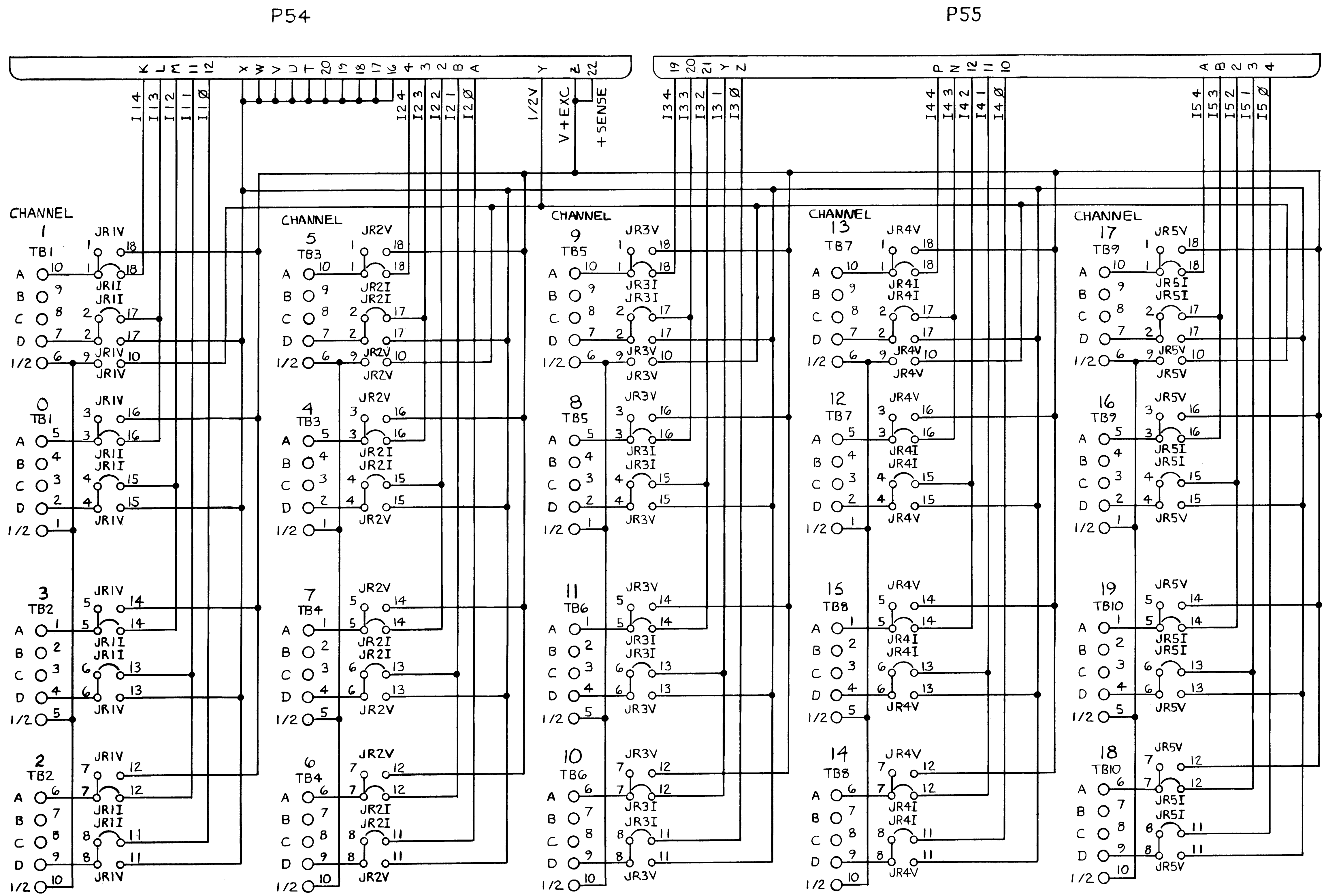

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.
2. JUMPERS ON JR1 – JR5 ARE SHOWN INSTALLED IN CURRENT CONFIGURATION.

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Figure 174-2. Transducer Excitation Connector Schematic Diagram

DESCRIPTION

The Isothermal Input Connector can be connected to the -162 Thermocouple/DC Volts Scanner for use with the -161 High Performance A/D Conveter or directly to the -165 Fast A/D Conveter. The following input channel configurations are possible:

- -162 Scanner/-161 A/D Converter

  A maximum of 20 thermocouple or voltage input channels are routed to the scanner. The connector attaches to the 88-pin edge connector at the rear of the scanner card.

- -165 A/D Converter

  A maximum of 20 differential input channel pairs or 40 single-ended input channels can be routed to the A/D Converter. The connector attaches to the 88-pin edge connector at the rear of the A/D

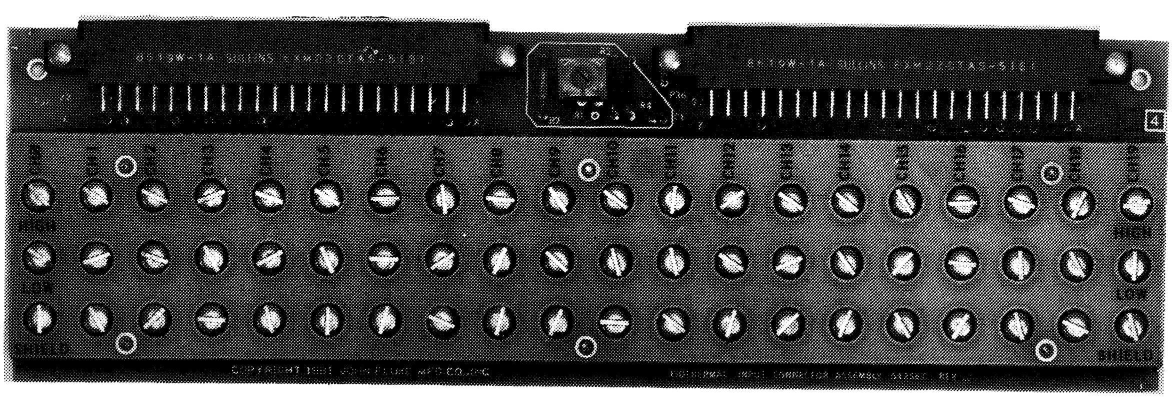


Figure 175-1. Isothermal Input Connector

The entire connector assembly is enclosed in a plastic connector housing that provides protection for terminal connections and strain relief for external wiring. When installed, the housing is attached to the Front End chassis with retaining screws on each side.

There are three screw terminals per channel: HIGH, LOW, and SHIELD. All channel terminals maintain 250V rms separation, and all terminals are surrounded by a block of aluminum that helps to maintain a uniform temperature among the terminals. A temperature sensor mounted in the isothermal block returns temperature readings to the Front End through either the -162 Thermocouple/DC Volts Scanner and the -161 A/D Converter, or the -165 Fast A/D Converter.

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: -175 Isothermal Input Connector theory of operation, performance tests, calibration procedures, a parts list, and schematics.

Installation, operating, and system configuration instructions are given in the Helios Plus System Manual.

Test equipment required to perform the procedures in this subsection is listed in Table 175-1. A summary of test equipment required to perform all procedures in this manual is given in Table 2-2 in Section 2.

Table 175-1. Required Test Equipment for -175

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
A/D Converter	NA	Fluke Option -161 or Fluke Option -165
Thermocouple/DC Volts Scanner	NA	Fluke Option -162 (only required with -161 A/D Converter)
Room Temperature Oil/Water Bath	NA	NA
Mercury Thermometer	0.02 degrees Celsius Resolution	Princo ASTM-56C
Thermocouple	Type J or K	Fluke P-20J or P-20K

THEORY OF OPERATION

The Isothermal Input Connector theory of operation includes a functional description and a detailed circuit description. The schematic diagram for this assembly is given at the end of this subsection.

Functional Description

By providing connections for up to 20 thermocouples through its screw terminals, the Isothermal Input Connector allows the Front End to make stable temperature readings. The assembly contains a temperature sensor that measures the isothermal block temperature, allowing automatic reference-junction compensation of thermocouple inputs. The isothermal aluminum block (that surrounds the terminals on the connector) maintains the terminals, input leads, and reference junction at the same temperature.

The Isothermal Input Assembly, when installed on either the Thermocouple/DC Volts Scanner, or the Fast A/D Converter, changes the type code of the scanner, thereby signaling the mainframe to permit thermocouple measurements on the channels associated with that Isothermal Input Connector.

Detailed Circuit Description

NOTE

The following description refers to the use of the High Performance A/D Converter. When using a Fast A/D Converter, no Thermocouple/DC Volts Scanner is required.

TERMINAL CIRCUIT

There are three terminals for each channel, one each for the high input (HI), the low input (LO), and shield (SHIELD). The terminals provide termination points for the wiring that carries incoming dc voltages from thermocouples or voltage sources. The incoming voltages are passed through the Isothermal Input Connector to the Thermocouple/DC Volts Scanner, where channels are selected and conditioned for conversion by the A/D Converter.

REFERENCE JUNCTION CIRCUIT

The temperature of the isothermal terminal block is sensed by the base-emitter junction of transistor Q1. Bias voltage is supplied to the transistor by the A/D Converter +6.2V reference voltage, which is passed through the Thermocouple/DC Volts Scanner and divided down by factory-chosen resistors. The Q1 base-emitter voltage of approximately 600 mV is divided in half by R3 and R4, with the 300 mV output of the divider supplied to the Thermocouple/DC Volts Scanner. The scanner and the A/D Converter measure this signal on the 512-mV range each time a thermocouple measurement is made on the associated input channels, thereby providing a measurement to the Front End for thermocouple linearization processes. Capacitor C1 reduces the sensor's susceptibility to electromagnetic interference (EMI), and resistor R5 provides a bias current return path.

GENERAL MAINTENANCE

The -175 Isothermal Input Connector normally does not require cleaning unless dirt, dust, or other contamination is visible on its surface. If cleaning is necessary, follow the instructions in Section 4 of this manual.

PERFORMANCE TESTS

The following performance test can be used to verify that the Isothermal Input Connector is functioning properly. The performance test can also be used as an initial acceptance test.

The performance test is divided into two parts: a Channel Integrity Test, which verifies that all channels on the connector are functional; and an Accuracy Verification Test, which verifies that the connector channels meet accuracy specifications. Each test may be performed independently. However, both parts must be performed to test the Isothermal Input Connector fully.

These tests can be performed using either one of two types of a/d converter: the -161 High Performance A/D Converter or the -165 Fast A/D Converter. The higher reading rates realized with the -165 Fast A/D Converter yield somewhat lower resolution and accuracy than with the -161 High Performance A/D Converter.

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES WHICH CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE DOING THE FOLLOWING PROCEDURE.

Channel Integrity Test

To conduct the Channel Integrity Test, perform the following procedure:

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Install either a -161 High Performance A/D Converter or a -165 Fast A/D Converter in the uppermost option slot of the Front End. Set the address switch on the appropriate A/D Converter to zero.

3. To avoid addressing conflict, remove all other installed options.

4. Connect a shorting wire between HI and LO terminals for channel 0 on the Isothermal Input Connector.

   Remove connections to all other isothermal connector terminals.

5. Now, referring to the A/D Converter-specific instructions below, install the -175 Isothermal Input Connector:

   o -161 High Performance A/D Converter

      A. Install a -162 Thermocouple/DC Volts Scanner in the slot directly below the A/D Converter.

      B. Install the -175 connector onto this -162 scanner.

   o -165 Fast A/D Converter

      A. Install the -175 connector directly onto this A/D Converter.

6. Reconnect the ac line cord to the Front End and switch the power ON.

7. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(0..19)=TC,TYPE=JNBS <CR>

FORMAT=DECIMAL <CR>

TUNIT=CELSIUS <CR>

SEND CHAN(0) <CR>
```

The value returned for the selected shorted channel should be approximately the ambient temperature.

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a temperature measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
120  PRINT #1,"def chan(0..19)=tc,type=jnbs"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  PRINT #1,"tunit=celsius"
170  GOSUB 300
180  REM make measurement and read in response
190  PRINT #1,"send chan(0..19)"
200  FOR I=0 TO 19
210  INPUT #1,T$
220  PRINT "chan";I;"=";
230  PRINT USING "###.#";VAL(T$);
240  PRINT " degrees"
250  NEXT I
260  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1%
50   OPEN "KB1:"AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Computer Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0..19)=tc,type=jnbs"
130  GOSUB 300
```

```
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  PRINT #1,"tunit=celsius"
170  GOSUB 300
180  REM make measurement and read in response
190  DIM T$(20)
200  PRINT #1,"send chan(0..19)"
210  FOR I%=0 TO 19\INPUT #2,T$(I%)\NEXT I%
220  X%=0\I%=0
230  FOR C%=0 TO 1
240  PRINT TAB(35*C%);"chan";I%;"=";
250  PRINT USING "S###.#",VAL(T$(X%));\PRINT" degrees";
260  X%=X%+1\I%=I%+1\IF X%>19 THEN 290
270  NEXT C%
280  GOTO 230
290  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

The value returned for the selected shorted channel(s) should be approximately the ambient temperature.

8. Remove the shorting wire and reconnect it to the terminals for the next channel to be tested.

9. Repeat steps 7 and 8 for each remaining voltage input channel (1 through 19), substituting the appropriate channel number in the SEND CHAN command if Terminal Mode is being used.

10. This completes the Channel Integrity Test.

Continue with the Accuracy Verification Test if you are conducting a complete performance test of the Isothermal Input Connector and you have not already performed the test on either the A/D Converter or the Thermocouple/DC Volts Scanner.

Accuracy Verification Test

To conduct the Accuracy Verification test, perform the following procedure:

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING ANY OF THE PROCEDURES IN THIS SECTION.

1. Switch OFF power to the Front End. Disconnect the line power cord and all other high voltage inputs.

2. Install either a -161 High Performance A/D Converter or a -165 Fast A/D Converter in the uppermost option slot of the Front End. Set the address switch on the appropriate A/D Converter to zero.

3. To avoid addressing conflict, remove all other installed options.

4. If a -161 A/D Converter is being used, install a -162 Thermocouple/DC Volts scanner in the slot directly below the a/d converter.

5. Connect a JNBS thermocouple to the HI and LO terminals for channel 11 on the Isothermal Input Connector.

6. Install the connector onto either the -162 Thermocouple/DC Volts Scanner or the Fast A/D Converter.

NOTE

> If other than a J type thermocouple is used, be sure that the TYPE parameter of the DEF CHAN command is consistent with the type of thermocouple being used.

7. Reconnect the ac line cord to the Front End and switch the power ON.

8. Insert the thermocouple and a mercury thermometer in a room temperature bath, and allow 20 minutes for thermal stabilization.

9. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

PROCEDURE A. TERMINAL MODE

If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

```
MODE=TERM <CR>

DEF CHAN(11)=TC,TYPE=JNBS <CR>

FORMAT=DECIMAL <CR>

TUNIT=CELSIUS <CR>

SEND CHAN(11) <CR>
```

The value displayed for channel 11 should be the temperature of the room temperature bath (within the tolerances in Table 175-2) as measured by the mercury thermometer. If the temperature measurement returned for channel 11 does not fall within these tolerances, refer to the calibration procedures, following PROCEDURE B.

Table 175-2. Thermocouple Accuracy Specifications

THERMOCOUPLE TYPE	90 DAYS @ 15-35 DEGREES C		1 YEAR @ 15-35 DEGREES C	
	-161 A/D	-165 A/D	-161 A/D	-165 A/D
JNBS	.35	.95	.4	1.0
KNBS	.4	1.2	.45	1.35
TNBS	.6	1.3	.65	1.35
ENBS	.3	.9	.35	.95
JDIN	.4	.9	.45	1.0
TDIN	.5	1.05	.55	1.1
NNBS	.6	1.7	.7	1.75

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a temperature measurement on the selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

> These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10  CLOSE 1
20  CLS
30  REM open communication port and empty Front End buffer
40  OPEN "com1:9600,n,8,1,cs,ds,cd"AS #1
50  PRINT #1,CHR$(3);
60  REM set up Front End
70  PRINT #1,"mode=comp"
80  GOSUB 300
90  PRINT #1,"count=off"
100 GOSUB 300
110 PRINT #1,"def chan(11)=tc,type=jnbs"
120 GOSUB 300
```

```
130 PRINT #1,"format=decimal"
140 GOSUB 300
150 PRINT #1,"tunit=celsius"
160 GOSUB 300
170 REM make measurement and read in response
180 PRINT #1,"send chan(11)"
190 INPUT #1,T$
200 PRINT USING "###.##";VAL(T$)
210 END
300 REM wait for message accepted prompt
310 INPUT #1,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

Program for 1722A:

```
10  CLOSE 1,2
20  PRINT CHR$(27);"[2J";
30  REM open communication port and empty Front End buffer
40  OPEN "KB1:"AS NEW FILE 1%
50  OPEN "KB1:"AS OLD FILE 2%
60  PRINT #1,CHR$(3);
70  REM set up computer Front End
80  PRINT #1,"mode=comp"
90  GOSUB 300
100 PRINT #1,"count=off"
110 GOSUB 300
120 PRINT #1,"def chan(11)=tc,type=jnbs"
130 GOSUB 300
140 PRINT #1,"format=decimal"
150 GOSUB 300
160 PRINT #1,"tunit=celsius"
170 GOSUB 300
180 REM make measurement and read in response
190 PRINT #1,"send chan(11)"
200 INPUT #2,T$
210 PRINT USING "S###.##",VAL(T$)
220 END
300 REM wait for message accepted prompt
310 INPUT #2,A$
320 IF A$<>"!" THEN GOTO 310
330 RETURN
```

The value returned for channel 11 should be the temperature of the room temperature bath (within the tolerances shown in Table 175-2) as measured by the mercury thermometer.

10. The Accuracy Verification Test is complete.

If thermocouple readings taken in the Accuracy Verification Tests are not within tolerance, calibrate the Thermocouple Input Connector.

CALIBRATION

To calibrate the Thermocouple Input Connector, perform the following procedure:

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING ANY OF THE PROCEDURES IN THIS SECTION.

1. Perform steps 1 through 8 of the Accuracy Verfication Test.

2. Take measurement readings (as described in PROCEDURE A or B of the Accuracy Verification Test), and adjust resistor R1 on the Thermocouple Input Connector until the Front End returns the same temperature reading as the mercury thermometer.

   In the Terminal Mode, repetitive measurements on a selected channel can easily be taken by sending the repeat command

   ! <CR>

   to the Front End each time you want to repeat the measurement.

   In the Computer Mode, repetitive measurements on a selected channel can be taken by modifying the loop in the Accuracy Verification Test program of Step 9 as follows:

   A. To modify the IBM PC program, change statement 210 to read

   ```
   210  GOTO 180
   ```

   B. To modify the Fluke 1722A program, change statement 220 to read

   ```
   220  GOTO 190
   ```

   Measurements on the selected channel(s) will now be continuously taken and displayed until the program is interrupted by the appropriate keyboard command.

3. Calibration of the Isothermal Input Connector is complete.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Isothermal Input Connector is given in Table 175-3.

For parts ordering information, see Section 6 of this manual.

Figure 175-2 is a schematic diagram of the Isothermal Input Connector.

TABLE 175-3. ISOTHERMAL INPUT CONNECTOR
(SEE FIGURE 175-2.)

REFERENCE DESIGNATOR A->NUMERICS--->		S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
C	1		CAP,CER,0.22UF,+-20%,50V,Z5U	519157	51406	RPE111Z5U224M50V	1		
H	1		WASHER,LOCK,SPLIT,S STEEL,#4	147603	89536	147603	6		
H	2		SCREW,MACH,PHS,BR,6-32X1/4	615591	89536	615591	60		
H	3		STEEL,CAD.PLATED,.125X .500	276493	89536	276493	4		
H	4		SCREW,MACH,PHP,S.STL,4-40X1-7/16	403782	89536	403782	6		
H	5		WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	4		
MP	1		BLOCK,ISOTHERMAL	579110	89536	579110	1		
MP	2		ISOTHERMAL,INSULATOR	579128	89536	579128	1		
MP	3		STANDOFF,BR,RD,SWGD,ANTI-ROT,6-32THRD	643148	89536	643148	60		
MP	4		CONNECTOR HOUSING, TOP	578971	89536	578971	1		
MP	5		CONNECTOR HOUSING, BOTTOM	656876	89536	656876	1		
MP	6		DECAL, ISOTHERMAL INPUT CONNECTOR	634584	89536	634584	1		
MP	7		DECAL, OPTION -175	634519	89536	634519	1		
MP	8		TAPE,FOAM,PVC,1/4W,3/8 THK	603134	89536	603134	2		
P	36, 37		CONN,PWB EDGE,REC,90,0.156 CTR,44 POS	614313	89536	614313	2	1	
Q	1		TRANSISTOR,SI,NPN,SELECTD,TEMP SENSOR	640862	89536	640862	1		
R	1		RES,VAR,CERM,50K,+-10%,0.5W	697300	89536	697300	1		
R	2		RES,MF,34.8K,+-1%,0.125W,25PPM	312181	89536	312181	1		
R	3		MATCHED RES. SET ISOTHERMAL	617597	89536	617597	1		
R	8		RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF551003F	1		

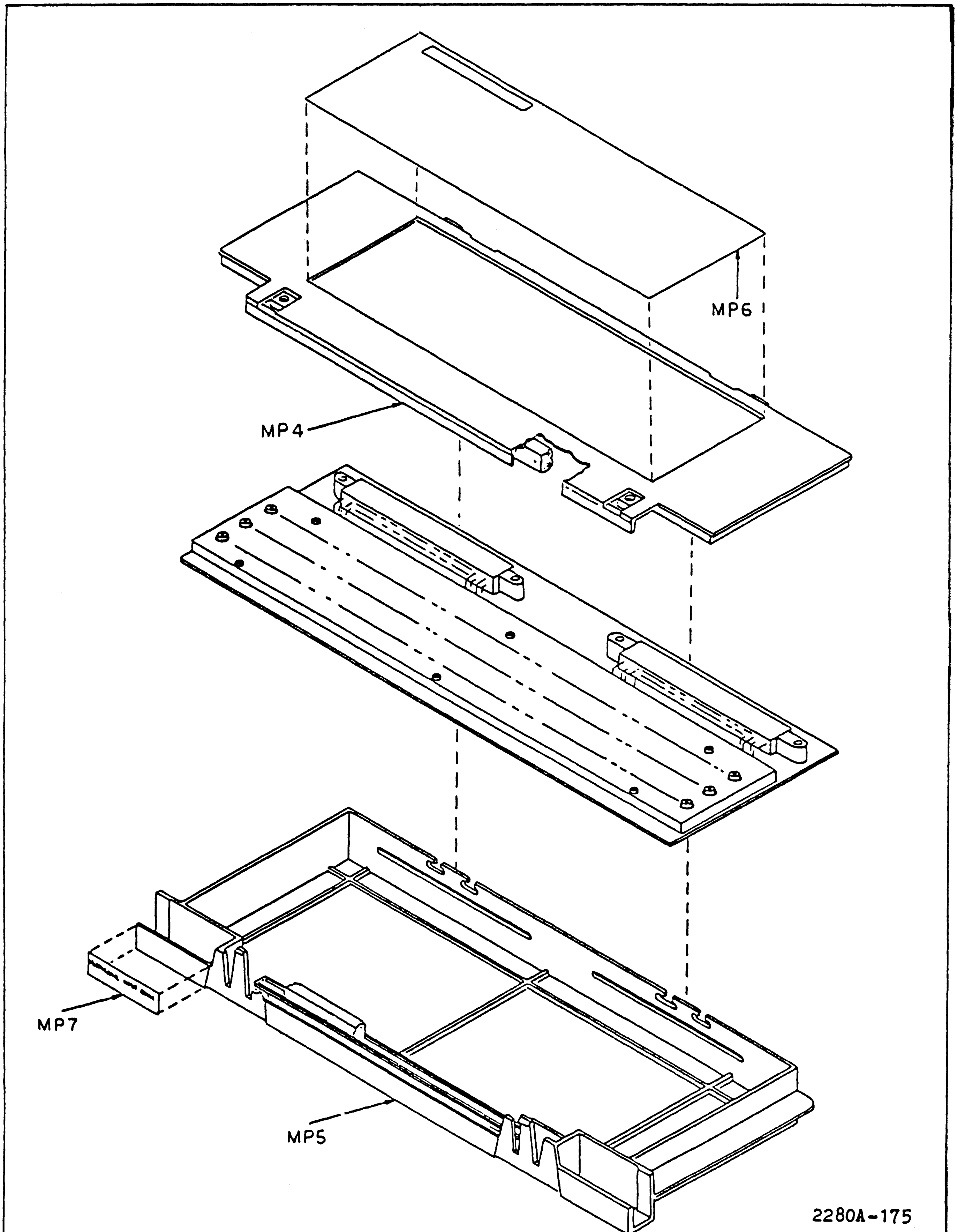
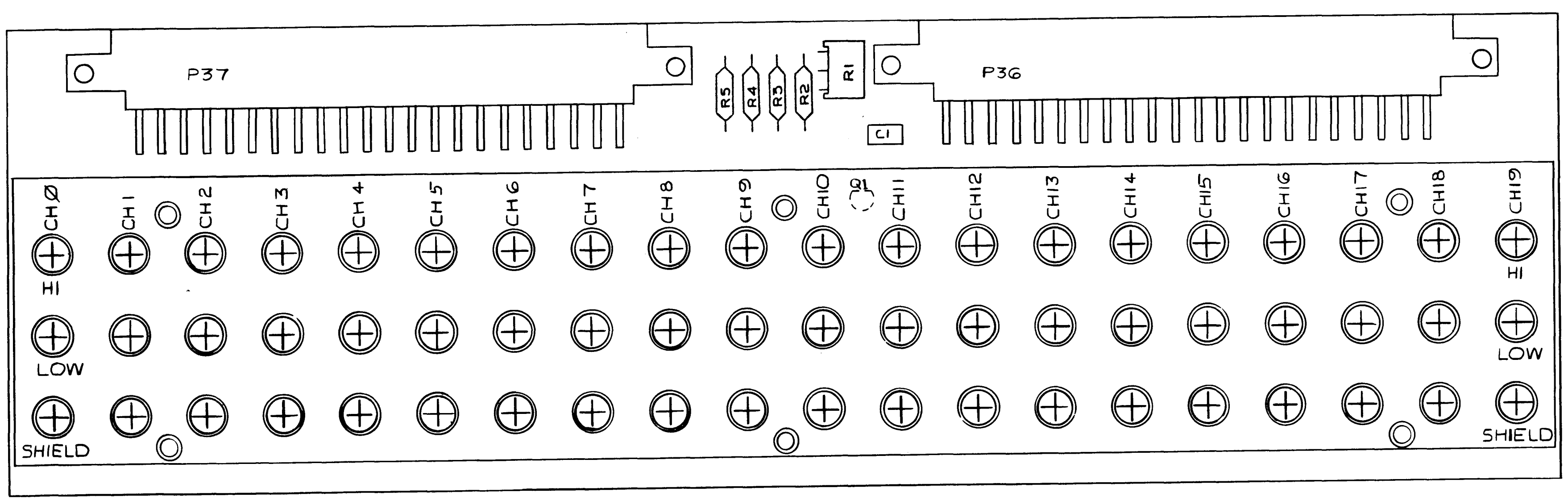
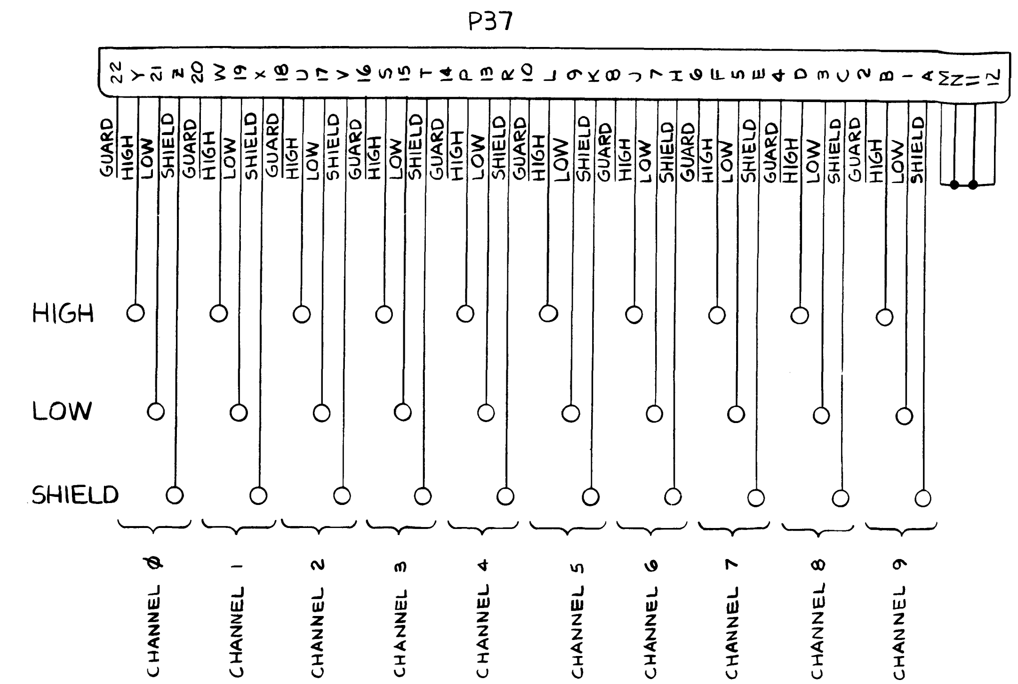
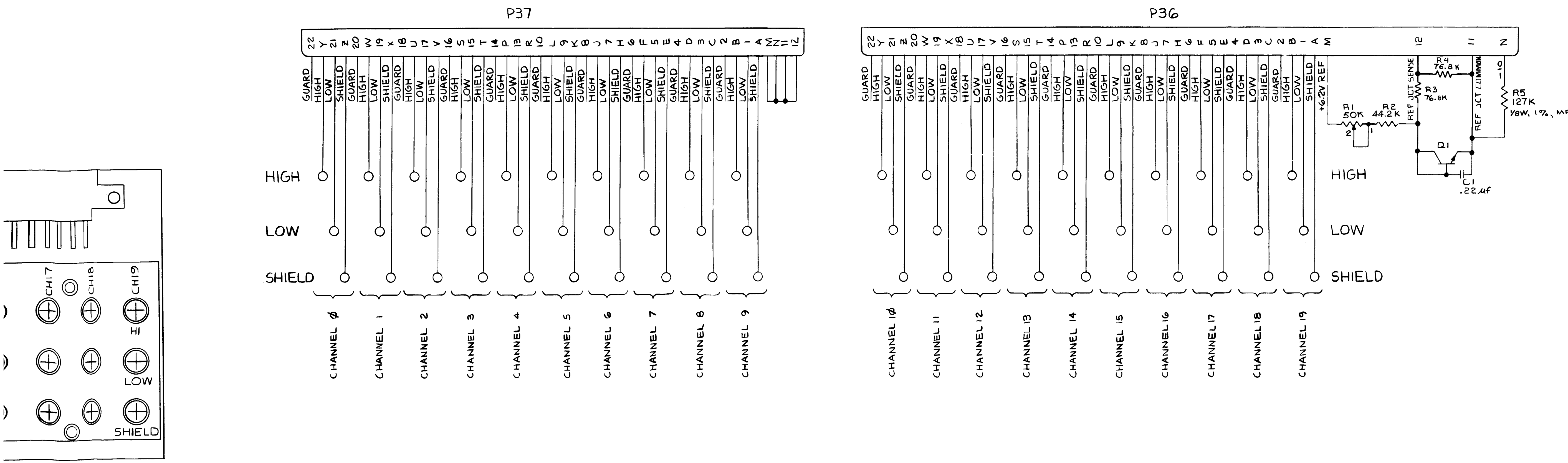


Figure 175-2. Isothermal Input Connector


P37
P36
R5
R4
R3
R2
R1
C1
CHØ
CH1
CH2
CH3
CH4
CH5
CH6
CH7
CH8
CH9
CH10
CH11
CH12
CH13
CH14
CH15
CH16
CH17
CH18
CH19
HI
LOW
SHIELD
HI
LOW
SHIELD


P37
GUARD
HIGH
LOW
SHIELD
HIGH
LOW
SHIELD
CHANNEL Ø
CHANNEL 1
CHANNEL 2
CHANNEL 3
CHANNEL 4
CHANNEL 5
CHANNEL 6
CHANNEL 7
CHANNEL 8
CHANNEL 9

2280A-1675



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCES ARE IN OHMS.
2. ALL RESISTORS ARE 1/8W, MF,.1%.
3. ALL CAPACITANCE IN MICROFARADS.
4. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.

REF DES
LAST USED
Q1
C1
R5

2280A-1075

Figure 175-2. Isothermal Input Connector Schematic Diagram

DESCRIPTION

The Voltage Input Connector can be attached either to the -162 Thermocouple/DC Volts Scanner for use with -161 High Performance A/D Converter, or directly to the -165 Fast A/D Converter.

- -162 Scanner/-161 A/D Converter

  A maximum of 20 voltage input channels are routed to the scanner. The connector attaches to the 88-pin edge connector at the rear of the scanner card.

- -165 A/D Converter

  A maximum of 20 differential input channel pairs or 40 single-ended input channels can be routed to the A/D Converter. The converter attaches to the 88-pin edge connector at the rear of the A/D Converter.

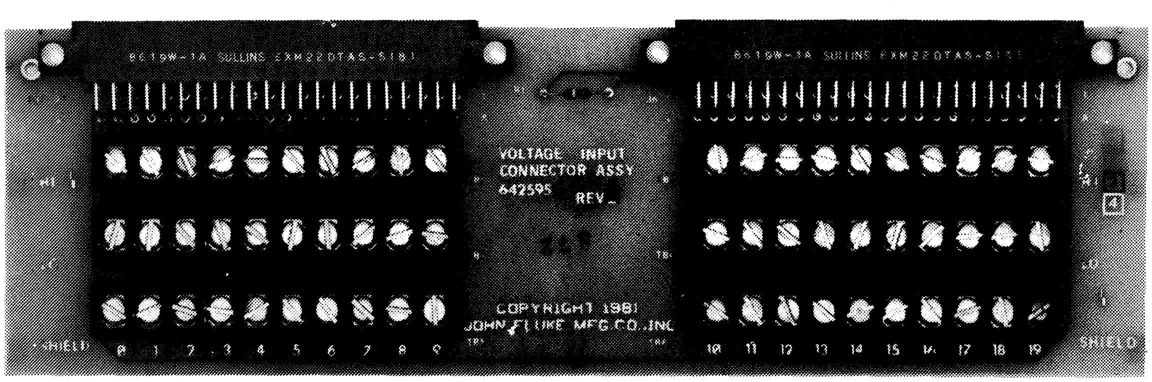


Figure 176-1. Voltage Input Connector

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Voltage Input Connector theory of operation, performance tests, a parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are found in the Helios Plus System Manual.

Test equipment required to perform the procedures in this subsection is listed in Table 176-1. A summary of test equipment required to perform all procedures in this manual is given in Table 2-2 in Section 2 of this manual.

Table 176-1. Required Test Equipment for -176

INSTRUMENT	REQUIRED SPECIFICATIONS	RECOMMENDED MODEL
DC Calibrator	+/- 31.3 mV +/- 20 uV +2.048V +/- 50 uV -2.048V +/- 2 uV of +2.048 500 mV +/- 20 uV 6.2V +/- 155 uV 6.8V +/- 0.1V 5.0V +/- 100 uV 7.9V +/- 200 uV *63V +/- 800 uV 1.008V, +/- 40 uV	Fluke 343
100:1 Divider	+/- 0.005%	Fluke Y2022
A/D Converter	NA	Fluke Option -161 or Fluke Option -165
Thermocouple/DC Volts Scanner	NA	Fluke Option -162 (only required with -161 A/D Converter)
Voltage Input Connector	NA	Fluke Option -176

* 63V output used for only one optional test.

THEORY OF OPERATION

The Voltage Input Connector theory of operation includes a functional description and a detailed circuit description. The schematic diagram for the connector is located at the end of this subsection.

Functional Description

The Voltage Input Connector provides screw terminal inputs for external dc voltage sources. Received voltages are then routed to either the Thermocouple/DC Volts Scanner, or the Fast A/D Converter.

Detailed Circuit Description

Up to 20 dc voltage sources can be attached to the Voltage Input Connector through HIGH, LOW and SHIELD terminals for each channel, with 250V rms spacing maintained between terminals.

The dc voltages across the high and low channel terminals are routed to the scanner through two card-edge connectors. The voltage inputs are then selected and conditioned, depending on the configuration used, by either the Thermocouple/DC Volts Scanner (for conversion by the High Performance A/D Converter), or by the Fast A/D Converter.

GENERAL MAINTENANCE

The -176 Voltage Input Connector normally does not require cleaning unless dirt, dust, or other contamination is visible on its surface. If cleaning is necessary, follow the instructions in Section 4 of this manual.

PERFORMANCE TEST

The following performance test can be used to verify that the Voltage Input Connector is functioning properly. The performance test can also be used as an initial acceptance test.

These tests can be performed using either one of two types of A/D Converter: the -161 High Performance A/D Converter or the -165 Fast A/D Converter. The higher reading rates realized with the -165 Fast A/D Converter yield somewhat lower resolution and accuracy than with the -161 High Performance A/D Converter.

WARNING

THE FRONT END CONTAINS HIGH VOLTAGES THAT CAN BE DANGEROUS OR FATAL. ONLY QUALIFIED PERSONNEL SHOULD ATTEMPT TO SERVICE THE EQUIPMENT. TURN OFF THE FRONT END AND REMOVE ALL POWER SOURCES BEFORE PERFORMING ANY OF THE PROCEDURES IN THIS SECTION.

1. Switch OFF power to the Front End. Disconnect the ac line power cord and all other high voltage inputs.

2. Install either a -161 High Performance A/D Converter or a -165 Fast A/D Converter in the uppermost option slot of the Front End. Set the address switch on the appropriate A/D Converter to zero.

3. To avoid addressing conflict, remove all other installed options.

4. Connect test leads to the HI and LO terminals for channel 0 on the -176 Voltage Input Connector.

5. Now, referring to the A/D Converter-specific instructions below, install the -176 Voltage Input Connector:

   o -161 High Performance A/D Converter

      A. Install a -162 Thermocouple/DC Volts Scanner in the slot directly below the A/D Converter.

      B. Install the -176 connector onto this -162 scanner.

   o -165 Fast A/D Converter

      A. Install the -176 connector directly onto this A/D Converter.

6. Reconnect the ac line cord to the Front End and switch the power ON.

7. Connect the calibrator output to the input of the 100:1 divider. Connect the divider output to the Voltage Input Connector test leads.

8. Set the calibrator output to 6.3000V dc (63 mV from the divider).

9. Program the Front End using either a terminal or a computer. (You can also run a terminal emulation program to use a computer behaving as a terminal.) For ease of testing, a terminal is the recommended host.

   Use either PROCEDURE A or PROCEDURE B, depending on whether performance testing will be done in Terminal or Computer Mode.

   PROCEDURE A. TERMINAL MODE

   If a terminal or a computer emulating a terminal is the selected host, send the following commands to the Front End.

   ```
   MODE=TERM <CR>

   DEF CHAN(0..19)=DVIN,MAX=0.063 <CR>

   FORMAT=DECIMAL <CR>

   SEND CHAN(0) <CR>
   ```

Depending on the A/D Converter in use, verify the returned value for the selected channel. Look for the following value ranges:

- o -161 High Performance A/D Converter

  6.29800E-02 through 6.30200E-02 (63±0.02 mV)

- o -165 Fast A/D Converter

  6.29500E-02 through 6.30500E-02 (63±0.05 mV)

PROCEDURE B. COMPUTER MODE

The following sample BASIC programs cause the Front End to take a dc voltage measurement on selected channel(s). One program was written for an IBM PC and one for a Fluke 1722A Instrument Controller.

NOTE

These programs are offered as examples. If you do not have an IBM PC or a Fluke 1722A Instrument Controller, enter a program that will run on your host.

Program for IBM PC:

```
10   CLOSE 1
20   CLS
30   REM open communication port, empty Front End buffer
40   OPEN "com1:9600,n,8,1,cs,ds,cd" AS #1
50   PRINT #1,CHR$(3);
60   REM set up Front End
70   PRINT #1,"mode=comp"
80   GOSUB 300
90   PRINT #1,"count=off"
100  GOSUB 300
110  PRINT #1,"def chan(0..19)=dvin,max=0.063"
120  GOSUB 300
130  PRINT #1,"format=decimal"
140  GOSUB 300
150  REM make measurement and read in response
160  PRINT #1,"send chan(0..19)"
170  FOR I=0 TO 19
180  INPUT #1,M$
190  PRINT "chan";I;"=";
200  PRINT USING "###.##";VAL(M$)*1000;
210  PRINT " millivolts DC"
220  NEXT I
230  END
300  REM wait for message accepted prompt
310  INPUT #1,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Program for 1722A:

```
10   CLOSE 1,2
20   PRINT CHR$(27);"[2J";
30   REM open communication port and empty Front End buffer
40   OPEN "KB1:"AS NEW FILE 1%
50   OPEN "KB1:"AS OLD FILE 2%
60   PRINT #1,CHR$(3);
70   REM set up Computer Front End
80   PRINT #1,"mode=comp"
90   GOSUB 300
100  PRINT #1,"count=off"
110  GOSUB 300
120  PRINT #1,"def chan(0..19)=dvin,max=0.063"
130  GOSUB 300
140  PRINT #1,"format=decimal"
150  GOSUB 300
160  REM make measurement and read in response
170  DIM M$(20)
180  PRINT #1,"send chan(0..19)"
190  FOR I%=0 TO 19\INPUT #2,M$(I%)\NEXT I%
200  X%=0\I%=0
210  FOR C%=0 TO 1
220  PRINT TAB(35*C%);"chan";I%;"=";
230  PRINT USING "S###.##",VAL(M$(X%))*1000;\PRINT" millivolts DC";
240  X%=X%+1\I%=I%+1\IF X%>19 THEN 270
250  NEXT C%
260  GOTO 210
270  END
300  REM wait for message accepted prompt
310  INPUT #2,A$
320  IF A$<>"!" THEN GOTO 310
330  RETURN
```

Depending on the A/D Converter in use, verify the returned value for the selected channel. Look for the following value ranges:

- -161 High Performance A/D Converter

  6.29800E-02 through 6.30200E-02 (63 ± 0.02 mV)

- -165 Fast A/D Converter

  6.29500E-02 through 6.30500E-02 (63 ± 0.05 mV)

10. Set the calibrator output to 0. Move the test leads of the Voltage Input Connector to the terminals to test the next channel.

11. Repeat steps 8 through 10 for each remaining voltage input channel (1 through 19), substituting the appropriate channel number in the SEND CHAN command if Terminal Mode is being used.

12. The Voltage Input Connector performance test is complete.

CALIBRATION

The Voltage Input Connector requires no calibration.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Voltage Input Connector is given in Table 176-2.

For parts ordering information, see Section 6 of this manual.

Figure 176-2 is a schematic diagram of the Voltage Input Connector.

TABLE 176-2. -176 VOLTAGE INPUT CONNECTOR
(SEE FIGURE 176-2.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	NOTE
H 1		STEEL,CAD.PLATED,.125X .500	276493	89536	276493	4	
H 2		WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	4	
MP 1		CONNECTOR HOUSING, TOP	578971	89536	578971	1	
MP 2		CONNECTOR HOUSING, BOTTOM	656876	89536	656876	1	
MP 3		DECAL, OPTION -176	634527	89536	634527	1	
MP 4		DECAL, VOLTAGE INPUT CONNECTOR	634592	89536	634592	1	
MP 5		TAPE,FOAM,PVC,1/4W,3/8 THK	603134	89536	603134	2	
P 36, 37		CONN,PWB EDGE,REC,90,0.156 CTR,44 POS	614313	89536	614313	2	
R 1		RES,CF,3.9K,+-5%,0.25W	342600	80031	CR251-4-5P3K9	1	
TB 1- 6		SINGLE ROW, .325 CENTERS, 10 POSITION	615328	89536	615328	6	

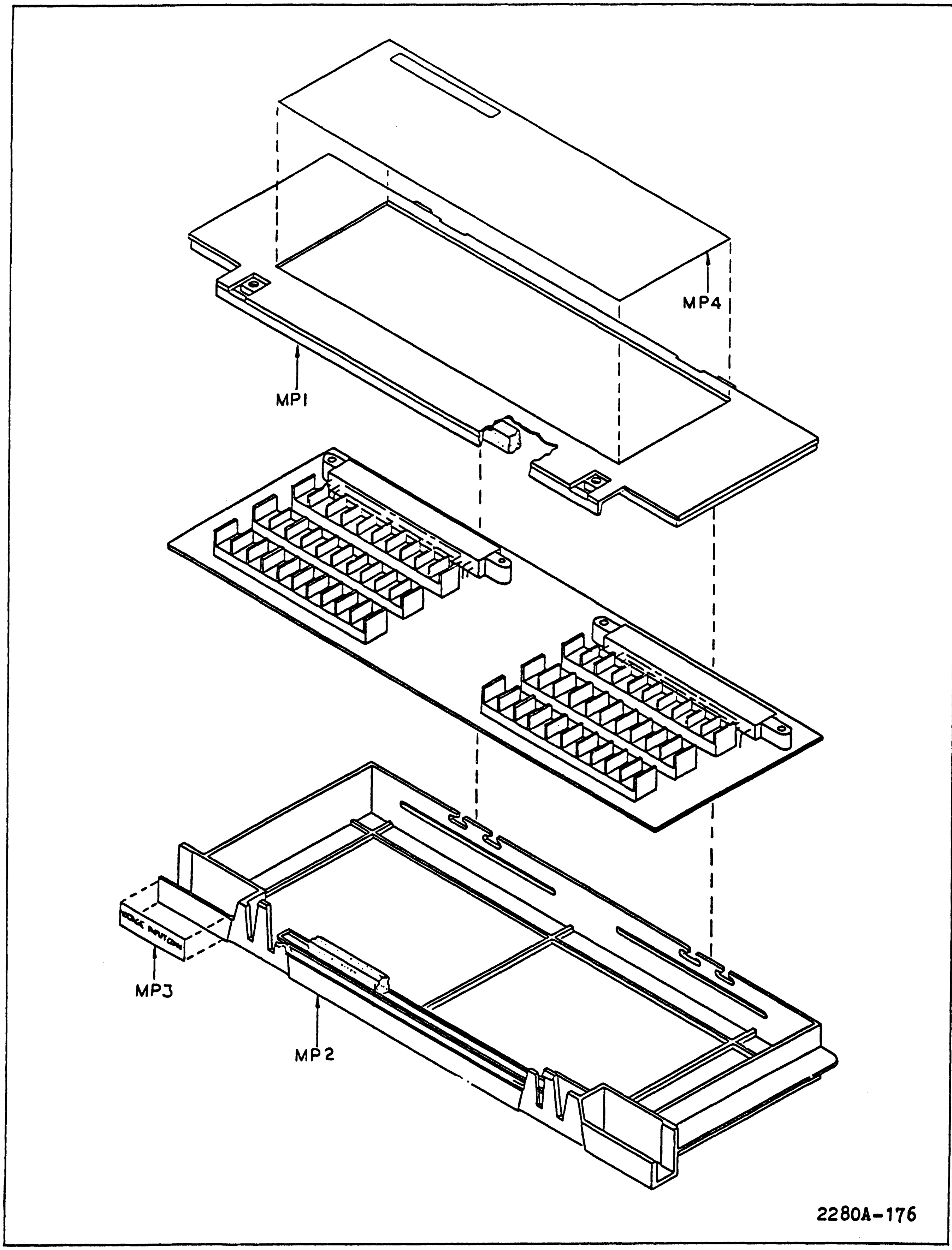
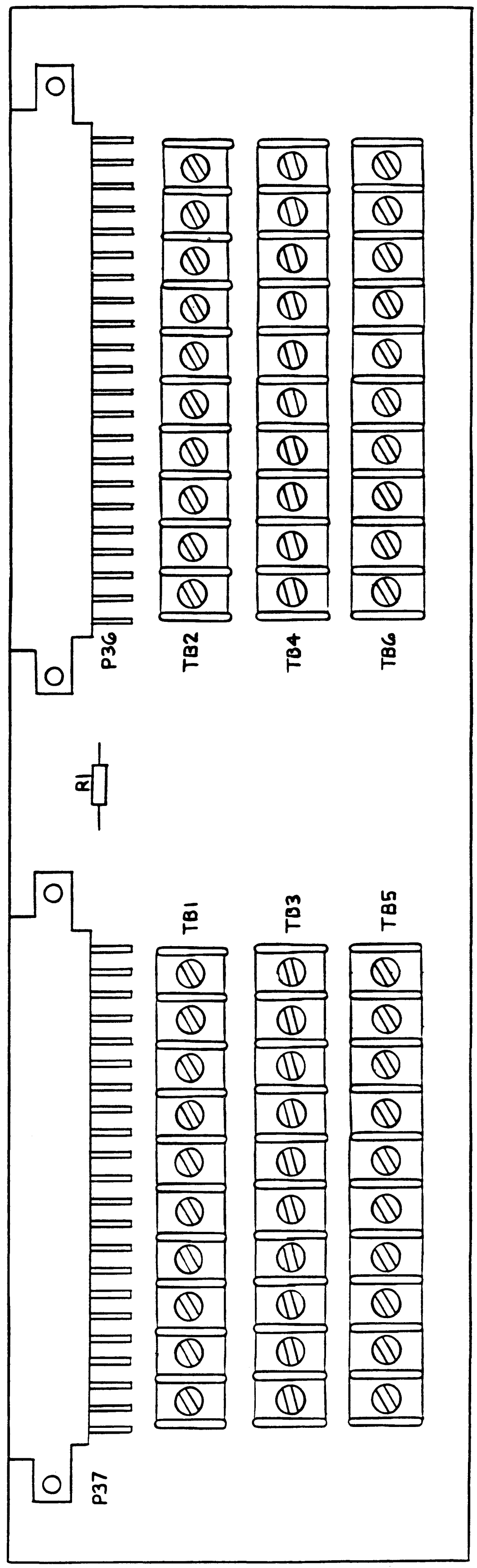


Figure 176-2. Voltage Input Connector



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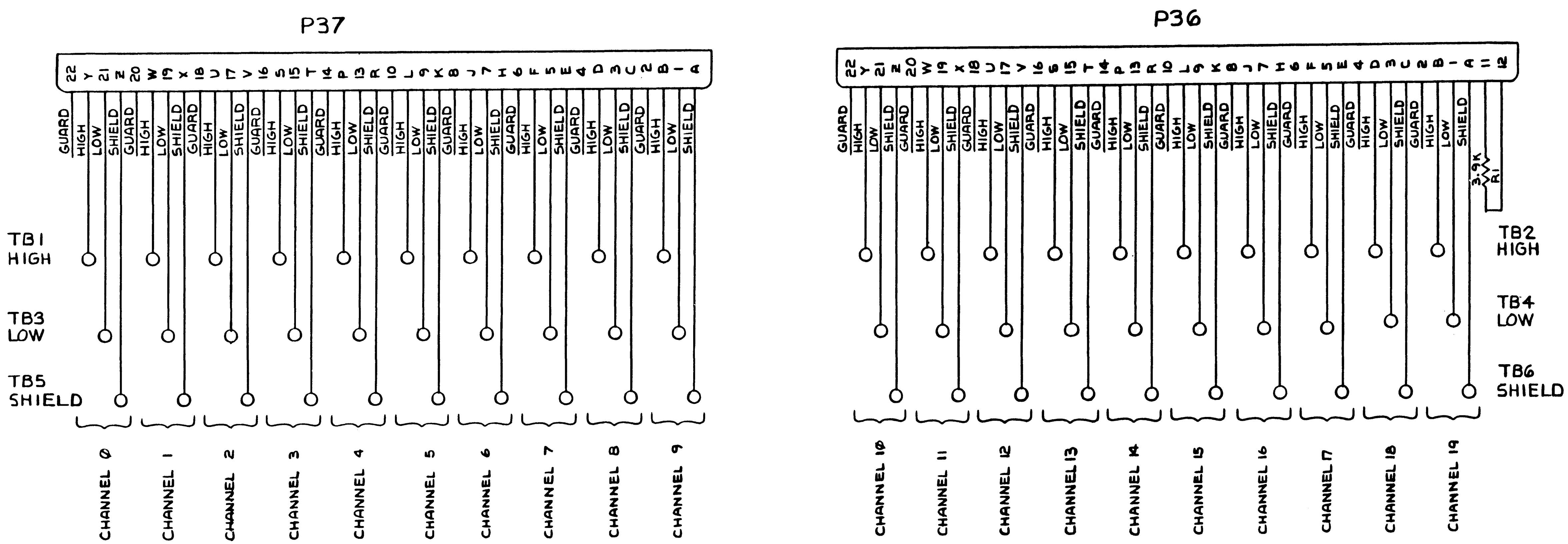

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Figure 176-2. Voltage Input Connector Schematic Diagram

DESCRIPTION

The -177 RTD/Resistance Connector (shown in Figure 177-1) mounts on the rear of the -163 RTD/Resistance Scanner and provides 20 sets of input screw terminals for connection to RTDs and resistances.

The -177 connector assembly is enclosed in a plastic housing that provides protection for terminal connections and strain relief for external wiring. Retaining screws at each end of the housing fasten the assembly to the Front End chassis.

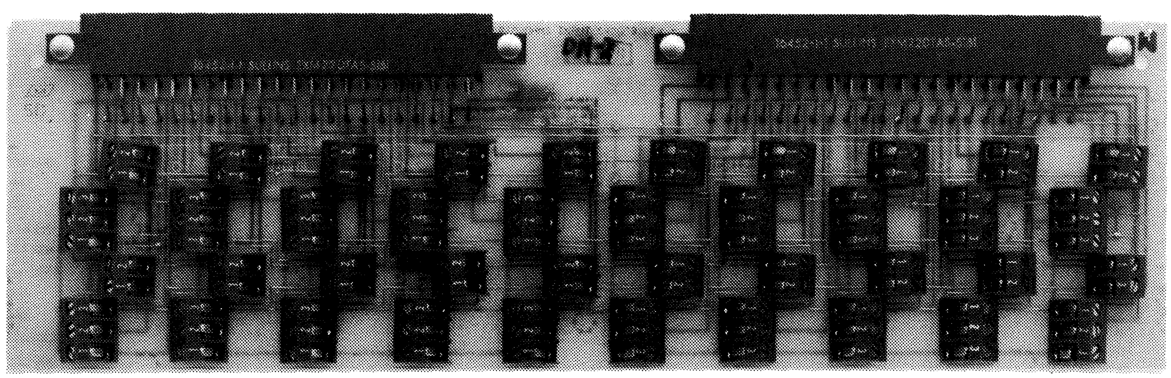


Figure 177-1. RTD/Resistance Input Connector

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: RTD/Resistance Input Connector theory of operation, performance test information, replacement parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are located in the Helios Plus System Manual.

THEORY OF OPERATION

The RTD/Resistance Input Connector theory of operation includes an overall level functional description and a detailed circuit description. The schematic diagram for the Input Connector is located at the end of this subsection.

Overall Functional Description

The RTD/Resistance Input Connector provides screw terminal inputs for connection to external resistances. These resistances are passed through two connectors to the -163 RTD/Resistance Scanner for conditioning.

Detailed Circuit Description

Twenty RTDs or other resistance sensors can be attached to the connector using five terminals per channel: HI EXC, HI, LO, LO EXC, and LO COM. Four terminals per channel are isolated from the other channels, providing for three 4-wire and one 3-wire mode of operation. The fifth terminal on each channel, LO COM, is a common return for either channels 0 through 9 or 10 through 19, providing for accuracy in 3-wire mode of operation. The 44-pin edge connectors provide paths through which the RTD/Resistance Scanner can select, excite, and measure resistances wired to the connector terminals.

GENERAL MAINTENANCE

The -177 RTD/Resistance Input Connector normally does not require cleaning unless dirt, dust, or other contamination is visible on the surface. If cleaning is necessary, refer to the cleaning instructions in Section 4 of this manual.

PERFORMANCE TEST

There is no separate performance test procedure for the -177 RTD/Resistance Input Connector.

The -177 connector is tested along with the -163 RTD/Resistance Scanner. Refer to the -163 RTD/Resistance Scanner subsection of Section 8.

CALIBRATION

The RTD/Resistance Input Connector does not require calibration.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the RTD/Resistance Input Connector is given in Table 177-1.

For parts ordering information, see Section 6 of this manual.

Figure 177-2 is a schematic diagram of the RTD/Resistance Input Connector.

TABLE 177-1. -177 RTD/RESISTANCE INPUT CONNECTOR
(SEE FIGURE 177-2.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	NOT-E
H 1		STEEL,CAD.PLATED,.125X .500	276493	89536	276493	4	
H 2		WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	4	
MP 1		CONNECTOR HOUSING, TOP	578971	89536	578971	1	
MP 2		CONNECTOR HOUSING, BOTTOM	656876	89536	656876	1	
MP 3		DECAL,RTD/OHMS INPUT CONN.	748038	89536	748038	1	
MP 4		DECAL, OPTION -177	748020	89536	748020	1	
MP 5		TAPE,FOAM,PVC,1/4W,3/8 THK	603134	89536	603134	2	
P 39, 40		CONN,PWB EDGE,REC,90,0.156 CTR,44 POS	614313	89536	614313	2	
TB 1- 10, 21-		TERM STRIP,PWB,ANGL ENTRY,2 CONTACTS	478867	89536	478867	20	
TB 30			478867				
TB 11- 20, 31-		TERM STRIP,PWB,ANGL ENTRY,3 CONTACTS	474221	89536	474221	20	
TB 40			474221				

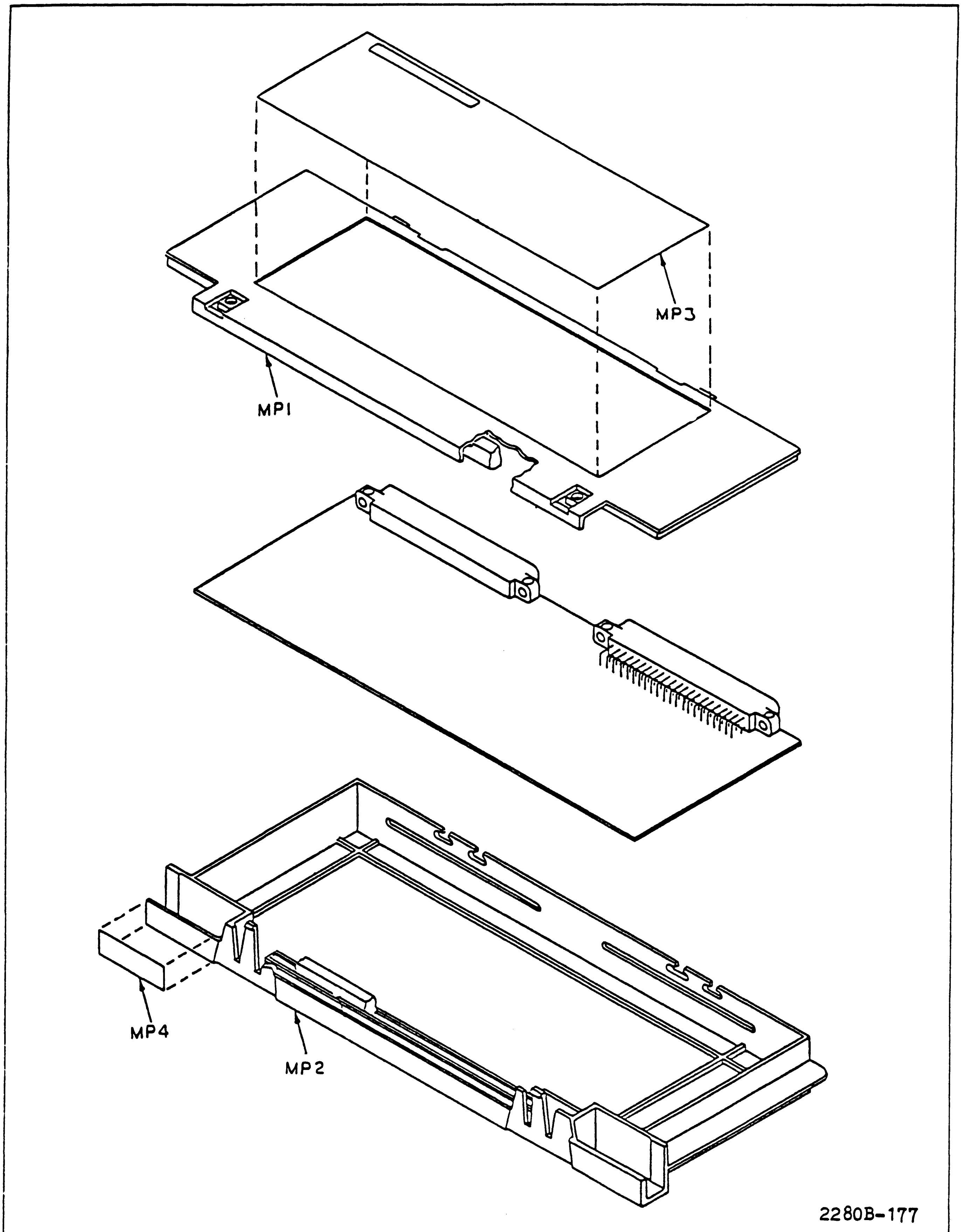
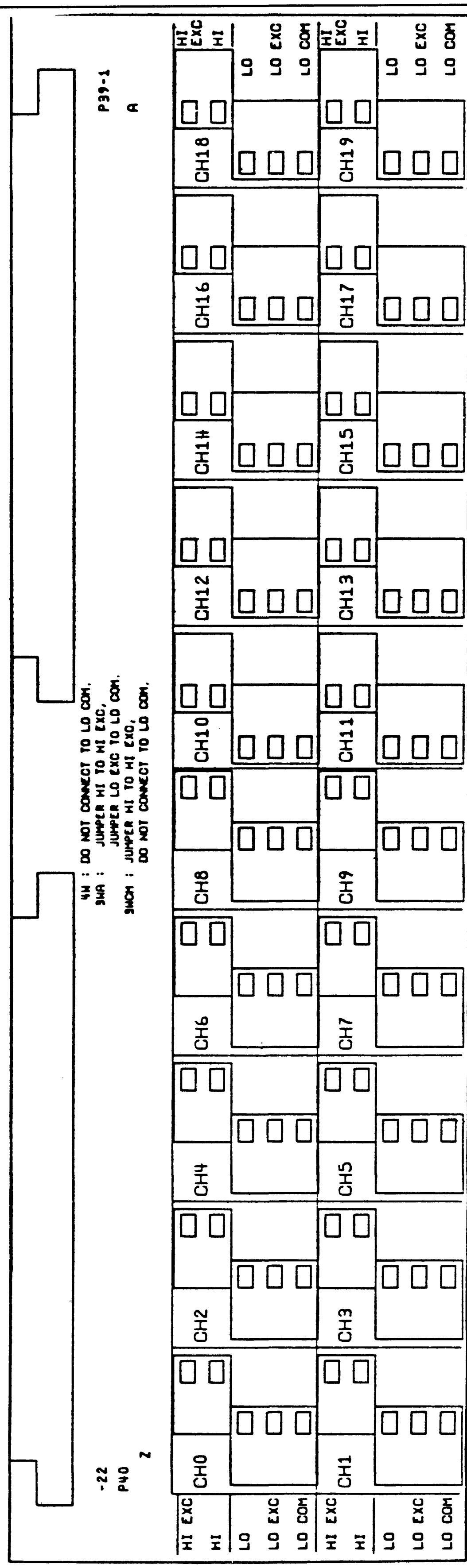


Figure 177-2. -177 RTD/Resistance Input Connector


P39-1
A
4W : DO NOT CONNECT TO LO COM.
3WA : JUMPER HI TO HI EXC,
JUMPER LO EXC TO LO COM.
3WCM : JUMPER HI TO HI EXC,
DO NOT CONNECT TO LO COM.
-22
P40
Z
HI EXC
HI
LO
LO EXC
LO COM
CH0
CH1
CH2
CH3
CH4
CH5
CH6
CH7
CH8
CH9
CH10
CH11
CH12
CH13
CH14
CH15
CH16
CH17
CH18
CH19

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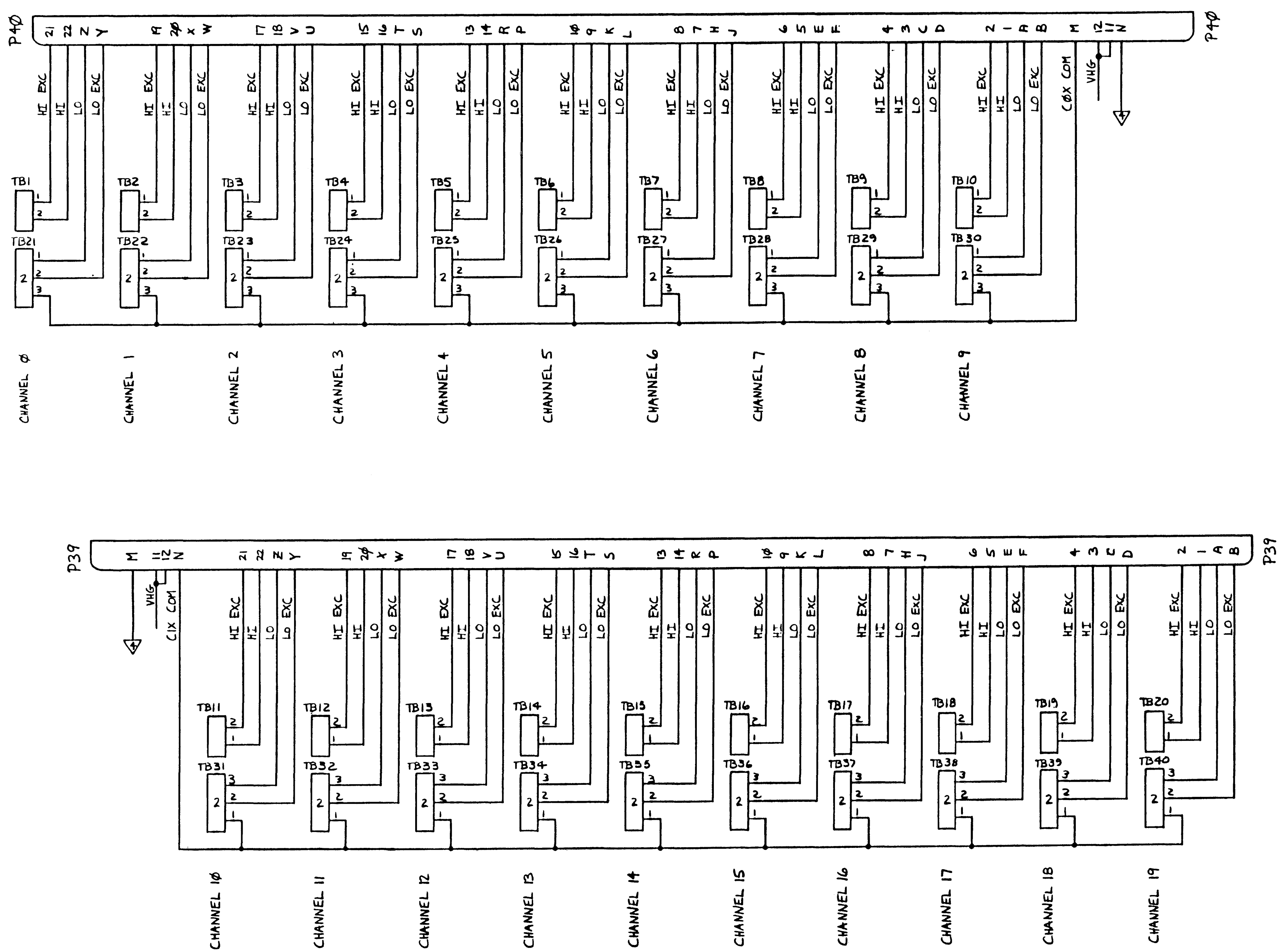

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.

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Figure 177-2. RTD/Resistance Connector Schematic Diagram

DESCRIPTION

The -179 Digital/Status Input Connector (shown in Figure 179-1) connects to the -168 Digital I/O Assembly, providing screw-terminal connections that allow the input of BCD digital data, binary digital data, or status input information to the Front End.

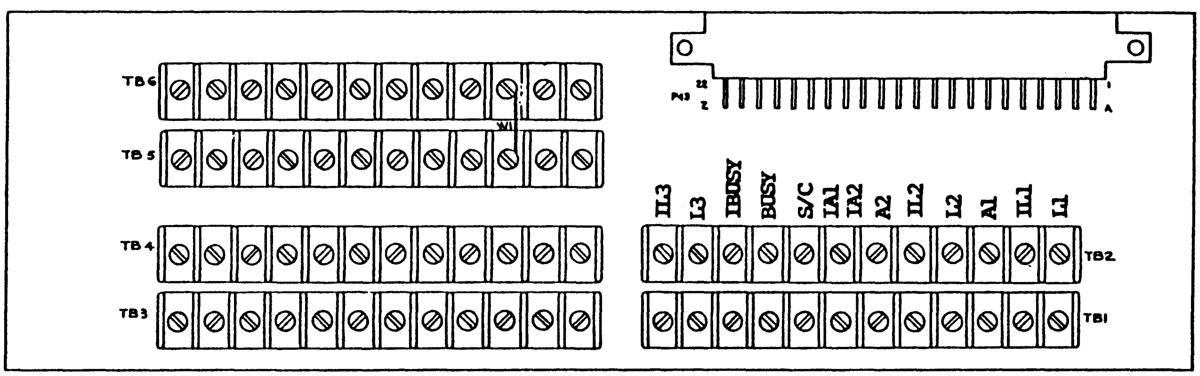


Figure 179-1. Digital/Status Input Connector

WHERE TO FIND ADDITIONAL INFORMATION

This subsection contains: Digital/Status Input Connector theory of operation, performance testing information, a replacement parts list, and a schematic diagram.

Installation, operating, and system configuration instructions are found in the Helios Plus System Manual.

Option specifications are found in an appendix of this manual and in the System Manual.

THEORY OF OPERATION

The Digital/Status Input Connector provides a path from screw terminals on the connector body to the card-edge connector pins on the Digital I/O Board. There is no circuitry on the Digital/Status Input Connector PCA other than printed traces. Instructions for configuring the connector are given in the Helios Plus Computer Front End System Manual.

When configured for status input, the Digital/Status Input Connector allows the -168 Digital I/O Assembly to accept a maximum of 20 separate one-bit inputs from an external source for each Digital I/O assembly installed in the Front End Mainframe or a 2281A Extender Chassis. Each bit is associated with a channel programmed as status input.

When configured for digital input, the Digital/Status Input Connector allows the Digital I/O Assembly to accept 20 bits of parallel digital data from an external source. This data is received at the channel address set on the associated Digital I/O Board.

GENERAL MAINTENANCE

The -179 Digital/Status Input Connector normally does not require cleaning, unless dirt, dust, or other contamination is visible on its surface. If cleaning is necessary, follow cleaning instructions in Section 4 of this manual.

PERFORMANCE TESTS

There is no separate performance test for the -179 Digital/Status Input Connector. The -179 connector is tested during input mode performance testing of the -168 Digital I/O Assembly performance test. Refer to the -168 Digital I/O assembly subsection of section 8.

CALIBRATION

There are no calibration adjustments for the Digital/Status Input Connector.

LIST OF REPLACEABLE PARTS AND SCHEMATIC DIAGRAM

An illustrated parts list for the Digital/Status Input Connector is given in Table 179-1.

For parts ordering information, see Section 6 of this manual.

Figure 179-2 is a schematic diagram of the Digital Status Input Connector.

TABLE 179-1. -179 DIGITAL/STATUS INPUT CONNECTOR
(SEE FIGURE 179-2.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	NOTE
H 1		STEEL,CAD.PLATED,.125X .500	276493	89536	276493	2	
H 2		WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	2	
MP 1		CONNECTOR HOUSING, TOP	578971	89536	578971	1	
MP 2		CONNECTOR HOUSING, BOTTOM	656876	89536	656876	1	
MP 3		DECAL,DIGITAL/STATUS INPUT CONN.	634626	89536	634626	1	
MP 4		DECAL, OPTION -179	634550	89536	634550	1	
MP 5		TAPE,FOAM,PVC,1/4W,3/8 THK	603134	89536	603134	2	
P 43		CONN,PWB EDGE,REC,90,0.156 CTR,44 POS	614313	89536	614313	1	
TB 1- 6		SINGLE ROW, .325 CENTERS, 12 POSITION	615690	89536	615690	6	

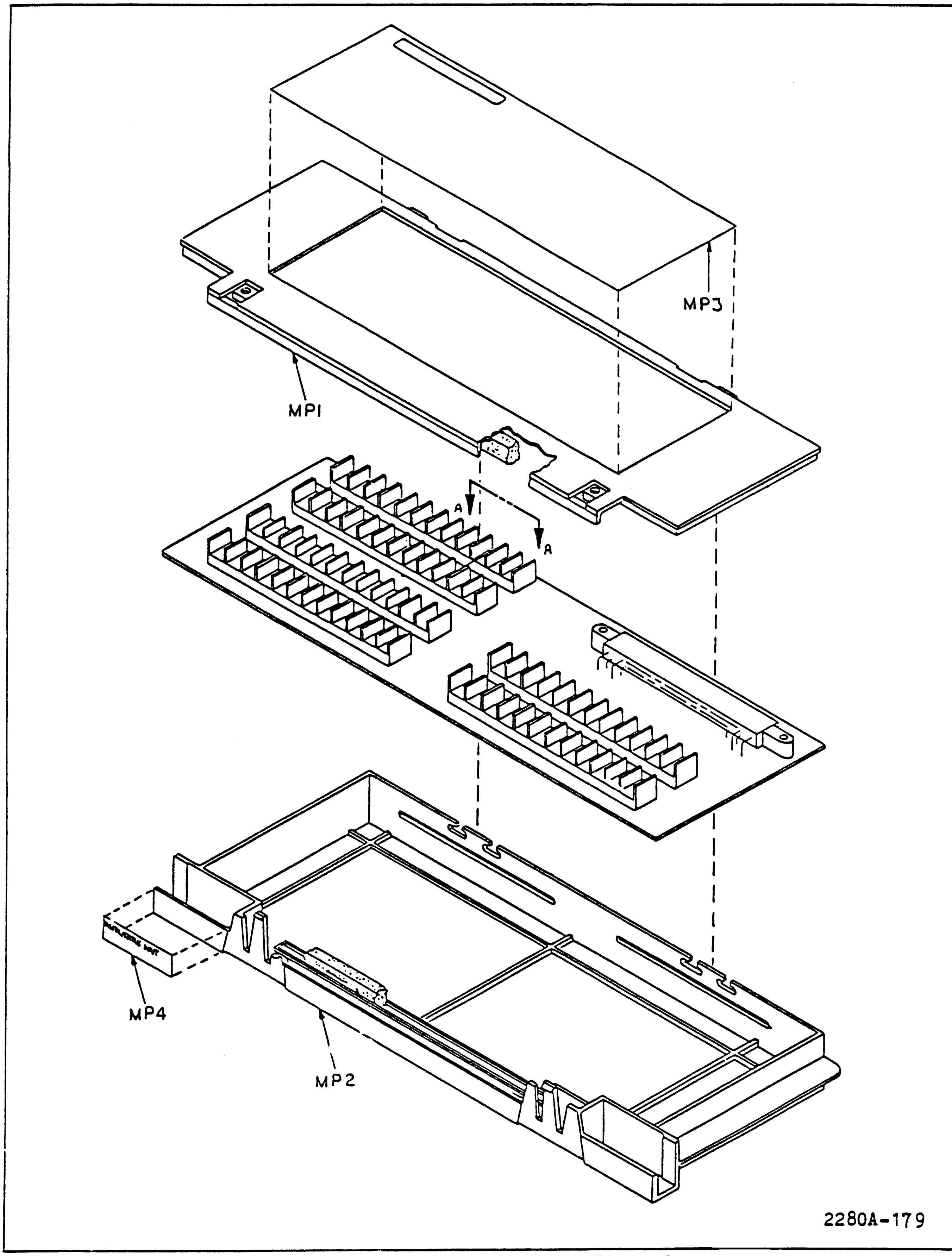
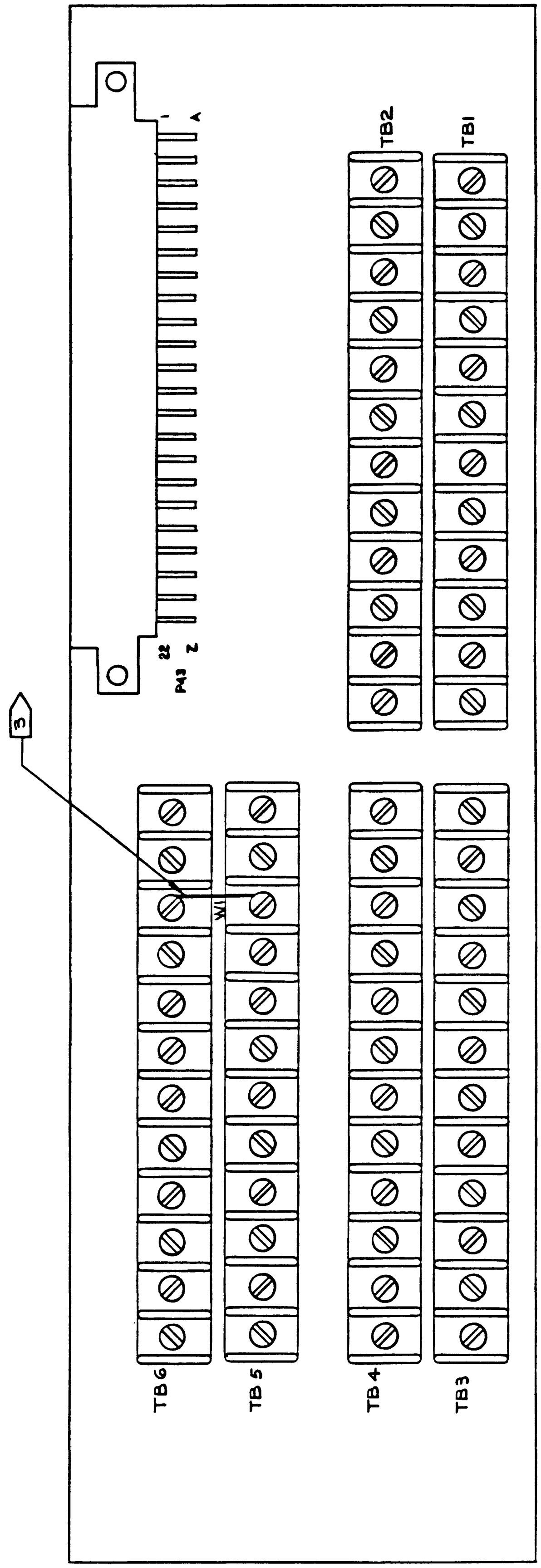


Figure 179-2. -179 Digital/Status Input Connector



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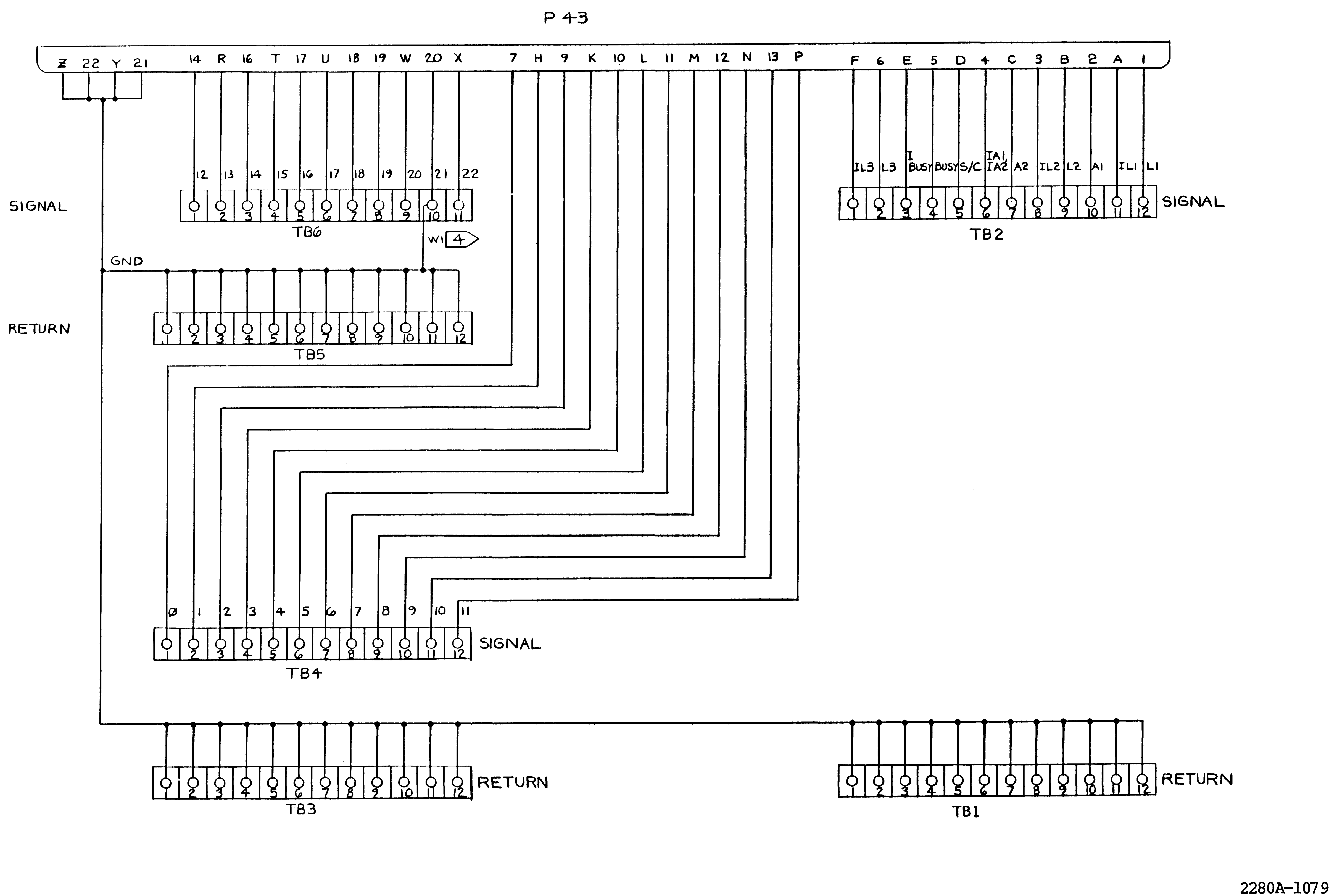

Figure 179-2. Digital/Status Input Connector Schematic Diagram

CONTENTS

APPENDIX A
SPECIFICATIONS

MAINFRAME SPECIFICATIONS

Channel Capacity
- Mainframe .... 120 Differential, or 240 Single-Ended (-165), or 120 Digital
- System .... 1000 maximum

Memory .... Nonvolatile, with 15 day typical, 10 day minimum battery backup

Scanning Speed (analog inputs)

Dependent on system configuration and programming, Maximum System Scanning Speed in Channels per Second

-161 High Performance A/D Converter

-161 Converters in System	Direct Voltage Readings
1	16
2	30
3	42
4	50

-165 Fast A/D Converter

-165 Converters in System	Direct Voltage Readings Continuous	Burst
1	70	1000
2	70	2000
3	70	3000
4	70	4000

Power
- AC .... 90-132V, 180-264V, 47-440 Hz
- Dissipation .... <40W

Temperature
- Operating .... 0 to 65°C
- Storage .... -40 to 70°C

Humidity (non-condensing)
- 0 to 25°C .... <95%
- 25 to 40°C .... <75%
- 40 to 50°C .... <45%

Weight .... 8.5 kg (19 lbs) Without options

Dimensions ....

Height	Width	Depth
23.8 cm x	43.9 cm	x 35.9 cm
9.35"	x 17.30"	x 14.13"

Altitude
- Operating .... 3050m (10,000 feet)
- Non-operating .... 12,200m (40,000 feet)

Shock and Vibration .... Meets MIL-T-28800C Class 5, Style F Standard

Interface Specifications

Type .... Asynchronous, either RS-232-C or RS-422

Connector .... 25-pin male; pinout depends on S1 setting: RS-232 or RS-422

25-Pin Host Connector Pinout (S1 in RS-232-C Position)

PIN NUMBER	SIGNAL
(1)	Shield
(2)	Transmitted Data
(3)	Received Data
(4)	Request to Send
(5)	Clear to Send
(6)	Data Set Ready
(7)	Signal Ground
(8)	Received Line Signal Detector
(12)	Secondary Received Line Signal Detector
(20)	Data Terminal Ready
(22)	Ring Indicator

Required RS-232-C Signals .... Transmit Data, Receive Data, Signal Ground. All other lines are passively asserted true. Instrument will operate if these other lines are left disconnected.

RS-232 Modem Control .... Full duplex

25-Pin Connector Pinout (S1 in RS-422 Position)

PIN NUMBER	SIGNAL
(1)	Shield
(7)	Common
(9)	Transmit +
(10)	Transmit -
(14)	Receive +
(15)	Receive -

NOTE

RS-232-C signals are present on their associated pins even when S1 is set for RS-422 operation, but they are not used when configured for RS-422.

25-Pin Printer Port Connector Pinout

PIN NUMBER	SIGNAL
1	Shield
2	Transmitted Data
3	Received Data
4	Request to Send
5	Clear to Send
6	Data Set Ready
7	Signal Ground

Baud Rate .... Switch-selectable: 110, 300, 600, 1200, 2400, 4800, 9600, 19200

ASCII format .... 7 or 8 bit, 1 or 2 stop bits. Switch-selectable

Parity .... Odd, even, or none. Switch- selectable

Multi-drop capability .... Available via RS-422. Ten mainframes can be addressed by a host through a single RS-422 port. Address is switch-selectable.

Alarm Annunciator Terminal Strip

TERMINAL NUMBER	FUNCTION
8	Connect to normal closed contact of the alarm acknowledgement push button.
7	Connect to normally open contact of the alarm acknowledgement push button.
6	Connect to common contact of the alarm acknowledgement push button.
5	no connection
2, 4	Normally open contacts for visual alarm light (max 110V ac, 1A)
1, 3	Normally open contacts for audible alarm. (max 110V ac, 1A)

OPTIONS SPECIFICATIONS

-160 AC Voltage Input Connector Specifications

Channels .... 10 AC, 10 DC
Terminals .... 40 (2 per channel)
AC Voltage
    Range .... 5V to 250V rms
    Resolution .... 0.1V ac
    Maximum Input .... 250V rms between two terminals
    Frequency Range .... 45 Hz to 450 Hz
    Accuracy .... See System Accuracy Specifications
    Conversion Method .... 1/2 wave, average responding, calibrated to indicate the rms value of a sine wave.
DC Voltage
    Ranges and Accuracy .... Determined by option -162.
    Maximum Input .... 250V dc between any two terminals
Maximum Common Mode Voltage ...... 250V dc or 250V ac rms between terminals or between a terminal and ground.
Compatibility .... Attaches to -162 Thermocouple/DC Volts Scanner, which is used with -161 High Performance A/D Converter.
Temperature
    Operating .... -20 to 70°C
    Storage .... -55 to 75°C
Relative Humidity (without condensation)
    Below 25°C .... <= 95%
    25 to 40°C .... <= 75%
    40 to 50°C .... <= 45%
    50 to 70°C .... <= 40%
Altitude
    Non-Operating .... 40,000 feet
    Operating .... 10,000 feet
Shock and Vibration .... Meets MIL-T-28800C, Class 5 Standards

-161 High Performance A/D Converter Specifications

Dynamic Range (internal)	±131,071 counts at 50 Hz ±109,226 counts at 60 Hz
Common Mode Rejection .... (with 100 ohm imbalance)	170 dB at 50 Hz ±0.1% 170 dB at 60 Hz ±0.1% 160 dB at dc
Normal Mode Rejection	60 dB at 50 Hz ±0.1% or 60 Hz ±0.1%
Isolation	250V dc or ac rms between -161 and any other module.
Measurement Method	Dual slope, integrating over 1 line cycle
Zero Stability	Automatic zero
Ranges, Resolution, Accuracy ...	Determined by Scanner (see -162 and -163 and application) See Accuracy sections: Temperature Measurement Using Thermocouples Temperature Measurement Using RTDs DC Voltage Measurement AC Voltage Measurement DC Current Measurement Resistance Measurement Strain Measurement
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

-162 Thermocouple/DC Volts Scanner Specifications

Channels	20	
Poles per Channel	3 (HI, LO, SHIELD)	
Input Impedance		
64 mV and 512 mV Ranges	>200 megohm in parallel with 6800 pF	
8V and 64V Ranges	10 megohm	
Voltage Offset (max)	1 uV	
Ranges and Displayed Resolution	60 Hertz	50 Hertz
64 mV Range	0.6 uV	0.5 uV
512 mV Range	5.0 uV	4.2 uV
8V Range	73 uV	61 uV
64V Range	0.6 mV	0.5 mV
Accuracy	Determined by application. See Accuracy sections: Temperature Measurement (Using Thermocouples; Using RTDs); DC Voltage Measurement; AC Voltage Measurement; DC Current Measurement; Resistance Measurement; Strain Measurement	
Zero Stability	Automatic Zero	
Input Isolation	250V dc or ac rms between any two channels or any channel and ground	
Overload without Damage	250V dc or 250V ac rms	
Common Mode Voltage (max)	250V dc or ac rms between any 2 terminals or a terminal and ground	
Common Mode Rejection (with 100 ohm imbalance)	170 dB at 50 Hz ±0.1% 170 dB at 60 Hz ±0.1% 160 dB at dc	
Normal Mode Rejection	60 dB at 50 Hz ±0.1% or 60 Hz ±0.1%	
Compatibility	Used with -162 Thermocouple/DC Volts Scanner or -164 Transducer Excitation Module (Configuration B).	
Temperature		
Operating	-20 to 70°C	
Storage	-55 to 75°C	
Relative Humidity (without condensation)		
Below 25°C	<= 95%	
25 to 40°C	<= 75%	
40 to 50°C	<= 45%	
50 to 70°C	<= 40%	
Altitude		
Non-Operating	40,000 feet	
Operating	10,000 feet	
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards	

Open Thermocouple Detection

Open Input .... Resistance greater than 10,000 ohms and shunt capacitance less than 0.1 uF.

9.99999E37 (overload) is returned. If SEND ERROR is sent, error 16 (OPEN TC) is returned.

Normal Input .... Resistance less than 1000 ohms, or shunt capacitance greater than 0.1 uF.

NOTE

For resistances between 1000 and 10,000 ohms, open thermocouple detection is indeterminate. Usually, a thermocouple with resistance in this range soon becomes an open input. During scanning, testing occurs with each thermocouple reading.

-163 RTD/Resistance Scanner Specifications

Channels	20
Poles per Channel	4 (HI EXCITATION, HI, LO, LO EXCITATION)
Common Return Poles	2 (LO COM for channels 0-9, LO COM for channels 10-19)
Measurement Modes (3)	4-Wire (4W) (no reed resistances in measurement path). 3-Wire Accurate (3WA) (no reed resistances in measurement path. Channels in a decade share a common return). 3-Wire Isolated (3WCM) (one reed resistance in measurement path).
Measurement Mode Selection	2 jumpers select scanner measurement mode
Current Sources	2 (1 mA, 32 uA)
Resistance Ranges, Resolution, and Excitation	
Range	256 ohm
Internal Resolution	2.4, 2.0 milliohm (60, 50 Hz.)
Excitation	1 mA
Range	2048 ohm
Internal Resolution	19, 16 milliohm (60, 50 Hz.)
Excitation	1 mA
Range	64 kilohm
Internal Resolution	0.6, 0.5 ohm (60, 50 Hz.)
Excitation	32 uA
Accuracy	Determined by application. See Accuracy sections: Temperature Measurement Using RTDs Resistance Measurement
Zero Stability	Automatic zero
Input Channel Isolation	
4-Wire (4W)	250V dc or ac rms between any two channels
3-Wire Accurate (3WA)	250V dc or ac rms between decades of channels
3-Wire Isolated (3WCM)	250V dc or ac rms between any two channels
Overload without Damage	30V dc or 24V ac rms between any two terminals of a channel
Common Mode Isolation	250V dc or ac rms between scanners, 250V dc or ac rms between decades of channels, 250V dc or ac rms between channels within a decade for 4-Wire (4W) and 3-Wire isolated (3WCM) measurement modes, 30V dc or 24V ac rms between any terminals in the same decade except between LO COM's for the 3-Wire Accurate (3WA) measurement mode
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

-164 Transducer Excitation Module Specifications

Outputs	5 constant current sources 1 constant voltage source
Channels of Excitation	20, selectable in groups of 4 for either voltage or current outputs
Common Mode Voltage	No user-applied common mode voltage allowed. All sensors must be isolated.
4-Wire Resistance Measurements	5 constant current sources. Each source excites up to 4 transducers.
3-Wire Resistance and Strain Gage Measurements	Any combination of 1/4, 1/2, and/or Full Bridge strain gages or 3-wire RTDs with voltage excitation and user-supplied bridge completion resistors.
Current Excitation	
Excitation Current	1.0 mA
Accuracy	
Initial Setting	0.005%
Temperature 15 to 35°C	0.015%
Time since calibration	90 days
Temperature 15 to 35°C	0.030%
Time since calibration	1 year
Temperature -20 to 70°C	0.050%
Time since calibration	1 year
Temperature Coefficient (<15 or >35°C)	10 ppm per °C
Maximum Compliance Voltage	0.6V
Voltage Excitation	
Excitation Voltage	switch selectable to 2.0V dc or 4.0V dc
2 Volt Accuracy	
Initial Setting	0.0025%
Temperature 15 to 35°C	0.03%
Time since calibration	90 days
Temperature 15 to 35°C	0.04%
Time since calibration	1 year
Temperature -20 to 70°C	0.05%
Time since calibration	1 year
4 Volt Accuracy	
Initial Setting	0.0035%
Temperature 15 to 35°C	0.015%
Time since calibration	90 days
Temperature 15 to 35°C	0.030%
Time since calibration	1 year
Temperature -20 to 70°C	0.05%
Time since calibration	1 year
Temperature Coefficient (<15 or >35°C)	7 ppm per °C
Maximum Current	250 mA
Accuracy	Determined by application. See the Accuracy Specifications section.

Temperature
- Operating .... -20 to 70°C
- Storage .... -55 to 75°C

Relative Humidity (without condensation)
- Below 25°C .... <= 95%
- 25 to 40°C .... <= 75%
- 40 to 50°C .... <= 45%
- 50 to 70°C .... <= 40%

Altitude
- Non-Operating .... 40,000 feet
- Operating .... 10,000 feet

Shock and Vibration .... Meets MIL-T-28800C, Class 5 Standards

-165 Fast A/D Converter Specifications

Operating temperature range
    System .... 0 to +65°C
    A/D .... -20 to +70°C
Storage temperature range ... -55 to +75°C
Humidity specifications...... < 90% up to 30°C
                              < 75% up to 40°C
                              < 45% up to 50°C
                              < 40% up to 70°C
Channels .... 20 differential, or 40 single-ended, or mixture of differential and single-ended
Input Impedance
    Power ON .... 100 Megohm in parallel with 0.001 uF for voltages <= ±12V
                             1 kilohm for voltages > ±12V
    Power OFF .... 1 kilohm
Ranges and Displayed Resolution

RANGE	RESOLUTION
64 mV	2 uV
512 mV	16 uV
8V	250 uV
10.5V	350 uV

Accuracy
    Determined by application. See Accuracy section.
Maximum Voltages

INPUT COMMON to EARTH GROUND (chassis ground)	170V peak
INPUT COMMON to EXTERNAL TRIGGER COMMON	170V peak
EARTH GROUND to TRIGGER COMMON	50V peak

Overload Protection (Analog Inputs)

1. Normal reading range includes +/- 10.5V around COMMON (shield terminals of connector). (Normal mode voltage + Common mode voltage < ±10.5V.)

2. An overload of up to 50V rms on a single channel has no effect on other channels and causes no damage.

3. Overloads between 50 and 240V rms on a single channel may blow out the fusible protection resistor on the affected channel but will not damage other channels.

4. Overvoltage inputs are normally internally clamped to approximately +/- 12.5 volts through a 1000-ohm input protection resistor. If several inputs exceed this value, and the resulting current into the protection circuitry exceeds approximately 120 milliamperes, the input protection circuitry will clamp all a/d inputs at approximately 0.5 volts until the overload is removed. If this occurs, measurements for all channels will be tagged as overrange readings.

Open Thermocouple Detection

Any input with resistance greater than 3000 ohms (and with shunt capacitance of less than 0.01 uF) is detected as an open input. An overload reading of 9.99999E37 is then returned. In response to a SEND ERROR command, error 16 OPEN TC is returned.

Any input with resistance less than 1000 ohms is treated as a good input.

For resistances between 1000 and 3000 ohms and shunt capacitances greater than 0.01 uF, open thermocouple detection is indeterminate. Usually, these conditions soon result in open inputs.

During scanning, each thermocouple is tested at intervals of less than 5 seconds.

DC Common Mode Rejection

Measurement conditions: 100-ohm unbalance, common mode voltage < 10.5 volts maximum between LOW and COMMON.

64 mV Range .... > 105 dB
512 mV Range .... > 90 dB
8V Range .... > 75 dB
10.5V Range .... > 70 dB

AC Common Mode Rejection

Measurement conditions: 120 dB rejection of ac common mode between LOW and COMMON, 1000-ohm unbalance.

160 dB rejection of ac common mode between COMMON and EARTH.

Normal Mode Rejection

OPERATING MODE	NOISE REJECTION
Burst Scan Mode (1000 readings/second)	none
Continuous Scan Mode (70 readings/second)	40 dB @ 50/60 Hz ±0.1%

External Trigger (used for Burst Scanning)

Trigger input, maximum common mode voltage to EARTH 50V
Trigger true level ..... < 2V
Trigger false level .... > 3V

Input impedance .... approximately 47 kohms pulled up to +5V
Minimum length trigger pulse 1 ms

Maximum input without damage ±50V
Trigger output .... Collector driver with 30 kilohm pullup to 5V, active low
    Maximum external pullup voltage 24V
    Maximum sink current .... 2 mA @ 1V, non-inductive
Maximum Reading Rates
    Continuous Mode .... 70 readings/second (DVIN)
        Channels are read in blocks of 10, with each block requiring 1/7 second reading time regardless of the number of channels used. The rates shown assume a full 10 channels in each block, with channel numbers beginning with 0 and ending with 9. If fewer channels are used, the reading rate changes. For example, if the five channels 0 through 4 are used in each of 7 blocks, 35 readings are made in one second.

    Continuous Mode .... 35 readings/second (TC)
        For TC measurements, an additional 1/7 second processing time is required for each block of ten. Using the example mentioned for DVIN (channels 0 through 4, 7 blocks), 17.5 readings are made and processed in one second.

    Burst Mode .... 1000 readings/second (plus 1 ms processing time between scans)

Power Consumption 3.0W

-167 Counter/Totalizer Specifications

Channels	6
Functions	Event counting and frequency measurement selectable by channel pairs
Timebase	
Frequency	10 MHz
Accuracy	±0.01%
Input Signals	
Types	TTL, CMOS, contacts, and analog waveforms
Minimum Pulse Width	1.25 microseconds
Minimum Signal Amplitude	175 mV rms 0.5V p-p sine wave 0.35V p-p square wave
Maximum Signal Amplitude	± 15V dc or ac peak
Adjustments	Signal threshold, deadband, and contact debounce
Frequency Measurement	
Minimum Frequency	2 Hz
Maximum Frequency	400 kHz
Accuracy	Timebase accuracy ± 1 digit
Totalizing Measurement	
Maximum Counts	8,388,607
Counting Rate	dc to 400 kHz
Isolation	30V dc or ac rms between any terminal and ground. No isolation between channels.
Power Consumption	4.0 watts maximum
Temperature	
Operating	-20 to 70 degrees Celsius
Storage	-55 to 75 degrees Celsius
Relative Humidity (without condensation)	
Below 25 degrees Celsius	<= 95%
25 to 40 degrees Celsius	<= 75%
40 to 50 degrees Celsius	<= 45%
50 to 70 degrees Celsius	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

-171 Current Input Connector Specifications

```
Channels ....................... 20
Terminals ...................... 2 per channel
Shunt Resistor ................. 8 ohms ±0.02 ohm
Measurement Range .............. 64 mA
Overload without Damage ........ 250 mA
Common Mode Voltage ............ 250V dc or ac rms between any two channels
                                 or between a channel and ground
Accuracy ....................... 0.25% Input ±4 uA
    Time since A/D calibration .. 90 days
Resolution ..................... 1 uA
Compatibility .................. Attaches to -162 Thermocouple/DC Volts
                                 Scanner, which is used with -161 High
                                 Performance A/D Converter
Temperature
    Operating .................. -20 to 70°C
    Storage .................... -55 to 75°C
Relative Humidity (without condensation)
    Below 25°C ................. <= 95%
    25 to 40°C ................. <= 75%
    40 to 50°C ................. <= 45%
    50 to 70°C ................. <= 40%
Altitude
    Non-Operating .............. 40,000 feet
    Operating .................. 10,000 feet
Shock and Vibration ............ Meets MIL-T-28800C, Class 5 Standards
```

-174 Transducer Excitation Connector Specifications

```
Channels ....................... 20
Terminals ...................... 5 per channel
Programming .................... 5 jumpers select voltage or current
                                 excitation on 5 groups of 4 channels
Compatibility .................. Attaches to Transducer Excitation Module
                                 (option 164)
Temperature
    Operating .................. -20 to 70°C
    Storage .................... -55 to 75°C
Relative Humidity (without condensation)
    Below 25°C ................. <= 95%
    25 to 40°C ................. <= 75%
    40 to 50°C ................. <= 45%
    50 to 70°C ................. <= 40%
Altitude
    Non-Operating .............. 40,000 feet
    Operating .................. 10,000 feet
Shock and Vibration ............ Meets MIL-T-28800C, Class 5 Standards
```

-175 Isothermal Input Connector Specifications

Channels	20 differential 40 single-ended (-165 A/D)
Terminals	60 (HI, LO, SHIELD per channel)
Maximum Voltage Rating (with -162 scanner)	250V dc or ac rms from any terminal to any other terminal or ground
Maximum Voltage Rating (with -165 A/D Converter) Measurement Inputs	±170V peak, any terminal to ground ±10.5V HI to COMMON (SHIELD) and/or LO to COMMON (SHIELD) for rated accuracy ±50V peak HI or LO to COMMON (SHIELD) without damage, ±50V on one channel causes no added error on other channels ±50 to 170V HI and/or LO to COMMON (SHIELD) opens fusible resistor, causing no added error on other channels All COMMON (SHIELD) terminals are connected together on the -165 and must be at the same voltage
External Trigger (uses channels 0, 20 when defined)	±50V peak from EXTERNAL TRIGGER COMMON to EARTH ±50V peak from EXTERNAL TRIGGER COMMON to MEASUREMENT COMMON
Compatibility	Attaches directly to -165 Fast A/D Converter, or to -162 Thermocouple/DC Volts Scanner if -161 High Performance A/D Converter used
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

-176 Voltage Input Connector Specifications

Channels	20 differential 40 single-ended (-165 A/D)
Terminals	60 (HI, LO, SHIELD per channel)
Maximum Voltage Rating (with -162 scanner)	250V dc or ac rms from any terminal to any other terminal or ground
Maximum Voltage Rating (with -165 A/D Converter) Measurement Inputs	±170V peak, any terminal to ground ±10.5V HI to COMMON (SHIELD) and/or LO to COMMON (SHIELD) for rated accuracy ±50V peak HI or LO to COMMON (SHIELD) without damage, ±50V on one channel causes no added error on other channels ±50 to 170V HI and/or LO to COMMON (SHIELD) opens fusible resistor, causing no added error on other channels All COMMON (SHIELD) terminals are connected together on the -165 and must be at the same voltage
External Trigger (uses channels 0, 20 when defined)	±50V peak from EXTERNAL TRIGGER COMMON to EARTH ±50V peak from EXTERNAL TRIGGER COMMON to MEASUREMENT COMMON
Compatibility	Attaches directly to -165 Fast A/D Converter, or to -162 Thermocouple/DC Volts Scanner if -161 High Performance A/D Converter used
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°C
Relative Humidity (without condensation)	
Below 25°C	<= 95%
25 to 40°C	<= 75%
40 to 50°C	<= 45%
50 to 70°C	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets MIL-T-28800C, Class 5 Standards

-177 RTD/Resistance Input Connector Specifications

Channels	20
Terminals	100 (HI EXC, HI, LO, LO EXC, and LO COM per Channel)
Maximum Wire Size	16 AWG
Maximum Voltage Rating and Mating RTD/Resistance Scanner Mode	
163 Measurement Mode	4-wire (4W)
Ratings	250V dc or ac rms between two channels or a channel and ground; 30V or 24V ac rms between channel terminals
163 Measurement Mode	3-wire Accurate (3WA)
Ratings	250V dc or ac rms between channels in different decades or between channels in a decade and ground; 30V dc or 24V ac rms between terminals within a decade except between LO COMs. (LO COMs of channels in a decade are connected internally.)
163 Measurement Mode	3-Wire Isolated (3WCM)
Ratings	Same as for 4-Wire
Compatibility	Attaches to RTD/Resistance Scanner (Option 163)
Temperature	
Operating	-20 to 70°C
Storage	-55 to 75°
Relative Humidity (without condensation)	
Below 25°	<= 95%
25 to 40°	<= 75%
40 to 50°	<= 45%
50 to 70°	<= 40%
Altitude	
Non-Operating	40,000 feet
Operating	10,000 feet
Shock and Vibration	Meets Mil-T-28800C, Class 5 standards

-179 Digital/Status Input Connector Specifications

Channels .... 20 single bit, or one 5 BCD digit word, or one 17-bit binary word
Terminals 72
Maximum Input Voltage .... 6V dc
Isolation .... 30V dc or ac rms between any terminal and ground
Compatibility .... Attaches to Digital I/O (option 168)
Temperature
    Operating .... -20 to 70°C
    Storage .... -55 to 75°C
Relative Humidity (without condensation)
    Below 25°C .... <= 95%
    25 to 40°C .... <= 75%
    40 to 50°C .... <= 45%
    50 to 70°C .... <= 40%
Altitude
    Non-Operating .... 40,000 feet
    Operating .... 10,000 feet
Shock and Vibration .... Meets MIL-T-28800C, Class 5 Standards

ACCURACY SPECIFICATIONS

Temperature Measurement Using Thermocouples (-161 A/D Converter)

Hardware Used ..... -161 High Performance A/D
-162 Thermocouple/DC Volts Scanner
-175 Isothermal Input Connector

Accuracy In ±°C

Thermocouple Type (Sensor Temperature Range) Sensor Temperature (°C)	Time Since A/D Calibration (Operating Temperature in °C)		
	90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
J NBS (-200 to 760°C)			
-100 to -25	0.45	0.5	0.8
-25 to +760	0.35	0.4	0.7
J DIN (-200 to 760°C)			
-100 to -25	0.5	0.56	0.9
-25 to +900	0.4	0.45	0.7
K NBS (-225 to 1350°C)			
0 to +900	0.4	0.45	0.7
+900 to 1350	0.52	0.65	1.3
T NBS (-230 to 400°C)			
-100 to +75	0.58	0.65	1.1
+75 to +150	0.35	0.39	0.7
+150 to +400	0.3	0.34	0.6
T DIN (-200 to 600°C)			
0 to +200	0.48	0.53	0.8
+200 to +600	0.37	0.41	0.7
E NBS (-250 to 838°C)			
-100 to -25	0.47	0.54	0.9
-25 to +750	0.3	0.33	0.6
+750 to +810	0.33	0.4	0.8
R NBS (0 to 1767°C)			
+250 to +450	0.9	1.0	1.3
+450 to +1767	0.8	0.9	1.4
S NBS (0 to 1767°C)			
+200 to +1767	0.97	1.1	1.6

Temperature Measurement Using Thermocouples (-161 A/D Converter) (cont.)

	90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
B NBS (200 to 1820°C)			
+600 to +800	1.4	1.6	1.9
+800 to +1820	0.96	1.1	1.3
N NBS (-200 to 400°C) (For 28-gauge thermocouple wire)			
-100 to +150	0.6	0.7	1.1
+150 to +400	0.4	0.44	0.7
C HOS (0 to 2315°C)			
+200 to +1000	0.57	0.66	0.94
+1000 to +2000	0.9	1.2	2.1
+2000 to +2315	1.3	1.7	2.9

Temperature Measurement Using Thermocouples
(-165 A/D Converter)

Hardware Used ..... -165 Fast A/D Converter
-175 Isothermal Input Connector

Accuracy In ±°C (Continuous Scan Mode)

Thermocouple Type (Sensor Temperature Range) Sensor Temperature (°C)	Time Since A/D Calibration (Operating Temperature in °C) 90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
J NBS (-200 to 760°C)			
-100 to -25	1.11	1.16	2.46
-25 to +760	0.95	1.0	2.04
J DIN (-200 to 900°C)			
-100 to -25	1.13	1.17	2.5
-25 to +900	0.9	0.98	2.04
K NBS (-275 to 1350°C)			
0 to 900	1.2	1.33	2.83
900 to 1350	1.51	1.7	3.6
T NBS (-230 to 400°C)			
-100 to 75	1.3	1.35	3.0
75 to +150	0.95	1.0	2.05
+150 to +400	0.85	0.9	1.9
T DIN (-200 to 600°C)			
0 to +200	1.04	1.07	2.3
+200 to +600	0.82	0.85	1.81
E NBS (-250 to 900°C)			
-100 to -25	1.1	1.15	2.4
-25 to +810	0.88	0.94	1.93
R NBS (0 to 1767°C)			
+250 to +450	3.0	3.0	7.0
+450 to +1767	2.71	2.76	6.3
S NBS (0 to 1767°C)			
+200 to +1767	3.26	3.3	7.7

Temperature Measurement Using Thermocouples (cont.)

	90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
B NBS (200 to 1820°C)			
+600 to +800	4.3	4.3	10.3
+800 to +1820	3.4	3.42	8.12
N NBS (-200 to 400°C) (For 28-gauge thermocouple wire)			
-100 to +150	1.7	1.75	3.9
+150 to +400	1.17	1.2	2.55
C HOS (0 to 2315°C)			
200 to 1000	1.86	2.0	4.43
1000 to 2000	3.0	3.35	7.4
2000 to 2315	4.1	4.55	10.1

Resolution: 0.1°C on Base Metal Thermocouples
0.5°C on Noble Metal Thermocouples
(R, S, B, C)

Accuracy (Burst Scan Mode)

Add the following to Continuous Scan Mode figures:

THERMOCOUPLE TYPE	ADD:
J,K,T,E	0.3°C
R,S,B,C	1.0°C

Temperature Measurement Using RTDs

Hardware Used ..... -161 High Performance A/D
-163 RTD/Resistance Scanner
-177 RTD/Resistance Input Connector

Performance

RTD Type, Scanner Range, and Scanner Measurement Mode (sensor temperature range) Sensor Temperature ($^{\circ}$C)	90 Days Since A/D Calibration 18 to 28°C Operating Temperature Temperature Shift dT/dt < 1°C / 10min		
	ACCURACY	RESOLUTION	REPEATABILITY
Platinum 385 DIN, High Resolution, 4-Wire (4W), and (-200 to 425°C)			
-200 to 150	0.09°C*	0.006°C	0.03°C
150 to 425	0.13°C	0.006°C	0.04°C
Platinum 385 DIN, High Temperature, 4-Wire (4W), and (-200°C to probe limit)			
-200 to 600	0.25°C	0.05°C	0.14°C
10 Ohm Copper, 4-Wire (4W) (-75°C to +150°C)	0.28°C	0.06°C	0.16°C
Platinum 385 DIN, 3-Wire Accurate (3WA)	+0.007°C**		+0.001°C**
10 Ohm Copper, 3-Wire Accurate (3WA)	+0.065°C**		+0.008°C**

NOTES:

* An ice-point initialization allows 385 DIN RTDs to have an accuracy of 0.05°C + probe conformity.

** Add $^{\circ}$C per ohm lead resistance to 4W specifications.

	ACCURACY	RESOLUTION	REPEATABILITY
Platinum 385 DIN, 3-Wire Isolated (3WCM)	±1.97°C***		±1.97°C***
10 Ohm Copper, 3-Wire Isolated (3WCM)	±18.2°C***		±18.2°C***
10 Ohm Copper, 3-Wire Isolated (3WCM) (Special, modified -163)	±0.8°C***		±0.8°C***

Performance

RTD Type, Scanner Range, and Scanner Measurement Mode (sensor temperature range) Sensor Temperature (°C)	90 Days Since A/D Calibration 15 to 35°C Operating Temperature Temperature Shift dT/dt < 1°C / 10min		
	ACCURACY	RESOLUTION	REPEATABILITY
Platinum 385 DIN, High Resolution, 4-Wire (4W), and (-200 to 425°C)			
-200 to 150	0.10°C	0.006°C	0.04°C
150 to 425	0.15°C	0.006°C	0.04°C
Platinum 385 DIN, High Temperature, 4-Wire (4W), and (-200°C to probe limit)			
-200 to 600	0.27°C	0.05°C	0.16°C

Performance

RTD Type, Scanner Range, and Scanner Measurement Mode (sensor temperature range) Sensor Temperature (°C)	90 Days Since A/D Calibration 15 to 35°C Operating Temperature Temperature Shift dT/dt < 1°C / 10min		
	ACCURACY	RESOLUTION	REPEATABILITY
10 Ohm Copper, 4-Wire (4W) (-75°C to +150°C)	0.3°C	0.06°C	0.16°C
Platinum 385 DIN, 3-Wire Accurate (3WA)	+0.007°C**		+0.001°C**
10 Ohm Copper, 3-Wire Accurate (3WA)	+0.065°C**		+0.008°C**
Platinum 385 DIN, 3-Wire Isolated (3WCM)	+1.97°C***		+1.97°C***
10 Ohm Copper, 3-Wire Isolated (3WCM)	+18.2°C***		+18.2°C***
10 Ohm Copper, 3-Wire Isolated (3WCM) (Special, modified -163)	+0.8°C**		+0.8°C**

NOTES:
** Add °C per ohm lead resistance to 4W specs
*** Add °C to 3WA specs

Performance

RTD Type, Scanner Range, and Scanner Measurement Mode (sensor temperature range) Sensor Temperature (°C)	1 Year Since A/D Calibration 15 to 35°C Operating Temperature Temperature Shift dT/dt < 1°C / 10min ACCURACY	 RESOLUTION
Platinum 385 DIN, High Resolution, 4-Wire (4W), and (-200 to 425°C)		
-200 to 150	0.11°C	0.006°C
150 to 425	0.16°C	0.006°C
Platinum 385 DIN, High Temperature, 4-Wire (4W), and (-200°C to probe limit)		
-200 to 600	0.28°C	0.05°C
10 Ohm Copper, 4-Wire (4W)		
(-75°C to +150°C)	0.3°C	0.06°C
Platinum 385 DIN, 3-Wire Accurate (3WA)		
(full range)	Add 0.008°C per ohm lead resistance to 4W specs	
10 Ohm Copper, 3-Wire Accurate (3WA)		
(full range)	Add 0.073°C per ohm lead resistance to 4W specs	
Platinum 385 DIN, 3-Wire Isolated (3WCM)		
(full range)	Add 2.53°C to 3WA specs	
10 Ohm Copper, 3-Wire Isolated (3WCM)		
(full range)	Add 23.4°C to 3WA specs	
10 Ohm Copper, 3-Wire Isolated (3WCM)		
(Special, modified -163)	Add 1.5°C to 3WA specs	

Performance

RTD Type, Scanner Range, and Scanner Measurement Mode (sensor temperature range) Sensor Temperature (°C)	1 Year Since A/D Calibration -20 to 70°C Operating Temperature Temperature Shift dT/dt < 1°C / 10min ACCURACY	RESOLUTION
Platinum 385 DIN, High Resolution, 4-Wire (4W), and (-200 to 425°C)		
-200 to 150	0.19°C	0.006°C
150 to 425	0.29°C	0.006°C
Platinum 385 DIN, High Temperature, 4-Wire (4W), and (-200°C to probe limit)		
-200 to 600	0.44°C	0.05°C
10 Ohm Copper, 4-Wire (4W) (-75°C to +150°C)	0.4°C	0.06°C
Platinum 385 DIN, 3-Wire Accurate (3WA) (full range)	Add 0.010°C per ohm lead resistance to 4W specs	
10 Ohm Copper, 3-Wire Accurate (3WA) (full range)	Add 0.096°C per ohm lead resistance to 4W specs	
Platinum 385 DIN, 3-Wire Isolated (3WCM) (full range)	Add 2.53°C to 3WA specs	
10 Ohm Copper, 3-Wire Isolated (3WCM) (full range)	Add 23.4°C to 3WA specs	
10 Ohm Copper, 3-Wire Isolated (3WCM) (Special, modified -163)	Add 1.5°C to 3WA specs	

Temperature Measurement Using RTDs (-161 A/D)

Hardware Used .... -161 High Performance A/D
-164 Transducer Excitation Module
-174 Transducer Excitation Connector
(with current excitation selected)
-162 Thermocouple/DC Volts Scanner
Choice of Connector:
-175 Isothermal Input
-176 Voltage Input
-160 AC Voltage Input

Performance

RTD Type and Scanner Range (sensor temperature range) Sensor Temperature (°C)	90 Days Since Calibration 15 to 35°C Operating Temperature ACCURACY	 RESOLUTION	 REPEATABILITY
Platinum 385 DIN (-200°C to probe limit)			
-200 to 600	0.2°C	0.013°C	0.08°C
10 Ohm Copper (full range)	1.0°C	0.1°C	0.2°C

Temperature Measurement Using RTDs (-165 A/D)

Hardware Used .... -165 Fast A/D Converter
Choice of Connector:
- -175 Isothermal Input
- -176 Voltage Input

-164 Transducer Excitation Module
-174 Transducer Excitation Connector
(with current excitation selected)

Performance

RTD Type and Scanner Range (sensor temperature range) Sensor Temperature (°C)	90 Days Since Calibration 15 to 35°C Operating Temperature		
	ACCURACY	RESOLUTION	REPEATABILITY
Platinum 385 DIN			
Platinum 392 DIN			
-200 to 125	0.4°C	0.43°C	0.66°C
125 to 600	0.54°C	0.62°C	0.97°C

DC Voltage Measurement Accuracy (-161 A/D)

Hardware Used ..... -161 High Performance A/D
-162 Thermocouple/DC Volts Scanner
Choice of Connector:
-175 Isothermal Input
-176 Voltage Input
-160 AC Voltage Input

Accuracy

Range	Internal Resolution (microvolts) 60Hz	Internal Resolution (microvolts) 50Hz	Time Since A/D Calibration (Operating Temperature in °C) (± % Input ± microvolts) 90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
±64 mV	0.6	0.5	0.005% + 7.0	0.01% + 8.0	0.03% + 9.0
±512 mV	5.0	4.2	0.005% + 30	0.01% + 40	0.03% + 50
±8V	73	61	0.005% + 700	0.01% + 800	0.03% + 900
±64V	600	500	0.009% + 3 mV	0.02% + 4 mV	0.05% + 5 mV

DC Voltage Measurement Accuracy (-165 A/D)

Hardware Used ..... -165 Fast A/D Converter
Choice of Connector:
-175 Isothermal Input
-176 Voltage Input

Range	Internal Resolution	Time Since A/D Calibration (Operating Temperature in °C) (± % Input ± uV or mV) 90 Days (15 to 35)	1 Year (15 to 35)	1 Year (-20 to +70)
DIFFERENTIAL INPUTS, CONTINUOUS SCAN MODE				
±64 mV	2 uV	.02% ±25 uV	.03% ±25 uV	.06% ±60 uV
±512 mV	16 uV	.02% ±100 uV	.03% ±100 uV	.06% ±140 uV
±8V	0.25 mV	.02% ±1.2 mV	.03% ±1.2 mV	.06% ±1.5 mV
±10V	0.32 mV	.02% ±1.7 mV	.03% ±1.7 mV	.06% ±2 mV
DIFFERENTIAL INPUTS, BURST SCAN MODE				
±64 mV	2 uV	.02% ±35 uV	.03% ±35 uV	.06% ±70 uV
±512 mV	16 uV	.02% ±150 uV	.03% ±150 uV	.06% ±190 uV
±8V	0.25 mV	.02% ±1.7 mV	.03% ±1.7 mV	.06% ±2.0 mV
±10.5V	0.32 mV	.02% ±2.2 mV	.03% ±2.2 mV	.06% ±2.5 mV
SINGLE ENDED INPUTS, CONTINUOUS SCAN MODE				
±64 mV	2 uV	.02% ±35 uV	.03% ±35 uV	.06% ±70 uV
±512 mV	16 uV	.02% ±150 uV	.03% ±150 uV	.06% ±190 uV
±8V	0.25 mV	.02% ±1.2 mV	.03% ±1.2 mV	.06% ±1.5 mV
±10.5V	0.32 mV	.02% ±1.7 mV	.03% ±1.7 mV	.06% ±2.0 mV
SINGLE ENDED INPUTS, BURST SCAN MODE				
±64 mV	2 uV	.02% ±45 uV	.03% ±45 uV	.06% ±80 uV
±512 mV	16 uV	.02% ±200 uV	.03% ±200 uV	.06% ±240 uV
±8V	0.25 mV	.02% ±1.7 mV	.03% ±1.7 mV	.06% ±2.0 mV
±10.5V	0.32 mV	.02% ±2.2 mV	.03% ±2.2 mV	.06% ±2.5 mV

AC Voltage Measurement Accuracy

Hardware Used ..... -161 High Performance A/D
-162 Thermocouple/DC Volts Scanner
-160 AC Voltage Input Connector

Performance

Range and Frequencies	90 Days Since A/D Calibration 15 to 35°C Operating Temperature	
	RESOLUTION	ACCURACY
5V to 250V ac rms, 45 Hz to 450 Hz	0.1V	±1% Input ±.1V

DC Current Measurement Accuracy (-161 A/D)

Hardware Used ..... -161 High Performance A/D
-162 Thermocouple/DC Volts Scanner
-171 Current Input Connector

Performance

Range	90 Days Since A/D Calibration 15 to 35°C Operating Temperature	
	RESOLUTION	ACCURACY
±64 mA	0.6 uA	±.25% ±4 uA

DC Current Measurement Accuracy (-165 A/D)

Hardware Used ..... -165 Fast A/D Converter
-176 Voltage Input Connector, or
-175 Isothermal Input Connector

641449 (Fluke Part Number)
Shunt Resistors (mounted on connector screw terminals): 8 ohm, ±0.25%

Performance

Range	90 Days Since A/D Calibration 15 to 35°C Operating Temperature	
	RESOLUTION	ACCURACY
±64 mA	2 uA	±0.3% ±12 uA

Resistance Measurement Accuracy

Hardware Used ..... -161 High Performance A/D
-163 RTD/Resistance Scanner
-177 RTD/Resistance Input Connector

Performance

Scanner Range and Measurement Mode	90 Days Since A/D Calibration, 18 to 28°C Operating Temperature, Temperature Shift dT/dt < 1°C / 10min			
	(mohm)		(±% Input ± mohm)	
	RESOLUTION 60Hz	50Hz	ACCURACY	REPEATABILITY
256 ohm, 4-Wire (4W)	2.4	2.0	0.0142% + 5.7	0.0037% + 5.7
2048 ohm, 4-Wire (4W)	19	16	0.0137% + 38	0.0032% + 38
64 kilohm, 4-Wire (4W)	600	500	0.055% + 1.2 ohm	0.0040% + 1.2 ohm**
All, 3-Wire Accurate (3WA)	same as 4W		Add 2.4 mohm per ohm lead resistance to 4W specs	Add 0.2 mohm per ohm lead resistance to 4W specs
All, 3-Wire Isolated (3WCM)	same as 4W		Add 0.7 ohm to 3WA specs	Add 0.7 ohm to 3WA specs

**Humidity 15%RH less than listed for the -163 Scanner

Resistance Measurement Accuracy (cont.)

Performance

Scanner Range and Measurement Mode	90 Days Since A/D Calibration, 15 to 35°C Operating Temperature, Temperature Shift dT/dt < 1°C / 10 min			
	(mohm) RESOLUTION		(±% Input ± mohm)	
	60Hz	50Hz	ACCURACY	REPEATABILITY
256 ohm, 4-Wire (4W)	2.4	2.0	0.0170% + 5.7	0.0065% + 5.7
2048 ohm, 4-Wire (4W)	19	16	0.0165% + 38	0.0060% + 38
64 kilohm, 4-Wire (4W)	600	500	0.06% + 1.2 ohm	0.0075% + 1.2 ohm**
All, 3-Wire Accurate (3WA)	same as 4W		Add 2.5 mohm per ohm lead resistance to 4W specs	Add 0.3 mohm per ohm lead resistance to 4W specs
All, 3-Wire Isolated (3WCM)	same as 4W		Add 0.7 ohm to 3WA specs	Add 0.7 ohm to 3WA specs

**Humidity 15%RH less than listed for the -163 Scanner

Performance

Scanner Range and Measurement Mode	1 Year Since A/D Calibration, 15 to 35°C Operating Temperature, Temperature Shift dT/dt < 1°C / 10 min		
	(MILLIOHMS) RESOLUTION		
	60Hz	50Hz	ACCURACY
256 ohm, 4-Wire (4W)	2.4	2.0	±.0175% Input ±5.7 mohm
2048 ohm, 4-Wire (4W)	19	16	±.0170% Input ±38 mohm
64 kilohm, 4-Wire (4W)	600	500	±.06% Input ±1.2 ohm
All, 3-Wire Accurate (3WA)	same as 4W		Add 2.8 mohm per ohm lead resistance to the 4W specifications
All, 3-Wire Isolated (3WCM)	same as 4W		Add 0.9 ohm to the 3WA specifications

Resistance Measurement Accuracy (cont.)

Performance

Scanner Range and Measurement Mode	(MILLIOHMS) RESOLUTION 60Hz	(MILLIOHMS) RESOLUTION 50Hz	ACCURACY — 1 Year Since A/D Calibration, -20 to 70°C Operating Temperature, Temperature Shift dT/dt < 1°C / 10 min
256 ohm, 4-Wire (4W)	2.4	2.0	±.0365% Input ±7 mohm
2048 ohm, 4-Wire (4W)	19	16	±.0360% Input ±38 mohm
64 kilohm, 4-Wire (4W)	600	500	±.23% Input ±1.2 ohm
All, 3-Wire Accurate (3WA)	same as 4W		Add 3.7 mohm per ohm lead resistance to the 4W specifications
All, 3-Wire Isolated (3WCM)	same as 4W		Add 0.9 ohm to the 3WA specifications

Resistance Measurement Accuracy (-161 A/D)

Hardware Used .... -161 High Performance A/D
-162 Thermocouple/DC Volts Scanner
Choice of Connector:
- -175 Isothermal Input
- -176 Voltage Input
- -160 AC Voltage Input

-164 Transducer Excitation Module
-174 Transducer Excitation Connector (with current excitation selected)

Performance

Range	90 Days Since Calibration, 15 to 35°C Operating Temperature		
	(MILLIOHMS) RESOLUTION 60Hz	(MILLIOHMS) RESOLUTION 50Hz	ACCURACY
64 ohm	0.6	0.5	±.02% Input ±7 mohm
512 ohm	5.0	4.2	±.02% Input ±30 mohm

Resistance Measurement Accuracy (-165 A/D)

Hardware Used .... -165 Fast A/D Converter
-175 Isothermal Input Connector, or
-176 Voltage Input Connector
-164 Transducer Excitation Module
-174 Transducer Excitation Connector (with current excitation selected)

Performance

Range	90 Days Since Calibration, 15 to 35°C Operating Temperature	
	(MILLIOHMS) RESOLUTION	ACCURACY
64 ohm	2.0	±0.035% Input ±25 mohm
512 ohm	16.0	±0.035% Input ±100 mohm

Strain Measurement Accuracy (-161 A/D)

Hardware Used .... -161 High Performance A/D
-164 Transducer Excitation Module
-174 Transducer Excitation Connector
(with voltage excitation selected)
-162 Thermocouple/DC Volts Scanner
Choice of Connector:
-175 Isothermal Input
-176 Voltage Input
-160 AC Voltage Input

Bridge Type	90 Days Since Calibration, 20 to 30°C Operating Temperature	
	RESOLUTION	ACCURACY
Full Bridge	0.25 uE	±.05% Input ±2 uE
1/2 Bridge	0.5 uE	±.05% Input ±13 uE
1/4 Bridge	0.5 uE	±.05% Input ±25 uE

Strain Measurement Accuracy (-165 A/D)

Hardware Used .... -165 Fast A/D Converter
-175 Isothermal Input Connector, or
-176 Voltage Input Connector
-164 Transducer Excitation Module
-174 Transducer Excitation Connector
(with current excitation selected)

Performance

Bridge Type	90 Days Since Calibration, 20 to 30°C Operating Temperature		
	RESOLUTION	ACCURACY	TEMPERATURE COEFFICIENT (in ACCURACY)
Full Bridge	1.0 uE	±0.1% Input ±6 uE	
1/2 Bridge	2.0 uE	±0.1% Input ±18 uE	±2 uE/°C
1/4 Bridge	2.0 uE*	±0.1% Input ±30 uE	±4 uE/°C

* Assume use of 4V excitation.