8505A

DIGITAL MULTIMETER

Instruction Manual

PN 638841
March 1983 Rev. 2 2/91

FLUKE ®

WARRANTY

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The JOHN FLUKE MFG. CO., INC., warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of 1-year from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90-days), or any product or parts which have been subject to misuse, neglect, accident, or abnormal conditions of operations.

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2. On receipt of the shipping instructions, forward the instrument, transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

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All shipments of JOHN FLUKE MFG. CO., INC., instruments should be made via United Parcel Service or "Best Way"* prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid and of adequate size. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon original delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

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

*For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206

OPERATOR SAFETY INFORMATION

SAFETY SYMBOLS

The following symbols appear on the front and rear of the instrument:

 Indicates hazardous voltage may be present at or connected to this terminal. Located on the front panel at input terminals.

 Indicates that the user should refer to the instruction manual and locate this symbol for further information. Located on the rear panel of the instrument.

INSTRUCTION MANUAL SAFETY MESSAGES

WARNING indicates a possible hazardous condition to the operator.

CAUTION indicates a possible condition that could lead to equipment damage or malfunction.

MULTIMETER SAFETY INFORMATION

This multimeter has been designed and tested to comply with IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus. Safety information and warnings contained in this instruction manual must be followed for safe operation.

The multimeter is a safety class I (grounded enclosure) instrument as defined in IEC 348.

WARNING

THE GROUNDING CONDUCTOR IN THE POWER CORD MUST BE CONNECTED TO ENSURE PROTECTION FROM ELECTRIC SHOCK. CHECK THE LINE VOLTAGE SETTING BEFORE APPLYING POWER TO THE INSTRUMENT.

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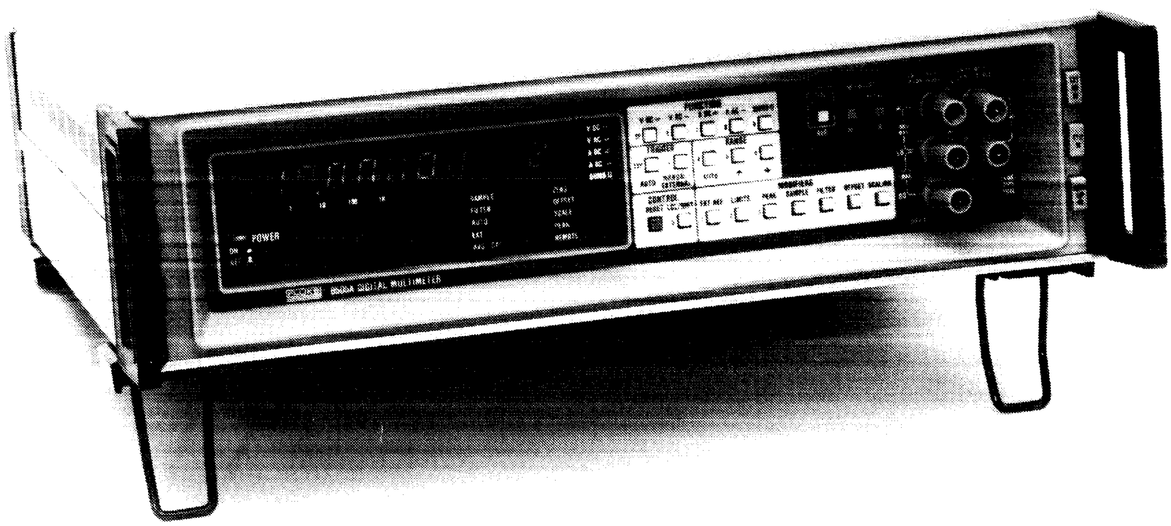


8505A Digital Multimeter

Section 1
Introduction & Specifications

1-1. INTRODUCTION

1-2. This eight-section manual provides comprehensive information for installing, operating and maintaining your Fluke digital multimeter. Complete descriptions and instructions are included for the instrument mainframe, for all modules necessary in making dc volts measurements, and for any optional modules ordered with the instrument. Appropriate sectionalized information is also included with any optional modules subsequently ordered and may be inserted in Section 6.

1-3. DESCRIPTION

1-4. The multimeter features 6-1/2 digit resolution, full annunciation and simplicity of operation. Modular construction, microprocessor control, and a bus structure provide excellent flexibility. Memory programming from the front panel (or through a remote interface) controls all measurement parameters, mathematic operations and special operations. An averaging mode is available to automatically optimize display resolution and stability for each function and range. The standard hardware configuration allows for measurement of dc volts in five ranges with 100 nV resolution on the lowest range. Optional modules are available for ac volts (four ranges), ac or dc current (five ranges), and resistance (eight ranges) in two-wire or four-wire arrangements.

1-5. Modular Construction

1-6. Considerable versatility is realized through unique contruction. All active components are contained in modules which plug into a mainframe motherboard. This module-motherboard mating, combined with bus architecture and microprocessor control, yields both ease of option selection and reduced downtime.

NOTE

The A3 Isolator PCB is standard in the 8505A. This assembly is documented in Section 6 of this manual as Option -08A.

1-7. Microprocessor Control

1-8. All modules function under direct control of a microprocessor based controller. Each module is addressed by the controller as virtual memory. External reference values and offsets can be applied separately, stored in memory, and automatically used as factors in all subsequent readings. Digital filtering utilizes averaged samples for each reading.

1-9. Software Calibration

1-10. The 8505A features microprocessor-controlled calibration of all ranges and functions. Any range can be calibrated using a reference input of any known value from 60% of range to full scale. Software calibration can be performed using front-panel or remote control, allowing recertification without opening the case or removing the multimeter from the system.

1-11. Recirculating Remainder A/D Conversion

1-12. The multimeter adapts Fluke's patented recirculating remainder (R^2) A/D conversion technique to microprocessor control. This combination provides fast, accurate, linear measurements and long-term stability.

1-13. Options and Accessories

1-14. Remote interfaces, ac converters, a current converter, and an ohms converter are among the numerous options and accessories available for use with the multimeter. Refer to Tables 1-1 and 1-2 for complete listings. AC conversion can be accomplished with either the AC Averaging module (Option 01) or the RMS module (Option 09A). Any one of the three Remote Interface modules (Option 05, 06, or 07) can be installed at one time.

1-15. SPECIFICATIONS

1-16. Mainframe specifications with dc volts and dc ratio measurement capability are presented in Table 1-3. Optional function specifications are supplied with the respective option modules and included in Section 6.

Table 1-1. Options

OPTION NO.	NAME	NOTES
01	AC/DC Converter (Averaging)	1, 3
02A	Ohms Converter	
03	Current Shunts	3
05	IEEE Standard 488-1975 Interface	2
06	Bit Serial Asynchronous Interface	2
07	Parallel Interface	2
09A	AC/DC Converter (True RMS)	1, 3

1) Options 01 and 09A cannot be installed simultaneously.

2) Only one of Options 05, 06, and 07 can be installed at any time.

3) For the ac portion of Option 03 to operate, either Option 01 or 09A must be installed.

Table 1-2. Accessories

MODEL OR PART NO.	NAME
M04-205-600	5¼-inch Rack Adapter
M00-260-610	18-inch Rack Slides
M00-280-610	24-inch Rack Slides
80K-6	High Voltage Probe
80K-40	High Voltage Probe
83RF	High Frequency Probe
85RF	High Frequency Probe
Y8001	IEEE Std. Cable, 1 Meter Length
Y8002	IEEE Std. Cable, 2 Meter Length
Y8003	IEEE Std. Cable, 4 Meter Length
MIS-7011K*	Extender Card
MIS-7190K*	Static Controller
MIS-7191K*	Test Module
MIS-7013K*	Bus Interconnect and Monitor

*For use during service or repair.

Table 1-3. Specifications

GENERAL SPECIFICATIONS

Dimensions .... 10.8 cm High x 43.2 cm Wide x 42.5 cm Long
(4.25 in High x 17 in Wide x 16.75 in Long) (See Figure 1-1)

Weight
- BASIC .... 10 kg (22 lbs)
- FULLY LOADED .... 12 kg (26 lbs)

Operating Power
- VOLTAGE .... 100V ac, 120V ac, 220V ac, or 240V ac (±10%)
- BASIC INSTRUMENT POWER .... 12 watts
- FULLY LOADED POWER .... 24 watts
- FREQUENCY .... 47 Hz to 63 Hz (400 Hz available on request)

Warm-Up .... 2 hours to rate accuracy

Shock and Vibration .... Meets requirements of MIL-T-28800 for type III, class 5, style E equipment.

Temperature Range
- OPERATING .... 0°C to 50°C
- NON-OPERATING .... -40°C to 70°C

Humidity Range
- 0°C TO 18°C .... 80% RH
- 18°C TO 40°C .... 75% RH
- 40°C TO 50°C .... 45% RH

⚠ **Maximum Terminal Voltage**
- LO TO GUARD .... 127V rms
- GUARD TO CHASSIS .... 500V rms
- HI SENSE TO HI SOURCE .... 127V rms
- LO SENSE TO LO SOURCE .... 127V rms
- HI SENSE TO LO SENSE .... 1000V rms or 1200V dc
- HI SOURCE TO LO SOURCE .... 280V rms

Table 1-3. Specifications (cont)

DC VOLTAGE

Input Characteristics

RANGE	FULL SCALE 6½ DIGITS	RESOLUTION 7½ DIGITS*	RESOLUTION 6½ DIGITS	INPUT RESISTANCE
100 mV	200.0000 mV	—	100 nV	>10,000MΩ
1V	2.000000V	—	1 μV	>10,000MΩ
10V	20.00000V	1 μV	10 μV	>10,000MΩ
100V	128.0000V	—	100 μV	10MΩ
1000V	1200.000V	—	1 mV	10MΩ

*7½-digit resolution: In AVG operating mode.

Accuracy

DC VOLTS: ±(% of Reading + Number of Counts)

RANGE	24-HOUR 23°C ±1°C[1]		90-DAY 23°C ±5°C	
	OPERATING MODE		OPERATING MODE	
	NORM	AVG	NORM	AVG[3]
100 mV	0.0018 + 15	0.0010 + 8	0.0025 + 40	0.0020 + 8
1V	0.0008 + 7	0.0005 + 4	0.0015 + 8	0.0012 + 6
10V	0.0006 or 6*	0.0005 or 50[2]*	0.0010 + 8	0.0008 + 60[2]
100V	0.0010 + 6	0.0005 + 5	0.0018 + 8	0.0015 + 6
1000V	0.0008 + 6	0.0005 + 5	0.0018 + 8	0.0015 + 6

*Whichever is greater

>90-Day: 23°C ±5°C
Add to the 90-day specification per month the following % of Reading and Number of Counts.

RANGE	OPERATING MODE NORM	OPERATING MODE AVG[3]
100 mV	0.00017 + 5.6	0.0001 + 0.1
1V	0.0001 + 0.1	0.0001 + 0.1
10V	0.0001 + 0.1	0.00008 + 1[2]
100V	0.00013 + 0.1	0.0001 + 0.1
1000V	0.00013 + 0.1	0.0001 + 0.1

NOTES:

[1]Relative to calibration standards, 4-hour warm-up, within 1 hour of dc zero. After software calibration, add the following to the 24 hour accuracy specification:

TIME SINCE INTERNAL (HARDWARE) CALIBRATION	NUMBER OF COUNTS*
<30 Days	0
<90 Days	1
<1 Year	2
>1 Year	3

*With 6½-digit display. For 7½-digits, multiply Number of Counts by 10.

[2]7½-digit mode of operation.

[3]After 4-hour warm-up, within 1 hour of dc zero.

Table 1-3. Specifications (cont)

Operating Characteristics

TEMPERATURE COEFFICIENT: ±(% of Reading + Number of Counts)/°C

RANGE	0°C TO 18°C AND 28°C TO 50°C
100 mV	0.0003 + 5
1V	0.0003 + 1
10V	0.0002 + 0.5*
100V	0.0003 + 1
1000V	0.0003 + 0.5

*Multiply Number of Counts by 10 for AVG operating mode (7½-digit).

INPUT BIAS CURRENT

AT TIME OF ADJUSTMENT	1-YEAR 23°C ±1°C	TEMPERATURE COEFFICIENT
<±5 pA	<±30 pA	<±1 pA/°C

ZERO STABILITY .... Less than 5 μV for 90 days after a four-hour warm-up. Front panel pushbutton zero is provided for permanent storage of a zero correction for each range. Zero may be turned off at any time.

MAXIMUM INPUT VOLTAGE .... ±1200V dc or 1000V rms ac to 60 Hz, or 1400V peak above 60 Hz may be applied continuously to any dc range without permanent damage. Maximum common mode rate of voltage rise is 1000V / μsec.

ANALOG SETTLING TIME

FILTER MODE	FILTER COMMAND	TO 0.01% OF STEP CHANGE	TO 0.001% OF STEP CHANGE
Bypassed	F1	2 ms	20 ms
Fast	F0 or F3	40 ms	50 ms
Slow	F or F2	400 ms	500 ms

DIGITIZING TIME

Line Synchronous .... For 2^0 to 2^{17} samples per reading digitizing time is from 4 ms to 9 minutes 6 seconds using a 60 Hz ac line with times increasing 20% using a 50 Hz ac line. Selectable in 18 binary steps.

Line Asynchronous .... 2 ms. (In 3 byte binary mode with dc zero, offset, limits and calibration factors turned off.)

NOISE REJECTION

Normal Mode Rejection

LINE FREQUENCY	FILTER MODE	4 SAMPLES/ READING	32 SAMPLES/ READING	128 SAMPLES/ READING
50 hertz	Fast	60 dB	70 dB	75 dB
50 hertz	Slow	85 dB	90 dB	95 dB
60 hertz	Fast	60 dB	70 dB	75 dB
60 hertz	Slow	90 dB	95 dB	100 dB

Common Mode Rejection .... 160 dB at 60 hertz with 1 kΩ in series with either lead, and 4 samples or more per reading. Greater than or equal to 100 dB with less than 4 samples per reading.

Table 1-3. Specifications (cont)

DC RATIO

Accuracy

EXTERNAL REFERENCE VOLTAGE*	ACCURACY[1]
±20V to ±40V	±(A + B + 0.001%)
$\pm V_{min}$ to ±20V	$\pm(A + B + (0.02\% / \lvert V_{xref} \rvert))$

*Maximum External Reference Voltage = ±40V between External Reference HI and LO terminals, providing neither terminal is greater than ±20V relative to the Sense LO or Ohms Guard[2] terminals.

Operating Characteristics

INPUT IMPEDANCE .... External Reference HI or LO >10,000 MΩ relative to Ohms Guard[2] or Sense LO.

BIAS CURRENT .... External Reference HI or LO relative to Ohms Guard[2] or Sense LO <5 nA.

SOURCE IMPEDANCE .... Resistive Unbalance (External Reference HI to LO) <4 kΩ. Total Resistance to Sense LO from either External Reference HI or LO <20 kΩ.

MAXIMUM OVERLOAD VOLTAGE ... ±180V dc or peak ac (relative to Ohms Guard[2] or Sense LO). ±360V dc or peak ac (External Reference HI to LO).

NOISE REJECTION

INPUT TERMINALS	NORMAL MODE	COMMON MODE
Sense	Same as dc volts	Same as dc volts
External Reference	line frequency and 2x line frequency >100 dB	line frequency and 2x line frequency >75 dB

RESPONSE TIME

Analog Settling Time

FILTER MODE	FILTER COMMAND	TO 0.01% OF STEP CHANGE	TO 0.001% OF STEP CHANGE
Bypassed	F1	2 ms	20 ms
Fast	F0 or F3	40 ms	50 ms
Slow	F or F2	400 ms	500 ms

NOTES: (DC Ratio)

[1]A 10V dc range accuracy for the appropriate period of time.

B Input signal function and range accuracy for the appropriate period of time.

V_{min} Minimum allowable External Reference Voltage = ±0.0001V, or $V_{input}/10^9$ (whichever is greater).
$\lvert V_{xref} \rvert$ Absolute value of the External Reference Voltage

[2]Ohms Guard is available through the rear input.

Table 1-3. Specifications (cont)

DC RATIO (cont)

Operating Characteristics (cont)

Digitizing Time	For 2^0 to 2^{17} samples per reading digitizing time is from 196 ms to 9 minutes 6 seconds using a 60 Hz ac line with times increasing 20% using a 50 Hz ac line. Selectable in 18 binary steps.
MAXIMUM RATIO DISPLAY	+1.00000 E±9

EXTERNAL TRIGGER INPUT

Polarity	May be wired internally for either rising or falling edge. Factory wired for falling edge.
High Level	+4.3V (minimum)
Low Level	+0.7V (maximum)
Pulse Width	10 μs (minimum)
Connector	BNC with the outer shell at interface common
Maximum Input	±30V
Maximum Shell to Ground Voltage	±30V

SCAN ADVANCE OUTPUT

Polarity	Positive
High Level	>+4V (TTL High)
Low Level	<+0.7V (TTL Low)
Pulse Width	3 μs (minimum)
Connector	BNC with the outer shell at interface common
Maximum Shell to Ground Voltage	±30V

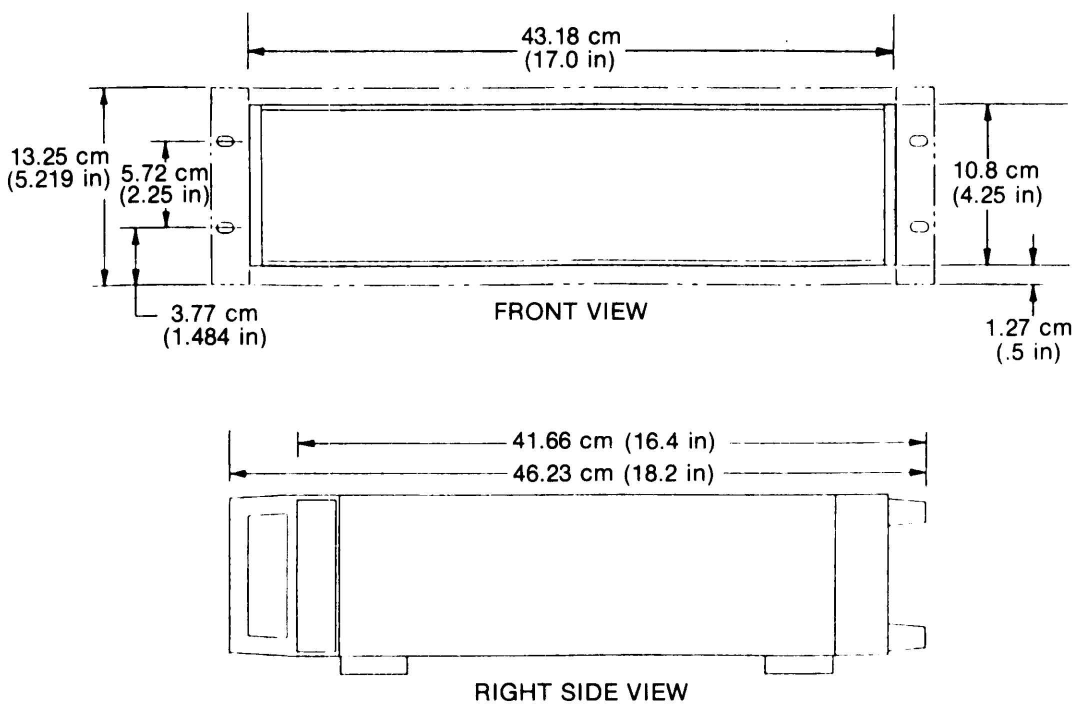


Figure 1-1. Dimension Drawing

Section 2
Operating Instructions

2-1. INTRODUCTION

2-2. Installation and operation of the multimeter are explained in this section. These instructions should be read thoroughly prior to multimeter operation. Once a familiarization with the instrument is achieved, parts of this section will serve as a quick reference. Explanations and applications are provided for all standard functions and operations. Should any difficulties arise, contact your nearest Fluke Sales Representative (listed in Section 5) or the John Fluke Mfg. Co., Inc.; P.O. Box C9090; Everett, WA. 98206; tel. (206) 342-6300).

2-3. SHIPPING INFORMATION

2-4. The multimeter is packaged and shipped in a foam-packed container. Upon receipt of the instrument, a thorough inspection should be made to reveal any possible shipping damage. Special instructions for inspection and claims are included with the shipping container.

2-5. If reshipment is necessary, the original container should be used. If the original container is not available, a new container can be obtained from John Fluke Mfg. Co., Inc. Please reference the instrument model number when requesting a new shipping container.

2-6. INSTALLATION

2-7. Non-marring feet and a tilt-down bail arrangement are installed on the instrument for field or bench use. A rack-mounting kit and rack slides are available for use with the standard 19-inch equipment racks. Information regarding installation and rack-mounting accessories is contained in Section 6.

2-8. The multimeter operates from 100, 120, 220, or 240V ac (±10%) at 50 or 60 Hz. Line voltage selection must be verified before the power cord is connected. This verification procedure is explained in Section 4.

WARNING

TO AVOID ELECTRICAL SHOCK, PROPERLY GROUND THE CHASSIS. A GROUND CONNECTION IS PROVIDED ON THE THREE-PRONG POWER CONNECTOR. IF PROPER GROUND IN YOUR POWER SYSTEM IS IN DOUBT, MAKE A SEPARATE GROUND CONNECTION TO THE REAR PANEL CHASSIS BINDING POST. OTHERWISE, THE POSSIBILITY OF ELECTRICAL SHOCK MAY EXIST IF HIGH VOLTAGE IS MEASURED WITH THE LEADS REVERSED (INPUT HI GROUNDED).

2-9. OPERATING FEATURES

2-10. Front and rear panel features are illustrated in Figure 2-1 and described in Table 2-1. Use this information for initial familiarization with the multimeter. A full explanation of all features is presented later in this section.

2-11. OPERATING NOTES

2-12. Input Power

2-13. A binding post on the rear panel has been provided as an earth ground connection. Line voltage selection (100, 120, 220, or 240V ac) is explained in Section 4. With the exception of proportionately slower reading rates and filter time-outs, operation at 50 Hz is identical to that at 60 Hz.

2-14. The line fuse (0.5A MDL Slow Blow for 100 or 120V ac, or 0.25 MDL Slow Blow for 220 or 240V ac) is located on the lower right side of the rear panel (in the heat sink). The current and ohms protection fuse (1.5A AGC) is located in the lower right-hand corner of the front panel for front input connections and on the left side of the rear panel (as seen from the rear) for rear input connections. Refer to Fuse Replacement in Section 4 before replacing any fuse.

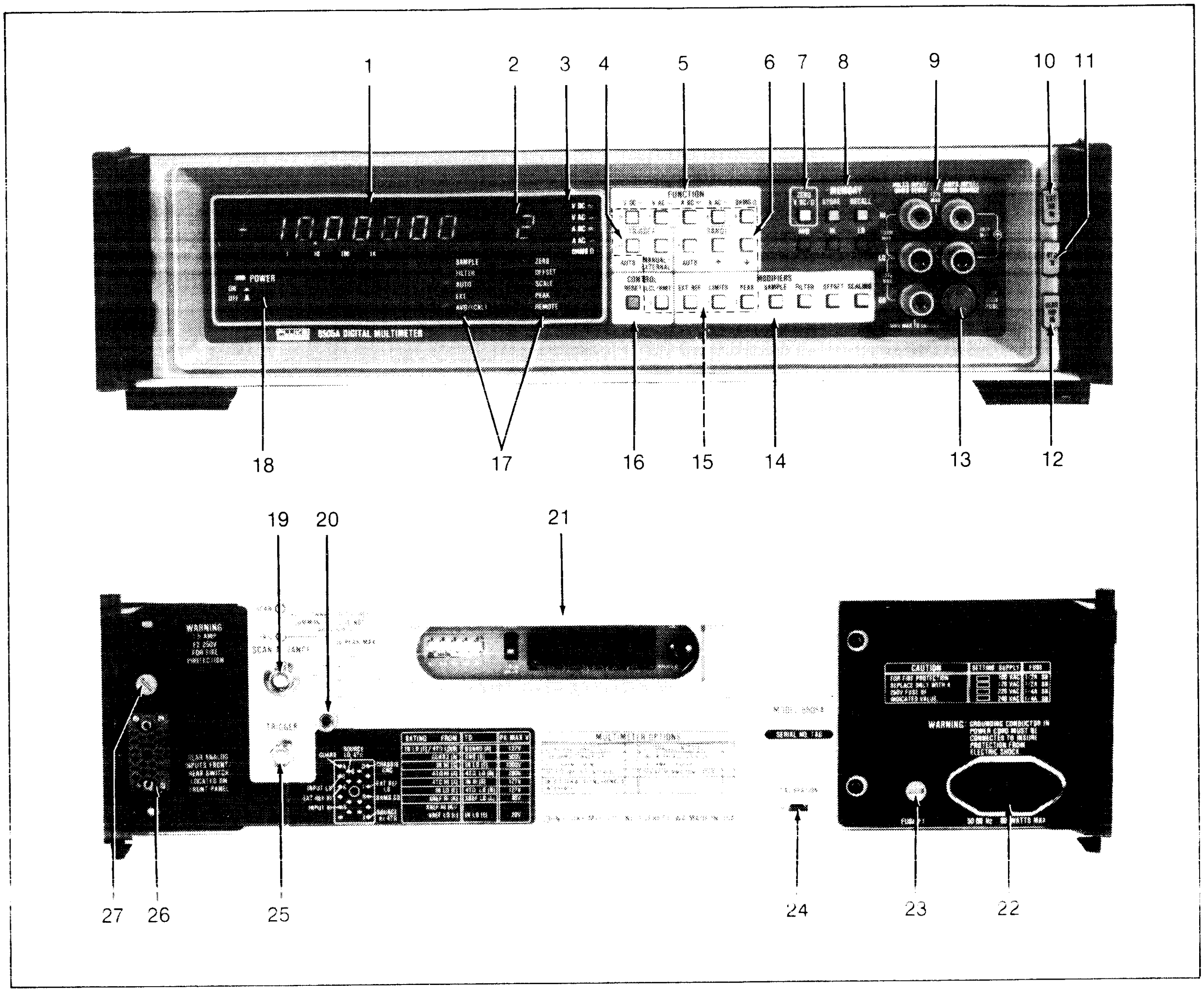


Figure 2-1. Controls, Indicators, and Connectors

Table 2-1. Controls, Indicators, and Connectors

ITEM	NAME	DESCRIPTION
1	Mantissa Field	Displays 5½, 6½ or 7½ digits with polarity and decimal point. Also displays errors and warnings, prompts, numerics, recalled values, and limits indications.
2	Exponent Field	Polarity and value of exponent shown for engineering notation of display value. In Averaging or Calibration mode, the exponent may be used as an extra digit of resolution.
3	Function Annunciators	Annunciator lights to indicate function selection. V DC and V AC annunciators will both light when respective functions are simultaneously selected and the RMS Converter is installed.
4	TRIGGER Push Buttons	TRIGGER push buttons used to select continuous (AUTO) or individual (MANUAL/EXTERNAL) measurement triggers.

Table 2-1. Controls, Indicators, and Connectors (cont)

ITEM	NAME	DESCRIPTION
5	FUNCTION Push Buttons	Used to select any of six measurement functions: voltage (V DC, V AC, or V DC and V AC), current (A DC or A AC), or resistance (OHMS).
6	RANGE Push Buttons	AUTO toggles into/out of Autoranging mode, changing range only when necessary. The up/down buttons exit Autoranging and increase/decrease one range with first use, step up/down one range with each additional use.
7	ZERO Push Button	Used to toggle into/out of the Zero mode (V DC or OHMS only). A new zero value is stored each time the mode is entered. This value is applied to the selected range and to all higher ranges within the same function. Also used to recall zero values. Refer to text for use with Calibration Memory.
8	MEMORY Push Buttons	STORE is used to initiate memory entry for displayed values or numeric entries. RECALL commands display of a memory value. HI and LO are used when storing or recalling limits, or when recalling peak values.
	Average Push Button	AVG toggles into/out of Averaging mode.
9	Input Terminals	Measurement connection terminals.
10	Guard Selector	GUARD is connected to SENSE LO when disengaged (out); GUARD is floated to allow external connection when engaged (in).
11	Ohms Selector	Push in for 4-wire ohms measurement using OHMS SENSE (HI, LO) and OHMS SOURCE (HI, LO) terminals. Push again to disengage for 2-wire ohms measurements using OHMS SENSE (HI, LO) terminals.
12	Rear Input Selector	Push in to connect rear analog input terminals and disconnect front terminals. Push again to disengage, reconnecting front terminals and disconnecting rear terminals. Position of the switch can be sensed remotely.
13	Current/Ohms Fuse	Use AGC 1.5A.
14	MODIFIERS Push Buttons	SAMPLE and FILTER modify the manner in which a reading is taken (measurement parameters). EXT REF, OFFSET, and SCALING modify the reading value (mathematic operations). LIMITS and PEAK modify the usage of the measurement value (special operations).
15	Numeric Entry Push Buttons	When enabled by initially pushing the STORE button, these push buttons can be used to enter numerics, exponents and related polarity signs.
16	CONTROL Push Buttons	RESET initiates a power-up reset. LCL/RMT usage depends on the remote interface in use: a. If the IEEE Interface (-05) is used, LCL/RMT toggles from remote to local, but not from local to remote. b. If the Bit Serial (-06) or Parallel (-07) Interface is used, LCL/RMT toggles between local and remote.

Table 2-1. Controls, Indicators, and Connectors (cont)

ITEM	NAME	DESCRIPTION
17	Status Annunciators	SAMPLE flashes to show a new reading in progress. FILTER lights whenever slow filter is selected. AUTO lights for Autoranging. EXT lights when External Reference is enabled (disables Scaling). AVG/CAL lights (steady) for Averaging or flashes for Calibration mode. ZERO lights when a V DC or OHMS zero correction value is in use. OFFSET lights when Offset mode is enabled. SCALE lights when Scaling mode is selected (disables Ext Ref). PEAK lights when Peak mode is enabled. REMOTE lights when the multimeter is controlled through a remote interface.
18	POWER Switch	Push ON/push OFF. The Calibration switch (item 24) must be off before cycling power on or off.
19	Scan Advance Output	TTL compatible output signals to external scanner (50-ohm output impedance).
20	Chassis Ground	Binding post for ground connections.
21	Remote Interface Access Port	Connector on optional remote interface module accessible here.
22	Power Connector	Three-prong connector accepting line cord with ground wire.
23	Line Fuse	Use ½A Slow Blow for 100 or 120V ac, ¼A Slow Blow for 220 or 240V ac. Refer to Fuse Replacement in Section 4.
24	Calibration Switch	Activates Calibration mode (AVG/CAL) annunciator flashes).
25	External Trigger Input	Enabled by front panel MANUAL/EXTERNAL push button.
26	Rear Analog Input Connection	Alternate connections for all front panel inputs — enabled when Rear Input Selector on front panel is pushed in. EXT REF HI and LO inputs are also included, but are not switched by the Rear Input Selector.
27	Rear Input Fuse	Use AGC 1.5A.

2-15. Required Hardware

2-16. The multimeter must be equipped with the following modules for standard operation (dc volts).

1. Controller (blank display if not installed)
2. Active Filter (Error 2 if not installed)
3. A/D Converter (Error 5 if not installed)
4. Isolator (Error 9 at power-up if not installed)

2-17. Additional modules are necessary when using the multimeter in ac volts, dc current, ac current, or resistance functions or for remote control. Separate modules for averaging ac or rms ac measurements are available: only one of these modules may be installed at one time. If it is necessary to check, install or replace modules, refer to Module Installation and Removal procedures in Section 4.

2-18. An "Error 9" indication appears in the multimeter display whenever an optional function is selected and the respective function module is faulty or missing. At power-up, the multimeter identifies all installed options by displaying "CXXXXXX" ("X" = Option number). An "8" in the exponent display identifies an installed Isolator.

2-19. Power-Up Configuration

2-20. At power initialization, or whenever the RESET button is pushed, the multimeter assumes the power-up configuration. Basically, the instrument assumes the V DC function with all modes and values disabled. The power-up configuration is fully defined in Table 2-2.

2-21. Display

2-22. MEASUREMENT READING

2-23. The measurement display consists of mantissa and exponent fields. The mantissa presents polarity, 5-1/2, 6-1/2, or 7-1/2 digit resolution (range and function dependent) and automatic decimal placement. In addition, the mantissa displays numeric storing entries, recalled values, error and warning information, and interactive programming information (prompts). Decimal point positions are labeled (1, 10, 100, 1k) to correspond with range settings (as defined in Figure 2-3).

2-24. When very large or small readings are displayed, the exponent field is also used to maintain maximum resolution. A negative or positive exponent field polarity indicates multiplication of the mantissa by the displayed power of ten (-3 means .001, +3 means 1000). Exponent values of -6, -3, +3, or +6 are available for displayed readings. Additional exponents of -9 and +9 are available for offset and scaling numeric entries.

2-25. When the Averaging mode is selected, the exponent may serve as an additional digit of resolution. When the Limits mode is selected, the entire measurement display is devoted to an indication of HI, LO, or PASS.

2-26. ANNUNCIATORS

2-27. Any valid function selection causes one of the function annunciators (V DC, V AC, A DC, A AC, OHMS) to light. The V DC annunciator normally lights in the power-up or reset configuration. However, if the DC Signal Conditioner module is faulty or not installed and a functional RMS Converter module is installed, power-up or reset causes the V AC annunciator to light. Two function annunciators (V DC and V AC) light when

Table 2-2. Default Configurations

	POWER-UP OR RESET		SELECTION OF NEW FUNCTION (1)	
	CONDITION	DISPLAY	CONDITION	DISPLAY
Function	DC Volts	V DC on	New Function	VDC,VAC,ADC, AAC or OHMS on
Range	1000V Manual	AUTO off	Autoranging	AUTO on
Trigger	Auto	SAMPLE flashes	Retains Previous Trigger Mode	SAMPLE flashing or off
Filter	F0	FILTER off	Retains Previous Filter Mode (2)	FILTER on or off
Sample	7	SAMPLE flashes	Retains Previous Sample Setting (2)	SAMPLE flashes
Offset	Off, Value 0	OFFSET off	Off, retains value	OFFSET off
Scaling	Off, Value 1	SCALE off	Off, retains value	SCALE off
External Reference	Off, Note 3	EXT REF off	Off, retains last value	EXT REF off
Limits	Off, Value 0	Normal Display	Off, retains last value	Normal Display
Peak	Off	PEAK off	Off, retains last values	PEAK off
Averaging	Off	AVG/(CAL) not on steady	Off (2)	AVG/(CAL) not on steady
Zero	On, Cal Memory Values	ZERO on	Retains mode values and state (4)	ZERO on (VDC,OHMS) or off
Calibration Mode	Note 4		Note 4	

Notes:

1. Re-selection of the same function sets autoranging (AUTO on), but retains all other mode values and states.
2. Disabling Average mode (by changing to a new function) sets filter mode F0 and sample setting 7. If the same function is re-selected, the state of Average mode is not changed, and the existing filter mode and sample setting are retained.
3. The External Reference value is initialized to the multimeter software number whenever power-up or reset occurs. RECALL EXT REF can then be used to display this number. Any subsequent activation of External Reference mode replaces the software number with the actual external reference value.
4. The Calibration mode state is on or off solely dependent on the position of the rear panel Calibration Switch. Do not cycle power on or off with this switch ON.

Calibration mode entries are applied to the reading as follows:

a. Gain correction factors are always applied (Calibration mode on or off).

b. Zero values are applied whenever Zero mode is on or off (Calibration mode on or off, VDC or OHMS selected). However, the zero values used depend on the Calibration mode state.

Modes	Zero applied
Cal mode on, zero off	Nothing
Cal mode on, zero on	Permanent Zero
Cal mode off, zero off	Permanent Zero
Cal mode off, zero on	Permanent Zero and Temporary Zero

the V DC and V AC push buttons are pressed simultaneously and the RMS AC Converter module is installed.

2-28. Status annunciators light to signify various modes of operation. Annunciators (as defined in parentheses) light when any of the following modes are enabled: Peak (PEAK), Scaling (SCALE), or External Reference (EXT), Averaging (AVG/CAL), Offset (OFFSET), Autoranging (AUTO), or V DC/Ohms Zero (ZERO). The FILTER annunciator lights (steadily) whenever the slow filter is selected. The SAMPLE annunciator flashes at the reading (display update) rate for sample settings from 0 through 7. The flash rate for setting 0, 1, or 2 is very rapid: SAMPLE appears steadily on. For sample settings from 8 through 17, the SAMPLE annunciator flashes at the sample setting 7 rate only. Since these higher sample settings may require considerable time for a display update, this feature is necessary to insure that the operator is aware of a reading in progress. With a distinctive display of HI, LO, or PASS, the Limits mode requires no separate status annunciator.

2-29. OVERRANGE INDICATION

2-30. The measurement display presents a distinct indication when overrange inputs are detected. An input voltage exceeding the full scale value for the range selected causes HHHHHH to flash. Overrange points for each range are defined in Table 2-3.

2-31. WARNING INDICATION

2-32. When in the Scaling, External Reference, Offset or Limits mode, there may be no readily discernible display of the true measurement value. Therefore, a single H is flashed in the exponent display when the voltage is 30V or higher at either the front panel input connections or the rear panel external reference terminals.

NOTE

Flashing indicators in the digit or exponent display are a warning only; they have no effect on instrument operation.

2-33. ERROR CODES

2-34. Error codes offer considerable help in identifying improper procedures or equipment configurations. These codes are explained in Table 2-4.

2-35. INTERACTIVE PROGRAMMING INFORMATION

2-36. The multimeter displays prompting messages during STORE and RECALL operations. Whenever the STORE button is pushed, the display responds with "?". The operator may now designate either the displayed value or keystroked numerics as the programming entry. If the displayed reading is being stored, pushing the appropriate terminator button (FILTER, SAMPLE, SCALING, HI OR LO - for LIMITS or OFFSET)

Table 2-3. Measurement Ranges

FUNCTION	DECIMAL POINT POSITION FOR RANGE INDICATED				EXP	OVERRANGE	UNDERRANGE	DIGITS
	1	10	100	1k				
V DC			100 mV		-3	200 mV	—	6½
	1V					2V	.17V	6½
		10V				20V	1.7V	6½
			100V			128V	12V	6½
				1000V		1200V	120V	6½
V AC	1V					2.5V	—	5½
		10V				20V	1.875V	5½
			100V			160V	15V	5½
				1000V		1000V	120V	5½
A AC			100 μA		-6	312.5 μA	—	5½
	1 mA				-3	2.5 mA	234 μA	5½
		10 mA			-3	20 mA	1.875 mA	5½
			100 mA		-3	160 mA	15 mA	5½
	1A					1.28 mA	120 mA	5½
A DC		100 μA			-6	250 μA	—	5½
	1 mA				-3	2 mA	187 μA	5½
		10 mA			-3	16 mA	1.5 mA	5½
			100 mA		-3	128 mA	12 mA	5½
	1A					1.28A	124 mA	5½
OHMS		10				20Ω	—	5½
			100			200Ω	18Ω	5½
	1K				+3	2 kΩ	180Ω	6½
		10K			+3	25 kΩ	1.8 kΩ	6½
			100k		+3	250 kΩ	18 kΩ	6½
	1M				+6	4.1 MΩ	180 kΩ	5½
		10M			+6	35 MΩ	1.8 MΩ	5½
			100M		+6	265 MΩ	18 MΩ	5½

Table 2-4. Error Codes

MOMENTARY ERROR CONDITIONS

(The reading in progress is aborted, but multimeter operation is automatically restored with the next trigger. The function annunciator remains on during a momentary error condition.)

CODE	FAULT	SOLUTION
Error 0	V DC/Ohm Zero, zero attempted in wrong function (not V DC or OHMS) or an overrange has been entered.	Check function. Only V DC and OHMS are permissible.
Error 1	Store attempted during overload condition.	Change to higher range or (if storing cal correction factors) use lower value source.
Error 6	Display overflow error.	Check offset and scaling values.
Error 7	External Reference error - voltage on one input exceeds 20V dc.	Revise external reference input.
Error 8	Controller module is faulty.	Power off; replace controller module.
Error b	Illegal push button sequence in Calibration mode.	Wait till display clears. Use correct sequence.
Error C	Invalid push-button sequence, or illegal value entered.	Wait till display clears. Use correct sequence or value within limits.
Error d	Calibration Memory faulty or not installed. Occurs when storing into, or recalling from, Calibration Memory, or at power-up.	Replace or install Calibration Memory chip.
Error F	Cal Memory check-sum problem.	Try new power-up. If necessary, reprogram Cal Memory. Replacement of Calibration Memory may be required.
Error H	Ohms connection problem.	Verify that all connections are proper. Check input fuses. Check input lead polarity in four-terminal connections.

LATCHING ERROR CONDITIONS

(A valid function must be selected to restore multimeter operation. All function annunciators are off during a latching error condition.)

CODE	FAULT	SOLUTION
Error	System error, usually appears at power-up or reset.	Repeat power-up or reset.
Error 2	Filter module faulty or not installed.	Power off; replace or install filter module.
Error 3	DC Signal Conditioner module faulty or not installed.	Power off; replace or install DC Signal Conditioner module.
Error 4	OHMS, A DC, or A AC error.	Check for improper input level. Check function causing error indication. Applicable module may need replacement or installation.
Error 5	Analog to Digital Converter Module error.	Power off; replace or install Analog to Digital Converter module.
Error 9	Function selection error. The function module selected is faulty or not installed. V DC problem causes Error 3.	Select valid function to clear error condition. Power off; replace or install appropriate module.
Error E	More than one ac converter, or the wrong ac converter, is installed. Also appears when Calibration Memory module is installed.	Power off, remove one ac converter, or install correct converter, or remove the Calibration Memory module (the multimeter uses a separate Calibration Memory as part of the Controller).

completes the operation. The multimeter adopts both the mode specified with the terminator and the value previously displayed. If keystroked numerics are being stored, the multimeter displays the digits as they are entered from the front panel. Once all numbers for a particular mode are entered, the appropriate terminator button is pushed. For either method, the display now resumes the measurement reading function or, if HI or LO were specified as the terminator, begins reading HI, LO, or PASS.

2-37. The RECALL button commands a display of a stored factor or value. The procedure requires the following two steps when recalling the offset value, the scaling factor, the filter mode, the sample setting, or the zero value:

1. Push the RECALL button (display responds with "?").
2. Push the appropriate terminator button (OFFSET, SCALING, FILTER, SAMPLE or ZERO). The respective value is displayed as long as the terminator button is held depressed. Once the terminator button is released, the multimeter resumes operation; no mode or value is changed.

2-38. The following three push button steps are required to recall a limit or peak value.

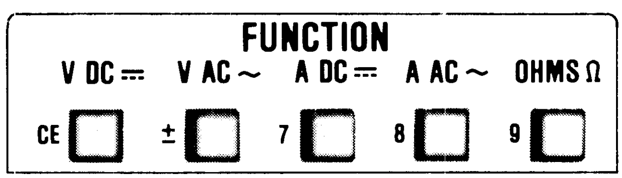
1. Push RECALL (display responds with "?").
2. Then specify whether upper or lower limit or peak is desired by pushing HI or LO (display responds with "YES?").
3. Finally, push the appropriate terminator button (LIMITS or PEAK).

2-39. Front Panel Push Buttons

2-40. The multimeter employs 25 color-coded push buttons on the front panel. Most of the push buttons control more than one function. For example, many mode control push buttons also serve as numeric entry push buttons when used during a store operation. The number of keystrokes required for any operation is kept to a minimum. Refer to Figure 2-2 for a description of each push button and, where applicable, examples of typical programming operations.

2-41. Operation of the multimeter is straightforward. Preset measurement configurations are made at power-up, reset, or function selection. Programmed values are retained whenever the range or function is changed. Desired mode changes are made independently following a programming hierarchy of:

1. Measurement Parameters
2. Mathematic Operations
3. Special Operations



The FUNCTION push buttons allow selection of the analog measurement function. Available functions include: dc volts (V DC), ac volts (V AC), dc current (A DC), ac current (A AC), and resistance (OHMS — two wire or four wire).

V DC

Push V DC for dc voltage measurements with 6½-digit resolution (V DC annunciator lights). This function is standard for the multimeter (no optional module required). Five ranges are available: 1000V, 100V, 10V, 1V, and 100 mV.

V AC

Push V AC for ac voltage measurements with 5½-digit resolution (V AC annunciator lights). This function can be used with either the -01 Averaging Converter or the -09A RMS Converter. Four ranges are available: 1000V, 100V, 10V, and 1V.

A DC

Push A DC for dc current measurements with 5½-digit resolution (A DC annunciator lights). This function can be used with the -03 Current Shunts module installed. Five ranges are available: 1A, 100 mA, 10 mA, 1 mA, and 100 μA.

A AC

Push A AC for ac current measurements with 5½-digit resolution (A AC annunciator lights). This function can be used when the -03 Current Shunts module and either the -01 Averaging Converter or the -09A RMS Converter is installed. Available ranges are identical to those in the A DC function.

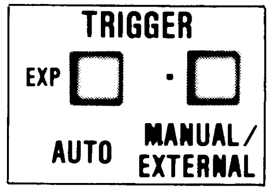
Figure 2-2. Front Panel Push Buttons

OHMS

Select the OHMS function to make resistance measurements (OHMS annunciator lights). The -02A Ohms Converter must be installed. Eight resistance ranges are available: 100 MΩ, 10 MΩ, 1 MΩ, 100kΩ, 10 kΩ, 1 kΩ, 100Ω and 10Ω.

NOTE

Either two-wire or four-wire resistance measurements can be made. Refer to Measurement Terminals and Controls.

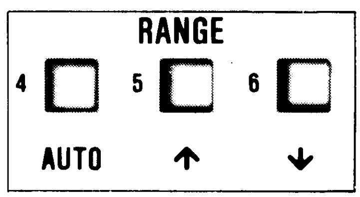


AUTO

The AUTO (trigger) push button selects the Auto Trigger mode. A flashing SAMPLE annunciator verifies Auto Trigger operation.

MANUAL/ EXTERNAL

Initial use of the MANUAL/EXTERNAL push button disables the Auto Trigger mode (SAMPLE annunciator stops flashing), enables the front panel Manual Triggering mode, and arms the External Triggering mode. Each succeeding use of the MANUAL/EXTERNAL push button triggers a new measurement: any reading already in progress is aborted and the new reading begun immediately. The SAMPLE annunciator verifies that a measurement has been triggered by flashing once, or several times (if the sample-per-reading setting is greater than 7, 2 exponent 7 = 128 samples). An external trigger applied through the rear panel external trigger jack similarly commands a new reading. An external trigger applied simultaneously with a front panel manual trigger will be ignored. AUTO must be pushed to reenter the Auto Triggering mode.



AUTO

AUTO RANGE toggles into/out of the Autoranging mode, changing the existing range if necessary. When enabled (AUTO annunciator lighted), Autoranging automatically selects a range that displays the measurement with maximum resolution.

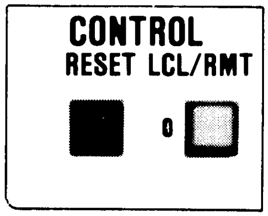
↑

Each use of this manual ranging push button selects the next higher available range. if AUTO RANGE was previously activated, use of the uprange push button toggles out of Autoranging (AUTO annunciator off) and steps to the next higher range. No range change is effected if the multimeter is already in the highest range.

↓

Use of the down-range push button causes the multimeter to toggle out of Autoranging (AUTO annunciator off) and assume the next lower available range. Each successive use of the down-range button selects the next lower range. This push button has no effect once the multimeter is in the lowest available range.

Figure 2-2. Front Panel Push Buttons (cont)



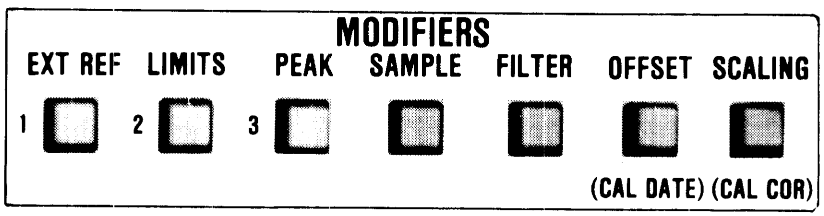
RESET

CAREFUL: The RESET push button is powerful: all modes and stored values (other than calibration factors) are lost if RESET is pressed. Once RESET is used, the multimeter assumes the Power-Up configuration (without actual power loss). Temporary zero values are replaced with zero values stored in Calibration Memory.

LCL/RMT

Depending on the remote interface being used, pushing the LCL/RMT button may cause one of three multimeter responses.

1.) If the -05 IEEE Interface is installed, LCL/RMT may be used to command local (front panel) control only if the multimeter is already in remote (REMOTE annunciator lighted). The push button has no effect if the multimeter is already in local.
2.) If the -06 Bit Serial Interface or the -07 Parallel Interface is installed, LCL/RMT may be used to toggle into/out of local control at any time.
3.) If no remote interface is installed, use of LCL/RMT causes a latching error condition.



EXT REF

The EXT REF button toggles into/out of the External Reference mode. Either External Reference or Scaling may be enabled: selection of one mode disables the other. After power-up or reset, RECALL EXT REF can be used to identify the software version.

NOTE

The external reference voltage, applied through the rear input connector, can be read in the display while EXT REF is held depressed.

LIMITS

The LIMITS push button toggles into/out of the Limits mode without changing stored limits values. A display of HI, LO, or PASS denotes use of the Limits mode.

PEAK

The PEAK push button toggles into/out of the Peak mode. While in the Peak mode (PEAK annunciator lighted), a continually updated record of the highest and lowest reading values is stored. These values are also held in memory after the mode is disabled. Reentry into the PEAK mode erases previously recorded values and begins a new recording.

SAMPLE

Different reading rates can be specified by selecting the number of samples averaged per measurement. There are two methods for making this selection.

1.) The SAMPLE button can be pushed to toggle between two commonly used reading rates: slow (1.9 readings-per-second, SAMPLE annunciator flashes slowly) and fast (7.5 readings-per-second, SAMPLE annunciator flashes rapidly).

Figure 2-2. Front Panel Push Buttons (cont)

2.) Any of 18 different reading rates can be specified using the following push button sequence:

STORE (0-17) SAMPLE

The SAMPLE annunciator now flashes at a specified rate. For settings of 0-7, this rate is the reading rate. For the slower settings of 8-17, a single rate is preset to indicate a reading in progress.

FILTER

Two methods are available for filter selection.

1.) By toggling the FILTER push button, the operator can select mode F (no mode number) or F0 (mode number 0).

2.) The following sequence can be used to select any of the five filter modes:

STORE (mode number) FILTER

MODE NUMBER	FILTER	TIMEOUT	FILTER LED
(blank)	slow	none	on
0	fast	none	off
1	bypass	none	off
2	slow	550 ms	on
3	fast	50 ms	off
(No Mode Number is used for slow filter without timeout. Push STORE FILTER.)			

OFFSET

The OFFSET push button can be used to toggle into/out of the Offset mode (OFFSET annunciator lights). Two methods are available for simultaneously entering an offset value and activating the Offset mode.

1.) A numeric value may be entered using a store sequence. For example, store an offset of 1.25 as follows:

STORE 1 . 2 5 OFFSET

2.) A displayed reading can be stored as the offset value. Use the following sequence:

STORE OFFSET

NOTE

In some instances, the displayed value may not be an appropriate offset value. For example, if the displayed value is being used to zero the multimeter, it is important to verify that no other mathematic operations are in effect. In such a case, check that OFFSET, SCALING, and EXT REF annunciators are all off before storing a new offset value.

Figure 2-2. Front Panel Push Buttons (cont)

(CAL DATE)

When the multimeter is in the Calibration Mode (AVG/(CAL) annunciator flashes), the (CAL DATE) push button is used to enter six digits which either denote the date or identify the multimeter by number. Refer to Calibration Mode later in this section.

SCALING

The SCALING push button can be used to toggle into/out of the Scaling mode without affecting any scaling value already stored. Either of the following two methods can be used to store a new scaling factor and enable the Scaling mode:

NOTE

Verify that the displayed value is the desired scaling value. Any mathematic operations (SCALING, EXT REF, OFFSET) already in effect must be cancelled if the actual measurement is desired as the scaling value. To cancel any of these modes, toggle SCALING, EXT REF, or OFFSET and verify that the respective annunciators are dark.

1. Use the following sequence to store the display as a scaling factor:

   STORE SCALING

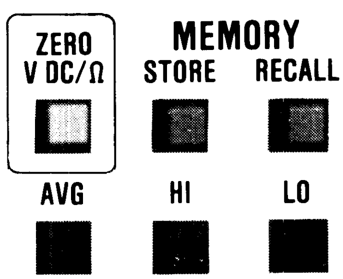
2. Numeric entry scaling factors must be programmed using the following procedure:

   STORE (numerics) SCALING

With either method, the Scaling mode is entered with the initial use of the SCALING button.

(CAL COR)

The (CAL COR) push button is used when storing calibration factors for each function and range, or when recalling uncorrected readings. Refer to Calibration Mode later in this section.



STORE

STORE is used as a first step in programming certain measurement parameters, mathematic operations, or special operations. STORE is the only push button that can activate the numeric entry keys. The multimeter prompts the second step by displaying "?". Following is a list of STORE operations:

Measurement Parameters:

	0-17	SAMPLE
STORE	0,1,2,3 or blank	FILTER

Figure 2-2. Front Panel Push Buttons (cont)

Mathematic Operations:

To store the displayed value as an offset or scaling value and enter the respective mode:

STORE { OFFSET / SCALING

To store a numeric entry as an offset or scaling value and enter the respective mode:

STORE (numerics) { OFFSET / SCALING

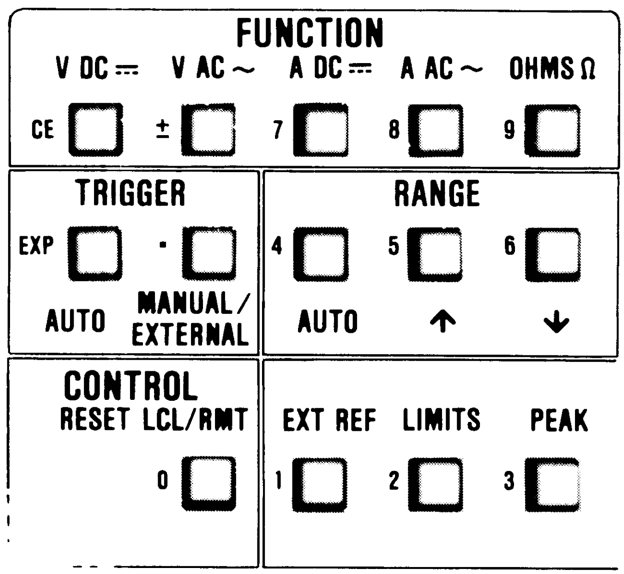
Special Operations:

To store the displayed value as a high or low limit and enter the Limits mode:

STORE { HI / LO

To store a numeric entry as a high or low limit and enter the Limits mode:

STORE (numerics) { HI / LO



The multimeter utilizes fourteen dual purpose push buttons as numeric entry keys. When programming sample settings or filter modes, a one- or two-digit entry is necessary. When programming limits, or scaling and offset values, a longer entry may be required. Therefore, the following sequence is available:

Mantissa Field: enter a maximum of seven digits, with decimal point. Toggle polarity (±) button as required.

Exponent Field: push EXP button, then enter a single digit exponent. Toggle the polarity button again to set the exponent polarity.

Use the CE push button at any time prior to the terminator (last button in a store numeric sequence) to clear all numerics and revert to a "?" display. Fresh numerics may then be entered immediately.

Figure 2-2. Front Panel Push Buttons (cont)

RECALL

The RECALL push button can be pressed to recall and display values stored in the Limits, Peak, Scaling, Offset, Zero, External Reference, Sample or Filter modes. For recall of uncorrected readings, dates and identifiers, refer to Calibration Mode later in this section. No stored value is affected during the RECALL operation. The recalled value will be displayed as long as the last push button in the sequence is held depressed.

To recall measurement parameters:

RECALL { SAMPLE / FILTER }

To recall mathematic operation values:

RECALL { OFFSET / SCALING / EXT REF / ZERO V DC/Ω }

To recall a special operation value:

RECALL { HI / LO } { LIMITS / PEAK }

ZERO V DC/Ω

The ZERO push button can be used to store a dc volts zero (any range) or ohms zero (any range). The zero value stored is also applied on all higher ranges in the same function. For discrete zero values on each range, zero must be stored sequentially on each range (from lowest to highest). With the initial button push, a new zero value is stored and the mode is enabled (ZERO annunciator on). Pushing ZERO a second time disables the mode, but retains the previous value. A new zero value is stored each time Zero mode is enabled. Refer to text for use with Calibration mode.

AVG

The AVG push button can be used to optimize sample and filter factors for each function and range combination. A stable reading is thereby assured. An additional digit (using the exponent display) is available in 10V dc range when in the Averaging mode.

HI

LO

The HI and LO push buttons are used to store or recall limit values and for recall only of peak values. Refer to STORE and RECALL push button descriptions for the applicable sequence.

Figure 2-2. Front Panel Push Buttons (cont)

2-42. Measurement parameters (range, sample, filter, trigger, averaging, zero) define all operations that affect the resolution, stability, and accuracy of the reading. For example, the range is specified to position the decimal point, and the filter mode may be changed to improve noise rejection.

2-43. Mathematic operations (External Reference or Scaling, Offset) alter the reading to operator requirements. For example, when Offset is used, only the difference between the reading and the offset value is displayed.

2-44. Special operations (limits, peak) specify how the reading is used. For example, Peak mode can be used to continuously update a record of the highest and lowest readings, or Limits mode may be used for a HI, LO, PASS display of the measurement reading. A comprehensive setup routine is summarized in Figure 2-3. All or part of this routine can be used to establish or change measurement parameters, mathematic operations, or special operations.

2-45. Error codes usually identify any programming problem and specify a solution (refer to Table 2-4). A numeric entry may be aborted at any time prior to termination by pushing the CE button. The multimeter responds by displaying "?": another numeric entry may now be made, or the displayed value may be stored by pushing the desired terminator button. A store or recall operation can be entirely aborted prior to execution by pressing STORE or RECALL a second time. The multimeter reverts to its state prior to the store or recall once a momentary Error C condition elapses.

NOTE

Errors due to thermal emf's should be considered when making low level, high resolution measurements. Thermal emf's (voltages produced by temperature differences between contacts of two dissimilar metals or by temperature gradients along a length of material) may cause differences of several microvolts. The use of low emf, shielded cables with copper spade lugs is recommended to minimize thermal emf errors.

If multiple programming steps are required, use the sequence presented here as a general guide. Use the push button(s) shown for the action described.

INITIALIZATION

CONFIGURATION AT POWER-UP OR RESET (V DC, 1000V, Auto, Sample 7, Filter F0, zero mode ON, no other modes or values). Calibration mode must be off before power-off.

STEP	ACTION	PUSH BUTTONS
1	FUNCTION selection a. Reselecting V DC sets autoranging. b. Push V AC and V DC simultaneously to measure ac voltage on a dc level (with RMS converter option -09A).	V AC, A DC, A AC, OHMS

CONFIGURATION AT FUNCTION CHANGE (Autorange; previous filter, sample and trigger retained; all other modes off but respective values retained.)

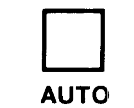
Figure 2-3. Programming Hierarchy

MEASUREMENT PARAMETERS

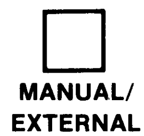
Measurement parameters establish reading resolution, noise rejection, stability and accuracy.

2 TRIGGER selection

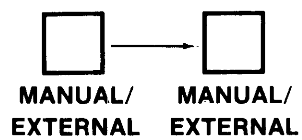
a. If in manual, change to auto



b. If in AUTO, change to manual

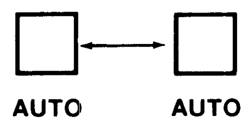


c. Manual triggers

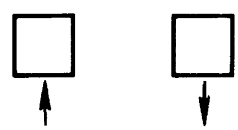


3 RANGE selection

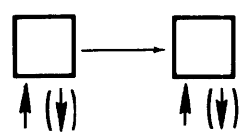
a. Toggle into/out of autoranging



b. Select manual ranging, step to next higher, lower range.

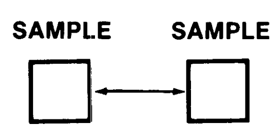


c. Continue stepping to available higher, (lower) ranges.



4 Reading Rate Selection

a. Toggle between sample settings 5 (2 exp 5 = 32) and 7 (2 exp 7 = 128)



b. Select any sample setting from 0 (2 exp 0 = 1) to 17 (2 exp 17 = 131,072)

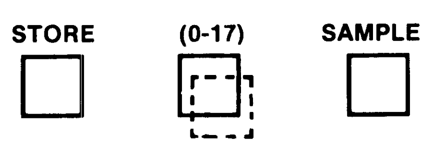


Figure 2-3. Programming Hierarchy (cont)

5	FILTER selection		
	a. Toggle between filter F (slow) and F0 (fast)	FILTER ↔ FILTER	
	b. Select filter F, F0, F1, F2, or F3.	STORE, (0,1,2,3, or blank), FILTER	
6	Averaging: toggle on/off (presets filter, sample)	AVG ↔ AVG	
7	V DC/OHMS Zero: toggle on/off (V DC or OHMS only). New zero stored each time mode is enabled. Refer to text for use with Calibration mode.	ZERO V DC/Ω ↔ ZERO V DC/Ω	

MATHEMATIC OPERATIONS

Stop here if only a direct measurement reading is desired. Further steps yield ratio, deviation, percentage variation and other special readings.

Refer to Applications in this Section for examples.

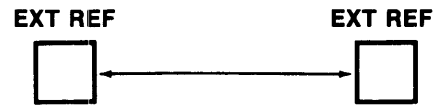
NOTE

Scaling (or External Reference) is applied first. The result of this operation is then offset.

8	SCALING selection (disables External Reference)	
	a. Store displayed value, enter Scaling mode	STORE, SCALING
	b. Store numeric value (non-zero), enter Scaling mode.	STORE, (numeric), SCALING
	c. Toggle into/out of Scaling mode while retaining value.	SCALING ↔ SCALING

Figure 2-3. Programming Hierarchy (cont)

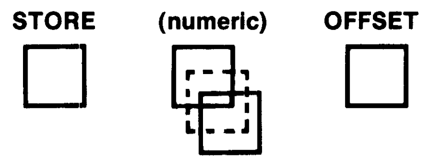
9 EXTERNAL REFERENCE selection (disables Scaling) — toggle on/off.



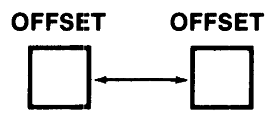
10 OFFSET selection

a. Store displayed value, enter Offset mode

b. Store numeric value, enter Offset mode



c. Toggle into/out of Offset mode while retaining value.



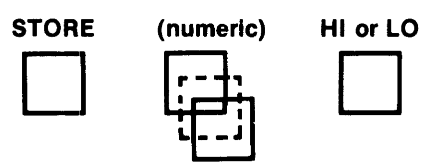
SPECIAL OPERATIONS

Use the reading, as modified by any math operations, for comparison with set limits, or record the reading maximum deviations.

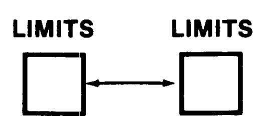
11 LIMITS selection

a. Store displayed value, enter Limits mode

b. Store numeric values, enter Limits mode



c. Toggle into/out of Limits mode while retaining values.



12 PEAK: toggle into/out of Peak mode. Previous peak values are lost each time the mode is reentered.

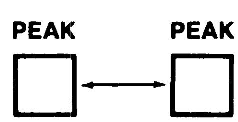


Figure 2-3. Programming Hierarchy (cont)

2-46. Measurement Terminals and Controls

2-47. GUARDING

2-48. General

2-49. Guarding may be used to reduce noise and improve accuracy. Common mode voltages, resulting from currents and voltage drops between two points otherwise electrically common, may cause significant errors. Proper use of a floating, guarded multimeter minimizes these errors.

2-50. Generally, guarding should be employed where long signal leads are used, when signal source impedance is high, when making measurements near high-level radiated noise (particularly at the power line frequency), or when making floating measurements.

NOTE

Errors due to thermal emf's should be considered when making low level, high resolution measurements. Thermal emf's (voltages produced by temperature differences between contacts of two dissimilar metals or by temperature gradients along a length of material) may cause differences of several microvolts. The use of low emf, shielded cables with copper spade lugs is recommended to minimize thermal emf errors.

2-51. Guard Selector

2-52. Correct use of the multimeter GUARD terminal both protects the instrument and provides more accurate readings. The EXT GD IN selector, when disengaged (out), enables the internal guard connection. In many cases accurate measurements may be made with the selector in this position (shown as A in Figure 2-4). Here, the difference in potential between multimeter ground and device ground is very small, or the measurement is not critical. When pushed in, the selector disables the internal guard connection and allows for external guard connections as shown in B and C of Figure 2-4. The connection shown in B is better than that in A, since some common mode current (ICM) is shunted away from the source resistance. The connection shown in C is necessary when the source may not be capable of driving the guard. The buffer amplifier shown in C prevents this source loading. Practical considerations usually dictate which of the three connections is used.

2-53. Guard Terminal

2-54. Recommended guard terminal connections are illustrated in Figure 2-4. The potential between GUARD and chassis ground must not exceed 500V. The potential between SENSE LO and GUARD must not exceed 127V.

2-55. VOLTS INPUT/OHMS SENSE (HI and LO) TERMINALS

2-56. The VOLTS INPUT/OHMS SENSE terminals are used when making voltage (dc and/or ac) and resistance measurements. Connections are shown in Figure 2-5. The input on the HI terminal with respect to the LO terminal must not exceed 1000V. The LO to GUARD potential must not exceed 127V. These terminals are internally shorted to the AMPS INPUT/OHMS SOURCE terminals (HI to HI, LO to LO) when the Ohms Selector (4T OHMS IN) is in the disengaged (2-wire) position.

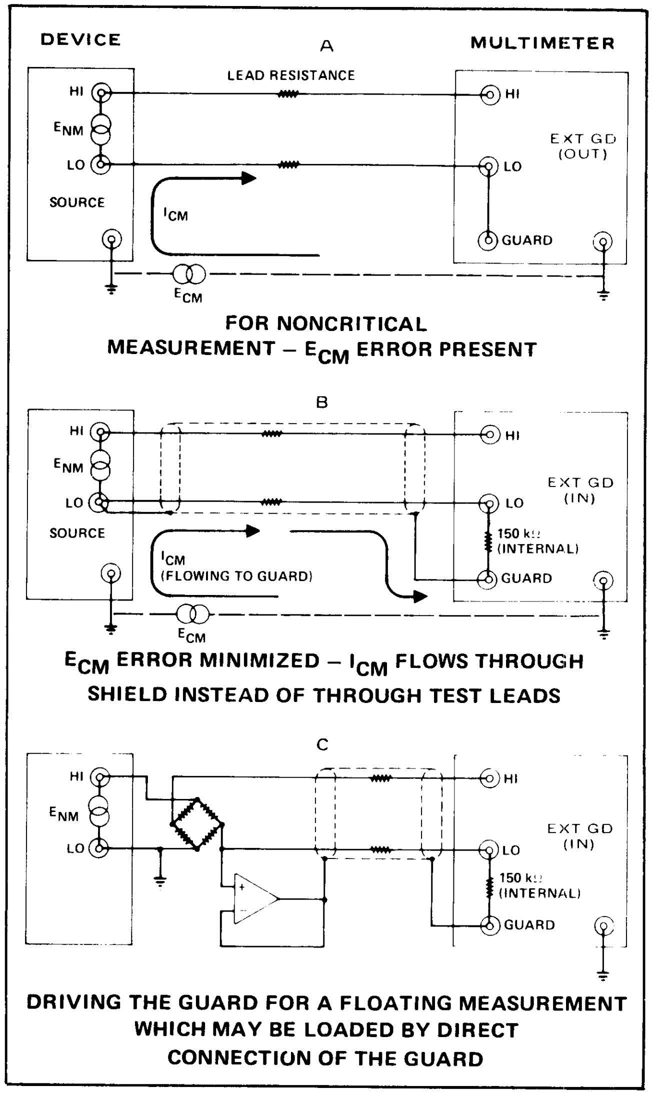


Figure 2-4. Guard Connections

NOTE

In OHMS measurements, the voltage at the SENSE INPUT terminals is sampled before the Ohms Converter (Option 02) is connected. No connection is made if excessive voltage (±10V dc) is present.

2-57. AMPS INPUT/OHMS SOURCE (HI and LO) TERMINALS

2-58. The AMPS INPUT/OHMS SOURCE terminals are used when making current (A DC or A AC) or four-wire resistance (OHMS) measurements. The potential between SOURCE HI and SOURCE LO must not exceed 280V. The potential between SOURCE HI and SENSE HI, or between SOURCE LO and SENSE LO must not exceed 127V.

NOTE

In current measurements, the voltage at the input terminals is sampled before the Current Shunts module (Option 03) is connected. No connection is made if excessive voltage (±45 V dc) is present.

2-59. OHMS SELECTOR

2-60. When engaged (in), the Ohms Selector isolates SENSE HI from SOURCE HI and SENSE LO from SOURCE LO; four-wire resistance measurements can then be made. When disengaged (out), SENSE HI is connected to SOURCE HI and SENSE LO is connected to SOURCE LO for two-wire resistance measurements. Refer to Figure 2-5. Note that this control should be in the disengaged (out) position only when two-wire resistance measurements are being made. The Ohms Selector has no control of the rear inputs (a four-wire configuration is preset).

2-61. REAR INPUT SELECTOR

2-62. When pushed in, the Rear Input Selector disconnects the front panel inputs and connects the rear input connector. The Ohms Selector and Guard Selector have no effect when rear inputs are enabled. The state of the Rear Input Selector can be sensed remotely through any of the remote interface options.

2-63. Function

2-64. Selection of a new function automatically cancels any previously selected function and places the multimeter in the function change configuration. If the same function is successively selected, the multimeter assumes the Autoranging mode, but retains all other modes and values existing prior to the reselection. A valid new function selection is verified when the appropriate display annunciator(s) lights (V DC, V AC, A DC, A AC, OHMS, or V DC + V AC). An invalid function selection occurs whenever the necessary analog measurement module is not installed or is faulty; either ERROR 9 or ERROR 3 appears in the display in such cases. Once an invalid function has been selected, the multimeter ignores all other push buttons until a valid function is selected.

2-65. Measurement Parameters

2-66. SAMPLING

2-67. The multimeter averages a number of samples for each reading (display update). Noise rejection is influenced by the number of samples-per-reading and by the filter selection. Each sample-per-reading setting yields a specific processing time. Additional processing time is necessary when mathematic operations (such as OFFSET or SCALING) are involved. Samples taken are synchronous to the line frequency for local operation. Synchronous or asynchronous operation can be specified remotely.

2-68. Sample settings are specified as exponents of two. For example, the SAMPLE push button can be used individually to toggle between settings 5 (2 exponent 5 = 32 samples-per-reading) and 7 (2 exponent 7 = 128 samples-per-reading). Further, any sample setting (exponent of 2) from 0 through 17 may be made using the STORE (numeric) SAMPLE sequence. If a setting of 0 through 6 is in effect when SAMPLE is toggled, the multimeter assumes setting 7. A previous setting of 7 through 17 is changed to 5 when SAMPLE is toggled.

2-69. The SAMPLE annunciator is controlled by both the sample setting and the trigger. At sample settings from 0 through 7, SAMPLE flashes once for each triggered reading. The rapid reading rate at 0 or 1 setting yields an apparent steady indication. At sample settings 8 through 17, the flash rate is preset to that of setting 7. This feature insures a reliable reading-in-progress indication at these slower reading rates.

2-70. TRIGGERING

2-71. Each new measurement is initiated with a trigger. In auto triggering, each trigger is generated internally at the end of the required reading time. Triggers may also be applied locally (from the front panel) or remotely.

2-72. Auto trigger commands a continuously updated reading. The frequency of this updating is influenced by the number of samples-per-reading and by any extra processing time required by mathematic operations. The SAMPLE annunciator flashes to indicate the triggering of a new reading.

2-73. Local triggers can be manually commanded from the front panel. The duration of each reading is determined in the same manner as the auto triggers (samples, mathematics). Each use of the MANUAL/EXTERNAL push button commands an immediate response from the multimeter; any reading already in progress is aborted and a new reading begun. During any manually triggered reading, use of any other push button halts the multimeter; a new trigger must then be entered. Conversely, between manually triggered readings, the multimeter is inhibited; no display update or SAMPLE annunciation is evident. During this interval, any measurement parameter, mathematic operation, or special operation may be entered, but is not initiated until the next manual trigger is entered.

2-74. External triggers are applied through the rear panel TRIGGER jack. A local trigger manually applied from the front panel overrides a simultaneously applied external trigger.

2-75. FILTERING

2-76. Two analog filters are available: either one of these, or filter bypass, may be selected. The slow filter provides better normal mode rejection. The fast filter allows for faster instrument settling while still providing a degree of noise rejection. Whenever a filter is used, a

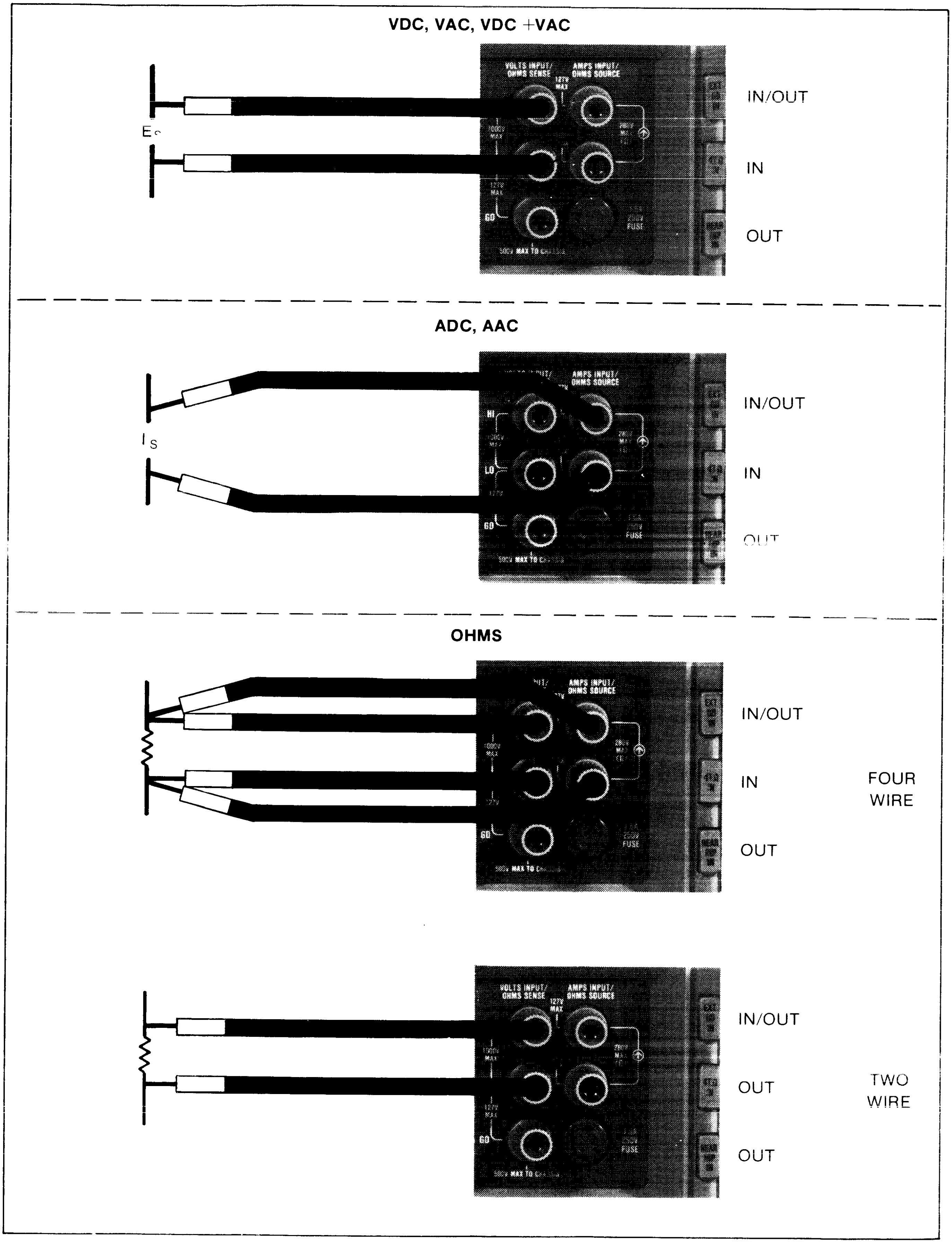


Figure 2-5. Measurement Connections

timeout (for settling delay) may also be inserted before each reading. No filtering is available for the external reference input.

2-77. Two methods of filter selection are available. Selection of any mode (F, F0, F1, F2, F3) is possible using the STORE (numeric) FILTER sequence. The FILTER push button by itself toggles between modes F and F0. The slow filter (F) is always selected when a toggle is performed with a fast filter (F0, F1, or F3) in effect. The fast filter (F0) is always selected when a slow filter (F or F2) is in effect. Mode F0 is preselected at power-up or reset.

2-78. AVERAGING

2-79. The Averaging mode presets the sample setting to 10 and the filter mode to F to provide optimum stability and resolution throughout the range of inputs. Subsequent FILTER or SAMPLE selection may jeopardize this intended optimization. Therefore, sample settings less than 10 cause the multimeter to exit the Averaging mode. Filter mode F2 can also be specified while in the Averaging mode. Selection of any filter other than F or F2 is accepted by the multimeter, but causes deactivation of Averaging mode.

2-80. The Averaging mode can be used to improve display stability (reduce rattle) in all ranges and to increase display resolution in certain ranges. Preset resolutions used for standard operation and for the Average mode are summarized in Table 2-5.

Table 2-5. Resolution

	RANGE	NORMAL DIGITS	AVERAGING DIGITS
V DC	100 mV	6½	6½
	1V	6½	6½
	10V	6½	7½
	100V	6½	6½
	1000V	6½	6½
V AC,	1V	5½	6½
OR	10V	5½	6½
V AC + V DC	100V	5½	6½
	1000V	5½	6½
A DC	100 μA	5½	6½(5½A AC)
or	1 mA	5½	6½
A AC	10 mA	5½	6½
	100 mA	5½	6½
	1A	5½	6½
OHMS	10Ω	5½	6½
	100Ω	5½	6½
	1 kΩ	6½	6½
	10 kΩ	6½	6½
	100 kΩ	6½	6½
	1 MΩ	5½	6½
	10 MΩ	5½	6½
	100 MΩ	5½	6½

2-81. RANGE

2-82. Ranges available in each function are summarized in Table 2-3. A power-up or reset condition sets the multimeter in the 1000V range, Autoranging disabled. Each function selection enables Autoranging (AUTO annunciator on). In Autoranging, the multimeter selects the range offering maximum resolution for the measured value. The AUTO (range) push button toggles Autoranging mode on or off. When toggling off, no range change is effected. Either of the up/down push buttons select manual ranging and step up/down one range when initially used. Each subsequent use steps to the next higher/lower range (if available).

2-83. V DC AND OHMS ZERO

2-84. In VDC or OHMS, internal dc drift may be corrected by zeroing. If Calibration mode is off, the values are stored in a temporary memory and do not affect Calibration Memory entries. The value stored at a zero input level is used as a zero correction for the selected range and for all higher ranges in the same function. Separate zero values for each range can thereby be stored by starting with the lowest range and working up. Calibration Memory values are automatically loaded into the temporary memory when power-up or reset occurs. The Temporary memory values are reset to zero when power-up or reset occurs. In this case, each zero value stored does not affect values on any other range.

2-85. Good quality, low thermal shorting bars (not shorted test leads) must be applied between INPUT HI and LO terminals during the zero operation. Initial use of the ZERO V DC/OHMS push button stores the zero correction value and activates the Zero mode (ZERO annunciator lights). Pressing ZERO V DC/OHMS a second time deactivates the Zero mode (ZERO annunciator goes off). A new zero value is entered each time the mode is enabled. Scaling and offset values are ignored in the stored correction value. Attempting to store zero in an illegal function (A DC, A AC, or V AC) results in an Error 0 indication. Exiting the zeroed function deactivates the Zero mode, but retains the stored values. Upon reentering the zeroed function, Zero mode and the old value are automatically restored. The zero value can be recalled for the selected range and function (VDC or OHMS).

2-86. Mathematic Operations

2-87. Mathematic operations can be specified to change the measured value (as influenced by measurement parameters) before it is actually displayed. Ratio, deviation, percentage variation and other mathematically manipulated displays are thereby possible. Scaling (or External Reference) can be used to divide the measured value and display the ratio. An offset value can be subtracted from the measured value to display only the deviation. Scaling (or External Reference) and Offset can be used in combination to display percentage variation. Examples of such operations are given under Applications later in this section.

2-88. Use of mathematic operations is expressed in the following formula:

$$\text{DISPLAY} = \frac{\text{MEASURED VALUE}}{\text{SCALING (OR EXTERNAL REFERENCE)}} - \text{OFFSET}$$

Measured value in this formula refers to the measurement as influenced by all selected measurement parameters. This value is subject to the following function-dependent considerations.

1. V DC function: measured value is the measured voltage less V DC Zero when the Zero mode is used.

2. OHMS function: measured value is obtained after any applicable OHMS Zero is applied.

2-89. SCALING

2-90. The Scaling mode divides the measured value (after application of V DC or OHMS zero) by a known amount and displays the quotient. Ratios, percentage deviations, or input/output relationships can thereby be displayed. The scaling divisor may be a previously displayed and stored value, or any non-zero numeric entry from $+10^9$ to $+10^{-9}$ and from -10^9 to -10^{-9}. When compared to External Reference, Scaling offers a much wider range. Only one scaling factor may be stored at a time.

2-91. Storing the displayed value as a scaling factor warrants a word of caution: insure that the displayed value is the true original display by first toggling out of Scaling and Offset modes (respective annunciators off). No stored scaling or offset value is lost in this manner. To store the desired display, push STORE SCALING.

NOTE

If the multimeter is in both Scaling and Offset modes, the scaling value is applied before the offset value.

2-92. EXTERNAL REFERENCE

2-93. Scaling and External Reference modes are mutually exclusive: selection of either mode automatically disables the other. The external reference value (always measured as a dc voltage) is applied as an unswitched input through the rear input connector.

2-94. Immediately after a power-up or reset, RECALL EXT REF can be used to verify the software version number. The first subsequent use of EXT REF to activate External Reference mode disables this software identification feature. When toggling into the mode, the reference voltage is displayed as long as the EXT REF button is depressed. The EXT annunciator is lighted when the mode is enabled.

2-95. The applied External Reference voltage may be a maximum of ±20V dc on either high or low input with respect to VOLTS INPUT LO. The voltage between External Reference high and low may not exceed 40V dc. The minimum acceptable External Reference voltage is the greater of ±100 uV or a value found with the following formula:

$$\text{Vmin} = \frac{\pm \text{Vin}}{10^9}$$

2-96. Normally, the External Reference low terminal is tied to VOLTS INPUT LO. In any event, the resistance between either External Reference terminal and VOLTS INPUT LO should be less than 20 kilohms. A reading rate of eight samples-per-reading and filter bypass are specified for each External Reference input.

2-97. OFFSET

2-98. In Offset mode, the display represents only the deviation from a stored offset value. Measurements of stability of analog variation are thereby possible. The multimeter automatically subtracts a programmed numeric (or previously stored display value) from the measurement and displays the result. No increase in resolution is displayed while in the Offset mode. One value (whether a numeric or a previous display) may be stored at a time. Programmed numerics may range from $+10^9$ to -10^9 (excluding 0). The stored offset value may be recalled at any time.

2-99. Special Operations

2-100. PEAK

2-101. The highest and lowest deviations in the displayed value may be recorded in the Peak mode. Measurement stability may thereby be checked over a period of time. The PEAK push button toggles into/out of the Peak mode. High and low Peak values may be recalled any time without exiting the Peak mode or interrupting further peak recording. The following sequence is used:

RECALL HI PEAK

RECALL LO PEAK

The high or low peak value is latched in the display as long as the PEAK button is held depressed.

2-102. Exiting the Peak mode (toggle PEAK once) halts further peak recording, but does not erase previously recorded high and low values. A multimeter function change disables Peak mode and retains peak values. At any time, reentry into the Peak mode (toggle Peak again) erases previously recorded values. Both Peak mode and peak values are lost during a Power-Up or Reset condition.

2-103. LIMITS

2-104. The Limits mode may be employed to display a pass-fail indication of measurement values. The mode is entered when a single high or low limit value is stored, or when the LIMITS button is pushed. A second store sequence must be used if both high and low limits are desired. Either the normally displayed value or programmed numerics may be used for the limit values. For example, high and low limits of 12.05 and 11.95 would be programmed as follows:

STORE 1 2 . 0 5 HI

STORE 1 1 . 9 5 LO

In this example, the multimeter enters the Limits mode when either the HI or LO button is first pushed. Mode entry is verified by a display of HI, LO, or PASS. In this case, readings higher than 12.05 yield a HI display, readings lower than 11.95 yield LO, and all other readings yield PASS. The limit value(s) are compared to the now transparent display reading with all other parameters and operations still in effect.

2-105. A display reading can also be stored as a limit value. Use the following sequence:

STORE HI (or LO)

2-106. Use of Limits mode does not interrupt other uses of the multimeter. No measurement parameter or mathematic operation is changed: The other special operation (Peak) may be used simultaneously with Limits mode. Any of the measurement parameters or operations may be enabled, changed, or recalled while in the Limits mode: the display responds in the normal fashion during this process and automatically reverts to limits indications once the process is complete. Limits values may be recalled at any time (Limits mode enabled or disabled). The recall sequence does not change the state of the Limits mode. The following recall sequence is used:

RECALL HI LIMITS

RECALL LO LIMITS

The recalled value is latched in the display as long as the LIMITS button is held depressed.

2-107. Pushing the LIMITS button toggles the multimeter into or out of the Limits mode whether or not limits values have been entered. A function change disables the Limits mode, but retains any existing limit values. Once stored, limits values are retained during all but Power-Up and Reset sequences.

2-108. Remote Control

2-109. The multimeter may be equipped with any of three remote interface modules. These modules are fully explained in Section 6. When the -05 IEEE Interface is installed, the front panel LCL/RMT push button can be used to enable local control, but cannot be used to enable remote control. Remote control can only be commanded from the remote location with this interface.

2-110. The LCL/RMT push button may be used to toggle into/out of remote control when either the -06 Bit Serial or the -07 Parallel Interface is installed. Whenever the multimeter is in remote control, whether commanded locally or from the remote, the REMOTE annunciator is lighted.

2-111. When in remote, only the POWER push button remains operational at all times. The LCL/RMT push button may remain operational, but is disabled by a local lockout or display off command from the remote (refer to Section 6). A power interruption returns the multimeter to local control.

2-112. Calibration Mode

2-113. DESCRIPTION

2-114. The rear panel calibration switch is used to enable or disable the Calibration mode (remove calibration seal for access). The AVG/(CAL) annunciator flashes when the Calibration mode is enabled, or is lit steadily when the Averaging mode is enabled. Regular multimeter operation is significantly altered while in the Calibration mode:

1. Power must not be cycled on or off when the Calibration mode is activated (rear panel Calibration Switch on).

2. Overrange conditions no longer cause a special flashing "HHHHHH" indication.

3. Averaging mode is locked out: the Calibration and Averaging modes are mutually exclusive. However, pushing the AVG button when Calibration mode is on does enable or disable latching error indications.

4. All mathematic operations and special operations are disabled.

5. 7-1/2 digits are displayed on 10V dc range and 6-1/2 digits are displayed on all other functions and ranges. A sign (±) is displayed for all functions to facilitate potentiometer adjustment.

6. Calibration correction factors (for each range in V DC, A DC, OHMS, and for VAC ranges at a frequency of interest) and the calibration date may be stored.

2-115. Hardware calibration is facilitated while in Calibration mode. Enhanced resolution allows for more precise potentiometer adjustment during hardware calibration. With no mathematic operations allowed, the display represents the true input value.

2-116. Troubleshooting is also aided by using the Calibration mode. Latching errors can be disabled to allow special module configurations.

CAUTION

Latching errors are intended for multimeter protection and must not be disabled during normal operation or calibration. Refer to Troubleshooting in Section 4.

2-117. USE

2-118. The multimeter uses three calibration controls: the rear panel calibration switch, and the front panel (CAL DATE) and (CAL COR) push buttons. The rear panel calibration switch activates the Calibration mode and enables use of the (CAL COR) and (CAL DATE) push buttons. Store operations with these two push buttons are used for software calibration and are explained in Appendix 7B. Recall operations can be performed at any time and are explained in the following paragraphs.

2-119. The (CAL DATE) push button can be used in all functions to recall a six digit number. This number may signify the calibration date. For example, a recalled 0 2 1 8 8 3 would signify February 18, 1983. Alternately, the six digits may be used to identify the multimeter.

2-120. To recall the six digit date (or identifier) while in the Calibration mode, push RECALL (CAL DATE). If the multimeter is not in the Calibration mode, the six digit date (or identifier) can be recalled using RECALL LO (CAL DATE).

2-121. The (CAL COR) push button may be used to recall the uncorrected reading when the multimeter is in the Calibration mode, use:

RECALL (CAL COR)

The uncorrected reading can also be recalled when the multimeter is not in the Calibration mode. Use the following sequence:

RECALL LO (CAL COR)

2-122. Scan Advance

2-123. The multimeter outputs a sync signal during each measurement sequence. This signal occurs after the measurement is complete, but before a new trigger is accepted. The sync signal thereby allows for faster bus communications by advancing a scanner before a new reading is triggered. The signal (positive going TTL, 3 microsecond pulse width, 50-ohm output impedance) is available at a BNC connector on the multimeter rear panel.

2-124. Systems Use

2-125. The availability of optional interface modules makes the multimeter adaptable to a large variety of digital systems. Operating and programming instructions related to remote operation are included with the appropriate optional module.

2-126. OPERATION

2-127. Initial Turn-On

2-128. Before initial turn-on, check that the line voltage specified on the rear panel sticker (near the line fuse) agrees with the line voltage actually being used. If there is any doubt concerning the line voltage setting, refer to Line Voltage Selection in Section 4. Also verify that the Calibration switch is off. Once these verifications have been made, connect the power cord and push the POWER button to ON.

2-129. The multimeter identifies its own software and hardware at initial turn-on. Software is identified with a display of "HI - Y.Y.Y", where "Y" represents the software version in use. Hardware is then identified with a display of "CXXXXX", where "X" signifies any installed options by number.

2-130. Power-up (reset) configuration is now established. The function is set for V DC, the 1000V range is set, along with filter F0, sample 7, auto trigger, zero mode on, and local operation. All other modes and values are disabled, The multimeter may now be programmed as described in this Section. A two-hour warm-up insures rated accuracy. Better accuracies can be obtained in the Average mode after a four-hour warm-up.

2-131. Measurement Instructions

2-132. Use the following procedures when making measurements from the front panel:

1. Remove multimeter inputs.
2. Select the desired function.
3. Referring to Figure 2-3, set measurement parameters.
4. Further programming from the front panel is often not necessary. If no mathematic operation or special operations are desired, proceed to Step 6.
5. If mathematic or special operations are desired, refer again to the guidelines in Figure 2-3.
6. Position the measurement terminal controls (right of terminals) as required. The Rear Input Selector must be disengaged (out) if the front panel inputs are being used. The Ohms Selector must be engaged (in) when four-wire resistance measurements are being made. The Guard Selector is normally left disengaged (out) for non-critical measurements. Refer to Measurement Terminals and Controls in this Section for other uses of these selectors.

7. Depending on the function selected, make the measurement connection illustrated in Figure 2-5.

2-133. APPLICATIONS

2-134. Specific applications using the multimeter are presented in Table 2-6. The applications may be used as examples to aid in familiarization with the multimeter. If the applications are duplicated, modes or values already programmed could interfere with the expected instrument response. Therefore, a power-up or reset instrument configuration is a precondition.

Table 2-6. Applications

STORING A DISPLAYED VALUE

STORE ——→ { OFFSET / SCALING / HI / LO }

APPLICATION 1

REQUIREMENT:	Monitor the stability of a power supply in terms of its deviation in volts from a present output of +5.03V.
METHOD:	Store the present output as an offset. Press: STORE ——→ OFFSET Offset is now enabled. The multimeter will read only the deviation from +5.03V.

APPLICATION 2

REQUIREMENT:	Monitor the stability of a power supply as a decimal ratio to its present reading of - 20.08V. DC zeroing appears to be necessary.
METHOD:	Perform V DC Zeroing for internal drift. Apply low thermal short between INPUT HI and LO (at the terminals). Press: ZERO VDC/Ω The value stored will be displayed as long as ZERO VDC/Ω is held depressed. Release of the switch will activate the Zero mode. Revise terminal interconnections for dc volts measurements. Connect the dc voltage. Apply power supply reading of -20.08V as a scaling factor. Press: STORE ——→ SCALING Display will now yield the ratio of subsequent readings to the scaling factor, e.g., an input of 22.08V yields a ratio of: $\frac{22.088}{20.08} = 1:1$

STORING A NUMERIC ENTRY

STORE
- ——→ 0 - 17 ——→ SAMPLE
- ——→ —,0,1,2,3 ——→ FILTER
- ——→ (VALUE) ——→ { OFFSET / SCALING / HI / LO }

Table 2-6. Applications (cont)

APPLICATION 3	
REQUIREMENT:	Identify the power supplies that have a tolerance of 15V ±100 mV.
METHOD:	Set high and low limits. Press: STORE ⟶ 1 ⟶ 5 ⟶ . ⟶ 1 ⟶ HI STORE ⟶ 1 ⟶ 4 ⟶ . ⟶ 9 ⟶ LO The multimeter will now display "HI," "LO", or "PASS" for each power supply.
APPLICATION 4	
REQUIREMENT:	For a group of 20V power supplies, determine the deviation in volts.
METHOD:	Offset the displayed reading by 20. Press: STORE ⟶ 2 ⟶ 0 ⟶ OFFSET Any value displayed now will equal the deviation from 20V.
APPLICATION 5	
REQUIREMENT:	Display the input error voltage for an operational amplifier by measuring the dc output error. Gain = 2.6847 x 10^4.
METHOD:	Divide the measured dc output error by a scaling factor (the op amp gain). Press: STORE ⟶ 2 ⟶ . ⟶ 6 ⟶ 8 ⟶ 4 7 ⟶ EXP ⟶ 4 ⟶ SCALING The multimeter will now divide the measured input by the gain of the op amp and display the input error voltage.
APPLICATION 6	
REQUIREMENT:	Make a series of measurements in a noisy environment. Speed of measurement is not important. Display only the deviation in volts.
METHOD:	Allow for extra settling between readings: Press: STORE ⟶ 3 ⟶ FILTER Increase digital filtering (average more samples per reading). Press: STORE ⟶ 9 ⟶ SAMPLE Offset by the nominal output (e.g., 15V). Press: STORE ⟶ 1 ⟶ 5 ⟶ OFFSET

Table 2-6. Applications (cont)

RECALLING

RECALL ——→ {
- **OFFSET**
- **ZERO VDC/Ω**
- **EXT REF**
- **SAMPLE**
- **SCALING**
- **FILTER**
- **HI** / **LO** ——→ **PEAK** / **LIMIT**

}

APPLICATION 7

REQUIREMENT:	Determine the highest and lowest readings encountered in measuring a group of 28V power supplies.
METHOD:	Press PEAK to record measurement extremes. Use a manual trigger for each measurement. When required measurements are complete, use the following sequence to recall high and low values. Press: RECALL ——→ LO ——→ PEAK RECALL ——→ HI ——→ PEAK (Hold PEAK in to read the recorded values.)

Section 2A
Remote Programming Commands

2A-1. INTRODUCTION

2A-2. This section documents remote operation of the multimeter with any of the following interface modules installed:

1. IEEE-488 Interface (Option -05)
2. Bit Serial Interface (Option -06)
3. Parallel Interface (Option -07)

2A-3. Basic remote operation for 8500 series multimeters is detailed in Table 2A-1. These operating features are generally compatible with the 8505A and 8506A multimeters. Table 2A-2 details additional remote operating features available with the 8505A and 8506A only.

2A-4. General information, theory of operation, maintenance information, parts lists, and schematic diagrams for each of the three remote interfaces are presented in Section 6 of this manual.

2A-5. Software calibration for each function can be accomplished locally or remotely. Complete software calibration information is presented in Section 7 of this manual.

Table 2A-1. Programming Instructions

The programming instructions in this table pertain to the 8500 Series Digital Multimeters with the IEEE-488 Interface (Option -05), the Bit Serial Interface (Option -06) or the Parallel Interface (Option -07) installed. Features and instructions unique to the DMM model or to the Interface used will be identified in the following manner:

1. 8500A or 8502A: the symbol ◆ will denote an explanation applicable to one DMM model only. The software version incorporated in the DMM may also be mentioned for further identification. To verify the software version incorporated in your instrument, observe the display indication at power on or reset. For example, in the 8502A, "HI-2.0.2" will appear in the display for models with software version 2.0.2.

2. -05, -06, or -07 Interface Options: the symbol ● will be used with a feature or instruction unique to a particular Interface.

INITIALIZATION

When power is applied, or the Reset character (*) is transmitted, the instrument assumes a preset default condition. This condition is defined by the following remote codes:

	REMOTE CODE	COMMAND
	V	Volts DC
	R4	1000V range
◆	S5 (8500A)	2^5 Samples per Reading
◆	S7 (8502A)	2^7 Samples per Reading
	F0	Fast Filter, Timeout Disabled (Panel Indicator OFF)
	X0	External Reference/Scaling Disabled
	P0	Offset Feature Disabled
	U0	Limits-Peak Value Storage Disabled
	T0	Single Reading Line Synchronous
	B0	Single Character ASCII Format
	D0	Front Panel Display Active
	L0	Deactivate Local Lockout
	J0	Deactivate Line Feed Suppression
	M0	Enable Cal Memory Factors
◆	Q0 (8502A)	Disable External Trigger
◆	W (8502A)	No Delay
●	Y0 (-06 Option only)	Echo mode off (Bit Serial IF)

In addition, the following instrument states are assumed at power on or Reset:

	Remote/Local	Local
	Offset	Zeroed
	V dc Zero	Zeroed or *
	Ohms Zero	Zeroed or *
	Cal Memory Factors	*
	Peak Values	Cleared
	Limits Values	Zeroed
	Ext. Ref/Scaling Values	1
●	8/16 Bit Mode (-07 Option only)	8 Bit

*Retained if Cal Memory Option -04 installed

Table 2A-1. Programming Instructions (cont)

PROGRAM SEQUENCE

When equipped with a remote interface option, the instrument is programmed through a sequence of commands ("command string") that will determine range, function, reading rate, etc. Examples of 5 possible command strings are:

1. V A R 2 S 5 F ?
   - ? — Execute, trigger and transmit
   - F — Slow filter, no time out
   - S 5 — 2^5 samples/reading
   - R 2 — 10 volt range
   - V A — AC voltage

2. T D Y ?
   - ? — Execute, trigger and transmit
   - Y — Echo characters
   - D — Turn display off
   - T — Continuous line synchronized readings

3. K N U 6 . 3
   - K N U 6 . 3 — Upper limit

   K N L 6 . 2 U ,
   - , — Execute
   - U — Enter limits mode
   - K N L 6 . 2 — Lower limit

4. Z R , S 5 $
   - $ — Clears command string to preceeding "," "?" or "@"
   - S 5 — 2^5 samples/reading
   - , — Execute
   - R — Auto range
   - Z — Ohms

5. % G 1 ?
   - ? — Execute, trigger and transmit
   - G 1 — Get status and transmit on trigger
   - % — Halt reading

Table 2A-1. Programming Instructions (cont)

All command string characters transmitted via the remote interface must be ASCII 7-bit upper case characters. A command string is a sequence of 1 to 31 characters. (For the 8505A and 8506A, a command string may have up to 59 characters.) Characters are classified as immediate, command or termination. The instrument may be placed in Remote mode by transmitting any character that the instrument will recognize from the remote controlling terminal.

● With the IEEE Interface installed, the REMOTE switch can only be used to select local mode if already in Remote.

REMOTE is the only front panel switch to remain active when in REMOTE mode; REMOTE may, however, be locked out by the local lockout command.

IMMEDIATE CHARACTERS

There are 5 immediate characters; each of these may be executed at any time and does not require a termination character.

[*] **Reset**

This immediate character will reset the instrument to the conditions described under INITIALIZATION.

◆ When transmitted, the reset character must not be followed by any other character for 3 seconds with the 8502A (2 seconds with the 8500A). Any carriage return or line feed following the reset character must be suppressed. The remote interface will be unable to accept programming characters during this time.

[%] **Halt**

The halt character is used to terminate the continuous mode and cause the instrument to wait for a command string. No other characters should precede the halt character if continuous mode is in effect. Upon receipt of the halt character, the transmission of readings is terminated immediately. The following trigger mode transitions will occur when halt is used:

From: Continuous Line Synchronous
To: Single Reading Line Synchronous

From: Continuous Asynchronous
To: Single Reading Asynchronous

[#] **Go To Local - Lock Out Remote**

● This character will command the instrument (Options -06 or -07 only) to enter local mode of operation and lock out the remote interface.

● The Remote mode may then be reentered by pressing the front panel REMOTE switch (for Option -06, -07). The Remote mode may not be reentered from the front panel when using the IEEE-488 Interface (Option -05).

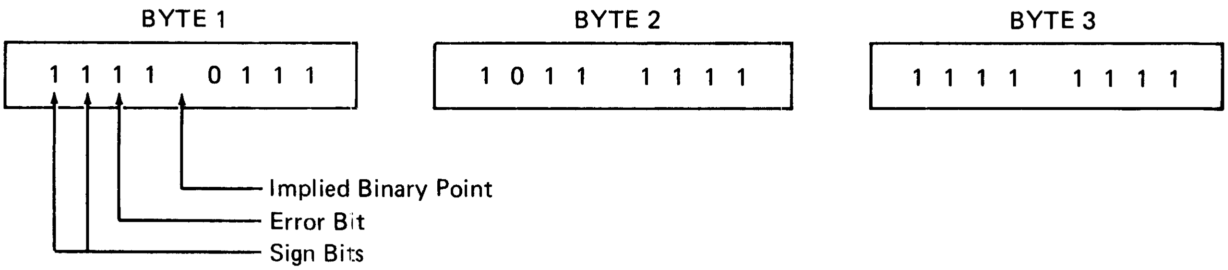
Table 2A-1. Programming Instructions (cont)

[#]	**Go To Local-Lock Out Remote (cont)**	The state of the instrument, when changing from remote to local operation will be modified as follows: 1. Ohms fast mode will be ignored. ◆ 2. Scaling mode will not be in effect (8500A only). ◆ 3. If the high averaged samples per reading rate was in effect, the samples per reading will be set to 2^7 (8500A only). The state of the instrument when changing from local to remote operation will be modified as follows: 1. Ohms fast mode (Z1) and continuous reading mode will be resumed if the DMM was in either mode when place into local. 2. Any error that occurred during local operation will be stored and available for recall.
[!]	**High Speed Reading Mode**	● The "!" character can be used with the Parallel Interface (Option -07) (and with the IEEE-488 Interface Option -05 in the 8502A only). The High Speed Reading mode provides a shortened 3-byte binary two's complement format response representing the input to the DMM's A/D Converter. Speeds up to 500 readings per second are possible in this mode of operation. True readings can be computed from this response using range and function dependent factors (refer to Fluke Application Bulletin 25). The High Speed Reading mode is suited to systems with very fast processors, to use with stored readings, or to applications not requiring direct numeric conversions (e.g., zero crossings or large deviations from a nominal value). ◆ Use of the "!" character will place the DMM in the High Speed Reading mode and trigger the first reading. Subsequent readings can be triggered by sending the "?" character. In addition, for the 8502A equipped with the -08A Option, subsequent readings can be triggered by sending the TTL pulse with the External Triggering Mode ("Q" or "Q1"). The High Speed Reading mode can be aborted at any time by transmitting a character other than "?" when a reading is to be triggered. The character sent in this case will do nothing more than cause the DMM to exit the High Speed Reading mode.

Table 2A-1. Programming Instructions (cont)

Voltage and Current Reading In "!"

The response data from the DMM will be in 3-byte format, as shown below, for each voltage or current reading. The first byte of this response contains sign and error bits, an implied binary point, and an implied scale factor of ten. Bytes 2 and 3 further define the reading. If the reading is negative, the sign bits will equal "1", and all three bytes must be two's complemented before conversion. If the error bit is equal to the complement of the sign bit, an error is defined.



In this example, the sign bits are "1" and the reading is negative. Since the complement of the sign bit does not equal the error bit ("1"), no error is defined.

To convert the response in this example, the two's complement must first be formed.

0000 1000	+	0100 0000	+	0000 0001
−(0 . 5	+	.015625 0	+	0 .000001)

= 0.515626 X 10 (the implied scale factor)

Further conversion to calculate the true reading Rt necessitates multiplication of the A/D Converter reading (RAD) by the scale factor for the instrument's range and function.

$[R_t = R_{AD} \text{ X Scale Factor}]$

Ohms Readings In "!"

The procedure for measuring ohms in High Speed Reading mode is more complex. High Speed Ohms readings differ from Fast Ohms (Z1) readings; when using the "!" character, the DMM will not compute the true reading. This conversion must be performed by the user. Up to 500 readings a second are possible when using High Speed Ohms. Refer to OPERATING NOTES, provided with Option -05 and -07 for High Speed Ohms Reading procedures.

/	**8/16 Bit Toggle**	The "/" character is used to toggle between the 8-bit and the 16-bit mode. When this character is used to toggle from one mode to another, the immmediate and/or termination character must be placed in the least significant byte (LSB) of the programming word.

Table 2A-1. Programming Instructions (cont)

TERMINATION CHARACTERS

Termination characters cause the execution of a command string. They are normally placed at the end of each programming statement.

Key	Instruction	Description
$	**Clear the Command String**	● (Normally used only with the Bit-Serial Interface -06 Option.) This character is used to erase an incorrect programming entry from the command string buffer, deleting all characters issued back to, but not including, the preceding termination character. A new command string is then needed to modify the state of the instrument.
,	**Execute the Command String**	This character is used to cause the execution of the previous command string. The instrument will then be in the defined state only; the character will not trigger a reading or produce a response from the instrument. When programming a string of characters, it is recommended that the execute character be used at frequent intervals; if an error is made, the string need then be cleared only back to the last execute character. This execute character is also required if a command string longer than 31 characters is used.
?	**Execute the Command String and Trigger**	This character will cause three actions: any previously entered command string will be executed, a reading will be taken, and that reading will be transmitted through the remote interface. If a command string was not entered immediately preceding this character, the instrument will take and transmit a reading in the last defined state. An exception occurs when a command string containing a "Get" command has been entered; the instrument will then respond with the value or status that was requested by the command string (no reading will be triggered). When issuing a program string terminated by the "?" character, the "CR" and/or "LF" delimiter characters should be, but do not have to be suppressed. If an error occurs during the reading, a single "0", followed by a "CR", will be transmitted. At this point, status should be requested to determine the cause of the error.
@	**Execute, Trigger, and Interrupt when Ready**	This character is used to trigger a reading and generate an interrupt when the reading is complete.

Table 2A-1. Programming Instructions (cont)

@ Execute, Trigger, and Interrupt when Ready (cont)

- To provide the interrupt, the Bit-Serial Interface (Option -06) and the Parallel Interface (Option -07) transmit a single "CR". The IEEE-488 Interface (Option -05) provides an interrupt by generating a service request (SRQ).

The reading triggered by the "@" character can be obtained by inserting a "G" (get) command in the following command string (terminated by a "?").

The "@" character and the IEEE-488 Bus command "Group Execute Trigger" perform the same function.

COMMAND CHARACTERS

Command characters are classified within the following five groups:

1. FUNCTION
2. RANGE
3. MODIFIERS
4. CONTROL
5. MEMORY

FUNCTION COMMAND CHARACTERS

There are 7 function command characters. Whenever one of these characters is used, the state of the instrument will be changed as follows:

RANGE	Auto
MODIFIERS	Offset, Scaling, Limits, Peaks modes are turned off; stored values for these modes are retained.
MEMORY, CONTROL	Unchanged

If a function is selected requiring an optional module which is not loaded, the function of the instrument will be undefined, and the error code will be set to 19.

V **DC Volts**

V A **AC Volts**

C **DC Coupled AC Volts**

I **DC Current**

I A **AC Current**

Table 2A-1. Programming Instructions (cont)

Z — **Ohms**

Z 1 — **Fast Ohms**

The Z1 character will place the instrument into the ohms function and the fast ohms mode. In normal ohms operation, the unknown resistor value Rx is computed from the following measurements:

V1-V2: the voltage across an internal precision resistor (Rr)

V0: the voltage across the unknown resistor (Rx).

The value of Rx is then computed with Ohm's Law:

$$Rx = Rr \frac{V0}{V1\text{-}V2}$$

Fast Ohms mode differs in that the value of $\frac{Rr}{(V1\text{-}V2)}$ is stored as a constant. The instrument will the find Rx by measuring V0 and multiplying this constant. The constant will change with a function change, range change or overload condition.

NOTE

Fast ohms ("Z1") differs from HIGH SPEED READING ("!"). When using "!" for ohms measurement, Rx is not computed by the DMM.

RANGE COMMAND CHARACTERS

The nine range commands specify the following maximum values by function.

	DC VOLTS	VA or C AC VOLTS	I or IA DC or AC CURRENT	Z or Z1 OHMS
R	Auto	Auto	Auto	Auto
R 0	312 mV	Auto	312 μA	31.25Ω
R 1	2.5V	2.5V	2.5 mA	250Ω
R 2	20V	20V	20 mA	2 kΩ
R 3	160V	160V	160 mA	32 kΩ
R 4	1200V	1000V	1.28A	256 kΩ
R 5	Auto	Auto	Auto	4.096 MΩ
R 6	Auto	Auto	Auto	32.768 MΩ
R 7	Auto	Auto	Auto	262.144 MΩ

Table 2A-1. Programming Instructions (cont)

MODIFIER COMMAND CHARACTERS

SAMPLES PER READING COMMAND CHARACTERS

The modifier command character "S" or "H" specifies the number of samples taken per reading. The times shown for these characters are approximate digitizing times per reading for 60 Hz line synchronous operation in dc volts, ac volts or current function.

S 0	**2^0 = 1 Sample/Reading (4 ms)**
S 1	**2^1 = 2 Samples/Reading (8 ms)**
S 2	**2^2 = 4 Samples/Reading (17 ms)**
S 3	**2^3 = 8 Samples/Reading (33 ms)**
S 4	**2^4 = 16 Samples/Reading (67 ms)**
S 5	**2^5 = 32 Samples/Reading (134 ms)**
S 6	**2^6 = 64 Samples/Reading (267 ms)**
S 7	**2^7 = 128 Samples/Reading (534 ms)**
H 0	**2^8 = 256 Samples/Reading (1.1s)**
H 1	**2^9 = 512 Samples/Reading (2.1s)**
H 2	**2^{10} = 1,024 Samples/Reading (4.3s)**
H 3	**2^{11} = 2,048 Samples/Reading (8.5s)**
H 4	**2^{12} = 4,096 Samples/Reading (17.1s)**
H 5	**2^{13} = 8,192 Samples/Reading (34.1s)**
H 6	**2^{14} = 16,384 Samples/Reading (68.3s)**
H 7	**2^{15} = 32,768 Samples/Reading (137s)**
H 8	**2^{16} = 65,536 Samples/Reading (273s)**
H 9	**2^{17} = 131,072 Samples/Reading (546s)**

Table 2A-1. Programming Instructions (cont)

FILTER COMMAND CHARACTERS

The "F" character is used to specify the type of filtering and the enabling of a time-out (for the filter settling time). This time-out causes a delay between a trigger command received and the actual reading taken. In the continuous trigger modes, the time-out will occur before each reading is initiated. The following "F" modifier command characters are used:

[F] **Slow filter, time-out disabled.**

[F][0] **Fast filter, time-out disabled.**

[F][1] **Bypass filter.**

[F][2] **Slow filter, time-out enabled (approximately 500 ms).**

[F][3] **Fast filter, time-out enabled (approximately 50 ms).**

TRIGGER COMMAND CHARACTERS

The "T" characters specify the instrument's trigger mode. These characters determine whether samples taken are line synchronous (every 4 or 5 ms) or line asynchronous (approximately every 1.7 ms), whether single or continuous readings are to be taken.

[T] **Continuous reading mode/line synchronized.**

[T][0] **Single reading mode/line synchronized.**

[T][1] **Continuous reading mode/line asynchronous.**

[T][2] **Single reading mode/line asynchronous.**

NOTE

When line asynchronous modes are selected, the display will be turned off to save time; the front panel switches are then ignored.

◆ When in the continuous mode, any character (except "%" HALT) will be ignored by the instrument (8502A).

When in the Single Reading mode ("T0" or "T2"),and IEEE Group Execute Trigger command, a "?" or "@" character, or a TTL trigger (for the 8502A-08A) must be sent for each reading.

With the Continuous Reading mode ("T" or "T1"), use of the "GET" command, "?", "@" or a TTL trigger will start continuous readings.

Table 2A-1. Programming Instructions (cont)

When each reading is accepted by the instrument controller, the next reading will be started. An exception to this sequence occurs in the "J1" Suppress Output mode; the next reading will now be taken immediately, without waiting for the output to the controller.

NOTE

The front panel display does not update in this mode unless the controller asks for a reading.

Use of the "%" character will halt the Continuous Reading mode and cycle the unit back to the Single Reading mode.

OFFSET COMMAND CHARACTERS

The "P" command characters specify whether an offset will be subtracted from a reading. The offset value may be entered by storing either a previous reading or a numerically entered offset.

◆ When storing readings, the 8500A will store the unprocessed reading, and the 8502A will store the displayed value.

Offset values may range from $\pm 1 \times 10^9$ to $\pm 1 \times 10^{-9}$ (including 0.0).

[P] **Offset subtracted (ON).**

[P] [0] **Offset not subtracted (OFF).**

EXTERNAL REFERENCE AND SCALING COMMAND CHARACTERS

The "X" command characters select External Reference or Scaling mode. Either mode is valid for any function and range. In External Reference mode, readings are divided by the signed magnitude of the external reference voltage. In Scaling mode, readings are divided by a numerically entered scale factor or by a previously read value.

[X] **External Reference On, Scaling Off**

The "X" External Reference mode uses the external reference voltage (Vxref) to divide the measured voltage. Vxref is measured during each reading cycle.

◆ Minimum Vxref = ±0.0001V or the input divided by the maximum display with the volts range, whichever is greater (8500A only).

◆ For the 8502A, the minimum Vxref is the input divided by 10^9.

Maximum Vxref = ±40V between Ext Ref Hi and Lo terminals, providing neither terminal is greater than ±20V relative to the Sense Lo or Ohms Guard Terminals.

Table 2A-1. Programming Instructions (cont)

X 0 — **External Reference Off, Scaling Off**

X 1 — **External Reference Off, Scaling On**

The "X1" Scaling mode will divide all readings by a previously taken external reference voltage or by a previously entered numeric scale factor. The read valued may not be used as a scaling factor.

NOTE

The 8502A can store the external reference voltage and the numerical scale factor separately. The 8500A can only store one or the other, not both.

- Minimum scaling factor = the same as the minimum Vxref, for the 8500A.
- For the 8502A minimum = 10^{-9}. Factors less than this will be set to 0, which is not a valid scale factor.

Maximum scaling factor = ±100 (8500A), or Input/Max Scale factor <10^{-9} (8502A).

NOTE

The "X" and "X1" modes are mutually exclusive.

LIMITS AND PEAKS COMMAND CHARACTERS

The "U" command characters specify selection of Limits or Peaks modes.

U — **Limits Testing On**

When this command character is sent, each instrument reading is compared to upper and lower limits. Limit values must be entered separately with a keep command (refer to KEEP COMMAND CHARACTERS). The output format from the instrument (when given a "G" command) is as follows:

"0" is transmitted for a reading within limits.

"1" is transmitted for a reading greater than the upper limit.

"-1" is transmitted for a reading less than the lower limit.

"2" is transmitted if an error occurs (e.g., overranging).

U 0 — **Disable Limits and Peak Mode(s)**

U 1 — **Save Highest and Lowest Values (Peaks On)**

Previous peak values are erased from memory whenever the "U1" command character is programmed.

Table 2A-1. Programming Instructions (cont)

[U] [1] **Save Highest and Lowest Values (Peaks On) (cont)**

◆ For the 8500A, storage of limit and peak values are mutually exclusive. For the 8502A, limit and peak values can be held in memory simultaneously.

NOTE

Limits are applied after all other modifier operations (Scaling, Offset, etc.) have been performed.

CONTROL COMMAND CHARACTERS

Output Format

The "B" characters activate binary or ASCII output format.

[B] **Single Byte Binary Format**

[B] [0] **Single Byte ASCII Format**

● [B] [1] **Binary 16-Bit Parallel**

● [B] [2] **16-Bit Parallel**

"B1","B2" used with Paralled ASCII Interface (Option -07) only.

The front panel DMM display is turned on when the ASCII mode is entered and off when the binary mode is entered.

The Binary Output Format

The binary output format consists of five bytes. The first four bytes comprise a 32-bit binary two's complement fixed point number. An implied binary point for this number is located between the first and second bytes. The first 8-bit byte thus serves as the integer portion. The 24 bits of the next 3 bytes serve as the binary fraction. Additionally, since this format cannot be used to hold the entire range of possible values for the DMM, a fifth byte is used as an exponent. This exponent is a two's complement binary number representing the decimal exponent of the binary fixed point number defined by the first 4 bytes. An exception occurs in Limits testing; the response will then be single byte binary two's complement number.

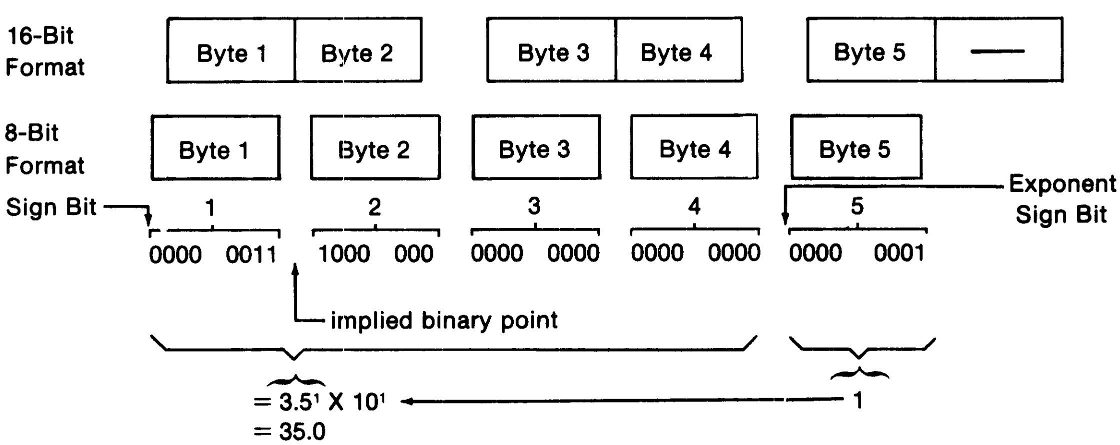


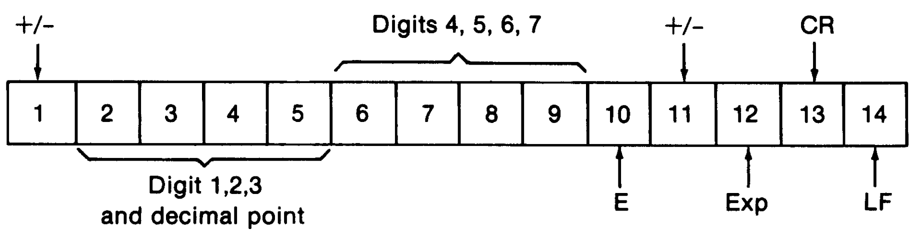
Table 2A-1. Programming Instructions (cont)

NOTE

In dc volts and ac volts, the exponent is always 1. In dc and ac current, the exponent is always -2. The exponent is range dependent in ohms function (1 for ohm ranges, 4 for kohm ranges, and 7 for Mohm ranges).

Errors will be indicated by 5 bytes of 0.

ASCII Data Output Format



The seventh digit in the ASCII format corresponds to the "Cal" or HIRES digit of the front panel display. In some ranges and functions (e.g., 100 mV dc) this digit is permanently zeroed since it exceeds the resolution of the instrument. (When in the "Cal" or HIRES mode, the front panel will display the value of the reading rounded to six significant digits.)

DISPLAY CONTROL

The "D" command characters turn the DMM front panel display on or off.

[D] **Display Off**

[D] [0] **Display On**

When the "D0" command is used, the instrument will no longer interrogate any of the front panel switches (local lockout). The display will be turned On when the ASCII output format is commanded.

LOCAL LOCKOUT CONTROL

The "L" command characters select the local lockout condition, in which the display remains activated while none of the front panel switches affect the instrument.

[L] **Local Lockout On**

[L] [0] **Local Lockout Off**

ECHO COMMAND CHARACTERS

● (used with Bit Serial Option -06 only)

[Y] **ECHO ON (Full-Duplex)**

[Y] [0] **ECHO OFF (Half-Duplex)**

Table 2A-1. Programming Instructions (cont)

LINE FEED CONTROL COMMAND CHARACTERS

J	**Suppress Line Feed Character**	This character suppresses the LF character normally sent at the end of a response line.
J 0	**Transmit Line Feed Character**	This character disables the "J" character; the "LF" character will be sent.
J 1	**Suppress Output of Readings** ◆	In the 8500A, use of J1 will suppress all output from the DMM. In the 8502A, use of J1 will suppress output with the following exceptions: Service Request (SRQ), status, recalled values. While in the J1 mode, use of the recall command "G ?" will retrieve a reading. Use of "J" or "J0" will exit the "J1" mode.

CALIBRATION CONSTANT

When the Calibration Memory (Option -04) module is installed, the "M" character will inhibit the adjustment of readings by the Calibration Memory correction factor. A slight increase in the speed of readings will result.

M	**Inhibit Calibration Memory Factors**
M 0	**Enable Calibration Memory Factors**

TRIGGER COMMAND CHARACTERS

◆ This set of command characters is available for the 8502A with the Isolator Option -08A.

Q	**Activate External Triggering Mode, Interrupt when Ready**	This character enables the External Triggering mode. Any external TTL trigger then initiates a reading and interrupts when ready (SRQ).
Q 0	**Deactivate External Triggering Mode**	
Q 1	**Activate External Triggering Mode, Transmit when Ready**	The Q1 character also enables External Triggering mode. Any external TTL trigger initiates and transmits a reading.

NOTE

The "?" and "@" characters remain operative during External Triggering.

Table 2A-1. Programming Instructions (cont)

◆ EXTERNAL TRIGGER DELAY COMMAND CHARACTERS (-08A with 8502A only)

The "W" command characters select the amount of delay between the external trigger signal and the initiation of the reading.

Command	Delay
W	No Delay
W 0	2.083 ms
W 1	4.166 ms
W 2	8.332 ms
W 3	16.66 ms
W 4	33.33 ms
W 5	66.66 ms
W 6	133.3 ms
W 7	266.6 ms
W 8	533.2 ms
W 9	1.066s
W 1 0	2.133s
W 1 1	4.266s
W 1 2	8.532s
W 1 3	17.06s
W 1 4	34.13s
W 1 5	68.26s

Table 2A-1. Programming Instructions (cont)

MEMORY COMMAND CHARACTERS

STORE

The "K" (Keep) command characters specify the storing of a reading or numeric entry.

[K] **Store Last Reading as Offset**

◆ The 8500A will store the unprocessed reading, whereas the 8502A will store the displayed reading.

[K] [0] **Store Last Voltage Taken as VDC Zero (on R0 Only)**

[K] [1] **Store Last Reading as Ohms Zero (on R0 Only)**

[K] [N] [P] **Store Numeric Value Following as Offset**

[K] [N] [X] **Store Numeric Value Following as Scaling Factor**
(Note: The read value may not be stored as a Scaling Factor.)

[K] [N] [U] **Store Numeric Value Following as Upper Limit**

[K] [N] [L] **Store Numeric Value Following as Lower Limit**

Offsets, Scaling Factors, Upper and Lower Limits may be entered via the "KN" command characters, followed by one of the modifier characters "P", "X", "U" or "L" and the numeric value (on ASCII string of numeric characters, and optional sign, decimal point and signed decimal exponent digit in "E" notation).

Examples of legal numeric strings are:

[K] [N] [P] [1] [0]

Keep Numeric offset of 10.0

[K] [N] [X] [1] [0] [.] [3] [E] [-] [1]

Keep numeric scaling factor of 10.3×10^{-1} or 1.03

[K] [N] [U] [7] [.] [6] [E] [4]

Keep numeric upper limit of 7.6×10^{4}

[K] [N] [L] [-] [1] [2] [3] [.] [4] [5] [6] [E] [+] [0]

Keep numeric lower limit of −123.456

Table 2A-1. Programming Instructions (cont)

An example of an illegal numeric string is:

[K] [N] [X] [2] [.] [0] [E] [-] [1] [3]

Exponent is limited to one signed integer digit, in this case the exponent would be -1 and the "3" would be ignored.

NOTE

Numeric entries are limited to the maximum display value. These values are:

+1.00000 E+9 to +1.00000 E-9, and-1.00000 E -9 to -1.00000 E +9

Numbers less the ±1.00000 E -9 are treated as zero.

RECALL

The "G" (Get) command characters specify the recall of a reading, a numeric entry or a status. Each "Get" command must be followed by a "?" termination character. The following memory "Get" commands may be used:

[G] **Recall Previous Reading and Send on Next Trigger**

[G] [0] **Recall DC Zero and Send on Next Trigger**

[G] [1] **Recall Status and Send on Next Trigger**

Status information from the DMM may be obtained with the command character "G1?". The status response will be returned in the following seven character format.

Error Codes

1	2					

Characters 1 and 2 define error code status. Each error code contains two digits: those codes with a zero for the first digit are related to remote operation only. All other codes contain the same second digit as the DMM's front panel error codes.

00 No Error
06 System Error
07 Illegal Numeric Entry
08 Remote Command String Error
09 Remote Overrange
10 V DC Zero/Ohms Zero Error
◆ 11 Offset Error (8500A) Store during Overrange (8502A)

Table 2A-1. Programming Instructions (cont)

Error Codes (cont)

12 Filter Module Faulty or not installed
13 DC Signal Conditioner Module Faulty or not installed
14 Excessive voltage present at terminals for Ohms/Current Measurement
15 Fast A/D Converter Faulty or not installed
16 Numeric Display Overflow
17 Magnitude of External Reference Input >20V
18 Controller Module Faulty
19 Function Module selected not installed

Range Codes

		3				

The third character of the status response contains the following range information:

0 100 mV dc, 100 μA, 10Ω
1 1V dc, 1V ac, 1 mA, 100Ω
2 10V dc, 10V ac, 10 mA, 1kΩ
3 100V dc, 100V ac, 100 mA, 10 kΩ
4 1000V dc, 1000V ac, 1A, 100 kΩ
5 1 MΩ
6 10 MΩ
7 100 MΩ

Sample Codes

			4			

The fourth status response character contains sample information identified by the following codes:

0 1 Sample per Reading
1 2 Samples per Reading
2 4 Samples per Reading
3 8 Samples per Reading
4 16 Samples per Reading
5 32 Samples per Reading
6 64 Samples per Reading
7 128 Samples per Reading or Greater

Function Codes

				5	<CR>	<LF>

The fifth response character identifies function:

0 DC Volts
1 AC Volts
2 DC Amps
3 AC Amps
4 Ohms
5 DC Coupled AC Volts
7 Function Not Defined

Table 2A-1. Programming Instructions (cont)

G N P	Recall Offset and Send on Next Trigger
◆ G N X	Recall External Ref or Scaling Factor and Send on Next Trigger (8500A) Recall Scaling Factor (8502A)
◆ G N R	Recall External Reference Factor and Send on Next Trigger (8502A)
G N U	Recall Upper and Send on Next Trigger
G N L	Recall Lower Limit and Send on Next Trigger

NOTE

The instrument will replay to "GNU" or "GNL" by transmitting the stored limit value.

G N Q	Recall Lowest (Peak) Value Found and Send on Next Trigger
G N W	Recall Highest (Peak) Value Found and Send on Next Trigger

Table 2A-2. Programming Instructions (8505A, 8506A)

The following discussion relates remote operation features available with the 8505A and the 8506A to existing documentation for remote operation of the 8500 series multimeters. The additional features for the 8505A and the 8506A are presented in this discussion in the same sequence as they would appear in the "Programming Instructions" table (Table 2A-1).

Most of the items documented in this table supplement features available with the 8502A and 8502A/AT. Incompatibilities have been kept to a minimum. Therefore, programs designed for the 8502A are generally compatible with the 8505A and the 8506A, and 8502A/AT programs are generally compatible with the 8506A. The few areas that are not compatible are briefly described below. Refer to appropriate areas in this table for a more detailed description.

1. High Speed Mode (!): Some High Speed mode scaling factors have been changed. Also, use of the reset command (*) causes the multimeter to both exit High Speed mode and perform a normal reset.
2. Range Commands: Full scale points and autoranging points have been changed in several instances.
3. Store Zero Commands (K0, K1): In the 8505A/8506A, the temporary zero correction values are set to 0 when the instrument is reset or powered up (similar to the 8502A without the calibration memory option). In the 8502A with the calibration memory option, resetting the instrument does NOT clear the stored zeros.

INITIALIZATION

CAUTION

Interruption of input power could affect Calibration Memory entries when the multimeter is in Calibration mode. Do not cycle input power to the multimeter when Calibration mode is activated. If power is ON, verify that the AVG/(CAL) annunciator is not flashing before cycling power to OFF. From the remote, Calibration mode status can be verified with the G5 command (response of 0 = mode off, response of 1 = mode on). If power is OFF, verify that the rear panel Calibration switch is off before cycling power to ON.

Both the 8505A and the 8506A assume the same configuration at power up as that described for 8502A, with the following exceptions:

1. The Average mode is disabled (O0).
2. Calibration Memory factors are retained at all times. These factors include zero corrections for each range in dc volts and ohms functions, gain corrections for each range in each function, and the calibration date (or instrument identification) number.
3. External Reference at power up or reset is used as temporary storage for the multimeter software version number. The GNR command can then be used to recall this number. Any use of the X command subsequent to power-up or reset replaces this number with the value applied at the external reference inputs.
4. Zero mode is enabled with all temporary zero correction values set to 0.

HIGH SPEED MODE

Selection of the High Speed mode sets the following conditions:

1. The "!" command both enters the High Speed mode and triggers a reading.
2. Use of any character (or bit pattern) other than "?" causes the multimeter to exit the High Speed mode. Use of "*" causes the multimeter to both exit the High Speed mode and perform a normal reset. The character used to exit High Speed mode must be sent by itself. Any commands to be executed after exiting High Speed mode must be sent in a separate transmission (i.e., in a separate statement in the instrument controller program).
3. Selection of High Speed mode specifies the binary output format. Any previously selected output format is restored once High Speed mode is exited.
4. The multimeter front panel display is blank while High Speed mode is on. The previously selected display mode is restored once High Speed mode is exited.

Table 2A-2. Programming Instructions (8505A, 8506A) (cont)

5. High Speed mode specifies asynchronous, single trigger mode (T2). The previously selected trigger mode is restored once High Speed mode is exited.

The high speed reading mode ("!") cannot be used for any ac volts function (normal, enhanced, or high accuracy) with the 8506A.

Voltage and Current Reading In "!"

The following scale factors are used:

FUNCTION	UNITS	RANGE				
		0	1	2	3	4
DC Volts (V)	V	1/100*	1/10*	1	64/10*	64
DC Amps (I)	mA	-1/80*	-1/10*	-8/10*	-64/10*	-512*
AC Volts (8505A only)	V	n/a	1/8	1	8	64
AC Amps (8505A only)	mA	1/64	1/8	1	8	64
*Differs from 8502A						

FUNCTION COMMAND CHARACTERS

The 8505A uses the same function command characters as those listed. The "C" command (dc coupled ac volts) can only be used when the True-RMS Converter (Option -09A) is installed. When an 8505A function is changed, the multimeter is configured as follows:

1. If the same function is re-selected, the multimeter assumes autoranging and retains all other existing modes and stored values.
2. If a new function is selected, the following configuration is set:
   a. Autoranging (R) is set.
   b. The existing trigger mode, sample, and filter are retained. However, if Average mode was previously on, it is turned off, sample is set to S7 and filter is set to F0.
   c. Offset, External Reference, Scaling, Limits, and Peaks are turned off (P0, X0, U0 respectively), with all respective values retained.
   d. Zero mode is toggled off if a function other than dc volts (V) or ohms (Z) is selected. If dc volts (V) or ohms (Z) is reselected, the Zero mode state (on or off) is restored to that in effect the last time the function was selected. The values of the temporary zeros are stored until the instrument is reset or powered off, or until new temporary zeros are stored.
   e. Calibration mode is on or off (as determined by the Calibration Switch setting) and gain correction factors are enabled (M0).

When an 8506A function is changed, the multimeter assumes a configuration defined by the variety of both old and new functions. One variety includes dc volts (V), ohms (Z), and dc amps (I). The second variety includes all ac volts functions (VA, VA1, VA2, C, C1, and C2). Four types of configuration change are therefore possible. Each of these changes resembles that detailed above for the 8505A, with the following exceptions:

1. Initial function was V, Z, or I — New function is V, Z, or I:

   The 8505A configuration is used.

Table 2A-2. Programming Instructions (8505A, 8506A) (cont)

2. Initial function was V, Z, or I — New function is ac or ac+dc volts:

   a. Filter mode off (F0) is set.

   b. No sample setting is allowed.

   c. Zero mode is off.

3. Initial function was ac or ac+dc volts — New function is V, Z, or I:

   a. Filter mode on (F) or off (F0) is retained.

   b. Sample S7 is set.

4. Initial function was ac volts — New function is ac volts:

   a. If the initial and new functions are both ac volts (or both ac+dc volts), manual ranging mode is retained at the same range, or autoranging is retained (starting at the same range).

   b. If the change is between an ac volts function (VA, VA1, VA2) and an ac+dc volts function (C, C1, C2), autoranging is automatically enabled.

   c. For all types of change (ac to ac, ac+dc to ac, ac to ac+dc, or ac+dc to ac+dc), Averaging mode (extended resolution) and all other modes and values are retained. No sample change is allowed in any 8506A ac volts function.

The following commands are used when initially selecting an 8506A ac volts function:

1. V A : V AC Normal
2. V A 1 : V AC Enhanced
3. V A 2 : V AC High Accuracy
4. C : V AC Normal (DC Coupled)
5. C 1 : V AC Enhanced (DC Coupled)
6. C 2 : V AC High Accuracy (DC Coupled)

NOTE

AC volts function commands used with the 8502A/AT are compatible with the 8506A. However, the six function commands mentioned above allow for faster, direct entry into the desired 8506A ac volts mode.

If the 8506A is already in an ac volts function, an abbreviated command can be used when selecting either of the other two ac volts functions. When selecting between ac or dc coupling for ac volts, the full command string mentioned above must be used. The abbreviated commands are as follows:

1. S 0 : V AC Normal
2. S 1 : V AC Enhanced
3. S 2 : V AC High Accuracy

Table 2A-2. Programming Instructions (8505A, 8506A) (cont)

RANGE COMMAND CHARACTERS

The nine range commands used with the 8505A or 8506A specify the full scale values by function as follows:

	DC VOLTS (V)	AC VOLTS 8505A	AC VOLTS 8506A	DC AMPS (I)	AC AMPS (IA) 8505A	OHMS (Z or Z1)
R	Auto	Auto	Auto	Auto	Auto	Auto
R 0	200 mV	Auto	125 mV	250 μA	312.5 μA	20 ohms
R 1	2V	2.5V	400 mV	2.0 mA	2.5 mA	200 ohms
R 2	20V	20V	1.25V	16 mA	20 mA	2 kohms
R 3	128V	160V	4V	128 mA	160 mA	20 kohms
R 4	1200V	1000V	12.5V	1.28A	1.28A	200 kohms
R 5	Auto	Auto	40V	Auto	Auto	4.1 Mohms
R 6	Auto	Auto	125V	Auto	Auto	35 Mohms
R 7	Auto	Auto	600V	Auto	Auto	265 Mohms

Resolution available for remote readings is as follows:

FUNCTION	RANGE	ASCII DIGITS* STANDARD MODE	ASCII DIGITS* AVERAGING OR CALIBRATION MODE
DC Volts (V)	100 mV (R0)	6½ (5½)	6½
	1V (R1)	6½	6½
	10V (R2)	6½	7½
	100V (R3)	6½	6½
	1000V (R4)	6½	6½
Ohms (Z)	10 ohms (R0)	6½	6½
	100 ohms (R1)	6½	6½
	1 kohm (R2)	6½	6½
	10 kohms (R3)	6½	6½
	100 kohms (R4)	6½	6½
	1 Mohm (R5)	6½	6½
	10 Mohms (R6)	6½	6½
	100 Mohms (R7)	6½	6½
DC Amps (I)	100 μA (R0)	6½ (5½)	6½
	1 mA (R1)	6½	6½
	10 mA (R2)	6½	6½
	100 mA (R3)	6½	6½
	1A (R4)	6½	6½
AC Amps (8505A only)	100 μA (R0)	5½	5½
	1 mA (R1)	6½	6½
	10 mA (R2)	6½	6½
	100 mA (R3)	6½	6½
	1A (R4)	6½	6½
AC Volts (VA) or AC + DC (C) (8505A only)	1V (R1)	6½	6½
	10V (R2)	6½	6½
	100V (R3)	6½	6½
	1000V (R4)	6½	6½

Table 2A-2. Programming Instructions (8505A, 8506A) (cont)

FUNCTION	RANGE	ASCII DIGITS*	
		STANDARD MODE	AVERAGING OR CALIBRATION MODE
AC Volts	100 mV (R0)	6½ (5½)	6½
(VA, VA1, VA2)	300 mV (R1)	6½ (5½)	6½
or AC + DC	1V (R2)	6½	6½
(C, C1, C2)	3V (R3)	6½	6½
(8506A only)	10V (R4)	6½	6½
	30V (R5)	6½	6½
	100V (R6)	6½	6½
	500V (R7)	6½	6½

*Resolution in binary mode is generally the same as in ASCII mode. Differing resolution in binary mode is shown in parentheses.

SAMPLES PER READING COMMAND CHARACTERS

Use of the sample commands is modified as follows:

1. With the 8505A, samples-per reading can be set with command S, followed by one or two digits (0-17). Digits greater than 17 cause a command string error (08). The H command can still be used, but the multimeter recognizes only one following digit (0-9, corresponding to S8 through S17 respectively).
2. With the 8506A (dc volts, ohms, dc amps only), samples-per-reading can be commanded in the manner described above.
3. With the 8506A set for ac volts, no sample changes are allowed. Therefore, commands S0 through S17 (or H0 through H9) cannot be used for sample settings when the 8506A is set for ac volts normal, enhanced, or high accuracy. However, the first three commands (S0, S1, S2) are used when commanding ac volts functions as follows:
   a. S0 commands ac volts normal. When initially commanding an ac volts function, only VA (for ac coupling) or C (for dc coupling) need be used. When the multimeter is already set for either of the other two ac volts functions, ac volts normal can be selected by using S0 only.
   b. S1 commands ac volts enhanced. When initially commanding an ac volts function, VA1 (for ac coupling) or C1 (for dc coupling) must be used. when the multimeter is already set for either of the other two ac volts functions, ac volts enhanced can be selected by using S1 only.
   c. S2 commands ac volts high accuracy. When initially commanding an ac volts function, VA2 (for ac coupling) or C2 (for dc coupling) must be used. when the multimeter is already set for either of the other two ac volts functions, ac volts high accuracy can be selected by using S2 only.

FILTER COMMAND CHARACTERS

Any filter command is acceptable for the 8505A or the 8506A (in V, Z, or I only). However, when Average mode is enabled, filter F is initially selected and can only be changed to F2 or re-selected. Any other filter selection (F0, F1, or F3), while accepted by the multimeter, sets the Average mode disabled and the sample at S7.

When the 8506A is in an ac volts function, only filter F0 (set at new function selection) or F (subsequently selected for inputs less than 40 Hz) is allowed.

TRIGGER COMMAND CHARACTERS

When the multimeter (8505A or 8506A) is in a continuous trigger mode (T or T1), the reset command (*) causes a normal multimeter reset. All other commands are buffered and examined only when the halt command (%) is sent.

Table 2A-2. Programming Instructions (8505A, 8506A) (cont)

With any trigger mode, no command string is examined until the existing reading or recalled value is returned. Any reading or recall value commanded (but not yet returned) can be discarded by sending the halt (%) command. If a continuous trigger mode (T or T1) is in effect when (%) is sent, the multimeter configuration is changed to single trigger mode (T0 or T2), and any buffered commands (with a terminating character) are executed.

AVERAGING COMMAND CHARACTERS

With the 8505A (all functions) and the 8506A (dc volts, ohms, dc amps only), the "O" character is used to command a preset sample and filter combination for each function and range to optimize accuracy and stability. Averaging also provides an extra digit of resolution in several ranges (as defined under RANGE COMMAND CHARACTERS). The following commands are available:

1. O: Averaging mode enabled.
2. O0 : Average mode disabled.

Enabling of Average mode in the situations defined above sets the multimeter to sample S10 and filter F. With Average mode enabled, samples S11-S17 or filter F2 can also be selected. Disabling of Average mode changes the sample and filter again and occurs under any of the following circumstances:

1. Command O0 is sent. Averaging mode is disabled. The sample is set to S7 and the filter is set to F0.
2. The function is changed. The sample is set to S7 and the filter is set to F0. If an ac volts function is initially selected with the 8506A, only filter F0 is set. If a change is made between 8506A ac volts functions (VA, VA1, VA2, C, C1, C2), Averaging (extended resolution) is retained.
3. A sample or filter not allowed in Average mode is commanded. If S0-S9 is commanded, Average mode is disabled, the new sample setting is accepted and the filter is set to F0. If a filter other than F or F2 is selected, Average mode is disabled, the new filter is accepted and the sample is set to S7.

With the 8506A set for any of the ac volts functions, Average mode is not available. However, the O or O0 command can still be used to enable or disable extended resolution (as defined under RANGE COMMAND CHARACTERS). In this situation, only the sample and filter restrictions defined by the 8506A ac volts functions are applicable. No sample change can be made. Only filter F0 or F (for input signals less than 40 Hz) can be selected. If a sample change is attempted or an unallowed filter is commanded, a momentary error is set and extended resolution is retained. Extended resolution in 8506A ac volts functions is disabled if the O0 command is sent. If a change is made between ac volts functions, extended resolution is retained with the existing filter mode. If dc volts, ohms, or dc amps is selected, extended resolution (Average mode) is disabled, the filter is not changed, and the sample is set to S7.

Whenever the "O" character is used (8505A or 8506A - any function), the multimeter responds with the following output format:

BINARY OUTPUT FORMAT

16-Bit Format (B1):

[BYTE 1 | BYTE 2] [BYTE 3 | BYTE 4] [BYTE 5 | BYTE 6]

8-Bit Format (B):

[BYTE 1] [BYTE 2] [BYTE 3] [BYTE 4] [BYTE 5] [BYTE 6]

Example:

0000 0011 1000 0000 0000 0000 0000 0000 0000 0000 0000 0001

Implied Binary Point

Sign Bit

Exponent Sign Bit

= 3.5 X 10 EXP 1

Table 2A-2. Programming Instructions (8505A, 8506A) (cont)

ASCII OUTPUT FORMAT

±	Digits 1, 2, 3 and decimal point.				Digits 4, 5, 6, 7, 8					E	±	Exp	CR	LF
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Digit 8 is used only on the 10V dc range to yield 7½ digit resolution. On all other ranges and functions, 6½ digit resolution is used and digit 8 is set to 0.

OFFSET COMMAND CHARACTERS

When storing the previous reading as an offset, both the 8505A and the 8506A use the displayed value in the same manner as does the 8502A.

LIMITS AND PEAKS COMMAND CHARACTERS

When Limits testing is enabled (U), an error is identified by either of the following responses:

1. The standard error response message (programmed with the K3 command) is normally returned.
2. If no such standard error response message has been programmed since the last power-up or reset, a "2" is returned to identify an error occurring during limits testing.

CONTROL COMMAND CHARACTERS

ASCII Data Output Format

Digit 7 is used with the 8505A and 8506A whenever 6½ digits of resolution are available. If 5½ digits are available, digit 7 is not needed and is consequently set to 0.

CALIBRATION CONSTANT

The Calibration Memory is a standard feature of the 8505A and 8506A. Therefore, the M and M0 commands may be used at any time to inhibit or enable all Calibration Memory gain correction factors:

M: inhibit all calibration gain correction factors.
M0: enable calibration gain correction factors.

The M1 and M2 commands may be used to inhibit or enable the temporary zero correction factors stored with the K0 and K1 commands (V DC and OHMS only). This has the same effect as turning the Zero mode off and on with the ZERO push button, except the M2 command does not store zeros:

M1: inhibit zero correction values (turn Zero mode off).
M2: enable zero correction values (turn Zero mode on).

The temporary zero correction factors are applied in dc volts (V) or ohms (Z) whenever the M2 command is in effect (i.e., whenever Zero mode is on). When the multimeter is powered-up or reset, the Zero mode is turned on and the temporary zero correction factors are reset to 0. During normal operation (Calibration mode off), the "permanent" zero correction factors in Calibration Memory are always in effect, and are not affected by the M1 and M2 commands.

Calibration Memory allows for software calibration of all functions and is fully described in Appendix 7B. Although software calibration procedures are not discussed here, the following considerations must be observed if Calibration mode is turned on (the Calibration mode is enabled or disabled with the rear panel Calibration Switch when the multimeter is in local control):

1. Calibration correction factors are always applied to readings unless the M command is sent. This is true whether Calibration mode is on or off.
2. When Calibration mode is on, the M1 and M2 commands enable and disable the "permanent" zero correction factors stored in Calibration Memory. Temporary zeros are not used in Calibration mode.
3. When Calibration mode is on, the resolution available for each range and function is the same as for Average mode (refer to RANGE COMMAND CHARACTERS).

Table 2A-2. Programming Instructions (8505A, 8506A) (cont)

MEMORY COMMAND CHARACTERS

STORE

Commands K0 (store dc volts zero) and K1 (store ohms zero) can be used with either the 8505A or the 8506A. However, the zero value is stored in the following new fashion:

1. If Calibration mode is on (G5 response = 1), any zero value entered with the K0 or K1 command is stored directly in the Calibration Memory and retained until a new value is stored during Calibration mode on. Software calibration uses this procedure and is fully described in Appendix 7B.

2. If Calibration mode is off (G5 response = 0), any zero value entered with the K0 or K1 command is stored in a separate, temporary memory. These values do not affect the values stored in Calibration Memory. The temporary zero values are retained and applied to subsequent readings until the multimeter is powered-off or reset. The temporary zero values are all reset to 0 at power-up or reset.

3. Whenever the K0 or K1 command is used (Calibration mode on or off), a separate zero value can be stored for each range.

   a. If Calibration mode is on, the zero value is stored for the range selected without affecting the value for any other range.

   b. If Calibration mode is off, any zero value stored is applied to the existing range and all higher ranges in the same function. Therefore, separate values for each range can be entered by using K0 (or K1) sequentially for each range (from lowest to highest).

The following additional store commands are available for the 8505A or the 8506A:

1. K N G : Keep gain correction on this range. This command is used when storing calibration gain correction factors with Calibration mode on. Software Calibration (Appendix 7B) deals with this procedure in detail.

2. K N D : Keep the following six digits as the calibration date or the multimeter identification. Any value totaling 999999 or less can be entered (with Calibration mode on). Zeros are not suppressed if less than six digits are entered. The full procedure is defined in Software Calibration (Appendix 7B).

3. K 3 : Keep the error response message. This command allows the operator to specify the response for an error condition. These characters (instead of the actual reading) are then automatically returned whenever an error condition occurs. For example, the word ERROR or an obviously illegal response value (such as 1E20) can be programmed as the error response message. The desired response must be reprogrammed after a power-up or reset condition occurs. The multimeter returns 0 as the error message if no other message has been programmed. The actual error can only be identified as the first and second characters of the G1 (Get Status) response. The following rules must be followed when making the K3 entry:

   a. A maximum of any 15 characters (excepting immediate and termination characters) can be programmed following the K3 command. Spaces can be used as part of the 15 character total. Characters in excess of 15 are ignored by the multimeter and do not cause an error condition.

   b. Nulls are discarded and not stored. Nulls are not counted for the 15 character limit.

   c. Any immediate character (including termination characters) terminates and executes the string normally.

   d. The $ command is an immediate character only when used with the Bit Serial Interface (Option -06). With the IEEE-488 Interface (Option -05) or Parallel Interface (Option -07), $ is not an immediate character and can be used as part of the K3 command string.

Table 2A-2. Programming Instructions (8505A, 8506A) (cont)

e. The # command is an immediate character only when used with the Bit Serial Interface (Option -06) or the Parallel Interface (Option -07). With the IEEE-488 Interface (Option -05), the # command is not an immediate character and can be used as part of the K3 command string.

4. K 4 G 1 : Clear all of Calibration Memory. If it is necessary to clear all calibration factors (as in a check sum error 25 condition or prior to hardware calibration of all functions), the K4G1 command string can be used. Depending on the number of entries being cleared, several seconds may be necessary to complete this operation. Completion of this comprehensive clearing operation is verified by return of the status response.

CAUTION

If any interrupting command is sent immediately after K4 (and before G1), the comprehensive clearing operation may be interrupted prior to completion. A check sum (error 25) condition would then be set. Do not send any interrupting command (immediate characters, reset, etc.) between K4 and G1.

5. K 2 : Store previous reading as scaling factor.

RECALL

Recall DC Zero (G0)

The G0 command (recall dc zero and send on next trigger) operates in the following fashion for either the 8505A or the 8506A:

1. The multimeter can store separate dc zero values for each range. If G0 is used when dc volts function is selected, the dc zero recalled is the value for the range selected. If G0 is used when any other function is selected, the dc zero recalled is the value for the 100 mV range only.

2. The multimeter can store both non-volatile ("permanent") and temporary dc zero values. Which values are recalled depends on the state of the Calibration mode at the time G0 is used. When Calibration mode is on, the zero values recalled are the permanent values, which are stored in Calibration Memory. When Calibration mode is off, the zero values recalled are the temporary values, which are stored in a separate, temporary memory. The temporary zero values are reset to 0 when the multimeter is powered-up or reset.

Recall Status (G1)

The first two digits of the G1 response (error codes) are identified in two steps. The first step involves a user-programmed error message that is returned whenever an error condition has been generated. This message is stored in an error response buffer and serves only as a "flag" that an error exists. It does not identify the error. An error message is programmed with the K3 command, followed by any combination of up to 15 characters. For example, an obviously illegal multimeter response of 1E20 could be specified as the error message. If no such special message has been programmed, a returned "0" is used. In any case, this message alone is returned whenever an error condition has been generated and a response from the multimeter has been commanded. The error message may be returned repeatedly. This depends on the type of error condition generated (momentary or latching) and subsequent corrective actions. The following rules apply:

1. Each momentary error condition generates only one error message.

2. A latching error condition, if not corrected, generates repeated errors. Therefore, the error message is returned for each attempted reading.

For the second step, the G1 (get status) command must be sent. The first and second characters of the status response then identify the error condition by number. This two-digit error code is stored in a separate error condition buffer and is subject to the following rules:

1. A single two-digit error code can occupy the error buffer.

2. If a multiple error condition exists, only the last error to have been generated is stored in the error buffer.

Table 2A-2. Programming Instructions (8505A, 8506A) (cont)

3. The error buffer is cleared (set to 00) when either of the following actions occurs:

   a. The G1 command is sent. The error is returned in the status response, and the buffer is reset to 00. If the error still exists, a new reading must be triggered to reload the error buffer (and return the error message). If another G1 command is sent before a new reading is triggered, no error (00) is identified in the response.

   b. A valid reading is triggered. The reading is returned and the buffer is reset to 00.

The multimeter employs both momentary and latching errors. A momentary error in the buffer can be cleared by sending the G1 command or by triggering a valid reading. If the momentary error does not reoccur, further multimeter operation is not impeded. A latching error, if not corrected, does impede further multimeter operation by generating another error (and returning the error message) each time a reading is triggered. Clearing the error buffer by sending G1 does not affect this impediment. Latching errors include 12, 13, 14, 15, 19, and 24.

A momentary error condition is illustrated in the following example. Assume that 1V dc is applied to a multimeter configured for dc volts. The following sequence of commands is sent: VR0? KG1? R1? The first command (VR0?) triggers an overrange, causing the error message to be returned. The second command (KG1?) attempts to store this overrange as an offset, loads momentary error 11 into the error buffer, and returns 11 (the most recent error to be generated) in the status response. The third command (R1?) triggers and returns a valid reading and resets the error buffer to 00.

A latching error condition is encountered in the following example. Assume that the multimeter is configured for dc volts (V), but not dc current measurement (I), and 1V dc is applied to the inputs. The following sequence of commands is sent: IR1? G1? ? V? The first command (IR1?) triggers an invalid reading, loads the error buffer with latching error 19, and causes the error message to be returned. The second command (G1?) returns 19 as the first two characters of the status response and resets the error buffer to 00. The third command (?) triggers another invalid reading, loads the error buffer with 19 again, and returns the error message. The fourth command (V?) is valid. Therefore, the actual reading is returned, and the error buffer is reset to 00.

NOTE

Latching errors are enabled at all times (Calibration mode on or off) when remote operation is in use. However, latching errors can be disabled locally (with Calibration mode on). This procedure is intended for use during troubleshooting only. Do not attempt to disable latching errors at any other time.

The following additional error conditions can occupy the error buffer for either the 8505A or the 8506A:

1. 23 : The Calibration Memory is faulty or not installed.

2. 24 : Illegal module configuration.
   This error occurs at power-up or reset. It may mean that a Calibration Memory module is installed. The 8505A and 8506A do not use a separate module for calibration memory entries (calibration memory is a standard part of the Controller module). If a Calibration Memory module is installed, it must be removed. Also, error 24 may mean that the wrong ac converter configuration is installed. The 8505A uses either the -01 Option or the -09A Option (not both). The 8506A uses only the Thermal True-RMS Converter. If an illegal ac converter is installed, it must be removed. If the illegal configuration is not corrected, the error buffer is cleared (G1 sent), and a valid function is subsequently selected, the illegal module configuration does not interrupt further multimeter operation. However, if both ac converters (-01 and -09A) are installed in the 8505A, the ac volts command (VA or C) causes selection of the -09A converter only.

3. 25 : The Calibration Memory check sum is wrong.
   This error condition may occur when applying power, when storing into Calibration Memory, or when recalling a Calibration Memory entry. It may be caused by an inadvertent cycling of power when the multimeter is in the Calibration mode. Ensure that Calibration mode is off, then try re-initializing power to the multimeter. If error 25 remains, it may be necessary to first clear, and then re-enter, all correction factors, zero values, and the calibration date (or instrument identification number). If error 25 recurs during the clearing procedure or during any subsequent programming attempt, the Calibration Memory may be faulty.

Table 2A-2. Programming Instructions (8505A, 8506A) (cont)

4. 27 : Ohms input problem
   Error 27 can occur under any of the following circumstances:

   a. At least one ohms input connection is open.

   b. An input polarity reversal has been made in four-terminal connections.

   c. An input protection fuse is bad. For input connections at either the front panel terminals or through the rear input connector, any of the input fuses on the Front/Rear Switch PCB could be bad. Either the front or rear current/ohms fuse could also cause this error condition.

The third character of the G 1 (recall status) response is modified when used with the 8506A in an ac volts function. The third character (range codes) is then defined as follows:

0	100 mV	3	3V	6	100V
1	300 mV	4	10V	7	500V
2	1V	5	30V		

The fifth character (function codes) of the response to G1 is modified for the 8506A. Since ac current cannot be measured with the 8506A, the fifth character cannot be defined as "3". Further, if the fifth character is a "1" (ac volts) or a "5" (dc coupled ac volts), the specific ac volts function must also be identified. Since sample codes are not used in 8506A ac volts functions, the fourth character (Sample) is utilized to define whether normal mode (fourth character = 0), enhanced mode (1), or high accuracy mode (2) is selected.

Additional Recall Commands

The following additional recall commands are available with either the 8505A or the 8506A:

1. G 2 : Recall multimeter configuration and send on next trigger. This recall command is useful in determining the multimeter type and identification number, verifying the installed modules prior to a performance test or calibration, and identifying the cause of an error 24 (illegal module configuration). A 22-character response identifies the multimeter and its hardware configuration as follows:

   a. Characters 1-5: the model number (e.g. 8506A)

   b. Characters 6-8: a special number (or blank)

   c. Character 9: a colon (:)

   d. Characters 10-22: 13 characters identifying the loaded modules.

      D : DC Signal Conditioner
      F : Active Filter
      C : A/D Converter
      1 : Averaging AC Converter (Option -01)
      2 : Ohms Converter (Option -02A)
      3 : Current Converter (Option -03)
      4 : Not used (always = -)
      5 : IEEE-488 Interface (Option -05)
      6 : Bit Serial Interface (Option -06)
      7 : Parallel Interface (OPtion -07)
      8 : Isolator
      9 : True-RMS Converter (Option -09A)
      A : Thermal True-RMS Converter

Table 2A-2. Programming Instructions (8505A, 8506A) (cont)

Any module not installed is noted with a (-) in the response. For the 8505A, a response of DFC12----78-- would signify a standard dc volts configuration (DFC) with the Isolator (8) and options for averaging ac (1), ohms (2), and parallel interfacing (7). For the 8506A, a response of DFC--3-5--8-A would identify a standard dc volts (DFC) with the Isolator (8) and thermal true-rms volts (A) configuration with options for dc current (3), and IEEE-488 interfacing (5). Modules allowed in either instrument are defined as follows:

POSSIBLE CONFIGURATION	ALLOWED CONFIGURATION (S = standard, O = optional, N = not allowed, - = not used)	
	8505A	8506A
D	S	S
F	S	S
C	S	S
1	O (1)	N
2	O	O (2)
3	O (1)	O (2)
4	-	-
5	O (3)	O (3)
6	O (3)	O (3)
7	O (3)	9 (3)
8	S (3)	S (3)
9	O (1)	B
A	N	S

NOTES:

(1) 8505A AC Volts (VA) uses either Averaging (Option -01) or True-RMS (Option -09A) converter. 8505A AC Amps (IA) uses Current Converter (Option -03) and either ac converter. If both ac converters are installed with ac volts or ac amps selected, the True-RMS converter (Option -09A) is used.

(2) 8506A can use either the Ohms Converter (Option -01A) or the Current Converter (Option -03) — not both.

(3) 8505A and 8506A: only one interface (Option -05, -06, or -07) can be installed at one time.

2. G3: recall front/rear input selector status on next trigger. Response is as follows:

   0 (rear inputs)
   1 (front inputs)

3. G 4 : recall the calibration date (or instrument identifying) number. Response includes six digits with no leading zero suppression. If the Calibration Memory is not installed, the response is 0 0 0 0 0 0, and no error is generated.

4. G 5 : recall Calibration mode status. A returned 0 identifies Calibration mode off, and a returned 1 identifies Calibration mode on.

5. G 6 : recall Ohms zero value and send on next trigger. If G6 is sent when the Ohms function is selected, the zero value for the range selected is returned. If any other function is selected when G6 is sent, the zero value for the 10 ohm range (R0) is returned.

If any unspecified G command is attempted (such as G7), the multimeter assumes that G (recall previous reading and send on next trigger) has been sent.

Section 3
Theory of Operation

3-1. INTRODUCTION

3-2. This section describes the theory of operation for the mainframe, which includes the modules necessary for dc volts and dc ratio measurements. Block Diagram Description gives an overview of the operation of the multimeter and an explanation of its bus structure. This description is followed by Circuit Analysis, which gives a more detailed description of the circuitry. Optional modules are described in Section 6.

3-3. BLOCK DIAGRAM DESCRIPTION

3-4. Bus Structure

3-5. The multimeter is constructed with a bus architecture similar to that of a computer. Figure 3-1 is an overall block diagram of the instrument with optional modules drawn in dashed lines. Figure 3-2 is a block diagram illustrating signal flow. A microprocessor-based Controller module controls information flow on the three buses. The Controller sets up each of the analog modules for a measurement by addressing the modules as memory locations. An unguarded digital interbus is used to connect the Controller to the front panel and to digital option modules.

3-6. The unguarded digital bus consists of the following lines:

1. Address/Control (IC)
2. Bidirectional data (ID)
3. Real time (RT)
4. Handshake (EXTINT, ACK, INA)
5. Input/Output (SCAN ADV, EXT TRIG, FRONT/REAR SENSE)
6. Power supply

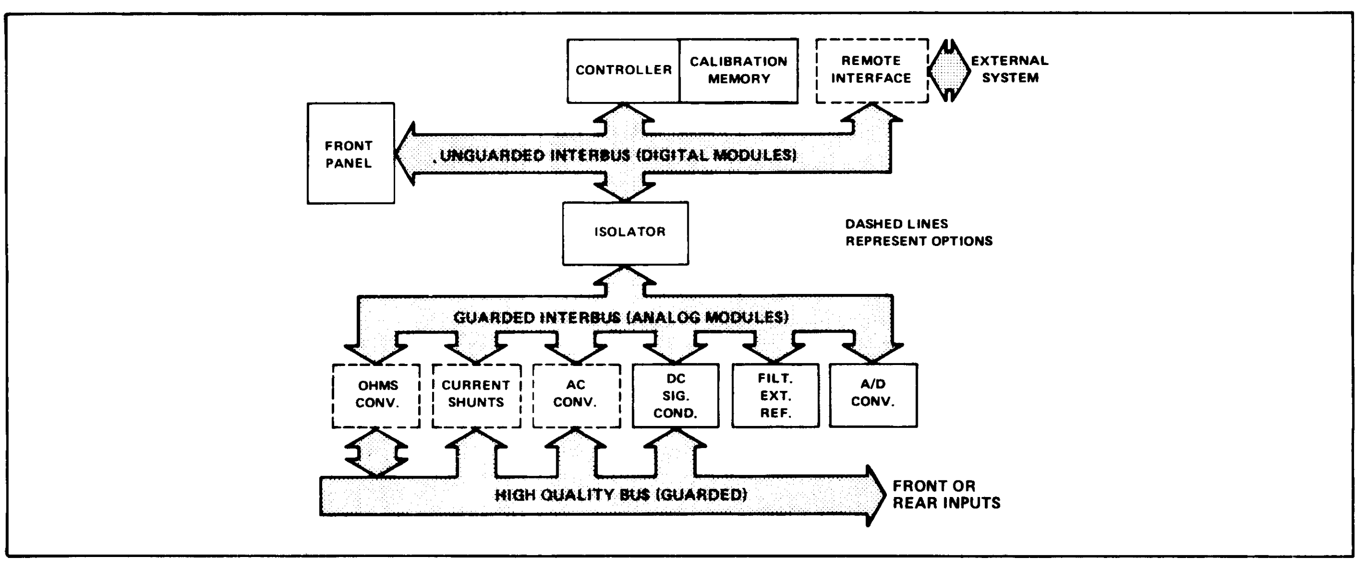


Figure 3-1. 8505A Block Diagram

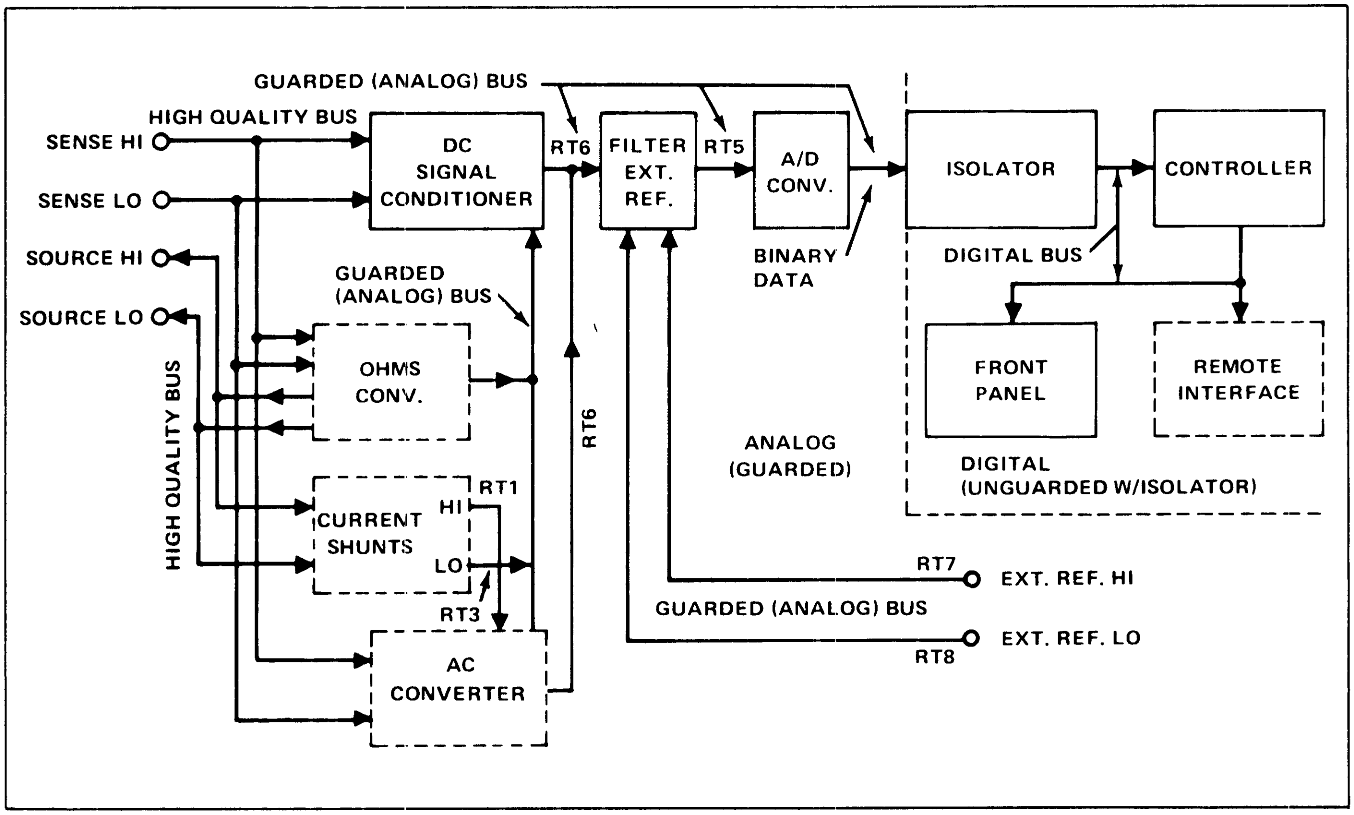


Figure 3-2. Analog Signal Flow

3-7. The guarded bus connects the Controller to the analog modules through the Isolator module. The guarded bus consists of the following lines:

1. Address/Control (IC)
2. Bidirectional data (ID)
3. Real time
4. Handshake (ACK)
5. Power Supply

3-8. The address, handshake, and data lines of the two buses serve the same functions. The real time and power supply lines may have differing functions. For example, the RT lines in the unguarded bus are unused except for RT5 (frequency reference). The RT lines in the guarded bus form an analog bus which carries all the conditioned and converted analog signals between the analog modules. The external reference input lines are part of the analog bus (RT7 and RT8). Logic supply lines (Vcc and Vss) are -15V and -20V with respect to analog common. With the Isolator installed, Vcc and Vss are isolated from analog common.

3-9. The high quality bus consists of lines connecting the input switch (Sense HI and LO, Source HI and LO, Guard, Ohms Guard) to the signal conditioning and converting modules (ac converters, ohms converter, etc.). Ohms guard is only available through the rear inputs.

3-10. Controller

3-11. Under the direction of the software program, the controller addresses and sets up each of the modules necessary to perform a function. Two types of addresses are used: direct and indirect. An indirect address requires a previous direct address to set up the indirect address response logic. Data transfers are accomplished with a handshake between the address (IC) lines and the acknowledge (ACK) line. When the controller addresses a module, it places data on the data (ID) lines or receives data from the addressed module. The addressed module must respond with an ACK signal signifying that it is receiving or sending data.

3-12. The controller directs the R^2 A/D converter in taking a sample and receives the sample data from the converter. The controller stores range and function information for application to the sample data. Using the arithmetic capability of the microprocessor, the software processes the data to arrive at a binary twos complement number which represents the polarity and value of the measurement. This number is made available to an optional remote interface either as is or after further processing to ASCII code. The number is further processed by the controller for application to the front panel display in a seven-segment LED format.

3-13. The software program consists of two parallel processes. A background process (Figure 3-3) is responsible for interrupt driven activities such as updating the display digits and directing the A/D converter in taking a sample. The foreground process (Figure 3-4) is responsible for the measurement cycle including accumulating data from the background process and performing required calculations.

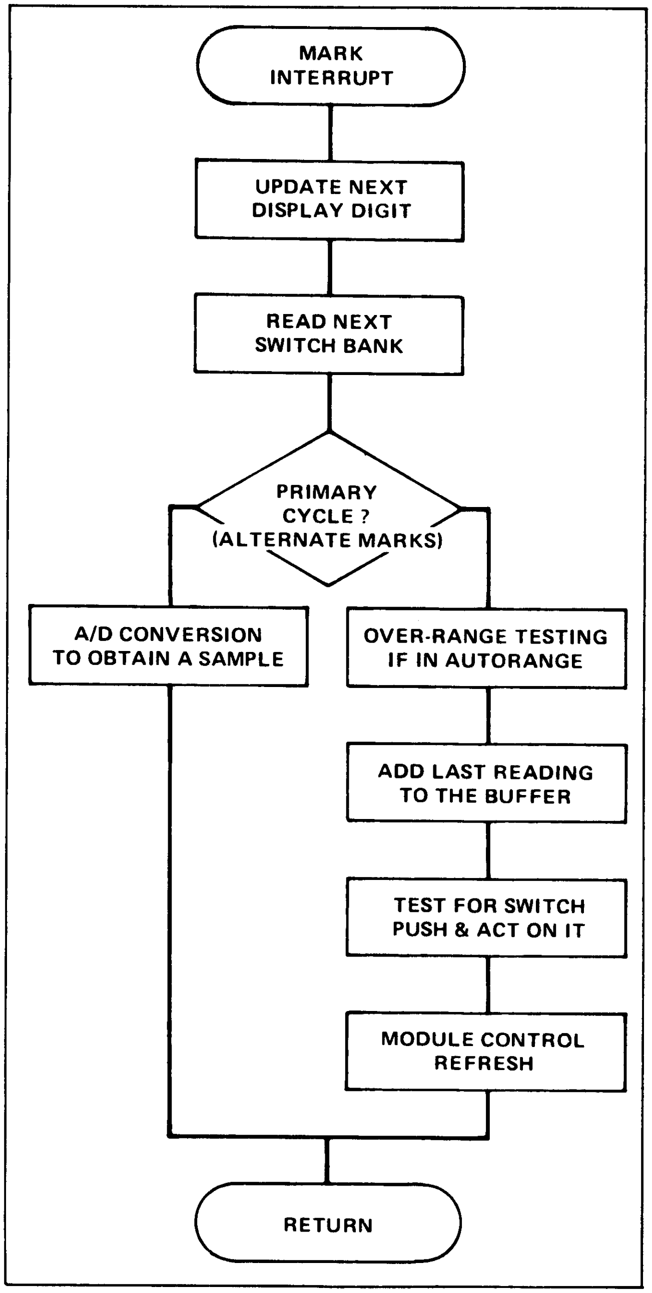


Figure 3-3. Background Software Process

3-14. The controller is structured around the Intel 8080 microprocessor. Figure 3-5 is a block diagram of the controller module. Hardware control functions have been minimized by software design. Sequences of events are timed from two sources. Basic operations of the microprocessor are run from a 1.7 MHz clock. The other source is generated by shaped line frequency pulses, which are applied to a phase-locked loop. The phase-locked loop multiplies the line frequency by eight. This signal is used to generate mark interrupts which time the background process.

3-15. Memory for the multimeter consists of two ROMs for software and one RAM for variables. Data lines (DB0-DB7) are used for bidirectional data flow. Address lines (A0-A15) determine the source or destination for data and instructions. Modules in the multimeter system are memory mapped and are accessed through normal memory reference instructions.

3-16. Interrupts are used to divert the microprocessor from the main program to service other routines. Interrupts are synchronized to an appropriate time in the microprocessor cycle through interrupt control, where assigned priorities vector module identity data onto the data bus. Module identity data words direct the microprocessor to the memory location containing the next instruction. Two interrupts are internally generated: ACKINT and MARKINT (priorities one and six respectively). ACKINT is generated when an acknowledge signal is not returned. MARKINT is used to synchronize A/D samples and display digit updates to the line frequency.

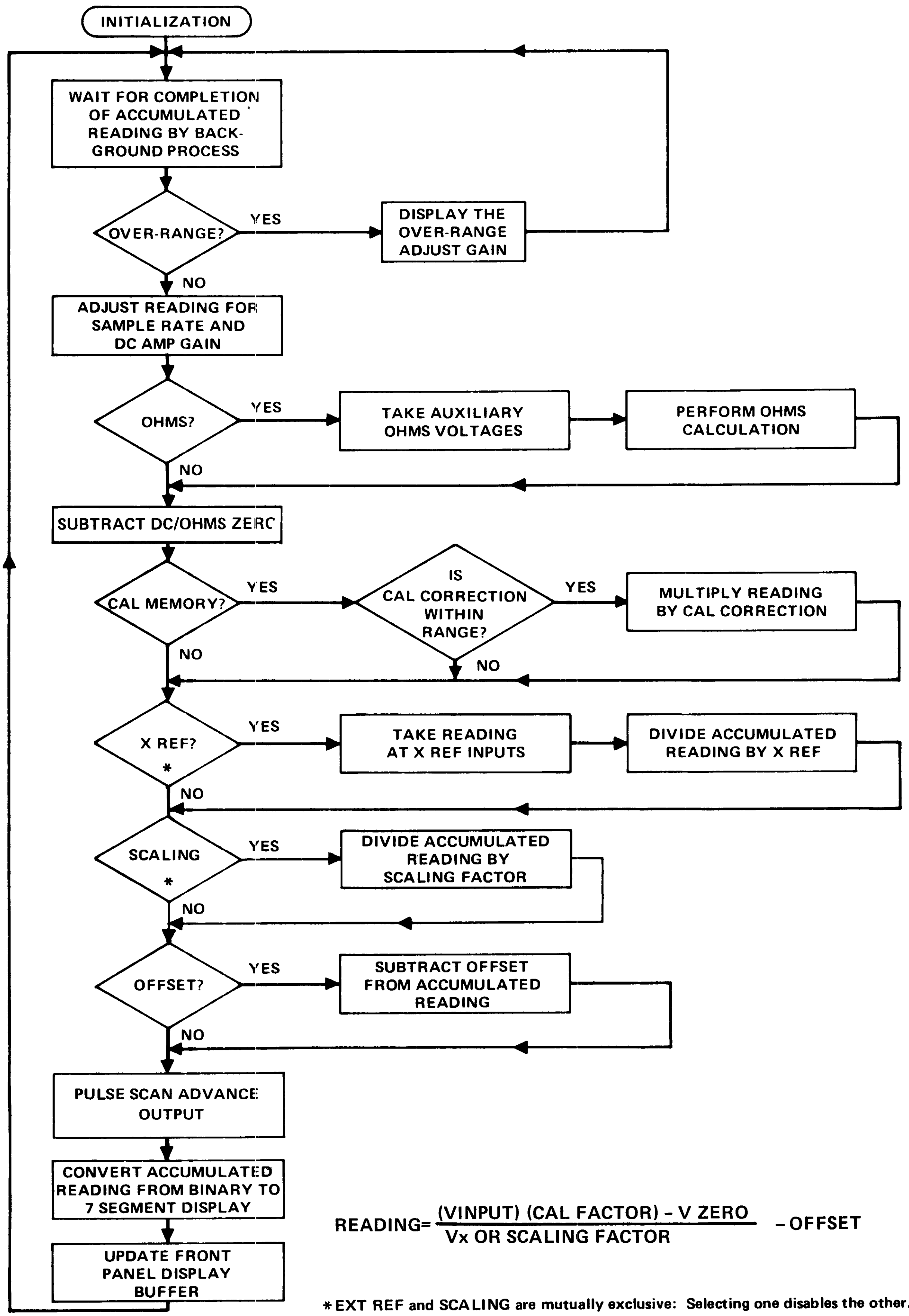
3-17. An interrupt may be externally requested by pulling the EXTINT line low. When the microprocessor is ready to accept the interrupt, the interrupt acknowledge (INA) signal is generated. The requesting module must respond with an ACK and a data bit (on ID1-ID3) which is used as a priority vector by interrupt control.

3-18. Software or hardware resets may occur. Software resets result from front panel requests or remote requests. Hardware resets are generated from the reset logic by monitoring line frequency on RT5. On power-up, or for line disturbances, the reset logic initializes the microprocessor and other logic. At power down, the reset signal prevents erroneous operation.

3-19. The control logic can be divided into two areas: control of the microprocessor and control of the external logic. The microprocessor control logic is used when the microprocessor enters and exits wait states. The external control logic is responsible for latching status information from the microprocessor at the beginning of each instruction cycle. The status information controls and synchronized the activities of the external logic.

3-20. Front Panel

3-21. The front panel serves as an interface between the operator and the controller. The display is multiplexed by the controller by means of addressing the front panel for each digit. One direct address, two indirect addresses, and



$$\text{READING} = \frac{\text{(VINPUT) (CAL FACTOR) - V ZERO}}{\text{Vx OR SCALING FACTOR}} - \text{OFFSET}$$

* EXT REF and SCALING are mutually exclusive: Selecting one disables the other.

Figure 3-4. Foreground Software Process

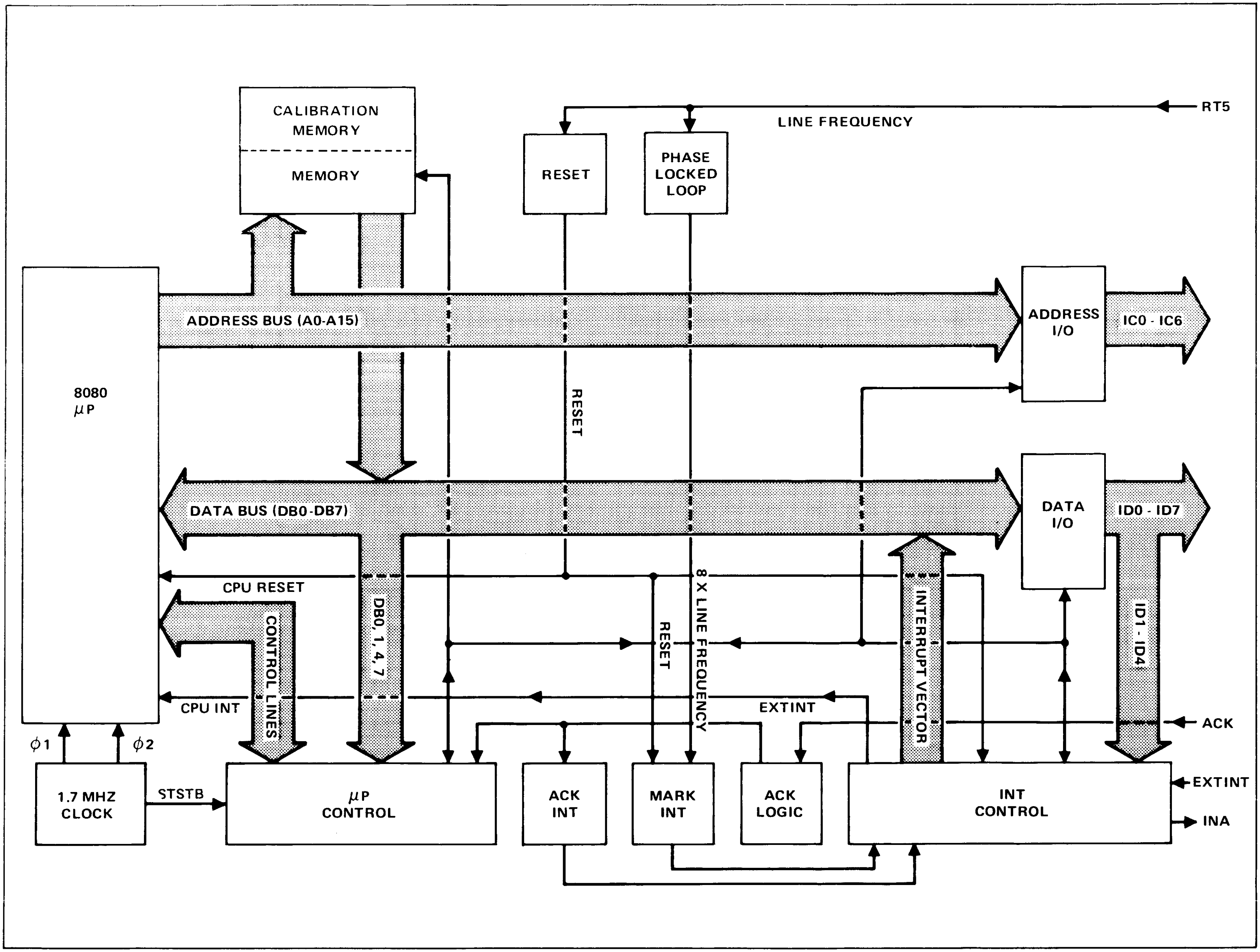


Figure 3-5. Controller Block Diagram

8505A

the accompanying data determine which digit or annunciator will light and which segments will light. An indirect address requires a previous, valid direct address to set up the indirect response. Another direct address enables the switch matrix to be read to determine if any function changes are desired. The cycle of updating each digit and annunciator and reading the switch matrix requires approximately 28 ms and is continuous. Input terminals, J1-J5, are physically located on the front panel but have no electrical interaction with the front panel.

3-22. DC Signal Conditioner

3-23. DC signals from either the input terminals or optional signal conditioners (Ohms or Current Shunts) are routed through the DC Signal Conditioner to be brought within the range of the A/D Converter (± 20V). Figure 3-6 is a block diagram of the DC Signal Conditioner. Gain or attenuation factors are selected by the microprocessor addressing the module. Data from the data bus is latched into the control circuitry and used to select relays in the attenuator and switched in the amplifier feedback circuit. The combination of the attenuator and feedback-controlled amplifier give gain factors of 1, 10, or 100 and attenuation factors of 8 or 64.

3-24. Active Filter

3-25. The purpose of the Active Filter module is to multiplex dc signals to the A/D Converter and to switch analog filters into the signal path. Figure 3-7 is a block diagram of the Filter/External Reference module. Five filter modes may be selected from the front panel. For external reference measurements, the signal conditioner input, the External Reference HI input and the External Reference LO input are mulitiplexed to the A/D Converter. Samples are taken of each input and arithmetically manipulated by the Controller to arrive at a reading. Outputs from the optional ac converter modules are applied to the Active Filter module, bypassing the DC Signal Conditioner.

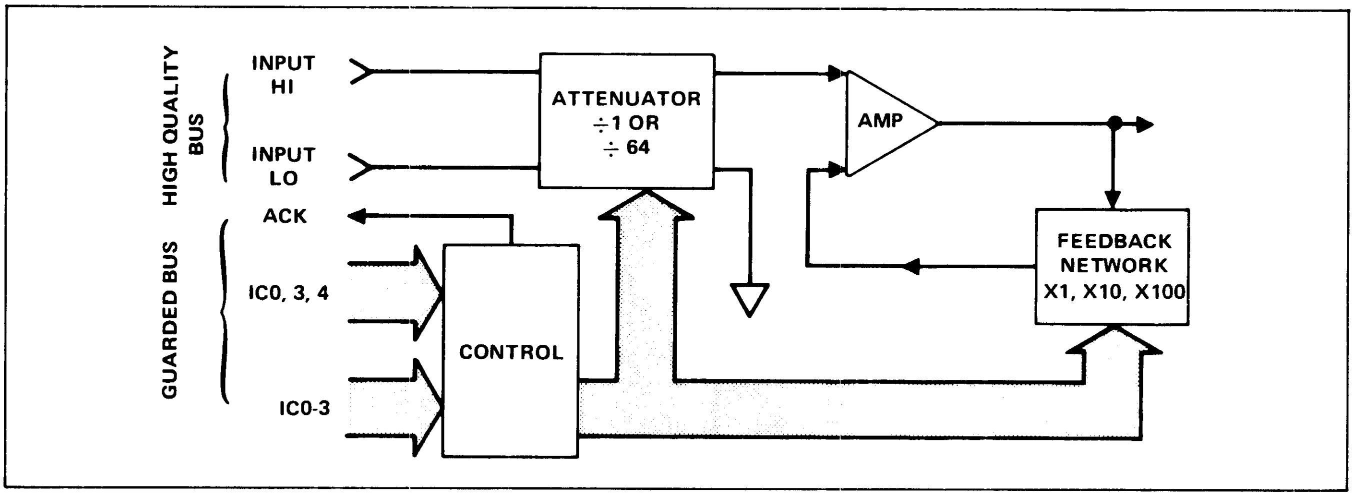


Figure 3-6. DC Signal Conditioner Block Diagram

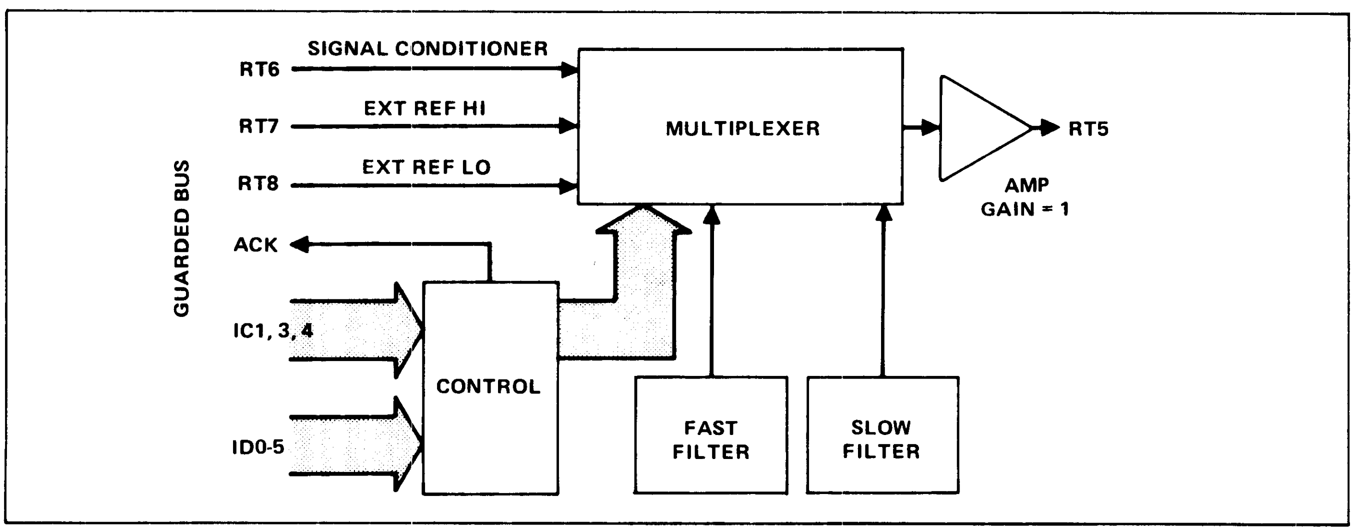


Figure 3-7. Active Filter Block Diagram

3-26. Fast R^2 A/D Converter

3-27. The Fast R^2 A/D Converter employs Fluke's patented recirculating remainder (R^2) technique for converting a dc input signal into a binary, bit-serial data stream. The R^2 technique has been modified for microprocessor control. Obtaining a sample is a five-step process. Each step consists of a decision period of five decisions and a subtraction period. Set-up of the converter, decisions, and reset are initialized by the Controller addressing the A/D Converter. Figure 3-8 is a block diagram of the R^2 A/D Converter.

3-28. During the first step, the input signal is applied to the Summing Node. The polarity of the input is detected and the resulting bit of information is transmitted to the Controller. On the basis of the returned polarity, the A/D module selects which reference polarity is required: positive for negative inputs, negative for positive inputs. The first of five precision currents is switched into the Summing Node and a polarity bit returned. If the polarity is changed the first current is switched off. If the polarity is not changed, the current is left on. Then the next current is switched into the Summing Node and another polarity bit returned. Another decision is made and so on until all five currents have been switched into the Summing Node and five decisions have been made. This completes the first decision period. The five precision currents are related by powers of two. The fifth current has a resolution of thirty two.

3-29. Following the decision period is a subtraction period. Feedback through the Remainder Storage nulls whatever remainder was left after the five currents have been switched into the Summing Node. The remainder is amplified by 16 in the Remainder Amp and is stored on a capacitor in Remainder Storage. This completes the first step. The input is now switched out of the Summing Node and the amplified remainder switched in for the next step. There are two remainder channels in Remainder Storage and they are alternated in the four subsequent steps. Since the fifth current has a resolution of thirty two and the Remainder Amp has a gain of 16, the first bit of a step has the same significance as the last bit of the previous step.

3-30. Of the five steps required to complete a sample, the first uses the input signal for decision and subtraction periods. The four subsequent steps alternate remainder channels to use the amplified remainder of the preceding step for decision and subtraction periods. Polarity bits returned at each decision are accumulated by the Controller and assembled into a 24-bit word describing the polarity and magnitude of the input.

3-31. Front/Rear Switch Assembly

3-32. Analog inputs are applied either at front panel terminals or through a rear panel connector. The Front/Rear Switch Assembly is controlled by the Rear Input Selector on the front panel. When disengaged (out), this selector routes front panel INPUT HI and LO,

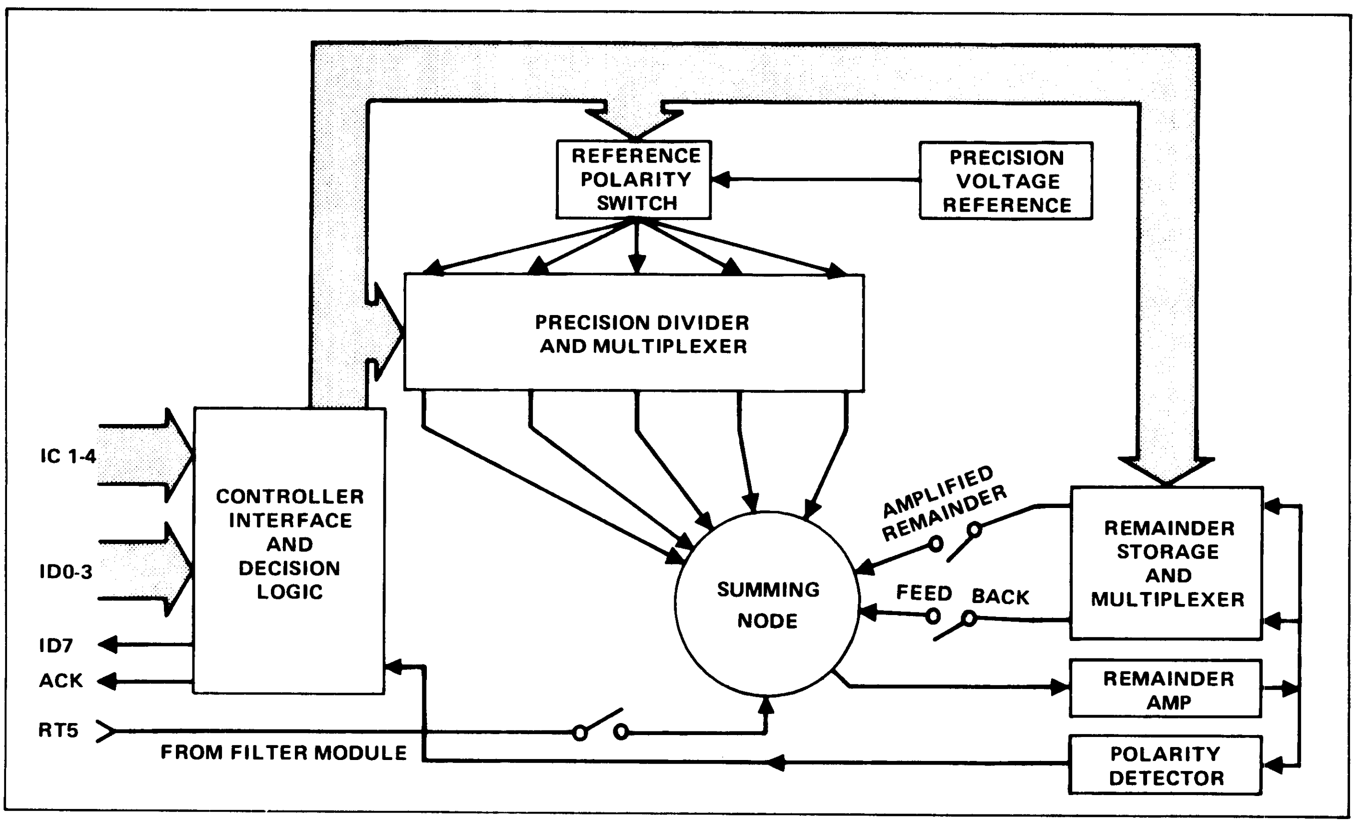


Figure 3-8. R^2 A/D Converter Block Diagram

SOURCE HI and LO, and GUARD connections to the multimeter analog bus. The front panel Ohms Selector and Guard Selector influence only the front panel inputs: these two selectors have no effect on the rear inputs. When engaged (in), the Rear Input Selector routes INPUT HI and LO, SOURCE HI and LO, GUARD, and OHMS GUARD from the rear input connector to the analog bus. External Reference HI and LO inputs are also applied through the rear input connector but are not switched. Separate fuse protection is used for front panel (INPUT HI, SOURCE HI) and rear (INPUT HI, SOURCE HI, GUARD) inputs. An LED on the Front/Rear Switch Assembly lights when front inputs are selected. The multimeter Controller senses this indication through a phototransistor on the Motherboard. Front input selection is also sensed by the IEEE-488 Bus.

3-33. CIRCUIT ANALYSIS

3-34. Introduction

3-35. Detailed circuit description of each module in the standard mainframe is presented in the following paragraphs. Optional modules are covered in Section 6. The block diagram description should be read first to get an understanding of the overall functioning of the instrument. Schematic diagrams are located in Section 8 (Section 6 for optional modules). Table 3-1 is a list of mnemonic definitions used in the Controller schematic.

3-36. Controller

3-37. TIMING

3-38. Refer to Figure 3-9. Timing for the microprocessor is derived from a 12V, two-phase clock (Ø1 and Ø2). The two-phase clock is generated by clock generator U14, which is designed to meet the timing requirements of the microprocessor. The clock generator also uses internal logic and a SYNC pulse from the microprocessor to generate an STSTB signal (which clocks microprocessor status information). The period of the Ø1 clock (585 ns) governs the duration of a machine cycle; there are three to five states in a machine cycle and one to five machine cycles in an instruction cycle.

3-39. Shaped line frequency pulses are applied to phase-locked loop U4 which, in conjunction with divide-by-eight counter U3, generates eight times the line frequency (480Hz for 60Hz line and 400Hz for 50Hz line). Line synchronization is achieved by using the output of the phase-locked loop to generate an internal interrupt (MARKINT).

3-40. ADDRESS AND DATA BUSES

3-41. ROM locations are decoded from A14 and A13, as chip selects and from A0 through A12. RAM locations are decoded from A14 and A11, as chip selects, and from A0 through A10. External modules are selected by setting A15 high. Inverted forms of A8 through A14 are sent out as IC0 through IC6 on the unguarded bus. The data bus lines (D0 through D7) are connected directly to internal memory and through tristate buffers to the external data bus (ID0 through ID7).

Table 3-1. Mnemonics

A0-A15	Address bus on controller
ACK	Acknowledge signal from module
ACKINT	Interrupt generated when module does not respond
CPUINT	Interrupt signal for μP
CPUREADY	Ready signal for μP
CPURESET	Reset signal
D0-D7	Data bus on controller
DBIN	Data bus input signal (from μP)
DLDACK	Delayed version of ACK
EXTCOM	Module communication signal
EXTINT	Interrupt from module
FLINE	Shaped line frequency signal
8xFLINE	8 times line frequency
FRONT/REAR	Front or rear input signal
IC0-IC7	Module address/control bus
ICENABLE	Enable module address signal
ID0-ID7	Module data bus
INA	Interrupt acknowledge signal in response to EXTINT
INP	I/O status signal
INTA	Interrupt acknowledge status signal
INTCLR	Clear interrupt signal
LINEREF	Line reference signal, bus input on RT5
MARKINT	Interrupt to synchronize to line frequency
Ø1	One phase of μP clock
Ø2	Other phase of μP clock
OUT	I/O status signal
READY	Signal to generate CPUREADY
RESET	Reset signal
RUN	Exit wait state signal
SCANADV	Scan advance signal, A/D conversion complete
STOP	Enter wait state signal
STSTB	Clock signal to latch μP status
SYNC	Signal from μP, used to generate STSTB
SYNCDEXTINT	Synchronized interrupt from module
Vbb	-5V supply
Vcc	+5V supply
Vdd	+12V supply
Vgg	-12V supply
Vss	Logic common
WAIT	μP in wait state signal
WR	Write data signal from μP

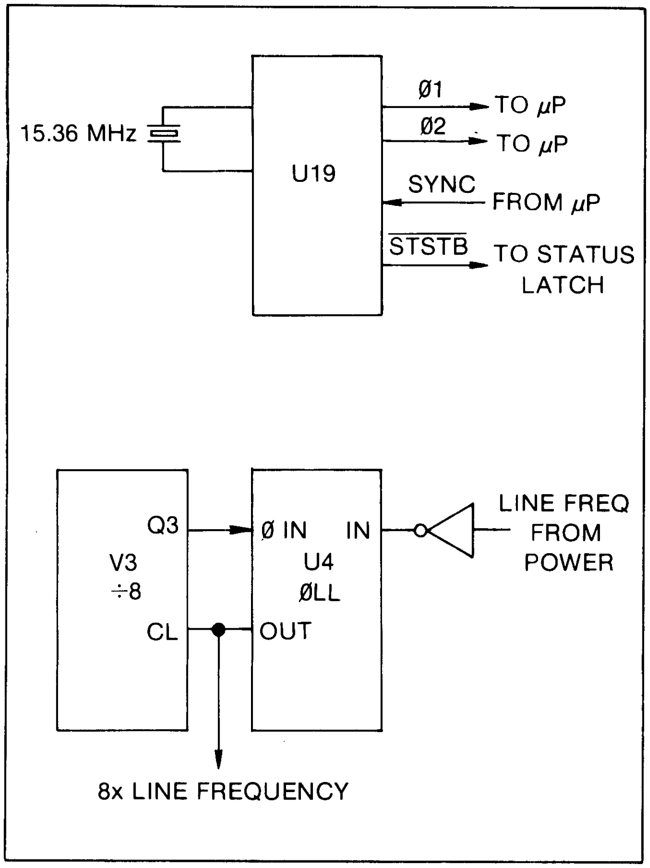


Figure 3-9. Timing Circuits

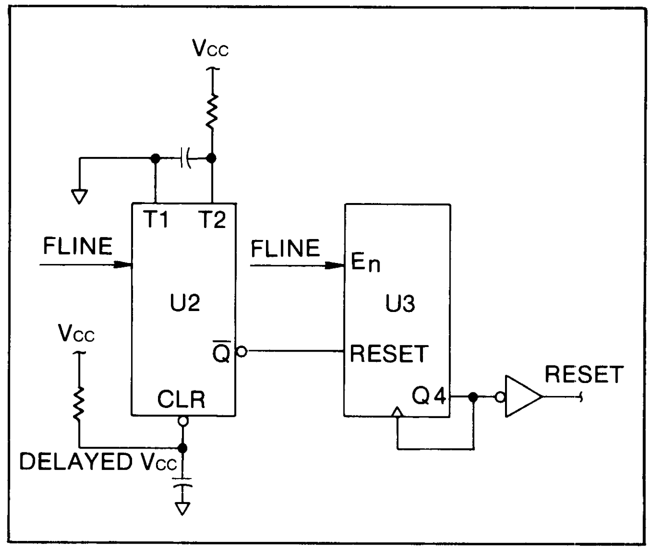


Figure 3-10. Reset Logic

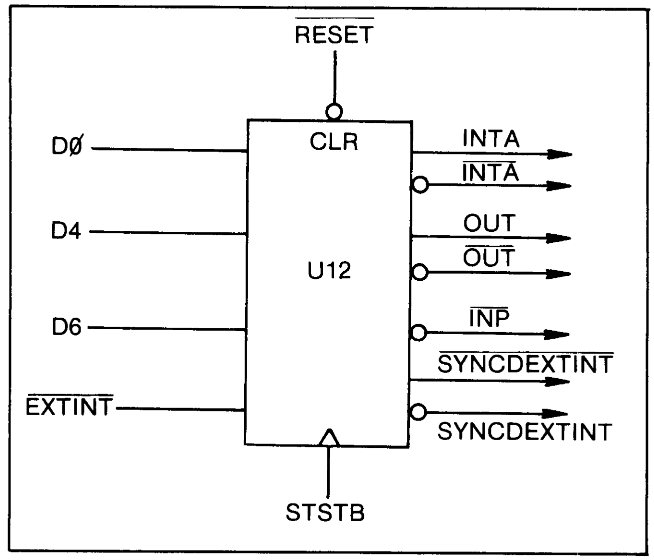


Figure 3-11. Status Latch

3-42. RESET

3-43. Refer to Figure 3-10. Shaped line frequency pulses are applied to U2 and U3, providing a hardware reset on power down, power up, or for missing line cycle pulses. In any of these three reset conditions, retriggerable one shot U2 (T=40 ms) generates a reset pulse for up counter U3. After the reset to U3 is removed (delayed Vcc high or a line frequency pulse), U3 must be clocked by eight line frequency pulses to raise Q4 high and remove the reset signal. The reset pulse is held for eight line cycles to allow time for the power supplies and microprocessor oscillator to stabilize.

3-44. STATUS LATCH

3-45. Refer to Figure 3-11. During the first state of every machine cycle, the microprocessor sends out a status word on the data bus. This status word contains the information for external logic to synchronize with microprocessor activity (e.g., memory read, interrupt acknowledge). Clock signal STSTB (from U19) clocks this information into quad D-type flip-flop U12 for use during the machine cycle. External interrupts are also latched into the status latch for synchronization to the microprocessor.

3-46. WAIT LOGIC

3-47. Refer to Figure 3-12. When the microprocessor addresses an external module, the wait state logic forces the microprocessor to enter a wait state and allow the module time to respond. When the microprocessor acknowledges an interrupt, the wait state is similarly forced to allow time for the interrupt vector to be generated. A wait state is entered when a rising edge on STOP (the clock input U1) sets READY low. Clock generator U19 then synchronizes READY to the timing requirements of the microprocessor and pulls CPUREADY low.

3-48. To exit the wait state, RUN (the clear input to U1) must be pulled low. Two events cause this to happen. ACKINT is asserted by the interrupt circuitry if the addressed module does not return an ACK in a specific time period. Alternately, DLDACK is asserted. DLDACK is asserted by a module returning an ACK or by response to a MARKINT.

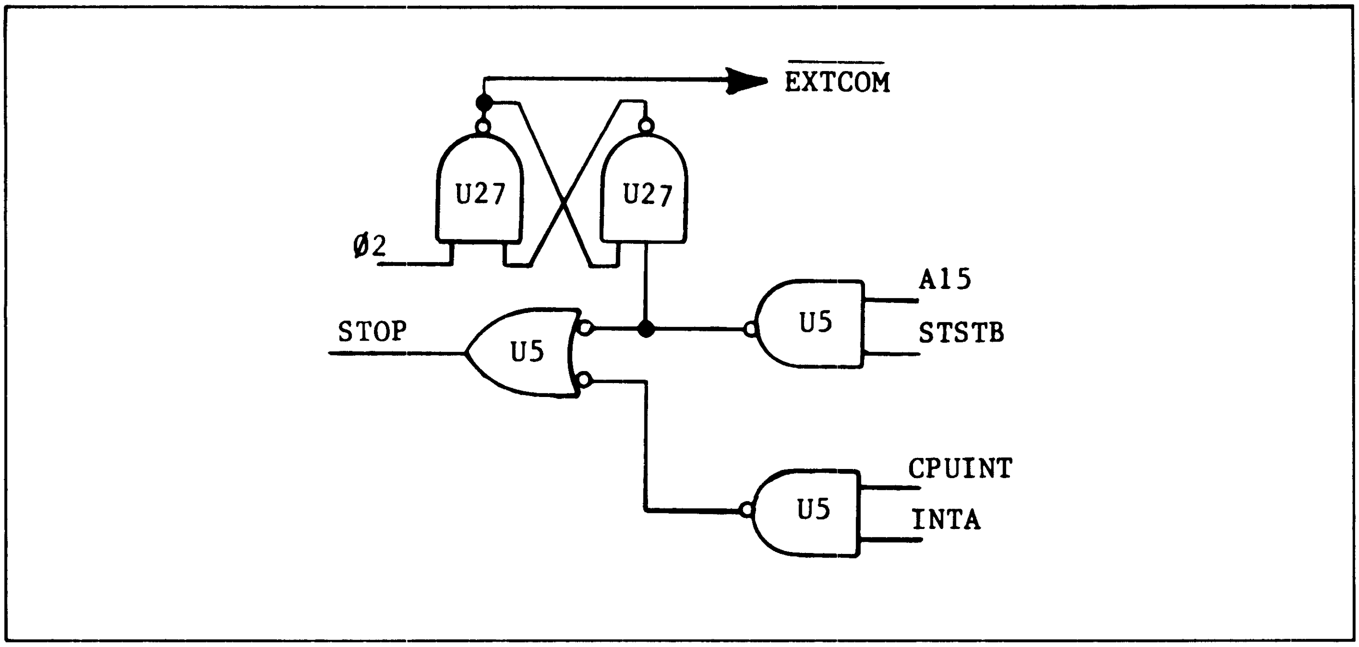


Figure 3-12. Wait Logic

3-49. ACK LOGIC

3-50. Refer to Figure 3-13. When a module is addressed by the controller or is enabled for interrupt identification by INA, it must return an ACK (high) to complete the handshake. ACK is delayed about 1.6 us to produce DKDACK. DLDACK is also generated in a MARKINT interrupt response cycle.

3-51. INTERRUPTS

3-52. Two possible internal interrupts (MARKINT and ACKINT) and three possible external interrupts (EXTINT) are able to drive CPUINT high and interrupt the microprocessor. The microprocessor samples the interrupt line at the end of each machine cycle. If an interrupt exists, the microprocessor asserts INTA in the status word of the next instruction fetch machine cycle. External logic is thereby enabled to place an interrupt vector (and not the next instruction) on the data bus. Refer to Figure 3-14.

3-53. Internal interrupts are ACKINT and MARKINT (Figure 3-14). The ACKINT logic consists of a retriggerable one-shot (U2) and a D-type flip-flop (U7). EXTCOM (A15 and STSTB) triggers U2. If DLDACK does not occur in the time constant of U2, U2 clocks U7 and asserts ACKINT. This action takes the microprocessor out of the wait state.

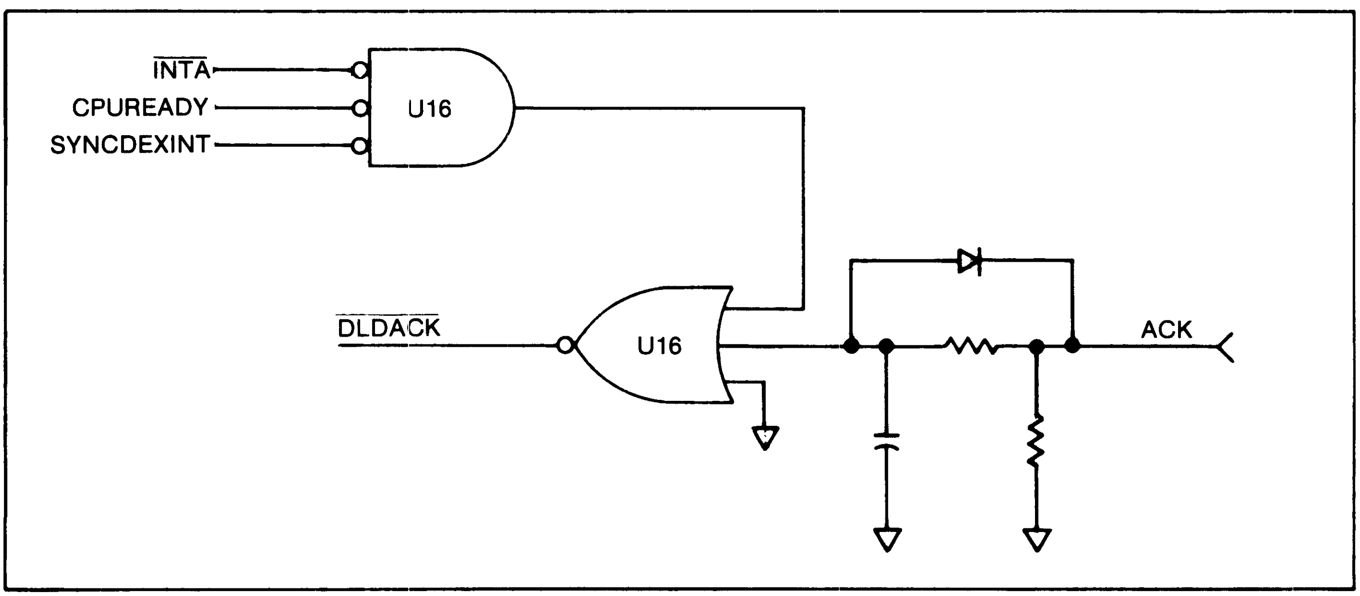


Figure 3-13. ACK Logic

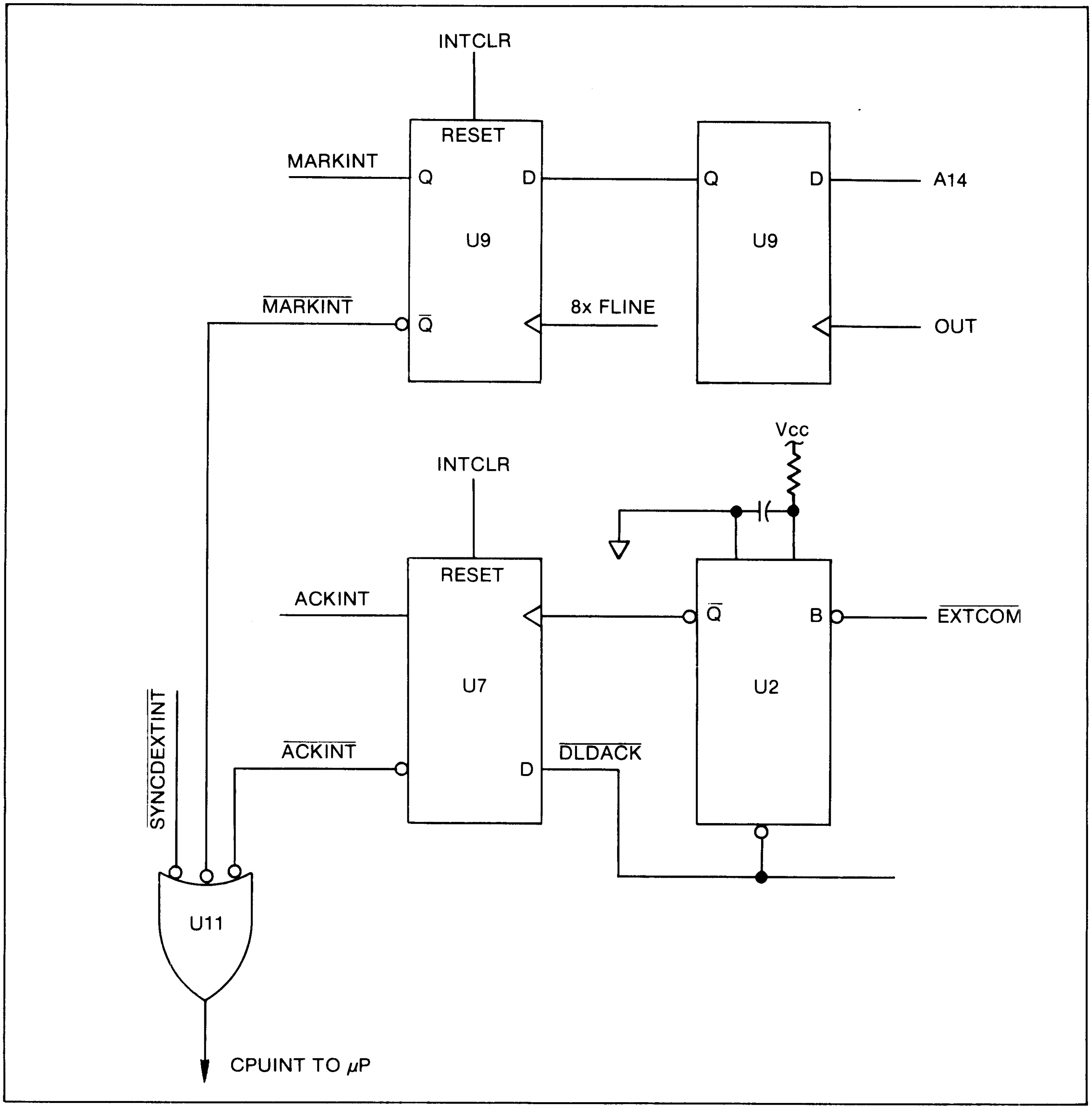


Figure 3-14. Interrupt Generation Logic

3-54. The MARKINT logic consists of two D-type flip-flops. The first (U9-1) can be written to enable or disable MARKINTS. The second (U9-12) is clocked by the eight times line frequency signal from the phase-locked loop.

3-55. Interrupts are prioritized by U-21 (refer to the controller schematic in Section 8). ACKINT interrupts have the highest priority, and MARKINT interrupts have the lowest priority. External modules must drive ID1, 2, or 3 high in response to INA, to generate the correct vector for that module.

3-56. Front Panel

3-57. Refer to Figure 3-15. Annunciator segment data is clocked into register one by the direct address, IC0, 1, 5 high. Data output from the switch matrix is also a direct address-IC0, 1, 6, high. For either direct address, the condition of ID7 (high for disable) is latched into U23 to enable an indirect address. Digit segment address-IC1, 5 high, and digit-annunciator select address-IC0, 5 are both indirect addresses. Data is clocked into the registers upon termination of the address. An update sequence is as follows:

1. Register 1 is addressed with all data lines low to blank the annunciator display and enable indirect addressing.

2. Register 2 is addressed indirectly with data lines low to blank the digit display.

3. Register 3 is addressed indirectly with all data lines high to turn off all LEDs, disable the switch matrix, and disable indirect addressing.

4. Register 1 is addressed with ID7 low to enable indirect addressing and with either annunciator segment data or digit 7SD data on ID0-6. The data is latched and applied to the annunciator LEDs (or to digit 7SD).

5. Register 2 is addressed with digit segment data on ID0-7 (U23 is not clocked by this address so ID7 may be high without disabling indirect addressing). The data is latched and applied to the digit LEDs.

6. Register 3 is addressed with ID7 high (disable indirect addressing) and one of the data lines, ID0-6 low to enable one digit LED and one annunciator LED. One bank of the switch matrix is also enabled.

7. The output buffer is addressed enabling the data from the previously enabled switch bank to be placed on the data bus. One or more lines being low indicates a change is desired. This address also keeps the kill circuit charged.

3-58. The seven steps just outlined are required for one digit-annunciator-switch bank update. The process is repeated seven times for a complete update. The kill circuit is used to blank the display if the Controller discontinues addressing the front panel.

3-59. DC Signal Conditioner

3-60. Relays K1 and K2 control the input to the DC Signal Conditioner and the attenuation of the input (Figure 3-16). If both relays are energized, the input is from the Volt/Ω input sense terminals with - 64 attenuation. If just K1 is energized, the input is from the Volt/Ω input terminals with no attenuation. If just K2 is energized, the input is from RT1 (optional signal conditioners). Q10, Q11, CR3, and CR4 provide overvoltage protection.

3-61. A differential amplifier (Q18, Q19) drives U3. FET switched (Q14, Q15, Q16) control the gain of Q18 and Q37. An output voltage swing of ±20V is achieved through bootstrapping; U4 provides a bootstrap for Q38 and Q37, and U5 and U6 provide a bootstrap for U3 and U4. Current sink and source for Q18 and Q19 are provided by Q38 and Q37 respectively.

3-62. The DC Signal Conditioner is addressed by IC0, 3, 4 high. Data on ID0-3 is latched up and decoded to determine which switches and relays will be energized. Figure 3-16 includes an example of the relay driver used to minimize thermal changes in the relays between the on and off states. RC coupling between the decoder and the relay driver provide voltage swings up to 4V or down to 0V to ensure positive relay action. Steady state voltages of 1.45V (off) and 2.75V (on) minimize current difference between the on and off states while maintaining the relay state under all conditions.

3-63. Filter/External Reference

3-64. All inputs to the A/D Converter are routed through the Filter/External Reference module. Refer to Figure 3-17. External measurements are made by multiplexing the three filter module inputs to the A/D Converter. Q18, Q19, and Q20 switch the signal conditioner input, the external reference LO input, and the external reference HI input respectively. Data controlling the switches is latched into U1 upon termination of the address (IC1, 3, 4 high).

3-65. Three-pole, active Bessel filters (U3 and U4) have different setting times and cut-off points. Either filter may be selected from the front input panel for application to the signal conditioner input. Bypass is automatically selected for external reference inputs and may be selected for signal conditioner inputs. The combination of Q32, Q25, Q23, Q24, or Q21, Q22 is turned on to select a filter mode.

3-66. A dual, super-beta transistor in a differential configuration (Q27) drives U5. A current source (Q26) and sink (Q30) bias Q27. Enough current is drawn through R19 by Q26 to bootstrap the input amplifier, Q27, 5V above the output. Gain of the amplifier is set at one by the combination of R21 and the input resistors. The external reference inputs have additional series resistors located on the Front/Rear Input Assembly.

3-67. Fast R^2 A/D Converter

3-68. The Fast R^2 A/D Converter may be separated for analysis into two component groups: analog and digital. Analog circuitry is responsible for producing a voltage reference, for summations, and for remainder amplification and storage. Digital circuitry interfaces the analog circuitry to the Contoller and is responsible for reference selection, decision in the summation process, remainder channel control, and autozeroing. Since functions within the A/D Converter are either directly controlled by the Controller module via the data bus or are clocked through their operations by the Controller addressing the A/D module, the A/D conversion program could be considered a functional part of the A/D Converter.

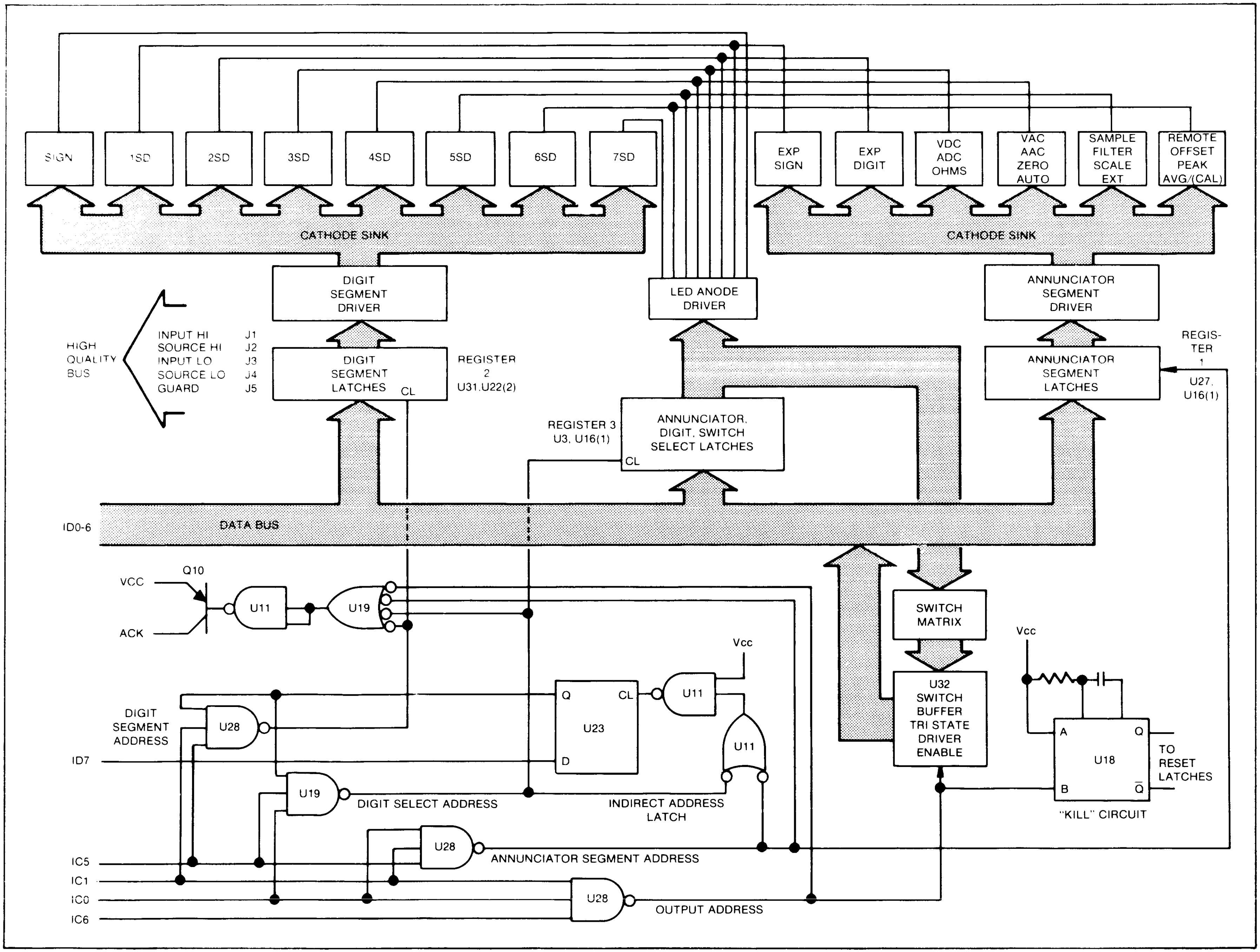


Figure 3-15. Front Panel

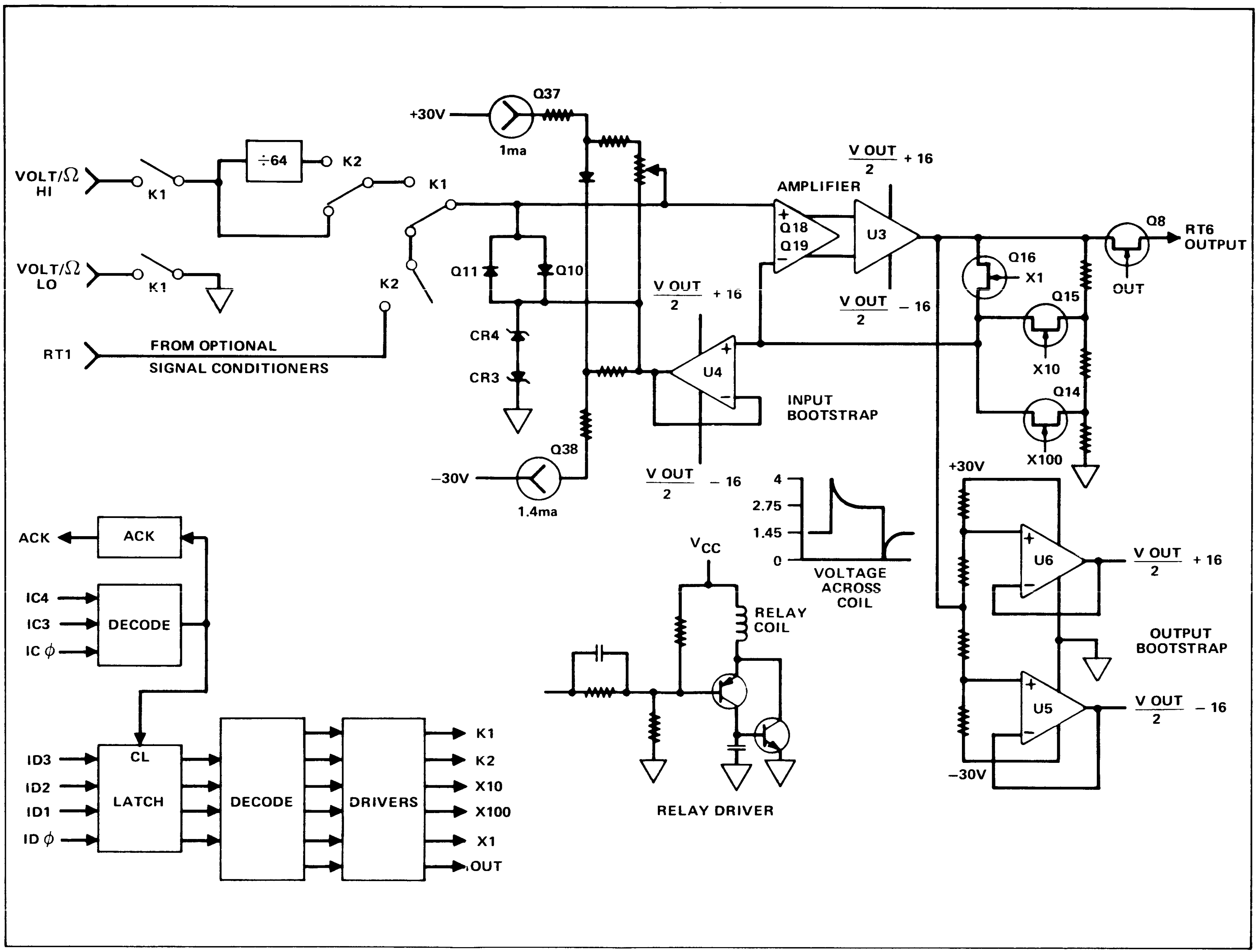


Figure 3-16. DC Signal Conditioner

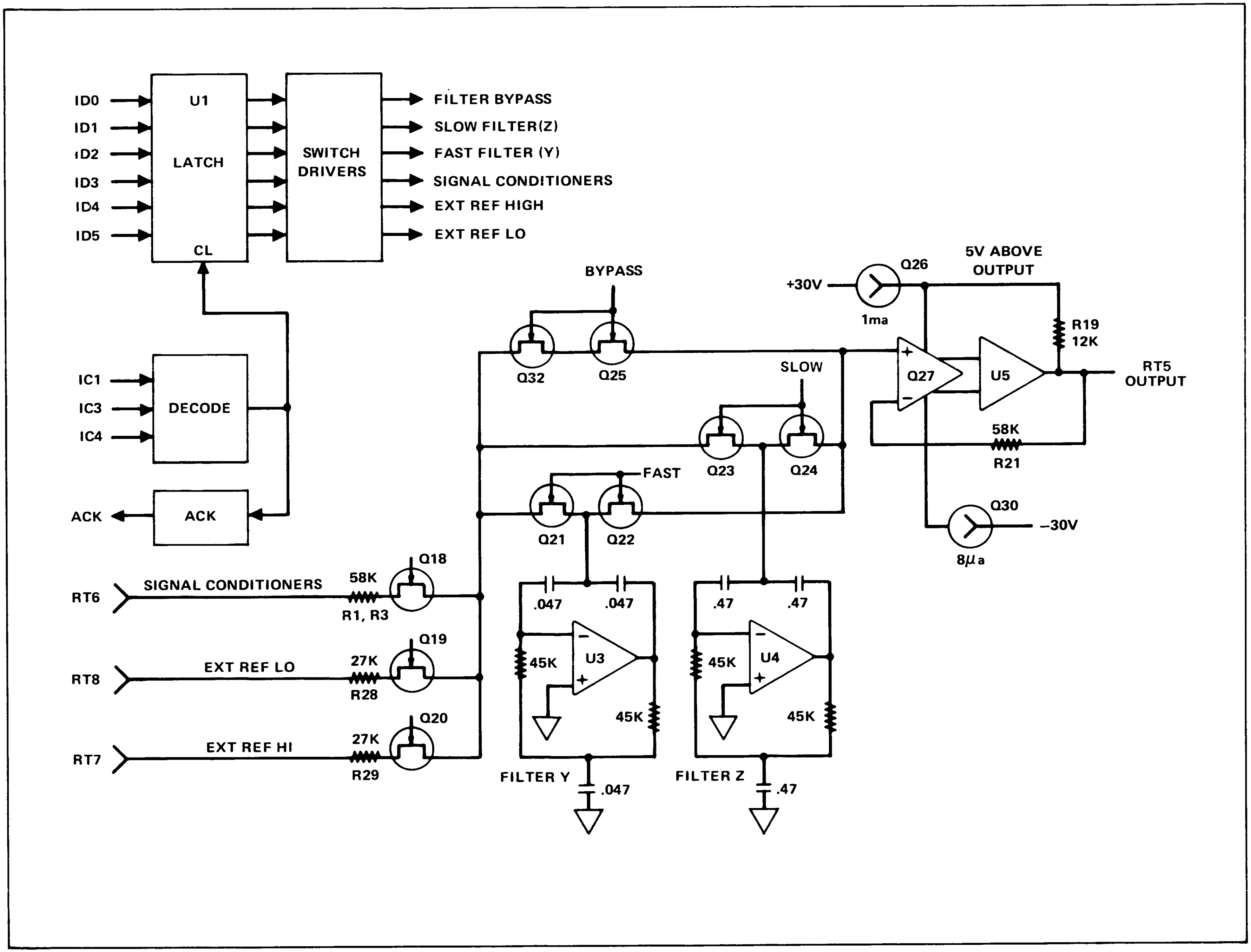


Figure 3-17. Filter/External Reference

3-69. ANALOG

3-70. Figure 3-18 is a simplified schematic of the analog portion of the A/D Converter. For clarity, switches are shown as a circle enclosing a letter designator. U1 is a reference and reference amplifier controlling U2, a current source. The -7V reference is set by R9 and R14. U3 serves as a highly regulated collector and zener supply for U1. Operation of the A/D Converter requires both a positive and negative reference (for negative and positive inputs, respectively). Q9 and U4 are a precision unity gain amplifier whose input is controlled by switches A1 and A2. With A1 closed and A2 open, Q9 and U4 are a noninverting amplifier.

3-71. An input signal is applied to the Summing Node of the remainder amplifier (Q27, U7) through switch I. Q27 and U7 are an inverting amplifier with two gain configurations. During the decision period, switch G is closed, applying the output of U7 to polarity detector Q28 and forming a feedback path through CR5 and CR6. Q28 sends a polarity bit to the digital portion of the circuitry. On the basis of this first polarity bit, a reference polarity is selected.

3-72. Switches B, C, D, E, and F are closed, one at a time, to switch a precise amount of current into the Summing Node. When a switch is closed, the opposite switch is opened and vice versa. For example, when D is closed, $\bar{D}$ is opened. After a switch is closed, a polarity bit is returned. If the polarity changed with respect to the original polarity selected for a step, the switch is opened; otherwise it is left closed. The next switch is closed, a polarity bit returned and a decision made, and so on until all five switches have been closed (and possibly opened again). This constitutes a decision period.

3-73. Following the decision period is the subtraction period. Switch G is opened and switches X and SX are closed to form a feedback path for the remainder amplifier through the X channel, A 400K resistor, R35, sets the gain of Q27 and U7 at sixteen. The feedback current completes the summation process and the amplified remainder is stored on the C10 in the X channel.

3-74. For the next decision period switches SX and X are opened and switches RX and G are closed. Since Q27 and U7 form an inverting amplifier, the opposite polarity reference from the original selection is automatically selected. The amplified remainder is applied to the Summing Node through U6 and R34. Five decisions are made, followed by a subtraction period using channel Y for feedback and remainder storage. The first decision-subtraction period applies the input signal to the Summing Node. The four following steps apply an amplified remainder, alternating between channel X and channel Y.

3-75. When a sample is complete, the circuits are autozeroed. U8 zeros the remainder amplifier through channel X. Any offset is stored on C13 at the noninverting input of Q27. The switching reference, Q9 and U4, is zeroed by first closing A1 and opening A2 to decrease settling time. Then A1 and A2 are both opened and the Z1 and Z2 switches are closed, storing any offset error on C5.

3-76. DIGITAL

3-77. For the following discussion, refer to the Digital Fast R^2 A/D schematic in Section 8. Direct address IC2, 3, 4 latches data into U34 and U35 controlling input switch I, remainder channel switches, autozero, and reset (digital). U31, a ring counter, is clocked to the C1 state enabling the indirect address decoder (U33) and the polarity detector (switch G). A polarity bit is returned and applied to U6.

3-78. Indirect address IC1, IC2 latches the polarity bit in U6, enables the tristate transmitter, U5, and clocks U31 to the C2 state. The transition of U31 from C1 to C2 clocks the polarity into U11 (the uppermost section) whose output determines whether switch A1 or A2 will be closed (reference polarity). At the same time, U1 (uppermost section) is clocked to set the other section of U11, closing the first reference switch, B, of the A/D Converter. The next indirect address clocks a new polarity bit (a result of closing the first reference switch B) into U6. If the polarity changed, the output of U6 will cause a reset of the previous switch latch, opening the previous switch. At termination of the address the next switch is closed. One direct address and six indirect addresses are required to complete a step. The last indirect address resets the control logic to the C0 state.

3-79. Switch selections are made through switch drivers which rely on Vcc and Vss being a -15V and -20V with respect to analog common. This allows simple transition from TTL levels to FET off voltages. D/A Converter switches are selected on transition of U31 from one state to the next. The transition clocks the first of two D-type flip-flops which sets the second. The output of the second latch resets the first and selects the switch. If the polarity does not change after closing a switch, the output of U6 plus the output of U11 (reference select) will place two highs on the input of one section of AND gate U25. Through OR gate, U16, a one will be applied to the D input of that switch latch. The next transition of U31 will clock the latch, keeping the switch closed. If the polarity had changed, a zero would be applied to the D input, opening the switch.

3-80. After the last step, at completion of a sample, the Controller addresses the A/D Converter for autozero. U31 is clocked to the C7 state causing a digital reset. When U6, storage capacitor disable, is reset, autozero is enabled. RC coupled gates delay the zero switch controls so that switch A1 may be closed and A2 opened in the reference switching circuit. This provides a faster settling time for the reference switching amplifier. Both A1 and A2 are opened during the autozero time.

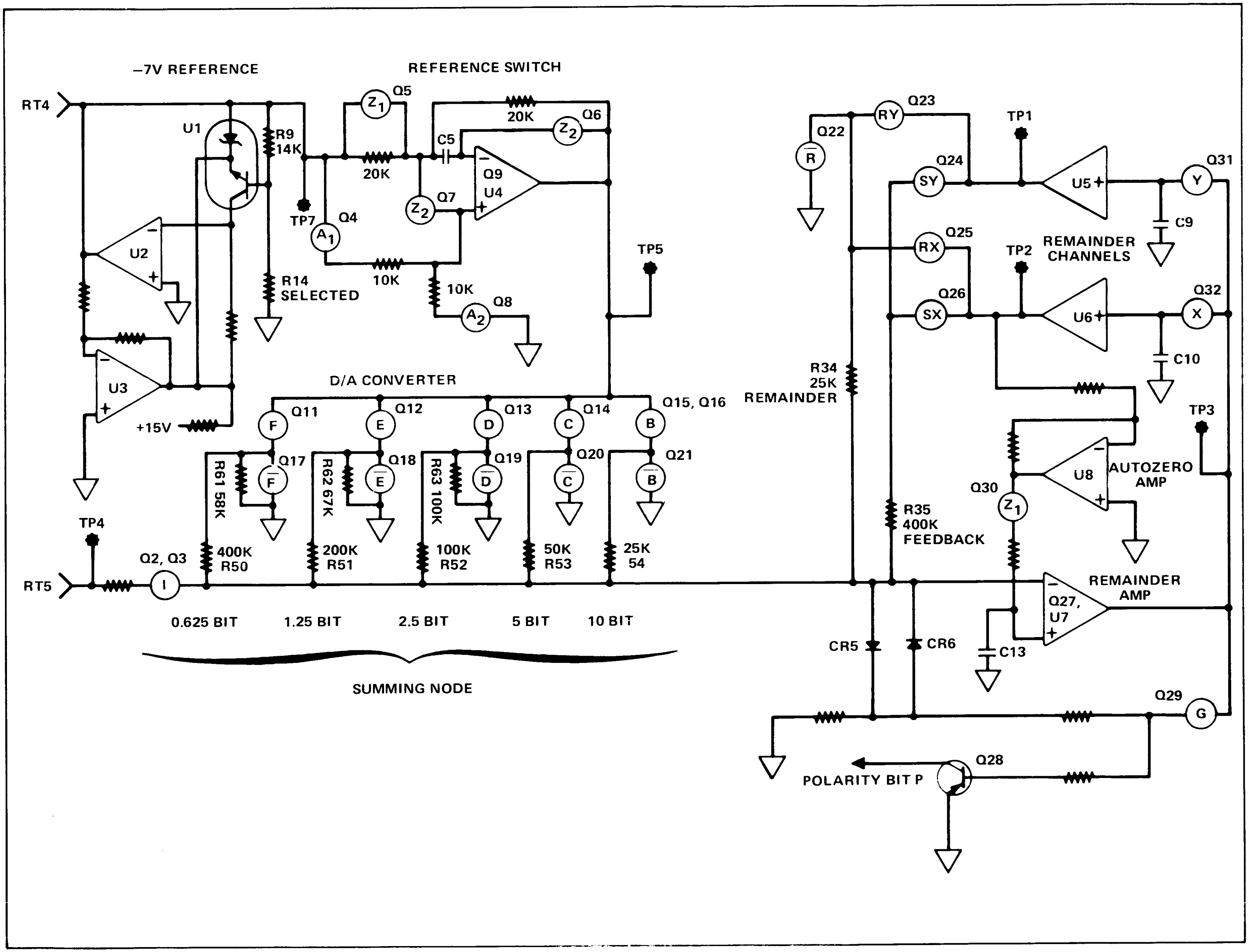


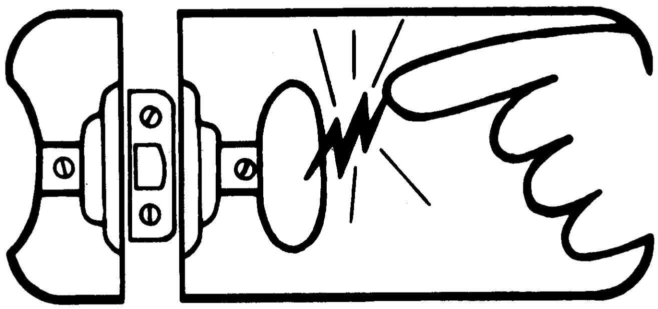
Figure 3-18. Fast R^2 A/D Converter (Analog)

8505A

static awareness

A Message From

John Fluke Mfg. Co., Inc.



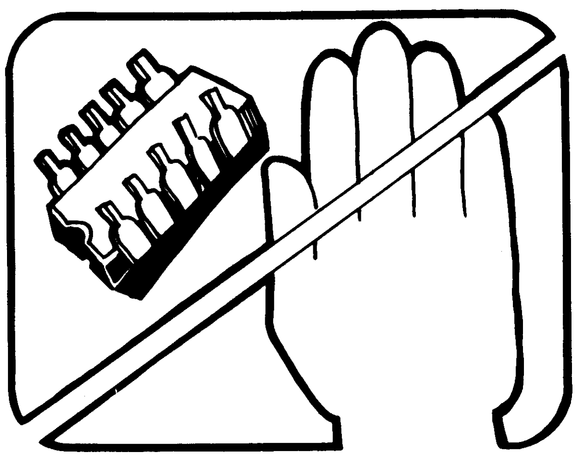
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

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.

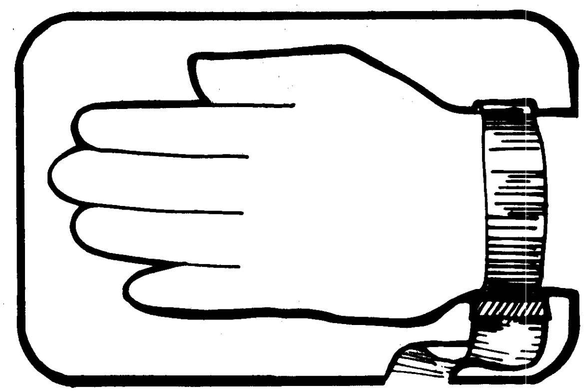
The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol

" "

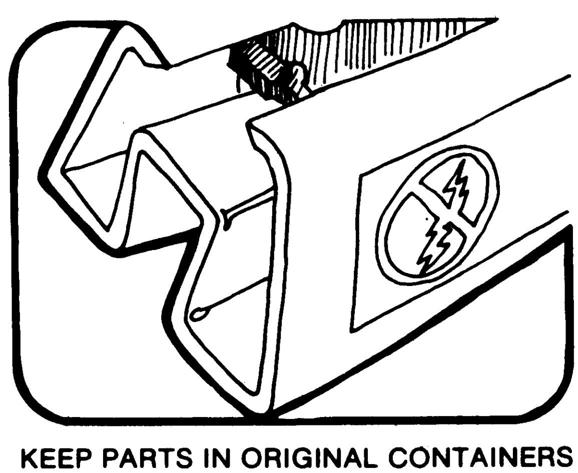
The following practices should be followed to minimize damage to S.S. devices.



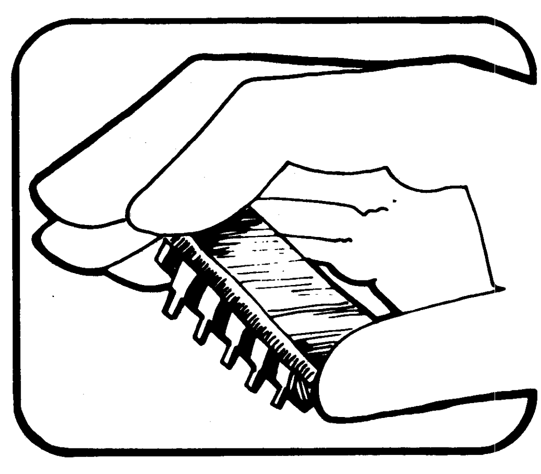
1. MINIMIZE HANDLING



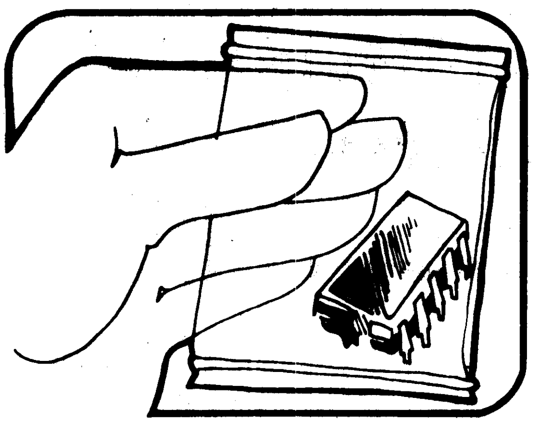
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



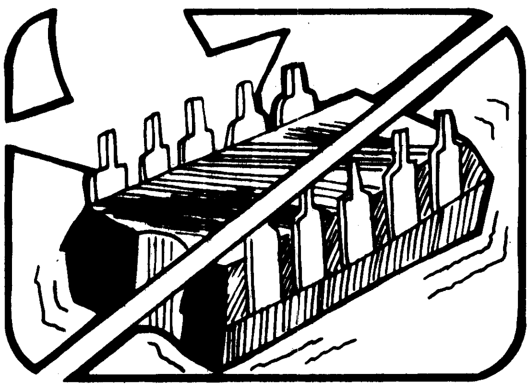
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



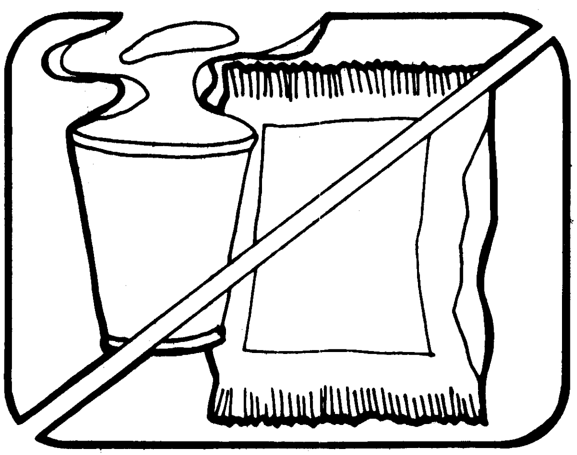
4. HANDLE S.S. DEVICES BY THE BODY



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

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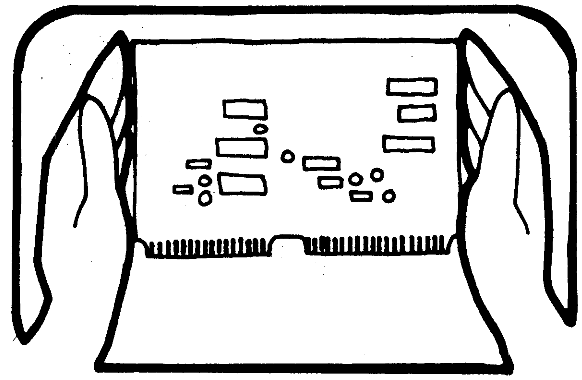
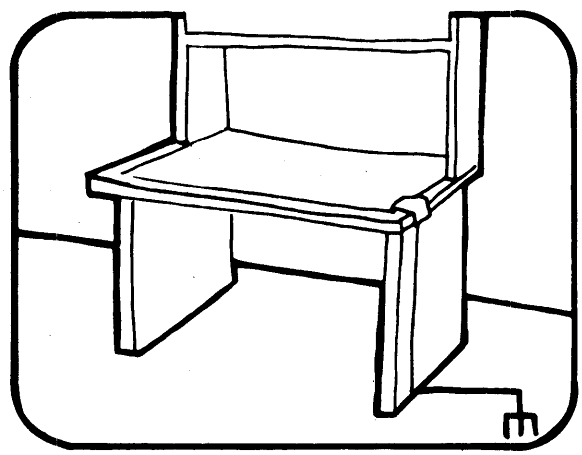


8. WHEN REMOVING PLUG-IN ASSEMBLIES, HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR HELPS TO PROTECT INSTALLED SS DEVICES.



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.
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EVERETT, WA 98204

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Section 4
Maintenance

WARNING!

THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

4-1. INTRODUCTION

4-2. This section of the manual contains maintenance information, performance tests, hardware calibration procedures, and troubleshooting procedures. Hardware calibration intervals may be determined by the user according to the accuracy desired (specifications are listed in Section 2). Software calibration may be performed at any time and is described in Section 7. Recommended test equipment is listed in Table 4-1.

4-3. SERVICE INFORMATION

4-4. Each instrument manufactured by the John Fluke Mfg. Co., Inc. is warranted for a period of 1 year upon delivery to the original purchaser. The warranty terms are located at the front of the manual.

4-5. Factory authorized calibration and service for each Fluke product are available at various worldwide locations. A complete list of domestic service centers is located in Section 7 of the manual. Shipping information is given in Section 2. If requested, the customer will be provided an estimate before any work begins on instruments that are beyond the warranty period.

4-6. GENERAL MAINTENANCE

4-7. Top and Bottom Cover Removal and Installation

WARNING

LINE VOLTAGE IS PRESENT ON THE POWER SUPPLY BOARD WHENEVER THE POWER CORD IS CONNECTED. TO AVOID SHOCK HAZARD, DO NOT TOUCH POWER SUPPLY COMPONENTS.

4-8. Each cover is secured with six screws. When replacing a cover, install the rear center (pivot) screw first.

4-9. Line Voltage Selection

4-10. Input line voltage can be set for 100V ac, 120V ac, 220V ac or 240V ac. This selection must be made, or verified, before the multimeter is initially turned on. Proceed as follows:

1. Push the POWER control to OFF and disconnect the line cord

Table 4-1. Test Equipment

NOMENCLATURE	MINIMUM USE SPECIFICATIONS	RECOMMENDED EQUIPMENT
DC Source	High Short-Term Stability Range: 0-1100V	Fluke Model 335A
Null Detector	10 μV Full-Scale Resolution	Fluke Model 335A
Reference Divider	±.001% Division Accuracy	Fluke Model 750A
Kelvin-Varley Divider	Linearity: ±.1 PPM of Input	Fluke Model 720A
Standard Cell Enclosure	Guildline 91	Guildline 9152 (R)
Oscilloscope	General Purpose with 10 MΩ Probe	Tektronix 465
Digital Multimeter	Voltage Accuracy: .01% Input Impedance: 1000 MΩ	Fluke Model 8800A
Low EMF, Shielded Connector Cables	Gold-plated Spade Lug Connectors	
Terminating Load	1 MΩ ±10%/0.22 μf Nonpolarized Parallel Load	
Extender Card		Fluke Model MIS-7011K
Bus Monitor		Fluke Model MIS-7013K
Static Controller		Fluke Model MIS-7190K
Test Module		Fluke Model MIS-7191K
AS REQUIRED BY INSTALLED OPTIONS		
AC Calibration System	Voltage Range: 0-1000V ac Frequency Range: 10 Hz - 300 kHz Accuracy: 10 Hz - 30 Hz: .1% 30 Hz - 20 kHz: .02% 20 kHz - 100 kHz: .05% 100 kHz - 300 kHz: .33%	Fluke Model 5200A with Fluke Model 5215A or Fluke Model 5205A
Current Calibrator with 200 kΩ Resistor	Accuracy: ±.02% ±.01%	Fluke Model 382A
Standard Resistors	10Ω at 30 ppm; 100Ω, 1.9kΩ, 10kΩ, 100 kΩ, 250 kΩ, 1 MΩ, 4 MΩ at 10 ppm; 10 MΩ at 50 ppm; 100 MΩ at 100 ppm	ESI SR-1010 ESI SR-1050

2. Remove the multimeter top cover.

3. The Line Voltage Selection switches are located in the left front of the instrument, just behind the main power control. Referring to Figure 4-1, set these two switches to indicate the desired line voltage (dot/switch pattern).

4. Verify installation of the line power fuse required by the line selected voltage. With the line cord still disconnected, remove and inspect the line fuse (rear panel, near the heatsink). For 100V ac or 120V ac operation, use an MDL 1/2A fuse. For 220V ac or 240V ac operation, use an MDL 1/4A fuse.

5. If no further maintenance is necessary, install the top cover.

CAUTION

If the Calibration mode is enabled, input power must not be cycled on or off. Before cycling power off, verify that the AVG/(CAL) annunciator is not flashing. Before cycling power on, check that the rear panel Calibration Switch is off.

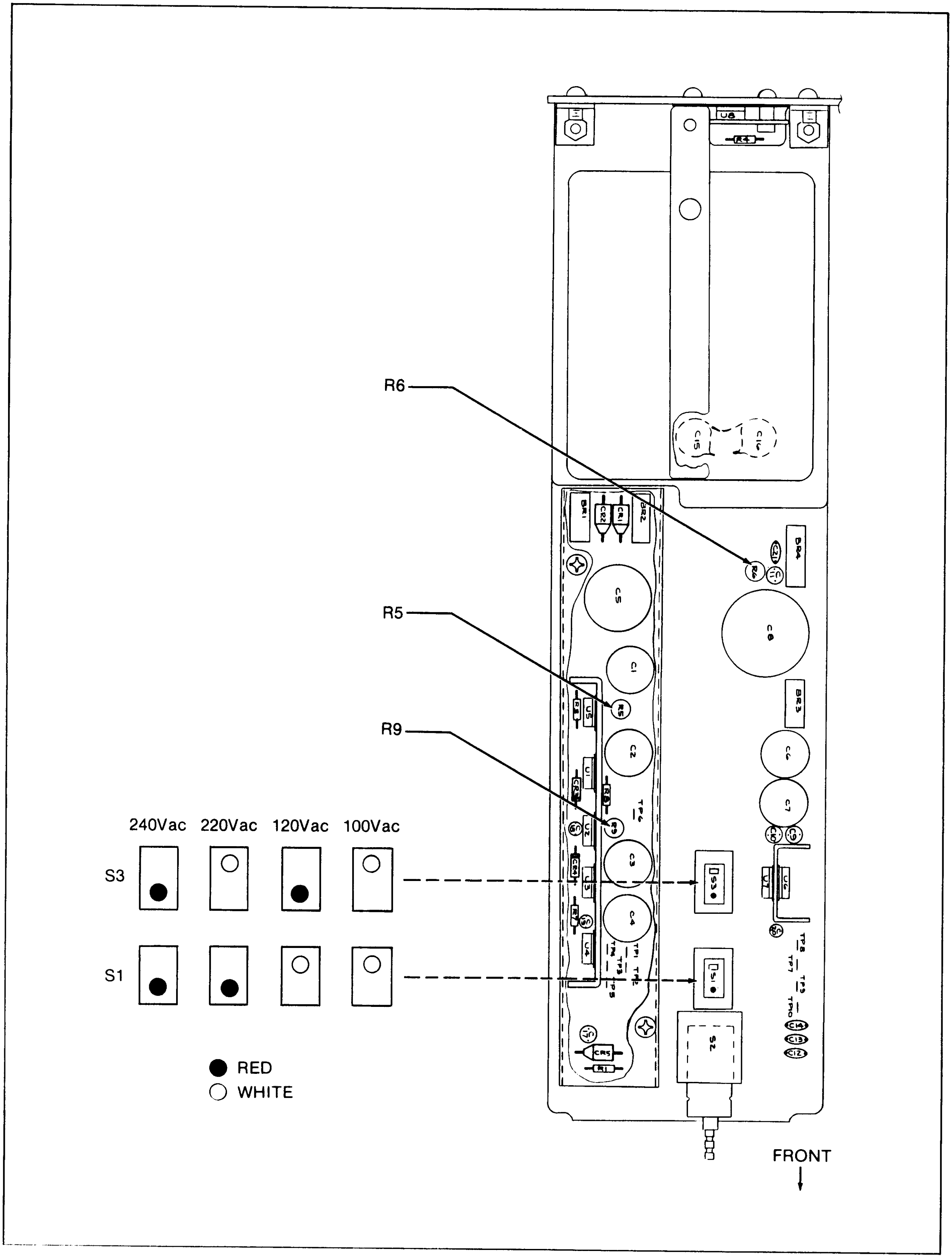

Figure 4-1. Power Supply Settings

4-11. Fuse Replacement

4-12. The line fuse can be replaced using the following procedure:

1. On the multimeter front panel, push the POWER switch to OFF (out).
2. Disconnect the line power cord.
3. Locate the line fuse on the rear panel heat sink.
4. Identify the selected line voltage and replace the fuse with one having the appropriate ratings:

   MDL 1/2 (for 100 or 120V ac line)
   MDL 1/4 (for 220 or 240V ac line)
5. Reconnect the line power cord.
6. Push the POWER switch to ON.

4-13. Module Installation

CAUTION

Installation or removal of a module with the POWER switch ON can cause damage to sensitive circuitry. To avoid this kind of damage, push the POWER switch to OFF before installing or removing a module.

4-14. Use the following procedure for module installation.

1. Push the POWER Control to OFF and disconnect the line cord.
2. Remove the top cover.

NOTE

The multimeter allows some choice in the placement of modules. For example, the Ohms Converter (Option -02) may be placed in slot A, B, C, or D. But the A/D Converter only functions in slot H. The Isolator must be installed in slot K.

3. With the correct slot chosen, slide the module down between the module guides.
4. Press the module firmly into place.
5. Open the hinged module top. Verify that the leaf spring (attached to one half of the module shield) is resting firmly over the flange of the opposite half of the module shield.
6. Close the module top and secure the module in position by engaging the two sliding clips.
7. Install the top cover.

4-15. Module Removal

4-16. Use the following procedure for module removal.

1. Push the POWER control to OFF and disconnect the line cord from the multimeter.
2. Remove the top cover.
3. Disengage the two sliding clips securing the module to be removed.
4. Grasp the module at both ends and pull up. Use an end-to-end rocking motion to help free the module from the connector.

4-17. Module Disassembly and Reassembly

4-18. Avoid using excessive force with the following procedure.

1. Pop open the lid on the module by using the indentations at either end and lifting up. Hinge the lid back.
2. Orient the module with one of the guides up.
3. Press down on the end of the case half above the words OPEN while pulling up lightly on the lip of the module guide. Slightly separate this end. Repeat this step for the other end.
4. Open the top of the module. The bottom catch automatically comes apart.
5. Press down on the top of the pcb while pulling out to free the pcb from the case half.
6. To reassemble the module, insert the pcb in the bottom half of the case and lightly press down on the top to snap it in place.
7. Ensuring that the spring shield connection is not caught behind the pcb, align the bottom center catch of the case halves and verify that the shield at either end fit together properly.
8. Close the two halves together, snapping the module guides closed.
9. Using a small screwdriver or similar tool, lift and position the leaf spring, attached to one half of the module shield, so that it rests firmly over the flange of the opposite half of the module shield.

4-19. Calibration Memory Replacement

4-20. Use the following procedure when replacing the Calibration Memory chip:

1. First ensure that the rear panel Calibration Switch is off, then push the POWER button to OFF and remove the line power cord.
2. Remove the top cover, then remove and disassemble the Controller module.
3. Install (or replace) the Calibration Memory chip (U20 on the Controller PCB).
4. Reassemble and install the Controller module, then replace the top cover.

5. Verify again that the Calibration Switch is off, then reconnect the line power cord and push the POWER button to ON.

NOTE

If a new Calibration Memory is installed, the comprehensive clearing procedure should first be performed, followed by re-programming of all desired entries. Refer to Section 7 for Calibration Memory programming instructions.

4-21. Front Panel PCB Removal

4-22. Use the following procedure to remove the Front Panel PCB:

1. Note the position of any LEDs needing replacement. Push the POWER control to OFF and remove the line cord.
2. Remove the multimeter top cover (six screws).
3. Remove the front panel bezel. Press down on the bezel center top and pull out.
4. Remove the five screws securing the Front Panel PCB. Unplug this pcb by alternately pulling up gently on its upper corners. Once disconnected, work the pcb forward to clear the power push button, then retract it through the front opening.
5. If necessary, replace any defective LEDs.
6. Replace the Front Panel PCB and the bezel in the reverse order.

4-23. Power Supply Removal

4-24. Remove the Power Supply PCB Assembly using the following procedure:

1. Push the POWER button to OFF and disconnect the line power cord from the multimeter.
2. Remove the three buttonhead screws attaching the Power Supply to the rear panel. As seen from the rear, one of these screws is found along the Power Supply left edge; the other two secure both the feet and the Power Supply right edge.
3. Pulling from the rear, retract the Power Supply PCB with a gentle rocking motion. Once disconnected from the card edge connector at the front, the pcb slides straight back.
4. Replace the Power Supply PCB by reversing the steps above. The left center buttonhead screw also serves as a ground connection between the Power Supply and the multimeter chassis. Tighten this screw securely.

4-25. Power Supply Interconnect PCB Removal

4-26. Remove the Power Supply Interconnect PCB using the following procedure:

1. Remove the Front Panel and Power Supply.
2. Remove the three screws securing the Power Supply Interconnect PCB to the framework.
3. Disconnect the card edge connector of the pcb from the Motherboard connector. Lift the pcb out through the front framework.
4. Reassemble in the reverse order.

4-27. Front/Rear Switch Assembly

4-28. REMOVAL

4-29. Use the following procedure to remove the Front/Rear Switch Assembly:

1. Push the POWER control to OFF and disconnect the line cord from the multimeter.
2. Remove the multimeter top cover.

NOTE

As seen from the front, the Front/Rear Switch Assembly is housed in the right side chassis. Although the Front/Rear Switch Assembly is mechanically secured to the vertically aligned rear panel, it is electrically connected to the horizontally aligned Motherboard PCB. Removal and replacement of the Front/Rear Switch Assembly each require a unique procedure.

3. At the front panel right side, pull on the three selector buttons until they disconnect from the Front/Rear Switch Assembly.
4. Remove the three buttonhead screws securing the Front/Rear Switch Assembly to the rear panel. Identify two of these screws as also attaching two of the rear panel feet.
5. Next, remove the three screws securing the assembly front-to-back along the right side.
6. The assembly must now be disengaged from the Motherboard PCB edge connector. Viewing the multimeter from the front, locate a slot in the chassis behind the Front Panel PCB (upper right side). A tab on the Front/Rear Switch PCB extends through this slot. Pry upward on this pcb tab to disengage the Front/Rear Switch Assembly from its Motherboard connector.
7. Once disconnected, the Front/Rear Switch Assembly can be withdrawn straight back.

4-30. REPLACEMENT

4-31. Use the following procedure to replace the Front/Rear Switch Assembly:

1. Replacement requires that the assembly be positioned in the rear panel slot and slid forward.

The pcb tab mentioned above must be inserted far enough into the front chassis slot so that the assembly rests flush against the rear panel.

2. The Front/Rear Switch Assembly is now aligned with the Motherboard edge connector. Push the assembly into this connector by simultaneously pressing on the center of the Front/Rear Switch PCB (through an access hole in the middle of the right side chassis) and on the pcb tab.

3. Replace the three side screws and the three rear panel buttonhead screws (with feet).

4. On the Front Panel right side, insert each of the three selector buttons through slots in the front panel and in the right side chassis. Align each button with the appropriate switch and press into place. The three selector buttons must be configured as follows:

a. EXT GD IN: top

b. 4T OHMS IN: middle

c. REAR INPUT IN: bottom

4-32. Motherboard PCB Removal

4-33. Remove the Motherboard PCB using the following procedure:

1. Push the POWER button to OFF and disconnect the power cord from the multimeter.

2. Remove the top and bottom covers.

3. Remove all modules, the Front Panel PCB, the Power Supply PCB, the Front/Rear Switch Assembly, and the Power Supply Interconnect PCB.

4. Remove the shield covering the bottom of the Motherboard. Remove the eight securing screws (accessed from the bottom) and the two top screws (accessed through holes in the center partition). The shield then slips off.

5. As seen from the top, unplug the SCAN ADV and TRIGGER connectors from the right rear corner of the Motherboard.

6. Remove the eight screws securing the Motherboard PCB (four each accessed from top and bottom).

7. Remove the front handle-frame assembly. Remove the three screws attaching each handle. Note that the longest screws must occupy the center holes during reassembly.

8. Pull off the front handle-frame assembly.

9. The Motherboard PCB is now disconnected and can be removed.

10. Replace the Motherboard PCB and reassemble the multimeter in reverse order.

4-34. Cleaning Instructions

4-35. Periodically (at least every 90 days) clean the multimeter using the following procedure:

1. Push the POWER switch to OFF and disconnect the power cord from the multimeter.

2. Remove the top and bottom covers from the instrument.

3. Disconnect the modules from the Motherboard and remove them from the instrument.

4. Clean the interior using low pressure clean, dry air or a vacuum cleaner.

5. Clean the Front Panel and exterior surfaces with anhydrous ethyl alcohol or a soft cloth dampened with a mild solution of detergent and water.

6. Replace the modules and covers if access to the instrument interior is no longer required.

4-36. PERFORMANCE TEST

4-37. Introduction

4-38. The following paragraphs contain a performance verification test which compares the operation of the instrument to the specifications in Section 1 of this manual. The test may be used to verify calibration of the equipment between scheduled calibration periods or as an aid in troubleshooting. The multimeter will be referred to as unit under test (UUT). The test equipment required for the Performance Test is listed in Table 4-1. If the recommended equipment is not available, replacements with equivalent specifications may be substituted.

4-39. If the instrument does not meet the specifications listed in the Performance Test, either software or hardware calibration or corrective maintenance should be performed, as determined by the symptoms. The test should be performed when the ambient temperature is between 18° and 28° Celsius and the relative humidity less than 75% to maintain test validity.

4-40. Low Range DC Voltage Tests

4-41. Perform the Low Range Tests as follows:

1. Connect the equipment shown with solid lines in Figure 4-2. Do not connect the UUT at this time.

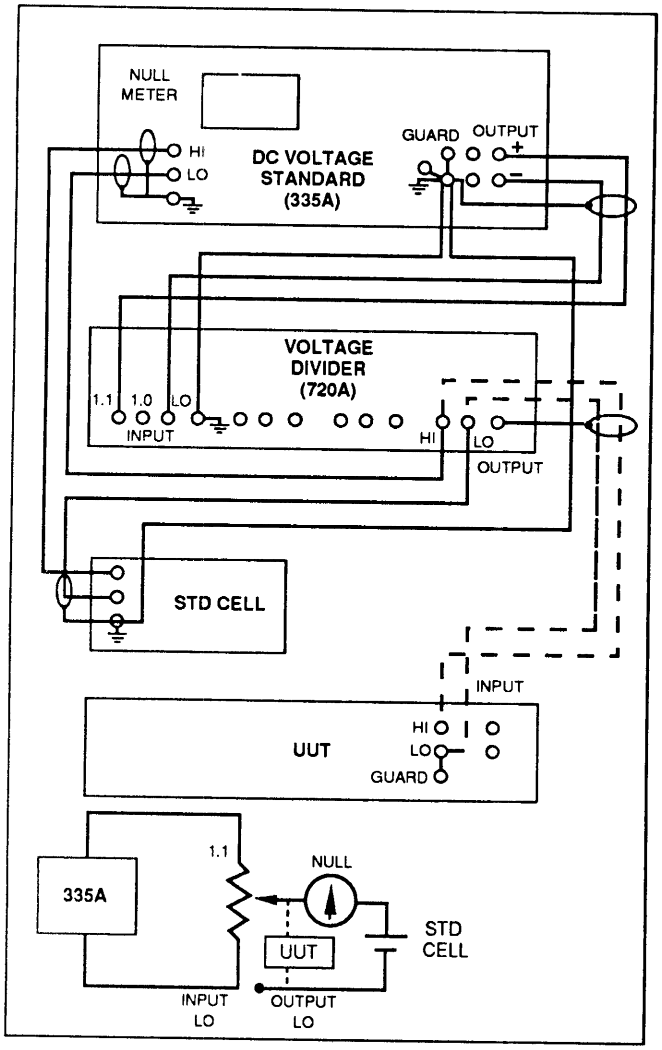

Figure 4-2. Connections for Low Range DC Voltage Tests

2. Verify that test equipment used in Figure 4-2 is operating properly and that respective warmup periods have been observed.

3. On the UUT, verify that the specified two-hour warm-up period has elapsed.

4. On the UUT, select the following features: VDC function, AUTO range, SAMPLE setting 5. All other features should be in the power-up configuration.

5. Set the Voltage Divider controls for one-tenth the standard cell certified value. Adjust the DC Voltage Standard output for a null on the null meter.

6. At the Voltage Divider output terminals, disconnect the existing leads and connect the UUT as shown with the broken lines in Figure 4-2.

7. Refer to Table 4-2. Without changing the DC Voltage Standard output setting, perform the six checks listed. For each check, set the specified Voltage Divider output, select the listed UUT range manually, and verify a UUT reading with the tolerances listed.

Table 4-2. Low Range DC Voltage Tests

RANGE	DIVIDER SETTING	UUT READING LOW	UUT READING HIGH
100 mV	.0010000	+9.9947 (-3)	+10.0053 (-3)
100 mV	.0100000	+99.9920 (-3)	+100.0080 (-3)
1 V	.0100000	+.099990	+.100010
1 V	.1000000	+.999972	+1.000028
10 V	.1000000	+.99991	+1.00009
10 V	1.0000000	+9.99982	+10.00018

8. At the DC Voltage Standard, reverse the output leads. Now repeat step (7), and check for negative UUT readings with the listed tolerances.

4-42. High Range DC Voltage Tests

4-43. Perform the High Range Test as follows:

1. Connect test equipment and the UUT as shown in Figure 4-3.

2. On the UUT, verify that the specified two-hour warm-up period has expired. Also verify that the test equipment is operating properly and that required warm-up periods have expired.

3. The UUT must be set for dc volts, 100V range (manual), and SAMPLE setting 5. All other features on the UUT must be in the power-up configuration.

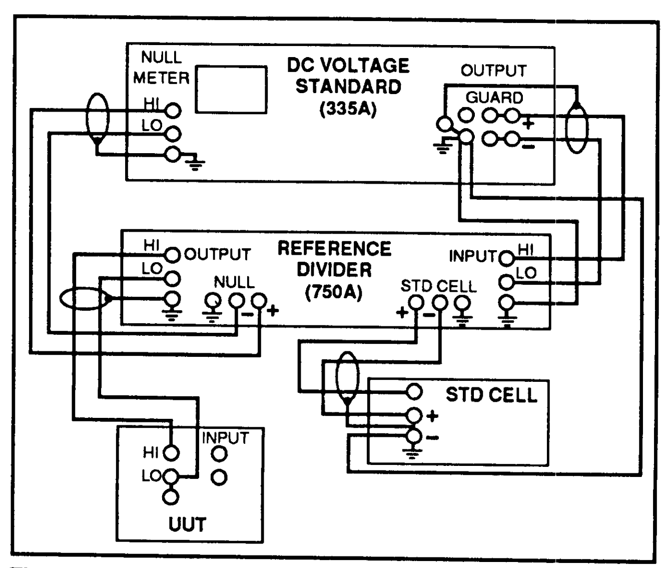

Figure 4-3. Connections for High Range DC Voltage Tests

4. On the Reference Divider, set the Standard Cell voltage controls to the standard cell certified value. Set both the input and output controls to 10 volts.

5. On the DC Voltage Standard, set the output controls for 10 volts. Next adjust this output for a null reading on the null meter.

6. On the UUT, verify a reading between +9.9990 and +10.0010.

7. On the Reference Divider, set the input and output controls to 100 volts.

8. On the DC Voltage Standard, set the output controls for 100 volts. Next, adjust this output for a null reading on the null meter.

9. On the UUT, verify a reading between +99.9974 and +100.0026.

10. On the UUT, manually select 1000V range.

11. On the UUT, verify a reading between +99.990 and +100.010.

12. On the Reference Divider, set the input and output controls to 1000 volts.

13. On the DC Voltage Standard, set the output to approximately 1000V. Next adjust this output for a null reading on the null meter.

14. On the UUT, verify a reading between +999.974 and +1000.026.

15. Set the DC Voltage Standard to standby.

Table 4-3. Autoranging

UUT CHANGES RANGE		APPROXIMATE READING
FROM	TO	
100 mV	1V	200 mV
1V	10V	2.0V
10V	100V	20V
100V	1000V	128V
1000V	100V	120V
100V	10V	12V
10V	1V	1.7V
1V	100 mV	0.17V

16. Reverse the leads at the DC Voltage Standard and at the Standard Cell terminals. In sequence, set the DC Voltage Standard output to 10 volts, and return this instrument to operate.

17. On the UUT, manually select the 10V range.

18. Now repeat steps (4) through (15), verifying negative readings on the UUT.

4-44. Autoranging Test

4-45. Test the UUT autoranging feature using the following procedure:

1. On the UUT, select V DC function and AUTO range.

2. Connect the DC Voltage Standard output directly to the UUT input.

3. Vary the DC Voltage Standard output, checking that the UUT autoranges up and down at the points listed in Table 4-3. These points are approximate and are determined without application of software calibration factors.

4-46. DC External Reference Test

4-47. Test the DC four-wire true ratio, using the following procedure:

1. Connect test equipment and the UUT as illustrated in Figure 4-4.

2. On the UUT, select V DC function and AUTO range.

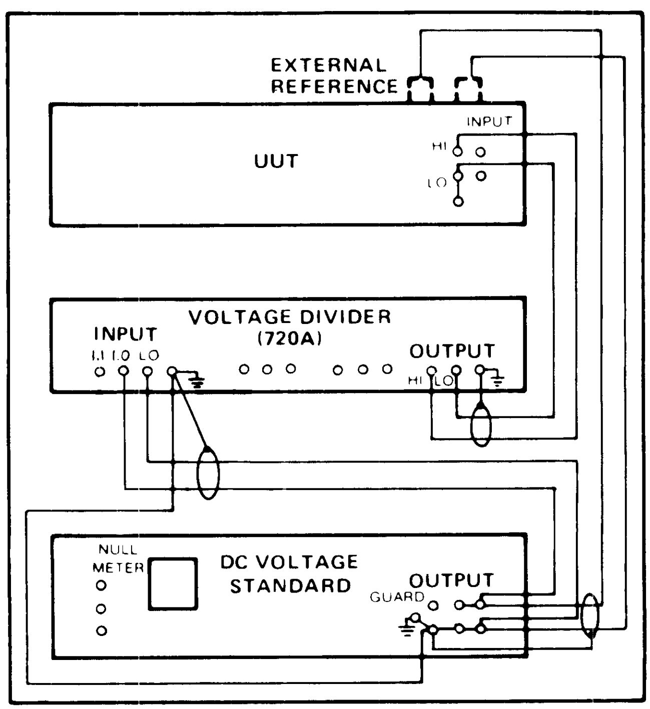

Figure 4-4. DC External Reference Test

3. On the DC Voltage Standard, set the output controls for +10.0000 volts.

4. On the Voltage Divider, set the controls for 1.000000.

5. On the UUT, push and hold the EXT REF button. Verify a reading of +9.99982 to +10.00018 while this button is held depressed.

6. Release the EXT REF push button on the UUT (EXT annunciator on). The UUT now computes and displays the ratio (Vin/Vref). Verify that this reading is 1.000000 ± (56 digits).

7. On the Voltage Divider, set the controls to 0.1000000.

8. Verify that the UUT reads 100.0000 (-3) ± (61 digits).

9. Push and release the EXT REF button to toggle the UUT out of External Reference mode (EXT annunciator goes off).

10. Remove the test equipment connections. This step completes the Performance Test procedures.

4-48. CALIBRATION ADJUSTMENTS

4-49. Calibration of the UUT is carried out on three levels. The first level consists of an accuracy check using the Performance Test. The Performance Test should be used to check the UUT for calibration every 90 days or 1 year, as required to meet the applicable accuracy specification. The Performance Test should also be used to check the UUT for calibration after any repairs are made to the instrument. The second level involves software calibration and can be performed at any time. Applicable procedures are described in Section 7. The third level involves hardware calibration and is described in the following paragraphs. Hardware Calibration procedures for all option can be found in Section 6 of this manual.

NOTE

If hardware calibration is necessary, software calibration entries must first be cleared. The extent of hardware calibration determines the clearing operation required (Discrete or Comprehensive Clear). These "clearing" operations can be found in Section 7 of this manual.

4-50. Adjustments and test points are accessible on the top edge of the pcb modules be opening the hinged module top. For any level of calibration, the ambient temperature should be 23 C ± 2 C and the relative humidity should be less than 75%. Refer to Table 4-1 for the recommended test equipment.

4-51. Power Supply

4-52. INITIAL PROCEDURE

4-53. With the POWER switch set to OFF, replace the Isolator Module with the Bus Monitor Board (MIS-7013K). Set the POWER switch to ON and allow the instrument to warm up for at least 2 hours before continuing with the calibration adjustment procedures.

4-54. CHECKS AND ADJUSTMENTS

4-55. Perform the following Power Supply checks and adjustments. All required test points are available on the Bus Monitor Board. All adjustments are found on the Power Supply Board, as illustrated in Figure 4-1.

CAUTION

The multimeter can be damaged if used to check its own supply voltage. To avoid this possibility, do not use the UUT to check UUT voltages.

1. Connect the test DMM HI input to Vcc on the Bus Monitor Board and the LO input to Vss.

2. Adjust R6 for a reading of 5.05V dc ± .05 to set the logic supply.

3. Transfer the HI DMM input lead to VA2.

4. Adjust R5 for a reading of 5.05V dc ± .05 to set the analog supply.

5. Verify that the voltages in Table 4-4 are within the prescribed limits.

6. Prepare the test DMM to read ac volts. Connect the HI DMM input lead to LINE on the Bus Monitor Board (LO to AR). If the UUT is set for 100V ac or 120V ac operation, verify a voltage reading of 13 to 17V ac. With 220V ac or 240V ac operation, verify a voltage between 6.5V ac and 8.5V ac.

7. On the UUT, push the POWER button to OFF, remove all test leads and the Bus Monitor Board, and replace the Isolator.

8. Reapply power to the UUT.

Table 4-4. Power Supply Verifications

TEST POINTS		VOLTAGE RANGE (VDC)		SUPPLY
HIGH	LOW	FROM	TO	
V_{DD}	V_{SS}	+11.4	+12.6	Logic
V_{GG}	V_{SS}	-11.4	-12.6	Logic
VA1	AR	+14.25	+15.75	Analog
VA2	AR	-14.25	-15.75	Analog
VA3	AR	+29.7	+31.7	Analog
VA4	AR	-29.7	-31.7	Analog

4-56. DC Calibration Procedure

4-57. Hardware calibration is described in the following paragraphs. Any software calibration entries for DC-Volts must first be cleared with procedures described in Section 7 under "Clear Operations". Ensure that the selectors on the front panel (right) are positioned as follows:

1. Guard Selector - disengaged (out - internal guard)

2. Ohms Selector - engaged (in -4T)

3. Rear Input Selector - disengaged (out - front inputs)

4-58. DC SIGNAL CONDITIONER ADJUSTMENTS

4-59. All adjustments in the following procedure are on the DC Signal Conditioner.

1. Select dc volts, 100 mV range, slow filter (toggle FILTER until the FILTER annunciator lights), sample 7 (toggle SAMPLE until the SAMPLE annunciator flashes slowly), Calibration switch ON (AVG/CAL annunciator flashes), and V DC/Ohms Zero off (ZERO annunciator off).

2. Place a short across the VOLTS INPUT/OHMS SENSE HI and LO terminals.

3. Adjust R53 for a UUT reading of 0.0000 ± .0002 (-3).

4. Remove the short from the input terminals. Place a 1 megohm resistor in parallel with a 0.22 uF capacitor across VOLTS INPUT/OHMS SENSE HI and LO terminals.

5. Adjust R52 for a UUT reading of 0.0000 ± .0030 (-3).

6. Repeat steps (2) through (5) until both readings are within range without further adjustment.

4-60. A/D CONVERTER CALIBRATION PROCEDURES

4-61. Use the following procedure to calibrate the A/D Converter module. All adjustments and test points mentioned in this procedure are found on the A/D Converter module. References are found at the top of the A/D Converter pcb or on the inside of the hinged module top. Only the hinged module top need be opened to access these test points and adjustments.

4-62. This paragraph contains the adjustment procedure for R64. This resistor requires adjustment only if R54 in the tens bit ladder has been replaced during repair. If no such replacement has been made, proceed to the next paragraph.

1. Connect a test DMM HI input to TP7, LO input to TP6.

2 Adjust R1 for a test DMM reading of -7.0000V ± .0002V.

3. Remove the test DMM connections.

4. Set the UUT for the 10V range.

5. Using the test connections in Figure 4-2, apply 10.100000V dc to the UUT input terminals.

6. On the UUT, adjust R64 for a reading of +10.100000 ± .000050.

7. Remove the test connections and proceed with the following adjustments.

4-63. A/D Zero Adjustment

4-64. Use the following steps to adjust auto zero on the A/D Converter module:

1. Verify that the 10V range is set on the UUT.

2. Short the UUT input terminals.

3. On the UUT, adjust R8 for a reading of 0.00000 ± .00001.

4-65. Control Setting A

4-66. To prepare the DC Voltage Standard for subsequent tests and adjustments, use the following procedure:

1. Connect test equipment as shown in Figure 4-2. Make only the connections shown as solid lines; the UUT is not connected at this time.

2. Set the Voltage Divider controls at one-tenth the standard cell certified value (standard cell value X 0.1).

3. Adjust the DC Voltage Standard output for a null on the null meter.

4. Record the dial setting of the DC Voltage Standard as Control Setting A. This value will be used later in the A/D Converter Calibration Procedures.

5. Disconnect the two leads at the Voltage Divider output terminals. Connect the UUT as shown in Figure 4-2 (broken lines).

4-67. A/D Ladder Adjustments

4-68. Use the following procedure when adjusting the A/D Ladder:

1. Verify that the UUT is set for the 10V range.

2. Set the Voltage Divider controls for a ratio of 1.0100000.

3. On the UUT, adjust R1 (POS. CAL) for a reading of +10.10000V ± .00001.

4. On the DC Voltage Standard, reverse the dc voltage polarity.

5. On the UUT, adjust R2 (NEG. CAL) for 10.10000V ± .00001. If the R1 and R2 adjustments cannot be made, perform the A/D Converter Calibration Procedures.

6. On the DC Voltage Standard, restore the positive dc voltage output polarity.

7. Set the Voltage Divider controls for a ratio of 0.0500000.

8. On the UUT, adjust R7 (REMAINDER) for a front panel display of +0.50000 ± .00001.

9. Repeat steps (2) through (8) until all readings are within tolerance without making further adjustments.

10. Set the Voltage Divider controls for a ratio of 0.5100000.

11. On the UUT, adjust R6 (5V LADDER) for a reading of +5.10000 ± .00001.

12. Set the Voltage Divider controls for a ratio of 0.2600000.

13. On the UUT, adjust R5 (2.5V LADDER) for a reading of +2.60000 ± .00001.

14. Set the Voltage Divider controls for a ratio of 0.1400000.

15. On the UUT, adjust R4 (1.25V LADDER) for a reading of +1.40000 ± .00001.

16. Set the Voltage Divider controls for a ratio of 0.0750000.

17. On the UUT, adjust R3 (.625V LADDER) for a reading of 0.75000 ± .00001.

18. Repeat steps 2 through 17 until all steps are within the stated tolerance.

4-69. LINEARITY VERIFICATION

4-70. Use the following procedure to check linearity for the UUT:

1. Verify that the UUT is set for the 10V range (manual) and sample setting 7.

2. Set the Voltage Divider controls for a ratio of 0.2000000.

3. Set the DC Voltage Standard for an output of approximately 100V. Adjust this output for a reading on the UUT of +20.00000 ±.00012.

4. Set the Voltage Divider controls for a ratio of 0.0000000 and verify that the UUT reading is 0.00000 ± .00001.

5. Reverse the polarity of the dc output voltage at the DC Voltage Standard.

6. On the UUT, verify a reading of -0.00000 ± .00001.

7. At the DC Voltage Standard, restore the dc output voltage positive polarity.

8. Refer to Table 4-5. For each of the Voltage Divider settings listed, verify a UUT reading within the listed tolerances.

Table 4-5. Linearity Checks

DIVIDER SETTING	READINGS		
	MINIMUM	NOMINAL	MAXIMUM
.0100000	0.99995	1.00000	1.00005
.0200000	1.99995	2.00000	2.00005
.0300000	2.99995	3.00000	3.00005
.0400000	3.99995	4.00000	4.00005
.0500000	4.99995	5.00000	5.00005
.0600000	5.99995	6.00000	6.00005
.0700000	6.99995	7.00000	7.00005
.0800000	7.99995	8.00000	8.00005
.0900000	8.99995	9.00000	9.00005
.1000000	9.99995	10.00000	10.00005
.1100000	10.99994	11.00000	11.00006
.1200000	11.99994	12.00000	12.00006
.1300000	12.99994	13.00000	13.00006
.1400000	13.99993	14.00000	14.00007
.1500000	14.99993	15.00000	15.00007
.1600000	15.99993	16.00000	16.00007
.1700000	16.99992	17.00000	17.00008
.1800000	17.99992	18.00000	18.00008
.1900000	18.99992	19.00000	19.00008
.2000000	19.99992	20.00000	20.00008

9. At the DC Voltage Standard, reverse the polarity of the dc output voltage. For each of the Voltage Divider settings in Table 4-5, verify a negative UUT reading within the listed tolerances.

10. At the DC Voltage Standard, restore positive polarity and adjust for Control Setting A.

11. Set the Voltage Divider controls for a ratio of 1.0000000.

12. On the UUT, verify a reading of +10.00000 ± .00001.

4-71. RANGE ADJUSTMENTS

4-72. All adjustments and test points in the following procedure are found on the DC Signal Conditioner. References mentioned in this procedure can be typically found on the top edge of the DC Signal Conditioner PCB and on the inside of the hinged module top. Only the hinged module top need be opened to access all adjustments and test points.

4-73. Use the following steps to adjust the 100 mV range:

1. Verify that the UUT is set for dc volts, FILTER annunciator off, sample setting 7, and ZERO annunciator off.

2. Verify that the DC Voltage Standard is set for Control Setting A.

3. Set the Voltage Divider controls for a ratio of .0000000.

4. On the UUT, manually select the 100 mV range. If required adjust R53 for 0 ± .0002 (-3).

5. Set the Voltage Divider controls for a ratio of .0200000.

6. On the UUT, adjust R49 for a front panel display of +200.0000 (-3) ± .0005.

4-74. Use the following procedure to adjust the 1V range:

1. On the UUT, select the 1V range.

2. Set the Voltage Divider controls for ratio of .20000000.

3. On the UUT, adjust R48 for a front panel display of +2.000000 ± .000001.

4-75. Use the following procedure to check the 10V range:

1. On the UUT, select the 10V range.

2. Connect the UUT directly to the DC Voltage Standard as shown in Figure 4-2.

3. On the DC Voltage Standard, set the output to Control Setting A.

4. On the UUT, verify a front panel display of +10.00000 ± .00002V.

4-76. Use the following procedure to adjust the 100V range:

1. Connect the equipment as shown in Figure 4-3.

2. On the UUT, select the 100V range.

3. On the Reference Divider, set the standard cell voltage controls to the standard cell certified value and both the input and output controls to 100V.

4. On the DC Voltage Standard, set the output to approximately 100.0000V and adjust for a null on the null meter.

5. On the UUT, adjust R47 for a front panel display of +100.0000 ± .0001V.

4-77. Use the following procedure to check the 1000V range:

1. On the UUT, select the 1000V range and slide the rear panel Calibration switch to OFF. Verify that the AVG/(CAL) annunciator is off.

2. Verify that the 100 volt setting on the Reference Divider is still nulled.

3. Verify a UUT reading of 100.000 ± .005.

4. Set the Reference Divider input and output controls to 500 volts.

5. Set the DC Voltage Standard to approximately 500 volts, then adjust its output for a null on the null meter.

6. The UUT should read 500.000 ± .010.

7. Set the Reference Divider input and output controls to 1000 volts.

8. Set the DC Voltage Standard to approximately 1000 volts, then adjust its output for a null on the null meter.

9. The UUT should read 1000.000 ± .014.

4-78. If no further hardware calibration is necessary, verify that the Calibration mode is disabled (rear panel switch off). Refer to Section 7 for software calibration procedures.

4-79. TROUBLESHOOTING

4-80. Static discharge can damage components contained in the UUT. The following precautions should be observed during troubleshooting, repair, or module replacement.

1. Never connect or disconnect modules or components without first pushing the UUT Power switch to OFF.

2. Perform all repairs at a static-free work station.

3. Minimize handling of ICs and pcb's; do not handle them by their connectors.

4. Keep repair parts in their original containers until ready for use.

5. Use static ground straps to discharge repair personnel.

6. Use conductive foam or anti-static containers to store replacement or removed ICs and pcb's

7. Remove all plastic, vinyl, and styrofoam products from the work area.

8. Do not slide static-sensitive devices over any surface.

9. Use only anti-static type solder removal tools.

10. Use grounded tip soldering irons.

4-81. A procedure for isolating faulty modules is contained in Table 4-6. It is important that the theory of operation given in Secton 3 be read before attemping to troubleshoot the UUT. The module isolation procedure involves making observation of the UUT behavior, then removing or replacing modules to establish cause-effect relationships. Do not remove or replace modules with the power on. Follow the procedure step by step all the way through to assure that the fault is isolated to the correct module. Faults in some modules may cause apparent faults in other modules.

WARNING

A HAZARDOUS COMMON MODE VOLTAGE MAY APPEAR ON THE OUTPUT CONNECTOR OF THE BIT SERIAL REMOTE INTERFACE IF THE BUS INTERCONNECT MONITOR BOARD IS INSTALLED AS A REPLACEMENT FOR THE ISOLATOR. TO AVOID THIS SHOCK HAZARD, REMOVE THE BIT SERIAL REMOTE INTERFACE BEFORE INSTALLING THE BUS INTERCONNECT MONITOR BOARD.

4-82. Figure 4-5 and Tables 4-6 through 4-11 contain symptom analysis troubleshooting information for each of the modules and pcb's contained in the mainframe. The possible failures are listed in order of probability. Troubleshooting information for optional modules is contained in Section 6.

GUARDED SUPPLY

SYMPTOM	POSSIBLE FAILURE
VA1 — BAD	U3,BR2, or Transformer
(+15V). Noisy	C3
VA2 — BAD	U4,BR2, or Transformer
(-15V) Noisy	C4
VA3 — BAD	U1,CR3,BR1, Transformer
(+30V) Noisy	C1
VA4 — BAD	U2,CR4,BR1, Transformer
(-30V) Noisy	C2
V_{CC} (Guarded)	U5,R5,R3,C5,CR1,CR2, Transformer

VA1 and VA2 are used as a reference for VA3 and VA4. VA3 and VA4 could load down VA1 and VA2. Check by lifting the reference diodes CR3 and CR4.

UNGUARDED SUPPLY

V_{DD} (+12V)	U6,C6,C9,C12,BR3, Transformer
V_{GG} (-12V)	U7,C13,C10,C7,BR3, Transformer
V_{CC} (+5V)	U8,R6,R4,C8,C14,C11,BR4, Transformer

The drawing below identifies test points on the Power Supply pcb. Input voltages to the regulators should be approximately 5V higher than the normal output voltages. If the output is higher or lower than specified and noise is not the problem, the regulator is bad.

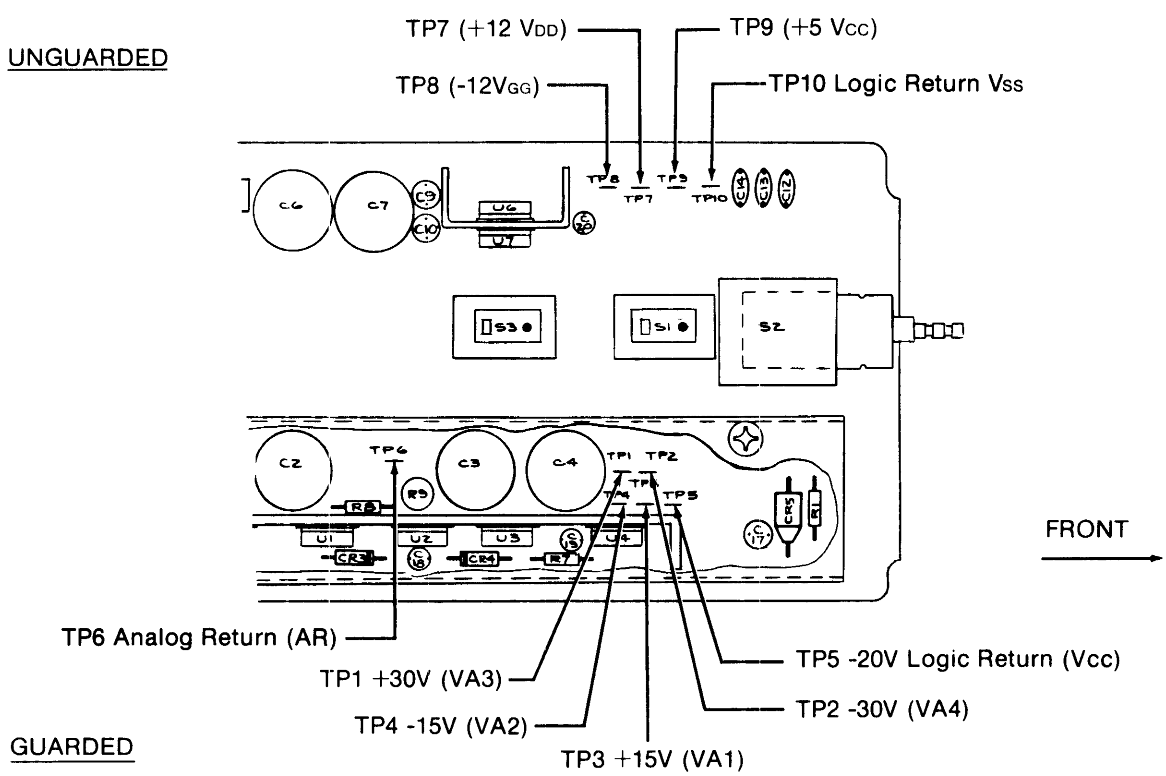

Figure 4-5. Power Supply Troubleshooting

Table 4-6. Faulty Module Isolation

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
1.	Turn the power ON. The following should be displayed: HI-Y.Y.Y. (Y=Program number) then CXXXXXX (X = installed option number) then 0.000 (±.050 DC Volts, 1000V range, fast sample rate)		
2.	Is the display blank	6	3
3.	Is the initial display other than HI-Y.Y.Y.	42	4
4.	Is the reading other than 0.000 ±.050	59	5
5.	Are the first three displays normal?	78	2
	DISPLAY BLANK AT POWER ON		
6.	Remove Isolator.		
7.	Turn power ON. Is HI-Y.Y.Y. displayed?	8	11
8.	Is "CXXXX" (Interface Option) and then "ERROR 9" displayed?	9	11
9.	Install interconnect-monitor in the Isolator slot. Is HI-Y.Y.Y, CXXXX,0000 displayed?	10	13
10.	Bad Isolator. Go to Section 6 under Isolator.		
11.	Is the power indicator on?	17	12
12.	Check the fuse. Is it bad (replace)?	1	17
13.	Remove Cal Memory Chip and remote interfaces if installed. Is HI-Y.Y.Y displayed?	14	17
14.	Replace Cal Memory Chip, Is HI-Y.Y.Y displayed?	16	15
15.	Bad Cal Memory Chip. Replace EE ROM.		
16.	Bad Remote Interface.		
17.	Install the Interconnect-Monitor PCB in the Isolator slot.		
18.	Check power supply voltages as follows. Test DMM Common to VSS. VDD = +11.4 to +12.6 VCC = +5.15 to 5.25 VGG = -11.4 to -12.6 LINE = 13V ac to 17V ac (at 100 or 120V ac), or 6.5V ac to 8.5V ac (at 220 or 240V ac) 6.5V ac to 8.5V ac		
19.	Are the power supplies within tolerance?	26	20
20.	Remove all modules except the Front Panel.		
21.	Recheck power supplies. Within tolerance?	22	23
22.	Replace modules one at a time (start with Controller), rechecking supplies after replacing each module. The last one put in when the supplies go bad is the problem. Go to the appropriate figure for that module.		
23.	Remove the front panel. Recheck supplies. Within tolerance?	25	24

Table 4-6. Faulty Module Isolation (cont)

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
24.	Problem on power supply, motherboard, or power supply interconnect.		
25.	Bad Front Panel. Go to Figure 4-7.		
26.	Remove Cal Memory Chip and the remote interface if installed.		
27.	Check IC 6, 5, 1, 0 on interbus. All moving?	28	30
28.	Check ACK line. Moving?	29	30
29.	Check ID0-7. All moving?	32	30
30.	Check Controller Sync Pulse at TP7. Moving?	33	31
31.	Bad Controller. Go to Figure 4-6.		
32.	Bad Front Panel. Go to Figure 4-7.		
33.	Remove analog modules, leaving only Controller, Front Panel, and Interconnect. Is the display normal?	34	35
34.	Faulty Analog Module. Replace one at a time — last one in is the problem. Go to the appropriate figure for that module.		
35.	Remove Front Panel, replace DC Signal Conditioner, Filter, A/D Converter.		
36.	Check IC lines, ACK line, ID lines. All moving?	38	37
37.	Bad Controller. Go to Figure 4-6.		
38.	Bad Front Panel. Go to Figure 4-7.		
	INITIAL DISPLAY OTHER THAN (HI-Y.Y.Y.)		
39.	Remove Interconnect PCB (or Isolator if installed).		
40.	Apply power. Is the display as follows? HI- Y.Y.Y. CXXXXXX Error 9	41	44
41.	Was the Isolator installed?	42	47
42.	Install Interconnect-Monitor PCB in Isolator slot. Is display normal?	43	48
43.	Bad Isolator. Go to Section 6.		
44.	Are Cal Memory Chip or remote interface installed?	45	47
45.	Remove Cal Memory Chip and remote. Display normal?	46	47
46.	Replace one at a time. Go to appropriate figure.		
47.	Install Interconnect-Monitor PCB.		
48.	Check for shorts between the IC and the ID lines. Shorts?	49	51
49.	Remove all modules except Front Panel. Removed short?	50	57

Table 4-6. Faulty Module Isolation (cont)

STEP NO.	ACTION	Go to the step number given for correct response YES	NO
50.	Reinstall modules one at a time (start with Controller), checking for shorts between modules. Last one in is the problem. Go to the figure for the appropriate module.		
51.	Are any of the IC, ID, or ACK lines always high or always low?	53	52
52.	Remove all modules except Front Panel and Controller. IC and ID moving?	56	53
53.	Remove Front Panel. Reinstall dc analog modules if removed.		
54.	Are the IC, ID, and ACK lines moving?	57	55
55.	Bad Controller. Go to Figure 4-6.		
56.	Is the display normal?	58	57
57.	Front Panel bad. Go to Figure 4-7.		
58.	Faulty Analog module. Replace one at a time until symptoms recur. Last one in is faulty. Go to the figure for the appropriate module.		
	READING NOT ZERO AT TURN ON		
59.	Remove all optional modules (except Isolator if installed), leaving Controller, (Isolator), DC Signal Conditioner, Filter, A/D, Front Panel.		
60.	Apply power. Is the reading zero?	61	62
61.	Replace modules one at a time until reading is not zero. Last one in is the problem. Go to Section 6.		
62.	Is the Isolator installed?	63	65
63.	Replace Isolator with Interconnect-Monitor PCB. Is the reading zero?	64	65
64.	Bad Isolator. Go to Section 6.		
65.	Install Interconnect Monitor if not already installed. Check supply voltages as follows. Test DMM LO on AR (analog return). VA1 = +14.25 to +15.75V VA4 = -29 to -32V VA2 = -14.25 to -15.75V VCC = -15V Difference must equal VA3 = +29 to +32V VSS = -20V 4.9 to 5.2V		
66.	Supply voltages in tolerance?	70	67
67.	Remove all modules except Front Panel. Supplies in tolerance?	69	68
68.	Repair power supply. Go to Figure 4-5.		
69.	Replace modules one at a time, checking supplies between modules. Last one in is faulty. Go to the appropriate figure.		
70.	Remove Filter module. CAL switch on. Select DC Volts, 1000V range.		
71.	Is the reading zero?	72	77
72.	Replace Filter module; remove DC Signal Conditioner.		

Table 4-6. Faulty Module Isolation (cont)

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
73.	Place a jumper (short) between RT2 and RT6.		
74.	Is the reading zero?	75	76
75.	DC Signal Conditioner bad. Go to Figure 4-8.		
76.	Filter module bad. Go to Figure 4-9.		
77.	A/D converter bad. Go to Figure 4-10.		
78.	Do the Performance Tests earlier in this section.		
79.	Is the unit within the tolerances given?		80
80.	Is the Cal Memory Chip installed?	81	83
81.	Remove the Cal Memory Chip. Is the unit now within tolerance?	82	83
82.	Faulty Cal Memory Chip.		
83.	Is the Isolator installed?	84	87
84.	Replace Isolator with Interconnect-Monitor PCB.		
85.	Is unit within tolerance?	86	87
86.	Bad Isolator. Go to Section 6.		
87.	Is the failure in DC Volts Performance Test?	89	88
88.	Go to Section 6 for the appropriate faulty function.		
89.	Remove all optional modules, leaving Front Panel, Controller, DC Signal conditioner, Active Filter, and A/D Converter.		
90.	Do the DC Volts Performance Test. Is the unit within tolerance?	91	92
91.	Reinstall options one at a time, rechecking DC Volts tolerance. Last module installed when unit becomes out of tolerance is faulty. Go to Section 6.		
92.	Check supply voltages according to the following chart. VA1 = +14.25 to +15.75V VA4 = -29 to -32V VA2 = -14.25 to -15.75V VCC = -15V Difference = 4.9 to 5.2V VA3 = +29 to +32V VSS = -20V		
93.	Are the supplies within tolerance?	97	94
94.	Remove all modules except Controller and Front Panel. Are the voltages correct?	95	96
95.	Replace modules one at a time until the voltages go bad. Last one in is the problem. Go to the appropriate figure.		
96.	Repair power supply. Go to Figure 4-5.		

Table 4-6. Faulty Module Isolation (cont)

STEP NO.	ACTION	Go to the step number given for correct response YES	NO
97.	Connect the test DMM LO to RT2 and HI to RT6. Apply known voltages to the input to test the DC Signal Conditioner. The following voltages are suggested inputs:		

RANGE	GAIN DC SIG COND	INPUT	TEST DMM READING
100 mV	X100	2 mV	200 mV
100 mV	X100	200 mV	20.0V
1V	X10	125 mV	1.25V
1V	X10	2V	20V
10V	X1	1V	1.0V
10V	X1	19V	19.0V
100V	÷64X10	1.28V	200 mV
100V	÷64X10	128V	20.0V
1000V	÷64X1	64V	1.0V
1000V	÷64X1	960V	15.0V

STEP NO.	ACTION	YES	NO
98.	Are the readings correct (noise or drift in the DC Signal Conditioner will show up on the Test DMM readings)?	100	99
99.	DC Signal Conditioner faulty. Go to Figure 4-8.		
100.	Connect Test DMM HI to RT5. Repeat table in step 97. The test DMM readings should be the same.		
101.	Are the Test DMM readings the same?	103	102
102.	Faulty Active Filter module. Go to Figure 4-9.		
103.	Faulty A/D Converter. Go to Figure 4-10.		

Table 4-7. Controller Troubleshooting

Note

Due to the speed and complexity of the Controller, it is recommended that, when a problem is isolated to the Controller, the unit be sent to the nearest Service Center for repair. The following information will assist in verifying Controller operation. Many problems require the use of an in-circuit tester.

Troubleshoot the Controller with only the Controller, Front Panel and Power Supply installed. The most common symptom of Controller failure is a blank display. Other symptoms include an improper display, a failure to read switches or respond to external interrupts, or an initialization display ("CXXXXXX") improperly indicating all optional modules present. The following checks verify basic Controller operation:

1. Check power supply voltages at the Controller. Test Points are located on the circuit board top edge and are identified on the inside of the hinged module top.

   Test DMM LO: TP1 (VSS)

   Test DMM HI: TP3 (VCC +5V)
   TP5 (VBB -5V)
   TP6 (VDD +12V)

   If any of these voltages are more than 5% out of tolerance, proceed to "Power Supply Troubleshooting" in this section.

2. If the power supply checks good, verify the presence of the following signals in sequence. If a signal is present, go on to the next check. If a signal is not present, the Controller may be faulty. Although probable fault causing components or circuits may be mentioned, the Controller will probably require repair at a Service Center.

   SYNC pulse at TP7

   If no SYNC pulse, check Ø1 at U15-22; Ø2 at U15-15. (test failure suggests U19).

   RESET signal at U10-2 on power-up: check for 0.1 sec low-going pulse. (Test failure suggests reset circuit.)

   CPUINT at TP4

   DLDACK at TP2

Table 4-8. Front Panel Troubleshooting

SYMPTOM	POSSIBLE FAILURE
No ACK Pulse	U28, U19 (Address Decoders) U23 (Indirect F/F) U19, U11, Q10 (ACK Circuit)
No Display (ACK Pulse Present)	U18 (Kill Circuit)
No Response to Switch Pushes (Display Good)	Switch Associated with Function U32, CR2-CR6 Open
Segment Bad in all LED's	Check path from Latch to Transistor drivers to LED Cathodes
One LED doesn't light	Check path from Latch to Inverter to Transistor Drivers to LED Anode
Segment or Decimal missing on only one LED	Bad LED
Display gives wrong numbers, one LED brighter	U11 (Reset to Indirect Address F/F, U23) Address Decoder. (Problem is indicative of front panel responding to an invalid address)

Table 4-9. DC Signal Conditioner Troubleshooting

SYMPTOM	POSSIBLE FAILURE
DC Inoperative all Ranges	Digital Control Logic Q8, Q6, Q7, Open K1, Q1, Q2 Open; Q18, Q19, U3 Bad
Display Blanks	U1 or U2
Locks in Overrange	U3
Reading Drifts	U4; Q14, Q15, Q16 Leaky
Won't Zero	U5 or U6
100 mV Range Bad	Q31, Q32, Q14
1V and 100V Range Bad	Q33, Q34, Q15
100V and 1000V Range Bad	K2, Q3, Q4
Random Readings	K1 Open, K2 Shorted
Nonlinear Readings	Q16, Q15, Q14 Leaky

ADDRESS AND DATA FIELD

DC SIGNAL CONDITIONER ADDRESS: IC, IC3, IC0 = 1

GAIN CONTROL

ID3	ID2	GAIN
0	1	X100
1	0	X10
1	1	X1

INPUT CONFIGURATION CONTROL

ID1	ID0	INPUT FROM	ATTENUATION
1	0	External	÷1
0	0	External	÷64
0	1	RT1*	÷1

*Used for ohms and dc current measurements.

NOTE: If R54-R57, Q18, Q19 or Q22 are replaced it will be necessary to return the module to the factory (attn. PARTS) to be temperature compensated anew.

Table 4-10. Active Filter Troubleshooting

SYMPTOM	POSSIBLE FAILURE
High Zero Offset	Q32, Q25, Q19, Q20 Shorted
DC Inoperative	Q18 Open - Q21, Q22, Q23, Q24 Open Q27, U5 Digital Logic
Overrange	U5 - Q19, Q20 Shorted
Noisy	
All Ranges	
Either Filter	Q25, Q32 Leaky - Q31, U5 Bad
Slow Filter (ON)	Q21, Q22 Leaky - U4 Bad
Fast Filter (OFF)	Q23, Q24 Leaky - U3 Bad
Nonlinear Readings	U5
Display Blanks	U1 or U2

ADDRESS AND DATA FIELD

ADDRESS	DATA
IC4, IC3, & IC1 = 1	ID0 = Filter Bypass ID1 = 1 Slow Filter ID2 = 1 Fast Filter ID3 = 1 Filter - Always on except in Ext. Ref. ID4 = 1 Ext. Ref. Lo ID5 = 1 Ext. Ref. Hi

Adjustment of R14

1. Short the UUT input terminals, and select 10V dc range.
2. Short RT6 to RT2 on the Bus Interconnect Monitor.
3. Adjust R14 for a reading of ±.000000 ±2 digits. (This requires that the A/D Converter is working accurately.)

Selection of R15 or R16.

If Q27 or U5 have been replaced, R15 and R16 will require reselection if adjustment of R14 does not zero the reading.

1. Only one of R15 and R16 will be installed. Replace whichever is installed with a short.
2. Connect the R15 short to the R16 short.
3. Short RT6 to RT2 on the Bus Interconnect Monitor.
4. Connect the test DMM HI to TP3 and LO to TP1 on the Active Filter module.
5. Select a resistor from the table below according to the measured offset. If the polarity is postive, install the resistor as R16; if negative as R15. (Maximum allowable offset in this step is 5200 μV.)

OFFSET (μV)	RESISTOR	FLUKE PART NO.
0-400	None	
401-1200	31.6k	261610
1201-2000	63.4K	235382
2001-2800	97.6K	241380
2801-3600	133.0K	289074
3601-4400	165.0K	376186
4401-5200	205.0K	375931

6. After installing the resistor, adjust R14.

Table 4-11. R^2 A/D Converter Troubleshooting

DIGITAL BOARD

SYMPTOM	POSSIBLE FAILURE
Display Blanks	U33, U34, U35 (Affecting ID Lines)
Improper Readings, Inoperative A/D, Nonlinear Readings	Check Transistor Array Outputs to J1 and J2 — The rise and fall times of these Switching Pulses Must be <2 μsec.
Flickering Display	Autozero Control — U25, U34
Direct Address	
IC4, 3, & 2 High	ID0 = 1 = Reset Counter ID1 = 1 = Auto Zero ID2 = 0 = Buffer Input ID2 = 1 = Remainder Input ID3 = 1 = Channel X (Auto Zero and remainders 1 and 3) ID3 = 0 = Channel Y (Remainders 2 and 4)
Indirect Address	
IC2 & 1 High (and Ring Counter not in C0 time period, C0 = 0)	This Indirect Address allows the ID7 enable to bring back Polarity Bits to the Controller Module

ANALOG BOARD

First Check TP5 — Should be switching between + and -7V. Typical failures in this circuit result in a portion of the switching slope having a slew rate less than 1V/μsec. A glitch at the zero point is normal.

SYMPTOM	POSSIBLE FAILURE
Noisy Readings	U1, U2, U3
Nonlinear Ladder	U4, Q9, Q10 (Q27)
Ladder out of Tolerance	FETS Q11-Q15 or Q17-Q21
All Digits Wrong	U7, Q31, Q32
Reading Locked (Doesn't Respond to Input Change) or Always Overrange	U4, Q9, U1, U2, U3, Q2, Q3
Bad Remainders (Lesser Digits)	Q22, U4, U6
No Polarity Bit Returned	Q29, Q28
Shifty Readings (Most or all Digits)	Autozero Settling Time Problems U8, Q30-Q8, Q7

NOTE: If U1, R9, R14-R16, R34, R35, R50-55, R67, Q1-Q3, Q11-Q16, Q25, or Q26 are replaced it will be necessary to return the module to the factory (attn. PARTS) to be temperature compensated anew.

4-83. Troubleshooting Notes

4-84. Latching errors are normally enabled, but are afforded special treatment for troubleshooting purposes when the Calibration mode is on. The following rules then apply:

1. Latching errors are automatically enabled whenever Calibration mode is enabled or disabled with the rear panel Calibration Switch.

2. If Calibration mode is on, latching errors can be disabled by pushing the AVG button. Since Average mode and Calibration mode are mutually exclusive, this operation does not enable Average mode. The multimeter front panel display responds with (Err. oFF).

3. With Calibration mode still on, latching errors are re-enabled and normal Calibration mode operation is restored when the AVG button is pushed again. If a latching error condition exists at this time, the error message is displayed. If no latching error exists, the multimeter front panel display responds with (Err. on).

CAUTION

Since latching errors may also identify an over voltage condition (as with Error 4) discretion must be used. Do not disable latching errors during normal multimeter operation or during calibration

4-85. If interaction between modules is a problem during troubleshooting, use of either the Static Controller or the Test Module could be helpful. With the Static Controller, bus IC, ID, and handshake signals may be applied separately to most analog and digital modules. The Test Module may be used to either check or troubleshoot the Controller module. Complete use information and troubleshooting techniques are provided with these test modules.

NOTE

Ground integrity within the multimeter is maintained via one of the Power Supply securing screws. If this screw is loose or missing, noise problems can be encountered. Viewing the multimeter from the rear, locate the three buttonhead screws along the left side of the heat sink. Verify that the middle screw is tightly secured.

4-86. Use the Bus Interconnect and Monitor Board (MIS-7013K) to access lines on either the digital (unguarded) or analog (guarded) interbus. In using the Bus Interconnect Monitor Board, note that RT1 physically does not extend to the Isolator-Interconnect slot. RT1 is accessible with the Monitor Board installed in any of the first four slots (J11A, B, C, or D). The output of the optional Ohms Converter and Current Shunts modules are on RT1.

CAUTION

Do not apply an input directly to the A/D Converter module. Damage to the A/D Converter may result. The DC Signal Conditioner may be bypassed by applying a signal directly to the Active Filter module, as outlined in the module isolation procedure.

4-87. Care should be exercised when soldering on multilayer printed circuit boards. Excessive heat can be especially ruinous. Note the following considerations:

1. Excessive heat can cause unseen damage to board laminations and through-hole plating.

2. Soldering tip temperatures above 700° F should be avoided in all cases.

3. Whenever possible, alternate soldering tool usage between divergent areas on a board. Concentration of heat in any one area will, thereby, be minimized.

4-88. Non-recurring Adjustments

4-89. Variable resistor R9 in the U3 Regulator circuit of the Power Supply Assembly is set at the factory and should not require additional adjustment. If any other Power Supply components are replaced, use the following procedure:

1. Connect a test DMM between -15V (VA2) and ANALOG RETURN (AR) at TP4 and TP6 respectively.

2. Record the value of the reading.

3. Connect the test DMM between +15V (VA1) and AR at TP3 and TP6 respectively.

4. Adjust R9 until the test DMM reads within ± 0.25V of the reading recorded in step 2 above.

5. Recheck the -15V and +15V supplies at the points given in steps 1 and 3 above respectively and verify that they read -15 ± 0.75V and +15 ± 0.75V. If either is outside the stated tolerance repeat steps 1 through 4 until both values are within tolerance.

Section 5
List of Replaceable Parts

TABLE OF CONTENTS

5-1. INTRODUCTION

5-2. This section contains an illustrated parts list for the instrument. 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.

5-3. Parts lists include the following information:

1. Reference Designation
2. Description of each part
3. FLUKE Stock Number
4. Federal Supply Code for Manufacturers (See Code-to-Name list at the end of this section)
5. Manufacturer's Part Number
6. Total Quantity per assembly or component

5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the FLUKE STOCK NUMBER. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions if necessary.

5-6. To ensure prompt and efficient handling of your order, include the following information.

1. Quantity
2. FLUKE Stock Number
3. Description
4. Reference Designation
5. Printed Circuit Board Part Number
6. Instrument Model and Serial Number

CAUTION

*

Indicated devices are subject to damage by static discharge.

5-7. Parts price information is available from the John Fluke Mfg. Co., Inc. or its representative. Prices are also available in a Fluke Replacement Parts Catalog, which is available upon request.

5-8. MANUAL STATUS INFORMATION

5-9. The following Manual Status Information table defines assembly revision levels documented in this manual. To identify the configuration of the pcb's used in your instrument, refer to the revision letter (marked in ink) on the component side of the pcb.

5-10. TECHNICAL SERVICE CENTERS

5-11. A list of technical service centers is included at the end of this section.

Manual Status Information

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	Q	R	S	T	U	V	W	X	Y	Z
A1	Front Panel Display PCB Assy	656637							X																				
A2	Motherboard PCB Assy	639385					X																						
A3	Isolator PCB Assy	486415																			X								
A4	Power Supply PCB Assy	639526																							X				
A5	Power Supply Interconnect PCB Assy	645960		X																									
A6	Controller PCB Assy	735696																								X			
A7	Front/Rear Switch PCB Assy	646281												X															
A8	DC Signal Conditioner PCB Assy	646307													X														
A9	Active Filter PCB Assy	383976														X													
A10A1	A/D Analog PCB Assy	383984																										X	
A10A2	A/D Digital PCB Assy	383760															X												

Table 5-1. 8505A Final Assembly
(See Figure 5-1.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
A 1	*	FRONT PANEL DISPLAY PCB ASSEMBLY	639419	89536	639419	1	
A 2	*	MOTHER BOARD PCB ASSEMBLY	639385	89536	639385	1	
A 3	*	ISOLATOR PCB ASSEMBLY	716365	89536	486415	1	
A 4	*	POWER SUPPLY PCB ASSEMBLY	683946	89536	639526	1	
A 5	*	POWER SUPPLY INTERCONNECT PCB	645960	89536	645960	1	
A 6	*	CONTROLLER PCB ASSEMBLY	660563	89536	638544	1	
A 7	*	FRONT/REAR SWITCH PCB ASSEMBLY	646281	89536	646281	1	
A 8	*	DC SIGNAL CONDITIONER PCB ASSEMBLY	660712	89536	646307	1	
A 9	*	ACTIVE FILTER ASSY.	716316	89536	383976	1	
A 10	*	FAST R2 A/D CONVERTER PCB ASSSEMBLY	716324	89536	383984	1	
C 1, 2		CAP,CER,360PF,+-5%,50V,C0G	528471	04222	SR215A361JAA	2	
CR 1, 2		VARISTOR,33V,+-10%,1.0MA	485391	S3385	SNR-D33K1	2	
H 1		WASHER,LOCK,INTRNL,STL,.267ID	110817	COMMERCIAL		1	
H 2		SCREW,PH,P,SS,LOCK,6-32,.437	362954	COMMERCIAL		6	
H 3		SCREW,PH,P,STL,LOCK,6-32,.250	152140	COMMERCIAL		2	
H 4		SCREW,PH,P,SEMS,STL,6-32,.250	178533	COMMERCIAL		27	
H 5		SCREW,PH,P,STL,LOCK,6-32,.312	152157	COMMERCIAL		8	
H 6		SCREW,PH,P,STL,SEMS,8-32,.375	436030	COMMERCIAL		2	
H 7		SCREW,CAP,SCKT,SS,8-32,.375	295105	COMMERCIAL		4	
H 8		SCREW,FH,P,STL,LOCK,8-32,.375	114116	COMMERCIAL		8	
H 9		SCREW,PH,P,STL,LOCK,8-32,.625	114983	COMMERCIAL		4	
H 10		SCREW,FH,P,STL,LOCK,8-32,.437	306159	COMMERCIAL		6	
H 11		WASHER,LOCK,INTRNL,STL,.512ID	641381	COMMERCIAL		4	
H 12		NUT,HEX,BR,1/4-28	110619	COMMERCIAL		1	
H 13		SCREW,FH,P,STL,LOCK,6-32,.500	114397	COMMERCIAL		4	
H 14		WASHER,LOCK,INTRNL,STL,.150ID	110338	COMMERCIAL		12	
H 15		NUT,HEX,MINI,SS,6-32	110569	COMMERCIAL		4	
H 16		SCREW,PH,P,STL,LOCK,4-40,.187	129882	COMMERCIAL		4	
H 17		SCREW,FHU,P,SS,LOCK,6-32,.250	320093	COMMERCIAL		12	
J 2, 5		CONN,COAX,BNC(F),PANEL	386888	91836	KC-79-67	2	
MP 1		PLASTIC PART,HOLE PLUG,POLYETH,.312	187799	82240	B-2328	2	
MP 2		DECAL,FRONT PANEL	640367	89536	640367	1	
MP 3		NAMEPLATE, SERIAL -REAR PANEL-	472795	89536	472795	1	
MP 4		FRONT PANEL PH2	857941	89536	857941	1	
MP 5		REAR,PANEL SCREENED PH2	857953	89536	857953	1	
MP 6		ASSY,CHASSIS.RH PH2	857933	89536	857933	1	
MP 7		ASSY,LH CHASSIS,PH2	857938	89536	857938	1	
MP 8		BULKHEAD	645887	89536	645887	1	
MP 9		ASSY,CENTER BULKHEAD	656652	89536	656652	1	
MP 10		TERM,RING 1/4 & 1/32,SOLDR	102566	79963	813	1	
MP 11		LENS,DISPLAY	659565	89536	659565	1	
MP 12		BOTTOM COVER	646182	89536	646182	1	
MP 13		MODULE GUIDE LATCH	646232	89536	646232	20	
MP 14		PUSH ROD MOLDED	646216	89536	646216	3	
MP 15		MODULE GUIDE MOLDED	646224	89536	646224	20	
MP 16		BUTTON,HOT STAMPED-REAR INPUT IN	660399	89536	660399	1	
MP 17		MOLDED FRONT PANEL	646240	89536	646240	1	
MP 18		BUTTON,HOT STAMPED 4T-OHM IN	660373	89536	660373	1	
MP 19		BUTTON,HOT STAMPED-EXT GD IN	660381	89536	660381	1	
MP 20		I/O BEZEL	416206	89536	416206	1	
MP 21		FOOT,MODIFIED	645945	89536	645945	4	
MP 22		COVER, REAR INPUT	823245	89536	823245	1	
MP 23		CORNER HANDLE,FRONT 4.25 IN, DK UMBER	656165	89536	656165	2	
MP 24		CORNER, PLASTIC 4.25 IN, DK UMBER	656215	89536	656215	2	
MP 25		FOOT, SINGLE BAIL TYPE (DARK UMBER)	653923	89536	653923	4	
MP 26	*	BAIL, INSTRUMENT	707877	89536	707877	2	
MP 27		BUTTON, POWER SWITCH	401646	89536	401646	1	
MP 28		BINDING POST HEAD, PLATED	225615	89536	225615	1	
MP 29		BINDING POST, METAL, PLATED	225623	89536	225623	1	
MP 30		SHIELD,BOTTOM COVER	660258	89536	660258	1	
MP 31		CABLE ACCESSORY,CLAMP,ADHESIVE,NYLON	838300	06915	MWSSEB-1-01A	1	
MP 32		DECAL,POWER SUPPLY	659649	89536	659649	1	
MP 33	*	SHIELD, MOTHER BOARD-HDWR	660282	89536	660282	1	
MP 34		TOP COVER	646174	89536	646174	1	
MP 35		DECAL, REAR CORNER	685222	89536	685222	2	
MP 36		SIDE TRIM-15"	525980	89536	525980	2	
MP 37		DECAL, FRONT CORNER, DARK UMBER	659219	89536	659219	2	
MP 38		CONN,RECT,CABLE,PLUG,20 POS	369231	91662	00-8016-020-000-803	1	
MP 39		DECAL CSA	525527	22678	525527	1	

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

Table 5-1. 8505A Final Assembly (cont.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
MP 40		FACTORY MUTUAL DECAL	524611	89536	524611	1	
TM 1		8505A INSTRUCTION MANUAL	638841	89536	638841	1	
TM 2		GETTING STARTED MANUAL	745448	89536	745448	1	
TM 3		8505A/8506A REFERENCE GUIDE	684357	89536	684357	1	
W 1	*	BNC ASSY SCAN ADV	651810	89536	651810	1	
W 2	*	BNC ASSY EXT TRIG	651802	89536	651802	1	
W 3		LANYARD,REAR INPUT CONN. COVER	842989	89536	842989	1	
W 4		CORD,LINE,5-15/IEC,3-18AWG,SVT	284174	70903	17239	1	

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

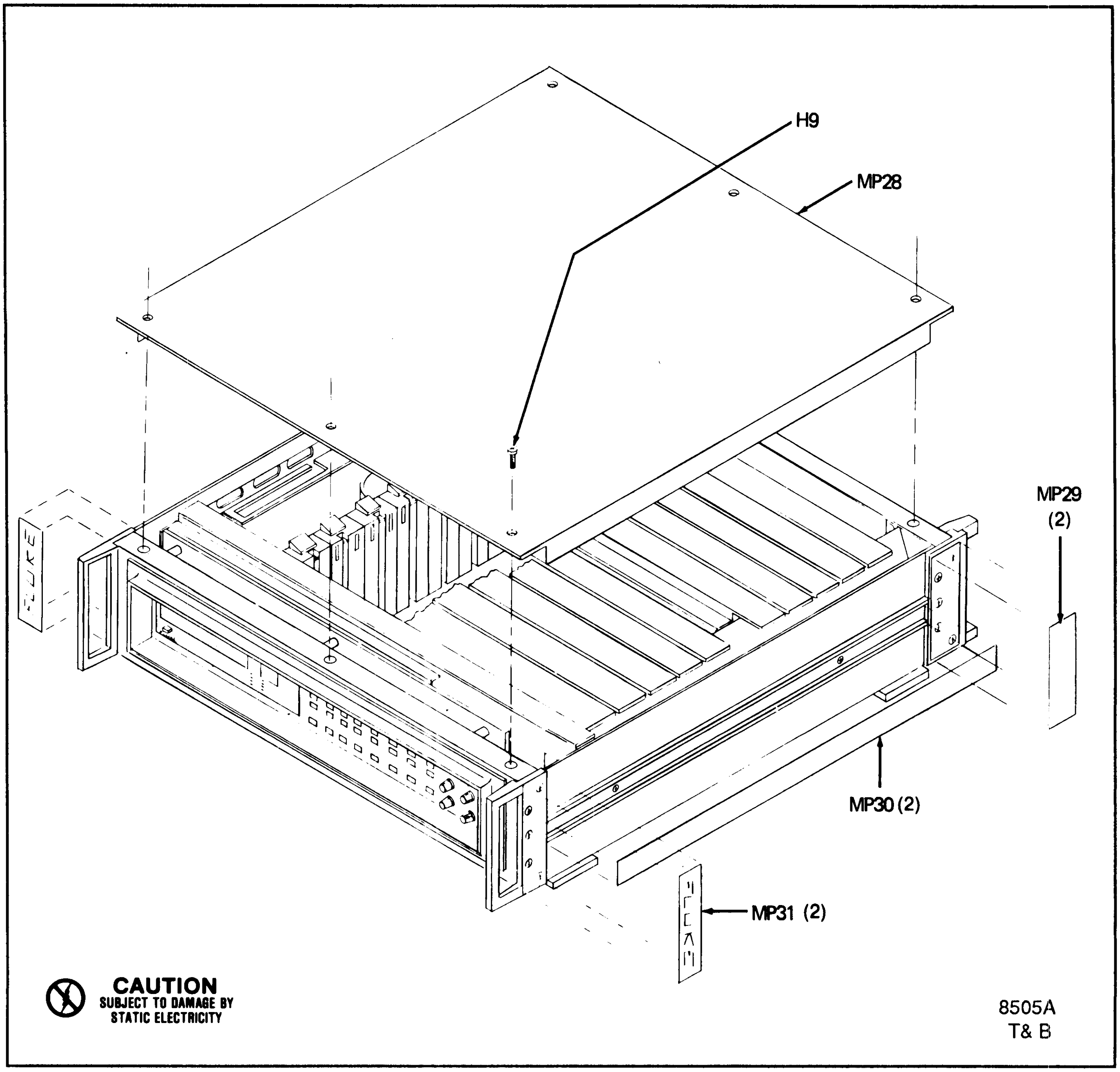

Figure 5-1. 8505A Final Assembly

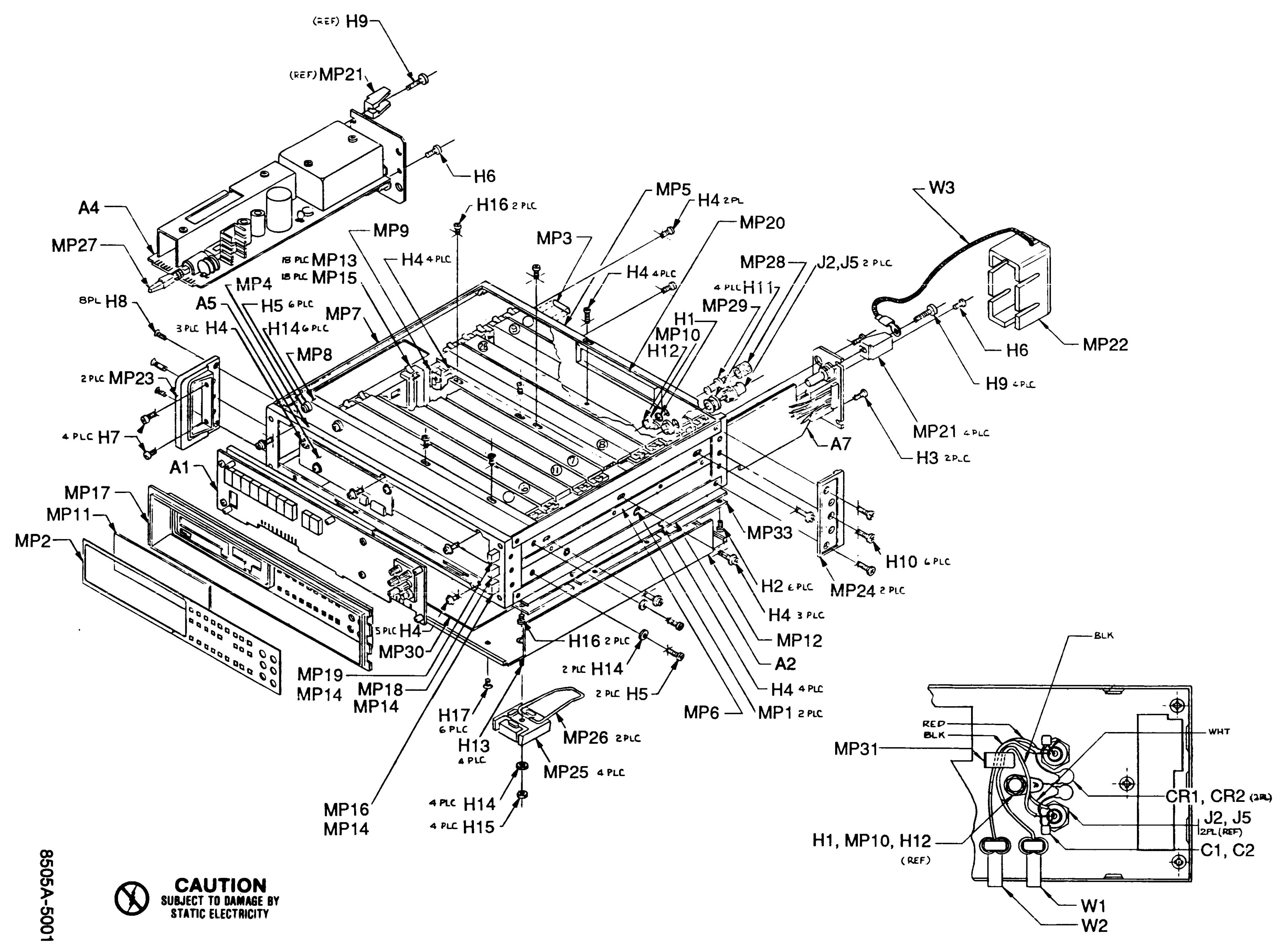

Figure 5-1. 8505A Final Assembly (cont)

Table 5-2. A1 Front Panel Display PCB Assembly
(See Figure 5-2.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	--------------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
C 1		CAP,CER,0.22UF,+-20%,50V,Z5U	309849	04222	SR215E224MAA	1	
C 2, 4		CAP,AL,47UF,+75-20%,25V	655191	62643	SM25T470M13X31LL	2	
C 3		CAP,CER,1200PF,+-20%,100V,X7R	816223	04222	SR071C122MAA	1	
CR 1- 6	*	DIODE,SI,BV=75V,IO=150MA,500MW	203323	15818	1N4448	6	
CR 7		LED,GREEN,RECTANGULAR,PCB MOUNT	650879	58361	MV54124	1	
E 1, 2		TERM,UNINSUL,FEEDTHRU,HOLE,TURRET	179283	88245	2010B-5	2	
F 1		FUSE,.25X1.25,1.5A,250V,FAST	739888	75915	31201.5	1	
F 2		WIRE,MAGNET,36H,130C,NYLEZE	160978	89536	160978	1	
H 1		NUT,HEX,BR,8-32	631614	COMMERCIAL		10	
H 2		SCREW,PH,P,STL,LOCK,6-32,.250	152140	COMMERCIAL		6	
J 1, 2		BINDING-POST-ASSY-BR-RED	637843	89536	637843	2	
J 3, 4		BINDING-POST-ASSY-BR-BLK	637850	89536	637850	2	
J 5		BINDING-POST-ASSY-BR-BLU	637876	89536	637876	1	
MP 1- 5, 10-		PUSHBUTTON-SQUARE-, WHITE	406744	89536	406744	14	1
MP 14, 20- 23			406744				
MP 7, 24- 27		PUSHBUTTON-SQUARE-, LIGHT PUTTY GREY	401307	89536	401307	5	1
MP 8, 9		PUSHBUTTON-SQUARE,YELLOW	419937	89536	419937	2	1
MP 16- 18		PUSHBUTTON-SQUARE-, DARK PUTTY GREY	406728	89536	406728	3	1
MP 19		PUSHBUTTON-SQUARE-, LIGHT BLUE	406736	89536	406736	1	1
MP 28		SPACER L.E.D	541284	89536	541284	1	
MP 29		CAP,FUSE	683995	89536	683995	1	
MP 30		INSULATOR,BINDING POST, MODIFIED	449363	89536	449363	1	
MP 31		SPACER,RND,PLASTIC,.500ID,.062	484832	89536	484832	1	
MP 32		DISPLAY SHIELD	646166	89536	646166	1	
MP 33		SPACER,SWAGED,.250 RND,BR,6-32,.500	284380	9W423	9537B-B-0632	5	
Q 1	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	330803	04713	MPS6560	1	
Q 2- 8	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	340026	65940	MPS6563	7	
Q 10	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1	
R 1		RES,CF,62,+-5%,0.25W	441634	59124	CF1-4 620 J B	1	
R 2, 6		RES,CF,200,+-5%,0.25W	441451	59124	CF1-4 201 J B	2	
R 3		RES,CF,100K,+-5%,0.25W	348920	59124	CF1-4 104 J B	1	
R 4		RES,CF,150,+-5%,0.25W	343442	59124	CF1-4 151 J B	1	
R 5		RES,CF,4.7K,+-5%,0.25W	348821	59124	CF1-4 472 J B	1	
R 8		RES,CC,10M,+-5%,0.25W	194944	01121	CB1065	1	
S 1- 5, 7-		SWITCH, MODIFIED ITT/SHADOW	860064	89536	860064	25	
S 14, 16- 27			860064				
U 1, 21, 25	*	IC,ARRAY,7 TRANS,NPN,COMMOM EMITTER	407866	56289	ULN2081A	3	
U 2	*	IC,CMOS,HEX INVERTER	404681	04713	MC14093BCP	1	
U 3, 27, 31	*	IC,CMOS,HEX D F/F,+EDG TRG,W/RESET	404509	27014	MM74C174N	3	
U 4, 12		DIODE,LED,RED,+/-1 OVERFLOW	504787	28480	5082-7656-QPT-S02	2	
U 5- 10, 13,		LED,RED,7 SEGMENT,NUMERIC	418012	28480	QDSP-3836	8	
U 34			418012				
U 11	*	IC,CMOS,QUAD 2 INPUT NAND GATE	355198	04713	MC14011UBCP	1	
U 14, 24, 26		LED,RED,10 SEGMENT,BAR GRAPH	685370	58361	MV57164	3	
U 16, 22, 23	*	IC,CMOS,DUAL D F/F,+EDG TRIG	340117	04713	MC14013BCP	3	
U 17, 20		RES,CERM,DIP,14 PIN,7 RES,60,+-5%	344069	89536	344069	2	
U 18	*	IC,CMOS,RETRIG/RESET MULTIVIBRATOR	393512	34371	CD4098BE	1	
U 19	*	IC,CMOS,DUAL 4 INPUT NAND GATE	355206	04713	MC14012BCP	1	
U 28	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	04713	MC14023UBCP	1	
U 29, 30		RES,CERM,DIP,16 PIN,8 RES,1K,+-5%	358119	91637	MDP16-03-102J	2	
U 32	*	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	04713	MC14503BCP	1	
U 33		RES,CERM,DIP,14 PIN,7 RES,4.7K,+-5%	386961	91637	MDP14-03-472J	1	
W 1, 5		WIRE,TEF,UL1180,26AWG,STRN,BLK	200766	89536	200766	2	
W 2		WIRE,TEF,UL1180,26AWG,STRN,RED	170217	89536	170217	1	
W 3		WIRE,TEF,UL1180,26AWG,STRN,ORN	200733	89536	200733	1	
W 4		WIRE,TEF,UL1180,26AWG,STRN,WHT	166991	89536	166991	1	
XF 1		HLDR,FUSE,1/4 X 1-1/4,PNL MT	435628	61935	FER	1	

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

NOTES:

NOTE 1 = Parts are installed on corresponding "S" reference designators in Figure 5-2.

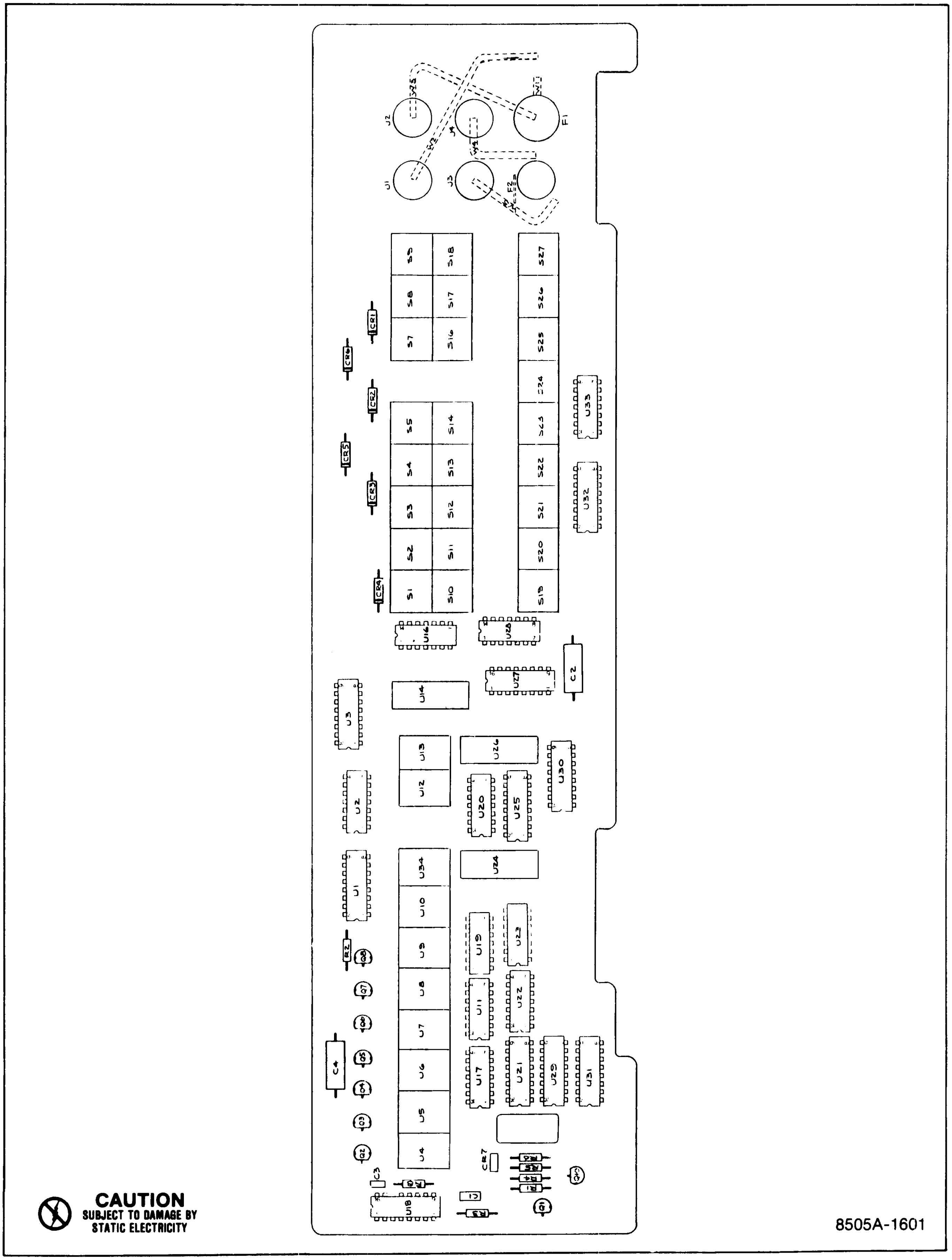

Figure 5-2. A1 Front Panel Display PCB Assembly

Table 5-3. A2 Motherboard PCB Assembly
(See Figure 5-3.)

REFERENCE DESIGNATOR -A>-NUMERICS---->		S	---DESCRIPTION---	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
H	1		SPACER,SWAGED,.250 RND,BR,4-40,.070	343996	9W423	9533B-B0440	2	
H	2		SPACER,SWAGED,.250 RND,BR,6-32,.187	351882	9W423	9533B-B-0632	3	
J	1, 14, 17		CONN,PWB EDGE,REC,.150CTR,8 POS	354951	00779	583407-5	3	
J	2		CONN,PWB EDGE,REC,.150CTR,18 POS	291906	00779	1-583407-0	1	
J	3, 5, 8,13A,		CONN,PWB EDGE,REC,.150CTR,4 POS	417550	00779	1-583694-1	7	
J	13B,13C,13D							
J	6		CONN,PWB EDGE,REC,.150CTR,20 POS	291914	00779	1-583407-1	1	
J	9		CONN,PWB EDGE,REC,.150CTR,16 POS	408484	00779	583407-9	1	
J	11A,11B,11C		CONN,PWB EDGE,REC,.150CTR,40 POS	422550	00779	2-583407-0	12	
J	11D,21G,22H			422550				
J	23H,29K,30K			422550				
J	31L,31M,31N			422550				
J	12A,12B,12C		CONN,PWB EDGE,REC,.150CTR,6 POS	291625	00779	583407-4	4	
J	12D							
MP	1		INS,FILM,MYLAR ADHSV,0.005THK	380923	89536	380923	35	
MP	2		CONN ACC,PWB EDGE,POLARIZING INSERT	293498	00779	530030-1	14	
MP	3		PIN,SINGLE,PWB,0.025 SQ	267500	00779	87623-1	4	
Q	1	*	PHOTOTRANS,DARLINGTON DETECTOR	742072	04713	MRD711	1	
R	1		RES,CF,1K,+-5%,0.25W	343426	59124	CF1-4 102 J B	1	
S	1		SWITCH,SLIDE,DPDT	697466	7Z884	SSS522	1	

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

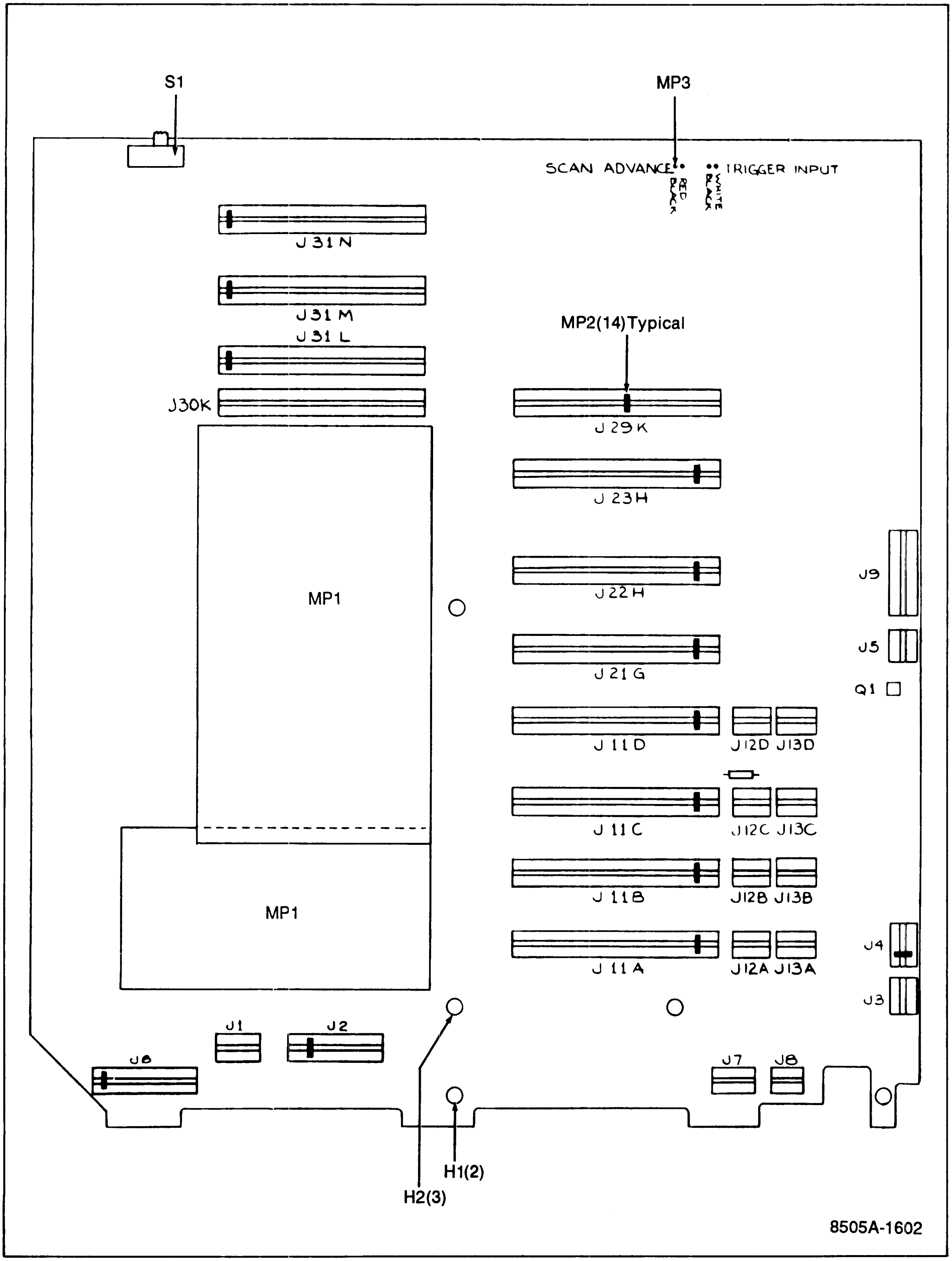

Figure 5-3. A2 Motherboard PCB Assembly

Table 5-4. A3 Isolator PCB Assembly
(See Figure 5-4.)

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, 4		CAP,MICA,220PF,+-5%,500V	170423	93790	CD15FD221J03	2	
C 2		CAP,MICA,18PF,+-5%,500V	266585	93790	CD15CD180J03	1	
C 3		CAP,CER,150PF,+-2%,100V,C0G	512988	04222	SR151A151JAT	1	
C 5		CAP,MICA,68PF,+-5%,500V	148510	93790	CD15ED680J03	1	
C 6		CAP,TA,39UF,+-20%,6V	163915	56289	199D396X0006DA2	1	
C 7		CAP,AL,150UF,+50-10%,16V	186296	62643	SM16T151T8X18LL	1	
C 8, 9		CAP,MICA,27PF,+-5%,500V	177998	93790	CD15ED270J03	2	
C 10, 12, 13,		CAP,CER,0.22UF,+-20%,50V,Z5U	309849	04222	SR215E224MAA	4	
C 16			309849				
C 11		CAP,CER,0.0047UF,+-10%,500V,Z5R	106724	60705	562CX5RCK501AJ472K	1	
C 17, 18, 20		CAP,CER,0.01UF,+-20%,50V,X7R	816249	04222	SR075C103MAATR1A	3	
CR 1, 2	*	DIODE,SI,BV= 75.0V,IO=150MA,500MW	698720	65940	1N4448	2	
H 1		SPRING,COIL,COMP,M WIRE,.380,.120	424465	83553	C0121-014-0380M	2	
H 2		SCREW,PH,P,STL,4-40,.625	868138	COMMERCIAL		2	
H 3		SPACER,SWAGED,.250 RND,BR,4-40,.500	380519	9W423	9537B-B-0440	2	
L 1		CHOKE,6TURN	320911	89536	320911	1	
MP 1		ISOLATOR,MODULE CASE ASSY (MP2-MP9)	486407	89536	486407	1	1
MP 2		DECAL,ISOLATOR/EXT.TRIGGER	477570	89536	477570	1	
MP 3		CASE HALF,MODULE	402990	89536	402990	2	
MP 4		COVER,MODULE CASE	794560	89536	794560	1	
MP 5		GUARD,FRONT,ISOLATOR,LEFT	487298	89536	487298	1	
MP 6		GUARD,REAR ISOLATOR	437947	89536	437947	1	
MP 7		SHIELD,COVER,ISOLATOR	437939	89536	437939	2	
MP 8.		GUARD,FRONT,ISOLATOR,RIGHT	487280	89536	487280	1	
MP 9		GUARD REAR,ISOLATOR,(RIGHT)	383349	89536	383349	1	
Q 1	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1	
Q 2	*	TRANSISTOR,SI,NPN,SELECTED IEBO,TO-92	218396	04713	2N3904	1	
R 1		RES,CF,220,+-5%,0.25W	574244	59124	CF1-4 221 J B	1	
R 2, 5, 8-		RES,CF,10K,+-5%,0.25W	573394	59124	CF1-4 103 J B	11	
R 13, 24- 26			573394				
R 3		RES,CF,47K,+-5%,0.25W	348896	59124	CF1-4 473 J B	1	
R 4, 7		RES,CF,4.7K,+-5%,0.25W	573311	59124	CF1-4 472 J B	2	
R 6		RES,CF,1K,+-5%,0.25W	343426	59124	CF1-4 102 J B	1	
R 14, 20		RES,CF,150,+-5%,0.25W	343442	59124	CF1-4 151 J B	2	
R 15		RES,CF,470,+-5%,0.25W	573121	59124	CF1-4 471 J B	1	
R 17		RES,CF,1K,+-5%,0.25W	573170	59124	CF1-4 102 J B	1	
R 18		RES,CF,100K,+-5%,0.25W	573584	59124	CF1-4 104 J B	1	
R 21		RES,CF,47K,+-5%,0.25W	573527	59124	CF1-4 473 J B	1	
T 1, 3, 6,		TORO,ISOLATOR	437608	89536	437608	4	
T 8			437608				
T 2, 4, 5,		TORO,ISOLATOR	437590	89536	437590	4	
T 7			437590				
U 1, 2, 5	*	IC,CMOS,HEX BUFFER	381830	04713	MC14050BCP	3	
U 3, 7	*	IC,TTL,8BIT PAR-IN,SER-OUT SHIFT RGS	293118	01295	SN74165N	2	
U 4, 15	*	IC,TTL,QUAD 2 INPUT NAND W/OPEN COL	408021	01295	SN7426N	2	
U 6, 24	*	IC,LSTTL,HEX INVERTER	393058	01295	SN74LS04N	2	
U 8, 14, 23	*	IC,LSTTL,RETRG MONOSTAB MULTIVB W/CLR	404186	01295	SN74LS123N	3	
U 9	*	IC,STTL,QUAD 2 INPUT NAND GATE	363580	01295	SN74S00N	1	
U 10	*	IC,LSTTL,TRIPLE 3 INPUT NAND GATE	393074	01295	SN74LS10N	1	
U 11, 19	*	IC,LSTTL,QUAD 2 INPUT NOR GATE	393041	01295	SN74LS02N	2	
U 12, 22, 26	*	IC,CMOS,QUAD 2 INPUT NOR GATE	355172	04713	MC14001BCP	3	
U 13, 21	*	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	04713	MC14503BCP	2	
U 16, 20	*	IC,TTL,8BIT SER-IN,PAR-OUT R-SHFT RGS	272138	01295	SN741642N	2	
U 17		RES,CERM,DIP,16 PIN,15 RES,10K,+-5%	355305	91637	MDP16-03-103J	1	
U 18	*	IC,CMOS,QUAD 2 INPUT AND GATE	408401	04713	MC14081BCP	1	
U 25	*	IC,CMOS,TRIPLE 3 INPUT NOR GATE	355180	04713	MC14025BCP	1	
U 31	*	IC,CMOS,DUAL D F/F,+EDG TRIG	340117	04713	MC14013BCP	1	
U 32	*	IC,CMOS,FAST QUAD 2 INPUT NAND GATE	413211	04713	MC14011BCP	1	
U 33	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	04713	MC14023UBCP	1	
U 35	*	IC,CMOS,HEX SCHMITT TRIGGER	477810	27014	MM74C914N	1	
W 1		WIRE,TEF,UL1180,22AWG,SOLID,WHT	654897	89536	654897	1	
W 2		WIRE,COPPER,BUS,20AWG	212704	89536	212704	1	
W 3		JUMPER,WIRE,NONINSUL,.125CTR	529719	89536	529719	1	

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

NOTES:

NOTE 1 = Use P/N 486407 to order case without pcb assembly.

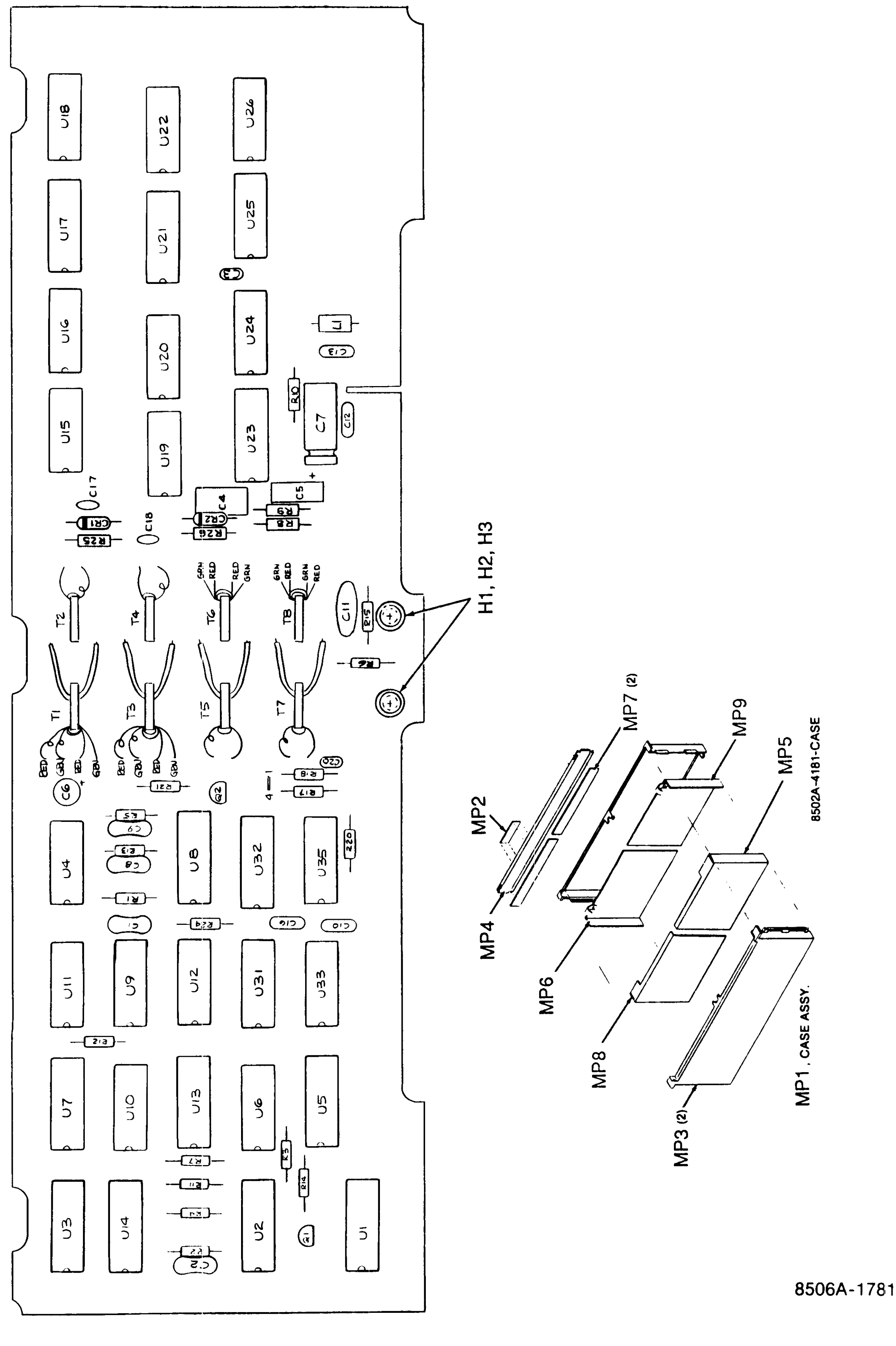

Figure 5-4. A3 Isolator PCB Assembly

Table 5-5. A4 Power Supply PCB Assembly
(See Figure 5-5.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	--------------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE -E-
BR 1- 3		DIODE,SI,RECT,BRIDGE,BV=200V,IO=1.5A	296509	30800	KBP 02M	3	
BR 4		DIODE,SI,RECT,BRIDGE,BV=50V,IO=3.0A	586115	30800	KBL 005	1	
C 1, 2		CAP,AL,330UF,+50-20%,100V	484436	62643	SM100VB331M16X35LLV	2	
C 3, 4, 6,		CAP,AL,470UF,+50-20%,50V	478792	62643	SM50VB47110X20LLV	4	
C 7			478792				
C 5		CAP,AL,3300UF,+30-10%,16V,SOLV PROOF	603472	62643	KME16VN332K23X27LLV	1	
C 8		CAP,AL,15000UF,+30-10%,16V,SOLV PROOF	603480	62643	KME16VN153Q31X37LLV	1	
C 9- 11, 17		CAP,AL,4.7UF,+-20%,35V	603993	62643	LL35VB4R7M5X11LLV	4	
C 12- 14, 21-		CAP,CER,0.22UF,+-20%,50V,Z5U	309849	04222	SR215E224MAA	7	
C 24			309849				
C 15, 16		CAP,CER,5000PF,+-20%,250V,X7R	485839	40402	WY12-5000PF/250V 20%-1	2	
C 18- 20		CAP,AL,2.2UF,+-20%,50V	614875	62643	LL50VB2R2M5X11C3	3	
C 25		CAP,CER,0.1UF,+-20%,100V,Z5V	149146	60705	565CZ5UBA101AW104M	1	
CR 1, 2, 5		DIODE,SI,50 PIV,2.0 AMP	347559	14936	P-300A-031	3	
CR 3, 4		DIODE,SI,100 PIV,1.0 AMP	698555	04713	IN4002RL	2	
F 1		FUSE,.25X1.25,0.5A,250V,SLOW	109322	71400	MDL-1/2	1	
FL 1		FILTER,LINE,250VAC-3A,IEC RECEPTACLE	721274	54583	ZUB2203-00	1	
H 1		WASHER,SHLDR,NYL,.115,.200,.030	436386	55566	5587 N 136 030 115	7	
H 2		WASHER,LOCK,INTRNL,S STEEL,#4	529255	COMMERCIAL		2	
H 3		SCREW,PH,P,STL,LOCK,4-40,.250	129890	COMMERCIAL		2	
H 4		SCREW,RH,SL,NYL,4-40,.250	574780	27440	1020-004-4B	5	
H 5		SCREW,PH,P,STL,LOCK,4-40..375	152124	COMMERCIAL		2	
H 6		SCREW,CAP,BH SCKT,STL,4-40,.500	528307	COMMERCIAL		2	
H 7		SCREW,PH,P,STL,LOCK,8-32,.375	114124	COMMERCIAL		2	
H 8		SCREW,PH,P,SS,LOCK,8-32,.375	559054	COMMERCIAL		3	
H 9		NUT,HEX,STL,4-40	184044	COMMERCIAL		5	
H 10		NUT,HEX,STL,8-32	110544	COMMERCIAL		2	
H 11		WASHER,LOCK,INTRNL,STEEL,#4	110403	COMMERCIAL		2	
H 12		WASHER,LOCK,INTRNL,STEEL,#8	110320	COMMERCIAL		2	
H 13		SCREW,RH,SL,NYL,4-40,.500	619205	COMMERCIAL		1	
H 14		SCREW,PH,P,SEMS,STL,6-32,.375	177022	COMMERCIAL		2	
H 15		SCREW,PH,P,STL,LOCK,6-32,.250	152140	COMMERCIAL		2	
H 16		WASHER,LOCK,EXTRNL,STEEL,0.500 ID	175943	COMMERCIAL		1	
H 17		SPACER,SWAGED,.250 RND,BR,4-40,1.750	658096	55566	3071-B-440-B-14	2	
MP 1		INSULATOR, POWER SWITCH	383158	89536	383158	1	
MP 2		INSUL PART,POWER,SI,.687,.562	508630	55285	7403-09FR-51	7	
MP 3		HEAT SINK	639864	89536	639864	1	
MP 4		HEAT DIS,VERT,1.18X1.00X0.50,TO-220	414128	13103	6030B-TT	1	
MP 5		HEATSINK, POWER SUPPLY, FINISHED	873674	89536	873674	1	
MP 6		SHIELD, POWER SUPPLY	639856	89536	639856	1	
MP 7		NUTPLATE	639807	89536	639807	1	
MP 8		INSULATOR,GASKET	654467	89536	654467	1	
MP 9		BRACKET,RT ANGLE,STL,8-32	166322	73734	J-1552	2	
MP 10		HLDR PART,FUSE,CAP,1/4X1-1/4	460238	61935	031.1666	1	
MP 11		TERM,RING 1/16 & 1/4,SOLDR	102558	79963	124	2	
MP 12		LABEL,WARNING	386250	22670	386250	2	
MP 13		INSULATOR,XFMR BASE	646133	89536	646133	1	
MP 14		SHIELD,DRAWN ALUM	650481	89536	650481	1	
MP 15		SUPPORT,HEAT SINK	646208	89536	646208	1	
MP 16		CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	06383	SST-1M	2	
R 1		RES,CF,3.3K,+-5%,0.25W	348813	59124	CF1-4 332 J B	1	
R 3, 4		RES,CF,390,+-5%,0.25W	441543	59124	CF1-4 391 J B	2	
R 5, 6		RES,VAR,CERM,50,+-20%,0.5W	320861	80294	3329H-1-500	2	
R 7		RES,CF,240,+-5%,0.25W	376624	59124	CF1-4 241 J B	1	
R 8		RES,CF,2.4K,+-5%,0.25W	441493	59124	CF1-4 242 J B	1	
R 9		RES,VAR,CERM,500,+-20%,0.5W	226068	80294	3329H-1-501	1	
S 1, 3		SWITCH,SLIDE,DPDT,POWER	234278	82389	11A1297A	2	
S 2		SWITCH, ON-OFF	453605	31918	453605	1	
T 1		POWER TRANSFORMER & HEADER	639815	89536	639815	1	
TP 1- 10		TERM,FASTON,TAB,.110,SOLDER	512889	00779	62395-1	10	
U 1	*	IC,VOLT REG,FIXED,+15 VOLTS,1.5 AMPS	413187	04713	MC7815CT	1	
U 2, 4	*	IC,VOLT REG,FIXED,-15 VOLTS,1.5 AMPS	413179	04713	MC7915CT	2	
U 3	*	IC,VOLT REG,ADJ,1.2 TO 37 V,1.5 AMPS	460410	27014	LM317T	1	
U 5	*	IC,VOLT REG,FIXED,+5 VOLTS,1.5 AMPS	355107	04713	MC7805CT	1	
U 6	*	IC,VOLT REG,FIXED,+12 VOLTS,1.5 AMPS	428854	04713	MC7812CT	1	
U 7	*	IC,VOLT REG,FIXED,-12 VOLTS,1.5 AMPS	381665	04713	MC7912CT	1	
U 8	*	IC,VOLT REG,FIXED,+5 VOLTS,1.5 AMPS	428847	04713	MC7805T	1	
W 1		WIRE,TEF,UL1180,22AWG,STRN,WHT	115667	89536	115667	1	
W 2		WIRE,TEF,UL1180,18AWG,STRN,GRN/YEL	386177	89536	386177	1	
W 3		WIRE,TEF,UL1180,22AWG,STRN,BLK	115774	89536	115774	1	
XF 1		HLDR PART,FUSE,BODY 1/4X1-1/4,5X20MM	375188	61935	031.1653	1	

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

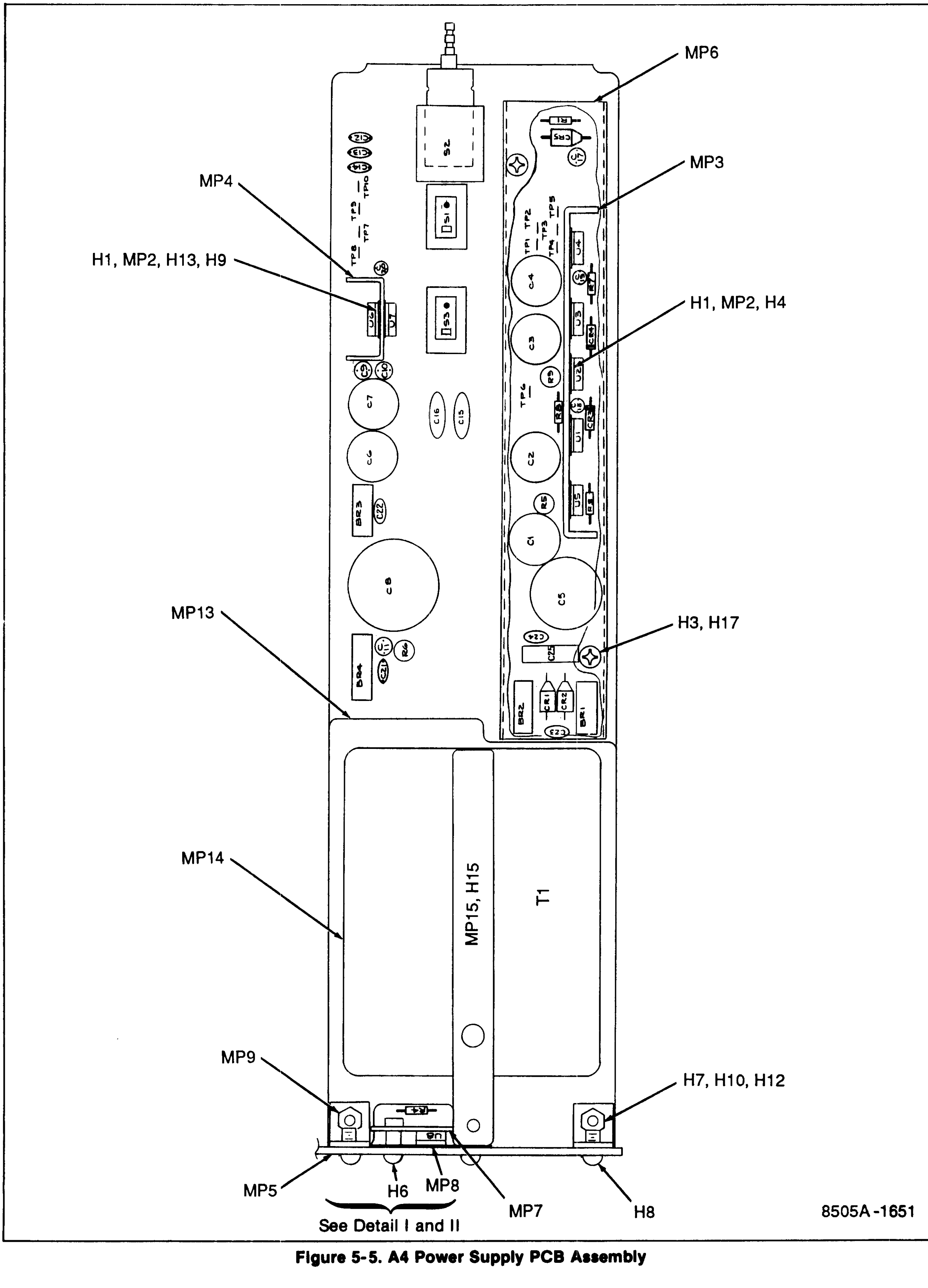

Figure 5-5. A4 Power Supply PCB Assembly

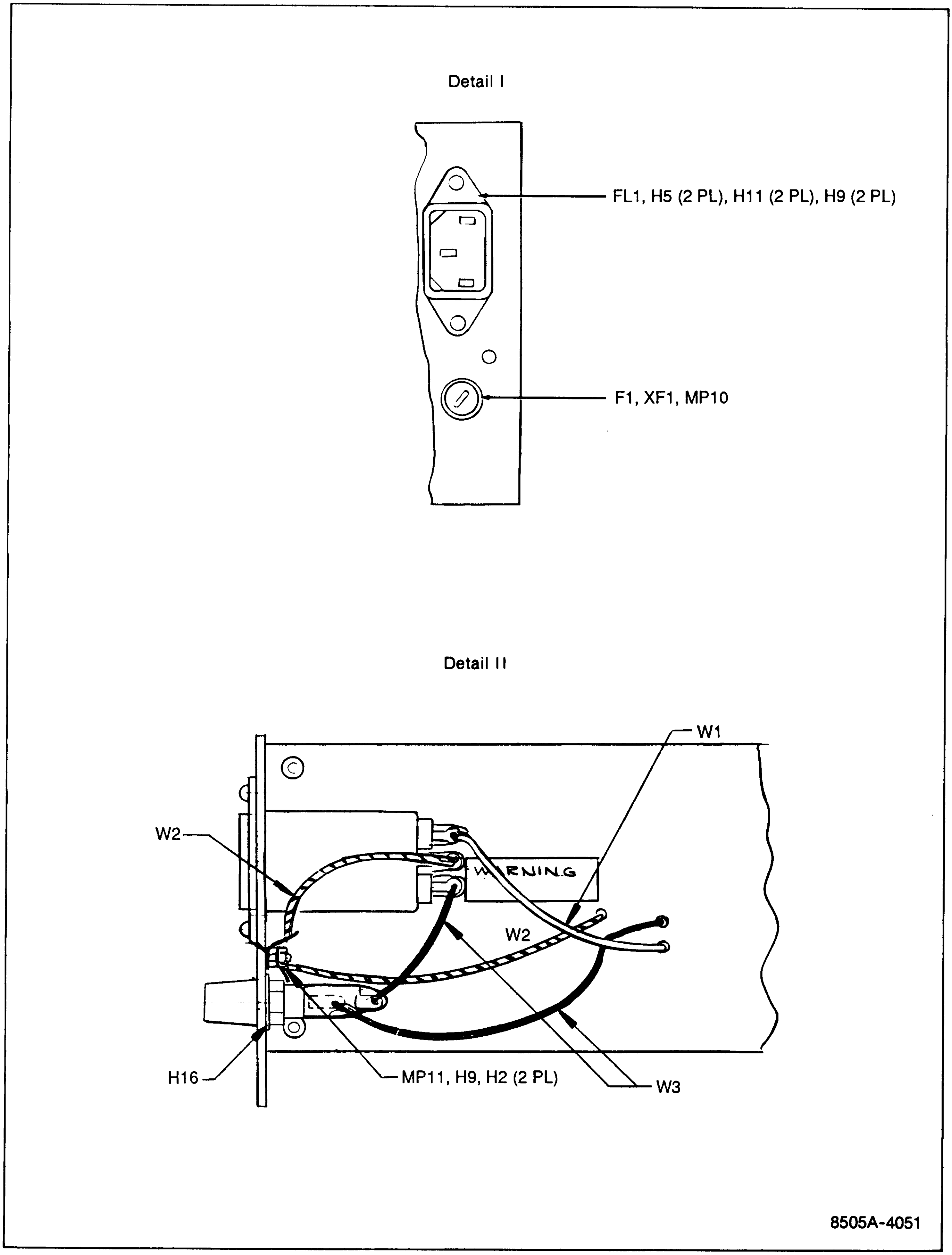

Figure 5-5. A4 Power Supply PCB Assembly (cont)

Table 5-6. A5 Power Supply Interconnect PCB Assembly
(See Figure 5-6.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	--------------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	N O T -E-
J 1		CONN,PWB EDGE,REC,.150CTR,14 POS	352682	00779	583694-2	1	
J 2		CONN,PWB EDGE,REC,.150CTR,6 POS	291625	00779	583407-4	1	
MP 1		CONN ACC,PWB EDGE,POLARIZING INSERT	293498	00779	530030-1	1	

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

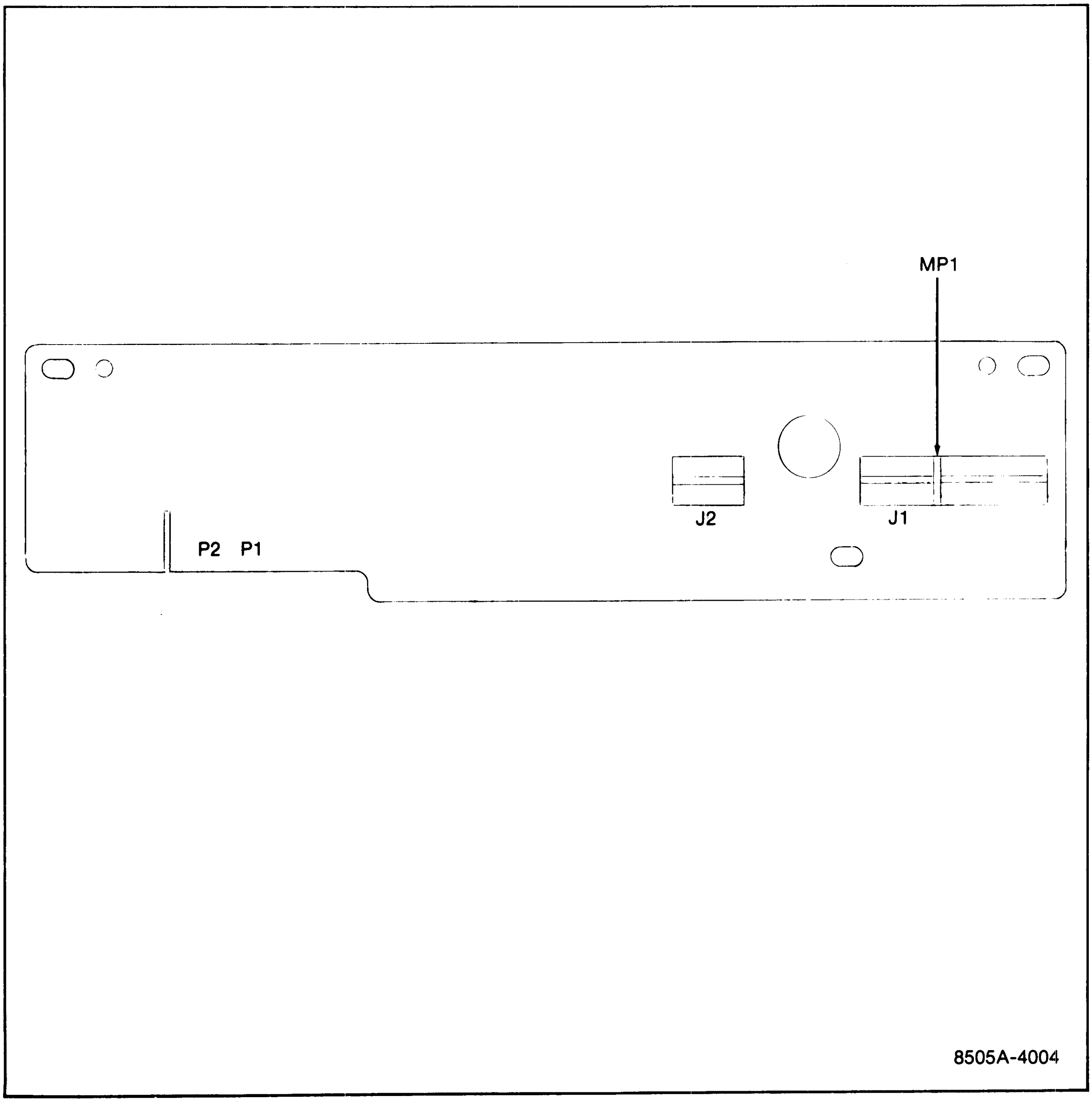

Figure 5-6. A5 Power Supply Interconnect PCB Assembly

Table 5-7. A6 Controller PCB Assembly
(See Figure 5-7.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	--------------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
C 1, 3, 5-		CAP,CER,0.22UF,+80-20%,50V,Z5U	649939	04222	SR595E224ZAATR1A	20	
C 7, 10- 12,			649939				
C 15, 17- 20,			649939				
C 22- 25, 27,			649939				
C 28, 30			649939				
C 2		CAP,CER,1800PF,+-5%,50V,C0G	832717	04222	SR595A182JAATR1A	1	
C 4		CAP,TA,6.8UF,+-10%,35V	182782	56289	150D685X9035B2	1	
C 8		CAP,TA,39UF,+-20%,6V	163915	56289	199D396X0006DA2	1	
C 9		CAP,POLYES,0.01UF,+-10%,50V	715037	60935	185-2/0.01/K/0050/R/A/B	1	
C 13		CAP,CER,33PF,+-5%,50V,C0G	714543	04222	SR595A330JAATR1A	1	
C 14		CAP,POLYES,0.1UF,+-10%,50V	649913	60935	185-2/0.1/K/0050/R/A/B	1	
C 16, 21, 26,		CAP,AL,47UF,+75-20%,25V	655191	62643	SM25T470M13X31LL	4	
C 29			655191				
CR 1	*	DIODE,SI,BV= 75.0V,IO=150MA,500MW	698720	65940	1N4448	1	
CR 2, 3	*	ZENER,UNCOMP,5.1V,5%,20.0MA,0.5W	535476	04713	IN5231B	2	
H 1		SPRING,COIL,COMP,M WIRE,.380,.120	424465	83553	C0121-014-0380M	1	
H 2		SCREW,PH,P,SS,LOCK,4-40,.375	256164	COMMERCIAL		1	
H 3		SPACER,SWAGED,.250 RND,BR,4-40,.187	335604	9W423	9533B-B-0440	1	
L 1		CHOKE,6TURN	320911	89536	320911	1	
MP 1		CASE, CONTROLLER ASSEMBLY (MP2-MP7)	638510	89536	638510	1	1
MP 2		CASE HALF,MODULE	402990	89536	402990	2	
MP 3		COVER,MODULE CASE	794560	89536	794560	1	
MP 4		GUARD, FRONT	383356	89536	383356	1	
MP 5		GUARD, REAR	383364	89536	383364	1	
MP 6		SHIELD, COVER	652172	89536	652172	1	
MP 7		DECAL, CONTROLLER	640359	89536	640359	1	
MP 8		PAD, ADHESIVE	735365	89536	735365	1	
R 1		RES,CF,200K,+-5%,0.25W	573634	59124	CF1-4 204 J B	1	
R 2		RES,CF,1M,+-5%,0.25W	573691	59124	CF1-4 105 J B	1	
R 3, 6		RES,CF,10K,+-5%,0.25W	573394	59124	CF1-4 103 J B	2	
R 4, 5, 9		RES,CF,1.5K,+-5%,0.25W	573212	59124	CF1-4 152 J B	3	
R 8		RES,CF,33K,+-5%,0.25W	573485	59124	CF1-4 333 J B	1	
R 10		RES,CF,2.7K,+-5%,0.25W	573261	59124	CF1-4 272 J B	1	
R 15		RES,CF,6.2K,+-5%,0.25W	573345	59124	CF1-4 622 J B	1	
RN 1, 2, 4		RES,CERM,SIP,10 PIN,9 RES,6.2K,+-2%	501536	91637	CSC10A-01-622G	3	
RN 3		RES,CERM,SIP,10 PIN,9 RES,2K,+-2%	446880	91637	CSC10B-01-202G	1	
RN 5		RES,CERM,DIP,16 PIN,8 RES,2K,+-5%	574905	91637	MDP16-03-202J	1	
TP 1- 7		JUMPER,WIRE,NONINSUL,0.200CTR	816090	91984	150T1	7	
U 1	*	IC,LSTTL,DUAL J-K F/F,+EDG TRIG	412999	01295	SN74LS109AN	1	
U 2	*	IC,CMOS,DUAL MONOSTABLE MULTIBRATOR	454017	04713	MC14538BCP	1	
U 3	*	IC,CMOS,DUAL SYNC BINRY UP CNTR	355164	04713	MC14520BCP	1	
U 4	*	IC,CMOS,PHASE LOCKED LOOP,16 PIN DIP	403584	04713	MC14046BCP	1	
U 5, 27	*	IC,LSTTL,QUAD 2 IN NAND W/SCHMT TRIG	504449	01295	SN74LS132N	2	
U 6	*	IC,LSTTL,TRIPLE 3 INPUT AND GATE	393082	01295	SN74LS11N	1	
U 7, 9	*	IC,CMOS,DUAL D F/F,+EDG TRG W/SET&RST	536433	04713	MC14013BCP	2	
U 8, 16	*	IC,CMOS,TRIPLE 3 INPUT NOR GATE	586453	04713	MC14025UBCP	2	
U 10	*	IC,CMOS,HEX INVERTER	381848	04713	MC14049UBCP	1	
U 11	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	04713	MC14023UBCP	1	
U 12	*	IC,LSTTL,QUAD D F/F,+EDG TRG,W/CLR	393215	01295	SN74LS175N	1	
U 13	*	IC,LSTTL,OCTL INV LINE DRVR W/3-STATE	429480	01295	SN74LS240N	1	
U 14	*	IC,CMOS,QUAD 2 INPUT NAND GATE	355198	04713	MC14011UBCP	1	
U 15	*	IC,NMOS,8 BIT MICROPROCESSOR	404541	34649	P8080A	1	
U 17, 26	*	IC,CMOS,QUAD 2 INPUT NOR GATE	355172	04713	MC14001BCP	2	
U 18	*	IC,256 X 4,PROM,PROGRAMMED	722744	01295	TBP14S10N	1	
U 19	*	IC,STTL,CLOCK GENERATOR	586230	34649	P8224	1	
U 20		IC, 512X8 EEPROM	722348	60395	X2804AP-45	1	
U 21	*	IC,CMOS,8 BIT PRIORITY ENCODER	412973	04713	MC14532BCP	1	
U 22	*	IC, 2K X 8 STAT RAM	584144	49569	IDT6116SA-45P	1	
U 23	*	PROM,PROGRAMMED	660449	89536	660449	1	
U 24	*	PROM,PROGRAMMED	660456	89536	660456	1	
U 25	*	IC,CMOS,OCTAL BUS TRANSCEIVER	722017	27014	MM74HCT245N	1	
U 28	*	IC,LSTTL,8BIT S-IN, P-OUT R-SHIFT RGS	408732	01295	SN74LS164N	1	
W 3		JUMPER,WIRE,NONINSUL,0.200CTR	816090	91984	150T1	1	
W 4, 6		JUMPER,WIRE,TEFLON INSUL,0.500CTR	484311	60386	J.TEFLON .500	2	
XU 18, 19		SOCKET,IC,16 PIN	276535	00779	2-640358-1	2	
XU 15		SOCKET,IC,40 PIN	429282	00779	2-640379-1	1	
XU 20, 22		SOCKET,IC,24 PIN	376236	00779	2-640361-1	2	
XU 23, 24		SOCKET,IC,28 PIN	448217	91506	228-AG39D	2	
Y 1		CRYSTAL,15.36MHZ,+-0.05%,HC-18/U	642728	5W664	15.36MHZ,.01%,HC-18/U	1	

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

NOTES:

NOTE 1 = Use P/N 638510 to order case without pcb assembly.
NOTE 2 = The following parts are shown on Figure 5-7, but are not installed on the 8506A A6 PCB: W1, W2, W3

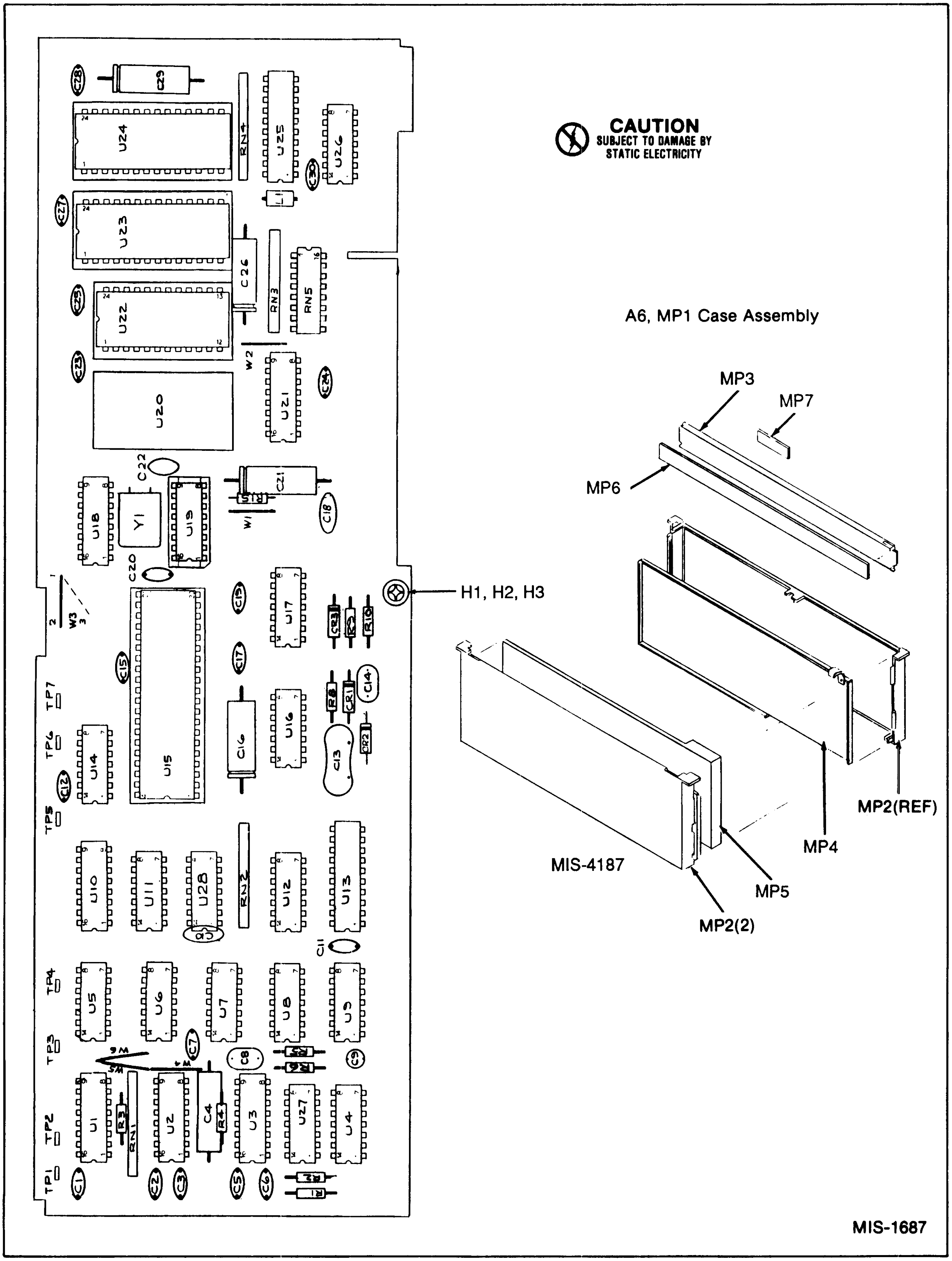

Figure 5-7. A6 Controller PCB Assembly

Table 5-8. A7 Front/Rear Switch PCB Assembly
(See Figure 5-8.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
CR 1		LED,RED,PCB MOUNT,LUM INT= >0.6 MCD	385914	09214	SSL-22	1	
E 1		SURGE PROTECTOR,145V,+-20%	442731	25088	B1-C145	1	
F 1, 2, 5,		FUSE,.406X.312,3A,300V,FAST,AXIAL	643833	71400	IJ0272	4	
F 6			643833				
F 3		FUSE,.25X1.25,1.5A,250V,FAST	739888	75915	31201.5	1	
F 4		WIRE,MAGNET,36H,130C,NYLEZE	160978	89536	160978	1	
H 1		NUT,PRESS,CLINCH,SS,2-56	603688	COMMERCIAL		2	
H 2		SCREW,CAP,SCKT,STL,2-56,.625	851733	COMMERCIAL		4	
H 3		WASHER,LOCK,EXTRNL,STEEL,0.500 ID	175943	COMMERCIAL		1	
H 4		SCREW,FH,P,SS,LOCK,2-56,.375	614388	COMMERCIAL		2	
J 1		REAR INPUT CABLE ASSY	639609	89536	639609	1	
J 2		CONN,HV,CABLE,REC/PLUG,2 CONTACT	603712	89536	603712	1	
L 1		RESISTOR COIL ASSEMBLY	438325	89536	438325	1	
L 2		ASSY,COMMON MODE CHOKE	656629	89536	656629	1	
MP 1		SPACER,SWAGED,.250 RND,BR,6-32,.265	650192	89536	650192	3	
MP 2		PIN,SINGLE,PWB,0.025 SQ	267500	00779	87623-1	2	
MP 3		SPACER,LED MOUNT,NYL,RIGHT ANGLE	658161	89536	658161	1	
MP 4		PLATE,REAR INPUT	651760	89536	651760	1	
MP 5		CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	06383	SST-1M	1	
MP 6		HLDR PART,FUSE,CAP,1/4X1-1/4	460238	61935	031.1666	1	
MP 7		DECAL,PLATE,REAR INPUT	680751	89536	680751	1	
R 1		RES,CF,330,+-5%,0.25W	368720	59124	CF1-4 331 J B	1	
R 2		THERMISTOR,RECT.,POS.,1K,+-40%,25C	494740	51406	PTH511G12BF102Q1000	1	
R 3, 4		RES,MF,30.9K,+-1%,0.5W,100PPM	247569	91637	CMF65 3092 F T-1	2	
R 5		RES,CF,270,+-5%,0.25W	348789	59124	CF1-4 271 J B	1	
S 1		PUSHBUTTON SWITCH 10POLE	647149	31918	647149	1	
S 2, 3		PUSHBUTTON SWITCH-2POLE	647131	31918	647131	2	
W 1, 3		WIRE,TEF,UL1180,22AWG,STRN,RED	115576	89536	115576	2	
W 2		WIRE,TEF,UL1180,22AWG,STRN,BLU	115675	89536	115675	1	
XF 3		HLDR PART,FUSE,BODY 1/4X1-1/4,5X20MM	375188	61935	031.1653	1	
XJ 2		CONN ACC,HV,CABLE HOOD	603720	88245	JFA2H	1	

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

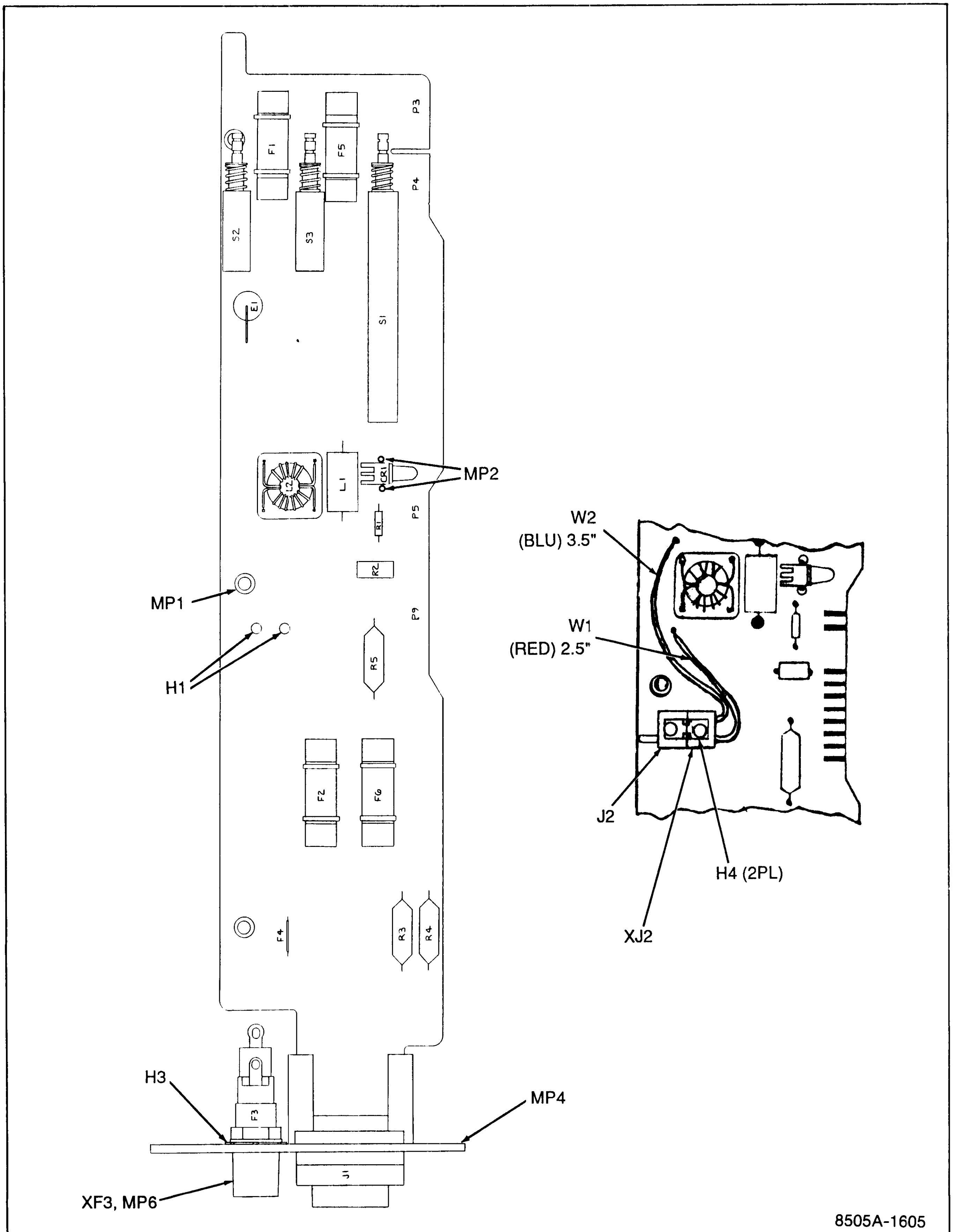

Figure 5-8. A7 Front/Rear Switch PCB Assembly

Table 5-9. A8 DC Signal Conditioner PCB Assembly
(See Figure 5-9)

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- 4		CAP,TA,4.7UF,+-20%,25V	161943	56289	199D475X0025BA2	4	
C	5		CAP,TA,39UF,+-20%,6V	163915	56289	199D396X0006DA2	1	
C	6		CAP,POLYPR,1000PF,+-1%,100V	844816	40402	KP1830102011%	1	
C	10, 11		CAP,AL,10UF,+-20%,50V,SOLV PROOF	799437	62643	KMC50VB10RM5X11RP	2	
C	12, 14		CAP,MICA,100PF,+-5%,500V	148494	93790	CD15FD101J03	2	
C	13		CAP,CER,0.01UF,+80-20%,100V,Z5V	149153	60705	562CZ5UCK101AF103Z	1	
C	15, 16		CAP,MICA,47PF,+-5%,500V	148536	93790	CD15ED470J03	2	
C	18, 19		CAP,CER,33PF,+-2%,50V,C0G	354852	04222	SR211A330GAA	2	
C	20		CAP,MICA,680PF,+-5%,500V	148403	93790	CD19FD681J03	1	
CR	1, 2, 7,	*	DIODE,SI,BV=75V,IO=150MA,500MW	203323	15818	1N4448	4	
CR	8	*		203323				
CR	5, 6	*	DIODE,SI,BV= 20.0V,IO= 50MA,SELCTD IR	348177	07263	FD7223	2	
CR	3, 4	*	ZENER,UNCOMP,22.0V,5%,5.6MA,0.4W	181073	04713	1N969B	2	
H	1		SCREW,PH,P,SS,LOCK,4-40,.375	256164	COMMERCIAL		1	
H	2		SPACER,SWAGED,.250 RND,BR,4-40,.187	335604	9W423	9533B-B-0440	1	
H	3		SPRING,COIL,COMP,M WIRE,.380,.120	424465	83553	C0121-014-0380M	1	
K	1, 2		RELAY,ARMATURE,4 FORM C,5V,LATCH	715078	61529	DS4EML2DC5VCH239	2	
MP	1		CASE,D.C.SIGNAL CONDITIONER (MP2-MP7)	651877	89536	651877	1	1
MP	2		DECAL, D.C. SIGNAL CONDITIONER	640391	22670	640391	1	
MP	3		CASE HALF,MODULE	402990	89536	402990	2	
MP	4		COVER,MODULE CASE	794560	89536	794560	1	
MP	5		GUARD, FRONT	383356	89536	383356	1	
MP	6		GUARD, REAR	383364	89536	383364	1	
MP	7		SHIELD,COVER, DC SIGNAL CONDITIONER	411918	2M021	411918	1	
MP	8		DECAL, D C SIGNAL CONDITIONER	651950	89536	651950	1	
MP	9		PAD, ADHESIVE	735365	89536	735365	1	
Q	1, 3, 7,	*	TRANSISTOR,SI,NPN,SELECTED IEBO,TO-92	218396	04713	2N3904	13	
Q	10- 13, 22,	*		218396				
Q	23, 32, 34,	*		218396				
Q	36, 38	*		218396				
Q	2, 4, 6,	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	04713	2N3906	6	
Q	31, 33, 35	*		195974				
Q	5	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1	
Q	8, 14- 16	*	TRANSISTOR,SI,N-JFET,HI-VOLTAGE,TO-92	393314	17856	J2086	4	
Q	18	*	TRANSISTOR,SI,NPN,DUAL,TO-78,HI-BETA	585109	34371	ITS31897	1	
Q	19	*	TRANSISTOR,SI,NPN,DUAL,TO-52	295717	18786	MP312-60	1	
Q	37	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	218388	07263	PN3645	1	
R	1		RES,CF,330,+-5%,0.25W	368720	59124	CF1-4 331 J B	1	
R	2, 3, 18,		RES,CF,3.3K,+-5%,0.25W	348813	59124	CF1-4 332 J B	4	
R	19			348813				
R	6		RES,CC,12,+-5%,0.5W	187831	01121	EB1205	1	
R	7		RES,CF,2.7K,+-5%,0.25W	386490	59124	CF1-4 272 J B	1	
R	8		RES,CC,150K,+-5%,2W	110122	01121	HB1541	1	
R	9		RES,CC,150K,+-10%,0.5W	108167	01121	EB1541	1	
R	10		RES,CF,150,+-5%,0.25W	343442	59124	CF1-4 151 J B	1	
R	11		RES,CF,47K,+-5%,0.25W	348896	59124	CF1-4 473 J B	1	
R	12, 13		RES,CF,15,+-5%,0.25W	348755	59124	CF1-4 150 J B	2	
R	14, 20,100,		RES,CF,1K,+-5%,0.25W	343426	59124	CF1-4 102 J B	4	
R	101			343426				
R	15, 93- 95		RES,CF,1M,+-5%,0.25W	348987	59124	CF1-4 105 J B	4	
R	16, 17, 87-		RES,CF,100K,+-5%,0.25W	348920	59124	CF1-4 104 J B	8	
R	92			348920				
R	24- 26		PRECISION RESISTOR DIVIDER SET	648212	89536	648212	1	
R	30		RES,CF,15K,+-5%,0.25W	348854	59124	CF1-4 153 J B	1	
R	31- 34		RES,CF,10K,+-5%,0.25W	348839	59124	CF1-4 102 J B	4	
R	35, 62		RES,MF,1M,+-1%,0.125W,100PPM	268797	91637	CMF55 1004 F T-1	2	
R	36	*	RES,CERM,100M,+-10%,1W	441758	64537	FL1 100M 10% 250	1	
R	47		RES,VAR,CERM,200,+-20%,0.5W	284711	80294	3009P-1-201	1	
R	48, 49		RES,VAR,CERM,50,+-20%,0.5W	267815	80294	3009P-1-500	2	
R	50		RES,CF,2.2,+-5%,0.25W	354944	59124	CF1-4 2R2J	1	
R	51		RES,CF,20,+-5%,0.25W	442202	59124	CF1-4 200 J B	1	
R	52		RES,VAR,CERM,100K,+-20%,0.5W	268581	80294	3009P-1-104	1	
R	53		RES,VAR,CERM,10K,+-20%,0.5W	267880	80294	3009P-1-103	1	
R	54		RES WW 8.5K +-4% 4500PPM 1/2W BOBBIN	323881	89536	323881	1	2
R	55		RES,MF,6.98K,+-1%,0.125W,100PPM	261685	91637	CMF55 6981 F T-1	1	2
R	56		RES,MF,124K,+-1%,0.125W,100PPM	288407	91637	CMF55 1243 F T-1	1	2
R	57		RES,MF,187K,+-1%,0.125W,100PPM	289462	91637	MFF1-81873F	1	2
R	58, 59		RES. SET, 2M T.C. MATCHED	290320	89536	290320	1	
R	61		RES,MF,86.6K,+-1%,0.125W,100PPM	291468	91637	CMF55 8662 F T-1	1	

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

Table 5-9. A8 DC Signal Conditioner PCB Assembly (cont.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	---DESCRIPTION---	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
R 63		RES,MF,1.87K,+-1%,0.125W,100PPM	267229	91637	CMF55 1871 F T-1	1	
R 64		RES,MF,1K,+-1%,0.125W,100PPM	168229	91637	CMF55 1001 F T-1	1	
R 70		RES,MF,52.3K,+-1%,0.125W,100PPM	237248	91637	CMF55 5232 F T-1	1	
R 71		RES,MF,3.01K,+-1%,0.125W,100PPM	312645	91637	CMF55 3011 F T-1	1	
R 72, 97		RES,MF,3.65K,+-1%,0.125W,100PPM	293779	91637	CMF55 3651 F T-1	2	
R 73- 75, 99		RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF55 1003 F T-1	4	
R 76		RES,MF,4.02K,+-1%,0.125W,100PPM	235325	91637	CMF55 4021 F T-1	1	
R 77		RES,MF,200K,+-1%,0.125W,100PPM	261701	91637	CMF55 2003 F T-1	1	
R 98		RES,MF,2.15K,+-1%,0.125W,100PPM	293712	91637	CMF55 2151 F T-1	1	
RN 1	*	INPUT DIVIDER RNET ASSY TESTED 8505	735159	89536	735159	1	
TP 1- 8		TERM,UNINSUL,FEEDTHRU,HOLE,TURRET	179283	88245	2010B-5	8	
U 1	*	IC,CMOS,QUAD D LATCH,W/XOR ENABLE	355149	34371	CD4042BE	1	
U 2	*	IC,GATE ARRAY,PROGRMMD,8505A-90700	876375	04713	876375	1	
U 3, 4	*	IC,OP AMP,SUPER BETA INPUT	722025	04713	LM11CLN	2	
U 5, 6	*	IC,OP AMP,GEN PURPOSE,TO-99/TO-78	271502	04713	LM301AH	2	
XR 54- 57		SOCKET,SINGLE,PWB,FOR 0.022-0.025 PIN	343285	04222	2-331272-6	8	

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

NOTES:

NOTE 1 = Use P/N 651877 to order case without pcb assembly.
NOTE 2 = Part selected at test. Part may not be the value indicated or may not be installed.

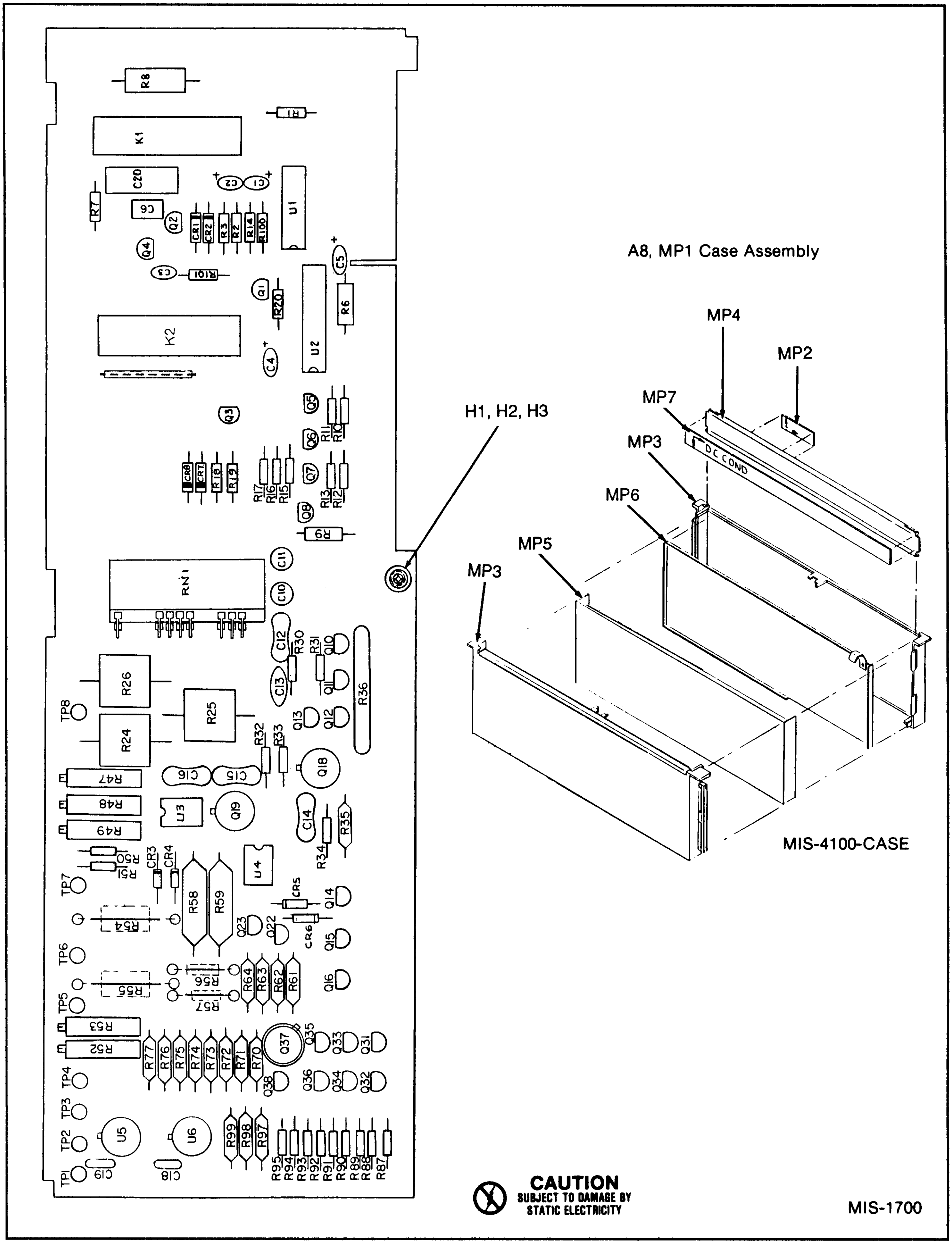

Figure 5-9. A8 DC Signal Conditioner PCB Assembly

Table 5-10. A9 Active Filter PCB Assembly
(See Figure 5-10.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
C 1- 3		CAP,POLYPR,0.047UF,+-10%,50V	413328	84411	JF-86-473 K 50	3	
C 4, 8- 10		CAP,MICA,33PF,+-5%,500V	160317	93790	CD15ED330J03	4	
C 5- 7		CAP,POLYPR,0.47UF,+-10%,50V	363085	84411	JF-86 474 K 50	3	
C 11, 14		CAP,AL,6.8UF,+50-10%,63V	218966	62643	SM63T-6.8	2	
C 12, 13		CAP,AL,10UF,+50-10%,25V	170266	62643	SM25T100M6AX13LL	2	
C 15		CAP,POLYPR,0.0022UF,+-10%,200V	442632	84411	JF-86-222 K 200	1	
CR 1	*	ZENER,UNCOMP,6.8V,5%,20.0MA,0.4W	260695	04713	1N754A	1	
CR 2	*	ZENER,UNCOMP,9.1V,5%,14.0MA,0.4W	386557	04713	1N960B	1	
CR 3	*	DIODE,SI,BV=75V,IO=150MA,500MW	203323	15818	1N4448	1	
E 1, 2		JUMPER,WIRE,TEFLON INSUL,0.400CTR	529206	60386	J.TEFLON .400	2	
H 1		SPACER,SWAGED,.250 RND,BR,4-40,.187	335604	9W423	9533B-B-0440	1	
H 2		SCREW,PH,P,SS,LOCK,4-40,.375	256164	COMMERCIAL		1	
H 3		SPRING,COIL,COMP,M WIRE,.380,.120	424465	83553	C0121-014-0380M	1	
MP 1		CASE,ACTIVE FILTER MODULE (MP2-MP7)	458976	89536	458976	1	1
MP 2		CASE HALF,MODULE	402990	89536	402990	2	
MP 3		COVER,MODULE CASE	794560	89536	794560	1	
MP 4		GUARD, FRONT	383356	89536	383356	1	
MP 5		GUARD, REAR	383364	89536	383364	1	
MP 6		SHIELD,COVER,ACTIVE FILTER	411959	89536	411959	1	
MP 7		DECAL ACTIVE FILTER	413443	89536	413443	1	
MP 8		SOCKET,SINGLE,PWB,FOR 0.022-0.025 PIN	343285	C4222	2-331272-6	4	
Q 1, 3, 5,	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	04713	2N3906	6	
Q 7, 9, 11	*		195974				
Q 2, 4, 6,	*	TRANSISTOR,SI,NPN,SELECTED IEBO,TO-92	218396	04713	2N3904	9	
Q 8, 10, 12,	*		218396				
Q 28- 30	*		218396				
Q 13	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1	
Q 14- 25, 31-	*	TRANSISTOR,SI,N-JFET,HI-VOLTAGE,TO-92	393314	17856	J2086	17	
Q 35	*		393314				
Q 26	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	218388	07263	PN3645	1	
Q 27	*	TRANSISTOR,SI,NPN,DUAL,TO-78,HI-BETA	585109	34371	ITS31897	1	
R 1		RES,CF,6.2K,+-5%,0.25W	442368	59124	CF1-4 622 J B	1	
R 2		RES,CF,150,+-5%,0.25W	343442	59124	CF1-4 151 J B	1	
R 3		RES,MF,51.1K,+-1%,0.125W,100PPM	289553	91637	CMF55 5112 F T-1	1	
R 4, 5		RES,CF,8.2K,+-5%,0.25W	441675	59124	CF1-4 822 J B	2	
R 8- 11		RES,MF,45.3K,+-1%,0.125W,100PPM	234971	91637	CMF55 4532 F T-1	4	
R 12, 19, 22		RES,MF,12.1K,+-1%,0.125W,100PPM	234997	91637	CMF55 1212 F T-1	3	
R 13		RES,MF,4.87K,+-1%,0.125W,100PPM	294850	91637	CMF55 4871 F T-1	1	
R 14		RES,VAR,CERM,20K,+-10%,0.5W	291609	80294	3386S-1-203	1	
R 15		RES,MF,31.6K,+-1%,0.125W,100PPM	261610	91637	CMF55 3162 F T-1	1	2
R 16		RES,MF,63.4K,+-1%,0.125W,100PPM	235382	91637	CMF55 6342 F T-1	1	2
R 17, 18		RES,MF,1M,+-1%,0.5W,25PPM	327510	91637	CMF65 1004 F T-9	2	
R 20, 23		RES,MF,249K,+-1%,0.125W,100PPM	268805	91637	CMF55 2493 F T-1	2	
R 21		RES,MF,57.6K,+-1%,0.125W,100PPM	289116	91637	CMF55 5762 F T-1	1	
R 24, 27		RES,CF,15,+-5%,0.25W	348755	59124	CF1-4 150 J B	2	
R 25, 26		RES,CF,100,+-5%,0.25W	348771	59124	CF1-4 101 J B	2	
R 28, 29		RES,MF,26.7K,+-1%,0.125W,100PPM	245779	91637	CMF55 2672 F T-1	2	
TP 1- 4		TERM,UNINSUL,FEEDTHRU,HOLE,TURRET	179283	88245	2010B-5	4	
U 1	*	IC,CMOS,HEX D F/F,+EDG TRG,W/RESET	404509	27014	MM74C174N	1	
U 2	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	04713	MC14023UBCP	1	
U 3, 4	*	IC,OP AMP,GEN PURPOSE,8 PIN DIP	363515	04713	LM301AN	2	
U 5	*	IC,OP AMP,GEN PURPOSE,COMPENSATD,TO-5	392902	12040	LM1436H	1	
U 6		RES,CERM,DIP,16 PIN,14 RES,100K,+-5%	404749	91637	MFP16-01-104J	1	
U 7		RES,CERM,DIP,16 PIN,8 RES,100K,+-5%	380618	91637	MDP16-03-104J	1	

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

NOTES:

NOTE 1 = Use P/N 458976 to order case without pcb assembly.
NOTE 2 = Part selected at test. Part may not be the value indicated or may not be installed.

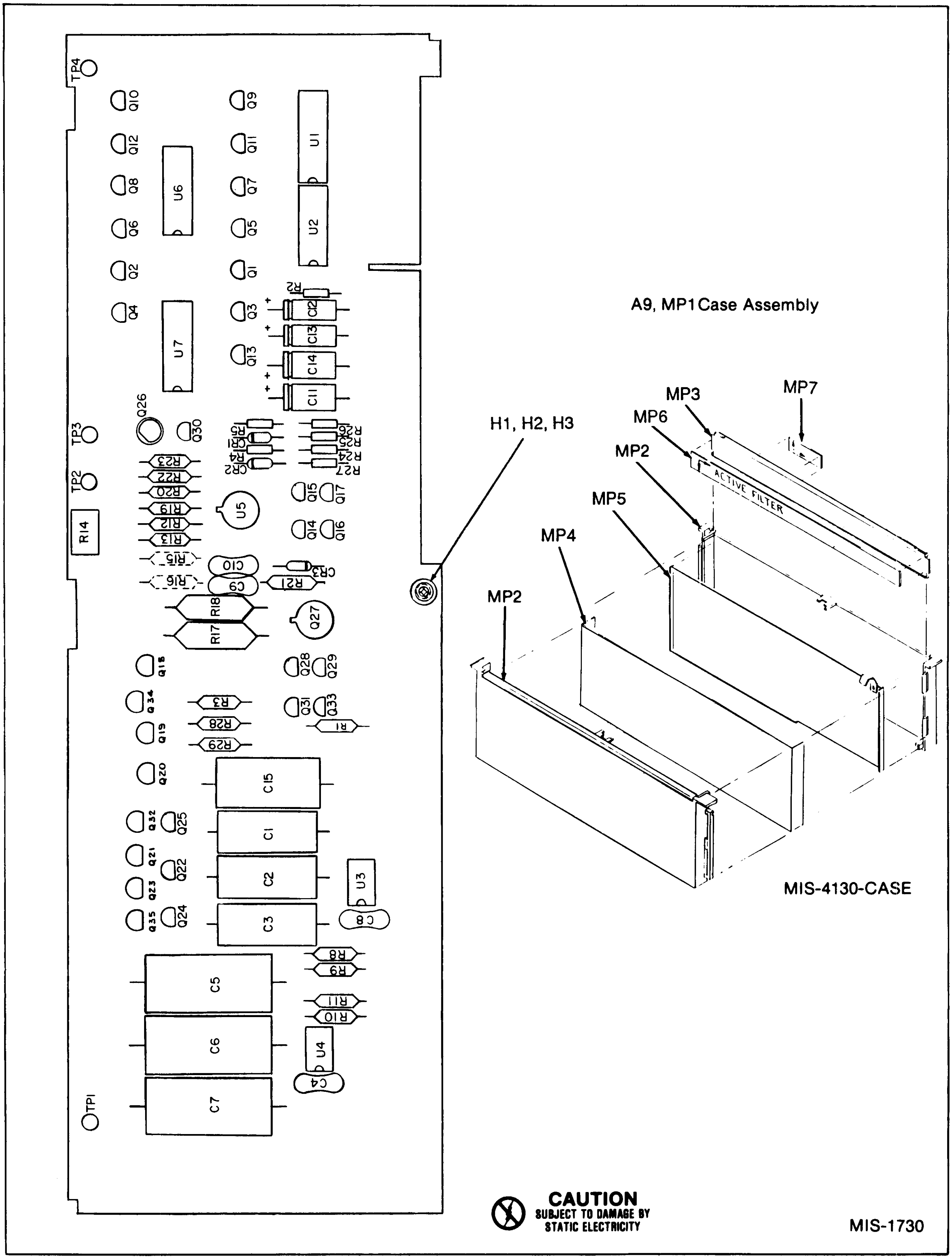

Figure 5-10. A9 Active Filter PCB Assembly

Table 5-11. A10 Fast R2 A/D Converter Assembly
(See Figure 5-11.)

REFERENCE DESIGNATOR -A>-NUMERICS---->		S	---DESCRIPTION---	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
A	1	*	FAST R2 A/D CONV ANALOG PCB ASSEMBLY				1	1
A	2	*	FAST R2 A/D CONV DIGTAL PCB ASSEMBLY				1	1
H	1		SCREW,PH,P,SS,LOCK,4-40,.250	256156	COMMERCIAL		3	
MP	1		CASE,A/D CONVERTOR MOD. (MP2-MP8)	458968	89536	458968	1	2
MP	2		CASE HALF,EXTENDED MODULE	402982	89536	402982	1	
MP	3		CASE HALF,MODULE	402990	89536	402990	1	
MP	4		COVER,MODULE CASE	794560	89536	794560	1	
MP	5		GUARD,FRONT, FAST A/D	383315	89536	383315	1	
MP	6		GUARD, REAR	383364	89536	383364	1	
MP	7		SHIELD,COVER, FAST A/D CONV.	411967	89536	411967	1	
MP	8		DECAL,FAST A/D CONVERTER	413450	89536	413450	1	

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

NOTES:

NOTE 1 = A1 and A2 are matched assemblies. Order P/N 716324 and replace complete A10 Assembly.
NOTE 2 = Use P/N 458968 to order case without pcb assembly.

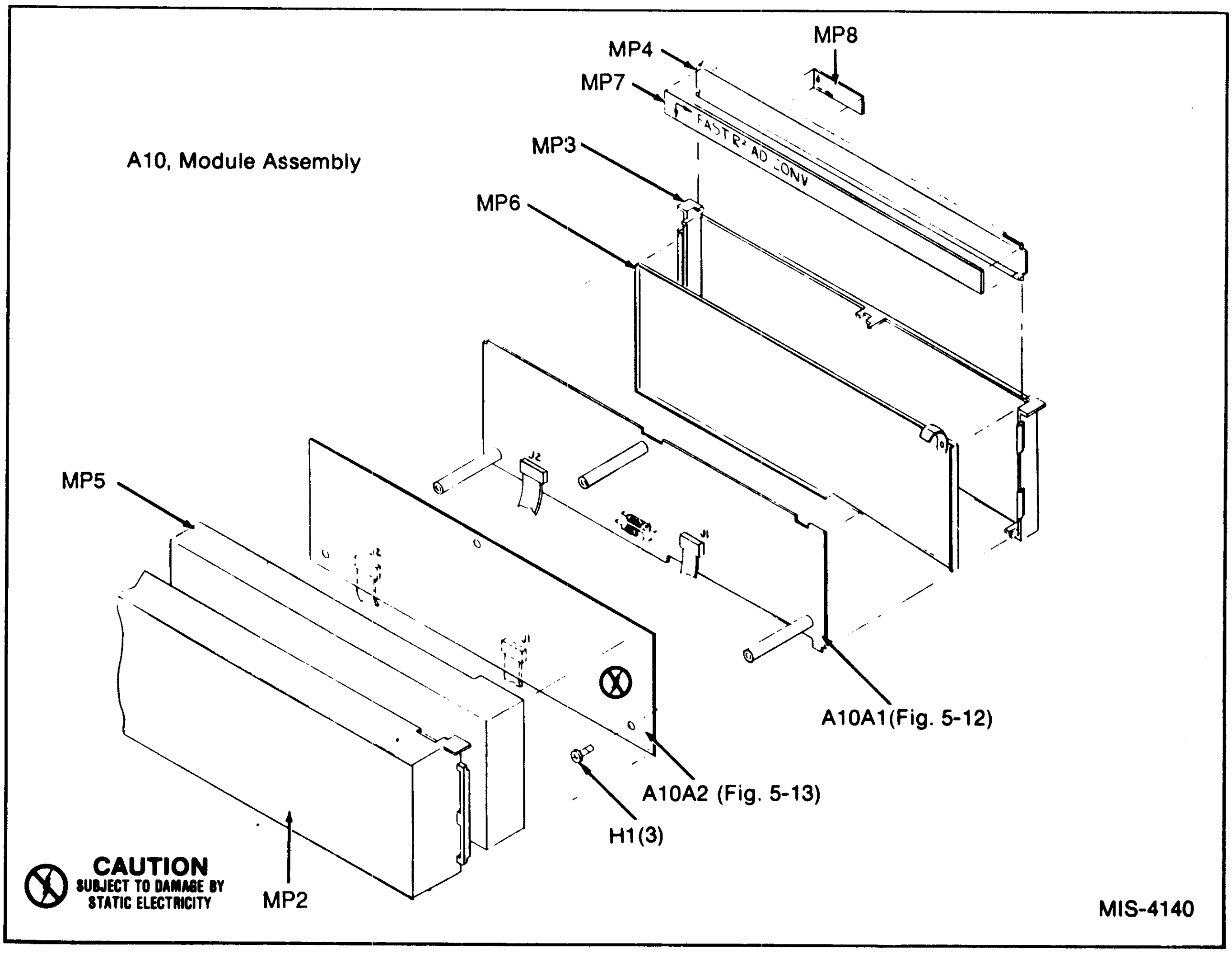

Figure 5-11. A10 Fast R2 A/D Converter Assembly

Table 5-12. A10A1 Fast R2 A/D Analog PCB Assembly
(See Figure 5-12.)

REFERENCE DESIGNATOR -A>-NUMERICS---->		S	--------------DESCRIPTION-------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE -E-
C	1, 2		CAP,TA,10UF,+-20%,35V	417683	56289	199D106X0035DA2	2	
C	3		CAP,MICA,33PF,+-5%,500V	160317	93790	CD15ED330J03	1	
C	4		CAP,MICA,30PF,+-5%,500V	340570	93790	CD15ED300J03	1	
C	5		CAP,POLYES,0.22UF,+-10%,80V	159392	56289	10304	1	
C	6		CAP,TA,4.7UF,+-20%,25V	161943	56289	199D475X0025BA2	1	
C	7, 8		CAP,MICA,150PF,+-5%,500V	148478	93790	CD15FD151J03	2	
C	9, 10		CAP,POLYST,C.047UF,+-10%,100V	260562	84411	X1263UW47310%100V	2	
C	11, 12, 14		CAP,MICA,47PF,+-5%,500V	148536	93790	CD15ED470J03	3	
C	13		CAP,AL,470UF,+50-10%,6.3V	187773	62643	SM6.3T471T10X21TPV	1	
C	15		CAP,CER,0.0047UF,+-10%,500V,Z5R	106724	60705	562CX5RCK501AJ472K	1	
C	16, 17, 22,		CAP,CER,0.22UF,+-20%,50V,Z5U	309849	04222	SR215E224MAA	4	
C	23			309849				
C	18		CAP,AL,33UF,+-20%,25V,SOLV PROOF	715250	62643	SRAC25VB33RM6X7C3	1	
C	20		CAP,TA,0.22UF,+-20%,35V	161331	56289	199D224X0035AA2	1	
C	21		CAP,POLYES,0.1UF,+-10%,50V	649913	60935	185-2/0.1/K/0050/R/A/B	1	
CR	1, 9	*	DIODE,SI,BV=75V,IO=150MA,500MW	203323	15818	1N4448	2	
CR	3, 4, 7,	*	DIODE,SI,BV= 20.0V,IO= 50MA,SELCTD IR	348177	07263	FD7223	4	
CR	8	*		348177				
CR	5, 6	*	DIODE,SI,BV= 50.0V,IO=150MA,SELCTD VF	234468	12040	1M916B	2	
H	1		SPACER,SWAGED,.250 RND,BR,4-40,.187	335604	9W423	9533B-B-0440	1	
H	2		SPACER,SWAGED,.250 RND,BR,4-40,1.375	417881	55566	3065-B-440-B-14	3	
H	3		SCREW,PH,P,SS,LOCK,4-40,.375	256164	COMMERCIAL		1	
H	4		SPRING,COIL,COMP,M WIRE,.380,.120	424465	83553	C0121-014-0380M	1	
MP	1		SPACER,TRANSISTOR MOUNT,DAP,TO-5	152207	07047	10123-DAP	1	
MP	2		SOCKET,SINGLE,PWB,FOR 0.022-0.025 PIN	343285	04222	2-331272-6	4	
Q	1- 3, 11-		PC.SET,N-CHANNEL,SELFROM #261578	256487	89536	256487	1	
Q	16, 25, 26			256487				
Q	4- 8	*	TRANSISTOR,SI,N-JFET,TO-92	343830	17856	J2078	5	
Q	9, 27	*	TRANSISTOR,SI,N-JFET,DUAL,TO-71	376087	17856	U-405	2	
Q	10	*	TRANSISTOR,SI,NPN,SELECTED IEBO,TO-92	218396	04713	2N3904	1	
Q	17- 24, 29-	*	TRANSISTOR,SI,N-JFET,TO-92,SWITCH	261578	17856	J2317	12	
Q	32	*		261578				
Q	28	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	04713	2N3906	1	
R	1		RES,VAR,CERM,500,+-20%,0.5W	267849	80294	3009P-1-501	1	
R	2, 64		RES,VAR,CERM,10,+-20%,0.5W	344135	80294	3009P-1-100	2	
R	3		RES,VAR,CERM,500,+-10%,0.5W	291120	80294	3386S-1-502	1	
R	4		RES,VAR,CERM,200,+-10%,0.5W	285148	80294	3386S-1-201	1	
R	5, 7		RES,VAR,CERM,50,+-10%,0.5W	285122	80294	3386S-1-502	2	
R	6		RES,VAR,CERM,20,+-20%,0.5W	261180	80294	3009P-1-200	1	
R	8		RES,VAR,CERM,50K,+-10%,0.5W	288290	80294	3386S-1-503	1	
R	9, 14- 16		REFERENCE AMP SET	415034	89536	415034	1	
R	10		RES,MF,3.4K,+-1%,0.125W,100PPM	260323	91637	CMF55 3401 F T-1	1	
R	11, 13		RES,MF,12.1,+-1%,0.125W,100PPM	296608	91637	CMF55 12R1 F T-1	2	
R	12		RES,MF,24.3,+-1%,0.125W,100PPM	281816	91637	CMF55 24R3 F T-1	1	
R	17, 18		RES,MF,10K,+-1%,0.125W,25PPM	328120	91637	CMF55 1002 F T-9	2	
R	19, 21, 49		RES,CF,100K,+-5%,0.25W	348920	59124	CF1-4 104 J B	3	
R	20, 28, 30		RES,MF,10K,+-1%,0.125W,100PPM	168260	91637	CMF55 1002 F T-1	3	
R	22, 23		REFERENCE INVERTER SET	409896	89536	409896	1	
R	24		RES,CF,470,+-5%,0.25W	343434	59124	CF1-4 471 J B	1	
R	25, 26		RES,MF,42.2K,+-1%,0.125W,100PPM	221655	91637	CMF55 4222 F T-1	2	
R	27		RES,CF,62,+-5%,0.25W	441634	59124	CF1-4 620 J B	1	
R	29, 60		RES,CF,33K,+-5%,0.25W	348888	59124	CF1-4 333 J B	2	
R	31		RES,MF,11.3K,+-1%,0.125W,100PPM	293639	91637	CMF55 1132 F T-1	1	
R	32		RES,MF,24.9K,+-1%,0.125W,100PPM	291369	91637	CMF55 2492 F T-1	1	
R	33, 37		RES,CF,47,+-5%,0.25W	441592	59124	CF1-4 470 J B	2	
R	34, 35, 50-		FAST R2 AD SUMMING RESISTOR SET	409946	89536	409946	1	
R	54, 56			409946				
R	36		RES,MF,26.7K,+-1%,0.125W,100PPM	245779	91637	CMF55 2672 F T-1	1	
R	38, 39, 41		RES,MF,75K,+-1%,0.125W,100PPM	291443	91637	CMF55 7502 F T-1	3	
R	40, 48		RES,CF,15K,+-5%,0.25W	348854	59124	CF1-4 153 J B	2	
R	42		RES,CF,3K,+-5%,0.25W	441527	59124	CF1-4 302 J B	1	
R	43		RES,CF,510,+-5%,0.25W	441600	59124	CF1-4 511 J B	1	
R	44		RES,CF,1.5K,+-5%,0.25W	343418	59124	CF1-4 152 J B	1	
R	45		RES,CF,470K,+-5%,0.25W	342634	59124	CF1-4 474 J B	1	
R	46		RES,MF,665,+-1%,0.125W,100PPM	320028	91637	CMF55 6650 F T-1	1	
R	47		RES,MF,1M,+-1%,0.125W,100PPM	268797	91637	CMF55 1004 F T-1	1	
R	55		RES,MF,56.2,+-1%,0.125W,100PPM	305938	91637	CMF55 56R2 F T-1	1	
R	58		RES,MF,2573,+-0.1%,0.125W,25PPM	321463	91637	CMF55 2573 B T-9	1	
R	61		RES,MF,57.6K,+-1%,0.125W,100PPM	289116	91637	CMF55 5762 F T-1	1	

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

Table 5-12 A10A1 Fast R2 A/D Analog PCB Assembly (cont.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	--------------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE -E-
R 62		RES,MF,66.5K,+-1%,0.125W,100PPM	289082	91637	CMF55 6652 F T-1	1	
R 63		RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF55 1003 F T-1	1	
R 65		RES,CF,820,+-5%,0.25W	442327	59124	CF1-4 821 J B	1	
R 66		RES,CF,5.1K,+-5%,0.25W	368712	59124	CF1-4 512 J B	1	
R 67		RES,MF,12.7,+-1%,0.125W,100PPM	441766	91637	CMF55 12R7 F T-1	1	
R 68		RES,CF,1M,+-5%,0.25W	348987	59124	CF1-4 105 J B	1	
R 70, 71		RES,CF,10K,+-5%,0.25W	348839	59124	CF1-4 102 J B	2	
TP 1- 7		TERM,UNINSUL,FEEDTHRU,HOLE,TURRET	179283	88245	2010B-5	7	
U 2, 3	*	IC,OP AMP,GEN PURPOSE,TO-99/TO-78	271502	04713	LM301AH	2	
U 4, 7	*	IC,OP AMP,JFET INPUT,TO-5 CASE	429837	27014	LF365BH	2	
U 5, 6	*	IC,OP AMP,SELECTED VOLTAGE FOLLOWER	288365	04713	LM310H	2	
U 8	*	IC,OP AMP,SELECTED,GEN PURPOSE,TO-78	225961	24355	AD3092	1	
U 15		RES,CERM,DIP,16 PIN,14 RES,33K,+-5%	413146	91637	MDP16-01-333J	1	
U 19		RES,CERM,DIP,16 PIN,8 RES,100K,+-5%	380618	91637	MDP16-03-104J	1	
W 1- 3		JUMPER,WIRE,NONINSUL,.125CTR	529719	89536	529719	3	
XJ 1, 2		SOCKET,IC,16 PIN	276535	00779	2-640358-1	2	

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

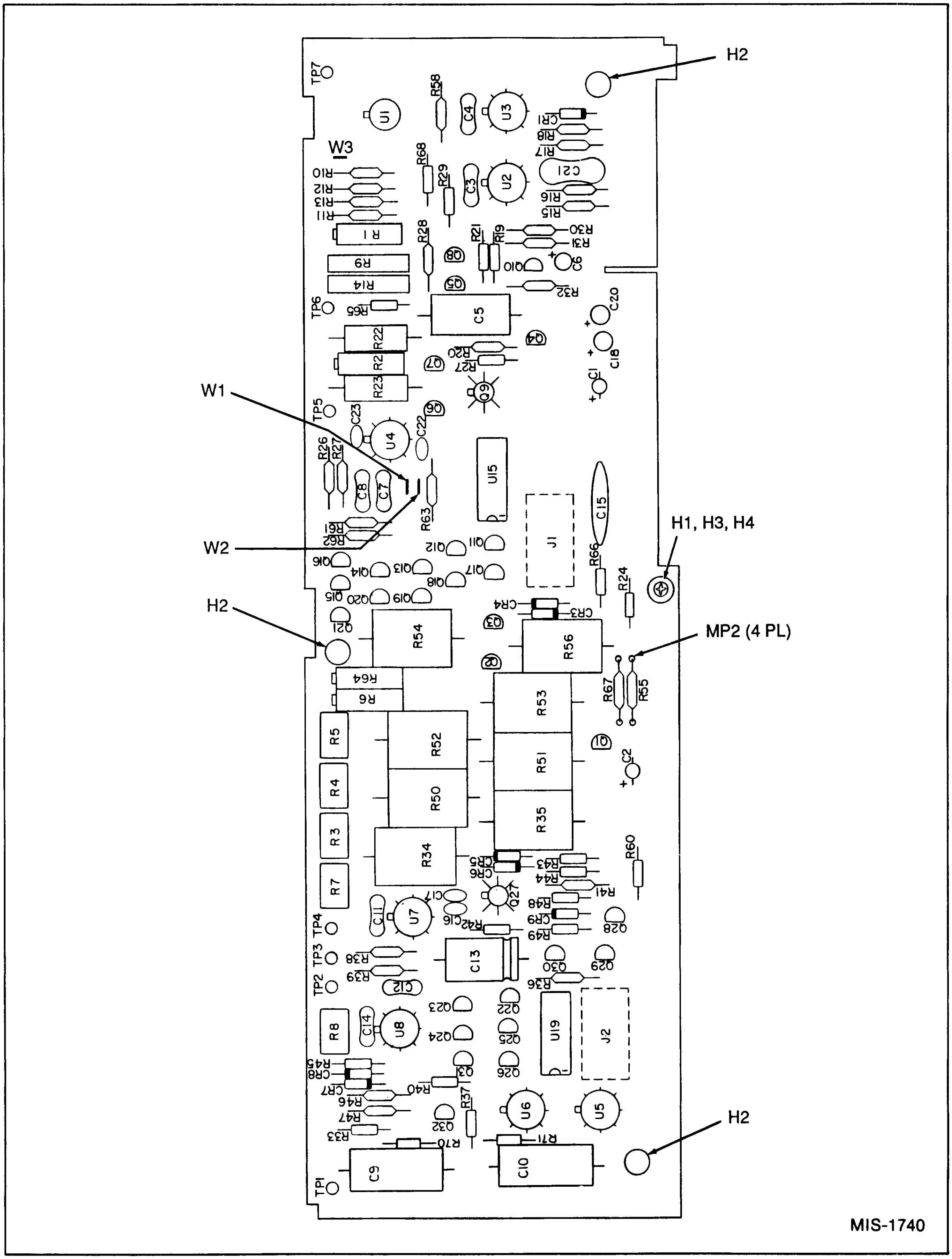

Figure 5-12. A10A1 A/D Analog PCB Assembly

Table 5-13. A10A2 Fast R2 A/D Digital Assembly
(See Figure 5-13.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
C 1, 4		CAP,AL,47UF,+-20%,25V,SOLV PROOF	697052	62643	LR25VB470M10X16LLV	2	
C 2, 3		CAP,MICA,82PF,+-5%,500V	148502	93790	CD15ED820J03	2	
C 5		CAP,CER,100PF,+-5%,50V,C0G	369173	04222	SR211A101JAA	1	
J 1, 2		CABLE ASSY,FLAT,16 COND,3.50,DIP CONN	380576	52072	CAD16P02-261-TT-003.5	2	
Q 1	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1	
R 1		RES,CF,47K,+-5%,0.25W	348896	59124	CF1-4 473 J B	1	
R 2, 3		RES,CF,20K,+-5%,0.25W	573444	59124	CF1-4 203 J B	2	
R 4		RES,CF,150,+-5%,0.25W	573030	59124	CF1-4 151 J B	1	
R 5- 7		RES,MF,100K,+-1%,0.125W,100PPM	719484	91637	CMF55 1003 F T-1	3	
TP 1, 2		TERM,FASTON,TAB,.110,SOLDER	512889	00779	62395-1	2	
U 1, 2, 6,	*	IC,CMOS,DUAL D F/F,+EDG TRIG	340117	04713	MC14013BCP	9	
U 11, 12, 22,	*		340117				
U 32, 34, 35	*		340117				
U 3, 7, 21	*	IC,CMOS,HEX INVERTER	404681	04713	MC14093BCP	3	
U 4, 13, 37		RES,CERM,DIP,16 PIN,8 RES,100K,+-5%	380618	91637	MDP16-03-104J	3	
U 5	*	IC,CMOS,DUAL CMPLMNTRY FET PAIR + INV	408013	04713	MC14007UBCP	1	
U 8, 36	*	IC,CMOS,QUAD 2 INPUT NAND GATE	355198	04713	MC14011UBCP	2	
U 14, 15, 17	*	IC,ARRAY,5 TRANS,NPN,5 ISOLATED TRANS	380188	34371	CA3183E	3	
U 16, 26	*	IC,CMOS,QUAD 2 INPUT OR GATE	408393	04713	MC14071BCP	2	
U 25	*	IC,CMOS,QUAD 2 INPUT AND GATE	408401	04713	MC14081BCP	1	
U 31	*	IC,CMOS,DIV BY 8 CNTR W/ 8DECODED OUT	403360	04713	MC14022CP	1	
U 33	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	04713	MC14023UBCP	1	
U 38	*	IC,ARRAY,5 TRANS,NPN,SELECT IECO=40NA	477778	18324	3183	1	

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

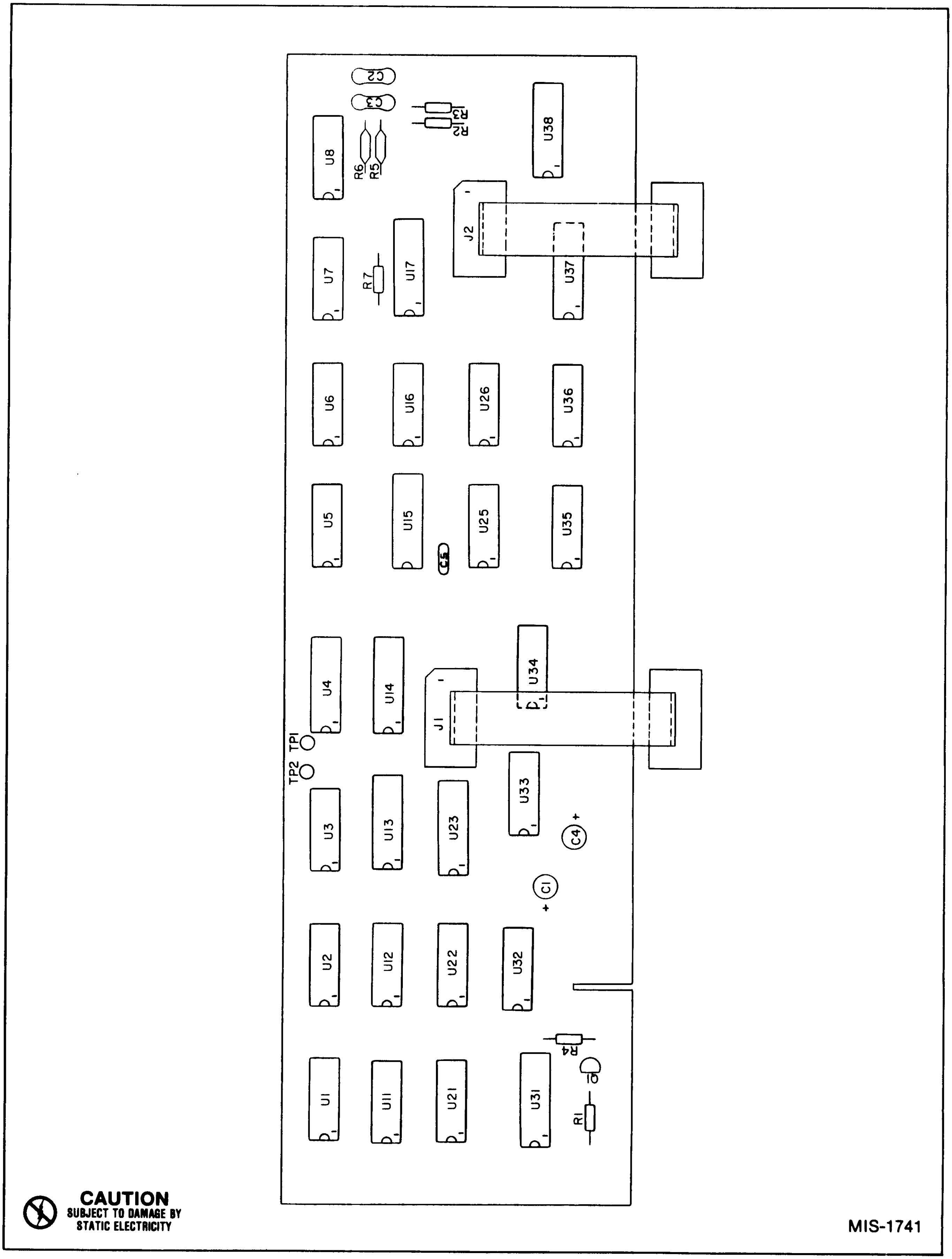

Figure 5-13. A10A2 Fast R² A/D Digital PCB Assembly

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S3385
Sanken Electric
Hoffman Estates, IL
c/o L-Squared
Kirkland, WA

00779
AMP, Inc.
Harrisburg, PA

01121
Bradley Co.
Milwaukee, WI

01295
Texas Instruments Inc.
Semiconductor Group
Dallas,TX

04222
AVX Corp.
AVX Ceramics Div.
Myrtle Beach, SC

04713
Motorola Inc.
Semiconductor Group
Phoenix, AZ

06383
Panduit Corp.
Tinley Park, IL

06473
Bunker Ramo Corp.
Amphenol NA Div.
SAMS Operation
Chatsworth, CA

06915
Richco Plastic Co.
Chicago, IL

07047
Ross Milton Co., The
Southampton, PA

07263
Fairchild Semiconductor
North American Sales
Ridgeview, CT

09214
General Electric Co.
Semiconductor Products Dept.
Auburn, NY
12040
National Semiconductor Corp.
Danbury, CT

12615
US Terminals Inc.
Cincinnati, OH

13103
Thermalloy Co., Inc.
Dallas, TX

14936
General Instrument Corp.
Discrete Semi Conductor Div.
Hicksville, NY

15818
Teledyne Inc. Co.
Teledyne Semiconductor Div.
Mountain View, CA

17856
Siliconix Inc.
Santa Clara, CA

18324
Signetics Corp.
Sacramento, CA

18786
Micro-Power
Long Island City, NY

2M021
EFAB Mfg. Inc.
Charlottesville, VA

22670
GM Nameplate
Seattle, WA

24355
Analog Devices Inc.
Norwood, MA

25088
Siemen Corp.
Isilen, NJ

27014
National Semiconductor Corp.
Santa Clara, CA
27264
Molex Inc.
Lisle, IL

27440
Industrial Screw Products
Los Angeles, CA

28480
Hewlett Packard Co.
Corporate HQ
Palo Alto, CA

30035
Jolo Industries Inc.
Garden Grove, CA

30800
General Instrument Corp.
Capacitor Div.
Hicksville, NY

30838
Fastec
Chicago,IL

31918
ITT-Schadow
Eden Prairie, MN

32997
Bourns Inc.
Trimpot Div.
Riverside, CA

33025
ComOmni Spectra, Inc.
(Replacing Omni Spectra)
Microwave Subsystems Div.
Tempe, AZ

34371
Harris Corp.
Harris Semiconductor
Products Group
Melbourne, FL

34649
Intel Corp.
Santa Clara, CA

40402
Roderstein Electronics Inc.
Statesville, NC

49569
IDT (International Develop-
ment & Trade)
Dallas, TX

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

51406
Murata Erie, No. America Inc.
Symrna, GA

52072
Circuit Assembly Corp.
Irvine, CA

54583
TDK
Garden City, NY

55285
Bercquist Co.
Minneapolis, MN

55566
R A F Electronic Hardware Inc.
Seymour, CT

55576
Synertek
Santa Clara, CA

56289
Sprague Electric Co.
North Adams, MA

58361
Quality Technologies (QTC)
Palo Alto, CA

58364
BYCAP Inc.
Chicago, IL

58451
Precision Lamp
Cotat, CA

59124
KOA-Speer Electronics Inc.
Bradford, PA

60386
Squires Electronics Inc
Cornelius, OR

60395
Xicor Inc.
Milpitas, CA

60395
Xicor Inc.
Milpitas, CA

60705
Cera-Mite Corp.
(formerly Sprague)
Grafton, WI

60935
Westlake Capacitor Inc.
Tantalum Div.
Greencastle, IN

61529
Aromat Corp.
New Providence, NJ

61935
Schurter Inc.
Petaluma, CA

62643
United Chemicon
Rosemont, IL

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64537
KDI Electronics
Whippany, NJ

65940
Rohm Corp
Irvine, CA

7Z884
ALPS
Seattle, WA

70903
Cooper-Belden Corp.
Geneva, IL

71002
Birnbach Co. Inc.
Farmingdale, NY

71400
Bussman Div. - Cooper Industries Inc.
St. Louis, MO

71707
Coto Corp.
Providence, RI

73734
Federal Screw Products Inc.
Chicago, IL

75915
Littelfuse Tracor
(Formerly: Tracor-Littelfuse)
Des Plaines, IL

79963
Zierick Mfg. Corp.
Mount Kisco, NY

80294
Bourns Instruments Inc.
Riverside, CA

82240
Simmons Fastner Corp.
Albany, NY

82389
Switchcraft Inc.
Sub of Raytheon Co.
Chicago, IL

83553
Associated Spring Barnes Group
Gardena, CA

84411
American Shizuki
TRW Capacitors Div.
Ogallala, NE

88245
Winchester Electronics
Litton Systems-Useco Div.
Van Nuys, CA

88786
Atlantic India Rubber Co.
Goshen, IN

89536
John Fluke Mfg. Co., Inc.
Everett, WA

9W423
Amatom
El Mont, CA

91293
Johanson Mfg. Co.
Boonton, NJ

91506
Augat Alcoswitch
N. Andover, MA

91637
Dale Electronics Inc.
Columbus, NE

91662
Elco Corp.
A Gulf Western Mfg. Co.
Connector Div.
Huntingdon, PA

91836
King's Electronics Co. Inc.
Tuckahoe, NY

91984
Maida Development Co.
Hampton, VA

93790
Cornell Dubilier Electronics
New Bedford, MA

98291
Sealectro Corp.
BICC Electronics
Trumbill, CT

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Depto. Tecnico Instrumentacion
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Bangkok 10240
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Inonu Caddesi 78/80
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Libertad 2525
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Tel: 598-2-789015

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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

Section 6
Option & Accessory Information

TABLE OF CONTENTS

6-1. INTRODUCTION

6-2. This section of the manual contains information concerning options and accessories available for use with the multimeter. Subsections are included for accessories and for each option. The Table of Contents identifies each item by name, number, and appropriate page number.

6-3. ACCESSORIES

6-4. Several accessories are documented in the first subsection. Additional accessories are listed in Section 1 of this manual. Complete documentation is provided for any accessory ordered for the multimeter.

6-5. OPTIONS

6-6. Documentation for all currently available options is also included in this section. A subsection is devoted to each option. Applicable pages are identified by section, option number, and page number within the subsection. For example, page 3 for the -02A option is identified as 602A-3.

6-7. Programming instructions for any of the remote interface options (-05, -06, or -07) are included in Section 2A of this manual. The Isolator, which is a standard module with the 8505A and 8506A, is documented in subsection 608A.

6-8. Each subsection includes all information to install, operate, and maintain the option. Specifications, a list of replaceable parts, and a schematic diagram are also provided.

6-9. Due to input switch characteristics, change the specifications for the Input Characteristics -Impedance listed in Table 601-1, 609-1 and the Voltage Burden listed in Table 603-1 as follows:

Tables 601-1 and 609-1:

INPUT IMPEDANCE <110pF

Table 603-1:

RANGE	VOLTAGE BURDEN
10 mA	⩽ 250 mV
100 mA	⩽ 300 mV
1A	⩽ 1.25 V

Accessories

600-1. RACK EAR MOUNTING ASSEMBLY

600-2. Figure 600-1 illustrates installation of the Rack Ear Mounting Assembly. Use the following procedure:

1. Remove the nameplate decals from the handles.
2. Remove the screws from the handles.
3. Attach the rack ears with #8-32 x 5/8 PHP screws (included with the kit).
4. Note the hole pattern in the top and bottom trim items. Remove the corresponding screws from the multimeter's top and bottom covers.
5. Attach the top and bottom trim items with #6-32 x 3/8 PHP screws and lock washers (included with the kit).

600-3. HIGH VOLTAGE PROBE (80K-6)

600-4. The 80K-6 extends the voltage measuring capability of an ac/dc voltmeter up to 6000 volts. A 1000:1 voltage divider provides a high input impedance. High accuracy is provided when the divider is used with a voltmeter having a 10 Mohm input impedance. A molded plastic body houses the divider and protects the user from the voltage being measured.

600-5. HIGH VOLTAGE PROBE (80K-40)

600-6. The 80K-40 is a high voltage accessory probe designed to extend the voltage measuring capability of an ac/dc voltmeter up to 40,000 volts. The probe is a precision 1000:1 voltage divider formed by two matched metal-film resistors. The unusually high input impedance offered by these resistors minimizes circuit loading and optimizes measurement accuracy. A special plastic body houses the divider and provides the user with isolation from the voltage being measured.

600-7. HIGH FREQUENCY PROBE (83RF)

600-8. The 83RF converts a dc voltmeter into a high frequency, 100 kHz to 100 MHz ac voltmeter. Conversion from ac to dc is on a one-to-one basis over a range of 0.25 to 30V rms. The probe's dc output is calibrated to be equivalent to the rms value of a sinewave input.

600-9. HIGH FREQUENCY PROBE (85RF)

600-10. The 85RF is designed to convert a dc voltmeter into a high frequency, 100 kHz to 500 MHz ac voltmeter. Ac to dc conversion ratio is one-to-one over a range of 0.25 to 30V rms. The probe's dc output is calibrated to be equivalent to the rms value of a sinewave output.

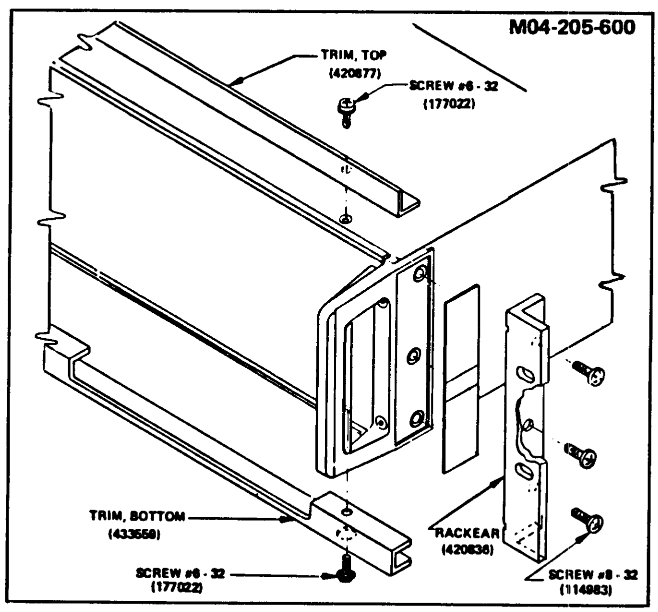


Figure 600-1. Rack Ear Mounting Installation

Option —01
AC/DC Converter (Averaging)

601-1. INTRODUCTION

601-2. The Average Responding AC Converter is used to convert ac signals to dc levels which can be measured by the A/D Converter. A maximum input of 1000V rms (or 2 x 10^7 Volt-hertz product, whichever is less) may be applied with resolutions available to one microvolt. Input impedance is 1 MΩ with less than 100 pf shunt capacity.

601-3. SPECIFICATIONS

601-4. Table 601-1 lists the specifications for the –01 option.

601-5. INSTALLATION

601-6. Refer to Section 4 of this manual under Module Installation and Removal for instructions on installing modules. The interconnect diagram in Section 8 contains a table listing the permissible and preferred slots for each module.

601-7. OPERATING NOTES

601-8. The operating instructions given in Section 2 of this manual apply for operation of the instrument with the AC/DC Converter (Averaging) installed. The lowest range available through the average responding ac converter is the 1V range.

601-9. For rated accuracy below 400 Hz, the slow filter (FILTER LED on) must be selected. This selects additional filtering in the ac converter as well as in the Active Filter module. External reference measurements may be made as described in Section 2 but the external reference inputs must be dc only.

601-10. Once the instrument is zeroed for DC Volts, no additional zeroing is required for AC Volts measurements. Using the Offset function as an AC Volts zero could result in greater error due to the nature of the floor digits specifications.

601-11. THEORY OF OPERATION

601-12. The AC/DC Converter accepts signals either from the input terminals or from the optional current shunts module (RT1 and RT3). Refer to Figure 601-1. Input signals are applied to the input range amplifier, U1, through a dc blocking capacitor, C1, and a 2 MΩ resistor, R2. R2 establishes the input resistance of the amplifier. U1 is a voltage amplifier controlling a current source, Q4 and Q6. Q4 and Q6 change the low impedance of U1 to a high impedance for driving CR10 and CR11. The high impedance at the collectors of Q4 and Q6 minimizes error introduced by the nonlinearity of CR10 and CR11, which have a relatively low impedance.

601-13. Distortion of the waveform occurs at the collectors of Q4 and Q6 due to the nonconducting regions of CR10 and CR11. During the portion of the waveform in which CR10 and CR11 are not conducting, the feedback path of the amplifier is effectively broken and the gain of the amplifier becomes very high. The time required for the waveform to cross the nonconducting region is determined by the slew rate of the amplifier. When CR10 and CR11 are conducting, the gain of the amplifier is controlled by R18 and associated parallel resistors as selected by K3, K4, and K5.

601-14. U6 is configured as a differential amplifier having a gain of approximately 8 times the average-to-rms scaling factor of 1.11. Signals from CR10 and CR11 are applied to U6 through a matched temperature coefficient resistor set which provides the gain setting for U6, and filtering with capacitors C18, C19, C21, and C22. When the slow filter is selected, additional filtering, C17 and C20, is switched in by Q12 and Q13.

Table 601-1. AC/DC Converter (Averaging) Specifications

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION		INPUT IMPEDANCE
		6½ DIGITS*	5½ DIGITS	
1V	2.50000V	1 µV	10 µV	1 MΩ shunted by <100 pf
10V	20.0000V	10 µV	100 µV	
100V	160.000V	100 µV	1 mV	
1000V	1000.00V	1 mV	10 mV	

*In AVG operating mode (8505A/8506A).

Accuracy ±(% of Reading + Number of Counts)[1]

FREQUENCY*	24-HOUR 23°C ±1°C		90-DAY 23°C ±5°C	
	0 to 500V	>500V	0V to 500V	>500V
30 Hz - 50 Hz	0.3 + 5	0.4 + 5	0.5 + 5	0.55 + 5
50 Hz - 10 kHz	0.035 + 5	0.075 + 5	0.05 + 5	0.1 + 5
10 kHz - 40 kHz	—	0.1 + 5	—	0.15 + 5
10 kHz - 50 kHz[2]	0.075 + 5	—	0.1 + 5	—
50 kHz - 100 kHz[3]	0.3 + 5	—	0.5 + 5	—

*Slow filter must be used for full accuracy below 400 Hz.

>90 DAY: 23°C ±5°C
ADD TO THE 90 DAY SPECIFICATION PER MONTH THE FOLLOWING % OF READING

FREQUENCY	0 TO 500V	>500V
30 Hz - 50 Hz	0.056	0.05
50 Hz - 10 kHz	0.0056	0.011
10 kHz - 40 kHz	—	0.017
10 kHz - 50 kHz	0.011	—
50 kHz - 100 kHz	0.056	—

Operating Characteristics

TEMPERATURE COEFFICIENT ±(% of Reading + Number of Counts /°C[1]

FREQUENCY	0°C TO 18°C AND 28°C TO 50°C
30 Hz to 50 kHz	0.003 + 0.5
50 kHz to 100 kHz	0.01 + 1.0

COMMON MODE REJECTION .... >120 dB, dc to 60 Hz, with 100Ω in series with either lead.

RESPONSE TIME

Analog Settling Time .... 100 ms with Fast Filter and 500 ms with Slow Filter, to within 0.05% of in-range step change.

Digitizing Time .... Same as dc volts (see Section 1)

MAXIMUM INPUT VOLTAGE .... 1000V rms, 1400V peak, or 2×10^7 volts-hertz whichever is less.

NOTES:

[1]With inputs between 0.1% of range and full scale, 5½ digit display. For 6½ digit display, multiply Number of Counts by 10.

[2]On 1V range add 7 counts.

[3]On 1V range add 35 counts.

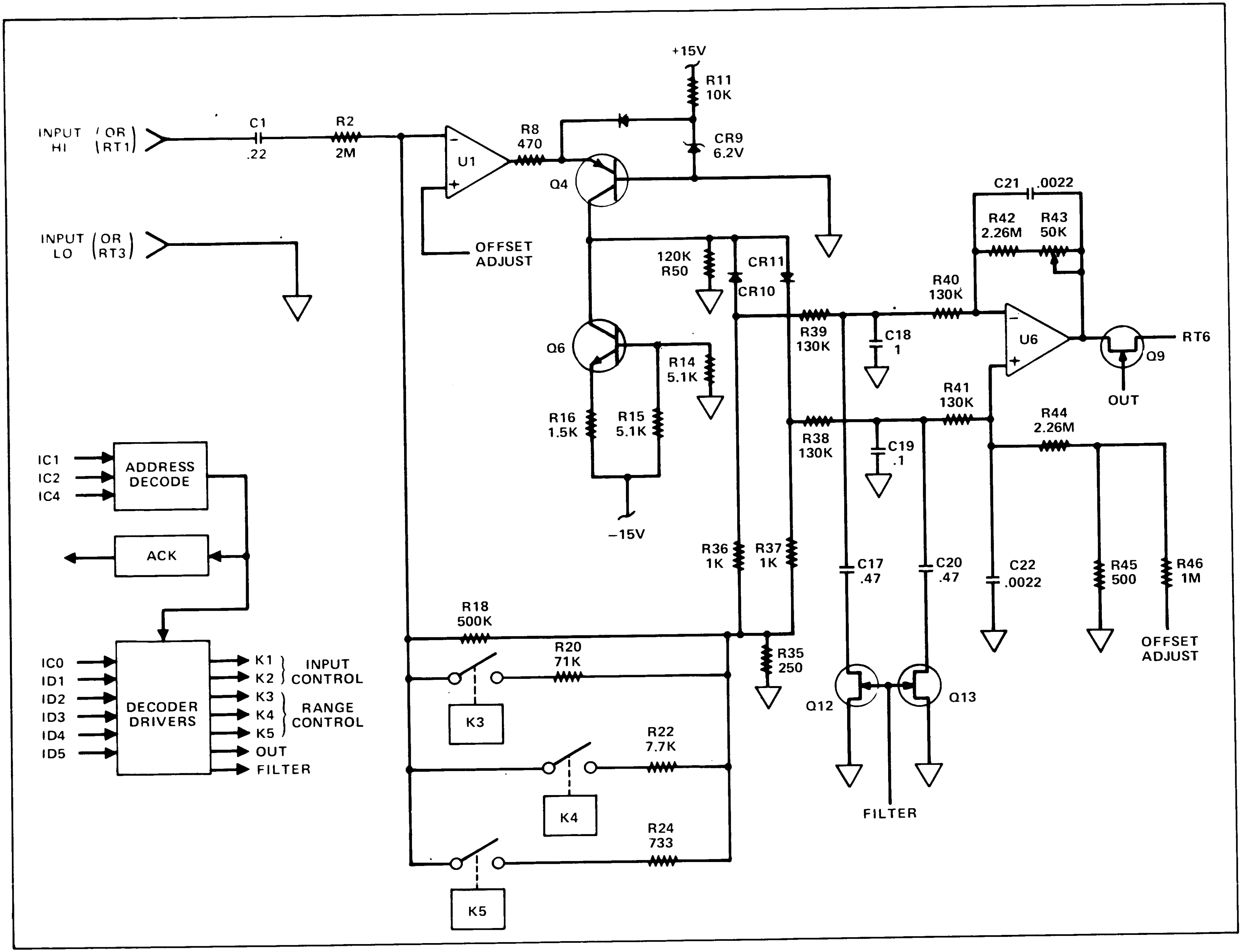


Figure 601-1. AC/DC Converter (Averaging)

601-15. MAINTENANCE

601-16. Performance Test

601-17. Sequentially apply the inputs listed in Table 601-2, ensuring that the reading is between the limits specified.

Table 601-2. Performance Test

Input Freq.	Voltage	8500 Reading	
		Low	High
10 kHz	1 V	0.99945	1.00055
50 kHz	1 V	0.99895	1.00105
10 kHz	10 V	9.9945	10.0055
50 kHz	10 V	9.9895	10.0105
10 kHz	100 V	99.945	100.055
50 kHz	100 V	99.895	100.105
10 kHz	1000 V	998.95	1001.05

601-18. Calibration

601-19. Use the DC portion of the instrument to adjust the AC balance of the AC/DC Converter using the following procedure.

1. Select DC Volts, 100 mV range, and slow filtering (FILTER indicator illuminated).
2. Connect TP1 on the AC/DC Converter to the Input HI terminal.
3. Adjust R17 (AC Balance) for a reading of 0 ± 20 μV.
4. Remove the connection between TP1 and Input HI.

601-20. Select AC Volts and manually select the 1000V range. Connect the AC Calibrator to the instrument. Sequentially apply the inputs listed in Table 601-3, making adjustments as required to the nominal value. Repeat steps 1 through 6 until all six steps are within the stated tolerance without amking any adjustments. Those inputs for which no adjustment is listed are to verify that the averaging Converter is within tolerance.

601-21. The adjustment in step 13 is performed using a computation derived from the readings in steps 13 and 14 if either step is out of tolerance. Use the following procedure to compute the value of the adjustment:

1. Subtract and record the absolute value of the reading in step 13 from the absolute value of the nominal reading, e.g. if the reading was 18.9322 you would subtract 189322 from 190000 for a result of +678.
2. Subtract and record the absolute value of the reading in step 14 from the absolute value of the nominal reading, e.g. if the reading was 1.90503 you would subtract 190503 from 190000 for a result of -503.

Table 601-3. Calibration Chart

Step	Input			Reading			Adjust
	Range	Voltage	Frequency	Minimum	Nominal	Maximum	
1	1000V	500	500 Hz	499.93	500.00	500.07	R43
2	1000V	500	60 kHz	499.92	500.00	500.08	C23
3	1000V	1	500 Hz	0.99	1.00	1.01	R47
4	1000V	1	100 kHz	0.97	0.98	0.98	C16
5	1V	1	500 Hz	0.99993	1.00000	1.00007	R19
6	1V	1	60 kHz	0.99975	1.00000	0.99990	C8
7	10V	10	500 Hz	9.9993	10.0000	10.0007	R21
8	10V	10	60 kHz	9.9991	10.0000	10.0009	C10
9	100V	100	500 Hz	99.993	100.000	100.007	R23
10	100V	100	60 kHz	99.991	100.000	100.009	C25
11	100V	100	10 kHz	99.975	100.000	100.025	
12	10V	19	30 Hz	18.9615	19.0000	19.0385	
13	10V	19	100 kHz	18.9520	19.0000	19.0480	
14	1V	1.9	100 kHz	1.89520	1.90000	1.90480	(R55)
15	1V	1.9	10 kHz	1.89520	1.90000	1.90050	
16	1V	.1	500 Hz	0.09995	0.10000	0.10005	
17	1000V	1000	20 kHz	999.50	1000.00	1000.50	
18	1V	5 0.025	50 kHz	0.02492	0.02500	0.2508	
19	1V	0.025	100 kHz	0.02465	0.02500	0.02535	

3. Algebraically add the two recorded results and double the result. With the example readings inserted the result is: 2*[+678+(-503)] = +350.

4. With R55 adjust the reading in step 13. If the number is positive (+) increment the reading the computed number of digits, if it is negative (-) decrement the reading the computed number of digits.

5. Repeat the process until both readings are within the stated tolerances.

601-22. Troubleshooting

601-23. Table 601-4 contains a procedure to ensure the problem actually is in the AC Converter. Figure 601-2 contains symptom analysis of the AC Converter and address and data information.

601-24. PARTS LIST

601-25. Table 601-5 contains a parts breakdown for the AC/DC Converter (Averaging). Refer to Section 5 of this manual for ordering and use code information.

CAUTION

Indicated devices are subject to damage by static discharge.

Table 601-4. AC Converter Isolation

STEP NO.	ACTION	Go to the step number given for correct response: YES	NO
1	Do the DC Performance Test (Section 4).		
2	Is DC Volts within tolerance?	3	Section 4
3	Is the Calibration Memory module installed?	4	6
4	Remove the Calibration Memory module. Is AC OK?	5	6
5	Bad Calibration Memory. Go to Section 604.		
6	Is Isolator installed?	7	10
7	Replace Isolator with Bus Interconnect/Monitor pcb.		
8	Is AC OK?	9	10
9	Bad Isolator. Go to Section 608.		
10	Remove DC Signal Conditioner. Is AC OK?	11	12
11	DC Signal Conditioner interfering with AC. The problem in the DC Signal Conditioner is one of the following: 1. Digital Logic Bad, 2. K1 or K2 shorted, 3. Q6, Q7, Q8 Bad.		
12	Install Bus Interconnect/Monitor if not already installed.		
13	Check power supply voltages as follows: VA1 = +14.25 to 15.75V; VA4 = –29 to –32V VA2 = –14.25 to –15.75V; Vcc = –15V, Vss = –20V } Difference = 4.9 to 5.2 VA3 = +29 to 32V		
14	Are the supply voltages OK?	15	Section 4
15	Go to Figure 601-2.		

SYMPTOM	POSSIBLE FAILURE
Noisy Reading	U1, U6
Single range bad	Digital logic, range relay
All ranges bad	U1, U6
Reading out of tolerance	Range relay, U1
Overrange	U6
High frequency bad	U6
No Output	Q9, Q10, Q11, U6, U1, K1, K2
Interfering with DC or Ohms reading	K1 shorted, Q9 leaky
Address: IC 4, 2, 1 high	
Data: ID0 = 1, ID1 = 0	AC Voltage Input Terminals
ID0 = 0, ID1 = 1	AC Current, RT1 and RT3
ID2 = 0	Filter on
ID3 = 0	10V range
ID4 = 0	100V range
ID5 = 0	1000V range
ID5, 4, 3 = 1	1V range

If U1, Q4, Q6, R51, R52, CR10, or CR11 are replaced it may be necessary to change the value of R51 or R52 to correct offset error. Use the following procedure.

1. Remove R51 or R52, whichever is installed.
2. Connect test DMM Hi to TP1, Lo to TP2.
3. With R17 fully CW, the reading should be more than +100 μV.
4. If not, center R17 and select a resistor value from the following table which has the closest corresponding offset voltage. For negative readings, install the resistor as R52. For positive readings, install the resistor as R51.

OFFSET	RESISTOR	J.F. PART #
.25 mV	2.7 MΩ	193490
.5	1.5M	182857
.75	910K	285338
1.0	680K	188433
1.25	560K	220533
1.5	470K	188441
1.75	390K	193383
2.0	360K	234690
2.25	300K	234682
2.5	270K	220061
2.75	240K	218016
3.0 3.25	220K	160937
3.5	200K	248781

Figure 601-2. Symptom Analysis

Table 601-5. AC/DC (Avg) PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
-01	AC/DC CONVERTER (AVG) PCB ASSEMBLY FIGURE 601-3 (MIS-4101T)	ORDER	BY	OPTION -01			
C1	CAP, FILM, 0.22 UF +/-20%, 1200V	268904	89536	268904	1		
C2	CAP, MICA, 47 PF +/-5%, 500V	148536	72136	CM15E470J	1		
C5	CAP, MICA, 33 PF +/-5%, 500V	160317	72136	DM15E330J	1		
C6	CAP, TA, 4.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	8		
C7	CAP, CER, 1 PF +/-0.25%, 100V	436477	80031	2222-638-C3108	1		
C8	CAP, VAR, 0.25-1.5 PF, 2000V	273151	74970	273-0001-002	2		
C9	CAP, MICA, 15 PF +/-2%, 500V	335612	72136	DM15C150G	2		
C10	CAP, VAR, 0.8-10 PF, 200V	229930	91293	JMC5201	1		
C11	CAP, MICA, 150 PF +/-1%, 500V	226134	72136	DM15F151F	1		
C12	CAP, MICA, 15 PF +/-2%, 500V	335612	72136	DM15C150G	REF		
C13	CAP, MICA, 1800 PF +/-2%, 500V	447441	72136	DM19F182G	1		
C14	CAP, TA, 4.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	REF		
C15	CAP, TA, 4.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	REF		
C16	CAP, VAR, CERMET, 1.7-10 PF, 250V	375238	52769	GKC10000	2		
C17	CAP, POLYESTER, 0.47 UF +/-10%, 100V	369124	89536	369124	2		
C18	CAP, POLYESTER, 0.10 UF +/-10%, 100V	393439	89536	393439	2		
C19	CAP, POLYESTER, 0.10 UF +/-10%, 100V	393439	89536	393439	REF		
C20	CAP, POLYESTER, 0.47 UF +/-10%, 100V	369124	89536	369124	REF		
C21	CAP, FILM, 0.0022 UF +/-10%, 50V	313239	06001	75F1R5A322	2		
C22	CAP, FILM, 0.0022 UF +/-10%, 50V	313239	06001	75F1R5A322	REF		
C23	CAP, VAR, 0.25-1.5 PF, 2000V	273151	74970	273-0001-002	REF		
C24	CAP, MICA, 68 PF +/-5%, 500V	148510	72136	DM15F680J	1		
C25	CAP, VAR, CERMET, 1.7-10 PF, 250V	375238	52769	GKC10000	REF		
C26	CAP, TA, 4.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	REF		
C27	CAP, TA, 4.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	REF		
C28	CAP, TA, 4.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	REF		
C29	CAP, TA, 4.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	REF		
C30	CAP, TA, 4.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	REF		
C31	CAP, TA, 22 UF +/-20%, 15V	423012	56289	196D226X0015KA1	2		
C32	CAP, TA, 22 UF +/-20%, 15V	423012	56289	196D226X0015KA1	REF		
C33	CAP, MICA, 10 PF +/-2%, 500V	335638	72136	DM15C100G	1		
CR1	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	6	2	
CR2	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR3	DIODE, SI, LO-CAP, LO-LEAK	348177	07263	FD7223	4	1	
CR4	DIODE, SI, LO-CAP, LO-LEAK	348177	07263	FD7223	REF		
CR5	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR6	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR7	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR8	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR9	DIODE, ZENER, UNCOMPENSATED	325811	07910	1N753A	2	1	
CR10	DIODE, SI, LO-CAP, LO-LEAK	348177	07263	FD7223	REF		
CR11	DIODE, SI, LO-CAP, LO-LEAK	348177	07263	FD7223	REF		
CR12	DIODE, ZENER, UNCOMPENSATED	325811	07910	1N753A	REF		
H1	SCREW, PHP, 4-40 X 3/16	129882	89536	129882	3		
H2	SCREW, PH FILISTER, 6-32 X 1/2 (not shown)	115006	89536	115006	3		
H3	SCREW, PHP, 4-40 X 3/8	256164	89536	256164	1		

Table 601-5. AC/DC (Avg) PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
K1	RELAY ASSY						
	RELAY, COIL, 6V	272070	71707	UD-6P	2		
	FOIL	313833	89536	313833	2		
	SWITCH, DRY REED	284091	95348	MR138	2		
	SWITCH, DRY REED	414300	95348	MR5830-7	2		
K2	RELAY ASSY				REF		
	RELAY, COIL, 6V	272070	71707	UD-6P	REF		
	FOIL	313833	89536	313833	REF		
	SWITCH, DRY REED	284091	95348	MR138	REF		
	SWITCH, DRY REED	414300	95348	MR5830-7	REF		
K3	RELAY, DRY REED	357566	71707	UF40069	3		
K4	RELAY, DRY REED	357566	71707	UF40069	REF		
K5	RELAY, DRY REED	357566	71707	UF40069	REF		
MP1	MODULE CASE ASSY., (INCLUDES MP2-MP9)	459016	89536	459016	1		1
MP2	CASE HALF, MODULE	402990	89536	402990	2		
MP3	CASE HALF, MODULE	402990	89536	402990	REF		
MP4	COVER, MODULE CASE	402974	89536	402974	1		
MP5	SHIELD, COVER	411926	89536	411926	1		
MP6	DECAL, AC/DC CONVERTER (AVERAGING)	413385	89536	413385	1		
MP7	DECAL, CAUTION	454504	89536	454504	1		
MP8	REAR GUARD	383364	89536	383364	1		
MP9	GUARD, FRONT	383356	89536	383356	1		
MP10	INSULATOR, AVG SHIELD (not shown)	437913	89536	437913	1		
MP11	SHIELD, AVG CONVERTER (not shown)	437905	89536	437905	1		
MP12	SHIELD, AVG CONVERTER, REAR (not shown)	437897	89536	437897	1		
MP13	SPRING, COIL (not shown)	424465	83553	C0120-014-0380	1		
MP14	SOCKET, COMPONENT LEAD	343285	00779	2-331272-6	8		
MP15	SPACER, STANOFF, 4-40	335604	89536	335604	1		
MP16	SPACER, STANDOFF, ROUND, 6-32	423806	89536	423806	3		
MP18	TERMINAL, FEED-THRU SLOT UNINSULATED	512012	88245	1308	2		
Q2	XSTR, SI, NPN	218396	04713	2N3904	4	1	
Q3	XSTR, SI, PNP	226290	04713	MPS3640	1	1	
Q4	XSTR, SI, PNP	195974	04713	2N3906	2	1	
Q5	XSTR, SI, NPN	218081	89536	218081	2	1	
Q6	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q7	XSTR, SI, NPN	218081	89536	218081	REF		
Q8	XSTR, FET, N-CHANNEL	352112	89536	352112	1	1	
Q9	XSTR, FET, N-CHANNEL	393314	89536	393314	1	1	
Q10	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q11	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q12	XSTR, FET, N-CHANNEL	343830	89536	343830	2	1	
Q13	XSTR, FET, N-CHANNEL	343830	89536	343830	REF		
Q14	XSTR, SI, NPN	218396	04713	2N3904	REF		
R2	RES, MTL. FILM, 2M +/-0.5%, 1W	354894	89536	354894	1		
R3	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	2		
R8	RES, DEP. CAR, 470 +/-5%, 1/4W	343434	80031	CR251-4-5P470E	1		

Table 601-5. AC/DC (Avg) PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
R9	RES, MTL. FILM, 49.9 +/-1%, 1/8W	305896	91637	CMF5549R9F	1		
R10	RES, MTL. FILM, 1M +/-1%, 1/8W	268797	91637	CMF551004F	1		
R11	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	3		
R12	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R13	RES, DEP. CAR, 75K +/-5%, 1/4W	394130	80031	CR251-4-5P75K	1		
R14	RES, DEP. CAR, 5.1K +/-5%, 1/4W	368712	80031	CR251-4-5P5K1	2		
R15	RES, DEP. CAR, 5.1K +/-5%, 1/4W	368712	80031	CR251-4-5P5K1	REF		
R16	RES, DEP. CAR, 1.5K +/-5%, 1/4W	343418	80031	CR251-4-5P1K5	1		
R17	RES, VAR, CERMET, 100K +/-10%, 1/2W	288308	89536	288308	3		
R18	RES, MTL. FILM, 500.85K +/-0.1%, 1/8W	424614	89536	424614	1		
R19	RES, VAR, CERMET, 5K +/-10%, 1/2W	288282	89536	288282	1		
R20	RES, MTL. FILM, 71.320K +/-0.1%, 1/8W	424515	89536	424515	1		
R21	RES, VAR, CERMET, 500 +/-10%, 1/2W	291120	89536	291120	1		
R22	RES, MTL. FILM, 7.704K +/-0.1%, 1/8W	436121	89536	436121	1		
R23	RES, VAR, CERMET, 50 +/-10%, 1/2W	285122	89536	285122	1		
R24	RES, MTL. FILM, 733.9 +/-0.1%, 1/8W	460212	89536	460212	1		
R25	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R26	RES, DEP. CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	3		
R27	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	1		
R28	RES, DEP. CAR, 22K +/-5%, 1/4W	348870	80031	CR251-4-5P22K	1		
R29	RES, DEP. CAR, 15K +/-5%, 1/4W	348854	80031	CR251-4-5P15K	1		
R30	RES, DEP. CAR, 8.2K +/-5%, 1/4W	441675	80031	CR251-4-5P8K2	1		
R31	RES, DEP. CAR, 51K +/-5%, 1/4W	376434	80031	CR251-4-5P51K	3		
R32	RES, DEP. CAR, 51K +/-5%, 1/4W	376434	80031	CR251-4-5P51K	REF		
R33	RES, DEP. CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	REF		
R34	RES, DEP. CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	REF		
R35-R42	RESISTOR SET	441873	89536	441873	1		2
R43	RES, VAR, CERMET, 50K +/-10%, 1/2W	288290	89536	288290	1		
R44-R46	RESISTOR SET, PART OF R35-R42						2
R47	RES, VAR, CERMET, 100K +/-10%, 1/2W	288308	89536	288308	REF		
R48	RES, DEP. CAR, 51K +/-5%, 1/4W	376434	80031	CR251-4-5P51K	REF		
R49	RES, DEP. CAR, 330 +/-5%, 1/4W	368720	80031	CR251-4-5P330E	1		
R50	RES, DEP. CAR, 120K +/-5%, 1/4W	441386	80031	CR251-4-5P120K	REF		
R51	RESISTOR, SELECTED AT TEST FUNCTION.				1		3
R52	RESISTOR, SELECTED AT TEST FUNCTION.				REF		3
R53	RES, DEP. CAR, 100 +/-5%, 1/4W	348771	80031	CR251-4-5P100E	2		
R54	RES, DEP. CAR, 100 +/-5%, 1/4W	348771	80031	CR251-4-5P100E	REF		
R55	RES, VAR, CERMET, 100K +/-10%, 1/2W	288308	89536	288308	REF		
TP1	TERMINAL, TEST POINT	179283	89536	179283	1		
U1	IC, LIN, OP AMP	429951	12040	LF357AH	1	1	
U2	⊘IC, C-MOS, HEX "D" FLIP FLOP	404509	12040	MM74C174N	1	1	
U3	⊘IC, C-MOS, QUAD, 2-INPUT NAND GATES	375147	02735	CD4023AE	1	1	
U4	⊘IC, C-MOS, HEX, INVERTER/BUFFER	381848	02735	CD4049AE	1	1	
U5	⊘IC, TTL, HEX, INVERTER, BUFFER/DRIVER	288605	01295	SN7416N	1	1	
U6	⊘IC, LIN, OP AMP	288928	12040	LM308AH	1	1	

1 USE P/N 459016 TO ORDER COMPLETE MODULE CASE, WITHOUT PCB ASSY.

2 R35 THRU R42 AND R44 THRU R46 ARE MATCHED RESISTORS. IF ANY ONE RESISTOR OF THIS SET NEEDS REPLACEMENT, THE WHOLE SET MUST BE INCLUDED IN THE REPLACEMENT.

3 RESISTORS ARE TEMPERATURE COMPENSATED AND MUST BE RETURNED FOR RESELECTION IF ANY REQUIRE REPLACEMENT. (R51 AND R52)

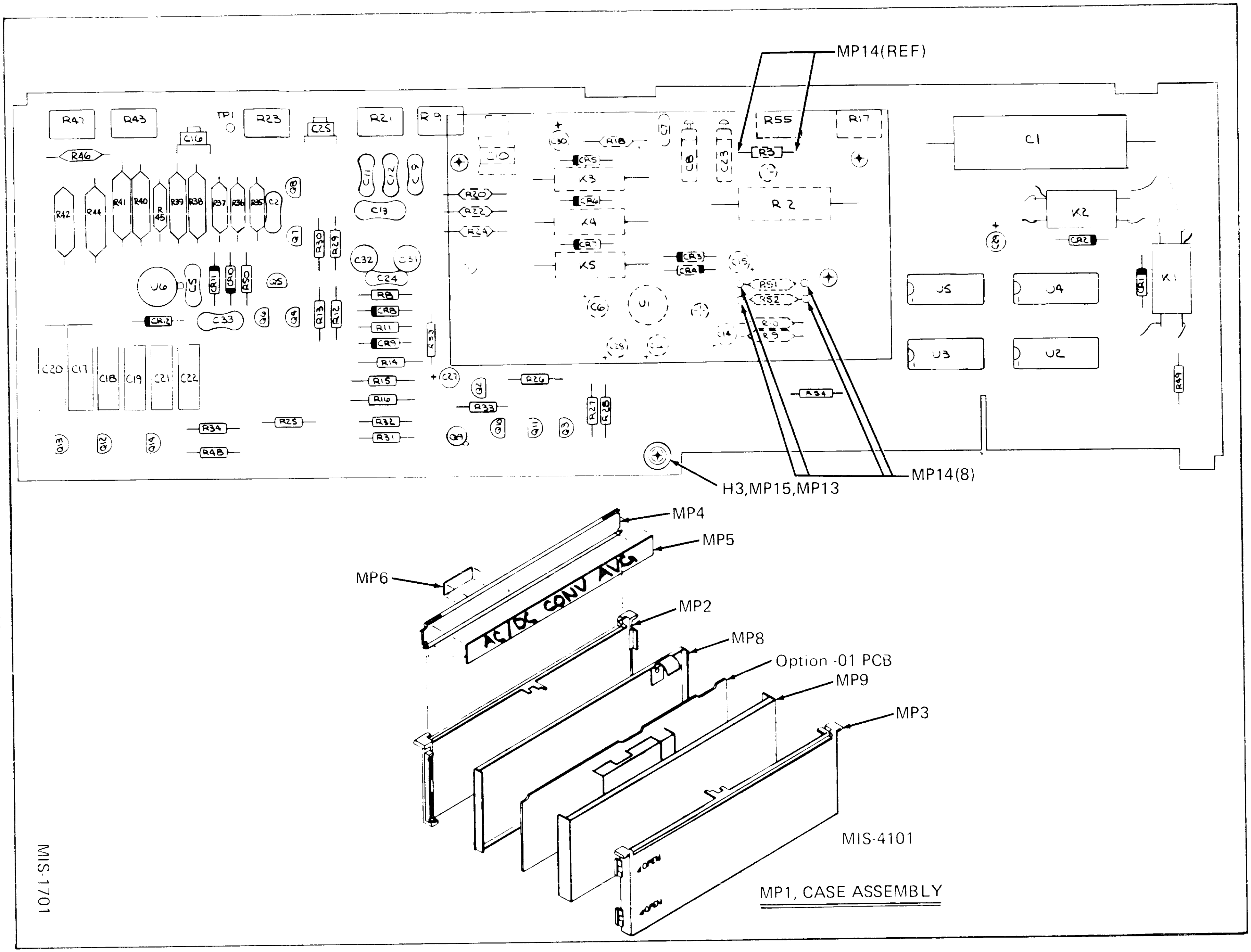
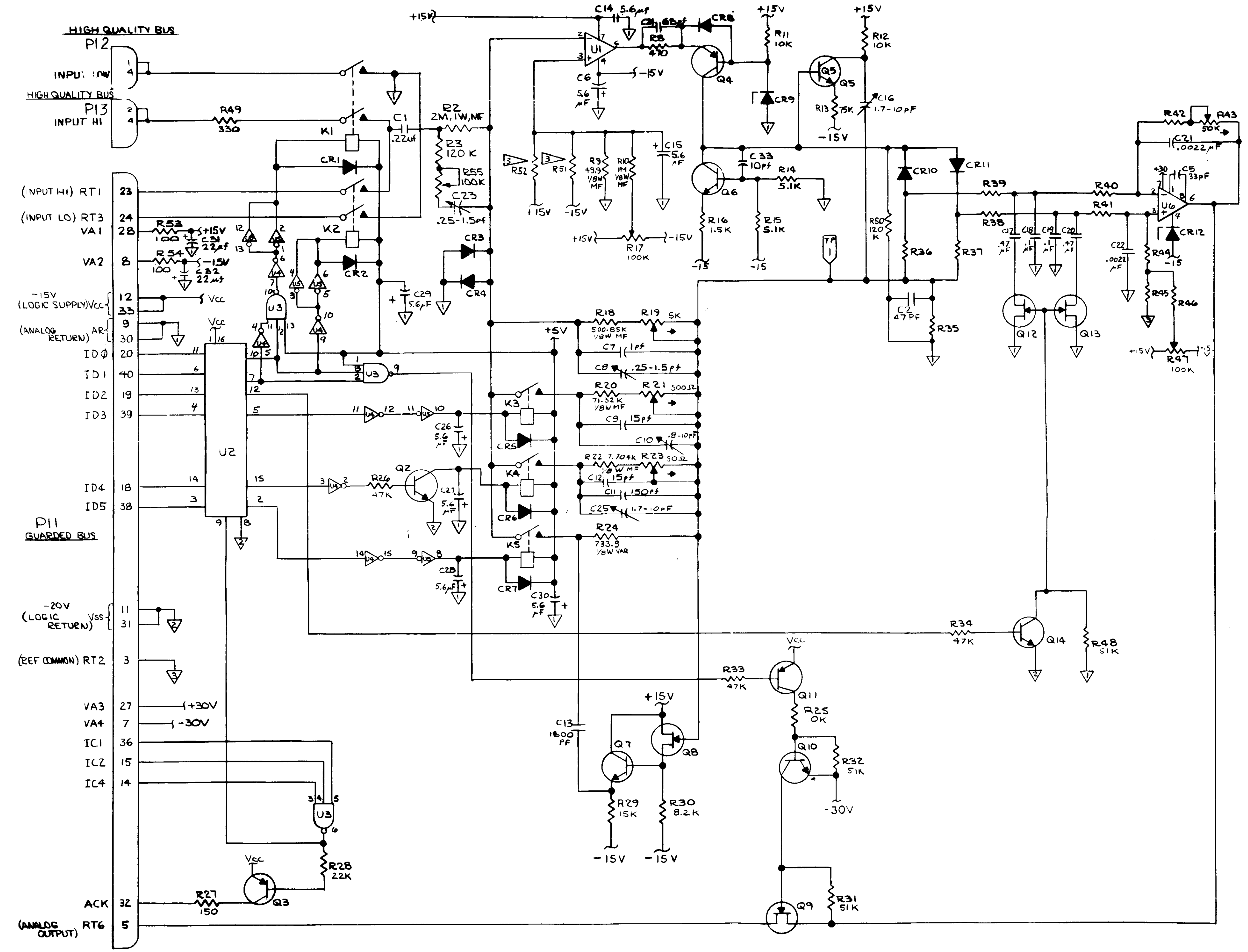


Figure 601-3. AC/DC (Avg) PCB Assembly



I.C. NO'S	TYP	VSS	VCC
U2	74C174	8	16
U3	4023	7	14
U4	4050	8	1
U5	7416	7	14

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTORS 1/4W CC, ALL RESISTANCE IN OHMS.

2 MATCHED RESISTOR SET.

3 FACTORY SELECTED PARTS.

Figure 601-3. AC/DC Converter (Averaging) PCB Assembly (cont)

Option -02B
Ohms Converter

602-1. INTRODUCTION

Installation of the Ohms Converter provides precision resistance measurement capability. Both two-terminal and four-terminal measurements may be made.

602-2. SPECIFICATIONS

Table 602-1 lists the specifications for the Ohms Converter.

602-3. INSTALLATION

Refer to Section 4 of this manual under Module Installation and Removal for instructions on installing and removing modules. Section 8 provides a list of permissible and preferred installation slots.

602-4. OPERATING NOTES

Operation of the front panel controls with the Ohms Converter installed is described in Section 2 of this manual. Eight resistance ranges are available: 10, 100, 1k, 10k, 100k, 1M, 10M and 100M. Manual or auto ranging is available. Figure 602-1 shows possible connections for both two-wire and four-wire configurations. Four-wire measurements provide maximum accuracy and can be made on the 10, 100, 1k, 10k and 100k ranges when the Ohms Selector is pushed in (4T IN). Two-wire measurements (Ohms Selector out) can be made on the 1M, 10M, and 100M ranges without affecting accuracy.

During normal operation (Calibration mode off), ohms zero can be made by shorting the input test leads to compensate for both multimeter internal drift and lead resistance. The front panel Ohms Selector must be pushed in (4T IN) for four-terminal zero corrections or out for two-terminal zero corrections. When Calibration mode is off, zero values are stored in temporary memory. Select the 10 ohm range and push the ZERO VDC/OHMS button. This zero value is then applied to the selected range (10 ohm) and all higher ranges. However, if greater measurement accuracy is desired, discrete zero values can be stored by subsequently pushing ZERO VDC/OHMS twice in each higher range (lowest to highest). Zero values entered in this fashion do not affect other zero values already entered into Calibration Memory during software calibration. If a power-up or reset occurs with Calibration mode off, the temporary values entered with the above procedure are replaced with the Calibration Memory values.

Zero values stored with Calibration mode on are permanently stored in Calibration Memory. This procedure differs in that corrections are made only for multimeter internal drift and the zero value is entered for the selected range only. Refer to Software Calibration (Section 7) for a full description. The temporary value (Calibration mode off) or the permanent value (Calibration mode on) for the range selected can be recalled by pushing RECALL ZERO VDC/OHMS.

602-5. GUARDING

The ohms guard connection is only available through the rear input connector. Figure 602-1 shows optimal use of the guard. Basically, the ohms guard is used to minimize leakage resistance between HI and LO input leads. This leakage would appear as a shunt resistance across high R_X values. In some high-resistance measurement set-ups, leakage resistance in or on the surface of insulating materials may provide enough shunt resistance to degrade the accuracy of the measurement. Figure 602-1 illustrates one such case. Connecting the ohms guard to the metal plate on which the standoffs are mounted reduces the affect of leakage resistance through or on the standoffs.

602-6. THEORY OF OPERATION

The function of the Ohms Converter is to produce a current through an unknown resistance such that the voltage across the unknown is proportional to the value of resistance. This is accomplished by configuring the unknown resistance, R_X, as the feedback element of an operational amplifier. A reference voltage, V_{REF}, is applied through a reference resistor, R_{REF}, to the summing

PN 881763 7/91

Table 602-1. Ohms Converter Specifications

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION		CURRENT THROUGH UNKNOWN
		6½ DIGITS*	5½ DIGITS	
10Ω	20.0000Ω	10 μΩ	100 μΩ	10 mA
100Ω	200.000Ω	100 μΩ		10 mA
1 kΩ	2.00000 kΩ	1 mΩ	6½	1 mA
10 kΩ	25.0000 kΩ	10 mΩ	Digits	78 μA
100 kΩ	250.000 kΩ	100 mΩ	Only	7.2 μA
1 MΩ	4.10000 MΩ	1Ω	10Ω	4.5 μA
10 MΩ	35.0000 MΩ	10Ω	100Ω	0.45 μA
100 MΩ	265.000 MΩ	100Ω	1 kΩ	56 nA

*In normal operating mode, 5½ or 6½ digits depending on range. In AVG operating mode, 6½ digits on all ranges.

Accuracy

±(% of Reading + Number of Counts)*		
RANGE	24-HOUR 23°C ±1°C	90-DAY 23°C ±5°C
10Ω	0.003 + 20	0.005 + 20
100Ω	0.002 + 1.4	0.003 + 1.4
1 kΩ	0.002 + 0.8	0.003 + 0.8
10 kΩ	0.002 + 0.8	0.003 + 0.8
100 kΩ	0.002 + 0.8	0.003 + 0.8
1 MΩ	0.002 + 0.8	0.003 + 0.8
10 MΩ	0.0075 + 0.8	0.02 + 0.8
100 MΩ	0.026 + 0.8	0.05 + 1

*With 5½ digit display. For 6½ digit display, multiply Number of Counts by 10.

>90 DAY: 23°C ±5°C
ADD TO THE 90 DAY SPECIFICATION PER MONTH THE FOLLOWING % OF READING

RANGE	% OF READING
10Ω	0.00056
100Ω - 1 MΩ	0.00033
10 MΩ	0.0022
100 MΩ	0.0056

Table 602-1. Ohms Converter Specifications (cont)

Operating Characteristics

TEMPERATURE COEFFICIENT

±(% OF READING + NUMBER OF COUNTS) /°C*	
RANGE	0°C TO 18°C AND 28°C TO 50°C
10Ω	0.0008 + 1.5
100Ω	0.0007 + 0.2
1 kΩ	0.0007 + 0.2
10 kΩ	0.0007 + 0.2
100 kΩ	0.0007 + 0.5
1 MΩ	0.001 + 0.5
10 MΩ	0.005 + 0.5
100 MΩ	0.02 + 0.5

*With 5½ digit display. For 6½ digit display, multiply Number of Counts by 10.

MAXIMUM LEAD RESISTANCE

RANGE	MODE	LEADS	LEAD RESISTANCE
10Ω - 100Ω	4 wire	Source	10Ω
1 kΩ	4 wire	Source	100Ω
10 kΩ - 100 MΩ	4 wire	Source	1 kΩ

OPEN CIRCUIT VOLTAGE

RANGE	VOLTAGE
10Ω - 100 kΩ	7 volts maximum
1 MΩ - 100 MΩ	25 volts maximum

MEASUREMENT CONFIGURATION.. Two-wire and four-wire available on all ranges.

MAXIMUM OVERLOAD VOLTAGE .. ±400V dc or peak ac continuous on any range with no damage.

RESPONSE TIME

Analog Settling Time .... 80 ms with Fast Filter or 800 ms with Slow Filter to rated accuracy.

Digitizing Time .... Depending on sample rate and filter selection the digitizing time will vary from 145 ms to 9 minutes 6 seconds using a 60 Hz ac line with times increasing 20% using a 50 Hz ac line.

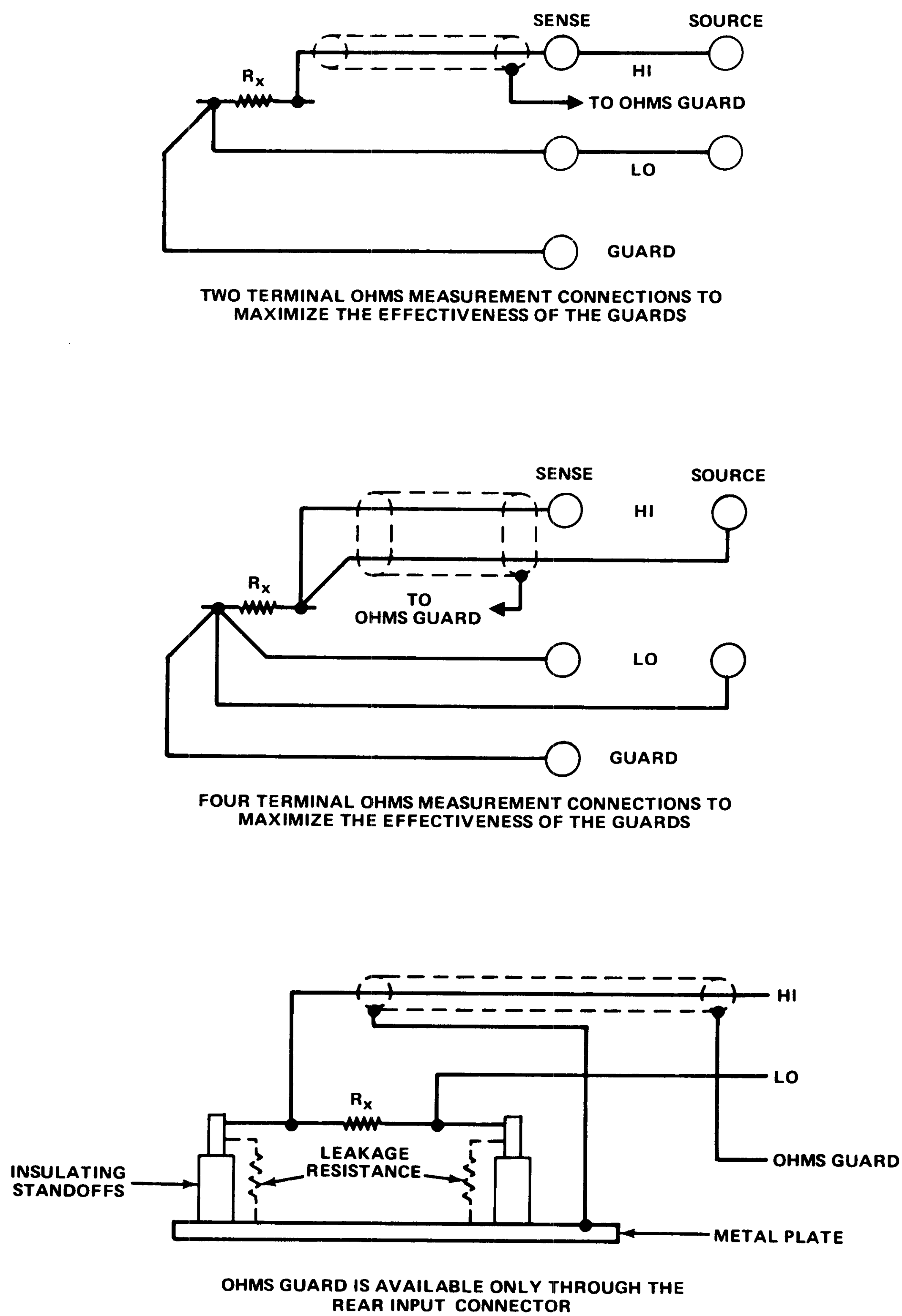


Figure 602-1. Ohms Measurement Connections and Guarding

node of the amplifier. By definition of an ideal operational amplifier, the current through R_X is the same current flowing through R_{REF} (the summing node represents virtual ground). Figure 602-2 is a simplified schematic of the Ohms Converter and contains an illustration of the derivation of the formula for R_X. A current flowing through R_{REF} equals $(V_1 - V_2)/R_{REF}$. Using the expression for current to obtain the value of R_X:

$$R_X = R_{REF}\ V_0/(V_1 - V_2)$$

The Ohms Converter multiplexes the voltages which, after being routed through the DC Signal Conditioner and Filter modules, are measured by the A/D Converter.

The current reference for the Ohms Converter is derived from the -7V reference (RT4) from the A/D Converter. Inverting amplifier U4 uses two possible feedback paths to produce either approximately +1.86V or +18.5V as V_1. U4 drives Q8. Q8 serves as a larger current source than is available from U4. R41, R45 and R56 are the reference resistors, each having an adjustment.

R_X is the feedback element for the operational amplifier composed of U6 and Q37. U6 drives Q37 which serves as a higher current source. This arrangement also allows a larger output voltage swing. Note that U6 is configured as an inverter, yet the output of U6 is a positive voltage. Q37 draws its emitter current through R48 and R49 from the -30V supply with CR18 and CR13 insuring that Q37 is not saturated. SOURCE voltages out are negative voltages at SOURCE LO with respect to circuit common. In the 100M range, the voltage applied to R41 is divided by 8. However, the unattenuated V_{REF} is measured. The factor of 8 is preserved by assigning R_{REF} the value of 8xR41 in the equation. As the Ohms Converter down ranges, R41 remains enabled so lower R_{REF} values are actually parallel combinations. V_2 is not measured in the three highest ranges (1M, 10M, 100M) since lead resistance is not large enough to affect accuracy.

Extensive overvoltage protection has been provided for the Ohms Converter. Refer to the full schematic. Voltages appearing on the SENSE or SOURCE HI terminals in excess of +28V or -19V (with respect to circuit common) are clamped to ground by Q14, CR17, Q10 and Q390. U5 is configured as a voltage comparator biased by CR19 and R14. The clamping action of Q14 or Q10 causes a voltage on the input Lo line which triggers comparator U5 through Q11 or Q15. In either case, the output at U5 pin 7 toggles to its maximum positive level, which places U2 in the high impedance output state. While all IC lines into U1 are high, the ACK logic is inhibited so an Error 4 is displayed and the module is reset to the power-up condition. CR13 and CR14 at the output of U6, Q37 are high voltage blocking diodes. E1 is a spark gap preventing voltages in excess of 400V between the guard shield and circuit common.

The Ohms Converter is addressed when IC1, 2, 3 are high, and IC0, 4 are low. It must be addressed for each sample voltage. Samples are multiplexed out at the rate of one every four msec. This requires the fastest response time in the DC Signal Conditioner of any measurement mode.

602-7. MAINTENANCE

602-8. Performance Test

Test the Ohms function using the following procedure:

1. Connect test leads to the instrument in the four-wire configuration. Ensure that the front panel Ohms Selector is pushed in (4T IN).
2. Select OHMS (function) and 10 ohm manual (range).
3. Short all leads together, then push ZERO VDC/OHMS.
4. Connect the standard resistor for the range selected. Check that the UUT reading falls within the limits specified in Table 602-2.
5. Select the next higher manual range.
6. Repeat steps 3, 4, and 5 for the 100, 1k, 10k, and 100k ranges.
7. Connect test leads in the two-wire configuration (Ohms Selector out).
8. Repeat steps 3,4, and 5 for the 1M, 10M, and 100M ranges.

602-9. Calibration

Use the following procedure for calibration of the Ohms Converter.

1. Allow for a two hour warm-up, then ensure that dc volts accuracy is within tolerance.
2. With the Calibration Switch set to on (AVG/(CAL) annunciator flashes), disable software calibration gain factors by pushing STORE (CAL COR) once for each of the eight ohms ranges.
3. Ensure that the Zero mode is off (ZERO annunciator off). If necessary, toggle the ZERO VDC/OHMS button.
4. Ensure that the Ohms Selector and the Guard Selector are both pushed in. Then apply a high quality, low-thermal short to the inputs in a four-terminal configuration.
5. Use manual range selection to prevent range changes while testing at the range extremities.
6. Select the 10-ohm range on the UUT.
7. Adjust R24 for a reading between -0.0003 and +0.0003.
8. Step through the other seven ranges, checking that the reading is 0 ±1 digit on all ranges.
9. Remove the four-terminal short and make four-terminal measurement connections. Select the 1M range and connect the input leads to a 4 Mohm standard resistor.

NOTE

Refer to Table 4-1 of the Instruction Manual for specifications on the Standard Resistors.

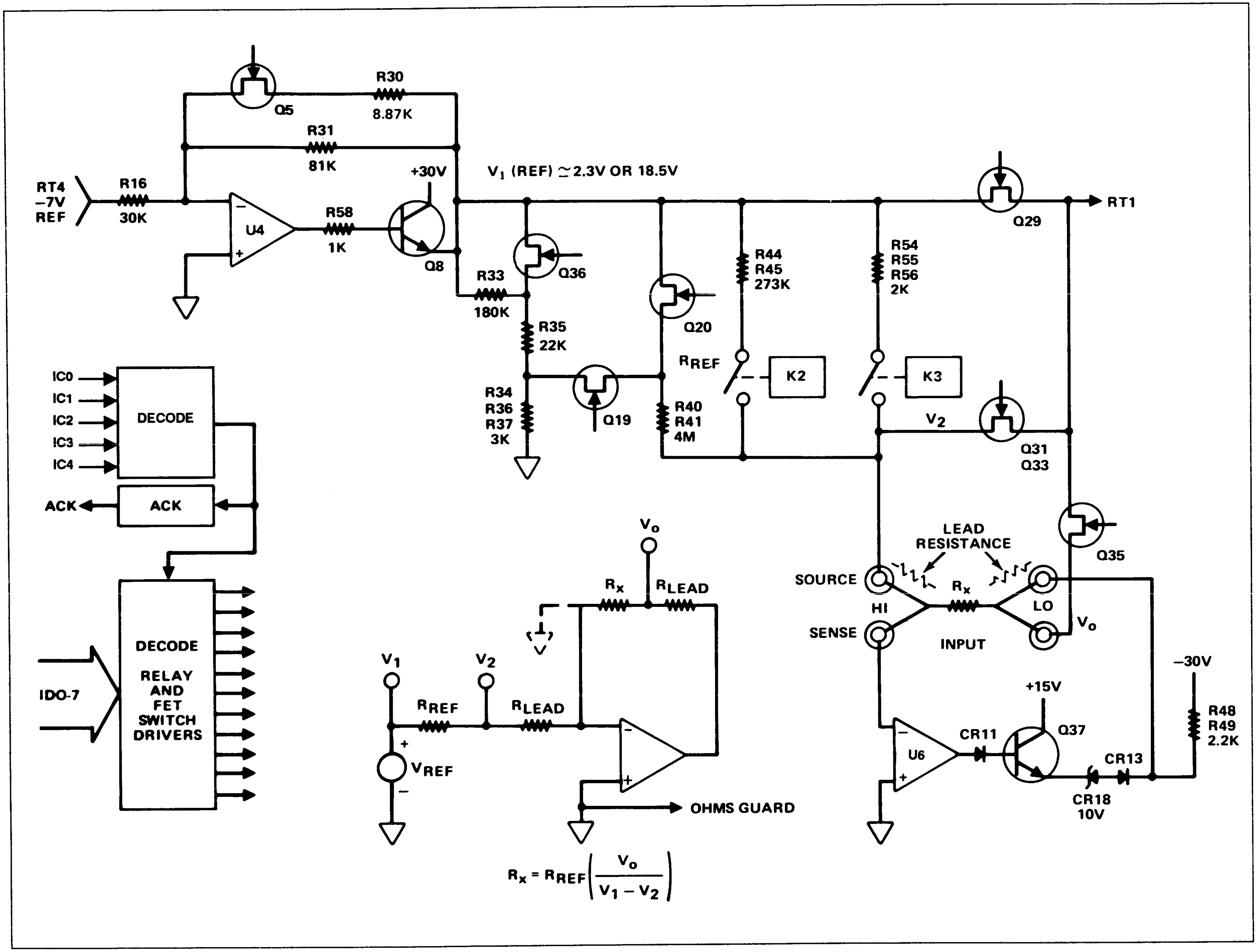


Figure 602-2. Ohms Converter Simplified Schematic

Table 602-2. Performance Test

Standard Resistor	UUT Reading	
	Low (exponent)	High (exponent)
10	9.9975	10.0025
100	99.995	100.005
1K	.99996 (+3)	1.00004 (+3)
10K	9.9996 (+3)	10.0004 (+3)
100K	99.996 (+3)	100.004 (+3)
1M	.99996 (+6)	1.00004 (+6)
10M	9.9979 (+6)	10.0021 (+6)
100M	99.949 (+6)	100.051 (+6)

10. Adjust R40 for a reading between 3.99998 (+6) and 4.00002 (+6).
11. Select the 100 Mohm range and connect the input leads to a 100 Mohm standard resistor.
12. Adjust R37 for a reading between 99.995 (+6) and 100.005 (+6).
13. Select the 100 kohm range and connect the input leads to a 250 kohm standard resistor.
14. Adjust R44 for a reading between 249.998 (+3) and 250.002 (+3).
15. Select the 1 kohm range and connect the input leads to a 1.9 kohm standard resistor.
16. Adjust R54 for a reading between 1.89998 (+3) and 1.90002 (+3).

NOTE

Software calibration of the 10 Mohm range per steps 17 through 19 is required whenever a hardware calibration is performed.

17. Select the 10 Mohm range and connect the input leads to a 19 Mohm standard resistor.

Table 602-3. Calibration Tests

Resistance Standard	Readings	
	Minimum	Maximum
10	9.9989	10.0011
100	99.997	100.003
1K	0.99997 (+3)	1.00003 (+3)
10K	9.9997 (+3)	10.0003 (+3)
100K	99.997 (+3)	100.003 (+3)
1M	0.99997 (+6)	1.00003 (+6)
10M	9.9989 (+6)	10.0011 (+6)
100M	99.969 (+6)	100.031 (+6)

18. Allow the UUT to take at least one reading. Then to store the actual value of the standard resistor as a cal correction, press STORE (numerics of standard resistor)(COR).
19. Disable the Calibration mode (Calibration Switch to off).
20. Short all four test leads and perform the ohms zero procedure for each range (lowest to highest). Ensure that a reading of all zeros (± 1 digit) is obtained on each range.
21. With Zero mode on, perform the standard resistor tests in Table 602-3. There are no adjustments for these readings. If any reading exceeds the listed tolerance, the module is faulty.

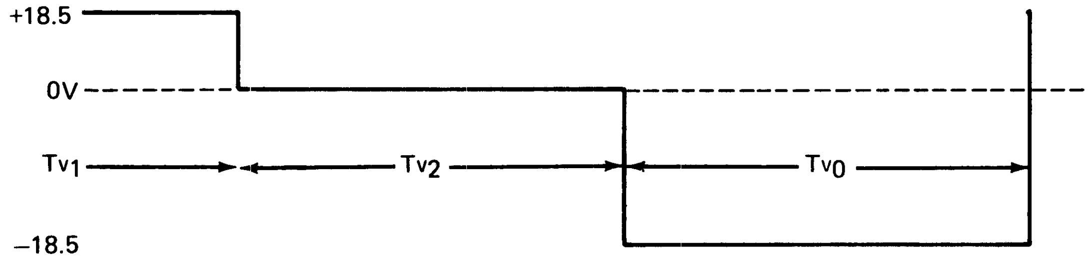
602-10. TROUBLESHOOTING

Troubleshooting procedures for the Ohms Converter follow the format used for the mainframe instrument. Table 602-4, Failure Isolation, assures that the problem is in the Ohms Converter. Table 602-5 lists symptoms and possible failures in the order of probability. Figure 602-3 shows timing relationships. Tables 602-6 through 602-8 give additional troubleshooting procedures. Always remove power before removing or installing a module.

602-11. PARTS LIST

Table 602-9 is a parts breakdown for the Ohms Converter. Refer to Section 5 of this manual for ordering information.

Voltages shown are at RT6, (DC Signal Conditioner Output).



Vo is proportional to Rx, Vo for full scale Rx is shown.

Sample Rate	Filter	T_{V1}	T_{V2} *	T_{V0}
Fast	No	30ms	30ms	200 ms
Fast	Yes	30ms	30ms	650ms
Slow	No	30ms	30ms	600ms
Slow	Yes	30ms	30ms	1060ms

These are approximate times.

*Except T_{V2} for ranges 1M, 10M, 100M is zero. No V_2 is measured for these ranges.

The first reading after a range change or overrange is modified with longer V_1 and V_2 periods.

Figure 602-3. Timing

Table 602-4. Failure Isolation

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
1	Perform DC Volts test (Section 4). Is DC Volts within tolerance?	2	Section 4
2	Perform Ohms test. Is Ohms with tolerance?	Section 4	3
3	Remove all optional modules except Isolator and Ohms converter.		
4	Is Ohms now within tolerance?	5	6
5	An optional module is affecting Ohms. Replace one at a time until Ohms goes bad. Last one in is faulty - go to appropriate portion of Section 6.		
6	Is Isolator installed?	7	9
7	Remove Isolator. Insert Jumper/Monitor pcb. Is Ohms within tolerance?	8	9
8	Bad Isolator. Go to Subsection 608.		
9	Check power supply voltages as follows. Test DMM LO on AR (analog return). VA1 = +14.25 to 15.75V VA4 = -29 to -32V VA2 = -14.25 to -15.75V Vcc = -15 Difference=4.9 to 5.2 VA3 = +29 to 32V Vss = -20 RT4 = -6.9993 to -7.0007		
10	Are the supply voltages within tolerance?	11	Section 4
11	The problem is probably in the Ohms board. However, the DC Signal Conditioner may contribute errors if the slew rates of the amplifiers are not fast enough. Go to Table 602-5.		

Table 602-5. Symptom Analysis

SYMPTOM	POSSIBLE FAILURE
No Ohms Readings	
(V_0)	U6, Q35, Digital Logic
(V_1)	U4, Q8, Q29, Digital Logic & Drivers
Ohms Zero Drift	U6
10K - 100K Ranges Bad	Q32, Q33, Digital
10 - 100 - 1K Ranges Bad	Q30, Q31, Digital
10M Full Scale Low	Q20, Q22
No ACK	U5, Q14, Q11, Q38
All Ranges Out of Tolerance	Q37, U6
100M Noisy, 30M High	Q10, K3 Shorted
1K, 100K, 10M, 100M Ranges Bad	Q5, Q4
100M Range Bad	Q20, Q22, Q19, U6 Leaky
Display Error 4 with no voltage at input	Q14
Noisy at 30M or Full Scale	CR15, CR17, CR4, CR8
Full Scale 1M, 10M, 100M Ranges Out of Tolerance	CR18

Table 602-6. Voltage Measurements

Range	Full Scale	V* R ref	R ref	I ref* (Source HI)	V_0* (Range Value)	V_1* (TP2)	V_2 (Offset)
10	31.25	+18.5V	2K	9.3 mA	.093V	+18.5V	<100 mV
100	250	+18.5V	2K	9.3 mA	.93V	+18.5V	<100 mV
1000	2000	1.86V	2K	0.93 mA	.93V	1.86V	<100 mV
10K	32K	+18.5V	256K	72 μA	.72V	+18.5V	<100 mV
100K	256K	1.86V	256K	7.2 μA	.72V	1.86V	<100 mV
1M	4.091M	+18.5V	4.091M	4.5 μA	4.5V	+18.5V	NA
10M	32.728M	1.86V	4.091M	0.45 μA	4.5V	1.86V	NA
100M	261.824M	1.86V/8	4.091M	56 nA	5.6V	1.86V	NA

*Approximate values (±5%)

TP1 is always -7.0V
TP3 Ref common (use for low side of measurements)
TP4 amplifier offset (<10 μV properly adjusted)
V_0 is proportional to RX
V_2 will vary some with range change

SCANNER: Voltages will appear on RT1 in order. V_0 — V_1 — V_2

Table 602-7. Range Switch Closures

0 = Switch Open
1 = Switch Closed

Chart applies for time the particular voltage is SCANNED.
All other times "0" applies.

	K1	K2	K3	Q5	Q19	Q20	V_0 Q29	V_{2a} Q31	V_{2b} Q33	V_1 Q35
10Ω	1	0	1	0	0	1	1	1	0	1
100Ω	1	0	1	0	0	1	1	1	0	1
1KΩ	1	0	1	1	0	1	1	1	0	1
10KΩ	1	1	0	0	0	1	1	0	1	1
100KΩ	1	1	0	1	0	1	1	0	1	1
1MΩ	1	0	0	0	0	1	1	0	0	1
10MΩ	1	0	0	1	0	1	1	0	0	1
100MΩ	1	0	0	1	1	0	1	0	0	1
OHMS	0	0	0	1	0	1	0	0	0	0

Table 602-8. Address and Data Coding

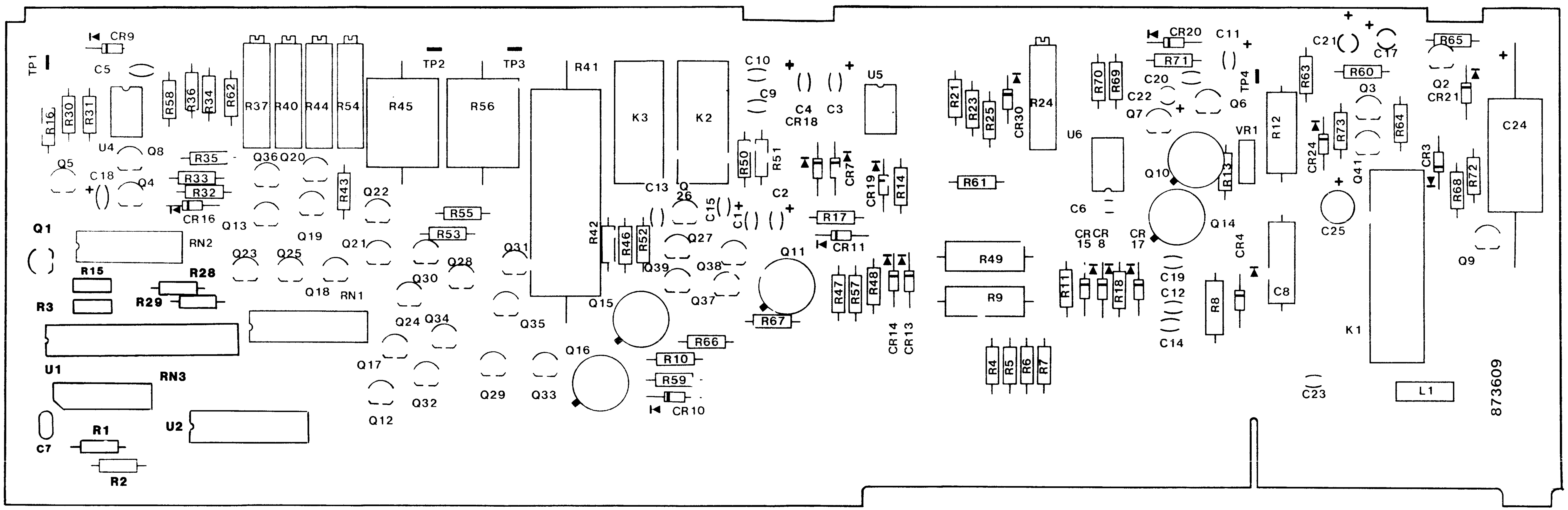
ADDRESS IC1, 2, 3 HIGH									
Range	V	IDϕ	ID1	ID2	ID3	ID4	ID5	ID6	ID7
10	Vϕ	0	1	1	0	0	1	1	0
	V1	1	0	1	0	0	1	1	0
	V2	1	1	0	0	0	1	1	0
100	Vϕ	0	1	1	0	0	1	1	0
	V1	1	0	1	0	0	1	1	0
	V2	1	1	0	0	0	1	1	0
1K	Vϕ	0	1	1	0	1	1	1	0
	V1	1	0	1	0	1	1	1	0
	V2	1	1	0	0	1	1	1	0
10K	Vϕ	0	1	1	0	0	0	1	1
	V1	1	0	1	0	0	0	1	1
	V2	1	1	0	0	0	0	1	1
100K	Vϕ	0	1	1	0	1	0	1	1
	V1	1	0	1	0	1	0	1	1
	V2	1	1	0	0	1	0	1	1
1M	Vϕ	0	1	1	0	0	1	1	1
	V1	1	0	1	0	0	1	1	1
10M	Vϕ	0	1	1	0	1	1	1	1
	V1	1	0	1	0	1	1	1	1
100M	Vϕ	0	1	1	0	1	1	0	1
	V1	1	0	1	0	1	1	0	1
OHMS		1	1	1	1	1	1	1	1

Table 602-9. Ohms Converter PCB Assembly

REFERENCE DESIGNATOR	DESCRIPTION	FLUKE STOCK NO	MFRS SPLY CODE	MANUFACTURERS PART NUMBER OR GENERIC TYPE	TOT QTY	NOTES
C 1- 4	CAP,TA,6.8UF,+-20%,35V	807602	56289	199D685X0035DG2	4	
C 5, 7	CAP,CER,33PF,+-5%,50V,C0G	714543	04222	SR595A330JAA	2	
C 6	CAP,CER,22PF,+-2%,50V,C0G	714832	04222	SR595A220GAA	1	
C 8	CAP,POLYST,100PF,+-10%,500V	446609	84411	446609	1	
C 9, 10, 12-	CAP,CER,0.01UF,+-10%,100V,X7R	557587	04222	SR591C103KAA	7	
C 11	CAP,TA,22UF,+-20%,10V	658971	56289	199D226X0010CG2	1	
C 17, 21	CAP,TA,4.7UF,+-20%,25V	807644	56289	199D475X0025BG2	2	
C 18	CAP,TA,0.47UF,+-20%,35V	161349	56289	199D474X0035AA2	1	
C 20	CAP,CER,2200PF,+-10%,500V,Z5R	817007	60705	562CRE501EG222KA09	1	
C 22	CAP,TA,0.33UF,+-20%,35V	408690	56289	100D334X0035AA2	1	
C 23	CAP,CER,0.22UF,+80-20%,50V,Z5U	733386	04222	SR595E224ZAATR1A	1	
C 24	CAP,AL,220UF,+50-10%,25V	369181	62643	SM25T221K10X26LL	1	
C 25	CAP,AL,33UF,+-20%,25V,SOLV PROOF	715250	62643	SRAC25VB33RM6X7C3	1	
CR 3, 11, 16,	⚡ DIODE,SI,BV=75.0V,IO=150MA,500MW	698720	65940	IN4448	8	
CR 4, 7, 8,	DIODE,SI,800 PIV,1.0 AMP	428144	04713	1N4006	7	
CR 9, 18	⚡ ZENER,UNCOMP,10.0V,5%,12.5MA,0.4W	698696	04713	1N961BSZ2388	2	
CR 10	⚡ DIODE,SI,MULTI-PELLET	375485	51605	IN4157 T/R	1	
CR 19	⚡ DIODE,SI,2 PELLET,BV= 20.0V,400 MW	375477	51605	C6342	1	
CR 30	⚡ ZENER,COMP,6.4V,5%,50PPM,1MA	330829	04713	SZG20119RL	1	
E 1	SURGE PROTECTOR,450V,+-10%	442723	25088	B2-B470-Y23	1	
K 1	RELAY,ARMATURE,4 FORM C,5V,LATCH	715078	61529	DS4EML2DC5VCH239	1	
K 2, 3	RELAY,REED,1 FORM A,4.5V	772285	71707	1240-0070	2	
L 1	INDUCTOR,100UH,+-5%,12MHZ,SHLD	174755	24759	MR-100	1	
MP 1	CASE ASSEMBLY, OHMS CONVERTER	873612	89536	873612	1	
MP 2, 3	CASE HALF,MODULE	402990	89536	402990	2	
MP 4	COVER,MODULE CASE	794560	89536	794560	1	
MP 5	GUARD, FRONT	383356	89536	383356	1	
MP 6	GUARD, REAR	383364	89536	383364	1	
MP 7	SHIELD,COVER,OHMS.CONV.	411942	2M021	411942	1	
MP 8	DECAL, OHMS CONVERTER	881719	89536	881719	1	
MP 9	TERM,RING #4,SOLDR	103531	79963	501	1	
MP 10	SPACER,SWAGE,.250 RND,BR,4-40,.437	442913	9W423	9534B-B-0440	1	
MP 11	SPRING,COIL,COMP,M WIRE,.380,.120	424465	83553	C0121-014-0380M	1	
Q 1	⚡ TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1	
Q 2, 12, 17,	⚡ TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	04713	2N3906	7	
Q 3, 4, 8,	⚡ TRANSISTOR,SI,NPN,SMALL SIGNAL,TO-92	218396	04713	2N3904	15	
Q 5, 19, 20,	⚡ TRANSISTOR,SI,N-JFET,TO-92,SWITCH	261578	17856	J2317	4	
Q 6, 7, 39	⚡ TRANSISTOR,SI,NPN,SMALL SIGNAL	168716	27014	ST10106	3	
Q 10, 11, 14-	⚡ TRANSISTOR,SI,NPN,SMALL SIGNAL	203489	07263	S43252	5	
Q 29, 31, 33,	⚡ TRANSISTOR,SI,N-JFET,HI-VOLTAGE,TO-92	393314	17856	J2086	4	
Q 41	⚡ TRANSISTOR,SI,PNP,SM SIG,DARLINGTON	524140	04713	MPS-A63	1	
R 1	RES,CF,47K,+-5%,0.25W	573527	59124	CF1/4 473J	1	
R 2, 4- 7,	RES,CF,150,+-5%,0.25W	573030	59124	CF1/4 151J	6	
R 3, 70	RES,CF,200K,+-5%,0.25W	573634	59124	CF1/4 204J	1	
R 10, 11, 14	RES,CF,20K,+-5%,0.25W	573444	59124	CF1/4 203J	5	
R 15, 62	RES,CF,10K,+-5%,0.25W	573394	59124	CF1/4 103J	2	
R 8	RES,CC,220K,+-5%,0.5W	109025	01121	EB2245	1	
R 9, 49	RES,CC,1.8K,+-5%,1W	180331	01121	GB1825	2	
R 12	RES,CC,100K,+-10%,1W	109397	01121	GB1041	1	
R 13, 58, 60,	RES,CF,1K,+-5%,0.25W	573170	59124	CF1/4 102J	5	

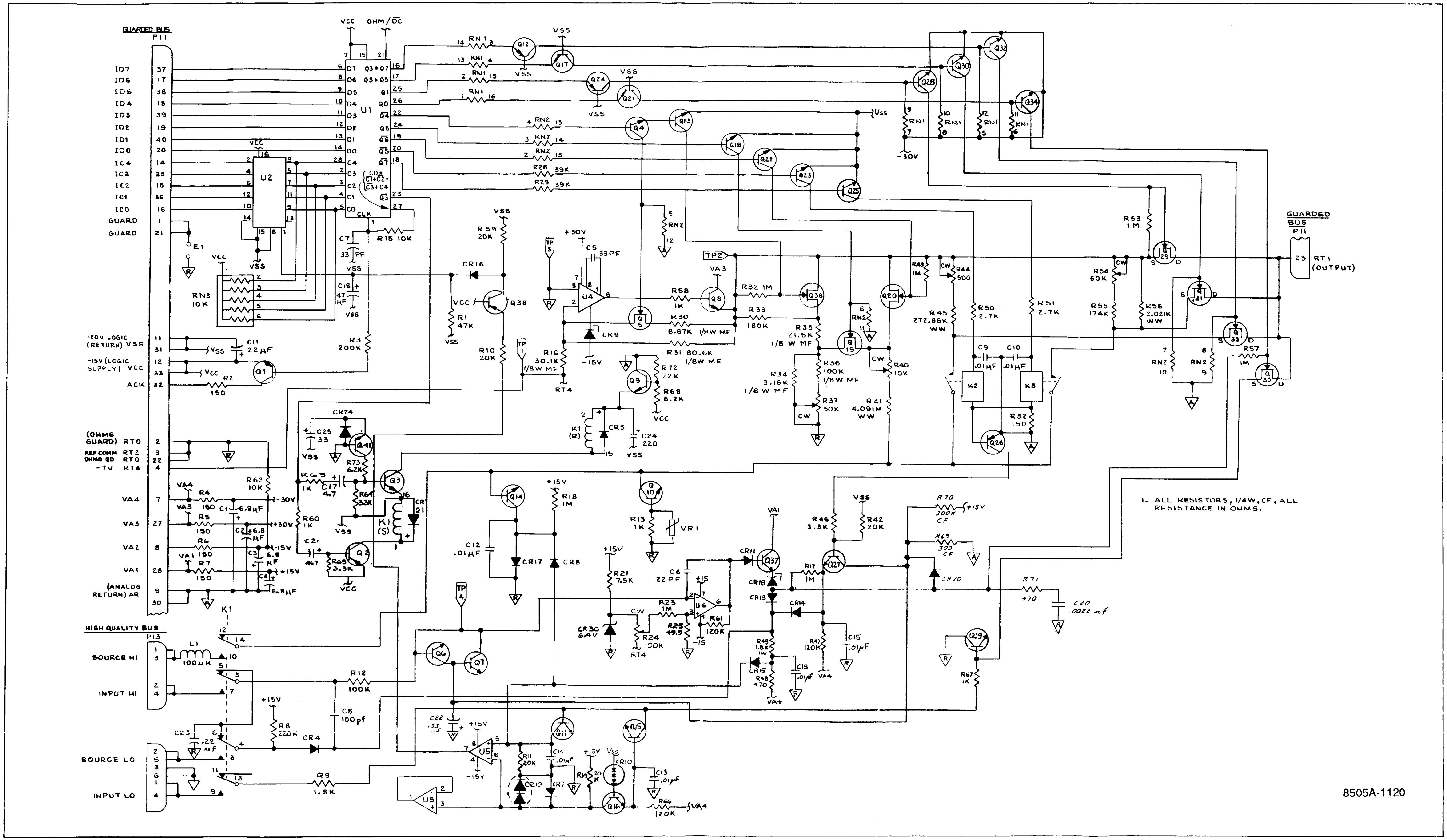
Table 602-9. Ohms Converter PCB Assembly (cont)

REFERENCE DESIGNATOR	DESCRIPTION	FLUKE STOCK NO	MFRS SPLY CODE	MANUFACTURERS PART NUMBER OR GENERIC TYPE	TOT QTY	NOTES
R 16	RES,MF,30.1K,+-1%,0.125W,25PPM	293431	91637	CMF-55 3012F T-9	1	
R 17, 18, 32,	RES,CF,1M,+-5%,0.25W	573691	59124	CF1/4 105J	6	
R 21	RES,MF,7.50K,+-1%,0.125W,100PPM	223529	91637	CMF-55 7501F T-1	1	
R 23	RES,MF,750K,+-1%,0.125W,100PPM	271361	91637	CMF-55 7503F T-1	1	
R 24	RES,VAR,CERM,100K,+-20%,0.5W	268581	80294	3009P-1-104	1	
R 25	RES,MF,49.9,+-1%,0.125W,25PPM	447177	91637	CMF-55 49R9F T-9	1	
R 28, 29	RES,CF,39K,+-5%,0.25W	442400	59124	CF1/4 393J	2	
R 30	RES,MF,8.87K,+-1%,0.125W,100PPM	294967	91637	CMF-55 8871F T-9	1	
R 31	RES,MF,80.6K,+-1%,0.125W,25PPM	312710	91637	CMF-55 8062FS T-1	1	
R 33	RES,CF,180K,+-5%,0.25W	573626	59124	CF1/4 184J	1	
R 34	RES,MF,3.16K,+-0.1%,0.125W,25PPM	340588	91637	CMF-55 3161B T-9	1	
R 35	RES,MF,21.5K,+-0.1%,0.125W,25PPM	344440	91637	CMF-55 2152B T-9	1	
R 36	RES,MF,100K,+-1%,0.125W,100PPM	719484	91637	CMF-55 1003F T-1	1	
R 37, 54	RES,VAR,CERM,50K,+-10%,0.5W	330688	80294	3009P-1-503	2	
R 40	RES,VAR,CERM,10K,+-20%,0.5W	267880	80294	3009P-1-103	1	
R 41	RES WW 4.091 M	412205	89536	412205	1	
R 44	RES,VAR,CERM,500,+-20%,0.5W	267849	80294	3009P-1-501	1	
R 45	RES WW 272.85K OHM	412197	89536	412197	1	
R 46, 64, 65	RES,CF,3.3K,+-5%,0.25W	573287	59124	CF1/4 332J	3	
R 47, 61, 66	RES,CF,120K,+-5%,0.25W	573592	59124	CF1/4 124J	3	
R 48, 71	RES,CF,470,+-5%,0.25W	573121	59124	CF1/4 471J	2	
R 50, 51	RES,CF,2.7K,+-5%,0.25W	573261	59124	CF1/4 272J	2	
R 55	RES,MF,174K,+-1%,0.125W,25PPM	706424	91637	CMF-55 1743F T-9	1	
R 56	RES WW 1/2W 2.021K	790634	89536	790634	1	
R 68, 73	RES,CF,6.2K,+-5%,0.25W	573345	59124	CF1/4 622J	2	
R 69	RES,CF,300,+-5%,0.25W	643502	59124	CF1/4 301J	1	
R 72	RES,CF,22K,+-5%,0.25W	573451	59124	CF1/4 223J	1	
RN 1, 2	RES,CERM,DIP,16 PIN,8 RES,100K,+-5%	380618	91637	MDP16-03-104J	2	
RN 3	RES,CERM,SIP,6 PIN,5 RES,10K,+-2 %	500876	91637	CSC06A-01-103G	1	
TP 1- 4	JUMPER,WIRE,NONINSUL,0.200CTR	816090	91984	150T1	4	
U 1	ϟ IC,CMOS,PROG ARRAY LOGIC,PRGMD,DIP	911441	89536	911441	1	
U 2	ϟ IC,CMOS,HEX BUFER W/3-STATE OUTPUT	408773	27014	MM80C95N	2	
U 4	ϟ IC,OP AMP,GEN PURPOSE,8 PIN DIP	363515	04713	LM301AN	1	
U 5	ϟ IC,OP AMP,SELECTED GBW 600KHZ	418566	18324	LM358	1	
U 6	ϟ IC,OP AMP,LOW VOS,TCIB,NOISE,SELECTED	854281	06665	OP97-005P	1	
VR 1	VARISTOR,8.2V,+-35%,1.0MA	715052	S3385	SNR-8R0MD07	1	
XU 1	SOCKET,IC,14 PIN	453514	89536	453514	2	
NOTES:	ϟ Static sensitive part.					



8505A-1720

Figure 602-4. Ohms Converter PCB Assembly



1. ALL RESISTORS, 1/4W, CF, ALL RESISTANCE IN OHMS.

8505A-1120

Figure 602-4. Ohms Converter PCB Assembly (cont)

Option —03 Current Shunts

603-1. INTRODUCTION

603-2. Installation of the Current Shunts module allows for current measurement in five ranges: 100 μA, 1 mA, 10 mA, 100 mA, and 1A. The 8506A DMM has dc current capability only. All other 8500 Series DMM's have both dc and ac current capabilities. For any of these DMM's, ac current measurements require installation of one of the ac converter options.

CAUTION

Selection of the autorange mode when using a constant current power source, e.g. the Fluke 3330B Constant Current Mode, can result in excessive voltage overloads. The overload results from the momentary open circuit at the DMM input terminals when ranging into or out of the 100 μA or 1A range. Constant voltage power sources are not affected.

603-3. SPECIFICATIONS

603-4. Table 603-1 lists the specifications for the Current Shunts module. These specifications cover both dc and ac current. All ac current specifications are not applicable to the 8506A. This DMM has dc current measurement capability only. All dc current specifications apply to any 8500 Series DMM. All references to the "6-1/2 digit display" apply to the 8505A and 8506A DMM's.

603-5. INSTALLATION

603-6. Refer to Section 4 of this manual under Module Installation and Removal for instructions on installing the Current Shunts module. The interconnect diagram in Section 8 contains a table listing permissible and preferred slots.

603-7. OPERATING NOTES

603-8. Operation of the front panel switches is the same as described in Section 2 of this manual. Inputs to the Current Shunts module are between Source HI and Source LO. Sense HI and Sense LO may be left connected with the shorting links provided.

NOTE

Position sensitivity of switches requires that the instrument be operated within 30° of its horizontal position.

603-9. THEORY OF OPERATION

603-10. The function of the Current Shunt module is to generate a voltage proportional to the current to be measured. Outputs from the Current Shunt module are applied either to the DC Signal Conditioner for dc currents or to an optional ac converter for ac currents.

603-11. Two modes of operation are used in the Current Shunt module, depending on the range selected. Figure 603-1 illustrates the two configurations and contains tables relating resistors, switches, and relays to each range. Mode A is used for the 100 μA, 1 mA, and 10 mA ranges. Input currents are applied to the summing node (virtual ground) of an operational amplifier through R4. R4 ensures stability when the current source is highly capacitive, while presenting a very low voltage burden. The formula given for determining floor digits (uncertainty) in the accuracy specifications is based on the feedback resistors used in the three lowest ranges. For source resistances less than approximately 10 x $R_{FEEDBACK}$, the gain of the circuit becomes greater than one for error sources such as offset voltages and current noise. Thus the basic uncertainty (digits) of a measurement increases as the source resistance decreases. The output voltage is equal to the input current multiplied by $R_{FEEDBACK}$.

Table 603-1. Current Shunts Specifications

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS		RESOLUTION*		VOLTAGE BURDEN
	DC	AC[3]	6½ DIGIT	5½ DIGIT	
100 μA	250.000 μA	312.500 μA	0.1 nA	1 nA	<=100 mV
1 mA	2.00000 mA	2.50000 mA	1 nA	10 nA	<=100 mV
10 mA	16.0000 mA	20.0000 mA	10 nA	100 nA	<=200 mV
100 mA	128.000 mA	160.000 mA	100 nA	1 μA	<=200 mV
1A	1.28000A	1.28000A	1 μA	10 μA	<=500 mV

*6½ digit resolution in AVG operating mode (8505A/8506A), 100 μA ac range is 5½ digits only.

DC Current Accuracy ±(% OF READING + NUMBER OF COUNTS)*

RANGE	24 HOUR 23°C ±1°C	90 DAY 23°C ±5°C	AT SOURCE RESISTANCE[1]
100 μA	0.02 + 10	0.03 + 10	>=80 kΩ
1 mA	0.02 + 10	0.03 + 10	>=10 kΩ
10 mA	0.02 + 10	0.03 + 10	>=1.25 kΩ
100 mA	0.03 + 20	0.05 + 20	>=40Ω
1A	0.03 + 20	0.05 + 20	>=10Ω

*With 5½ digit display. For 6½ digit display multiply Number of Counts by 10.

>90 DAY 23°C ±5°C
ADD TO THE 90 DAY SPECIFICATIONS PER MONTH THE FOLLOWING % OF READING

RANGE	% OF READING
100 μA	0.0022
1 mA	0.0022
10 mA	0.0022
100 mA	0.0056
1A	0.0056

AC Current Accuracy ±(% OF READING + NUMBER OF COUNTS)[3]

24 HOUR 23°C ±1°C*

RANGE	FREQUENCY	AVERAGE RESPONDING OPTION -01	TRUE RMS OPTION -09A
100 μA	10 Hz-20 Hz	—	0.7 + 110
	20 Hz-50 Hz	0.55 + 9	0.55 + 35
	50 Hz-10 kHz	0.3 + 9	0.28 + 35
	10 kHz-20 kHz	0.5 + 9	0.7 + 110
	20 kHz-50 kHz	1.0 + 9	1.0 + 260
	50 kHz-100 kHz	2.0 + 9	2.8 + 760
1 mA and 10 mA	10 Hz-20 Hz	—	0.7 + 110
	20 Hz-50 Hz	0.35 + 9	0.35 + 35
	50 Hz-10 kHz	0.05 + 9	0.08 + 35
	10 kHz-20 kHz	0.08 + 9	0.14 + 110
	20 kHz-50 kHz	0.08 + 9	0.2 + 260
	50 kHz-100 kHz	0.35 + 9	0.7 + 760
100 mA	10 Hz-20 Hz	—	0.7 + 150
	20 Hz-50 Hz	0.34 + 55	0.35 + 80
	50 Hz-10 kHz	—	0.18 + 80
	50 Hz-100 kHz	0.16 + 55	—
1A	10 Hz-20 Hz	—	0.07 + 160
	20 Hz-50 Hz	0.34 + 65	0.35 + 90
	50 Hz-10 kHz	0.16 + 65	0.18 + 90

*With 5½ digit display. For 6½ digit display, multiply Number of Counts by 10. Same source resistance as dc current.

Table 603-1. Current Shunts Specifications (cont)

AC Current Accuracy (cont)[3]

90 DAY 23°C ±5°C*			
RANGE	FREQUENCY	AVERAGE RESPONDING OPTION -01	TRUE RMS OPTION -09A
100 μA	10 Hz-20 Hz	—	1.0 + 110
	20 Hz-50 Hz	0.8 + 9	0.8 + 35
	50 Hz-10 kHz	0.4 + 9	0.4 + 35
	10 kHz-20 kHz	0.7 + 9	1.0 + 110
	20 kHz-50 kHz	1.5 + 9	1.5 + 260
	50 kHz-100 kHz	3.0 + 9	4.0 + 760
1 mA and 10 mA	10 Hz-20 Hz	—	1.0 + 110
	20 Hz-50 Hz	0.5 + 9	0.5 + 35
	50 Hz-10 kHz	0.06 + 9	0.11 + 35
	10 kHz-20 kHz	0.11 + 9	0.2 + 110
	20 kHz-50 kHz	0.12 + 9	0.3 + 260
	50 kHz-100 kHz	0.51 + 9	1.0 + 760
100 mA	10 Hz-20 Hz	—	1.0 + 150
	20 Hz-50 Hz	0.5 + 55	0.5 + 80
	50 Hz-10 kHz	—	0.26 + 80
	50 Hz-100 kHz	0.24 + 55	—
1A	10 Hz-20 Hz	—	1.0 + 160
	20 Hz-50 Hz	0.5 + 65	0.5 + 90
	50 Hz-10 kHz	0.24 + 65	0.26 + 90

*With 5½ digit display. For 6½ digit display, multiply Number of Counts by 10. Same source resistance as dc current.

>90 DAY 23°C ±5°C* ADD TO THE 90 DAY SPECIFICATIONS PER MONTH THE FOLLOWING % OF READING			
RANGE	FREQUENCY	AVERAGE RESPONDING OPTION -01	TRUE RMS OPTION -09A
100 μA	10 Hz-20 Hz	—	0.11
	20 Hz-50 Hz	0.089	0.089
	50 Hz-10 kHz	0.044	0.044
	10 kHz-20 kHz	0.089	0.11
	20 kHz-50 kHz	0.17	0.17
	50 kHz-100 kHz	0.33	0.44
1 mA and 10 mA	10 Hz-20 Hz	—	0.11
	20 Hz-50 Hz	0.056	0.056
	50 Hz-10 kHz	0.0067	0.012
	10 kHz-20 kHz	0.012	0.022
	20 kHz-50 kHz	0.013	0.033
	50 kHz-100 kHz	0.057	0.11
100 mA	10 Hz-20 Hz	—	0.11
	20 Hz-50 Hz	0.056	0.056
	50 Hz-10 kHz	—	0.029
	50 Hz-100 kHz	0.029	—
1A	10 Hz-20 Hz	—	0.11
	20 Hz-50 Hz	0.056	0.056
	50 Hz-10 kHz	0.029	0.029

Table 603-1. Current Shunts Specifications (cont)

Operating Characteristics

TEMPERATURE COEFFICIENT ±(% OF READING + NUMBER OF COUNTS) /°C*

0°C TO 18°C AND 28°C TO 50°C			
RANGE	DC[2]	TRUE RMS AC[3]	AVERAGE RESPONDING AC[3]
100 μA	0.0025 + 0.6	0.005 + 3.5	0.004 + 1.5
1 mA	0.0025 + 0.6	0.005 + 3.5	0.004 + 1.5
10 mA	0.0025 + 0.6	0.005 + 3	0.004 + 1
100 mA	0.0035 + 0.6	0.005 + 9	0.004 + 7
1A	0.0035 + 0.6	0.005 + 9	0.004 + 7

*With 5½ digits display. For 6½ digits display, multiply Number of Counts by 10.

CREST FACTOR (RMS ac) .... >4.5 at full scale, increasing down scale by $4.5 \times \sqrt{I\ range / I\ input}$

MAXIMUM OVERLOAD .... 1.5A maximum, ±140V dc or peak ac to 60 Hz, or 200V peak ac above 60 Hz on any range with no damage. Protected by a 1.5A fuse

SETTLING AND DIGITIZING TIME ... Same as dc volts (see Section 1).

NOTES:

[1]For Source Resistance less than specified replace the Number of Counts in the dc Accuracy specification with the following:

RANGE	NUMBER OF COUNTS*
100 μA	9 x (1 + 8 kΩ/Rs)
1 mA	9 x (1 + 1 kΩ/Rs)
10 mA	9 x (1 + 125Ω/Rs)

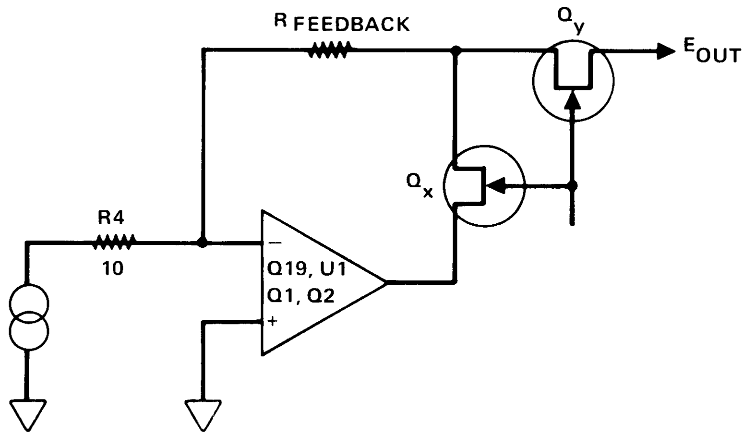
*With 5½ digit display. For 6½ digits, multiply Number of Counts by 10.

[2]For Source Resistance less than specified replace the Number of Counts per °C in the dc Temperature Coefficient specification with the following:

RANGE	NUMBER OF COUNTS /°C*
100 μA	0.5 x (1 + 8 kΩ/Rs)
1 mA	0.5 x (1 + 1 kΩ/Rs)
10 mA	0.5 x (1 + 125Ω/Rs)

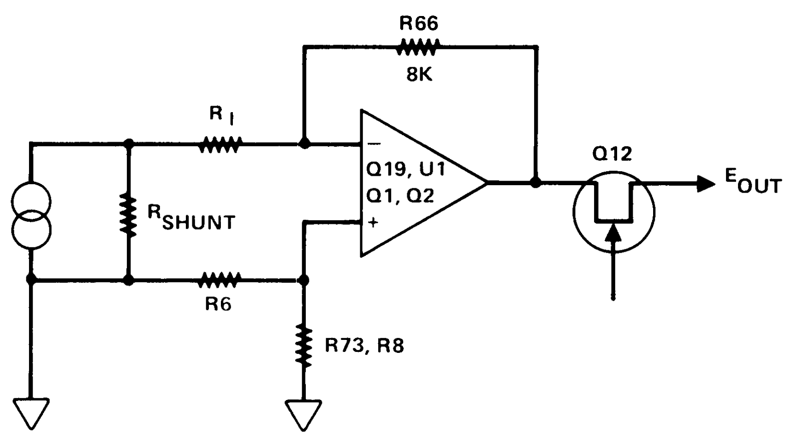
*With 5½ digit display. For 6½ digits, multiply Number of Counts by 10.

[3]AC Current cannot be measured with the 8506A



MODE A — 100 μA, 1 mA, 10 mA

RANGE	$R_{FEEDBACK}$	Q_X	Q_Y	RELAYS	FULL SCALE E_{OUT}
100 μA	R30, R31	Q30	Q31	K3, K4	.8 V
1 mA	R33, R34	Q7	Q10	K3, K4	1.0 V
10 mA	R36, R37	Q9	Q8	K3, K4	1.25 V



MODE B 100 mA, 1A

RANGE	R_{SHUNT}	R_I	RELAYS	FET SWITCHES	FULL SCALE E_{OUT}
100 mA	R2, R1	R7, R70, R71	K1, K3	Q20, Q32, Q29, Q12	1.6V
1 A	R1	R7, R68, R69	K2, K3	Q20, Q29, Q28, Q12	2.0V

Q11 and either Q3 or Q4 will be conducting in all ranges

Figure 603-1. Current Shunt Configurations And Range Information

603-12. Mode B configures the amplifier as a difference amplifier measuring the voltage across a shunt. The ratio of the feedback resistor, R66, to R_I sets the gain of the amplifier at approximately 20 $[R66/R_I = (R8 + R73)/R6]$.

603-13. The amplifier consists of a dual FET (Q19), U1, Q1, and Q2. Refer to the schematic. R18 biases Q19 from the −7V reference (from the A/D Converter). R57 and R58 are selected to compensate for offset error (one of them will always be 10Ω). R55 and R56 are selected for temperature coefficient compensation. Q1 and Q2 are a complementary pair (for either polarity output) to increase the current output capability of the amplifier.

603-14. Q11 and relay K3 are always closed for current measurements. Q3 and Q4 control the ground reference selection for the amplifier. In the dc mode, Q3 connects the noninverting input of the amplifier to reference common. In the ac mode the amplifier is referenced to the ac module ground (RT3) through Q4.

603-15. The Current Shunts module is addressed by IC0, 1, 3 high. At the first address, an ACK is returned and K5 is energized to sample the input voltage. If the voltage exceeds ± 45V, one section of U6 will have a high output, depending on the input polarity. The output from U6 is stored on C10. At the next address the voltage on C10 will prevent the return of the ACK response and will prevent control data from being latched into U2. An Error 4 will be displayed. In addition to overvoltage protection provided by U6, overcurrent protection is provided by CR9 and CR10 in the 100 μA, 1 mA, and 10 mA ranges, and by CR5 and CR6 in the 100 mA and 1 A ranges. A fuse in series with the Source HI terminal is located on the front panel for additional overcurrent protection.

603-16. At the second address, if the input voltage did not exceed ± 45V, termination of the address clocks range and reference control data into U2. Since relay common is Vcc, relay drivers must go low to energize a relay. FET switch drivers are configured to use a low from U2 to turn on the FET (close the switch) by turning off the gate control transistor.

603-17. MAINTENANCE

603-18. Performance Test

603-19. Test the direct current function by using the following procedure.

1. Select ADC and AUTO.
2. Connect the direct current source output HI to the instrument SOURCE HI and output LO to SOURCE LO.
3. Using Table 603-2, sequentially apply the inputs shown, manually selecting the range after the first reading. The instrument must read within the limits specified.

Table 603-2. Performance Test

Range	DC Input	Reading	
		Low (exp.)	High (exp.)
100 uA	10 uA	9.987 (−6)	10.013 (−6)
100 uA	100 uA	99.960 (−6)	100.040 (−6)
100 uA	250 uA	249.915 (−6)	250.085 (−6)
1 mA	0.1 mA	0.09987 (−3)	0.10013 (−3)
1 mA	1.0 mA	0.99960 (−3)	1.00040 (−3)
1 mA	2.0 mA	1.99930 (−3)	2.00070 (−3)
10 mA	1.0 mA	0.9996 (−3)	1.0004 (−3)
10 mA	10 mA	9.9960 (−3)	10.0040 (−3)
10 mA	15 mA	14.9945 (−3)	15.0055 (−3)
100 mA	10 mA	9.930 (−3)	10.070 (−3)
100 mA	100 mA	99.930 (−3)	100.070 (−3)
100 mA	150 mA	149.905 (−3)	150.095 (−3)
1A	0.1A	0.09975	0.10025
1A	1A	0.99930	1.00070

603-20. Calibration

603-21. Before calibrating any part of the instrument, the Calibration Memory module should be removed if installed. Apply power and allow a two hour warm-up period. All adjustments are on the Current Shunts module. DC calibration should be performed before calibrating current. Use the following procedure to calibrate the Current Shunts module.

1. Verify that the instrument is in the 1A range and the Cal mode (CAL indicator illuminated).
2. Connect the test DVM HI input lead to TP3 and the LO input to TP1.
3. The test DVM must read less than 200 mV.
4. Remove the test DVM.
5. Select the 100 mA range on the instrument.
6. Adjust R17 for a reading between -0.000-1 and +0.000-1 (0.000 ± 1 cal digit).
7. Set the current source controls for an output of 20.0000V dc.
8. Connect the instrument HI input to the current source HI output inserting a 200 kΩ ± 0.01% resistor in series with the instrument HI input lead. Connect the LO input terminal to the current source LO output.
9. Select the 100 μA range on the instrument and adjust R31 for a reading between +99.999 and +100.001.
10. Disconnect the instrument HI input lead from the current source, remove the inserted resistor and reconnect the HI input lead.
11. Select a current source output of +1.00000 mA.
12. Adjust R34 for a reading between +0.99999-0 and +1.00001-0.

13. Select a current source output of 10.0000 mA.

14. Adjust R37 for a reading between +9.9999-0 and +10.0001-0.

15. Select a current source output of 100.000 mA.

16. Adjust R71 for a reading between +99.999-0 and +100.001-0.

17. Select a current source output of 1.00000A.

18. Adjust R68 for a reading between +0.99999-0 and +1.00001-0.

19. Select the VDC function and Autorange on the instrument.

20. Select a 50V dc output from the current source.

21. Select the ADC function on the instrument.

22. ERROR 4 is displayed to show excessive voltage in the current function.

603-22. Troubleshooting.

603-23. Troubleshooting procedures for the Current Shunts module follow the format used for the mainframe instrument. Table 603-3 assures that the problem is in the Current Shunts module. Figure 603-2, Symptom Analysis, lists symptoms and possible failures in the order of probability. Table 603-4 contains address and data information used to set up the module.

603-24. Always remove power before removing or installing modules.

603-25. PARTS LIST

603-26. Table 603-5 is a parts breakdown for the Current Shunts module. Refer to Section 5 of this manual for ordering and use code information.

Table 603-3. Current Shunts Isolation

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
1	Perform DC Volts test (Section 4). Is DC within tolerance?	2	Section 4
2	Perform Current test. Is Current within tolerance?		3
3	Remove all optional modules except Isolator and Current Shunts. Is Current now within tolerance?	4	5
4	Replace modules one at a time, testing Current between modules. Last one in when Current goes bad is faulty. Go to appropriate subsection of Section 6.		
5	Remove Isolator. Install Interconnect/Monitor pcb. Is Current within tolerance?	6	7
6	Bad Isolator. Go to subsection 608.		
7	Bad Current Shunts module. Go to figure 603-2.		

SYMPTOM	POSSIBLE FAILURE
Zero noisy or out of tolerance	Q21, Q20, Q29, U1, Q3, Q4, leaky output FETS
No zero reading	K3, K4, Q19, U1, Q1, Q2
Always zero	K3 or Q11 open
100μA, 1 mA, 10 mA ranges bad, others OK	K4 open, Q29, Q20, leaky protection diodes
100 mA, 1 A ranges bad, others OK	Q20, Q29, leaky protection diodes, Q12
High random – full-scale readings	Q19, U1, Q1, Q2
No display	U5, U2
No ACK – Error 9 or Error 4	Voltage limit circuit, U6 or leaky diode (CR14, CR15), U5, Q18
Only 100 μA range bad	Q30, Q31, Digital Control
Only 1 mA range bad	Q7, Q10, Digital Control
Only 10 mA range bad	Q8, Q9, Digital Control
Only 100 mA range bad	K2, Q32, Digital Control
Only 1 A range bad	K2, Q28, Digital Control

Q19 DC Readings with Zero Input

Drains (10Ω resistors) ≃ –0.6 V dc
Sources (40 KΩ resistors) ≃ 8.0 V dc
U1 pin 6 ≃ 0V dc

Differences between ADC and AAC

1. AC/DC Reference (ground)
2. Frequency response in AAC
3. RT1 outputs are applied to DC Signal Conditioner for DC and to optional AC module for AC (DC Signal Conditioner bypassed)

If Q19, R15, R16, R55, or R56 are replaced, it is necessary to return the module to the factory (attn: PARTS) for temperature compensation.

Figure 603-2. Symptom Analysis

Table 603-4. Address and Data Field

Address – IC0, 1, 3 High						
	ID0	ID1	ID2	ID3	ID4	ID5
Current LO Input (K3) and Output FET (Q11)	X	X	X	0	X	X
DC Reference (Q3)	0	X	X	0	X	X
AC Reference (Q4)	1	X	X	0	X	X
100μA Range	X	1	1	0	1	1
1 mA Range	X	1	1	0	0	1
10 mA Range	X	1	1	0	1	0
100 mA Range	X	1	0	0	1	1
1A Range	X	0	1	0	1	1
Voltage Check	0	0	0	0	0	0
Reset	1	1	1	1	1	1

Table 603-5. Current Shunts Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
-03	⊘ CURRENT SHUNTS PCB ASSEMBLY FIGURE 603-3 (MIS-4104T)	ORDER	BY	OPTION -03			
C1, C2	CAP, TA, 0.47 UF +/-20%, 35V	161349	56349	196D474X0035HA1	2		
C3	CAP, MICA, 47 PF +/-1%, 500V	284802	72136	DM15E470F	1		
C4	CAP, MICA, 150 PF +/-5%, 500V	148478	72136	DM15F151J	1		
C5, C6	CAP, MICA, 100 PF +/-5%, 500V	148494	72136	DM15F101J	2		
C7	CAP, CER, 1200 PF +/-20%, 100V	358283	80031	2222-630-01-122	1		
C8, C9	CAP, MICA, 39 PF +/-5%, 500V	148544	72136	DM15E390J	2		
C10	CAP, TA, 4.7 UF +/-20%, 25V	161943	56289	196D475X0025KA1	1		
C11	CAP, TA, 220 UF +/-20%, 6V	408682	56289	196D227X0006TE4	1		
C12, C13	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	2		
C14	CAP, MICA, 390 PF +/-5%, 500V	148437	72136	DM15F391J	1		
C15-C17	CAP, TA, 10 UF +/-20%, 15V	193623	56289	196D106X0015A1	3		
CR1-CR4	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	14	4	
CR5-CR10	DIODE, SI	680447	14552	MT2061A	6	2	
CR11	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR12	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR14	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR15	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR16	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR17	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR18	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR19	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR20	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR21	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
CR22	DIODE, ZENER	325803	07910	TD333408	1	1	
H1	SCREW, PHP, 4-40 X 3/8	256164	89536	256164	1		
K1	RELAY ASSY						
	COIL, REED RELAY	269019	71707	U-6-P	5		
	SWITCH, DRY REED	602714	15636	V1101	5		
K2	RELAY ASSY						
	COIL, REED RELAY	269019	71707	U-6-P	REF		
K3	RELAY ASSY						
	COIL REED RELAY	269019	71707	U-6-P	REF		
K4	RELAY ASSY						
	COIL, REED RELAY	269019	71707	U-6-P	REF		
K5	RELAY ASSY						
	COIL, REED RELAY	269019	71707	U-6-P	REF		
MP1	CASE ASSEMBLY	459008	89536	459008	1		1
MP2	CASE HALF, MODULE	402990	89536	402990	REF		
MP3	CASE HALF, MODULE	402990	89536	402990	REF		
MP4	COVER, MODULE, CASE	402974	89536	402974	REF		
MP5	SHIELD, COVER	412015	89536	412015	REF		
MP6	DECAL, CURRENT SHUNTS ASSY	413419	89536	413419	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	GUARD, FRONT	383356	89536	383356	REF		
MP10	SOCKET, COMP. LEAD (not shown)	343285	27264	02-09-2133	10		

Table 603-5. Current Shunts Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
MP11	SPACER, COMPONENT (not shown)	296319	32559	T0806	10		
MP12	SPRING, COIL (not shown)	424465	83553	C0120-014-0380	1		
MP13	SPACER, STANDOFF (not shown)	335604	89536	335604	1		
Q1	XSTR, SI, NPN	218396	04713	2N3904	13	3	
Q2	XSTR, SI, PNP	195974	04713	2N3906	3	1	
Q3	DIODE, HI-SPEED, SWITCHING	203323	07910	1N4448	REF		
Q3, Q4	XSTR, FET, N-CHANNEL	261578	89536	261578	13	3	
Q5, Q6	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q7-Q10	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q11	XSTR, FET, N-CHANNEL	393314	89536	393314	1	1	
Q12	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q13-Q16	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q17	XSTR, SI, PNP	195974	04713	2N3906	REF		
Q18	XSTR, SI, PNP	226290	04713	MPS3640	1	1	
Q19	XSTR, FET, DUAL, N-CHANNEL (SELECTED)	267963	89536	267963	1	1	
Q20	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q21-Q23	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q25-Q27	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q28-Q32	XSTR, FET, N-CHANNEL	261578	89536	261578	REF		
Q33	XSTR, SI, PNP	195974	04713	2N3906	REF		
R1	RES, WW, 0.1 +/-0.05%, 1/2W	374611	89536	374611	1		
R2	RES, WW, 0.7 +/-0.1%, 1/4W	440404	89536	440404	1		
R3	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	23		
R4	RES, MTL. FILM, 10 +/-1%, 1/8W	268789	91637	MFF1-8A100F	4		
R5	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R6	RES, MTL. FILM, 383 +/-1%, 1/8W	375899	91637	MFF1-88380F	1		
R7	RES, WW, 419 +/-0.1%, 2W	440883	89536	440883	1		
R8	RES, MTL. FILM, 7.87K +/-1%, 1/8W	294934	91637	MFF1-87871F	1		
R9-R14	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R15, R16	RES, WW, 40K +/-0.1%	271403	89536	271403	2		
R17	RES, VAR, CERMET, 10 +/-20%, 1/2W	344135	75378	190PC100B	1		
R18	RES, MTL. FILM, 19.1K +/-1%, 1/8W	234963	91637	MFF1-81912F	1		
R19	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	2		
R20	RES, DEP. CAR, 18K +/-5%, 1/4W	348862	80031	CR251-4-5P18K	2		
R21	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R22	RES, DEP. CAR, 18K +/-5%, 1/4W	348862	80031	CR251-4-5P18K	REF		
R23, R24	RES, DEP. CAR, 39 +/-5%, 1/4W	340836	80031	CR251-4-5P39E	2		
R25-R29	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R30	RES, WW, 7975	440909	89536	440909	2		
R31	RES, VAR, CERMET, 50 +/-20%, 1/2W	267815	75378	190PC500B	1		
R32	RES, WW, 1020 +/-0.05%, 0.2W	440891	89536	440891	1		
R33	RES, MTL. FILM, 47.5K +/-1%, 1/8W	289546	91637	MFF1-84752F	1		
R34	RES, VAR, CERMET, 10K +/-20%, 1/2W	267880	75378	190PC103B	1		
R35	RES, WW, 128 +/-0.05%, 0.2W	440875	89536	440875	1		
R36	RES, MTL. FILM, 4.99K +/-1%, 1/8W	168252	91637	MFF1-84991	1		
R37	RES, VAR, CERMET, 1K +/-20%, 1/2W	267856	75378	190PC102B	1		
R38	RES, DEP. CAR, 150 +/-[illegible], 1/4W	[illegible]	80031	CR251-4-5P150E	1		

Table 603-5. Current Shunts Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
R39	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	5		
R40	RES, MTL. FILM, 49.9K +/-1%, 1/8W	268821	91637	MFF1-84992F	1		
R41, R42	RES, MTL. FILM, 100K +/-0.5%, 1/8W	291054	91637	MFF1-81003D	2		
R43	RES, COMP, 10M +/-10%, 1/2W	108142	01121	EB1061	2		
R44	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R45	RES, DEP. CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	1		
R46, R47	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R48	RES, MTL. FILM, 150K +/-1%, 1/8W	241083	91637	MFF1-81503F	1		
R49-R52	RES, DEP. CAR, 20K +/-5%, 1/4W	441477	80031	CR251-4-5P20K	REF		
R53	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R54	RES, MTL. FILM, 13K +/-1%, 1/8W	335539	91637	MFF1-81302F	1		
R55	RES, SELECTED				2		2
R56	RES, SELECTED				REF		
R57-R59	RES, MTL. FILM, 10 +/-1%, 1/8W	268789	91637	MFF1-8A100F	REF		
R60	RES, DEP. CAR, 5.6K +/-5%, 1/4W	442350	80031	CR251-4-5P5K6	1		
R61	RES, COMP, 10M +/-10%, 1/2W	108142	01121	EB1061	REF		
R62-R65	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R66	RES, WW, 7975	440909	89536	440909	REF		
R67	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R68	RES, VAR, CERMET, 5K +/-20%, 1/2W	267872	75378	190PC502B	2	1	
R69	RES, MTL. FILM, 12.4K +/-1%, 1/8W	261644	91637	MFF1-81242F	1		
R70	RES, MTL. FILM, 13.3K +/-1%, 1/8W	296566	91637	MFF1-81332F	1		
R71	RES, VAR, CERMET, 5K +/-20%, 1/2W	267872	75378	190PC502B	REF		
R72	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	REF		
R73	RES, MTL. FILM, 100 +/-1%, 1/8W	168195	91637	MFF1-81000F	1		
R74	RES, DEP. CAR, 6.8K +/-5%, 1/4W	368761	80031	CR251-4-5P6K8	1		
TP1-TP3	TERMINAL, TURRET	179283	88245	2010B-6	3		
U1	IC, LIN, OP AMP	483495	12040	LM318H	1	1	
U2	⊘ IC, C-MOS, HEX "D" FLIP FLOP	404509	12040	MM74C174N	1	1	
U3	⊘ IC, C-MOS, HEX, INVERTER/BUFFER	381848	02735	CD4049AE	1	1	
U4	IC, TTL, HEX INVERTER, BUFFER/DRIVER	327775	01295	SN7416J	1	1	
U5	⊘ IC, C-MOS, TRIPLE, 3-INPUT NAND GATES	375147	02735	CD4023AE	1	1	
U6	IC, LIN, OP AMP, DUAL	418566	12040	LM358N	1	1	
U7	⊘ IC, C-MOS, QUAD, 2-INPUT NOR GATES	355172	02735	CD4001AE	1	1	

1 ORDER P/N 459088 FOR COMPLETE MODULE CASE ASSY., WITHOUT PCB ASSY.

2 RESISTORS ARE TEMPERATURE COMPENSATED AND MUST BE RETURNED FOR RESELECTION IF ANY REQUIRE REPLACEMENT. (R55 AND R56)

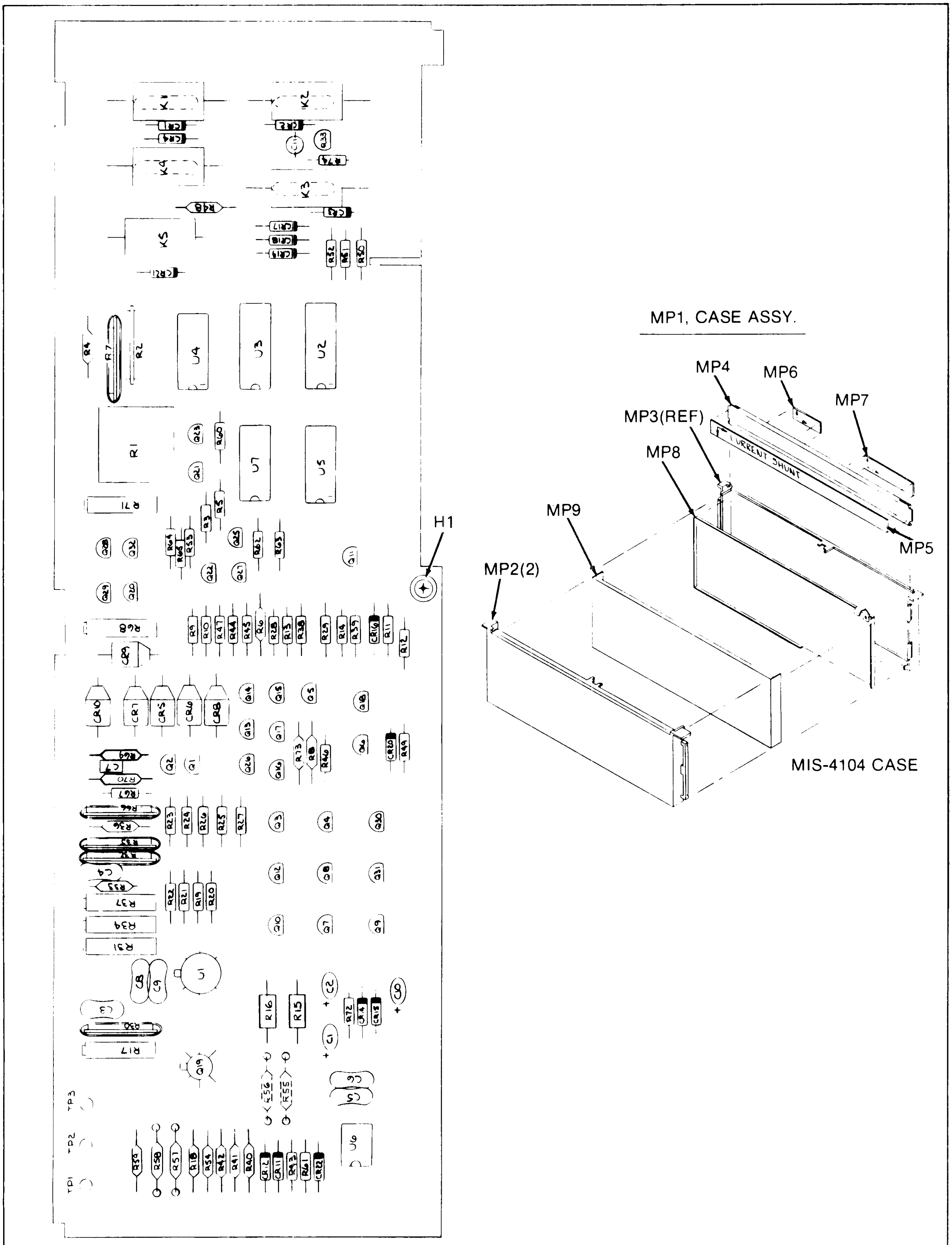
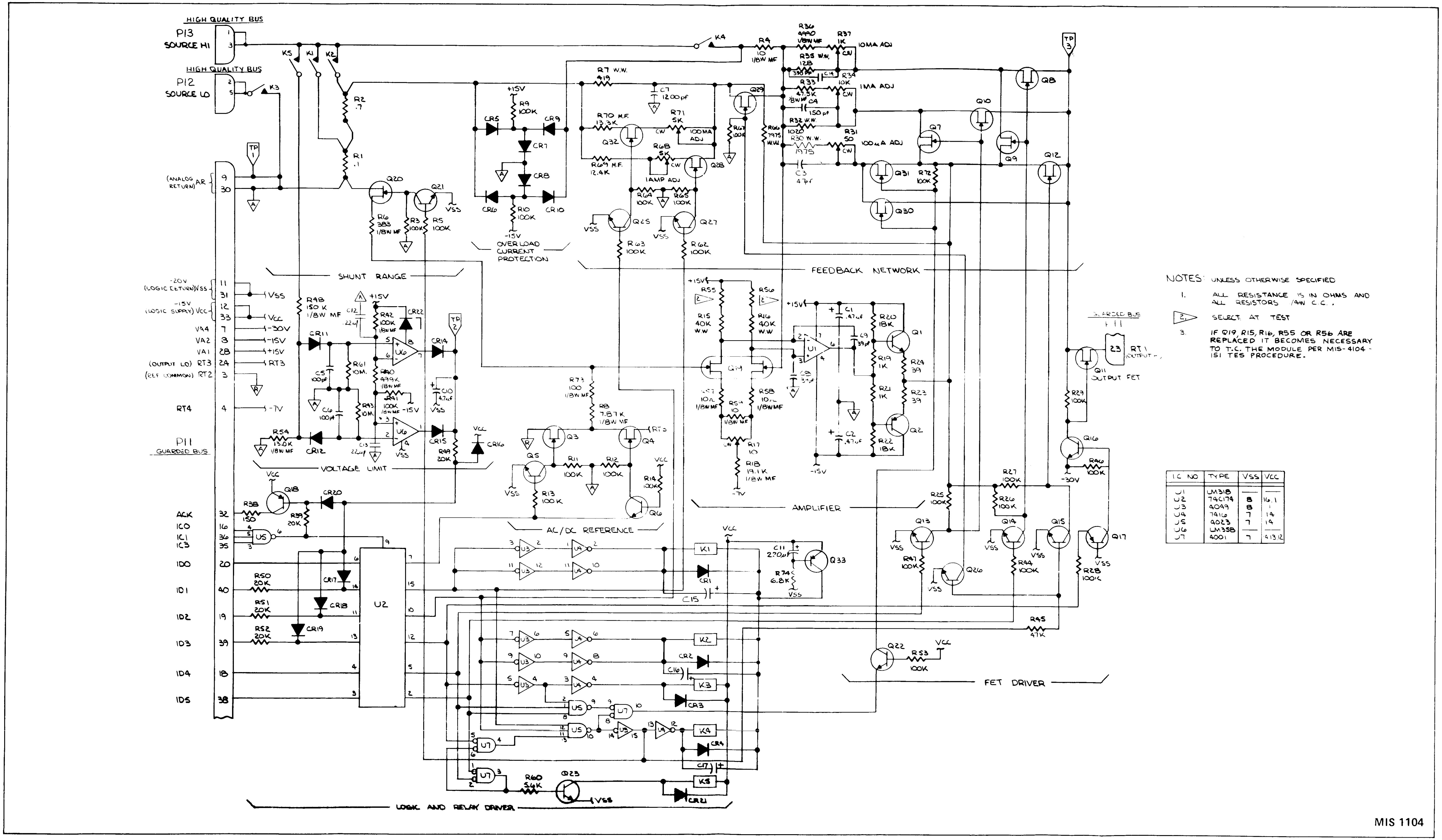


Figure 603-3. Current Shunts Assembly



I.C NO	TYPE	VSS	VCC
U1	LM318	—	—
U2	74C174	8	16, 1
U3	4049	8	1
U4	7416	7	14
U5	4023	7	14
U6	LM358	—	—
U7	4001	7	4,13,12

Figure 603-3. Current Shunts Assembly (cont)

Option -05
IEEE-488 Interface

605-1. INTRODUCTION

605-2. This manual will specifically describe the IEEE Interface (Option -05); refer to the IEEE standard for general IEEE-488 bus interface information. Descriptions unique to the IEEE Interface will be presented separately from Programming Instructions in this manual. The Systems Multimeter Programming Card provided with the DMM lists condensed programming instructions. Refer also to Fluke Application Bulletins 25 and 36, and the IEEE Standard 488-1975 Digital Interface for Programmable Instrumentation.

605-3. SPECIFICATIONS

605-4. Specifications for the IEEE 488-1975 Standard Interface, Option -05, conform to those established in the IEEE Standard Digital Interface for Programmable Instrumentation as published by the Institute of Electrical and Electronics Engineers; 345 E. 47th Street, New York, N.Y. 10017. For an explanation of the IEEE 488-1975 Standard, refer to the Standard Document.

605-5. INSTALLATION

605-6. The IEEE-488 Interface is easily installed as a module in the 8500 Series DMM. Use the following installation procedure:

1. On the DMM, press power OFF and remove the line power cord.

2. Remove the DMM's top cover.

3. The Interface module fits in the rear slot, bus connector and addresss switches facing to the rear. Slide the module vertically between the module guides, and press firmly into place.

NOTE

Make sure the leaf spring, attached to one-half of the module shield, is resting firmly over the flange of the opposite half of the module shield.

4. If installed, remove the Interconnect PCB from slot K. This slot can be identified as the only slot with connectors on the analog and digital bus lines. To remove the Interconnect PCB, grasp the board at both ends and pull up. An end-to-end rocking motion may be necessary to free the PCB from its connectors.

5. The Isolator module must be installed in slot K whenever a remote interface (Option -05, -06 or -07) is used in the DMM.

NOTE

Use Isolator -08 with the 8500A; Isolator -08A must be used with the 8502A.

6. Connect the Interface to the IEEE-488 Bus. Attach a standard 24-pin cable to the bus connector accessed through the DMM's rear panel. Standard cables, listed in Table 605-1, are available from John Fluke Mfg. Co., Inc.

7. Optionally, connect the cable shield to chassis ground. The shield, pin 12 in the connector, is accessed from the rear panel via a banana jack. Chassis ground is available at a binding post on the DMM's rear panel.

8. Set the Interface address switches (A1-A5) as required. Controls and connections accessed through the rear panel are illustrated in Figure 605-1. Refer to Table 605-2 for permissable address settings. Depressing a switch to the bottom sets the associated address bit true (true = 1). TALK address bits T1 through T5 are equal to LISTEN address bits L1 through L5.

NOTE

If the other devices in the system are listeners only, the DMM may be place in TALK ONLY mode by toggling the TALK/ADDRESSABLE switch; access to this switch is through the rear panel.

9. Replace the DMM's top cover.

10. Energize the DMM.

11. Remote can be entered by sending any character that the DMM recognizes. While in remote, only the POWER switch (local lockout on) or the POWER and LCL/RMT switches (local lockout off) remain active on the front panel.

Table 605-1. IEEE-488 Standard Cables

ORDER NUMBER	DESCRIPTION
Y8001	IEEE-488 Cable, 1 meter
Y8002	IEEE-488 Cable, 2 meters
Y8003	IEEE-488 Cable, 4 meters

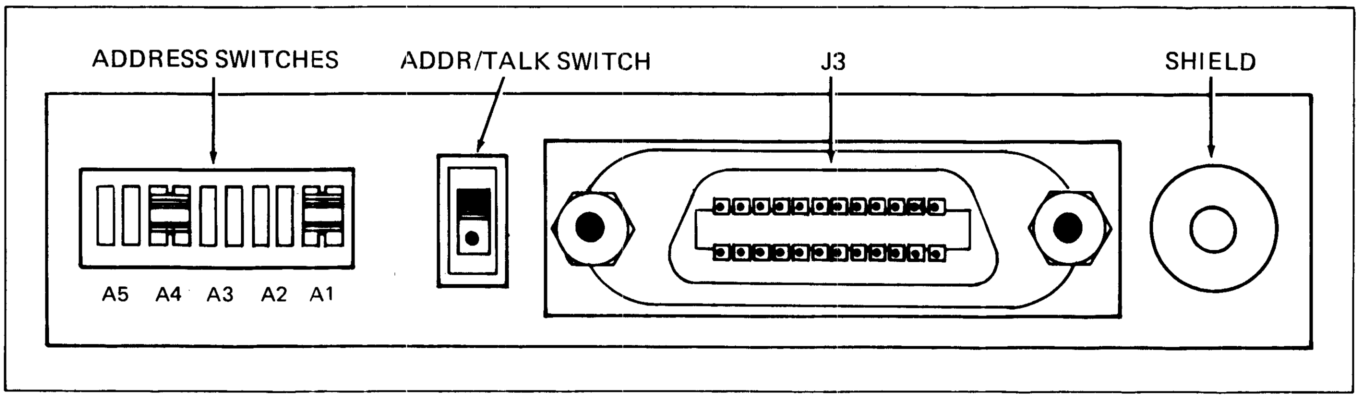


Figure 605-1. Rear Panel Access

Table 605-2. Allowable Listen and Talk Addresses

DECIMAL	5 4 3 2 1 BINARY	ASCII CHARACTER LISTEN	ASCII CHARACTER TALK	DECIMAL	5 4 3 2 1 BINARY	ASCII CHARACTER LISTEN	ASCII CHARACTER TALK
0	0 0 0 0 0	SP	@	16	1 0 0 0 0	0	P
1	0 0 0 0 1	!	A	17	1 0 0 0 1	1	Q
2	0 0 0 1 0	"	B	18	1 0 0 1 0	2	R
3	0 0 0 1 1	#	C	19	1 0 0 1 1	3	S
4	0 0 1 0 0	$	D	20	1 0 1 0 0	4	T
5	0 0 1 0 1	%	E	21	1 0 1 0 1	5	U
6	0 0 1 1 0	&	F	22	1 0 1 1 0	6	V
7	0 0 1 1 1	'	G	23	1 0 1 1 1	7	W
8	0 1 0 0 0	(	H	24	1 1 0 0 0	8	X
9	0 1 0 0 1	)	I	25	1 1 0 0 1	9	Y
10	0 1 0 1 0	*	J	26	1 1 0 1 0	:	Z
11	0 1 0 1 1	+	K	27	1 1 0 1 1	;	[
12	0 1 1 0 0	,	L	28	1 1 1 0 0	<	\
13	0 1 1 0 1	–	M	29	1 1 1 0 1	=	]
14	0 1 1 1 0	.	N	30	1 1 1 1 0	>	\
15	0 1 1 1 1	/	O				

605-7. OPERATING FEATURES

605-8. Attached to the assembly and accessible through a port on the rear panel (Figure 605-1) are a standard specified connector, five address switches and a Talk Only Mode switch. The connector is standard for the IEEE bus and is specified by the standard document. The address of the instrument is set using the five address switches. The characters used to address the instrument in the talk and listen mode are given in Table 605-1. The five low order bits of the message determine the address, the next two higher bits differentiate between the Talk and Listen modes. Normal operation allows the instrument to both talk and listen to the bus. The Listen mode can be disabled with the Talk Only switch, if desired.

605-9. OPERATING NOTES

605-10. Interface Control

605-11. Information is input to the interface from the controller on the system bus, which contains eight data lines, three handshake lines and five bus management lines. Control of the handshake and management lines is from the controller and will vary with the controller used. Refer to the instructions with the system controller for the information on how to obtain the correct level on these lines. The lines and a brief explanation of their function are given in Table 605-3. Refer to the IEEE 488-1975 Standard Manual for a further explanation of their function.

605-12. Interface Messages

605-13. Multiple line messages are input to the interface from the controller using the data lines. The messages used within the instrument are listed with their codes in Table 605-4. Further information on the messages can be obtained from the IEEE 488-1975 Standard Manual.

605-14. Status Request Responses

605-15. If enabled by the applicable Interface Interrupt Enable Code, a service request (SRQ) can be generated within the interface by either an error or ready condition. When the instrument is addressed during a serial poll operation by the IEEE 488 Controller, and an interrupt is generated, the response byte will be a zero for ready or the numeric of the applicable Error Code. If the SRQ was not generated, the response is a null character (binary 000000000) to the controller.

605-16. THEORY OF OPERATION

605-17. The IEEE Interface provides for communication between the IEEE system bus and the DMM internal bus structure. The IEEE system bus is defined by the IEEE standard; the DMM internal bus structure is discussed in the instrument Instruction Manual. System bus signal lines will be referred to by their mnemonic designators (refer to Table 605-3 for definitions).

605-18. The IEEE Interface consists of two interconnected pcb's in one module. Each pcb will have its own reference designator system. To distinguish between the two, reference designators mounted on the Piggyback board will be followed by a (PB).

605-19. Data Lines

605-20. System bus data lines (DI01-08) are applied to the interface through receiver/drivers, U21 and U24. The receivers consist of noninverting buffers, while the drivers are gates with a common enable line from U32-8.

NOTE
True conditions on the system data bus are defined as a low; true conditions on the instrument bus are defined as a high.

Outputs from the data line receiver drivers are applied directly to address decoders, U19 and U12, through address switch S1 to address decoders U6 and U3, and through inverters to a data register consisting of U30 and part of U31.

605-21. The internal DMM data bus is applied to a response register consisting of U26 and U29. This register latches data up for application to the system bus lines (the system bus requires that data be held longer than is desirable to tie up the instrument controller). Instrument data is also applied to the control register on the Piggyback board (U11-PB, U16-PB, U14-PB).

605-22. Addresses

605-23. Instrument address lines (IC0-IC6) are applied to address decoders located on the Piggyback board. All of the following listed addresses cause an ACK to be returned to the instrument controller through U6 (PB)-1.

1. IC 1, 5 and 4 High: Decoded U12 (PB)-6 to enable the response register.
2. IC 6, 4 and 3 High: U12(PB)-10 to clock data into the control register; if ID0 is high, this address also causes a Return to Local signal from U8(PB)-3.
3. IC 5, 3 and 0 High: Decoded by U13(PB)-6 to cause a software reset through U8(PB)-10.
4. IC 6, 0 and 4 High: Decoded by U13(PB)-9 to enable the status register (U28 and part of U31).
5. IC, 6, 1 and 4 High: Decoded by U13(PB)-10 to enable the data register (U30 and part of U31).

605-24. Addresses to the IEEE Interface from the system are received on the data lines when ATN is true. Address switch S1 routes My Listen Address (MLA) and My Talk Address (MTA). Decoding for MLA is done by U6-13; the DAV signal clocks this address into U11-1. The MTA flip-flop U11-1 is cleared by the UNL (Unlisten) signal (decoded by U19-13). The Message Decoder (U9, U5 and U8) is enabled by the ATN and U12-10 (decoded by DI02, DI06, DI07).

Table 605-3. Mnemonics

PIN	MNEMONICS	FUNCTION	COMMENTS
1	DIO 1	Data	
2	DIO 2	Data	
3	DIO 3	Data	
4	DIO 4	Data	Data input/output lines. Message bytes are carried on the DIO lines in a bit-parallel byte-serial form, asynchronously, and generally in a bidirectional manner.
13	DIO 5	Data	
14	DIO 6	Data	
15	DIO 7	Data	
16	DIO 8	Data	
5	EOI	End Or Identify	Used to indicate the end of a nultiple byte message.
6	DAV	Data Available	Is asserted TRUE by the sender of data when NRFD goes TRUE, remains TRUE until NDAC is sent TRUE by the data receiver.
7	NRFD	Not Ready For Data	When all devices are ready to receive data this line goes high. Remains high until DAV is sent TRUE.
8	NDAC	Not Data Accepted	When all receiving devices are through with the data on the bus, this line goes high, indicating that the sender may remove the data and set DAV low. When DAV goes to the receiving devices then pull NDAC low again.
9	IFC	Interface Clear	Sent high by the controller. It places all device interfaces in a known quiescent state.
10	SRQ	Service Request	This line is used by any device to get the attention of the controller.
11	ATN	Attention	Used by the controller to notify all other devices what type of message (interface versus device dependent) is on the data bus. When ATN is TRUE, messages sent are interface messages and all devices capable of receiving messages must handshake the transfer. When false, device dependent messages are sent and only devices that have been addressed remain active.
12		Shield*	Surrounds all conductors.
17	REN	Remote Enable	Must be TRUE to place instruments into remote. Once in Remote, if REN goes false all instruments must go to local.
18	GND	Return for DAV	
19	GND	Return for NRFD	
20	GND	Return for NDAC	
21	GND	Return for IFC	
22	GND	Return for SRQ	
23	GND	Return for ATN	
24	GND	Logic common for DIO 1-DIO 8, EOI, and REN	

**The cable shield is routed to a banana jack on the rear of the Option –05 interface adjacent to the programming conductor. This banana jack may be tied to the DMM chassis ground post located on the rear panel. However, caution must be exercised to prevent ground loops in the system.*

Table 605-4. Interface Messages

MNEMONIC	MESSAGE	CODING			ALL DEVICES RESPOND (Universal)	ADDRESSED DEVICES ONLY RESPOND	DEVICE IN LOCAL RESPONDS AND GOES TO REMOTE	NOTE
		BINARY	OCTAL	HEX				
MLA	My Listen Address	X F T A5 A4 A3 A2 A1				X	X	1
MTA	My Talk Address	X T F A5 A4 A3 A2 A1				X	X	1
UNL	Unlisten	X F T T T T T T	077	3F	X			
UNT	Untalk	X T F T T T T T	137	5F	X		X	
OTA	Other Talk Address	X X X X X X X X					X	2
SPE	Serial Poll Enable	X F F T T F F F	030	18	X		X	
SPD	Serial Poll Disable	X F F T T F F T	031	19	X		X	
LLO	Local Lockout	X F F T F F F T	021	11	X		X	
GTL	Go To Local	X F F F F F F T	001	01		X		
DCL	Device Clear	X F F T F T F F	024	14	X			
SDO	Selected Clear	X F F F F T F F	004	04		X		

605-25. Resets

605-26. Power-on or software resets may occur. At power-on, U8(PB)-10 causes an interface reset to prevent unwanted states in the interface logic. Software resets, decoded by U13(PB)-6, may occur as a result of a momentary power interruption, a front panel request, or a system request.

605-27. Control Register

605-28. The following six "D" flip-flops compose the control register:

1. Interrupt enable U14(PB)-2 remains true, except during the power-on routine.
2. A service request (SRQ) to the system controller is initiated by U14(PB)-13.
3. The instrument controller being ready for data (RFD) is indicated by U16(PB)-1.
4. At the last data byte of a message to the system from the instrument controller, U11(PB)-13 goes true.
5. Data accepted (DAC) is sent and RFD is reset by U16(PB-13.
6. When the instrument is a talker, U11(PB)-2 is used to generate the data available (DAV) signal.

605-29. Status Register

605-30. The status register consists of U28 and part of U31. The instrument address decoded by U13(PB)-9 enables a status byte to be placed on the data bus (ID0-ID7). This status byte is defined as follows:

1. ID0: true from U28-7 when in the talk only mode.
2. ID1: true from U28-9 when remote enable (REN) from the system controller is false.
3. ID2: true from U28-9 when go to local (GTL) is true from the message decoder U5-4.
4. ID3: true from U28-3 for an interface message.
5. ID4: true from U31-3 for an interface message.
6. ID5: true from U31-5 to indicate a device dependent message.
7. ID6: true from U31-7 during the serial poll mode when the system controller is requesting status.
8. ID7: true from U31-9 when the system controller is requesting data from the instrument.

605-31. Message Decoder

605-32. Interface messages sent by the system controller on the data bus are decoded by U9, U5 and U8. The device dependent messages GET, SCD and GTL require the interface to be a listener before the instrument controller is interrupted. For group execute trigger (GET), U8-11 is true. For selected device clear (SDC), U8-10 is true. For go to local (GTL), U5-4 is true. The universal messages DCL and LLO are unique in that they cause the instrument controller to be interrupted when in local. For local lockout (LLO), U5-3 is true. For device clear (DCL), U5-10 is true. In addition, U8-4 goes true for the serial poll mode (SPE), and U8-3 is true for serial poll disable (SPD).

605-33. Mode Register

605-34. The mode register consists of the following four J-K flip-flops: U11-1 (clocks in MLA), U11-15 (clocks in MTA), U15-1 (true in remote mode) and U15-15 (true in serial poll mode).

605-35. Instrument Interrupts

605-36. Except during the power-on routine, interrupts are enabled by U14(PB)-2. The interrupt flip-flop may be clocked by the DAV signal through U4(PB)-4 and U4(PB)-3 or by U6(PB)-13 when the instrument is to be an active talker.

605-37. MAINTENANCE

605-38. Refer to Section 4 of the Instruction Manual for information on cleaning the module. The two pcb's are disassembled by removing the screws and standoffs fastening them together. To prevent damage to the electrical connectors, pull the boards straight apart.

605-39. PERFORMANCE TEST

605-40. Operation of the IEEE Interface can be verified by programming changes in range, output and mode, and by observing response data.

605-41. CALIBRATION

605-42. The IEEE Interface does not require calibration.

605-43. TROUBLESHOOTING

605-44. Troubleshooting the -05 IEEE Remote Interface Option consists of the tabular flow chart in Table 605-5. When a step in the flow chart is completed, check for a decision transfer, If no decision is required, perform the next step of the table in sequence.

605-45. Programming Instructions

605-46. Programming commands and instrument responses are explained in Table 605-6. For the 8505A and 8506A, refer to Section 2A.

605-47. PARTS LIST

605-48. Table 605-6 provides a detailed parts list for the Interface PCB; Table 605-7 lists parts for the Piggyback PCB. Refer to Section 5 of this manual for ordering information.

Table 605-5. Troubleshooting

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
	NOTE *Due to the speed and complexity of the data on the bus system, it is recommeded that the pcb be sent to the nearest Fluke Service Center for repair when a problem is isolated to the interface. The following table will be of some assistance when troubleshooting simpler problems; however, manu many problems will require the use of a Fluke Trendar, or similar logic board tester. The instrument must be connected through a bus network to a system controller, e.g., the Tektronix 4051 or HP 9825, to operate.*		
1	This test is based on the assumption that the DMM was checked and found opeational in local operation prior to installation of the IEEE Interface.		
2	Install the IEEE Interface Assembly in the instrument and apply power from the front panel switch.		
3	Is the front panel display correct?	6	4
4	If the display is blank, check the ACK circuit on the PB PCB.		
5	If the display is incorrect, check the input latches and output buffers on the Main PCB. Repair as required and return to step 2.		
6	Address the instrument on the IEEE bus with the applicable address. Does the instrument go into remote?	8	7
7	On the Main Board check the address lines through the Receiver/Driver, the address switches, the MLA circuitry, and the REN and DAV signals. On the Piggyback Board check the INT circuit. Repair as required then resume at step 2.		
8	Program an instruction from the remote controller. Is the output display as programmed?	10	9
9	Check the output latches and buffers, the UNL circuitry and the Receiver/Driver on the Main Board. Repair as required and return to step 8.		
10	Does the instrument respond to and "SRQ" from an Interrupt Ready or Error?	12	11
11	Check the SRQ line inand the Receiver/Driver on the Main Board and the status latches on the Piggyback Board. Repair as required then resume at step 10.		
12	Does the interface clear from the system controller?	14	13
13	Check the IFC input and the IFC circuit. Repair as required, then resume at step 12.		
14	Can the Front Panel be locked out from the system controller?	16	15
15	Check the LLO line and the decoder circuit. Repair as required then resume at step 14.		
16	Troubleshooting of the IEEE Interface, as applicable at this level, is complete.		

Table 605-6. IEEE 488-1975 Interface PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
-05⊗	IEEE 488-1975 INTERFACE PCB ASSEMBLY FIGURE 605-2 (MIS-4172T)	ORDER	BY	OPTION -05			
	⊗IEEE 488-1975 PIGGYBACK PCB ASSEMBLY FIGURE 605-3 (MIS-4074)				1		
C1	CAP, MICA, 270 PF +/-5%, 500V	148452	72136	DM15F271J	2		
C2	CAP, MICA, 270 PF +/-5%, 500V	148452	72136	DM15F271J	REF		
C4-C8	CAP, CER, 0.22 UF +/- 20%, 50V	309849	71590	CW30C224K	5		
C9	CAP, MICA, 100 PF +/-5%, 500V	148494	72136	DM15F101J	1		
CR1	DIODE, SI, HI-SPEED SWITCH	203323	07910	1N4448	1	1	
H1	LOCKWASHER, SPLIT, 8-32	111070	89536	111070	2		
H2	SCREW, PHP, 4-40 X 3/8 (not shown)	256164	89536	256164	1		
H3	SCREW, CONN MTG, (USE ON J3)	429472	89536	429472	2		
J2	POST, CONTACT	447813	22526	65501-136	3		
J3	CONN, CABLE, 24-PIN, MODIFIED	534107	89536	534107	1		
MP1	CASE ASSY (INCLUDES MP2-MP8)	458935	89536	458935	1		1
MP2	CASE HALF, MODULE	402990	89536	402990	REF		
MP3	CASE HALF, MODULE, MODIFIED	456079	89536	456079	REF		
MP4	COVER, MODULE CASE	402974	89536	402974	REF		
MP5	SHIELD, COVER	441022	89536	441022	REF		
MP6	DECAL, IEEE INTERFACE ASSY	413518	89536	413518	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	COIL, SPRING (not shown)	424465	83553	C0120-014-0380	1		
MP10	SPACER, 4-40 X .187 (not shown)	335604	89536	335604	1		
MP11	SPACER, 4-40 X .340	380329	89536	380329	2		
MP12	SPACER, 6-32 X .550	312421	89536	312421	2		
MP13	SPACER, 6-32 X .220	261727	89536	261727	2		
Q1	XSTR, SI, NPN	218396	04713	2N3904	1	1	
R1	RES, DEP. CAR, 18K +/-5%, 1/4W	348862	80031	CR251-4-5P18K	1		
R2	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	1		
R3	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	1		
R4	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	1		
R5	RES, DEP. CAR, 15K +/-5%, 1/4W	348854	80031	CR251-4-5P15K	1		
S1	SWITCH, MODULE SPDT, 5-POS.	417766	00779	435470-4	1	1	
S2	SWITCH, SLIDE, SPDT	417287	95146	MSS-1040-1	1	1	
U1⊗	IC, C-MOS, QUAD, 2-INPUT NAND GATE	355198	02735	CD4011AE	1	1	
U2⊗	IC, COS/MOS, DUAL, 4-INPUT, NOR GATES	363820	02735	CD4002AE	1	1	
U3⊗	IC, C-MOS, 8-INPUT, NOR GATES	408781	02735	CD4078BE	3	1	
U4⊗	IC, C-MOS, QUAD, 2-INPUT AND GATE	408401	02735	CD4081BE	2	1	
U5⊗	IC, COS/MOS, QUAD, 2-INPUT NOR GATES	355172	02735	CD4001AE	3	1	
U6⊗	IC, C-MOS, 8-INPUT, NOR GATES	408781	02735	CD4078BE	REF		
U7⊗	IC, COS/MOS, TRIPLE, 3-INPUT NOR GATES	355180	02735	CD4025AE	1	1	
U8⊗	IC, COS/MOS, QUAD, 2-INPUT, NOR GATES	355172	02735	CD4001AE	REF		
U9⊗	IC, C-MOS, DCDR/MULTIPLEXER	408369	04713	MC14556CP	1	1	
U10⊗	IC, C-MOS, QUAD, 2-INPUT OR GATE	408393	02735	CD4071BE	1	1	

Table 605-6. IEEE 488-1975 Interface PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
U11⊗	IC, COS/MOS, DUAL, JK MASTER FLIP FLOP	355230	02735	CD4027AE	2	1	
U12⊗	IC, C-MOS, TRIPLE 3-INPUT NAND GATES	375147	02735	CD4023AE	1	1	
U13⊗	IC, C-MOS, HEX INVERTER	404681	02735	CD4069BE	2	1	
U14⊗	IC, COS/MOS, QUAD, 2-INPUT NOR GATES	355172	02735	CD4001AE	REF		
U15⊗	IC, COS/MOS, DUAL, JK MASTER FLIP FLOP	355230	02735	CD4027AE	REF		
U16⊗	IC, C-MOS, QUAD, 2-INPUT, NAND	404632	02735	CD4093BE	1	1	
U17⊗	IC, C-MOS, QUAD, 2-INPUT AND GATE	408401	02735	CD4081BE	REF		
U18⊗	IC, C-MOS, HEX INVERTER	404681	02735	CD4069BE	REF		
U19⊗	IC, C-MOS, 8-INPUT, NOR GATES	408781	02735	CD4078BE	REF		
U20	IC, QUAD, INTERFACE, BUS XCVR	428649	04713	MC3446P	4	1	
U21	IC, QUAD, INTERFACE, BUS XCVR	428649	04713	MC3446P	REF		
U22⊗	IC, C-MOS, HEX INVERTER BUFFER	381848	02735	CD4049AE	2	1	
U24	IC, QUAD, INTERFACE, BUS XCVR	428649	04713	MC3446P	REF		
U25⊗	IC, C-MOS, HEX INVERTER BUFFER	381848	02735	CD4049AE	REF		
U26⊗	IC, COS/MOS, QUAD, LOCKED D LATCH	355149	02735	CD4042AE	2	1	
U27	IC, QUAD, INTERFACE, BUS XCVR	428649	04713	MC3446P	REF		
U28⊗	IC, C-MOS, TRI HEX NON INV BUFFERS	407759	12040	MM80C97N	3	1	
U29⊗	IC, COS/MOS, QUAD, LOCKED D LATCH	355149	02735	CD4042AE	REF		
U30⊗	IC, C-MOS, TRI HEX NON INV BUFFERS	407759	12040	MM80C97N	REF		
U31⊗	IC, C-MOS, TRI HEX NON INV BUFFERS	407759	12040	MM80C97N	REF		
U32	IC, TTL, QUAD, 2-INPUT NAND GATES	393033	01295	SN74LS00N	1	1	
U33	RES. NETWORK, 4.7K	412916	89536	412916	2	1	
U34	RES. NETWORK, 4.7K	412916	89536	412916	REF		

1 ORDER P/N 458935 FOR COMPLETE MODULE CASE ASSY., WITHOUT PCB ASSY.

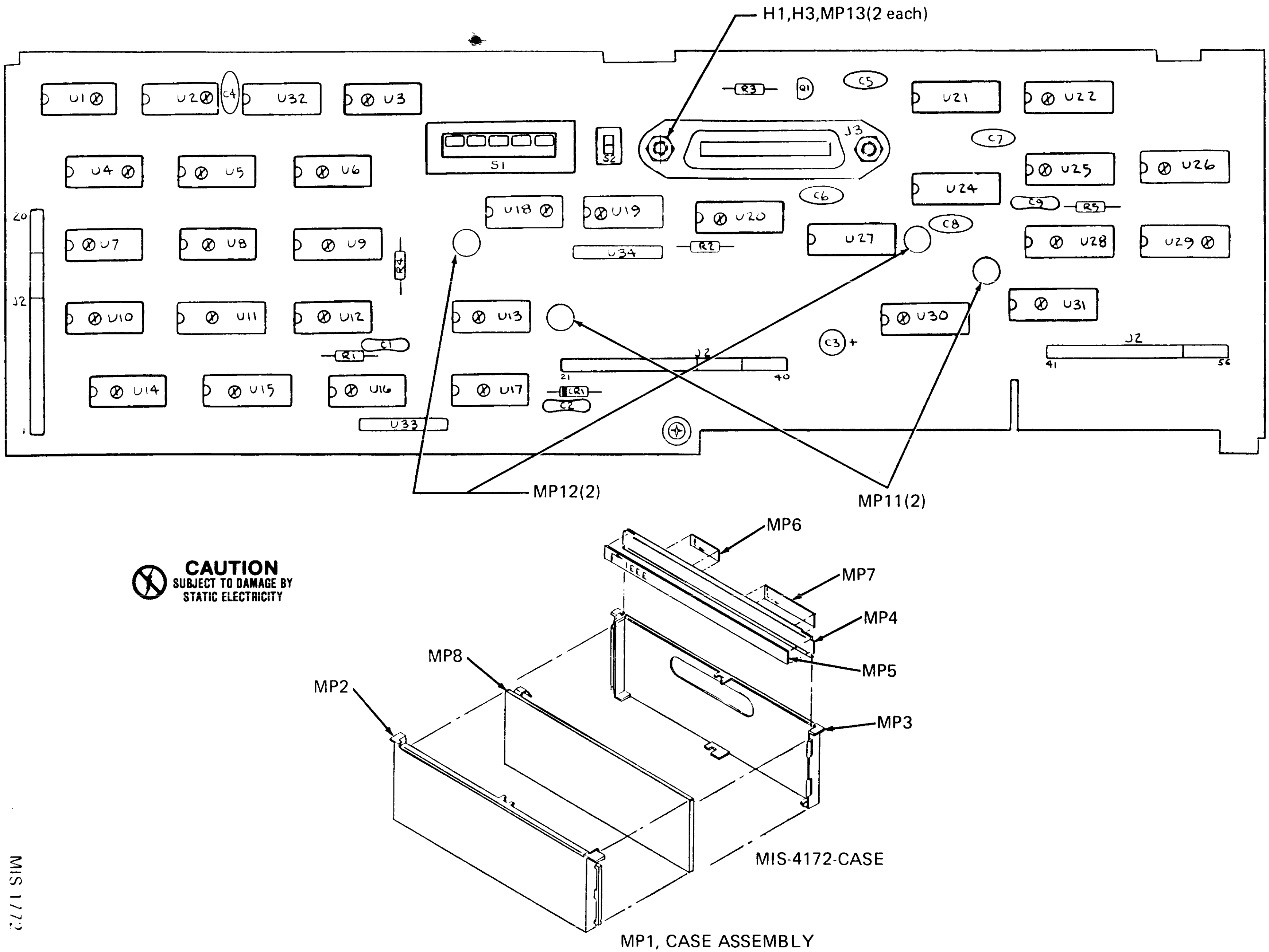


Figure 605-2. IEEE 488-1975 Interface PCB Assembly

MIS 1772

Table 605-7. IEEE 488-1975 Piggy Back PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO.	TOT QTY	REC QTY	NOTE
-05P⊗	IEEE-488-1975 PIGGY BACK PCB ASSEMBLY FIGURE 605-3 (MIS-4074)	PART	OF	OPTION -05			
C1	CAP, MICA, 270 PF +/-5%, 500V	148452	72136	DM15F271J	2		
C2	CAP, MICA, 100 PF +/-5%, 500V	148494	72136	DM15F101J	1		
C3	CAP, TA, 1 UF +/-20%, 35V	161919	56289	196D105X0035JA1	1		
C4	CAP, MICA 270 PF +/-5%, 500V	148452	72136	DM15F271J	REF		
CR1	DIODE, HI-SPEED SWITCHING	203323	07910	1N4448	1	1	
H1	WASHER, FLAT, S/S 1/4 INCH (W/P4)	200980	86928	5710-65-16	1		
H2	WASHER, INT LOCK, 1/4 INCH (W/P4)	110817	73734	1308	1		
P2	CONNECTOR, SOCKET, 20 PIN	447110	30035	SK-109-1-20	2		
	CONNECTOR, SOCKET, 16 PIN	447102	20447	SS-109-1-16	1		
P4	BINDING POST	441741	89536	441741	1		
Q1	XSTR, SI, NPN	218396	04713	2N3904	1	1	
Q2	XSTR, SI, PNP	226290	04713	MPS3640	1	1	
R1	RES, DEP CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	3		
R2	RES, DEP CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	2		
R3	RES, DEP CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	2		
R4	RES, DEP CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R5	RES, DEP CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R6	RES, DEP CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	REF		
R7	RES, DEP CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R8	RES, DEP CAR, 15K +/-5%, 1/4W	348854	80031	CR251-4-5P15K	1		
R9	SELECTED AT TEST (may or may not be added)						
U1⊗	IC, C-MOS, DUAL "D" FLIP-FLOP	340117	02735	CD4013AE	5	1	
U2⊗	IC, COS/MOS, QUAD, 2-INPUT NOR GATES	355172	02735	CD4001AE	2	1	
U3⊗	IC, C-MOS, QUAD, 2-INPUT NAND GATE	404632	02735	CD4093BE	1	1	
U4⊗	IC, COS/MOS, QUAD, 2-INPUT NOR GATES	355172	02735	CD4001AE	REF		
U5⊗	IC, C-MOS, HEX INVERTER	404681	02735	CD4069BE	2	1	
U6⊗	IC, COS/MOS, DUAL, 4-INPUT NOR GATES	363820	02735	CD4002AE	1	1	
U7⊗	IC, C-MOS, HEX INVERTER	404681	02735	CD4069BE	REF		
U8⊗	IC, C-MOS, QUAD, 2-INPUT, NAND GATES	355198	02735	CD4011AE	2	1	
U9⊗	IC, C-MOS, QUAD, 2-INPUT, NAND GATES	355198	02735	CD4011AE	REF		
U10⊗	IC, C-MOS, HEX INVERTER BUFFERS	381848	02735	CD4049AE	1	1	
U11⊗	IC, C-MOS, DUAL "D" FLIP-FLOP	340117	02735	CD4013AE	REF		
U12⊗	IC, C-MOS, TRIPLE 3-INPUT AND GATES	408807	02735	CD4073BE	1	1	
U13⊗	IC, C-MOS, TRIPLE 3-INPUT NAND GATES	375147	02735	CD4023AE	1	1	
U14⊗	IC, C-MOS, DUAL "D" FLIP-FLOP	340117	02735	CD4013AE	REF		
U16⊗	IC, C-MOS, DUAL "D" FLIP-FLOP	340117	02735	CD4013AE	REF		
U17⊗	IC, C-MOS, TRIPLE 3-INPUT NOR GATES	355180	02735	CD4025AE	1	1	
U18⊗	IC, C-MOS, DUAL "D" FLIP-FLOP	340117	02735	CD4013AE	REF		

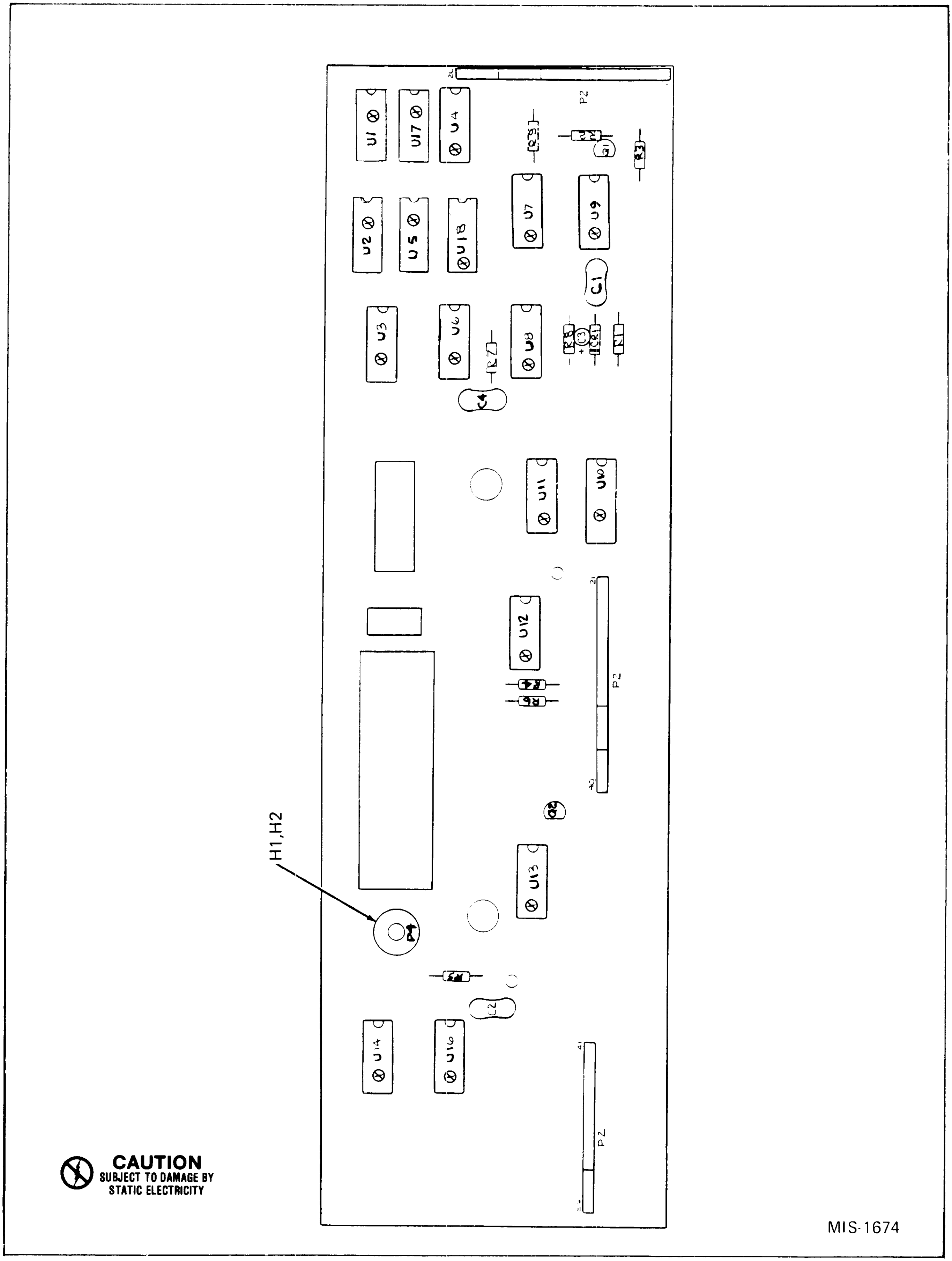
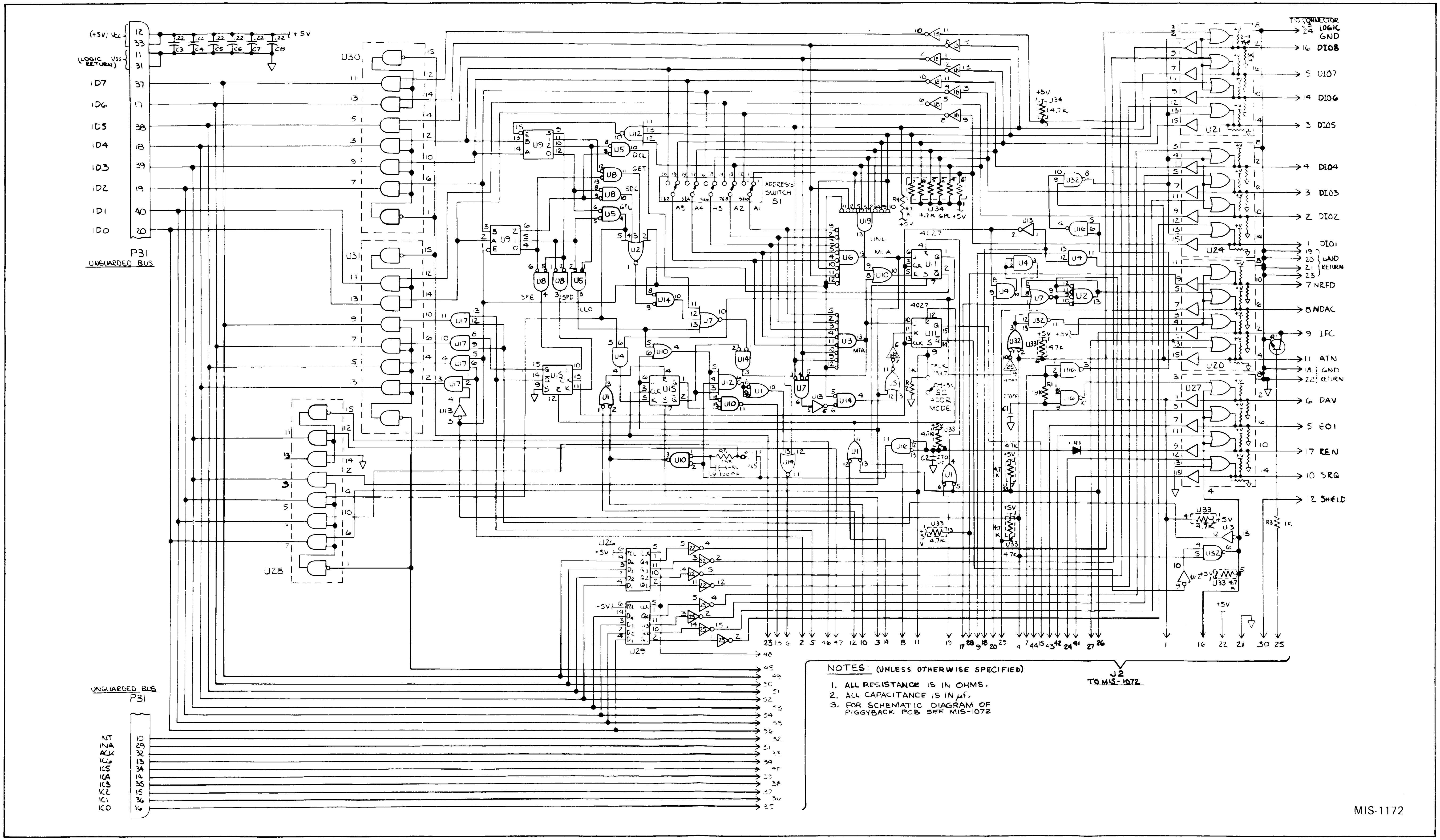


Figure 605-3. IEEE 488-1975 Piggy Back PCB Assembly



NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTANCE IS IN OHMS.
2. ALL CAPACITANCE IS IN μf.
3. FOR SCHEMATIC DIAGRAM OF PIGGYBACK PCB SEE MIS-1072

MIS-1172

Figure 605-4. IEEE 488-1975 Interface Schematic

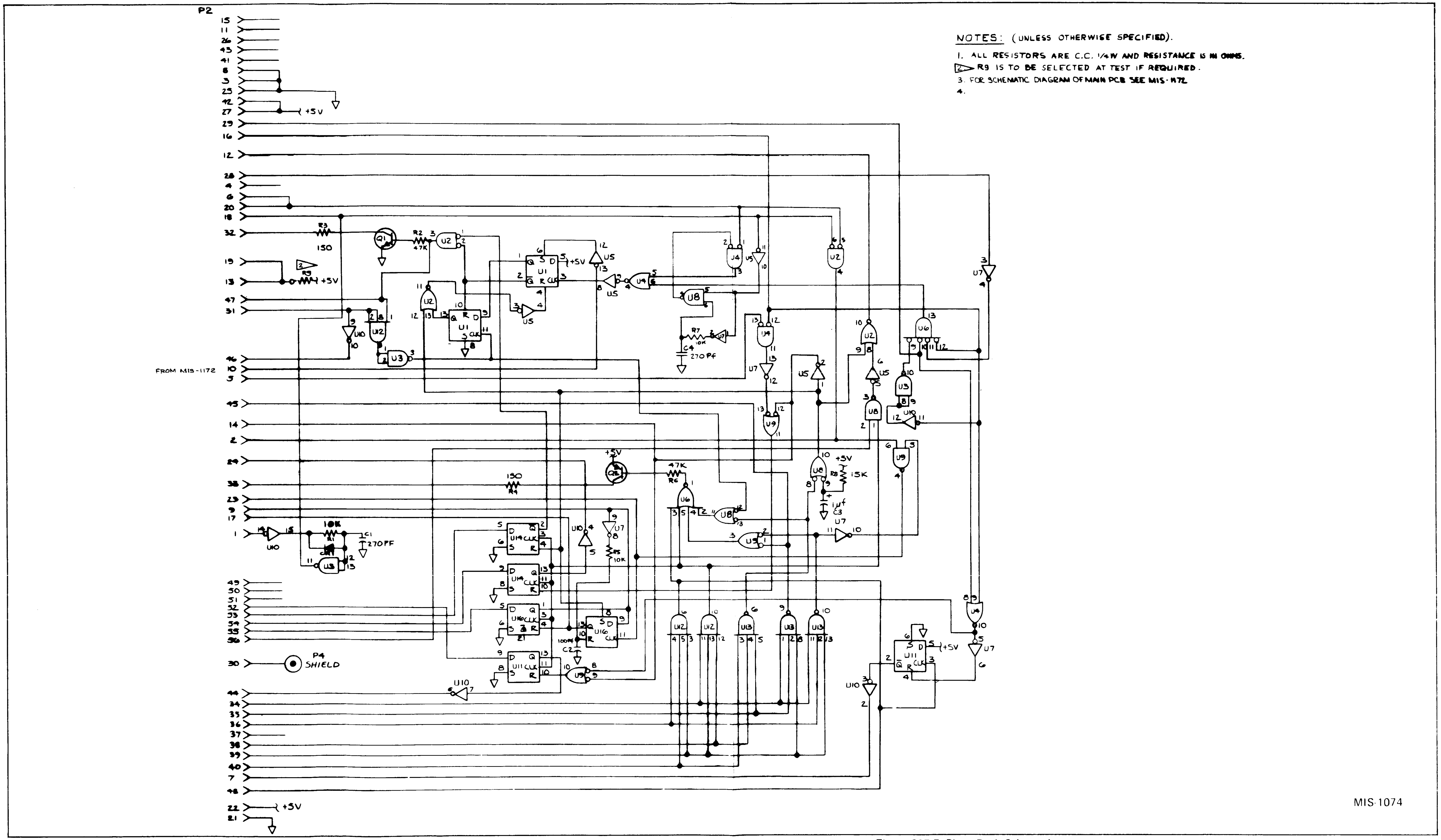


Figure 605-5. Piggy Back Schematic

Option -06
Bit Serial Interface

606-1. INTRODUCTION

606-2. The Bit Serial Asynchronous Interface provides remote programming capability in applications where speed is not a critical factor. Switch selectable baud rates, stop bits, and current requirements permit maximum flexibility.

606-3. SPECIFICATIONS

606-4. The Bit Serial Asynchronous Interface meets or exceeds the requirements for data transmission and reception of EIA Standard RS-232B or C, MIL-STD-188B, CCITT V24 and 20 mA current loop. Specifications are as follows:

Input Format	Byte Serial, 8-bit parallel.
Timing Format	Asynchronous.
Output Format	Bit Serial.
Baud Rates	50, 75, 110, 134.5, 150, 200, 300, 600, 1200, 1800, 2400, 4800 and 9600.
Operating Power	Derived from the DMM.
Operating Temperature	0° to 50°C.

606-5. INSTALLATION

606-6. The Bit Serial Interface is easily installed as a module in the 8500 series DMM. Use the following installation procedure:

1. On the DMM, press power OFF and remove the line power cord.

2. Remove the DMM's top cover.

3. The Interface module fits in the rear slot, bus connector and address switches facing to the rear. Slide the module vertically between the module guides, and press firmly into place.

NOTE

Make sure the leaf spring, attached to one-half of the module shield, is resting firmly over the flange of the opposite half of the module shield.

4. If installed, remove the Interconnect PCB from slot K. This slot can be identified as the only slot with connectors on the analog and digital bus lines. To remove the Interconnect PCB, grasp the board at both ends, and pull up. An end-to-end rocking motion may be necessary to free the PCB from its connectors.

5. The Isolator module must be installed in slot K whenever a remote interface (Option -05, -06 or -07) is used in the DMM.

NOTE

Use Isolator -08 with the 8500A; Isolator -08A must be used with the 8502A.

6. Replace the DMM's top cover.

606-7. GENERAL

606-8. EIA Standard RS-232-C provides the electronics industry with the ground rules necessary for independent manufacturers to design and produce both data terminal and data communication equipment that conforms to a common interface requirement. As a result, a data communications system can be formed by connecting an RS-232-C data terminal (such as the 8502A) to an RS-232-C data communications peripheral (such as a TTY, MODEM, computer, etc.). This works fine on paper. However, in practice the user must be aware of the subtleties of serial binary data interchange to ensure that any two pieces of RS-232-C equipment will be compatible. For example, the two instruments must share at least one of the features from each of the following characteristics.

1. Timing Format - Synchronous or Asynchronous.
2. Transmission Mode - Simplex, half-duplex, or full duplex.
3. Baud Rate (bits per second) - 50, 75, 110, 134.5, 150, 200, 300, 600, 1200, 1800, 2400, 4800, 9600.
4. Bits per character - 5, 6, 7, 8.
5. Parity Bit - Odd, even, high, low, not used.
6. Data Interface Levels - EIA or 20 mA current loop.

606-9. Timing formats conforming to both synchronous and asynchronous operation are shown in Figure 617-1. In asynchronous operation each character is bracketed by both start and stop bits. These bits separate the characters and synchronize both the transmission and receipt of data. When data is not being sent the data line is held high. In synchronous operation a sync character is sent prior to each data stream (a data stream usually consists of a block of characters). When the line is idle, a fill or sync character is continuously transmitted.

606-10. Transmission mode is an overall system requirement. It defines the communication ability of both instruments in the system configuration. Simplex indicates data transmission in one direction only. Half-duplex permits two way communication, but not simultaneously. Simultaneous transmission of data in both directions defines the full duplex system. Obviously, an instrument capable of full duplex operation can be downgraded to simplex operation. However, the reverse is not possible without degrading the system capability.

606-11. Baud rate is usually selectable on the RS-232-C Interface. If it is not, the manufacturer usually offers a choice when the instrument is purchased.

606-12. Character format (bits per character and parity) is somewhat flexible between instruments. Investigate the requirement of both instruments before committing either to a system configuration.

606-13. Data interface levels can occur as either EIA voltage levels or as a 20 mA current loop. At times an interface offers both simultaneously. The 20 mA current loop is used almost exclusively for teletypewriter, or paper tape punch/reader interface. EIA voltage levels are: 1 or OFF = -15 to -3V dc, 0 or ON = +3 to +15V dc.

606-14. OPERATING FEATURES

606-15. Attached to the PCB and accessible through a port on the rear panel (Figure 606-1) are a standard specified connector and a switch module with eight micro-switches. The connector is standard for the RS-232 Interface and is specified by the standard document. The eight switches control the operating modes of the interface and the BAUD rate. The modes selected by the switches are shown in Table 606-1 and Table 606-2. The selection of Odd or Even parity with switch 8 is applicable only if the parity feature has been selected using the jumpers described below.

606-16. The interface is shipped configured for an eight bit character without parity. Selection of parity and five, six or seven bit characters can be accomplished by installing jumpers into the PCB as shown in Table 606-3.

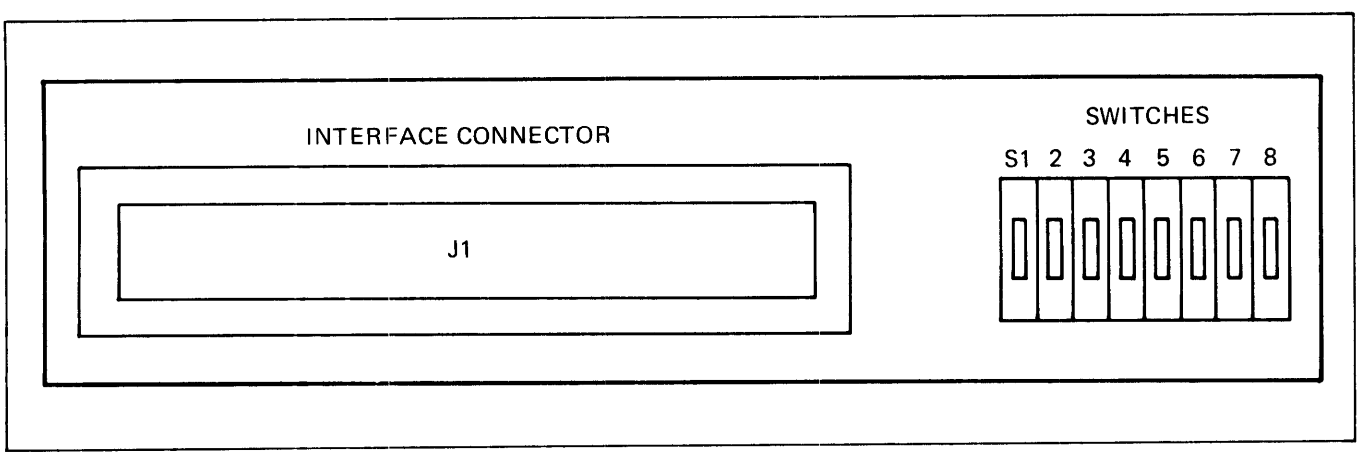


Figure 606-1. Rear Panel Access

Table 606-1. Mode Selection

SW#	SELECTION	SW ON	SW OFF
S1	Current Loop/RS232	Current	RS232
S2	RS232B/RS232C	RS232B	RS232C
S3	Stop Bits	1 Bit	2 Bits
S4	Baud Rate	*	*
S5	Baud Rate	*	*
S6	Baud Rate	*	*
S7	Baud Rate	*	*
S8	Parity	Odd	Even

* Defined in Table 606-2

Table 606-2. Baud Rate Selection

COUNT	S4	S5	S6	S7	BAUD RATE
0	OFF	OFF	OFF	OFF	110
1	OFF	OFF	OFF	ON	150
2	OFF	OFF	ON	OFF	300
3	OFF	OFF	ON	ON	2400
4	OFF	ON	OFF	OFF	1200
5	OFF	ON	OFF	ON	1800
6	OFF	ON	ON	OFF	4800
7	OFF	ON	ON	ON	9600
8	ON	OFF	OFF	OFF	2400
9	ON	OFF	OFF	ON	600
10	ON	OFF	ON	OFF	200
11	ON	OFF	ON	ON	134.5
12	ON	ON	OFF	OFF	75
13	ON	ON	OFF	ON	50

Table 606-3. Jumper Arrangements

	JUMPER #1 INSTALLED	JUMPER #2 INSTALLED	JUMPER #3 INSTALLED
Bit 5	Yes	Yes	N/A
Bit 6	No	Yes	N/A
Bit 7	Yes	No	N/A
Bit 8	No	No	N/A
Parity	N/A	N/A	Yes
No Parity	N/A	N/A	No

606-17. THEORY OF OPERATION

606-18. General

606-19. The bit serial interface alters and transmits data between the eight bit (byte) parallel format used on the instrument bus and the bit serial format of the system bus. As shown on the schematic, data inputs from either the system bus or the instrument bus are latched into universal asynchronous receiver transmitter (UART) U9, which is driven by a progammable clock (U3) set at the selected baud rate. Data in the Instrument Bus (ID0-ID7) is latched into the UART on DB1 through DB8 and output from the UART to the instrument bus on RD1 through RD8. Four separate functions are decoded from the control lines, and the receipt of any one generates a common acknowledgement signal (ACK). An interrupt function can be generated to notify the instrument controller the received data is available, allowing polled or interrupt control of the interface.

606-20. Functions

606-21. An address of IC0, IC4 and IC6 high with the remaining lines low generates the STATIN function. This generates ACK and enables the tri-state transmitters on the ID0-ID3 lines so that DA (received data available at RD1-RD8), OR (overrun; i.e., a new character received prior to final transmission of the previous character), RVMT (transmitter buffer empty and ready for the next character) and/or FE (framing error; i.e., no stop bit with received character) can be placed on the data lines.

606-22. The DATIN function (IC1, IC4, IC6 only high) strobes the RDE and RDA input to the UART. The UART is enabled to place data on the instrument bus by RDE and to receive another serial character from the system bus by RDA.

606-23. With IC2, IC4 and IC5 high, COUT is decoded to reset the UART and clock U5-3. If ID7 is high with COUT, the interrupt capability is disabled by enabling the reset at U5-10. This action prevents an interrupt signal to the instrument controller until removed. If ID8 is low, the interrupt circuitry is enabled.

606-24. DATOUT is decoded from IC3, IC4 and IC6 high, to strobe the DS input to the UART. The rising edge of DS initiates serial transmission of the character from SO onto the system bus. It is available at both J1-2 for RS-232 and J1-11 for the 20 mA current loop, for the users selection.

606-25. Interrupt

606-26. When DA (received data available) goes high, an interrupt is generated (unless it has been disabled by the COUT function) for a low at INT. The instrument controller responds with an INA, generating an ACK and enabling U8-15 to pass the output of the interrupt flip-flop to the instrument controller for interrupt vectoring. The removal of INA by the instrument controller causes the Interrupt flip-flop to reset itself and prepare the circuit for the next interrupt.

606-27. MAINTENANCE

606-28. Refer to Section 4 of the Instruction Manual for information on module disassembly and cleaning.

606-29. PERFORMANCE TEST

606-30. Operation of the Bit Serial Interface may be verified by programming changes in range, output and mode, and by observing response data.

606-31. CALIBRATION

606-32. The Bit Serial Interface does not require calibration.

606-33. TROUBLESHOOTING

606-34. Troubleshooting for the -06 Bit Serial Asynchronous Remote Interface Option consists of the tabular flow chart in Table 606-4. When a step in the flow chart is completed, check for a decision transfer. If no decision is required, perform the next step of the table in sequence.

606-35. PROGRAMMING INSTRUCTIONS

606-36. Programming commands and instrument responses are explained in Table 606-5. For the 8505A and 8506A, refer to Section 2A.

606-37. LIST OF REPLACEABLE PARTS

606-38. Table 606-5 is a list of replaceable parts for the Bit Serial Interface Option. Refer to Section 5 for an explanation of the columnar entries.

Table 606-4. Bit Serial Interface Troubleshooting

STEP NO.	ACTION	Go to the step number given for correct response YES	NO
	NOTE *The instrument must be connected through a bus network to a system controller, e.g., the Tektronix 4051 or HP 9825, to operate.*		
1	This troubleshooting procedure is based on the assumption that the instrument has been checked in local and found to be operational in all aspects prior to installation of the Bit Serial Interface.		
2	Install the Bit Serial Interface in the instrument and apply power from the front panel switch.		
3	Is the display blank?	4	7
4	Check the address lines and address decoders.		
5	Check for a high ACK line. Repair as required and resume at step 2.		
6	If the display is incorrect (garbled or wrong), check the input ID lines and gates. Repair as required and resume at step 2.		
7	Using the controller, instruct the instrument to go to remote (program the character "J").		
8	Does the instrument go into remote?	10	9
9	Check the input gates (TP1), the UART (U9), the baud rate at TP3, the INT circuit, and the status output buffer.		
10	Program several instructions from the remote controller.		
11	Does the instrument respond correctly to the programmed instructions?	13	12
12	Check the UART (U9), the output gates (U4), and the data input gate (U7). Repair as required and resume at step 10.		
13	Troubleshooting of the Bit Serial Interface, as applicable at this level, is complete.		

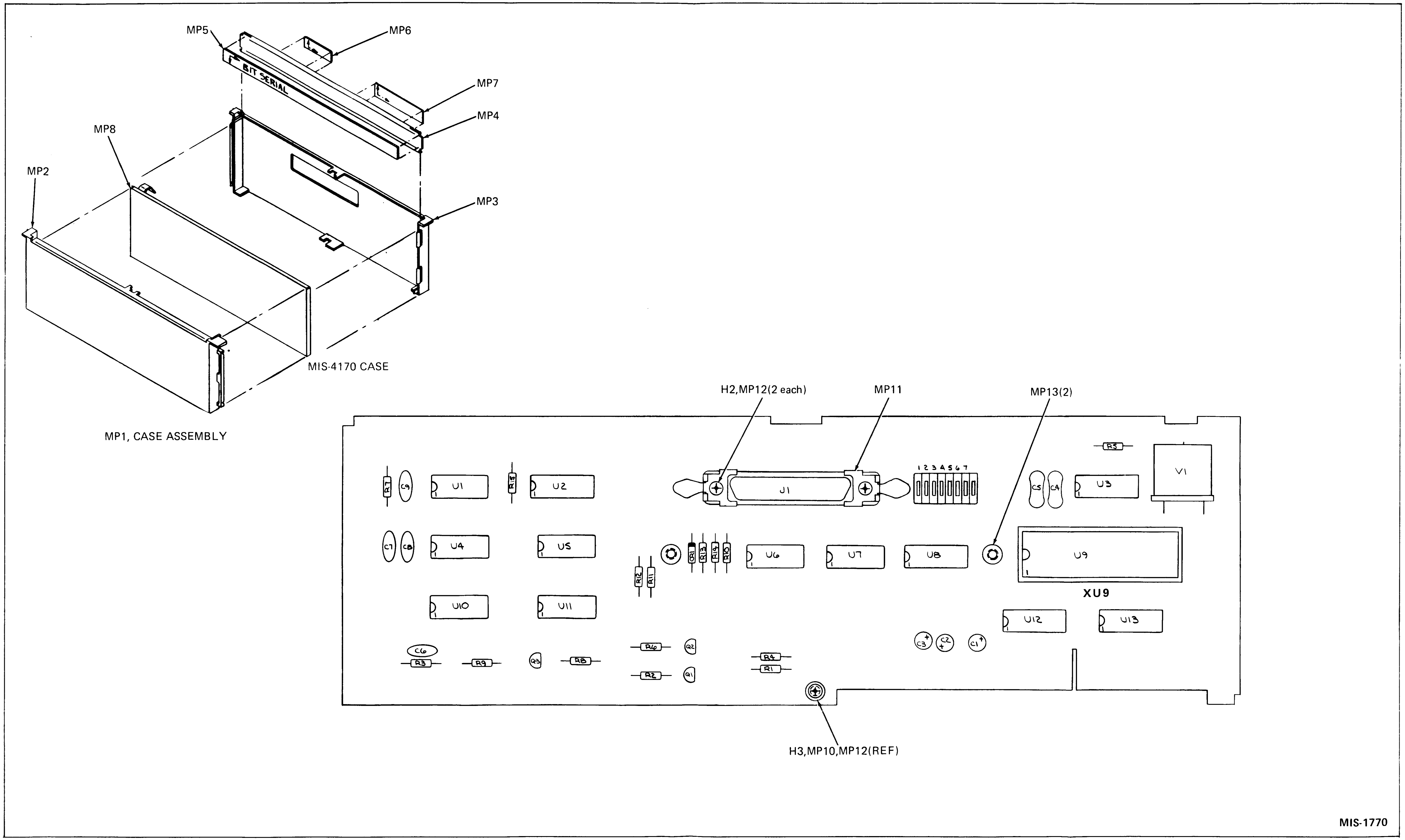
Table 606-5. Bit Serial Asynchronous Interface PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
-06⊗	BIT SERIAL ASYNCHRONOUS INTERFACE ASSY FIGURE 606-3 (MIS-4170T)	ORDER	BY	OPTION -06			
C1	CAP, TA, 5.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	3		
C2	CAP, TA, 5.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	REF		
C3	CAP, TA, 5.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	REF		
C4	CAP, MICA, 56 PF +/-5%, 500V	148528	72136	DM15F560J	2		
C5	CAP, MICA, 56 PF +/-5%, 500V	148528	72136	DM15F560J	REF		
C6	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	4		
C7	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C8	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
C9	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	REF		
CR1	DIODE, SI, HIGH-SPEED SWITCHING	203323	07910	1N4448	1	1	
H1	SCREW, FHP, U/C, 6-32 X 1/4 (not shown)	320093	89536	320093	2		
H2	SCREW, PHP, 4-40 X 1/4	129890	73734	19022	2		
H3	SCREW, RHP, 4-40 X 3/8	256164	89536	256164	1		
J1	CONNECTOR, D, SUB-MINI	413898	71785	DB25PV	1		
MP1	CASE ASSY (INCLUDES MP2-MP8)	458943	89536	458943	1		1
MP2	CASE HALF, MODULE	402990	89536	402990	REF		
MP3	CASE HALF, MODULE, MODIFIED	412031	89536	412031	REF		
MP4	COVER MODULE CASE	402974	89536	402974	REF		
MP5	SHIELD, COVER	411983	89536	411983	REF		
MP6	DECAL, BIT SERIAL INTERFACE	413492	89536	413492	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	SHIELD, FRONT	383372	89536	383372	1		
MP10	SPRING, COIL	424465	83553	C0120-014-0380	1		
MP11	SPRING CLIP ASSY KIT	330134	02660	17-529	1		
MP12	STANDOFF	385604	89536	385604	3		
MP13	STANDOFF	312421	89536	312421	2		
MP14	TERMINAL (not shown)	179283	89536	179283	3		
MP15	TERMINAL (not shown)	208363	89536	208363	6		
Q1	XSTR, NPN, SI	218396	04713	2N3904	1	1	
Q2	XSTR, PNP, SI	226290	04713	MPS3640	1	1	
Q3	XSTR, PNP, SI	195974	04713	2N3906	1	1	
R1	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	2		
R2	RES, DEP. CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	1		
R3	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	1		
R4	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R5	RES, COMP, 10M +/-5%, 1/4W	194944	01121	CB1065	1		
R6	RES, DEP. CAR, 33K +/-5%, 1/4W	348888	80031	CR251-4-5P33K	1		
R7	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	2		
R8	RES, DEP. CAR, 2.2K +/-5%, 1/4	343400	80031	CR251-4-5P2K2	1		
R9	RES, DEP. CAR, 47 +/-5%, 1/4W	441592	80031	CR251-4-5P47E	1		
R10	RES, DEP. CAR, 750 +/-5%, 1/4W	441659	80031	CR251-4-5P750E	1		
R11	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	3		
R12	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		

Table 606-5. Bit Serial Asynchronous Interface PCB Assembly (cont)

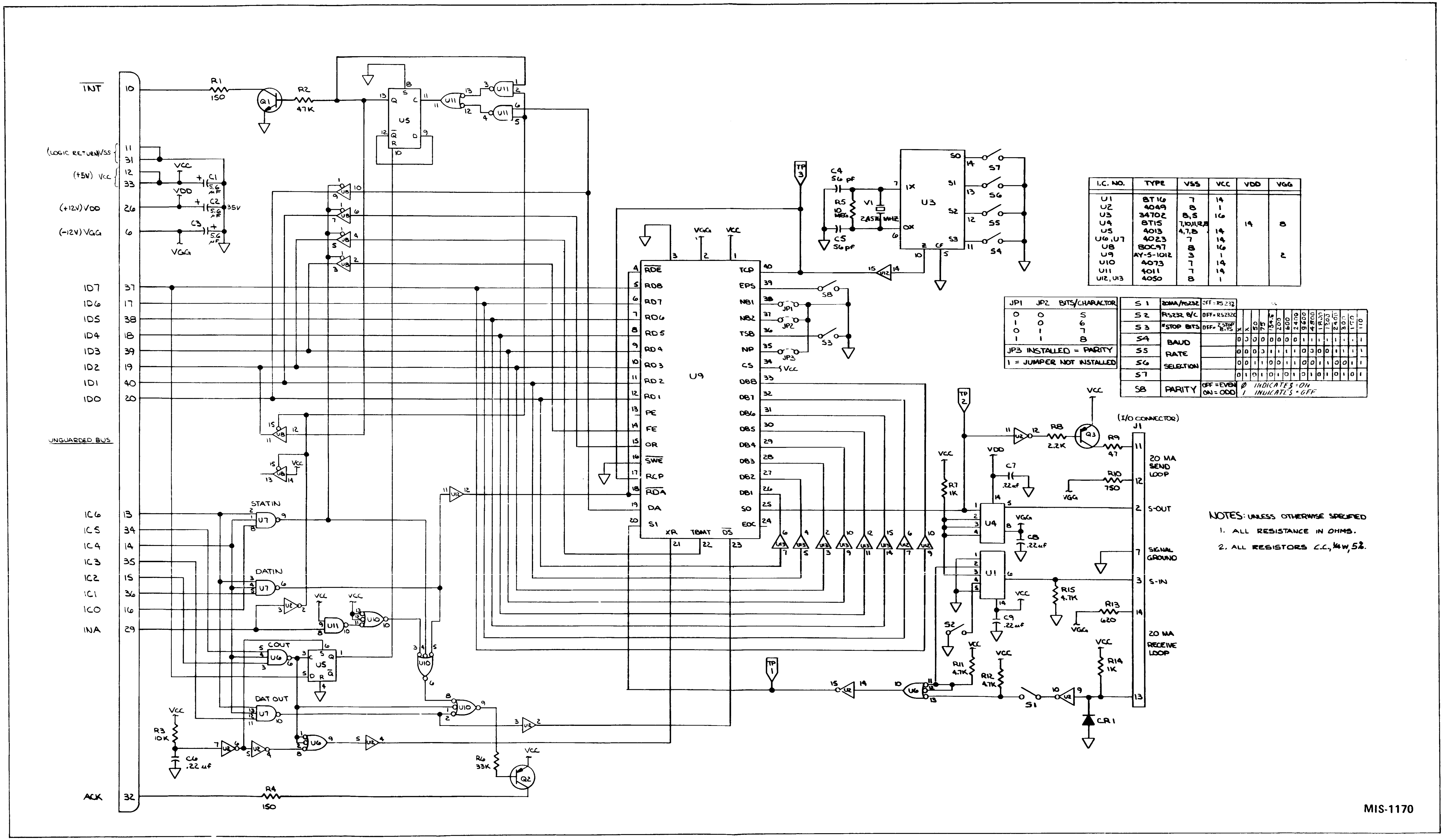
REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R13	RES, DEP. CAR, 620 +/-5%, 1/4W	442319	80031	CR251-4-5P620E	1		
R14	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R15	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
S1	SWITCH, SPST, 8-POS.	414490	00779	435166-5	1		
U1	IC, TTL, DUAL EIA/MIL LINE RECEIVER	354704	18324	8T16A	1	1	
U2⊗	IC, C-MOS, HEX BUFFER INVERTER	381848	02735	CD4049UBE	1	1	
U3⊗	IC, C-MOS, PRGMBLE BIT RATE GEN	418731	07263	F4702/34702	1	1	
U4	IC, TTL, MSI, DUAL EIA/MTL	354696	18324	N8T15A	1	1	
U5⊗	IC, C-MOS, DUAL "D" FLIP-FLOP	340117	02735	CD4013AE	1	1	
U6⊗	IC, C-MOS, NAND GATES, TRIPLE, 3-INPUT	375147	02735	CD4023AE	2	1	
U7⊗	IC, C-MOS, NAND GATES, TRIPLE, 3-INPUT	375147	02735	CD4023AE	REF		
U8⊗	IC, C-MOS, TRI, HEX, NON INV BUFFERS	407759	12040	MM80C97N	1	1	
U9	IC, UA, RECEIVER TRANSMITAL	354753	05828	AY-5-1013	1	1	
U10⊗	IC, C-MOS, TRIPLE, 3-INPUT AND GATE	408807	02735	CD4073BE	1	1	
U11⊗	IC, C-MOS, QUAD, 2-INPUT NAND GATE	355198	02735	CD4011AE	1	1	
U12⊗	IC, C-MOS, HEX, INV BUFFER	381830	02735	CD4050AE	1	1	
U13⊗	IC, C-MOS, HEX, INV BUFFER	381830	02735	CD4050AE	REF		
V1	CRYSTAL, QUARTZ	435370	89536	435370	1		
XU9	SOCKET, IC, 40-PIN	429282	09922	DILB40P-108	1		

1 ORDER P/N 458943 FOR COMPLETE MODULE CASE ASSY., WITHOUT PCB ASSY.



MIS-1770

Figure 606-2. Bit Serial Asynchronous Interface PCB Assembly



I.C. NO.	TYPE	VSS	VCC	VDD	VGG
U1	8T16	7	14		
U2	4049	8	1		
U3	34702	8,5	16		
U4	8T15	7,10,11,12,13		14	8
U5	4013	4,7,8	14		
U6,U7	4023	7	14		
U8	80C97	8	16		
U9	AY-5-1012	3	1		2
U10	4073	7	14		
U11	4011	7	14		
U12, U13	4050	8	1		

JP1	JP2	BITS/CHARACTOR
0	0	5
1	0	6
0	1	7
1	1	8
JP3 INSTALLED = PARITY		
1 = JUMPER NOT INSTALLED		

S1	20MA/RS232	OFF = RS 232																
S2	RS232 B/C	OFF = RS232C																
S3	#STOP BITS	OFF = 2 STOP BITS	x	x	50	75	134.5	200	600	2400	9600	4800	1800	1200	2400	300	150	110
S4	BAUD RATE SELECTION		0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
S5			0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
S6			0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
S7			0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
S8	PARITY	OFF = EVEN ON = ODD	Ø INDICATES = ON 1 INDICATES = OFF															

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCE IN OHMS.
2. ALL RESISTORS C.C, 1/4W, 5%.

Figure 606-2. Bit Serial Asynchronous Interface PCB Assembly (cont)

Option -07
Parallel Interface

607-1. INTRODUCTION

607-2. Installation of the Parallel Interface provides external programming capability in mini- and microcomputer systems. Program inputs must be in ASCII code. Outputs are remotely selectable between ASCII or binary (2's complement) and 8 or 16 bit characters.

607-3. Interfacing to a wide variety of devices is accomplished with a plug-in header termed a "personality card". By defining the pins, this card can be tailored to perform control of the DMM through the external device. Table 607-1 lists pins and definitions for the personality card. The personality card plugs into J2, as seen in Figure 607-1. Available personality cards are listed in Table 607-2.

607-4. Descriptions unique to the Parallel Interface will be provided separately from Programming Instructions in this manual. The Systems Multimeter Programming Card provided with the DMM lists condensed programming instructions. Fluke Application Bulletin #25 contains useful information concerning the use of the Parallel Interface.

Table 607-1. Personality Card Pin Definition

PIN NO.	INTERFACE MNEMONIC	BOARD - PIN DEFINITION
1	COS-B	= Control Output Strobe Buffered
2	$\overline{\text{COS-B}}$	= Control Output Strobe Inverted Buffered
3	COS	= Control Output Strobe
4	OR2A	= OR Gate 2 Input A
5	OR2B	= OR Gate 2 Input B
6	OR2A + OR2B	= OR Gate 2 Output
7	$\overline{\text{COS-B}}$	= Control Output Strobe Inverted Buffered
8	COEN	= LSB Output Enable
9	DOEN	= MSB Output Enable
10	OSLE	= Output Strobe Latch Enable
11	ILAT	= Data Input MSB Latch
12	SLAT	= Control Input LSB Latch
13	ISLE	= Input Strobe Latch Enable
14	ILS	= Data Input Latch Strobe

Table 607-1. Personality Card Pin Definition (cont)

PIN NO.	INTERFACE MNEMONIC	BOARD-PIN DEFINITION
15	SLS	= Control Input Latch Strobe
16	DLR	= Data Output Latch Reset
17	CLR	= Control Output Latch Reset
18	QP	= High Output Delay Pulse
19	GND	= Ground
20	VCC	= +5V dc
21	$\overline{\text{INT}}$	= Interrupt Clock
22	$\overline{\text{CIS}}$	= Control Input Strobe Clock Inverted
23	$\overline{\text{QP}}$	= Low Output Delay Pulse
24	$\overline{\text{CIS-B}}$	= Control Input Strobe Inverted Buffered
25	$\overline{\text{IQ}}$	= Data Input Ready Low
26	IQ	= Data Input Ready High
27	$\overline{\text{DQ}}$	= Data Output Ready Low
28	DQ	= Data Output Ready High
29	TTL PU	= TTL Pull Up
30	OR1A	= OR Gate 1 Input A
31	OR1B	= OR Gate 1 Input B
32	OR1A + OR1B	= OR Gate 1 Output
33	$\overline{\text{CIS B}}$	= Control Input Strobe Inverted Buffered
34	CIS B	= Control Input Strobe Buffered
35	CIS	= Control Input Strobe
36	NC	= No Connection
37	HT	= High Trigger Delay Pulse
38	$\overline{\text{COR}}$	= Control Output Ready Inverted
39	LT	= Low Trigger Delay Pulse
40	$\overline{\text{CIR}}$	= Control Input Ready Inverted

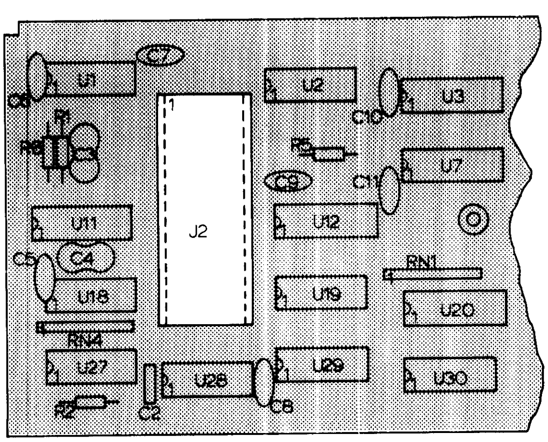


Figure 607-1. Personality Card Location

Table 607-2. Personality Cards

DESIGNATION	DESCRIPTION
-07A	Duplex Parallel Interface for PDP-11, DR11C, DRV-11.
-07B	Duplex Parallel Interface for PDP-11, PC11.
-07D	Duplex Parallel Interface (wiring completed by user).
-07H	Duplex Parallel Interface for HP12566B, 9825A.
-07L	Similar to the 07A, but used in noisier systems.

607-5. INSTALLATION

607-6. The Parallel Interface is easily installed as a module in the 8500 series DMM. Use the following installation procedure:

1. On the DMM, press power OFF and remove the line power cord.

2. Remove the DMM's top cover.

3. Ensure that the desired personality card is installed on the Interface PCB. If necessary, refer to "Module Disassembly" in Section 4 of the Instruction Manual when accessing the Interface PCB.

NOTE

If the -07L Personality Card is used remove jumpers W1 and W2 from the Interface PCB.

4. Plug the personality card into J2 on the Parallel Interface PCB. The location of J2 is illustrated in Figure 607-1.

5. Reassemble the module (PCB and shield covers).

6. The Interface module fits in the rearmost slot, bus connector and address switches facing the rear. Slide the module vertically between the module guides, and press firmly into place.

NOTE

Make sure the leaf spring, attached to one-half of the module shield, is resting firmly over the flange of the opposite half of the module shield.

7. Remove the Interconnect PCB, if installed, from slot K. This slot can be identified as the only one with connectors on the analog and digital bus lines. To remove the Interconnect PCB, grasp the board at both ends, and pull up. An end-to-end rocking motion may be necessary to free the PCB from its connectors. The Isolator module must be installed in slot K whenever a remote interface (Option -05, -06 or -07) is used in the DMM.

NOTE

Use Isolator -08 with the 8500A; Isolator -08A must be used with the 8502A.

8. Replace the DMM's top cover.

9. Energize the DMM.

607-7. OPERATING DIRECTIONS

607-8. The normal power-up condition of the Parallel Interface is eight-bit ASCII input and output. Command codes can change this to 16-bit ASCII input (two characters per transfer), 16-bit ASCII output, 8-bit Binary output, or 16-bit Binary output in character serial format.

607-9. When the front panel remote switch is pressed on the 8500A, the DMM stops measurements and waits for stimulation from the external device. On the 8502A, pressing the front panel remote switch results in the Parallel Interface trying to output data (ASCII 8-bit) in a continuous talk only mode.

607-10. THEORY OF OPERATION

607-11. Block Diagram Analysis

607-12. Data transfer through the Parallel Interface involves handshake processes between the interface and either the system controller or the instrument controller. Refer to the Block Diagram, Figure 607-2, during the following descriptions.

607-13. At power on, a reset circuit in the interface holds the control latches in the proper state until Vcc stabilizes. The instrument controller sends a software reset and an interrupt enable signal to the interface during its power on routine. This enables I/O operations to proceed.

607-14. This paragraph describes a typical two-wire handshake process for transferring commands through the interface to the DMM. Before the system controller attempts to send data to the instrument it verifies that the DMM is ready to accept the data. If the Control Input Ready (CIR) handshake signal indicates the DMM is ready, the system controller can strobe the Control Input Strobe (CIS) handshake signal line. The CIS has three functions. One clocks the input data placed by system controller on the input lines into the data input latches of the -07 interface. The second generates an interrupt request to the instrument controller. The last toggles the CIR handshake signal to indicate that the DMM is not ready and cannot accept additional input data. The CIS interrupts the DMM which responds by accepting the input data from the -07 interface data input latches and toggling the CIR handshake signal to indicate that the -07 interface is now ready to accept additional data from the system controller. This process is repeated for each input operation

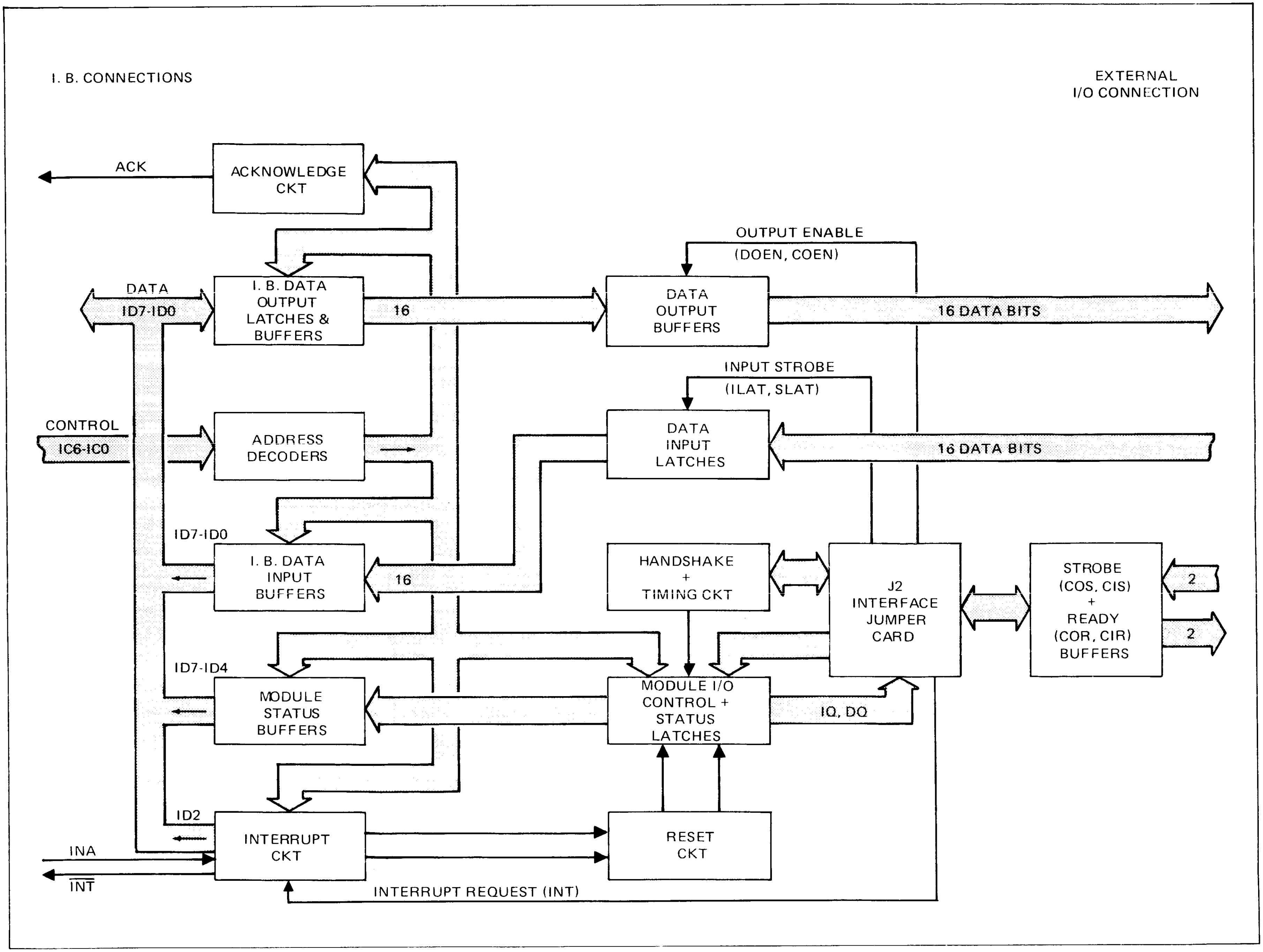


Figure 607-2. Parallel Interface Block Diagram

607-15. A typical two-wire data output transaction from the DMM is handled in a similar manner to the command input operation described above. When a data output transaction is initiated the instrument loads the data into the data output latches of the -07 interface and toggles the Control Output Ready (COR) handshake signal. This indicates that the -07 interface contains data to be transferred to the receiving device. The receiving device may accept the output data via the Data Out/Control Out Signal lines while enabling the Data Output Buffers. The receiving device strobes the Control Output Strobe (COS) handshake signal line either while or after it accepts the data. This toggles the COR handshake signal to indicate acceptance of the previously output data and to permit subsequent data output operations to occur. This process is repeated for each output operation.

607-16. Due to the wide variety of handshaking protocols, a personality card is used to match the logical and electrical characteristics of the system interface handshake signals to the -07 interface circuitry. The personality card connects the handshake lines to interface control and status signals. However, if the handshake protocol warrants additional circuitry may be used in the personality card connection configuration. The additional circuitry may be from either logic and timing circuitry existing on the -07 interface PCB, or additional circuitry on the personality card. Typical personality card connections have I-LAT, S-LAT, $\overline{\text{INT}}$, and SLS stimulated through the CIS handshake signal and CIR stimulated by IQ for input operations. I-LAT and S-LAT are used to store input data over the Data In and Control In signal lines. $\overline{\text{INT}}$ is used to generate the interrupt request to the instrument controller. SLS toggles the CIR signal. For output operations, COR is stimulated through DQ and COS stimulated by CLR. CLR toggles the COS signal.

607-17. Circuit Analysis

607-18. The following circuit analysis is accurate for Parallel Interface with Personality Card DR11C (4062) installed; control signals COS, CIS, COR, and CIR are therefore positive true logic. Refer to the Schematic Diagram during the following circuit descriptions. Table 607-3 defines interface connections.

607-19. RESETS

607-20. Power up resets are controlled by the RC network connected to U19-13. The reset signal is applied through U1-11 and U8-4 to the control latches (U29-8 and U28-8 are reset, while U29-5 and U28-5 are set). Address IC5, 3, 2, decoded by U25-10, provides software resets.

607-21. ADDRESSES

607-22. For all addresses, an ACK response is returned to the instrument controller through U31-10 and Q1. Upon termination of the address, U30-12 is clocked. If ID7 is high, the interface is reset through U23-10, U23-11 and U19-12 and interrrupts are disabled. If ID7 is low at address IC5, 3, and 2, interrupts are enabled, U30-12 goes high. Since U30-2 was reset, U19-6 is high; U19-4 places a high on U30-5. When U30-2 is clocked, an interrupt will be generated from U20-11. When triggered by U19-10, U11-12 goes low to clear U29-5 and U28-5. The signal from U28-5, routed through the personality card to generate CIR, indicates to the system controller that the instrument is ready to receive data.

607-23. DATA INPUTS

607-24. The system controller strobes the CIS line to make U2-2 low and applies it through the personality card to I-LAT, S-LAT, and LT. U2-4 also goes high and is applied to SLS through the personality card. I-LAT and S-LAT from the personality card clock the input data on the Data In and Control In lines into the data latches U3, U7, U13, and U14 at the termination of the CIS strobe. The termination of CIS also triggers a pulse (QP) at U11-2 through the LT signal at U11-1 which connects through the personality card to $\overline{\text{INT}}$. $\overline{\text{INT}}$, through U19-10, clocks U30-2 which enables the tri-state U20-11 to interrupt the instrument controller. SLS, through U18-8 and U27-4 clocks U28-5 (IQ) high. IQ, through the personality card and U2-6, drives CIR to indicate to the system controller that the -07 interface is not ready to accept additional data. The instrument controller responds to $\overline{\text{INT}}$ with an $\overline{\text{INA}}$ which drives U8-2 low to enable tri-state U12-13 to place a high (from U30-1) on ID2 for use as the interrupt vector in the instrument controller. INA is also applied directly to U23-2 which drives U23-3 and U19-10 low to cause an ACK response. Termination of INA clocks U30-1 low, ending the interrupt signal.

607-25. The interrupt vector tells the instrument controller to read data out of the interface. Address IC1, 4, 6 is decoded by U24-10 to enable tri-state buffers U12, U21 and U22. The low from U24-10 is applied through U27-4 to the clock input of U28-5. Termination of the address clocks IQ (U28-4) low. This state, transferred through the personality card and U2-6, causes CIR to go high and signals the system controller that the instrument is ready for more data.

607-26. In the double character mode, data of the most significant byte (DATA IN) is read first and the least significant byte (CONTROL IN) is read second. In the data output mode the MSB is loaded first. All termination and immediate command characters must use the CONTROL IN data lines.

607-27. DATA OUTPUTS

607-28. Data bytes are loaded into data latches U15, U16, U17, and U26 by addresses IC0, 3, 5 (decoded by U25-9) and IC1, 3, 5 (decoded by U25-6). Termination of the addresses also clock DQ (U28-8) low. Applied through the personality card to U2-8, this low sets COR high. The receiving device now sees that data is ready to be read from the interface.

607-29. The COS strobe is used by the receiving device to complete the output handshake. Since data output buffers U4, U5, and U6 are enabled by DOEN and COEN low through personality card connections, output data is available on Data Out and Control Out lines. The COS strobe is generated, either while or after, the receiving device accepts the data. A high on U2-10 from COS is applied through the personality card to the CLR line (U18-4) and eventually to the clock input of DQ (U28-11). Termination of COS clocks DQ high which toggles COR and informs the instrument controller that more data may be transferred to the receiving device via the -07 interface.

607-30. One complete reading in the 16-bit mode consists of seven transfers in ASCII (six with line feed suppression), or three transfers in binary code. Each reading in the eight bit mode consists of fourteen transfers in ASCII (thirteen with line feed suppression) or five transfers in binary code. When a complete reading has been sent in either mode, the instrument controller resets the interface and enables interrupts. CIR goes high to indicate that the instrument is ready to receive data.

607-31. Detailed Input Processes Description

607-32. For a graphical representation of the signal timing relationships, refer to Figure 607-3 and Table 607-4. Before inputting any information to the DMM, the -07 interface must indicate that it is ready to accept input data. This is

Table 607-3. Parallel Interface Connections

TITLE	MNEMONIC	J1 PIN NO.	SIGNAL FLOW
Input Strobe	CIS	31	From Control Device
Output Strobe	COS	37	From Control Device
MSD Bit 15 Input	I7	14	From Control Device
MSD Bit 14 Input	I6	15	From Control Device
MSD Bit 13 Input	I5	16	From Control Device
MSD Bit 12 Input	I4	17	From Control Device
MSD Bit 11 Input	I3	18	From Control Device
MSD Bit 10 Input	I2	19	From Control Device
MSD Bit 9 Input	I1	20	From Control Device
MSD Bit 8 Input	I0	21	From Control Device
LSD Bit 7 Input	S7	6	From Control Device
LSD Bit 6 Input	S6	7	From Control Device
LSD Bit 5 Input	S5	8	From Control Device
LSD Bit 4 Input	S4	9	From Control Device
LSD Bit 3 Input	S3	10	From Control Device
LSD Bit 2 Input	S2	11	From Control Device
LSD Bit 1 Input	S1	12	From Control Device
LSD Bit 0 Input	S0	13	From Control Device
Output Ready	COR	1	To Control Device
Input Ready	CIR	29	To Control Device
MSD Bit 15 Output	D7	46	To Control Device
MSD Bit 14 Output	D6	45	To Control Device
MSD Bit 13 Output	D5	44	To Control Device
MSD Bit 12 Output	D4	43	To Control Device
MSD Bit 11 Output	D3	42	To Control Device
MSD Bit 10 Output	D2	41	To Control Device
MSD Bit 9 Output	D1	40	To Control Device
MSD Bit 8 Output	D0	39	To Control Device
LSD Bit 7 Output	C7	22	To Control Device
LSD Bit 6 Output	C6	23	To Control Device
LSD Bit 5 Output	C5	24	To Control Device
LSD Bit 4 Output	C4	25	To Control Device
LSD Bit 3 Output	C3	50	To Control Device
LSD Bit 2 Output	C2	49	To Control Device
LSD Bit 1 Output	C1	48	To Control Device
LSD Bit 0 Output	C0	47	To Control Device

reflected by Data Input Ready Indicator, IQ or $\overline{\text{IQ}}$. The Data Ready Indicator, DQ, is at a low level when the DMM is ready to accept data (prior to T9). (Conversely, $\overline{\text{DQ}}$ is at a high level to reflect this condition.) With this indicating ready, data on data lines I0-I7 and S0-S7 if appropriate, can be strobed into the data latches. This is done by a low to high transition on ILAT and SLAT as appropriate (T4). (S0-S7 and SLAT are only used for 16 bit mode input operations.)

607-33. The Data Input Ready Indicator must be toggled to reflect that the interface is no longer able to accept data. ISLE and SLS are used to toggle Data Input Ready. The logical NAND of ISLE and SLS is formed. This signal is termed $\overline{\text{CIS}}$. With both ISLE and SLS in a high state, the high to low transition of SLS toggles the Indicator (T7). $\overline{\text{CIS}}$ is low with both ISLE and SLS high. The high to low transition of SLS causes a low to high transition on $\overline{\text{CIS}}$ (T8), toggling the Data Input Ready Indicator (T9). $\overline{\text{CIS}}$ must remain high until the input cycle is complete. This means that both ISLE and SLS must not be high simultaneously. again until the completion of the input cycle (T12).

607-34. To initiate processing of the data from the interface into the DMM, a low going pulse must be placed on $\overline{\text{INT}}$. Its trailing edge initiates the activity (T13). $\overline{\text{INT}}$ must not again make a low to high transition until the subsequent input transaction.

607-35. Following the $\overline{\text{INT}}$ signal, the DMM is processing the data from its interface. When it has completed this processing, it will toggle the Data Input Ready Indicator (T12). When this has occurred, the DMM input operation is complete. Additional data may now be transferred to the interface from the external device as necessary.

607-36. Detailed Output Processes Description

607-37. For a graphical representation of the signal timing relationships, refer to Figure 607-4 and Table 607-5. An output cycle is started by the DMM indicating that its interface contains data to be transferred to the external device. This is shown by the Data Output Ready Indicator, DQ or $\overline{\text{DQ}}$. DQ is at a low level and $\overline{\text{DQ}}$ is at a high level when output data is available from the DMM (prior to T2).

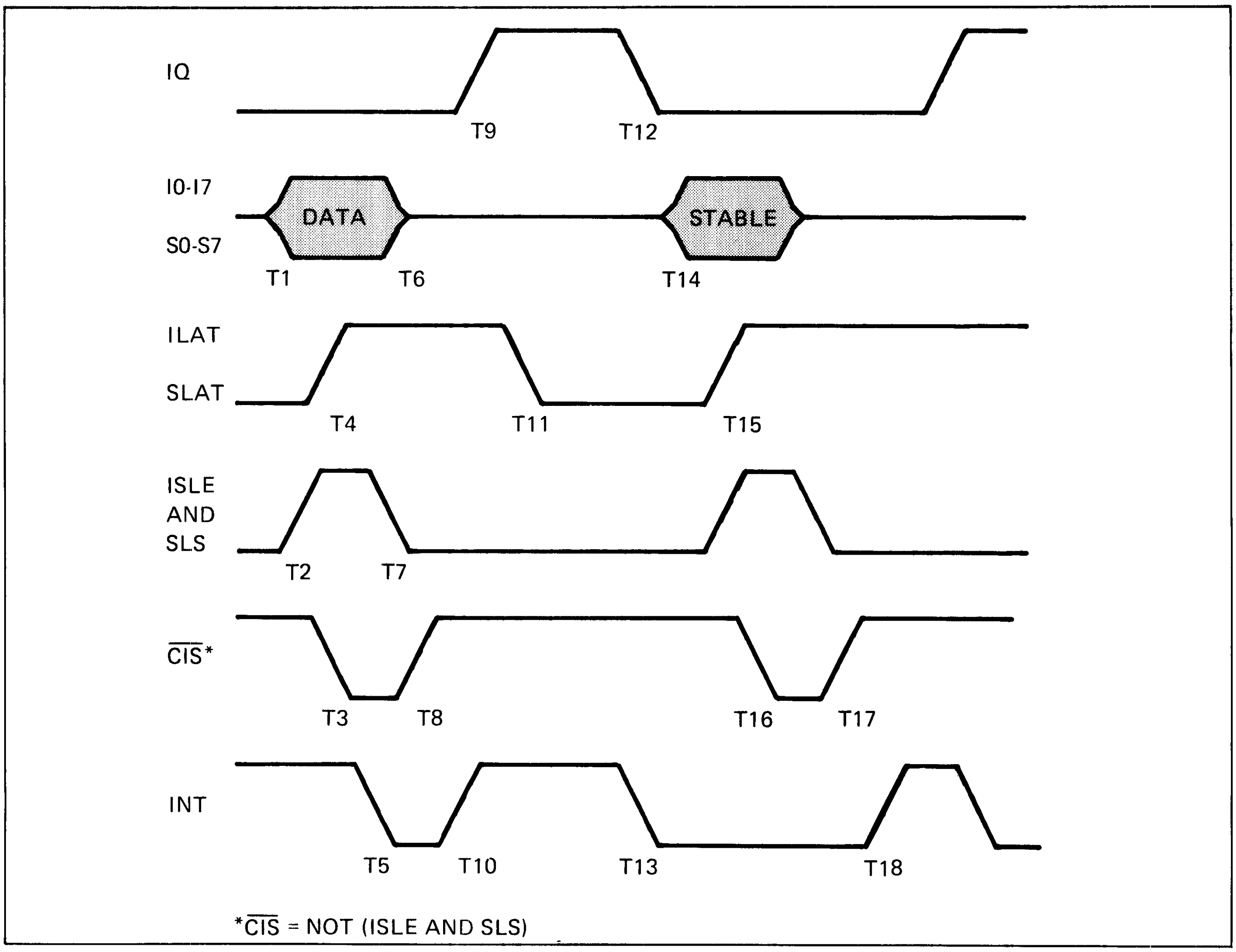


Figure 607-3. Interface Input Control Signal Timing Diagram

Table 607-4. Input Timing Parameters

T_1-T_4	5 ns	Data set up time preceding SLAT or ILAT low to high transition
T_4-T_6	3 ns	Data hold time following SLAT or ILAT low to high transition
T_{12}-T_{14}	0 ns	Minimum wait time following the ready transition of IQ or $\overline{IQ}$ before new data can be placed on data lines
T_4-T_{11}	10 ns	Minimum time SLAT or ILAT can be high
T_{11}-T_{15}	3 ns	Minimum time SLAT or ILAT can be low
T_3-T_8	250 ns	Maximum time from when ISLE and SLS both become high to the high to low transition of $\overline{CIS}$
T_7-T_8	250 ns	Maximum time from when either ISLE or SLS become low to when $\overline{CIS}$ becomes high
T_8-T_9	300 ns	Time for the low to high transition of CIS to toggle IQ or $\overline{IQ}$
T_{16}-T_{17}	15 ns	Minimum time $\overline{CIS}$ may be low
T_{12}-T_{16}	0 ns	Minimum wait time following the ready transition of IQ until $\overline{CIS}$ may enter a low condition
T_5-T_{10}	500 ns	Minimum time for $\overline{INT}$ to remain low preceding the low to high transition
T_{10}-T_{12}	500 ns	Typical time for IQ or $\overline{IQ}$ to respond to $\overline{INT}$ transition (8 bit mode)
	920 ns	Typical time for IQ or $\overline{IQ}$ to respond to $\overline{INT}$ transition (16 bit mode)
T_{10}-T_{13}	500 ns	Minimum time $\overline{INT}$ must remain high
T_{17}-T_{18}	0 ns	Minimum wait time following the $\overline{CIS}$ transition before the $\overline{INT}$ transition

607-38. At this point, data is stored in latches on the -07 interface (T3). For this data to be on data lines C0-C7 and D0-D7 if appropriate, the output driver circuitry must be enabled. A low level on COEN enables the data line drivers on C0-C7. Similarly, a low level on DOEN enables data line drivers on D0-D7. D0-D7 need only to be enabled when data is transferred in the two byte, 16 bit format. A high level on either of these enable lines disables the tri-state drive circuitry and presents a high impedance to the appropriate data lines from the interface.

Table 607-5. Output Timing Parameters

T_1-T_3	40 ns	Minimum enabling time for data line driving circuitry
T_{10}-T_{11}	30 ns	Minimum disabling time for data line driving circuitry
T_2-T_3	1170 ns	Minimum time from data ready transition until valid data
T_2-T_4	0 ns	Minimum time following ready transition until start of ready toggle pulse
T_4-T_5	250 ns	Maximum time from when both CLR and OSLE become high until $\overline{DQTGL}$ makes a high to low transition
T_6-T_7	250 ns	Maximum time for $\overline{DQTGL}$ to make a low to high transition following either CLR or OSLE becoming high
T_5-T_7	15 ns	Minimum ready toggle pulse time
T_7-T_8	315 ns	Time to toggle the ready indicator following the toggle pulse
T_8-T_9	1 us	Time following ready indicator toggle before data is not valid

607-39. With the acceptance of the data from the interface, the external device must toggle the Data Output Ready Indicator. This indicates that the output cycle is complete. Subsequent operations may then proceed (such as another output cycle, another measurement, subsequent command processing, etc.). To toggle the Data Output Ready Indicator, OSLE and CLR are used. OSLE and CLR are NANDed together to generate the signal which toggles the Data Output Ready Indicator. (This combined signal is termed $\overline{DQTGL}$ in the timing diagram.) A rising edge on this signal toggles the indicator (T7). From the completion of the previous output cycle, OSLE and CLR cannot both be at a high level simultaneously. One or the other or both must be low at all times. To toggle the indicator, both OSLE and CLR should be at or change to a high state (T4), and then CLR should make a high to low transition (T6). The Output Data Ready Indicator toggles (T8) and completes the output cycle.

607-40. TROUBLESHOOTING

607-41. Troubleshooting the Parallel Interface requires an external control device with a parallel I/O, such as a PDP 11 with the DR11C Interface. When a problem is isolated to the Parallel Interface, it is recommended that the faulty unit be sent to the nearest service center for repair. Table 607-6 additionally provides a tabular flow chart approach to troubleshooting. When a step on the flow chart is completed, check for a decision transfer. If no decision is required, perform the next step in sequence.

607-42. PROGRAMMING INSTRUCTIONS

607-43. Programming command instructions are provided in Table 607-7. For the 8505A and 8506A, refer to Section 2A.

607-44. PARTS LIST

607-45. Table 607-7 gives a parts breakdown for the Parallel Interface. Refer to Section 5 of this manual for ordering information.

CAUTION

Indicated devices are subject to damage by static discharge.

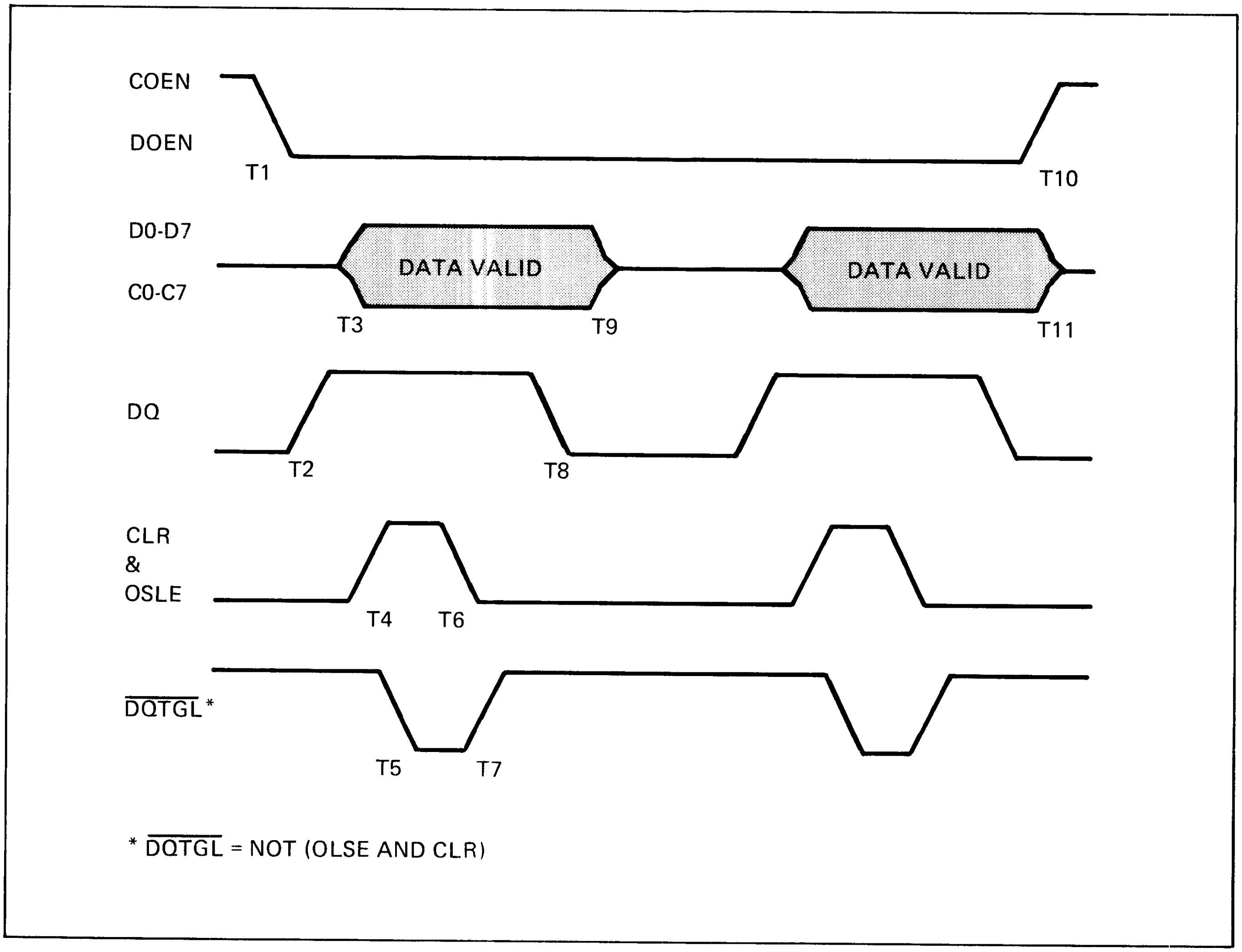


Figure 607-4. Interface Output Control Signal Timing Diagram

Table 607-6. Troubleshooting

STEP NO.	ACTION	Go to the step number given for correct response YES	NO
1	This troubleshooting procedure is based on the assumption that the instrument has been checked in local and found to be operational in all aspects prior to installation of the Parallel Interface.		
2	Install the Parallel Interface in the instrument and apply power from the front panel switch.		
3	Is the display blank?	4	6
4	Check for an address (IC) line held low. Check the address decoders.		
5	Check for the ACK line held high. Check the ACK circuitry. Repair as required and return to step 2.		
6	Is the wrong option configuration displayed at power on or reset?	7	8
7	Check for an address (IC) line held high. Check the address decoder. Repair as required and return to step 2.		
8	Is the display incorrect or garbled?	9	10
9	Check for an ID line held high or low. Check the input latch, output buffer, and INT set flip-flop.		
10	Instruct the instrument to go to remote by inputting a valid program character. Does the instrument go to remote?	12	11
11	Check the input strobe (CIS) J2-34; check for the INT circuit not being set (U30,19); check for the INT from the input strobe (J2-21).		
12	Select a mode from remote. Is the right mode selected?	14	13
13	Check the input data latches or buffers. Check the data strobe at J2-22, -12.		
14	Check the response data. Is there any, or is it correct?	16	15
15	Check the ready (COR) line. Check the output strobe (COS). Check the output latches or buffer.		
16	Is the response only a single byte of data?	17	18
17	Check the status flip-flops (U28, U29) for reset.		
18	Is the ready line hung?	18	19
19	Check for incorrect data out or bad input data.		
20	If there is no input, check for a bad input ready (CIR).		
21	Troubleshooting of the Parallel Interface as applicable at this level, is complete.		

Table 607-7. Parallel Interface PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
-07⊗	PARALLEL INTERFACE PCB ASSEMBLY FIGURE 607-5 (MIS-4175T)	ORDER	BY	OPTION -07			
C1	CAP, TA, 5.6 UF +/-20%, 25V	368969	56289	196D565X0025KA1	1		
C2	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	1		
C3	CAP, MICA, 100 PF +/-1%, 500V	226126	72136	DM15F101F	1		
C4	CAP, MICA, 390 PF +/-5%, 500V	148437	72136	DM15F391J	1		
C5	CAP, CER, 560 PF +/-10%, 600V	106203	72982	801-00-X5R0-561K	1		
C6-C12	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	7		
H1	SCREW, PHP, 4-40 X 1/4	129890	73734	19022	2		
H2	SCREW, PHP, 4-40 X 3/8	256164	89536	256164	1		
H3	WASHER, INT/LK #4	110403	73734	99402	2		
H4	SCREW, FHP, 6-32 X 1/4 (not shown)	320093	89536	320093	2		
J2	CONNECTOR, SOCKET, 20 PIN	447110	89536	447110	2		
MP1	CASE ASSY (INCLUDES MP2-MP8)	458950	89536	458950	1		
MP2	CASE, HALF	402990	89536	402990	REF		
MP3	CASE HALF, MODULE	427625	89536	427625	REF		
MP4	COVER, MODULE CASE	402974	89536	402974	REF		
MP5	SHIELD, COVER	411991	89536	411991	REF		
MP6	DECAL, PARALLEL INTERFACE	413500	89536	413500	REF		
MP7	DECAL, CAUTION	454504	89536	454504	REF		
MP8	GUARD, REAR	383364	89536	383364	REF		
MP9	LATCH	412700	13511	57-1001	2		
MP10	SPRING, COIL	424465	83553	C0120-014-0380	1		
	(not shown)						
MP11	SPRING, CONNECTOR	412718	71785	436-99-22-205	2		
MP12	SHIELD, FRONT (not shown)	383372	89536	383372	1		
MP13	SPACER, SWAGED	312421	89536	312421	2		
MP14	SPACER, SWAGED	335604	89536	335604	3		
P1	CONNECTOR, CABLE, 50-PIN, MODIFIED	413138	13511	57-20500-31	1		
Q1	XSTR, SI, PNP	226290	04713	MPS3640	1	1	
R1	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	2		
R2	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	2		
R3	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R4	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	1		
R5	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R6	RES, DEP. CAR, 2K +/-5%, 1/4W	441469	80031	CR251-4-5P2K	1		
R7	RES, DEP CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	1		
RN1-RN4⊗	RESISTOR NETWORK, 4.7K, 8-PINS	412916	89536	412916	4		
U1	IC, TTL, 2-INPUT POS OR GATE	393108	01295	SN74LS32N	1	1	
U2	IC, TTL, POS NAND GATES	292979	01295	SN7404N	1	1	
U3	IC, TTL, LO-PWR SCHOTTKY	393215	01295	SN74S175N	4	1	
U4-U6	IC, TTL, TRISTATE, HEX BUFFERS	408765	01295	SN74367N	3	1	
U7	IC, TTL, LO-PWR SCHOTTKY	393215	01295	SN74S175N	REF		
U8⊗	IC, C-MOS, HEX INVERTER/BUFFER	381848	02735	CD4049AE	1	1	
U9, U10⊗	IC, C-MOS, HEX INVERTER/BUFFER	381830	02735	CD4050AE	2	1	
U11⊗	IC, LO-PWR SCHOTTKY	404186	01295	SN74LS123N	1	1	
U12⊗	IC, MOS, TRISTATE HEX BUFFER	407759	12040	MM80C97N	4	1	

Table 607-8. Parallel Interface PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
U13	IC, TTL, LO-PWR SCHOTTKY	393215	01295	SN74S175N	REF		
U14	IC, TTL, LO-PWR SCHOTTKY	393215	01295	SN74S175N	REF		
U15-U17⊗	IC, COS/MOS, QUAD, CLOCKED D LATCH	355149	02735	CD4042AE	4	1	
U18⊗	IC, TTL, QUAD, 2-INPUT POS NAND GATE	393033	01295	SN74LSOON	1	1	
U19⊗	IC, C-MOS, QUAD, 2-INPUT, AND GATE	408401	02735	CD4081BE	2	1	
U20-U22⊗	IC, MOS, TRISTATE HEX BUFFER	407759	12040	MM80C97N	REF		
U23⊗	IC, C-MOS, QUAD, 2-INPUT NAND GATES	355198	02735	CD4011AE	1	1	
U24, U25⊗	IC, C-MOS, TRPL, 3-INPUT NAND GATE	375147	02735	CD4023AE	2	1	
U26⊗	IC, COS/MOS, QUAD, CLOCKED D LATCH	355149	02735	CD4042AE	REF		
U27⊗	IC, C-MOS, QUAD, 2-INPUT, AND GATE	408401	02735	CD4081BE	REF		
U28, U29	IC, LO-PWR SCHOTTKY	393124	01295	SN74LS74N	2	1	
U30⊗	IC, C-MOS, DUAL TYPE "D" FLIP-FLOP	340117	02735	CD4013AE	1	1	
U31⊗	IC, C-MOS, TRIPLE 3-INPUT, AND GATE	408807	02735	CD4073B	1	1	
	07A, DR11-C, LN1 PERSONALITY CARD PCB ASSY (MIS-4062) (NOT SHOWN)	523043	89536	523043			
CR1	DIODE, SI, HIGH-SPEED SWITCHING	203323	07910	1N4448	4	1	
CR2	DIODE, SI, HIGH-SPEED SWITCHING	203323	07910	1N4448	REF		
CR3	DIODE, SI, HIGH-SPEED SWITCHING	203323	07910	1N4448	REF		
CR4	DIODE, SI, HIGH-SPEED SWITCHING	203323	07910	1N4448	REF		
MP1	CONNECTOR, POST	267500	00779	87022-1	40		
R1	RES, COMP, 4.7K +/-5%, 1/4W	148072	01121	CB4725	1		
	07B, DR11-C, HN1 PERSONALITY CARD PCB ASSY (MIS-4063) (NOT SHOWN)	523068	00779	87022-1	40		
	PC11 PERSONALITY CARD PCB ASSY (MIS-4069) (NOT SHOWN)	449447	89536	449447			
	SFH PERSONALITY CARD PCB ASSY (MIS-4070) (NOT SHOWN)	449454	89536	449454			
	07D, GP PERSONALITY CARD PCB ASSY (MIS-4071) (NOT SHOWN)	449462	89536	449462			
CR1	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	4	1	
CR2	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR3	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR4	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
MP1	CONNECTOR, POST	267500	00779	87022-1	40		
	07H, HP PERSONALITY CARD PCB ASSEMBLY (MIS-4067T) (NOT SHOWN)	476218	89536	476218	1		
C1	CAP, CER, 0.01 UF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	1		
C2	CAP, MICA, 100 PF +/-5%, 500V	148494	72136	DM15F101J	1		
R1	RES, DEP. CAR, 330 +/-5%, 1/4W	368720	80031	CR251-4-5P330E	2		
R2	RES, DEP. CAR, 220 +/-5%, 1/4W	342626	80031	CR251-4-5P220E	2		
R3	RES, DEP. CAR, 330 +/-5%, 1/4W	368720	80031	CR251-4-5P330E	REF		
R4	RES, DEP. CAR, 220 +/-5%, 1/4W	342626	80031	CR251-4-5P220E	REF		
R5	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	1		
U1	IC, TTL, QUAD, 2-INPUT, POS AND GATES	393066	01295	SN74LS08	1	1	
U2	IC, TTL, LO-PWR SCHTKY MNSTB MULTVBRS	404186	01295	SN74LS123N	1	1	

THE DR11-C/HN1, PC11, SFH, AND GP PERSONALITY CARDS HAVE THE SAME COMPONENT PARTS.

1 ORDER P/N 458950 FOR COMPLETE MODULE CASE ASSY., WITHOUT PCB ASSY.

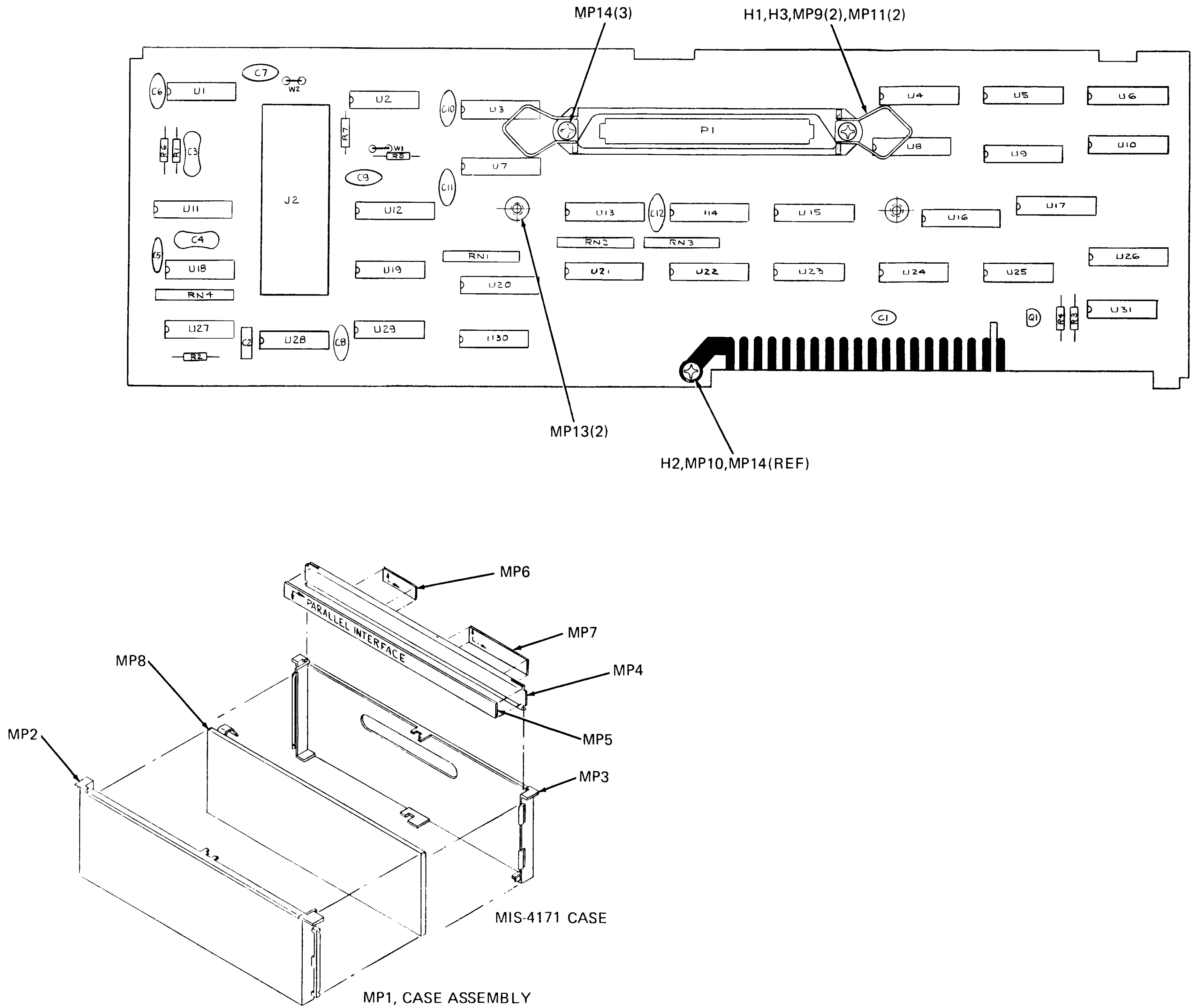


Figure 607-5. Parallel Interface PCB Assembly

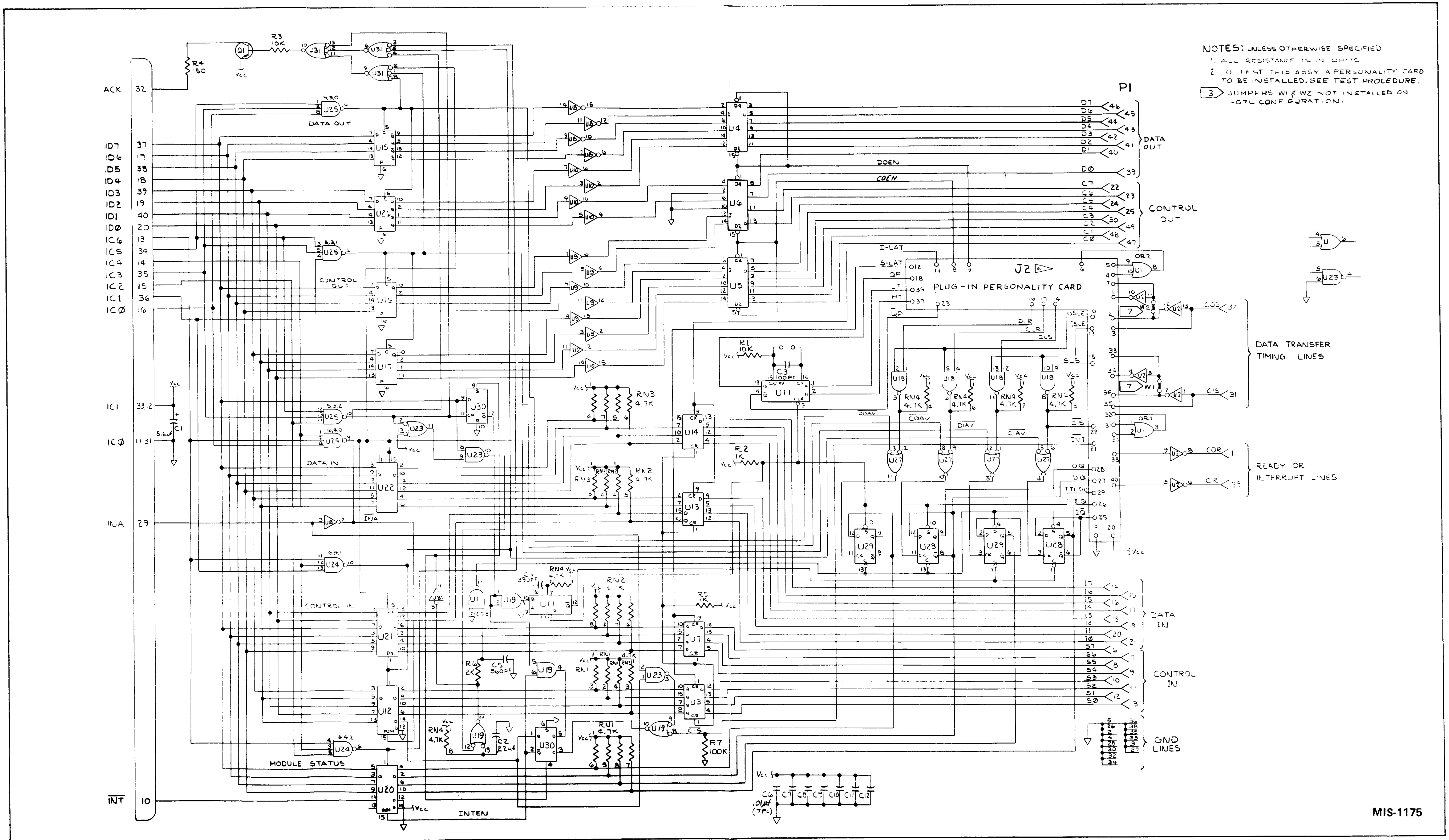
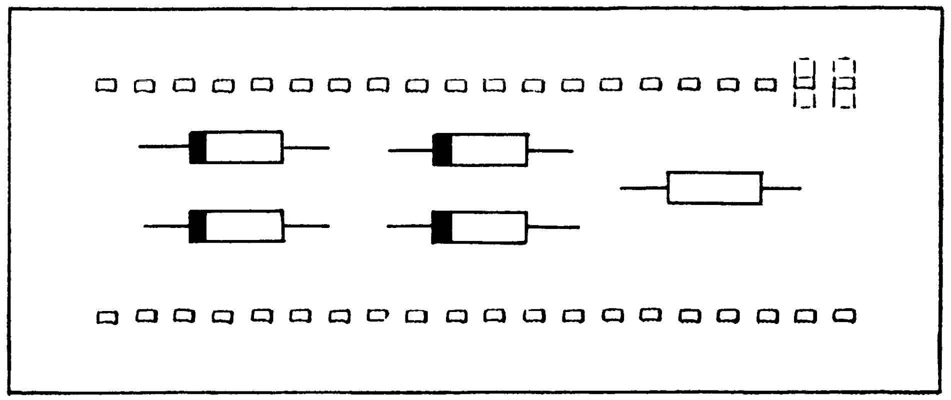
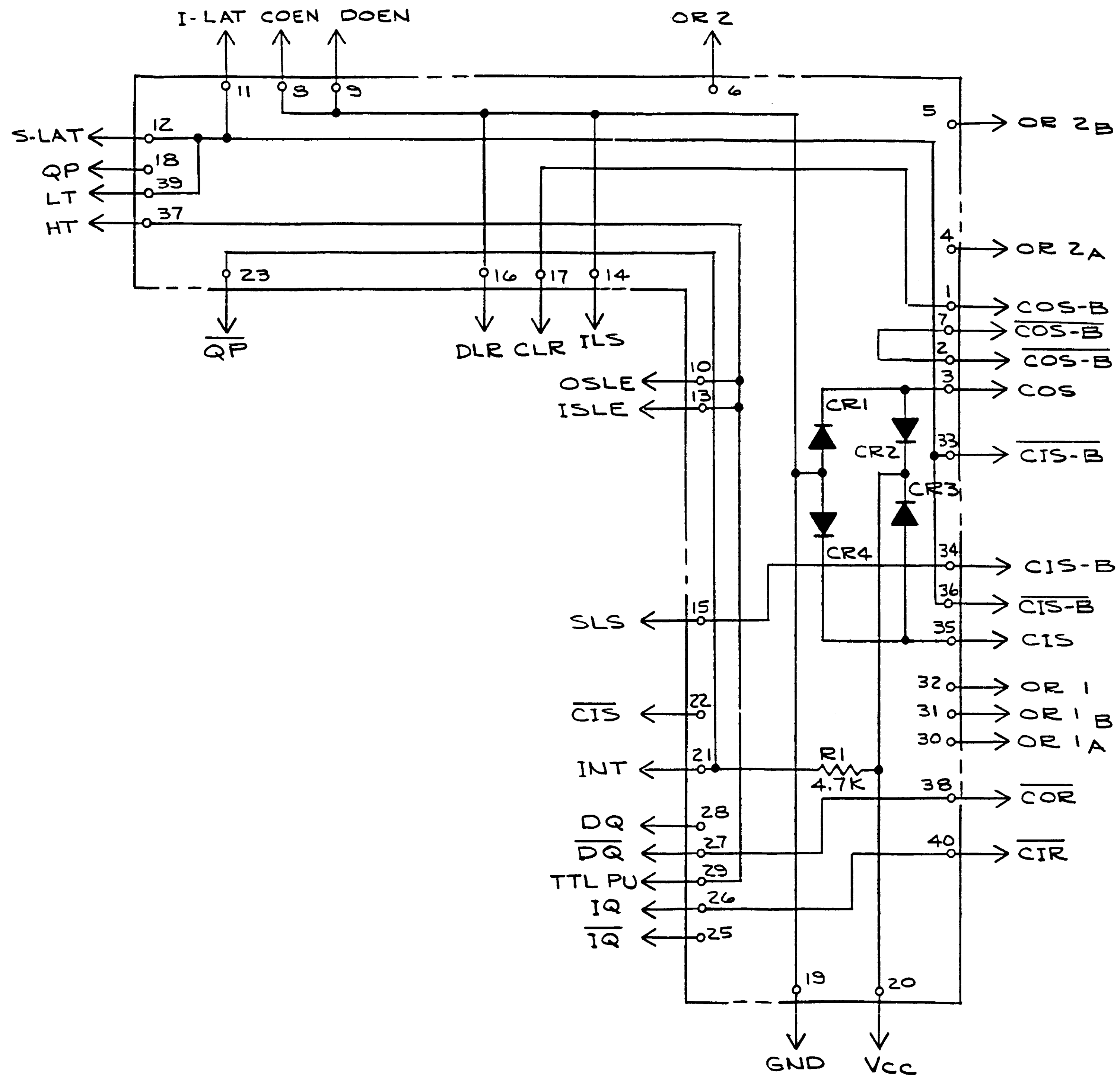


Figure 607-5. Parallel Interface PCB Assembly (cont)

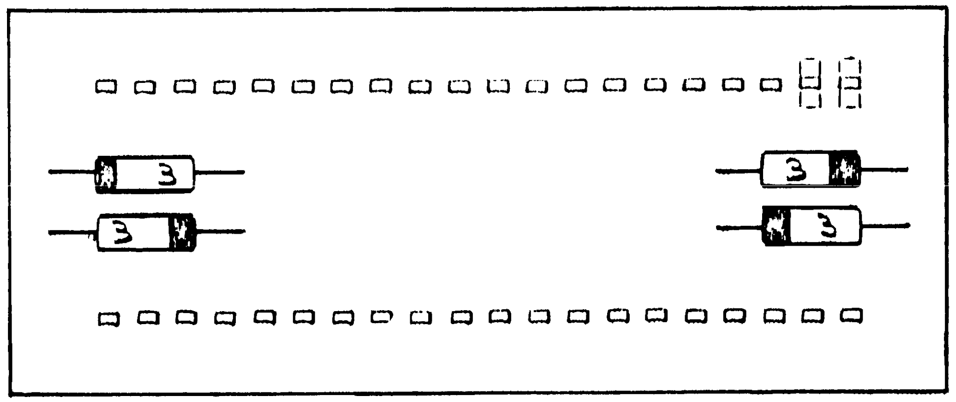


MIS 4 MIS-4062



MIS-1062

Figure 607-6. –07A Personality Card PCB Assembly



MIS-4069

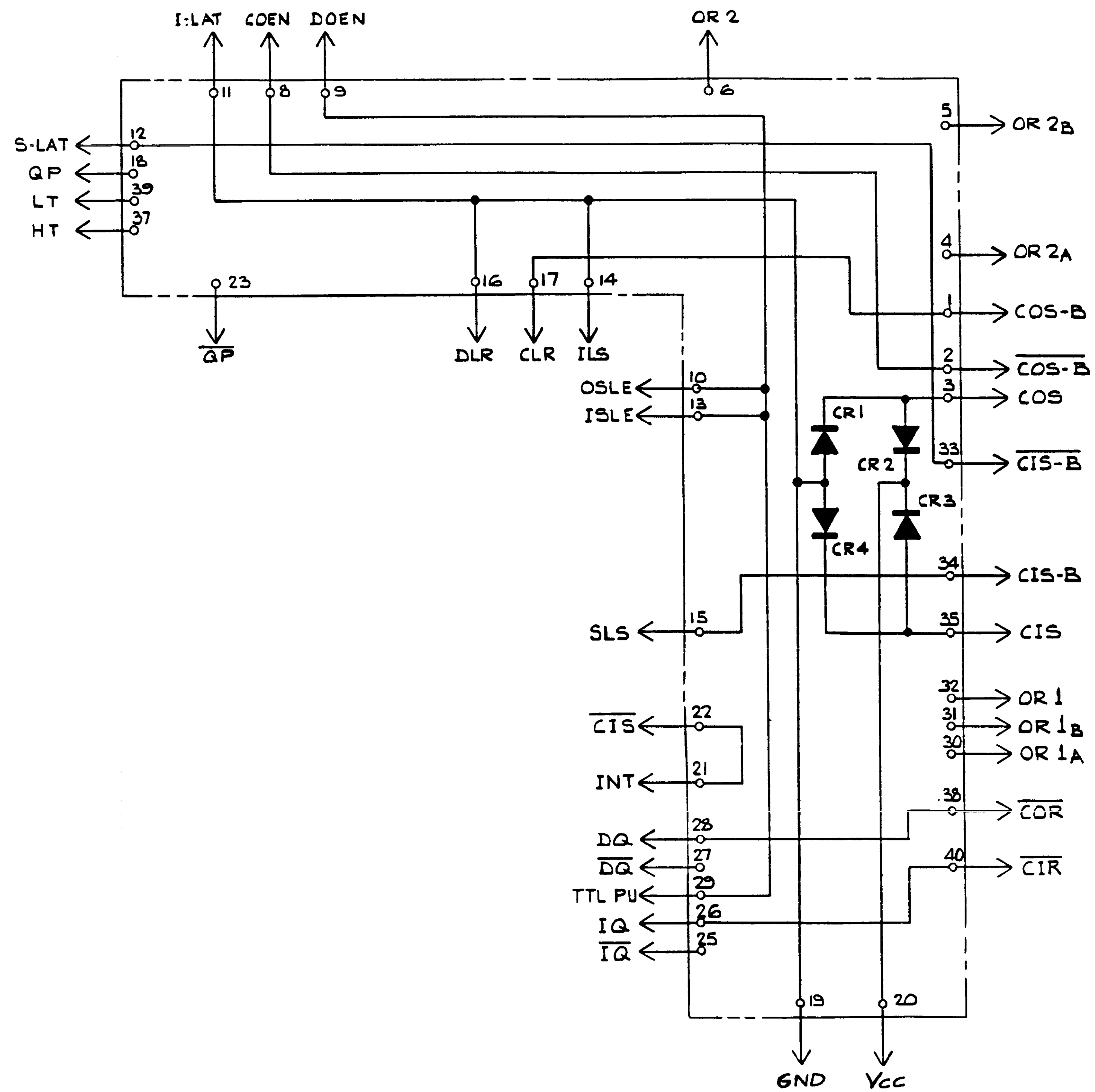


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Figure 607-7. —07B Personality Card PCB Assembly

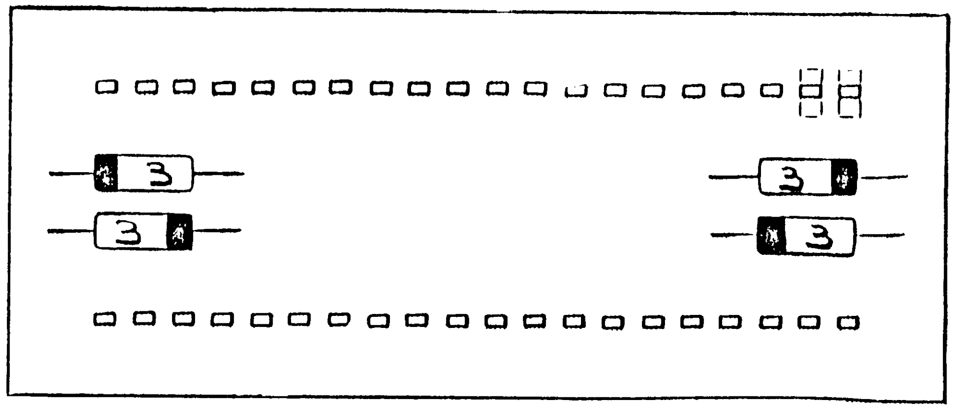
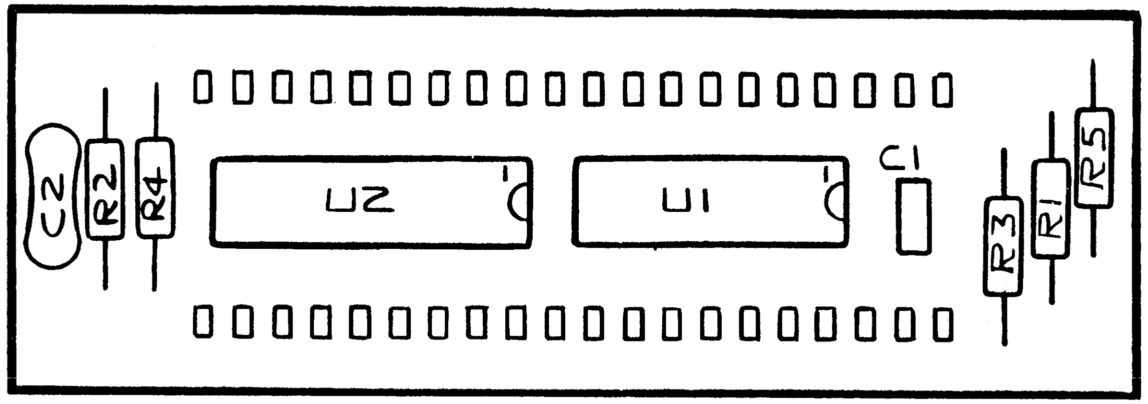
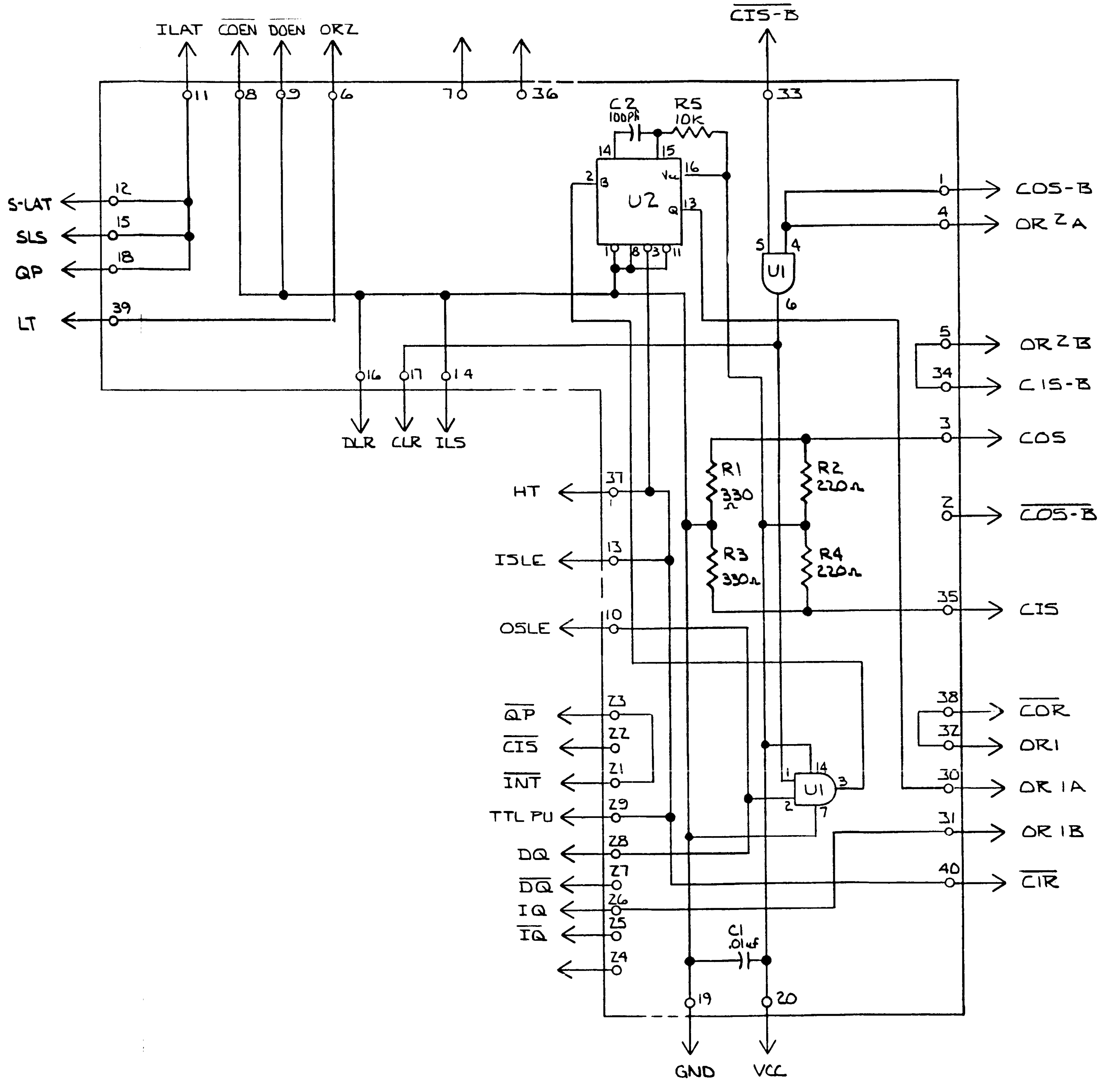


Figure 607-8. –07D Personality Card PCB Assembly



MIS-1767



MIS-1067

Figure 607-9. –07H Personality Card PCB Assembly

A3 Isolator Assembly (External Trigger)

608-1. INTRODUCTION

The Isolator maintains the guarded nature of the analog bus by isolating the analog signal processing and converting circuitry from the digital processing, control, display, and input/output circuits. The following description pertains to the Isolator only. The Isolator provides the capability for external triggering of the Digital Multimeter (DMM). The 8500A DMM does not have provision for external triggering and consequently cannot make use of the external trigger capability.

608-2. SPECIFICATIONS

608-3. Input

The trigger input is factory-wired for a high level of 4.3V (minimum) and a low level of 0.7V (maximum); pulse width should be greater than 10 µs. Common will be the same as interface logic common.

The outer connector for external triggering is at interface common. There should be no more than 10V between the outer connector and earth ground.

608-4. Trigger Processing Time

The time between trigger edge and first A/D conversion (not including filter timeouts or programmed delays) is:

1. Non-line synchronous mode, .8 to .9 ms
2. Line synchronous mode, 1 to 6 ms
3. High speed mode (Option -05 or -07 installed), 114 ±.5 µs

608-5. OPERATING NOTES

The External Triggering mode may be activated locally from the front panel or through remote interfacing commands.

608-6. Local Operation

The External Triggering mode may be enabled from the DMM's front panel. To activate this mode, press TRIGGER. The SAMPLE LED will now stop flashing to denote that both External Triggering and Manual Triggering modes are in effect. Apply a negative going TTL level pulse to the external trigger input connector located on the rear panel. The SAMPLE LED will now flash once for each trigger received.

The following considerations apply when External Triggering mode is in use:

1. A manual trigger attempted from the front panel will take precedence over an external trigger. If manual TRIGGER is pressed while a reading is in progress, the reading will be aborted and a new one started.
2. All other front panel switch applications will abort the reading in progress. A new reading will not start until another trigger is received; the numeric display will not update until the new reading is complete.

608-7. Remote Operation

External Triggering can be enabled and controlled remotely when a remote interface (Option -05, -06, or -07) are installed. The command characters in Table 608-1 can be used from the remote.

608-8. Trigger Polarity

Either positive or negative going external triggers may be accepted by the Isolator; factory settings will be for negative triggers. Separate jumper wire arrangements are employed for negative and positive triggers. Refer to Figure 608-1 for the location of jumper terminals on the Isolator. To change the jumper arrangement, use the following procedure;

1. On the DMM, press POWER OFF and disconnect the line cord.
2. Remove the Isolator.
3. Observe Static Sensitive device precautions listed in Section 4 of the Instruction Manual. Avoid touching connector terminals on the Isolator.

Table 608-1. Remote Commands

Ext. Trigger Commands	
Q1	Ext. Trigger - Interrupt when ready
Q1	Ext. Trigger and Transmit Reading
Q2	Disable Ext. Trigger
External Trigger Delay Commands	
W	No Delay
W0	2.083 ms
W1	4.166 ms
W2	8.332 ms
W3	16.66 ms
W4	33.33 ms
W5	66.66 ms
W6	133.3 ms
W7	266.6 ms
W8	533.2 ms
W9	1.066 s
W10	2.133 s
W11	4.266 s
W12	8.532 s
W13	17.06 s
W14	34.13 s
W15	68.26 s

4. Remove the Guard Covers from the Isolator using techniques outlined in Section 4 of the Instruction Manual (Module Assembly and Disassembly).
5. For negative going triggers, there will be a jumper between point 1 and point 4 to Schmitt Trigger U35.
6. For positive going triggers, remove the jumper between points 1 and 4 and jumper point 1 to 2 and point 3 to 4.
7. Reassemble the module, replace in DMM.

608-9. THEORY OF OPERATION

The Isolator accepts parallel data and address bytes, shifts them to serial format for transfer across isolation transformers, and converts them back to parallel format. Seven address (IC) and eight data (ID) lines are used. Lines IC5 and IC6 are always low. The Controller can send data to any addressed module; the A/D Converter will be the only analog module that sends data back to the Controller (bit serial data stream on ID7). Refer to the Isolator Schematic (Figure 608-3) and the Functional Block Diagram (Figure 608-2) for the following circuit descriptions.

NOTE

Vcc and Vss in the unguarded digital bus are isolated from analog common.

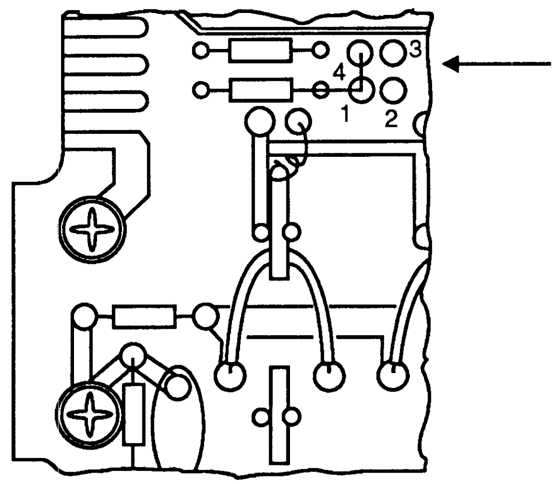


Figure 608-1. Trigger Polarity Connections

The description given in this paragraph will detail how data (ID0-ID7) and address (IC0-IC4) levels on the unguarded digital bus are loaded into shift registers (U3 and U7) in the Isolator. Inputs on address lines (IC0-4) for either direct or indirect addresses are applied through inverters to shift register U7. Inputs on data lines (ID0-7) are applied to U7 (ID0, ID1) and U3 (ID2-7). A low on U14-12 will clock both address and data levels into the shift registers; the relaxation oscillator made up of U9-6 and U9-8 will be disabled by this same low during the load time. Monostable multivibrator U14-12 is clocked by a low going signal on U10-12. Two inputs to U10-12 will always be high (IC5, IC6 will always be low and are inverted). The third input will be a high from U10-8, which is enabled with any direct address on IC0-4 (IC0, 3, or 4 will have at least one high). The length of the load time will be determined by R2 and C2.

At the end of the load time, relaxation oscillator U9-6 and U9-8 will be enabled, and data will be serially shifted out of registers U3 and U7, across isolation transformers T1 and T2, and into registers U20 and U16. Oscillator pulses from U11-10 and U11-13 clock serial data out of U3 and U7, and into U20 and U16. When this data transfer is complete, U19-10 will go high to enable address gates U22 and U26-4 and disable loading clock pulses to U20 and U16. Parallel data will then be applied through output

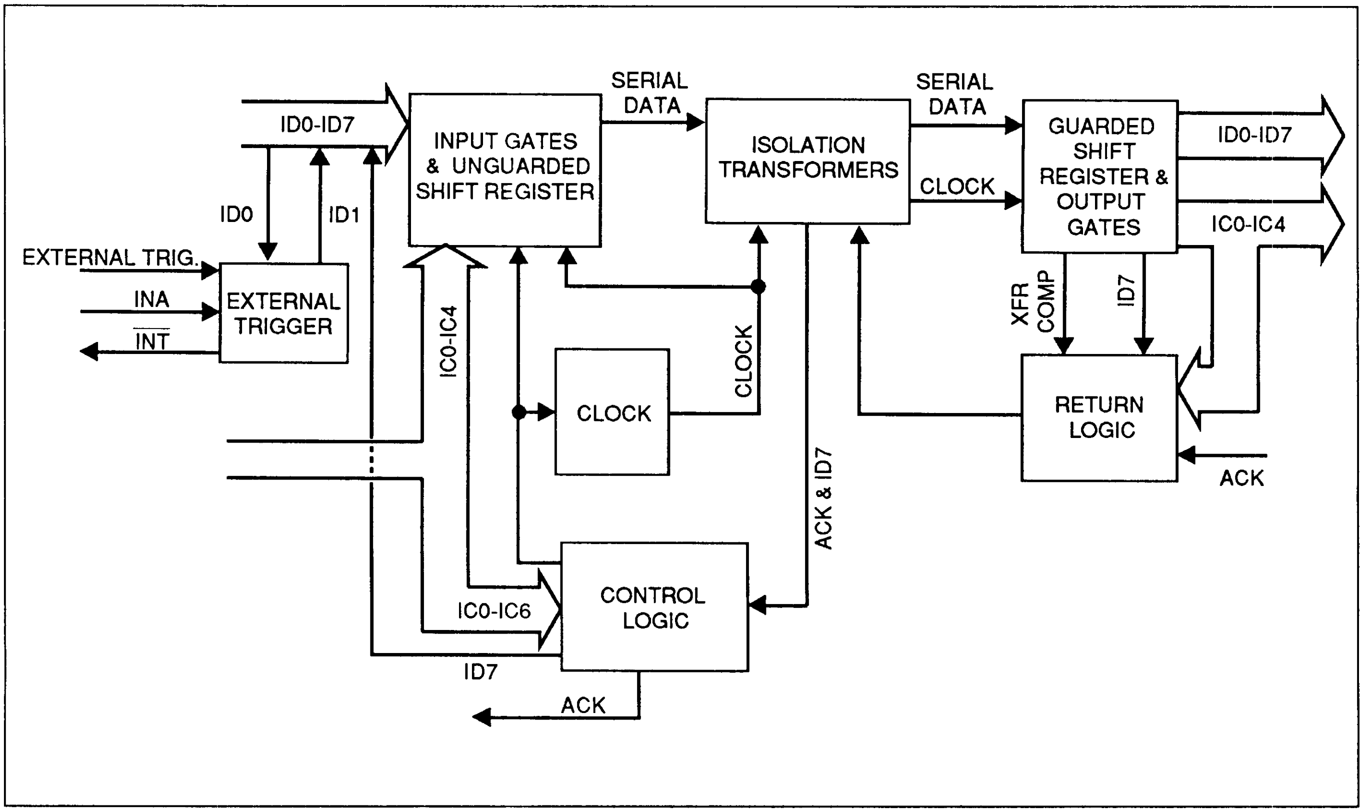


Figure 608-2. Isolator Block Diagram

buffers to ID0-7 on the guarded analog bus. Parallel address levels will be applied through the enabled address gates to address lines IC0-4 on the guarded analog bus.

The clock pulse for U9-6 and U9-8 is disabled during the load period (U14-12 low). When clock pulses cease from U24-4, retriggerable monostable multivibrator U23-13 places a low on U20-9 and U16-9 to clear any previously latched data.

An acknowledge (ACK) signal is transferred from the guarded analog bus to the unguarded digital bus by way of an isolation transformer. A low at U23-12 will enable U19-1 whenever an ACK is returned. With U19-1 high, a clock pulse from U24-4 and U24-12 is applied through U15-3, U15-6, T8 and T7. This pulse then clocks U8-2, resulting in an ACK signal out on U8-13.

In order to obtain a data bit return on ID7, the indirect address is used in three ways. First, the address (IC1, IC2 high) is sent to the A/D Converter through the Isolator's shift register system. The address will also be used to enable U9-11 on the unguarded side of the Isolator. Thirdly, on the Isolator's guarded side, IC1 and IC2 high will enable address decoders U18-4 and U25-9. With U18-3 consequently high, tri-state device U21-13 is placed in the high impedance mode. A path is now enabled for ID7 levels from the guarded analog bus to be transferred back to the unguarded digital bus. For instance, with a high on U19-5, ID7 high will enable U19-4. Clock pulses from U24-4 and U19-4 high enable U15-11 and U15-8. While U9-11 enables U13-9, U8-5 clocked high places ID7 high on the unguarded digital bus.

The following sequence of events takes place in the Isolator during external triggering. Dual D flipflop U31 will be enabled by a low on ID0 and high at U33-9. Address lines IC4, IC5, and IC6 must all be high for U33-9 to go low. With Vcc applied to U31-5, a positive going external trigger from U35-10 will clock U31-1 high. The network of R24 and C16 will detect Vcc at power on and disable the module's interrupt capability. The high at U31-1 set $\overline{\text{INT}}$ low and places a high at pin 12 of tri-state buffer U13. A returned high on INA then gates U13-11 high onto ID1. The controller will react to this high on ID1 by taking a reading. When data from the reading is accepted, ID0 will again go low, resetting U31 ready for the next external trigger. Triggers received prior to ID0 going low will be ignored.

608-10. TROUBLESHOOTING

Table 608-2 gives a symptom analysis routine for troubleshooting the Isolator.

608-11. PARTS LIST

Table 608-3 gives a detailed parts breakdown of the Isolator PCB Assembly . Refer to Section 5 of the Instruction Manual for ordering information.

Table 608-2. Isolator Troubleshooting

SYMPTOM	FAILURE
No Display at Power On	IC line held low U5, U12, U35
Display Bad	IC line held high U5, U12, U35 ID line held high or low U1, U2, U13
UNGUARDED SECTION	
Error 9 at Power On	Oscillator check U11-10 Shift Register U31-1, U7 Not transferring pulses U4, core winding ACK bad U9, U12, Q1, U6, U7, U2, U8
Option Configuration Wrong	Address lines hung
Can't Call Proper Ranges	Data lines hung U1, U2, U3
Constant Bad Reading Displayed	ID7 not returned U8, U13, core winding U12, U10, U9, U35, U6.
GUARDED SECTION	
Error 9 Configuration Wrong	U19-10, U16-1, U23-13 (Address Data) U25, U19, U15, U24 (ACK) U24, U23 (Address)
Can't Call Proper Ranges	U16, U21, U18
Constant Bad Reading Displayed	U18, U26, U25, U19, U15 (ID7)

Table 608-3. Isolator PCB Assembly

REFERENCE DESIGNATOR	DESCRIPTION	FLUKE STOCK NO	MFRS SPLY CODE	MANUFACTURERS PART NUMBER OR GENERIC TYPE	TOT QTY	NOTES
C 1, 4	CAP,MICA,220PF,+-5%,500V	170423	93790	CD15FD221J03	2	
C 2	CAP,CER,10PF,+-5%,100V,C0G	566042	04222	SR155A100JAT	1	
C 3	CAP,CER,33PF,+-2%,100V,C0G	513226	04222	SR151A330GAA	1	
C 5	CAP,MICA,68PF,+-5%,500V	148510	93790	CD15ED680J03	1	
C 6	CAP,TA,39UF,+-20%,6V	163915	56289	199D396X0006DA2	1	
C 7	CAP,AL,150UF,+50-10%,16V	186296	62643	SM16T151T8X18LL	1	
C 8, 9	CAP,MICA,27PF,+-5%,500V	177998	93790	CD15ED270J03	2	
C 10, 12, 13, C 16	CAP,CER,0.22UF,+-20%,50V,Z5U	309849 309849	04222	SR215E224MAA	4	
C 11	CAP,CER,0.0047UF,+-10%,500V,Z5R	106724	60705	562CX5RCK501AJ472K	1	
C 17, 18, 20	CAP,CER,0.01UF,+-20%,50V,X7R	816249	04222	SR075C103MAATR1A	3	
CR 1- 3	ϟ DIODE,SI,BV= 75.0V,IO=150MA,500MW	698720	65940	1N4448	3	
CR 4, 5	ϟ DIODE,SI,SCHOTTKY BARRIER,SMALL SIGNL	313247	28480	5082-6264 T25	2	
E 1	JUMPER,WIRE,NONINSUL,.125CTR	529719	60386	529719	1	
H 1	SCREW,PH,P,STL,4-40,.625	868138	89536	COMMERCIAL	2	
L 1	CHOKE,6TURN	320911	89536	320911	1	
MP 1, 2	SPRING,COIL,COMP,M WIRE,.380,.120	424465	83553	C0121-014-0380M	2	
MP 3	CASE ASSEMBLY, ISOLATOR (MP6-15)	873638	89536	873638	1	
MP 4, 5	SPACER,SWAGE,.250 RND,BR,4-40,.500	380519	9W423	9537B-B-0440	2	
MP 6	DECAL, ISOLATOR	881706	89536	881706	1	
MP 7, 8	CASE HALF,MODULE	402990	89536	402990	2	
MP 9	COVER,MODULE CASE	794560	89536	794560	1	
MP 10	GUARD,FRONT,ISOLATOR,LEFT	487298	89536	487298	1	
MP 11	GUARD,REAR ISOLATOR	437947	89536	437947	1	
MP 12, 13	SHIELD,COVER,ISOLATOR	437939	89536	437939	2	
MP 14	GUARD,FRONT,ISOLATOR,RIGHT	487280	89536	487280	1	
MP 15	GUARD REAR,ISOLATOR,(RIGHT)	383349	89536	383349	1	
Q 1	ϟ TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1	
Q 2	ϟ TRANSISTOR,SI,NPN,SMALL SIGNAL,TO-92	218396	04713	2N3904	1	
R 1	RES,CF,220,+-5%,0.25W	574244	59124	CF1/4 221J	1	
R 2	RES,CF,5.1K,+-5%,0.25W	573329	59124	CF1/4 512J	1	
R 3	RES,CF,47K,+-5%,0.25W	348896	59124	CF1/4 473J	1	
R 4, 7	RES,CF,4.7K,+-5%,0.25W	573311	59124	CF1/4 472J	2	
R 5, 8- 13, R 24- 26	RES,CF,10K,+-5%,0.25W	573394 573394	59124	CF1/4 103J	10	
R 6	RES,CF,1K,+-5%,0.25W	343426	59124	CF1/4 102J	1	
R 14, 20	RES,CF,150,+-5%,0.25W	343442	59124	CF1/4 151J	2	
R 15	RES,CF,470,+-5%,0.25W	573121	59124	CF1/4 471J	1	
R 17	RES,CF,1K,+-5%,0.25W	573170	59124	CF1/4 102J	1	
R 18	RES,CF,100K,+-5%,0.25W	573584	59124	CF1/4 104J	1	
R 21	RES,CF,47K,+-5%,0.25W	573527	59124	CF1/4 473J	1	
R 27	RES,CF,1.5K,+-5%,0.25W	573212	59124	CF1/4 152J	1	
T 1- 4	TORO,ISOLATOR	437608	89536	437608	4	
T 5- 8	TORO,ISOLATOR	437590	89536	437590	4	
U 1, 2, 5	ϟ IC,CMOS,HEX BUFFER	381830	04713	MC14050BCP	3	
U 3, 7	ϟ IC,TTL,8BIT PAR-IN,SER-OUT SHIFT RGS	293118	01295	SN74165N	2	
U 4, 15	ϟ IC,TTL,QUAD 2 INPUT NAND W/OPEN COL	408021	01295	SN7426N	2	
U 6, 24	ϟ IC,LSTTL,HEX INVERTER	393058	01295	SN74LS04N	2	
U 8, 14, 23	ϟ IC,LSTTL,RETRG MONOSTAB MULTIVB W/CLR	404186	01295	SN74LS123N	3	
U 9	ϟ IC,STTL,QUAD 2 INPUT NAND GATE	363580	01295	SN74S00N	1	
U 10	ϟ IC,LSTTL,TRIPLE 3 INPUT NAND GATE	393074	01295	SN74LS10N	1	
U 11, 19	ϟ IC,LSTTL,QUAD 2 INPUT NOR GATE	393041	01295	SN74LS02N	2	
U 12, 22, 26	ϟ IC,CMOS,QUAD 2 INPUT NOR GATE	355172	04713	MC14001BCP	3	
U 13, 21	ϟ IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	04713	MC14503BCP	2	
U 16, 20	ϟ IC,TTL,8BIT SER-IN,PAR-OUT R-SHFT RGS	272138	01295	SN74164 2N	2	
U 18	ϟ IC,CMOS,QUAD 2 INPUT AND GATE	408401	04713	MC14081BCP	1	
U 25	ϟ IC,CMOS,TRIPLE 3 INPUT NOR GATE	355180	04713	MC14025BCP	1	
U 31	ϟ IC,CMOS,DUAL D F/F,+EDG TRIG	340117	04713	MC14013BCP	1	
U 32	ϟ IC,CMOS,FAST QUAD 2 INPUT NAND GATE	413211	04713	MC14011BCP	1	
U 33	ϟ IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	04713	MC14023UBCP	1	
U 35	ϟ IC,CMOS,HEX SCHMITT TRIGGER	477810	27014	MM74C914N	1	
W 1	WIRE,TEF,UL1180,22AWG,SOLID,WHT	654897	04946	654897	1	
W 2	WIRE,COPPER/TIN,BUS,20AWG	212704	04946	212704	1	
Z 17	RES,CERM,DIP,16 PIN,15 RES,10K,+-5%	355305	91637	MDP16-03-103J	1	
NOTES:	ϟ Static sensitive part.					

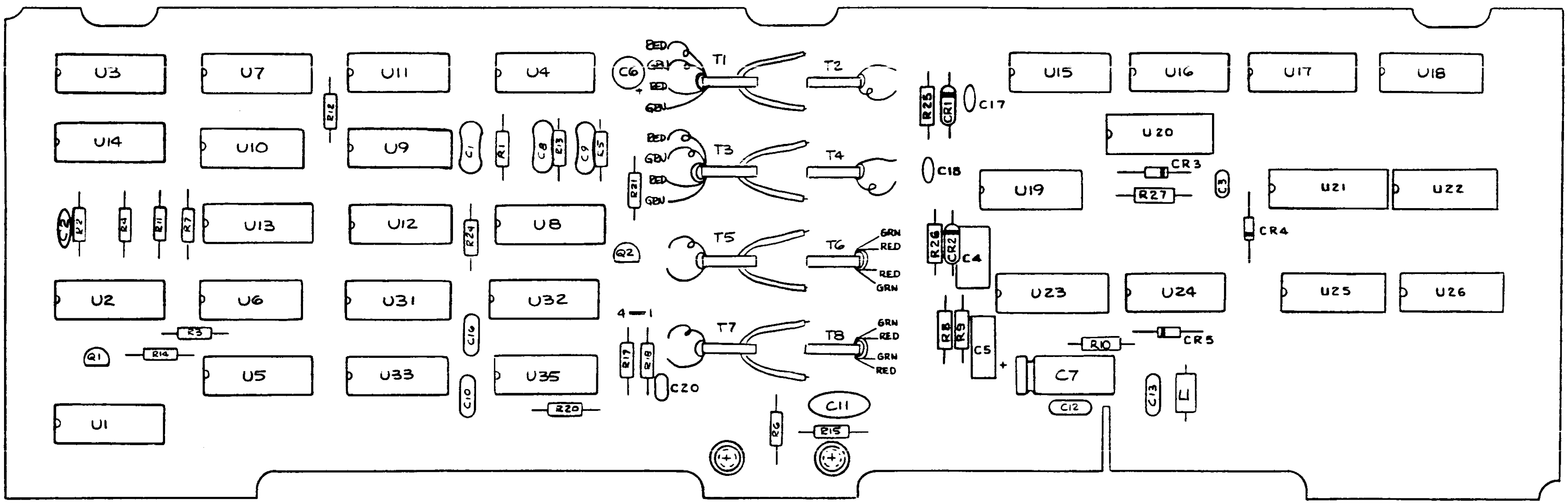


Figure 608-3. Isolator PCB Assembly

8505A-1781

UNGUARDED BUS SIDE		
I.C. NO	Vcc	Vss
U32	1, 2, 5, 6, 8, 9, 14	7
U1	1	8
U2	1, 11, 14	7, 8
U3, U7, U8, U13, U14	16	8
U4, U6, U9, U10, U11, U12, U31, U33	14	7
U5	1, 14	8
U35	1, 3, 5, 14	7

GUARDED BUS SIDE		
I.C. NO	Vcc	Vss
U15, U16, U18, U19 U20, U22, U24, U25	14	7
U21, U23	16	8
U26	8, 9, 12, 13, 14	7

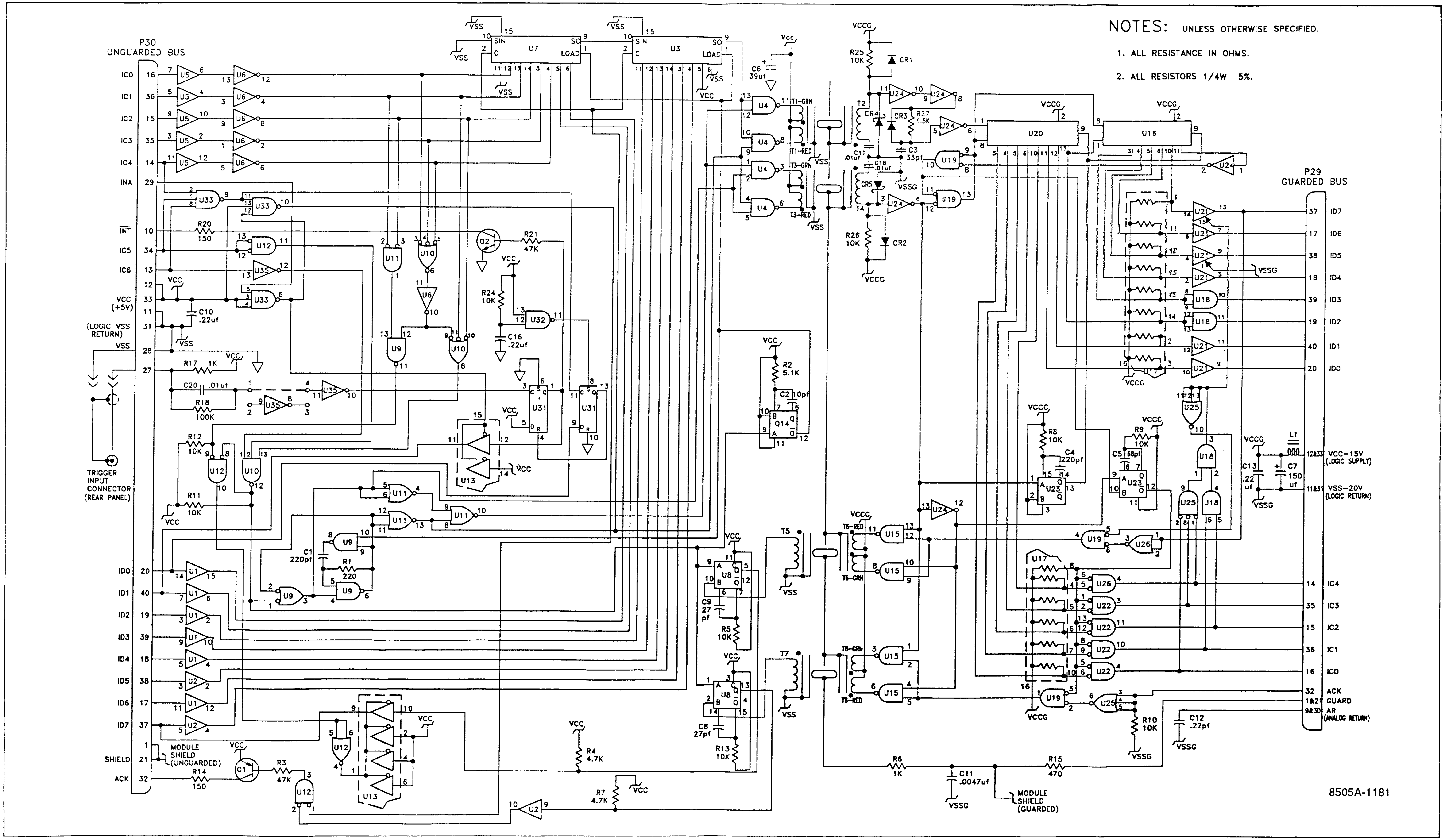


Figure 608-3. Isolator PCB Assembly (cont)

Option -09A
AC RMS Converter

609-1. INTRODUCTION

The AC RMS Converter is used to provide accurate ac or ac + dc measurements without error due to waveform distortion. Measurements up to 1000V ac in four ranges with a bandwidth of 10 Hz to 300 kHz may be made (input volt-hertz product not to exceed 2×10^7). Input impedance is 1 MΩ shunted by less than 100 pf.

609-2. SPECIFICATIONS

Table 609-1 lists the specifications for the AC RMS Converter.

609-3. INSTALLATION

Refer to Section 4 of this manual under Module Installation and Removal for instructions on installing the AC RMS Converter module. The interconnect diagram in Section 8 contains a table listing permissible and preferred slots.

609-4. OPERATING NOTES

Operation of the front panel controls is the same as described in Section 2. An ac voltage on a dc level may be measured by depressing both the Vdc and Vac function switches at the same time. The reading displayed will be the rms value of the two voltages combined. External reference inputs at the rear panel must be dc voltages only. The slow filter (FILTER LED illuminated) must be selected for full accuracy below 400 Hz.

609-5. THEORY OF OPERATION

The function of the RMS Converter is to accept signals from either the input terminals of the optional Current Shunts module and to convert the input signal to a dc level proportional to the rms value of the input. The dc output from the RMS Converter is routed on the Guarded Bus to the Active Filter module and then to the A/D Converter. True rms conversion is mathematically obtained by averaging the squared value of the input, then taking the square root ($V_{rms} = \sqrt{\overline{V_{in}^2}}$). Limitations to the realization of this mathematical formula using operational techniques are crest factor (ratio of the peak value to rms value, limited by the dynamic range of the amplifiers), frequency response, and acccuracy.

Input signals are applied to the Range Amplifier (Q1,U3) to be brought within the 1V rms range. Refer to Figure 609-1. Before a signal can be operationally squared, it must be converted to an absolute value. Balance Amplifier (U4, Q10) performs this function by inverting and rectifying the signal from U3. Outputs from the Range Amplifier and the Balance Amplifier are applied through R33 and R31 to the summing node of the Squaring Amplifier (U5, Q11). Due to the ratio of R33 to R31, the inverted negative half-cycles from the Balance Amplifier are twice the amplitude of the negative half-cycles from the Range Amplifier. When summed, the waveform is the absolute value of the output from the Range Amplifier. The conversion to rms is performed by the Squaring Amplifier, Integrator, and Square Root Amplifier. Implementation of these functions depends on the logarithmic response of PN junctions. Since two PN junctions are used in each of two parts of a feedback loop, a double logarithmic response is generated ($2 \log X = \log X^2$). The Squaring Amplifier converts the signal to a current flowing through the emitters of two transistors, Q8A and Q12A. These two transistors are configured with two additional transistors. Q12B and Q8B, in a feedback loop which constrains the output voltage to be the square root of the integral of the square of the current flowing in Q8A and Q12A.

609-6. Circuit Description

Refer to the schematic for the following discussion.

609-7. RANGE AMPLIFIER

The Range Amplifier is an inverting amplifier with gain control provided by switching feedback impedances. Feedback impedances are controlled by relays K4, K5, or K6, and consist of parallel resistors and capacitors adjusted for proper gain and frequency response. Relays K1, K2, and K7 control the input to the amplifier. K1 is energized for inputs from the input terminals. K7 is energized for inputs

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Table 609-1. AC RMS Converter Specifications

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION		INPUT IMPEDANCE
		6½ DIGITS*	5½ DIGITS	
1V 10V 100V 1000V	2.50000V 20.0000V 160.000V 1000.00V	1 µV 10 µV 100 µV 1 mV	10 µV 100 µV 1 mV 10 mV	1 MΩ shunted by <120 pf (front) <110 pf (rear)

*In AVG operating mode.

Accuracy ±(% OF READING + % OF FULL SCALE)[1]

24 HOUR 23°C ±1°C				90 DAY 23°C ±5°C			
FREQUENCY*	% OF READING	% FS		FREQUENCY*	% OF READING	% FS	
		AC	AC + DC			AC	AC + DC
DC	0.075	—	0.03	DC	0.1	—	0.03
10 Hz - 20 Hz	0.75	0.04	0.06	10 Hz - 20 Hz	1.0	0.04	0.06
20 Hz - 50 Hz	0.35	0.012	0.03	20 Hz - 50 Hz	0.5	0.012	0.03
50 Hz - 10 kHz	0.075	0.012	0.03	50 Hz - 10 kHz	0.1	0.012	0.03
10 kHz - 30 kHz	0.15	0.04	0.06	10 kHz - 30 kHz	0.2	0.04	0.06
30 kHz - 50 kHz	0.2	0.1	0.12	30 kHz - 50 kHz	0.3	0.1	0.12
50 kHz - 100 kHz	0.75	0.3	0.3	50 kHz - 100 kHz	1.0	0.3	0.3
100 kHz - 300 kHz	1.5	0.5	0.5	100 kHz - 300 kHz	2.0	0.5	0.5
300 kHz - 1 MHz	2.9	1.3	1.3	300 kHz - 1 MHz	3.3	1.8	1.8

*Slow filter must be used for full accuracy below 400 Hz.

>90 DAY 23°C ±5°C
ADD TO THE 90 DAY SPECIFICATIONS PER MONTH THE FOLLOWING %:

FREQUENCY*	% OF READING	% FS	
		AC	AC + DC
DC	0.011	—	0.0033
10 Hz - 20 Hz	0.11	0.0044	0.0067
20 Hz - 50 Hz	0.056	0.0031	0.0033
50 Hz - 10 kHz	0.011	0.0031	0.0033
10 kHz - 30 kHz	0.022	0.0044	0.0067
30 kHz - 50 kHz	0.033	0.056	0.014
50 kHz - 100 kHz	0.11	0.033	0.033
100 kHz - 300 kHz	0.089	0.056	0.056
300 kHz - 1 MHz	0.044	0.033	0.033

Operating Characteristics

CREST FACTOR .... >7 at Full Scale, increasing down range by: $7 \times \sqrt{\text{V Range / V Reading}}$

TEMPERATURE COEFFICIENT ±(% OF READING + % OF FULL SCALE) /°C*

MODE	0°C TO 18°C AND 28°C TO 50°C
AC	0.004 + 0.002
AC + DC	0.004 + 0.004

*For frequencies <10 kHz.

Table 609-1. AC RMS Converter Specifications (cont)

COMMON MODE REJECTION	>120 dB, dc to 60 Hz, with 100Ω in series with either lead.
RESPONSE TIME	
Analog Settling Time	100 ms with Fast Filter and 500 ms with Slow Filter to within 0.1% of in-range step change.
Digitizing Time	Same as dc volts (see Section 1).
MAXIMUM INPUT VOLTAGE	1000V rms, 1400V peak, or volts-hertz limit, whichever is less.
VOLTS-HERTZ LIMIT	1×10^7 for 1V and 10V ranges 2×10^7 for 100V and 1000V ranges

NOTES:

[1]For inputs >0.1% of range to full scale.
For inputs >500V, multiply accuracy specification by (Input voltage + 2000V) / 2000V.

from the Current Shunts module. K2 is energized when selecting ac + dc measurements. Gain of the amplifier is set for a 1V rms output with a full-scale sine wave input with the exception of the 1000V range in which the full-scale output is .8V rms. Q1 and U3 provide the forward gain of the amplifier. CR6, CR7, CR21, and CR22 provide input protection. Q2 drives the guard for the summing node of the operational amplifier.

609-8. BALANCE AMPLIFIER

The Balance Amplifier is an inverting, unity-gain amplifier with diodes in the feedback paths to provide rectification. CL1 and Q10 are configured as a current source driven by U4. A high impedance current source is used to minimize the effects of the diodes on the gain of the amplifier. Due to the unity gain of the inverting amplifier and the ratio of R33 to R31, the negative half-cycles from the Range Amplifier are summed with positive half-cycles having twice the amplitude from the Balance Amplifier. The result is the absolute value of the output from the Range Amplifier. Q6 is used to extend the frequency response of the amplifier.

609-9. COMPUTATION

The Squaring Amplifier, Square Root Amplifier, and Integrator Amplifier work together to perform the rms conversion. This is accomplished by regulating the current in four transistors, Q8A, Q12A, Q8B, and Q12B, matched for temperature coefficient and response characteristics. The Squaring Amplifier sums the outputs from the Range Amplifier and the Balance Amplifier so that the current flowing through its feedback path (Q8A,Q12A) is proportional to the absolute value of the input signal. Forward gain of the amplifier is provided by U5 and Q11 with Q7 extending the frequency response.

Q12 is configured so that the integral of its collector current is the output voltage. U7 and U8 integrate the collector current of Q12B. Q8B is configured so that its collector current is proportional to the output voltage. The current through Q8B controls the gain of U6, the Square Root Amplifier, which in turn partially controls the current flowing in Q12B. The integrating time constant of U7 and U8 is determined by R56 and R65 in parallel with C27 or C27 plus C28, depending on which filter is selected from the front panel. The proportionality constant of the converter is such that a full-scale input produces a 20V output on RT6.

609-10. MAINTENANCE

609-11. Performance Test

Use the following procedure as a performance determination for the AC RMS Converter. The DC Volts Performance Test given in Section 4 should be done first to ensure proper DC accuracy.

1. Select AC Volts and Autoranging.
2. Connect the AC Calibrator output to the instrument input terminals.
3. Sequentially apply the input voltages and frequencies listed in Table 609-2, verifying that the instrument reading is within the listed tolerance.
4. Disconnect the AC Calibrator and connect the DC Calibrator.
5. Simultaneously select DC Volts and AC Volts (both indicators illuminated).
6. Select an output from the DC Calibrator of +10.0000 Vdc.
7. The instrument display should be within 9.9840 and 10.0160.

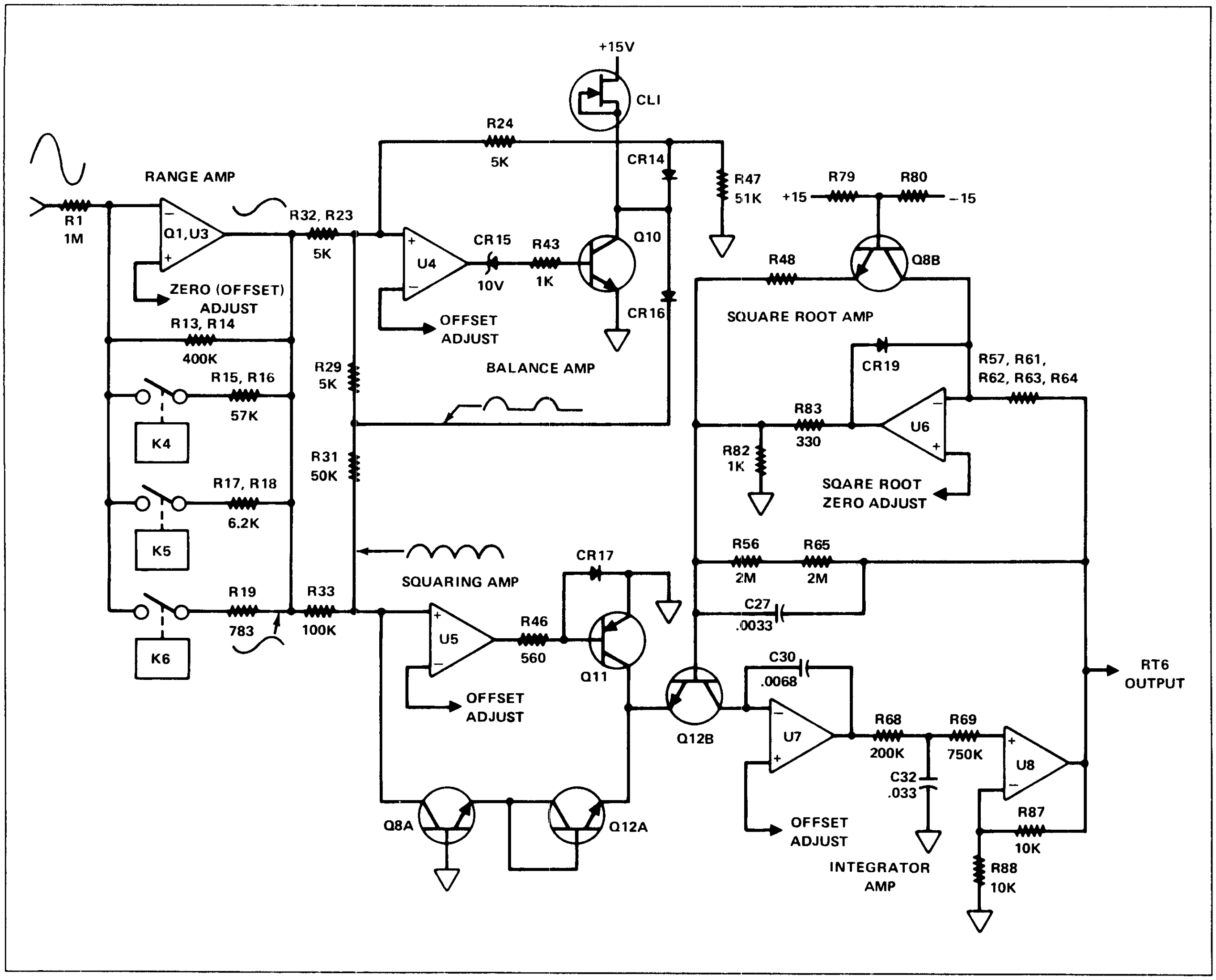


Figure 609-1. AC RMS Converter

8. Reverse the leads at the output of the DC Calibrator. The display should still read within the limits of Step 8.

609-12. Calibration

Before calibrating the AC RMS Converter, perform the DC Calibration procedure in Section 4. Remove the Calibration Memory if installed and allow a two hour warm-up. Allow adequate warm-up time for the Calibrator used, as specified in the Calibration manual. After calibration is complete, reinstall the Calibration Memory and enter new values at the cardinal points of each range (zero may be entered).

Use the following procedure to calibrate the AC RMS Converter. All adjustments given are on the RMS Converter and are accessible at the top of the module. R66, R55, C24, and R38 are adjustments not accessible from the top of the module, which should not require adjustment unless parts have been replaced. Adjustment procedures for these adjustments are given in Trouble- shooting in this section of the manual.

Table 609-2. Performance Test

INPUT		DMM READING	
FREQ	VOLTAGE	LOW	HIGH
10 kHz	1 V	0.99870	1.00130
50 kHz	1 V	0.99450	1.00550
10 kHz	10 V	9.9876	10.0124
50 kHz	10 V	9.9500	10.0500
10 kHz	100 V	99.881	100.119
50 kHz	100 V	99.540	100.460
10 kHz	1000 V	998.48	1001.52

Range Zero Adjustment is accomplished using the following steps:

1. Select the 10V range.
2. Simultaneously select DC Volts and AC Volts (both indicators illuminated).
3. Connect the test DVM HI to TP5, LO to TP1.
4. Short the input terminals.
5. Adjust R12, RANGE ZERO, for a reading on the test DVM of 0+/-30 uV.
6. Remove the input short and the test DVM.

Balance Zero Adjustment is accomplished using the following steps:

1. Apply -0.2000000 to the input terminals from the DC Calibrator. Record the reading.
2. Reverse the polarity of the input.
3. Adjust R42, BALANCE ZERO, twice as far as required to reach the reading noted.
4. Reverse polarity again. Readjust R42 until the readings are with- in 10 uV for either polarity without further adjustment.

Balance Gain Adjustment is accomplished using the following steps:

1. Select the Cal mode (CAL switch down, CAL indicator illuminated). Ignore the cal digit for the remainder of this procedure.

NOTE

Entering the cal mode allows overrange inputs without the overrange indication flashing.

2. Apply -20.00000 Vdc to the input from the DC Calibrator. Note the reading.
3. Reverse the polarity.
4. Adjust R32, BALANCE GAIN, to the reading noted.
5. Reverse the polarity again. Readjust R32 until the readings with both polarities are within 10 digits without further adjustment.

AC Zero Adjustment is accomplished using the following steps:

1. Select AC Volts, 1V range.
2. Connect the AC Calibrator to the input terminal.
3. Apply 2.5 mV AC, 500 Hz to the input.
4. Adjust R45, AC ZERO, for a reading between 0.00245 and 0.00255.

609-13. Calibration Adjustments

Sequentially apply the input voltages and frequencies listed in Table 609-3, performing the adjustments as necessary to bring the reading within the stated tolerance. Select AC Volts and manual ranging for these adjustments. If in the first step R64 does not have the required range, perform the coarse calibration in the troubleshooting section. Steps 9 and 24 require a 50Ω termination at the instrument input terminals and the use of four-wire sensing with the AC Calibrator. Two test cables, each with twisted wires, may be used.

609-14. Troubleshooting

Troubleshooting procedures for the AC RMS Converter follow the format used in Section 4. Table 609-4 assures that the problem actually is in the AC RMS Converter. Figure 609-2 gives a symptom analysis approach to troubleshooting, with possible failures listed in order of probability, and gives the address and data field used to set up the module. DO NOT remove or install modules with the power on.

If Q8 or Q12 are replaced, the module must be returned to the factory (Attn: PARTS) for temperature compensation. This is also the only time R38, CREST FACTOR ADJUST, should require readjustment. Do not attempt to adjust R38 because no crest factor generators are commercially available.

609-15. Preliminary Calibration

If other parts are replaced, it may be necessary to make the following adjustments before continuing with the calibration procedure. The following procedure should be completed to assure proper functioning of the module. Many of the adjustments must be performed again in the final calibration procedure. Always perform final calibration from the beginning of the procedure. Select the cal mode by placing the CAL switch in the down position. Ignore the cal digit for this procedure. Some of these adjustments are not accessible from the top of the module. Center all adjustments before beginning calibration except for R38, C24, and R64. R64 should be set fully counterclockwise. R38 should NOT be changed.

CAUTION

When high voltages are applied to the input terminals and the module is not enclosed in the case, hazardous voltages are present on the board. Use an insulated tool for making adjustments while keeping hands away from the PCB.

1. Select AC Volts and the 1V range (manually) and short the input terminals.
2. Short TP3 and TP4 to the metal divider on the board.
3. Connect the test DVM HI to TP2 and LO to TP1.

Table 609-3. Calibration Adjustments

STEP	RANGE	INPUT		ADJUST/ CHECK	TOLERANCE	
		VOLTAGE	FREQUENCY		LOW	HIGH
1	1000V	500V[1]	500 Hz	R64	499.90	500.10
2	1000V	500V[1]	50 kHz	C4	499.80	500.20
3	1000V	1000V[1]	10 kHz	Wait 30 sec. Check	999.20	1000.80
4	1V	2.5V	500 Hz	R14	2.49975	2.50025
5	1V	2.5V	50 kHz	C9	2.49900	2.50100
6	10V	20V	500 Hz	R16	19.9980	20.0020
7	10V	20V	50 kHz	C11	19.9900	20.0100
8	10V	10V	1 MHz	Check (R75)[2]	9.8000	10.2000
9	1V	1V	1 MHz[3]	Check (R75)[2]	0.9800	1.02000
10	1V	2.5V	300 kHz	Check	2.48000	2.52000
11	1V	2.5V	20 kHz	Check	2.49900	2.50100
12	1V	2.5V	50 Hz[4]	Check	2.49900	2.50100
13	1V	2.5V	100 kHz	Check	2.49000	2.51000
14	1V	.25V	100 kHz	Check	0.24600	0.25400
15	1V	2.5 mV	50 kHz	Check	0.00150	0.00350
16	1V	2.5 mV	500 Hz	Check	0.00230	0.00270
17	1V	.8V	500 Hz	Check	0.79960	0.80040
18	100V	160V[1]	500 Hz	R18	159.960	160.020
19	100V	160V[1]	50 kHz	C14	159.960	160.040
20	100V	67V	300 kHz	Check	66.800	68.200
21	10V	20V	300 kHz	Check	19.7500	20.2500
22	1V	.8V	300 kHz	Check	0.78500	0.81500
23	1V	.2V	300 kHz	Check	0.18800	0.21200
24	1V	.1V	1 MHz[3]	Check	0.07000	0.13000

1. Use CAUTION, Dangerous voltage.
2. If R75 is adjusted, repeat the previous steps.
3. Terminate cable in 50Ω; use four-wire sense on Calibrator as explained in the text.
4. FILTER must be ON.

Table 609-4. AC RMS Converter Isolation

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
1	Do the DC Performance Test (Section4).		
2	Is DC Volts within tolerance?	3	Section 4
3	Is the Calibration Memory module installed?	4	6
4	Remove the Calibration Memory module. Is AC OK?	5	6
5	Bad Calibration Memory. Go to Section 604.		
6	Is Isolator installed?	7	10
7	Replace Isolator with Bus Interconnect/Monitor pcb.		
8	Is AC OK?	9	10
9	Bad Isolator. Go to Section 608.		
10	Remove DC Signal Conditioner. Is AC OK?	11	12
11	DC Signal Conditioner interfering with AC. The problem in the DC Signal Conditioner is one of the following: 1. Digital Logic Bad, 2. K1 or K2 shorted, 3. Q6, Q7, Q8 Bad.		
12	Install Bus Interconnect/Monitor if not already installed.		
13	Check power supply voltages as follows: VA1 = +14.24 to 15.75V VA4 = −29 to −32V VA2 = −14.25 to −15.75V Vcc = −15V Difference =4.9 VA3 = +29 to 32V Vss = −20V to 5.2		
14	Are the supply voltages OK?	15	Section 4
15	Go to Figure 609-2.		

4. Adjust R66, INTEGRATOR ZERO, for 0V+/-100 uV.
5. Remove the short from TP3.
6. Add a jumper from the bottom of R57 (junction with R61) to a jumper added across R48.
7. Connect the test DVM HI to TP3.
8. Adjust R55, SQUARE ROOT ZERO, for 0V +/-100 uV.
9. Remove the short from TP4 and the jumper from R48.
10. Simultaneously select AC Volts and DC Volts; manually select the 10V range.
11. Connect the test DVM HI to TP5.
12. Adjust R12. RANGE ZERO, for 0V +/-30 uV.
13. Disconnect the test DVM and remove the short from the input terminals.
14. Center R45, AC ZERO, and apply -0.2V from the DC Calibrator to the input terminals. Note the reading on the display.
15. Reverse the polarity of the input and adjust R41, BALANCE ZERO, twice as far as required to reach the reading noted.
16. Reverse the polarity again and readjust R42 until the readings obtained with both polarities are within 10 digits without further adjustment.
17. Apply -20V DC to the input and note the reading.
18. Reverse the input polarity and adjust R32, BALANCE GAIN, for the same reading as noted in the last step +/-5 digits.
19. Apply -0.02V DC and adjust R45, AC Zero, for a reading of 0.0200 +/-5 digits.
20. Disconnect the DC Calibrator and connect the AC Calibrator.
21. Select AC Volts and the 1000V range.
22. Set R64 fully counterclockwise.
23. Apply 500V @ 500 Hz to the input from the AC Calibrator.
24. Note the reading and clip links according to Table 609-5. Link 1 is across R61, link 2 is across R62, and link 3 is across R63.
25. Adjust R64, 1000V LOW FREQ. ADJUST, for a reading of 500.000V +/-20 digits.

SYMPTOM	POSSIBLE FAILURE
High reading on display with open inputs, 1000V range	C24 misadjusted, Q9, Q10, U4
High frequency (300 kHz) bad	C24 misadjusted or bad, U3
Reading not stable	U3, U4
Crest factor bad	Q8, Q12
AC breaks down (overload source above 500V)	K7
AC out of tolerance in slow filter mode	Q13 and Q14, Q16 and Q17
One range bad	Digital Logic Range Relays, CR14, CR16
All ranges bad	U3, Q1, U5, Q7, U7, U8, K8, K1
Excessive noise	U3, Q2
Display blanks	U1, U10

The largest single failure items tend to be relays and electrolytic capacitors

Note: If Q8 or Q12 is replaced, the module should be returned to the factory (Attn. Parts) for temperature compensation and adjustment of R38.

Address IC 0, 2, 4 high

IDO =0, ID1 = 0	–DC Coupled AC
IDO = 1, ID1 =0	–AC Volts
DIO = 0, ID1 = 1	–RT1 input for AC Current
ID2 =0	–Filter On
ID3 =0	–10V range
ID4 =0	–100V range
ID5 =0	–1000V range

ID3 through ID5 = 1–1V range

Figure 609-2. Symptom Analysis

26. Change the frequency to 50 kHz and adjust C4, 1000V HIGH FREQ ADJUST, for 500.000V +/-20 digits.

27. Apply 2.5 @500 Hz to the input and manually select the 1V range.

28. Adjust R14, 1V LF, for 2.50000 +10 digits.

29. Change the input frequency to 500 kHz and adjust C9, 1V HF-1, for 2.50000 +100 digits.

30. Change the input frequency to 500 kHz and adjust C24, 1V HF-2, to bring the reading toward 2.5V. Adjusting C24 will require readjusting C9. Alternately adjust C9 as in step 29, then C24 @ 500 kHz until a reading of 2.50000V + 3000 digits is obtained.

NOTE

C9 has approximately twice the effect at 500 kHz as at 50 kHz. If C24 hasn't enough range, adjust R75, 1MHz. Turn it clockwise to raise the reading or CCW counterclockwise lower the reading (1/2 turn is about 3000 digits).

31. Check the stability by selecting the 1000V range and applying 1000V @ 10 kHz. The reading should be 1000.00 +/-80 digits. Wait thirty seconds. If the reading is out of tolerance, use an insulated tool, and proceed with caution to adjust C24 slightly beyond the point where a stable reading is displayed. Recheck steps 29 and 30.

32. Apply 20V @ 500 Hz and select the 10V range.

33. Adjust R16, 10V LF, for a reading of 20.0000 +/-20 digits.

34. Change the frequency to 50 kHz and adjust C11, 10V HF, for 20.0000 +/-100 digits.

35. Apply 10V @ 1 MHz using four-wire sensing (without the 50Ω termination).

36. Adjust R75, 1 MHz, for a reading of 10.0000 +/-100 digits.
37. Apply 1V @ 1 MHz using four-wire sensing with the 50Ω termination at the input terminals. Manually select the 1V range.
38. Initially note the reading without adjusting R75. If this reading is not 1.00000V +/-.036V, adjust C24 until the reading is within +/-.036V and note this reading. Adjust R75 until the reading is halfway between the noted reading and 1.00000V. This final reading should be 1.00000V +/-.018V.
39. Apply 500V @ 50 kHz. The reading should be 500.00 +/-20 digits (adjust C4 if necessary).
40. Apply 2.5V @ 500 kHz and check the reading for 2.50000 +/-.03V. Adjust C24 if necessary to bring the reading within the specification.
41. If C24 was adjusted in Step 40, check the stability by applying 1000V @ 10 kHz. The reading should be stable at 10000.00 +/-.8V. Readjust C24 and repeat Step 40 if the reading is un- stable.
42. Apply 2.5V @ 50 kHz. Adjust C9 if necessary for a reading of 2.50000 +/-.001V.
43. Apply 20V @ 50 kHz and adjust C11 if necessary for a reading of 20.0000 +/-.01V.
44. Apply 10V @ 1 MHz using a four-wire cable. The reading should be 10.0000 +/-.2V.
45. Apply 1V @ 1 MHz using a four-wire cable with a 50Ω termination. The reading should be 1.00000 +/- .02V.
46. If Steps 44 or 45 are out of tolerance, repeat Steps 36 through 45.
47. Select the 100V range and apply 160V @ 500Hz. Verify that R18, 100V LF, will adjust the reading to 160.000V +/-50 digits.
48. Check the output ripple by turning the filter off and applying 2.5V @ 200 Hz from a lab oscillator on the 1V range, and adjust the oscillator output for a reading of 2.50000V +/-1000 digits. Connect the oscilloscope HI to TP2, LO to shield. The ripple should be less than 20 mV P-P.

Table 609-5. High Voltage, Low Frequency Coarse Adjustment

Reading	Links Previously Clipped	Clip Links	Replace Links
500 - 495.5 N/A (Pot R64 should adjust properly)		None	None
495.5 - 491.1	1	2	1
	2	1	None
	1 & 2	3	1 & 2
	3	1	None
	1 & 3	2	1
	2 & 3	1	None
500 - 504.5	1	None	1
	2	1	2
	1 & 2	None	1
	3	1 & 2	3
	1 & 3	None	1
	2 & 3	1	3
	1, 2, & 3	None	1

49. Change the frequency to 20 Hz and turn the filter on. Readjust the oscillator leveled output as in step 48. The ripple should be less than 80 mV P-P.
50. Perform the Calibration procedure.

609-16. PARTS LIST

Table 609-6 gives a parts breakdown for the AC RMS Converter. Refer to Section 5 for ordering information.

CAUTION

Indicated devices are subject to damage by static discharge.

Table 609-6. AC RMS Converter PCB Assembly

REFERENCE DESIGNATOR	DESCRIPTION	FLUKE STOCK NO	MFRS SPLY CODE	MANUFACTURERS PART NUMBER OR GENERIC TYPE	TOT QTY	NOTES
C 1	CAP,POLYES,0.22UF,+-20%,1200V	268904	84411	JF-65 224M1200V	1	
C 2	CAP,PORC,1.5PF,+-0.25PF,1700V AC	461004	51406	UV471R5C	1	
C 3	CAP,MICA,220PF,+-5%,500V	170423	93790	CD15FD221J03	1	
C 4, 9	CAP,VAR,0.25-1.5PF,1700V,TEFLON	218206	52769	ER-530-000	2	
C 5	CAP,CER,430PF,+-5%,50V,C0G	732644	04222	SR595A431JAA	1	
C 7, 34	CAP,POLYES,0.1UF,+-10%,100V	393439	68919	MKS4-104-K-100V	2	
C 8	CAP,PORC,5.6PF,+-0.25PF,1000V AC	460568	51406	UV475R6C	1	
C 10	CAP,MICA,43PF,+-0.5PF,500V	277202	97930	CD15ED430D03	1	
C 11	CAP,VAR,0.8-10PF,250V,AIR	229930	51406	MVM010W-3	1	
C 12	CAP,POLYES,0.047UF,+-10%,250V	162008	37942	160-473K250AC	1	
C 13	CAP,MICA,390PF,+-1%,500V	355339	00853	CD15FD391F03	1	
C 14	CAP,VAR,6-50PF,250V,CER	404301	52769	GKB50000	1	
C 15	CAP,CER,3600PF,+-2%,50V,C0G	747477	04222	SR215A362GAA	1	
C 16, 20, 26,	CAP,MICA,27PF,+-5%,500V	177998	93790	CD15ED270J03	5	
C 17	CAP,MICA,8PF,+-10%,500V	216986	93790	CD15CD080K03	1	
C 18, 40, 46	CAP,MICA,15PF,+-5%,500V	148569	93790	CD15CD150J03	3	
C 19, 22	CAP,MICA,1000PF,+-5%,500V	148387	93790	CD19FD102J03	2	
C 21	CAP,MICA,2PF,+-0.5PF,500V	175208	93790	CD15CD020D03	1	
C 23, 36, 37,	CAP,TA,15UF,+-10%,20V	153056	56289	150D154X9020B2	4	
C 24	CAP,VAR,2-10.0PF,250V,CER	321109	52769	GKB10000	1	
C 25	CAP,MICA,390PF,+-5%,500V	148437	93790	CD15FD391J03	1	
C 27, 42	CAP,POLYES,0.003UF,+-10%,50V	402867	19701	712A1BB332PK401SK	2	
C 28	CAP,POLYES,0.01UF,+-10%,400V	402818	37942	160-103K400AC	1	
C 29, 41	CAP,POLYES,0.022UF,+-10%,250V	234484	37942	160223K250AC	2	
C 30	CAP,POLYES,0.0068UF,+-20%,200V	106070	56289	10304	1	
C 32, 35	CAP,POLYES,0.033UF,+-10%,250V	234492	37942	160333K250AC	2	
C 33	CAP,POLYES,0.0047UF,+-10%,50V	260844	56699	713D1BD472PK401SK	1	
C 38, 44	CAP,MICA,4PF,+-0.5PF,500V	190397	93790	CD15CD040D03	2	
C 43	CAP,TA,6.8UF,+-20%,35V	363713	56289	199D685X0035DA2	1	
C 47	CAP,POLYES,0.001UF,+-10%,200V	159582	56289	10304	1	
CL 1	ϟ DIODE,SI,N-JFET,CURRENT REG,IF=3.0 MA	429373	17856	J9009	1	
CR 2- 5, 8-	ϟ DIODE,SI,BV=75V,IO=150MA,500MW	203323	09214	IN4448	8	
CR 6, 7, 20,	ϟ DIODE,SI,BV=20V,IO=50MA,SELECTED IR	348177	07263	FD7223	4	
CR 11, 15, 18,	ϟ ZENER,UNCOMP,10.0V,5%,12.5MA,0.4W	246611	04713	1N961B	4	
CR 14, 16	ϟ DIODE,SI,SCHOTTKY BARRIER,SMALL SIGNL	313247	28480	5082-6264 T25	2	
CR 19	ϟ DIODE,SI,BV= 90.0V,IO= 75MA,SELCTD IR	260554	14552	CD55105	1	
CR 21, 22	ϟ ZENER,UNCOMP,6.8V,5%,20.0MA,0.4W	260695	04713	1N754A	2	
H 1	SCREW,RH,SL,NYL,6-32,.500	115006	27440	1020-006-8B	3	
H 2	SCREW,PH,P,LOCK,SS,4-40,.375	256164	74594	256164	1	
K 1, 2	RELAY,REED,2 FORM A,4.5VDC	441931	71707	1235-0093	2	
K 4- 6, 8	RELAY,REED,1 FORM A,4.5VDC	357566	71707	1240-0069	4	
L 2	COIL,REED,125AT,0.42 OD,0.141ID,0.82L	269019	71707	1320-06-01	1	
MP 1	ϟ MODULE CASE ASSY (MP2-MP9)	425231	89536	425231	1	
MP 2, 3	CASE HALF,MODULE	402990	89536	402990	2	
MP 4	COVER,MODULE CASE	794560	89536	794560	1	
MP 5	SHIELD,COVER, AC/DC CONVERTER RMS	468462	89536	468462	1	
MP 6	DECAL,R.M.S. CONVERTER	413401	89536	413401	1	
MP 8	GUARD, REAR	383364	89536	383364	1	
MP 9	GUARD, FRONT	383356	89536	383356	1	
MP 10	TERM,INSUL,FEEDTHRU,BIFURCATED	281865	12615	SL-841-777	4	
MP 11	HEAT DIS,DUAL,TO-18	347740	92218	260-18D	1	
MP 12	INSULATOR RMS SHIELD	426932	89536	426932	1	
MP 13	SHIELD, RMS CONVERTER	416214	89536	416214	1	
MP 14	SHIELD,INPUT, R.M.S. CONV	468470	89536	468470	1	
MP 15	SOCKET,SINGLE,PWB,FOR 0.014-0.026 PIN	343285	04222	2-331272-6	7	
MP 16	SPRING,COIL,COMP,M WIRE,.380,.120	424465	83553	C0121-014-0380M	1	
MP 17	TERM,INSUL,STANDOFF,BIFURCATED	275719	15849	1497B	6	
MP 18	SPACER,SWAGE,.250 RND,BR,6-32,.437	423806	55566	3050-B-632-B-14	3	
MP 19	SPACER,SWAGE,.250 RND,BR,4-40,.187	335604	9W423	9533B-B-0440	1	
MP 20	TERM,UNINSUL,FEEDTHRU,HOLE,TURRET	179283	88245	2010B-5	4	
MP 21	FOIL WRAP REED SWITCH	313833	89536	313833	1	
Q 1	ϟ N-CHANNEL,JUNCTION,RO-120	287623	89536	287623	1	
Q 2, 6, 7	ϟ TRANSISTOR,SI,N-JFET,TO-92	343103	27014	SF55087	3	
Q 4, 10, 18,	ϟ TRANSISTOR,SI,NPN,SMALL SIGNAL,TO-92	218396	04713	2N3904	4	
Q 8	TRANSISTOR,MATCHED (Q8 & Q12)	504191	89536	504191	1	
Q 11	ϟ TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	04713	2N3906	1	
Q 13, 16, 17	ϟ TRANSISTOR,SI,N-JFET,TO-92	288324	21845	F2629	3	
Q 14	ϟ TRANSISTOR,SI,N-JFET,HI-VOLTAGE,TO-92	393314	17856	J2086	1	
Q 15	ϟ TRANSISTOR,SI,PNP,SMALL SIGNAL	218388	07263	PN3645	1	
Q 20	ϟ TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1	
R 1	RES,MF,1M,+-0.1%,1W,6PPM	340265	89536	340265	1	
R 2	RES,MF,16.9K,+-1%,0.125W,100PPM	267146	91637	CMF-55 1692F T-1	1	
R 3	RES,CC,200,+-5%,0.25W	193482	01121	CB2015	1	
R 4	RES, SELECTED					1
R 5, 8	RES,CF,120K,+-5%,0.25W	441386	59124	CF1/4 124J	2	1

Table 609A-6. AC RMS Converter PCB Assembly (cont)

REFERENCE DESIGNATOR	DESCRIPTION	FLUKE STOCK NO	MFRS SPLY CODE	MANUFACTURERS PART NUMBER OR GENERIC TYPE	TOT QTY	NOTES
R 6, 7, 31	RES,MF,50K,+-0.1%,0.125W,25PPM	340257	91637	CMF-55 5001B T-9	3	
R 9, 53, 59,	RES,CF,1M,+-5%,0.25W	348987	59124	CF1/4 105J	5	
R 10	RES,CF,470,+-5%,0.25W	343434	59124	CF1/4 471J	1	
R 11	RES,CF,12K,+-5%,0.25W	348847	59124	CF1/4 123J	1	
R 12, 42, 45	RES,VAR,CERM,1M,+-10%,0.5W	334722	80294	3386-1-105	3	
R 13	RES,MF,399K,+-0.1%,0.125W,25PPM	417212	91637	CMF-55 3993B T-9	1	
R 14	RES,VAR,CERM,5K,+-10%,0.5W	288282	80294	3386S-1-502	1	
R 15	RES,MF,56.89K,+-0.1%,0.125W,25PPM	417220	91637	CMF-55 56891B T-9	1	
R 16	RES,VAR,CERM,500,+-10%,0.5W	291120	80294	3386S-1-502	1	
R 17	RES,MF,6324,+-0.1%,0.125W,25PPM	417238	91637	CMF-55 63240B T-9	1	
R 18, 32	RES,VAR,CERM,50,+-10%,0.5W	285122	80294	3386S-1-502	2	
R 19	RES,MF,782.8,+-0.1%,0.125W,25PPM	417246	91637	CMF-55 782R8B T-9	1	
R 20, 84	RES,CF,4.7K,+-5%,0.25W	348821	59124	CF1/4 472J	2	
R 21	RES,CF,100,+-5%,0.25W	348771	59124	CF1/4 101J	1	
R 22, 49, 83	RES,CF,330,+-5%,0.25W	368720	59124	CF1/4 331J	3	
R 23	RES,MF,4.975K,+-0.1%,0.125W,25PPM	340232	91637	CMF-55 4975B T-9	1	
R 24	RES,CF,5.1K,+-5%,0.25W	368712	59124	CF1/4 512J	1	
R 25	RES,CF,2K,+-5%,0.25W	441469	59124	CF1/4 202J	1	1
R 26	RES,CF,3.9K,+-5%,0.25W	342600	59124	CF1/4 392J	1	
R 27, 58	RES,MF,1M,+-1%,0.125W,100PPM	268797	91637	CMF-55 1004F T-1	2	
R 28	RES,MF,121,+-1%,0.125W,100PPM	343160	91637	CMF-55 1210F T-1	1	
R 29	RES,MF,5K,+-0.1%,0.125W,25PPM	340240	91637	CMF-55 5001B T-9	1	
R 30, 37, 40	RES,CF,5.6K,+-5%,0.25W	442350	59124	CF1/4 562J	3	
R 33	RES,MF,100K,+-0.1%,0.125W,25PPM	340166	91637	CMF-55 1003B T-9	1	
R 34	RES,MF,35.7K,+-1%,0.125W,100PPM	288480	91637	CMF-55 3572F T-1	1	
R 35	RES,CF,620K,+-5%,0.25W	442509	59124	CF1/4 6203JB	1	
R 36	RES,CF,82,+-5%,0.25W	442277	59124	CF1/4 820J	1	
R 38	RES,VAR,CERM,3,+-25%,0.5W	347963	80294	3329H-J81-3R0	1	
R 39	RES, SELECTED					1
R 43, 76, 82	RES,CF,1K,+-5%,0.25W	343426	59124	CF1/4 102J	3	
R 44	RES,CF,9.1K,+-5%,0.25W	441691	59124	CF1/4 912J	1	
R 46, 54, 60	RES,CF,560,+-5%,0.25W	385948	59124	CF1/4 561J	3	
R 47	RES,CF,51K,+-5%,0.25W	376434	59124	CF1/4 513J	1	
R 48	RES, SELECTED					1
R 50	RES,CF,2.7,+-5%,0.25W	442061	59124	CF1/4 2R7J	1	1
R 51	RES,CF,47K,+-5%,0.25W	348896	59124	CF1/4 473J	1	
R 52	RES,MF,4.02M,+-1%,0.25W,100PPM	417253	91637	CMF-60 4024F T-1	1	
R 55, 66	RES,VAR,CERM,1M,+-10%,0.5W	276691	80294	3386R-1-105	2	
R 56, 65	RES,MF,2M,+-0.25%,0.5W,25PPM	327502	91637	CMF-65 2004C T-9	2	
R 57	RES,MF,930K,+-0.25%,0.25W,50PPM	417345	91637	CMF-60 9303C T-2	1	
R 61	RES,MF,17.4K,+-1%,0.125W,100PPM	236802	91637	CMF-55 1742F T-1	1	
R 62	RES,MF,34K,+-1%,0.125W,100PPM	261602	91637	CMF-55 3402F T-1	1	
R 63	RES,MF,68.1K,+-1%,0.125W,100PPM	236828	91637	CMF-55 6812F T-1	1	
R 64	RES,VAR,CERM,20K,+-10%,0.5W	291609	80294	3386S-1-203	1	
R 68	RES,CF,200K,+-5%,0.25W	681841	59124	CF1/4 204J	1	
R 69	RES,CF,750K,+-5%,0.25W	747543	59124	CF1/4 754J	1	
R 71	RES,CF,470K,+-5%,0.25W	342634	59124	CF1/4 474J	1	
R 72	RES,CF,22K,+-5%,0.25W	348870	59124	CF1/4 223J	1	
R 73	RES,CF,100K,+-5%,0.25W	348920	59124	CF1/4 104J	1	
R 74, 85	RES,CF,20K,+-5%,0.25W	441477	59124	CF1/4 151J	2	
R 75	RES,VAR,CERM,10K,+-10%,0.5W	285171	80294	3386-1-103	1	
R 77	RES,MF,23.2K,+-1%,0.125W,100PPM	291351	91637	CMF-55 2322F T-1	1	
R 78	RES,MF,10,+-1%,0.125W,100PPM	268789	91637	CMF-55 10R0F T-1	1	
R 79	RES, SELECTED					1
R 80	RES, SELECTED					1
R 86, 90	RES,CF,150,+-5%,0.25W	343442	59124	CF1/4 151J	2	
R 87, 88	RES,CF,10K,+-5%,0.25W	697102	59124	CF1/4 103J	2	
R 89	RES,MF,42.2K,+-1%,0.125W,100PPM	221655	91637	CMF-55 4222F T-1	1	
R 92	RES,CF,10K,+-5%,0.25W	348839	59124	CF1/4 102J	1	
RT 4	THERM,CHIP,NEGATIVE,10K,+-10%,25 C	501304	50157	1D101	1	
RT 81	THERMISTOR,DISC,NEG.,10K,+-10%,25C	104596	15801	140-103LAG-A01	1	
S 2	SWITCH,REED,1 FORM A,12VA,55AT	284091	15636	V1086	1	
U 1	⚡ IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	04713	MC14023UBCP	1	
U 2	⚡ IC,TTL,HEX INVERTER W/OPEN COLLECTOR	288605	01295	SN7416N	1	
U 3	⚡ IC,OP AMP,SELECTED 40V/US SLEW RATE	329912	27014	LM318H	1	
U 4	⚡ IC,OP AMP,SELECTED,GEN PURPOSE,TO-78	225961	24355	AD3092	1	
U 5	⚡ IC,OP AMP,GEN PURPOSE,TO-78 METAL CAN	288928	04713	LM308AH	1	
U 6, 7	⚡ IC,OP AMP,GENERAL PURPOSE,TO-5 CASE	284760	04713	LM308H	2	
U 8	⚡ IC,OP AMP, UNCOMP GEN PURPOSE,TO-99	381889	04713	MLM201AG	1	
U 9	⚡ IC,CMOS,HEX INVERTER	381848	04713	MC14049UBCP	1	
U 10	⚡ IC,CMOS,HEX D F/F,+EDG TRG,W/RESET	404509	27014	MM74C174N	1	
U 11	⚡ IC,CMOS,QUAD 2 INPUT NAND GATE	355198	04713	MC14011UBCP	1	

NOTES:

⚡ ⚡Static sensitive part.

1. FACTORY SELECTED PART, MODULE MUST BE RETURNED IF ANY REQUIRE REPLACEMENT.

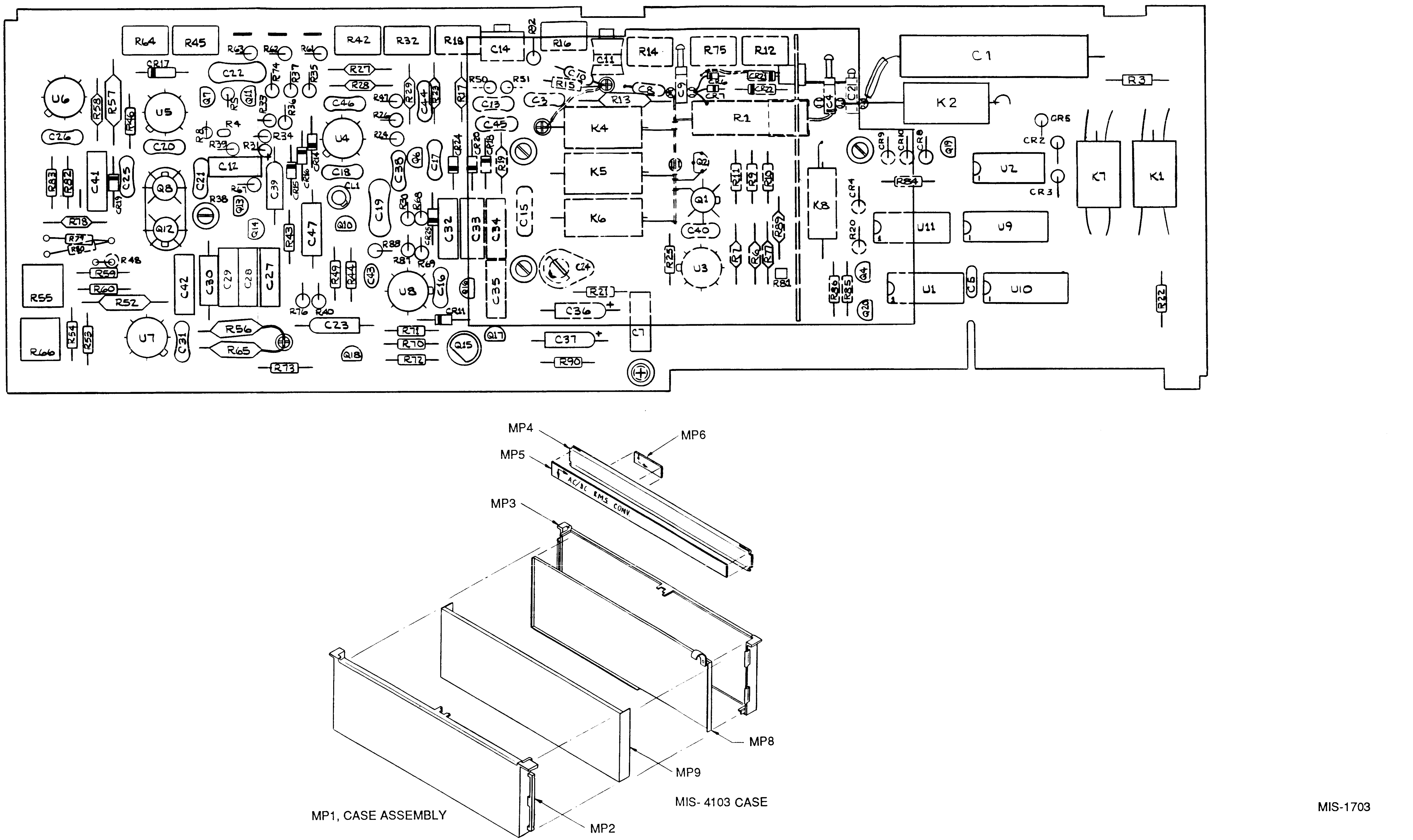
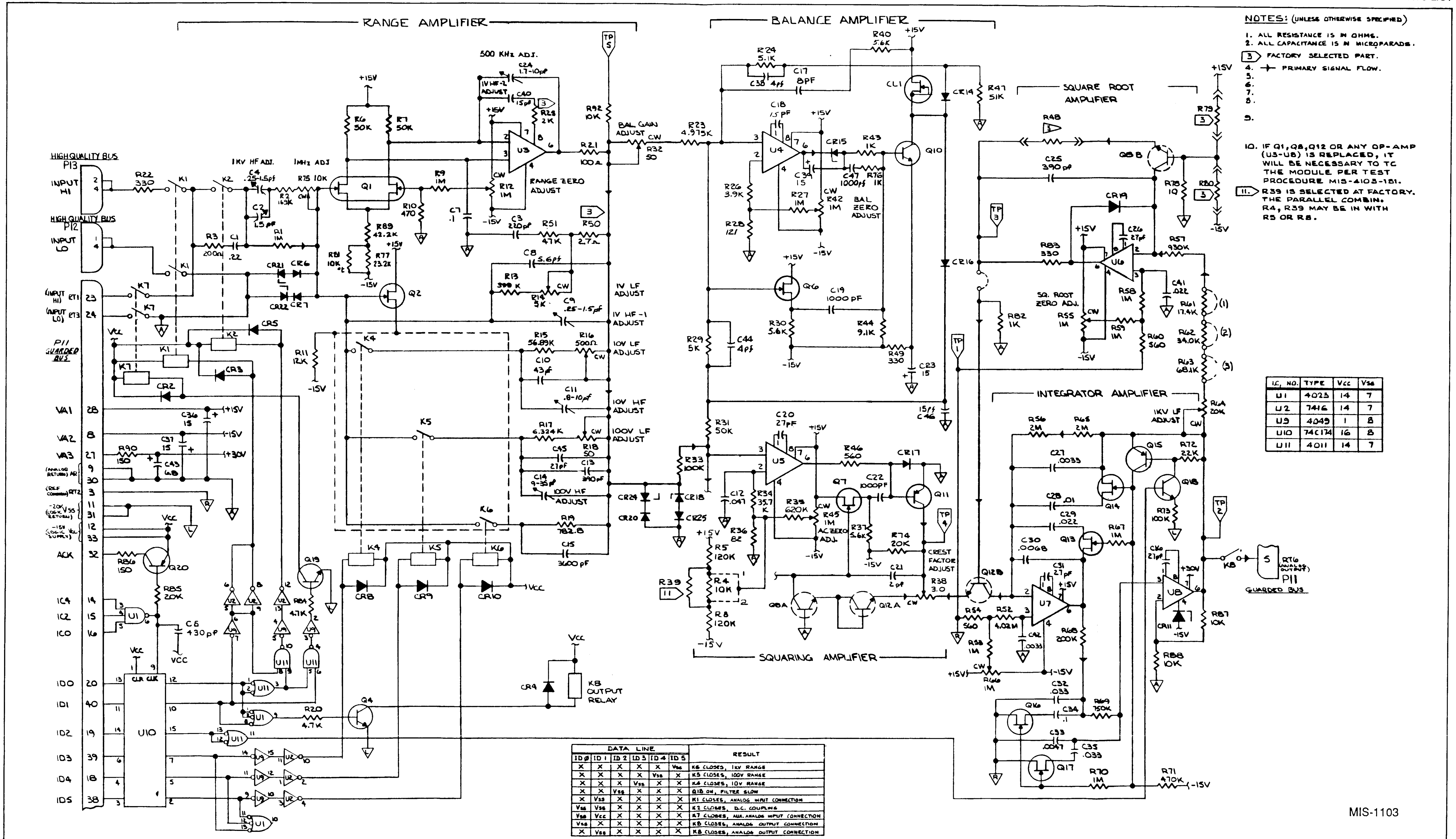


Figure 609-3. AC RMS Converter PCB Assembly



NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTANCE IS IN OHMS.
2. ALL CAPACITANCE IS IN MICROFARADS.
3. FACTORY SELECTED PART.
4. —▸— PRIMARY SIGNAL FLOW.
5.
6.
7.
8.
9.
10. IF Q1, Q8, Q12 OR ANY OP-AMP (U3-U8) IS REPLACED, IT WILL BE NECESSARY TO TC THE MODULE PER TEST PROCEDURE MIS-4103-151.
11. R39 IS SELECTED AT FACTORY. THE PARALLEL COMBIN. R4, R39 MAY BE IN WITH R5 OR R8.

I.C. NO.	TYPE	Vcc	Vss
U1	4023	14	7
U2	7416	14	7
U9	4049	1	8
U10	74C174	16	8
U11	4011	14	7

DATA LINE						RESULT
IDØ	ID1	ID2	ID3	ID4	ID5	
X	X	X	X	X	Vss	K6 CLOSES, 1KV RANGE
X	X	X	X	Vss	X	K5 CLOSES, 100V RANGE
X	X	X	Vss	X	X	K4 CLOSES, 10V RANGE
X	X	Vss	X	X	X	Q18 ON, FILTER SLOW
X	Vss	X	X	X	X	K1 CLOSES, ANALOG INPUT CONNECTION
Vss	Vss	X	X	X	X	K2 CLOSES, D.C. COUPLING
Vss	Vcc	X	X	X	X	K7 CLOSES, AUX. ANALOG INPUT CONNECTION
Vss	X	X	X	X	X	K8 CLOSES, ANALOG OUTPUT CONNECTION
X	Vss	X	X	X	X	K8 CLOSES, ANALOG OUTPUT CONNECTION

Figure 609-3.AC RMS Converter PCB Assembly (cont)

Section 7
Software Calibration

7-1. INTRODUCTION

7-2. This section of the manual describes the theory and procedures for software calibration. The following major topics are covered:

General Description
Detailed Description/Operation
Calibration Procedures

7-3. The General Description is a brief overview of the software calibration feature of the instrument. The Detailed Description/Operation is a comprehensive explanation of the theory and operation of software correction. The calibration procedures are step-by-step instructions for performing the calibration. Local calibration procedures (using front panel control pushbuttons) are explained first, then remote calibration procedures are described.

7-4. GENERAL DESCRIPTION

7-5. The 8505A uses a nonvolatile, read/write memory for microprocessor-controlled calibration of each range in each function. The Calibration Memory is a standard part of the Controller module with these multimeters. Software calibration offers the following benefits:

- Cover removal is unnecessary (physical access to the multimeter is not required).
- Uncertainties due to internal temperature differentials and thermal equilibrium can be eliminated.
- Calibration is more convenient when the multimeter is stacked or mounted in a rack.
- The procedure can be accomplished from local (front panel) or remote locations.
- The multimeter does not need to be removed from the system.
- Extended intervals between hardware calibration are possible.
- Software calibration can be performed at any time, as determined by the user's accuracy requirements.

7-6. Specifications attainable with software calibration are defined in Section 1 (standard functions) and in Section 6 (optional functions). If the multimeter has been repaired, hardware calibration may be necessary. Once hardware calibration has been carried out, 24-hour specifications are in effect and immediate software calibration is not necessary.

7-7. Software calibration requires a combination of zero offsets and gain corrections. The function being calibrated determines the calibration corrections that are necessary. Applicable correction points are summarized in Table 7-1.

7-8. The operator activates the Cal Mode via a cal slide switch on the rear panel before making calibration entries from either a local or remote location. An identifying number or calibration date can also be entered when the Cal Mode is activated. When the Cal Mode is activated, the front panel AVG/(CAL) annunciator flashes and the following special conditions should be noted:

1. Power must not be cycled on or off when the Cal Mode is activated (the rear panel calibration switch is on).

2. Overrange conditions no longer cause a special flashing HHHHHH indication.

Table 7-1. Software Calibration Points

FUNCTION	CALIBRATION POINTS			
	Zero Corrections	Positive Gain	Negative Gain	Specified Frequencies
DC Volts (VDC or V)	X	X	X	
DC Amps (ADC or I)		X	X	
Ohms (OHMS or Z)	X	X		
AC Volts				
(HI ACCUR or VA2)				X
(HI ACCUR+VDC or C2)				X

3. Averaging mode is locked out; the Calibration and Averaging modes are mutually exclusive. However, pressing the AVG pushbutton when Cal Mode is on does enable or disable latching error indications.

CAUTION

Catastrophic damage to the instrument could occur if latching errors are disabled during software calibration. The latching error disable feature should be used only during troubleshooting when normally disallowed module configurations may be necessary. Since latching errors may identify an overvoltage condition (as with local Error 4 or remote error 14), proper safety precautions must be used.

4. All mathematic operations and special operations are disabled.

5. 7½ digits are displayed on the 10V dc range, and 6½ digits are displayed on all other functions and ranges. A ± sign is displayed for all functions to facilitate potentiometer adjustment.

6. Calibration correction factors (for each range in volts dc, amps dc, ohms, and for volts ac functions at a frequency of interest) and the calibration date may be stored.

7-9. Zero correction values can be entered for each range in dc volts and ohms functions. Gain correction factors can be stored for each range in each function by appling a reference input and entering a numeric string representing that reference value. The multimeter then computes the gain correction factor necessary to read the reference value. Depending on the function being calibrated, gain corrections are made once or twice (for ± polarities) for each range.

7-10 The multimeter may be interrogated from local or remote locations (Cal Mode on or off) for the recall of zero values (volts dc or ohms) and the calibration date (or identification number). The last uncorrected reading (without any gain correction) can also be recalled from the front panel at any time. Uncorrected readings can be verified from a remote location by sending a calibration factor inhibit command (M) and commanding a new reading.

7-11. DETAILED DESCRIPTION/OPERATION

7-12. Software Cal Mode Switch

7-13. Entering the Cal Mode via the rear panel calibration switch enables use of the following two additional front panel data storage pushbuttons:

(CAL COR): for entering gain corrections
(CAL DATE): for entering the calibration date of the multimeter

7-14. The rear panel calibration switch also enables unique memory locations for the placement of permanent zero offset correction values (to be distinguished from the temporary zero offsets when not in the Cal Mode).

7-15. Zero Corrections

7-16. After the Cal Mode is activated, zero corrections can be made separately for each range in dc volts and ohms functions (other functions do not require them) without affecting values for other ranges. Each zero value stored is applied to subsequent readings in the selected range and function only. These values are stored permanently in Calibration Memory and can be changed only by storing new entries when Cal Mode is on.

7-17. Software calibration does not use the temporary zeros that can be stored during normal operation (with Cal Mode off). The temporary zeros are stored in a separate memory and do not affect the permanent zero values stored in Calibration Memory. The temporary zeros are used to correct for short-term dc drift.

7-18. Permanent zero values perform the same function as adjusting a zero potentiometer during a hardware calibration. Thus, they are continually applied to a measured reading in normal operation (Cal Mode off) whether the front panel zero mode is enabled or disabled. However, when the multimeter is in Cal Mode, turning off the zero mode disables these permanent zero values and prevents them from being applied to a reading. This feature allows adjustments of zero potentiometers during a hardware cal.

Modes	Zero Applied
Cal Mode on, zero off	No zeros applied
Cal Mode on, zero on	Permanent zero
Cal Mode off, zero off	Permanent zero
Cal Mode off, zero on	Permanent zero and temporary zero

7-19. STORE OPERATIONS

7-20. When permanent zeros are stored during calibration of the dc volts function, the INPUT HI and INPUT LO terminals must be shorted with a high-quality, low-thermal shorting bar. When permanent zeros are stored during calibration of the OHMS function, the four-wire configuration should be selected and the INPUT HI, INPUT LO, SENSE HI, and SENSE LO terminals shorted with a high-quality, low-thermal, four-terminal shorting bar. Shorting the test leads does not provide adequate connection for calibration.

7-21. To initialize the procedure, slide the rear panel switch to Cal Mode ([AVG/(CAL)] annunciator flashing) and disable the zero mode (ZERO annunciator off). The displayed reading will be the uncorrected short at the front panel.

7-22. A new permanent zero value can then be entered by pressing the ZERO VDC/OHMS pushbutton so that the ZERO annunciator turns on. This procedure stores a nonvolatile permanent zero value in Calibration Memory for the function and range presently selected. Applied permanent zero values can be altered from the front panel by reinitializing this procedure.

7-23. RECALL OPERATIONS

7-24. Zero values for dc volts or ohms can be recalled by pressing [RECALL][ZERO VDC/OHMS]. The recalled zero value may be either of the following:

1. If Cal Mode is off, the value recalled is a temporary zero.

2. If Cal Mode is on, the zero value recalled is the permanent zero value stored in Calibration Memory.

7-25. The RECALL operation can be repeated for each range without affecting the stored zero value(s) or the zero mode status. If the multimeter is in dc volts or ohms, the zero value for the range and function selected is recalled. If the multimeter is not in dc volts or ohms, an Error 0 condition is set.

7-26. Gain Corrections

7-27. Gain correction software performs the same function as adjusting a potentiometer for scale factor during a hardware calibration. The gain correction values are continually applied to a measured reading as soon as they are entered and continue to be applied whether Cal Mode is on or off.

7-28. Each gain correction value stored is applied to subsequent readings in the selected range and function only and does not affect values for other ranges or functions. These values are stored permanently in Calibration Memory and can be changed or erased only while in the Cal Mode.

7-29. Separate gain correction values for both positive and negative inputs can be stored for dc volts and dc amps functions. This operation must be performed twice (once for positive, once for negative) to ensure new correction values for the full range of possible inputs.

7-30. Achieving accurate gain correction values is contingent upon the application of accurate reference sources. A reference source input can be any value from 60% to full scale of multimeter range. Input signal parameters for each function are defined in Table 7-2. It is recommended that reference inputs near full scale be used to minimize reading errors.

7-31. STORE OPERATIONS

7-32. When storing gain corrections, set the calibration switch on the rear panel to on, and use the up/down range pushbuttons to set function and range to be calibrated. The permanent zero offset correction procedure must be performed before storing gain corrections for both the dc volts and ohms functions.

7-33. The reference source is applied to either the front panel INPUT HI and LO terminals or through the rear panel input connector. (The multimeter updates the displayed measurement.) The reference value defined by the source can be stored using the front panel push-

Table 7-2. Gain Correction Parameters

	RANGE	RECOMMENDED	MINIMUM	MAXIMUM
DC Volts	100 mV	.190V	60 mV	200 mV
	1V	1.9V	0.6V	2V
	10V	19V	6V	20V
	100V	120V	60V	128V
	1000V	1000V	600V	1200V
Ohms (1)	10Ω	20Ω	6Ω	20Ω
	100Ω	200Ω	60Ω	200Ω
	1 kΩ	2 kΩ	600Ω	2 kΩ
	10 kΩ	20 kΩ	6 kΩ	25 kΩ
	100 kΩ	200 kΩ	60 kΩ	250 kΩ
	1 MΩ	2 MΩ	600 kΩ	4.1 MΩ
	10 MΩ	20 MΩ	6 MΩ	35 MΩ
	100 MΩ	100 MΩ	60 MΩ	265 MΩ
DC Amps	100 μA	190 μA	60 μA	250 μA
	1 mA	1.9 mA	600 μA	2 mA
	10 mA	10 mA	6 mA	16 mA
	100 mA	100 mA	60 mA	128 mA
	1A	1.0A	600 mA	1.28A
AC Volts (2)	100 mV	120 mV	60 mV	125 mV
	300 mV	390 mV	180 mV	400 mV
	1V	1.2V	600 mV	1.25V
	3V	3.9V	1.8V	4V
	10V	12V	6V	12.5V
	30V	35V	18V	40V
	100V	120V	60V	125V
	500V	500V	300V	600V

Notes: 1. Four terminal connections must be used for soft-cal.
2. Gain corrections entered at 1 kHz, checked at 10 kHz and 100 kHz.

buttons. For example, for a reference of 1.9V dc on the 1V dc range, press [STORE][1.9][(CAL COR)].

7-34. The multimeter algorithmically computes the gain correction factor necessary to display the stored source value. This factor is then applied to all subsequent readings in this function and range.

7-35. Proper entry of the reference value can be verified by allowing the multimeter to take another reading. This reading should be the actual reference value (± accuracy specifications) for the multimeter function and range. The storage operation must be repeated for each range.

7-36. The volts dc function uses all three correction points (permanent zero, positive gains, and negative gains) and is used as an example in the following discussion (see Figure 7-1).

7-37. The volts dc function requires that zero, negative gain, and positive gain corrections be made. Assume that the 1V dc range is being calibrated. Zero corrections for volts dc (point A in Figure 7-1) is first performed with the multimeter input shorted. Front panel ZERO is turned off (annunciator off) and the DMM takes its first reading (Example: 0.000032V). The displayed reading is then stored as a permanent zero offset for the 1V dc range by pressing ZERO on the front panel (annunciator on).

7-38. The positive gain correction is then defined by removing the front panel short and inserting any reference value from 60% to full scale of the 1V dc range (see Table 7-2). To minimize the percentage of reading error and to avoid saturation of the DMMs a/d converter, a sample value of 1.9V is selected (point B in Figure 7-1). Allowing the DMM to make a measurement, the displayed sample

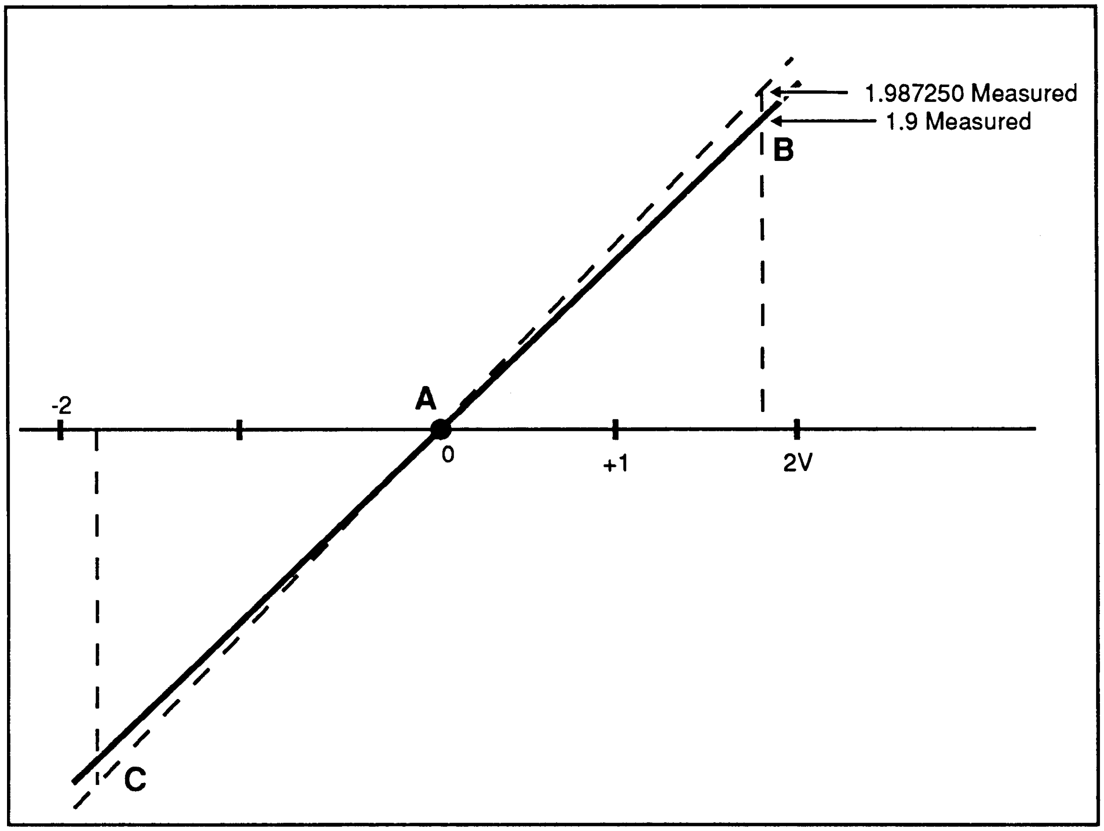


Figure 7-1. DC Voltage Calibration

value (without gain correction) would be 1.987250V (1.987282 minus the permanent zero offset correction).

7-39. The operator enters the reference input numerically by pressing [STORE] [1.9] [CAL COR]. Gain correction is then computed as:

$$\frac{\text{Reference Input}}{\text{Measured Value (Uncorrected) + Zero Correction}}$$

7-40. This linear correction factor is now applied to any input between 0 and +2V. Errors cause by polarity reversals can be eliminated by storing a separate correction factor that uses a negative voltage. A procedure identical to that used with a positive reference input yields a linear gain correction that is applied to all inputs between -2V and 0.

7-41. The final displayed value is then calculated as:

Displayed Reading = (Gain Correction) x [(Measured Value) + (Zero Correction)]

7-42. RECALL OPERATIONS

7-43. The last uncorrected gain reading can be recalled for display at any time (Cal Mode on or off). If the Cal Mode is on, the sequence used to recall the uncorrected reading is RECALL (CAL COR). If the multimeter is not in the Cal Mode, the sequence used is RECALL LO (CAL COR).

7-44. Calibration Date and Identification Number

7-45. The operator can enter up to six integers signifying the calibration date into the Calibration Memory from the front panel. The Cal Mode must be activated before entering the calibration date. The first two digits could represent the year, the third and fourth digits could define the month, and the fifth and sixth digits could represent the day. For example, January 2, 1983 is entered as [STORE][830102][(CAL DATE)].

7-46. In lieu of a calibration date, the operator can enter an instrument identification number from the front panel. An identification number of 242 is entered as [STORE][242][(CAL DATE)]. Only integers may be entered. If a decimal point or exponent is used, an Error C condition is set. The multimeter can store only one set of six integers at a time.

7-47. The last calibration date (or identification number) can be recalled for display at any time (Cal Mode on or off). When the Cal Mode is on, the procedure used to recall the number is RECALL (CAL DATE). If the multimeter is not in Cal Mode, the sequence used is RECALL LO (CAL DATE).

7-48. The calibration date (or identification number) can also be erased from the front panel by pressing [STORE] [(CAL DATE)].

7-49. Clear Operations

7-50. SELECTED CLEAR

7-51. While in the Cal Mode, the operator can erase individual gain correction factors by using the STORE (CAL COR) sequence (without numerics) once for each range in each function. Using STORE (CAL COR) once clears both positive and negative gain corrections for the selected range in volts dc or amps dc. This sequence will not erase any permanent zero values.

7-52. COMPREHENSIVE CLEAR

7-53. The operator can use a single operation to erase gain correction values for all ranges and functions, permanent zero correction values for all volts dc and ohms ranges, and the calibration date (or instrument identifier). This operation may be necessary if either of the following two conditions exist: an Error F condition (checksum error) cannot be cleared with a multimeter reset, or if it is necessary to clear software calibration entries for all functions prior to a total hardware calibration. The comprehensive clear procedure is as follows:

1. Activate Cal Mode via the rear panel calibration switch.

2. Press [STORE][ZERO VDC/OHMS] on the front panel. The display responds with: CLEAr?. The clear operation can then be aborted and the existing correction factors can be retained by pressing any pushbutton other than ZERO VDC/OHMS. The multimeter would then respond with a momentary Error C display and revert to the normal Cal Mode display.

3. Press [ZERO VDC/OHMS] again to complete the clear operation. Depending on the extent of Calibration Memory entries, the clear operation may require several seconds. Completion of the clear operation is verified by the removal of CLEAr?, a momentary blanking of the digit display, and extinguishing of the ZERO annunciator. If manual triggering is in effect, the display remains blank until the next manual trigger.

7-54. Error Conditions

7-55. The multimeter uses both momentary and latching error software features. A momentary error automatically clears, and further multimeter operation is not impaired. A latching error does not automatically clear and does impede further multimeter operation until the cause for the error has been corrected. Latching errors include Error, Error 2, Error 3, Error 4, Error 5, Error 9, and Error E. Latching errors are normally enabled but are afforded special treatment when the Cal Mode is on. The following rules then apply:

1. Latching errors are automatically enabled whenever Cal Mode is enabled or disabled with the rear panel calibration switch.

2. If the Cal Mode is on, latching errors can be disabled by pressing the [AVG] pushbutton. The display should respond with Err.°FF, indicating latching errors have been disabled. If a latching error exists when this procedure is performed, the display will indicate an error message. In this case, pressing any function pushbutton will clear the error message. Pressing [AVG] in the Cal Mode does not enable the Average Mode; the Average Mode is mutually exclusive with Cal mode.

CAUTION

Catastrophic damage to the instrument could occur if the latching error feature is disabled during software calibration. The latching error disable feature should be used only during troubleshooting when normally disallowed module configurations may be necessary. Since latching errors may identify an overvoltage condition (as with local Error 4 or remote error 14), proper safety precautions must be used.

3. If the latching errors have been disabled, they are reenabled and normal Cal Mode operation is restored when the AVG pushbutton is pressed again. If a latching error condition exists at this time, the error message is displayed. If no latching error exists, the multimeter front panel display responds with Err. on.

7-56. The front panel display identifies numerous error conditions. A full description of error conditions is presented in Section 2. The following list identifies error conditions specifically applicable to front panel calibration procedures.

1. Error 0: Store 0 error:
A zero STORE or RECALL has been attempted in an unallowed function. Zero corrections can be made only in volts dc or ohms.

2. Error 1: Store during overrange:
The STORE(CAL COR) sequence has been performed while the previously taken reading was an overrange. This reading cannot be used in the multimeter's gain correction computation. The applied source value must be revised immediately to fall within the limits defined in Table 2. Error 1 signifies that the gain correction factor has not been

stored. With a legal value applied to the multimeter, the numerics representing that value must be entered again with the STORE(CAL COR) sequence.

3. Error b: Not allowed in Cal Mode:
An unallowed pushbutton sequence has been attempted in the Cal Mode. Use the correct sequence once the display has cleared.

4. Error C: Invalid pushbutton sequence:
This error can occur under the following conditions:

- Numerics representing a value less than 60% of range or more than full scale have been entered during the STORE(CAL COR) sequence. Select a new value and repeat this sequence.

- The wrong sequence has been used to clear all Calibration Memory entries while in Cal Mode.

- Error C also occurs when attempting to clear all Calibration Memory entries when not in Cal Mode.

5. Error d: Calibration Memory is faulty or not installed.

6. Error F: Calibration Memory checksum error:
This error condition may occur when power is applied, when storing into Calibration Memory, or during a recall operation. It may be caused by an inadvertent cycling of input power when the multimeter is in the Cal Mode. Reset the multimeter. If Error F remains, it may be necessary to first clear, and then reenter, all correction factors, zero values, and the calibration date (or instrument identification number). If Error F recurs during either the clearing procedure or a subsequent programming attempt, the Calibration Memory may be faulty.

NOTE

If an error condition identifies a faulty Calibration Memory chip, refer to Calibration Memory Replacement in Section 4. If a new Calibration Memory is installed, the comprehensive clearing procedure should first be performed, followed by reprogramming of all desired entries.

7. Error H: Ohms input error:
This error can be caused by an open input during ohms measurements, a bad protection fuse, or a polarity reversal in connections for four-terminal ohms measurements.

8. Error 4: Excessive voltage present at inputs (OHMS, ADC, AAC): An improper input level has been used for ohms or resistance calibration. The appropriate function must be reselected, and the input level must be revised.

9. Error E: Invalid module configuration:
An illegal AC-Converter configuration. Only the Thermal True-RMS Converter is allowed. Additional AC-Converters must be removed.

7-57. LOCAL CALIBRATION

7-58. Table 7-3 lists reference sources sufficiently accurate to calibrate the multimeter. Reference source connections are described in Section 4 (standard functions) and Section 6 (optional functions). Reference source inputs can be made either at the front panel terminals (local) or through the rear input connector (remote). Local calibration is accomplished using the front panel pushbuttons.

CAUTION

Do not cycle input power to the multimeter when Cal Mode is activated. Interruption of input power could damage Calibration Memory entries when the multimeter is in Cal Mode.

NOTE

If a new Calibration Memory is installed, the comprehensive clearing procedure should first be performed, followed by reprogramming of all desired entries.

7-59. DC Voltage

7-60. PERMANENT ZEROS

7-61. The following procedure describes how to manually calibrate dc voltage using permanent zeros:

1. Enable the Cal Mode by sliding the rear panel calibration switch to on (AVG/(CAL) annunciator flashes).

2. Select the volts dc function and 100 mV range, (using the range [arrow down] pushbutton).

3. Apply a good-quality, low-thermal shorting bar between INPUT SENSE HI and the LO terminal. Allow sufficient thermal voltage settling time before proceeding to the next step.

4. Press the [ZERO VDC/OHMS] pushbutton to off (zero annunciator off).

5. Allow the multimeter to take at least one reading, then press the [ZERO VDC/OHMS]

Table 7-3. Reference Sources

NOMENCLATURE	MINIMUM USE SPECIFICATIONS	RECOMMENDED EQUIPMENT
	DC Voltage	
DC Source	High Short-Term Stability (0-1100V)	Fluke Model 335A
Null Detector	10 μV Full-Scale Resolution	Fluke Model 335A
Kelvin-Varley Divider	Lineartiy ±1 ppm of Input	Fluke Model 750A
Standard Cell Enclosure	Guildline 91	Guildline 9152®
	Ohms 4-Terminal Set-Up	
Standard Resistors	20Ω: 30 ppm 200Ω - 20 MΩ: 50 ppm 200 MΩ: 100 ppm	ESI SR-1010 ESI SR-1050
	DC Current	
DC Current Calibrator	Accuracy ±.02%	Fluke Model 382A
200 kΩ Resistor	Accuracy ±.01%	
	AC Current	
AC Current Calibrator	Verification Dependent	Fluke Model 5100

pushbutton again to initialize the zero mode (zero annunciator on). This stores a permanent zero for this range only.

6. Manually select the next higher volts dc range, (using the range [arrow up] pushbutton). Repeat steps 4 and 5. In sequence, repeat these steps for each higher volts dc range. This procedure ensures that a discrete permanent zero value is stored for each volts dc range.

7. Remove the shorting bar.

7-62. GAIN CORRECTIONS

7-63. Refer to Table 7-2 and select the reference value for the range being calibrated. Generally, any value between 60% of range and full scale may be selected. However, values near the full scale point ensure minimum percentage of reading error. The values given in the following steps (in parentheses) are recommended to both minimize percentage of reading error and avoid saturation problems. Perform the following procedure to store positive gain corrections:

1. Verify that the UUT is still in Cal Mode (Cal/(AVG) annunciator flashes).

2. Manually select the 10V range. With the reference value (19.000000V) applied to INPUT SENSE HI and LO terminals, press [STORE] (numerics of reference value) [(CAL COR)]. Ignore polarity when entering numerics for the reference value. The gain correction is automatically applied to the next reading in this range.

3. Verify proper reference value entry by observing that subsequent readings equal the known reference value (± multimeter accuracy specifications). If necessary, recall the uncorrected reading for comparison by using the RECALL (CAL COR) sequence.

4. Manually select the 100 mV range, apply an appropriate reference value (0.190V), allow the multimeter to take one reading, then press [STORE] (reference numerics) [(CAL COR)] once again, and verify the result.

5. Repeat this entry procedure in sequence for the 1V, 100V, and 1000V dc ranges. The following reference values are recommended:

RANGE	VALUE
1V	1.9000000V
100V	120.00000V
1000V	1000.0000V

7-64. The following steps store negative gain corrections for each range.

WARNING

HIGH VOLTAGE MAY EXIST AT THE REFERENCE SOURCE AND MULTIMETER TERMINALS. TO AVOID SHOCK HAZARD, USE CAUTION WHEN PEFORMING THE FOLLOWING PROCEDURE.

1. Set the reference output to zero and then reverse the input connections to the multimeter.

2. Manually select the 10V range on the multimeter. With the reference value (19.000000V) applied to INPUT SENSE HI and LO terminals, press [STORE] (numerics of reference value) [(CAL COR)]. Ignore polarity when entering numerics for the reference value. The gain correction is automatically applied to the next reading in this range.

3. Verify proper reference value entry by observing that subsequent readings equal the known reference value (± multimeter accuracy specifications). If necessary, recall the uncorrected reading for comparison by using the RECALL (CAL COR) sequence.

4. Manually select the 100 mV range, apply an appropriate reference value (0.190V), allow the multimeter to take one reading, then press [STORE] (reference numerics) [(CAL COR)] once again, and verify the result.

5. Repeat this entry procedure in sequence for the 1V, 100V, and 1000V dc ranges. The following reference values are recommended:

RANGE	VALUE
1V	1.9000000V
100V	120.00000V
1000V	1000.0000V

6. Set the reference output to zero, and then remove connections between the reference source and the multimeter. The dc voltage calibration is now complete.

7. Disable the Cal Mode by sliding the rear panel switch to OFF (if no further calibration is required).

7-65. AC Volts

7-66. AC voltage software calibration involves storing only one gain correction factor for each range. Permanent zero values and plus/minus polarities are not applicable for the VAC functions.

7-67. The same sequence (1-kHz reference signal applied at a level between 60% of range and full scale) is used for each range in High Accuracy mode. Accuracy is then checked at several higher frequencies. Gain corrections stored in High Accuracy mode are subsequently applied to all ac volts modes (High Accuracy, Enhanced, or Normal). A separate set of gain corrections can be stored for the AC + DC function. Reference source connections are described in Section 4 of this manual.

7-68. Refer to Table 7-2 to select the reference value for the range being calibrated. Generally, any value between 60% of range and full scale may be selected. However, values near the full scale point ensure minimum percentage of reading error. The values given in parentheses in the following steps are recommended to minimize percentage of reading error and avoid saturation problems.

NOTE

Four-terminal configurations must be used for VAC gain corrections to minimize input capacitance and attain accuracy specifications.

1. Activate Cal Mode by sliding the rear panel calibration switch to ON (AVG/(CAL) annunciator flashes). Remember never to cycle input power to the multimeter when Cal Mode is on. (See the caution under the heading Local Calibration.)

2. Select the ac volts high accuracy function (VAC HI ACCUR) and 100 mV range.

3. Select the appropriate reference value (see Table 7-2). Recommended values are as follows:

RANGE	VALUE
100 mV	120 mV @ 1 kHz
300 mV	390 mV @ 1 kHz
1V	1.2V @ 1 kHz
3V	3.9V @ 1 kHz
10V	12V @ 1 kHz
30V	35V @ 1 kHz
100V	120V @ 1 kHz
500V	500V @ 1 kHz

4. Apply this value to the INPUT HI and LO terminals. Ensure that the four-terminal ohms selector is pressed in to minimize input capacitance.

5. Allow the multimeter to take at least one reading, then press [STORE] (reference value numerics) [(CAL COR)]. The multimeter computes the gain correction factor and automatically applies it to the next reading in this range.

6. Verify proper reference value entry by observing that subsequent readings equal the known reference value (± accuracy specifications). If necessary, recall the uncorrected reading for comparison by using the [RECALL] [(CAL COR)] sequence.

7. Verify accuracy at higher input frequencies. The required check frequencies are 10 kHz and 100 kHz.

8. Manually incrementing for range, repeat steps 3 through 7 for each of the higher ranges in order (300 mV, 1V, 3V, 10V, 30V, 100V, 500V).

WARNING

HIGH VOLTAGE MAY EXIST AT THE REFERENCE SOURCE AND MULTIMETER TERMINALS. USE CAUTION WHEN PERFORMING THE FOLLOWING STEPS.

9. Set the reference output to zero, and then remove all connections. The ac volts calibration is complete once gain corrections have been entered for each of the eight ranges. If software calibration is required for the VAC + VDC function, repeat the entire procedure for that function.

10. Disable the Cal Mode by sliding the rear panel calibration switch to OFF (if no further calibration is required).

7-69. Ohms

7-70. Ohms software calibration is accomplished using both permanent zero correction factors and gain corrections for each range. Four-terminal configuration must be used for accurate measurements. Reference source connections are described in Section 6 of this manual. Remember never to cycle input power to the multimeter when the Cal Mode is on. (See the caution under the heading Local Calibration.)

7-71. PERMANENT ZEROES

7-72. Use the following steps to calibrate ohms using permanent zero correction factors:

1. Enable the Cal Mode by sliding the rear panel calibration switch to on (AVG/(CAL) annunciator flashes).

2. Select the OHMS function and manually select the lowest range (10Ω).

3. Apply a good quality, low-thermal shorting bar to the HI and LO inputs in a four-wire configuration. If connections are made at the front panel terminals, the Ohms Selector must be in (4T) and the Guard Selector must be out (internal guard). Allow sufficient thermal voltage settling time before proceeding to the next step.

4. Press the [ZERO VDC/OHMS] pushbutton (zero annunciation OFF).

5. Allow the multimeter to take at least one reading, then press the [ZERO VDC/OHMS] pushbutton (zero annunciator on). This stores a discrete permanent zero for this range.

6. Manually select the next higher OHMS range. Allow the multimeter to take at least one reading, then press [ZERO VDC/OHMS] (zero annunciator off). Let the multimeter take a new reading, then press [ZERO VDC/OHMS] again (zero annunciator on). In sequence, repeat this step for each higher OHMS range. This procedure ensures that a discrete permanent zero value is stored for each of the eight ohms ranges.

7. Remove the shorting bar.

7-73. GAIN CORRECTIONS

7-74. Refer to Table 7-2 to select the reference value for the range being calibrated. Generally, any value between 60% of range and full scale may be selected. However, values near the full scale point ensure minimum percentage of reading error. The values given in the following steps (in parentheses) are recommended to both minimize percentage of reading error and avoid saturation problems.

1. Verify the Cal Mode is still enabled (AVG/(CAL) annunciator flashes).

2. Manually select the lowest ohms range (10Ω). With the reference resistance for the 10-ohm range (19Ω) applied to the SOURCE/SENSE HI and LO terminals (four-wire configuration), allow the multimeter to take at least one reading and then press [STORE] (reference numerics) [(CAL COR)]. The gain correction is automatically applied to the next reading in this range.

3. Verify the proper reference value has been entered by observing that subsequent readings equal the known reference value (± multimeter accuracy specifications). If necessary, recall the uncorrected reading for comparison by using the [RECALL] [(CAL COR)] sequence.

4. Manually increment the range and apply an appropriate reference resistance value. Allow the multimeter to take at least one reading and press [STORE] (reference numerics) [(CAL COR)]. Repeat this step for each higher OHMS range (total of eight). Recommended reference resistance values are as follows:

RANGE	VALUE
10Ω	19Ω
1 kΩ	1.9 kΩ
10 kΩ	19 kΩ
100 kΩ	199 kΩ
1 MΩ	1.9 MΩ
10 MΩ	19 MΩ
100 MΩ	99 MΩ

5. The ohms resistance calibration is now complete. Disconnect the reference resistance source and disable the Cal Mode by sliding the rear panel calibration switch to OFF.

7-75. DC Current

7-76. DC current calibration is very similar to the positive and negative gain corrections used with volts dc calibration (permanent zero correction values are not required.) Remember never to cycle input power to the multimeter when the Cal Mode is on. (See the caution following the heading Local Calibration.)

7-77. Refer to Table 7-2 to select the reference value for the range being calibrated. Generally, any value between 60% of range and full scale may be selected. However, values near the full scale point ensure minimum percentage of reading error. The values given in the following steps (in parentheses) are recommended to both minimize percentage of reading error and avoid saturation problems. Reference Source connections are described in Section 6 of this manual.

1. Enable the Cal Mode by sliding the rear panel calibration switch to ON (AVG/(CAL) annunciator flashes).

2. Select the DC Current function and manually select the lowest range (100 μA).

3. Select the appropriate reference value (see Table 7-2). Recommended values are as follows:

RANGE	VALUE
100 μA	190 μA
1 mA	1.9 mA
10 mA	10 mA
100 mA	100 mA
1A	1.0A

4. Ensure that the reference value for the 100 μA range (190 μA) is applied to the INPUT SOURCE HI and LO terminals (not the Sense terminals). Allow the multimeter to take at least one reading, then press STORE (numerics of reference value) (CAL COR). Ignore the polarity when entering the reference value numerics. The gain correction is automatically applied to the next reading in this range.

5. Verify the proper reference value has been entered by observing that subsequent readings equal the known reference value (± multimeter accuracy specifications). If necessary, recall the uncorrected reading for comparison by using the RECALL (CAL COR) sequence.

6. Manually increment the range and apply the appropriate reference value. Allow the multimeter to take at least one reading, then press STORE (reference numerics) (CAL COR). Repeat this step in sequence for each higher dc current range.

NOTE

The following steps store negative gain corrections for each range.

7. Set the reference output to zero amps and reverse the input connections to the multimeter.

8. Manually select the 100 μA range and repeat steps 2 through 6. Ignore polarity when entering the reference value numerics.

9. Set the reference output to zero amps and remove all connections to the multimeter. Front panel dc current calibration is complete once positive and negative gain corrections have been entered for each of the five ranges. If no further calibration is required, disable the Cal Mode by sliding the rear panel switch to OFF.

7-78. REMOTE CALIBRATION

7-79. Remote calibration procedures are similar to those used for local (front panel) calibration. The parameters defined in Tables 7-1 and 7-2 are also used in remote calibration. Remote calibration is performed using any of the remote interface options available for the multimeter (IEEE-488, Bit Serial, or Parallel). The multimeter must be in local control before the Cal Mode is enabled.

7-80. Zero Corrections

7-81. Storing zero values involves separate commands for the dc voltage and resistance functions. Cal Mode must be enabled when storing zero correction values during software calibration. A high-quality, low-thermal shorting bar must be applied across the input terminals. The zero value is stored as an offset (in the dc voltage function) by first allowing sufficient thermal voltage settling time, verifying that the multimeter has returned at least one reading, and then sending the K0 command. This operation stores the last reading as a dc voltage zero in the existing range and function. Ohms zero values are sorted using the K1 command. Remote commands M1 (inhibit all zero values) and M2 (enable all zero values) can be sent at any time without affecting the stored values.

7-82. Gain Corrections

7-83. Gain corrections are initiated remotely with the KNG command. Reference values are the same as those used for front panel calibration. Source connections for standard functions are described in Section 4. Source connections for optional functions are described in Section 6. Remote verification of Cal Mode status can be made by sending the G5 command. A returned 0 signifies that the Cal Mode is off, and a returned 1 signifies that the Cal Mode is on.

7-84. Remote calibration for each range and function is accomplished by first taking a reading of the reference input and then programming the actual reference value. The programming step consists of the KNG command, followed by numerics representing the reference value. The first non-numeric following this entry terminates the numeric entry.

7-85. Calibration Date and Identification Number

7-86. The calibration date or identification number can be programmed remotely with the KND command. As in front panel calibration, Cal Mode must first be activated. A maximum of six digits can be programmed following the KND command. The digits programmed with KND command can be recalled at any time (Cal Mode on or off) by sending the G4 command.

7-87. Recall Operations

7-88. Various commands are used to recall calibration entries. The following list identifies these commands:

1. G0: Recall the dc voltage zero value. If the multimeter is in the dc voltage function, the zero value for the existing range is returned. If some other function is selected, the zero value for the 100 mV range is returned.

2. G2: Recall multimeter configuration and send on next trigger. This recall command is useful when determining the multimeter type and identification number, verifying the installed modules prior to a performance test or calibration, and identifying the cause of an error 24 (illegal module configuration). A 22-character response identifies the multimeter and its hardware configuration as follows:

   a. Characters 1-5: the model number (e.g., 8505A)

   b. Characters 6-8: a special number (or blank)

   c. Character 9: a colon (:)

   d. Characters 10-22: 13 characters identifying the loaded modules.

      D = DC Signal Conditioner
      F = Active Filter
      C = A/D Converter
      1 = Averaging AC Converter (Option -01)
      2 = Ohms Converter (Option -02A)
      3 = Current Converter (Option -03)
      4 = Not used
      5 = IEEE-488 Interface (Option -05)
      6 = Bit Serial Interface (Option -06)
      7 = Parallel Interface (Option -07)
      8 = Isolator
      9 = True-RMS Converter (Option -09A)
      A = Thermal True-RMS Converter

Any module not installed is noted with a (-) in the response. Example: A response of DFC—3-5—8-A would identify a standard dc volts (DFC) and thermal true-rms volts (A) configuration with the Isolator (8) and options for dc current (3) and IEEE-488 interface (5).

NOTE

The 8505A can use either the Ohms Converter (Option -02A) or the Current Converter (Option -03). In addition, only one interface (Option -05, -06, or -07) can be installed at one time.

3. G4: recall the calibration date or instrument identification number on the next trigger. A total of six digits is returned (there is no leading zero suppression).

4. G5: recall Cal Mode status. A returned 0 identifies Cal Mode off, and a returned 1 identifies Cal Mode on.

5. G6: recall the ohms zero value. If the multimeter is in the ohms function, the zero value for the existing range is returned. If some other function is selected, the zero value for the 10 ohm range is returned.

6. M: inhibit calibration factors. Remotely, both zero correction values and gain correction factors can be inhibited or enabled with the following commands:

M inhibit gain correction factors
M0 enable gain correction factors
M1 inhibit zero values
M2 enable zero values

7-89. Clear Operations

7-90. The following procedures are used to remove or replace Calibration Memory entries from the remote location:

- In the dc volts or ohms function, zero correction values can be replaced by entering new values. Existing values can be inhibited by sending the M1 command (or enabled with the M2 command).

- Any Calibration Memory gain correction entry can be replaced by merely making a new entry. Where multiple gain correction factors are stored (as in dc volts), separate new factors must be stored (one for positive gain, one for negative gain).

- Gain correction factors for the function selected can be erased by using the K N G 0 command string once for each range. Using K N G 0 once clears both positive and negative gain corrections for the selected range in dc volts (V) or dc amps (I).

- All calibration factors can be inhibited (but not cleared) with the M command. The M0 command reapplies these factors.

CAUTION

If any interrupting command is sent immediately after K4 (and before G1), the comprehensive clearing operation may be interrupted before to completion. A checksum (error 25) condition would then be set. Do not send any interrupting command (immediate characters, reset, etc.) between K4 and G1.

- If it is necessary to clear all calibration factors (as in a checksum error 25 condition or before hardware calibration of all functions), the K4G1 command string can be used. Depending on the number of entries being cleared, several seconds may be necessary to complete this operation. Completion of this comprehensive clearing operation is verified by return of the status response.

7-91. Error Conditions

7-92. An error condition is identified by a user-defined response. The operator responds by entering the K3 command, followed by any combination of up to 15 characters. For example, an obviously illegal response of 1E20 could be specified to flag an error condition. If an error exists, the 1E20 response is returned whenever a reading is attempted. The G1 (get status) command must then be sent to identify and note the specific error. This command can only be used once for each error response generated. The following error codes (defined in the first and second characters of the G1 response) may be encountered during remote calibration:

08 Command string error.

10 VDC/OHMS Zero error.

14 Excessive voltage present (Ohms or Current function). This is a latching error condition and requires revision of the input level and reselection of the appropriate function before further calibration.

16 Numeric display overflow.

23 The Calibration Memory is faulty or not installed.

24 Illegal module configuration. The wrong ac converter(s) may be installed. The 8505A uses only the Thermal True-RMS Converter. Remove any disallowed module.

25 The Calibration Memory checksum is wrong. This error condition may occuwhen applying power, when storing into Calibration Memory, or when recalling a Calibration Memory entry. The error may be caused by an inadvertent cycling of power when the multimeter is in the Cal Mode. Reset the multimeter. If error 24 remains, it may be necessary to first clear, and then reenter, all correction factors, zero values, and the calibration date (or instrument identification number). If error 25 recurs during the clearing procedure or during any subsequent programming attempt, the Calibration Memory may be faulty.

NOTE

If an error condition identifies a faulty Calibration Memory chip, refer to Calibration Memory replacement in Section 4. If a new Calibration Memory is installed, the comprehensive clearing procedure should first be performed, followed by reprogramming of all desired entries.

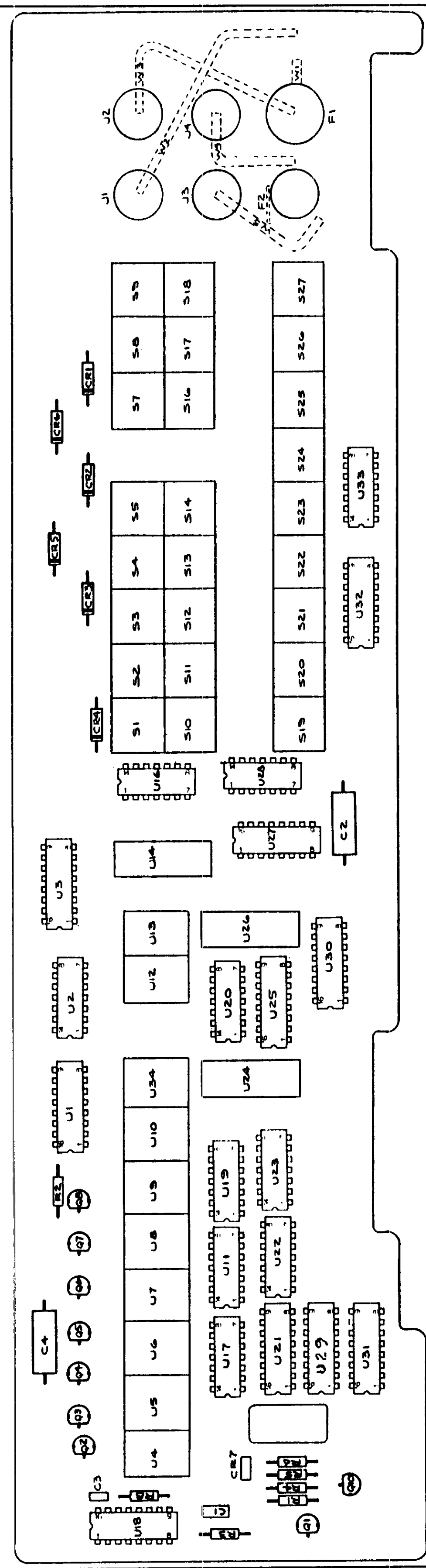
27 Ohms connections are faulty. Error 27 can occur when an ohms connection is open, a protection fuse is bad, or a polarity reversal has been made with the four-terminal connection.

Section 8
Schematic Diagrams

TABLE OF CONTENTS

LIST OF MNEMONICS

A0-A15	Address bus on controller
ACK	Acknowledge signal from module
ACKINT	Interrupt generated when module does not respond
CPUINT	Interrupt signal for μP
CPUREADY	Ready signal for μP
CPURESET	Reset signal
D0-D7	Data bus on controller
DBIN	Data bus input signal (from μP)
DLDACK	Delayed version of ACK
EXTCOM	Module communication signal
EXTINT	Interrupt from module
FLINE	Shaped line frequency signal
8xFLINE	8 times line frequency
FRONT/REAR	Front or rear input signal
IC0-IC7	Module address/control bus
ICENABLE	Enable module address signal
ID0-ID7	Module data bus
INA	Interrupt acknowledge signal in response to EXTINT
INP	I/O status signal
INTA	Interrupt acknowledge status signal
INTCLR	Clear interrupt signal
LINEREF	Line reference signal, bus input on RT5
MARKINT	Interrupt to synchronize to line frequency
Ø1	One phase of μP clock
Ø2	Other phase of μP clock
OUT	I/O status signal
READY	Signal to generate CPUREADY
RESET	Reset signal
RUN	Exit wait state signal
SCANADV	Scan advance signal, A/D conversion complete
STOP	Enter wait state signal
STSTB	Clock signal to latch μP status
SYNC	Signal from μP, used to generate STSTB
SYNCDEXTINT	Synchronized interrupt from module
Vbb	-5V supply
Vcc	+5V supply
Vdd	+12V supply
Vgg	-12V supply
Vss	Logic common
WAIT	μP in wait state signal
WR	Write data signal from μP



8505A-1601

Figure 8-1. A1 Front Panel Display PCB Assembly

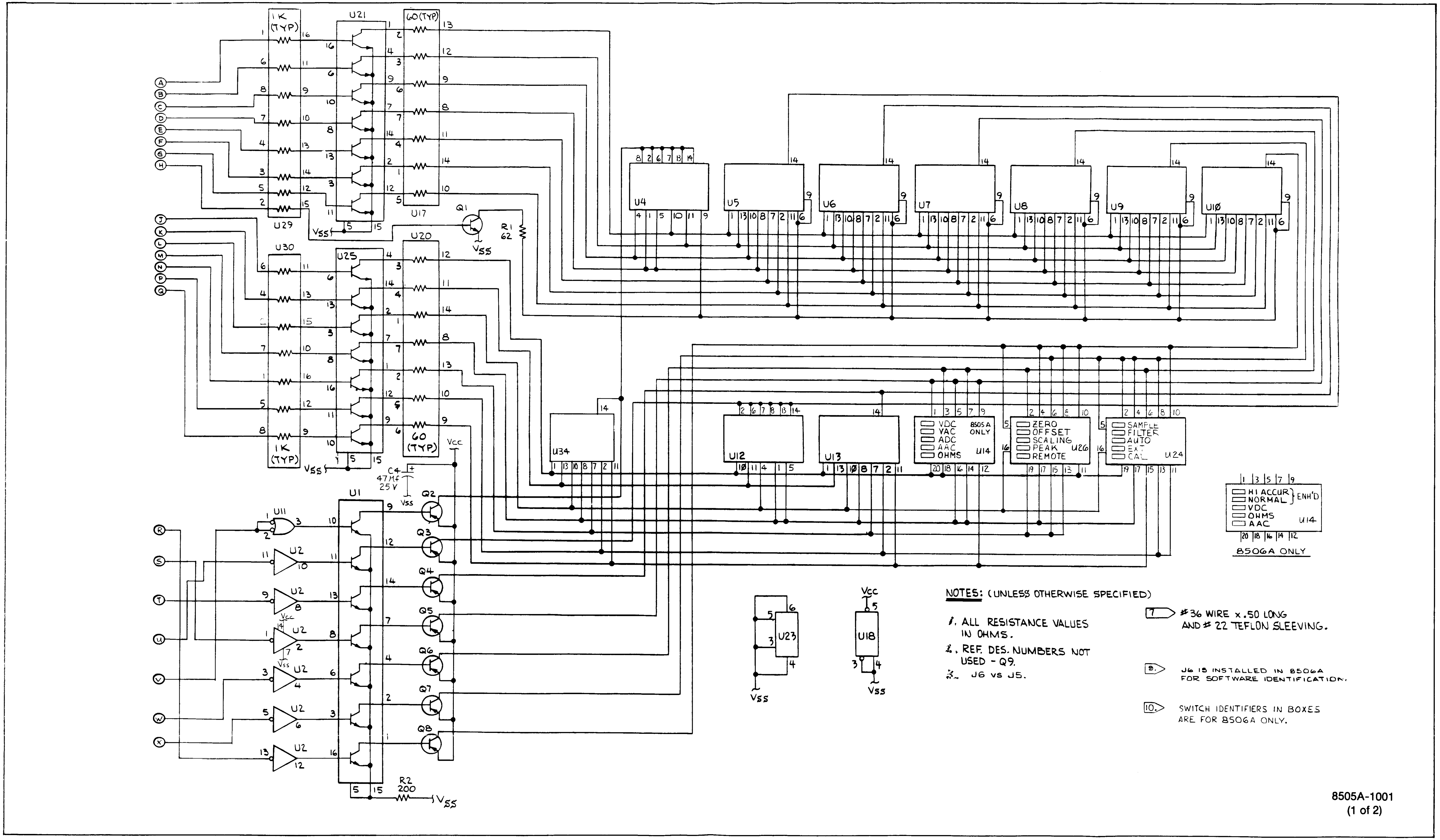
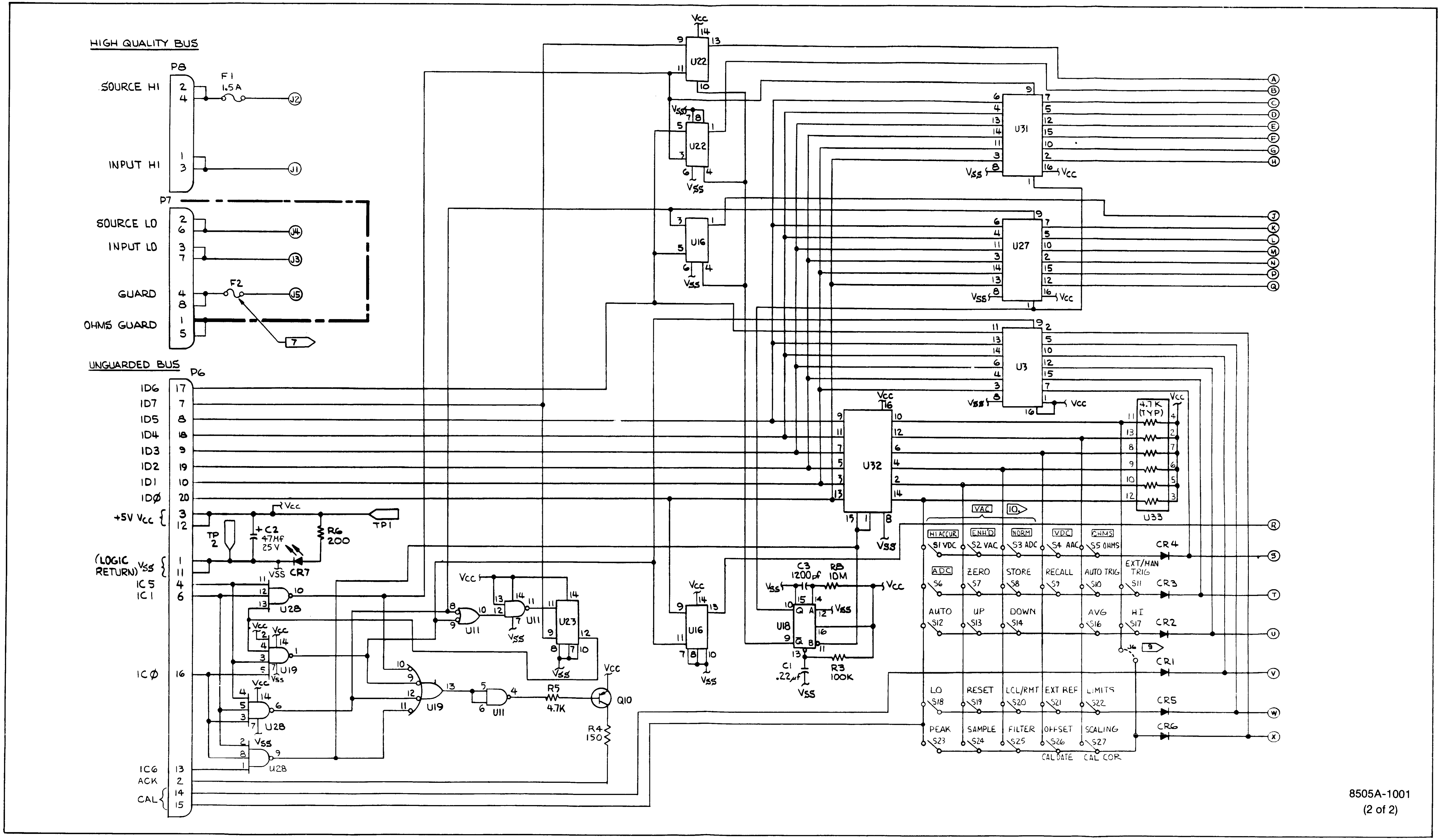


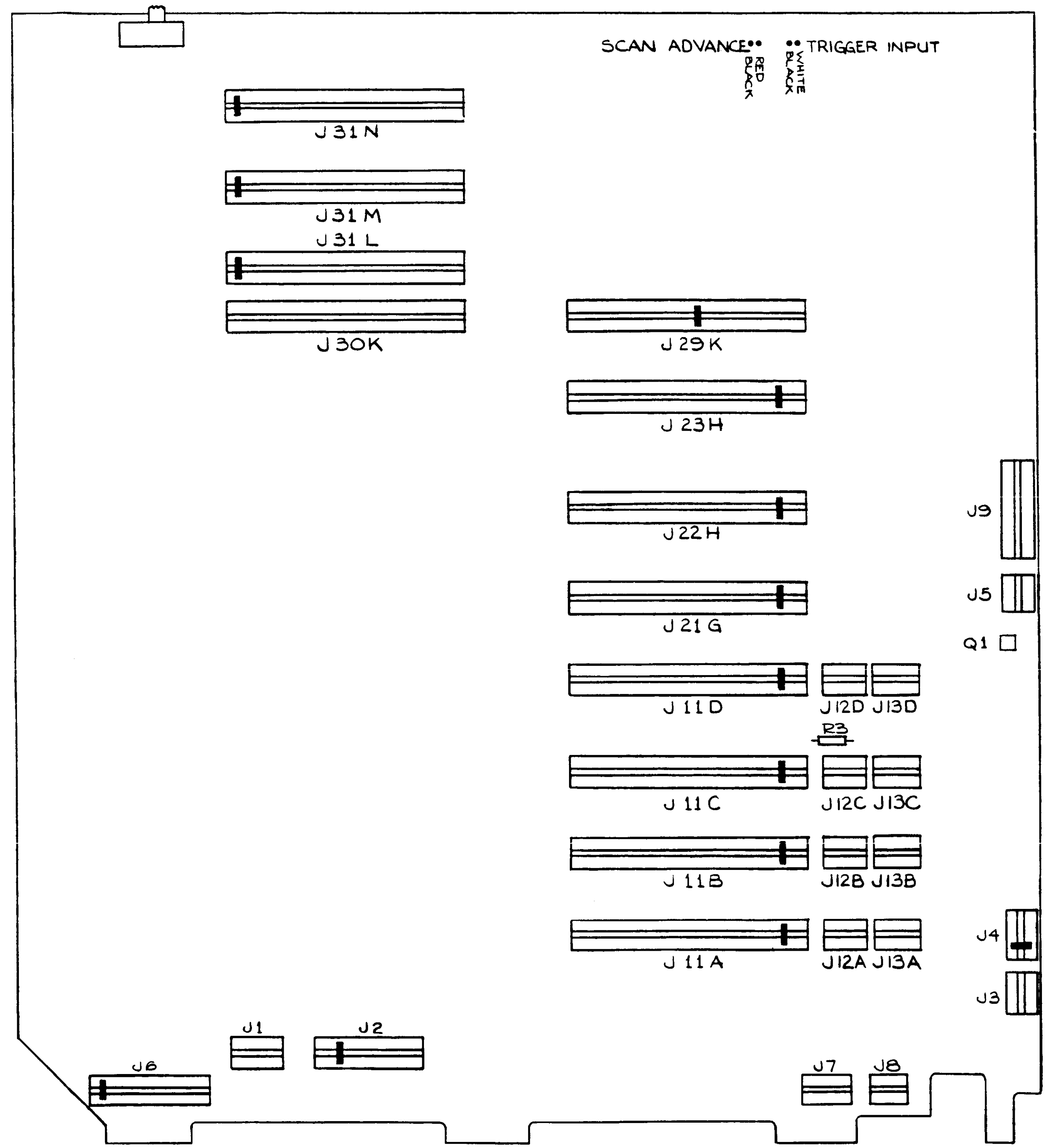
Figure 8-1. A1 Front Panel Display PCB Assembly (cont)



8505A-1001
(2 of 2)

Figure 8-1. A1 Front Panel Display PCB Assembly (cont)

SLOT	8505A	8506 A
N	-05,-06, OR -07	-05,-06, OR -07
M	CONTROLLER	CONTROLLER
L	CONTROLLER	CONTROLLER
K	-08A OR BUS INTERCONNECT	-08A OR BUS INTERCONNECT
H	A/D CONVERTER	A/D CONVERTER
H	A/D CONVERTER	A/D CONVERTER
G	ACTIVE FILTER	ACTIVE FILTER
D	-02,-03,-01, OR -09A**	THERMAL TRUE RMS CONVERTER
C	DC SIGNAL CONDITIONER	THERMAL TRUE RMS CONVERTER
B	-02,-03,-01, OR -09A**	DC SIGNAL
A	-02,-03,-01, OR -09A**	-02 OR 03



8505A-1602

Figure 8-2. A2 Motherboard PCB Assembly

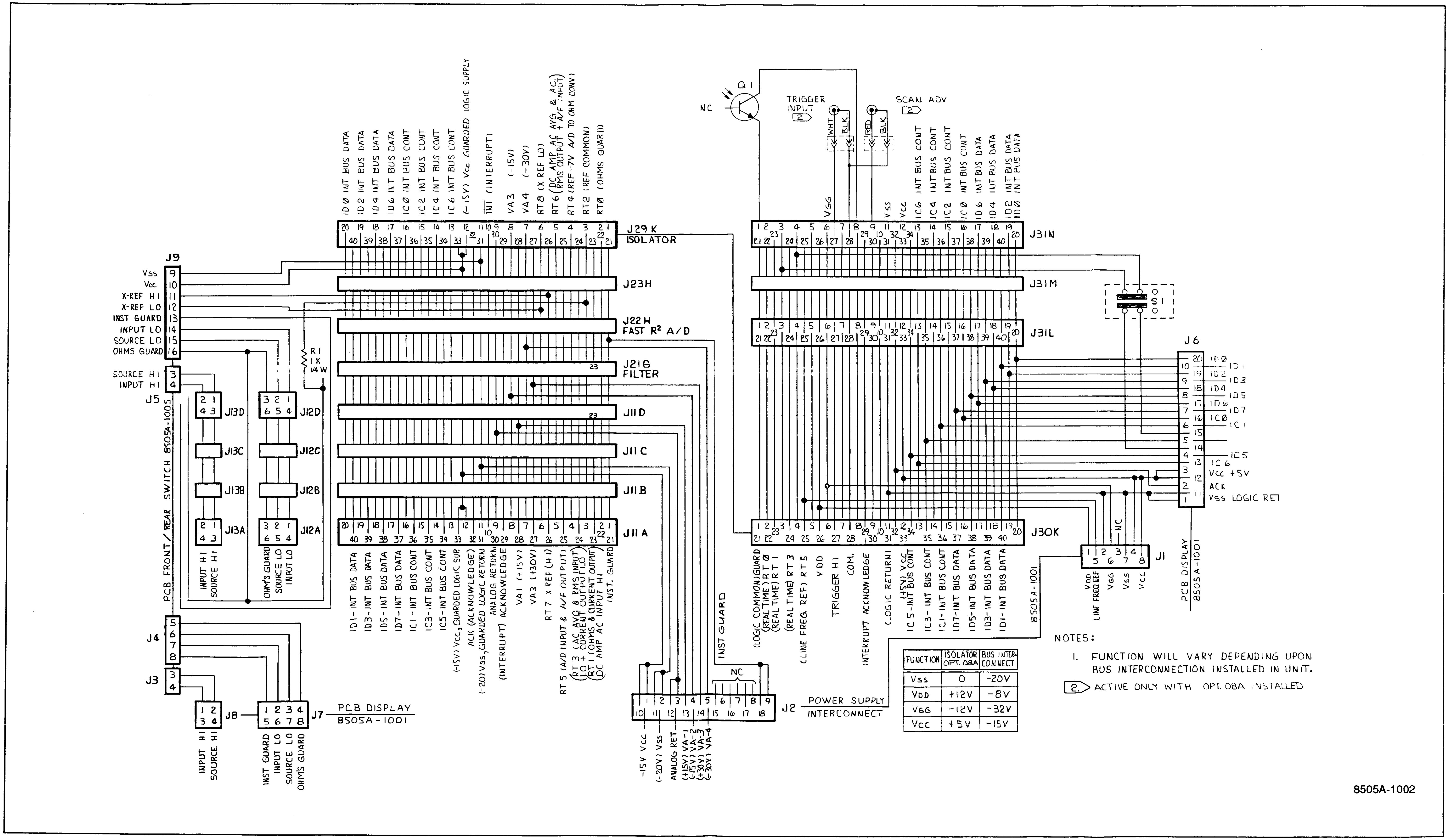


Figure 8-2. A2 Motherboard PCB Assembly (cont)

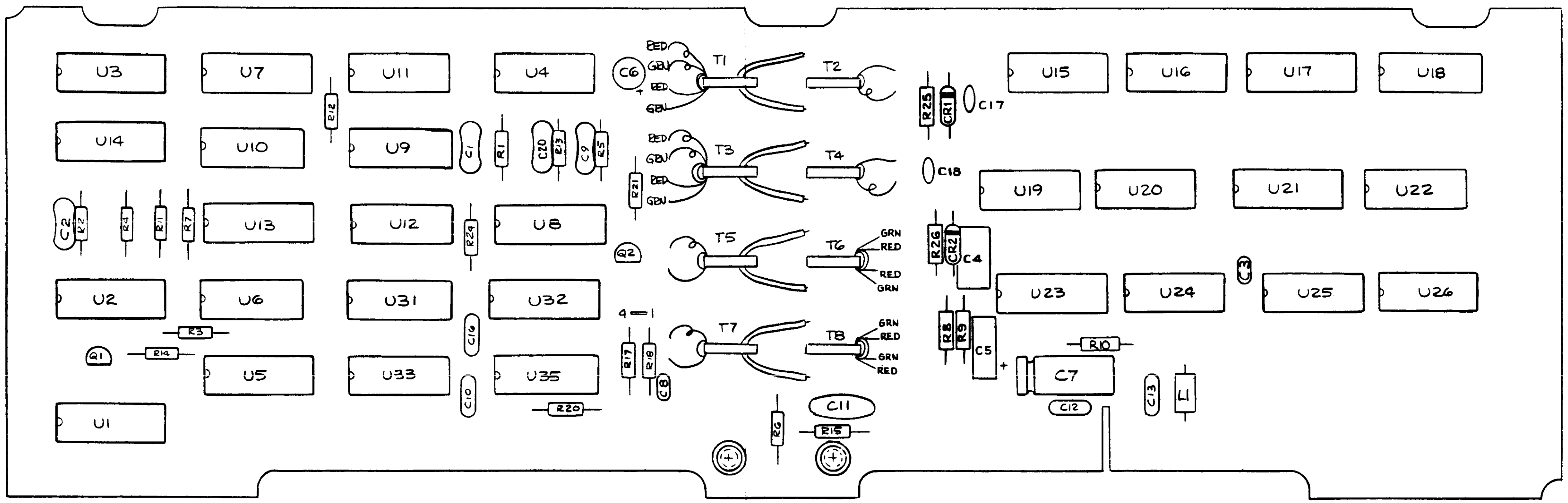
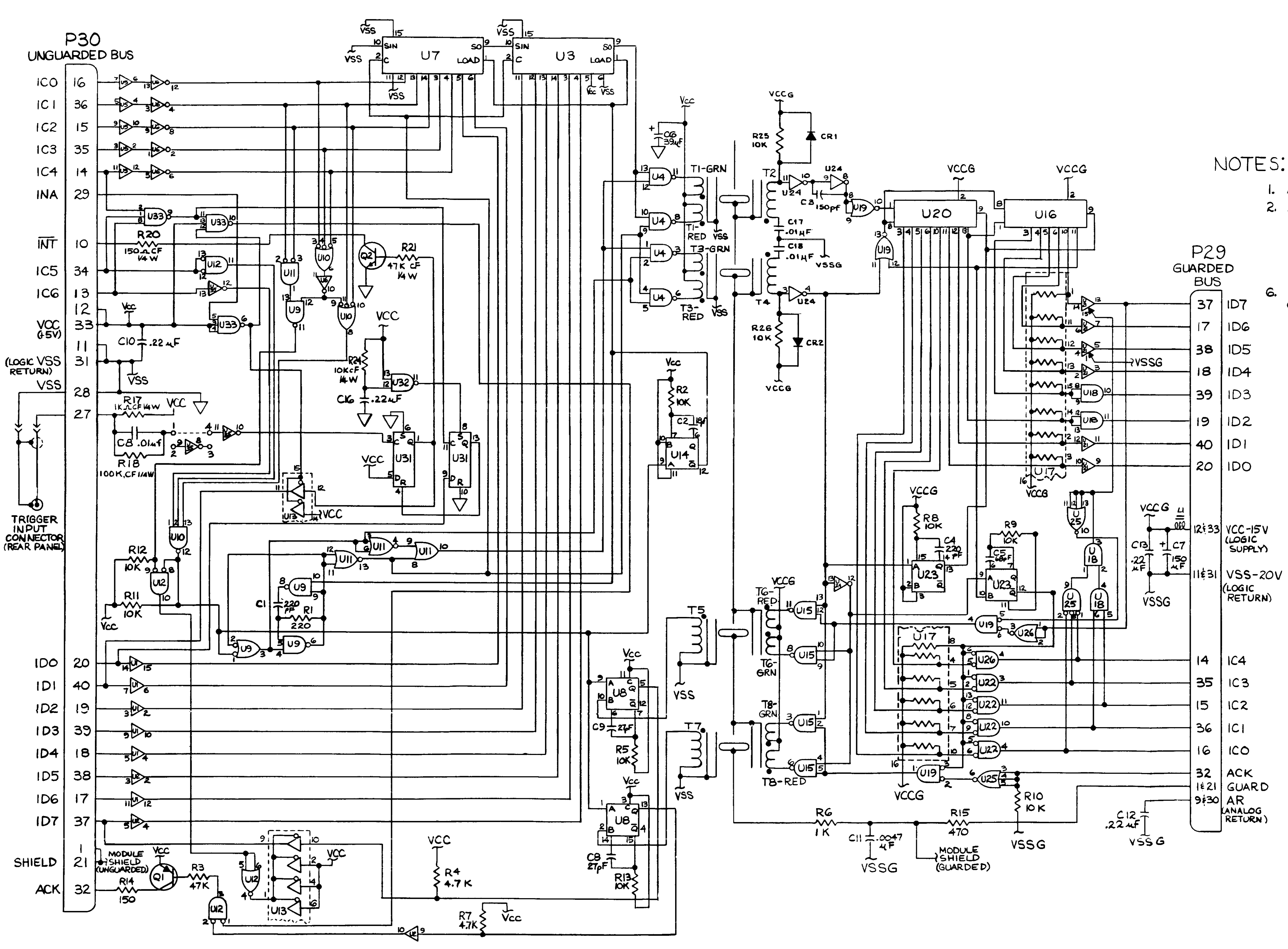


Figure 8-3. A3 Isolator PCB Assembly



NOTES: UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTANCE IN OHMS.
2. ALL RESISTORS 1/4W 5%.

6. REF. DES. NO'S. LAST USED; C19, CR2, R26, U26, Q2, T8.

UNGUARDED BUS SIDE		
I.C. NO	VCC	VSS
U32	1,2,5,6,8, 9, 14	7
U1	1	8
U2	1, 11, 14	7, 8
U3, U7, U8, U13, U14	16	8
U4, U6, U9, U10, U11, U12, U31, U33	14	7
U5	1, 14	8
U35	1,3,5, 14	7

GUARDED BUS SIDE		
I.C. NO.	VCC	VSS
U15, U16, U19, U20, U22, U24, U25, U18	14	7
U21, U23	16	8
U26	8,9,12, 13, 14	7

Figure 8-3. A3 Isolator PCB Assembly (cont)

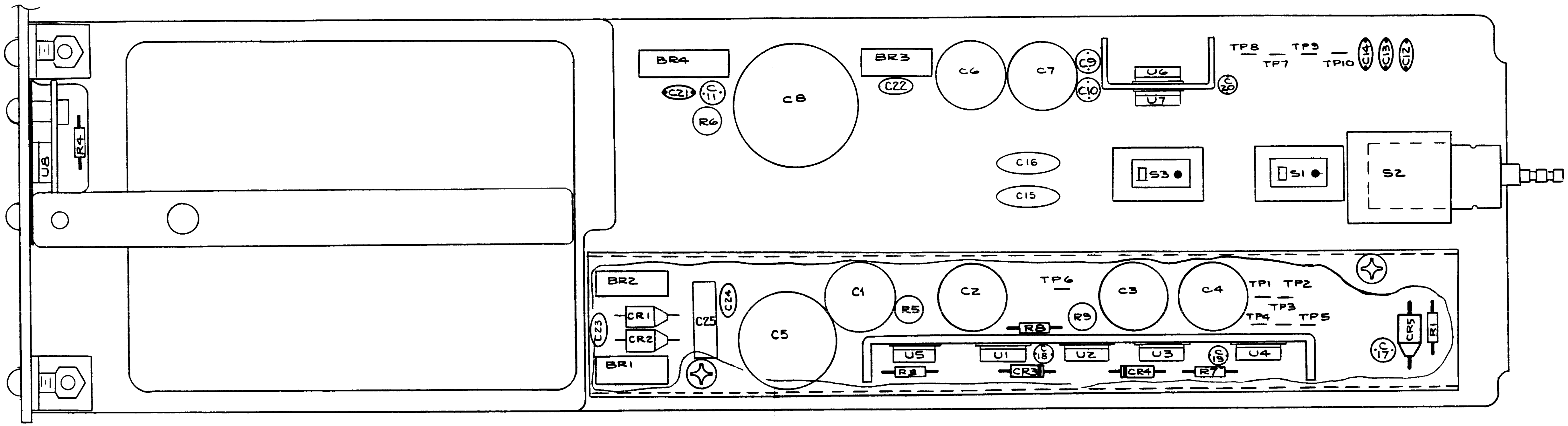
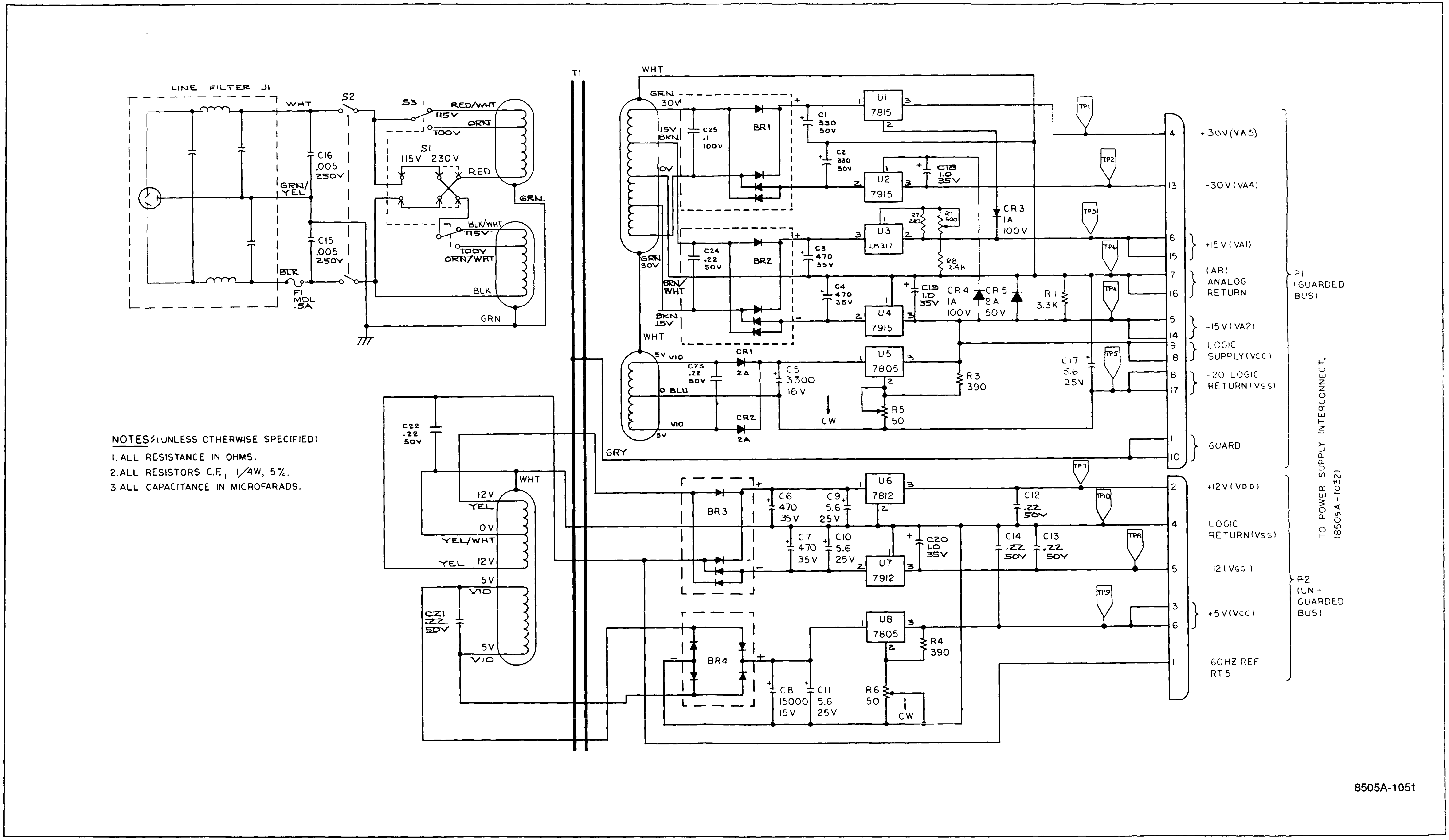


Figure 8-4. A4 Power Supply PCB Assembly



NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTANCE IN OHMS.
2. ALL RESISTORS C.F., 1/4W, 5%.
3. ALL CAPACITANCE IN MICROFARADS.

Figure 8-4. A4 Power Supply PCB Assembly (cont)

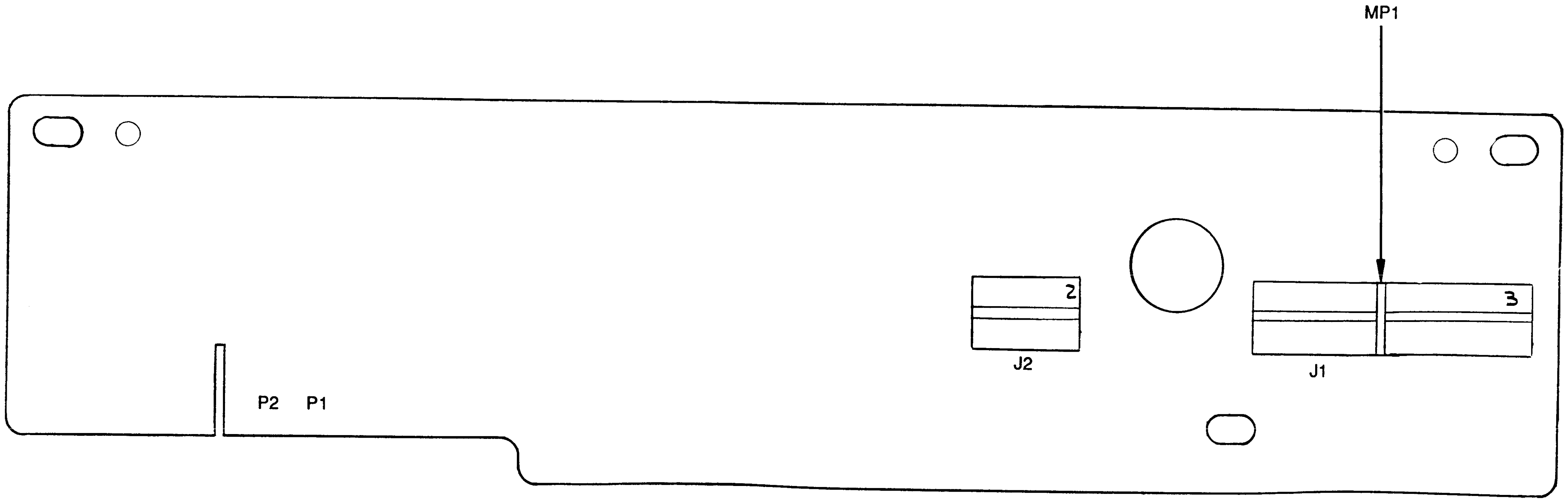


Figure 8-5. A5 Power Supply Interconnect PCB Assembly

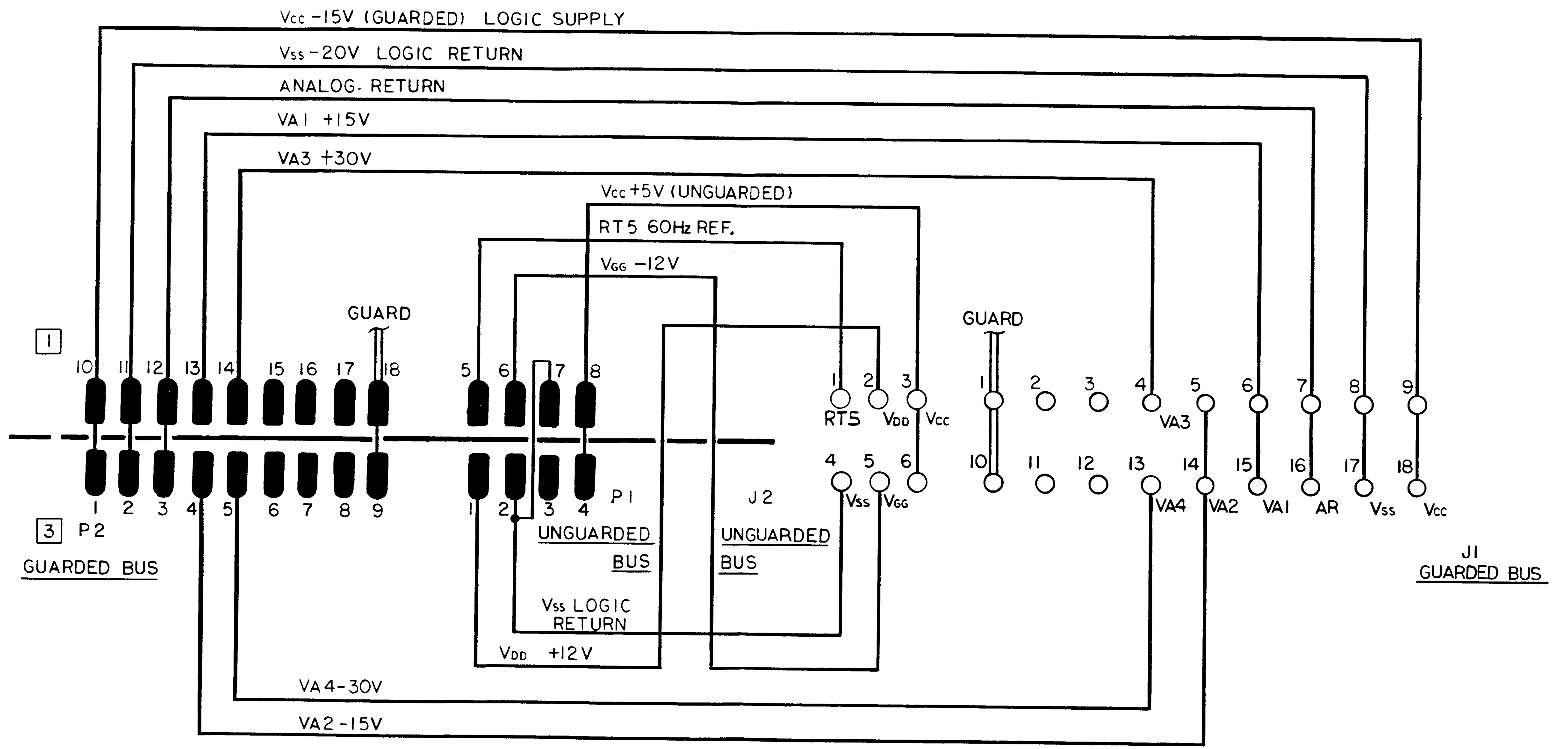
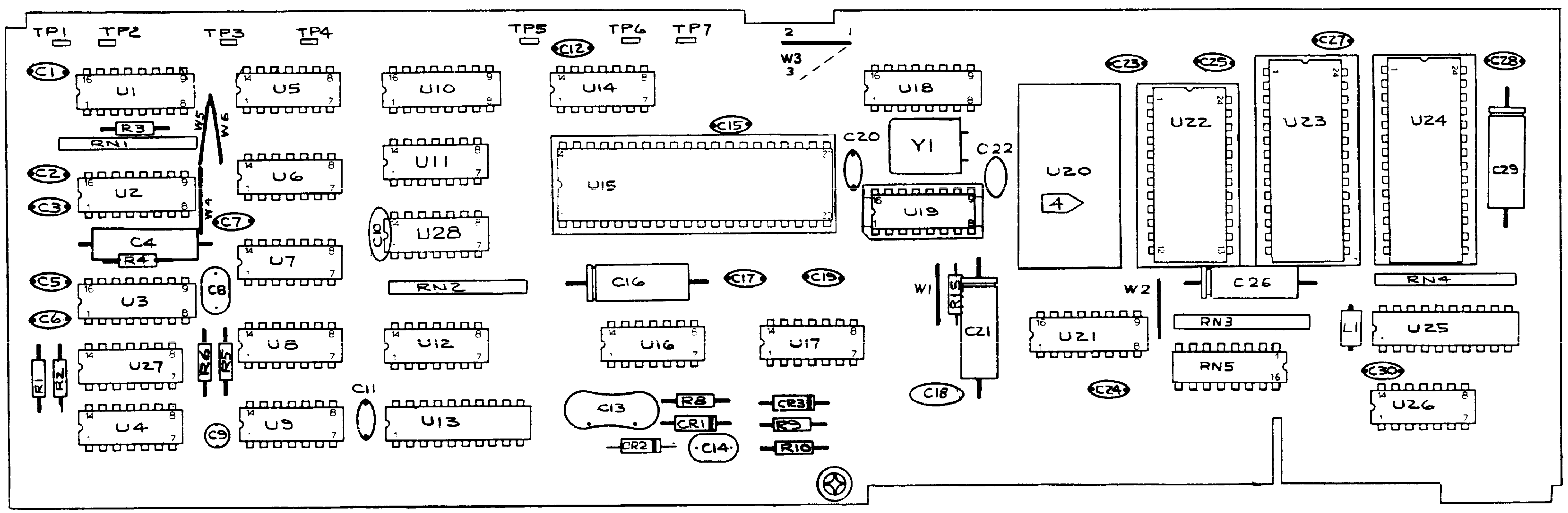


Figure 8-4. A4 Power Supply Interconnect PCB Assembly (cont)



MIS-1687

Figure 8-6. A6 Controller PCB Assembly

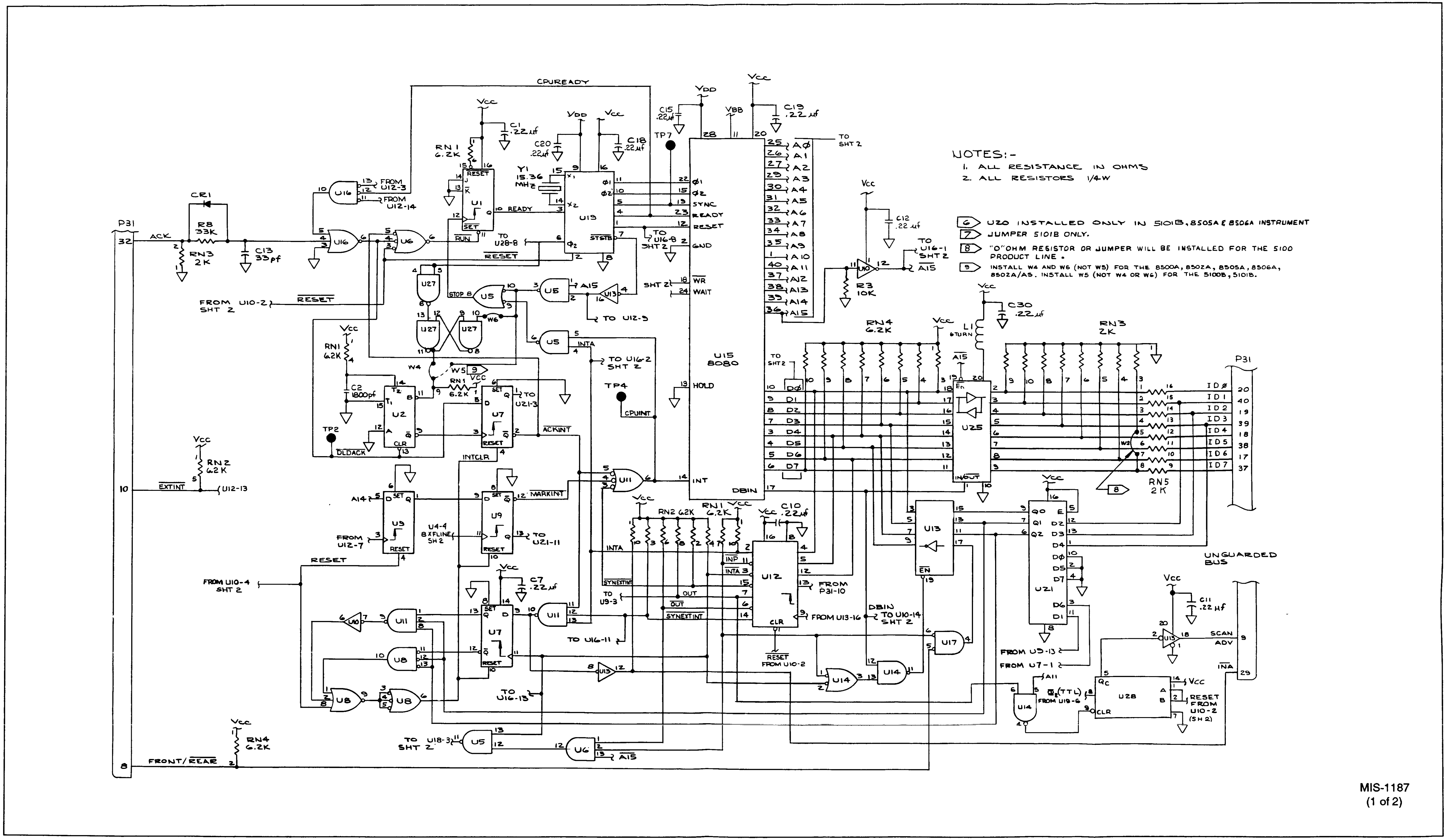


Figure 8-6. A6 Controller Assembly (cont)

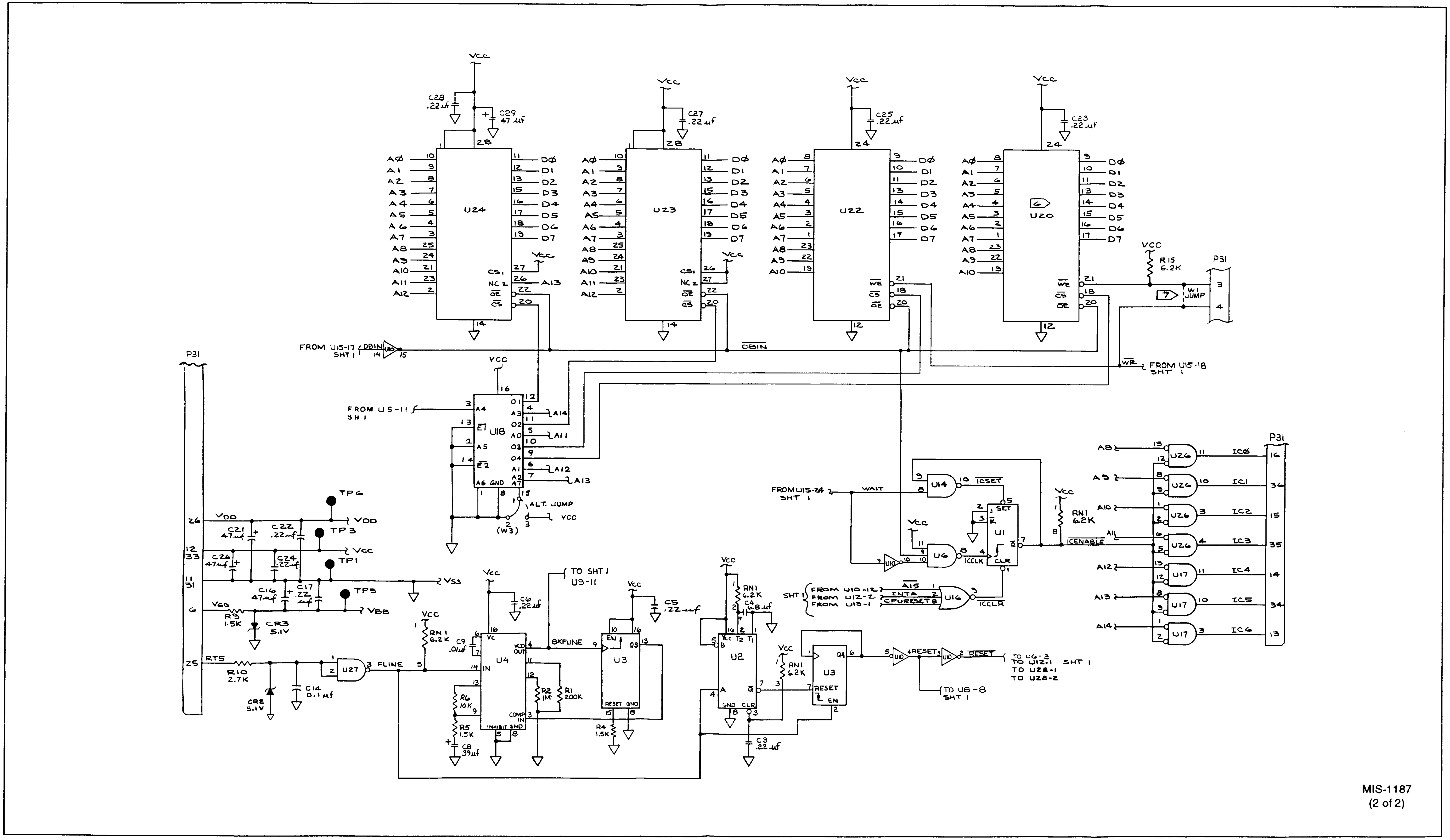


Figure 8-6. A6 Controller Assembly (cont)

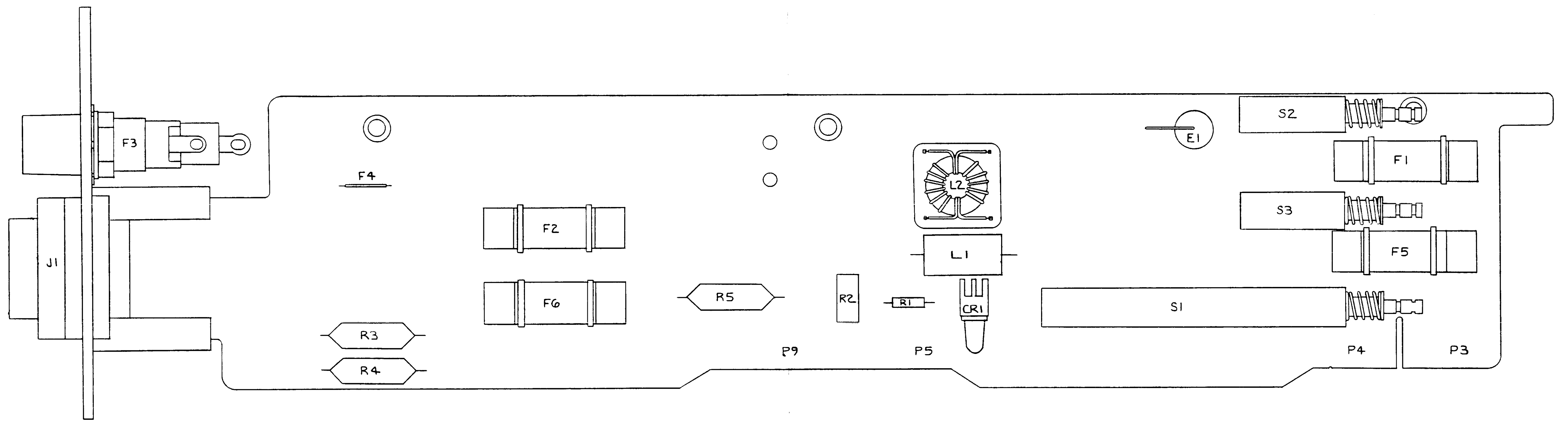


Figure 8-7. A7 Front/Rear Switch PCB Assembly

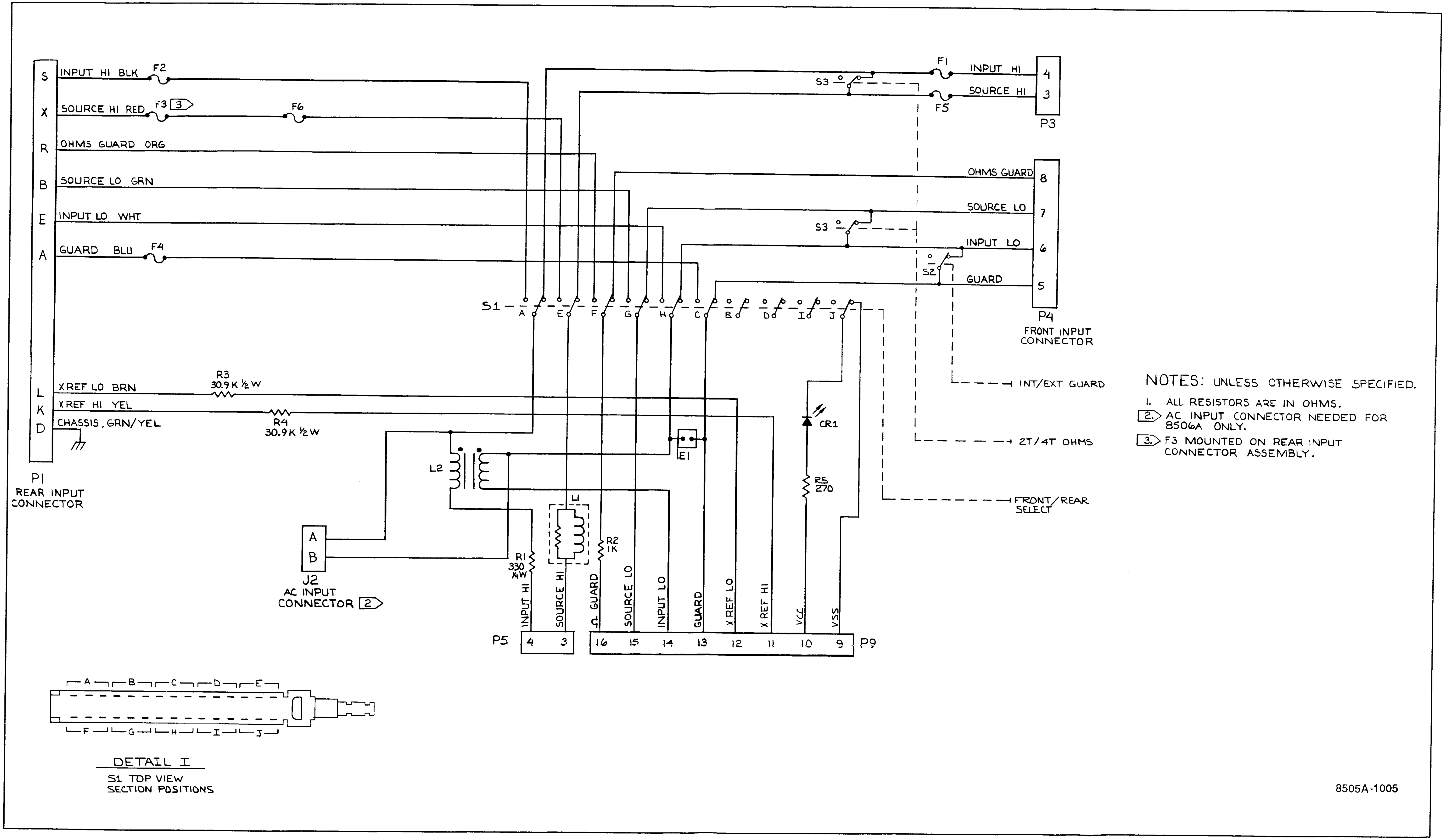


Figure 8-7. A7 Front/Rear Switch Assembly (cont)

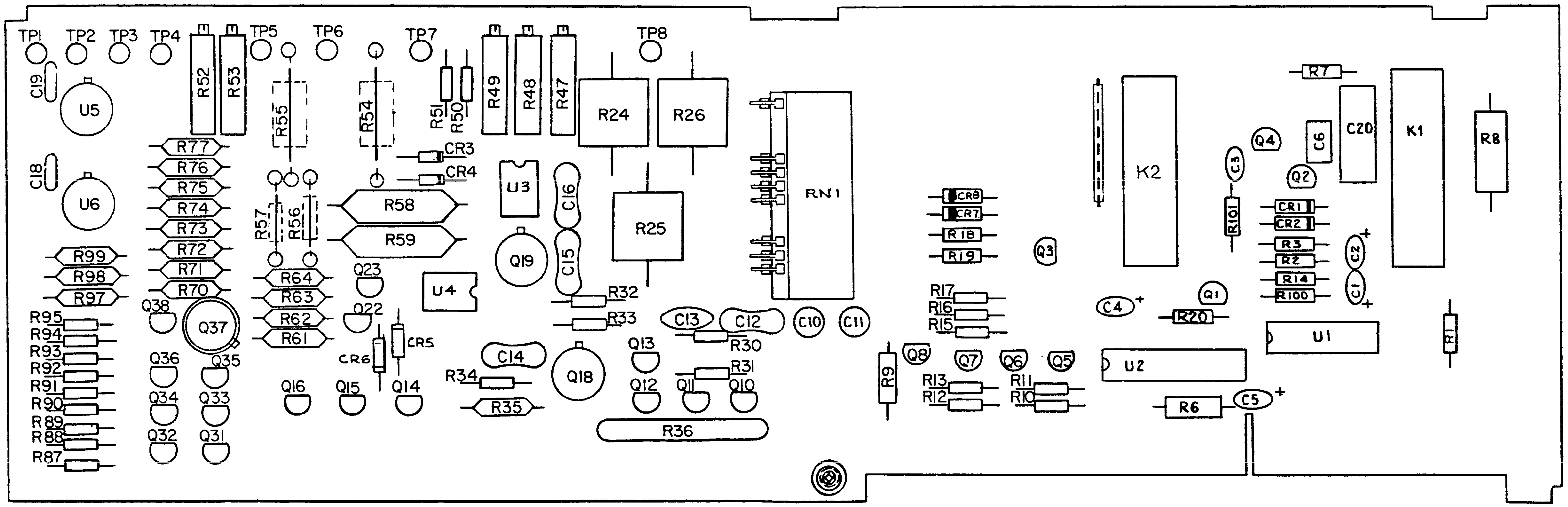
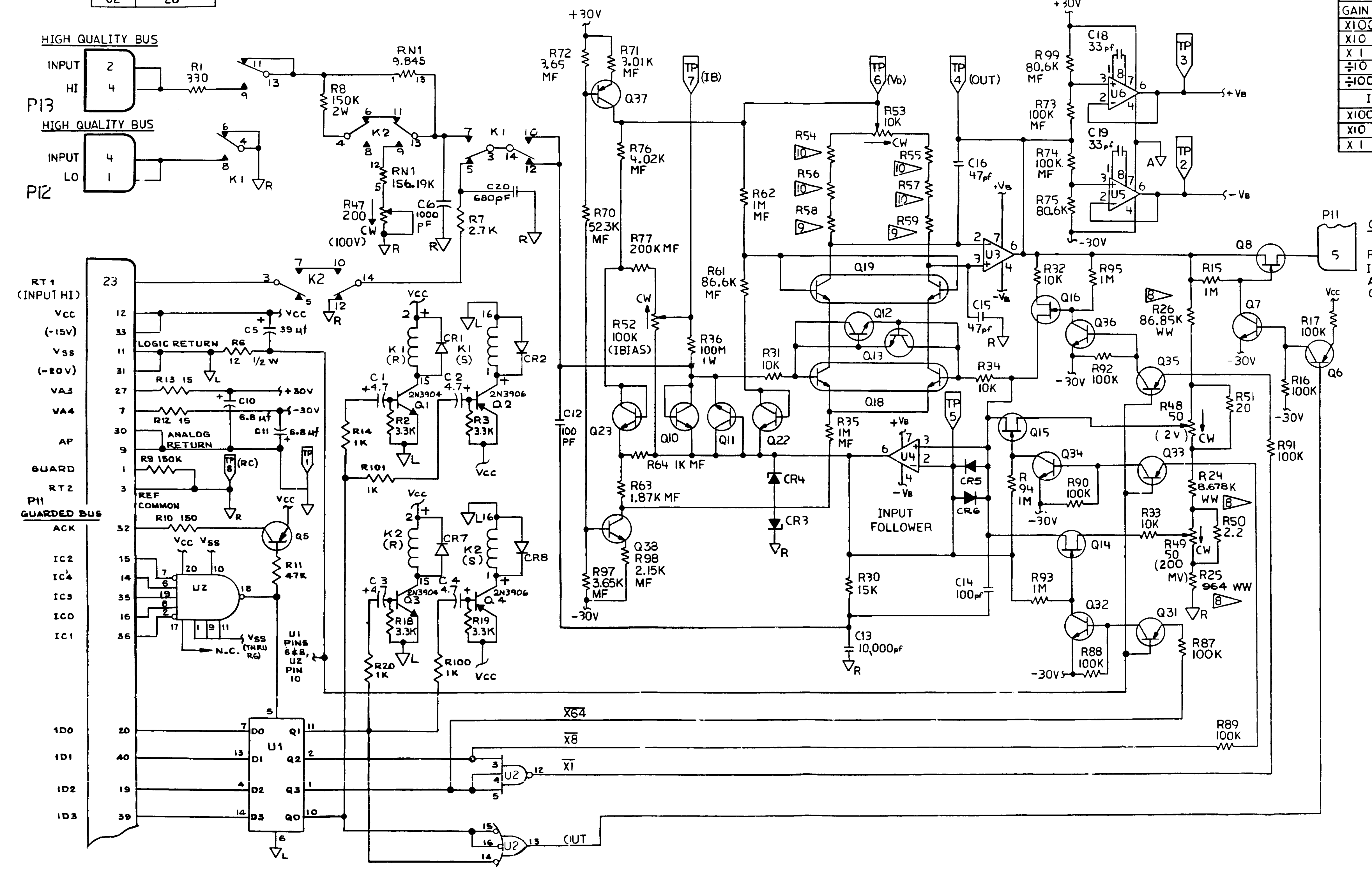


Figure 8-8. A8 DC Signal Conditioner PCB Assembly

IC	Vcc (PIN)
U1	16
U2	20

BINDING POST INPUT					
GAIN	RANGE	ID3	ID2	ID1	IDØ
X100	200 MV	0	1	1	0
X10	2V	1	0	1	0
X 1	20V	1	1	1	0
÷10	100V	1	0	0	0
÷100	1000V	1	1	0	0
INTERBUS INPUT (RT2)					
X100	200MV	0	1	0	1
X10	2V	1	0	0	1
X 1	20V	1	1	0	1



8505A-1100

NOTES: (UNLESS OTHERWISE NOTED)

1. ALL RESISTORS 1/4 W, CC. AND ALL RESISTANCE IN OHMS.

5. LAST REF DES NO'S USED: U6, Q38 CR5, R101, C21, RN1.

6. REF DES NO'S NOT USED: Q9, Q17, Q20, Q21, Q24-Q30, R4, R5, R27-R29, R37-R46, R60, R65-R69, R78-R86, R96, C7-C9, C17.

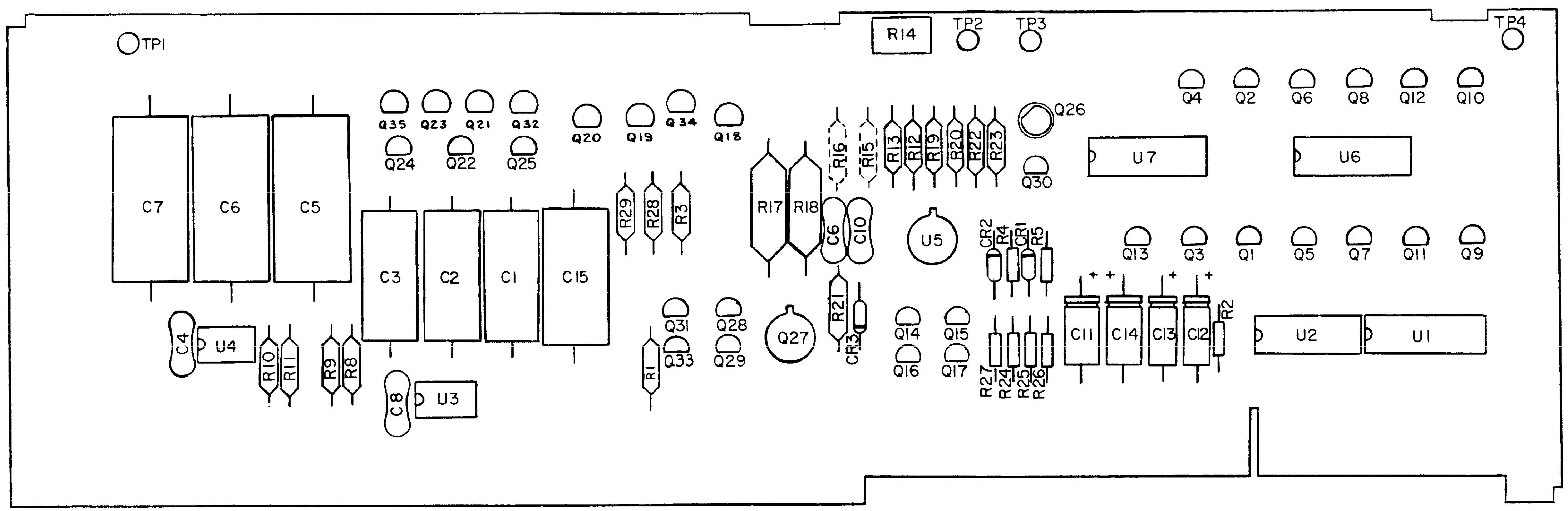
8. R24-R26 DC RANGE RESISIOR SET.

9. R58, R59 MATCHED RESISTOR SET.

10. R54-R57 FACTORY SELECTED PARTS.

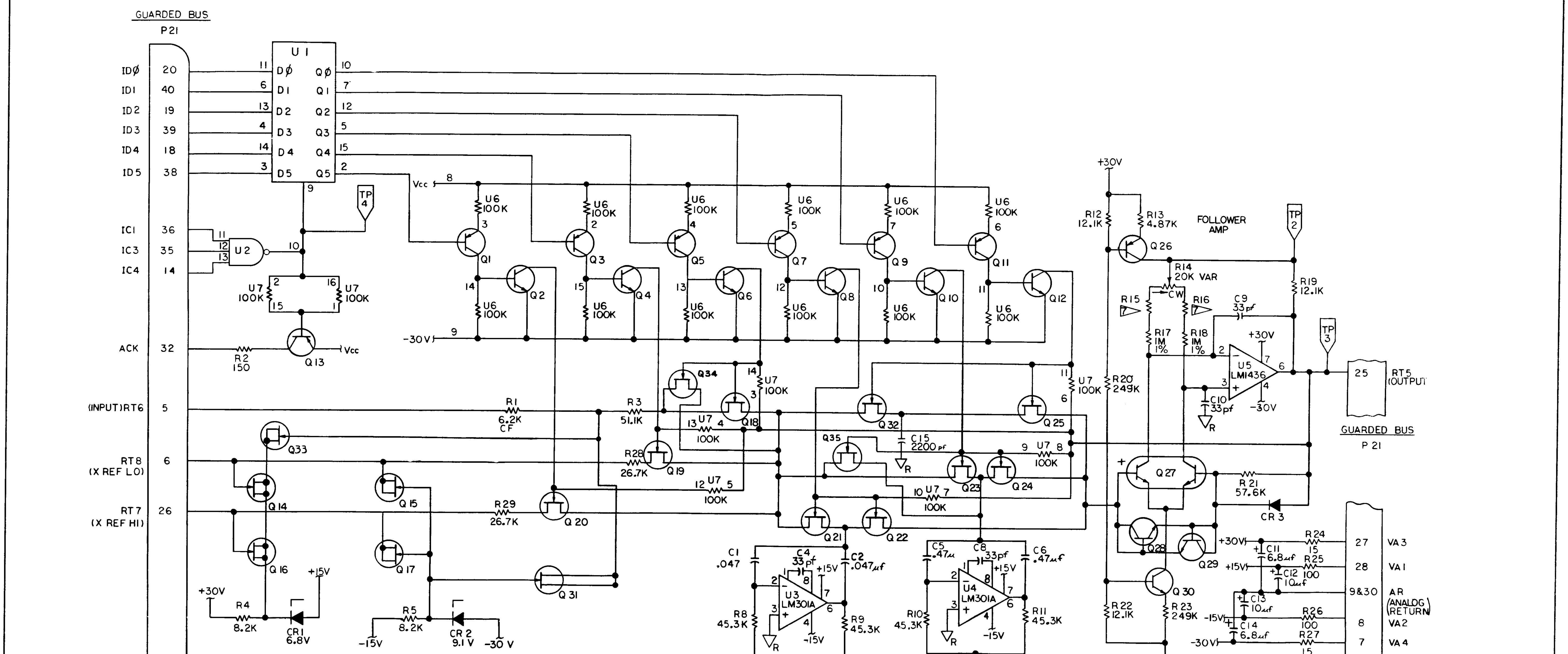
11. IF Q18, Q19, Q22, R54 OR R55 ARE REPLACED IT WILL BE NECESSARY TO T.C. THE MODULE PER MIS-4:00-151 TEST PROCEDURE.

Figure 8-8. A8 DC Signal Conditioner PCB Assembly (cont)



MIS-1730

Figure 8-9. A9 Active Filter PCB Assembly



INPUT	ID5	ID4	ID3
SIGNAL CONDITIONERS (RT6)	0	0	1
EXT. REF. LO (RT8)	0	1	0
EXT. REF. HI (RT7)	1	0	0
FILTERING	**ID2**	**ID1**	**ID0**
FAST (WAIT = 50MSEC)	1	0	0
SLOW (WAIT = 500MSEC)	0	1	0
BYPASS (WAIT = 10MSEC)	0	0	1

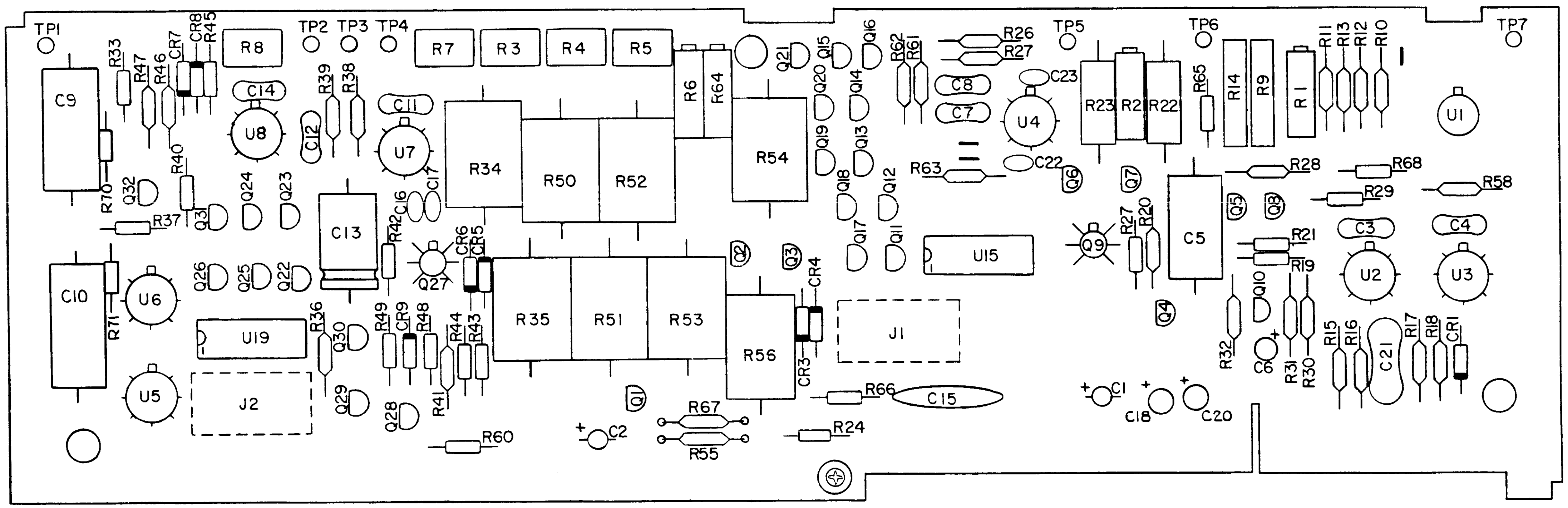
NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCE IS IN OHMS.
2. LAST REF. DES. NOS USED R29, C15, U7, Q33, CR3.
3. REF. DES. NOS NOT USED-R6, R7

FACTORY SELECTED PART.

MIS-1130

Figure 8-9. A9 Active Filter PCB Assembly (cont)



MIS-1740

Figure 8-10. A10A1 A/D Analog PCB Assembly

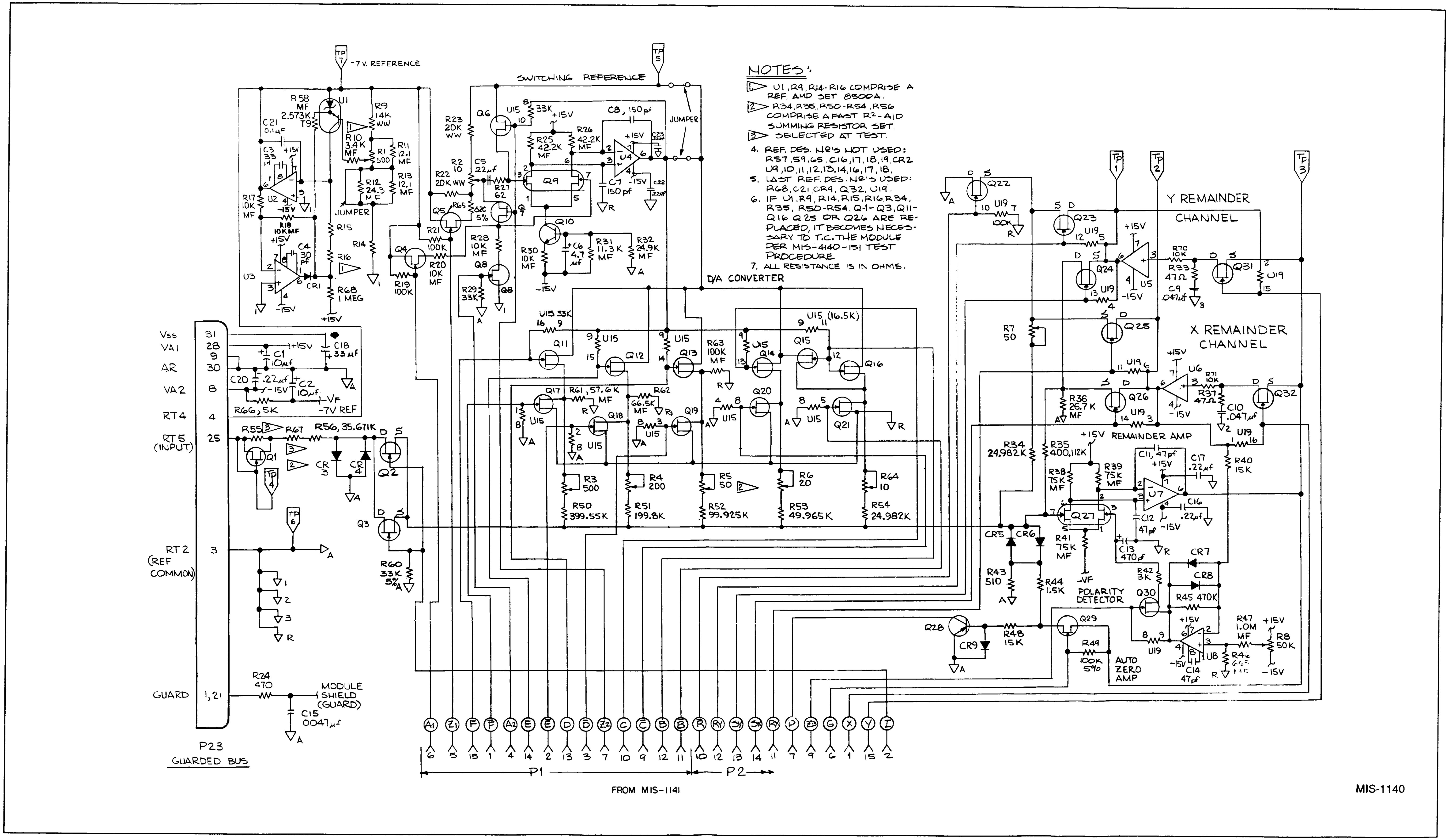
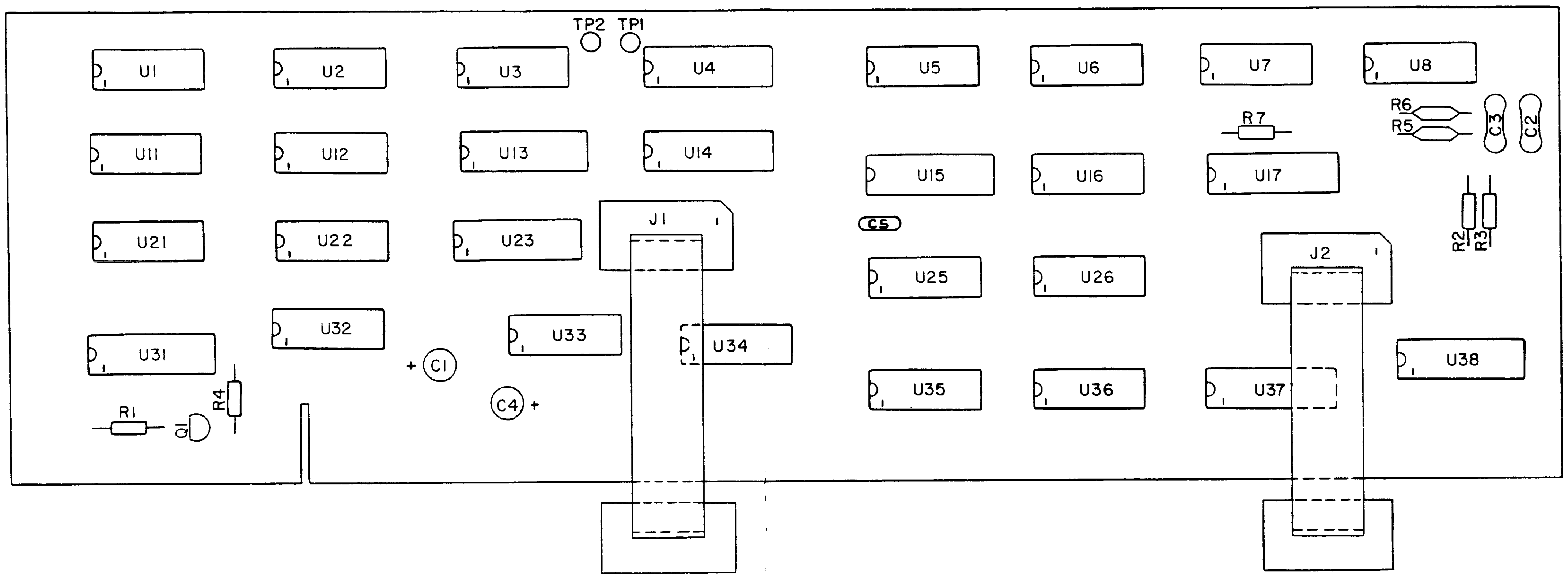
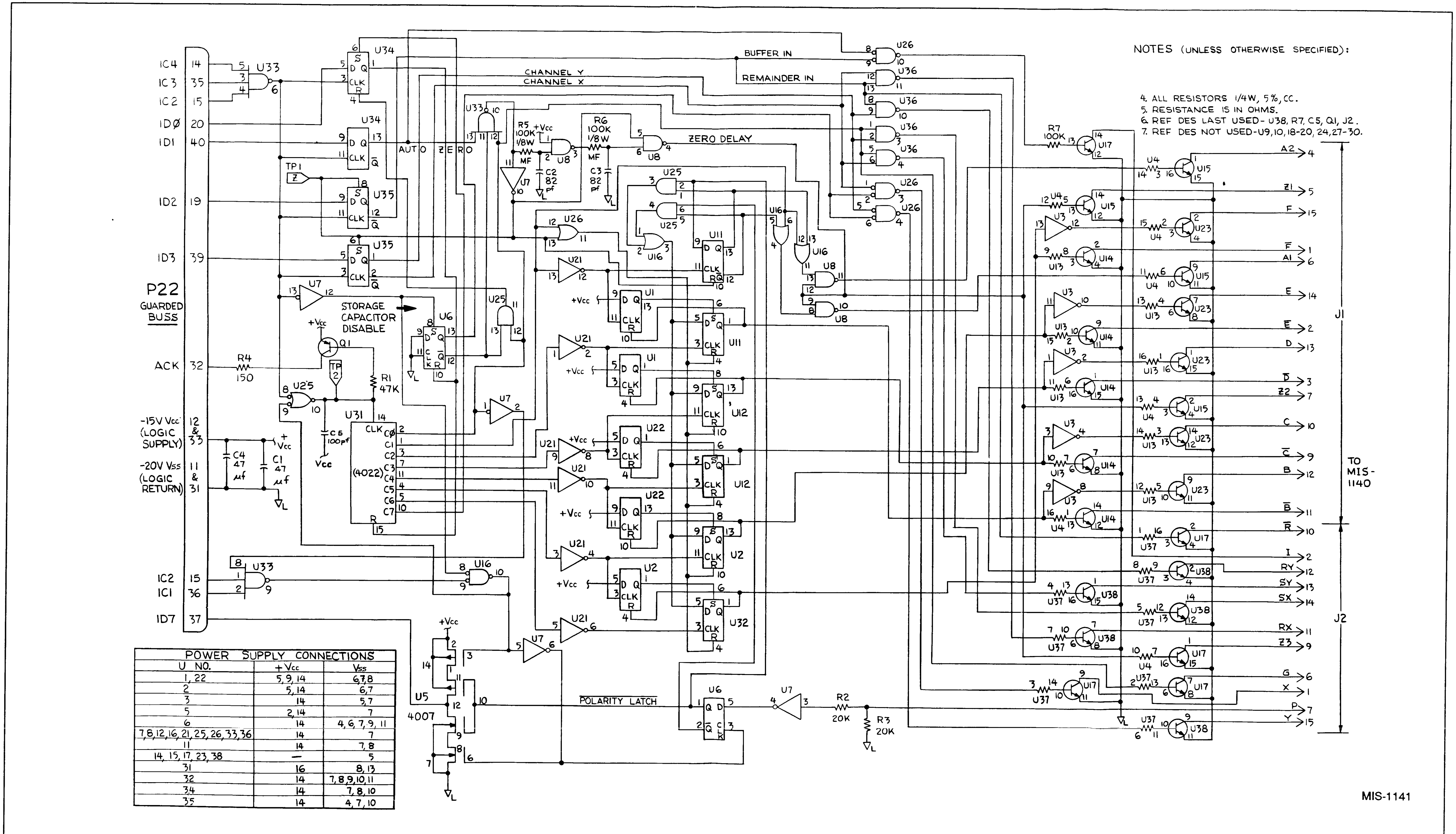


Figure 8-10. A10A1 A/D Analog PCB Assembly (cont)



MIS-1741

Figure 8-11. A10A2 Fast R2 A/D Converter Digital PCB Assembly



NOTES (UNLESS OTHERWISE SPECIFIED):

4. ALL RESISTORS 1/4W, 5%, CC.
5. RESISTANCE IS IN OHMS.
6. REF DES LAST USED- U38, R7, C5, Q1, J2.
7. REF DES NOT USED-U9, 10, 18-20, 24, 27-30.

POWER SUPPLY CONNECTIONS		
U NO.	+Vcc	Vss
1, 22	5, 9, 14	6, 7, 8
2	5, 14	6, 7
3	14	5, 7
5	2, 14	7
6	14	4, 6, 7, 9, 11
7, 8, 12, 16, 21, 25, 26, 33, 36	14	7
11	14	7, 8
14, 15, 17, 23, 38	—	5
31	16	8, 13
32	14	7, 8, 9, 10, 11
34	14	7, 8, 10
35	14	4, 7, 10

Figure 8-11. A10A2 Fast R2 A/D Converter Digital PCB Assembly (cont)

CHANGE/ERRATA INFORMATION

ISSUE NO: 1 11/93

This change/errata contains information necessary to ensure the accuracy of the following manual. Enter the corrections in the manual if either one of the following conditions exist:

1. The revision letter stamped on the indicated PCA is equal to or higher than that given with each change.

2. No revision letter is indicated at the beginning of the change/errata.

MANUAL

Title:	8505A ph2
Part Number:	926639
Print Date:	October 1992
Rev.- Date:	---

C/E PAGE EFFECTIVITY

Page No.	Print Date
1	11/93
2	11/93

CHANGE #1 - 47073

On page 5-4, Table 5-1,

```
CHANGE:   TM1|8505A INSTRUCTION MANUAL|638841|89536|638841|1
TO:       TM1|8505A INSTRUCTION MANUAL|926639|89536|926639|1
```

CHANGE #2 - 47126
Rev. -C, A8 DC Signal Conditioner PCA (8505A-4115T)

On pages 5-22 and 5-23, make the following changes:

```
FROM:     VR3,4|ZENER,UNCOMP,22.0V,5%,5.6MA,0.4W
                                          |181073|04713|1N969B|2
TO:       CR3,4|ZENER,UNCOMP,22.0V,5%,5.6MA,0.4W
                                          |181073|04713|1N969B|2

FROM:     Q10,11|DIODE,SI,N-JFET,CURRENT REG,IF-2.0MA
                                          |284927|21845|F2783|2
TO:       VR3,4|DIODE,SI,N-JFET,CURRENT REG,IF-2.0MA
                                          |284927|21845|F2783|2
```

CHANGE #3 - 46951
Rev. -AA, A10A1 Fast R2 A/D Analog PCA (MIS-4140)

On page 5-29, Table 5-12, make the following changes:

```
FROM:    Q1-3,11-16,25,26|PC,SET,N-CHANNEL,SELFROM #261578
                                          |256487|89536|256487|1
TO:      Q1-3,11-16,25,26|PC,SET,N-CHANNEL,SELFROM #888263
                                          |893094|89536|893094|1

FROM:    Q32             |TRANSISTOR,SI,N-JFET,TO-92,SWITCH
                                               |261578|17856|J2317|
TO:      Q17-24,29-32|TRANSISTOR,SI,N-JFET,TO-92,SWITCH
                                               |888263|89536|888263|12
```

CHANGE #4 - 47602
Rev. -W, Option -01 AC/DC (Avg) PCB Assembly (MIS-4101)

On page 601-7, Table 601-5, make the following changes:

```
DELETE:  C8|CAP,VAR,0.25-1.5PF,2000V|273151|74970|273-0001-002|2

FROM:    C10  |CAP,VAR,0.8-10PF,200V    |229930|91293|JMC5201|1
TO:      C8,10|CAP,VAR,0.8-10PF,250V    |229930|91293|JMC5201|2

FROM:    C23|CAP,VAR,0.25-1.5PF,2000V|273151|74970|273-0001-002|REF
TO:      C23|CAP,VAR,0.25-1.5PF,1700V|273151|74970|273-0001-002|1
```

On page 601-11/601-12,

Change the value of C8,

FROM: 1.5PF TO: 0.8-10PF

CHANGE #5 - 47365
Rev. -V, Option -01 AC/DC (Avg) PCB Assembly (MIS-4101)

On page 601-9, Table 601-5, make the following changes:

FROM: R18|RES,MTL,FILM,500.85K +/-0.1%,1/8W
|424614|89536|424614|1
TO: R18|RES,MTL,FILM,499K +/-0.1%,0.125,25PPM
|260513|89536|260513|1

FROM: R20|RES,MTL. FILM,71.320K +/-0.1%,1/8W
|424515|89536|424515|1
TO: R20|RES,MTL. FILM,71.5K +/-0.1%,0.125W,25PPM
|312702|89536|312702|1

On page 601-11/601-12, Figure 601-3,

Change the value of R18,

FROM: 500.85K TO: 499K

Change the value of R20,

FROM: 71.320K TO: 71.5K

ERRATA #1

On page 603-2, Table 603-1, under VOLTAGE BURDEN,

CHANGE: <=100 mV
<=100 mV
<=200 mV
<=200 mV
<=500 mV

TO: <=100 mV
<=100 mV
<=250 mV
<=300 mV
<=1.25V

On page 603-6, Table 603-2,

CHANGE:	100 mA	150 mA	149.905 (-3)	150.095 (-3)
TO:	100 mA	120 mA	119.920 (-3)	120.080 (-3)

CHANGE/ERRATA INFORMATION

ISSUE NO: **5** 6/92

This change/errata contains information necessary to ensure the accuracy of the following manual. Enter the corrections in the manual if either one of the following conditions exist:

1. The revision letter stamped on the indicated PCB is equal to or higher than that given with each change.

2. No revision letter is indicated at the beginning of the change/errata.

MANUAL

Title:	8505A
Print Date:	March 1983
Rev.- Date:	2, 2/91

C/E PAGE EFFECTIVITY

Page No.	Print Date
1	8/91
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8	6/92
9	6/92
10	6/92

CHANGE #1 - 42549
Rev. -AJ, RMS Converter PCB Assembly (MIS-4103S)

On page 609A-10, Table 609A-6,

DELETE: C2|CAP,PORC,1.5PF +/-0.25PF,1.7V ACK|461004|95275|VY10CA1R5CA|1

CHANGE: C4,9 |CAP,VAR,0.25-1.5PF,2000V|218206|72982|530-000|2
TO: C2,4,9|CAP,VAR,0.25-1.5PF,2000V|218206|72982|530-000|3

On page 609A-15, Figure 609A-3, change the view of C2 as shown in Figure A.

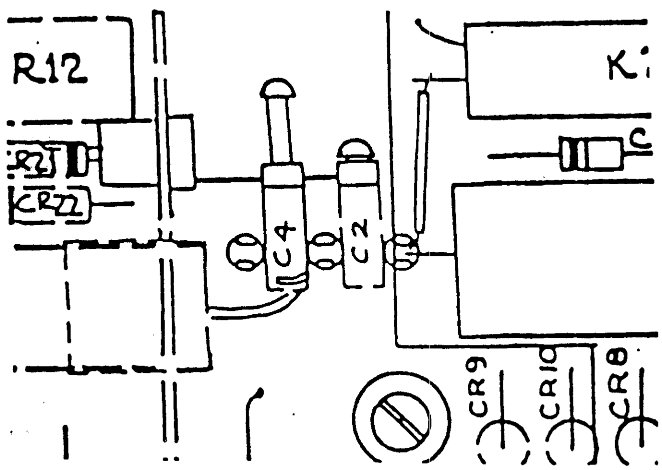


Figure A.
MIS-1703

On page 609A-16, Figure 609A-3, change the symbol for C2 as shown in Figure B.

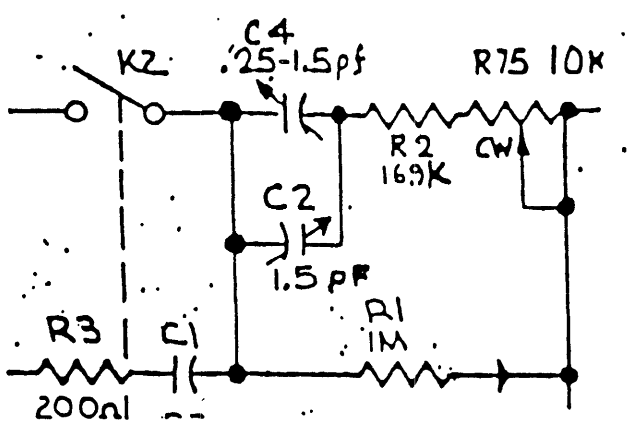


Figure B.
MIS-1103

ERRATA #1

On page 1-4, Table 1-3, under NOISE REJECTION,

CHANGE: Normal Mode Rejection
TO: Normal Mode Rejection (for NM signals < or = 80% of range)

ERRATA #2

Refer to the option -08 section for current A3 Isolator information.

ERRATA #3

On pages 602-12 and 602-13, Table 602-9,

CHANGE: C9,10,12-|................................
TO: C9,10,12-15,19|...........................

CHANGE: CR3,11,16,|...............................
TO: CR3,11,16,20,21,24|.........................

CHANGE: CR4,7,8,|.................................
TO: CR4,7,8,13-15,17|...........................

CHANGE: Q2,12,17,|................................
TO: Q2,12,17,21,24,26,38|.......................

CHANGE: Q3,4,8,|..................................
TO: Q3,4,8,9,13,18,22,23,25,27,28,30,32,34,37|...

CHANGE: Q5,19,20,|................................
TO: Q5,19,20,36|................................

CHANGE: Q10,11,14-|...............................
TO: Q10,11,14-16|...............................

CHANGE: Q29,31,33,|...............................
TO: Q29,31,33,35|...............................

CHANGE: R2,4-7,|..................................
TO: R2,4-7,52|..................................

CHANGE: R10,11,14,|...............................
TO: R10,11,14,42,59|............................

CHANGE: R13,58,60,|...............................
TO: R13,58,60,63,67|............................

CHANGE: R17,18,32,|...............................
TO: R17,18,32,43,53,57|.........................

CHANGE #2 - 32779
Rev. -L, A1 Front Panel Display PCB Assembly (8505A-4001)

On page 5-7, Table 5-2,

CHANGE: F2|WIRE,MAGNET,36H,130C,NYLEZE|160978|89536|160978|1
TO: F2|WIRE,COPPER/TIN,BUS,36AWG |845081|04946|845081|1

CHANGE #3 - 43378
Rev. W, A4 Power Supply PCB Assembly (8505A-4015S)

On page 5-13, Table 5-5,

DELETE: MP1|INSULATOR,POWER SWITCH|383158|89536|383158|1

CHANGE #4 - 44444
Rev. -K, A7 Front/Rear Switch PCB Assembly (8505A-4005)

On page 5-19, Table 5-8,

CHANGE: F4|WIRE,MAGNET,36H,130C,NYLEZE|160978|89536|160978|1
TO: F4|WIRE,COPPER/TIN,BUS,36AWG |845081|04946|302-4 |1

CHANGE #5 - 45536
On page 3-12, replace the DC Signal Conditioner text with the following:

3-59. DC Signal Conditioner

3-60. Relays K1 and K2 control the input to the DC Signal Conditioner and the attenuation of the input (Figure 3-16). If both relays are energized, the input is from the Volt/Ohm input terminals with no attenuation. If just K2 is energized, the input is from RT1 with no attenuation. CR3, CR4, CR11 and CR12 provide over voltage input protection.

3-61. A precision op amp (U3) and gain boosting stage (U2) buffers the input of the instrument. RET switches (Q14, Q15, Q16) control the gain of the buffer. An input and output voltage swing of +/- 20V is achieved through bootstrapping; Q22 and Q23 provide a bootstrap for U4, and U5 and U6 provide a bootstrap for U3. U4 provides guard voltage and input bias current compensation.

3-62. The DC Signal Conditioner is addressed by IC0, 3, 4 high and IC1, 2 low. Data on ID0-3 is latched up and decoded to determine which switches and relays will be energized. Latching relays are used to eliminate thermal changes in the relays between on an off states. RC coupling between the decoder and the relay driver provide pulses, which activate the appropriate coil of the relay long enough to ensure proper operation of the relay, on each level shift of the decoded signal.

On page 3-14, replace Figure 3-16 with the following:

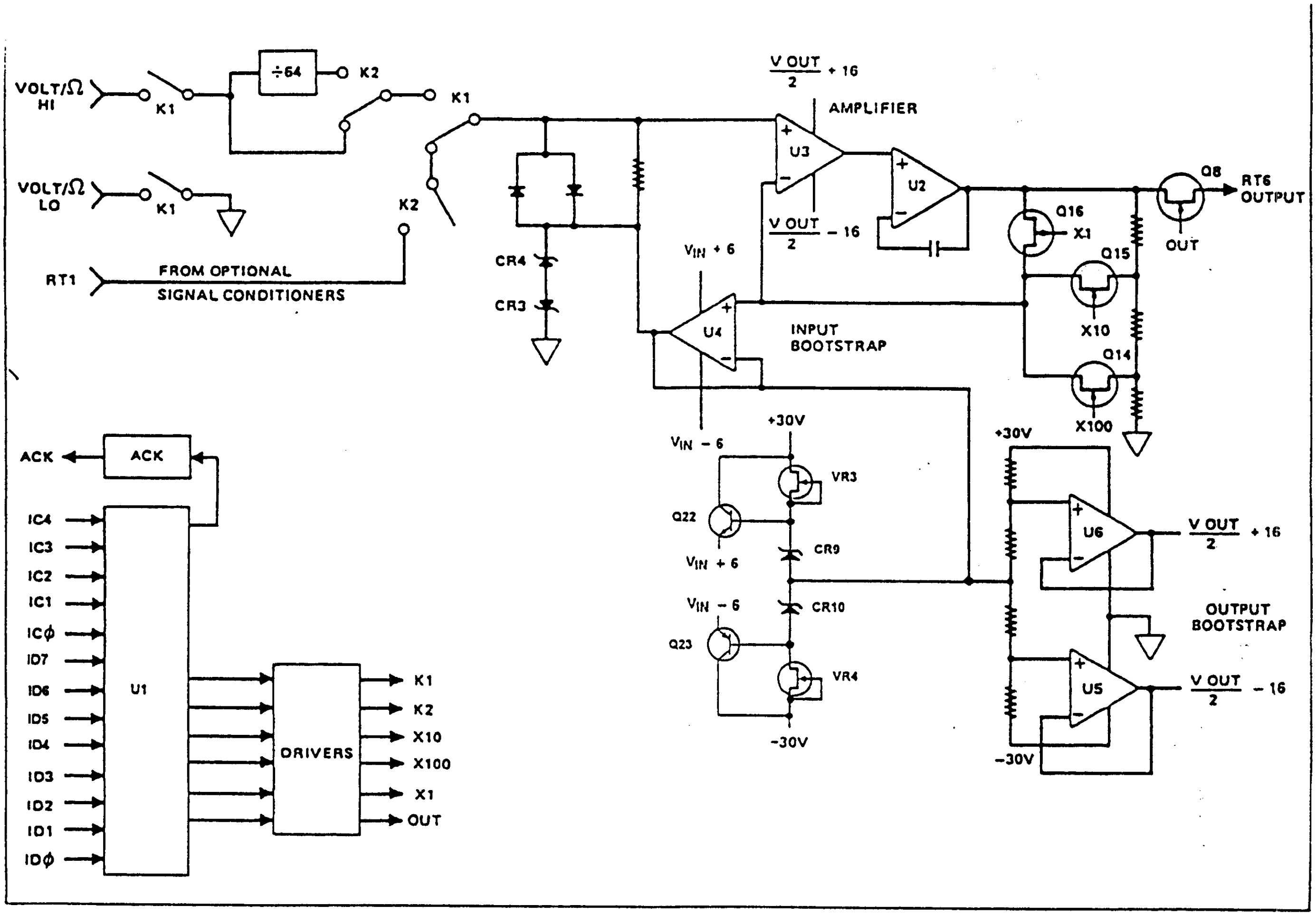


Figure 3-16. DC Signal Conditioner

On page 4-21, Table 4-9,

CHANGE:	Digital Control Logic Q8, Q6, Q7, Open K1,Q1,Q2 Open; Q18,Q19,U3 Bad	
TO:	Digital Control Logic Q8,Q6,Q7, Open K1,Q1,Q2 Open; U2, U3 Bad	
CHANGE:	Locks in Overrange	U3
TO:	Locks in Overrrange	U2,U3

On page 5-4, Table 5-1

CHANGE: A8|DC SIGNAL CONDITIONER PCA|660712|89536|646307|1
TO: A8|DC SIGNAL CONDITIONER PCA|881722|89536|881722|1

On page 5-21, replace Table 5-9 with the following:

Table 5-9. A8 DC Signal Conditioner PCA

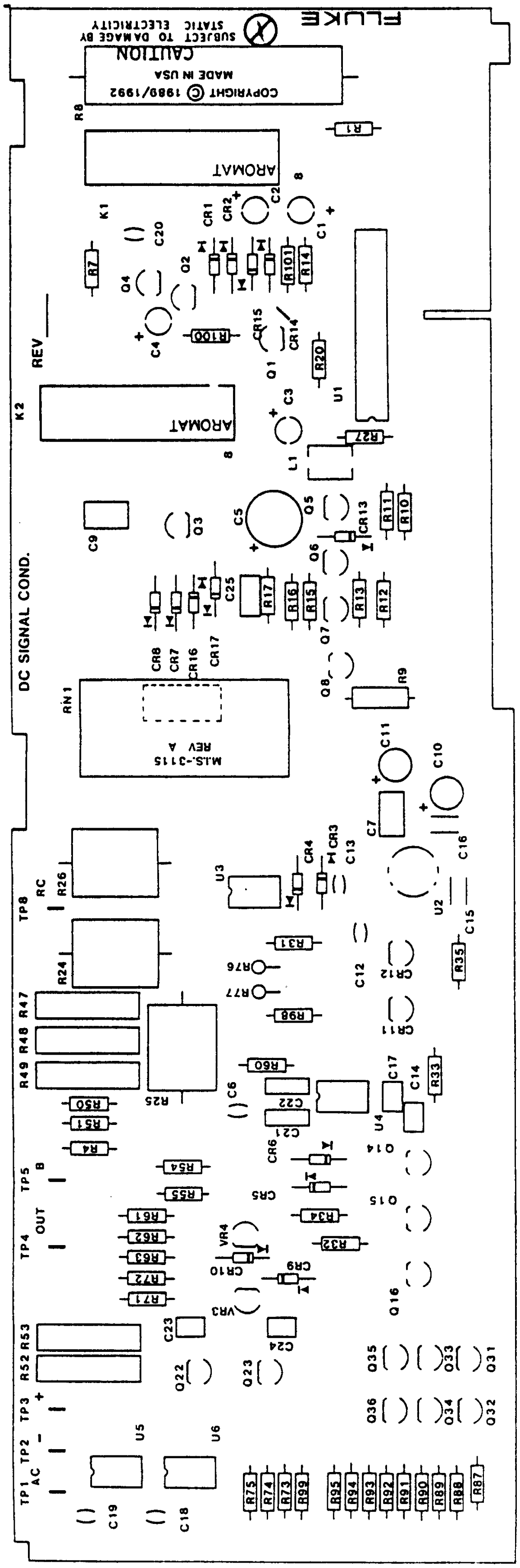
REFERENCE DESIGNATOR -A>	-NUMERICS--->	S	---DESCRIPTION---	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-	TOT QTY-	NOTE -E-
C	1- 4		CAP,TA,4.7UF,+-20%,25V	807644	56289	199D475X0025BE2	4	
C	5		CAP,AL,470UF,+-20%,16V,SOLV PROOF	875497	62643	KME16VB471M10X12FT	1	
C	6		CAP,CER,180PF,+5%,100V,COG	837625	04222	SR151A181JAA	1	
C	7		CAP,POLYPR,2200PF,+-5%,100V	854505	68919	FKP2222J100V	1	
C	9		CAP,POLYPR,1000PF,+-1%,100V	844816	68919	FKP2102F100V	1	
C	10, 11		CAP,AL,10UF,+-20%,50V,SOLV PROOF	799437	62643	KMC50T10RM5X11RP	2	
C	12		CAP,CER,100PF,+-5%,50V,COG	831495	04222	SR595A101JAA	1	
C	13, 15, 16		CAP,CER,0.01UF,+-10%,100V,X7R	557587	04222	SR591C103KAA	3	
C	14, 17, 23,		CAP,CER,1000PF,+-5%,100V,COG	627018	04222	SR151A102JAA	4	
C	24			627018				
C	18, 19		CAP,CER,33PF,+-5%,50V,COG	714543	04222	SR595A330JAA	2	
C	20		CAP,CER,680PF,+-5%,50V,COG	528273	04222	SR215A681JAA	1	
C	21, 22		CAP,POLYES,0.1UF,+-10%,50V	649913	68919	MKS2104K50	2	
C	25		CAP,CER,0.22UF,+-20%,50V,25U	309849	04222	SR215E224MAA	1	
CR	1, 2, 7,	*	DIODE,SI,BV=75V,IO=150MA,500MW	203323	65940	1N4448	9	
CR	8, 13-17	*		203323				
CR	5, 6	*	DIODE,SI,BV=20V,IO=50MA,SELECTED IR	348177	07263	FD7223	2	
CR	9, 10	*	ZENER,COMP,6.35V,4%,10PPM,2MA	357848	04713	SZF20118	2	
CR	11, 12	*	DIODE,SI,BV=35V, LOW LEAKAGE	723817	17856	J2723	2	
H	1		SCREW,PH,P,LOCK,SS,4-40,.375	256164	74594	256164	1	
H	2		SPACER,SWAGE,.250 RND,BR,4-40,.187	335604	55566	3046B440B14-MOD.-.187	1	
H	3		SPRING,COIL,COMP,M WIRE,.380,.120	424465	83553	C0121-014-0380M	1	
K	1, 2		RELAY,ARMATURE,4 FORM C,5V,LATCH	715078	61529	DS4EML2DC5VCH239	2	
L	1		CHOKE,6TURN	320911	89536	320911	1	
MP	1		SHUNT BAR,PWB,4 INCH	454157	28213	5020	1	
MP	2		DC SIGNAL CONDITIONER, CASE	872577	89536	872577	1	1
MP	3		CASE HALF,MODULE	402990	89536	402990	2	
MP	4		COVER,MODULE CASE	794560	89536	794560	1	
MP	5		GUARD, FRONT	383356	89536	383356	1	
MP	6		GUARD, REAR	383364	89536	383364	1	
MP	7		SHIELD, COVER, DC SIGNAL CONDITIONER	873617	2M021	873617	1	
MP	8		DECAL, DC SIGNAL CONDITIONER	881727	89536	881727	1	
MP	9		PAD, ADHESIVE	735365	89536	735365	1	
Q	1, 3, 22	*	TRANSISTOR,SI,NPN,SMALL SIGNAL,TO-92	698225	27014	2N3904	3	
Q	2, 4, 6,	*	TRANSISTOR,SI,PNP,T092	698233	04713	2N3906	7	
Q	23, 31, 33,	*		698233				
Q	35	*		698233				
Q	5	*	TRANSISTOR,SI,PNP,SWITCHING,TO-92	831446	04713	MPS3640	1	
Q	7, 32, 34,	*	TRANSISTOR,SI,NPN,SMALL SIGNAL,TO-92	816298	04713	MPS8099	4	
Q	36	*		816298				
Q	8, 14- 16	*	TRANSISTOR,SI,N-JFET,HI-VOLTAGE,TO-92	393314	17856	J2086	4	
Q	10, 11	*	DIODE,SI,N-JFET,CURRENT REG,IF=2.0 MA	284927	21845	F2783	2	
R	1		RES,CF,330,+-5%,0.25W	573089	59124	CF1/4 331J	1	
R	4, 27, 32,		RES,CF,10K,+-5%,0.25W	348839	59124	CF1/4 102J	4	
R	33			348839				
R	7		RES,CF,2.7K,+-5%,0.25W	386490	59124	CF1/4 272J	1	
R	8		RES,WW,200K,+-5%,10W,20PPM	246850	91637	RS-102003J	1	
R	9		RES,CC,150K,+-10%,0.5W	108167	01121	EB1541	1	
R	10, 60		RES,CF,150,+-5%,0.25W	343442	59124	CF1/4 151J	2	
R	11		RES,CF,47K,+-5%,0.25W	348896	81349	RCR07G473JS	1	
R	35, 73-75, 99		RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF-55 1003F T-1	5	
R	12, 13		RES,CF,15,+-5%,0.25W	348755	59124	CF1/4 150J	2	
R	14, 20,100,		RES,CF,1K,+-5%,0.25W	343426	59124	CF1/4 102J	4	
R	101			343426				
R	15, 93- 95		RES,CF,1M,+-5%,0.25W	348987	59124	CF1/4 105J	4	
R	16, 17, 87-		RES,CF,100K,+-5%,0.25W	348920	59124	CF1/4 104J	8	
R	92			348920				
R	24- 26		PRECISION RESISTOR DIVIDER SET	648212	89536	648212	1	
R	31, 34		RES,MF,10K,+-1%,0.125W,100PPM	168260	91637	CMF-55 1002F T-1	2	
R	47		RES,VAR,CERM,200,+-20%,0.5W	284711	80294	3009P-1-201	1	
R	48, 49		RES,VAR,CERM,50,+-20%,0.5W	267815	80294	3009P-1-500	2	
R	50		RES,CF,2.2,+-5%,0.25W	354944	59124	CF1/4 2R2J	1	
R	51		RES,CF,20,+-5%,0.25W	442202	59124	CF1/4 200J	1	
R	52, 53		RES,VAR,CERM,10K,+-20%,0.5W	267880	80294	3009P-1-103	2	
R	54, 55		RES,MF,3.01K,+-1%,0.125W,100PPM	312645	91637	CMF-55 3011F T-1	2	
R	61, 62		RES,MF,10,+-1%,0.125W,100PPM	268789	91637	CMF-55 10R0F T-1	2	
R	63		RES,MF,10K,+-0.1%,0.125W,50PPM	343459	91637	CMF-55 1002B T-2	1	
R	71, 72		RES,CF,5.6K,+-5%,0.25W	442350	59124	CF1/4 562J	2	
R	76, 77		RES,MF,10.7M,+-1%,0.125W,100PPM	756593	59124	MF50D1075F	2	
R	98		RES,CF,750,+-5%,0.25W	441659	59124	CF1/4 751J	1	
RN	1	*	INPUT DIVIDER RNET ASSY TESTED 8505	735159	89536	735159	1	
TP	1- 5, 8		JUMPER,WIRE,NONINSUL,0.200CTR	816090	91984	150T1	6	
U	1	*	IC,CMOS,GAL,PRGMD,8505A-90720,DIP	911441	89536	911441	1	
U	2	*	IC,OP AMP,SINGLE,HIGH VOLTAGE	782342	34371	HA2-2645-5	1	
U	3	*	IC,OP AMP,LOW VOS,TCIB,NOISE,SELECTED	854281	06665	OP97-005P	1	
U	4	*	IC,OP AMP,CHOPPER STABLIZED,8 PIN PKG	831263	64155	LT1052CN8	1	
U	5, 6	*	IC,OP AMP,GEN PURPOSE,8 PIN DIP	363515	27014	LM301AN	2	
VR	3, 4	*	ZENER,UNCOMP,22.0V,5%,5.6MA,0.4W	853502	04713	1N969B	2	
XU	1		SOCKET,IC,14 PIN	453514	00779	2-640377-3	1	

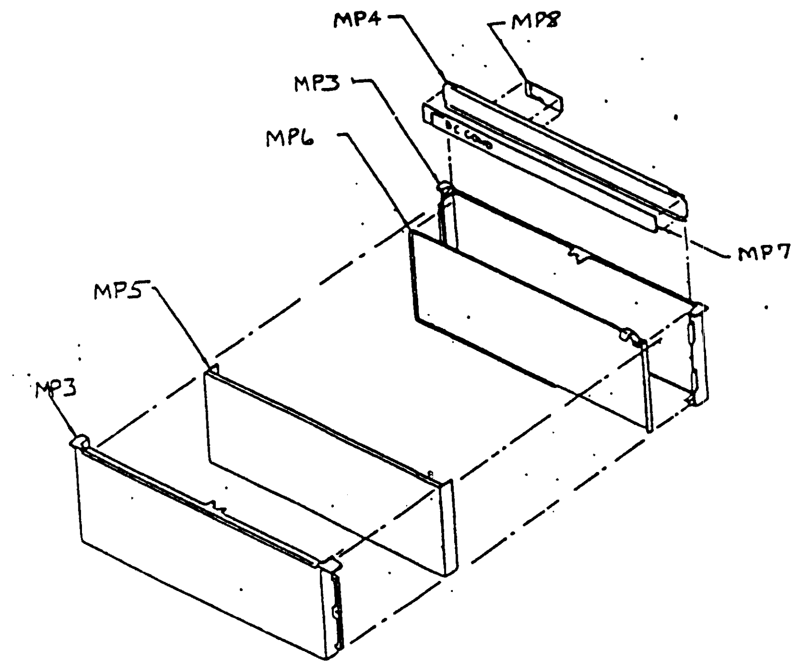
An * in 'S' column indicates a static-sensitive part.

NOTES:

1 Use P/N 872577 to order case without PCA.

On page 5-23 & 8-22, replace Figure 5-9 & Figure 8-8 with the following:





MIS-1715

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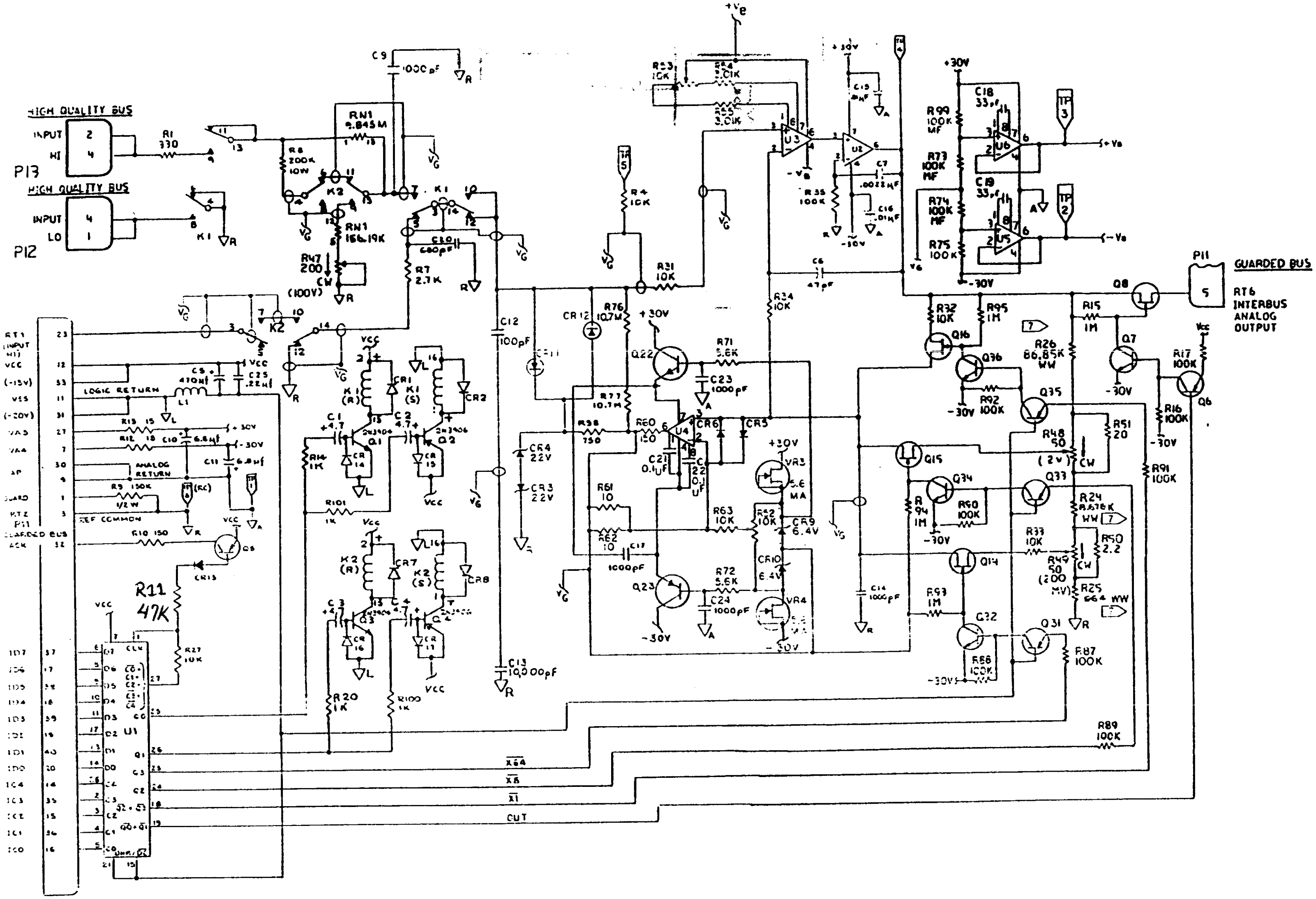
On page 8-23 replace Figure 8-8 with the following:



BINDING POST INPUT					
GAIN	RANGE	ID3	ID2	ID1	ID0
X100	200 MV	0	1	1	0
X10	2V	1	0	1	0
X1	20V	1	1	1	0
÷10	100V	1	0	0	0
÷100	1000V	1	1	0	0
INTERBUS INPUT (RT2)					
X100	200MV	0	1	0	1
X10	2V	1	0	0	1
X1	20V	1	1	0	1

8505A-1115

NOTES: (UNLESS OTHERWISE NOTED)

1. ALL RESISTORS 1/4 W, CC, AND ALL RESISTANCE IN OHMS.

5. LAST REF DES NO'S USED: U6, Q36, CR17, K2, C25, R101, TP8, RN1, VR4, L1.

6. REF DES NO'S NOT USED: Q9, Q12, Q13, Q17-Q21, Q24-Q30, C8, R5, R21-R23, R28-R30, R36-R46, R56-R59, R64-R70, R78-R86, R96, R97, TP6, TP7, R2, R3, R6, R18, R19.

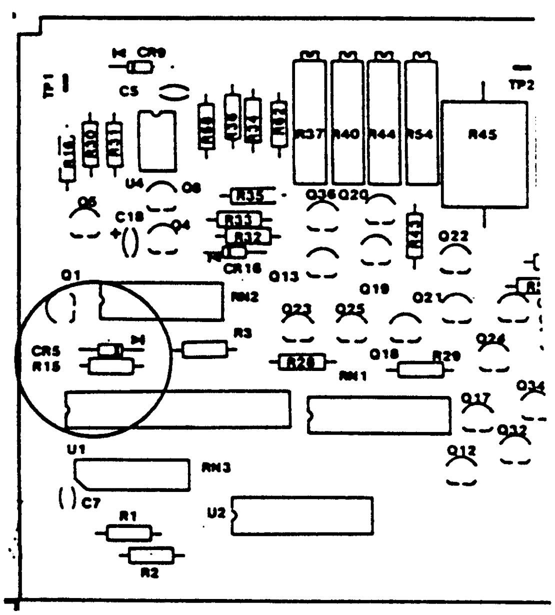
7 R24, R25 AND R26 DC RANGE RESISTOR SET.

CHANGE #7 -44219
Rev. C, -02B Ohms Converter PCB Assembly (8505A-4120S)

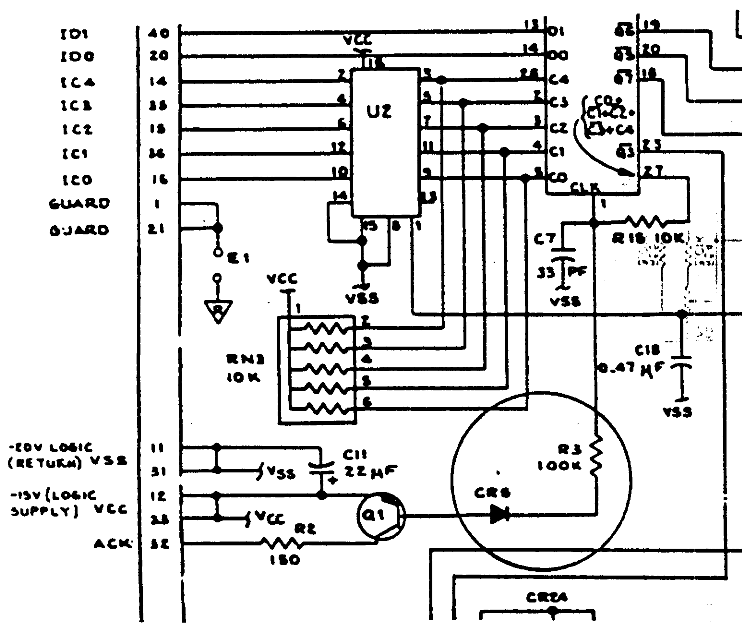
On page 602-12 and 602-13, Table 602-9,

```
CHANGE:   CR3,11,16|............................................|8
          CR3,5,11,16,20,21,24|.................................|7

CHANGE:   R3,70|RES,CF,200K,+-5%,0.25W|573634|59124|CF1/4 204J |2
TO:       R70  |RES,CF,200K,+-5%,0.25W|441485|81349|RCR07G204JS|1

CHANGE:   R3   |RES,CF,200K,+-5%,0.25W|573634|59124|CF1/4 204J|2
TO:       R3   |RES,CF,100K,+-5%,0.25W|348920|59124|CF1/4104J |1
```

On page 602-14 and 602-15/602-16, Figure 602-4, add CR5 and revise the value of R3 as shown in Figures E & F.



8505A-1720
Figure E



8505A-1120
Figure F

ERRATA #4
On page 602-12 and 602-13, Table 602-9,

```
CHANGE:   R10,11,14|............................................|5
TO:       R10,11,14,42,59|......................................|5

CHANGE:   U2|...................................................|2
TO:       U2|...................................................|1

CHANGE:   R15,62 |RES,CF,10K,+-5%,0.25W|573394|59124|CF1/4 103J |2
TO:       R15,62 |RES,CF,10K,+-5%,0.25W|348839|81349|RCR07G103JS|2
```

ERRATA #5

On page 4-7, replace Table 4-2 with the following:

Table 4-2. Low Range DC Voltage Tests

RANGE	DIVIDER SETTING	UUT READING	
		LOW	HIGH
100 mV	.0010000	+9.9957 (-3)	+10.0043 (-3)
100 mV	.0100000	+99.9935 (-3)	+100.0065 (-3)
1V	.0100000	+.099990	+.100010
1V	.1000000	+.999977	+1.000023
10V	.1000000	+.99991	+1.00009
10V	1.0000000	+9.99982	+10.00018

ERRATA #6

On page 4-7, paragraph 4-41, change step 4,

FROM:

4. On the UUT, select the following features: VDC function, AUTO range, SAMPLE setting 5. All other features should be in the power-up configuration.

TO:

4. Manually set the UUT for the 100mV DC range. The [SAMPLE] annunciator should be flashing approximately once per second (S7).

Paragraph 4-43, change step 3,

FROM:

3. The UUT must be set for dc volts, 100V range (manual), and SAMPLE setting 5. All other features on the UUT must be in the power-up configuration.

TO:

3. Manually set the UUT for the 100V DC range. The [SAMPLE] annunciator should be flashing approximately once per second (S7).

ERRATA #7

On page 4-10, paragraph 4-55, after step 4 add step 5 and 6. Renumber steps 5,6,7, & 8 to steps 6,7,8, & 9.

5. Transfer the test DMM Lo input to AR (analog return) and note the reading (typically -15V +-.75V).

6. Transfer the test DMM Hi input to AR1 (+15V) and adjust R9 to match the reading as noted in step 5.

On Table 4-4, delete the following:

VA3	AR	+29.7	+31.7	Analog
VA4	AR	-29.7	-31.7	Analog

ERRATA #8

On page 609-10, Table 609-6,

CHANGE: K1,2|..............................
TO: K1,7|..............................