



## OPERATION MANUAL

# PSD60-2R FUEL QUANTITY TEST SET

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## ELECTROSTATIC DISCHARGE GENERAL WARNINGS FOR ALL EQUIPMENT

**CAUTION:** THIS EQUIPMENT MAY CONTAIN ELECTROSTATIC DISCHARGE (ESD) SENSITIVE COMPONENTS. TO PREVENT ESD SENSITIVE EQUIPMENT FROM POSSIBLE DAMAGE, OBSERVE THE FOLLOWING PRECAUTIONS WHEN HANDLING ANY ESD SENSITIVE COMPONENTS, OR UNITS CONTAINING ESD SENSITIVE COMPONENTS:

- a. Maintenance or service personnel must be grounded through a conductive wrist strap, or a similar grounding device, using a 1 M $\Omega$  series resistor for equipment protection against static discharge, and personal protection against electrical shock.
- b. All tools must be grounded (including soldering tools) that may come into contact with the equipment. Hand contact will provide sufficient grounding for tools that are not otherwise grounded, provided the operator is grounded through an acceptable grounding device such as a wrist strap.
- c. Maintenance or service of the unit must be done at a grounded, ESD workstation.
- d. Before maintenance or service of the equipment, disconnect all power sources, signal sources, and loads connected to the unit.
- e. If maintenance or service must be performed with power applied, take precautions against accidental disconnection of equipment components. Specifically, do not remove integrated circuits or printed circuit boards from equipment while the equipment has power applied.
- f. All ESD sensitive components are shipped in protective tubes or electrically conductive foam. The components should be stored using the original container/package when not being used or tested. If the original storage material is not available, use similar or equivalent protective storage material.
- g. When ESD sensitive components are removed from a unit, the components must be placed on a conductive surface, or in an electrically conductive container.
- h. When in storage or not being repaired, all printed circuits boards must be kept in electrically conductive bags, or other electrically conductive containers.
- i. Do not unnecessarily pick up, hold, or directly carry ESD sensitive devices.

Failure to comply with these precautions may cause permanent damage to ESD sensitive devices. This damage can cause devices to fail immediately, or at a later time without apparent cause.

# Safety and Regulatory Information

***Review this product and related documentation to familiarize yourself with safety markings and instructions before you operate this equipment.***

**WARNING** The **WARNING** notice denotes a hazard. It calls attention to a procedure, practice, or the like, that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a **WARNING** notice until the indicated conditions are fully understood and met.

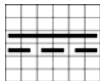
**CAUTION** The **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a **CAUTION** notice until the indicated conditions are fully understood and met.



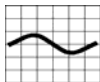
**Caution (refer to accompanying documents).** Attention – refer to the manual. This symbol indicates that information about usage of a feature is contained in the manual.

## Equipment Markings

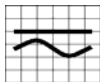
The following markings may appear on this equipment:



**Direct current.** This symbol indicates that the equipment requires direct current input.



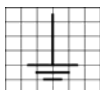
**Alternating current.** This symbol indicates that the equipment requires alternating current input.



**Both direct and alternating current.** This symbol indicates that the equipment requires either ac or dc input at the same connector.



**Three-phase alternating current.** This symbol indicates that the equipment requires 3-phase ac input.



**Earth (ground) terminal.** This symbol indicates the ground (earth) terminal.



**Protective conductor terminal.** This symbol indicates the protective ground (earth) terminal.



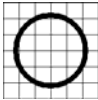
**Frame or chassis terminal.** This symbol indicates the frame or chassis terminal for connection to ground.



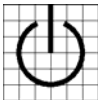
**Equipotentiality.** This symbol indicates an equipotentiality terminal.



**On (Supply).** This symbol indicates that the power line switch is ON.



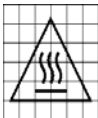
**Off (Supply).** This symbol indicates that the power line switch is OFF.



**Standby.** This symbol indicates that the power line switch is in STANDBY.



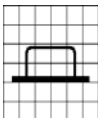
**Caution, risk of electric shock.** Danger – high voltage.



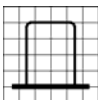
**Caution, hot surface.** Danger – high temperature surface.



**Caution (refer to accompanying documents).** Attention – refer to the manual. This symbol indicates that information about usage of a feature is contained in the manual.



**In-position of a bistable push control.** This symbol indicates the in (on) position of a bistable push control.



**Out-position of a bistable push control.** This symbol indicates the out (off) position of a bistable push control.



**CE Mark.** <sup>TM</sup> of the European Community.



**Fuse Symbol.** To indicate a fuse.

## Warnings

**WARNING** Do not use the equipment in a manner not specified in this manual!

**WARNING** Equipment should only be serviced by authorized personnel.

**CLEANING WARNING**

Keep the equipment dry to avoid damage to the equipment. To prevent damage, never apply solvents to the equipment housing. For cleaning, wipe the equipment with a cloth that is lightly dampened with water, mild detergent, or alcohol. Do not use aromatic hydrocarbons, chlorinated solvents, or methanol-based fluids.

**DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES**

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

**WARNING** Equipment contains no-rechargeable batteries. Use only 1.5-V size C alkaline cells. Never attempt to recharge these cells.

**NOTE** For EMC testing M17/84-RG223 double shielded coaxial cable, 4.5 m long, with BNC connectors, shielding terminated 360° at both end connectors, and unterminated at far end were used at terminals (ports) INDICATOR LOZ (J1), INDICATOR HIZ (J2), INDICATOR COMP (J3), TANK UNITS LOZ (J4), TANK UNITS HIZ (J5), AND TANK UNITS COMP (J6).

**CAUTION** This equipment is electrostatic discharge (ESD) sensitive. Use of the supplied ESD wrist strap with cord (JPN 90-0283-02), or equivalent, must be used at all times when operating this unit. See the manufacturer's instructions that come with each package for proper connection and use.

**REVISION HISTORY BY DRAWING NUMBER**

MANUAL: PSD60-2R Fuel Quantity Test Set Operation

REVISION: 0 – January 12, 2007

<b><u>DRAWING NO.</u></b>	<b><u>REV. LEVEL</u></b>	<b><u>DRAWING NO.</u></b>	<b><u>REV. LEVEL</u></b>
Safety and Regulatory Information	00		
Table of Contents	00		
Section I	00		
Section II	00		
Section III	00		
Section IV	00		
Appendix A	00		

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## **SECTION I GENERAL INFORMATION**

### **1.1 INTRODUCTION**

This manual provides operational information for the Aeroflex PSD60-2R Fuel Quantity Gauging System Test Set.

The PSD60-2R Fuel Quantity Gauging System Test Set is an instrument that permits complete functional checkout and calibration of an AC Fuel Gauging System, on or off the aircraft. The test set can accurately measure the capacitance of Tank Units, Compensators, or entire systems. The test set can also simulate capacitance values for the operation of Indicators, as well as measure the insulation resistance of Tank Units and cabling.

The insulation resistance measurement circuit normally operates in three terminal configuration. If a direct short is present from signal source to ground the system will display short. If a direct short is present from signal return to ground the systems reading is undefined.

Operation of the test set is essentially automatic (no manual nulling required). To evaluate a particular system, connect it to the applicable input. Panel controls are set to determine what is displayed on the digital display.

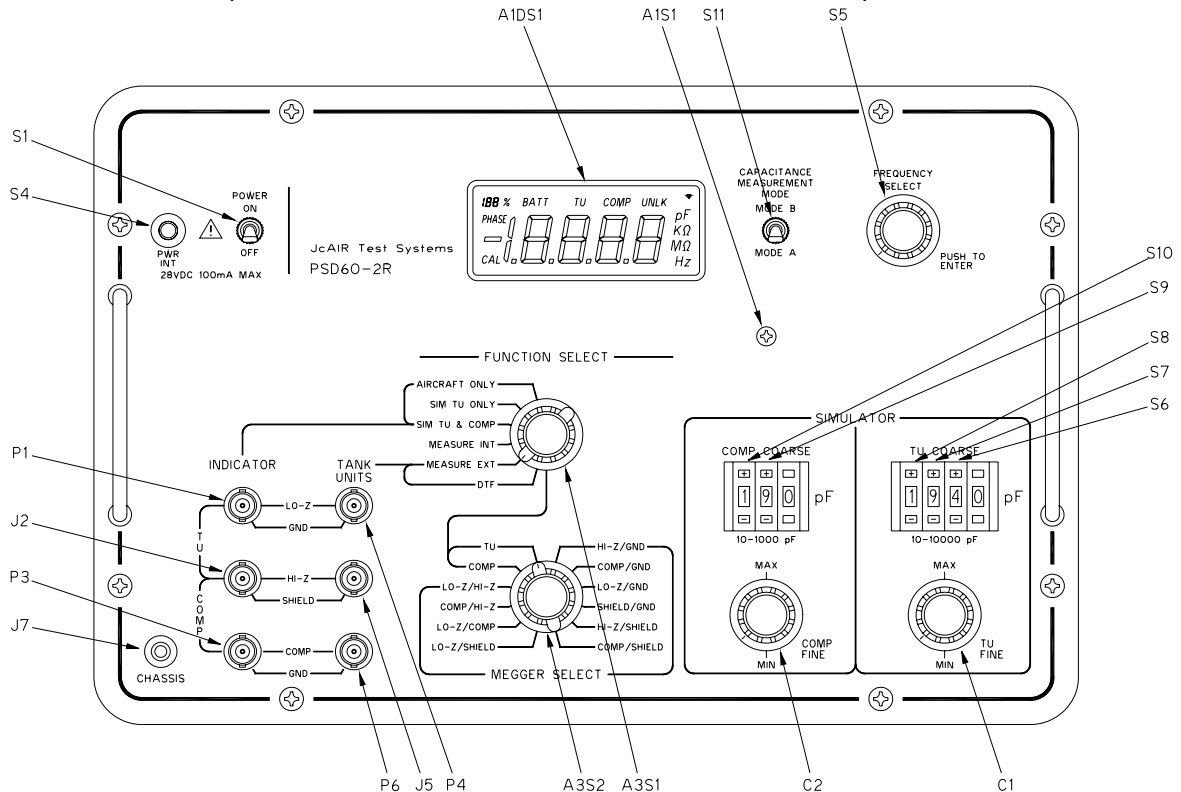
The test set is powered by 18 C sized alkaline batteries. The batteries may be replaced without need of test set recalibration. Battery condition is displayed on the digital readout.

The test set is shipped with a chassis ground cable. In order to properly test a system, specific aircraft interface cables are required but not furnished with the test set.



## 1.2 EQUIPMENT DESCRIPTION

Figure 1-1 shows the front panel of the test set. Refer to Table 1-1 for the description and function of each item.



**FIGURE 1-1**

ITEM	FUNCTION	DESCRIPTION
S4	POWER INTERRUPT SWITCH	Turns power off when lid is closed regardless of the position of Power Switch
S1	POWER SWITCH	Applies power to the test set.
A3S1	FUNCTION SELECT	Used to select function to be performed.
	MEASURE EXT	Use to select measurement of TANK UNIT parameters through P4, J5, P6 and/or J7 depending on MEGGER SELECT switch (A3S2) position.
	MEASURE INT	Use to select measurement of SIMULATOR capacitance depending on SELECT switch S3 (TU or COMP) position.
	DTF	Sets the unit to measure distance to fault.
	SIM TU & COMP	Connects the two simulators to the INDICATOR jacks (P1, J2, & P3) for capacitance output.
	SIM TU ONLY	Connects the TU SIMULATOR to the INDICATOR TU jacks (P1 & J2) for capacitance output.
	AIRCRAFT ONLY	Disconnects both simulators from the INDICATORS jacks (P1, J2, & P3)

A3S2	MEGGER SELECT	Use to select parameter to measure depending on the position of the FUNCTION SELECT switch.
A1DS1	LCD Display	Displays: <ol style="list-style-type: none"> <li>1. Frequency of LO-Z signal.</li> <li>2. Capacitance under test, either internal or external.</li> <li>3. Insulation resistance of system wiring or unit under test.</li> <li>4. Relative charge of the PSD60-2R batteries.</li> <li>5. Capacitance measurement mode</li> </ol>
A1S1	CALIBRATION MODE Switch	To put the unit in Calibration mode, the screw is removed and the switch beneath the screw hole is held depressed during power up.
P1	INDICATOR LO-Z	Allows connection from test set TU SIMULATOR to aircraft FQGs.
J2	INDICATOR HI-Z	Allows connection from test set SIMULATOR (TU, and COMP) HI-Z line to aircraft FQGs.
P3	INDICATOR COMP	Allows connection from test set COMP SIMULATOR to aircraft FQGs.
P4	TANK UNITS LO-Z	Allows connection from test set measurement circuits to aircraft tanks.
J5	TANK UNITS HI-Z	Allows connection from test set measurement circuits to aircraft tanks.
P6	TANK UNITS COMP	Allows connection from test set measurement circuits to aircraft tanks.
J7	CHASSIS	Access to PSD60-2R chassis ground. Normally required to connect the PSD60-2R to aircraft ground.
S5	FREQUENCY SELECT	Use to enter the LO-Z frequency. Also used to calibrate the unit
S6, S7 & S8	TU DECADE CAPACITOR	Increments TU SIMULATOR by 10, 100, or 1000 pF increments depending on decade chosen (increments are not calibrated)
S9 & S10	COMP DECADE CAPACITOR	Increments COMP SIMULATOR by 10 or 100 pF increments depending on decade chosen (increments are not calibrated)
S11	CAPACITANCE MEASUREMENT MODE	Used to select between measuring Mode B (magnitude capacitance) and Mode A (parallel capacitance).
C1	TU FINE	Rotate for fine adjustment of TU simulation capacitance.
C2	COMP FINE	Rotate for fine adjustment of COMP simulation capacitance.
<b>NOTE:</b>	C1 and C2 have 180 degree rotation for minimum to maximum value with no stops. It is therefore possible to have an increasing value in either the clockwise or counter clockwise direction.	

**TABLE 1-1**

### 1.3 UNPACKING AND INSPECTING EQUIPMENT

Exercise extreme care when unpacking the unit. Make a visual inspection of the unit for evidence of damage incurred during shipment. If a claim for damage is to be made, save the shipping container to substantiate the claim. When the equipment has been unpacked, return all the packing material to the container for future use in storing or shipping of the equipment. Remove any protective covers from connectors before using the equipment. Replace any covers on the connectors after using the PSD60-2R.

### 1.4 SPECIFICATIONS

#### Environmental Specifications

The environmental specifications are as follows:

Size:	16.5 cm H x 35.6 cm W x 26.9 cm D (6.5" H x 14" W x 10.6" D)
Mass (Weight):	5.4 kg (12 lbs.)
Container:	High-impact plastic
Operating Temperature:	-25 °C to +55 °C
Relative Humidity (Non-Condensing):	80% maximum for $\leq 30$ °C Decrease linearly to 50% at 40 °C 40 °C $\leq$ 50% maximum $\leq$ 55 °C
Operating Altitude:	$\leq 2\,000$ m
IEC Overvoltage Category:	II
Pollution Degree:	2
Intrinsic Safety:	1 $\mu$ J @ 0.02 $\mu$ F (normal operation)

#### Measurement Range

##### Capacitance Measurement Range

<u>Range</u>		<u>Resolution</u>
Low	0 - 199.99 $\rho$ F	0.01 $\rho$ F
Mid	200 - 1999.9 $\rho$ F	0.1 $\rho$ F
High	2,000 - 19,999 $\rho$ F	1 $\rho$ F
	20.00K - 39.99 K $\rho$ F	10 $\rho$ F
DTF	0 - 19,999 $\rho$ F	1 $\rho$ F
	20.00K - 39.99 K $\rho$ F	10 $\rho$ F

##### Resistance Measurement Mode (9 ranges)

10 m $\Omega$  to 1999 M $\Omega$   
(optional) 2000 M $\Omega$  to 19999 M $\Omega$

#### Measurement Accuracy

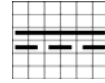
AC Capacitance:	
Mode A	Greater of +/- 0.1% of reading or 0.05 $\rho$ F from 0 – 39.99 K $\rho$ F at 0° Phase Shift.
Mode B	Greater of +/- 0.1% of reading or 0.05 $\rho$ F from 0 – 39.99 K $\rho$ F at 0° to 359° Phase Shift.
DTF	Greater of +/- 0.1% of reading or 2 $\rho$ F
Resistance:	Greater of 2% of reading or 0.1 ohm +/- 5% of reading for R > 2000 M ohm

Capacitance Simulators Range

Tank Unit:	10 $\mu$ F – 9900 $\mu$ F infinite resolution
Compensator:	10 $\mu$ F – 990 $\mu$ F infinite resolution. The capacitance simulators are calibrated to an exact value by using MEASURE INT TU or COMP and, therefore, are as accurate as the capacitance measurement circuitry.

Power

Batteries:	27 V, 150 mA maximum. 18 C sized Alkaline batteries
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## 1.5 ACCESSORIES SUPPLIED

The following is a list of accessories that are supplied with the PSD60-2R:

1. Ground strap cable, JPN 55-7002-00.
2. Operation Manual, JPN 06-0597-01.

## 1.6 EQUIPMENT REQUIRED BUT NOT SUPPLIED

The following is a list of equipment that is referenced in this manual but not supplied with a PSD60-2R:

1. Aircraft Interface Cabling

## **SECTION II OPERATION**

### **2.1 GENERAL INFORMATION**

The PSD60-2R is a general purpose test set and must be used in conjunction with an aircraft specific interface cable in order to gain access to the aircraft fuel quantity system. Manufacturers of test sets historically have made or specified cables which best utilize their particular test set. Contact Aeroflex for interface cabling.

**The following precautions should be observed at all times:**

- A. Connect the PSD60-2R chassis jack to airframe ground during all operations (measurement and simulation).**
- B. Never connect cable leads to the TANK UNITS and INDICATOR jacks at the same time. (PSD60-2R TANK UNITS jacks are always active.)**
- C. Do not use cables which may connect shield to airframe ground within the cables. SHIELD and GROUND must be isolated to allow correct operation of the megger.**

### **2.2 CAPACITANCE MEASUREMENT**

1. Connect CHASSIS jack (J7) to Airframe.
2. Turn power ON, select the desired LO-Z frequency, and allow three minutes for test set to stabilize.
3. Check battery condition, if "LO BAT" is displayed on the display replace batteries.
4. Connect TANK UNITS LO-Z, HI-Z and COMP connectors (P4, J5, and P6) to the aircraft interface with the appropriate interface cables.
5. Turn the FUNCTION SELECT switch (A3S1) to MEASURE EXT.
6. Turn the MEGGER SELECT switch (A3S2) to COMP or TU.
7. Select the correct Capacitance Measurement Mode by setting S11.
8. The capacitance of the system's TU or COMP is measured and displayed in pF on the test set's display.

## 2.3 CAPACITANCE SIMULATION

**CAUTION:** Some procedures may specify that the test set should not be connected to airframe ground when simulating capacitance. This is because some test sets connect airframe ground and shield together, thereby grounding the shield at a point other than the "Single-Point" ground. This test set isolates case and shield ground in the simulate mode, so this precaution is not necessary. **The test set should be connected to airframe ground for all tests.**

1. Connect CHASSIS jack (J7) to Airframe.
2. Turn power ON, select the desired LO-Z frequency, and allow three minutes for test set to stabilize.
3. Check battery condition, if "LO BAT" is displayed on the display replace batteries.
4. Turn the FUNCTION SELECT switch (A3S1) to MEASURE INT.
5. Connect INDICATOR LO-Z, HI-Z, and COMP connectors (P1, J2, and P3) to the aircraft interface with the appropriate interface cables. Assure that no cables are connected to P4, J5, and P6.
6. Turn the MEGGER SELECT switch (A3S2) to TU.
7. Adjust TU decade (S6, S7, and S8) below desired capacitance value.
8. Adjust TU FINE knob (C1) to desired capacitance value.
9. Turn the MEGGER SELECT switch (A3S2) to COMP and adjust COMP decade (S9 and S10) and COMP FINE knob (C2) to desired capacitance value.
10. Turn FUNCTION SELECT switch (A3S1) to SIM TU & COMP.

**NOTE:** Connecting test harnesses and interface boxes should not add capacitance to the system. However, if the cable is suspect, connect only the cable to P4, J5, and P6 and read its capacitance per measurement procedure. If cable capacitance is less than 1 pF above displayed reading with no cables connected to test set, subtract its capacitance from the amount being simulated. If over 1 pF, repair cable; shields are probably improperly terminated.

**NOTE:** When simulating tank unit only, as in the case of an uncompensated system, FUNCTION SELECT switch (A3S1) should be in the SIM TU ONLY position.

**NOTE:** The AIRCRAFT ONLY position disconnects both simulators. This is used when delta values are simulated and actual dry tanks are used for empty.

## **2.4 RESISTANCE MEASUREMENT**

1. Connect CHASSIS jack (J7) to Airframe.
2. Turn power ON, select the desired LO-Z frequency, and allow three minutes for test set to stabilize.
3. Check battery condition, if "LO BAT" is displayed on the display replace batteries.
4. Connect TANK UNITS LO-Z, HI-Z and COMP connectors (P4, J5, and P6) to the aircraft interface with the appropriate interface cables.
5. Turn the FUNCTION SELET switch (A3S1) to MEASURE EXT, and select desired points to be measured using the MEGGER SELECT switch. (A3S1)
6. The resistance between the points selected will be displayed in ohms on the test set display.

## **2.5 DTF MEASUREMENT**

1. Connect CHASSIS jack (J7) to Airframe.
2. Turn power ON, select the desired LO-Z frequency, and allow three minutes for test set to stabilize.
3. Check battery condition, if "LO BAT" is displayed on the display replace batteries.
4. Connect TANK UNITS LO-Z, HI-Z and COMP connectors (P4, J5, and P6) to the interface box with the appropriate interface cable.
5. Without the aircraft interface connected to the airplane, place the FUNCTION SELECT switch (A3S1) in DTF mode.
6. When the unit nulls all stray capacitance, 0pF will be indicated on the units display.
7. Connect the interface to the airplane and read the capacitance indicated on the units display.
8. Divide the displayed capacitance by the capacitance per foot of the specific coax measured. This number will yield the length of the coax, or the distance to the fault of the coax.

## **2.6 ERROR CODES**

ER0 –

Not used at this time.

ER1 – LO-Z SHORT

The LO-Z signal is shorted and/or the REFHI/REFLO signal is to low.

ER2 – INVALID FUNCTION

This error appears when attempting to calibrate the unit with one of the selector switches placed in an invalid position.

ER3 –

Not used at this time.

ER4 –

Not used at this time.

ER5 –

Not used at this time.

ER6 – CAL DATA ERROR

This error code is caused by the loss of calibration data in the EEPROM chip.

ER7 – A/D ERROR

The A/D converter is not communicating correctly with the processor.

ER8 – STACK ERROR

The microprocessor had a stack overflow.

ER9 – DIVIDE BY 0 ERROR

The main board microprocessor tried to divide by 0.

ER10 – SWITCH ERROR

The microprocessor detected that the function select switches are in an invalid mode.

-ER- - INVALID FUNCTION

The function switches are in an invalid position.

%BATT displays 'LO BATT'

The batteries do not have sufficient charge to operate the unit.

%BATT displays 'Er'

The processor is bypassing the calibration data error (ER6).



## **SECTION III THEORY OF OPERATION**

### **3.1 GENERAL INFORMATION**

The PSD60-2R Theory of Operation is detailed in the PSD60-2R Maintenance Manual (PN: 06-0597-00 for hard copy, E6-0597-00 for CD) available separately from Aeroflex.

## **SECTION IV MAINTENANCE**

### **4.1 GENERAL MAINTENANCE**

**CLEANING WARNING:**

Keep the equipment dry to avoid damage to the equipment. To prevent damage, never apply solvents to the equipment housing. For cleaning, wipe the equipment with a cloth that is lightly dampened with water, mild detergent, or alcohol. Do not use aromatic hydrocarbons, chlorinated solvents, or methanol-based fluids.

**CAUTION:** THE PSD60-2R CONTAINS ESD SENSITIVE DEVICES. OPEN AND CALIBRATE AT ESD PROTECTED AREA ONLY.

- A. Battery Replacement:: a "LO BAT" indication will illuminate on the digital display when batteries require replacement. Remove the front panel and replace used batteries with fresh alkaline batteries.
- B. Calibration: The suggested calibration interval is 1 year. A test procedure, JPN 04-0597-00 is included in the PSD60-2R Maintenance Manual (PN: 06-0597-00 for hard copy, E6-0597-00 for CD) available separately from Aeroflex. It contains a section that tests the units accuracy, a section that calibrates the unit, and a section that does complete testing of the unit. Periodic calibration and certification service is also provided by:

Aeroflex  
400 New Century Parkway  
New Century KS 66031  
Telephone: (800) 237-2831 / (913) 764-2452  
Attn: Service Dept.

### **4.2 BILLS OF MATERIAL, ASSEMBLY DRAWINGS, SCHEMATICS & TEST PROCEDURE**

To assist in the maintenance of the PSD60-2R, bills of material, assembly drawings, schematics and a test procedure are included in in the PSD60-2R Maintenance Manual (PN: 06-0597-00 for hard copy, E6-0597-00 for CD) available separately from Aeroflex.

## APPENDIX A

### THREE TERMINAL MEGGER

#### A.1 PSD60-2R THREE TERMINAL MEGGER

The PSD60-2R incorporates a three terminal megger in order to accurately measure the insulation resistance of each element. This method is required due to the complexity of the network to be measured. An equivalent circuit for a two terminal megger is shown in Figure A-1.

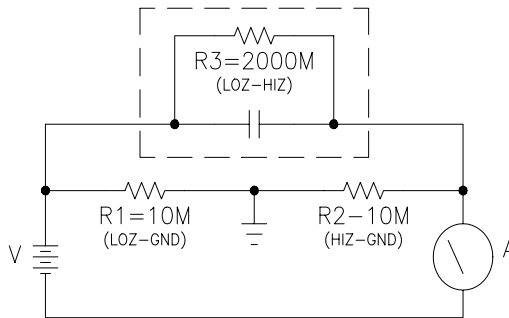


FIGURE A-1

In Figure A-1, the insulation resistance reading would be approximately 20 M $\Omega$ , which is unacceptable. This is because the main current is through  $R1$  and  $R2$  not the tank unit.

The three terminal measurement used in the PSD60-2R measures the current through the element under test. (Figure A-2) As you can see, the resistance in the ammeter is infinitely smaller than  $R1$  or  $R2$ . By using this method we can accurately measure the tank unit insulation resistance.

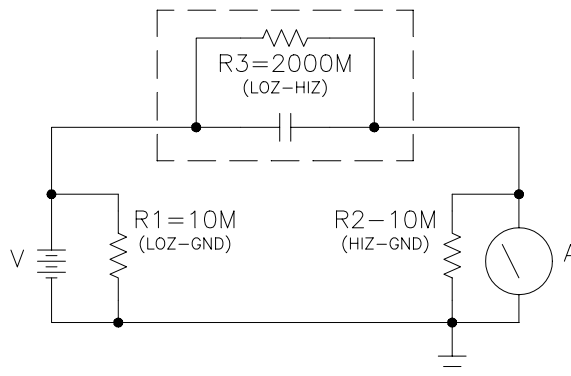


FIGURE A-2

The three terminal measurement as described above works well in identifying problems except when a direct short is in the system. For example, if R1 is shorted no current will reach R3 and it shows infinite resistance or if R2 is shorted no current will reach the current sensing device also indicating an incorrect reading. When connected to an entire system, this will cause erroneous readings on many portions of the select switch. Table A-1 shows a typical result.

<u>SELECT POSITION</u>	<u>NORMAL READING</u>	<u>SHORT FROM LoZ TO HiZ</u>
LoZ - HiZ	0 $\Omega$	0 $\Omega$
Comp - HiZ	10 M $\Omega$	INFINITY
LoZ - Comp	10 M $\Omega$	INDETERMINATE
LoZ - Shield	10 M $\Omega$	INDETERMINATE
Comp - Shield	10 M $\Omega$	10 M $\Omega$
HiZ - Shield	10 M $\Omega$	INDETERMINATE
Shield - GND	10 M $\Omega$	10 M $\Omega$
LoZ - GND	10 M $\Omega$	INDETERMINATE
Comp - GND	10 M $\Omega$	10 M $\Omega$
HiZ - GND	10 M $\Omega$	INDETERMINATE

TABLE A-1

Of the five points measured (LoZ, HiZ, Comp, Shield, GND) only four of the readings are correct. The "TWO TERMINAL MEASUREMENT" switch is provided to help eliminate this confusion by lifting the third leg of the megger so it will act as a two terminal device. This method of testing will provide the best of both three and two terminal measurements by allowing accurate measurement of system parameters while allowing for quick identification of a direct short.