

**FLUKE 80 SERIES**  
**83, 85, 87**

# **FLUKE**

# **80 Series**

# **Multimeters**

**Service Manual**

P/N 834168

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Rev. 1, 8/89

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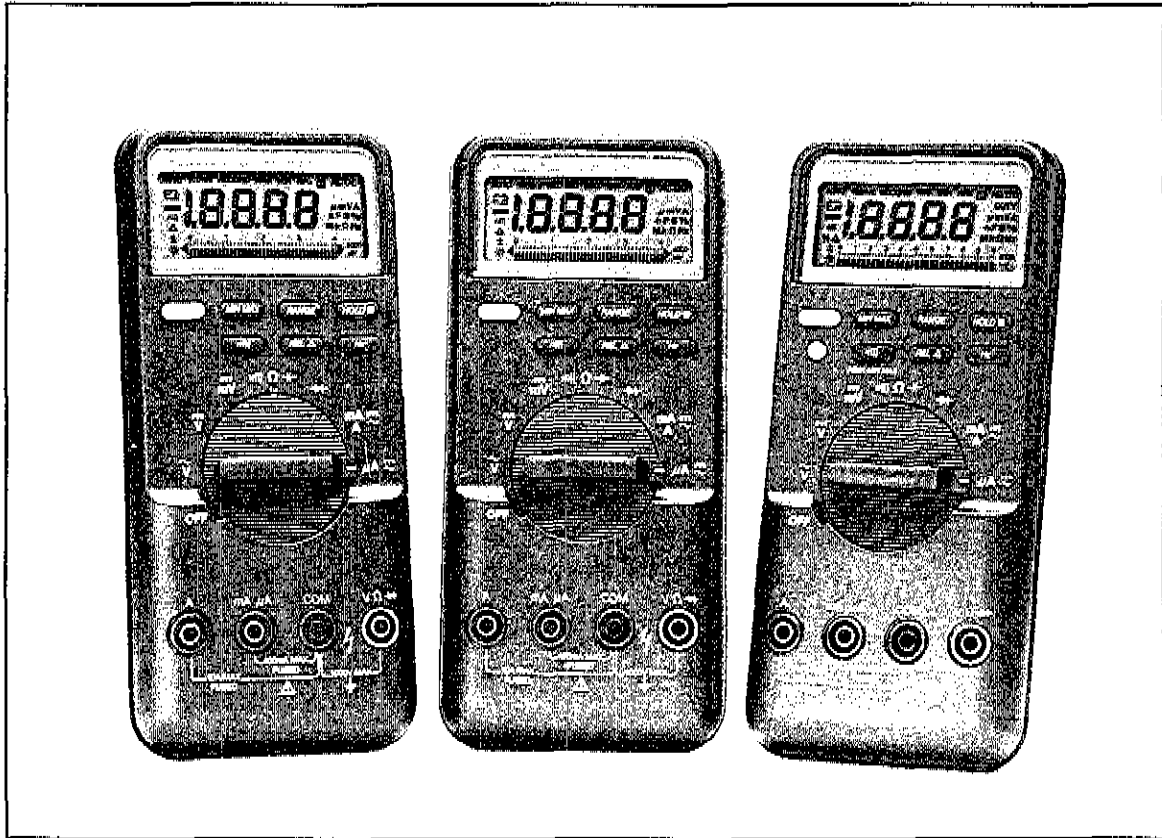
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Frontispiece

# Section 1

## Introduction and Specifications

### 1-1. INTRODUCTION

This manual covers servicing information for Fluke multimeter Models 83, 85, and 87. This service manual will prove useful for tasks ranging from routine maintenance to troubleshooting and repair. Specifications, theory of operation, calibration routines, testing and troubleshooting procedures, parts replacement information, and schematic diagrams are provided.

A meter under warranty will be promptly repaired or replaced (at Fluke's option) and returned at no charge. See the registration card for warranty terms. If the warranty has lapsed, the meter will be repaired and returned for a fixed fee. Contact the nearest Service Center for information and prices. A list of U.S. and International Service Centers is included at the end of Section 4 of this manual.

### 1-2. ORGANIZATION OF THE SERVICE MANUAL

The following descriptions for the various sections serve to introduce the manual.

#### SECTION 1. INTRODUCTION AND SPECIFICATIONS

This section describes both use of the Service Manual and application of special terminology (conventions) to describe the meter's circuitry. A complete set of specifications appears at the end of this section.

#### SECTION 2. THEORY OF OPERATION

This section first categorizes instrument circuitry into functional blocks, with a description of each block's role in overall operation. A detailed circuit description is then given for each block. These descriptions explore operation to the component level and fully support troubleshooting and repair procedures defined in Section 3.

#### SECTION 3. MAINTENANCE

Provides complete maintenance information, from general maintenance and cleaning instructions to detailed troubleshooting and repair procedures to the component level. Troubleshooting and repair procedures rely closely on both the Theory of Operation presented in Section 2 and the Schematic Diagrams shown in Section 5.

#### SECTION 4. LIST OF REPLACEABLE PARTS

Includes parts lists for all standard assemblies. Information on how and where to order parts is also provided.

#### SECTION 5. SCHEMATIC DIAGRAMS

Includes schematic diagrams for all assemblies. A list of mnemonic definitions is also included to aid in identifying signal name abbreviations.

### 1-3. CONVENTIONS

Throughout the manual, certain notational conventions are used. A summary of these conventions follows:

- Instrument Reference

When the discussion involves common features of the Fluke 80 Series multimeters, the term multimeter is used, and the model number is not used. Where features differ among models, further identification is made by model number (Model 83, 85, or 87).

- Printed Circuit Assembly

The term *pca* is used to represent a printed circuit board and its attached parts.

## 80 Series Service

- Signal Logic Polarity

Signal names followed by a - are active (or asserted) low. Signals not so marked are active high.

- Circuit Nodes

Individual pins or connections on a component are specified with a dash (-) following the component reference designator. For example, pin 19 of U30 would be U30-19.

- User Notation

Generally, buttons to be pressed, function positions to select, input terminals to use, and

display notation to be read are presented in this manual as they are seen on the multimeter. However, one button on the Model 83/85 and two buttons on the Model 87 use no terminology and are identified by color (blue or yellow) in this manual.

Special terms (mnemonics) used in text descriptions of multimeter circuitry correspond to terms used on the schematic diagrams in Section 5.

### 1-4. SPECIFICATIONS

Specifications for Models 83 and 85 are presented in Table 1-1. Model 87 specifications are presented in Table 2-2.

Table 1-1. Specifications, Models 83 and 85

FUNCTION	RANGE	RESOLUTION	ACCURACY <sup>1</sup>		
			50 Hz - 60 Hz	45 Hz - 5 kHz	
$\tilde{V}$ (Fluke 83)	400.0 mV	0.1 mV	$\pm(1.0\% + 4)$	$\pm(1.5\% + 4)$	
	4.000V	0.001V	$\pm(1.0\% + 3)$	$\pm(1.5\% + 3)$	
	40.00V	0.01V	$\pm(1.0\% + 3)$	$\pm(1.5\% + 3)$	
	400.0V	0.1V	$\pm(1.0\% + 3)$	$\pm(1.5\% + 3)$	
	1000V	1V	$\pm(1.0\% + 3)$	$\pm(2.5\% + 3)$	
$\tilde{V}$ (Fluke 85)	400.0 mV	0.1 mV	$\pm(0.5\% + 4)$	$\pm(1.0\% + 4)$	$\pm(2.0\% + 4)$
	4.000V	0.001V	$\pm(0.5\% + 2)$	$\pm(1.0\% + 2)$	$\pm(4.0\% + 4)$
	40.00V	0.01V	$\pm(0.5\% + 2)$	$\pm(1.0\% + 2)$	$\pm(4.0\% + 4)$
	400.0V	0.1V	$\pm(0.5\% + 2)$	$\pm(1.0\% + 2)$	$\pm(4.0\% + 4)$
	1000V	1V	$\pm(0.5\% + 2)$	$\pm(2.0\% + 2)$	Unspecified
				<b>Fluke 83</b>	<b>Fluke 85</b>
$\overline{V}$	4.000V	0.001V	$\pm(0.3\% + 1)$	$\pm(0.1\% + 1)$	
	40.00V	0.01V	$\pm(0.3\% + 1)$	$\pm(0.1\% + 1)$	
	400.0V	0.1V	$\pm(0.3\% + 1)$	$\pm(0.1\% + 1)$	
	1000V	1V	$\pm(0.3\% + 1)$	$\pm(0.1\% + 1)$	
$\overline{mV}$	400.0 mV	0.1 mV	$\pm(0.3\% + 1)$	$\pm(0.1\% + 1)$	
$\Omega$	400.0 $\Omega$	0.1 $\Omega$	$\pm(0.4\% + 1)$	$\pm(0.2\% + 1)$	
	4.000 k $\Omega$	0.001 k $\Omega$	$\pm(0.4\% + 1)$	$\pm(0.2\% + 1)$	
	40.00 k $\Omega$	0.01 k $\Omega$	$\pm(0.4\% + 1)$	$\pm(0.2\% + 1)$	
	400.0 k $\Omega$	0.1 k $\Omega$	$\pm(0.4\% + 1)$	$\pm(0.2\% + 1)$	
	4.000 M $\Omega$	0.001 M $\Omega$	$\pm(0.4\% + 1)$	$\pm(0.2\% + 1)$	
	40.00 M $\Omega$	0.01 M $\Omega$	$\pm(1\% + 3)$	$\pm(1\% + 3)$	
(nS)	40.00 nS	0.01 nS	$\pm(1\% + 10)$	$\pm(1\% + 10)$	

<sup>1</sup> Accuracy is given as  $\pm([\% \text{ of reading}] + [\text{number of least significant digits}])$  at 18° C to 28° C with relative humidity up to 90%, for a period of one year after calibration. AC conversions are ac-coupled, average responding, and calibrated to the rms value of a sine wave input.

Table 1-1. Specifications, Models 83 and 85 (cont)

FUNCTION	RANGE	RESOLUTION	ACCURACY <sup>2</sup>		
Capacitance	5.00 nF	0.01 nF	$\pm(1\% + 35)^3$		
	0.0500 $\mu$ F	0.0001 $\mu$ F	$\pm(1\% + 2)$		
	0.500 $\mu$ F	0.001 $\mu$ F	$\pm(1\% + 2)$		
	5.00 $\mu$ F	0.01 $\mu$ F	$\pm(1\% + 2)$		
Diode Test	3.000V	0.001V	$\pm(2\% + 1)$		

FUNCTION	RANGE	RESOLUTION	ACCURACY		BURDEN VOLTAGE TYPICAL
			Fluke 83	Fluke 85	
mA A ~ (45 Hz to 2 kHz)	40.00 mA	0.01 mA	$\pm(1.2\% + 2)$	$\pm(0.6\% + 2)$	1.6 mV/mA
	400.0 mA	0.1 mA	$\pm(1.2\% + 2)$	$\pm(0.6\% + 2)$	1.6 mV/mA
	4000 mA	1 mA	$\pm(1.2\% + 2)$	$\pm(0.6\% + 2)$	0.03 V/A
	10.00A <sup>4</sup>	0.01A	$\pm(1.2\% + 2)$	$\pm(0.6\% + 2)$	0.03 V/A
mA A =	40.00 mA	0.01 mA	$\pm(0.4\% + 2)$	$\pm(0.2\% + 2)$	1.6 mV/mA
	400.0 mA	0.1 mA	$\pm(0.4\% + 2)$	$\pm(0.2\% + 2)$	1.6 mV/mA
	4000 mA	1 mA	$\pm(0.4\% + 2)$	$\pm(0.2\% + 2)$	0.03 V/A
	10.00A <sup>4</sup>	0.01A	$\pm(0.4\% + 2)$	$\pm(0.2\% + 2)$	0.03 V/A
$\mu$ A (45 Hz to 2 kHz)	400.0 $\mu$ A	0.1 $\mu$ A	$\pm(1.2\% + 2)$	$\pm(0.6\% + 2)$	100 $\mu$ V/ $\mu$ A
	4000 $\mu$ A	1 $\mu$ A	$\pm(1.2\% + 2)$	$\pm(0.6\% + 2)$	100 $\mu$ V/ $\mu$ A
$\mu$ A =	400.0 $\mu$ A	0.1 $\mu$ A	$\pm(0.4\% + 2)$	$\pm(0.2\% + 2)$	100 $\mu$ V/ $\mu$ A
	4000 $\mu$ A	1 $\mu$ A	$\pm(0.4\% + 2)$	$\pm(0.2\% + 2)$	100 $\mu$ V/ $\mu$ A

FUNCTION	RANGE	RESOLUTION	ACCURACY
Frequency (0.5 Hz to 200 kHz, pulse width >2 $\mu$ s)	199.99	0.01 Hz	$\pm(0.005\% + 1)$
	1999.9	0.1 Hz	$\pm(0.005\% + 1)$
	19.999 kHz	0.001 kHz	$\pm(0.005\% + 1)$
	199.99 kHz	0.01 kHz	$\pm(0.005\% + 1)$
	>200 kHz	0.1 kHz	Unspecified

2 With film capacitor or better

3  $\pm(1\% + 2)$  if Relative mode is used to zero residual

4 10A continuous, 20A for 30 seconds maximum

Table 1-1. Specifications, Models 83 and 85 (cont)

FREQUENCY COUNTER SENSITIVITY AND TRIGGER LEVEL					
INPUT RANGE	MINIMUM SENSITIVITY (RMS SINEWAVE)		APPROXIMATE TRIGGER LEVEL (DC VOLTAGE FUNCTION)		
	5 Hz-20 kHz	0.5 Hz-200 kHz			
(Maximum input for specified accuracy = 10X Range or 1000V)					
400 mV dc	70 mV (to 400 Hz)	70 mV (to 400 Hz)	40 mV		
400 mV ac	150 mV	150 mV	—		
4V	0.3V	0.7V	1.7V		
40V	3V	7V	4V		
400V	30V	70V ( $\leq 140$ kHz)	40V		
1000V	300V	700V ( $\leq 14$ kHz)	400V		
Duty Cycle	0.1 to 99.9%	(0.5 Hz to 200 kHz, pulse width $> 2 \mu\text{s}$ )			
Accuracy:	Within $\pm(0.05\%$ per kHz + 0.1%) of full scale for a 5V logic family input on the 4V dc range.				
	Within $\pm((0.06 \times \text{Voltage Range}/\text{Input Voltage}) \times 100\%)$ of full scale for sine wave inputs on ac voltage ranges.				
FUNCTION	OVERLOAD PROTECTION <sup>5</sup>	INPUT IMPEDANCE (nominal)	COMMON MODE REJECTION RATIO (1 k $\Omega$ unbalance)	NORMAL MODE REJECTION RATIO	
$\overline{\text{V}}$	1000V rms	10 M $\Omega$ < 100 pF	>120 dB at dc, 50 Hz or 60 Hz	>60 dB at 50 Hz or 60 Hz	
$\overline{\text{mV}}$	1000V rms	10 M $\Omega$ < 100 pF	>120 dB at dc, 50 Hz or 60 Hz	>60 dB at 50 Hz or 60 Hz	
$\tilde{\text{V}}$	1000V rms	10 M $\Omega$ < 100 pF (ac-coupled)	>60 dB, dc to 60 Hz		
$\Omega$	1000V rms <sup>6</sup>	OPEN CIRCUIT TEST VOLTAGE	FULL SCALE VOLTAGE		SHORT CIRCUIT CURRENT
			To 4.0 M $\Omega$	40 M $\Omega$ or nS	
		<1.3V dc	<450 mV dc	<1.3V dc	<500 $\mu\text{A}$
Diode Test	1000V rms <sup>6</sup>	<3.9V dc	3.000V dc		1.0 mA typical

<sup>5</sup> 10<sup>7</sup> V Hz max

<sup>6</sup> For circuits < 0.3A short circuit, 660V for high energy circuits.

Table 1-1. Specifications, Models 83 and 85 (cont)

MIN MAX Recording	NOMINAL RESPONSE	ACCURACY, (5% to 100% of range)
	100 ms to 80%	specified accuracy $\pm 12$ digits for changes $> 200$ ms in duration ( $\pm 40$ digits in AC with beeper on)
1 s	same as specified accuracy for changes $> 2$ seconds in duration ( $\pm 40$ digits in AC with beeper on)	

FUSE PROTECTION		MAXIMUM VOLTAGE BETWEEN ANY TERMINAL AND EARTH GROUND
mA or $\mu$ A A	1A 600V FAST Fuse 15A 600V FAST Fuse	1000 Volts

<b>Display</b>	Digital: 4000 counts, updates 4/sec Analog: 43 segments, updates 40/sec Frequency: 19,999 counts, updates 3/sec @ $> 10$ Hz
<b>Operating Temperature</b>	-20°C to 55°C
<b>Storage Temperature</b>	-40°C to 60°C
<b>Temperature Coefficient</b>	0.05 x (specified accuracy)/°C ( $< 18^\circ\text{C}$ or $> 28^\circ\text{C}$ )
<b>Relative Humidity</b>	0% to 90% (0°C to 35°C) 0% to 70% (35°C to 55°C)
<b>Battery Type</b>	9V, NEDA 1604 or 6F22 or 006P
<b>Battery Life</b>	500 hrs typical with alkaline
<b>Shock, Vibration</b>	Per MIL-T-28800 for a Class 2 Instrument
<b>Size (HxWxL)</b>	1.25 in x 3.41 in x 7.35 in (3.1 cm x 8.6 cm x 18.6 cm)
<b>With Holster and Flex-Stand:</b>	2.06 in x 3.86 in x 7.93 in (5.2 cm x 9.8 cm x 20.1 cm)
<b>Weight</b>	12.5 oz (355g)
<b>With Holster and Flex-Stand:</b>	22.0 oz (624g)
<b>Safety</b>	Designed to Protection Class II per IEC 348, ISA-DS82, and UL1244

Table 1-2. Specifications, Model 87

FUNCTION	RANGE	RESOLUTION	ACCURACY <sup>1</sup>		
			50 Hz-60 Hz	45 Hz-5 kHz	5 kHz-20 kHz <sup>2</sup>
$\tilde{V}$	400.0 mV	0.1 mV	$\pm(0.7\% + 4)$	$\pm(1.0\% + 4)$	$\pm(2.0\% + 4)$
	4.000V	0.001V	$\pm(0.7\% + 2)$	$\pm(1.0\% + 4)$	$\pm(2.0\% + 4)$
	40.00V	0.01V	$\pm(0.7\% + 2)$	$\pm(1.0\% + 4)$	$\pm(2.0\% + 4)$
	400.0V	0.1V	$\pm(0.7\% + 2)$	$\pm(1.0\% + 4)$	$\pm(2.0\% + 4)$
	1000V	1V	$\pm(0.7\% + 2)$	$\pm(1.0\% + 4)^2$	Unspecified
$\overline{V}$	4.000V	0.001V	$\pm(0.1\% + 1)$		
	40.00V	0.01V	$\pm(0.1\% + 1)$		
	400.0V	0.1V	$\pm(0.1\% + 1)$		
	1000V	1V	$\pm(0.1\% + 1)$		
$\overline{mV}$	400.0 mV	0.1 mV	$\pm(0.1\% + 1)$		
$\Omega$	400.0 $\Omega$	0.1 $\Omega$	$\pm(0.2\% + 1)$		
	4.000 k $\Omega$	0.001 k $\Omega$	$\pm(0.2\% + 1)$		
	40.00 k $\Omega$	0.01 k $\Omega$	$\pm(0.2\% + 1)$		
	400.0 k $\Omega$	0.1 k $\Omega$	$\pm(0.2\% + 1)$		
	4.000 M $\Omega$	0.001 M $\Omega$	$\pm(0.2\% + 1)$		
	40.00 M $\Omega$	0.01 M $\Omega$	$\pm(1\% + 3)$		
	(nS)	40.00 nS	0.01 nS	$\pm(1\% + 10)$	

FUNCTION	RANGE	RESOLUTION	ACCURACY <sup>3</sup>
Capacitance	5.00 nF	0.01 nF	$\pm(1\% + 35)^4$
	0.0500 $\mu$ F	0.0001 $\mu$ F	$\pm(1\% + 2)$
	0.500 $\mu$ F	0.001 $\mu$ F	$\pm(1\% + 2)$
	5.00 $\mu$ F	0.01 $\mu$ F	$\pm(1\% + 2)$
Diode Test	3.000V	0.001V	$\pm(2\% + 1)$

FUNCTION	RANGE	RESOLUTION	ACCURACY	BURDEN VOLTAGE TYPICAL
$\frac{mA}{A} \sim$ (45 Hz to 2 kHz)	40.00 mA	0.01 mA	$\pm(1.0\% + 2)$	1.6 mV/mA
	400.0 mA	0.1 mA	$\pm(1.0\% + 2)$	1.6 mV/mA
	4000 mA	1 mA	$\pm(1.0\% + 2)$	0.03 V/A
	10.00A <sup>5</sup>	0.01A	$\pm(1.0\% + 2)$	0.03 V/A
$\frac{mA}{A} \overline{=}$	40.00 mA	0.01 mA	$\pm(0.2\% + 2)$	1.6 mV/mA
	400.0 mA	0.1 mA	$\pm(0.2\% + 2)$	1.6 mV/mA
	4000 mA	1 mA	$\pm(0.2\% + 2)$	0.03 V/A
	10.00A <sup>5</sup>	0.01A	$\pm(0.2\% + 2)$	0.03 V/A

1 Accuracy is given as  $\pm([\% \text{ of reading}] + [\text{number of least significant digits}])$  at 18° C to 28° C, with relative humidity up to 90%, for a period of one year after calibration. In the 4½-digit mode, multiply the number of least significant digits (counts) by 10. AC conversions are ac-coupled, true rms responding, calibrated to the rms value of a sine wave input, and valid from 5% to 100% of range. AC crest factor can be up to 3 at full scale, 6 at half scale.

2 Below 10% of range, add 16 counts.

3 With film capacitor or better

4  $\pm(1\% + 2)$  if Relative mode is used to zero residual

5 10A continuous. 20A for 30 seconds maximum

Table 1-2. Specifications, Model 87 (cont)

FUNCTION	RANGE	RESOLUTION	ACCURACY	BURDEN VOLTAGE TYPICAL
$\tilde{\mu}A$ (45 Hz to 2 kHz)	400.0 $\mu A$	0.1 $\mu A$	$\pm(1.0\% + 2)$	100 $\mu V/\mu A$
	4000 $\mu A$	1 $\mu A$	$\pm(1.0\% + 2)$	100 $\mu V/\mu A$
$\overline{\mu}A$	400.0 $\mu A$	0.1 $\mu A$	$\pm(0.2\% + 2)$	100 $\mu V/\mu A$
	4000 $\mu A$	1 $\mu A$	$\pm(0.2\% + 2)$	100 $\mu V/\mu A$

FUNCTION	RANGE	RESOLUTION	ACCURACY
Frequency (0.5 Hz to 200 kHz, pulse width >2 $\mu s$ )	199.99	0.01 Hz	$\pm(0.005\% + 1)$
	1999.9	0.1 Hz	$\pm(0.005\% + 1)$
	19.999 kHz	0.001 kHz	$\pm(0.005\% + 1)$
	199.99 kHz	0.01 kHz	$\pm(0.005\% + 1)$
	>200 kHz	0.1 kHz	Unspecified

FREQUENCY COUNTER SENSITIVITY AND TRIGGER LEVEL			
INPUT RANGE	MINIMUM SENSITIVITY (RMS SINEWAVE)		APPROXIMATE TRIGGER LEVEL (DC VOLTAGE FUNCTION)
	5 Hz-20 kHz	0.5 Hz-200 kHz	
(Maximum input for specified accuracy = 10X Range or 1000V)			
400 mV dc	70 mV (to 400 Hz)	70 mV (to 400 Hz)	40 mV
400 mV ac	150 mV	150 mV	—
4V	0.3V	0.7V	1.7V
40V	3V	7V	4V
400V	30V	70V ( $\leq 140$ kHz)	40V
1000V	300V	700V ( $\leq 14$ kHz)	400V

Duty Cycle	0.0 to 99.9% (0.5 Hz to 200 kHz, pulse width >2 $\mu s$ )		
Accuracy:	Within $\pm(0.05\%$ per kHz + 0.1%) of full scale for a 5V logic family input on the 4V dc range.  Within $\pm((0.06 \times \text{Voltage Range}/\text{Input Voltage}) \times 100\%)$ of full scale for sine wave inputs on ac voltage ranges.		

Table 1-2. Specifications, Model 87 (cont)

FUNCTION	OVERLOAD PROTECTION <sup>6</sup>	INPUT IMPEDANCE (nominal)	COMMON MODE REJECTION RATIO (1 k $\Omega$ unbalance)	NORMAL MODE REJECTION
$\overline{\text{V}}$	1000V rms	10 M $\Omega$ <100 pF	>120 dB at dc, 50 Hz or 60 Hz	>60 dB at 50 Hz or 60 Hz
$\overline{\text{mV}}$	1000V rms	10 M $\Omega$ <100 pF	>120 dB at dc, 50 Hz or 60 Hz	>60 dB at 50 Hz or 60 Hz
$\widehat{\text{V}}$	1000V rms	10 M $\Omega$ <100 pF (ac-coupled)	>80 dB, dc to 60 Hz	
		OPEN CIRCUIT TEST VOLTAGE	FULL SCALE VOLTAGE	
			To 4.0 M $\Omega$	40 M $\Omega$ or nS
$\Omega$	1000V rms <sup>7</sup>	<1.3V dc	<450 mV dc	<1.3V dc
Diode Test	1000V rms <sup>7</sup>	<3.9V dc	3.000V dc	
				SHORT CIRCUIT CURRENT
				<500 $\mu$ A
				1.0 mA typical

	NOMINAL RESPONSE	ACCURACY
MIN MAX Recording	100 ms to 80%	Specified accuracy $\pm$ 12 digits for changes >200 ms in duration ( $\pm$ 40 digits in AC)
	1 s	Same as specified accuracy for changes >2 seconds in duration
	1ms	Specified accuracy +/- 40 digits for changes >1 ms in duration. (+/- 100 digits typical for mV, 400 $\mu$ A dc, 40 mA dc, 4000 mA dc).

FUSE PROTECTION	
mA or $\mu$ A A	1A 600V FAST Fuse 15A 600V FAST Fuse

MAXIMUM VOLTAGE BETWEEN ANY TERMINAL AND EARTH GROUND
1000 Volts

6: 10<sup>7</sup> V Hz max

7: For circuits < 0.3A short circuit, 660V for high energy circuits.

Table 1-2. Specifications, Model 87 (cont)

<b>Display</b>	Digital: 4000 counts, updates 4/sec 19,999 counts (4 ½-digit mode), updates 1/sec Analog: 4 x 32 segments (equivalent to 128), updates 40/sec Frequency: 19,999 counts, updates 3/sec @ > 10 Hz Backlight: On for 68 seconds when selected.
<b>Operating Temperature</b>	-20°C to 55°C
<b>Storage Temperature</b>	-40°C to 60°C
<b>Temperature Coefficient</b>	0.05 x (specified accuracy)/°C (<18°C or >28°C)
<b>Relative Humidity</b>	0% to 90% (0°C to 35°C) 0% to 70% (35°C to 55°C)
<b>Battery Type</b>	9V, NEDA 1604 or 6F22 or 006P
<b>Battery Life</b>	400 hrs typical with alkaline
<b>Shock, Vibration</b>	Per MIL-T-28800 for a Class 2 Instrument
<b>Size (HxWxL)</b>	1.25 in x 3.41 in x 7.35 in (3.1 cm x 8.6 cm x 18.6 cm)
<b>With Holster and Flex-Stand:</b>	2.06 in x 3.86 in x 7.93 in (5.2 cm x 9.8 cm x 20.1 cm)
<b>Weight</b>	12.5 oz (355g)
<b>With Holster and Flex-Stand:</b>	22.0 oz (624g)
<b>Safety</b>	Designed to Protection Class II per IEC 348, ISA-DS82, and UL1244

## Section 2

# Theory of Operation

### 2-1. INTRODUCTION

This section describes the theory of operation for the Fluke 83, Fluke 85, and Fluke 87. Unless otherwise specified, the descriptions apply to all three instruments.

Functional block descriptions present an initial overview of circuit operation. Detailed circuit descriptions then cover the major circuit functions in more detail. For reference, detailed schematic diagrams are included in Section 5.

### 2-2. FUNCTIONAL BLOCK DESCRIPTION

Refer to Figure 2-1 for a block diagram of the Fluke 80 Series Multimeters. The instrument is partitioned into analog and digital sections. The integrated multimeter chip (U4) performs both analog and digital functions. Also, note that the Fluke 87 incorporates additional analog circuits.

The analog section of U4 contains the a/d converter, active filter, ac converter (for Models 83 and 85), frequency comparator, analog signal routing, range switching, and power supply functions.

The digital logic portion of U4 provides the state machine for synchronous a/d converter control and the 16-bit counter used for a/d converter counts and frequency measurements. Also, the digital logic section contains bus and interrupt control circuits (to facilitate the microcomputer interface) and registers for analog switch drive.

The microcomputer section of U4 executes software functions, formats data for the display, drives the display, and controls most analog and digital logic functions. The mode switch push buttons initiate various operating modes for the microcomputer. Output from the microcomputer can be presented visually on the liquid crystal display (LCD) and audibly on the beeper.

### 2-3. DETAILED CIRCUIT DESCRIPTION

Each of the functional blocks in Figure 2-1 is discussed in greater detail in the following paragraphs. The schematic diagrams located at the end of this manual can be consulted for details not portrayed in the figures in this section.

### 2-4. Input Overload Protection

Overload protection for the  $V\Omega$  input is provided by a network of two metal-oxide varistors (RV1 and RV2), three current-limiting resistors (R1, R2, and RT1), and spark gap E1. The 1 k $\Omega$ , 2W fusible resistor R1 opens when an extremely high energy signal is present. Thermistor RT1 rises to a high impedance during a sustained voltage overload in the millivolts dc, ohms, or diode test mode. A voltage clamp network is formed by transistors Q1, Q2, and Q6, diodes CR7 and CR8, and resistor R58. During ohms and diode test overloads, this clamp circuit limits the overload current to U4 at 10 mA. Power supply regulation and system operation is maintained during any of these overloads.

Overload protection for the mA  $\mu$ A input is provided by F1, rated at 1A/600V. The A input is protected by F2, rated at 15A/600V. In addition, the microamp shunt resistors (R4 and R43) are protected from overload currents below the F1 fusing level by the U1 and CR1 diode network.

The 83/85/87 Input-Alert feature provides a beeper warning signal when an input jack is connected to a current input and a non-current function is selected with the rotary switch. The meter detects the presence of an input connection by using split jacks at the mA  $\mu$ A and A inputs. One side of the jack is connected to an overload protection resistor (R7 for mA  $\mu$ A, R10 for A). In turn, R7 and R10 are connected to U4 sense lines AP4 and AP5 (pins 89 and 88). Resistors R8 and R48

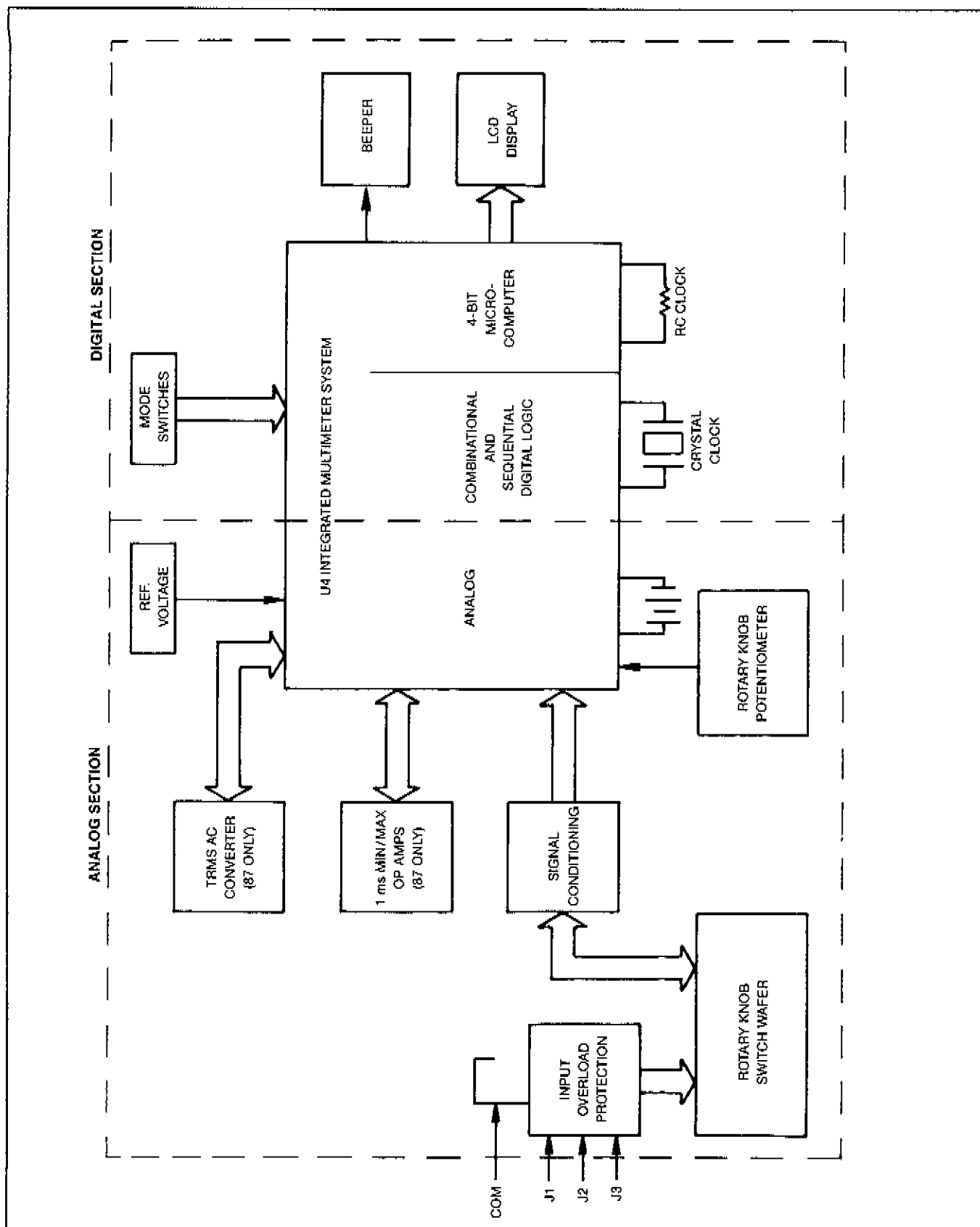


Figure 2-1. Overall Functional Block Diagram

provide Vdd pull up for AP4, and R11 is the pull up resistor for AP5. When a connection is made at mA  $\mu$ A or A, the sense side of the jack is pulled to COM. This condition is detected and compared with the selected function by U4. If a conflict exists, the beeper warning is activated.

### 2-5. Rotary Knob Switch and Potentiometer

Input signals are routed from the overload protection circuits to a double-sided switch wafer, which provides the necessary switching to implement the various signal conditioning. The function-encoding potentiometer is attached to the associated rotary switch shaft. After turn on, or a knob position change, U4 performs a voltage ratio measurement on this potentiometer to determine the new function.

### 2-6. Input Signal Conditioning Circuits

Each input signal is routed through signal conditioning circuitry before reaching U4. Input signals received through the V $\Omega$ - $\rightarrow$  input are routed through Z1, a precision resistor network. This input divider network provides precise input scaling for the various voltage ranges and precision reference resistors for the ohms and capacitance functions. The capacitors in parallel with the various resistors in Z1 are used for high frequency compensation.

The input divider is used in two modes. In volts functions, a series mode is used to provide four divider ratios. In the ohms function, a parallel mode provides five reference resistors. During the following discussion, refer to the schematic and signal flow diagrams in Section 5.

### 2-7. VOLTS

In Volts functions, signal flow for input divider Z1 begins with the unknown voltage at the V $\Omega$ - $\rightarrow$  input, which is connected to the high end of the 9.996 M $\Omega$  resistor (pin 1 of Z1) through R1 and RT1. In AC volts, C1 is also connected in series. In DC volts, C1 is shorted by S1 (contacts 3 and 4). Internal switches connect the 9.996 M $\Omega$  and 1.1111 M $\Omega$  resistors (pin 2 to pin 3 of Z1). The low end of the 1.1111 M $\Omega$  resistor (pin 7 of Z1) is connected to COM through S1 contacts 1 and 2, producing the divide-by-10 ratio used in the 400 mV ac, 4V ac, and 4V dc ranges.

For the 40V range, internal switches connect a 101.01 k $\Omega$  resistor to provide a divide-by-100 ratio. In the 400V range, 10.01 k $\Omega$  is used for a divide-by-1000 ratio. And a 1.0001 k $\Omega$  resistor is used in the 1000V range to provide a divide-by-10000 ratio.

The internal switch resistance connecting the 1.1111 M $\Omega$  and 9.996 M $\Omega$  with the other resistors is approximately 4 k $\Omega$ . Since the A/D senses the voltage at APV1 of U4 (pin

3 of Z1), the internal switch resistance adds to the 9.996 M $\Omega$  resistor, making for a circuit total of 10 M $\Omega$ .

### 2-8. OHMS

In the 400 ohm range the internal switches connect the 9.996 M $\Omega$  resistor (pin 2 of Z1) to the 1.0001 k $\Omega$  resistor (pin 6 of Z1); contacts 5 and 3 of S1 connect the remaining ends to of these resistors, making a reference resistor of 1 k $\Omega$ . Again, the 4 k $\Omega$  internal switch resistance adds to the 9.996 M $\Omega$ .

The source voltage is connected internally at both APV0 and APV4 of U4. The current is routed through the 1.0001 k $\Omega$  and 9.996 M $\Omega$  resistors, into S1 at contacts 3 and 5, out of S1 at contact 4, through R1 and RT1, out the V $\Omega$ - $\rightarrow$  input, through the unknown resistance, and back to COM. The same current flows through the unknown resistance and the reference resistor. The voltage dropped across the unknown resistance is sensed from the V $\Omega$ - $\rightarrow$  input jack through R2 and S1 (contacts 11 and 12) to AP1 of U4.

The A/D senses the voltage drop across the 1K reference resistor through the low (AP2 of U4 through R13) and high (APV0 and APV4) points. These two voltages are used by the A/D Converter to perform a ratiometric measurement.

For the 4 k $\Omega$  range, the 10.010 k $\Omega$  resistor used in parallel with the 9.996 M $\Omega$  resistor forms a 10 k $\Omega$  reference resistor. In the 40 k $\Omega$  range, 101.01 k $\Omega$  and 9.996 M $\Omega$  form a 100 k $\Omega$  reference resistor. And in the 400 k $\Omega$  range, 1.1111 M $\Omega$  and 9.996 M $\Omega$  provide a 1 M $\Omega$  reference resistor. The 4 M $\Omega$  and 40 M $\Omega$  use only the 9.996 M $\Omega$  resistor.

### 2-9. Analog Section of Integrated Multimeter IC (U4)

The analog-to-digital converter, autorange switching, frequency comparator, and most of the remaining analog circuitry are contained in the analog section of U4. Peripherals to this U4 analog section include the crystal clock, the system reference voltage, and some filter and amplifier resistors and capacitors. Included in the Fluke 87 only is a peripheral 1 ms MIN/MAX circuit and a true rms (root-mean-square) ac-to-dc converter.

Analog-to-digital conversion is accomplished within U4 using the dual-rate, dual-slope a/d converter circuit shown in Figure 2-2. For most measurements, the basic a/d rate cycle lasts 25 ms, for 40 measurements-per-second. A single conversion at this rate is called a minor cycle sample. Each minor cycle sample is used to provide 40 updates-per-minute for the fast response bar graph display, fast MIN/MAX recording, and fast autoranging.

Eight minor cycle samples are necessary to accumulate data for displaying a full-resolution (4000 count full scale)

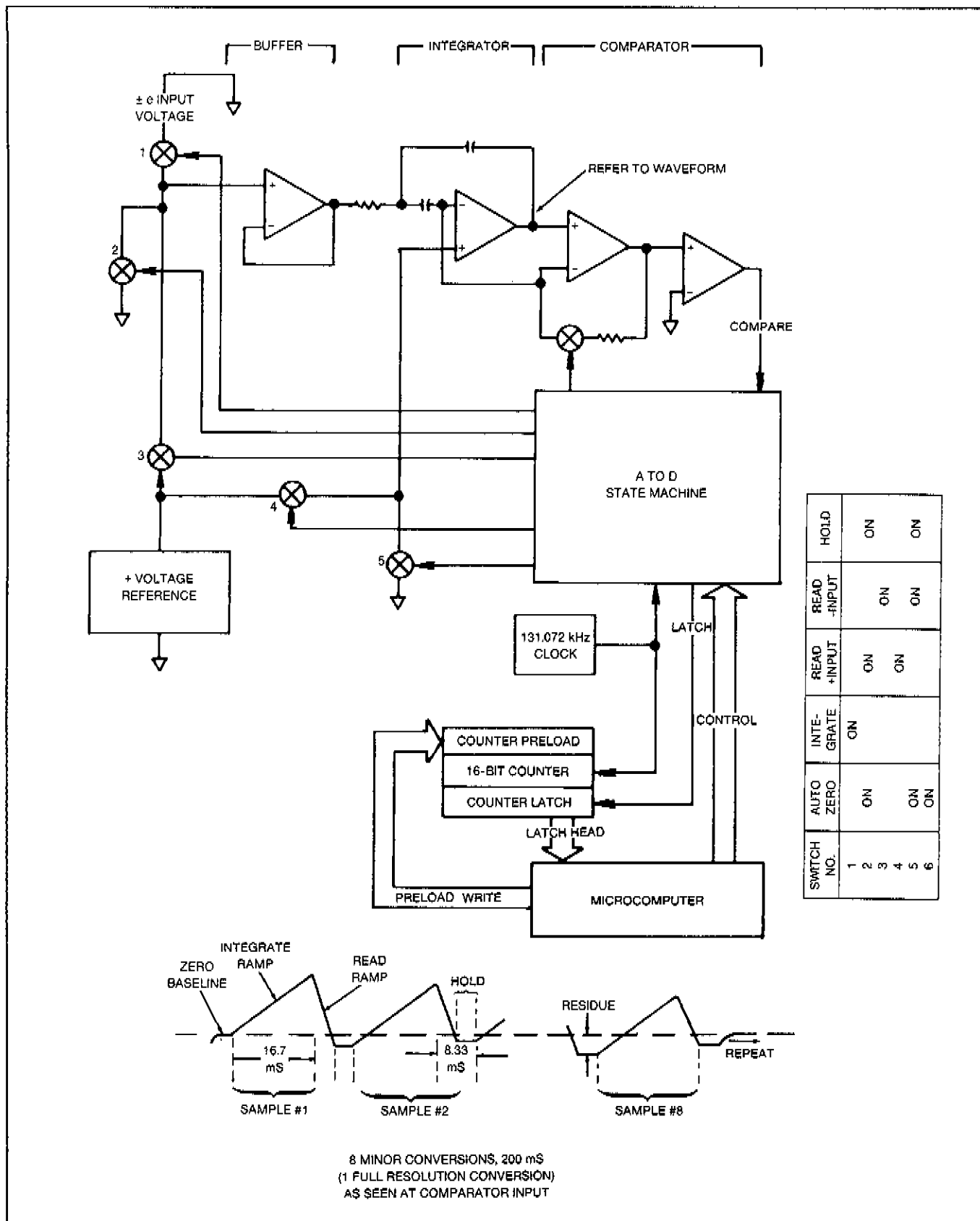


Figure 2-2. A/D Conversion

measurement on the digital display. A 40 ms autozero phase occurs following every eight-sample sequence. Therefore, each digital display update requires 240 ms, approximating 4 updates-per-minute.

Basic a/d conversion elements and waveforms are illustrated in Figure 2-2. As this figure shows, a residual charge is retained by the integrator capacitor due to the overshoot past the true-zero base line. In the absence of an autozero phase, the residual charge would normally produce a significant error in the sample taken next. However, a digital algorithm eliminates the error and accounts for the residual as it propagates through all eight samples.

Basic timing for the a/d converter is defined as a series of eight integrate read cycles, followed by a 40 ms autozero phase. However, the 40 M $\Omega$ , capacitance, overload recovery, autoranging, Touch-Hold, 100 ms Min/Max, 1 ms Min/Max (Fluke 87 only), and rotary knob potentiometer modes all require variations from the basic timing.

Capacitance measurements to 5.0  $\mu$ F are made by measuring the charge required to change the voltage across the unknown capacitor from zero to the system reference voltage. This technique is referred to as a ballistic type of measurement, the elements of which are shown in Figure 2-3. The unknown capacitor is fully charged from zero during the a/d converter integrate cycle. The signal integrated by the a/d converter constitutes the voltage drop across one or more precision resistors (Z1). The reference voltage is the de-integration signal for the a/d. Cx is discharged during de-integrate, hold, and autozero. The microcomputer calculates a display value from the latched count, which is proportional to the unknown capacitance. Capacitance mode uses two samples per display update.

A voltage comparator, with microcomputer configurable offsets, is used for both signal detection in frequency and duty cycle modes and threshold detection in continuity mode. In frequency and duty cycle modes, digital pulses from the voltage comparator are routed to the 16-bit counter.

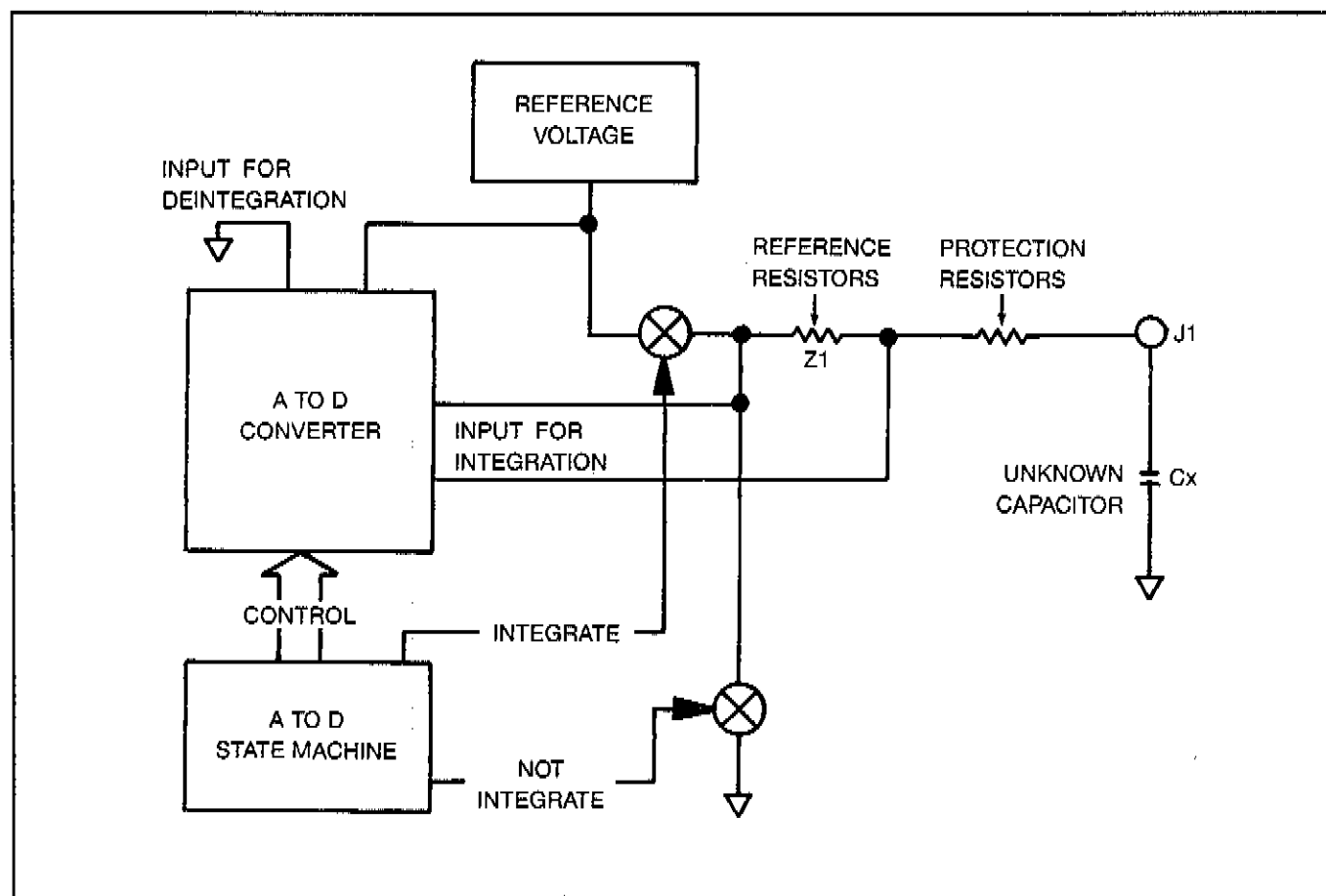


Figure 2-3. Capacitance Measurement Elements

### 2-10. Digital Section of Integrated Multimeter IC (U4)

Digital circuitry in U4 (excluding the microcomputer) is partitioned into five functional blocks, as shown in Figure 2-4.

- A bus control cell performs address decoding and manages selective power down, split jack sense, and low battery signals.
- The interrupt control cell manages and multiplexes four interrupts to the microcomputer. These interrupts are for 16-bit and 8-bit counter carries and voltage comparator transitions.
- A 48-bit write-only register latches microcomputer data for analog switch drive.
- A 16-bit counter (with parallel preload and latch registers) is used as a read counter for a/d conversions and as a pulse counter for frequency and duty-cycle measurements.
- The a/d converter is controlled by a 4-bit state machine with output decoding ROM.

Figure 2-5 is a block diagram of frequency counter components. For frequency and duty cycle measurements, the 16-bit counter in the digital section of U4 is partitioned into two 8-bit counters. Each of these counters is then extended to 20 bits using microcomputer software and hardware. The gating logic controls the start and stop of each reading. In frequency mode, signal A is the unknown frequency, and signal B is the crystal clock signal. After enough counts have been accumulated in each 20-bit register, the microcomputer calculates the unknown frequency from the ratio of the counter values.

In making a duty cycle measurement, signal A (Figure 2-5) is again the unknown signal, but signal B is the logical AND of the unknown and reference signals. As with frequency measurement, the microcomputer controls the start and stop of a measurement cycle via the gating logic. The ratio of the counter values yields the duty cycle value.

### 2-11. Microcomputer Control

A 4-bit microcomputer, integrated within U4, controls the various instrument functions and drives the display. A/D converter and counter measurements are controlled via the microcomputer interface lines shown in Figure 2-4. Min/Max, Touch-Hold, and REL (relative) modes involve additional data processing by the microcomputer to generate the display value.

The microcomputer/digital logic interface consists of both RAM that has been mapped into the digital logic and an interrupt line back to the microcomputer. The four interrupts are maskable, readable, and resettable. Note that the microcomputer runs on its own RC clock at a frequency of 525 to 800 kHz and is asynchronous from the crystal clock.

The microcomputer exercises direct control over the ranging and signal routing analog switches. A specific word is written to the switch drive register for each function/range selection. In autoranging (default) mode, the microcomputer determines the correct range based on the input. In addition, for autoranging during voltage, ohms, or current measurements, the active filter fast mode is enabled for quick response. In frequency or duty cycle mode, pushing the range button causes a range change in the primary function (volts, amps, etc.) that may change the sensitivity or offset.

The microcomputer sets the required a/d converter mode, which determines the on-chip analog signal ports to be used for the integrate and de-integrate signals. The microcomputer also selects one of the three available gain resistors in Z1 for integrate and de-integrate. All voltage and current conversions use either a 400 mV or a 40 mV full scale mode. Other modes are used for ohms, highohms, 40 M $\Omega$ , nS, and capacitance. Since the a/d state machine timing is under direct software control, a mode invoked in another function or range can use different timing.

Frequency measurements are also controlled by the microcomputer section of U4. The microcomputer initializes the counters, monitors the count accumulation, arms and disarms the logic signal gating, and calculates the display value from the counter values.

Min/Max Record (1s and 100 ms), Touch-Hold, and Relative are secondary software functions. This means that the microcomputer performs either a different control algorithm or a different math routine on the data, as explained below.

- In Min/Max Record mode, the maximum and minimum readings after initialization are stored in memory, and a true running average is calculated after each reading. The running average is updated for a maximum of 36 hours. The MIN MAX button allows the user to scroll through the min, max, average, and present readings. In 100 ms Min/Max a single sample is used to calculate the display value, while in 1s Min/Max a full resolution conversion is used. Note that 1 ms Peak Min/Max (Fluke 87 only) requires additional analog peak hold amplifiers external to U4.

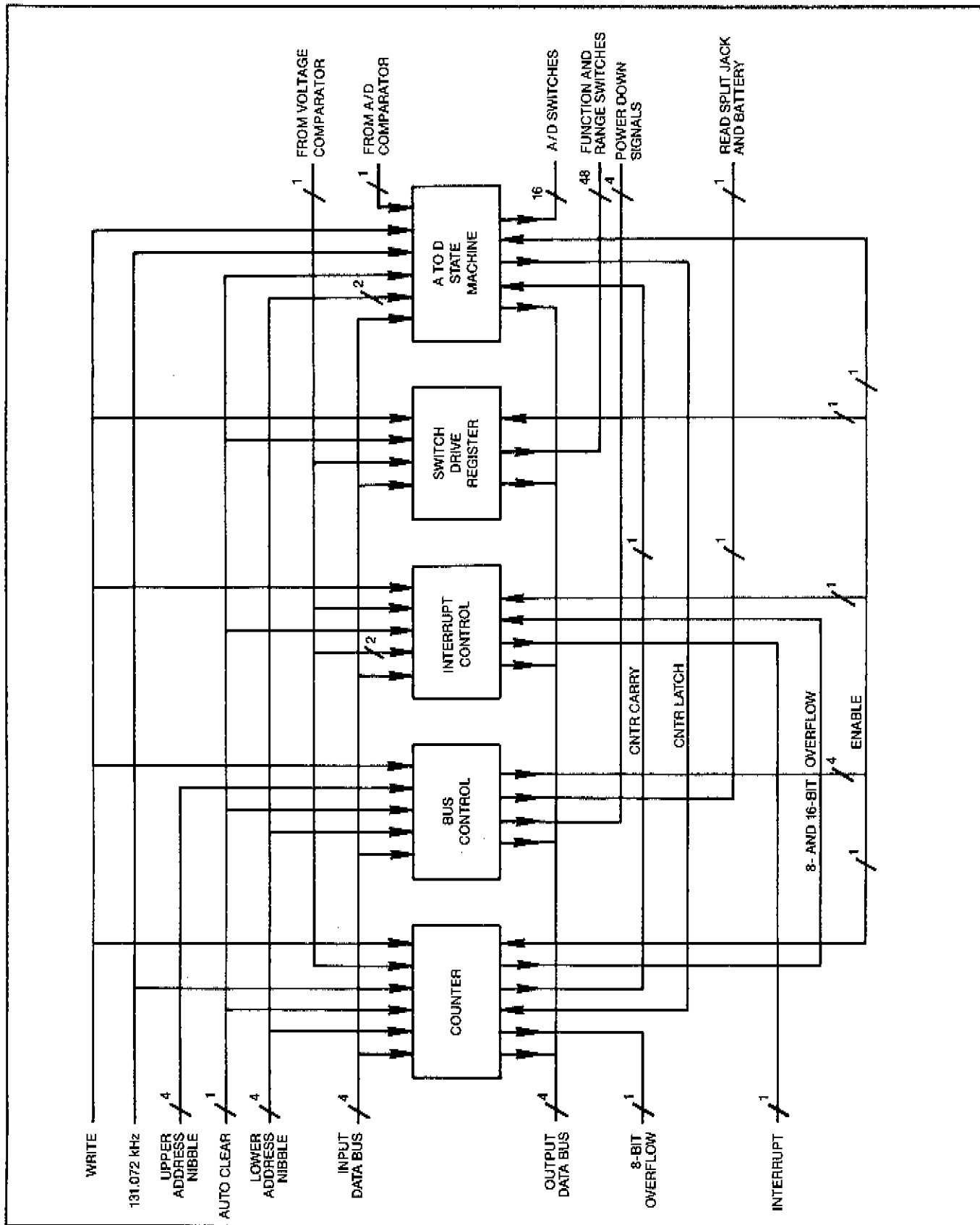


Figure 2-4. Digital Circuitry Within U4

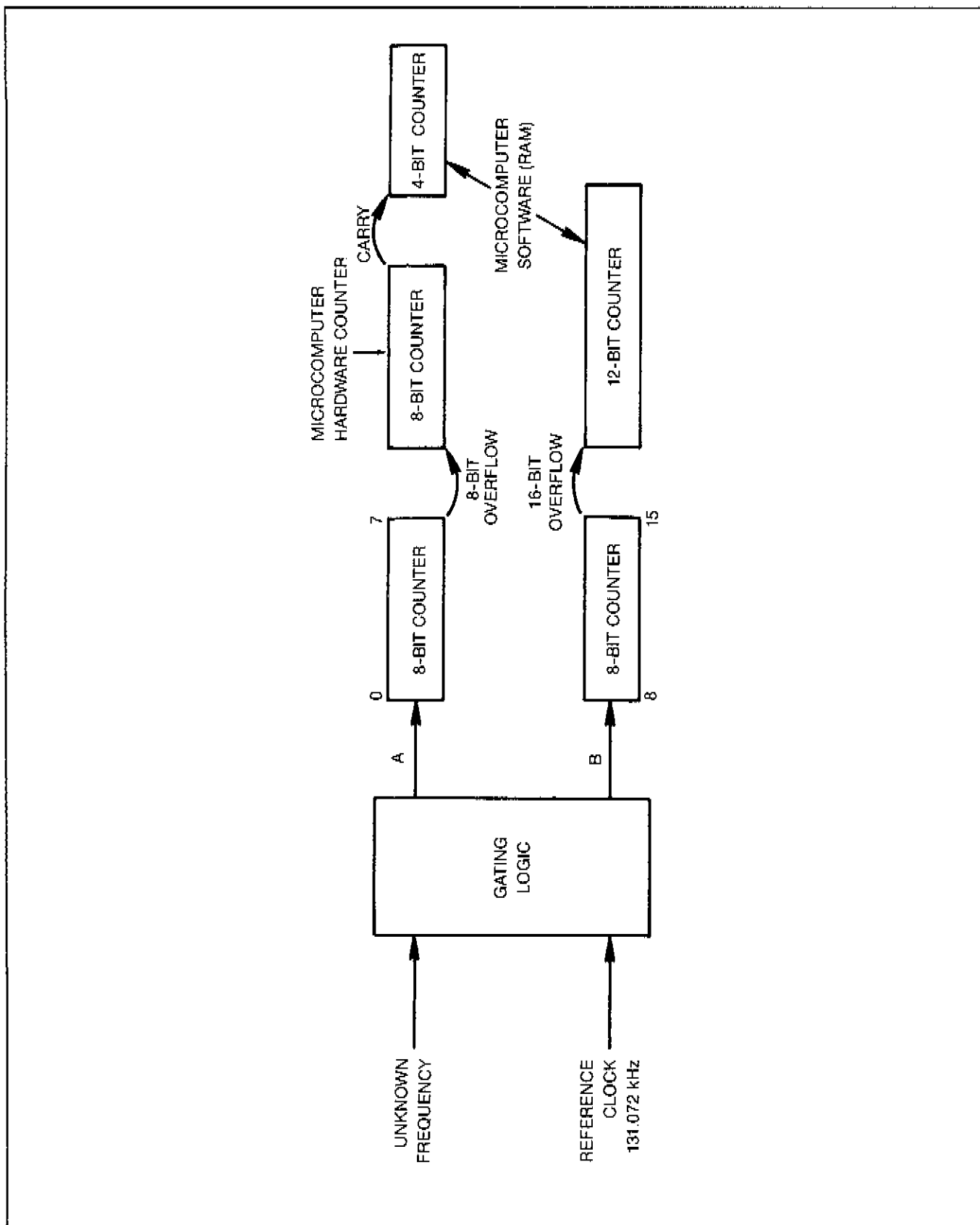


Figure 2-5. Frequency Counter Elements

- When Touch-Hold is selected, the microcomputer does not allow a full resolution conversion to be completed unless the input signal is stable. When a stable reading occurs, the conversion is completed, and the microcomputer generates and freezes the corresponding display. The microcomputer now waits for a change in the signal to exceed a certain threshold, then begins watching for a stable reading again. Note that a reading is forced when Touch Hold is first selected. Also, open test lead signals do not update the display.
- With the REL button (relative) selected, the microcomputer stores the present reading as an offset. This value is subtracted from all subsequent readings (provided that they are on scale) to give the display value.

#### 2-12. Peripherals to U4

In addition to input overload protection and input signal conditioning circuits, other devices peripheral to U4 are needed to support 80 series features. The ac converter, active filter, and a/d converter circuits require off-chip resistors and capacitors. Digital drive and level-shifting circuits are needed for the beeper drive, quick turn off, true RMS converter power down (Fluke 87 only), and LCD back light (also Fluke 87 only) features. A voltage reference is generated separate from U4, and some discrete resistors and transistors support the power supply. The Fluke 87 also uses two analog peak hold circuits (1 ms Min/Max).

#### 2-13. AC BUFFER

The ac buffer circuit differs between the Fluke 83/85 and the Fluke 87. On the Fluke 83/85, R14, R15, C5, and C27 are part of the ac buffer circuit that drives the ac converter and guard. The Fluke 83/85 ac buffer can be configured for an ac gain of 1 or 10. For the Fluke 87, R14, R15, R46, C5, and C27 support the ac buffer. This buffer can be configured for an ac gain of 1/2, 1, 5, or 10. The gains of 1/2 and 5 are needed for the true rms converter, which uses a 200 mV full scale input. In the Fluke 87, the ac buffer drives the rms ac converter, guard, and peak hold amplifiers.

#### 2-14. AC CONVERTER

The Fluke 83/85 average ac converter uses off-chip components R30, R31, R34, R40, C24, C28, and C29. This ac converter is a full-wave rectifying converter with a differential output and gain selected to give a dc output equal to the rms value for a sine wave input. Filtering is provided by C28 and C29.

#### 2-15. RMS CONVERTER

The Fluke 87 uses an integrated rms-to-dc converter (U2). Devices R34, R45, C6, and C7 support U2, while Q4, R32, and R39 drive the power on/off pin.

#### 2-16. ACTIVE FILTER

On all models, the active filter uses off-chip passive components R17, R18, C8, and C9. The active filter is a second order low pass filter with two poles at 5.9 Hz in normal mode. It filters input signal noise and ac ripple from the ac converter, yielding stable a/d converter readings. The microcomputer can disable the filter completely or enable the filter fast response mode.

#### 2-17. A/D CONVERTER

Pins 8, 9, and 10 on precision resistor network Z1 connect to the three a/d converter gain resistors. Pin 8 connects to 190 k $\Omega$  for a gain of 0.87. Pin 9 connects to 160 k $\Omega$  for a gain of 1, and pin 10 connects to 16 k $\Omega$  for a gain of 10. Pin 11 is the common connection. The autozero capacitor (C10) stores op amp and comparator offsets. The integration capacitor is C11.

#### 2-18. BEEPER

Devices Q9, Q11, R56, R57 and CMOS hex inverter U6 make up the double-ended beeper drive circuit. Transistor Q12 is connected to provide quick microcomputer power down when the instrument is turned off.

The system reference voltage (1.235V) is generated by VR1 and R44. The 1.000V reference voltage for the a/d converter is supplied through U4-1 (REFI). This voltage is adjusted by R21, the dc calibration potentiometer. In addition to generating the a/d reference, the VR1 voltage is used for power supply reference, voltage comparator selectable offset generation, and the ohms source level.

#### 2-19. POWER SUPPLY

The power supply consists of two regulators, one shunt and one series, which set V<sub>dd</sub> at +3.0V and V<sub>ss</sub> at -3.2V for all battery voltages down to 6.7V. The shunt (common) regulator sets V<sub>dgn</sub> - V<sub>ss</sub> (V<sub>dgn</sub> = COM = 0V) and consists of an uncompensated op amp and large current shunt devices integrated on U4. Resistors R37 and R38 provide voltage division. The series (V<sub>dd</sub>) regulator, which sets V<sub>dd</sub> - V<sub>dgn</sub>, is made up of another on-chip, uncompensated op amp, along with devices Q3, R24, and R25. Q3 is the series regulator element, and R24 and R25 are for voltage sensing. Capacitors C14 and C21 provide circuit compensation and power supply decoupling for the shunt and series regulators, respectively. Voltage level information is presented in Table 2-1.

**Table 2-1. Typical Voltage Levels and Tolerance**

VDD	3.0 $\pm$ 0.3
VSS	-3.2 $\pm$ 0.3
VBT+	3.5 $\pm$ 0.3
VBT-	-3.5 (battery at full 9V charge)
	3.0 (battery at low charge of 6.5V)
REFH	1.235 $\pm$ 0.012
PS0	1.235 $\pm$ 0.15
PS1	0 $\pm$ 0.15
AP6	-0.5 to -0.15
VOA	2.2 to 1.7 (referenced from VSS)
VOB	1.07 to .91 (referenced from VSS)

**2-20. PEAK HOLD**

The 1ms Min/Max mode on the Fluke 87 is implemented using the peak hold circuit consisting of the dual op amp package AR1, diodes CR2 and CR3, C12, C13, R22, and R23. The op amp connected to CR2 charges C12 to the most positive voltage at its input after initialization

(which can be positive or negative in amplitude.) CR2 prevents C12 from being discharged after the peak input is no longer present. The op amp connected to CR3 works in a similar fashion, but captures negative peaks. Upon selection of 1ms Min/Max, U4 initializes the circuit by connecting AP7 (pin 86) to Vss and AP8 (pin 85) to Vdd via on-chip switches. Leakage currents are controlled so that the voltages on C12 and C13 drift towards the AR1 op amp input level. The voltages stored on C12 and C13 are read, in a single sample, to give the display minimum and maximum values.

**2-21. Display**

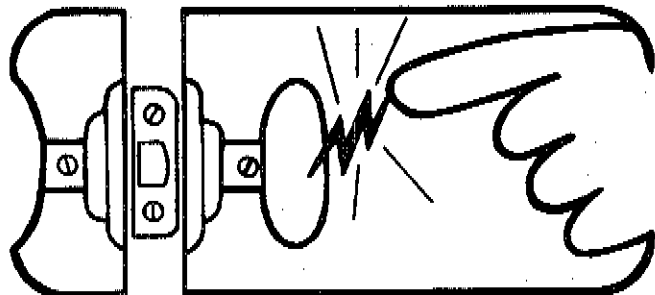
The liquid-crystal display (LCD) operates under direct control of the microcomputer. Characters are generated by the computer and displayed on the LCD. Both digital readings and an analog bar-graph (or pointer for Fluke 87) display are presented, in conjunction with annunciators and decimal points. The Fluke 87 features a transreflective LCD with a light-emitting diode (LED) back light. Refer to the Fluke 83/85 or 87 Operator's Manual for a more detailed description of the display.



# static awareness



A Message From  
**John Fluke Mfg. Co., Inc.**

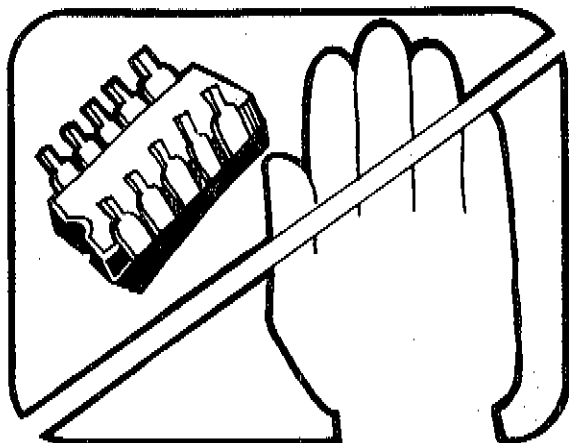


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

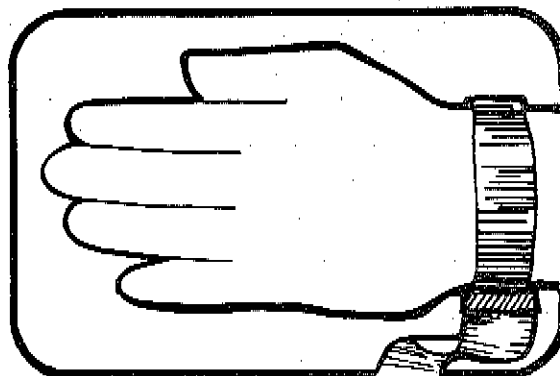
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

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

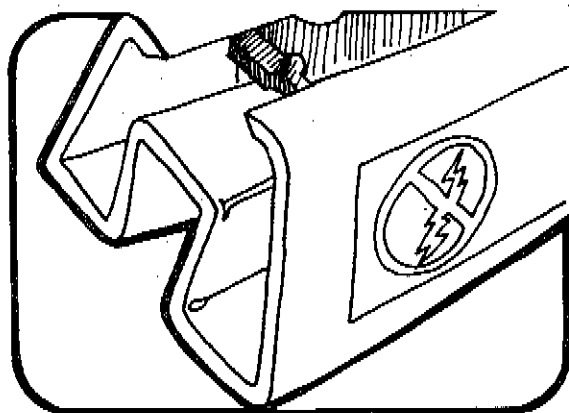
The following practices should be followed to minimize damage to S.S. devices.



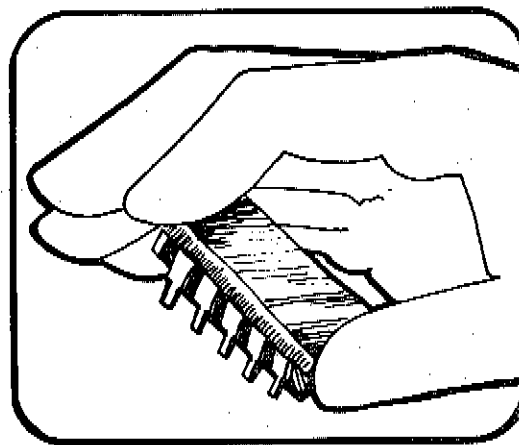
1. MINIMIZE HANDLING



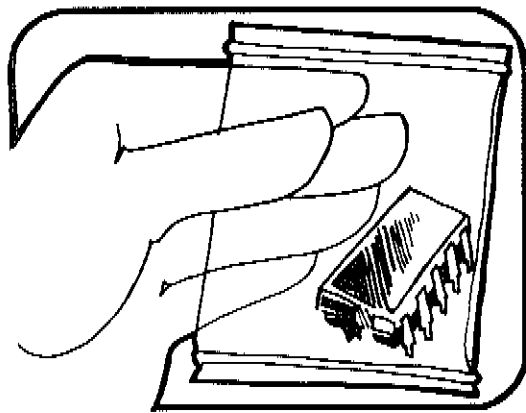
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



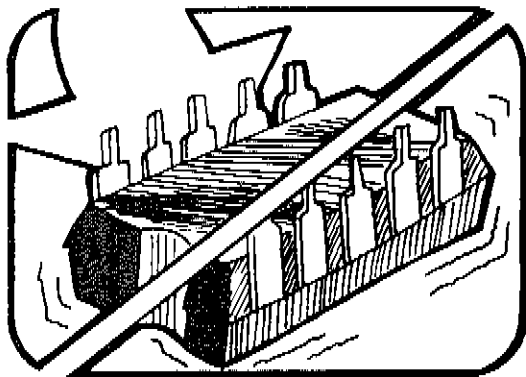
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



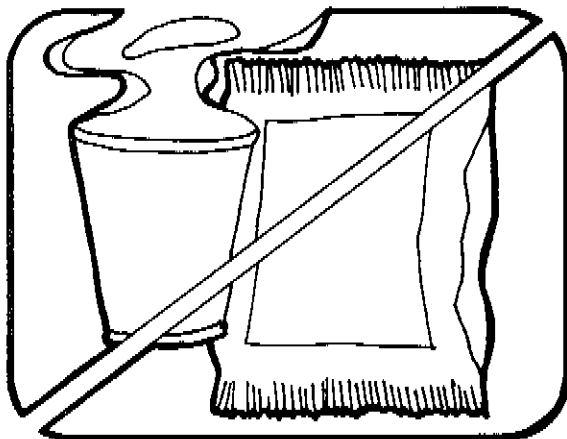
4. HANDLE S.S. DEVICES BY THE BODY



5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT

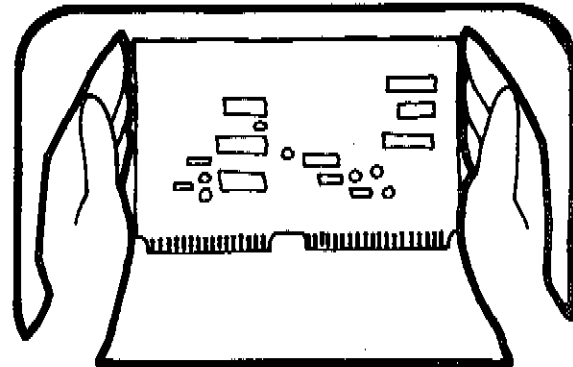


6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE

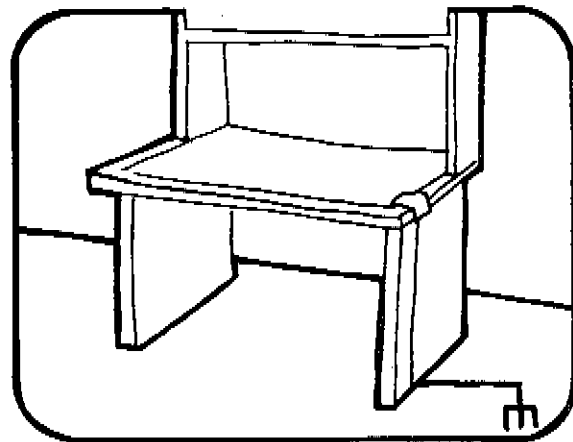


7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA

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AND GENERAL DYNAMICS, POMONA DIV.



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



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION
10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.
11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

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

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

## Section 3 Maintenance

### WARNING

**SERVICING DESCRIBED IN THIS SECTION IS TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY. TO AVOID ELECTRICAL SHOCK, DO NOT PERFORM ANY SERVICING UNLESS YOU ARE QUALIFIED TO DO SO.**

### 3-1. INTRODUCTION

This section of the 80 Series Service Manual provides procedures in the following areas:

- Routine and preventive maintenance.
- Performance verifications.
- Calibration.
- Troubleshooting (to the component level.)

### 3-2. REQUIRED TOOLS AND EQUIPMENT

Required equipment is listed in Table 3-1. If the recommended models are not available, equipment with equivalent specifications may be used. Repairs or servicing should be performed only by qualified personnel.

### 3-3. OPERATOR MAINTENANCE

#### WARNING

**TO AVOID ELECTRICAL SHOCK, REMOVE THE TEST LEADS AND ANY INPUT SIGNALS BEFORE REPLACING THE BATTERY OR FUSES. TO PREVENT DAMAGE OR INJURY, INSTALL ONLY QUICK ACTING FUSES WITH THE AMP/VOLT RATINGS SHOWN IN FIGURE 3-1.**

### 3-4. Case Disassembly

Use the following procedure to disassemble the Multimeter.

1. Disconnect test leads from any live source, turn the rotary switch to OFF, and remove the test leads from the front terminals.
2. The case rear is secured to the case front by three screws and two internal snaps (at the LCD end). Using a Phillips-head screwdriver, remove the three screws from the case rear.

#### NOTE

*The gasket between the two case halves is sealed to, and must remain with, the lower case half. The upper case half lifts away from the gasket easily. Do not damage the gasket or attempt to separate the lower case half from the gasket.*

3. Now turn the case over (display side up), and, lifting up on the input terminal end, disengage the upper case half from the gasket. Gently unsnap the upper case half at the display end. See Figure 3-2.

#### CAUTION

With its case removed, the Multimeter presents exposed circuit connections. To avoid unintended circuit shorting, always place the uncovered multimeter assembly on a protective surface.

### 3-5. Circuit Assembly Removal and Installation

Once the outer case has been removed, the circuit assembly can be disconnected from its covering shields with the following procedure:

Table 3-1. Required Equipment

EQUIPMENT	REQUIRED CHARACTERISTICS	RECOMMENDED MODEL
DMM Calibrator	AC Voltage Range: 0-1000V ac Accuracy: $\pm 2\%$  Frequency Range: 60-20000 Hz Accuracy: $\pm 1\%$  DC Voltage Range: 0-1000V dc Accuracy: $\pm 0.05\%$  Current Range: 350 $\mu$ A-35 mA Accuracy: $\pm 2\%$	Fluke 5100B, 5101B, or 5102B
Function Generator		Philips PM 5193
Power Amplifier	Range: to 1000V dc Accuracy: 50 Hz to 10 kHz: $\pm(800 \text{ ppm} + 100 \text{ mV})$ 10 to 50 kHz: $\pm(1200 \text{ ppm} + 150 \text{ mV})$	Fluke 5205A
Resistance Calibrator	Range: 1 $\Omega$ -100 M $\Omega$ Accuracy: .065%	Fluke 5450A
Decade Capacitor	Range: 5 nF to 1 $\mu$ F Accuracy: $\pm 35\%$	Genrad 1413 or 1423
Transconductance Amplifier	Current Range: 10A Accuracy: AC (60 Hz to 1 kHz): $\pm 3\%$ DC: $\pm 1\%$	Fluke 5220A

## EQUIPMENT USAGE IN PERFORMANCE TESTS

	TRANSCONDUCTANCE AMPLIFIER	CALIBRATOR	FUNCTION GENERATOR	POWER AMPLIFIER	RESISTANCE CALIBRATOR	DECADE CAPACITOR
AC Voltage		X		X		
Frequency						
Accuracy			X			
Sensitivity			X			
Trigger Level			X			
DC Voltage		X				
1-Ms MIN MAX		X				
mV DC		X				
Ohms					X	
Capacitance						X
Diode		X				
mA		X				
$\mu$ A		X				
A	X					

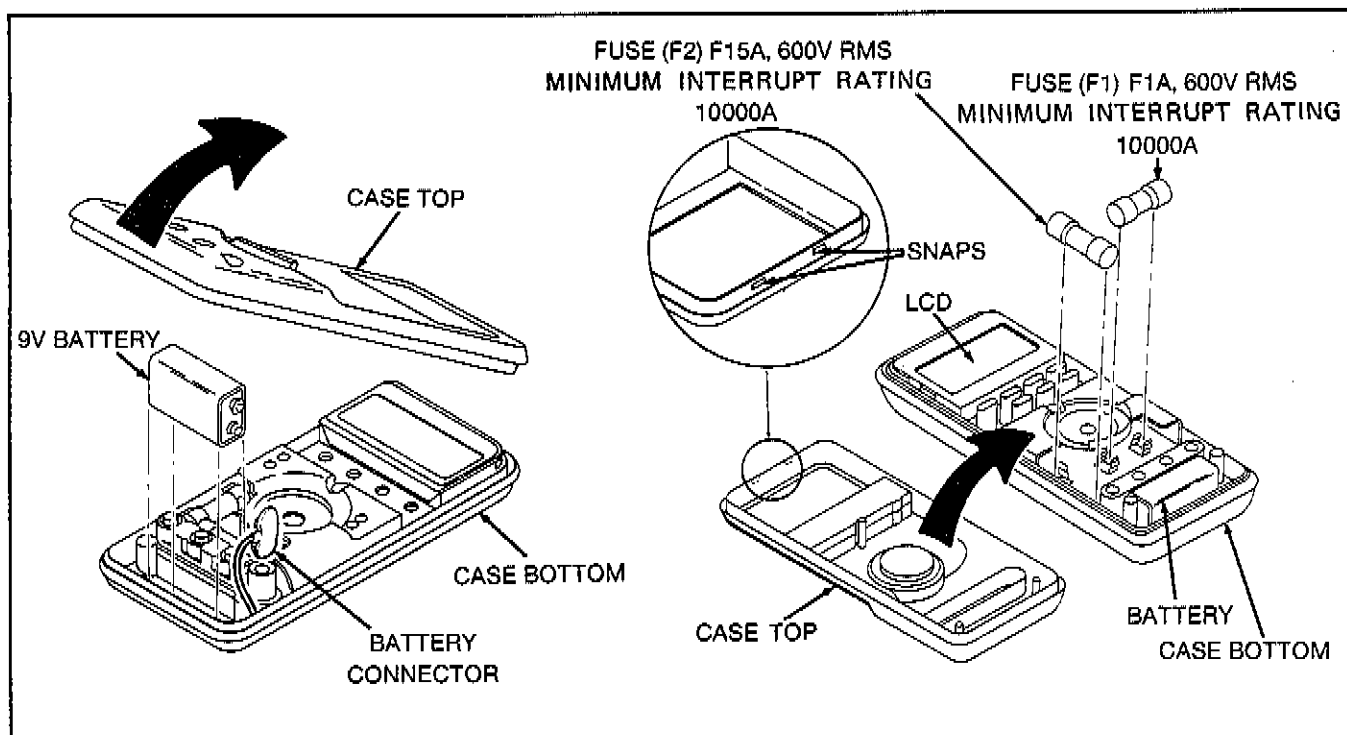


Figure 3-1. Battery and Fuse Replacement

1. Remove the one Phillips-head screw securing the back shield to the circuit assembly. Then remove the back shield.
2. The front shield can now be disconnected from the circuit assembly by detaching the four snaps (one at a time) found on the top-front.

#### CAUTION

Be gentle when detaching or attaching the four securing snaps. Excessive force can deform or fracture the snaps.

3. To reattach the circuit assembly, push the front shield on so that the four clips engage gently and simultaneously. Then turn the assembly over, and replace the Phillips-head screw and back shield.

#### NOTE

Ensure that the shields are tightly attached. Accurate multimeter operation relies on properly fitted shields.

#### 3-6. Case Reassembly

Use the following procedure to reassemble the Multimeter.

1. Check that the case top rotary switch and circuit board switch are in the OFF position.
2. Ensure that the gasket remains secured to the lower case half. Then, starting with the two snaps at the display end and finishing at the terminal end, cradle the upper case half into the gasket.
3. Reinstall the three screws from the lower case half.
4. Repeat the Performance Test (found in this section of the manual) after reassembly.

#### 3-7. Battery Replacement

The meter is powered by a single 9V battery (NEDA 1604, 6F22, or 006P). Referring to Figure 3-1, use the following procedure to replace the battery:

1. Remove the multimeter case as described under Case Disassembly.
2. Lift the battery from the case bottom, and carefully disconnect the battery connector leads.
3. Snap the battery connector leads to the terminals of a new battery and reinsert the battery into the case bottom. Dress the battery leads so that they will not be pinched between the case bottom and case top.

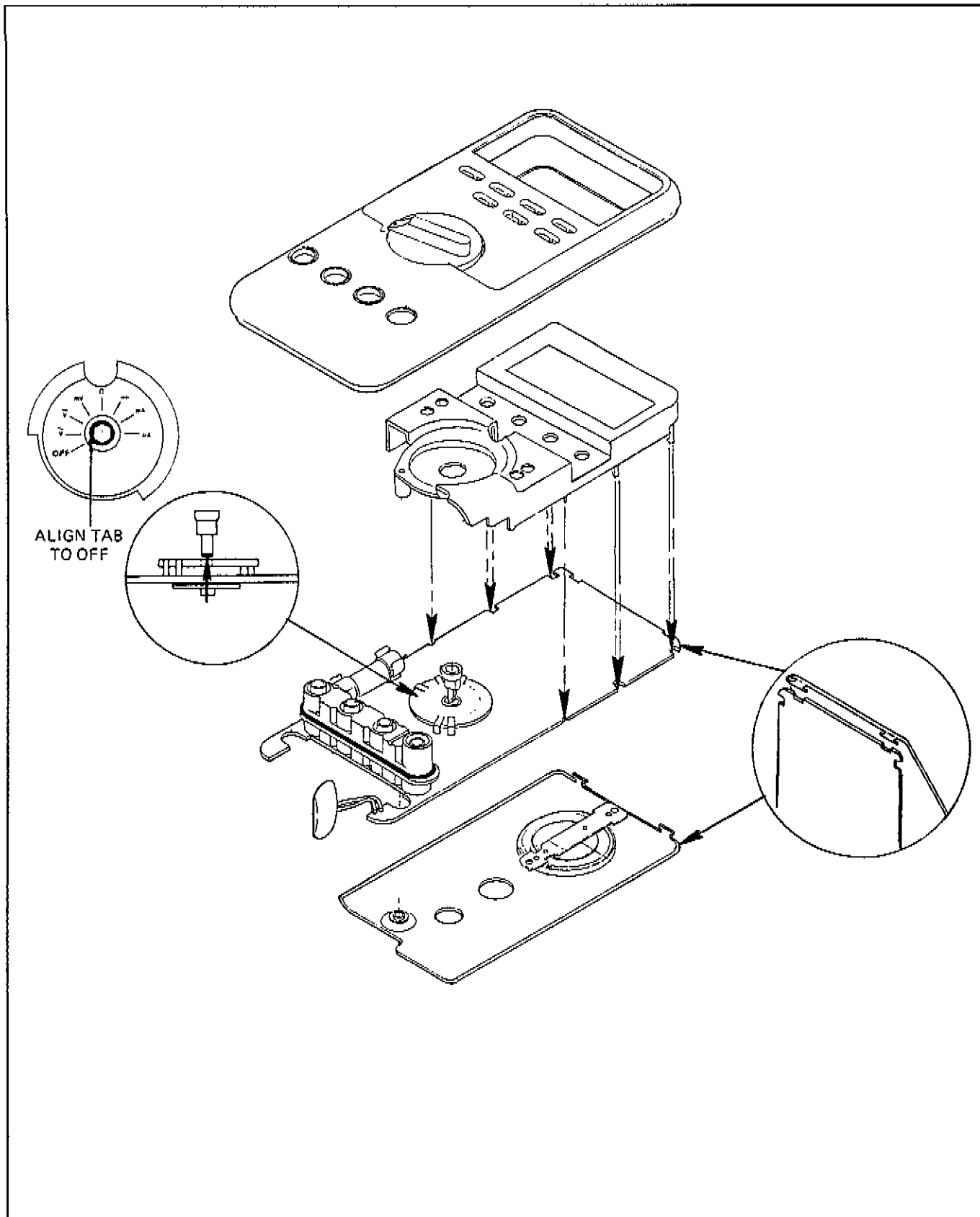


Figure 3-2. Assembly Details

4. Reassemble the Multimeter as described under Case Reassembly.

### 3-8. Fuse Test

Use the following procedure to test the internal fuses of the meter.

1. Turn the rotary selector switch to the  $\Omega$  position.
2. Plug a test lead into the  $V\Omega$  input terminal, and touch the probe to the [A] input terminal. Because the receptacles of the input terminals contain split contacts, be sure that you touch the probe to the half of the receptacle contact that is nearest the LCD.
3. The display should indicate between 00.0 and 00.5 ohms. This tests F2 (15A, 600V). If the display reads OL (overload), replace the fuse and test again. If the display reads any other value, further servicing is required.
4. Move the probe from the A input terminal to the mA  $\mu$ A input terminal.
5. The display should read between 0.995 kilohms and 1.005 kilohms. This procedure tests F1 (1A, 600V). If the display reads a high resistance or OL (overload), replace the fuse and test again. If the display reads any other value, further servicing is required.

### 3-9. Fuse Replacement

Referring to Figure 3-1, use the following procedure to examine or replace the meter's fuses:

1. Perform steps 1 through 3 of the battery replacement procedure.
2. Remove the defective fuse by gently prying one end of the fuse loose and sliding the fuse out of the fuse bracket.
3. Install a new fuse of the same size and rating. Make sure the new fuse is centered in the fuse holder.
4. Ensure that the case top rotary switch and circuit board switch are in the OFF position.
5. Ensure that the gasket remains secured to the lower case half. Then, starting with the two snaps at the display end and finishing at the terminal end, cradle the upper case half into the gasket.

6. Reinstall the three screws from the lower case half.

### 3-10. Cleaning

#### WARNING

**TO AVOID ELECTRICAL SHOCK OR DAMAGE TO THE METER, NEVER ALLOW WATER INSIDE THE CASE. TO AVOID DAMAGING THE METER'S HOUSING, NEVER APPLY SOLVENTS TO THE METER.**

If the meter requires cleaning, wipe it down with a cloth that is lightly dampened with water or a mild detergent. Do not use aromatic hydrocarbons, chlorinated solvents, or methanol-based fluids when wiping down the meter.

### 3-11. INPUT TERMINALS

Water, dirt, or other contamination in the A or mA  $\mu$ A terminals may activate the Input Alert (beeper) feature even though test leads are not inserted. With all test leads removed, such contamination might be dislodged by turning the multimeter over and gently tapping on the case. However, the following procedure is recommended as a much more effective treatment:

1. Turn the multimeter off and remove all test leads.
2. Use a clean swab in each of the four terminals to dislodge and clean out the contamination.
3. Moisten a new swab with a cleaning and oiling agent (such as WD40). Work this swab around in each of the four terminals. Since the oiling agent insulates the terminals from moisture-related shorting, this preventive treatment ensures against future erroneous Input Alerts.

### 3-12. ROTARY SWITCH

Clean the rotary knob potentiometer used by function selector switch S2 with the following procedure:

1. Remove the circuit assembly as described earlier in this section (Circuit Assembly Removal and Installation).
2. From the back of the circuit assembly, push the switch shaft in, and remove the polymer thick film (ptf) contact assembly.
3. Clean the ptf contact assembly and the potentiometer on the circuit assembly with alcohol. Blow these parts dry with clean, dry air.
4. Push and secure the ptf contact assembly back on the switch shaft.

5. Reassemble the circuit assembly, shields, and case parts as described earlier in the section (Case Reassembly).
6. Repeat the Performance Test after reassembly.

### 3-13. PERFORMANCE TEST

Basic operability of an 80 Series Multimeter can be checked by turning the rotary switch to  $\Omega$  and connecting a test lead from the  $V\Omega$  input to the mA  $\mu A$  input. (If you are using a test probe, touch the half of the input contact nearest the LCD.) The display should read 1.000 k $\Omega$   $\pm$  5 digits. With the rotary switch still at  $\Omega$ , test the A fuse (15A) by inserting the plug end of the test lead into the A input; then test the mA  $\mu A$  fuse (1A) by inserting the plug end of the test lead into the mA  $\mu A$  input. The beeper emits an Input Alert if the fuses are good.

A more involved operability and accuracy check is detailed in the following paragraphs. Each function is checked for accuracy to the specifications listed in Section 1 of this manual. Note that for performance verification purposes, the case covers do not need to be removed and no adjustments are necessary. Merely make the input connections called for, and check the display for accuracy.

### 3-14. Setup

Equipment setup is defined for each accuracy verification procedure. Equipment requirements are presented in Table 3-1. Accuracy figures are valid for a period of one year after calibration, when measured at an operating temperature of 18 to 28 degrees C and at a maximum of 90% relative humidity.

### 3-15. Display Test

Switch the meter on and compare the display with the appropriate example in Figure 3-3. Hold any button down to hold the instrument in Display Test.

### 3-16. Rotary Switch Test

This test verifies correct operation of the rotary function selector switch. Internally, the selector circuit relies on the interface between a ptf region on the circuit assembly and a rotating contact assembly on the switch shaft. The rotary switch test exercises this interface by checking the various range codes and displaying their representative numbers.

To enter the rotary switch test mode, hold down the RANGE button while turning the rotary switch from OFF to  $V=$ . Normal meter functions are now disabled, and a number appears in the display. Refer to Table 3-2. Continue rotating the switch one function at a time, checking for appropriate number displays. To exit the Rotary Switch mode, turn the rotary switch first to OFF, then (without holding down the RANGE button) back to any function selection.

Table 3-2. Rotary Switch Test

FUNCTION	DISPLAY ( $\pm 12$ )	FUNCTION	DISPLAY ( $\pm 12$ )
OFF	n/a	OHMS	-96
ACV	0	DIODE	-128
DCV	-32	mA/A	-160
mV DC	-64	$\mu A$	-192

### 3-17. AC Voltage Test

Use the following procedure to verify accuracy in the ac voltage ranges.

1. Connect the Calibrator to the  $V\Omega$  and COM inputs on the Multimeter.
2. Set the Calibrator for the voltage and frequency called for in step 1 of Table 3-3. Check that the multimeter display is within the limits shown for your 80 Series Multimeter (Model 83, 85, or 87).

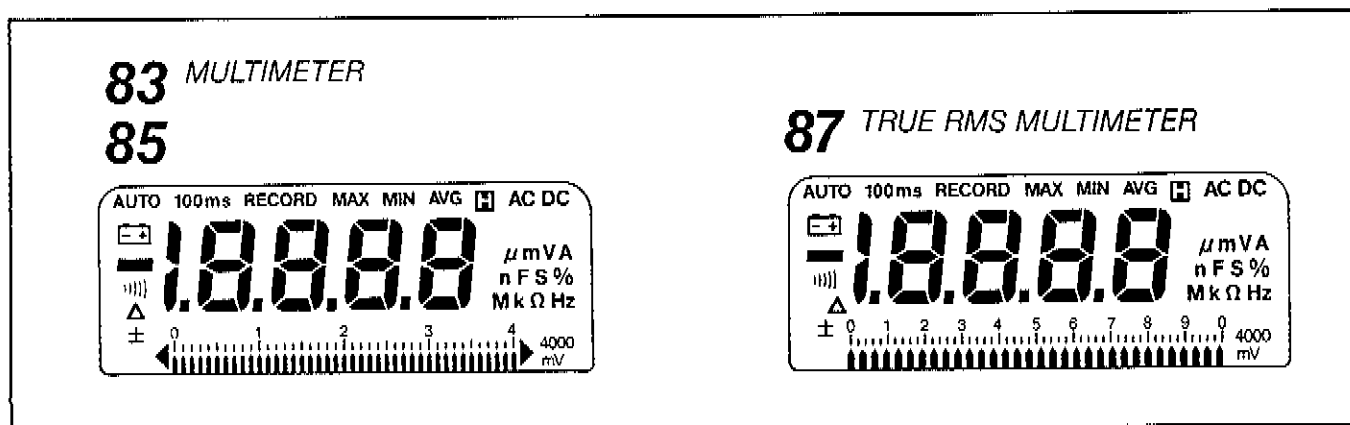


Figure 3-3. Display Test

Table 3-3. AC Voltage Test

STEP	INPUT		DISPLAY READING		
	VOLTAGE	FREQUENCY	83	85	87
1	350 mV	60 Hz	346.1 to 353.9	347.9 to 352.2	347.2 to 352.9
2	350 mV	5 kHz	344.4 to 355.7	346.1 to 353.9	346.1 to 353.9
3	350 mV	20 kHz	n/a	342.6 to 357.4	342.6 to 357.4
4	3.500V	60 Hz	3.462 to 3.538	3.481 to 3.520	3.474 to 3.527
5	3.500V	5 kHz	3.444 to 3.556	3.464 to 3.537	3.461 to 3.539
6	3.500V	20 kHz	n/a	3.356 to 3.644	3.426 to 3.574
7	35.00V	60 Hz	34.62 to 35.38	34.81 to 35.20	34.74 to 35.27
8	35.00V	5 kHz	34.44 to 35.56	34.63 to 35.37	34.61 to 35.39
9	35.00V	20 kHz	n/a	33.56 to 36.44	34.26 to 35.74
10	350.0V	60 Hz	346.2 to 353.8	348.1 to 352.0	347.4 to 352.7
11	350.0V	5 kHz	344.4 to 355.6	346.3 to 353.7	346.1 to 353.9
12	100.0V	20 kHz	n/a	95.6 to 104.4	97.6 to 102.4
13	200.0V	20 kHz	n/a	191.6 to 208.4	195.6 to 204.4
14	300.0V	20 kHz	n/a	287.6 to 312.4	293.6 to 306.4
15	350.0V	20 kHz	n/a	335.6 to 364.4	342.6 to 357.4
16	1000V	60 Hz	987 to 1013	993 to 1007	991 to 1009
17	1000V	5 kHz	972 to 1028	978 to 1022	986 to 1014

Table 3-4. Frequency Test

STEP	SINE WAVE INPUT		DISPLAY READING 83/85/87
	VOLTAGE	FREQUENCY	
1	150 mV rms	19.000 kHz	18.998 to 19.002
2	150 mV rms	190.00 kHz	189.98 to 190.02

- Repeat this procedure for steps 2 through 9 of Table 3-3.
- Now connect the Power Amplifier between the Calibrator and the Multimeter.
- Check for display accuracy at each input called for in steps 10 through 17 of Table 3-3.

### 3-18. Frequency Test

The following procedure verifies Multimeter accuracy in Frequency mode.

- Connect the Function Generator to the  $V\Omega$  and COM inputs on the Multimeter. Note that the frequency accuracy of the Function Generator used must be appropriate for the specified accuracy of the Multimeter.
- With the Multimeter in the 400 mV ac range, press the HZ button to enter the Frequency Counter mode.
- Set the Function Generator for the sine wave voltage and frequency called for in step 1 of Table 3-4. Check for a reading within the limits shown.

**3-19. Frequency Sensitivity and Trigger Level Test**

The following procedure verifies the counter sensitivity and trigger levels. For any function and range, the sensitivity and trigger level is the same in both frequency and duty cycle modes.

1. Connect the Function Generator to the  $V\Omega$  and COM inputs on the Multimeter.
2. Select the 400 mV ac range, and press the HZ button twice to choose Duty Cycle mode.
3. Apply the input from step 1 of Table 3-5, and check for the called-for response on the Multimeter.
4. On the Multimeter, press the RANGE button to enter the 4V ac range. The annunciator on the right side of the bar graph displays the present range.
5. Apply the step 2 input, and check for the desired reading.
6. Select the 4V dc range, and press the HZ button twice to choose Duty Cycle mode.

7. Apply the input from step 3 of Table 3-5, and check for the called-for response on the Multimeter.
8. On the Multimeter, press RANGE button to enter the 40V dc range.
9. For each of steps 4, 5, 6, 7, and 8, apply the indicated input and check for the appropriate reading.

**3-20. DC Voltage Test**

Use this procedure to verify accuracy in the dc voltage function. Note that a separate verification procedure for dc millivolts (mV) is provided later in this section.

1. Connect the Calibrator to the  $V\Omega$  and COM inputs on the Multimeter.
2. Rotate the multimeter function control to  $V=$ .
3. Check for the multimeter response called for in each step of Table 3-6.

**Table 3-5. Frequency Counter Sensitivity and Trigger Level Tests**

For all tests: 1) Waveform = Triangle 2) Frequency = 100 Hz						
STEP	RANGE	AMPLITUDE (PEAK-PEAK)	OFFSET	MEASUREMENT MODE	UPPER LIMIT	LOWER LIMIT
1	400 mV ac	425 mV	0	Duty Cycle	54%	46%
2	4V ac	848 mV	0	Duty Cycle	66%	32%
3	4V dc	3.40V	1.70V	Duty Cycle	64%	36%
4	40V dc	7.00V	4.00V	Duty Cycle	93%	7%

**Table 3-6. DC Voltage Test**

STEP	DC INPUT VOLTAGE	DISPLAY READING		
		83	85	87
1	3.500V	3.488 to 3.512	3.495 to 3.505	3.495 to 3.505
2	35.00V	34.88 to 35.12	34.95 to 35.05	34.95 to 35.05
3	-35.00V	-34.88 to -35.12	-34.95 to -35.05	-34.95 to -35.05
4	350.0V	348.8 to 351.2	349.5 to 350.5	349.5 to 350.5
5	1000V	996 to 1004	998 to 1002	998 to 1002

**3-21. 1-MS MIN MAX Test (Model 87 only)**

The following procedure checks the minimum/maximum hold feature of the Model 87 Multimeter.

1. Apply 2.0V ac at 60 Hz (step 1, Table 3-7) from the Calibrator to the  $V\Omega$  and COM inputs of the Multimeter. Prior to entering the MIN MAX mode, rotate the function selector knob to either dc volts (for dc coupling of the input) or ac volts (for capacitive coupling of the input).

**NOTE**

*The rms converter is not used in Peak mode. The digital display represents the actual peak value of the input.*

2. Press the MIN MAX button to enter the Min/Max mode.
3. Press the beeper button to both enter the 1-millisecond mode and begin display of maximum values.
4. Check for the maximum reading called for in step 1 of Table 3-7.
5. Press the MIN MAX button to begin display of minimum values.
6. Check for the minimum reading called for in step 2 of Table 3-7.

**3-22. mV DC Tests**

The following test verifies accuracy in the dc millivolt ranges.

1. Connect the Calibrator to the  $V\Omega$  and COM inputs on the Multimeter.
2. Set the Multimeter to the mV function.
3. Apply 350.0 mV and check for the appropriate multimeter display, as follows:

Model 83	348.8 to 351.2
Model 85	349.5 to 350.5
Model 87	349.5 to 350.5

**3-23. Ohms Tests**

Use the following procedure to verify resistance measurement accuracy.

1. Connect the Resistance Calibrator to  $V\Omega$  and COM on the Multimeter.
2. Rotate the multimeter function selector to  $\Omega$ .
3. Check for the required display for each input called for in steps 1 through 4 of Table 3-8.
4. Press the RANGE button on the Multimeter to enter the 40-nanosiemen range, used for conductance tests of high resistances. Then proceed with step 5 of Table 3-8.

**3-24. Capacitance Tests**

The Multimeter measures capacitance by charging the capacitor with a known direct current, measuring the resultant voltage, and calculating the capacitance. If the same capacitance is measured on an impedance bridge, a different reading may result. This variance is likely to be greater at higher frequencies.

Table 3-7. 1-MS MIN MAX Test

STEP	AC INPUT		DISPLAY READING		
	VOLTAGE	FREQUENCY	83	85	87
1	2.0V	60 Hz	n/a	n/a	2.783 to 2.873
2	2.0V	60 Hz	n/a	n/a	-2.783 to -2.873

Table 3-8. Ohms Tests

STEP	RESISTANCE	DISPLAY READING		
		83	85	87
1	190.0 $\Omega$	189.1 to 190.9	189.5 to 190.5	189.5 to 190.5
2	19.00 k $\Omega$	18.91 to 19.09	18.95 to 19.05	18.95 to 19.05
3	1.900 M $\Omega$	1.891 to 1.909	1.895 to 1.905	1.895 to 1.905
4	19.00 M $\Omega$	18.78 to 19.22	18.78 to 19.22	18.78 to 19.22
5	100.0 M $\Omega$	9.80 to 10.20	9.80 to 10.20	9.80 to 10.20

The following procedure verifies the capacitance measuring accuracy of your Multimeter.

1. Connect the Precision Decade Capacitor to the  $V\Omega$  and COM inputs on the Multimeter.
2. For steps 1 through 3 in Table 3-9, turn the rotary switch to  $\Omega$ , press the blue button, connect the test leads to the capacitor, and check for the appropriate display on your Multimeter. The meter selects the proper range automatically. Each measurement takes about one second per range.
3. For step 4, first use the Relative mode (REL) to zero the display and automatically subtract the residual meter and test lead capacitance. Note that the Relative mode puts the multimeter into manual ranging.

### 3-25. Diode Test

Use the following procedure to check the diode function:

1. Rotate the multimeter function selector to  $\rightarrow$ .
2. Connect the Calibrator to the  $V\Omega$  and COM inputs on the Multimeter.

### NOTE

On Fluke 5100 series calibrators, activate the  $50\Omega$  divider override.

3. Apply 3.000V, and look for a display response of  $3.000 \pm 0.061V$  dc.

### 3-26. mA Tests

The following procedure verifies accuracy of both ac and dc current measurement when the multimeter function selector is set to mA/A.

1. Connect the Calibrator to the mA  $\mu A$  and COM inputs on the Multimeter.
2. Set the multimeter function to mA/A.
3. Perform steps 1 and 2 in Table 3-10, checking for the appropriate multimeter display for each input.
4. Press the blue button on the Multimeter to toggle to ac current measurement.
5. Perform steps 3 through 6 in Table 3-10, checking for the appropriate multimeter display for each input.

Table 3-9. Capacitance Tests

STEP	CAPACITANCE	DISPLAY READING		
		83	85	87
1	1.0 $\mu F$	0.97 to 1.03	0.97 to 1.03	0.97 to 1.03
2	0.470 $\mu F$	0.463 to 0.477	0.463 to 0.477	0.463 to 0.477
3	0.0470 $\mu F$	0.0463 to 0.0477	0.0463 to 0.0477	0.0463 to 0.0477
4	4.70 nF	4.63 to 4.77	4.63 to 4.77	4.63 to 4.77

Table 3-10. mA Tests

STEP	DC CURRENT		DISPLAY READING		
			83	85	87
1	35.00 mA		34.84 to 35.16	34.91 to 35.09	34.91 to 35.09
2	350.0 mA		348.4 to 351.6	349.1 to 350.9	349.1 to 350.9
	AC CURRENT	FREQ	83	85	87
3	35.00 mA	60 Hz	34.56 to 35.44	34.77 to 35.23	34.63 to 35.37
4	35.00 mA	1.0 kHz	34.56 to 35.44	34.77 to 35.23	34.63 to 35.37
5	350.0 mA	60 Hz	345.6 to 354.4	347.7 to 352.3	346.3 to 353.7
6	350.0 mA	1.0 kHz	345.6 to 354.4	347.7 to 352.3	346.3 to 353.7

**3-27.  $\mu\text{A}$  Tests**

The following test verifies accuracy in the microamp ( $\mu\text{A}$ ) measurement mode.

1. Connect the Calibrator to the mA  $\mu\text{A}$  and COM inputs on the Multimeter.
2. Rotate the multimeter function selector to  $\mu\text{A}$   $\overline{\sim}$ .
3. Verify correct display readings for the given dc inputs in steps 1 and 2 of Table 3-11.
4. Press the blue button on the Multimeter to enable ac measurements.
5. Check for the appropriate multimeter readings for steps 3 through 6 of Table 3-11.
3. Connect the Calibrator to the A and COM inputs of the Multimeter.
4. Perform steps 1 and 2 in Table 3-12. For each input, check that a display appropriate for your Multimeter is obtained.
5. Set the calibrator output to 0. Now press the blue button on the Multimeter to toggle to ac current measurement once again.
6. Perform steps 3 through 6 in Table 3-12.

**3-28. A Tests**

Use the following procedure to verify measurement accuracy in the ampere (A) mode.

1. If necessary, set the calibrator output to 0.
2. Rotate the multimeter function selector to mA/A  $\overline{\sim}$ .

**3-29. CALIBRATION**

Calibrate the meter once a year to ensure that it performs according to specifications. Connect the Calibrator to the  $V\Omega$   $\rightarrow$  and COM inputs on the Multimeter. Calibration adjustment points are identified in Figure 3-4. The slightly different routines required for each model of the 80 Series are presented in the following paragraphs.

**3-30. Models 83 and 85 Calibration**

Calibrate the Fluke 83 or 85 with the following procedure:

1. Set the source for VDC, 0V.
2. On the multimeter, select the  $V$   $\overline{\sim}$  function.

Table 3-11.  $\mu\text{A}$  Tests

STEP	DC CURRENT		DISPLAY READING		
			83	85	87
1	350.0 $\mu\text{A}$		348.4 to 351.6	349.1 to 350.9	349.1 to 350.9
	3500 $\mu\text{A}$		3484 to 3516	3491 to 3509	3491 to 3509
3	AC CURRENT	FREQ	83	85	87
	350.0 $\mu\text{A}$	60 Hz	345.6 to 354.4	347.7 to 352.3	346.3 to 353.7
4	350.0 $\mu\text{A}$	1.0 kHz	345.6 to 354.4	347.7 to 352.3	346.3 to 353.7
5	3500 $\mu\text{A}$	60 Hz	3456 to 3544	3477 to 3523	3463 to 3537
6	3500 $\mu\text{A}$	1.0 kHz	3456 to 3544	3477 to 3523	3463 to 3537

Table 3-12. A Tests

STEP	DC CURRENT		DISPLAY READING		
			83	85	87
1	3500 mA		3484 to 3516	3491 to 3509	3491 to 3509
	10.00A		9.94 to 10.06	9.96 to 10.04	9.96 to 10.04
3	AC CURRENT	FREQ	83	85	87
	3500 mA	60 Hz	3456 to 3544	3477 to 3523	3463 to 3537
4	3500 mA	1.0 kHz	3456 to 3544	3477 to 3523	3463 to 3537
5	10.00A	60 Hz	9.86 to 10.14	9.92 to 10.08	9.88 to 10.12
6	10.00A	1.0 kHz	9.86 to 10.14	9.92 to 10.08	9.88 to 10.12

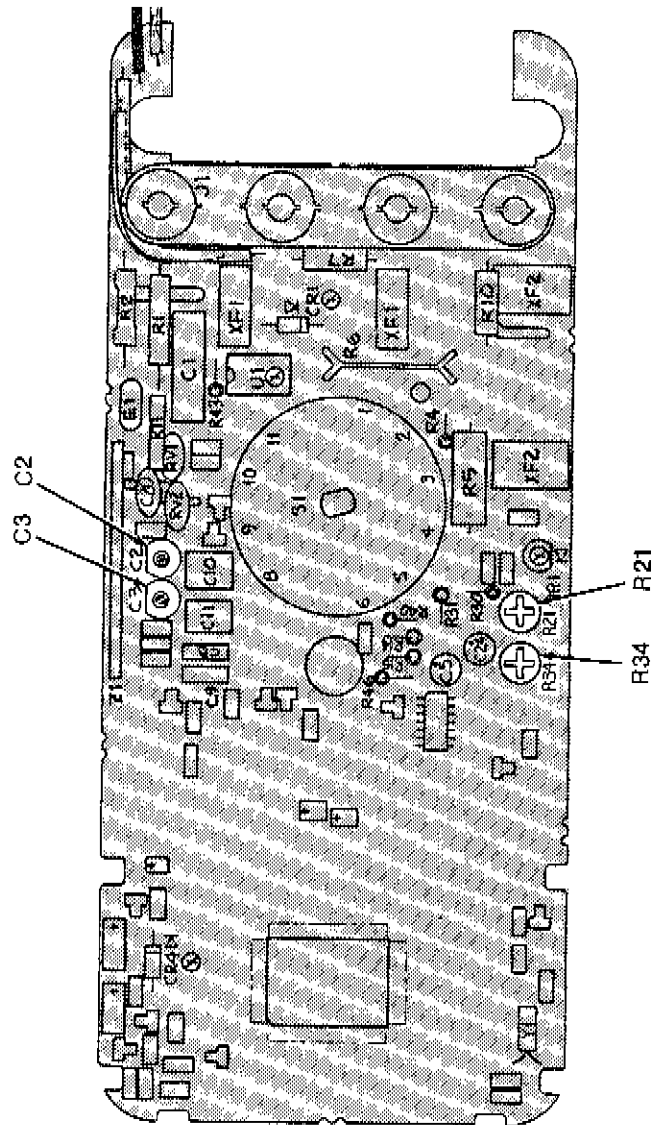


Figure 3-4. Calibration Adjustment Points

3. Connect the source to the  $V\Omega\rightarrow$  and COM inputs on the multimeter.
4. Set the source for 3.500V dc output.
5. The multimeter should now display 3.500  $\pm$ 0.001. If necessary, adjust R21 to obtain the proper display.
6. Now set the multimeter to the  $V\sim$  function, then set the source for an output of 3.500V at 100 Hz.
7. The multimeter should now display 3.500  $\pm$ 0.002. If necessary, adjust R34 to obtain the proper display.
8. Set the source for an output of 3.500V at 10 kHz.
9. The multimeter should now display 3.500  $\pm$ 0.004. If necessary, adjust C2 to obtain the proper display.
10. Set the source for an output of 35.00V at 10 kHz.
11. The multimeter should now display 35.00  $\pm$ 0.04. If necessary, adjust C3 to obtain the proper display.

### 3-31. Model 87 Calibration

Calibrate the Fluke 87 with the following procedure:

1. Set the source for VDC, 0V.
2. On the Model 87, select the  $V\equiv$  function.
3. Connect the source to the Model 87  $V\Omega\rightarrow$  and COM inputs.
4. Set the source for 3.500V dc output.
5. The Model 87 should now display 3.500  $\pm$ 0.001. If necessary, adjust R21 to obtain the proper display.
6. Now set the Model 87 to the  $V\sim$  function, then set the source for an output of 3.513V at 50 Hz.
7. The Model 87 should now display 3.500  $\pm$ 0.002. If necessary, adjust R34 to obtain the proper display.
8. Set the source for an output of 3.500V at 10 kHz.

9. The Model 87 should now display 3.500  $\pm$ 0.004. If necessary, adjust C2 to obtain the proper display.
10. Set the source for an output of 35.00V at 10 kHz.
11. The Model 87 should now display 35.00  $\pm$ 0.04. If necessary, adjust C3 to obtain the proper display.

### 3-32. TROUBLESHOOTING

If the meter fails, check the battery and fuses and replace as needed. If problems persist, verify that you are operating the meter correctly by reviewing the operating instructions found in the User's Manual. If these measures suggest a fault with the multimeter, consult the power supply troubleshooting procedures in this section and the signal flow diagrams in Section 5 of this manual.

### 3-33. Servicing Surface-Mount Assemblies

The 80 Series multimeters incorporate Surface-Mount Technology (SMT) for printed circuit assemblies (pcas). Surface-mount components are much smaller than their predecessors, with leads soldered directly to the surface of a circuit board; no plated through-holes are used. Unique servicing, troubleshooting, and repair techniques are required to support this technology. The information offered in the following paragraphs serves only as an introduction to SMT. It is not recommended that repair be attempted based only on the information presented here. Refer to the Fluke Surface Mount Device Soldering Kit for a complete demonstration and discussion of these techniques (call 1-800-526-4731 to order).

Since sockets are seldom used with SMT, shotgun troubleshooting cannot be used; a fault should be isolated to the component level before a part is replaced. Surface-mount assemblies are probed from the component side. The special probes make contact only with the pads in front of the component leads. With the close spacing involved, ordinary test probes can easily short two adjacent pins on an SMT IC.

This Service Manual is a vital source for component locations and values. With limited space on the circuit board, chip component locations are seldom labeled. Figures provided in Section 4 of this manual provide this information. Also, remember that chip components are not individually labeled; keep any new or removed component in a labeled package.

Surface-mount components are removed and replaced by reflowing all the solder connections at the same time. Special considerations are required.

Table 3-13. Functional Description of Power Supply Components

COMPONENT	FUNCTION
R24, R25	Vdd Regulator series regulator device
Q8	Power on/off device
Q10	Power supply startup device. Q10 provides Q3 base startup current. Q10 is always off during meter operation.
CR5	CR5 is in the power supply series loop, allowing for generation of Vbt=+3.6V for diode test.
VR1	VR1 provides the system reference voltage. It is used for the A/D Converter reference and as a reference for both power supply regulators.
C14	Vdd regulator compensation and bypass.
C21	Common regulator compensation and bypass.
C35	Battery and CR5 bypass.
C32	Q8 gate bypass.
R24, R25	Vdd regulator voltage sensing resistors.
R37, R38	Common regulator voltage sensing resistors.
R44	Supplies bias current to VR1.
R54	Q8 gate pull-up resistor.

- The solder tool uses regulated hot air to melt the solder; there is no direct contact between the tool and the component.
- Surface-mount assemblies require rework with wire solder rather than with solder paste. A 0.025 inch diameter wire solder composed of 63% tin and 37% lead is recommended. A 60/40 solder is also acceptable.
- A good connection with SMT requires only enough solder to make a positive metallic contact. Too much solder causes bridging, while too little solder can cause weak or open solder joints. With SMT, the anchoring effect of the through-holes is missing; solder provides the only means of mechanical fastening. Therefore, the pca must be especially clean to ensure a strong connection. An oxidized pca pad causes the solder to wick up the component lead, leaving little solder on the pad itself.

Refer to the Fluke Surface Mount Device Soldering Kit for a complete discussion of these techniques.

### 3-34. TROUBLESHOOTING - POWER SUPPLY

The two regulator circuits are interrelated; a malfunction in either the common regulator or the Vdd regulator may cause a problem in the other. Refer to Tables 3-13 and 3-14 for descriptions of power supply components and voltage levels, respectively. To isolate the problem regulator circuit, disconnect the battery, and drive Vdd - Vss = 6.2V with a power supply. This procedure tests the common regulator independently of the Vdd regulator.

Table 3-14. Voltage Levels

VDD	3.0 ±0.3
VSS	-3.2 ±0.3
VBT+	3.5 ±0.3
VBT-	-5.5 (battery at full 9V charge) -3.0 (battery at low charge of 6.5V)
REFH	1.235 ±0.012
PS0	1.235 ±0.15
PS1	0 ±0.15
AP6	-0.5 to -0.15
VOA	2.2 to 1.7 (referenced from VSS)
VOB	1.07 to .91 (referenced from VSS)

Now check for Vd<sub>gnd</sub> - Vss = -3.2V ±0.3V. If this test is successful, the problem lies with the Vdd regulator; refer to Vdd Regulator Troubleshooting later in this section. If this test is not successful, the problem lies with the common regulator; continue with the Common Regulator Troubleshooting below.

Note that if the common regulator works or has been repaired, check both supplies with the 9V battery supply.

### 3-35. Common (Shunt) Regulator Troubleshooting

To troubleshoot the common regulator, connect the power supply so that Vdd, Vss, and DGND (digital ground) are supplied from an external power supply. This procedure over-drives the large on-chip shunt transistors; the bias current from the power supply ranges from 10 mA to 100 mA. Refer to Figure 3-5 for a simplified diagram of the common regulator. Make the following tests:

1. Check for  $+1.235V \pm 20 \text{ mV}$  ( $V_{refh}$ ) at the cathode of VR1. If  $V_{refh}$  is not correct, check VR1, R19, R20, and R44 and the traces to these parts carefully. If  $V_{refh}$  is still incorrect, U4 is bad.
2. If  $V_{refh}$  is correct, measure the voltage at U4 pin 6 (PS1). If  $V_{ps1}$  is not equal to  $0V \pm 0.15V$ , check R37 and R38 and their associated traces. If  $V_{ps1}$  is still at an incorrect voltage, U4 is bad.
3. A DGND and  $V_{ss}$  current much larger than 100 mA may indicate a problem with Q12 (Vdgn-d-to- $V_{ss}$  quick turn-off clamp) or its base drive signal from U6. The Q12 clamp is off when the instrument is on and on when the instrument is off.
4. Check the bias generator circuit. With the exception of resistor R35 (620 k $\Omega$ ), the bias generator (which sets the bias level for all U4 analog circuitry) is internal to U4. A problem with this circuit could cause the on-chip power supply op amps to not work. Measure the dc voltage between U4 pin 8 ( $V_{bias}$ ) and DGND. If  $-0.2V < V_{bias} > +0.2V$  the bias generator is okay. If  $V_{bias}$  is not correct, check R35. If  $V_{bias}$  is still wrong, replace U4.
5. Measure the ac voltage between Vdgn-d and  $V_{ss}$ . If it is greater than 10 mV ac, check C21. (An open C21 causes common regulator instability.) The dc level may also be incorrect.
6. If the common regulator still does not work, circuitry internal to U4 is bad. Replace U4.

### 3-36. Vdd (Series) Regulator Troubleshooting

If a problem still exists after the common regulator troubleshooting, continue on with the following Vdd regulator troubleshooting. Often, a short or sneak current path causes power supply problems. Refer to Figure 3-5 for a simplified diagram of the Vdd (Series) Regulator. Make the following tests:

1. Measure the dc operating current from the 9V battery. If it is greater than 1.2 mA for an 83/85 or greater than 1.4 mA for an 87, a sneak current path exists. A sneak current path can be very difficult to find.

2. First, visually check for both solder bridges on U4 pins and other circuit board shorts.

Isolate the current path at the negative battery terminal ( $V_{bt-}$ ). The components connected to  $V_{bt-}$  are C35, CR4, R56, U6, Q8, and the rotary knob fingers. Remove these parts one at a time (except Q8). Measure  $I(\text{bat})$  after each removal to isolate the problem.

1. If the excess battery current stops after removing R56, either R56, R57, Q9, or Q11 may be bad. If one of these four parts is bad a problem may not be noticed until U6 is removed.
2. If the extra current is still present with all parts except Q8 removed, remove Q10 and check for excess battery current. If  $I(\text{bat})$  is now correct, Q10 is bad. If  $I(\text{bat})$  is still excessive, U4 is probably at fault.

If the power supply is not working, but battery current is normal, perform the following tests.

1. With the 9V battery attached, cycle the unit off and on. If both supplies are less than 1.0V, a problem probably exists with the on/off circuit. Check Q8, R54, and C32.
2. Check the rotary knob wiper contacts; verify that the Q8 gate voltage is close to  $V_{bt+}$ .
3. If  $V_{dd} - V_{ss}$  is low, a problem may exist with start up device Q10. Check Q10 by momentarily connecting  $V_{ss}$  to  $V_{bt-}$ . If both  $V_{ss}$  and  $V_{bt-}$  now start up and operate correctly, check Q10 for an open.
4. Measure the ac voltage between  $V_{dd}$  and  $V_{ss}$ . An unstable Vdd regulator can be caused by an open C14. If it is greater than 10 mV ac, check C14. The dc level may also be incorrect.

For a final check of U4, remove the battery and supply  $V_{dd} = +3.0V$ ,  $V_{dgn-d} = 0$ , and  $V_{ss} = -3.2V$  from an external power supply. Measure the voltage at U4 pin 7 ( $V_{ps0}$ ). If it does not equal  $1.235V \pm 0.15V$  then check R24 and R25 carefully. If  $V_{ps0}$  is still incorrect, U4 is bad.

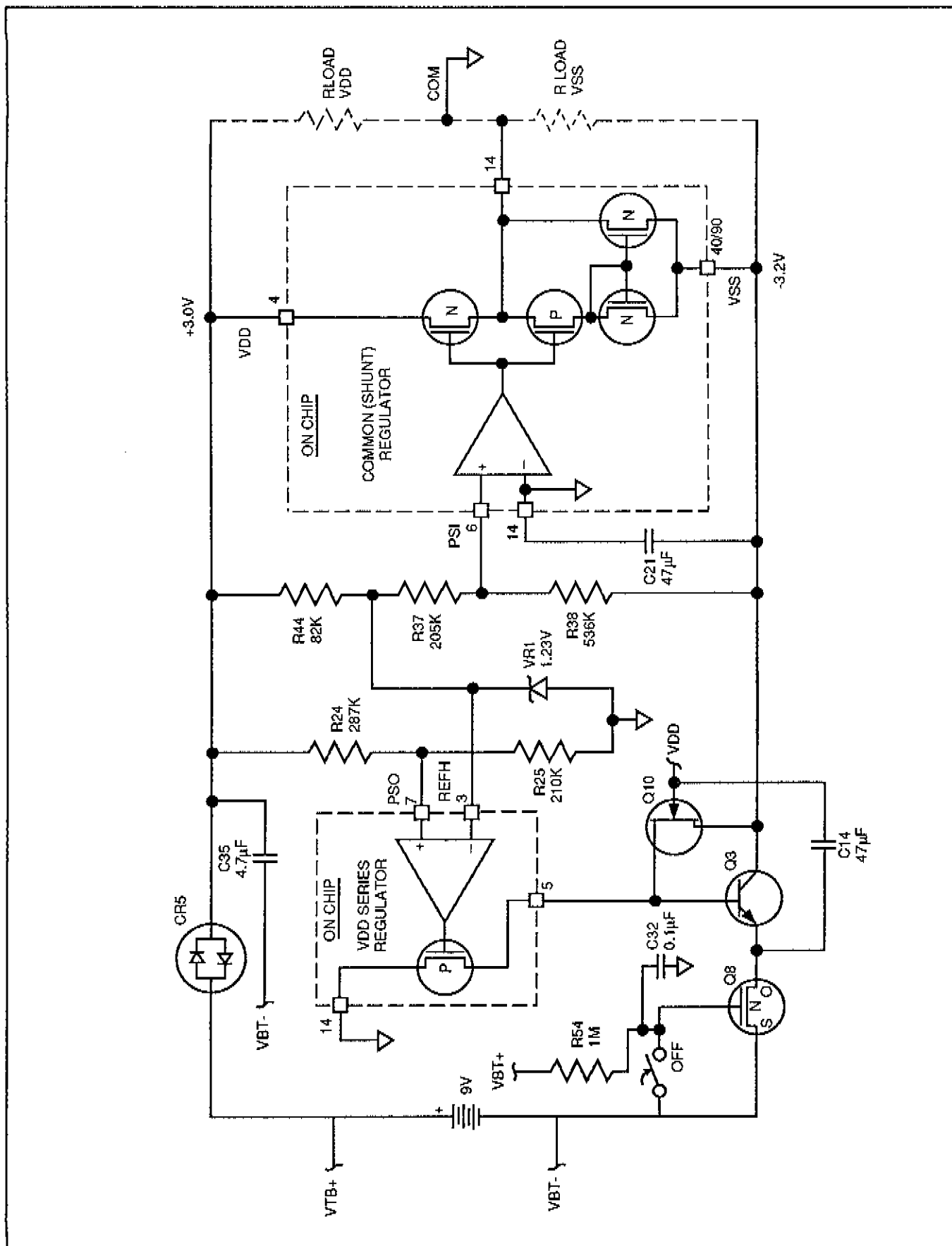


Figure 3-5. Simplified Power Supply Schematic

## Section 4 List of Replaceable Parts

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ASSEMBLY NAME	DRAWING NO.	TABLE		FIGURE	
		NO.	PAGE	NO.	PAGE
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Fluke 83 A1 Main PCA	Fluke 83-4001	4-2	4-6	4-2	4-8
Fluke 85 Final Assembly	Fluke 85 T/B	4-3	4-10	4-3	4-11
Fluke 85 A1 Main PCA	Fluke 85-4001	4-4	4-12	4-4	4-14
Fluke 87 Final Assembly	Fluke 87 T/B	4-5	4-16	4-5	4-17
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#### 4-1. INTRODUCTION

Section 4 provides illustrated parts lists for the 80 Series Multimeters. A separate list is provided for each model (83, 85, and 87).

Parts are listed alphanumerically by assembly and reference designator. Each part is shown in an accompanying illustration.

The parts lists provide the following information for each part:

- Reference designator
- Description
- Fluke stock number
- Federal supply code for manufacturers
- Manufacturers' part number
- Total quantity of components per assembly
- Recommended quantity

The recommended quantity is 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 electronics parts at the maintenance site. For maintenance of 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 sub-assemblies, 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 sites in that particular assembly.

#### 4-2. HOW TO OBTAIN PARTS

All components may be ordered from the John Fluke Mfg. Co., Inc. or an authorized representative using the **FLUKE STOCK NUMBER**. In the U.S., order directly from the Fluke Parts Dept. by calling 1-800-526-4731.

Some components may be ordered directly from the manufacturer using the manufacturer's part number.

In the event that the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

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

1. Instrument Model and Serial Number
2. Fluke Stock Number
3. Reference Designator
4. Printed circuit assembly (pca) part number and revision letters
5. Description
6. Quantity

Price information for parts is available from the John Fluke Mfg. Co., Inc., and its authorized representatives. Prices are also available in a Fluke Replacement Parts Catalog, which is available on request.

#### CAUTION

**An asterisk (\*) indicates a device that may be damaged by static discharge.**

Refer to the end of this section for a list of U. S. and international sales areas for Fluke products and a list of technical service centers.

#### 4-4. MANUAL STATUS INFORMATION

This section contains information necessary to backdate the manual to conform with earlier pca configurations. To identify the configuration of the pca's used in your instrument, refer to the revision letter (marked in ink) on the component side of each pca assembly. Tables 4-7 through 4-9 define assembly revision levels documented in this manual for Models 83, 85, and 87, respectively.

#### 4-5. NEWER INSTRUMENTS

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

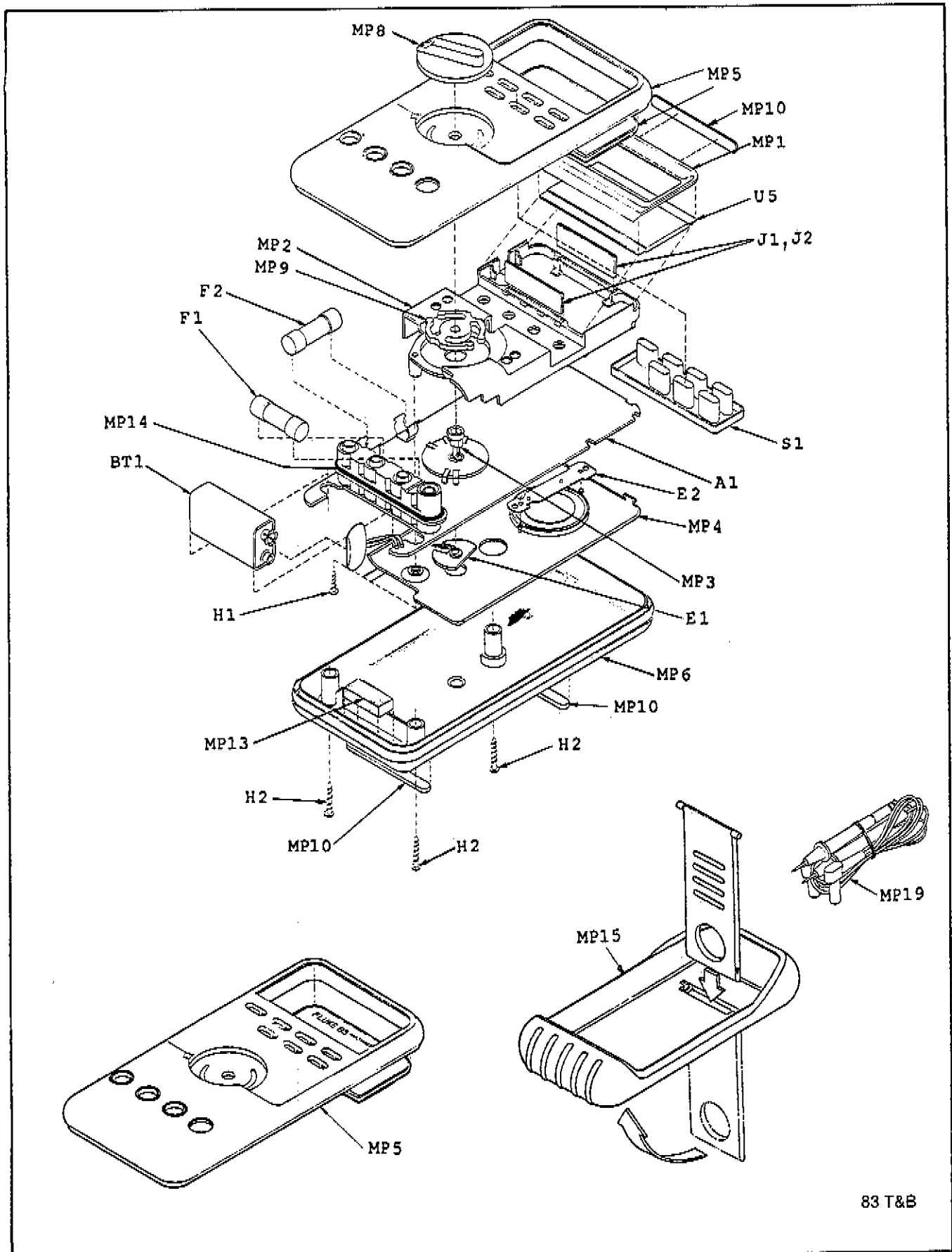
80 Series Service

Table 4-1. Fluke 83 Final Assembly  
(See Figure 4-1.)

REFERENCE DESIGNATOR		FLUKE STOCK	MFRS SPLY	MANUFACTURERS PART NUMBER	TOT	N R O \$ T
-A>-NUMERIC>	S-----DESCRIPTION-----	--NO--	-CODE-	-OR GENERIC TYPE----	QTY-	-Q -E-
A	1					
	* MAIN PCA	819284	89536	819284	1	
BT	1	696534	77542	D1604	1	1
E	1	822676	89536	822676	1	1
E	2	822791	89536	822791	1	
F	1	830828	71400	EBS-1	1	5
F	2	820829	71400	KLK-15	1	5
H	1	832220	89536	832220	1	
H	2	832246	89536	832246	3	
J	1, 2	817460	89536	817460	2	1
MP	1	822684	89536	822684	1	
MP	2	824516	89536	824516	1	
MP	3	822635	89536	822635	1	
MP	4	824524	89536	824524	1	
MP	5	828657	89536	828657	1	1
MP	6	819250	89536	819250	1	
MP	8	857271	89536	857271	1	
MP	9	822643	89536	822643	1	1
MP	10	824466	89536	824466	3	
MP	12	826198	89536	826198	1	1
MP	13	828541	89536	828541	1	
MP	14	831933	89536	831933	1	1
MP	15	822809	89536	822809	1	
MP	19	642033	89536	642033	1	
MP	21	853924	89536	853924	1	
S	1	809988	89536	809988	1	
TM	5	852426	89536	852426	1	
TM	6	852434	89536	852434	1	
U	5	782763	89536	782763	1	1

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

NOTE 1 - MP5 includes MP8 and MP9.



83 T&B

Figure 4-1. Fluke 83 Final Assembly

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Table 4-2. A1 Main PCA  
(See Figure 4-2.)

REFERENCE DESIGNATOR	FLUKE STOCK	MFRS SPLY	MANUFACTURERS PART NUMBER	TOT QTY	R O \$ T	N O -E-			
-A>-NUMERIC->>> S	-----DESCRIPTION-----	--NO--	-OR CODE- -OR GENERIC TYPE----	QTY	-Q-	-E-			
C 1			CAP, POLYES, 0.01UF, +-10%, 1000V	822361	89536	822361	1		
C 2			CAP, VAR, 3-11PF, 100V, CER	641712	89536	641712	1		
C 3			CAP, VAR, 9-90PF, 50V, CER	643130	89536	643130	1		
C 4			CAP, CER, 130PF, +-2%, 50V, COG, 1206	851816	89536	851816	1		
C 5			CAP, TA, 15UF, +-20%, 6.3V	807636	56289	199D156X06R3BA1	1		
C 8, 9			CAP, POLYCA, 0.027UF, +-10%, 63V	720979	89536	720979	2		
C 10			CAP, POLYES, 0.47UF, +-10%, 50V	697409	84411	J1320R47MF10PCT50V	1		
C 11			CAP, POLYPR, 0.022UF, +-10%, 63V	821579	89536	821579	1		
C 14, 21			CAP, TA, 47UF, +-20%, 10V	746990	89536	746990	2		
C 15, 16, 32			CAP, CER, 0.1UF, +-10%, 25V, X7R, 1206	747287	89536	747287	3		
C 17, 18			CAP, CER, 22PF, +-10%, 50V, COG, 1206	740563	89536	740563	2		
C 19			CAP, CER, 8.2PF, +-10%, 50V, COG, 1206	747303	89536	747303	1		
C 20			CAP, CER, 5.6PF, +-0.25PF, 1500V, COH	851811	89536	851811	1		
C 22			CAP, CER, 1000PF, +-10%, 50V, COG, 1206	747378	89536	747378	1		
C 24			CAP, TA, 10UF, +-20%, 10V	714766	56289	199D106X0010BA1	1		
C 27			CAP, CER, 100PF, +-10%, 50V, COG, 1206	740571	89536	740571	1		
C 28, 29			CAP, TA, 0.47UF, +-20%, 50V	807990	89536	807990	2		
C 30			CAP, CER, 220PF, +-10%, 50V, COG, 1206	758078	89536	758078	1		
C 31, 33, 34			CAP, CER, 0.01UF, +-10%, 50V, X7R, 1206	747261	89536	747261	3		
C 35			CAP, TA, 4.7UF, +-20%, 15V	745976	89536	745976	1		
C 36			CAP, CER, 68PF, +-10%, 50V, COG, 1206	853861	89536	853861	1		
CR 1, 4			DIODE, SI, 1K PIV, 1.0 AMP	707075	04713	SR4348RL	2	1	
CR 5, 7, 8	*		DIODE, SI, BV=70.0V, IO=50MA, DUAL, SOT23	742320	89536	742320	3	1	
E 1			SURGE PROTECTOR, 1500V, +-20%	655134	89536	655134	1		
J 1			INPUT RCPT ASSY	826214	89536	826214	1		
Q 1, 2, 6	*		TRANSISTOR, SI, NPN, SELECTED IEBO, SOT23	821637	89536	821637	3	1	
Q 3, 9, 12	*		TRANSISTOR, SI, NPN, SMALL SIGNAL, SOT23	742676	89536	742676	3	1	
Q 8	*		TRANSISTOR, SI, N-DMOS FET, SOT23	830851	89536	830851	1	1	
Q 10	*		TRANSISTOR, SI, P-CHAN, SOT-23	832477	89536	832477	1	1	
Q 11	*		TRANSISTOR, SI, PNP, SMALL SIGNAL, SOT23	742684	89536	742684	1	1	
R 1			RES, MF, 1K, +-1%, 100PPM, FILMFRF, FUSIBLE	832550	89536	832550	1	1	
R 2	*		RES, TINOX, 909K, +-1%, 2W	831594	89536	831594	1		
R 3	*		RES, CERM, 1.5K, +-5%, .125W, 250PPM, 1206	746438	89536	746438	1		
R 4			RES, MF, 110.1, +-0.1%, 0.125W, 100PPM	821728	89536	821728	1		
R 5			RES, WW, 0.991, +-0.1%, 2.5W	821645	89536	821645	1		
R 6			RES, WW, 0.010, +-0.1%, 1W, 100PPM	807305	89536	807305	1		
R 7, 10	*		RES, CERM, 1M, +-5%, 1W	655175	89536	655175	2		
R 8, 48	*		RES, CERM, 15M, +-5%, .125W, 300PPM, 1206	811968	89536	811968	2		
R 9, 13, 29	*		RES, CERM, 100K, +-5%, .125W, 250PPM, 1206	740548	89536	740548	3		
R 11	*		RES, CERM, 10M, +-5%, .125W, 250PPM, 1206	783274	89536	783274	1		
R 12	*		RES, CERM, 10K, +-5%, .125W, 250PPM, 1206	746610	89536	746610	1		
R 14			RES, MF, 10K, +-0.1%, 0.125W, 100PPM	658955	89536	658955	1		
R 15			RES, MF, 90K, +-0.1%, 0.125W, 100PPM	658906	89536	658906	1		
R 17, 18, 42, 54	*		RES, CERM, 1M, +-5%, .125W, 250PPM, 1206	746826	89536	746826	4		
R 19	*		RES, CERM, 56.2K, +-1%, .125W, 100PPM, 1206	831305	89536	831305	1		
R 20, 37	*		RES, CERM, 205K, +-1%, .125W, 100PPM, 1206	769836	89536	769836	2		
R 21			RES, VAR, CERM, 100K, +-20%, 0.3W	649897	89536	649897	1		
R 24	*		RES, CERM, 287K, +-1%, 0.125W, 100PPM, 1206	853895	89536	853895	1		
R 25	*		RES, CERM, 210K, +-1%, .125W, 100PPM, 1206	821660	89536	821660	1		
R 28	*		RES, CERM, 84.5K, +-1%, .125W, 100PPM, 1206	853510	89536	853510	1		
R 30			RES, MF, 20K, +-0.25%, 0.125W, 50PPM	715029	59124	MFF1-82002C	1		
R 31, 40			RES, MF, 22.6K, +-0.25%, 0.125W, 50PPM	715011	59124	MFF1-82262C	2		
R 34			RES, VAR, CERM, 1K, +-20%, 0.3W	831420	89536	831420	1		
R 35	*		RES, CERM, 620K, +-5%, .125W, 250PPM, 1206	811919	89536	811919	1		
R 38, 60	*		RES, CERM, 536K, +-1%, .125W, 100PPM, 1206	845420	89536	845420	2		
R 41, 47	*		RES, CERM, 0.05MAX, .125W, 1206	810747	89536	810747	2		
R 43			RES, MF, 1K, +-0.1%, 0.125W, 100PPM	821694	89536	821694	1		
R 44	*		RES, CERM, 82K, +-5%, .125W, 250PPM, 1206	811794	89536	811794	1		
R 46			RES JUMPER, 0.02, 0.25W	682575	89536	682575	1		
R 56, 57	*		RES, CERM, 22K, +-5%, .125W, 250PPM, 1206	746651	89536	746651	2		
R 58	*		RES, CERM, 120K, +-5%, .125W, 250PPM, 1206	746719	89536	746719	1		
R 59	*		RES, CERM, 510, +-5%, .125W, 250PPM, 1206	746388	89536	746388	1		
RT 1			THERMISTOR, RECT, POS, 1.5K, +-30%, 25 C	822015	89536	822015	1	1	
RV 1, 2			VARISTOR, 910V, +-10%, 1.0MA	817106	89536	817106	2	1	
S 1			SWITCH, ROTARY	819334	89536	819334	1		
U 1			DIODE, SI, RECT, BRIDGE, BV=50V, IO=1.0A	418582	14936	DF005	1		
U 4	*		IC CMOS OLYMPUS, ASSEMBLY TESTED	809301	89536	809301	1	1	
U 6	*		IC, CMOS, HEX INVERTER, SOIC	838375	89536	838375	1	1	

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

Table 4-2. A1 Main PCA (cont.)

REFERENCE DESIGNATOR	FLUKE STOCK	MFRS SPLY	MANUFACTURERS PART NUMBER	TOT QTY	R S	N T
-A>-NUMERICS-->	5-----	DESCRIPTION-----	NO-- -CODE- -OR GENERIC TYPE-----	QTY-	-Q-	-E-
VR 1	*	BANDGAP, TAPED	729202 89536 729202	1	1	
W 1		JUMPER WIRE NEG	834994 89536 834994	1		
W 2		JUMPER WIRE, POS	835009 89536 835009	1		
XBT 1		CONNECTOR, BATTERY	825976 89536 825976	1		
XF 1		CONTACT, 600V, FUSE	659524 89536 659524	2		1
XF 2		600 VOLT FUSE CONTACT	707190 89536 707190	2		2
Y 1		CRYSTAL, 131.072KHZ, 0.0034, 3X8MM	831453 89536 831453	1	1	
Z 1		RES NET THK FILM TESTED	828152 89536 828152	1		

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

NOTE 1 - Ref. Designator XF1 is two (2) parts. They are used with F1 on the Final Assembly.

NOTE 2 - Ref. Designator XF2 is two (2) parts. They are used with F2 on the Final Assembly.

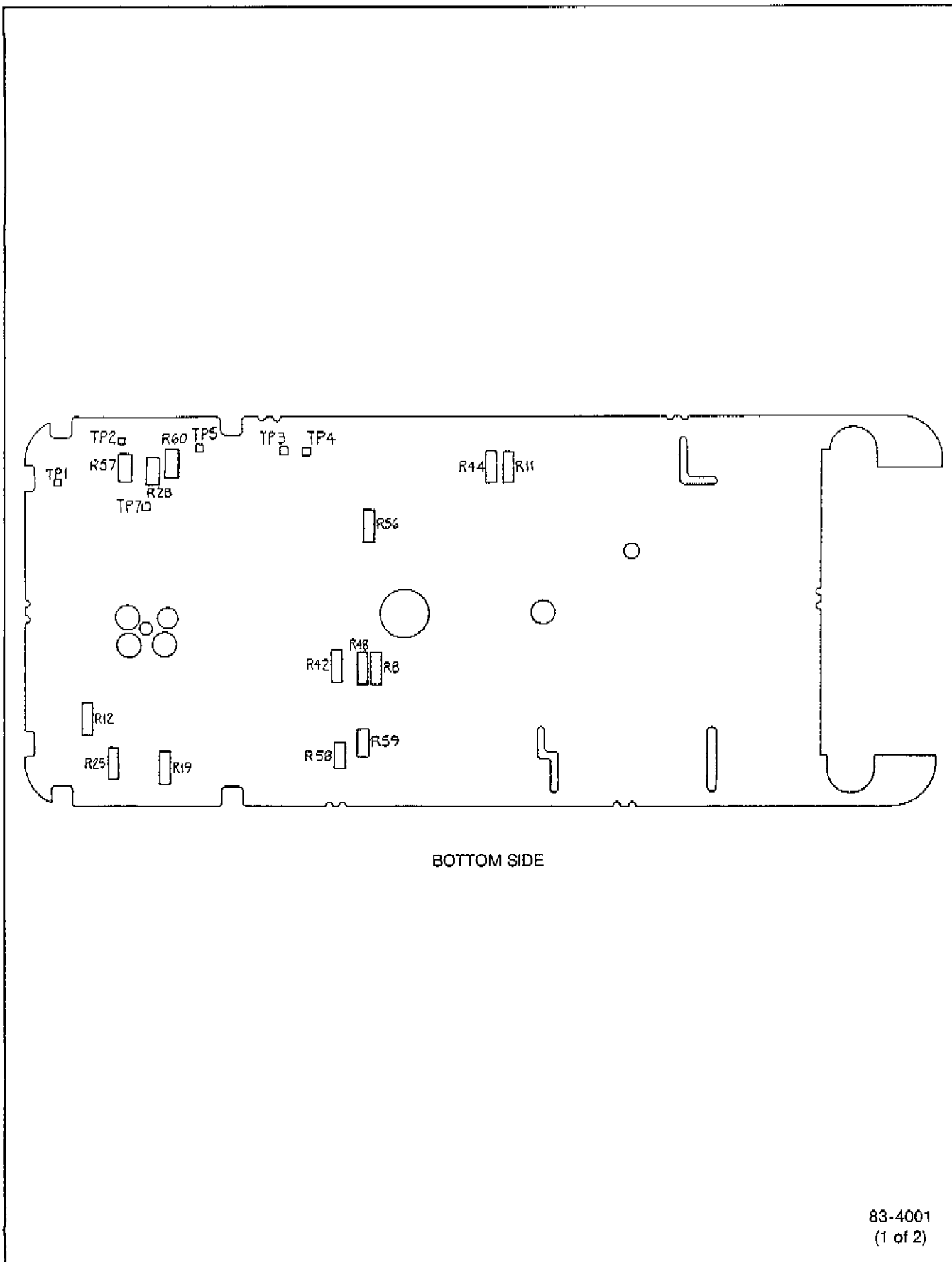


Figure 4-2. Fluke 83 A1 Main PCA

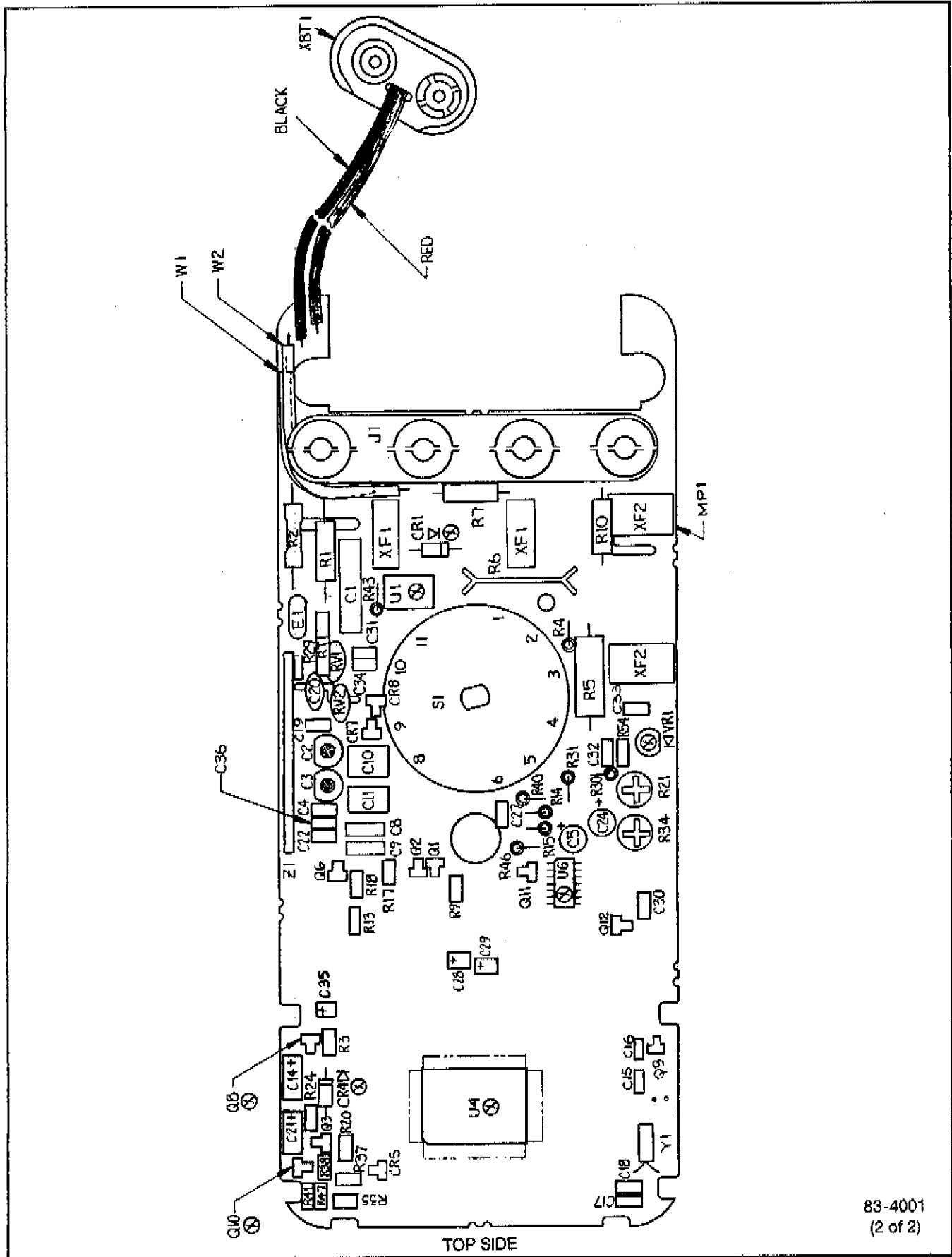


Figure 4-2. Fluke 83 A1 Main PCA (cont)

83-4001  
(2 of 2)

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Table 4-3. Fluke 85 Final Assembly  
(See Figure 4-3.)

REFERENCE DESIGNATOR		FLUKE STOCK	MFRS SPLY	MANUFACTURERS PART NUMBER	TOT	R	N
-A>-NUMERICS----->	S-----DESCRIPTION-----	--NO--	-CODE-	-OR GENERIC TYPE-----	QTY-	-Q-	-E-
A	1						
	* MAIN PCA	819276	89536	819276	1		
BT	1	696534	77542	D1604	1	1	
E	1	822676	89536	822676	1	1	
E	2	822791	89536	822791	1		
F	1	830828	71400	BBS-1	1	5	
F	2	820829	71400	KLK-15	1	5	
H	1	832220	89536	832220	1		
H	2	832246	89536	832246	3		
J	1	817460	89536	817460	2	1	
MP	1	822684	89536	822684	1		
MP	2	824516	89536	824516	1		
MP	3	822635	89536	822635	1		
MP	4	824524	89536	824524	1		
MP	5	824540	89536	824540	1	1	
MP	6	819250	89536	819250	1		
MP	8	857271	89536	857271	1		
MP	9	822643	89536	822643	1	1	
MP	10	824466	89536	824466	3		
MP	12	826198	89536	826198	1	1	
MP	13	828541	89536	828541	1		
MP	14	831933	89536	831933	1	1	
MP	15	822809	89536	822809	1		
MP	19	642033	89536	642033	1		
MP	21	853924	89536	853924	1		
S	1	809988	89536	809988	1		
TM	5	852426	89536	852426	1		
TM	6	852434	89536	852434	1		
U	5	782763	89536	782763	1	1	

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

NOTE 1 - MP5 includes MP8 and MP9.

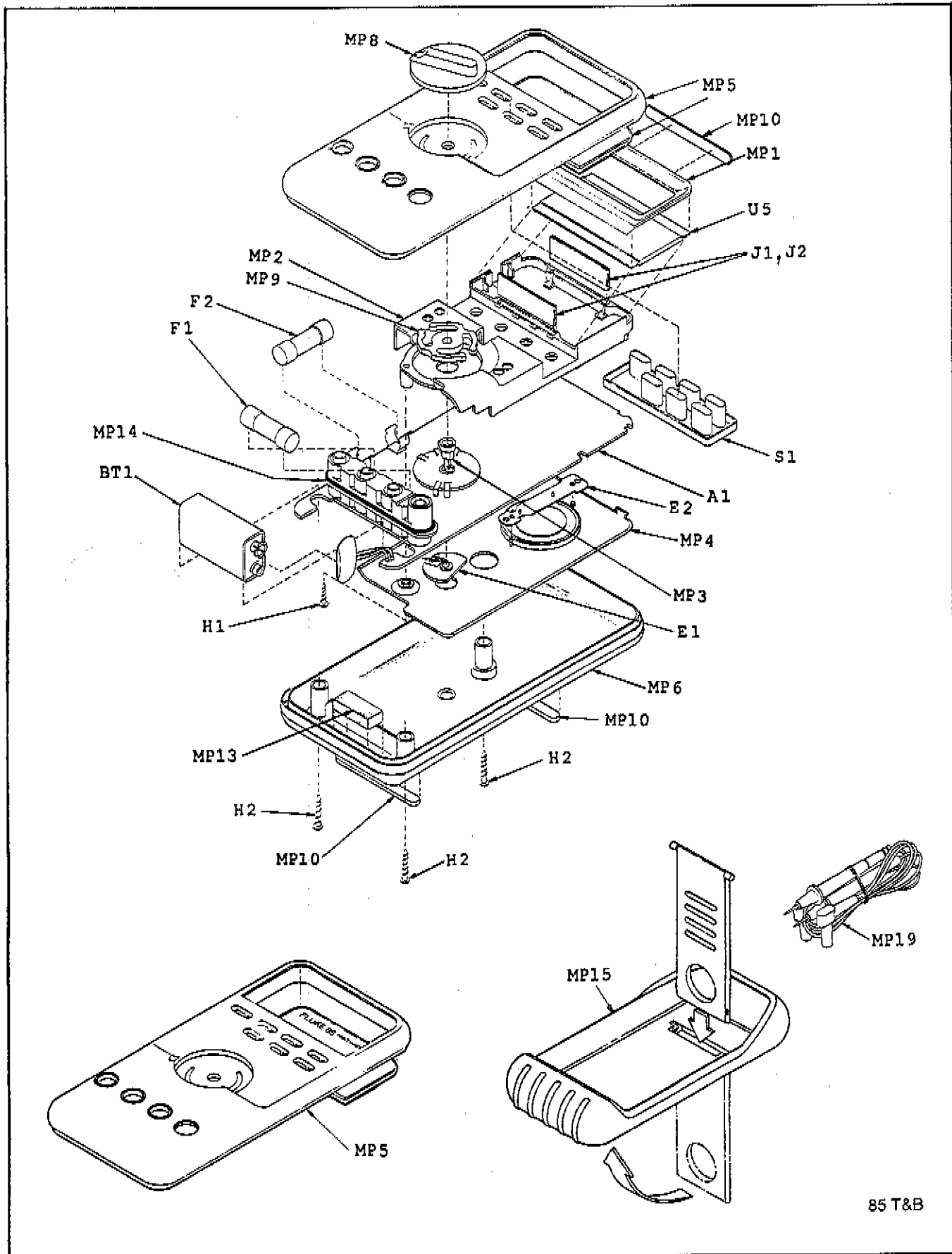


Figure 4-3. Fluke 85 Final Assembly

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80 Series Service

Table 4-4. AI Main PCA  
(See Figure 4-4.)

REFERENCE DESIGNATOR	FLUKE STOCK	MFRS SPLY	MANUFACTURERS PART NUMBER	TOT	R O S T			
-A>-NUMERIC->>> S-----DESCRIPTION-----	--NO--	-CODE-	-OR GENERIC TYPE-----	QTY-	-Q -E-			
C 1			CAP, POLYES, 0.01UF, +-10%, 1000V	822361	89536	822361	1	
C 2			CAP, VAR, 3-11PF, 100V, CER	641712	89536	641712	1	
C 3			CAP, VAR, 9-90PF, 50V, CER	643130	89536	643130	1	
C 4			CAP, CER, 430PF, +-2%, 50V, COG, 1206	851816	89536	851816	1	
C 5			CAP, TA, 15UF, +-20%, 6.3V	807636	56289	199D156X06R3BA1	1	
C 8, 9			CAP, POLYCA, 0.027UF, +-10%, 63V	720979	89536	720979	2	
C 10			CAP, POLYES, 0.47UF, +-10%, 50V	697409	84411	J1320R47MF10PCT50V	1	
C 11			CAP, POLYPR, 0.022UF, +-10%, 63V	821579	89536	821579	1	
C 14, 21			CAP, TA, 47UF, +-20%, 10V	746990	89536	746990	2	
C 15, 16, 32			CAP, CER, 0.1UF, +-10%, 25V, X7R, 1206	747287	89536	747287	3	
C 17, 18			CAP, CER, 22PF, +-10%, 50V, COG, 1206	740563	89536	740563	2	
C 19			CAP, CER, 8.2PF, +-10%, 50V, COG, 1206	747303	89536	747303	1	
C 20			CAP, CER, 5.6PF, +-0.25PF, 1500V, COH	851811	89536	851811	1	
C 22			CAP, CER, 1000PF, +-10%, 50V, COG, 1206	747378	89536	747378	1	
C 24			CAP, TA, 10UF, +-20%, 10V	714766	56289	199D106X0010BA1	1	
C 27			CAP, CER, 100PF, +-10%, 50V, COG, 1206	740571	89536	740571	1	
C 28, 29			CAP, TA, 0.47UF, +-20%, 50V	807990	89536	807990	2	
C 30			CAP, CER, 220PF, +-10%, 50V, COG, 1206	758078	89536	758078	1	
C 31, 33, 34			CAP, CER, 0.01UF, +-10%, 50V, X7R, 1206	747261	89536	747261	3	
C 35			CAP, TA, 4.7UF, +-20%, 15V	745976	89536	745976	1	
C 36			CAP, CER, 68PF, +-10%, 50V, COG, 1206	853861	89536	853861	1	
CR 1, 4			DIODE, SI, 1K PIV, 1.0 AMP	707075	04713	SR4348RL	2	1
CR 5, 7, 8	*		DIODE, SI, BV-70.0V, IO-50MA, DUAL, SOT23	742320	89536	742320	3	1
E 1			SURGE PROTECTOR, 1500V, +-20%	655134	89536	655134	1	
J 1			INPUT RCPT ASSY	826214	89536	826214	1	
Q 1, 2, 6	*		TRANSISTOR, SI, NPN, SELECTED IEBO, SOT23	821637	89536	821637	3	1
Q 3, 9, 12	*		TRANSISTOR, SI, NPN, SMALL SIGNAL, SOT23	742676	89536	742676	3	1
Q 8	*		TRANSISTOR, SI, N-DMOS FET, SOT23	830851	89536	830851	1	1
Q 10	*		TRANSISTOR, SI, P-CHAN, SOT-23	832477	89536	832477	1	1
Q 11	*		TRANSISTOR, SI, PNP, SMALL SIGNAL, SOT23	742684	89536	742684	1	1
R 1			RES, MF, 1K, +-1%, 100PPM, FLMPRF, FUSIBLE	832550	89536	832550	1	
R 2	*		RES, TINOX, 909K, +-1%, 2W	831594	89536	831594	1	
R 3	*		RES, CERM, 1.5K, +-5%, .125W, 250PPM, 1206	746438	89536	746438	1	
R 4			RES, MF, 110.1, +-0.1%, 0.125W, 100PPM	821728	89536	821728	1	
R 5			RES, WW, 0.991, +-0.1%, 2.5W	821645	89536	821645	1	
R 6			RES, WW, 0.010, +-0.1%, 1W, 100PPM	807305	89536	807305	1	
R 7, 10	*		RES, CERM, 1M, +-5%, 1W	655175	89536	655175	2	
R 8, 48	*		RES, CERM, 15M, +-5%, .125W, 300PPM, 1206	811968	89536	811968	2	
R 9, 13, 29	*		RES, CERM, 100K, +-5%, .125W, 250PPM, 1206	740548	89536	740548	3	
R 11	*		RES, CERM, 10M, +-5%, .125W, 250PPM, 1206	783274	89536	783274	1	
R 12	*		RES, CERM, 10K, +-5%, .125W, 250PPM, 1206	746610	89536	746610	1	
R 14			RES, MF, 10K, +-0.1%, 0.125W, 100PPM	658955	89536	658955	1	
R 15			RES, MF, 90K, +-0.1%, 0.125W, 100PPM	658906	89536	658906	1	
R 17, 18, 42, 54	*		RES, CERM, 1M, +-5%, .125W, 250PPM, 1206	746826	89536	746826	4	
R 19	*		RES, CERM, 56.2K, +-1%, .125W, 100PPM, 1206	831305	89536	831305	1	
R 20, 37	*		RES, CERM, 205K, +-1%, .125W, 100PPM, 1206	769836	89536	769836	2	
R 21			RES, VAR, CERM, 100K, +-20%, 0.3W	649897	89536	649897	1	
R 24	*		RES, CERM, 287K, +-1%, 0.125W, 100PPM, 1206	853895	89536	853895	1	
R 25	*		RES, CERM, 210K, +-1%, .125W, 100PPM, 1206	821660	89536	821660	1	
R 28	*		RES, CERM, 84.5K, +-1%, .125W, 100PPM, 1206	853510	89536	853510	1	
R 30			RES, MF, 20K, +-0.25%, 0.125W, 50PPM	715029	59124	MFF1-82002C	1	
R 31, 40			RES, MF, 22.6K, +-0.25%, 0.125W, 50PPM	715011	59124	MFF1-82262C	2	
R 34			RES, VAR, CERM, 1K, +-20%, 0.3W	831420	89536	831420	1	
R 35	*		RES, CERM, 620K, +-5%, .125W, 250PPM, 1206	811919	89536	811919	1	
R 38, 60	*		RES, CERM, 536K, +-1%, .125W, 100PPM, 1206	845420	89536	845420	2	
R 41, 47	*		RES, CERM, 0.05MAX, .125W, 1206	810747	89536	810747	2	
R 43			RES, MF, 1K, +-0.1%, 0.125W, 100PPM	821694	89536	821694	1	
R 44	*		RES, CERM, 82K, +-5%, .125W, 250PPM, 1206	811794	89536	811794	1	
R 46			RES JUMPER, 0.02, 0.25W	682575	89536	682575	1	
R 56, 57	*		RES, CERM, 22K, +-5%, .125W, 250PPM, 1206	746651	89536	746651	2	
R 58	*		RES, CERM, 120K, +-5%, .125W, 250PPM, 1206	746719	89536	746719	1	
R 59	*		RES, CERM, 510, +-5%, .125W, 250PPM, 1206	746388	89536	746388	1	
RT 1			THERMISTOR, RECT, POS, 1.5K, +-30%, 25 C	822015	89536	822015	1	1
RV 1, 2			VARISTOR, 910V, +-10%, 1.0MA	817106	89536	817106	2	1
S 1			SWITCH, ROTARY	819334	89536	819334	1	
U 1			DIODE, SI, RECT, BRIDGE, BV-50V, IO-1.0A	418582	14936	DF005	1	
U 4	*		IC CMOS OLYMPUS, ASSEMBLY TESTED	809301	89536	809301	1	1
U 6	*		IC, CMOS, HEX INVERTER, SOIC	838375	89536	838375	1	1

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

Table 4-4. A1 Main PCA (cont.)

REFERENCE DESIGNATOR		FLUKE STOCK	MFRS SPLY	MANUFACTURERS PART NUMBER	TOT	R S	O T
-A> NUMERICS	S	--NO--	-CODE-	-OR GENERIC TYPE	QTY-	-Q-	-E-
VR 1	* BANDGAP, TAPED	729194	89536	729194	1	1	
W 1	JUMPER WIRE NEG	834994	89536	834994	1		
W 2	JUMPER WIRE POS	835009	89536	835009	1		
XBT 1	CONNECTOR, BATTERY	825976	89536	825976	1		
XF 1	CONTACT, 600V, FUSE	659524	89536	659524	1		1
XF 2	600 VOLT FUSE CONTACT	707190	89536	707190	2		2
Y 1	CRYSTAL, 131.072KHZ, 0.0034, 3X8MM	831453	89536	831453	1	1	
Z 1	* RES NET THK FILM TESTED	813824	89536	813824	1		

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

NOTE 1 = Ref. designator XF1 is two (2) parts. They are used with F1 on the Final Assembly.  
 NOTE 2 = Ref. designator XF2 is two (2) parts. They are used with F2 on the Final Assembly.

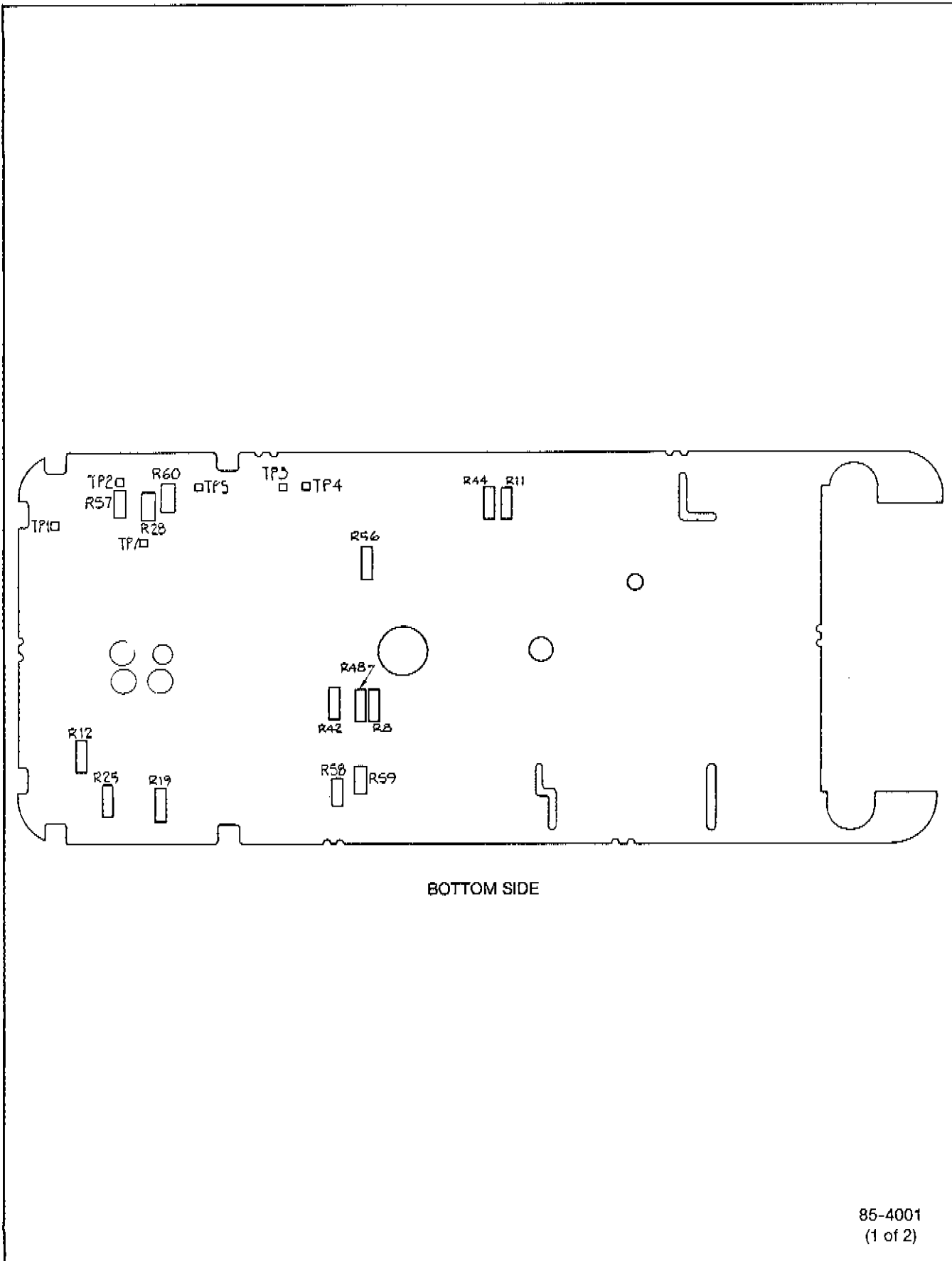


Figure 4-4. Fluke 85 A1 Main PCA

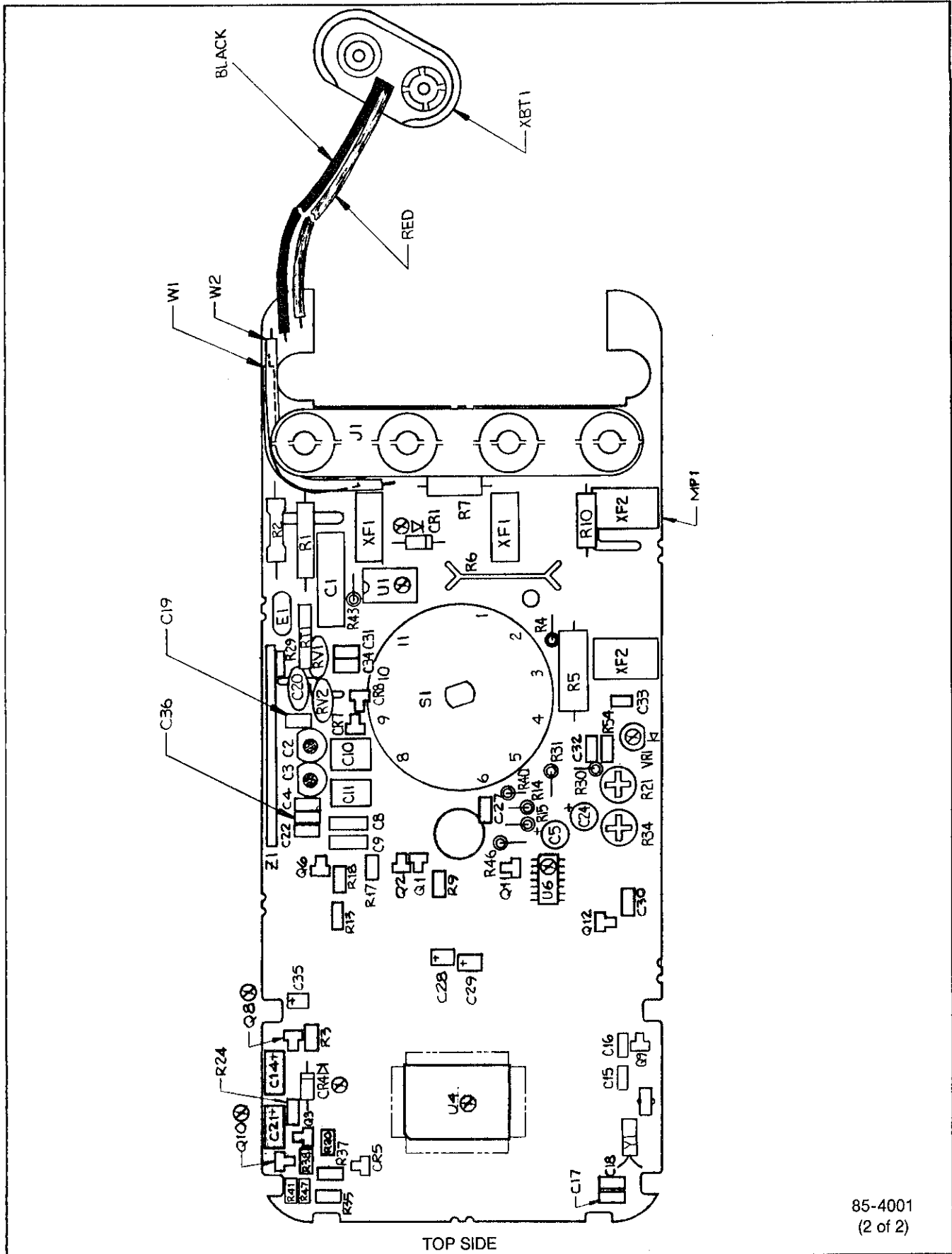


Figure 4-4. Fluke 85 A1 Main PCA (cont)

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(2 of 2)

## 80 Series Service

Table 4-5. Fluke 87 Final Assembly  
(See Figure 4-5.)

REFERENCE DESIGNATOR		FLUKE STOCK	MFRS SPLY	MANUFACTURERS PART NUMBER	TOT QTY	R S	O T	N E
-A>-NUMERICS-->	S-----	-----DESCRIPTION-----	--NO--	-CODE-	-OR GENERIC TYPE-----	QTY-	-Q-	-E-
A	1	* MAIN PCA	819268	89536	819268	1		
BT	1	BATTERY, 9V, 0-200MA	614487	OFFP1	522	1	1	
CR	6	BACKLIGHT	619342	89536	819342	1		
E	1	CONTACT, PTF	822676	89536	822676	1	1	
E	2	CONTACT, ANNUNCIATOR	822791	89536	822791	1		
F	1	FUSE, .406X1.375, 1A, 600V, FAST	830828	71400	BBS-1	1	5	
F	2	FUSE, .406X1.5, 15A, 600V, FAST	820829	71400	KLK-15	1	5	
H	1	SCREW, THD FORM, PH, P, STL, 4-14X0.562	832220	89536	832220	1		
H	2	SCREW, THD FORM, PH, P, STL, 5-14X0.750	832246	89536	832246	3		
J	1, 2	CONN, ELASTOMERIC, LCD TO PWB, 1.540 L	817460	89536	817460	2	1	
MP	1	MASK, LCD	822684	89536	822684	1		
MP	2	SHIELD, TOP	824516	89536	824516	1		
MP	3	SHAFT, SWITCH	822635	89536	822635	1		
MP	4	SHIELD, BOTTOM	824524	89536	824524	1		
MP	5	CASE, TOP & WINDOW ASSEMBLY	824532	89536	824532	1		1
MP	6	CASE, BOTTOM	819409	89536	819409	1		
MP	8	KNOB, SWITCH (PAD XFER)	857271	89536	857271	1		
MP	9	SPRING, DETENT	822643	89536	822643	1		
MP	10	FOOT, NON SKID	824466	89536	824466	3		
MP	12	GASKET, CASE	826198	89536	826198	1		1
MP	13	SHOCK ABSORBER	828541	89536	828541	1		
MP	14	O-RING, SYN RUBBER, 1.670 ID, 0.047 WIDE	831933	89536	831933	1		1
MP	15	HOLSTER&FLEXSTAND ASSY (YELLOW)	822809	89536	822809	1		
MP	19	TEST LEADS	642033	89536	642033	1		
MP	21	FOOT, ADHESIVE, RUBBER, GREY, .50X.23	853924	89536	853924	1		
S	1	SWITCH PAD, MOMENTARY	809970	89536	809970	1		
TM	5	87 USER'S MANUAL (ENGLISH)	852418	89536	852418	1		
TM	6	87 USER'S MANUAL (INTERNATIONAL)	852421	89536	852421	1		
U	5	LCD, 4.5 DIGIT, BAR GRAPH, MULTIPLEXED	832188	89536	832188	1		1

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

NOTE 1 - MP5 includes MP8 and MP9.

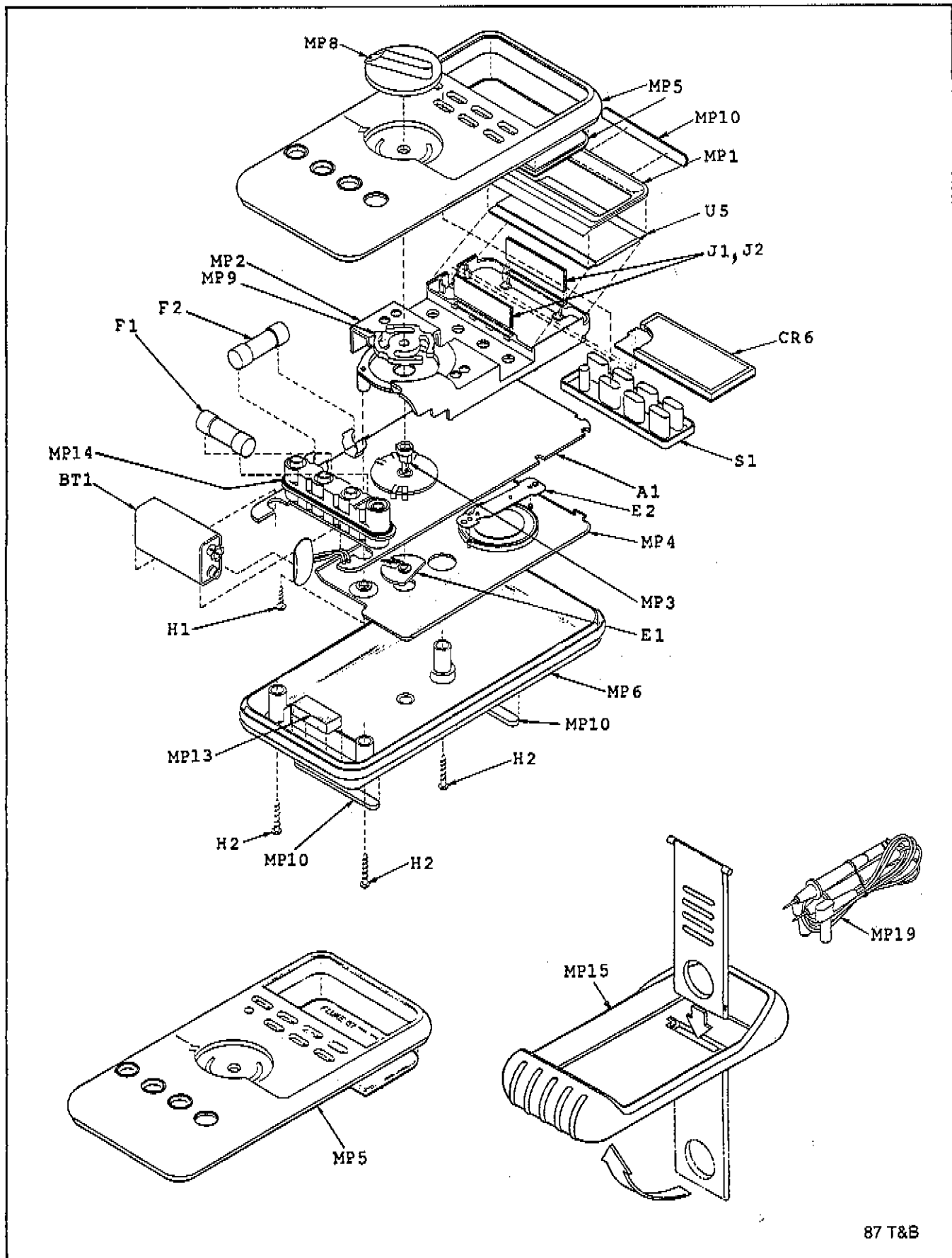


Figure 4-5. Fluke 87 Final Assembly

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80 Series Service

Table 4-6. A1 Main PCA  
(See Figure 4-6.)

REFERENCE DESIGNATOR	DESCRIPTION	FLOKE STOCK NO	MFRS SPLY CODE	MANUFACTURERS PART NUMBER OR GENERIC TYPE	TOT QTY	R S T	N O E
-A>-NUMERIC	-> S-----	NO	-CODE-		QTY-	-Q-	-E-
AR 1	* IC, OP AMP, DUAL, FIX MED POWER, SOIC	830810	89536	830810	1	1	
C 1	CAP, POLYES, 0.01UF, +-10%, 1000V	822361	89536	822361	1		
C 2	CAP, VAR, 3-11PF, 100V, CER	641712	89536	641712	1		
C 3	CAP, VAR, 9-30PF, 50V, CER	643130	89536	643130	1		
C 4	CAP, CER, 430PF, +-2%, 50V, COG, 1206	851816	89536	851816	1		
C 5	CAP, TA, 15UF, +-20%, 6.3V	807636	56289	199D156X06R3BA1	1		
C 6	CAP, TA, 22UF, +-20%, 10V	658971	56289	199D226X0010CA1	1		
C 7	CAP, TA, 10UF, +-20%, 10V	714766	56289	199D106X0010BA1	1		
C 8, 9	CAP, POLYCA, 0.027UF, +-10%, 63V	720979	89536	720979	2		
C 10	CAP, POLYES, 0.47UF, +-10%, 50V	697409	84411	J1320R47MFI0PCT50V	1		
C 11	CAP, POLYPR, 0.022UF, +-10%, 63V	821579	89536	821579	1		
C 12, 13	CAP, POLYPR, 0.068UF, +-20%, 100V	852132	89536	852132	2		
C 14, 21	CAP, TA, 47UF, +-20%, 10V	746990	89536	746990	2		
C 15, 16, 32	CAP, CER, 0.1UF, +-10%, 25V, X7R, 1206	747287	89536	747287	3		
C 17, 18	CAP, CER, 22PF, +-10%, 50V, COG, 1206	740563	89536	740563	2		
C 19	CAP, CER, 8.2PF, +-10%, 50V, COG, 1206	747303	89536	747303	1		
C 20	CAP, CER, 5.6PF, +-0.25PF, 1500V, COH	851811	89536	851811	1		
C 22	CAP, CER, 1000PF, +-10%, 50V, COG, 1206	747378	89536	747378	1		
C 27	CAP, CER, 100PF, +-10%, 50V, COG, 1206	740571	89536	740571	1		
C 30	CAP, CER, 220PF, +-10%, 50V, COG, 1206	758078	89536	758078	1		
C 31, 33, 34	CAP, CER, 0.01UF, +-10%, 50V, X7R, 1206	747261	89536	747261	3		
C 35	CAP, TA, 4.7UF, +-20%, 15V	745976	89536	745976	1		
C 36	CAP, CER, 68PF, +-10%, 50V, COG, 1206	853861	89536	853861	1		
CR 1, 4	DIODE, SI, 1K PIV, 1.0 AMP	707075	04713	SR4340RL	2	1	
CR 2, 3	* DIODE, SI, BV= 20.0V, IO= 50MA, 250 MW	836288	89536	836288	2	1	
CR 5, 7, 8	* DIODE, SI, BV=70.0V, IO=50MA, DUAL, SOT23	742320	89536	742320	3	1	
E 1	SURGE PROTECTOR, 1500V, +-20%	655134	89536	655134	1		
J 1	INPUT RCPT ASSY	826214	89536	826214	1		
J 2	SOCKET, 1 ROW, PWB, 0.100CTR, 2 POS	832634	89536	832634	1		
Q 1, 2, 6	* TRANSISTOR, SI, NPN, SELECTED IEBO, SOT23	821637	89536	821637	3	1	
Q 3, 4, 7,	* TRANSISTOR, SI, NPN, SMALL SIGNAL, SOT23	742676	89536	742676	5	1	
Q 9, 12	*	742676					
Q 5, 11	* TRANSISTOR, SI, PNP, SMALL SIGNAL, SOT23	742684	89536	742684	2	1	
Q 8	* TRANSISTOR, SI, N-DMOS FET, SOT23	830851	89536	830851	1	1	
Q 10	* TRANSISTOR, SI, P-CHAN, SOT-23	832477	89536	832477	1	1	
R 1	RES, MF, 1K, +-1%, 100PPM, FLMPRF, FUSIBLE	832550	89536	832550	1	1	
R 2	* RES, TINOK, 909K, +-1%, 2W	831594	89536	831594	1		
R 3	* RES, CERM, 1.5K, +-5%, .125W, 250PPM, 1206	746438	89536	746438	1		
R 4	RES, MF, 110.1, +-0.1%, 0.125W, 100PPM	821728	89536	821728	1		
R 5	RES, WW, 0.991, +-0.1%, 2.5W	821645	89536	821645	1		
R 6	RES, WW, 0.010, +-0.1%, 1W, 100PPM	807305	89536	807305	1		
R 7, 10	* RES, CERM, 1M, +-5%, 1W	655175	89536	655175	2		
R 8, 48	* RES, CERM, 15M, +-5%, .125W, 300PPM, 1206	811968	89536	811968	2		
R 9, 13, 29,	* RES, CERM, 100K, +-5%, .125W, 250PPM, 1206	740548	89536	740548	4		
R 53	*	740548					
R 11	* RES, CERM, 10M, +-5%, .125W, 250PPM, 1206	783274	89536	783274	1		
R 12	* RES, CERM, 10K, +-5%, .125W, 250PPM, 1206	746610	89536	746610	1		
R 14	RES, MF, 10K, +-0.1%, 0.125W, 100PPM	658955	89536	658955	1		
R 15	RES, MF, 40K, +-0.1%, 0.125W, 100PPM	821702	89536	821702	1		
R 17, 18, 42,	* RES, CERM, 1M, +-5%, .125W, 250PPM, 1206	746826	89536	746826	4		
R 54	*	746826					
R 19	* RES, CERM, 56.2K, +-1%, .125W, 100PPM, 1206	831305	89536	831305	1		
R 20, 37	* RES, CERM, 205K, +-1%, .125W, 100PPM, 1206	769836	89536	769836	2		
R 21	RES, VAR, CERM, 100K, +-20%, 0.3W	649897	89536	649897	1		
R 22, 23	* RES, CERM, 2K, +-5%, .125W, 250PPM, 1206	746461	89536	746461	2		
R 24	* RES, CERM, 287K, +-1%, 0.125W, 100PPM, 1206	853895	89536	853895	1		
R 25	* RES, CERM, 210K, +-1%, .125W, 100PPM, 1206	821660	89536	821660	1		
R 28	* RES, CERM, 84.5K, +-1%, .125W, 100PPM, 1206	853510	89536	853510	1		
R 31	RES JUMPER, 0.02, 0.25W	682575	89536	682575	1		
R 32	* RES, CERM, 75K, +-5%, .125W, 250PPM, 1206	811901	89536	811901	1		
R 34	RES, VAR, CERM, 100+-20%, 0.3W	831412	89536	831412	1		
R 35	* RES, CERM, 620K, +-5%, .125W, 250PPM, 1206	811919	89536	811919	1		
R 38, 60	* RES, CERM, 536K, +-1%, .125W, 100PPM, 1206	845420	89536	845420	2		
R 39	* RES, CERM, 56K, +-5%, .125W, 250PPM, 1206	746701	89536	746701	1		
R 43	RES, MF, 1K, +-0.1%, 0.125W, 100PPM	821694	89536	821694	1		
R 44	* RES, CERM, 82K, +-5%, .125W, 250PPM, 1206	811794	89536	811794	1		
R 45, 50	* RES, CERM, 0.05MAX, .125W, 1206	810747	89536	810747	2		
R 46	RES, MF, 50K, +-0.1%, 0.125W, 100PPM	821710	89536	821710	1		
R 56, 57	* RES, CERM, 22K, +-5%, .125W, 250PPM, 1206	746651	89536	746651	2		

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

Table 4-6. A1 Main PCA (cont.)

REFERENCE DESIGNATOR	FLUKE STOCK	MFRS SPLY	MANUFACTURERS PART NUMBER	TOT	R	N
-A>-NUMERICS-->	S	-NO--	-OR- GENERIC TYPE	QTY	-Q	-E-
R 58	*	RES, CERM, 120K, +-5%, .125W, 250PPM, 1206	746719	89536	746719	1
R 59	*	RES, CERM, 510, +-5%, .125W, 250PPM, 1206	746388	89536	746388	1
RT 1		THERMISTOR, RECT, POS, 1.5K, +-30%, 25 C	822015	89536	822015	1 1
RV 1, 2		VARISTOR, 910V, +-10%, 1.0MA	817106	89536	817106	2 1
S 1		SWITCH, ROTARY	819334	89536	819334	1
U 1		DIODE, SI, RECT, BRIDGE, BV=50V, IO=1.0A	418582	14936	DF005	1 1
U 2	*	TAPE & REEL, SMD, SO	835538	89536	835538	1
U 4	*	IC CMOS OLYMPUS, ASSEMBLY TESTED	842294	89536	842294	1
U 6	*	IC, CMOS, HEX INVERTER, SOIC	838375	89536	838375	1 1
VR 1	*	BANDGAP, TAPED	729194	89536	729194	1 1
W 1		JUMPER WIRE NEG	834994	89536	834994	1
W 2		JUMPER WIRE POS	835009	89536	835009	1
XBT 1		CONNECTOR, BATTERY	825976	89536	825976	1
XF 1		CONTACT, 600V, FUSE	659524	89536	659524	2 1
XF 2		600 VOLT FUSE CONTACT	707190	89536	707190	2 1
Y 1		CRYSTAL, 131.072KHZ, 0.003%, 3X9MM	831453	89536	831453	1 1
Z 1	*	RES NET THK FILM TESTED	813824	89536	813824	1

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

NOTE 1 - Ref. designator XF1 is two (2) parts. They are used with F1 on the Final Assembly.

NOTE 2 - Ref. designator XF2 is two (2) parts. They are used with F2 on the Final Assembly.

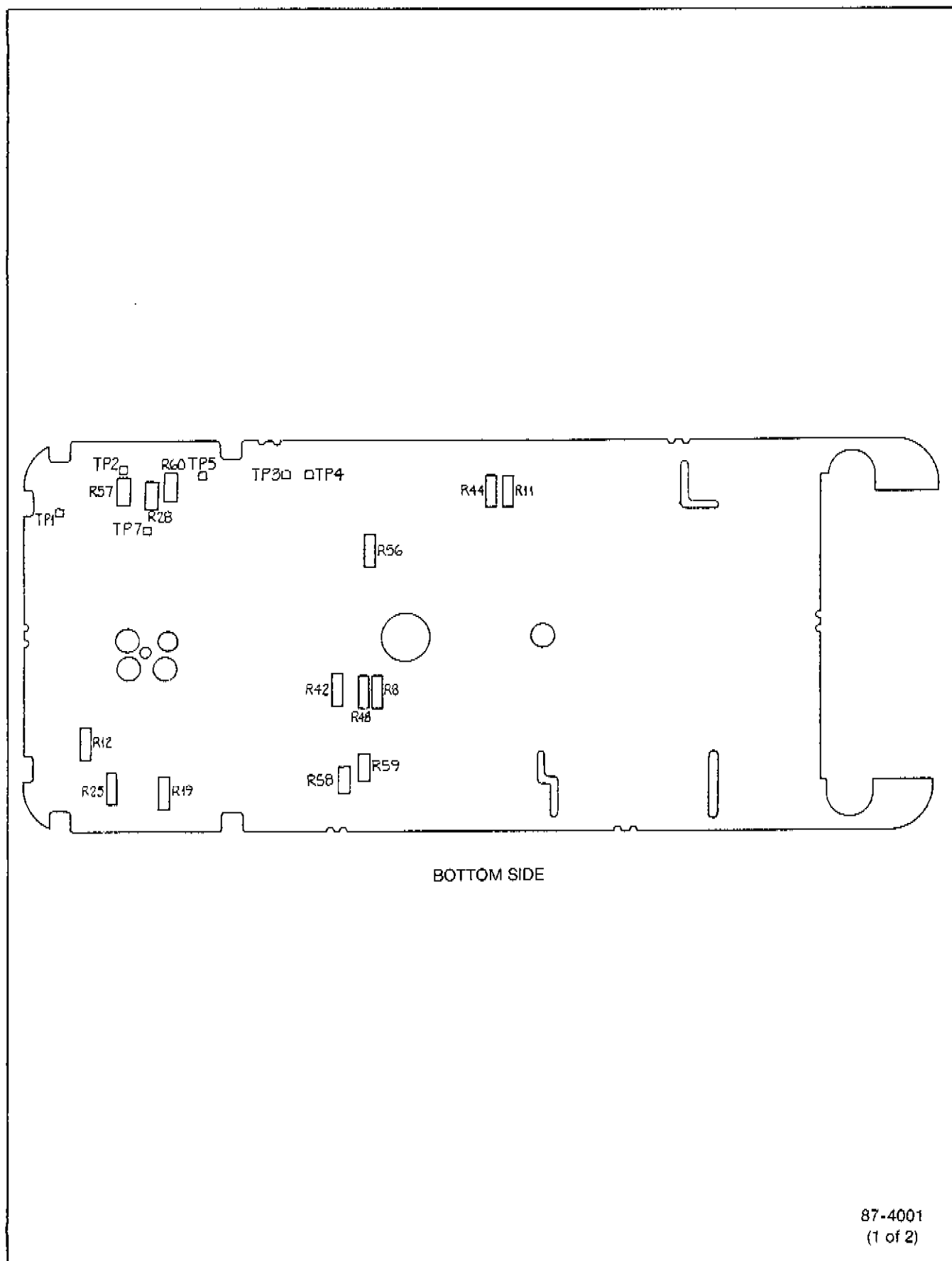
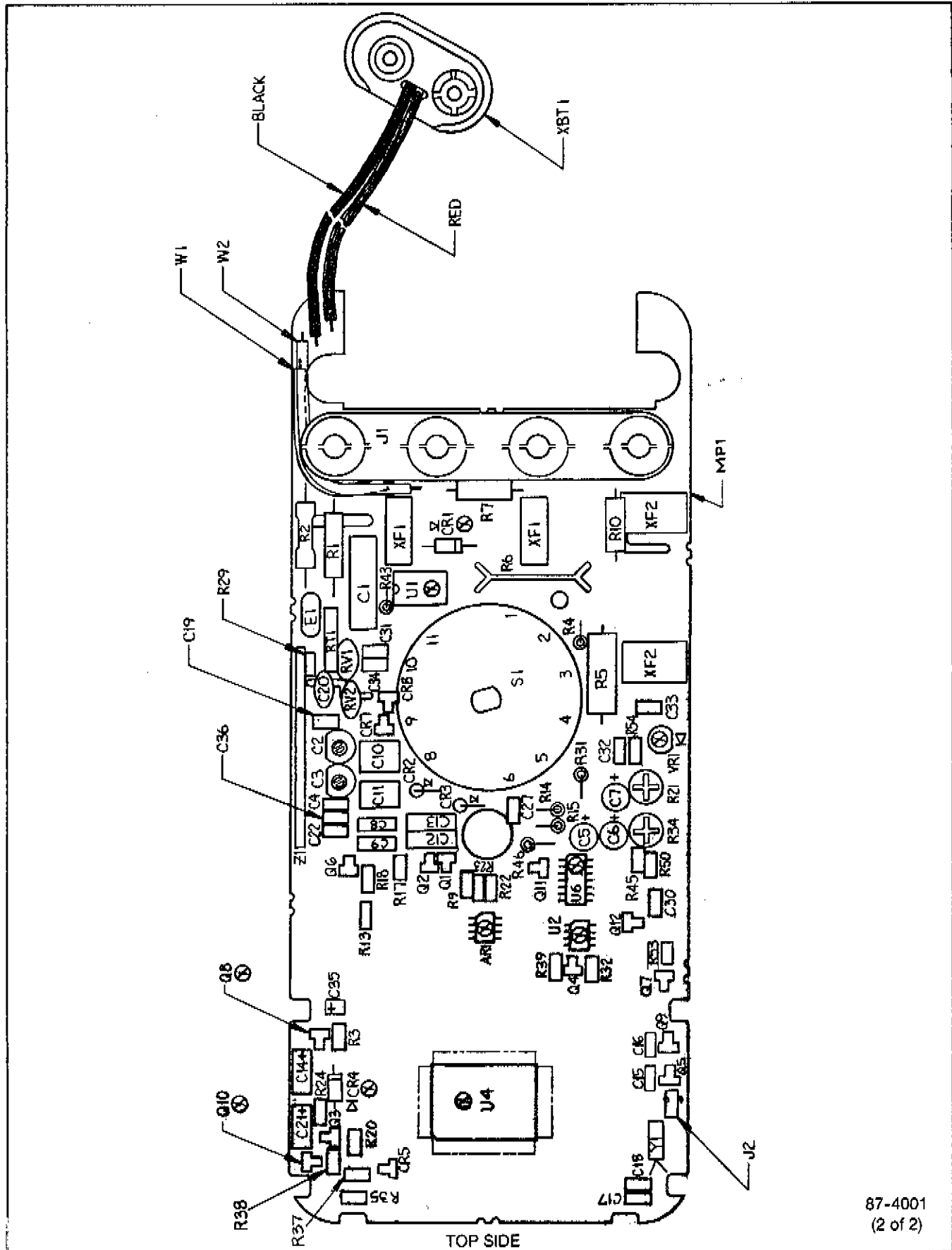


Figure 4-6. Fluke 87 A1 Main PCA



87-4001  
(2 of 2)

Figure 4-6. Fluke 87 A1 Main PCA (cont)

# FEDERAL SUPPLY CODES FOR MANUFACTURERS

D9816 Westermann Wilhelm Augusta-Anlage Mannheim-Nackarau Germany	02533 Leigh Instruments Ltd. Frequency Control Div. Don Mills, Ontario, Canada	04713 Motorola Inc. Semiconductor Group Phoenix, Arizona	06665 Precision Monolithics Sub of Bourns Inc. Santa Clara, California
00199 Marcon Electronics Corp Kearny, New Jersey	02606 Fenwal Labs Division of Travenal Labs Morton Grove, Illinois	05236 Jonathan Mfg. Co. Fullerton, California	06666 General Devices Co. Inc. Indianapolis, Indiana
00213 Nytronics Comp. Group Inc. Darrington, South Carolina	0266 Bunker Ramo-Eltra Corp. Amphenol NA Div. Broadview, Illinois	05245 Corcom Inc. Libertyville, Illinois	06739 Electron Corp. Littleton, Colorado
00327 Welwyn International Inc. Westlake, Ohio	02735 RCA-Solid State Div. Somerville, New Jersey	05276 ITT Pomona Electronics Div. Pomona, California	06743 Gould Inc. Foil Div. Eastlake, Ohio
00656 Aerovox Corp. New Bedford, Massachusetts	02799 Arco Electronics Inc. Chatsworth, California	05277 Westinghouse Elec. Corp. Semiconductor Div. Youngwood, Pennsylvania	06751 Components Inc. Sencor Div. Phoenix, Arizona
00686 Film Capacitors Inc. Passaic, New Jersey	03508 General Electric Co. Semiconductor Products & Batteries Auburn, New York	05397 Union Carbide Corp. Materials Systems Div. Cleveland, Ohio	06776 Robinson Nugent Inc. New Albany, Indiana
00779 AMP, Inc. Harrisburg, Pennsylvania	03797 Genisco Technology Corp. Electronics Div. Rancho Dominguez, Calif.	05571 Sprague Electric Co. (Now 56289)	06915 Richco Plastic Co. Chicago, Illinois
01121 Allen Bradley Co. Milwaukee, Wisconsin	03877 Gilbert Engineering Co. Inc. Incon Sub of Transatron Electronic Corp. Glendale, Arizona	05574 Viking Connectors Inc Sub of Criton Corp. Chatsworth, Calif.	06961 Vernitron Corp. Piezo Electric Div. Bedford, Ohio
01281 TRW Electronics & Defense Sector Lawndale, California	03888 KDI Electronics Inc. Pyrofilm Div. Whippany, New Jersey	05820 EG & G Wakefield Engineering Wakefield, Massachusetts	06980 Varian Associates Inc. Eimac Div. San Carlos, California
01295 Texas Instruments Inc. Semiconductor Group Dallas, Texas	03911 Clairex Corp. Clairex Electronics Div. Mount Vernon, New York	05972 Loctite Corp. Newington, Connecticut	07047 Ross Milton Co., The Southampton, Penna.
01537 Motorola Communications & Electronics Inc. Franklin Park, Illinois	03980 Muirhead Inc. Mountainside, New Jersey	06001 General Electric Co. Electric Capacitor Product Section Columbia, S. Carolina	07138 Westinghouse Electric Corp. Industrial & Government Tube Div. Horseheads, New York
01686 RCL Electronics/Shallcross Inc. Electro Components Div. Manchester, New Hampshire	04009 Cooper Industries, Inc. Arrow Hart Div. Hartford, Connecticut	06141 Fairchild Weston Systems Inc. Data Systems Div. Sarasota, Florida	07233 Benchmark Technology Inc. City of Industry, Calif.
01884 Sprague Electric Co. (Now 56289)	04217 Essex International Inc. Wire & Cable Div. Anaheim, California	06192 La Deau Mfg. Co. Glendale, California	07239 Biddle Instruments Blue Bell, Penna.
01961 Varian Associates Inc. Pulse Engineering Div. Convoy, Connecticut	04221 Midland-Ross Corp. Midtex Div. N. Mankato, Minnesota	06229 Electrovert Inc. Elmsford, New York	07256 Silicon Transistor Corp. Sub of BBF Inc. Chelmsford, Massachusetts
02111 Spectral Electronics Corp. City of Industry, California	04222 AVX Corp. AVX Ceramics Div. Myrtle Beach, S. Carolina	06383 Panduit Corp. Tinley Park, Illinois	07261 Avnet Corp. Culver City, California
02114 Amperex Electronic Corp. Ferrox Cube Div. Saugerties, New York	04423 Telonic Berkley Inc. Laguna Beach, California	06473 Bunker Ramo Corp. Amphenol NA Div. SAMS Operation Chatsworth, California	07263 Fairchild Camera & Instrument Semiconductor Div. Mountain View, California
02131 General Instrument Corp. Government Systems Div. Westwood, Massachusetts		06555 Beede Electrical Instrument Penacook, New Hampshire	07344 Bircher Co. Inc., The Rochester, New York
02395 Senar Radio Corp. Hollywood, Florida			

FEDERAL SUPPLY CODES FOR MANUFACTURERS (CONT)

07557 Campion Co. Inc. Philadelphia, Penna.	09423 Scientific Components Inc. Santa Barbara, California	11711 Genefal Instrument Corp. Rectifier Div. Hicksville, New York	12954 Microsemi Corp. Components Group Scottsdale, Arizona
07597 Burdy Corp. Tape/Cable Div. Rochester, New York	09579 CTS of Canada, Ltd Streetsville, Ontario	11726 Qualidyne Corp. Santa Clara, California	12969 Unitrode Corp. Lexington, Massachusetts
07716 TRW Inc. (Can use 11502) IRC Fixed Resistors/ Burlington Burlington, Iowa	09922 Burdy Corp. Norwalk, Connecticut	12014 Chicago Rivet & Machine Co. Naperville, Illinois	13050 Potter Co. Wesson, Mississippi
07792 Lema Engineering Corp. Northampton, Massachusetts	09969 Dale Electronics Inc. Yankton, South Dakota	12040 National Semiconductor Corp. Danbury, Connecticut	13103 Thermalloy Co., Inc. Dallas, Texas
07810 Bock Corp. Madison, Wisconsin	09975 Burroughs Corp. Electronics Components Detroit, Michigan	12060 Diodes Inc. Northridge, California	13327 Solitron Devices Inc. Tappan, New York
07933 Raytheon Co. Semiconductor Div. Mountain View, Calif.	10059 Barker Engineering Corp. Kenilworth, New Jersey	12136 PHC Industries Inc. Formerly Philadelphia Handle Co. Camden, New Jersey	13511 Bunker-Ramo Corp. Amphenol Cadre Div. Los Gatos, California
08235 Industro Transistor Corp. Long Island City, New York	10389 Illinois Tool Works Inc. Licon Div. Chicago, Illinois	12300 AMF Canada Ltd. Potter-Brumfield Guelph, Ontario, Canada	13606 Sprague Electric Co. (Use 56289)
08261 Spectra-Strip An Eltra Co. Garden Grove, Calif.	10582 CTS of Asheville Skyland, N. Carolina	12323 Practical Automation Inc. Shelton, Connecticut	13689 SPS Technologies Inc. Hatfield, Pennsylvania
08530 Reliance Mica Corp. Brooklyn, New York	11236 CTS Corp. Berne Div. Berne, Indiana	12327 Freeway Corp. Cleveland, Ohio	13919 Burr-Brown Research Corp. Tucson, Arizona
08718 ITT Cannon Electric Phoenix Div. Phoenix, Arizona	11237 CTS Corp of California Paso Robles Div. Paso Robles, California	12443 Budd Co.,The Plastics Products Div. Phoenixville, Pennsylvania	14099 Semtech Corp. Newbury Park, California
08806 General Electric Co. Miniature Lamp Products Cleveland, Ohio	11295 ECM Motor Co. Schaumburg, Illinois	12581 Hitachi Metals International Ltd. Hitachi Magna-Lock Div. Big Rapids, Missouri	14140 McGray-Edison Co. Commercial Development Div. Manchester, New Hampshire
08863 Nylomatic Fallsington, Penna.	11358 Columbia Broadcasting System CBS Electronic Div. Newburyport, Massachusetts	12581 Hitachi Metals International Ltd. Hitachi Magna-Lock Div. Big Rapids, Missouri	14193 Cal-R-Inc. Santa Monica, California
08988 Skottie Electronics Inc. Archbald, Pennsylvania	11403 Vacuum Can Co. Best Coffee Maker Div. Chicago, Illinois	12615 US Terminals Inc. Cincinnati, Ohio	14298 American Components Inc. an Insilco Co. RPC Div. Conshohocken, Pennsylvania
09021 Airco Inc. Airco Electronics Bradford, Penna.	11502 TRW Inc. TRW Resistive Products Div. Boone, North Carolina	12617 Hamlin Inc. Lake Mills, Wisconsin	14298 ACIC Inc. Sub of Insilco Corp. Research Triangle Park, NC
09023 Cornell-Dublier Electronics Fuquay-Varina, N. Carolina	11503 Keystone Columbia Inc. Freemont, Indiana	12697 Clarostat Mfg. Co. Inc. Dover, New Hampshire	14329 Wells Electronics Inc. South Bend, Indiana
09214 General Electric Co. Semiconductor Products Dept. Auburn, New York	11532 Teledyne Relays Teledyne Industries Inc. Hawthorne, California	12749 James Electronic Inc. Chicago, Illinois	14482 Watkins-Johnson Co. Palo Alto, California
09353 C and K Components Inc. Newton, Massachusetts		12856 MicroMetals Inc. Anaheim, California	14552 Microsemi Corp. Santa Ana, California
		12881 Metex Corp. Edison, New Jersey	14655 Comell-Dublier Electronics Div. of Federal Pacific Electric Co. Govt Cont Dept. Newark, New Jersey
		12895 Cleveland Electric Motor Co. Cleveland, Ohio	

## FEDERAL SUPPLY CODES FOR MANUFACTURERS (CONT)

14704 Crydom Controls (Division of Int Rectifier) El Segundo, California	16733 Cablewave Systems Inc. North Haven, Connecticut	18927 GTE Products Corp. Precision Material Products Business Parts Div. Titusville, Pennsylvania	23936 William J. Purdy Co. Pamotor Div. Burlingame, California
14752 Electro Cube Inc. San Gabriel, California	16742 Paramount Plastics Fabricators Inc. Downey, California	19315 Bendix Corp., The Navigation & Control Group Teaboro, New Jersey	24347 Penn Engineering Co. S. El Monte, California
14936 General Instrument Corp. Discrete Semi Conductor Div. Hicksville, New York	16758 General Motors Corp. Delco Electronics Div. Kokomo, Indiana	19451 Perine Machinery & Supply Co.. Kent, Washington	24355 Analog Devices Inc. Norwood, Massachusetts
14949 Trompeter Electronics Chatsworth, California	17069 Circuit Structures Lab Burbank, California	19613 Minnesota Mining & Mfg. Co. Textool Products Dept. Electronic Product Div. Irving, Texas	24444 General Semiconductor Industries, Inc. Tempe, Arizona
15412 Amtron Midlothian, Illinois	17117 Electronic Molding Corp. Woonsocket, Rhode Island	19647 Caddock Electronics Inc. Riverside, California	24655 Genrad Inc. Concord, Massachusetts
15542 Scientific Components Corp. Mini-Circuits Laboratory Div. Brooklyn, New York	17338 High Pressure Eng. Co. Inc. Oklahoma City, Oklahoma	19701 Mepco/Centralab Inc. A N. American Philips Co. Mineral Wells, Texas	24759 Lenox-Fugle Electronics Inc. South Plainfield, New Jersey
15636 Elec-Trol Inc. Saugus, California	17545 Atlantic Semiconductors Inc. Asbury Park, New Jersey	20584 Enochs Mfg. Inc. Indianapolis, Indiana	24796 AMF Inc. Potter & Brumfield Div. San Juan Capistrano, Calif.
15782 Bausch & Lomb Inc. Graphics & Control Div. Austin, Texas	17745 Angstrom Precision, Inc. Hagerstown, Maryland	20891 Cosar Corp. Dallas, Texas	24931 Specialty Connector Co. Greenwood, Indiana
15801 Fenwal Electronics Inc. Div. of Kidde Inc. Framingham, Massachusetts	17856 Siliconix Inc. Santa Clara, California	21317 Electronics Applications Co. El Monte, California	25088 Siemen Corp. Isilen, New Jersey
15818 Teledyne Inc. Co. Teledyne Semiconductor Div. Mountain View, California	18178 E G & Gvactee Inc. St. Louis, Missouri	21604 Buckeye Stamping Co. Columbus, Ohio	25099 Cascade Gasket Kent, Washington
15849 Uscco Inc. (Now 88245)	18324 Signetics Corp. Sacramento, California	21845 Solitron Devices Inc. Semiconductor Group Riviera Beach, Florida	25403 Amperex Electronic Corp. Semiconductor & Micro-Circuit Div. Slatersville, Rhode Island
15898 International Business Machines Corp. Essex Junction, Vermont	18520 Sharp Electronics Corp. Paramus, New Jersey	22526 DuPont, El DeNemours & Co. Inc. DuPont Connector Systems Advanced Products Div. New Cumberland, Pennsylvania	25706 Daburn Electronic & Cable Corp. Norwood, New Jersey
16245 Conap Inc. Olean, New York	18542 Wabash Inc. Wabash Relay & Electronics Div. Wabash, Indiana	22767 ITT Semiconductors Palo Alto, California	26629 Frequency Sources Inc. Sources Div. Chelmsford, Massachusetts
16258 Space-Lok Inc. Burbank, California	18565 Chomerics Inc. Woburn, Massachusetts	22784 Palmer Inc. Cleveland, Ohio	26806 American Zettler Inc. Irvine, California
16352 Codi Corp. Linden, New Jersey	18612 Vishay Intertechnology Inc. Vishay Resistor Products Group Malvern, Pennsylvania	23050 Product Comp. Corp. Mount Vernon, New York	27014 National Semiconductor Corp. Santa Clara, California
16469 MCL Inc. LaGrange, Illinois	18632 Norton-Chemplast Santa Monica, California	23732 Tracor Applied Sciences Inc. Rockville, Maryland	27167 Corning Glass Works Corning Electronics Wilmington, North Carolina
16473 Cambridge Scientific Industries Div. of Chemed Corp. Cambridge, Maryland	18677 Scanbe Mfg. Co. Div. of Zero Corp. El Monte, California	23880 Stanford Applied Engineering Santa Clara, California	27264 Molex Inc. Lisle, Illinois
	18736 Voltronics Corp. East Hanover, New Jersey		27440 Industrial Screw Products Los Angeles, California

FEDERAL SUPPLY CODES FOR MANUFACTURERS (CONT)

27745 Associated Spring Barnes Group Inc. Syracuse, New York	30800 General Instrument Corp. Capacitor Div. Hicksville, New York	33297 NEC Electronics USA Inc. Electronic Arrays Inc. Div. Mountain View, California	49956 Raytheon Company Executive Offices Lexington, Massachusetts
27956 Relcom (Now 14482)	31019 Solid State Scientific Inc. Willow Grove, Pennsylvania	33919 Nortek Inc. Cranston, Rhode Island	50088 Thomson Components-Mostek Corp. Carrollton, Texas
28198 Positronic Industries Springfield, Missouri	31091 Alpha Industries Inc. Microelectronics Div. Hatfield, Pennsylvania	34333 Silicon General Inc. Garden Grove, California	50120 Eagle-Picher Industries Inc. Electronics Div. Colorado Springs, Colorado
28213 Minnesota Mining & Mfg. Co. Consumer Products Div. 3M Center Saint Paul, Minnesota	31323 Metro Supply Company Sacramento, California	34225 Advanced Micro Devices Sunnyvale, California	50157 Midwest Components Inc. Muskegon, Mississippi
28425 Serv-O-Link Eules, Texas	31448 Army Safeguard Logistics Command Huntsville, Alabama	34359 Minnesota Mining & Mfg. Co. Commercial Office Supply Div. Saint Paul, Minnesota	50541 Hypertronics Corp. Hudson, Massachusetts
28478 Deltrol Corporation Deltrol Controls Div. Milwaukee, Wisconsin	31746 Cannon Electric Woodbury, Tennessee	34371 Harris Corp. Harris Semiconductor Products Group Melbourne, Florida	50579 Litronix Inc. Cupertino, California
28480 Hewlett Packard Co. Corporate HQ Palo Alto, California	31827 Budwig Ramona, California	34649 Intel Corp. Santa Clara, California	51167 Aries Electronics Inc. Frenchtown, New Jersey
28484 Emerson Electric Co. Gearmaster Div. McHenry, Illinois	31918 ITT-Schadow Eden Prairie, Minnesota	34802 Electromotive Inc. Kenilworth, New Jersey	51372 Verbatim Corp. Sunnyvale, California
28520 Heyco Molded Products Kenilworth, New Jersey	32293 Intersil Cupertino, California	34848 Hartwell Special Products Placentia, California	51406 Murata Eric, No. America Inc. (Also see 72982) Marietta, Georgia
29083 Monsanto Co. Santa Clara, California	32539 Mura Corp. Westbury, Long Island, N.Y.	35009 Renfrew Electric Co. Ltd. IRC Div. Toronto, Ontario, Canada	51499 Amtron Corp. Boston, Massachusetts
29604 Stackpole Components Co. Raleigh, North Carolina	32559 Bivar Santa Ana, California	36665 Mitel Corp. Kanata, Ontario, Canada	51605 CODI Semiconductor Inc. Kenilworth, New Jersey
29907 Omega Engineering Inc. Stamford, Connecticut	32767 Griffith Plastics Corp. Burlingame, California	37942 Mallory Capacitor Corp. Sub of Emhart Industries Indianapolis, Indiana	51642 Centre Engineering Inc. State College, Pennsylvania
30035 Jolo Industries Inc. Garden Grove, California	32879 Advanced Mechanical Components Northridge, California	39003 Maxim Industries Middleboro, Massachusetts	51791 Statek Corp. Orange, California
30146 Symbex Corp. Painesville, Ohio	32897 Murata Eric North America Inc. Cardisle Operations Cardisle, Pennsylvania	40402 Roderstein Electronics Inc. Statesville, North Carolina	51984 NEC America Inc. Falls Church, Virginia
30148 AB Enterprise Inc. Ahoskie, North Carolina	32997 Bourns Inc. Trimpot Div. Riverside, California	42498 National Radio Melrose, Massachusetts	52063 Exar Integrated Systems Sunnyvale, California
30161 Aavid Engineering Inc. Laconia, New Hampshire	33096 Colorado Crystal Corp. Loveland, Colorado	43543 Nytronics Inc.(Now 53342)	52072 Circuit Assembly Corp. Irvine, California
30315 Itron Corp. San Diego, California	33173 General Electric Co. Owensboro, Kentucky	44655 Ohmite Mfg. Co. Skokie, Illinois	52152 Minnesota Mining & Mfg. Saint Paul, Minnesota
30323 Illinois Tool Works Inc. Chicago, Illinois	33246 Epoxy Technology Inc. Billerica, Massachusetts	49671 RCA Corp. New York, New York	52333 API Electronics Hauppauge, Long Island, New York

## FEDERAL SUPPLY CODES FOR MANUFACTURERS (CONT)

52361 Communication Systems Piscataway, New Jersey	54590 RCA Corp. Electronic Components Div. Cherry Hill, New Jersey	58104 Simco Atlanta, Georgia	64155 Linear Technology Milpitas, California
52525 Space-Lok Inc. Lerco Div. Burbank, California	55026 American Gage & Machine Co. Simpson Electric Co. Div. Elgin, Illinois	58474 Superior Electric Co. Bristol, Connecticut	64834 West M G Co. San Francisco, Calif.
52531 Hitachi Magnetics Edmore, Missouri	55112 Plessey Capacitors Inc. (Now 60935)	59124 KOA-Speer Electronics Inc. Bradford, Pennsylvania	65092 Sangamo Weston Inc. Weston Instruments Div. Newark, New Jersey
52745 Timco Los Angeles, California	55261 LSI Computer Systems Inc. Melville, New York	59640 Supertex Inc. Sunnyvale, California	65940 Rohm Corp & Whatney Irvine, California
52763 Stettner-Electronics Inc. Chattanooga, Tennessee	55285 Bercquist Co. Minneapolis, Minnesota	59660 Tusonix Inc. Tucson, Arizona	65964 Evvox Inc. Bannockburn, Illinois
52769 Sprague-Goodman Electronics Inc. Garden City Park, New York	55576 Synertek Santa Clara, California	59730 Thomas and Betts Corp. Iowa City, Iowa	66150 Entron Inc. Winslow Teltronics Div. Glendale, New York
52771 Moniterm Corp. Amatrom Div. Santa Clara, California	55680 Michicon/America/Corp. Schaumburg, Illinois	59831 Semtronics Corp. Watchung, New Jersey	66608 Bering Industries Fremont, California
52840 Western Digital Corp. Costa Mesa, California	56282 Utek Systems Inc. Olathe, Kansas	60395 Xicor Inc. Milpitas, California	70290 Almetal Universal Joint Co. Cleveland, Ohio
53021 Sangamo Weston Inc. (See 06141)	56289 Sprague Electric Co. North Adams, Massachusetts	60399 Torin Engineered Blowers Div. of Clevepak Corp. Torrington, Connecticut	70485 Atlantic India Rubber Works Inc. Chicago, Illinois
53217 Technical Wire Products Inc. Santa Barbara, California	56365 Square D Co. Corporate Offices Palatine, Illinois	60705 Cera-Mite Corp. (formerly Sprague) Grafton, Wisconsin	70563 Amperite Company Union City, New Jersey
53342 Opt Industries Inc. Phillipsburg, New Jersey	56375 DAL Industries Inc. Wescorp Div. Mountain View, California	60935 Westlake Capacitor Inc. Tantalum Div. Greencastle, Indiana	70903 Belden Corp. Geneva, Illinois
53944 Glow-Lite Pauls Valley, Oklahoma	56481 Shugart Associates Sub of Xerox Corp. Sunnyvale, California	61804 M/A Corn Inc. Burlington, Massachusetts	71002 Bimbach Co. Inc. Farmingdale, New York
54294 Shalleross Inc. Smithfield, North Carolina	56708 Zilog Inc. Campbell, California	61857 SAN-O Industrial Corp. Bohemia, Long Island, NY	71034 Bliley Electric Co. Erie, Pennsylvania
54453 Sullins Electronic Corp. San Marcos, California	56856 Vamistor Corp. of Tennessee Sevierville, Tennessee	61935 Schurter Inc. Petaluma, California	71183 Westinghouse Electric Corp. Bryant Div. Bridgeport, Connecticut
54473 Matsushita Electric Corp. (Panasonic) Secaucus, New Jersey	56880 Magnetics Inc. Baltimore, Maryland	62351 Apple Rubber Lancaster, New York	71400 Bussman Manufacturing Div. McGraw-Edison Co. St. Louis, Missouri
54583 TDK Garden City, New York	57026 Endicott Coil Co. Inc. Binghamton, New York	62793 Lear Siegler Inc. Energy Products Div. Santa Ana, California	71450 CTS Corp. Elkhart, Indiana
54869 Pihler International Corp. Arlington Heights, Illinois	57053 Gates Energy Products Denver, Ohio	63743 Ward Leonard Electric Co. Inc. Mount Vernon, New York	71468 ITT Cannon Div. of ITT Fountain Valley, California
54937 DeYoung Mfg. Bellevue, Washington	58014 Hitachi Magnalock Corp. (Now 12581)	64154 Lamb Industries Portland, Oregon	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	73445 Amperex Electronic Corp. Hicksville, New York	75378 CTS Knights Inc. Sandwich, Illinois	79727 C - W Industries Southampton, Pennsylvania
71707 Coto Corp. Providence, Rhode Island	73559 Carlingswitch Inc. Hartford, Connecticut	75382 Kulka Electric Corp. (Now 83330) Mount Vernon, New York	79963 Zierick Mfg. Corp. Mount Kisco, New York
71744 General Instrument Corp. Lamp Div/Worldwide Chicago, Illinois	73586 Circle F Industries Trenton, New Jersey	75915 Tracor Littlefuse Des Plaines, Illinois	80009 Tektronix Beaverton, Oregon
71785 TRW Inc. Cinch Connector Div. Elk Grove Village, Illinois	73734 Federal Screw Products Inc. Chicago, Illinois	76854 Oak Switch Systems Inc. Crystal Lake, Illinois	80031 Mepco/Electra Inc. Morristown, New Jersey
71984 Dow Corning Corp. Midland, Michigan	73743 Fischer Special Mfg. Co. Cold Spring, Kentucky	77122 TRW Assemblies & Fasteners Group Fastener Div. Moutainside, New Jersey	80032 Ford Aerospace & Communications Corp. Western Development Laboratories Div. Palo Alto, California
72005 AMAX Specialty Metals Corp. Newark, New Jersey	73893 Microdot Mt. Clemens, Mississippi	77342 AMP Inc. Potter & Brumfield Div. Princeton, Indiana	80145 LFE Corp. Process Control Div. Clinton, Ohio
72136 Electro Motive Mfg. Corp. Florence, South Carolina	73899 JFD Electronic Components Div. of Murata Erie Oceanside, New York	77542 Ray-O-Vac Corp Madison, Wisconsin	80183 Sprague Products (Now 56289)
72228 AMCA International Corp. Continental Screw Div. New Bedford, Massachusetts	73905 FL Industries Inc. San Jose, California	77638 General Instrument Corp. Rectifier Div. Brooklyn, New York	80294 Boums Instruments Inc. Riverside, California
72259 Nytronics Inc. New York, New York	73949 Guardian Electric Mfg. Co. Chicago, Illinois	77900 Shakeproof Lock Washer Co. (Now 78189)	80583 Hammedund Mfg. Co. Inc. Paramus, New Jersey
72619 Amperex Electronic Corp. Dialight Div. Brooklyn, New York	74199 Quam Nichols Co. Chicago, Illinois	77969 Rubbercraft Corp. of CA Ltd. Torrance, California	80640 Computer Products Inc. Stevens-Arnold Div. South Boston, Mass.
72653 G C Electronics Co. Div. of Hydrometals Inc. Rockford, Illinois	74217 Radio Switch Co. Marlboro, New Jersey	78189 Illinois Tool Works Inc. Shakeproof Div. Elgin, Illinois	81073 Grayhill Inc. La Grange, Illinois
72794 Dzus Fastner Co. Inc. West Islip, New York	74306 Piezo Crystal Co. Div. of PPA Industries Inc. Carlisle, Pennsylvania	78277 Sigma Instruments Inc. South Braintree, Mass.	81312 Litton Systems Inc. Winchester Electronics Div. Watertown, Connecticut
72928 Gulton Industries Inc. Gudeman Div. Chicago, Illinois	74542 Hoyt Elect.Instr. Works Inc. Penacook, New Hampshire	78290 Struthers Dunn Inc. Pitman, New Jersey	81439 Therm-O-Disc Inc. Mansfield, Ohio
72982 Murata Erie N. America Inc. Erie, Pennsylvania	74840 Illinois Capacitor Inc. Lincolnwood, Illinois	78553 Eaton Corp. Engineered Fastener Div. Cleveland, Ohio	81483 International Rectifier Corp. Los Angeles, California
73138 Beckman Industrial corp. Helipot Div. Fullerton, California	74970 Johnson EF Co. Waseca, Minnesota	78592 Stoeger Industries South Hackensack, New Jersey	81590 Korry Electronics Inc. Seattle, Washington
73168 Fenwal Inc. Ashland, Massachusetts	75042 TRW Inc. IRC Fixed Resistors Philadelphia, Pennsylvania	79136 Waldes Kohinoor Inc. Long Island City, New York	81741 Chicago Lock Co. Chicago, Illinois
73293 Hughes Aircraft Co. Electron Dynamics Div. Torrance, California	75297 Litton Systems Kester Solder Div. Chicago, Illinois	79497 Western Rubber Co. Goshen, Indiana	82227 Airpax Corp. Cheshire Div. Cheshire, Connecticut
	75376 Kurz-Kasch Inc. Dayton, Ohio		82240 Simmons Fastner Corp. Albany, New York

FEDERAL SUPPLY CODES FOR MANUFACTURERS (CONT)

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 Bames 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 Francisco, 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  
EBCO 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  
Seaelectro Corp.  
BICC Electronics  
Trumbull, 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

Table 4-7. Manual Status Information, Model 83

REF OR OPTION NO.	ASSEMBLY NAME	FLUKE PART NO.	X = The PCA revision levels documented in this manual.																
			-	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A1	Main PCA	819284					X												
			* X = The PCA revision levels documented in this manual.																

Table 4-8. Manual Status Information, Model 85

REF OR OPTION NO.	ASSEMBLY NAME	FLUKE PART NO.	X = The PCA revision levels documented in this manual.																
			-	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A1	Main PCA	819276					X												
			* X = The PCA revision levels documented in this manual.																

Table 4-9. Manual Status Information, Model 87

REF OR OPTION NO.	ASSEMBLY NAME	FLUKE PART NO.	X = The PCA revision levels documented in this manual.																
			-	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A1	Main PCA	819268						X											
			* X = The PCA revision levels documented in this manual.																

## Section 5 Schematic Diagrams

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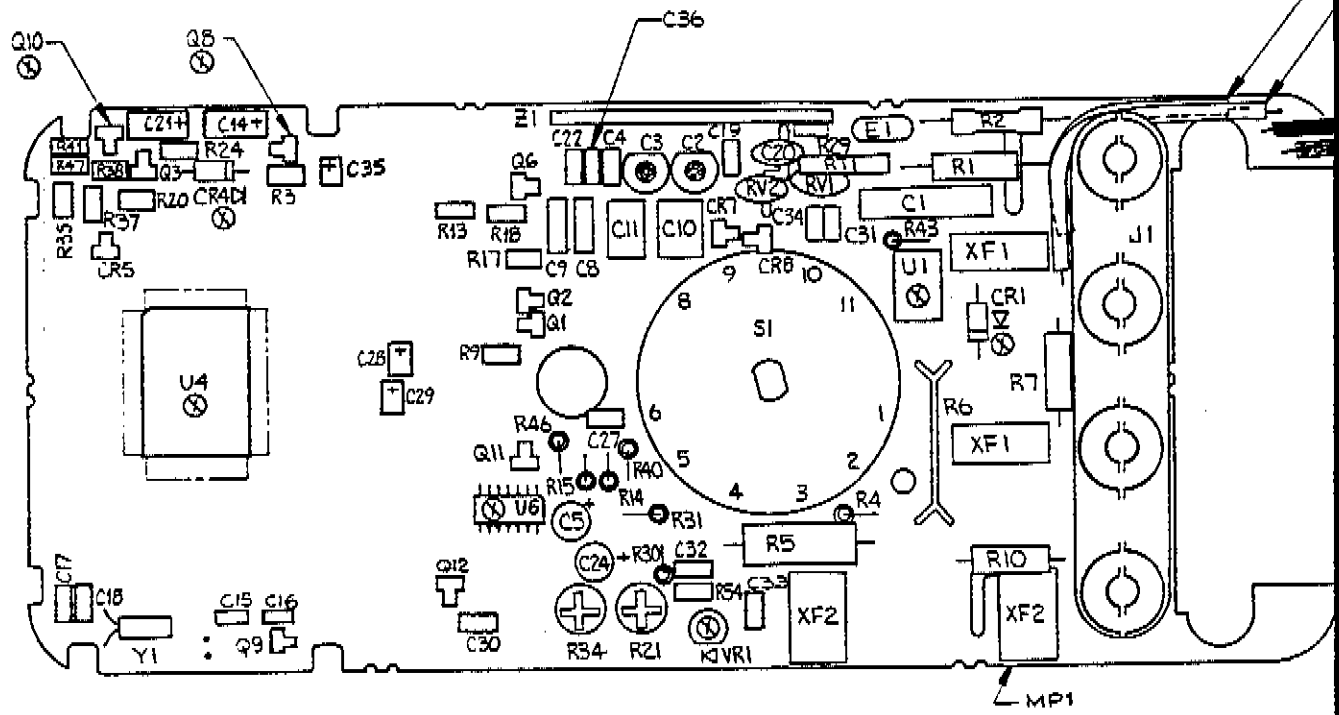
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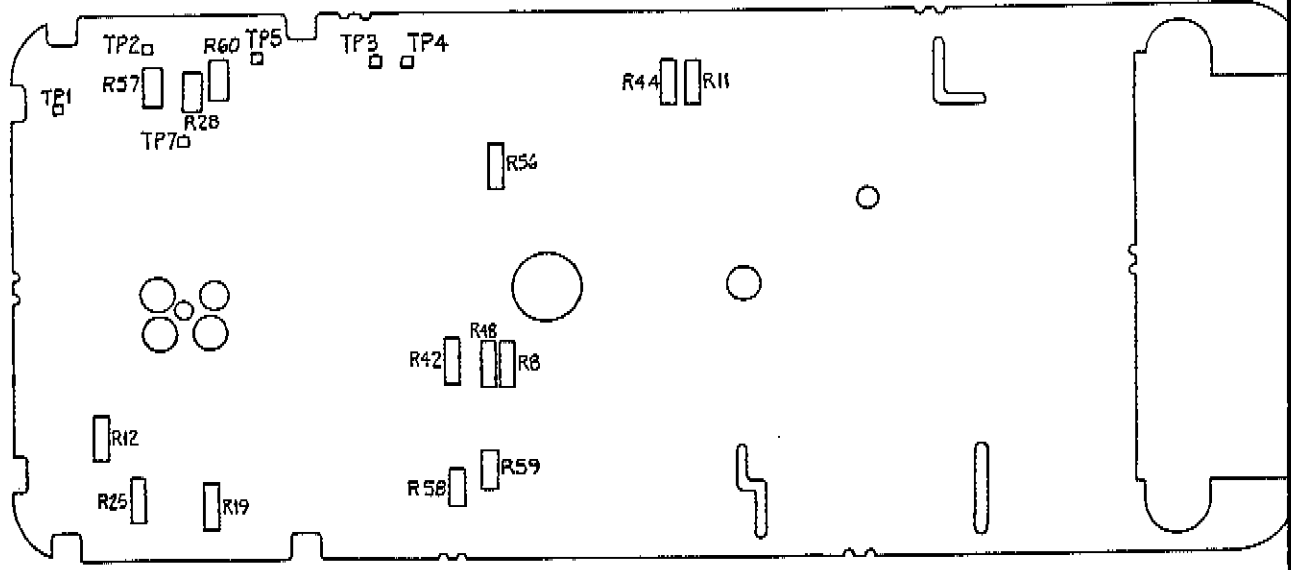
Table 5-1. Signal Abbreviations

ACBM	AC Buffer Minus (inverting input)	K1	Buffer output times 1
ACBO	AC Buffer Output	K2	Buffer output times 10
AFI	Active Filter Input	PDS	Power Down (off) Signal
AFO	Active Filter Output	P00	Port 00 (keypad)
AGND	Analog Ground	P01	Port 01 (keypad)
AP0	Analog Port 0 (guard)	P02	Port 02 (keypad)
AP1	Analog Port 1 (ohms, millivolts sense)	P03	Port 03 (PTF reference and position change sense)
AP2	Analog Port 2 (ohms reference sense)	P10	Port 10 (keypad)
AP3	Analog Port 3 (amps sense)	P11	Port 11 (keypad)
AP4	Analog Port 4 (milli/micro amps jack sense)	P12	Port 12 (keypad)
AP5	Analog Port 5 (amps jack sense)	P13	Port 13 (PW2, RMS power down drive)
AP6	Analog Port 6 (PTF position sense)	PS0	Power Supply 0 (feed back for VDD regulator)
AP7	Analog Port 7 (peak hold min sense)	PS1	Power Supply 1 (feed back for common regulator)
AP8	Analog Port 8 (peak hold max sense)	PS2	Power Supply 2 (output for common regulator)
APV0	Analog Port Voltage 0 (divider input)	PW2	Power 2 (power down drive for RMS converter)
APV1	Analog Port Voltage 1 (divide by 10)	REFH	Reference High (1.23V)
APV2	Analog Port Voltage 2 (divide by 100)	REFI	Reference In (1.00V)
APV3	Analog Port Voltage 3 (divide by 1000)	RESET	Reset for $\mu P$
APV4	Analog Port Voltage 4 (divide by 10000)	S0	LCD Segment drive 0
APCC	Analog Port Compensation Capacitor	•	
AVAM	Absolute Value Amplifier Minus (inverting input)	•	
AVAOM	Absolute Value Amplifier Output Minus	•	
AVAOP	Absolute Value Amplifier Output Positive	S31	LCD Segment drive 31
AZ	Auto Zero	TEST	Factory Test
CK1	Clock 1 (RC clock output)	VBT+	Plus battery voltage
CK2	Clock 2 (RC clock input)	VBT-	Minus battery voltage
COM	Common	VDD	Plus system supply
FAI	Filter Active Input	VDGND	Digital Ground
FAO	Filter Active Output	VOA	2/3 voltage for LCD drive
H1	LCD backplane drive 1	VOB	1/3 voltage for LCD drive
H2	LCD backplane drive 2	VSS	Minus system supply
H3	LCD backplane drive 3		
H4	LCD backplane drive 4		
INT	Integrator output		
K0	Buffer output times .874		

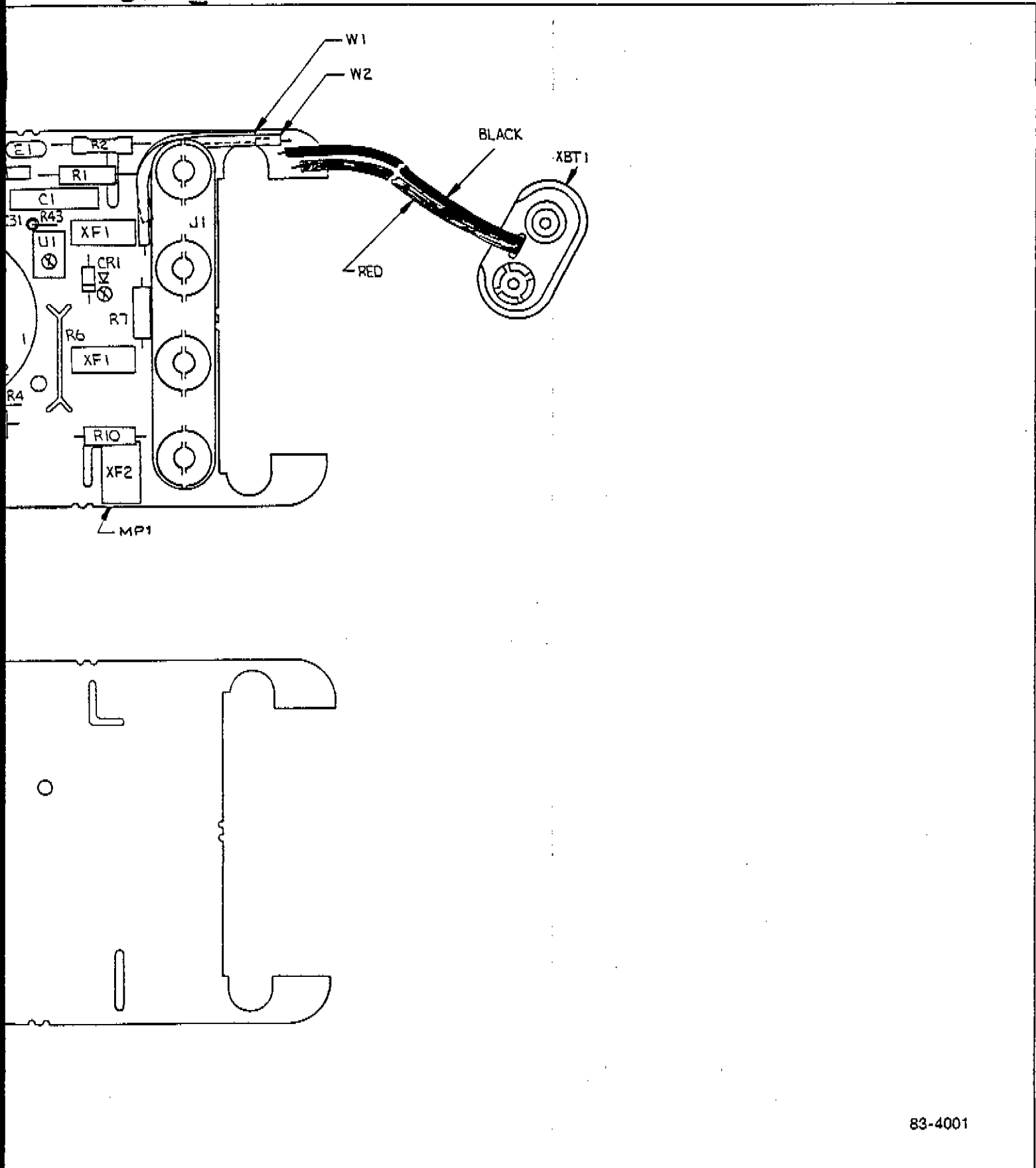
FIG. 5-1  
SHT. 1 OF 2



TOP SIDE



BOTTOM SIDE



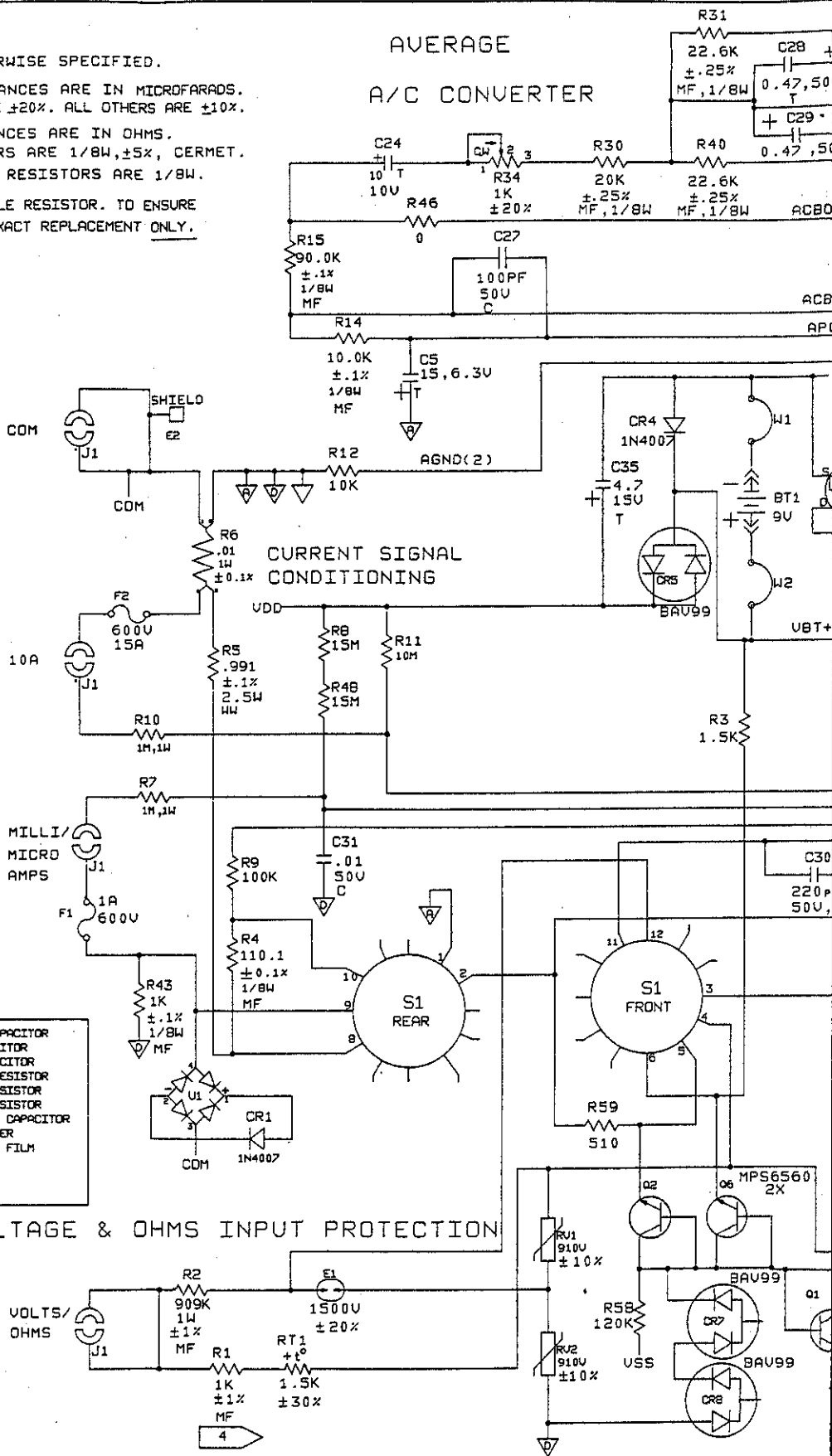
83-4001

Figure 5-1. Fluke 83 A1 Main PCA

FIG. 5-1a  
SMT. 1 OF 3

NOTES: UNLESS OTHERWISE SPECIFIED.

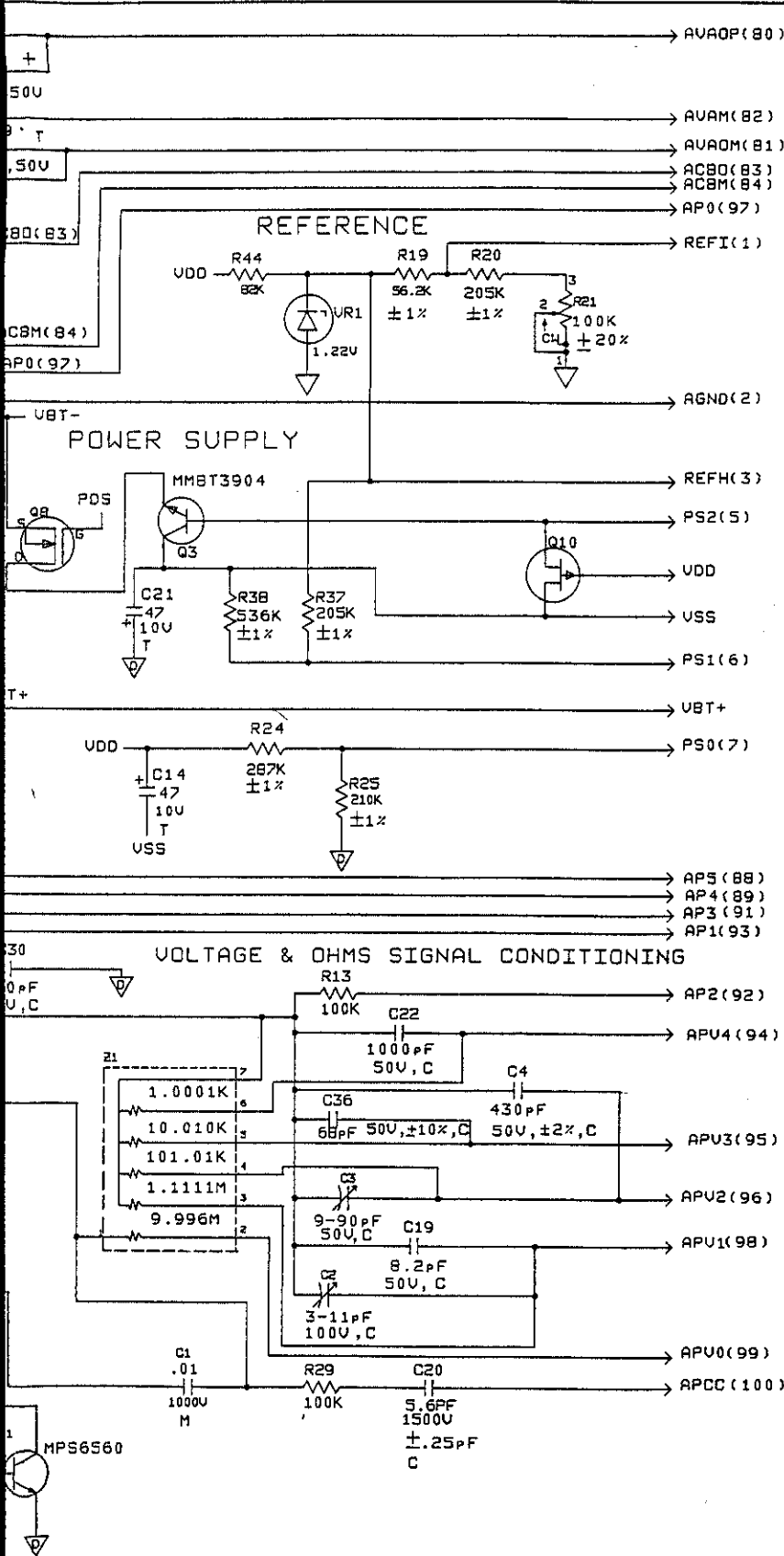
1. ALL CAPACITANCES ARE IN MICROFARADS. TANTALUMS ARE  $\pm 20\%$ . ALL OTHERS ARE  $\pm 10\%$ .
  2. ALL RESISTANCES ARE IN OHMS. ALL RESISTORS ARE 1/8W,  $\pm 5\%$ , CERMET.  $\pm .25\%$  &  $\pm 1\%$  RESISTORS ARE 1/8W.
- 4  $\rightarrow$  R1 IS A FUSIBLE RESISTOR. TO ENSURE SAFETY, USE EXACT REPLACEMENT ONLY.



MF	DESIGNATES MYLAR FILM CAPACITOR
C	DESIGNATES CERAMIC CAPACITOR
T	DESIGNATES TANTALUM CAPACITOR
MG	DESIGNATES METAL GLAZE RESISTOR
W	DESIGNATES WIRE WOUND RESISTOR
MF	DESIGNATES METAL FILM RESISTOR
PC	DESIGNATES POLYCARBONATE CAPACITOR
M	DESIGNATES MYLAR/POLYESTER
PP	DESIGNATES POLYPROPYLENE FILM

LAST USED	NOT - USED
U	2,3,4,5
R	6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100
C	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100
Q	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100
CR	1,2,3,6
MS	1
TR	1
TP	1
RT	1
J	1





ROTARY SWITCH INFORMATION

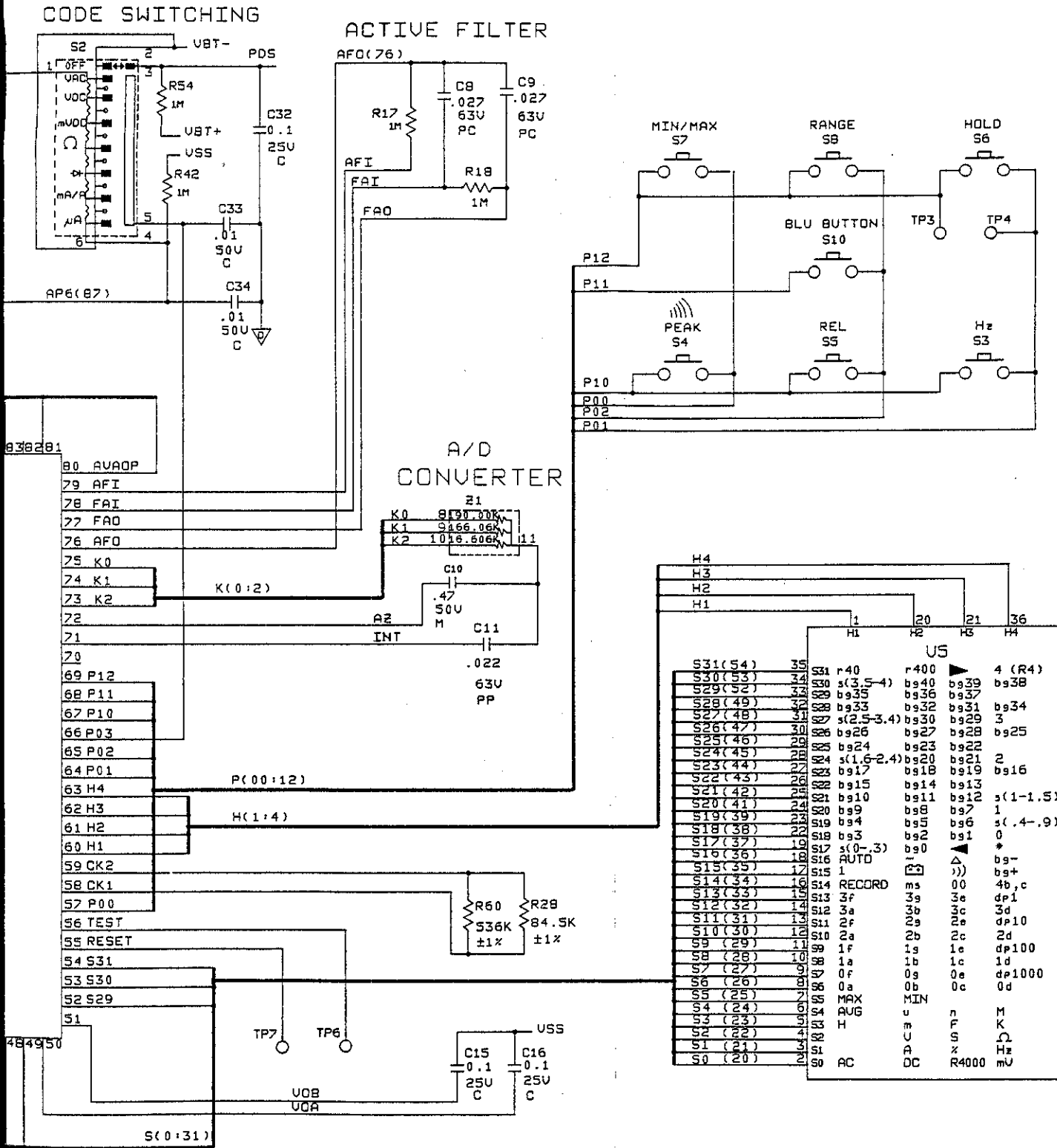
POSITION	FRONT	REAR	TEST ROTARY SWITCH** ± 12 COUNTS
OFF		1-2*	0
ACV		1-2	32
DCV	3-4	1-2	64
mVDC	3-4	11-12	96
Ω	3-4-5	11-12	128
mA/A	4-6	1-2	160
µA	3-4*	9-8	192
		1-2*	
		10-9	

\* CONNECTION NOT USED FOR OPERATION  
\*\* POWER UP OPTION  
PRESS RANGE BUTTON DOWN FOR 2 SECS WHILE TURNING ON METER

83-1201  
(1 of 2)

Figure 5-1. Fluke 83 A1 Main PCA (cont)



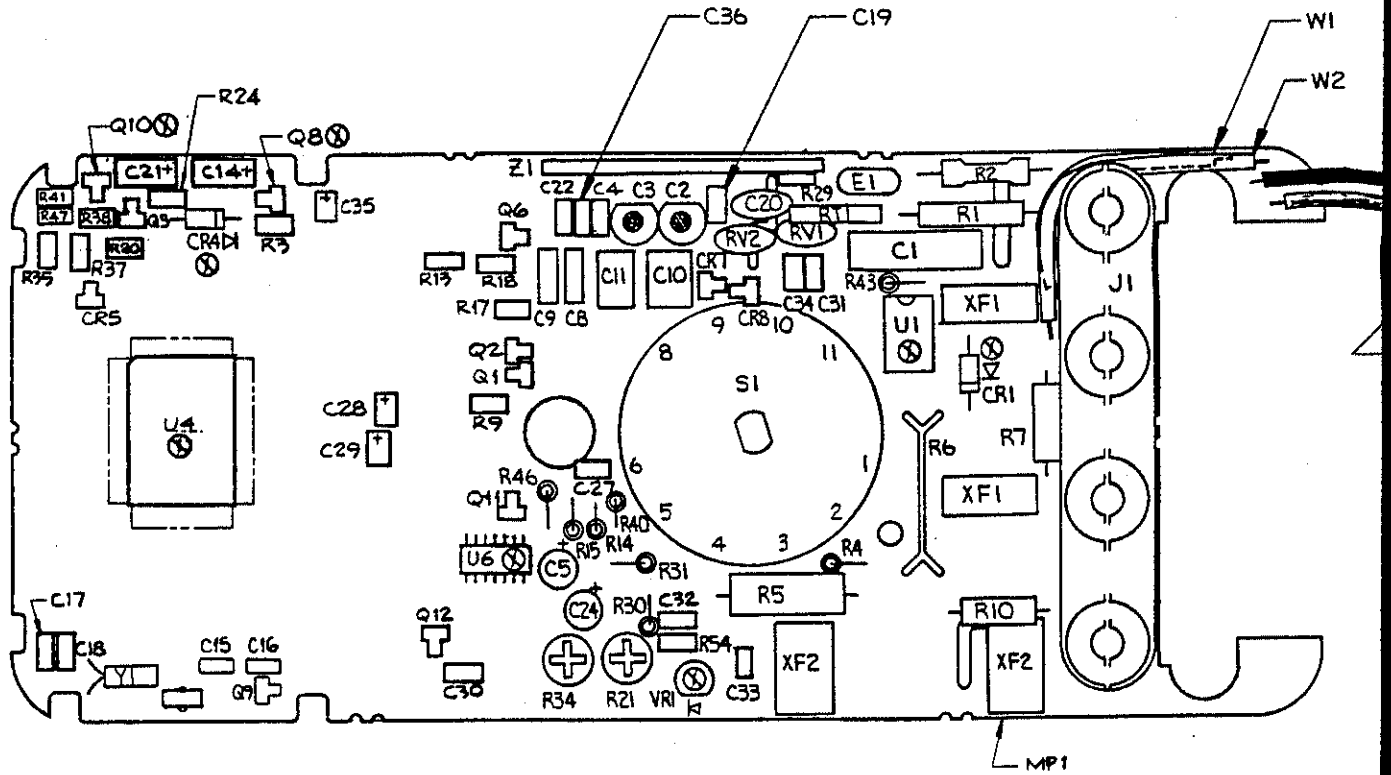


83-1201  
(2 of 2)

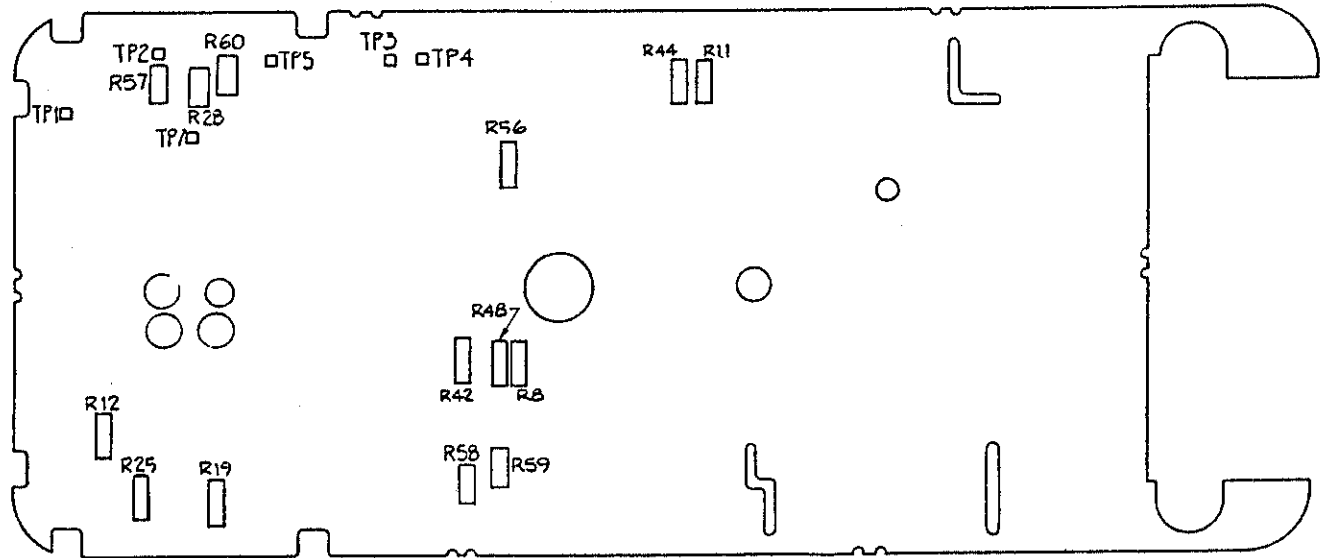
Figure 5-1. Fluke 83 A1 Main PCA (cont)

FIG. 5-2  
SHT. 1 OF 2

80 Series Service



TOP SIDE



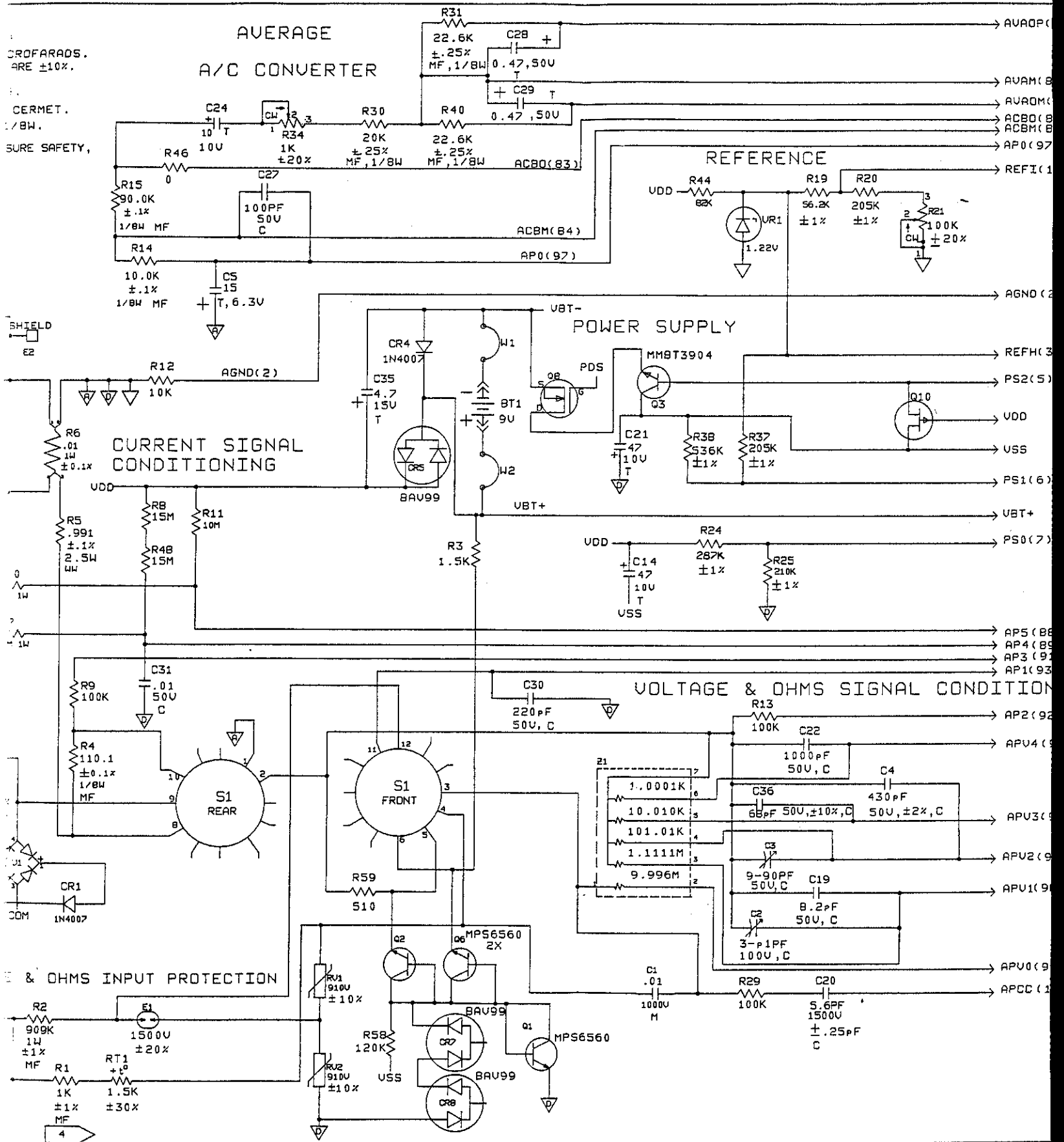
BOTTOM SIDE

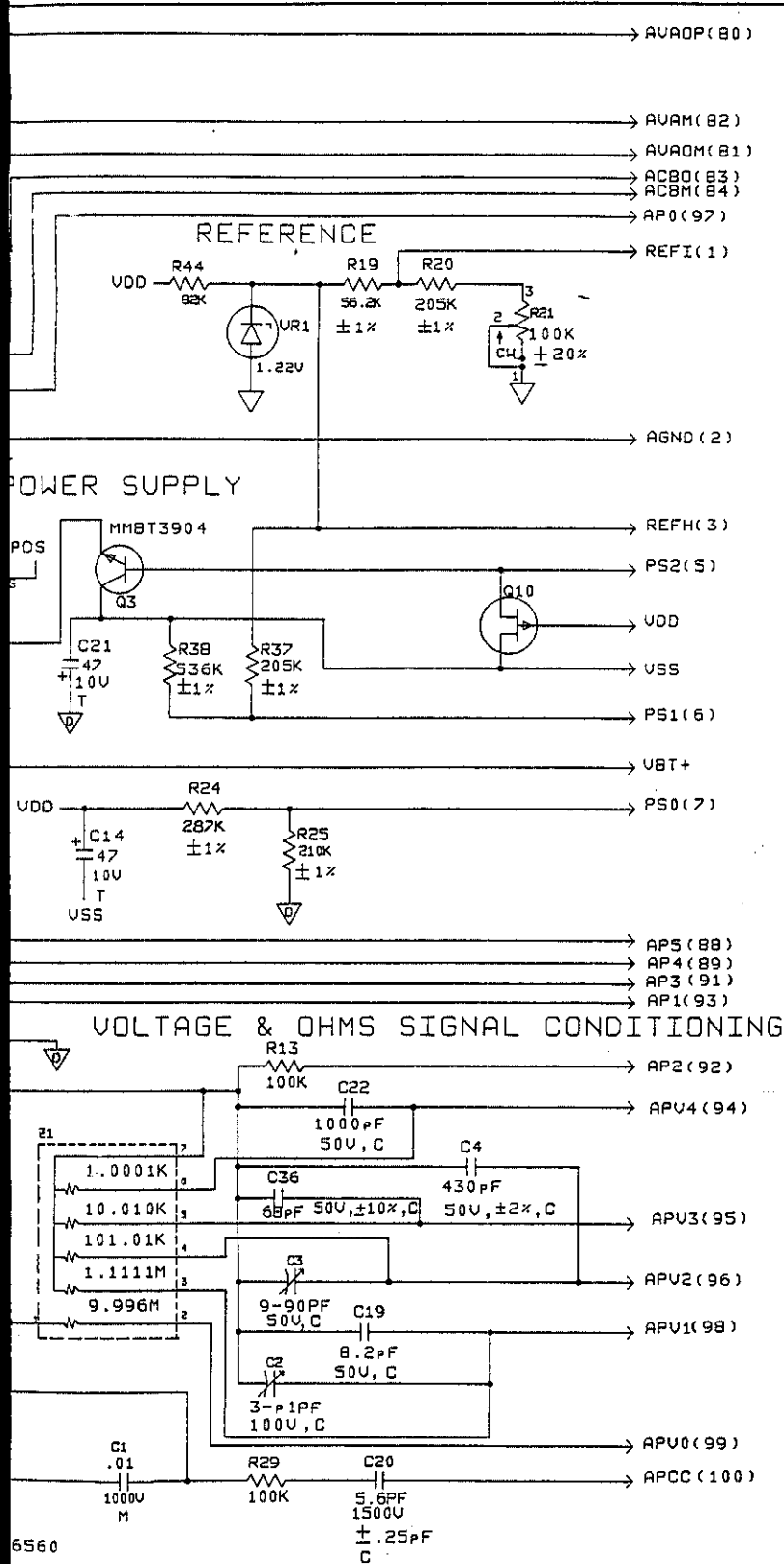
Figure 5-2. Fluke 85





FIG. 5-2a  
SHT. 2 OF 3





ROTARY SWITCH INFORMATION

POSITION	FRONT	REAR	TEST ROTARY SWITCH** ± 12 COUNTS
OFF		1-2*	
ACV		1-2	0
DCV	3-4	1-2	32
mVDC	3-4		64
Ω	3-4-5		96
↯	11-12		
↯	4-6	1-2	128
mA/A	11-12		
		9-8	160
		1-2*	
μA	3-4*	10-9	192

\* CONNECTION NOT USED FOR OPERATION  
\*\* POWER UP OPTION  
PRESS RANGE BUTTON DOWN FOR 2 SECS WHILE TURNING ON METER

85-1201  
(1 of 2)

Figure 5-2. Fluke 85 A1 Main PCA (cont)

FIG. 5-26  
SHT. 1 OF 3

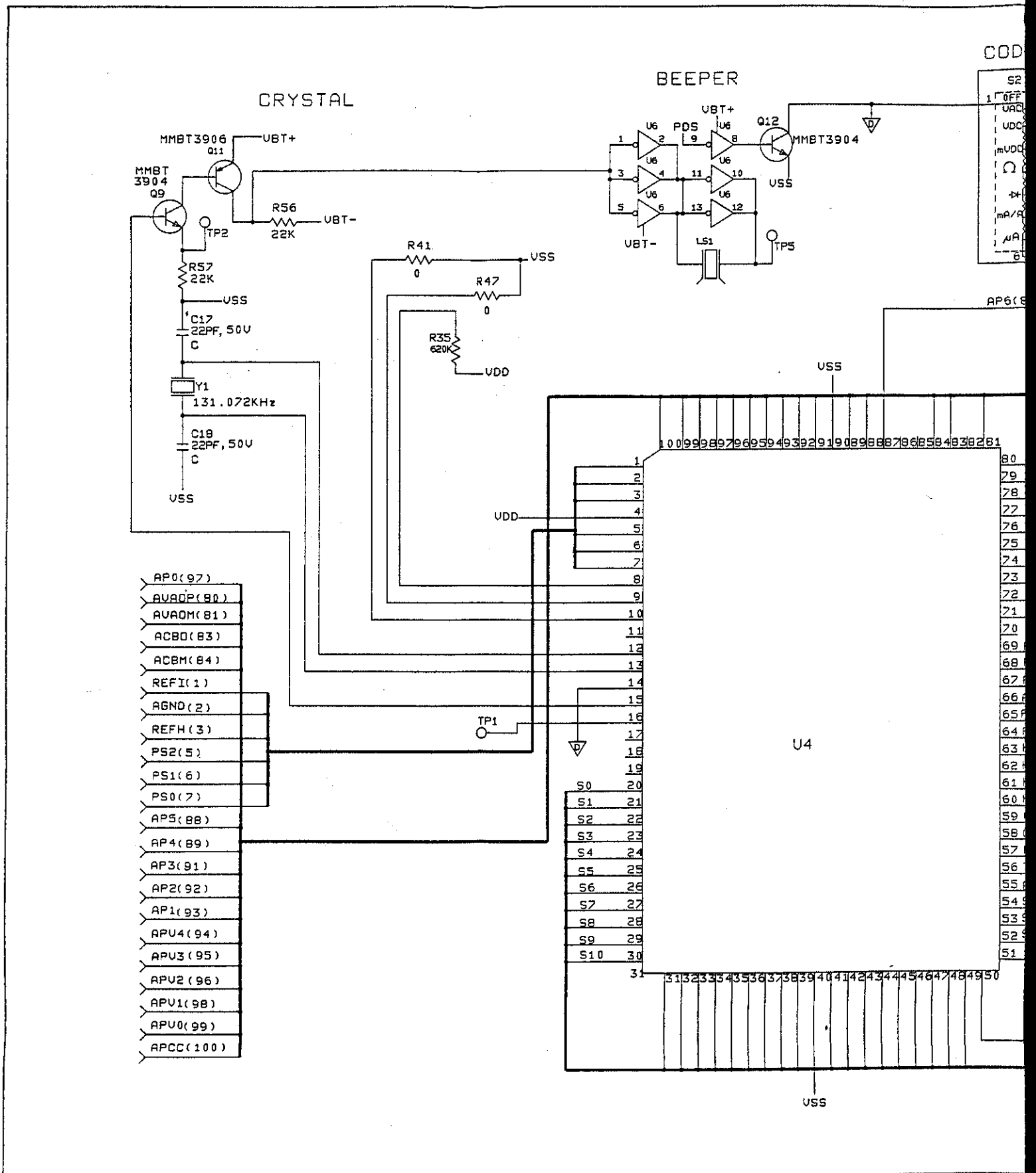


FIG. 5-2 b  
 SHT. 2 OF 3

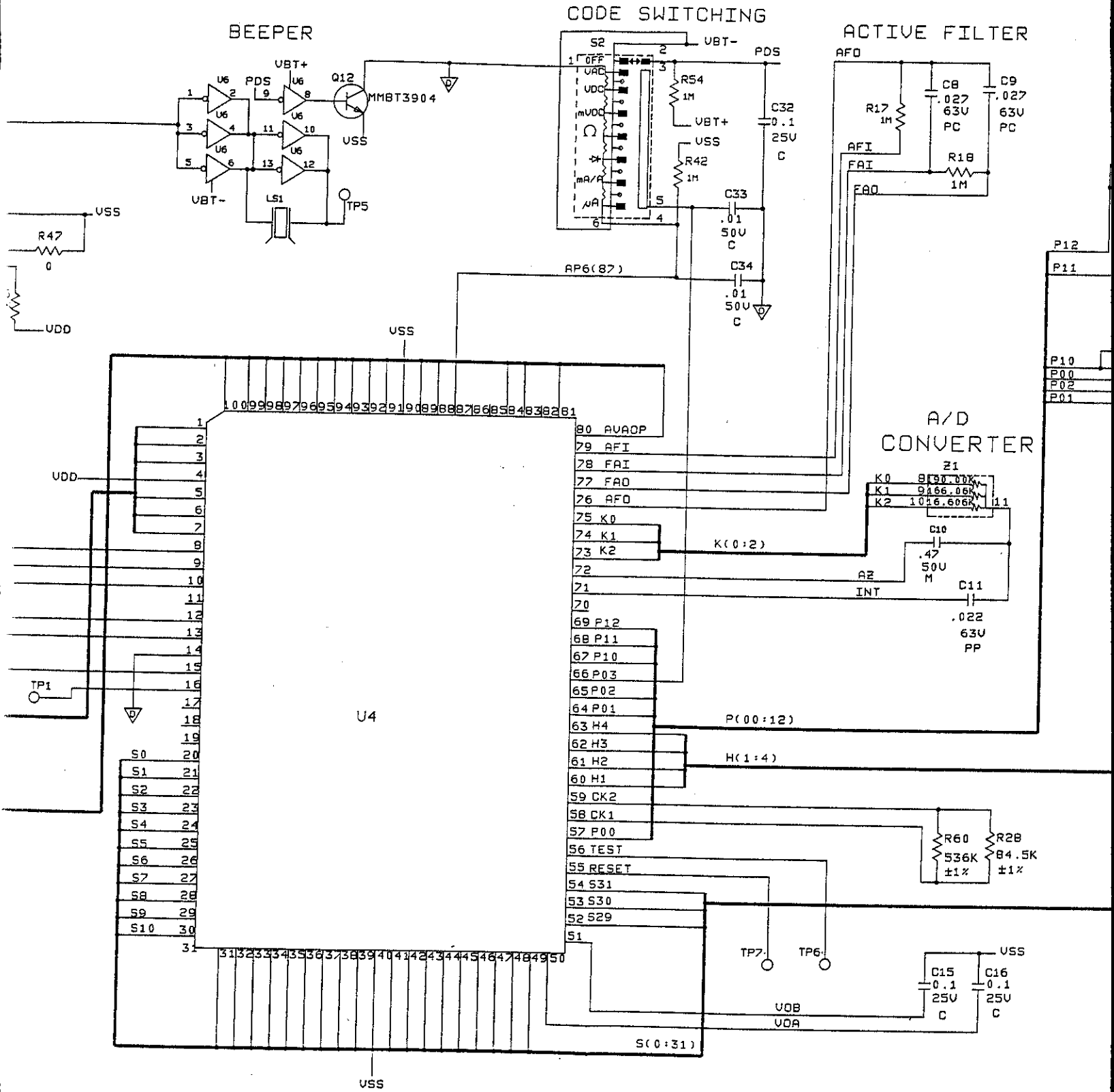
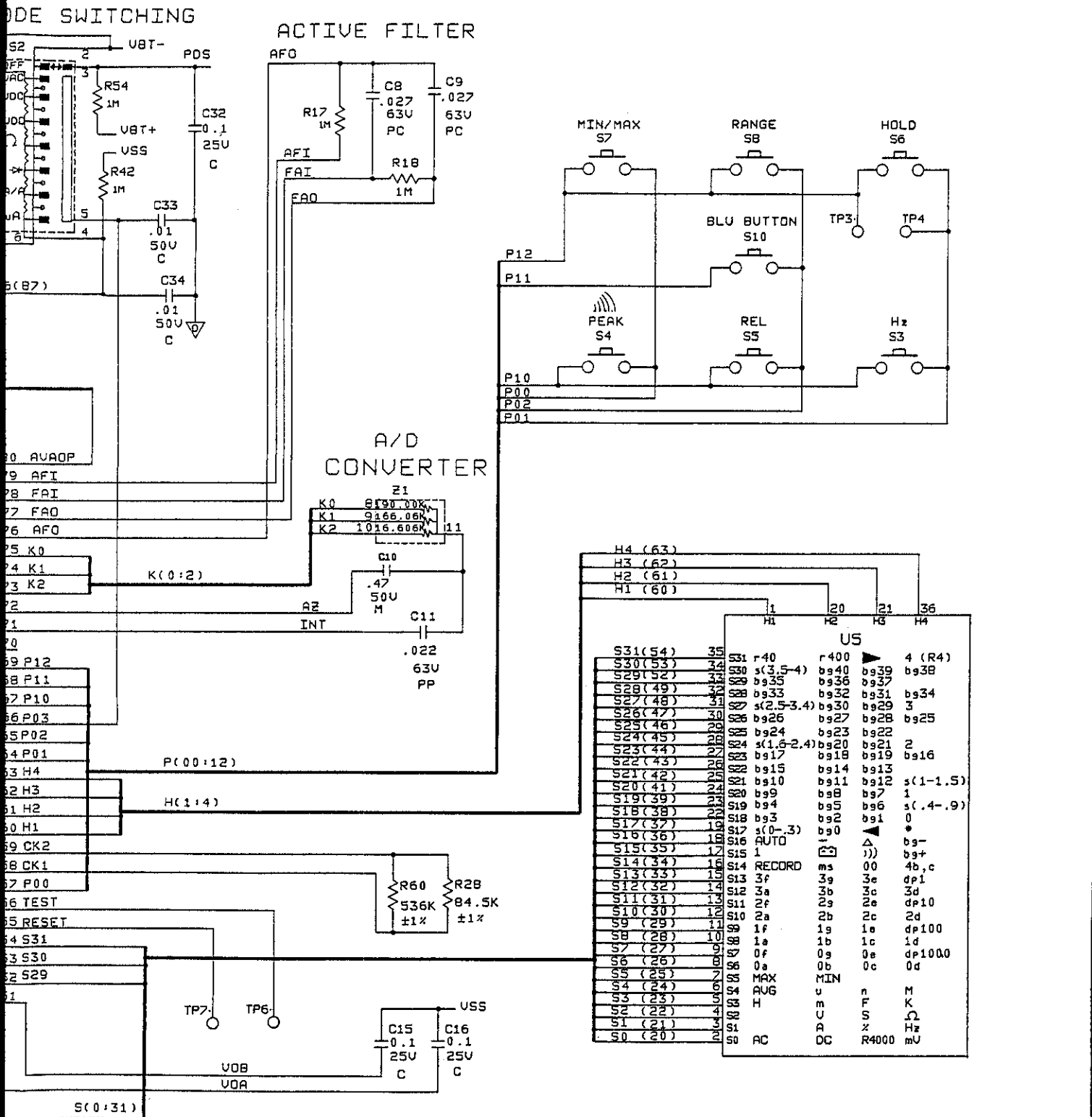


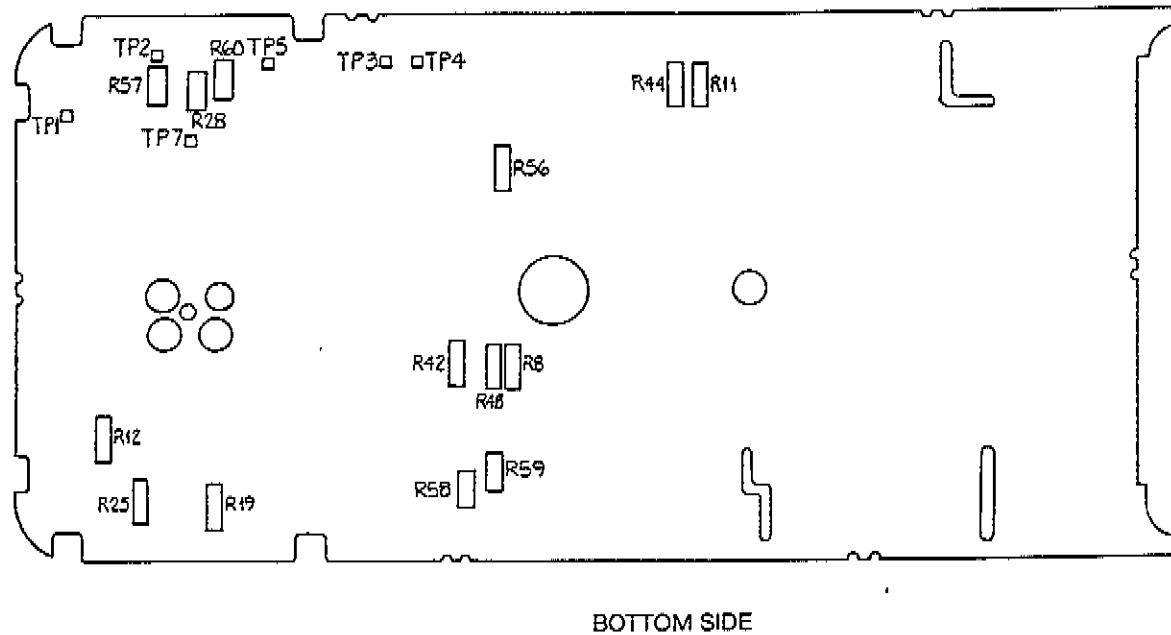
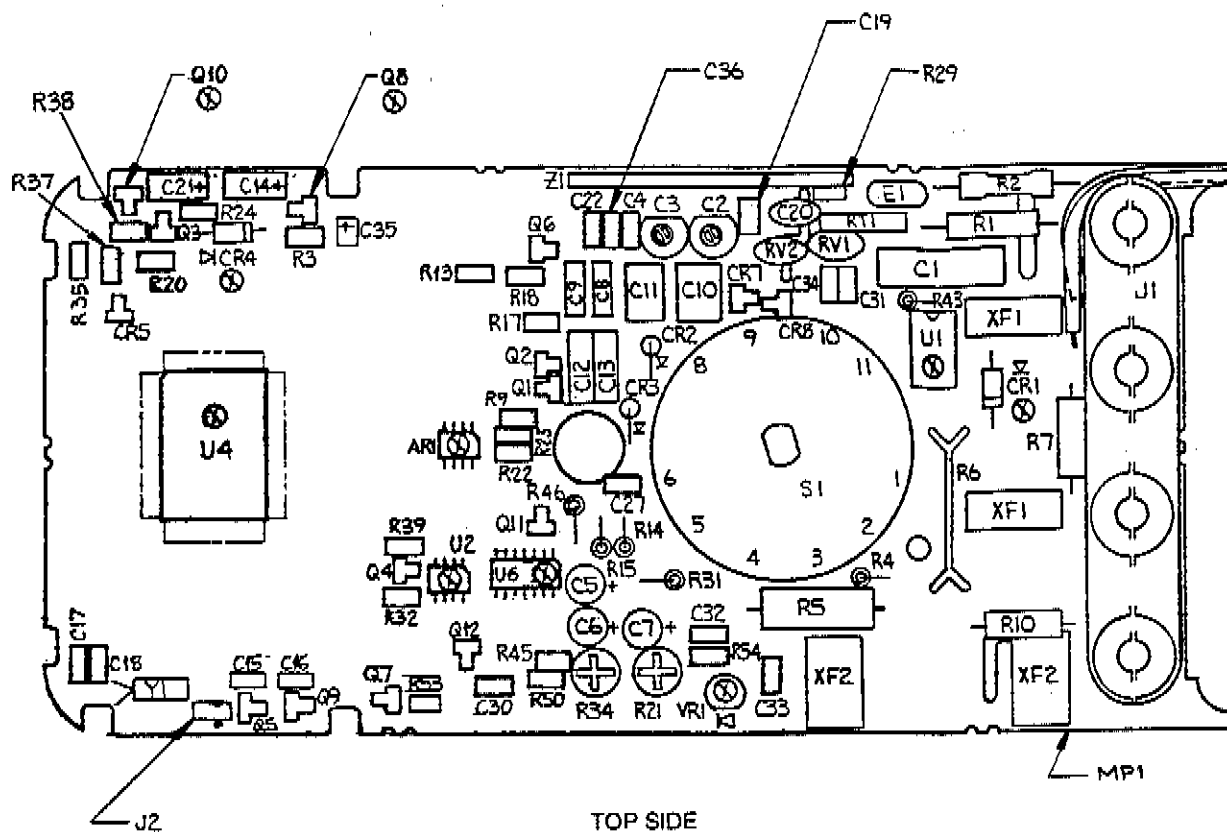
Figure 5-2. Fluke 85 A1 Main PCA (cont)



85-1201  
(2 of 2)

Figure 5-2. Fluke 85 A1 Main PCA (cont)

FIG. 5-3  
SHT. 1 OF 2



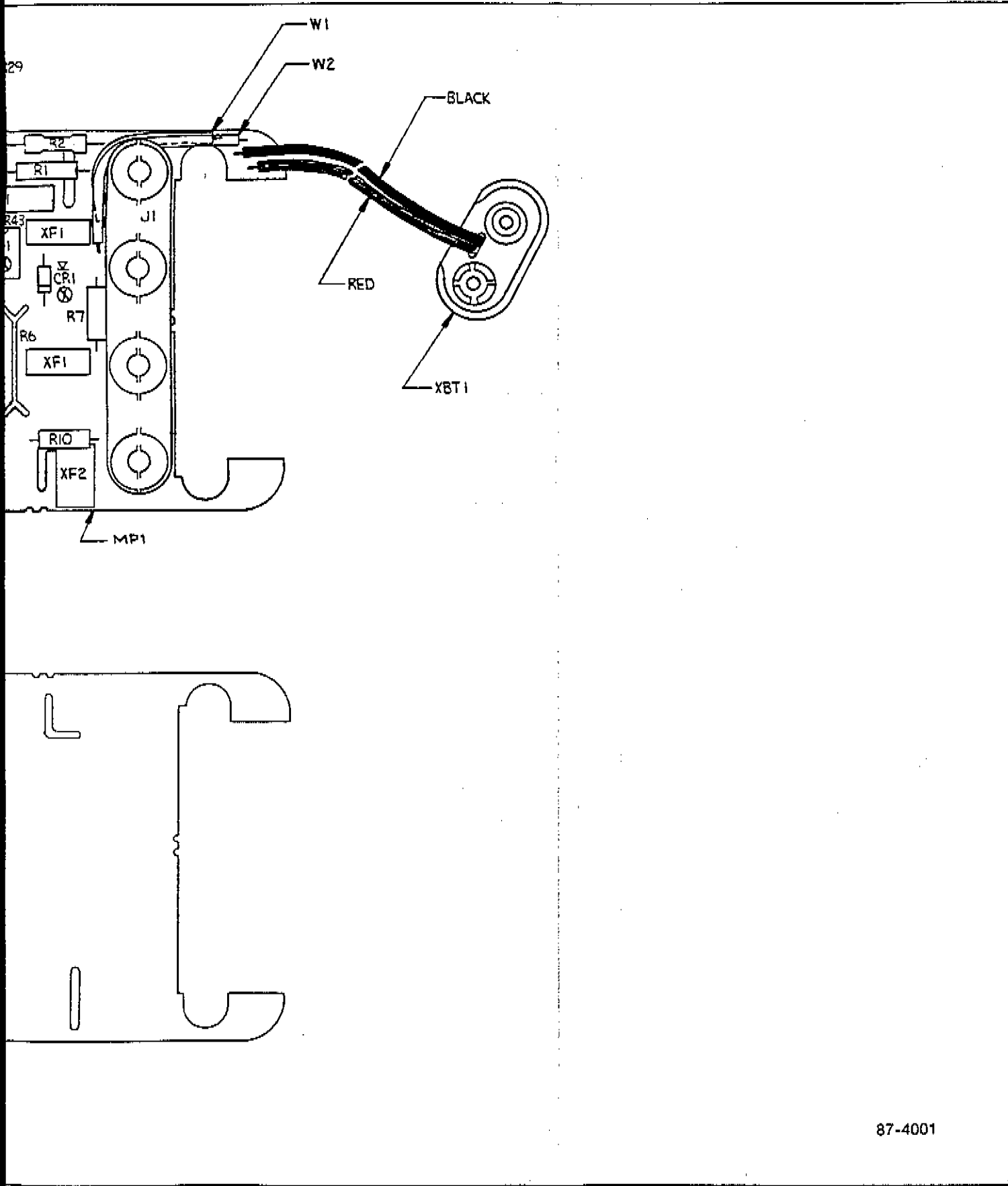


Figure 5-3. Fluke 87 A1 Main PCA



FIG. 5-3a  
 SHE. 2 OF 3

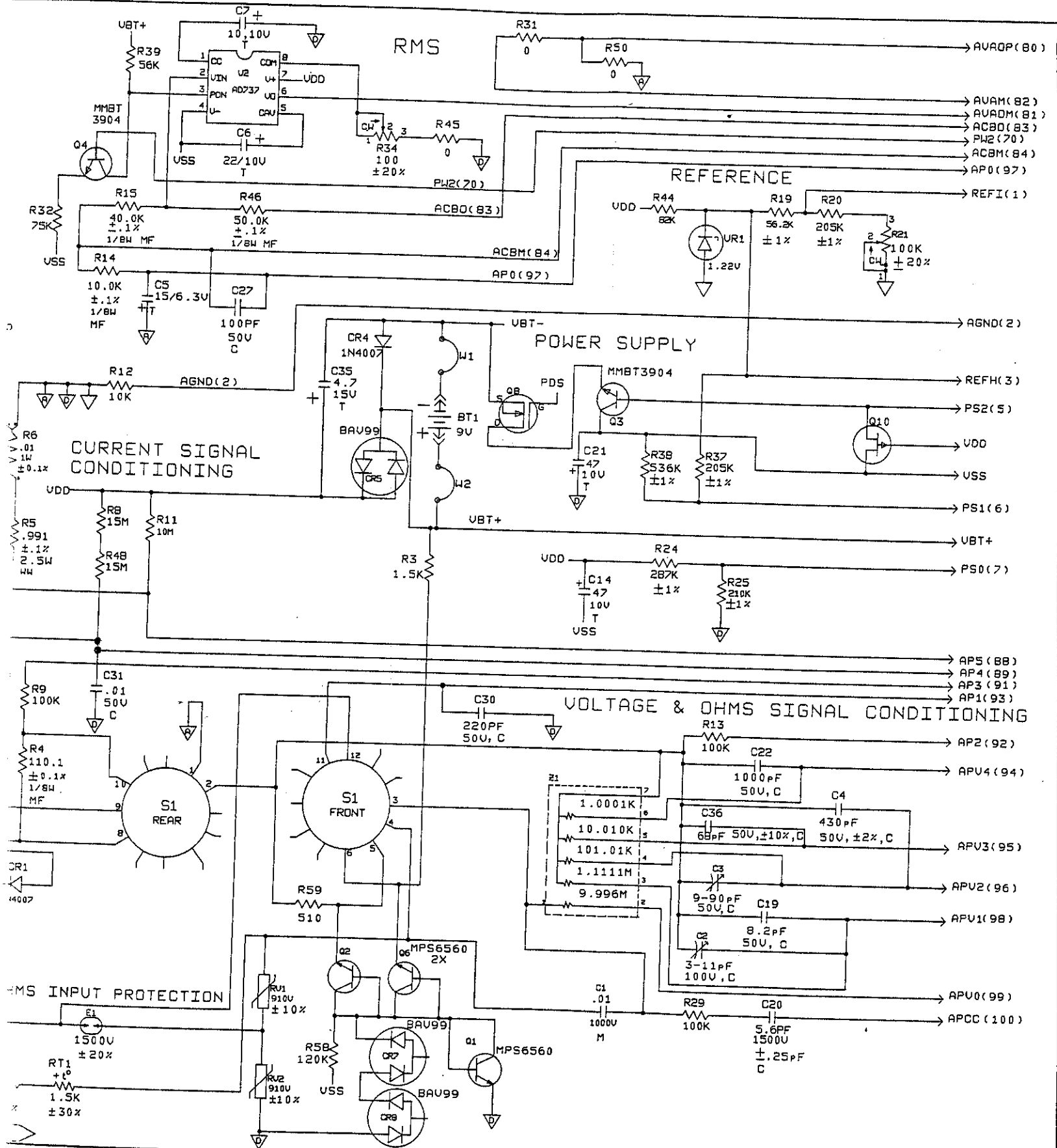
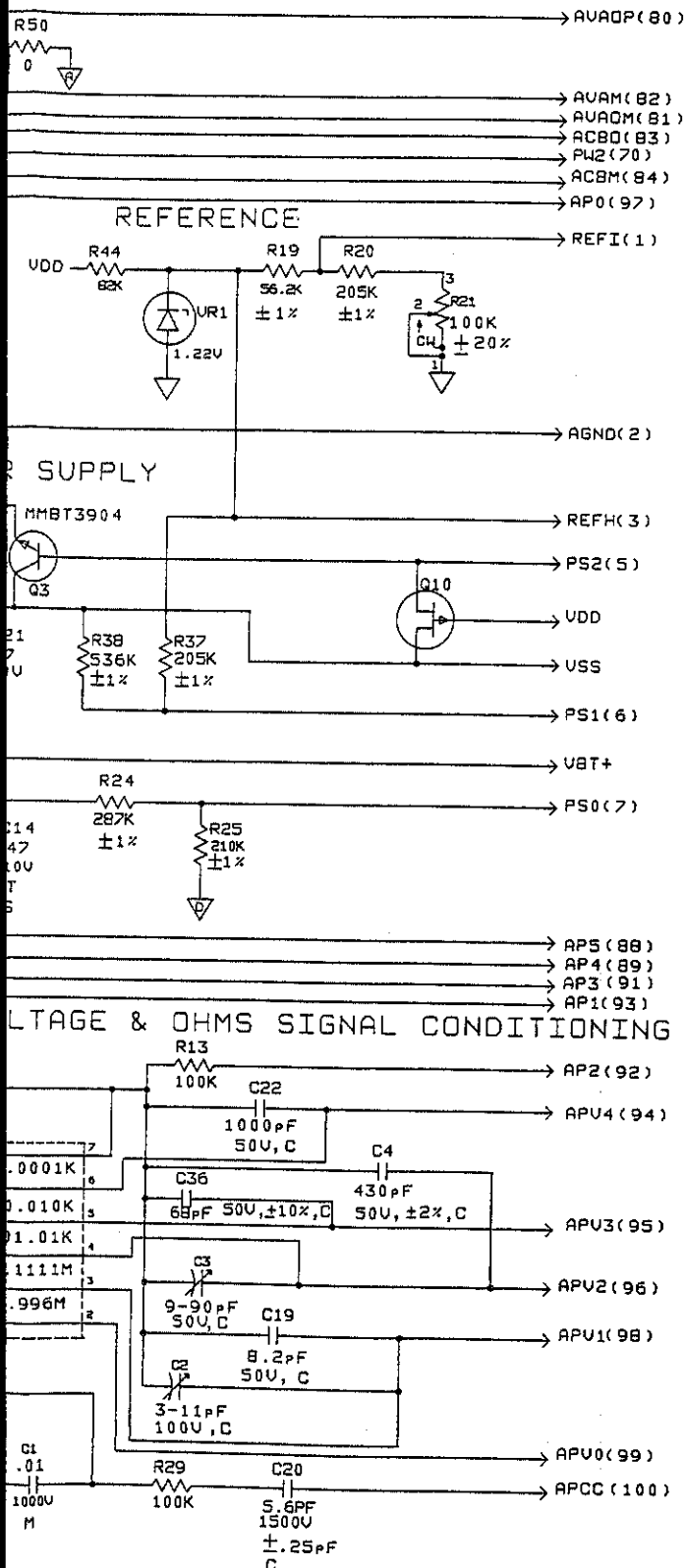


Figure 5-3. Fluke 87 A1 Main PCA (cont)



NOTES: UNLESS OTHERWISE SPECIFIED.

1. ALL CAPACITANCES ARE IN MICROFARADS. TANTALUMS ARE  $\pm 20\%$ . ALL OTHERS ARE  $\pm 10\%$ .
2. ALL RESISTANCES ARE IN OHMS. ALL RESISTORS ARE 1/8W,  $\pm 5\%$  CERMET.  $\pm .25\%$  &  $\pm 1\%$  RESISTORS ARE 1/8W.

4 R1 IS A FUSIBLE RESISTOR. TO ENSURE SAFETY, USE EXACT REPLACEMENT ONLY.

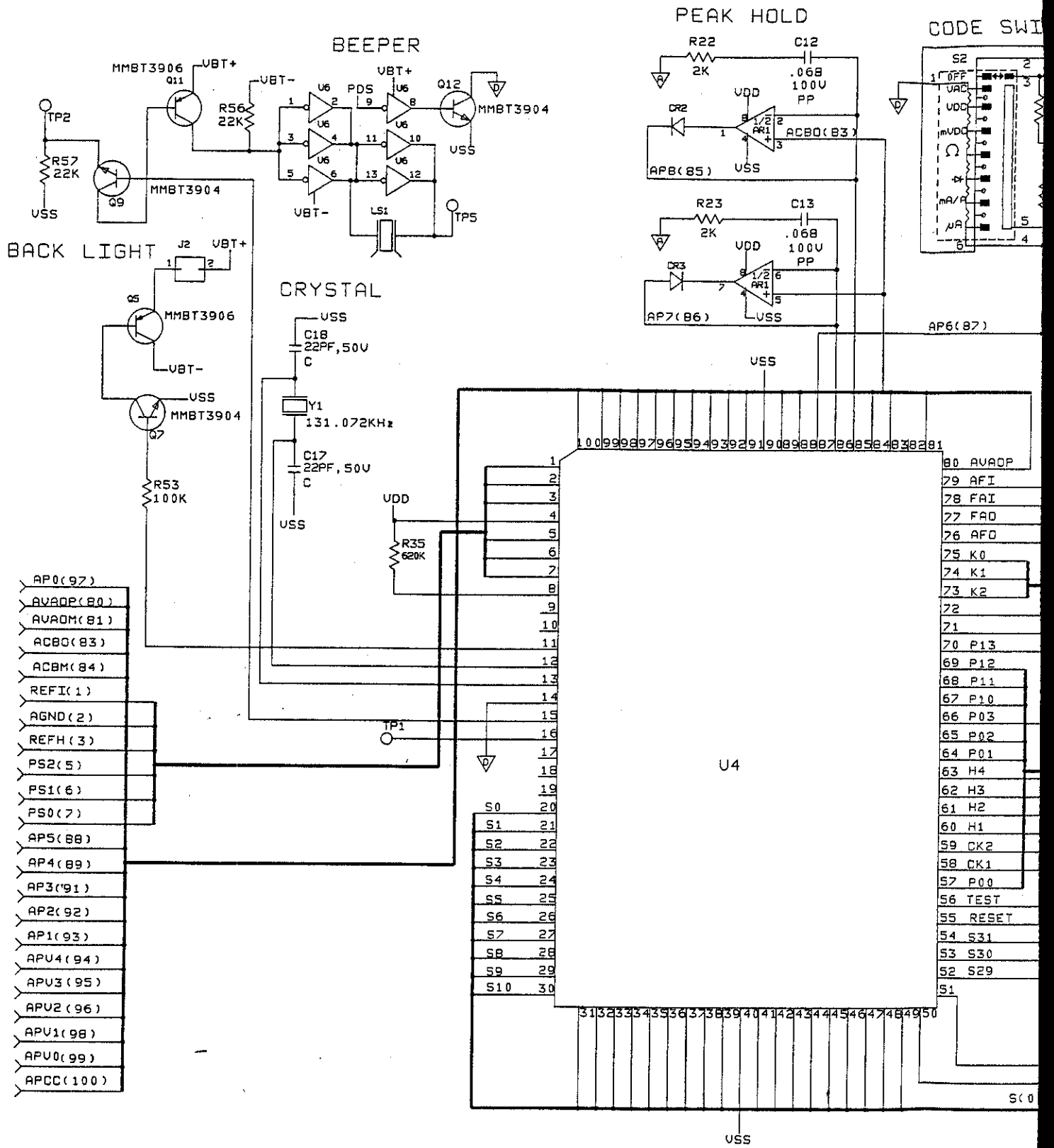
ROTARY SWITCH INFORMATION

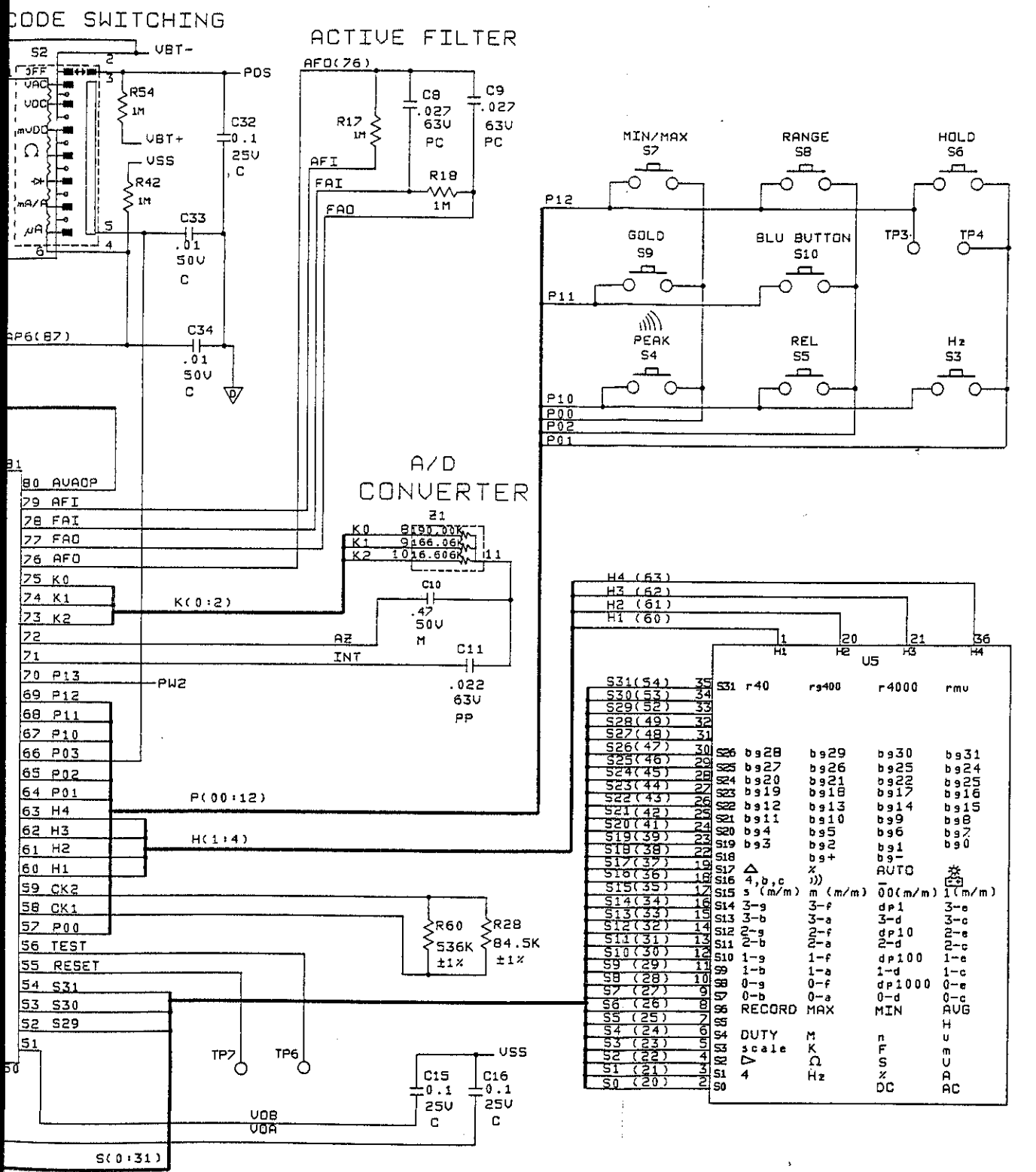
POSITION	FRONT	REAR	TEST ROTARY SWITCH** # 12 COUNTS
OFF		1-2*	
ACV		1-2	0
DCV	3-4	1-2	32
mVDC	3-4		64
$\Omega$	3-4-5		96
$\nabla$	11-12		
	3-4-5	11-12	96
mA/A	4-6	1-2	128
	11-12		
		9-8	160
		1-2*	
$\nabla$ A	3-4*	10-9	192

\* CONNECTION NOT USED FOR OPERATION  
\*\* POWER UP OPTION  
PRESS RANGE BUTTON DOWN FOR 2 SECS WHILE TURNING ON METER

Figure 5-3. Fluke 87 A1 Main PCA (cont)

FIG. 5-3b  
SHT. 1 OF 2





87-1201  
(2 of 2)

Figure 5-3. Fluke 87 A1 Main PCA (cont)

Fig 5-4  
 Skt 10b2  
 80 Series Service

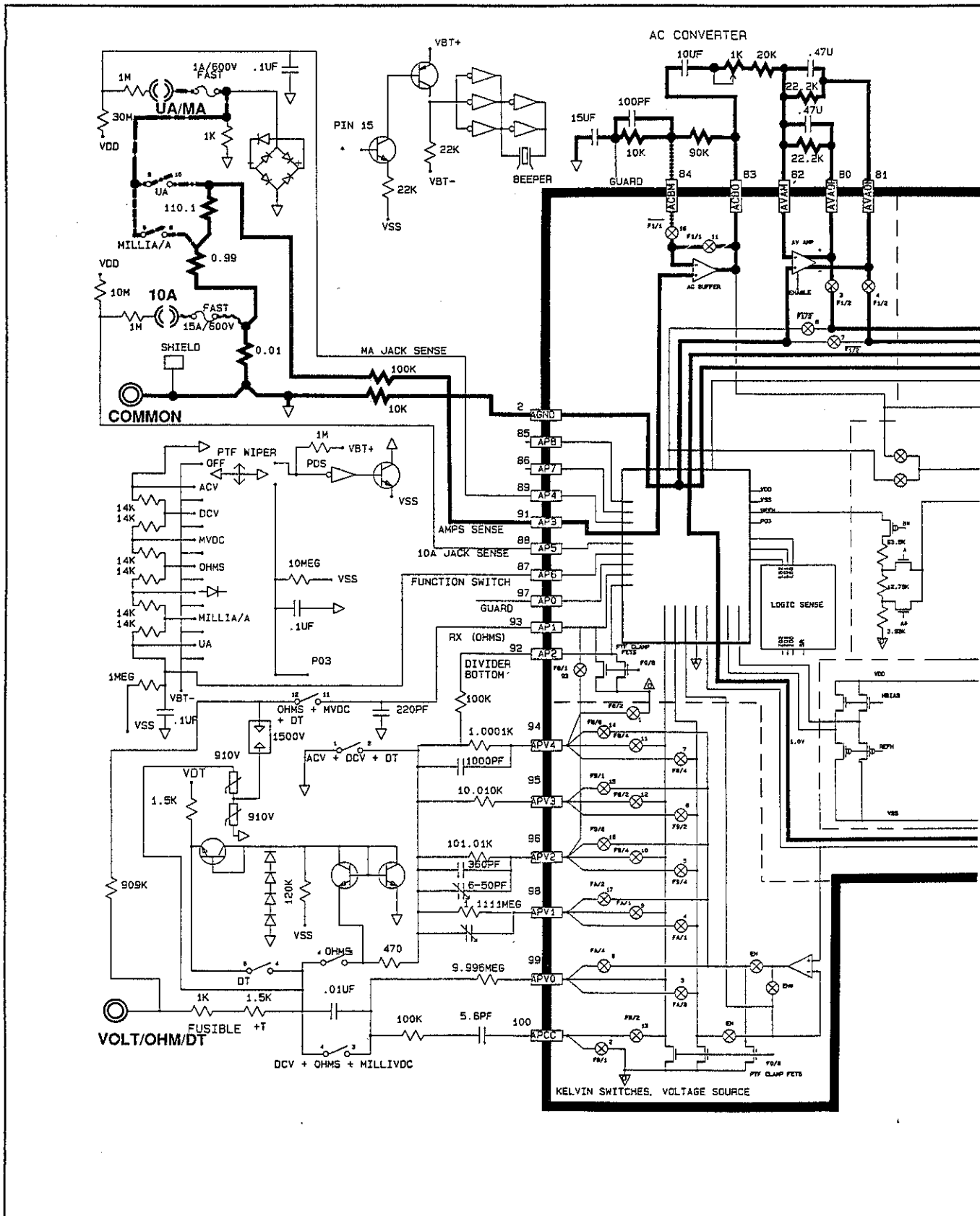
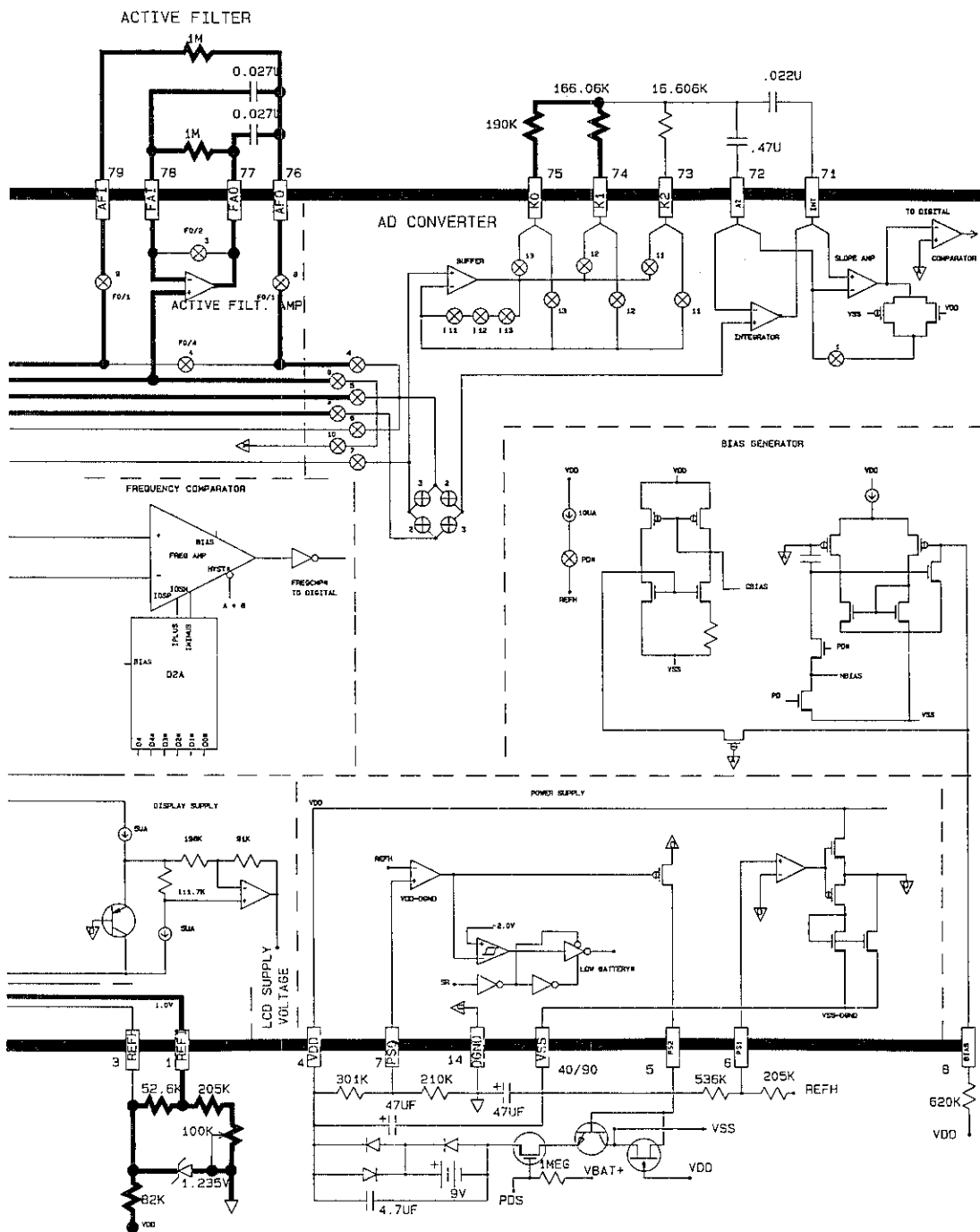


Figure 5-4. AC Current Signal Flow

Fig 5-4  
Skt 2 of 2



**AC CURRENT:**

4000 uA, 400.0 uA, 40.00 mA, 400.0 mA	—————
4000 uA, 400.0 uA	—————
40.00 mA, 400.0 mA	—————
4000 mA, 10.00A	—————
400.0 uA, 40.00 mA, 4000 mA	—————
4000 uA, 400.0 mA, 10.00A	—————
ALL RANGES	—————

Fig 55  
Skt 1082

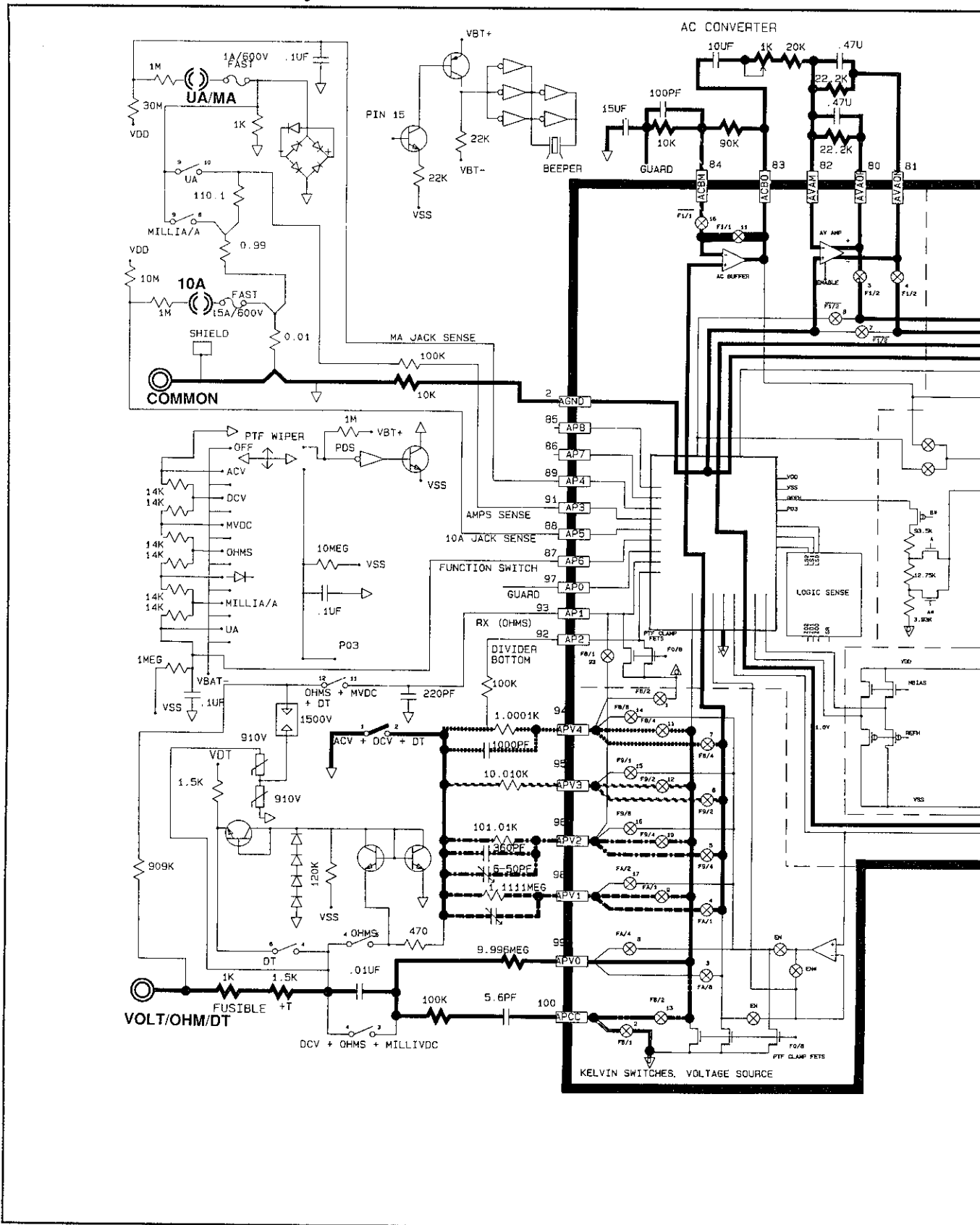


Figure 5-5. AC Volts Signal Flow (Models 83, 85)

Fig 5-5  
Sht 2 of 2

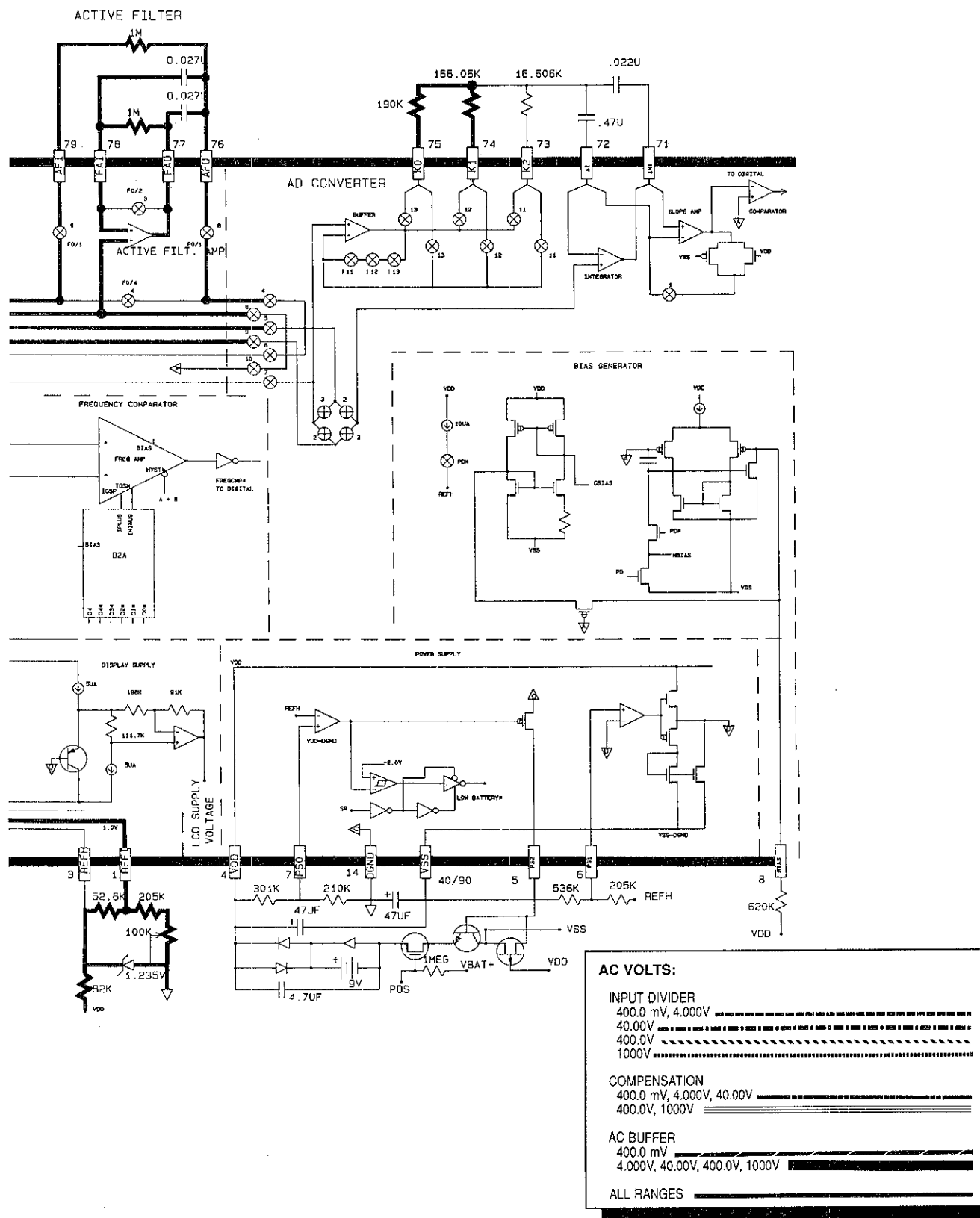
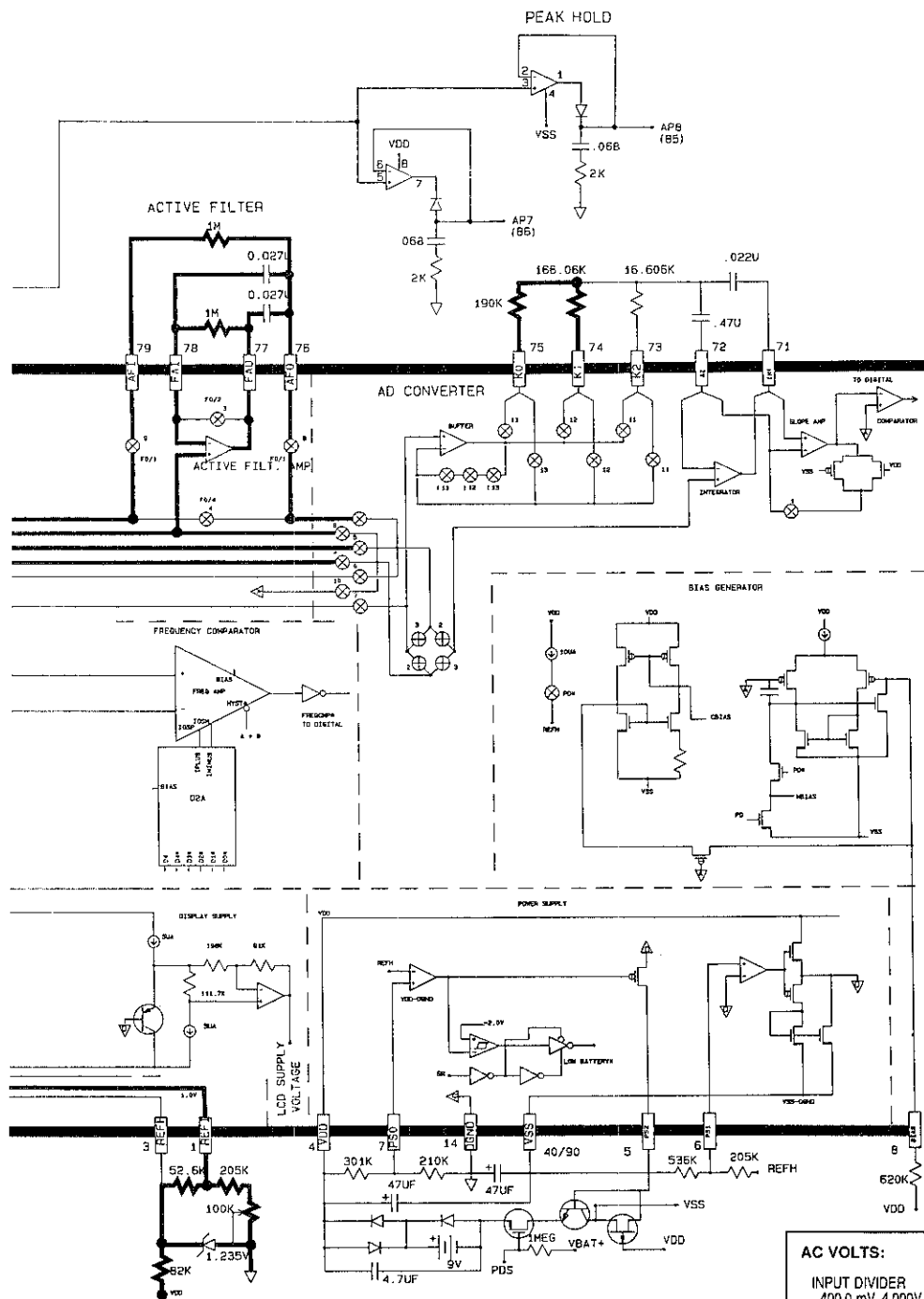




Fig 5-6  
510 282

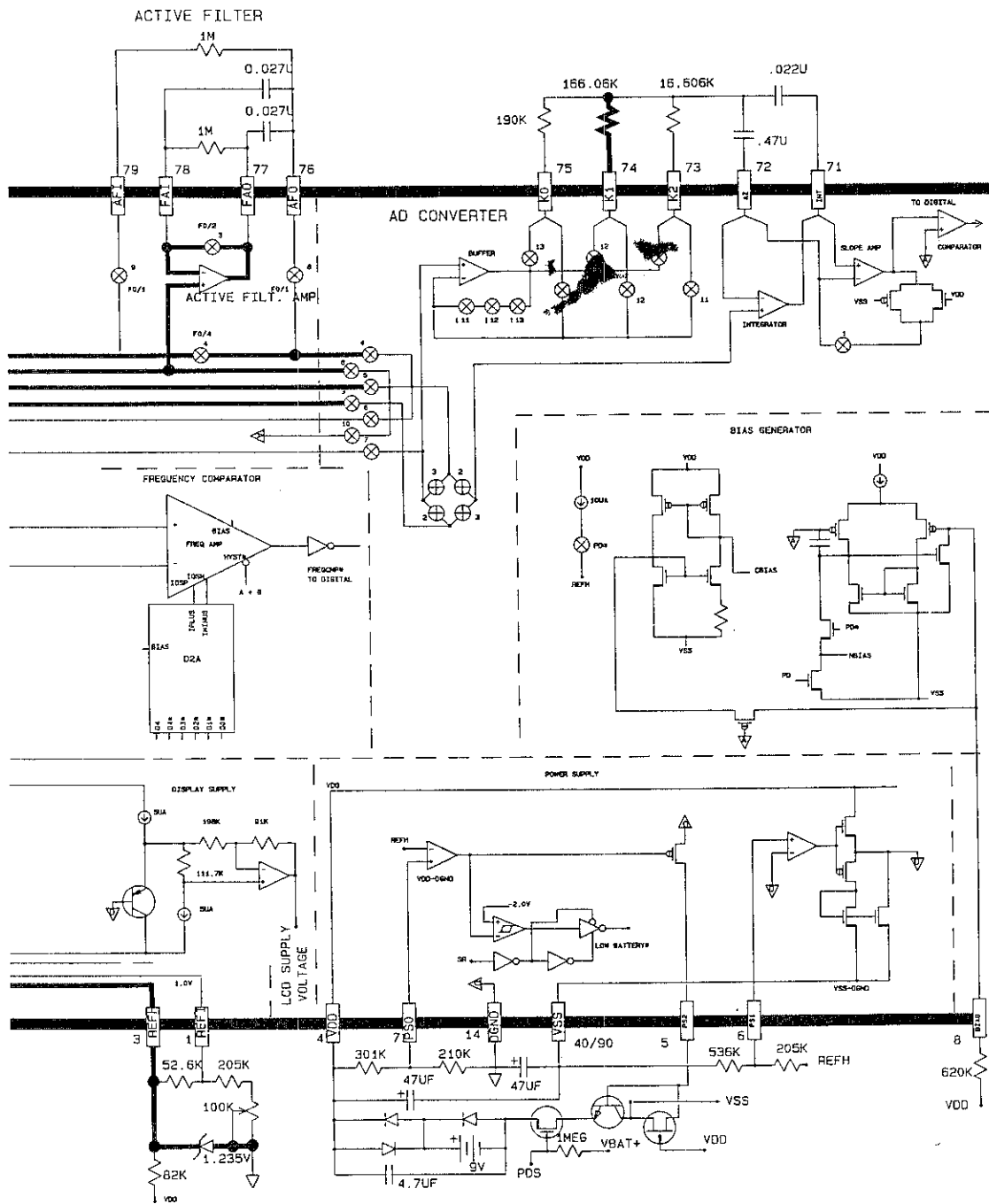


**AC VOLTS:**

<b>INPUT DIVIDER</b>	400.0 mV, 4.000V
	40.00V
	400.0V
	1000V
<b>COMPENSATION</b>	400.0 mV, 4.000V, 40.00V
	400.0V, 1000V
<b>AC BUFFER</b>	400.0 mV
	4.000V, 40.00V, 400.0V, 1000V
<b>ALL RANGES</b>	



Fig 5-7  
Sht 2 of 2

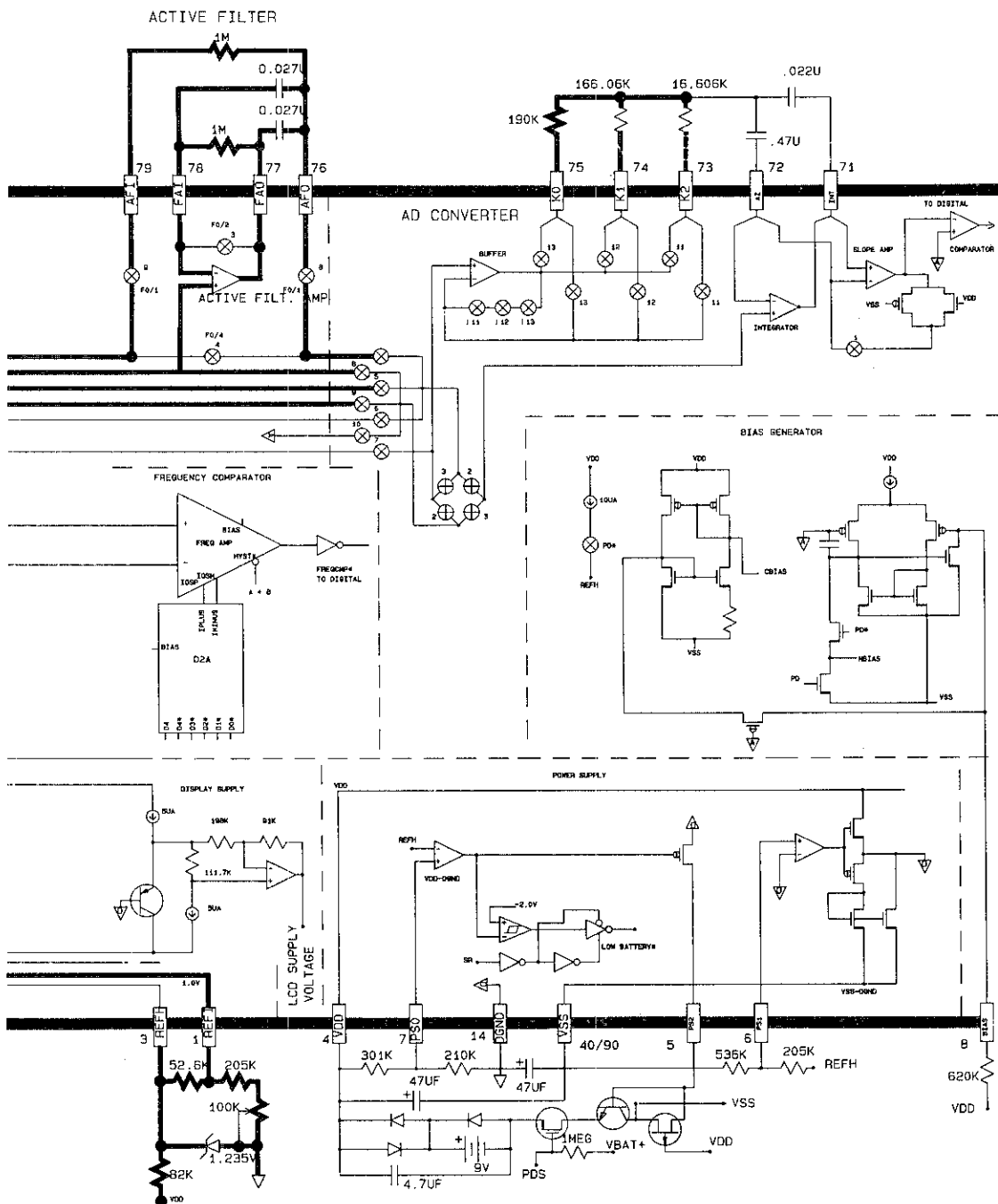


**CAPACITANCE:**

5.00 nF	
0.0500 μF	
0.500 μF	
5.00 μF	
COMMON	



Fig 5-8  
Sht 2 of 2



**DC CURRENT:**

400.0 uA, 4000 uA, 40.00 mA, 400.0 mA	-----
400.0 uA, 4000 uA	-----
4000 uA, 400.0 mA, 10.00A	-----
400.0 uA, 40.00 mA, 4000 mA	-----
40.00 mA, 400.0 mA	-----
4000 mA, 10.00A	-----
ALL RANGES	-----

Fig 5-9  
Sht 1 of 2

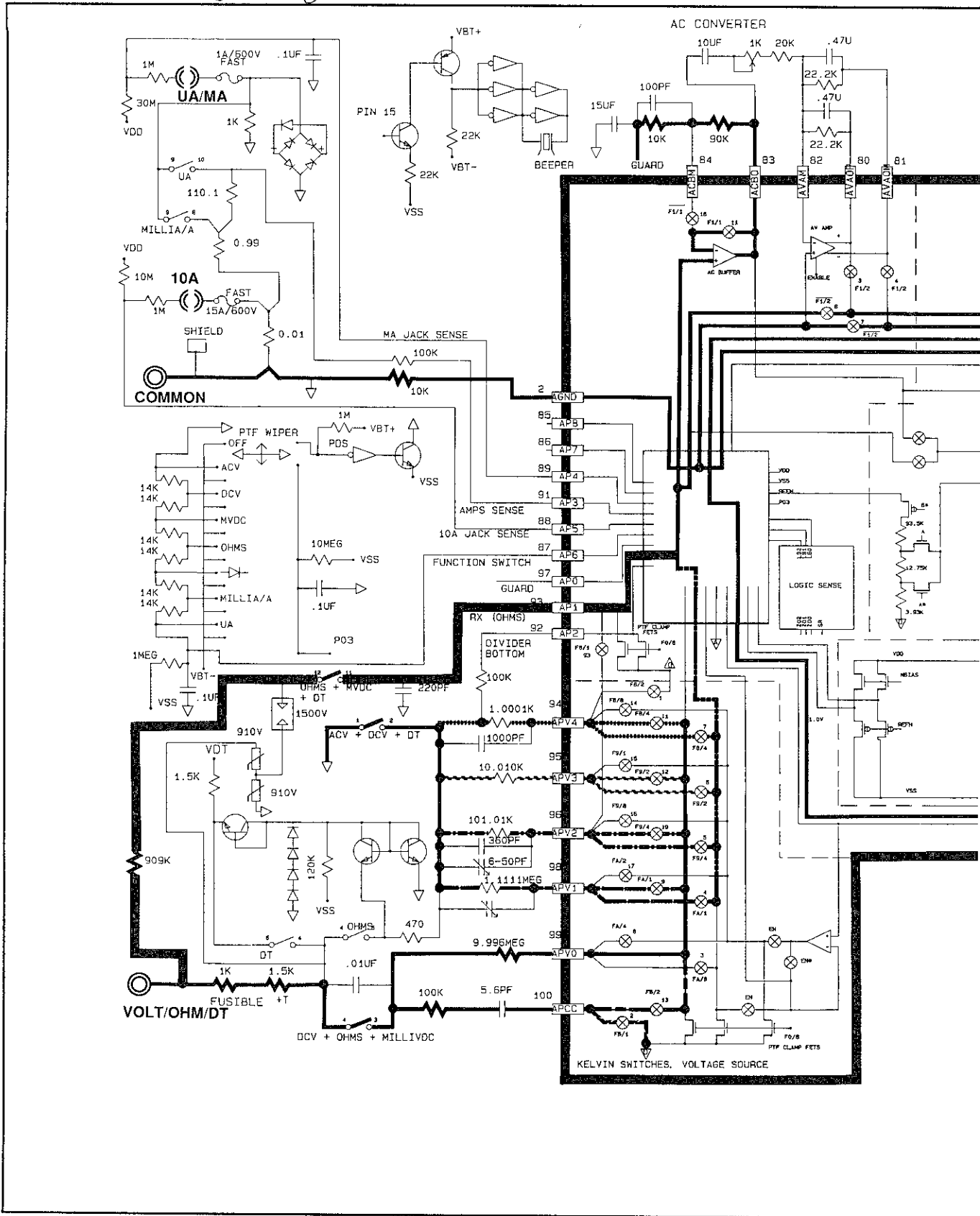


Figure 5-9. DC Millivolts and DC Volts Signal Flow

Fig 5-9  
Sht 2 of 2

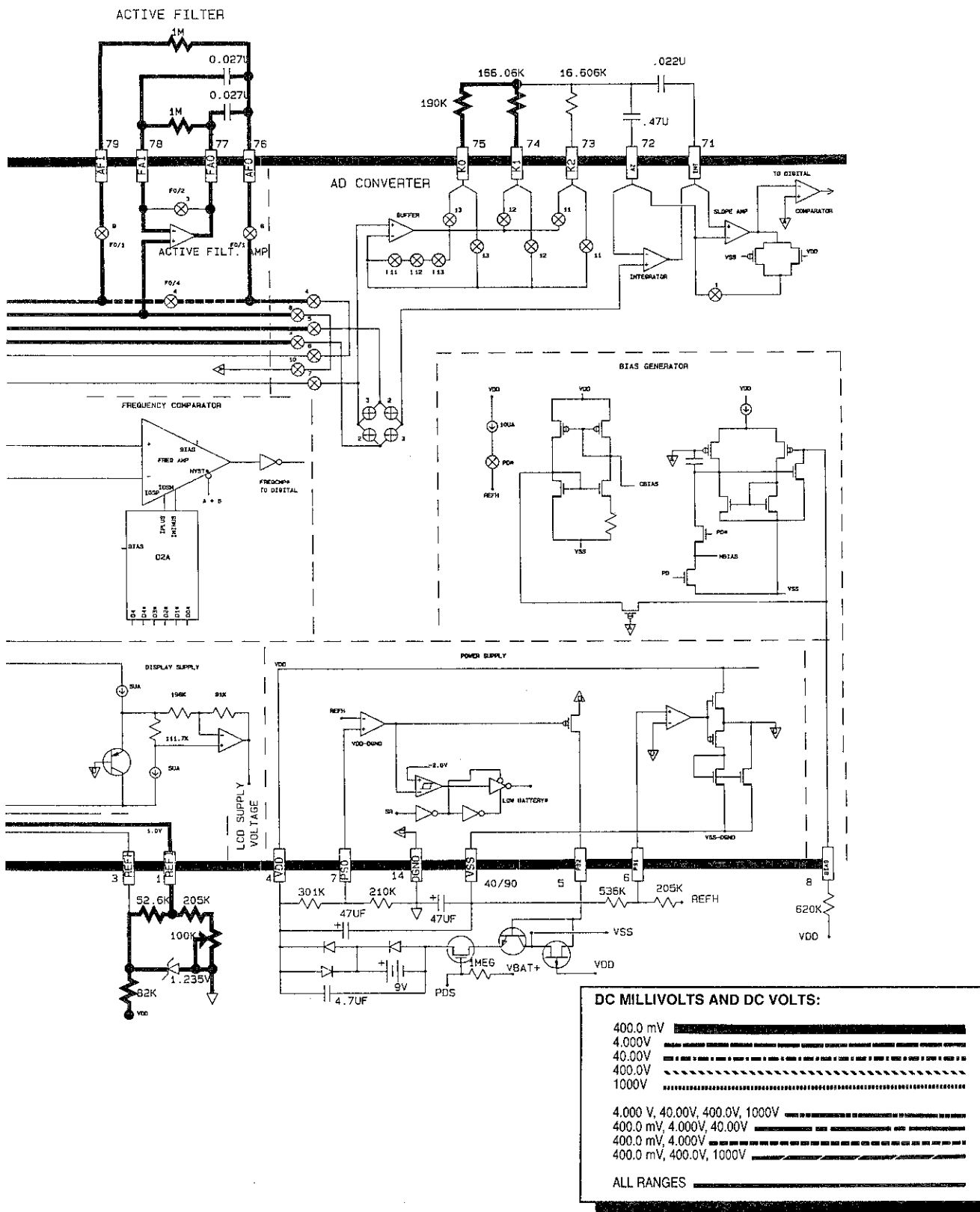


Fig 5-10  
Skt 1062

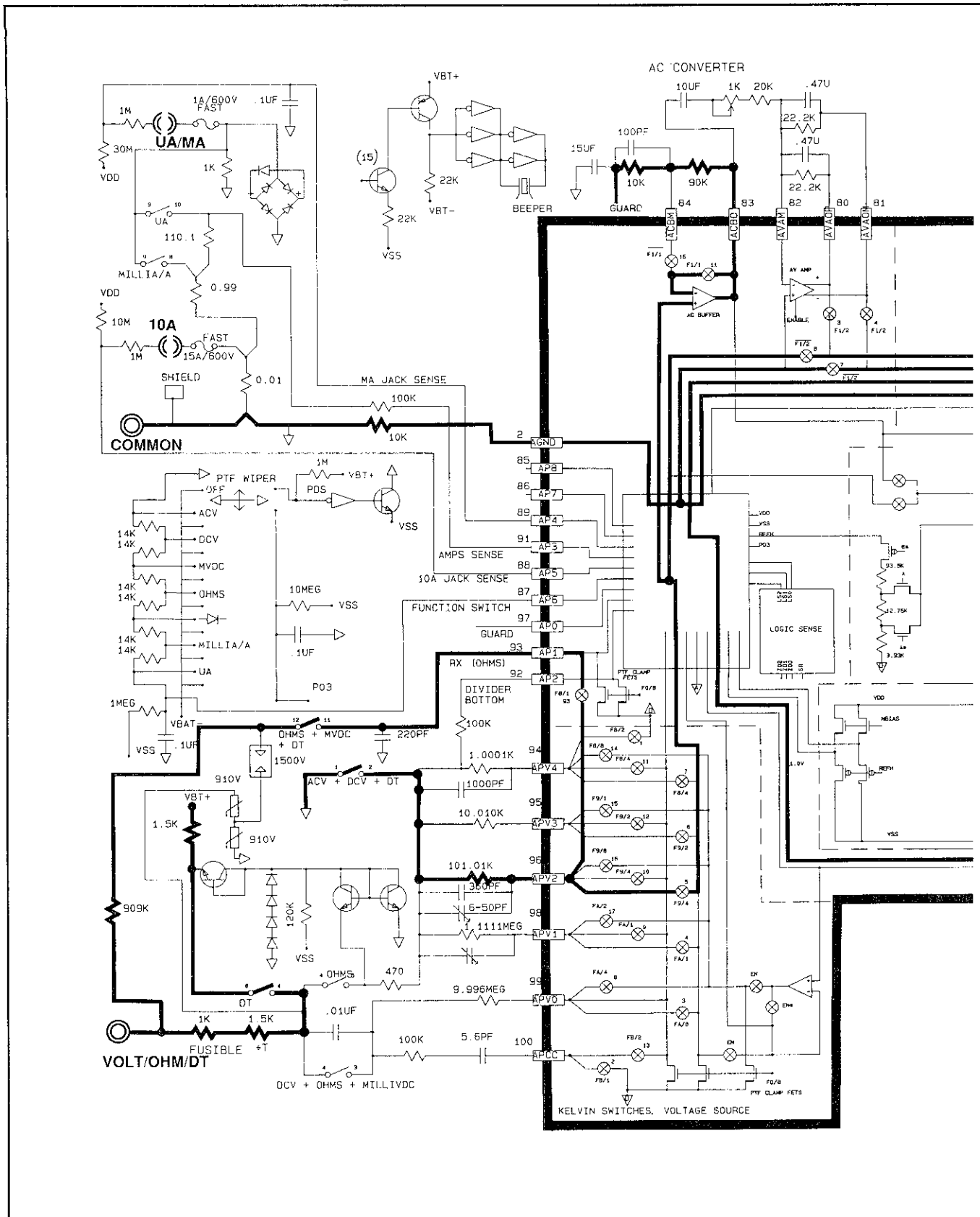


Figure 5-10. Diode Test Signal Flow

Fig 5-10  
Sht 2 of 2

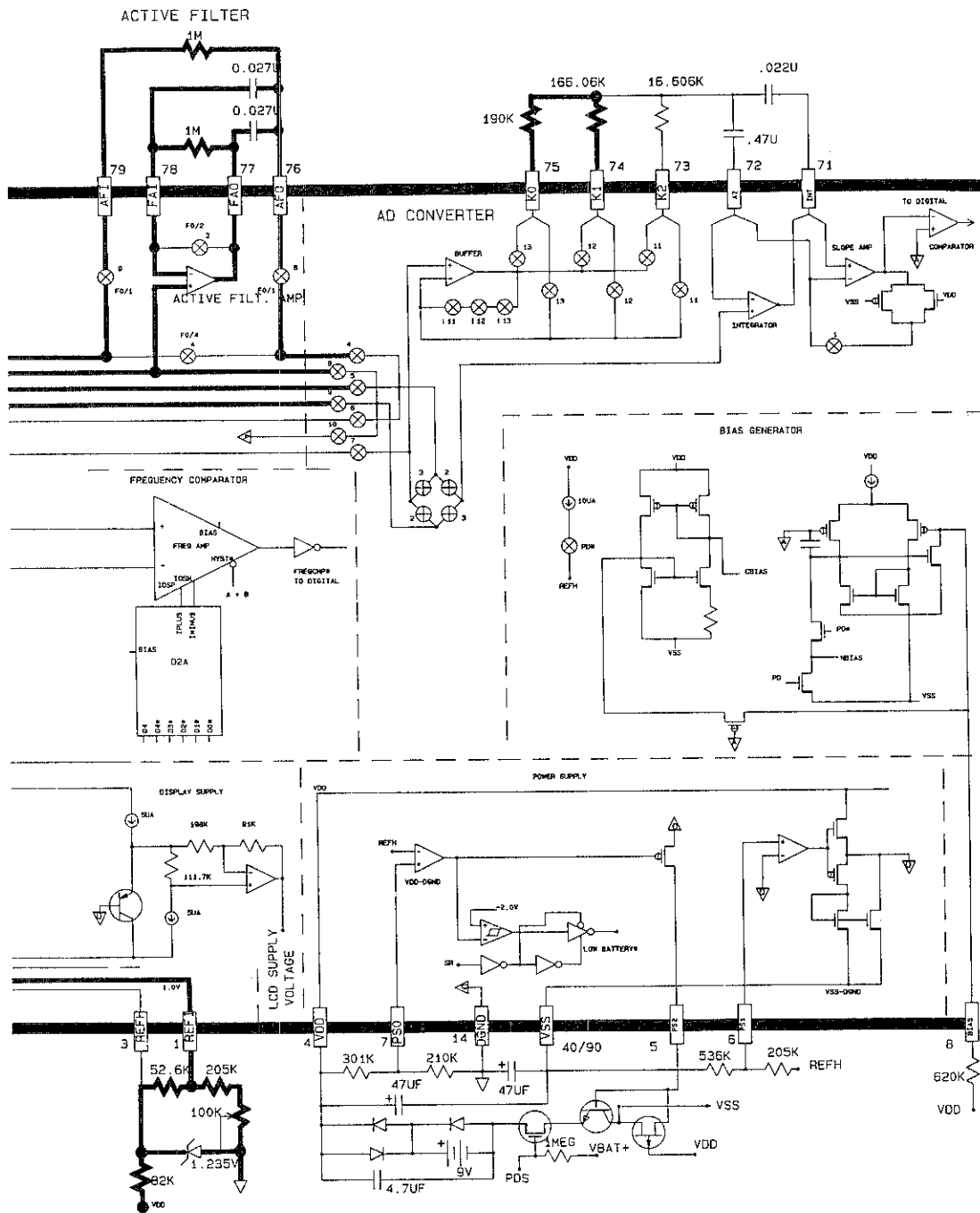


Fig 5-11  
Sht 1 of 2

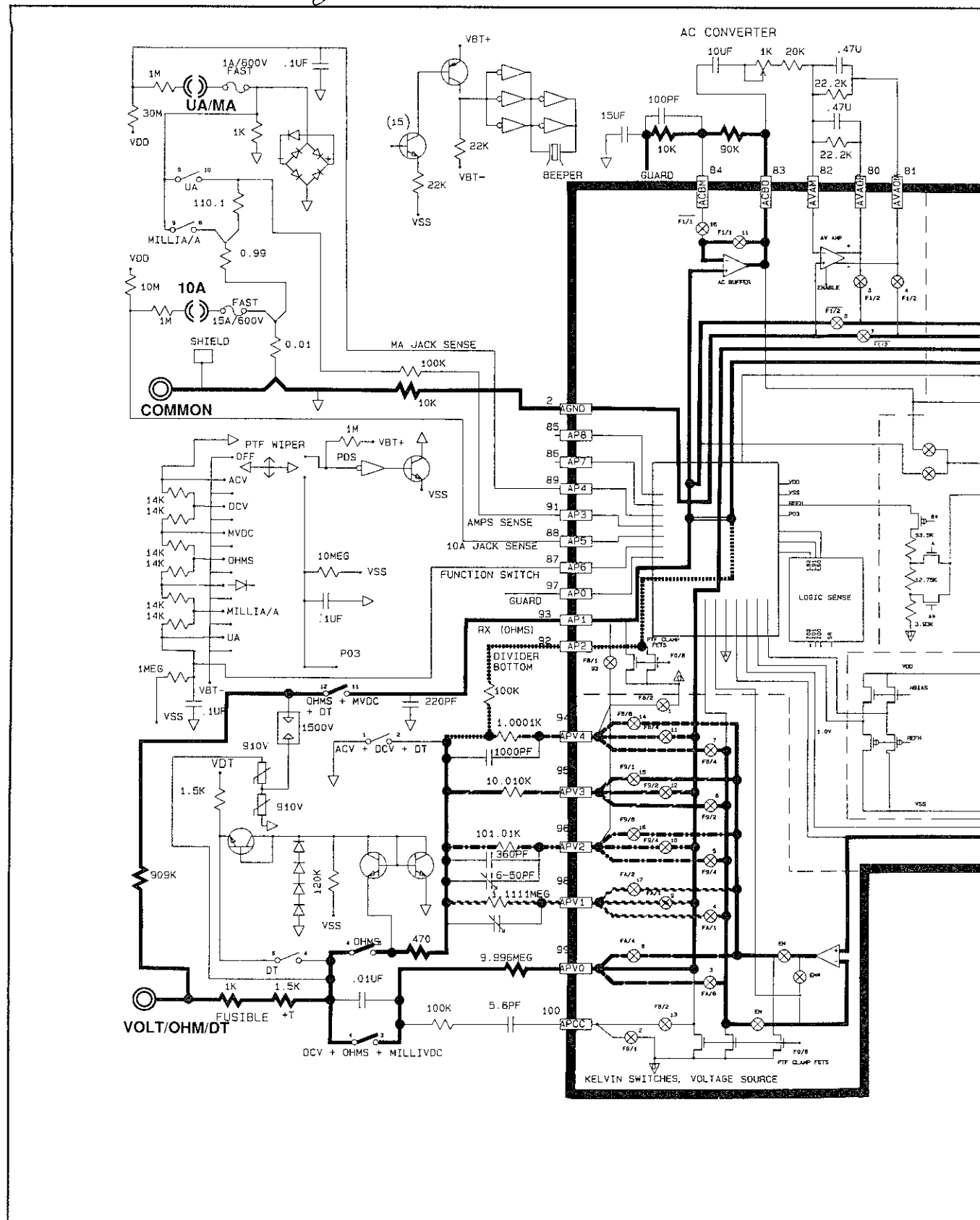


Figure 5-11. Ohms Signal Flow



Fig 5-11  
SHE 282

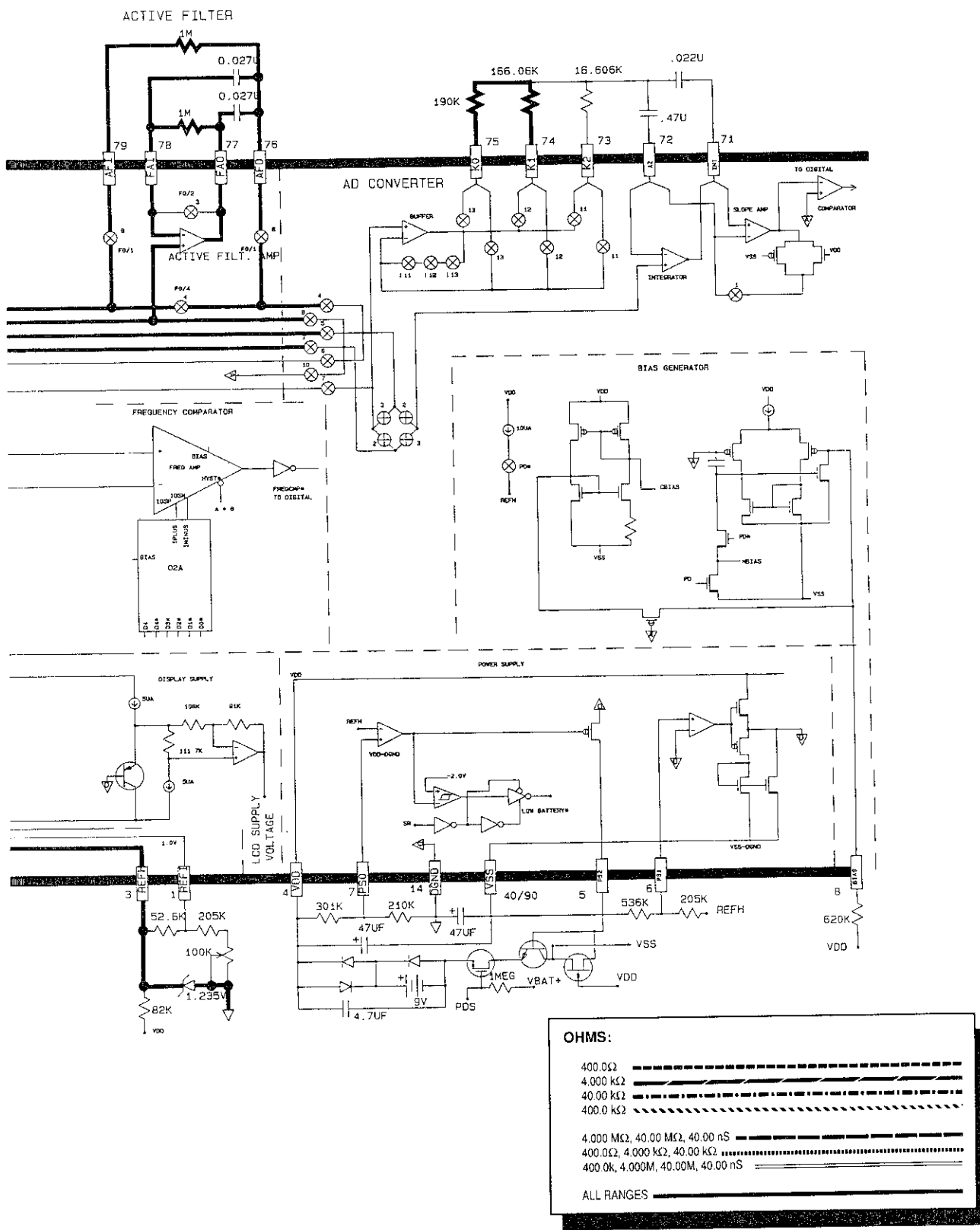


Fig 5-12  
SHE 2 of 2

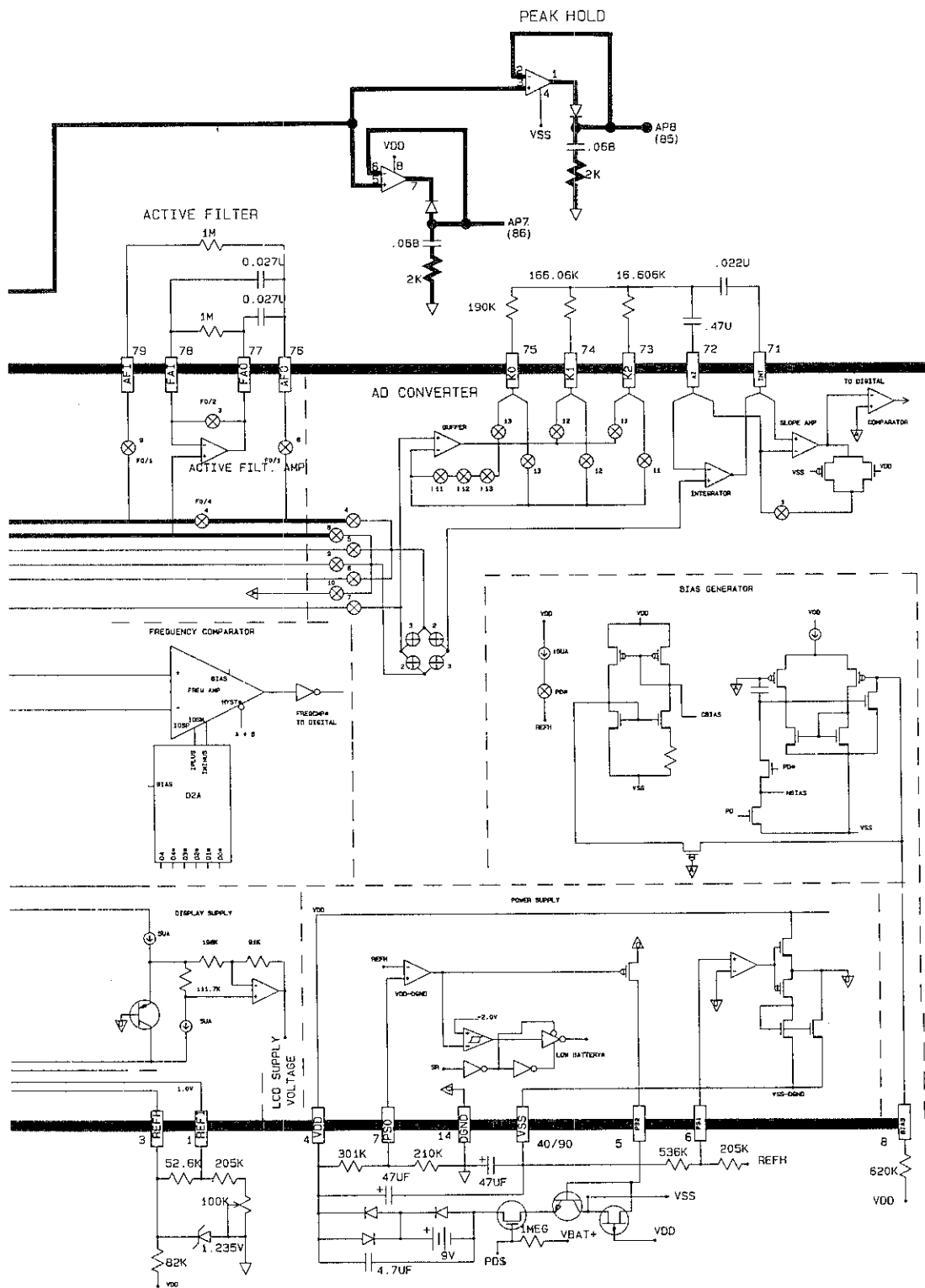


Fig 5-13  
Sht 1 of 2

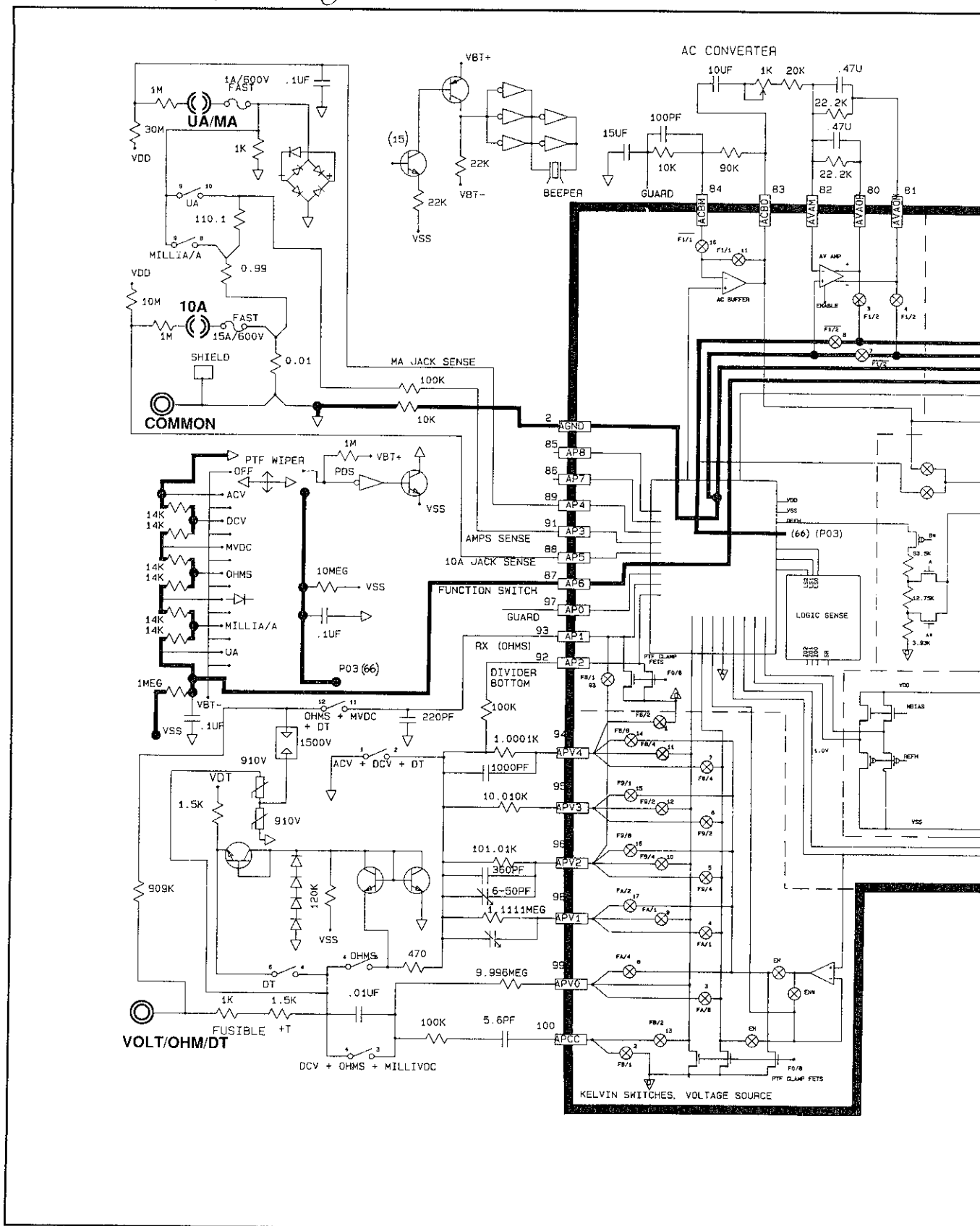


Figure 5-13. Function Switch Range Signal Flow

Fig 5-13  
 Sht 2 of 2

