FLUKE ®
Biomedical

ESA612

Electrical Safety Analyzer

Service Manual

PN 3477999
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Certification

This instrument was thoroughly tested and inspected. It was found to meet Fluke Biomedical's manufacturing specifications when it was shipped from the factory. Calibration measurements are traceable to the National Institute of Standards and Technology (NIST). Devices for which there are no NIST calibration standards are measured against in-house performance standards using accepted test procedures.

WARNING

Unauthorized user modifications or application beyond the published specifications may result in electrical shock hazards or improper operation. Fluke Biomedical will not be responsible for any injuries sustained due to unauthorized equipment modifications.

Restrictions and Liabilities

Manufacturing Location

The ESA~~612~~ Electrical Safety Analyzers are manufactured at Fluke Biomedical, 6920 Seaway Blvd., Everett, WA, U.S.A.

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Introduction and Specifications

Introduction

The Fluke Biomedical ESA~~612~~ Electrical Safety Analyzer (hereafter the Analyzer) is a full-featured, compact, portable analyzer, designed to verify the electrical safety of medical devices. The Analyzer tests to domestic (ANSI/AAMI ES1, NFPA 99) and international (IEC62353, AN/NZS 3551, and parts of IEC 60601-1) electrical-safety standards. The integrated ANSI/AAMI ES1 and IEC60601-1 patient loads are easily selectable.

Intended Use

The Analyzer is intended for use by trained service technicians to perform periodic inspections on a wide range of medical equipment. The testing procedures are menu-driven, and simple to operate.

Electrical Symbols

Table 1-1 lists the symbols with their definitions found on the Analyzer and used in this manual.

Table 1-1. Symbols

Symbol	Description
⚠	Important information; refer to manual.
	Do not dispose of this product as unsorted municipal waste. Go to Fluke's website for recycling information.
N10140	Conforms to relevant Australian EMC requirements
C US ®	Conforms to relevant Canadian and US standards
	Hazardous voltage
CE	Conforms to European Union directives
CAT II	IEC Measurement Category II – CAT II equipment designed to protect against transients from energy-consuming equipment supplied from fixed installations.
	Accessible Functional Earth Terminal

Product Manuals

The Analyzer ships with a printed Getting Started Manual and a Users Manual on a CD. The *ESA~~612~~ Getting Started Manual* gives a brief overview of the Analyzers controls and connections. The *ESA~~612~~ Users Manual* provides details on operating the Analyzer.

About this Manual

This is the *Service Manual* for the Analyzer. It contains all of the information a technician will need to verify the Analyzer's performance to specifications and calibration adjustments to bring the Analyzer's performance within specification. The manual is divided into the following chapters:

Chapter 1 "Introduction and Specifications" provides information on how to safely use the Analyzer and specifications.

Chapter 2 "Theory of Operation" provides information on how the Analyzer's circuitry functions.

Chapter 3 "Verification and Calibration" provides information on how to verify the

Analyzer's performance and bring its performance within specification.

Chapter 4 "Remote Operation" contains the remote commands to operate the Analyzer through its computer port.

Chapter 5 "List of Replaceable Parts" contains a complete list of part numbers with descriptions and associated illustrations to help locate each part.

Chapter 6 "Schematics" contain the schematics of the Analyzer.

Safety Information

In this manual, a **Warning** identifies hazardous conditions and actions that could cause bodily harm or death. A **Caution** identifies conditions and actions that could damage the Analyzer, the equipment under test, or cause permanent loss of data.

⚠⚠ Warning

To avoid possible electrical shock or personal injury, follow these guidelines:

- **Use this Analyzer only in the manner specified by the manufacturer or the protection provided may be impaired.**
- **Read the Users Manual before operating the Analyzer.**
- **Do not connect the Analyzer to a patient or equipment connected to a patient. The Analyzer is intended for equipment evaluation only and should never be used in diagnostics, treatment or in any other capacity where the Analyzer would come in contact with a patient.**
- **Do not use the product in wet or damp locations, around explosive gases or dust.**
- **Inspect the Analyzer before using it. Do not use the Analyzer if abnormal conditions of any sort are noted (such as a faulty display, broken case, etc.)**
- **Inspect the test leads for damaged insulation or exposed metal. Check test lead continuity. Replace damaged leads before using the Analyzer.**
- **When testing, always be sure to keep your fingers behind the safety barriers on the test leads.**
- **Never open the Analyzer's case. Dangerous voltages are present. There are no user replaceable parts in the Analyzer.**
- **Have the Analyzer serviced only by qualified personnel.**
- **The Analyzer must be properly earthed. Only use a supply socket that has a protective earth contact. If there is any doubt as to the effectiveness of the supply socket earth, do not connect the Analyzer. Do not use a two-conductor adapter or extension cord; this will break the protective ground connection.**
- **Do not use the 15-20 A adapter to power devices rated in excess of 15 A. Doing so may overload the installation.**

- **Use extreme caution when working with voltages above 30 V.**
- **Use the proper terminals, functions and ranges for the test being performed.**
- **Do not touch metal parts of the device under test (DUT) during analysis. The DUT should be considered an electrical shock hazard when connected to the Analyzer as some tests involve high voltages, high currents, and/or the removal of DUT earth bond.**

Specifications

Will be using ESA615 specs. So don't waste time marking this up.

Temperature	
Operating	10 °C to 40 °C (50 °F to 104 °F)
Storage	-20 °C to 60 °C (-4 °F to 140 °F)
Humidity	10 % to 90 % non-condensing
Altitude	
120 V ac mains supply voltage	5000 m
230 V ac mains supply voltage	2000 m
Display	LCD display
Communications	USB device port for computer control
Modes of Operation	Manual and remote
Power	
120 Volt power outlet	90 to 132 V ac rms, 47 to 63 Hz, 20 A maximum
230 Volt power outlet	180 to 264 V ac rms, 47 to 63 Hz, 16 A maximum
Weight	1.6 kg (3.5 lb)
Size	28.5 cm x 17.6 cm x 8.4 cm (11.2 in x 6.9 in x 3.3 in)
Safety Standards	
CE	IEC/EN61010-1 2nd Edition; Pollution degree 2
CSA	CAN/CSA-C22.2 No 61010-1; UL61010-1
Electromagnetic Compatibility Standards (EMC)	
European EMC	EN61326-1

Detailed Specifications

Test Standard Selections	ANSI/AAMI ES-1, IEC62353, IEC60601-1, and AN/NZS 3551
Voltage	
Ranges (Mains voltage)	90.0 to 132.0 V ac rms 180.0 to 264.0 V ac rms
Range (Point to point voltage)	0.0 to 300.0 V ac rms
Accuracy	±(2 % of reading + 0.2 V)
Earth Resistance	
Modes	Two terminal
Test Current	>200 mA ac
Range	0.000 to 2.000 Ω
Accuracy	±(2 % of reading + 0.015 Ω)
Equipment Current	
Range	0.0 to 20.0 A ac rms
Accuracy	±(5 % of reading + (2 counts or 0.2 A, whichever is greater))
Duty cycle	15 A to 20 A, 5 min. on/5 min. off 10 A to 15 A, 7 min. on/3 min. off 0 A to 10 A, continuous

Leakage Current

Modes*	AC+DC (True rms) AC only DC only * Modes: AC+DC, AC only, and DC only available for all leakages with exception of MAP that are available in True rms (shown as AC+DC)
Patient Load Selection	AAMI ES1-1993 Fig. 1 IEC 60601: Fig. 15
Crest factor	≤3
Ranges	0.0 to 199.9 μA 200 to 1999 μA 2.00 to 10.00 mA
Accuracy	
DC to 1 kHz	±(1 % of reading + (1 μA or 1 LSD, whichever is greater))
1 to 100 kHz	±(2 % of reading + (1 μA or 1 LSD, whichever is greater))
1 to 5 kHz (current > 1.6 mA)	±(4 % of reading + (1 μA or 1 LSD, whichever is greater))
100 kHz to 1 MHz	±(5 % of reading + (1 μA or 1 LSD, whichever is greater))

Note

Accuracy for Isolation, MAP, Direct AP, Alternative AP, and Alternative Equipment leakage tests all ranges are ±(2.5 μA or 1 LSD, whichever is greater).

Mains on applied part test voltage	100 % ±7 % of Mains for AAMI, current limited to 1 mA ±25 % per AAMI 100 % ±7 % of Mains for IEC 62353 current limited to 3.5 mA ±25 % per IEC 62353 100 % ±7 % of Mains for IEC 60601-1 current limited to 7.5 mA ±25 % per IEC 60601-1

Differential leakage

Ranges	75 to 199 μA 200 to 2000 μA 2.00 to 20.00 mA
Accuracy	±(10 % of reading + (2 counts or 20 μA, whichever is greater))

Insulation resistance

Ranges	0.5 to 20.0 MΩ 20.0 to 100.0 MΩ
Accuracy	
20 MΩ Range	±(2 % of reading + 0.2 MΩ)
100 MΩ Range	±(7.5 % of reading + 0.2 MΩ)
Source test voltage	500 V dc (+20 %, -0 %) 2.0 ±0.25 mA short circuit current or 250 V dc selectable
Maximum load capacitance	1 μF

ECG Performance Waveforms

Accuracy	
Frequency	±2 %
Amplitude	±5 % of 2 Hz square wave only, fixed @ 1 mV Lead II configuration
Waveforms	
ECG Complex	30, 60, 120, 180, and 240 BPM
Ventricular Fibrillation	
Square wave (50 % duty cycle)	0.125 Hz and 2 Hz
Sine wave	10, 40, 50, 60, and 100 Hz
Triangle wave	2 Hz
Pulse (63 ms pulse width)	30 BPM and 60 BPM

Chapter 2
Theory of Operation

Title	Page

Introduction

⚠⚠ Warning

To avoid electric shock, personal injury, or death, use extreme caution when servicing the Analyzer. The Analyzer can generate high voltages and currents.

The Analyzer tests electrical safety of medical equipment by making the following measurements:

- Resistance from the case of the instrument under test case to the power cord earth connection.
- Leakage current to the case of the instrument under test. This and all other leakage currents are measured across one of two standardized patient loads that simulate a human body
- Leakage current to earth
- Leakage current to patient electrical connections
- Leakage current to patient electrical connections when mains voltage is applied to the connections
- Insulation resistance from mains supply to various instrument under test points
- Although not a measure of electrical safety, mains voltage and equipment current are also measured
- These tests are preformed in various configurations as specified by different regulatory agencies. See the *ESA~~612~~ Users Manual* for more information of the agency standards.

Block Diagram Description

The Block Diagram shown in Figure 2-1 shows the two printed circuit assemblies (PCAs) ~~and the interconnection between them and the Analyzer connections.~~ A unique number in the upper-left corner of each block in the diagram references the Analyzer assemblies as follows: C = Chassis, P = ~~A1~~ Power pca, M = ~~A2~~ Meter ~~and User Interface (Meter) pca.~~ These numbers do not directly correlate to reference designators on the schematics.

~~A1~~ Power PCA

The mains connection is supplied through the Power Entry Module (C5), a 14-gauge cable (C4), a connector (P23), and the fuses (P16). The main power supply is a switching power supply module (P13). It is powered directly from mains power and operates from 90 to 264 V ac. The Analyzer has two circuit sections galvanically isolated from each other; one is earth referenced and is used mainly for the Equipment Outlet circuitry, and the other is used for the Meter circuits. The Earthed +12 V Supply [P13] drives the Isolated ±5 V Regulator (Reg) (P8), the Isolated +3.3 V Reg (P9), the Earthed +3.3 V Reg (P10) and is routed to the Meter PCA at connector (P1). The Isolated ±5 V Reg (P8) supplies power to the 250/500 V Reg (P3) and the 0.2 A Current Source (P4). The 250/500 V Reg is used for insulation resistance tests, which are measured by placing the voltage across the device and measuring the resultant current to calculate the resistance in the range of 0.5 - 100.0 MΩ. The 0.2 A is used for low resistance tests. The current is routed through the device to be measured and the resultant voltage is measured and used to calculate the resistance in the range of 0.0 – 2.0 Ω.

The Mains on applied part transformer (P14, MAP XFORMER) has a 1:1 ratio to generate an isolated mains voltage. MAP Current Limit (P11) sets the MAP current limit to 1 mA, 3.5 mA, or 7.5 mA for the various regulatory standards.

The Mains Meter (P15) attenuates mains voltage, measures it, and converts it to digital format. The digital signal is routed to the meter microprocessor (M19) on the A1 Meter pca through The Digital Isolator (P12) which provides galvanic isolation between the mains attenuator and the meter.

The Test Setup Relays (P5) connect the various current sources and voltages for different test setups. The relays are controlled by relay drivers (P6), which are isolated by the digital isolators (P7).

The Equipment Outlet (C7) is connected to the A1 Power pca through a 14-gauge cable (C6) and a connector (P24). Power relays are used to control the configuration of the Equipment Relay. Reverse Relays (P20) are for reversing hot and neutral. On/Off Relays (C19) are for opening hot, neutral or earth. There is a solid-state relay (P18), which is turned off before changing the state of the other equipment outlet relays and then turned on again to prevent arcing on loaded relays. The other set of reverse relays (P17) are used to reverse the polarity of incoming power if the Analyzer senses mains are reversed at the main input, thus providing extra relay protection by insuring that hot is routed through the solid state relay.

Two feed-through transformers ~~are connected in front of the equipment outlet to monitor current drawn by the device under test.~~ The Differential Current Transformer (P22, DIFF CUR XFORMER) monitors the difference in current between hot and neutral for the differential current test and for ground fault current detection. These signals are routed to the test setup relays (P5).

There are two cables between the two pcas, a 24-gauge cable (C2) between the connector (P1) and the connector (M34) for power signals and a Ribbon Cable (C3) connected between connector (P2) connector (M35) for digital signals.

~~A2~~ Meter and User Interface PCA

Power for the ~~A2~~ Meter and User Interface (Meter and U/I, or Meter) PCA is supplied by U/I Supplies (M22) and Meter Supplies (M23). These are powered from the Earthed +12 V Supply (P13) on the A1 Power PCA.

The U/I microprocessor (M14) operates the various user interface components. It writes to the display driver (M9) which controls the display (C1) through connector (M7). The display contrast is set by display contrast (M10). The U/I microprocessor reads the keys (M1) and sets the warning LED (M2). In addition, it controls the Audio Indicator (M8). It communicates with the meter microprocessor (M19) using an RS232 format through the digital isolators (M18). The U/I microprocessor also communicates with the port using an RS232 format through the digital isolators (M15) and the RS232 to USB converter (M11).

The meter microprocessor (M19) sets up tests by controlling all the relay drivers on both pcas (M17, M20, P6). The measured signal comes from several places: the meter jacks (M5), applied parts (AP) jacks (M4), and the equipment outlet (C7). These are routed through the test setup relays (M21) to the patient load (M32) and then to the buffer amplifier (M30, BUFFER AMP). The signal is then separated by the AC Only Filter (M26) and the dc Only Filter (M29). The ac signal is converted to a dc voltage proportional to the rms value by rms converter (M25) and converted to digital format by the multi-channel analog-to-digital converter (ADC) (M24). The meter microprocessor (M19) reads the ADC (M24), formats it for the specific measurement being taken, and sends it to the U/I microprocessor (M14). The BUFFER AMP (M30) is protected by the over-voltage detect (M31) which can open all relays through relay driver disable (M28). The ground Fault Detect (M33, GFI) receives a signal from the DIFF CUR XFORMER (P22) on the A1 Power PCA, and if the signal is over the programmable threshold, it shuts down the relays through the relay driver disable (M28).

The AP jacks (M4) are connected in various combinations to measurement circuit points depending on the test being performed. This is done by the relays (M13) and relay drivers (M17). The ECG waveform from the meter microprocessor (M19) is buffered and amplified by the ECG amplifier (M16, ECG AMP) and attenuated to the low voltages required for the ECG signals by the ECG Attenuator (M12, ECG ATTEN).

The null jack (M6) is connected only during the ground resistance check and is used to zero out the resistance of the test leads.

Block Diagram to Schematic Cross Reference

Tables 2-1 and 2-2 refer to one of the two schematics. The number in the first column references the number of a block on the block diagram (Figure 2-1). The second column is the page number for that pca’s particular schematic. The third column references the main parts on the schematic for that circuit. Some block diagram blocks do not have parts but are included for clarity only.

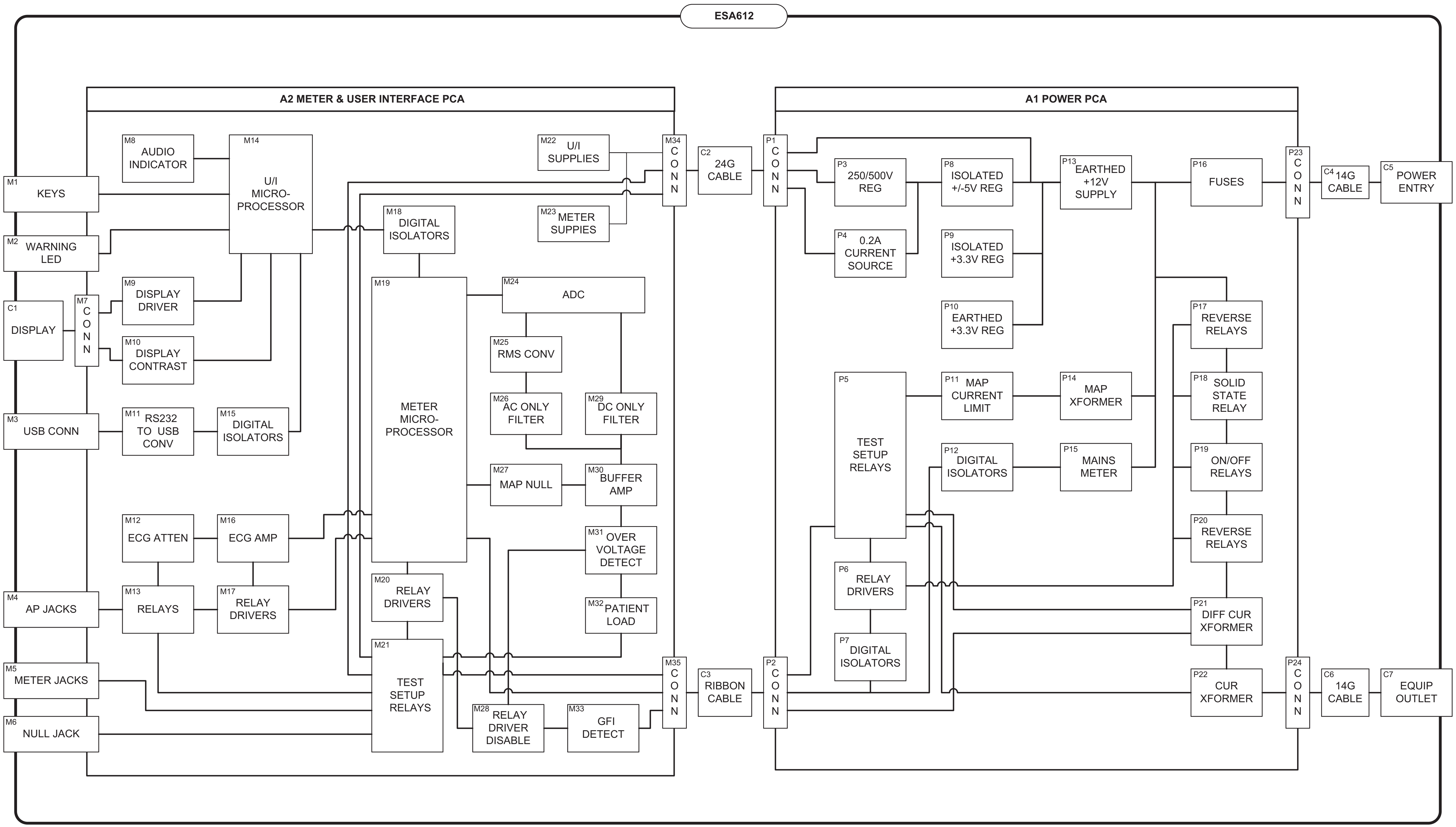


Figure 2-1. ESA612 Block Diagram

A1 Power PCA Schematic

Table 2-1 lists the cross-references for the A1 Power PCA schematics.

Table 2-1. A1 Power PCA to Schematic Cross Reference

Block Number	Schematic Page	Reference Designators
P1	3	J2
P2	3	J4
P3	4	T2 U17 U24
P4	4	U23 Q4
P5	1 2 4	K8 K9 U8 K12 K14 K17 K16 K13
P6	3	U14 U13 U16 U15 U25
P7	2	U2
P8	4	U18
P9	3	U28
P10	3	U12
P11	2	Q1 Q2
P12	3	U5
P13	4	U9
P14	2	T1
P15	1	R2-R7 R17 R18 U4 U3
P16	1	F1-F3
P17	1	K1 K2
P18	1	K3 K19
P19	1	K4 K5
P20	1	K6 K7
P21	1	L1 U1
P22	1	L3
P23	1	J5
P24	1	J1

A2 Meter and User Interface PCA Schematic

Table 2-2 lists the cross-references for the A2 Meter and User Interface PCA Schematics.

Table 2-2. A2 Meter and User Interface PCA Schematic Cross Reference

Block Number	Schematic Page	Reference Designators
M1	7	S3 S4
M2	6	DS1 Q1
M3	8	J3
M4	4	J60-J64
M5	1	P12 P13
M6	1	P24
M7	7	J1
M8	6	LS1 Q2
M9	7	U3
M10	7	U6 U5
M11	8	U7
M12	4	R53-R61
M13	4	K1-K10 K12 K22 K23
M14	6	U2
M15	8	U8
M16	4	U13
M17	4	U32 U33 U34 U35
M18	5	U42
M19	5	U40
M20	3	U35 U36 U55 U56 U38
M21	1 2	K13 K15-K19 K21U27 U25 U39
M22	8	U11 U10
M23	3	U48-U52
M24	2	U24
M25	2	U23
M26	2	U28 U26
M27	1	U21 U22
M28	3	U47 U49 U14
M29	2	U29 U31
M30	2	U54

Table 2-2. A2 Meter and User Interface PCA Schematic Cross Reference (cont.)

Block Number	Schematic Page	Reference Designators
M31	1	U18
M32	1	R78 R79 C100 R156
M33	3	U16 U17
M34	4	J20
M35	4	J4

Detailed Circuit Description

The following section describes the operation of the Analyzer circuits.

A1 Power PCA

The A1 Power PCA contains the power supplies, transformers, power relays, Equipment Outlet, and some of the test selection relays.

Equipment Outlet Relays

The circuitry along the top of the schematic on sheet 1 of the A1 Power PCA schematic controls the Equipment Outlet (EO). Mains is connected to the pca at J5. The EO is protected by fuses F1 and F2. Relays K1 and K2 reverse the polarity of mains in the event it is reversed at the input. Following this is a solid state relay, K19. This is turned off when any of the mechanical relays controlling the EO are switched, and then it is turned on again. This protects the mechanical relays from damage caused by inductive or incandescent loads or shorts. In the case of an EO short, the solid state relay can pass up to 900 amps for the time it takes the fuses (F1 and F2) to open. Relay K3 shorts out the solid state relay after all relay switching is done to keep power dissipation low. Relays K4 and K5 turn on the EO. Relays K6 and K7 reverse the polarity. EO ground is opened by relay K11.

Relay K12 connects the resistance measuring, current source return to the EO ground pin for earth resistance tests. Relay K14 connects the EO ground pin to the meter for earth leakage tests. Relay K8 connects the EO hot and neutral pins together for leakage and insulation resistance tests. Relays K9 and K10 connect the shorted EO hot and neutral pins to the meter, 500 V or the MAP voltage as required.

Equipment Outlet Current Measurements

Transformer L1 is a differential transformer with hot and neutral running through it. The difference in current between these is detected by the transformer. U1 converts the current to a voltage that is used for differential leakage measurements. This is selected for measurement by connecting it to PWR_GRP by closing U8 pins 14 and 15. The output of U1 is also connected to GFI_SENSE for measurement by the GFI Detect circuit on the A2 Meter PCA.

Transformer L3 is a current transformer that monitors the EO current for the equipment current measurement. ~~This~~ is selected for measurement by U8 pins 2 and 3.

Mains Measurement

Hot is routed through fuse F3 to protect the Analyzer's internal circuitry from excessive current. Mains voltages are measured and used to detect open ground, reverse polarity, and out of range conditions. Resistors R2, R3, R4, and R17 attenuate the hot to ground voltage and U4B buffers it. The neutral to ground voltage is similarly attenuated by resistors R5, R6, R7, and R18 then buffered by U4A. These analog signals are converted to digital signals by the two-channel analog to digital converter (U3, ADC). This has a two-wire serial port containing a clock and data line and a third line for chip selection. See page 3 of the A1 Power PCA schematic for further routing of the digital signals to and from the ADC. U7 monitors the hot to ground and neutral to ground signals to generate a mains zero-cross signal used by the meter microprocessor.

Isolated Mains Voltage (Mains on Applied Parts or MAP)

Transformer T1 is a 1:1 transformer that generates the isolated mains voltage used by many of the Analyzer tests. Transistors Q1 and Q2 form an active current limit circuit. The current limit can be set to 3 different values, 1 mA, 3.5 mA, and 7.5 mA depending on the selected international standard. U10 selects 3.5 mA, U29 selects 7.5 mA. As the current increases, the voltage across the selected resistor increases until it reaches about 7.5 V. At this point, Q2 begins to conduct preventing Q1 from being turned on any further. This clamps the current, but the voltage across Q1 can continue to increase. The bridge CR12-CR15 allows the circuit to operate with both polarities of current. Relay K17 connects the output to the test circuits and relay K16 reverses the polarity of the voltage.

Connectors

There are two connectors between the A1 Power PCA and the A2 Meter PCA. Jack J2 is a 6-pin 22-guage wire connector for high current signals. Jack J4 is a 20-pin ribbon cable for digital signals and low-current power supplies.

Isolation

To maintain galvanic isolation between the meter circuits and the earthed circuits, the digital signals are isolated by digital isolators U2 and U5. U2 isolates the relay driver signals and U5 isolates the Mains ADC signals. Optical isolators are used to isolate signals not needing the bandwidth of the digital isolators. U11 isolates the relay driver strobe and U6 isolates the mains zero cross signal. Power for the earthed side of the isolations is from the +3.3V supply U12. Power for the isolated side is from the +3.3V supply U28.

Relay Drivers

U14 and U16 are serial-in parallel-out shift registers. These have a three-wire serial interface with clock, data, and strobe lines. A fourth line, output enable (/OE), is used to enable or disable all the outputs and thus the relays. The outputs of the shift registers control the relay drivers U13 and U15.

Isolated Signals

Meter signal lines that control circuits on the isolated side are expanded by shift register U25, like the relay driver shift registers.

Power Supplies

The main power supply for the Analyzer is U9. This is a switching supply that can be driven from an ac source between 90 – 264 V ac and 50 - 60 Hz. The output is +12 V and is isolated from mains.

U18 is an isolated dc to dc converter module with output switching ±5 V dc. It powers the resistance measuring current source and the insulation resistance voltage source.

Resistance Current Source

Resistance is measured by applying a current to the resistance to be measured and measuring the voltage developed across it. The Analyzer uses a 200 mA ac source. U23 and Q4 form a precision current source. The current is set to 400 mA by the 1 Ω resistance made up of R85, R86, R76, and R59. U23 sets the voltage across the resistors equal to the reference voltage at pin 3. The reference voltage is from U22, a 1.2 V reference, divided down to 0.4 V by R77 and R78. Q4 provides the high output impedance needed for a true current source. Isolator U19 is switched on and off to turn the current source on and off to make the 200 mA ac current.

Insulation Resistance Test Voltage

The 500 V dc voltage source uses a transformer to boost the voltage. A pulse width modulator drives the primary of transformer T2 to set the secondary voltage. CR5 and CR10 rectify the secondary and C29 and C42 filter it, resulting in 500 V dc. The voltage is attenuated to 5 V by resistors R41, R56, R57, and R46. U17 compares this to its 5 V reference voltage and sets the width of the output pulses to maintain the divided voltage at 5 V. The voltage can be set to 250 V by turning off Q5 and turning on Q6. This changes the attenuator such that the output voltage is 250 V. U24 senses the return current to the transformer and shuts off the supply if it exceeds 1.5 mA. Relay K13 connects the supply for tests and when not selected, connects a resistance to ground to discharge capacitance in the device under test, R63 and R64.

~~A2~~ Meter and User Interface PCA Schematic

The A2 Meter and User Interface PCA contains the two microprocessors, the meter circuit, test jacks, keyboard USB port and display driver.

Meter Inputs

The meter input jacks are P12 and P13. These are connected for various tests by relays. Relay K13 connects the red jack to the patient load for leakage tests. Relay K15 connects the red jack to a voltage attenuator used for the Point to Point voltage. Relay K16 connects the red jack to earth through a current limiter. Relay K19 connects the red jack to the resistance current source. Relay K17 connects the black jack to the negative input of the meter, –Meter (GNDMA). Relay K21 connects the black jack to the resistance current source return. The null post, P24, is connected to –Meter (GNDMA) by relays K17 and K18 for nulling the test lead resistance for earth resistance measurements.

Patient Load

Leakage currents are measured across the patient load. Resistors R78 and R79 form the 1-kΩ resistance for the input of the AAMI and IEC60601 patient loads. For leakage currents greater than 2 mA, the meter input is switched from resistors R78 and R79 to divide the voltage by five. Resistor R68, capacitor C100, and resistor R156 form the rest of the patient load. Closing U27 pins 14 and 15 forms an AAMI load. Closing U27 pins 10 and 11 forms an IEC60601 load. Closing U27 pints 6 and 7 connects the load to the measurement circuits on page 2 of the meter schematic. With this open and U27 pins 2 and 3 shorted, the differential current and equipment current from the A1 Power PCA are selected.

Overvoltage Protection

Small over-voltages at the meter inputs are clamped by CR9, VR6, and VR7. Severe over-voltages over about 50 V are sensed through the attenuator U83, R86, and U18. This is routed to schematic page 2.

Mains on Applied Parts Compensation

The isolated mains voltage (MAP) used in many AP leakage tests causes a residual leakage that must be compensated for. Digital to analog converter (DAC) U21 and amplifier U22 generate an ac voltage waveform that accurately tracks the MAP voltage. This is summed with the meter input leakage current through C76. The digital value set in U21 sets the amplitude of this signal which is adjusted to cancel the residual leakage.

AC Only

U54 buffers the signal from the meter input circuitry. In the ac only mode, the signal is routed through U39 pins 10 and 11 to the ranging amplifiers U28 and U26. The gain is selectable to be 0.15, 1.5 or 15 by the state of analog switches U25. This signal is then AC coupled by C77 to the RMS converter U23. This generates a dc voltage equivalent to the rms value of the input signal. U31A forms a two-pole-low-pass filter to smooth out the signal from U23. Then the analog to digital converter (ADC) U24 converts this to digital format which is read serially by the meter microprocessor.

DC Only

The signal from buffer U54 is routed through U39 pins 14 and 15 for dc only mode. U29 and U31B form a five-pole low-pass filter with a cutoff frequency of 5 Hz. This removes all mains and higher frequencies. The resultant dc is then routed to the ADC.

Resistance Measurement

The current source used for resistance measurement is on the A1 Power PCA and is described above. U15 inverts the signal and U39 pins 14 and 15 and U39 pins 2 and 3 are toggled to rectify it. The signal at U46 pins 12 and 13 blanks both polarities for a period after the current is switched to eliminate inductive and capacitive effects.

Relay Drivers

U37, U36, U55, and U56 drive the relays on the A2 Meter PCA. The circuit is similar to the relay drivers section described in the A1 Power PCA section.

Meter Power Supplies

The meter is galvanically isolated from the earthed circuits. The power supplies are isolated by using isolated dc to dc converter modules. U48 is an isolated dc to dc converter modules that generates the +12 V isolated supply from the earthed +12 V supply for the relays. U51 is another dc to dc converter that outputs +5 V. U50 re-regulates this down to +3.3 V for the meter microprocessor. U49 outputs ±12 V used by the amplifiers and analog switches on the meter input. U53 and U52 re-regulate these to ±5 V for the remainder of the amplifiers.

Relay Disable

The overvoltage signal from page 1 of the meter schematic, /FAULT_SENSE, sets the RS flip-flop composed of U47A and B. This signal causes the /RELAY_EN (not relay enable) signal at U19 pin 13 to go high, shutting off all relay drivers in the instrument. To clear this fault, the meter microprocessor sets pin U47 pin 2 low to clear the flip flop. U14 is a brown-out detector which will also set the flip-flop at power up and power down to prevent the relays from being in undefined states while the microprocessor is powering up and down.

The /GFI_SENSE signal from the differential transformer on the power PCA is at mains frequency analog voltage. This is rectified and filtered by CR8 and C67. DAC U16 generates a digitally controlled voltage that is compared to the GFI signal at U17. When the voltage proportional to the GFI current exceeds the preset voltage, the output of U17 goes low setting the flip-flop, U47C and D, and, in turn, disabling the relays.

Applied Parts

The applied parts relay drivers, U32, U33, U34, and U35, operate as described previously. Each applied part post can be connected to several circuit points: Open, ECG Wave, Earth, +Meter, -Meter or 500 V. For the V1 post this is performed by relays K1, K2, K12, and K11. The other apples parts jacks operate similarly.

Meter Microprocessor

U40 is the meter microprocessor. It is a single-chip controller with built-in Program memory (FLASH), RAM, serial peripheral interfaces, and timers. Calibration data and configuration data is stored in an external serial EEPROM (U44). The processor is clocked at 12 MHz by the crystal, Y2. The two microprocessors in the Analyzer communicate over a galvanically isolated serial port with U42 providing the isolation. The U/I processor is the master and can reset the meter microprocessor through U43. U41 is a brownout detector that resets the processor on power up and power down. The JTAG port (J21) is used for debugging and downloading firmware.

User Interface Microprocessor

U2 is the user interface microprocessor. It contains program memory (FLASH), RAM, timers, I/O ports, and communication ports. It is clocked at 12 MHz by the crystal, Y1. It runs off of the +3.3 V power supply and an internally generated +1.8 V supply. U1 is a serial FLASH memory for storing test data. U59 is an FRAM for temporary test data storage. Only entire test records are transferred to the FLASH memory. The warning LED DS1 is turned on by the U/I microprocessor to indicate when there are dangerous voltages or currents on any test jacks. The beeper, LS1, beeps as required. The internal temperature of the unit is monitored by RT1. At a preset temperature, the U/I microprocessor informs the meter microprocessor to shut down the relays and a message is placed on the display. The JTAG port (J2) is used for debugging and downloading code into FLASH memory.

Keyboard and Display

The keyboard and display are controlled by the U/I microprocessor. The Keyboard, S3 and S4, is arranged in rows and columns. It is read by consecutively setting each row line low and then reading the columns. The key pressed is at the intersection of the row and column. The display is controlled by the Display controller, U3, which is connected between the U/I microprocessor and the display at J1. Quad op-amp U6 generates the voltages needed to bias the LCD display. Switching voltage supply U5 generates the highest voltage in this string, and by varying this, the contrast is varied. This is varied by the CONTRAST signal at R22. The display can be shut off by the ENABLE_20 V signal which disconnects the +12 V supply from the +20 V supply. The display backlight can be turned on and off by Q3.

USB Port

U7 and U8 form the USB port. U8 provides galvanic isolation between the Analyzer and the communication port. U7 communicates with the U/I microprocessor in RS232 format. It converts incoming data from USB to RS232 and outgoing data from RS232 to USB format. U9 protects the port from ESD. The connector, U3, is a standard “type B” up-stream pointing USB connector. The components on the USB side of the isolator, U8, are bus powered.

U/I Power Supplies

U11 is a switching regulator that generates the +3.3 V supply for the U/I microprocessor. U10 is a linear regulator that generates a 3.0 V supply for the display driver.

Chapter 3
Verification and Calibration

Title	Page

Introduction

This section provides performance tests to verify the Analyzer is operating within published specifications and a calibration procedure for bringing the Analyzer within specifications. The verification procedure and, if necessary, the calibration procedure can be performed both periodically and after service or repair.

Required Equipment

Table 3-1 lists the equipment required for performance testing and calibrating the Analyzer.

Table 3-1. Required Equipment for Analyzer Verification

Instrument Type	Recommended Model
Digital Multimeter	Fluke 8846A
Calibrator	Fluke 5520A
AC and DC Current Source	Keithley 6221
Programmable AC Power Supply	Elgar CW 1251
Personal Computer with Hyperterminal	
Receptacle Wiring Tester	Woodhead 1750
Oscilloscope	TEK TDS 3012B
Current Shunt	Fluke A40A, 20 A capable
Current Load	
Differential Amplifier	AM Systems 3000 AC-DC
Resistor Decade Box: 1.800 Ω, 1.400 Ω, and 0.450 Ω rated at 1 watt	General Resistance RDS-41A
Resistor: 110 kΩ rated at ½ watt	
Resistor Decade Box: 0.7 MΩ, 1.0 MΩ, 2.0 MΩ, 3.1 MΩ, 6.5 MΩ, 10 MΩ, 18 MΩ, 22 MΩ, 60 MΩ, and 100 MΩ rated at 500 V and 1.5 mA	IET Labs HRRS-B-7-1K
Resistor: 0.1 Ω rated at 75 watts	
Outlet Tension Tester	Extech 475040
USB Cable	
Test Leads	

Analyzer Verification

The following sections cover the setup and procedural steps for verifying the Analyzer is operating within the product specifications.

Outlet Tension Tests

To test the equipment outlet for proper tension:

1. Insert the tension tester into the hot (L1) pin of the Analyzer test receptacle. Set the tension tester to measure peak ounces.
2. Zero the tension tester indicators.
3. Slowly pull the tension tester out of the receptacle.
4. Read and record the reading on the tension tester.
5. Repeat steps 1 through 4 on the neutral and ground pins of the test receptacle.

Setup

Perform the following steps to prepare the Analyzer for performance verification.

1. Power on all test equipment and allow a 1-hour warm up time.
2. Power on the PC and log in.
3. Connect the PC USB cable to the Analyzer.
4. Power on the Analyzer with the programmable ac power supply.
5. Establish serial communication with the Analyzer (Applicable COM port using USBView, 115200 Baud, N,8,1 bits, HW Flow control) Under File→ Properties and the Settings tab, click the ASCII Setup button, and ensure "Send line ends with line feeds" and "Echo typed characters locally" are CHECKED.
6. If the Analyzer is a non-US unit, the firmware must be switched to indicate a US version.
   a. Send command: `REMOTE=F2810 <CR>`
   b. Receive *
   c. Send command: `NOMINAL? <CR>`
   d. Receive the current nominal voltage setting. Note this value for reconversion at the completion of verification.
   e. Send command: `NOMINAL=115 <CR>`
   f. Receive *
   g. Send command: `LOCAL <CR>`
   h. Receive *

Note

Many tests are preceded by the `HIGH_RES-ON`, and `STD=XXX` commands. These settings will not be "lost" when switching between tests, and are not required to be repeated if the Analyzer hasn't been taken out of remote mode. They are intended to allow the procedure to be used in part or in whole for testing. Use them as needed throughout this procedure. When an `MREAD` is used to report a reading, the tenth reading is often specified. This is to allow settling time for the Analyzer. However, any reading after stabilization is sufficient.

Verification Procedure

The following steps make up the procedure for verifying the operation of the Analyzer and coincide with the verification datasheet found in Appendix A.

A. Functional

1. Send command: `REMOTE <CR>`
2. Receive *
3. Send command: `DIAG=F2810 <CR>`
4. Receive *
5. Send command: `IDENT <CR>`
6. Verify that the Analyzer identifies itself with UI & MTR firmware revision level. Record UI & MER firmware revisions.
7. Send command: `LED=ON <CR>`
8. Receive *
9. Verify that the red warning LED is lit.
10. Send command: `LED=OFF <CR>`
11. Receive * and verify the red warning LED is off. Record PASS/FAIL.
12. Send command: `BEEP <CR>`
13. Receive * and verify the beeper beeps once. Record PASS/FAIL.
14. Send command: `CONT=09 <CR>`
15. Receive *
16. Send command: `CONT=07 <CR>`
17. Receive *
18. Send command: `CONT=05 <CR>`
19. Receive *
20. Send command: `CONT=03 <CR>`
21. Receive *
22. Send command: `CONT=09 <CR>`
23. Receive *
24. Send command: `CONT=11 <CR>`
25. Receive *
26. Send command: `CONT=13 <CR>`

27. Receive *
28. Send command: `CONT=15 <CR>`
29. Receive *
30. Send command: `CONT=09 <CR>`
31. Receive *
32. Verify that the contrast gets lighter for lower values of CONT and darker for higher values. Record PASS/FAIL.
33. Send command: `KEY <CR>`
34. Receive *
    a. Depress all keys on the keypad and check for the correct returned digit in Table 3-2.

Table 3-2. Keypad Verification

Key	Response
V	1
MΩ	2
μA	3
	4
Ω	5
A	6
POINT TO POINT	7
SETUP	8
F1	9
F2	10
F3	11
F4	12
POLARITY	13
NEUTRAL	14
EARTH	15
SAVE	16
▲	17
◄	18
►	19
▼	20
TEST	21

35. Press the ESC key, receive a carriage return only. Record PASS/FAIL

36. Send command: PON <CR>
37. Receive *
38. Send command: POFF <CR>
39. Receive *
40. Verify that all pixels on the display came on and then went off. Record PASS/FAIL.
41. Send command: LITE=OFF <CR>
42. Receive *
43. Send command: LITE=ON <CR>
44. Receive *
45. Verify that the backlight goes off and comes back on. Record PASS/FAIL
46. Send command: EXIT <CR>
47. Receive *
48. Send command: LOCAL <CR>
49. Receive *
50. Send command: REMOTE <CR>
51. Receive *

B. Electrical Outlet Polarity Testing

1. Connect the receptacle wiring tester to the equipment outlet (EO) as shown in Figure 3-1.

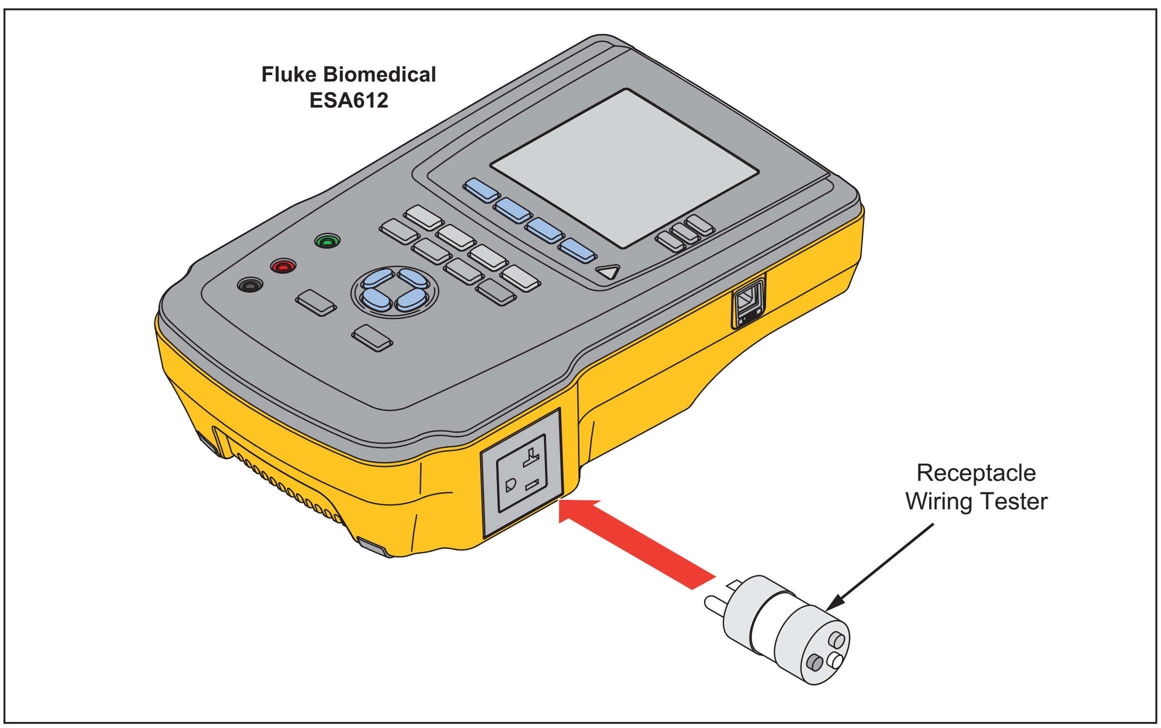


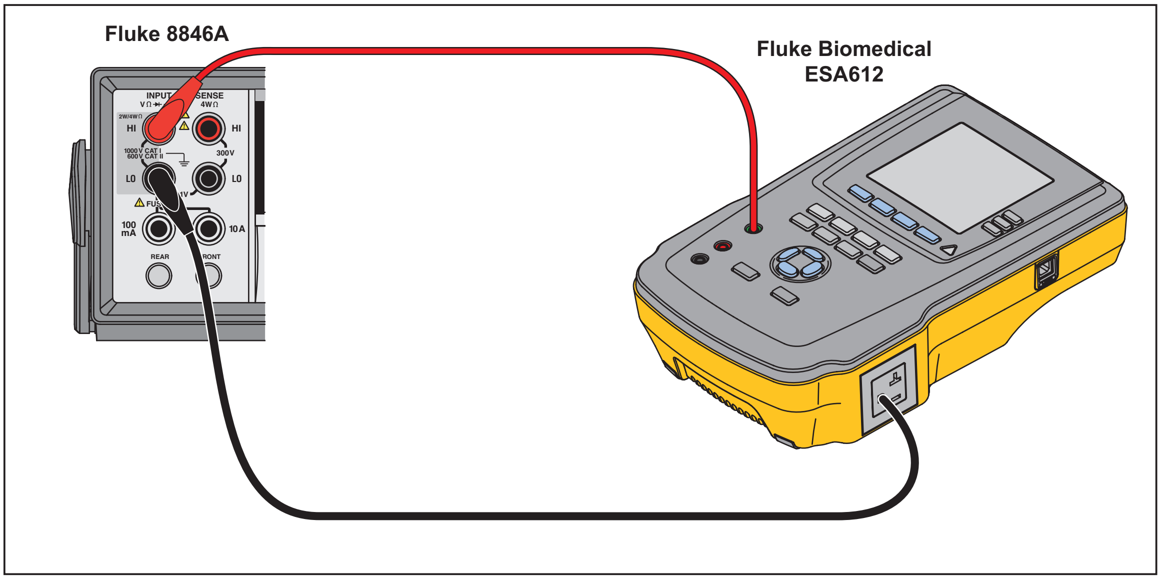
Figure 3-1. Electrical Equipment Outlet Polarity Test

2. Send command: `ENCL <CR>`

3. Receive *
4. Send command: `POL=N <CR>`
5. Receive *
6. Send command: `NEUT=C <CR>`
7. Receive *
8. Send command: `EARTH=C <CR>`
9. Receive *
10. Verify the yellow and white lights are lit. Record PASS/FAIL.
11. Send command: `EARTH=O <CR>`
12. Receive *
13. Verify the yellow light is lit. Record PASS/FAIL.
14. Send command: `NEUT=O <CR>`
15. Receive *
16. Send command: `EARTH=C <CR>`
17. Receive *
18. Verify the white light is lit. Record PASS/FAIL.
19. Send command: `LOCAL <CR>`
20. Receive *
21. Send command: `REMOTE <CR>`
22. Receive *
23. Send command: `ENCL <CR>`
24. Receive *
25. Send command: `POL=R <CR>`
26. Receive *
27. Verify the red light is lit. Record PASS/FAIL.
28. Send command: `NEUT=C <CR>`
29. Receive *
30. Verify the red and yellow lights are lit. Record PASS/FAIL.
31. Send command: `EARTH=O <CR>`
32. Receive *
33. Verify the yellow light is lit. Record PASS/FAIL.
34. Send command: `LOCAL <CR>`
35. Receive *
36. Send command: `REMOTE <CR>`
37. Receive *
38. Remove all testing connections from the UUT.

C. Electrical Outlet Ground to NULL Jack Resistance

1. Connect the DMM Input (+) to the NULL Jack and the Input (-) to the EO Ground as shown in Figure 3-2. Select the 1 GΩ range on the DMM.



gfi103.eps

Figure 3-2. Electrical Outlet Ground to NULL Jack Resistance

2. Send command: `CAL=F2810 <CR>`
3. Receive *
4. Send command: `EOGNULL=O <CR>`
5. Receive *
6. If the DMM reads OPEN, record PASS. Otherwise, record FAIL.
7. Change the DMM to the 10 Ω range. Send command: `EOGNULL=C <CR>`
8. Read and record the DMM resistance value.
9. Send command: `EXIT <CR>`
10. Receive *
11. Disconnect all testing connections to the UUT.

D. Mains Voltage

1. Send command: `HIGH_RES=ON <CR>`
2. Receive *
3. Send command: `STD=AAMI <CR>`
4. Receive *
5. Send command: `MAINS=L1-L2 <CR>`
6. Receive *
7. Send command: `READ <CR>`
8. Receive and record response.
9. Send command: `MAINS=L1-GND <CR>`

10. Receive *
11. Send command: `READ <CR>`
12. Receive and record response.
13. Remove all testing connections from the UUT.

E. GFI Verification

1. Connect the current source between EO Neutral and EO ground as shown in Figure 3-3. Set the current source for 4.5 mA (6.364 mA p-p), 60 Hz with a compliance voltage of 40 V.

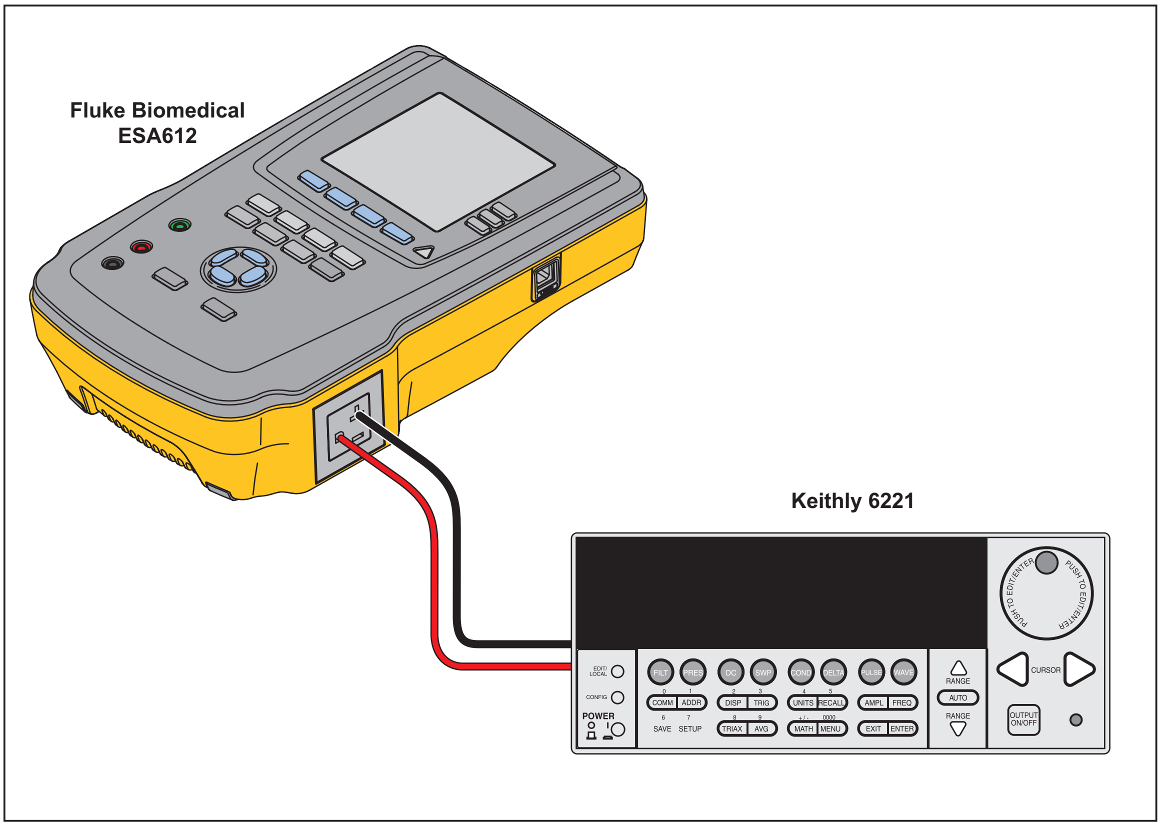


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Figure 3-3. GFI Verification Connections

2. command: `PPV <CR>`
3. Receive *
4. Send command: `GFI=5MA <CR>`
5. Receive *
6. Send command: `EQCURR <CR>`
7. Receive *
8. Turn on the current source output.
9. Send command: `STAT3 <CR>`
10. Receive status word 3. The 4xxx bits will not be set if the Analyzer passes the test.

Note

If the 8xxx and 4xxx bits are set, the status word returned will be C000. This still indicates the 4xxx bit is set, and is a failing condition.

11. Record PASS/FAIL.
12. Turn off the current source output.
13. Send command: `GFIR <CR>`
14. Receive *
15. Set the current source to 5.5 mA (7.778 mA p-p), 60 Hz.
16. Send command: `GFI=5MA <CR>`
17. Receive *
18. Send command: `EQCURR <CR>`
19. Receive *
20. Turn on the current source output.
21. Send command: `STAT3 <CR>`
22. Receive status word 3. The 4xxx bit will be set if the Analyzer passes this test (GFI tripped).
23. ~~Record PASS/FAIL.~~
24. Turn off the current source output.
25. Send command: `GFIR <CR>`
26. Receive *
27. Set the current source to 9 mA (12.727 mA p-p), 60 Hz, with a 40 V compliance voltage.
28. Send command: `PPV <CR>`
29. Receive *
30. Send command: `GFI=10MA <CR>`
31. Receive *
32. Send command: `EQCURR <CR>`
33. Receive *
34. Turn on the current source output.
35. Send command: `STAT3 <CR>`
36. Receive status word 3. The bit xxx8 shall be set, indicating medium GFI level, but the 4xxx bit will not be set if the Analyzer passes this test.
37. Turn off the current source output.
38. Record PASS/FAIL.
39. Send command: `GFIR <CR>`
40. Receive *

41. Set the current source to 11 mA (15.556 mA p-p), 60 Hz.
42. Send command: `GFI=10MA <CR>`
43. Receive *
44. Send command: `EQCURR <CR>`
45. Receive *
46. Turn on the current source output.
47. Send command: `STAT3 <CR>`
48. Receive status word 3. The 4xx8 bit will be set if the Analyzer passes this test (GFI tripped).
49. Turn off the current source output.
50. Record PASS/FAIL.
51. Send command: `GFIR <CR>`
52. Receive *
53. Set the current source to 22.5 mA (31.82 mA p-p), 60 Hz.
54. Send command: `PPV <CR>`
55. Receive *
56. Send command: `GFI=25MA <CR>`
57. Receive *
58. Send command: `EQCURR <CR>`
59. Receive *
60. Turn on the current source output.
61. Send command: `STAT3 <CR>`
62. Receive status word 3. The 4xxx bit will not be set if the Analyzer passes this test.
63. Turn off the current source output.
64. Record PASS/FAIL.
65. Send command: `GFIR <CR>`
66. Receive *
67. Set the current source to 27.5 mA (38.89 mA p-p), 60 Hz.
68. Send command: `GFI=25MA <CR>`
69. Receive *
70. Send command: `EQCURR <CR>`
71. Receive *
72. Turn on the current source output.
73. Send command: `STAT3 <CR>`

74. Receive status word 3. The 4xxx bit will be set if the Analyzer passes this test (GFI tripped).
75. Turn off the current source output.
76. Record PASS/FAIL.
77. Remove all testing connections.
78. Send command: `GFIR <CR>`
79. Receive *

F. Point to Point Voltage

1. Send command: `HIGH_RES=ON <CR>`
2. Receive *
3. Send command: `STD=AAMI <CR>`
4. Receive *
5. Send command: `PPV <CR>`
6. Receive *
7. Connect the Normal Outputs of the calibrator to the red and black jacks on the Analyzer as shown in Figure 3-4. Set the calibrator to 1 V, 120 Hz, and set the calibrator to OPR.

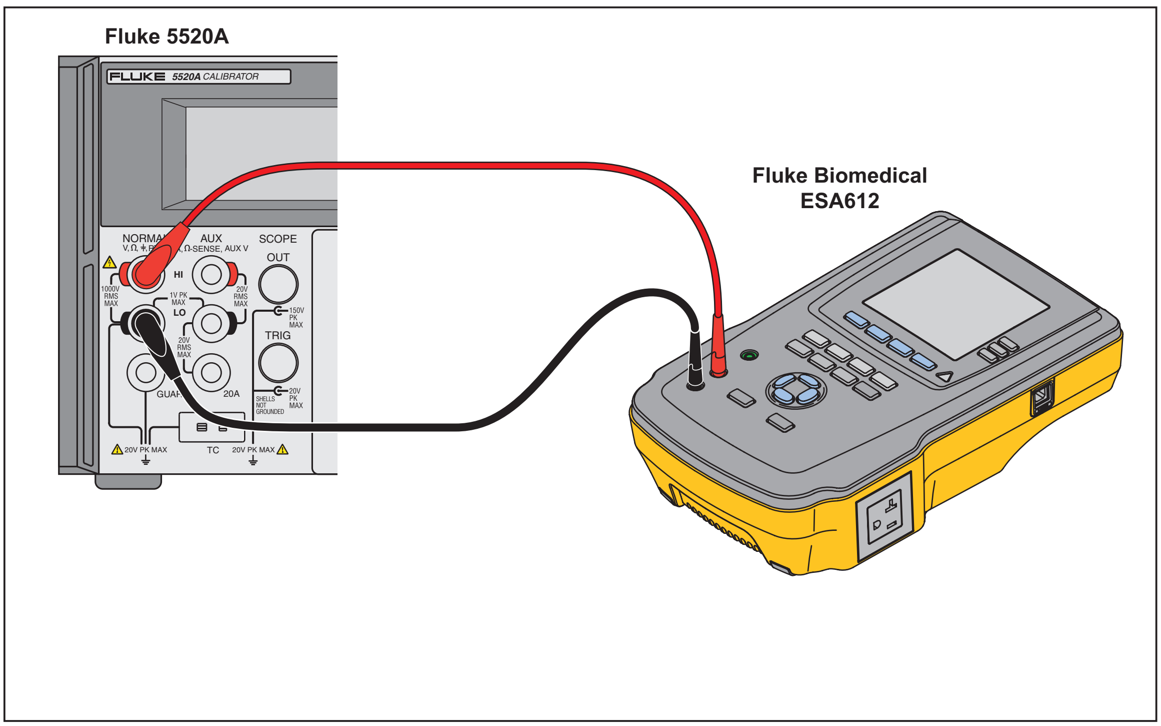

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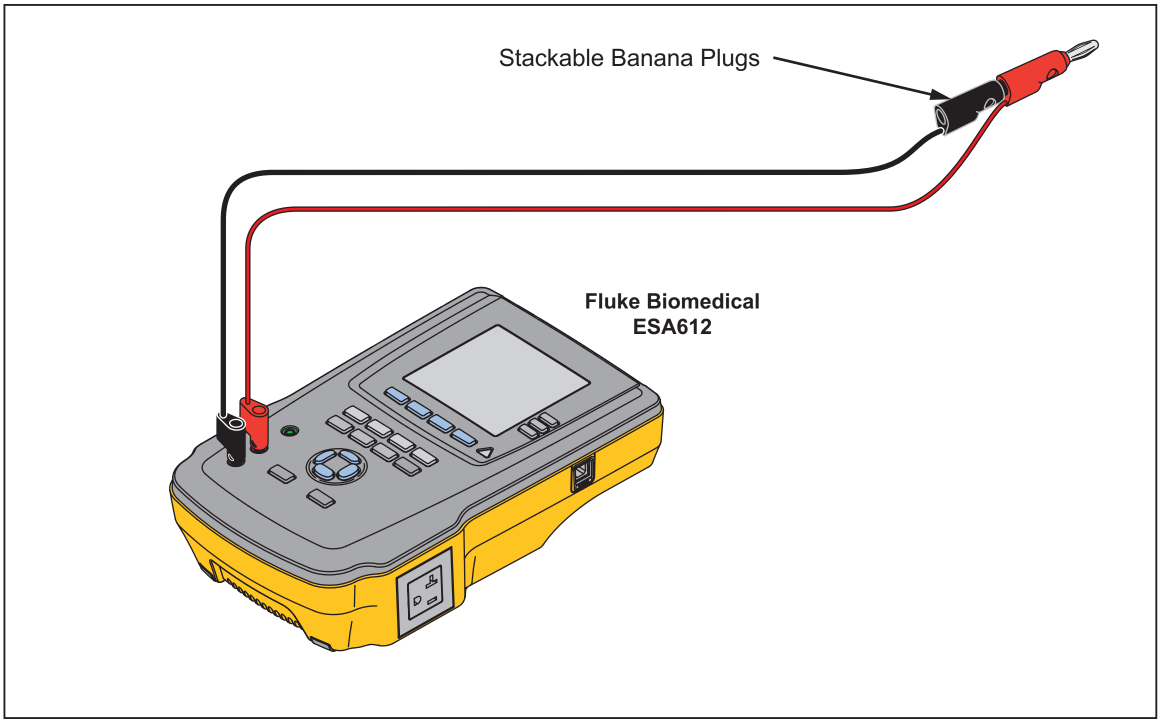
Figure 3-4. Point to Point Voltage Verification Connections

8. Send command: `READ <CR>`
9. Receive and record response.
10. Set the calibrator to 250 V, 120 Hz.

11. Send command: READ <CR>
12. Receive and record response.
13. ~~Set the calibrator to 100 V, 633 Hz.~~
14. ~~Send command: READ <CR>~~
15. ~~Receive and record response. Based upon the design of the patient load, this value is expected to have a SQRT(2)/2 drop from the source voltage.~~
16. Set the calibrator to 4 V, 120 Hz.
17. Send command: READ <CR>
18. Receive and record response.
19. Set the calibrator to 8 V, 120 Hz.
20. Send command: READ <CR>
21. Receive and record response.
22. Set the calibrator to 10 V, 120 Hz.
23. Send command: READ <CR>
24. Receive and record response.
25. Set the calibrator to 25 V, 120 Hz.
26. Send command: READ <CR>
27. Receive and record response.
28. Set the calibrator to 40 V, 120 Hz.
29. Send command: READ <CR>
30. Receive and record response.
31. Set the calibrator to 80 V, 120 Hz.
32. Send command: READ <CR>
33. Receive and record response.
34. Set the calibrator to 130 V, 120 Hz.
35. Send command: READ <CR>
36. Receive and record response.
37. Set the calibrator to 240 V, 120 Hz.
38. Send command: READ <CR>
39. Receive and record response.
40. Turn the calibrator output to STBY. Disconnect all testing connections to the UUT.

G. Resistance

1. Connect two test leads to the red and black jacks. Short these two leads together as shown in Figure 3-5.



gfi108.eps

Figure 3-5. Point to Point Resistance Verification Connections

2. Send command: `HIGH_RES=ON <CR>`
3. Receive *
4. Send command: `STD=AAMI <CR>`
5. Receive *
6. Send command: `PPR <CR>`
7. Receive *
8. Send command: `ZERO <CR>`
9. Receive *
10. Send command: `READ <CR>`
11. Receive and record response.
12. Connect the two leads across a 1.800 Ω resistor.
13. Send command: `READ <CR>`
14. Receive and record response. Compare with the actual value of the resistor.
15. Move the lead from the black jack to the equipment outlet ground. Short the two leads together again.
16. Send command: `ERES <CR>`
17. Receive *
18. Send command: `ZERO <CR>`
19. Receive *
20. Send command: `READ <CR>`

21. Receive and record response.

22. Connect these same two leads across a 1.800 Ω resistor.

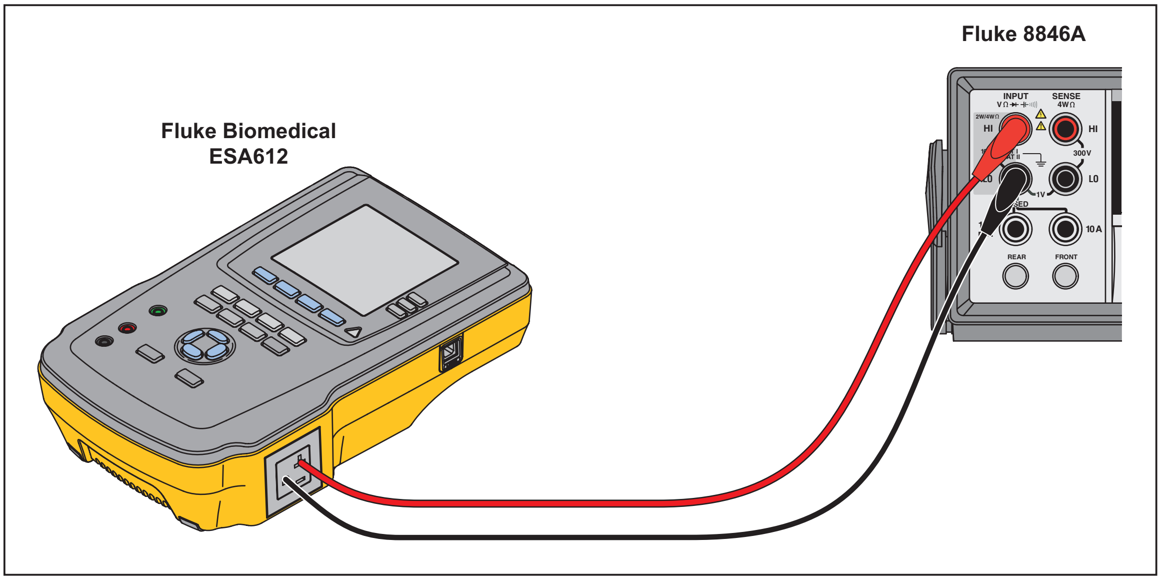
23. Send command: `READ <CR>`

24. Receive and record response. Compare to the actual value of the 1.800 Ω resistor.

25. Remove all testing connections to the UUT.

H. Insulation Resistance

1. Connect the EO ground to the Input (-) of the DMM and the EO Neutral to the Input (+) as shown in Figure 3-6. Set the DMM for 1000 V ac mode.



gjc109.eps

Figure 3-6. Insulation Resistance Verification Connections

2. Send command: `HIGH_RES=ON <CR>`
3. Receive *
4. Send command: `STD=AAMI <CR>`
5. Receive *
6. Send command: `MINS <CR>`
7. Receive *
8. Send command: `INS=LOW <CR>`
9. Receive *
10. Send command: `MREAD <CR>`
11. Receive multiple readings. While the Analyzer is conducting its read, record the value of the DMM voltage.
12. Press the ESC key. The Analyzer will stop reporting readings.
13. Send command: `INS=HIGH <CR>`
14. Receive *
15. Send command: `MREAD <CR>`

16. Receive multiple readings. While the Analyzer is conducting its read, record the value of the DMM voltage.
17. Press the ESC key. The UUT will stop reporting readings.
18. Connect the EO ground to one side of a 110 kΩ resistor. Connect the other side to the Input (-) of the DMM. Connect the 400 mA jack of the DMM to the EO Neutral. See Figure 3-7. Set the DMM to 10 mA ~~ac~~ mode.

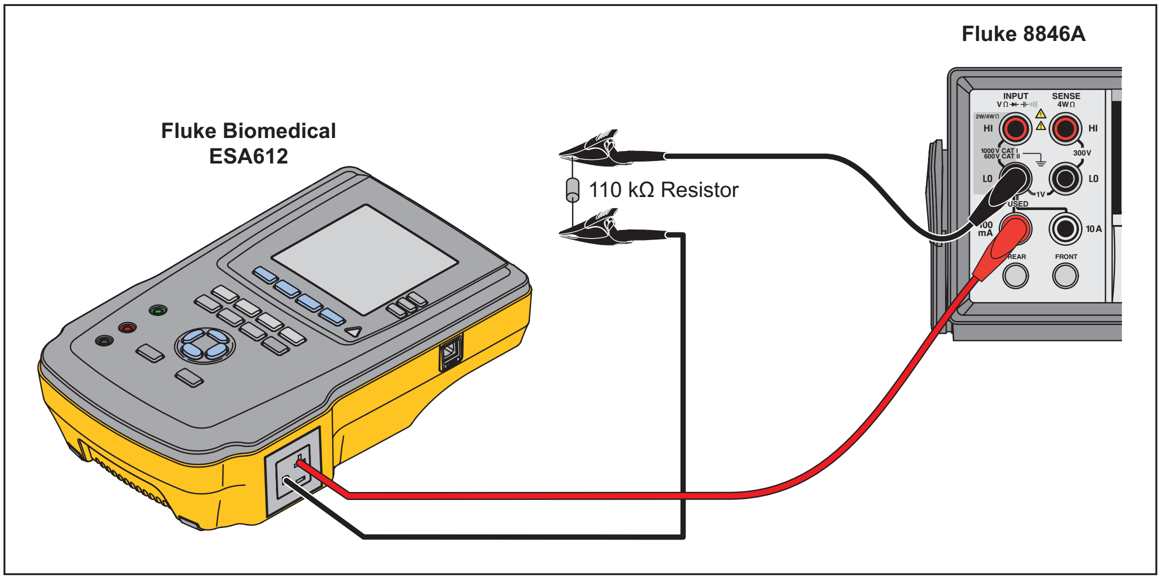


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Figure 3-7. Insulation Resistance with 110 kΩ Resistor Connections

19. Send command: `MREAD <CR>`
20. Receive multiple readings. While the Analyzer is conducting its read, record the value of the DMM current.
21. Press the ESC key. The Analyzer will stop reporting readings.
22. Remove all testing connections to the Analyzer.

Mains to PE

23. Connect the EO Neutral and the EO ground across a 10.0-MΩ resistor as shown in Figure 3-8.

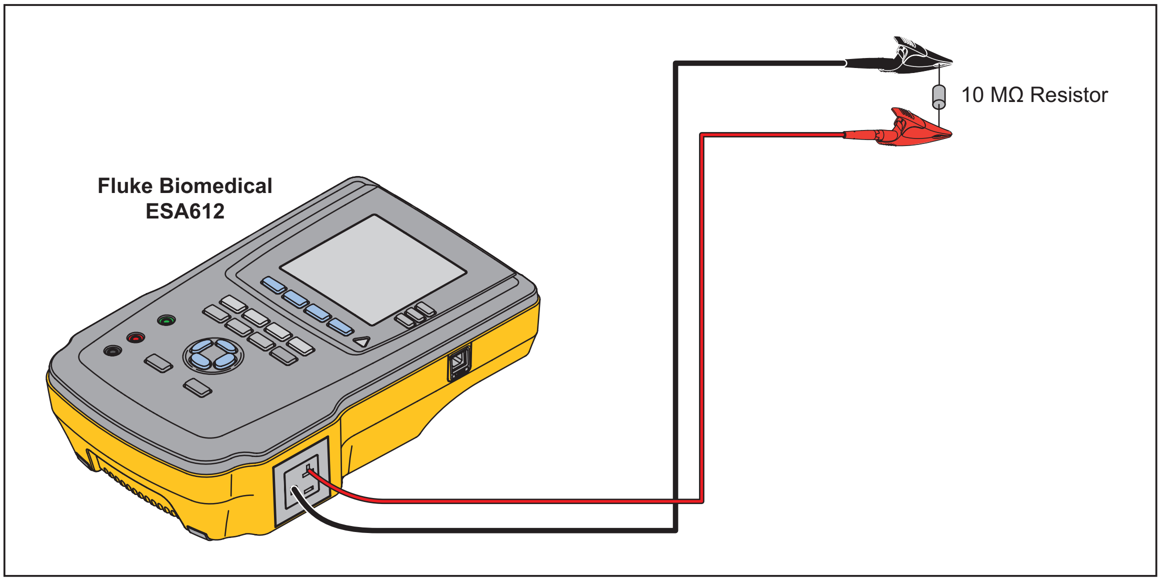

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Figure 3-8. Mains to PE Verification Connections

24. Send command: `HIGH_RES=ON <CR>`
25. Receive *
26. Send command: `STD=AAMI <CR>`
27. Receive *
28. Send command: `MINS <CR>`
29. Receive *
30. Send command: `INS=HIGH <CR>`
31. Receive *
32. Send command: `MREAD <CR>`
33. Following the tenth reading, press the ESC key. Record the tenth reading.

AP to PE

34. Disconnect the lead from the EO Neutral and connect it to the RA Applied Part. The other lead should remain connected to the EO ground. Both leads should still be attached to the 10-MΩ resistor. See Figure 3-9.

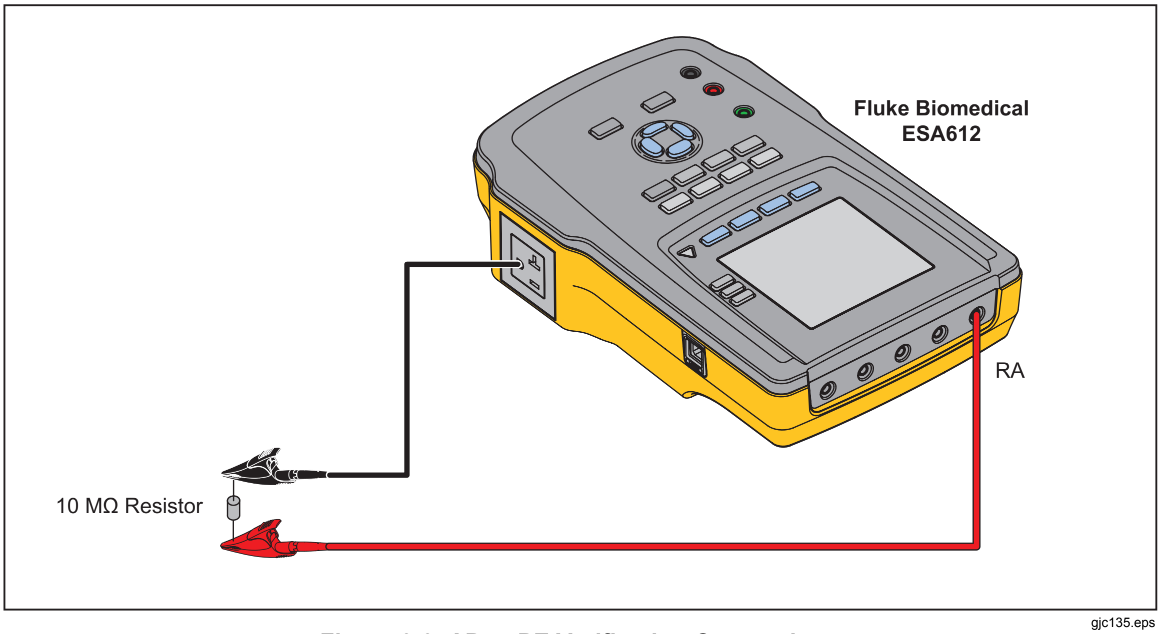

Figure 3-9. AP to PE Verification Connections

35. Send command: `HIGH_RES=ON <CR>`
36. Receive *
37. Send command: `STD=AAMI <CR>`
38. Receive *
39. Send command: `APINS <CR>`
40. Receive *
41. Send command: `INS=HIGH <CR>`
42. Receive *
43. Send command: `MREAD <CR>`
44. Following the tenth reading, press the ESC key. Record the tenth reading.

AP to NE

45. With one side of the 10 MΩ resistor still connected to RA, connect the other side to the red jack as shown in Figure 3-10.

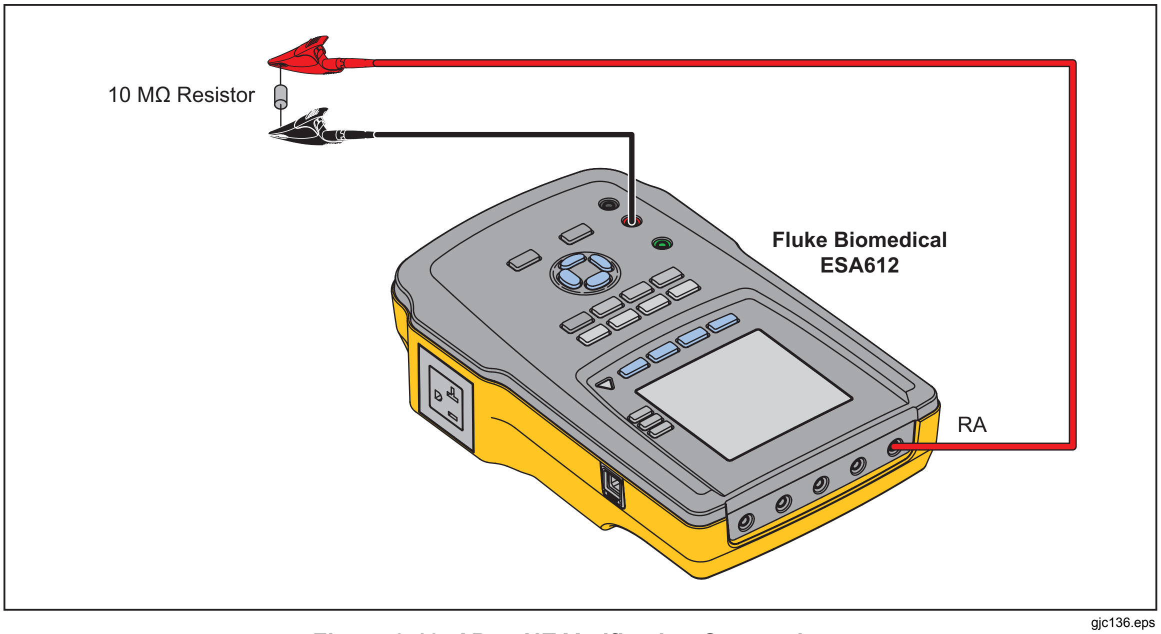

Figure 3-10. AP to NE Verification Connections

46. Send command: `HIGH_RES=ON <CR>`
47. Receive *
48. Send command: `STD=AAMI <CR>`
49. Receive *
50. Send command: `INSD <CR>`
51. Receive *
52. Send command: `INS=HIGH <CR>`
53. Receive *
54. Send command: `MREAD <CR>`
55. Following the tenth reading, press the ESC key. Record the tenth reading.

Mains to NE

56. Connect the red jack to one side of a 10-MΩ resistor. Connect EO Hot to the other side of the resistor as shown in Figure 3-11.

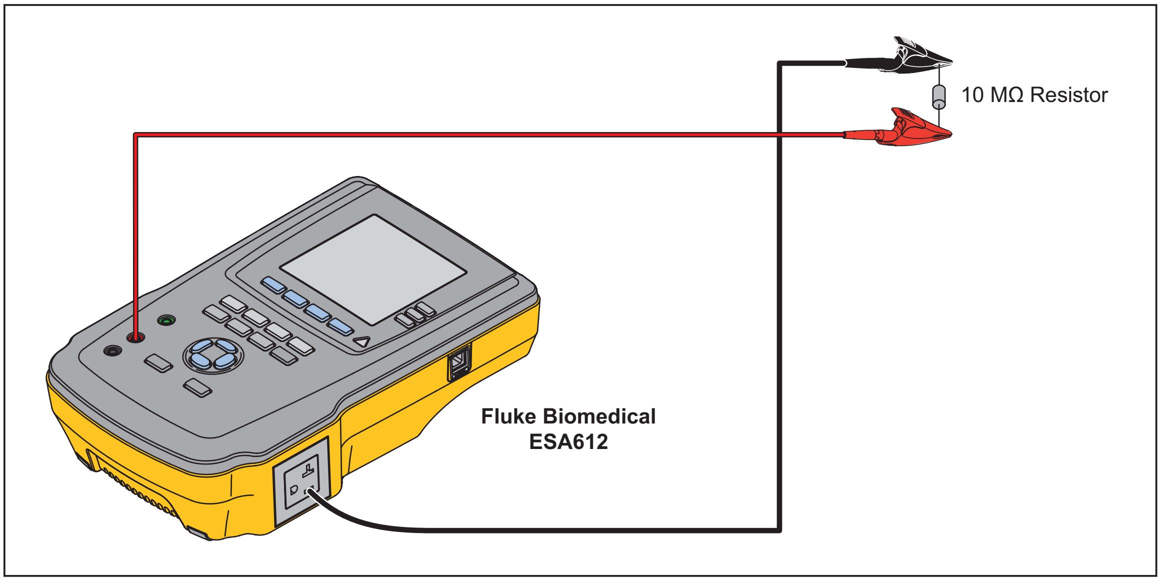

Figure 3-11. Mains to NE Verification Connections

57. Send command: `HIGH_RES=ON <CR>`
58. Receive *
59. Send command: `STD=AAMI <CR>`
60. Receive *
61. Send command: `INSB <CR>`
62. Receive *
63. Send command: `INS=HIGH <CR>`
64. Receive *
65. Send command: `MREAD <CR>`
66. Following the tenth reading, press the ESC key. Record the tenth reading.

Mains to AP

67. With the EO Hot still connected to one side of a 10 MΩ resistor, connect the other side of the resistor to the RA Applied Part as shown in Figure 3-12.

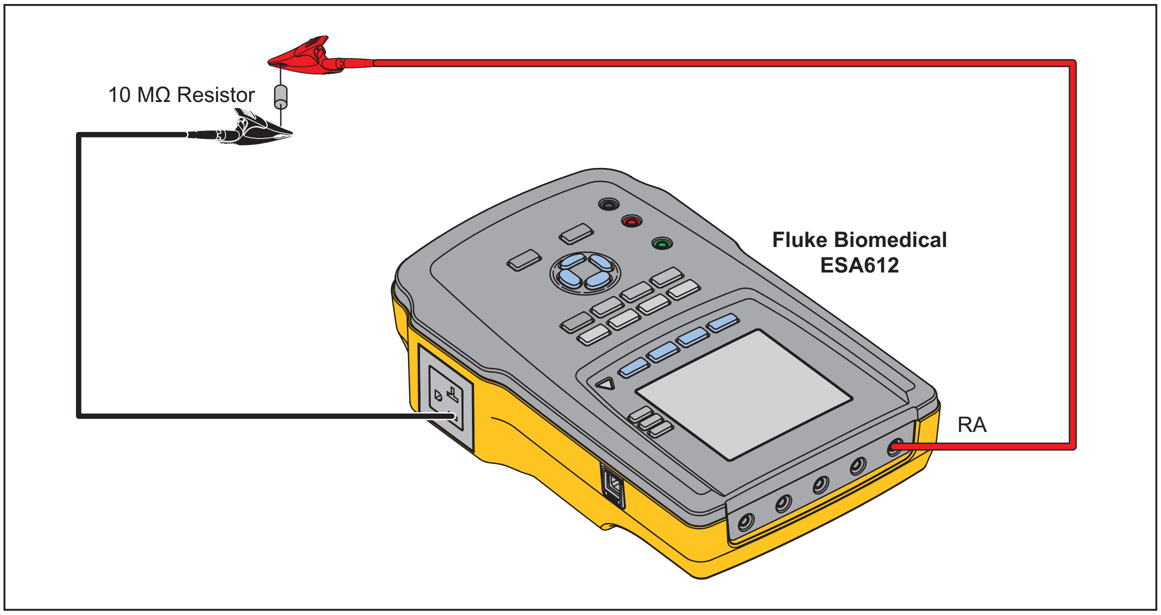

Figure 3-12. Mains to AP Verification Connections

68. Send command: `HIGH_RES=ON <CR>`
69. Receive *
70. Send command: `STD=AAMI <CR>`
71. Receive *
72. Send command: `INSE <CR>`
73. Receive *
74. Send command: `INS=HIGH <CR>`
75. Receive *
76. Send command: `MREAD <CR>`
77. Following the tenth reading, press the ESC key. Record the tenth reading.
78. Repeat steps 76-77 for each of the other Applied Parts: LL, LA, RL, and V1.
79. Change the 10 MΩ resistor for a 0.7 M resistor, while still connected to V1 and EO hot.
80. Send command: `INS=LOW <CR>`
81. Receive *
82. Send command: `MREAD <CR>`
83. Following the tenth reading, press the ESC key. Record the tenth reading.
84. Send command: `INS=HIGH <CR>`
85. Receive *

86. Send command: `MREAD <CR>`
87. Following the tenth reading, press the ESC key. Record the tenth reading.
88. Repeat steps 80-87 for each resistance value of 1.0 MΩ, 6.5 MΩ, 18 MΩ, 22 MΩ, 60 MΩ, and 100 MΩ.
89. Disconnect all testing connections from the Analyzer.

I. DC Leakage

1. Connect the red and black jacks to the Input (+) and Input (-) jacks of the DMM and set the DMM for 1-kΩ range as shown in Figure 3-13.

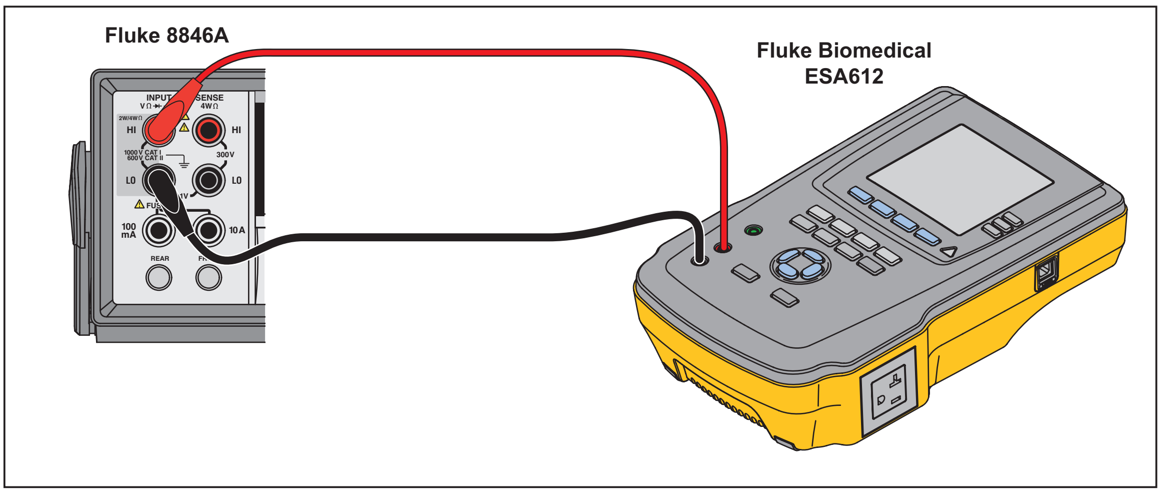

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Figure 3-13. DC Leakage Verification Connections

2. Send command: `HIGH_RES=ON <CR>`
3. Receive *
4. Send command: `STD=AAMI <CR>`
5. Receive *
6. Send command: `PPL <CR>`
7. Receive *
8. Send command: `MODE=ACDC <CR>`
9. Receive *
10. Read and record the load value from the DMM.
11. Remove all testing connections from the Analyzer.

12. Connect the current source to the red and black jacks as shown in Figure 3-14. Set the current source for 10 µA dc.

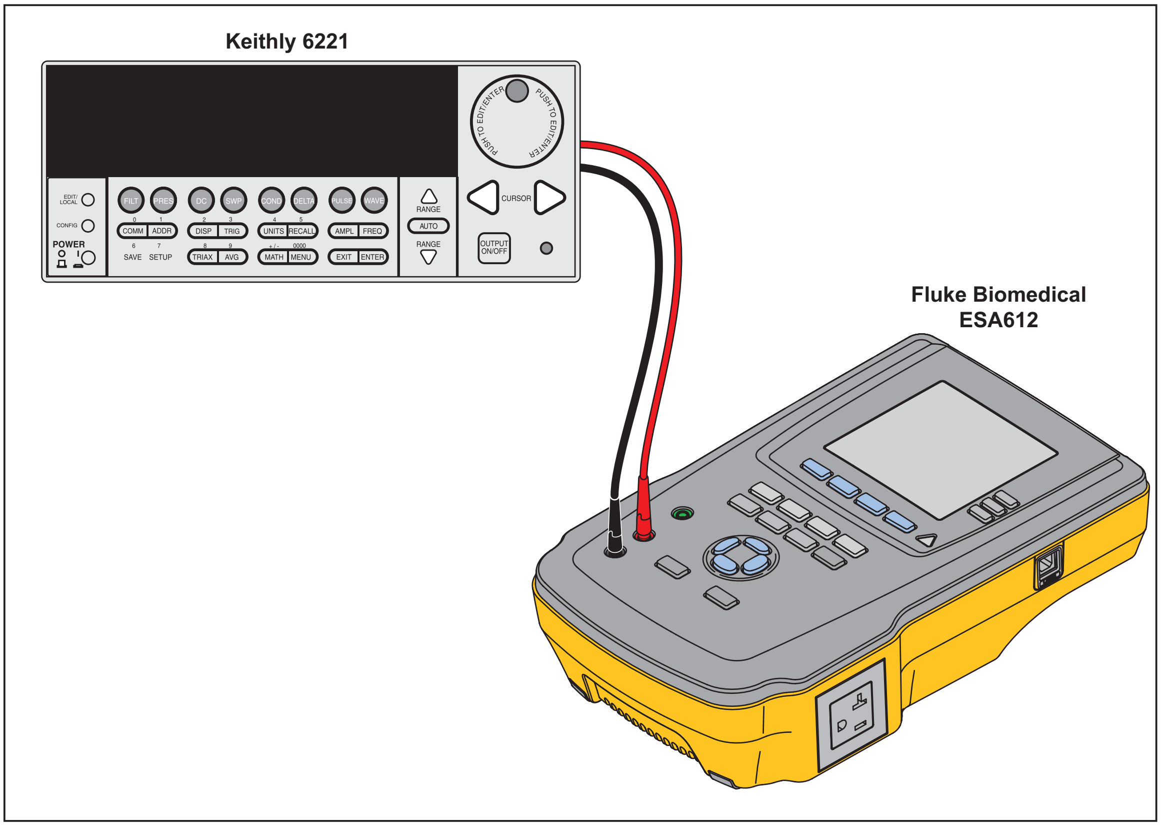

Figure 3-14. DC Leakage Current Verification Connection

13. Send command: `HIGH_RES=ON <CR>`
14. Receive *
15. Send command: `STD=AAMI <CR>`
16. Receive *
17. Send command: `PPL <CR>`
18. Receive *
19. Send command: `MODE=DC <CR>`
20. Receive *
21. Turn on the current source output.
22. Send command: `MREAD <CR>`
23. Receive multiple readings. Record the tenth reading.
24. Press the ESC key. The UUT will stop reporting readings.
25. Adjust the current source for 50 µA dc.
26. Send command: `MREAD <CR>`
27. Receive multiple readings. Record the tenth reading.
28. Press the ESC key. The UUT will stop reporting readings.

29. Adjust the current source for 100 µA dc.
30. Send command: `MREAD <CR>`
31. Receive multiple readings. Record the tenth reading.
32. Press the ESC key. The UUT will stop reporting readings.
33. Adjust the current source for 160 µA dc.
34. Send command: `MREAD <CR>`
35. Receive multiple readings. Record the tenth reading.
36. Press the ESC key. The UUT will stop reporting readings.
37. Adjust the current source for 0.340 mA dc.
38. Send command: `MREAD <CR>`
39. Receive multiple readings. Record the tenth reading.
40. Press the ESC key. The UUT will stop reporting readings.
41. Adjust the current source for 0.500 mA dc.
42. Send command: `MREAD <CR>`
43. Receive multiple readings. Record the tenth reading.
44. Press the ESC key. The UUT will stop reporting readings.
45. Adjust the current source for 1.000 mA dc.
46. Send command: `MREAD <CR>`
47. Receive multiple readings. Record the tenth reading.
48. Press the ESC key. The UUT will stop reporting readings.
49. Adjust the current source for 1.600 mA dc.
50. Send command: `MREAD <CR>`
51. Receive multiple readings. Record the tenth reading.
52. Press the ESC key. The UUT will stop reporting readings.
53. Adjust the current source for 3.400 mA dc.
54. Send command: `MREAD <CR>`
55. Receive multiple readings. Record the tenth reading.
56. Press the ESC key. The UUT will stop reporting readings.
57. Adjust the current source for 5.000 mA dc.
58. Send command: `MREAD <CR>`
59. Receive multiple readings. Record the tenth reading.
60. Press the ESC key. The UUT will stop reporting readings.
61. Adjust the current source for 7.000 mA dc.
62. Send command: `MREAD <CR>`
63. Receive multiple readings. Record the tenth reading.

64. Press the ESC key. The UUT will stop reporting readings.
65. Turn off the current source output and disconnect all testing connections from the Analyzer.

J. AC Leakage Filter Frequency Response

1. Connect the current source to the red jack and the DMM 400 mA current input jack. Connect the DMM Input (-) to the black jack. See Figure 3-15. Set the current source to 1.000 mA (1.4142 mA p-p), 60 Hz, with a 25 V compliance voltage, and the DMM to the 1 mA ac range.

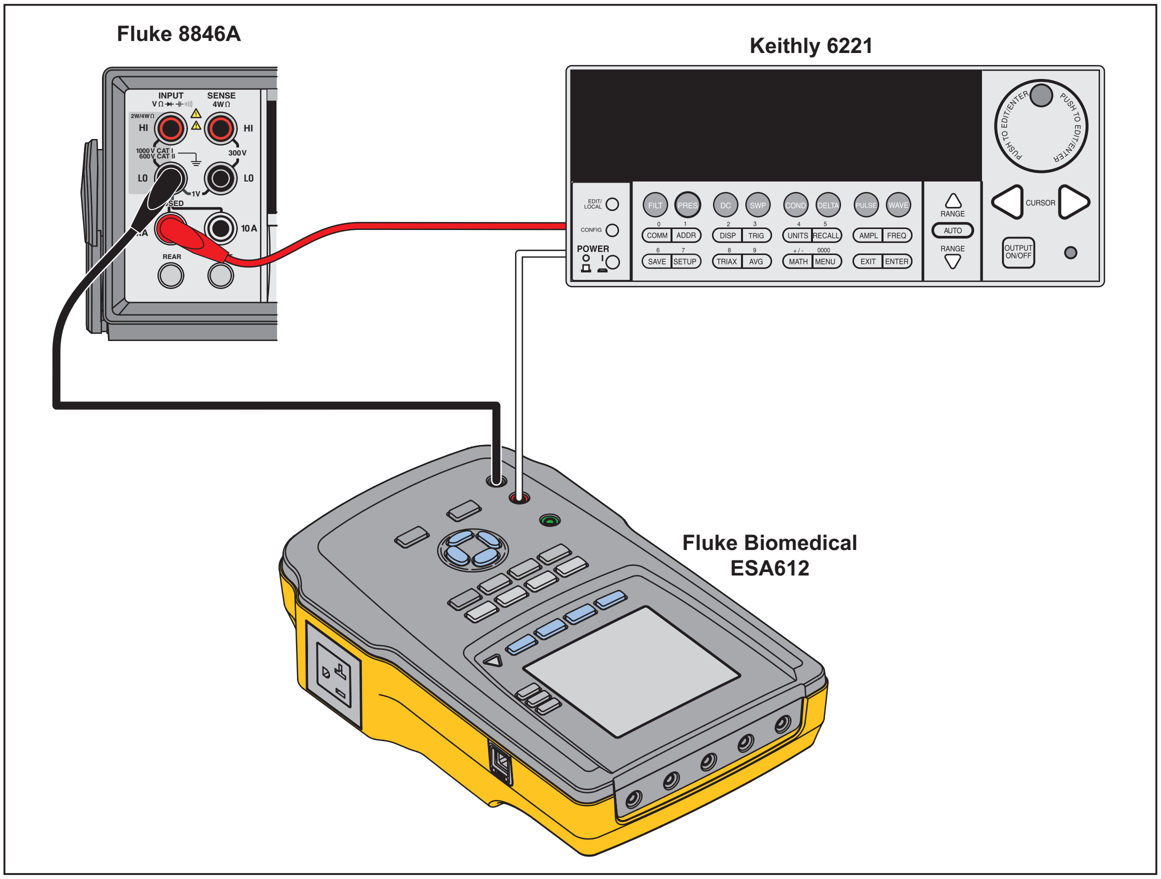

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Figure 3-15. AC Leakage Filter Frequency Response Connections

2. Send command: `PPL <CR>`
3. Receive *
4. Send command: `LOAD=AAMI <CR>`
5. Receive *
6. Turn on the current source output.
7. Send command: `READ <CR>`
8. Receive and record response of the Analyzer as the Analyzer current. Record the DMM current as the measured current.

9. Calculate the measured transfer ratio: divide the measured current by the Analyzer current. Record this transfer ratio, and compare to the design transfer ratio.

$$TR_{meas} = \frac{I_{meas}}{Analyzer\ Current}$$

   For this frequency, the design transfer ratio is 0.9980

10. Turn off the current source.
11. Calculate the transfer ratio limits: multiply the design transfer ratio by the tolerance. Add this value to the result of the offset current divided by the measured current. Record this calculated transfer ratio limit. Add and subtract this limit to the design transfer ratio to obtain the maximum and minimum, respectively.

$$TR_{Limit} = (TR_{design} * \%TOL) + \left(\frac{Offset}{I_{meas}}\right)$$

   For this frequency, the tolerance is 0.5 % and the offset is 0.005 mA.

12. Verify that: $TR_{design} - TR_{Limit} \leq TR_{meas} \leq TR_{design} + TR_{limit}$
13. Set the current source to 1.000 mA, 1,000 Hz, and turn on the output.
14. Send command: `READ <CR>`
15. Receive and record response. Turn off the current source output.
16. Perform the same calculations that were completed in steps 9 through 12 above. The design transfer ratio for this frequency is 0.6910, the tolerance is 2.0 %, and the Offset current is 0.005 mA.
17. Set the current source to 1.000 mA, 10,000 Hz and turn on the output.
18. Send command: READ <CR>
19. Receive and record response. Turn off the current source.
20. Perform the same calculations that were completed in steps 9 through 12 above. The design transfer ratio for this frequency is 0.09558, the tolerance is 2.0 %, and the Offset current is 0.005 mA.
21. Turn off the current source. Disconnect all test connections.

K. Differential Leakage

1. Connect the current source to the EO Neutral and the DMM 400 mA current input jack. Connect the DMM Input (-) to the EO ground. See Figure 3-16. Set the current source to 76.00 µA (107.48 µA p-p), 100 Hz, with a 25 V compliance voltage, and the DMM to the 100 µA ac range.

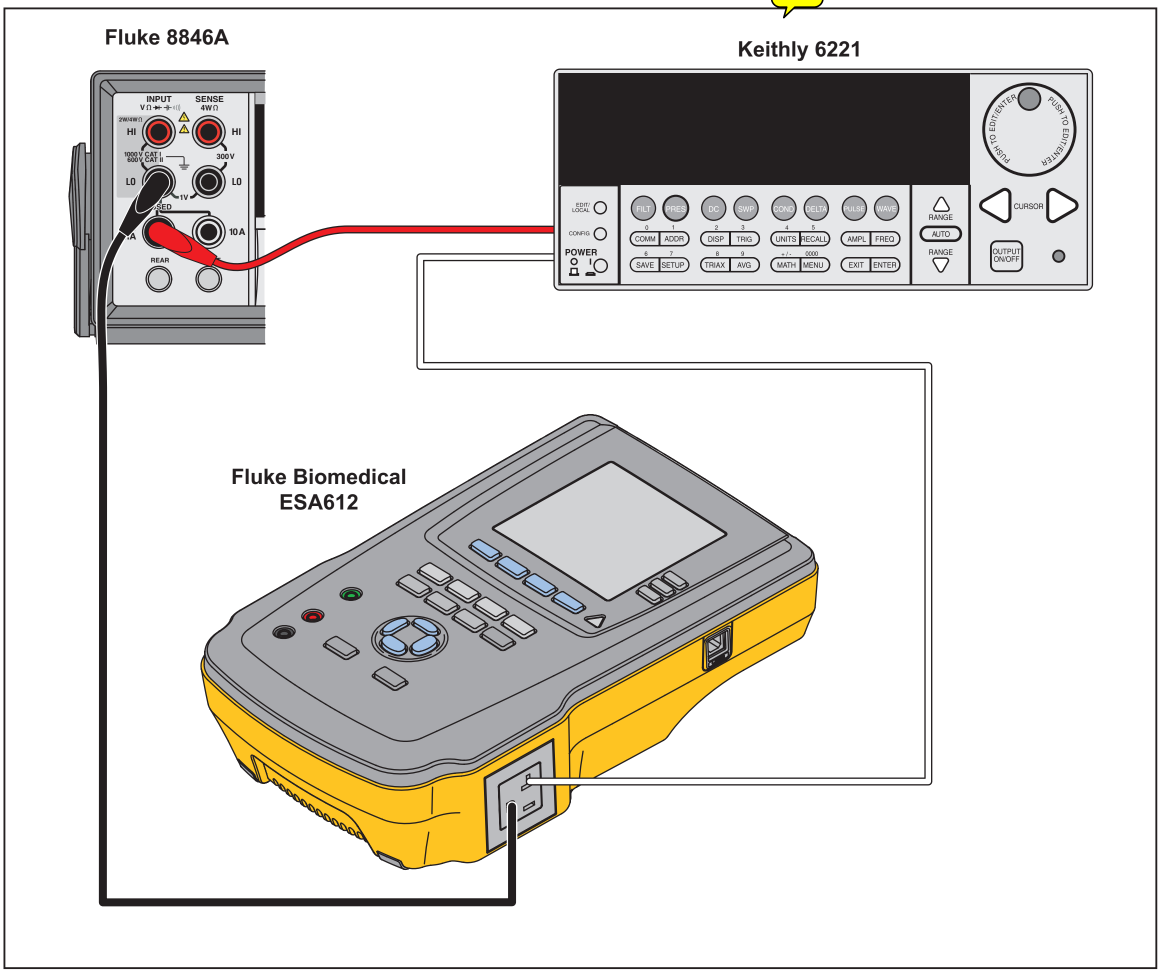

Figure 3-16. Differential Leakage Verification Connections

2. Send command: `DIFF <CR>`
3. Receive *
4. Send command: `EARTH=C <CR>`
5. Receive *
6. Send command: `POL=N <CR>`
7. Receive *
8. Send command: `NOMINAL=OFF <CR>`
9. Receive *
10. Turn on the current source output.
11. Send command: `READ <CR>`

~~12. Receive and record response; compare it to the actual current received by the DMM.~~

~~13. Adjust the DMM to the 1 mA range and repeat steps 11 and 12 with the current source set to 0.16mA (0.2263 mA p-p), 0.24 mA (0.3394 mA p-p), 0.50 mA (0.7071 mA p-p), 0.76 mA (1.0748 mA p-p), 100 Hz.~~

~~14. Adjust the DMM to the 10 mA range and repeat steps 11 and 12 with the current source set to 1.6 mA (2.263 mA p-p), 2.4 mA (3.394 mA p-p), 5 mA (7.071 mA p-p), and 7.6 mA (10.748 mA p-p), 100 Hz.~~

~~15. Adjust the DMM to the 100 mA range and repeat steps 11 and 12 with the current source set to 16 mA (22.63 mA p-p), 100 Hz.~~

~~16. Turn off the current source output and disconnect all testing connections from the Analyzer.~~

L. ECG Leakage Functionality

1. Connect the DMM Input (+) to the RA applied part. Connect the DMM Input (-) to the EO ground. See Figure 3-17. Set the DMM for 1 KΩ resistance range. During this test, the DMM will function as both a current source and an ohmmeter.

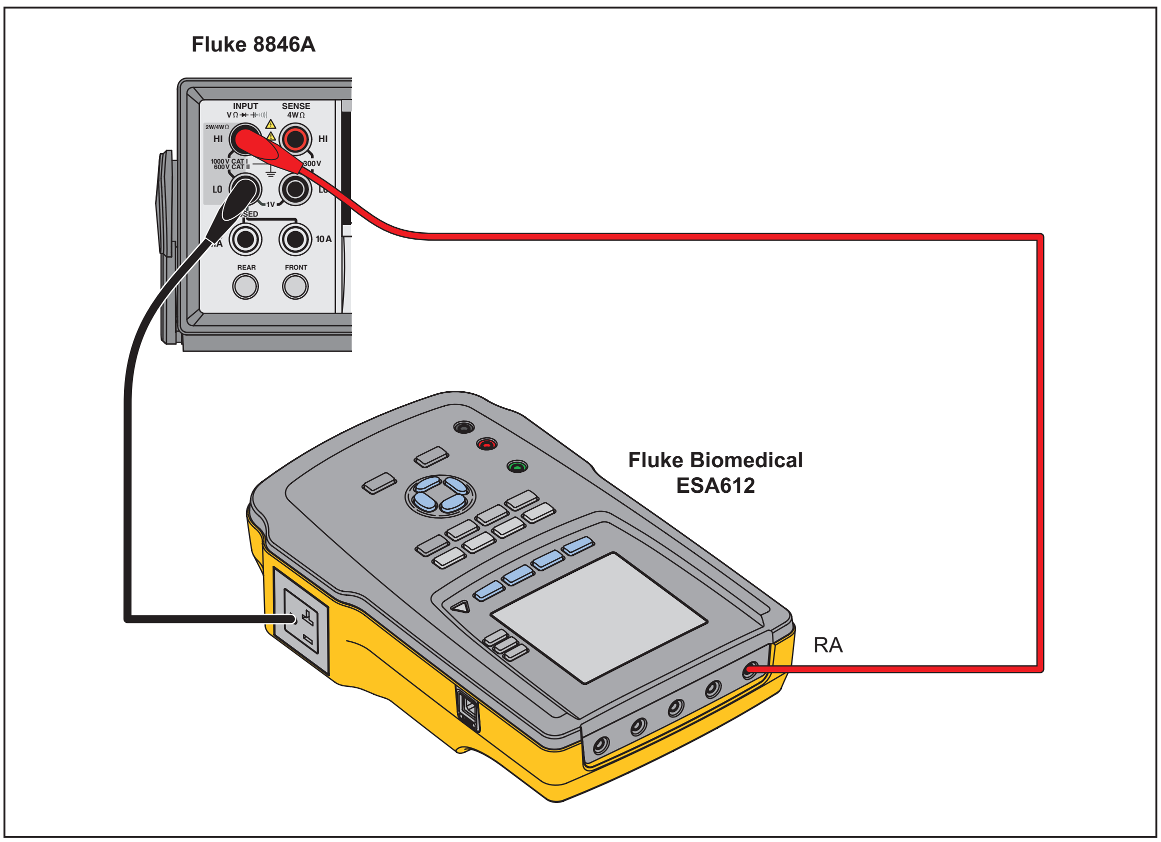

Figure 3-17. ECG Leakage Functionality Connections

2. Send command: HIGH_RES=ON <CR>
3. Receive *
4. Send command: STD=601 <CR>

5. Receive *
6. Send command: PAT <CR>
7. Receive *
8. Send command: NOMINAL=OFF <CR>
9. Receive *
10. Send command: MODE=DC <CR>
11. Receive *
12. Send command: AP=RA//GND <CR>
13. Receive *
14. Send command: READ <CR>
15. Receive response. The DMM is acting as a current source, and should be supplying approximately 100 µA. If the Analyzer responds accordingly, record PASS. If it responds with 0 µA, record FAIL.
16. Send command: AP=LL//OPEN <CR>
17. Receive *
18. Note the reading from the DMM. If it reads OL (open), this indicates that the RA applied part is connected to the Open Bus. Record PASS. If the DMM indicates a significant resistance or a short (0 Ω), record FAIL.
19. Send command: AP=LL//GND <CR>
20. Receive *
21. Note the reading from the DMM. If it reads 0 Ω, this indicates that the RA applied part is connected to ground. Record PASS. If the DMM indicates a significant resistance or OL (open), record FAIL.
22. Move the lead connected to Input (+) from RA to LL. Repeat steps 14 – 21 for each applied part (LL, LA, RL, and V1).
23. Remove all test connections from the DMM.

M. Direct Applied Part Leakage, Alternative Applied Part Leakage: Ground to RA

1. Connect the RA Applied Part to one side of a 110 kΩ resistor. Connect the 400 mA jack of the DMM to the other side of the 110 kΩ resistor. Connect the DMM Input (-) to the EO ground. See Figure 3-18.

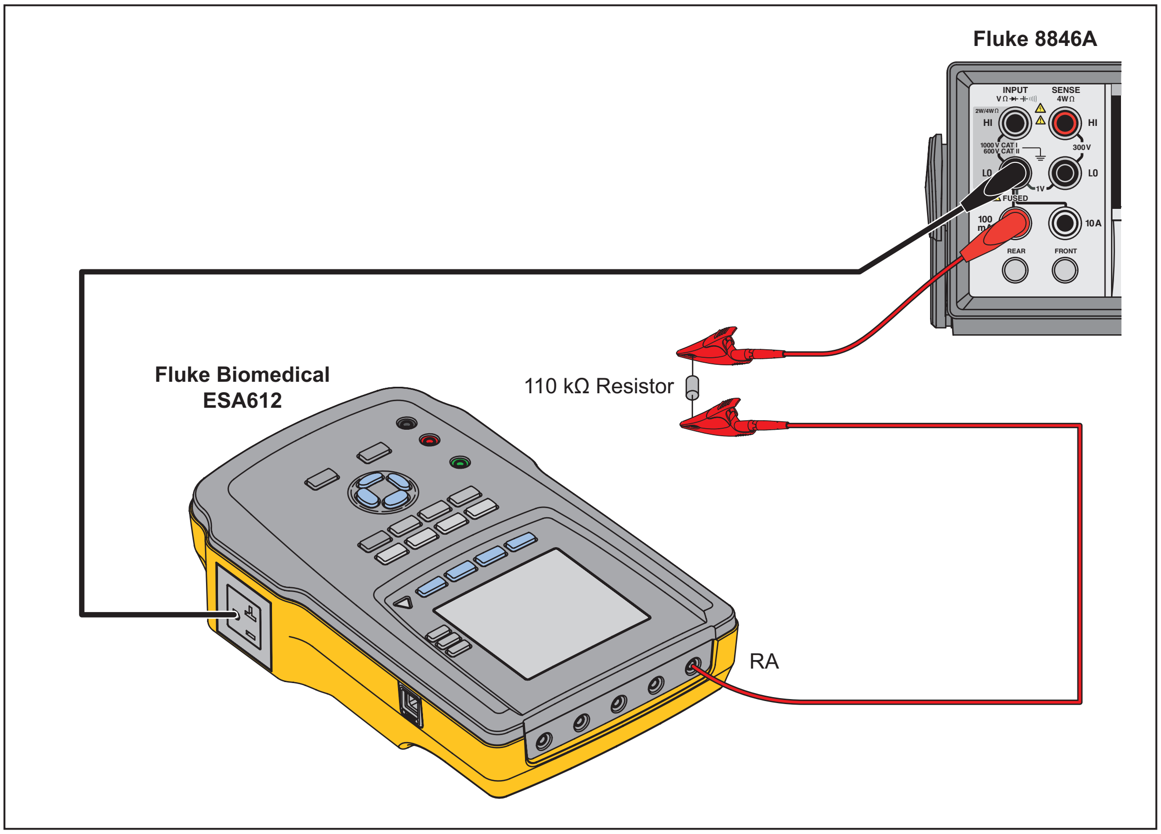

Figure 3-18. Direct Applied Part Verification Ground to RA Connections

2. Send command: `NOMINAL=OFF <CR>`
3. Receive *
4. Send command: `HIGH_RES=ON <CR>`
5. Receive *
6. Send command: `STD=353 <CR>`
7. Receive *
8. Send command: `DMAP <CR>`
9. Receive *
10. Send command: `MAP=3.5MA <CR>`
11. Receive *
12. Send command: `POL=N <CR>`
13. Receive *
14. Send command: `AP=RA/RL/GND <CR>`
15. Receive *

16. Send command: `MODE=AC <CR>`
17. Receive *
18. Send command: `MREAD <CR>`
19. Receive multiple readings, all approximately 1 mA ac. While the Analyzer is conducting its read, record the value of the DMM current.
20. Receive and record response; compare it to the actual current received by the DMM.
21. Press the ESC key. The Analyzer will stop reporting readings.
22. Send command: `NOMINAL=OFF <CR>`
23. Receive *
24. Send command: `HIGH_RES=ON <CR>`
25. Receive *
26. Send command: `STD=353 <CR>`
27. Receive *
28. Send command: `SPAT <CR>`
29. Receive *
30. Send command: `MAP=3.5MA <CR>`
31. Receive *
32. Send command: `AP=ALL// <CR>`
33. Receive *
34. Send command: `MODE=AC <CR>`
35. Receive *
36. Send command: `MREAD <CR>`
37. Receive multiple readings, all approximately 1 mA ac. While the Analyzer is conducting its read, record the value of the DMM current.
38. Receive and record response; compare it to the actual current received by the DMM.
39. Press the ESC key. The Analyzer will stop reporting readings.
40. Send command: `IDLE <CR>`
41. Receive *

N. Direct Applied Part Leakage, Alternative Applied Part Leakage: Red to RA

1. Move the lead connected to the EO ground to the red jack; the other end should be connected to the DMM Input (-). The RA Applied Part should still be connected to one end of the 110-kΩ resistor. See Figure 3-19.

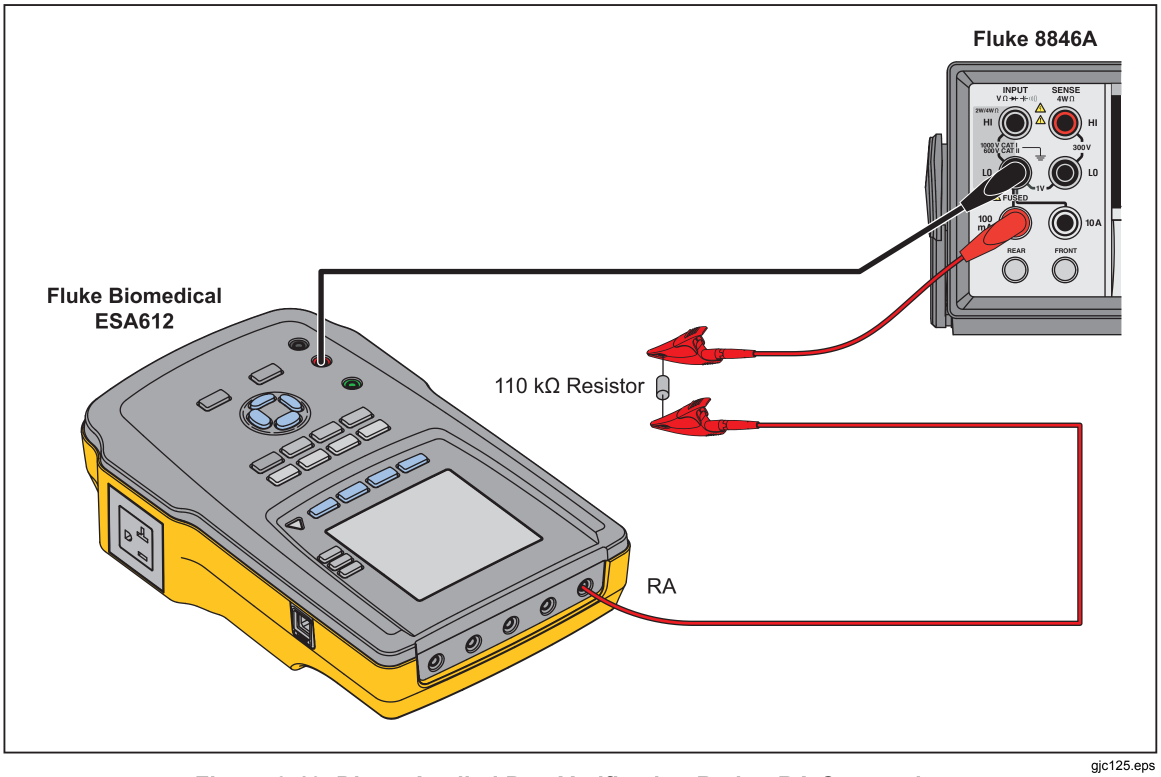

Figure 3-19. Direct Applied Part Verification Red to RA Connections

2. Send command: `NOMINAL=OFF <CR>`
3. Receive *
4. Send command: `HIGH_RES=ON <CR>`
5. Receive *
6. Send command: `STD=353 <CR>`
7. Receive *
8. Send command: `DMAP <CR>`
9. Receive *
10. Send command: `MAP=3.5MA <CR>`
11. Receive *
12. Send command: `POL=N <CR>`
13. Receive *
14. Send command: `AP=RA/RL/GND <CR>`
15. Receive *
16. Send command: `MODE=AC <CR>`

17. Receive *
18. Send command: `MREAD <CR>`
19. Receive multiple readings, all approximately 1 mA ac. While the Analyzer is conducting its read, record the value of the DMM current.
20. Receive and record response; compare it to the actual current received by the DMM.
21. Press the ESC key. The Analyzer will stop reporting readings.
22. Send command: `NOMINAL=OFF <CR>`
23. Receive *
24. Send command: `HIGH_RES=ON <CR>`
25. Receive *
26. Send command: `STD=353 <CR>`
27. Receive *
28. Send command: `SPAT <CR>`
29. Receive *
30. Send command: `MAP=3.5MA <CR>`
31. Receive *
32. Send command: `AP=ALL// <CR>`
33. Receive *
34. Send command: `MODE=AC <CR>`
35. Receive *
36. Send command: `MREAD <CR>`
37. Receive multiple readings, all approximately 1 mA ac. While the Analyzer is conducting its read, record the value of the DMM current.
38. Receive and record response; compare it to the actual current received by the DMM.
39. Press the ESC key. The Analyzer will stop reporting readings.
40. Send command: `IDLE <CR>`
41. Receive *

O. Alternative Equipment Leakage: Red to Hot

1. Move the lead from the RA applied part to the EO hot; the other end should still be connected to the 110-kΩ resistor. The red jack should be connected to the DMM Input (-). See Figure 3-20.

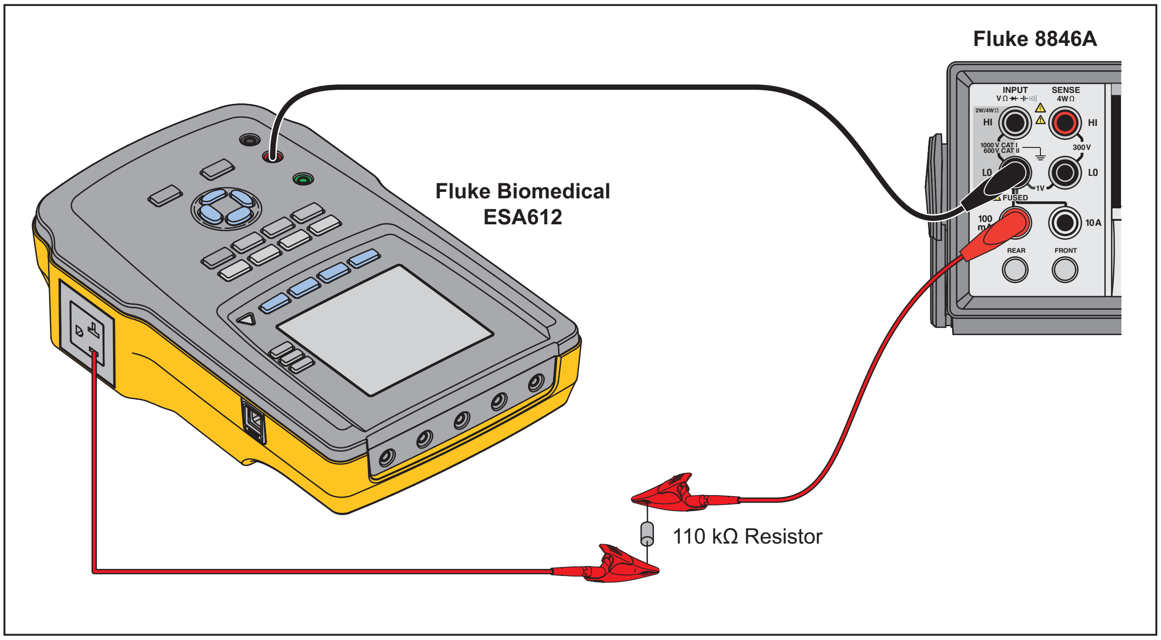

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Figure 3-20. Alternate Equipment Leakage: Red to Hot Connections

2. Send command: NOMINAL=OFF <CR>
3. Receive *
4. Send command: HIGH_RES=ON <CR>
5. Receive *
6. Send command: STD=353 <CR>
7. Receive *
8. Send command: SAF <CR>
9. Receive *
10. Send command: MAP=3.5MA <CR>
11. Receive *
12. Send command: ~~AP=ALL// <CR>~~
13. Receive *
14. Send command: ~~MODE=AC <CR>~~
15. Receive *
16. Send command: ALTEARTH=C <CR>
17. Receive *
18. Send command: MREAD <CR>

19. Receive multiple readings, all approximately 1 mA ac. While the Analyzer is conducting its read, record the value of the DMM current.
20. Receive and record response; compare it to the actual current received by the DMM.
21. Press the ESC key. The Analyzer will stop reporting readings.
22. Send command: `IDLE <CR>`
23. Receive *

P. Alternative Equipment Leakage, Alternative Applied Part Leakage: RA to Hot

1. Move the lead from the Red jack to the RA applied part, the other end should still be connected to the Input (-) of the DMM. The EO hot should still be connected to the 110-kΩ resistor. See Figure 3-21.

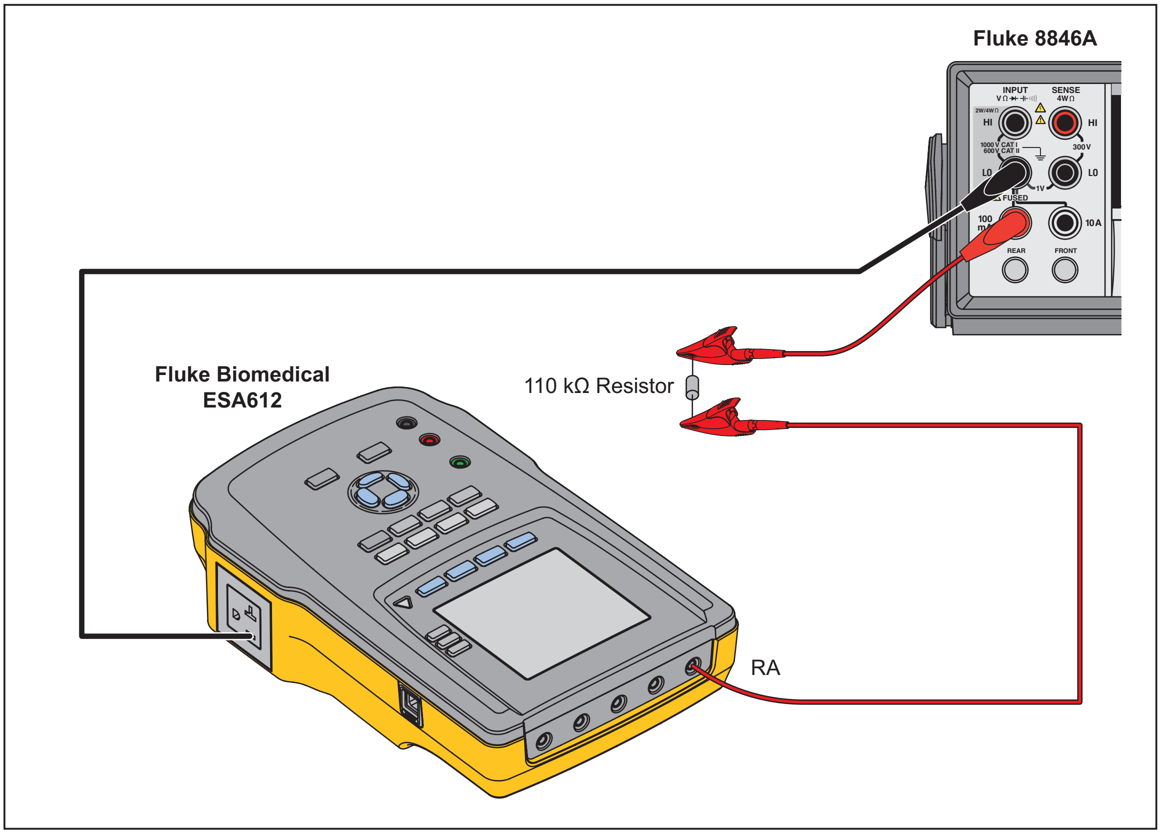


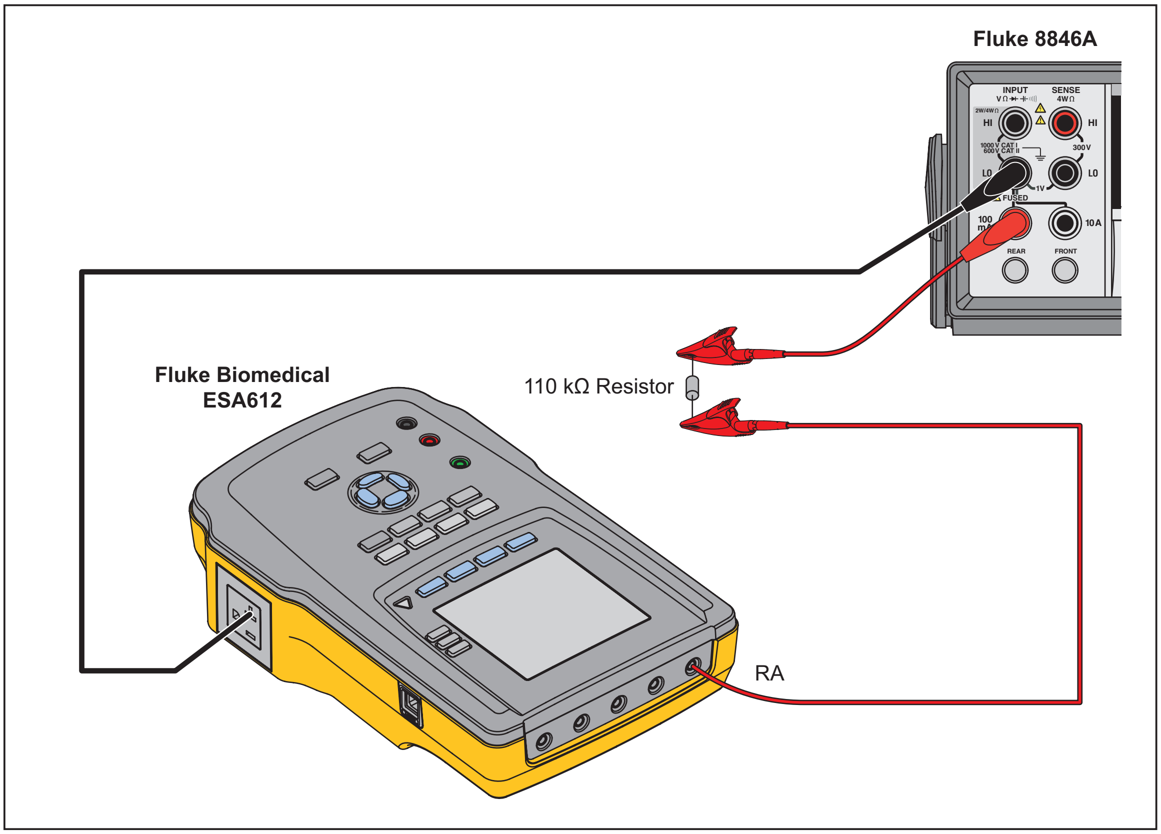
Figure 3-21. Alternative Applied Part Leakage: RA to Hot

2. Send command: `NOMINAL=OFF <CR>`
3. Receive *
4. Send command: `HIGH_RES=ON <CR>`
5. Receive *
6. Send command: `STD=353 <CR>`
7. Receive *
8. Send command: `SAF <CR>`

9. Receive *
10. Send command: `MAP=3.5MA <CR>`
11. Receive *
12. Send command: `MODE=AC <CR>`
13. Receive *
14. Send command: `AP=ALL// <CR>`
15. Receive *
16. Send command: `ALTEARTH=C <CR>`
17. Receive *
18. Send command: `MREAD <CR>`
19. Receive multiple readings, all approximately 1 mA ac. While the Analyzer is conducting its read, record the value of the DMM current.
20. Receive and record response; compare it to the actual current received by the DMM.
21. Press the ESC key. The Analyzer will stop reporting readings.
22. Send command: `NOMINAL=OFF <CR>`
23. Receive *
24. Send command: `HIGH_RES=ON <CR>`
25. Receive *
26. Send command: `STD=353 <CR>`
27. Receive *
28. Send command: `SPAT <CR>`
29. Receive *
30. Send command: `MAP=3.5MA <CR>`
31. Receive *
32. Send command: `AP=ALL// <CR>`
33. Receive *
34. Send command: `MODE=AC <CR>`
35. Receive *
36. Send command: `MREAD <CR>`
37. Receive multiple readings, all approximately 1 mA ac. While the Analyzer is conducting its read, record the value of the DMM current.
38. Receive and record response; compare it to the actual current received by the DMM.
39. Press the ESC key. The Analyzer will stop reporting readings.
40. Send command: `IDLE <CR>`
41. Receive *

Q. Alternative Applied Part Leakage: RA to Neutral

1. Move the lead from the EO hot to the EO neutral, the other end should still be connected to the 110-kΩ resistor. The RA applied part lead should still be connected to the DMM Input (-). See Figure 3-22.



gjc132.eps

Figure 3-22. Alternative Applied Part Leakage: RA to Neutral Connections

2. Send command: `NOMINAL=OFF <CR>`
3. Receive *
4. Send command: `HIGH_RES=ON <CR>`
5. Receive *
6. Send command: `STD=353 <CR>`
7. Receive *
8. Send command: `SPAT <CR>`
9. Receive *
10. Send command: ~~`AP=ALL// <CR>`~~
11. Receive *
12. Send command: ~~`MAP=3.5MA <CR>`~~
13. Receive *
14. Send command: `MODE=AC <CR>`
15. Receive *

16. Send command: `MREAD <CR>`
17. Receive multiple readings, all approximately 1 mA ac. While the Analyzer is conducting its read, record the value of the DMM current.
18. Receive and record response; compare it to the actual current received by the DMM.
19. Press the ESC key. The Analyzer will stop reporting readings.
20. Send command: `IDLE <CR>`
21. Receive *
22. Disconnect all test leads from the 100 kΩ resistor.

R. Patient Auxiliary Leakage: RA to RL

1. Connect the current source to the 400 mA jack of the DMM and to the RL applied part. The DMM Input (-) should still be connected to the RA applied part. See Figure 3-23. Set the DMM to the 100 µA ac range and the current source to 100.000 µA (141.42 µA p-p), 100 Hz, with a 25 V compliance voltage.

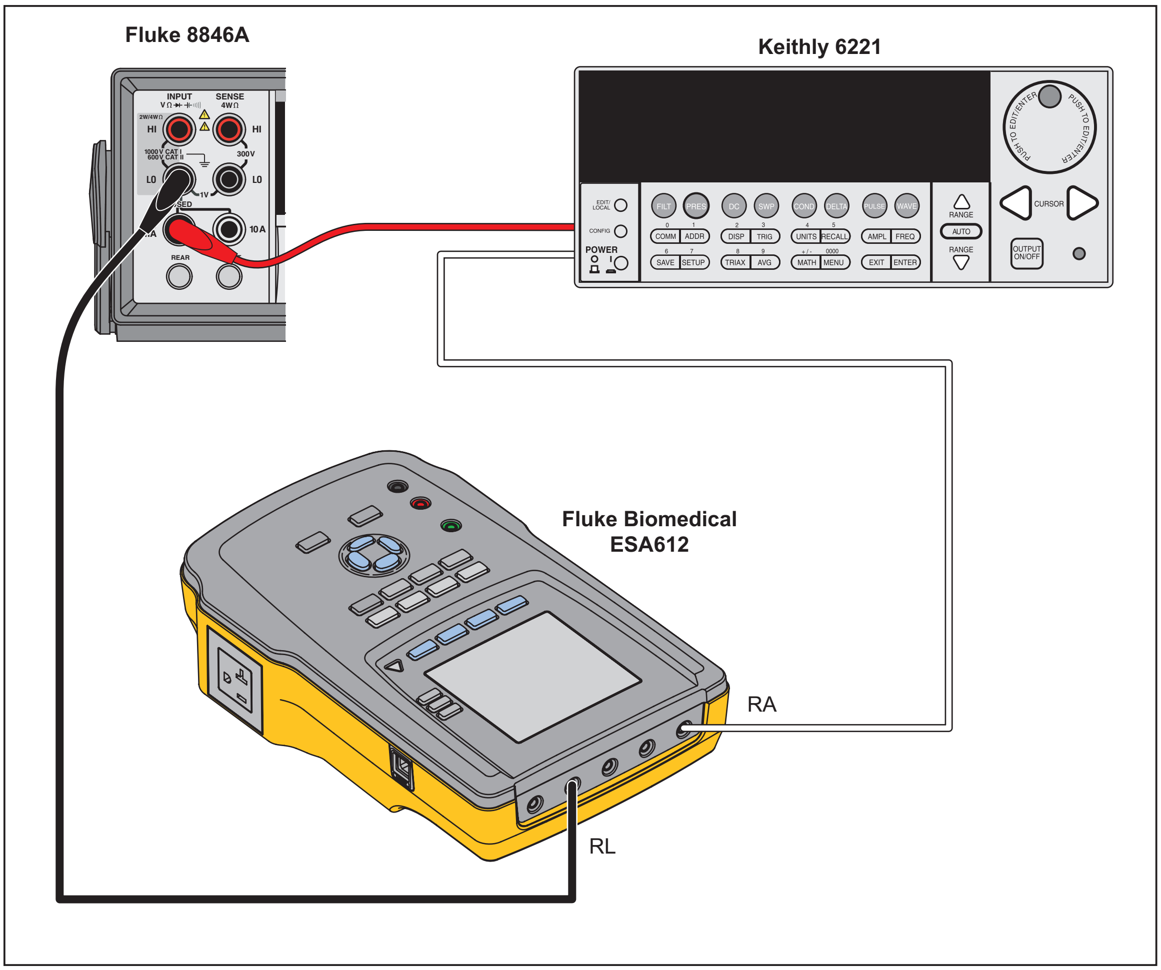


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Figure 3-23. Patient Auxiliary Leakage: RA to RL Connections

2. Send command: `NOMINAL=OFF <CR>`
3. Receive *

4. Send command: `HIGH_RES=ON <CR>`
5. Receive *
6. Send command: `STD=601 <CR>`
7. Receive *
8. Send command: `AUX <CR>`
9. Receive *
10. Send command: `AP=RA/RL/GND <CR>`
11. Receive *
12. Send command: `POL=N <CR>`
13. Receive *
14. Send command: `MODE=AC <CR>`
15. Receive *
16. Send command: `NEUT=C <CR>`
17. Receive *
18. Send command: `EARTH=C <CR>`
19. Receive *
20. Turn on the current source output.
21. Send command: `READ <CR>`
22. Receive and record response; compare it to the actual current received by the DMM.
23. Turn off the current source output.
24. Send command: `IDLE <CR>`
25. Receive *

S. Direct Equipment Leakage, Patient Leakage: Ground to RA

1. Move the lead from the RL applied part to the EO ground, the other end should still be connected to the current source. The RA applied part lead should still be connected to the DMM Input (-). See Figure 3-24.

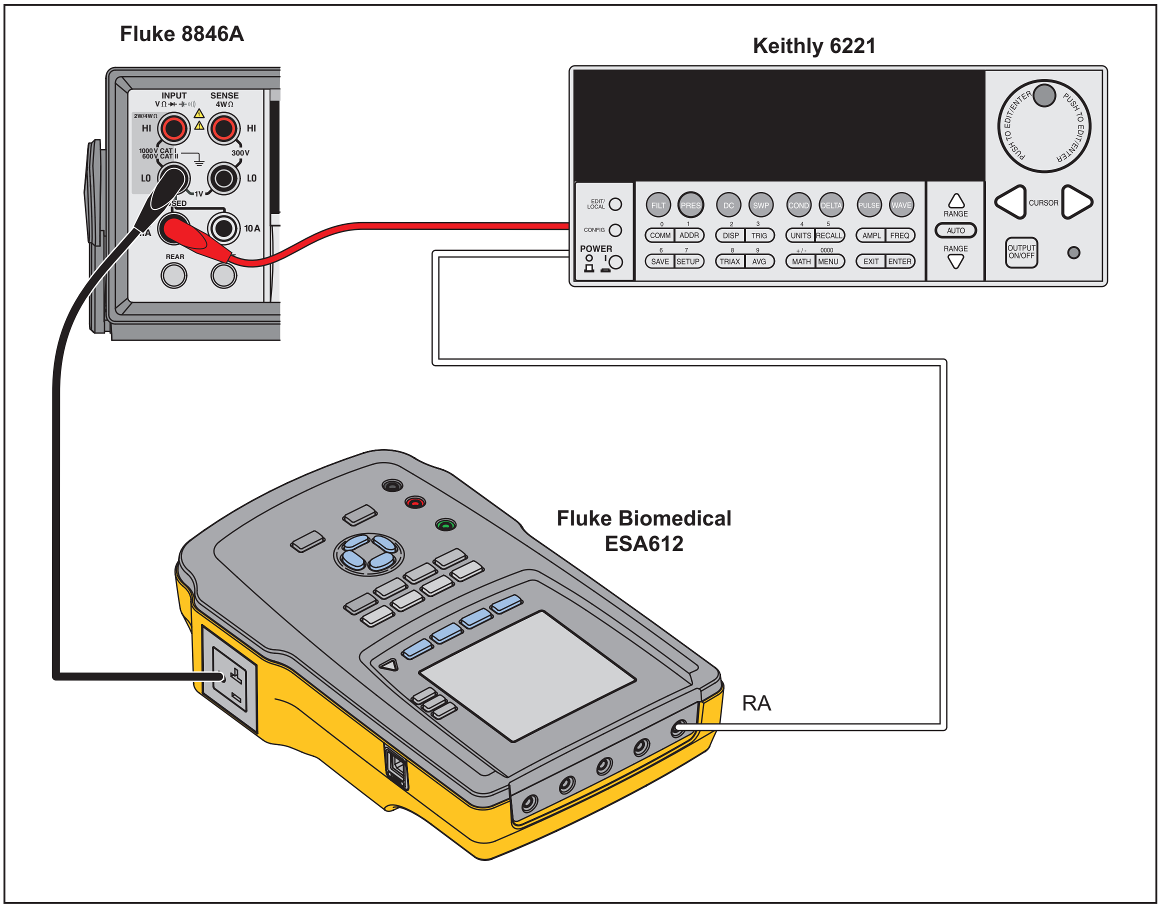

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Figure 3-24. Direct Equipment Leakage, Patient Leakage: Ground to RA

2. Send command: `NOMINAL=OFF <CR>`
3. Receive *
4. Send command: `HIGH_RES=ON <CR>`
5. Receive *
6. Send command: `STD=353 <CR>`
7. Receive *
8. Send command: `DIRL <CR>`
9. Receive *
10. Send command: ~~AP=RA/RL/GND <CR>~~
11. Receive *
12. Send command: ~~POL=N <CR>~~
13. Receive *

14. Send command: ~~`MODE=AC <CR>`~~
15. Receive *
16. Send command: ~~`EARTH=C <CR>`~~
17. Receive *
18. Turn on the current source output.
19. Send command: `READ <CR>`
20. Receive and record response; compare it to the actual current received by the DMM.
21. Turn off the current source output.
22. Send command: `IDLE <CR>`
23. Receive *
24. Send command: `NOMINAL=OFF <CR>`
25. Receive *
26. Send command: `HIGH_RES=ON <CR>`
27. Receive *
28. Send command: `STD=601 <CR>`
29. Receive *
30. Send command: `PAT <CR>`
31. Receive *
32. Send command: `AP=RA/RL/GND <CR>`
33. Receive *
34. Send command: `POL=N <CR>`
35. Receive *
36. Send command: `MODE=AC <CR>`
37. Receive *
38. Send command: `NEUT=C <CR>`
39. Receive *
40. Send command: `EARTH=C <CR>`
41. Receive *
42. Turn on the current source output.
43. Send command: `READ <CR>`
44. Receive and record response; compare it to the actual current received by the DMM.
45. Turn off the current source output.
46. Send command: `IDLE <CR>`
47. Receive *

T. Direct Equipment Leakage, Enclosure Leakage: Ground to Red

1. Move the lead from the RA applied part to the Red jack, the other end should still be connected to the DMM Input (-). The EO ground lead should still be connected to the current source. See Figure 3-25.

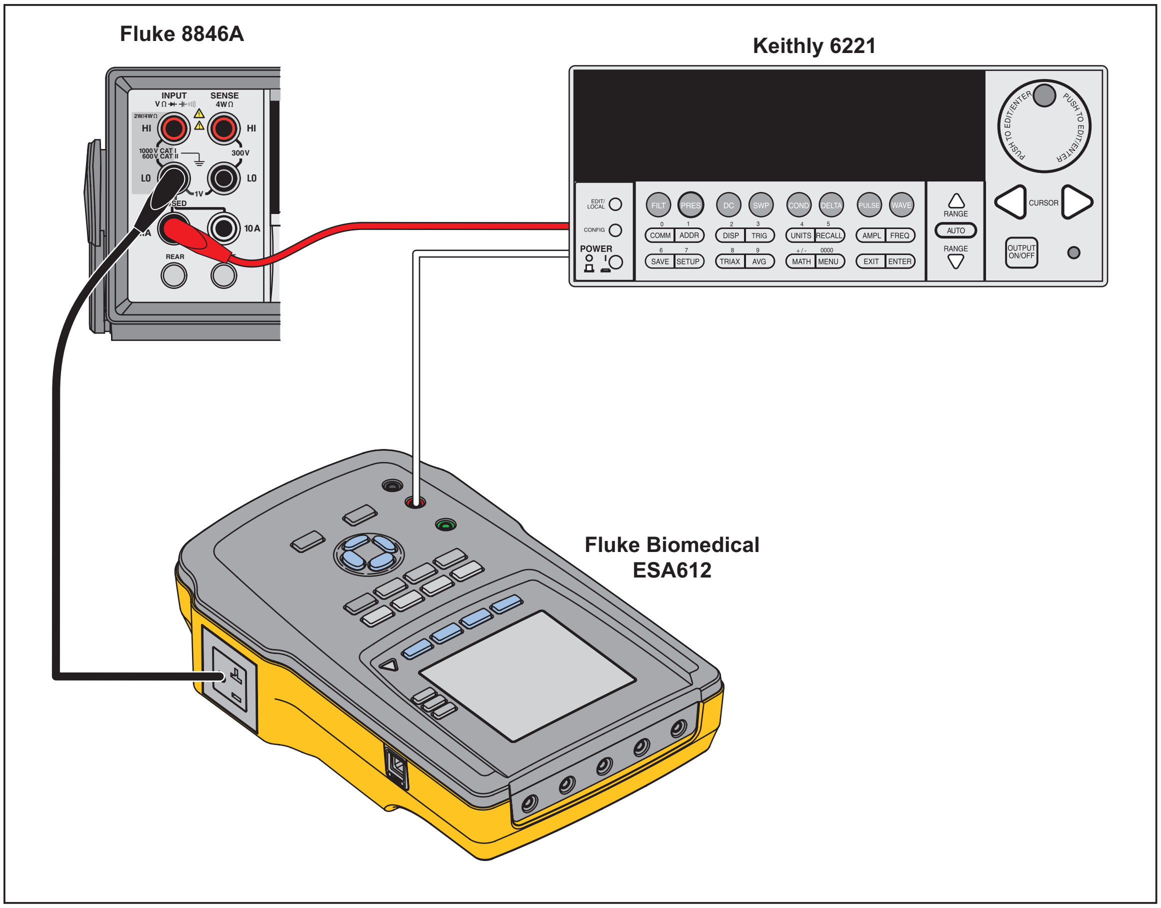

Figure 3-25. Direct Equipment Leakage, Enclosure Leakage: Ground to Red Connections

2. Send command: `NOMINAL=OFF <CR>`
3. Receive *
4. Send command: `HIGH_RES=ON <CR>`
5. Receive *
6. Send command: `STD=353 <CR>`
7. Receive *
8. Send command: `DIRL <CR>`
9. Receive *
10. Send command: ~~AP=RA/RL/GND <CR>~~
11. Receive *
12. Send command: ~~POL=N <CR>~~
13. Receive *

14. Send command: ~~MODE=AC <CR>~~
15. Receive *
16. Send command: ~~EARTH=C <CR>~~
17. Receive *
18. Turn on the current source output.
19. Send command: READ <CR>
20. Receive and record response; compare it to the actual current received by the DMM.
21. Turn off the current source output.
22. Send command: IDLE <CR>
23. Receive *
24. Send command: NOMINAL=OFF <CR>
25. Receive *
26. Send command: HIGH_RES=ON <CR>
27. Receive *
28. Send command: STD=601 <CR>
29. Receive *
30. Send command: ENCL <CR>
31. Receive *
32. Send command: POL=N <CR>
33. Receive *
34. Send command: MODE=ACDC <CR>
35. Receive *
36. Send command: NEUT=C <CR>
37. Receive *
38. Send command: EARTH=C <CR>
39. Receive *
40. Turn on the current source output.
41. Send command: READ <CR>
42. Receive and record response; compare it to the actual current received by the DMM.
43. Turn off the current source output.
44. Send command: IDLE <CR>
45. Receive *
46. Do not disconnect any connections.

U. Filter Tests

1. Attempt to measure ac current with the dc filter: set the current source to generate 100.00 µA (141.42 µA p-p), 100 Hz, with a 25 V compliance voltage.
2. Send command: `NOMINAL=OFF <CR>`
3. Receive *
4. Send command: `HIGH_RES=ON <CR>`
5. Receive *
6. Send command: `STD=601 <CR>`
7. Receive *
8. Send command: `ENCL <CR>`
9. Receive *
10. Send command: `POL=N <CR>`
11. Receive *
12. Send command: `MODE=DC <CR>`
13. Receive *
14. Send command: `NEUT=C <CR>`
15. Receive *
16. Send command: `EARTH=C <CR>`
17. Receive *
18. Turn on the current source output.
19. Send command: `READ <CR>`
20. Receive and record response. The result should be approximately zero.
21. Turn off the current source output.
22. Set the current source to generate 100 µA dc and turn the output on.
23. Send command: `MODE=AC <CR>`
24. Receive *
25. Send command: `READ <CR>`
26. Disconnect all testing connections from the Analyzer.

V. MAP Voltage and Current Limits

1. Connect the DMM Input (+) to the RA applied part and the DMM Input (-) to the EO ground as shown in Figure 3-26. Set the DMM to the 1000 V ac range.

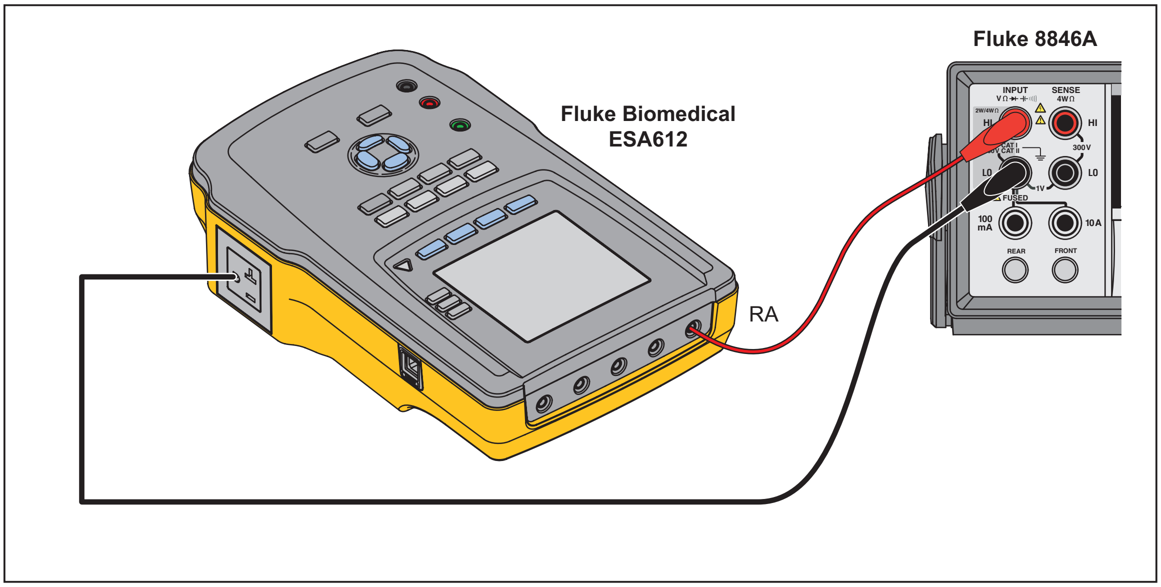

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Figure 3-26. MAP Voltage and Current Limits Connections

2. Send command: `DMAP <CR>`
3. Receive *
4. Send command: `MAP=NORM <CR>`
5. Receive *
6. Send command: `AP=RA/RL/GND <CR>`
7. Receive *
8. Send command: `MREAD <CR>`
9. Receive multiple readings. While the Analyzer is conducting its read, record the value of the DMM voltage.
10. Press the ESC key. The Analyzer will stop reporting readings.
11. Turn off the output of the programmable ac power supply. Adjust it for 230 V, 50 Hz, and turn on the output.
12. Once the ESA612 powers on again, it will report an error code of "!53" and the display will show "Fault detected…Mains out of range," Send command: `REMOTE=F2810 <CR>`
13. Receive *. The WARNING LED will remain lit.
14. Send command: `DMAP <CR>`
15. Receive *
16. Send command: `MAP=3.5MA <CR>`
17. Receive *
18. Send command: `AP=RA/RL/GND <CR>`

19. Receive *
20. Send command: `MREAD <CR>`
21. Receive multiple readings. While the Analyzer is conducting its read, record the value of the DMM voltage.
22. Press the ESC key. The Analyzer will stop reporting readings.
23. Move the lead connected to the RA applied part from the DMM Input (+) to the 400 mA jack. The DMM Input (-) should still be connected to EO ground. Set the DMM to the 10 mA range.
24. Send command: `DMAP <CR>`
25. Receive *
26. Send command: `MAP=3.5MA <CR>`
27. Receive *
28. Send command: `AP=RA/RL/GND <CR>`
29. Receive *
30. Send command: `MREAD <CR>`
31. Receive multiple readings. While the Analyzer is conducting its read, record the value of the DMM current.
32. Press the ESC key. The Analyzer will stop reporting readings.
33. Send command: `DMAP <CR>`
34. Receive *
35. Send command: `MAP=7.5MA <CR>`
36. Receive *
37. Send command: `AP=RA/RL/GND <CR>`
38. Receive *
39. Send command: `MREAD <CR>`
40. Receive multiple readings. While the Analyzer is conducting its read, record the value of the DMM current.
41. Press the ESC key. The Analyzer will stop reporting readings.
42. Turn off the output of the programmable ac power supply. Readjust it for 115 V, 60 Hz, and turn on the output.
43. Once the ESA612 powers on again, it will report the model number and firmware version. Send command: `REMOTE <CR>`
44. Receive *
45. Send command: `DMAP <CR>`
46. Receive *
47. Send command: `MAP=1MA <CR>`
48. Receive *
49. Send command: `AP=RA/RL/GND <CR>`

50. Receive *
51. Send command: `MREAD <CR>`
52. Receive multiple readings. While the Analyzer is conducting its read, record the value of the DMM current.
53. Press the ESC key. The Analyzer will stop reporting readings.
54. Disconnect all testing connections from the Analyzer.

W. ECG Waveform

1. Connect the Input (+) of the differential amplifier to the RA applied part and the Input (-) of the differential amplifier to the RL applied part. Connect the differential amplifier output to the oscilloscope. See Figure 3-27.

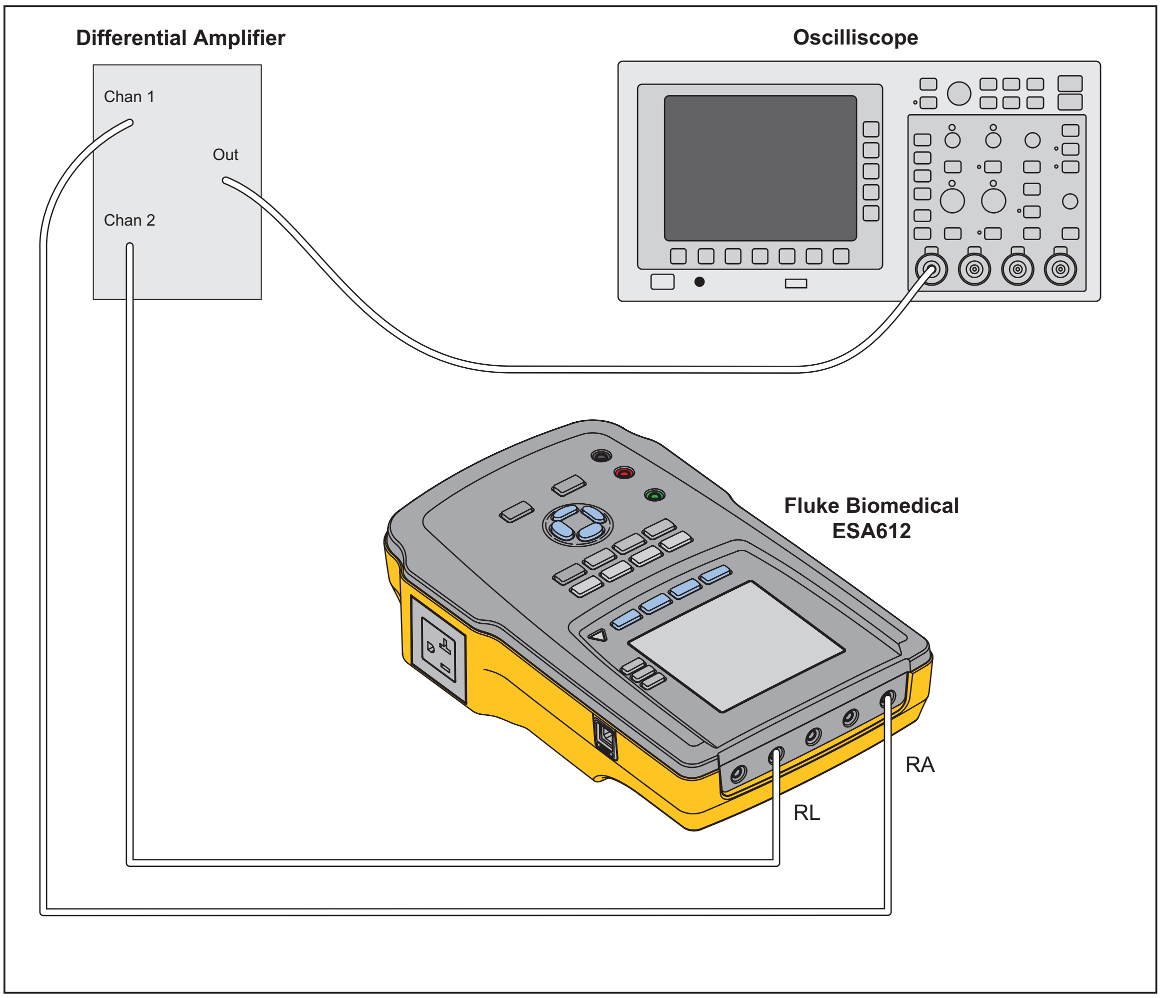

Figure 3-27. ECG Waveform Connections

2. Establish the following settings for the differential amplifier:
   a. GAIN = 1K
   b. Divide by 100 = Out
   c. (+) Input = DC
   d. (-) Input = DC

e. HF -3dB = 0.1

f. LF -3db = DC OFFSET

3. Send command: `STD=AAMI <CR>`
4. Receive *
5. Send command: `ECG <CR>`
6. Receive *
7. Send command: `SQ2 <CR>`
8. Receive *
9. Verify the waveform has a 2.000 ±0.04 Hz frequency. Record PASS/FAIL.
10. Connect the RA applied part to the DMM Input (+) and the RL applied part to the DMM Input (-) and set the DMM for 100 mV dc range.
11. Using DMM MIN MAX function, record the waveform peak to peak amplitude.
12. Move the DMM Input (+) from the RA applied part to the LL applied part. Repeat step 11 for each of the following applied parts: LL, LA, and V1.
13. Press ESC. Receive only a carriage return.
14. Send commend: `EXIT <CR>`
15. Receive *
16. Disconnect all testing connections.

X. Equipment Current Verification

1. Connect the current shunt to the DMM using the voltage inputs. Connect the EO hot to the DMM Input (+) side of the current shunt and the EO ground to one side of the variable current load. Connect the other side of the variable current load to the current shunt jack corresponding to the Input (-) of the DMM. Set the DMM to the 10 V dc range.

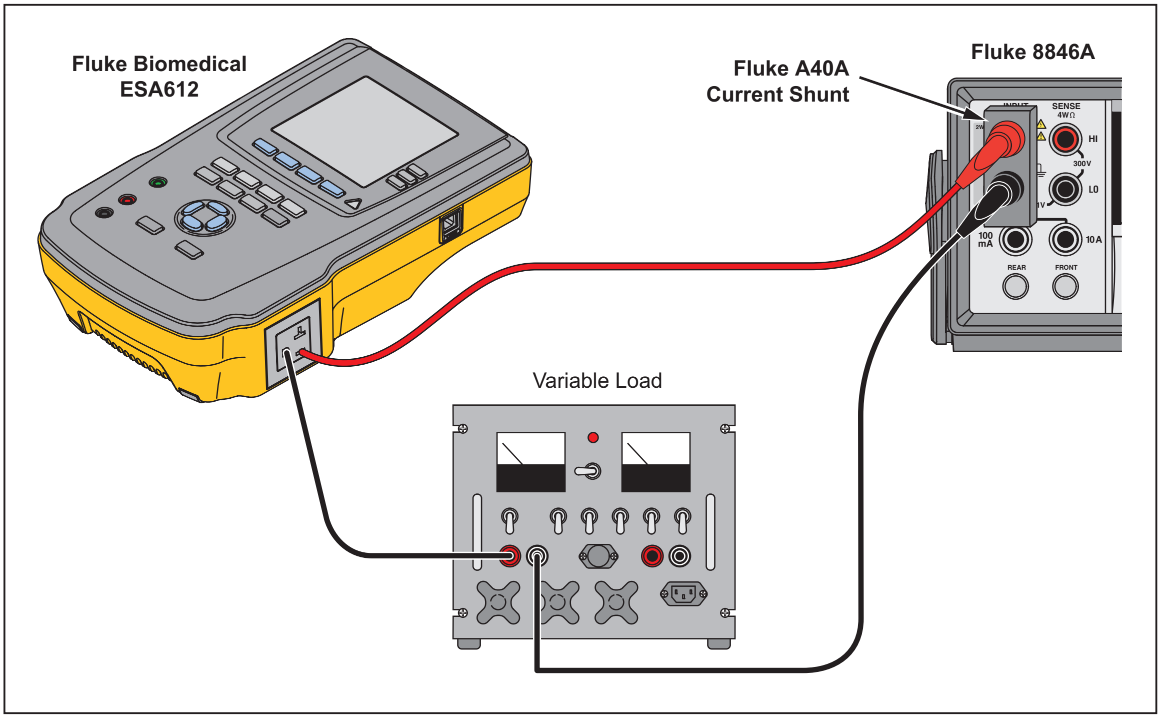

Figure 3-28. Equipment Current Calibration Connection

2. Send command: `STD=AAMI <CR>`
3. Receive *
4. Send command: `EQCURR <CR>`
5. Receive *
6. Establish an 8 A draw through the current load, with the shunt resistor in series with the load.
7. Send command: `READ <CR>`
8. Receive *
9. Receive and record response. Compare to the actual current flowing through the load as read on the DMM.
10. Establish a 3 A draw through the current load.
11. Send command: `READ <CR>`
12. Receive and record response. Compare to the actual current flowing through the load as read on the DMM.
13. Establish a 1 A draw through the current load.
14. Send command: `READ <CR>`

15. Receive and record response. Compare to the actual current flowing through the load as read on the DMM.
16. Turn off the equipment outlet. Send command: `PPL <CR>`
17. Receive *
18. Remove all testing connections.

Y. Save Calibration Information

If this is AS LEFT verification and the device has passed verification, record the new calibration date and technician information.

1. Send command: `CAL=F2810 <CR>`
2. Receive *
3. Write new calibration date in the format of MxxDyyYzzzz, where xx stands for the two digits of the current month, yy stands for the two digits of the current day, and zzzz stands for the four digits of the current year.
4. Send command: `DATE=MxxDxxYxxxx <CR>`
5. Receive *
6. Write calibration technician in the format of xxxxx, where xxxxx stands for the five digits of the technician's employee number.
7. Send command: `TECH=xxxxx <CR>`
8. Receive *
9. Check Analyzer serial number, cal date, and cal technician are correct.
10. Send command: `INFO= <CR>`
11. Receive serial number, cal date, and cal technician in response. Record response.
12. Send command: `SAVE <CR>`
13. Send command: `EXIT <CR>`
14. Receive *
15. If the unit did not come in with a nominal voltage of 115, readjust the nominal voltage according to the destination country.
    a. Send command: NOMINAL=xxx <CR> where xxx is the value recorded when the unit was originally converted for verification. See Table 3-3 for standard nominal values.

Table 3-3. Nominal Values

Country	Value
Europe	230
UK	230
Australia	240
Israel	230
France/Belgium	230
US	120
Swiss	230
Thailand	220
Japan	100

b. Receive *

16. Turn the Analyzer power off.
17. After the Analyzer has restarted, verify the device has retained its calibration date by pressing **SETUP**. Next press the softkey labeled **More** twice, and then the softkey labeled **Instrument Information**. Verify the calibration date, firmware version, and serial number are correct.
18. Turn the Analyzer off and remove all connections.

Calibration Procedure

The following steps will bring the Analyzer into published specifications. The required equipment for this procedure is shown in Table 3-1.

Setup

Perform the following steps to prepare the Analyzer for calibration.

1. Power on all test equipment and allow a 1-hour warm up time.
2. Power on the PC and log in.
3. Connect the PC USB cable to the UUT. Power on the UUT.
4. Establish serial communication with the Analyzer (Applicable COM port using USBView, 115200 Baud, N,8,1 bits, HW Flow control) Under File->Properties and the Settings tab, click the ASCII Setup button, and ensure “Send line ends with line feeds” and “Echo typed characters locally” are CHECKED.
5. Many of the calibrations require ac or dc meter calibration to be completed first. If the ac or dc meter calibration is changed, all other calibrations should at least be verified.

Adjustments

The following procedure calibrates the Analyzer to the published specifications and coincides with the calibration datasheet found in Appendix A:

A. AC Meter Calibration

1. Send command: `REMOTE <CR>`
2. Receive *
3. Send command: `CAL=F2810 <CR>`

4. Receive *
5. Send command: `IDENT <CR>`
6. Receive and record UI & MTR firmware revision level.
7. Send command: `EXIT <CR>`
8. Receive *
9. Send command: `NOMINAL? <CR>`
10. Receive and record the current nominal voltage.
11. If nominal is not set to 115 V, reset nominal and restart the Analyzer.
    a. Send command: `NOMINAL=115 <CR>`
    b. Receive *
    c. Send command: `RSTUI <CR>`
    d. When the Analyzer restarts, receive the identification information.
    e. Send command: `REMOTE <CR>`
    f. Receive *
12. Send command: `DIAG=F2810 <CR>`
13. Receive *
14. Send command: `XFLASHT <CR>`
15. Receive and record PASS/FAIL
16. Send command: `EXIT <CR>`
17. Receive *
18. Send command: `CAL=F2810 <CR>`
19. Receive *
20. Send command: `DEFAULTS <CR>`
21. Receive *
22. Connect the calibrator to the red and black jacks as shown in Figure 3-29. Set the calibrator for 2.000 V, 120 Hz (±200 mV).

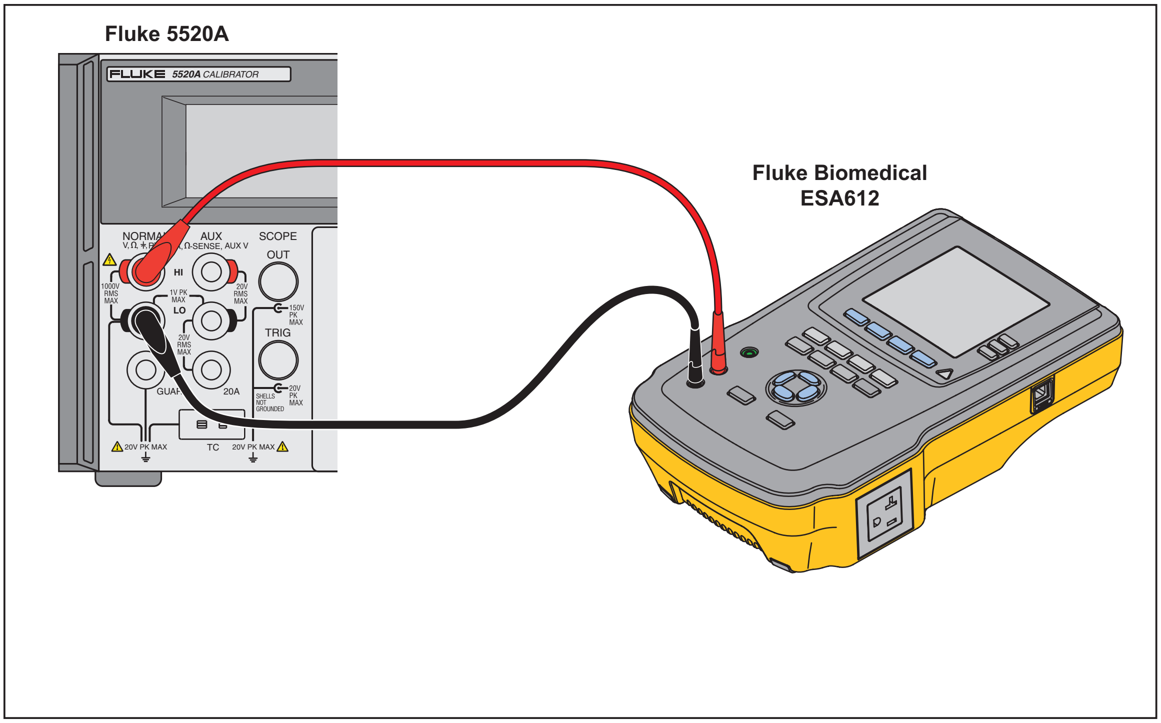

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Figure 3-29. AC Meter Calibration Connections

23. Send command: `METER_AC <CR>`
24. Receive *
25. Send command: `RANGE=1,0,0 <CR>`
26. Receive *
27. Turn on the calibrator output.
28. Send command: `GAIN=2000.00 <CR>`
29. Receive *
30. Adjust the calibrator output to 1.000 V, 120 Hz (±100 mV).
31. Send command: `GAIN=1000.00 <CR>`
32. Receive *
33. Adjust the calibrator output to 200 mV, 120 Hz (±20 mV).
34. Send command: `RANGE=2,0,0 <CR>`
35. Receive *
36. Send command: `GAIN=200.00 <CR>`
37. Receive *
38. Adjust the calibrator output to 20.00 mV, 120 Hz (±2 mV).
39. Send command: `RANGE=3,0,0 <CR>`
40. Receive *
41. Send command: `GAIN=200.00 <CR>`
42. Receive *

43. Short the Red and Black jacks together using a test lead.
44. Send command: `OFFSET <CR>`
45. After a significant delay, receive *
46. Reconnect the normal outputs of the calibrator to the red and black jacks. Adjust the calibrator output to 1.500 V, 120 Hz.
47. Send command: `RANGE=1,0,0 <CR>`
48. Receive *
49. Send command: `READ <CR>`
50. Receive and record response.
51. Adjust the calibrator output to 500.0 mV, 120 Hz.
52. Send command: `READ <CR>`
53. Receive and record response.
54. Adjust the calibrator output to 150.0 mV, 120 Hz.
55. Send command: `RANGE=2,0,0 <CR>`
56. Receive *
57. Send command: `READ <CR>`
58. Receive and record response.
59. Adjust the calibrator output to 15.0 mV, 120 Hz.
60. Send command: `RANGE=3,0,0 <CR>`
61. Receive *
62. Send command: `READ <CR>`
63. Receive and record response.
64. Disconnect the calibrator.

B. DC Meter Calibration

1. Short the red and black jacks together using a test lead.
2. Send command: `METER_DC <CR>`
3. Receive *
4. Send command: `OFFSET <CR>`
5. Receive *
6. Connect the calibrator the red and black jacks, and adjust the calibrator output for 2000 mV dc.
7. Send command: `GAIN=2000.00 <CR>`
8. Receive *
9. Adjust the calibrator output to 1500 mV dc.
10. Send command: `READ <CR>`
11. Receive and record response.
12. Disconnect the calibrator.

C. Leakage Calibration (Dependent upon AC Meter)

1. Connect the current source to the red jack and the 400 mA jack of the DMM. Connect the DMM Input (-) to the black jack. See Figure 3-30. Set the current source to 1.00 mA (1.4142 mA p-p), 60 Hz with a 10 V compliance voltage and the DMM to 1 mA ac mode.

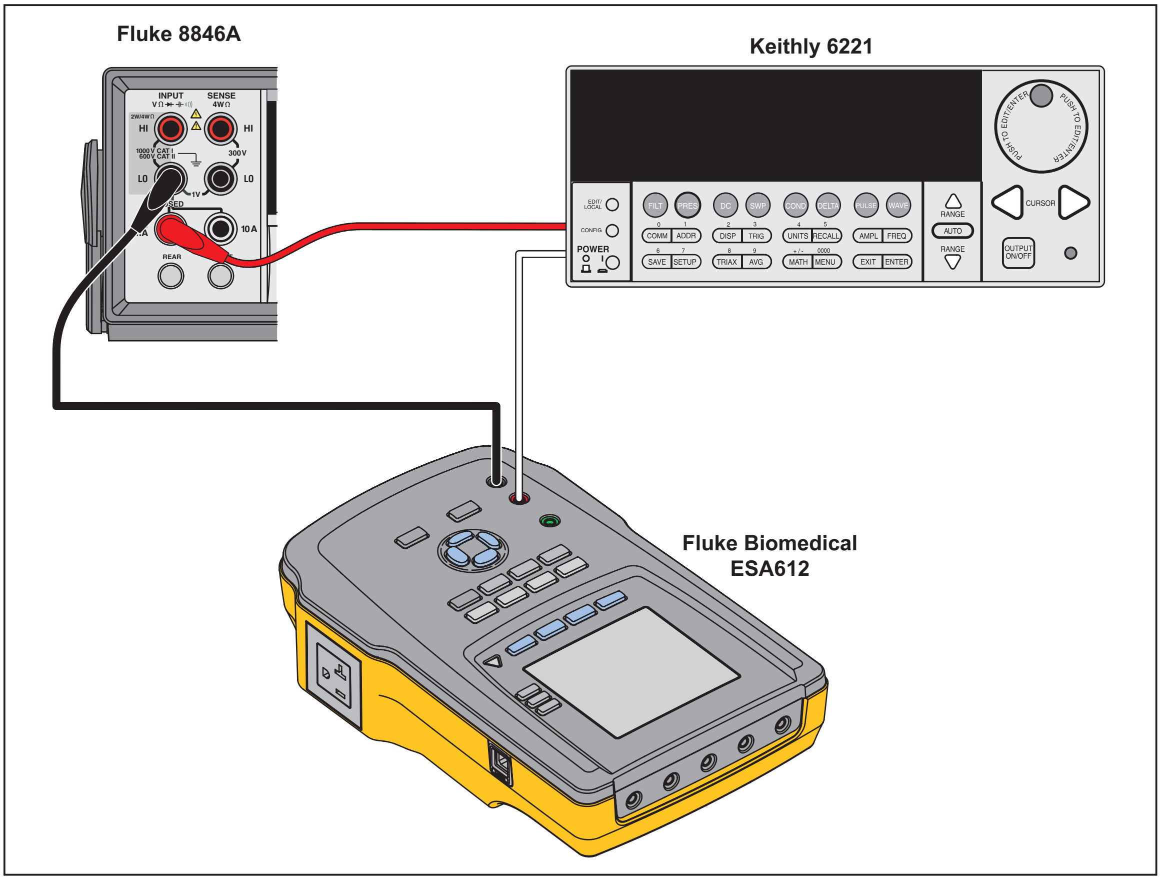

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Figure 3-30. Leakage Calibration

2. Send command: `PPL <CR>`
3. Receive *
4. Send command: `LOAD=601 <CR>`
5. Receive *
6. Send command: `RANGE=0,0,2 <CR>`
7. Receive *
8. Turn on the current source.
9. Send command: `GAIN=X.XXXX <CR>` where `x.xxxx` is the actual value of the current in mA measured by the DMM.
10. Receive *
11. Adjust the current source to 0.5 mA (0.7071 mA p-p).
12. Send command: `READ <CR>`
13. Receive and record response. Also record the DMM reading.

14. Turn off the current source output. Adjust the current source to 5.00 mA (7.071 mA p-p), 60 Hz. Set the DMM to the 10 mA range.
15. Send command: RANGE=0,0,1 <CR>
16. Receive *
17. Turn on the current source output.
18. Send command: GAIN=X.XXXX <CR> where X.XXXX is the actual value of the current in mA measured by the DMM.
19. Receive *
20. Adjust the current source to 3.0 mA (4.243 mA p-p).
21. Send command: READ <CR>
22. Receive and record response. Also record the DMM reading.
23. Turn off the current source and disconnect all testing connections.

D. Point to Point Calibration (Dependent on AC Meter)

1. Connect the calibrator to the red jack and black jacks as shown in Figure 3-31. Set the calibrator to 300.0 V, 120 Hz.

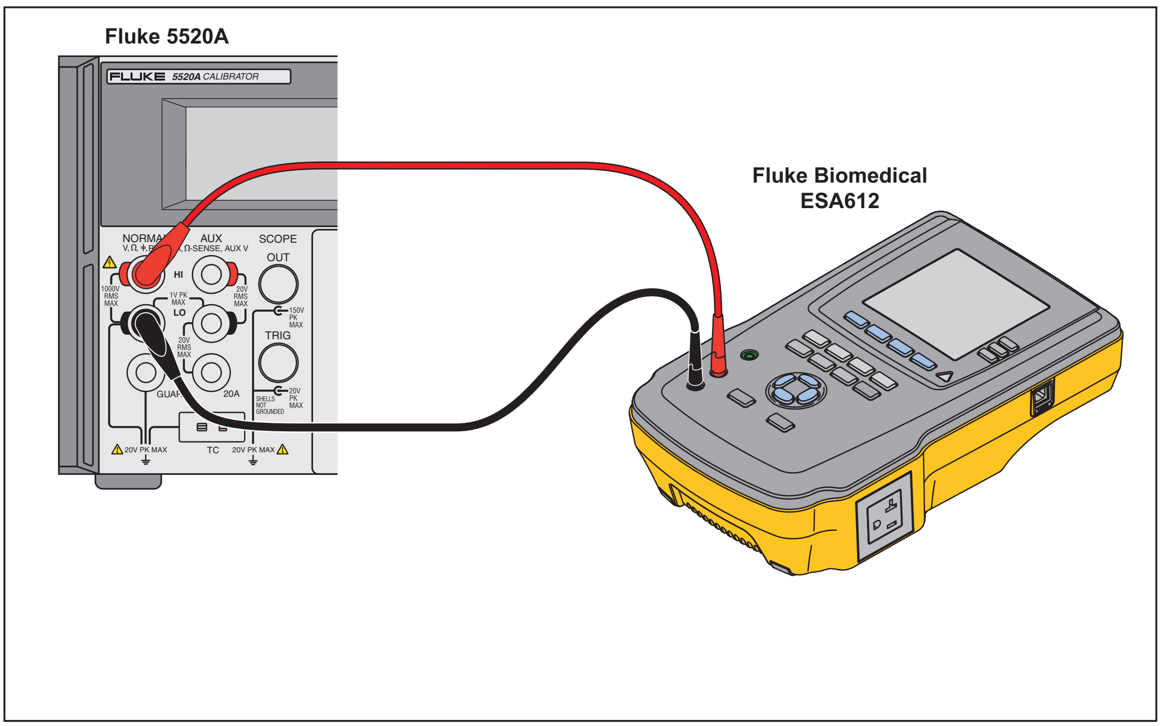


Figure 3-31. Point to Point Calibration Connections

2. Send command: PPV <CR>
3. Receive *
4. Turn on the calibrator output.
5. Send command: GAIN=300.00 <CR>
6. Receive *
7. Adjust the calibrator output to 250.0 V, 120 Hz.

8. Send command: `READ <CR>`
9. Receive and record response.
10. Turn off the calibrator output and disconnect the calibrator.

E. MAP Compensation Calibration (Dependent on AC Meter)

1. Remove all connections except mains power and the USB cable.
2. Send command: COMP <CR>
3. After significant delay, receive * if the null was found.
4. If no null was found, `!33` will be returned, and the device needs repair prior to calibration.

F. Insulation HV Calibration (Dependent on AC Meter)

1. Connect the DMM to the RA applied part and the red jack as shown in Figure 3-32 and set it for the 1000 V dc range.

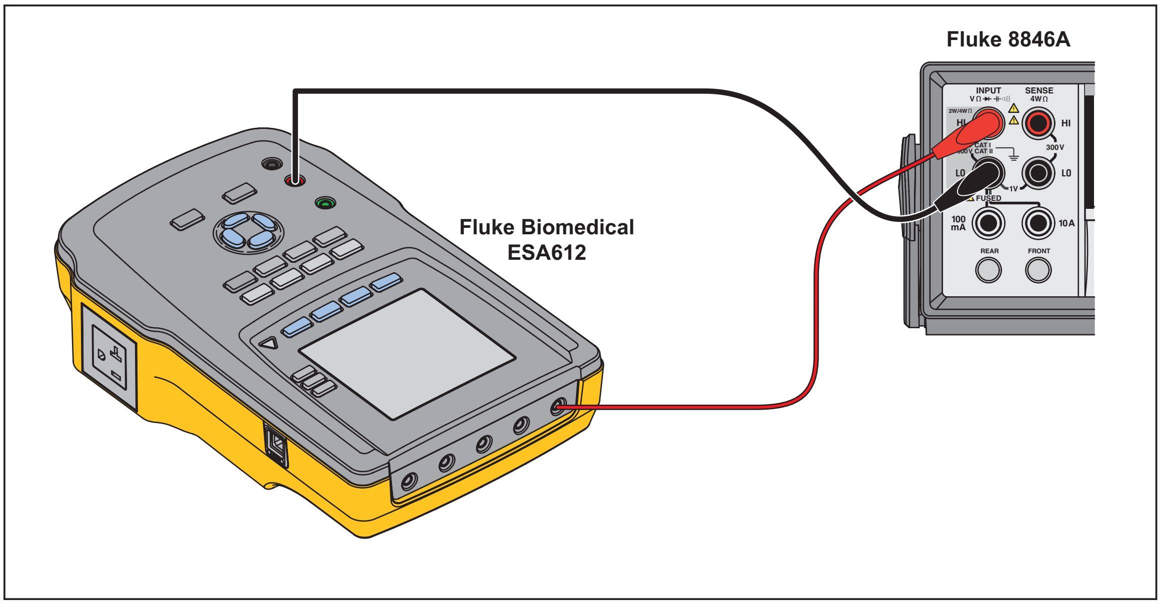


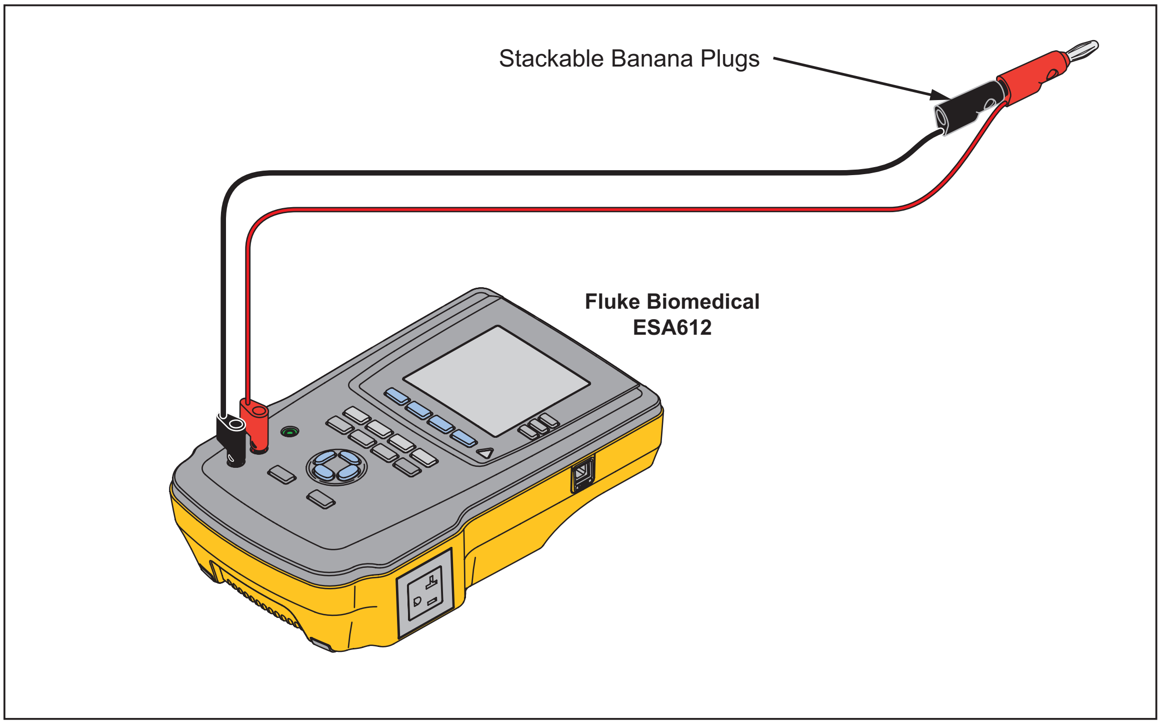
Figure 3-32. Insulation HV Calibration Connections

2. Send command: `INSD <CR>`
3. Receive *
4. Send command `INS=HIGH <CR>`
5. Receive *
6. Send command: `MREAD <CR>`
7. Receive multiple readings, all approximately 10 MΩ. While the Analyzer is conducting is read, note the stabilized voltage reading from the DMM.
8. Press ESC to stop `MREAD`.
9. Send command: `GAIN=XXX.XXX <CR>` where `XXX.XXX` is the actual value of the voltage measured by the DMM.
10. Receive *
11. Connect the applied part and the red jack across a 10 MΩ resistor.

12. Send command: `READ <CR>`
13. Receive and record response.
14. Disconnect all testing connections.

G. Resistance Calibration (Dependent on AC Meter)

1. Connect two leads to the red and black jacks, then short the other ends together as shown in Figure 3-33.



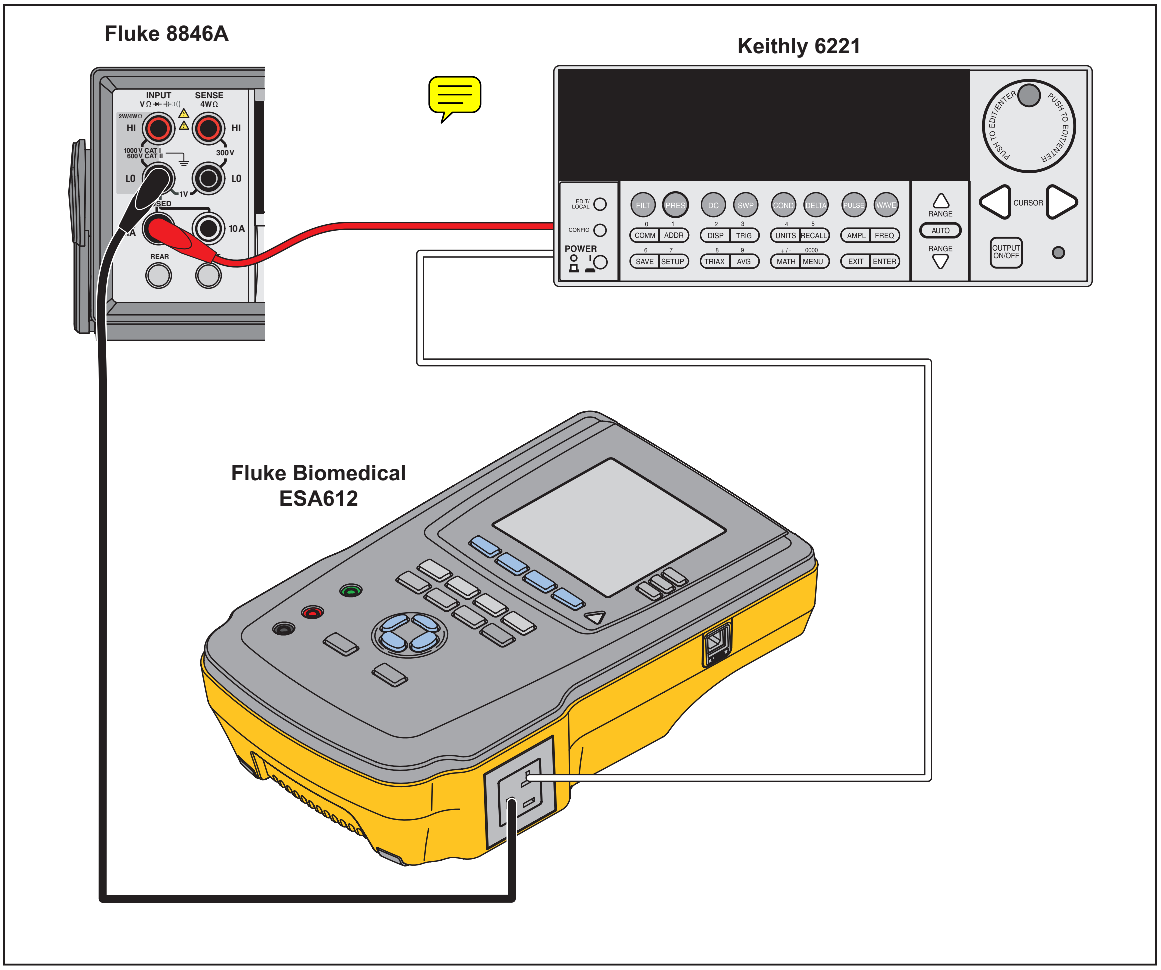
gjc108.eps

Figure 3-33. Resistance Calibration Connections

2. Send command: `PPR <CR>`
3. Receive *
4. Send command: `OFFSET <CR>`
5. Receive *
6. Connect the test leads across a 4.0 Ω (3.6 – 4.4 Ω) resistor.
7. Send command: `GAIN=X.XXX <CR>` where `X.XXX` is the actual value of the resistor.
8. Receive *
9. Exchange the 4.0 Ω resistor for a 3.0 Ω resistor.
10. Send command: `READ <CR>`
11. Receive and record response.
12. Disconnect all testing connections.

H. Differential Leakage Calibration (Dependent on AC Meter)

1. Connect the current source to the EO neutral and the 400 mA jack of the DMM. Connect the DMM Input (-) to the EO ground. See Figure 3-34. Set the current source to 15.0 mA (21.21 mA p-p), 120 Hz with a 10 V compliance voltage and the DMM to 100 mA ac range.



gjc118.eps

Figure 3-34. Differential Leakage Calibration Connections

2. Send command: DIFF <CR>
3. Receive *
4. Send command: EARTH=C <CR>
5. Receive *
6. Send command: POL=N <CR>
7. Receive *
8. Turn on the current source output. Note the reading on the DMM.
9. Send command: GAIN=XX.XXXX <CR> where XX.XXXX is the actual value of the current in mA measured by the DMM.
10. Receive *
11. Set the current source to 11 mA (15.556 mA p-p).

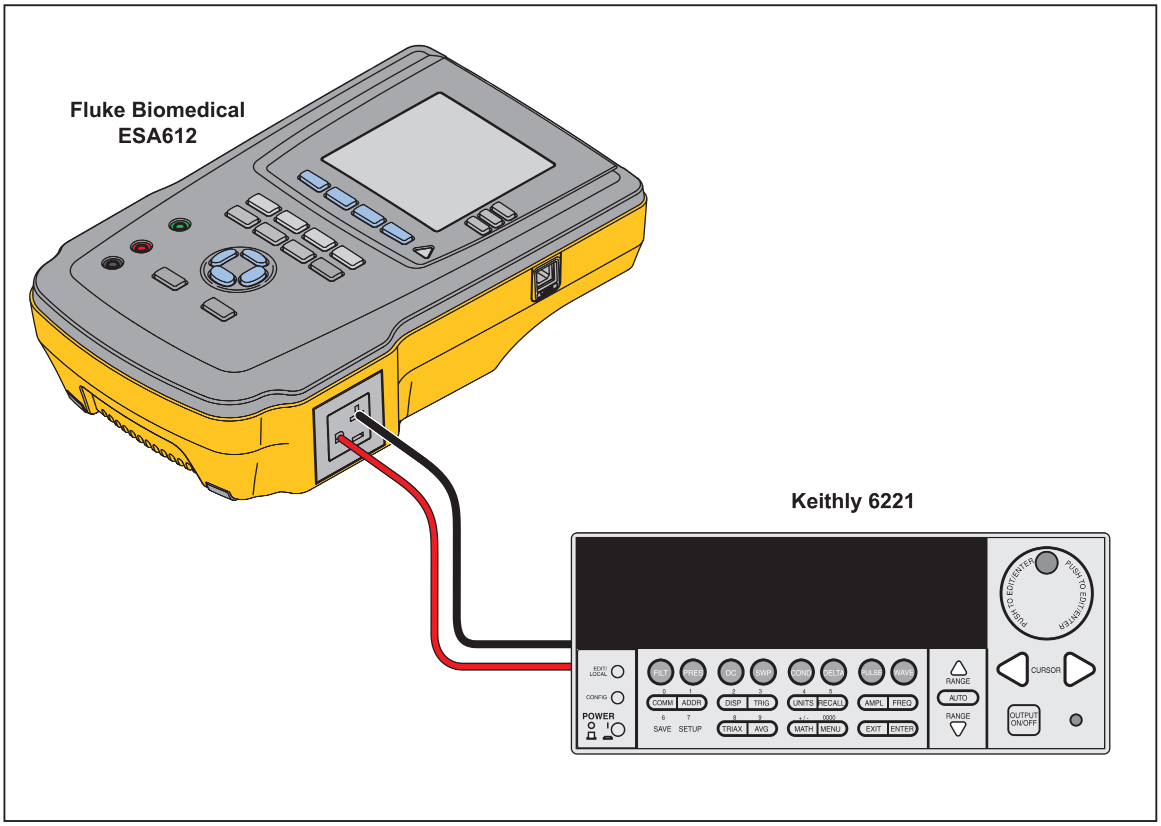
~~12. Send command: `READ <CR>`~~

~~13. Receive and record response. Compare it to the actual value of the current.~~

~~14. Turn off the current source and disconnect all testing connections.~~

I. GFI Calibration

1. Connect the current source to the EO neutral and EO ground as shown in Figure 3-35. Set the current source to 5.0 mA (7.071 mA p-p), 60 Hz with a 40 V compliance voltage.



gjc141.eps

Figure 3-35. GFI Calibration Connections

2. Send command: `PPV <CR>`
3. Receive *
4. Send command: `GFI=5MA <CR>`
5. Receive *
6. Turn on the current source output.
7. Send command: `CAL_GFI <CR>`
8. Receive *
9. Turn off the current source output.
10. Set the current source to 4.5 mA (6.364 mA p-p), 60 Hz.
11. Send command: `GFI=5MA <CR>`
12. Receive *

13. Send command: `EQCURR <CR>`
14. Receive *
15. Turn on the current source output.
16. Send command: `STAT3 <CR>`
17. Receive status word 3. The 4xxx bits will not be set if the Analyzer passes the test.

Note

If the 1xxx and 4xxx bits are set, the status word returned will be 5000. This still indicates the 4xxx bit is set, and is a failing condition.

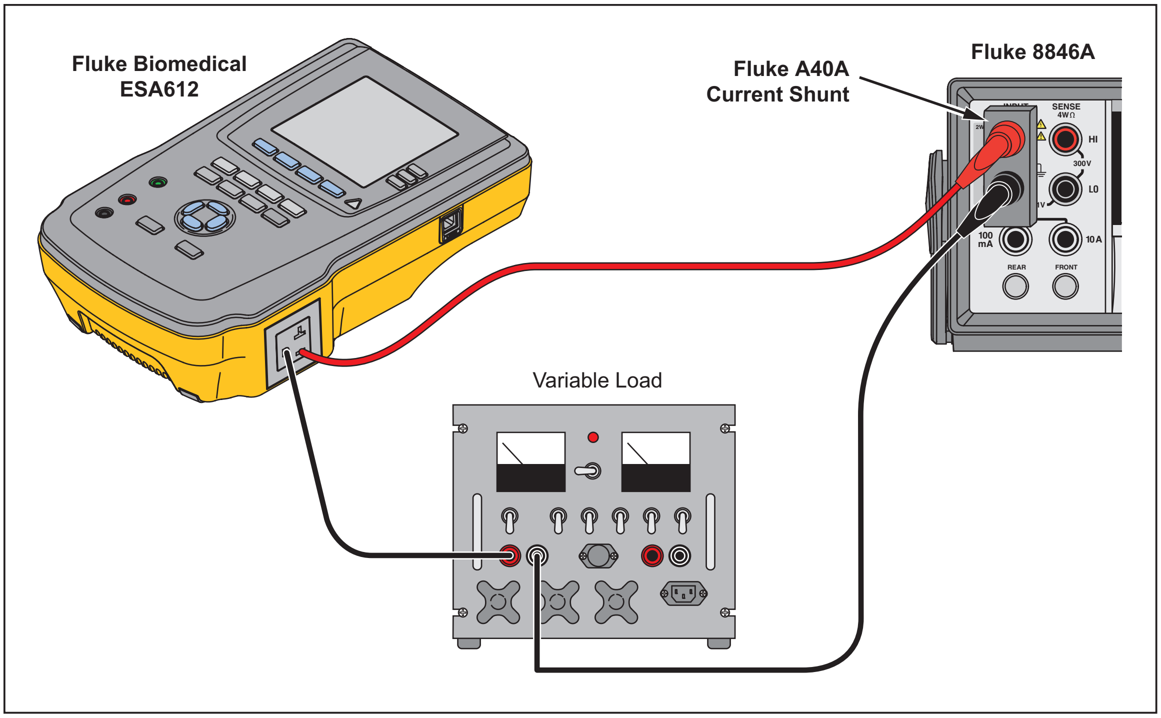
18. Record PASS/FAIL.
19. Turn off the current source output.
20. Send command: `GFIR <CR>`
21. Receive *
22. Set the current source to 5.5 mA (7.778 mA p-p), 60 Hz.
23. Send command: `EQCURR <CR>`
24. Receive *
25. Turn on the current source output.
26. Send command: `STAT3 <CR>`
27. Receive status word 3. The 4xxx bits will be set if the Analyzer passes this test (GFI tripped).
28. Verify the device is in a GFI tripped state: send command: `PPV <CR>`
29. Receive error code `!50` (GFI error).
30. Record PASS/FAIL; pass if `!50` is received.
31. Turn off the current source output.
32. Send command: `GFIR <CR>`
33. Receive *
34. Set the current source to 10.0 mA (14.142 mA p-p), 60 Hz, with a 40 V Compliance voltage.
35. Send command: `PPV <CR>`
36. Receive *
37. Send command: `GFI=10MA <CR>`
38. Receive *
39. Turn on the current source output.
40. Send command: `CAL_GFI <CR>`
41. Receive *
42. Turn off the current source output.
43. Set the current source to 9 mA (12.728 mA p-p), 60 Hz.

44. Send command: `GFI=10MA <CR>`
45. Receive *
46. Send command: `EQCURR <CR>`
47. Receive *
48. Turn on the current source output.
49. Send command: `STAT3 <CR>`
50. Receive status word 3. The status bit xxx8 shall be set, indicating Medium GFI level, but the 4xxx bit will NOT be set if the Analyzer passes this test.
51. Turn off the current source output.
52. Record PASS/FAIL
53. Send command: `GFIR <CR>`
54. Receive *
55. Set the current source to 11 mA (15.556 mA p-p), 60 Hz.
56. Send command: `GFI=10MA <CR>`
57. Receive *
58. Send command: `EQCURR <CR>`
59. Receive *
60. Turn on the current source output.
61. Send command: `STAT3 <CR>`
62. Receive status word 3. The 4xx8 bit will be set if the Analyzer passes this test (GFI tripped).
63. Turn off the current source output.
64. Record PASS/FAIL
65. Send command: `GFIR <CR>`
66. Receive *
67. Set the current source to 25.0 mA (35.36 mA p-p), 60 Hz.
68. Send command: `PPV <CR>`
69. Receive *
70. Send command: `GFI=25MA <CR>`
71. Receive *
72. Turn on the current source output.
73. Send command: `CAL_GFI <CR>`
74. Receive *
75. Turn off the current source output.
76. Set the current source to 22.5 mA (31.82 mA p-p), 60 Hz.
77. Send command: `GFI=25MA <CR>`
78. Receive *

79. Send command: `EQCURR <CR>`
80. Receive *
81. Turn on the current source output.
82. Send command: `STAT3 <CR>`
83. Receive status word 3. The 4xxx bit will NOT be set if the Analyzer passes this test.
84. Turn off the current source output.
85. Record PASS/FAIL
86. Send command: `GFIR <CR>`
87. Receive *
88. Set the current source to 27.5 mA (38.89 mA p-p), 60 Hz.
89. Send command: `GFI=25MA <CR>`
90. Receive *
91. Send command: `EQCURR <CR>`
92. Receive *
93. Turn on the current source output.
94. Send command: `STAT3 <CR>`
95. Receive status word 3. The 4xxx bit will be set if the Analyzer passes this test (GFI tripped).
96. Turn off the current source output.
97. Record PASS/FAIL
98. Remove all testing connections.
99. Send command: `GFIR <CR>`
100. Receive *

J. Equipment Current Calibration (Dependent on AC Meter)

1. Connect the current shunt to the DMM using the voltage inputs. Connect the EO hot to the DMM Input (+) side of the current shunt and the EO ground to one side of the variable current load. Connect the other side of the variable current load to the current shunt jack corresponding to the (-) DMM Input.



gjc146.eps

Figure 3-36. Equipment Current Calibration Connection

2. Send command: `EQCURR <CR>`
3. Receive *
4. Establish an 8 A draw through the current load, with the shunt resistor in series with the load.
5. Note the actual current flowing in the circuit using the current shunt and DMM.
6. Send command: `GAIN=XX.XXXX <CR>` where `XX.XXXX` is the actual current calculated in amperes.
7. Receive *
8. Establish an 3 A draw through the current load.
9. Send command: `READ <CR>`
10. Receive and record response. Compare it with the actual value of the current flowing through the current shunt.
11. Turn off the equipment outlet. Send command: `PPL <CR>`
12. Receive *
13. Remove all testing connections.
14. Clear GFI faults. Send command: `GFIR <CR>`
15. Receive *

K. Mains Calibration Part I

Note

During the mains calibration, the differential current offset is also calculated and stored. Ensure nothing is connected to the Analyzer except mains power and the USB cable.

1. Send command: `MAINS=L1-GND <CR>`
2. Receive *
3. Send command: `GAIN=XXX.X <CR>` where `XXX.X` is the actual value of the hot line voltage (90 – 264 V ac).
4. Receive *
5. Adjust the Elgar power supply to 100 V ac, 60 Hz.
6. Send command: `READ <CR>`
7. Receive and record response.

L. Mains Calibration Part II

1. Send command: `SAVE <CR>`
2. Receive *
3. Send command: `EXIT <CR>`
4. Receive *
5. Send command: `LOCAL <CR>`
6. Receive *
7. Turn off the Analyzer.
8. Chang the power supply configuration such that:
    a. L2 → hot
    b. L1 → neutral
    c. GND → ground
    d. Adjust voltage back to 115 V, 60 Hz.
9. Turn the Analyzer on. The error code `!55` will be received.
10. Send command: REMOTE=F2810 <CR>
11. Receive *
12. Send command: CAL=F2810 <CR>
13. Receive *
14. Send command: MAINS=L2-GND <CR>
15. Receive *
16. Send command: `GAIN=XXX.X <CR>` where `XXX.X` is the actual value of the hot line voltage (90 – 264 V ac).
17. Receive *
18. Adjust the Elgar power supply to 100 V ac, 60 Hz.
19. Send command: `READ <CR>`

20. Receive and record response.
21. Return the Elgar power supply to 115 V ac, 60 Hz. Do not turn off power to the Analyzer until section M is completed.

M. Save Calibration

1. Write new calibration date in the format of MxxDyyYzzzz, where xx stands for the two digits of the current month, yy stands for the two digits of the current day, and zzzz stands for the four digits of the current year.
2. Send command: `DATE=MxxDxxYxxxx`
3. Receive *
4. Write calibration technician in the format of xxxxx, where xxxxx stands for the five digits of the technician's employee number.
5. Send command: `TECH=xxxxx <CR>`
6. Receive *
7. Check Analyzer serial number, cal date, and cal technician are correct.
8. Send command: `INFO= <CR>`
9. Receive serial number, cal date, and cal technician in response. Record response.
10. Save the primary cal data. Send command: `SAVE <CR>`
11. Exit cal mode. Send command: `EXIT <CR>`
12. Receive *
13. Return to local mode. Send command: `LOCAL <CR>`
14. Receive *

N. Conduct Verification

Chapter 4
Remote Operations

Introduction

The Analyzer is designed for remote operation by sending it commands through its computer port. Measurement data and command responses are returned through the computer port for computer or user analysis. This remote capability can be employed to automate the verification, calibration, and troubleshooting procedures described in this manual.

Extensive automation can be realized by writing a computer program that sends commands to the Analyzer and evaluates the responses to generate a user report. Or, individual commands can be typed and responses read using a program such as Hyperterminal. The degree of automation is up to the users needs.

This chapter describes how to connect and setup the Analyzer for remote operation. Also included is a complete list of valid commands, each with a functional description, proper command syntax, Analyzer response, associated command parameters, and examples. A set of diagnostic commands are also included to help isolate problems in some functions and circuits while troubleshooting the Analyzer.

Serial Communication Connections

When unprogrammed devices are connected to a PC, they look different to Windows. Without intervention, Windows will enumerate each device separately.

To force Windows to ignore the serial numbers of FT232R devices, add a registry setting.

- Edit the registry to add an entry at: "HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\UsbFlags\".
- Add a REG_BINARY entry "IgnoreHWSerNum04036001".
- Set the binary value to "01".
- Refer to FTDI Application Note AN232B-10 "Advanced Driver Options".

Note

This only works if you add the registry entry before connecting any FTDI devices. You might have to uninstall FTDI device drivers with their "FTCLEAN" utility, then reload the drivers.

You can force Windows (2000, XP, and above) to use the LocId of the USB port so all FTDI devices on a port are assigned to the same COM port number. Refer to FTDI Application Note AN232B-07 "Configuring FTDI's VCP Drivers to use Location IDs".

Note

If you properly set IgnoreHWSerNum04036001 as described above, you shouldn't have to use LocId.

Serial Communication

These are common specifications for all serial ports:

Baud rate: 115,200 baud

Format: 8 data bits, no parity, 1 stop bit

Modes

The following is a list of Analyzer modes with a brief description of each:

1. Power Up
    - The Analyzer performs a number of self-diagnotic tests during this temporary

start-up mode.

- The display shows a “splash” screen during this period.

2. Local

- This is the default mode entered after power-up.
- The user controls the Analyzer by pressing buttons and viewing the display.
- The computer interface is active at any of the user menus, but the UI can only execute a few commands: those that put the Analyzer into remote mode or request instrument status. All other commands are illegal.

3. Remote

- The display indicates that the Analyzer is under remote control.
- The UI receives commands from the USB interface to control the Analyzer.
- The Analyzer can be put back to local mode by a command or by pressing a key.
- The UI will directly execute some commands that it can without contacting the Meter.
- Other commands not executable by the UI will be forwarded to the Meter exactly as received. Then, the UI will get the response from the Meter and pass it back to the computer as received.

4. Cremote

- Same as Remote Mode, except that responses from the Analyzer are enclosed in ‘packets.’ Commands from the PC to the Analyzer must also follow this format.
- This protocol also applies to sub-modes within remote control.
- When returning to Local Mode, the communication protocol is restored to normal operation.
- The packet format is defined below:

STX	Byte Count	Data	ETX	Checksum	NULL
1 byte	4 bytes	N bytes	I byte	2 bytes	1 byte

STX = ‘0x02’ character

Byte count = Number of bytes in the Data field only (N bytes)

Data = Command to or response from the Analyzer

ETX = ‘0x03’ character

Checksum = Sum of bytes in the byte count and data fields only (4 + N bytes)

NULL = ‘0x00’ character

Note

Special characters that do not need to be followed by carriage return/line feed, such as ESC and BACKSPACE characters, must be sent outside of packets.

5. Error

- The Analyzer enters the error mode when it detects an internal fault.
- The display shows an error screen where the user is prompted to take a given

action to correct the error.

6. Test
   - This is a special mode for Engineering testing purposes only.
   - The Analyzer is placed in an infinite loop, where it continuously takes measurements that are shown on the display.
7. Sub-modes
   - The Analyzer can be put in certain sub-modes within remote control.
   - Sub-modes can allow only certain commands.
   - UI sub-modes for the Analyzer are Diagnostic and Calibration.

Reading Formats

Readings returned by the meter microprocessor have a fixed number of decimal places, which may very from test to test. Table 4-1 lists the tests and their associated returned reading formats.

Note

Readings do not have leading zeroes, except when preceding the decimal point.

Table 4-1. Reading Formats

Test	Character Preceding Reading Value	Maximum Number of Digits before Decimal Point	Number of Decimal Places	Example [1]
Voltage	V	3	1	"V221.2"
Resistance	O	1	3	"O1.001"
Insulation Resistance	M	2	1	"M5.3"
Current	A	2	1	"A10.4"
Leakage (mA)	L	Depends on range	Depends on range	Depends on range
Leakage (µA)	U	Depends on range	Depends on range	Depends on range

[1] All reading values are preceded by a letter that specifies the type of reading.

Command Specifications

The following sections list the available commands which remotely control the Anaylzer. The commands are divided into the following functional analyzer categories: General, Remote, ECG, Calibration, Diagnostic, and Error.

General and global setup commands ready the Analyzer for remote operation from a computer. The calibration commands are used to calibrate the Analyzer remotely. The diagnostic category of commands are for isolating problems in certain Analyzer functions and circuits.

General Commands

General commands set the Analyzer up for remote operation and are used to extract Analyzer information such as its calibration and current mode of operation.

CREMOTE

Description Puts the Analyzer in computer remote control.

Parameters <P > P = Packet mode

Examples `CREMOTE=P`

Note

To escape from packet mode, return the Analyzer to local mode and reenter remote mode.

IDENT

Description Queries the Analyzer for identification.

Query IDENT Returns the Analyzer model, UI firmware version, and meter processor firmware version.

Note

When in calibration or diagnostic mode, the UI firmware and meter microprocessor firmware version are listed separately .

LOCAL

Description Exits remote control and returns to local control.

REMOTE

Description Sets the Analyzer to remote control mode.

RESEND

Description Resends the last response to the PC.

RSTUI

Description Resets the Analyzer.

RSTM

Description Resets the meter microprocessor.

STAT

Description Returns the UI status word.

Remote Commands

The remote commands are used to select or retrieve the tests and perform the necessary setup conditions for the various tests. Some control is also available for retrieving readings from the Analyzer through these commands.

ALTEARTH

Description Opens or closes the ground to the equipment outlet during Alternative Equipment Leakage function.

Parameters <C/O > C closes equipment outlet ground and O opens it.

Examples `ALTEARTH=C` Closes equipment outlet ground.

AP

Description Selects applied parts to connect to meter (+), applied parts to and connect to meter (-), and where to connect the remaining applied parts.

Parameters <[parts+]/[parts-]/[remaining parts]>
parts+ = list of parts to connect to meter (+)
parts- = list of parts to connect to meter (–)

		parts remaining = where to connect remaining parts.
Examples	`AP=RL,LL/RA,V1/GND`	Connects RL and LL to meter (+), RA and V1 to meter (-), and all others to ground (GND).

APINS

Description Selects applied parts insulation test.

AUX

Description Select patient auxiliary leakage test.

CAL

Description	Enters Analyzer calibration mode.	
Parameters	<F2810>	F2810 = Password for the Analyzer.
Examples	`CAL=F2810`	Puts Analyzer in calibration mode.

DIAG

Description	Enters Analyzer diagnostic mode.	
Parameters	<F2810>	F2810 = Password for the Analyzer.
Examples	`DIAG=F2810`	Puts Analyzer in diagnostic mode.

DIFF

Description Selects differential current test.

DIRL

Description Selects direct leakage test.

DMAP

Description Selects direct applied part leakage test. Uses MAP voltage.

EARTH

Description	Opens or closes the ground to the equipment outlet.	
Parameters	<C/O >	C closes equipment outlet ground and O opens it.
Examples	`EARTH=C`	Closes equipment outlet ground.

EARTHL

Description Selects earth leakage test.

ECG

Description Enters ECG simulation mode and connects all applied parts to ECG.

ENCL

Description Selects Enclosure Leakage measurement.

EOGNULL

Description	Opens or closes the connection between the NULL jack and the the equipment outlet ground.	
Parameters	<C/O >	C closes connection between NULL jack and equipment outlet ground and O opens it.
Examples	`EARTH=C`	Closes connection between NULL jack and equipment outlet ground.

EQCURR

Description Selects equipment current test.

ERES

Description Selects earth resistance 200 mA current.

FN

Description Returns the current function number.

Examples `FN`

0 = No function selected
1 = Mains voltage
2 = Equipment current
3 = Earth resistance
4 = Mains to earth insulation
5 = Applied parts to earth insulation
6 = Earth leakage
7 = Enclosure leakage
8 = Patient leakage
9 = Patient auxiliary leakage
10 = Direct equipment leakage
11 = Direct applied parts leakage
12 = MAP leakage
13 = Alternative applied parts leakage
14 = Alternative equipment leakage
15 = Differential leakage
16 = Not used
17 = Point to point leakage
18 = Not used
19 = Point to point voltage
20 = Point to point resistance
21 = Mains to neutral insulation
22 = Applied parts to neutral insulation
23 = Mains to applied parts insulation
24 = Lead isolation leakage

GFI

Description Selects ground fault interrupt (GFI) trip level.

Parameters <nnMA> nn = 5, 10, or 25

Examples `GFI=5MA` Sets ground fault interrupt to 5 mA.

GFIR

Description Resets ground fault interrupt ATTENTION.

HIGH_RES

Description Controls the number of digits in the displayed reading.

Parameters <ON/OFF>

Examples `HIGH_RES=ON` Increases the number of digits in the displayed reading.

IDLE

Description Turns off all relays and ASWs, clears faults and status words.

INS

Description Controls the insulation resistance test voltage.

Parameters	<xxxx>	xxxx = Insulation voltage variable. LOW = Selects 250 V insulation voltage HIGH = Selects 500 V insulation voltage (default)
Examples	`INS=LOW`	Sets insulation voltage to 250 V.

INSB

Description Selects insulation test B.

INSD

Description Selects insulation test D.

INSE

Description Selects insulation test E.

LEAD_ISO

Description Selects lead isolation function.

LOAD

Description Selects the load for the meter input.

Parameters	<xxxx>	xxxx = Meter load variable. 601 = IEC 60601 patient load AAMI = ANSI/AAMI patient load NONE = IEC 60601 patient load
Examples	`LOAD=601`	Selects the IEC 60601 patient load.

LOADDSP

Description Puts the meter microprocessor in boot loader mode.

LOCAL

Description Puts the Analyzer in local control mode.

MAINS

Description Selects the mains voltage measurement test.

Parameters	<xxxxxx>	L1-L2 = Measures ac, hot to neutral. L1-GND = Measures ac, hot to ground. L2-GND = Measures ac, neutral to ground.
Examples	`MAINS=L1-L2`	Sets measurement for ac, hot to neutral.

MAP

Description Selects the mains on applied parts test.

Parameters	<xxxxxx>	LOW = Switches to MAP level of 100 %. NORM = Switches to normal polarity MAP voltage. REV = Switches to reverse polarity MAP voltage. 1MA = Sets MAP limit to 1 mA. 3.5MA = Sets MAP limit to 3.5 mA. 7.5MA = Sets MAP limit to 7.5 mA.
Examples	`MAP=LOW`	Sets MAP voltage to 100 %.

MINS

Description Selects mains insulation test.

MODE

Description Selects voltage measurement mode.

Parameters <xxxx>
DC = Selects dc measurement mode.
AC = Selects ac measurement mode.
ACDC = Selects ac+dc measurement mode.

Examples `MODE=AC` Selects ac measurement mode.

MREAD

Description Returns meter readings continuously (~400 ms on a single range) until an escape character is received.

NEUT

Description Opens or closes the neutral to the equipment outlet.

Parameters <C/O> C = Closes equipment outlet neutral and O opens it.

Examples `NEUT=C` Closes neutral to equipment outlet.

NOMINAL

Description Causes all leakage except differential to be multiplied by the ratio of Nominal Mains/Actual Mains.

Parameters <xxx/ON/OFF>
ON = leakage multiplied by ratio Nominal Mains/Actual Mains.
OFF = leakage without multiplier.
xxx = Nominal value to be stored by user.

Examples `NOMINAL=ON` Leakage value multiplied by Nominal Mains/Actual Mains.

NOMINAL?

Description Returns the current stored value for nominal.

NOSHOW

Description Return reading only during MREAD command (default at power-on).

OVR

Description Resets over voltage ATTENTION.

PAT

Description Selects patient leakage test.

POL

Description Sets equipment outlet polarity.

Parameters <OFF/N/R>
OFF = Sets equipment outlet polarity off.
N = Sets equipment outlet polarity to normal.
R = Sets equipment outlet polarity to reverse.

Examples `POL=R` Sets equipment outlet polarity to reverse.

PPL

Description Selects point to point leakage test.

PPR

Description Selects point to point resistance test and set the test current value.

Parameters < LOW > LOW = Selects low current (200 mA).

Note

A PPR command without a parameter just selects the test.

Examples `PPR=LOW` Selects the point to point resistance test.

PPV

Description Selects point to point voltage test.

READ

Description Returns a single meter reading.

RPTIME

Description Sets the equipment outlet (EO) polarity switch time between zero and five seconds.

Parameters <n> n = Time in seconds (0 – 5).

Examples `RPTIME=3` Sets EO polarity switch time to 3 seconds.

SAF

Description Selects substitute appliance fault leakage test.

SHOWALL

Description Returns range, ADC count, and reading during MREAD command.

SN

Description Returns ESA612 serial number.

SPAT

Description Selects substitute patient leakage test.

STAT1

Description Returns ASCII hex status word 1.

STAT2

Description Returns ASCII hex status word 2.

STAT3

Description Returns ASCII hex status word 3.

STD

Description Selects the test standard for tests. Based on the standard, the Analyzer automatically sets the load, GFI trip, and MAP voltage and current values.

Parameters <xxxx> xxxx = Desired test standard.
601 = IEC 60601 standard
AAMI = ANSI/AAMI standard
ASNZ = AS/NZS 3551 standard
353 = IEC 62353 standard

Examples `STD=AAMI` Selects the ANSI/AAMI standard.

ZERO

Description Zero the resistance meter.

$

Description Puts the UI microprocessor in boot loader mode.

ECG Commands

The following commands control the ECG function of the Analyzer.

CPL30

Description Runs ECG complex wave @ 30 Hz.

CPL60

Description Runs ECG complex wave @ 60 Hz.

CPL120

Description Runs ECG complex wave @ 120 Hz.

CPL180

Description Runs ECG complex wave @ 180 Hz.

CPL240

Description Runs ECG complex wave @ 240 Hz.

EXIT

Description Exits ECG simulation mode and disconnects all applied parts.

PLS30

Description Runs ECG 63 ms pulse @ 30 Hz.

PLS60

Description Runs ECG 63 ms pulse @ 60 Hz.

RESEND

Description Resends the last response to the PC.

SN10

Description Runs ECG sine wave @ 10 Hz.

SN40

Description Runs ECG sine wave @ 40 Hz.

SN50

Description Runs ECG sine wave @ 50 Hz.

SN60

Description Runs ECG sine wave @ 60 Hz.

SN100

Description Runs ECG sine wave @ 100 Hz.

SQ125

Description Runs ECG square wave @ 0.125 Hz.

SQ2

Description Runs ECG square wave @ 2.0 Hz.

TR2

Description Runs ECG triangle wave @ 2 Hz.

VFIB

Description Runs ECG ventricular fibrillation.

Calibration Commands

The following commands are used to remotely calibrate the Analyzer.

APINS

Description	Selects applied parts insulation test.	

CAL_GFI

Description	The GFI level must be selected before running this command. Current must be supplied from AC Hot to GND, and CAL_GFI must be executed. This will calibrate the selected GFI (5 mA, 10 mA, or 25 mA) to trip at the current value supplied.	

CLEAREE

Description	Clears all data stored in EEPROM (both UI and meter data).	

COMP

Description	Generates MAP comp DAC offset value.	

DATE

Description	Programs calibration date into Analyzer EEPROM.	
Parameters	<MxxDyyYzzzz>	Mxx = Month number Dnn = Day number Ynnnn = Year number
Examples	`M11D23Y2009`	Sets Calibration date to 11/23/2009.

DEFAULTS

Description	Sets calibration constants to defaults.	

DIFF

Description	Selects differential current test.	

DIS_FAULT

Description	Enables or disables GFI and OV faults.	
Parameters	<0/1>	0 = Enables GFI and OV faults 1 = Disables GFI and OV faults
Examples	`DIS_FAULT=0`	Enables GFI and OV faults.

EARTH

Description	Opens or closes the ground to the equipment outlet.	
Parameters	<C/O>	C = Closes equipment outlet ground and O opens it.
Examples	`EARTH=C`	Closes ground to equipment outlet.

EQCURR

Description	Selects equipment current test.	

ERES

Description	Selects earth resistance test.	
Parameters	<LOW>	LOW = 200 mA test current
Examples	`ERES=LOW`	Sets earth resistance test current to 200 mA.

EXIT

Description	Exits the calibration mode.	

FN

Description	Returns the current function number.	

Examples	FN	0 = No function selected 1 = Mains voltage 2 = Equipment current 3 = Earth resistance 4 = Mains to earth insulation 5 = Applied parts to earth insulation 6 = Earth leakage 7 = Enclosure leakage 8 = Patient leakage 9 = Patient auxiliary leakage 10 = Direct equipment leakage 11 = Direct applied parts leakage 12 = MAP leakage 13 = Alternative applied parts leakage 14 = Alternative equipment leakage 15 = Differential leakage 16 = Not used 17 = Point to point leakage 18 = Not used 19 = Point to point voltage 20 = Point to point resistance 21 = Mains to neutral insulation 22 = Applied parts to neutral insulation 23 = Mains to applied parts insulation 24 = Lead isolation leakage 25 = Meter ac 26 = Meter dc

GAIN

Description Allows the Analyzer to record current meter value and calculate counts per unit gain, which is then stored in EEPROM.

Parameters	<nnnn>	nnnn = Actual value of applied signal.
Examples	`GAIN=115.0`	Command to calibrate current meter value to an applied signal (in this case, mains voltage).

GFI

Description Selects ground fault interrupt (GFI) trip level.

Parameters	<nnMA>	nn = 5, 10, or 25
Examples	`GFI=5MA`	Sets ground fault interrupt to 5 mA.

GFIR

Description Resets ground fault interrupt ATTENTION.

HIGH_RES

Description Increases the number of digits displayed in the reading. This command is only used by automated calibration.

Parameters	<ON/OFF>	ON = increase the number of display digits. OFF = normal number of display digits..
Examples	`HIGH_RES=ON`	Increase the number of display digits.

INFO

Description	Returns serial number, calibration date, and technician number.	

INS

Description	Controls the insulation resistance test voltage.	
Parameters	<xxxx>	xxxx = Insulation voltage variable. LOW = Selects 250 V insulation voltage HIGH = Selects 500 V insulation voltage (default)
Examples	`INS=LOW`	Sets insulation voltage to 250 V.

INSWAP

Description	Swaps MAINS input neutral and hot.	
Parameters	<0/1>	0 = MAINS neutral and hot to normal polarity 1 = MAINS neutral and hot to reverse polarity.
Examples	`INSWAP=0`	Sets MAINS neutral and hot to normal polarity.

LEAD_ISO

Description	Selects the lead isolation function.	

LOAD

Description	Selects the load for the meter input.	
Parameters	<xxxx>	xxxx = Meter load variable. 601 = IEC 60601 patient load AAMI = ANSI/AAMI patient load NONE = IEC 60601 patient load
Examples	`LOAD=601`	Selects the IEC 60601 patient load.

MAINS

Description	Selects the mains voltage measurement test.	
Parameters	<xxxxxx>	L1-L2 = Measures ac, hot to neutral. L1-GND = Measures ac, hot to ground. L2-GND = Measures ac, neutral to ground.
Examples	`MAINS=L1-L2`	Sets measurement for ac, hot to neutral.

MAP

Description	Selects the mains on applied parts test.	
Parameters	<xxxxxx>	LOW = Switches to MAP level of 100 %. NORM = Switches to normal polarity MAP voltage. REV = Switches to reverse polarity MAP voltage. 1MA = Sets MAP limit to 1 mA. 3.5MA = Sets MAP limit to 3.5 mA. 7.5MA = Sets MAP limit to 7.5 mA.
Examples	`MAP=LOW`	Sets MAP voltage to 100 %.

METER_AC

Description	Selects a test that measures ac voltage on red and black jacks without the potential divider, i.e. connects directly to the meter.	

Note

Like the PPV test, this command forces IEC filtering.

METER_DC

Description Selects a test that measures dc voltage on red and black jacks without the potential divider, i.e. connects directly to the meter.

Note

Like the PPV test, this command forces IEC filtering.

MODE

Description Selects voltage measurement mode.

Parameters <xxxx> DC = Selects dc measurement mode.
AC = Selects ac measurement mode.
ACDC = Selects ac+dc measurement mode.

Examples `MODE=AC` Selects ac measurement mode.

MREAD

Description Returns meter readings continuously (on a single range) until an escape character is received.

NOSHOW

Description Return reading only during MREAD command (default at power-on).

OFFSET

Description Sets offsets to zero all ranges for the current function.

OVR

Description Resets over voltage ATTENTION.

POL

Description Sets equipment outlet polarity.

Parameters <OFF/N/R> OFF = Sets equipment outlet polarity off.
N = Sets equipment outlet polarity to normal.
R = Sets equipment outlet polarity to reverse.

Examples `POL=R` Sets equipment outlet polarity to reverse.

PPL

Description Selects point to point leakage test.

PPR

Description Selects point to point resistance test and set the test current value.

Parameters <LOW > LOW = Selects low current (200 mA).

Note

A PPR command without a parameter just selects the test.

Examples `PPR=LOW` Selects the point to point resistance test.

PPV

Description Selects point to point voltage test.

PSN

Description Sets serial number into EEPROM.

Parameters <nnnnnnn> nnnnnnn = serial number up to seven digits.

Examples `PSN=1234567`

RANGE

Description Sets the meter range.

Parameters	<n,n,n>	n = range and function numbers (0 – 4).
Query	`RANGE?`	Returns the number of the meter range.
Examples	`RANGE=0,0,1`	Sets the ac meter range to range 1.

READ

Description Returns a single meter reading with no autoranging.

RPTIME

Description Sets the equipment outlet (EO) polarity switch time between zero and five seconds.

Parameters	<n>	n = Time in seconds (0 – 5).
Examples	`RPTIME=3`	Sets EO polarity switch time to 3 seconds.

RSTM

Description Resets the meter processor.

RSTUI

Description Resets the Analyzer.

RSTEECAL

Description Clears the meter calibration constants stored in EEPROM.

SAVE

Description Saves the current calibration constants into EEPROM.

SHOWALL

Description Returns range, ADC count, and reading during MREAD command.

STAT

Description Returns the UI ASCII hex status word.

STAT1

Description Returns ASCII hex status word 1.

STAT2

Description Returns ASCII hex status word 2.

STAT3

Description Returns ASCII hex status word 3.

STD

Description Selects the test standard for tests. Based on the standard, the Analyzer automatically sets the load, GFI trip, and MAP voltage and current values.

Parameters	<xxxx>	xxxx = Desired test standard. 601 = IEC 60601 standard AAMI = ANSI/AAMI standard ASNZ = AS/NZS 3551 standard 353 = IEC 62353 standard
Examples	`STD=AAMI`	Selects the ANSI/AAMI standard.

TECH

Description Programs technician code into EEPROM. Twenty alphanumeric characters allowed.

TIMEOUT

Description Turns the UI to DSP communications timeout on and off.

Parameters <ON/OFF > ON = Turns on timeout.
OFF = Turns off timeout

Examples `TIMEOUT=ON`

UPLOAD

Description DSP sends formatted EEPROM data to USB port.

ZERO

Description Zero the resistance meter.

Diagnostic Commands

The following commands set specific conditions within the Analyzer and are used strictly for troubleshooting Analyzer problems. These commands allow isolation of, and access to, functional blocks of the Analyzer. These commands can also be used during Analyzer verification and calibration.

BEEP

Description Sounds the beeper once.

CONT

Description Sets the contrast to the specified value (in ASCII hex). Range is 00 to 11.

Examples `CONT=0F` Sets contrast.

DAC

Description Sets ECG DAC register to a specified hex value

Parameters <xxx> xxx = Hex value

Examples `DAC=0F0` Sets ECG DAC to 0F0.

DSPECHO

Description Runs continuous DSP communication test. ("ESC" to stop). Characters received from USB are shown on the display and sent to the DSP. The DSP echoes the character back to the UI, which then sends it to the PC.

DUPDATE

Description Turns the display update on or off.

Parameters <ON/OFF>

Examples `DUPDATE=ON` Display update on.

EEPROMV

Description Returns the UI EEPROM values.

ENCL

Description Selects Enclosure Leakage measurement.

EXIT

Description Exits diagnostic mode.

FLASH

Description Returns the UI flash checksum [XXXX].

FRAMT

Description Runs an FRAM test and returns “PASS” or “FAIL”.

GFIR

Description Resets ground fault interrupt ATTENTION.

IDENT

Description Queries the Analyzer for identification.

Query IDENT — Returns the Analyzer model, UI firmware version, and meter processor firmware version.

Note

When in calibration or diagnostic mode, the UI firmware and meter microprocessor firmware version are listed separately .

KEY

Description Runs continuous keypad test (“ESC” to stop). Pressed key number is shown in the display.

KRL

Description Disables all relays by asserting the RELAY_DISABLE line.

LED

Description Turns LED on or off.

Parameters <ON/OFF>

Examples `LED=ON` — Turns LED on.

LITE

Description Turns backlight on or off.

Parameters <ON/OFF>

Examples `LITE=ON` — Turns backlight on.

MCS

Description Returns the meter microprocessor flash checksum [xxxx].

OTEMP

Description Returns the over temperature status bit.

OVR

Description Resets over voltage ATTENTION.

POFF

Description Turns off all display pixels.

PON

Description Turns on all display pixels.

PXL

Description Write pixel column (8-bit) to the display, given the address and value (all in ASCII hex).

Parameters <Row, column, data>

Examples	`PXL=05,0A7,FF`	Writes FF to row 5 and column 0A7.

R

Description Repeat last command.

READ_AD

Description Returns A/D value. Takes up to 100 ms.

RESEND

Description Resends the last response to the PC.

RFRAM

Description Reads the value (8-bit) from the specified FRAM location.

Parameters	<xxxx>	xxxx = Memory address (0000 – 7FFF).
Examples	`RFRAM=0023`	Returns the 8-bit word at address 0023.

RXFLASH

Description Reads the value (8-bit) from the specified external FLASH location.

Parameters	<xxxx>	xxxx = Memory address (000000 – 20FFFF).
Examples	`RXFLASH=000023`	Returns the 8-bit word at address 000023.

SET_GFI

Description Sets GFI DAC register to a specified hex value

Parameters	<xxx>	xxx = Hex value
Examples	`SET_GFI=00A`	Sets GFI DAC register to 00A.

SET_MAP

Description Sets MAP DAC register to a specified hex value

Parameters	<xxx>	xxx = Hex value
Examples	`SET_MAP=002`	Sets MAP DAC register to 002.

SPI

Description Writes single SPI byte.

Parameters	<x,y,z>	x = SPI byte (0 – 9) y = value (0x00 – 0xFF) z = loop (Z=1 means loop until ESC).
Examples	`SPI=5,01,1`	Write 01 to SPI byte 5 repeatedly until escape character is received.

SPIR

Description Returns SPI 0-9 values.

STAT1

Description Returns ASCII hex status word 1.

STAT2

Description Returns ASCII hex status word 2.

STAT3

Description Returns ASCII hex status word 3.

UIECHO

Description Runs continuous USB test ("ESC" to stop). Characters received from USB are shown on the display and echoed back to the PC.

WFRAM

Description Writes the value (8-bit) to the specified external FRAM location.

Parameters <xxxx>, <dd> xxxx = Memory address (0000 – 7FFF)
dd = data.

Examples `WFRAM=0023, A3` Writes A3 to address 0023.

WXFLASH

Description Writes the value (8-bit) from the specified external FLASH location.

Parameters <xxxxxx> xxxxxx = Memory address (000000 – 20FFFF)
dd = data.

Examples `WXFLASH=000023, A3` Writes A3 to address 000023.

XFLASHT

Description Runs a test on the external FLASH chip and returns "PASS" or "FAIL".

ZOMBIE

Description Places the Analyzer in test mode.

Parameters <ON/OFF>

Examples `ZOMBIE=ON` Turns test mode on.

Error Responses

Table 4-2 list the error codes and their descriptions, that may be returned from the Analyzer.

Table 4-2. Error Responses

Code	Description
00	No commands allowed now
01	Unknown command
02	Illegal command, not allowed in current mode
03	Illegal parameter
04	Receive buffer overrun
05	General failure
06	Option not installed
21	Analog to Digital Converter out of range
30	Test passed
31	Test failed
32	No current
33	Can not null
37	No reading available

Table 4-2. Error Responses (cont.)

Code	Description
38	Load discharge timeout
40	Over temperature
41	CREMOTE protocol error
42	Initialization error
50	GFI
51	Overvoltage
52	Analyzer out of calibration
53	Mains out of range
54	Open ground
55	Reverse voltage
56	Polarity time wait
58	External memory error

Status Word Definitions

Table 4-3 lists the status word bit definitions.

Table 4-3. Status Word Definitions

Description	Status Word	Definition
UI Status Word Bit Definitions		
POWER_UP	0x0001	Device is in power-up mode
LOCAL	0x0002	Device is in local mode
REMOTE	0x0004	Device is in remote mode
CREMOTE	0x0008	Device is in cremote mode
DIAG	0x0010	Device is in diagnostic mode
CAL	0x0020	Device is in cal mode
ERROR	0x0040	Device is in error mode
TEST	0x0080	Device is in test mode
OVER_TEMP	0x0100	Overtemp condition
SPARE	0x0200	Spare
SPARE	0x0400	Spare
SPARE	0x0800	Spare
SPARE	0x1000	Spare
SPARE	0x2000	Spare
SPARE	0x4000	Spare

Table 4-3. Status Word Definitions (cont.)

Description	Status Word	Definition
SPARE	0x8000	Spare
Status Word 1 Bit Definitions		
REMOTE	0x0001	Device is in remote mode
DIAG	0x0002	Device is in diagnostic mode
CAL	0x0004	Device is in cal mode
ECG	0x0008	Device is in ECG mode
Spare	0x0010	Spare
SVOLTS	0x0020	Measure from 0 to 300 volts
SLEAK	0x0040	Measure from 0 to 10,000 μA
SOHMS	0x0080	Measure from 0 to 2 Ω @ 200 mA
Spare	0x0100	Spare
SMEG	0x0200	Measure from 0 to 100 MΩ
SEQUIP	0x0400	Measure from 0 to 20 A ac
SDIFF	0x0800	Measure from 0 to 10 mA ac
AC_ONLY	0x1000	Measure ac only
DC_ONLY	0x2000	Measure dc only
ACDC	0x4000	Measure ac+dc
SPARE	0x8000	Spare
Status Word 2 Bit Definitions		
LDAAMI	0x0001	AAMI load selected
Spare	0x0002	Spare
LD601	0x0004	601 load selected
EO	0x0008	Equipment outlet on
Spare	0x0010	Spare
MAPR	0x0020	MAP reverse selected
MAPON	0x0040	MAP voltage on
L2OPEN	0x0080	Neutral open
EOPEN	0x0100	Earth open
POLR	0x0200	EO polarity reversed
GFIL	0x0400	GFI low selected
GFIH	0x0800	GFI high selected
INS_ON	0x1000	Insulation voltage (500 V) on
RCURON	0x2000	Resistance current on

Table 4-3. Status Word Definitions (cont.)

Description	Status Word	Definition
MAINS0	0x4000	MAINS0-MAINS1 = Mains parameter selection.
MAINS1	0x8000	MAINS0-MAINS1: 00 = Not Used 01 = L2-GND 10 = L1-GND 11 = L1-L2
Status Word 3 Bit Definitions		
RPT0	0x0001	RPT0 – RPT2 reverse EO polarity switch time = 0 – 3.5 sec
RPT1	0x0002	RPT0 – RPT2 is a count of 1 sec increments
RPT2	0x0004	
GFIM	0x0008	GFI medium level (10 mA) selected
SHOWALL	0x0010	SHOWALL selected
NOMINAL	0x0020	NOMINAL selected
INS_LOW	0x0040	1 – insulation volts = 250 V; 0 – insulation volts = 500 V
MAP3MA	0x0080	MAP test – current limit = 3.5 mA if on or 1 mA if off
Spare	0x0100	Spare
MAINS	0x0200	0 = 115 V ac, 1 = 230 V ac Mains
EEP_CS_ERR	0x0400	EEPROM checksum error
VOLT_BAD	0x0800	MAINS – voltage L1-L2 out of range
BAD_GND	0x1000	MAINS – AC GND bad
REV_PWR	0x2000	MAINS – L1 and L2 reversed
GFITRIP	0x4000	GFI interrupt has occurred
FAULT	0x8000	FAULT interrupt has occurred

Firmware Updates

To update the firmware in the Analyzer, two firmware updates must be done: one for the meter and one for the UI.

⚠ Caution

To prevent damage to the Analyzer, do not interrupt the firmware download process. If this should happen, then both boards will have to be returned to the factory for reinitialization. Do not attempt to return the Analyzer to an earlier firmware version. This could result in a corrupt firmware load, and both boards will have to be returned to the factory for reinitialization.

1. ~~With the Analyzer powered off, connect your PC to the Analyzer and run AnsurMLC.exe.~~
2. ~~Click Tools->Upload Firmware.~~
3. ~~Select ESA612, select the appropriate COM port, and click NEXT.~~
4. ~~Browse to the appropriate DSP and UI firmware HEX files, and click NEXT.~~
5. ~~Power the Analyzer on.~~
6. ~~Click UPLOAD.~~
7. ~~The LCD will blank but AnsurMLC will begin downloading the new firmware. When both downloads are complete, cycle power to the Analyzer and verify the new firmware has been correctly uploaded.~~

Chapter 5
Maintenance

Title **Page**

Introduction

This chapter covers the general maintenance as well as troubleshooting information for isolating failed Analyzer components. The Analyzer needs little maintenance or special care. However, treat it as a calibrated measuring instrument. Avoid dropping or other mechanical abuse that could cause a shift in the calibrated settings.

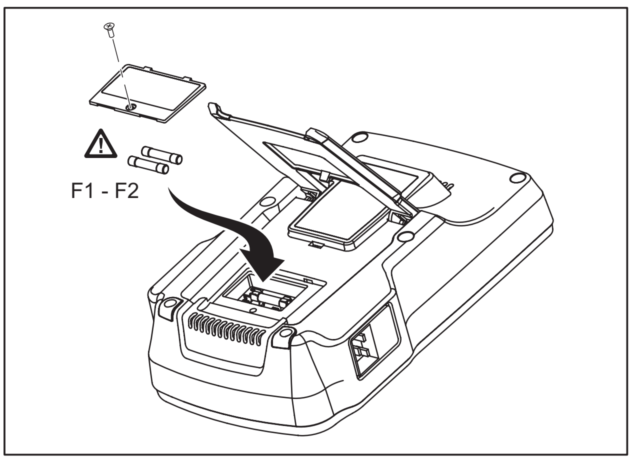
Testing and Replacing the Fuses

⚠⚠ Warning

To prevent electric shock, remove all power cords and test leads from the Analyzer before opening the fuse door.

For electrical protection of the equipment outlet, the Analyzer uses two fuses, one in the live (L1) line and one in the neutral (L2) line. To test the fuses, do the following while referring to Figure 5-1:

1. Turn the Analyzer so the case bottom is facing up.
2. Flip up the tilt stand.
3. Remove the fuse door from the Analyzer by removing the screw holding the fuse door with a #2 Phillips head screwdriver and lifting the fuse door from the Analyzer.
4. Remove the fuses from the Analyzer.



fis111.eps

Figure 5-1. Fuse Access

5. Using a multimeter, measure the continuity of each fuse.

   If one or both fuses do not show continuity, replace the fuse(s) with fuses that have the same current and voltage rating. Appropriate fuse ratings are posted on the case bottom label of the Analyzer. The final assembly table in the Replaceable Parts chapter lists available fuses with Fluke Biomedical part numbers.
6. Reinstall the fuse door and secure it with the screw.

Cleaning the Analyzer

⚠⚠ Warning

To avoid electric shock, do not clean the Analyzer plugged into mains or attached to a DUT.

⚠ Caution

Do not pour fluid onto the Analyzer surface; fluid seepage into the electrical circuitry may cause the Analyzer to fail.

⚠ Caution

Do not use spray cleaners on the Analyzer; such action may force cleaning fluid into the Analyzer and damage electronic components.

Clean the Analyzer occasionally utilizing a damp cloth and mild detergent. Take care to prevent the entrance of liquids.

Wipe down the adapter cables with the same care. Inspect them for damage to and deterioration of the insulation. Check the connections for integrity before each use.

Disassembly/Assembly

To disassemble the Analyzer, do the following:

1. Turn the Analyzer so the case bottom is facing up.
2. Remove the six screws in the case bottom with a Philips screwdriver
3. Lift the case bottom off of the case top and disconnect the cables that connect the two circuit boards together. The A1 Power PCA will remain attached to the case bottom and the A2 Meter PCA will remain with the case top.

To reassemble the Analyzer, follow the disassembly steps in reverse order.

Troubleshooting

The verification procedure contained in this manual is an effective troubleshooting tool; based upon the section of the test that has failed, or on the failure mode, the component that has caused the malfunction can be isolated.

Power on Failure

If the Analyzer fails to power up, verify fuses F1 and F2 inside the rear fuse-panel door have not blown. If they have not blown, verify power is applied to the power inlet assembly and that the wiring on the power switch internal to the device is correct.

Failures during power up are usually related to mismatched firmware or to power supply problems. To verify firmware, if the device will power up and gives an "Initialization Error," it may be possible to reach the remote mode through the USB port. Establish hyperterminal communication with the device and send the following command:

```
REMOTE=F2810 <CR>
```

If the device displays "Remote Mode" on the front panel and responds with a "*," determine the firmware status.

```
CAL=F2810 <CR>
Receive *
IDENT
```

Receive the meter and UI firmware builds. Verify that the two are matched; if they are not, upload the latest firmware to the device and try again.

If the firmware matches and is up to date, verify the power and data cables connecting the A1 Power PCA and A2 Meter PCA are connected at J4 and J7 on the power board and at J4 and J20, respectively, on the meter board; also inspect the soldering of the connectors to the pcas. If these connections are not at fault, verify the power supplies for the processors and for the device as a whole are functional. First verify U9, the power supply module at the bottom of the power board, is functional and that CR4, the red LED, is on. Then verify the outputs of U12 and U28 are correct. On the meter board, check that Q9 and U48 – U53 are all operating correctly. Finally, check the power inputs and resets to the microprocessors.

Output Failures

If sourcing a current or voltage through the electrical outlet, such as during an Earth Resistance, or powering a device with normal or reversed polarity, such as during a leakage test, and no signal is applied to the electrical outlet, failures could reside in the physical construction of the electrical outlet, in the reversing relays, or in the signal generation circuit.

Verify the electrical outlet wiring is in accordance with the J1 annotation on the pca. Also, if troubleshooting an Australian Analyzer, measure the impedance of the ground connector of the electrical outlet; some outlets have been found to have more than 0.5 Ω. These should be replaced. For US electrical outlets, ensure the backing plate is fully installed; this forces the insulation displacement crimp connection to engage. If this backing plate has been separated, replace the entire electrical outlet.

If sourcing a mains power source through the electrical outlet, measure the voltage at the electrical outlet in normal and reversed polarity. If the power configuration is incorrect, inspect the reversing relays on the power PCB: K1-K2, K4-K7. If GFCI trips are also a symptom, verify proper operation of the solid-state relay. K9 and K10 deliver the insulation resistance and MAP signals to the equipment outlet, respectively, and are a good place to half-split the source circuit. The protective earth resistance signal is selected via K12. For leakage measurements, the return path from the electrical outlet is selected by K14.

The MAP signal is generated by transformer T1 and regulated by Q1, Q2, and the supporting resistors and is routed through K16 and K17. The insulation resistance voltage is created by transformer T2 and rectified by the nearby circuitry, including Q7; the resultant signal is sensed by U24.

Meter Failures

While most measurements made by the Analyzer are made by the A2 Meter PCA directly, several are detected or analyzed directly on the A1 Power PCA.

MAINS Power

Most Mains voltage measurements that are erroneous are the result of power supply failures in U9, isolated supply U18, or in calibration failures. If a calibration error is suspected, calibrate the Mains voltage to determine if this can correct the problem. Otherwise, evaluate F3, the resistor network R2 through R7, U3, and U4 for failures.

Differential Current and Equipment Current

Both differential and equipment currents are measured at the outlet of the reversing relays, just prior to the Equipment Outlet using L1 and L3, respectively, installed on the backside of the A1 Power PCA beneath the SSR. If all the solder connections on the inductors are good, verify U1, U8, and the supporting circuitry.

Meter Troubleshooting

If the source signal is functional for a particular measurement, but no measurement is read by the Analyzer, then the meter inputs are suspect. K13 and K15-K18 connect the meter jacks, Red, Black, and Null, to the positive and negative sides of the meter for measurement or resistance nulling.

The patient load is the circuit by which a human body is simulated for patient leakage measurements, and is comprised of R78 and R79 (800 and 200 Ω, respectively). For greater leakage currents of 2 mA or more, the meter input is shifted from R78 to R79.

To troubleshoot leakage measurements, for ac measurements, half split the circuit at the output of the rms converter, U23 pin 5 or the input of the low pass filter, U31 pin 3. The input to the analog-to-digital converter for ac measurements is at TP95. For dc measurements, use the output of the low pass filter, TP 91.

Resistance measurements are driven by the power supplies on the A1 Power PCA, but is inverted by U15.

Applied parts problems should be troubleshot separately than leakage measurements, if possible. First, determine if a single ECG post is affected, or the entire bank. If a single ECG has a failure, inspect the diodes CR24, 29, and 46, L9, or relays K9, K10, and K22 (or respective components with other ECG posts).

If all applied parts are affected equally, verify K11 or inspect the signal source (MAP, 500 V dc, etc). For ECG waveform problems, the buffer U13 or resistor network of R53-61 drive the entire circuit; the waveform itself is generated by the meter microprocessor.

U/I and meter microprocessor failures will normally result in complete nonfunctionality of the Analyzer. Calibration data table and configuration information failures indicate a problem in U44; a loss or corruption of stored test data indicates a failure in U1 or U59.

Display board failures are investigated through the driver, which consists of U3 and the power supply of U5, U6, R22 and Q3. Otherwise, the display is replaced as a unit.

Chapter 6
Replaceable Parts

Title	Page

Introduction

This section contains an illustrated list of replaceable parts for the Analyzer. 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. Refer to Table 6-1.

The parts lists give the following information:

- Reference designator (for example, “R52”)
- An indication if the part is subject to damage by static discharge (* near the part description)
- Description
- Fluke stock number

⚠Caution

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

How to Obtain Parts

Electronic components may be ordered directly from Fluke Biomedical and its authorized representatives by using the part number under the heading Fluke Stock No. Parts price information is available from Fluke Biomedical or its representatives.

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

- North America
  1-800-850-4608 (Email: orders@flukebiomedical.com)
- Europe, Middle East, and Africa
  +31-402-675-300 (Email: ordersupport.emea@flukebiomedical.com)
- All other countries
  1-440-248-9300 (Email: orders@flukebiomedical.com)

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

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

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

Parts List

Tables 6-1 though 6-3 lists the replaceable parts of the Analyzer and their location identified in Figures 6-1 though 6-3.

Table 6-1. Final Assembly

<table>
<tr><th>Item</th><th colspan="2">Description</th><th>Fluke Stock No.</th></tr>
<tr><td>A1</td><td colspan="2">ESA612-4002,PCA, POWER</td><td>3316505</td></tr>
<tr><td>A2</td><td colspan="2">ESA612-4001,PCA, METER</td><td>3316497</td></tr>
<tr><td>C1</td><td colspan="2">ESA612-4401,CABLE ASSY, AC INPUT</td><td>3316689</td></tr>
<tr><td>C2</td><td colspan="2">ESA612-4402,CABLE ASSY, POWER -METER</td><td>3316692</td></tr>
<tr><td>C3</td><td colspan="2">ESA612-4403,CABLE ASSY, POWER TO METER SUPPLY</td><td>3316704</td></tr>
<tr><td rowspan="11">F1, F2</td><td>US</td><td rowspan="2">⚠FUSE,20A,250V,3AB,TIME LAG,.25X1.25,BULK</td><td rowspan="2">2183691</td></tr>
<tr><td>Japan</td></tr>
<tr><td>France</td><td rowspan="5">⚠FUSE,16A,250V,TIME LAG,6.3X32,CERAMIC BODY,BULK</td><td rowspan="5">3321245</td></tr>
<tr><td>Europe</td></tr>
<tr><td>Israel</td></tr>
<tr><td>United Kingdom</td></tr>
<tr><td>Thailand</td></tr>
<tr><td>Australia</td><td rowspan="2">⚠FUSE ,FUSE,.25X1.25,10A,250V,SLOW</td><td rowspan="2">109298</td></tr>
<tr><td>Switzerland</td></tr>
<tr><td>H1</td><td colspan="2">SCREW,5-14,.750,PAN,PHILLIPS,STEEL,BLACK CHROMATE,THD FORMING</td><td>832246</td></tr>
<tr><td>H2</td><td colspan="2">SCREW,4-14,.375,PAN,PHILLIPS,STEEL,ZINC-ROHS CLEAR,THREAD FORM</td><td>448456</td></tr>
<tr><td>H3</td><td colspan="2">SCREW,M3X0.5,6MM,PAN,PHILLIPS,STEEL,ZINC-BLACK CHROMATE</td><td>2032792</td></tr>
<tr><td>H4</td><td colspan="2">SCREW,M3X0.5,5MM,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK</td><td>2032811</td></tr>
<tr><td>H5</td><td colspan="2">SCREW,6-32,.312,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK</td><td>152157</td></tr>
<tr><td>H6</td><td colspan="2">SCREW,8-32,.375,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK</td><td>114124</td></tr>
<tr><td>MP1</td><td colspan="2">ESA612-2008,CASE TOP ASSY</td><td>3274779</td></tr>
<tr><td>MP2</td><td colspan="2">ESA612-2010,CASE BOTTOM ASSY</td><td>3276744</td></tr>
<tr><td>MP3</td><td colspan="2">ESA612-2007-02,FEET SET, LEFT, RIGHT</td><td>3359523</td></tr>
<tr><td>MP4</td><td colspan="2">ESA612-2004,DOOR, FUSE ACCESS</td><td>3236200</td></tr>
<tr><td>MP5</td><td colspan="2">ESA612-2009,PLATE, TOP END</td><td>3236274</td></tr>
<tr><td>MP6</td><td colspan="2">ESA612-2006,BRACKET, DISPLAY</td><td>3236239</td></tr>
<tr><td>MP7</td><td colspan="2">ESA612-2019,INSULATOR, INPUT RECEPTACLE</td><td>3383167</td></tr>
<tr><td>MP8</td><td colspan="2">ESA612-8002,KEYPAD, UPPER</td><td>3258971</td></tr>
<tr><td>MP9</td><td colspan="2">ESA612-8002-01,KEYPAD, LOWER</td><td>3258980</td></tr>
<tr><td>MP10</td><td colspan="2">CONTRACT MFG ITEM, RELAY SOLID STATE 75A VDECSA</td><td>2077927</td></tr>
</table>

Table 6-1. Final Assembly (cont.)

Item	Description		Fluke Stock No.
MP11	LCD MODULE,320X240,FSTN,3.8 IN MONO GRAPHIC,TRANSFLCTV,WHITE LED,0.22MM PITCH		3299802
MP12	POWER ENTRY MODULE,A/C INLET,ON/OFF SWITCH,2-POLE,20A,250VAC,SNAP-IN,BULK		2791306
MP13	LABEL,SERIAL NUMBER		3097856
MP14	US Japan	ESA612-8009,DECAL, BOTTOM CASE, 20 AMP	3343933
	France Europe Israel United Kingdom Thailand	ESA612-8009-01,DECAL, BOTTOM CASE, 16 AMP	3343940
	Australia Switzerland	ESA612-8009-02,DECAL, BOTTOM CASE, 10 AMP	3343957
MP15	US Japan	ESA612-4405,WIRE ASSY, EQUIPMENT OUTLET	3316728
	France	ESA612-4411,WIRE ASSY, EQUIPMENT OUTLET	3343887
	Europe	ESA612-4412,WIRE ASSY, EQUIPMENT OUTLET	3343893
	Israel	ESA612-4413,WIRE ASSY, EQUIPMENT OUTLET	3343902
	Australia	ESA612-4415,WIRE ASSY, EQUIPMENT OUTLET	3343916
	United Kingdom	ESA612-4410,WIRE ASSY, EQUIPMENT OUTLET	3316762
	Switzerland	ESA612-4416,WIRE ASSY, EQUIPMENT OUTLET	3343925
	Thailand	ESA612-4418,WIRE ASSY, EQUIPMENT OUTLET	3474220
Not Shown	US Japan	LINE CORD,N AMER,20A/125V,5-20/C19,12-3 SJT,2.5M,BLK	2238680
	France Europe	75026,PWRCORDSET EUROPE W/IEC320	2238615
	Israel	LINE CORD,ISRAEL,16A/250V,SI 32 STRAIGHT OR RT ANG/C19,BLACK,2.5 METERS	2434122
	Australia	75025,PWRCORD SET AUST W/IEC320	2238603
	United Kingdom	75024,PWRCORD SET UK W/IEC320	2238596
	Switzerland	FBC-ESA620-4420,SWISS 10A POWER CORD ASSY WITH C-19 CONNECTOR	3379149
	Thailand	75033,POWERCORD US WITH C19 PLUG	2238644
Not Shown	ESA612-2016,BJ2ECG ADAPTER ASSY		3359538

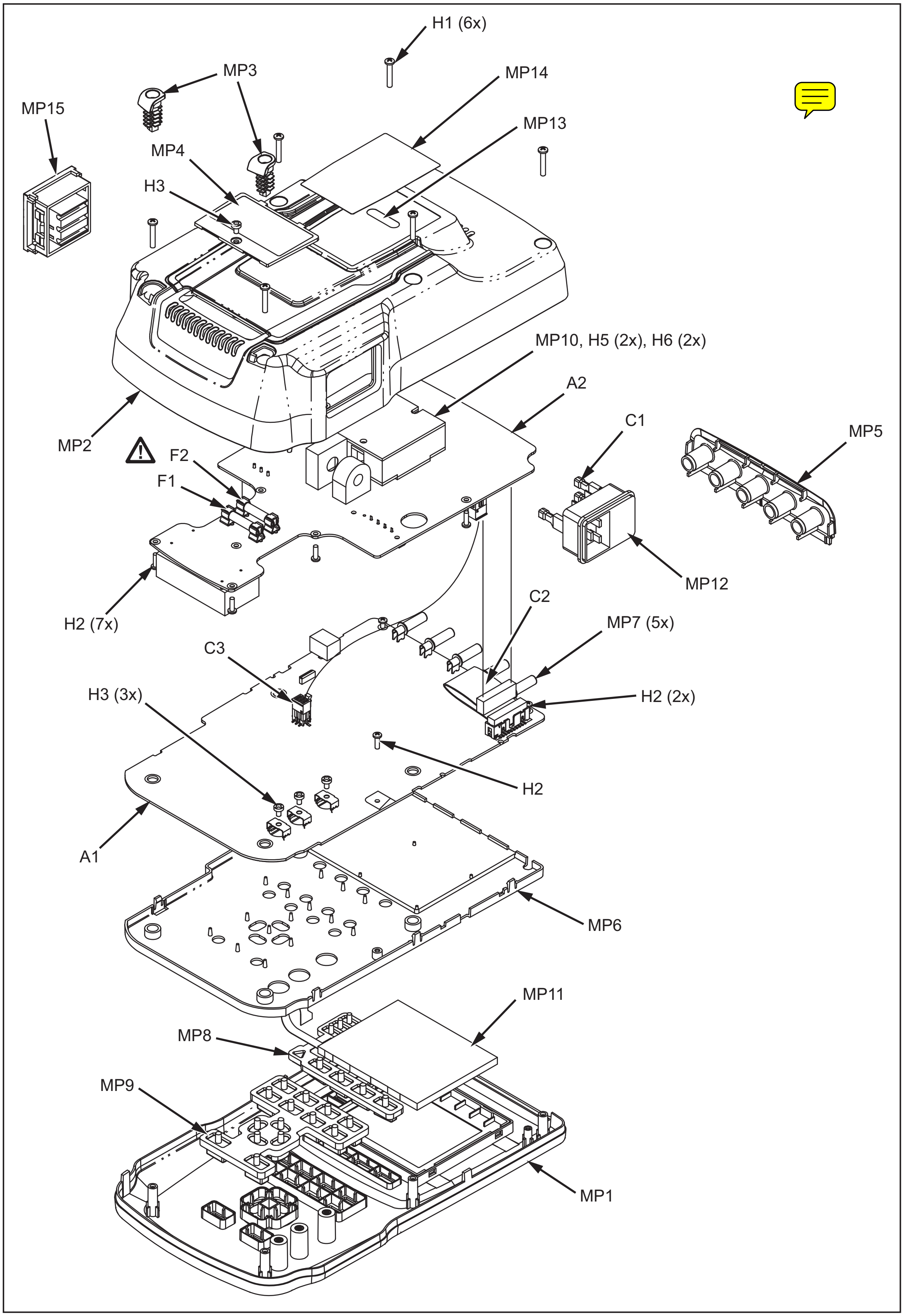


Figure 6-1. Final Assembly

Table 6-2. A1 Power PCA

Item	Description	Fluke Stock No.
C2 C4 C6 C7 C11 C14 C17 C19-26 C32 C35 C36 C41 C43	CAPACITOR,CERAMIC,0.1UF,+-10%,50V,X7R,0805,TAPE	690500
C3 C12 C15 C18 C28 C53 C55 C60	CAPACITOR,ELECTROLYTIC,TANTALUM,10UF,+-20%,16V,3216,TAPE	3093654
C5 C38-40	CAPACITOR,CERAMIC,1UF,+-20%,25V,X5R,0805,TAPE	2530275
C8 C9 C37	CAPACITOR,CERAMIC,0.047UF,+-10%,50V,X7R,0805,TAPE	1708909
C10	CAPACITOR SMR,CAP,CER,4700PF,+-10%,50V,X7R,0805	604231
C13 C54	CAPACITOR,CERAMIC,0.01UF,+-10%,50V,X7R,0805,TAPE	106146
C27 C74	CAPACITOR,CERAMIC,10PF,+-5%,100V,C0G,0805,TAPE	3331432
C29 C42	CAPACITOR,CERAMIC,0.047UF,\+-10%,500V,X7R,1812,TAPE	644077
C30 C33 C44 C57 C73	CAPACITOR SMR,CAP,CER,1000PF,+-10%,50V,X7R,0805	484378
C31	CAPACITOR SMR,CAP,CER,470PF,+-1%,50V,C0G,0805	929476
C34	560180002224,CAP-SM,0805,16V,10%,X7R,.22UF	2331299
C45-52 C56 C58 C59 C61-71	CAPACITOR SMR,CAP,CER,100PF,+-1%,50V,C0G,0805	867650
C72	CAPACITOR,ELECTROLYTIC,TANTALUM,47UF,+-10%,16V,200MOHM ESR,7343,TAPE	3352434
CR1	ZENER,UNCOMP,MMBZ5235B,6.8V,5%,20MA,225MW,SOT-23,TAPE	837195
CR2 CR3 CR11 CR19	ZENER,UNCOMP,MMBZ5242B,12V,5%,20MA,225MW,SOT-23,TAPE	2044054
CR4	LED,RED,AM2520,280MCD,20MA,2.5V,20 DEG VIEW ANGLE,GULL WING PREP,T3/4,TAPE	2281407
CR5 CR10	DIODE,SI,PN,S1M,1KV,1A,75NS,SMA,TAPE	2087962
CR6 CR16-18 CR20	DIODE,SI,BAS16,75V,200MA,6NS,SOT-23,TAPE	830489
CR7 CR12-15	DIODE,SI,PN,S1M,1KV,1A,1.8US,DO-214AC,TAPE	2646221
F3	FUSE,2.5A,250V,TIME LAG,8X8.5MM,RADIAL	3331539
H1 H2	SPACER,ROUND,4.2MM ID,2.0MM HEIGHT,8.74MM OD,STEEL,TIN,SMD,TAPE	3350760
H3 H4	SPACER,ROUND,3.6MM ID,2.0MM HEIGHT,7.14MM OD,STEEL,TIN,SMD,TAPE	3352172
J1	CONNECTOR,TERMINAL BLOCK,6.35MMCTR,VERT PWB,30A,300V,3 POS	3342141
J2	CONNECTOR,SOCKET,2 ROW,3.0MM CTR,VERT SMD,6 POS,TAPE	3343846

Table 6-2. A1 Power PCA (cont.)

Item	Description	Fluke Stock No.
J4	CONNECTOR,HEADER,2 ROW,0.1 CTR,VERT SMT,SHROUDED,20 POS,TAPE	2791599
J5	CONNECTOR,HEADER,1 ROW,.25 CTR,RT ANG PWB,LOCKING,W/EARS,5 POS,BULK	3351138
K1-7 K11	RELAY,ARMATURE,1 FORM C,12V,1 C/O CONTACT.16A,29X12.7MM,BULK	2152365
K8 K9 K13 K17	RELAY,ARMATURE,2 FORM C,12VDC,SINGLE STABLE,15X7.4MM,TAPE	2082903
K10 K12 K14 K16	RELAY,ARMATURE,2 FORM C,12V,15X9MM,SMT,TAPE	3301088
L1	TRANSFORMER,SIGNAL,200:1,DIFFERENTIAL,SHIELDED,VERTICAL TOROID,26X27X11MM,4-PIN,BULK	3405268
L3	TRANSFORMER,SIGNAL,CURRENT SENSOR,2-20A,100 OHM,50/60HZ,3PIN,BULK	2750107
Q1	MOSFET,SI,N,IRFBF20S,900V,1.7A,8 OHMS,3.1W,D2-PAK,TAPE	2742520
Q2	TRANSISTOR,SI,NPN,MMBT5089,30V,50MA,50MHZ,200MW,SOT-23,TAPE	820902
Q3	MOSFET,SI,N,IRLR3410,100V,17A,105 MOHMS,3W,D-PAK,TAPE	1579273
Q4	MOSFET,SI,N,FQB5N90,900V,5.4A,2.3 OHMS,3.13W,D2-PAK,TAPE	3343629
Q5 Q6	MOSFET,SI,N,2N7002E,60V,240MA,3 OHMS,350MW,SOT-23,TAPE	1756473
Q7-9	TRANSISTOR,SI,NPN,MUN2216,50V,100MA,DIGITAL,R1=4.7K,R2=INF,230MW,SC-59,TAPE	2002486
R2-7 R23 R24 R27	RESISTOR,METAL FILM,330K,+-1%,0.25W,50PPM,CYLINDRICAL 0204,MELF,TAPE	3326205
R9 R16 R20 R43 R58	RESISTOR,CERMET,100,+-1%,0.125W,100PPM,0805,TAPE	928937
R12	RESISTOR,CERMET,10,+-1%,0.125W,100PPM,0805,TAPE	928924
R13	RESISTOR,CERMET,16.2K,+-1%,0.125W,100PPM,0805,TAPE	2005953
R14 R15 R25 R30 R31 R33 R34 R39 R44 R54 R62 R65 R69-74 R79-83 R88-91 R96-99 R101-113	RESISTOR,CERMET,1K,+-1%,0.1W,100PPM,0805,TAPE	928713
R17 R18 R21 R22	RESISTOR,CERMET,6.2K,+-1%,0.125W,100PPM,0805,TAPE	3336652
R19 R52 R67 R68 R128	RESISTOR,CERMET,100K,+-1%,0.125W,100PPM,0805,TAPE	928866
R26	RESISTOR,CERMET,7.5K,+-1%,0.125W,100PPM,0805,TAPE	2278492
R10	RESISTOR SMR,RES,CERM,332,+-1%,0.1W,100PPM,0805	604926
R11 R100	RESISTOR,CERMET,33,+-1%,0.125W,100PPM,0805,TAPE	2803420

Table 6-2. A1 Power PCA (cont.)

Item	Description	Fluke Stock No.
R29	RESISTOR SMR,RES,CERM,1.82K,+-1%,0.1W,100PPM,0805	930172
R32 R37 R49 R51 R55 R61	RESISTOR,CERMET,10K,+-1%,0.125W,100PPM,0805,TAPE	928791
R41 R56 R57	RESISTOR,METAL FILM,1M,+-1%,0.25W,50PPM,CYLINDRICAL 0204,MELF,TAPE	3326231
R42 R53 R59 R76 R85 R86	RESISTOR,CERMET,1,+-1%,0.125W,400PPM,0805,TAPE	2005982
R45	RESISTOR,CERMET,56K,+-1%,0.125W,100PPM,0805,TAPE	3331360
R46	RESISTOR,CERMET,11.5K,+-1%,0.1W,100PPM,0805,TAPE	1997330
R47	RESISTOR,CERMET,1M,\+-1%,0.125W,100PPM,0805,TAPE	928945
R48	RESISTOR,CERMET,4.7K,+-1%,0.125W,100PPM,0805,TAPE	3326333
R50	RESISTOR SMR,RES,CERM,332K,+-1%,0.1W,100PPM,0805	602695
R60	RESISTOR,CERMET,470,+-1%,0.125W,100PPM,0805,TAPE	2803447
R63 R64	RESISTOR,CERMET,68K,+-5%,1W,200PPM,2512,TAPE	3331385
R66	RESISTOR,CERMET,23.2K,+-1%,0.125W,100PPM,0805,TAPE	3331397
R77	RESISTOR,CERMET,6.81K,+-1%,0.1W,100PPM,0805,TAPE	2087241
R78	RESISTOR,CERMET,3.6K,+-1%,0.125W,100PPM,0805,TAPE	3331415
R92-95	RESISTOR,CERMET,200,+-1%,0.125W,100PPM,0805,TAPE	3372234
R114-118	RESISTOR,CERMET,2M,+-5%,1W,200PPM,2512,TAPE	3310288
R119-127	RESISTOR,CERMET,JUMPER,0,+0.05 MAX,0.125W,1206,TAPE	810747
RV1 RV2	VARISTOR R05R,VARISTOR,430V,+-10%,1MA	706838
RV40 RV75	THERMISTOR,POSITIVE,1.1K,+-20%,COATED,RADIAL,TAPE	1277360
T1	TRANSFORMER,POWER,115/230V,50/60HZ,2X102V@2.5MA,0.51VA,EI30/12.5,PC MOUNT,BULK	3342134
T2	TRANSFORMER,FLY-BACK,6V,20KHZ,1:10:10,1.5W,HV,FLUKE-165X,RM6,SMT8,TAPE	2032204
TP12 TP29 TP33-37	CONNECTOR,TERMINAL,TEST POINT,SMD,510 PH BRONZE,TAPE	602125
U1	IC,OP AMP,AD8510,+-4.5V TO +-18V,0.9MV OFFSET,8MHZ,PRECISION,JFET,S08,TAPE	2434633
U2 U5	IC,DIGITAL ISOLATOR,ADUM1401,QUAD,3/1,10MHZ,2500V,3V/5V,SOICW16,TAPE	3331444
U3	IC,ADC,MCP3202,2.7-5.5V,12BIT,2-CHANNEL,SPI,S08,TAPE	3331459
U4	IC,OP AMP,TLV2372,2.7V TO 16V,4.5MV OFFSET,3MHZ,DUAL,R/R,S/S,SO8,TAPE	3329934
U6 U10 U11 U19-21 U29	OPTICAL,OPTOCOUPLER,PHOTO TRANSISTOR,SMD DIP4,TUBE	3328473
U7	IC,COMPARATOR,LMV7271,1.8V TO 5V,4MV OFFSET,R/R INPUT,LO PW,800NS PD,SOT-23-5,TAPE	3332950
U8	IC,ANALOG SWITCH,ADG431,5-44V,24 OHMS,QUAD,SPST,NO,SO16,TAPE	3367437

Table 6-2. A1 Power PCA (cont.)

Item	Description	Fluke Stock No.
U9	POWER SUPPLY,SW,15W,85-264VAC,12V@1.25A,32X64MM,PCB MOUNT,BULK	3331480
U12 U28	IC,VOLTAGE REGULATOR,LINEAR,LP2985,3.3V,150MA,LDO,LOW POWER,SOT-23-5,TAPE	2559443
U13 U15	TRANSISTOR,SI,NPN,ULN2003,50V,500MA,HEPTA-DARLINGTON,3.5W,SO16,TAPE	2113871
U14 U16 U25	IC,LOGIC,74HC595,2.0V-6.0V,8-BIT SHIFT REGISTER,TRI-STATE,SOIC16,TAPE	904388
U17	IC,PULSE WIDTH MODULATOR,UCC3805,4V,35MA,1MHZ,10V SUPPLY,SO8,TAPE	1541378
U18	POWER SUPPLY,DC-DC,2W,12VDC,+-5V@200MA,3KV ISO,SIP5,TUBE	3338710
U22	603022-008,VOLTAGE REF 1.2V LM4041CM3	1790839
U23 U24	IC,OP AMP,TLV2371,2.7V TO 16V,4.5MV OFFSET,3MHZ,R/R,S/S,SOT-23-5,TAPE	3331500
U26 U27	IC,LOGIC,NC7SZ32,1.65V-5.5V,SINGLE OR GATE,NON-INV,SOT23-5,TAPE	1604581
VR2 VR3	TVS DIODE,SMA6J6.5A,6.5V,5%,UNIPOLAR,SMA,TAPE	3385450
W1	WIRE,PVC,UL1015,600V,105C,14AWG,STRANDED,BLU	2198323
W2	WIRE,PVC,UL1015,14AWG,STRANDED,INDIVIDUAL TINNED,BRN	2148907
XAF1 XAF2 XBF1 XBF2	FUSE CLIP,FUSE CLIP PCB	756460

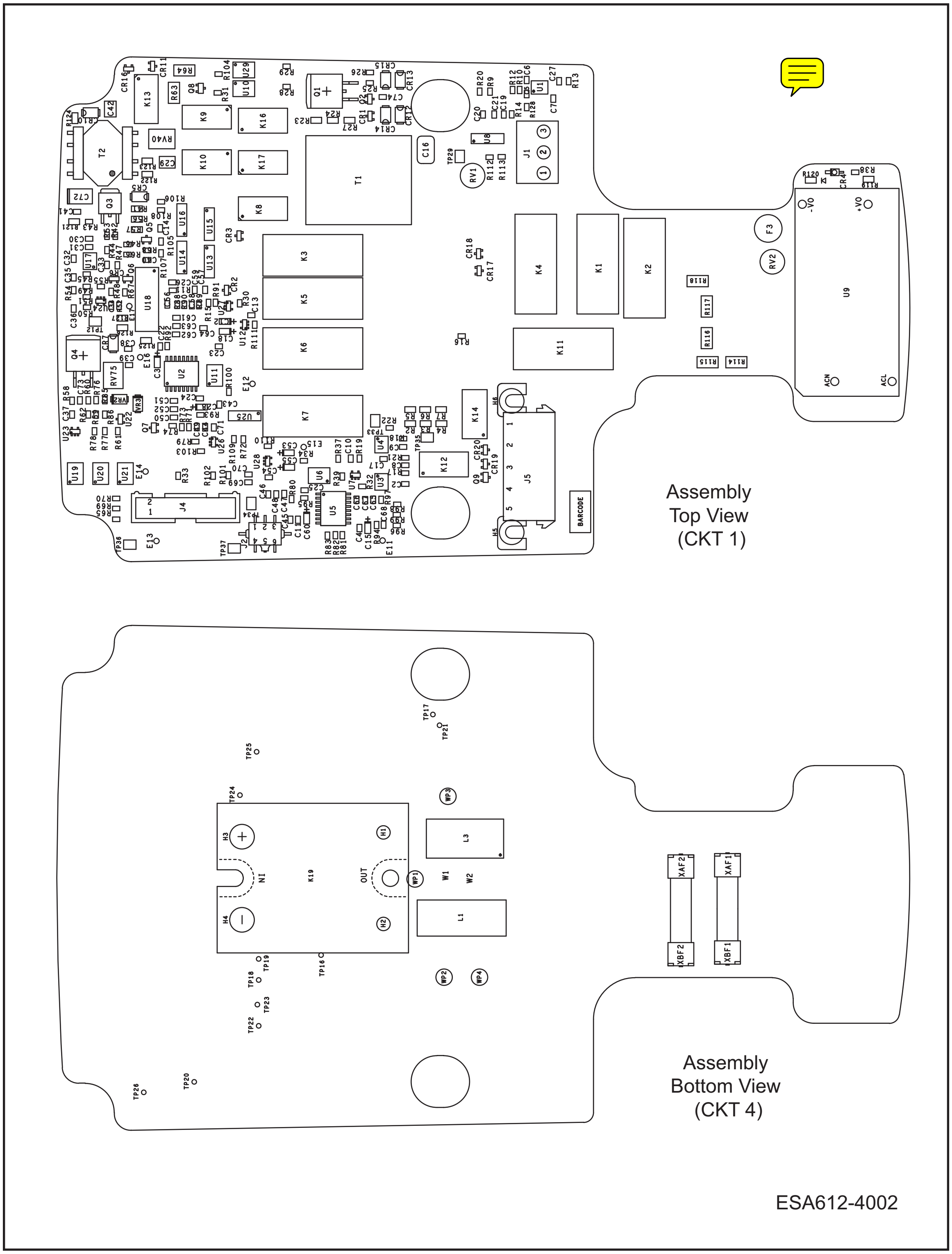


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Figure 6-2. A1 Power PCA

Table 6-3. A2 Meter PCA

Item	Description	Fluke Stock No.
C1 C73 C103 C116 C132 C157 C194	CAPACITOR SMR,CAP,CER,1000PF,+-10%,50V,X7R,0805	484378
C2	CAPACITOR,CERAMIC,0.33UF,+-10%,16V,X7R,0805,TAPE	1745562
C3-8 C10 C11 C14-21 C35-45 C47 C48 C63 C64 C69 C70 C72 C74 C75 C79-83 C93 C94 C98 C99 C105 C107-112 C114 C119 C123 C124 C126 C127 C129-131 C133 C135-137 C141-145 C155 C163-165 C167 C168 C170 C174 C177-179	CAPACITOR,CERAMIC,0.1UF,+-10%,50V,X7R,0805,TAPE	690500
C9	CAPACITOR,CERAMIC,4.7UF,+-10%,10V,X7R,0805,TAPE	3092853
C12	CAPACITOR,CERAMIC,2.2UF,+-10%,10V,X5R,0805,TAPE	3093102
C13	CAPACITOR SMR,CAP,CER,470PF,+-1%,50V,C0G,0805	929476
C22 C46 C50 C57 C58 C60 C61 C104 C117 C122 C146-150 C171	CAPACITOR,ELECTROLYTIC,TANTALUM,10UF,+-20%,16V,3216,TAPE	3093654
C24 C25	CAPACITOR SMR,CAP,CER,22PF,+-5%,200V,C0G,0805	643459
C26 C27 C29-34 C51 C62 C67 C106 C113 C115 C120 C121 C169 C189-191	CAPACITOR,CERAMIC,1UF,+-20%,25V,X5R,0805,TAPE	2530275
C28 C96 C97	CAPACITOR SMR,CAP,CER,4.7PF,+-0.25PF,50V,C0G,0805	806760
C49 C52 C118 C139	CAPACITOR,CERAMIC,0.01UF,+-10%,50V,X7R,0805,TAPE	106146

Table 6-3. A2 Meter PCA (cont.)

Item	Description	Fluke Stock No.
C53-56 C134 C140 C151-154 C156 C159-162 C166	CAPACITOR SMR,CAP,CER,100PF,+-1%,50V,C0G,0805	867650
C65	560380008223,CAP-SM,0805,50V,10%,X7R,.022UF	2332024
C68	560380008333,CAP-SM,.033UF,50V,10%,X7R,0805	2332036
C71 C76	CAPACITOR SMR,CAP,CER,4700PF,+-10%,50V,X7R,0805	604231
C77 C78 C87 C88 C90 C91	CAPACITOR,CERAMIC,0.47UF,+-5%,16V,X7R,0805,TAPE	3341246
C86 C92	CAPACITOR,CERAMIC,0.047UF,+-5%,50V,X7R,0805,TAPE	3341222
C89	CAPACITOR,CERAMIC,0.1UF,+-5%,50V,X7R,0805,TAPE	3349793
C95 C125	CAPACITOR,CERAMIC,15PF,+-5%,50V,C0G,0805,TAPE	514174
C101 C102	CAPACITOR,CERAMIC,33PF,+-5%,50V,C0G,0805,TAPE	603172
C175 C193	CAPACITOR,CERAMIC,0.027UF,+-10%,1000V,X7R,1812,TAPE	1579931
C180 C181 C187 C188	CAPACITOR,CERAMIC,100PF,+-5%,50V,C0G,0402,TAPE	2813217
C182-186	CAPACITOR,CERAMIC,0.1UF,+-20%,16V,X7R,0402,TAPE	2812858
CR1 CR8 CR15 CR17	DIODE,BAT54A SMR,DIODE,SI,SCHOTT,DUAL,30V,200MA,SOT-23	942594
CR2 CR5 CR10 CR11	DIODE,SI,BAS16,75V,200MA,6NS,SOT-23,TAPE	830489
CR3 CR4	DIODE,MBR0530 SMR,DIODE,SI,SCHOTTKY,30V,0.5A,SOD-123	691717
CR6 CR20-29 CR33-37	TVS DIODE,SMAJ440CA,440V,5%,BIPOLAR,SMA,TAPE	2636264
CR9 CR41	DIODE,SI,PN,MMBD1503A,150V,200MA,DUAL,SERIES,LOW LEAKAGE,SOT-23,TAPE	928143
CR18	TVS DIODE,SMAJ5.0CA,5V,5%,BIPOLAR,SMA,TAPE	2073208
CR19 CR30-32 CR38	VARISTOR,0603 3.6 V VARISTOR (CLAMP @ 10 V), VC060303A100	2764916
CR42-46	DIODE,SI,PN,BAV199,70V,215MA,3US,DUAL,SERIES,SOT-23,TAPE	605805
DS1	LED,RED,AM2520,280MCD,20MA,2.5V,20 DEG VIEW ANGLE,GULL WING PREP,T3/4,TAPE	2281407
F1	THERMISTOR,PTC,50,+-20%,300V,3A MAX,8MM RADIAL,BULK	3339126
H1	CABLE ACCESSORY ,CABLE ACCESS,TIE,5.50L,.10W,1.25 DIA	530360
J1	CONNECTOR,FLAT-FLEX,RECEPTACLE,SINGLE SIDE,0.5MM PITCH,VERTICAL SMD,20 POS,TAPE	2739499
J2 J21	CONNECTOR,FLAT FLEX,1MMCTR,VERTICAL SMD,ZIF,LOCKING,10 POS,TAPE	3408166
~~J3~~	~~CONNECTOR,MICRO-RIBBON, USB,SERIES B, RECEPTACLE,RT ANG PWB,4 POS,BULK~~	~~1541856~~

Table 6-3. A2 Meter PCA (cont.)

Item	Description	Fluke Stock No.
J4	CONNECTOR,HEADER,2 ROW,0.1 CTR,VERT SMT,SHROUDED,20 POS,TAPE	2791599
J20	CONNECTOR,SOCKET,2 ROW,3.0MM CTR,VERT SMD,6 POS,TAPE	3343846
J60-64	CONNECTOR,HOLDER,FUSE,5MM DIA,RT ANG SURFACE MOUNT,TAPE	1620687
L1 L2	INDUCTOR,10UH,20%,1.8ADC,140MOHMS,6X6X3MM,SMT,TAPE	3338177
L3-10	INDUCTOR,BEAD,95 OHMS@100MHZ,1ADC,1MOHM,3612,TAPE	867734
LS1	AUDIO TRANSDUCER,MAGNETIC,SOUNDER,2.4KHZ,5V,TOP PORT,13MM SQ,TAPE	690271
P12 P13 P24	ESA612-8003,STRAP, INPUT	3258998
Q1	MOSFET,SI,N,2N7002,60V,115MA,7.5 OHMS,225MW,SOT-23,TAPE	927538
Q2-4	NPN,MMBT3904 SMR,TRANSISTOR,SI,NPN,60V,350MW,SOT-23	742676
Q7	MOSFET,SI,P,FDN338P,20V,1.6A,115 MOHMS,500MW,SOT-23,TAPE	2538867
Q8	TRANSISTOR,SI,NPN,MMUN2211,50V,100MA,DIGITAL,R1=10K,R2=10K,246 MW,SOT-23,TAPE	3331929
R2	RESISTOR,CERMET,130,+-1%,0.125W,100PPM,0805,TAPE	690644
R3 R5 R11-15 R33 R40-43 R50 R70-72 R74 R82 R90 R91 R102 R119 R133 R135-140 R146 R147 R168-171 R194 R195 R243-245 R249-257 R260 R404 R405 R408 R412 R413	RESISTOR,CERMET,10K,+-1%,0.125W,100PPM,0805,TAPE	928791
R4 R21 R23 R36-39 R45-48 R77 R95 R96 R118 R129 R131 R132 R134 R141 R148 R149 R172 R190-193 R196-199 R203 R215 R218 R225 R230-232 R236-239 R246-248 R270 R271 R345 R346	RESISTOR,CERMET,1K,+-1%,0.1W,100PPM,0805,TAPE	928713

Table 6-3. A2 Meter PCA (cont.)

Item	Description	Fluke Stock No.
R7 R29-32 R73 R144 R150 R157-167 R206-214 R217 R233-235 R240 R407	RESISTOR,CERMET,100,+-1%,0.125W,100PPM,0805,TAPE	928937
R16 R20 R76 R80 R81 R86 R92 R117 R121 R142 R143 R145 R179 R180 R223	RESISTOR,CERMET,100K,+-1%,0.125W,100PPM,0805,TAPE	928866
R19	RESISTOR,CERMET,2M,+-1%,0.125W,100PPM,0805,TAPE	3326041
R22	RESISTOR,CERMET,24K,\+-1%,0.125W,100PPM,0805,TAPE	2499314
R24 R25 R27 R28	RESISTOR,CERMET,121K,+-1%,0.125W,100PPM,0805,TAPE	801560
R26 R53	RESISTOR,CERMET,1.5M,+-1%,0.125W,100PPM,0805,TAPE	3326090
R34 R35	RESISTOR SMR,RES,CERM,150,+-1%,0.1W,100PPM,0805	930086
R44	RESISTOR,CERMET,16.2K,+-1%,0.125W,100PPM,0805,TAPE	2005953
R49 R226-229	RESISTOR,CERMET,3.01K,+-1%,0.125W,100PPM,0805,TAPE	1591278
R51	40034,RES,9.53K,1/10W,1%,0805	2499039
R52	RESISTOR SMR INAC,RES,CERM,13.7K,+-1%,0.1W,100PPM,0805	928812
R54	576186043120,RES-SM,0805,1/10W,1%,TF,604K	2338933
R55	RESISTOR,CERMET,732K,+-1%,0.125W,100PPM,0805,TAPE	1727162
R56	RESISTOR,CERMET,487K,+-1%,0.1W,100PPM,0805,TAPE	1665340
R57-61	RESISTOR,CERMET,499,+-1%,0.125W,100PPM,0805,TAPE	928978
R62 R104	RESISTOR,CERMET,30.1K,+-1%,0.125W,100PPM,0805,TAPE	2005994
R63 R182	RESISTOR SMR,RES,CERM,11K,+-1%,0.1W,100PPM,0805	928796
R64-66 R98-100	RESISTOR,METAL FILM,330K,+-1%,0.25W,50PPM,CYLINDRICAL 0204,MELF,TAPE	3326205
R67	RESISTOR,CERMET,6.81K,+-1%,0.1W,100PPM,0805,TAPE	2087241
R68	RESISTOR,WIREWOUND,10K,+-1%,3W,20PPM,AXIAL,TAPE	2076480
R75	RESISTOR,CERMET,4.99K,+-1%,0.125W,100PPM,0805,TAPE	928767
R78	RESISTOR,WIREWOUND,800,+-1%,5W,20PPM,AXIAL,TAPE	2741174
R79	RESISTOR,WIREWOUND,200,+-1%,3W,20PPM,AXIAL,TAPE	2741195
R83-85	RESISTOR,METAL FILM,1M,+-1%,0.25W,50PPM,CYLINDRICAL 0204,MELF,TAPE	3326231
R87-89 R127	RESISTOR,CERMET,150K,+-1%,0.125W,100PPM,0805,TAPE	1612759

Table 6-3. A2 Meter PCA (cont.)

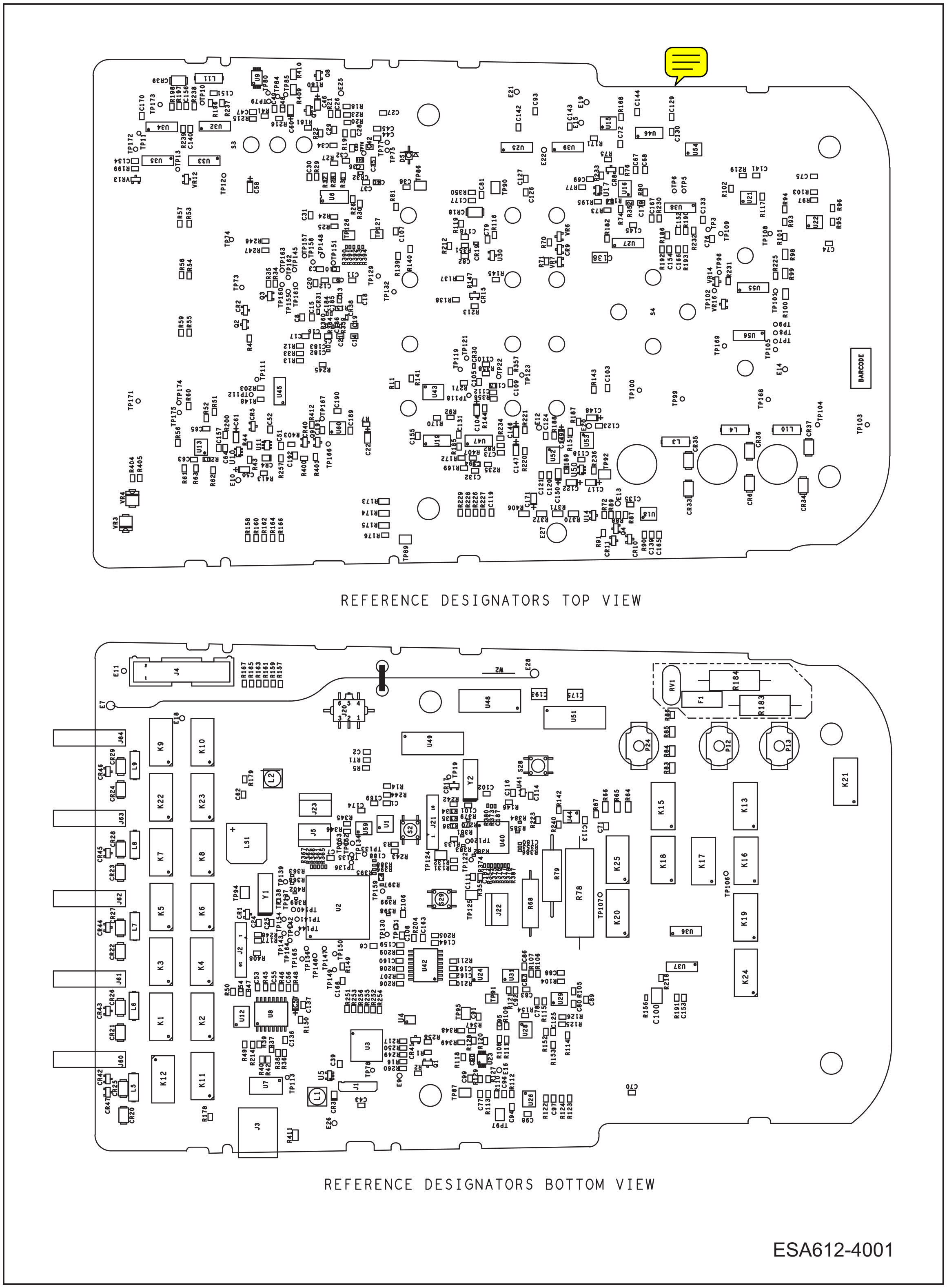
Item	Description	Fluke Stock No.
R93 R94 R101 R103	RESISTOR,CERMET,3.92K,+-1%,0.125W,100PPM,0805,TAPE	1591284
R97	RESISTOR,CERMET,8.06K,+-1%,0.125W,100PPM,0805,TAPE	928788
R105	RESISTOR,CERMET,360K,+-1%,0.125W,100PPM,0805,TAPE	3326268
R106	RESISTOR,CERMET,43.2K,+-1%,0.125W,100PPM,0805,TAPE	2499017
R107	RESISTOR,CERMET,432K,+-1%,0.125W,100PPM,0805,TAPE	1641918
R108 R110 R112 R122 R124 R154	RESISTOR,CERMET,2.43K,+-1%,0.125W,100PPM,0805,TAPE	928754
R109 R152	RESISTOR,CERMET,931,+-1%,0.125W,100PPM,0805,TAPE	3339167
R111 R113 R123 R153	RESISTOR,CERMET,1.1K,+-1%,0.125W,100PPM,0805,TAPE	691014
R114 R115 R125 R126	RESISTOR,CERMET,51.1K,+-1%,0.125W,100PPM,0805,TAPE	2011360
R116	RESISTOR,CERMET,4.7K,+-1%,0.125W,100PPM,0805,TAPE	3326333
R120	RESISTOR,CERMET,23.2K,+-1%,0.125W,100PPM,0805,TAPE	3331397
R128 R347-349	RESISTOR,CERMET,10M,+-1%,0.125W,400PPM,0805,TAPE	943659
R156	RESISTOR,CERMET,100,+-1%,0.1W,100PPM,0603,TAPE	642196
R173-175 R409-411	RESISTOR,METAL FILM,3.32M,+-1%,0.25W,50PPM,CYLINDRICAL 0204,MELF,TAPE	3408749
R176	RESISTOR,CERMET,39.2K,+-1%,0.1W,100PPM,0805,TAPE	943092
R177 R178 R185 R186 R200 R201 R204 R205 R219 R242 R352	RESISTOR,CERMET,33,+-1%,0.125W,100PPM,0805,TAPE	2803420
R18 R151 R187-189 R220 R221	RESISTOR,CERMET,10,+-1%,0.125W,100PPM,0805,TAPE	928924
R181 R258	RESISTOR,CERMET,1M,\+-1%,0.125W,100PPM,0805,TAPE	928945
R183 R184	RESISTOR,CERAMIC COMPOSITION,27,+-10%,2W,-1300 +-300PPM,AXIAL,TAPE	3454161
R216	RESISTOR,CERMET,51.1,+-1%,0.125W,100PPM,0805,TAPE	2005930
R350 R351	RESISTOR SMR,RES,CERM,249,+-1%,0.1W,100PPM,0805	606092
R353 R354 R362 R363 R366-368 R373 R374 R379 R388 R389 R392 R395-399	122421,RES - 102R, 1%, 1/16W, 0402, PB-FREE	3093309
R355-358 R401	RESISTOR,CERMET,JUMPER,0,+0.05 MAX,0.125W,0805,TAPE	928705

Table 6-3. A2 Meter PCA (cont.)

Item	Description	Fluke Stock No.
R359-361 R364 R365	RESISTOR,CERMET,10K,+-1%,0.063W,100PPM,0402,TAPE	1706323
R370-372 R406	RESISTOR SMR,RES,CERM,261K,+-1%,.125W,100PPM,1206	877014
R375-378 R380-387 R390 R391 R393 R394 R402	RESISTOR,CERMET,499,+-1%,0.063W,100PPM,0402,TAPE	3254825
RT1	THERMISTOR,NTC,10K,+-5%,NON-LINEAR,0805,TAPE	2030909
RV1	VARISTOR,VARISTOR,430V,+-10%,1.0MA	105871
TP86 TP87 TP89-92 TP94 TP95 TP97 TP124-127	CONNECTOR,TERMINAL,TEST POINT,SMD,510 PH BRONZE,TAPE	602125
U1	~~IC,MEMORY,FLASH,45DB161,16MB,2MX8,2.7-3.6V,20MHZ,SERIAL,SPI,SO8,TAPE~~	~~3328276~~
U2	IC,MICROPROCESSOR,AT32UC3A,1.65-1.95V,32-BIT,66MZH,512K FLASH,64K SRAM,LQFP144,TAPE	3337006
U3	IC,LCD CONTROLLER,3.3V,32K SRAM,8-BIT,TQFP64	3328311
U4	OSCILLATOR,HCMOS CLOCK,40MHZ,3.3V,100PPM,15PF LOAD,TRI-STATE,3.2X2.5MM SMT,TAPE	3328327
U5	IC,VOLTAGE REGULATOR,SWITCHING,1615-1,ADJ,100MA,STEP UP,SOT-23-5,TAPE	1791133
U6	IC, OP AMP,LP324,+-3V TO +-32V,+-2MV OFFSET,100KHZ,QUAD,BIPOLAR,SOIC14,TAPE	2841280
U7	~~IC,COMM,FT232RL,3.3V-5.25V,USB TO RS232 UART,SSOP28,TAPE~~	~~2670615~~
U8 U42	IC,DIGITAL ISOLATOR,ADUM1402,QUAD,2/2,2MHZ,2500V,3V/5V,SOICW16,TAPE	2528074
U9	IC,COMM,SN75240,USB TRANSIENT SUPPRESSOR 15KV,7VBR,TSSOP8,TAPE	2044695
U10	IC,VOLTAGE REGULATOR,LINEAR,LP2980,3V,50MA,LDO,LO PWR,W/SHUT DOWN,SOT-23-5,TAPE	3328412
U11	IC,VOLTAGE REGULATOR,SWITCHING,LT1616,ADJ,600MA,1.4MHZ,STEP DOWN,SOT-23-6,TAPE	3328447
U12 U43	OPTICAL,OPTOCOUPLER,PHOTO TRANSISTOR,SMD DIP4,TUBE	3328473
U13 U15 U54	IC,OP AMP,AD8510,+-4.5V TO +-18V,0.9MV OFFSET,8MHZ,PRECISION,JFET,S08,TAPE	2434633
U14	IC,DIGITAL,SUPERVISORY RESET IC,ACTIVE HIGH,SOT23-3,TAPE	3328499
U16 U21	IC,DAC,TLV5623,2.7V-5.5V,8-BIT,SPI,VOUT,SOIC8,TAPE	2761956
U17	589085015001,IC-SM,LMV331,SGL COMPTR,SOT235	2343218
U18	IC,COMPARATOR,LM393,+-1V TO +-18V,5MV OFFSET,DUAL,LOW PWR,SO8,TAPE	837211

Table 6-3. A2 Meter PCA (cont.)

Item	Description	Fluke Stock No.
U19	CMOS 74HC02 SMR,IC,CMOS,QUAD INPUT NOR GATE,SOIC	830711
U22	IC,OP AMP,TLV2372,2.7V TO 16V,4.5MV OFFSET,3MHZ,DUAL,R/R,S/S,SO8,TAPE	3329934
U23	IC,RMS CONVERTER,LTC1967,5V,LOW POWER,R/R INPUT,MS0P8,TAPE	3385912
U24	IC,ADC,AD7799,2.7V-5.25V,24-BIT,3-CH,500HZ,SIGMA-DELTA,SERIAL,TSSOP16,TAPE	2630817
U25 U27 U39	IC,ANALOG SWITCH,ADG431,5-44V,24 OHMS,QUAD,SPST,NO,SO16,TAPE	3367437
U26 U28	IC,OP AMP,AD8034,5V TO 24V,2MV OFFSET,80 MHZ,DUAL,FET INPUT,SO8,TAPE	2558152
U29 U31	IC,OP AMP,AD8539,2.7 TO 5.5V,15UV OFFSET,430KHZ,R/R,S/S,DUAL,S08,TAPE	3385920
U30	CONTRACT MFG ITEM, IC 2.5V REF LM4040CIM3-2.5	2073591
U32 U34 U37 U38 U55	IC,LOGIC,74HC595,2.0V-6.0V,8-BIT SHIFT REGISTER,TRI-STATE,SOIC16,TAPE	904388
U33 U35 U36 U56	TRANSISTOR,SI,NPN,ULN2003,50V,500MA,HEPTA-DARLINGTON,3.5W,SO16,TAPE	2113871
U40	IC,MICROCONTROLLER,LPC2138,3.3V,16/32 BIT,512KB FLASH,ARM7,25MHZ,LQFP64,TAPE	3329792
U41	IC,VOLTAGE MONITOR,MAX803,VTH=2.93V,MICROPOCESSOR RESET CIRCUIT,OPEN-DRAIN OUTPUT,SOT23-3,TAPE	3350940
U44	IC,MEMORY,EEPROM,93LC66A,4KB,256X16,2.5-5.5V,2MHZ,SERIAL,SO8,TAPE	3344058
U45 U46	CMOS 74HC00 SMR,IC,CMOS,QUAD INPUT NAND GATE,SOIC	830703
U47	CMOS 74HC132 SMR,IC,CMOS,QUAD 2 IN NAND W/SCHMT,SOIC	837245
U48	POWER SUPPLY,DC-DC,2W,12VDC,12V@167MA,3KV ISO,SIP4,TUBE	3338731
U49	POWER SUPPLY,DC-DC,2W,12VDC,+-12V@83MA,3KV ISO,SIP5,TUBE	3338746
U50	IC,VOLTAGE REGULATOR,LINEAR,LP2985,3.3V,150MA,LDO,LOW POWER,SOT-23-5,TAPE	2559443
U51	POWER SUPPLY,DC-DC,2W,12VDC,5V@400MA,3KV ISO,SIP4,TUBE	3338754
U52	589480084001,IC-SM,MC79L05A,-5V REG,8-SOIC	2343646
U53	BIPOLAR 78L05 SMR,IC,VOLT REG,FIXED,5 VOLTS,0.1 A,SOIC8	604105
U59	IC,MEMORY,FRAM,FM25L256B,256KB,32KX8,2.7-3.6V,SERIAL,SO8,TAPE	3374127
U60	IC,VOLTAGE CONVERTER,LTC1144,SWITCH CAP,WIDE INPUT RANGE,SO8,TAPE	2609823
VR3 VR4	TVS DIODE,SMBJ15A,15V,5%,UNIPOLAR,SMB,TAPE	2813982
VR6 VR7	ZENER,UNCOMP,MMBZ5236B,7.5V,5%,20MA,225MW,SOT-23,TAPE	837138
VR12-14 VR16	ZENER,UNCOMP,MMBZ5242B,12V,5%,20MA,225MW,SOT-23,TAPE	2044054
W2	WIRE,PVC,UL1015,600V/105C,14AWG,STRAND,INDIVIDUAL TIN,GRN/YEL	2279979
Y1 Y2	CRYSTAL,12MHZ,50/100PPM,20PF,PLASTIC ENCAPSULATED,SMD,TAPE	2041235



gjc133.eps

Figure 6-3. A2 Meter PCA

Chapter 7
Schematics

Introduction

The schematic and pca layout diagrams for the ESA612 are shown in Figures 7-1 through 7-3.

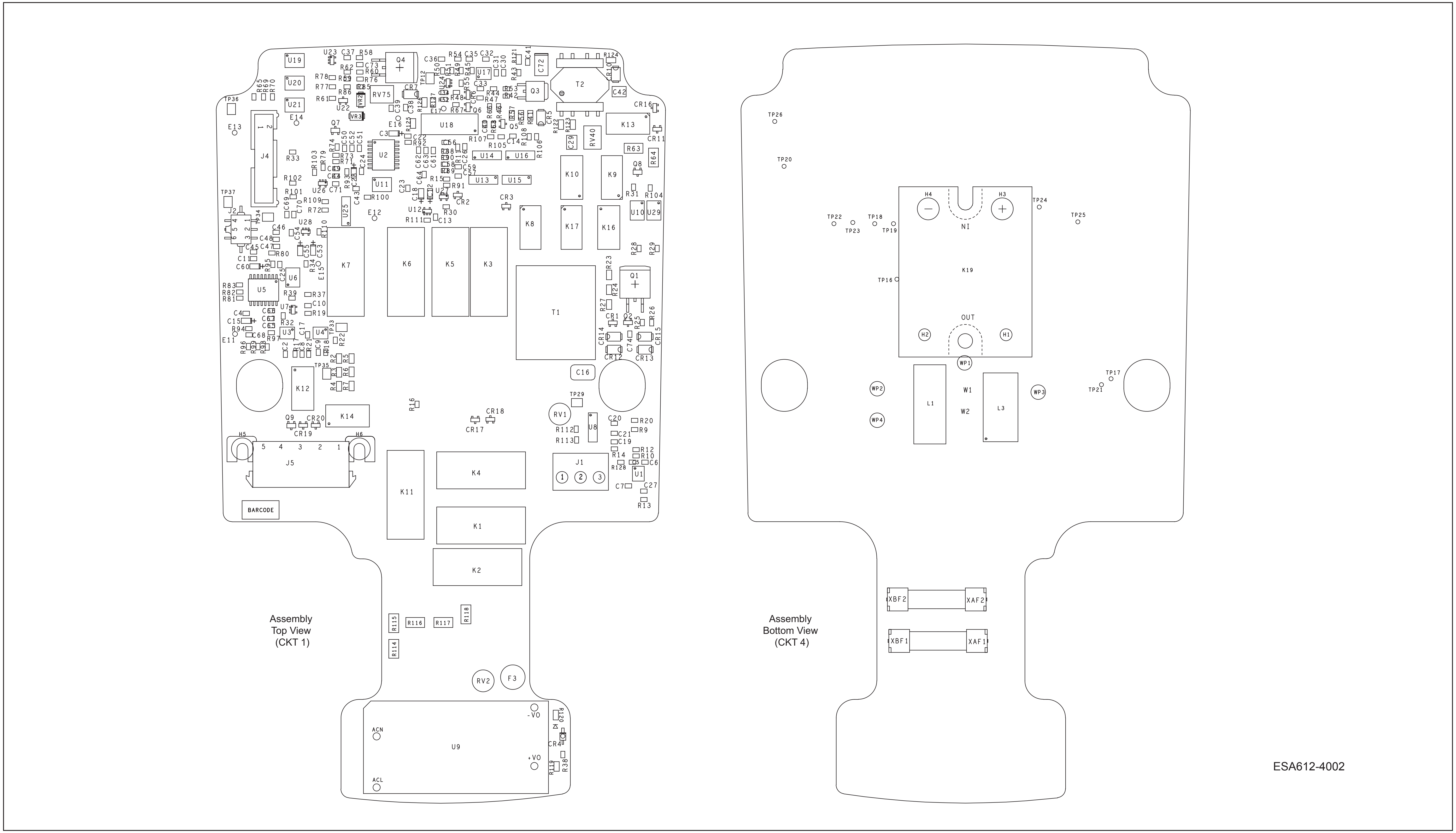
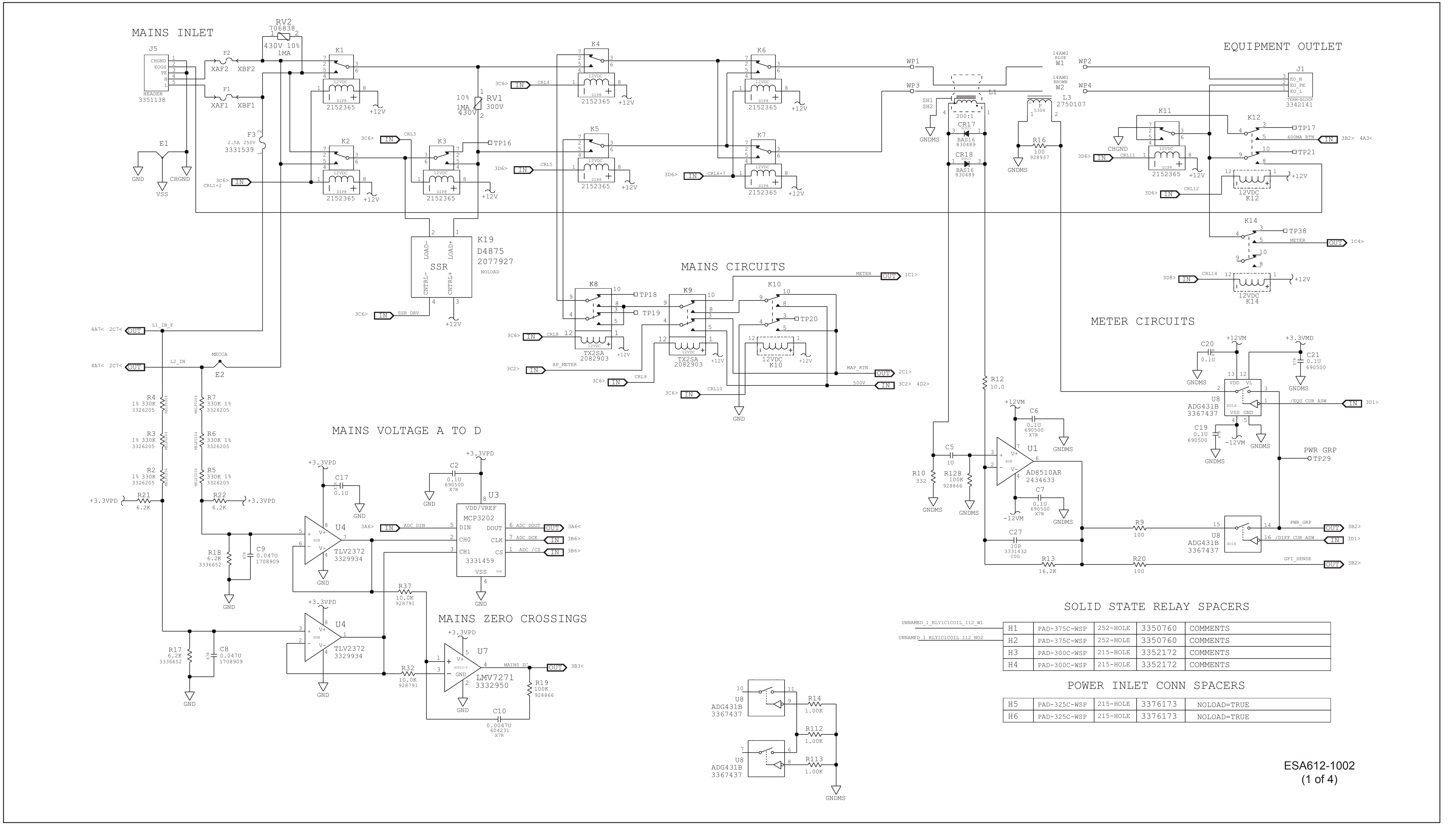


Figure 7-1. A1 Power PCA



H1	PAD-375C-WSP	252-HOLE	3350760	COMMENTS
H2	PAD-375C-WSP	252-HOLE	3350760	COMMENTS
H3	PAD-300C-WSP	215-HOLE	3352172	COMMENTS
H4	PAD-300C-WSP	215-HOLE	3352172	COMMENTS

H5	PAD-325C-WSP	215-HOLE	3376173	NOLOAD=TRUE
H6	PAD-325C-WSP	215-HOLE	3376173	NOLOAD=TRUE

Figure 7-1. A1 Power PCA (cont.)

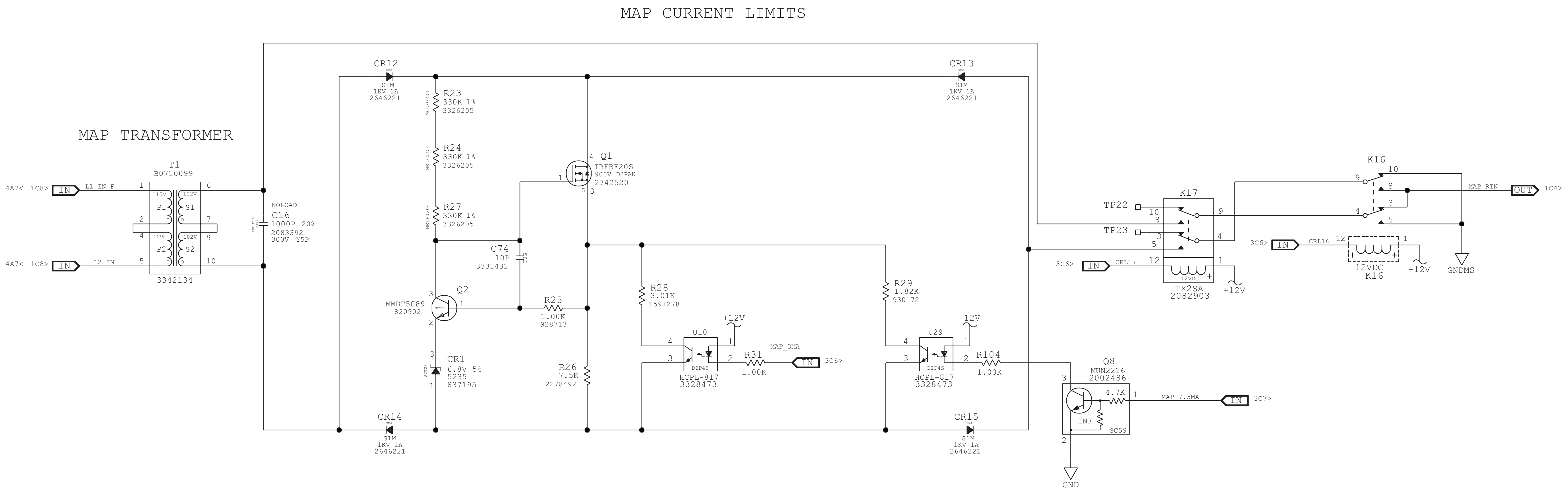


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Figure 7-1. A1 Power PCA (cont.)

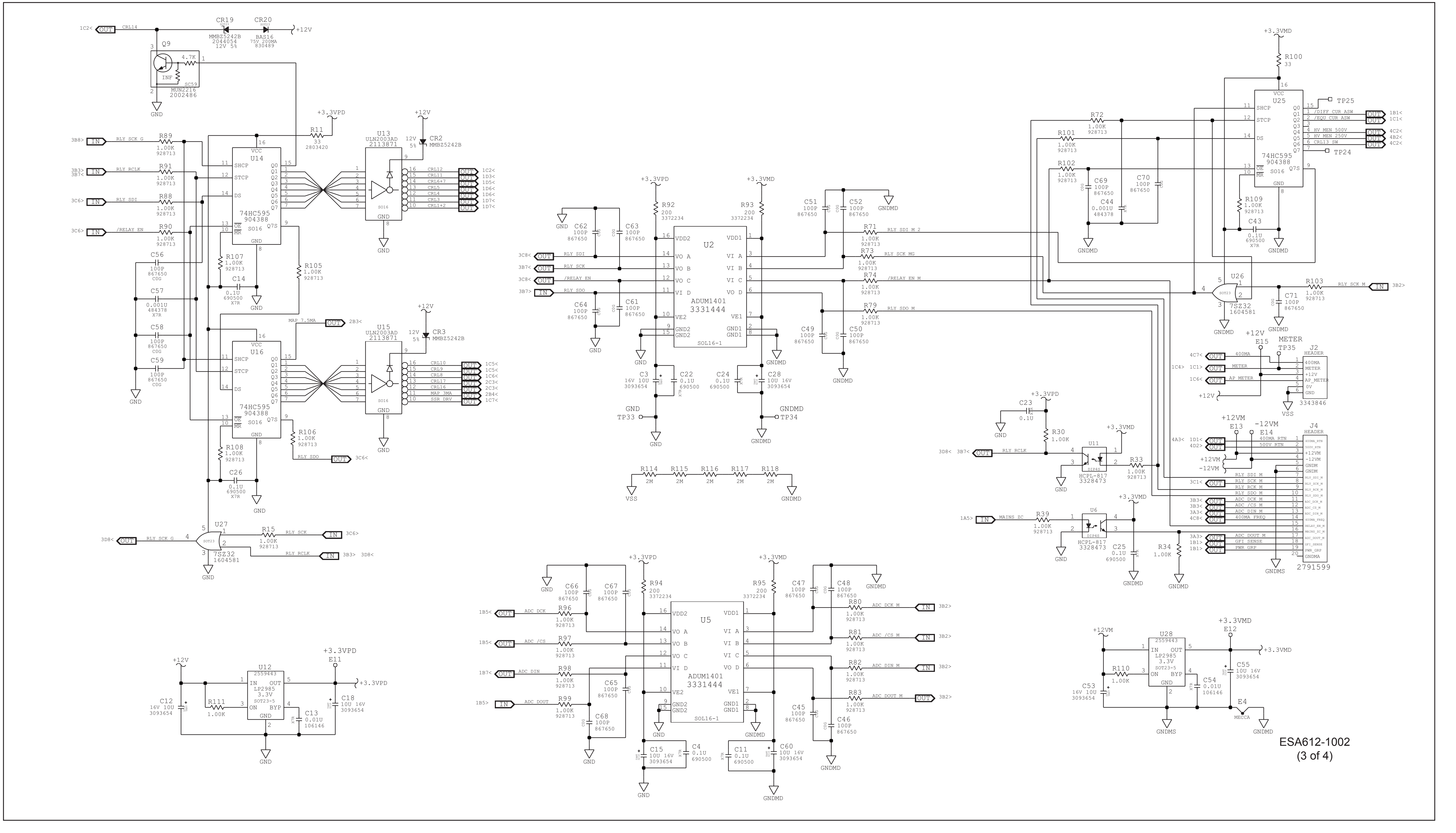

Figure 7-1. A1 Power PCA (cont.)

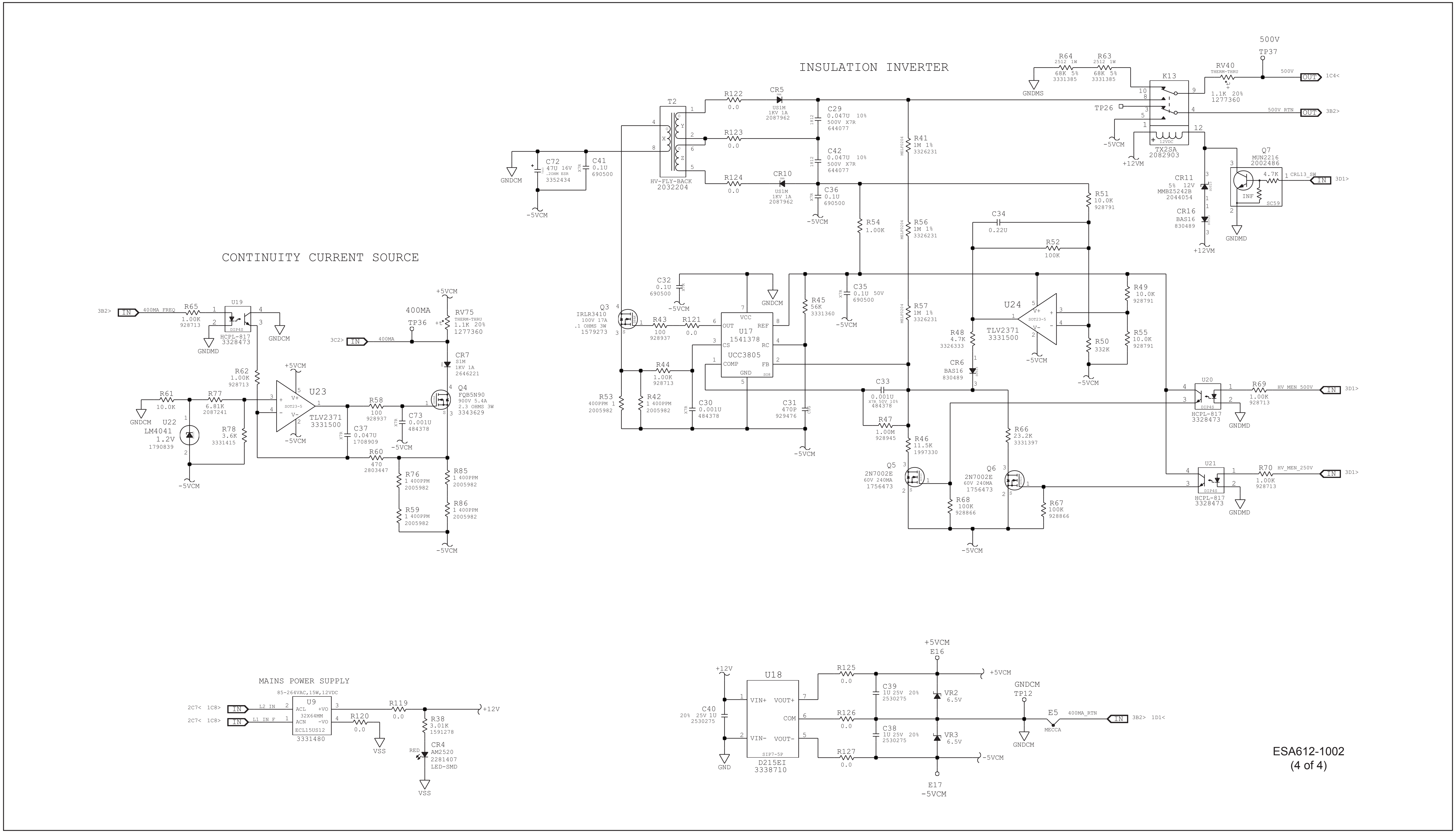

Figure 7-1. A1 Power PCA (cont.)

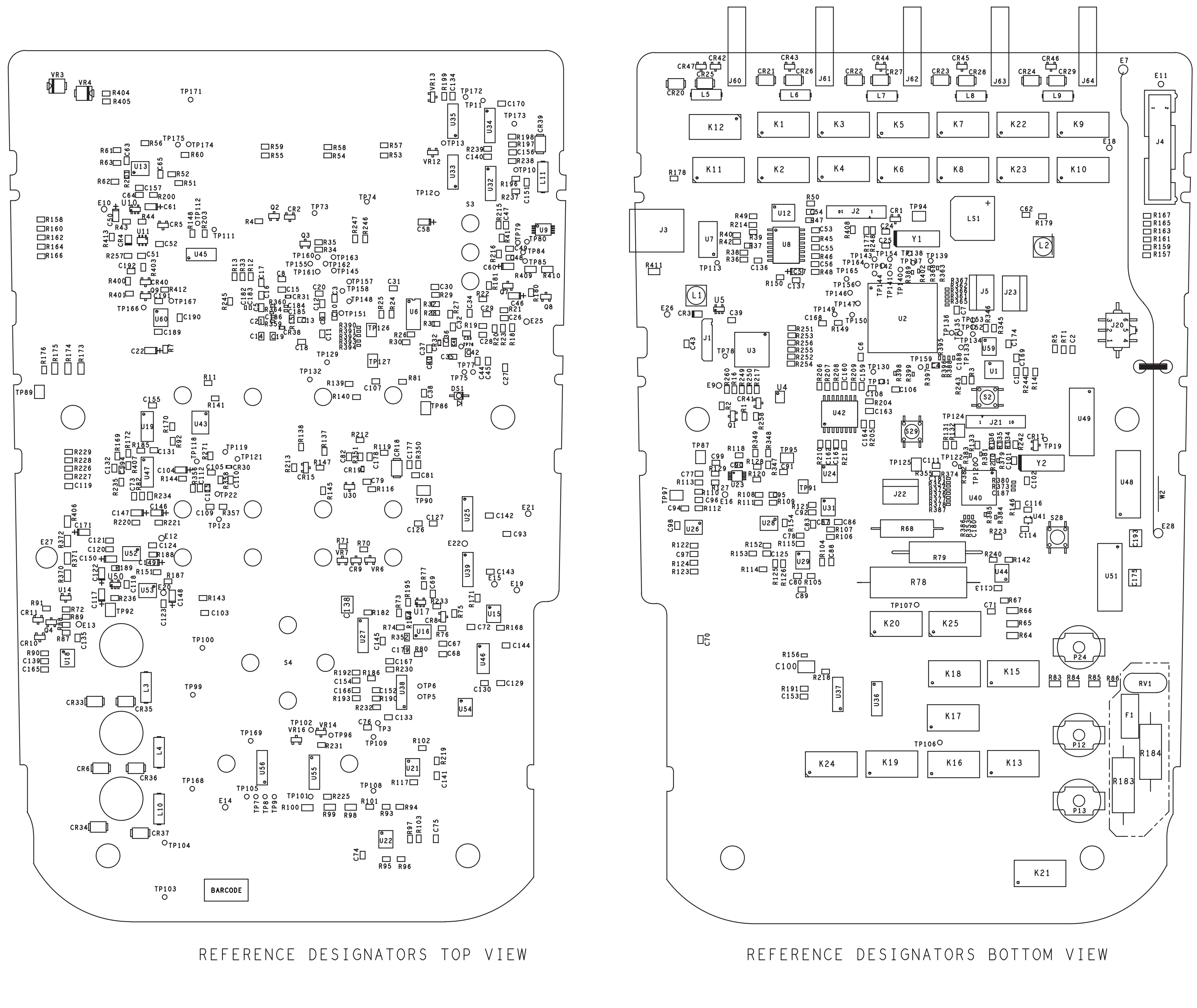

Figure 7-2. A2 Meter PCA

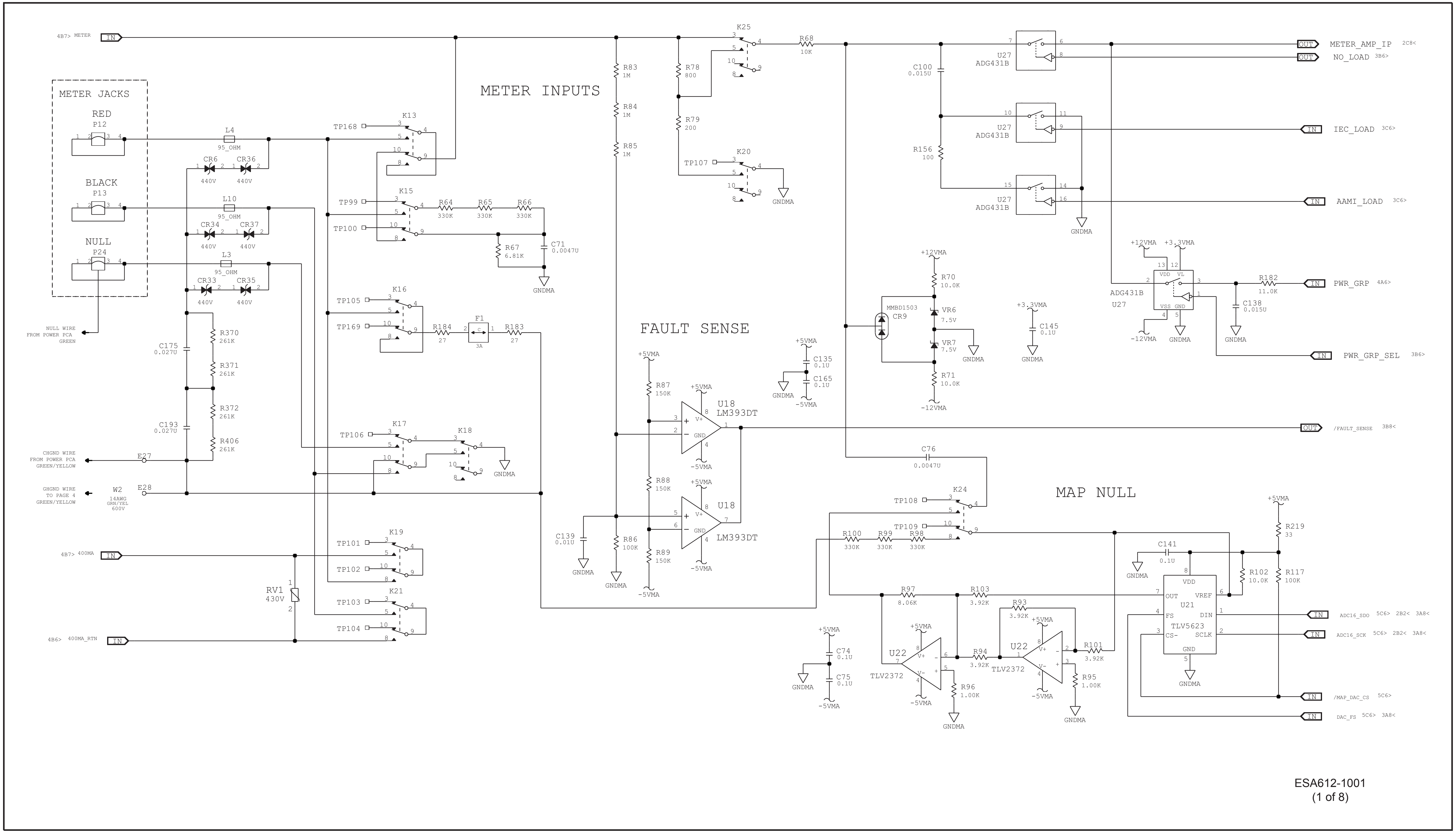

Figure 7-2. A2 Meter PCA (cont.)

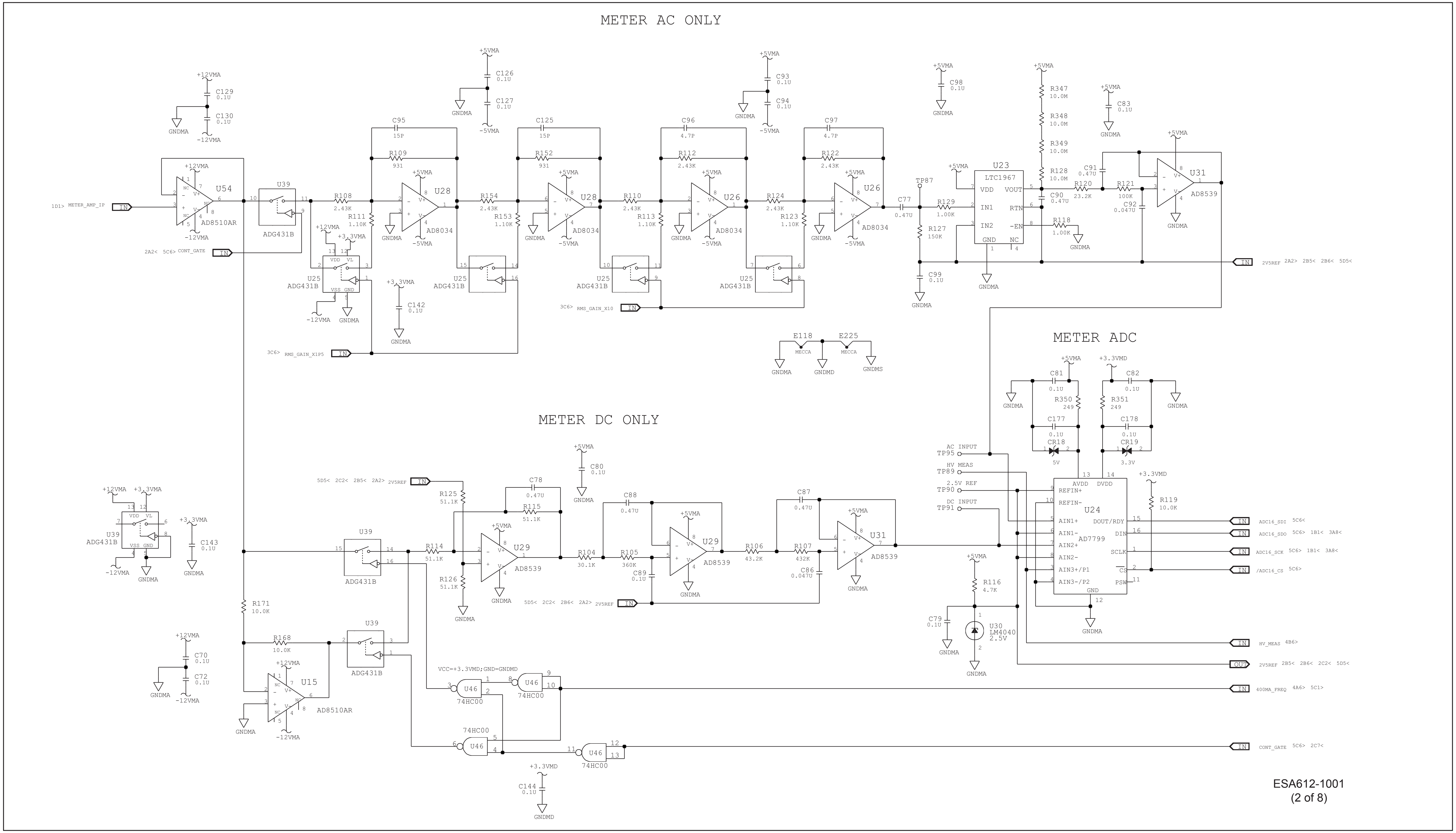

Figure 7-2. A2 Meter PCA (cont.)

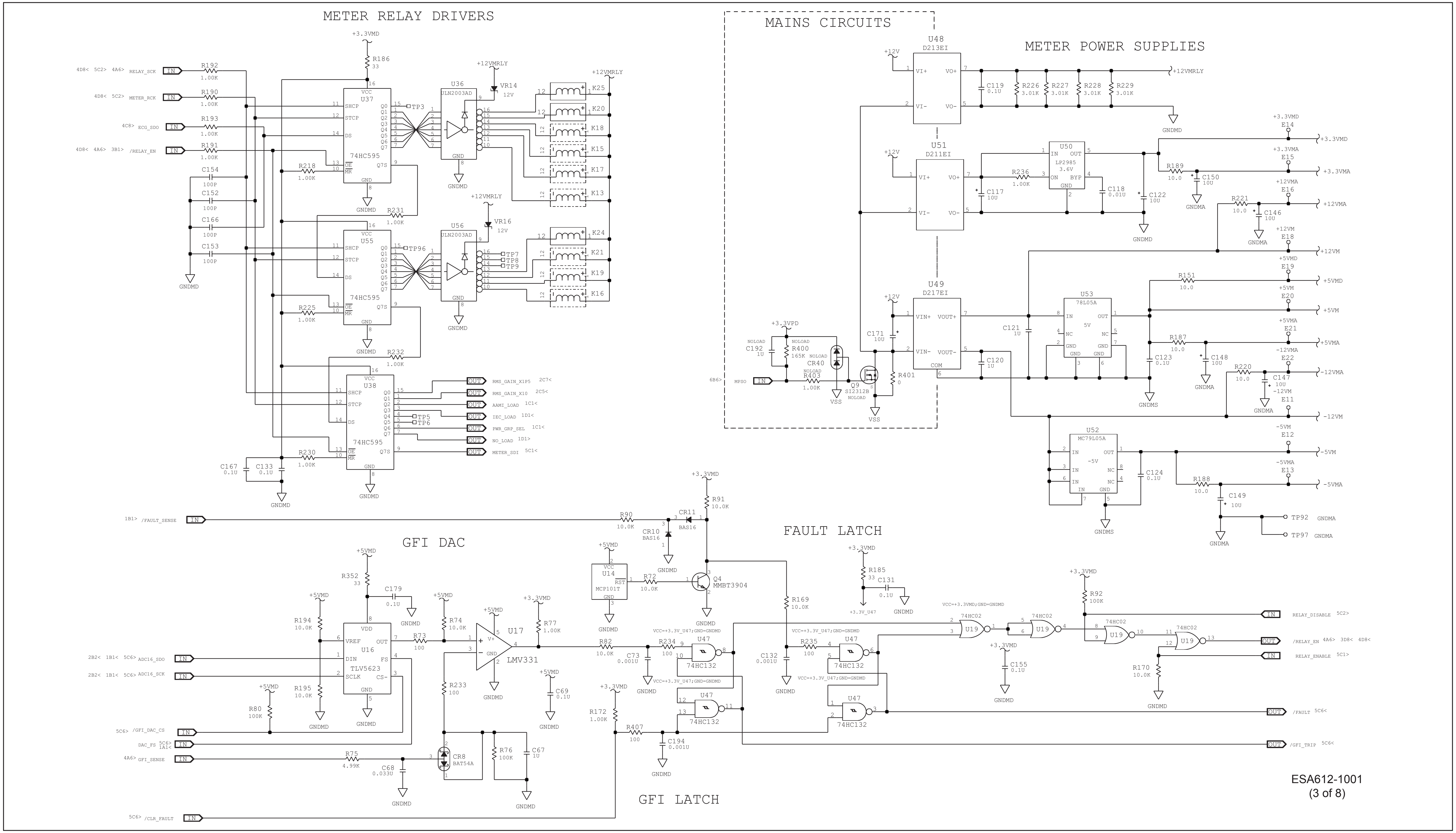

Figure 7-2. A2 Meter PCA (cont.)

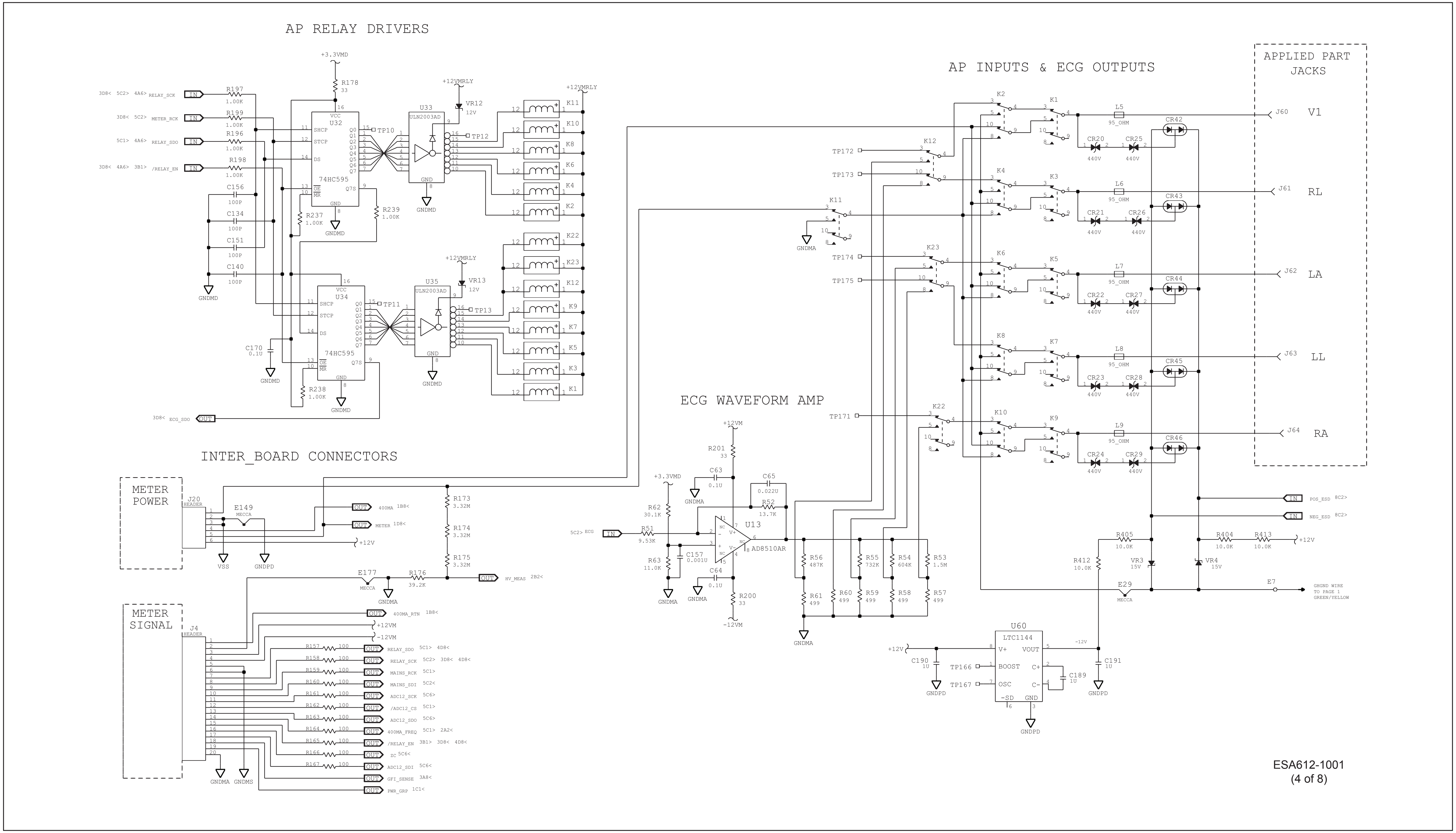

Figure 7-2. A2 Meter PCA (cont.)

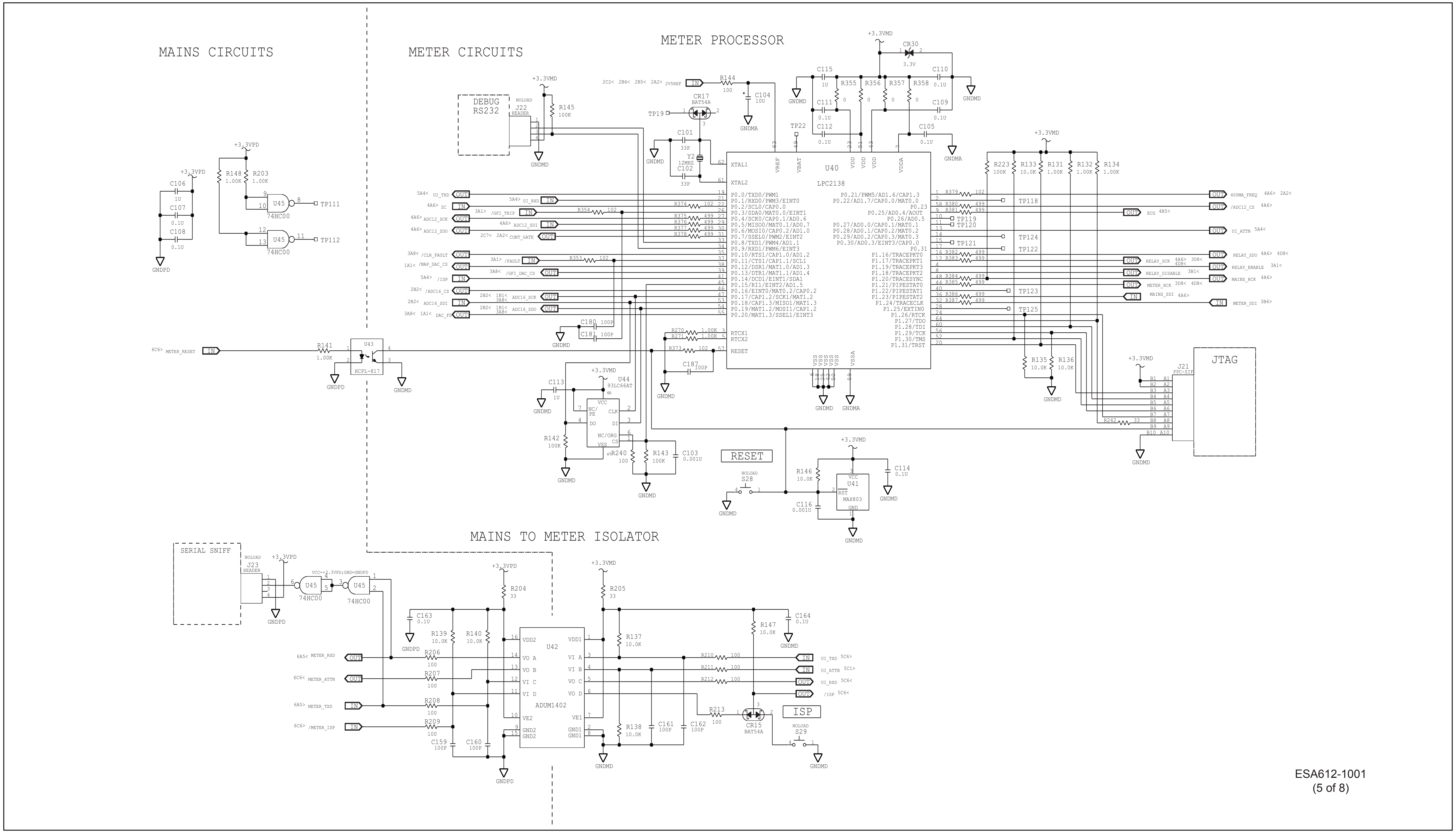

Figure 7-2. A2 Meter PCA (cont.)

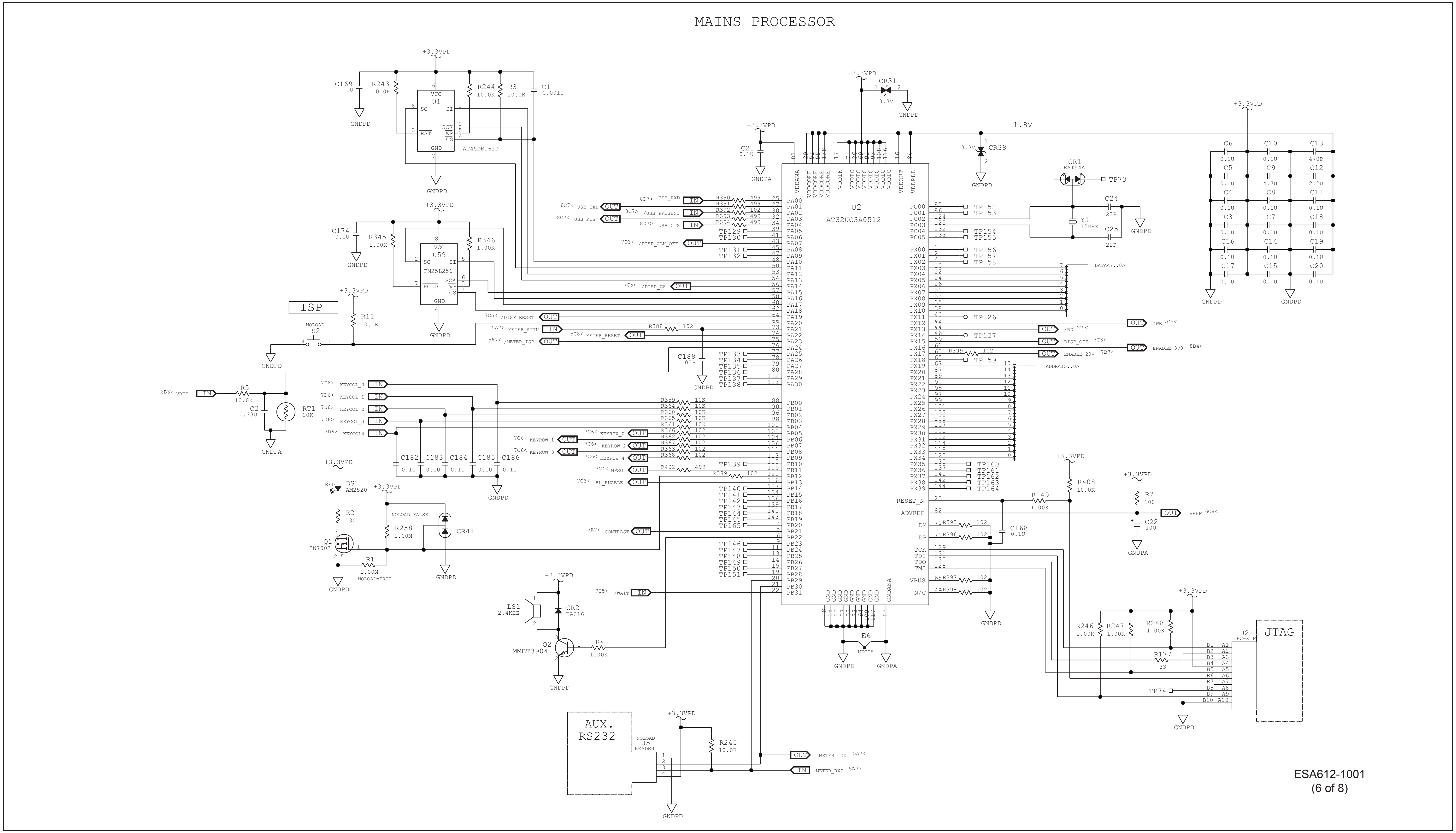

Figure 7-2. A2 Meter PCA (cont.)

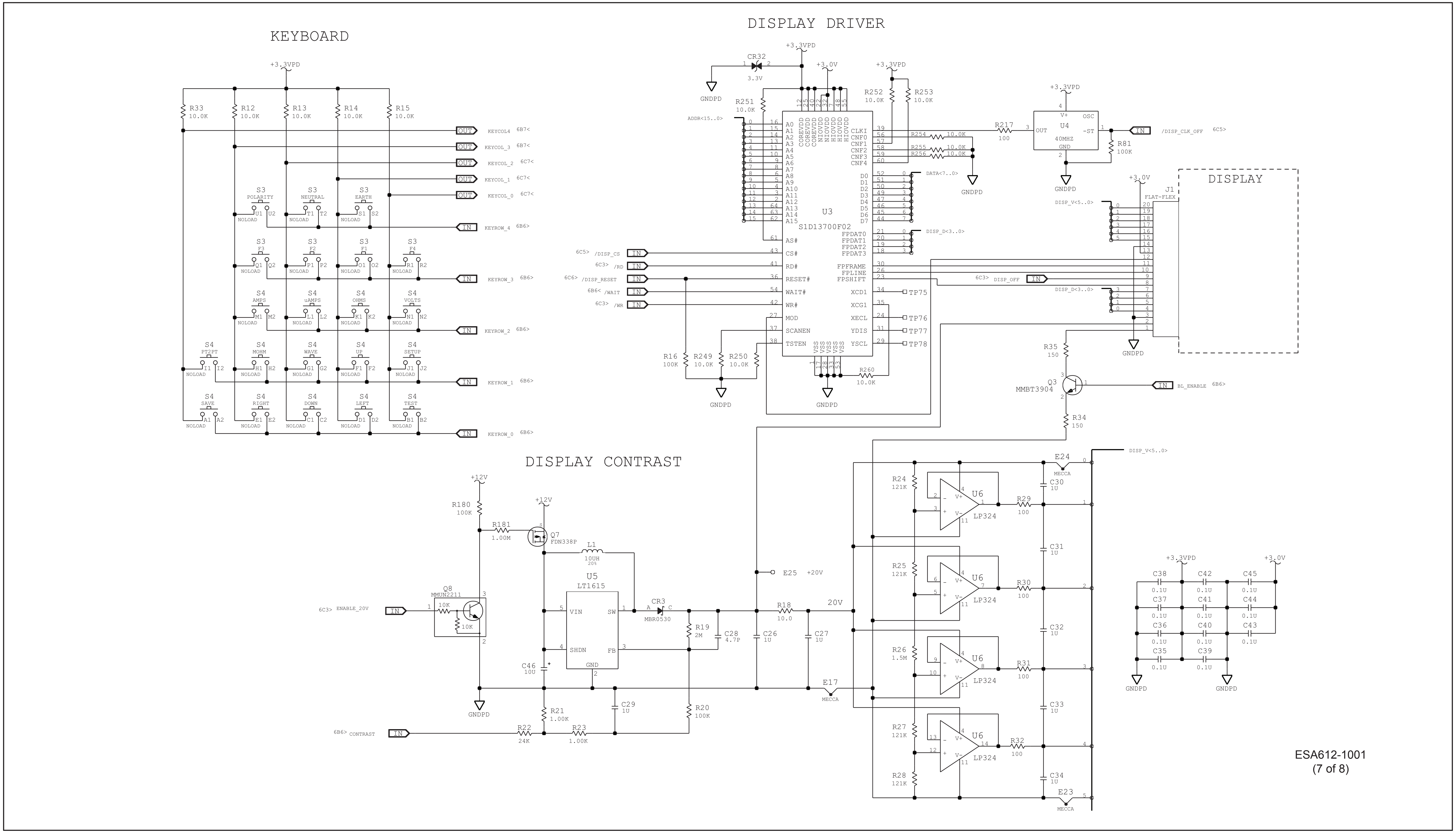

Figure 7-2. A2 Meter PCA (cont.)

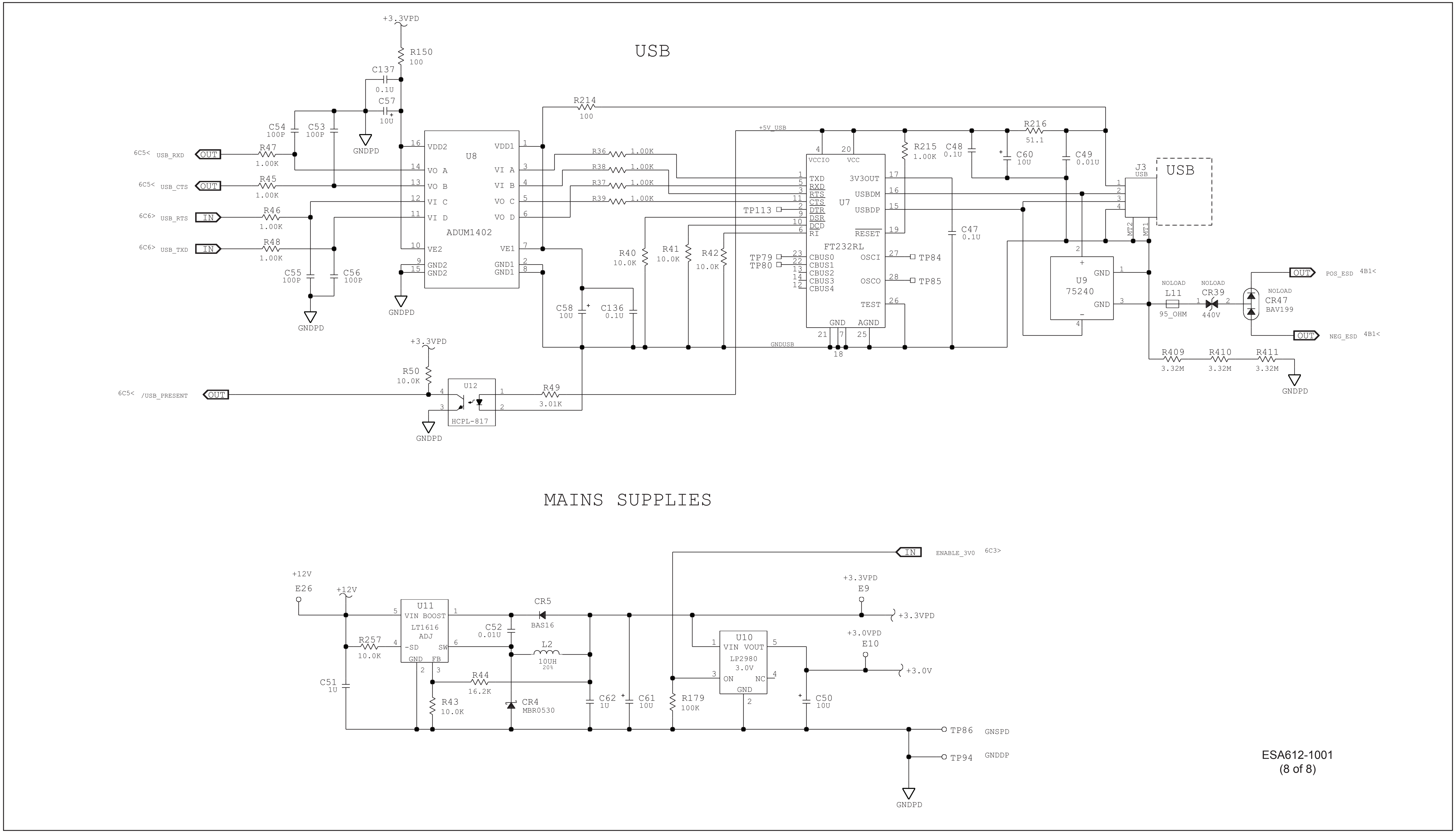

Figure 7-2. A2 Meter PCA (cont.)

Appendix A
Datasheets

Introduction

Table A-1 is the datasheet for recording the results of the Analyzer verification procedure while the datasheet in Table A-2 is for recording calibration procedure results.

Table A-1. ESA612 Verification Datasheet

Step No.	Measured Value	Limits	Nominal (Actual) [1]	Range	Percentage
Outlet Tension					
A		>24 oz			
B		>24 oz			
C		>8 oz			
Functional					
A.11	PASS FAIL				
A.13	PASS FAIL				
A,32	PASS FAIL				
A.36	PASS FAIL				
A.41	PASS FAIL				
A.46	PASS FAIL				
Electrical Outlet Polarity					
B.10	PASS FAIL				
B.13	PASS FAIL				
B.18	PASS FAIL				
B.27	PASS FAIL				
B.30	PASS FAIL				
B.33	PASS FAIL				
EO Ground to NULL Jack					
C.6	PASS FAIL				
C.8		0 to 2.5 Ω	0	+2.5 Ω	+2.5 Ω
Mains Voltage					
D.8		112.5 – 117.5 V	115.0 V	±2.5 V	±2.0 % +0.2 V
D.12		112.5 – 117.5 V	115.0 V	±2.5 V	±2.0 % +0.2 V
GFI Verification					
E.11	PASS FAIL				
E.23	PASS FAIL				
E.38	PASS FAIL				
E.50	PASS FAIL				
E.64	PASS FAIL				
E.76	PASS FAIL				

Table A-1. ESA~~612~~ Verification Datasheet (cont.)

Step No.	Measured Value	Limits	Nominal (Actual) [1]	Range	Percentage
Point to Point Voltage					
F.9		0.78 to 1.22 V	1.00 V (120 Hz)	±0.22 V	±2.0 % +0.2 V
F.12		244.8 to 255.2 V	250 V (~~60~~ Hz)	±5.20 V	±2.0 % +0.2 V
~~F.15~~		~~60.10 to 81.32 V~~	~~70.71 V (633 Hz)~~	~~±10.61 V~~	~~±15.0 %~~
F.~~21~~		3.72 to 4.28 V	4.00 V	±0.28 V	±2.0 % +0.2 V
F.~~24~~		7.64 to 8.36 V	8.00 V	±0.36 V	±2.0 % +0.2 V
F.~~27~~		9.60 to 10.40 V	10.00 V	±0.40 V	±2.0 % +0.2 V
F.~~30~~		24.30 to 25.70 V	25.00 V	±0.70 V	±2.0 % +0.2 V
F.~~33~~		39.00 to 41.00 V	40.00 V	±1.00 V	±2.0 % +0.2 V
F.~~36~~		78.20 to 81.80 V	80.00 V	±1.80 V	±2.0 % +0.2 V
F.~~39~~		127.2 to 132.8 V	130.00 V	±2.80 V	±2.0 % +0.2 V
F.~~42~~		235.00 to 245.00 V	240.00 V	±5.00 V	±2.0 % +0.2 V
Resistance					
G.11		-0.015 to +0.015 Ω	0.0000 Ω	±0.015 Ω	±2.0 % +0.015 Ω
G.14 [1]			1.~~800~~ Ω (Actual: blank)		±2.0 % +0.015 Ω
G.~~21~~		-0.015 to +0.015 Ω	0.0000 Ω	±0.015 Ω	±2.0 % +0.015 Ω
G.~~24~~ [1]			1.800 Ω (Actual: blank)		±2.0 % +0.015 Ω
Insulation Resistance					
H.11		250.0 to 300.0 V	250.0 V	+50.0 V	+20.0 %
H.16		500.0 to 600.0 V	500 V	+100.0 V	+20.0 %
H.20		1.750 to 2.250 mA	2.000 mA	±0.250 mA	±12.5 %

Table A-1. ESA612 Verification Datasheet (cont.)

Step No.	Measured Value	Limits	Nominal (Actual) [1]	Range	Percentage
Mains to PE					
		9.6 to 10.4 MΩ	10.000 MΩ	±0.4 MΩ	±2.0 % +0.2 MΩ
AP to PE					
H.44		9.6 to 10.4 MΩ	10.000 MΩ	±0.4 MΩ	±2.0 % +0.2 MΩ
AP to NE					
H.57		9.6 to 10.4 MΩ	10.000 MΩ	±0.4 MΩ	±2.0 % +0.2 MΩ
Mains to NE					
H.68		9.6 to 10.4 MΩ	10.000 MΩ	±0.4 MΩ	±2.0 % +0.2 MΩ
Mains to AP					
H.79.RA		9.6 to 10.4 MΩ	10.000 MΩ	±0.4 MΩ	±2.0 % +0.2 MΩ
LL		9.6 to 10.4 MΩ	10.000 MΩ	±0.4 MΩ	±2.0 % +0.2 MΩ
LA		9.6 to 10.4 MΩ	10.000 MΩ	±0.4 MΩ	±2.0 % +0.2 MΩ
RL		9.6 to 10.4 MΩ	10.000 MΩ	±0.4 MΩ	±2.0 % +0.2 MΩ
V1		9.6 to 10.4 MΩ	10.000 MΩ	±0.4 MΩ	±2.0 % +0.2 MΩ
250		0.486 to 0.914 MΩ	0.700 MΩ	±0.214 MΩ	±2.0 % +0.2 MΩ
500		0.486 to 0.914 MΩ	0.700 MΩ	±0.214 MΩ	±2.0 % +0.2 MΩ
250		0.780 to 1.220 MΩ	1.000 MΩ	±0.220 MΩ	±2.0 % +0.2 MΩ
500		0.780 to 1.220 MΩ	1.000 MΩ	±0.220 MΩ	±2.0 % +0.2 MΩ
250		6.170 to 6.830 MΩ	6.500 MΩ	±0.330 MΩ	±2.0 % +0.2 MΩ
500		6.170 to 6.830 MΩ	6.500 MΩ	±0.330 MΩ	±2.0 % +0.2 MΩ
250		17.440 to 18.560 MΩ	18.000 MΩ	±0.560 MΩ	±2.0 % +0.2 MΩ
500		17.440 to 18.560 MΩ	18.000 MΩ	±0.560 MΩ	±2.0 % +0.2 MΩ

Table A-1. ESA612 Verification Datasheet (cont.)

Step No.	Measured Value	Limits	Nominal (Actual) [1]	Range	Percentage
250		20.150 to 23.850 MΩ	22.000 MΩ	± 1.850 MΩ	± 7.5 % +0.2 MΩ
500		20.150 to 23.850 MΩ	22.000 MΩ	± 1.850 MΩ	± 7.5 % +0.2 MΩ
250		55.300 to 64.700 MΩ	60.00 MΩ	± 4.700 MΩ	± 7.5 % +0.2 MΩ
500		55.300 to 64.700 MΩ	60.00 MΩ	± 4.700 MΩ	± 7.5 % +0.2 MΩ
250		92.30 to 107.70 MΩ	100.00 MΩ	± 7.70 MΩ	± 7.5 % +0.2 MΩ
500		92.30 to 107.70 MΩ	100.00 MΩ	± 7.70 MΩ	± 7.5 % +0.2 MΩ
DC Leakage					
I.10		0.980 to 1.020 KΩ	1.000 KΩ	±0.02 KΩ	±2.0 %
I.23		8.900 to 11.100 µA	10.00 µA	±1.1 µA	±1.00 % +1.0 µA
I.27		48.500 to 51.500 µA	50.00 µA	±1.5 µA	±1.00 % +1.0 µA
I.31		98.000 to 102.000 µA	100.00 µA	±2.0 µA	±1.00 % +1.0 µA
I.35		157.40 to 162.600 µA	160.00 µA	±2.6 µA	±1.00 % +1.0 µA
I.39		335.60 to 344.40 µA	340.00 µA	±4.4 µA	±1.00 % +1.0 µA
I.43		494.00 to 506.00 µA	500.00 µA	±6.0 µA	±1.00 % +1.0 µA
I.47		0.989 to 1.011 mA	1.000 mA	±0.011 mA	±1.00 % +0.001 mA
I.51		1.583 to 1.617 mA	1.600 mA	±0.017 mA	±1.00 % +0.001 mA
I.55		3.356 to 3.444 mA	3.40 mA	±0.044 mA	±1.00 % +0.01 mA
I.59		4.940 to 5.060 mA	5.00 mA	±0.060 mA	±1.00 % +0.01 mA
I.63		6.020 to 7.080 mA	7.00 mA	±0.080 mA	±1.00 % +0.01 mA

Table A-1. ESA612 Verification Datasheet (cont.)

Step No.	Measured Value	Limits	Nominal (Actual) [1]	Range	Percentage
AC Filter Frequency Response					
J.8		Analyzer Current			
		Measured Current			
J.9		0.98801 – 1.00799	0.99800	±0.00999	
J.15		Analyzer Current			
		Measured Current			
		0.67218 – 0.70982	0.69100	±0.01882	
J.19		Analyzer Current			
		Measured Current			
		0.088669 – 0.102492	0.09558	±0.0069116	
Differential Leakage					
K.12 [1]			76.00 µA		±10.0 % +20.0 µA
K.13 [1]			160.00 µA		±10.0 % +20.0 µA
K.13 [1]			240.00 µA		±10.0 % +20.0 µA
K.13 [1]			500.00 µA		±10.0 % +20.0 µA
K.13 [1]			760.00 µA		±10.0 % +20.0 µA
K.14 [1]			1.600 mA		±10.0 % +0.02 mA
K.14 [1]			2.40 mA		±10.0 % +0.02 mA
K.14 [1]			5.00 mA		±10.0 % +0.02 mA
K.14 [1]			7.60 mA		±10.0 % +0.02 mA
K.15 [1]			16.00 mA		±10.0 % +0.02 mA

Table A-1. ESA612 Verification Datasheet (cont.)

Step No.	Measured Value	Limits	Nominal (Actual) [1]	Range	Percentage
Leakage Functionality					
ECG Leakage Functionality					
RA					
L.15	PASS FAIL				
L.18	PASS FAIL				
L.21	PASS FAIL				
LL					
L.15	PASS FAIL				
L.18	PASS FAIL				
L.21	PASS FAIL				
LA					
L.15	PASS FAIL				
L.18	PASS FAIL				
L.21	PASS FAIL				
RL					
L.15	PASS FAIL				
L.18	PASS FAIL				
L.21	PASS FAIL				
V1					
L.15	PASS FAIL				
L.18	PASS FAIL				
L.21	PASS FAIL				
Direct Applied Part, Alternative Applied Part: Ground to RA					
M.20 [1]			1.000 mA		±1.00 % +1.0 µA
M.38 [1]			1.000 mA		±1.00 % +1.0 µA
Direct Applied Part, Alternative Applied Part: Red to RA					
N.20 [1]			1.000 mA		±1.00 % +1.0 µA
N.38 [1]			1.000 mA		±1.00 % +1.0 µA

Table A-1. ESA612 Verification Datasheet (cont.)

Step No.	Measured Value	Limits	Nominal / (Actual) [1]	Range	Percentage
Alternative Equipment: Red to Hot					
O.20 [1]			1.000 mA		±1.00 % +1.0 µA
Alternate Equipment Leakage, Alternative Applied Part: RA to Hot					
P.20 [1]			1.000 mA		±1.00 % +1.0 µA
P.38 [1]			1.000 mA		±1.00 % +1.0 µA
Alternative Applied Part Patient: RA to Neutral					
Q.18 [1]			1.000 mA		±1.00 % +1.0 µA
Patient Auxiliary: RA to RL					
R.22 [1]			100.00 µA		±1.00 % +1.0 µA
Direct Equipment, Patient: Ground to RA					
S.20 [1]			100.00 µA		±1.00 % +1.0 µA
S.44 [1]			100.00 µA		±1.00 % +1.0 µA
Direct Equipment, Enclosure: Ground to Red					
T.20 [1]			100.00 µA		±1.00 % +1.0 µA
T.42 [1]			100.00 µA		±1.00 % +1.0 µA
Filter Tests					
U.20 [1]			0.000 µA		±1.00 % +1.0 µA
U.26 [1]			0.000 µA		±1.00 % +1.0 µA

Table A-1. ESA612 Verification Datasheet (cont.)

Step No.	Measured Value	Limits	Nominal (Actual) [1]	Range	Percentage
MAP Voltage and Current Limits					
V.9			115.0 V		±5.0 %
V.21			230.0 V		±5.0 %
V.31			3.500 mA		±25.0 %
V.40			7.500 mA		±25.0 %
V.52			1.000 mA		±25.0 %
ECG Waveforms					
W.9	PASS FAIL				
W.11			0.674 mV		±5.0 %
LL			1.673 mV		±5.0 %
LA			1.384 mV		±5.0 %
V1			2.074 mV		±5.0 %
Equipment Current					
X.9 [1]			8.000 A		±5.0 % +0.2 A
X.12 [1]			3.000 A		±5.0 % +0.2 A
X.15 [1]			1.000 A		±5.0 % +0.2 A

[1] These steps require measurement of the standard prior to testing the UUT. The value of the standard is entered into the “Actual” block, and the range and limits are filled in based on this value.

Serial Number on Analyzer: ______________________

UI Firmware Revision: ______________________

Meter Firmware Revision: ______________________

Nominal Voltage: ______________________

Final Data

Serial Number: ______________________

Cal Date: ______________________

Technician Number: ______________________

Technician Signature: ______________________

Table A-2. Calibration Datasheet

Step No.	Measured Value	Limits	Nominal (Actual) [1]	Range	Percentage
A.15	PASS FAIL				
A.50		1470.00 – 1530.00 mV	1.500 V	±30 mV	±2 %
A.53		490.00 – 510.00 mV	0.5000 V	±10 mV	±2 %
A.58		147.00 – 153.00 mV	150.00 mV	±3 mV	±2 %
A.63		14.70 – 15.30 mV	15.00 mV	±0.3 mV	±2 %
B.11		1470.00 – 1530.00 mV	1.500 V	±30 mV	±2 %
C.13 [1]			0.5000 mA		±1 % +0.1 µA
C.22 [1]			3.0000 mA		±1 % +0.1 µA
D.9		244.8 – 255.2 V	250.00 V	±5.2 V	±2 % +0.2 V
F.13 [1]			10.000 MΩ		±2 % +0.2 MΩ
G.11 [1]			3.000 Ω		±2 % +0.015 Ω
H.13 [1]			11.000 mA		±10 % +0.02 mA
I.18	PASS FAIL				
I.30	PASS FAIL				
I.52	PASS FAIL				
I.64	PASS FAIL				
I.85	PASS FAIL				
I.97	PASS FAIL				
J.12 [1]			3.000 A		±5 % +0.2 A
K.7		97.8 – 102.2 v	100 V	±2.2 V	±2.0 % +0.2 V
L.20		97.8 – 102.2 v	100 V	±2.2 V	±2.0 % +0.2 V

[1] These steps require measurement of the standard prior to testing the UUT. The value of the standard is entered into the "Actual" block, and the range and limits are filled in based on this value.

Serial Number on Analyzer: ____________________________

UI Firmware Revision: ____________________________

Meter Firmware Revision: ____________________________

Nominal Voltage: ____________________________

Final Data

Serial Number: ____________________________

Cal Date: ____________________________

Technician Number: ____________________________

Technician Signature: ____________________________