FLUKE ®

78

Automotive Meter

Service Manual

For IEC 61010 CAT II Meters Only

PN 666617
November 1998

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Safety Information

This meter complies with EN 61010-1:1993, ANSI/ISA S82.01-1994 and CAN/CSA C22.2 No. 1010.1-92 Overvoltage Category II. Use the meter only as specified in the Users Manual, otherwise the protection provided by the meter may be impaired.

A **Warning** identifies conditions and actions that pose hazards to the user; a **Caution** identifies conditions and actions that might damage the meter. International electrical symbols used on the meter are shown below.

⚠ Warning

To avoid possible electric shock or personal injury:

- **Do not use the meter if it is damaged. Before use, inspect the case for cracks or missing plastic. Pay particular attention to the insulation surrounding the connectors.**
- **Always turn off power to the circuit before cutting, unsoldering, or breaking the circuit. Small amounts of current can be dangerous.**
- **Inspect the test leads for damaged insulation or exposed metal. Check test lead continuity. Replace damaged leads.**
- **To avoid damage or injury, never use the meter on unprotected circuits that exceed 4800 volt-amps.**
- **Do not use the meter if it operates abnormally. Protection may be impaired. When in doubt, have the meter serviced.**
- **Do not operate the meter around explosive gas, vapor or dust.**
- **Do not apply more than 300 V dc or ac rms (sine) between terminals or between any terminal and earth ground.**
- **Before each use, verify the meter's operation by measuring a known voltage.**
- **When servicing the meter, use only specified replacement parts.**
- **Use caution when working above 30 V ac rms, 42 V ac peak, or 60 V dc. Such voltages pose a shock hazard.**
- **Keep your fingers behind the finger guards on the probe when making measurements.**
- **Connect the common test lead before connecting the live test lead. Disconnect the live test lead first.**
- **Remove test leads from the meter before opening the case.**
- **Use only a single 9 V battery, properly installed in the meter case, to power the meter.**
- **Follow all equipment safety procedures.**
- **Before measuring current, check the meter's fuses (see "How to Test the Fuse").**
- **Never touch the probe to a voltage source when the test leads are plugged into the 10 A input jack.**

- **Always use clamp-on probes (dc current clamps) when measuring current exceeding 10 A.**
- **DO NOT connect thermocouple to voltages exceeding 30 V.**
- **Always use a high voltage probe to measure voltage if peak voltage might exceed 300 V.**
- **To avoid false readings, which could lead to possible electric shock or personal injury, replace the meter's battery as soon as the low battery indicator (⊟) appears.**
- **To avoid fire hazard, only use a fuse identical in type, voltage rating, and current rating to that specified on the fuse rating label located on the case bottom.**
- **Do not operate the meter if it is disassembled. Always operate the meter with the case top and bottom properly assembled. Disassembly procedures and warnings are in the 78 Automotive Service Manual. Service procedures are for qualified personnel only.**

Caution

To avoid possible damage to the meter or to equipment under test:

- **Disconnect the power to the circuit under test and discharge all high voltage capacitors before testing resistance, continuity or diodes.**
- **Use the proper function and range for your measurement applications.**
- **When measuring current, turn off circuit power before connecting the meter in the circuit. Remember to place the meter in series with the current.**

Symbols

Symbol	Meaning
⚠	Important information. See manual.
⏚	Ground
⏛	Fuse
⧈	Double insulation (Protection Class II)
CE	Conforms to European Union directives

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Chapter 1
Introduction and Specifications

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1-1. Introduction

This Service Manual provides information on maintaining, troubleshooting, and repairing the Fluke 78 Automotive Meter. This information includes the following:

- Specifications
- Theory of operation
- Calibration
- Performance testing and troubleshooting procedures
- Replacement parts lists
- Schematic diagrams

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 expired, 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 Fluke telephone numbers is included at the end of Chapter 4 of this manual.

1-2. Organization of the Service Manual

This service manual has the following five chapters.

Chapter 1. Introduction and Specifications

Chapter 1 describes the Service Manual, explains special terminology and conventions, and provides complete meter specifications.

Chapter 2. Theory of Operation

Chapter 2 treats the meter's circuitry as 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 explain operation to the component level and support the troubleshooting and repair procedures in Chapter 3.

Chapter 3. Maintenance

Chapter 3 provides maintenance information, detailed repair procedures to the component level, and performance tests. Troubleshooting and repair procedures rely on the Theory of Operation presented in Chapter 2 and the Schematic Diagrams in Chapter 5.

Chapter 4. List of Replaceable Parts

Chapter 4 provides parts lists and information on how and where to order parts.

Chapter 5. Schematic Diagrams

Chapter 5 provides schematic diagrams for all assemblies and a list of mnemonic definitions to aid in identifying signal name abbreviations.

1-3. Conventions

The following conventions are used in this manual:

- Printed Circuit Assembly (PCA)

  A "pca" is a printed circuit board and its attached parts.

- Circuit Nodes

  A pin or connection on a component is specified by a dash (-) and number following the component reference designator.

  For example, pin 19 of U30 would be U30-19.

- User Notation

  Switch positions, input terminals, and display annunciators are usually shown as they appear on the meter.

  Mnemonics used in the meter circuit descriptions correspond to those on the schematic diagrams in Chapter 5.

1-4. Specifications

Specifications for the Fluke 78 are in Table 1-1. Accuracy is specified for a period of one year after calibration, at 18°C to 28°C (64°F to 82°F) with relative humidity to 95%. AC conversions are ac-coupled, average responding, and calibrated to the rms value of a sine wave input.

Accuracy Specifications are given as:

±([% of reading] + number of least significant digits)

Table 1-1. Specifications

Maximum Voltage Between any Terminal and Earth Ground	300 V
Fuse Protection	15 A 600 V FAST Fuse
Display	Digital: 4000 counts, updates 4/s
	Bar Graph: 64 segments, update rate 40/s
	Frequency: 9,999 counts, updates 3/s
Operating Temperature	0°C to 55°C (32°F to 131°F)
Storage Temperature	40°C to 60°C (40°F to 140°F)
Temperature Coefficient	0.1 x (specified accuracy) per °C ambient
	(<18°C or >28°C). Temperature, 0.04% + 0.1°C per °C
Relative Humidity	0% to 95%, to 30°C (86°F)
	0% to 75%, to 40°C (104°F)
	0% to 45%, to 55°C (131°F)
Altitude	2000 meters maximum
Electromagnetic Compatibility	In an RF field of 1 V/m on all ranges and functions: Total Accuracy = Specified Accuracy +0.7% or range Performance above 1 V/m is not specified.
Battery Type	9 V, NEDA 1604 or 6F22 or 006P
Battery Life	Alkaline: 500 hrs (typical) Carbonzinc: 300 hrs (typical)
Continuity Beeper	4096 Hz
Shock, Vibration	Per MILT28800E for a Type III, Class 3 Style D, Instrument
Size (HxWxL)	1.12 in x 2.95 in x 6.55 in
	(2.8 cm x 7.5 cm x 16.6 cm)
Weight	12 oz (340g)
Safety	Complies with EN 610101:1993, ANSI/ISA S82.011994 and CAN/CSA C22.2 No. 1010.192 Overvoltage Category II.
Safety Approvals	CSA Certified, TUV Product Service licensed, UL
EMI Regulation	Complies with FCC Part 15, Class B, VDE 0871B, Vfg. 2431991
Inductive Pickup	Input: Magnetic field from spark plug Output: Pulse to trigger Fluke 78
Thermocouple	Type: K (Chromel vs. Alumel)
	(Fluke 80PK1) Not suitable for immersion in liquid. Accuracy: ±1.1°C (2°F) between 0°C to 260°C (32°F-500°F).
	Typically within 1.1°C (2°F) of NBS tables for temperatures between 40°C (40°F) to 0°C (32°F).
	Temperature Range: 40°C to 260°C.
	(40°F to 500°F). Above 260°C (500°F), toxic gas might be emitted.
	NOTE: The temperature range is primarily a function of the thermal limitations of the thermocouple's insulation.
	Cable Insulation: Teflon
MIN MAX Recording	Accuracy: Specified accuracy of measurement function ±16 digits for changes > 200 ms in duration (±52 digits in 400 Ω).
	Nominal response time (5 to 100% of range) 100 ms to 80%

Table 1-1. Specifications (cont)

Function	Range	Resolution	Accuracy	Burden Voltage (Typical)
AC Volts* (45 Hz to 1 kHz) To 20 kHz	4.000 V 40.00 V 300.0 V 300 V --	0.001 V 0.01 V 0.1 V 1 V --	± (2.5%+2) ± (2.5%+2) ± (2.5%+2) ± (2.5%+2) ± 1.5 dB typical	N/A
DC Volts*	400.0 mV 4000 mV 4.000 V 40.00 V 300.0 V 300 V	0.1 mV 1 mV 0.001 V 0.01 V 0.1 V 1 V	± (0.3%+5) ± (0.3%+1) ± (0.3%+1) ± (0.3%+1) ± (0.3%+1) ± (0.3%+1)	N/A
Resistance	400.0 Ω 4.000 kΩ 40.00 kΩ 400.0 kΩ 4.000 MΩ 40.00 MΩ	0.1Ω 0.001 Ω 00.01 kΩ 000.1 kΩ 0.001 MΩ 0.01 MΩ	± (0.5%+2) ± (0.5%+1) ± (0.5%+1) ± (0.5%+1) ± (0.5%+1) ± (1%+3)	N/A
Continuity	400.0 Ω	0.1Ω	Beeper on @ <30 Ω for short of 1 ms or longer	Open circuit voltage < 1.5 V
Diode Test	2.500 V	0.001 V	± 2% typical	Open circuit voltage < 3.3 V
AC Current (45 Hz to 1 kHz)	10.00 A**	0.01 A	± (2.5%+2)	0.03 V/A
DC Current	4.000 A 10.00 A**	0.001 A 0.01 A	± (1.0%+5) ± (1.0%+2)	0.03 V/A 0.03 V/A

* Input impedance: 10 MΩ (nominal), < 150 pF.
** 10 A continuous, 20 A overload for 30 seconds maximum.

Function	Range	Resolution	Accuracy
Frequency (1 Hz to 20 kHz) (10^7 V-Hz maximum)	99.99 999.9 9.999 kHz 20.00 kHz >20.00 kHz to 99.99 kHz 500.0 kHz	0.01 Hz 0.1 Hz 0.001 kHz 0.01 kHz 0.01 kHz 0.1 kHz	± 0.01%+2) ± (0.01%+2) ± (0.01%+2) ± (0.01%+2) Usable Usable
RPM 1	70-7,000 RPM (usable to 9,999)	1RPM	± (0.2% + 2)
RPM 1	120-7,000 RPM (usable to 9,999)	1RPM	± (0.2% + 2)
Dwell Angle	0-120	1 degree	± 2 degrees
Duty Cycle	0.0-99.9% (1 Hz to 20 kHz, pulse width> 5 µs)	0.1%	± (0.2% per kHz +0.1%) (for rise time <1 µs)
Temperature*	-40 to +999°C @ >20°C ambient, to +980°C below 20°C ambient	1 degree	± (0.3%+6°C) @ -40 to -20°C ± (0.3%+4°C) @ -20 to 0°C ± (0.3%+3°C) @ 0 to 170°C ± (0.3%+5°C) @ 170 to 260°C ± (0.3%+6°C) @ 260 to 700°C ± (0.3%+7°C) @ 700 to 999°C

* When measuring temperature, the accuracy of the system is the combined accuracy of the meter and the thermocouple.

Table 1-1 Specifications (cont)

Frequency Counter Sensitivity and Trigger Level			
Input Range	**Minimum Sensitivity (Rms Sine Wave)**		**Approximate Trigger Level (DC Volts Function)**
	1 Hz to 5 Hz	5 Hz to 20 kHz	
400.0 mV dc	--	--	400 mV
4000 mV dc	--	--	400 mV
4.00 V	0.7 V	0.3 V	1.7 V
40.00 V	7 V	3 V	4 V
300.0	70 V	30 V	40 V

Chapter 2
Theory of Operation

Title	Page

2-1. Introduction

Chapter 2 provides theory of operation for the Fluke 78 Automotive Meter.

An overview of circuit operation is presented in the form of functional block descriptions. Circuit descriptions cover the major circuit functions in more detail. Schematic diagrams are in Chapter 5.

2-2. Functional Block Description

The instrument is partitioned into analog and digital sections. See Figure 2-1. The integrated multimeter IC (U1) performs both analog and digital functions, which are explained in more detail below.

The analog section of U1 contains the a/d converter, active filter, ac converter, frequency comparator, analog signal routing, range switching, and power supply functions.

The digital section of U1 executes software functions, formats data for the display, drives the display, and controls most analog and digital logic functions. The pushbutton selects various operating modes for the meter. Output from the digital section can be viewed on the liquid crystal display (LCD) and is audible through the beeper.

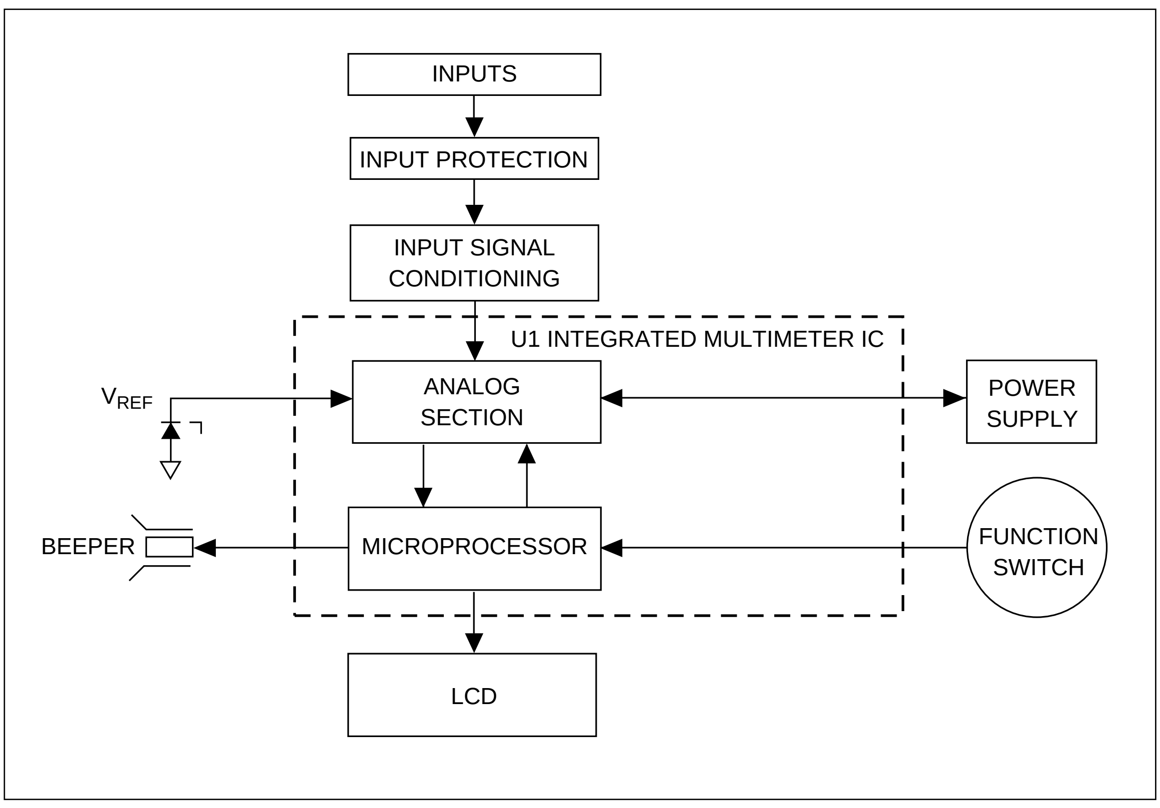


Figure 2-1. Block Diagram

2-3. Circuit Descriptions

Each of the functional blocks in Figure 2-1 is discussed in more detail in the following paragraphs. Refer to the schematic diagrams in Chapter 5 for circuit details not provided in this chapter.

2-4. Input Overload Protection

The VΩ⯈⊢ input is protected from overload by a network consisting of metal-oxide varistor (RV1), three current-limiting resistors (R1, R2, and RT1) and spark gap E1. Under extremely high energy conditions, R1 will help limit overload current until RT1 heats up. Thermistor RT1 rises to a high impedance during a sustained voltage overload in the ohms or temperature mode. Transistors Q1 and Q2 form a voltage clamp network. This clamp performs a current-limiting function on the overload current to U1 at 10 mA during ohms and temperature overloads. Power supply regulation and system operation is maintained during any of these overloads. The 10 A input is protected from overloads by F1 (15 A/600 V). R40 limits the input current in RPM, while Q11 and Q12 clamp the voltage seen by U4.

2-5. Rotary Knob Switch

Input signals are routed from the overload protection circuits to a double-sided switch wafer. This switch wafer provides the necessary connections to implement signal conditioning and function-encoding for U1.

2-6. Input Signal Conditioning Circuits

Each input signal is routed through signal conditioning circuitry before reaching IC U1. Incoming signals received through the VΩ⯈⊢ input are routed to precision resistor network Z1. This divider network precisely scales the input for the various voltage ranges and provides precision reference resistors that are used for the ohms and capacitance functions.

Input divider Z1 is used in two modes, series and parallel. In volts functions, a series mode provides four divider ratios. In the ohms function, a parallel mode provides five reference resistors.

2-7. Volts Functions

During the following discussion of the volts function, refer to schematic and signal flow diagrams in Chapter 5. In volts functions, signal flow for input divider Z1 begins with a voltage that appears at the VΩ⯈⊢ input. (See Figure 2-2, 4V Range Simplified Schematic.) This input is connected to the high end of the 9.996-MΩ resistor (Z1-1) through R1 and RT1. If the AC volts function is selected, dc blocking capacitor C1 is also connected in series. If the DC volts function is selected, C1 is shorted by S1 (contacts 5 and 6).

Internal switches connect the 9.996-MΩ and 1.1111-MΩ resistors (Z1-2 and -3). The low end of the 1.1111-MΩ resistor (Z1-7) is connected to the COM input through S1 contacts 11 and 12. This produces the divide-by-10 ratio needed for the 400 mV dc, 4000 mV dc, 4 V dc, and 4 V ac ranges. The 4 V ac range requires frequency compensation, which is supplied by C2.

For the 40 V range, internal switches connect the Z1-4 (101.01 kΩ) resistor to provide a divide-by-100 ratio. In the 300.0 V range, Z1-5 (10.01 kΩ) produces a divide-by-1,000 ratio. And in the 300 V range, the Z1-6 (1.0001kΩ) resistor provides a divide-by-10,000 ratio.

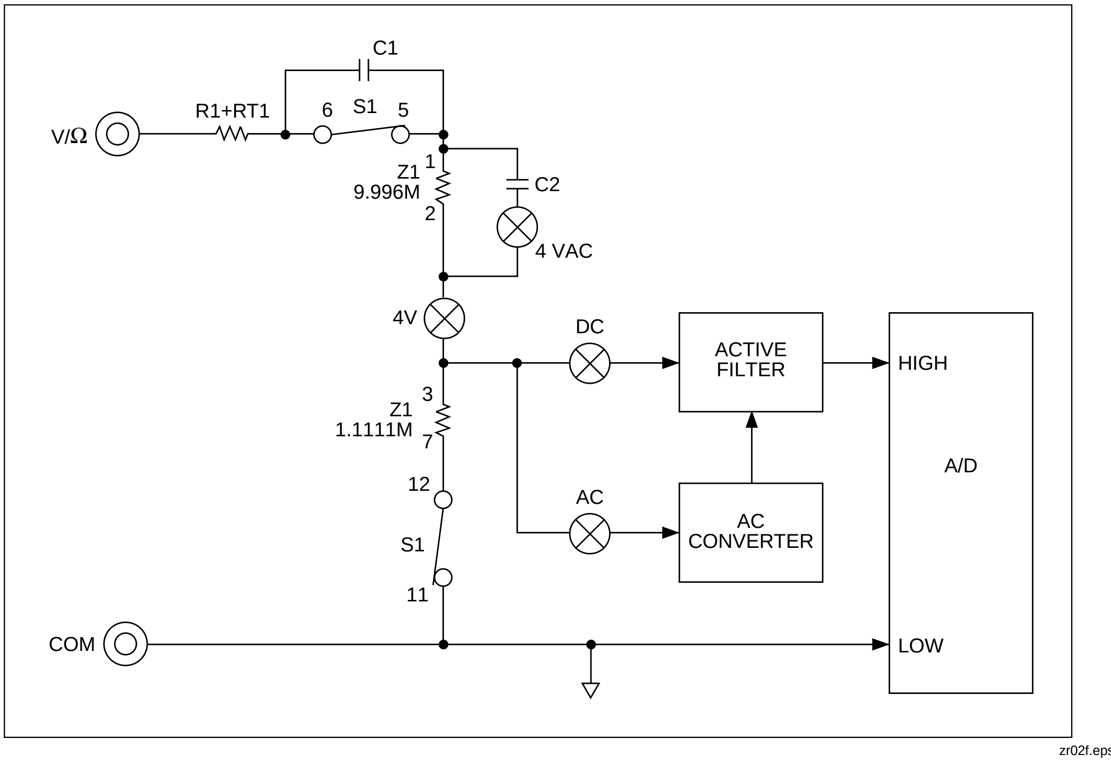


Figure 2-2. 4 V Range Simplified Schematic

2-8. Ohms Function

When the 400-ohm range is selected, internal switches connect the resistor Z1-2 (9.996 MΩ) to resistor Z1-6 (1.0001 kΩ). (See Figure 2-3, 400-Ohm Range Simplified Schematic.) Then through switch contacts S1 5, 6, and 9, these resistors form a reference resistor of 1 kΩ.

The source voltage is connected internally at both V0 and V4 of U1. The current is routed through two parallel resistors Z1-6 and Z1-2 (1.0001 kΩ and 9.996 MΩ) into S1 at contacts 5 and 9. The signal then travels out of S1 at contact 6, through RT1 and R1 and to the **VΩ→⊢** input. The signal then goes through the unknown resistance and back to the COM input. The same current flows through the unknown resistance and the reference resistor. The voltage dropped across the unknown resistance is sensed from the **VΩ→⊢** input jack through R2 and S1 (contacts 2 and 3) to SENS of U1.

The a/d converter senses the voltage drop across the 1 kΩ reference resistor through the low (RRS of U1 through R8) and high (V0 and V4) points. These two voltages are used by the a/d converter to perform a ratiometric measurement. Since the same current flows through the reference and unknown resistors, the ratio of the resistance values is the same as the ratio of the voltage drops across them.

For the 4-kΩ range, the 10.010-kΩ resistor (Z1-5) used in parallel with the 9.996-MΩ resistor (Z1-2) forms a 10-kΩ reference resistor. For the 40-kΩ range, 101.01 kΩ(Z1-4) and 9.996 MΩform a 100-kΩ reference resistor. And for the 400-kΩ range, 1.1111 MΩ (Z1-3) and 9.996 MΩ provide a 1-MΩ reference resistor. The 4-MΩ and 40-MΩ ranges use the 9.996-MΩ resistor alone.

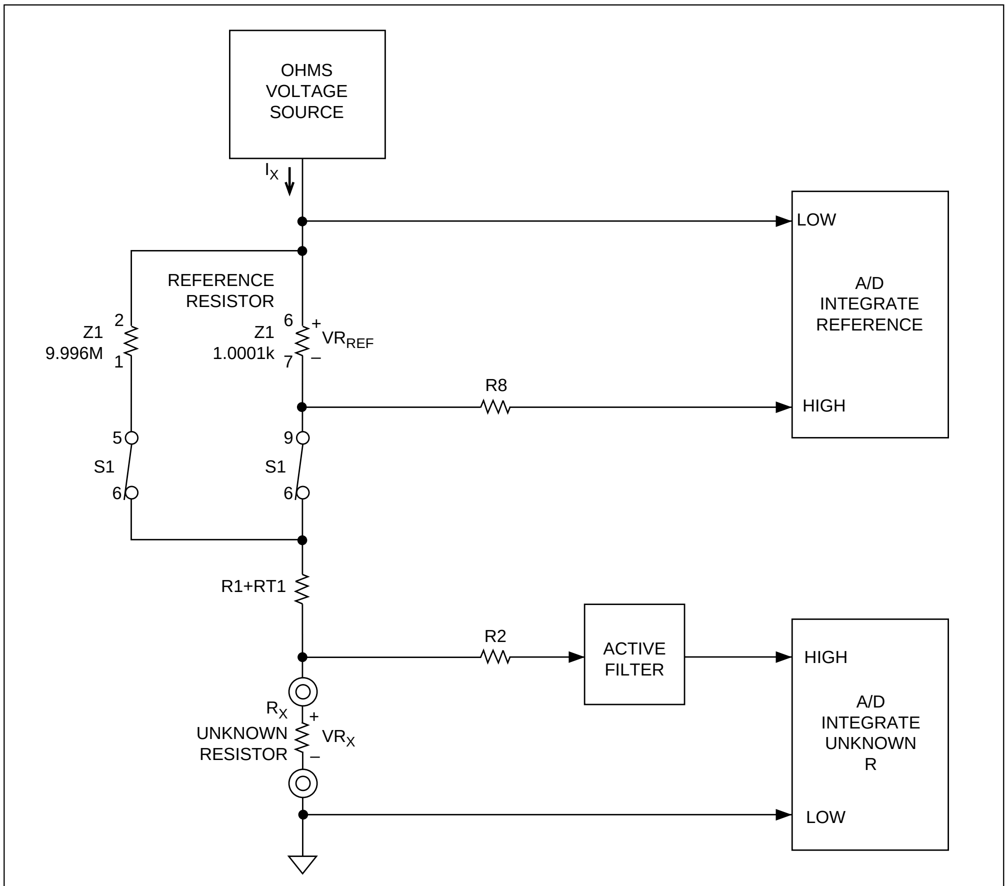
2-9. Continuity

The continuity function is the 400 Ω range of the ohms function with no active filtering of the input signal. A comparator is used to turn on the beeper when the input drops below about 50 Ω.

2-10. Temperature Function

The thermocouple voltage is measured by the a/d converter through R2, S1-2 and S1-3, and the SENS input of U1-93. The voltage is the result of any temperature difference between the thermocouple and the reference junction (at the meter). U3 produces an output voltage of 10 mV per degree C, proportional to the meter temperature (reference junction), which is divided by R15 and R16, and measured by the a/d converter. The thermocouple and reference junction measurements are combined, resulting in the temperature of the thermocouple.

At the beginning of each measurement cycle, an open thermocouple detect voltage (OTD, U1-89) is applied to the U1 SENS input through resistor R12. If the thermocouple wire is broken (open) or not installed, the SENS is driven high enough to be measured as an overload. The display then flashes the meter (reference junction) temperature.



$$\frac{VR_X}{VR_{REF}} = \frac{I_X \bullet R_X}{I_X \bullet R_{REF}} = \frac{R_X}{R_{REF}}$$

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Figure 2-3. 400 Ohm Range Simplified Schematic

2-11. *Diode Test Function*

Q4 provides the source current for the diode test function. The input is sensed through R2. R2 and R9 form a 10:1 divider for measuring the voltage in diode test. A single beep sounds when the input drops below about 0.77 V; a continuous tone sounds for inputs below about 60 mV.

2-12. RPM *Function*

The output signal pulses of the RPM80 Inductive Pickup are divided by input resistors R40 and R41, then applied to comparator U4. Resistors R42 and R43 set the trigger level for U4 (and the protection clamp voltage for Q12), while R44 and R45 provide hysteresis. When Q13 is turned on, R47 parallels R43, resulting in the lower input trigger level. Q13 off produces the higher input trigger level. The lower trigger level is annunciated on the display as a 4 V range, while the higher trigger level is annunciated as a 40 V range. The output of U4 drives the frequency counter in U1. To convert to rpm, the frequency is multiplied by 60 for RPM1 (1 revolution/spark), or 120 for RPM2 (2 revolutions/spark). The 10 A input serves as a common for the RPM input. Fuse F1 must be intact for RPM to work.

2-13. *Current Function*

Input current through R11 develops a voltage that is proportional to the input. The dc voltage is routed to the active filter and a/d converter inside U1. The ac voltage is routed to the ac buffer, ac converter, active filter, and a/d converter.

2-14. Analog Section of Integrated Multimeter IC (U1)

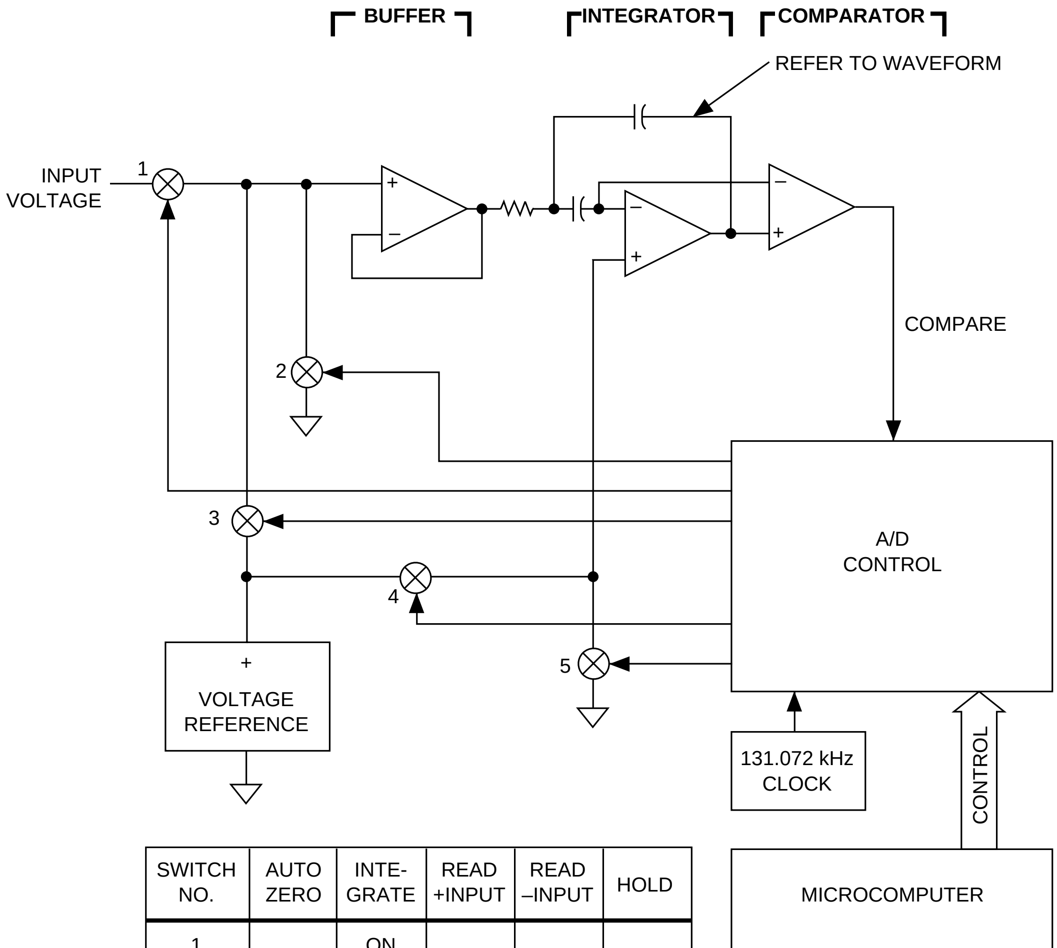
The a/d converter, autorange switching, frequency comparator, and most of the remaining analog circuitry are contained in the analog section of U1. Peripherals to this U1 analog section include the crystal clock, the system reference voltage, the filter and amplifier resistors, and capacitors.

U1 uses the dual-rate, dual-slope a/d converter circuit shown in Figure 2-4, A/D Converter. For most measurements, the basic a/d conversion cycle is 25 ms, for a rate of 40 measurements per second. A single conversion at this rate is called a minor cycle sample. Each minor cycle sample is used to provide updates at a rate of 40 per second for the fast response bar graph display, and also provides fast autoranging.

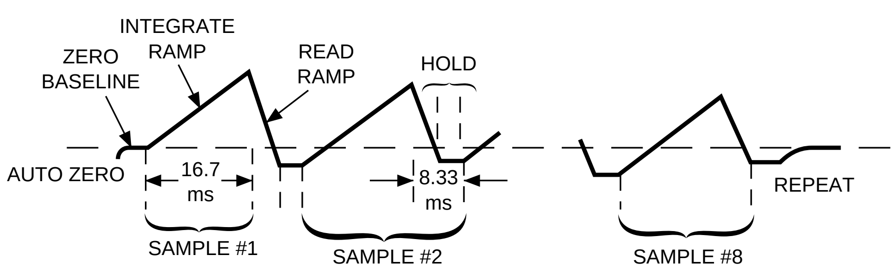
Eight minor cycle samples are necessary to accumulate data for displaying a full-resolution (4000-count full scale) measurement on the digital display. A 40-ms autozero phase occurs following every eight-sample sequence. Therefore, each digital display update requires 240 ms, approximating four updates per second.

Basic a/d conversion elements and waveforms are illustrated in Figure 2-4, A/D Converter. A voltage level proportional to the unknown input signal charges (integrates) integrator capacitor C12 for an exact amount of time. This capacitor is then discharged by a reference voltage of opposite polarity. The discharge (read) time, which is proportional to the level of the unknown input signal, is measured by the digital circuits in U1 and sent to the display.

Basic timing for the a/d converter is defined as a series of eight integrate and read cycles, followed by a 40-ms autozero phase. However, the 40-MΩ, overload recovery, and autoranging modes all require variations from the basic timing.



SWITCH NO.	AUTO ZERO	INTE-GRATE	READ +INPUT	READ –INPUT	HOLD
1		ON			
2	ON		ON		ON
3				ON	
4			ON		
5	ON			ON	ON



8 MINOR CONVERSIONS, 200 ms
(1 FULL RESOLUTION CONVERSION)
AS SEEN AT INTEGRATOR OUTPUT

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Figure 2-4. A/D Converter

2-15. Frequency Measurements

A voltage comparator is used for both signal detection in frequency mode and threshold detection in continuity mode. In frequency mode, digital pulses from the voltage comparator are routed to the counter. Pressing the range push button while in frequency mode causes a range change in the primary function (ac or dc volts) that may change the sensitivity.

2-16. Dwell and Duty Cycle Measurements

Dwell is a duty cycle measurement of the input waveform taken in the 40 V dc range. A voltage comparator and frequency counter are used. Information from the selected number of cylinders is combined with the duty cycle to compute dwell (the number of degrees of distributor rotation that the points are closed).

The duty cycle function is performed in the 4 V dc range. Changing the trigger slope in Duty Cycle (momentary button press) also changes the trigger slope for Dwell. The meter returns to the default slope (-) when entering the sleep mode or when turned off.

2-17. Microcomputer Control

A microcomputer, integrated within U1, controls the various instrument functions and drives the display. The position of the rotary switch, S1, is decoded by the microcomputer from the three inputs F0, F1, and F2. All function modes, input ranging, signal routing, active filter enable, a/d timing, and mode are controlled by the microcomputer.

2-18. Peripherals to U1

In addition to input overload protection and input signal conditioning circuits, other devices peripheral to U1 are needed to support the meter’s 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. A voltage reference is generated separately from U1, and some discrete resistors and transistors support the power supply.

2-19. AC Buffer

The ac buffer drives the converter and the frequency comparator and provides a driven guard voltage.

2-20. AC converter

The averaging ac converter uses components R14, R18, R19, C4, C6, and C7. This ac converter is a full-wave rectifying converter with a differential output, and it is gain selected to give a dc output equal to the rms value for a sine wave input. Filtering is provided by C4 and C7.

2-21. Active Filter

The active filter uses components R21, R22, C9, and C10. 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 by shorting R21 and R22 with internal IC switches.

2-22. A/D Converter

Precision resistor network Z1-8, 9, and 10 connects to the three a/d buffer/integrator range resistors. Z1-8 connects to 190 kΩ for the 1-volt (read) range. Z1-9 connects to

166 kΩ for the 400-mV range, and Z1-10 connects to 16 kΩ for the 40-mV range. Z1-11 is the summing node of the integrator circuit. The autozero capacitor (C11) stores op amp and comparator offsets. The integrator capacitor is C12.

The system reference voltage (1.23 V) is generated by VR1 and R23. The 1.000 V reference voltage for the a/d converter is supplied through U1-1 (REFI). This voltage is adjusted by R26, the dc calibration potentiometer in conjunction with R24 and R25. In addition to generating the a/d reference, the VR1 voltage is used for power supply reference, voltage comparator offset generation, the ohms source voltage, and the open thermocouple detect source voltage.

2-23. Beeper

Devices Q5, Q6, R27, R28, and R29 make up the beeper drive circuit.

2-24. Power Supply

The power supply consists of two regulators, one shunt and one series, which set Vdd at +3.1 V and Vss at -3.2 V for all battery voltages down to about 7 V. The shunt (common) regulator sets |Vdgnd - Vss| (Vdgnd = COM = 0V) and consists of an op amp and current shunt devices integrated on U1. Resistors R34 and R35 provide voltage division. The series (Vdd) regulator, which sets |Vdd-Vdgnd|, is made up of another on-chip op amp, along with devices Q7, R32, and R33. Q7 is the series regulator element, and R32 and R33 are for voltage sensing. Capacitors C16 and C17 provide circuit compensation and power supply decoupling for the shunt and series regulators, respectively. Q8 provides base drive for Q7 at turn on. Voltage level information is presented in Table 2-1.

2-25. Display

The liquid-crystal display (LCD) operates under control of the microcomputer. Segments are driven by the computer and displayed on the LCD. Both digital readings and an analog bar-graph display are presented in conjunction with annunciators and decimal points. Refer to the Fluke 78 Users Manual for information about the display.

Table 2-1. Typical Voltage Levels and Tolerance (Referenced to Common)

VBT +	3.7 ±0.2
VDD	3.1 ±0.2
VSS	-3.2 ±0.2
VBT-	-5.3 (battery at full 9 V charge of 6.9 V) -3.2 (battery at low charge of 6.9 V)
REFH	1.23 ±0.04
PS0	1.23 ±0.15
PS1	0 ±0.15
VOA	2.2 to 1.7 (referenced from VSS)
VOB	1.07 to .85 (referenced from VSS)

Chapter 3
Maintenance

Title	Page

⚠Warning

Service procedures described in Chapter 3 should be performed by qualified personnel only. To avoid electric shock, perform only those procedures described in this service manual.

3-1. Introduction

Chapter 3 contains maintenance information for the Fluke 78 meter and includes performance tests, calibration, general maintenance procedures, and troubleshooting. For operator maintenance, refer to the Fluke 78 Users Manual.

The performance tests are recommended as a preventive maintenance tool to verify proper instrument operation. A one year calibration cycle is recommended to maintain the specifications given in the Users Manual.

3-2. Recommended Equipment

Test equipment recommended for the performance tests and calibration is listed in Table 3-1. If the recommended equipment is not available, instruments with equivalent specifications may be used.

3-3. Operator Maintenance

⚠Warning

To avoid electrical shock, remove the test leads before opening the case, and close the case before operating the meter. To prevent fire, install fuse with the rating shown on the back of the meter.

Caution

To avoid contamination with oil from the fingers, handle the pca by the edges or wear gloves. PCA contamination may not cause immediate instrument failure in controlled environments. Failures typically show up when contaminated units are operated in humid areas.

3-4. Case Disassembly

Use the following procedure to disassemble the case:

1. Set the rotary switch to OFF and disconnect the test leads if they are installed.
2. Remove the four Phillips screws from the case bottom.
3. Turn the meter face up, grasp the case top, and pull the case top from the meter.

3-5. Battery Replacement

⚠Warning

To avoid false readings, which could lead to possible electric shock or personal injury, replace the battery as soon as the battery indicator (−+) appears.

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

1. Remove the upper case as described under Case Disassembly.
2. Lift the battery from the case bottom and install the new battery.

Table 3-1. Recommended Test Equipment

Equipment	Minimum Specifications	Recommended Model
DMM Calibrator	DC Voltage: 0-500 V Accuracy: .05% AC Voltage: 0-500 V Accuracy: 0.5% Frequency: 100 Hz-20 kHz DCA: 3.5-10 A Accuracy: 0.2% ACA: 10 A Accuracy: 0.5% Frequency: 45 Hz-1 kHz Range: 0-35 MΩ Accuracy: 0.1%	Fluke Model 5500A
High Accuracy Function Generator	Waveforms: Sine, Square & Triangle Voltage: 8 V peak DC offset voltage: 0-4 V Frequency: 10 Hz-20 kHz Frequency Accuracy: .002%	Philips Models PM 5191, PM 5192, or PM 5193
DMM	100 mV DC Voltage Range Accuracy: 0.5% Resolution: 100 μ V	Fluke 20 Series, 70 Series or 80 Series
Thermometer	Accuracy: 0.2 °C @ Ambient	Mercury or Digital
Temperature Probe	Resolution: 0.1 °C or °F. Must fit inside of a banana jack	Fluke 80T-150U
Lag Bath	Room Temperature Water	
For Testing the RPM-80 Inductive Pickup		
Function Generator	Single Cycle Triangle Waveform, -pi/2 Start Phase, 10 ms Repetition Rate Frequency: 600 Hz Output Voltage: 20 V (unterminated)	Philips Models PM 5133 or PM 5134
Oscilloscope	50 MHz, 3% vertical error 2 10X scope probes	Philips PM 3055, Fluke 93, 95, or 97
Adapter	Binding Post to BNC Male	Pomona Model 1296
Resistor	10 Ohm, ± 1.0%	NA
Wire	14 or 16 AWG, 1 foot insulated	NA

3-6. Fuse Test

Use the following procedure to test the meter's internal fuse:

1. Turn the rotary selector switch to the Ω position.
2. Plug a test lead into the VΩ⊣▶⊢ input terminal, and touch the probe to the 10 A input terminal.
3. The display should indicate between 0.1 and 0.5 ohms. This tests F1 (15 A, 600 V). If the display reads OL (overload), replace the fuse and test again. If the display reads any other value, further servicing is required.

3-7. Fuse Replacement

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

1. Remove the upper case.
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. Reinstall the four Phillips screws into the case bottom.

3-8. Circuit Assembly Removal

1. Remove the 15 A fuse (F1) to access the screw that holds the pca to the case bottom (refer to Fuse Replacement, above).

Note

Be careful not to lose the spring located directly under the screw on the back side of the pca.

2. Remove the pca from the case bottom.

3-9. Display Access

Caution

To prevent contamination, do not handle the conductive edges of the LCD interconnects. If they are contaminated, clean them with alcohol.

Refer to Figure 3-1.

1. Remove the four Phillips screws from the back side of the pca.
2. Remove the LCD assembly.
3. Insert a small screwdriver under the edges of the display mask bracket, and gently pry the bracket loose from the snaps.
4. Turn the bracket (with LCD) upside down to remove the LCD.
5. Before installing a new LCD, make sure that all connector contact points are clean. If needed, they may be cleaned with alcohol.

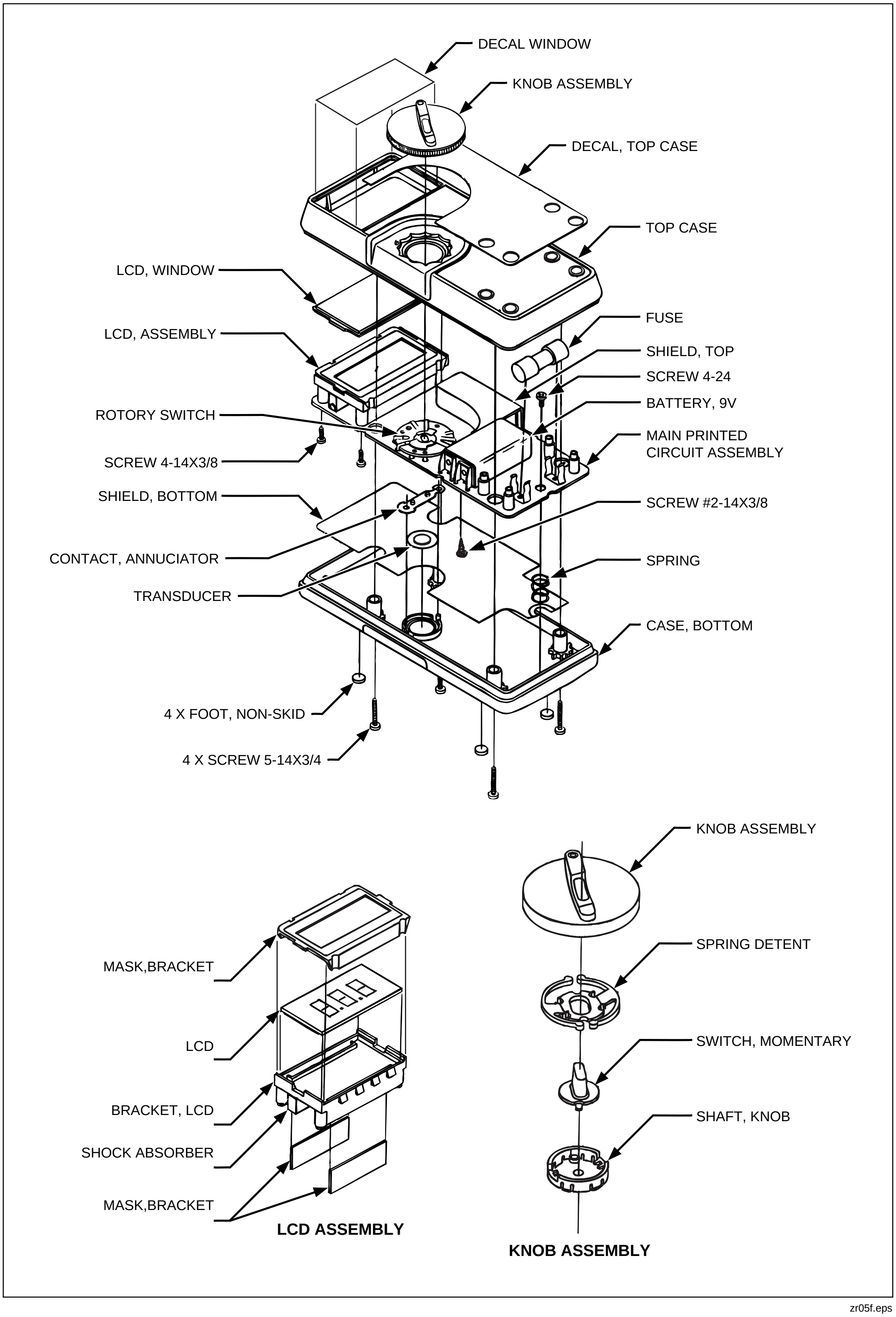

Figure 3-1. Disassembled Fluke 78

3-10. Cleaning

Caution

To avoid damaging the meter, do not use aromatic hydrocarbons or chlorinated solvents for cleaning. These solutions will react with the plastics used in the instruments.

Do not allow the LCD to get wet. Remove the display assembly before washing the pca and do not reinstall it until the pca is completely dry.

Do not use detergent of any kind for cleaning the pca.

Do not remove lubricants from the switch when cleaning the pca.

Clean the instrument case with a mild detergent and water.

The pca may be washed with isopropyl alcohol or deionized water and a soft brush. Remove the display assembly and fuses before washing, and avoid washing the switch if possible. Dry the pca with clean dry air at low pressure, then bake it at 50°C for 24 hours.

3-11. Performance Tests

Performance tests are recommended for incoming inspection, periodic maintenance, and for verifying the specifications. If the instrument fails any part of the test, calibration and/or repair is indicated.

3-12. Setup

1. Allow the Fluke 78 to stabilize to room temperature 23°C +/- 5°C (73°F +/- 9°F).
2. Check the fuse and battery, and replace them if necessary. (Refer to the battery and fuse replacement procedures in this chapter.)

⚠Warning

To prevent fire, install the fuse in accordance with the rating shown on the back of the meter.

Injury hazard. Connect the ground/common/low side of the ac calibrator to common on the Fluke 78.

3-13. Display Test

To test the display, hold the pushbutton down and turn the Fluke 78 on. All segments will remain on as long as the pushbutton is held down. Check whether all display segments come on as indicated in Figure 3-2.

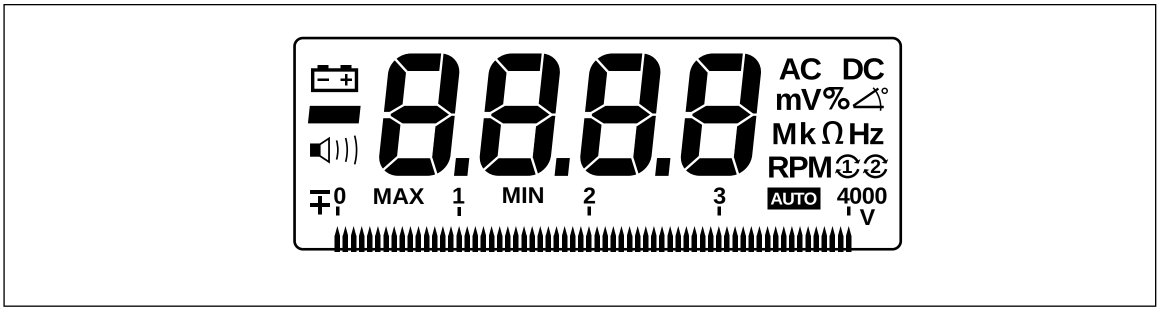

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Figure 3-2. Display

3-14. DC Voltage Test

1. Set the Fluke 78 rotary switch to V⎓ and connect the DC Voltage Calibrator output to the VΩ▶| and COM input terminals of the meter.

Note

For autorange to include the 400 mV (lowest) range, press the pushbutton three times.

2. Referring to Table 3-2, set the DC Voltage Calibrator for the output indicated, and verify that the Fluke 78 display reading is within the limits shown.
3. Reset the source to 0 V.

Table 3-2. DC Voltage Test

Step	Input		Display Reading
	Range	Voltage	
1	400.0 mV	short	0 to +/-000.5 m V DC
2	4000 mV or 4.000 V	+3.500 V	3488 to 3512 V mV DC or 3.488 to 3.512 V DC
3	4000 mV or 4.000 V	- 3.500 V	-3488 to 3512 mV DC -3.488 to -3.512 V DC (and within 2 counts of +3.5 V reading)
4	40.00 V	+35.00 V	34.88 to 35.12 V DC
5	300.00 V	+350 V	348.8 to 351.2 V DC
6	300 V	+500 V	497 to 503 V DC

3-15. AC Voltage Test

⚠Warning

Injury hazard. Connect the ground/common/low side of the AC calibrator to common on the Fluke 78.

1. Set the Fluke 78 rotary switch to **Ṽ** and connect the AC Voltage Calibrator to the **VΩ→⊢** and COM input terminals.
2. Set the AC Voltage Calibrator for the output given in Table 3-3, and verify that the Fluke 78 display reading is within the limits shown in the table.
3. Reset the source to 0 V.

Note

When the input is open in the V AC function, it is normal for the meter to read some counts on the display. This is due to the ac pickup in the ac amplifier when the ac amplifier is unterminated.

Table 3-3. AC Voltage Test

Step	Input			Display Reading
	Range	Voltage	Frequency	
1	4 V	short	----	0 to .002 V AC
2	4 V	3.500 V	100 Hz	3.410 to 3.590 V AC
3	4 V	3.500 V	1 kHz	3.410 to 3.590 V AC
4	40 V	35.00 V	1 kHz	34.10 to 35.90 V AC
5	300.0 V	350 V	1 kHz	341.0 to 359.0 V AC
6	300 V	500 V	1 kHz	485 to 515 V AC

3-16. Frequency Test

1. Set the Fluke 78 rotary switch to **Hz~** and press the pushbutton for 2 seconds to put the meter in the ac-coupled frequency function.
2. Connect the Function Generator output to the **VΩ→⊢** and COM input terminals of the meter.

Note

The frequency accuracy of the Function Generator must be appropriate for the specified accuracy of the Fluke 78.

3. Referring to Table 3-4, set the Function Generator for the output indicated in the steps. Verify that the Fluke 78 display reading is within the limits shown in the table.

Table 3-4. Frequency Test

Step	Sine Wave Input			Display Reading
	Range	Voltage	Frequency	
1	4 V	300 mV rms (848 mV p-p)	20 kHz	19.98 kHz to 20.02 kHz

3-17. Frequency, Dwell, and Duty Cycle Trigger Level Test

1. Connect the High Accuracy Function Generator output to the **VΩ→⊢** and COM input terminals on the Fluke 78.
2. Referring to Table 3-5, set the High Accuracy Function Generator for the output indicated in the steps.
3. Verify that the Fluke 78 display reading is within the limits shown for each function.

Note

For tests: waveform = Triangle and Frequency = 100 Hz.

Table 3-5. Frequency, Dwell, and Duty Cycle Trigger Level Test

Step	Function	Amplitude (Peak-Peak)	DC Offset	Display Reading
1	Dwell	8.00 V	4.00 V	4-33 to 4-71
2	Duty Cycle	3.40 V	1.70 V	36% to 64%

3-18. RPM *Test*

1. Connect the High Accuracy Function Generator output to the RPM+ and 10 A input terminals on the Fluke 78.

Note

Be sure that fuse F1 is installed and intact for RPM to work.

2. Referring to Table 3-6, set the High Accuracy Function Generator for the output indicated in the steps. Verify that the Fluke 78 display reading is within the limits shown for each range.

Note

For tests: Waveform = Square and Frequency = 10 Hz.

Table 3-6. RPM Test

Step	Range	Amplitude (peak-peak)	DC Offset	Display Reading
1	4 V	2 V	1.7 V	1196 to 1204 RPM (2)
2	40 V	2 V	1.7 V	0000 RPM (2)
3	40 V	2 V	3.8 V	1196 to 1204 RPM (2)
4	4 V	2 V	3.8 V	0000 RPM (2)

3-19. Ohms Test

1. Set the Fluke 78 rotary switch to the Ω function.
2. Connect the Ohms Calibrator or Decade Resistor to the **VΩ→|–** and COM input terminals of the meter.
3. Referring to Table 3-7, set the Decade Resistor or Ohms Calibrator to the resistance value indicated in steps 1 through 7. Verify that the display reading is within the limits shown in the table.

Table 3-7. Resistance Test

Step	Range	Input Resistance	Display Reading
1	400 Ω	short	000.0 to 000.2 Ω
Decades of 1:			
2	400 Ω	100 Ω	99.3 to 100.7 Ω (plus 0 reading)
3	4 kΩ	1 kΩ	.994 to 1.006 kΩ
4	40 kΩ	10 kΩ	9.94 to 10.06 kΩ
5	400 kΩ	100 kΩ	99.4 to 100.6 kΩ
6	4 MΩ	1 MΩ	.994 to 1.006 MΩ
7	40 MΩ	10 MΩ	9.87 to 10.13 MΩ
Decades of 1.9:			
2	400 Ω	190 Ω	188.8 to 191.2 Ω(plus 0 reading)
3	4 kΩ	1.9 kΩ	1.889 to 1.911 kΩ
4	40 kΩ	19 kΩ	18.89 to 19.11 kΩ
5	400 kΩ	190 kΩ	188.9 to 191.1 kΩ
6	4 MΩ	1.9 MΩ	1.889 to 1.911 MΩ
7	40 MΩ	19 MΩ	18.78 to 19.22 MΩ
Decades of 3.5:			
2	400 Ω	350 Ω	348.0 to 352.0 Ω (plus 0 reading)
3	4 kΩ	3.5 kΩ	3.481 to 3.519 kΩ
4	40 kΩ	35 kΩ	34.81 to 35.19 kΩ
5	400 kΩ	350 kΩ	348.1 to 351.9 kΩ
6	4 MΩ	3.5 MΩ	3.481 to 3.519 MΩ
7	40 MΩ	35 MΩ	34.62 to 35.38 MΩ

3-20. Continuity Test

1. Set the Fluke 78 rotary switch to ◁))) and press the pushbutton for 2 seconds to put the meter in the continuity test function.
2. Referring to Table 3-8, apply inputs as indicated. Verify that the Fluke 78 display and beeper indicate as shown in the table.

Table 3-8. Continuity Test

Step	Range	Input	Display Reading
1	400 Ω	open	OL
2	400 Ω	30 Ω	tone

3-21. Diode Test

1. Set the Fluke 78 rotary switch to ⏩ and press the pushbutton for 2 seconds to put the meter in the diode test function.
2. Connect the DC Voltage Calibrator output to the **VΩ⏩** and COM input terminals of the meter.
3. Referring to Table 3-9, set the DC Voltage Calibrator for the output indicated in the steps. Verify that the Fluke 78 display reading is within the limits shown in the table.

Table 3-9. Diode Test

Step	Range	Input	Display Reading
1	2.45 V	open	OL
2	2.45 V	+2.00 V	1.920 to 2.080 V DC

3-22. DC and AC Current Test

1. Set the Fluke 78 rotary switch to **Ã**.
2. Set the output of the Current Calibrator to standby and connect it to the 10 A and Common input terminals of the meter.
3. Set the Current Calibrator to the output shown in Table 3-10, and verify that the Fluke 78 display reading is within the limits shown in the table.

Table 3-10. DC and AC Current Test

Step	Input			Display Reading
	Range	A	Frequency	
1	4 A DC	+3.5 A	--	3.460 to 3.540 DC
2	10 A DC	+10 A	--	9.88 to 10.12 DC
Note *To enter AC Amps, press and hold the button for 2 seconds.*				
3	10 A AC	10 A	1 kHz	9.73 to 10.27 AC

3-23. Temperature Test

Note

The meter and any test leads plugged into the input during the temperature test must be at the same room temperature, 23 °C +/-5°C. Handling, and nearby warm equipment, can alter temperature readings.

1. Set the Fluke 78 rotary switch to **°C°F**. Apply a short between the **VΩ⏩** and COM inputs.

   The display will show a steady reading of the meter’s internal temperature.
2. Remove the short from the input. The display will flash the same temperature reading about once every 1.3 seconds.
3. Construct an ambient temperature lag bath as shown in Figure 3-3. Immerse the thermometer into the bath.

4. Insert the 80T-150U into the DMM and select a DC mV range with 100 µV resolution. Turn on the 80T-150U to °C or °F to match the lag bath thermometer.
5. Immerse the probe of the 80T-150U into the lag bath to the same depth as the thermometer and allow the system to stabilize.
6. Note the difference in temperature readings between the 80T-150U/DMM and the lag bath thermometer.

   If the 80T-150U/DMM reads higher than the thermometer, subtract the difference from the 80T-150U/DMM reading in step 8.

   If the 80T-150U/DMM reads lower, add the difference to the 80T-150U/DMM reading in step 8.
7. Remove the 80T-150U probe from the lag bath and insert it down into the COM input terminal on the Fluke 78, making contact at the bottom.
8. Select the temperature function on the Fluke 78, °C or °F to match the 80T-150U. Allow the readings to settle.

   The flashing reading of the Fluke 78 should be within 3 °C or 5.5 °F of the 80T-150/DMM reading after taking into account the reading difference noted in step 6.

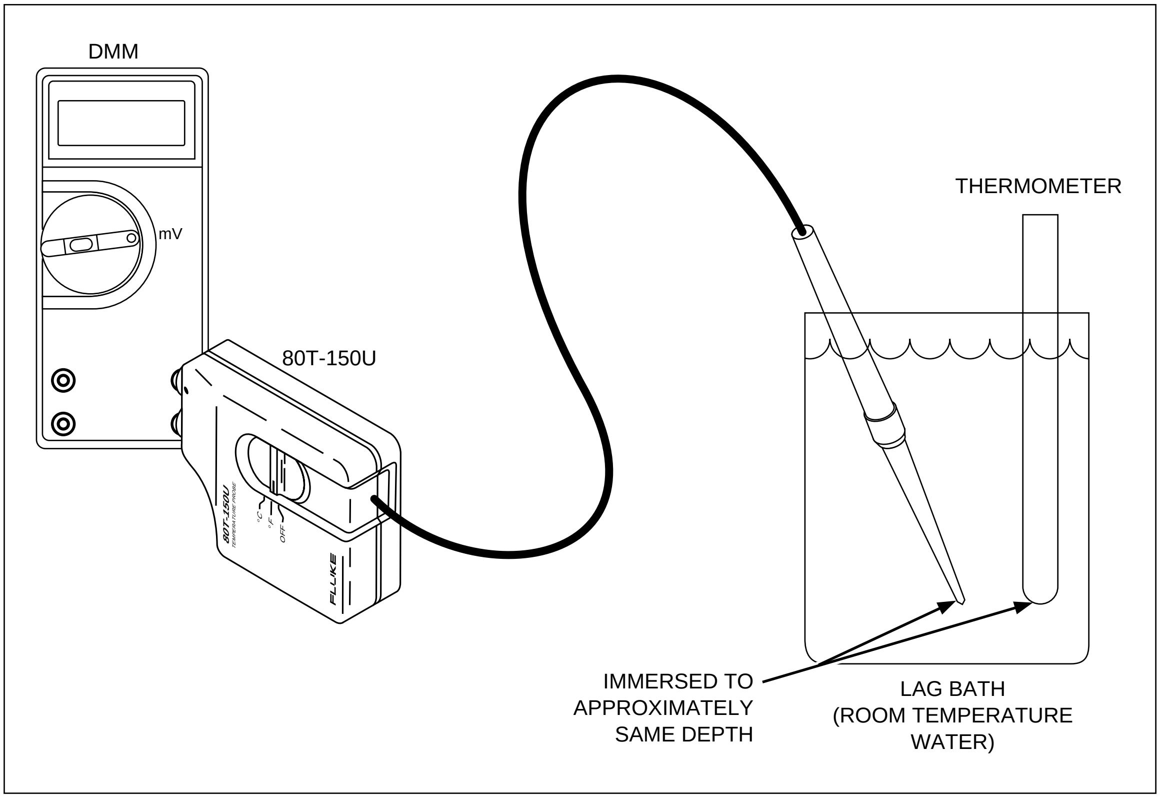

Figure 3-3. Ambient Temperature Lag Bath

3-24. RPM80 Inductive Pickup Test (Optional Accessory)

To test the RPM-80 inductive pickup, a triangle wave from a Function Generator will simulate automobile spark plug signals on a loop of wire containing a 10-ohm resistor. The pickup will be clamped to the wire, and output voltage from the pickup will be monitored by an oscilloscope.

To test the RPM80 Inductive Pickup, proceed as follows, referring to Figures 3-4 and 3-5 as necessary:

1. Solder a 10-inch piece of 14 or 16-AWG wire to one end of the 10-ohm resistor.
2. Connect the other end of the resistor to the LOW and the wire to the HIGH of the binding-post-to-BNC adapter. Connect the adapter to the output of the Function Generator. See Figure 3-4.
3. Connect a 10X-scope probe from channel 2 (dc-coupled) of the oscilloscope across the 10-ohm resistor (not across the Function Generator output).
4. Clamp the inductive pickup to the wire loop as shown in Figure 3-4. Make sure that the jaws of the inductive pickup are closed completely, and that the side of the pickup which says "SPARK PLUG" points toward the HIGH output of the Function Generator.
5. Connect a 10X-scope probe from channel 1 (dc-coupled) of the oscilloscope across the output of the inductive pickup.
6. Set up the Function Generator as follows:

FREQ RANGE Hz	2M
FREQUENCY	0.600 MHz
ATTENUATION	None
MOD/SWEEP PERIOD s	.1 (PM5133)
MOD/SWEEP PERIOD s	10 ms (PM5134)
MODE	SINGLE
WAVEFORM	Triangle
CONT	Out
LIN	In
DUTY CYCLE	Out
OUTPUT	50 Ohms
PERIOD	Halfway (PM5133)
PERIOD	x1 (PM5134)
START PHASE	$\pi/2$
DC OFFSET	In

7. Set channel 2 of the oscilloscope for 0.5 V/DIV at 0.5 µs/DIV time base.
8. Trigger channel 2 on the triangle waveform. Adjust the amplitude of the Function Generator for an output of 3 V peak. See Figure 3-5.
9. Set channel 1 of the oscilloscope for 1.0 V/DIV at 5 ms/DIV time base.
10. Trigger channel 1 on the inductive pickup waveform. Adjust the Function Generator PERIOD for a 10 ms repetition rate.
11. Check that the peak voltage is greater than 5.5 V and decays to less than 1.0 V between pulses. See Figure 3-5.
12. Turn the inductive pickup so that "SPARK PLUG" points toward the LOW output of the Function Generator. Check that the waveform is less than 2 V.

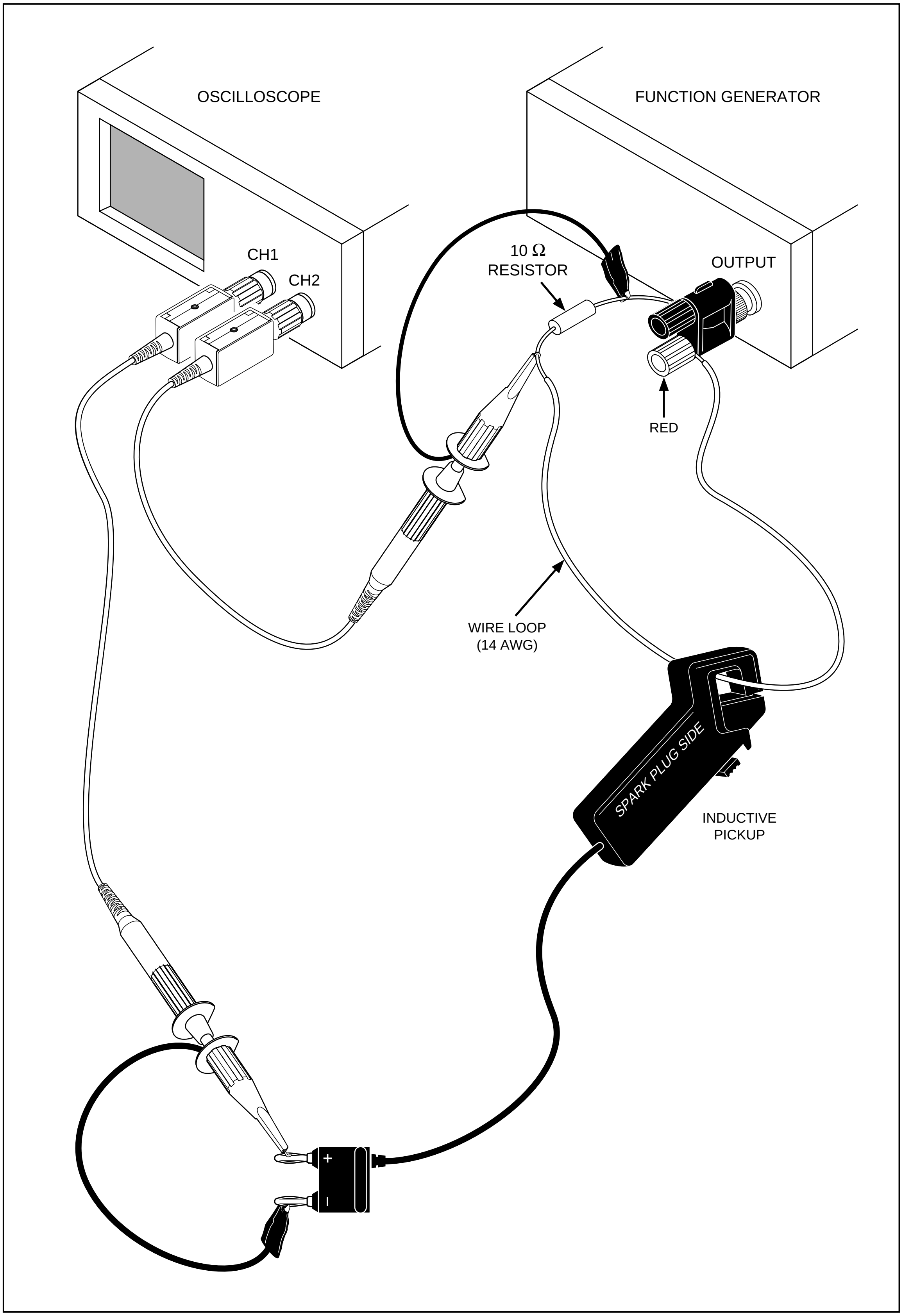

Figure 3-4. Setup for RPM80 Inductive Pickup Test

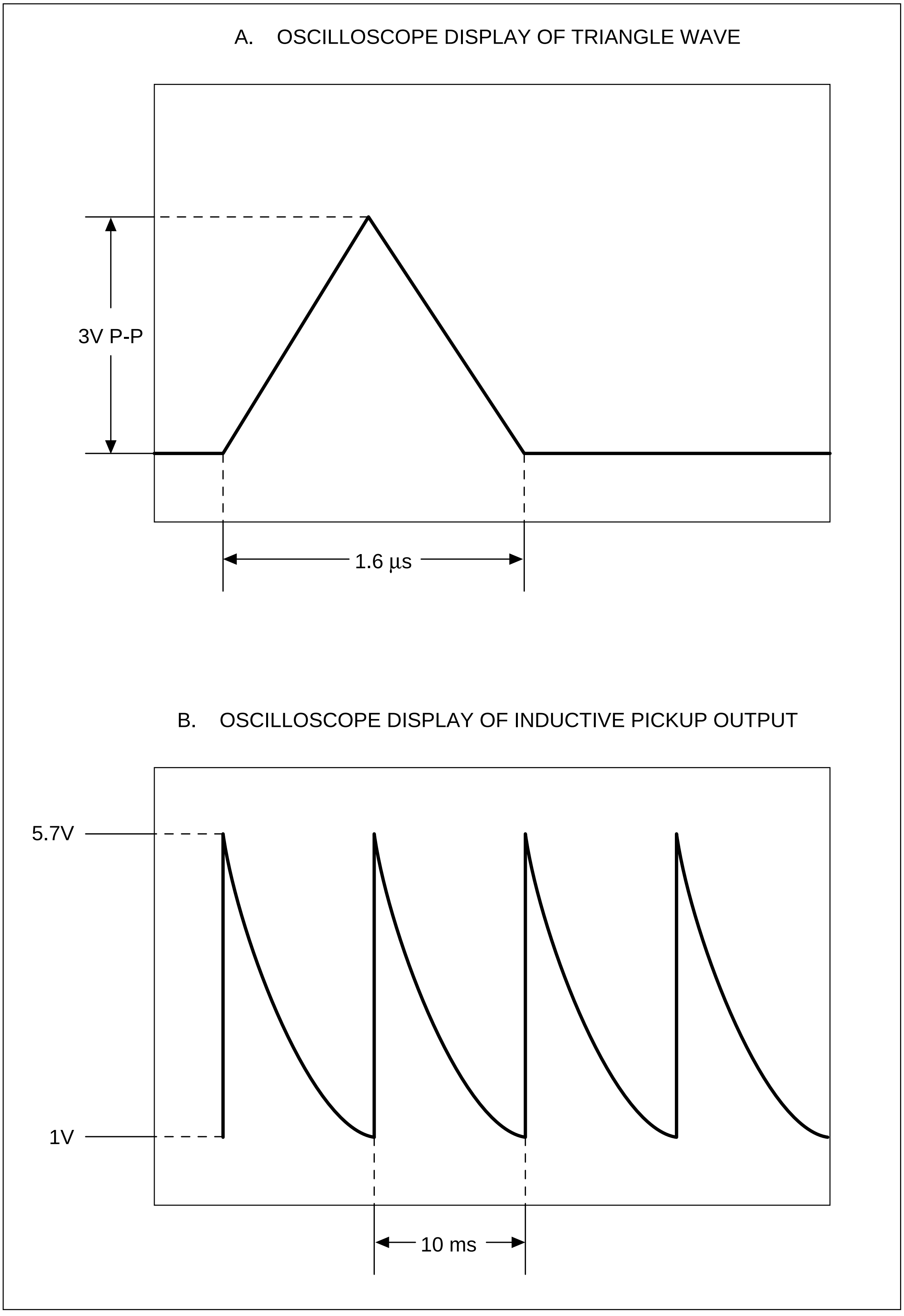

Figure 3-5. Typical Waveforms for Inductive Pickup Test

3-25. Calibration

Calibrate the meter once a year to ensure that it performs according to specifications. The calibration adjustment point is identified in Figure 3-6. Use the following procedure to calibrate the Fluke 78.

1. Set the DC Voltage Calibrator to 0 volts.
2. Set the Fluke 78 rotary switch to $\overline{\overline{\text{V}}}$.
3. Connect the DC Voltage Calibrator to the VΩ⏵| and COM input terminals of the meter.

Note

For autorange with the 4 V range as the lowest range, press the pushbutton 5 times.

4. Set the DC Voltage Calibrator for an output of +3.5 V dc.
5. The Fluke 78 should display 3.500 V dc +/- 0.001. If necessary, remove the four case screws and case top and adjust R26.

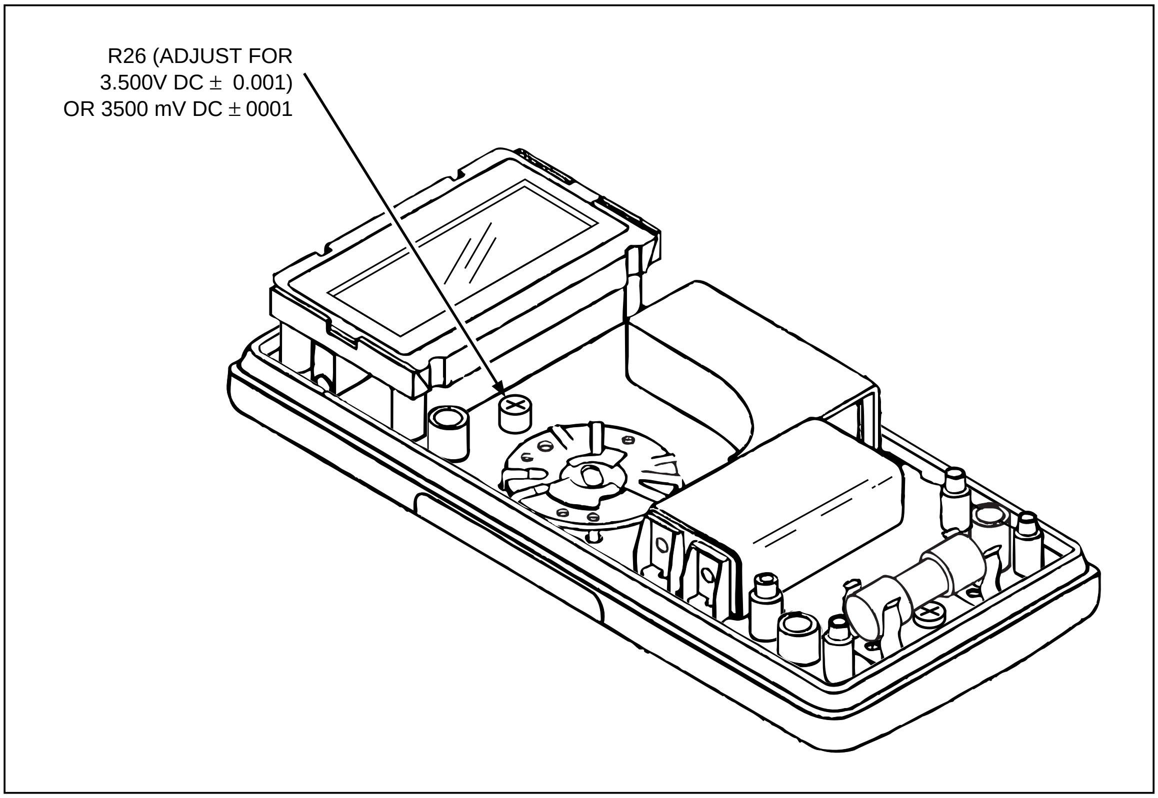

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Figure 3-6. Calibration Adjustment Point

3-26. Troubleshooting

The procedures provided in these paragraphs will help isolate problems with the meter.

When troubleshooting the Fluke 78 Automotive Meter, follow the precautions listed on the "Static Awareness" sheet to prevent damage from static discharge.

3-27. Surface Mount Assemblies

The Fluke 78 Automotive Meter incorporates surface-mount technology (SMT) on the printed circuit assembly (pca). 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. We do not recommend that you attempt a repair based only on the information presented here.

Since sockets are seldom used with SMT, "shotgun" troubleshooting cannot be used; isolate a fault to the component level before replacing a part. Surface-mount assemblies are probed from the component side. The probes should contact only 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.

Due to the limited space on the surface of the circuit board, component locations are not labeled. Therefore, this service manual is a vital source for component locations and values. Figures provided in Chapter 5 of this manual provide component location 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.

- 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.

3-28. Power Supply Related Troubleshooting

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 3-11 and 3-12 for descriptions of power supply components and voltage levels. To isolate the problem regulator circuit, disconnect the battery, and drive Vdd - Vss = 6.3 V with a power supply. This procedure tests the common regulator independently of the Vdd regulator.

Now check for DGND - Vss = -3.2 V +/-0.2 V. If this test is successful, the problem lies with the Vdd regulator; refer to Vdd Regulator Troubleshooting later in this chapter. If this test is not successful, the problem lies with the common regulator; continue with the Common Regulator Troubleshooting. Note that if the common regulator works or has been repaired, check both supplies with the 9 V battery supply.

Table 3-11. Functional Description of Power Supply Components

Component	Function
Q8	Power supply startup device. Q8 provides Q7 base startup current. Q8 is always off during meter operation.
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.
C16	Vdd regulator compensation and bypass.
C17	Common regulator compensation and Vss bypass.
R32, R33	Vdd regulator voltage sensing resistors.
R34, R35	Common regulator voltage sensing resistors.
R23	Supplies bias current to VR1.

Table 3-12. Voltage Levels

Signals	Levels
VBT+	3.7 ±0.2
VDD	3.1 ±0.2
VSS	-3.2 ±0.2
VBT-	-5.3 (battery at full 9 V charge)
	-3.2 (battery at low charge of 6.9 V)
REFH	1.23 ±0.04
PS0	1.23 ±0.15
PS1	0 ±0.15
VOA	2.2 to 1.7 (referenced from VSS)
VOB	1.07 to 0.85 (referenced from VSS)

3-29. 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 overdrives the large on-chip shunt transistors; the bias current from the power supply ranges from 10 mA to 100 mA. Refer to the schematic for a diagram of the common regulator.

Make the following tests:

1. Check for +1.23 V +/-40 mV (Vrefh) at the cathode of VR1. If Vrefh is not correct, check VR1, R23, R24, R25 and R26 carefully. If Vrefh is still incorrect, U1 is bad.

2. If Vrefh is correct, measure the voltage at U1 pin 6 (PS1). If Vps1 is not equal to 0 V +/-0.15 V, check R34 and R35. If Vps1 is still at an incorrect voltage, U1 is bad.
3. Check the bias generator circuit. With the exception of resistor R31 (649 kΩ), the bias generator (which sets the bias level for all U1 analog circuitry) is internal to U1. A problem with this circuit could cause the on-chip power supply op amps to fail. Measure the dc voltage between U1 pin 8 (Vbias) and DGND. If -0.2 V < Vbias < +0.2 V the bias generator is okay. If Vbias is not correct, check R31. If Vbias is still wrong, replace U1.
4. Measure the ac voltage between DGND and Vss. If it is greater than 10 mV ac, check C17. (An open C17 causes common regulator instability.) The dc level may also be incorrect.
5. If the common regulator still does not work, circuitry internal to U1 is bad. Replace U1.

3-30. Vdd (Series) Regulator Troubleshooting

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

1. Measure the dc operating current from the 9 V battery. If the current is greater than 1.2 mA, a sneak current path exists. Although a sneak current path can be very difficult to find, the following troubleshooting steps may be helpful in isolating the current path.
2. First, visually check for both solder bridges on U4 pins and other circuit board shorts.
3. Isolate the current path at the negative battery terminal (Vbt-). The components connected to Vbt- are LS1, Q7, CR1, and R29. Remove these parts one at a time. Measure I(bat) after each removal to isolate the problem.
4. If the excess battery current stops after removing R29, either R27, R29, Q5, or Q6 may be bad.
5. If the extra current is still present with all parts removed, remove Q8 and check for excess battery current. If I(bat) is now correct, Q8 is bad. If I(bat) is still excessive, U1 is probably at fault.

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

1. If Vdd - Vss is low, a problem may exist with start-up device Q8. Check Q8 by momentarily connecting Vss to Vbt-. If both Vss and Vbt- now start up and operate correctly, check Q8 for an open.
2. Measure the ac voltage between Vdd and Vss. An unstable Vdd regulator can be caused by an open C16. If the voltage is greater than 10 mV ac, check C16. The dc level may also be incorrect.

For a final check of U1, remove the battery and supply Vbt+ = +3.7 V, DGND = 0, and Vss = -3.2 V from an external power supply. Measure the voltage at U1 pin 7 (PS0). If it does not equal 1.23 V +/-0.15 V, check R32 and R33 carefully. If PS0 is still incorrect, U1 is bad.

Chapter 4
List of Replaceable Parts

4-1. Introduction

This chapter contains an illustrated list of replaceable parts for the Fluke 78 Automotive Meter. Parts are listed by assembly; alphabetized by reference designator. Each assembly is accompanied by an illustration showing the location of each part and its reference designator. The parts lists give the following information:

- Reference designator
- An indication if the part is subject to damage by static discharge
- Description
- Fluke stock number
- Total quantity
- Any special notes (i.e., factory-selected part)

Caution

A * symbol indicates a device that may be damaged by static discharge.

4-2. How to Obtain Parts

Electrical components may be ordered directly from the manufacturer by using the manufacturers part number, or from the Fluke Corporation and its authorized representatives by using the part number under the heading FLUKE STOCK NO. To order components directly from Fluke Corporation, call (toll-free) 800-526-4731. Parts price information is available from the Fluke Corporation or its representatives.

To ensure prompt delivery of the correct part, include the following information when you place an order:

- Fluke stock number
- Description (as given under the Description heading)
- Quantity
- Reference designator
- Part number and revision level of the pca containing the part.
- Instrument model and serial number

4-3. Manual Status Information

The Manual Status Information table that precedes the parts list defines the assembly revision levels that are documented in the manual. Revision levels are printed on the component side of each pca.

4-4. Service Centers

To contact Fluke, call one of the following telephone numbers:

USA and Canada: 1-888-99-FLUKE (1-888-993-5853)
Europe: +31 402-678-200
Japan: +81-3-3434-0181
Singapore: +65-738-5655
Anywhere in the world: +1-425-356-5500

Or, visit Fluke's Web site at www.fluke.com.

Ni-Cd *Note*

This instrument may contain a Nickel-Cadmium battery. Do not mix with the solid waste stream. Spent batteries should be disposed of by a qualified recycler or hazardous materials handler. Contact your authorized Fluke service center for recycling information.

4-5. Parts Lists

The following tables list the replaceable parts for the 78 Automotive Meter. Parts are listed by assembly; alphabetized by reference designator. Each assembly is accompanied by an illustration showing the location of each part and its reference designator. The parts lists give the following information:

- Reference designator
- An indication if the part is subject to damage by static discharge
- Description
- Fluke stock number
- Total quantity
- Any special notes (i.e., factory-selected part)

Caution

A * symbol indicates a device that may be damaged by static discharge.

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Manual Status Information

Ref or Option No.	Assembly Name	Fluke Part No.	Revision Level
A1	Main PCA	919709	F

Table 4-1. Fluke 78 Final Assembly

Reference Designator	Description	Fluke Stock Number	Qty	Notes
A 1	*MAIN PCA		1	
BT 1	BATTERY,9 V,0-15 MA	696534	1	
⚠F 1	FUSE,.406X1.5, 15 A, 600 V,FAST	820829	1	1
H 1	SCREW,PH,P,THD FORM,STL,4-24,.250	519116	1	
H 2	SCREW,PH,P,THD FORM,STL,2-14,.375	821140	1	
H 3- 6	SCREW,PH,P,THD FORM,STL,4-14,.375	448456	4	
H 7- 10	SCREW,PH,P,THD FORM,STL,5-14,.750	733410	4	
LS 1	AF TRANSD,PIEZO,20 MM	642991	1	
MP 9	SHIELD,TOP	885855	1	
MP 10-13	FOOT,NON-SKID	640565	4	
MP 14	CASE,BOTTOM	926985	1	
MP 15	SHIELD,BOTTOM	896225	1	
MP 16	SPRING,COIL,COMP,M WIRE,.500,.360	697227	1	
MP 17	CASE,TOP, PAD TRANSFERRED	666636	1	
MP 18	WINDOW,LCD	919717	1	
MP 19	BRACRET,LCD	646653	1	
MP 20	MASK,BRACKET	885848	1	
MP 21, 22	CONN,ELASTOMERIC,LCD TO PWB,1.900 L	649632	2	
MP 23	KNOB,SWITCH	885843	1	
MP 24	SHAFT,KNOB	646661	1	
MP 25	SPRING,DETENT	646679	1	
MP 26	SHOCK ABSORBER	428441	1	
MP 27	DECAL,TOP CASE	919691	1	
MP 28	LABEL, WINDOW	844340	1	
MP 31	HOLSTER & FLEXSTAND ASSY, YELLOW	890298	1	
MP 32	INSERT,CONTAINER	919829	1	
MP 33	CONTAINER,DISPLAY	666633	1	
MP 35	ACCESSORY PACK,FLUKE &*	919824	1	
TM 1	USERS MANUAL,ENGLISH FLUKE 78	666625	1	
TM 2	USERS MANUAL,INTL.,FLUKE 78	666628	1	
TM 3	QUICK REFERENCE CARD, FLUKE 78	926915	1	
S 2	SWITCH,MOMENTARY, YELLOW	890280	1	
S 4	CONTACT,ANNUNCIATOR	642983	1	
U 2	LCD,4.5 DIGIT,BAR GRAPH,MULTIPLEXED	912477	1	

Notes: * Static sensitive part.
1 Part must meet specifications.
⚠To ensure safety, use exact replacement only

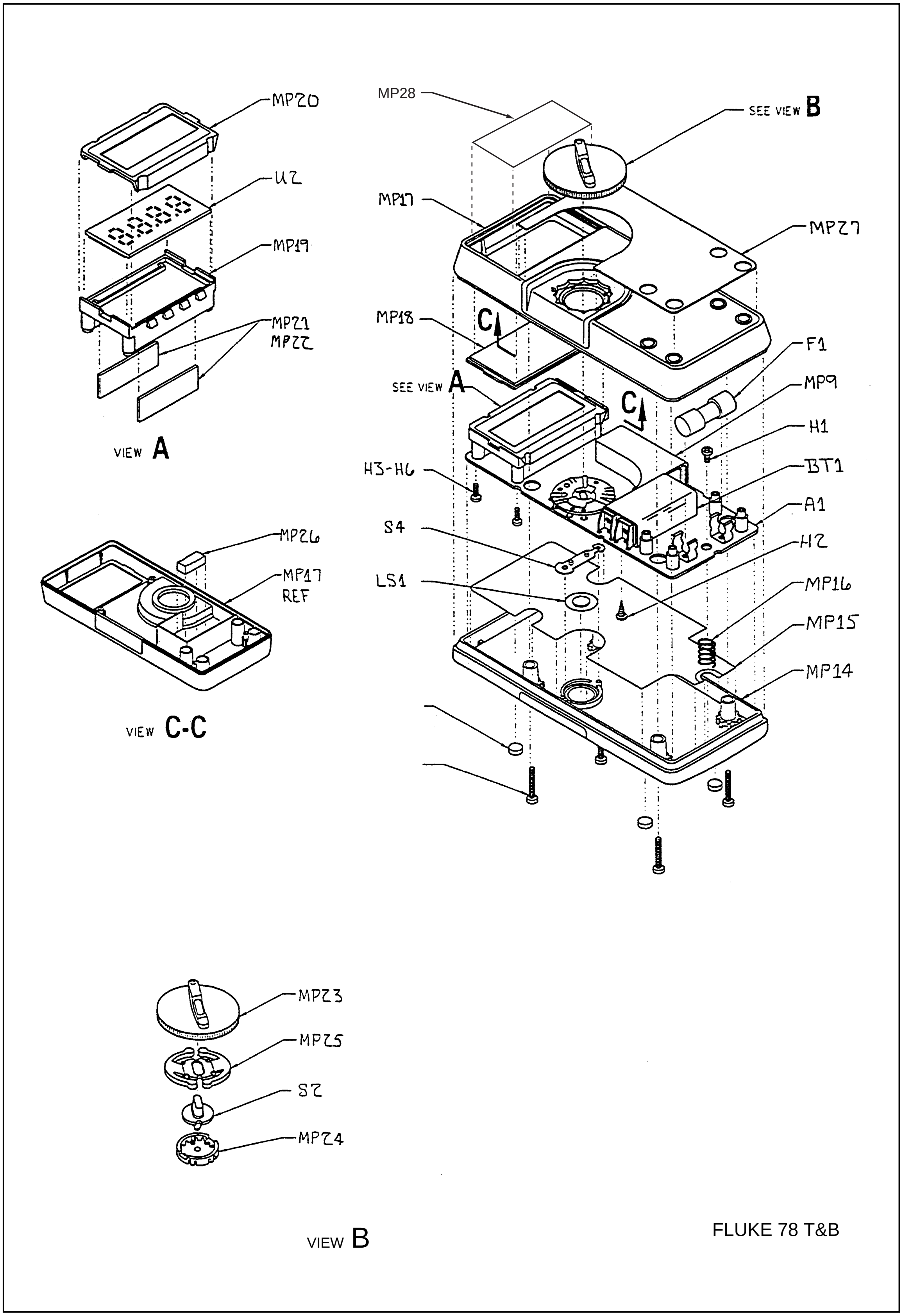

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Figure 4-1. Fluke 78 Final Assembly

Table 4-2. A1 Main PCA

Reference Designator	Description	Fluke Stock Number	Qty	Notes
C 1	CAP, POLYES, 0.01 µF, ±10%, 1000 V	822361	1	
C 2	CAP, CER, 3.3PF, ±0.25 PF, 1500 V, COJ	904636	1	
C 3, 8	CAP, CER, 150PF, ±5%, 50 V, COG,0805	866533	2	
C 4,7,11,20	CAP,TA,0.47 µF,±20%%,25 V, 3216	876180	4	
C 5,15,18,19,21	CAP,CER,0.1µF,±10%,25V,X7R,1206	747287	5	
C 6	CAP,TA,10µF,±20%,16 V,6032	867572	1	
C 9,10	CAP,POLYCA,0.027 µF,±10%,63 V	720979	2	
C 12	CAP,POLYCA,0.022 µF,±10%,63 V	821579	1	
C 13,14	CAP,CER,22 PF,±10%,50 V,COG,1206	740563	2	
C 16,17	CAP,TA,47 µF±20%,10 V,7343	867580	2	
CR 1	DIODE,SI,100 PIV,1 AMP,SURFACE MOUNT	912451	1	
CR 2	* DIODE.SI.BV=70.0 V.IO=50XA.DUAL.SOT23	742320	1	
E 1	SURGE PROTECTOR,1500 V,+-20%	655134	1	
J 1- 4	RECEPTACLE, INPUT	642959	4	
MP 3, 4	600 VOLT FUSE CONTACT	707190	2	
MP 6	CONTACT,BATTERY	642967	1	
MP 7	CONTACT,BATTERY	654228	1	
Q 1, 2	*TRANSISTOR,SI,NPN,SELECT IEBO,SOT-23	821637	2	
Q 3, 5, 7, 11, 13	*TRANSISTOR,SI,NPN,25 V,SOT-23	820902	5	
Q 4	*TRANSISTOR,SI,PNP,SELECT ICER,SOT-23	887179	1	
Q 6	*TRANSISTOR,SI,PNP,SYALL SIGNAL,SOT-23	742684	1	
Q 8	*TRANSISTOR,SI,P-CHAN,SOT-23	332477	1	
Q 9	*TRANSISTOR.SI,NPN,SMALL SIGNAL,S0T-23	912469	1	
Q 10, 12	TRANSISTOR,SI,PNP,50 V,0.2 W,S0T-23	820910	2	
R 1	RES,WW, 2 K,+-5%, 2.5 W	107698	1	1
R 2	*RES,CERM,IX,+-1%,2 W,100 PPM	876177	1	1
R 3, 4	*RES,CERM.IK.+-5%,.125 W,200 PPM,1206	745992	2	
R 5-8,10,28,43	*RES,CERM,100 K,+-1%,.125 W,100 PPM,1206	769802	7	
R 9	*RES.CERM.109 K,+-0.5%,100 PPM,1206	913830	1	
R 11	RES,WW,0.010,+-0.25%,1 W,100 PPM	877076	1	
R 12	*RES.CERM,4.7 M,+-5%,.125 W,200 PPM,1206	783282	1	
R 14, 19	*RES,CERM,22.25 K,+-1%,100 PPM,1206	913850	2	
R 15,16, 18	*RES,CERM,20K,+-0.5%.125 W,100 PPM,1206	913728	3	
R 17	*RES,CERM,150K,+-1%,.125 W,100 PPM,1206	867697	1	
R 20, 46	*RES.CERM.10K.+-5%,.125 W,200 PPM,1206	746610	2	
R 21, 22, 36,41,45	*RES,CERM,IM,+-1%,.125 W,100 PPM,1206	836387	5	
R 23, 27	*RES,CERM,33K,+-5%,.125 W,200 PPM,1206	746669	2	
R 24, 44	*RES,CERM,56.2K,+-1%.125 W,100 PPM,1206	831305	2	
R 25, 33, 34,48,49	*RES,CERM,205K,+-1%,.125 W,100 PPM,1206	769836	5	
R 26	RES,VAR,CERM,100 K,+-25%	912493	1	
R 29	*RES,CERM,2.2 M,+-5%,.125 W,200 PPM,1206	746479	1	
R 31	*RES,CERM,649 K,+-1%.125 W,100 PPM,1206	867473	1	
R 32	*RES,CERM,301 K,+-1%.125 W,100 PPM,1206	821652	1	
R 35, 37	*RES,CERM,536 K,+-1%,.125 W,100 PPM,1206	845420	2	
R 40	*RES,CERM,1 M,+-5%,1 W	655175	1	1
R 42	*RES,CERM,43.2 K,+-1%,.125 W,100 PPM,1206	887109	1	
R 47	RES,CERM,26.1 K,+-1%,.125 W,100 PPM,1206	807685	1	
RT 1	THERMISTOR,RECT.,POS., 1 K,+-40%,25C	446849	1	1
RV 1	VARISTOR, 910,+- 10%,1.0 MA	876193	1	
S 1	SWITCH, ROTARY	919712	1	
U 1	IC N-WELL MOJO, ASSEMBLY TESTED	900469	1	
U 3	*IC,TEMP SENSOR,CENT,10 MV/C,SEL,TO-92	913843	1	
U 4	*IC,CMOS,COMARATOR,DUAL,UPOWER,SO8	913835	1	
VR 1	*IC, 1.23 V,150 PPM T.C., BANDGAP V.REF	634451	1	
Z 1	RES NET THK FILM TESTED	828152	1	

Notes: * Static sensitive part
1 Requires exact replacement
⚠ To ensure safety, use exact replacement only

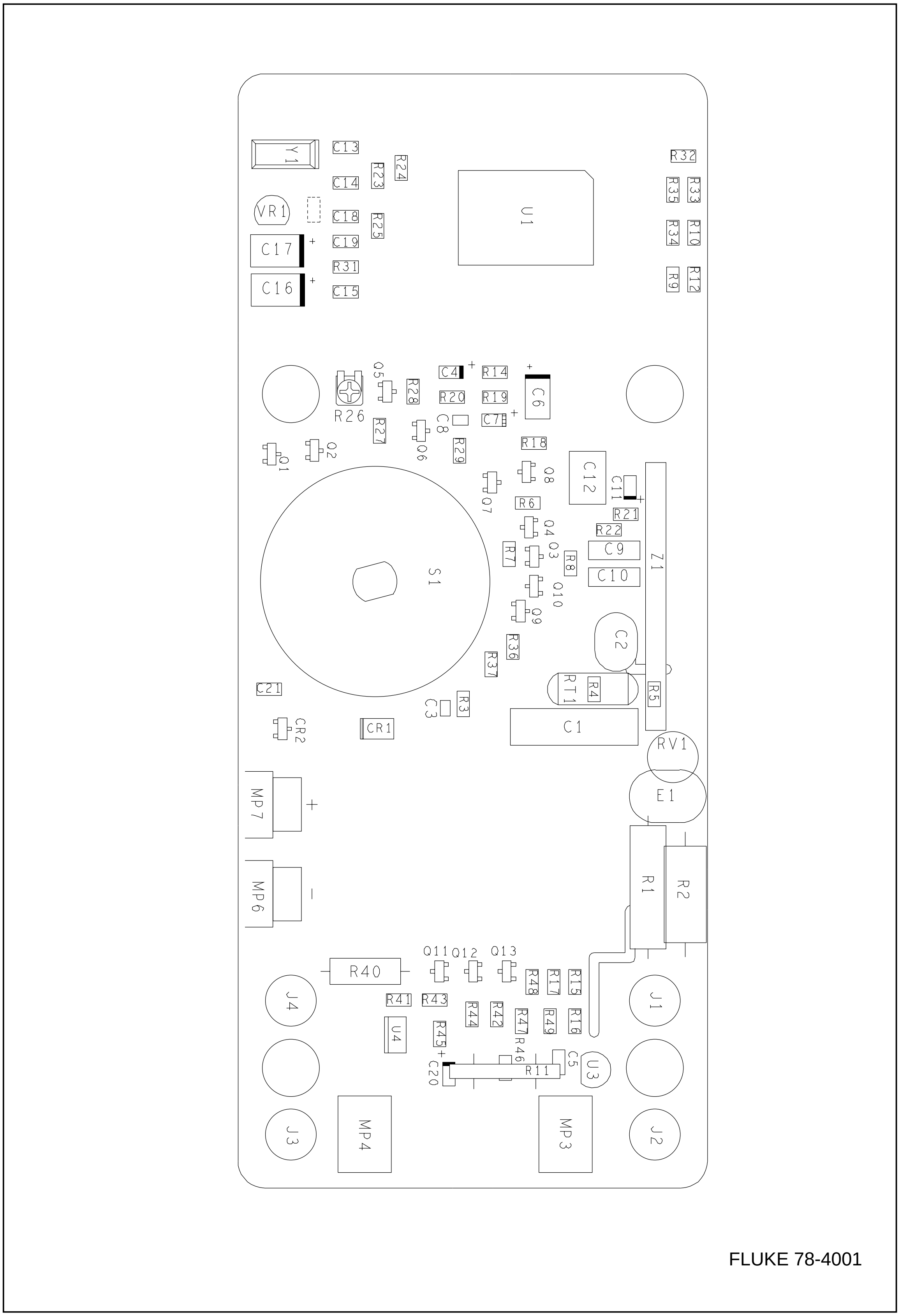

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Figure 4-2. A1 Main PCA

Chapter 5
Schematic Diagrams

Table 5-1. Signal Abbreviations

Number	Name	Description
1	REFI	REFerence Input
2	AGND	Analog GrouND
3	REFH	REFerence High
4	VDD	plus power supply
5	PS2	Power Supply 2
6	PSI	Power Supply 1
7	PS0	Power Supply 0
8	BIAS	BIAS input
9	DO	Digital Output
10	P21	Port 2, bit 1
11	DTS	Diode Test Source
12	OSCI	OSCillator Input
13	OSCO	OSCillator Output
14	DGND	Digital GrouND
15	BPR	BeePeR drive
16	AZEN	Auto Zero ENd signal
17	P31	Port 3, bit 1
18	P32	Port 3, bit 2
19	P33	Port 3, bit 3
20	S0	Icd Segment 0
21	S1	icd Segment 1
22	S2	Icd Segment 2
23	S3	Icd Segment 3
24	S4	Icd Segment 4
25	S5	Icd Segment 5
26	S6	Icd Segment 6
27	S7	Icd Segment 7
28	S8	Icd Segment 8
29	S9	Icd Segment 9
30	S10	Icd Segment 10
31	S11	Icd Segment 11
32	S12	Icd Segment 12
33	S13	Icd Segment 13
34	S14	Icd Segment 14
35	S15	Icd Segment 15
36	S16	Icd Segment 16
37	S17	Icd Segment 17
38	S18	Icd Segment 18
39	S19	Icd Segment 19
40	VSS	minus power supply
41	S20	Icd Segment 20
42	S21	Icd Segment 21
43	S22	Icd Segment 22
44	S23	Icd Segment 23
45	S24	Icd Segment 24
46	S25	Icd Segment 25
47	S26	Icd Segment 26
48	S27	Icd Segment 27
49	S28	Icd Segment 28
50	VOA	Icd drive VOltage A
51	VOB	Icd drive VOltage B
52	S29	Icd Segnment 29
53	S30	Icd Segment 30
54	S31	lcd Segment 31
55	RES*	RESet, active low

Table 5-1. Signal Abbreviations (cont)

Number	Name	Description
56	TEST	TEST
57	P00	Port 0, bit 0
58	CK1	ClocK 1
59	CK2	ClocK 2
60	H1	lcd backplane 1
61	H2	lcd backplane 2
62	H3	lcd backplane 3
63	H4	lcd backplane 4
64	PUD*	Power Up Digital output, active low
65	TT	Temperature Test
66	RPM	RPM function input
67	FO	Function bit 0
68	F1	Function bit 1
69	F2	Function bit 2
70	P13	Port 1, bit 3
71	INT	INTegrator amplifier output
72	AZ	Auto Zero
73	B.04	Buffer output, .04 V range
74	B 4	Buffer output, .4 V range
75	Bi	Buffer output, 1 V range
76	AFO	Active Filter Output
77	FAO	Filter Amplifier Output
78	FAI	Filter Amplifier Inverting input
79	AFI	Active Fiiter Input
80	AVOP	Absolute Value amplifier Output Plus
81	AVOM	Absolute Value amplifier Output Minus
82	AVIM	Absolute Value amplifier Input Minus
83	ACBO	AC Buffer amplifier Output
84	ACBM	AC Buffer amplifier Minus ~nput
85	AP8	Analog Port 8
86	DTD	Diode Test Divider
87	REFJ	REFerence Junction input
88	LOTR	RPM LOw TRigger level
89	OTD	Open Thermocouple Detect
90	VSS	Minus power supply
91	AIN	Amps INput
92	RRS	Ohms Reference Resistor Sense
93	SENS	SENSe input
94	V4	Voltage divide by 10^4
95	V3	Voltage divide by 10^3
96	V2	Voltage divide by 10^2
97	GRD	GuaRD
98	V1	Voltage divide by 10^1
99	V0	Voltage divider input
100	CC	4 V ac range Compensation Capacitor

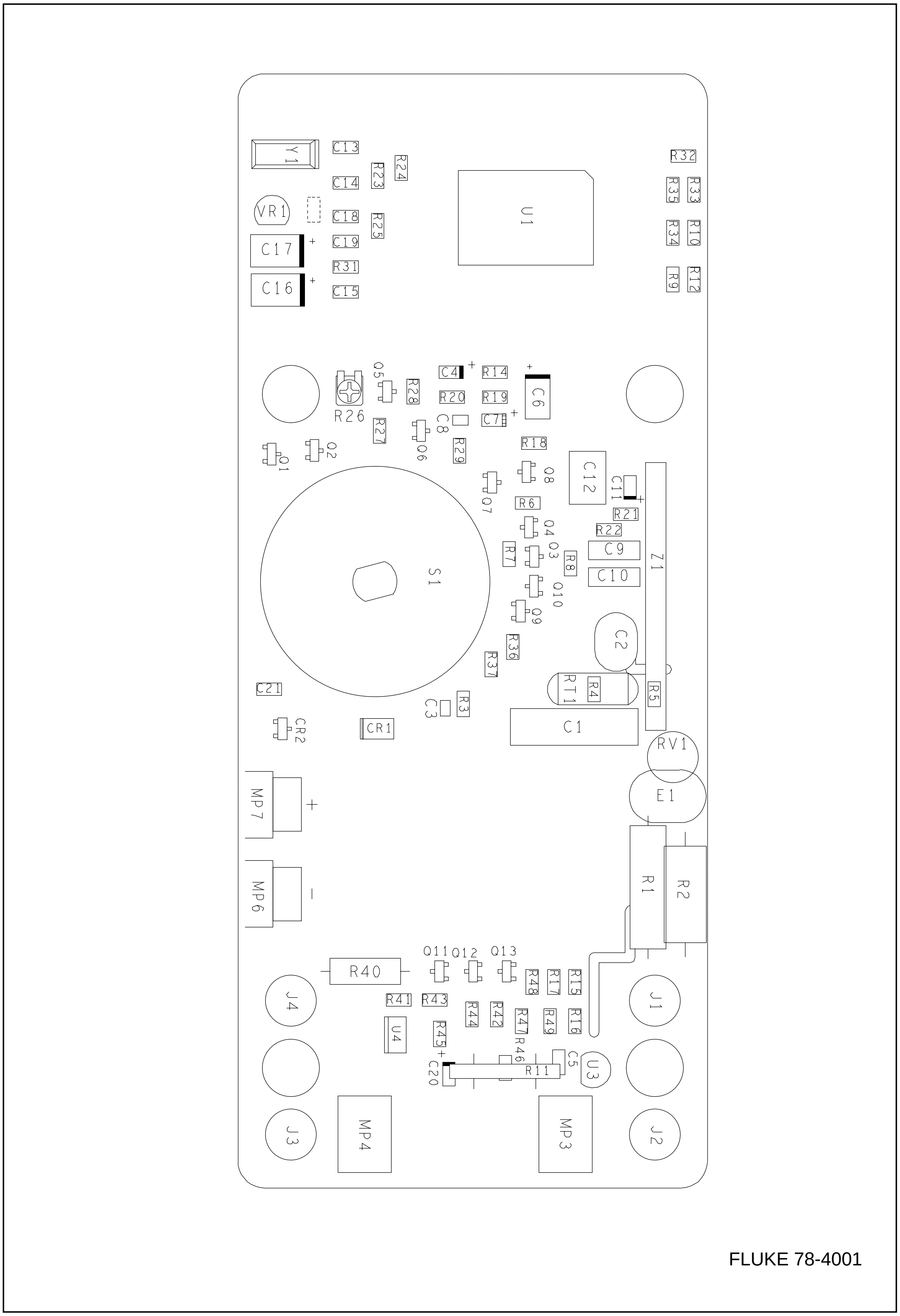

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Figure 5-1. A1 Main PCA

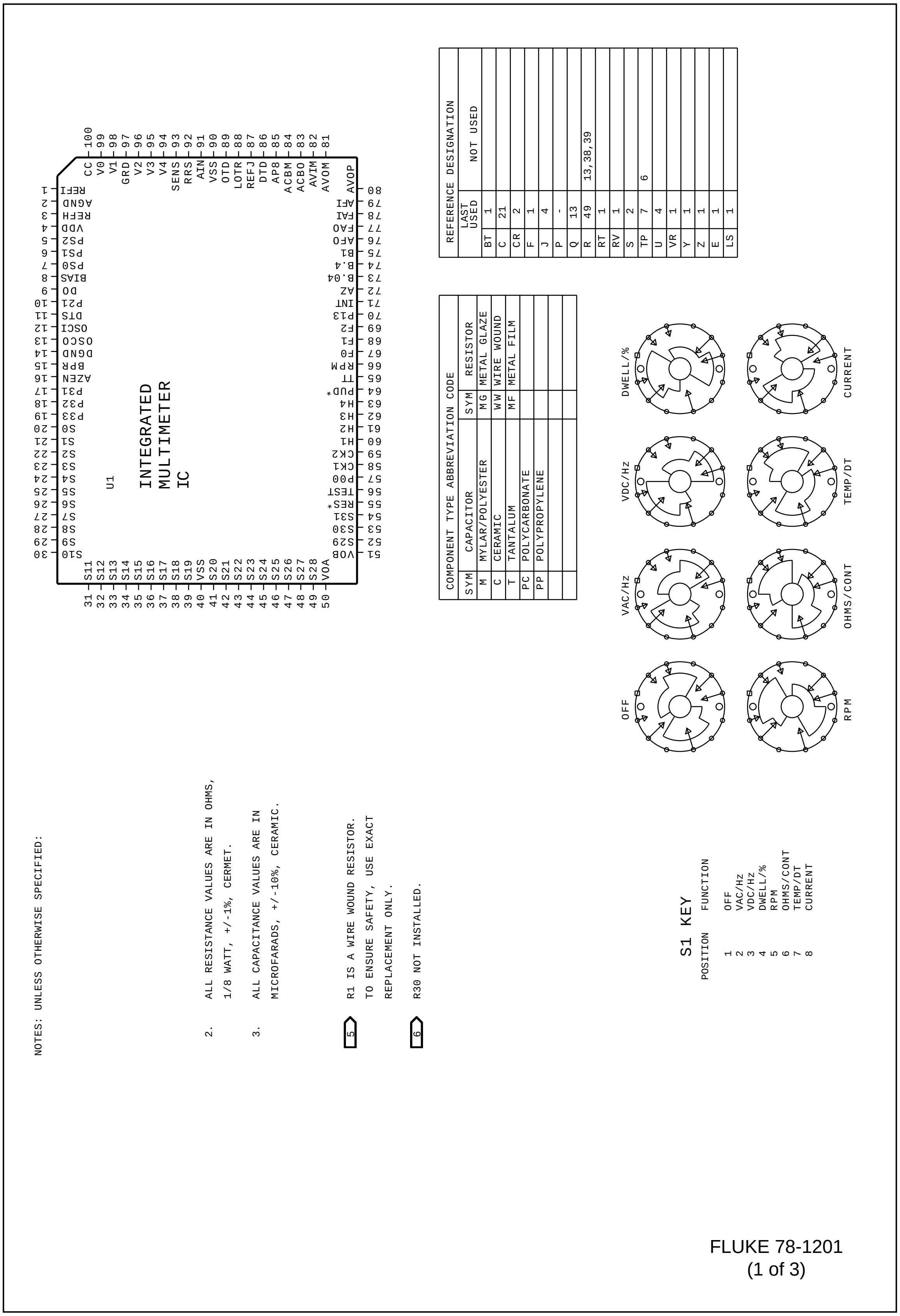

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Figure 5-1. A1 Main PCA (cont)

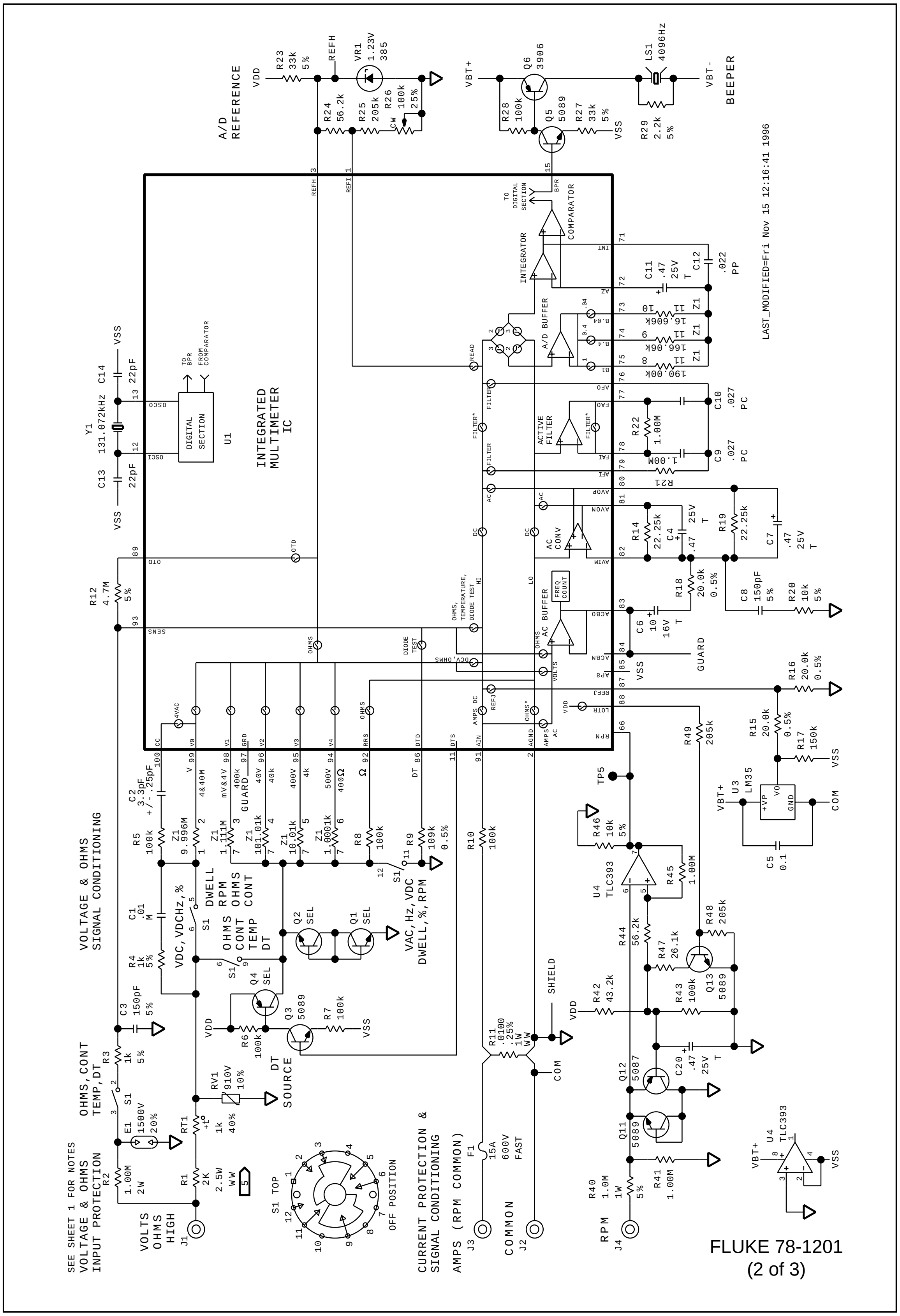

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Figure 5-1. A1 Main PCA (cont)

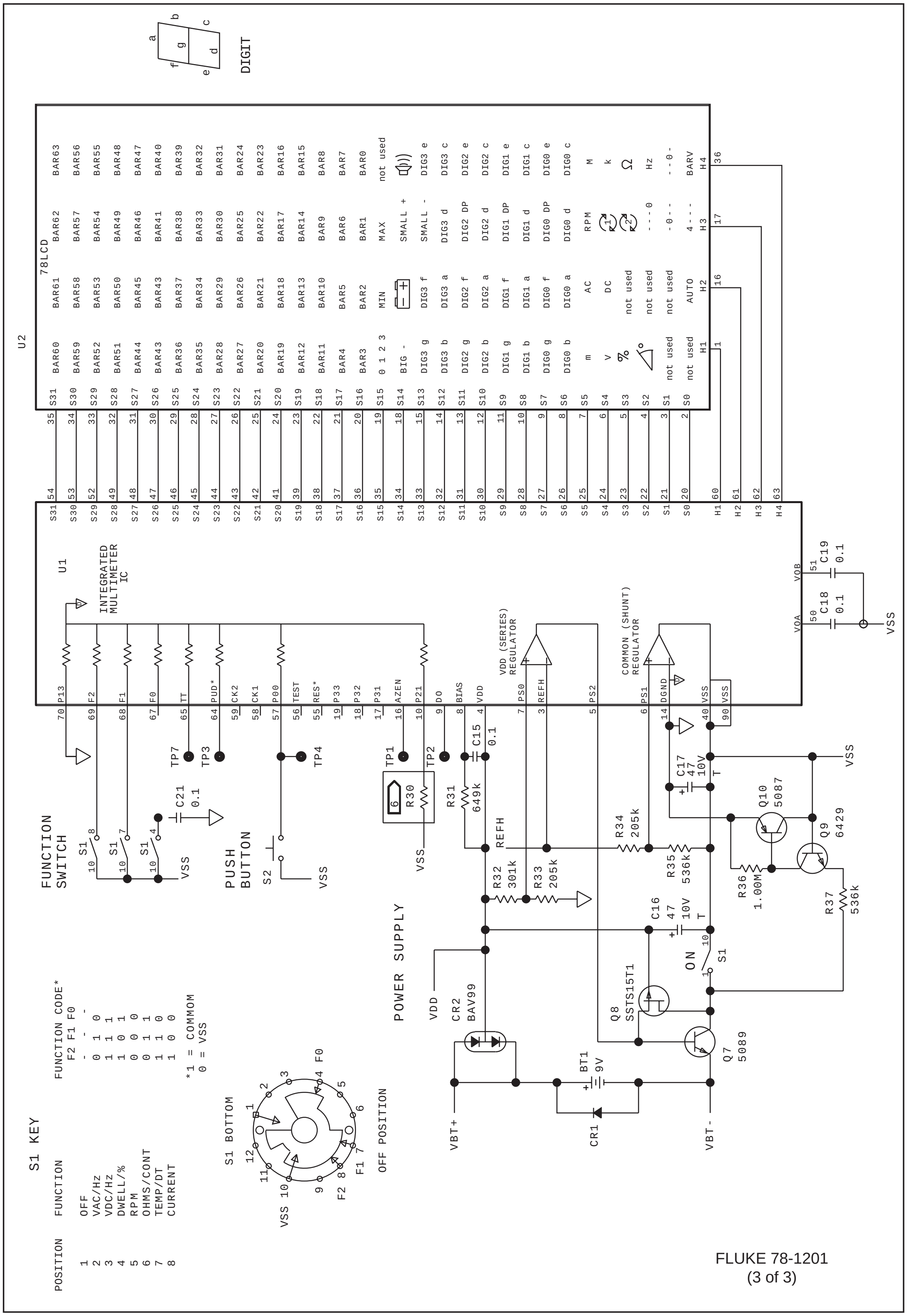

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Figure 5-1. A1 Main PCA (cont)