FLUKE ®

Calibration

792A

AC/DC Transfer Standard

Instruction Manual

PN 871723
Rev.1, 12/92

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Declaration of the Manufacturer or Importer

We hereby certify that Fluke Model 792A is in complaiance with Postal Regulation Vfg. 1045/1984 and is RFI suppressed. The marketing and sale of the equipment was reported to the German Postal Service. The right to retest this equipment to verify compliance with the regulation was given to the German Postal Service.

Bescheinigung des Herstellers/Importeurs

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John Fluke Mfg. Co., Inc.

SAFETY SUMMARY

SAFETY TERMS IN THIS MANUAL

This instrument has been designed and tested in accordance with IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus. This Operator Manual contains information, warnings, and cautions that must be followed to ensure safe operation and to maintain the transfer standard in a safe condition. Use of this equipment in a manner not specified herein may impair the protection provided by the equipment.

WARNING statements identify conditions or practices that could result in damage to equipment.

CAUTION statements identify conditions or practices that could result in personal injury or loss of life.

SYMBOLS MARKED ON EQUIPMENT

DANGER — High voltage.

Ground (earth) terminal.

Attention — refer to the manual. This symbol is to indicate that information about usage of a feature is contained in the manual.

POWER SOURCE

The power pack is intended to operate from a power source that will not apply more than 264V ac rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation during battery charging.

USE THE PROPER FUSE

To avoid fire hazard, use only a fuse identical in type, voltage rating, and current rating as specified on the rear panel fuse rating label. The use of makeshift fuses and bypassing fuse holders is prohibited.

GROUNDING THE TRANSFER STANDARD

The transfer standard is a Safety Class I (grounded enclosure) instrument as defined in IEC 348. The enclosure must be grounded through the grounding conductor of the power pack power cord, or if operated with the power pack unplugged, through the front panel GROUND binding post.

USE THE PROPER POWER CORD

Use only the power cord and connector appropriate for the voltage and plug configuration in your country.

Use only a power cord that is in good condition.

Refer cord and connector changes to qualified service personnel.

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

To avoid explosion, do not operate the transfer standard in an atmosphere of explosive gas.

DO NOT REMOVE COVER

To avoid personal injury or death, do not remove the transfer standard or power pack cover. Do not operate the transfer standard without the cover properly installed. Normal calibration is accomplished with the cover closed, and there are no user-serviceable parts inside the transfer standard, so there is no need for the operator to ever remove the cover. Access procedures and the warnings for such procedures are contained in the Service Manual. Service procedures are for qualified service personnel only.

DO NOT ATTEMPT TO OPERATE IF PROTECTION MAY BE IMPAIRED

If the transfer standard appears damaged or operates abnormally, protection may be impaired. Do not attempt to operate it. When in doubt, have the instrument serviced.

DO NOT SERVICE UNLESS QUALIFIED TO DO SO

Do not perform internal service or adjustment of this product, including replacing the batteries in the power pack, unless you are qualified to do so.

USE CARE WHEN SERVICING WITH POWER ON

High voltages exists at several points inside the power pack. To avoid personal injury, do not touch exposed connections and components while power is on.

Disconnect power before removing protective panels, soldering, or replacing components.

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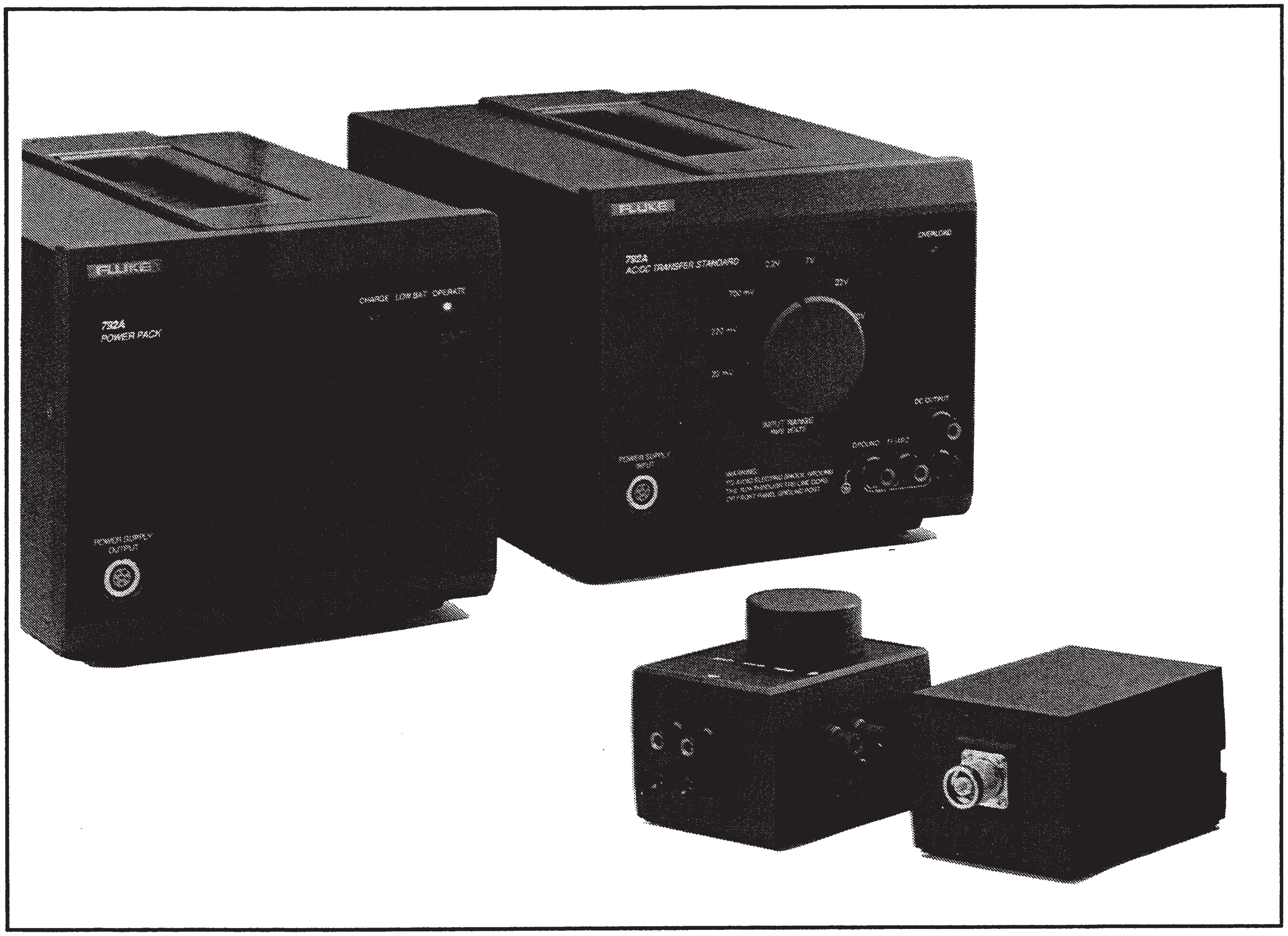


792A AC/DC Transfer Standard

Section 1
Introduction and Specifications

INTRODUCTION 1-1.

The 792A AC/DC Transfer Standard is a laboratory standard instrument that calibrates ac voltage calibrators, ac/dc transfer standards, and ac voltmeters. It consists of four main components: a transfer standard sensor unit (called the transfer standard in this manual), power pack, 1000V range resistor, and transfer switch.

Inputs are accepted in the range 2 mV to 1000V rms, 10 Hz up to 1 MHz, with a maximum Volt-Hertz product of 10^8. The 792A compares the heating effect of an ac voltage with that of a known dc voltage (or other ac voltage). Sensing the rms value is done entirely without thermocouples and the drawbacks that accompany them. (See The Fluke RMS Sensor, paragraph 1-3, for more information.)

The transfer standard accepts dc and ac voltages through a stainless steel Type "N" INPUT connector and presents a dc voltage at the front panel DC OUTPUT binding posts that is linearly proportional to the rms potential of the input. A digital voltmeter of 6½-digit resolution or better can be used to resolve the 2.0V nominal full-scale output.

An OVERLOAD indicator and beeper warns of input overloads. Even though the transfer standard is protected electronically from overloads, it is a delicate laboratory instrument and should be treated with extreme care.

Before operating the transfer standard, be sure to read Sections 2 and 3, particularly the WARNING that explains the restriction to use only sources that are current-limited to 200 mA or less (at the beginning of Section 2), and the CAUTION about observing the voltage protection level limits for each INPUT RANGE setting (at the beginning of Section 3).

THE FLUKE RMS SENSOR 1-2.

At the center of the 792A is the patented Fluke RMS Sensor, a solid-state TVC (thermal voltage converter) that offers many advantages over thermocouple-based TVCs. Thermocouple-based ac/dc transfer standards present an output with a square-law response and require a Lindeck potentiometer or nanovoltmeter to resolve their millivolt-level output.

The Fluke RMS Sensor circuit operates in the 2V range, so its output can be resolved by the dc voltage function of a 6½-digit DMM such as the Fluke 8505A. The Fluke RMS Sensor has a shorter time constant, small reversal error, and better frequency response. In addition, the output of the 792A has a linear rather than square-law response.

STANDARD EQUIPMENT 1-3.

Model 792A includes one of each of the separate components described next. Additional power packs can be ordered for operating convenience.

792A AC/DC Transfer Standard 1-4.

The 792A AC/DC Transfer Standard is called the transfer standard in this manual. To operate, it must be connected to a charged Model 792A-7001 Power Pack. The front panel has an INPUT RANGE knob, an OVERLOAD indicator, and low-thermal tellurium-copper binding posts for OUTPUT HI, LO, GUARD, and GROUND (earth). The rear panel has a stainless steel Type "N" input connector for the signal to be measured. This connector also mates with the 792A-7002 1000V Range Resistor for use in the 2.2V INPUT RANGE setting to provide a 1000V range.

792A-7001 Power Pack 1-5.

The 792A-7001 Power Pack provides operating power for the transfer standard. The power pack contains batteries that power the transfer standard for 20 to 80 hours on a charge, depending on the INPUT RANGE setting. The state of calibration of the transfer standard is unaffected by variations in power packs, so spare power packs can be used when continuous operation for longer periods is required. If the transfer standard requires calibration, ship only the transfer standard unit and 1000V range resistor to Fluke. Power pack battery charge time and life are provided in the specifications.

792A-7002 1000V Range Resistor 1-6.

The 792A-7002 1000V Range Resistor is a precision resistor with a low power coefficient designed specifically for fast-settling ac-dc transfers. Inputs between 200V and 1000V are accepted by the 1000V range resistor INPUT connector. The 1000V range resistor OUTPUT is connected directly to the transfer standard rear panel INPUT connector. The transfer standard range is set to 2.2V. The 1000V range resistor is calibrated with the transfer standard and is therefore not interchangeable with other 1000V range resistors.

792A-7003 Transfer Switch 1-7.

The 792A-7003 Transfer Switch provides a way to switch between transfer standard input sources with minimal error. The switch is recommended whenever separate ac and dc or ac and ac sources are used in a transfer.

Stainless Steel Type "N" Extender 1-8.

One Type "N" extender is shipped with each 792A. Install the extender on the transfer standard rear panel INPUT connector and leave the extender in place. The transfer standard was calibrated with this extender in place (plus one half of a Type "N" tee connector).

The extender serves two purposes:

1. It makes it easier to reach the tightening ring to firmly secure the connector to the 1000V range resistor or transfer switch.

2. It saves the transfer standard INPUT connector from wearing out. When the Type "N" connector begins to wear out, the part wearing out is this disposable extender. The extender is relatively inexpensive and can easily be replaced by ordering Fluke part number 875443.

Power Pack Cable 1-9.

One power pack cable is supplied to connect the transfer standard to the power pack. An extra power pack cable can serve as a backup if the power cable is lost, or as an operating convenience for users who keep extra power packs on hand. Extra power pack cables can be obtained by ordering Fluke part number 867254.

ACCESSORY 792A-7004 FLUKE A40 CURRENT SHUNT ADAPTER 1-10.

The optional accessory 792A-7004 Fluke A40 Current Shunt Adapter provides a way to attach a Fluke Model A40 Current Shunt to the transfer standard INPUT connector. Appendix B has a diagram that shows how to connect and use this adapter to make current measurements or transfers using the 792A.

SERVICE AND CALIBRATION INFORMATION 1-11.

When manufactured, each 792A is calibrated and thoroughly verified using a system of standards and methods that meets or exceeds the requirements of MIL-STD-45662A. The 792A is warranted to the original purchaser for a period of one year beginning on the date received. The warranty is located at the front of this manual.

See the 792A Test Report that was shipped with your transfer standard for the date recertification is due. The ac-dc difference values on the Test Report are valid for one year. Recertification requires reshipping the 792A transfer standard unit and 1000V range resistor to the Fluke Technical Service Center in Everett, WA. (See the current Fluke catalog for the address.) Do not send the power pack. Use the original carton to ship the transfer standard. If the original carton is not available, you can order a new one from a Fluke Technical Service Center. The cost of calibrating to original specifications is shown in the Fluke catalog as number 792A-000 in the price list.

WARNING

SERVICE PROCEDURES, INCLUDING REPLACEMENT OF BATTERIES IN THE 792A POWER PACK, ARE TO BE DONE BY QUALIFIED SERVICE PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK OR FIRE, DO NOT SERVICE THE 792A UNLESS YOU ARE QUALIFIED TO DO SO.

Section 5 contains servicing information, the tuning procedure, and a basic calibration procedure. However, be sure that you want to take over the traceability responsibilities if you do not send the unit to Fluke for repair, adjustment, or calibration. Any procedure that involves opening the cover of the transfer standard sensor unit or 1000V range resistor invalidates calibration.

SPECIFICATIONS 1-12.

Specifications in Table 1-1 are valid after the 792A has stabilized with the power on or off for at least 12 hours in the working environment, and after it has warmed up with the power on for at least 15 minutes. For best accuracy in the 22 mV, 220 mV, and 700 mV ranges, set the INPUT RANGE knob to the correct range at least five minutes before beginning the first transfer in that range. Absolute uncertainty includes stability, temperature coefficient, and traceability to legal standards.

Table 1-1. 792A Specifications

Corrected Absolute AC/DC Uncertainty
1 year, $T/_{CAL}$ ±5°C

VOLTAGE		AC/DC UNCERTAINTY ±PPM INPUT — FREQUENCY											
VOLTAGE RANGE	VOLTAGE INPUT	10 Hz	20 Hz	40 Hz	100 Hz	1 kHz	10 kHz	20 kHz	50 kHz	100 kHz	300 kHz	500 kHz	1 MHz
22 mV	2 mV	2200	1600	1600	1600	1600	1600	1600	1600	1900	2500	4500	5000
	10 mV	320	280	280	280	280	280	280	300	500	700	1200	1500
	20 mV	280	180	140	140	140	140	140	200	450	650	1100	1300
220 mV	20 mV	350	230	190	190	190	190	190	220	450	650	1100	1900
	100 mV	210	90	50	50	50	50	50	100	150	450	600	600
	200 mV	200	80	40	40	40	40	40	100	150	450	600	600
700 mV	200 mV	220	80	50	50	50	50	50	100	150	450	600	600
	600 mV	200	70	30	25	25	25	25	45	60	140	430	550
2.2V	600 mV	200	65	30	25	25	25	25	45	60	120	430	550
	1V	190	60	30	15	15	15	15	40	50	115	430	450
	2V	190	60	25	10	10	10	10	40	50	115	430	450
7V	2V	190	65	30	25	25	25	25	45	55	120	440	470
	6V	190	60	25	10	10	10	10	40	50	120	430	460
22V	6V	190	65	30	25	25	25	25	45	55	120	440	480
	10V	190	60	30	20	20	20	20	40	50	120	430	480
	20V	190	60	25	15	15	15	15	40	50	120	430	480
70V	20V	190	65	30	25	25	25	25	55	70	130		
	60V	190	60	25	20	20	20	20	50	65	130		
220V	60V	190	65	40	40	40	40	40	65	70	130		
	100V	190	65	30	30	30	30	30	65	70			
	200V	190	60	27	27	27	27	27	60	70			
1000V	200V	190	90	40	40	40	40	40	65	70			
	1000V			27	27	27	27	27	60	70			

Maximum Volt-Hertz Product: 1×10^8 @ 100 kHz, 2.2×10^7 @ 1 MHz
Waveform Requirements: Sinusoidal, distortion less than 1%

Table 1-1. 792A Specifications (cont)

Corrected Absolute AC/DC Uncertainty 1 year, $T/_{CAL}$ ±12°C													
		AC/DC UNCERTAINTY ±PPM INPUT											
VOLTAGE		FREQUENCY											
VOLTAGE RANGE	VOLTAGE INPUT	10 Hz	20 Hz	40 Hz	100 Hz	1 kHz	10 kHz	20 kHz	50 kHz	100 kHz	300 kHz	500 kHz	1 MHz
22 mV	2 mV	2300	1700	1700	1700	1700	1700	1700	1700	2000	2700	5000	5600
	10 mV	500	300	300	300	300	300	300	300	600	800	1400	2000
	20 mV	400	200	200	200	200	200	200	250	600	800	1300	1700
220 mV	20 mV	450	250	220	220	220	220	220	280	700	900	1500	2100
	100 mV	240	100	55	55	55	55	55	110	160	500	650	650
	200 mV	220	90	45	45	45	45	45	110	160	500	650	650
700 mV	200 mV	230	90	55	55	55	55	55	110	160	500	650	650
	600 mV	210	75	35	30	30	30	30	50	65	140	460	650
2.2V	600 mV	210	65	30	25	25	25	25	45	60	120	430	550
	1V	200	60	30	15	15	15	15	40	50	120	430	450
	2V	200	60	25	10	10	10	10	40	50	120	430	450
7V	2V	200	65	30	25	25	25	25	45	85	120	450	530
	6V	200	60	25	10	10	10	10	40	50	120	440	520
22V	6V	200	65	30	25	25	25	25	45	55	120	460	590
	10V	200	60	30	20	20	20	20	40	50	120	450	590
	20V	200	60	25	15	15	15	16	40	50	120	450	590
70V	20V	200	70	30	25	25	25	25	55	70	130		
	60V	200	65	25	20	20	20	20	50	65	130		
220V	60V	200	70	40	40	40	40	40	65	70	130		
	100V	200	70	30	30	30	30	30	65	70			
	200V	200	65	30	27	27	27	27	60	70			
1000V	200V	200	95	40	40	40	40	40	65	70			
	1000V			30	27	27	27	27	60	70			

Maximum Volt-Hertz Product: 1×10^8 @ 100 kHz, 2.2×10^7 @ 1 MHz
Waveform Requirements: Sinusoidal, distortion less than 1%

Table 1-1. 792A Specifications (cont)

Maximum AC-DC Difference
$T/_{CAL}$ ±12°C

VOLTAGE		MAXIMUM AC-DC DIFFERENCE ±PPM INPUT — FREQUENCY											
VOLTAGE RANGE	VOLTAGE INPUT	10 Hz	20 Hz	40 Hz	100 Hz	1 kHz	10 kHz	20 kHz	50 kHz	100 kHz	300 kHz	500 kHz	1 MHz
22 mV	2 mV	2300	1700	1700	1700	1700	1700	1700	1700	2000	3000	5000	5600
	10 mV	1000	500	300	300	300	300	300	700	1500	3000	4000	5000
	20 mV	1000	500	200	200	200	200	300	700	1500	3000	4000	5000
220 mV	20 mV	450	250	220	220	220	220	220	280	700	900	1500	2500
	100 mV	600	150	60	60	60	60	80	110	300	750	1500	2500
	200 mV	900	300	60	60	60	60	80	110	300	750	1500	2500
700 mV	200 mV	600	150	60	60	60	60	80	110	300	750	1500	2500
	600 mV	900	300	60	60	60	60	80	100	300	750	1500	2500
2.2V	600 mV	300	65	30	30	25	45	55	75	150	200	430	550
	1V	600	150	30	30	20	45	55	75	150	200	430	500
	2V	900	300	60	30	20	45	55	75	150	200	430	500
7V	2V	600	150	30	30	25	45	55	75	150	200	450	530
	6V	900	300	60	30	20	45	55	75	150	200	440	520
22V	6V	300	65	30	30	25	45	55	75	150	200	460	590
	10V	600	150	30	30	20	45	55	75	150	200	450	590
	20V	900	300	60	30	20	45	55	75	150	200	450	590
70V	20V	600	150	30	30	25	45	55	75	150	200		
	60V	900	300	60	30	20	45	55	75	150	200		
220V	60V	300	70	40	40	40	45	55	75	150			
	100V	600	150	30	30	30	45	55	75	150			
	200V	900	300	60	30	27	45	55	75	150			
1000V	200V	300	95	40	40	40	45	55	75	150			
	1000V	900	400	60	30	27	45	55	75	150			

NOTE: This table represents the **maximum** correction that could be required to achieve specified ac-dc uncertainties. A test report supplied with each 792A shows the actual ac-dc corrections.

Table 1-1. Specifications (cont)

Settling Time

RANGE	SETTLING TIME (SECONDS)
22 mV	60
220 mV	60
700 mV	60
2.2V	30
7V	30
22V	30
70V	30
220V	30
1000V	30

Output Characteristics

Impedance: <30 milliohms

Current: up to 20 mA drive capability

Protection: Protected against damage due to high voltage up to 200V, provided the peak current does not exceed 50 mA. May be shorted indefinitely without damage to the instrument.

Tolerance: The nomial output voltage at full scale, with tolerances, is shown below.

INPUT RANGE	FULL SCALE OUTPUT	TOLERANCE
22 mV	2.0V	5% + 5.3 mV
220 mV	2.0V	5% + 760 μV
700 mV	2.0V	5% + 500 μV
2.2V	1.9V	10% + 300 μV
7V	2.0V	10% + 300 μV
22V	2.0V	10% + 300 μV
70V	2.0V	10% + 300 μV
220V	2.0V	10% + 300 μV
1000V	1.8V	10% + 300 μV

Battery Characteristics

The Power Pack contains four 6V sealed, lead-acid, gelled-electrolyte batteries. The following characteristics are typical and apply at 23°C:

Battery Life: 22 mV to 700 mV ranges, 24 hours ; 2.2V to 1000V ranges, 72 hours

Battery Charge Time: 16 hours to full charge

Operating Time Remaining with LOW BAT Lit: 22 mV to 700 mV ranges, 30 minutes; 2.2V to 1000V ranges, 60 minutes

Table 1-1. Specifications (cont)

DC Reversal Error

The following table is relative to the input voltage and applies over each entire range.

INPUT RANGE	INPUT VOLTAGE	MAXIMUM REVERSAL ERROR
22 mV	2 to 22 mV	90 µV
220 mV	22 to 220 mV	90 µV
700 mV	220 to 700 mV	90 µV
2.2V	700 mV to 2.2V	10 ppm
7V	2.2 to 7V	10 ppm
22V	7 to 22V	10 ppm
70V	22 to 70V	10 ppm
220V	70 to 220V	10 ppm
1000V	220V to 1000V	10 ppm

Input Impedance

INPUT RANGE	INPUT IMPEDANCE	
	RESISTANCE	SHUNT CAPACITANCE
22 mV	10 MΩ	<40 pF
220 mV	10 MΩ	<40 pF
700 mV	10 MΩ	<40 pF
2.2V	420Ω	<20 pF
7V	1.2 kΩ	<20 pF
22V	4.0 kΩ	<20 pF
70V	12 kΩ	<20 pF
220V	40 kΩ	<20 pF
1000V	200.4 kΩ	<20 pF

Maximum Input Voltage

The following table lists both the maximum operational and the non-destructive rms voltages.

INPUT RANGE	MAXIMUM INPUT VOLTAGE	
	OPERATIONAL	NON-DESTRUCTIVE
22 mV	22 mV	3V
220 mV	220 mV	3V
700 mV	700 mV	3V
2.2V	2.2V	50V
7V	7V	50V
22V	22V	50V
70V	70V	130V
220V	220V	250V
1000V	1000V	1000V

Table 1-1. Specifications

General Specifications

Temperature Stabilization: Allow 12 hours stabilization time in the environment of use.

Warm-up Time: 15 minutes with the power on, after stabilization time.

Temperature Performance: Operating: 11°C to 35°C.
Calibration: 18°C to 28°C.
Storage: -40°C to 50°C.

Relative Humidity: Operating: <75% to 30°C, <70% to 35°C.
Storage: <95%, non-condensing.

Altitude: Operating: to 3,050m (10,000 ft). Non-operating: to 12,200m (40,000 ft).

Safety: Designed to comply with UL1244(Rev.1987); IEC 348-1978; IEC 1010-1-1990; CSA BULLETIN 556B; and ANSI/ISA-S82.01-1988.

Input Low Isolation: 20V pk to chassis; 10V pk to guard

Guard Isolation: 10V pk to chassis ; 10V pk to input connector shell

EMI/RFI: Meets VDE 0875 Level K. Complies with FCC Rules Part 15, Sub-Part B, Class B.

Reliability: {MIL-STD-28800D, para 3.13.3}

Line Power: 50 to 60 Hz ±5% allowed about selectable nominal line voltages: 100V, 120V, 220V, 240V ±10%. Maximum power: 45 VA

Size:

Transfer Unit: Height 17.8 cm (7 in), plus 1.5 cm (0.6 in) for feet; Width 21.6 cm (8.5 in); Depth 30.5 cm (12 in).

Power Pack: Height 17.8 cm (7 in), plus 1.5 cm (0.6 in) for feet; Width 21.6 cm (8.5 in); Depth 30.5 cm (12 in).

1000V Range Resistor: Height 7.6 cm (3 in); Width 8.9 cm (3.5 in); Depth 14.0 cm (5.5 in).

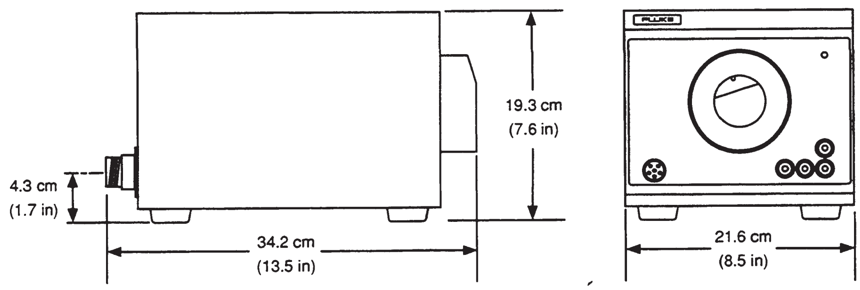
Transfer Switch: 7.6 cm (3 in); Width 8.9 cm (3.5 in); Depth 14.0 cm (5.5 in).

Weight:

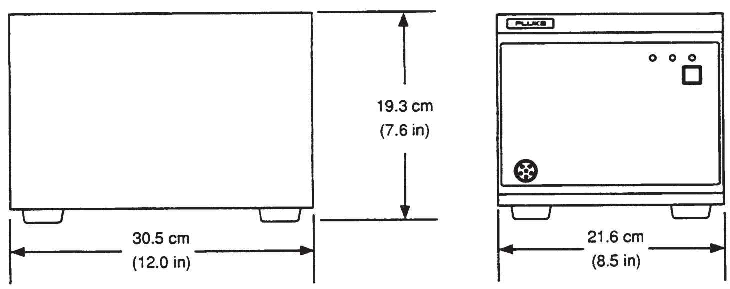
Transfer Unit: 8.4 kg (18.5 lbs)
Power Pack: 8.9 kg (19.5 lbs)
1000V Range Resistor: 1.6 kg (3.5 lbs)
Transfer Switch: 1.6 kg (3.5 lbs)

Table 1-1. Specifications (cont)

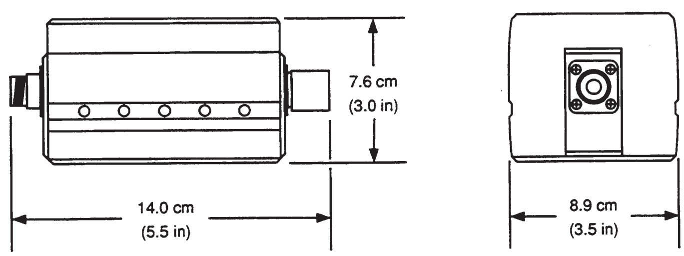
792A TRANSFER UNIT



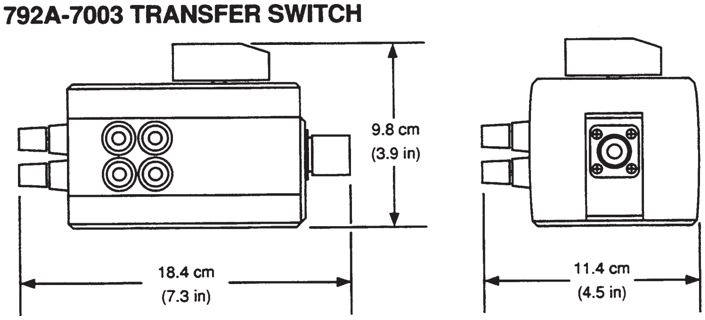
792A-7001 POWER PACK



792A-7002 1000V RANGE RESISTOR



792A-7003 TRANSFER SWITCH



Section 2
Installation

WARNING

TO AVOID ELECTRIC SHOCK AND TO CONFORM TO IEC SAFETY CLASS I, USE ONLY WITH SOURCES THAT ARE PROTECTED FROM SHORT CIRCUIT WITH CURRENT-LIMITING TO 200 mA OR LESS.

INTRODUCTION 2-1.

This section provides instructions for the following:

- Unpacking
- Installation
- Selecting line voltage
- Replacing the power pack fuse
- Connecting the power pack to line power

Because this section explains fusing and operating environment requirements, you should read this section before operating the 792A. Instructions for connecting cables to other standards and to a UUT (Unit Under Test) during operation are in Section 3.

UNPACKING AND INSPECTION 2-2.

The 792A is shipped in a container that is specially designed to prevent damage during shipping. Inspect the 792A carefully for damage, and immediately report any damage to the shipper. Instructions for inspection and claims are included in the shipping container.

If you need to reship the 792A, use the original carton. If the original carton is unavailable, you can order a new carton from a Fluke Technical Service Center.

When you unpack the 792A, check for all the standard equipment listed in Table 2-1. Also check for accessories if any were ordered. Report any shortage to the place of purchase or to the nearest Technical Service Center. (A List of Technical Service Centers is located in Appendix B of this manual.) If performance tests are required for your acceptance procedures, refer to Section 5 for instructions.

Line power cords available from Fluke are listed in Table 2-2 and illustrated in Figure 2-1.

Table 2-1. Standard Equipment

ITEM	MODEL OR PART NUMBER
792A AC/DC Transfer Standard	792A
792A Power Pack	792A-7001
792A 1000V Range Resistor	792A-7002
792A Transfer Switch	792A-7003
Power Pack Cable	867254
AC Line Cord	(See Table 2-2 and Figure 2-1)
Spare .25A, SLOW BLOW 250V Fuse	166306
Stainless Steel Type "N" Extender	875443
792A Instruction Manual	871723
792A Test Report	(None)
Certificate of Calibration	(None)

Table 2-2. AC Line Cords Available for Fluke Instruments

TYPE	VOLTAGE/CURRENT	FLUKE OPTION NUMBER
North America	120V/15A	LC-1
North America	240V/15A	LC-2
Universal Euro	220V/16A	LC-3
United Kingdom	240V/13A	LC-4
Switzerland	220V/10A	LC-5
Australia	240V/10A	LC-6
South Africa	240V/5A	LC-7

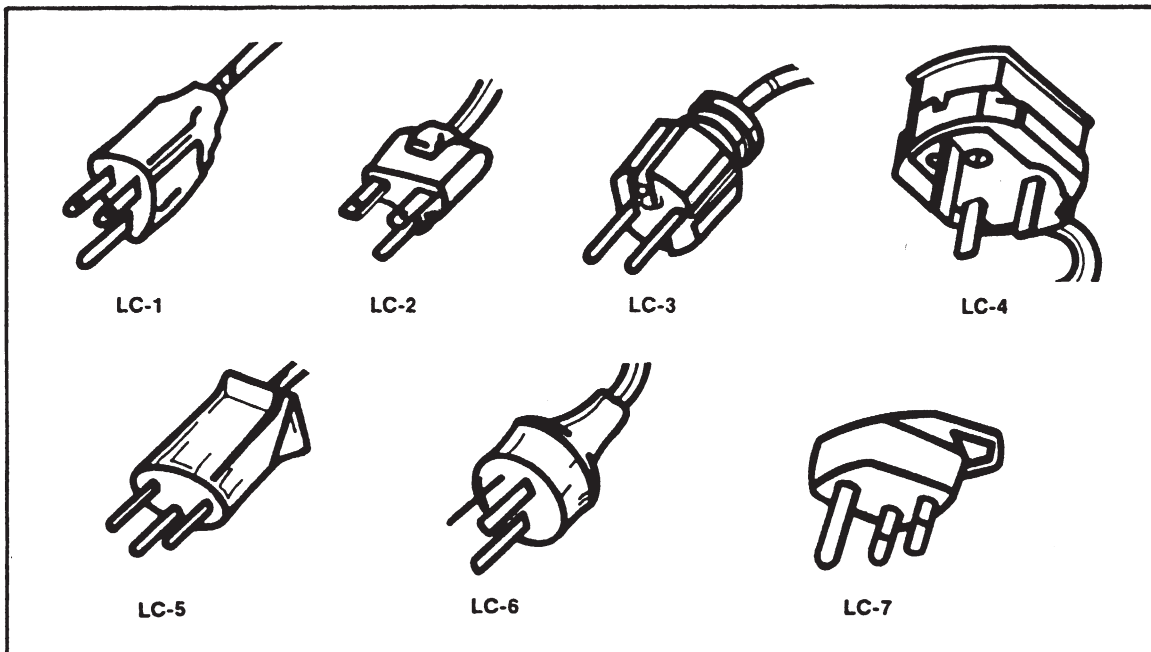


Figure 2-1. Line Power Cords Available for Fluke Instruments

ENVIRONMENTAL AND INPUT REQUIREMENTS 2-3.

Use the transfer standard in a temperature-controlled environment after it has been allowed to stabilize there for at least 12 hours.

At the level of uncertainty specified for the 792A, environmental conditions are important. The 792A is specified for IEC installation category I and pollution degree 1. Installation category I refers to degree of restriction on voltage inputs to the instrument. See the next paragraph for input restrictions. Pollution degree 1 requires an atmosphere with no pollution, or only dry, non-conductive pollution.

Sources connected to the 792A must be current-limited to 200 mA and be free of high-energy transients. In the 22 mV and 220 mV ranges, the INPUT is clamped to ±1.2V. In the 700 mV range, the INPUT is clamped to ±1.8V. On the passive ranges (2.2-220V), clamps at the sensor and peak detectors protect the rms sensor. Refer to Section 4 for more information about the protection circuitry.

CAUTION

Always ensure that the proper 792A range has been selected before applying input voltages. Inputs that exceed the protection level shown on the rear panel label may disrupt the state of calibration and cause instrument damage.

SELECTING LINE VOLTAGE AND ACCESSING THE FUSE 2-4.

CAUTION

To avoid blowing the ac line fuse, verify the position of the line voltage selection drum before plugging in the power pack. Rotate the drum if necessary to match local line power.

CAUTION

To prevent instrument damage, verify that the correct fuse is installed for the line voltage setting. Use only a .25A, 250V SLOW BLOW fuse when the line voltage setting is 220 or 240V, and a .5A, 250V SLOW BLOW fuse when the line voltage setting is 100 or 120V.

The power pack has four line voltage settings: 100V, 120V, 220V, and 240V. Each voltage setting has a voltage tolerance of ±10% and accepts line frequencies of 50 or 60 Hz.

To select line voltage and verify the fuse, or to replace the fuse, refer to Figure 2-2, and proceed as follows:

1. Disconnect the ac line cord from the wall outlet and the rear panel.
2. Using a small screwdriver, pop open the line voltage selection module door from the top.
3. Using the screwdriver, pry the tab of the fuse holder to slide out the fuse holder.
4. Verify the fuse type and rating using the data on the rear panel or Figure 2-2, and replace it.

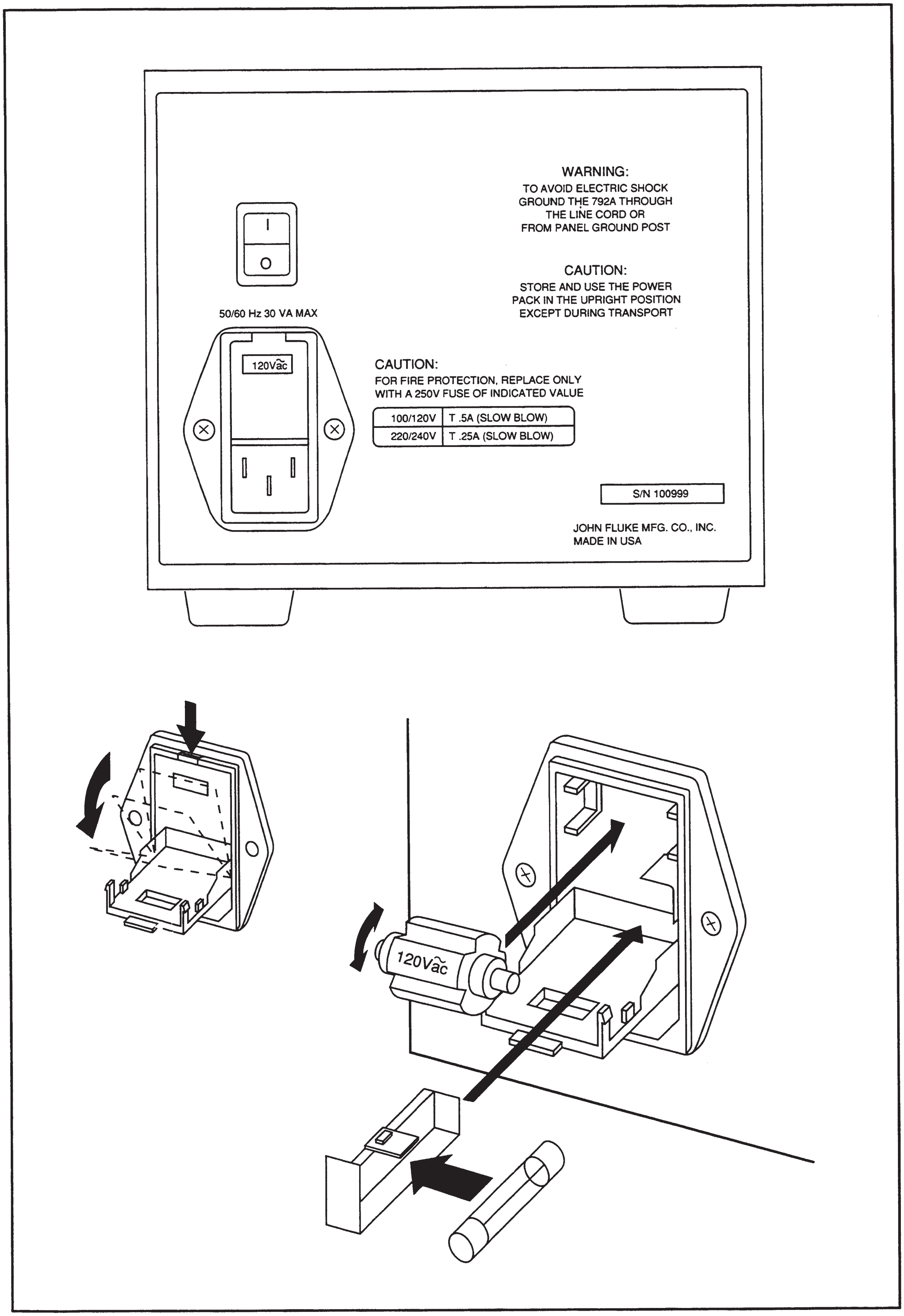


Figure 2-2. Fuse Rating Label and Fuse Location

5. If you need to change the line voltage setting, remove the drum and rotate it so that the desired voltage is facing outward. Replace the drum.

6. Push the line voltage selection module door closed.

CONNECTING TO LINE POWER 2-5.

WARNING

TO AVOID ELECTRIC SHOCK WHILE CHARGING OR USING THE POWER PACK WITH THE LINE CORD PLUGGED IN, CONNECT THE FACTORY SUPPLIED, THREE CONDUCTOR LINE POWER CORD TO A PROPERLY GROUNDED POWER OUTLET. DO NOT USE A TWO-CONDUCTOR ADAPTER OR EXTENSION CORD; THIS WILL BREAK THE PROTECTIVE GROUND CONNECTION.

After verifying that the line voltage setting and fuse are correct, turn off the power pack POWER switch, connect the line cord to the power pack, and plug the line cord into a properly grounded three-prong outlet.

WARNING

TO AVOID ELECTRIC SHOCK DURING TRANSFER STANDARD OPERATION, GROUND THE 792A THROUGH THE LINE CORD OR FRONT PANEL GROUND POST.

The transfer standard is an IEC Safety Class I (grounded enclosure) instrument, and must be properly connected to earth ground. Ground it either through the power pack ac line cord or the transfer standard GROUND binding post on the front panel below and to the right of the INPUT RANGE knob. When the ac line cord is plugged into a properly grounded three-prong outlet, the safety ground path for the power pack is through the line cord. In this case, the transfer standard unit does not need an additional safety ground because it can be used only with sources that are current-limited to 200 mA or less. The transfer standard without outside stimulus contains only low voltage.

NOTE

For additional information about using the power pack, both connected to line power or disconnected from line power, refer to Using the Power Pack, in Section 3.

Section 3
Operation

WARNING

TO AVOID ELECTRIC SHOCK AND TO CONFORM TO IEC SAFETY CLASS I, USE ONLY WITH SOURCES THAT ARE PROTECTED FROM SHORT CIRCUIT WITH CURRENT-LIMITING TO 200 mA OR LESS.

CAUTION

Inputs that exceed the protection level may disrupt the state of calibration and cause instrument damage. Read this section before applying any voltages to the transfer standard.

INTRODUCTION 3-1.

This section provides operating instructions for the 792A AC/DC Transfer Standard. It describes the controls, indicators, and other features of all parts of the transfer standard in a set of illustrations and tables. Instructions tell how to use the power pack, set up and connect instruments to the transfer standard, and how to make an ac-dc transfer. Further on, the section explores potential sources of error and explains how to defeat them. You may want to use procedures in this section as a general guide to developing your own techniques for your particular applications.

SUMMARY OF FEATURES 3-2.

Please read the following summary of features before operating the transfer standard. Separate illustrations and tables describe the functions and locations of features on the transfer standard, power pack, 1000V range resistor, and transfer switch.

792A AC/DC Transfer Standard Front Panel 3-3.

Figure 3-1 shows the transfer standard front panel features (indicators, controls, binding posts, connectors, and labels). Table 3-1 describes these features.

792A AC/DC Transfer Standard Rear Panel 3-4.

Figure 3-2 shows the transfer standard rear panel features (connectors and labels). Table 3-2 describes these features.

792A-7001 Power Pack Front Panel 3-5.

Figure 3-3 shows the power pack front panel features (indicators, connectors, and labels). Table 3-3 describes these features.

792A-7001 Power Pack Rear Panel 3-6.

Figure 3-4 shows the power pack rear panel features (connectors, labels, and fuse). Table 3-4 describes these features.

792A-7002 1000V Range Resistor 3-7.

Figure 3-5 shows the 1000V range resistor. Table 3-5 explains the use of its two connectors.

792A-7003 Transfer Switch 3-8.

Figure 3-6 shows the transfer switch. Table 3-6 explains the use of connectors and the knob on the transfer switch.

792A Test Report 3-9.

Figure 3-7 shows a sample 792A Test Report. Table 3-7 explains the meaning of the entries in the 792A Test Report.

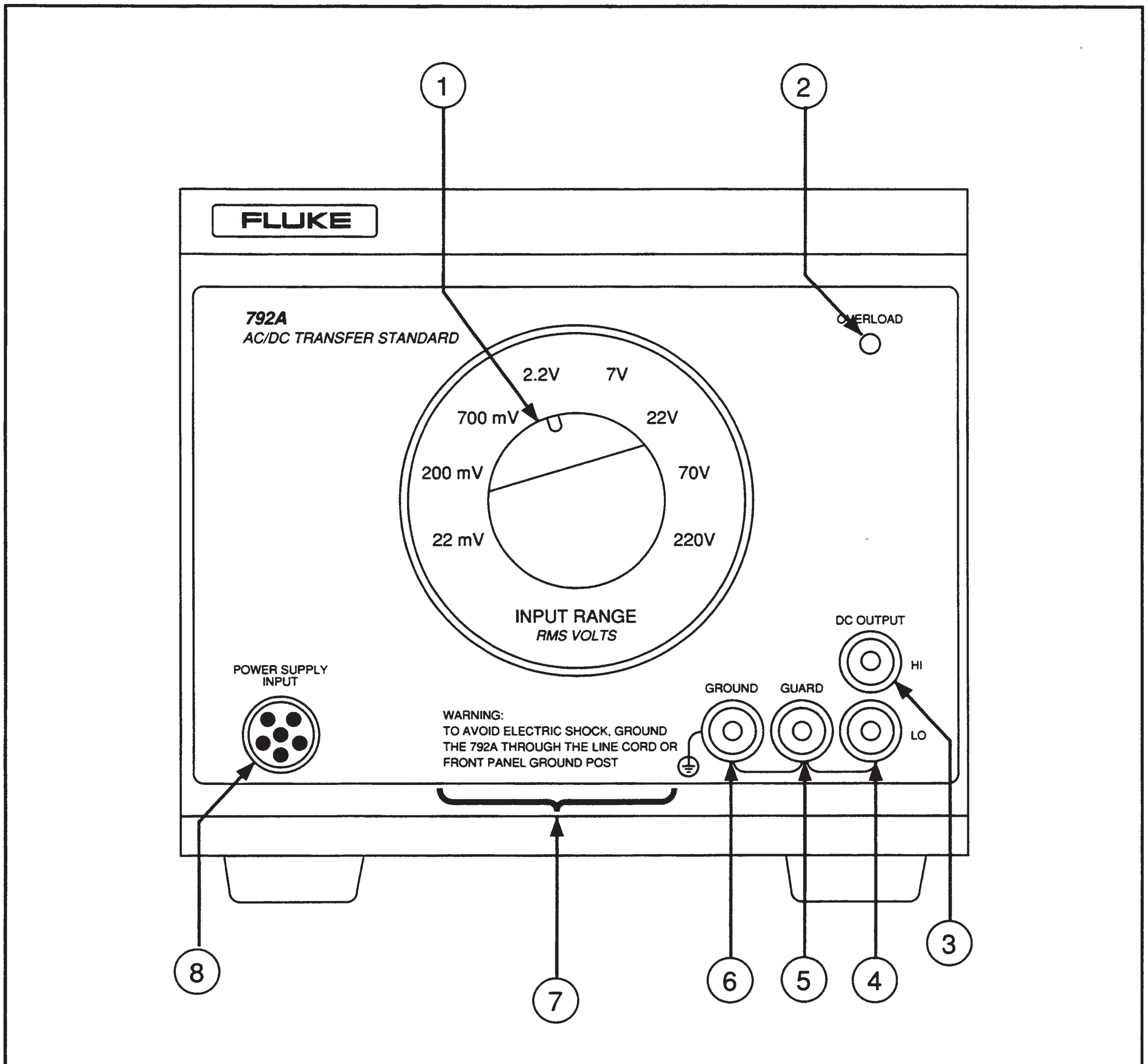


Figure 3-1. 792A AC/DC Transfer Standard Front Panel

Table 3-1. 792A AC/DC Transfer Standard Front Panel

① **INPUT RANGE Knob**

Selects the input range. Inputs greater in magnitude than the protection limit may damage the transfer standard. Protection limits are shown in Table 3-8 and on the rear panel of the transfer standard. For the input impedance of each range, see Table 3-10.

② **OVERLOAD Indicator**

Blinks when a source attached to the rear panel input exceeds the maximum voltage for the range setting. Reset is automatically attempted several times/second, and OVERLOAD continues to blink and the beeper sounds until the excessive input is removed.

③ **DC OUTPUT HI Binding Post**

For reading the scaled dc voltage output, the DC OUTPUT HI binding post is the connection point for a voltmeter high input. Full-scale output is nominally 1.8 - 2.0V, depending on the input range. See Table 1-1 Specifications for full details.

④ **DC OUTPUT LO Binding Post**

For reading the scaled dc voltage output, the DC OUTPUT LO binding post is the connection point for a voltmeter common input. This binding post is internally connected to the rear panel INPUT connector shell. The maximum allowable potential between DC OUTPUT LO and GUARD is 10V pk.

⑤ **GUARD Binding Post**

Provides an external connection point for the internal guard or floating shield. Make sure that all guards are grounded at only one point in the system. The maximum allowable potential between the GUARD connector and GROUND is 10V pk.

⑥ **GROUND Binding Post**

If the transfer standard is the location of the earth ground reference point in a system, the GROUND binding post can be used for connecting the transfer standard GUARD and other instrument guards, if so equipped, to earth ground. (The transfer standard is normally connected to earth ground through the power pack three-conductor ac line cord instead of through the GROUND binding post.)

⑦ **Safety Ground WARNING**

The transfer standard is an IEC Safety Class I (grounded enclosure) instrument, and must be properly connected to earth ground. Ground it either through the power pack ac line cord or the transfer standard GROUND binding post on the front panel below and to the right of the INPUT RANGE knob. When the ac line cord is plugged into a properly grounded three-prong outlet, the safety ground path for the power pack is through the line cord. In this case, the transfer standard unit does not need an additional safety ground because it can be used only with sources that are current-limited to 200 mA or less. The transfer standard without outside stimulus contains only low voltage.

Table 3-1. 792A AC/DC Transfer Standard Front Panel (cont)

⑧	**POWER SUPPLY INPUT Connector** Connects to the power pack cable. Conductors in the power pack cable carry operating voltage from the power pack and provide a ground path for the transfer standard chassis when the power pack is plugged into a properly grounded three-prong outlet. (All other connectors are isolated from the transfer standard chassis.) The power pack cable ends are identical. Plug either end into the POWER SUPPLY INPUT connector.

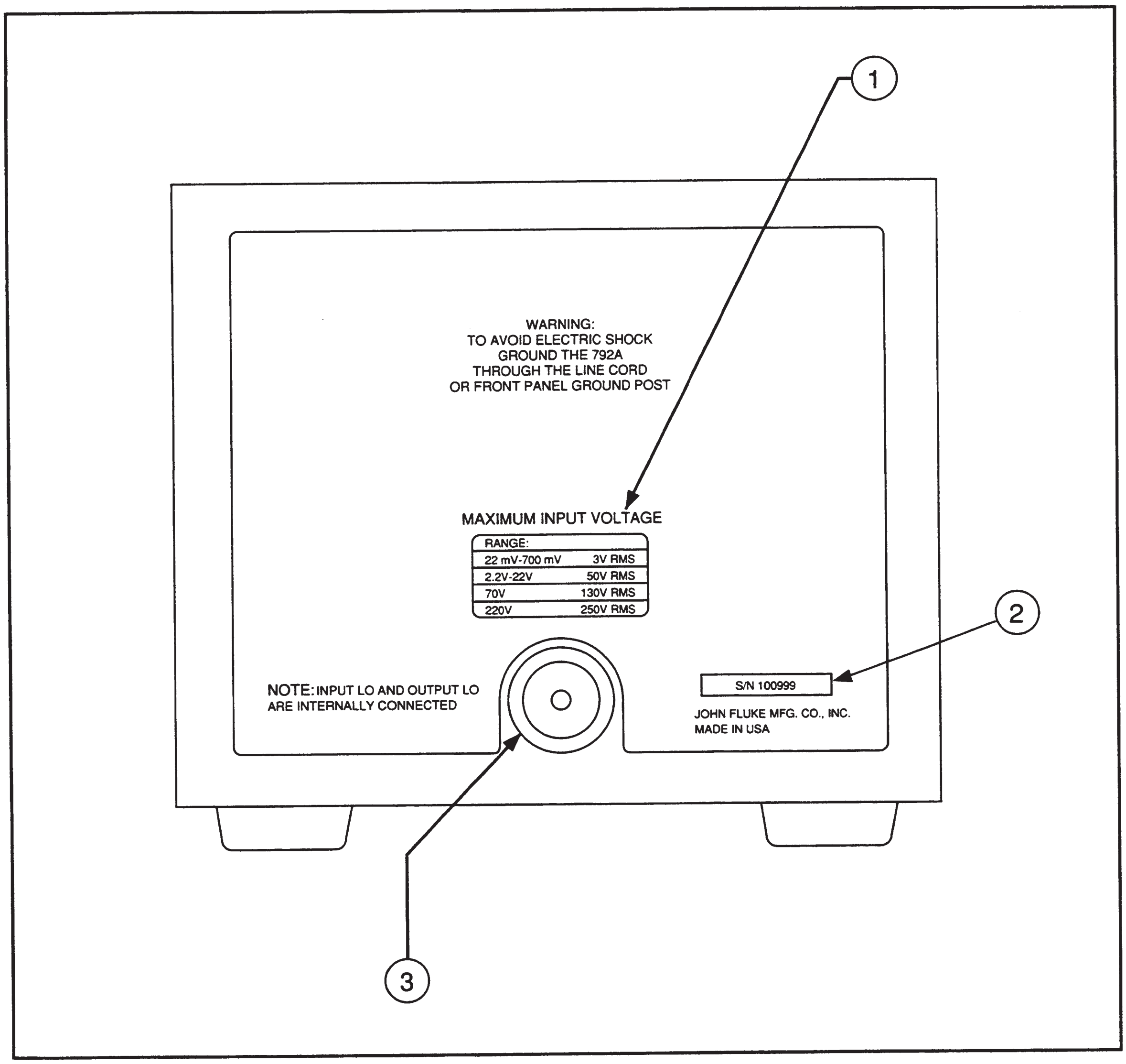


Figure 3-2. 792A AC/DC Transfer Standard Rear Panel

Table 3-2. 792A AC/DC Transfer Standard Rear Panel

①	**MAXIMUM INPUT VOLTAGE Range Label** **CAUTION** **Inputs that exceed the protection level may disrupt the state of calibration and may cause instrument damage.** This label defines the protection level for each range setting. (See INPUT RANGE knob entry in the previous table for details.)
②	**Serial Number** Use the transfer standard serial number combined with the transfer standard model number to positively identify a particular transfer standard and matched 1000V range resistor. (The 1000V range resistor and transfer standard are calibrated together as a set. Range resistors are not interchangeable.)
③	**INPUT Connector** A stainless steel 50Ω Type "N" connector for applying ac and dc voltages to the transfer standard. The INPUT connector shell is isolated from the transfer standard chassis, and is internally connected to the front panel OUTPUT LO binding post. The INPUT usually is connected to the transfer switch or the 1000V range resistor. To save the INPUT connector from wearing out, attach the Type "N" extender coupler supplied with the unit. The transfer standard was calibrated with the extender installed.

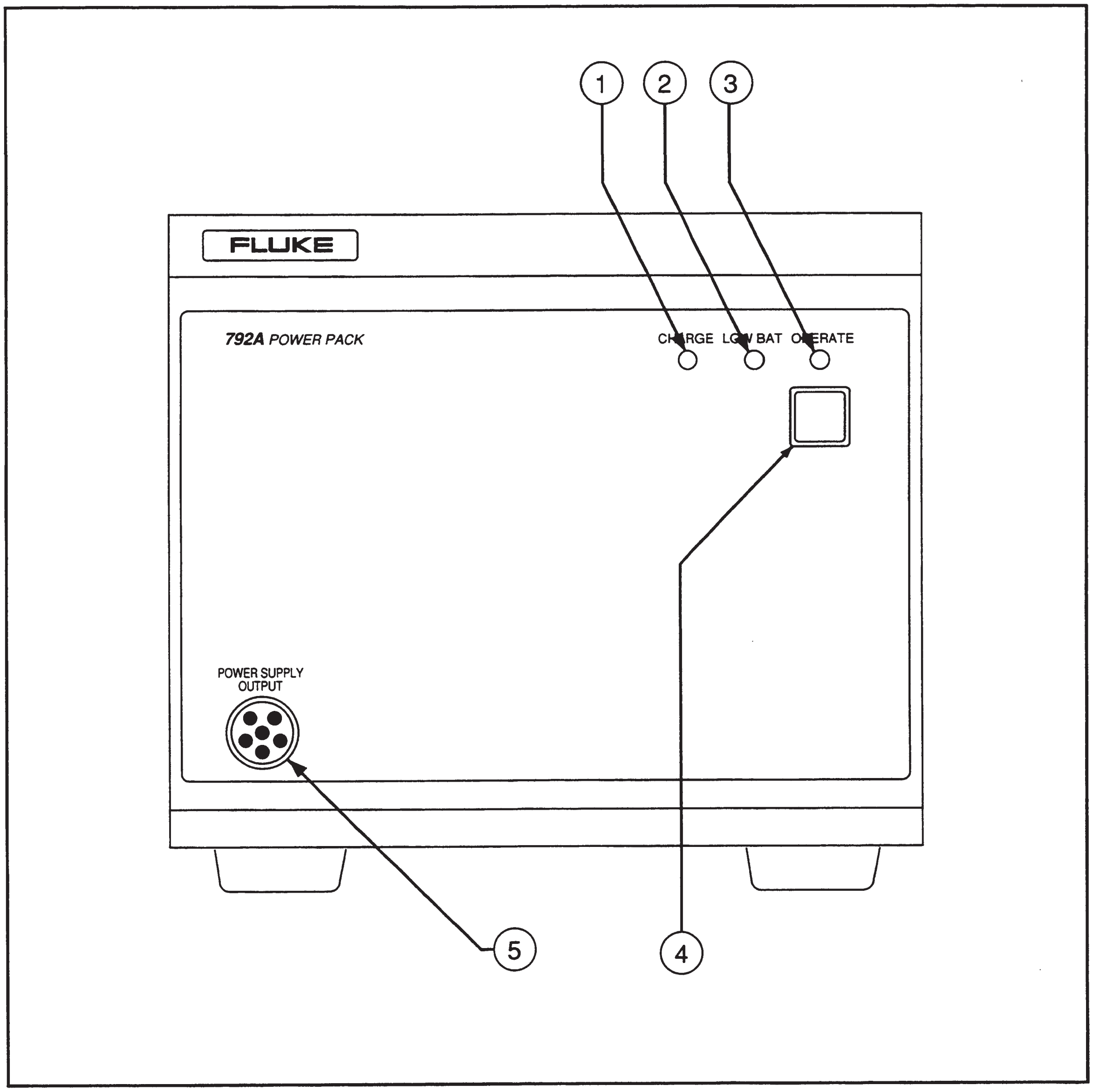


Figure 3-3. 792A-7001 Power Pack Front Panel

Table 3-3. 792A-7001 Power Pack Front Panel

①	**CHARGE Indicator** Lights whenever the ac line cord is plugged in, the rear panel POWER switch is set to (on), and the power pack is in charge mode. The CHARGE indicator remains lit until the OPERATE switch is pressed, because the batteries are constant-voltage trickle charged after they reach full capacity. (No charging takes place in OPERATE or LOW BAT modes.)
②	**LOW BAT Indicator** Lights when the batteries are discharged to the point where only one hour or less of operating time remains. The power pack is still usable until the batteries are almost completely discharged. But beware that in less than an hour, operating voltage will automatically shut off and the power pack will go into charge mode if it is plugged in and turned on. To avoid having power shut off during a transfer, when the LOW BAT indicator lights finish the transfer in progress, then plug the power pack in and turn on the rear panel POWER switch to begin recharging the batteries. The power pack is not usable during the charging period. It takes approximately 16 hours to develop a full charge.
③	**OPERATE Indicator** Signifies that dc operating voltage is turned on and is available for the transfer standard at the POWER SUPPLY OUTPUT connector. When the batteries are almost completely discharged, the OPERATE indicator goes out, operating voltage is automatically shut off, and the power pack goes into charge mode if it is plugged in and turned on. Until the batteries are sufficiently recharged, the power pack will not function. The LOW BAT indicator warns the operator when only one hour or less remains on the charge. Apply recharging voltage within one hour of operation after the LOW BAT indicator lights. Operation when LOW BAT is lit does not invalidate any of the performance specifications.
④	**OPERATE Switch** Turns on dc operating voltage for the transfer standard. If the OPERATE indicator does not light when you momentarily press the OPERATE switch, the batteries may be insufficiently charged.
⑤	**POWER SUPPLY OUTPUT Connector** Connects to the power pack cable. Conductors in the power pack cable carry operating voltage to the transfer standard and provide the earth ground and fault current path when the power pack is plugged into a properly grounded three-prong outlet. The power pack cable ends are identical. Plug either end into the POWER SUPPLY OUTPUT connector.

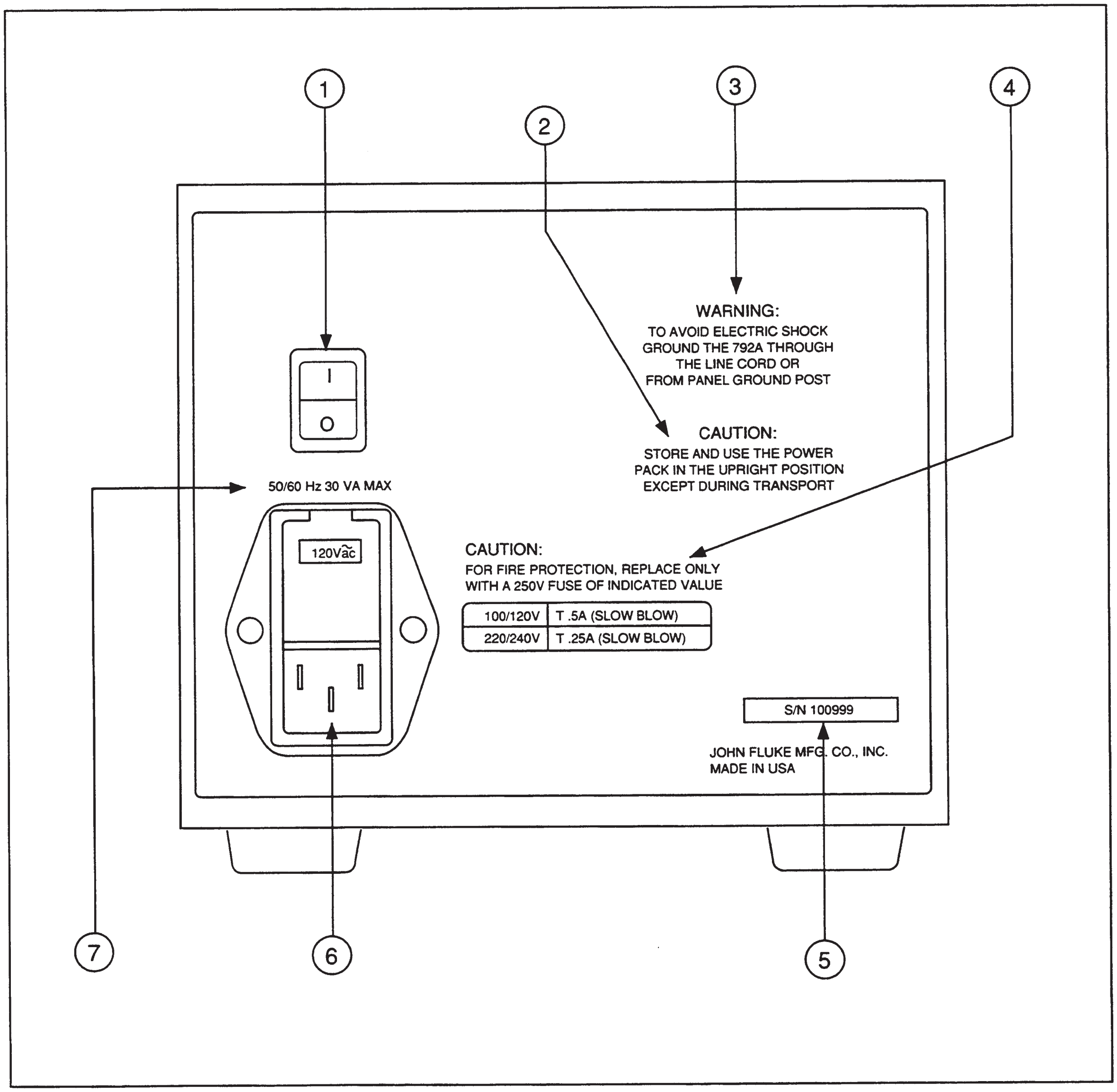


Figure 3-4. 792A-7001 Power Pack Rear Panel

Table 3-4. 792A-7001 Power Pack Rear Panel

①	**POWER Switch** Internally connects ac line power to the charging circuits. The batteries will not charge unless this switch is set to (on), and the OPERATE switch is pressed so that the OPERATE indicator is off.
②	**Battery Position CAUTION** During charging and discharging, the sealed lead-acid batteries used in the power pack must be in the upright position to vent properly. During off-line storage and transportation, the batteries require no venting; therefore, any position is acceptable.
③	**Safety Ground WARNING** The transfer standard is an IEC Safety Class I (grounded enclosure) instrument and must be properly connected to earth ground. Ground it either through the power pack ac line cord or the transfer standard GROUND binding post on the front panel below and to the right of the INPUT RANGE knob. When the ac line cord is plugged into a properly grounded three-prong outlet, the safety ground path for the power pack is through the line cord. In this case, the transfer standard unit does not need an additional safety ground because it can be used only with sources that are current-limited to 200 mA or less. The transfer standard without outside stimulus contains only low voltage.
④	**Fuse CAUTION and Rating Label** States the correct fuse type and rating for use in the 100 to 120V range, or the 220 to 240V range. Use of an improper fuse defeats the safety design of the power pack and can cause instrument damage.
⑤	**Serial Number** The Serial Number combined with the power pack model number identifies a particular power pack unit only. The number may be different from the Serial Number on the companion transfer standard unit. Substituting a different power pack has no effect on the state of calibration of the transfer standard. Use the Serial Number on the transfer standard in all correspondence with Fluke and for calibration tracking and traceability purposes.
⑥	**AC Line Cord Connector, Line Voltage Selection, and Fuse Module** Houses the ac line fuse and the male three-prong connector for an IEC-type power cord. The plastic cover covers the fuse so it can be accessed only when the power cord is not connected.
⑦	**AC Line Frequency and Power Requirement Label** Specifies the acceptable ac line power frequency (50/60 Hz) and the power drawn by the power pack when recharging discharged batteries.

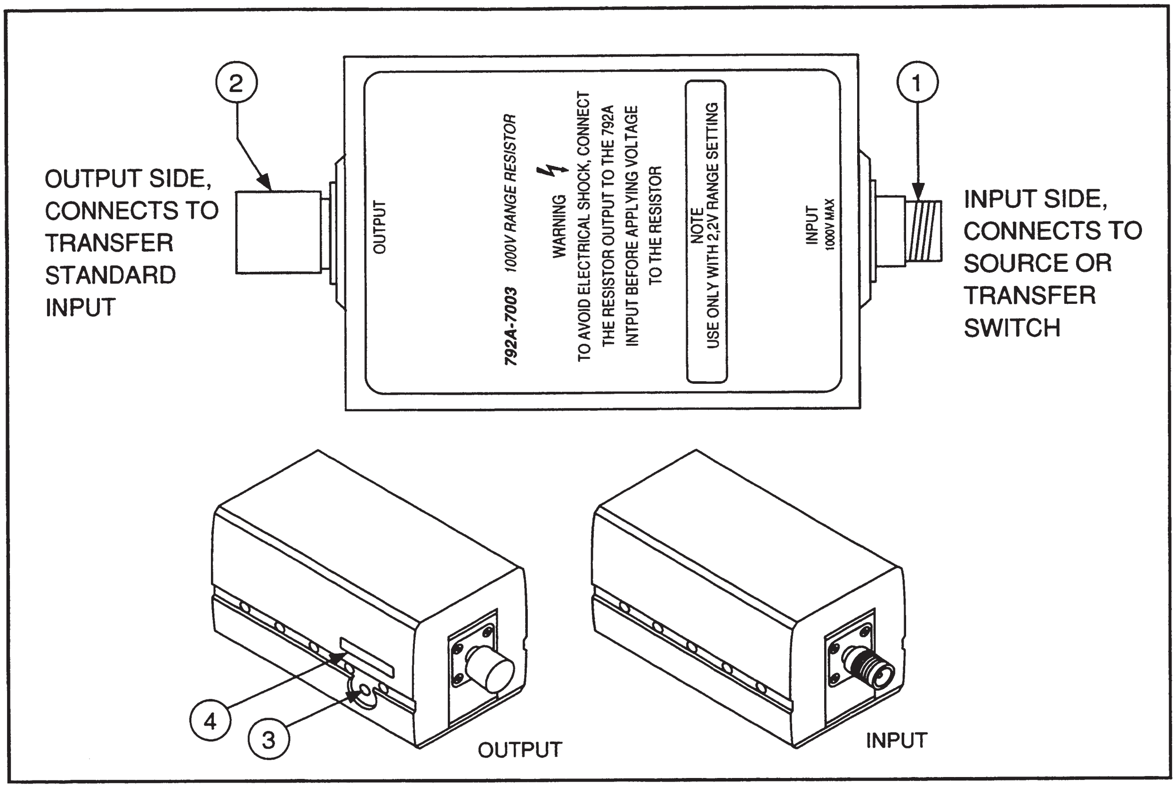


Figure 3-5. 792A-7002 1000V Range Resistor

Table 3-5. 792A-7002 1000V Range Resistor

① **INPUT Connector**

WARNING

TO AVOID ELECTRIC SHOCK, CONNECT THE 1000V RANGE RESISTOR OUTPUT TO THE TRANSFER STANDARD INPUT BEFORE APPLYING ANY VOLTAGE TO THE 1000V RANGE RESISTOR.

A stainless steel 50Ω Type "N" connector that accepts outputs from sources (usually through the transfer switch) supplying between 200V and 1000V. This connector, once attached to the transfer standard INPUT, becomes the transfer standard INPUT and plane of reference for inputs between 200 and 1000V. The INPUT RANGE knob must be set to 2.2V for use with the 1000V range resistor.

② **OUTPUT Connector**

A stainless steel 50Ω Type "N" connector for connecting to the transfer standard INPUT. Always connect the 1000V range resistor to the transfer standard INPUT, and set the range to 2.2V before connecting to a source.

③ **Tuning Access Hole**

Used only during the tuning procedure described in Section 5, Maintenance.

CAUTION

Adjustment of this control invalidates the state of calibration of the 1000V range.

④ **Serial Number**

Use the serial number to positively identify the range resistor matched to a particular transfer standard. The 1000V range resistor and transfer standard are calibrated together; therefore, 1000V range resistors are not interchangeable.

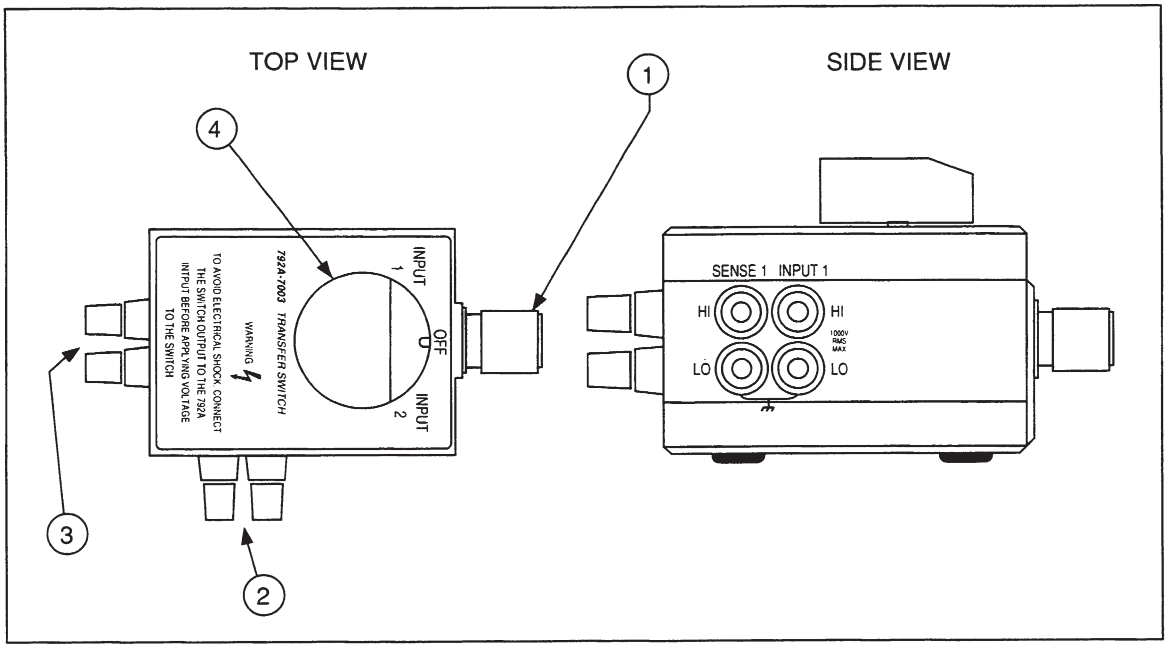


Figure 3-6. 792A-7003 Transfer Switch

Table 3-6. 792A-7003 Transfer Switch

① **OUTPUT connector**

A stainless steel 50Ω Type "N" connector that attaches to the transfer standard or 1000V range resistor INPUT. The plane of reference after attaching the switch becomes the switch rotor (unless two transfer standards are teed together, which places the plane of reference at the center of the coaxial tee).

② **INPUT 1 Binding Posts**

Located on the right side of the transfer switch viewed from the top, these binding posts labeled SENSE 1 HI and LO and INPUT 1 HI and LO provide the connection to a source. The SENSE binding posts provide connection points for external sense leads from the first source.

③ **INPUT 2 Binding Posts**

The end of the transfer switch has binding posts labeled SENSE 2 HI and LO and INPUT 2 HI and LO for connecting to a second source. The SENSE binding posts provide connection points for external sense leads from the second source.

④ **INPUT Select Knob**

In the INPUT 1 position, this knob opens the connection from the INPUT 2 binding posts and connects the INPUT 1 binding posts to the transfer standard. In the INPUT 2 position, this knob opens the connection from the INPUT 1 binding posts and connects the INPUT 2 binding posts to the transfer standard. In the OFF position, the knob opens the connection between the transfer standard and both sets of INPUT binding posts.

FLUKE

792A AC/DC TRANSFER STANDARD
TEST REPORT S/N 1234567 23-Feb-90

RANGE	INPUT	10Hz	20Hz	40Hz	100Hz	1kHz	10kHz	20kHz	50kHz	100kHz	300kHz	500kHz	1MHz
22mV	2mV	-547	44	25	84	-18	139	88	476	793	1514	1671	2757
	10mV	-534	86	140	98	17	82	77	163	300	585	625	1040
	20mV	-151	186	150	103	13	72	69	108	170	217	164	488
220mV	20mV	-116	25	51	25	-22	4	8	39	61	31	8	330
	100mV	-147	43	36	21	6	12	23	47	80	128	145	393
	200mV	182	112	58	21	-1	2	12	[illegible]	-8	-124	-263	-284
700mV	200mV	-381	-8	13	11	8	5	-5	8	-26	-151	-324	-222
	600mV	-74	65	30	6	[illegible]	[illegible]	-1	[illegible]	10	-2	-35	6
2.2V	600mV	130	14	0	0	3	3	[illegible]	24	38	62	64	18
	1V	171	23	9	2	1	11	12	27	39	64	67	9
	2V	477	107	26	[illegible]	[illegible]	14	18	29	47	80	86	-15
7V	2V	112	22	[illegible]	[illegible]	3	6	7	10	16	35	50	48
	6V	484	30	31	[illegible]	9	10	13	18	22	40	55	69
22V	6V	119	24	5	5	5	4	3	2	-4	-8	4	52
	10V	164	24	7	-1	-3	-2	-6	-7	-7	-16	-10	9
	20V	479	121	28	3	3	4	4	0	-1	-12	-19	21
70V	20V	141	24	4	2	1	4	3	3	5	20		
	60V	464	112	21	-2	-4	5	2	8	1	49		
220V	60V	104	13	-2	-6	-8	3	-2	-2	-15			
	100V	187	33	4	-5	-5	-3	-3	-4	-12			
	200V	477	113	26	3	0	2	0	2	6			
1000V	200V	121	11	1	0	1	8	15	22	51			
	1000V			28	4	0	6	20	30	48			

All values of ac/dc difference are in ppm

Tested using reference 792A S/N 4000105
Temperature of calibration = 23.3 C

Note: A positive ac/dc difference indicates that more alternating than direct voltage is required to produce the same 792A output.

SAMPLE

Figure 3-7. Sample 792A Test Report

Table 3-7. 792A Test Report

① **Serial Number and Date**

The serial number is for positively identifying a Test Report. The date is the date of calibration, which is the beginning of a one-year calibration cycle.

② **AC-DC Difference Data**

The ac-dc difference data are the error with respect to the corrected response of a reference 792A. The reference 792A is maintained in the Fluke factory with corrections that are traceable to NIST.

All ac-dc differences are in ppm (parts per million). A positive ac-dc difference indicates that more alternating than direct voltage is required to produce the same 792A output. The formula for ac-dc difference is:

$$\text{ac-dc difference} = \frac{\text{792A output [dc known in]} - \text{792A output [ac corrected in]}}{\text{792A output [dc known in]}}$$

③ **Reference 792A Serial Number and Temperature of Calibration**

The serial number of the reference 792A is included for traceability purposes. The ambient temperature is recorded at the time of calibration.

④ **RANGE Column**

This column lists the settings of the INPUT RANGE knob.

⑤ **INPUT Column**

This column lists the test voltages.

⑥ **Test Frequencies**

This column lists the test frequencies.

USING THE POWER PACK 3-10.

NOTE

Variations in power supplies have no effect on the state of calibration of the transfer standard. Any 792A-7001 Power Pack may be used with any 792A AC/DC Transfer Standard. For that reason, spare power packs may be used. When reshipping a 792A for calibration, send only the transfer standard unit and the 1000V range resistor.

The power pack provides dc operating voltage for the transfer standard. It can be plugged into ac line power, or it can be used offline. In OPERATE or LOW BAT, even if the line cord is plugged in and the POWER switch is on, the transfer standard operates on battery power (and the batteries are not being charged) to maintain isolation from the ac line. Three choices for operating the battery pack/transfer standard combination are described next.

1. Line cord plugged in and power on all the time.
   - Advantage: power pack will trip into charge state whenever it is needed.
   - Disadvantage: least amount of isolation from noise on the ac line. Any cabling connected to the power pack and transfer standard can pick up emi (electromagnetic interference). For the best emi immunity, disconnect the line cord from the power pack rear panel and ground the front panel GROUND connector.
2. Line cord plugged in, but rear panel POWER turned on only when needed for charging.
   - Advantage: better isolation from ac line because there is no current in the transformer primary.
   - Disadvantage: power pack will not trip into charge state automatically when it is needed. Attached line cord is route for emi to get in.
3. Line cord disconnected (note that the transfer standard must be grounded at its front panel GROUND binding post).
   - Advantage: total isolation from ac line. Disconnecting the ac line also removes one route for emi pickup. This configuration is recommended for extremely sensitive transfers.
   - Disadvantage: power pack will not trip into charge state automatically when it is needed.

Transfer standard operating power lasts for 20 to 80 hours, depending on the INPUT RANGE setting. (The active ranges, 22 to 700 mV, consume more power.) When the LOW BAT indicator lights, the power pack will work for only one hour or less on the remaining charge. When the batteries are discharged, operating voltage shuts off and the power pack automatically goes into charge mode if it is plugged in and turned on. The power pack is not usable during the charging period.

The power pack recharges fully in about 16 hours. To recharge the power pack, plug it in and set the rear panel POWER switch to | (on). You can leave the power pack plugged in and on all the time; internal circuitry prevents damage from overcharging.

Attach the power cable between the power pack POWER SUPPLY OUTPUT connector and the transfer standard POWER SUPPLY INPUT connector. This cable contains the ground path for the transfer standard chassis whenever the ac line cord is plugged into a properly grounded outlet.

PREPARING TO MAKE A TRANSFER 3-11.

A "transfer" is called that because it is the process of comparing an ac voltage to a known dc voltage, thereby transferring the low uncertainty of the dc voltage to the ac voltage. The 792A can be used to perform two different types of ac-dc transfers:

1. An ac measurement
2. An ac-dc difference measurement

In an ac measurement, the transfer standard is used to determine absolute rms ac voltage level. In an ac-dc difference measurement, the transfer standard is a reference that tests the ac and dc response of another transfer standard. The goal of an ac measurement is to determine the error of the ac source or ac voltmeter under test. The goal of an ac-dc difference measurement is to determine a value called the "ac-dc difference," which is positive when more ac voltage than dc voltage is required to produce the same output in the transfer standard under test.

Step-by-step procedures are provided under the heading Making a Transfer, for three types of ac-dc transfers, all of which fall in to the ac measurement category. The first two procedures test the ac level accuracy of an ac source. The third procedure tests the accuracy of an ac voltmeter. An example of an ac-dc difference measurement is the 792A calibration procedure provided in Section 5.

Using the 792A Test Report 3-12.

A 792A Test Report made for the particular transfer standard is shipped with each transfer standard. The Test Report is the result of the calibration process done as part of the manufacturing process in the factory in Everett, Washington. Data in the Test Report is valid for one year from the date printed at the top.

To get the most benefit from the transfer standard, select voltage and frequency points included in the Test Report whenever you make a transfer. The ac-dc difference in the report is a correction factor you algebraically add to the results you obtain by measurement. By applying the corrections from the 792A Test Report to your measured (apparent) results, you achieve the highest possible level of accuracy.

NOTE

Transfer voltage and/or frequency can vary from a cardinal point in the Test Report by ±2%. For points 100 Hz or above use the correction factor and uncertainty specification unchanged. For points below 100 Hz, calculate a new correction factor by using the method described in Appendix C.

The correction data in the Test Report are ac-dc differences with respect to a reference 792A. All ac-dc differences are in ppm. A positive ac-dc difference indicates that more alternating than direct voltage is required to produce the same 792A output. The formula for ac-dc difference is:

$$\text{ac-dc difference} = \frac{\text{792A output [dc known in]} - \text{792A output [ac corrected in]}}{\text{792A output [dc known in]}}$$

The reference 792A is maintained in the Fluke factory with its own table of corrections that are traceable to NIST. The serial number of the standard that was used to calibrate your 792A appears on the Test Report. The serial number of the 792A to which the Test Report belongs also appears on the transfer standard. You may want to make a copy of the test report and keep it in a safe place. It is an important part of the instrument.

Using the Fluke 5700A with the Transfer Standard 3-13.

If you are using a 5700A for the ac source, sub-ppm stability can be achieved by using the AC Xfer OFF (internal transfer off) feature. This allows you to turn off the monitoring system that normally makes adjustments for load changes. The Xfer OFF feature is available only in the ranges below 220V, and at frequencies below 120 kHz.

The Xfer OFF function remains active until the 5700A is reset or the power is turned off. For remote control applications, the same feature is accessible through the remote command XFER OFF. Send the command XFER ON to restore internal ac transfers to normal operation.

Turn off internal ac transfers as follows:

1. Press the "Setup Menus" softkey.
2. Press the "Special Functns" softkey.
3. Press the "AC Xfer Choice" softkey so that ON appears. This turns on an "AC Xfers" softkey in the ac voltage output function.
4. Press PREV MENU twice.
5. After setting the output for an ac voltage, press the "AC Xfers" softkey so that OFF appears before making a transfer with the 792A.

Initial Setup and Warmup 3-14.

Before you use the transfer standard, connect it to a charged 792A-7001 Power Pack and warm up it up. Proceed as follows to thermally stabilize and warm up the transfer standard:

1. Allow the transfer standard to thermally stabilize in the environment in which it will be used (with the power off) for at least 12 hours.
2. If the power pack is not fully charged, charge it for 16 hours. Charging is controlled by circuitry in the power pack. The power pack cannot be overcharged.
3. Connect the power pack cable between POWER SUPPLY OUTPUT on the power pack and POWER SUPPLY INPUT on the transfer standard.

4. Press the OPERATE switch on the power pack.

5. The transfer standard is ready for use, but for best accuracy, wait 15 minutes after turning it on.

Cable Connections for Making a Transfer 3-15.

CAUTION

To avoid dielectric breakdown, use only cables and connectors with correct voltage ratings.

CAUTION

Always ensure that the proper transfer standard range has been selected before applying input voltages. Inputs that exceed the protection level may disrupt the state of calibration and cause instrument damage.

Whenever possible, directly connect instruments to the transfer switch or INPUT connector using shielded adapters (and as few as possible). Make all screw-on connections tight. When calibrating an ac source, if it is impossible to directly connect the ac source to the transfer switch, use the shortest possible length of coaxial cable or equivalent. Also realize that if you do add a length of cable, you calibrate the source to the end of the cable.

When calibrating an ac voltmeter, the path from the ac source to the transfer switch is no longer critical, and a longer cable can be used. Coaxial cable and connectors minimize the possibility that radiated electromagnetic energy will disrupt sensitive measurements.

CONNECTING AND USING THE TRANSFER SWITCH 3-16.

For inputs that will be in the 200 to 1000V range, connect the 1000V range resistor OUTPUT to the transfer standard INPUT (through the Type "N" extension to preserve the INPUT connector), and connect the resistor INPUT connector to the transfer switch Type "N" connector.

For inputs below 200V, connect the transfer switch to the Type "N" extension at the transfer standard INPUT. Now the transfer switch is ready to accept inputs from two sources.

CONNECTING A DC DMM TO THE TRANSFER STANDARD DC OUTPUT 3-17.

Use a 6 1/2-digit or better dc DMM such as the Fluke 8505A to read the transfer standard output. The output nominally approaches 2V full scale. Use shielded test leads, such as shielded twisted-pair or Twinax cable, with the shield connected to the transfer standard GUARD and the 8505A GUARD. Low thermal cables are not required, since relative amplitude rather than absolute amplitude is the critical measurement.

For all types of transfers, connect the DMM to the transfer standard as follows:

1. Set the DMM for external guard if it has a guard.
2. Connect shielded test leads between the DMM INPUT HI and the transfer standard OUTPUT HI, and between the DMM INPUT LO and the transfer standard OUTPUT LO.
3. Connect the test lead shield between the DMM guard and the transfer standard GUARD. If the DMM has no guard terminal, leave this lead unconnected.

CONNECTING DC VOLTAGE SOURCES TO THE INPUT 3-18.

Shielded test leads should be used for connecting to dc voltage sources. The best choice for dc voltage sources is shielded cables with low-thermal emf connectors. A second set for external sensing at the transfer switch INPUT 1 or INPUT 2 binding posts should be used for the passive ranges (2.2V and above).

NOTE

External sensing is not needed for ac-dc difference measurements when calibrating one transfer standard against another as in the 792A calibration procedure in Section 5.

For inputs that will be above 200V, make sure the 1000V range resistor is installed between the transfer standard INPUT and the transfer switch. Set the INPUT RANGE knob to 2.2V.

CONNECTING AC VOLTAGE SOURCES TO THE INPUT 3-19.

For inputs that will be above 200V, make sure the 1000V range resistor is installed between the transfer standard INPUT and the transfer switch. Set the INPUT RANGE knob to 2.2V.

When the ac source is the unit to be calibrated, it is important to shorten the path between the source binding posts and the transfer switch to keep the plane of reference as close as possible to the ac source binding posts. Connect the ac source to the transfer switch INPUT 1 or INPUT 2 directly using adapters, or through a short length of coaxial cable. Make sure cables and connectors are rated for the voltage that will be used. Do not use external sensing from the ac source, unless you want to calibrate the ac source at the end of a cable.

When the ac source is not the unit to be calibrated, for example when calibrating an ac voltmeter, the path between the source binding posts and the transfer switch is no longer critical. However, use a short length of cable to minimize distortion from the ac source. The path is no longer critical because the plane of reference is the center of a tee connector, and the ac source is adjusted as necessary to correct the amplitude as measured by the transfer standard at the tee.

WHEN TO USE FOUR-WIRE SENSING 3-20.

Four-wire sensing from the ac or dc source is unnecessary when calibrating another transfer standard, i.e., making an ac-dc difference measurement. An example of this type of measurement is the 792A calibration procedure in Section 5. This is because there is a relatively wide tolerance for the nominal test voltage.

For all the transfer procedures in this section, absolute dc voltage is required at the transfer standard INPUT to determine absolute ac voltage. Set up the dc voltage reference for the transfer standard INPUT with external sensing at the transfer switch binding posts when using the passive ranges (2.2V and above). This is to remove errors caused by voltage drops in the cables, i.e., to maintain the plane of reference as close as possible to the transfer switch. This is especially important in the passive ranges (2.2V and above), where the transfer standard input impedance is lower.

Four-wire sensing is also important whenever you use a fixed-polarity dc source. When using a fixed-polarity dc source you must disconnect and reverse the cables, which introduces changes in contact resistance. By using four-wire sensing (if the source has the capability), you minimize the effects of contact resistance as well as cable voltage drops.

AC voltage sources sometimes have external sensing capability. However, do not use external sensing when calibrating an ac source unless you want to move the plane of reference to the end of a length of cable. Normally, ac sources are calibrated at their binding posts, so sensing at the binding posts with straps or internal connection is appropriate.

CONNECTING THE GUARD AND GROUND 3-21.

NOTE

Spurious currents in the ground wires will degrade measurements at the accuracy level made possible by the transfer standard. Make sure the GUARD terminals of all interconnected instruments are tied to earth ground at one point and **one point only** *in the system, and all LO or common terminals are tied to GUARD at only one point in the system.*

The transfer standard GUARD is an electrical shield around the sensitive analog circuitry, insulated from chassis ground and the rest of the transfer standard. The GUARD provides a low-impedance path for common-mode noise and ground currents. The guard eliminates the chance of ground currents in the signal leads caused by plugging the power pack into an ac main with a different ground potential than other interconnected instruments.

Ground currents can occur if instrument guards are not connected properly, resulting in annoying and often subtle measurement errors. The basic rule is, in any system of measurement instruments, all instrument guards should be grounded at one and one point only. Circuit common (the transfer standard INPUT connector shell or OUTPUT LO) should be electrically connected to the guards at one and only one point as well; preferably where the guards are grounded. If an instrument in the system has a grounded input or output, select it as the common earth ground point for all guards in the system. Otherwise, use the ac voltage source used for the transfer as the point to ground the guards and common.

With line power disconnected, you can confirm the integrity of your guarding and grounding scheme by checking each instrument with an ohmmeter to find hidden or internal connections between guard, common, and ground. If you have any question about proper guarding and grounding, draw a guarding diagram for your system of instruments, and make sure all instrument guards are tied together and grounded at only one point.

For more information about grounding and guarding, read *Grounding and Shielding Techniques in Instrumentation,* by Ralph Morrison, ©1977, John Wiley & Sons.

MAKING A TRANSFER 3-22.

Two methods are recommended for making a transfer to determine absolute ac voltage. The first is to simply observe the change in transfer standard output, or deflection, as indicated on the DMM, from the dc reference to the ac source. For this method, accuracy of the transfer relies on the linearity of the transfer standard, which is typically better than the ac voltage source, but not as good as a dc voltage calibrator such as the Fluke 5440B or the dc voltage function of the Fluke 5700A.

The second method is to apply the ac source, then apply the dc reference and adjust it for the same DMM reading. This method relies on the linearity of the dc voltage source, which is typically better than the transfer standard and the ac voltage source. The two methods just described are used in the first two procedures for accurately determining the rms value of an ac voltage source. The third procedure provided in the section is for accurately determining the response of an ac DMM. Section 5 provides an example of an ac-dc difference measurement in the 792A calibration procedure.

Absolute accuracy of the dc DMM is not its critical specification for transfer standard applications. Its linearity and short-term stability are more important, since what you are measuring is the magnitude of the change in transfer standard output from one transfer standard input voltage to the next.

In all these procedures, sources and DMMs different than those called out may be substituted. The dc source must be capable of reversing polarity internally, or if it has fixed polarity, it must be capable of external four-wire sensing to compensate for changes in contact resistance resulting from moving the cables.

Before putting these procedures into practice, read the information at the end of this section under Techniques for Reducing Transfer Error. Observing the hints provided there will help ensure accurate transfers.

Before applying any voltage to the transfer standard INPUT, confirm that the INPUT RANGE setting is correct. Table 3-8 shows the levels that must not be exceeded, and normal operating levels accepted, for each range.

Always correct for reversal error when making a transfer. In general, you do this by applying one polarity of dc, then the other, then averaging 792A dc output readings. DC reversal correction is part of the step-by-step examples further on in this section.

Table 3-8. Protection Limits for Each Range

INPUT RANGE	OPERATING INPUT VOLTAGE (RMS)	PROTECTION LIMIT (RMS)	
		200 mA SOURCE	100 mA SOURCE
22 mV	2 to 22 mV	3V	50V
220 mV	22 to 220 mV	3V	50V
700 mV	220 to 700 mV	3V	50V
2.2V	700 mV to 2.2V	50V	50V
7V	2.2 to 7V	50V	50V
22V	7 to 22V	50V	50V
70V	22 to 70V	130V	130V
220V	70 to 220V	250V	250V
1000V	200 to 1000V	1000V	1000V

Using a Deflection Method to Measure an AC Voltage Source 3-23.

The method of making a transfer described here directly detects the error of an ac source by observing the change in the DMM reading, and relies on the linearity of the transfer standard. Proceed as follows to make an ac-dc transfer using the deflection method:

CAUTION

Always ensure that the proper range has been selected before applying voltage to the transfer standard INPUT. Inputs that exceed the protection level shown on the rear panel label may disrupt the state of calibration and cause instrument damage.

1. Set up for the transfer:

   a. Connect the ac and dc sources, the DMM, and the transfer switch to the transfer standard as shown in Figure 3-8. Verify that all instruments have satisfied their warmup requirements. (For the transfer standard, the warmup requirement is 15 minutes.) Use the 1000V range resistor and the 2.2V INPUT RANGE setting if the transfer voltage is between 200V and 1000V.

   b. Choose a voltage and frequency point for the transfer that is included in the 792A Test Report shipped with the transfer standard. Do not activate any sources yet.

   c. Set the INPUT RANGE knob to the appropriate position. For best results, always use the lowest range that will accept the input.

   d. Set the transfer switch to the OFF position, and the sources to standby.

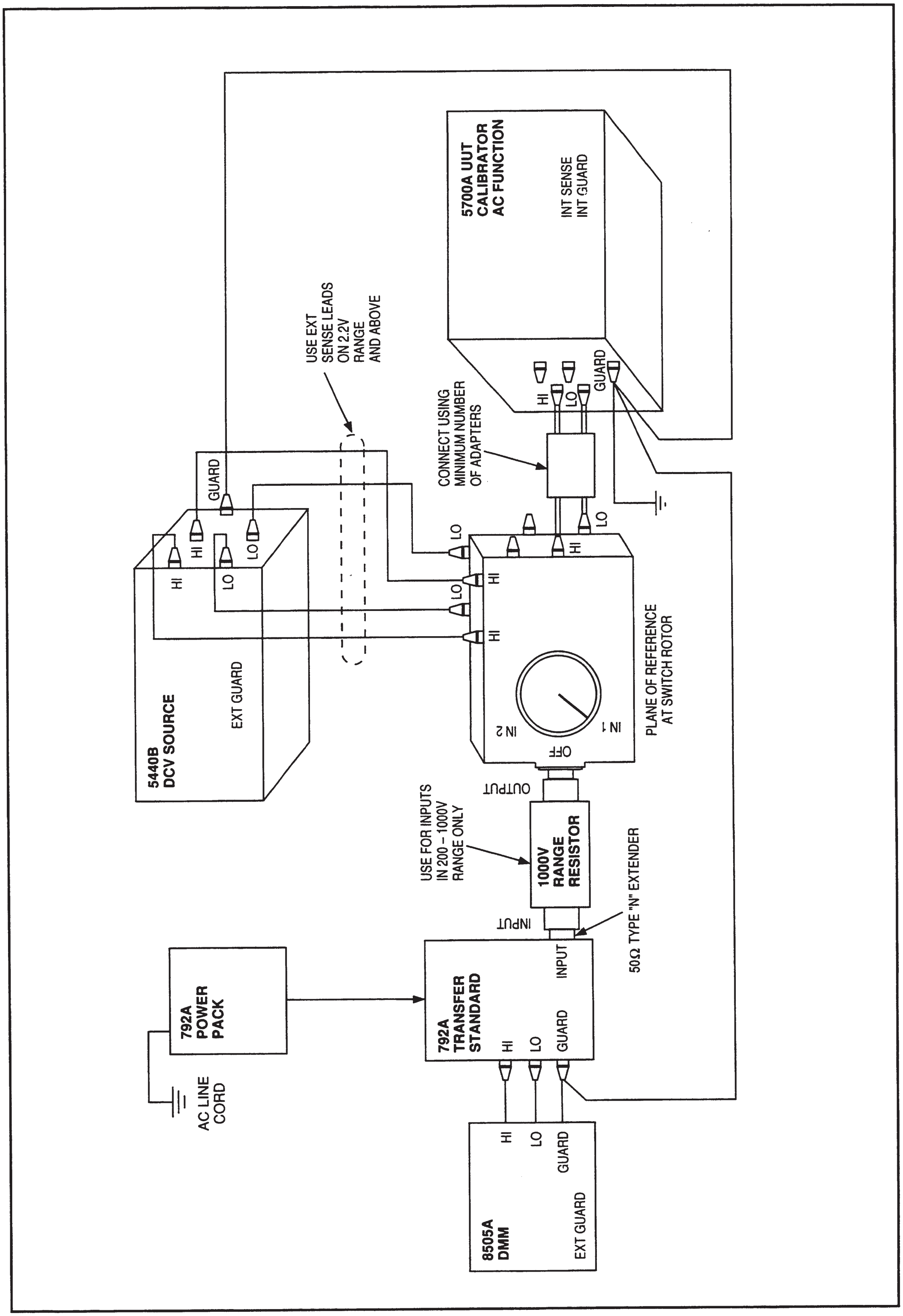


Figure 3-8. Calibrating an AC Voltage Source

2. Establish the dc voltage reference value as a DMM scale factor:

NOTE

The method presented here assumes that a DMM with a scaling function is used. For DMMs without a scaling function, you can do the equivalent by keeping track of the values and solving mathematically for the result.

   a. Confirm the INPUT RANGE setting, and set the dc voltage reference. Set the transfer switch to the dc source position and activate the source if it is in standby.

   b. Allow the DMM reading to stabilize. Table 3-9 shows minimum recommended settling times for new inputs at each RANGE SELECT setting. Note the DMM reading.

   c. Reverse the polarity of the dc source using its controls.

NOTE

If the source has fixed polarity, put it in standby, then quickly reverse the leads. The fixed polarity source must have external sensing capability, and must be cabled for external sensing to compensate for changes in contact resistance.

   Note the DMM reading again.

   d. Average the reading taken for each polarity, and enter the result as a scaling factor on the DMM. On the 8505A, you can enter the scaling factor through its keypad. For example:

If the reading for a positive input is	1.723555
and the reading for a negative input is	1.723551
the scale factor to use is	1.723553

Table 3-9. Recommended Settling Times for Each INPUT RANGE Setting

RANGE	RECOMMENDED SETTLING TIME (SECONDS)*
22 mV	60
220 mV	60
700 mV	60
2.2V	30
7V	30
22V	30
70V	30
220V	30
1000V	30

* For best accuracy, apply the voltage to be measured for this much time before beginning a transfer. Subsequently, apply other sources at the same voltage with minimal wait time to reduce any cooling effects.

3. Get the apparent error of the ac voltage source:

   a. Quickly switch the transfer switch to the ac source position and apply the ac voltage. Allow the meter reading to stabilize.

   b. Subtract 1 from the value displayed on the DMM and convert the decimal result to ppm (multiply it by 10^6) to get the apparent error of the ac voltage source. For example:

      If the DMM reads 1.000031,
      the apparent error of the ac voltage source is +31 ppm.

4. Calculate the corrected error by applying the correction from the 792A Test Report:

   a. Look up the correction for the voltage and frequency in use for the transfer standard in the 792A Test Report.

   b. Algebraically add the correction value from the Test Report to the apparent error. For example, if the table reads -3 ppm for the voltage and frequency point used, and the apparent error of the ac voltage source is +31 ppm, the corrected error of the ac voltage source is:

      +31 ppm + (-3 ppm) = +28 ppm

   This means that the ac source is 28 ppm higher than nominal ± the uncertainty for the frequency and voltage point in the Specifications, combined with the uncertainty of the dc source.

NOTE

If there is ever any confusion over whether to add or subtract the correction from the Test Report, refer to the wording on the Test Report: "A positive ac-dc difference indicates that more alternating than direct voltage is required to produce the same 792A output." In other words, a positive ac-dc difference means that the transfer standard is slightly less sensitive to ac voltage stimulus than it should be.

Using a Nulling Method to Measure an AC Voltage Source 3-24.

The method of making a transfer described here detects the ac-dc difference by adjusting the dc voltage source to achieve the same DMM reading as produced by the ac voltage input. This method relies on the linearity of the dc voltage source. Proceed as follows to make an ac-dc transfer using the nulling method:

CAUTION

Always ensure that the proper range has been selected before applying voltage to the transfer standard INPUT. Inputs that exceed the protection level shown on the rear panel label may disrupt the state of calibration and cause instrument damage.

1. Set up for the transfer:

   a. Connect the ac and dc sources, the DMM, and the transfer switch to the transfer standard as shown in Figure 3-8. Verify that all instruments have satisfied their warmup requirements. (For the transfer standard, the warmup requirement is 15 minutes.) Use the 1000V range resistor and the 2.2V INPUT RANGE setting if the transfer voltage is between 200V and 1000V.

   b. Choose a voltage and frequency point for the transfer that is included in the 792A Test Report shipped with the transfer standard. Do not activate any sources yet.

   c. Set the INPUT RANGE knob to the appropriate position. For best results, always use the lowest range that will accept the input.

   d. Set the transfer switch to the OFF position, and the sources to standby.

2. Establish the ac voltage source (UUT) reading as a DMM scale factor:

   NOTE

   The method presented here assumes that a DMM with a scaling function is used. For DMMs without a scaling function, you can do the equivalent by keeping track of the values and solving mathematically for the result.

   a. Confirm the INPUT RANGE setting, and switch in the ac voltage source. Allow the DMM reading to stabilize. Table 3-9 shows minimum recommended settling times for new inputs at each RANGE SELECT setting.

   b. Enter the DMM reading as a scaling factor and turn on scaling. On the 8505A, you can enter the scaling factor through its keypad. The DMM should now read 1.000000.

3. Apply the dc source:

   a. Switch in the dc voltage source without stopping at the OFF position on the transfer switch and allow the DMM reading to stabilize. Now adjust the dc source until the DMM reads 1.000000. Note the setting of the dc source.

   b. Reverse the polarity of the dc source using its controls.

   NOTE

   If the source has fixed polarity, put it in standby, then quickly reverse the leads. The fixed polarity source must have external sensing capability, and be wired for external sensing, to compensate for changes in contact resistance.

c. Adjust the dc source so that the DMM reads 1.000000. Record the setting of the dc voltage source.

d. Average the absolute values (i.e. ignore the signs) of the two dc source settings from steps a and c. For example the average of |+10.00030V| and |-9.99900V| yields an average of 9.99965V.

e. Calculate the apparent error of the ac voltage source as follows:

$$\text{Apparent error in ppm} = 10^6 \times \frac{\text{averaged dc source setting - nominal voltage}}{\text{nominal voltage}}$$

For example, if the averaged ±dc value is 9.99965V, the apparent error in rms value of the ac source in ppm is:

$$10^6 \times \frac{9.99965 - 10}{10} = \frac{1000000 \times (0.00035)}{10} = -35 \text{ ppm}$$

4. Apply the published value from the 792A Test Report:

a. Look up the correction for the voltage and frequency in use for the transfer standard in the Test Report.

b. Add the value from the Test Report to the apparent error calculated in step 3c. For example, if the table reads -15 ppm for the voltage and frequency point used, and the apparent error in rms value is -35 ppm, the error in rms value of the ac voltage source is:

-35 ppm + (-15 ppm) = -50 ppm,

meaning the rms value of the ac source is 50 ppm lower than nominal ± the uncertainty for the voltage and frequency in the Specifications, combined with the uncertainty of the dc source.

NOTE

If there is ever any confusion over whether to add or subtract the correction from the Test Report, refer to the wording on the Test Report: "A positive ac-dc difference indicates that more alternating than direct voltage is required to produce the same 792A output." In other words, a positive ac-dc difference means that the transfer standard is slightly less sensitive to ac voltage stimulus than it should be.

Determining the Error of an AC Voltmeter 3-25.

This procedure uses the transfer standard to determine the absolute ac voltage applied to an ac voltmeter input. Simply observe the ac voltmeter reading to read its error at a particular voltage and frequency. The input of the UUT (in this case an ac voltmeter) is connected in parallel with the transfer standard input using a Type "N" tee connector as shown in Figure 3-9. The plane of reference is the center of this tee.

Proceed as follows to make an ac-dc transfer to determine the error of an ac voltmeter:

CAUTION

Always ensure that the proper range has been selected before applying voltage to the transfer standard INPUT. Inputs that exceed the protection level shown on the rear panel label may disrupt the state of calibration and cause instrument damage.

1. Set up for the transfer:

   a. Connect the ac and dc sources, the DMM, the ac voltmeter, tee connector, and the transfer switch to the transfer standard as shown in Figure 3-9. Verify that all instruments have satisfied their warmup requirements. (For the transfer standard, the warmup requirement is 15 minutes.) Use the 1000V range resistor and the 2.2V INPUT RANGE setting if the transfer voltage is between 200V and 1000V.

   b. Choose a voltage and frequency point for the transfer that is included in the 792A Test Report shipped with the transfer standard. Do not activate any sources yet.

   c. Set the INPUT RANGE knob to the appropriate position. For best results, always use the lowest range that will accept the input.

   d. Set the transfer switch to the OFF position, and the sources to standby.

2. Establish the dc voltage reference value as a DMM scale factor:

   NOTE

   The method presented here assumes that a DMM with a scaling function is used. For DMMs without a scaling function, you can do the equivalent by keeping track of the values and solving mathematically for the result.

   a. Confirm the INPUT RANGE setting, and set the dc voltage reference. Set the transfer switch to the dc source position.

   b. Allow the DMM reading to stabilize. Table 3-9 shows minimum recommended settling times for new inputs at each RANGE SELECT setting. Note the DMM reading.

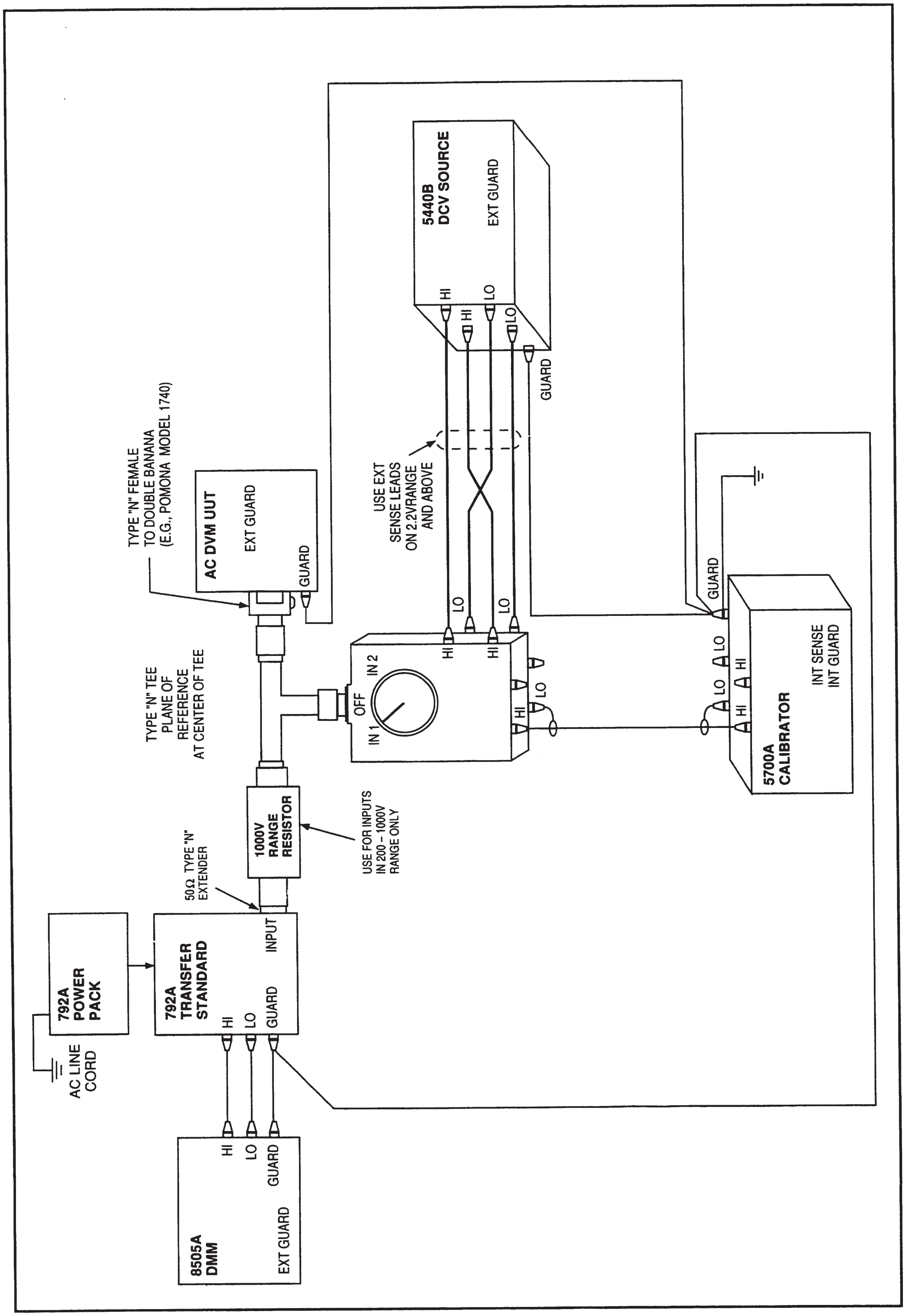


Figure 3-9. Calibrating an AC Voltmeter

c. Reverse the polarity of the dc source using its controls.

NOTE

If the source has fixed polarity, put it in standby, then quickly reverse the leads. The fixed polarity source must have external sensing capability, and must be cabled for external sensing to compensate for changes in contact resistance.

Note the DMM reading again.

d. Average the reading taken for each polarity, and enter the result as a scaling factor for the DMM and turn on scaling. This produces a DMM reading of 1.00000. On the 8505A, you can enter the scaling factor through its keypad. For example:

If the positive reading is	1.723555
and the negative reading is	1.723551
the scale factor to use is	1.723553

e. Look up the correction factor for the nominal voltage and frequency on the 792A Test Report. Convert the correction factor from ppm to decimal (multiply by 10^{-6}). Now subtract the correction factor from 1.0. The result is what you will adjust the ac voltage source for in the next step. For example, if the correction factor for the nominal voltage and frequency is +24, reverse its sign and add it as follows:

1.000000	(Scale factor set at the average of dc)
-.000024	(Correction from Test Report)
0.999976	(DMM reading for corrected ac voltage)

NOTE

The correction factor sign is always reversed before the correction factor is algebraically added to the scale factor.

NOTE

If there is ever any confusion over whether to add or subtract the correction from the Test Report, refer to the wording on the Test Report: "A positive ac-dc difference indicates that more alternating than direct voltage is required to produce the same 792A output." In other words, a positive ac-dc difference means that the transfer standard is slightly less sensitive to ac voltage stimulus than it should be.

3. Adjust the ac source for a DMM reading equal to the corrected scale factor:

a. Quickly switch the transfer switch to the ac source position and apply the ac voltage. Allow the meter reading to stabilize.

b. Adjust the ac voltage source to get a dc DMM reading equal to the result in step 2e. Now the ac voltage source is supplying ac voltage corrected to within the uncertainty of the 792A combined with the uncertainty of the dc voltage source to the center of the tee.

4. Calculate the ac voltmeter error. Use the following formula:

$$\text{error in ppm} = \frac{\text{ac voltmeter reading - nominal rms value}}{\text{nominal rms value}} \times 10^6$$

For example, if the nominal voltage is 10V rms and the ac voltmeter reads 10.00018, the error of the ac voltmeter is:

$$\text{error in ppm} = \frac{10.00018 - 10}{10^6} = +18 \text{ ppm}$$

5. Test other frequency and voltage points as required by the calibration procedure in the ac voltmeter manual.

Calibrating Another Transfer Standard 3-26.

See Section 5 for an example of calibrating another transfer standard. The 792A is maintained by a reference 792A, which in turn is traceable to NIST standards.

TECHNIQUES FOR REDUCING TRANSFER ERRORS 3-27.

In making ac-dc transfers for the purpose of determining absolute ac voltage, errors can come from dc reversal, loading (both cable induced and instrument input), thermal emfs, changes in mechanical contact, spurious ground currents in the signal leads, and emi. Loading errors can be ignored when making an ac-dc difference measurement, where the nominal test voltage has a relatively wide tolerance.

Knowing more about these errors can help shortcut the amount of time spent experimenting and debugging to get the best possible results. Once you are confident that error sources are minimized, it is a good rule to always take three measurements. That way, a faulty measurement will stand out.

DC Reversal 3-28.

DC reversal error relative to input voltage is typically 5 ppm or lower on the passive ranges (2.2V to 1000V). However, in order to meet specifications, you must correct for dc reversal when doing a transfer. Apply both polarities of dc to the transfer standard INPUT and average the results.

On the active ranges (22 mV to 700 mV), dc reversal error relative to input voltage can be as high as 90 μV, with input bias current as high as 0.00003 μA. This can add to dc offset errors if the source resistance is large enough. As with the passive ranges, you can compensate for these dc offsets by applying both polarities of dc to the INPUT and averaging the results.

Loading 3-29.

The input impedance of the transfer standard may affect ac voltage source output levels significantly. Refer to Table 3-10 for the transfer standard input impedance on each range. Sources with resistive dividers on the output are especially sensitive to loading errors. Cables present an additional capacitive load to the source. If possible in your configuration, avoid cables entirely by connecting the ac voltage source directly to the transfer switch through an adapter or adapters.

Table 3-10. Input Impedances for Each Range

INPUT RANGE	INPUT IMPEDANCE	
	RESISTANCE	SHUNT CAPACITANCE
22 mV	10 MΩ	<40 pF
220 mV	10 MΩ	<40 pF
700 mV	10 MΩ	<40 pF
2.2V	420Ω	<20 pF
7V	1.2 kΩ	<20 pF
22V	4.0 kΩ	<20 pF
70V	12 kΩ	<20 pF
220V	40 kΩ	<20 pF
1000V	200.4 kΩ	<20 pF

Check the specifications and instruction manual for each type of ac voltage source before connecting the source to the transfer standard. Avoid exceeding the drive capability of the ac voltage source, no matter what the transfer application is. When in doubt, use an oscilloscope or spectrum analyzer to make sure the ac source is not loaded to the point that it is producing a distorted signal.

Before you calibrate an ac voltage source, there is another source of loading error to consider. What will the ac voltage source be used for after calibration? Many meters have highly capacitive inputs and present a much heavier load than the transfer standard. One way to compensate for meter loading is to simulate a meter load during calibration with the transfer standard. To simulate a meter load, connect a load equivalent in capacitance and resistance to the meter input across the INPUT of the transfer standard.

Mechanical Contact 3-30.

Connection contact resistance variation is a potential error source on the 2.2V, 7V and 22V ranges. By using high quality cables and connectors, you can minimize this source of error. Use stainless steel coaxial connectors if possible. They are machined with more precise threads, which make better electrical contact. The Type "N" connectors on the transfer standard, transfer switch, and 1000V range resistor are all stainless steel.

To achieve the highest quality measurements, do not disturb the instrumentation setup during the course of a transfer, especially in the passive ranges (2.2V and above). Try not to move, jostle, or vibrate the transfer standard, the DMM, or any of the input signal wiring from the time you apply the first input voltage until you take the last reading of the transfer.

If you are using the transfer switch, make sure that the switching action does not change the stresses on the input wiring, thereby changing the connector contact resistance and degrading the measurement.

When using a fixed-polarity dc source you must disconnect and reverse the cables, which introduces changes in contact resistance. Four-wire sensing minimize the effects of changes in contact resistance as well as cable voltage drops. That is why the procedures in this manual require that fixed-polarity sources have sensing capability.

NOTE

Most importantly, always repeat the measurements until you are satisfied that the results are repeatable relative to the specification being measured.

Thermal EMFs 3-31.

Thermal emf errors can adversely affect ac-dc transfers. A stable thermal emf error on the dc DMM input leads (reading the output of the transfer standard) will not affect the transfer. However, all it takes to change the emf error and adversely affect a transfer is to briefly touch a connector or binding post. It typically takes five minutes to thermally stabilize a connection after it has been touched.

Thermal emf errors in the cabling between the dc voltage source and the transfer switch or transfer standard input should be avoided whether they are stable or not. They will increase the uncertainty of the dc voltage output as seen by the transfer standard.

To reduce thermal emf errors, use low thermal emf cables and connectors and avoid changing the temperature of any connection during a transfer.

EMI 3-32.

The transfer standard is a broadband instrument, so it is sensitive to rf energy applied to its input. If emi is in the environment, you should try to remove the source of radiation, and also pay attention to cabling which can be an antenna for picking up the emi.

Soldering irons, fluorescent lights, anything with a motor, and all similar things can radiate emi. Turn off soldering irons and keep the transfer setup away from fluorescent lights.

To minimize cable pickup, use short coaxial leads when possible, especially at test voltages below 2V. Shielded cables and connectors can minimize the contribution of emi to transfer uncertainty.

By removing the ac line cord from the power pack during operation, you have removed a length of cable that could pick up emi and introduce it in a measurement. The power pack does have emi filtering at the power cord input, but no amount of filtering will remove 100% of the interference present at an input.

Section 4
Theory of Operation

INTRODUCTION 4-1.

This section presents theory of operation in increasing level of detail. The 792A Transfer Standard and the 792A Power Pack are first broadly defined in an overall functional description and block diagram. Following that, theory is presented by assembly or major circuit in a detailed circuit analysis.

OVERALL FUNCTIONAL DESCRIPTION 4-2.

The 792A is a precision ac/dc transfer standard built around the Fluke RMS Sensor. The transfer standard is capable of making ac/dc transfers with any voltage between 2 mV and 1000V rms at frequencies from 10 Hz up to 1 MHz. Refer to Figure 4-1 for the following discussion.

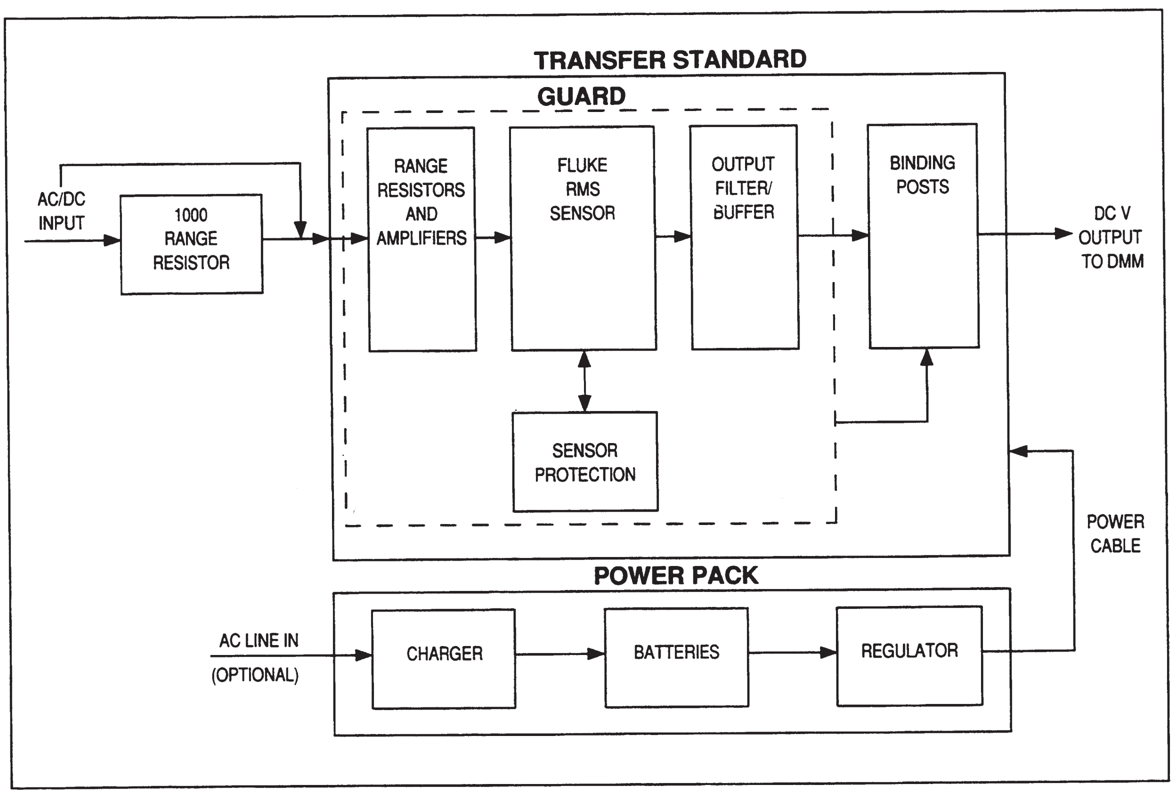


Figure 4-1. 792A Block Diagram

Range Resistors and Amplifiers 4-3.

Eight ranges of voltage are accepted by the input, selected by the INPUT RANGE knob: 22 mV, 220 mV, 700 mV, 2.2V, 7V, 22V, 70V, and 220V. The Fluke RMS sensor operates with inputs up to 2.2V, so in the 2.2V range setting, inputs are essentially passed straight through to the rms sensor circuit. Ranges below 2.2V are amplified to the 2V level. Ranges above 2.2V are resistively divided to the 2V level. The 1000V range resistor is an external 200 kΩ resistor that forms a 500:1 divider when connected to the input of the transfer standard set to 2.2V.

RMS Sensing and Sensor Protection 4-4.

AC and dc voltage inputs are converted to a scaled dc output by the Fluke RMS Sensor. The rms sensor is protected from high-voltage transients and steady over-range inputs by several circuits.

Output Filter/Buffer 4-5.

The scaled dc voltage output is filtered by a five-pole Bessel filter to remove unwanted ripple. An output buffer then provides a low-impedance output for reading on a dc DMM.

Binding Posts 4-6.

Multistage rf filters are present on the +11V, -11V, DC OUTPUT HI, and OVERLOAD lines to remove any emi before signals enter the ac can, which covers and is electrically connected to the ac plate, holding the A2 Sensor PCA.

792A-7001 Power Pack 4-7.

The power pack contains four lead-acid gelled electrolyte batteries, which power the transfer standard. The batteries are connected in two sets of series-connected 6V cells, for +12V and -12V nominal outputs. Voltage regulators maintain +11V and -11V until a series-connected pair of batteries becomes discharged to 11.6V. When regulation drops out, the power pack trips out of OPERATE state.

When the charger is active, power for the transfer standard is disabled. This is to maintain a high degree of isolation from the ac line. Usually, the power pack is used with the ac line cord removed.

DETAILED CIRCUIT DESCRIPTION 4-7.

Refer to the Schematic diagrams in Section 8 for the following discussion.

Fluke RMS Sensor Circuit 4-8.

The central component in the 792A is the Fluke rms sensor (U111), a monolithic integrated circuit that contains two identical thermal voltage converters. In each TVC, the heater resistor is thermally coupled to a transistor, and the base-emitter junction voltage senses the power being dissipated in the resistor.

Voltage at the 792A input connector (after appropriate scaling) is applied to the heater resistor at pins 6 and 7. The transistor at pins 3, 4, and 5 senses the power in the resistor. The feedback loop applies a dc voltage to the resistor at pins 9 and 10, which produces equal power as sensed by the transistor at pins 1, 2, and 3. This dc voltage is then filtered by a five-pole Bessell filter (U103 and U104) to remove unwanted ripple.

In the Fluke RMS Sensor, the process of converting heater resistor power to transistor voltage produces a nonlinear loop gain, which would result in longer settling times for small input voltages. The piecewise linear square root amplifier U102 substantially cancels this effect and yields a more uniform settling time. Resistor R105 is adjusted to cancel the offset voltage of the rms sensor for a more linear input-to-output response.

Diode CR100 prevents negative output voltages which would latch up the feedback loop, while U102A provides the drive current for square root amplifier U102B. Diodes CR108-CR110 prevent any overload transients at the output, which could damage the dc side of the RMS Sensor.

Passive (Non-Amplified) Ranges 4-9.

Five ranges are passive: 2.2V, 7V, 22V, 70V, and 220V. On the 2.2V range, the input signal passes through a 20Ω resistor to the heater resistor of the rms sensor. The 7V, 22V, 70V, and 220V ranges incorporate 800Ω, 3.6 kΩ, 11.6 kΩ, and 39.6 kΩ resistors, respectively, in series with the 400Ω sensor heater resistor.

Each range except 2.2V is tuned by an air-dielectric variable capacitor. When one of these ranges is engaged, its tuning capacitor is effectively connected across the sensor heater resistor. The air-variable capacitors are adjusted for zero ac-dc difference at 1 MHz.

792A-7002 1000V Range Resistor 4-10.

The 792A-7002 1000V Range Resistor is a Fluke 200 kΩ low temperature coefficient, hermetically sealed, thin-film resistor packaged in a heat sink for high power dissipation. The OUTPUT connector of the 1000V range resistor is plugged into the transfer standard INPUT connector, with the RANGE SELECT knob set to 2.2V. The source is then applied to the INPUT of the 1000V range resistor. This resistor is frequency tuned for zero ac-dc difference at 100 kHz. The low power coefficient and high heat dissipation capabilities of this resistor give the 1000V range a fast settling time.

Active (Amplified) Ranges 4-11.

The active ranges are so named because they introduce amplifiers and other active components into the input signal path. For input voltages below 700 mV, a high input impedance amplifier is necessary for the following two reasons:

- To amplify the input signal to match the dynamic range of the rms sensor
- To provide a high impedance buffer for the voltage source

The three active ranges are 22 mV, 220 mV, and 700 mV full scale. For the 700 mV range, a 10 dB amplifier is switched between the input signal and the rms sensor. For the 220 mV range, a 20 dB amplifier is switched between the input signal and the rms sensor. The 22 mV range adds one more 20 dB amplifier in series with the 220 mV range.

Clamp diodes CR1-CR5 protect the input to the amplifiers. Resistors R3, R18, and R34 improve the capacitive load handling ability of the amplifiers by preventing 90 MHz and higher oscillations in the 3554 output stage. The 10 MΩ resistors R6 and R21 tie the input of the amplifiers to common when no input load is present, preventing the outputs from seeking one supply or the other during a no-load condition. Air-variable capacitors C3, C13, and C26 adjust the frequency response of each amplifier for zero ac/dc difference at 1 MHz.

Op amps U2, U4, and U8 form the dc components of noninverting composite amplifiers in conjunction with U1, U3, and U6. These precision dc amplifiers improve the offset voltage and voltage noise of each active range, but do not substantially affect the circuit performance above 2 Hz. Resistors R12, R27, and R48 are used to adjust the active ranges for zero ac-dc difference. The network of C36, R45, C37, and R46 is required for amplifier stability with various source impedances.

Each active range amplifier is only powered up when it is selected on the range switch. The third deck of the range switch enables a soft-start circuit for each amplifier, which uses MOSFETs Q1, Q4, Q5, Q8, Q9, and Q12 as the series pass elements. These soft-start circuits allow power to the enabled amplifier to ramp up slowly to prevent the power supply from tripping out.

Sensor Protection Circuit 4-12.

Protection circuits prevent damage to the rms sensor, range resistors, and input amplifiers. The first line of defense is a pair of zener diodes that clamp the input to the Fluke RMS Sensor to ±6.8V. The relatively high junction capacitances of the zener diodes are removed from the circuit in non-overload conditions by two PIN diodes (CR111 and CR112).

Large voltage overloads are clamped directly by a series of of gas-filled surge arrestors which are effectively connected across each input range. This protection technique works only if sources are current-limited to 200 mA maximum.

The second line of defense is from a pair of peak detectors, one each for positive and negative excursions. The peak detectors compare the current through the rms sensor at R122 with a limit set by U108 and U109 and their associated resistors. When the circuit detects excessive sensor current, the output of U104 goes low, causing the two MOSFETs Q102 and Q103 to go to a high impedance state and interrupt the input current flow. This action also turns on the front panel OVERLOAD indicator. The transfer standard attempts to reset this protection condition six times per second, but as long as the input overdrive condition persists, reset attempts will be unsucessful.

A third line of defense protects from steady inputs that are slightly beyond the protection limit, but which would not trigger the peak detectors. U112A senses the level of voltage at pin 3 of U111, and turns on the protection when the rms input to the RMS Sensor exceeds a safe level. The voltage at pin 3 of U111 indicates the rms voltage applied to the sensor.

Power Pack 4-13.

The current-limited constant voltage battery chargers are composed of U301, U302, and their associated resistors. Pressing S301 (the OPERATE switch) pulses K303 and K304 and connects the batteries to the regulator circuitry. The mirror image low dropout regulators are formed by U304, Q301, and Q302. Lag networks C314, C315, R335, and R336 are needed for the stability of the regulator circuit. Resistors R313 and R314, in conjunction with U203 monitor the regulator output current. If an overcurrent condition is detected, U306C, U306D, and U309 pulse the relays into the off position to go into charge mode.

OVERCURRENT PROTECTION 4-14.

An overcurrent condition changes the output state of comparators U306C and U306D, which in turn cause U307 to toggle the relays to the charge position, shutting off power to the output.

BATTERY VOLTAGE MONITOR 4-15.

The battery voltage monitor circuit is formed by comparators U305, U306, and their associated resistors. When the battery voltage for either supply drops to 11.6V, U305A or U306A changes state and lights the LOW BAT indicator. This indicator warns the user that one hour or less of battery operation time remains, and the batteries need charging. When the battery voltage for either supply drops to 11.3V, U305B or U306B changes state, and U307 toggles the relays to the charge position, disconnecting the batteries from the load. All relays are toggled when S301 (OPERATE) is pressed.

ON/OFF CIRCUIT 4-16.

U307 is configured as a simple flip-flop, always powered by the +12V batteries. Its output is toggled on or off by S301, or any of the fault and/or battery level conditions mentioned under the heading Relays. U309 ensures proper start-up of the on/off circuit.

RELAYS 4-17.

Four relays are used in the power pack, two latching types (K303, K304) that are pulsed by battery power, and two non-latching types (K301, K302) powered by the transformer secondaries. Relay configuration for the various operating states are as follows:

- POWER on, CHARGE indicator lit: K301 and K302 are de-energized, K303 and K304 are in the reset position, and the batteries are connected to the charging circuit.

- POWER on, either LOW BAT or OPERATE indicators lit: K303 and K304 are pulsed to the set position (via S301, U307, Q303-Q306), and K301 and K302 are energized (via optocoupler U308).

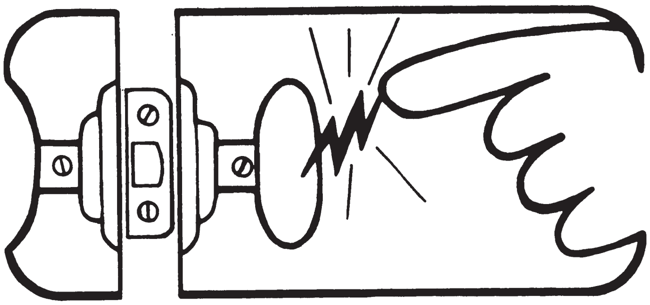
- POWER off, no indicators lit: All relays are in the de-energized or reset condition. Batteries are connected to the charging circuit, but the circuit is turned off.

- AC line off, either LOW BAT or OPERATE indicators lit: K303 and K304 are pulsed to the set position, connecting the batteries to the regulators. The contacts of K301 and K302 are still in the de-energized position, connecting the batteries to the charging circuit, but the charging circuit is turned off.

static awareness

A Message From

John Fluke Mfg. Co., Inc.

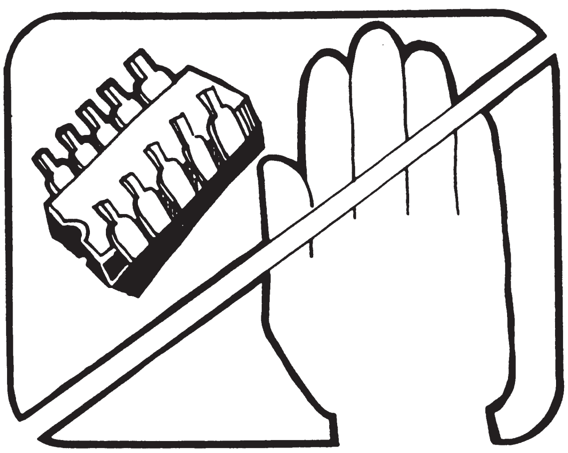


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

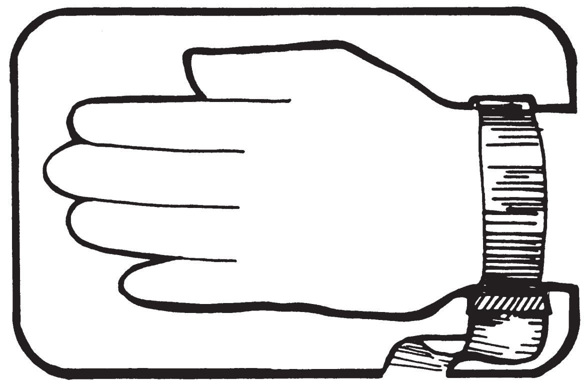
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

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

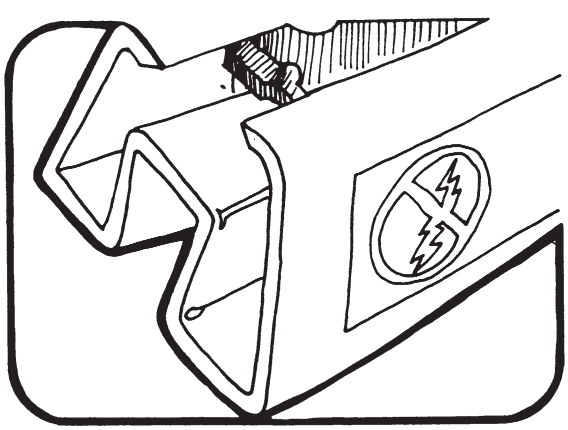
The following practices should be followed to minimize damage to S.S. devices.



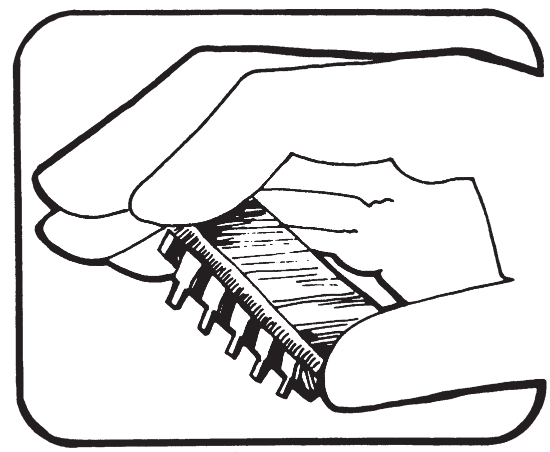
1. MINIMIZE HANDLING



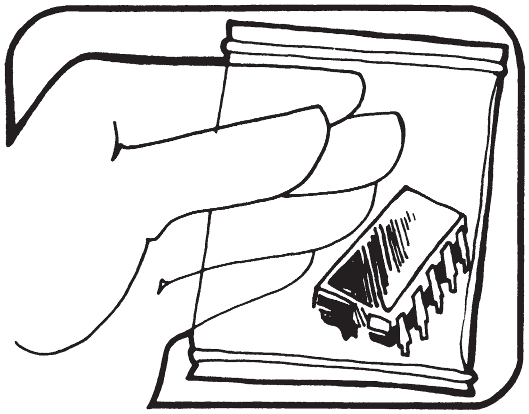
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES



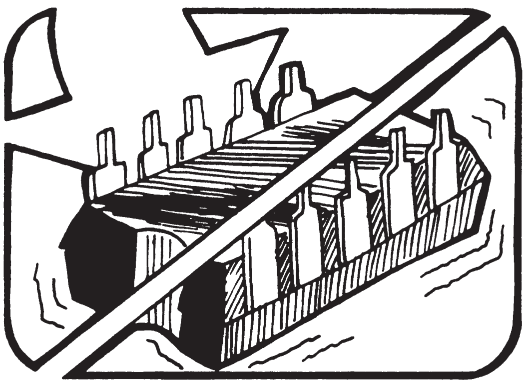
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



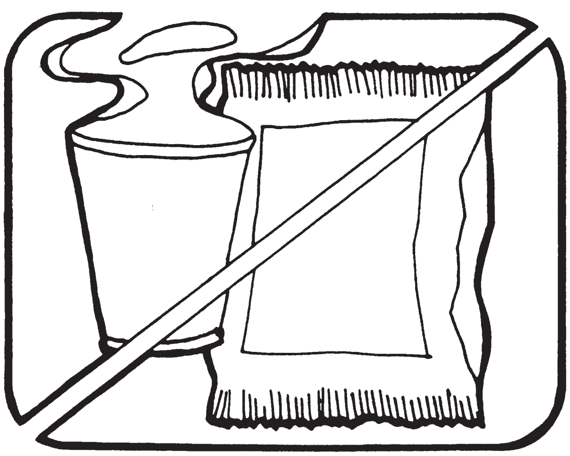
4. HANDLE S.S. DEVICES BY THE BODY



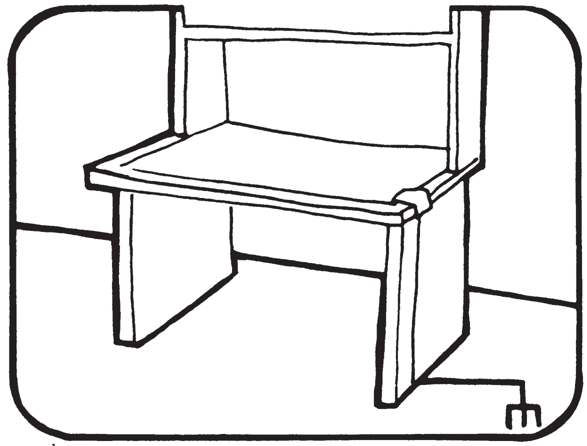
5. USE ANTI-STATIC CONTAINERS FOR HANDLING AND TRANSPORT



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



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



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

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

10. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

Anti-static bags, for storing S.S. devices or pcbs with these devices on them, can be ordered from the John Fluke Mfg. Co., Inc.. See section 5 in any Fluke technical manual for ordering instructions. Use the following part numbers when ordering these special bags.

John Fluke Part No.	Bag Size
453522	6" x 8"
453530	8" x 12"
453548	16" x 24"
454025	12" x 15"

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Section 5
Maintenance

WARNING

SERVICING DESCRIBED IN THIS SECTION IS TO BE DONE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK OR FIRE, DO NOT SERVICE THE 792A UNLESS YOU ARE QUALIFIED TO DO SO.

CAUTION

Any procedure that involves opening the cover of the transfer standard sensor unit or 1000V range resistor invalidates calibration. You can send the 792A to Fluke for calibration and repair, or you can use the procedures in this section to do it yourself. However, if you do not send the 792A to Fluke for calibration, you assume the traceability responsibilities.

INTRODUCTION 5-1.

This section explains how to calibrate the 792A and how to do other maintenance tasks. The calibration procedure is a guideline only. The recommended method for maintaining traceability of your transfer standard is to return it to Fluke for recertification. (See Section 1 for details.)

REPLACING THE FUSE 5-2.

Refer to Section 2 for the fuse access procedure.

GENERAL CLEANING 5-3.

To keep the 792A looking like new, clean the cases with a soft cloth slightly dampened with water or a non-abrasive mild cleaning solution that does not harm plastics.

CAUTION

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. They can damage the plastic materials used in the 792A.

CALIBRATION 5-4.

See Section 1 for information about the warranty, calibration cycle, and how to return the transfer standard to Fluke for recertification (calibration). Use the calibration procedure in this section only if you plan to maintain 792A traceability yourself instead of through Fluke. For a complete description of how Fluke achieves traceability of the 792A, refer to the technical paper by Les Huntley in Appendix D.

This procedure uses a 792A calibrated by NIST (National Institute of Standards and Technology) called the reference unit, to calibrate your 792A, called the UUT (Unit Under Test). The goal of calibration is to produce a new Test Report. The previous Test Report becomes obsolete.

NOTE

In the Fluke factory, 792A calibration is done using an automated calibration station with specially developed software that produces extremely accurate, repeatable correction factors for the 792A under test. The technical paper by Don Matson in Appendix E goes into detail about such an automated calibration station.

Four-wire sensing from the ac or dc source is unnecessary when calibrating the transfer standard, i.e., making an ac-dc difference measurement. This is because there is a relatively wide tolerance for the nominal test voltage.

NOTE

Equivalent DMMs and an equivalent calibrator may be substituted in the calibration procedure, as long as they are at least as accurate as those specified.

CAUTION

Always ensure that the proper range has been selected before applying voltage to the transfer standard INPUT. Inputs that exceed the protection level shown on the rear panel label may disrupt the state of calibration and cause instrument damage.

Table 5-1 lists the equipment required for this procedure. Proceed as follows to calibrate the transfer standard:

1. Set up the instruments for calibration:

   a. Connect the calibrator, the DMMs, the reference unit, and tee connector to the UUT as shown in Figure 5-1. Verify that all instruments have satisfied their warmup requirements. (For the transfer standard, the warmup requirement is 15 minutes.)

Table 5-1. Equipment Required to Calibrate the Transfer Standard

EQUIPMENT	MANUFACTURER AND MODEL
Two 6½-digit DMMs	Fluke 8505A
Multifunction Calibrator	Fluke 5700A with software rev. E or higher
Amplifier for Above	Fluke 5205A (for higher Volt-Hertz product)
Type "N" tee	Male-Male-Male (Amphenol 4850 or equivalent)
Reference Transfer Standard	Fluke 792A, calibrated by NIST or other national standards laboratory

*Rev. E and higher software includes the Xfer OFF function.

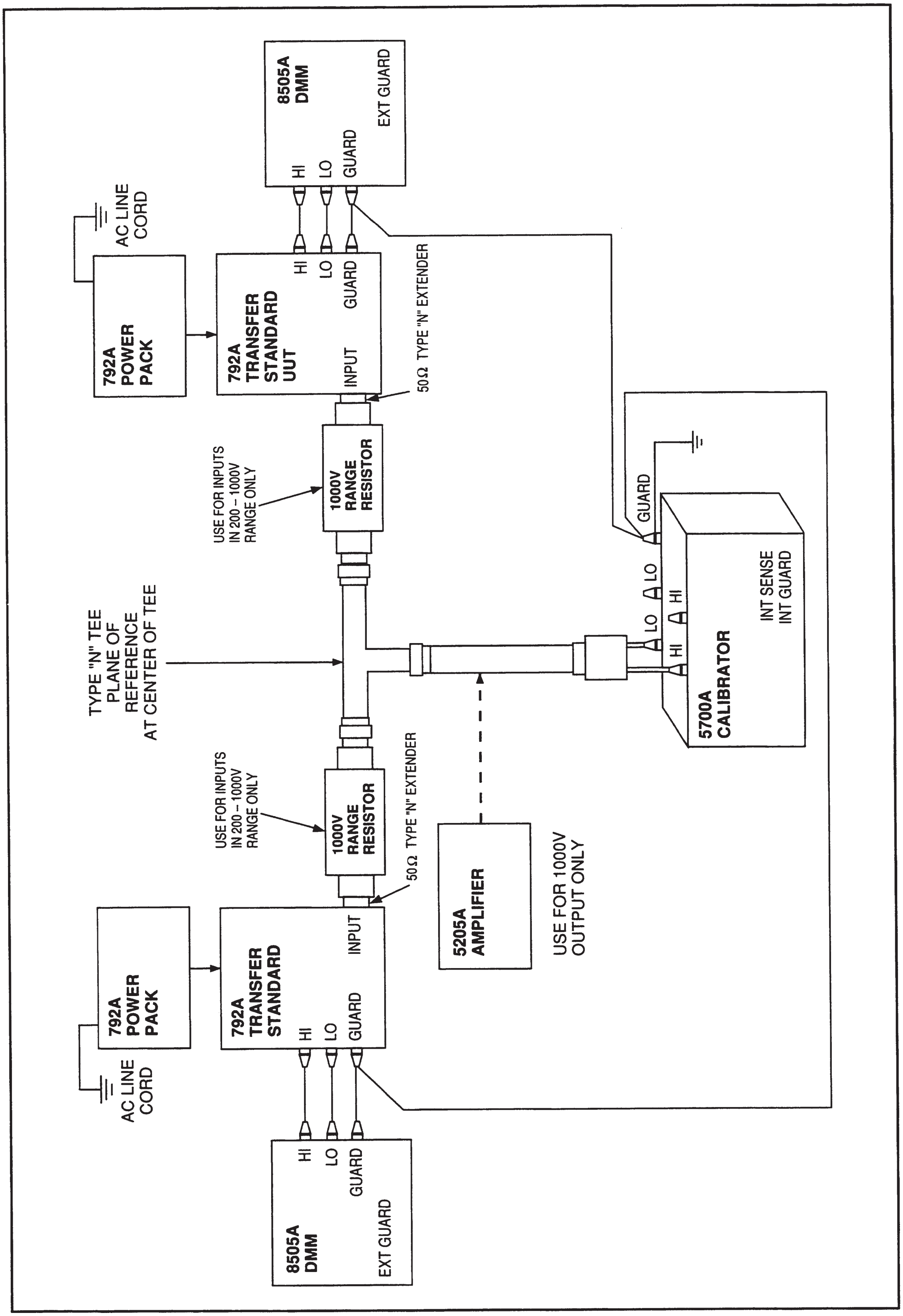

Figure 5-1. 792A Calibration Setup

NOTE

This procedure uses one multifunction calibrator as the ac and dc source, and no transfer switch. You can also use separate ac and dc sources and the transfer switch.

b. Monitor the ambient temperature and make certain that it is 23 ±5°C throughout the entire calibration process.

2. Set up the 5700A as follows so that its internal ac transfers are off:

   a. Press the "Setup Menus" softkey.

   b. Press the "Special Functns" softkey.

   c. Press the "ACXfer Choice" softkey so that ON appears.

   d. Press PREV MENU twice.

   e. Set the 5700A to 1V, 1 kHz, operate. Press the "Intrnl Xfers" softkey so that OFF appears. (The "Intrnl Xfers" softkey appears only in the 5700A ranges below 220V and at frequencies below 120 kHz.)

   f. Press 0, V, 0, HZ, ENTER, OPR/STBY on the 5700A.

3. Set up the 792As for a calibration point:

   a. Choose a calibration point consisting of a voltage and frequency in the Test Record (Table 5-2).

   b. Set both 792As to the appropriate input range.

   c. If the voltage is over 200V, make sure that both 792As have their respective 1000V range resistors connected between their INPUTs and the Type "N" tee. If the voltage is under 200V, make sure that units are directly connected to the Type "N" tee and that the 1000V resistors are out of the circuit.

4. Make an ac-dc transfer as follows:

WARNING

THE FOLLOWING STEPS MAY INVOLVE LETHAL VOLTAGES. USE EXTREME CAUTION.

   a. Activate the ac test voltage on the 5700A.

   b. Allow the readings on the DMMs to stabilize, and store each as a scaling factor on the associated meter. Now both meters should read close to 1.000000.

   c. Set the 5700A frequency to dc. (Press 0, Hz, ENTER.)

   d. Adjust the 5700A output using the knob for a reading of 1.000000 on the reference DMM.

Table 5-2. 792A Calibration Test Record

VOLTAGE RANGE	VOLTAGE INPUT	10 Hz	20 Hz	40 Hz	100 Hz	1 kHz	10 kHz	20 kHz	50 kHz	100 kHz	300 kHz	500 kHz	1 MHz
22 mV	2 mV	—	—	—	—	—	—	—	—	—	—	—	—
	10 mV	—	—	—	—	—	—	—	—	—	—	—	—
	20 mV	—	—	—	—	—	—	—	—	—	—	—	—
220 mV	20 mV	—	—	—	—	—	—	—	—	—	—	—	—
	100 mV	—	—	—	—	—	—	—	—	—	—	—	—
	200 mV	—	—	—	—	—	—	—	—	—	—	—	—
700 mV	200 mV	—	—	—	—	—	—	—	—	—	—	—	—
	600 mV	—	—	—	—	—	—	—	—	—	—	—	—
2.2V	600 mV	—	—	—	—	—	—	—	—	—	—	—	—
	1V	—	—	—	—	—	—	—	—	—	—	—	—
	2V	—	—	—	—	—	—	—	—	—	—	—	—
7V	2V	—	—	—	—	—	—	—	—	—	—	—	—
	6V	—	—	—	—	—	—	—	—	—	—	—	—
22V	6V	—	—	—	—	—	—	—	—	—	—	—	—
	10V	—	—	—	—	—	—	—	—	—	—	—	—
	20V	—	—	—	—	—	—	—	—	—	—	—	—
70V	20V	—	—	—	—	—	—	—	—	—	—	N/A	N/A
	60V	—	—	—	—	—	—	—	—	—	—	N/A	N/A
220V	60V	—	—	—	—	—	—	—	—	—	N/A	N/A	N/A
	100V	—	—	—	—	—	—	—	—	—	N/A	N/A	N/A
	200V	—	—	—	—	—	—	—	—	—	N/A	N/A	N/A
1000V	200V	—	—	—	—	—	—	—	—	—	N/A	N/A	N/A
	1000V	N/A	N/A	—	—	—	—	—	—	—	N/A	N/A	N/A

e. Record the reading on the UUT DMM.

f. Toggle the 5700A polarity. (Press ±, ENTER.)

g. Adjust the output of the 5700A using the knob until the reference DMM reads 1.000000.

h. Record the reading on the UUT DMM.

i. Calculate the ac-dc difference of the UUT (in ppm) for this calibration point as:

$$\left[\frac{(\text{UUT reading}_{pos}) + (\text{UUT reading}_{neg})}{2} - 1\right] \times 10^{6} + \text{reference ac-dc difference at calibration point}$$

j. Set the 5700A to 0V, 0 Hz, and STANDBY to clear the output voltage.

k. Record in the test record the UUT ac-dc difference at the calibration point.

5. Repeat steps 3 and 4 for each calibration point in the test record.

6. Verify that none of the ac-dc difference data points recorded are greater than their corresponding maximum ac-dc differences listed in the Specifications. If any ac-dc difference is out of tolerance, the transfer standard must be tuned and/or repaired before it can be calibrated.

PERFORMANCE TESTING 5-5.

When a problem occurs with the transfer standard, first verify that the problem is actually in the instrument. The following tests determine which if any of the transfer standard units is malfunctioning: the power pack, the power pack interconnect cable, sensor unit, 1000V range resistor, or transfer switch. Table 5-3 lists equipment required for the performance tests. Procedures for tuning the sensor unit and troubleshooting the sensor unit and power pack are further on in this section.

Table 5-3. Equipment Required for Performance Testing

EQUIPMENT	MANUFACTURER AND MODEL
Two 6½-digit DMMs	Fluke 8505A
Oscilloscope	Philips PM3050
Multifunction Calibrator	Fluke 5700A with software rev. E or higher
Amplifier for Above	Fluke 5205A (for higher Volt-Hertz product)
Type "N" tee	Male-Male-Male (Amphenol 4850 or equivalent)
Reference Transfer Standard	Fluke 792A, calibrated by NIST or other national standards laboratory

*Rev. E and higher software includes the Xfer OFF function.

Testing the Power Pack 5-6.

To test for correct operation of the power pack, proceed as follows:

1. Remove all connections to the power pack.
2. Toggle the front panel POWER switch. The green OPERATE indicator or the red LOW BAT light should appear. If either does not light, proceed as follows:
   a. Make sure the rear panel fuse is intact and of the correct rating, make sure the line voltage setting is correct, then connect the power pack to line voltage. Turn on the rear panel power switch, and let it charge for at least 16 hours.
   b. Repeat step 2 after charging the batteries. If the OPERATE indicator does not light, the power supply is malfunctioning.
3. If the OPERATE or LOW BAT light does appear, measure the ±11V supplies at the power supply output connector at the location shown in Figure 5-2a. One or more voltages that are out of specification here indicate a power supply malfunction.
4. Use an oscilloscope to check that no power supply outputs measured at the output connector are oscillating.

NOTE

To troubleshoot further, refer to Troubleshooting the Power Pack.

Testing the Power Pack Interconnect Cable 5-7.

To test for a fault in the power supply interconnect cable, use an ohmmeter to check the continuity of each wire as shown in Figure 5-2b. Also use the ohmmeter to verify that no two pins are shorted.

Testing the Transfer Switch 5-8.

Verify that the transfer switch is not at fault by using the four wire ohms function of a DMM to verify the switch contact integrity between the OUTPUT connector and the INPUT 1 and INPUT 2 binding posts.

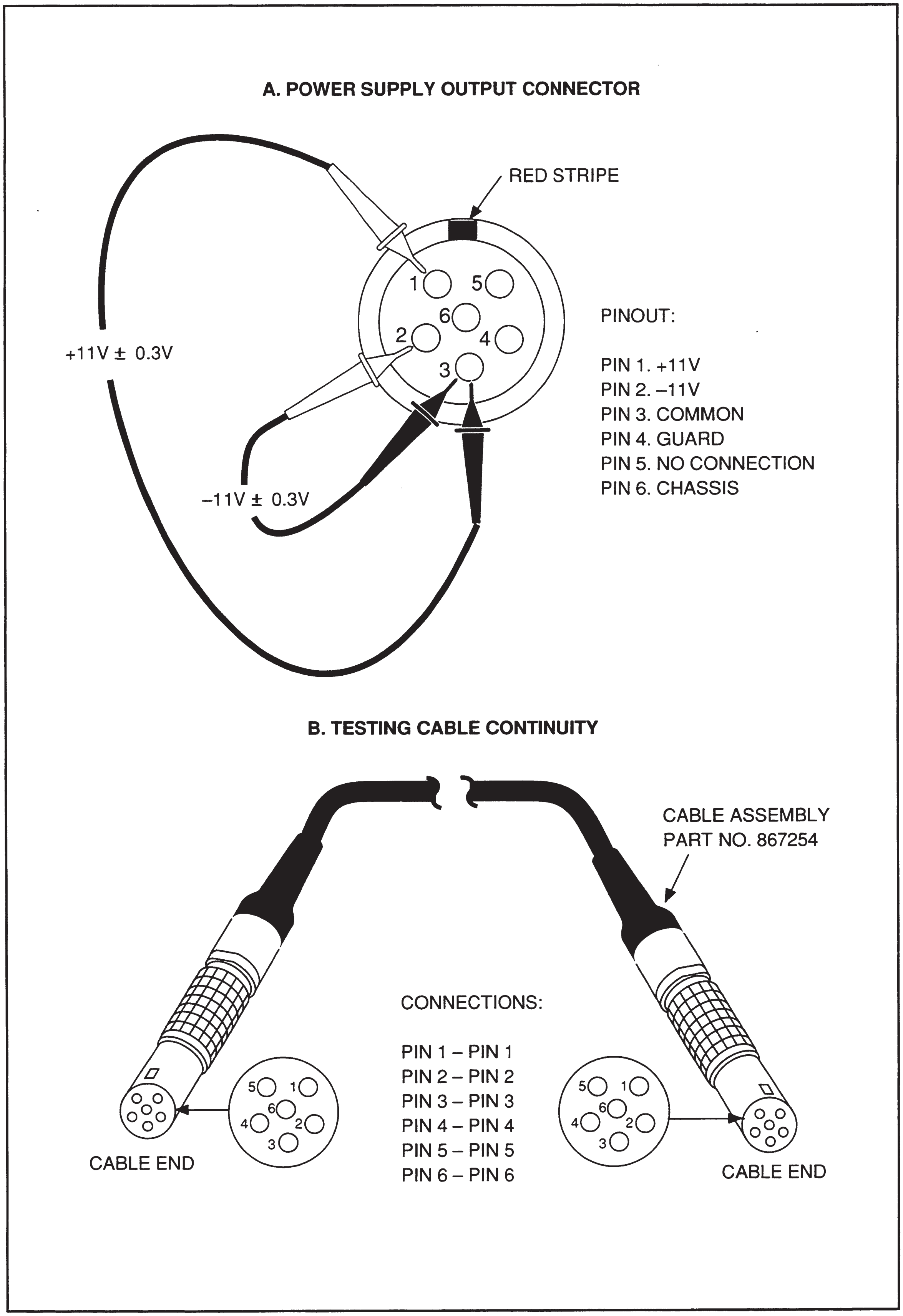

Figure 5-2. Power Pack Cable and Output Voltage

Testing the Sensor Unit and 1000V Range Resistor 5-9.

To test the performance of the sensor unit and the 1000V resistor, use the calibration procedure to verify that at each point in Table 5-4 the ac-dc difference is not greater than the values in the ALLOWABLE AC-DC DIFFERENCE column.

If one or more test points in Table 5-4 are out of tolerance, the transfer standard must be tuned and/ or repaired before it can be calibrated. The sensor unit tuning procedure is provided further on in this section. If the sensor unit malfunctions in any other way, or cannot be tuned to within allowable ac-dc differences, it must be repaired. Troubleshooting information for the sensor unit is provided further on in this section.

Table 5-4. Allowable AC-DC Difference for Performance Test

INPUT RANGE	INPUT VOLTAGE	FREQUENCY	ALLOWABLE AC-DC DIFFERENCE (PPM)
22 mV	20 mV	10 Hz	1000
22 mV	20 mV	1 kHz	200
22 mV	20 mV	1 MHz	5000
220 mV	200 mV	10 Hz	900
220 mV	200 mV	1 kHz	60
220 mV	200 mV	1 MHz	2500
700 mV	600 mV	10 Hz	900
700 mV	600 mV	1 kHz	60
700 mV	600 mV	1 MHz	2500
2.2V	2V	10 Hz	900
2.2V	2V	1 MHz	500
7V	6V	1 MHz	520
22V	20V	1 MHz	590
70V	60V	300 kHz	200
220V	200V	100 kHz	150
1000V	1000V	100 kHz	150

ACCESS PROCEDURES 5-10.

WARNING

BREATHING DUST OR FUMES FROM BERYLLIUM OXIDE CERAMICS IS HAZARDOUS.

In the 792A, the Fluke RMS Sensor (U111), and some of the range resistors, including the external 1000V range resistor, contain beryllium oxide ceramics. Normal use of the 792A and its components is safe. It is safe to handle and replace beryllium oxide ceramic parts. However, BERYLLIUM OXIDE DUST OR FUMES ARE HIGHLY TOXIC, AND BREATHING THEM CAN RESULT IN SERIOUS PERSONAL INJURY OR DEATH. Never alter, disassemble, grind, lap, fire, chemically clean, or perform any other operation on any ceramic parts that could possibly generate dust or fumes.

The following information describes how to access internal components in the four transfer standard units. To open the 1000V range resistor or transfer switch, remove the four screws securing the bottom plate.

Power Pack Initial Access Procedure 5-11.

To access the A3 Power Supply PCA or the batteries, proceed as follows:

1. Turn off the power, and remove all cables from the power pack.
2. Remove the five Phillips-head screws on each side and the four 2-mm (5/64") hex-head screws from the top of the cover, and remove the cover.
3. Remove the GUARD cover.

ACCESSING THE A3 POWER SUPPLY PCA 5-12.

Proceed as follows to access the A3 Power Supply PCA:

1. Do the previous three steps.
2. Remove the three Phillips-head screws from the bottom of the front panel and the eight Phillips-head screws from the right-angle brackets on each side of the front panel.
3. Lift away the front panel.

REPLACING THE BATTERIES 5-13.

When the batteries can be charged to only 80% of their original capacity, they should be replaced. When one battery is bad, the others may also wear out soon, so it is recommended that the batteries always be replaced as a set of four. The correct batteries are available from Fluke by ordering Fluke P/N 739961, quantity 4. Proceed as follows to replace the batteries:

1. Do the steps under Power Pack Initial Access Procedure.
2. Remove the Phillips-head screws that fasten the battery box cover, and remove the battery box cover.

WARNING

AVOID SHORTING THE BATTERY TERMINALS. FIRE OR EXPLOSION COULD RESULT.

3. Unplug the eight battery leads, being careful not to damage the spade lugs, then lift the battery spacer and leads together out of the way.
4. Replace the four batteries with new ones, and reconnect the battery leads as shown in Figure 5-3.

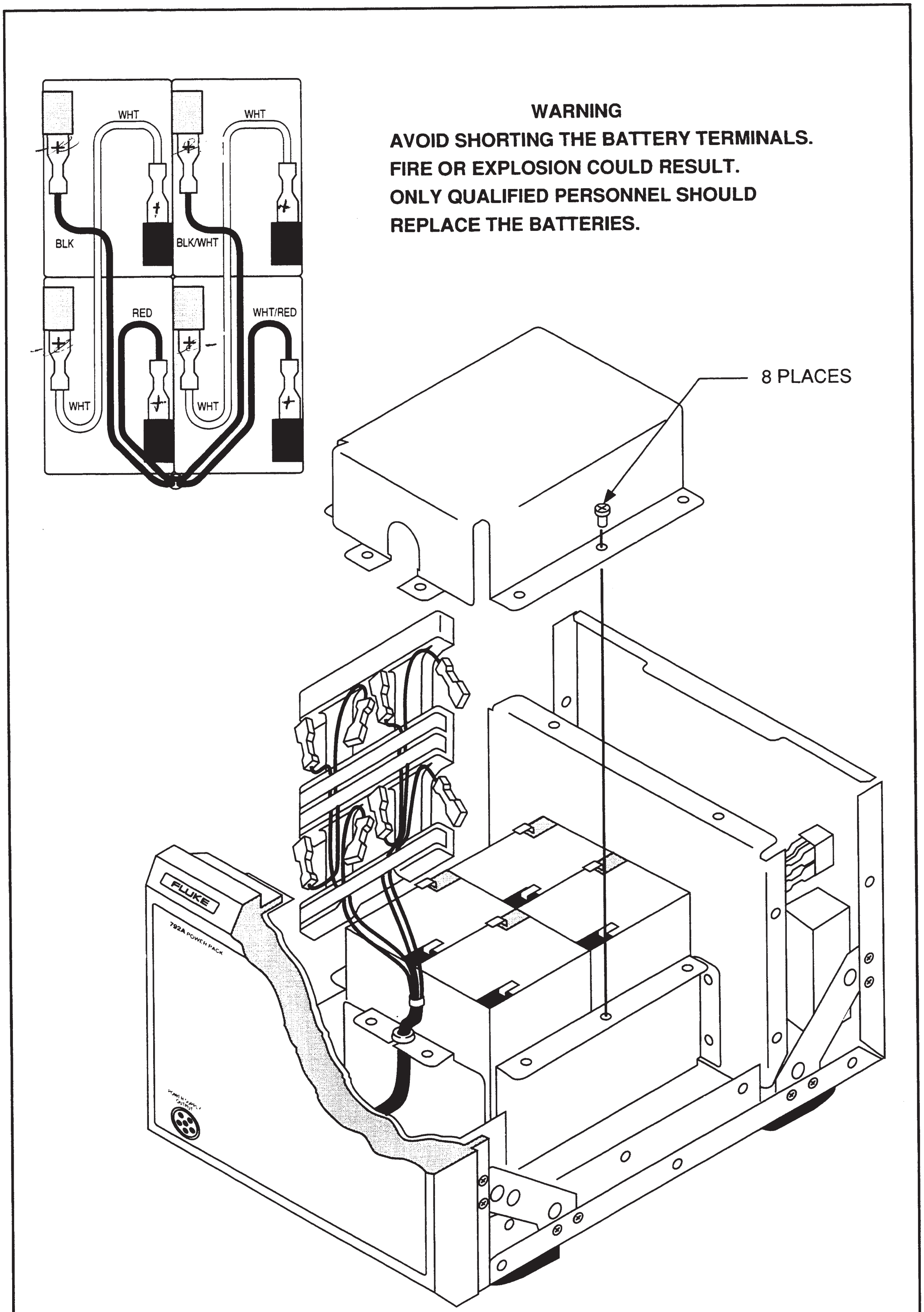

Figure 5-3. Accessing the Battery and Battery Lead Wiring

Sensor Unit Initial Access Procedure 5-14.

Refer to Figure 5-4 and proceed as follows to access components inside the transfer standard sensor unit:

NOTE

Before reassembly, make sure that a light film of lubrication exists on each of the switch contacts. If the switch contacts need lubrication, apply a thin coating of high-quality contact grease, thinned with tolulene, as described under Lubricating the Transfer Switch, at the end of this section.

1. Turn off the power, and remove all cables from the sensor unit.
2. Remove the five Phillips-head screws on each side and the four 2-mm (5/64") hex-head screws from the top of the cover, and remove the cover.
3. Remove the 14 Phillips-head screws that fasten the guard cover, and remove the guard cover.

REPLACING THE FLUKE RMS SENSOR (U111) 5-15.

Refer to Figure 5-4 and proceed as follows to access the A2 Sensor PCA and Fluke RMS Sensor (U111):

1. Do the previous three steps.
2. Remove the four Phillips-head screws from the top of the ac can, and lift off the ac can.
3. Rotate the INPUT RANGE knob until either slot in the knob shaft coupler is vertically oriented.
4. Remove the four Phillips-head screws that fasten the legs of the switch bracket assembly to the ac plate.
5. Lift off the switch bracket assembly. This will disconnect the twelve socketed leads between the switch and the A2 Sensor PCA. To make reassembly easier, try not to bend the leads.
6. Rotate the RMS Sensor Clamp out of the way.
7. Lift U111 out of its socket by routing two small cable ties alongside the pins, under each side of U111. Close the wire ties into loops, then pull the loops straight up to lift U111 out of its socket.

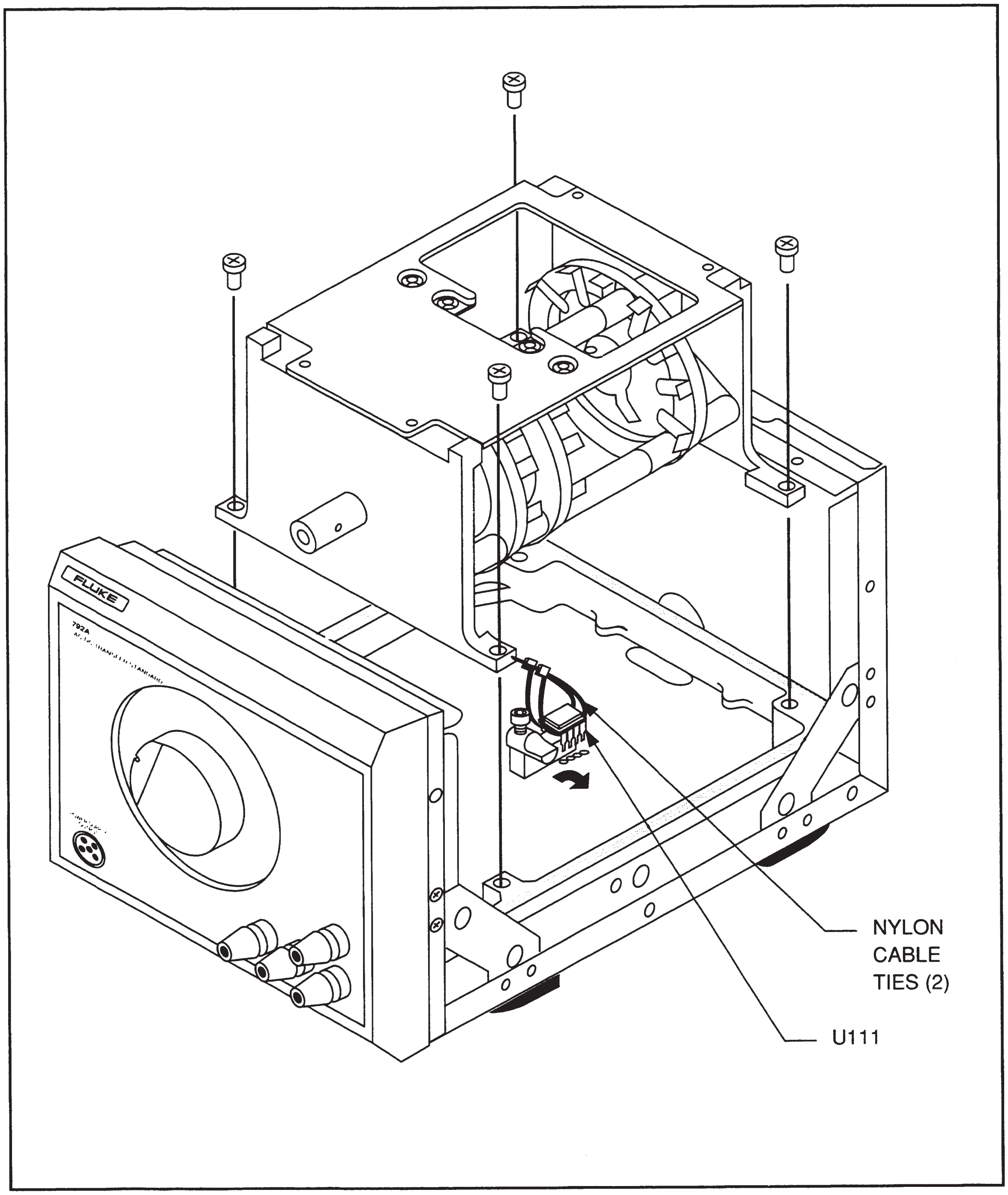

Figure 5-4. Replacing U111

ACCESSING THE FILTER PCA 5-16.

Proceed as follows to access the A1 Filter PCA:

1. Do the Initial Access Procedure and remove the ac can and switch bracket as in the previous steps 1 through 3.
2. Remove the three Phillips-head screws from the bottom of the front panel and the eight Phillips-head screws from the right-angle brackets on each side of the front panel. Lift away the front panel.

TUNING THE SENSOR UNIT 5-17.

This procedure uses another calibrated 792A, called the reference unit, to facilitate adjusting the unit under test for best performance. Tuning is required if the transfer standard fails the performance test for maximum ac-dc difference. Tuning adjustments are not part of normal calibration. Table 5-5 lists equipment required for the tuning procedure.

Table 5-5. Equipment Required for Tuning the Sensor Unit

EQUIPMENT	MANUFACTURER AND MODEL
Two $6^1/_2$-digit DMMs	Fluke 8505A
Multifunction Calibrator	Fluke 5700A with software rev. E or higher*
Amplifier for Above	Fluke 5725A or 5205A (for higher Volt-Hertz product)
Type "N" tee	Male-Male-Male (Amphenol 4850 or equivalent)
Reference Transfer Standard	Fluke 792A, calibrated by NIST or other national standards laboratory

*Rev. E and higher software includes the Xfer OFF function.

CAUTION

Always ensure that the proper range has been selected before applying voltage to the transfer standard INPUT. Inputs that exceed the protection level shown on the rear panel label may disrupt the state of calibration and cause instrument damage.

Proceed as follows to tune the transfer standard for frequency flatness. Figure 5-5 shows the location of adjustments accessible on the ac plate. Figure 5-6 shows the location of adjustments accessible through the ac can.

1. Set up the instruments for tuning:
   a. Remove the cover, guard, and ac can as described in the access procedures. Make sure that U111 is installed. Also check that C401 through C406 are in place and correctly connected.
   b. Reinstall the ac can and screw it into place.

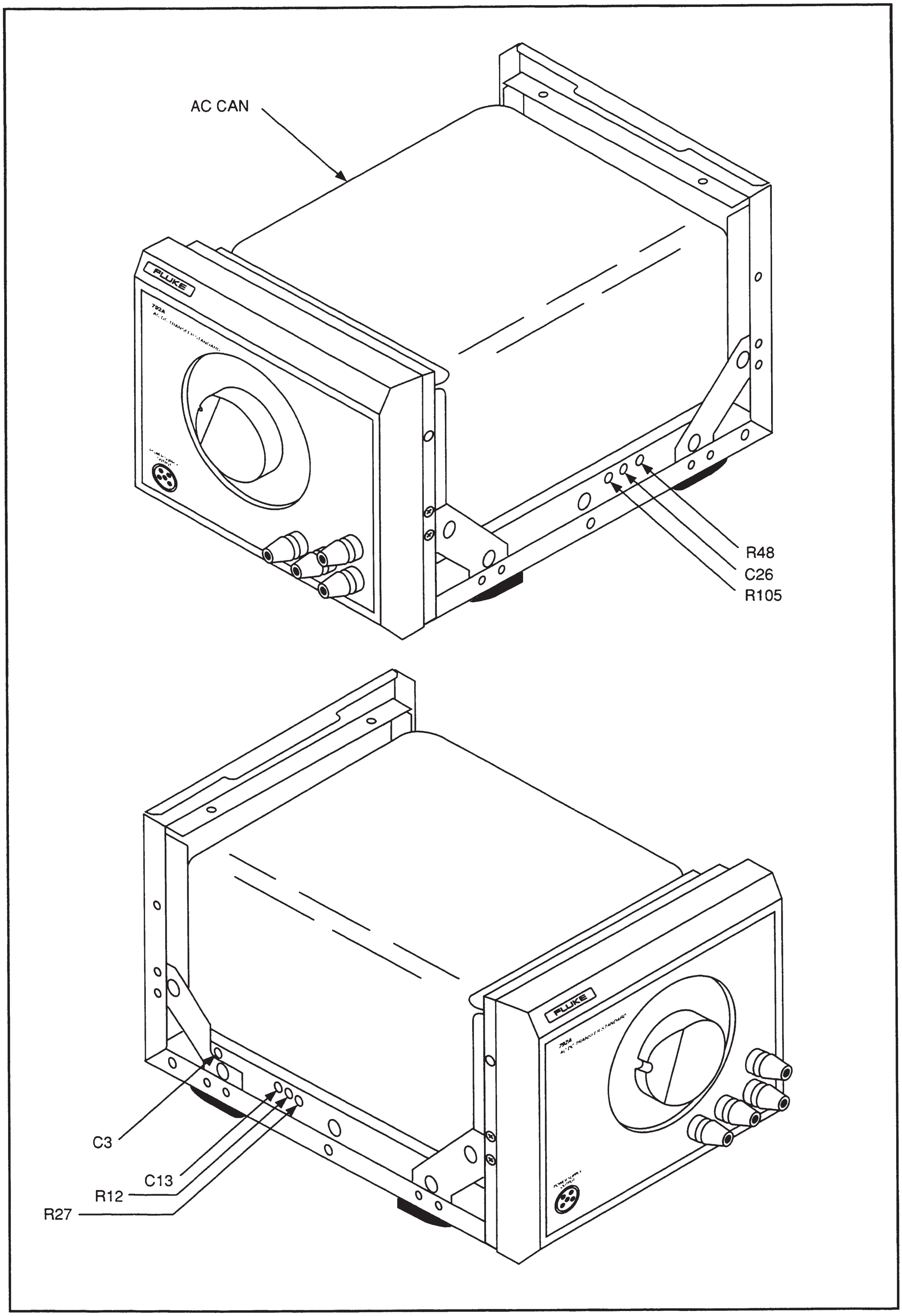

Figure 5-5. Location of Adjustments on the AC Plate

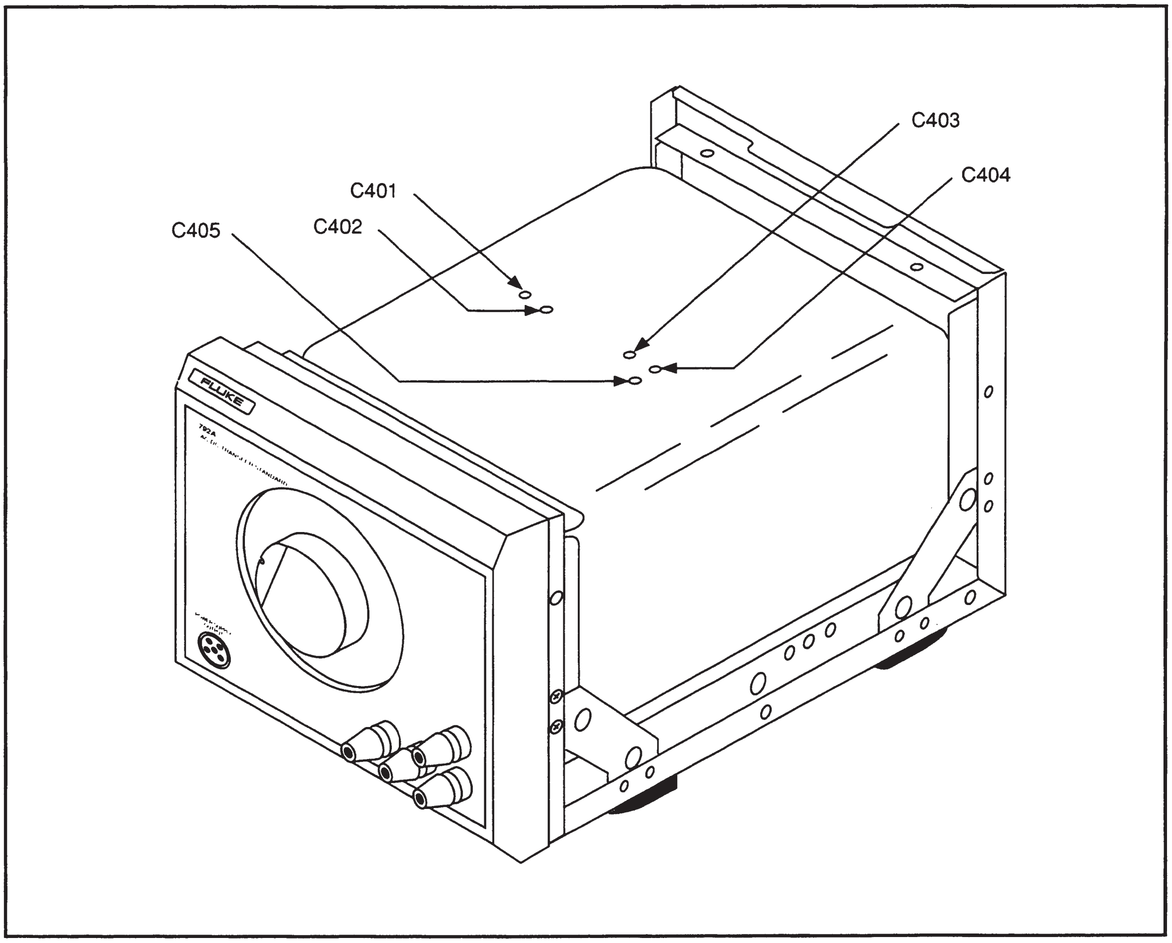

Figure 5-6. Location of Adjustments on the AC Can

c. Connect the calibrator, the DMMs, the reference 792A, tee connector, and the transfer switch to the transfer standard as shown in Figure 5-1. Verify that all instruments have satisfied their warmup requirements. (For the transfer standard, the warmup requirement is 15 minutes.)

NOTE

This procedure uses one multifunction calibrator as the ac and dc source, and no transfer switch. You can also use separate ac and dc sources and the transfer switch.

2. Set up the 5700A as follows so that its internal ac transfers are off:

   a. Press the "Setup Menus" softkey.

   b. Press the "Special Functns" softkey.

   c. Press the "ACXfer Choice" softkey so that ON appears.

   d. Press PREV MENU twice.

e. Set the 5700A to 1V, 1 kHz, operate. Press the "Intrnl Xfers" softkey so that OFF appears. (The "Intrnl Xfers" softkey appears only in the 5700A ranges below 220V and at frequencies below 120 kHz.)

f. Press 0, V, 0, HZ, ENTER, OPR/STBY on the 5700A.

3. Adjust the sensor offset:

a. Set both 792As to the 2.2V range.

b. Set the 5700A to 1V, and press the "Range" softkey so the LOCK appears.

c. Set the 5700A to 50 mV. (Press 5, 0, m, V, ENTER, OPR/STBY.)

d. Adjust R105 on the UUT until the UUT DMM reads 43 mV ±1 mV.

e. Set the 5700A to 10 mV. (Press 1, 0, m, V, ENTER.)

f. Adjust R105 on the UUT until the UUT DMM reads 8.5 mV ±1 mV.

g. Press OPR/STBY on the 5700A.

4. Adjust the passive ranges (7V and above) for frequency flatness:

NOTE

No frequency flatness adjustment is necessary for the 2.2V range.

a. Back out passive range frequency adjustment capacitors C401 through C405 until the slugs are even with the ends of the barrels.

b. Turn each capacitor clockwise the number of turns specified below:

- C401 (7V range): 6 turns
- C402 (22V range): 5 turns
- C403 (70V range): 5 turns
- C404 (220V range): 12 turns
- C405 (220V range): 12 turns

c. Set both 792As to the 7V range. Do a 1-kHz to 1-MHz transfer at 6V as follows:

NOTE

The next four substeps are repeated at different test voltages. The test voltage and 792A range are the only variable elements in substeps 1 through 4.

1. Set the 5700A to 6V, 1 kHz, operate.

2. Allow the readings on the voltmeters to stabilize, and store each as the scaling factor on that meter. Now both meters should read close to 1.000000.

3. Set the 5700A to 1 MHz. (Press 1, M, Hz, ENTER.)

4. Adjust the 5700A using the knob until the reference DMM reads 1.000000 minus the ac-dc difference from the reference test report at the voltage and frequency in use.

d. Adjust C401 for a UUT DMM reading of 1.000000 $\pm 10 \times 10^{-6}$.

e. Set both units to the 22V range. Do a 1-kHz to 1-MHz transfer at 20V as in substeps 1 through 4 of step c, then adjust C402 for UUT DMM reading of 1.000000 $\pm 10 \times 10^{-6}$.

f. Set both units to the 70V range. Do a 1-kHz to 1-MHz transfer at 20V as in substeps 1 through 4 of step c, then adjust C403 for a UUT DMM reading of 1.000000 $\pm 10 \times 10^{-6}$.

g. Set both units to the 220V range. Do a 1-kHz to 1-MHz transfer at 20V as in substeps 1 through 4 of step c, then adjust C404 and C405 for a UUT DMM reading of 1.000000 $\pm 10 \times 10^{-6}$.

h. Unscrew the tee connector; attach the UUT 1000V range resistor to the UUT, and attach the reference 1000V range resistor to the reference 792A. (The 1000V range resistors are not interchangeable.)

i. Screw the tee onto the 1000V resistors and set both units to the 2.2V range.

WARNING

THE FOLLOWING STEP INVOLVES LETHAL VOLTAGES. USE EXTREME CAUTION.

j. Do a 1 kHz-to-100 kHz transfer at 700V as in substeps 1 through 4 of step 4c, then adjust the variable capacitor accessible through the hole in the side of the UUT 1000V range resistor for a UUT DMM reading of 1.000000 $\pm 10 \times 10^{-6}$.

k. Set the 5700A to 0V, 0 Hz, and STANDBY to clear the output voltage.

l. Unscrew the 1000V resistors and set them aside. Reconnect the two 792As to the tee connector.

5. Adjust the active ranges (below 2.2V) for frequency flatness as follows:

   a. Set the 792As to the 700 mV range, and wait at least two minutes for the range to stabilize.

   b. Do a 1-kHz to 1-MHz transfer at 600 mV as in substeps 1 through 4 of step 4c, then adjust C3 for a UUT DMM reading of 1.000000 $\pm 10 \times 10^{-6}$.

   c. Set the 5700A to 200 mV, 1 kHz. (Press 200 mV, 1, k, HZ, ENTER.)

   d. Set the 792As to the 220 mV range, and wait at least two minutes for the range to stabilize.

   e. Do a 1-kHz to 1-MHz transfer at 200 mV as in substeps 1 through 4 of step 4c, and adjust C13 for a UUT DMM reading of 1.000000 $\pm 10 \times 10^{-6}$.

   f. Repeat step e one time.

   g. Set the 5700A to 20 mV, 1 kHz. (Press 20 mV, 1, k, HZ, ENTER.)

   h. Set the 792As to the 22 mV range, and wait at least 2 minutes for the range to stabilize.

   i. Do a 1-kHz to 1-MHz transfer at 20 mV as in substeps 1 through 4 of step 4c, and adjust C26 for a UUT DMM reading of 1.000000 $\pm 10 \times 10^{-6}$.

   j. Repeat step i one time.

   k. Press OPR/STBY on the 5700A.

6. Adjust the ac-dc difference on the active ranges.

   a. Set the 792As to the 700 mV range, and let the range stabilize at least two minutes.

   b. Do a dc-to-1 kHz transfer at 600 mV as follows:

NOTE

The next four substeps are repeated at different test voltages. The test voltage and 792A range are the only variable elements in substeps 1 through 7.

      1. Set the 5700A to 600 mV dc, operate.

      2. Allow the readings on the voltmeters to stabilize, and record the readings on both DMMs.

      3. Reverse the 5700A output polarity. (Press ±, ENTER.)

      4. Allow the readings on the voltmeters to stabilize, and record the readings on both DMMs.

5. For each DMM, average the reading for a positive input (step 2) with the reading for a negative input (step 4), and enter the result as the scale factor on that respective DMM.

6. Set the 5700A frequency to 1 kHz. (Press 1, k, HZ, ENTER.)

7. Adjust the 5700A using the knob until the reference DMM reads 1.000000 minus the ac-dc difference from the reference test report at the voltage and frequency in use.

c. Adjust R12 for a reading on the UUT DMM of 1.000000 $\pm 3\text{x}10^{-6}$.

d. Set the 5700A to 200 mV dc. (Press 2, 0, 0, m, V, 0, HZ, ENTER.)

e. Set both 792As to the 220 mV range, and do a dc-to-1 kHz transfer at 200 mV as in substeps 1 through 7 of step 6b.

f. Adjust R27 for a reading on the UUT DMM of 1.000000 $\pm 3\text{x}10^{-6}$.

g. Set the 5700A to 20 mV dc. (Press 2, 0, m, V, 0, HZ, ENTER.)

h. Set both 792As to the 22 mV range and do a dc-to-1 kHz transfer at 20 mV as in substeps 1 through 7 of step 6b.

i. Adjust R48 for a reading on the UUT DMM of 1.000000 $\pm 20\text{x}10^{-6}$.

TROUBLESHOOTING 5-18.

WARNING

TO AVOID ELECTRIC SHOCK OR EQUIPMENT DAMAGE, USE EXACT REPLACEMENT PARTS FOR ALL PROTECTION COMPONENTS.

The transfer standard is designed to be easily maintained and repaired. The instrument's circuits allow troubleshooting and repair with basic electronic equipment such as a multimeter and oscilloscope. Table 5-6 lists equipment required to troubleshoot the power pack and sensor unit.

Table 5-6. Equipment Required for Troubleshooting

EQUIPMENT	MANUFACTURER AND MODEL
5½-digit DMM	Fluke 8840A or better
Oscilloscope	Philips PM 3050
Multifunction Calibrator	Fluke 5700A
or AC and DC Calibrators	–

Troubleshooting the Power Pack 5-19.

Proceed as follows to troubleshoot the power pack:

1. If the power pack does not turn on, check that the battery voltages are present at J303 (POWER SUPPLY OUTPUT). You should measure about 12V at pin 1 with respect to pin 2 and about 12V at pin 3 with respect to pin 4 (see Figure 2a).

2. Make sure that fuses F301 and F302 are intact by checking that the voltage across each is 0.

3. Measure the supply voltage of U307 at pin 14 with respect to pin 7. It should also be about 12V.

4. If the OPERATE indicator goes on momentarily and then goes out, the most likely cause is that a short circuit on one of the supply outputs (perhaps in the cable or the sensor unit) is activating the overcurrent shut-off circuit. Use a DMM to check for short circuits between any of the following: TP302 (+11V), TP304 (-11V), and TP305 (VCOM). Automatic shutdown is also activated by a low battery condition, so check the raw battery levels at J303.

CAUTION

You can disable automatic shutdown during troubleshooting by disconnecting one end of CR310, but be careful not to let Q301 and Q302 become hot enough to burn up.

5. If the battery charger circuit is malfunctioning, check the rear panel fuse and line voltage setting.

6. Use an oscilloscope to measure the raw charge voltages at pin 2 of U301 and pin 3 of U302 with respect to TP308 (CHCOM). You should see half-sine waves with an amplitude of approximately 24V pk.

7. Check the charge logic supply with a DMM. You should read 22V dc between the cathode of CR309 and TP308.

Troubleshooting the Sensor Unit 5-20.

Proceed as follows to troubleshoot the sensor unit:

1. Connect the power pack to the sensor unit and press OPERATE.

2. Set the range switch to 2.2V, and check the ±11V supplies with a DMM at the test points shown in Figure 5-7.

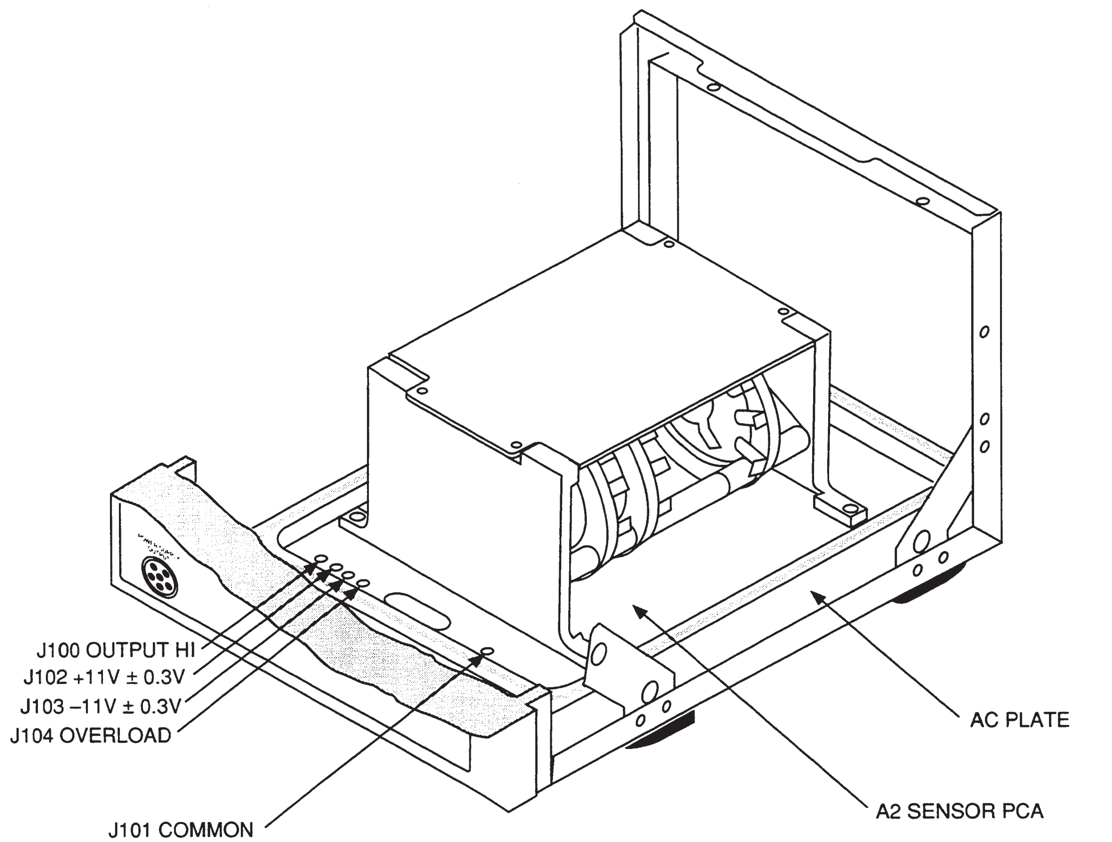

Figure 5-7. AC Plate Voltage Test Points

3. Use an oscilloscope to check for oscillations on the supplies. Set the range switch for 22 mV, and check the supplies again.

4. If you suspect that a severe INPUT overload has caused damage, check the continuity of diodes CR111, CR112, VR110, and VR111 by applying ±10V dc from the calibrator to the INPUT on the 2.2V range. The calibrator should trip into current limit in both polarities.

5. Measure the sensor input resistor (pins 6 and 7 of U111). If it is no longer between 368 and 432Ω, U111 must be replaced.

NOTE

A failed Fluke RMS Sensor (U111) may indicate a failure of one or more sections of the protection system.

6. The passive range resistors can be overstressed by a severe overload. Verify their integrity by measuring each one with an ohmmeter. They should meet the tolerances in Table 5-7.

Table 5-7. Passive Range Resistor Tolerances

RANGE RESISTOR	TOLERANCE
2.2V	20Ω ±1%
7V	800Ω ±1%
22V	3.6 kΩ ±1%
70V	11.6 kΩ ±1%
220V	39.6 kΩ ±1%

7. Check the active ranges for overload damage by testing the continuity of diodes CR1 through CR5, by applying ±3V dc from the calibrator to the INPUT on the 200 mV and 600 mV ranges. The calibrator should trip into current limit in both polarities.

8. Measure R2 and R17 and make sure that both are between 46 and 56Ω. Damage to any of CR1 through CR5 or R2 and R17 indicates that a severe overload has been applied to an active range, and that U1 through U4 and the passive components associated with them may be damaged.

PROTECTION CIRCUIT 5-21.

Test the operation of the protection circuit as follows:

1. Turn the unit on.

2. Verify the rms limit by applying +3.5V dc to INPUT on the 2.2V range. Use an oscilloscope to check the output of pin 1 of U112A with respect to the ac plate. The waveform should look like that in Figure 5-8.

3. Test the level detectors by applying ±5V dc to the 2.2V range. The output of pin 1 of U112A with respect to the ac plate should look like the waveform in Figure 5-9 for both positive and negative voltages at the INPUT.

OUTPUT CIRCUIT 5-22.

Test the output circuit as follows:

1. Apply +2V dc to the 2.2V range.

2. Connect the DMM across the DC OUTPUT binding posts, and set it for the dc current function. The current limit should be 25 mA ±20%.

3. To test the voltage limit function, connect the dc calibrator LO lead to the ac plate; connect the HI lead to pin 2 of Z100, and set the calibrator for +4V dc. The output at the DC OUTPUT binding posts should be 2.7V ±20%.

4. Verify the performance of the output filter section as follows:

   a. Connect the ac calibrator between the ac plate and pin 2 of Z100, and apply 2V, 10 Hz.

   b. With an the oscilloscope grounded to the ac plate, check pin 3 of U105 for a 20-Hz signal with an amplitude of 10 mV p-p.

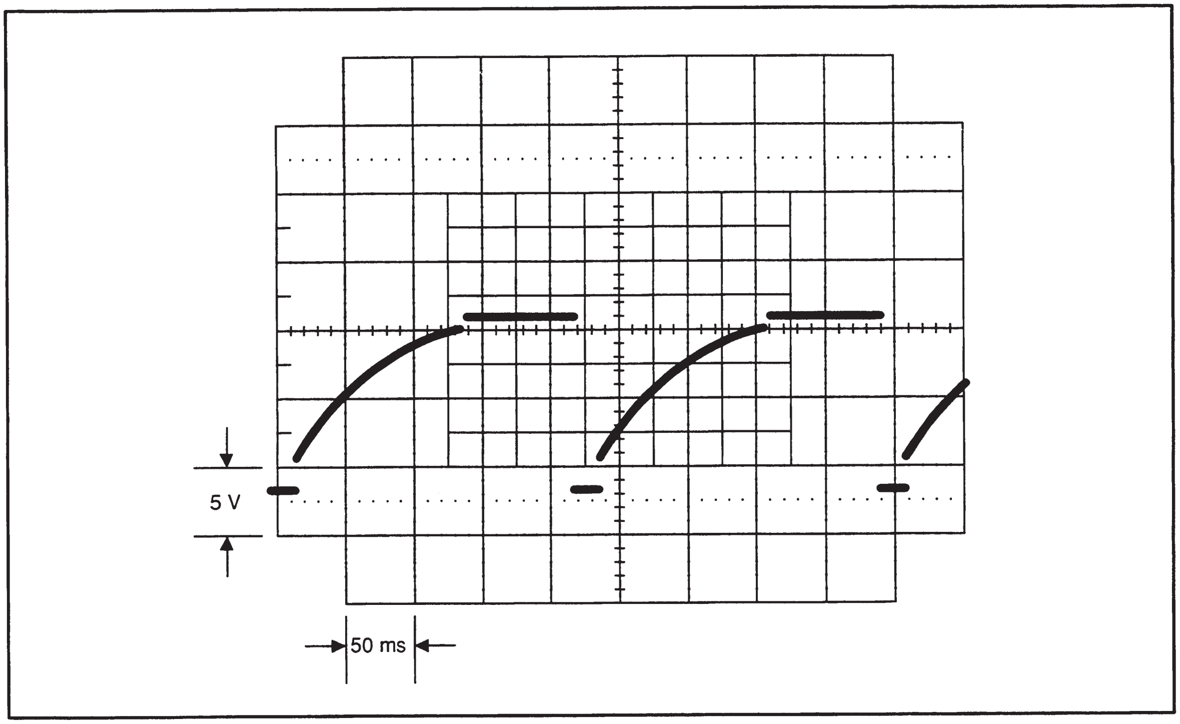

Figure 5-8. Waveform at U112, Pin 1, 3.5V DC Input

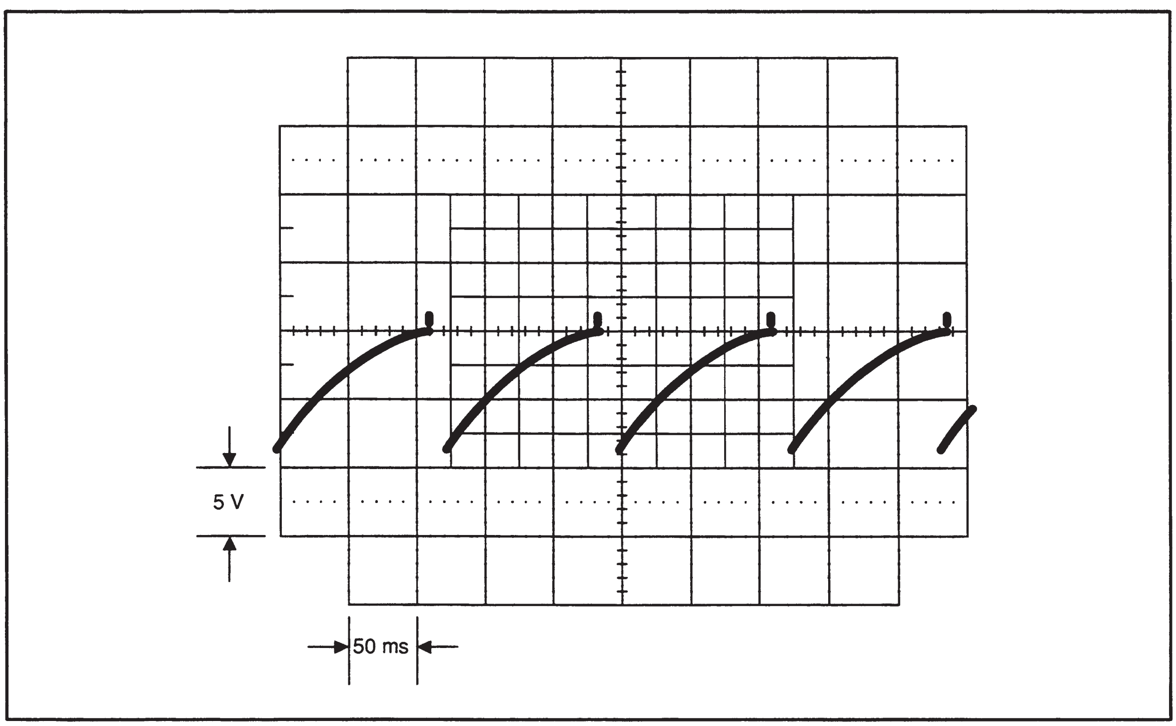

Figure 5-9. Waveform at U112, Pin 1, 5V DC Input

CLEANING PCA'S 5-23.

Printed circuit assemblies need cleaning only after repair work. After soldering on a PCA, remove flux residue using isopropyl alcohol and a cotton swab.

LUBRICATING THE TRANSFER SWITCH 5-24.

Lubricate the transfer switch contacts and detent every 10,000 actuations or every two years, which ever comes first. Use a high-quality contact grease such as Rykon 0EP*. The following procedure involving thinning the grease with tolulene (for the metal surfaces only) is recommended. Figure 5-10 shows the lubrication points.

NOTE

You can obtain a ¾-oz. container of Rykon 0EP (or equivalent) from Fluke by ordering Fluke PN 344572. You can obtain tolulene in pint or larger sizes from scientific supply dealers in most major cities.

CAUTION

Tolulene can dissolve plastic. Keep the tolulene-lubricant solution away from the star-shaped switch detent and any other plastic part.

1. Remove the four screws that fasten the bottom cover of the switch.
2. Lubricate the plastic switch detent with grease only.
3. Mix a small amount of grease with a small amount of tolulene.
4. Use a small artist's brush the apply the grease solution to both sides of the rotor, and each stator pair. Do not let any of the grease solution touch a plastic part.
5. Rotate the switch through all positions to evenly distribute the lubricant. The tolulene evaporates, leaving a very thin, even, almost invisible coating on the switch contacts.

*Rykon is a trademark of the American Oil Co.

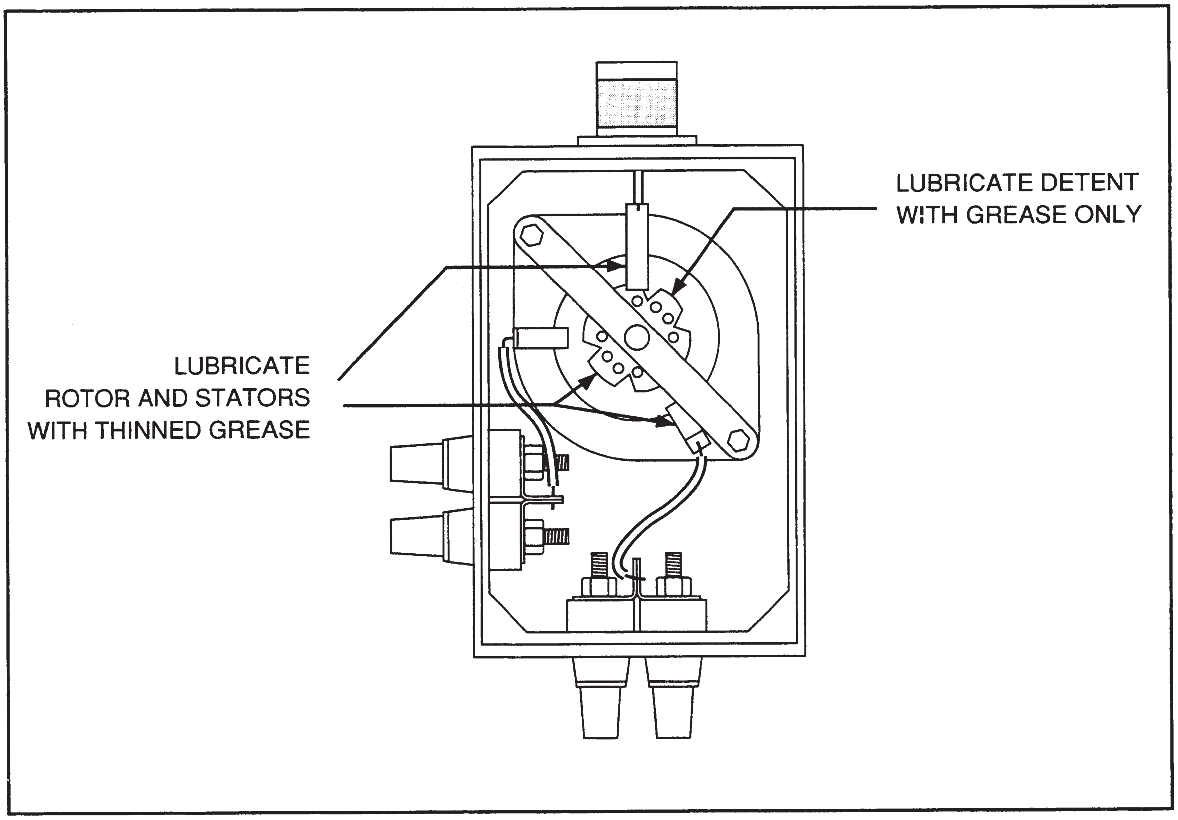

Figure 5-10. Transfer Switch Lubrication Points

Section 6
List of Replaceable Parts

CONTENTS

Manual Status Information

REF OR OPTION NO.	ASSEMBLY NAME	FLUKE PART NO.	X = The PCA revision levels documented in this manual.																		
			–	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P		
A1	Front Panel/Filter PCA	871673				X															
A2	Sensor PCA	871678					X														
A3	Power Pack PCA	871681		X																	

INTRODUCTION 6-1.

This section contains an illustrated list of replaceable parts for the 792A AC/DC Transfer Standard. 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
- Manufacturer's supply code
- Manufacturer's part number or generic type
- Total quantity
- Any special notes (i.e., factory-selected part)

CAUTION

Parts with an asterisk * in the "S" column are subject to damage by static discharge.

HOW TO OBTAIN PARTS 6-2.

Electrical components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. and its authorized representatives by using the part number under the heading FLUKE STOCK NO. A list of federal supply codes is provided at the end of this section.

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)
- Reference designator
- Quantity
- Part number and revision level of the pca containing the part.

Parts price information is available from the John Fluke Mfg. Co., Inc. or its representatives.

MANUAL STATUS INFORMATION 6-3.

A table preceding the parts lists defines the printed circuit assembly revision levels that are documented in this manual. Revision levels are printed on the component side of each pca.

Table 6-1. Sensor Unit Final Assembly
(See Figure 6-1.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	--------------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE -E-
A 1	*	FRONT PANEL/FILTER PCA	871673	89536	871673	1	
A 2	*	SENSOR PCA	871678	89536	871673	1	
C 401-405		CAP,VAR,1-20PF,250V,AIR,HARDWARE	876482	91293	5501-110	5	
C 406		CAP,CER,47PF,+-2%,100V,COG	512368	04222	SR201A476GATR	1	
E 401-405		SURGE PROTECTOR,90V,+40 -0	198507	25088	B1-F90	5	
E 407		SURGE PROTECTOR,145V,+-20%	442731	25088	B1-C145	1	
E 408		SURGE PROTECTOR,450V,+-10%	442723	25088	B2-B470-Y23	1	
FL 401-405		FILTER,RF,BOLT TYPE,3000PF	721456	00779	859617-1	5	
H 1		CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	06383	SST-1M	2	
H 2		SCREW,MACH,PH,P,STL,6-32X0.312	152157		COMMERCIAL	40	
H 3		NUT, BINDING POST	882985	20584	882985	3	
H 4		SCREW,MACH,PH,P,STL,6-32,.500	152173		COMMERCIAL	6	
H 5		WASHER,LOCK,INTRNL,STEEL,0.512 ID	641381		COMMERCIAL	1	
H 6		WASHER,FLAT,BRASS,#8,0.032 THK	631606		COMMERCIAL	3	
H 7		WASHER,SHLDR,NYL,.141,.375,.112	867395		COMMERCIAL	20	
H 8		WASHER,FLAT,STL,.149,.375,.031	110270		COMMERCIAL	14	
H 9		SCREW,SET,SCKT,STL,8-32,.187	114991		COMMERCIAL	3	
H 10		SCREW,MACH,PH,P,STL,6-32X0.375	152165		COMMERCIAL	8	
H 11		SCREW,CAP,SCKT,SHLDR,STL,10-24,.625	876045		COMMERCIAL	1	
H 12		SPRING,COIL,COMP,M WIRE,.500,.300	876057	84830	LC-026-D-2	1	
H 13		WASHER,FLAT,BLK,SS,.195,.469,.010	867705		COMMERCIAL	8	
H 14		WASHER,CRESCENT,STL,.190,.370,.063	867569		COMMERCIAL	4	
H 15		SCREW,MACH,PH,P,STL,6-32X0.625	152181		COMMERCIAL	6	
H 16		SCREW,MACH,PH,P,STL,10-32X0.625	114066		COMMERCIAL	10	
H 17		SCREW,MACH,PH,P,STL,6-32X0.187	381087		COMMERCIAL	16	
H 18		SCREW,SET,SCKT,STL,6-32X3/16	146282		COMMERCIAL	2	
H 19		NUT,SPEED,U TYPE,STL,6-32	101113		COMMERCIAL	8	
H 20		TERM,RING #6,3/32 - 2 PLACES,SOLDR	132399	71002	2104-06-00	5	
H 21		SCREW,MACH,FHU,P,SS,LOCKIN,6-32,.250	769893	73734	6-32X1/4FHUCPS2A	16	
H 22		SCREW,CAP,SCKT,SS,8-32,.375	295105	74594	295105	4	
H 23		SCREW,MACH,FHU,P,SS,6-32,.312	867234		COMMERCIAL	10	
H 24		WASHER,SHLDR,NYL,.194,.500,.050	295048		COMMERCIAL	6	
H 25		WASHER,FLAT,STL,.203,.434,.031	110262	86928	5702-16-31	6	
H 26		SCREW,MACH,PH,P,STL,6-32X0.250	152140		COMMERCIAL	20	
H 27		SCREW SET,SCKT,STL,8-32,.500	876599	6W060	28704-98C-8	2	
J 107		CONN,COAX,N(F),BULKHEAD MT,SOLDER CUP	875427	21845	SF5090-6003	1	
J 401		SOCKET,SINGLE,FOR .058 PIN,24-20 AWG	312439	00779	61119-1	1	
J 402		SWITCH JUMPER SET	860465	89536	860465	1	
L 101		CORE,BEAD,FERRITE,.250X.560X.1.125	714055	18565	83-10-A636-1000	1	
MP 101		FRONT GUARD, SENSOR	860317	89536	860317	1	
MP 102		SENSOR, FRONT PLATE, BEARING ASSEMBLY	871780	89536	871780	1	
MP 103		SHAFT, KNOB	871967	89536	871967	1	
MP 104		COUPLING,SHAFT,SPLIT HUB,.250 BORE	875935	59076	5Z15-332508	1	
MP 105		INSULATOR,REAR,BINDING POST,BLACK	860361	89536	860361	3	
MP 108		INSULATOR,BINDING POST,FRONT,BLACK	860411	89536	860411	4	
MP 112		BINDING POST-RED	860452	89536	860452	1	
MP 113		BINDING POST, BLACK	860457	89536	860457	1	
MP 114		BINDING POST, GREEN	871616	89536	871616	1	
MP 115		BINDING POST, BLUE	871637	89536	871637	1	
MP 116		KNOB, PAINTED	879705	89536	879705	1	
MP 117		FLUKE NAMEPLATE	879770	89536	879770	1	
MP 118		DECAL,RANGE	871905	89536	871905	1	
MP 119		DECAL,BRUSHED ALUM,SENSOR	871889	89536	871889	1	
MP 120		ADAPTER, BINDING POST	882993	89536	882993	3	
MP 123		GROUND ADAPTER, BINDING POST	882998	89536	882998	1	
MP 124		AC CAN, PLATED	883004	89536	883004	1	
MP 125		BEARING,CYL,PLAIN,BRONZE,.251 ID	875997	59076	7B4-P013	2	
MP 127		CONN PART,CIRC,PANEL,REC HOUSING,6POS	867387	2P953	EGG2B306CLMYZ	1	
MP 128		ADHESIVE SHEET	860267	89536	860267	1	
MP 201		CHASSIS, SENSOR	860333	89536	860333	1	
MP 204		INSULATOR, SPACER	860374	89536	860374	2	
MP 206		BOTTOM FOOT, MOLDED	860390	89536	860390	4	
MP 210		GUARD CHASSIS, RIVETED, SENSOR	871595	89536	871595	1	
MP 211		DECAL,REAR SENSOR	871900	89536	871900	1	
MP 401		GASK,RFI,WIRE MESH,STEEL,CIRCULAR	714436	12881	01-0104-0006	1	
MP 402		SHIELD, SENSOR	860338	89536	860338	1	
MP 403		AC PLATE, PLATED	871918	89536	871918	1	
MP 406		SWITCH MOUNTING PLATE,REAR, PLATED	871921	89536	871921	1	
MP 407		RETAINER, THERMAL, SENSOR	860275	89536	860275	1	

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

Table 6-1. Sensor Unit Final Assembly (cont)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	---DESCRIPTION---	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE -E-
MP 408		GROUND STRIP,BECU,SPRING,1.090	875740	34641	97-438-17	1	
MP 409		SWITCH MOUNTING PLATE,FRONT, PLATED	871926	89536	871926	1	
MP 411		SUPPORT, CAPACITOR, PLATED	871934	89536	871934	1	
MP 412		DISK ASSEMBLY	860304	89536	860304	1	
MP 413		SPACER,RND,NYL,.192,.250	867390	55566	121710N0	6	
MP 601		HANDLE RETAINER, PAINTED	879713	89536	879713	1	
MP 602		COVER, TOP, PAINTED	879718	89536	879718	1	
MP 603		CARRYING HANDLE, PAINTED	879721	89536	879721	1	
MP 604		DECAL, FLUKE-PHILIPS	883033	89536	883033	1	
MP 605		PIN,DOWEL,SS,.1875,.625	867411	59076	9X31-0620	4	
MP 609		BEARING,CYL,PLASTIC,.187 ID	867630	14108	C1022101	4	
MP 613		FOOT,NON-SKID	640565	2K262	640565	4	
MP 701		GUARD COVER, SENSOR	860312	89536	860312	1	
MP 702		SUPPORT,BRACKET	860341	89536	860341	4	
MP 704		SWITCH CAN, PLATED	871897	89536	871897	1	
MP 705		ADAPTER,COAX,N(F),N(M)	875443	21845	SF5097-6004	1	
MP 709		LABEL,VINYL,.3,1.5,BAR CODE	844712	89536	844712	1	
R 401		RESISTOR ASSY. 6V RANGE	879684	89536	879684	1	
R 402		RESISTOR ASSY. 20V RANGE	879697	89536	879697	1	
R 403		RESISTOR ASSY. 60V RANGE	879689	89536	879689	1	
R 404		RESISTOR ASSY. 200V RANGE	879692	89536	879692	1	
R 405,406		RES,MF,40.2,+-1%,1W,25PPM	810960	64537	PME7540R2F T-9	2	
SW 401		SWITCH,RANGE SELECTION	871772	89536	871772	1	
TM 1		792A AC/DC TRANSFER STANDARD MANUAL	871723	89536	871723	1	
U 111		RMS SENSOR 400 OHM BERYLLIUM OX	842604	89536	842604	1	
U 401-403	*	IC,OP AMP,WIDEBAND,FAST-SETTLING	810945	13919	3554BM	3	
W 101		CABLE ASSY,LEMO CONN.	871764	89536	871764	1	
W 401		CABLE ASSY, AC FILTER	871640	89536	871640	1	
W 701		CABLE ASSY,6 COND,6P CIRC,6P CIRC,3FT	867254	89536	867254	1	

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

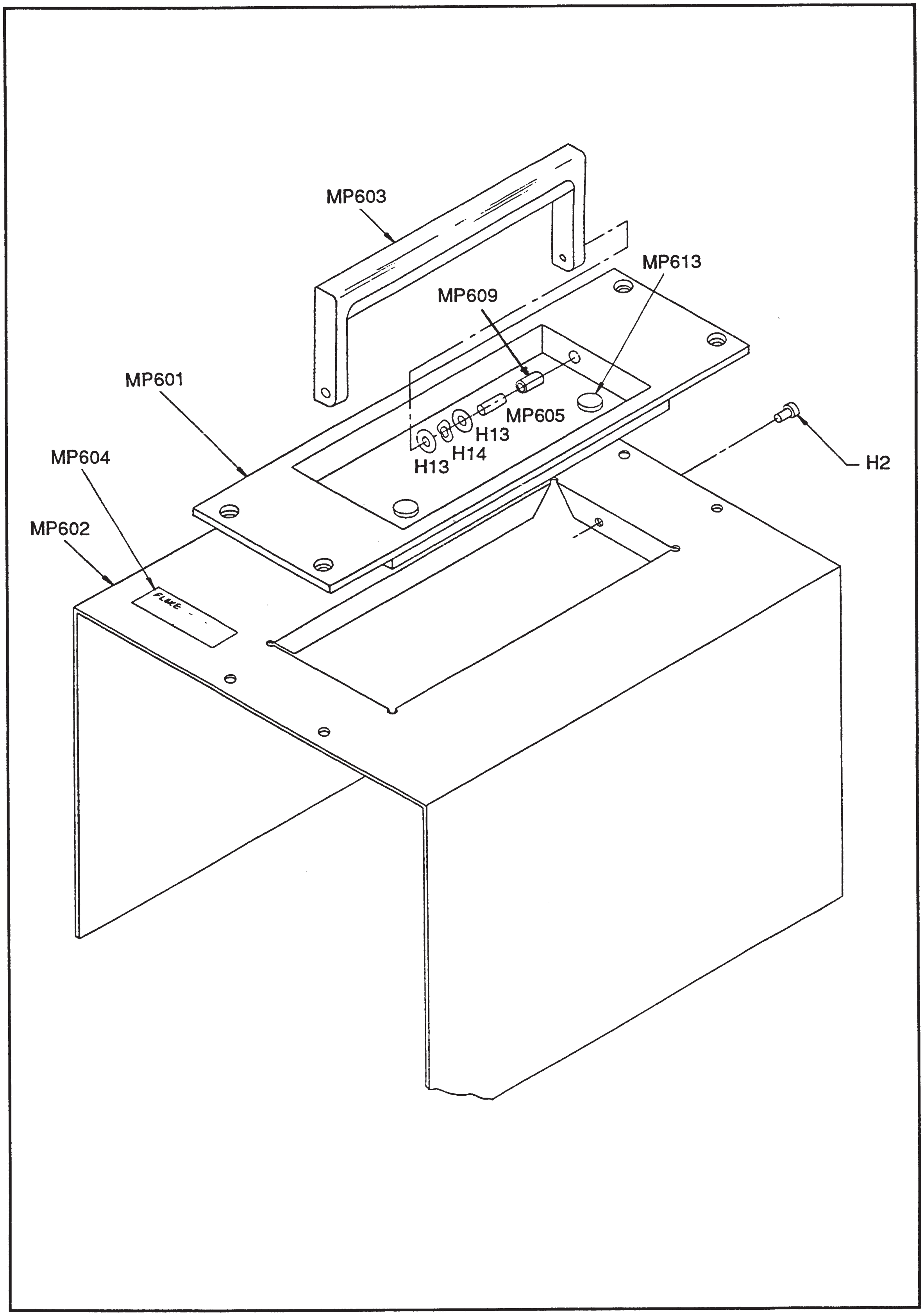

Figure 6-1. Sensor Unit Final Assembly

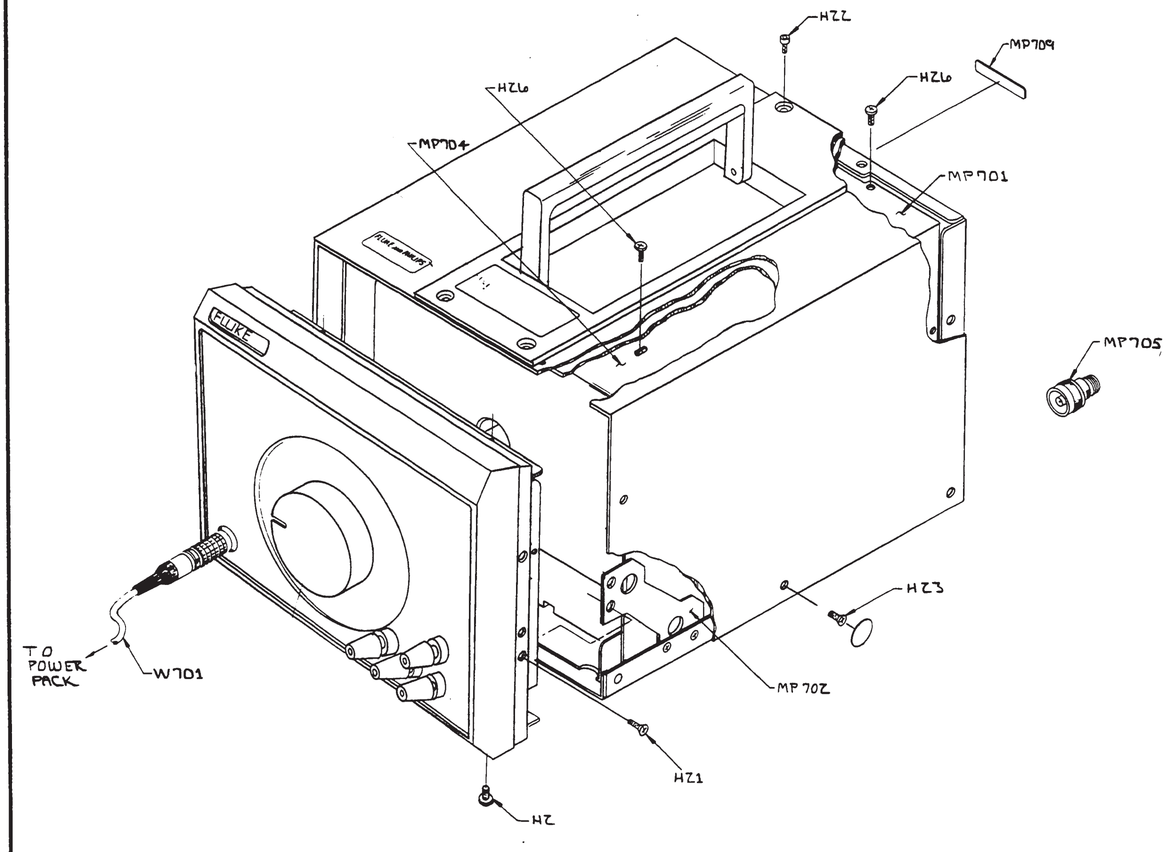

Figure 6-1. Sensor Unit Final Assembly (cont)

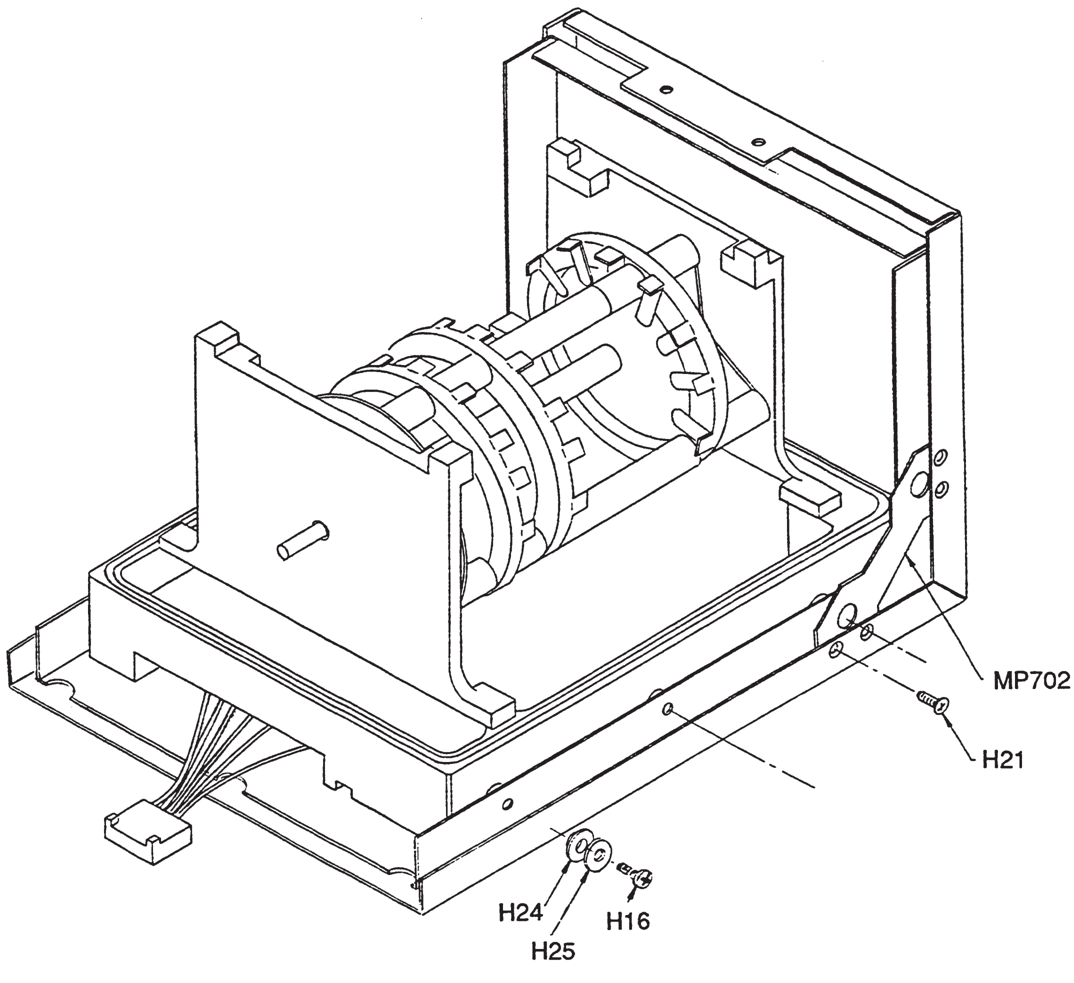

Figure 6-1. Sensor Unit Final Assembly (cont)

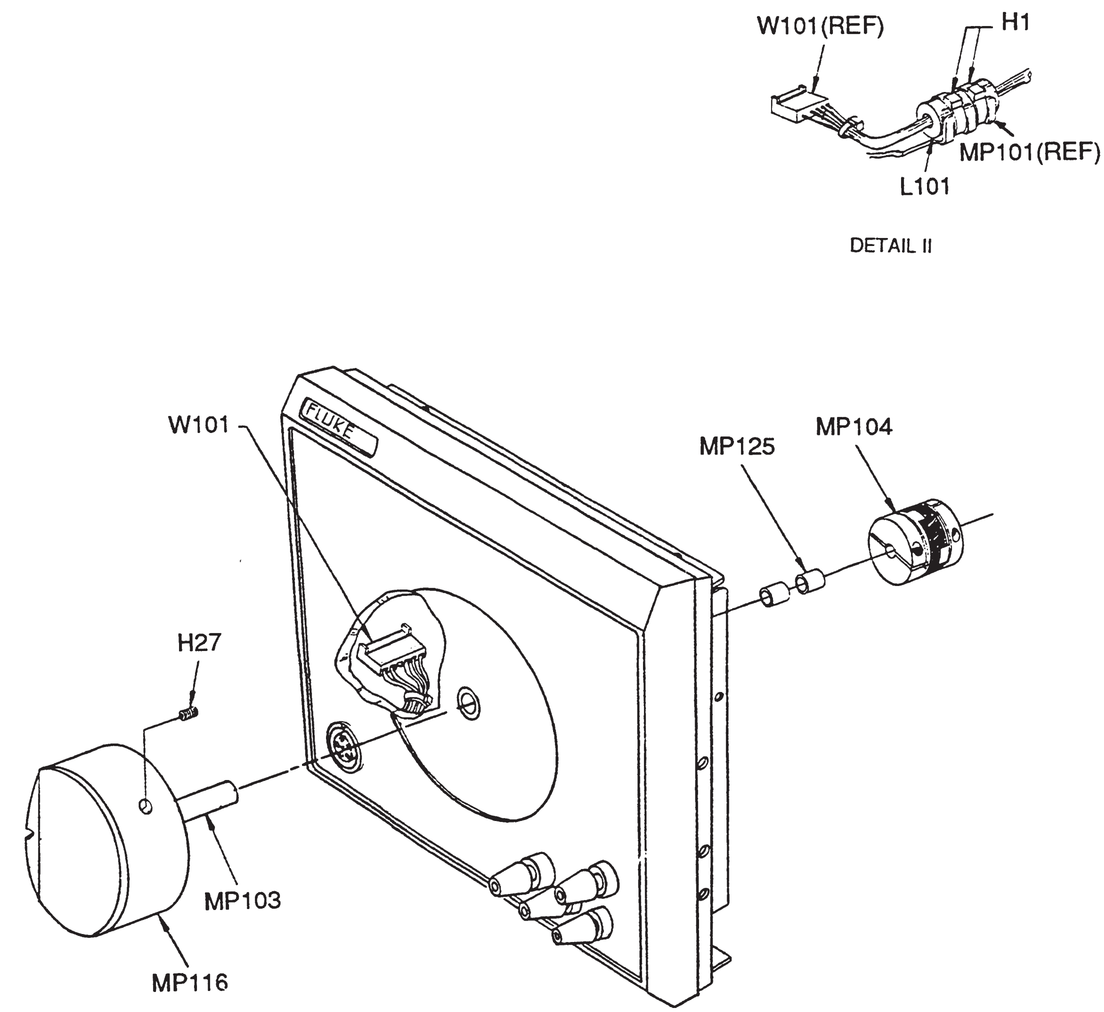

Figure 6-1. Sensor Unit Final Assembly (cont)

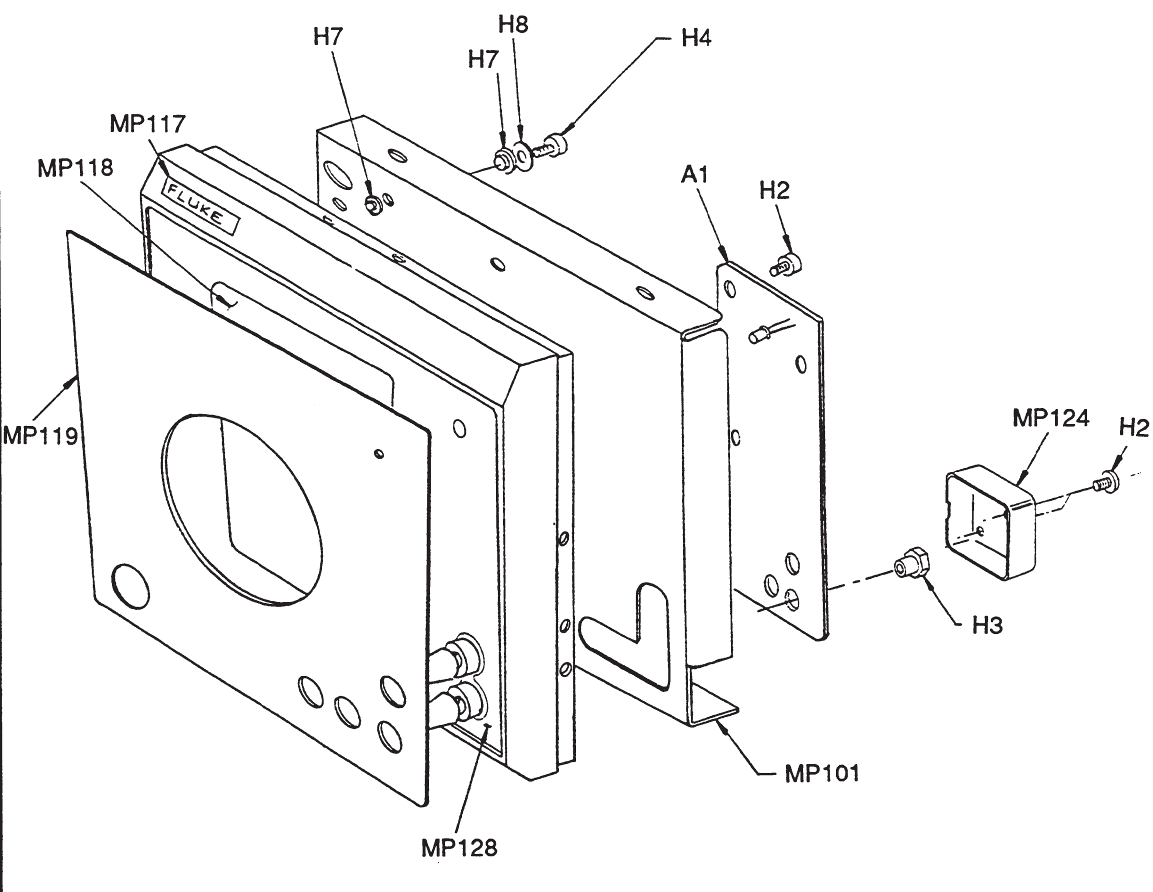

Figure 6-1. Sensor Unit Final Assembly (cont)

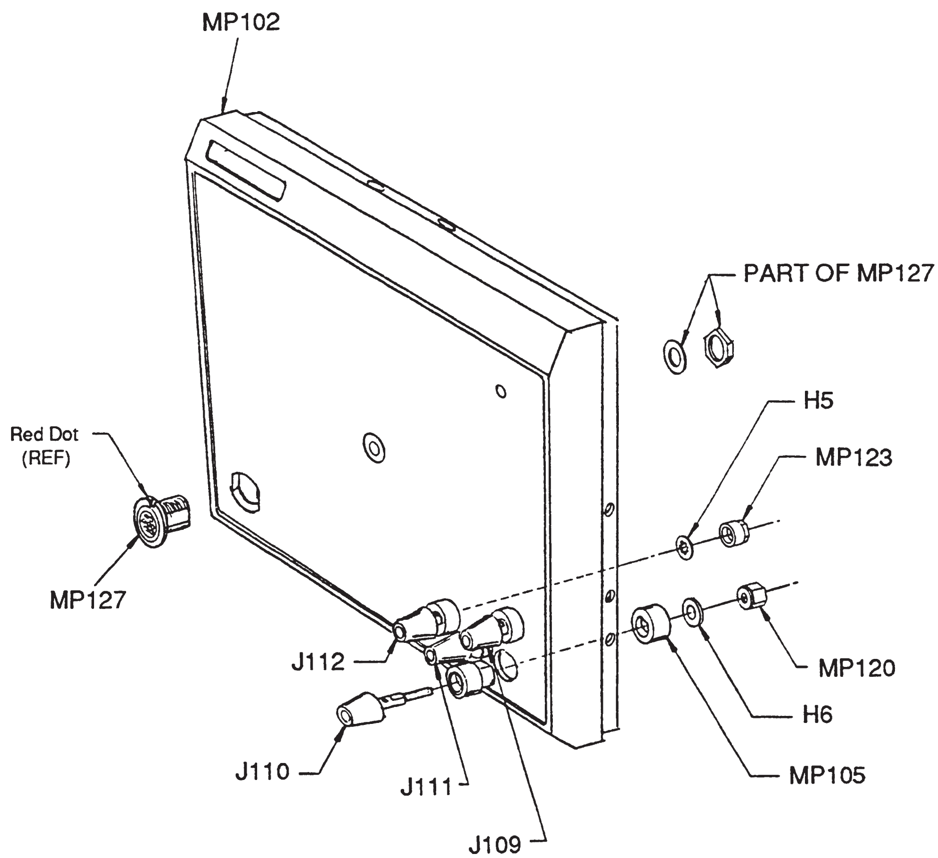

Figure 6-1. Sensor Unit Final Assembly (cont)

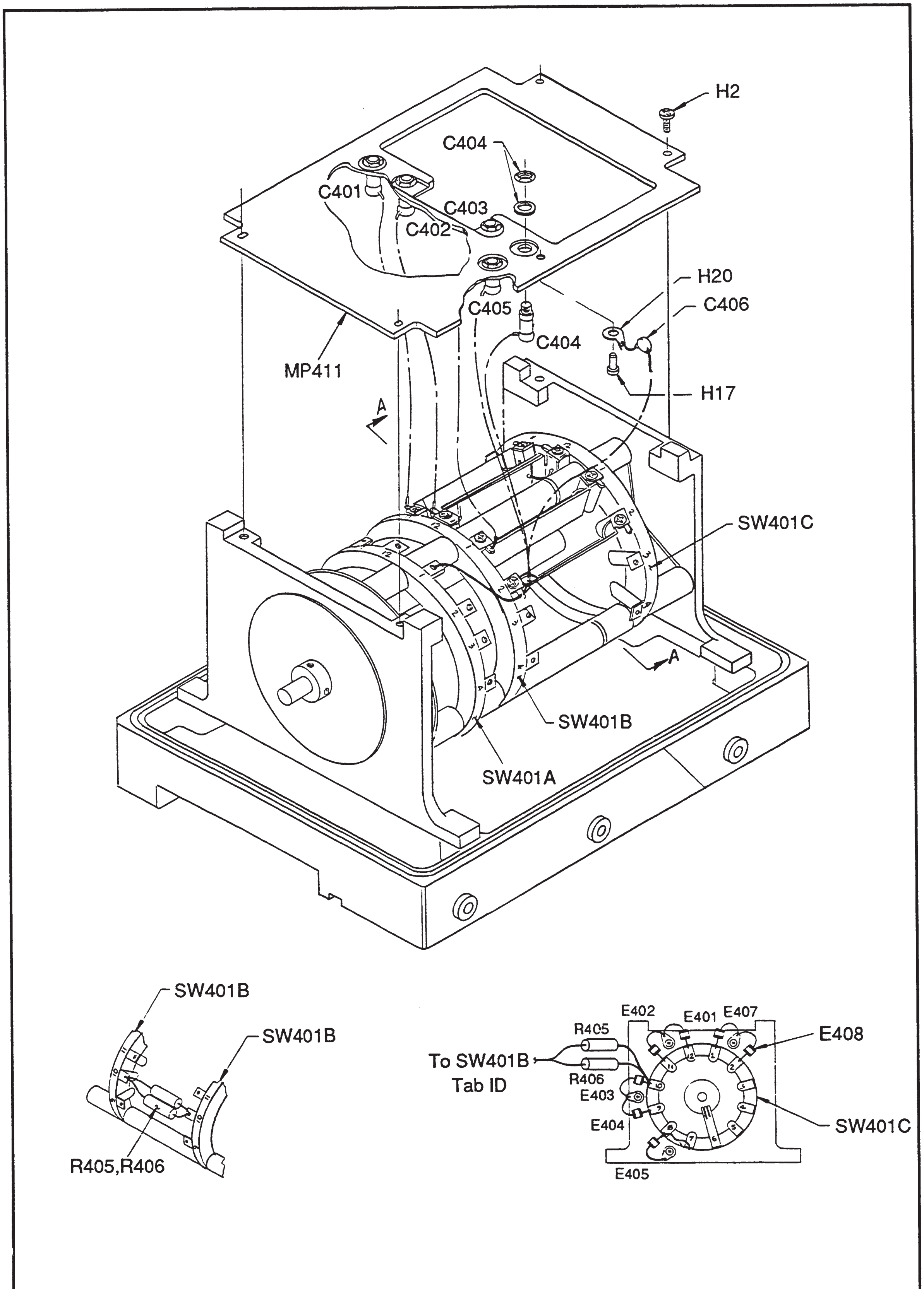

Figure 6-1. Sensor Unit Final Assembly (cont)

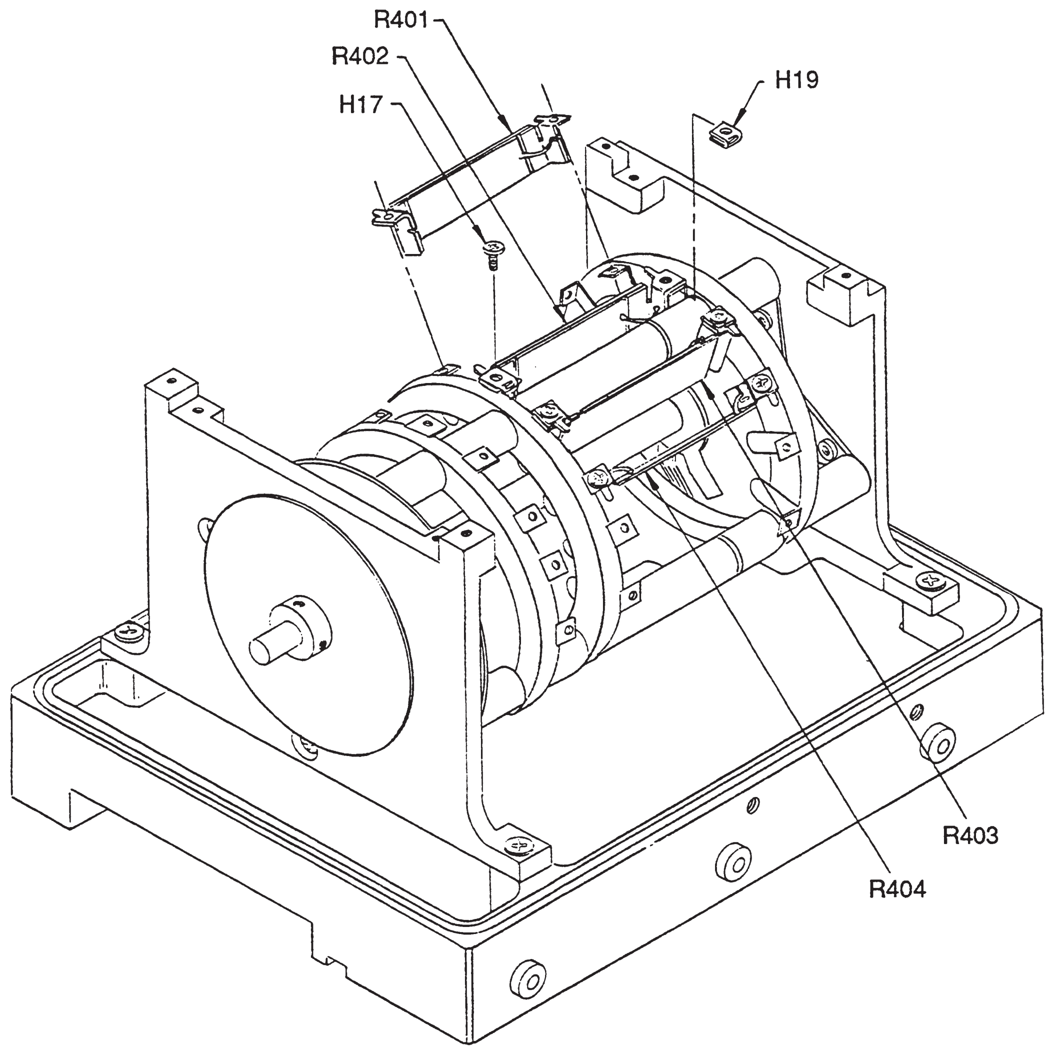

Figure 6-1. Sensor Unit Final Assembly (cont)

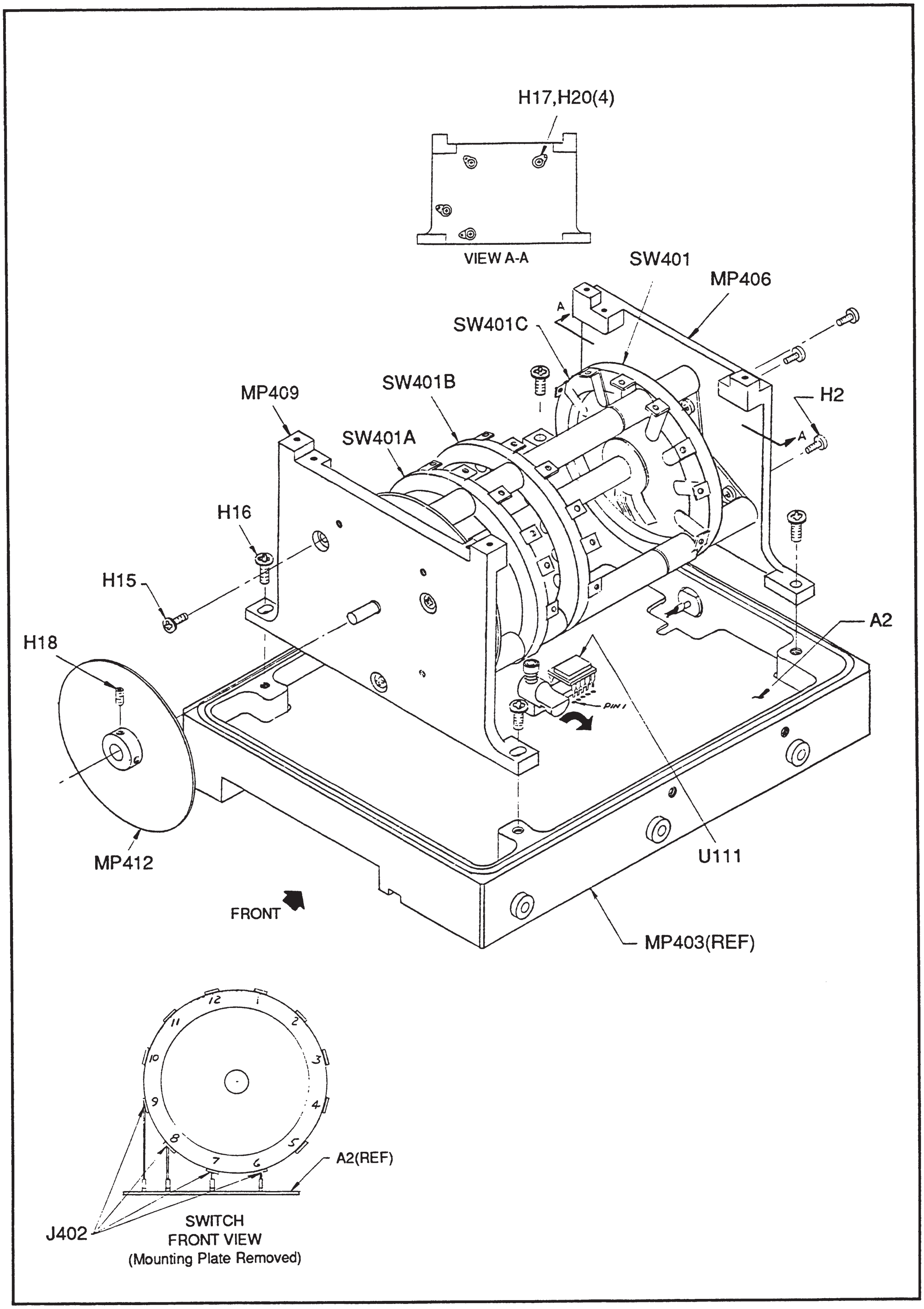

Figure 6-1. Sensor Unit Final Assembly (cont)

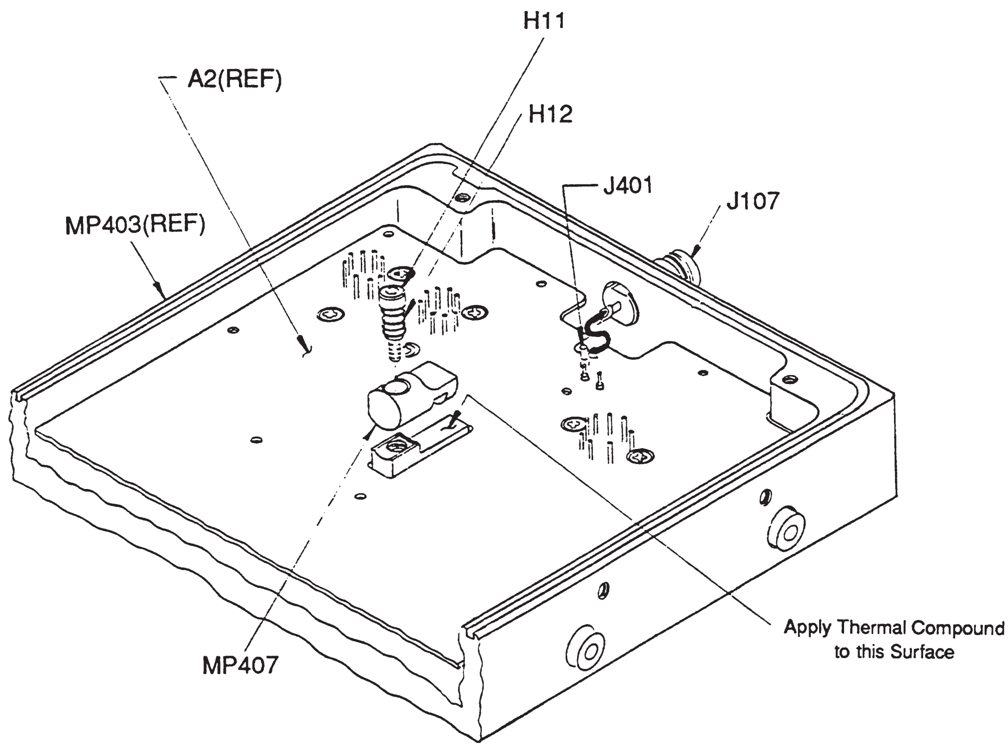

Figure 6-1. Sensor Unit Final Assembly (cont)

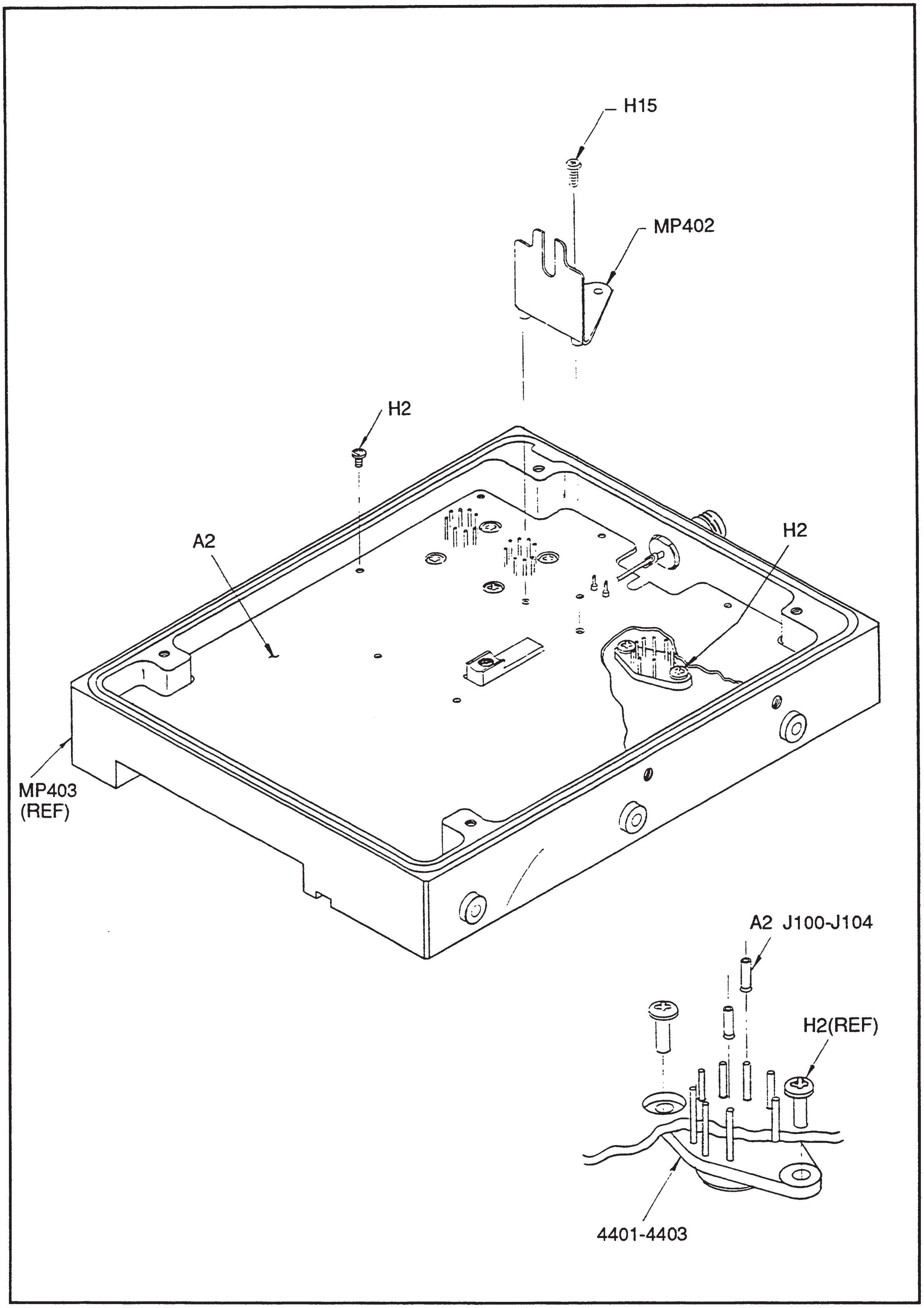

Figure 6-1. Sensor Unit Final Assembly (cont)

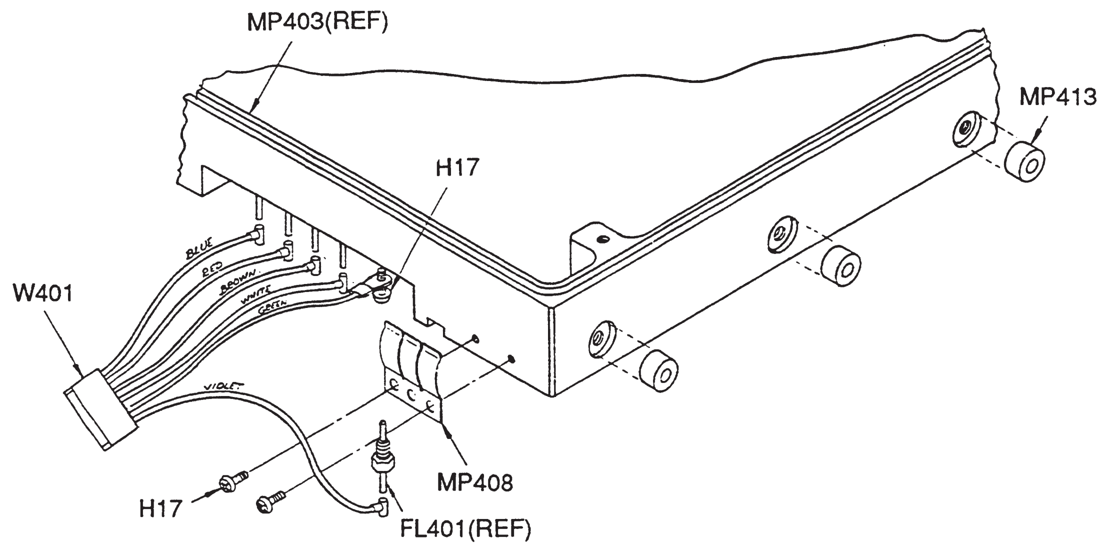

Figure 6-1. Sensor Unit Final Assembly (cont)

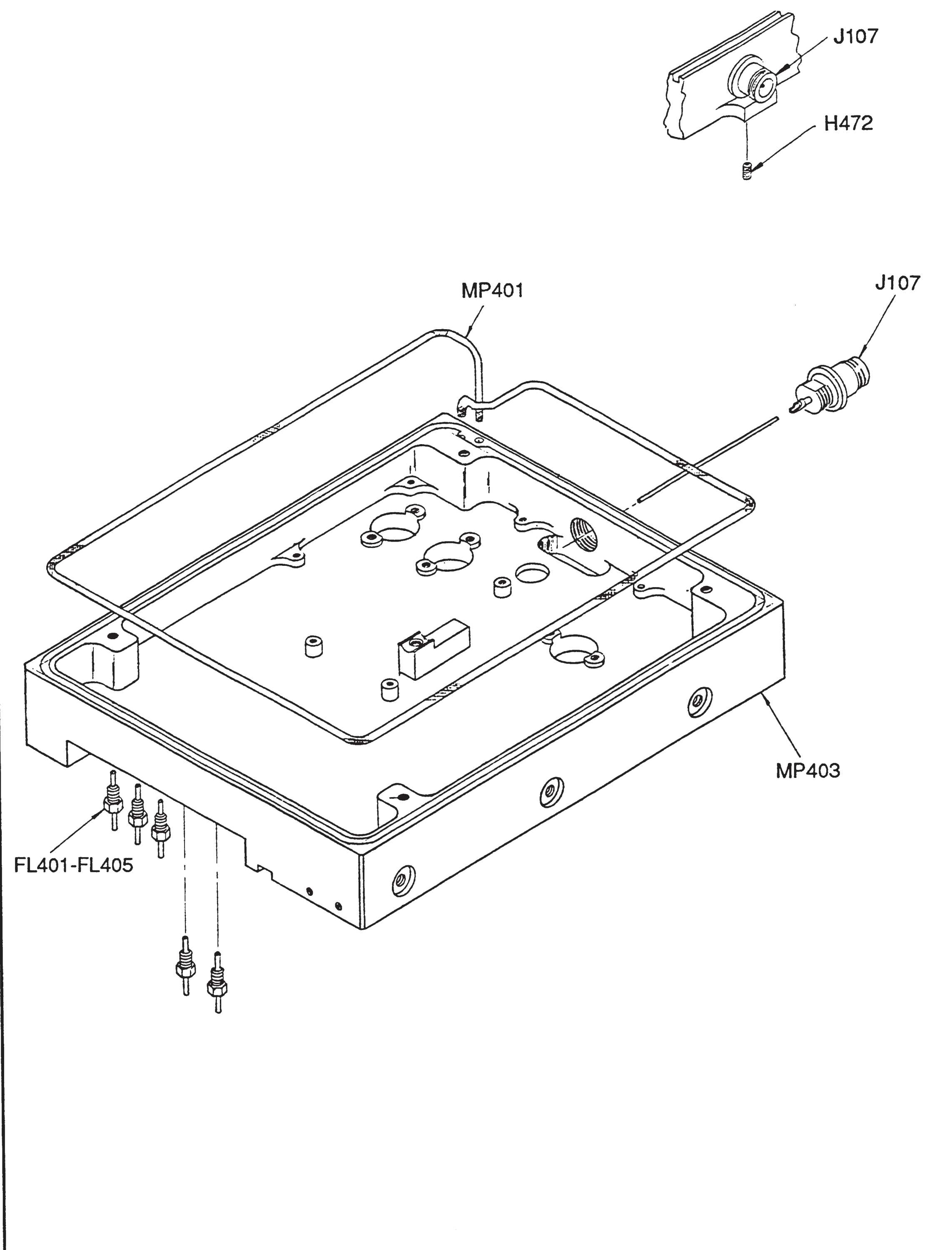

Figure 6-1. Sensor Unit Final Assembly (cont)

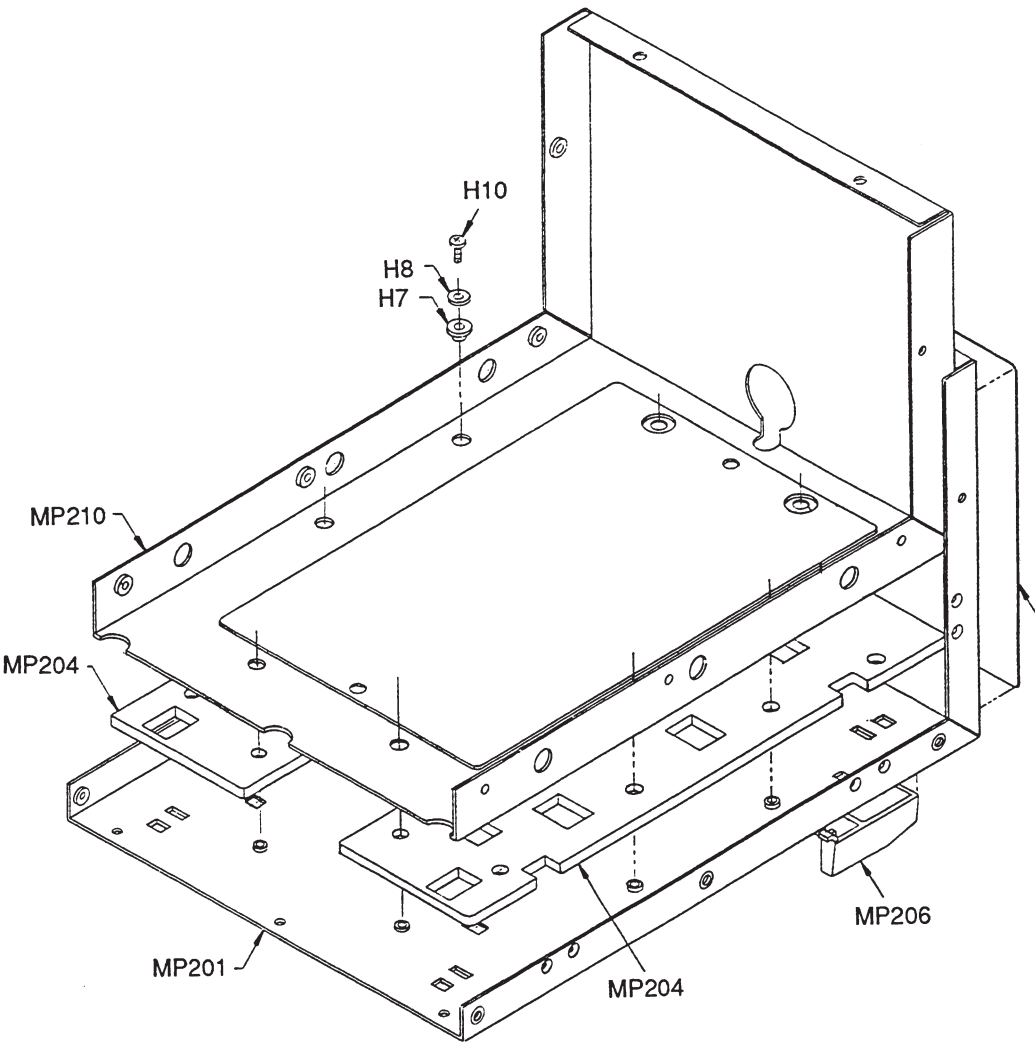

Figure 6-1. Sensor Unit Final Assembly (cont)

Table 6-2. A1 Front Panel/Filter PCA
(See Figure 6-2.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	--------------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE -E-
C 201-204		CAP,CER,0.01UF,+-10%,50V,X7R,1206	747261	04222	12065C103KAT060R	4	
C 205		CAP,CER,620PF,+-5%,50V,C0G	528513	04222	SR215A621JAT	1	
DS 201		LED,RED,4MM FLAT TOP,5.4 MCD	867283	28480	HLMP-M201	1	
FL 201,202		FILTER,RF,PIN-SLEEVE STYLE,2000PF	807271	00779	859612-1	2	
J 106,108		HEADER,1 ROW,.100CTR,6 PIN	758003	00779	641126-6	2	
L 201-210		CHOKE,6TURN	320911	89536	320911	10	
LS 201		AF TRANSD,PIEZO,24 MM	602490	51406	PKM24-4A1	1	
MP 101		SPACER,SWAGED,RND,BR,6-32,.750	334151	9W423	9541B-B-0632	2	
R 201,203,205,	*	RES,CERM,100,+-5%,.125W,200PPM,1206	746297	91637	CRCW1206-1000JB02	5	
R 207,209	*		746297				
R 202,204,206,	*	RES,CERM,51.1,+-1%,.125W,100PPM,1206	806422	91637	CRCW1206-51R1FB02	5	
R 208,213	*		806422				
R 210,211		RES,MF,200K,+-0.1%,0.125W,25PPM	435149	91637	CMF55 2003 B T-9	2	
R 212	*	RES,CERM,560,+-5%,.125W,200PPM,1206	740514	91637	CRCW1206-561JB02	1	
RV 201,202	*	ZENER,TRANS SUPPRESSOR,10V,5%	875757	24444	1.5KE10CA	2	
U 201	*	IC,CMOS,HEX INVERTER	404681	04713	MC14093BCP	1	
VR 201	*	ZENER,UNCOMP,6.8V,5%,37.0MA,1.0W	454595	04713	1N4736ARL	1	

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

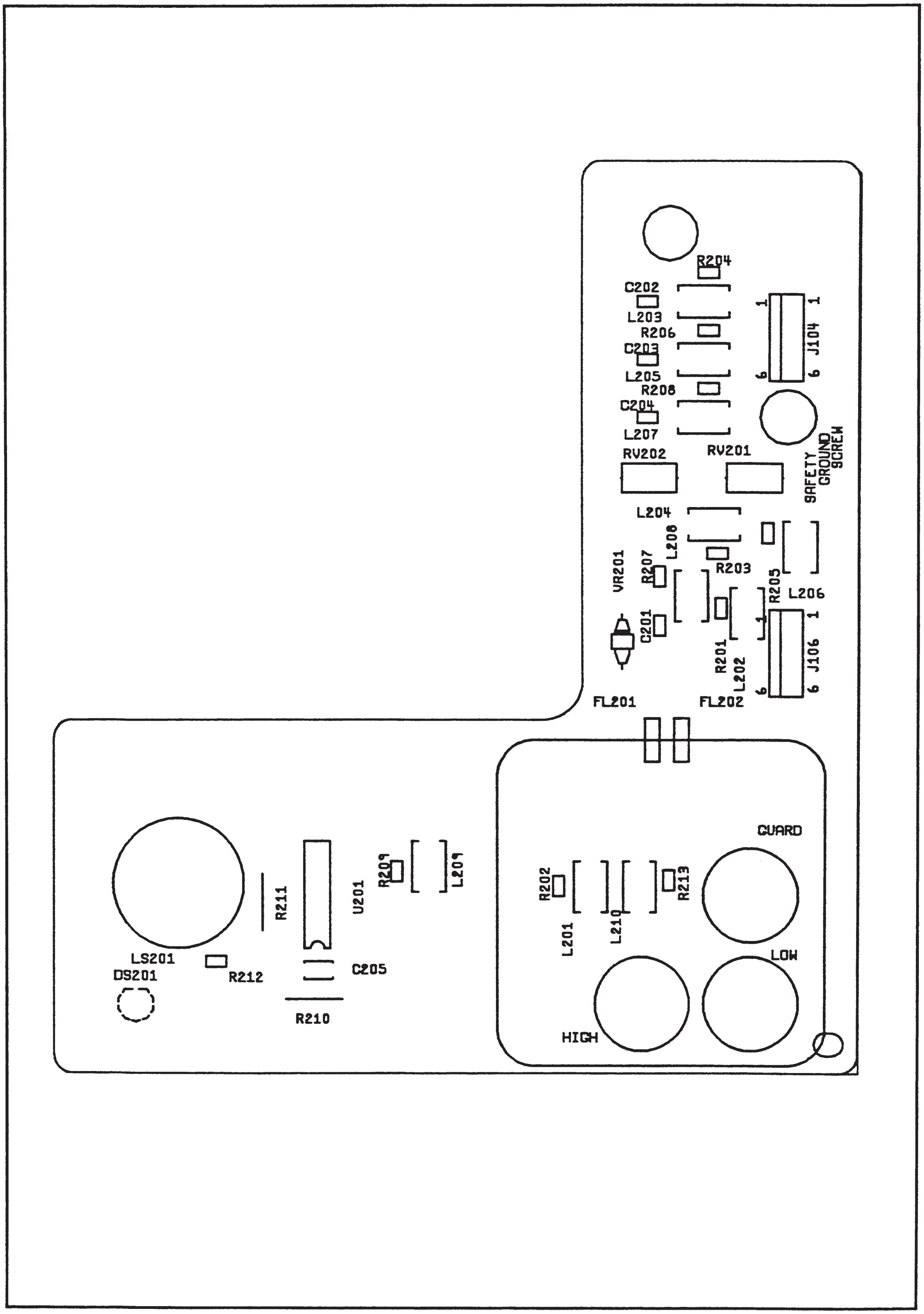

Figure 6-2. A1 Front Panel/Filter PCA

Table 6-3. A2 Sensor PCA
(See Figure 6-3.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	---DESCRIPTION---	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE -E-
C 1, 7, 10,		CAP,CER,0.22UF,+80-20%,50V,Y5V,1206	740597	51406	GRM42-Y5U221Z050PB	26	
C 11, 17, 20,			740597				
C 21, 23, 33,			740597				
C 40- 42,100-			740597				
C 103,106-109,			740597				
C 115-118,131,			740597				
C 132			740597				
C 2, 9, 12,		CAP,TA,22UF,+-20%,15V	746982	56289	195D226X0015G2B	12	
C 19, 22, 24,			746982				
C 122-125,127,			746982				
C 128			746982				
C 3		CAP,VAR,1-20PF,250V,AIR	603449	91293	5201	1	
C 4, 14, 28		CAP,POLYES,0.47UF,+-10%,50V	697409	68919	MKS2-474-K-50V	3	
C 5		CAP,CER,6.8PF,+-10%,50V,C0G,1206	747295	04222	12065A6R8KAT050B	1	
C 8, 18, 35,		CAP,POLYES,0.22UF,+-~~10%~~ 5%,50V 747519	~~706028~~	68919	MKS~~2~~ 2-224-~~K~~ J-50V	7	
C 49- 51,121			~~706028~~				
C 13, 26		CAP,VAR,0.8-10PF,250V,AIR	229930	51406	MVM010W-3	2	
C 16, 27, 29,		CAP,CER,1800PF,+-10%,50V,C0G,1206	769786	04222	12065A182KAT060B	6	
C 30, 32, 34			769786				
C 36		CAP,CER,20PF,+-10%,50V,C0G,1206	747345	04222	12065A200KAT060B	1	
C 37		CAP,CER,8.2PF,+-10%,50V,C0G,1206	747303	04222	12065A8R2KAT050B	1	
C 104,105,111		CAP,POLYPR,1UF,+-10%,160V	501395	68919	MKP10-105-K-160V	3	
C 110		CAP,POLYPR,2.2UF,+-5%,160V	867077	68919	MKP10-225-J-160V	1	
C 112-114		CAP,POLYCA,1UF,+-10%,50V	271619	84411	X463UW105K50	3	
C 119,120,130		CAP,POLYES,0.01UF,+-10%,50V	715037	68919	MKS2 103 K 50V	3	
C 126		CAP,POLYES,1UF,+-10%,50V	733089	68919	MKS2-105-K-50V	1	
C 129		CAP,CER,100PF,+-10%,50V,C0G,1206	740571	04222	12065A101KAT060B	1	
CR 1- 5,100-	*	DIODE,SI,BV=70.0V,IO=50MA,DUAL,SOT23	742320	25403	BAV99	15	
CR 103,105-110	*		742320				
CR 6	*	DIODE,SI,SCHOTTKY,30V,1.1A,SOT89	782573	61752	10JQ030TRRM	1	
CR 104	*	DIODE,SI,BV=125.0V,IO=150MA,500 MW	272252	07263	FDH333	1	
CR 111,112	*	DIODE,SI,PIN,200V,100MA,SELECTED IR	887299	28480	5082-3001	2	
E 1, 3- 13		PIN,SINGLE,PWB,0.058 DIA	233411	00779	60599-3	12	
J 13		SOCKET,SINGLE,FOR .058 PIN,24-20 AWG	312439	00779	61119-1	1	
J 100-104		SOCKET,SINGLE,PWB,FOR .042-.049 PIN	544056	00779	50871-1	5	
L 1- 6		CHOKE,6TURN	320911	89536	320911	6	
MP 111		SOCKET,1 ROW,PWB,.100CTR,SEALED,5 POS	867374	23730	P05-8059-PED	2	
MP 326		AIDE,PCB PULL	541730	89536	541730	2	
Q 1, 5, 9,	*	TRANSISTOR,SI,P-DMOS,100V,3A,DPAK	866905	81483	IRFR9110TR	4	
Q 103	*		866905				
Q 2, 6, 11	*	TRANSISTOR,SI,N-JFET,SOT-23	820860	17856	SSTH17-T1	3	
Q 3, 7, 10,	*	TRANSISTOR,SI,NPN,SMALL SIGNAL,SOT23	742676	04713	MMBT3904T	5	
Q 107,108	*		742676				
Q 4, 8, 12,	*	TRANSISTOR,SI,N-DMOS,100V,4.7A,DPAK	866900	81483	IRFR110	4	
Q 102	*		866900				
Q 101	*	TRANSISTOR,SI,NPN,DUAL,TO-5	640656	27014	LM394CH	1	
Q 104	*	TRANSISTOR,SI,VMOS,PWR,TO-237,VN10KM	640516	17856	V11809	1	
Q 105,106	*	TRANSISTOR,SI,PNP,SMALL SIGNAL,SOT23	742684	04713	MMBT3906T	2	
R 1, 15, 30,	*	RES,CERM,1M,+-5%,.125W,200PPM,1206	746826	91637	CRCW1206-1004JB02	11	
R 31, 39, 52,	*		746826				
R 54- 56, 58,	*		746826				
R 111	*		746826				
R 2, 17	*	RES,CERM,51.1,+-1%,.125W,100PPM,1206	806422	91637	CRCW1206-51R1FB02	2	
R 3, 18, 34	*	RES,CERM,22,+-5%,.125W,200PPM,1206	746230	91637	CRCW1206-22R0JB02	3	
R 4, 7, 13,	*	RES,CERM,100K,+-1%,.125W,100PPM,1206	769802	91637	CRCW1206-104FB02	13	
R 19, 28, 44,	*		769802				
R 53,124,126,	*		769802				
R 128,131,132,	*		769802				
R 139	*		769802				
R 5, 20, 37,		RES,MF,453,+-1%,.125W,10PPM,1206	867838	56637	BLU-1206453P10PPMB	6	
R 59, 62, 64			867838				
R 6, 9, 10,	*	RES,CERM,10M,+-5%,.125W,200PPM,1206	783274	91637	CRCW1206-1005JB02	10	
R 16, 21, 22,	*		783274				
R 24, 25, 43,	*		783274				
R 57	*		783274				
R 8, 14, 23,	*	RES,CERM,26.1K,+-1%,.125W,100PPM,1206	807685	91637	CRCW1206-2612FB02	10	
R 29, 41, 51,	*		807685				
R 65- 67,136	*		807685				
R 11, 63		RES,MF,210,+-1%,.125W,10PPM,1206	867825	56637	BLU-1206211P10PPMB	2	

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

Table 6-3. A2 Sensor PCA (cont)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	--------------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE -E-
R 12, 27, 48		RES,VAR,CERM,20K,+-20%,0.5W	267898	80294	3009P-1-203	3	
R 26, 33, 36,		RES,MF,100,+-1%,.125W,10PPM,1206	867853	56637	BLU-1206101P10PPMB	8	
R 38, 42, 47,			867853				
R 60, 61			867853				
R 32, 35, 40,	*	RES,CERM,560,+-5%,.125W,200PPM,1206	740514	91637	CRCW1206-561JB02	4	
R 45	*		740514				
R 46	*	RES,CERM,1K,+-1%,.125W,100PPM,1206	783241	91637	CRCW1206-102FB02	1	
R 100,108,109,	*	RES,CERM,9.1K,+-5%,.125W,200PPM,1206	746602	91637	CRCW1206-9101JB02	4	
R 123	*		746602				
R 101		RES,MF,80.6K,+-1%,0.125W,25PPM	312710	91637	CMF558062F T-1	1	
R 102		RES,MF,200K,+-0.1%,0.125W,25PPM	435149	91637	CMF55 2003 B T-9	1	
R 103,104		RES,MF,374K,+-0.1%,0.5W,25PPM	867150	91637	CMF-653743B T-9	2	
R 105		RES,VAR,BMF,5K,+-10%,0.5W,25PPM	867346	18612	1202-Y-5K-10%	1	
R 106,133,137,	*	RES,CERM,10K,+-5%,.125W,200PPM,1206	746610	91637	CRCW1206-1002JB02	5	
R 141,142	*		746610				
R 107	*	RES,CERM,2.7K,+-5%,.125W,200PPM,1206	746503	91637	CRCW1206-J2700B02	1	
R 110	*	RES,CERM,61.9K,+-1%,.125W,100PPM,1206	821330	91637	CRCW1206-6192FB02	1	
R 112		RES,MF,76.8K,+-0.1%,0.125W,25PPM	346833	91637	CMF55 7682 B T-9	1	
R 113,121		RES,MF,42.2K,+-1%,0.125W,100PPM	221655	91637	CMF55 4222 F T-1	2	
R 114		RES,MF,118K,+-1%,0.125W,100PPM	291310	91637	CMF55 1183 F T-1	1	
R 115		RES,MF,25.5K,+-1%,0.125W,100PPM	291377	91637	CMF55 2552 F T-1	1	
R 116		RES,MF,46.4K,+-1%,0.125W,50PPM	715185	91637	CMF55 4642 B T-2	1	
R 117,119,120	*	RES,CERM,5.11K,+-1%,.125W,100PPM,1206	810663	91637	CRCW-1206-5111FB02	3	
R 118		RES,MF,20.5,+-1%,0.125W,100PPM	281808	91637	CMF55 20RF T-1	1	
R 122		RES,CF,0.51,+-5%,0.25W	381954	59124	CF1-4 0R51 J B	1	
R 125		RES,MF,158K,+-1%,0.125W,25PPM	312751	59124	MF55E1583F	1	
R 127,129	*	RES,CERM,43,+-5%,.125W,200PPM,1206	810598	91637	CRCW1206-43R0JB02	2	
R 130	*	RES,CERM,390K,+-5%,.125W,200PPM,1206	746784	91637	CRCW1206-391B02	1	
R 134,135	*	RES,CERM,620K,+-5%,.125W,200PPM,1206	811919	91637	CRCW1206-6203JB02	2	
R 138	*	RES,CERM,76.8K,+-1%,.125W,100PPM,1206	866884	91637	CRCW1206-7682FB02	1	
R 140		RES,MF,3.16K,+-0.1%,0.125W,25PPM	340588	91637	CMF553161B T-9	1	
U 2, 4, 8,	*	IC,OP AMP,VLOW IB,LOW VOS,8 PIN DIP	875760	64155	LT1012ACN8	4	
U 101	*		875760				
U 100,103-105	*	IC,OPAMP,SELECTED LO VOS DRIFT,IBIAS	723361	64155	AD41422	4	
U 102	*	IC,OP AMP,DUAL,JFET IN,HIGH SPEED	855069	64155	LT1057CN8	1	
U 106,107	*	IC, 1.23V,150 PPM T.C.,BANDGAP V. REF	634451	12040	LM385Z-1.2D26Z	2	
U 108-110	*	IC,COMPARATOR,GENERAL PURPOSE,DIP	845065	64155	LT1011ACN8	3	
U 112	*	IC,COMPARATOR,DUAL,LOW PWR,SOIC	837211	27014	LM393M FLOW-63	1	
VR 100,101,108	*	ZENER,COMP, 6.4V, 2%, 2 PPM TC, 0.5MA	393579	55801	DT-2006	3	
VR 102-105	*	ZENER,UNCOMP,15V,5%,20MA,350MW,SOT23	837187	04713	MMBZ5245BT1	4	
VR 106,107	*	ZENER,UNCOMP,82.0V,5%,1.5MA,0.5W	844977	04713	1N5268B	2	
VR 109	*	ZENER,UNCOMP,6.8V,5%,20MA,350MW,SOT23	837195	04713	MMBZ5235BT1	1	
VR 110,111	*	ZENER,UNCOMP,6.8V,10%,175.0MA,5.0W	483446	04713	1N5342B	2	
Z 100	*	RNET,8840A OUTPUT DIVIDER	655811	89536	655811	1	

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

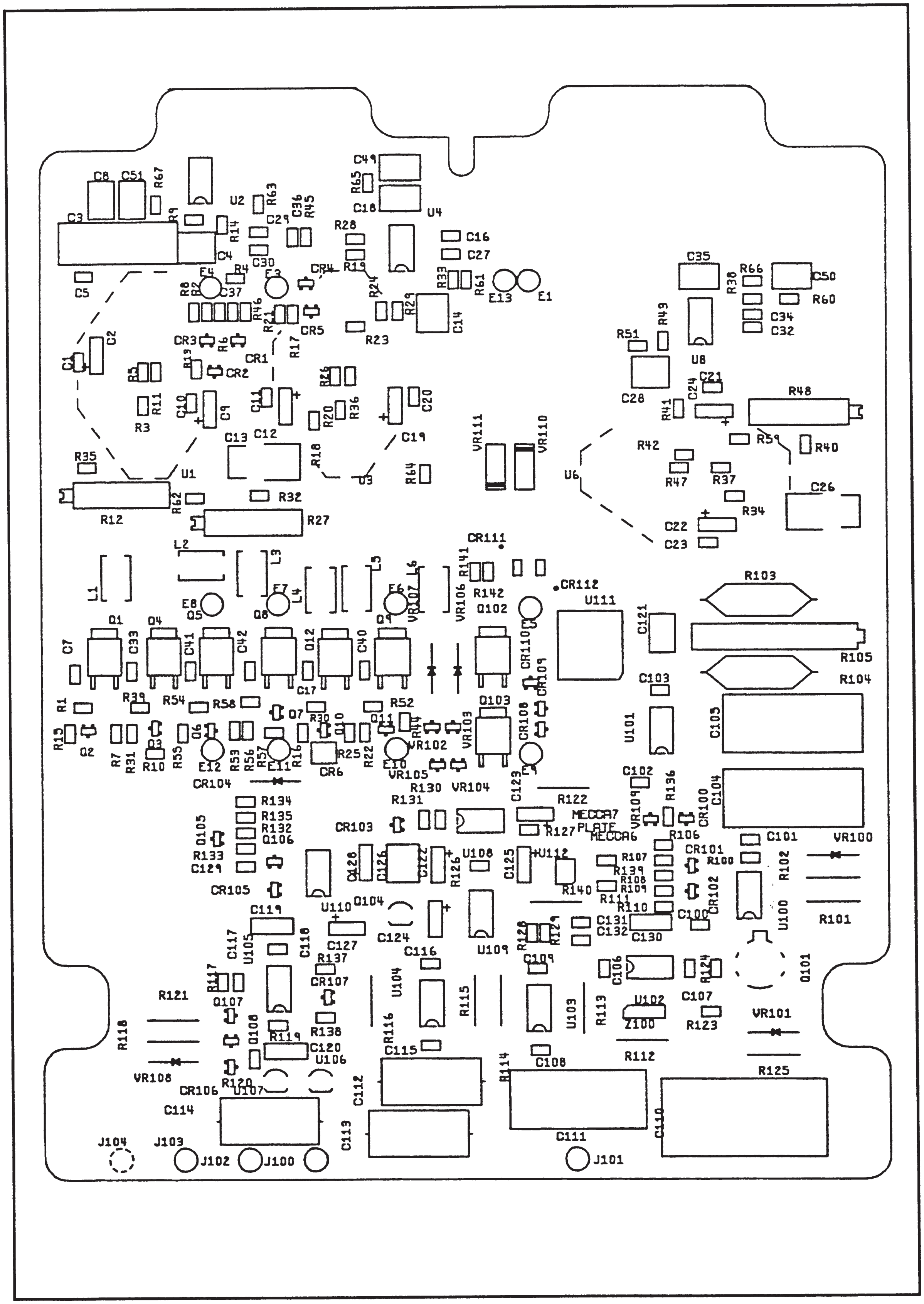

Figure 6-3. A2 Sensor PCA

Table 6-4. Power Pack Final Assembly
(See Figure 6-4.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	--------------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
A 3		POWER PACK PCA	871681	89536	871681	1	
BT 501-504		BATTERY,LEAD-ACID,GEL,6.0V,4.0AH	739961	89536	739961	4	
F 701		FUSE,.25X1.25,0.5A,250V,SLOW	109322	71400	MDA1/2	1	1
H 1		CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	06383	SST-1M	2	
H 2		SCREW,MACH,PH,P,STL,6-32X0.312	152157	73734	19043	23	
H 3		SCREW,MACH,PH,P,STL,6-32,.500	152173	73734	19046	6	
H 4		WASHER,SHLDR,NYL,.141,.375,.112	867395		COMMERCIAL	20	
H 5		WASHER,FLAT,STL,.149,.375,.031	110270	86928	5202-12-31	14	
H 6		GROMMET,SLOT,RUBBER,.188,.313	135269	88786	2286	1	
H 7		GROMMET,SLOT,RUBBER,.750,.875	380782	83478	68	1	
H 8		SCREW,MACH,PH,P,STL,6-32X0.375	152165	73734	19044	8	
H 9		SCREW,MACH,FHU,P,SS,LOCKIN,6-32,.250	769893	73734	6-32X1/4FHUCPS2A	16	
H 10		SCREW,MACH,PH,P,STL,8-32X0.312	807123		COMMERCIAL	2	
H 11		SCREW,MACH,PH,P,SEMS,STL,6-32,.375	177022		COMMERCIAL	2	
H 12		SCREW,MACH,FH,P,SS,4-40X.375	256024		COMMERCIAL	2	
H 13		WASHER,FLAT,BLK,SS,.195,.469,.010	867705		COMMERCIAL	8	
H 14		WASHER,CRESCENT,STL,.190,.370,.063	867569		COMMERCIAL	4	
H 15		SCREW,CAP,SCKT,SS,8-32,.375	837575		COMMERCIAL	4	
H 16		SCREW,MACH,FHU,P,SS,6-32,.312	867234		COMMERCIAL	10	
H 17		SCREW,MACH,PH,P,STL,6-32X0.250	152140		COMMERCIAL	16	
L 301		CORE,BEAD,FERRITE,.250X.560X.1.125	714055	18565	83-10-A636-1000	1	
MP 301		PLATE,FRONT,PAINTED	879700	89536	879700	1	
MP 302		FRONT GUARD, POWER SUPPLY	860416	89536	860416	1	
MP 303		FLUKE NAMEPLATE	879770	89536	879770	1	
MP 304		DECAL,BRUSHED ALUM,POWER SUPPLY	871892	89536	871892	1	
MP 305		CONN PART,CIRC,PANEL,REC HOUSING,6POS	867387	2P953	EGG2B306CLMYZ	1	
MP 306		ADHESIVE SHEET, POWER PACK	860291	89536	860291	1	
MP 503		INSULATOR, SPACER	860374	89536	860374	2	
MP 505		BOTTOM FOOT, MOLDED	860390	89536	860390	4	
MP 509		BATTERY SPACER/GUIDE	860408	89536	860408	1	
MP 510		CHASSIS, POWER SUPPLY	860429	89536	860429	1	
MP 511		TRANSFORMER BRACKET, POWER SUPPLY	860432	89536	860432	1	
MP 512		COVER, BATTERY, POWER SUPPLY	860440	89536	860440	1	
MP 513		GUARD CHASSIS, RIVETED, POWER SUPPLY	871590	89536	871590	1	
MP 514		DECAL,REAR PANEL,PWR SUPPLY	871587	89536	871587	1	
MP 515		FOAM PAD, BATTERY	871954	89536	871954	2	
MP 601		HANDLE RETAINER, PAINTED	879713	89536	879713	1	
MP 602		COVER, TOP, PAINTED	879718	89536	879718	1	
MP 603		CARRYING HANDLE, PAINTED	879721	89536	879721	1	
MP 605		PIN,DOWEL,SS,.1875,.625	867411	59076	9X31-0620	4	
MP 604		DECAL, FLUKE-PHILIPS	883033	89536	883033	1	
MP 609		BEARING,CYL,PLASTIC,.187 ID	867630	14108	C1022101	4	
MP 613		FOOT,NON-SKID	640565	2K262	640565	4	
MP 801		SUPPORT,BRACKET	860341	89536	860341	4	
MP 803		GUARD COVER, POWER SUPPLY	860424	89536	860424	1	
MP 823		LABEL,VINYL,.3,1.5,BAR CODE	844712	89536	844712	1	
MP 824		CORD,LINE,5-15/IEC,3-18AWG,SVT	284174	70903	17239	1	
S 301		KEYTOP, BLACK	883038	89536	883038	1	
SW 501		SWITCH,ROCKER,DPST	800649	62440	232KW20B2C	1	
T 501		POWER TRANSFORMER	871629	89536	871629	1	
W 301		CABLE ASSY,LEMO CONN.	871764	89536	871764	1	
W 501		HARNESS,LINE FILTER,PWR SUPPLY	871751	89536	871751	1	
W 502		HARNESS,BATTERY,PWR SUPPLY	871756	89536	871756	1	
W 503,504		CABLE ASSY,BATTERY JUMPER PWR SUPPLY	871769	89536	871769	2	

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

1 FOR 230V CONFIGURATION, ORDER PART NUMBER 166306.

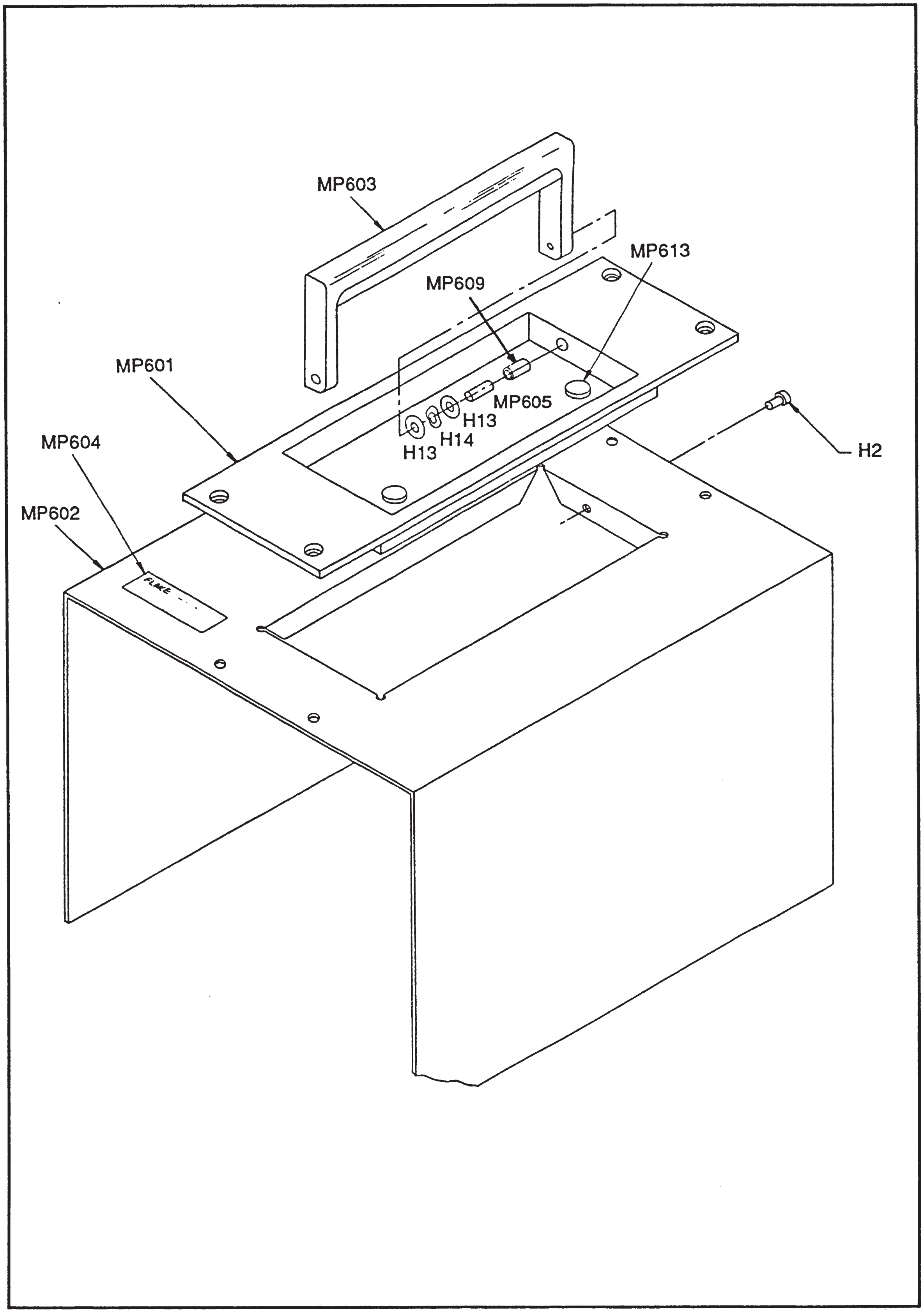

Figure 6-4. Power Pack Final Assembly

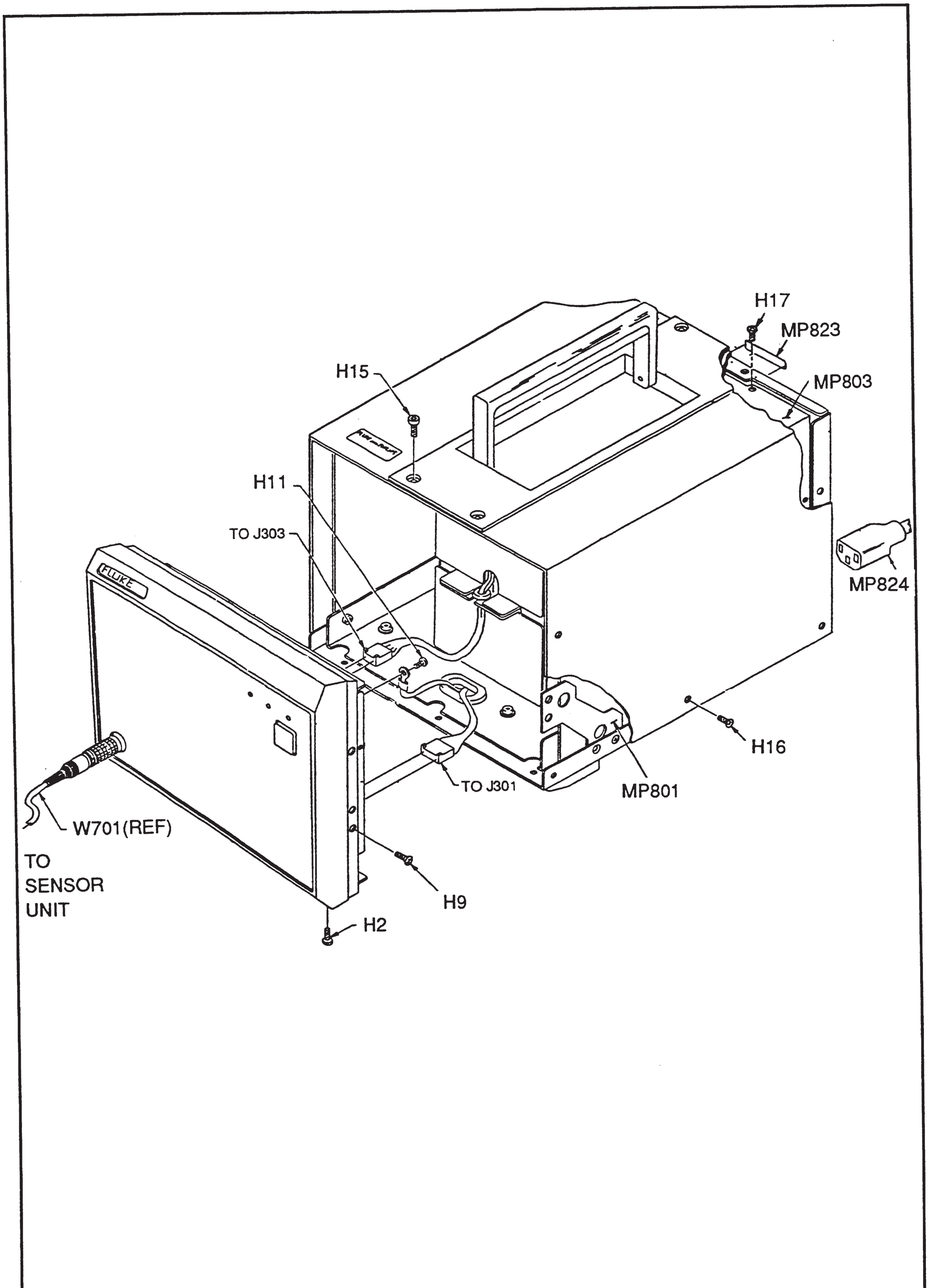

Figure 6-4. Power Pack Final Assembly (cont)

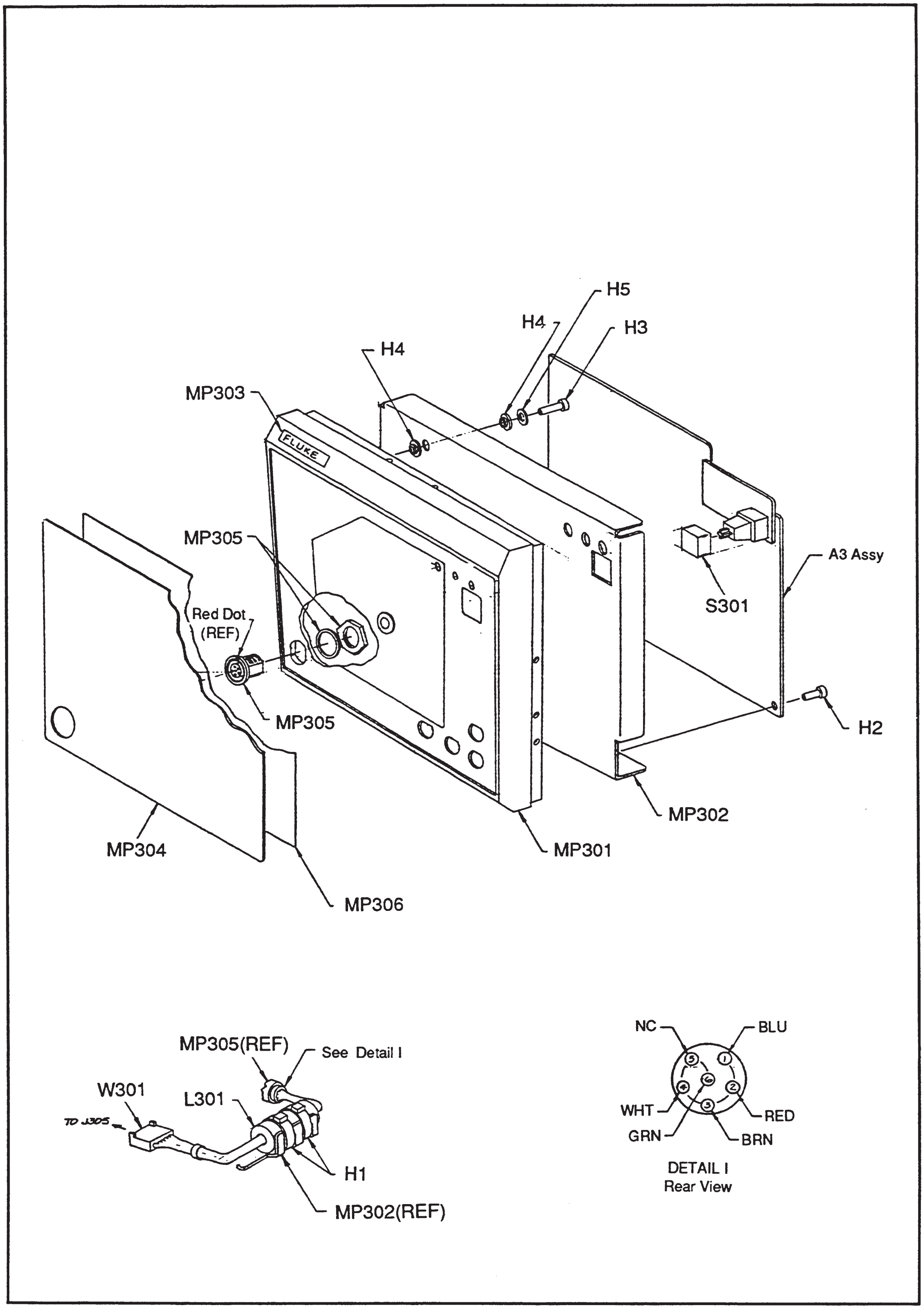

Figure 6-4. Power Pack Final Assembly (cont)

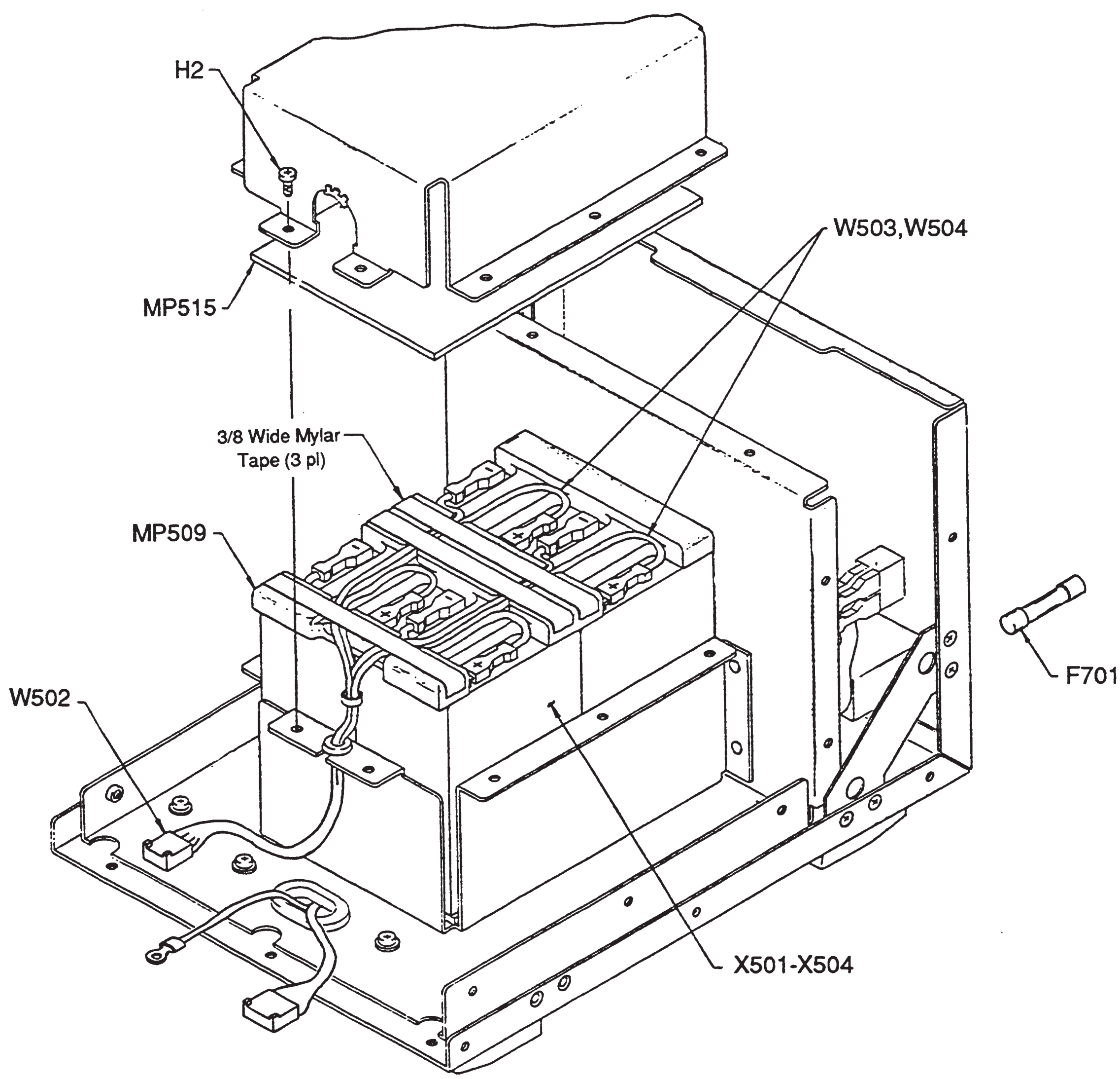

Figure 6-4. Power Pack Final Assembly (cont)

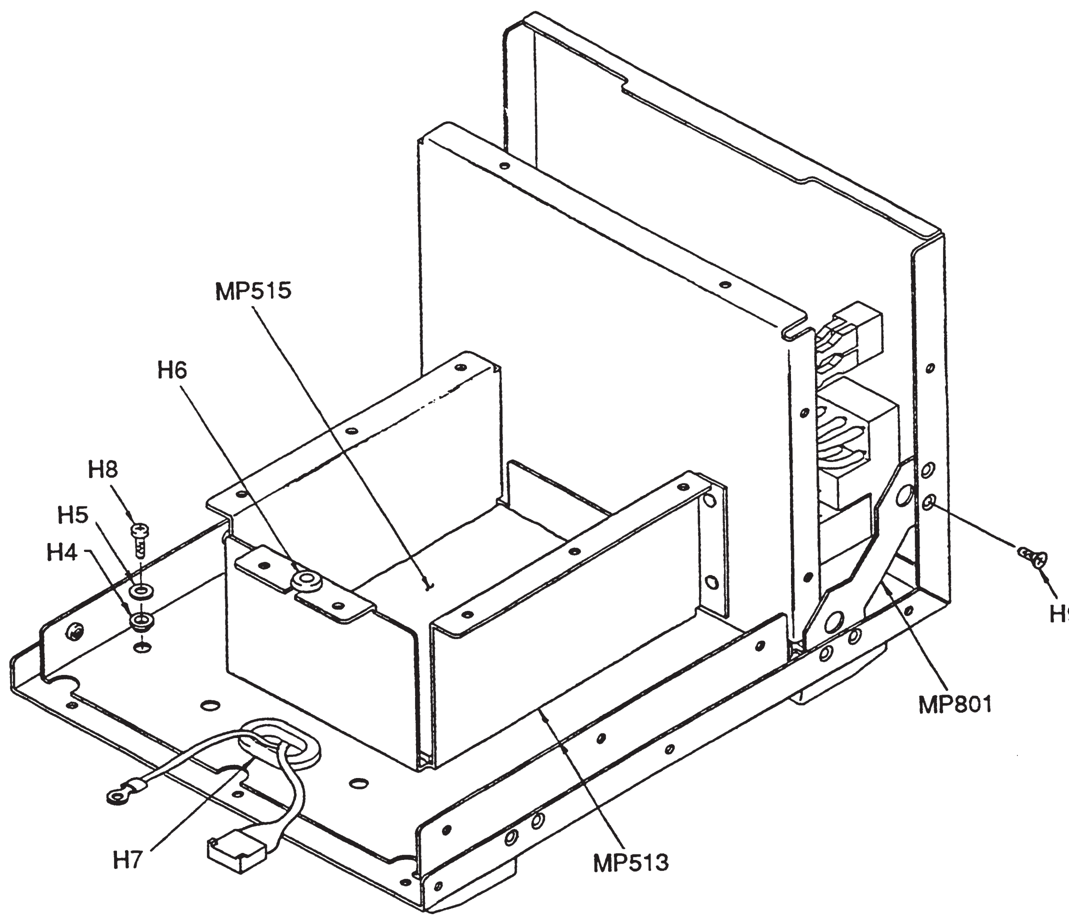

Figure 6-4. Power Pack Final Assembly (cont)

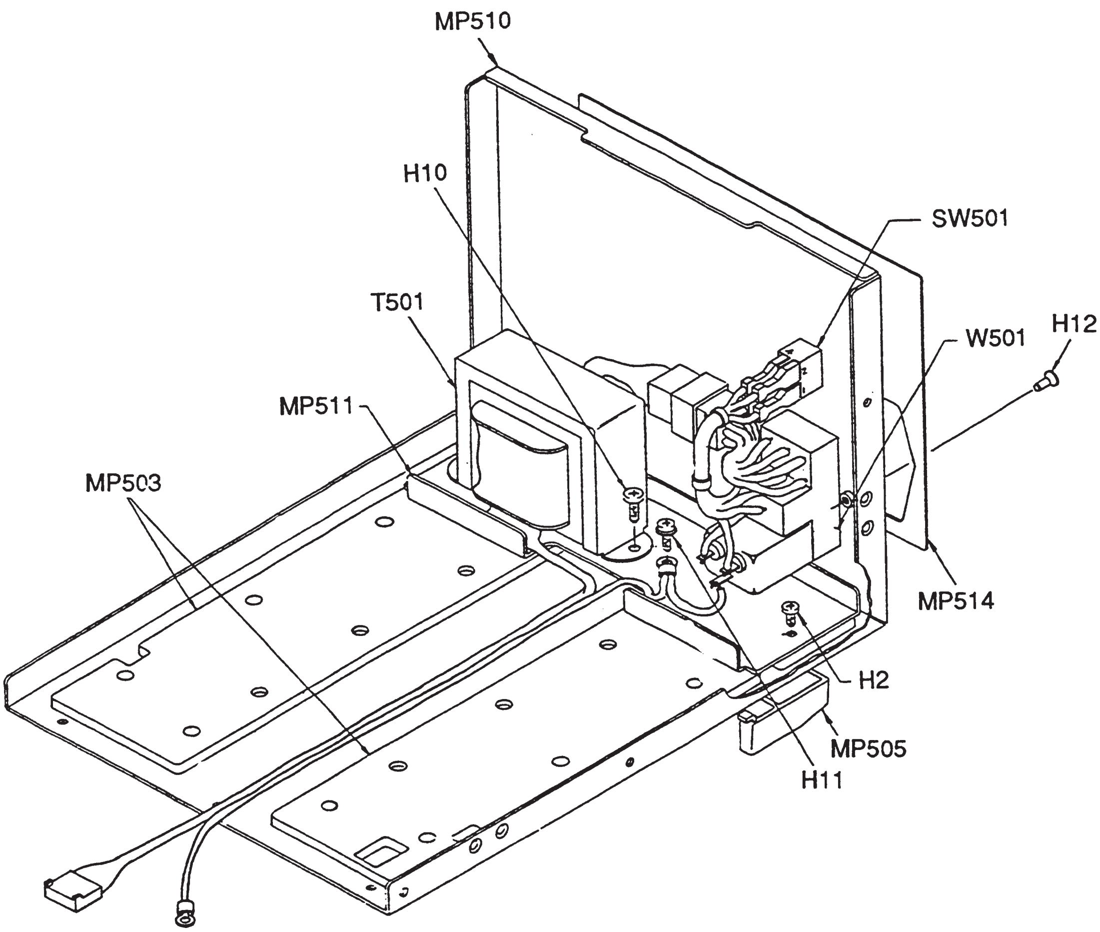

Figure 6-4. Power Pack Final Assembly (cont)

Table 6-5. A3 Power Pack PCA
(See Figure 6-5.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	--------------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE -E-
C 301		CAP,AL,330UF,+-20%,100V,SOLV PROOF	816785	62643	KME100VB331M16X25LL	1	
C 302,321		CAP,POLYES,1UF,+-10%,50V	733089	68919	MKS2-105-K-50V	2	
C 303,304,319,		CAP,POLYES,0.1UF,+-10%,100V	393439	68919	MKS4-104-K-100V	4	
C 320			393439				
C 305		CAP,CER,100PF,+-20%,50V,C0G	721605	04222	SR215A101MAT	1	
C 306		CAP,POLYES,0.047UF,+-10%,50V	820548	68919	MKS2-473-K-50V	1	
C 307,308		CAP,AL,3300UF,+30-10%,16V,SOLV PROOF	603472	62643	KME16VN332K23X27LLV	2	
C 309,316-318		CAP,TA,1UF,+-10%,35V	161919	56289	199D104X0035AA2	4	
C 310-313,322,		CAP,POLYES,0.1UF,+-10%,50V	649913	68919	MKS2-104-K-50V	6	
C 328			649913				
C 314,315		CAP,POLYES,2200PF,+-10%,50V	832683	68919	MKS2-2200-K-50V	2	
C 323,324		CAP,TA,10UF,+-20%,10V	714766	56289	199D106X0010BG2	2	
C 325,326,329,		CAP,TA,2.2UF,+-10%,35V	697433	56289	199D225X9035BG2	4	
C 330			697433				
C 327		CAP,TA,10UF,+-20%,35V	816512	56289	199D106X0035DG2	1	
CR 301-306,309		DIODE,SI,200 PIV,3.0 AMP	331090	14099	SS6252	7	
CR 307,308,310-	*	DIODE,SI,BV= 75.0V,RADIAL INSERTED	659516	03508	1N4448	10	
CR 313,315-318	*		659516				
CR 314	*	THYRISTOR,SI,TRIAC,VBO=200V,8.0A	413013	02735	T2800B	1	
DS 301		LED,GREEN,4MM FLAT TOP,6.7 MCD	867288	28480	HLMP-M501	1	
DS 302,303		LED,RED,4MM FLAT TOP,5.4 MCD	867283	28480	HLMP-M201	2	
F 301,302		FUSE,.19X.60,5A,125V,SLOW,AXIAL	875898	75915	230-005	2	
H 301		NUT,EXT LOCK,STL,6-32,.344OD	152819	78189	511-061800-00	4	
J 306-308		HEADER,1 ROW,.100CTR,4 PIN	417329	00779	103747-4	4	
K 301,302		RELAY,ARMATURE,2 FORM C,5V	733063	61529	DS2E-S-DC5V	2	
K 303,304		RELAY,ARMATURE,2 FORM C,5V,LATCH	769307	61529	DS2EML2DC5VCH284	2	
MP 301		HEAT DIS,HORIZ,1.88X1.40X1.25,TO-3	643593	13103	6016B-1.25	2	
MP 307		HEAT DIS,PWB MT,.75X.50X.50,TO-220	816587	30161	5968B	2	
MP 317		HEAT DIS,ACC,AL FOIL,TO-3	838169	14601	AL155105	2	
MP 319		HEAT DIS ACC,NYL,TO-3	853952	13103	8181-E1	2	
P 301,305		HEADER,1 ROW,.100CTR,6 PIN	758003	00779	641126-6	2	
P 303		HEADER,1 ROW,.100CTR,4 PIN	800821	00779	643756-4	1	
Q 301	*	TRANSISTOR,SI,P-MOS,0.3 OHM,TO-220	782516	81483	IRF9531	1	
Q 302	*	TRANSISTOR,SI,NMOS,75W,TO-220	586107	04713	MTP12N08	1	
Q 303,305,311,	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	698225	04713	2N3904RLRA2	4	
Q 312	*		698225				
Q 304,306-310,	*	TRANSISTOR,SI,PNP,T092	698233	04713	2N3906RLRA	7	
Q 313	*		698233				
R 301,349,352		RES,CF,1K,+-5%,0.25W	780585	59124	CF1-4 VT 102 J B	3	
R 302,320		RES,CF,220K,+-5%,0.25W	851837	59124	CF1-4 VT 224 J B	2	
R 303,304,313,		RES,WW,0.1,+-5%,2W	404293	23237	SPHR1005%	4	
R 314			404293				
R 305,306		RES,MF,249,+-1%,0.125W,100PPM	168203	91637	CMF55 2490 F T-1	2	
R 307,317,318		RES,CF,33K,+-5%,0.25W	733667	59124	CF1-4 VT 333 J B	3	
R 308,345-348		RES,CF,100K,+-5%,0.25W	658963	59124	CF1-4 VT 104 J B	5	
R 309,310,361,		RES,MF,665,+-1%,0.125W,100PPM	320028	91637	CMF55 6650 F T-1	4	
R 365			320028				
R 311,312		RES,MF,1.87K,+-1%,0.125W,100PPM	267229	91637	CMF55 1871 F T-1	2	
R 315,316,341,		RES,MF,12.7K,+-1%,0.125W,25PPM	335349	59124	MF55E1272F	4	
R 342			335349				
R 319,357		RES,MF,5K,+-.1%,.125W,25PPM	706135	91637	CMF55E5001B T-9	2	
R 321,322		RES,MF,267,+-1%,0.125W,100PPM	386821	91637	CMF55 2670 F T-1	2	
R 323,331,350		RES,CF,4.7K,+-5%,0.25W	721571	59124	CF1-4 VT 472 J B	3	
R 324,355		RES,MF,499,+-1%,0.125W,100PPM	816462	91637	CMF55 4990 F T-1	2	
R 325,326,339,		RES,MF,9.09K,+-1%,0.125W,25PPM	335406	59124	MF55E9091F	4	
R 340			335406				
R 327-330		RES,CF,1M,+-5%,0.25W	649970	59124	CF1-4 VT 105 J B	4	
R 332,337		RES,CF,3.3K,+-5%,0.25W	854554	59124	CF1-4VT 332J B	2	
R 333,334		RES,CF,20K,+-5%,0.25W	697110	59124	CF1-4 VT 203 J B	2	
R 335,336		RES,MF,200K,+-1%,0.125W,100PPM	719831	91637	CMF55 2003 F T-1	2	
R 338		RES,CF,2K,+-5%,0.25W	810457	59124	CF1-4 VT 202 J B	1	
R 343		RES,CC,300,+-5%,1W	185876	01121	GB3025	1	
R 344,351,358		RES,CF,47K,+-5%,0.25W	721787	59124	CF1-4 VT 473 J B	3	
R 353		RES,CC,560,+-5%,1W	266361	01121	GB5615	1	
R 354		RES,MF,5.9K,+-1%,0.125W,100PPM	267351	91637	CMF55 5901 F T-1	1	
R 356		RES,MF,5.62K,+-1%,0.125W,100PPM	720417	91637	CMF55 5621 F T-1	1	
R 359,363		RES,VAR,CERM,200,+-10%,0.5W	474973	80294	3352W-10-201	2	
R 360,364		RES,MF,8.06K,+-1%,0.125W,100PPM	294942	91637	CMF55 8061 F T-1	2	
R 366		RES,CC,1,+-5%,0.5W	218693	01121	EB1R05	1	

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

Table 6-5. A3 Power Pack PCA (cont)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	--------------DESCRIPTION--------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE -E-
RT 301,302		THERMISTOR,DISC,0.18,25C	875273	1EJ84	RXE135	2	
S 301		SWITCH,PUSHBUTTON,SPST,MOMENTARY	743161	31918	DC-61-43	1	
TP 301-317		JUMPER,WIRE,NONINSUL,0.200CTR	816090	91984	150T1	17	
U 301	*	IC,VOLT REG,HIGH VOLTAGE	723353	27014	LM317HVK	1	
U 302	*	IC,VOLT REG,ADJ,NEG,-1.2V TO -47V	816702	27014	LM337HVK	1	
U 303,304	*	IC,OP AMP,DUAL,LO OFFST,VOLT,LO-DRIFT	685164	27014	LF412CN	2	
U 305,306	*	IC,COMPARATOR,QUAD,14 PIN DIP	387233	27014	LM339N	2	
U 307	*	IC,CMOS,HEX INVERTER	404681	04713	MC14093BCP	1	
U 308,309	*	ISOLATOR,OPTO,LED TO TRANSISTOR	504977	04713	ODL-340	2	
VR 301,302	*	ZENER,COMP, 6.4V, 2%, 2 PPM TC, 0.5MA	393579	55801	DT-2006	2	
VR 303,304	*	ZENER,UNCOMP,15.0V,5%,1.0MA,0.4W	352377	14552	DZ720825D	2	
VR 305,306	*	ZENER,UNCOMP,5.4V,5%,0.03MA,4.0W	680504	22767	Z7350	2	
VR 307,308	*	ZENER,UNCOMP,82.0V,5%,1.5MA,0.5W	844977	04713	1N5268B	2	

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

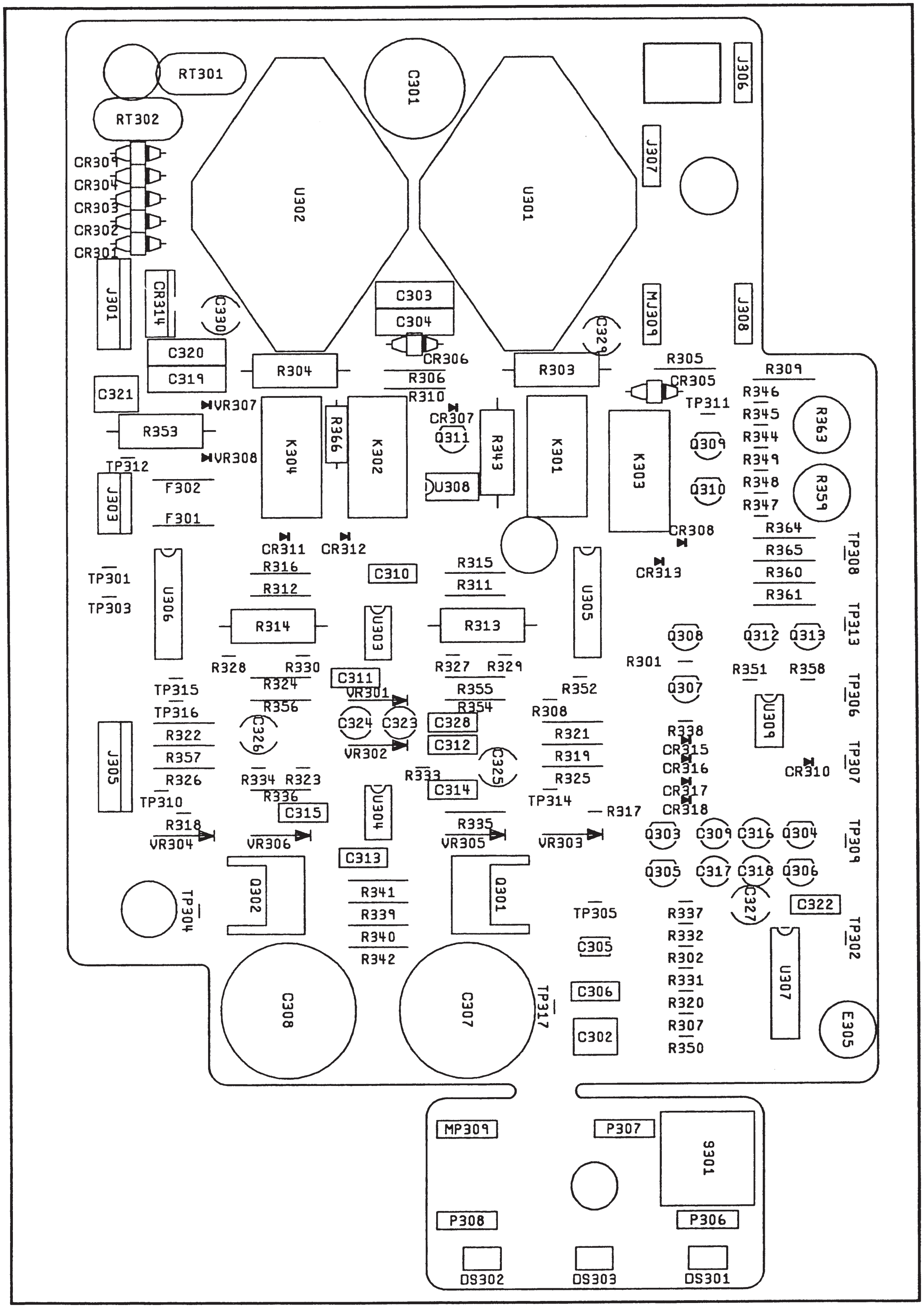

Figure 6-5. A3 Power Pack PCA

Table 6-6. 1000V Range Resistor
(See Figure 6-6.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	---------------DESCRIPTION---------------	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE
C 851		CAP,VAR,1-120PF,1000V,GLASS	875278	52769	GFR12100	1	
C 852,853		CAP,CER,47PF,+-20%,1000V,C0G	369132	60705	561CC0GCK102EG470M	2	1
H 1		SCREW,CAP,SCKT,STL,8-32X.625	448431		COMMERCIAL	10	
H 2		SCREW,MACH,PH,P,STL,6-32X0.625	152181		COMMERCIAL	4	
H 3		SCREW,MACH,PH,P,STL,4-40X0.312	152116		COMMERCIAL	8	
J 851		CONN,COAX,N(F),PANEL,SOLDER CUP	875435	21845	5050-6025	1	
MP 852		RAIL MOUNTING CLAMP	871624	89536	871624	2	
MP 855		RESISTOR CASE, BOTTOM	871608	89536	871608	1	
MP 856		FOOT,ADHESIVE,RUBBER,BLACK,.50X.14	513820	28213	SJ5012	4	
MP 860		RESISTOR CASE, PAINTED	883017	89536	883017	1	
MP 861		DECAL, 1000V RESISTOR	882980	89536	882980	1	
MP 864		LABEL,VINYL,.3,1.5,BAR CODE	844712	89536	844712	1	
MP 866		TERM,RING #10,3/32 - 2 PLACES,SOLDR	237180	78189	2104-10-00	1	
P 852		CONN,COAX,N(M),PANEL,SOLDER CUP	875430	21845	5055-J6018	1	
R 851		1000V RESISTOR ASSEMBLY	871728	89536	871728	1	

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

1 C852 AND C853 REQUIRED FOR TUNING.

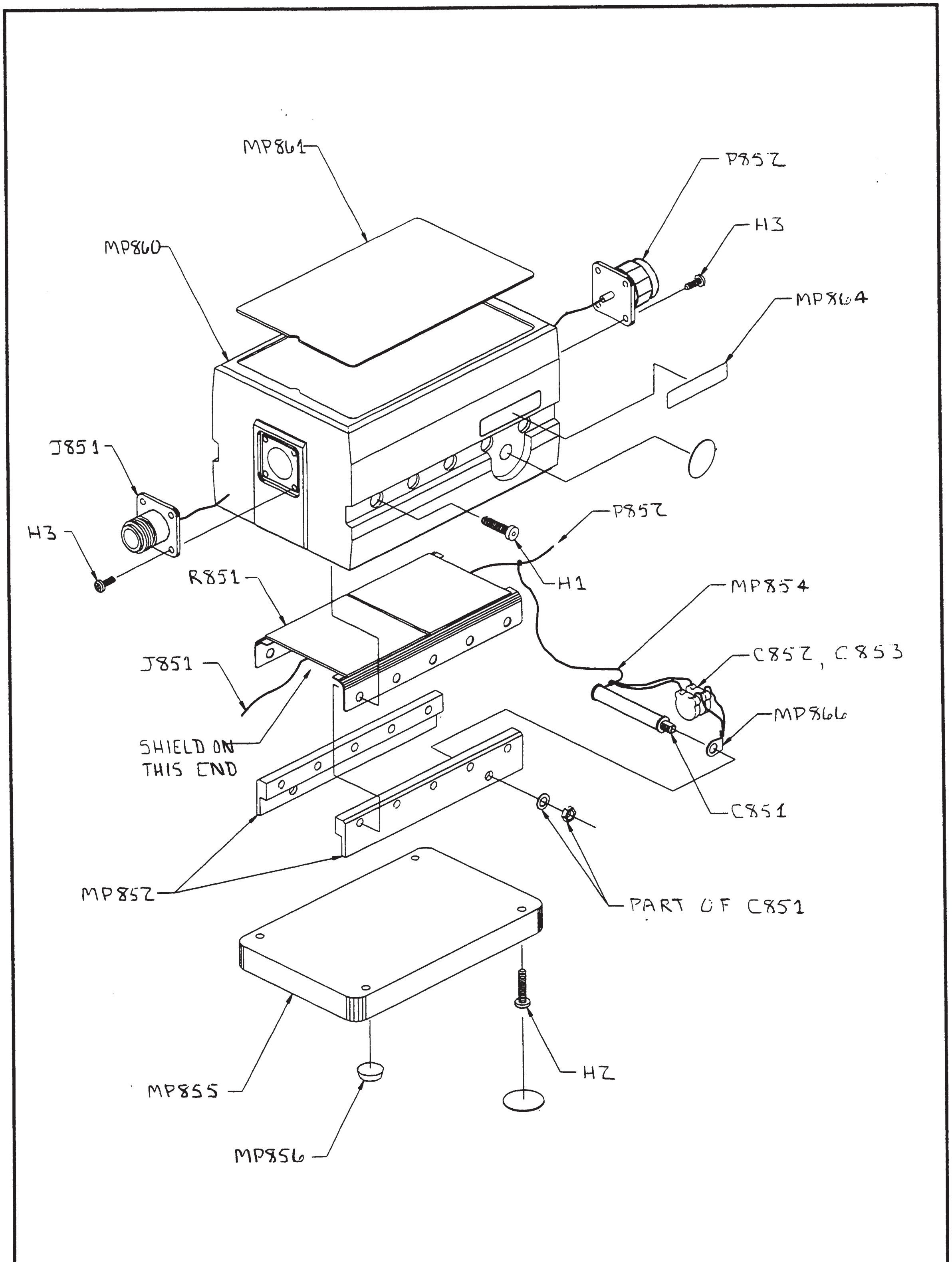

Figure 6-6. 1000V Range Resistor

Table 6-7. Transfer Switch
(See Figure 6-7.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	---DESCRIPTION---	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	NOTE -E-
H 1		NUT, #8 LOW THERMAL	850334	89536	850334	8	
H 2		TERM,RING .120 & .250,SOLDR	101022	79963	29A.120.015COPR,ELEC-TN	4	
H 3		SCREW,FHU,P,LOCK,SS,8-32,.312	855189	2M530	855189	2	
H 4		SCREW,MACH,PH,P,STL,4-40X0.312	152116		COMMERCIAL	4	
H 5		SCREW,MACH,PH,P,STL,6-32X0.312	152157		COMMERCIAL	4	
H 6		WASHER,FLAT,BRASS,#8,0.032 THK	631606		COMMERCIAL	4	
H 7		SCREW,SET,SCKT,STL,8-32,.187	876599		COMMERCIAL	2	
J 903,904,913,		BINDING POST-RED	860452	89536	860452	4	
J 914			860452				
J 901,902,911,		BINDING POST, BLACK	860457	89536	860457	4	
J 912			860457				
MP 901		AC/DC SWITCH CASE- PAD TRANSFER	860460	89536	860460	1	
MP 902		COVER, CASE	871884	89536	871884	1	
MP 906		FOOT,ADHESIVE,RUBBER,BLACK,.50X.14	513820	28213	SJ5012	4	
MP 910		INSULATOR,REAR,BINDING POST,BLACK	860361	89536	860361	4	
MP 914		INSULATOR,BINDING POST,FRONT,BLACK	860411	89536	860411	8	
MP 930		KNOB, PAINTED	879705	89536	879705	1	
MP 931		DECAL, AC/DC SWITCH	879775	89536	879775	1	
MP 932		GROUND ADAPTER, BINDING POST	882998	89536	882998	4	
MP 937		LABEL,VINYL,.3,1.5,BAR CODE	844712	89536	844712	1	
P 901		CONN,COAX,N(M),PANEL,SOLDER CUP	875430	21845	5055-J6018	1	
SW 901		SWITCH,ROTARY,1 POLE,3 POS,HIGH BV	876040	74217	R861A0360001	1	

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

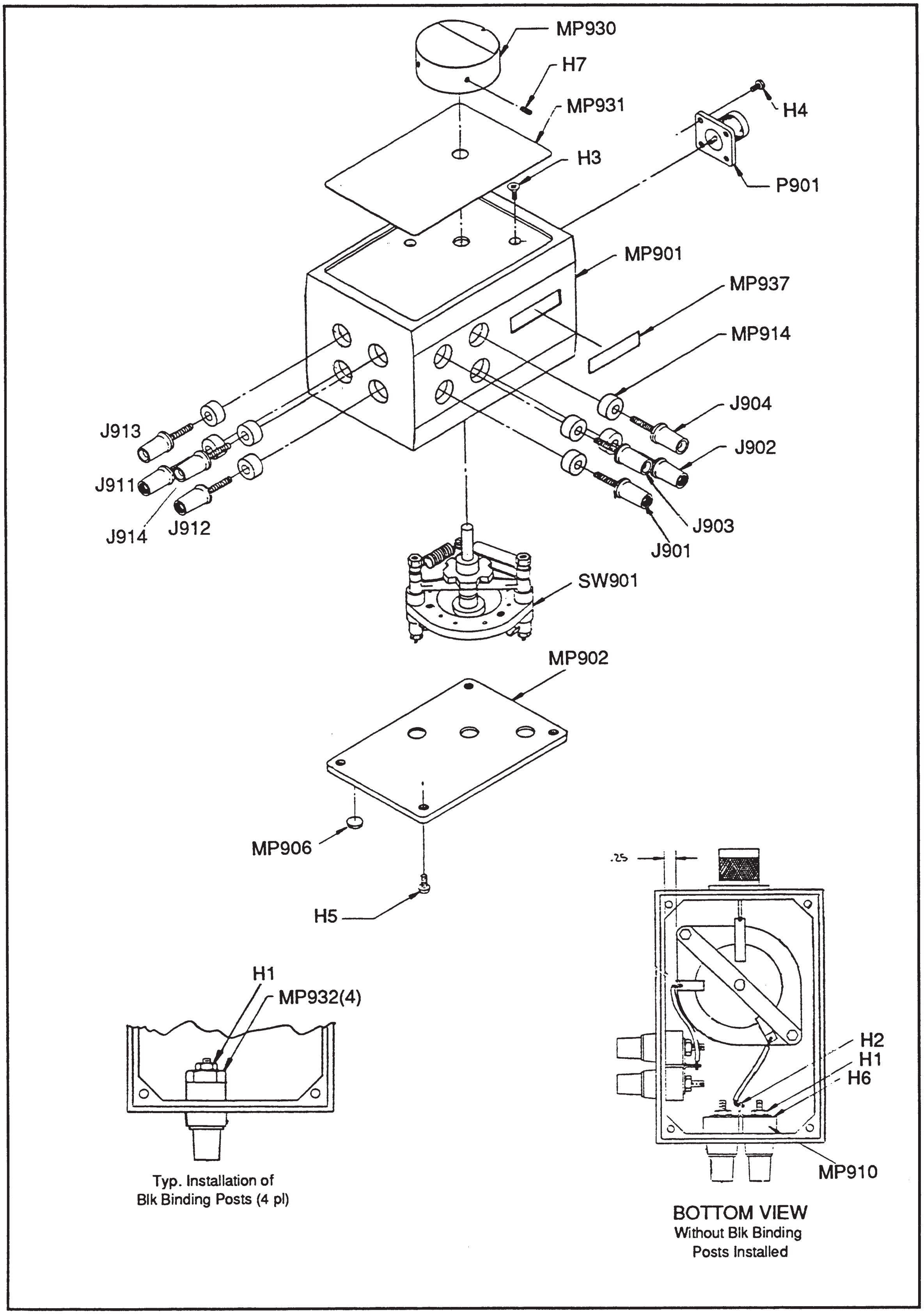

Figure 6-7. Transfer Switch

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Section 7
Schematic Diagrams

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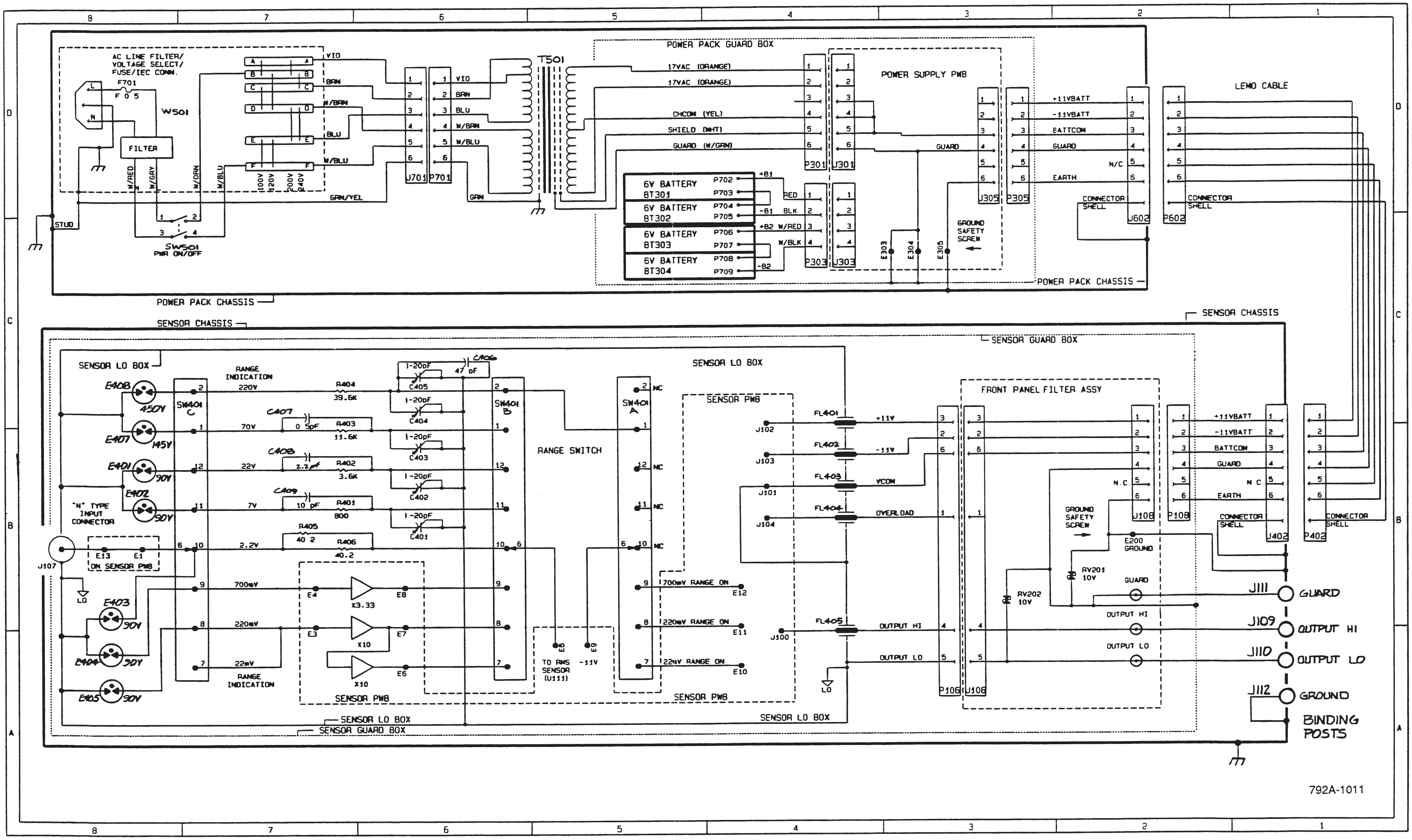

Figure 7-1. Interconnect/Range Switch

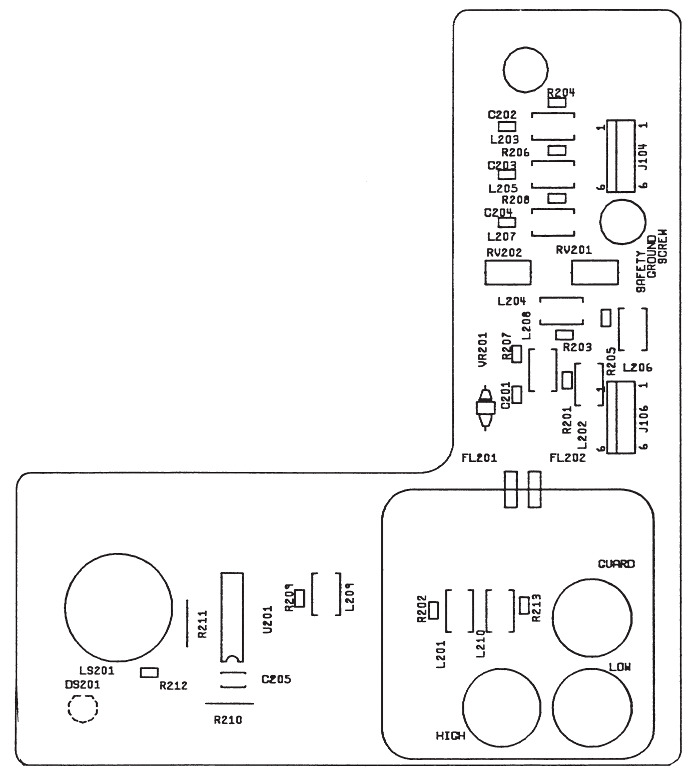

Figure 7-2. A1 Front Panel/Filter PCA

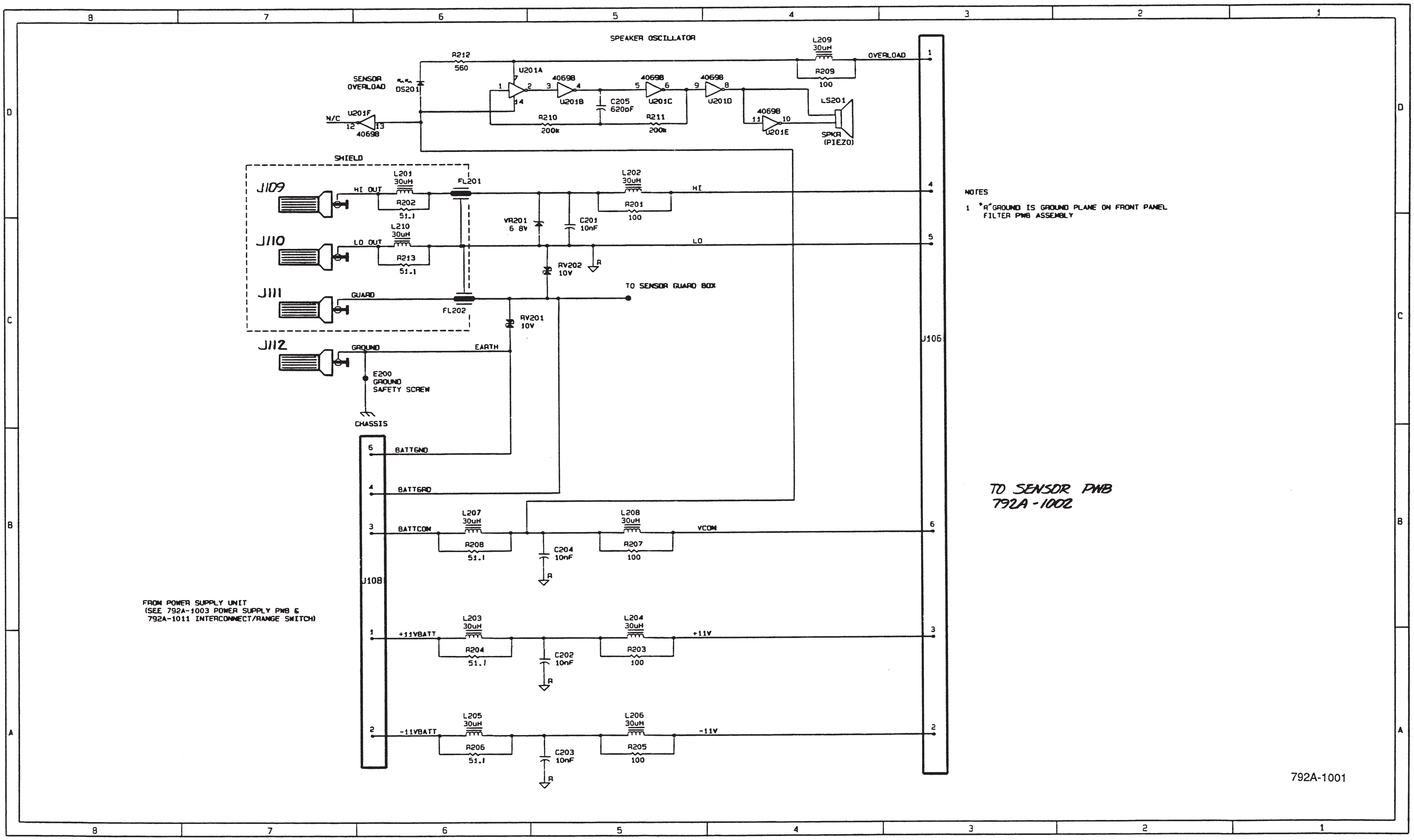

Figure 7-2. A1 Front Panel/Filter PCA (cont)

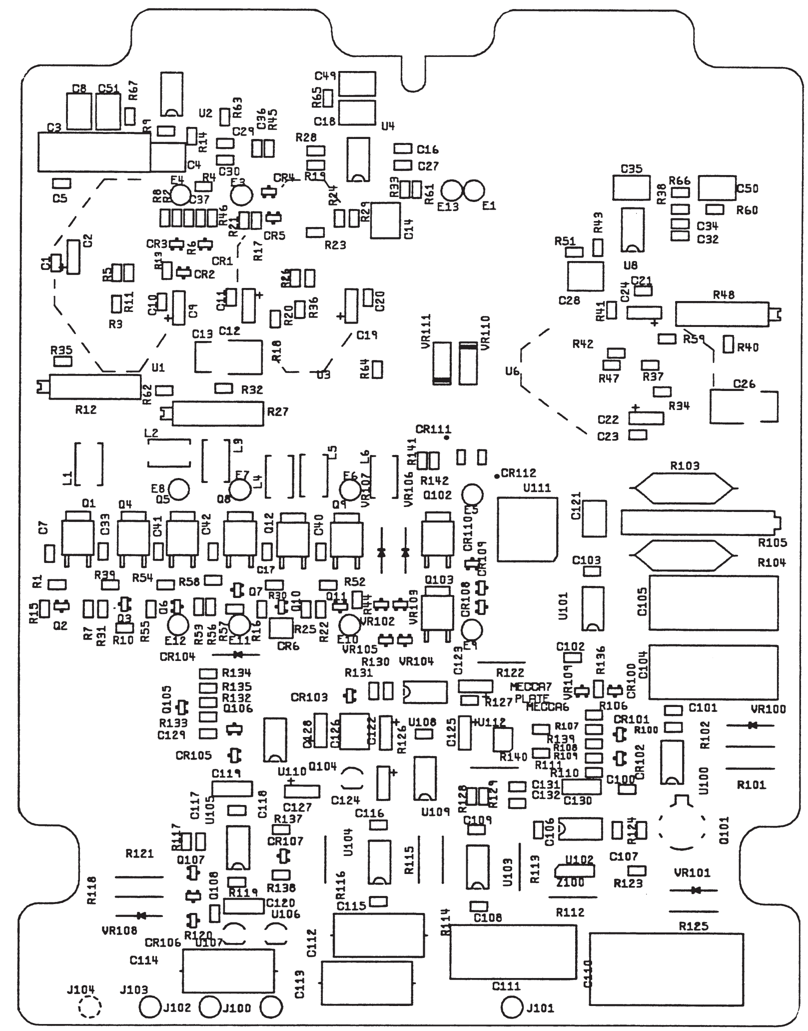

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Figure 7-3. A2 Sensor PCA

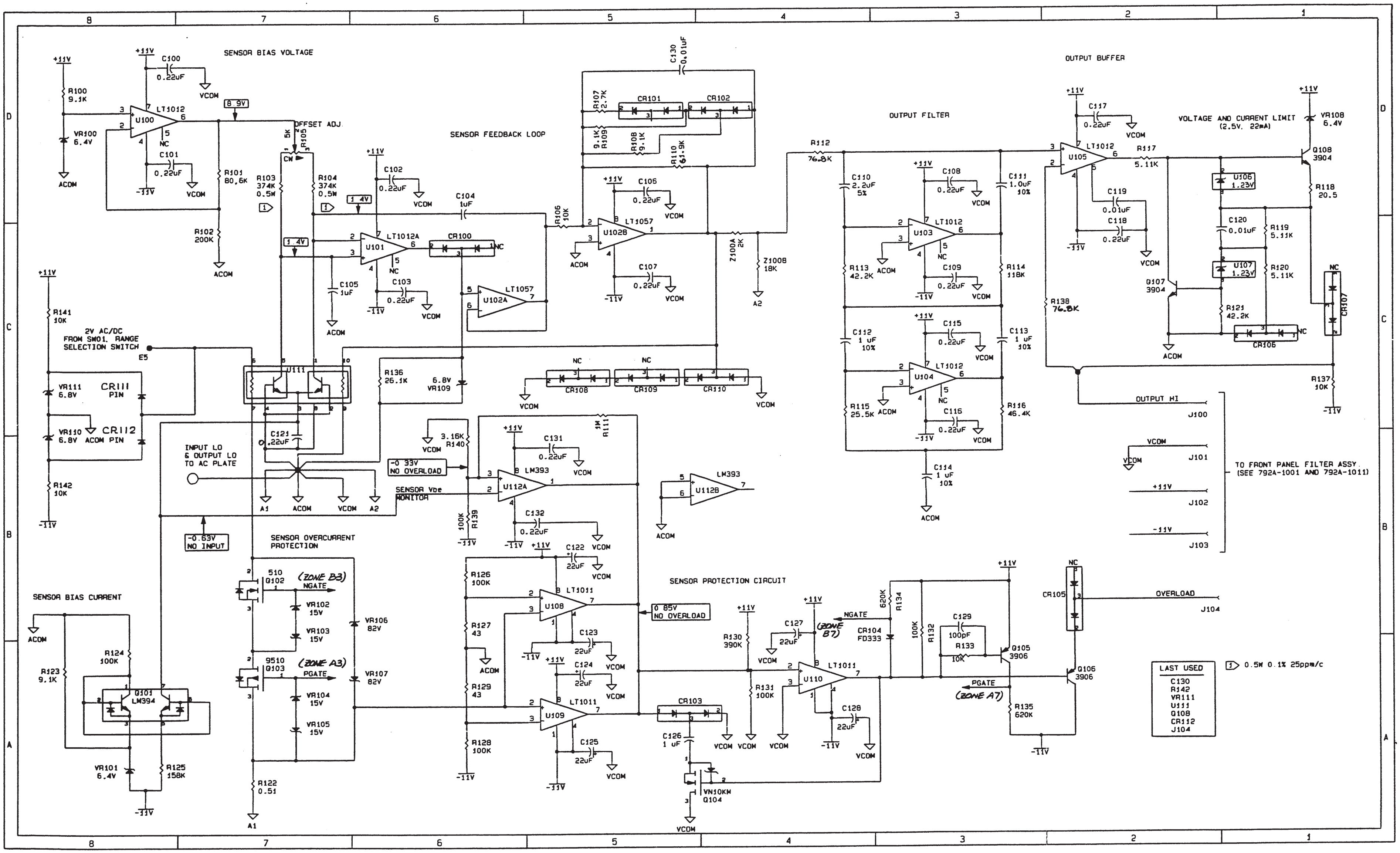

Figure 7-3. A2 Sensor PCA (cont)

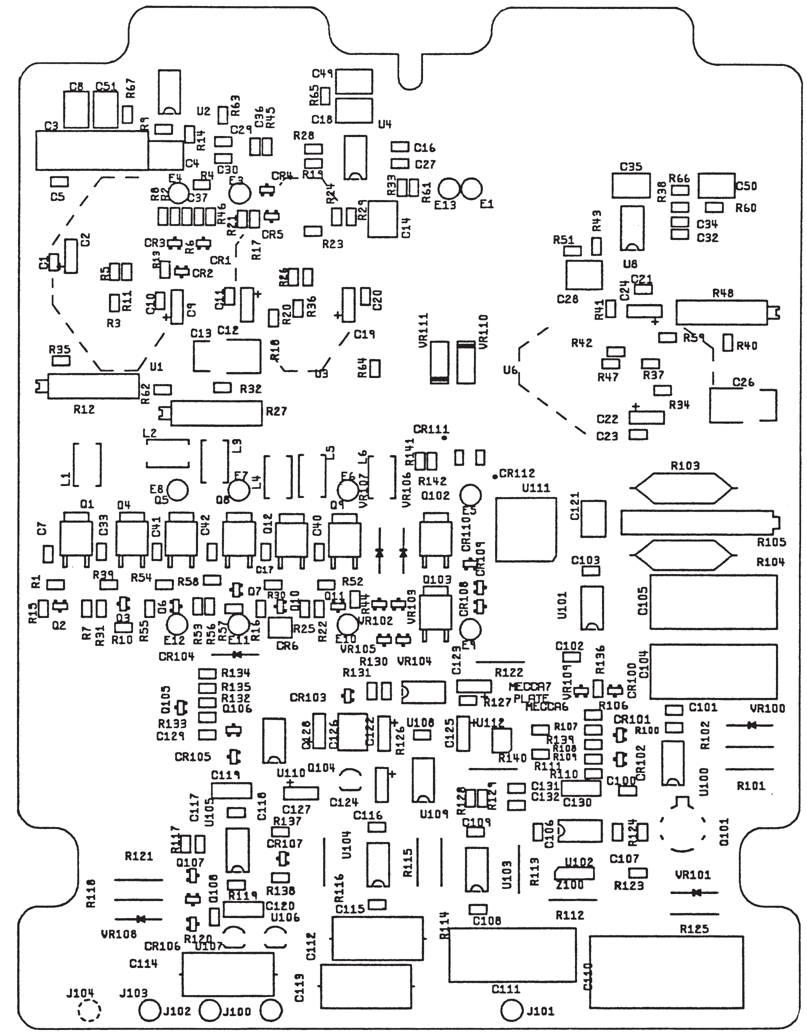

Figure 7-3. A2 Sensor PCA (cont)

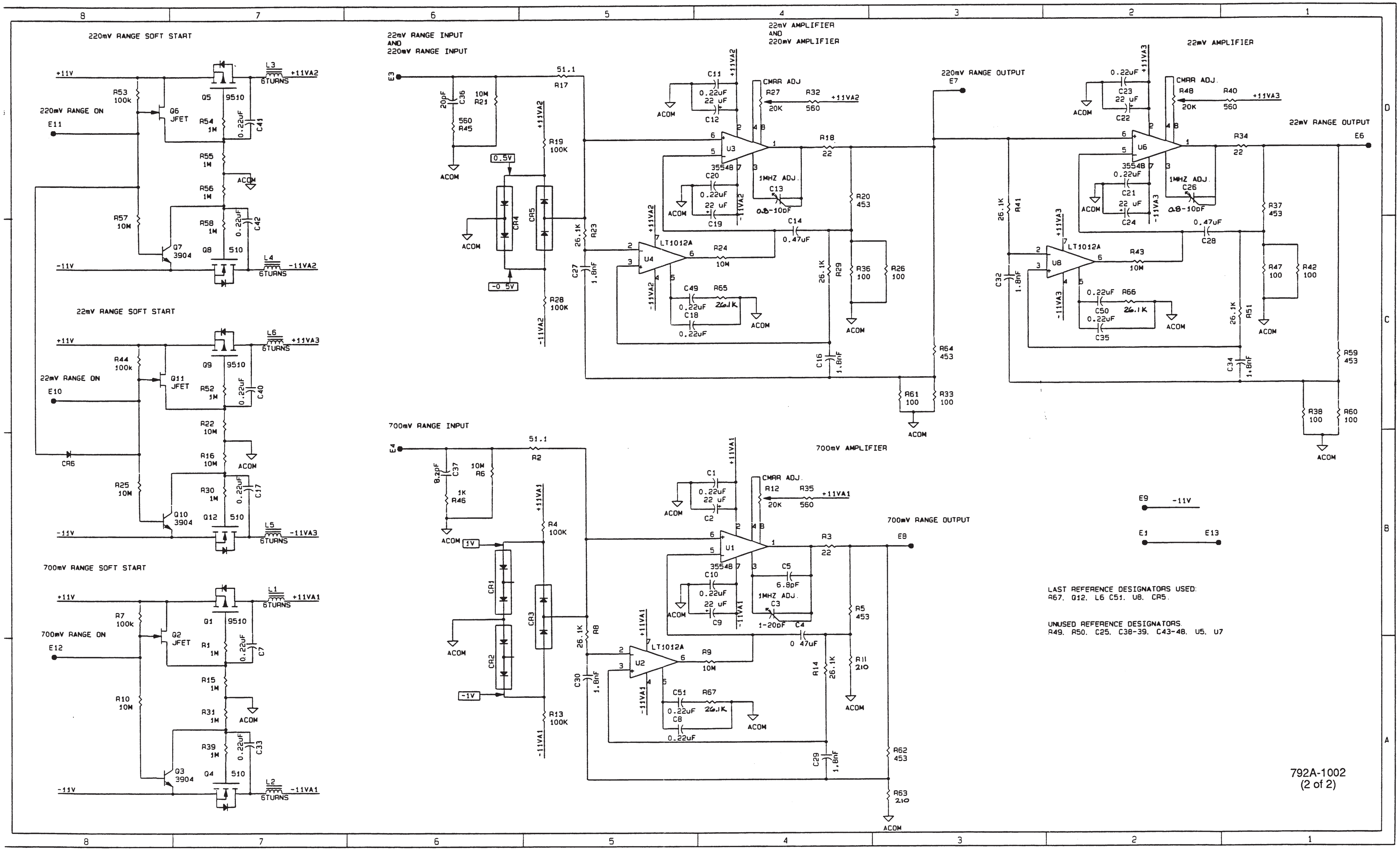

Figure 7-3. A2 Sensor PCA (cont)

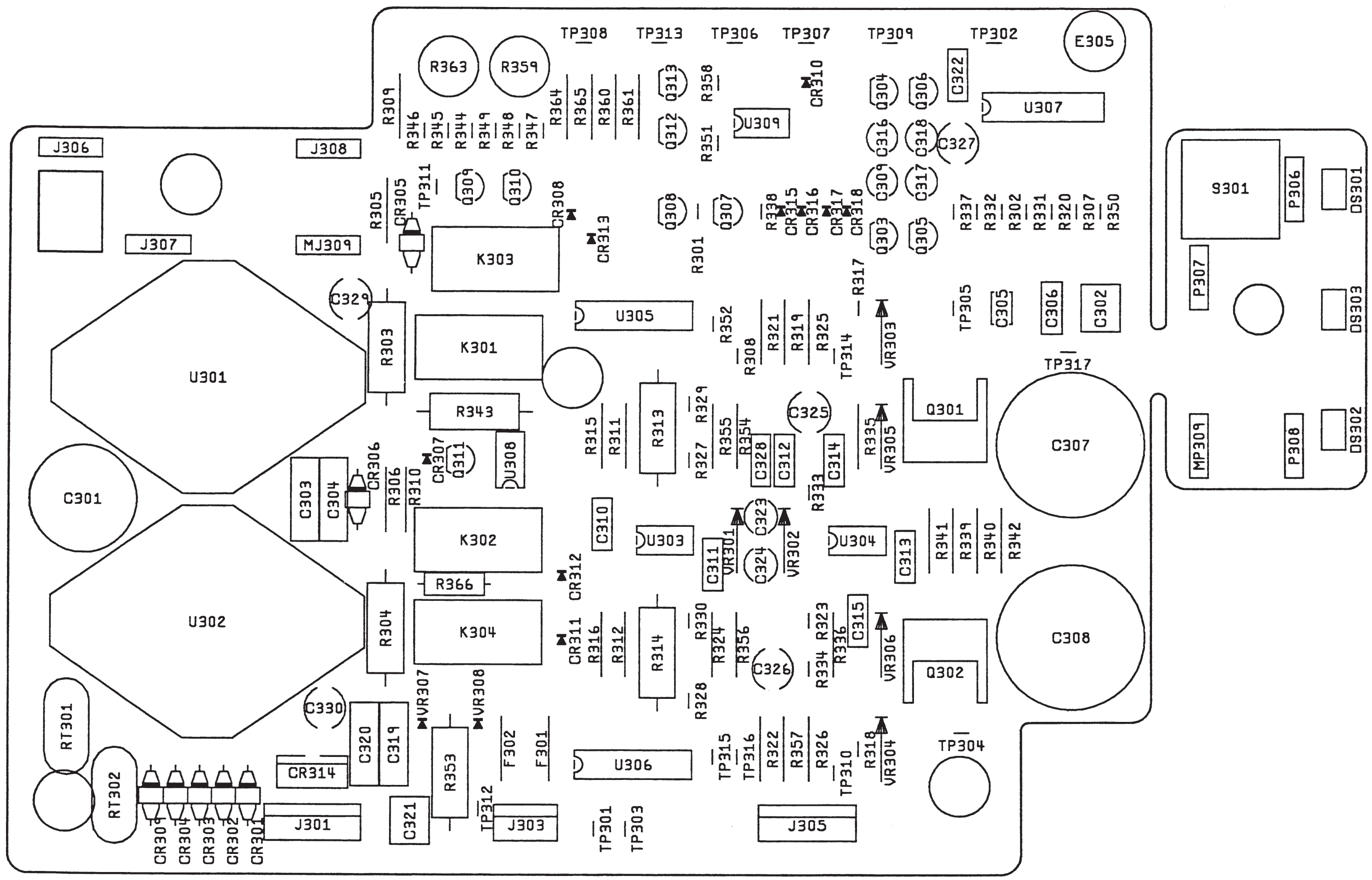

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Figure 7-4. A3 Power Pack PCA

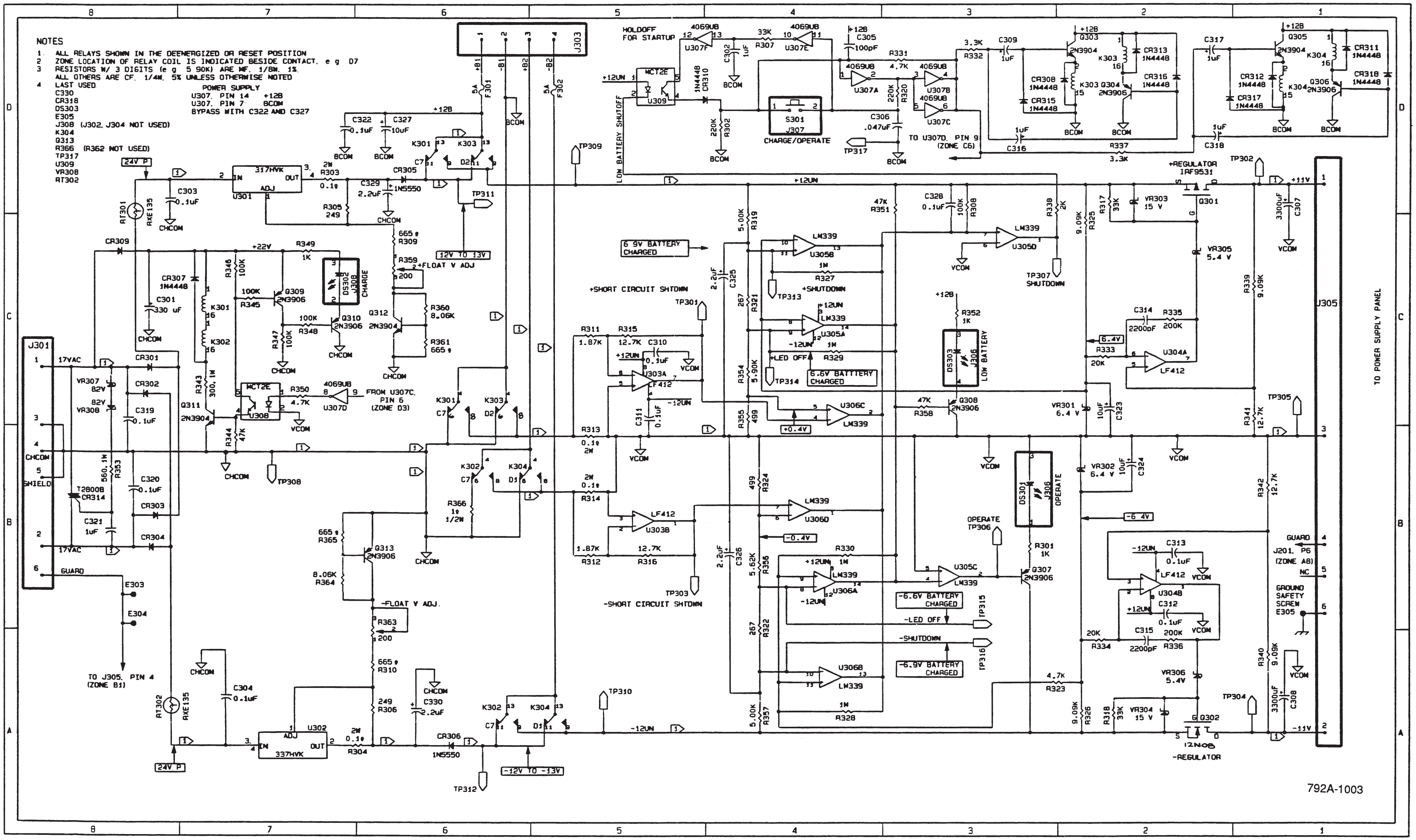


Figure 7-4. A3 Power Pack PCA (cont)

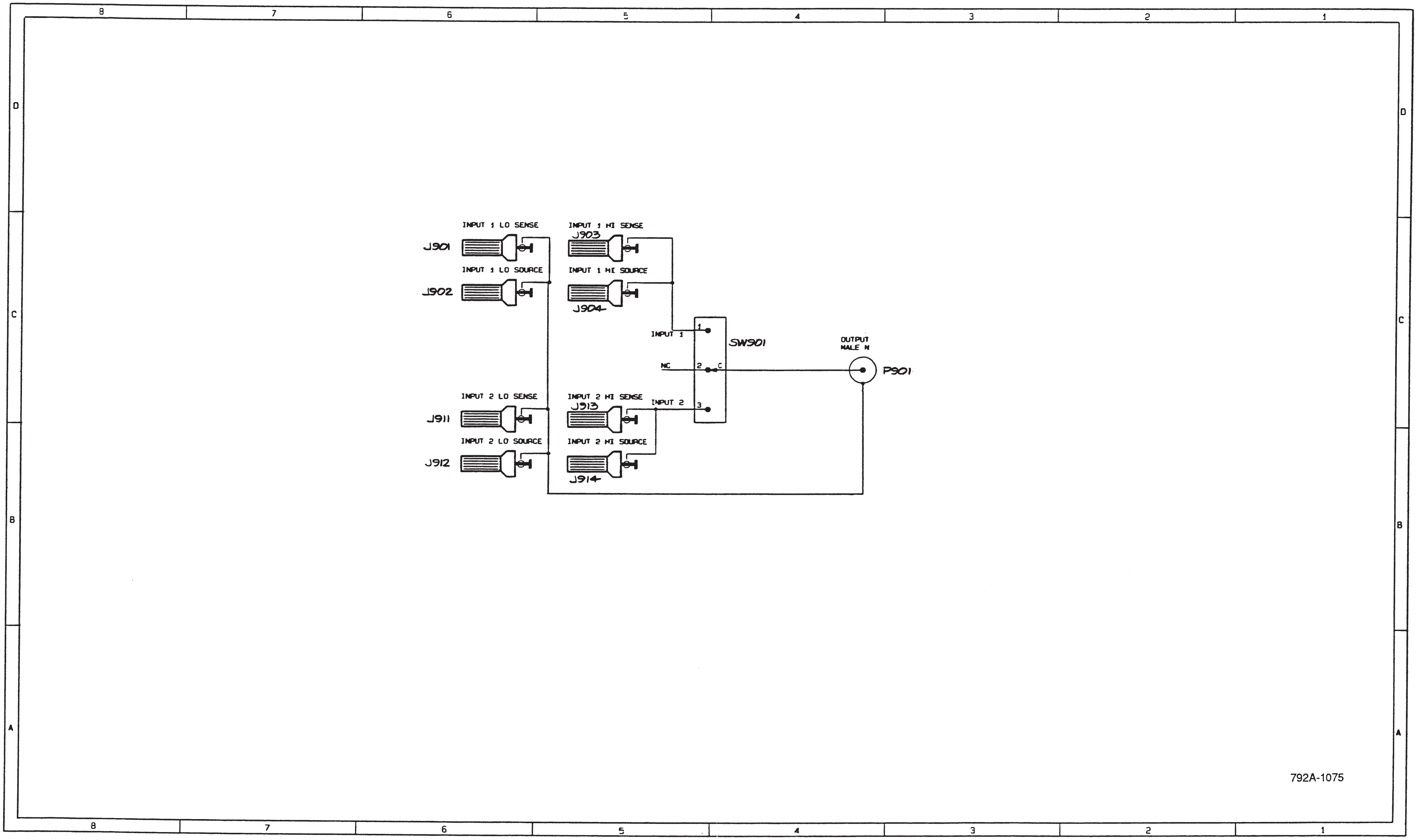


Figure 7-5. Transfer Switch

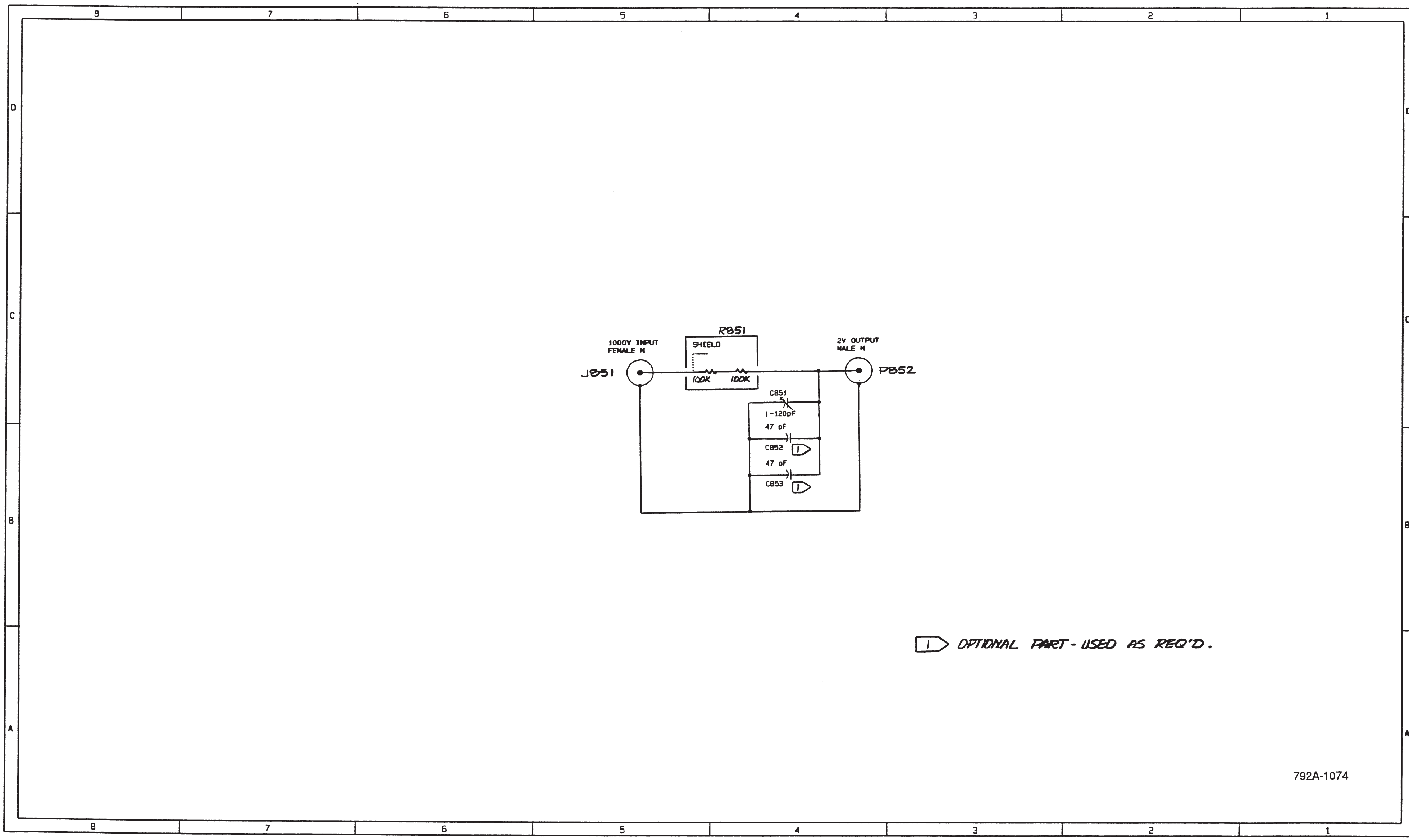


Figure 7-6. 1000V Range Resistor

Appendix A
Glossary of AC-DC Transfer Related Terms

absolute uncertainty

Uncertainty specifications that include the error contributions made by all equipment and standards used to calibrate the instrument. Absolute uncertainty is the number to compare with the UUT for determining test uncertainty ratio.

accuracy

The degree to which the measured value of a quantity agrees with the true (correct) value of that quantity. Accuracy is the same as 1 minus % uncertainty. (See "uncertainty.") For example, an instrument specified to ±1% uncertainty is 99% accurate.

ac-dc absolute uncertainty

Includes all known error sources contributing to the uncertainty of an ac-dc difference correction. This includes NIST (National Institute of Standards and Technology) uncertainties, transfer uncertainty from a primary standard to a working standard, and internal error contributions (both random and temperature related).

ac-dc transfer

The process of comparing an ac voltage to a known dc voltage, thereby transferring the low uncertainty of the dc voltage to the ac voltage. The 792A can be used to perform two different types of ac-dc transfers:

1. An ac measurement

2. An ac-dc difference measurement

In an ac measurement, the transfer standard is used to determine absolute rms ac voltage level. In an ac-dc difference measurement, the transfer standard is a reference that tests the ac and dc response of another transfer standard. The goal of an ac measurement is to determine the error of the ac source or ac voltmeter under test. The goal of an ac-dc difference measurement is a value called the "ac-dc difference," which is positive when more ac voltage than dc voltage is required to produce the same output in the transfer standard under test.

ac-dc difference

A measurement of an ac-dc transfer device's accuracy. The ac-dc difference is a transfer device's error when it compares a dc voltage to the same ac rms voltage. A positive ac-dc difference indicates that more alternating than direct voltage is required to produce the same 792A output. The formula for ac-dc difference is:

$$\text{ac-dc difference} = \frac{\text{792A output [dc known in]} - \text{792A output [ac corrected in]}}{\text{792A output [dc known in]}}$$

active ranges

In the 792A, the 22 mV, 220 mV, and 700 mV ranges are called the active ranges because inputs on these ranges are amplified before they are applied to the Fluke RMS Sensor.

base units

Units in the SI system that are dimensionally independent. All other units are derived from base units. The only base unit in electricity is the ampere.

burden voltage

The maximum sustainable voltage across the terminals of a load.

calibration

The comparison of a measurement system or device of unknown accuracy with a measurement system or device of known and greater accuracy to detect or correct any variation from required performance of the unverified measurement system or device.

calibration constant

A correction factor that is applied manually or automatically to correct the output or reading of an instrument.

calibration curve

A smooth curve drawn through a graph of calibration points.

calibration interval

The interval after which calibration must occur to maintain the performance of an instrument as stated in its specifications.

calibration report

A record of uncertainty and/or correction factors for an instrument as determined during calibration. The 792A Test Report is an example.

calibrator

A device that supplies outputs with a known uncertainty for use in checking the accuracy of measurement devices.

characterization

The development of a table of calibration constants or correction factors for use in correcting the output or reading of an instrument.

common mode noise

An undesired signal that exists between a device's terminals and ground. Common mode noise is at the same potential on both terminals of a device.

compliance voltage

The maximum voltage that a constant-current source can supply.

control chart

A chart devised to monitor one or more processes in order to detect the excessive deviation from a desired value of a component or process.

crest factor

The ratio of the peak voltage to the rms voltage of a waveform (with the dc component removed). Also see rms.

derived units

Units in the SI system that are derived from base units. Volts, ohms, and watts are derived from amperes and other base and derived units.

error

Deviation from correct value. The different types of error described in this glossary are offset, linearity, random, retrace, reversal, scale, systematic, and transfer error.

flatness

A measure of the variation of the actual output of an ac voltage source at different frequency points when set to the same nominal output level. A flat voltage source exhibits very little error throughout its frequency range.

floor

The part of the uncertainty specification of an instrument that is typically a fixed offset plus noise. Floor can be expressed as units such as microvolts or counts of the least significant digit. For Fluke calibrators, the floor specification is combined with fixed range errors in one term.

full scale

The maximum reading of a range of a meter, analog-to-digital converter, or other measurement device, or the maximum attainable output on a range of a calibrator.

gain error

Same as scale error. Scale or gain error results when the slope of the meter's response curve is not exactly 1. A meter with only gain error (no offset or linearity error), will read 0V with 0V applied, but something other than 10V with 10V applied.

ground

The voltage reference point in a circuit. Earth ground is a connection through a ground rod or other conductor to the earth, usually accessible through the ground conductor in an ac power receptacle.

ground loop

Undesirable current induced when there is more than one chassis ground potential in a system of instruments. Ground loops can be minimized by connecting all instruments in a system to ground at one point.

guard

A floating shield around sensitive circuitry inside an instrument. The guard provides a low-impedance path to ground for common-mode noise and ground currents, thereby eliminating errors introduced by such interference.

International System of Units

Same as "SI System of Units"; the accepted system of units. See also "units," "base units," and "derived units."

legal units

The highest echelon in a system of units, for example the U.S. National Bureau of Standards volt.

life-cycle cost

The consideration of all elements contributing to the cost of an instrument throughout its useful life. This includes initial purchase cost, service and maintenance cost, and the cost of support equipment.

linearity

The relationship between two quantities when a change in the first quantity is directly proportional to a change in the second quantity.

linearity error

Linearity error occurs when the response curve of an instrument is not exactly a straight line. This type of error is measured by fixing two points on the response curve, drawing a line through the points, then measuring how far the curve deviates from the straight line at various points on the response curve.

MAP (Measurement Assurance Program)

A program for a measurement process. A MAP provides information to demonstrate that the total uncertainty of the measurements (data), including both random error and systematic components of error relative to national or other designated standards is quantified, and sufficiently small to meet requirements.

maximum transfer time

Maximum time that an ac-dc transfer can be made to stay within the stated ac-dc absolute uncertainty.

minimum V_{in}

For each range of an ac/ac transfer standard, the minimum input rms voltage for which uncertainty specifications apply. Also see rms.

metrology

The science of, and the field of knowledge concerned with measurement.

minimum use specifications

A compilation of specifications that satisfies the calibration requirements of a measurement system or device. The minimum use specifications are usually determined by maintaining a specified test uncertainty ratio between the calibration equipment and the unit under test.

noise

A signal containing no useful information that is superimposed on a desired or expected signal.

noise floor

For an ac-dc transfer standard, the transfer uncertainty due to noise factors.

normal mode noise

An undesired signal that appears between the terminals of a device.

offset error

Same as zero error. The reading shown on a meter when an input value of zero is applied is its offset or zero error.

output stability

For an ac-dc transfer standard, the change in output value over time, with the input left constant.

parameters

Independent variables in a measurement process such as temperature, humidity, test lead resistance, etc.

passive ranges

In the 792A, the 2.2 V, 7V, 22V, 70V, 220V, and 1000V ranges are called the passive ranges because inputs on these ranges are not amplified before they are applied to the Fluke RMS Sensor. The 2.2V range is virtually unscaled, and the other passive ranges are resistively divided to the 2V level.

precision

The degree of agreement among independent measurements of a quantity under the same conditions. (Same as "repeatability.")

The precision of a measurement process is the coherence, or the closeness to the one result, of all measurement results. High precision, for example would result in a tight pattern of arrow hits on a target, without respect to where on the target the tight pattern falls.

predictability

A measure of how accurately the output value of a device can be assumed after a known time following calibration. If a device is highly stable, it is also predictable. If a device is not highly stable, but its value changes at the same rate every time after calibration, its output has a higher degree of predictability than a device that exhibits random change.

primary standard

A standard defined and maintained by some authority and used to calibrate all other secondary standards.

process metrology

Tracking the accuracy drift of calibration and other equipment by applying statistical analysis to correction factors obtained during calibration.

random error

Any error that varies in an unpredictable manner in absolute value and in sign when measurements of the same value of a quantity are made under effectively identical conditions.

range

The stated upper end of a measurement device's span. Usually, however, a measurement device can measure quantities for a specified percentage overrange. (The absolute span including overrange capability is called "scale.") For the 792A, however, range and scale are identical.

reference standard

The highest-echelon standard in a laboratory; the standard that is used to maintain working standards that are used in routine calibration and comparison procedures.

relative uncertainty

For the 792A, relative uncertainty includes only stability, temperature coefficient, noise, and linearity specifications. Relative uncertainty excludes the error contributions of its own calibration process and transfer error during use.

reliability

A measure of the "uptime" of an instrument.

repeatability

The degree of agreement among independent measurements of a quantity under the same conditions. (Same as "precision.")

resistance

A property of a conductor that determines the amount of current that will flow when a given amount of voltage exists across the conductor. Resistance is measured in ohms. One ohm is the resistance through which one volt of potential will cause one ampere of current to flow.

resolution

The smallest change in quantity that can be detected by a measurement system or device. For a given parameter, resolution is the smallest increment that can be measured, generated or displayed.

reversal error

Also called turnover error, the difference in output of an ac-dc transfer standard for the same dc input but with polarity reversed. The output logged for the dc reference should be the average of the two readings.

retrace error

For an ac-dc transfer standard, the degree of agreement of output value readings when input is applied, removed, and reapplied over a specified time period.

rf (radio frequency)

The frequency range of radio waves; from 150 kHz up to the infrared range.

rms (root-mean-square)

The value assigned to an ac voltage or current that results in the same power dissipation in a resistance as a dc current or voltage of the same value. The rms value of a sine wave is equal to 0.707 times the peak value. The formula used to compute the rms value of an ac voltage is: the square root of the means of the squares of the instantaneous values over a complete period.

rms sensor

A device that converts an ac voltage to a proportional dc voltage with great repeatability. RMS sensors operate by measuring the heat generated by a voltage through a known resistance (i.e., power), or by performing an analog computation. Also see rms (root-mean-square).

scale

The absolute span of the reading range of a measurement device including overrange capability.

scale error

Same as gain error. Scale or gain error results when the slope of the meter's response curve is not exactly 1. A meter with only scale error (no offset or linearity error), will read 0V with 0V applied, but something other than 10V with 10V applied.

secondary standard

A standard maintained by comparison with a primary standard.

sensitivity

The degree of response of a measuring device to the change in input quantity, or a figure of merit that expresses the ability of a measurement system or device to respond to an input quantity.

settling time

The time it takes for the transfer standard output to stabilize after a voltage is applied to the input. Settling time for the 792A is 60 seconds on the active ranges (below 2.2V) and 30 seconds on the passive ranges (2.2V to 1000V).

shield

A grounded covering device designed to protect a circuit or cable from electromagnetic interference.

SI System of Units

The accepted International System of Units. See also "units," "base units," and "derived units."

specifications

A precise statement of the set of requirements satisfied by a measurement system or device.

square law

Defines the response of a device whose output is proportional to the square of the applied stimulus. Thermocouple-type transfer devices have a square-law response.

stability

A measure of the freedom from drift in value over time and over changes in other variables such as temperature. Note that stability is not the same as uncertainty.

standard

A device that is used as an exact value for reference and comparison.

systematic errors

Errors in repeated measurement results that remain constant or vary in a predictable way.

temperature coefficient

A factor per °C deviation from a nominal value or range by which the uncertainty of an instrument increases. This specification is necessary to account for the thermal coefficients in an instrument.

temperature coefficient of ac-dc difference

For an ac-dc transfer standard, the change of ac-dc difference correction with a specified change in temperature.

temperature coefficient of output

The change of the output value of an instrument with a specified change in temperature, but no change of the input value.

thermal emf

The voltage generated when two dissimilar metals joined together are heated.

traceability

The ability to relate individual measurement results to national standards or nationally accepted measurement systems through an unbroken chain of comparisons, i.e., a calibration "audit trail."

Measurements, measurement systems, or devices have traceability to the designated standards if and only if scientifically rigorous evidence is produced on a continuing basis to show that the measurement process is producing measurement results for which the total measurement uncertainty relative to national or other designated standards is qualified.

transfer

See "ac-dc transfer."

transfer error

The sum of all new errors induced during the process of comparing one quantity with another. Also see "ac-dc absolute uncertainty." (This quantity can also be expressed as "transfer uncertainty.")

transfer stability

Change in the ac-dc difference correction over time, with stated conditions.

transfer standard

Any working standard used to compare a measurement process, system or device at one location or level with another measurement process, system, or device at another location or level.

transport standard

A transfer standard that is rugged enough to allow shipment by common carrier to another location.

true value

Also called legal value, the accepted consensus, i.e., the correct value of the quantity being measured.

uncertainty

The maximum difference between an accepted or true value and the measured value of a quantity. Uncertainty is normally expressed in units of ppm (parts per million) or as a percentage. (Accuracy is the same as 1 - % uncertainty.)

For example, if it is known that a calibrator outputs 10V dc with a known accuracy of 99.97%, the uncertainty of the calibrator is said to be 0.03%.

units

Symbols or names that define the measured quantities. Examples of units are: V, mV, A, kW, and dBm. See also “SI System of Units.”

UUT (Unit Under Test)

An abbreviated name for an instrument that is being tested or calibrated.

volt

The unit of emf (electromotive force) or electrical potential in the SI system of units. One volt is the difference of electrical potential between two points on a conductor carrying one ampere of current, when the power being dissipated between these two points is equal to one watt.

watt

The unit of power in the SI system of units. One watt is the power required to do work at the rate of one joule/second. In terms of volts and ohms, one watt is the power dissipated by one ampere flowing through a one-ohm load.

wideband

AC voltage at frequencies up to and including the radio frequency spectrum.

verification

Checking the functional performance and uncertainty of an instrument or standard without making adjustments to it or changing its calibration constants.

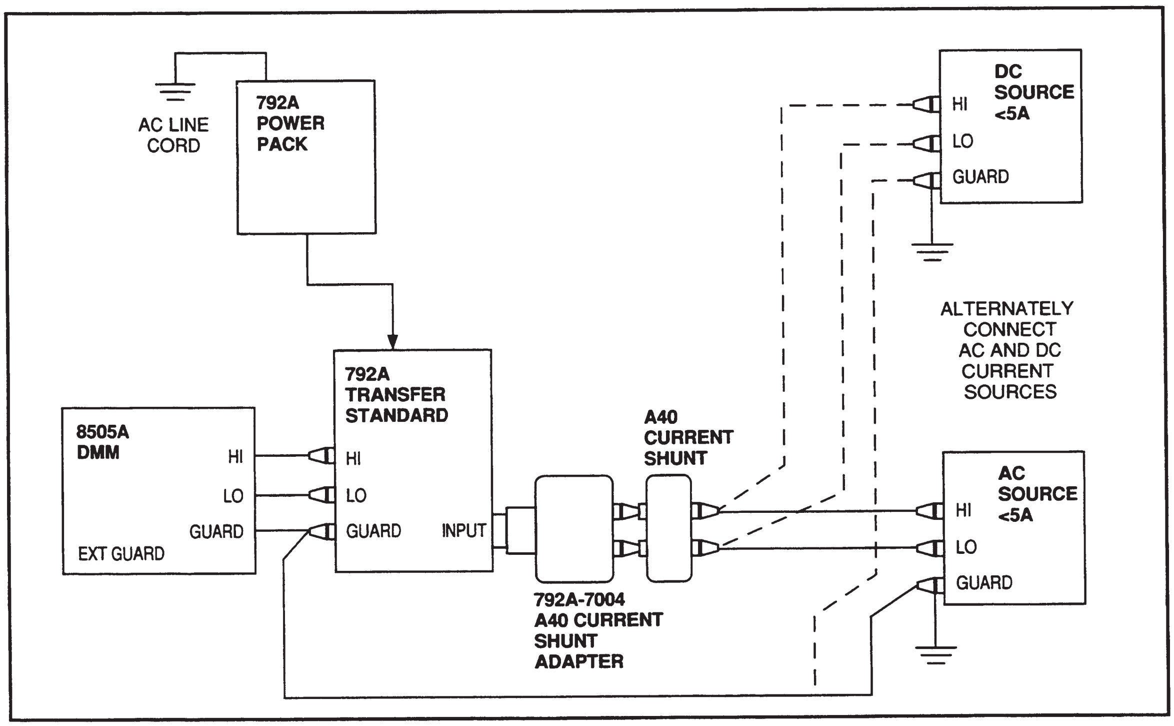
working standard

A standard that is used in routine calibration and comparison procedures in the laboratory and is maintained by comparison to reference standards.

zero error

Same as offset error. The reading shown on a meter when an input value of zero is applied is its zero or offset error.

Appendix B
Using the 792A-7004 A40 Current Shunt Adapter



Using the 792A-7004 A40 Current Shunt Adapter

Appendix C
Calculating Correction Factors for F<100 Hz

Ideally, any voltage-frequency pair used has a calibration point, or cardinal point, included in the 792A Test Report. However, if the voltage or frequency desired is near a cardinal point, the correction and uncertainty may still be usable. The correction for ac-dc difference from the Test Report and the uncertainty from the Specifications still apply if:

1. The operating frequency is in the range of 100 Hz to 1 MHz and,

2. The variation in frequency and/or voltage from the calibration point is 2% or less.

To calculate a new correction factor for different frequencies in the 10 Hz to 100 Hz range (but still within 2% of nominal frequency), see FREQUENCY VARIATIONS. To calculate a new correction factor for different voltages in the 10 Hz to 100 Hz range (but still within 2% of nominal voltage), see VOLTAGE VARIATIONS. The interpolation techniques under those headings only apply for the 2.2V range and above.

NOTE

AC-DC difference corrections for the input ranges 700 mV and below in the frequency range 10 Hz to 100 Hz are functions of two separate second-order terms, making it difficult to apply interpolation techniques. However, once a correction has been assigned through calibration, the correction is stable and the same uncertainty applies.

Table C-1. Summary of Frequency and Voltage Interpolation Techniques

VOLTAGE RANGE	10 Hz 20 Hz 40 Hz	100 Hz 1 kHz 10 kHz 20 kHz 50 kHz 100 kHz 300 kHz 500 kHz 1 MHz
22 mV 220 mV 700 mV	In this area interpolation **doesn't work**	In this area interpolation is not required for voltages and frequencies within 2% of a cardinal point in the Test Report. The correction and uncertainty specification still apply.
2.2V 7V 22V 70V 220V 1000V	In this area Calculate using: "diff = a freq ^{2}+ b" or "diff = V_{in}^2 + d"	

FREQUENCY VARIATIONS

For nominal frequencies from 10 Hz to 100 Hz in the voltage ranges of 2.2V and above, the ac-dc difference is proportional to the inverse of the frequency squared, i.e.,

$$\text{ac-dc difference} = \frac{a}{(\text{freq})^2} + b \qquad (1)$$

At the voltage of interest, select the two frequencies on the same voltage range nearest the frequency of interest (freq), and using those values, solve for a and b in equation (1) above, i.e.

$$\text{ac-dc diff1} = \frac{a}{(\text{freq}_1)^2} + b$$

$$\text{ac-dc diff2} = \frac{a}{(\text{freq}_2)^2} + b$$

Once a and b have been determined, use equation (1) to calculate a new correction for frequencies different from, but within 2% of cardinal point frequencies in the Test Report. The uncertainty specification remains the same as that for the associated cardinal point on the Test Report.

EXAMPLE:

Assume the following ac-dc difference corrections from the 792A Test Report:

RANGE	INPUT	10 Hz	20 Hz	40 Hz
2.2V	2.0V	450	108	29

Problem:

Calculate the ac-dc difference at 19.6 Hz and 2V.

Solution:

Using the above equations,

$\text{ac-dc diff}_1 = 450$ ppm
$\text{ac-dc diff}_2 = 108$ ppm
$\text{freq}_1 = 10$ Hz
$\text{freq}_2 = 20$ Hz

Substituting:

$$450 = \mathbf{a} \quad 10^2 + \mathbf{b}$$
$$108 = \mathbf{a} \quad 20^2 + \mathbf{b}$$

Solving for a and b yields:

$$\mathbf{a} = 45{,}600$$
$$\mathbf{b} = -6$$

Substituting into equation (1) above:

$$\text{ac-dc difference} = \text{at 2V, 19.6 kHz} = \frac{45{,}600}{(19.6^2)} + -6$$
$$= \mathbf{113\ ppm}$$

NOTE

The uncertainty is the same as the uncertainty for 2V at 20 Hz.

VOLTAGE VARIATIONS

For frequencies from 10 Hz to 100 Hz in the voltage ranges of 2.2V and above, the ac-dc difference is proportional to the voltage squared, i.e.,

$$\text{ac-dc difference} = \mathbf{c} \times V_{in}^2 + \mathbf{d} \qquad (2)$$

At the frequency of interest, select the two voltages on the same voltage range nearest the voltage of interest (Vin), and using those values, solve for c and d in equation (2) above, i.e.

$$\text{ac-dc diff1} = \mathbf{c} \times V_{in1}^2 + \mathbf{d}$$

$$\text{ac-dc diff2} = \mathbf{c} \times V_{in2}^2 + \mathbf{d}$$

Once c and d have been determined, use equation (2) to calculate a new correction for voltages different from, but within 2% of cardinal point voltages in the Test Report. The uncertainty specification remains the same as that for the associated cardinal point on the Test Report.

EXAMPLE

Assume the following ac-dc difference corrections from the 792A Test Report:

RANGE	INPUT	10 Hz
2.2V	0.6V	114
2.2V	1.0V	158
2.2V	2.0V	440

Problem:

Calculate the ac-dc difference at 10 Hz and 1.96V

Solution:

Using the above equations,

$$\begin{aligned} \text{ac-dc diff}_1 &= 440 \text{ ppm} \\ \text{ac-dc diff}_2 &= 158 \text{ ppm} \\ V_{in1} &= 2\text{V} \\ V_{in2} &= 1\text{V} \end{aligned}$$

Substituting:

$$440 = \mathbf{c} \times 2^2 + \mathbf{d}$$
$$158 = \mathbf{c} \times 1^2 + \mathbf{d}$$

Solving for c and d yields:

$$\mathbf{c} = 94$$
$$\mathbf{d} = 64$$

Substituting into equation (2) above:

$$\text{ac-dc difference at 19.6V, 10 Hz} = 94 \times (1.96)^2 + 64$$
$$= \mathbf{425\ ppm}$$

NOTE

The uncertainty is the same as the uncertainty for 2V at 10 Hz.

Appendix D
Establishing Traceability for a High Performance AC/DC Transfer Standard

Establishing Traceability for a High Performance AC/DC Transfer Standard

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ABSTRACT

Introduction of new, high accuracy alternating voltage DMMs and calibrators in the past few years has presented the electronics test equipment industry with the challenge of supporting their accuracy. A group at Fluke was tasked with developing an AC/DC Transfer Standard having uncertainties of about ±10 ppm at moderate levels and frequencies, an accuracy which results in a ratio of product specification to NIST uncertainty of about 2:1. A major challenge was to develop and communicate a credible calibration system to support this product. Rigorous application of statistical principles to successive intercomparisons of nearly identical artifacts had already been proven capable of maintaining a Direct Voltage Standard within a few parts in 100 million of the 10 volt standard maintained at NIST, a ratio of about 1.2:1. This paper describes the system which was developed to support traceable calibration of this new AC/DC Transfer Standard through application of these proven statistical techniques.

INTRODUCTION

Fluke's 8506A Digital Multimeter (DMM), among others, has improved accuracy of routine measurement of alternating voltage to the point that calibrators are hard pressed to keep up. One new DMM can be *adjusted* using only a 10 volt DC standard and two resistors, but still must be *verified* by comparison to independent standards in order to confirm that the internal metrology is actually working as it was designed to work. The 8506A is calibrated (adjusted) in the conventional way, by bringing up a known, higher accuracy standard of alternating voltage.

Calibrator manufacturers have responded to the challenge by introducing new, ever more accurate instruments including Fluke's 5700A and competing products. The 5700A uses "Artifact Calibration" to support the accuracy of DC functions and resistance, and depends upon the stability of an internal AC/DC Transfer Standard for its AC accuracy. The accuracy of the internal AC/DC standard must be independently verified at least each two years for the calibrator to perform to specifications.

Mil-Std-45662A mandates a 4:1 Test Uncertainty Ratio (TUR) between the calibrator and the instrument calibrated unless another ratio can be justified. Currently manufactured calibrators have accuracies which are already less than 4 times the uncertainty routinely provided by NIST at some levels and frequencies. It is obvious that another approach will be required to support these calibrators. NIST has addressed this problem by offering extra-cost improved uncertainties (as small as ±5 ppm at some levels and frequencies). Fluke has developed the 792A AC/DC Transfer Standard to provide a traceable standard which meets the requirements of the 5700A and other existing calibrators. Design goals for the standard require an accuracy at time of use of approximately ±10 ppm at moderate levels and frequencies, a TUR of 2:1 from NIST's best accuracy.

Supporting a TUR as low as 2:1 cannot be accomplished by the usual procedure of shipping a standard to NIST for calibration, then using it for a year at the uncertainty NIST assigned to it. A much more complex approach is required, one which utilizes the principles of measurement process control. This paper describes the calibration system which was developed to support the accuracy of Fluke's new 792A AC/DC Transfer Standard. At the time of this writing, the first complete transfer from NIST had not yet been accomplished, so some of the statements and conclusions are necessarily in the future tense.

APPROACH

Precedents

Statistical methods for computing and controlling the accuracy of calibrations were developed by NBS and others over twenty years ago, and have gradually begun to be adopted in industry. Application of these statistical methods makes it unnecessary to maintain arbitrary TURs since the uncertainty in any transfer can be computed with confidence. One of the more useful statistical approaches utilizes linear regression (linear curve fitting) to predict the drift rate of a standard, to compute a value for the standard which is "better" than the result of any one calibration, and to predict a value at points (times) different from the calibration points.

(References [1] and [2] have good descriptions of the statistics of linear regression. Reference [3] is an especially clear presentation of the application of statistics to measurements.)

Rolf Schumacher [4] has shown that the value computed from linear regression on a set of data is less uncertain than any individual calibration result, even when that result was provided by a NIST calibration. Deming (as quoted by Schrenkenbach [5]) reached a similar conclusion based on his understanding that variability exists in every process, and that overadjusting to respond to variability in a process can actually double the resultant variability. The common practice of using the latest NIST value as the proper value until another calibration is performed can actually degrade the accuracy of a given calibration system.

Fluke has had extensive experience with application of statistical methods to calibration of instruments in designing and implementing its corporate 10 volt voltage standard [6], and its Direct Voltage Maintenance Program (DVMP) [7]. The uncertainties which can be achieved with well behaved standards and repeated transfers to a stable and well maintained standard at NIST are almost incredibly small. For example, the drift rate of Fluke's Corporate voltage standard is now known to within about ±0.02 ppm per year, and its absolute value *relative to NIST's 10 volts* is known to within about ±0.05 ppm.

These uncertainties are the result of an unusually high number of transfers to NIST, and more importantly, to the existence of an unusually well designed and maintained system for the calibration of 10 volts at NIST. The situation will be less ideal for the AC/DC standard, but nonetheless, the approach is valid, and has been chosen as the best one for maintaining accuracy of AC/DC Difference at Fluke.

The Calibration Support System

Because of the very small TURs involved, the 792A will be provided with a correction table instead of being constructed to provide a specified absolute accuracy at time of use. That is, the accuracy will be provided through correction tables, not through hardware, as is done for many standards. Therefore, part of the production process will consist of calibrating the 792A and generating the correction table. As a result of this requirement, traceability must be provided for the product as shipped. A flow chart for traceability from NIST to the Fluke Primary Standards Laboratory, then to production test, and finally to the product is presented in Figure 1.

Two 792A AC/DC Transfer Standards have been established in the Fluke Primary Standards Laboratory to form the Fluke Corporate Reference Standard for AC/DC Difference. The reference standard will be calibrated by connecting a NIST calibrated 792A to the test port and "test" 792As will be calibrated by connecting them to the same port. A constant bias in the comparison of the (internal) reference standards will not cause an error so long as nearly identical devices are being compared. The reference standard is thus little more than an apparatus for storing and transferring values obtained from NIST via the first transfer standard. Two (or more) transfer standards, also 792As, are compared to the Reference Standard frequently, and for an extended time period. These comparisons establish the offset between the Reference Standard and the Transfer Standards, and as well as any difference in drift rates which may exist. These transfer standards will transfer NIST values to the reference standard and from the reference standard to production test.

Figure 2 is a block diagram of the comparison system. The 792As, utilizing the Fluke RMS Sensor, provide a full-scale output of approximately 2 volts DC, which is measured by a Fluke 8500 series digital multimeter. Since the reference standard consists of two 792As, and the "standard" AC/DC difference is the mean of the two, it is appropriate to compare "test" instruments to both standards at once. This is accomplished by connecting the "test" instrument to the test port, the open end of type N tee #1. The reference plane for the comparison apparatus is the center of that tee.

Both DC and alternating voltage are supplied to the input port of type N tee #1 from a 5700A/5725A combination. The responses of the 3 792As are measured by means of the 8500-series DVMs, which are read over the IEEE bus by the Fluke 1722A Instrument Controller. The controller also sets levels and frequencies for the calibrator, computes AC/DC differences, and prints results onto a floppy disk as well as an

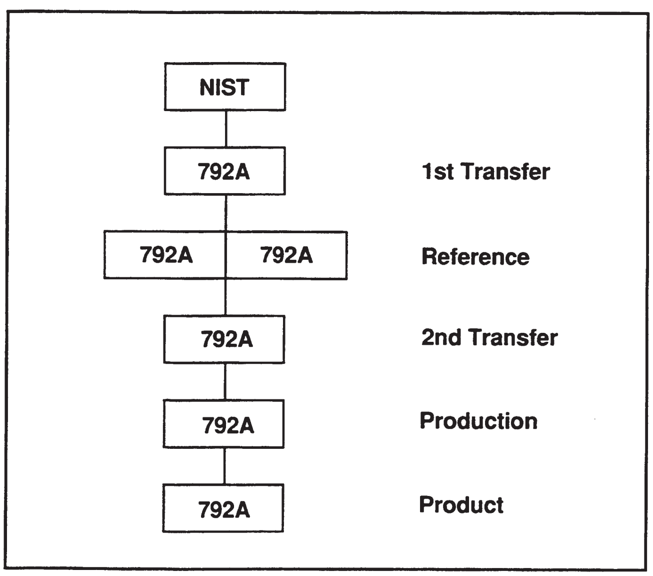

Figure 1. Flow Chart for Traceability from NIST to Product.

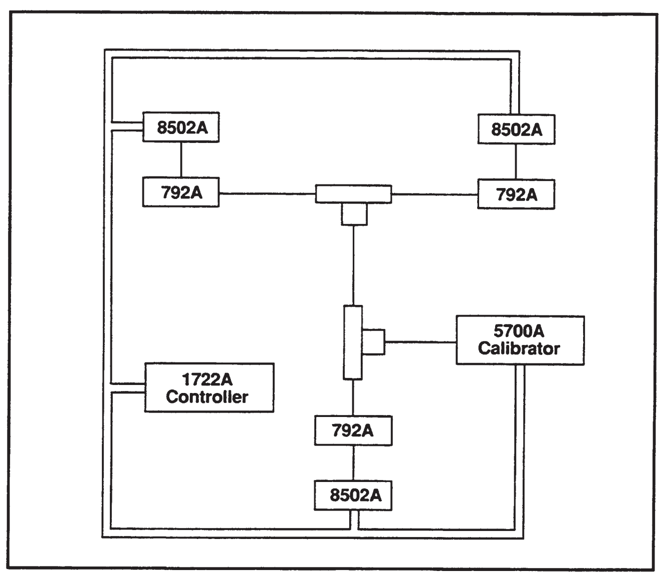

Figure 2. Block Diagram of the 792A Comparison System.

Epson LQ-850 Printer. Except for the turning of the 792A range switches, the operation is completely automated. Typical standard deviations for repeat comparisons at moderate levels and frequencies is approximately 0.25 ppm, increasing at higher and lower levels and frequencies.

After the comparisons are completed, one of the transfer standards is shipped to NIST for calibration, a process which is expected to require about ten weeks, since the highest available accuracy is required. At the end of the ten weeks, the standard is returned to Fluke, and additional comparisons to the reference standard are performed to detect any changes in its offset which might have occurred while the transfer standard was away from the laboratory. At this early stage, any such changes are attributed to the transfer standard drifting relative to the reference standard. It is possible to calibrate the reference standard in the presence of such drifts, because the relative drift rate has been determined, and the time of the NIST calibration is known.

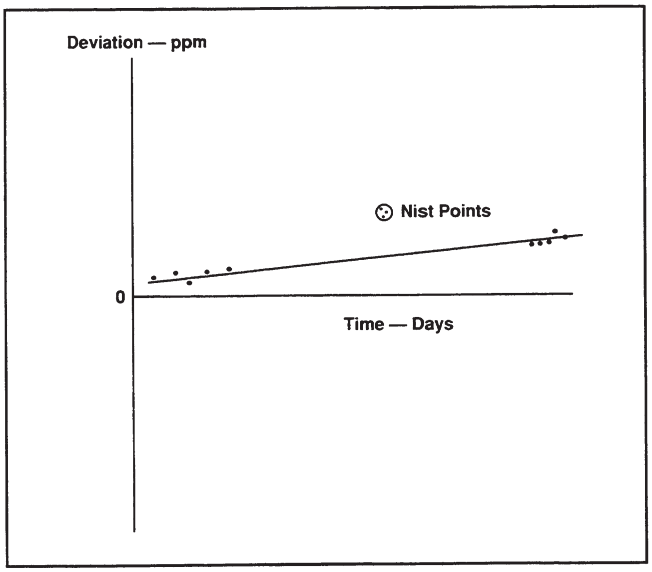

Figure 3. A "Typical" Transfer From NIST.

Upon completion to this second set of comparisons, we have completed the first calibration of the reference standard, a process which has required some sixteen weeks to accomplish. Figure 3 illustrates the transfer from NIST to the reference standard. The comparisons at Fluke establish transfer standard drift rate and offset relative to the reference standard. At this point, the calibration of the second transfer standard is also completed, since it has been previously and repeatedly compared to the reference standard. When the comparisons to the reference have been completed, the first transfer standard is returned to NIST for a second calibration, and the process is repeated until the uncertainty in the reference standard's drift rate and offset from NIST standards have been reduced to acceptable levels.

It is planned to support the production standard in the same way as the reference standard, by repeatedly comparing the second transfer standard to the Production standard in the factory. This requires an additional echelon between NIST and production, however, and may be eliminated in favor of direct calibration of the production standard against the reference standard. The presentation here will assume use of a second transfer standard, since that is the more conservative approach.

MATHEMATICAL CONSIDERATIONS

Ultimately, the need is for bounding the difference between the AC/DC Difference assigned to a product manufactured at Fluke and the AC/DC Difference which would be assigned at NIST, that is, for assigning an uncertainty to a production instrument as it is shipped from the factory. (To avoid repeating "AC/DC difference" and "difference in the AC/DC difference" in the following, the word "value" will be used instead. This should cause no difficulty to the reader who has been warned that this is being done.)

In the following, it is assumed that everywhere in the traceability chain, except for the calibration at NIST, information about the value of a transfer standard is transferred by means of direct comparisons of nearly identical items. To the extent that this is true, it is possible to transfer values without bias, bias being defined as a consistent tendency for the measuring system to produce a value which is different from the "true value" of the difference between the two instruments.

Given unbiased comparisons, with the further assumptions that differences between two instruments actually yield a straight line representing value versus time, and that measured points are random, independent, and normally distributed about the line, it is appropriate to apply statistical methods developed for analysis of linear regression. Under these assumptions, a *confidence interval* for the line for a particular time, T, is given by

$$Y = A + BT \text{ +/- } ts*Sqr[1/n + (T - T_{bar})^2/((n-1)s_t^2]$$

where n is the number of points used in the regression, s is the sample standard deviation, t is student's t for n-2 degrees of freedom and confidence level (1-Alpha) (Fluke uses 99%), s_t^2 is the variance in T, and T_{bar} is average time over which the data are taken. The meaning of a prediction interval is as follows: If a large number of determinations of A and B are made each utilizing n independent samples from the same population, approximately (1-Alpha) of them are expected to fall within the computed confidence interval.

A *prediction interval* for a particular time, T, is given by

$$Y = A + BT \text{ +/- } ts*Sqr[1 + 1/n + (T - T_{bar})^2/((n-1)s_t^2]$$

For the average of n2 measurements, a modified prediction interval is

$$Y_{bar} = A + BT \text{ +/- } ts*Sqr[1/n^2 + 1/n + (T - T_{bar})^2/((n-1)s_t^2]$$

where n here refers to the total number of points used in the regression. Given the regression over n data points, with the assumptions listed above, a future value of Y (or Y_{bar}) can be expected to fall within the prediction interval a fraction (1-Alpha) of the time.

These equations apply only at a particular time, T, and the results at different times cannot be combined by the usual statistical methods because they are not independent, individual values having the standard deviation, s, in common. For those cases where the *whole line* is under consideration, which includes this case, student's t in the equations should be replaced by Sqr(2F) where F is the F-function for (2, n-2) degrees of freedom and the desired confidence level.

SAMPLE UNCERTAINTY CALCULATION

The test is initiated by comparing the first transfer instrument to the reference standard maintained in the Fluke Primary Standards Laboratory. This instrument will then be shipped to NIST, where it will be calibrated, then returned to Fluke after about 70 days. Upon its return, it will again be compared to the reference standard to determine whether there have been significant shifts in the difference between transfer and reference instruments. If such shifts are present, they will be assumed to be due to linear drift in transfer instrument, the reference units, or both. For these comparisons the equation is

$$V_r - V_{t1} = A_1 + B_1T \pm t_1s_1 * \mathrm{Sqr}[1/n_1 + (T - T_{bar})^2/((n_1-1)s_t^2]$$

where V_r is the value assigned to the reference unit, V_t^1 is the value assigned to the first transfer standard, t_1 and s_1 are student's t and standard deviation, n_1 is the number of points over which the regression is performed, and T_{bar} is the average time. For convenience later, write this as

$$V_r - V_{t1} = A_1 + B_1T \pm U_1$$

The transfer instrument is calibrated at NIST at average time T_n, with result

$$V_{t1} - V_n = A_n \pm U_n$$

where V_n is the value as measured by NIST and U_n is the NIST uncertainty. NIST does not separate its smallest uncertainties into random and systematic components, so for this analysis, the NIST uncertainty is considered to be systematic, and will be added to the random components of uncertainty. If time, T_n, is reported, then the reference standard may be calibrated using this transfer standard, even when the two are drifting relative to one another, since the difference versus time is known from the first equation.

With the results obtained so far, the reference standard can be calibrated and an approximate uncertainty calculated.

$$(V_r - V_{t1}) + (V_{t1} - V_n) = V_r - V_n$$

$$V_r - V_n = A_1 + B_1T + A_n \pm (U_1 + U_n)$$

The reference standard calibration is only an interim calibration, pending more data from NIST, since any possible drift in the reference has not been identified. At least one more NIST calibration is required to give *any* information about drift in the reference, and at least five will be required to provide a reasonable level of confidence in drift rate of the standard.

With the reference standard calibrated, the second transfer standard can now be calibrated. In this case, assume that there have been daily comparisons to the reference standard for the past 30 days. The equation is

$$V_{t2} - V_r = A_2 + B_2T \pm t_2s_2 * \mathrm{Sqr}[1/n_2 + (T - T_{2bar})^2/((n^2-1)s_{T2}^2)]$$

$$V_{t2} - V_r = A_2 + B_2T \pm U_2$$

Expressing this result in terms of the NIST value

$$(V_{t2} - V_r) + (V_r - V_n) = V_{t2} - V_n$$

$$V_{t2} - V_n = A_1 + A_2 + A_n + (B_1 + B_2)T \pm U$$

$$U = \mathrm{Sqr}(U_1^2 + U_2^2) + U_n$$

This uncertainty is approximate because it is not strictly proper to combine uncertainties in this way, even when dealing with normal distributions and equal confidence levels. However, it is possible to show that such a combination of uncertainties will always overestimate the uncertainty for normal distributions having equal confidence levels. For the purposes of this discussion, the approximation is sufficiently accurate. A rigorous treatment is available [8] and will be used in the actual error analysis.

Now the standard used in production test can be calibrated. For this example, it will be assumed that two transfers per week have occurred over the past 5 weeks, so that the calibration can be accomplished immediately upon completion of the transfer from NIST. For this transfer, the equation is

$$V_t - V_2 = A_3 + B_3T \pm U_3$$

$$U_3 = t_3s_3 * \mathrm{Sqr}[1/n_3 + (T - T_{bar})/((n_3-1)s_T^2)]$$

Expressing in terms of the NIST value

$$V_t - V_n = A_1 + A_2 + A_3 + A_n + (B_1 + B_2 + B_3)T \pm U$$

$$U = \mathrm{Sqr}(U_1^2 + U_2^2 + U_3^2) + Un$$

With the production test instrument calibrated, it is possible to calibrate product. Here a single measurement is made, and

$$V_p - V_t = A_4 \pm U_4$$

where $U_4 = 3s$ and s is a pooled standard deviation obtained from repeat measurements on several production instruments. Expressing in terms of NIST values

$$V_p - V_n = A_1 + A_2 + A_3 + A_4 + A_n + (B_1 + B_2 + B_3)T \pm U_p$$

$$U_p = \mathrm{Sqr}(U_1^2 + U_2^2 + U_3^2 + U_4^2) + U_n$$

Through this long string of transfers, a product has been calibrated traceable to NIST. What is the resultant uncertainty, U_p? More information is needed. Assume:

$$s = 0.5 \text{ ppm}$$

$n_1 = 10$	$t_1 = 3.355$	$T_{1bar} = 40$	$T = 80$
$n_2 = 30$	$t_2 = 2.763$	$T_{2bar} = 65$	$T = 80$
$n_3 = 10$	$t_3 = 3.355$	$T_{3bar} = 65$	$T = 80$

$$U_n = 5.0 \text{ ppm}$$

Using the equations developed above, the uncertainties at time of cal, here assumed to be 80 days after first measurements of the difference between transfer instrument #1 and the reference, are

$U_1 = 0.78$ ppm	$U_4 = 1.50$ ppm
$U_2 = 0.50$ ppm	$U_n = 5.00$ ppm
$U_3 = 0.61$ ppm	

$$U_p = 6.9 \text{ ppm}$$

Sixty days after cal (140 days after first measurement) the uncertainties will be, assuming no additional calibrations

$U_1 = 1.50$ ppm $\quad U_4 = 1.50$ ppm

$U_2 = 2.20$ ppm $\quad U_n = 5.00$ ppm

$U_3 = 2.67$ ppm

$$U_p = 9.1 \text{ ppm}$$

This result is not acceptable for supporting a 10 ppm 1-year spec, since there is no room for possible drift in the instrument. What this means is that the transfer and production standards must be calibrated more frequently than each 60 days if the product is to be supported. Current planning requires transfer to the second transfer instrument nearly continuously, and to production on a weekly basis.

Evidently, given the standard deviations and uncertainties listed here, the 792A can be calibrated in production with sufficient accuracy to support an "at cal" specification of ±10 ppm, even using this fairly conservative method of combining errors. If the BIPM recommendations for combining uncertainties were to be followed, and the NIST uncertainty were to be taken as a 3s estimate, all the 1s estimates of uncertainty would be combined in quadrature, then multiplied by 3, yielding $U_p = 5.3$ and 6.4 ppm for the two cases considered.

What has been demonstrated here is just a small part of the total task of supporting the calibration of the 792A in production, since only one level and frequency have been considered. In actuality, 13 voltage levels are calibrated at up to 14 frequencies, resulting in a total of 126 calibration points. Each point must be evaluated for total uncertainty just as was the single point in the example. Obviously, this will not be a manual calibration, and data must be collected, processed, and to a large extent, interpreted by computer.

Customers for the 792A will be spared the cost and effort of developing a sophisticated system to support their instruments, since they will be able to have them calibrated directly by NIST, or by another provider of calibration services, such as the Fluke Technical Centers.

CONCLUSION

This paper has described the approach adopted for establishing traceability of the Fluke 792A AC/DC Transfer Standard as shipped from production. The test uncertainty ratio between product spec at time of use and uncertainty provided at NIST will be about 2:1, and there are 4 transfers between NIST and product. As a result, the test uncertainty ratio for any given transfer must approach 1.1:1. The system adopted utilizes statistical treatment of data to achieve the required low transfer uncertainties. An example of the uncertainty analysis shows that for the most critical ranges — those where NIST provides ±5 ppm and product spec is about ±10 ppm, the achievable test uncertainty ratios are adequate for the purpose.

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Appendix E
Using a Linear Thermal Transfer Standard for Precision AV/DV Transfers

Using a Linear Thermal Transfer Standard for High Precision AV/DV Transfers.

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Abstract

A linear solid state thermal transfer standard (Fluke 792A) has been developed to make high precision aV/dV transfers between 10 Hz and 1 MHz for input voltages between 2 mV and 1000 V. This paper highlights the unique characteristics of the new thermal transfer standard and then derives the equations and algorithms for making high precision aV/dV transfers. Using the new thermal transfer standard with these equations and algorithms, aV/dV transfers have been made with accuracies of 0.5 parts per million.

Introduction

A linear solid state thermal transfer standard (Fluke 792A) has been recently developed to make high precision aV/dV transfers between 10 Hz and 1 MHz. This new transfer standard has robust input protection, fast settling times, low output drift, and accepts any input between 2 mV and 1000 V. In order to efficiently use this device, new algorithms that can take advantage of the linearity of the thermal transfer standard were developed. This paper describes how the new algorithms were derived, beginning with the definition of the aV/dV difference, and then describing some of the unique characteristics of the 792A. Next is a brief description of the test system and its requirements. Once all of this background information has been presented, the algorithms and equations for making aV/dV transfers are derived, and some of the advantages of using the 792A are discussed.

Definition of the AV/DV Difference

The aV/dV difference of a transfer standard is defined [1] as

$$\delta|_{E_A = E_D} = \frac{V_A - V_D}{V_D} \tag{1}$$

where V_A is the ac input voltage, V_D is the average of the two directions of dc input voltage, and E_A and E_D are the ac and dc outputs respectively. It is often important to minimize the effects of output drift when determining δ. This can be accomplished by sequencing the input voltages in the following manner: DC+, AC, DC- or AC, DC+, DC-, AC. The second sequence is used for our tests and the dc inputs are adjusted, if necessary, to keep the transfer device operating at the same output voltage. Since both the dc source and the 792A are linear, it is easy to quickly adjust the input to get the desired output. Figure 1 shows how this sequencing can cancel the effect of the drift. If the second sequence is used V_A is the average of the two AC inputs, but if the first sequence is used V_A is the AC input. Even though the output drift rate of the 792A is negligible, it still may be necessary to cancel out the drift of the test device which can be significant. A good example of a device that has significant thermal drift is a thermal voltage converter (TVC).

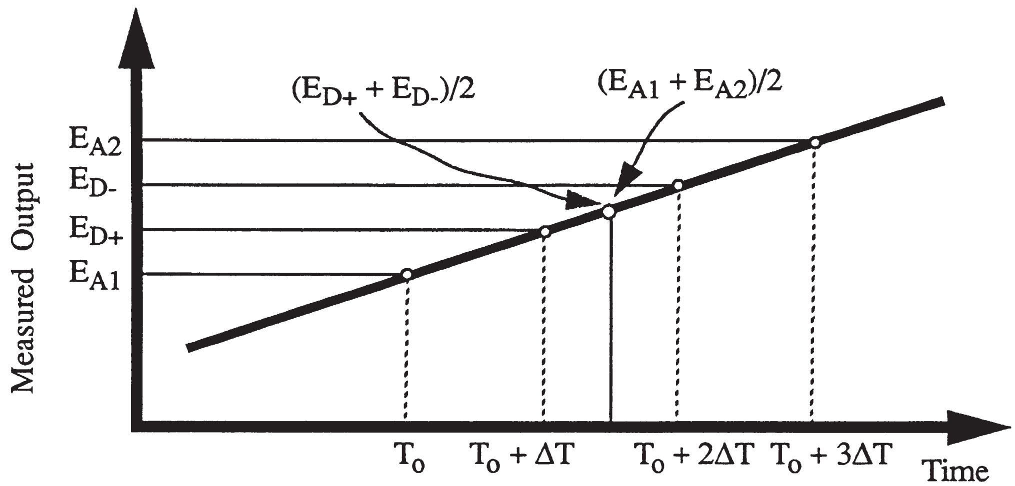

Figure 1. Thermal Drift Compensation

Thermal Transfer Standard Characteristics

One of the nice features of the 792A is that it converts AC voltage to DC voltage in a quasi-linear manner. From figure 2, it can be seen that the converter is linear to the first order, over its full dynamic range. However, for use as a high accuracy linear transfer standard the device needs to be linear to within a couple of parts per million (ppm) over the range of interest. Typically transfer standards are linearized by running an 'n test' [2]. If the 792A were perfect n would be exactly 1 for all input voltages. Unfortunately the 792A is not perfect and n does vary slightly from 1. Figure 3 shows the measured worst case values of n for all of the 792A ranges. Although n varies with input voltage even in the worst case n varies from 1 by less than 0.34%. This small variation from ideal behavior is insignificant when determining the test device's aV/dV difference.

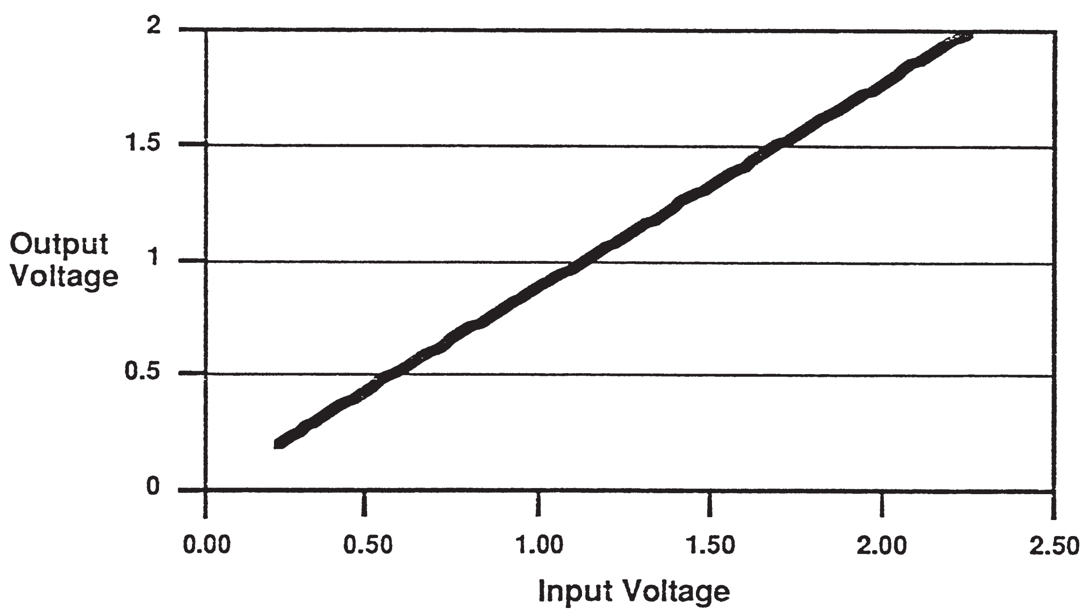

Figure 2. Linearity: 2 V Range, 0.22 to 2.2 Volts

Range	n	Range	n
22 mV	1.003	22 V	1.0030
220 mV	1.001	70 V	1.0032
700 mV	1.001	220 V	1.0034
2.2 V	1.0005	1000V	1.0034
7 V	1.0024		

Figure 3. Worst Case 792A 'n' Test Results

In addition to being linear, it is also important that the 792A settles quickly to input changes and that its output has negligible drift over the measurement period. The 792A does respond quickly to input changes. Even for a full-scale input, the 792A output settles in less than 30 seconds in the passive ranges and 60 seconds in the active ranges. For the 792A, the active ranges are 700 mV and below, and the passive ranges are all greater than 700 mV. Figure 4 shows typical settling times for full-scale input changes in the 220 mV, 2.2 V, and 1000 V ranges, where the 792A output has been normalized versus its output at its settling time of either 30 or 60 seconds. The normalization equation is Output(N sec)=(Output(settling time) - Output(N sec))/Output(settling time)*1E6. For both Figures 4 and 5, the transfer devices were idle for ten minutes before the constant DC input was applied. Figure 5 shows how slowly the 792A drifts even with a full scale step input in the 220 mV, 2.2 V, and 1000 V ranges. The fast settling time allows the measurements to be taken quickly, and the negligible drift means that the special sequencing and extra measurements taken to cancel out drift may be eliminated if the test device does not have significant drift.

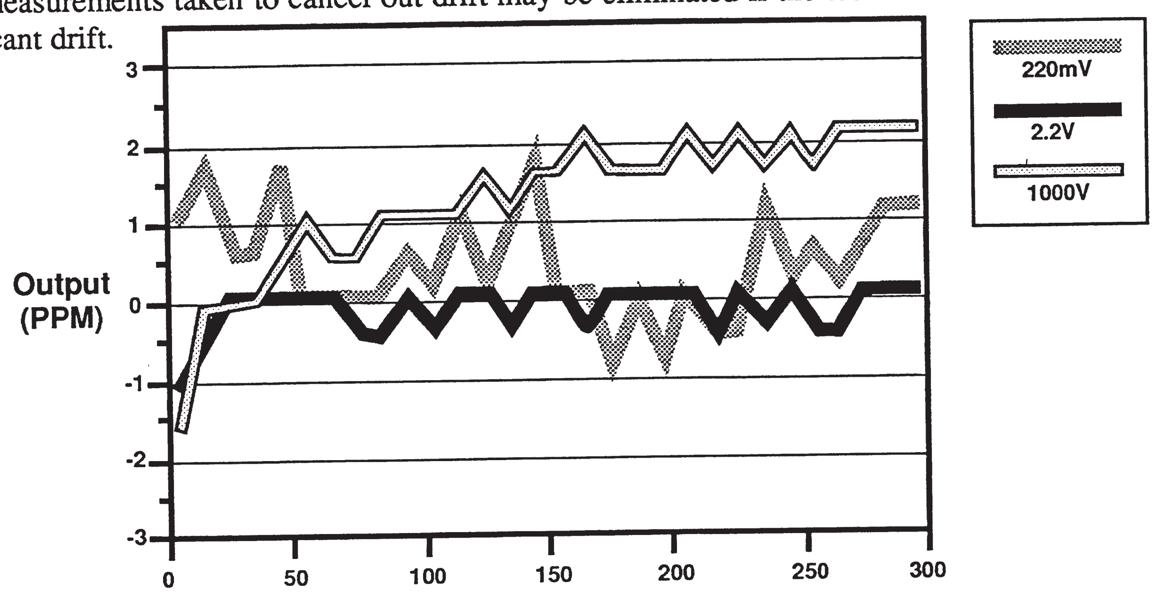

Figure 4. 792A Output Settling: 220 mV, 2.2 V & 1000 V Ranges

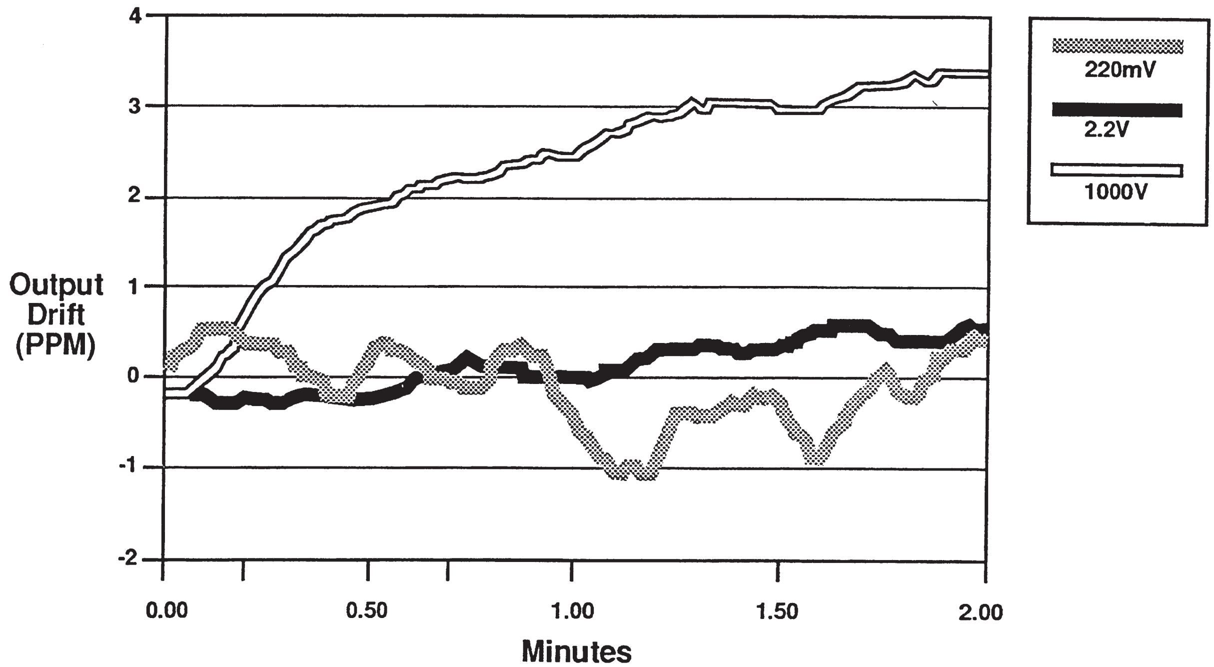

Figure 5. 792A Output Drift: 220 mV, 2.2 V & 1000 V Ranges

Hardware Configuration

The transfer system (Figure 6) consists of an IEEE-488 controller, a programmable source for

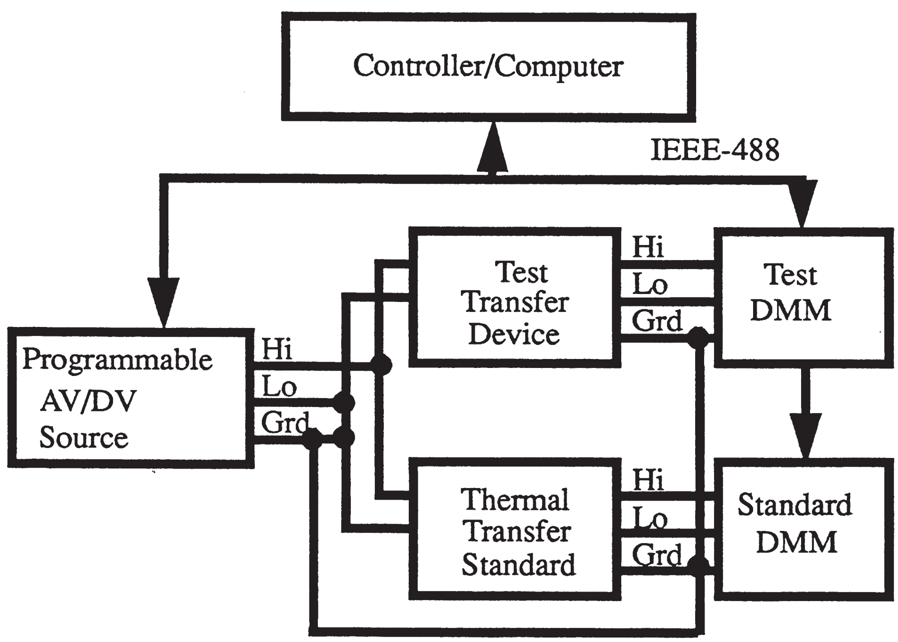

Figure 6. AV/DV Tranfer System Block Diagram

both alternating and direct volts, a thermal transfer standard, a test device, and two digital multimeters (DMM). For the general case, no assumptions need to be made about the characteristics of the test device. The controller/computer controls the sequencing and the timing of the system and records the DMM's readings. It then calculates the aV/dV difference of the test device using the

DMM readings and the characterized differences of the standard 792A. Since the full scale output voltage of the 792A is 2.0 V, the DMM needs to have at least 1 uV of resolution to provide accuracies of 0.5 ppm. A bottom of scale input will produce 0.6 V output for most ranges. Thus a DMM with 1 uV resolution can be accurate to within 1.33 ppm at bottom of scale. In addition to the resolution requirements, it is also very important that the DMM is linear. The requirements of the test DMM will depend upon the characteristics of the test device. The programmable source must be stable, and its output power spectrum should be free of unwanted signals that are within 60 dB of the primary output signal's magnitude. This requirement can be difficult when the source's output is 2 mV. The key to this system is the linear thermal transfer standard. Its linearity, fast settling time, and low drift rate, which simplifies the calculations necessary to make a transfer, come from its use of a solid state thermal RMS sensor [3]. Combining this hardware into a system allows a user to quickly and easily make high precision transfers from 2 mV to 1000 V for any frequency between 10 Hz and 1 MHz.

Software Algorithms

The procedure for making the aV/dV transfer is very similar to that used for making high precision transfers between thermal voltage converters (TVC) using the deflection method [2]. For the general case where the test device may be nonlinear, a test, such as the 'n' test for TVCs, is run to linearize the test device. Once this test has been run and the appropriate linearization constants are calculated, the transfers can begin. First AC, then DC+ is sourced into the test setup. The DC+ input may have to be adjusted to keep the test device operating at the same output level. Since the 792A is linear it is usually easiest to adjust the input by calculating the necessary shift from the 792A, and then checking the test device to make sure it has returned to the same operating point. Next DC- is input and adjusted if necessary. AC can be reapplied if there is a need to compensate for output drift in the test device. Once these steps have been done, the aV/dV difference of the test device can be calculated from the measured results.

Two different equations are derived below for making the aV/dV difference transfer. The first equation (11) is for a nonlinear test device, the second equation (14) is for any linear device. For all of these equations the 's' and the 't' subscript signify standard or test device respectively, and the 'd' and 'a' subscripts signify dc and ac respectively.

Transfers From a 792A to a nonlinear Test Device

For the general case, the test device may be a linear or a nonlinear device; thus, the first thing that must be done is to linearize the test device at the desired operating point. This is the 'n test' for TVCs, or some other test that is capable of determining the slope of the function at the points of interest. For a TVC the output is related to the input by $E = kV^n$. Values of n can be determined at several levels by applying known voltage changes ΔV/V and observing the output E and the changes in output ΔE. The equation for determining n is:

$$n = \frac{\Delta E}{E}\frac{V}{\Delta V} \qquad (2)$$

Now that the test device is linearized, it is time to determine the aV/dV difference. Applying equation (1) to figure 7, the aV/dV difference of the test and standard devices is seen to be the following

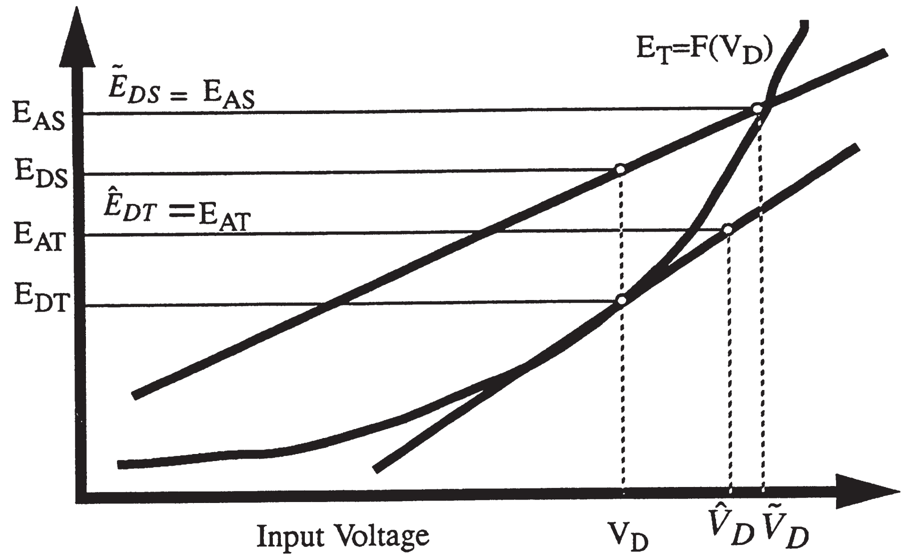

Figure 7. Linearization of the Test Device

$$\delta_T = \frac{V_A - \hat{V}_D}{\hat{V}_D} \tag{3}$$

$$\delta_S = \frac{V_A - \tilde{V}_D}{\tilde{V}_D} \tag{4}$$

Referring again to figure 7, it can be seen that $\tilde{V}_D$ and $\hat{V}_D$ are as follows.

$$\tilde{V}_D = V_D + \frac{E_{AS} - E_{DS}}{n_S E_{DS}} V_D \tag{5}$$

$$\hat{V}_D = V_D + \frac{E_{AT} - E_{DT}}{n_T E_{DT}} V_D \tag{6}$$

Solving (3) and (4) and for V_A and then setting them equal, equation (7) is generated.

$$(1 + \delta_T)\,\hat{V}_D = (1 + \delta_S)\,\tilde{V}_D \tag{7}$$

Equations (5) and (6) are substituted into equation (7) to yield

$$(1 + \delta_T)\left(1 + \frac{E_{AT} - E_{DT}}{n_T E_{DT}}\right) V_D = (1 + \delta_S)\left(1 + \frac{E_{AS} - E_{DS}}{n_S E_{DS}}\right) V_D \tag{8}$$

Then by dividing both sides of the equation by V_D and then doing some rearranging on equation (8), it can be transformed into this:

$$\delta_T\left(1 + \frac{E_{AT} - E_{DT}}{n_T E_{DT}}\right) = 1 + \delta_S + (1 + \delta_S)\frac{E_{AS} - E_{DS}}{n_S E_{DS}} - \left(1 + \frac{E_{AT} - E_{DT}}{n_T E_{DT}}\right) \tag{9}$$

Now solving for δ_T:

$$\delta_T = \frac{\left(\delta_S + (1+\delta_S)\dfrac{E_{AS}-E_{DS}}{n_S E_{DS}} - \dfrac{E_{AT}-E_{DT}}{n_T E_{DT}}\right)}{\left(1+\dfrac{E_{AT}-E_{DT}}{n_T E_{DT}}\right)} \tag{10}$$

Equation (10) can easily be programmed on a computer to obtain a solution for δ_T, but it is cumbersome to compute manually and it has some insignificant terms. It can be simplified by noting that $\delta_S \ll 1$, and by adjusting the dc input so that the term $(E_{AT} - E_{DT})/n_T E_{DT} = 0.001 \ll 1$. Also even for the worst case in the 792A, $n_S = 1.00$. (Refer back to figure 3 for a list of measured worst case values of n_S for the different ranges of the 792A.) The equation can thus be simplified to become:

$$\delta_T = \delta_S + \frac{E_{AS}-E_{DS}}{E_{DS}} - \frac{E_{AT}-E_{DT}}{n_T E_{DT}} \tag{11}$$

This equation is fairly simple and is similar to the equation for making transfers between TVCs. The major difference is that nothing special had to be done to linearize the 792A and using the 792A's output to adjust the DC inputs is faster and easier than using a TVC's output for the same purpose. It is important to minimize the differences $(E_{AS} - E_{DS})$ and $(E_{AT} - E_{DT})$ to obtain the highest accuracies using equation (11). A good rule of thumb would be to adjust the dc input so that E_{DS} was within 100 ppm of E_{AS}. The dc input can be adjusted using equation (5) and the fact that $n_S = 1.00$. Typically it only takes one adjustment to get the dc output to the desired level because the 792A is very linear.

Transfers From a 792A to another Linear Device

For the special case where the test device is another linear device, δ_T can be determined without doing a linearization. The second AC input step can also be skipped if the thermal drift rate of the test device is insignificant. For a linear test device with insignificant offset, $n_T = 1$. Substitute this into equation (10) to obtain equation (12).

$$\delta_T = \frac{\left(\delta_S + (1+\delta_S)\dfrac{E_{AS}-E_{DS}}{E_{DS}} - \dfrac{E_{AT}-E_{DT}}{E_{DT}}\right)}{\left(1+\dfrac{E_{AT}-E_{DT}}{E_{DT}}\right)} \tag{12}$$

Now doing some simplifications to the denominator and numerator, equation (13) is generated.

$$\delta_T = \frac{\left(\delta_S \dfrac{E_{AS}}{E_{DS}} + \dfrac{E_{AS}-E_{DS}}{E_{DS}} - \dfrac{E_{AT}-E_{DT}}{E_{DT}}\right)}{\left(\dfrac{E_{AT}}{E_{DT}}\right)} \tag{13}$$

Finally by eliminating the redundant terms and multiplying through the equation becomes

$$\delta_T = (1+\delta_S)\frac{E_{AS}}{E_{DS}}\frac{E_{DT}}{E_{AT}} - 1 \qquad (14)$$

When using equation (14), it is still necessary to adjust the source when the dc and the ac output voltages of the test and standard devices are not equal to within a small tolerance, say 100 ppm. This equation is a bit different from equation (11) because the only assumptions used to derive equation (14) is that n_T and n_S are 1.00

Conclusion

The 792A provides high accuracy aV/dV transfers with fast settling times, low or negligible output drift rates, and robust input protection. New algorithms and equations have been developed and proven to take full advantage of this new transfer standard. These algorithms allow the 792A to be used to make transfers to any transfer standard. These algorithms and equations combined with the new hardware will simplify the work necessary for making high precision aV/dV transfers.

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