NOTE

This manual documents Model 8506A and its assemblies at the revision levels shown in Appendix 7A. If your instrument contains assemblies with different revision letters, it will be necessary for you to either update or backdate this manual. Refer to the supplemental change/errata sheet for newer assemblies, or to the backdating sheet in Appendix 7A for older assemblies.

8506A

THERMAL TRUE RMS MULTIMETER

Instruction Manual

P/N 638858
MARCH 1983 Rev 1. 10/85

FLUKE®

WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive:

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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If any failure occurs, the following steps should be taken:

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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.

SHIPPING TO MANUFACTURER FOR REPAIR OR ADJUSTMENT

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.

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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 5053, 5004 EB, Tilburg, The Netherlands.

*For European customers, Air Freight prepaid.

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

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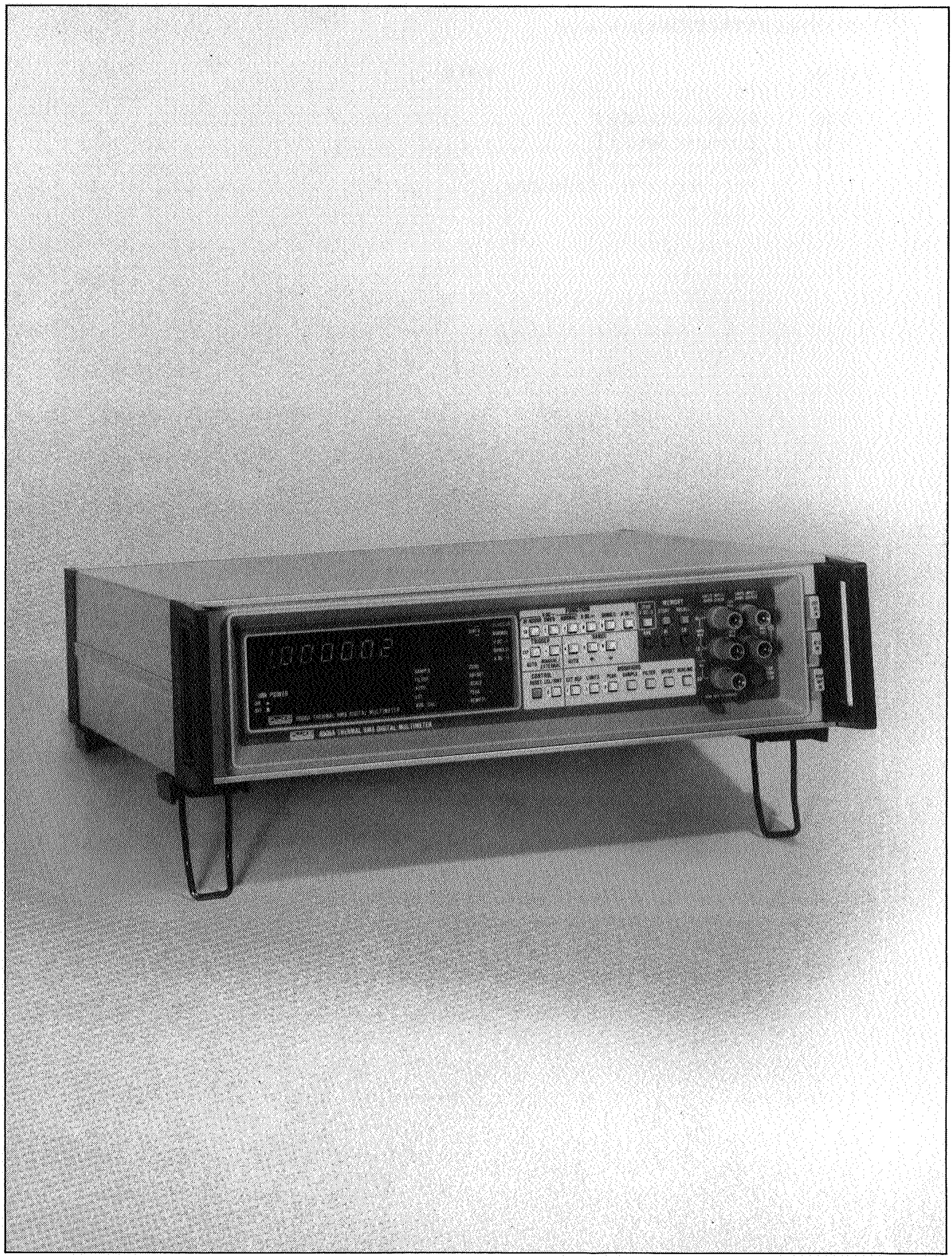


8506A Thermal RMS Digital Multimeter

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 thermal true-rms and dc volts measurements, and for any optional modules ordered with the instrument. Appropriate sectionalized information is 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, mathematical operations and special operations. The standard hardware configuration allows for measurement of thermal true-rms volts on eight ranges and dc volts in five ranges. An averaging mode is available to automatically optimize display resolution and stability for each range in dc volts, resistance, and dc current functions. Extended resolution is also available in the ac volts function. Optional modules are available for dc current (five ranges), and resistance (eight ranges) in two-wire or four-wire arrangements.

1-5. Thermal True-RMS Conversion

1-6. The thermal true-rms feature allows the operator to measure the true-rms value of an ac signal at accuracies of up to .012% with a reading rate of one every six seconds. This response time compares favorably with that of existing thermal transfer standards which can take up to five minutes to complete a measurement.

1-7. Modular Construction

1-8. Considerable versatility is realized through unique modular construction. All active components are contained in modules which plug into a mainframe motherboard. This module-to-motherboard mating, combined with bus architecture and microprocessor control, yields ease of option selection.

1-9. Microprocessor Control

1-10. All modules function under direct control of a microprocessor based controller. Each module is addressed by the controller as virtual memory. Scaling factors and offset values can be applied separately, stored in memory, and automatically used as factors in all subsequent readings. Digital filtering utilizes averaged samples for each reading.

1-11. Software Calibration

1-12. The 8506A 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.

1-13. Recirculating Remainder A/D Conversion

1-14. 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.

1-15. Options and Accessories

1-16. Remote interfaces, a dc current converter, and an ohms converter are among the options and accessories available for use with the multimeter. Refer to Tables 1-1 and 1-2 for complete listings. Any one of the three Remote Interface modules (Option 05, 06, or 07) may be installed at one time.

1-17. SPECIFICATIONS

1-18. Mainframe specifications for ac volts, 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
02A	Ohms Converter	1
03	Current Shunts	1
05	IEEE Standard 488-1975 Interface	2
06	Bit Serial Asynchronous Interface	2
07	Parallel Interface	2

1) Either Option 02A or Option 03 can be installed at one time.

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

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
Y8021	IEEE Std. Cable, 1 Meter Length
Y8022	IEEE Std. Cable, 2 Meter Length
Y8023	IEEE Std. Cable, 4 Meter Length
629170	TRMS Extender Card
MIS-7190K*	Static Controller
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 rated 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)

AC VOLTAGE

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION		INPUT IMPEDANCE
		6½ DIGITS*	5½ DIGITS	
100 mV	125.000 mV	—	1 μV	1 MΩ
300 mV	400.000 mV	—	1 μV	
1V	1.25000V	1 μV	10 μV	±1%
3V	4.00000V	1 μV	10 μV	
10V	12.5000V	10 μV	100 μV	Shunted by
30V	40.0000V	10 μV	100 μV	
100V	125.000V	100 μV	1 mV	<180 pF
500 V	600.000V	100 μV	1 mV	

*In AVG operating mode.

Accuracy

HIGH ACCURACY MODE ±(% of Reading + Number of Counts)[1]

24 HOUR: 23°C ±1°C[2]

RANGE	FREQUENCY IN HERTZ						
	10 TO 40*	40 TO 20k	20k TO 50k	50k TO 100k	100k TO 200k	200k TO 500k	500k TO 1M
100 mV	0.08 + 0	0.02 + 5	0.04 + 5	0.2 + 0	0.6 + 0	1.5 + 0	3.5 + 0
300 mV to 10V	0.08 + 0	0.012 + 0	0.04 + 0	0.2 + 0	0.5 + 0	1.5 + 0	3.5 + 0
30V	0.08 + 0	0.012 + 0	0.04 + 0	0.2 + 0	0.5 + 0	3.5 + 0	12 + 0
100V	0.08 + 0	0.012 + 0	0.04 + 0	0.2 + 0	1.0 + 0	3.5 + 0	—
500V[3]	0.08 + 0	0.012 + 0	0.04 + 0	0.2 + 0	—	—	—

90 DAY: 23°C ±5°C

RANGE	FREQUENCY IN HERTZ						
	10 TO 40*	40 TO 20k	20k TO 50k	50k TO 100k	100k TO 200k	200k TO 500k	500k TO 1M
100 mV	0.08 + 0	0.026 + 5	0.06 + 0	0.2 + 0	0.6 + 0	1.5 + 0	3.5 + 0
300 mV to 10V	0.08 + 0	0.016 + 0	0.06 + 0	0.2 + 0	0.5 + 0	1.5 + 0	3.5 + 0
30V	0.08 + 0	0.016 + 0	0.06 + 0	0.2 + 0	0.5 + 0	3.5 + 0	12 + 0
100V	0.08 + 0	0.016 + 0	0.06 + 0	0.2 + 0	1.0 + 0	3.5 + 0	—
500V[3]	0.08 + 0	0.016 + 0	0.06 + 0	0.2 + 0	—	—	—

*With slow filter

Table 1-3. Specifications (cont)

AC VOLTAGE (cont)

Input Characteristics (cont)

>90 DAY: 23°C ±5°C ADD TO THE 90 DAY SPECIFICATION PER MONTH THE FOLLOWING % OF READING							
ALL RANGES	FREQUENCY IN HERTZ						
	10 TO 40	40 TO 20k	20k TO 50k	50k TO 100k	100k TO 200k	200k TO 500k	500k TO 1M
	0.008	0.001	0.0025	0.012	0.021	0.06	0.11

NOTES:

[1] AC coupled, 5½ digits, input level >0.25 x full scale. For 6½ digits multiply Number of Counts by 10. For input levels between 0.1 x and 0.25 x full scale, add 5 counts for the 100 mV, 1V, 10V, and 100V ranges, add 15 counts for the 300 mV, 3V, 30V ranges, and add 25 counts for the 500V range.

[2] Relative to calibration standards, within 1 hour of dc zero.

[3] Add 0.02 x $(\text{Input voltage} / 600)^2$ % of Reading to the specification.

ENHANCED MODE: Add the following (% of Reading + Number of Counts) to the High Accuracy Mode Specifications.

RANGE	TIME SINCE FIRST READING	
	<5 MINUTES	<30 MINUTES
100 mV, 1V, 10V, 100V	0 + 0	0.003 + 4
300 mV, 3V, 30V	0 + 0	0.003 + 4
500V	0 + 0	0.003 + 6

*AC-coupled, 5½ digits, temperature change <1°C, input level >0.25 x full scale. For input levels between 0.1x and 0.25x full scale, multiply % of Reading adder by 10.

NORMAL MODE: Add the following % of Reading to the High Accuracy Mode Specification.

SEGMENT OF SCALE	24 HOUR, 90 DAY	>90 DAY ADD PER MONTH
0.25x to 1x full scale	0.4	0.044
0.1x to 0.25x full scale	0.6	0.055

AC+DC COUPLED MODES: ±(1.1 times the ac specification for the appropriate mode + the result (Adder) from the following table).

RANGE	ADDER
100 mV to 1V	±(150 μV x (dc volts / total rms volts))
3V and 10V	±(1 mV x (dc volts / total rms volts))
30V and 100V	±(10 mV x (dc volts / total rms volts))
500V	±(50 mV x (dc volts / total rms volts))

Table 1-3. Specifications (cont)

Operating Characteristics

STABILITY: ±(1% of Reading + Number of Counts)*

RANGE	24 HOUR	90 DAY
100 mV, 1V, 10V, 100V	0.0025 + 1	0.004 + 1
300 mV, 3V, 30V	0.0025 + 3	0.004 + 4
500V	0.0025 + 5	0.004 + 6

*High Accuracy Mode, ac coupled, 5½ digits, input level >0.25x full scale, 40 Hz to 20 kHz, temperature change <1°C. For 6½ digits, multiply Number of Counts by 10. For input levels between 0.1x and 0.25x full scale, add to the Number of Counts specification 2 counts for the 100 mV, 1V, 10V, and 100V ranges, 6 counts for the 300 mV, 3V, and 30V ranges, and 10 counts for the 500V range.

CREST FACTOR .... Up to 8:1 at full 90 day (or greater) accuracy for input signals with peaks less than two times full scale, and highest frequency components within the 3 dB bandwidth. Up to 4:1 for signals with peaks less than four times full scale, with an addition of 0.03 to the % of Reading.

3 dB BANDWIDTH .... 3 MHz for the 100 mV range and 10 MHz for the 300 mV, 1V, 3V and 10V ranges (typical).

MAXIMUM INPUT VOLTAGE .... ±600V rms or dc, 840V peak, or 1x 10^7 volts-hertz product.

TEMPERATURE COEFFICIENT ...... 0°C to 18°C and 28°C to 50°C
1/10 of 90 day Specification per °C

COMMON MODE REJECTION .... >120 dB, dc to 60 hertz, with 100Ω in series with either lead.

SETTLING TIME

High Accuracy Mode .... Sample time = 3.5 seconds
Hold time = 2.5 seconds
Measurement time = 6 seconds

If the state of the instrument is unknown, two complete measurement times will be required to guarantee a correct reading. Use of the external trigger mode will always allow a 6 second measurement time.

Enhanced Mode .... The first reading requires the same time as the High Accuracy Mode. Subsequent readings occur every 500 milliseconds. If the input changes 1% the analog settling time to 90 Day mid-band accuracy is 1.5 seconds.

Normal Mode .... Settling times for large changes are non-linear. Zero to Full Scale changes require 2.0 seconds to settle to 90 Day, mid-band specifications. Full scale to 1/10th full scale changes require 3.0 seconds to settle to 1/10th full scale, mid-band; 90 day specifications. Small changes (<1%) settle to mid-band specifications in <1.5 seconds.

Table 1-3. Specifications (cont)

AC VOLTAGE (cont)

Operating Characteristics (cont)

AUTORANGE POINTS

RANGE	UPRANGE	DOWNRANGE
100 mV	125.000 mV	None
300 mV	400.000 mV	110 mV
1V	1.25000V	0.352V
3V	4.00000V	1.1V
10V	12.5000V	3.52V
30V	40.0000V	11V
100V	125.000V	35.2V
500V	None	110V

OPERATING RANGE

RANGE	UNDERRANGE DISPLAY LLLLL	MINIMUM SPECIFIED LEVEL	OVERRANGE DISPLAY HHHHH
100 mV	None	12.5 mV	125.000 mV
300 mV	20 mV	40 mV	400.000 mV
1V	62.5 mV	125 mV	1.25000V
3V	200 mV	400 mV	4.00000V
10V	625 mV	1.25V	12.5000V
30V	2V	4V	40.0000V
100V	6.25V	12.5V	125.000V
500V	30V	60V	600.000V

DC VOLTAGE

Input Characteristics

RANGE	FULL SCALE 6½ DIGITS	RESOLUTION		INPUT RESISTANCE
		7½ DIGITS*	6½ DIGITS	
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.

Table 1-3. Specifications (cont)

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	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 4-hour warm-up. Front panel ZERO push button stores a zero correction factor for each range.

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	±(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). ±300V 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

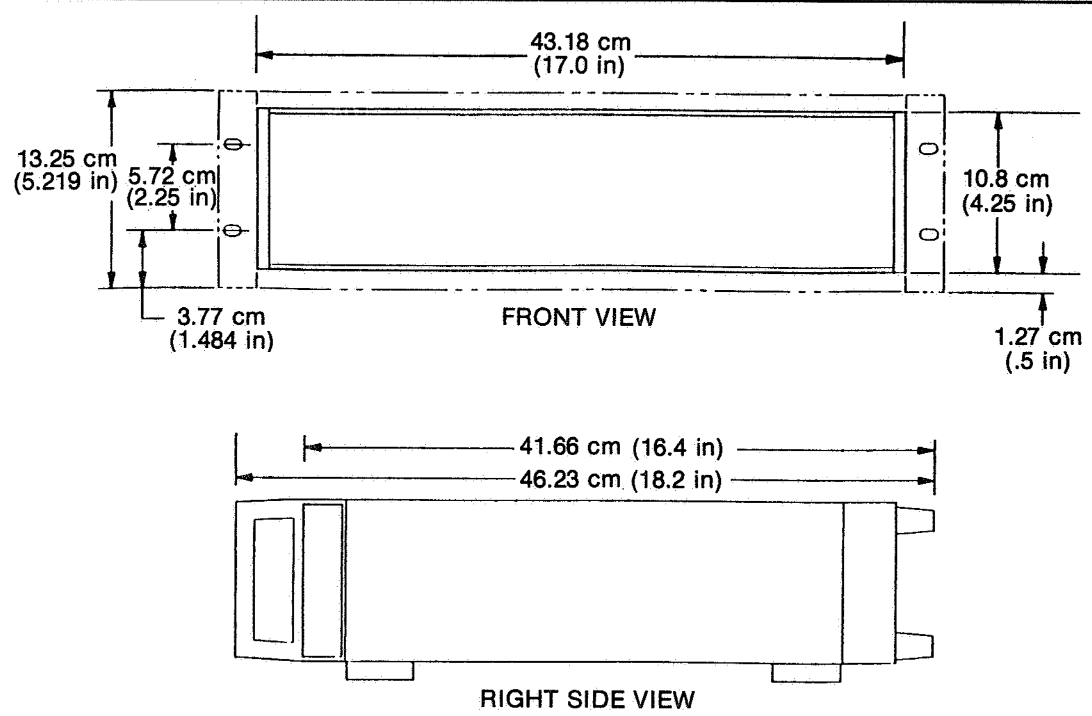


Figure 1-1. Dimension Drawing

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 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 7) 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.

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 slower reading rates and filter time-outs, operation at 50 Hz is identical to that at 60 Hz.

2-14. Fuse Location

2-15. 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 (next to the power connector). 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

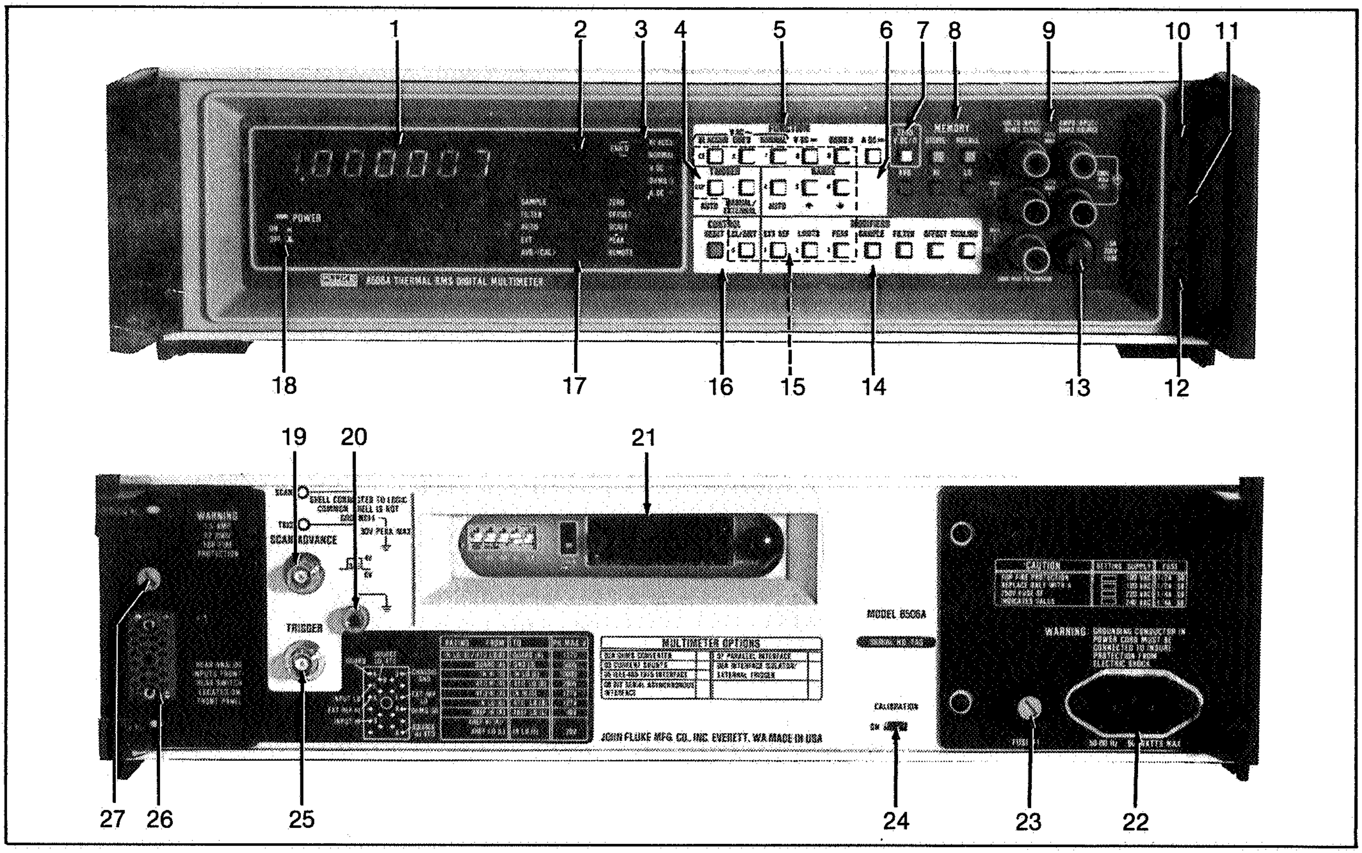


Figure 2-1. Controls, Indicators, and Connectors

Table 2-1. Controls, Indicators, and Connectors

ITEM	NAME	DESCRIPTION
1	Mantissa Field	Displays 5½, 6½, or 7½ digits with decimal point. Also displays errors, overrange warnings, underrange warnings (V AC only), prompts, numerics, recalled values, and limits indications.
2	Exponent Field	Polarity and value of exponent shown for engineering notation of display value.
3	Function Annunciators	Annunciator(s) light to indicate function selected.
4	TRIGGER Push Buttons	TRIGGER push buttons are used to select continuous (AUTO) or individual (MANUAL/EXTERNAL) measurement triggers.
5	FUNCTION Push Buttons	These buttons are used to select any of nine measurement functions: ac volts (HI ACCUR, ENH'D, NORMAL); dc volts (V DC); dc coupled ac volts (simultaneously push V DC and one of the three ac volts buttons); resistance (OHMS), or dc current (A DC).
6	RANGE Push Buttons	AUTO toggles into/out of Autoranging mode, changing range only when necessary. (Up)/(Down) push buttons exit Autoranging and increase/decrease one range with first use. Each succeeding use steps to the next higher/lower range (if available).
7	ZERO Push Button	Toggles Zero mode on and off (used in V DC and OHMS only). Each time Zero mode is toggled on, a new zero correction value is stored for the selected range and all higher ranges in the same function. The zero correction values are applied in that function while Zero mode is on. Refer to text for use during calibration.

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

ITEM	NAME	DESCRIPTION
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/LO are used when storing or recalling limit values, or recalling peak values.
	Average Push Button	AVG toggles into/out of Averaging mode in V DC, OHMS, or A DC, and enables extended resolution in V AC.
9	Input Terminals	Measurement connections.
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 measurements 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. In V AC functions, use of the 4T position is required to minimize input capacitance and attain accuracy specifications. The Ohms Selector has no effect on rear inputs.
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	MODIFIER Push Buttons	SAMPLE selects the number of samples-per-reading in V DC, OHMS, or A DC. (Not used in V AC). FILTER selects the filter mode. OFFSET, SCALING, EXT REF { Mathematic Operations that modify the reading value. LIMITS, PEAK { Special Operations that modify the use of the reading.
15	Numeric 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.
17	Status Annunciators	SAMPLE flashes to show a new reading in progress. FILTER lights whenever a slow filter is selected. AUTO lights for Autoranging. EXT lights when External Reference is enabled (disables Scaling). AVG/(CAL) lights (steady) for Averaging mode or flashes for Calibration mode. ZERO lights when Zero mode is on (V DC and OHMS only). OFFSET lights when Offset mode is enabled. SCALE lights when Scaling mode is selected (disables External Reference). PEAK lights when Peak mode is enabled. REMOTE lights when the multimeter is controlled through a remote interface.

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

ITEM	NAME	DESCRIPTION
18	POWER Switch	Push ON/push OFF. Calibration mode must be off before cycling power on or off.
19	Scan Advance Output	TTL compatible control signals to external scanner (50-ohm output impedance).
20	Chassis Ground	Binding post for ground connections.
21	Remote Interface	Connector on optional remote interface module.
22	Power Connector	Three-prong connector accepting line cord with ground wire.
23	Line Fuse	Use 1/2A Slow Blow for 100 or 120V ac, 1/4A 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	Enabled by front panel MANUAL/EXTERNAL push button.
26	Rear Analog Input	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.
27	Rear Input Fuse	Use AGC 1.5A.

input connections. Refer to Fuse Replacement in Section 4 before replacing any fuse.

2-16. Required Hardware

2-17. The multimeter must be equipped with the following modules for standard operation (ac volts and 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)
5. DC Signal Conditioner (Error 9 if not installed)
6. Thermal True-RMS Converter

NOTE

The Thermal True-RMS Converter is the only ac converter that can be used in the 8506A. If another type of ac converter is installed in the 8506A, an Error E condition will be specified at power-up or reset.

2-18. Additional modules are necessary when using the multimeter in resistance or dc current functions or for remote control. The resistance and dc current modules (Options 02 and 03 respectively) cannot be installed at the same time. If it is necessary to check, install or replace modules, refer to Module Installation and Removal procedures in Section 4.

2-19. An "Error 9" indication appears in the multimeter display whenever a function is selected and the respective function module is faulty or missing. Refer to Error Codes later in this section for error descriptions and remedies. At power-up, the multimeter identifies the hardware configuration by displaying "C"and a series of alphanumerics. The Thermal True-RMS Converter is identified as "A". Optional modules are identified by the respective option number. An "8" appears in the exponent display at power-up or reset when the Isolator is installed. For example, a multimeter configured with the Current Shunts (Option 03), the IEEE Remote Interface (Option 05), and the Isolator is identified with a power-up display of "C35A 8".

2-20. Power-Up Configuration

2-21. 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, 1000V manual range, filter mode F0, sample factor 7, with all modes and values disabled. The power-up (or reset) configuration is fully defined in Table 2-2.

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,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	See Notes 2,3 and chart	FILTER on or off
Sample	7	SAMPLE flashes	See Note 3 and chart	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 4	EXT REF off	Off, retains last value	EXT REF off
Limits	Off, Value 0	Normal Display	Off, retains value	Normal Display
Peak	Off	PEAK off	Off, retains last values	PEAK off
Averaging	Off	AVG/(CAL) not on steady	Off (3)	AVG/(CAL) not on steady
Zero	On, Value 0	ZERO on	Retains mode values and state (5)	ZERO on (VDC,OHMS) or off
Calibration Mode	Note 5		Note 5	

Notes:

1. Re-selection of the same function sets autoranging (AUTO on), but retains all other mode values and states.

2. In VAC functions, only filter modes F and F0 are allowed. In VDC, OHMS, or ADC, filter modes F, F0, F1, F2, and F3 are allowed.

3. Averaging mode is available in VDC, OHMS, and ADC only. The AVG button can also be used in VAC functions to command extended resolution only. If Averaging mode was in effect, selecting VDC, OHMS, or ADC sets filter mode F0 and sample setting 7. If VDC, OHMS, or ADC is re-selected without changing the function, the state of Average mode is not changed, and the existing filter mode and sample setting are retained.

4. 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. While in VAC functions, EXT REF cannot be used to either recall the software number or activate External Reference mode.

5. 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.

FROM:	TO: VAC	VDC OHMS ADC	
VAC	X		If manual ranging, retains manual ranging and previous range. If autoranging, retains autoranging beginning at previous range. Filter mode retained.
VAC		X	Autoranging Begins at highest range (1000V, 100 Megohms, or 1A) Retains previous filter mode (F or F0) Sample factor 7
VDC OHMS ADC	X		Autoranging Begins at r500 Filter mode off (F0)
VDC OHMS ADC		X	Autoranging Begins at highest range (1000V, 100 Megohms, or 1A) Retains previous filter mode (F, F0, F1, F2, or F3) Retains previous sample factor

2-22. Display

2-23. MEASUREMENT READING

2-24. 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 range identifiers (V AC only), numeric storing entries, recalled values, error and warning information, and interactive programming information (prompts).

2-25. When very large or small readings are displayed, the exponent field is also used to maintain maximum resolution. A negative exponent field polarity indicates multiplication of the mantissa by the displayed power of ten (-3 means .001). A positive exponent field polarity indicates multiplication of the mantissa (+3 means 1000). Exponent values of -6, -3, +3, or +6 are available for displayed readings. Additional exponents of -9 or +9 are displayed when storing offset or scaling factors entered with the front panel push buttons.

2-26. The measurement display is altered when the Average mode or the Limits mode is enabled. When the Average mode is enabled (AVG/(CAL) annunciator on), an extra digit of resolution is provided in the V DC, A DC, and OHMS functions for certain ranges: In V DC, 6-½ digits are displayed for all ranges except the 10V range, for which 7-½ digits are displayed (the 7th digit is displayed in the exponent field); in A DC and OHMS, 6-½ digits are displayed for all ranges. The Average mode is not available in the V AC functions, but the AVG push button can still be used to enable extended resolution. Resolution in each range and function is summarized in Table 2-3. When the Limits mode is enabled, the display indicates HI, LO, or PASS instead of a numeric reading.

NOTE

When the Average mode is enabled in the 10V dc range, the exponent field displays the seventh mantissa digit and does not indicate the reading's exponent. In this case, the reading's decade multiplier cannot be interpreted from the display if a math function (such as offset or scaling) is enabled.

2-27. ANNUNCIATORS

2-28. Selecting a valid function causes the respective annunciator(s) to light. One annunciator lights if ac volts high accuracy (HI ACCUR), ac volts normal (NORMAL), dc volts (V DC), resistance (OHMS), or dc current (A DC) is selected. Two annunciators light if ac volts enhanced (ENH'D) or ac volts normal (or high accuracy) and dc coupled ac volts (HI ACCUR + V DC, or NORMAL + V DC) are selected. Three annunciators light when dc coupled ac volts enhanced (ENH'D + V DC) is selected. Ordinarily, the V DC annunciator lights in the power-up or reset configuration.

2-29. 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), Offset (OFFSET), Autoranging (AUTO), or V DC/Ohms Zero (ZERO). The FILTER annunciator lights (steadily) whenever the slow filter is selected (filter on mode in V AC). With a distinctive display of HI, LO, or PASS, the Limits mode requires no separate status annunciator.

2-30. The SAMPLE annunciator blinks to signify a new reading in progress. Depending on the function selected, two response patterns are available. If the multimeter is in one of the ac volts functions (NORMAL, HI ACCUR, or ENH'D), SAMPLE blinks at predetermined rates. AC Volts High Accuracy causes SAMPLE to blink on once every six seconds. AC Volts Normal causes SAMPLE to blink on once every 0.5 second. AC Volts Enhanced causes SAMPLE to blink on once as an initial high accuracy reading is taken, then (after six seconds) to continue blinking once every 0.5 second.

2-31. When the multimeter is set for dc volts, resistance, or dc current functions, the SAMPLE annunciator flashes at the reading (display update) rate for sample settings from 0 through 7. The flash rate for sample settings 0, 1, and 2 is very rapid and causes the SAMPLE annunciator to appear to be steadily lighted. 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.

2-32. RANGE IDENTIFIER

2-33. The multimeter momentarily displays a range identifier whenever a V AC function is selected and when a new range is selected in a V AC function. For example, r500 is displayed when a V AC function is selected (and the previous function was V DC, A DC, or OHMS). When changing from one V AC function to another, the previously enabled range is retained and momentarily displayed. The appropriate range identifier is displayed for any subsequent range change (whether the instrument is in auto or manual ranging). The range can be verified at any time by reselecting the same V AC function. This action causes no change in the multimeter, other than a momentary interruption of measurements (during which the range identifier is displayed). In V DC, A DC, and OHMS functions, the range is identified by the position of the decimal point.

2-34. OVERRANGE INDICATION

NOTE

The accuracy of a VAC reading is a function of the input level. Therefore, accuracy is specified within the minimum and overrange input levels defined in Table 2-4. VAC inputs outside this range are not displayed.

Table 2-3. Display

The reading (with decimal point) is displayed as shown in each function and range. The use of mathematic operations (SCALING or EXT REF and OFFSET) may alter these patterns. The use of LIMITS causes a display of HI, LO, or PASS.

	RANGE IDENTIFIER*	DISPLAY MANTISSA[1]	DISPLAY EXPONENT
V AC	r100 (-3)	1 8 8.8 8 8	-3
	r300 (-3)	8 8 8.8 8 8	-3
	r1	1.8 8 8 8 8	
	r3	8.8 8 8 8 8	
	r10	1 8.8 8 8 8	
	r30	8 8.8 8 8 8	
	r100	1 8 8.8 8 8	
	r500	8 8 8.8 8 8	

		DISPLAY MANTISSA[2]	DISPLAY EXPONENT
V DC	100 mV	± 8 8 8.8 8 8 8	-3
	1V	± 8.8 8 8 8 8 8	
	10V	± 8 8.8 8 8 8 8	
	100V	± 8 8 8.8 8 8 8	
	1000V	± 8 8 8 8.8 8 8	
OHMS	10Ω	8 8.8 8 8 8	
	100Ω	8 8 8.8 8 8	
	1 kΩ	8.8 8 8 8 8 8	÷3
	10 kΩ	8 8.8 8 8 8 8	÷3
	100 kΩ	8 8 8.8 8 8 8	÷3
	1 MΩ	8.8 8 8 8 8	÷6
	10 MΩ	8 8.8 8 8 8	÷6
	100 MΩ	8 8 8.8 8 8	÷6
A DC	100 µA	± 8 8 8.8 8 8	-6
	1 mA	± 8.8 8 8 8 8	-3
	10 mA	± 8 8.8 8 8 8	-3
	100 mA	± 8 8 8.8 8 8	-3
	1A	± 8.8 8 8 8 8	

NOTES:
1. Additional digit in V AC extended resolution is shown in lighter print.
2. Additional digit in Averaging mode is shown in lighter print.
3. In the 10V dc range, the exponent is used to display an additional mantissa digit when Averaging mode is selected.

Table 2-4. Operating Range

V AC

RANGE	UNDERRANGE (LLLLLL)	MINIMUM SPECIFIED LEVEL	OVERRANGE (HHHHHH)
100 mV	None	12.5 mV	125 mV
300 mV	20 mV	40 mV	400 mV
1V	62.5 mV	125 mV	1.25V
3V	200 mV	400 mV	4V
10V	625 mV	1.25V	12.5V
30V	2V	4V	40V
100V	6.25V	12.5V	125V
500V	30V	60V	600V

V DC

RANGE	OVERRANGE (HHHHHH)
100 mV	200 mV
1V	2V
10V	20V
100V	128V
1000V	1200V

A DC

RANGE	OVERRANGE (HHHHHH)
100 μA	250 μA
1 mA	2 mA
10 mA	16 mA
100 mA	128 mA
1A	1.28A

OHMS

RANGE	OVERRANGE (HHHHHH)
10Ω	20Ω
100Ω	200Ω
1 kΩ	2 kΩ
10 kΩ	25 kΩ
100 kΩ	250 kΩ
1 MΩ	4.1 MΩ
10 MΩ	35 MΩ
100 MΩ	265 MΩ

2-35. The measurement display presents a distinct indication when overrange inputs are detected in any function. An input voltage exceeding the full scale value for the range selected causes a display of HHHHHH. In V AC functions, full scale values approximate maximum specified levels (as required to maintain accuracy). The overrange indication therefore also serves as an upper accuracy limit indication.

2-36. LOW INPUT INDICATION

2-37. In the V AC functions, the multimeter notifies the user if the input level is too low to maintain specified reading accuracy. If a V AC function is selected, the multimeter displays LLLLLL whenever the input voltage is less than approximately 5% of full scale. The only exception is the 100 mV ac range, which has no underrange limit.

2-38. WARNING INDICATION

2-39. When in the Scaling, External Reference, Offset or Limits mode, there may be no readily discernible display of the true measurement value. In these modes of operation, the multimeter provides a distinctive display when the voltage is 30V or higher at the front panel input connections. If this voltage exceeds the overload point for the range in use, the Overrange Indication (flashing HHHHHH) is displayed. If this voltage does not exceed the range overload point, a single H is flashed in the exponent display.

NOTE

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

2-40. ERROR CODES

2-41. Error codes offer considerable help in identifying improper procedures or equipment configurations. These codes are explained in Table 2-5.

Table 2-5. 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 or OHMS are permissible.
Error 1	Store attempted during overrange 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 A	Illegal push button usage in any of the three V AC modes.	Use correct button(s).
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 chip faulty or not installed. Occurs when storing into, or recalling from, Calibration Memory.	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 necessary.
Error H	Ohms connection problem.	Verify proper connections. Check input protection fuses.

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, or A DC 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.	Push RESET to clear error condition.
Error E	At power-up or reset only, an unallowed ac converter is installed or the Calibration Memory module is installed.	Power off, remove the unallowed ac converter or the Calibration Memory module. The Thermal True RMS Converter is the only ac converter allowed in the 8506A. The Calibration Memory is a standard part of the controller.

2-42. INTERACTIVE PROGRAMMING INFORMATION

2-43. 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 (SCALING, HI OR LO for limits, or OFFSET) 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 (SCALING, HI, LO, OFFSET) is pushed. With V DC, OHMS, or A DC functions, keystroked numerics can be used to enter the filter mode and sample factor. When either the displayed value or keystroked numerics have been entered, the display resumes the measurement reading function (or HI, LO, PASS in the Limits mode) when the terminator button is pushed.

2-44. 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.

2-45. Three push button steps are required to recall a limit or peak value. First press RECALL ("?"). Then specify whether upper or lower limit or peak is desired by pressing HI or LO (display responds with "YES?"). Finally, push the appropriate terminator button (LIMITS or PEAK).

2-46. Front Panel Push Buttons

2-47. The multimeter employs 26 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.

2-48. 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

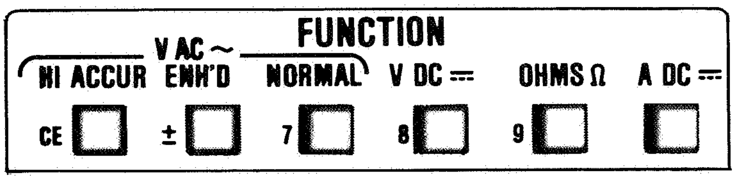
3. Special Operations

2-49. Measurement parameters define operations that affect the resolution, stability, and accuracy of the reading. Depending on the function selected, a specific set of parameters is available. In V AC functions (HI ACCUR, ENH'D, NORMAL), range, filter, extended resolution, and trigger may be specified. In V DC, OHMS, and A DC functions, range, filter, trigger, sample, and averaging may be specified. The Zero operation can be performed in the V DC and OHMS functions only.

2-50. 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. External Reference may not be used in V AC functions.

2-51. 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, and/or Limits mode may be used for a HI, LO, or 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.

2-52. Use the push buttons in a steady and methodical manner when programming the multimeter. Error codes usually identify any programming problem and specify a solution (refer to Table 2-5). 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 may 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.



The FUNCTION push buttons allow selection of the analog measurement function. Standard functions include: ac volts (NORMAL, ENH'D, HI ACCUR) and dc volts (V DC). Optional functions include resistance (OHMS) and current (A DC).

HI ACCUR

Push HI ACCUR for maximum ac volts accuracy with six second reading times. Eight ranges are available (100 mV, 300 mV, 1V, 3V, 10V, 30V, 100V, 500V). Standard resolution is 5½ digits on all ranges. Extended resolution (6½ digits) is available when the AVG button is pushed.

ENH'D

Push ENH'D for an initial HI ACCUR measurement, which is used to correct subsequent measurements made at NORMAL mode speed. The same eight ranges are available. Extended resolution (6½ digits) is available when the AVG button is pushed.

NORMAL

Push NORMAL for somewhat reduced ac volts accuracy, but with fast reading times. The same eight ranges are available. Extended resolution (6½ digits) is available when the AVG button is pushed.

V DC

Push V DC for dc voltage measurements with 6½ digit resolution on five ranges (100 mV, 1V, 10V, 100V, 1000V).

OHMS

Push OHMS to make resistance measurements with 5½ or 6½ digit resolution on eight ranges (10 ohms, 100 ohms, 1 kilohm, 10 kilohms, 100 kilohms, 1 Megohm, 10 Megohms, 100 Megohms). The Ohms Converter module (Option 02) must be installed.

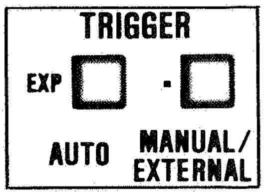
NOTE

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

A DC

Push A DC for dc current measurements with 5½ digit resolution on five ranges (100 μA, 1 mA, 10 mA, 100 mA, 1A). The Current Shunts module (Option 03) must be installed.

Figure 2-2. Front Panel Push Buttons

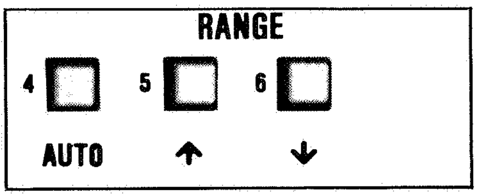


AUTO

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

MANUAL/ EXTERNAL

If used in Auto Trigger mode, 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. If used in Manual Trigger mode, the MANUAL/EXTERNAL push button triggers a new measurement: any reading already in progress is aborted and the new reading begun immediately. The display, once updated, is held until the next manual trigger. 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. The AUTO annunciator lights when Autoranging is selected.

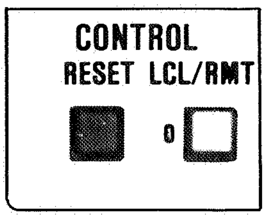
↑

Each use of this manual ranging push button selects the next higher available range. If AUTO was previously activated, use of the up-range 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. No range change is effected if the multimeter is already in the lowest range.

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



RESET

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).

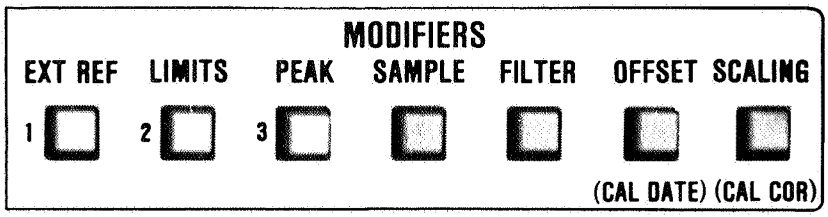
LCL/RMT

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

1.) If the IEEE Interface (Option 05) is installed, LCL/RMT can be used to command local control only if the multimeter is already in remote control. LCL/RMT cannot command remote control.

2.) If the Bit Serial Interface (Option 06) or the Parallel Interface (Option 07) is installed, LCL/RMT can be used to alternately select local or remote control.

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 in V DC, OHMS, and A DC functions only. 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, is displayed as long as 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 continuously 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 causes previously recorded values to be erased and a new series of peak values to be stored.

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

SAMPLE

If the dc volts (V DC), resistance (OHMS), or dc current (A DC) function is selected, SAMPLE can be used to select the number of samples to be averaged for each display update. SAMPLE cannot be used in V AC functions.

FILTER

AC Volts functions normally use filter mode F0. The filter can be selected for these functions (if the input frequency is less than 40 Hz) by pushing FILTER. The accuracy of the instrument is degraded if the filter is selected for higher input frequencies.

If V DC, A DC, or OHMS is selected, FILTER can be used to toggle between the slow filter (mode F - FILTER annunciator on) and the fast filter (F0 - FILTER annunciator off). Alternately, any of five combinations of filter and timeouts can be selected as programmed numerics.

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.

(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. These digits may be recalled at any time.

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:

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

STORE SCALING

2.) Numeric entry scaling values may 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.

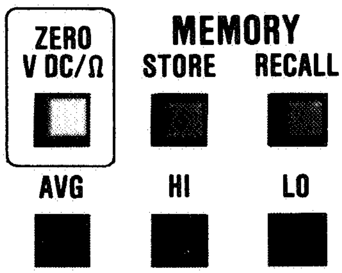
NOTE

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.

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

(CAL COR)

With the multimeter in Calibration mode, calibration correction factors can be entered for each range in V DC, OHMS, and A DC functions. Correction factors can also be stored at a frequency of interest in V AC functions. Correction factors are automatically applied to the uncorrected reading. Uncorrected readings can be recalled when the Calibration mode is either enabled or disabled. 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 (for V DC, OHMS, A DC only):

STORE { 0 - 17 → SAMPLE; 0,1,2,3 or no key → FILTER }

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 }

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

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. Use the following sequence:

1 – **0**

Mantissa Field: Enter up to 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.

CE

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.

±

•

EXP

RECALL

The RECALL push button can be pressed to recall and display values stored in the Limits, Peak, Scaling, Offset, Zero, External Reference, (V DC, OHMS, A DC functions only), Sample or Filter modes. For recall of uncorrected readings, or calibration dates, 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 (not in V AC) / V DC/OHMS ZERO }

To recall a special operation value:

RECALL { HI / LO } { LIMITS / PEAK }

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

ZERO VDC/Ω

The ZERO push button can be used to zero any offsets in the V DC and OHMS functions. To zero the offsets for a particular range, proceed as follows:

1. Select the V DC or OHMS function and select the desired range.

2. Short INPUT HI and LO. If in OHMS, select the two-terminal configuration or also short SENSE HI and LO. (To zero the multimeter's internal offsets, short the inputs with a high-quality, low-thermal shorting bar. To also zero the offsets in the external test system, short the inputs with the test leads instead.)

3. Press ZERO (the ZERO annunciator will light). The zero correction remains in effect until ZERO is pressed again or a function other than V DC or OHMS is selected (the ZERO annunciator will turn off).

A new zero correction is stored each time the ZERO annunciator is toggled on. The multimeter uses the same zero for all higher ranges in the same function. A separate zero may be stored for each range. (Start with the lower ranges so that later zeros do not overwrite previous zeros.) Zero correction factors are reset to 0 at reset or power-up. Appendix 7B explains how the ZERO push button is used in Calibration mode.

AVG

The AVG push button can be used to optimize sample and filter factors for each range in V DC, OHMS, and A DC functions only. In V AC functions, Average mode is not available, but the AVG button can be used to command an extra digit of resolution on most ranges.

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)

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, manual range, auto trigger, filter mode F0, zero mode on, no other modes or values). Calibration mode must be off before power-up.

STEP	ACTION	PUSH BUTTONS
1	FUNCTION selection V AC a. Selecting any V AC function sets autorange, filter mode F0. b. Push V AC HI ACCUR, V AC ENH'D, or V AC NORMAL and V DC simultaneously for dc-coupled ac measurements.	V AC HI ACCUR V AC ENH'D V AC NORMAL

Figure 2-3. Programming Hierarchy

2 FUNCTION selection (V DC, OHMS, A DC)

V DC **OHMS** **A DC**

a. If previous function was V AC, the following conditions are set:
   - Autoranging
   - Filter mode retained
   - Sample factor 7
   - All mathematic and special operations values retained, modes disabled

b. If previous function was V DC, OHMS, or A DC, the following conditions are set:
   - Autoranging
   - Previous filter mode retained
   - Previous sample factor retained
   - All mathematic and special operations values retained, modes disabled
   - Previous trigger mode retained

MEASUREMENT PARAMETERS

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

3 TRIGGER selection

a. If in manual, change to auto — **AUTO**

b. If in AUTO, change to manual — **MANUAL/ EXTERNAL**

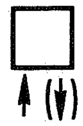
c. Manual triggers — **MANUAL/ EXTERNAL** → **MANUAL/ EXTERNAL**

4 RANGE selection

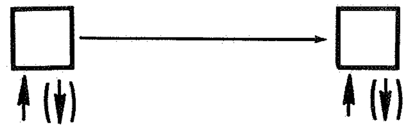
a. Toggle into/out of autoranging — **AUTO** ↔ **AUTO**

Figure 2-3. Programming Hierarchy (cont)

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

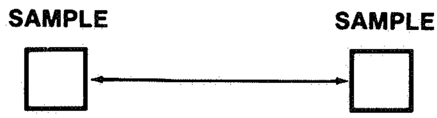


c. Continue stepping to available higher, (lower) ranges.

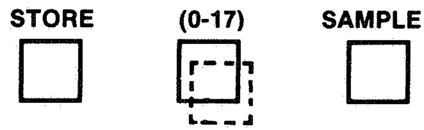


5 Reading Rate Selection (V DC, OHMS, A DC only)

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

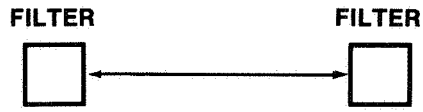


b. Select any sample setting from 0 (2 exp 0 = 1) to 17 (2 exp 17 = 131,072)



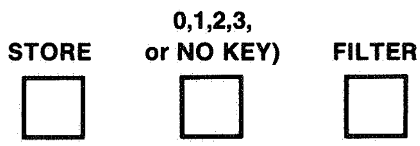
6 FILTER selection

a. V AC functions only: toggle between filter mode F0 and F

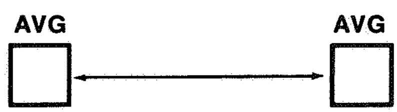


b. V DC, OHMS, A DC only: toggle between slow filter (F) and fast filter (F0).

c. V DC, OHMS, A DC only: select filter F, F0, F1, F2, or F3.



7 V DC, OHMS, A DC only: toggle the Averaging mode on or off. In V AC, enables extended resolution.



8 V DC/OHMS Zero: toggle on/off (V DC or OHMS only). New zero stored each time Zero mode is enabled. Refer to Appendix 7B for use with Calibration mode.

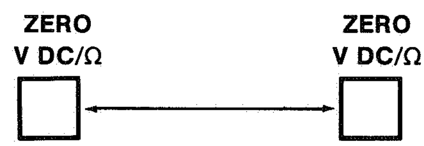


Figure 2-3. Programming Hierarchy (cont)

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.

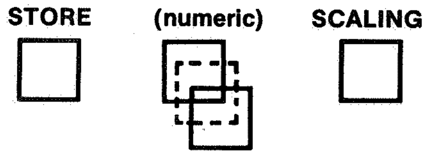
NOTE

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

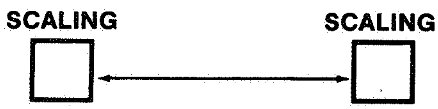
9 SCALING selection (disables External Reference)

a. Store displayed value, enter Scaling mode

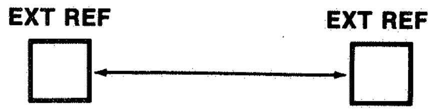
b. Store numeric value (non-zero), enter Scaling mode.



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



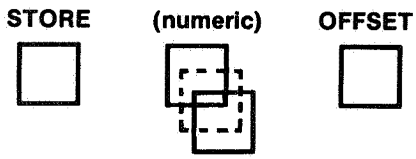
10 External Reference selection (disables Scaling) — toggle on/off. Not available in V AC functions.



11 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.

Figure 2-3. Programming Hierarchy (cont)

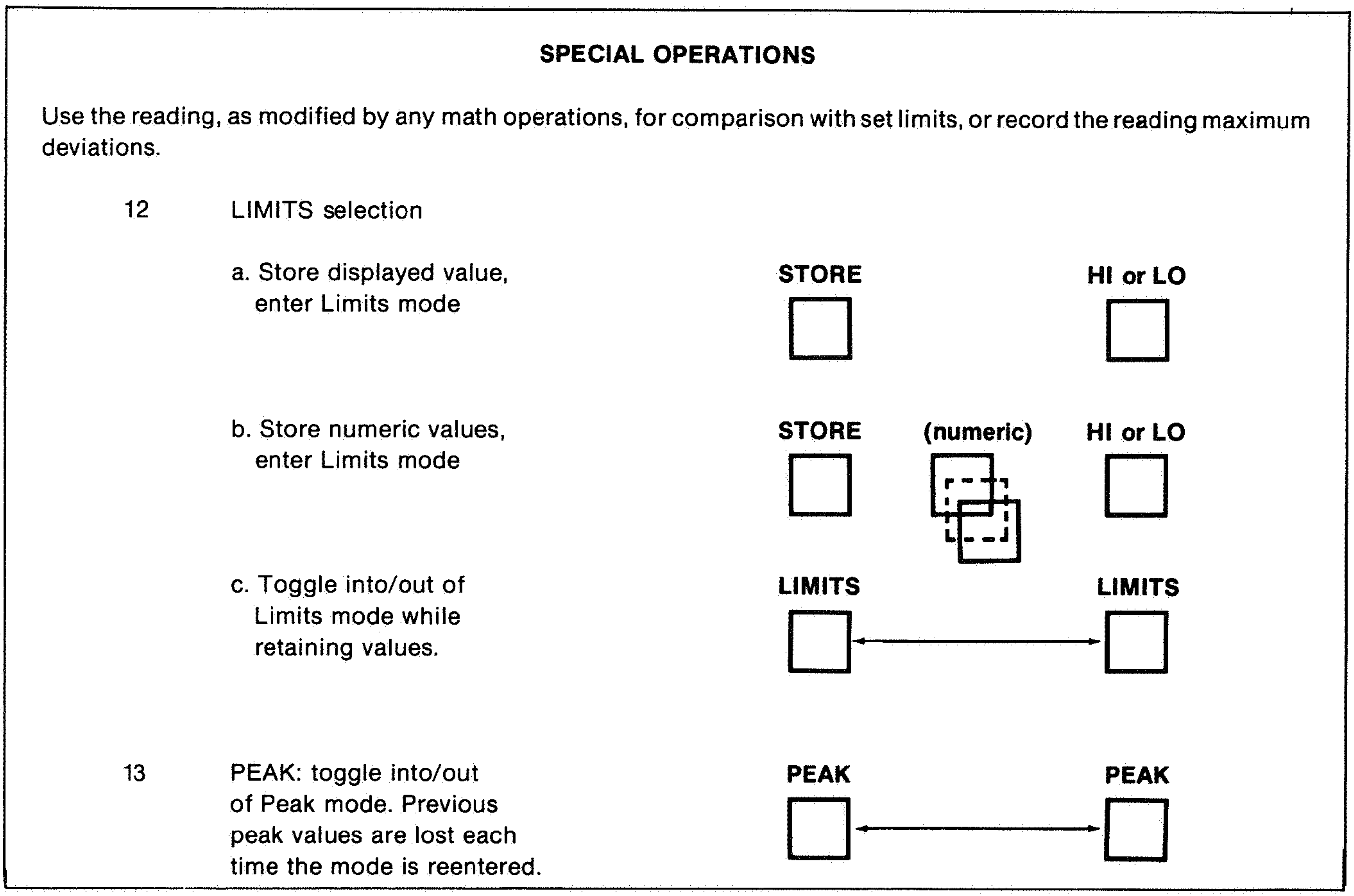


Figure 2-3. Programming Hierarchy (cont)

2-53. Measurement Terminals and Controls

2-54. GUARDING

2-55. General

2-56. 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.

2-57. 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. Since the multimeter utilizes copper input terminals, the use of low emf, shielded cables with copper spade lugs minimizes thermal emf errors.

2-58. Guard Selector and Guard Terminal

2-59. Correct use of the multimeter GUARD terminal both protects the instrument and provides more accurate readings. The Guard Selector (EXT GD IN), when disengaged (out), connects the internal guard. 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.

2-60. Guard terminal connections are shown in Figure 2-4. Guard to chassis ground potential must not exceed 500V. Guard to SENSE LO potential must not exceed 127V.

2-61. VOLTS INPUT/OHMS SENSE (HI and LO) TERMINALS

2-62. Voltage and resistance measurements are made with the VOLTS INPUT/OHMS SENSE terminals, as 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 is in the disengaged (2-wire) position.

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.

2-63. AMPS INPUT/OHMS SOURCE (HI and LO) TERMINALS

2-64. The AMPS INPUT/OHMS SOURCE terminals are used when making current (A DC) 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. When the Ohms Selector is in the disengaged (2T) position, these terminals are internally shorted to the VOLTS INPUT/OHMS SOURCE terminals (HI to HI, LO to LO).

NOTE

In A DC 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.

2-65. OHMS SELECTOR

2-66. When engaged (in), the Ohms Selector control 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. The Ohms Selector does not influence the rear inputs (which are preset in a four-wire configuration). Refer to Figure 2-5. The Ohms Selector may remain disengaged (2T) for V DC or A DC measurements. However, for V AC measurements, it is recommended that the Ohms Selector be engaged (4T) in order to minimize input capacitance.

2-67. REAR INPUT SELECTOR

2-68. When pushed in, the Rear Input Selector disconnects all front panel inputs and connects the rear input connector. Rear inputs are identical to those on the front panel (with the addition of Ohms Guard). External reference inputs (HI and LO) are always applied through the rear connector (not switched). The Ohms Selector and Guard Selector have no effect when the rear inputs are enabled. The state of the Rear Input Selector can be determined remotely through any of the remote interface options.

2-69. Function

2-70. AC volts (HI ACCUR, NORMAL, or ENH'D), dc volts, and dc coupled ac volts are standard with the multimeter. Optional functions include resistance (OHMS) and dc current (A DC). Selection of a new function automatically cancels any previously selected function and places the multimeter in the function change configuration (refer to Table 2-2). 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. One, two, or three annunciators light to verify a valid function selection. 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.

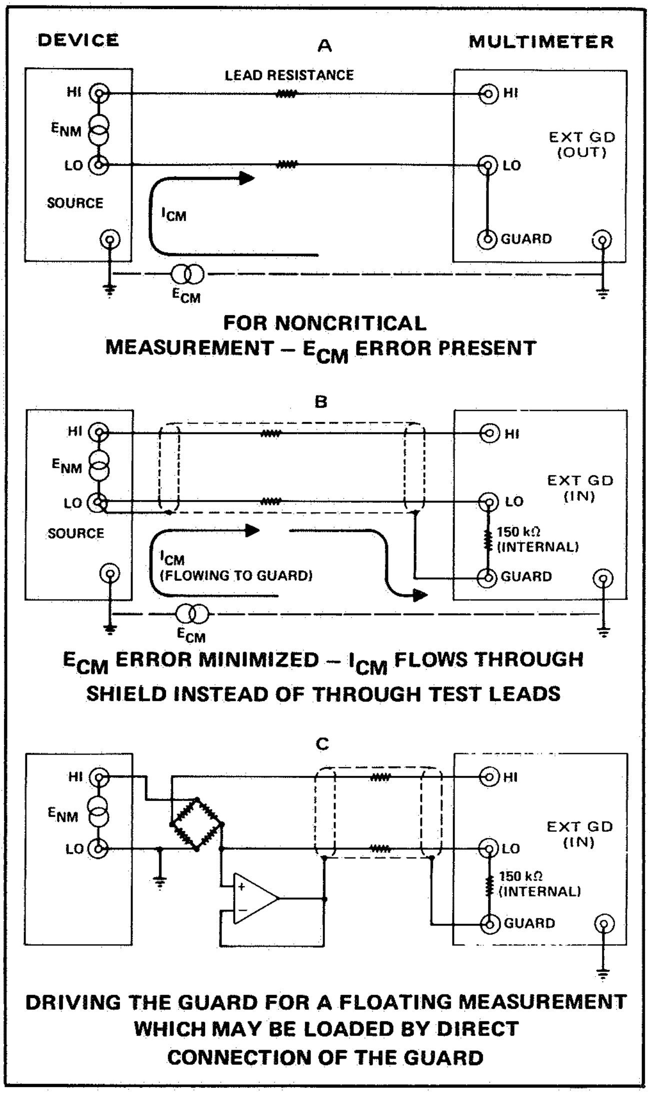


Figure 2-4. Guard Connections

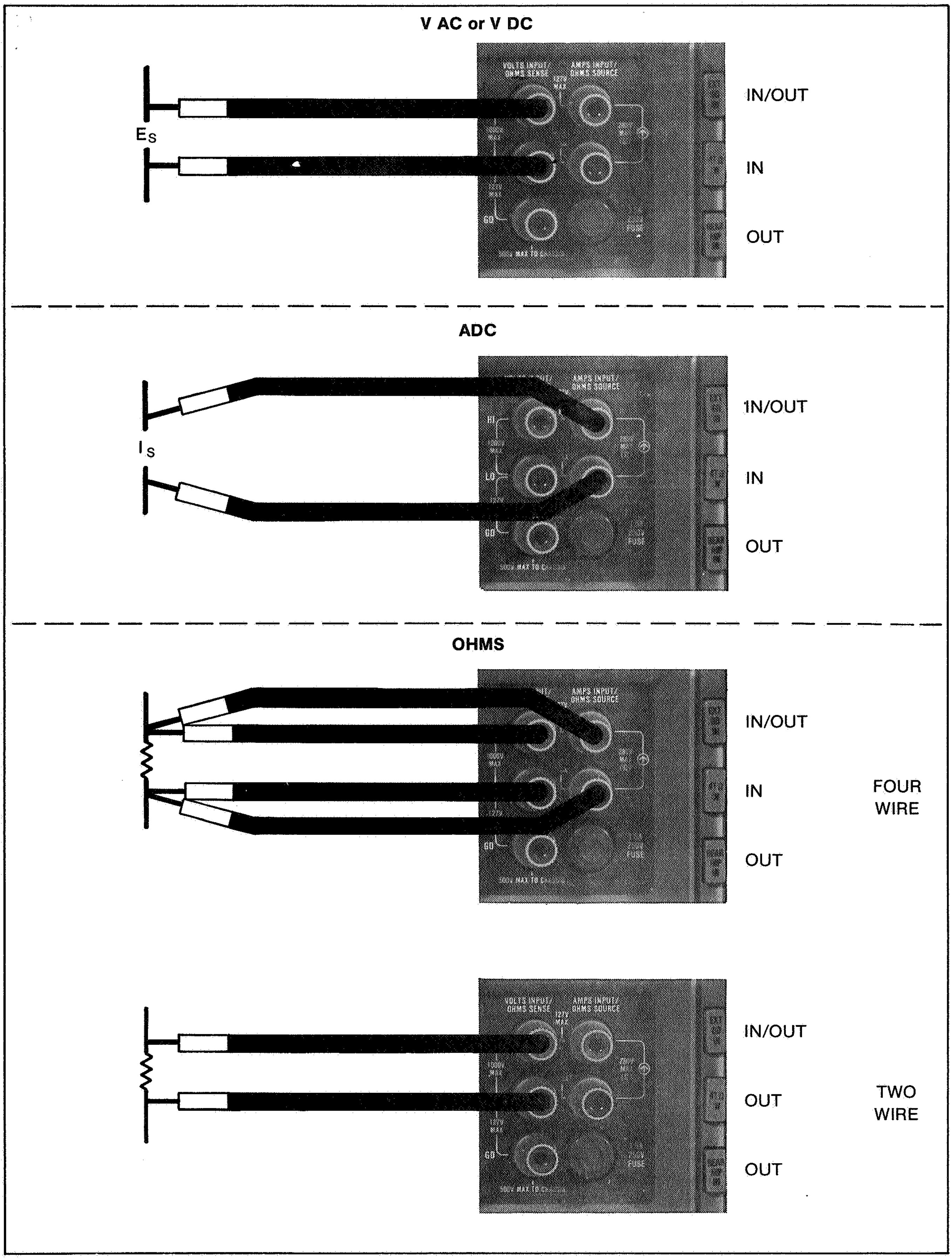


Figure 2-5. Measurement Connections

2-71. The Thermal True-RMS Converter uses three front panel function push buttons (V AC HI ACCUR, V AC NORMAL, and V AC ENH'D). The high accuracy mode (V AC HI ACCUR) requires approximately six seconds per reading, but the resulting accuracies of up to 0.016% rival those of thermal transfer standards (at a fraction of the time). The normal mode (V AC NORMAL) displays an rms value of the input (updated every 0.5 second), but with reduced accuracies since no sensor linearization is performed. The enhanced mode (V AC ENH'D) takes one initial high accuracy measurement. This measurement is then used to correct subsequent measurements, which are made at normal mode speed (0.5 second). The enhanced mode is specified as long as the following conditions are maintained: the input cannot vary more than ±1% from that used for the initial high accuracy reading, the temperature cannot vary more than ±1°C, and the time lapse cannot exceed one hour. If the input changes by more than ±1% from that used in the initial high accuracy reading, another high accuracy reading is taken to automatically update the correction factor.

2-72. Measurement Parameters

2-73. SAMPLING

2-74. AC Volts Functions

2-75. One sample is taken for each V AC reading. Reading time in NORMAL is approximately 0.5 second. HI ACCUR readings require six seconds. ENH'D requires an initial six second high accuracy reading, then reverts to 0.5 second normal readings. Any of these reading times may be lengthened slightly when mathematic operations are in effect. The SAMPLE push button is inoperative when the multimeter is set for ac volts measurements (pushing SAMPLE causes an Error A). A new high accuracy measurement can be commanded in the enhanced mode (ENH'D) by pushing the ENH'D button again. Similarly, when the dc coupled enhanced mode is used, a new high accuracy measurement can be commanded by simultaneously pushing the ENH'D and V DC buttons.

NOTE

In the Enhanced mode, the Thermal True-RMS Converter automatically takes a new reading to establish a new correction factor if the range changes (either manual or autorange), the filter setting changes, or the difference between the reading and the present correction factor is ≈1%.

2-76. DC Volts, Resistance, and DC Current Functions

2-77. The multimeter averages a selectable number of samples for each reading (display update) in V DC, OHMS, or A DC. 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 (front panel) operation. Synchronous or asynchronous operation may be specified remotely.

2-78. 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 setting 5 when SAMPLE is toggled.

2-79. 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.

2-80. TRIGGERING

2-81. Each new measurement is initiated with a trigger. In AUTO triggering, the trigger is generated internally at the end of the required reading time. Triggers may also be applied locally (from the front panel) or remotely.

2-82. 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.

2-83. 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.

2-84. 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.

2-85. FILTERING

2-86. AC Volts Functions

2-87. Two filter modes (off and on) are available when the multimeter is set for ac volts measurements (HI ACCUR, NORMAL, or ENH'D). The filter off mode (F0) is set when changing into a V AC function from V DC, A DC, or OHMS. Most V AC measurements use the filter off mode. The filter on mode (F) is to be used only when the input signal frequency is below 40 Hz. Degraded accuracies result if filter on mode is used at higher signal frequencies. The filter mode can be changed by toggling the FILTER button (FILTER annunciator is on for filter on mode and off for filter off mode). When any V AC function is selected while a V AC function is already in effect, no filter mode change is made.

2-88. DC Volts, Resistance, DC Current Functions

2-89. Five filter modes are available. Either of two analog filters (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 timeout (for settling delay) may also be inserted before each reading. No filtering is available for the external reference inputs. Table 2-6 defines the five filter modes.

2-90. Two methods of filter selection are available in V DC, A DC, or OHMS. 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 (slow, no timeout, annunciator on) and F0 (fast, no timeout, annunciator off). The multimeter uses a preset selection pattern if a mode other than F or F0 is already selected when FILTER is toggled. 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. RECALL FILTER may be used at any time to verify the filter combination in use (without changing the filter mode).

2-91. AVERAGING

2-92. The Averaging mode presets the sample setting to 10 (2 exponent 10 = 1024 samples-per-reading) and the filter mode to F (slow filter, no time out). These settings provide optimum stability and resolution throughout the range of inputs. Subsequent use of the SAMPLE or FILTER push button while in Averaging mode may jeopardize this intended optimization. Therefore, sample settings less than 10 cause the multimeter to exit the Averaging mode. For example, a sample setting of 12, which specifies greater noise rejection than the setting of 10, is accepted and retained for all ranges within the same function. Conversely, a sample setting of 7, offering less stability, is accepted (but causes the multimeter to exit the Averaging mode).

Table 2-6. Filter Modes (V DC, A DC, OHMS)

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.)			

2-93. Filter mode F2 can also be selected in Averaging mode. Any filter selected other than F or F2 is accepted by the multimeter, but causes deactivation of Averaging mode.

2-94. The Average mode can be used to improve display stability (reduce rattle) for measurements in V DC, OHMS, or A DC. Averaging mode is not available in any of the ac volts functions (although the AVG pushbutton can be used to command extended resolution in V AC functions). In V DC, OHMS, and A DC functions, the Average mode provides increased display stability in all ranges and an increase in display resolution in certain ranges. In V DC (10V range only), a total of 7-1/2 digits is now available. Other V DC ranges still provide 6-1/2 digits of resolution. In A DC, 6-1/2 digits (instead of the standard 5-1/2) are now available in all ranges. In OHMS, a total of 6-1/2 digits is available on all ranges. Preset resolutions used for standard operation and for the Average mode are summarized in Table 2-7.

NOTE

When the Average mode is enabled in the 10V dc range, the exponent field displays the seventh mantissa digit and does not indicate the reading's exponent. In this case the reading's decade multiplier cannot be interpreted from the display if a math function (such as offset or scaling) is enabled.

2-95. RANGE

2-96. Ranges available in each function are summarized in Table 2-3. A power-up or reset condition sets the multimeter in the 1000V range (V DC function), Autoranging disabled. Any function selection enables Autoranging (AUTO annunciator on). Autoranging begins on the highest range for each function (1000V dc, 500V ac, 100 Megohm, or 1A). In V AC only, autoranging begins at the previous range when selecting between V AC functions. 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). A range identifier is also displayed with each range change in V AC functions. This identifier may also be used at any time in VAC to verify the range in use: just reselect the V AC function being used.

2-97. AC volts can be measured on the following eight ranges: 100 mV, 300 mV, 1V, 3V, 10V, 30V, 100V, and 500V. Resolutions vary respectively from 1 uV to 1 mV in standard operation (or from 1 uV to 100 uV when the AVG button has been used to command extended resolution). Input impedance is 1 megohm/<180 pF. Resolution in each range is illustrated in Table 2-3.

2-98. DC volts can be measured on five successive ranges from 100 mV to 1000V. Respective resolutions vary from 100 nV to 1 mV. Refer to Table 2-3 for a presentation of display resolution in each range. Input impedance on the 100V and 1000V ranges is 10 Megohms. On the lower three ranges it is greater than 10,000 Megohms.

2-99. Out of range indications are displayed whenever the reading does not fall within the specified rating in a particular range. When the multimeter is in autoranging, autoranging points cause an automatic new range selection, averting an out of range indication. An out of range indication cannot be averted if the reading is less than that allowed in the lowest range (LLLLLL displayed in V AC functions only) or greater than that allowed in the highest range (HHHHHH displayed in all functions). When the multimeter is in manual ranging, an out of range indication can be disabled by manually selecting a higher or lower range. Out of range values are presented in Table 2-4.

Table 2-7. Resolution

	RANGE	STANDARD DIGITS	AVERAGING DIGITS
V DC	100 mV	6½	6½
	1V	6½	6½
	10V	6½	7½
	100V	6½	6½
	1000V	6½	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
A DC	100 μA	5½	6½
	1 mA	5½	6½
	10 mA	5½	6½
	100 mA	5½	6½
	1A	5½	6½

2-100. V DC AND OHMS ZERO

2-101. During normal operation (Calibration mode OFF), the ZERO push button is used to store and apply temporary zero correction factors for the V DC and OHMS functions. These "temporary zeros" correct for drifts in dc offsets that may have occurred since the last calibration. The temporary zeros may also be used to correct for offsets in the external test system, such as in the test leads or in an external scanner. The temporary zeros supplement non-volatile ("permanent") zeros which are stored during calibration.

2-101a. Pressing the ZERO push button toggles Zero mode on and off. While Zero mode is on (ZERO annunciator lit), the multimeter applies both the permanent and the temporary zeros to V DC and OHMS readings. While Zero mode is off (ZERO annunciator off), the multimeter applies only the permanent zeros. Attempting to toggle Zero mode on in the A DC or V AC functions causes the multimeter to indicate Error 0.

2-101b. Every time Zero mode is toggled on (ZERO annunciator lit), the multimeter stores a new temporary zero for the range that is presently selected. The multimeter automatically stores the same zero for all higher ranges in the same function. A separate zero may be stored for each range. (Start with the lower ranges so that later zeros do not overwrite previous zeros.) The temporary zeros are all set to 0 when the multimeter is reset or powered up.

2-101c. Exiting the zeroed function deactivates Zero mode, but retains the stored zero values. Reselecting the zeroed function automatically reactivates Zero mode and restores the old zero values.

2-101d. Whenever a zero is stored (i.e, whenever Zero mode is toggled on), the INPUT HI and INPUT LO terminals must be shorted together. (If storing a zero in the OHMS function, select the two-wire configuration or also short SENSE HI and SENSE LO.) To zero the multimeter's internal offsets, short the inputs with a high-quality, low-thermal shorting bar. To also zero the offsets in the external test system, short the inputs with the test leads instead.

2-101e. The RECALL push button can be used to recall the zero correction factors. For an explanation of the use of the ZERO push button during calibration, refer to Appendix 7B.

2-102. Mathematic Operations

2-103. 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 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 and Offset can be used in combination to display percentage variation. Examples of such operations are given in Applications later in this section.

2-104. Use of mathematic operations is expressed in the following formula:

$$\text{DISPLAY} = \frac{\text{MEASURED VALUE}}{\text{SCALING}} - \text{OFFSET}$$

(OR EXTERNAL REFERENCE)

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. VDC or OHMS functions: any applied zero value is first subtracted, yielding the measured value.

2. VAC functions: External Reference cannot be used.

2-105. SCALING

NOTE

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

2-106. 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.

2-107. Storing the displayed value as a scaling factor warrants a word of caution: ensure 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.

2-108. EXTERNAL REFERENCE

NOTE

External Reference mode is not available in ac voltage functions (NORMAL, ENH'D, or HI ACCUR). Attempting to enter External Reference mode in any V AC function causes an Error A condition.

2-109. 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.

2-110. Immediately after a power-up or reset, RECALL EXT REF can be used to verify the multimeter's software number. The first subsequent use of EXT REF to activate External Reference mode disables this software identification feature. When enabling External Reference 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.

2-111. The external reference voltage may be a maximum of ±20V dc on either high or low External Reference 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:

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

2-112. Usually, the External Reference low terminal is externally 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 the External Reference input.

2-113. OFFSET

2-114. In Offset mode, the display represents the deviation from a stored offset value. Measurements of stability or 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. The stored offset value may be recalled at any time.

2-115. Special Operations

2-116. PEAK

2-117. The highest and lowest deviations in the displayed value may be recorded in the Peak mode. Source 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 at 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.

2-118. 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.

2-119. LIMITS

2-120. 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 regularly 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.

2-121. A display reading can also be stored as a limit value. Use the following sequence:

STORE HI (or LO)

2-122. 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 standard 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.

2-123. 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.

2-124. Remote Control

2-125. The multimeter may be equipped with any of three remote interface modules. These modules are fully explained in Section 6. When the IEEE Remote Interface (Option 05) 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.

2-126. The LCL/RMT push button may be used to toggle into/out of remote control when either the Bit Serial Remote Interface (Option 06) or the Parallel Remote Interface (Option 07) is installed. Whenever the multimeter is in remote control, whether commanded locally or from the remote, the REMOTE annunciator is lighted.

2-127. When in remote, only the POWER push button remains operational in all circumstances. 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, whether caused by line failure or toggling of the power push button, returns the multimeter to local control.

2-128. Calibration Mode

2-129. DESCRIPTION

2-130. 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. Underrange conditions in V AC functions no longer cause a "flashing L" indication.

4. 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.

5. All mathematic operations and special operations are disabled.

6. 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.

7. 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.

2-131. 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.

2-132. 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.

2-133. USE

2-134. 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.

2-135. The (CAL DATE) push button can be used in all functions (including the three V AC 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.

2-136. 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) may be recalled using the following sequence:

RECALL LO (CAL DATE)

2-137. 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)

2-138. Scan Advance

2-139. 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.

2-140. Systems Use

2-141. 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.

2-142. OPERATION

2-143. Initial Turn-On

2-144. 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.

2-145. 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 (or the Thermal True-RMS Converter as A).

2-146. The power-up (reset) configuration is now established. The multimeter is set for the V DC function, the 1000V manual range, filter mode F0, sample factor 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 ensures rated accuracy. Better accuracies can be obtained in the Averaging mode (after a four-hour warm-up).

2-147. Initial Set-Up

2-148. The three front panel terminal controls (Rear Input Selector, Ohms Selector, and Guard Selector) must be positioned correctly prior to taking measurements. Use the following guidelines:

1. The Rear Input Selector must be disengaged (out) for front panel inputs or engaged (in) for inputs applied through the rear panel connector. Ohms Guard is only available through the rear connection. External Reference HI and LO is always available through the rear input connector (not switched).

2. The Ohms Selector must be disengaged (out) for two-wire resistance measurements or engaged (in) for four-wire resistance measurements. For all other functions, the Ohms Selector can be left disengaged. However, it is recommended that the Ohms Selector be engaged (in) whenever making

V AC measurements. This setting minimizes input capacitance.

NOTE

The Ohms Selector has no affect on rear inputs. Rear inputs are dedicated in a four-wire configuration.

3. The Guard Selector is disengaged (out) for non-critical measurements. Refer to Measurement Terminals and Controls for a full description of guarding when this selector is engaged (in). The Guard Selector has no affect on the rear inputs.

2-149. Measurement parameters, mathematic operations, and special operations can be specified prior to or during measurements. These parameters and operations can be applied to measurements in any function, with the following exceptions:

1. External Reference mode is not available in any of the V AC functions (HI ACCUR, NORMAL, or ENH'D).

2. Averaging is not available in any of the V AC functions (HI ACCUR, NORMAL, or ENH'D). The AVG pushbutton may be used in the V AC functions to enable an extended display resolution.

2-150. Front panel programming of the multimeter is best accomplished in a sequential manner. This sequence is fully explained in Figure 2-3. Often, only measurement parameters need be specified. Programming of any mathematic operation requires consideration of mathematics already in effect.

2-151. Refer to Figure 2-5 for an outline of measurement connections. Also refer to Measurement Terminals and Controls earlier in this Section.

2-152. Measurement Instructions

2-153. AC VOLTS (THERMAL TRUE-RMS)

NOTE

It is recommended that all ac volts measurements be made with the the Ohms Selector in the engaged (in) position to minimize input capacitance.

2-154. Thermal ac-ac transfer measurements can be made using the Thermal True-RMS Converter Module. Select the mode of operation desired, as determined by the degree of accuracy and speed required.

2-155. AC Volts Normal Mode (V AC NORMAL)

2-156. Use the following procedure when measuring ac volts with the normal mode of the Thermal True-RMS Converter:

1. Push the V AC NORMAL button (NORMAL annunciator lights).

2. The multimeter assumes autoranging (beginning at the 500V range) when a V AC function is selected. However, if a V AC function was previously in effect, the previous range is retained as the starting point for any possible autoranging.

3. Select the filter by pushing the FILTER button if the frequency of the input signal is ≤40 Hz. (The accuracy of the instrument is degraded if the filter is selected for higher input frequencies).

4. Connect the ac voltage to the HI and LO SENSE INPUT terminals).

2-157. AC Volts Enhanced Mode (V AC ENH'D)

2-158. Use the following procedure when measuring ac volts with the enhanced mode of the Thermal True-RMS Converter:

1. Push the V AC ENH'D button (ENH'D annunciators light).

2. The multimeter assumes autoranging (beginning at the 500V range) when a V AC function is selected. However, if a V AC function was previously in effect, the previous range is retained as the starting point for any possible autoranging.

3. Select the filter by pushing the FILTER button if the frequency of the input signal is ≤40 Hz. (The accuracy of the instrument is degraded if the filter is selected for higher input frequencies).

4. Connect the unknown ac voltage to the HI and LO SENSE INPUT terminals.

5. The initial high accuracy measurement requires six seconds. The rms voltage should be displayed within 0.5 second of the completion of this initial high accuracy reading and updated every 0.5 second thereafter.

6. A new high accuracy measurement can be commanded at any time by pushing the ENH'D button again. After six seconds, the SAMPLE annunciator flashes briefly and 0.5 second updates resume.

NOTE

The Thermal True-RMS Converter automatically takes a new reading to establish a new correction factor if the range changes (either manual or autorange), the filter setting changes, or the difference between the reading and the present correction factor is ≥1%.

2-159. AC Volts High Accuracy Mode

2-160. Use the following procedure when measuring ac volts with the high accuracy mode of the Thermal True-RMS Converter:

1. Push the V AC HI ACCUR button (HI ACCUR annunciator lights).

2. The multimeter assumes autoranging (beginning at the 500V range) when a V AC function is selected. However, if a V AC function was previously in effect, the previous range is retained as the starting point for any possible autoranging.

3. Select the filter by pushing the FILTER button if the frequency of the input signal is ≤40 Hz. (The accuracy of the instrument is degraded if the filter is selected for higher input frequencies).

4. Connect the unknown voltage to HI and LO SENSE INPUT terminals.

5. The multimeter requires approximately six seconds for each high accuracy measurement.

2-161. AC VOLTS - DC COUPLED (THERMAL TRUE-RMS)

2-162. AC Volts Normal Mode on DC Volts

2-163. Use the following procedure when measuring ac volts (dc coupled) with the normal mode of the Thermal True-RMS Converter:

1. Simulaneously push the V AC NORMAL and V DC buttons (NORMAL and V DC annunciators light).

2. The multimeter assumes autoranging (beginning at the 500V range) when a V AC function is selected. However, if a V AC function was previously in effect, the previous range is retained as the starting point for any possible autoranging.

3. Select the filter by pushing the FILTER button if the frequency of the input signal is ≤40 Hz. (The accuracy of the instrument is degraded if the filter is selected for higher input frequencies).

4. Connect the unknown voltage to the HI and LO SENSE INPUT terminals.

5. The ac voltage display is updated every 0.5 second.

2-164. AC Volts Enhanced Mode (DC Coupled)

2-165. Use the following procedure when measuring ac volts (dc coupled) with the enhanced mode:

1. Simultaneously push the V AC ENH'D and V DC buttons (ENH'D and V DC annunciators light).

2. The multimeter assumes autoranging (beginning at the 500V range) when a V AC function is selected. However, if a V AC function was previously in effect, the previous range is retained as the starting point for any possible autoranging.

3. Select the filter by pushing the FILTER button if the frequency of the input signal is ≤40 Hz. (The accuracy of the instrument is degraded if the filter is selected for higher input frequencies).

4. Connect the unknown voltage to the HI and LO SENSE INPUT terminals.

5. The multimeter requires approximately six seconds for the initial high accuracy measurement. The ac voltage should be displayed within 0.5 second after completion of the initial measurement and updated every 0.5 second thereafter.

6. A new high accuracy measurement can be commanded at any time by pushing the ENH'D button again. After six seconds, the SAMPLE annunciator flashes briefly and 0.5 second updates resume.

NOTE

The Thermal True-RMS Converter automatically takes a new reading to establish a new correction factor if the range changes (either manual or autorange), the filter setting changes, or the difference between the reading and the present correction factor is ≥1%.

2-166. AC Volts High Accuracy Mode (DC Coupled)

2-167. Use the following procedure when measuring ac volts high accuracy (dc coupled) using the Thermal True-RMS Converter:

1. Simultaneously push the V AC HI ACCUR and V DC buttons (HI ACCUR and V DC annunciators light).

2. The multimeter assumes autoranging (beginning at the 500V range) when a V AC function is selected. However, if a V AC function was previously in effect, the previous range is retained as the starting point for any possible autoranging.

3. Select the filter by pushing the FILTER button if the frequency of the input signal is ≤40 Hz. (The accuracy of the instrument is degraded if the filter is selected for higher input frequencies).

4. Connect the unknown voltage to HI and LO SENSE INPUT terminals.

5. The multimeter requires approximately six seconds for each accuracy measurement.

2-168. DC VOLTAGE (V DC)

2-169. Use the following procedures when making dc voltage measurements from the front panel:

1. Push the V DC button (V DC annunciator lights).

2. The multimeter assumes the autoranging mode at the highest (1000V dc) range. Manual range selection may also be made. Available ranges are: 1000V, 100V, 10V, 1V, and 100 mV.

3. Set or revise the required measurement parameters, mathematic operations, and special operations (refer to Figure 2-3).

4. Apply the unknown voltage to the HI and LO SENSE INPUT terminals.

2-170. APPLICATIONS

2-171. Specific applications using the multimeter are presented in Table 2-8. If these examples are duplicated on the multimeter, a power-up or reset configuration is first required.

Table 2-8. Applications

APPLICATION 1 (V AC)	
REQUIREMENT:	Characterize on AC Standard (Fluke 5200A) using the multimeter and a known ac source.
METHOD:	Connect the multimeter (set for V AC HI ACCUR) to a known value ac source (such as a characterized Fluke 5200A). Record the reading. Now connect the multimeter to another 5200A (the one being characterized). Adjust this second 5200A for a High Accuracy reading equal to that originally recorded.
APPLICATION 2 (V AC)	
REQUIREMENT:	Monitor the stability of an ac source in terms of its deviation in volts from a present output of 10V ac.
METHOD:	Store the present output as an offset. Push: STORE OFFSET Offset mode is now enabled. The multimeter will read only the deviation from the original 10V ac reading.
APPLICATION 3 (V DC)	
REQUIREMENT:	Determine which of a group of power supplies has 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.

Table 2-8. Applications (cont)

APPLICATION 4 (V DC)	
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 VDC/Ω ZERO 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: $\frac{22.088}{20.08} = 1:1$
APPLICATION 5 (V DC)	
REQUIREMENT:	Display the input error voltage for an operational amplifier by measuring the dc output error. Gain = 2.6847×10^4.
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.

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 Appendix 7B 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.

BYTE 1	BYTE 2	BYTE 3
1 1 1 1 0 1 1 1	1 0 1 1 1 1 1 1	1 1 1 1 1 1 1 1

Byte 1, bits 1–2: Sign Bits; bit 3: Error Bit; after bit 4: Implied Binary Point.

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.

0 0 0 0 1 0 0 0	+	0 1 0 0 0 0 0 0	+	0 0 0 0 0 0 0 1
– (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.

[$R_t = R_{AD}$ 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.

$	**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)

Command	Function	Description
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.

Command	Function	Description
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**	"B1","B2" used with Paralled ASCII Interface (Option -07) only.
● B 2	**16-Bit Parallel**	

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.

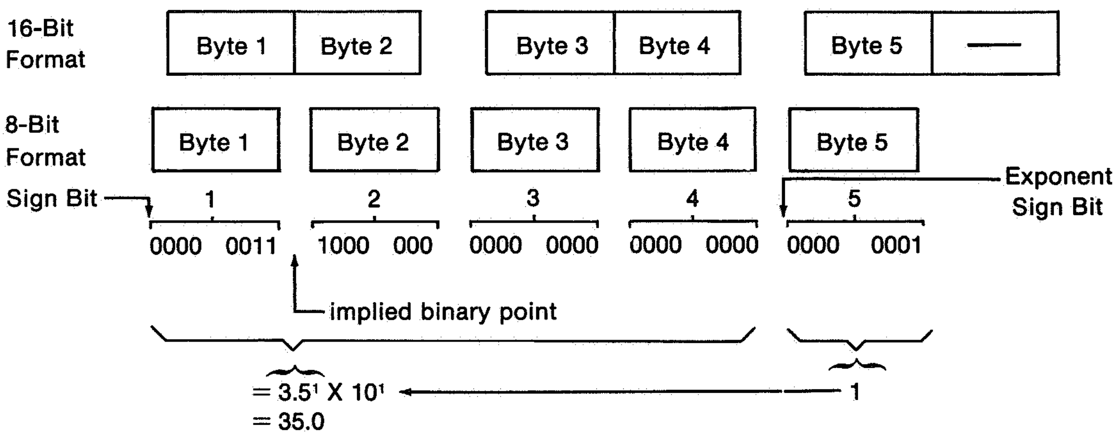


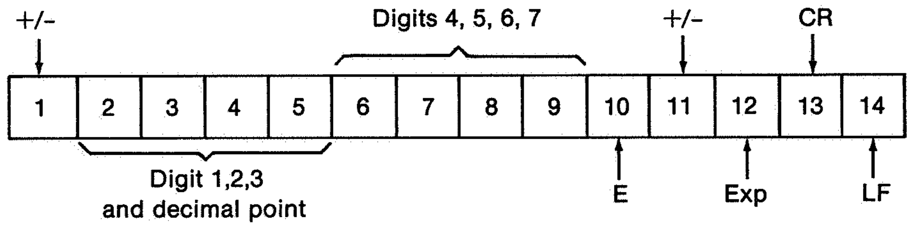
Table 2A-1. Programming Instructions (cont)

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.

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 X 10^{-1} or 1.03

[K][N][U][7][.][6][E][4]
Keep numeric upper limit of 7.6 X 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.

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

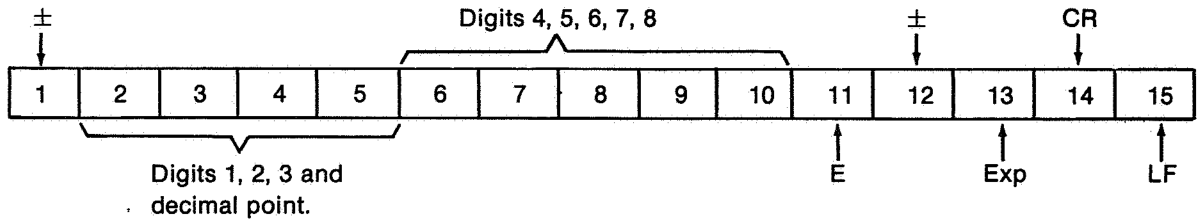
Sign Bit

Exponent Sign Bit

= 3.5 X 10 EXP 1

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

ASCII OUTPUT FORMAT



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 ac volts, 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 such as the IEEE-488 Remote Interface.

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

1. Address/Control (IC)
2. Bidirectional data (ID)
3. Real time (RT)

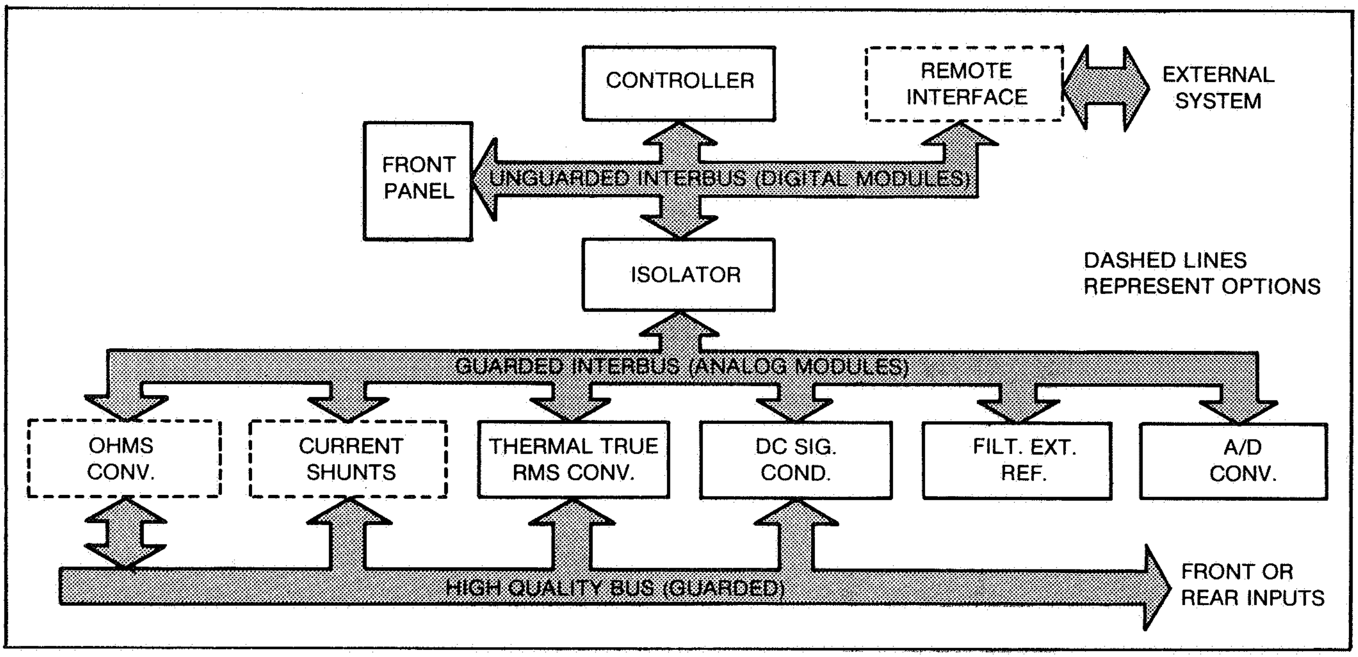


Figure 3-1. Block Diagram

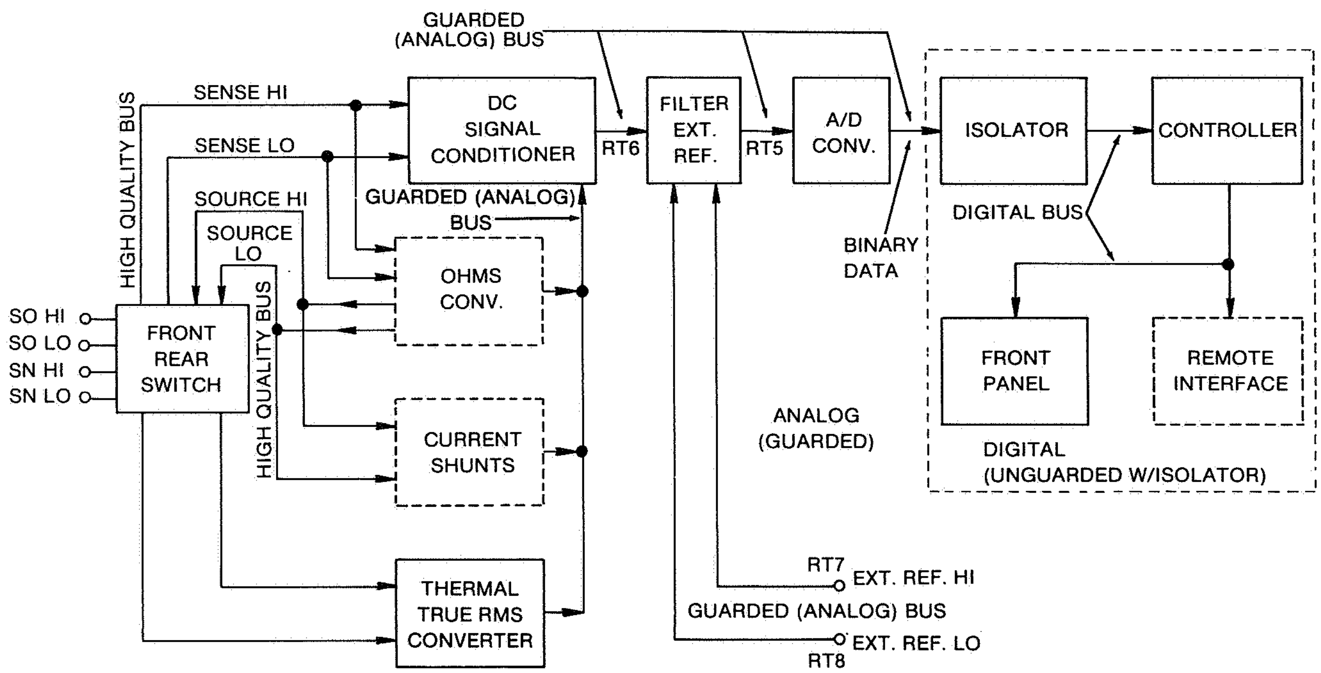


Figure 3-2. Analog Signal Flow

4. Handshake (EXTINT, ACK, INA)

5. Input/Output (SCAN ADV, EXT TRIG, FRONT/REAR SENSE)

6. Power supply

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 (RT)

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 isolated from analog common when the Isolator is installed.

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. 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 each step of sample processing. The A/D Converter is first directed to take the selected number of samples-per-reading (2 exponent 0 through 2 exponent 17). Using the arithmetic capability of the microprocessor, Controller software then sums all samples and divides by the number of samples to compute the average sample value. This digital filtering reduces noise. The average sample value is then scaled to correct for the integer gain and attenuation of analog modules used in taking the reading, and then corrected by any stored calibration factors for those analog modules. If the multimeter is in Zero mode (V DC and OHMS functions only), the value is also corrected by the temporary zero correction value. The averaged, corrected reading is then scaled by either the Scaling mode or External Reference mode factor, and finally offset by the Offset mode value. The result of these processes is the value of the reading. Peak and Limit modes are applied to this reading. The resulting number (or indication in Limits mode) is made available to an optional remote interface either in binary two's complement form, or, after further processing, in ASCII code. This number (or indication) is further processed by the controller for application to the front panel display in a seven-segment LED format. Each sample (prior to any correction or processing) may also be transmitted directly across the remote interface by using the High Speed mode.

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.

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, one RAM for variables, and one EEROM for calibration memory. 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.

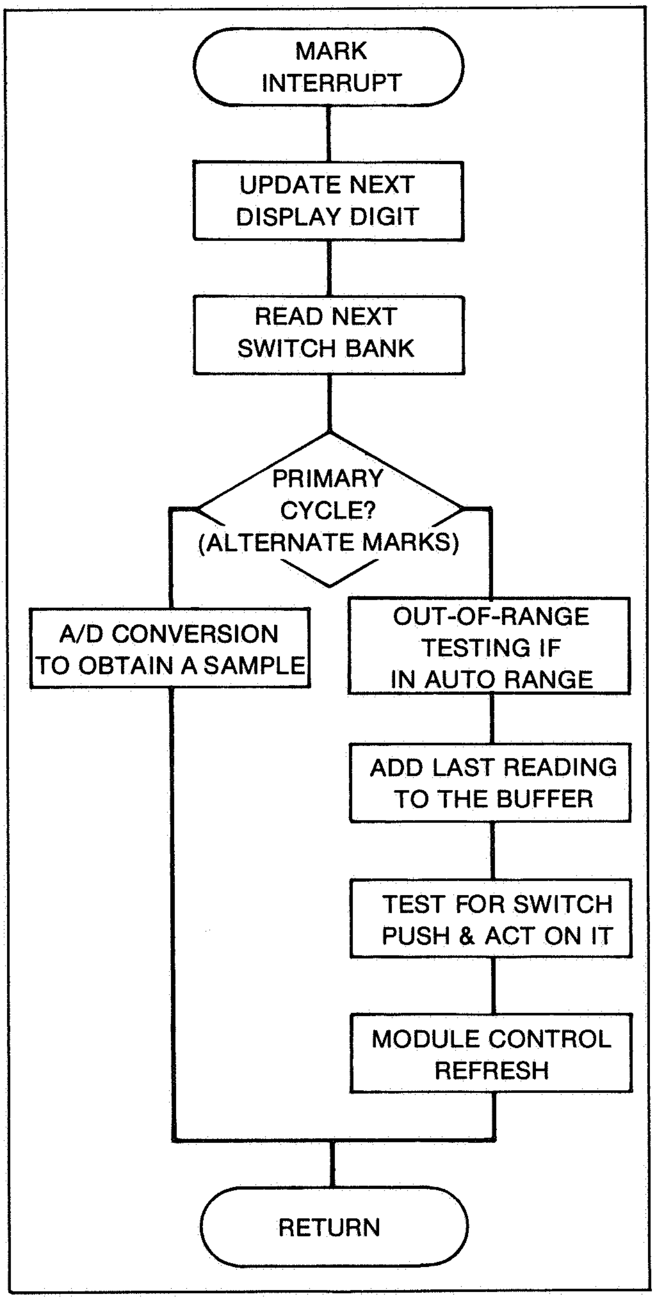


Figure 3-3. Background Software Process

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 updates to the line frequency.

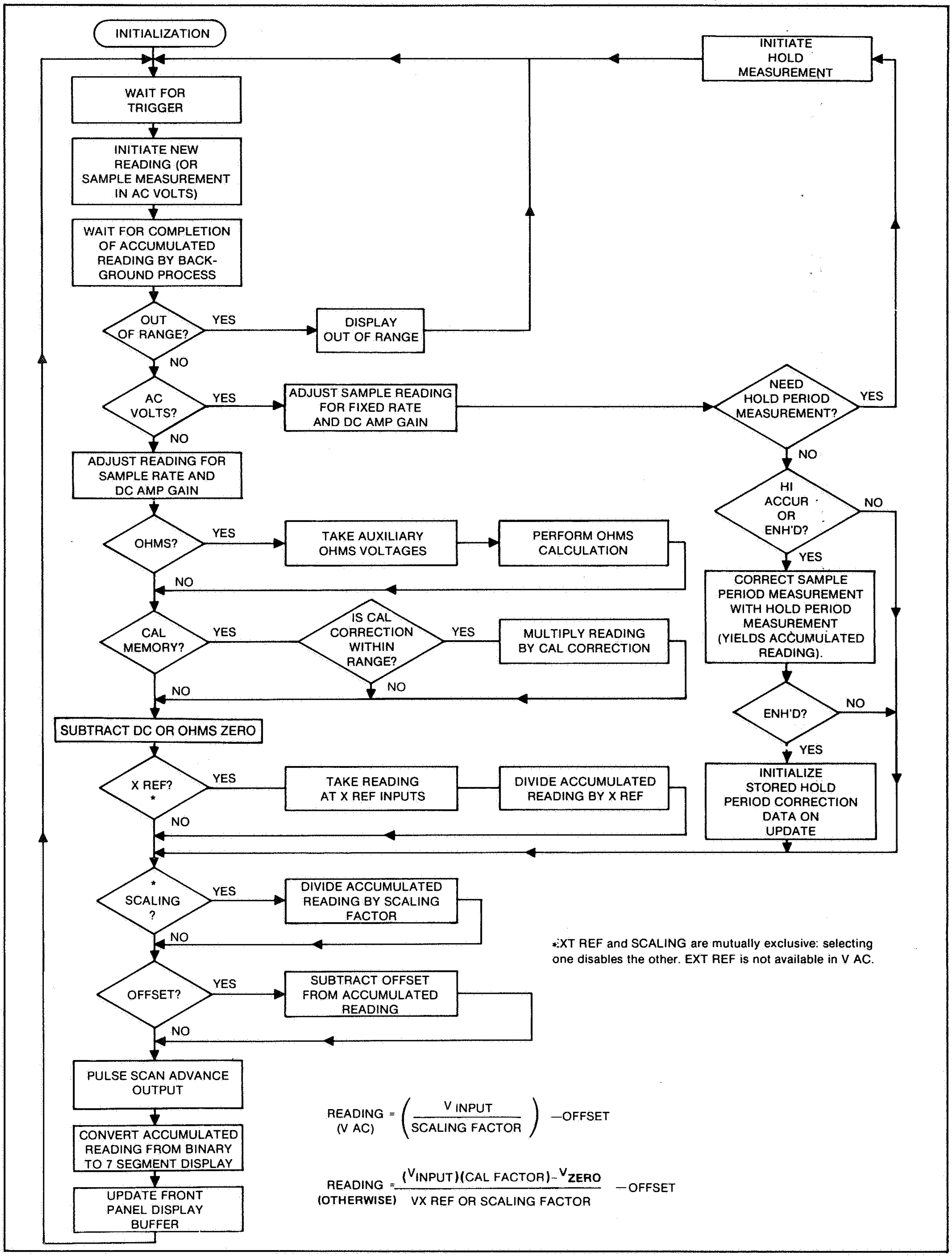


Figure 3-4. Foreground Software Process

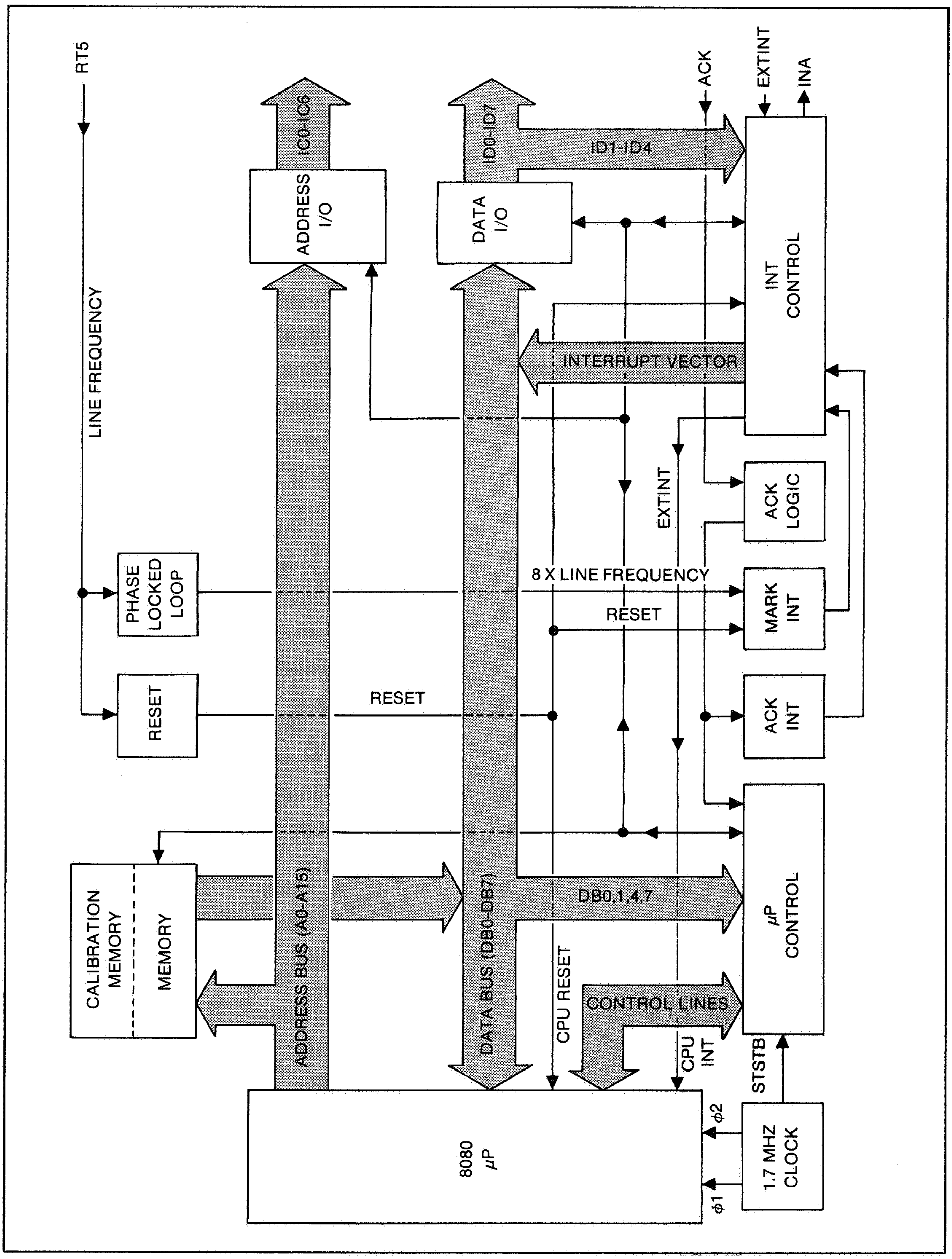


Figure 3-5. Controller Block Diagram

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 synchronizes 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 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 the input terminals (direct in V DC), from the Thermal True RMS Converter (V AC), or from optional signal conditioners (OHMS or A DC) 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 switches 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 1 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 multiplexed to the A/D Converter. Samples are taken of each input and arithmetically manipulated by the Controller to arrive at a reading.

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.

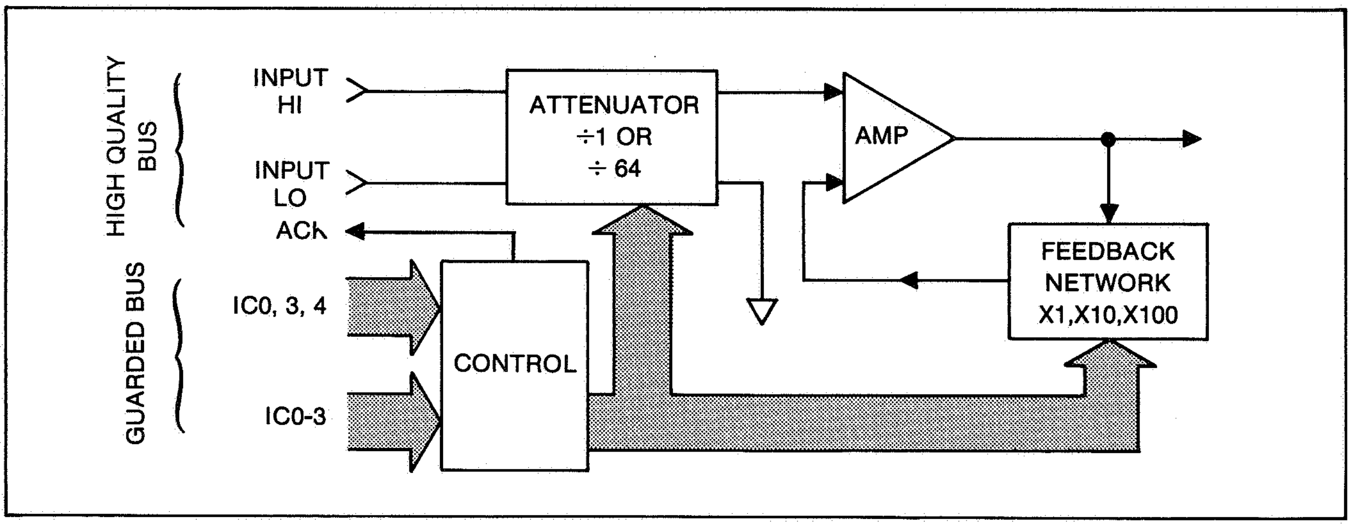


Figure 3-6. DC Signal Conditioner Block Diagram

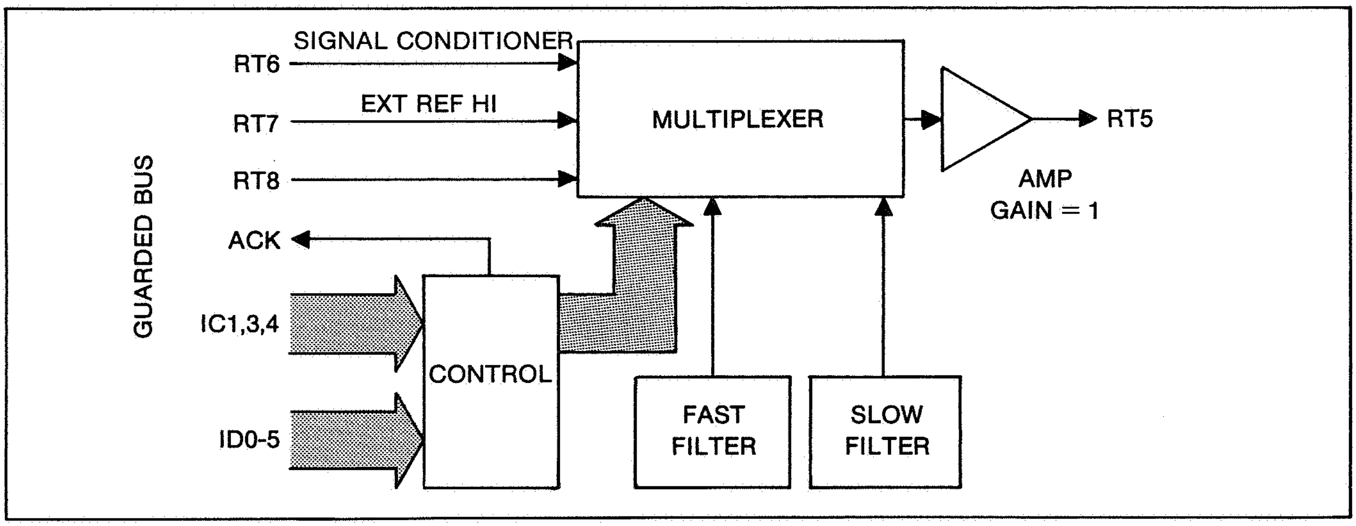


Figure 3-7. Active Filter Block Diagram

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

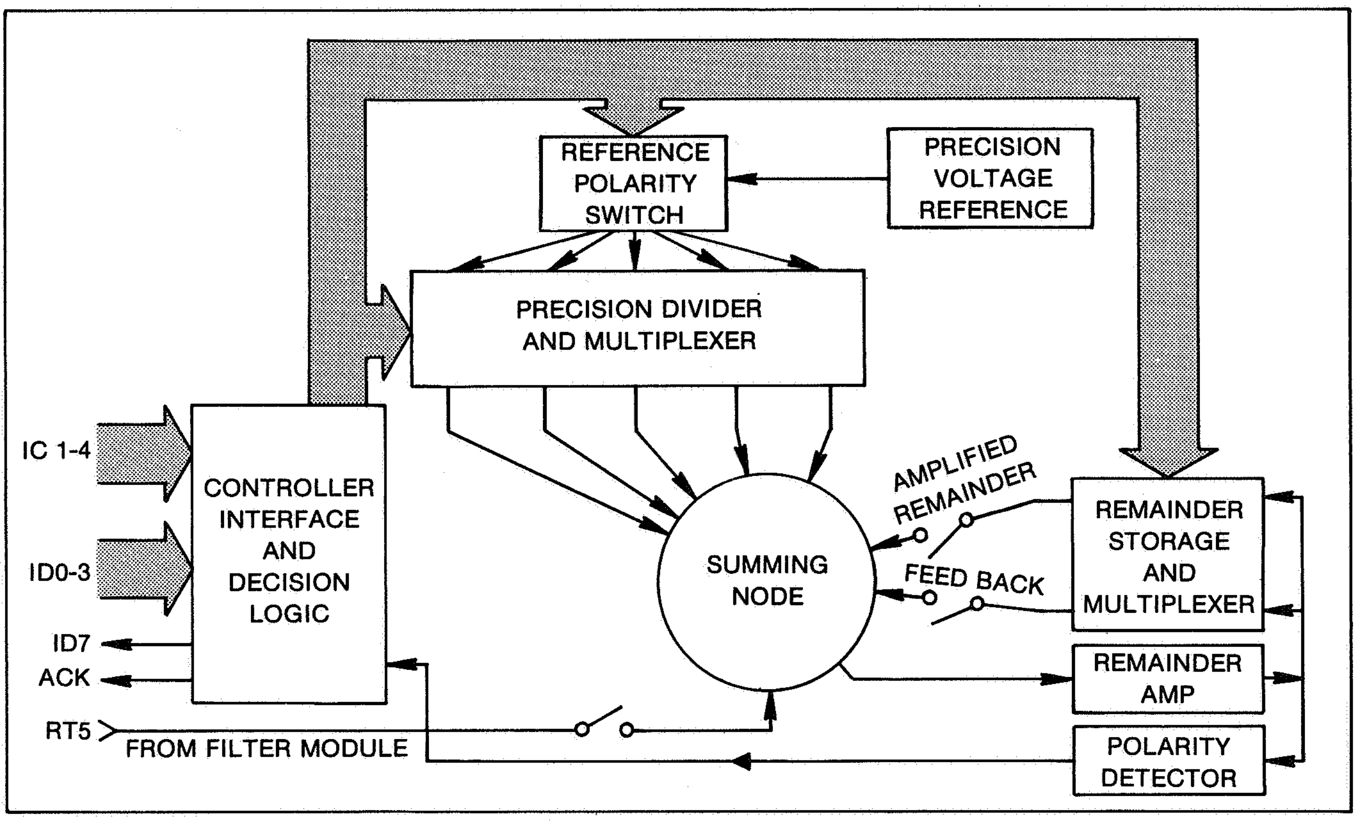


Figure 3-8. R² A/D Converter Block Diagram

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. Thermal True RMS Converter

3-32. This description is divided into two parts. The first is a theoretical description of the rms converter. The second is the operation of the rms converter within the multimeter.

3-33. THEORETICAL DESCRIPTION

3-34. Previously AC/DC transfer measurements were made by sequentially applying an unknown ac voltage and a variable dc voltage to an rms sensor until the outputs were equal. The rms voltage was then assumed to be equal to the value of the dc voltage applied at the time the two inputs were equal. The Thermal True RMS Converter module differs in that it uses the dc equivalent value of the rms sensor's first output to serve as the first approximation for the comparison. Therefore, if a computation capability is available, and the transfer curve of the sensor is reasonably smooth, the first iteration is the only one necessary to obtain a high accuracy measurement.

3-35. Figure 3-9 shows an ideal curve where the rms input (X) equals the dc output (Y), an example of an actual curve, and the positions on the curves for two separate readings. X1 represents the value of the original unknown rms input and Y1 represents the dc value of the sensor output. The difference, or error, between the two values is represented by E1. A second dc voltage (X2) equal to Y1 is applied to the sensor which produces an output Y2. From these it can be seen that: Y1=X1+E1, Y2=X2+E2, and X2=Y1. Substituting these values into the formula 2(Y1)-(Y2) the rms value of the original input can be computed from the following derived formula.

$$\begin{aligned} X\ (\text{computed}) &= 2(Y1)-(Y2) \\ &= 2(X1+E1)-(X2+E2) \\ &= 2(X1+E1)-(X1+E1+E2) \\ &= X1+(E1-E2) \end{aligned}$$

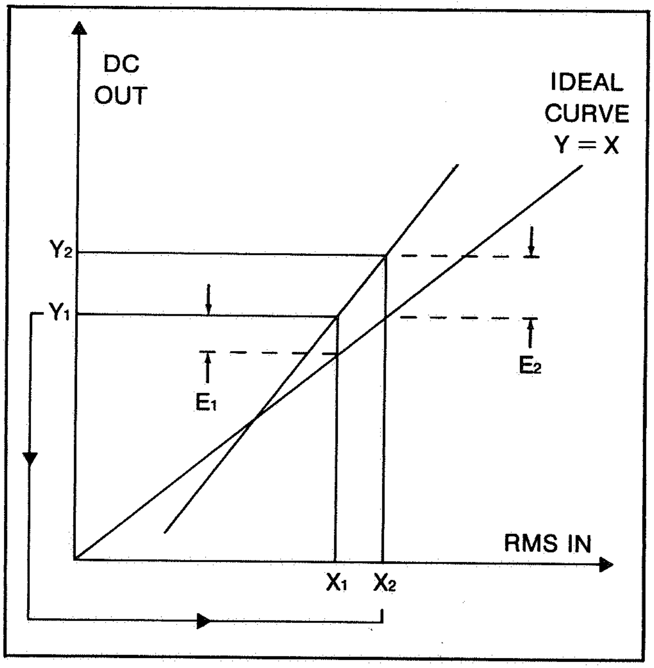


Figure 3-9. Ideal Curve

3-36. Solution of the example formula shows that by doubling the first sensor output and subtracting the second sensor output, the original input can be computed to an accuracy determined by how much the error changes between the two readings. The closer together the two points and the smoother the error curve, the lower the resultant error (E1-E2).

3-37. SYSTEM OPERATION

3-38. Figure 3-10 is a block diagram of the Thermal True RMS Converter in relation to the multimeter when used in the thermal true rms function. The unknown ac signal is applied through the input attenuators, ranging amplifier, and sensor switching circuits to the Fluke thermal sensor. The sensor output is simultaneously measured by the multimeter and routed through the sensor switching circuits for storage by the sample/hold circuit. The measured value is doubled and the result stored in memory (part of the controller). The controller module then commands the logic control circuit to alter the sensor switching circuits to open the path from the ranging amplifier output and to close the path from the sample/hold output (the stored sensor measurement) to the thermal sensor input. The sensor output is then measured again by the multimeter and the result subtracted from the stored value (twice the first measurement). The difference is displayed as the rms value of the original input signal.

3-39. The unknown input signal must be within the dynamic range of the measuring circuit to use this technique. The input attenuator circuit and ranging amplifier, as directed by the controller (system software) through the logic circuit, bring the input signal within the

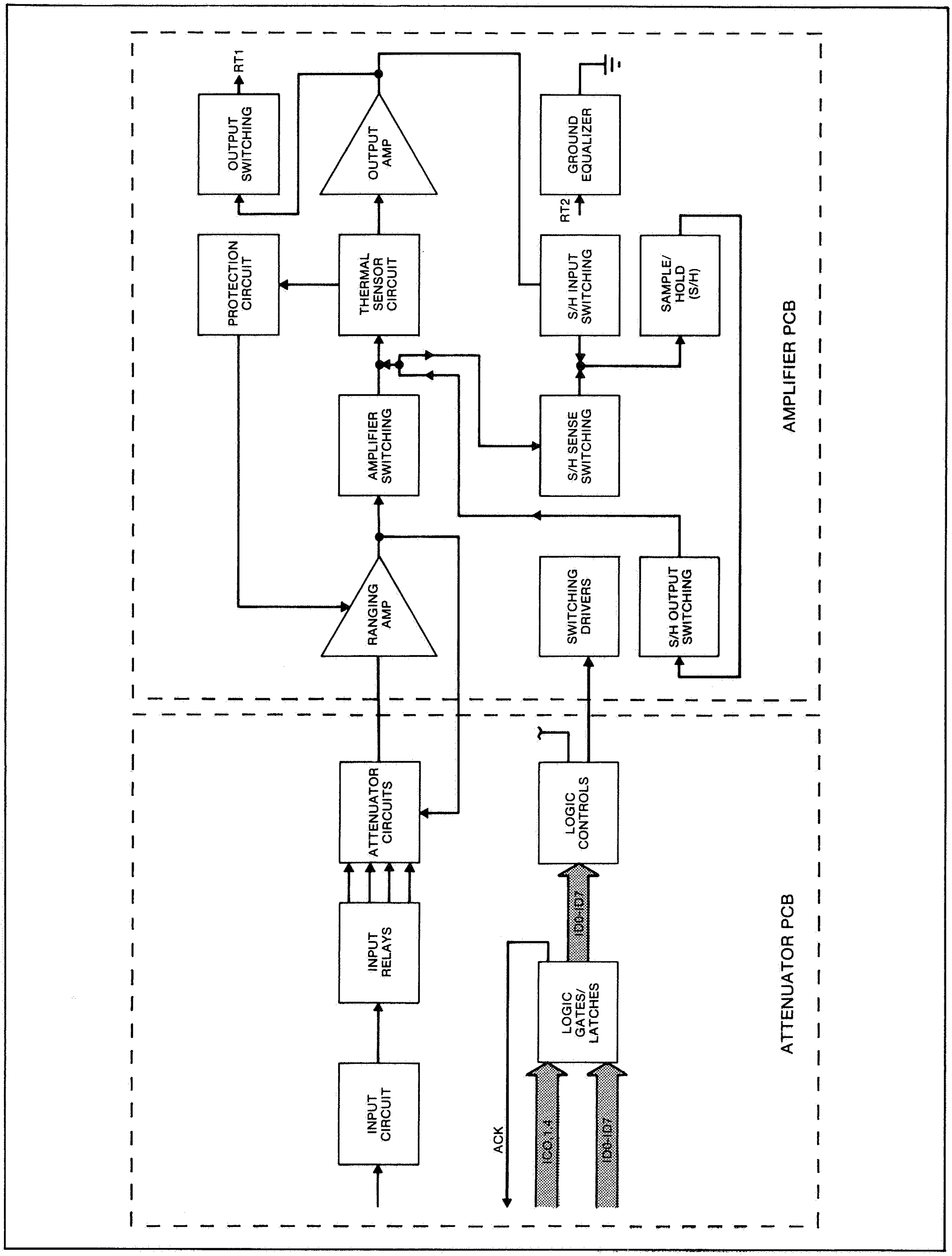


Figure 3-10. Thermal True RMS Functional Block Diagram

range required. AC accuracy limitations at full scale for this technique are primarily due to the flatness of the input attenuator and the ranging amplifier. At one tenth of full scale the limitation is 1/f noise in the sensor. DC accuracy limitations are primarily due to the input drift of the ranging amplifier. The 6-second response time is determined by the thermal sensor time constants and the associated circuitry.

3-40. Front/Rear Switch Assembly

3-41. 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, 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 (SOURCE HI) and rear (SOURCE HI) inputs. Front/Rear Switch position is sensed by the Controller via a photocoupler. This arrangement allows for interrogation of the Front/Rear Switch position through a remote interface while maintaining guard integrity.

3-42. CIRCUIT ANALYSIS

3-43. Introduction

3-44. 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.

3-45. Controller

3-46. TIMING

3-47. Refer to Figure 3-11. Timing for the microprocessor is derived from a 12V, two-phase clock (01 and 02). 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 01 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.

3-48. Shaped line frequency pulses are applied to phase-locked loop U26 which runs at eight times the line frequency (480 Hz for 60 Hz line, 400 Hz for 50 Hz line).

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

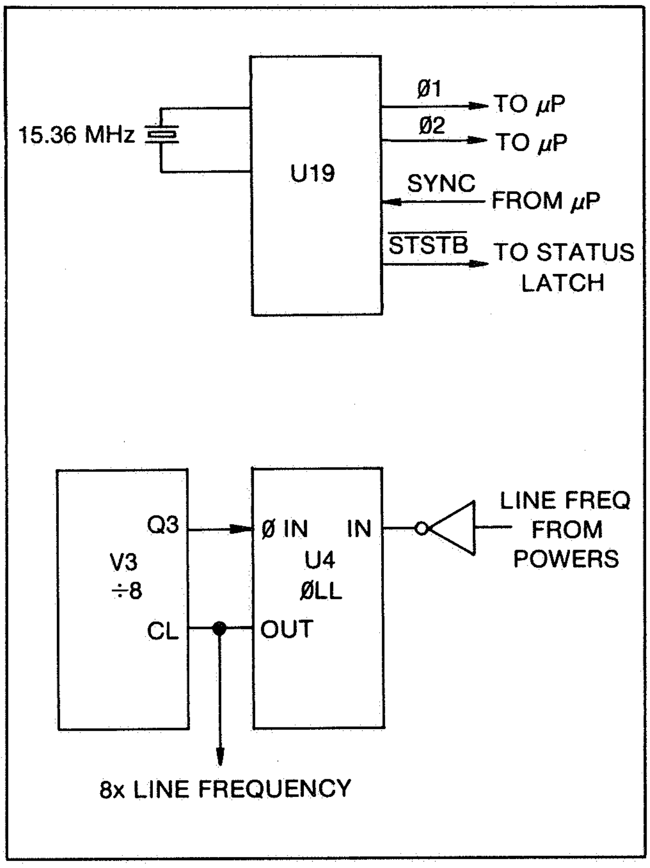


Figure 3-11. Timing Circuits

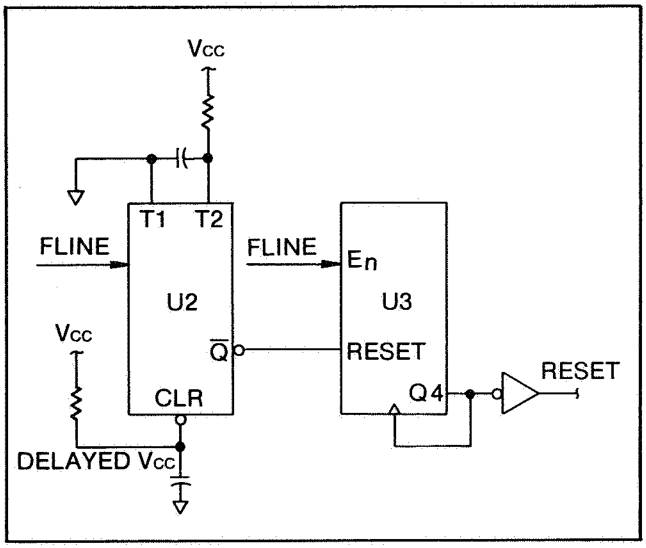


Figure 3-12. Reset Logic

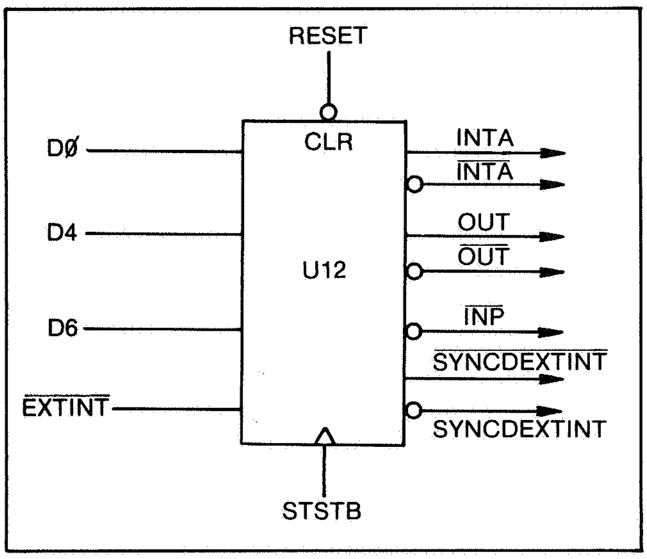


Figure 3-13. Status Latch

3-49. ADDRESS AND DATA BUSES

3-50. 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).

3-51. RESET

3-52. Refer to Figure 3-12. 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.

3-53. STATUS LATCH

3-54. Refer to Figure 3-13. 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.

3-55. WAIT LOGIC

3-56. Refer to Figure 3-14. 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

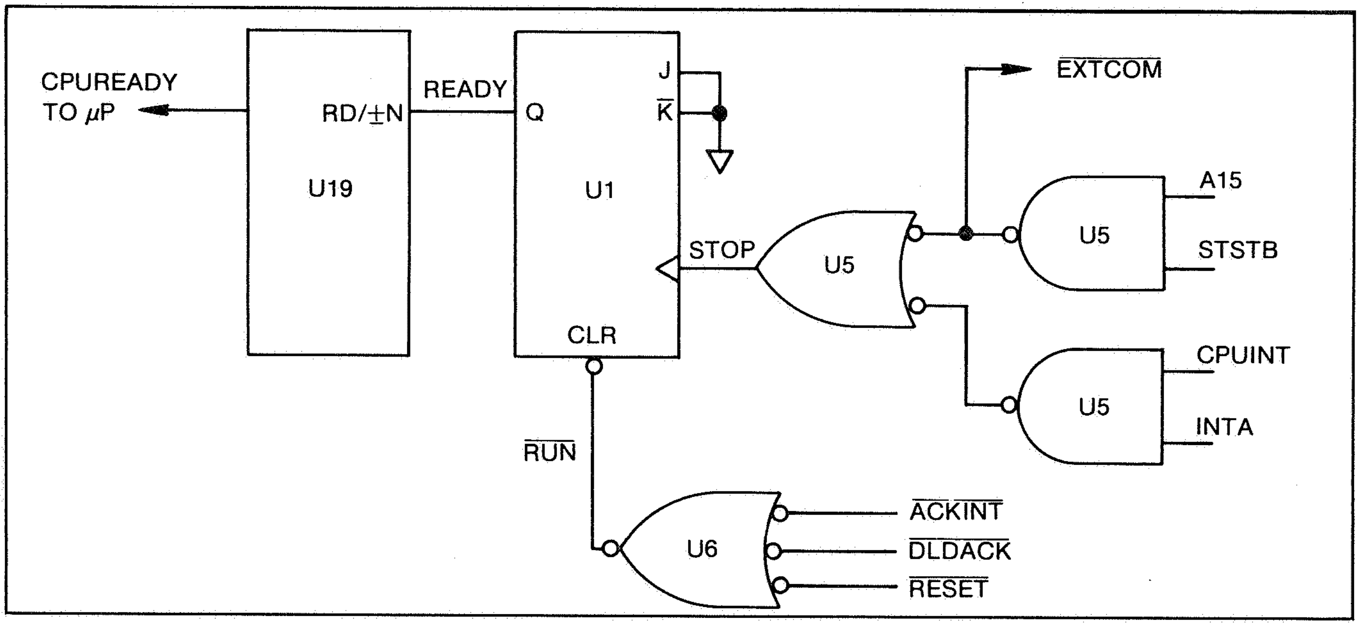


Figure 3-14. Wait Logic

generator U19 then synchronizes READY to the timing requirements of the microprocessor and pulls CPUREADY low.

3-57. 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.

3-58. ACK LOGIC

3-59. Refer to Figure 3-15. 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 DLDACK. DLDACK is also generated in a MARKINT interrupt response cycle.

3-60. INTERRUPTS

3-61. 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 3-16.

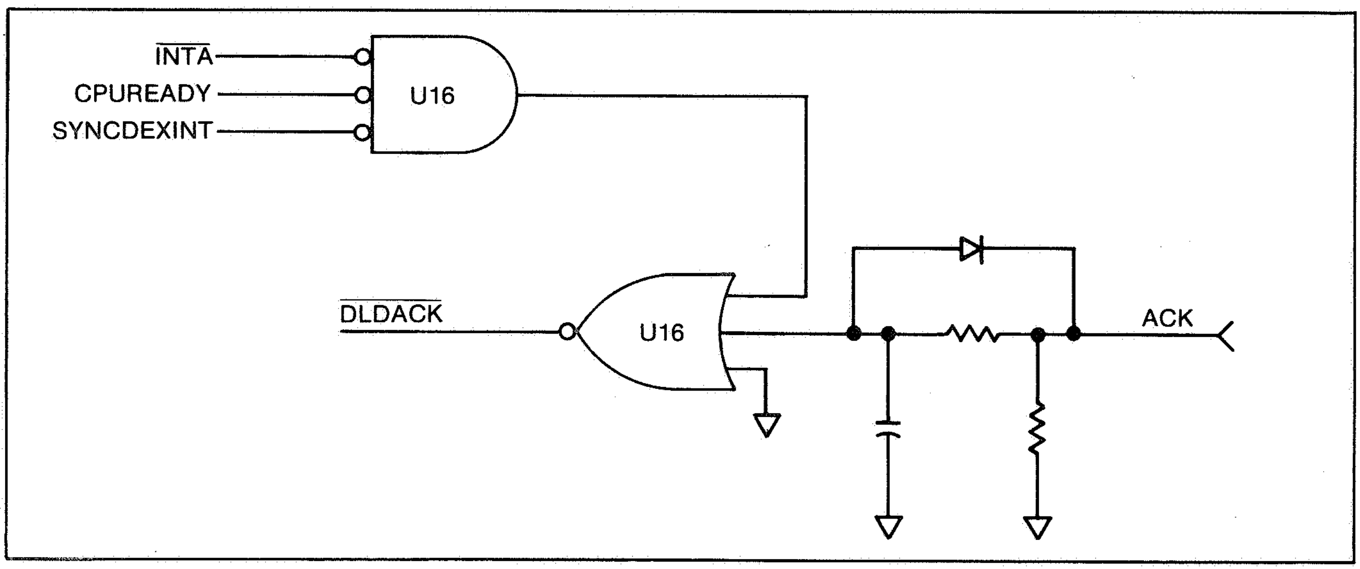


Figure 3-15. ACK Logic

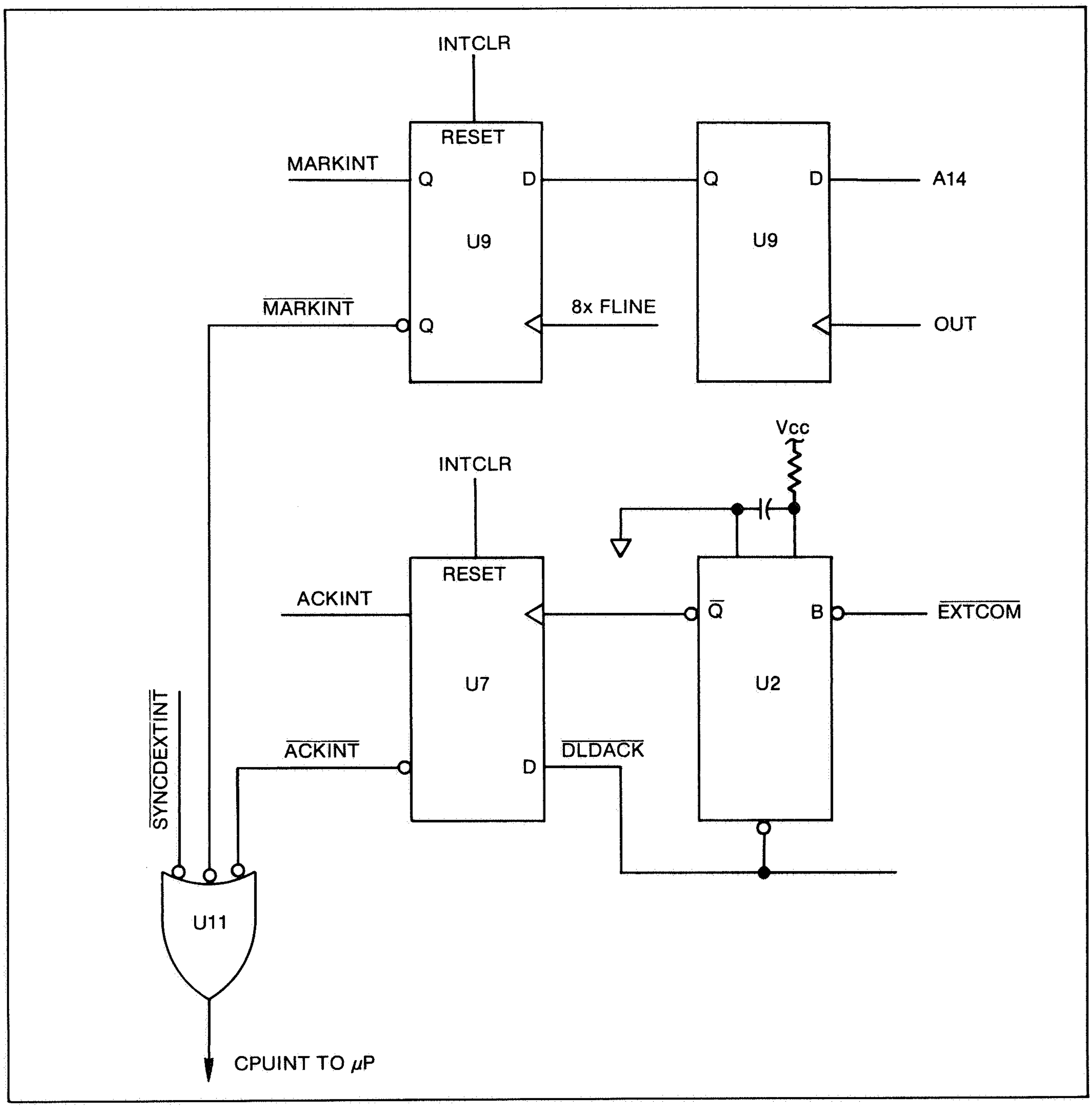


Figure 3-16. Interrupt Generation Logic

3-62. Internal interrupts are ACKINT and MARKINT (Figure 3-16). 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.

3-63. 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.

3-64. 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.

3-65. Front Panel

3-66. Refer to Figure 3-17. 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

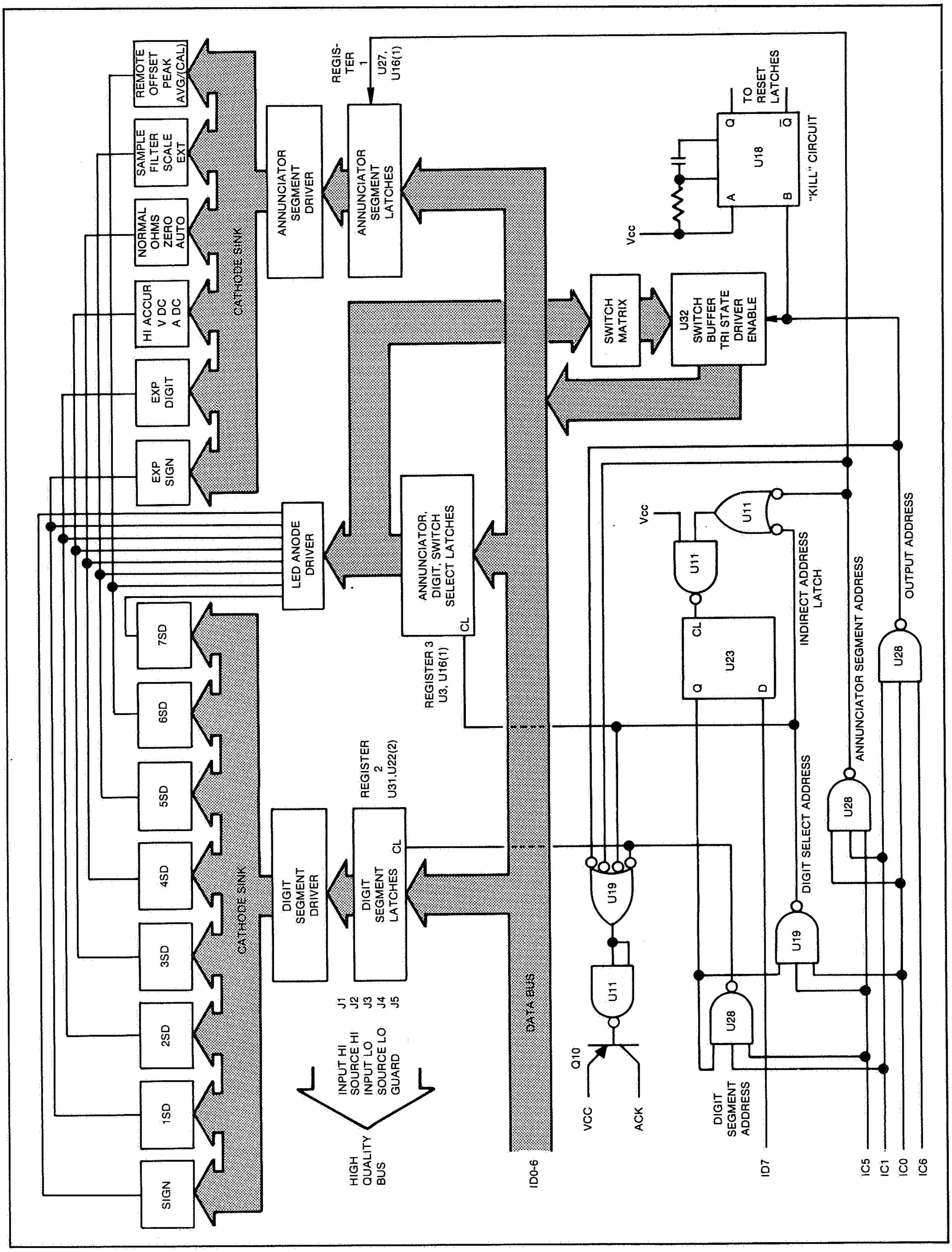


Figure 3-17. Front Panel

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.

3-67. 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.

3-68. DC Signal Conditioner

3-69. Relays K1 and K2 control the input to the DC Signal Conditioner and the attenuation of the input (Figure 3-18). 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 with no attenuation. Q10, Q11, CR3, and CR4 provide overvoltage protection.

3-70. 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.

3-71. 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 3-18 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.

3-72. Filter/External Reference

3-73. All inputs to the A/D Converter are routed through the Filter/External Reference module. Refer to Figure 3-19. 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).

3-74. 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.

3-75. 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.

3-76. Fast R^2 A/D Converter

3-77. 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

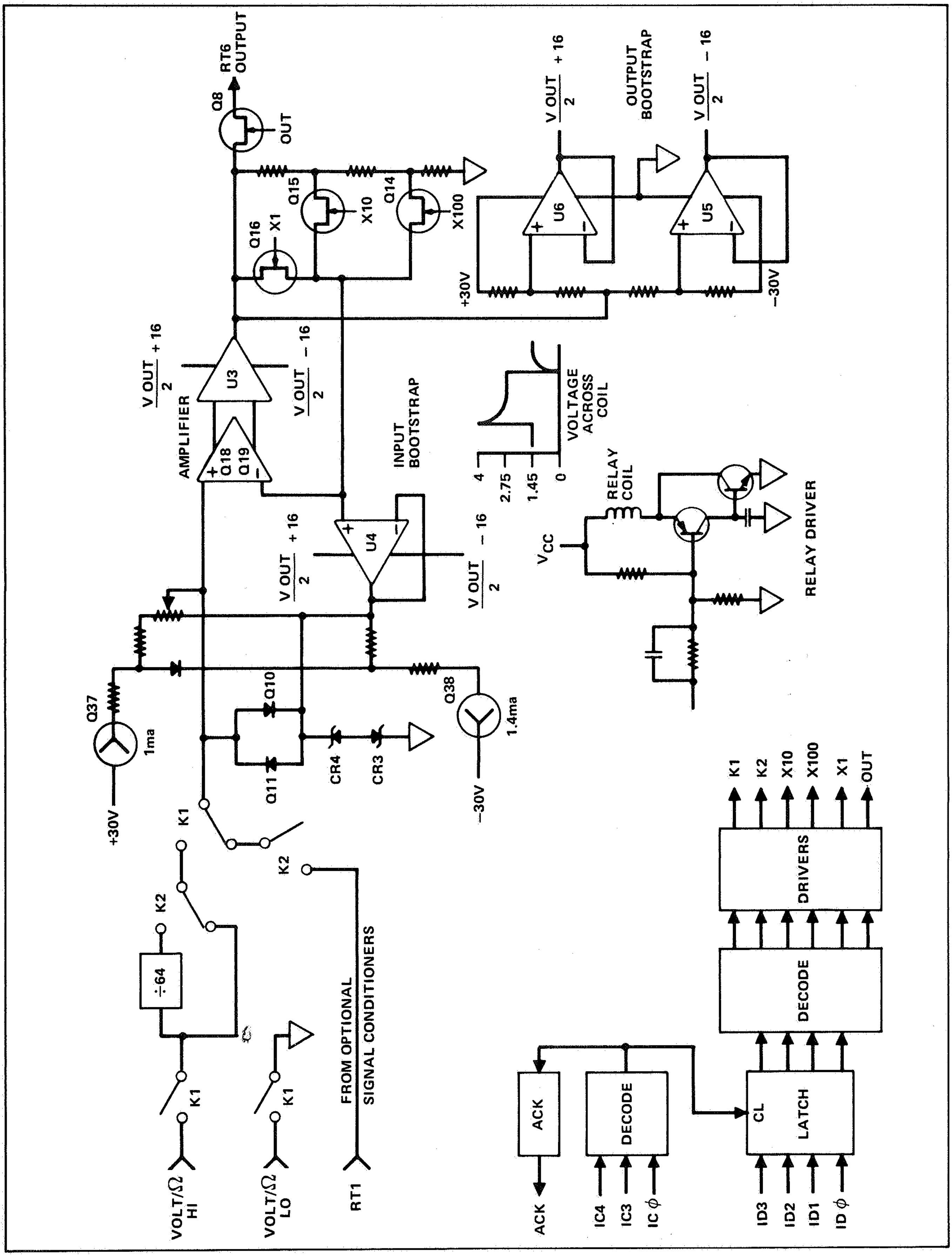


Figure 3-18. DC Signal Conditioner

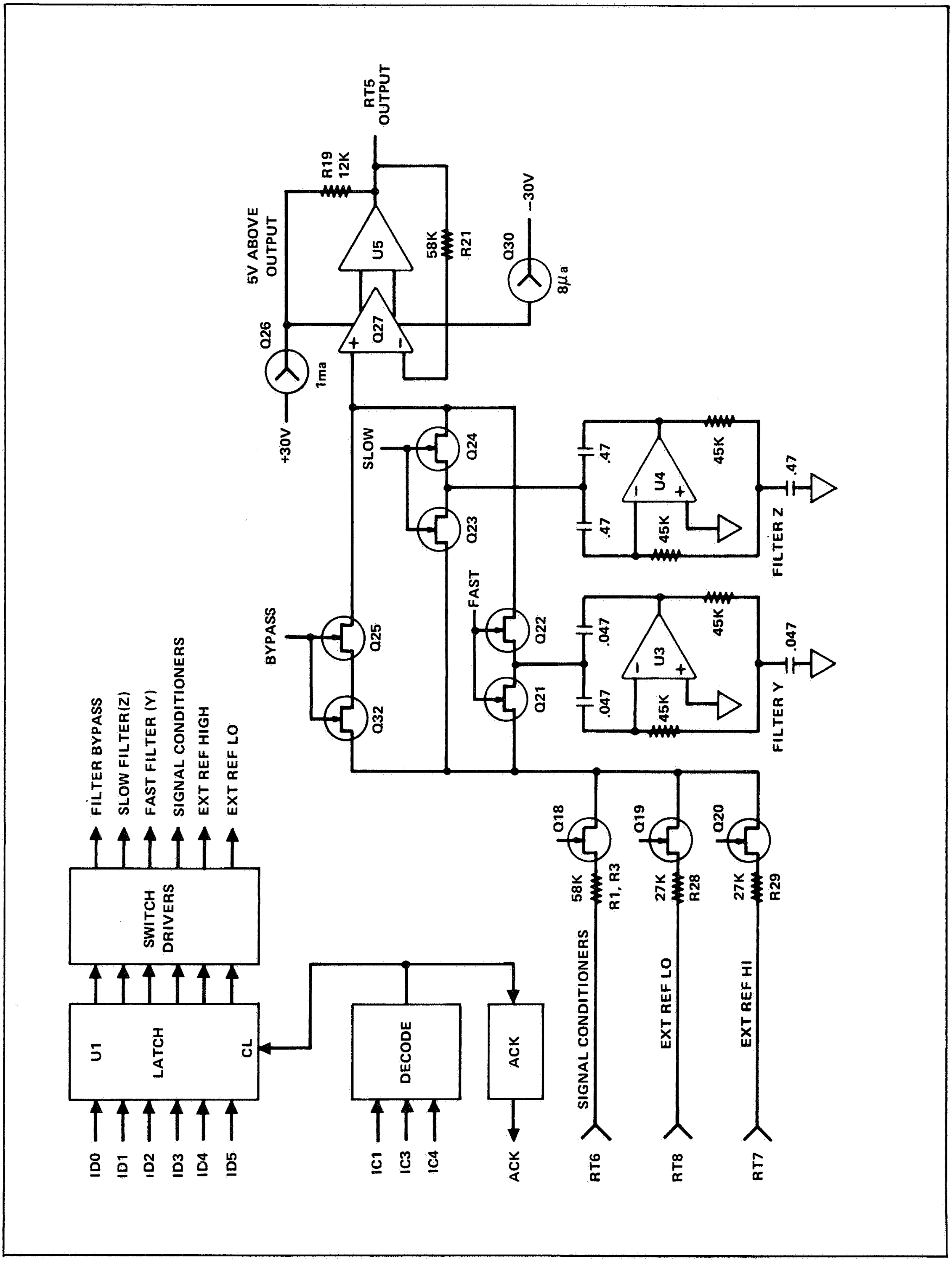


Figure 3-19. Filter/External Reference

addressing the A/D module, the A/D conversion program could be considered a functional part of the A/D Converter.

3-78. ANALOG

3-79. Figure 3-20 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.

3-80. 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.

3-81. 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.

3-82. 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.

3-83. 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.

3-84. 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.

3-85. DIGITAL

3-86. 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 (RX, RY, SX, SY), autozero (Z1), 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.

3-87. Indirect address IC1 and 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.

3-88. 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.

3-89. 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

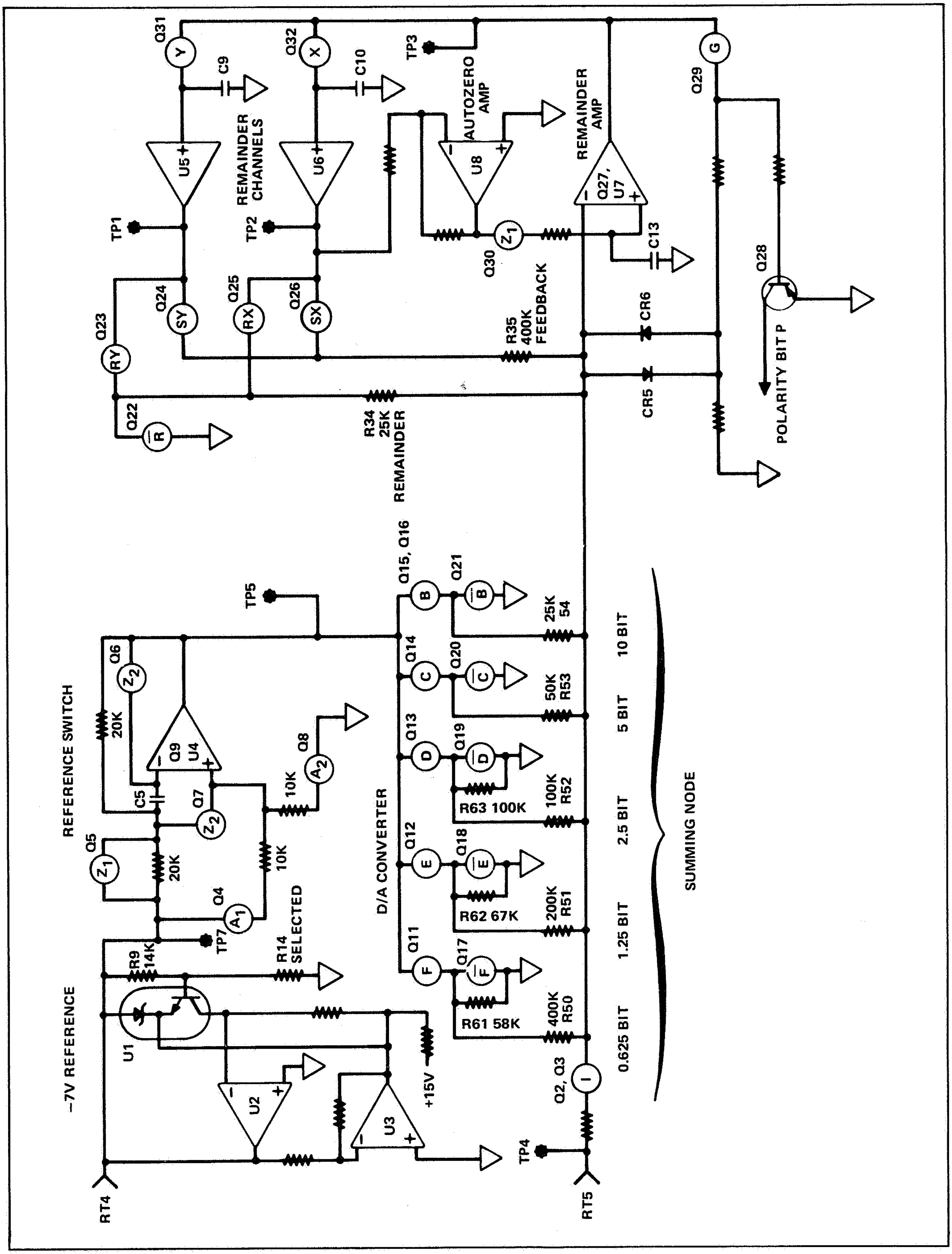


Figure 3-20. Fast R² A/D Converter (Analog)

time for the reference switching amplifier. Both A1 and A2 are opened during the autozero time.

3-90. Thermal True RMS Converter Module

3-91. The following description of the Thermal True RMS Converter module explains a full operating cycle of the high accuracy mode including both a sample mode and hold mode in succession. If the normal mode is selected, the module performs only an abbreviated sample mode and displays the direct output of the Thermal Sensor Circuit, which is updated every 0.5 seconds. If the enhanced mode is selected, one high accuracy measurement is made, and a correction factor computed and stored. The instrument then reverts to a measurement mode similar to that used during normal mode operations, but with the software correction applied to the sensor output. Enhanced is therefore a hybrid mode, using the speed of the normal mode and nearly the same accuracy as found in the high accuracy mode. Due to the hybrid nature of the enhanced mode, the following conditions must be maintained to preserve accuracy: the high accuracy measurement must be made within one hour at a temperature within ±1°C of the working measurement and the deviation of the input from the level of the high accuracy measurement must be less than 1%. If the latter condition is not maintained, the instrument automatically re-initiates a new high accuracy measurement.

3-92. The description of the Thermal True RMS Converter module is divided into four sections. The first explains the mode timing. The second covers the decoding of the logic to control the module operation. The third and fourth sections deal with the two basic modes of operation, the sample mode and the hold mode. Refer to the block diagram of the module in Figure 3-10 and the diagram of the module in the multimeter operation in Figure 3-21 as required during the explanation.

3-93. MODE TIMING

3-94. A high accuracy measurement with the Thermal True RMS Converter module requires a full cycle of operation, i.e. one sample mode (3.5 seconds) and one hold mode (2.5 seconds). The instrument constantly cycles between sample and hold modes during high accuracy measurements; however, if the input is not present at the beginning of the cycle, the accuracy of the measurement cannot be guaranteed. To ensure full settling time and complete accuracy for the first reading, either trigger the instrument from the front panel or wait until the second reading is displayed (a maximum of 12 seconds).

3-95. The measurement takes a total of 6 seconds to complete. Three seconds are required for the thermal sensor to settle, and half a second is required for the dc measurement to be made. Then, while the multimeter processes the sensor output via the normal dc signal path, the stored sensor output is applied to the sensor which requires an additional 2 seconds to settle and another half second for the second dc measurement to be made.

3-96. LOGIC CONTROL

3-97. Controlling instructions enter the module on the IC and ID Bus lines from the controller module. The instructions may originate at the front panel or on the IEEE Bus from a remote source. Address lines IC0, IC1 and IC4 must be high for the module to be addressed. If the proper address is decoded in the Logic Gates/Latches, an ACK is returned to the bus and the data on the ID Bus is latched into flip-flops. The data is then decoded in the Logic Controls block and used to control gain, switches, relays and attenuators in the circuit. The data required on ID4 through ID7 to select the mode of operation (Sample or Hold), select the filter IN or OUT, select AC or AC+DC coupling, and to activate or deactivate the module is shown in Table 3-2. The data required on ID0 through ID3 to control the Attenuation, Gain, and Range selected is given in Table 3-3.

3-98. SAMPLE MODE

3-99. The unknown rms signal is applied to the Input Circuit where it is coupled to the Input Relays. Either AC (through a capacitor) or AC+DC (bypassing the capacitor) coupling is selected by the Logic Controls. One of the Input Relays is energized by the Logic Controls to route the signal to the Attenuator Circuits for attenuation by either 0.00167, 0.008, 0.08, or 0.8 according to the selected range. The attenuation brings the signal to within a 0.1 to 1-volt span before it is applied to the Ranging Amplifier. When the signal leaves the Attenuator PCB Assembly it passes through a cable with a driven Guard en route to the Ranging Amplifier, which is on the Amplifier PCB Assembly.

3-100. The gain of the Ranging Amplifier is either 2, 6.25, or 20, as determined by the ID Bus inputs to the Logic Controls. The Ranging Amplifier output is applied to the Amplifier Switching circuit and to the Attenuator Circuits on the Attenuator PCB Assembly through a coaxial cable as feedback for compensation at high frequencies. The Amplifier Switching circuit is enabled during the sample mode to allow the input rms signal to be applied to the Thermal Sensor Circuit.

3-101. The Thermal Sensor Circuit consists of a Fluke thermal sensor, a sensor amplifier, and a square root amplifier. Combined they produce a dc output that is equivalent to the rms signal input, plus the error of the sensor. The thermal sensor senses the difference between the dc on the output and the ac on the input, the sensor amplifier provides feedback to bring the output dc to the value equal to the ac input, and the square root amplifier enhances transient response. The output is applied first to the Output Amplifier (X1) and then the Output Switching circuit for routing, under software logic control, to the instrument main bus for action by the DC Signal

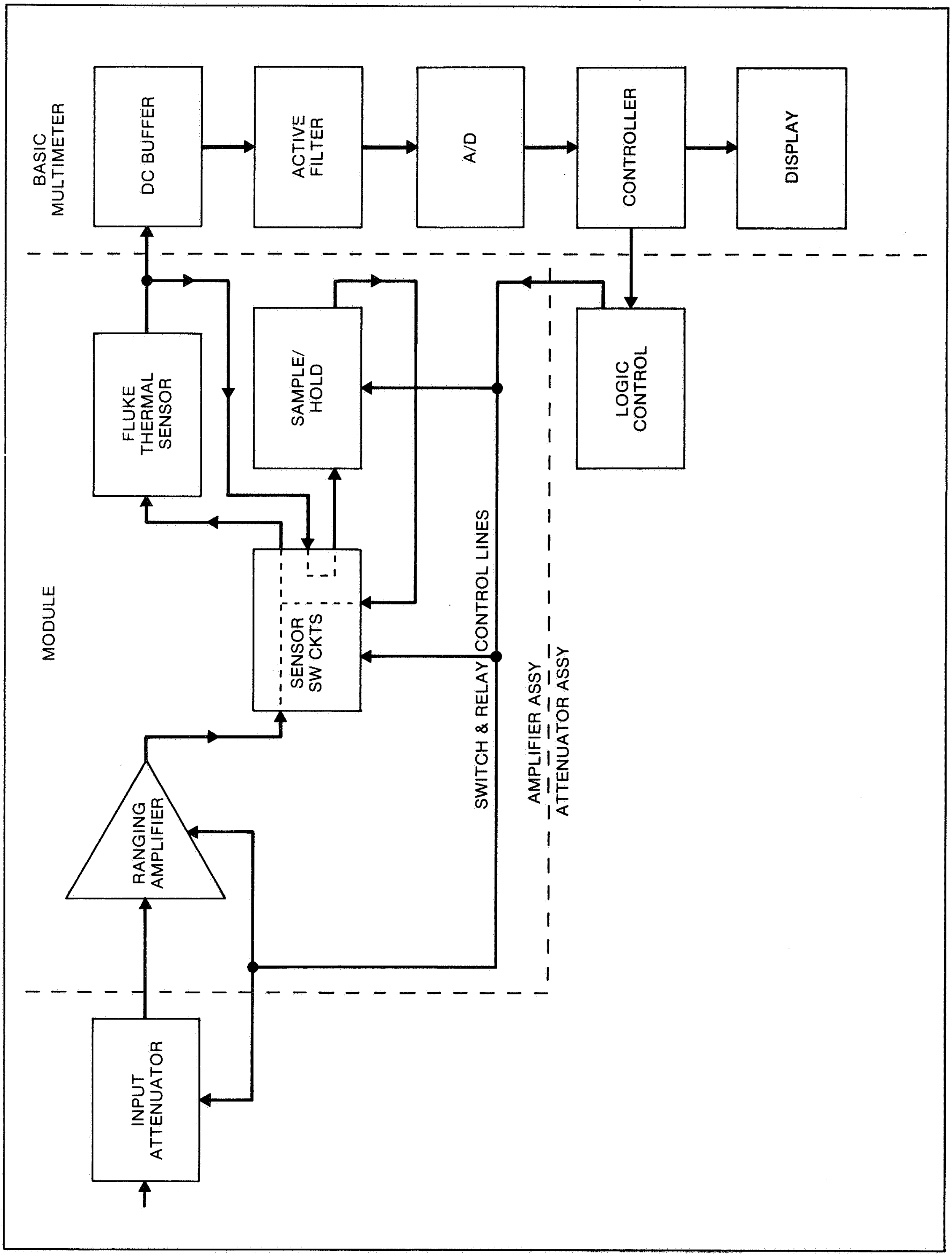


Figure 3-21. Thermal True RMS Conversion

Table 3-2. Module Commands Logic

ID4	ID5	ID6	ID7	SAMPLE/HOLD	FILTER	COUPLING	MODULE
L	L	L	L	HOLD	OUT	AC	ON
L	L	L	H	HOLD	OUT	AC	OFF
L	L	H	L	HOLD	OUT	AC + DC	ON
L	L	H	H	HOLD	OUT	AC + DC	OFF
L	H	L	L	HOLD	IN	AC	ON
L	H	L	H	HOLD	IN	AC	OFF
L	H	H	L	HOLD	IN	AC + DC	ON
L	H	H	H	HOLD	IN	AC + DC	OFF
H	L	L	L	SAMPLE	OUT	AC	ON
H	L	L	H	SAMPLE	OUT	AC	OFF
H	L	H	L	SAMPLE	OUT	AC + DC	ON
H	L	H	H	SAMPLE	OUT	AC + DC	OFF
H	H	L	L	SAMPLE	IN	AC	ON
H	H	L	H	SAMPLE	IN	AC	OFF
H	H	H	L	SAMPLE	IN	AC + DC	ON
H	H	H	H	SAMPLE	IN	AC + DC	OFF

Table 3-3. Decoded ID Bus Logic

ID0	ID1	ID2	ID3	ATTENUATOR (AT)	GAIN (AV)	RANGE
L	L	L	H	0.8	X20	100 mV
L	L	H	L	0.8	X6.25	300 mV
L	L	H	H	0.8	X2	1V
L	H	H	H	0.00167	X2	500V
H	L	H	L	0.008	X6.25	30V
H	L	H	H	0.008	X2	100V
H	H	H	L	0.08	X6.25	3V
H	H	H	H	0.08	X2	10V
NOTE: Logic High = -15V DC, Logic Low = -20V DC						

Conditioner. The Protection Circuit monitors the temperature of the Thermal Sensor Circuit. If the internal temperature of the Fluke thermal sensor reaches approximately 100°C, the Protection Circuit limits the output of the Ranging Amplifier.

3-102. The signal from the Output Amplifier is also routed to the S/H Input Switching circuit for application to the sample/hold circuit. When the sample mode is in progress the S/H Input Switching is enabled while S/H Sense Switching and S/H Output Switching are disabled. The sample/hold circuit multiplies the signal from the Output Amplifier by five. The resultant signal is stored on a capacitor (C34). The signal is multiplied to reduce the effect of leakage current in the storage capacitor. The sample mode is complete when the signal is stored in the capacitor.

3-103. HOLD MODE

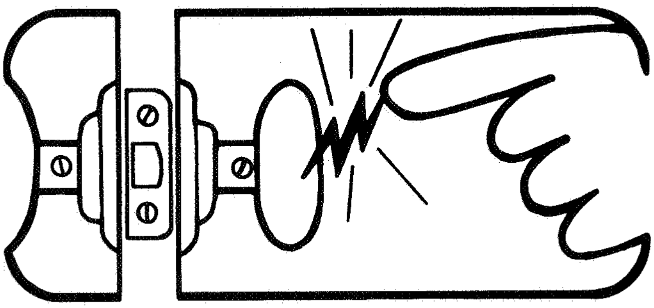
3-104. When the module goes into the hold mode the Amplifier Switching and S/H Input Switching circuits are disabled and the S/H Sense Switching and S/H Output Switching circuits are enabled. The unknown rms signal is still applied to the input circuits but it is blocked at the Amplifier Switching circuit from going into the Thermal Sensor Circuit. Instead, the value stored in the sample/hold circuit is withdrawn from the capacitor and divided by five to return the stored value to the original magnitude. The result is then applied to the Thermal Sensor Circuit through the S/H Output Switching circuit. The value applied is sensed at the Thermal Sensor input and returned through the S/H Sense Switching circuit to the sample/hold circuit. The signal from the sample/hold circuit is processed by the Thermal Sensor circuit in exactly the same manner as the unknown signal from Input circuit. The output is directed through the Output Amplifier and Output Switching circuits to the DC Signal Conditioner.

3-105. The hold mode result and the sample mode result are processed in the Controller Module to obtain the true rms value of the input signal. The result of the computation is then sent to the Front Panel for display until another cycle is performed.

static awareness

A Message From

John Fluke Mfg. Co., Inc.

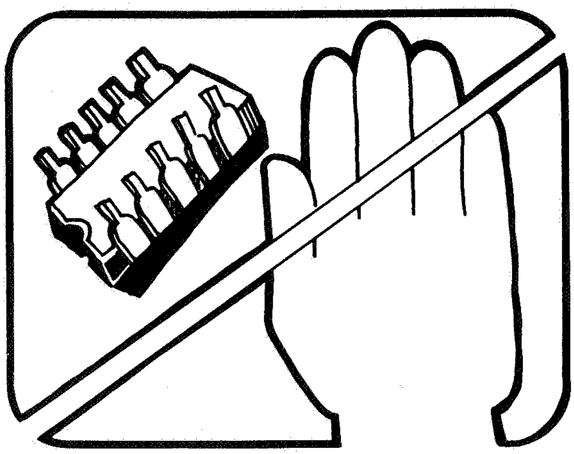


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

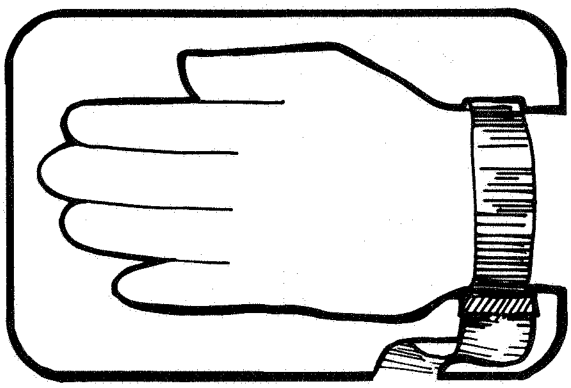
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

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

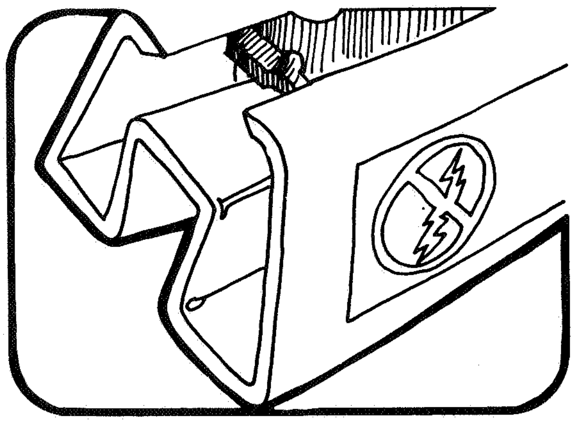
The following practices should be followed to minimize damage to S.S. devices.



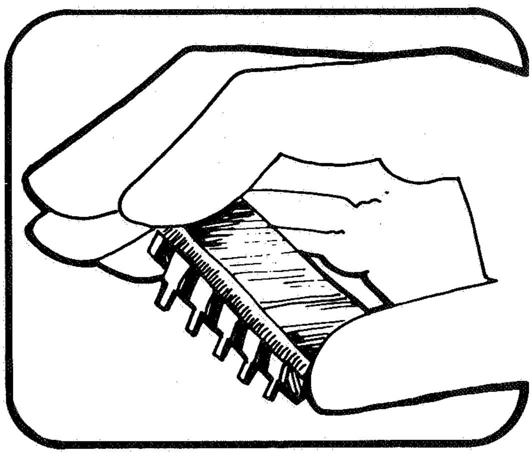
1. MINIMIZE HANDLING



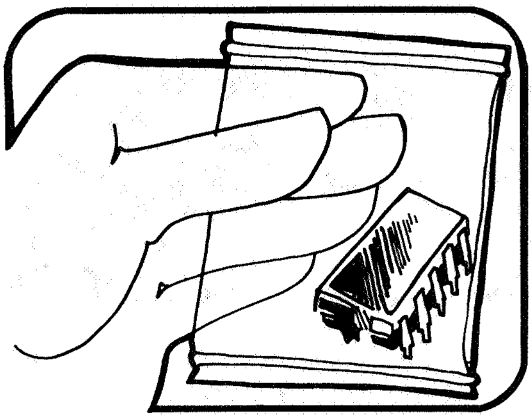
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



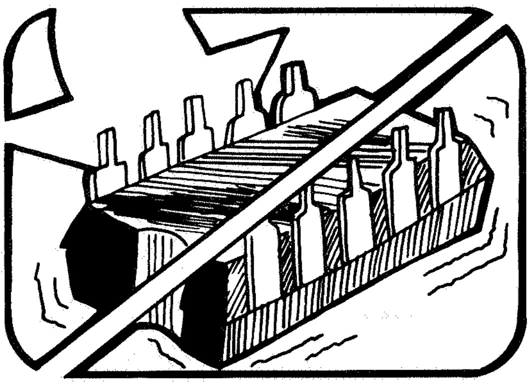
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



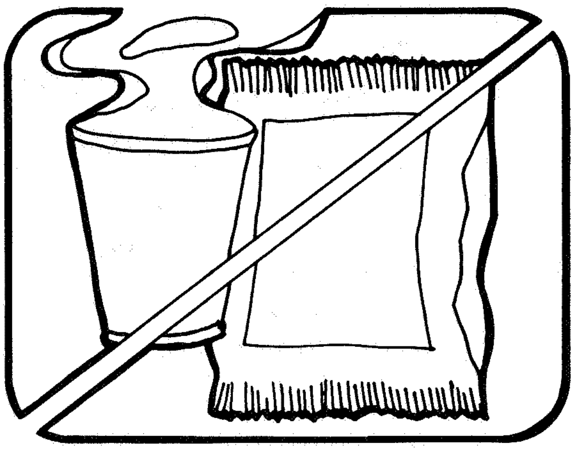
4. HANDLE S.S. DEVICES BY THE BODY



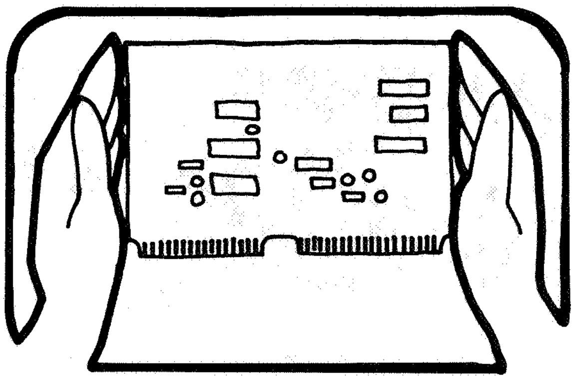
5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT



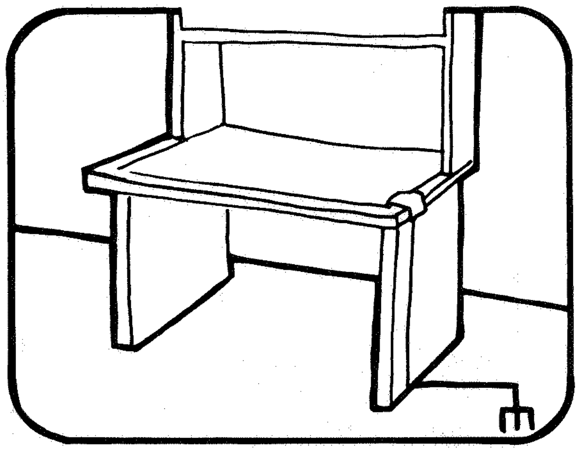
6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



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



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



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

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

11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

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

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

® Dow Chemical

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

Section 4
Maintenance

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 1). Software calibration may be performed at any time and is described in Appendix 7B. 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. When requested, an estimate is provided 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:

CAUTION

If Calibration mode is on, 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.

1. Push the POWER control to OFF, disconnect the line cord and remove the multimeter top cover.

2. 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).

3. Verify installation of the line power fuse required by the selected line voltage. Refer to Fuse Replacement.

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.

Table 4-1. Test Equipment

NOMENCLATURE	MINIMUM USE SPECIFICATIONS	RECOMMENDED EQUIPMENT
AC Calibration System	Voltage Range: 0-1000V ac Frequency Range: 20 Hz-1 MHz Accuracy: Refer to Table 4-4.	Fluke Model 5200A with Fluke Model 5215A or with Fluke Model 5205A
Thermal Transfer Standard	Refer to Accuracy Table 4-4.	Fluke Model 540B
True-RMS Differential Voltmeter	Within 90 Day Calibration	Fluke Model 931B
Ratio Transformer	1 ppm or better	ESI DT72A
DC Source	High Short-Term Stability Range: 0-1100V	Fluke Model 335D*
Null Detector	10 μV Full-Scale Resolution	Fluke Model 335D*
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	Copper Spade Lug Connectors	
Terminating Load	BNC, 50-Ohm Feed Through	Fluke Y9103
Adapter	BNC to Double Banana Plugs	Fluke Y9108
Attenuator	BNC, 50-Ohm, 2 Watt, 20 dB	Fluke Y9102
T-Adapter	BNC T	Fluke Y9106
Extender Card		Fluke P/N 629170
Bus Monitor		Fluke Model MIS-7013k
Static Controller		Fluke Model MIS-7190K
		*Fluke Model 5440A may be substituted for this equipment.
AS REQUIRED BY INSTALLED OPTIONS		
Current Calibrator with 200 kΩ Resistor	Accuracy: ±.02% ±.01%	Fluke Model 382A
Standard Resistors	10Ω at 30 ppm; 100Ω, 1.9 kΩ, 10 kΩ, 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
Terminating Load	1 MΩ ±10% 1.22 μF Nonpolarized Load.	

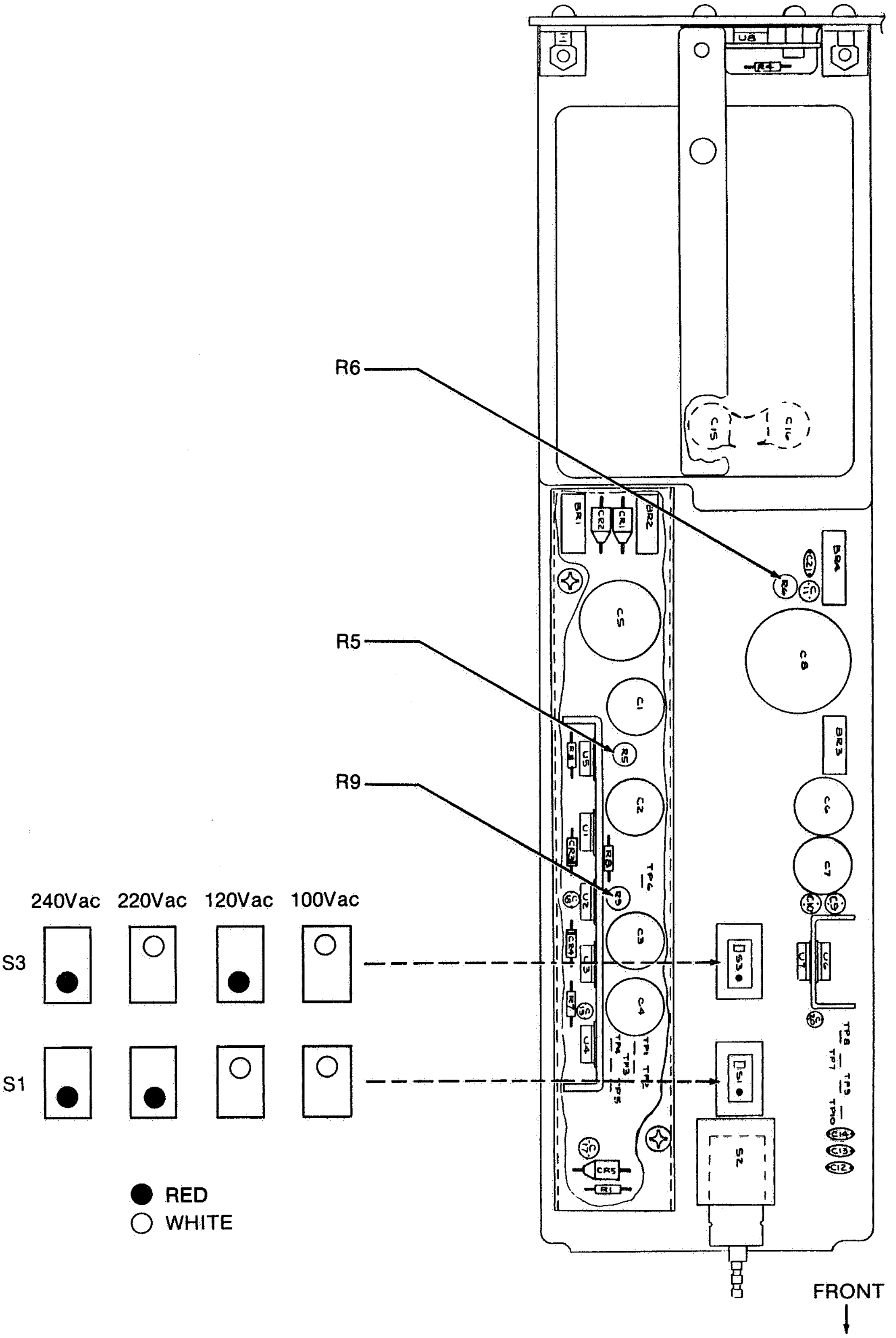


Figure 4-1. Power Supply Settings

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 first four module slots (A, B, C, D) are reserved for signal conditioning modules. the Thermal True-RMS Converter requires slots C and D. The DC Signal Conditioner can be installed in slot A. The remaining Slot (B) can be used for either the Ohms Converter (Option 02A) or the Current Shunts (Option 03). The Isolater must be installed in slot K. Refer to Section 8 for a complete listing of preferred and permissible slots for all modules.

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. For the Thermal True-RMS Converter, attach the cable connector to the jack on the Front/Rear Switch Assembly. This jack is accessible through a hole in the center of the right side chassis.

7. Close the module top and secure the module in position by engaging the two sliding clips.

8. 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 multimeter top cover.

3. Disengage the two sliding clips securing the module to be removed.

4. If the Thermal True-RMS Converter is being removed, disconnect the cable connector at the right side chassis.

5. 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. Reassembly 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.

6. Refer to Appendix 7B 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 PCB Assembly Removal

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

1. Push the POWER button to OFF and remove 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 Assembly Removal

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

1. Remove the Front Panel and Power Supply.

2. Remove the three screws securing the Power Supply Interconnect Assembly 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 remove 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 unique procedures.

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. INSTALLATION

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

1. Installation 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 line 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 Assembly.

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. The multimeter can be cleaned using the following procedure:

1. Push the POWER button to OFF and disconnect the line 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 is 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 is less than 75%.

4-40. DC Performance Test

4-41. LOW RANGE DC VOLTAGE TESTS

4-42. 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.

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

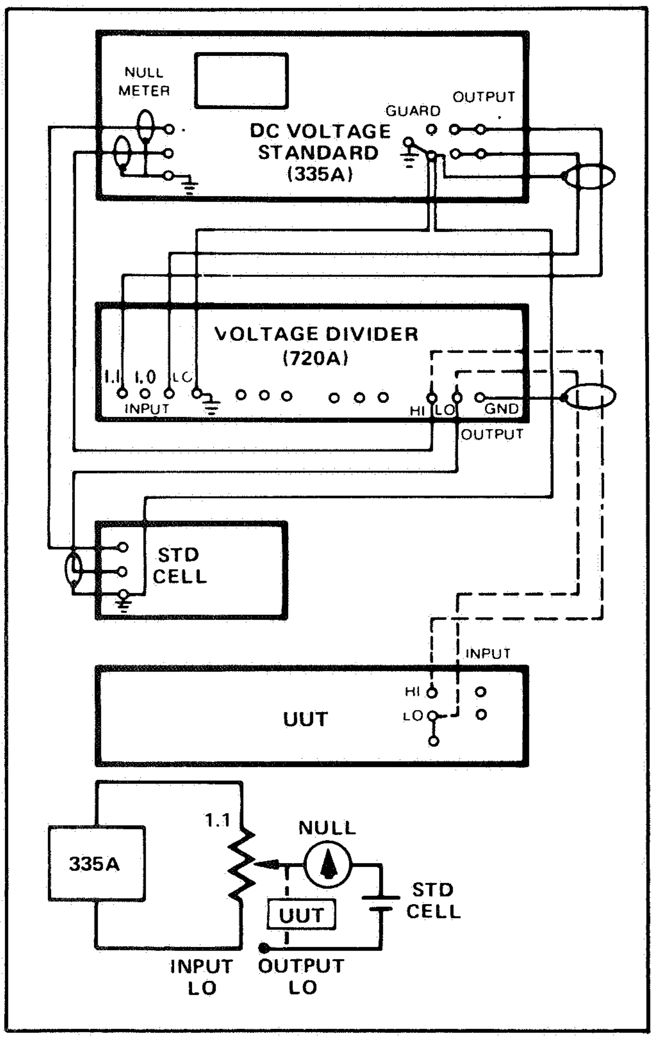


Figure 4-2. Connections for Low Range DC Voltage Tests

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

4. On the UUT, ensure that the V DC and AUTO annunciators are on, and that the SAMPLE annunciator flashes at approximately eight times per second (32 samples per reading). All other annunciators should be dark.

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. (Note: This will be approximately 11V).

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.

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

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

4-43. HIGH RANGE DC VOLTAGE TESTS

4-44. 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 (V DC), 100V manual range, and SAMPLE setting 5 (SAMPLE

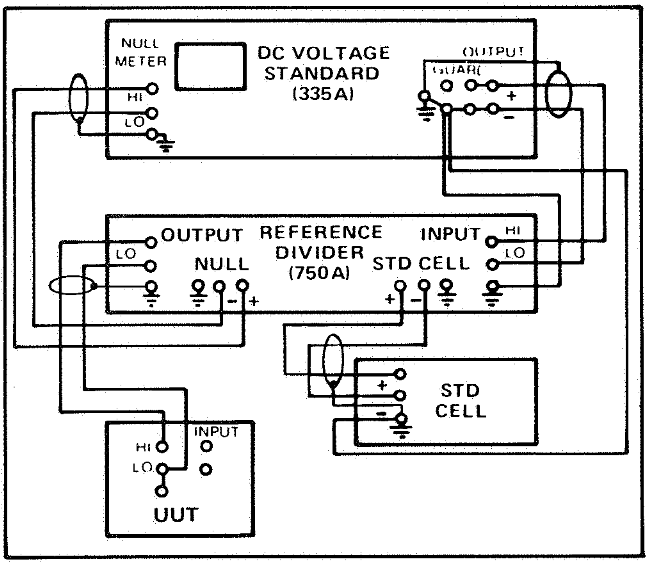


Figure 4-3. Connections for High Range DC Voltage Tests

annunciator flashes approximately eight times per second). All other features on the UUT must be in the power-up configuration.

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.

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.

4-45. AUTORANGING TEST

4-46. 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.

Table 4-3. Autoranging

RANGE	UPRANGE POINT	DOWNRANGE POINT
	DC VOLTS	
100 mV	200 mV	NA
1V	2.0V	.17V
10V	20V	1.7V
100V	128V	12V
1000V	NA	120V
	AC VOLTS	
100 mV	125.000 mV	NA
300 mV	400.000 mV	110 mV
1V	1.25000V	0.352V
3V	4.000V	1.1V
10V	12.50000V	3.52V
30V	40.0000V	11V
100V	125.000V	35.2V
500V	NA	110V

4-47. DC EXTERNAL REFERENCE TEST

4-48. 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.

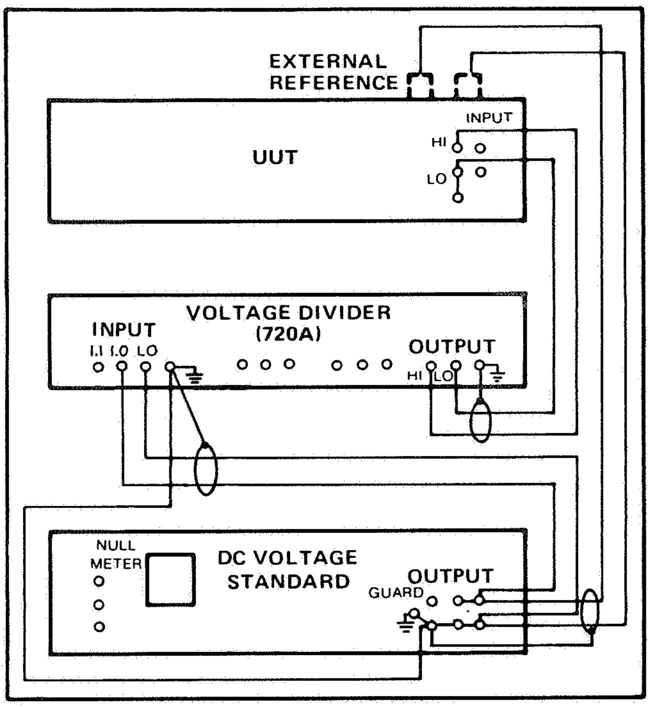


Figure 4-4. DC External Reference Test

3. On the DC Voltage Standard, set the output controls for +11.0000 volts.

4. On the Voltage Divider, set the controls for .999999X.

5. On the UUT, push and hold the EXT REF button. Verify a reading of +9.99980 to +10.00020 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 between 0.999960 and 1.000040.

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

8. Verify that the UUT reads between 99.9950 (-3) and 100.0050 (-3).

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.

4-49. Thermal True-RMS Converter Performance Test

4-50. The following test equipment is required for the Performance Test of the Thermal True-RMS Converter:

1. A 540B Thermal Transfer Standard with corrections data.

2. A 5200A AC Standard and a 335D DC Standard (both on 90 day calibration cycles).

3. A flatness verified 20 dB attenuator with a proper 50 ohm load.

4. A 1 ppm Ratio Transformer.

4-51. Before starting the Performance Test, verify that the ambient temperature is 23 ±2°C, the relative humidity is <70%, and the instrument has completed the warm-up period of two hours. Remember that the characterized voltage test must be readjusted whenever the frequency is changed.

4-52. Perform the test with the high accuracy mode selected. If the voltage or frequency output of the source is changed, allow the source to settle before taking a reading for record. This can be accomplished by waiting for the first update of the UUT display.

4-53. Complete the UUT Performance Test using the following procedure:

1. Connect the 5200A, 335D, and the 540B for DC to AC Transfer Measurements as shown in Figure 4-5.

2. Set the DC Standard for the output listed in Table 4-4.

3. Set the 540B to the range listed in Table 4-4 and in the DC Transfer mode. Adjust the 540B to obtain a null indication on the meter.

4. Reverse the DC input leads to the 540B and adjust the null to compensate for positive and negative turnover.

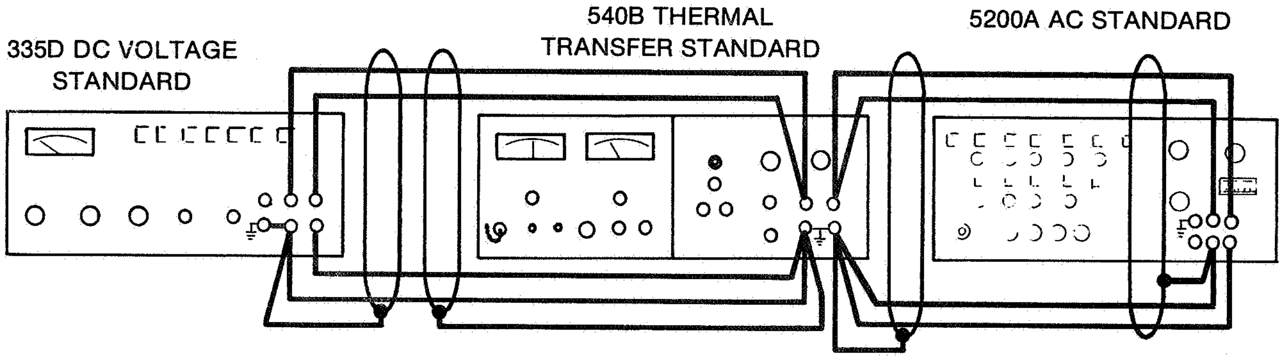
5. Select the 5200A output listed in Table 4-4.

6. Switch the 540B to the AC Transfer mode and adjust the 5200A output to obtain a null indication on the 540B.

7. Record the output setting on the 5200A for future usage.

8. Repeat steps 1 through 7 for all points listed in Table 4-4.

9. Connect the 5200A output terminals to the input of the Ratio Transformer and connect the output of the Ratio Transformer to the input terminals of the UUT as shown in Figure 4-6.



5200A SELECT:
VOLTAGE: Per Procedure
VOLTAGE RANGE: Per Procedure
FREQUENCY: Per Procedure
SENSE: External (straps removed)
PHASE LOCK: Off
INPUT POWER: Connect to same source as other equipment

540B SELECT:
MODE: Per Procedure
RANGE: Per Procedure
POWER: On
SENSITIVITY: Adjust for null per procedure
REFERENCE ADJUST: Use for null adjustment in conjunction with sensitivity
SENSITIVITY TEST: OPR
GALV: Lock and Momentary during null adjustment and Oper when changing Ranges or Modes

335D SELECT:
VOLTAGE: Per Procedure
VOLTAGE RANGE: Per Procedure
TRIP: 1000
CURRENT LIMIT: Fully clockwise
SENSITIVITY: I output monitor
INPUT MODE: TVM
INPUT POWER: Connect to same source as other equipment

Figure 4-5. Equipment Set-Up A

Table 4-4. Characterization Points

540B RANGE ****	5200A RANGE	335D/ 5200A VOLT-	5200A FREQUENCY (Hz)						
			20	1k	10k	20k	50k	100k	200k
.5V	1V	390 mV	390 mV 0.01%**	390 mV* 0.005%**		390 mV* 0.005%**	390 mV 0.01%**		
1V	1V	1.1V	110 mV*** 0.01%**	110 mV* *** 0.005%**		110 mV*** 0.005%**	110 mV* *** 0.01%**		
1V	1V	1V	1V 0.01%**	1V* 0.005%**		1V* 0.005%**	1V 0.01%**		
5V	10V	3.9V	3.9V 0.01%**	3.9V* 0.005%**		3.9V 0.005%**	3.9V* 0.01%**		
10V	10V	10V	10V 0.01%**	10V* 0.005%**		10V 0.005%**	10V* 0.01%**		
50V	100V	35V	35V 0.01%**	35V 0.005%**		35V 0.005%**	35V 0.01%**		35V 0.05%**
100V	100V	100V	100V 0.01%**	100V* 0.005%**		100V 0.005%**	100V* 0.01%**	100V 0.05%**	
300V	1000V	300V	300V 0.01%**	300V 0.005%**	300V 0.005%**				

All accuracy tolerances are plus or minus (±). The 540B must be characterized by a standards lab to support these accuracy tolerances.

*Characterized points also used in the Calibration Procedure.

**Accuracy requirement for voltage at frequency points.

***110 mV levels are established using the 540B and other equipment as detailed on the performance test.

****The required ranges, frequencies and uncertainties are detailed below. All 540B characterizations need to be performed at full range only.

540B RANGE	UNCERTAINTY OF CORRECTION (±)					
	500 Hz	10 kHz	20 kHz	50 kHz	100 kHz	200 kHz
0.5V	0.005%	-	0.005%	0.01%	-	-
1V	0.005%	-	0.005%	0.01%	-	-
5V	0.005%	-	0.005%	0.01%	-	-
10V	0.005%	-	0.005%	0.01%	-	-
50V	0.005%	-	0.005%	0.01%	-	0.05%
100V	0.005%	-	0.005%	0.01%	0.05%	-
300V	0.005%	0.005%	-	-	-	-

10. Using the 5200A settings recorded in step 7 above, check the first two voltage/frequency combinations (20 Hz and 1 kHz) in Table 4-5 for the stated tolerances. Record the displayed reading on the UUT for 1 kHz.

11. Complete the Low Frequency Attenuator Accuracy Test (described under Calibration).

12. Connect the 5200A, 540B, and the flatness verified 20 dB attenuator as shown in Figure 4-7.

13. Adjust the 5200A output (at 1 kHz) for the reading recorded on the UUT display in step 10 and adjust the 540B for a null indication. Note the 5200A output setting. Do not adjust the 540B controls until steps 14 and 15 have been completed.

14. While maintaining a null on the 540B by adjusting the 5200A output, check the last three voltage/frequency combinations in Table 4-5 for the stated tolerances.

15. Return the 5200A output level (at 1 kHz) to the setting noted in step 13 and check for repeatability. Verify that the 540B is within 0.002%

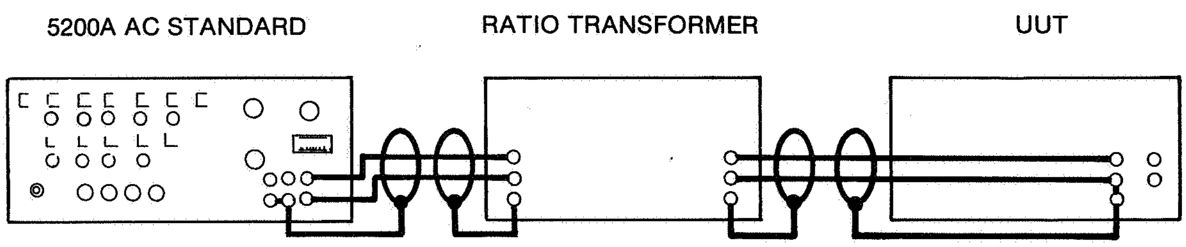
of null. If this verification cannot be made, repeat steps 13 through 15.

16. Connect the 5200A to the UUT input terminals as shown in Figure 4-8.

17. Using the 5200A settings recorded in step 7 above, check the voltage/frequency combinations in Tables 4-6 through 4-14 for the stated tolerances.

18. Connect the 5200A/5205A (5215A) combination to the UUT input terminals as shown in Figure 4-9.

19. Using the 5200A/5205A (5215) settings recorded in step 7 above, check the voltage/frequency combinations in Table 4-15 for the stated tolerances.



5200A SELECT:
VOLTAGE: Per Procedure
VOLTAGE RANGE: Per Procedure
FREQUENCY: Per Procedure
SENSE: External (straps installed)
PHASE LOCK: Off
INPUT POWER: Connect to same source as UUT

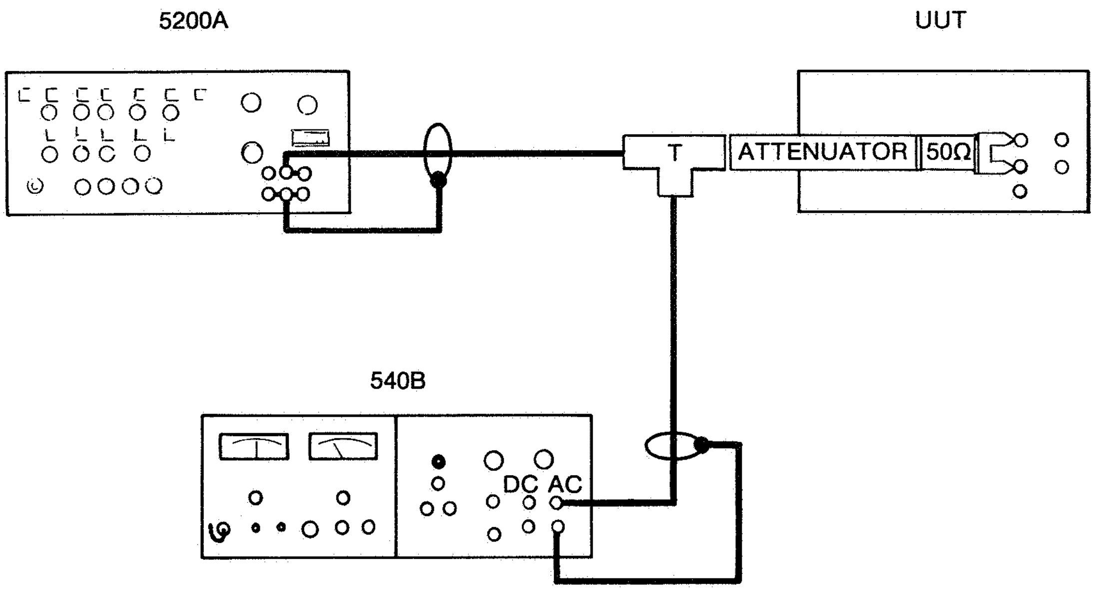
RATIO TRANSFORMER SELECT:
DIAL SETTINGS: Per Procedure

UUT SELECT:
VOLTAGE RANGE: Per Procedure
SENSE: Two terminal (selector out)
MODE: Per Procedure
INPUT POWER: Connect to same source as the 5200A
CONNECTIONS: All other instruments or IEEE cable connections must be removed

Figure 4-6. Equipment Set-Up B

Table 4-5. 110 mV Tests

FREQUENCY (Hz)	RANGE: 100 mV		
	MINIMUM	NOMINAL	MAXIMUM
20	109.912 (-3)	110.000 (-3)	110.088 (-3)
1k	109.967 (-3)	110.000 (-3)	110.033 (-3)
20k	109.967 (-3)	110.000 (-3)	110.033 (-3)
50k	109.934 (-3)	110.000 (-3)	110.066 (-3)
1M	106.150 (-3)	110.000 (-3)	113.850 (-3)



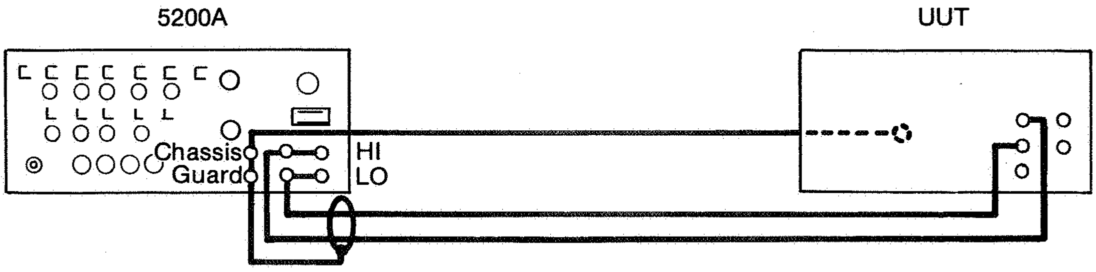
5200A SELECT:
VOLTAGE: Per Procedure
VOLTAGE RANGE: Per Procedure
FREQUENCY: Per Procedure
SENSE: External (straps installed)
INPUT POWER: Connect to same source as UUT
PHASE LOCK: Off
CONNECTIONS: All other instruments or IEEE cable connections must be removed

540B SELECT:
MODE: AC Transfer
RANGE: Per Procedure
POWER: On
SENSITIVITY: Adjust for null per procedure
REFERENCE ADJUST: Use for null adjustment in conjunction with sensitivity
SENSITIVITY TEST: OPR
GALV: Lock and Momentary during null adjustment and Oper when changing Ranges or Modes

UUT SELECT:
VOLTAGE RANGE: Per Procedure
SENSE: Ohms Selector in (4T)
MODE: Per Procedure
INPUT POWER: Connect to same source as the 5200A
CONNECTIONS: All other instruments or IEEE cable connections must be removed

20db ATTENUATOR:
Requires Flatness Verification

Figure 4-7. Equipment Set-Up C



5200A SELECT:
VOLTAGE: Per Procedure
VOLTAGE RANGE: Per Procedure
FREQUENCY: Per Procedure
SENSE: External (straps installed)
PHASE LOCK: Off
INPUT POWER: Connect to same source as UUT, not through 5205A
CONNECTIONS: All other instrument or IEEE cable connectors must be removed

UUT SELECT:
VOLTAGE RANGE: Per Procedure
SENSE: Ohms Selector in (4T)
MODE: Per Procedure
INPUT POWER: Connect to same source as 5200A
CONNECTIONS: All other instrument or IEEE cable connections must be removed
GUARD: Internal

Figure 4-8. Equipment Set-Up D

Table 4-6. 390 mV on the 300 mV Range Tests

FREQUENCY (Hz)	Range: 300 mV		
	MINIMUM	NOMINAL	MAXIMUM
20	389.688 (-3)	390.000 (-3)	390.312 (-3)
1k	389.938 (-3)	390.000 (-3)	390.062 (-3)
20k	389.938 (-3)	390.000 (-3)	390.062 (-3)
50k	389.766 (-3)	390.000 (-3)	390.234 (-3)
1M	366.700 (-3)	380.000 (-3)	393.300 (-3)

Table 4-7. 390 mV on the 3V Range Tests

FREQUENCY (Hz)	RANGE: 3V		
	MINIMUM	NOMINAL	MAXIMUM
20	.38954	.39000	.39046
1k	.38979	.39000	.39021
20k	.38979	.39000	.39021
50k	.38962	.39000	.39038
1M	.37620	.39000	.40380

Table 4-8. 1V on the 1V Range Tests

FREQUENCY (Hz)	RANGE: 1V		
	MINIMUM	NOMINAL	MAXIMUM
20	.99920	1.00000	1.00080
1k	.99984	1.00000	1.00016
20k	.99984	1.00000	1.00016
50k	.99940	1.00000	1.00060
1M	.96500	1.00000	1.03500

Table 4-9. 3.9V on the 3V Range Tests

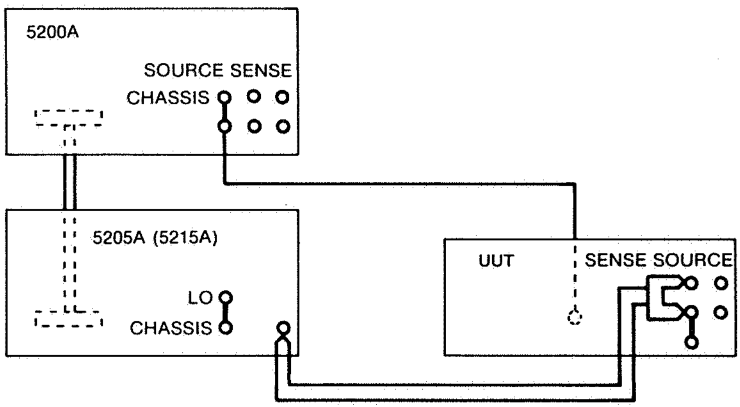
FREQUENCY (Hz)	RANGE: 3V		
	MINIMUM	NOMINAL	MAXIMUM
20	3.89688	3.90000	3.90312
1k	3.89938	3.90000	3.90062
20k	3.89938	3.90000	3.90062
50k	3.89766	3.90000	3.90234
1M	3.66700	3.80000	3.93300

Table 4-10. 3.9V on the 30V Range Tests

FREQUENCY (Hz)	RANGE: 30V		
	MINIUM	NOMINAL	MAXIMUM
20	3.8954	3.9000	3.9046
1k	3.8979	3.9000	3.9021
20k	3.8979	3.9000	3.9021
50k	3.8962	3.9000	3.9038
1M	3.4305	3.9000	4.3665

Table 4-11. 10V on the 10V Range Tests

FREQUENCY (Hz)	RANGE: 30V		
	MINIMUM	NOMINAL	MAXIMUM
20	9.9920	10.0000	10.0080
1k	9.9984	10.0000	10.0016
20k	9.9984	10.0000	10.0016
50k	9.9940	10.0000	10.0060
1M	9.6500	10.0000	10.3500



5200A/5205A (5215A) SELECT:
VOLTAGE: Per Procedure
VOLTAGE RANGE: 1000V
FREQUENCY: Per Procedure
SENSE: Internal (straps removed)
PHASE LOCK: Off
INPUT POWER: Connect 5205A (5215A) and UUT to same source. Connect 5200A through 5205A
CONNECTIONS: IEEE cable may be connected provided controller chassis is connected to 5200A chassis. All other instrument connections must be removed

UUT SELECT:
VOLTAGE RANGE: Per Procedure
SENSE: Ohms Selector in (4T)
MODE: Per Procedure
INPUT POWER: Connect to same source as 5205A
CONNECTIONS: IEEE cable may be connected provided controller chassis is connected to 5200A chassis. All other instrument connections must be removed
GUARD: Internal

Figure 4-9. Equipment Set-Up E

Table 4-12. 35V on the 30V Range Tests

FREQUENCY (Hz)	RANGE: 30V		
	MINIMUM	NOMINAL	MAXIMUM
20	34.9720	35.0000	35.0280
1k	34.9944	35.0000	35.0056
20k	34.9944	35.0000	35.0056
50k	34.9790	35.0000	35.0210
200k	34.8250	35.0000	35.1750

Table 4-13. 100V on the 100V Range Tests

FREQUENCY (Hz)	RANGE: 100V		
	MINIMUM	NOMINAL	MAXIMUM
20	99.982	100.000	100.080
1k	99.984	100.000	100.016
20k	99.984	100.000	100.016
50k	99.940	100.000	100.060
100k	99.800	100.000	100.200

Table 4-14. 100V on the 500V Range Tests

FREQUENCY (Hz)	RANGE: 500V		
	MINIMUM	NOMINAL	MAXIMUM
20	99.895	100.000	100.105
1k	99.959	100.000	100.041
20k	99.959	100.000	100.041
50k	99.915	100.000	100.085
100k	99.775	100.000	100.225

Table 4-15. 300V on the 500V Range Tests

FREQUENCY (Hz)	RANGE: 500V		
	MINIMUM	NOMINAL	MAXIMUM
20	299.745	300.000	300.255
1k	299.937	300.000	300.063
10k	299.937	300.000	300.063

4-54. CALIBRATION ADJUSTMENTS

NOTE

The standards called out in the following procedure are required to meet the published accuracy specifications. If published accuracy is not required for a particular function (e.g. resistance, dc current, etc), standards with a lower rated accuracy may be used.

4-55. Introduction

4-56. 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 specifications. 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 Appendix 7B. The third level involves hardware calibration and is described in the following paragraphs. Power supply adjustments are shown in Figure 4-1. Adjustments and test points are accessible on the top edge of the pcb by 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.

4-57. Initial Procedure

4-58. With the power switch set to OFF, replace the Isolator with the Bus Interconnect and Monitor Board, MIS-7013K. Set the power switch to ON and allow the instrument to warm-up for at least two hours before continuing with the calibration adjustment procedures.

4-59. Power Supply

4-60. Perform the following Power Supply checks and adjustments. All required test points are available on the Bus Interconnect and 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 Interconnect and 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 4-16 are within the prescribed limits.

Table 4-16. Power Supply Verifications

TEST POINTS		VOLTAGE RANGE (VDC)		SUPPLY
HIGH	LOW	FROM	TO	
V_{DD}	Vss	+11.4	+12.6	Logic
V_{GG}	Vss	-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

6. Prepare the test DMM to read ac volts. Connect the HI DMM input lead to LINE on the Bus Interconnect and 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 Interconnect and Monitor Board, and replace the Isolator.

8. Reapply power to the UUT.

4-61. DC Calibration Procedure

4-62. There are two methods of performing dc calibration on the UUT. The first method uses the Calibration Memory to store separate correction factors for each range and function and is explained later in this manual. The second method does not use the Calibration Memory and is dealt with in this section. The following preliminary steps are required to ensure that no zero or calibration correction factors are in effect during dc calibration:

1. Select V DC function and 100 mV range.

2. Slide the rear panel Calibration Switch to the ON position and verify that the AVG/(CAL) annunciator is flashing.

3. Toggle the ZERO V DC/OHMS button so that the ZERO annunciator goes dark.

4. For each range, push STORE (CAL COR). This operation disables the software calibration correction factors for VDC function.

4-63. 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 input)

4-64. DC SIGNAL CONDITIONER ADJUSTMENTS

4-65. 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.

4-66. A/D CONVERTER CALIBRATION PROCEDURES

4-67. 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.

4-68. 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.

4-69. A/D Zero Adjustment

4-70. 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 reading of 0.00000 ± .00001.

4-71. Control Setting A

4-72. 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 is 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).

4-73. A/D Ladder Adjustments

4-74. 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.

4-75. Linearity Verification

4-76. 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 ± .00001.

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 4-17. For each of the Voltage Divider settings listed, verify a UUT reading within the listed tolerances.

Table 4-17. 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 4-17, 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.

4-77. RANGE ADJUSTMENTS

4-78. 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.

4-79. 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.

4-80. 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.

4-81. 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.

4-82. 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.

4-83. 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 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.

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

11. Select the DC Volts function, 100 mV range.

12. Slide the rear panel Calibration switch to ON. Verify that the AVG/(CAL) annunciator is flashing.

13. Toggle the zero V DC/OHMS button so that the zero annunciator goes dark and the display goes to zero. Push the zero V DC/OHMS button again so that zero is stored in calibration memory. Repeat the same procedure for ranges 1V through 1000V.

14. Slide the rear Calibration switch to OFF. Verify that the AVG/(CAL) annunciator is not flashing.

4-84. If no further hardware calibration is necessary, disable the Calibration mode by sliding the rear panel switch to off. To enable software calibration mode and store cal corrections for each range, refer to Appendix 7B.

4-85. AC Calibration Procedure (Thermal True-RMS Converter)

4-86. REQUIRED TEST EQUIPMENT

4-87. The following items of test equipment are required to calibrate the Thermal True-RMS Converter:

1. A 540B Thermal Transfer Standard (with corrections data).

2. A 5200A AC Standard (on a 90 day calibration cycle).

3. A 335D DC Standard (on a 90 day calibration cycle).

4. A flatness verified 20 dB attenuator with a proper 50 ohm load.

5. A ratio transformer (1 ppm or better).

4-88. Before starting the Calibration Procedure, verify that the ambient temperature is 23 /+/-1°C, the relative humidity is <70%, and the instrument has completed the warm-up period of 2 hours. If the frequency is changed during the test, the characterized voltage must be readjusted to conform to the new frequency.

4-89. Perform the Calibration Procedure with the High Accuracy mode and the Calibration mode selected. Any software calibration entries for ac volts must first be cleared with procedures described in Appendix 7B. When the voltage or frequency output of the source is changed, allow the source to settle before taking a reading for record. This can be accomplished by waiting for the first update of the UUT display. If an adjustment is required, select the Enhanced mode while making the adjustment, then return to the High Accuracy mode to verify the reading before proceeding with the procedure.

4-90. GROUND EQUALIZER ADJUSTMENT

4-91. Perform the Ground Equalizer Adjustment using the following procedure.

1. Select the DC Volts function, 100 mV range.

2. Connect the HI input terminal to the metal bar in the center of the Thermal True RMS Converter Module Case. Leave the LO input terminal open.

3. Adjust R50 (Amplifier PCB) for a display reading of 0 ±2 uV dc.

4-92. AMPLIFIER ZERO ADJUSTMENT

4-93. Perform the Amplifier Zero Adjustment using the following procedure:

1. Select the AC + DC NORMAL function, 500V range.

2. Connect the HI input terminal to the metal bar in the center of the Thermal True-RMS Converter Module Case. Leave the LO input terminal open.

3. Connect a test DVM HI lead to TP3 (the left side of R70) through a 10 kilohm resistor. If TP3 is not accessible the lead may be placed on the metal adjustment portion of C12. Connect LO to TP1 on the Attenuator PCB.

4. Adjust R15 for a reading on the test DVM of 0 ±2 uV dc.

4-94. SENSOR ADJUSTMENT

4-95. Perform the Sensor Adjustment using the following procedure:

1. Connect the 5200A to the UUT input terminals as shown in Figure 4-8.

2. Select the HI ACCUR function on the UUT.

3. Manually select the 1V range on the UUT.

4. Select a 1.25V (at 1 kHz) output from the 5200A.

5. Adjust R35 (Amplifier PCB) until the reading displayed in the NORMAL mode is within ±.00065 of the reading obtained in the HI ACCUR mode.

6. Select a 0.125V (at 1 kHz) output from the 5200A.

7. Adjust R26 (Amplifier PCB) until the reading displayed in the NORMAL mode is within ±.00013 of the reading obtained in the HI ACCUR mode.

8. Repeat steps 3 through 7 until no further adjustments are required.

4-96. ATTENUATOR AND AMPLIFIER ADJUSTMENTS

4-97. DC to AC Transfer Measurement Procedure

4-98. Perform the dc to ac transfer measurement procedure as follows:

1. Connect the 5200A, 335D, and the 540B for DC to AC Transfer Measurements as shown in Figure 4-5.

2. Set the DC Standard for the first characterized point required to complete the calibration procedure listed in Table 4-4.

3. Set the 540B to the range listed in Table 4-4 and to the DC Transfer mode. Adjust to obtain a null indication.

4. Reverse the DC input leads to the 540B and adjust null to compensate for positive and negative turnover error.

5. Select the 5200A output listed in Table 4-4.

6. Switch the 540B to the AC Transfer mode and adjust the 5200A output to obtain a null indication on the 540B.

7. Record the output setting on the 5200A in a characterization points table for future usage.

8. Perform the above procedure for all characterized points required for calibration (listed in Table 4-4).

4-99. Adjustment Procedure

4-100. Perform the attenuator and amplifier adjustments using the following procedure:

1. Connect the 5200A output to the UUT input terminals as shown in Figure 4-8.

2. Perform the test and adjustments for steps 1 through 4 listed in Table 4-18 using the characterized points table recorded above.

3. Repeat step 1 of Table 4-18 and verify the displayed reading is within the stated tolerance. If an adjustment is required, perform the four steps until all four readings are within tolerance without any further adjustments.

4. Perform the test and adjustments for steps 5 and 6 in Table 4-18 using the characterized points table recorded above.

5. Perform the test and adjustments for steps 7 and 8 in Table 4-18. Repeat the test until both steps are within tolerance without further adjustments.

6. Perform the test and adjustments for steps 9 and 10 in Table 4-18.

7. Perform the test and adjustments for steps 11 and 12 in Table 4-18 using the characterized points table recorded above. Repeat the tests until both steps are within tolerance without further adjustment.

8. Verify that the readings for steps 9 and 10 in Table 4-18 are still within tolerance. Repeat steps 9 through 12 in Table 4-18 until all four steps are within tolerance without further adjustment.

9. Perform the test and adjustments for steps 13 and 14 in Table 4-18.

10. Perform the test and adjustments for steps 15 and 16 in Table 4-18 using the characterized points table recorded above.

11. Connect the 5200A output terminals to the input of the Ratio Transformer and connect the output of the Ratio Transformer to the input terminals of the UUT as shown in Figure 4-6.

Table 4-18. Amplifier and Attenuator Adjustments

REQUIRED CHARACTERIZED POINTS TO BE USED		5200A VOLTS	5200A HERTZ	UUT RANGE	READING BETWEEN MINIMUM	READING BETWEEN MAXIMUM	ADJUSTMENT
1	✓	1	1K	1V	.99998	1.00002	R1(Atten)
2	✓	390 mV	1K	300 mV	389.995 (-3)	390.005 (-3)	R54(Ampl)
3	✓	3.9V	1K	3V	3.89995	3.90005	R2(Atten)
4	✓	10	1K	10V	9.9998	10.0002	R52(Ampl)
5	✓	100	1K	100V	99.998	100.002	R3(Atten)
6	✓	100	1K	500V	99.994	100.006	R5(Atten)
7	✓	390 mV	20K	300 mV	389.995 (-3)	390.005 (-3)	C8(Atten)
8	✓	1	20K	1V	.99998	1.00002	C11(Ampl)
9	N/A	3.9V	1M	3V	See Note 1	See Note 1	
10	N/A	10V	1M	10V	See Note 1	See Note 1	R13(Atten)
11	✓	10V	50K	10V	9.9994	10.0006	C15(Atten)
12	✓	3.9V	50K	3V	3.89844	3.90156	C12(Ampl)
13	N/A	10V	1M	100V	See Note 2	See Note 2	
14	N/A	10V	1M	30V	See Note 2	See Note 2	R16(Atten)
15	✓	100V	50K	100V	99.998	100.002	C20(Atten)
16	✓	100V	50K	500V	99.996	100.004	C27(Atten)
17	✓	1.1V	1K	100 mV	109.997 (-3)	110.003 (-3)	R56(Ampl)
18	✓	1.1V	50K	100 mV	109.997 (-3)	110.003 (-3)	R72(Ampl)

Note 1

First, compute RA1 using the following formula:

RA1 = 10 + (R1 * .5) - (R2 * 1.25) ±.0150

Where:

R1 = recorded reading at 10V, 1 MHz, 10V range

R2 = recorded reading at 3.9V, 1 MHz, 3V range

Second, adjust R13 for RA1.

Note 2

Where:

R3 = recorded reading at 10V, 1 MHz, 30V range

R4 = recorded reading at 10V, 1 MHz, 100V range

If 20 - R4 <= R3, then no adjustment of R16 is required.

If 20 - R4 > R3, then adjust R16 so that the reading at 10V, 1 MHz on the 30V range is equal to 10 + 1/2(R3-R4) ±.015.

12. Perform the test and adjustment for step 17 in Table 4-18 using the characterized points table recorded above. Record the displayed reading on the UUT.

13. Connect the 5200A, 540B, and the flatness verified 20 dB attenuator as shown in Figure 4-7. (Before performing this step complete the Low Frequency Attenuator Accuracy Test.)

14. Adjust the 5200A output for the reading recorded on the UUT display in step 17 of Table 4-18 and adjust the 540B for a null indication. Record the 5200A setting.

15. While maintaining a null on the 540B by adjusting the 5200A output, perform the test and adjustment for step 18 in Table 4-18.

16. Repeat step 14 with the recorded 5200A setting and check for repeatability within .002% of null indication on the 540B.

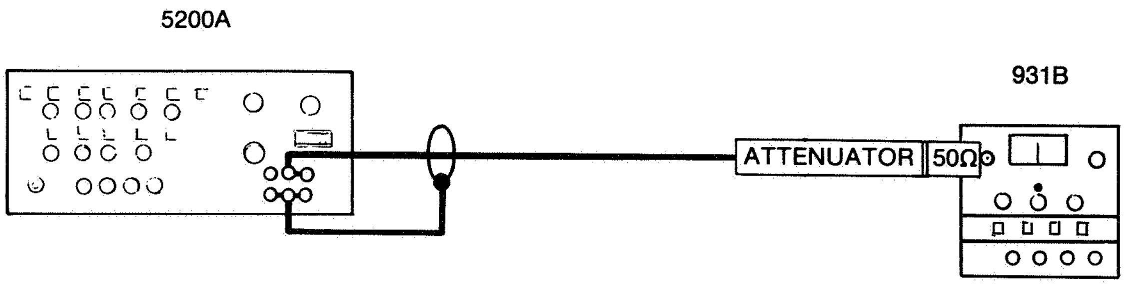
4-101. LOW FREQUENCY ATTENUATOR ACCURACY TEST

4-102. Perform this test immediately prior to usage of the attenuator.

1. Connect the 5200A, 931B, and the 20 dB attenuator as shown in Figure 4-10.

2. Select a 1V (at 1 kHz) output on the 1V range from the 5200A.

3. Record the reading on the 931B. Save this reading for future reference.



5200A SELECT:
VOLTAGE: Per Procedure
VOLTAGE RANGE: Per Procedure
FREQUENCY: Per Procedure
SENSE: External (straps installed)
PHASE LOCK: Off
INPUT POWER: Connect to same source as other equipment
CONNECTIONS: All other instrument or IEEE cable connections must be removed

931B SELECT:
POWER: BAT OPR
RANGE: Per Procedure
MODE: .1% Null for testing and XI TVM when changing Ranges or Setting
DIALS: Per Procedure

Figure 4-10. Equipment Set-Up F

4. Verify that the 931B reading is within the attenuator manufacturer's specification for dc attenuation accuracy.

NOTE

The Attenuator Flatness Verification Test need only be performed every five years, or if the attenuator fails the Low Frequency Attenuator Accuracy Test.

4-103. ATTENUATOR FLATNESS VERIFICATION TEST

4-104. 931B Characterization Procedure

4-105. Characterize attenuation versus frequency flatness for the 931B using the following procedure.

1. Connect the 5200A, 540B, and the 931B as shown in Figure 4-11.

2. Select a 250 mV (at 500 Hz) output on the 1V range from the 5200A.

3. With the 0.5Vrange and the AC Transfer mode set on the 540B, adjust the 5200A output to obtain a null indication on the 931B.

4. While still maintaining a null on the 931B, adjust the 540B for a null indication on the galvanometer.

5. Select a frequency of 20 kHz from the 5200A.

6. Record the reading on the 931B.

7. Repeat steps 5 and 6 above for 50 kHz.

8. Repeat steps 5 and 6 above for 100 kHz.

9. Repeat steps 5 and 6 above for 500 Hz and check for repeatability within .002% of null.

4-106. Attenuator Flatness Verification Test Procedure

4-107. Perform the flatness verification test on the 20dB attenuator using the following procedure:

1. Connect the 5200A, 540B, 931B, and the 20 dB attenuator as shown in Figure 4-12.

2. Select a 2.5V (at 500 Hz) output on the 10V range from the 5200A.

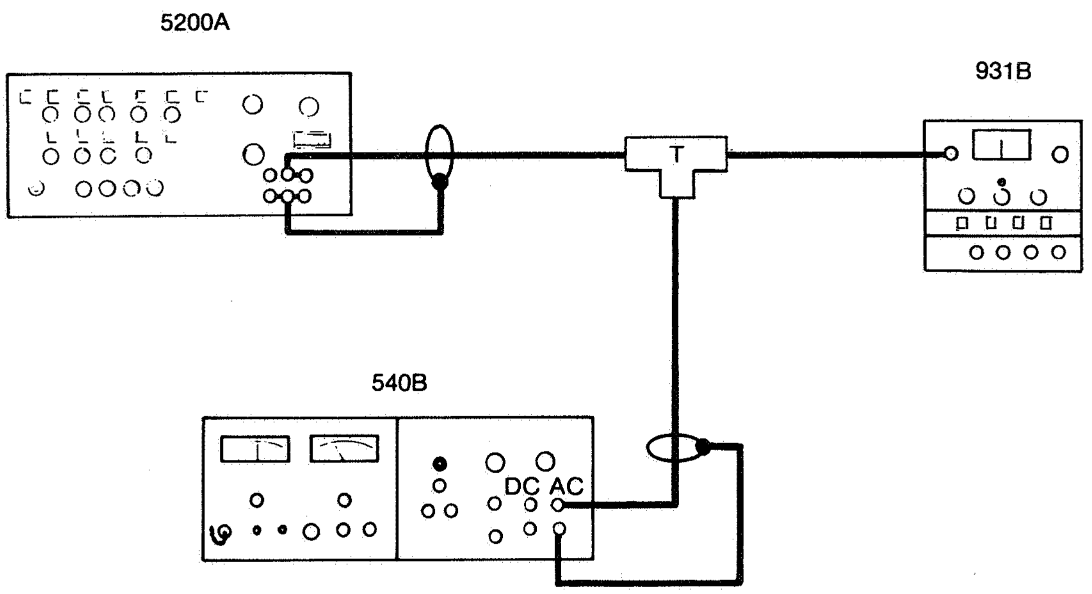
3. With the 931B on the 1V range adjust the 5200A output to obtain a null indication on the 931B.

4. With the 540B on the 2V range in the AC Transfer mode adjust for a null indication on the 540B while still maintaining a null on the 931B.

5. Increase the frequency output on the 5200A to 20 kHz.

6. Adjust the 5200A output level to obtain a null indication on the 540B meter.

7. Record the reading on the 931B.

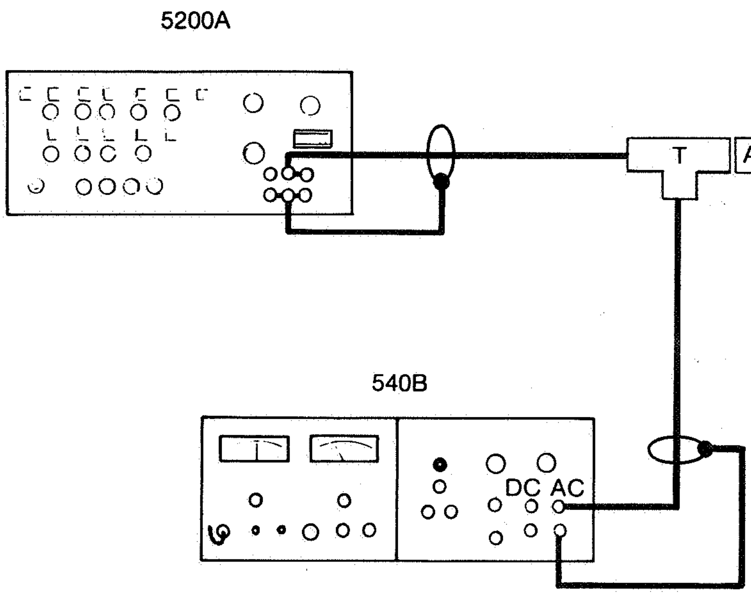


5200A SELECT:
VOLTAGE: Per Procedure
VOLTAGE RANGE: Per Procedure
FREQUENCY: Per Procedure
SENSE: External (straps installed)
PHASE LOCK: Off
INPUT POWER: Connect to same source as other equipment
CONNECTIONS: All other instrument or IEEE cable connections must be removed

540B SELECT:
MODE: AC Transfer
RANGE: Per Procedure
POWER: On
SENSITIVITY: Adjust for null per procedure
REFERENCE ADJUST: Use for null adjustment in conjunction with sensitivity
SENSITIVITY TEST: OPR
GALV: Lock or Momentary during null adjustment and Open when changing Ranges or Modes

931B SELECT:
POWER: Bat OPR
RANGE: Per Procedure
MODE: .1% Null for testing and X1 TVM when changing Ranges or Settings
DIALS: Per Procedure

Figure 4-11. Equipment Set-Up G



5200A SELECT:
VOLTAGE: Per Procedure
VOLTAGE RANGE: Per Procedure
FREQUENCY: Per Procedure
SENSE: External (straps installed)
INPUT POWER: Connect to same source as other equipment
PHASE LOCK: Off
CONNECTIONS: All other instrument or IEEE cable connections must be removed

540B SELECT:
MODE: AC Transfer
RANGE: Per Procedure
POWER: On
SENSITIVITY: Adjust for null per procedure
REFERENCE ADJUST: Use for null adjustment in conjunction with sensitivity
SENSITIVITY TEST: OPR
GALV: Lock or Momentary during null adjustment and Open when changing Ranges or Modes

931B SELECT:
POWER: BAT OPR
RANGE: Per Procedure
MODE: .1% Null for testing and X1 TVM when changing Ranges or Settings
DIALS: Per Procedure

Figure 4-12. Equipment Set-Up H

8. Repeat steps 6 and 7 for 50 kHz.

9. Repeat steps 6 and 7 for 100 kHz.

10. Compare the 931B readings at each frequency with the characterized readings obtained in the 931B Characterization Procedure. Verify that any differences between these readings are within the tolerances listed below:

a. At 20 kHz: ±.006% correction factor.

b. At 50 kHz: ±.015% correction factor.

c. At 100 kHz: ±.030% correction factor.

4-108. TROUBLESHOOTING

4-109. Troubleshooting the multimeter may require module configurations that normally generate latching error conditions. If this situation does occur, the following procedure can be used to override latching errors:

1. With power on, enable Calibration mode by sliding the rear panel Calibration Switch to on.
2. Push the AVG button. The display should read "Err. oFF", indicating latching errors are now disabled. (If a latching error exists when this procedure is performed, the display will instead indicate an error message. In this case, press any function button to clear the error message.) Pressing AVG in Calibration mode does not enable the Average mode; the Average mode is mutually exclusive with Calibration mode.
3. To reenable latching errors, push the AVG button again. If no latching error conditions exist at this time, the display responds with "Err. on", and the multimeter assumes the normal Calibration mode configuration. If a latching error condition does exist, the error is identified in the display and must be corrected before the multimeter assumes the normal Calibration mode configuration.
4. If Calibration mode is no longer required, slide the rear panel Calibration Switch to off. Latching errors are automatically reenabled whenever the Calibration Switch is cycled on or off.

CAUTION

Disabling latching errors overrides protection circuitry between the multimeter's pcbs. Since latching errors may also identify an overvoltage condition (as with Error 4), discretion must be used to avoid damaging the multimeter. Do not disable latching errors during normal operation or calibration.

4-110. A procedure for isolating faulty modules is contained in Table 4-19. It is important that the theory of operation given in Secton 3 be read before attempting 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 (OPTION -06) 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.

4-111. Symptom analysis troubleshooting is provided for standard modules in this section. Possible failures are listed in order of probability. Troubleshooting information for optional modules is contained in Section 6. The following tables and figures provide troubleshooting procedures for standard modules:

1. Controller - Table 4-20
2. Front Panel - Table 4-21
3. DC Signal Conditioner - Table 4-22
4. Active Filter - Table 4-23
5. A/D Converter - Table 4-24
6. Power Supply - Figure 4-13
7. Thermal True-RMS Converter Module - Table 4-25
   a. RMS Sensor Troubleshooting and Replacement - Table 4-26
   b. Thermal True-RMS Converter Typical Test Voltages - Table 4-27
   c. Thermal True-RMS Converter Attenuator Logic - Table 4-28

4-112. 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.

NOTE

If a component is replaced during troubleshooting, reselection of a selected component, adjustment of a non-recurring adjustment, or some other specific component replacement procedure may become necessary. Refer to applicable instructions later in this section.

4-113. If troubleshooting requires opening the Thermal True-RMS Converter while power is applied to the instrument, proceed as follows:

1. Push the POWER button to OFF.
2. Remove the Thermal True-RMS Converter.
3. Attach the Thermal True-RMS Converter to a special extender pcb (Fluke Order Number 8502A-7001K).
4. Install the converter-extender in the original position.
5. Push the POWER button to ON.

4-114. Troubleshooting Notes

NOTE

The ground integrity of 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.

4-115. If interaction between modules is a problem during troubleshooting, use of either the Static Controller or the Test Module could be helpful. Using 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.

4-116. 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 outputs 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.

4-117. 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 is thereby minimized.

4-118. Non-Recurring Adjustments

4-119. POWER SUPPLY

4-120. 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.

4-121. THERMAL TRUE-RMS CONVERTER

4-122. Thermal True-RMS Amplifier Assembly

4-123. Variable resistor R34 in the Square Root Amplifier circuit controls the Sensor circuit transient response. It is set at the factory and should not require any additional adjustment. If any components in the circuit are replaced during troubleshooting, adjust or verify the R34 setting as follows:

1. Manually select the AC + DC Normal function and the 1V range.
2. Apply an input of 0.625V dc to the UUT input terminals.

3. Connect a test DVM between TP4 (HI) and TP1 (LO).

4. Adjust R34 for a test DVM reading of 2.5 ±0.03V dc.

4-124. Variable resistor R61 in the Sensor Protect circuit controls the maximum voltage applied to the rms sensor. It is set at the factory and should not require any additional adjustment. If any components in the circuit are replaced during troubleshooting the circuit can be adjusted or verified using the following procedure:

1. Adjust R61 fully clockwise (CW).

2. Manually select the AC + DC function and the 1V range.

3. Apply a 2V dc input to the UUT input terminals.

4. Connect a test DVM between TP6 (HI) and TP1 (LO).

5. Adjust R61 for a test DVM reading of 2.2 ±0.01V dc.

4-125. Variable resistor R78 in the Ranging Amplifier is the coarse adjustment for the zero adjustment R15. It is set at the factory and does not require calibration adjustment. However, if any components in the circuit are replaced during troubleshooting, or if R15 is at one extreme without bringing the circuit into tolerance, R78 can be adjusted using the following procedure:

1. Adjust R15 to the center of its adjustment range.

2. Connect a test DVM between TP3 (HI) through a 10 kilohm resistor and TP1 (LO).

3. Adjust R78 for a test DVM reading of 0 ±2 uV dc.

4. Perform the Thermal True Converter Adjustments to verify the calibration of the UUT.

4-126. Variable capacitor C8 compensates the ranging amplifier in the X20 setting and requires adjustment only if repair or replacement of components takes place in the ranging amplifier. Use the following procedure to adjust C8 if required.

1. Short the center wire of P2 to ground. The shell of the P2 connector is not at ground.

2. Select the 100 mV range on the UUT.

3. Connect an oscilloscope probe to TP3 with the ground clip in TP1. Select oscilloscope settings of 50 mV/div and 0.5 ms/div.

4. Adjust C8 for minimum noise on the scope display.

5. Select an oscilloscope sweep speed of 0.01 us/div.

6. Verify that the amplifier is stable, i.e., not oscillating.

7. If the amplifier is unstable, readjust C8 until the minimum noise is obtained without causing the amplifier to oscillate.

4-127. Variable capacitor C9 compensates the ranging amplifier in the X6.25 setting and requires adjustment only if repair or replacement of components takes place in the ranging amplifier. Use the following procedure to adjust C9 if required.

1. Short the center wire of P2 to ground. The shell of the P2 connector is not at ground.

2. Select the 300 mV range on the UUT.

3. Connect an oscilloscope probe to TP3 with the ground clip in TP1. Nominal scope settings are 50 mV/div and 0.01 us/div.

4. Adjust C9 for minimum capacitance, i.e., with the center adjustment screw all the way out.

5. Adjust C9 in toward maximum capacitance until the oscillations stop. Adjust C9 in at least two full turns (720°).

4-128. Thermal True-RMS Attenuator Assembly

4-129. Variable capacitor C13 in the X.08 Attenuator circuit is the coarse adjustment for the 10V range adjustment C15. It is set at the factory and does not require calibration adjustment. However, if any components in the circuit are replaced during troubleshooting, or if C15 is at one extreme without bringing the circuit into tolerance, C13 can be adjusted using the following procedure:

1. Adjust C15 to the center of its adjustment range.

2. Manually select the AC HI ACCUR function and the 10V range.

3. Apply an input of 10V at 50 kHz to the UUT input terminals.

4. Adjust C13 for a UUT reading between 9.9850 and 10.0150V ac.

5. Perform the Thermal True-RMS Converter Adjustments to verify the calibration of the UUT.

Table 4-19. Faulty Module Isolation

STEP NO.	ACTION	Go to the step number given for correct response: YES	NO
1.	Push POWER ON. The following should be displayed: HI—Y.Y.Y (Y = Software Number) CXXXXXA (X = Option Number) 0.000 (DC Volts, 1000V range, sample 7, filter F0)		
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 ±.005?	59	5
5.	Are the first three displays normal?	78	2
	DISPLAY BLANK AT POWER ON		
6.	Remove Isolator.		
7.	Turn power ON.		
8.	Is HI-Y.Y.Y, then CXXXXXA, then error 9 displayed?	8	11
9.	Install interconnect-monitor in the Isolator slot. Is HI—Y.Y.Y 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 EEROM.		
16.	Bad Remote Interface. Go to Section 6 under the appropriate 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 (100 or 120V AC), or 6.5V ac to 8.5V ac (220 or 240V 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 or table for that module.		
23.	Remove the front panel. Recheck supplies. Within tolerance?	25	24
24.	Problem on power supply, motherboard, or power supply interconnect.		
25.	Bad Front Panel. Go to Table 4-21.		
26.	Remove Cal Memory chip and the remote interface if installed.		
27.	Check IC 6, 5, 1, 0 on interbus. All moving?	28	30

Table 4-19. Faulty Module Isolation (cont)

STEP NO.	ACTION	Go to the step number given for correct response YES	NO
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 Table 4-20.		
32.	Bad Front Panel. Go to Table 4-21.		
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 table 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 Table 4-20.		
38.	Bad Front Panel. Go to Table 4-21.		
	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 CXXXXXA 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
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 Table 4-20.		

Table 4-19. Faulty Module Isolation (cont)

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
56.	Is the display normal?	58	57
57.	Front Panel bad. Go to Table 4-21.		
58.	Faulty Analog module. Replace one at a time until symptoms recur. Last one in is faulty. Go to the table 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 Different 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 4-13.		
69.	Replace modules one at a time, checking supplies between modules. Last one in is faulty. Go to the appropriate figure or table.		
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.		
73.	Place a jumper (short) between RT2 and RT6.		
74.	Is the reading zero?	75	76
75.	DC Signal Conditioner bad. Go to Table 4-22.		
76.	Filter module bad. Go to Table 4-23.		
77.	A/D converter bad. Go to Table 4-24.		
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.		

Table 4-19. Faulty Module Isolation (cont)

STEP NO.	ACTION	Go to the step number given for correct response YES	NO
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 Different = 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 4-13.		
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: (see table below)		
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 Table 4-22.		
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 Table 4-23.		
103.	Faulty A/D Converter. Go to Table 4-24.		

Step 97 suggested inputs:

GAIN RANGE	DC SIG COND	TEST DMM INPUT	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	X10÷64	1.28V	200 mV
100V	X10÷64	128V	20.0V
1000V	X1÷64	64V	1.0V
1000V	X1÷64	960V	15.0V

Table 4-20. 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 01 at U15-22; 02 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 4-21. 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 4-22. 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 4-23. 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 4-24. 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 $<2\ \mu$sec.
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.

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.

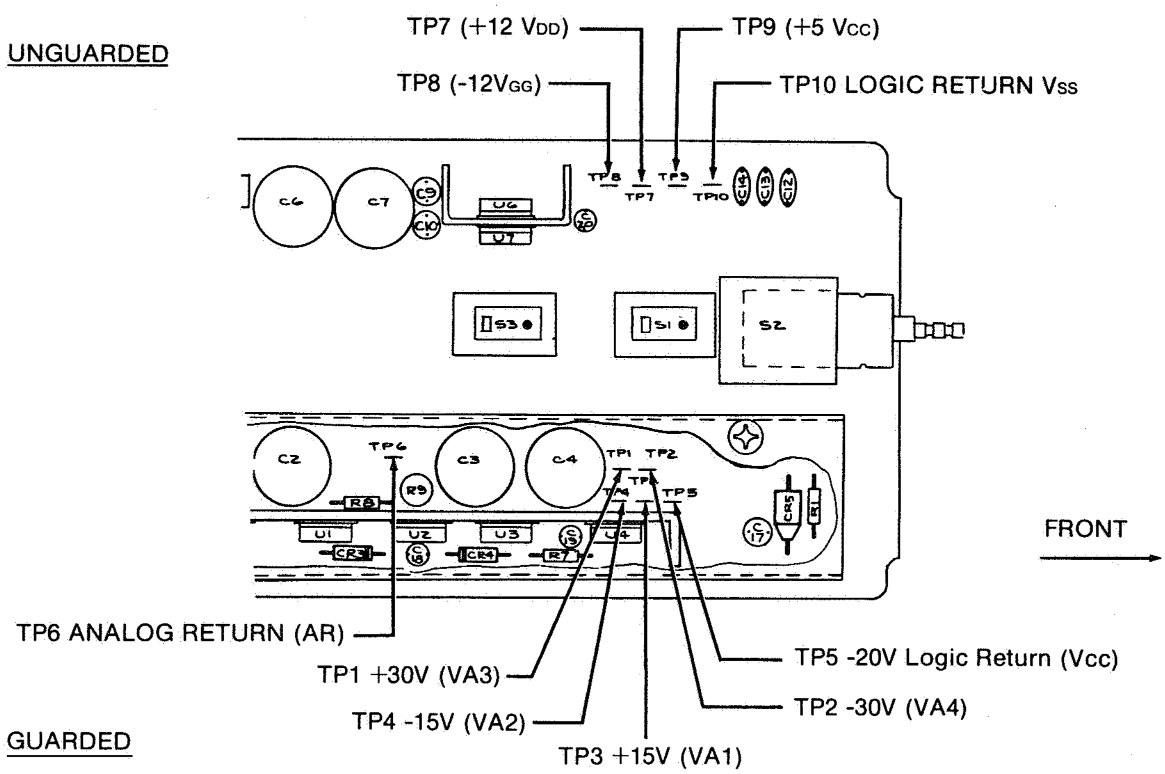


Figure 4-13. Power Supply Troubleshooting

Table 4-25. Thermal True RMS Converter Module Troubleshooting

STEP NO.	ACTION	Go to the step number given for correct response YES	NO
1	Perform the DC Volts Performance Test		
2	Is the DC Volts Performance Test within the listed tolerances?	4	3
3	Troubleshoot the DC portion of the instrument using the procedure in Table 4-19. Repair as required then resume at step 1.		
4	Perform the Thermal True RMS Performance Test.		
5	Is the Thermal True RMS Performance Test within the listed tolerances?	45	6
6	Remove modules not required for Thermal True RMS option, i.e., the Ohms Converter, Isolator, and IEEE Interface, then repeat the Thermal True RMS Performance Test.		
7	Is the Thermal True RMS Performance Test now within the listed tolerances?	8	9
8	Replace the modules one at a time until the failed reading returns. Repair or replace the last module reinserted in the instrument then resume at step 4.		
9	Check the Supply voltages. Place the test DMM LO on AR (P11-9/30). VA1 (P11-28) +14.25 to +15.75 Vdc VA2 (P11-8) -14.25 to -15.75 Vdc VA4 (P11-7) (Ampl PCB only) -29 to -32 Vdc Vcc (P11-12/33) (Atten PCB only) = -15 Vdc Vss (P11-11/31) = -20 Vdc Vcc (DMM HI) to Vss (DMM LO) +4.9 to +5.2 Vdc		
10	Are the supply voltages within the listed tolerances?	12	11
11	Check the power supply and instrument bus using the procedures previously given. Repair or replace as required then resume at step 4.		
12	Is the voltage between TP1 (DMM HI) and Input Low (DMM LO) equal to 0 ±50 uV?	21	13
13	With the DMM LO on TP1 is the signal at U5-7 (Ampl) >5 Vdc and at U5-1 (Ampl) <-5 Vdc?	14	15
14	Check U13, Q32, Q33, and their associated components on the Amplifier PCB. Repair as required then resume at step 4.		
15	With the DMM LO on TP1 is the signal at U5-6 (Ampl) >-0.7 Vdc?	16	17
16	Check U5 and its associated components on the Amplifier PCB. Repair as required then resume at step 4.		
17	Remove and disconnect power from the UUT. Measure the resistance between TP1 and TP2 and between TP1 and TP5 of the Amplifier PCB using a test multimeter whose ohms function output is less than 5 mA.		

Table 4-25. Thermal True RMS Converter Module Troubleshooting (cont)

STEP NO.	ACTION	Go to the step number given for correct response YES	NO
18	Is the resistance reading 294 ohms ±7% between TP1 and TP3, and 389 ohms ±8% between TP1 and TP5?	19	20
19	Check in sequence the following items on the Amplifier PCB: a. Switching transistors Q26, Q12, Q14, Q16, and their associated components. b. Q28 and its associated components. 3. Q19, Q18, Q31, and their associated components. d. Q10, Q8, and their associated components. (The gate voltages on Q8 and Q10 normally vary approximately 1V from off to on.) e. Amplifier U1 and its associated components. Repair as required then resume at step 4.		
20	Check the RMS Sensor using the procedure in Table 4-26. Repair or replace then resume at step 4.		
21	Does the fault occur only if the high accuracy and/or the fast enhanced modes are selected?	22	26
22	Connect a test DMM between TP8 (HI) and TP1 (LO) on the Amplifier PCB, then apply a full scale voltage input to the UUT terminals. (Apply an input equal to the full scale reading rather than the range title of the defective range.).		
23	With the high accuracy mode selected, does the reading at TP8 remain stable (±50 uV) after the initial settling period of approximately 0.5 second (the settling period repeats every 3 seconds).	24	25
24	Check the sensor adjustment portion of the Calibration Procedure. Adjust or repair as required then resume at step 4.		
25	Check U11, U12, Q19, Q18, Q31, and their associated components. Repair as required then resume at step 4.		
26	Select the AC Normal + DC Volts function and Autorange. Apply a 1V dc signal to the UUT input terminals.		
27	With the instrument still in Autorange and the input unchanged, select the AC Volts Normal function.		
28	Is the instrument reading within the required tolerance with the AC Normal + DC Volts function selected and approximately zero with the AC Volts Normal function selected?		
29	Check the following items in the sequence listed until the fault is located, repair as required, then resume at step 4. If the fault is not located in one of these areas, proceed to the next step in the table. a. K2 and K3 on the Attenuator PCB for the proper switching action. b. C1 through C4 on the Attenuator PCB. c. U3 and its associated components on the Amplifier PCB. d. Voltages at Q1-7 using the typical voltages in Table 4-27. e. Attenuator circuits on the Attenuator PCB.	29	37

Table 4-25. Thermal True RMS Converter Module Troubleshooting (cont)

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
30	Check the voltages present at TP5 against the typical voltages in Table 4-27.		
31	Are the readings at TP5 comparable to the typical voltages in the Table?	34	32
32	Check the voltages present at TP3 against the typical voltages in Table 4-27.		
33	Are the readings at TP3 comparable to the typical voltages in the Table?	17	19
34	Check the voltages present at TP6 against the typical voltages in Table 4-27.		
35	Are the readings at TP6 comparable to the typical voltages in the Table?	42	36
36	Check U9 and Q22 (for correct switching) on the Amplifier PCB. Repair as required then resume at step 4.		
37	Select the AC Volts Normal function and Autorange. Apply a 1V ac at 1 kHz signal to the UUT input terminals.		
38	Is the displayed reading approximately 1V?	39	29
39	Are all of the RMS tests at frequencies at 20 kHz or less within tolerance?	41	40
40	Check the attenuator logic levels using the information in Table 4-28. Repair as required then resume at step 4.		
41	Are all of the RMS tests at frequencies greater than 20 kHz within tolerance?	45	42
42	Test the switching hybrids on the Attenuator PCB using the following tests (unless otherwise noted all test points are on the Attenuator PCB and TP1 is LO): a. Apply a 12.5 mV ac input and take a reading in the high accuracy mode for AC and AC DC. The difference in the two readings should be less than 10 uV. b. With the instrument in the normal mode and no input, the difference in the readings between TP3 and TP1 on the Amplifier PCB in the 1V range and the 500V range should be less than 400 uV. c. U8-6 to TP1 reads +7±1V dc for all ranges. d. U8-9 to TP1 reads -7±1V dc for all ranges. e. U8-1 To TP1 reads -0.7±0.4V dc for all ranges except 500V. f. U7-1 to TP1 reads -3±1.8V dc for all ranges except 30V and 100V. g. U6-1 to TP1 reads -8±1V dc for all ranges except 4V and 10V. h. U5-1 to TP1 reads -8±1V dc for all ranges except 1V.		
43	Are the switching hybrids within the stated tolerances?	45	44
44	Replace any components indicated. If replacement does not cure the trouble, resume with the tests in step 29.		
45	Perform the Calibration Procedure and Performance Tests for the UUT.		
46	Does the UUT pass all tests?	47	2
47	Troubleshooting of the Thermal True RMS Converter is complete.		

Table 4-26. RMS Sensor Troubleshooting and Replacement

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
1	Unsolder the suspect RMS Sensor (U6) from the Amplifier PCB using a grounded soldering iron.		
2	Remove R24 or R28, if either is installed, and replace the resistor in the circuit with a bus wire.		
3	Install the Attenuator PCB and the Amplifier PCB on the special Thermal True RMS Converter extender board in the open configuration. Insure the ground jumper on the back of the Amplifier PCB is installed.		
4	Apply power to the instrument and compare the voltages at Q1-7 for the 100 mV, 300 mV 1V ranges against the typical voltages in Table 4-27.		
5	Are the readings comparable?	6	7
6	Check the following items in the sequence listed until the fault is located: a. K2 and K3 on the Attenuator PCB for the proper switching action. b. C1 through C4 on the Attenuator PCB. c. U3 and its associated components on the Amplifier PCB. d. Voltages at Q1-7 using the typical voltages in Table 4-27. e. Attenuator circuits on the Attenuator PCB. Repair as required, then resume at step 4.		
7	Compare the voltages at TP3 on the Amplifier PCB for the 100 mV, 300 mV, and 1V ranges against the typical voltages in Table 4-27.		
8	Are the readings comparable?	10	9
9	Check in sequence the following items on the Amplifier PCB: a. Switching transistors Q26, Q12, Q14, Q16, and their associated components. b. Q28 and its associated components. c. Q19, Q18, Q31, and their associated components. d. Q10, Q8 and their associated components. (The gate voltages on Q8 and Q10 normally vary approximately 1V from off to on.) e. Amplifier U1 and its associated components. Repair as required, then resume at step 7.		
10	Select the V AC Normal Function and set the UUT for the 1V range. Apply +2V dc to the UUT input terminals.		
11	Does the test DMM connected between TP3 (HI) and TP1 (LO) read ‖+3.2V dc?	15	12
12	Connect a jumper from the cathode of CR1 to TP1.		

STEP NO.	ACTION	Go to the step number given for correct response: YES	NO
13	Does the test DMM connected between TP3 (HI) and TP1 (LO) now read <+2.5V dc?	15	14
14	Check U5, Q24, Q25, and their associated components on the Amplifier PCB. Repair as required, then resume at step 10.		
15	Apply -2V dc to the UUT input terminals.		
16	Does the test DMM connected between TP3 (HI) and TP1 (LO) read ll3.2V dc?	20	17
17	Connect a jumper from the cathode of CR1 to TP1.		
18	Does the test DMM connected between TP3 (HI) and TP1 (LO) now read <-2.5V dc?	20	19
19	Check U5, Q24, Q25, and their associated components on the Amplifier PCB. Repair as required, then resume at step 15.		
20	Remove power from the instrument and replace the RMS Sensor.		
21	Perform the Sensor Adjustment portion of the Calibration Procedure.		
22	Can the Sensor Adjustment procedure be successfully completed?	27	23
23	Does R26 run out of adjustment in the clockwise direction?	24	25
24	Replace R24 on the Amplifier PCB with a 20-kilohm, 1% metal film resistor, then resume at step 21.		
25	Does R26 run out of adjustment in the counterclockwise direction?	26	21
26	Replace R28 on the Amplifier PCB with a 20-kilohm, 1%, metal film resistor, then resume at step 21.		
27	Remove the ground jumper on the back of the Amplifier PCB, then close and reinsert the module in the UUT.		
28	Perform the Calibration Procedure and Performance Test.		
29	Does the UUT Calibrate and pass the Performance Test?	31	30
30	Troubleshoot the instrument using the procedure in Table 4-25.		
31	Troubleshooting of the UUT is complete.		

Table 4-27. Thermal True RMS Converter Typical Test Voltages

INPUT	RANGE	Q1-7	TP3	TP4*	TP5	TP6	TP7	TP8
SHORT	ALL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1V	1V	0.80	1.60	6.40	1.60	1.60	1.60	1.60
1V	3V	0.08	0.50	0.63	0.50	0.50	0.50	0.50
100 mV	100 mV	0.08	1.60	6.40	1.60	1.60	1.60	1.60
100 mV	300 mV	0.08	0.50	0.63	0.50	0.50	0.50	0.50
1V	10V	0.08	0.16	0.06	0.16	0.16	0.16	0.16
10V	10V	0.80	1.60	6.40	1.60	1.60	1.60	1.60
10V	100V	0.08	0.16	0.06	0.16	0.16	0.16	0.16
100V	100V	0.80	1.60	6.40	1.60	1.60	1.60	1.60
100V	500V	0.16	0.33	0.28	0.33	0.33	0.33	0.33
500V	500V	1.00	2.00	10.00	2.00	2.00	2.00	2.00

All measurements are made on the Amplifier PCB with reference to TP1

*Value at TP4 ≅ 2.50 * $(A_V{}^*V_{IN}{}^*A_T)^2$

(See Table 3-3 for A_V and A_T values)

Table 4-28 Thermal True RMS Converter Attenuator Logic Table

FUNCTION \ TEST POINT	J1—W	J1—K	J1—L	J1—M	J1—P	J1—S	J1—N	J1—O	U17—4	U17—3	U17—10	U17—11	U10—6	U10—3	U16—6
SAMPLE: F OUT	X	X	X	X	H	L	H	L	X	X	X	X	X	X	L
HOLD: F OUT	L	H	H	H	L	H	H	L	X	X	X	X	X	X	L
SAMPLE: F IN	X	X	X	X	G	L	L	L	X	X	X	X	X	X	L
HOLD: F IN	L	H	H	H	L	H	L	L	X	X	X	X	X	X	L
RANGE: 500V	L	L	H	H	X	X	X	L	L	H	H	H	X	X	L
RANGE: 100V	L	L	H	H	X	X	X	L	H	L	H	H	X	X	L
RANGE: 30V	H	H	L	H	X	X	X	L	H	L	H	H	X	X	L
RANGE: 10V	L	L	H	H	X	X	X	L	H	H	L	H	X	X	L
RANGE: 3V	H	H	L	H	X	X	X	L	H	H	L	H	X	X	L
RANGE: 1V	L	L	H	H	X	X	X	L	H	H	H	L	X	X	L
RANGE: 300 mV	H	H	L	H	X	X	X	L	H	H	H	L	X	X	L
RANGE: 100 mV	H	H	H	L	X	X	X	L	H	H	H	L	X	X	L
MODE: AC	X	X	X	X	X	X	X	X	X	X	X	X	H	L	L
MODE: AC + DC	X	X	X	X	X	X	X	X	X	X	X	X	L	H	L

X = Don't Care   H = Logic High = 1 = -15V   L = Logic Low = 0 = -20V

4-130. Factory Selected Component Replacement Procedures

4-131. The values of some components in the Thermal True-RMS Converter are selected at the factory. These components do not normally need reselection unless there is a failure and subsequent replacement of some component in the circuit. For those cases the selection procedure is given in the following paragraphs. After selecting the appropriate value, refer to paragraph 4-143 for ordering information.

4-132. AMPLIFIER OFFSET SELECTION

4-133. If certain components are replaced, the Amplifier Offset Adjustment R15 may not bring the reading within the accepted tolerance. These components include the amplifier U1, components associated with U1 (especially in the U1 input circuit), and components in the attenuator circuit. If R15 cannot be properly adjusted, use the following procedure to reselect R10 or R13.

1. Set R15 to approximately the mechanical center of its range.

2. Connect the test DMM between TP3 (HI) and TP1 (LO). Insert a 10 kilohm, 5% resistor in line with the test DMM connection to TP3 (HI). This resistor must be connected within one foot of TP3.

3. On the UUT, select the 100 mV range and apply a high quality, low-thermal short across the SENSE HI and LO inputs.

4. Note the test DMM reading. Match this reading (positive or negative) to the appropriate voltage range shown in Table 4-29.

5. For a positive test DMM reading, compute a new value for R10 by adding the respective resistance shown in Table 4-29 to the original R10 value. Then replace R10 with a 1% resistor nearest this new value.

6. For a negative test DMM reading, compute a new value for R13 by adding the respective resistance shown in Table 4-29 to the original R13 value. Then replace R13 with a 1% resistor nearest this new value.

7. Adjust R15 for a test DMM reading of 0.000000 ±.000002.

8. If the R15 adjustment does not yield the required test DMM reading, select a 1% resistor next closest to the newly computed value for R10 or R13.

9. Replace R10 (or R13) and repeat step 7.

10. Once R15 is satisfactorily adjusted, remove the test DMM leads and the UUT short.

Table 4-29. Amplifier Offset Resistor Selection

VOLTAGE (±)	OHMS	VOLTAGE (±)	OHMS
0.050982		0.018962	
0.047762	25.3	0.017606	9.4
0.045763	24.2	0.016250	8.7
0.043855	23.2		
0.041944	22.2	0.014991	8.0
0.040031	21.2	0.013727	7.4
0.038116	20.2	0.012467	6.7
0.036298	19.2	0.011301	6.1
0.034572	18.3	0.010134	5.5
0.032843	17.4	0.008966	4.9
0.031213	16.5	0.007798	4.3
0.029574	15.7	0.006728	3.7
0.027940	14.8	0.005654	3.2
0.026398	14.0	0.004583	2.6
0.024855	13.2	0.003507	2.1
0.023311	12.4	0.002435	1.5
0.021864	11.6	0.001458	1.0
0.020411	10.9	0.000480	0.5
0.018962	10.1	0.000000	0.0

4-134. RMS SENSOR GAIN SELECTION

4-135. If the RMS Sensor U6 or any of its associated components are replaced, the RMS Sensor Gain Adjustment R26 may not be able to bring the reading within the accepted tolerance. If this occurs, use the following procedure to reselect R24 or R28 so that R26 can adjust the RMS Sensor Gain.

1. Remove R24 or R28, if either is installed, and replace the resistor in the circuit with a bus wire.

2. Perform the Sensor Adjustment portion of the Calibration Procedure.

3. If the Sensor Adjustment procedure cannot be successfully completed, check the direction of rotation of R26. If R26 runs out of adjustment in the clockwise direction replace the bus wire in the R24 position on the Amplifier PCB with a 20 kilohm, 1%, metal film resistor. If R26 runs out of adjustment in the counterclockwise direction, replace the bus wire in the R28 position on the Amplifier PCB with a 20 kilohm, 1%, metal film resistor.

4. Perform the Sensor Adjustment portion of the Calibration Procedure if a resistor was inserted in either the R24 or R28 position.

4-136. LOW VOLTAGE 50 kHz CAPACITOR SELECTION

4-137. Capacitor C7 is selected depending upon the value of the components installed in C5 and C6. Use the following procedure to select the value of C7.

1. On the Attenuator PCB set the variable capacitor C8 for the minimum capacitance, and the variable capacitors C20 and C27 for the maximum capacitance; insure that the C7 position is vacant.

2. Select the V AC function, high accuracy mode, and the 1V range on the UUT.

3. Apply a 1V, 50 kHz input to the UUT input terminals.

4. Select the column in the Table 4-30 that corresponds to the values of the components installed in the C5 and C6 positions. Find the reading in that column nearest the instrument reading and install in the C7 position the capacitance value for that line.

5. After C7 has been installed take a new reading and verify that it is within the instrument tolerance for that voltage and frequency. If it is not, decrease the value of C7 to lower the voltage, or increase the value C7 to increase the voltage until the reading is within tolerance. If the reading is >1.03640 install a 6.2 pF capacitor in the C6 position and repeat the test using the appropriate column.

6. Perform the Calibration Procedure and Performance Test to reset C9, C20, and C27.

4-138. HIGH VOLTAGE 50 kHz CAPACITOR SELECTION

4-139. Select the value of C18 on the Attenuator PCB using the following procedure:

1. Ensure that no component is installed in the C18 position.

2. Select the V AC function, HI ACCUR mode, and the 100V range on the UUT.

3. Apply a 100V, 50 kHz input to the UUT input terminals.

4. Compare the UUT displayed reading to the values in Table 4-31. Install the value of capacitor on the line including the displayed voltage.

5. Perform the Performance Test to verify that the UUT meets its specifications requirements.

4-140. Select the value of C25 on the Attenuator PCB using the following procedure:

1. Ensure that no component is installed in the C25 position.

2. Select the V AC function, HI ACCUR mode, and the 500V range on the UUT.

Table 4-30. C7 Selection Values

C7 (pF)	C5 = 36 pF C6 = OPEN	C5 = 27 pF C6 = OPEN	C5 = 27 pF C6 = 6.2 pF
0.0	< 1.00500	< 1.00600	< 1.00550
1.0	1.00500 to 1.00940	1.00600 to 1.01020	1.00550 to 1.00960
1.5	1.00941 to 1.01160	1.01021 to 1.01280	1.00961 to 1.01190
2.2	1.01161 to 1.01460	1.01281 to 1.01360	1.01191 to 1.01590
3.0	1.01461 to 1.01870	1.01361 to 1.02040	1.01591 to 1.01870
3.9	1.01871 to 1.02190	1.02041 to 1.02490	1.01871 to 1.02280
5.6	1.02191 to 1.02910	1.02491 to 1.03340	1.02281 to 1.03030
6.2	1.02911 to 1.03160	1.043341 to 1.03640	1.03031 to 1.03300

Table 4-31. C18 Selection Values

C18 VALUE	VOLTAGE READING
0 pF	< 100.15
15 pF	100.15 to 100.90
27 pF	100.91 to 101.58
39 pF	101.59 to 102.25
47 pF	102.26 to 102.80
56 pF	102.81 to 103.56
68 pF	103.57 to 104.52

3. Apply a 100V, 50 kHz input to the UUT input terminals.

4. Compare the UUT displayed reading to the values in Table 4-32. Install the value of capacitor on the line including the displayed voltage.

5. Perform the Performance Test to verify that the UUT meets its specifications requirements.

4-141. Select the value of C26 on the Attenuator PCB using the following procedure:

1. Ensure that no component is installed in the C26 position.

2. Select the V AC function, HI ACCUR mode, and the 600V range on the UUT.

3. Apply a 100V, 50 kHz input to the UUT input terminals.

4. Compare the UUT displayed reading to the values in Table 4-33. Use the column of Table 4-33 that corresponds to the value selected for C25 and install in C26 the value of capacitor on the line including the voltage nearest to the displayed reading.

5. Perform the Performance Test to verify that the UUT meets its specifications requirements.

4-142. SELECTED CAPACITOR ORDERING INFORMATION

4-143. To order capacitors with selected values, see Table 4-34 for the Fluke Stock No. associated with a given value.

Table 4-32. C25 Selection Values

C25 VALUE	VOLTAGE READING
0 pF	< 100.820
100 pF	100.821 to 100.990
150 pF	100.991 to 101.550
220 pF	101.551 to 102.400
270 pF	102.401 to 103.100
330 pF	103.101 to 104.030

Table 4-33. C26 Selection Values

C26	C25=0	C25=100	C25=150	C25=220	C25=270	C25=330
0	< 100.170	< 100.170	< 100.170	< 100.170	< 100.170	< 100.170
15	100.170 to 100.280	100.170 to 100.310	100.170 to 100.330	100.170 to 100.350	100.170 to 100.370	100.170 to 100.390
27	100.281 to 100.370	100.311 to 100.430	100.331 to 100.460	100.351 to 100.510	100.371 to 100.540	100.391 to 100.570
39	100.371 to 100.460	100.431 to 100.550	100.461 to 100.600	100.511 to 100.660	100.541 to 100.700	100.571 to 100.750
47	100.461 to 100.520	100.551 to 100.630	100.601 to 100.690	100.661 to 100.760	100.701 to 100.810	100.751 to 100.880
56	100.521 to 100.600	100.631 to 100.730	100.691 to 100.790	100.761 to 100.880	100.811 to 100.950	100.881 to 101.020
68	100.601 to 100.700	100.731 to 100.860	100.791 to 100.990	100.881 to 101.050	100.951 to 101.120	101.021 to 101.210
82	100.701 to 100.820	100.861 to 101.010	100.911 to 101.120	101.051 to 101.240	101.121 to 101.330	101.211 to 101.430
100	100.821 to 100.980	101.011 to 101.230	101.212 to 101.340	101.241 to 101.500	101.331 to 101.610	101.431 to 101.730

Table 4-34. Ordering Information for Selected Capacitors

C7		C18		C25		C26	
VALUE (pf)	STOCK NO.	VALUE (pf)	STOCK NO.	VALUE (pf)	STOCK NO.	VALUE (pf)	STOCK NO.
1.0	603571	15	369074	100	512848	15	369074
1.5	603589	27	362749	150	512988	27	362749
2.2	603936	39	512962	220	512111	39	512962
3.0	603944	47	512368	270	614586	47	512368
3.9	603597	56	512970	330	528620	56	512970
5.6	603928	68	362756			68	362756
6.2						82	512350
						100	512848

Section 5
List of Replaceable Parts

TABLE OF CONTENTS

5-1. INTRODUCTION

5-2. This section contains an illustrated parts breakdown of the instrument. A similiar parts list is included in the Options and Accessories Section for each of the options. 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.
5. Manufacturer's Part Number.
6. Total Quantity of Components Per Assembly.
7. Recommended quantity: This entry indicates the recommended number of spare parts necessary to support one to five instruments for a period of 2 years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for 1 year or more at an isolated site, it is recommended that at least one of each assembly in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc., that are not always part of the instrument or are deviations from the basic instrument model, the REC QTY column lists the recommended spares quantity for the items in that particular assembly.

5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. or an authorized representative by using the FLUKE STOCK NUMBER. In the event the part ordered has been replaces 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 and Revision Letter.
6. Instrument Model and Serial Number.

5-7. A Recommended Spare Parts Kit for your basic instrument is available from the factory. This kit contains those items listed in the REC QTY column for the parts lists in the quantities recommended.

5-8. 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.

CAUTION

Indicated devices are subject to damage by static discharge.

TABLE 5-1. 8506A 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	R S -Q	N O T -E
A 1	*	DISPLAY PCB ASSEMBLY	656637	89536	656637	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 ASSEMBLY	735167	89536	735167	1		
A 8	*	DC SIGNAL CONDITIONER PCB ASSEMBLY	660712	89536	646307	1		
A 9	*	ACTIVE FILTER ASSEMBLY	716316	89536	383976	1		
A 10	*	FAST R2 A/D CONVERTER ASSEMBLY	716324	89536	383984	1		
A 11	*	THERMAL TRUE-RMS CONVERTER ASSEMBLY	683938	89536	651794	1		
C 1, 2		CAP,CER,360PF,+-5%,50V,COG	528471	04222	SR215A360KAA	2		
CR 1, 2		VARISTOR,33V,+-10%,1.0MA	485391	09019	V33ZA1	2		
H 1		SCREW,MACH,PHP,STL,4-40X3/16	129882	73734	19022	4		
H 2		SCREW,CAP,SCKT,STL,8-32X3/8	295105	89536	295105	4		
H 3		SCREW,MACH,FHP,STL,8-32X3/8	114116	89536	114116	8		
H 4		SCREW,MACH,PHP,STL,8-32X5/8	114983	89536	114983	4		
H 5		SCREW,MACH,FHUP,S.STL,6-32X1/4	320093	89536	320093	12		
H 6		SCREW,MACH,PHP SEMS, STL, 6-32X1/4	178533	89536	178533	12		
H 8		SCREW,MACH,FHP,STL,6-32X1/2	114397	89536	114397	4		
H 9		WASHER,LOCK,INTRNL,STEEL,#8	110320	89536	110320	4		
H 10		SCREW,MACH,PHP,STL,6-32X5/16	152157	89536	152157	8		
H 11		SCREW,MACH,FHP,STL,8-32X1/16	306159	89536	306159	6		
H 12		SCREW,MACH,PHP SEMS,STL,8-32X3/8	436030	89536	436030	2		
H 13		NUT,MACH,HEX,BR,1/4-28	110619	89536	110619	1		
H 14		WASHER,LOCK,INTRNL,STEEL,#6	110338	89536	110338	12		
H 15		SCREW,MACH,PHP,S.STL,6-32X1-7/16	362954	89536	362954	6		
H 16		WASHER,LOCK,INTRNL,STEEL,0.512 ID	641381	89536	641381	4		
H 17		NUT,HEX,MINI,S.STL,6-32	110569	73734	70206	4		
H 18		WASHER,SPRING,STL,0.153X0.312X0.040	543405	86928	5808-87-25-C2	6		
H 19		SCREW,MACH,FHP,2-56X3/8(W/J3)	614388	89536	614388	2		
‡J 1, 2		CONN,COAX,BNC(F),PANEL	386888	14949	BJ27	2		
‡J 3		CONNECTOR,HV,CABLE,REC/PLUG,2 CONTACT	603712	91637	G16P-A	1		
‡J 4		CONN,RECT,CABLE,PLUG,20 POS	369231	91662	00-8016-000-703	1		
‡J 5		CONN PART,CONTACT,FOR TABLE 369231	369280	91662	000-60-8017-03-13	9		
‡J 6		CONN PART,CONTACT,FOR TABLE 269231	369298	91662	217-60-8017-05-13	9		
‡J 7		CONNECTOR, ACG,HV,CABLE HOOD	603720	91637	G16H	1		
MP 1		BAIL, INSTRUMENT	707877	89536	707877	2		
MP 2		I/O BEZEL	416206	89536	416206	1		
MP 3		BULKHEAD	645887	89536	645887	1		
MP 4	*	BULKHEAD, CENTER, ASSEMBLY	656652	89536	656652	1	1	
MP 5		LUG, SOLDER (NOT SHOWN)	102566	79963	813	1		
MP 6		BOTTOM COVER	646182	89536	646182	1		
MP 7		LENS,DISPLAY	659557	89536	659557	1		
MP 8		TOP COVER	646174	89536	646174	1		
MP 9		CORNER HANDLE,FRONT 4.25 INCH	656165	89536	656165	2		
MP 10		CORNER, PLASTIC 4.25	656215	89536	656215	2		
MP 11		DECAL,FRONT PANEL	640375	89536	640375	1		
MP 12		FOOT,MOULDED	645945	89536	645945	4		
MP 13		FOOT, SINGLE BAIL TYPE (DARK UMBER)	653923	89536	653923	4		
MP 14		FRONT PANEL	639492	89536	639492	1		
MP 15		MOLDED FRONT PANEL	646240	89536	646240	1		
MP 16		MODULE GUIDE LATCH	646232	89536	646232	18		
MP 17	*	CHASSIS, LEFT HAND	656371	89536	656371	1		
MP 18		HOLE PLUG, POLYETHELENE, F/5/16 HOLE	187799	82240	B-2328	2		
MP 19		MODULE GUIDE MOLDED	646224	89536	646224	18		
MP 20		PUSH ROD MOLDED	646216	89536	646216	3		
MP 21		BUTTON,HOT STAMPED-EXT GD IN	660381	89536	660381	1		
MP 22		BINDING POST PART,HEAD,BRASS,1/4-28	225615	89536	225615	1		
MP 23		BINDING POST,BRASS,1/4-28	225623	89536	225623	1		
MP 24		BUTTON,HOT STAMPED-REAR INPUT IN	660399	89536	660399	1		
MP 25		BUTTON,HOT STAMPED 4T-OHM IN	660373	89536	660373	1		
MP 26		REAR PANEL, SCREENED	660316	89536	660316	1		
MP 27	*	CHASSIS, RIGHT HAND ASSY	638569	89536	638569	1		
MP 29		DECAL,POWER SUPPLY	659649	89536	659649	1		
MP 30		SHIELD,BOTTOM COVER	660258	89536	660258	1		
MP 31		DECAL, REAR CORNER	685222	89536	685222	2		
MP 32		SIDE TRIM-15'	525980	89536	525980	2		
MP 33		DECAL, FRONT CORNER	659219	89536	659219	2		
MP 34		BUTTON, POWER SWITCH	401646	89536	401646	1		
MP 35		TRIGGER, (EXT), ASSY,BNC (NOT SHOWN)	651802	89536	651802	1		
MP 36		ADVANCE SCAN, ASSY,BNC (NOT SHOWN)	651810	89536	651810	1		
TM 1		8506A INSTRUCTION MANUAL	638858	89536	638858	1		
TM 2		8505A/8506A REFERENCE GUIDE	684357	89536	684357	1		
TM 3		GETTING STARTED MANUAL	745448	89536	745448	1		
TM 4		8502A SYSTEMS MULTIMETER PROGRAM CARD	776658	89536	776658	1		
W 1		WIRE,TEF,EE,UL1180,22AWG,STRN,RED	115576	89536	115576			
W 2		WIRE,TEF,EE,UL1180,22AWG,STRN,BLU	115675	89536	115675			
W 3		CORD,LINE,5-15/IEC,3-18AWG, NOT SHOWN	284174	89536	284174	1		

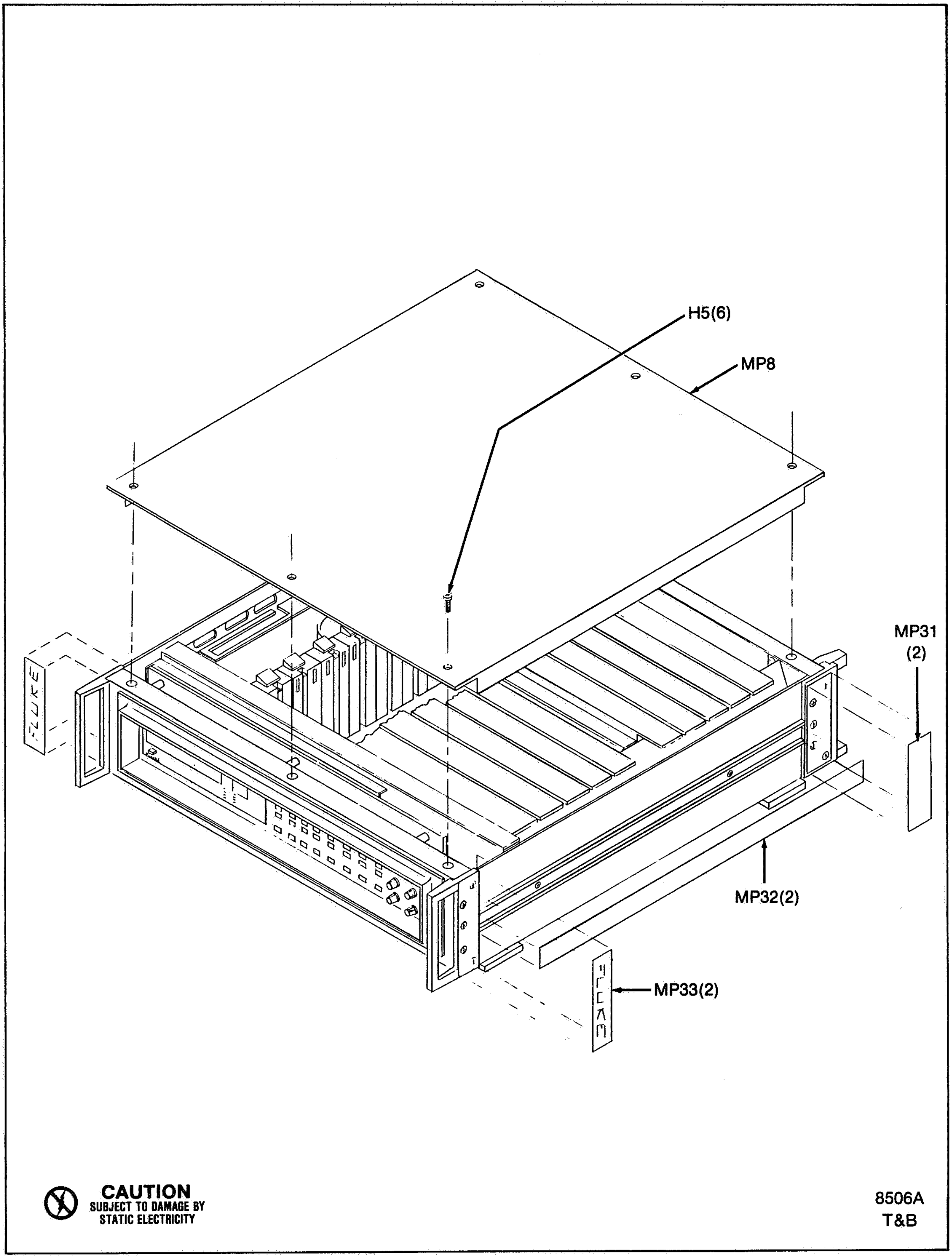


Figure 5-1. 8506A Final Assembly

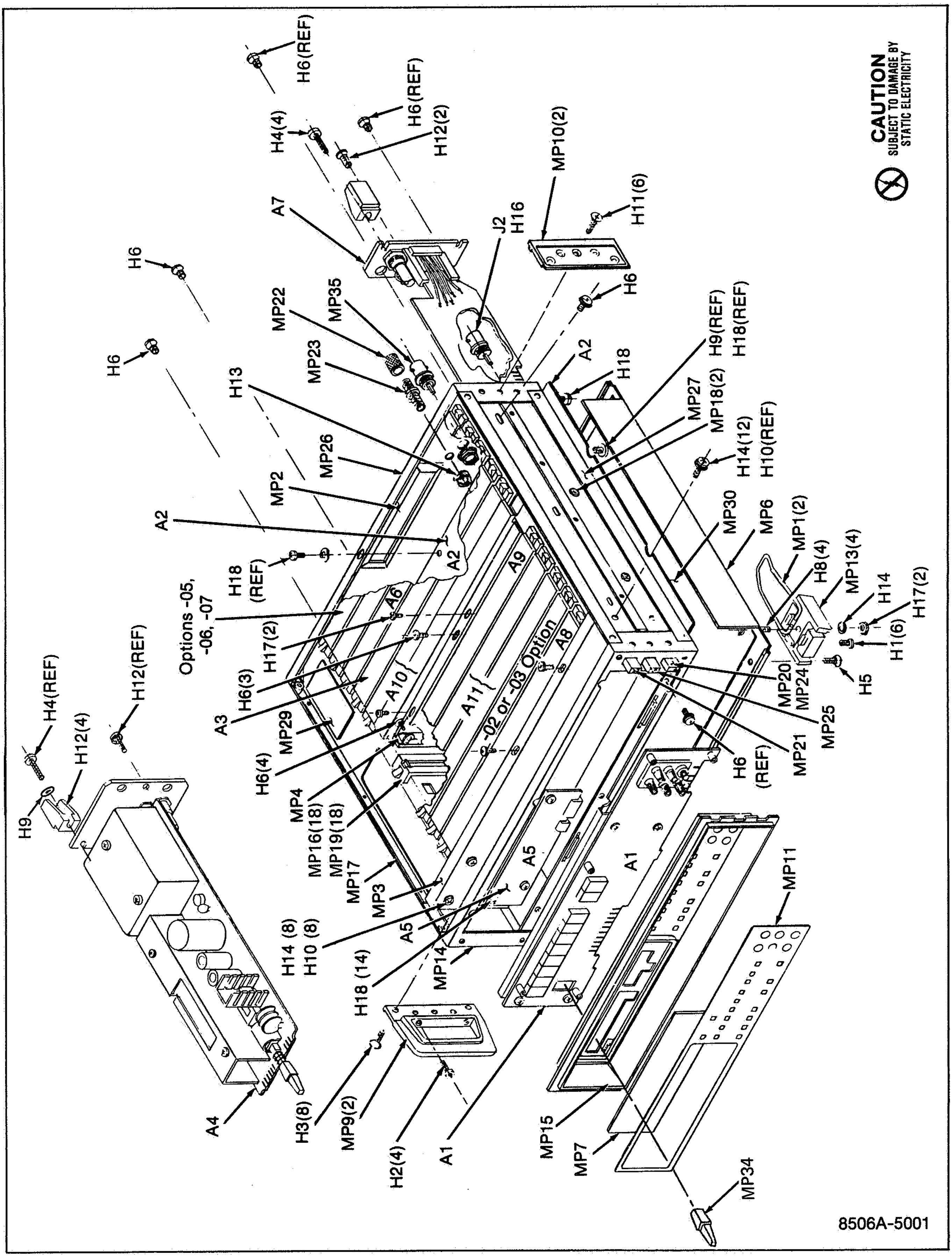
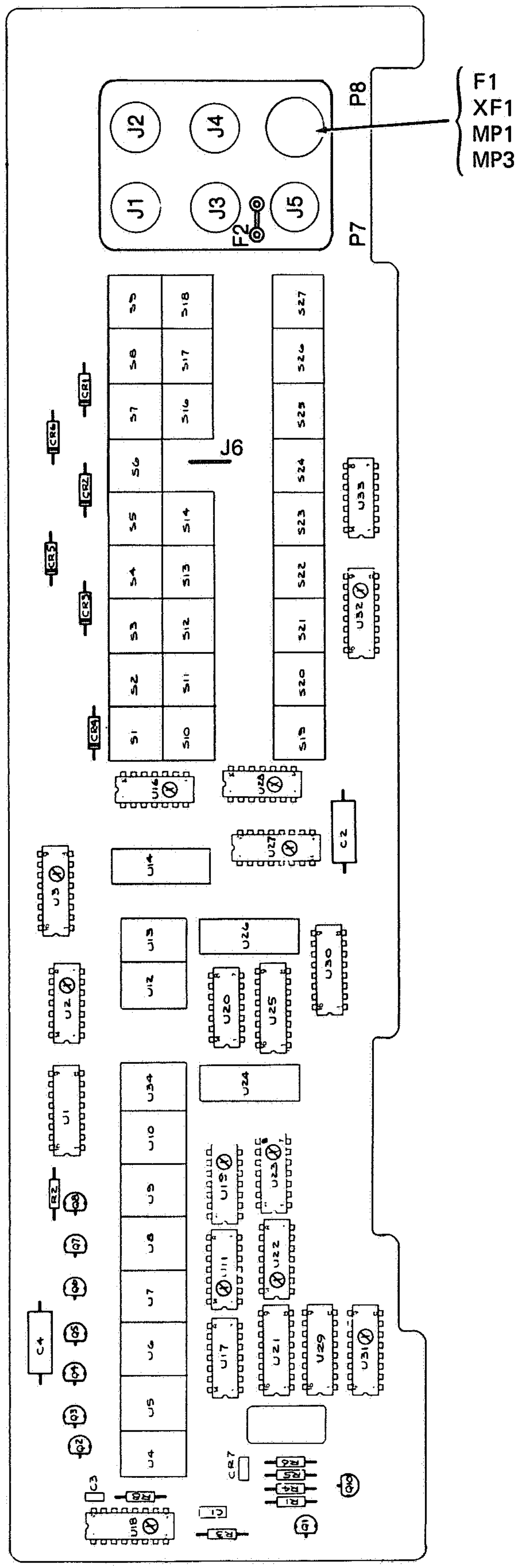


Figure 5-1. 8506A Final Assembly (cont)

TABLE 5-2. A1 DISPLAY 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	R S -Q	N O T -E
C 1		CAP,CER,0.22UF,+-20%,50V,Z5U	309849	71590	CW3C0C224K	1		
C 2, 4		CAP,AL,47UF,+75-20%,25V	655191	89536	655191	2		
C 3		CAP,CER,1200PF,+-20%,100V,X7R	358283	72982	8121-A100-W5R-122M	1		
CR 1- 6	*	DIODE,SI,BV= 75.0V,IO=150MA,500 MW	203323	07910	1N4448	6		
CR 7	*	LED,GREEN,RECTANGULAR,PCB MOUNT	650879	12040	NSL54124	1		
DS 14, 24, 26	*	DIODE,LED,RED,10 SEGMENT,BAR GRAPH	685370	74276	MV57164	3		
F 1		FUSE,1/4X1-1/4,FAST,1.5A,250V	739888	89536	739888	1	1	
F 2		WIRE,MAGNET,36H,130C,SOLDERABLE	160978	89536	160978			
H 1		NUT,MACH,HEX,BR,8-32 (NOT SHOWN)	631614	89536	631614	5		
H 2		SCREW,MACH,PHP,STL,6-32X1/4(NOT SHOWN	152140	89536	152140	6		
H 3		WASHER,SPRING,STL,0.138X0.281X0.020	571968	27745	B0281-010	6		
J 1, 2		BINDING-POST-ASSY-BR-RED	637843	89536	637843	2	5	
J 3, 4		BINDING-POST-ASSY-BR-BLK	637850	89536	637850	2		
J 5		BINDING-POST-ASSY-BR-BLU	637876	89536	637876	1		
J 6		JUMPER, WIRE	484311	89536	484311	1		
MP 1		CAP,FUSE	683995	89536	683995	1		
MP 2		SPACER L.E.D	541284	89536	541284	1		
MP 3		SPACER,RND,PLASTIC,0.500IDX0.062	484832	89536	484832	1		
MP 4		DISPLAY SHIELD (NOT SHOWN)	646166	89536	646166	1		
MP 5		SPACER,RND,BRASS, (NOT SHOWN)	284380	89536	284380	5		
Q 1	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	330803	07263	MPS6560	1	1	
Q 2- 8	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	340026	04713	MPS6563	7	1	
Q 10	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1	2	
R 1		RES,CF,62,+-5%,0.25W	441634	80031	CR251-4-5P62E	1	1	
R 2, 6		RES,CF,200,+-5%,0.25W	441451	80031	CR251-4-5P200E	2		
R 3		RES,CF,100K,+-5%,0.25W	348920	80031	CR251-4-5P100K	1		
R 4		RES,CF,150,+-5%,0.25W	343442	80031	CR251-4-5P150E	1		
R 5		RES,CF,4.7K,+-5%,0.25W	348821	80031	CR251-4-5P4K7	1		
R 8		RES,CC,10M,+-5%,0.25W	194944	01121	CB1065	1		
S 1- 5, 10-		PUSHBUTTON-SQUARE-, WHITE	406744	89536	406744	12		
S 14, 20- 23			406744					
S 7, 24- 27		PUSHBUTTON-SQUARE,LIGHT PUTTY GREY	401307	89536	401307	5		
S 8, 9		PUSHBUTTON-SQUARE,YELLOW	419937	89536	419937	2		
S 16- 18		PUSHBUTTON-SQUARE-, DARK PUTTY GREY	406728	89536	406728	3		
S 19		PUSHBUTTON-SQUARE-, LIGHT BLUE	406736	89536	406736	1		
U 1, 21, 25	*	IC,ARRAY,7 TRANS,NPN,COMMOM EMITTER	407866	49671	CA3081	3	1	
U 2	*	IC,CMOS,HEX INVERTER	404681	02735	CD4069BE	1	1	
U 3, 27, 31	*	IC,CMOS,HEX D F/F,+EDG TRG,W/RESET	404509	12040	MM74C174N	3	1	
U 4, 12	*	DIODE,LED,RED,+/-1 OVERFLOW	504787	28480	5082-7656	2	2	
U 5- 10, 13,	*	DIODE,LED,RED,7 SEGMENT,NUMERIC	418012	28480	5082-7651	8	2	
U 34	*		418012					
U 11	*	IC,CMOS,QUAD 2 INPUT NAND GATE	355198	04713	MC14011UBCP	1	1	
U 14, 24, 26	*	DIODE,LED,RED,10 SEGMENT BAR GRAPH	650796	28480	HDSP4830	3		
U 16, 22, 23	*	IC,CMOS,DUAL D F/F,+EDG TRIG	340117	02735	CD4013AE	3		
U 17, 20		RES,NET,DIP,14 PIN,7 RES,60,+-5%	344069	89536	344069	2	1	
U 18	*	IC,CMOS,RETRIG/RESET MULTIVIBRATOR	393512	02735	CD4098BE	1	1	
U 19	*	IC,CMOS,DUAL 4 INPUT NAND GATE	355206	04713	MC14012BCP	1	1	
U 28	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	02735	CD4023UBE	1	1	
U 29, 30		RES,NET,DIP,16 PIN,8 RES,1K,+-5%	358119	89536	358119	2		
U 32	*	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	12040	MM80C97N	1	1	
U 33		RES,NET,DIP,14 PIN.7 RES,4.7K,+-5%	386961	89536	386961	1		
XF 1		HLDR,FUSE,1/4 X 1-1/4,PNL MT	435628	89536	435628	1		



CAUTION
SUBJECT TO DAMAGE BY STATIC ELECTRICITY

8506A-1601

Figure 5-2. A1 Front Panel Display Assembly

TABLE 5-3. A2 MOTHER BOARD 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	R S -Q	N O T -E
J 1, 14, 17		CONN,PWB EDGE,REC,0.150 CTR,8 POS	354951	00779	583407-5	3		
J 2		CONN,PWB EDGE,REC,0.150 CTR,18 POS	291906	00779	1-583407-0	1		
J 3, 5, 8,		CONN,PWB EDGE,REC,0.150 CTR,4 POS	417550	00779	1-583694-2	7	1	
J 13A 13B 13C			417550					
J 13D			417550					
J 6		CONN,PWB EDGE,REC,0.150 CTR,20 POS	291914	00779	1-583407-1	1		
J 9		CONN,PWB EDGE,REC,0.150 CTR,16 POS	408484	00779	583407-9	1		
J 11A 11B 11C		CONN,PWB EDGE,REC,0.150 CTR,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,0.150 CTR,6 POS	291625	00779	583407-4	4		
J 12D			291625					
J 40		PIN,SINGLE,PWB,0.025 SQ	267500	00779	87623-1	4		
MP 2		CONN ACC,PWB EDGE,POLARIZING INSERT	293498	00779	530030-1	14		
MP 3		INS,FILM,MYLAR ADHSV,0.005THK	380923	89536	380923	35		
MP 4		SPACER,SWAGED,RND,BRASS,4-40X0.070	343996	89536	343996	2		
MP 5		SPACER,SWAGED,RND,BRASS,6-32X0.187	351882	89536	351882	3		
R 3		RES,CF,1K,+-5%,0.25W	343426	80031	CR251-4-5P1K	1		
S 1		SWITCH,SLIDE,DPDT	697466	89536	697466	1		
U 1		PHOTOTRANS,DARLINGTON DETECTOR	742072	04713	MRD711	1		

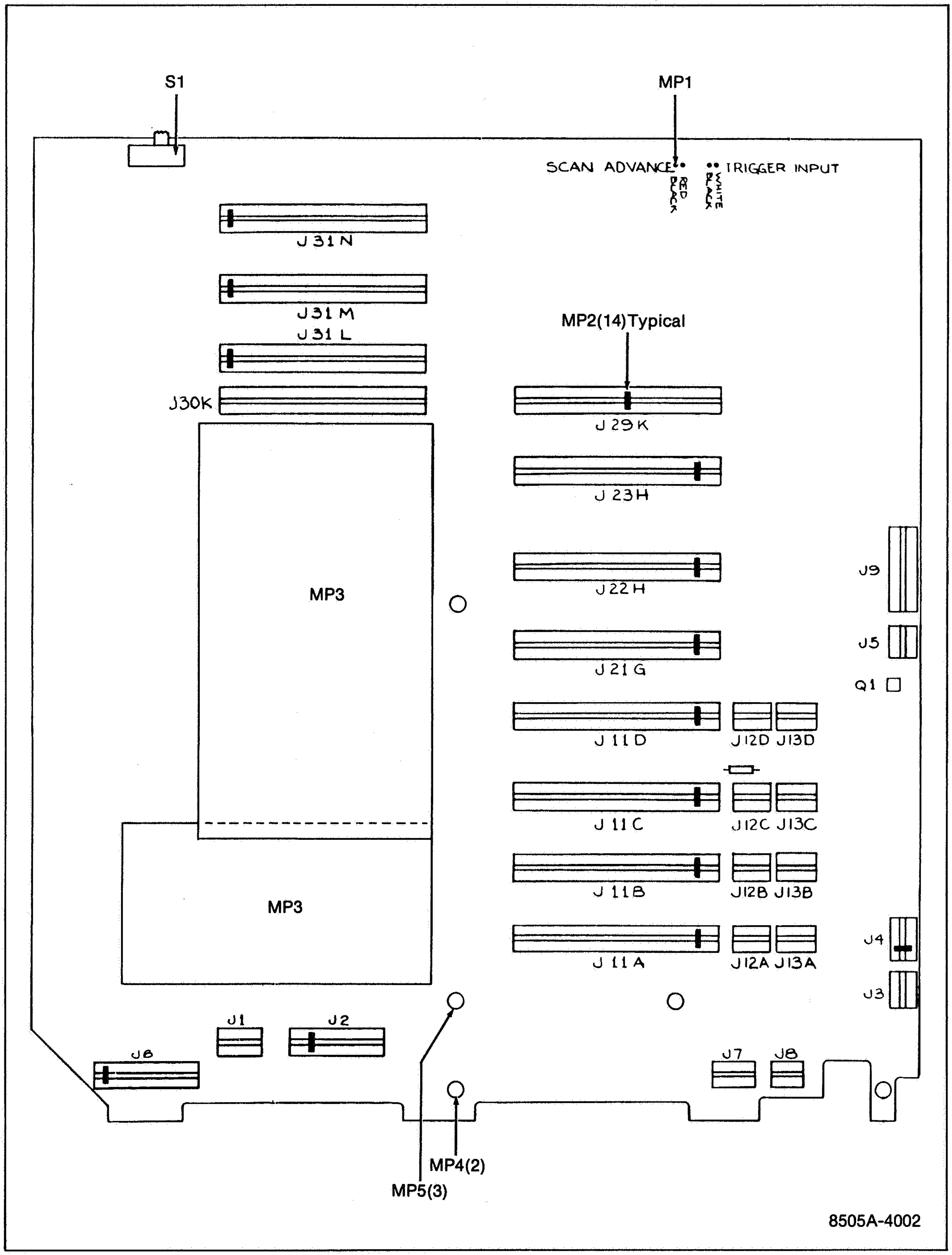


Figure 5-3. A2 Mother Board PCB Assembly

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	R S -Q	N O T -E
C	1, 4		CAP,MICA,220PF,+-5%,500V	170423	72136	DM15F221J	2		
C	2		CAP,MICA,18PF,+-5%,500V	266585	72136	DM15C180J	1		
C	3		CAP,MICA,330PF,+-5%,500V	148445	72136	DM15E331J	1		
C	5		CAP,MICA,68PF,+-5%,500V	148510	72136	DM15F680J	1		
C	6		CAP,TA,39UF,+-20%,6V	163915	56289	196D394X0020KA1	1		
C	7		CAP,AL,150UF,+50-10%,16V	186296	73445	ET151X016A5	1	1	
C	8, 9		CAP,MICA,27PF,+-5%,500V	177998	72136	DM15E270J	2		
C	10, 12, 13,		CAP,CER,0.22UF,+-20%,50V,Z5U	309849	71590	CW3C0C224K	4		
C	16			309849					
C	11		CAP,CER,0.0047UF,+-10%,500V,Z5R	106724	71590	CF-472	1		
H	1		SCREW,MACH,PHP,STL,4-40X5/8	145813	89536	145813	2		
L	1		CHOKE,6TURN	320911	89536	320911	1		
MP	1		ISOLATOR,CASE ASSEMBLY (MP2 - MP11)	486407	89536	486407	1		1
MP	2, 3		CASE HALF, MODULE	402990	89536	402990	2		
MP	4		COVER, MODULE, CASE	486340	89536	486340	1		
MP	5		SHIELD,COVER,ISOLATOR	437939	89536	437939	2		
MP	6		DECAL, ISOLATOR/EXT.TRIGGER	477570	89536	477570	1		
MP	7		DECAL; CAUTION	454504	89536	454504	1		
MP	8		GUARD, REAR, ISOL., LEFT SIDE	437947	89536	437947	1		
MP	9		GUARD,REAR,ISOLATOR,RIGHT SIDE	383349	89536	383349	1		
MP	10		GUARD, FRONT, ISOL., LEFT SIDE	487298	89536	487298	1		
MP	11		GUARD,FRONT,ISOL., RIGHT SIDE	487280	89536	487280	1		
MP	12		SPRING,COIL, (NOT SHOWN)	424465	89536	424465	2		
MP	13		SPACER,SWAGED, (NOT SHOWN)	380519	89536	380519	2		
Q	1	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1		
Q	2	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	1		
R	1		RES,CF,220,+-5%,0.25W	574244	80031	CR251-4-5P220E	1	1	
R	2, 5, 8-		RES,CF,10K,+-5%,0.25W	573394	80031	CR251-4-5P10K	9		
R	13, 24			573394					
R	3, 21		RES,CF,47K,+-5%,0.25W	573527	80031	CR251-4-5P47K	2		
R	4, 7		RES,CF,4.7K,+-5%,0.25W	573311	80031	CR251-4-5P4K7	2		
R	6, 17		RES,CF,1K,+-5%,0.25W	573170	80031	CR251-4-5P1K	2		
R	14, 20		RES,CF,150,+-5%,0.25W	343442	80031	CR251-4-5P150	2		
R	15		RES,CF,470,+-5%,0.25W	573121	80031	CR251-4-5P470E	1		
R	18		RES,CF,100K,+-5%,0.25W	573584	80031	CR251-4-5P100K	1		
T	1, 3, 6,		INDUCTOR	437590	89536	437590	4		
T	8			437590					
T	2, 4, 5,		INDUCTOR	437608	89536	437608	4		
T	7			437608					
U	1, 2, 5	*	IC,CMOS,HEX BUFFER	381830	02735	CD4050BE	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	18324	01295 SN7426M	2	1	
U	6, 24	*	IC,LSTTL,HEX INVERTER	393058	01295	SN74LS04N	2	1	
U	8, 14, 23	*	IC,LSTTL,RETRG MONOSTAB MULTIVB W/CLR	404186	01295	SN74LS123N	3	1	
U	9	*	IC,STTL,QUAD 2 INPUT NAND GATE	363580	01295	SN7400SN	1	1	
U	10	*	IC,LSTTL,TRIPLE 3 INPUT NAND GATE	393074	01295	SN74LS10N	1	1	
U	11, 19	*	IC,LSTTL,QUAD 2 INPUT NOR GATE	393041	01295	SN74LS02N	2	1	
U	12, 22, 26	*	IC,CMOS,QUAD 2 INPUT NOR GATE	355172	02735	CD4001AE	3	1	
U	13, 21	*	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	12040	MM80C97N	2	1	
U	16, 20	*	IC,TTL,8BIT SER-IN,PAR-OUT R-SHFT RGS	272138	01295	SN74164N	2	1	
U	18	*	IC,CMOS,QUAD 2 INPUT AND GATE	408401	02735	CD4081BE	1	1	
U	25	*	IC,CMOS,TRIPLE 3 INPUT NOR GATE	355180	02735	CD4025BE	1	1	
U	31	*	IC,CMOS,DUAL D F/F,+EDG TRIG	340117	02735	CD4013AE	1	1	
U	32	*	IC,CMOS,FAST QUAD 2 INPUT NAND GATE	413211	12040	34011PC/4011PC	1	1	
U	33	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	02735	CD4023UBE	1	1	
U	35	*	IC,CMOS,HEX SCHMITT TRIGGER	477810	12040	MM74C914N	1	1	
W	1		WIRE,BUS,22 AWG,TINNED COPPER	115469	89536	115469		1	
W	2		WIRE,BUS,20 AWG,TINNED COPPER	212704	89536	212704			
W	3		WIRE,TEF,E,22AWG,SOLID,WHT	375170	89536	375170			
Z	17		RES,NET,DIP,16 PIN,15 RES,10K,+-5%	355305	89536	355305	1	1	

NOTE 1 = USE P/N 486407 TO ORDER CASE WITHOUT PCB ASSEMBLY.

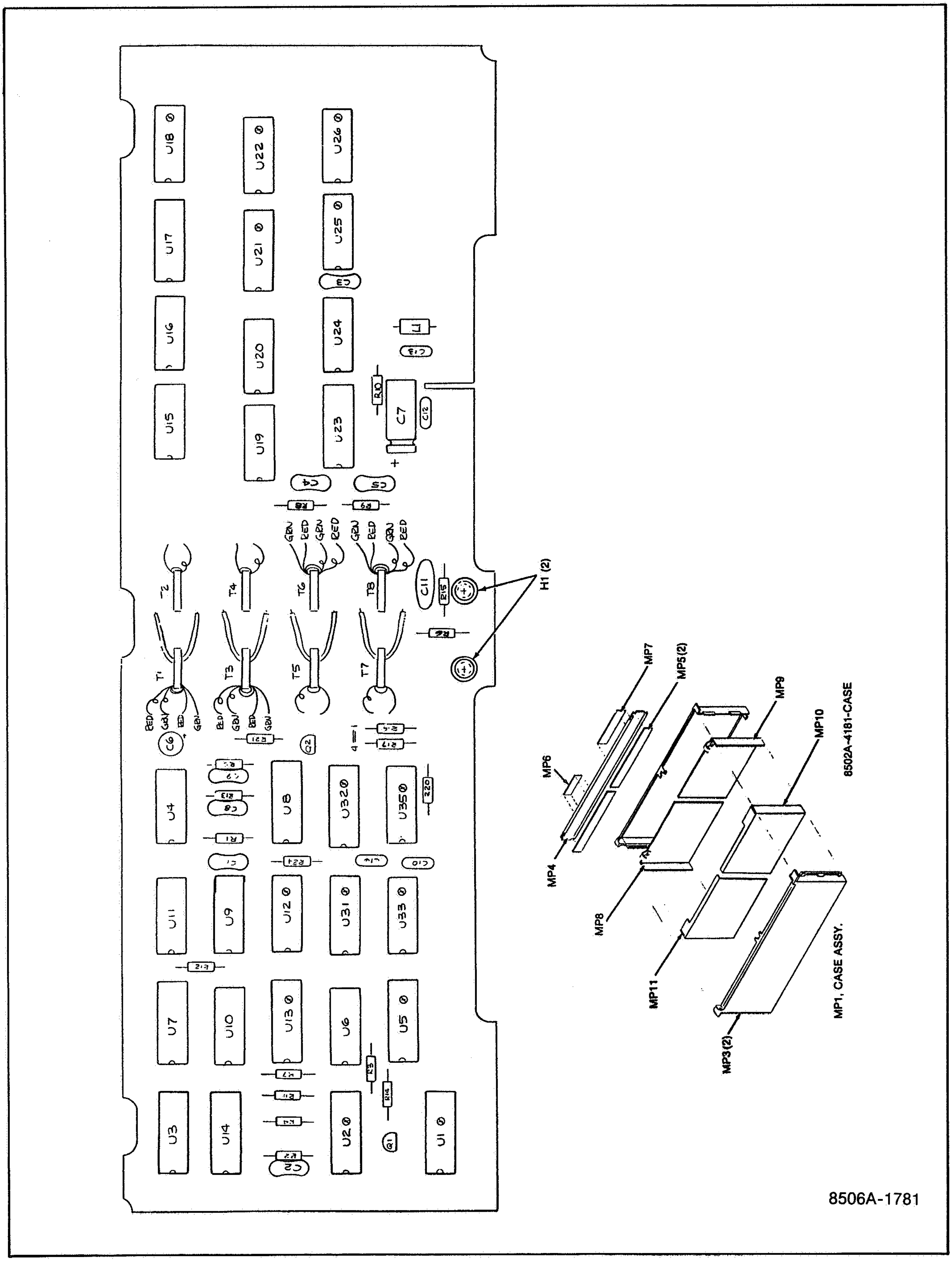


Figure 5-4. A3 Isolator PCB Assembly

TABLE 5-5. A4 POWER SUPPLY PCB ASSEMBLY
(SEE FIGURE 5-4.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
C 1, 2		CAP,AL,330UF,+50-20%,100V	484436	89536	484436	2		
C 3, 4, 6,		CAP,AL,470UF,+50-20%,50V	478792	89536	478792	4		
C 7			478792					
C 5		CAP,AL,3300UF,+30-20%,16V	603472	89536	603472	1		
C 8		CAP,AL,15000UF,+30-20%,16V	603480	89536	603480	1		
C 9- 11, 17		ELECTRO, MIN,LO LEAK, 4.7MF, 35V	603993	89536	603993	4		
C 12- 14, 21		CAP,CER,0.22UF,+-20%,50V,Z5U	309849	71590	CW3COC224K	4		
C 15, 16		CAP,CER,5000PF,+-20%,250V,X7R	485839	89536	485839	2		
C 18- 20		CAP,AL,2.2UF,+-20%,50V	614875	89536	614875	3	1	
C 22		CAP,AL,4.7UF,+-20%,50V	746891	89536	746891			
CR 1- 3	*	DIODE,SI,RECT,BRIDGE,BV=200V,IO=1.0A	296509	09423	FB200	3	1	
CR 1, 2, 5	*	DIODE,SI, 50 PIV, 2.0 AMP	347559	04713	1N5400RL	3	1	
CR 3, 4	*	DIODE,SI, 100 PIV, 1.0 AMP	343491	01295	1N4002	2	1	
CR 4	*	DIODE,SI,RECT,BRIDGE,BV= 50V,IO=3.0A	586115	14936	KBL005	1	1	
F 1		FUSE,1/4 X 1-1/4,SLOW,0.5A,250V	109322	71400	MDL1-2	1	5	
FL 1		FILTER,LINE,250V/1A MAX	649988	89536	649988	1		
H 1		NUT,MACH,HEX,STL,4-40	184044	73734	8002A-NP	5		
H 2		NUT,MACH,HEX,STL,8-32	110544	89536	110544	2		
H 3		SCREW,MACH,RHS,NYL,4-40X1/4	574780	89536	574780	5		
H 4		SCREW,MACH,FHP,BR,4-40X3/8	493932	89536	493932	2		
H 5		SCREW,CAP,BH SCKT, STL, 4-40 X 1/2	528307	89536	528307	2		
H 6		SCREW,MACH,PHP,STL,6-32X1/4	152140	89536	152140	2		
H 7		SCREW,MACH,PHP,STL,8-32X3/8	114124	89536	114124	2		
H 8		SCREW,CAP,BH SCKT, STL, 8-32 X 3/8	658583	89536	658583	3		
H 9		SCREW,MACH,RHS,NYL,4-40X1/2	619205	89536	619205	1		
H 10		WASHER,LOCK,INTRNL,STEEL,#4	110403	89536	110403	2		
H 11		WASHER,LOCK,INTRNL,STEEL,#8	110320	89536	110320	2		
H 12		WASHER,SHLDR,NYLON,#4	436386	86928	5607-45	7		
H 13		SCREW,MACH,PHP SEMS,STL,6-32X3/8	177022	89536	177022	2		
H 15		WASHER,LOCK,EXTRNL,STEEL,0.500 ID	175943	89536	175943	1		
MP 1		BRACKET	166322	73734	1552	2		
MP 2		HEATSINK	414128	13103	6030B-TT	1	1	
MP 3		HEAT SINK, POWER SUPPLY	639849	89536	639849	1		
MP 4		HEATSINK	639864	89536	639864	1		
MP 5		INSUL PART,TRANS,SILICONE,POWER	508630	89536	508630	7		
MP 6		INSULATOR,GASKET	654467	89536	654467	1		
MP 7		INSULATOR, POWER SWITCH	383158	55285	7403-09FR-51	1	1	
MP 8		LABEL,WARNING	386250	89536	386250	2		
MP 9		LUG, SOLDER, #4	102558	89536	102558	2		
MP 10		NUT PLATE	639807	89536	639807	1		
MP 11		SHIELD, POWER SUPPLY	639856	89536	639856	1	1	
MP 12		SUPPORT,HEAT SINK	646208	89536	646208	1		
MP 13		HLDR PART,FUSE,CAP,1/4 X 1-1/4,GREY	460238	61935	031.1666	1		
R 1		RES,CF,3.3K,+-5%,0.25W	348813	80031	CR251-4-5P3K3	1		
R 3, 4		RES,CF,390,+-5%,0.25W	441543	80031	CR251-4-5P390E	2		
R 5, 6		RES,VAR,CERM,50,+-20%,0.5W	320861	02111	62-1-1-500	2		
R 7		RES,CF,240,+-5%,0.25W	376624	80031	CR251-4-5P240E	1		
R 8		RES,CF,2.4K,+-5%,0.25W	441493	80031	CR251-4-5P2K4	1		
R 9		RES,VAR,CERM,500,+-20%,0.5W	226068	02111	62-1-1-501	1		
S 1, 3		SWITCH,SLIDE.DPDT,POWER	234278	82389	11A1297A	2		
S 2		SWITCH, ON-OFF	453605	89536	453605	1		
T 1		POWER TRANSFORMER & HEADER	639815	89536	639815	1		
TP 1- 10		TERM,FASTON,TAB,SOLDR,0.110 WIDE	512889	02660	62395-1	10		
U 1	*	IC,VOLT REG,FIXED,+15 VOLTS,1.5 AMPS	413187	04713	MC7815CT	1	1	
U 2, 4	*	IC,VOLT REG,FIXED,-15 VOLTS,1.5 AMPS	413179	04713	MC7915CP	2	1	
U 3	*	IC,VOLT REG,ADJ,1.2 TO 37 V,1.5 AMPS	460410	12040	LM317T	1	1	
U 5	*	IC,VOLT REG,FIXED,+5 VOLTS,1.5 AMPS	355107	12040	LM340T-5	1		
U 6	*	IC,VOLT REG,FIXED,+12 VOLTS,1.5 AMPS	428854	04713	MC7812CT	1	1	
U 7	*	IC,VOLT REG,FIXED,-12 VOLTS,1.5 AMPS	381665	04713	MC7912CP	1	1	
U 8	*	IC,VOLT REG,FIXED,+5 VOLTS,1.5 AMPS	428847	04713	MC7805CT	1	1	
W 1		WIRE,TEF,EE,UL1180,22AWG,STRN,WHT	115667	89536	115667			
W 2		WIRE,TEF,EE,UL1180,22AWG,STRN,BLK	115774	89536	115774			
W 3		WIRE,TEF,EE,UL1180,18AWG,STRN,GRN/YEL	386177	89536	386177			
XF 1		HLDR PART,FUSE,BODY 1/4X1-1/4,5X20MM	375188	61935	031.1653	1		

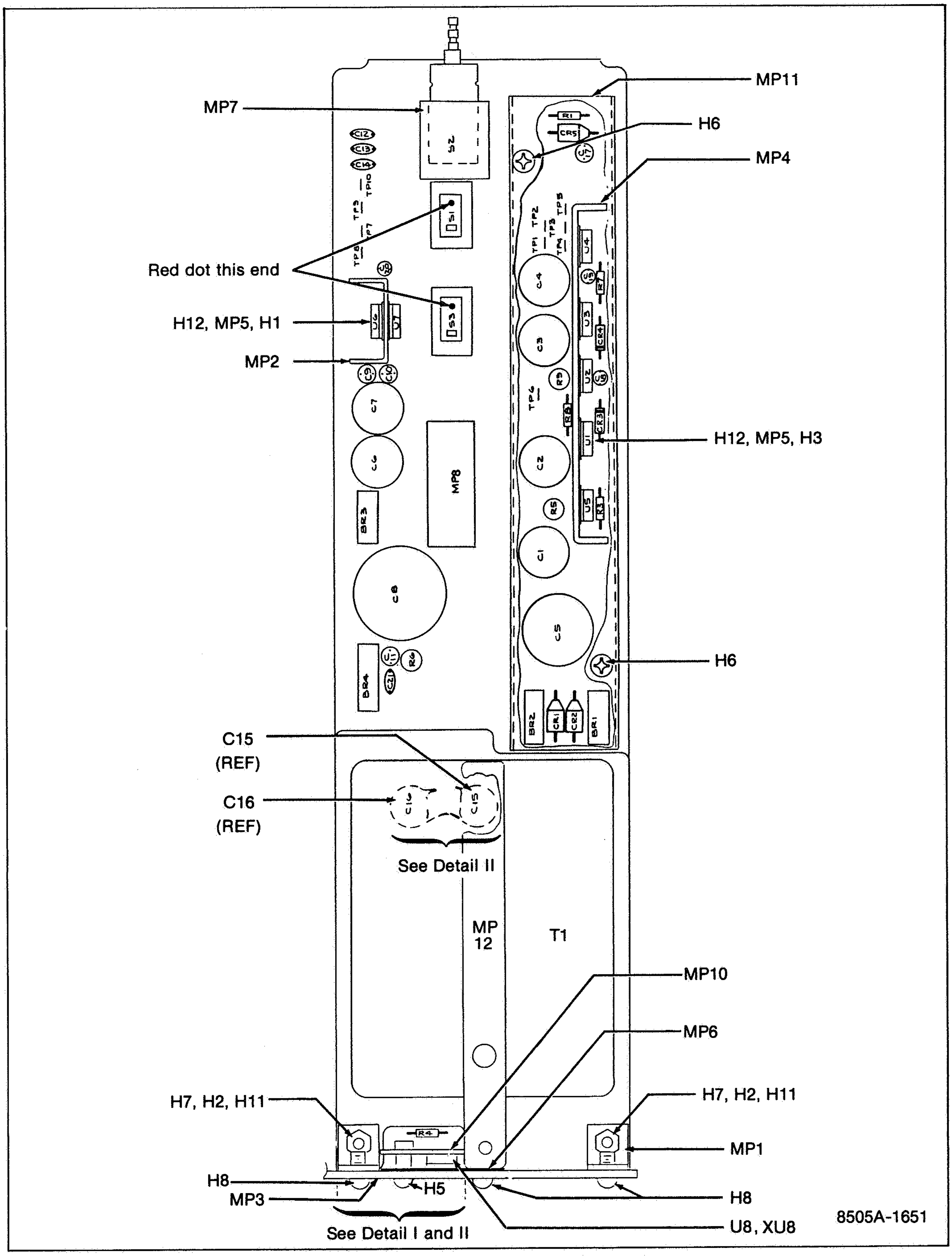
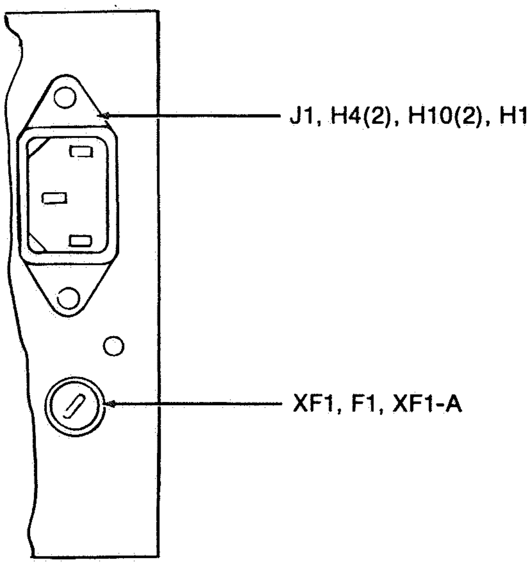
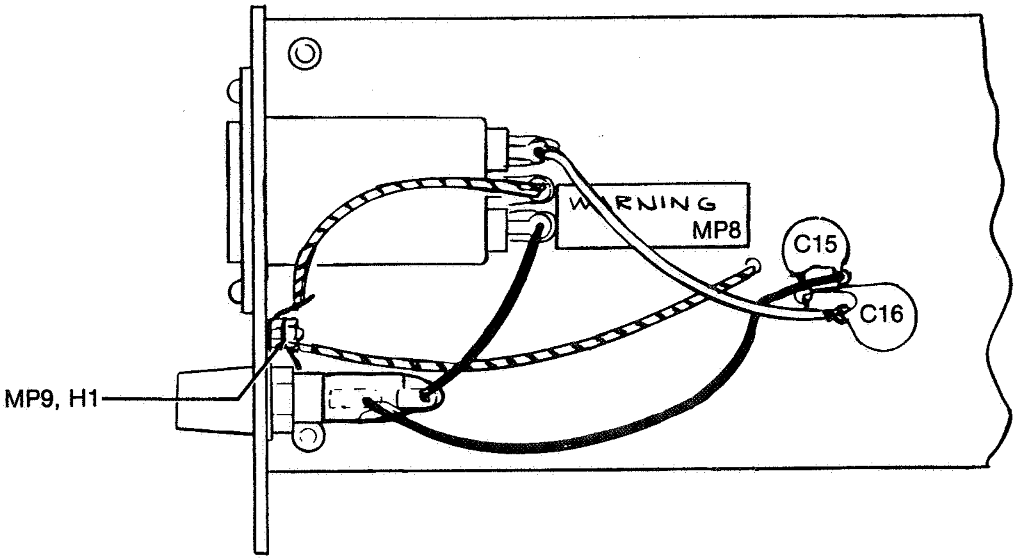


Figure 5-5. A4 Power Supply PCB Assembly

Detail I



Detail II



8505A-4051

Figure 5-5. A4 Power Supply PCB Assembly (cont)

TABLE 5-6. A5 POWER SUPPLY INTERCONNECT
(SEE FIGURE 5-6.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
J 1		CONN,PWB EDGE,REC,0.150 CTR,6 POS	291625	00779	583650-1	1		
J 2		CONN ACC,PWB EDGE,POLARIZING INSERT	293498	89536	293498	1		
J 3		CONN,PWB EDGE,REC,0.150 CTR,14 POS	352682	00779	583694-2	1		

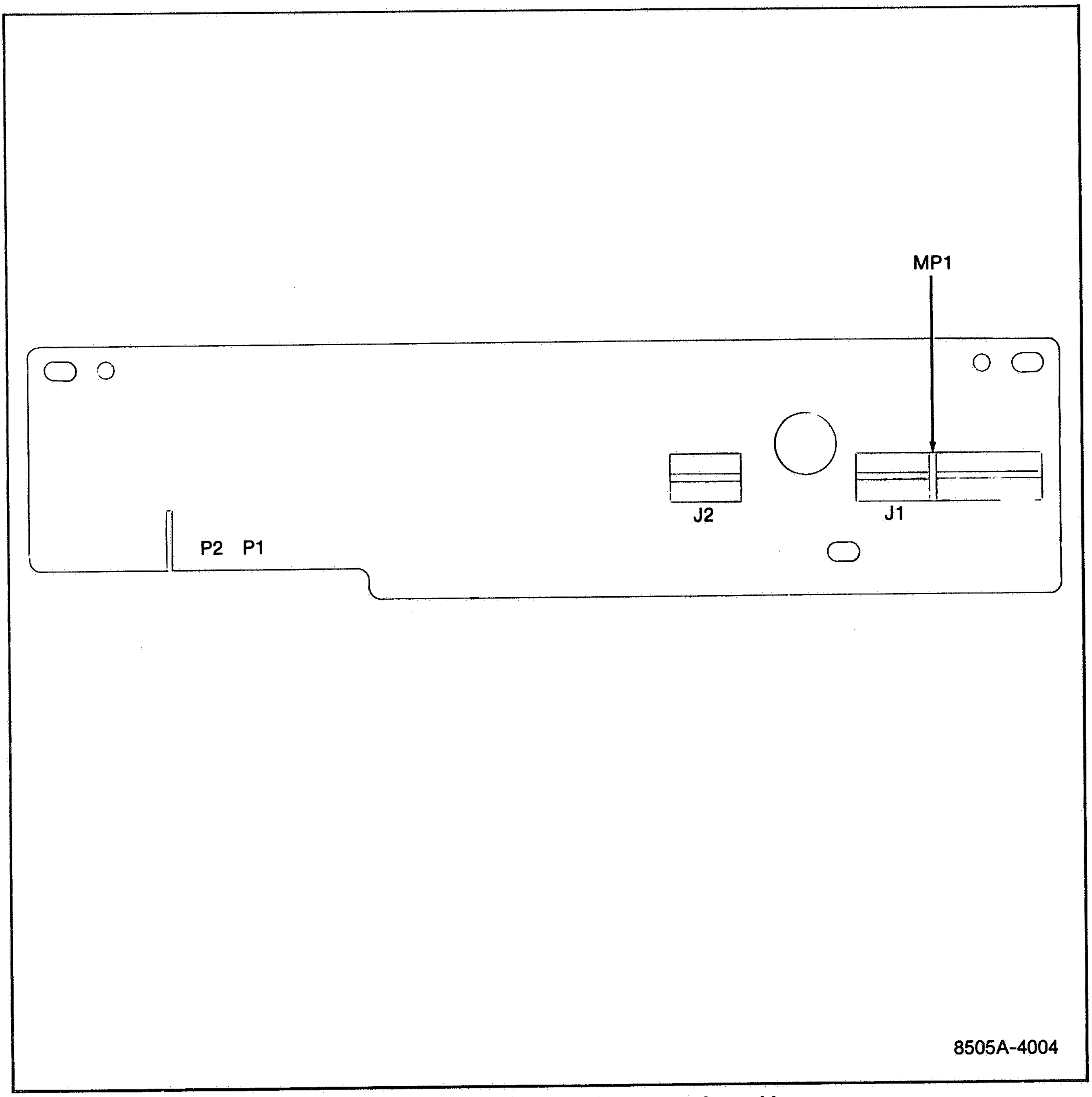


Figure 5-6. A5 Power Supply Interconnect Assembly

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	R S -Q	N O T -E
C 1, 3, 5-		CAP,CER,0.22UF,+-20%,50V,Z5U	309849	71590	CW3C0C224K	20		
C 7, 10- 12,			309849					
C 15, 17- 20,			309849					
C 22- 25, 27,			309849					
C 28, 30			309849					
C 2		CAP,CER,1800PF,+-5%,50V,COG	528547	89536	528547	1		
C 4		CAP,TA,6.8UF,+-10%,35V	182782	56289	150D687X0035	1		
C 8		CAP,TA,39UF,+-20%,6V	163915	56289	196D394X0020KA1	1		
C 9		CAP,CER,0.01UF,+-20%,100V,X7R	407361	72982	8121A100W5R103M	1		
C 13		CAP,MICA,33PF,+-5%,500V	160317	02799	DM15E330J	1		
C 14		CAP,CER,0.1UF,+-20%,50V,X7R	573808	72892	8131050W5R100NFM	1		
C 16, 21, 26,		CAP,AL,47UF,+75-20%,25V	655191	89536	655191	4		
C 29			655191					
CR 1	*	DIODE,SI,BV= 75.0V,IO=150MA,500 MW	203323	07910	1N4448	1	1	
H 1		SCREW,MACH,PHP,S.STL,4-40X3/8	256164	89536	256164	1		
L 1		CHOKE,6TURN	320911	89536	320911	1		
MP 1		CASE,CONTROLLER,ASSEMBLY (MP2 - MP8)	638510	89536	638510	1		1
MP 2		CASE HALF,MODULE	402990	89536	402990	2		
MP 3		COVER,MODULE CASE	402974	89536	402974	1		
MP 4		SHIELD, COVER	652172	89536	652172	1		
MP 5		DECAL, CONTROLLER	640359	89536	640359	1		
MP 6		DECAL,CAUTION	454504	89536	454504	1		
MP 7		GUARD, REAR	383364	89536	383364	1		
MP 8		GUARD, FRONT	383356	89536	383356	1		
MP 9		SPRING,COIL, 6 - 3/4 (WITH H1)	424465	83553	C01200140380M	1	1	
MP 10		SPACER,STANDOFF 4-40 (NOT SHOWN)	335604	89536	335604	1		
R 1		RES,CF,100K,+-5%,0.25W	573584	80031	CR251-4-5P100K	1		
R 2		RES,CF,620K,+-5%,0.25W	641183	80031	CR251-4-5P620K	1		
R 3, 6		RES,CF,10K,+-5%,0.25W	573394	80031	CR251-4-5P10K	2	1	
R 4, 5, 9		RES,CF,1.5K,+-5%,0.25W	573212	80031	CR251-4-5P1K5	3		
R 8		RES,CF,33K,+-5%,0.25W	573485	80031	CR251-4-5P33K	1		
R 10		RES,CF,2.7K,+-5%,0.25W	573261	80031	CR251-4-5P2K7	1		
R 15		RES,CF,6.2K,+-5%,0.25W	442368	80031	CR251-4-5P6K2	1	1	
RN 1, 2, 4		RES,NET,SIP,10 PIN,9 RES,6.2K,+-2%	501536	89536	501536	3		
RN 3		RES,NET,SIP,10 PIN,9 RES,2K,+-2%	446880	89536	446880	1		
RN 5		RES,NET,DIP,16 PIN,8 RES,2K,+-5%	574905	89536	574905	1	1	
TP 1- 7		TERM,FASTON,TAB,SOLDR,0.110 WIDE	512889	02660	62395-1	7		
U 1	*	IC,LSTTL,DUAL J-K F/F,+EDG TRIG	412999	01295	SN74LS109N	1	1	
U 2	*	IC,CMOS,DUAL MONOSTABLE MULTIBRATOR	454017	04713	MC14538BCP	1	1	
U 3	*	IC,CMOS,DUAL SYNC BINRY UP CNTR	355164	04713	MC14520BCP	1	1	
U 4	*	IC,CMOS,PHASE LOCKED LOOP,16 PIN DIP	403584	02735	CD4046BE	1	1	
U 5, 27	*	IC,LSTTL,QUAD 2 IN NAND W/SCHMT TRIG	504449	01295	SN74LS132N	2	1	
U 6	*	IC,LSTTL,TRIPLE 3 INPUT AND GATE	393082	04713	SN74LS11N	1	1	
U 7, 9	*	IC,CMOS,DUAL D F/F,+EDG TRG W/SET&RST	536433	04713	MC4013BCP	2	1	
U 8, 16	*	IC,CMOS,TRIPLE 3 INPUT NOR GATE	586453	04713	MC14025UBCP	2		
U 10	*	IC,CMOS,HEX INVERTER	381848	02735	CD4049UBE	1	1	
U 11	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	02735	CD4023UBE	1	1	
U 12	*	IC,LSTTL,QUAD D F/F,+EDG TRG,W/CLR	393215	01295	SN74LS175N	1	1	
U 13	*	IC,LSTTL,OCTL INV LINE DRVR W/3-STATE	429480	01295	SN74LS240N	1	1	
U 14	*	IC,CMOS,QUAD 2 INPUT NAND GATE	355198	04713	MC14011UBCP	1	1	
U 15	*	IC,NMOS,8 BIT MICROPROCESSOR	404541	01295	TMS8080	1		
U 17, 26	*	IC,CMOS,QUAD 2 INPUT NOR GATE	355172	02735	CD4001BE	2	1	
U 18	*	IC,256 X 4 PROM ,W,3-STATE OUT	722744	01295	TBP24S10N	1	1	
U 19	*	IC,STTL,CLOCK GENERATOR	586230	34649	P8224	1	1	
U 20	*	IC,NMOS,512X8 BIT EEPROM	685545	60395	XD28014A	1	1	
U 21	*	IC,CMOS,8 BIT PRIORITY ENCODER	412973	02735	CD4532BE	1	1	
U 22	*	IC, 2K X 8 STAT RAM	584144	33297	UPD4016C-2	1	1	
U 22	*	IC, 512X8 EEPROM	722348	89536	722348	1	1	
U 23	*	PROM, PROGRAMMED	660449	89536	660449	1		
U 24	*	PROM, PROGRAMMED	660456	89536	660456	1		
U 25	*	IC, CMOS, OCTAL BUS TRANSCEIVER	535906	36665	MD74SC245AC	1		
U 28	*	IC,TTL,8BIT SER-IN,PAR-OUT R-SHFT RGS	408732	01295	SN74LS164N	1		
VR 2, 3	*	ZENER,UNCOMP, 5.1V, 5%, 20.0MA, 0.5W	535476	04713	1N5231B	2	1	
XU 15		SOCKET,IC,40 PIN	429282	91506	240-AG39G	1		
XU 19		SOCKET,IC,16 PIN	276535	91506	316-AG39D	1		
XU 22		SOCKET,IC,24 PIN	376236	91506	224-AG39D	2		
XU 23, 24		SOCKET,IC,28 PIN	448217	91506	228-AG39D	2		
Y 1	*	CRYSTAL,15.36MHZ,+-0.05%,HC-18/U	642728	89536	642728	1		

NOTE 1 = USE P/N 638510 TO ORDER CASE WITHOUT PCB ASSEMBLY.

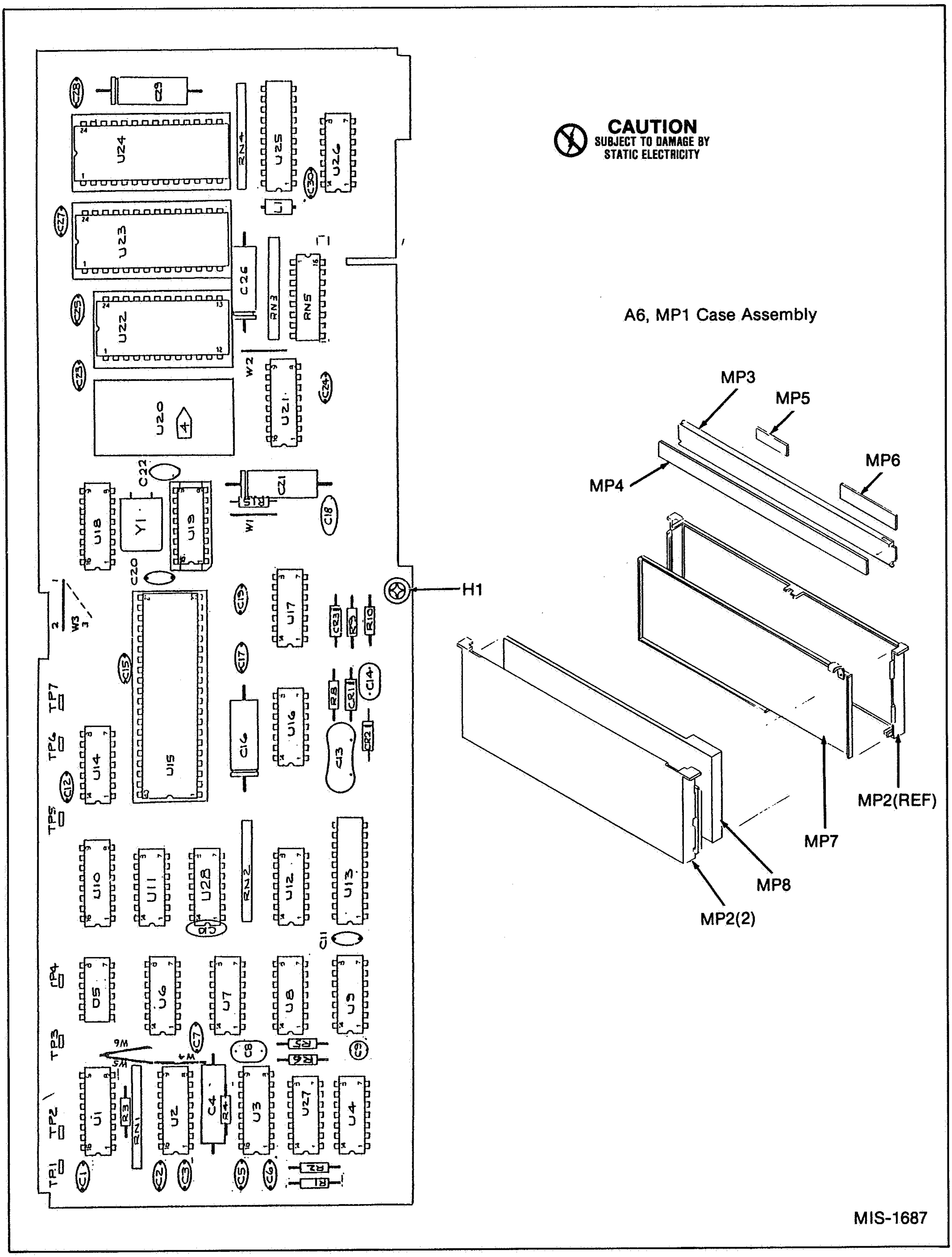


Figure 5-7. A6 Controller PCB Assembly

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	R S -Q	N O T -E
CR 1	*	LED,RED,PCB MOUNT,LUM INT=1.3MCD	385914	09214	SSL-22	1		
E 1		SURGE PROTECTOR, 145V, +-20%	442731	25088	B1-C145	1		
F 1, 2, 5,		FUSE,13/32 X 1-5/16,FAST,3A,300V	643833	71400	1J0272	4	1	
F 6			643833					
F 3		FUSE,1/4X1-1/4,FAST,1.5A,250V	739888	89536	739888	1		
F 4		WIRE,MAGNET,36H,130C,SOLDERABLE	160978	89536	160978			
H 1		SCREW,MACH,FIHS,STL,2-56X5/8	370270	89536	370270	4		
H 2		WASHER,LOCK,EXTRNL,(W/F3)	175943	89536	175943	1		
H 3		NUT,PRESS,CLINCH,S.STL,2-56	603688	89536	603688	2		
J 1		REAR INPUT CABLE ASSY	639609	89536	639609	1	1	
J 2		PIN,SINGLE,PWB,0.025 SQ	267500	00779	87022-1	2		
L 1		RESISTOR COIL ASSEMBLY	438325	89536	438325	1	1	
L 2		ASSY,COMMON MODE CHOKE	656629	89536	656629	1		
MP 1		PLATE,REAR INPUT	651760	89536	651760	1		
MP 2		FUSE HOLDER (W/F3)	375188	61935	031.1653	1		
MP 3		TIEPOINT, FUSE (W/F1,2,5,6)	172080	06383	SST-1M	9		
MP 4		SPACER,MOUNT,RIGHT ANGLE (W/CR1)	658161	89536	658161	1		
MP 5		CAP, FUSE HOLDER (W/F3)	460238	61935	031.1666	1	5	
MP 7		SPACER,SWAGED,RND,BRASS,6-32X0.265	650192	89536	650192	3		
MP 8		DECAL,PLATE,REAR INPUT	680751	89536	680751	1		
R 1		RES,CF,330,+-5%,0.25W	368720	80031	CR251-4-5P330E	1		
R 2		THERMISTOR,RECT.,POS.,1K,+-40%,25C	494740	50157	180Q10215	1		
R 3, 4		RES,MF,30.9K,+-1%,0.5W,100PPM	247569	91637	CMF653092F	2	1	
R 5		RES,CF,270,+-5%,0.25W	348789	80031	CR251-4-5P270E	1		
S 1		PUSHBUTTON SWITCH 10POLE	647149	89536	647149	1	1	
S 2, 3		PUSHBUTTON SWITCH-2POLE	647131	89536	647131	2		
W 1		WIRE,TEFLON, RED, #22 (W/F3)	115576	89536	115576			

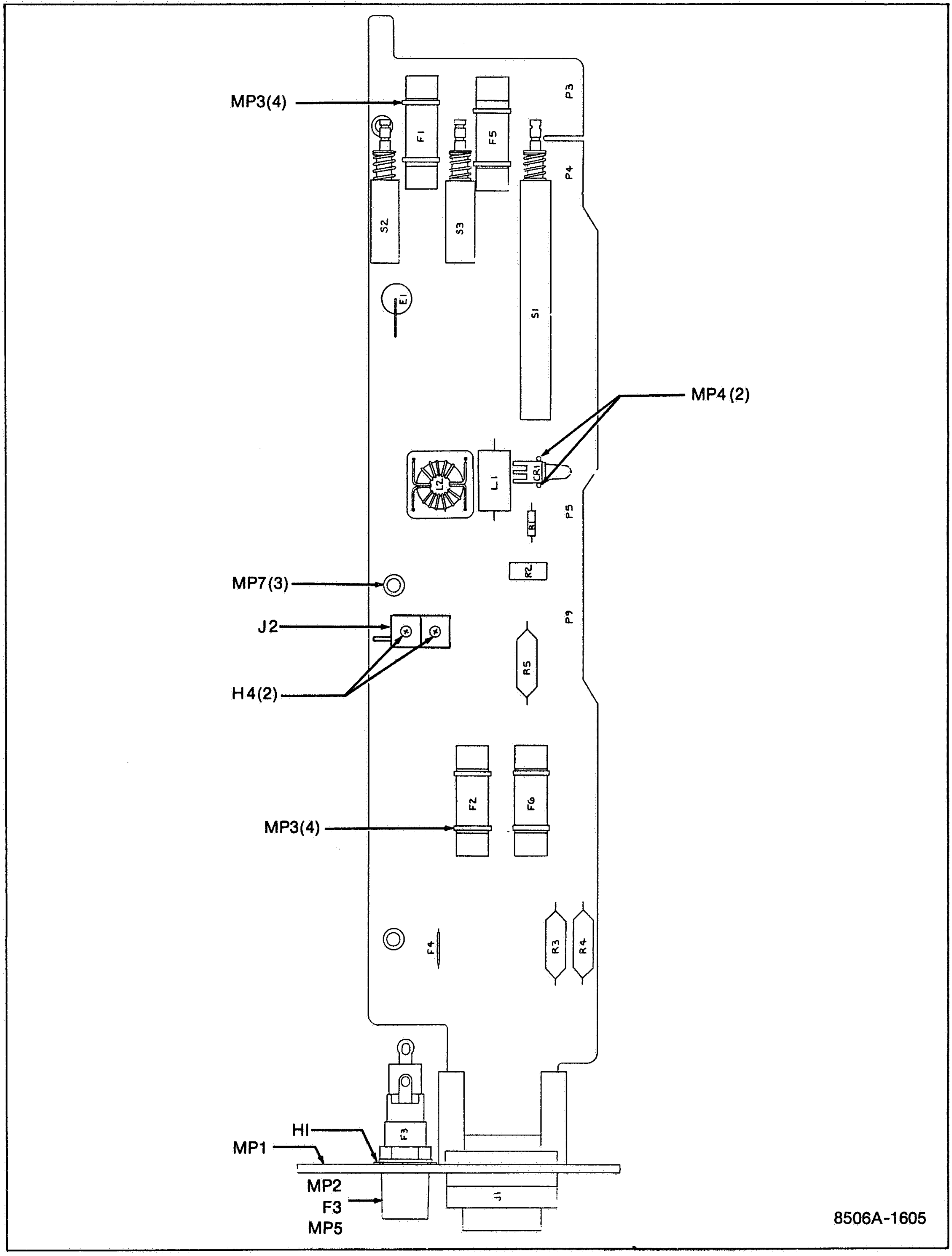


Figure 5-8. A7 Front/Rear Switch PCB Assembly

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	R S -Q	N O T -E
C 1- 4		CAP,TA,4.7UF,+-20%,25V	161943	56289	196D475X0025KA1	4		
C 5		CAP,TA,39UF,+-20%,6V	163915	56289	196D394X0020KA1	1		
C 6		CAP,POLYPR,4700PF,+-10%,200V	512830	89536	512830	1		
C 10, 11		CAP,AL,6.8UF,+50-10%,63V	218966	73445	ET6P8X063A3	2		
C 12, 14		CAP,MICA,100PF,+-5%,500V	148494	72136	DM15F101J	2		
C 13		CAP,CER,0.01UF,+80-20%,100V,Z5V	149153	56289	C023B101F103M	1		
C 15, 16		CAP,MICA,47PF,+-5%,500V	148536	72136	CM15E470J	2		
C 18, 19		CAP,CER,33PF,+-2%,50V,COG	354852	72982	8121-A100-COG-330G	2		
C 20		CAP,MICA,680PF,+-5%,500V	148403	14655	CD19FD681J0	1		
CR 1, 2, 7,	*	DIODE,SI,BV= 75.0V,IO=150MA,500 MW	203323	07910	1N4448	4	1	
CR 8	*		203323					
CR 5, 6	*	DIODE,SI,BV= 20.0V,IO= 50MA,SELCTD IR	348177	07263	FD7223	2	1	
H 1		SCREW,MACH,PHP,S.STL,4-40X3/8	256164	89536	256164	1		
K 1, 2		RELAY, ARMATURE, 4 FORM C,5V,LATCHING	715078	89536	715078	2	1	
MP 1		CASE,DC SIGNAL CONDITIONER (MP2 - MP9)	458992	89536	458992	1		1
MP 2, 3		CASE, HALF MODULE	402990	89536	402990	2		
MP 4		COVER, MOD. CASE	402974	89536	402974	1		
MP 5		SHIELD, COVER	411918	89536	411918	1		
MP 6		DECAL	413377	89536	413377	1		
MP 7		DECAL, CAUTION	454504	89536	454504	1		
MP 8		GUARD, REAR	383364	89536	383364	1		
MP 9		GUARD, FRONT	383356	89536	383356	1		
MP 10		SPACER,RND,SOLUBLE	334797	32559	TO-35-15-E	2		
MP 11		SPACER,SWAGED,RND,BRASS,4-40X0.187	335604	89536	335604	1		
MP 14		SPACER,TRANSIPAD (NOT SHOWN)	152207	07047	10123-DAP	1	1	
MP 16		DECAL, D C SIGNAL CONDITIONER	651950	89536	651950	1		
Q 1, 3, 7,	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	13	1	
Q 10- 13, 22,	*		218396					
Q 23, 32, 34,	*		218396					
Q 36, 38	*		218396					
Q 2, 4, 6,	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	64713	2N3906	6	1	
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	5T3824	4	3	
Q 18	*	TRANSISTOR,SI,NPN,DUAL,TO-78,HI-BETA	585109	89536	585109	1	1	
Q 19	*	TRANSISTOR,SI,NPN,DUAL,TO-52	295717	89536	295717	1	1	
Q 37	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	218388	07263	2N3645	1	2	
R 1		RES,CF,330,+-5%,0.25W	368720	80031	CR251-4-5P330E	1		
R 2, 3, 18,		RES,CF,3.3K,+-5%,0.25W	348813	80031	CR251-4-5P3K3	4		
R 19			348813					
R 6		RES,CF,470,+-5%,0.25W	343434	80031	CR251-4-5P470E	1		
R 7		RES,CF,2.7K,+-5%,0.25W	386490	80031	CR251-4-5P2K7	1		
R 8		RES,CC,150K,+-5%,2W	110122	01121	HB1545	1		
R 9		RES,CC,150K,+-10%,0.5W	108167	01121	EB1541	1		
R 10		RES,CF,150,+-5%,0.25W	343442	80031	CR251-4-5P150	1		
R 11		RES,CF,47K,+-5%,0.25W	348896	80031	CR251-4-5P47K	1		
R 12, 13		RES,CF,15,+-5%,0.25W	348755	80031	CR251-4-5P15E	2		
R 14, 20		RES,CF,1K,+-5%,0.25W	343426	80031	CR251-4-5P1K	2		
R 15, 93- 95		RES,CF,1M,+-5%,0.25W	348987	80031	CR251-4-5P1M	4		
R 16, 17, 87-		RES,CF,100K,+-5%,0.25W	348920	80031	CR251-4-5P100K	8		
R 92			348920					
R 21- 23		RES, SET, SIG. CON. DIVIDER	434605	89536	434605	1		
R 24, 26		PRECISION RESISTOR DIVIDER SET	648212	89536	648212	1		
R 30		RES,CF,15K,+-5%,0.25W	348854	80031	CR251-4-5P15K	1		
R 31- 34		RES,CF,10K,+-5%,0.25W	348839	80031	CR251-4-5P10K	4		
R 35, 62		RES,MF,1M,+-1%,0.125W,100PPM	268797	91637	CMF551004F	2		
R 36		RES,CERM,100M,+-10%,1W	441758	89536	441758	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	80031	CR251-4-5P2E2	1		
R 51		RES,CF,20,+-5%,0.25W	442202	80031	CR251-4-5P20E	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 58, 59		RES. SET, 2M T.C. MATCHED	290320	89536	290320	1		
R 61		RES,MF,86.6K,+-1%,0.125W,100PPM	291468	91637	CMF558662F	1		
R 63		RES,MF,1.87K,+-1%,0.125W,100PPM	267229	91637	CMF551871F	1		
R 64		RES,MF,1K,+-1%,0.125W,100PPM	168229	91637	CMF551001F	1		
R 70		RES,MF,52.3K,+-1%,0.125W,100PPM	237248	91637	CMF555232F	1		
R 71		RES,MF,3.01K,+-1%,0.125W,100PPM	312645	91637	CMF553011F	1		
R 72, 97		RES,MF,3.65K,+-1%,0.125W,100PPM	293779	91637	CMF553651F	2	1	
R 73- 75, 99		RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF551003F	4		
R 76		RES,MF,4.02K,+-1%,0.125W,100PPM	235325	91637	CMF554021F	1		
R 77		RES,MF,200K,+-1%,0.125W,100PPM	261701	91637	CMF552003F	1		
R 98		RES,MF,2.15K,+-1%,0.125W,100PPM	293712	91637	CMF552151F	1		
U 1	*	IC,CMOS,QUAD D LATCH,W/XOR ENABLE	355149	02739	CD4042BE	1		
U 2	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	02735	CD4023UBE	1	1	
U 3, 4	*	IC,OP AMP,SUPER BETA INPUT	722025	12040	LM11CLN	2	1	
U 5, 6	*	IC,OP AMP,GEN PURPOSE,TO-99/TO-78	271502	12040	LM301A	2	1	
VR 3, 4	*	ZENER,UNCOMP, 22.0V, 5%, 5.6MA, 0.4W	181073	04713	1N969B	2	1	
W 1		WIRE,BUS,22 AWG,TINNED COPPER	115469	89536	115469			
XJ 1		SOCKET,SINGLE,PWB,FOR 0.022-0.025 PIN	343285	00779	2-331272-6	8		

NOTE 1 = USE P/N 458992 TO ORDER CASE WITHOUT PCB ASSEMBLY.

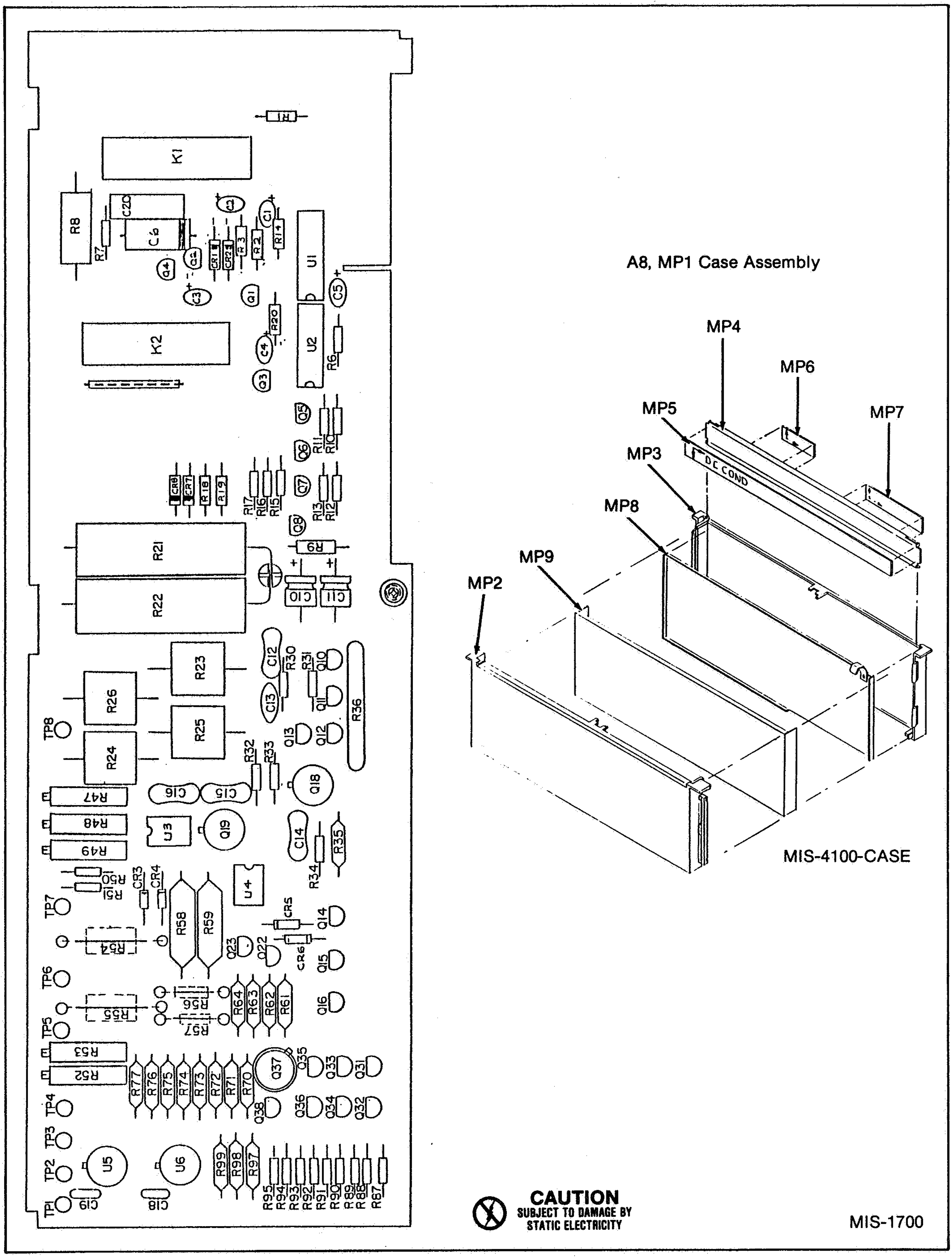


Figure 5-9. A8 DC Signal Conditioner PCB Assembly

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	R S -Q	N O T -E
C 1- 3		CAP,POLYPR,0.047UF,+-10%,50V	413328	89536	413328	3		
C 4, 8- 10		CAP,MICA,33PF,+-5%,500V	160317	02799	DM15E330J	4		
C 5- 7		CAP,POLYPR,0.47UF,+-10%,50V	363085	89536	363085	3		
C 11, 14		CAP,AL,6.8UF,+50-10%,63V	218966	73445	ET6P8X063A3	2		
C 12, 13		CAP,AL,10UF,+50-10%,25V	170266	73445	ET100X025A2	2		
C 15		CAP,POLYPR,0.0022UF,+-10%,200V	442632	89536	442632	1		
CR 1	*	ZENER,UNCOMP, 6.8V, 5%, 20.0MA, 0.4W	260695	07910	1N754A	1	1	
CR 2	*	ZENER,UNCOMP, 9.1V, 5%, 14.0MA, 0.4W	386557	04713	1N960B	1		
CR 3	*	DIODE,SI,BV= 75.0V,IO=150MA,500 MW	203323	07910	1N4448	1	1	
H 1		SCREW,MACH,PHP,S.STL,4-40X3/8	256164	89536	256164	1		
MP 1		CASE,ACTIVE FILTER (MP2 - MP8)	458976	89536	458976	1		1
MP 3		CASE HALF,MODULE	402990	89536	402990	2		
MP 4		COVER,MODULE CASE	402974	89536	402974	1		
MP 5		SHIELD,COVER,ACTIVE FILTER	411959	89536	411959	1		
MP 6		DECAL ACTIVE FILTER	413443	89536	413443	1		
MP 7		DECAL,CAUTION	454504	89536	454504	1		
MP 8		GUARD, REAR	383364	89536	383364	1		
MP 9		GUARD, FRONT	383356	89536	383356	1		
MP 10		SPACER,TRANSIPAD (W/Q26)	152207	07047	10123-DAP	1	1	
MP 11		SPACER, PCB (NOT SHOWN)	335604	89536	335604	1		
MP 12		SPRING,COIL,COMP,SQUARED END,M WIRE	424465	89536	424465	1		
Q 1, 3, 5,	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	64713	2N3906	6	1	
Q 7, 9, 11	*		195974					
Q 2, 4, 6,	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	9	2	
Q 8, 10, 12,	*		218396					
Q 28- 30	*		218396					
Q 13	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1	3	
Q 14- 25, 31-	*	TRANSISTOR,SI,N-JFET,HI-VOLTAGE,TO-92	393314	89536	393314	15	1	
Q 33	*		393314					
Q 26	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	218388	07263	2N3645	1	2	
Q 27	*	TRANSISTOR,SI,NPN,DUAL,TO-78	284075	32293	ITS1099	1	1	
R 1		RES,CF,6.2K,+-5%,0.25W	442368	80031	CR251-4-5P6K2	1		
R 2		RES,CF,150,+-5%,0.25W	343442	80031	CR251-4-5P150E	1		
R 3		RES,MF,51.1K,+-5%,0.125W,100PPM	289553	91637	CMF555112F	1		
R 4, 5		RES,CF,8.2K,+-5%,0.25W	441675	80031	CR251-4-5P8K2	2		
R 8- 11		RES,MF,45.3K,+-1%,0.125W,100PPM	234971	91637	CMF554532F	4		
R 12, 19, 22		RES,MF,12.1K,+-1%,0.125W,100PPM	234997	91637	CMF551212F	3		
R 13		RES,MF,4.87K,+-1%,0.125W,100PPM	294850	91637	CMF554871F	1		
R 14		RES,VAR,CERM,20K,+-10%,0.5W	291609	89536	291609	1		
R 15, 16		SELECTED IN TEST	191910	89536	191910			
R 17, 18		RES,MF,1M,+-1%,0.5W,25PPM	327510	91637	CMF651004F	2		
R 20, 23		RES,MF,249K,+-1%,0.125W,100PPM	268805	91637	CMF552493F	2		
R 21		RES,MF,57.6K,+-1%,0.125W,100PPM	289116	91637	CMF555762F	1		
R 24, 27		RES,CF,15,+-5%,0.25W	348755	80031	CR251-4-5P15E	2		
R 25, 26		RES,CF,100,+-5%,0.25W	348771	80031	CR251-4-5P100E	2		
R 28, 29		RES,MF,26.7K,+-1%,0.125W,100PPM	245779	91637	CMF552672F	2		
U 1	*	IC,CMOS,HEX D F/F,+EDG TRG,W/RESET	404509	12040	MM74C174N	1		
U 2	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	02735	CD4023UBE	1	1	
U 3, 4	*	IC,OP AMP,GEN PURPOSE,8 PIN DIP	363515	12040	LM301AN	2	1	
U 5	*	IC,OP AMP,GEN PURPOSE,COMPENSATD,TO-5	392902	12040	LM1436H	1	1	
W 1		WIRE,BUS,22 AWG,TINNED COPPER	115469	89536	115469			
‡XR 15, 16		SOCKET,SINGLE,PWB,FOR 0.022-0.025 PIN	343285	00779	2-331272-6	4		
Z 6		RES,NET,DIP,16 PIN,14 RES,100K,+-5%	404749	89536	404749	1	1	
Z 7		RES,NET,DIP,16 PIN,8 RES,100K,+-5%	380618	89536	380618	1		

NOTE 1 = USE P/N 458976 TO ORDER CASE WITHOUT PCB ASSEMBLY.

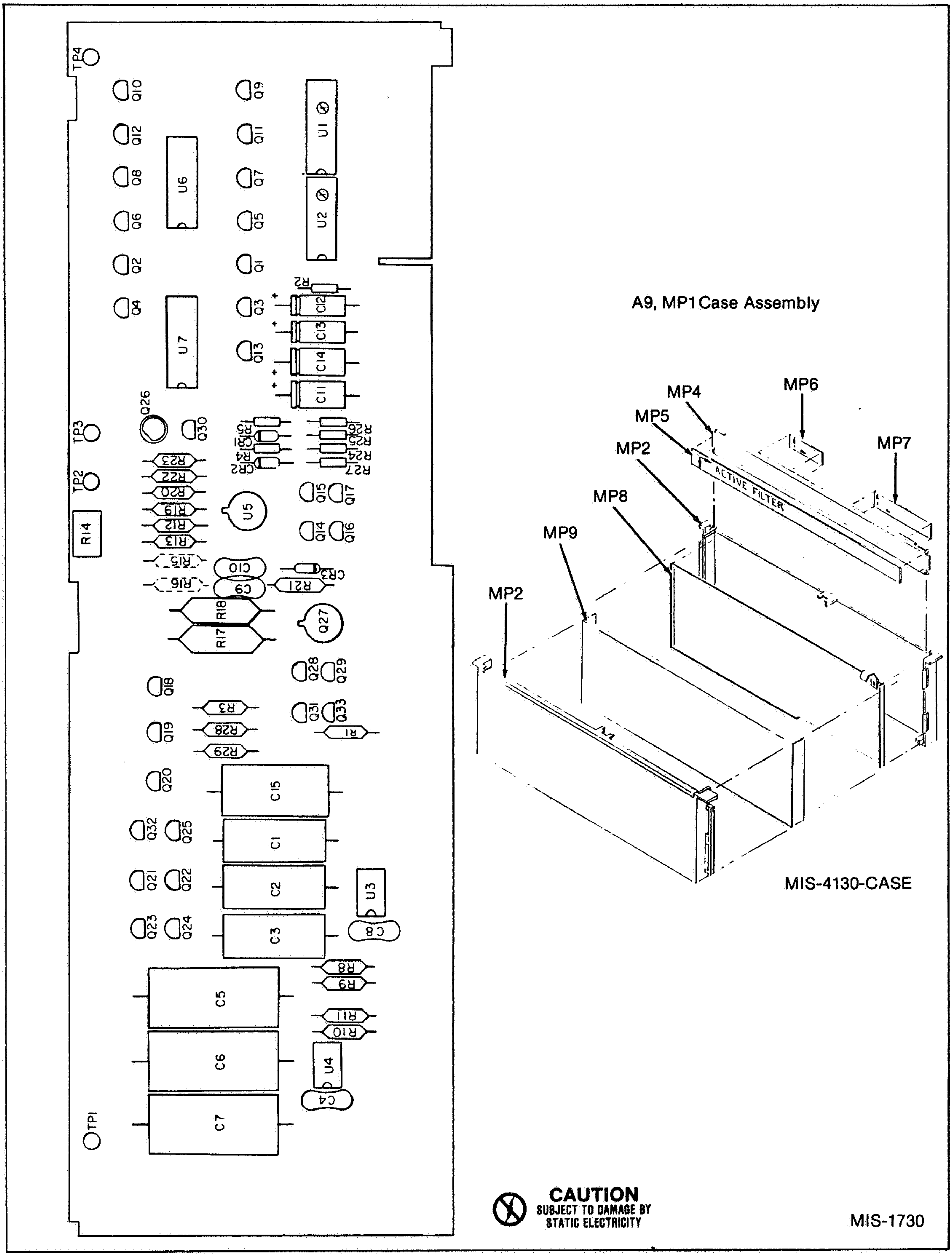


Figure 5-10. A9 Active Filter PCB Assembly

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	R S -Q	N O T -E
A 10	*	FAST R2 A/D CONVERTER ASSEMBLY	383984	89536	383984	1		1
		A10A1 A/D ANALOG ASSEMBLY				1		
		A10A2 FAST R2 A/D DIGITAL ASSEMBLY				1		
MP 1		CASE, A/D CONVERTOR MOD. (MP2 - MP9)	458968	89536	458968	1		2
MP 2		CASE HALF,MODULE	402990	89536	402990	1		
MP 3		CASE HALF,EXTENDED MODULE	402982	89536	402982	1		
MP 4		COVER,MODULE CASE	402974	89536	402974	1		
MP 5		SHIELD, COVER	411967	89536	411967	1		
MP 6		DECAL,FAST A/D CONVERTER	413450	89536	413450	1		
MP 7		DECAL,CAUTION	454504	89536	454504	1		
MP 8		GUARD, REAR	383364	89536	383364	1		
MP 9		GUARD,FRONT, FAST A/D	383315	89536	383315	1		

NOTE 1 = A10A1 AND A10A2 ARE MATCHED ASSEMBLIES. ORDER P/N 383984 AND REPLACE COMPLETE A10 ASSEMBLY.

NOTE 2 = USE P/N 458968 TO ORDER CASE WITHOUT PCB ASSEMBLY.

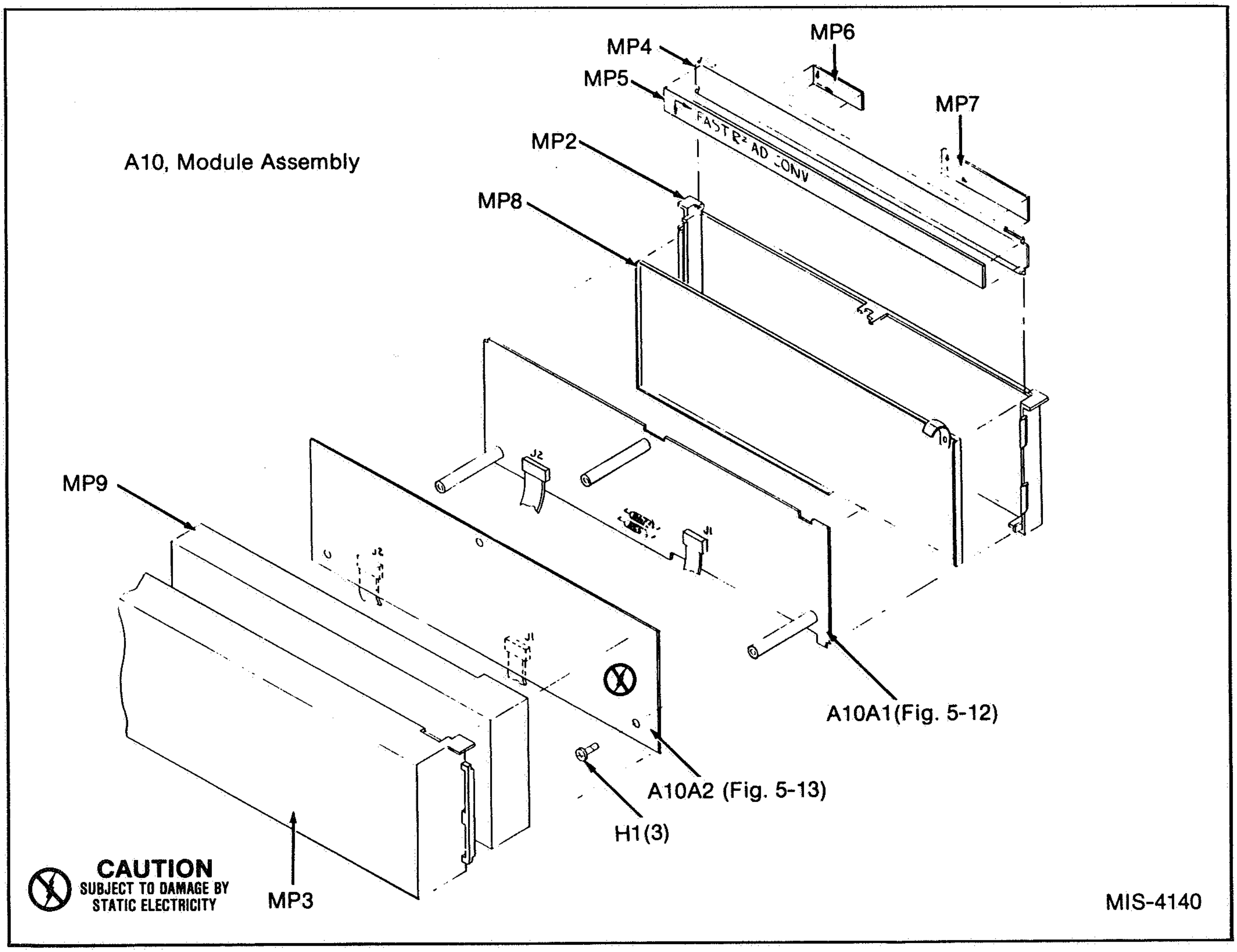


Figure 5-11. A10 Fast R2 A/D Converter Assembly

TABLE 5-12. A10A1 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	R S -Q	N O T -E
C 1, 2		CAP,TA,10UF,+-20%,35V	417683	56289	196D106X0035KA1	2		
C 3		CAP,MICA,33PF,+-5%,500V	160317	02799	DM15E330J	1		
C 4		CAP,MICA,30PF,+-5%,500V	340570	72136	DM15E300J	1		
C 5		CAP,POLYES,0.22UF,+-10%,80V	159392	56289	192P2249R8	1		
C 6		CAP,TA,4.7UF,+-20%,25V	161943	56289	196D475X0025KA1	1		
C 7, 8		CAP,MICA,150PF,+-5%,500V	148478	72136	DM15F151J	2		
C 9, 10		CAP,POLYST,0.047UF,+-10%,100V	260562	84411	1263UW47391	2		
C 11, 12, 14		CAP,MICA,47PF,+-5%,500V	148536	72136	DM15E470J	3		
C 13		CAP,AL,470UF,+50-10%,6.3V	187773	89536	187773	1		
C 15		CAP,CER,0.0047UF,+-10%,500V,Z5R	106724	71590	CF-472	1		
C 16, 17, 22,		CAP,CER,0.22UF,+-20%,50V,Z5U	309849	89536	309849	4		
C 23			309849					
C 18		CAP,AL,33UF,+-20%,25V	715250	89536	715250	1	1	
C 20		CAP,TA,0.22UF,+-20%,35V	161331	56289	196D224X0035HA1	1		
C 21		CAP,MICA,1800PF,+-5%,500V	148353	14655	CD19FD182J0	1		
CR 1, 9	*	DIODE,SI,BV= 75.0V,IO=150MA,500 MW	203323	07910	1N4448	2	1	
CR 3, 4, 7,	*	DIODE,SI,BV= 20.0V,IO= 50MA,SELCTD IR	348177	07263	FD7223	4	1	
CR 8	*		348177					
CR 5, 6	*	DIODE,SI,BV= 50.0V,IO=150MA,SELCTD VF	234468	07263	FDH9274	2	1	
H 1		SCREW,MACH,PHP,S.STL,4-40X1/4	256156	89536	256156	3		
H 2		SCREW,MACH,PHP,S.STL,4-40X3/8	256164	89536	256164	1		
MP 1		SPRING, COIL	424465	83553	C0120-014-0380M	1		
MP 2		SPACER,TRANSIPAD (NOT SHOWN)	152207	07047	10123-DAP	1		
MP 3		SPACER,SWAGED,RND,BRASS,4-40X0.187	335604	89536	335604	1		
MP 4		SPACER,SWAGED,RND,BRASS,4-40X1.375	417881	89536	417881	3		
Q 1- 3, 11-	*	TRANSISTOR, FET, (SELECTED)	256487	89536	256487	11	3	
Q 16, 25, 26	*		256487					
Q 4- 8	*	TRANSISTOR,SI,N-JFET,TO-92	343830	12040	27014	5		
Q 9, 27	*	TRANSISTOR,SI,N-JFET,DUAL,TO-71	376087	89536	376087	2		
Q 10	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	1	1	
Q 17- 24, 29-	*	TRANSISTOR,SI,N-JFET,TO-92,SWITCH	261578	27014	NSSFS1148	12	1	
Q 32	*		261578					
Q 28	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	64713	2N3906	1	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	89536	291120	1		
R 4		RES,VAR,CERM,200,+-10%,0.5W	285148	89536	285148	1		
R 5, 7		RES,VAR,CERM,50,+-10%,0.5W	285122	89536	285122	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	89536	288290	1		
R 10		RES,MF,3.4K,+-1%,0.125W,100PPM	260323	91637	CMF553401F	1		
R 11, 13		RES,MF,12.1,+-1%,0.125W,100PPM	296608	91637	CMF5512R1F	2		
R 12		RES,MF,24.3,+-1%,0.125W,100PPM	281816	91637	CMF5524R3F	1		
R 17, 18		RES,MF,10K,+-1%,0.125W,25PPM	328120	89536	328120	2		
R 19, 21, 49		RES,CF,100K,+-5%,0.25W	348920	80031	CR251-4-5P100K	3		
R 20, 28, 30		RES,MF,10K,+-1%,0.125W,100PPM	168260	91637	CMF551002F	3		
R 22, 23		REFERENCE INVERTER SET	409896	89536	409896	2		
R 24		RES,CF,470,+-5%,0.25W	343434	80031	CR251-4-5P470E	1		
R 25, 26		RES,MF,42.2K,+-1%,0.125W,100PPM	221655	91637	CMF554222F	2		
R 27		RES,CF,62,+-5%,0.25W	441634	80031	CR251-4-5P62E	1		
R 29, 60		RES,CF,33K,+-5%,0.25W	348888	80031	CR251-4-5P33K	2		
R 31		RES,MF.11.3K,+-1%,0.125W,100PPM	293639	91637	CMF551132	1		
R 32		RES,MF,24.9K,+-1%,0.125W,100PPM	291369	91637	CMF552492F	1		
R 33, 37		RES,CF,47,+-5%,0.25W	441592	80031	CR251-4-5P47E	2		
R 34, 35, 50-		FAST R2 AD SUMMING RESISTOR SET	409946	89536	409946	8		
R 54, 56			409946					
R 36		RES,MF,26.7K,+-1%,0.125W,100PPM	245779	91637	CMF552672F	1		
R 38, 39, 41		RES,MF,75K,+-1%,0.125W,100PPM	291443	91637	CMF557502F	3		
R 40, 48		RES,CF,15K,+-5%,0.25W	348854	80031	CR251-4-5P15K	2		
R 42		RES,CF,3K,+-5%,0.25W	441527	80031	CR251-4-5P3K	1		
R 43		RES,CF,510,+-5%,0.25W	441600	80031	CR251-4-5P510E	1		
R 44		RES,CF,1.5K,+-5%,0.25W	343418	80031	CR251-4-5P1K5	1		
R 45		RES,CF,470K,+-5%,0.25W	342634	80031	CR251-4-5P470K	1		
R 46		RES,MF,665,+-1%,0.125W,100PPM	320028	91637	CMF556650F	1		
R 47		RES,MF,1M,+-1%,0.125W,100PPM	268797	91637	CMF551004F	1		
R 55		RES,MF,56.2,+-1%,0.125W,100PPM	305938	91637	CMF5556R2F	1		
R 58		RES,MF,2573,+-0.1%,0.125W,25PPM	321463	89536	321463	1		
R 61		RES,MF,57.6K,+-1%,0.125W,100PPM	289116	91637	CMF555762F	1		
R 62		RES,MF,66.5K,+-1%,0.125W,100PPM	289082	91637	CMF556652F	1		
R 63		RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF551003F	1		
R 65		RES,CF,820,+-5%,0.25W	442327	80031	CR251-4-5P820E	1		
R 66		RES,CF,5.1K,+-5%,0.25W	368712	80031	CR251-4-5P5K1	1		
R 67		RES,MF,12.7,+-1%,0.125W,100PPM	441766	91637	CMF5512R7F	1		
R 68		RES,CF,1M,+-5%,0.25W	348987	80031	CR251-4-5P1M	1		

TABLE 5-12. A10A1 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	R S -Q	N O T -E
R 70, 71		RES,CF,10K,+-5%,0.25W	348839	80031	CR251-4-5P10K	2		
TP 2		TERMINAL, TEST POINT	179283	88245	2010B-5	7		
U 1	*	REFERENCE AMP SET (U1,R9,R14,R15,R16)	415034	89536	415034	1	1	
U 2, 3	*	IC,OP AMP,GEN PURPOSE,TO-99/TO-78	271502	12040	LM301A	2		
U 4, 7	*	IC,OP AMP,JFET INPUT,TO-5 CASE	429837	12040	LF356F	2	1	
U 5, 6	*	IC,OP AMP,SELECTED VOLTAGE FOLLOWER	288365	12040	LM310H	2	1	
U 8	*	IC,OP AMP,SELECTED,GEN PURPOSE,TO-78	225961	24355	AD3092	1	1	
U 15		RES,NET,DIP,16 PIN,14 RES,33K,+-5%	413146	89536	413146	1		
U 19		RES,NET,DIP,16 PIN,8 RES,100K,+-5%	380618	89536	380618	1		
XJ 2- 5		SOCKET,SINGLE,PWB,FOR 0.022-0.025 PIN	343285	00779	2-331272-6	4		
XJ 9, 14		SOCKET,IC,16 PIN	276535	91506	316-AG39D	2	1	

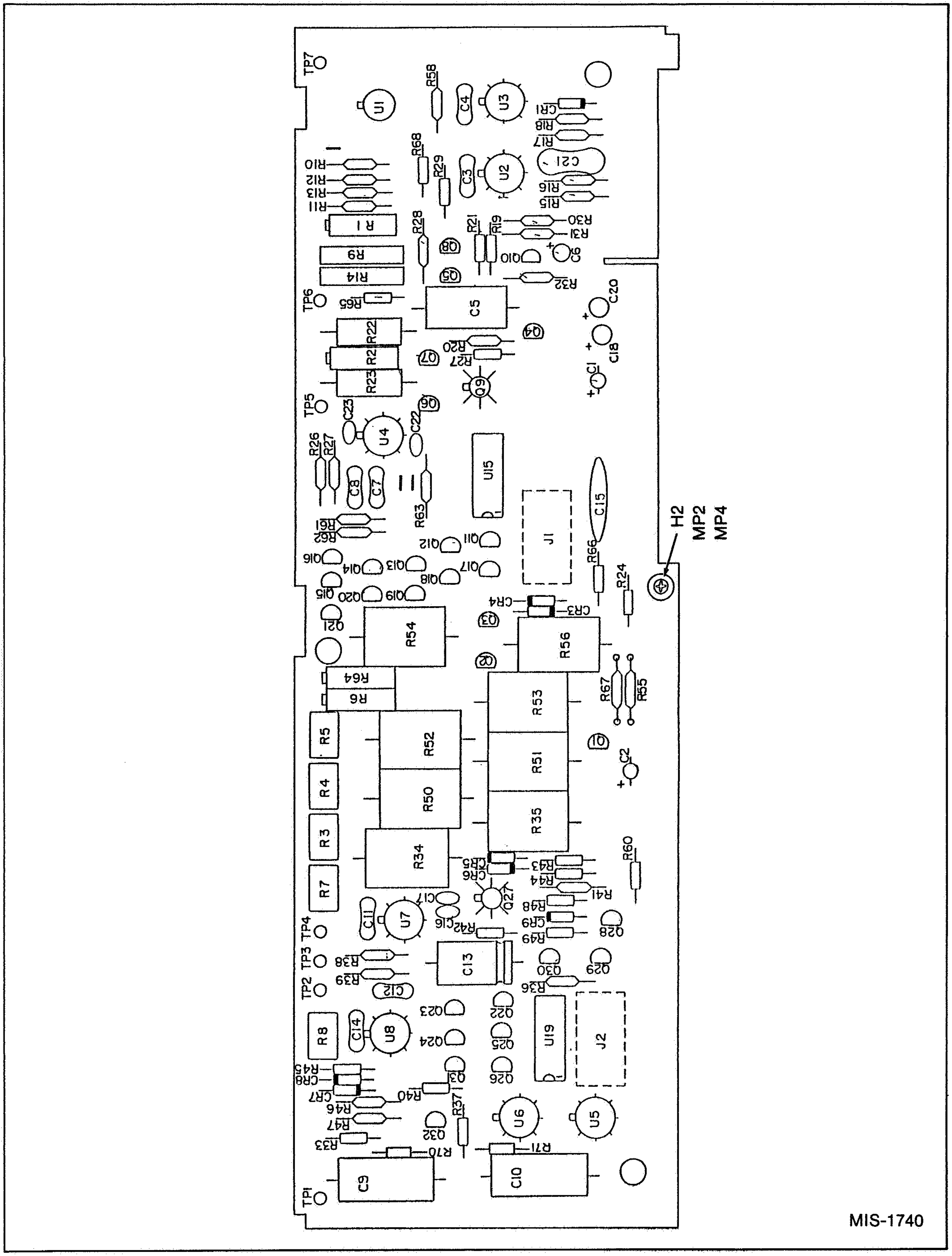
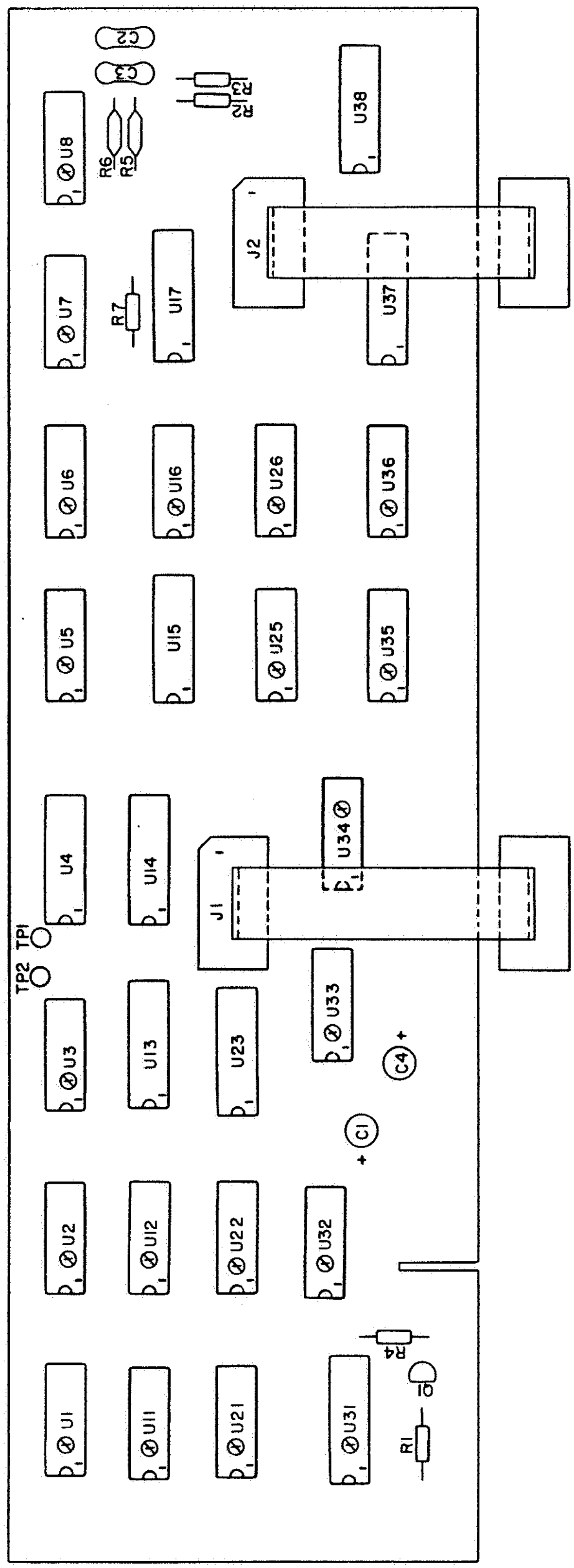


Figure 5-12. A10A1 A/D Analog PCB Assembly

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	R S -Q	N O T -E
C 1, 4		CAP,AL,47UF,+-20%,25V	697052	89536	697052			
C 2, 3		CAP,MICA,82PF,+-5%,500V	148502	14655	CD15FD820J0	2	1	
J 1, 2		CABLE ASSY,FLAT,16 COND,3.50,DIP CONN	380576	08261	5112-003.5	2		
Q 1	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1		
R 1		RES,CF,47K,+-5%,0.25W	348896	80031	CR251-4-5P47K	1		
R 2, 3		RES,CF,20K,+-5%,0.25W	573444	80031	CR251-4-2P20K	2	1	
R 4		RES,CF,150,+-5%,0.25W	573030	80031	CR251-4-5P150E	1		
R 5, 6		RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF551003F	2		
R 7		RES,CF,100K,+-5%,0.25W	348920	80031	CR251-4-5P100K	1		
TP 1, 2		TERMINAL, TEST POINT	179283	88245	2010B-5	2		
U 1, 2, 6,	*	IC,CMOS,DUAL D F/F,+EDG TRIG	340117	02735	CD4013AE	9	1	
U 11, 12, 22,	*		340117					
U 32, 34, 35	*		340117					
U 3, 7, 21	*	IC,CMOS,HEX INVERTER	404681	02735	CD4069UBE	3	1	
U 4, 13, 37		RES,NET,DIP,16 PIN,8 RES,100K,+-5%	380618	89536	380618	3		
U 5	*	IC,CMOS,DUAL CMPLMNTRY FET PAIR + INV	408013	02735	CD4007AE	1	1	
U 8, 36	*	IC,CMOS,QUAD 2 INPUT NAND GATE	355198	04713	MC14011UBCP	2	1	
U 14, 15, 17	*	IC,ARRAY,5 TRANS,NPN,5 ISOLATED TRANS	380188	02735	CA3183E	3	1	
U 16, 26	*	IC,CMOS,QUAD 2 INPUT OR GATE	408393	02735	CD4071BE	2	1	
U 23, 38	*	IC,ARRAY,5 TRANS,NPN,SELECT IECO=40NA	477778	89536	477778	1		
U 25	*	IC,CMOS,QUAD 2 INPUT AND GATE	408401	02735	CD4081BE	1	1	
U 31	*	IC,CMOS,DIV BY 8 CNTR W/ 8DECODED OUT	403360	02735	CD4022AE	1		
U 33	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	02735	CD4023UBE	1	2	



CAUTION
SUBJECT TO DAMAGE BY
STATIC ELECTRICITY

MIS-1741

Figure 5-13. A10A2 Fast R² A/D Digital PCB Assembly

TABLE 5-14. A11 THERMAL TRUE-RMS CONVERTER ASSEMBLY
(SEE FIGURE 5-14.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
A 11		THERMAL TRUE-RMS CONVERTER ASSEMBLY	683938	89536	683938	1		1
A	*	A11A1 ATTENUATOR PCB ASSEMBLY				1		2
A	*	A11A2 AMPLIFIER PCB ASSEMBLY				1		2
H 1		SCREW,MACH,PHP,STL,6-32X1/4	152140	89536	152140	3		
H 2		SCREW,MACH,PHP,NYL,6-32X1/2	115006	89536	115006	1		
H 3		NUT, ALTERED	617944	89536	617944	1		
MP 1		SHIELD, AMPLIFIER	613596	89536	613596	1		
MP 2		CASE, THERMAL TRUE-RMS (MP2 - MP11)	656298	89536	656298	1		3
MP 3		GUARD,FRONT	656678	89536	656678	1		
MP 4		GUARD, REAR	576454	89536	576454	1		
MP 5		SHIELD,COVER	577007	89536	577007	1		
MP 6		DECAL, THERMAL TRUE RMS CONVERTER	640383	89536	640383	1		
MP 7		DECAL,CAUTION	454504	89536	454504	1		
MP 8		DECAL TRIM ADJUSTMENT	536011	89536	536011	1		
MP 9		COVER,MODULE CASE	402974	89536	402974	1		
MP 10		CASE HALF-MODIFIED	660241	89536	660241	1		
MP 11		CASE HALF EXTENDED,MODIFIED	656249	89536	656249	1		

NOTE 1 = A11A1 AND A11A2 ARE MATCHED ASSEMBLIES. ORDER P/N 683938 AND REPLACE COMPLETE A11 ASSEMBLY.

NOTE 2 = SELECT AT TEST

NOTE 3 = ORDER P/N 656298 FOR CASE ONLY, DOES NOT INCLUDE PCB BOARDS.

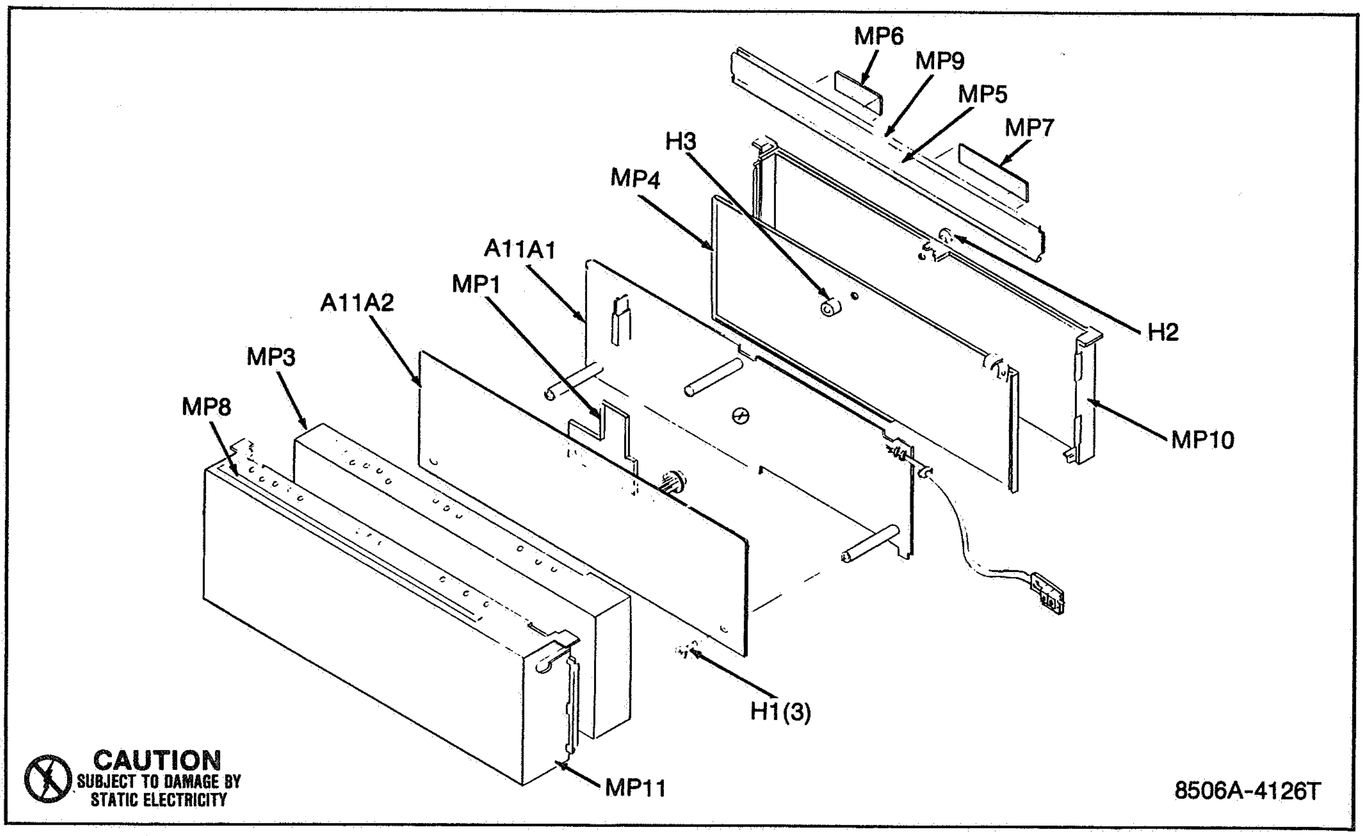


Figure 5-14. A11 Thermal True-RMS Converter PCB Assembly

TABLE 5-15. A11A1 ATTENUATOR PCB ASSEMBLY
(SEE FIGURE 5-15.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
C 1- 3		CAP,POLYES,0.22UF,+-10%,1200V	275495	89536	275495	3	1	
C 4		CAP,CER,0.05UF,+80-20%,500V,Z5U	105676	60705	565CBA501AU503ZA02	1		
C 5		CAP,PORC,36PF,+-0.36PF,1000V	614891	95275	VY10CA360FA	1		
C 6		CAP,PORC,6.2PF,+-0.25PF,1000V	603928	95275	VY10CA6R2CE	1		
C 7, 18, 25,		CAP,CER,27PF (SELECTED)	362749	89536	362749			
C 26			362749					
C 8, 15		CAP,VAR,0.8-10PF,250V,AIR	229930	91293	5201	2		1
C 9		CAP,PORC,3.9PF,+-0.25PF,1000V	603597	95275	VY10CA3R9CE	1		
C 10, 16		CAP,PORC,1.5PF,+-0.25PF,1000V	603589	95275	VY10CA1R5CE	2		
C 11		CAP,MICA,330PF,+-5%,500V	148445	72136	DM15E331J	1		
C 12		CAP,PORC,2.2PF,+-0.25PF,1000V	603936	95275	VY10CA2R2CE	1		
C 13, 20, 27		CAP,VAR,1-20PF,250V,AIR	603449	91293	5501	3		1
C 14		CAP,PORC,1.0PF,+-0.25PF,1000V	603571	95275	VY10CA1R0CE	1		
C 17		CAP,CER,47PF,+-2%,100V,COG	512368	89536	512368	1		
C 19		CAP,CER,100PF,+-2%,100V,COG	512848	51406	RPE121	1		
C 21		CAP,PORC,0.5PF,+-0.25PF,1000V	603514	95275	VY10CA0R5CE	1		
C 24		CAP,CER,220PF,+-2%,100V,COG	512111	89536	512111	1		
C 28		CAP,TA,39UF,+-20%,6V	163915	56289	196D394X0020KA1	1		
C 29, 30		CAP,TA,22UF,+-20%,15V	423012	56289	196D226X0015KA1	2		
C 31		CAP,CER,1.5PF,+-0.25PF,100V,COK	529909	89536	529909	1		
C 34		CAP,CER,56PF,+-2%,100V,COG	512970	89536	512970	1		
H 1		SCREW,MACH,PHP,S.STL,4-40X3/8	256164	89536	256164	1		
H 3		SCREW,MACH,PHP SEMS,STL,6-32X3/8	177022	89536	177022	2		
J 2, 3		SOCKET, CONNECTOR	352450	98291	51-051-0000	1		
K 1, 3, 4		RELAY,REED,1 FORM A,5VDC	603340	71707	3200-0056	3		
K 2, 5- 7		RELAY,REED,1 FORM A,4.5VDC	441949	71707	1240-0094	4		
MP 1		SHIELD, CAPACITOR	576371	89536	576371	1		
MP 3		SPRING,COIL	424465	89536	424465	1		
MP 4		SHIELD, PCB	656702	89536	656702	1		
MP 5		POST, CONNECTOR	267500	00779	87022-1	10		
MP 6		GROMMET	135269	89536	135269	1		
MP 7		SPACER, 0.187	335604	89536	335604	1		
MP 8		SPACER, 0.138	543652	89536	543652	3		
P 1		RIBBON CABLE, 10 CONDUCTOR	603886	89536	603886	1		
Q 1	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1	1	
R 1		RES,VAR,CERM,5K,+-20%,0.5W	267872	80294	3009P-1-502	1	1	
R 2		RES,VAR,CERM,100,+-20%,0.5W	267823	80294	3009P-1-101	1		
R 3		RES,VAR,CERM,1K,+-20%,0.5W	267856	80294	3009P-1-102	1		
R 4		RES,MF,237K,+-1%,0.125W,100PPM	288373	91637	CMF552373F	1		
R 5		RES,VAR,CERM,50K,+-10%,0.5W	330688	80294	3009P-1-503	1		
R 6		RES,CF,47K,+-5%,0.25W	348896	80031	CR251-4-5P47K	1		
R 7		RES,CF,150,+-5%,0.25W	343442	80031	CR251-4-5P150	1		
R 8, 9		RES,CF,1.5K,+-5%,0.25W	343418	80031	CR251-4-5P1K5	2		
R 10		RES,CF,510,+-5%,0.25W	441600	80031	CR251-4-5P510E	1		
R 11		RES,MF,49.9,+-1%,0.125W,100PPM	305896	91637	CMF5549R9F	1		
R 12		RES,CF,620,+-5%,0.25W	442319	80031	CR251-4-5P620E	1		
R 13		RES,VAR,CERM,5K,+-10%,0.5W	288282	89536	288282	1		
R 15		RES,MF,25.5K,+-1%,0.125W,100PPM	291377	91637	CMF552552F	1		
R 16		RES,VAR,CERM,200,+-10%,0.5W	285148	89536	285148	1		
R 17		RES,MF,11,+-1%,0.125W,100PPM	441204	91637	CMF5511R0F	1		
R 18		RES,MF,26.7K,+-1%,0.125W,100PPM	245779	91637	CMF552672F	1		
U 1	*	RES NETWORK ASSEMBLY	540641	89536	540641	1		
U 2	*	RES NETWORK ASSEMBLY	576025	89536	576025	1		
U 3		RES NETWORK ASSEMBLY	540799	89536	540799	1		
U 3	*	SWITCHING NETWORK HYBRID, TESTED	544361	89536	544361	1		
U 4	*	RES NETWORK ASSEMBLY	546796	89536	546796	1		
U 5, 6	*	SWITCHING NETWORK ASSEMBLY, TESTED	731984	89536	731984	2		
U 10, 11, 16,	*	IC,TTL,DUAL NAND DRIVER	604108	56289	UDN5712M	4	1	
U 18	*		604108					
U 12	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	02735	CD4023UBE	1		
U 13,104	*	IC,CMOS,QUAD D LATCH,W/XOR ENABLE	355149	02739	CD4042BE	2	1	
U 15	*	IC,CMOS,HEX INVERTER	404681	02735	CD4069UBE	1	1	
U 17	*	IC,CMOS,QUAD 2 INPUT NAND GATE	355198	04713	MC14011UBCP	1	1	
VR 1, 2	*	ZENER,UNCOMP, 7.5V, 5%, 20.0MA, 0.4W	256446	04713	1N755A	2		
W 1		CABLE, INPUT	577031	89536	577031	1		
W 2		CABLE, RIGID	612598	89536	612598	1		

NOTE 1 = THESE CAPACITORS ARE MATCHED ITEMS AND ARE INSTALLED AT THE TESTED LEVEL. THE HARDWARE THAT MAY BE SHIPPED WITH THESE CAPACITORS WILL NOT BE USED.

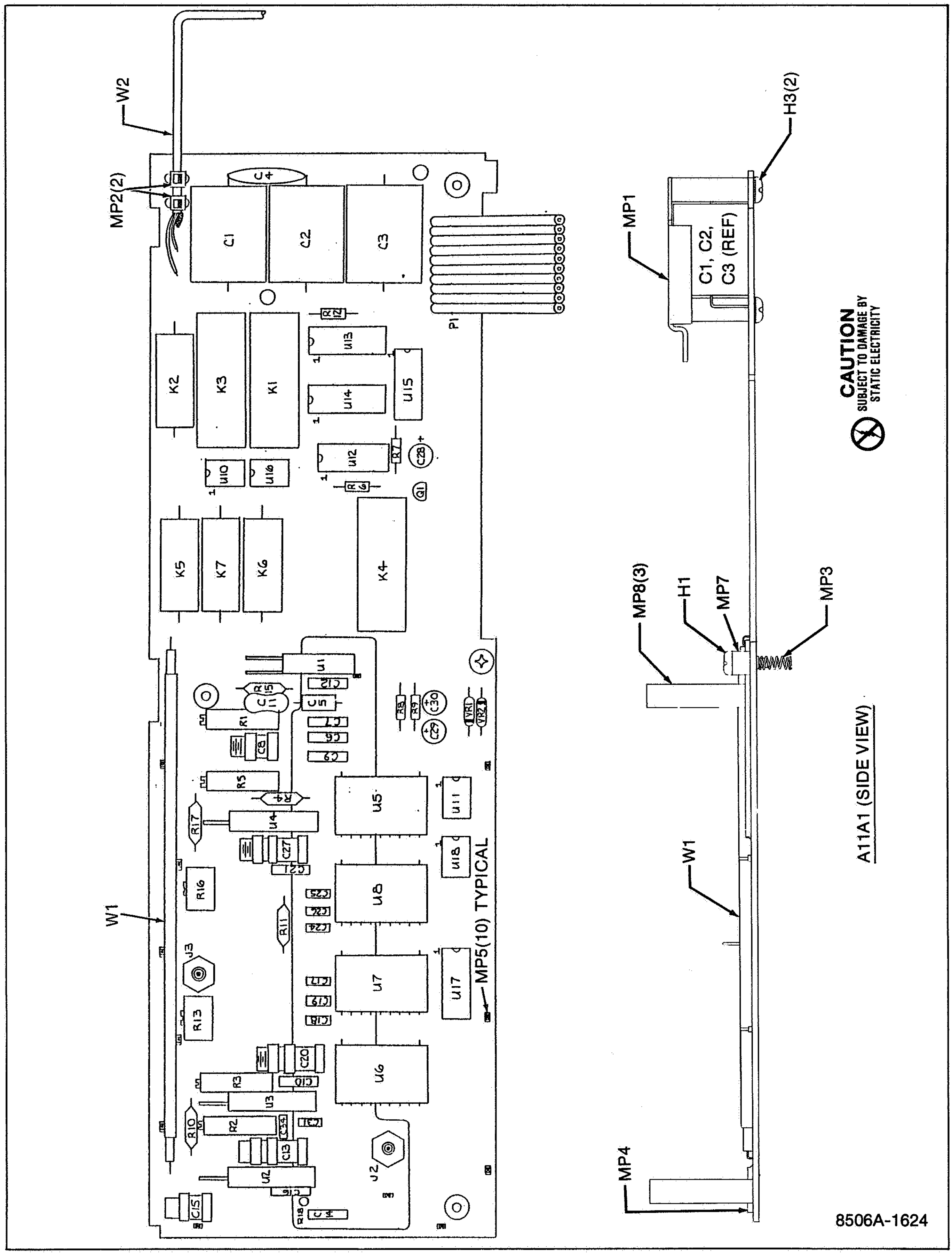


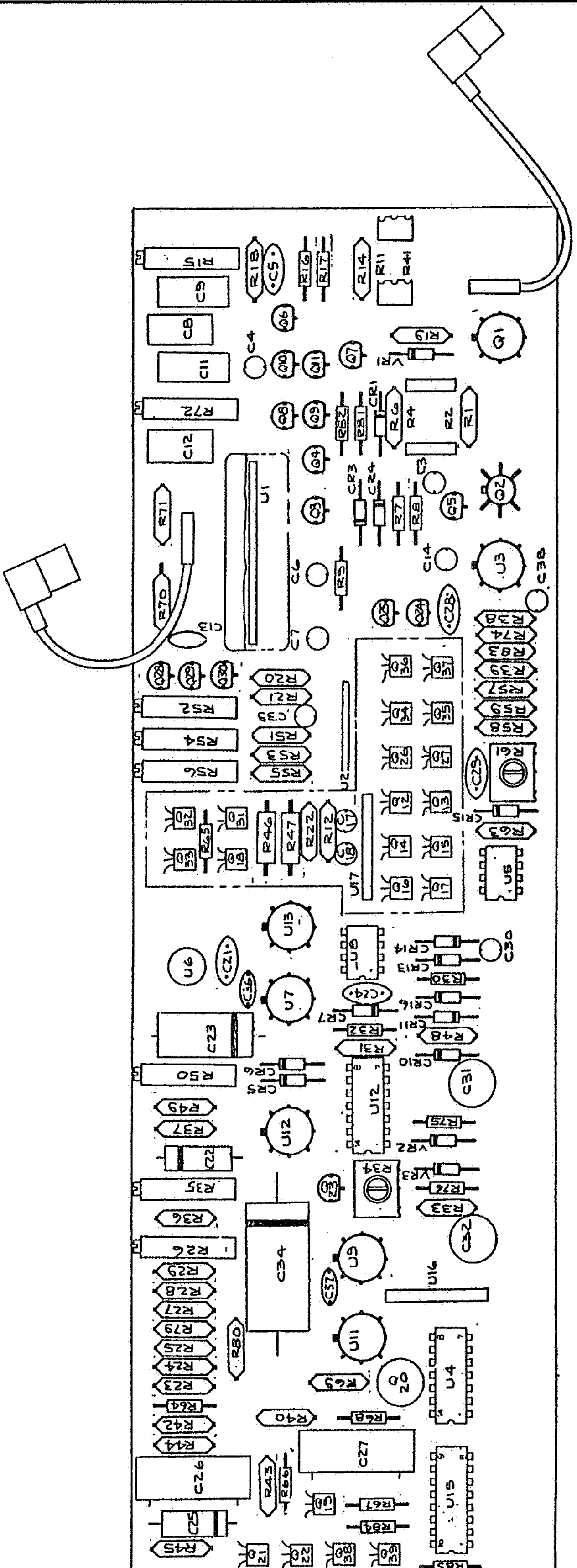
Figure 5-15. A11A1 Attenuator PCB Assembly

TABLE 5-16. A11A2 AMPLIFIER PCB ASSEMBLY
(SEE FIGURE 5-16.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
C 3, 4, 6,		CAP,TA,10UF,+-20%,20V	330662	56289	196D106X0020KA1	5		
C 7, 30			330662					
C 5		CAP,CER,0.05UF,+80-20%,25V,Y5U	148924	72982	5855-000-Y5U-503Z	1		
C 8, 12		CAP,VAR,0.35-3.5PF,250V,AIR	603456	91293	5801	2		
C 9		CAP,VAR,0.8-10PF,250V,AIR	229930	91293	5201	1		
C 10		CAP,CER,22PF,+-2%,100V,COG	512871	89536	512871	1		
C 11		CAP,VAR,1-20PF,250V,AIR	603449	91293	5501	1		
C 13		CAP,CER,4.7PF,+-0.25PF,100V,COH	362772	89536	362772	1		
C 14		CAP,TA,2.2UF,+-10%,15V	364216	56289	196D225X0015HA1	1		
C 17		CAP,CER,3.9PF,+-0.25PF,100V,COJ	512947	89536	512947	1		
C 18		CAP,CER,0.68PF,+-0.25PF,100V,M7J	485011	89536	485011	1		
C 21, 28, 29		CAP,CER,0.01UF,+80-20%,100V,Z5V	149153	59660	805-000-Z5V-103Z	3		
C 22, 25		CAP,POLYCA,0.15UF,+-5%,50V	343616	89636	343616	2		
C 23		CAP,POLYCA,1UF,+-10%,50V	271619	89536	271619	1		
C 24		CAP,CER,82PF,+-10%,500V,S3N	105585	59660	831-000-S3N0-820K	1		
C 26, 27		CAP,POLYST,0.01UF,+-2%,100V	168385	89536	168385	2		
C 31, 32		CAP,TA,39UF,+-20%,20V	358234	56289	196D396X0020PE4	2		
C 34		CAP,POLYPR,1.8UF,+-10%,100V	603548	14752	S910D1C185K	1		
C 36, 38		CAP,CER,33PF,+-2%,100V,COG	513226	89536	513226	2		
C 38		CAP,CER,1200PF,+-20%,100V,X7R	358283	72982	8121-A100-W5R-122M	1		
C 39		CAP,CER,39PF,+-2%,100V,COG	512962	89536	512962	1		
CR 1, 5- 7,	*	DIODE,SI,BV= 75.0V,IO=150MA,500 MW	203323	07910	1N4448	9	1	
CR 10, 11, 13,	*		203323					
CR 14, 16	*		203323					
CR 3, 4	*	DIODE,SI,BV= 20.0V,IO= 50MA,250 MW	375907	07263	FD7223	2	1	
CR 15	*	DIODE,SI,HOT CARRIER,HI-SPEED SWITCH	256339	28480	5082-2900	1	2	
H 1		SCREW,MACH,PHP,S.STL,2-56X3/8	379214	89536	379214	2		
J 1		SOCKET, IN-LINE, 10 POS. (NOT SHOWN)	477661	00779	583773-1	1		
MP 1		COVER, ASSEMBLY	613521	89536	613521	1		
MP 2		SPACER, ALTERNATE	613604	89536	613604	2		
MP 3		SUPPORT,RESISTOR (NOT SHOWN)	545079	89536	545079	2		
MP 4		SPACER,RND,(NOT SHOWN)	296319	32559	T0806	12		
Q 1	*	TRANSISTOR,SI,N-JFET,DUAL,TO-78	495036	89536	495036	1	1	
Q 2	*	TRANSISTOR,SI,PNP,DUAL,TO-71	453829	32293	ITS31042	1	1	
Q 4	*	TRANSISTOR MATCHED	630814	89536	630814	1	1	
Q 5	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	225599	07263	2N4250	1	1	
Q 6, 7	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	333898	89536	333898	2	1	
Q 8- 11, 21	*	TRANSISTOR,SI,N-JFET,TO-92	343830	12040	NSSF50024	5	1	
Q 12- 16, 17,	*	TRANSISTOR,SI,N-JFET,REMOTE CUTOFF	429977	89536	429977	13	1	
Q 26, 27, 30,	*		429977					
Q 34- 37	*		429977					
Q 18, 19	*	TRANSISITOR,FET,MATCHED PAIR (Q18,Q19	265744	89536	265744	2	3	
Q 20	*	TRANSISTOR,SI,N-JFET,TO-72	328237	89536	328237	1		
Q 22	*	TRANSISTOR,SI,N-JFET,HI-VOLTAGE,TO-92	393314	89536	393314	1		
Q 23, 32, 38	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	3	1	
Q 24	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	330803	07263	MPS6560	1	1	
Q 25	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	418707	04713	MPS56562	1	1	
Q 28, 31	*	TRANSISTOR,SI,N-JFET,TO-92,SWITCH	261578	27014	NSSF51148	2	1	
Q 29	*	TRANSISTOR,SI,N-JFET,TO-92	535039	89536	535039	1	1	
Q 33, 39	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	64713	2N3906	2	1	
R 1, 6		RES,MF,787,+-1%,0.125W,25PPM	459909	91637	CMF557870F	2		
R 2- 4, 11,		RES,MF,37.4 SELECTED	714501	89536	714501			
R 24, 28, 41			714501					
R 7		RES,CF,510,+-5%,0.25W	441600	80031	CR251-4-5P510E	1	1	
R 8, 9		RES,CF,33,+-5%,0.25W	414524	80031	CR251-4-5P330E	2		
R 11, 41		RES,MF,20,+-1%,0.125W,100PPM	236844	91637	CMF550200F	2	1	
R 12		RES,MF,200K,+-1%,0.125W,100PPM	261701	91637	CMF552003F	1		
R 14		RES,MF,976,+-1%,0.125W,50PPM	320341	91637	CMF559760F	1		
R 15, 26		RES,VAR,CERM,20K,+-20%,0.5W	267898	80294	3009P-1-203	2		
R 16, 17		RES,CF,100,+-5%,0.25W	348771	80031	CR251-4-5P100E	2		
R 18		RES,MF,1.58K,+-1%,0.125W,50PPM	385344	91637	CMF551581F	1		
R 19, 33		RES,MF,8.06K,+-1%,0.125W,100PPM	294942	91637	CMF558061F	2		
R 20, 21		RES,MF,10K,+-1%,0.125W,100PPM	168260	91637	CMF551002F	2		
R 22		RES,MF,40.2K,+-1%,0.125W,100PPM	235333	91637	CMF554022F	1		
R 23, 29		RES,MF,250K,+-0.25%,0.125W,50PPM	340141	91637	CMF552503C	2		
R 25, 27		RES,MF,383K,+-1%,0.125W,100PPM	288498	91637	CMF553833F	2		
R 30		RES,MF,357K,+-1%,0.125W,100PPM	235002	91637	CMF553573F	1		
R 31		RES,MF,20K,+-1%,0.125W,100PPM	291872	91637	CMF552002F	1		
R 32		RES,CF,2.2K,+-5%,0.25W	343400	80031	CR251-4-5P2K2	1		
R 34		RES,VAR,CERM,10K,+-10%,0.5W	309674	89536	309674	1		
R 35		RES,VAR,CERM,2K,+-20%,0.5W	267864	80294	3009P-1-202	1		
R 36		RES,MF,13.7K,+-1%,0.125W,100PPM	236752	91637	CMF551372F	1		
R 37		RES,MF,2.8K,+-1%,0.125W,100PPM	325670	91637	CMF552801F	1		
R 38, 39, 65-		RES,CC,10M,+-5%,0.25W	194944	01121	CB1065	6		

TABLE 5-16. A11A2 AMPLIFIER PCB ASSEMBLY
(SEE FIGURE 5-16.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
R 68			194944					
R 40, 44		RES,MF,2K,+-1%,0.125W,100PPM	235226	91637	CMF552001F	2		
R 42		RES,MF,178K,+-1%,0.125W,25PPM	312769	91637	CMF551783F	1		
R 43		RES,MF,1M,+-1%,0.125W,25PPM	460535	91637	CMF551004F	1		
R 45		RES,MF,39.2K,+-1%,0.125W,100PPM	236414	91637	CMF553922F	1		
R 46, 47		RES,CC,510,+-5%,0.5W	108951	01121	RC20GF511JS	2		
R 48		RES,MF,24.9,+-1%,0.125W,100PPM	296657	91637	CMF5524R9F	1		
R 49		RES,MF,499K,+-1%,0.125W,100PPM	268813	91637	CMF554993F	1		
R 50		RES,VAR,CERM,200K,+-20%,0.5W	381509	80294	3009P-1-204	1		
R 51		RES,MF,127K,+-1%,0.125W,100PPM	291328	91637	CMF551273F	1		
R 52		RES,VAR,CERM,50K,+-10%,0.5W	330688	80294	3009P-1-503	1		
R 53		RES,MF,137.04K,+-0.1%,0.125W,50PPM	404046	89536	404046	1		
R 54, 56		RES,VAR,CERM,25K,+-20%,0.5W	285213	80294	3009P-1-253	2		
R 55		RES,MF,64.9K,+-1%,0.125W,25PPM	312694	91637	CMF556492F	1		
R 57, 59		RES,MF,20.5K,+-1%,0.125W,100PPM	261669	91637	CMF552052F	2		
R 58		RES,MF,110K,+-1%,0.125W,100PPM	234708	91637	CMF551103F	1		
R 61		RES,VAR,CERM,2K,+-10%,0.5W	309666	89536	309666	1		
R 63		RES,MF,169K,+-1%,0.125W,100PPM	289454	91637	CMF551693F	1		
R 64, 84, 85		RES,CF,100K,+-5%,0.25W	348920	80031	CR251-4-5P100K	3		
R 69		RES,MF,60.4K,+-1%,0.125W,100PPM	291419	91637	CMF556042F	1		
R 70, 74, 83		RES,MF,10K,+-1%,0.125W,50PPM	291633	91637	CMF551002F	3		
R 71		RES,MF,499,+-1%,0.125W,50PPM	289256	91637	CMF554990F	1		
R 72		RES,VAR,CERM,50,+-20%,0.5W	267815	80294	3009P-1-500	1		
R 75		RES,CF,15K,+-5%,0.25W	348854	80031	CR251-4-5P15K	1		
R 76		RES,CF,470,+-5%,0.25W	343434	80031	CR251-4-5P470E	1		
R 79		RES,MF,38.3K,+-1%,0.125W,100PPM	241372	91637	CMF553832F	1		
R 80		RES,MF,2.49K,+-1%,0.125W,100PPM	226209	91637	CMF552491F	1		
R 81, 82		RES,CC,4700M,+-10%,0.25W	603530	01121	RC07GF478KS	2		
TP 1- 7		CONNECTOR, TEST POINT	512889	02660	62395	7		
U 1	*	AMPL OUTPUT HYBRID,TESTED	539759	89536	539759	1		
U 2	*	RES NET TESTED-PREC AC DIV.--8502-100	541953	89536	541953	1		
U 3	*	IC,OP AMP,SELECTED VOLTAGE FOLLOWER	288365	12040	LM310H	1		
U 4	*	IC,BIPLR,5CHNL HI-VOLT DISPLAY DRIVER	504795	56289	UPH-480	1	1	
U 5, 8	*	IC,OP AMP,SELECTED GBW 600KHZ	418566	12040	LM358N	2	1	
U 6		400 OHM RMS SENSOR	521625	89536	521625	1	1	
U 7, 9	*	IC,OP AMP,GEN PURPOSE,TO-78 METAL CAN	288928	12040	LM308AH	2	1	
U 10	*	IC,ARRAY,5 TRANS,NPN,3 ISO,2 DIFF CON	248906	12040	LM3046N	1		
U 11	*	IC,OP AMP,SELECTED LO-NOISE,JFET IN	385450	12040	SH29467	1	1	
U 12	*	IC,OP AMP,SELECTED 2 UV P-P NOISE	381962	12040	SH61140	1	1	
U 13	*	IC,OP AMP,LO-NOISE,TO-99,METAL CAN	741066	89536	741066	1		
U 15	*	IC,BIPLR,7CHNL HI-VOLT DISPLAY DRIVER	504894	56289	UPH481	1	1	
U 16		RES,NET,SIP,8 PIN,7 RES,100K,+-2%	412908	89536	412908	1	1	
U 17		RES,NET,SIP,8 PIN,4 RES,1M,+-2%	603498	89536	603498	1	1	
VR 1	*	ZENER,COMP, 6.4V, 5%, 5 PPM TC, 1.0MA	330829	07910	1N4571	1	1	
VR 2	*	ZENER,UNCOMP, 5.6V, 5%, 20.0MA, 0.4W	277236	07910	1N752A	1	1	
VR 3	*	ZENER,UNCOMP, 13.0V, 5%, 9.5MA, 0.4W	110726	04713	1N964B	1	1	
W 2, 3		CABLE ASSY,AMPLIFIER	577023	89536	577023	2		
XJ 11, 41		SOCKET,3-PIN, (W/R11,R41)	402958	27264	10-18-2031	1		
XR 2, 4		SOCKET, 4-PIN (W/R2,R3,R4,R5)	417311	30035	SS-109-1-04	2		
XU 6		SOCKET,TRANS,10 PIN	714386	91506	8059-2G	1		



8506A-1625

Figure 5-16. A11A2 Amplifier PCB Assembly

Section 6
Option & Accessory Information

TABLE OF CONTENTS

NOTE

Option -08A is standard equipment on the 8506A.

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.

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.

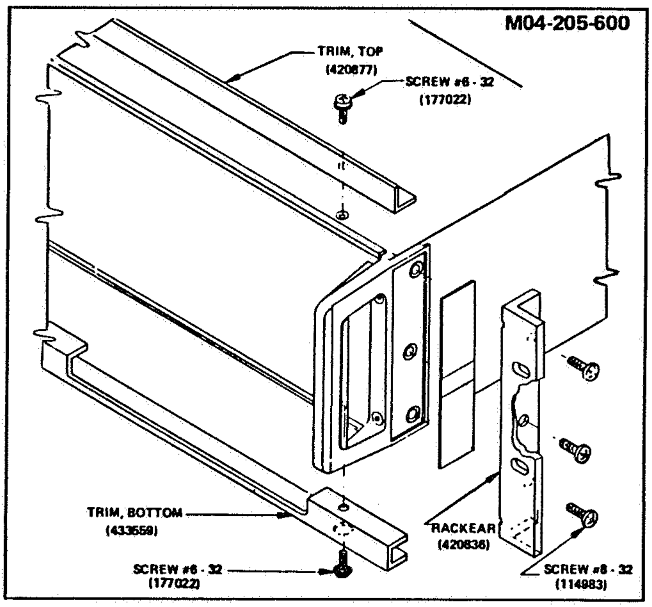


Figure 600-1. Rack Ear Mounting Installation

Option -02A
Ohms Converter

602A-1. INTRODUCTION

602A-2. Installation of the Ohms Converter provides precision resistance measurement capability. Both two-terminal and four-terminal measurements may be made.

602A-3. SPECIFICATIONS

602A-4. Table 602A-1 lists the specifications for the Ohms Converter.

602A-5. INSTALLATION

602A-6. 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.

602A-7. OPERATING NOTES

602A-8. 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 602A-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.

602A-9. 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 10Ω range and push the ZERO VDC/OHMS button. This zero value is then applied to the selected range (10Ω) and all higher ranges. 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.

602A-10. 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 (Appendix 7B) 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.

602A-11. GUARDING

602A-12. The ohms guard connection is only available through the rear input connector. Figure 602A-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 shunt resistance across high Rx 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 602A-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.

602A-13. THEORY OF OPERATION

602A-14. 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

Table 602A-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 602A-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

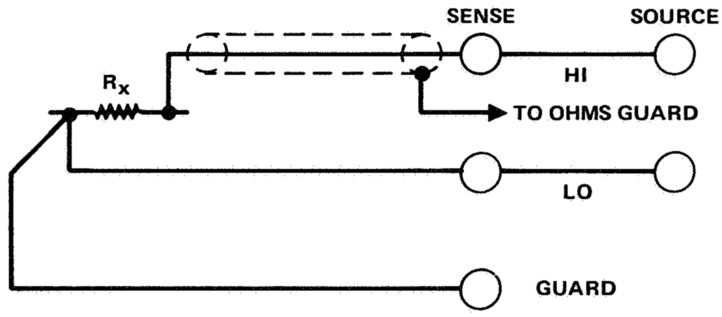
MEASUREMENT CONFIGURATION .. Two-wire and four-wire available on all ranges.

MAXIMUM OVERLOAD VOLTAGE .. ±400V dc or peak ac continuous on any range with no damage.

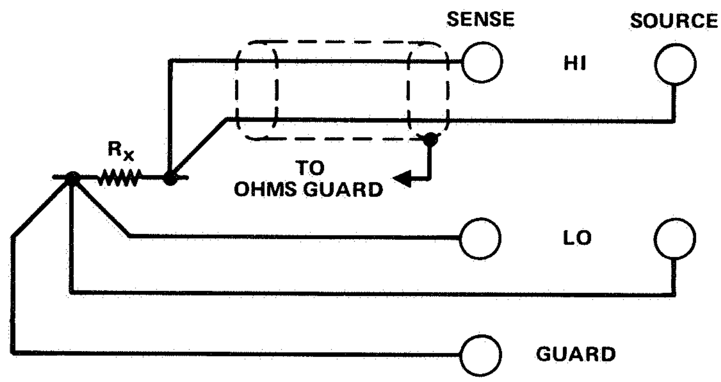
RESPONSE TIME

Analog Settling Time .... 80 ms with Fast Filter or 800 ms with Slow Filter to rated accuracy.

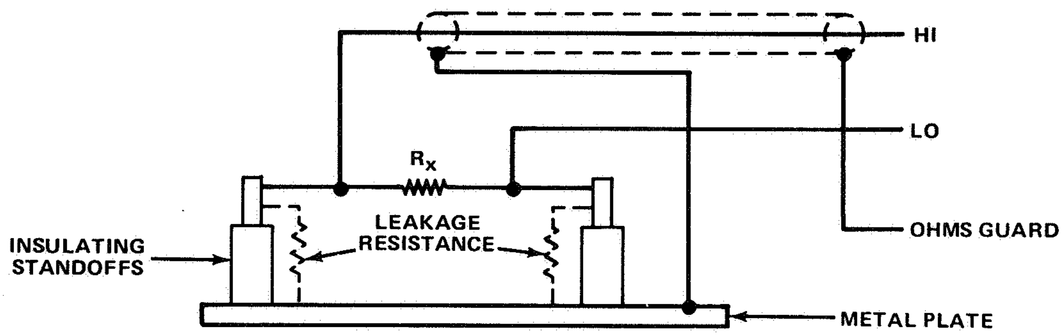
Digitizing Time .... Depending on sample rate and filter selection the digitizing time will vary from 145 ms to 9 minutes 6 seconds using a 60 Hz ac line with times increasing 20% using a 50 Hz ac line.



TWO TERMINAL OHMS MEASUREMENT CONNECTIONS TO MAXIMIZE THE EFFECTIVENESS OF THE GUARDS



FOUR TERMINAL OHMS MEASUREMENT CONNECTIONS TO MAXIMIZE THE EFFECTIVENESS OF THE GUARDS



OHMS GUARD IS AVAILABLE ONLY THROUGH THE REAR INPUT CONNECTOR

Figure 602A-1. Ohms Measurement Connections And Guarding

applied through a reference resistor, RREF, to the summing node of the amplifier. By definition of an ideal operational amplifier, the current through Rx is the same current flowing through RREF (the summing node represents virtual ground). Figure 602A-2 is a simplified schematic of the Ohms Converter and contains an illustration of the derivation of the formula for Rx. A current flowing through RREF equals $(V_1-V_2)/R_{REF}$. Using the expression for current to obtain the value of Rx:

$$R_x = R_{REF}\,\frac{V_0}{(V_1-V_2)}$$

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.

602A-15. 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.

602A-16. Rx is the feedback element for the operational amplifier composed of Q9 and U5. U5 drives Q37 which serves as a higher current source. This arrangement also allows a larger output voltage swing. Note that Q9 and U5 are configured as an inverter, yet the output of U5 is a positive voltage. Q37 draws its emitter current through R48 and R49 from the -30V supply with CR18 and CR13 ensuring that Q37 need not be in a state of saturation. 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 VREF is measured. The factor of 8 is preserved by assigning RREF the value of 8 x R41 in the equation. As the Ohms Converter downranges, R41 remains enabled so lower RREF 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.

602A-17. 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 -3V (with respect to circuit common) are clamped to ground by Q14, CR17, Q10, and Q39. 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, clocking U3 while placing a high on the ID3 line. This opens relay K1 and removes the input voltages from the module. The high from U5 also inhibits the ACK logic so an Error 4 is displayed. CR13 and CR14 at the output of Q9, U5 are high voltage blocking diodes. E1 is a spark gap preventing voltages in excess of 400V between the guard shield and circuit common.

602A-18. The Ohms Converter is addressed by IC1, 2, 3 high, and 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.

602A-19. MAINTENANCE

602A-20. Performance Test

602A-21. 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 10Ω 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 602A-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.

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)

602A-22. Calibration

602A-23. Use the following procedure for hardware calibration of the Ohms Converter.

1. Allow for a two hour warm-up, then ensure that dc volts accuracy is within tolerance.

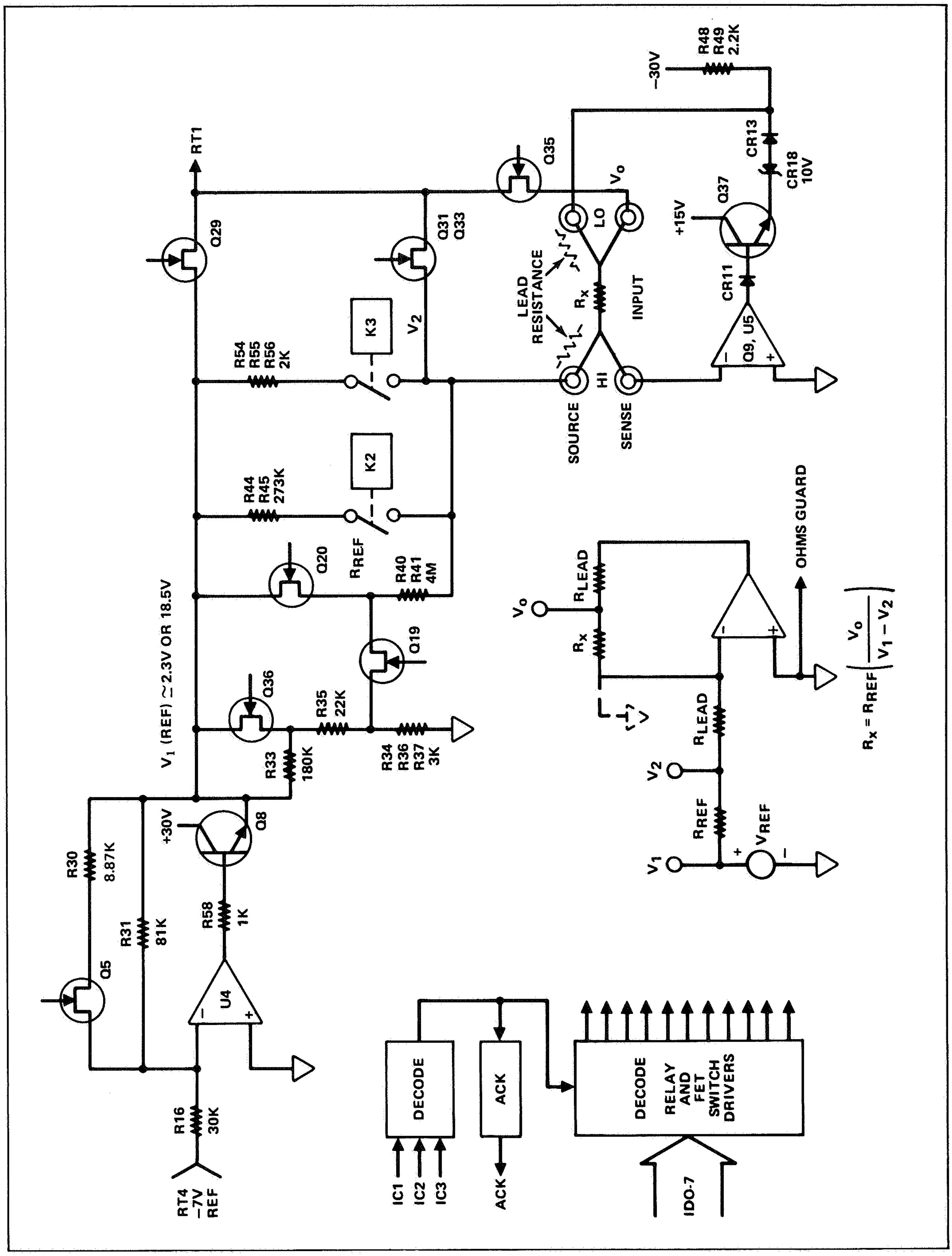


Figure 602A-2. Ohms Converter

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 10Ω 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 MΩ standard resistor.

NOTE

Refer to Table 4-1 of the Instruction Manual for specifications on the Standard Resistors.

10. Adjust R40 for a reading between 3.99998 (+6) and 4.00002 (+6).

11. Select the 100 MΩ range and connect the input leads to a 100 MΩ standard resistor.

12. Adjust R37 for a reading between 99.995 (+6) and 100.005 (+6).

13. Select the 100 kΩ range and connect the input leads to a 250 kΩ standard resistor.

14. Adjust R44 for a reading between 249.998 (+3) and 250.002 (+3).

15. Select the 1 kΩ range and connect the input leads to a 1.9 kΩ standard resistor.

16. Adjust R54 for a reading between 1.89998 (+3) and 1.90002 (+3).

17. Disable the Calibration mode (Calibration Switch to off).

Table 602-3. Calibration Tests

Resistance Standard	Readings		
	Minimum	Nominal	Maximum
10	9.9989	10.0000	10.0011
100	99.997	100.000	100.003
1k	0.99997 (+3)	1.00000 (+3)	1.00003 (+3)
10k	9.9997 (+3)	10.0000 (+3)	10.0003 (+3)
100k	99.997 (+3)	100.000 (+3)	100.003 (+3)
1M	0.99997 (+6)	1.00000 (+6)	1.00003 (+6)
10M	9.9989 (+6)	10.0000 (+6)	10.0011 (+6)
100M	99.969 (+6)	100.000 (+6)	100.031 (+6)

18. 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.

19. With Zero mode on, perform the standard resistor tests in Table 602A-3. There are no adjustments for these readings. If any reading exceeds the listed tolerance, the module is faulty.

602A-24. TROUBLESHOOTING

602A-25. Troubleshooting procedures for the Ohms Converter follow the format used for the mainframe instrument. Table 602A-4, Failure Isolation, assures that the problem is in the Ohms Converter. Table 605A-5 lists symptoms and possible failures in the order of probability. Figure 602A-3 shows timing relationships. Tables 602A-6 through 602A-8 give additional troubleshooting procedures.

602A-26. Always remove power before removing or installing a module.

602A-27. PARTS LIST

602A-28. Table 602A-9 is a parts breakdown for the Ohms Converter. Refer to Section 5 of this manual for ordering and use code information.

Table 602A-4. Failure Isolation

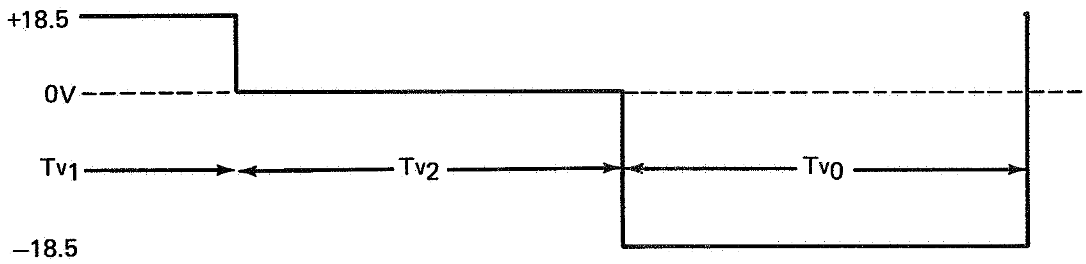
STEP NO.	ACTION	Go to the step number given for correct response: YES	NO
1	Perform DC Volts test (Section 4). Is DC Volts within tolerance?	2	Section 4
2	Perform Ohms test. Is Ohms within tolerance?	Section 4	3
3	Remove all optional modules except Isolator and Ohms converter.		
4	Is Ohms now within tolerance?	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; VA2 = –14.25 to –15.75V; VA3 = +29 to 32V VA4 = –29 to –32V; Vcc = –15V, Vss = –20V (Difference = 4.9 to 5.2) RT4 = –6.993 to –7.007		
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 602A-5. Symptom Analysis

SYMPTOM	POSSIBLE FAILURE
No Ohms Readings (V_0)	U5, Q9, Q35, Digital Logic
(V_1)	U4, Q8, Q29 Digital Logic & Drivers
Ohms Zero Drift	U5, Q9
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, U5
100M Noisy, 30M High	Q10, K3 Shorted
1K, 100K, 10M, 100M Ranges Bad	Q5, Q4
100M Range Bad	Q20, Q22, Q19 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
DC SIGNAL CONDITIONER	
Slew Rates Bad	Q37, Q38, Q19, U3, U5, U6

Note: If Q9, Q19, U5, R19, R20, R21, R23, R25, or R26 are replaced it is necessary to return the module to the factory (Attn: Parts) for temperature compensation.

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 602A-3. Timing

Table 602A-6. Voltage Measurements

Range	Full Scale	V* TP2	R ref	1 ref* (Source HI)	V_0* (Range Value)	V_1* (TP1)	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 602A-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 602A-8. Address and Data Coding

ADDRESS IC1, 2, 3 HIGH									
Range	V	IDϕ	ID1	ID2	ID3	ID4	ID5	ID6	ID7
10	V_ϕ	0	1	1	0	0	1	1	0
	V_1	1	0	1	0	0	1	1	0
	V_2	1	1	0	0	0	1	1	0
100	V_ϕ	0	1	1	0	0	1	1	0
	V_1	1	0	1	0	0	1	1	0
	V_2	1	1	0	0	0	1	1	0
1K	V_ϕ	0	1	1	0	1	1	1	0
	V_1	1	0	1	0	1	1	1	0
	V_2	1	1	0	0	1	1	1	0
10K	V_ϕ	0	1	1	0	0	0	1	1
	V_1	1	0	1	0	0	0	1	1
	V_2	1	1	0	0	0	0	1	1
100K	V_ϕ	0	1	1	0	1	0	1	1
	V_1	1	0	1	0	1	0	1	1
	V_2	1	1	0	0	1	0	1	1
1M	V_ϕ	0	1	1	0	0	1	1	1
	V_1	1	0	1	0	0	1	1	1
10M	V_ϕ	0	1	1	0	1	1	1	1
	V_1	1	0	1	0	1	1	1	1
100M	V_ϕ	0	1	1	0	1	1	0	1
	V_1	1	0	1	0	1	1	0	1
OHMS		1	1	1	1	1	1	1	1

TABLE 602A-9. OHMS CONVERTER PCB ASSEMBLY
(SEE FIGURE 602A-4.)

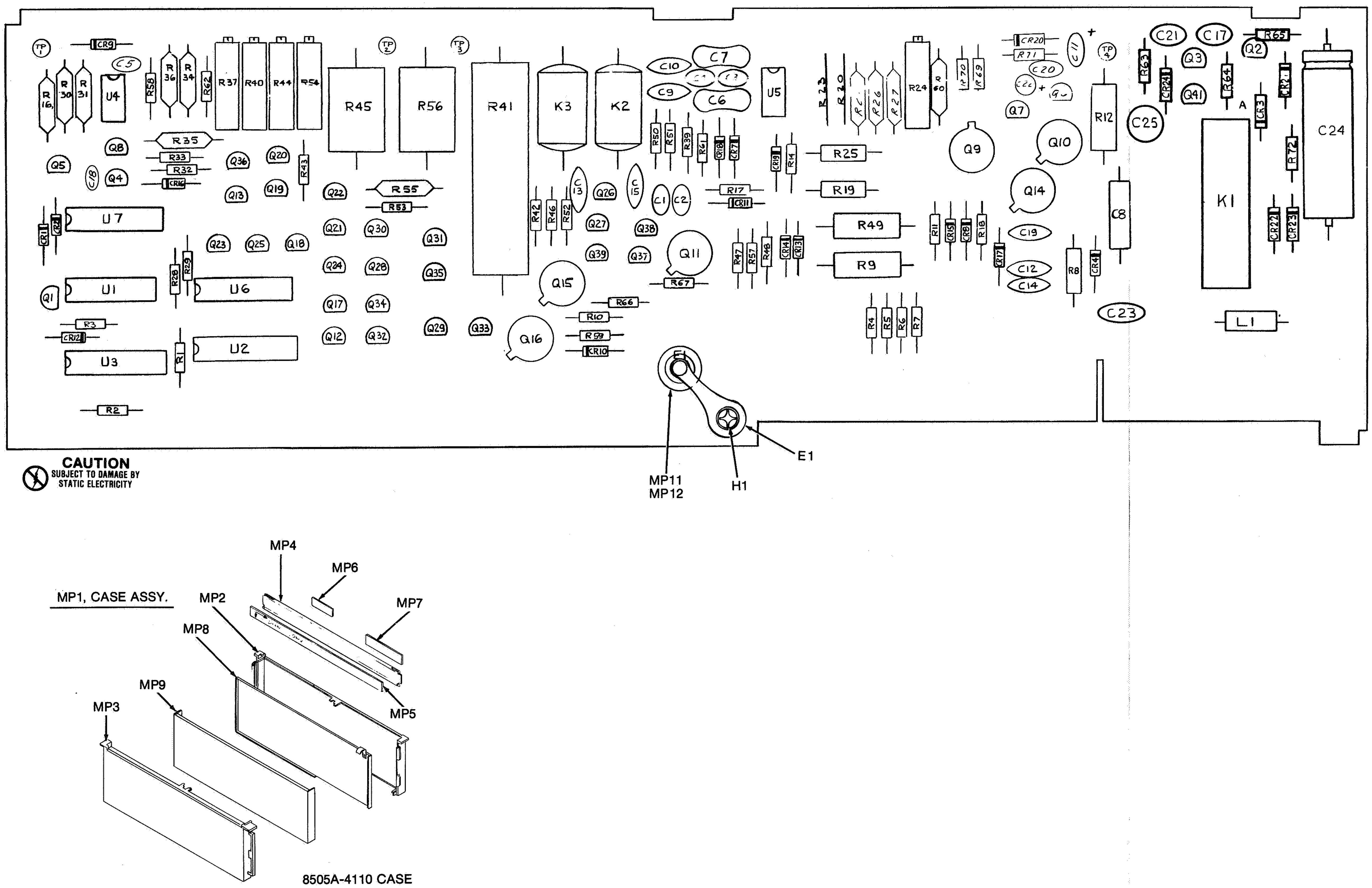
REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
C 1- 4		CAP,TA,6.8UF,+-20%,35V	363713	56289	196D685X0035KA1	4		
C 5		CAP,CER,33PF,+-2%,50V,COG	354852	72982	8121-A100-COG-330G	1		
C 6, 7		CAP,CER,1200PF,+-20%,100V,X7R	358283	72982	8121-A100-W5R-122M	2		
C 8		CAP,POLYST,100PF,+-10%,500V	446609	89536	446609	1		
C 9, 10, 12-		CAP,CER,0.01UF,+80-20%,100V,Z5V	149153	56289	C023B101F103M	7		
C 15, 19			149153					
C 11		CAP,TA,22UF,+-20%,15V	423012	56289	196D226X0015KA1	1		
C 17, 21		CAP,TA,4.7UF,+-20%,25V	161943	56289	196D475X0025KA1	2		
C 18		CAP,TA,0.47UF,+-20%,35V	161349	56349	196D474X0035HA1	1		
C 20		CAP,CER,0.0022UF,+-10%,500V,Z5R	268425	32897	851000Z5R222K	1		
C 22		CAP,TA,0.33UF,+-20%,35V	408690	56289	196D334X0035HA1	1		
C 23		CAP,CER,0.22UF,+-20%,50V,Z5U	309849	71590	CW3COC224K	1		
C 24		CAP,AL,220UF,+50-10%,25V	369181	89536	369181	1		
C 24		CAP,AL,33UF,+-20%,25V	715250	89536	715250	1		
CR 1- 3, 11,	*	DIODE,SI,BV= 75.0V,IO=150MA,500 MW	203323	07910	1N4448	9		
CR 16, 20, 21,	*		203323					
CR 23, 24	*		203323					
CR 4, 7, 8,	*	DIODE,SI, 800 PIV, 1.0 AMP	428144	01295	1N4006	7	1	
CR 13, 14, 15,	*		428144					
CR 17	*		428144					
CR 9, 18	*	ZENER,UNCOMP, 10.0V,10%, 12.5MA, 0.4W	113324	07910	1N961A	2	2	
CR 10, 12	*	DIODE,SI,MULTI-PELLET	375485	09214	MPD300	2		
CR 19	*	DIODE,SI,2 PELLET,BV= 20.0V,400 MW	375477	09214	MPD200	1	1	
CR 22	*	ZENER,UNCOMP, 13.0V, 5%, 9.5MA, 0.4W	110726	04713	1N964B	1	1	
E 1		SURGE PROT,450V,+-10%	442723	25088	B1-C145	1		
H 1		SCREW,MACH,PHP,S.STL,4-40X5/8	413062	89536	413062	1		
K 1		RELAY,ARMATURE,4 FORM C,5V,LATCH	715078	89536	715078	1		
K 2, 3		RELAY,REED,1 FORM A,4.5V	772285	89536	772285	2	1	
L 1		INDUCTOR,100UH,+/-5%,12 MHZ,SHLDED	174755	89536	174755	1		
MP 1		MODULE CASE (INCLUDES MP2-MP9)	651885	89536	651885	1		2
MP 2, 3		CASE HALF, MODULE	402990	89536	402990	2		2
MP 4		COVER, MODULE CASE	402974	89536	402974	1		2
MP 5		SHIELD, COVER	411942	89536	411942	1		2
MP 6		DECAL, OHMS CONVERTER	650572	89536	650572	1		2
MP 7		DECAL, CAUTION	454504	89536	454504	1		2
MP 8		GUARD, REAR	383364	89536	383364	1		2
MP 9		GUARD, FRONT	383356	89536	383356	1		2
MP 10		SPRING,COIL,COMP,SQUARED END,M WIRE	424465	89536	424465	1		
MP 11		SPACER,SWAGED,RND,BRASS,4-40X0.437	442913	89536	442913	1		
MP 12		LUG	103531	77963	501	1		
Q 1	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1	1	
Q 2, 4, 8,	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	14	2	
Q 13, 18, 22,	*		218396					
Q 23, 25, 27,	*		218396					
Q 28, 30, 32,	*		218396					
Q 34, 37	*		218396					
Q 3, 12, 17,	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	64713	2N3906	7		
Q 21, 24, 26,	*		195974					
Q 28	*		195974					
Q 5, 19, 20,	*	TRANSISTOR,SI,N-JFET,TO-92,SWITCH	261578	15818	U2366J	4	1	1
Q 36	*		261578					1
Q 6, 7, 39	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	168716	07263	S19254	3	3	
Q 9	*	N-CHANNEL JUNCTION RO-120-SELECTED	476309	89536	476309	1		1
Q 10, 11, 14-	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	203489	09214	11C2322	5	1	
Q 16	*		203489					
Q 29, 31, 33,	*	TRANSISTOR,SI,N-JFET,HI-VOLTAGE,TO-92	393314	17856	5T3824	4	1	
Q 35	*		393314					
Q 41	*	TRANSISTOR,SI,PNP,SM SIG,DARLINGTON	524140	04713	MPS-A63	1	1	
R 1, 3, 10,		RES,CF,20K,+-5%,0.25W	573444	80031	CR251-4-2P20K	7		
R 11, 14, 42,			573444					
R 59			573444					
R 2, 4- 7,		RES,CF,150,+-5%,0.25W	573030	80031	CR251-4-5P150E	6	1	
R 52			573030					
R 8		RES,CC,220K,+-5%,0.5W	109025	01121	EB2245	1	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 16		RES,MF,30.1K,+-1%,0.125W,25PPM	293431	91637	CMF553012F	1		
R 17, 18, 32,		RES,CF,1M,+-5%,0.25W	573691	80031	CR251-4-5P1M	6		
R 43, 53, 57			573691					
R 19, 25		RES,WW,40K,+-0.1%,0.125W	271403	89536	271403	2		1
R 20, 23		WIRE,BUS,22 AWG,TINNED COPPER	115469	89536	115469	2		1
R 21, 26		RES,MF,10,+-1%,0.125W,100PPM	268789	91637	CMF5510R0F	2		1
R 24		RES,VAR,CERM,100,+-20%,0.5W	267823	11236	190PC101B	1		
R 27		RES,MF,20K,+-1%,0.125W,100PPM	291872	91637	CMF552002F	1		

TABLE 602A-9. OHMS CONVERTER PCB ASSEMBLY
(SEE FIGURE 602A-4.)

REFERENCE DESIGNATOR A->NUMERICS--->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
R 28		RES,CF,39K,+-5%,0.25W	442400	80031	CR251-4-5P39K	1		
R 29		RES, CF, 39K, +-5%, 0.25W	573501	89536	573501	1		
R 30		RES,MF,8.87K,+-1%,0.125W,100PPM	294967	91637	CMF558871F	1		
R 31		RES,MF,80.6K,+-1%,0.125W,25PPM	312710	91637	CMF558062F	1		
R 33		RES,CF,180K,+-5%,0.25W	348946	80031	CR251-4-5P180K	1		
R 34		RES,MF,3.16K,+-0.1%,0.125W,25PPM	340588	91637	CMF553161F	1		
R 35		RES,MF,21.5K,+-0.1%,0.125W,25PPM	344440	91637	CMF552152F	1	1	
R 36		RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF551003F	1		
R 37, 54		RES,VAR,CERM,50K,+-10%,0.5W	330688	75378	190PC503B	2		
R 39		RES,CF,1.6K,+-5%,0.25W	348805	80031	CR251-4-5P1K6	1		
R 40		RES,VAR,CERM,10K,+-20%,0.5W	267880	75378	190PC103B	1		
R 41		WIRE WOUND RESISTOR 4.091 M	412205	89536	412205	1	1	
R 44		RES,VAR,CERM,500,+-20%,0.5W	267849	11236	190PC501B	1		
R 45		272.85K(	412197	89536	412197	1	2	
R 46, 64, 65		RES,CF,3.3K,+-5%,0.25W	573287	80031	CR251-4-5P3K3	3		
R 47, 61, 62,		RES,CF,120K,+-5%,0.25W	573592	89536	573592	4		
R 66			573592					
R 48, 71		RES,CF,470,+-5%,0.25W	573121	80031	CR251-4-5P470E	2		
R 50, 51		RES,CF,2.7K,+-5%,0.25W	573261	80031	CR251-4-5P2K7	2		
R 55		RES,MF,174K,+-1%,0.125W,25PPM	706424	89536	706424	1		
R 56		RES WW HERM 1/2W 2.021K	790634	89536	790634	1	1	
R 58, 63, 67,		RES,CF,1K,+-5%,0.25W	573170	80031	CR251-4-5P1K	5	1	
R 72			573170					
R 60		RES,MF,1M,+-1%,0.125W,100PPM	268797	91637	CMF551004F	1		
R 69		RES,CF,300,+-5%,0.25W	643502	80031	CR251-4-5P300E	1		
R 70		RES,CF,200K,+-5%,0.25W	573634	80031	CR251-4-5P200K	1		
‡TP 1- 4		TERM,UNINSUL,FEEDTHRU,HOLE,TURRET	179283	88245	2010B-5	4	1	
U 1	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	02735	CD4023UBE	1		
U 2, 3	*	IC,CMOS,QUAD D LATCH,W/XOR ENABLE	355149	02739	CD4042AE	2	1	
U 4	*	IC,OP AMP,GEN PURPOSE,8 PIN DIP	363515	12040	LM301AN	1	1	
U 5	*	IC,OP AMP,SELECTED GBW 600KHZ	418566	12040	LM358N	1		
‡XR 20, 21, 23,		SOCKET,SINGLE,PWB,FOR 0.022-0.025 PIN	343285	00779	2-331272-6	8		
‡XR 26			343285					
Z 6, 7		RES,NET,DIP,16 PIN,8 RES,100K,+-5%	380618	89536	380618	2	1	

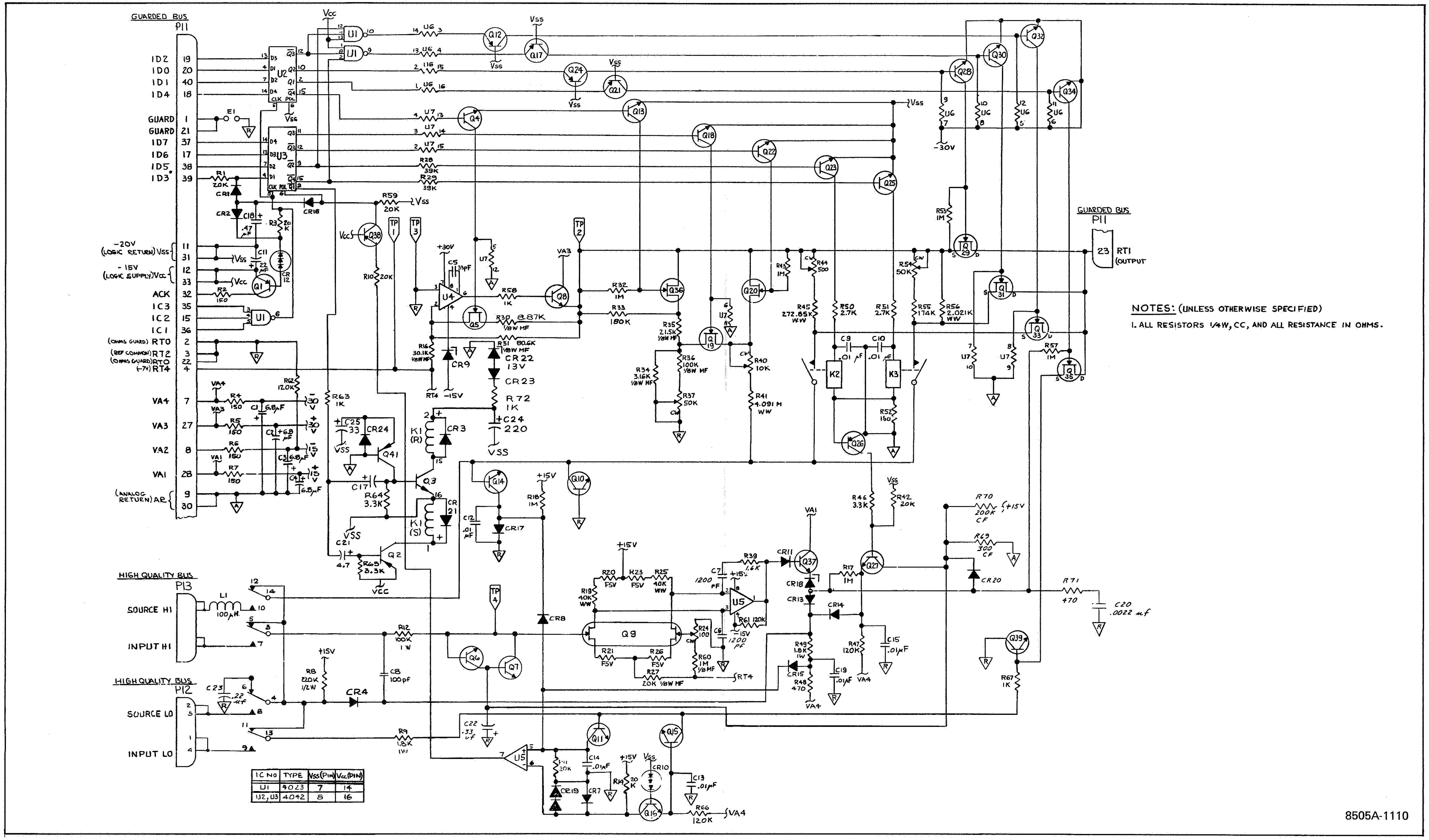
NOTE 1 = IF Q9,Q19,U5,R19,R20,R21,R25 OR R26 ARE REPLACED, IT IS NECESSARY TO RETURN THE MODULE TO THE FACTORY (ATTN: PARTS DEPT.) FOR TEMPERATURE COMPENSATION.

NOTE 2 = ORDER P/N 458927 FOR MODULE CASE WITHOUT PCB ASSEMBLY.



MIS-1710

Figure 602A-4. Ohms Converter PCB Assembly



IC NO	TYPE	Vss(PIN)	Vcc(PIN)
U1	4023	7	14
U2, U3	4042	8	16

Figure 602A-9. Ohms Converter PCB Assembly (cont)

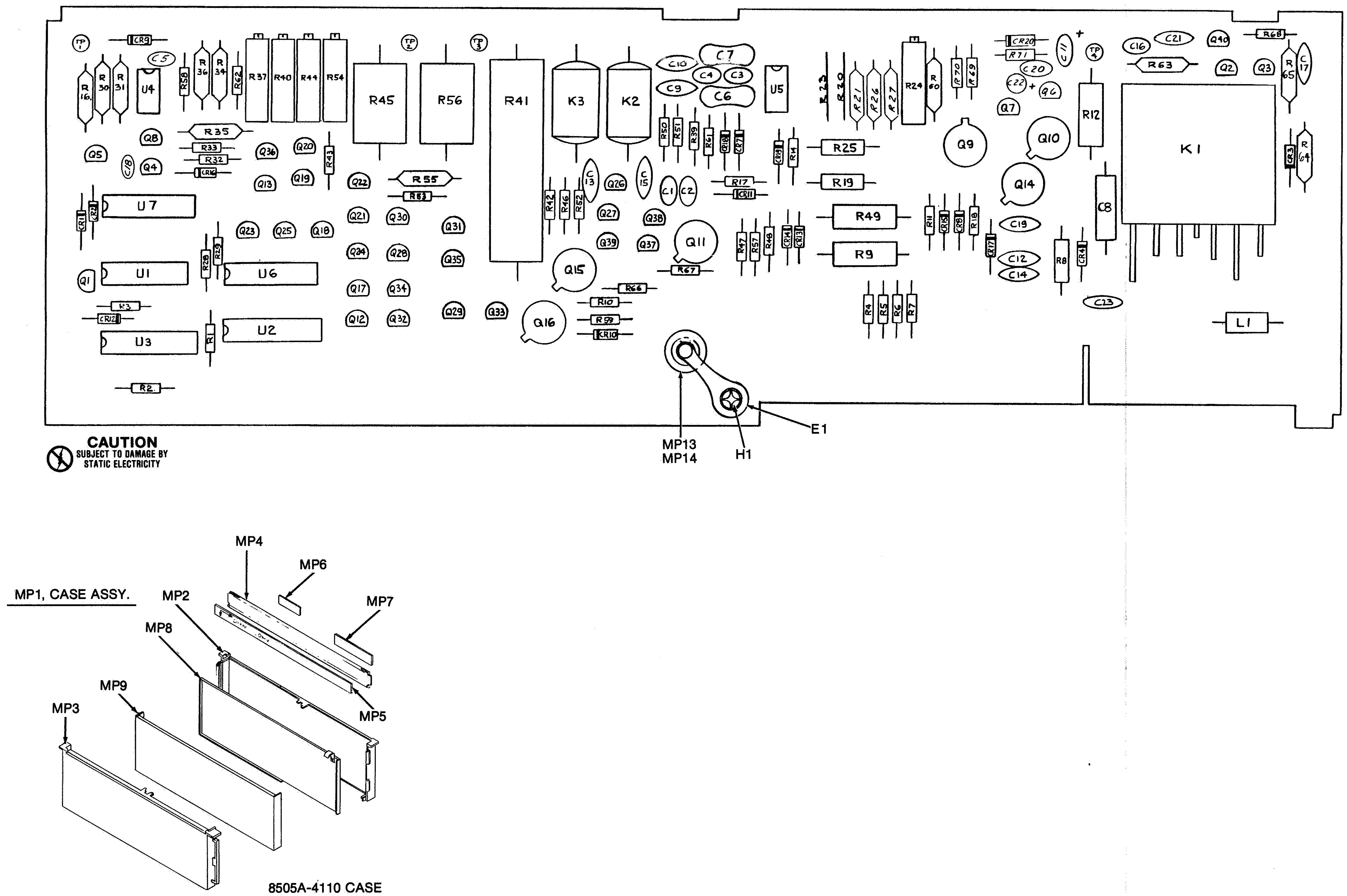


Figure 602A-4. Ohms Converter PCB Assembly

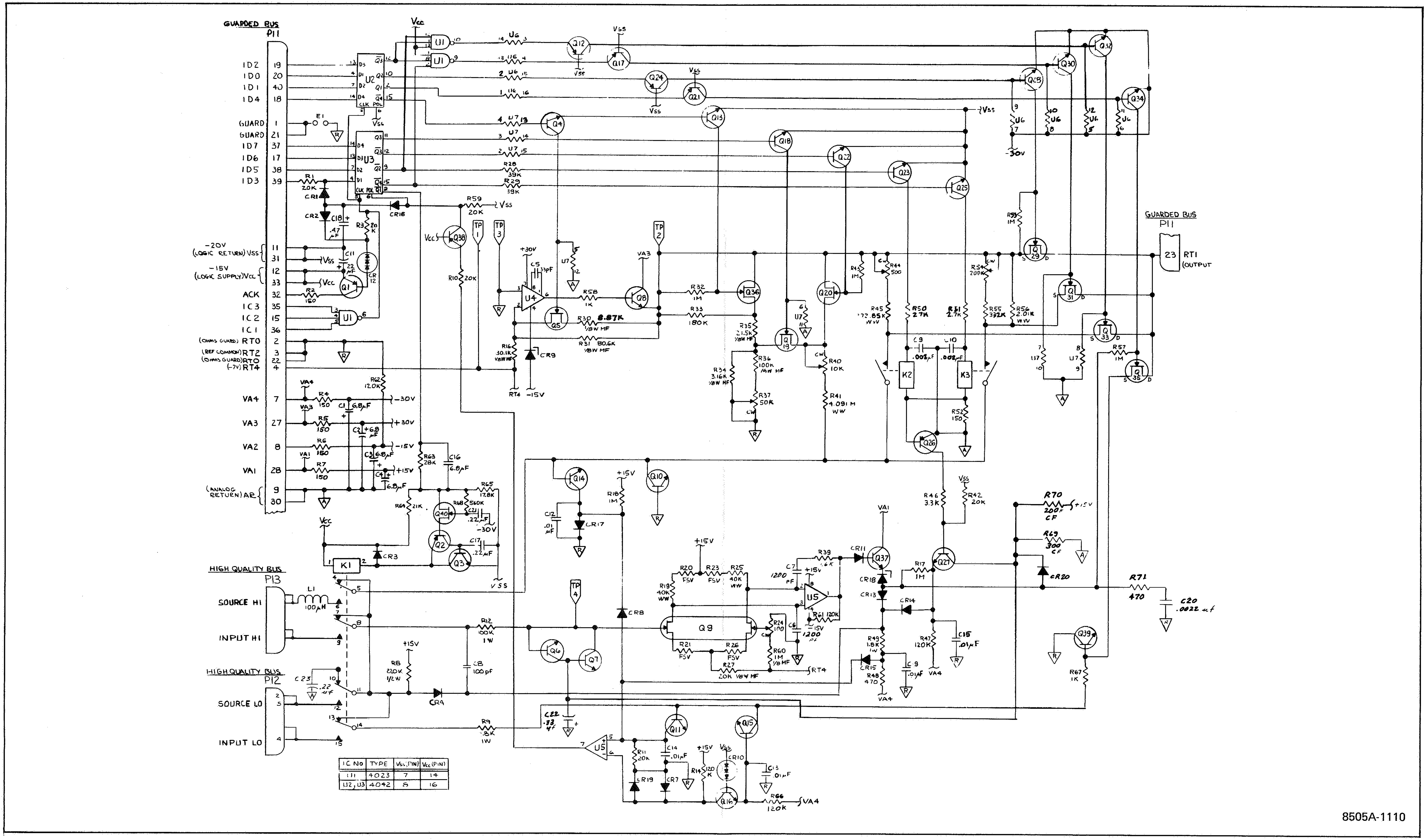


Figure 602A-9. Ohms Converter PCB Assembly (cont)

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 $4.5 \times \sqrt{\text{I range / I input}}$

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:

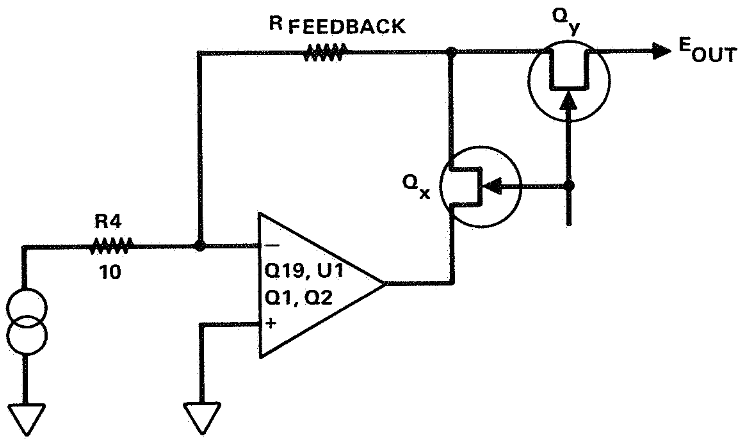
[1]For Source Resistance less than specified replace the Number of Counts in the dc Accuracy specification with the following:

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:

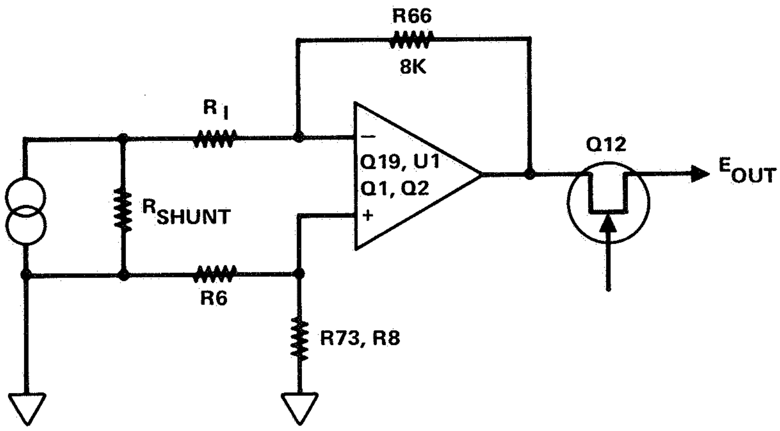
RANGE	NUMBER OF COUNTS /°C*
100 μA	0.5 x (1 + 8 kΩ/Rs)
1 mA	0.5 x (1 + 1 kΩ/Rs)
10 mA	0.5 x (1 + 125Ω/Rs)
*With 5½ digit display. For 6½ digits, multiply Number of Counts by 10.	

[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 1 mA 10 mA	R30, R31 R33, R34 R36, R37	Q30 Q7 Q9	Q31 Q10 Q8	K3, K4 K3, K4 K3, K4	.8 V 1.0 V 1.25 V



MODE B 100 mA, 1A

RANGE	R_{SHUNT}	R_I	RELAYS	FET SWITCHES	FULL SCALE E_{OUT}
100 mA 1 A	R2, R1 R1	R7, R70, R71 R7, R68, R69	K1, K3 K2, K3	Q20, Q32, Q29, Q12 Q20, Q29, Q28, Q12	1.6V 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 +/-5%, 1/4W	34344[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)

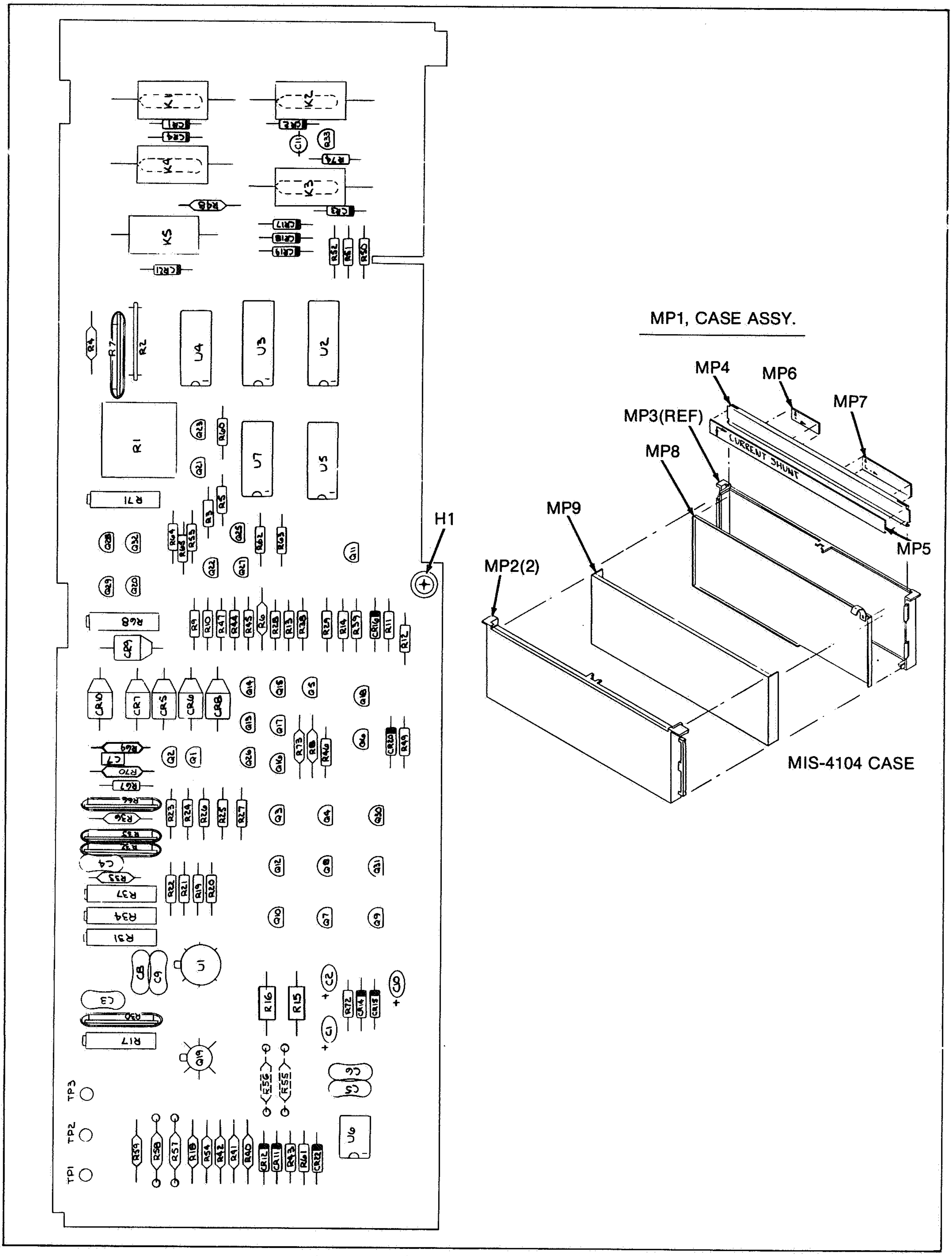
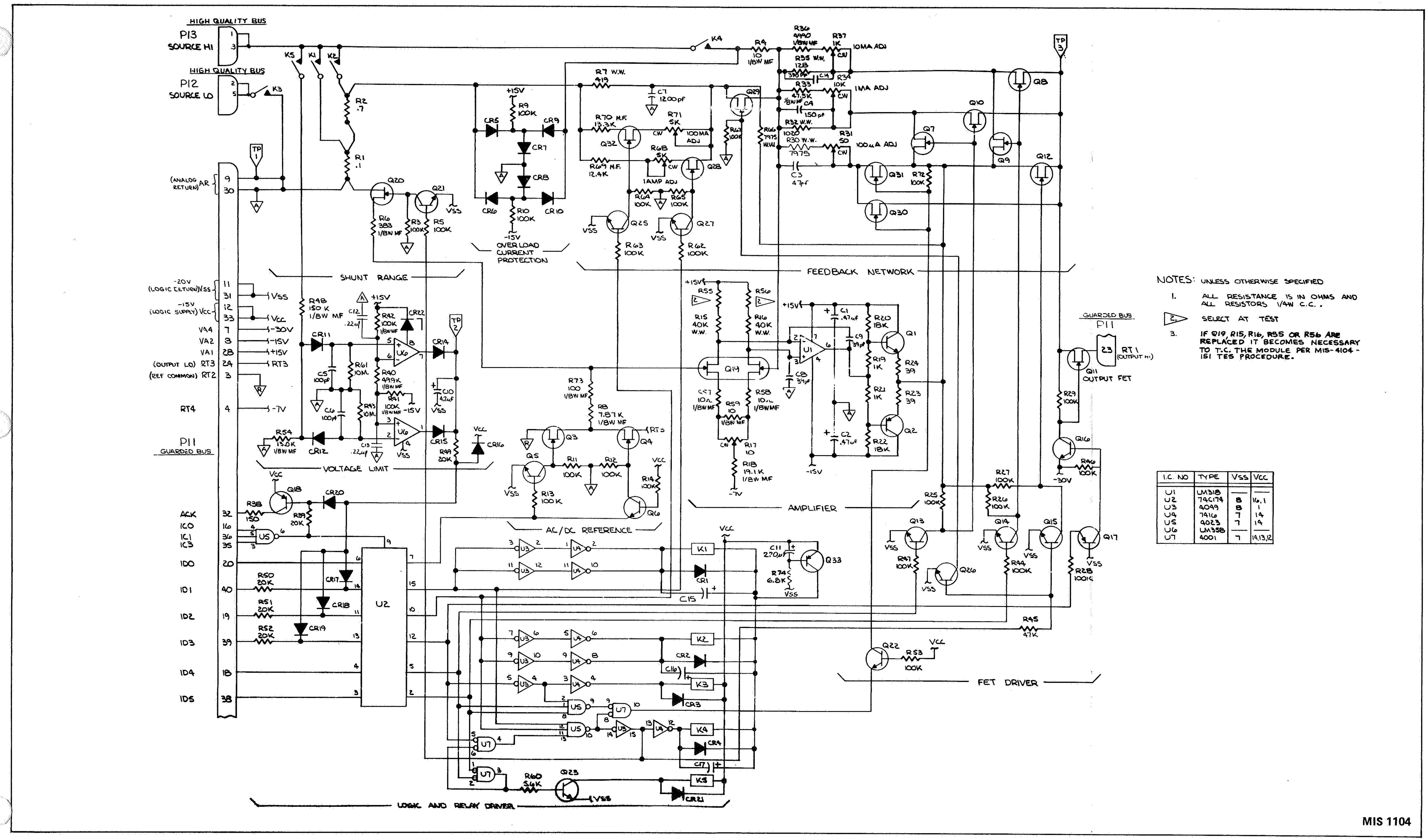


Figure 603-3. Current Shunts Assembly



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCE IS IN OHMS AND ALL RESISTORS 1/4W C.C..
2. SELECT AT TEST
3. IF Q19, R15, R16, R55 OR R56 ARE REPLACED IT BECOMES NECESSARY TO T.C. THE MODULE PER MIS-4104-151 TES PROCEDURE.

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	14,13,12

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

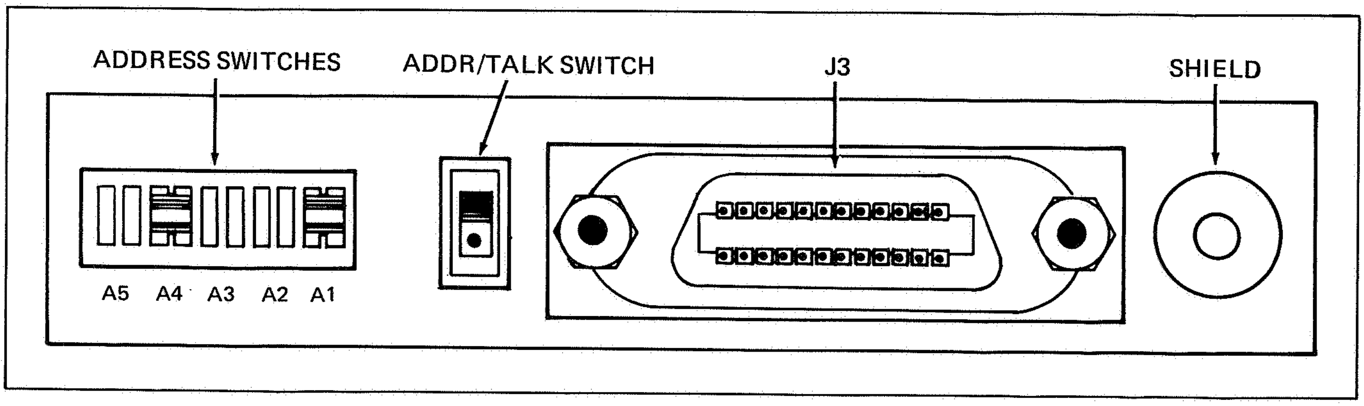


Figure 605-1. Rear Panel Access

Table 605-2. Allowable Listen and Talk Addresses

DECIMAL	5 4 3 2 1 BINARY	ASCII CHARACTER		DECIMAL	5 4 3 2 1 BINARY	ASCII CHARACTER	
		LISTEN	TALK			LISTEN	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.

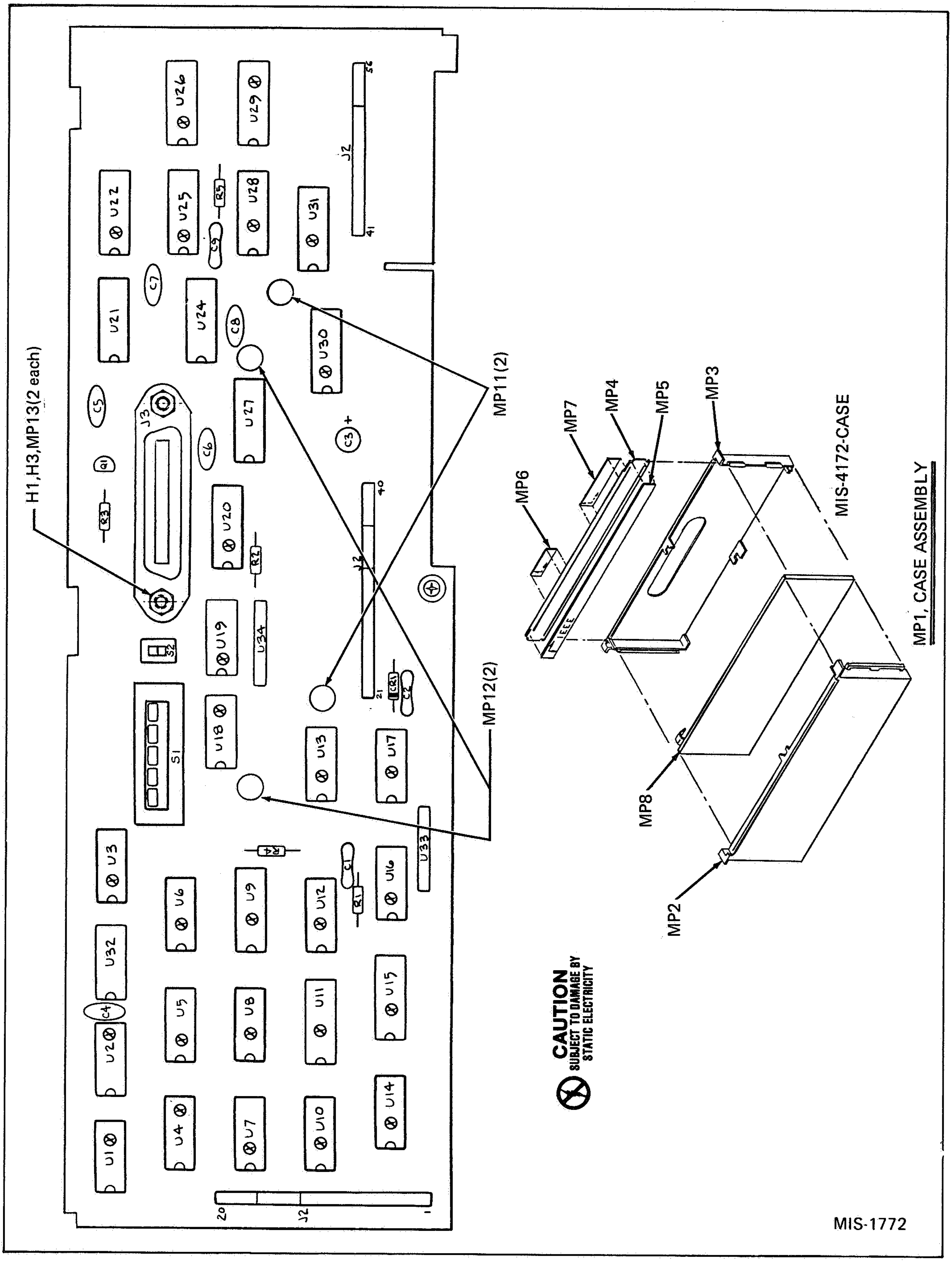
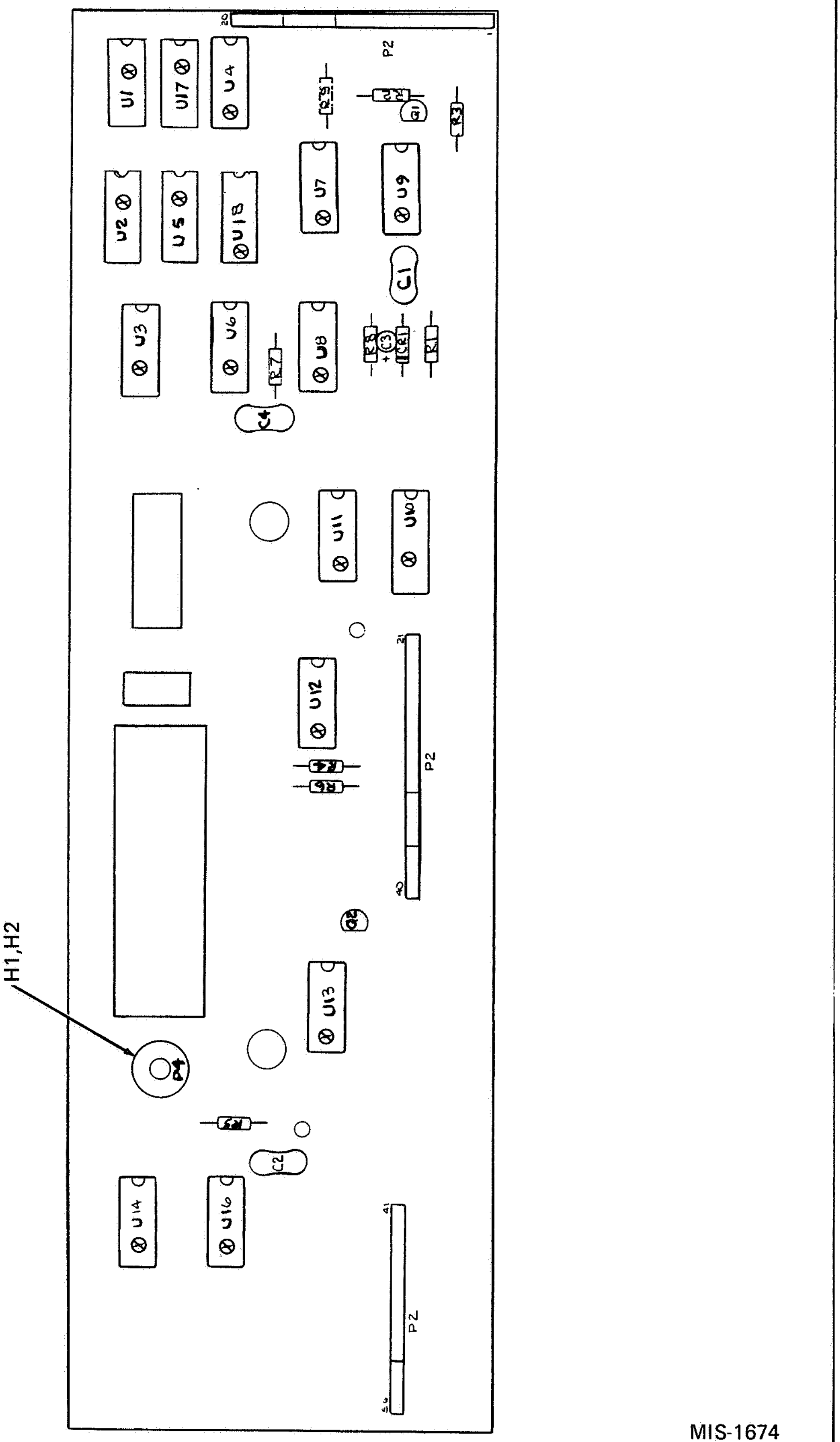


Figure 605-2. IEEE 488-1975 Interface PCB Assembly

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		



CAUTION
SUBJECT TO DAMAGE BY STATIC ELECTRICITY

Figure 605-3. IEEE 488-1975 Piggy Back PCB Assembly

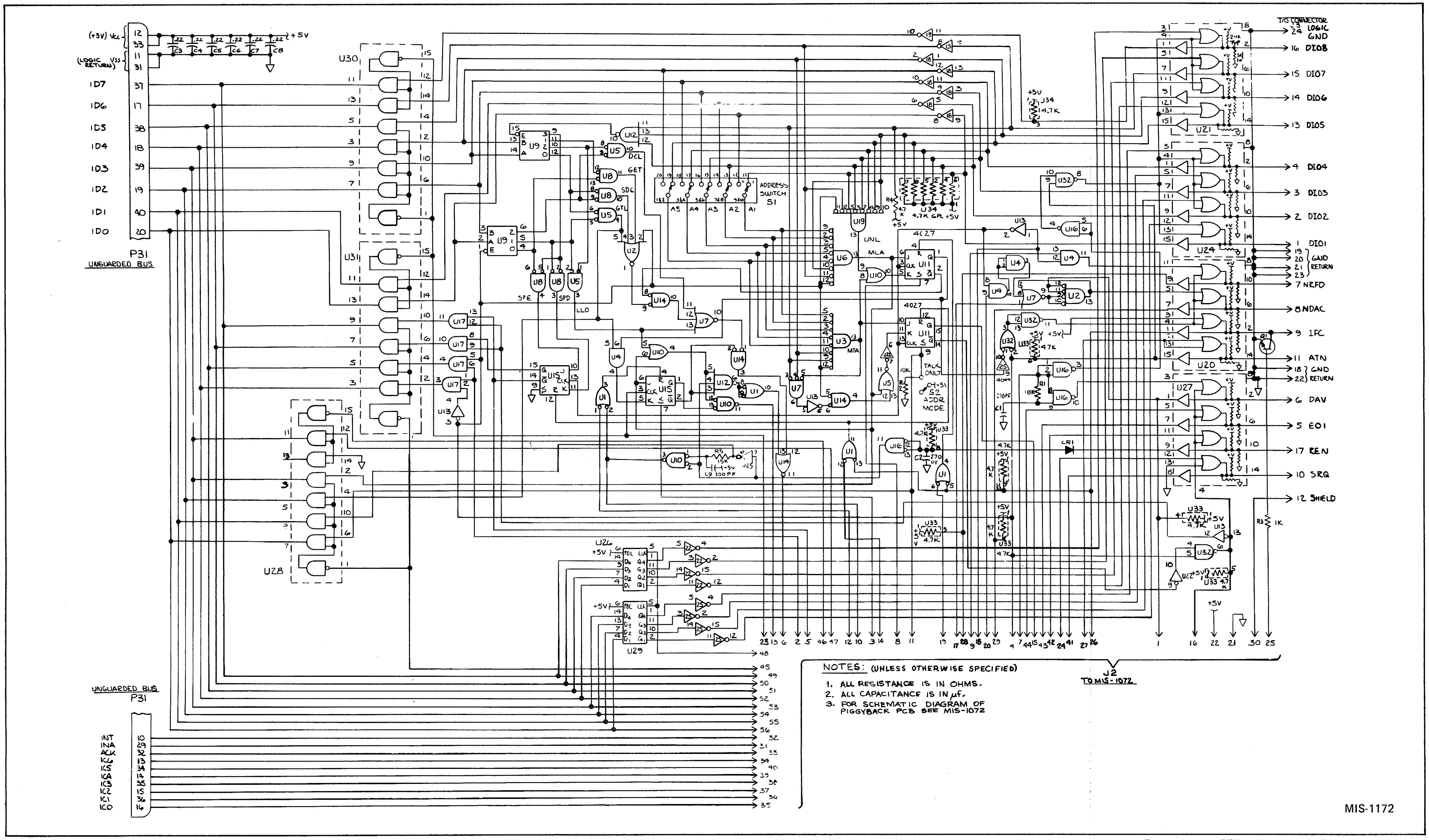
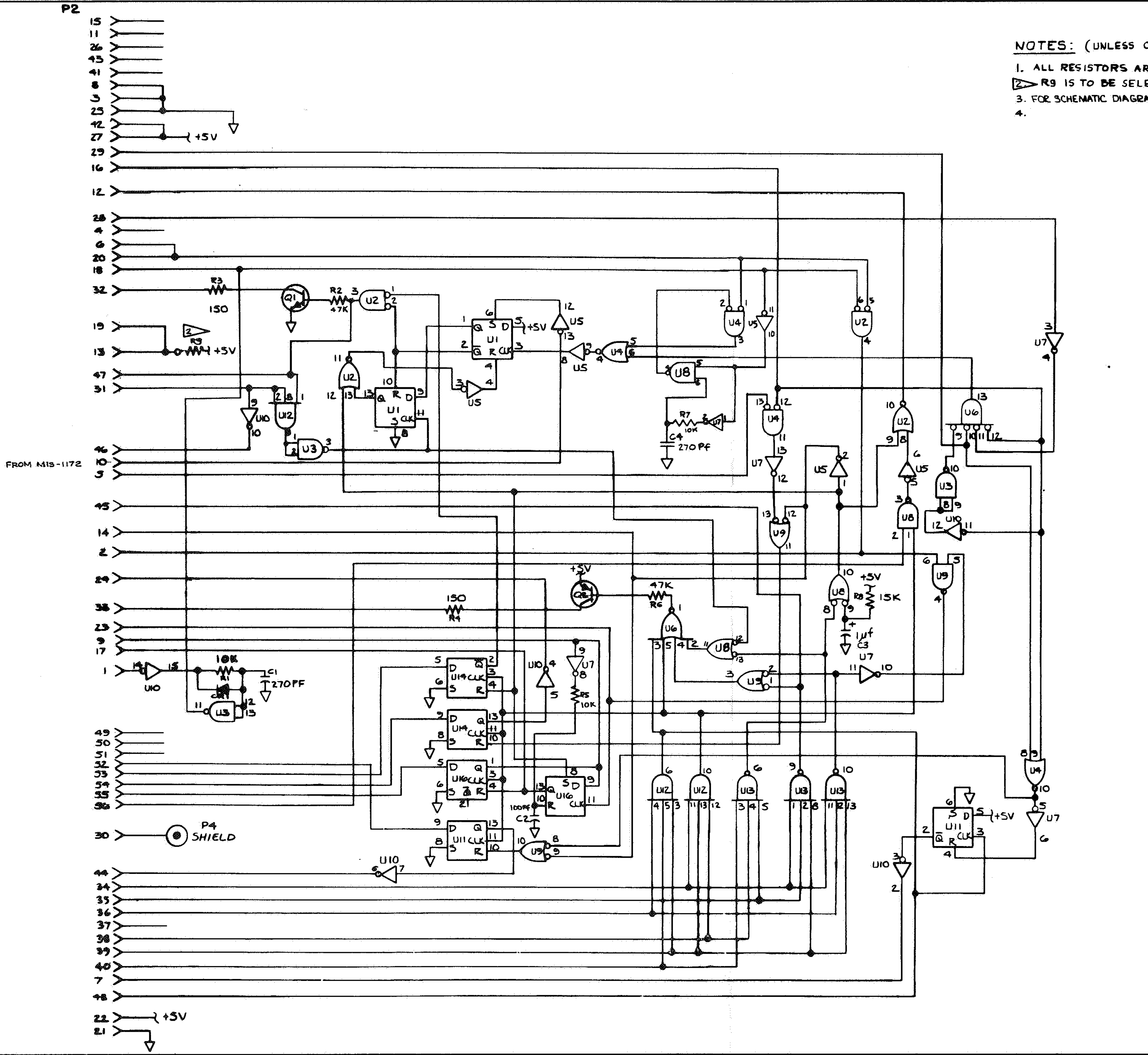


Figure 605-4. IEEE 488-1975 Interface Schematic

NOTES: (UNLESS OTHERWISE SPECIFIED).

1. ALL RESISTORS ARE C.C. 1/4W AND RESISTANCE IS IN OHMS.
2. R9 IS TO BE SELECTED AT TEST IF REQUIRED.
3. FOR SCHEMATIC DIAGRAM OF MAIN PCB SEE MIS-1172
4.



MIS-1074

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.

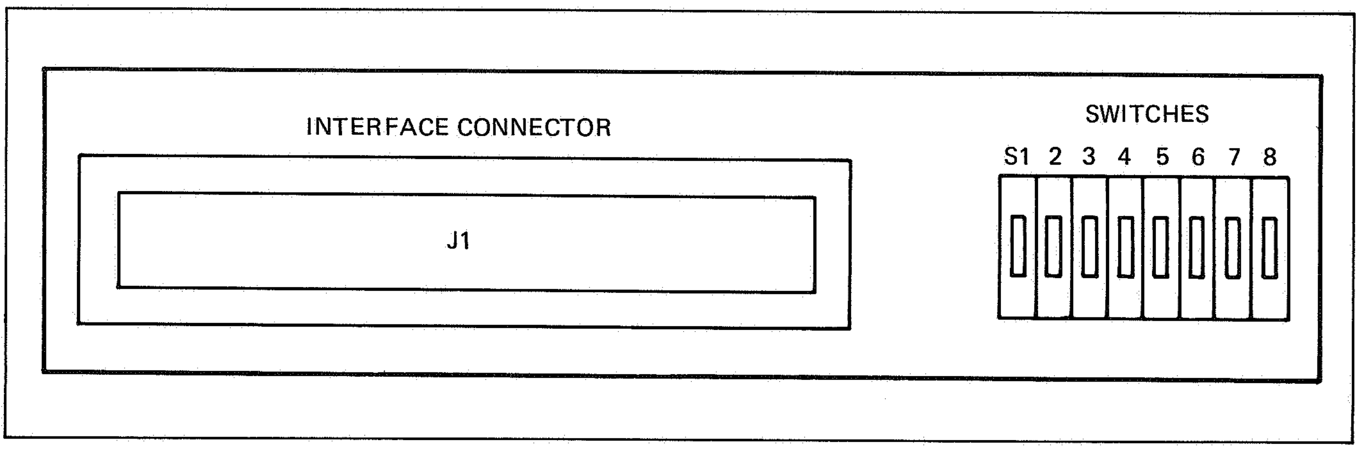


Figure 606-1. Rear Panel Access

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.		

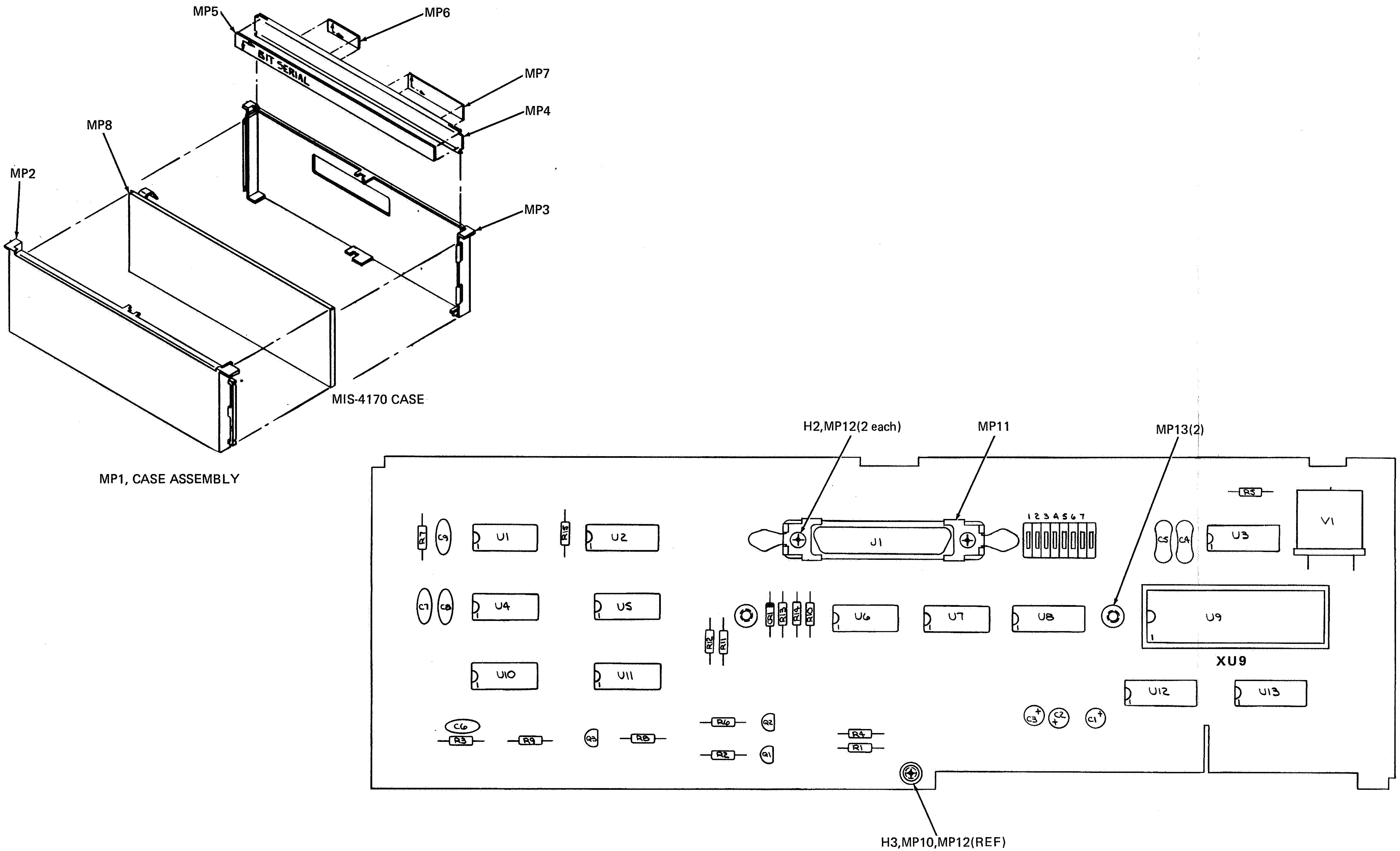
Table 606-5. Bit Serial Asynchronous Interface PCB Assembly

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)

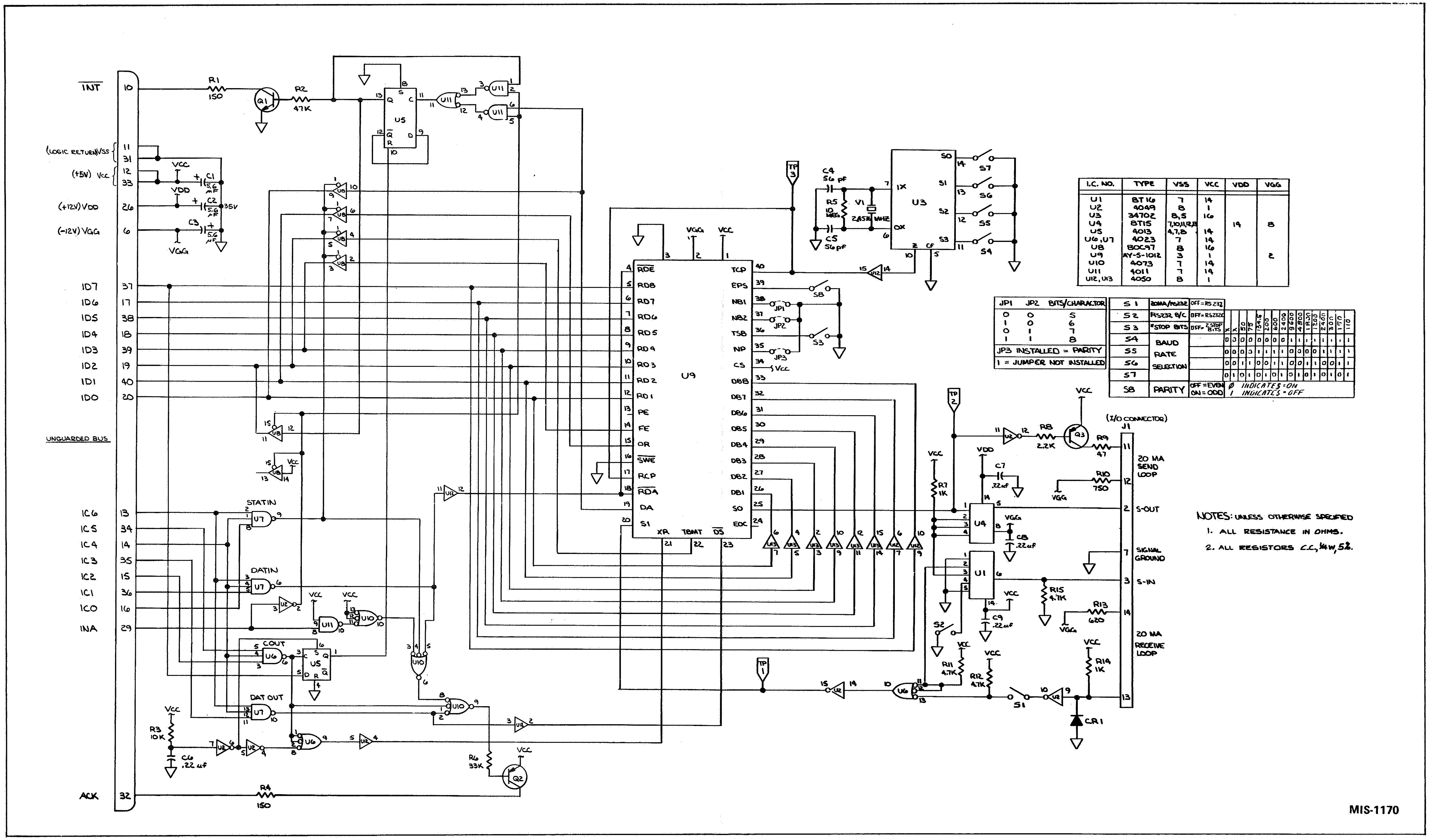
REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R13	RES, DEP. CAR, 620 +/-5%, 1/4W	442319	80031	CR251-4-5P620E	1		
R14	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R15	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
S1	SWITCH, 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	$\overline{INT}$	= Interrupt Clock
22	$\overline{CIS}$	= Control Input Strobe Clock Inverted
23	$\overline{QP}$	= Low Output Delay Pulse
24	$\overline{CIS\text{-}B}$	= Control Input Strobe Inverted Buffered
25	$\overline{IQ}$	= Data Input Ready Low
26	IQ	= Data Input Ready High
27	$\overline{DQ}$	= 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	$\overline{CIS\ B}$	= 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	$\overline{COR}$	= Control Output Ready Inverted
39	LT	= Low Trigger Delay Pulse
40	$\overline{CIR}$	= Control Input Ready Inverted

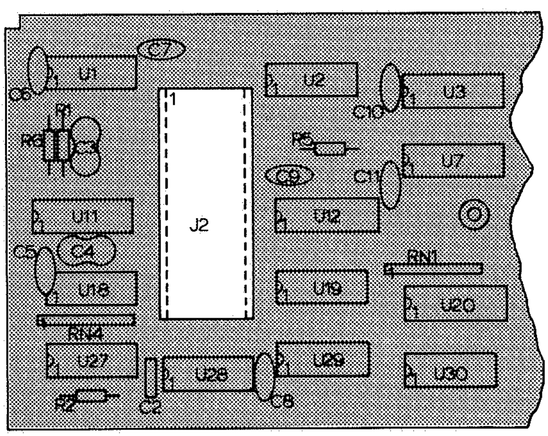


Figure 607-1. Personality Card Location

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

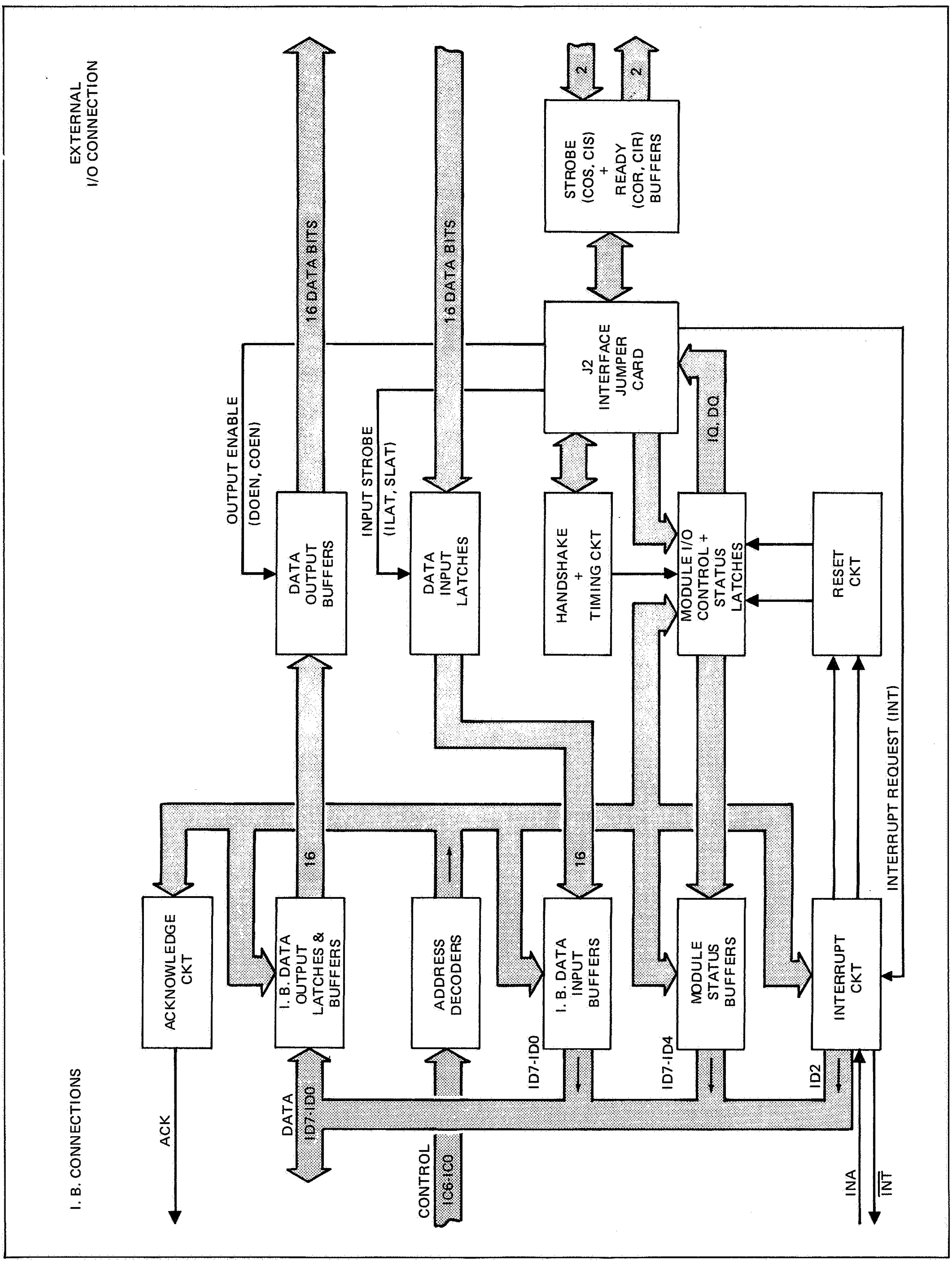


Figure 607-2. Parallel Interface Block Diagram

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, $\overline{INT}$, 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. $\overline{INT}$ 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 $\overline{INT}$. $\overline{INT}$, 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 $\overline{INT}$ with an $\overline{INA}$ 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 $\overline{IQ}$. The Data Ready Indicator, DQ, is at a low level when the DMM is ready to accept data (prior to T9). (Conversely, $\overline{DQ}$ 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 $\overline{CIS}$. With both ISLE and SLS in a high state, the high to low transition of SLS toggles the Indicator (T7). $\overline{CIS}$ is low with both ISLE and SLS high. The high to low transition of SLS causes a low to high transition on $\overline{CIS}$ (T8), toggling the Data Input Ready Indicator (T9). $\overline{CIS}$ 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 $\overline{INT}$. Its trailing edge initiates the activity (T13). $\overline{INT}$ must not again make a low to high transition until the subsequent input transaction.

607-35. Following the $\overline{INT}$ 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 $\overline{DQ}$. DQ is at a low level and $\overline{DQ}$ is at a high level when output data is available from the DMM (prior to T2).

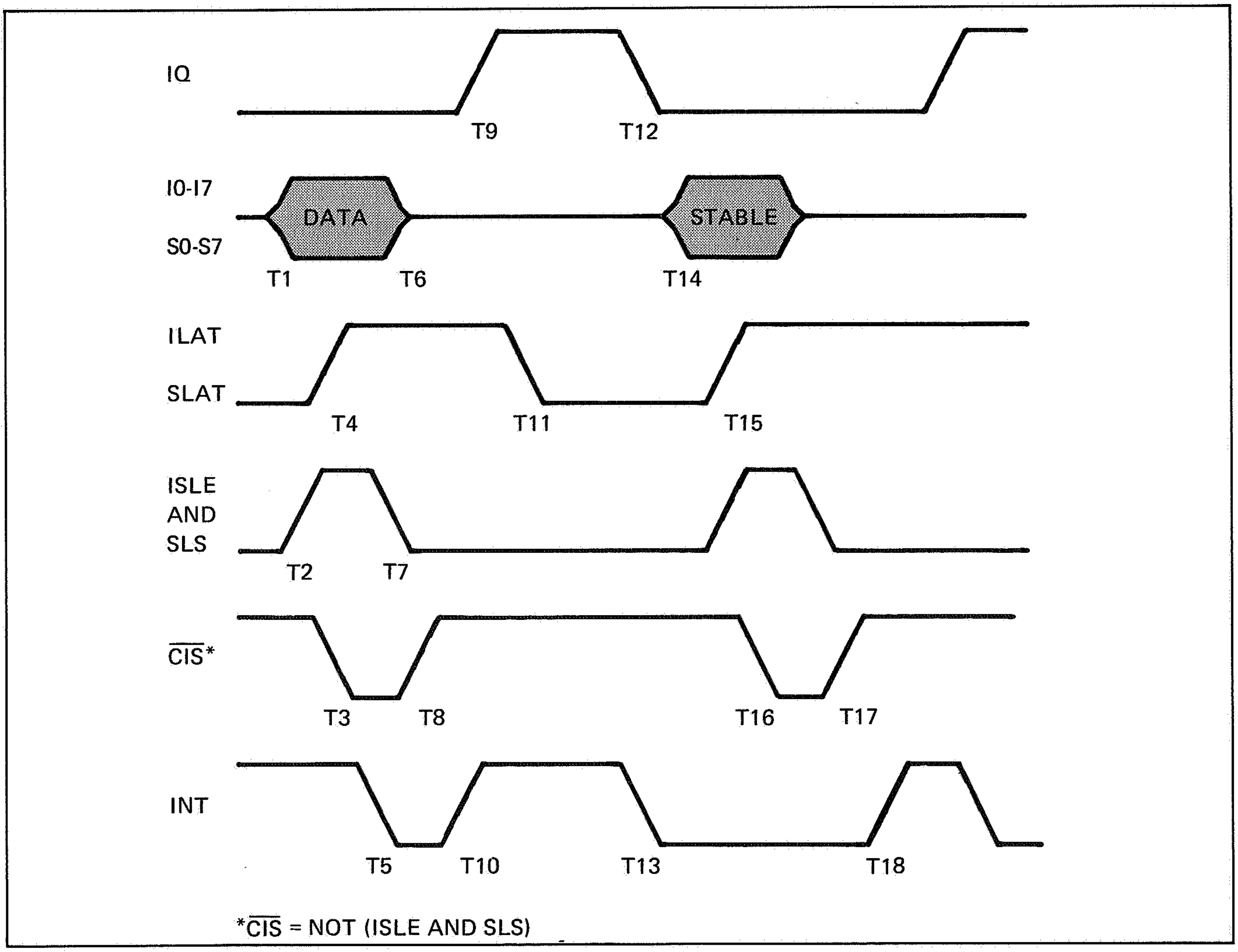


Figure 607-3. Interface Input Control Signal Timing Diagram

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.

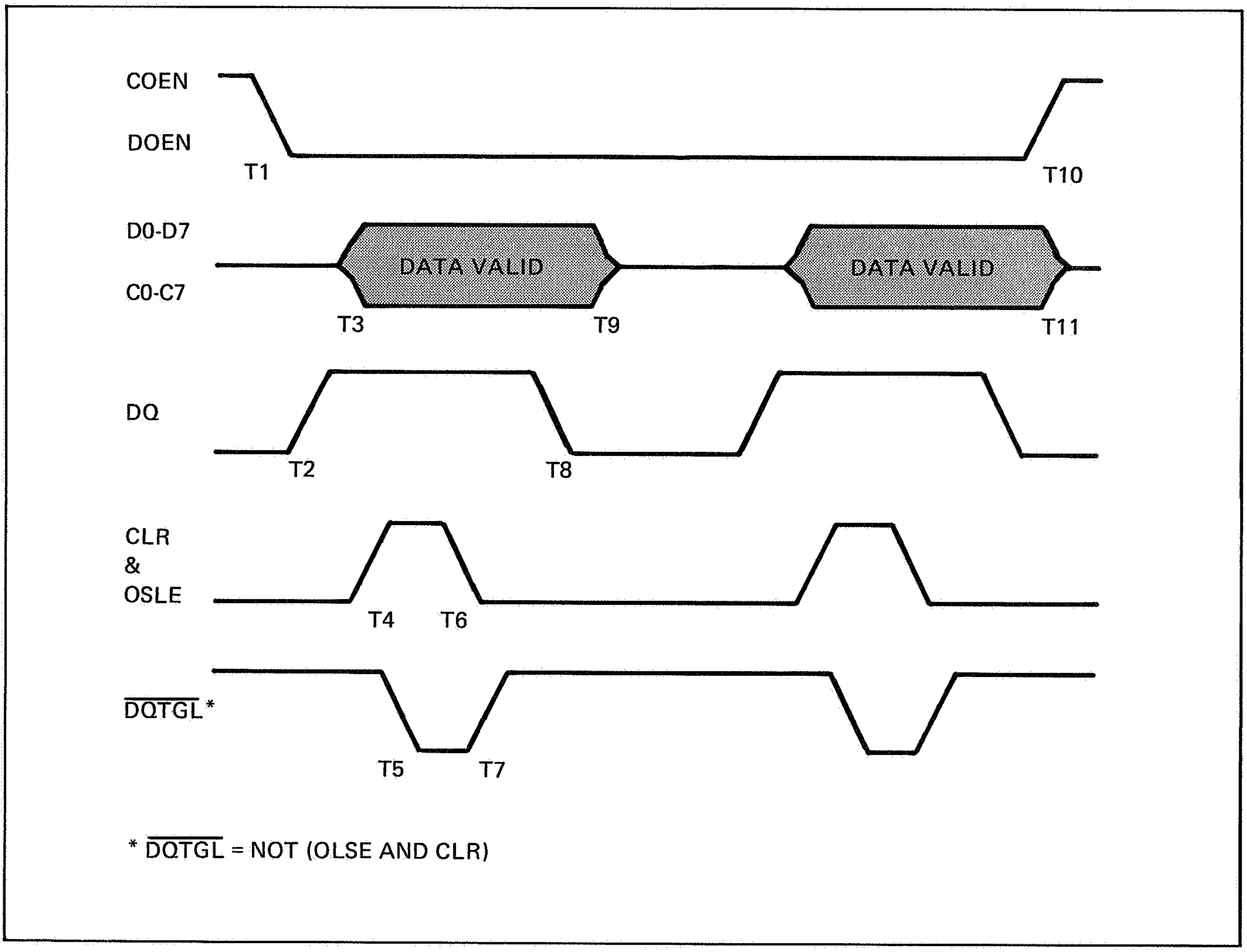


Figure 607-4. Interface Output Control Signal Timing Diagram

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 (not shown)	424465	83553	C0120-014-0380	1		
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.

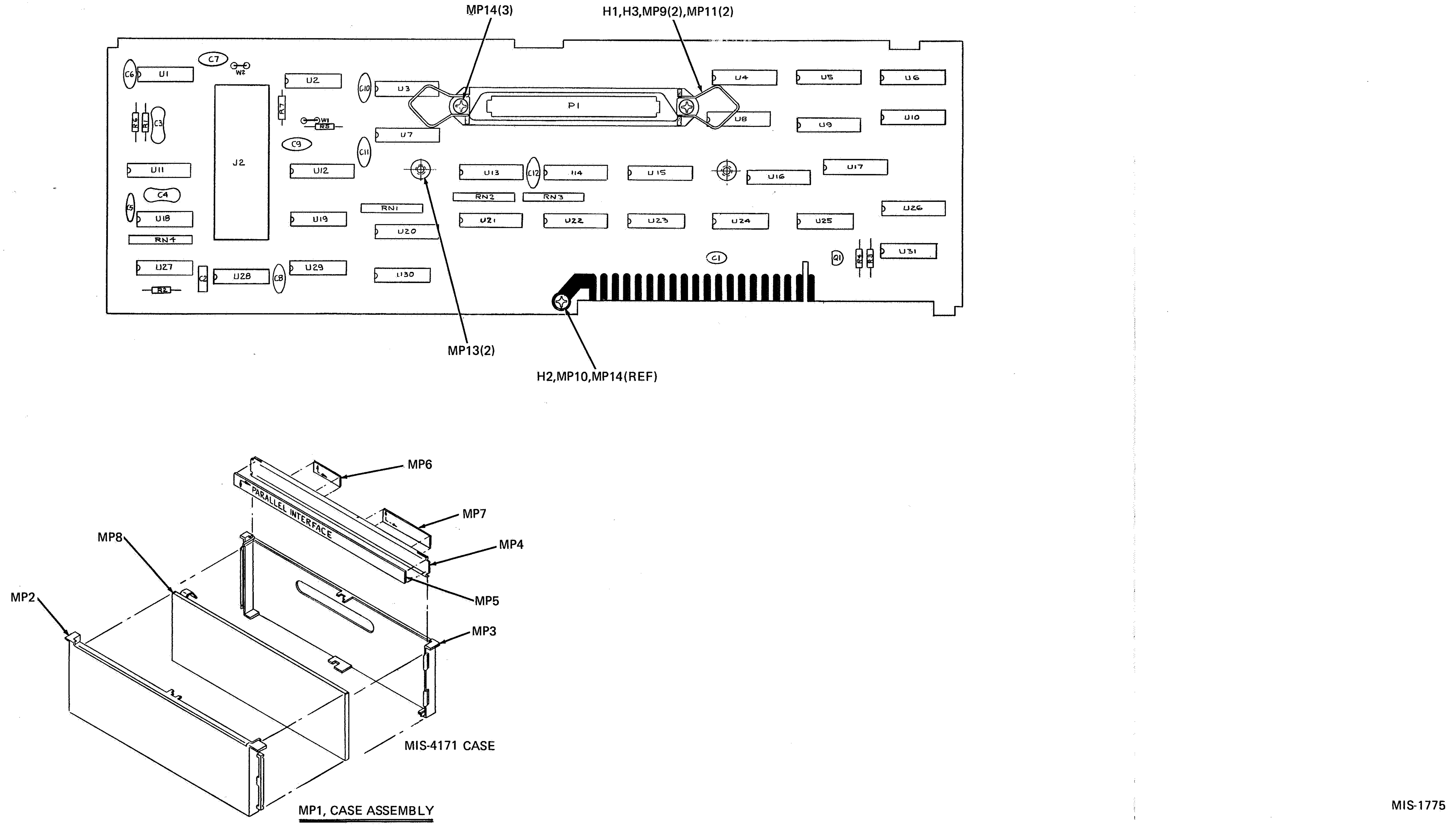


Figure 607-5. Parallel Interface PCB Assembly

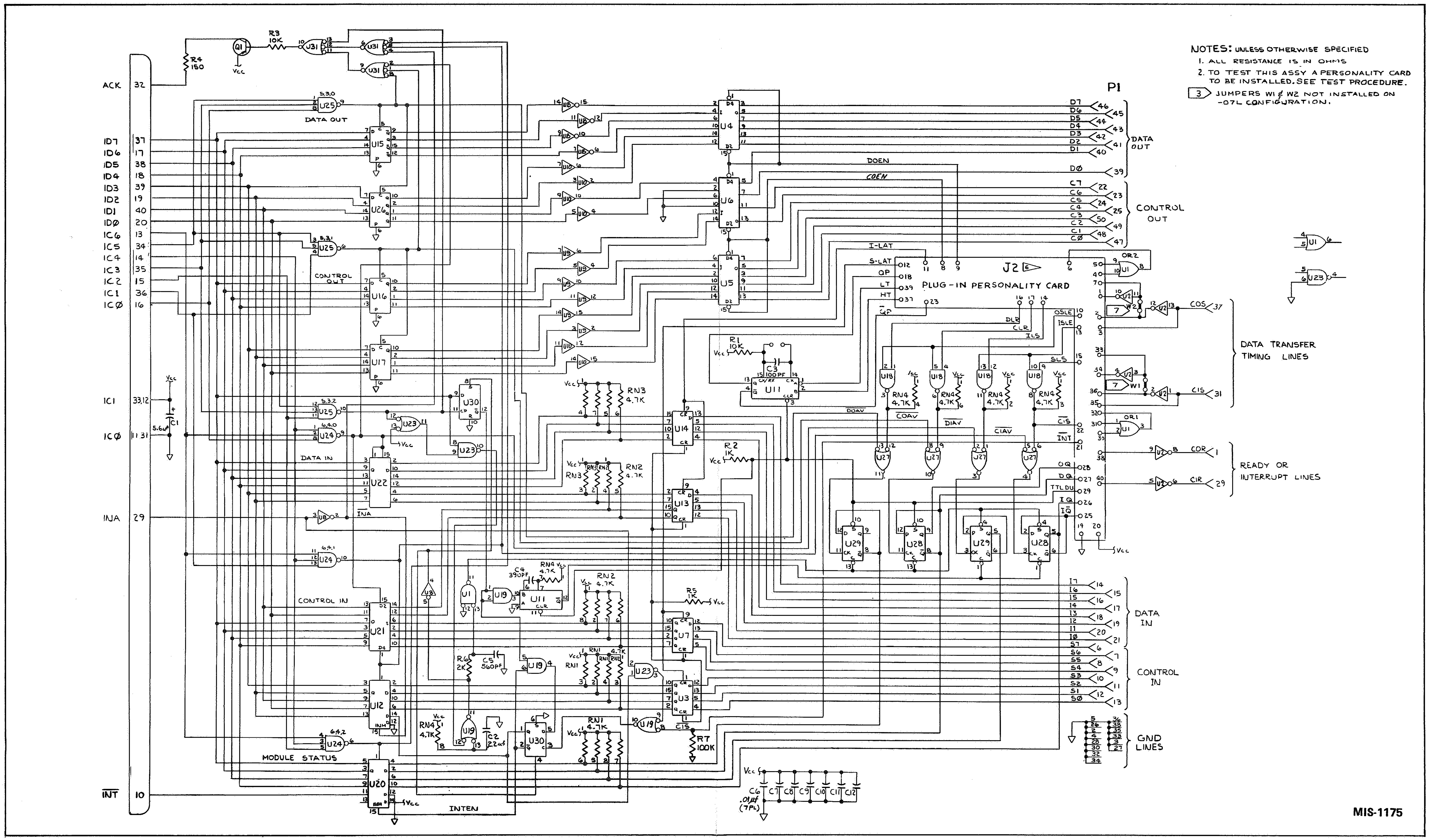
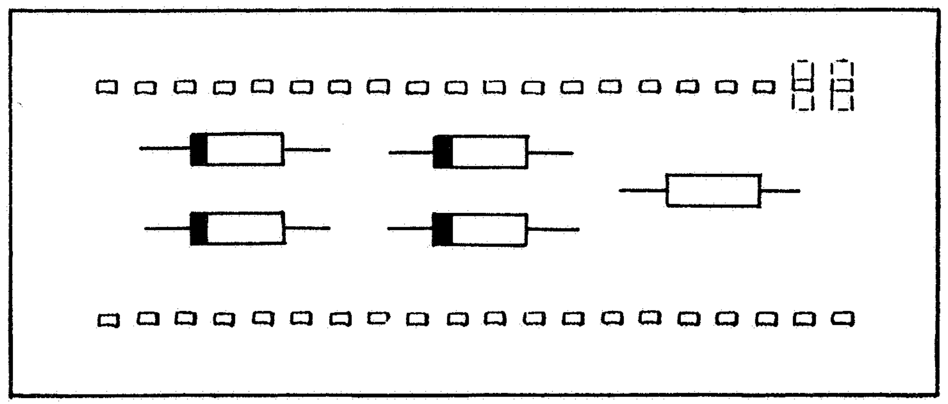
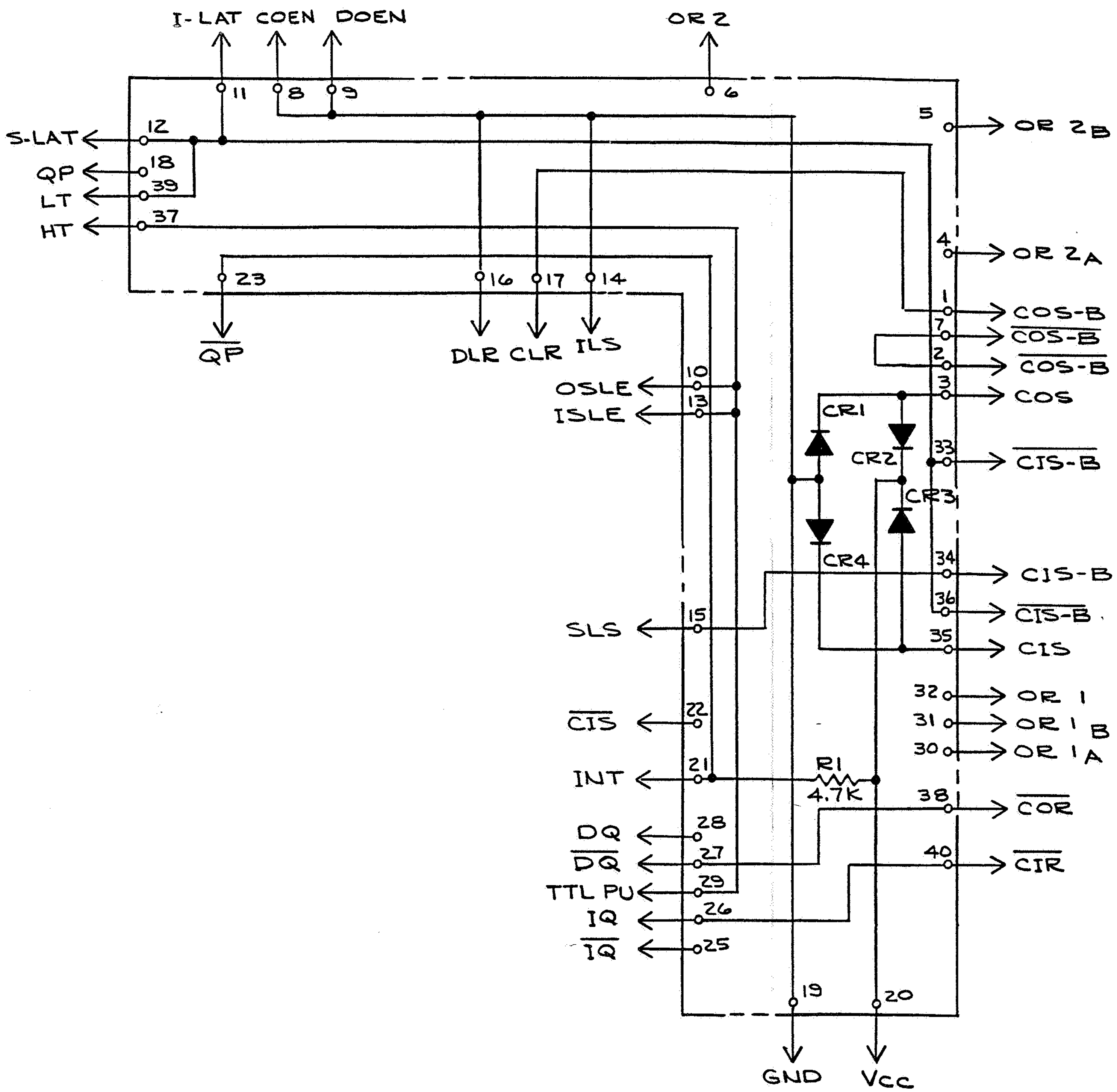


Figure 607-5. Parallel Interface PCB Assembly (cont)

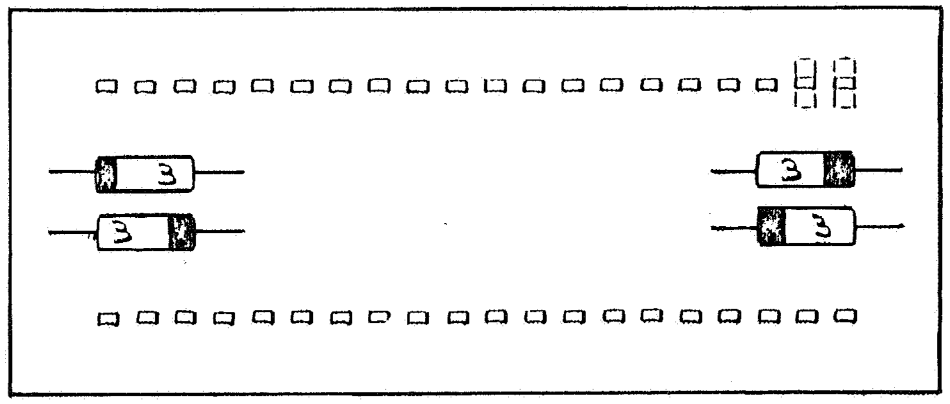


MIS 4 MIS-4062

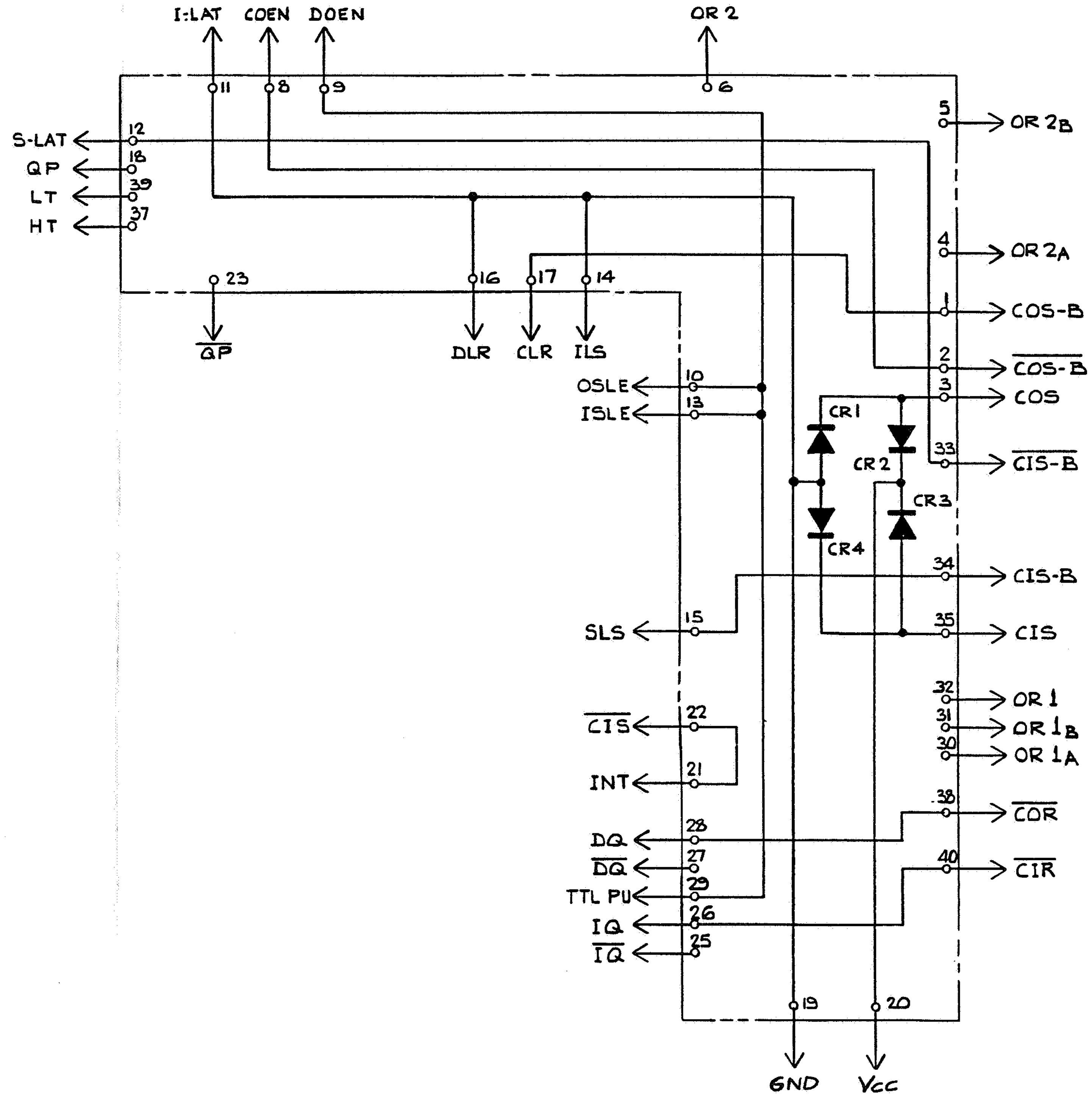


MIS-1062

Figure 607-6. –07A Personality Card PCB Assembly

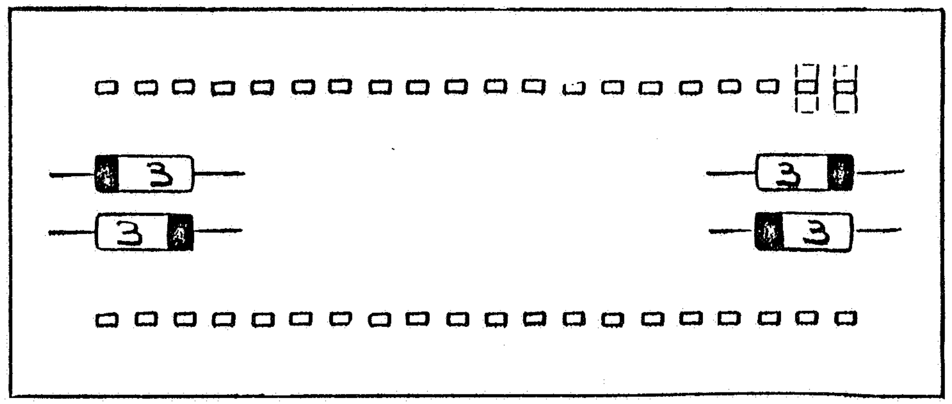


MIS-4069



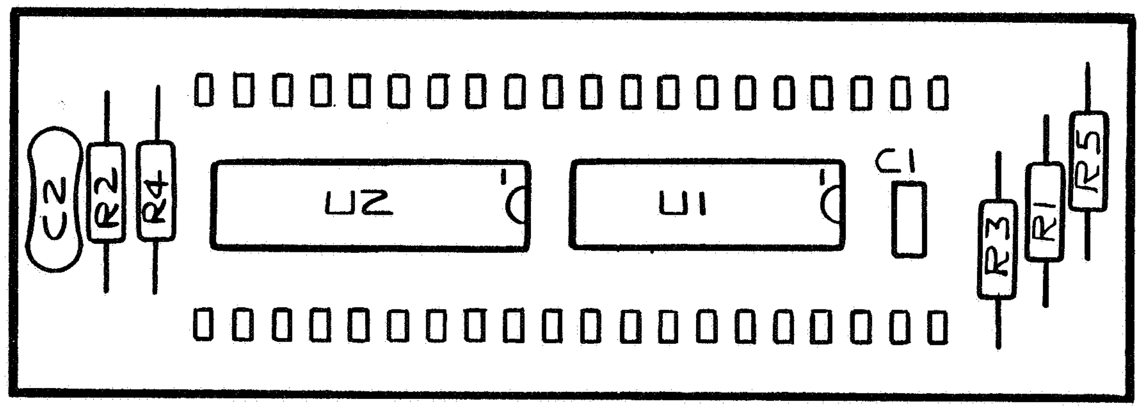
MIS-1069

Figure 607-7. —07B Personality Card PCB Assembly

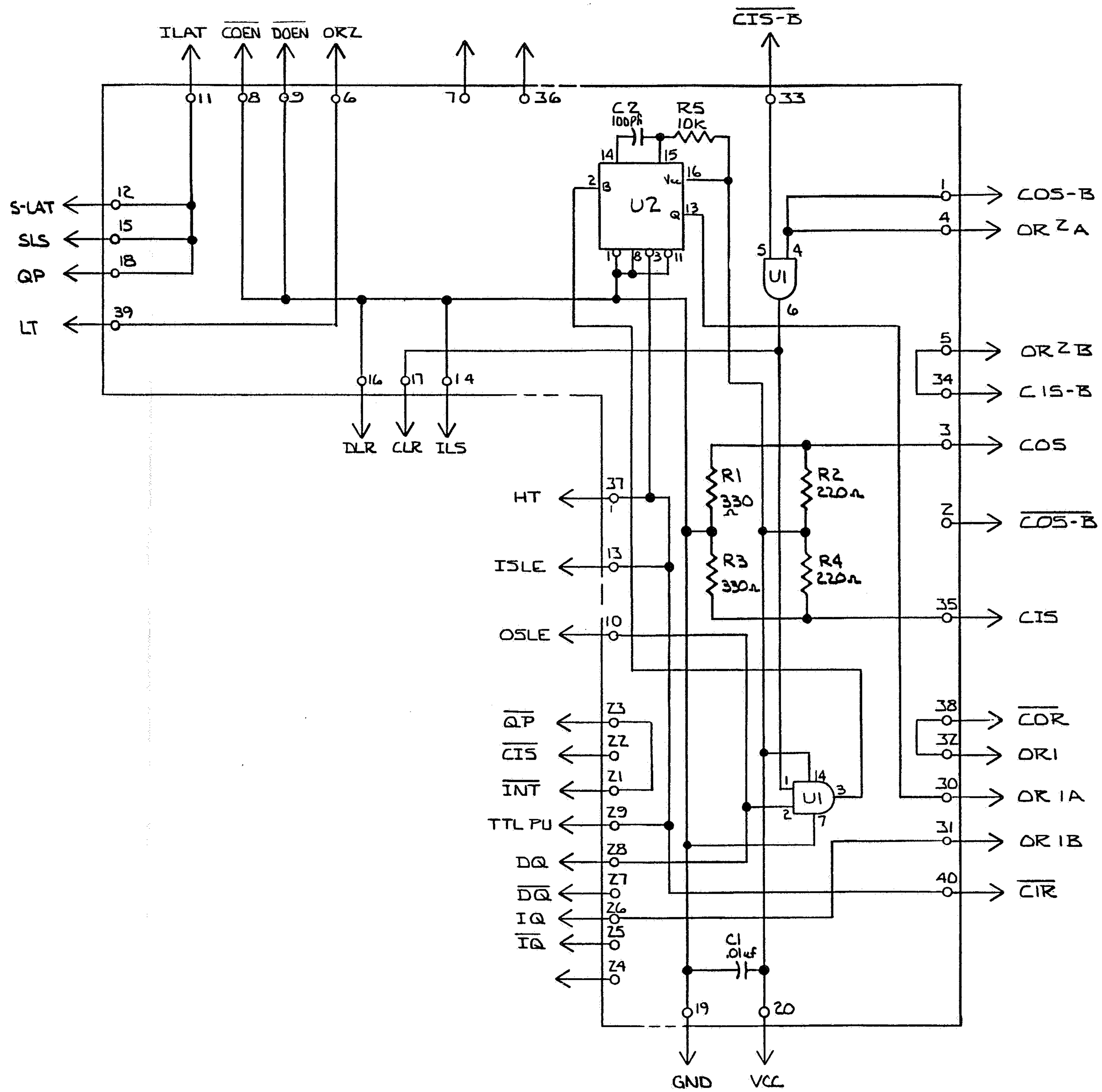


MIS-4071

Figure 607-8. —07D Personality Card PCB Assembly



MIS-1767



MIS-1067

Figure 607-9. —07H Personality Card PCB Assembly

Isolator -08A (External Trigger)

608A-1. INTRODUCTION

608A-2. The Isolator module 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. An Isolator module must be installed whenever a remote interface (option -05, -06, or -07) is used in an 8500 series DMM. The following description pertains to the Isolator -08A only. This module provides the capability for external triggering of the DMM. The 8500A DMM does not have provision for external triggering and consequently must use the -08 Isolator or the -08A without external triggering.

608A-3. INSTALLATION

608A-4. Refer to Section 4 of the Instruction Manual for general module installation procedures. The Isolator module uses slot K (which can be identified as the only module slot with connectors on both the analog and digital bus lines). Section 8 contains further information on module slot locations.

608A-5. SPECIFICATIONS

608A-6. Input

608A-7. 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.

608A-8. The outer connector for external triggering is at interface common. There should be no more than 10V between the outer connector and earth ground.

608A-9. Trigger Processing Time

608A-10. 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

608A-11. OPERATING NOTES

608A-12. Installation of the Isolator (Option -08A) will not affect standard operation of the instrument. The External Triggering mode may, however, be activated locally from the front panel or through remote interfacing commands.

608A-13. Local Operation

608A-14. The External Triggering mode may be enabled from the DMM's front panel (Option -08A must be installed). 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.

608A-15. 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.

608A-16. Remote Operation

608A-17. External Triggering can be enabled and controlled remotely when a remote interface (Option -05, -06, or -07) and the Isolator (Option -08A) are installed. The command characters in Table 608A-1 can be used from the remote.

608A-18. Trigger Polarity

608A-19. Either positive or negative going external triggers may be accepted by the Isolator (Option -08A); factory settings will be for negative triggers. Separate jumper wire arrangements are employed for negative and positive triggers. Refer to Figure 608A-1 for the location of jumper terminals on the Isolator PCB. To change the jumper arrangement, use the following procedure:

1. On the Digital Multimeter (8500 series), press POWER OFF and disconnect the line cord.
2. Remove the Isolator module.
3. Observe Static Sensitive device precautions listed in Section 4 of the Instruction Manual. Avoid touching connector terminals on the Isolator PCB.
4. Remove the Guard Covers from the Isolator PCB 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 pin 1 and pin 4 on Schmitt Trigger U35.
6. For positive going triggers, remove the jumper between pins 1 and 4 and jumper pin 1 to 2 and 3 to 4 on U35.
7. Reassemble module, replace in Digital Multimeter.

Table 608A-1. Remote Commands

	Ext. Trigger Commands
Q	Ext. Trigger—interrupt when ready
Q1	Ext. Trigger and Transmit Reading
Q0	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	1,066s
W10	2.133s
W11	4.266s
W12	8.532s
W13	17.06s
W14	34.13s
W15	68.26s

608A-20. THEORY OF OPERATION

608A-21. 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 (ID) and eight data (ID) lines are used. Lines IC5 and IC6 are always low. The

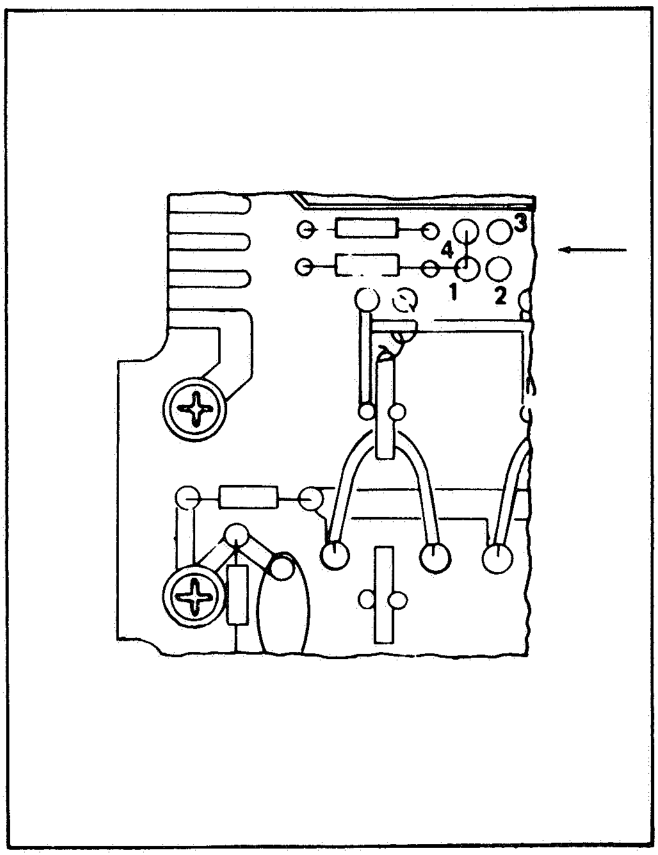


Figure 608A-1. Trigger Polarity Connections

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 608A-3) and the Functional Block Diagram (Figure 608A-2) for the following circuit descriptions.

NOTE

When the Isolator is Installed, Vcc and Vss in the unguarded digital bus are isolated from analog common.

608A-22. 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.

608A-23. 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, U16-11 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 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.

608A-24. 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.

608A-25. 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.

608A-26. 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

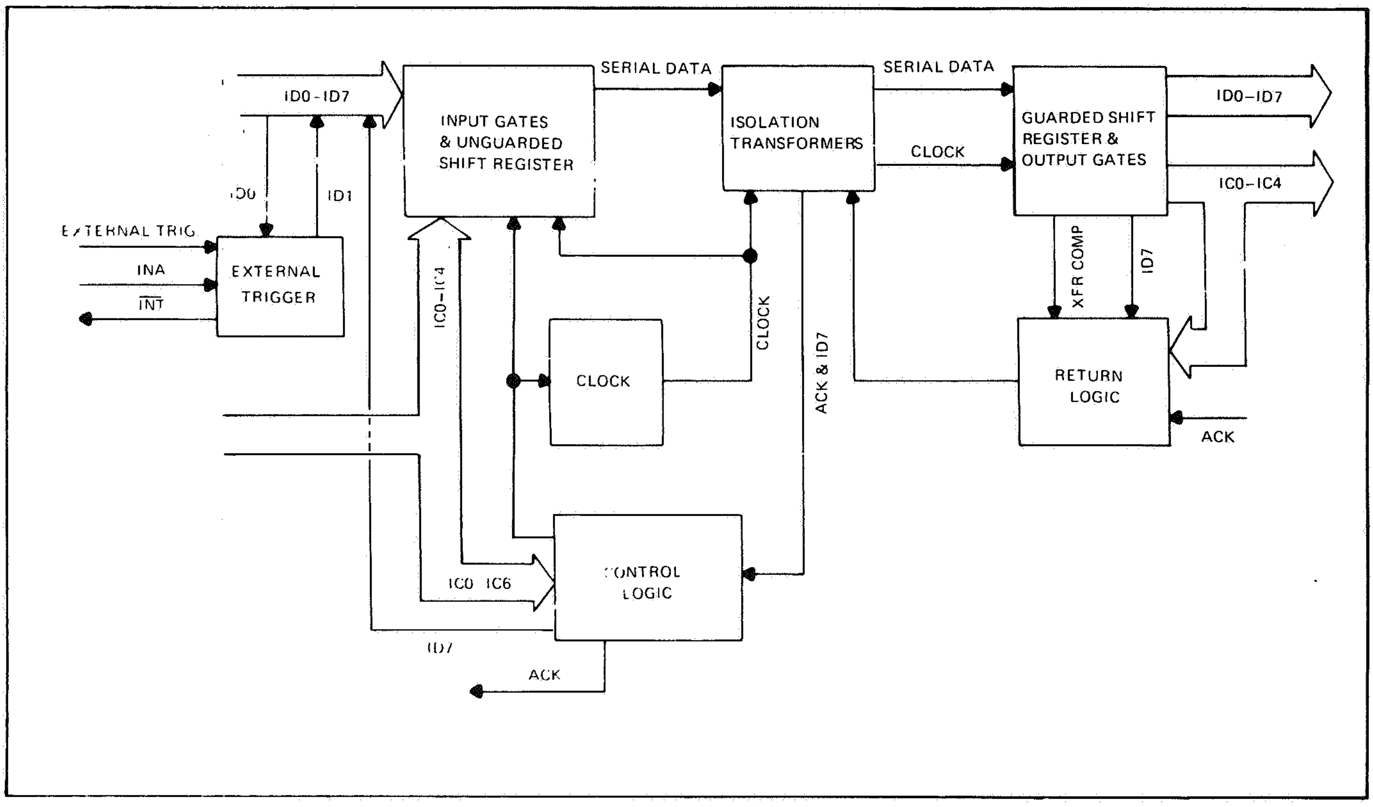


Figure 608A-2. Isolator Block Diagram

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.

608A-27. The following sequence of events takes place in the Isolator during external triggering. Dual D flip-flop 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 C6 will detect Vcc at power on and disable the module's interrupt capability. The high at U31-1 sets 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.

608A-28. TROUBLESHOOTING

608A-29. Table 608A-2 gives a symptom analysis routine for troubleshooting the Isolator module.

608A-30. PARTS LIST

608A-31. Table 608A-3 gives a detailed parts breakdown of the Isolator (Option -08A). Refer to Section 5 of the Instruction Manual for ordering information.

Table 608A-2. Isolator Troubleshooting

SYMPTOM	POSSIBLE 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 windings 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 or 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 608A-3. ISOLATOR PCB ASSEMBLY
(SEE FIGURE 608A-3)

REFERENCE DESIGNATOR A->NUMERICS--->	S	----------DESCRIPTION----------------	FLUKE STOCK --NO--	MFRS SPLY CODE-	MANUFACTURERS PART NUMBER --OR GENERIC TYPE--	TOT QTY	R S -Q	N O T -E
C 1, 4		CAP,MICA,220PF,+-5%,500V	170423	72136	DM15F221J	2		
C 2		CAP,MICA,18PF,+-5%,500V	266585	72136	DM15C180J	1		
C 3		CAP,MICA,330PF,+-5%,500V	148445	72136	DM15E331J	1		
C 5		CAP,MICA,68PF,+-5%,500V	148510	72136	DM15F680J	1		
C 6		CAP,TA,39UF,+-20%,6V	163915	56289	196D394X0020KA1	1		
C 7		CAP,AL,150UF,+50-10%,16V	186296	73445	ET151X016A5	1	1	
C 8, 9		CAP,MICA,27PF,+-5%,500V	177998	72136	DM15E270J	2		
C 10, 12, 13,		CAP,CER,0.22UF,+-20%,50V,Z5U	309849	71590	CW3C0C224K	4		
C 16			309849					
C 11		CAP,CER,0.0047UF,+-10%,500V,Z5R	106724	71590	CF-472	1		
H 1		SCREW,MACH,PHP,STL,4-40X5/8	145813	89536	145813	2		
L 1		CHOKE,6TURN	320911	89536	320911	1		
MP 1		ISOLATOR,CASE ASSEMBLY (MP2 - MP11)	486407	89536	486407	1		1
MP 2, 3		CASE HALF, MODULE	402990	89536	402990	2		
MP 4		COVER, MODULE, CASE	486340	89536	486340	1		
MP 5		SHIELD,COVER,ISOLATOR	437939	89536	437939	2		
MP 6		DECAL, ISOLATOR/EXT.TRIGGER	477570	89536	477570	1		
MP 7		DECAL, CAUTION	454504	89536	454504	1		
MP 8		GUARD, REAR, ISOL., LEFT SIDE	437947	89536	437947	1		
MP 9		GUARD,REAR,ISOLATOR,RIGHT SIDE	383349	89536	383349	1		
MP 10		GUARD, FRONT, ISOL., LEFT SIDE	487298	89536	487298	1		
MP 11		GUARD,FRONT,ISOL., RIGHT SIDE	487280	89536	487280	1		
MP 12		SPRING,COIL, (NOT SHOWN)	424465	89536	424465	2		
MP 13		SPACER,SWAGED, (NOT SHOWN)	380519	89536	380519	2		
Q 1	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	226290	04713	MPS3640	1		
Q 2	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	1		
R 1		RES,CF,220,+-5%,0.25W	574244	80031	CR251-4-5P220E	1	1	
R 2, 5, 8-		RES,CF,10K,+-5%,0.25W	573394	80031	CR251-4-5P10K	9		
R 13, 24			573394					
R 3, 21		RES,CF,47K,+-5%,0.25W	573527	80031	CR251-4-5P47K	2		
R 4, 7		RES,CF,4.7K,+-5%,0.25W	573311	80031	CR251-4-5P4K7	2		
R 6, 17		RES,CF,1K,+-5%,0.25W	573170	80031	CR251-4-5P1K	2		
R 14, 20		RES,CF,150,+-5%,0.25W	343442	80031	CR251-4-5P150	2		
R 15		RES,CF,470,+-5%,0.25W	573121	80031	CR251-4-5P470E	1		
R 18		RES,CF,100K,+-5%,0.25W	573584	80031	CR251-4-5P100K	1		
T 1, 3, 6,		INDUCTOR	437590	89536	437590	4		
T 8			437590					
T 2, 4, 5,		INDUCTOR	437608	89536	437608	4		
T 7			437608					
U 1, 2, 5	*	IC,CMOS,HEX BUFFER	381830	02735	CD4050BE	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	18324	01295 SN7426M	2	1	
U 6, 24	*	IC,LSTTL,HEX INVERTER	393058	01295	SN74LS04N	2	1	
U 8, 14, 23	*	IC,LSTTL,RETRG MONOSTAB MULTIVB W/CLR	404186	01295	SN74LS123N	3	1	
U 9	*	IC,STTL,QUAD 2 INPUT NAND GATE	363580	01295	SN7400SN	1	1	
U 10	*	IC,LSTTL,TRIPLE 3 INPUT NAND GATE	393074	01295	SN74LS10N	1	1	
U 11, 19	*	IC,LSTTL,QUAD 2 INPUT NOR GATE	393041	01295	SN74LS02N	2	1	
U 12, 22, 26	*	IC,CMOS,QUAD 2 INPUT NOR GATE	355172	02735	CD4001AE	3	1	
U 13, 21	*	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	12040	MM80C97N	2	1	
U 16, 20	*	IC,TTL,8BIT SER-IN,PAR-OUT R-SHFT RGS	272128	01295	SN74164N	2	1	
U 18	*	IC,CMOS,QUAD 2 INPUT AND GATE	408401	02735	CD4081BE	1	1	
U 25	*	IC,CMOS,TRIPLE 3 INPUT NOR GATE	355180	02735	CD4025BE	1	1	
U 31	*	IC,CMOS,DUAL D F/F,+EDG TRIG	340117	02735	CD4013AE	1	1	
U 32	*	IC,CMOS,FAST QUAD 2 INPUT NAND GATE	413211	12040	34011PC/4011PC	1	1	
U 33	*	IC,CMOS,TRIPLE 3 INPUT NAND GATE	375147	02735	CD4023UBE	1	1	
U 35	*	IC,CMOS,HEX SCHMITT TRIGGER	477810	12040	MM74C914N	1	1	
W 1		WIRE,BUS,22 AWG,TINNED COPPER	115469	89536	115469		1	
W 2		WIRE,BUS,20 AWG,TINNED COPPER	212704	89536	212704			
W 3		WIRE,TEF,E,22AWG,SOLID,WHT	375170	89536	375170			
Z 17		RES,NET,DIP,16 PIN,15 RES,10K,+-5%	355305	89536	355305	1	1	

NOTE 1 = USE P/N 486407 TO ORDER CASE WITHOUT PCB ASSEMBLY.

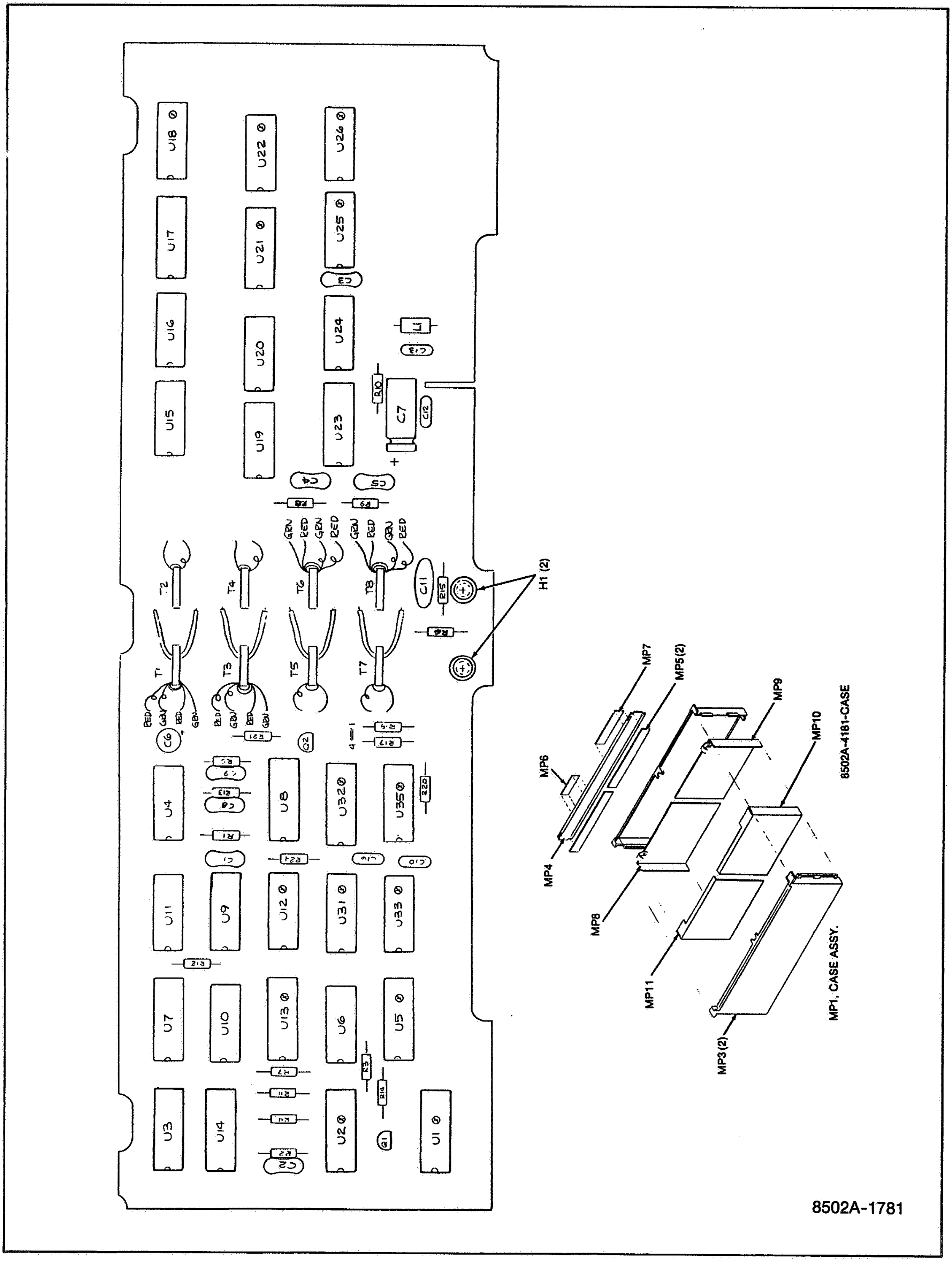
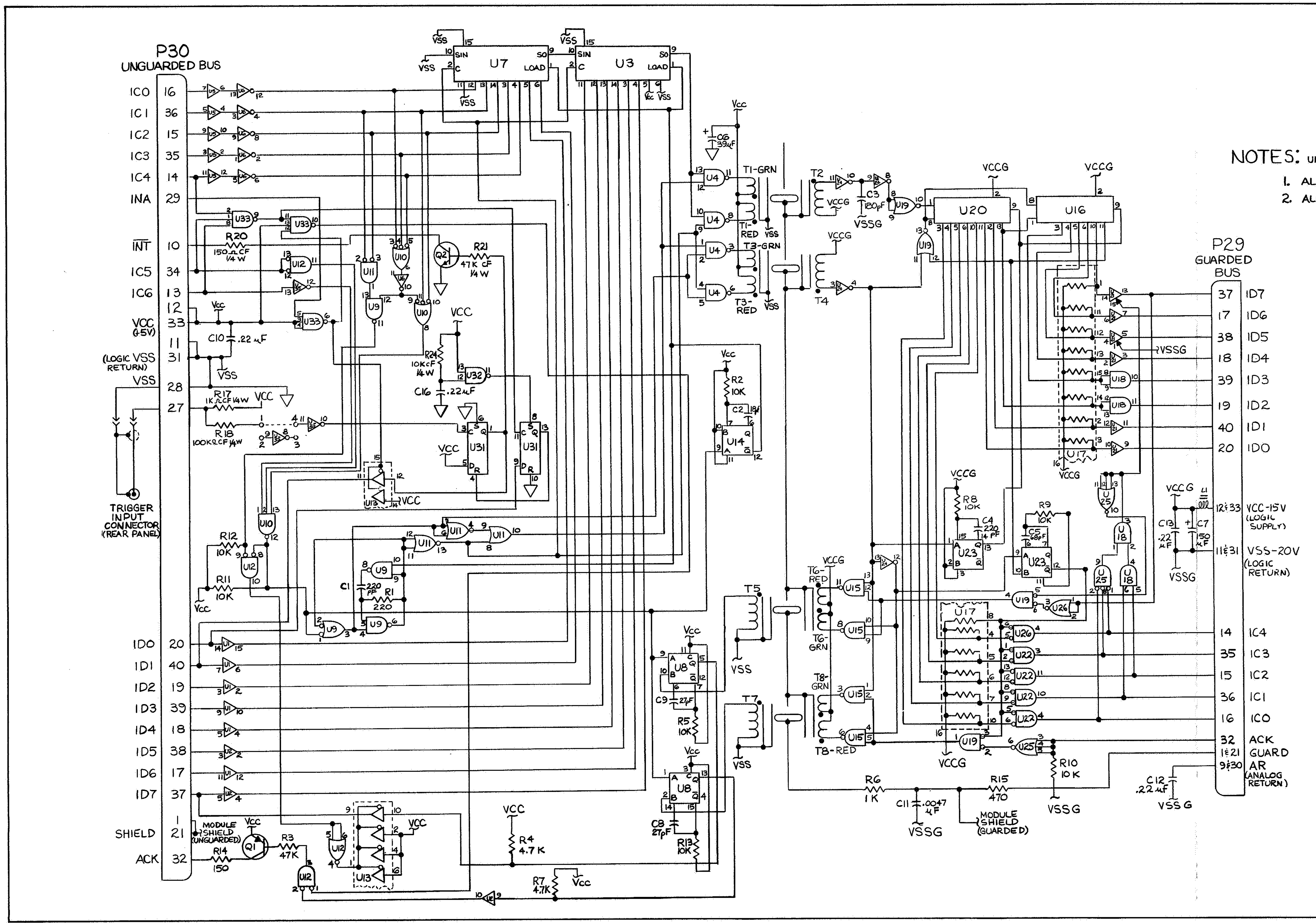


Figure 608A-3. Isolator PCB Assembly



NOTES: UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTANCE IN OHMS.
2. ALL RESISTORS C.C. 1/4 W 5%.

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

8502A-1181

Figure 608A-3. Isolator PCB Assembly (cont)

Section 7

General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable Parts contained in Section 5.

List of Abbreviations and Symbols

A or amp	ampere
ac	alternating current
af	audio frequency
a/d	analog-to-digital
assy	assembly
AWG	american wire gauge
B	bel
bcd	binary coded decimal
°C	Celsius
cap	capacitor
ccw	counterclockwise
cer	ceramic
cermet	ceramic to metal(seal)
ckt	circuit
cm	centimeter
cmrr	common mode rejection ratio
comp	composition
cont	continue
crt	cathode-ray tube
cw	clockwise
d/a	digital-to-analog
dac	digital-to-analog converter
dB	decibel
dc	direct current
dmm	digital multimeter
dvm	digital voltmeter
elect	electrolytic
ext	external
F	farad
°F	Fahrenheit
FET	Field-effect transistor
ff	flip-flop
freq	frequency
FSN	federal stock number
g	gram
G	giga (10^9)
gd	guard
Ge	germanium
GHz	gigahertz
gmv	guaranteed minimum value
gnd	ground
H	henry
hd	heavy duty
hf	high frequency
Hz	hertz
IC	integrated circuit
if	intermediate frequency
in	inch(es)
intl	internal
I/O	input/output
k	kilo (10^3)
kHz	kilohertz
kΩ	kilohm(s)
kV	kilovolt(s)
lf	low frequency
LED	light-emitting diode
LSB	least significant bit
LSD	least significant digit
M	mega (10^6)
m	milli (10^{-3})
mA	milliampere(s)
max	maximum
mf	metal film
MHz	megahertz
min	minimum
mm	millimeter
ms	millisecond
MSB	most significant bit
MSD	most significant digit
MTBF	mean time between failures
MTTR	mean time to repair
mV	millivolt(s)
mv	multivibrator
MΩ	megohm(s)
n	nano (10^{-9})
na	not applicable
NC	normally closed
(-) or neg	negative
NO	normally open
ns	nanosecond
opnl ampl	operational amplifier
p	pico (10^{-12})
para	paragraph
pcb	printed circuit board
pF	picofarad
pn	part number
(+) or pos	positive
pot	potentiometer
p-p	peak-to-peak
ppm	parts per million
PROM	programmablle read-only memory
psi	pound-force per square inch
RAM	random-access memory
rf	radio frequency
rms	root mean square
ROM	read-only memory
s or sec	second (time)
scope	oscilloscope
SH	shield
Si	silicon
serno	serial number
sr	shift register
Ta	tantalum
tb	terminal board
tc	temperature coefficient or temperature compensating
tcxo	temperature compensated crystal oscillator
tp	test point
u or μ	micro (10^{-6})
uhf	ultra high frequency
us or μs	microsecond(s) (10^{-6})
uut	unit under test
V	volt
v	voltage
var	variable
vco	voltage controlled oscillator
vhf	very high frequency
vlf	very low frequency
W	watt(s)
ww	wire wound
xfmr	transformer
xstr	transistor
xtal	crystal
xtlo	crystal oscillator
Ω	ohm(s)
μ	micro (10^{-6})

Federal Supply Codes for Manufacturers

D9816
Westermann Wilhelm Augusta-Anlage
Mannheim-Nackarau Germany

00199
Marcon Electronics Corp
Kearny, New Jersey

00213
Nytronics Comp. Group Inc.
Darrlingon, South Carolina

00327
Welwyn International Inc.
Westlake, Ohio

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors Inc.
Passaic, New Jersey

00779
AMP, Inc.
Harrisburg, Pennsylvania

01121
Allen Bradley Co.
Milwaukee, Wisconsin

01281
TRW Electronics & Defense Sector
Lawndale, California

01295
Texas Instruments Inc.
Semiconductor Group
Dallas,Texas

01537
Motorola Communications &
Electronics Inc.
Franklin Park, Illinois

01686
RCL Electronics/Shallcross Inc.
Electro Components Div.
Manchester, New Hampshire

01884
Sprague Electric Co.
(Now 56289)

01961
Varian Associates Inc.
Pulse Engineering Div.
Convoy, Connecticut

02111
Spectrol Electronics Corp.
City of Industry, California

02114
Amperex Electronic Corp.
Ferrox Cube Div.
Saugerties, New York

02131
General Instrument Corp.Government
Systems Div.
Westwood, Massachusetts

02395
Sonar Radio Corp.
Hollywood, Florida

02533
Leigh Instruments Ltd.
Frequency Control Div.
Don Mills, Ontario, Canada

02606
Fenwal Labs
Division of Travenal Labs
Morton Grove, Illinois

0266
Bunker Ramo-Eltra Corp.
Amphenol NA Div.
Broadview, Illinois

02735
RCA-Solid State Div.
Somerville, New Jersey

02799
Arco Electronics Inc.
Chatsworth, California

03508
General Electric Co.
Semiconductor Products& Batteries
Auburn, New York

03797
Genisco Technology Corp.
Eltronics Div.
Rancho Dominquez, Calif.

03877
Gilbert Engineering Co.Inc
Incon Sub of Transitron
Electronic Corp.
Glendale, Arizona

03888
KDI Electronics Inc.
Pyrofilm Div.
Whippany, New Jersey

03911
Clairex Corp.
Clairex Electronics Div.
Mount Vernon, New York

03980
Muirhead Inc.
Mountainside, New Jersey

04009
Cooper Industries, Inc.
Arrow Hart Div.
Hartford, Connecticut

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, California

04221
Midland-Ross Corp.
Midtex Div.
N. Mankato, Minnesota

04222
AVX Corp.
AVX Ceramics Div.
Myrtle Beach, S. Carolina

04423
Telonic Berkley Inc.
Laguna Beach, California

04713
Motorola Inc.
Semiconductor Group
Phoenix, Arizona

05236
Jonathan Mfg. Co.
Fullerton, California

05245
Corcom Inc.
Libertyville, Illinois

05276
ITT Pomona
Electronics Div.
Pomona, California

05277
Westinghouse Elec. Corp.
Semiconductor Div.
Youngwood, Pennsylvania

05397
Union Carbide Corp.
Materials Systems Div.
Cleveland. Ohio

05571
Sprague Electric Co.
(Now 56289)

05574
Viking Connectors Inc
Sub of Criton Corp.
Chatsworth, Calif.

05820
EG & G Wakefield Engineering
Wakefield, Massachusetts

05972
Loctite Corp.
Newington, Connecticut

06001
General Electric Co.
Electric Capacitor Product Section
Columbia, S. Carolina

06141
Fairchild Weston Systems Inc.
Data Systems Div.
Sarasota, Florida

06192
La Deau Mfg. Co.
Glendale, California

06229
Electrovert Inc.
Elmsford, New York

06383
Panduit Corp.
Tinley Park, Illinois

06473
Bunker Ramo Corp.
Amphenol NA Div.
SAMS Operation
Chatsworth, California

06555
Beede Electrical Instrument
Penacook, New Hampshire

06665
Precision Monolithics
Sub of Bourns Inc.
Santa Clara, California

06666
General Devices Co. Inc.
Indianapolis, Indiana

06739
Electron Corp.
Littleton, Colorado

06743
Gould Inc.
Foil Div.
Eastlake, Ohio

06751
Components Inc.
Semcor Div.
Phoenix, Arizona

06776
Robinson Nugent Inc.
New Albany, Indiana

06915
Richco Plastic Co.
Chicago, Illinois

06961
Vernitron Corp.
Piezo Electric Div.
Bedford, Ohio

06980
Varian Associates Inc.
Eimac Div.
San Carlos, California

07047
Ross Milton Co., The
Southampton, Penna.

07138
Westinghouse Electric Corp.
Industrial & Government
Tube Div.
Horseheads, New York

07233
Benchmark Technology Inc.
City of Industry, Calif.

07239
Biddle Instruments
Blue Bell, Penna.

07256
Silicon Transistor Corp.
Sub of BBF Inc.
Chelmsford, Massachusetts

07261
Avnet Corp.
Culver City, California

07263
Fairchild Camera & Instrument
Semiconductor Div.
Mountain View, California

07344
Bircher Co. Inc., The
Rochester, New York

Federal Supply Codes for Manufacturers (cont)

07557
Campion Co. Inc.
Philadelphia, Penna.

07597
Burndy Corp.
Tape/Cable Div.
Rochester, New York

07716
TRW Inc. (Can use 11502)
IRC Fixed Resistors/
Burlington
Burlington, Iowa

07792
Lerma Engineering Corp.
Northampton, Massachusetts

07810
Bock Corp.
Madison, Wisconsin

07933
Raytheon Co.
Semiconductor Div.
Mountain View, Calif.

08235
Industro Transistor Corp.
Long Island City, New York

08261
Spectra-Strip
An Eltra Co.
Garden Grove, Calif.

08530
Reliance Mica Corp.
Brooklyn, New York

08718
ITT Cannon Electric
Phoenix Div.
Phoenix, Arizona

08806
General Electric Co.
Minature Lamp Products
Cleveland, Ohio

08863
Nylomatic
Fallsington, Penna.

08988
Skottie Electronics Inc.
Archbald, Pennsylvania

09021
Airco Inc.
Airco Electronics
Bradford, Penna.

09023
Cornell-Dublier Electronics
Fuquay-Varina, N. Carolina

09214
General Electric Co.
Semiconductor Products Dept.
Auburn, New York

09353
C and K Components Inc.
Newton, Massachusetts

09423
Scientific Components Inc.
Santa Barbara, California

09579
CTS of Canada, Ltd
Streetsville, Ontario

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, South Dakota

09975
Burroughs Corp.
Electronics Components
Detroit, Michigan

10059
Barker Engineering Corp.
Kenilworth, New Jersey

10389
Illinois Tool Works Inc.
Licon Div.
Chicago, Illinois

10582
CTS of Asheville
Skyland, N. Carolina

11236
CTS Corp.
Berne Div.
Berne, Indiana

11237
CTS Corp of California
Paso Robles Div.
Paso Robles, California

11295
ECM Motor Co.
Schaumburg, Illinois

11358
Columbia Broadcasting System
CBS Electronic Div.
Newburyport, Massachusetts

11403
Vacuum Can Co.Best Coffee Maker Div.
Chicago, Illinois

11502
TRW Inc.
TRW Resistive Products Div.
Boone, North Carolina

11503
Keystone Columbia Inc.
Freemont, Indiana

11532
Teledyne Relays Teledyne
Industries Inc.
Hawthorne, California

11711
General Instrument Corp.
Rectifier Div.
Hicksville, New York

11726
Qualidyne Corp.
Santa Clara, California

12014
Chicago Rivet & Machine Co.
Naperville, Illinois

12040
National Semiconductor Corp.
Danbury, Connecticut

12060
Diodes Inc.
Northridge, California

12136
PHC Industries Inc.
Formerly Philadelphia Handle Co.
Camden, New Jersey

12300
AMF Canada Ltd.
Potter-Brumfield
Guelph, Ontario, Canada

12323
Practical Automation Inc.
Shelton, Connecticut

12327
Freeway Corp.
Cleveland, Ohio

12443
Budd Co.,The
Plastics Products Div.
Phoenixville, Pennsylvania

12581
Hitachi Metals International Ltd.
Hitachi Magna-Lock Div.
Big Rapids, Missouri

12615
US Terminals Inc.
Cincinnati, Ohio

12617
Hamlin Inc.
Lake Mills, Wisconsin

12697
Clarostat Mfg. Co. Inc.
Dover, New Hampshire

12749
James Electronic Inc.
Chicago, Illinois

12856
MicroMetals Inc.
Anaheim, California

12881
Metex Corp.
Edison, New Jersey

12895
Cleveland Electric Motor Co.
Cleveland, Ohio

12954
Microsemi Corp.
Components Group
Scottsdale, Arizona

12969
Unitrode Corp.
Lexington, Massachusetts

13050
Potter Co.
Wesson, Mississippi

13103
Thermalloy Co., Inc.
Dallas, Texas

13327
Solitron Devices Inc.
Tappan, New York

13511
Bunker-Ramo Corp.
Amphenol Cadre Div.
Los Gatos, California

13606
Sprague Electric Co.
(Use 56289)

13689
SPS Technologies Inc.
Hatfield, Pennsylvania

13919
Burr-Brown Research Corp.
Tucson, Arizona

14099
Semtech Corp.
Newbury Park, California

14140
McGray-Edison Co.
Commercial Development Div.
Manchester, New Hampshire

14193
Cal-R-Inc.
Santa Monica, California

14298
American Components Inc.
an Insilco Co. RPC Div.
Conshohocken, Pennsylvania

14298
ACIC Inc.
Sub of Insilco Corp.
Research Triangle Park, NC

14329
Wells Electronics Inc.
South Bend, Indiana

14482
Watkins-Johnson Co.
Palo Alto, California

14552
Microsemi Corp.
Santa Ana, California

14655
Cornell-Dublier Electronics
Div. of Federal Pacific
Electric Co. Govt Cont Dept.
Newark, New Jersey

Federal Supply Codes for Manufacturers (cont)

14704
Crydom Controls
(Division of Int Rectifier)
El Segundo, California

14752
Electro Cube Inc.
San Gabriel, California

14936
General Instrument Corp.
Discrete Semi Conductor Div.
Hicksville, New York

14949
Trompeter Electronics
Chatsworth, California

15412
Amtron
Midlothian, Illinois

15542
Scientific Components Corp.
Mini-Circuits Laboratory Div.
Brooklyn, New York

15636
Elec-Trol Inc.
Saugus, California

15782
Bausch & Lomb Inc.
Graphics & Control Div.
Austin, Texas

15801
Fenwal Eletronics Inc.
Div. of Kidde Inc.
Framingham, Massachusetts

15818
Teledyne Inc. Co.
Teledyne Semiconductor Div.
Mountain View, California

15849
Useco Inc.
(Now 88245)

15898
International Business
Machines Corp.
Essex Junction, Vermont

16245
Conap Inc.
Olean, New York

16258
Space-Lok Inc.
Burbank, California

16352
Codi Corp.
Linden, New Jersey

16469
MCL Inc.
LaGrange, Illinois

16473
Cambridge Scientific Industries
Div. of Chemed Corp.
Cambridge, Maryland

16733
Cablewave Systems Inc.
North Haven, Connecticut

16742
Paramount Plastics
Fabricators Inc.
Downey, California

16758
General Motors Corp.
Delco Electronics Div.
Kokomo, Indiana

17069
Circuit Structures Lab
Burbank, California

17117
Electronic Molding Corp.
Woonsocket, Rhode Island

17338
High Pressure Eng. Co. Inc.
Oklahoma City, Oklahoma

17545
Atlantic Semiconductors Inc.
Asbury Park, New Jersey

17745
Angstrohm Precision, Inc.
Hagerstown, Maryland

17856
Siliconix Inc.
Santa Clara, California

18178
E G & Gvactee Inc.
St. Louis, Missouri

18324
Signetics Corp.
Sacramento, California

18520
Sharp Electronics Corp.
Paramus, New Jersey

18542
Wabash Inc.
Wabash Relay & Electronics Div.
Wabash, Indiana

18565
Chomerics Inc.
Woburn, Massachusetts

18612
Vishay Intertechnology Inc.
Vishay Resistor Products Group
Malvern, Pennsylvania

18632
Norton-Chemplast
Santa Monica, California

18677
Scanbe Mfg. Co.
Div. of Zero Corp.
El Monte, California

18736
Voltronics Corp.
East Hanover, New Jersey

18927
GTE Products Corp.
Precision Material Products
Business Parts Div.
Titusville, Pennsylvania

19315
Bendix Corp., The
Navigation & Control Group
Terboro, New Jersey

19451
Perine Machinery & Supply Co..
Kent, Washington

19613
Minnesota Mining & Mfg. Co.
Textool Products Dept.
Electronic Product Div.
Irving, Texas

19647
Caddock Electronics Inc.
Riverside, California

19701
Mepco/Centralab Inc.
A N. American Philips Co.
Mineral Wells, Texas

20584
Enochs Mfg. Inc.
Indianapolis, Indiana

20891
Cosar Corp.
Dallas, Texas

21317
Electronics Applications Co.
El Monte, California

21604
Buckeye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Semiconductor Group
Rivera Beach, Florida

22526
DuPont, EI DeNemours & Co. Inc.
DuPont Connector Systems
Advanced Products Div.
New Cumberland, Pennsylvania

22767
ITT Semiconductors
Palo Alto, California

22784
Palmer Inc.
Cleveland, Ohio

23050
Product Comp. Corp.
Mount Vernon, New York

23732
Tracor Applied Sciences Inc.
Rockville, Maryland

23880
Stanford Applied Engineering
Santa Clara, California

23936
William J. Purdy Co.
Pamotor Div.
Burlingame, California

24347
Penn Engineering Co.
S. El Monte, California

24355
Analog Devices Inc.
Norwood, Massachusetts

24444
General Semiconductor
Industries, Inc.
Tempe, Arizona

24655
Genrad Inc.
Concord, Massachusetts

24759Lenox-Fugle Electronics Inc.
South Plainfield, New Jersey

24796
AMF Inc.
Potter & Brumfield Div.
San Juan Capistrano, Calif.

24931
Specialty Connector Co.
Greenwood, Indiana

25088
Siemen Corp.
Isilen, New Jersey

25099
Cascade Gasket
Kent, Washington

25403
Amperex Electronic Corp.
Semiconductor & Micro-Circuit Div.
Slatersville, Rhode Island

25706
Dabum Electronic & Cable Corp.
Norwood, New Jersey

26629
Frequency Sources Inc.
Sources Div.
Chelmsford, Massachusetts

26806
American Zettler Inc.
Irvine, California

27014
National Semiconductor Corp.
Santa Clara, California

27167
Corning Glass Works Corning
Electronics
Wilmington, North Carolina

27264
Molex Inc.
Lisle, Illinois

27440
Industrial Screw Products
Los Angeles, California

Federal Supply Codes for Manufacturers (cont)

27745
Associated Spring Barnes Group Inc.
Syracuse, New York

27956
Relcom (Now 14482)

28198
Positronic Industries
Springfield, Missouri

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

28425
Serv-O-Link
Euless, Texas

28478
Deltrol Corporation
Deltrol Controls Div.
Milwaukee, Wisconsin

28480
Hewlett Packard Co.
Corporate HQ
Palo Alto, California

28484
Emerson Electric Co.
Gearmaster Div.
McHenry, Illinois

28520
Heyco Molded Products
Kenilworth, New Jersey

29083
Monsanto Co.
Santa Clara, California

29604
Stackpole Components Co.
Raleigh, North Carolina

29907
Omega Engineering Inc.
Stamford, Connnecticut

30035
Jolo Industries Inc.
Garden Grove, California

30146
Symbex Corp.
Painesville, Ohio

30148
AB Enterprise Inc.
Ahoskie, North Carolina

30161
Aavid Engineering Inc.
Laconia, New Hampshire

30315
Itron Corp.
San Diego, California

30323
Illinois Tool Works Inc.
Chicago, Illinois

30800
General Instrument Corp.
Capacitor Div.
Hicksville, New York

31019
Solid State Scientific Inc.
Willow Grove, Pennsylvania

31091
Alpha Industries Inc.
Microelectronics Div.
Hatfield, Pennsylvania

31323
Metro Supply Company
Sacramento, California

31448
Army Safeguard Logistics Command
Huntsville, Alabama

31746
Cannon Electric
Woodbury, Tennessee

31827
Budwig
Ramona, California

31918
ITT-Schadow
Eden Prairie, Minnesota

32293
Intersil
Cupertino, California

32539
Mura Corp.
Westbury, Long Island, N.Y.

32559
Bivar
Santa Ana, California

32767
Griffith Plastics Corp.
Burlingame, California

32879
Advanced Mechanical Components
Northridge, California

32897
Murata Erie North America Inc.
Carlisle Operations
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Div.
Riverside, California

33096
Colorado Crystal Corp.
Loveland, Colorado

33173
General Electric Co.
Owensboro, Kentucky

33246
Epoxy Technology Inc.
Billerica, Massachusetts

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

33919
Nortek Inc.
Cranston, Rhode Island

34333
Silicon General Inc.
Garden Grove, California

34225
Advanced Micro Devices
Sunnyvale, California

34359
Minnesota Mining & Mfg. Co.
Commercial Office Supply Div.
Saint Paul, Minnesota

34371
Harris Corp.
Harris Semiconductor
Products Group
Melbourne, Florida

34649
Intel Corp.
Santa Clara, California

34802
Electromotive Inc.
Kenilworth, New Jersey

34848
Hartwell Special Products
Placentia, California

35009
Renfrew Electric Co. Ltd.
IRC Div.
Toronto, Ontario, Canada

36665
Mitel Corp.
Kanata, Ontario, Canada

37942
Mallory Capacitor Corp.
Sub of Emhart Industries
Indianapolis, Indiana

39003
Maxim Industries
Middleboro, Massachusetts

40402
Roderstein Electronics Inc.
Statesville, North Carolina

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc.(Now 53342)

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Executive Offices
Lexington, Massachusetts

50088
Thomson Components-Mostek Corp.
Carrollton, Texas

50120
Eagle-Picher Industries Inc.
Electronics Div.
Colorado Springs, Colorado

50157
Midwest Components Inc.
Muskegon, Mississippi

50541
Hypertronics Corp.
Hudson, Massachusetts

50579
Litronix Inc.
Cupertino, California

51167
Aries Electronics Inc.
Frenchtown, New Jersey

51372
Verbatim Corp.
Sunnyvale, California

51406
Murata Erie, No. America Inc.
(Also see 72982)
Marietta, Georgia

51499
Amtron Corp.
Boston, Massachusetts

51605
CODI Semiconductor Inc.
Kenilworth, New Jersey

51642
Centre Engineering Inc.
State College, Pennsylvania

51791
Statek Corp.
Orange, California

51984
NEC America Inc.
Falls Church, Virginia

52063
Exar Integrated Systems
Sunnyvale, California

52072
Circuit Assembly Corp.
Irvine, California

52152
Minnesota Mining & Mfg.
Saint Paul, Minnesota

52333
API Electronics
Haugpauge,Long Island,New York

52361
Communication Systems
Piscataway, New Jersey

52525
Space-Lok Inc.
Lerco Div.
Burbank, California

52531
Hitachi Magnetics
Edmore, Missouri

52745
Timco
Los Angeles, California

52763
Stettner-Electronics Inc.
Chattanooga, Tennessee

52769
Sprague-Goodman Electronics Inc.
Garden City Park, New York

52771
Moniterm Corp.
Amatrom Div.
Santa Clara, California

52840
Western Digital Corp.
Costa Mesa, California

53021
Sangamo Weston Inc.
(See 06141)

53217
Technical Wire Products Inc.
Santa Barbara, California

53342
Opt Industries Inc.
Phillipsburg, New Jersey

53944
Glow-Lite
Pauls Valley, Oklahoma

54294
Shallcross Inc.
Smithfield, North Carolina

54453
Sullins Electronic Corp.
San Marcos, California

54473
Matsushita Electric Corp.
(Panasonic)
Secaucus, New Jersey

54583
TDK
Garden City, New York

54869
Piher International Corp.
Arlington Heights, Illinois

54937
DeYoung Mfg.
Bellevue, Washington

54590
RCA Corp.
Electronic Components Div.
Cherry Hill, New Jersey

55026
American Gage & Machine Co.
Simpson Electric Co. Div.
Elgin, Illinois

55112
Plessey Capacitors Inc.
(Now 60935)

55261
LSI Computer Systems Inc.
Melville, New York

55285
Berquist Co.
Minneapolis, Minnesota

55576
Synertek
Santa Clara, California

55680
Michicon/America/Corp.
Schaumburg, Illinois

56282
Utek Systems Inc.
Olathe, Kansas

56289
Sprague Electric Co.
North Adams, Massachusetts

56365
Square D Co.
Corporate Offices
Palatine, Illinois

56375
DAL Industries Inc.
Wescorp Div.
Mountain View, California

56481
Shugart Associates
Sub of Xerox Corp.
Sunnyvale, California

56708
Zilog Inc.
Campbell, California

56856
Vamistor Corp. of Tennessee
Sevierville, Tennessee

56880
Magnetics Inc.
Baltimore, Maryland

57026
Endicott Coil Co. Inc.
Binghamton, New York

57053
Gates Energy Products
Denver, Ohio

58014
Hitachi Magnalock Corp.
(Now 12581)

58104
Simco
Atlanta, Georgia

58474
Superior Electric Co.
Bristol, Connecticut

59124
KOA-Speer Electronics Inc.
Bradford, Pennsylvania

59640
Supertex Inc.
Sunnyvale, California

59660
Tusonix Inc.
Tucson, Arizona

59730
Thomas and Betts Corp.
Iowa City, Iowa

59831
Semtronics Corp.
Watchung, New Jersey

60395
Xicor Inc.
Milpitas, California

60399
Torin Engineered Blowers
Div. of Clevepak Corp.
Torrington, Connecticut

60705
Cera-Mite Corp.
(formerly Sprague)
Grafton, Wisconsin

60935
Westlake Capacitor Inc.
Tantalum Div.
Greencastle, Indiana

61804
M/A Com Inc.
Burlington, Massachusetts

61857
SAN-O Industrial Corp.
Bohemia, Long Island, NY

61935
Schurter Inc.
Petaluma, California

62351
Apple Rubber
Lancaster, New York

62793
Lear Siegler Inc.
Energy Products Div.
Santa Ana, California

63743
Ward Leonard Electric Co.Inc.
Mount Vernon, New York

64154
Lamb Industries
Portland, Oregon

64155
Linear Technology
Milpitas, California

64834
West M G Co.
San Francisco, Calif.

65092
Sangamo Weston Inc.
Weston Instruments Div.
Newark, New Jersey

65940
Rohm Corp & Whatney
Irvine, California

65964
Evox Inc.
Bannockburn, Illinois

66150
Entron Inc.
Winslow Teltronics Div.
Glendale, New York

66608
Bering Industries
Fremont, California

70290
Almetal Universal Joint Co.
Cleveland, Ohio

70485
Atlantic India Rubber Works Inc.
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71002
Bimbach Co. Inc.
Farmingdale, New York

71034
Bliley Electric Co.
Erie, Pennsylvania

71183
Westinghouse Electric Corp.
Bryant Div.
Bridgeport, Connecticut

71400
Bussman Manufacturing
Div. McGraw-Edison Co.
St. Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Div. of ITT
Fountain Valley, California

71482
General Instrument Corp.
Clare Div.
Chicago, Illinois

Federal Supply Codes for Manufacturers (cont)

71590
Mepco/Centralab
A North American Philips Co.
Fort Dodge, Iowa

71707
Coto Corp.
Providence, Rhode Island

71744
General Instrument Corp.
Lamp Div/Worldwide
Chicago, Illinois

71785
TRW Inc.
Cinch Connector Div.
Elk Grove Village, Illinois

71984
Dow Corning Corp.
Midland, Michigan

72005
AMAX Specialty Metals Corp.
Newark, New Jersey

72136
Electro Motive Mfg. Corp.
Florence, South Carolina

72228
AMCA International Corp.
Continental Screw Div.
New Bedford, Massachusetts

72259
Nytronics Inc.
New York, New York

72619
Amperex Electronic Corp.
Dialight Div.
Brooklyn, New York

72653
G C Electronics Co.
Div. of Hydrometals Inc.
Rockford, Illinois

72794
Dzus Fastner Co. Inc.
West Islip, New York

72928
Gulton Industries Inc.
Gudeman Div.
Chicago, Illinois

72982
Murata Erie N. America Inc.
Erie, Pennsylvania

73138
Beckman Industrial corp.
Helipot Div.
Fullerton, California

73168
Fenwal Inc.
Ashland, Massachusetts

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrance, California

73445
Amperex Electronic Corp.
Hicksville, New York

73559
Carlingswitch Inc.
Hartford, Connecticut

73586
Circle F Industries
Trenton, New Jersey

73734
Federal Screw Products Inc.
Chicago, Illinois

73743
Fischer Special Mfg. Co.
Cold Spring, Kentucky

73893
Microdot
Mt. Clemens, Mississippi

73899
JFD Electronic Components
Div. of Murata Erie
Oceanside, New York

73905
FL Industries Inc.
San Jose, California

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74199
Quam Nichols Co.
Chicago, Illinois

74217
Radio Switch Co.
Marlboro, New Jersey

74306
Piezo Crystal Co.
Div. of PPA Industries Inc.
Carlisle, Pennsylvania

74542
Hoyt Elect.Instr. Works Inc.
Penacook, New Hampshire

74840
Illinois Capacitor Inc.
Lincolnwood, Illinois

74970
Johnson EF Co.
Waseca, Minnesota

75042
TRW Inc.
IRC Fixed Resistors
Philadelphia, Pennsylvania

75297
Litton Systems
Kester Solder Div.
Chicago, Illinois

75376
Kurz-Kasch Inc.
Dayton, Ohio

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
(Now 83330)
Mount Vernon, New York

75915
Tracor Littlefuse
Des Plaines, Illinois

76854
Oak Switch Systems Inc.
Crystal Lake, Illinois

77122
TRW Assemblies & Fasteners Group
Fastener Div.
Moutainside, New Jersey

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, Indiana

77542
Ray-O-Vac Corp
Madison, Wisconsin

77638
General Instrument Corp.
Rectifier Div.
Brooklyn, New York

77900
Shakeproof Lock Washer Co.
(Now 78189)

77969
Rubbercraft Corp. of CA Ltd.
Torrance, California

78189
Illinois Tool Works Inc.
Shakeproof Div.
Elgin, Illinois

78277
Sigma Instruments Inc.
South Braintree, Mass.

78290
Struthers Dunn Inc.
Pitman, New Jersey

78553
Eaton Corp.
Engineered Fastener Div.
Cleveland, Ohio

78592
Stoeger Industries
South Hackensack, New Jersey

79136
Waldes Kohinoor Inc.
Long Island City, New York

79497
Western Rubber Co.
Goshen, Indiana

79727
C - W Industries
Southampton, Pennsylvania

79963
Zierick Mfg. Corp.
Mount Kisco, New York

80009
Tektronix
Beaverton, Oregon

80031
Mepco/Electra Inc.
Morristown, New Jersey

80032
Ford Aerospace & Communications Corp.
Western Development
Laboratories Div.
Palo Alto, California

80145
LFE Corp.
Process Control Div.
Clinton, Ohio

80183
Sprague Products
(Now 56289)

80294
Bourns Instruments Inc.
Riverside, California

80583
Hammerlund Mfg. Co. Inc.
Paramus, New Jersey

80640
Computer Products Inc.
Stevens-Arnold Div.
South Boston, Mass.

81073
Grayhill Inc.
La Grange, Illinois

81312
Litton Systems Inc.
Winchester Electronics Div.
Watertown, Connecticut

81439
Therm-O-Disc Inc.
Mansfield, Ohio

81483
International Rectifier Corp.
Los Angeles, California

81590
Korry Electronics Inc.
Seattle, Washington

81741
Chicago Lock Co.
Chicago, Illinois

82227
Airpax Corp.
Cheshire Div.
Cheshire, Connecticut

82240
Simmons Fastner Corp.
Albany, New York

82305
Palmer Electronics Corp.
South Gate, California

82389
Switchcraft Inc.
Sub of Raytheon Co.
Chicago, Illinois

82415
Airpax Corp
Frederick Div.
Frederick, Maryland

82872
Roanwell Corp.
New York, New York

82877
Rotron Inc.
Custom Div.
Woodstock, New York

82879
ITT
Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83014
Hartwell Corp.
Placentia, California

83055
Signalite Fuse Co.
(Now 71744)

83058
TRW Assemblies & Fasteners Group
Fasteners Div.
Cambridge, Massachusetts

83259
Parker-Hannifin Corp.
O-Seal Div.
Culver City, California

83298
Bendix Corp.
Electric & Fluid Power Div.
Eatonville, New Jersey

83315
Hubbell Corp.
Mundelein, Illinois

83330
Kulka Smith Inc.
A North American Philips Co.
Manasquan, New Jersey

83478
Rubbercraft Corp. of America
West Haven, Connecticut

83553
Associated Spring Barnes Group
Gardena, California

83740
Union Carbide Corp.
Battery Products Div.
Danbury, Connecticut

84171
Arco Electronics
Commack, New York

84411
American Shizuki
TRW Capacitors Div.
Ogallala, Nebraska

84613
FIC Corp.
Rockville, Maryland

84682
Essex Group Inc.
Peabody, Massachusetts

85367
Bearing Distributing Co.
San Fransisco, California

85372
Bearing Sales Co.
Los Angeles, California

85480
W. H. Brady Co.
Industrial Product
Milwaukee, Wisconsin

85932
Electro Film Inc.
Valencia, California

86577
Precision Metal Products Co.
Peabody, Massachusetts

86684
Radio Corp. of America
(Now 54590)

86928
Seastrom Mfg. Co. Inc.
Glendale, California

87034
Illuminated Products Inc.
(Now 76854)

88219
GNB Inc.
Industrial Battery Div.
Langhorne, Pennsylvania

88245
Winchester Electronics
Litton Systems-Useco Div.
Van Nuys, California

88486
Triangle PWC Inc.
Jewitt City, Connecticut

88690
Essex Group Inc.
Wire Assembly Div.
Dearborn, Michigan

89020
Amerace Corp.
Buchanan Crimptool Products Div.
Union, New Jersey

89265
Potter-Brumfield
(See 77342)

89536
John Fluke Mfg. Co., Inc.
Everett, Washington

89597
Fredericks Co.
Huntingdon Valley, Penna.

89709
Bunker Ramo-Eltra Corp.
Amphenol Div.
Broadview, Illinois

89730
General Electric
Lamp Div.
Newark, New Jersey

90201
Mallory Capacitor Co.
Sub of Emhart Industries Inc.
Indianapolis, Indiana

90215
Best Stamp & Mfg. Co.
Kansas City, Missouri

90303
Duracell Inc.
Technical Sales & Marketing
Bethel, Connecticut

91094
Essex Group Inc.
Suflex/IWP Div.
Newmarket, New Hampshire

91247
Illinois Transformer Co.
Chicago, Illinois

91293
Johanson Mfg. Co.
Boonton, New Jersey

91462
Alpha Industries Inc.
Logansport, Indiana

91502
Associated Machine
Santa Clara, California

91506
Augat Inc.
Attleboro, Massachusetts

91507
Froeliger Machine Tool Co.
Stockton, California

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
A Gulf Western Mfg. Co.
Connector Div.
Huntingdon, Pennsylvania

91737
ITT Cannon/Gremar
(Now 08718)

91802
Industrial Devices Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91836
King's Electronics Co. Inc.
Tuckahoe, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934
Miller Electric Co.
Woonsocket, Rhode Island

91984
Maida Development Co.
Hampton, Virginia

91985
Norwalk Valve Co.
S. Norwalk, Connecticut

92914
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, Massachusetts

94144
Raytheon Co.
Microwave & Power Tube Div.
Quincy, Massachusetts

94222
Southco Inc.
Concordville, Pennsylvania

94988
Wagner Electric Corp.
Sub of Mcgraw-Edison Co.
Whippany, New Jersey

95146
Alco Electronic Products Inc.
Switch Div.
North Andover, Massachusetts

95263
Leecraft Mfg. Co.
Long Island City, New York

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, Ohio

95348
Gordo's Corp.
Bloomfield, New Jersey

95354
Methode Mfg. Corp.
Rolling Meadows, Illinois

Federal Supply Codes for Manufacturers (cont)

95573
Campion Laboratories Inc.
Detroit, Michigan

95712
Bendix Corp.
Electrical Comp. Div.
Franklin, Indiana

95987
Weckesser Co. Inc.
(Now 85480)

96733
SFE Technologies
San Fernando, California

96853
Gulton Industries Inc.
Measurement & Controls Div.
Manchester, New Hampshire

96881
Thomson Industries Inc.
Port Washington, New York

97525
EECO Inc.
Santa Ana, California

97540
Whitehall Electronics Corp.
Master Mobile Mounts Div.
Fort Meyers, Florida

97913
Industrial Electronic
Hardware Corp.
New York, New York

97945
Pennwalt Corp.
SS White Industrial Products
Piscataway, New Jersey

97966
CBS
Electronic Div.
Danvers, Massachusetts

98094
Machlett Laboratories Inc.
Santa Barbara. California

98159
Rubber-Teck Inc.
Gardena, California

98278
Malco A Microdot Co.
South Pasadena, California

98291
Sealectro Corp.
BICC Electronics
Trumbill, Connecticut

98372
Royal Industries Inc.(Now 62793)

98388
Lear Siegler Inc.
Accurate Products Div.
San Deigo, California

99120
Plastic Capacitors Inc.
Chicago, Illinois

99217
Bell Industries Inc.
Elect. Distributor Div.
Sunnyvale, California

99378
ATLEE of Delaware Inc.
N. Andover, Massachusetts

99392
Mepco/Electra Inc.
Roxboro Div.
Roxboro, North Carolina

99515
Electron Products Inc.
Div. of American Capacitors
Duarte, California

99779
Bunker Ramo- Eltra Corp.
Barnes Div.
Lansdown, Pennsylvania

99800
American Precision Industries
Delevan Div.
East Aurora, New York

99942
Mepco/Centralab
A North American Philips Co.
Milwaukee, Wisconsin

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41-C New London Turnpike
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(313) 522-9140

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(612) 854-5526

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Greensboro, NC 27408
(919) 273-1918

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West 75 Century Road
Paramus, NJ 07652
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NM, Albuquerque
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Rochester, NY 14622
(716) 323-1400

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Middleburg Heights, OH 44130
(216) 234-4540

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John Fluke Mfg. Co., Inc.
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Suite 111
Kettering, OH 45429
(513) 436-2224

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OR, Portland
(503) 227-2042

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John Fluke Mfg. Co., Inc.
200 Lindenwood Drive
Malvern, PA 19355
(215) 647-9550

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(915) 533-3508

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John Fluke Mfg. Co., Inc.
10417 Gulfdale
San Antonio, TX 78216
(512) 340-0498

UT, Salt Lake City
(801) 268-9331

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John Fluke Mfg. Co., Inc.
5020 148th Ave. N.E.
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Redmond, WA 98052
(206) 881-6966

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USAF	(513) 436-2224, OH (512) 340-2621, TX
Security	(301) 770-1570, MD

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IL, Chicago (312) 705-0500
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NJ, Paramus (201) 262-9550
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TLX: (790) 25887 A/B: ELSCOAA 25887
FAX: 61-2-733663

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12 Maroondah Highway
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P.O. Box 154
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Elmeasco Instruments Pty, Ltd.
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FAX: (61) (9) 322-2075

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1220 Vienna, Austria
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FAX: 43-222-25-72-75

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Basma W.L.L.
P.O. Box 5701
Manama, Bahrain
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FAX: (965) 245218

Bangladesh ●
Motherland Corporation
24 Hatkhola Road, Tikatuli
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Cable: "MOTHERLAND" DACCA

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Industrial & Electro-Acoustic Systems
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Tlx: 35000 phtc nl
Fax: 040-785651

Bolivia ●
Coasin Bolivia S.R.L.
Casilla 7295
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Cable: COALAP

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ATP/Hi-Tek Eletronica Ltda.
Al. Amazonas 422,
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Sao Paulo, Brazil
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TLX: (391) 1171413 HITK BR

Brunei ●
Rank O'Connor's SDN BHD
No. 8 Blk D
Sufri Shophouse Complex
Mile 1 Jalan Tutong
Bandar Seri Begawan
Negara Brunei Darussalam
Tel: 673-2-23109 or 23557
TLX: (799) BU 2265 RANKOC

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Fax: (403) 291-5219

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Fax: (613) 723-9458

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Intronica Chile, Ltda.
Casilla 16228 (Mail)
Santiago 9, Chile
Tel: 56-2-2321886
TLX: (332) 346351 INTRON CK

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Fluke International Corporation
P.O. Box 9085
Beijing
People's Republic of China
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TLX: (716) 222237 FBSC CN

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57, Xisi Dong Da Jie
Xicheng-qu
Beijing
Peoples Republic of China
Tel: 86-01-65-7281

Colombia ●
Sistemas E Instrumentacion, Ltda.
Carrera 13, No. 37-43, Of. 401
Ap. Aereo 29583
Bogota DE, Colombia
Tel: 57-232-4532
TLX: (396) 45787 COASN CO

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Chris Radiovision, Ltd.
P.O. Box 1989
Nicosia, Cyprus
Tel: 357-21-66121; TLX: (826) 2395

Cyprus, Northern ■
Ucok Buroteknik
2C & 2D Muftu Ziyai Street
Lefkosa, Northern Cyprus
Mersin 10, Turkey
Tel: 90-741-357-20-71777
TLX: (821) 57267

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Fax: 44-9328-61919

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Eastern European Countries ■
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Proteco Coasin Cia., Ltda.
P.O. Box 228-A
Ave. 12 de Octubre 2285
y Orellana
Quito, Ecuador
Tel: 593-2-529684
TLX: (393) 22085 ESIND

Egypt
Electronic Engineering Liaison Office
P.O. Box 2891 Horreya
11361 Heliopolis, Cairo
Egypt
Tel: 20-2-695705, TLX: (927) 22782

England
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5600 MD Eindhoven
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Tlx: 35000 phtc nl
Fax: 040-785651

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Awa New Zealand Limited
37 Freeston Road
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FAX: 679-314379

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P.O. Box 64
02631 Espoo 63
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TLX: (857) 124426 HAVUL SF
FAX: (358) 0-5021073
Teletex: (857) 8-100155 INSTRUE

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M.B. Electronique S.A.
606, Rue Fourney
P.O. Box 31
78530 BUC, France
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TLX: (842) 695414
Fax: (33) (1) 3956-53-44

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Tlx: 35000 phtc nl
Fax: 040-785651

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Hellenic Scientific Representations Ltd.
11, Vrassida Street
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18th Floor, Great Eagle Centre
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Section 7A
Manual Change Information

INTRODUCTION

This section of the manual contains information necessary to backdate the manual to conform with earlier pcb configurations. To identify the configuration of the pcb's, refer to the revision letter (marked in ink) on the component side of each pcb assembly. Table 1 defines the revision levels documentated in this manual.

NEWER INSTRUMENTS

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

OLDER INSTRUMENTS

To backdate this manual to conform with earlier revision levels, perform the changes indicated in Table 1.

Table 7A-1. Manual Status and Backdating Information

Ref Or Option No.	Assembly Name	Fluke Part No.	* To adapt manual to earlier rev configurations perform changes in desending order (by no.), ending with change under desired rev letter														
			—	A	B	C	D	E	F	G	H	J	K	L	M	N	P
A1	Front Panel Display PCB Assy	639419	●	●	●	●	●	●	X								
A2	Mother Board 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	638544	●	●	●	●	●	X									
A7	Front/Rear Switch PCB Assy	735167	●	●	●	●	●	●	●	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							
A11A1	Attenuator PCB Assy	656272	●	X													
A11A2	Amplifier PCB Assy	656280	●	●	●	●	●	●	X								

* X = The PCB revision levels documented in this manual.
● = These revision letters were never used in the instrument.
—= No revision letter on the PCB.

Appendix 7B
Software Calibration

7B-1. INTRODUCTION

The 8505A and 8506A use 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. Extended intervals between hardware calibration are possible. The scale factor for each range can be calibrated using any reference input value from 60% of range to full scale. The following paragraphs first discuss the general procedure used in software calibration, then detail the procedure used for each function.

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, locally verify that the AVG/(CAL) annunciator is not flashing or remotely verify that Calibration mode is off (G5 response = 0) before cycling power to OFF. If power is OFF, verify that the rear panel Calibration switch is off before cycling power to ON.

Software calibration entails a combination of zero offset and gain corrections. The Calibration mode must be activated when making calibration entries from either a local or remote location. This mode can only be entered by accessing the Calibration switch on the multimeter rear panel. The calibration sticker must be removed and the slide switch positioned to ON when the multimeter is in local (front panel) control. The front panel AVG/(CAL) annunciator flashes to denote activation of Calibration mode. Zero correction values can then be entered for each range in dc voltage (VDC) and resistance (OHMS) functions only. Gain correction factors can be stored for each range in each function by applying 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 each range. A number representing the calibration date or identifying the multimeter can also be entered when the Calibration mode is activated.

The zero offset correction values are applied to the reading whenever the Zero mode is on (ZERO annunciator lit). The gain correction factors are applied to the reading as soon as they are entered and continue to be applied whether Calibration mode is on or off.

NOTE

In Calibration mode, the multimeter uses the "permanent" zero offset corrections stored in Calibration Memory; it does not use the "temporary zeros" that can be stored when Calibration mode is off.

Locally, application of zero correction values can be interrupted by turning the Zero mode off. Remotely, both zero correction values and gain correction factors can be inhibited or enabled with the following commands:

1. M : inhibit gain correction factors

2. M 0 : enable gain correction factors

3. M 1 : inhibit zero values

4. M 2 : enable zero values

The multimeter may be interrogated from local or remote locations (Calibration mode on or off) for recall of zero values (VDC or OHMS) or the calibration date (multimeter identification) number. The last uncorrected reading can also be recalled from the front panel at any time. Remotely, uncorrected readings can be verified by sending a calibration factor inhibit command (M) and commanding a new reading.

Software calibration offers numerous benefits. Physical access to the multimeter is not necessary: no cover need be removed. Uncertainties due to internal temperature differentials and thermal equilibrium can thereby be eliminated. The procedure also proves convenient where the multimeter is stacked or mounted in a rack. The multimeter does not need to be removed from the system during software calibration: the procedure can be accomplished from local (front panel) or remote locations.

When the multimeter is in Calibration mode (AVG/(CAL) annunciator flashes) the following special conditions should be noted:

1. Locally, the multimeter display is altered to provide 7-1/2 digits on the 10V dc volts range and 6-1/2 digits on all other ranges and functions. Overrange indications (flashing H's) are not available. On the 8506A only, underrange indications (flashing L's) are not available.

CAUTION

Do not disable latching errors during multimeter calibration. The latching error disable feature is useful during troubleshooting (when normally disallowed module configurations may be necessary). Since latching errors may also identify an over voltage condition (as with local Error 4 or remote error 14), discretion must be used.

2. Averaging mode is locked out (Calibration and Averaging modes are mutually exclusive). However, the AVG button can be pushed locally to disable latching error conditions. Pushing AVG a second time enables latching errors once again.

3. All mathematic operations (Offset, Scaling, External Reference) and special operations (Limits, Peaks) are disabled.

7B-2. DESCRIPTION

The function being calibrated determines the calibration corrections that are available. Applicable correction points are summarized in Table 1. DC voltage (VDC) uses all three possible correction points (zero, positive, negative) and is used as an example in the following discussion. Refer to Figure 1 and Table 1. The dc voltage function requires that a zero correction and negative and positive gain corrections be made. Software algorithms (Y=MX + C) are used to perform these corrections. The constant C represents the zero correction value. This value can be stored on any range in the dc voltage (VDC) or resistance (OHMS) function. The constant M is computed by the multimeter. This computation is made by dividing the actual reference input (entered as a numeric) by the measured reference input (the uncorrected reading). Separate computations are made for negative and positive inputs.

Table 1. Calibration Points

FUNCTION	CALIBRATION POINTS			
	Zero Corrections	Positive Gain	Negative Gain	Specified Frequencies
8505A Software Calibration				
DC Volts (VDC or V)	X	X	X	
DC Amps (ADC or I)		X	X	
Ohms (OHMS or Z)	X	X		
AC Volts				
Averaging Option -01 (VAC or VA)				X
True-RMS Option 09A				
(VAC or VA)				X
(VAC+VDC or C)				X
AC Amps (AAC or IA)				X
8506A Software Calibration				
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

For example, assume that the 1V dc range is being calibrated from the front panel. VDC zero (point A in Figure 1) is first performed with the multimeter input shorted to define the offset constant C. The positive gain correction constant M is then defined using any reference value from 600 mV (60% of range) to 2V (full scale). A value of 1.9V (point B in Figure 1) is selected in this case to minimize percentage of reading error and avoid saturation of the A/D Converter. Without correction, the multimeter reads 1.987250V. The correction constant M is therefore computed as:

$$M = \frac{1.9V}{1.987250V}$$

This linear correction factor is now applied to any input between 0 and +2V. Errors due to polarity reversals can be eliminated by storing a separate correction factor using 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.

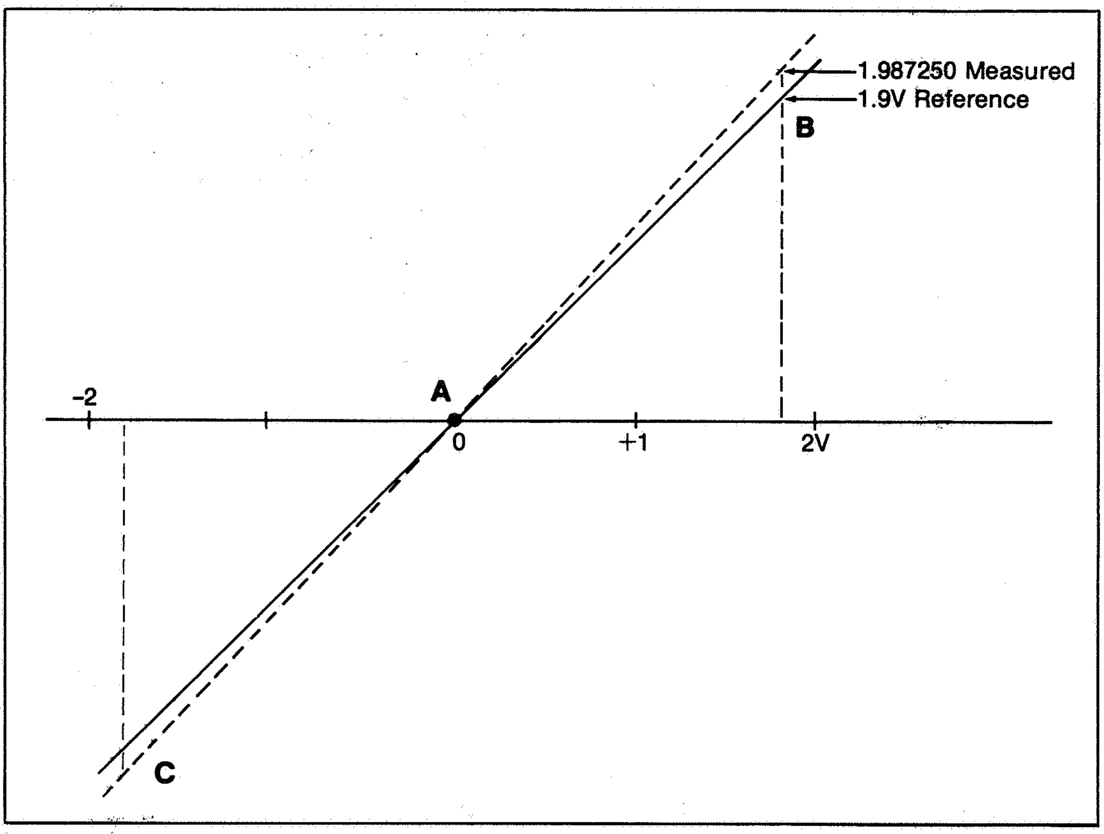


Figure 1. DC Voltage Calibration

Gain correction points for each function and range can be ascertained using Tables 1 and 2. For calibration of ac voltage, separate sets of correction points are used for the 8505A and the 8506A. A list of reference sources sufficiently accurate to calibrate the multimeters is presented in Table 3. Reference source connections are described in Section 4 (standard functions) and Section 6 (optional functions).

NOTE

The accuracy of the calibration correction factor reflects the accuracy of the reference source. To maintain accuracy, use only the sources listed in Table 3 or calibrated sources of equal or better accuracy.

7B-3. LOCAL (FRONT PANEL) CALIBRATION

Local calibration is carried out using several of the push buttons on the front panel. If necessary, refer to Section 2 of the appropriate Instruction Manual for a review of push button operation.

7B-4. Equipment Configurations

Front panel calibration can be made using zero or reference value connections either at the front panel terminals or through the rear input connector. Connections are described in Section 2 of the appropriate Instruction Manual. The following general considerations should be noted:

1. When using the front panel terminals, the three input selectors must be positioned as follows:

   a. Guard Selector: in or out, as required.

Table 2. Gain Correction Parameters

	RANGE	RECOMMENDED	MINIMUM	MAXIMUM
DC Volts	100 mV	190 mV	60 mV	200 mV
	1V	1.9V	0.6V	2V
	10V	19V	6V	20V
	100V	120V	60V	128V
	1000V	1000V	600V	1200V
Ohms	10 ohms	20 ohms	6 ohms	20 ohms
	100 ohms	200 ohms	60 ohms	200 ohms
	1 kohms	2 kohms	600 ohms	2 kohms
	10 kohms	20 kohms	6 kohms	25 kohms
	100 kohms	200 kohms	60 kohms	250 kohms
	1 Mohm	2 Mohms	600 kohms	4.1 Mohms
	10 Mohms	20 Mohms	6 Mohms	35 Mohms
	100 Mohms	100 Mohms	60 Mohms	265 Mohms
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 Amps (1) (8505A)	100 μA	200 μA	60 μA	312.5 μA
	1 mA	2.0 mA	600 μA	2.5 mA
	10 mA	19 mA	6 mA	20 mA
	100 mA	150 mA	60 mA	160 mA
	1A	1.0A	600 mA	1.28A
AC Volts (2) (8505A)	1V	2V	600 mV	2.5V
	10V	19V	6V	20V
	100V	100V	60V	160V
	1000V	900V	600V	1000V
AC Volts (3) (8506A)	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. Gain correction entered at 1 kHz. Actual value must be verified at source output.
2. Gain correction entered at 1 kHz, checked at 10 kHz, 50 kHz, 100 kHz (Averaging Converter Option -01) or at 100 kHz, 500 kHz, 1 MHz (True-RMS Converter Option -09A).
3. Gain correction entered at 1 kHz, checked at 10 kHz and 100 kHz.

Table 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	Linearity ±1 ppm of Input	Fluke Model 750A
Standard Cell Enclosure	Guildline 91	Guildline 9152(R)
	AC Voltage (8505A)	
AC Calibration System	0-1000V ac Accuracy: 1 kHz: .02% 10 kHz: .02% 50 kHz: .05% 100 kHz-1 MHz: .33%	Fluke Model 5200A with Fluke Model 5215A or 5205A
	(refer to Section 4 for 8506A specifications, setup)	
	Ohms	
Standard Resistors	20 ohm: 30 ppm 200 ohm - 20 Mohm: 50 ppm 200 Mohm: 100 ppm	ESI SR-1010 ESI SR-1050
	DC Current	
DC Current Calibrator	Accuracy ±.02%	Fluke Model 382A
200 kohm Resistor	Accuracy ±.01%	
	AC Current	
AC Current Calibrator	Verification Dependent	Fluke Model 5100

b. Ohms Selector: In (4T) for Ohms Zero and Ohms gain corrections (8505A and 8506A) and for VAC corrections (8506A only). The Guard Selector can be in or out for other calibration connections at the front panel terminals.

c. Rear Input Selector: out.

2. When the rear input connector is being used, the Guard Selector and the Ohms Selector have no affect. The Rear Input Selector must be pushed in. Rear inputs are dedicated to a four terminal configuration. Four terminal connections must be used for Ohms Zero and Ohms gain corrections (8505A and 8506A) and for VAC corrections (8506A).

7B-5. Zero Corrections

Zero corrections require activation of the Calibration mode (slide rear panel Calibration switch to on). Zero corrections can then be made separately for each range (without affecting values for other ranges) in dc volts and ohms functions. 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 only be changed by storing new entries when Calibration mode is on.

Software calibration does not use the "temporary" zeros which can be stored during normal operation (with Calibration mode off). The temporary zeros are stored in a separate memory, and do not affect the "permanent" calibration zero values stored in Calibration Memory. The temporary zeros are used to correct for dc drift between calibrations.

The multimeter applies the zero values to the multimeter's readings as follows:

1. If Calibration mode is on, the multimeter applies the permanent values stored in Calibration Memory during software calibration.

2. If Calibration mode is off, the multimeter uses the permanent zeros, supplemented by any temporary zeros stored with the ZERO button during normal operation.

NOTE

The temporary zero values are always reset to 0 when the multimeter is reset or turned off.

When storing permanent zeros during calibration of the V DC function, the INPUT HI and INPUT LO terminals must be shorted with a high-quality, low-thermal shorting bar. When storing permanent zeros 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.

7B-6. Gain Corrections

Corrections at reference input points require activation of the Calibration mode (slide rear panel Calibration switch to on). A reference input can be made at any point from 60% of range to full scale. Reference input parameters for each function are defined in Table 2. It is recommended that reference inputs near the full scale point be used to minimize reading errors. Reference sources are defined in Table 3. Reference source connections for standard functions (dc volts with the 8505A, dc volts and ac volts with the 8506A) are described in Section 4. Source connections for optional functions are described in Section 6. The following procedure is used for each range:

1. Manually select the range to be calibrated (push the up range or down range button).

2. Apply the reference value either to the front panel INPUT HI and LO terminals or through the rear panel input connector.

3. Allow the multimeter to take one reading.

4. Using the front panel push buttons, store the reference value defined by the source. For example, for a reference of 1.9V dc on the 1V dc range, push STORE 1 . 9 (CAL COR).

5. The multimeter computes the gain correction factor necessary to display the stored source value. This factor is then automatically applied to all subsequent readings in this function and range.

6. Verify proper entry of the reference value by allowing the multimeter to take a reading. This reading should be the actual reference value (±accuracy specifications for the multimeter function and range).

7. Repeat steps 1 through 6 for each range.

7B-7. Calibration Date (Multimeter Identification)

Up to six integers signifying the calibration date or identifying the multimeter can also be entered from the front panel. If the calibration date is being entered, 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 month. For example, January 1, 1983 is entered as STORE 8 3 0 1 0 1 (CAL DATE). Alternately, an instrument identification number of 242 is entered as STORE 2 4 2 (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.

7B-8. Recall Operations

The last uncorrected reading and the calibration date (or instrument identifying) number can be recalled for display at any time (Calibration mode on or off). If the Calibration mode is on (AVG/(CAL) annunciator flashes), the sequences used to recall the uncorrected reading and the number are, respectively:

RECALL (CAL COR)

RECALL (CAL DATE)

If the multimeter is not in the Calibration mode (AVG/(CAL) annunciator not flashing), the following sequences must be used:

RECALL LO (CAL COR)

RECALL LO (CAL DATE)

Zero values for the function selected (VDC or OHMS) can be recalled by pushing:

RECALL ZERO VDC/OHMS

This operation can be repeated for each range and does not affect either the stored zero value(s) or the zero mode status. If the multimeter is in VDC or OHMS, the zero value for the range and function selected is recalled. If the multimeter is not in VDC or OHMS, an Error 0 condition is set.

The zero value recalled may be either of the following:

1. If Calibration mode is off, the value recalled is a temporary zero. (Temporary zeros are stored values with the ZERO VDC/OHMS button when Calibration mode is off.) Temporary zero values are reset to zero when the multimeter is reset or turned off.

2. If Calibration mode is on, the zero value recalled is always that stored in Calibration Memory.

7B-9. Error Conditions

The multimeter employs both momentary and latching errors. Once a momentary error automatically clears, 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 Calibration mode is on. The following rules then apply:

CAUTION

Do not disable latching errors during multimeter calibration. The latching error disable feature is useful during troubleshooting (when normally disallowed module configurations may be necessary). Since latching errors may also identify an over voltage condition (as with local Error 4 or remote error 14), discretion must be used.

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. The display should respond with "Err. oFF", indicating latching errors have been disabled. (If a latching error exists when this procedure is performed, the display will instead indicate an error message. In this case, pressing any function button will clear the error message.) Pressing AVG in Calibration mode does not enable the Average mode; the Average mode is mutually exclusive with Calibration mode.

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).

The front panel display identifies numerous potential error conditions. A full description of error conditions is presented in Section 2 of the appropriate Instruction Manual. 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 only be made in VDC or OHMS.

2. Error 1: Store during overrange:
The STORE (CAL COR) sequence has been performed when the previously taken reading was 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. Damage to the multimeter could otherwise result. In any event, 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 Calibration mode:
An unallowed push button sequence has been attempted in the Calibration mode. Use the correct sequence once the display has cleared.

4. Error C: Invalid push button sequence:
This error can occur under the following conditions:

a. 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.

b. The wrong sequence has been used to clear all Calibration Memory entries when the Calibration mode is activated.

c. Error C also occurs when attempting to clear all Calibration Memory entries when not in Calibration mode.

5. Error d: Calibration Memory is faulty or not installed.

6. Error F: Calibration Memory check sum 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 Calibration 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 re-programming 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 re-selected, and the input level must be revised.

9. Error E: Invalid module configuration:
A Calibration Memory module may be 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. This error may also identify an illegal ac converter configuration. For the 8505A, only one ac converter (-01 Option or -09A Option) is allowed. For the 8506A, only the Thermal True-RMS Converter is allowed. Additional ac converters must be removed.

7B-10. Clear Operations

Calibration correction entries can also be removed or replaced from the front panel. The following procedures are available:

1. Applied zero correction values can be altered from the front panel as follows:

a. Temporary zero corrections (which are only used while Calibration mode is off) can be reset to 0 by pressing RESET or by cycling power off and on again (be sure that Calibration mode is off). This does not affect the values stored in Calibration Memory.

NOTE

When Calibration mode is off, application of temporary zero corrections can be disabled by toggling the ZERO annunciator off with the ZERO VDC/OHMS push button. The zeros in Calibration Memory are still applied.

When Calibration mode is on, application of all zero corrections can be disabled by toggling the ZERO annunciator off with the ZERO VDC/OHMS push button.

b. New zero values can be entered by first connecting a high-quality, low-thermal, shorting bar across the input terminals and then pressing the ZERO VDC/OHMS button so that the ZERO annunciator turns on. If Calibration mode is on, this procedure stores a non-volatile ("permanent") zero value in Calibration Memory for the function and range presently selected. When Calibration mode is off, this procedure stores a temporary zero value for the selected range and all higher ranges. The temporary values do not affect Calibration Memory. This procedure is allowed only in V DC and OHMS.

2. Since only one or two gain correction factors are allowed per range (depending on the function), storing a new correction factor automatically replaces any previously stored correction factor. For those functions requiring two gain corrections per range (VDC and ADC), this operation must be performed twice (once for positive, once for negative) to ensure new correction factors for the full range of possible inputs.

NOTE

If hardware calibration is necessary, software calibration entries must first be cleared. The extent of hardware calibration determines the clearing operation required. If all functions are to be hardware calibrated, the procedure in step (4.) must be used. If select functions only are to be hardware calibrated, respective gain correction factors must be cleared with the procedure in step (3.), and zero factors must be disabled where appropriate.

3. Gain correction factors can be erased 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 VDC or ADC.

4. Calibration memory factors for all ranges and functions, zero correction values for all VDC and OHMS ranges, and the calibration date (or instrument identifier) can also be erased using a single operation. This operation may be necessary if an Error F condition (check sum error) cannot be cleared with a multimeter reset or if it is necessary to clear software calibration entries for all functions prior to hardware calibration. With the multimeter in the Calibration mode, the following procedure is used:

a. To initialize the clear procedure, push STORE ZERO VDC/OHMS.

b. If the multimeter is not in the Calibration mode, a momentary Error C condition is set. After a brief pause, the multimeter reverts to the normal display to signify that no change has been initiated.

c. If the multimeter is in the Calibration mode, the display responds with: CLEAr?. At this point, the clear operation can be aborted and the existing correction factors retained by pushing any button other than ZERO VDC/OHMS. The multimeter would then respond with a momentary Error C display and revert to the normal Calibration mode display.

CAUTION

If RESET is pushed during the clearing interval, the clear operation may be interrupted prior to completion. A check sum (Error F) condition would then be set. Do not push the RESET button until the final clearing step (d) has been completed.

d. If the operation is to be completed (not aborted), all zero correction values, calibration correction factors, and the calibration date (instrument identification) number can be cleared by pushing the ZERO VDC/OHMS button a second time. 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 extinguishment of the ZERO annunciator. If manual triggering is in effect, the display remains blank until the next manual trigger.

7B-11. REMOTE CALIBRATION

Remote calibration procedures are similar to those used for front panel calibration. The parameters defined in Tables 1 and 2 are also used in remote calibration.

7B-12. Equipment Configurations

Remote calibration can be made using zero or reference value connections either at the front panel terminals or through the rear input connector. Connections are described in Section 2 of the appropriate Instruction Manual. The following general considerations should be noted:

1. When using the front panel terminals, the three input selectors must be positioned as follows:

   a. Guard Selector: in or out, as required.

   b. Ohms Selector: In (4T) for Ohms Zero and Ohms gain corrections (8505A and 8506A) and for VAC corrections (8506A only). The Guard Selector can be in or out for other calibration connections at the front panel terminals.

   c. Rear Input Selector: out.

2. When the rear input connector is being used, the Guard Selector and the Ohms Selector have no affect. The Rear Input Selector must be pushed in. Rear inputs are dedicated to a four terminal configuration. Four terminal connections must be used for Ohms Zero and Ohms Gain corrections (8505A and 8506A) and for VAC corrections (8506A only).

7B-13. Local/Remote Control

Remote calibration is carried out using any of the remote interface options available for the multimeter (IEEE-488, Bit Serial, or Parallel). Remote calibration requires that the multimeter be placed in local control prior to enabling the Calibration mode. Refer to the following local/remote control guidelines:

1. To select local control:

   a. From the front panel: push the LCL/RMT button and verify that the REMOTE annunciator is off.

   b. From the remote location: send the # character (go to local, lockout remote) when using the Bit Serial Remote Interface (Option -06) or the Parallel Remote Interface (Option -07). With the IEEE-488 Remote Interface (Option -05), send a Go-to-Local (GTL) command.

2. To select remote control:

a. From the front panel: push the LCL/RMT button and verify that the REMOTE annunciator is on (Bit Serial and Parallel Interfaces only). With the IEEE-488 Interface, remote control cannot be selected from the front panel.

b. From the remote location: With the Bit Serial or Parallel Interface, remote control can be selected by sending any character that the multimeter recognizes. However, if local control was originally commanded with the # character, the front panel LCL/RMT button must be pushed. With the IEEE-488 Interface, remote is selected (with REN asserted) by sending an MLA. Some IEEE-interfaced controllers (such as the Fluke 1720A) automatically supply an MLA with any transmitted command string.

7B-14. Entry Format

Numeric entry commands are terminated by any subsequent non-numeric character. For calibration entries, an execution command must be included at the end of the string. Execution commands are not included in the instructions provided in this discussion but must be included in practice. The following terminating commands are available:

1. "," is used to execute the command string.
2. "?" is used to execute the command string and return a reading.
3. "@" is used to execute the command string, take a reading, and interrupt when ready.

7B-15. Zero Corrections

Storing zero values involves separate commands for the dc voltage and resistance functions. Calibration mode must be enabled when storing zero correction values during Software Calibration. With a high-quality, low-thermal shorting bar 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 stored using the K1 command.

For the V DC function, the shorting bar must be applied to the INPUT HI and LO terminals. For the OHMS function, a four-terminal shorting bar must be connected between INPUT HI, INPUT LO, SENSE HI, and SENSE LO, and the four-wire configuration must be selected. (Shorting the test leads does not provide adequate connection for calibration.)

Remote commands M1 (inhibit all zero values) and M2 (enable all zero values) can be sent at any time without affecting the stored values.

7B-16. Gain Corrections

The Calibration mode must be activated prior to entering gain correction factors. With the multimeter in local (front panel) control, the rear panel Calibration switch is positioned to ON (causing the AVG/(CAL) annunciator to begin flashing).

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 (dc volts with the 8505A, dc volts and ac volts with the 8506A) are described in Section 4. Source connections for optional functions are described in Section 6. Remote verification of Calibration mode status can be made by sending the G5 command. A returned 0 signifies that the Calibration mode is off, and a returned 1 signifies that the Calibration mode is on.

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. The KNG command is only executed if followed by a terminating character (, ? or @). The multimeter now computes and stores the gain correction factor. If the KNG is not followed by a number, or is followed by zero, the gain correction for the range selected is disabled (none stored).

7B-17. Calibration Date (Multimeter Identification)

The identifying number can be programmed remotely with the KND command. As in front panel calibration, Calibration mode must first be activated. A maximum of six digits can be programmed following the KND command. One set of digits can be stored at a time. Digits could be entered for the day, month, and year of the calibration date. February 18, 1983 is programmed as K N D 2 1 8 8 3. Alternately, an instrument identification number of 242 is entered as K N D 2 4 2. Any non-numeric entry following these digits causes termination of the entry.

The digits programmed with the KND command can be recalled at any time (Calibration mode on or off) by sending the G4 command. The response is expanded to six digits with the inclusion of leading zeros (0 2 1 8 8 3, or 0 0 0 2 4 2 for the examples mentioned above).

7B-18. Recall Operations

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 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

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) and thermal true-rms volts (A) configuration with the Isolator (8) and options for dc current (3) and IEEE-488 interfacing (5).

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 -02A) 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.

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 Calibration mode status. A returned 0 identifies Calibration mode off, and a returned 1 identifies Calibration 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. This command can be used to take a reading with calibration correction disabled. Once the uncorrected reading has been noted, calibration correction factors can be enabled by sending the M0 command.

7B-19. Error Conditions

An error condition is identified by a user-defined response. This response is entered with 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, this 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 G 1 response) may be encountered during remote calibration:

1. 08 : Command string error

2. 10 : VDC/OHMS Zero error

3. 14 : Excessive voltage present (Ohms or Current function)
This is a latching error condition and necessitates, in sequence, revision of the input level and re-selection of the appropriate function prior to further calibration.

4. 16 : Numeric display overflow

5. 23 : The Calibration Memory is faulty or not installed.

6. 24 : Illegal module configuration
A Calibration Memory module may be 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). Also, the wrong ac converter(s) may be installed. The 8505A uses either the -01 Option or the -09A Option (not both). The 8506A uses only the Thermal True-RMS Converter. Remove any disallowed module.

7. 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. Reset the multimeter. If error 25 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 re-programming of all desired entries.

8. 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.

7B-20. Clear Operations

The following procedures are available to remove or replace Calibration Memory entries from the remote location:

1. 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).

2. 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).

3. 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).

NOTE

If hardware calibration is necessary, software calibration entries must first be cleared. The extent of hardware calibration determines the clearing operation required. If all functions are to be hardware calibrated, the procedure in step (5.) must be used. If select functions only are to be hardware calibrated, respective gain correction factors must be inhibited with the procedure in step (3.), and zero values must be disabled where appropriate.

4. 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 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. 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.

7B-21. CALIBRATION PROCEDURES

7B-22. DC Voltage

7B-23. LOCAL (FRONT PANEL) PROCEDURE

Front panel dc voltage calibration can be accomplished using reference inputs and the front panel push buttons. Calibration mode must first be enabled by sliding the rear panel Calibration switch to ON (AVG/(CAL) annunciator flashes). Remember never to cycle input power to the multimeter when the Calibration mode is on. Then proceed as follows:

1. On the multimeter, select VDC function and 100 mV (manual) range.

2. Apply a good-quality, low-thermal shorting bar between INPUT SENSE HI and LO terminals. Allow sufficient thermal voltage settling time before proceeding to the next step.

3. Allow the multimeter to take at least one reading, then push the ZERO VDC/OHMS button.

4. Manually select the next higher VDC range, then push ZERO VDC/OHMS twice. In sequence, repeat this step for each higher VDC range. This procedure ensures that a discrete zero value is stored for each VDC range.

5. Remove the shorting bar.

6. Refer to Table 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. Values too near the full scale point may cause saturation problems in the A/D Converter. The values given here (in parentheses) are recommended to both minimize percentage of reading error and avoid saturation problems.

7. Manually select the 10V range. With the reference value (19.000000V) applied to INPUT SENSE HI and LO terminals, push:
STORE (numerics of reference value) (CAL COR).

8. The gain correction is automatically applied to the next reading in this range. Verify proper reference value entry by observing that subsequent readings of the reference value equal that known value ± multimeter accuracy specifications. If

necessary, recall the uncorrected reading for comparison by using the RECALL (CAL COR) sequence.

9. Manually select the 100 mV range, apply an appropriate reference value (190.00000 mV), allow the multimeter to take one reading, push STORE (reference numerics) (CAL COR) once again, and verify the result. Repeat this procedure in sequence for each higher VDC range. The following reference values are recommended:

a. 1V range: 1.9000000V

b. 10V range: 19.000000V

c. 100V range: 120.00000V

d. 1000V range: 1000.0000V

10. The following steps store negative gain corrections for each range. Reverse the input connections to the multimeter.

11. Now return the reference source to the value used for the 10V range (19.000000V), and manually select the 10V range on the multimeter.

12. First allow the multimeter to take at least one reading, then push STORE (reference numerics) (CAL COR). Ignore polarity when entering numerics for the reference value.

13. The gain correction is automatically applied to the next reading in this range. Verify proper reference value entry by observing that subsequent readings of the reference value equal that known value ± multimeter accuracy specifications. If necessary, recall the uncorrected reading for comparison by using the RECALL (CAL COR) sequence.

14. Manually select the 100 mV range, apply an appropriate reference value (190.00000 mV), allow the multimeter to take at least one reading, push STORE (reference numerics) (CAL COR) once again, and verify the result. Using the preferred reference values mentioned above, repeat this procedure in sequence for each higher VDC range.

15. Set the reference output to zero, and remove connections between the reference source and the multimeter.

16. Front panel dc voltage calibration is complete once zero values and positive and negative gain corrections have been entered for each of the five ranges.

17. If no further calibration is required, disable the Calibration mode by sliding the rear panel switch to OFF.

7B-24. REMOTE PROCEDURE

Remote calibration employs the same sequence as that used for local calibration. The Calibration mode must be enabled when the multimeter is in local control (REMOTE annunciator off). The rear panel Calibration switch can then be positioned to ON (front panel AVG/(CAL) annunciator flashes) and remote control selected. Remember never to cycle input power to the multimeter when Calibration mode is on. The full calibration procedure is as follows:

1. Select the dc volts function (V) and 100 mV (manual) range (R0).

2. Apply a good-quality, low-thermal shorting bar between input SENSE HI and LO inputs. Allow sufficient thermal voltage settling time before proceeding to the next step.

3. Allow the multimeter to take at least one reading, then send K0 (store last reading as dc volts zero).

4. Send the next higher dc volts range command, allow the multimeter to return at least one reading, then send K0 again. In sequence, repeat this step for each higher dc volts range (R1, R2, R3, R4). This procedure ensures that a discrete zero value is stored for each dc volts range.

5. Remove the shorting bar.

6. Refer to Table 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. Values too near the full scale point may cause saturation problems in the A/D Converter. The values given here (in parentheses) are recommended to both minimize percentage of reading error and avoid saturation problems.

7. Send the R2 command (10 volt range).

8. With the reference value (19.000000V) for the 10V range applied to SENSE HI and LO inputs, send the following command:

K N G (numerics of reference value)

9. The gain correction is automatically applied to the next reading in this range. Verify proper reference value entry by observing that subsequent readings of the reference value equal that known value ± multimeter accuracy specifications.

10. Revise the reference source output to the value used for the 100 mV range (190.00000 mV). Then send the R0 command.

11. Allow the multimeter to return at least one reading, then send KNG (reference numerics), and verify the result. Repeat this procedure in sequence for each higher dc volts range (R1, R2, R3, R4). The following reference values are recommended:

   a. 1V range (R1): 1.9000000V

   b. 10V range (R2): 19.000000V

   c. 100V range (R3): 120.00000V

   d. 1000V range (R4): 1000.0000V

12. Now send the R2 command again, and return the reference source to the value used for the 10V range (19.000000V).

13. The following steps store negative gain corrections for each range. Reverse the input connections to the multimeter.

14. First allow the multimeter to return at least one reading, then send KNG (reference numerics). Ignore polarity when entering numerics for the reference value.

15. The gain correction is automatically applied to the next reading in this range. Verify proper reference value entry by observing that subsequent readings of the reference value equal that known value ± multimeter accuracy specifications.

16. Apply a reference value appropriate for the 100 mV range (190.00000 mV), allow the multimeter to return at least one reading, send KNG (reference numerics), and verify the result. Using the preferred reference values mentioned above, repeat this procedure in sequence for each higher dc volts range (R1, R2, R3, R4).

17. Set the reference output to zero, and remove connections between the reference source and the multimeter.

18. Remote dc voltage calibration is complete once zero values and positive and negative gain corrections have been entered for each of the five ranges.

19. If no further calibration is required, disable the Calibration mode by sliding the rear panel switch to OFF.

7B-25. AC Volts

AC voltage software calibration involves storing one gain correction factor for each range. The type of multimeter (8505A or 8506A), the variety of ac converter installed, and the ac volts function selected (ac or ac + dc) are all factors that determine the exact procedure to use. Separate sets of ac volts gain corrections can be stored for the following configurations:

1. 8505A, Averaging Converter (Option -01) installed, VAC (VA) selected. AC + DC (C) cannot be selected for use with the Averaging Converter.

2. 8505A, True-RMS Converter (Option -09A) installed, VAC (VA) selected. If both the Averaging and True-RMS converters are installed, selecting VAC (VA) automatically connects the True-RMS Converter.

3. 8505A, True-RMS Converter (Option -09A) installed, VAC + VDC (C) selected.

4. 8506A, Thermal True-RMS Converter installed, VAC HI ACCUR (VA) selected.

5. 8506A, Thermal True-RMS Converter installed, VAC HI ACCUR + VDC (C) selected.

7B-26. 8505A AC VOLTS

The three possible ac volts configurations for the 8505A each require the same calibration procedure. First, a 1 kHz reference signal is applied at a level between 60% of range and full scale, and the reference level is entered numerically. Second, accuracy is checked at several higher frequencies. These accuracy checks are made at different sets of frequencies for the Averaging Converter and the True-RMS Converter.

7B-27. Local (Front Panel) Procedure

Refer to Table 2 for the allowed range of reference values and Table 3 for reference source requirements. Calibration mode must first be activated (with the multimeter in local control) by sliding the rear panel Calibration switch to ON (AVG/(CAL) annunciator flashes). Remember never to cycle input power to the multimeter when Calibration mode is on.

1. Select the ac volts function (VAC for either ac converter, VAC + VDC for True-RMS Converter only) and the lowest range (1V manual).

2. Select the appropriate reference value with the aid of Table 2. Recommended values are as follows:

   a. 1V range: 2V @ 1 kHz

   b. 10V range: 19V @ 1 kHz

   c. 100V range: 100V @ 1 kHz

   d. 1000V range: 900V @ 1 kHz

3. Apply this value to the INPUT SENSE HI and LO terminals and allow the multimeter to take at least one reading.

4. Now push the following buttons:

STORE (reference value numerics)(CAL COR)

5. The multimeter computes the gain correction factor and automatically applies it to the next reading in this range. Verify proper reference value entry by observing that subsequent readings of the reference value equal that known value ± accuracy specifications. If necessary, recall the uncorrected reading for comparison by using the RECALL (CAL COR) sequence.

6. Verify accuracy at higher input frequencies. The required check frequencies (depending on the type of ac converter) are as follows:

   a. Averaging Converter (Option -01), VAC only: 10 kHz, 50 kHz, 100 kHz.

   b. True-RMS Converter (Option -09A), VAC or VAC + VDC: 100 kHz, 500 kHz, and 1 MHz.

7. Manually increment the range, apply the appropriate reference value (at 1 kHz), allow the multimeter to return at least one reading, and then push STORE (reference numerics) (CAL COR) once again.

8. Verify gain correction entry by either observing subsequent readings or using the RECALL (CAL COR) routine.

9. Verify accuracy at the higher frequencies specified above.

10. Repeat steps 7, 8, and 9 for each higher range (10V, 100V, 1000V).

11. Front panel ac volts calibration is complete once gain corrections have been entered for each of the five ranges. If required, a maximum of three sets of correction factors can be stored (one set each for Averaging Converter and VAC, True-RMS Converter and VAC, True-RMS Converter and VAC + VDC). Just repeat the entire procedure with the desired function and module. Remember that the True-RMS Converter is always selected if both ac converters are installed.

NOTE

If ac converters are improperly interchanged, software calibration is defeated. The calibration correction factors for each type of ac converter are stored in the Controller module. Therefore, it is possible to remove either type of ac converter, replace it with another ac converter of the same type, and retain software calibration factors. But remember, these factors are unique to the combination of the originally calibrated ac converter and this multimeter only.

12. If no further calibration is required, disable the Calibration mode by sliding the rear panel switch to OFF.

7B-28. Remote Procedure

Remote ac volts calibration can be carried out when the multimeter is in the Calibration mode. With the multimeter in local control, position the rear panel Calibration switch to ON. Refer to Table 2 for the allowed range of reference values and Table 3 for reference source requirements. Remember never to cycle input power to the multimeter when Calibration mode is on. Then select remote control and continue with the following procedure:

1. Send the appropriate ac volts command (VA for either ac converter, C for True-RMS Converter only) and the 1V range command (R1).

2. Select the appropriate reference value with the aid of Table 2. Recommended values are as follows:

   a. 1V range (R1): 2V @ 1 kHz

   b. 10V range (R2): 19V @ 1 kHz

   c. 100V range (R3): 100V @ 1 kHz

   d. 1000V range (R4): 900V @ 1 kHz

3. Apply this value to the SENSE HI and LO inputs and allow the multimeter to return at least one reading.

4. Now send the following commands:

   K N G (reference numerics)

5. The multimeter computes the gain correction factor and automatically applies it to the next reading in this range. Verify proper reference value entry by observing that subsequent returned readings of the reference value equal that known value ± accuracy specifications.

6. Verify accuracy at higher input frequencies. The required check frequencies (depending on the type of ac converter) are as follows:

   a. Averaging Converter (Option -01), VAC only: 10 kHz, 50 kHz, 100 kHz.

   b. True-RMS Converter (Option -09A), VAC or VAC + VDC: 100 kHz, 500 kHz, and 1 MHz.

7. Send the next higher range command, apply the appropriate reference value (at 1 kHz), allow the multimeter to return at least one reading, and then send KNG (reference numerics) once again.

8. Verify gain correction entry by observing subsequently returned readings.

9. Verify accuracy at the higher frequencies specified above.

10. Perform steps 7, 8, and 9 for each higher range (R2, R3, R4).

11. Remote ac volts calibration is complete once gain corrections have been entered for each of the five ranges. If required, a maximum of three sets of correction factors can be stored (one set each for Averaging Converter and VAC, True-RMS Converter and VAC, True-RMS Converter and VAC + VDC). Just repeat the entire procedure with the desired function and module. Remember that the True-RMS Converter is always selected if both ac converters are installed.

NOTE

If ac converters are improperly interchanged, software calibration is defeated. The calibration correction factors for each type of ac converter are stored in the Controller module. Therefore, it is possible to remove either type of ac converter, replace it with another ac converter of the same type, and retain software calibration factors. But remember, these factors are unique to the combination of the originally calibrated ac converter and this multimeter only.

12. If no further calibration is required, disable the Calibration mode by sliding the rear panel switch to OFF.

7B-29. 8506A AC VOLTS

The same procedure (1 kHz reference signal applied at a level between 60% or range and full scale, reference level entered numerically) is used for each range in High Accuracy mode for the 8506A. Gain corrections stored in High Accuracy mode are subsequently applied in all ac volts modes (High Accuracy, Enhanced, or Normal). Separate sets of gain corrections can be stored for VAC (VA2) or VAC and VDC (C2).

7B-30. Local (Front Panel) Procedure

Refer to Table 2 for the allowed range of reference values and Table 3 for reference source requirements. Calibration mode must first be activated (with the multimeter in local control) by sliding the rear panel Calibration switch to ON (AVG/(CAL) annunciator flashes). Remember never to cycle input power to the multimeter when Calibration mode is on.

1. Select the ac volts high accuracy function (VAC HI ACCUR) and 100 mV manual range.

2. Select the appropriate reference value with the aid of Table 2. Recommended values are as follows:

   a. 100 mV range: 120 mV @ 1 kHz

   b. 300 mV range: 390 mV @ 1 kHz

   c. 1V range: 1.2V @ 1 kHz

d. 3V range: 3.9V @ 1 kHz

e. 10V range: 12V @ 1 kHz

f. 30V range: 35V @ 1 kHz

g. 100V range: 120V @ 1 kHz

h. 500V range: 500V @ 1 kHz

3. Apply this value to the INPUT HI and LO terminals in a four-terminal configuration. Ensure that the Ohms Selector is pushed in (4T).

4. Allow the multimeter to take at least one reading, then push the following buttons:

STORE (reference value numerics) (CAL COR)

5. The multimeter computes the gain correction factor and automatically applies it to the next reading in this range. Verify proper reference value entry by observing that subsequent readings of the reference value equal that known value ± accuracy specifications. If necessary, recall the uncorrected reading for comparison by using the RECALL (CAL COR) sequence.

6. Verify accuracy at higher input frequencies. The required check frequencies are: 10 kHz and 100 kHz.

7. Manually increment the range, apply the appropriate reference value (at 1 kHz), allow the multimeter to return at least one reading, and then push STORE (reference numerics) (CAL COR) once again.

8. Verify gain correction entry by either observing subsequent readings or using the RECALL (CAL COR) routine.

9. Verify accuracy at the higher frequencies specified above.

10. Repeat steps 7, 8, and 9 for each higher range (1V, 3V, 10V, 30V, 100V, 500V).

11. Front panel ac volts calibration is complete once gain corrections have been entered for each of the eight ranges. If required, a separate set of correction factors can be stored for dc coupled ac volts (VAC HI ACCUR + VDC). Just repeat the entire procedure with the new function.

12. If no further calibration is required, disable the Calibration mode by sliding the rear panel switch to OFF.

7B-31. Remote Procedure

Remote ac volts calibration can be carried out when the multimeter is in the Calibration mode. With the multimeter in local control, position the rear panel Calibration switch to ON. Refer to Table 2 for the allowed range of reference values and Table 3 for reference source requirements. Remember never to cycle input power to the multimeter when Calibration mode is on. Then select remote control and continue with the following procedure:

1. Send the desired ac volts function command (VA2 for ac coupled, or C2 for dc coupled High Accuracy ac volts) and the R0 range command.

2. Select the appropriate reference value with the aid of Table 2. Recommended values are as follows:

   a. 100 mV range (R0): 120 mV @ 1 kHz

   b. 300 mV range (R1): 390 mV @ 1 kHz

   c. 1V range (R2): 1.2V @ 1 kHz

   d. 3V range (R3): 3.9V @ 1 kHz

   e. 10V range (R4): 12V @ 1 kHz

   f. 30V range (R5): 35V @ 1 kHz

   g. 100V range (R6): 120V @ 1 kHz

   h. 500V range (R7): 500V @ 1 kHz

3. Apply this value to the HI and LO SENSE inputs and allow the multimeter to return at least one reading.

4. Now send the following commands: K N G (reference numerics).

5. The multimeter computes the gain correction factor and automatically applies it to the next reading in this range. Verify proper reference value entry by observing that subsequent returned readings of the reference value equal that known value ± accuracy specifications.

6. Verify accuracy at higher input frequencies. The required check frequencies are: 10 kHz and 100 kHz.

7. Send the next higher range command, apply the appropriate reference value (at 1 kHz), allow the multimeter to return at least one reading, and then send KNG (reference numerics) once again.

8. Verify gain correction entry by observing subsequently returned readings.

9. Verify accuracy at the higher frequencies specified above.

10. Perform steps 7, 8, and 9 for each higher range (R2, R3, R4, R5, R6, R7).

11. Remote ac volts calibration is complete once gain corrections have been entered for each of the eight ranges. If required, a separate set of correction factors can be stored for dc coupled ac volts (C2). Just repeat the entire procedure with the new function selected.

12. If no further calibration is required, disable the Calibration mode by sliding the rear panel switch to OFF.

7B-32. Resistance

7B-33. LOCAL (FRONT PANEL) PROCEDURE

Front panel OHMS calibration is accomplished using zero corrections and positive gain corrections for each range. The Calibration mode must be enabled. With the multimeter in local control, the rear panel Calibration switch is positioned to ON (AVG/(CAL) annunciator flashes). Remember never to cycle input power to the multimeter when the Calibration mode is on. The complete calibration procedure is as follows:

1. 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).

2. Allow sufficient thermal voltage settling time before proceeding to the next step.

3. Push the OHMS button and manually select the lowest range (10 ohms).

4. Allow the multimeter to take at least one reading. If an Error H condition is encountered, a multimeter protection fuse may be bad, or the four-terminal connections may be faulty. In either case, the problem must be corrected before proceeding with the calibration procedure.

5. Once a reading is properly returned, push the ZERO VDC/OHMS button.

6. Manually select the next higher OHMS range. Allow the multimeter to take at least one reading and then push ZERO VDC/OHMS twice. In sequence, repeat this step for each higher OHMS range. Eight ranges are zeroed in this fashion.

7. Remove the shorting bar.

8. Manually select the lowest OHMS range (10 ohms) once again.

9. Positive gain corrections are next stored for each OHMS range. Refer to Table 2 and select the reference resistance value for the range being calibrated. Recommended values are shown (in parentheses) in the following procedure. Also refer to Table 3 for reference resistance tolerance requirements.

10. With the reference resistance for the 10 ohm range (20 ohms) applied to the INPUT HI and LO terminals (four wire configuration), allow the multimeter to take at least one reading and then push:

    STORE (reference numerics) (CAL COR).

11. The gain correction is automatically applied to the next reading in this range. Verify proper reference value entry by observing that subsequent readings of the reference value equal that known value ± multimeter accuracy specifications. If necessary, recall the uncorrected reading for comparison by using the RECALL (CAL COR) sequence.

12. Manually increment the range, apply an appropriate reference resistance value, allow the multimeter to take at least one reading, and push STORE (reference numerics) (CAL COR) once again. Repeat this step in sequence for each higher OHMS range (total of eight). Recommended reference resistance values are as follows:

a. 100 ohm range: 200 ohms

b. 1 kohm range: 2 kohms

c. 10 kohm range: 20 kohms

d. 100 kohm range: 200 kohms

e. 1 Mohm range: 2 Mohms

f. 10 Mohm range: 20 Mohms

g. 100 Mohm range: 100 Mohms

13. Front panel resistance calibration is complete once zero corrections and positive gain corrections have been entered for each of the eight ranges.

14. If no further calibration is required, disable the Calibration mode by sliding the rear panel switch to OFF.

7B-34. REMOTE PROCEDURE

Remote resistance calibration follows the same pattern as that used for front panel calibration. Calibration mode must be enabled for all calibration procedures. With the multimeter in local control, position the rear panel Calibration switch to ON (AVG/(CAL) annunciator on front panel flashes). Remember never to cycle input power to the multimeter when the Calibration mode is on. Select remote control and use the following calibration procedure:

1. 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.

2. Verify that ohms connections are correct and multimeter protection fuses are good before proceeding. Use the following sequence:

   a. Send the G2 command (recall status). Ignore the response.

   b. Send the ohms function command (Z) and the 10 ohm range command (R0).

   c. Trigger a reading. If the error response is returned, send G2 again. If error 27 is defined (first two digits of the response), the four terminal connections may be faulty or a protection fuse may be bad.

   d. In either case, correct the problem before proceeding with ohms software calibration.

3. Once a proper reading has been returned, send the K1 command (store last reading as ohms zero).

4. Send the next higher range command. Allow the multimeter to return at least one reading, and then send K1 again. In sequence, repeat this step for each higher OHMS range. Eight ranges are zeroed in this fashion.

5. Remove the shorting bar.

6. Send the R0 (10 ohms) command again.

7. Positive gain corrections are next stored for each OHMS range. Refer to Table 2 and select the reference resistance value for the range being calibrated. Recommended values are shown (in parentheses) in the following procedure. Also refer to Table 3 for reference resistance tolerance requirements.

8. With the reference resistance for the 10 ohm range (20 ohms) applied to the INPUT HI and LO terminals (four wire configuration), allow the multimeter to return at least one reading and then send:

K N G (reference numerics)

9. The gain correction is automatically applied to the next reading in this range. Verify proper reference value entry by observing that subsequently returned readings of the reference value equal that known value ± multimeter accuracy specifications.

10. Send the next higher range command, apply an appropriate reference resistance value, allow the multimeter to return at least one reading, and send KNG (reference numerics) once again. Repeat this step in sequence for each higher OHMS range (total of eight). Recommended reference resistance values are as follows:

a. 100 ohm range (R1): 200 ohms

b. 1 kohm range (R2): 2 kohms

c. 10 kohm range (R3): 20 kohms

d. 100 kohm range (R4): 200 kohms

e. 1 Mohm range (R5): 2 Mohms

f. 10 Mohm range (R6): 20 Mohms

g. 100 Mohm range (R7): 100 Mohms

11. Remote resistance calibration is complete once zero corrections and positive gain corrections have been entered for each of the eight ranges.

12. If no further calibration is required, disable the Calibration mode by sliding the rear panel switch to OFF.

7B-35. DC Current

DC current calibration procedures are very similar to the positive and negative gain corrections used with dc voltage calibration. With the multimeter in local control, Calibration mode can be enabled by sliding the rear panel Calibration switch to ON (AVG/(CAL) annunciator flashes). Remember never to cycle input power to the multimeter when the Calibration mode is on.

7B-36. LOCAL (FRONT PANEL) PROCEDURE

Use the front panel push buttons as follows:

1. Push the ADC button and manually select the lowest (100 uA) dc current range.

2. Refer to Table 2 and select the reference value for the range being calibrated. Recommended reference values are mentioned in the following steps. Also refer to Table 3 for dc current reference source requirements.

3. With the reference value for the 100 uA range (190 uA) applied to the INPUT SOURCE HI and LO terminals, allow the multimeter to take at least one reading, then push:

STORE (numerics of reference value) (CAL COR)

4. The gain correction is automatically applied to the next reading in this range. Verify proper reference value entry by observing that subsequent readings of the reference value equal that known value ± multimeter accuracy specifications. If necessary, recall the uncorrected reading for comparison by using the RECALL (CAL COR) sequence.

5. Manually increment the range, apply the appropriate reference value, allow the multimeter to take at least one reading, and then push STORE (reference numerics) (CAL COR) once again. Repeat this step in sequence for each higher ADC range. Recommended reference values are as follows:

a. 1 mA range: 1.9 mA

b. 10 mA range: 10 mA

c. 100 mA range: 100 mA

d. 1A range: 1.0A

6. Return the reference output to the value used for the 100 uA range. Then manually select the 100 uA range on the multimeter.

7. Reverse the reference output polarity.

8. Repeat steps 3, 4, and 5. Ignore polarity when entering the reference value numerics.

9. Front panel dc current calibration is complete once positive and negative gain corrections have been entered for each of the five ranges.

10. If no further calibration is required, disable the Calibration mode by sliding the rear panel switch to OFF.

7B-37. REMOTE PROCEDURE

Remote dc current calibration employs the same sequence as used for local calibration. Proceed as follows:

1. Select the required function and range by sending: I (for dc current) and R0 (for 100 uA range).

2. Refer to Table 2 and select an appropriate reference value. Recommended reference values are shown in the following steps. Also refer to Table 3 for reference source requirements. Apply the selected reference value for R0 range (190 uA) to SOURCE HI and LO inputs.

3. Allow the multimeter to return at least one reading, then send: KNG (numerics of reference value).

4. Proper gain correction storage can be verified by comparing subsequently returned readings to the reference value(s) used ± multimeter accuracy specifications.

5. Increment the range by sending the next higher range command (R1, R2, R3, R4), apply an appropriate reference value, allow the multimeter to return at least one reading, and send K N G (reference numerics). Repeat this step for each higher range in the dc current function. Recommended reference values are as follows:

   a. 1 mA range (R1): 1.9 mA

   b. 10 mA range (R2): 10 mA

   c. 100 mA range (R3): 100 mA

   d. 1A range (R4): 1.0A

6. Return the reference output to the value used for the R0 (100 uA) range. Send the R0 command again to select the 100 uA range on the multimeter.

7. Reverse the reference output polarity.

8. Repeat steps 3, 4, and 5. Ignore polarity when sending reference value numerics.

9. Remote dc current calibration is complete once positive and negative gain corrections have been entered for each of the five ranges.

10. If no further calibration is required, disable the Calibration mode by sliding the rear panel switch to OFF.

7B-38. AC Current

The ac current function is available with the 8505A, but not with the 8506A. Before software calibration (using either the RMS Converter or the Averaging Converter) is carried out, the following conditions must be met:

1. The Current Shunts module (Option -03) must be installed.

2. Either the Averaging AC Converter (Option -01) or the True-RMS Converter (Option -09A) must be installed.

3. With the multimeter in local control, Calibration mode must be enabled by sliding the rear panel Calibration switch to ON (AVG/(CAL) annunciator flashes). Remember never to cycle input power to the multimeter when the Calibration mode is on.

4. AC current function (AAC push button, or remote command 1 A) must be selected.

7B-39. LOCAL (FRONT PANEL) PROCEDURE

Front panel AAC calibration is accomplished using gain correction factors at mid-band (1 kHz) for each range. The following procedure is used:

1. Select the ac current function (AAC) and manually select the 100 uA range.

2. Select the appropriate reference value with the aid of Table 2. The recommended value for the 100 uA range is 200 uA. Apply this value (verified level at 1 kHz) to the INPUT SOURCE HI and LO terminals.

NOTE

The actual reference level must be verified at the source output.

3. Allow the multimeter to take at least one reading. Now push the following buttons:

STORE (numerics for verified value) (CAL COR)

4. The gain correction is automatically applied to the next reading in this range. Verify proper reference value entry by observing that subsequent readings of the reference value equal that known value ± applicable accuracy specifications. If necessary, recall the uncorrected reading for comparison by using the RECALL (CAL COR) sequence.

5. On the multimeter, select the next higher range.

6. Select a reference value for the next higher multimeter range. Verify this reference value at the source output. Recommended reference values are as follows:

   a. 1 mA range: 2.0 mA @ 1 kHz

   b. 10 mA range: 19 mA @ 1 kHz

   c. 100 mA range: 150 mA @ 1 kHz

   d. 1A range: 1.0A @ 1 kHz

7. With the verified reference value (at 1 kHz) applied to the multimeter, allow at least one reading to be returned.

8. Now push STORE (numerics for verified reference value) (CAL COR) once again.

9. Repeat steps 5, 6, 7, and 8 for each higher range.

10. Front panel ac current calibration is complete once gain corrections have been entered for each of the five ranges.

11. If no further calibration is required, disable the Calibration mode by sliding the rear panel switch to OFF.

7B-40. REMOTE PROCEDURE

Remote ac current calibration is accomplished using gain correction factors at mid-band (1 kHz) for each range. The following procedure is used:

1. Select the required function and range by sending I A (for ac current) and R 0 (for 100 uA range).

2. Refer to Table 2 and select an appropriate reference value. The recommended value for the 100 uA range (R0) is 200 uA at 1 kHz. Apply this value (verified level at 1 kHz) to the Source Hi and Lo inputs.

NOTE

The actual reference level must be verified at the source output.

3. Allow the multimeter to return at least one reading.

4. Now send: K N G (numerics for verified reference level).

5. Proper gain correction storage can be verified by comparing subsequently returned readings of the reference value to that known value ± applicable accuracy specifications.

6. Increment the multimeter range by sending the next higher range command.

7. Select a reference value for the next higher multimeter range. Verify this value at the source output. Recommended reference values are as follows:

   a. 1 mA range (R1): 2.0 mA @ 1 kHz

   b. 10 mA range (R2): 19 mA @ 1 kHz

   c. 100 mA range (R3): 150 mA @ 1 kHz

   d. 1A range (R4): 1.0A @ 1 kHz

8. With the verified reference value applied, allow the multimeter to return at least one reading.

9. Now send K N G (numerics for verified reference level).

10. Repeat steps 6, 7, 8, and 9 for each of the remaining ac current ranges.

11. Remote ac current calibration is complete once gain corrections have been entered for each of the five ranges.

12. If no further calibration is required, disable the Calibration mode by sliding the rear panel switch to OFF.

7B-41. SPECIFICATIONS

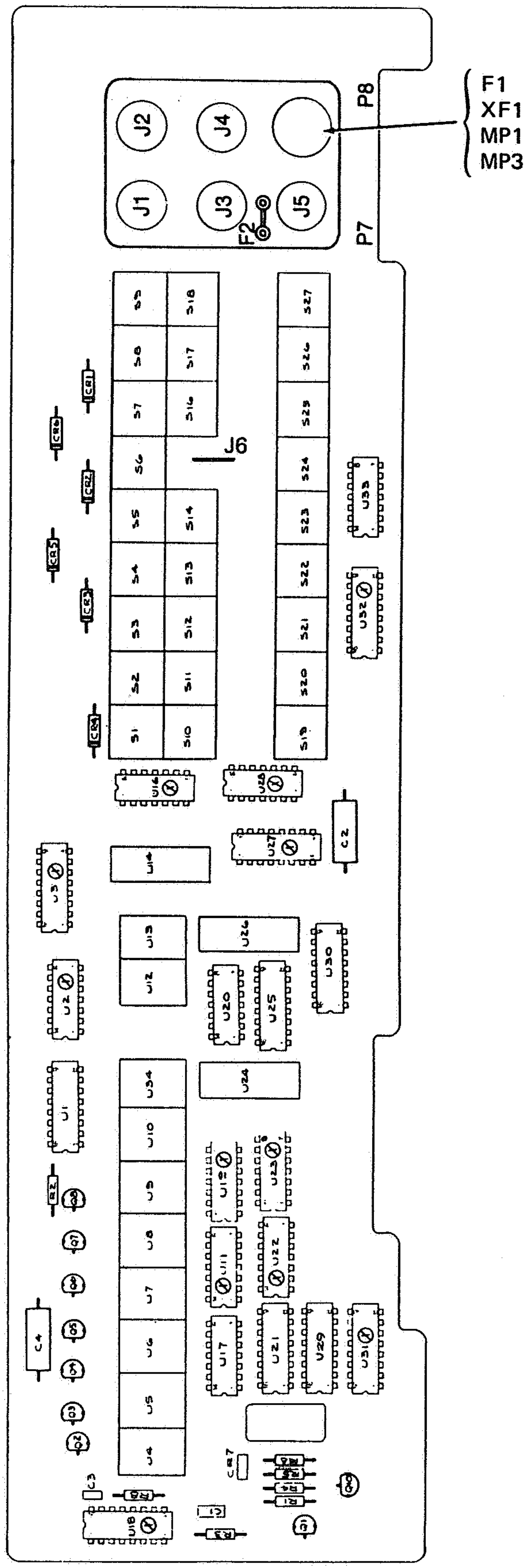
Use of software calibration allows for extended intervals between hardware calibration. Software calibration can be performed at any time, as determined by the user's accuracy requirements. Specifications attainable with software calibration are defined in Section 1 (standard functions) and Section 6 (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.

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

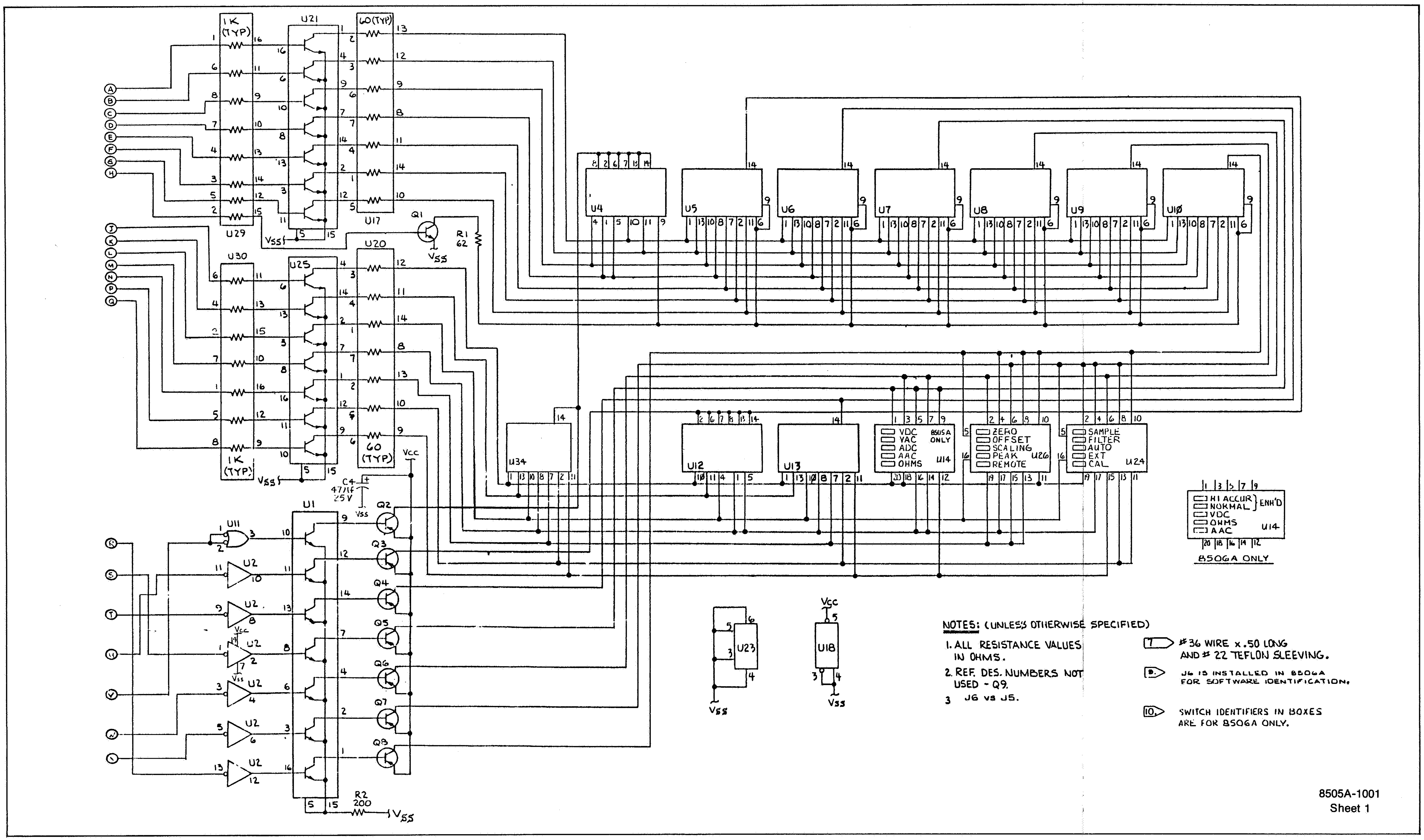
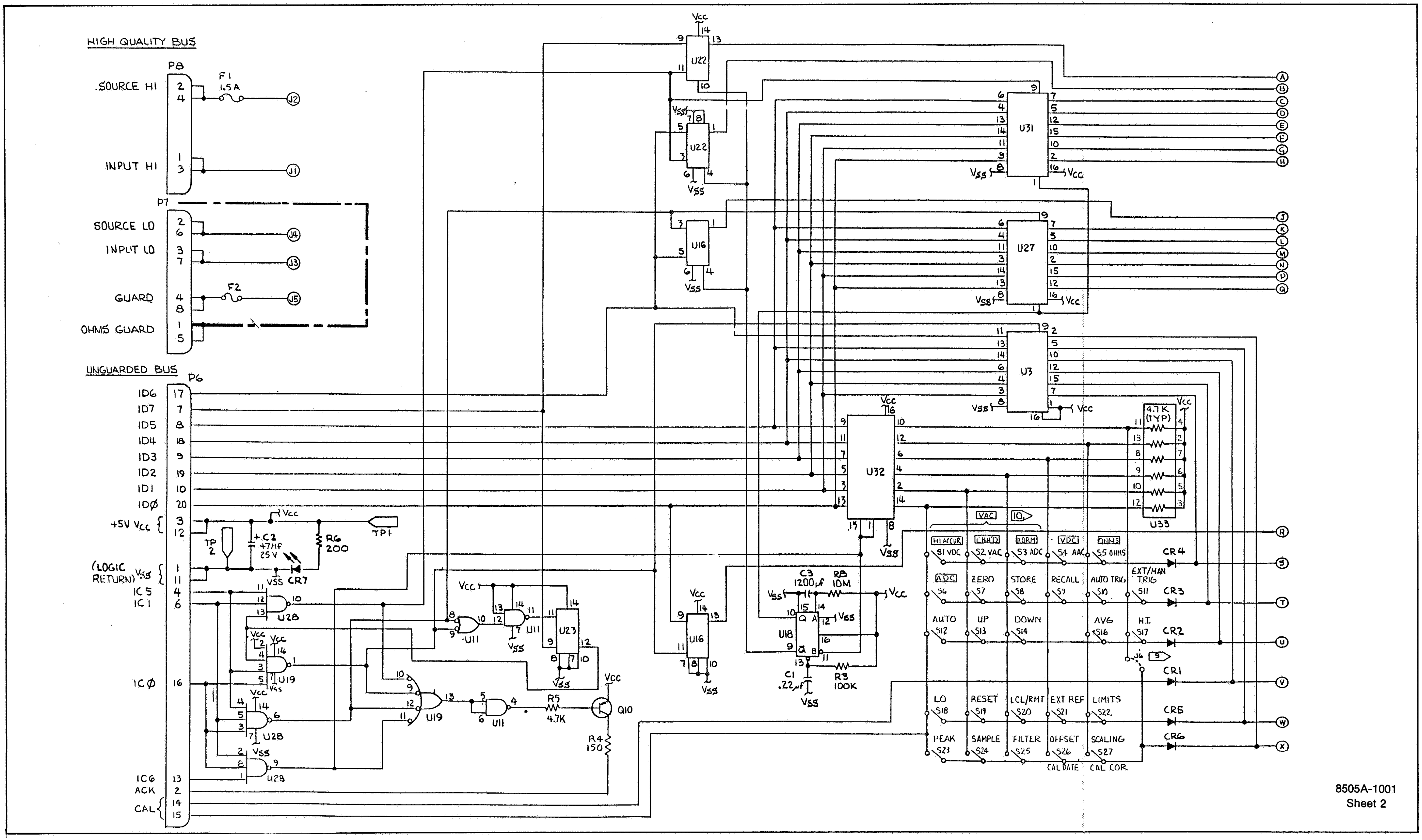


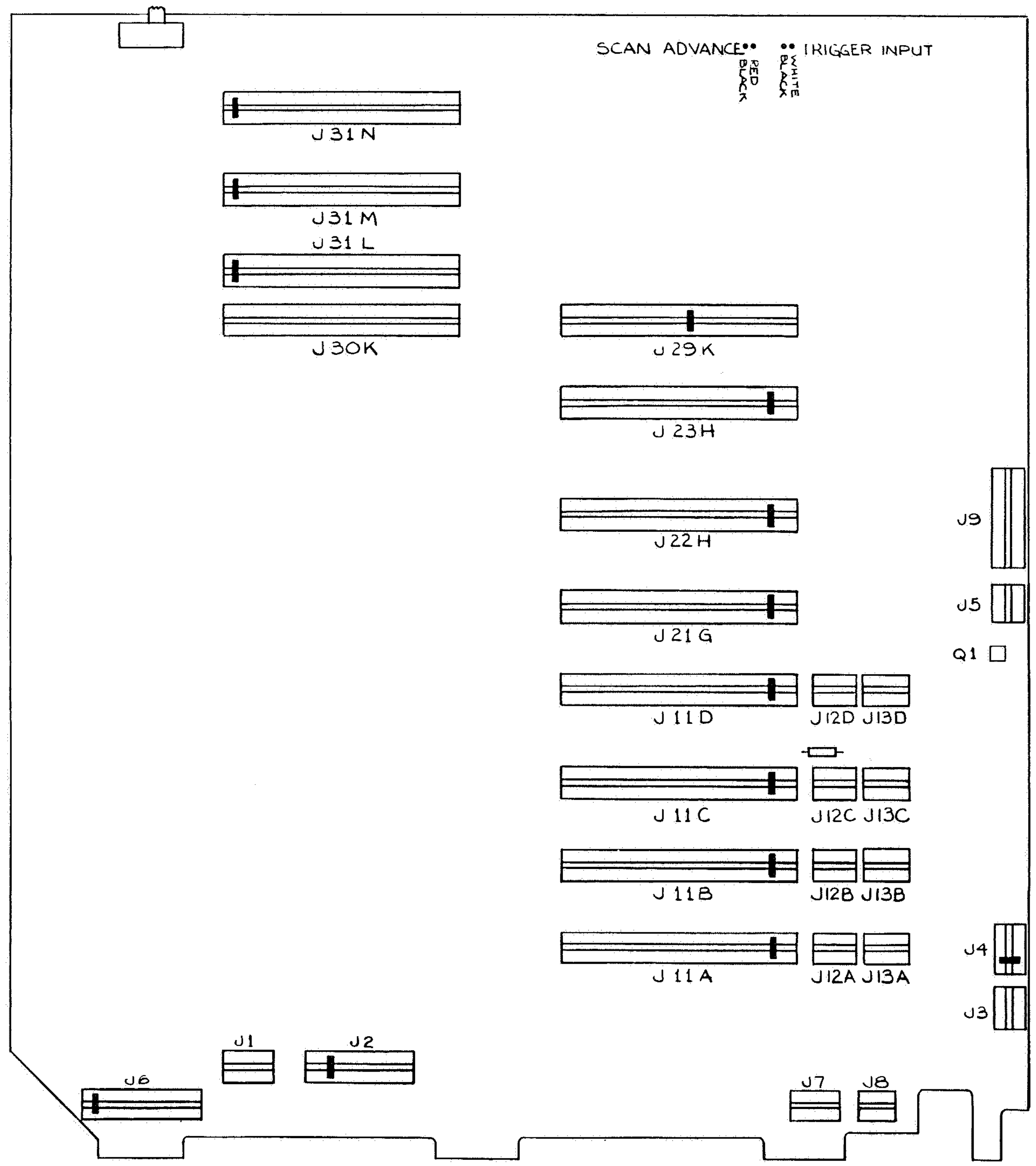
Figure 8-1. A1 Front Panel Display PCB Assembly (cont)



8505A-1001
Sheet 2

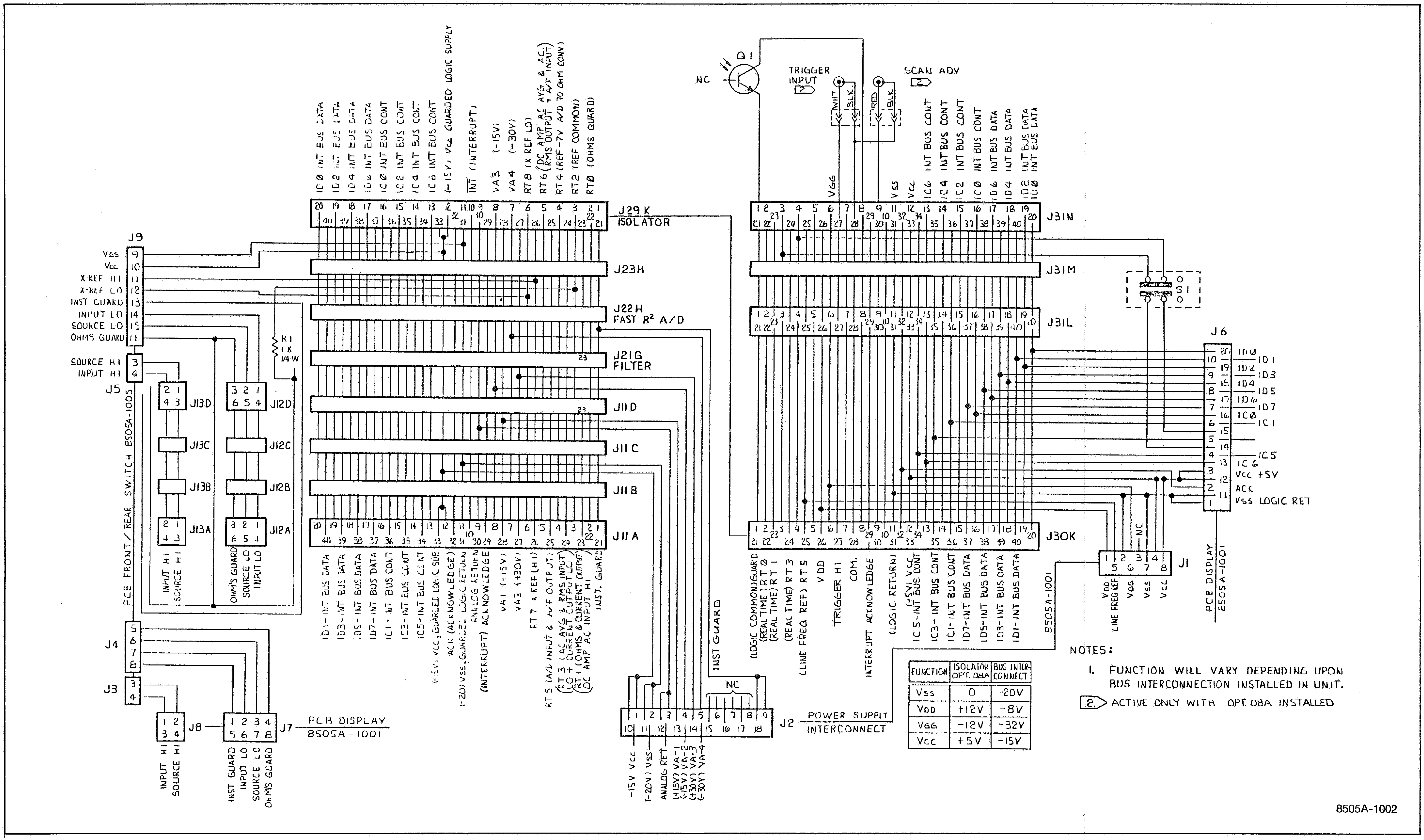
Figure 8-1. A1 Front Panel Display PCB Assembly (cont)

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	-02,-03,-01,OR-09A**	THERMAL TRUE RMS CONVERTER
B	-02,-03,-01,OR-09A**	-02 OR 03
A	DC SIGNAL CONDITIONER	DC SIGNAL



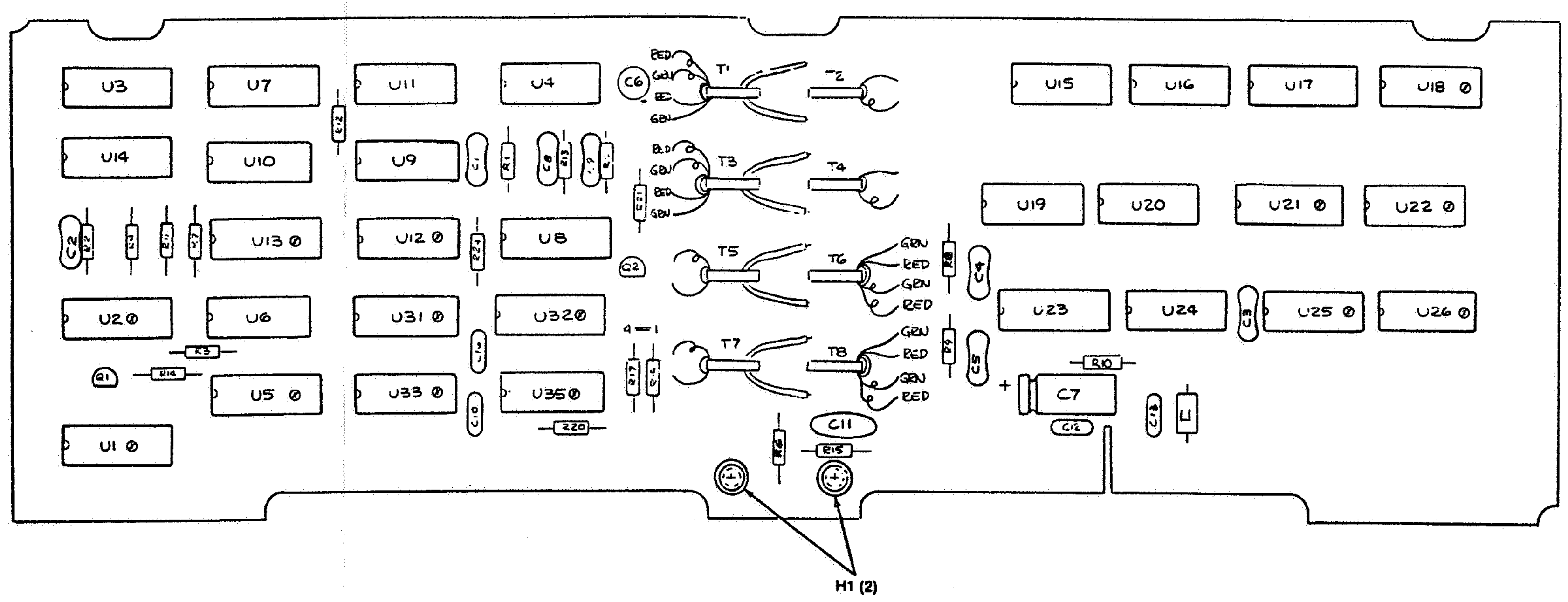
8505A-1602

Figure 8-2. A2 Motherboard PCB Assembly



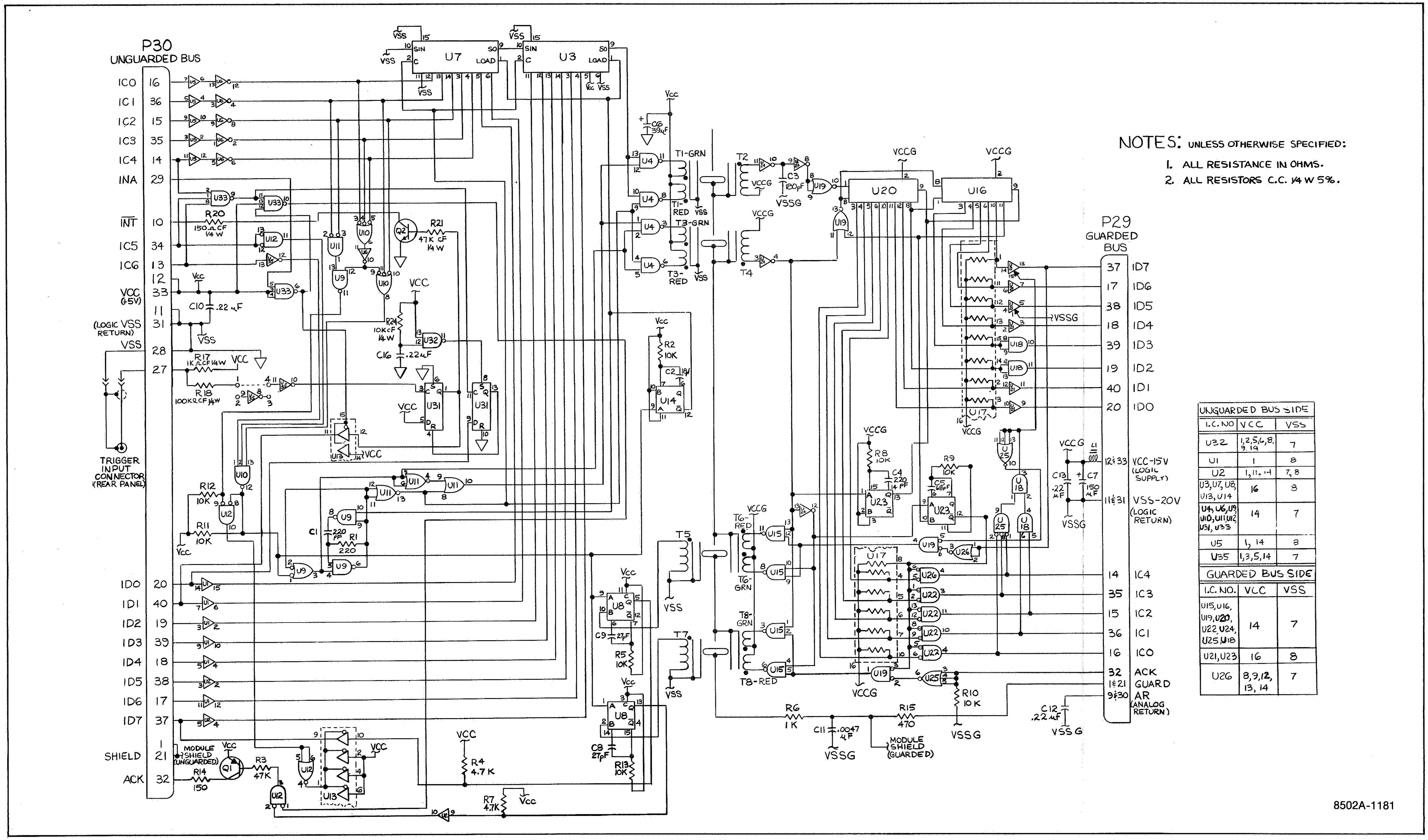
FUNCTION	ISOLATOR OPT. 08A	BUS INTERCONNECT
Vss	0	-20V
VDD	+12V	-8V
VGG	-12V	-32V
Vcc	+5V	-15V

Figure 8-2. A2 Motherboard PCB Assembly (cont)



8502A-1781

Figure 8-3. A3 Isolator PCB Assembly



NOTES: UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTANCE IN OHMS.
2. ALL RESISTORS C.C. 1/4 W 5%.

UNGUARDED BUS SIDE

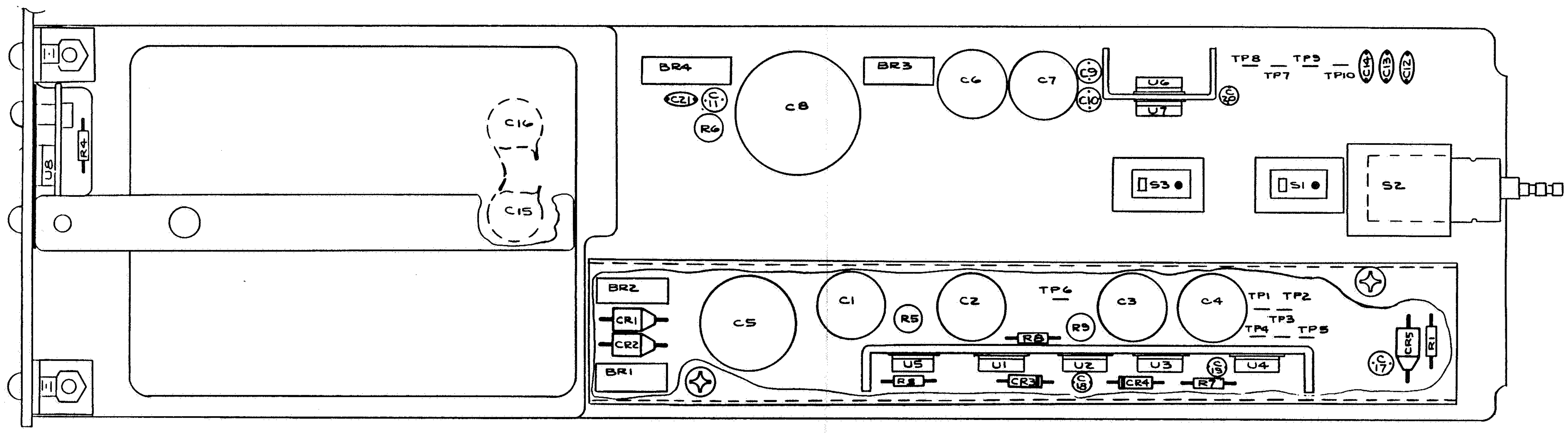
I.C. NO	VCC	VSS
U32	1,2,5,6,8,9,14	7
U1	1	8
U2	1,11,14	7,8
U3,U7,U8,U13,U14	16	8
U4,U6,U9,U10,U11,U12,U31,U33	14	7
U5	1,14	8
U35	1,3,5,14	7

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

8502A-1181

Figure 8-3. A3 Isolator PCB Assembly (cont)



8505A-1651

Figure 8-4. A4 Power Supply PCB Assembly

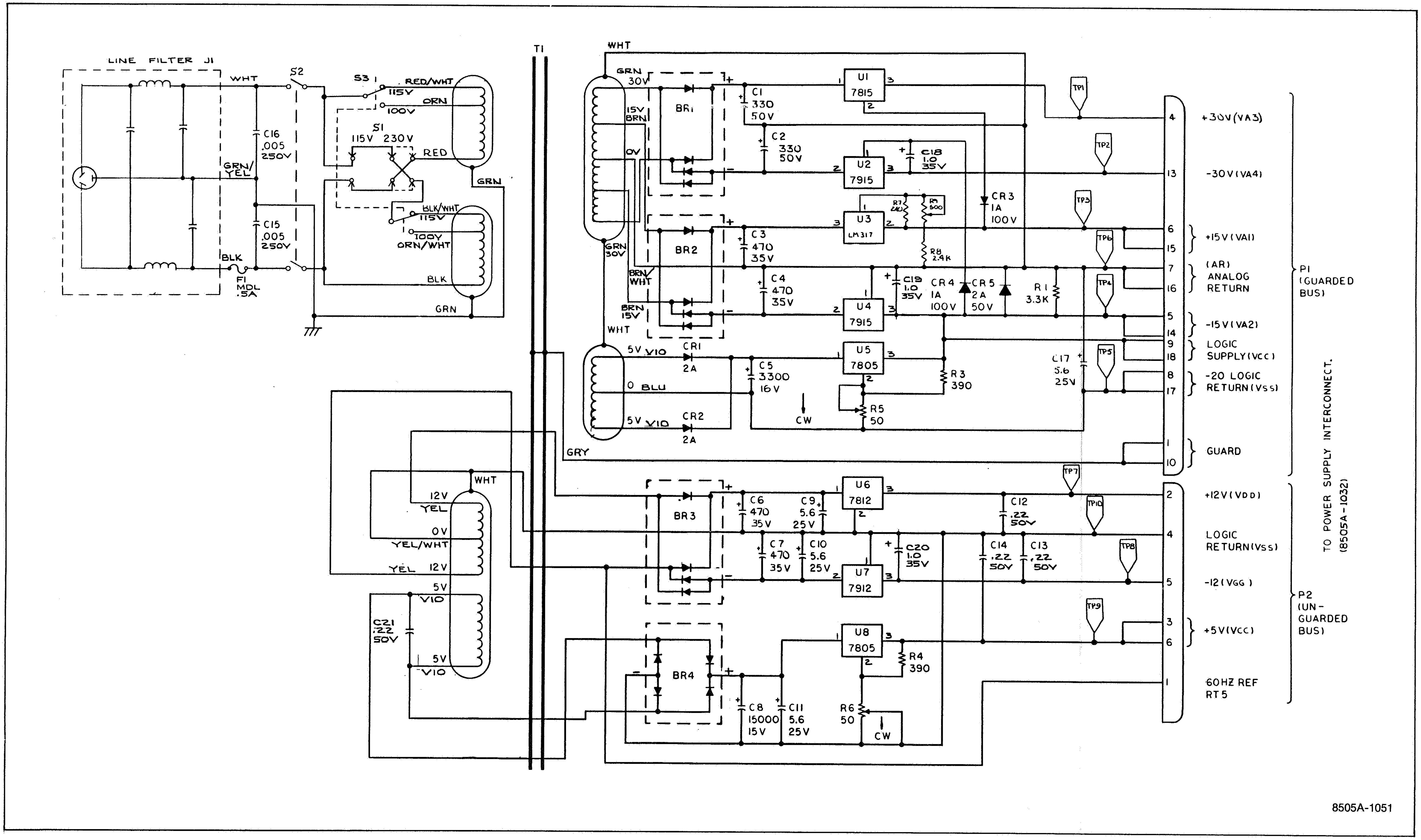


Figure 8-4. A4 Power Supply PCB Assembly (cont)

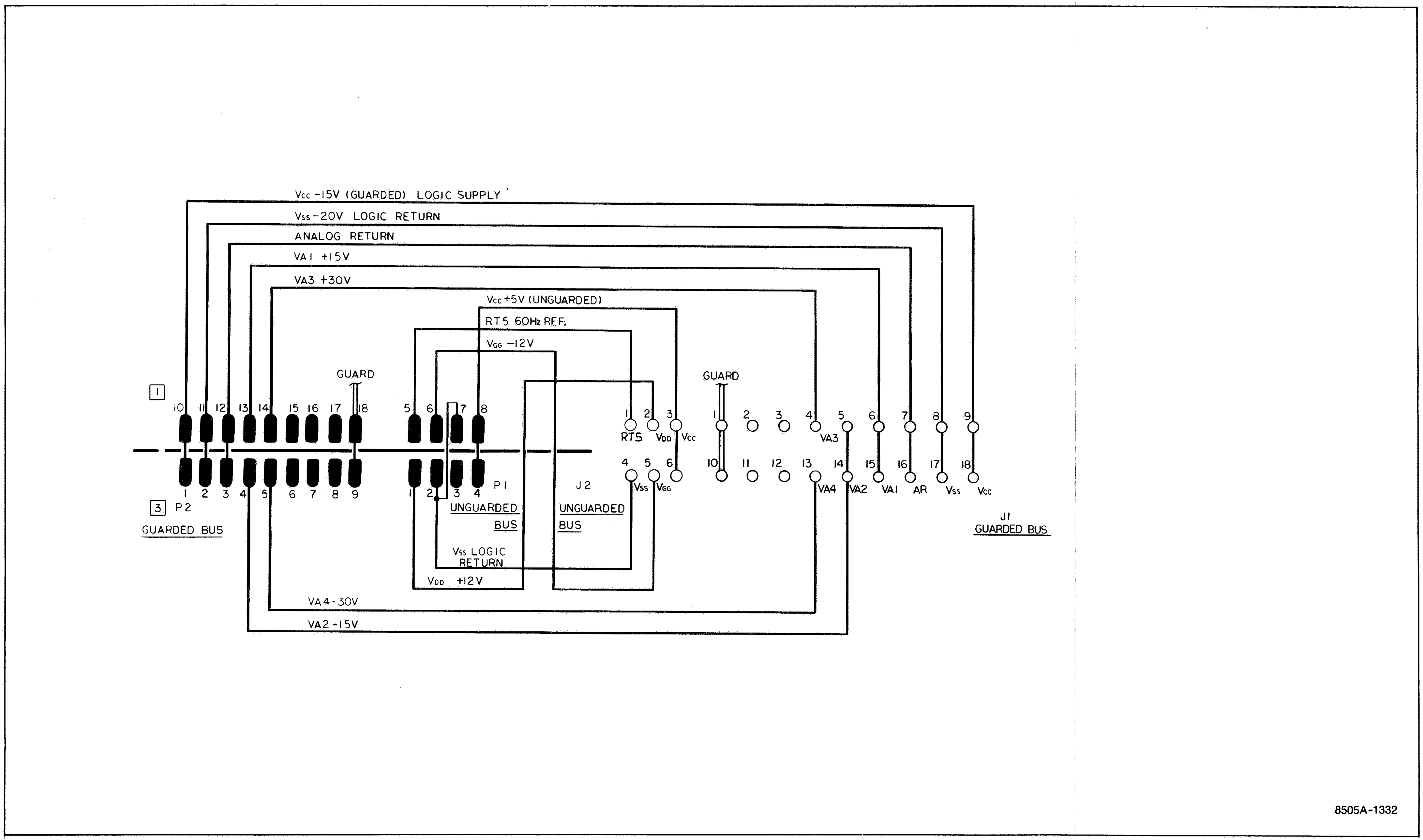
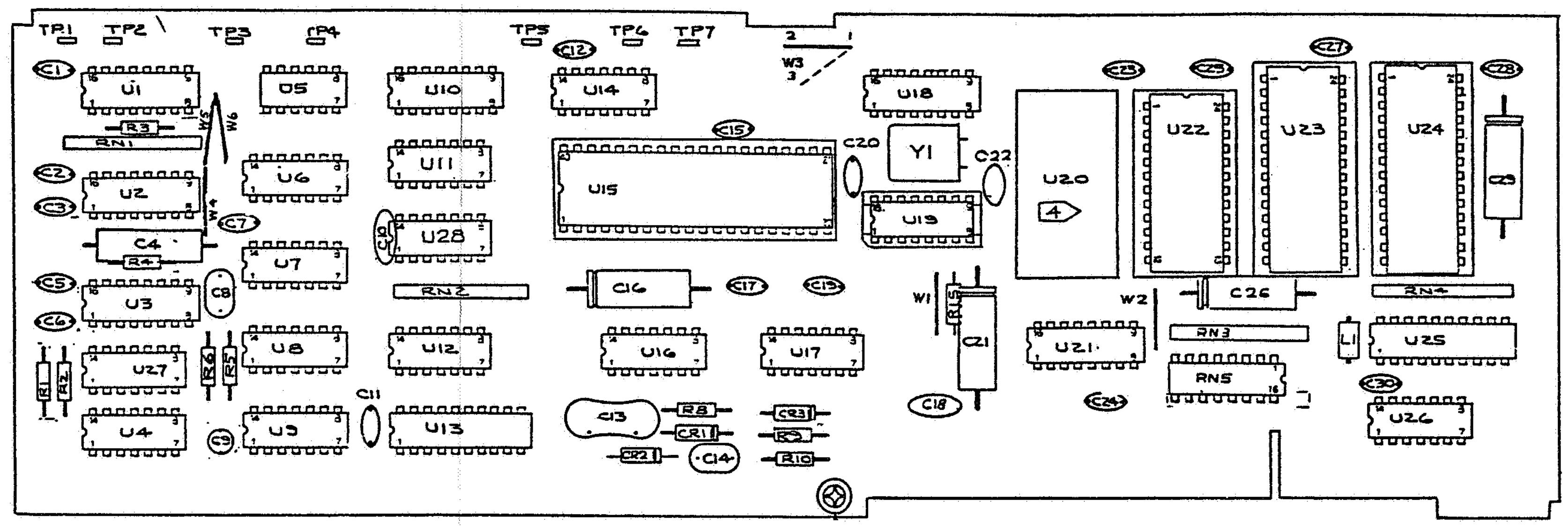


Figure 8-5. A5 Power Supply Interconnect



MIS-1687

Figure 8-6. A6 Controller PCB Assembly

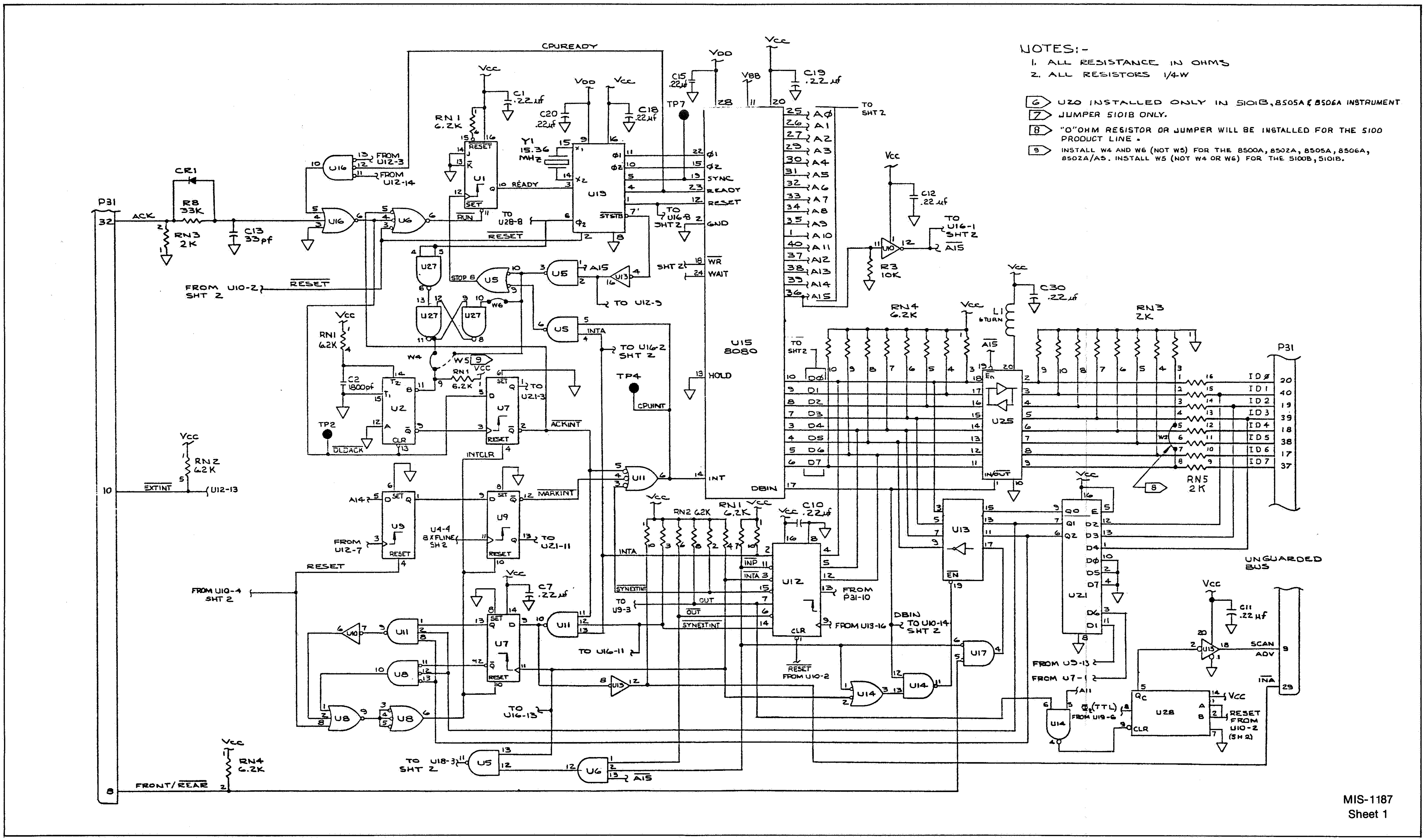


Figure 8-6. A6 Controller PCB Assembly (cont)

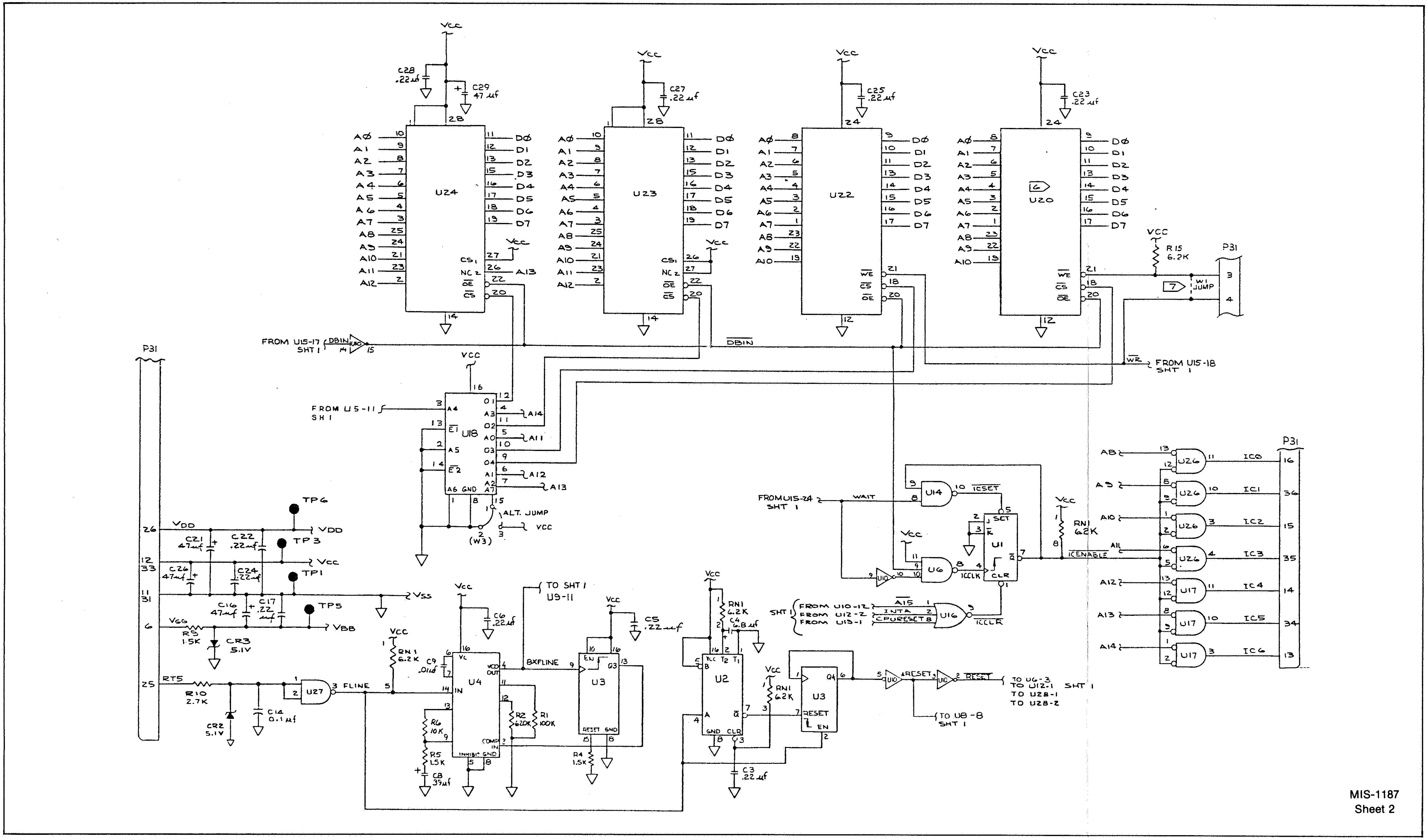
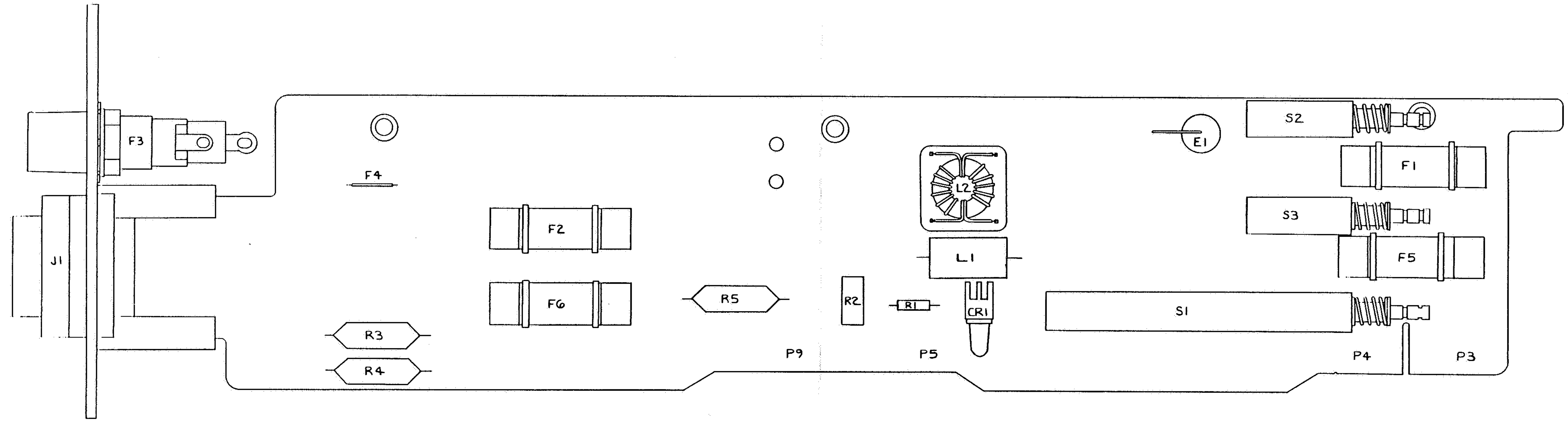


Figure 8-6. A6 Controller PCB Assembly (cont)



8505A-1605

Figure 8-7. A7 Front/Rear Switch Assembly

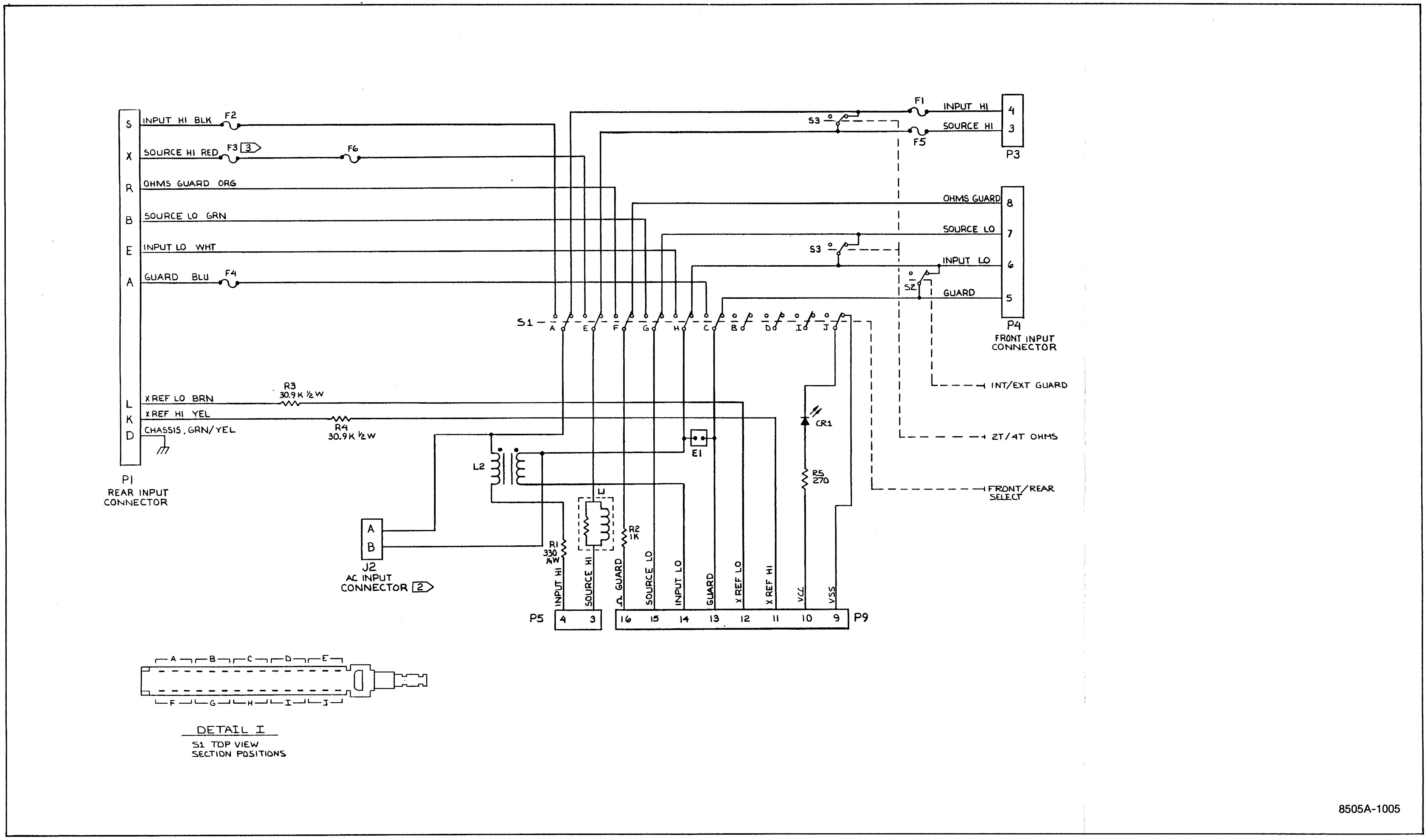


Figure 8-7. A7 Front/Rear Switch Assembly (cont)

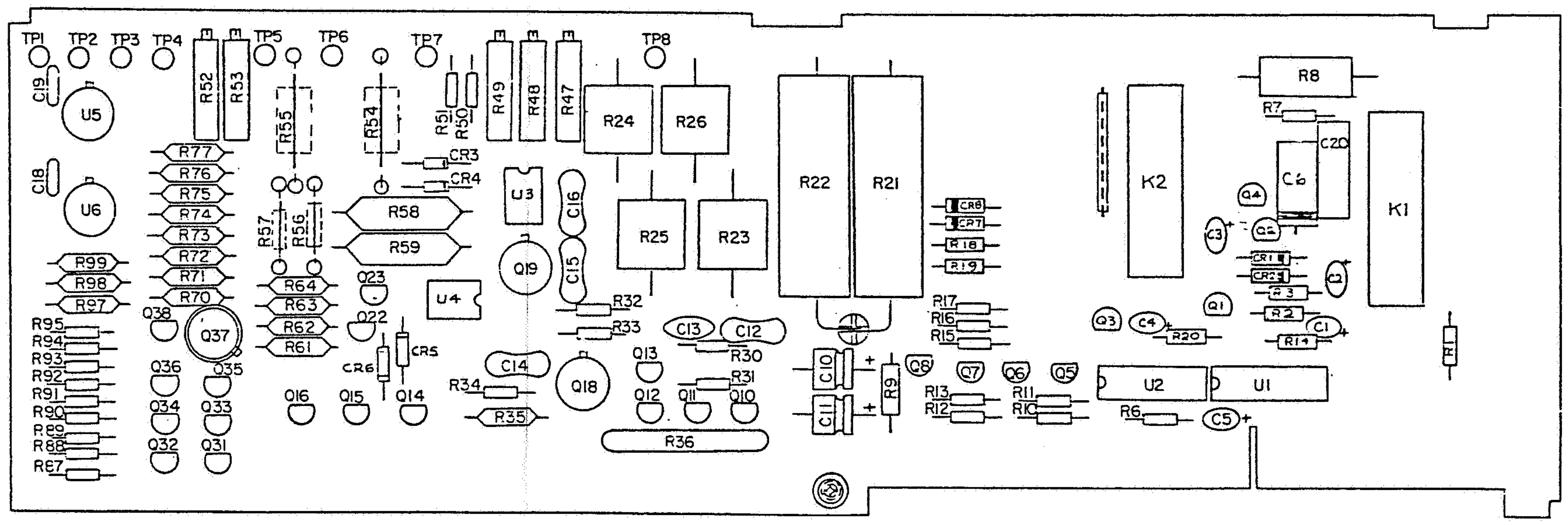
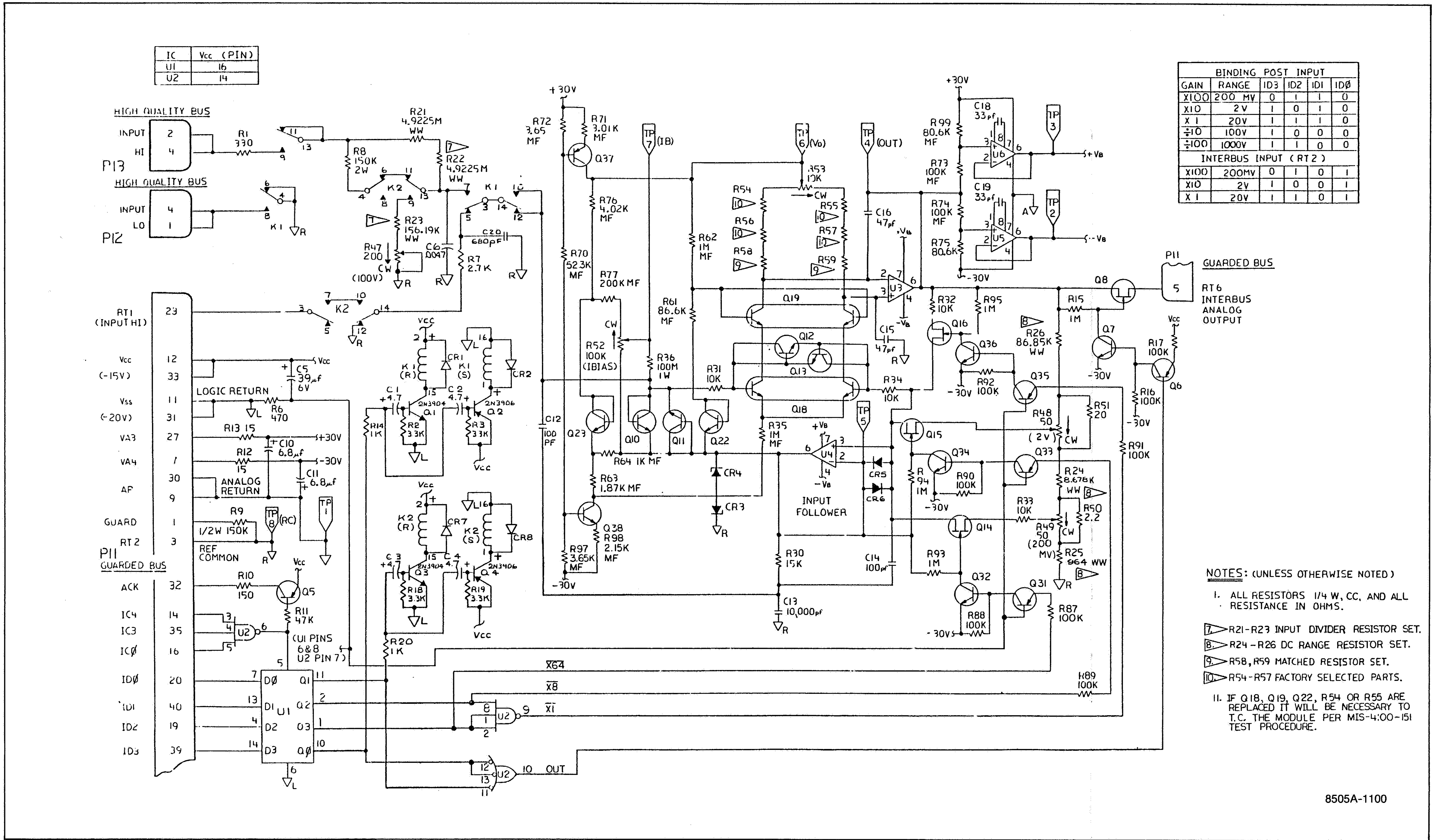


Figure 8-8. A8 DC Signal Conditioner PCB Assembly

IC	Vcc (PIN)
U1	16
U2	14

BINDING POST INPUT					
GAIN	RANGE	ID3	ID2	ID1	IDØ
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



NOTES: (UNLESS OTHERWISE NOTED)

I. ALL RESISTORS 1/4 W, CC, AND ALL RESISTANCE IN OHMS.

7 R21-R23 INPUT DIVIDER RESISTOR SET.

8 R24-R26 DC RANGE RESISTOR SET.

9 R58, R59 MATCHED RESISTOR SET.

10 R54-R57 FACTORY SELECTED PARTS.

II. 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.

8505A-1100

Figure 8-8. A8 DC Signal Conditioner PCB Assembly (cont)

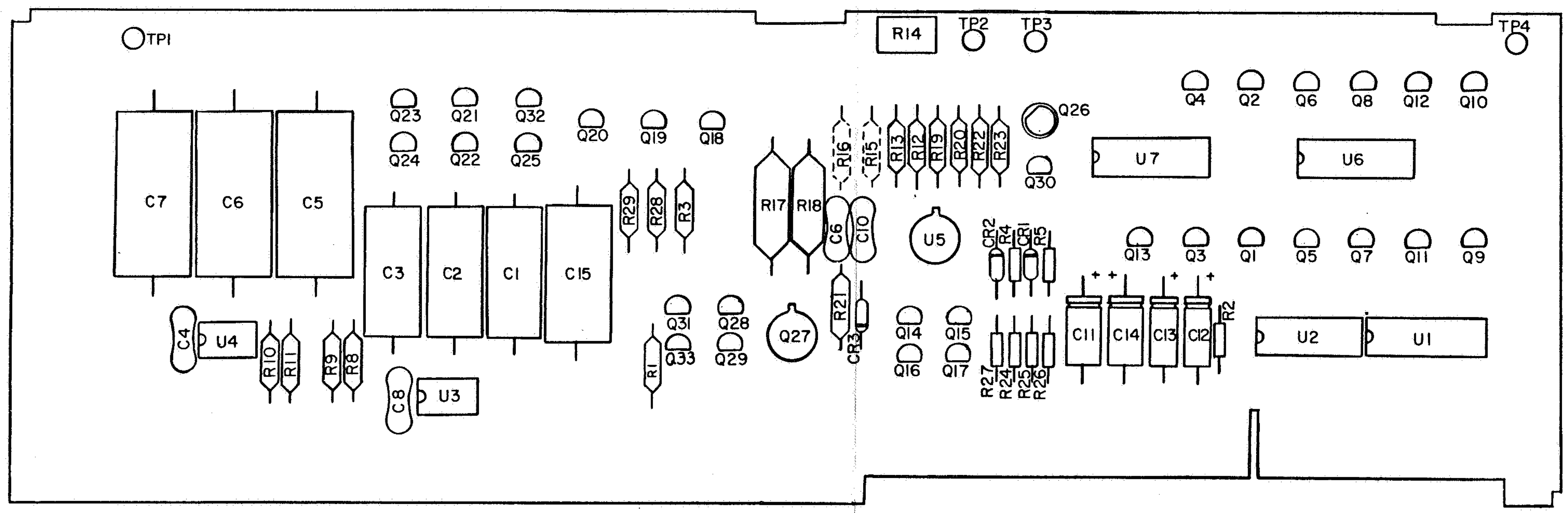
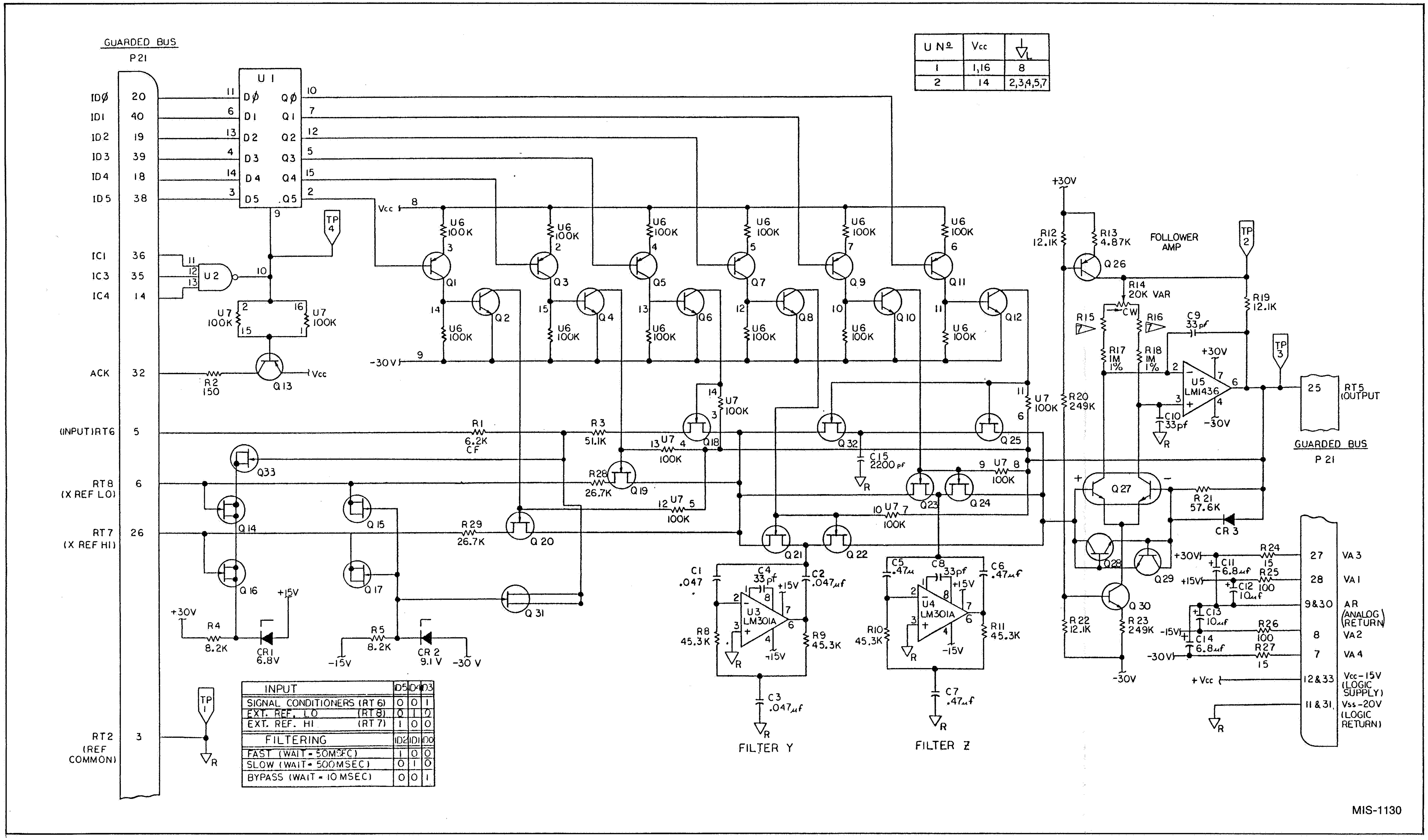


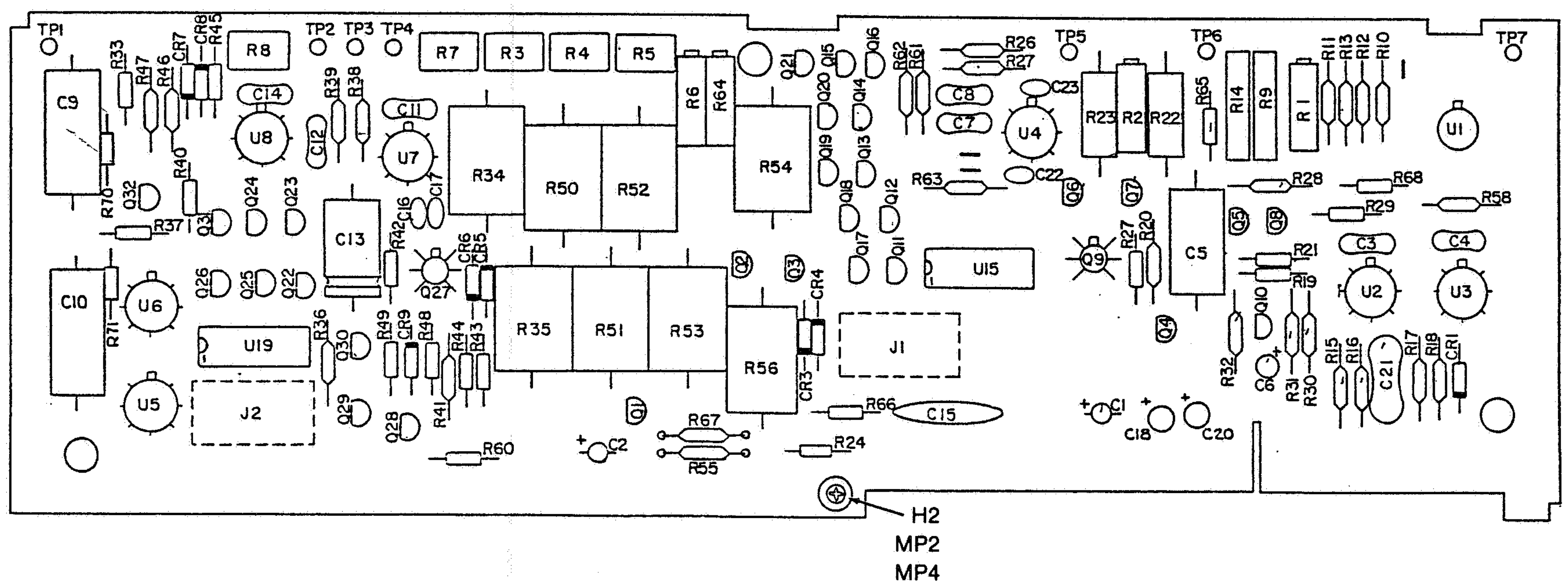
Figure 8-9. A9 Active Filter PCB Assembly



U N°	Vcc	⏚L
1	1,16	8
2	14	2,3,4,5,7

INPUT	ID5	ID4	ID3
SIGNAL CONDITIONERS (RT 6)	0	0	1
EXT. REF. LO (RT 8)	0	1	0
EXT. REF. HI (RT 7)	1	0	0
FILTERING	ID2	ID1	ID0
FAST (WAIT = 50MSEC)	1	0	0
SLOW (WAIT = 500MSEC)	0	1	0
BYPASS (WAIT = 10 MSEC)	0	0	1

Figure 8-9. A9 Active Filter PCB Assembly (cont)



MIS-1740

Figure 8-10. A10A1 A/D Analog PCB Assembly

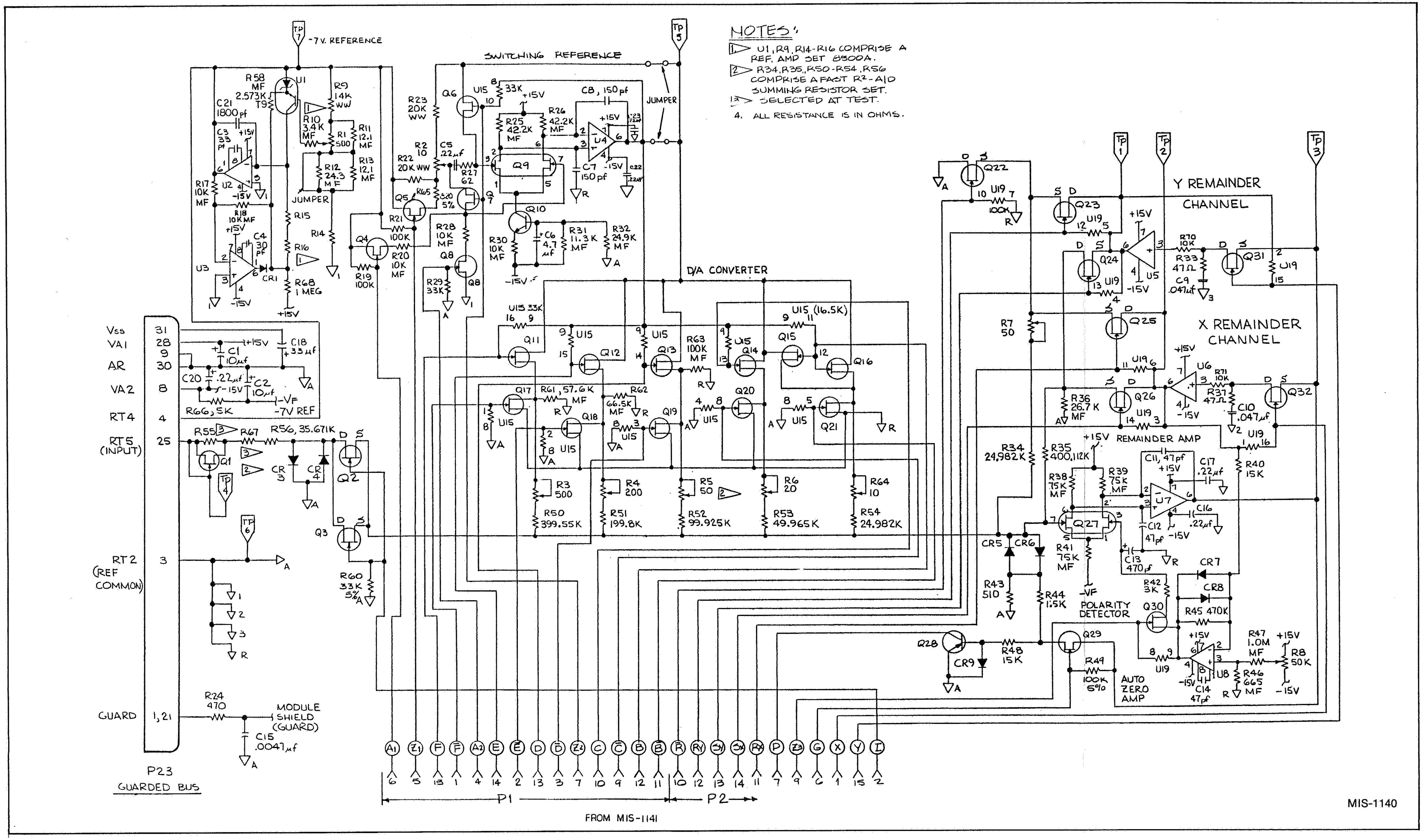
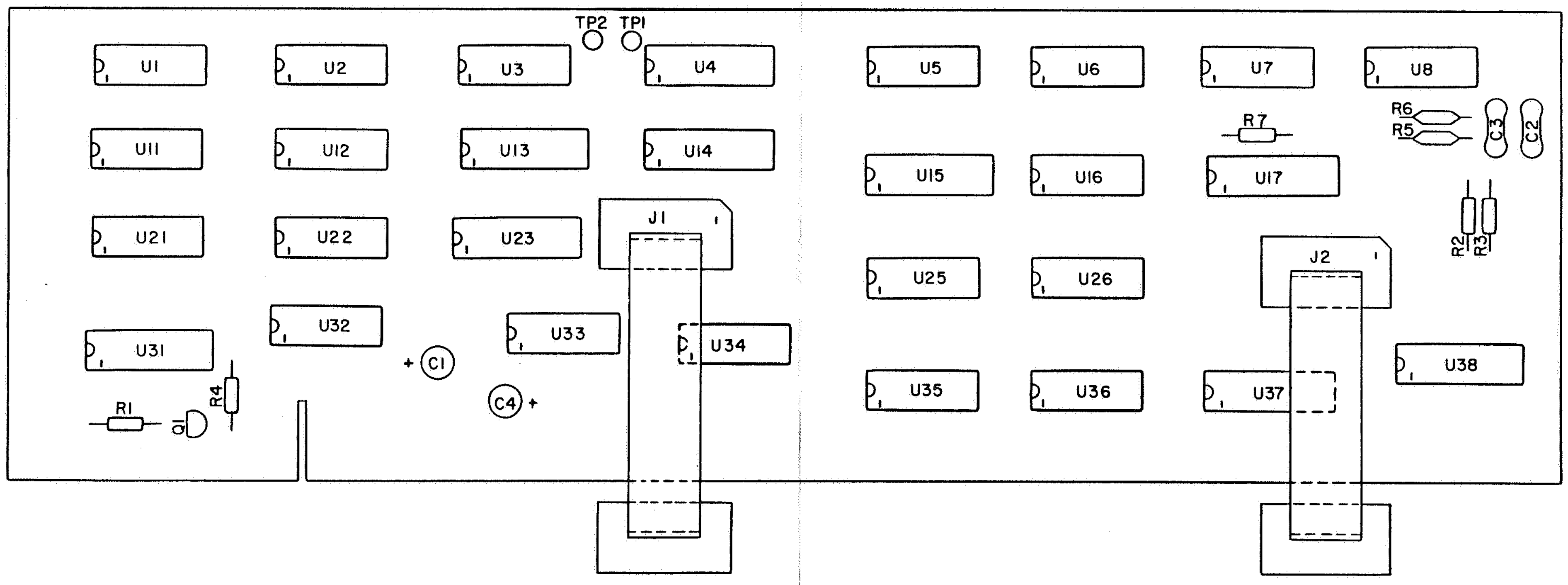
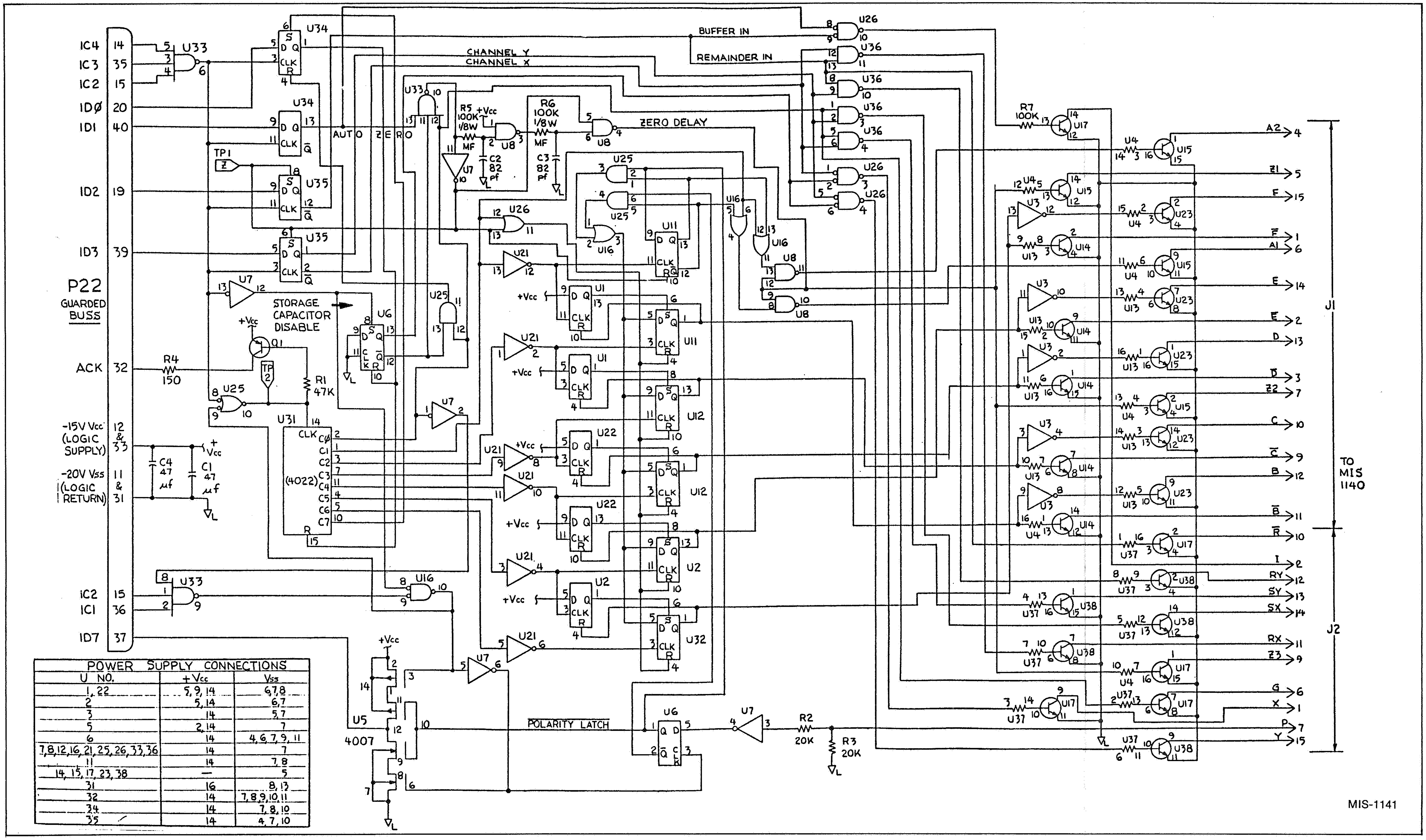


Figure 8-10. A10A1 A/D Analog PCB Assembly (cont)



MIS-1741

Figure 8-11. A10A2 Fast RR A/D Converter Digital PCB Assembly



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

MIS-1141

Figure 8-11. A10A2 Fast RR A/D Converter Digital PCB Assembly (cont)

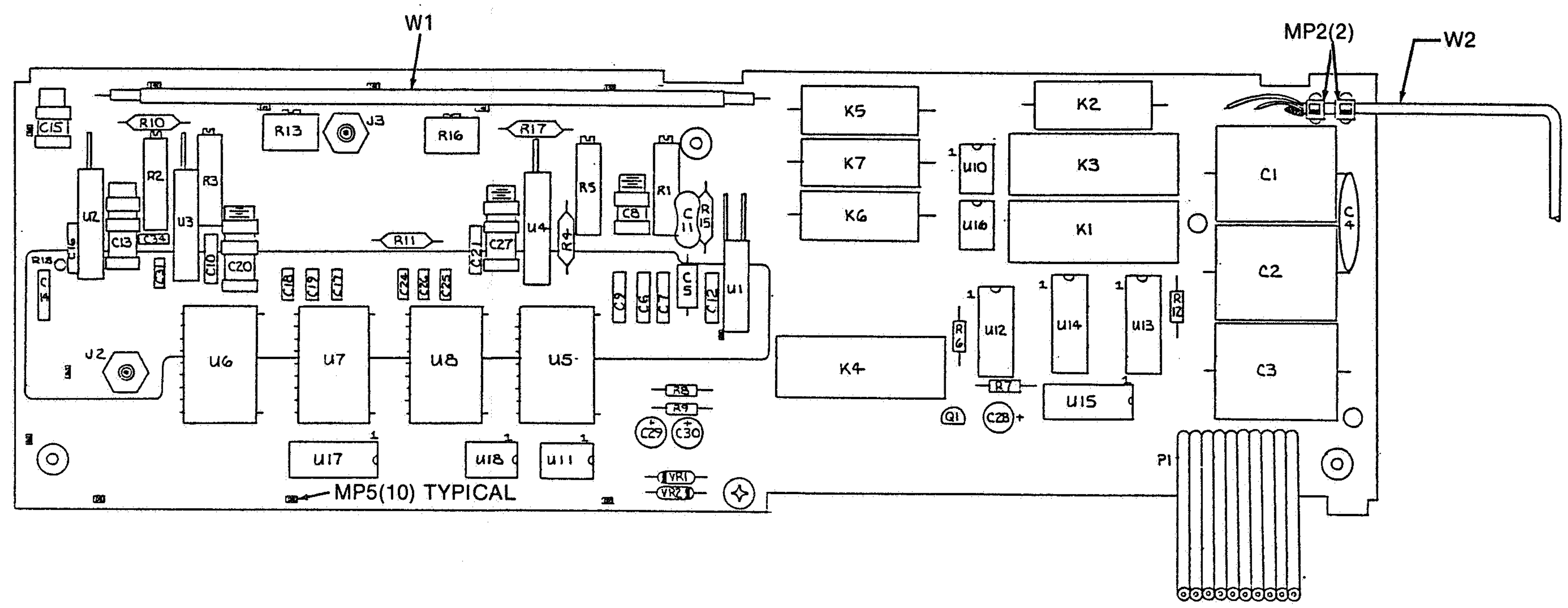
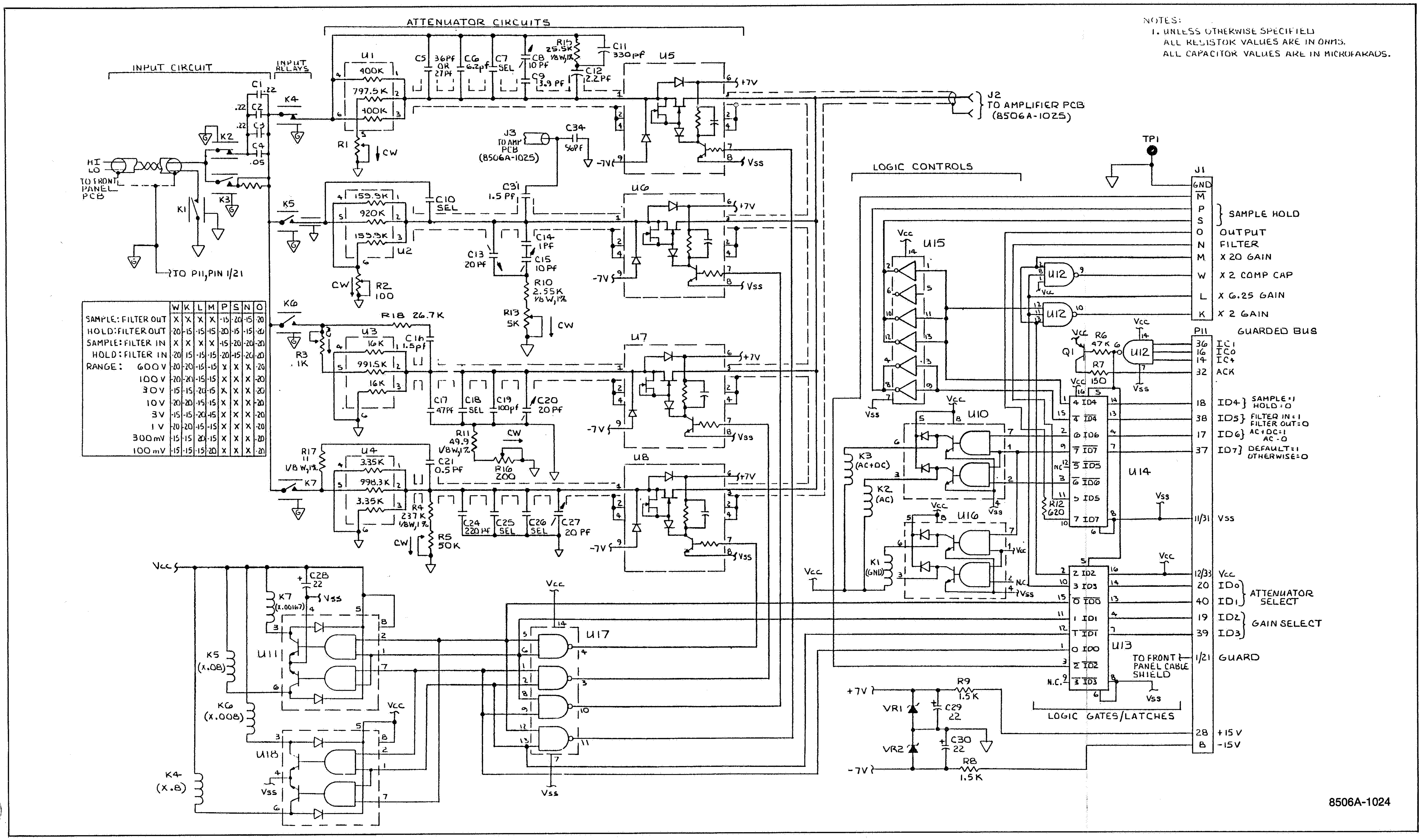
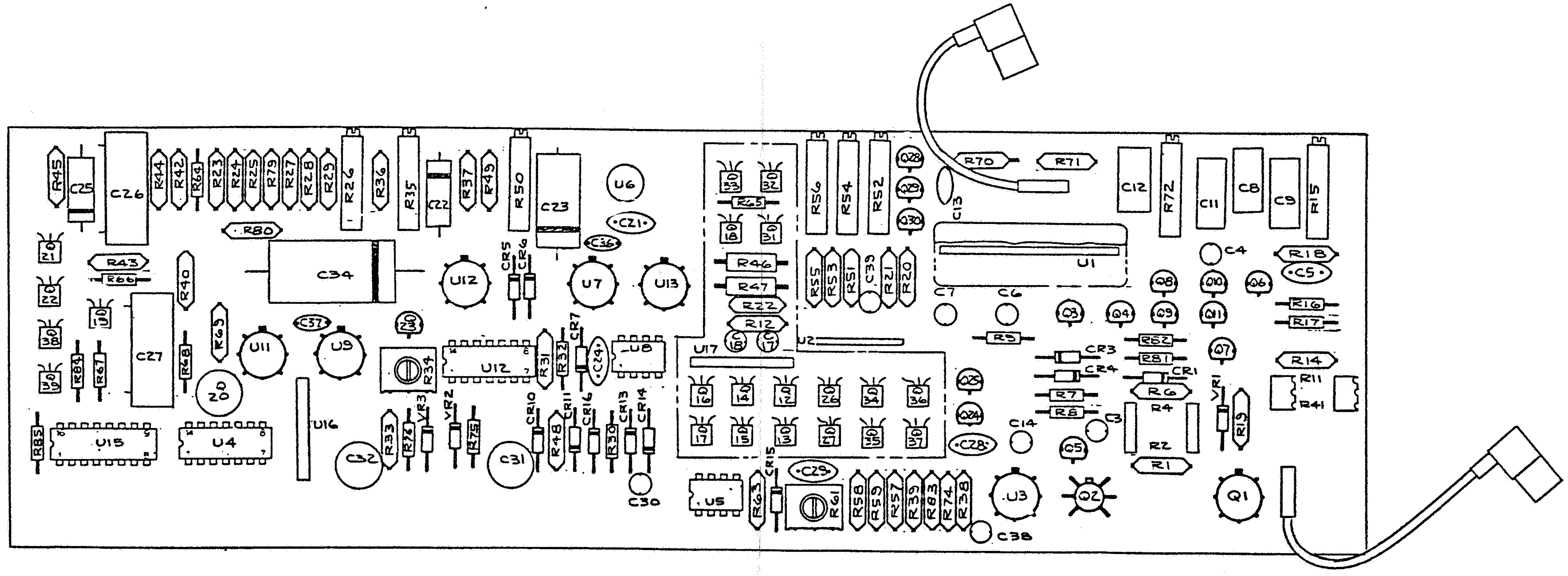


Figure 8-12. A11A1 Attenuator PCB Assembly



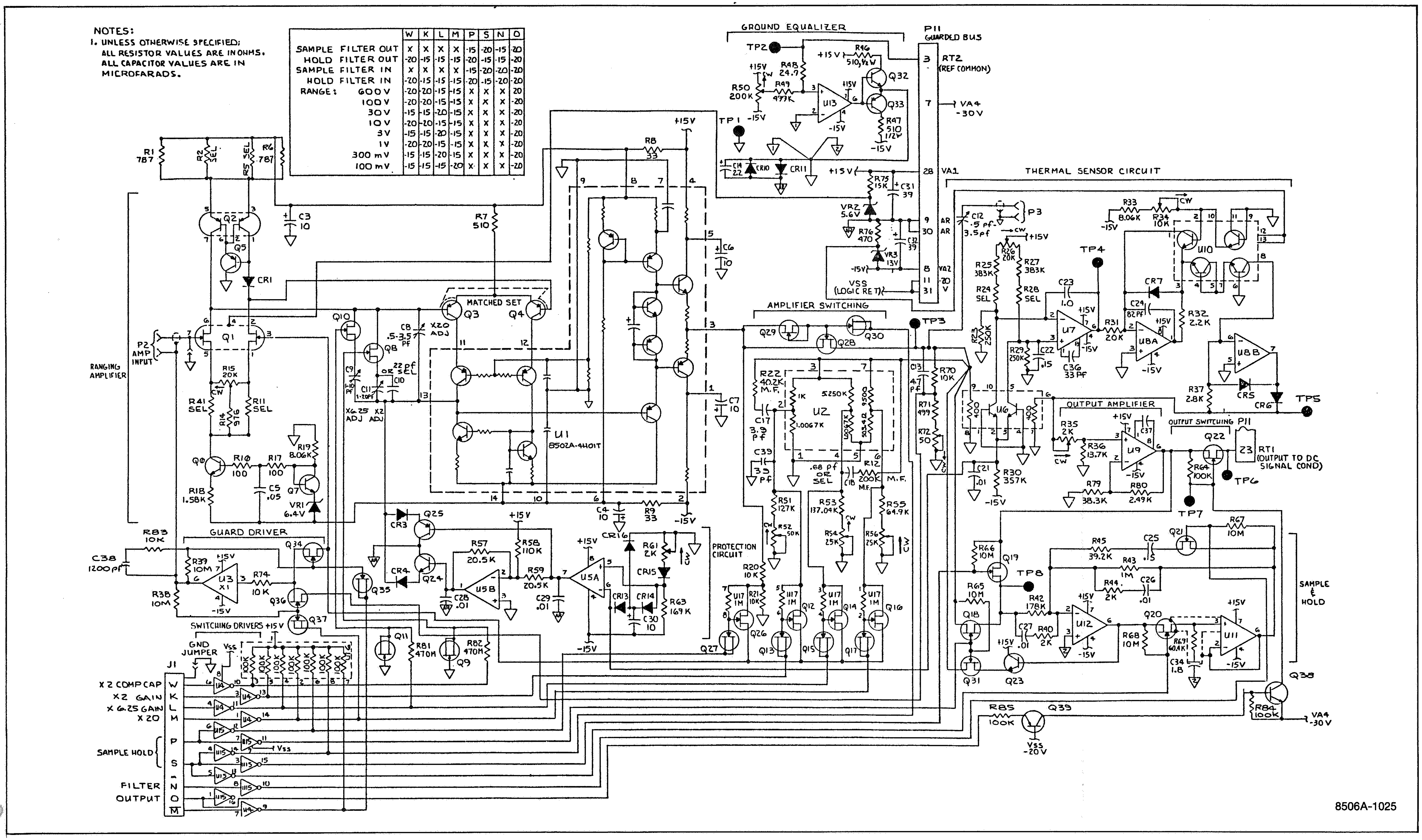
	W	K	L	M	P	S	N	O
SAMPLE: FILTER OUT	X	X	X	X	-15	-20	-15	-20
HOLD: FILTER OUT	-20	-15	-15	-15	-20	-15	-15	-20
SAMPLE: FILTER IN	X	X	X	X	-15	-20	-20	-20
HOLD: FILTER IN	-20	15	-15	-15	-20	-15	-20	-20
RANGE: 600 V	-20	-20	-15	-15	X	X	X	-20
100 V	-20	-20	-15	-15	X	X	X	-20
30 V	-15	-15	-20	-15	X	X	X	-20
10 V	-20	-20	-15	-15	X	X	X	-20
3 V	-15	-15	-20	-15	X	X	X	-20
1 V	-20	-20	-15	-15	X	X	X	-20
300 mV	-15	-15	20	-15	X	X	X	-20
100 mV	-15	-15	-15	-20	X	X	X	-20

Figure 8-12. A11A1 Attenuator PCB Assembly (cont)



8506A-1625

Figure 8-13. A11A2 Amplifier PCB Assembly



	W	K	L	M	P	S	N	O
SAMPLE FILTER OUT	X	X	X	X	-15	-20	-15	-20
HOLD FILTER OUT	-20	-15	-15	-15	-20	-15	-15	-20
SAMPLE FILTER IN	X	X	X	X	-15	-20	-20	-20
HOLD FILTER IN	-20	-15	-15	-15	-20	-15	-20	-20
RANGE: 600 V	-20	-20	-15	-15	X	X	X	20
100 V	-20	-20	-15	-15	X	X	X	-20
30 V	-15	-15	-20	-15	X	X	X	-20
10 V	-20	-20	-15	-15	X	X	X	-20
3 V	-15	-15	-20	-15	X	X	X	-20
1 V	-20	-20	-15	-15	X	X	X	-20
300 mV	-15	-15	-20	-15	X	X	X	-20
100 mV	-15	-15	-15	-20	X	X	X	-20

Figure 8-13. A11A2 Amplifier PCB Assembly (cont)