DNI NEVADA

231D/232D
Electrical Safety Analyzers
Operating Manual

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DNI NEVADA
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Revision History		
Revision	Description	Date
E	Firmware Version 2.02	3/95
F	Correction to specifications	3/97
G	Corrections	11/97

Copyright

Standard Terms and Conditions

Refunds & Credits

Please note that only serialized products (products labeled with a distinct serial number) and accessories are eligible for partial refund and/or credit. Nonserialized parts and accessory items (cables, carrying cases, auxiliary modules, etc.) are not eligible for return or refund. In order to receive a partial refund/credit of a product purchase price on a serialized product, the product must not have been damaged by the customer or by the common carrier chosen by the customer to return the goods, and the product must be returned complete (meaning all manuals, cables, accessories, etc.) within 90 days of original purchase and in "as new" and resellable condition. The *Return Procedure* must be followed to assure prompt refund/credit.

Restocking Charges

Only products returned within 90 days from the date of original purchase are eligible for refund/credit. Products returned within 30 days of original purchase are subject to a minimum restocking fee of 15%. Products returned in excess of 30 days after purchase, but prior to 90 days, are subject to a minimum restocking fee of 20%. Additional charges for damage and/or missing parts and accessories will be applied to all returns. Products not returned within 90 days of purchase, or products which are not in "as new" and resellable condition, are not eligible for credit return and will be returned t the customer.

Return Procedure

Every product returned for refund/credit must be accompanied by a Return Material Authorization (RMA) number, to be obtained from our Order Processing Department. All items being returned must be sent freight prepaid to our factory location.

Certification

This instrument was thoroughly tested and inspected and found to meet DNI Nevada'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.

Warranty

Warranty and Product Support

This instrument is warranted by DNI Nevada against defects in materials and workmanship for one full year from the date of original purchase. During the warranty period, we will repair or, at our option, replace at no charge a product that proves to be defective, provided you return the product, shipping prepaid, to DNI Nevada, Inc. This warranty does not apply if the product has been damaged by accident or misuse or as the result of service or modification by other than DNI Nevada. IN NO EVENT SHALL DNI NEVADA BE LIABLE FOR CONSEQUENTIAL DAMAGES.

Only serialized products and their accessory items (those items bearing a distinct serial number tag) are covered under this one–year warranty. PHYSICAL DAMAGE CAUSED BY MISUSE OR PHYSICAL ABUSE IS NOT COVERED UNDER THE WARRANTY. Items such as cables and nonserialized modules are not covered under this warranty.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state, province to province, or country to country. This warranty is limited to repairing the instrument to DNI Nevada's specifications.

When you return an instrument to DNI Nevada, Inc., for service, repair, or calibration, we recommend using United Parcel Service, Federal Express, or Air Parcel Post. We also recommend that you insure your shipment for its actual replacement cost. DNI Nevada will not be responsible for lost shipments or instruments that are received in damaged condition due to improper packaging or handling. All warranty claim shipments must be made on a freight prepaid basis. Also, in order to expedite your claim, please include a properly completed copy of the Service Return Form. Recalibration of instruments, which have a recommended semiannual calibration frequency, is not covered under the warranty.

Warranty Disclaimer

Should you elect to have your instrument serviced and/or calibrated by someone other than DNI Nevada, please be advised that the original warranty covering your product becomes void when the tamper-resistant Quality Seal is removed or broken without proper factory authorization. We strongly recommend, therefore, that you send your instrument to DNI Nevada for factory service and calibration, especially during the original warranty period.

In all cases, breaking the tamper-resistant Quality Seal should be avoided at all cost, as this seal is the key to your original instrument warranty. In the event that the seal must be broken to gain internal access to the instrument (e.g., in the case of a customer-installed firmware upgrade), you must first contact DNI Nevada's technical support department at 702-883-3400. You will be required to provide us with the serial number for your instrument as well as a valid reason for breaking the Quality Seal. You should break this seal only after you have received factory authorization. Do not break the Quality Seal before you have contacted us! Following these steps will help ensure that you will retain the original warranty on your instrument without interruption.

WARNING

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

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Abbreviations

NOTE: This column is alphabetized.

ANSI	American National Standards Institute
A	ampere
AAMI	Association for the Advancement of Medical Instrumentation
BPM	beats per minute
dB	decibel
°C	degrees Celsius (centigrade)
°F	degrees Fahrenheit
DMM	digital multimeter
EEPROM	electrically erasable PROM
ECG	electrocardiograph or electrocardiogram
EUT	equipment under test
Hz	hertz
in	inch
k	kilo– (10^3)
kHz	kilohertz
kΩ	kilohm
LED	light–emitting diode
LCD	liquid crystal display
M	meg(a)– (10^6)
MHz	megahertz
MΩ	megohm
m	-meter
µ	micro- (10^{-6})
µA	microampere
µV	microvolt
m	milli- (10^{-3})
mA	milliampere
mV	millivolt
Ω	ohm
lb	pound
PROM	programmable read–only memory
s	second
TRMS	true root mean square
V	volt
w	watts

Chapter 1

System Familiarization

Read this chapter to acquaint yourself with the specifications and features of DNI's 231D and 232D Safety Analyzers.

SAFETY CONSIDERATIONS

General

This instrument and related documentation must be reviewed for familiarization with safety markings and instructions before you operate the instrument. Refer to the 231D/232D Operating Manual for operating instructions.

Safety Symbols

The symbol to the left is the Operating Manual symbol. When you see this symbol on the instrument, refer to the Operating Manual.

WARNING! Denotes a hazard. **WARNING!** calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a **WARNING!** sign until the indicated conditions are fully understood and met.

CAUTION. Denotes a hazard. **CAUTION** calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the instrument. Do not proceed beyond a **CAUTION** sign until the indicated conditions are fully understood and met.

Introduction

The DNI Models 231D and 232D Safety Analyzers are precision voltage, current, and resistance meters designed expressly for testing the electrical safety level of both the patient environment and associated electrically operated equipment.

Both electrical safety analyzers measure

- grounding resistance of the equipment power cord;
- leakage current from the equipment's chassis or ground wire;
- equipment load current;
- voltage gradient (mV) and intergrounding resistance (mOhms) using the external meter function; and
- power system AC voltages:
  - neutral to hot,
  - neutral to ground, and
  - hot to ground.

A test receptacle mounted on the top panel of both meters is used to simulate a wide range of power system fault conditions to assist the operator in assessing the equipment's level of safety. Push–button switches on the front panel select

- neutral (open and closed),
- ground (open and closed), and
- polarity (normal and reverse).

An internal ground fault circuit interrupter (GFCI) protects both the operator and the equipment under test. If a hot line to ground fault condition exceeding 10 milliamperes occurs, line voltage is immediately removed from the test receptacle.

For conducting more extensive power system tests, both electrical safety analyzers are compatible with the DNI Model 202A Isolated Power and GFCI Test Module. Contact your DNI Nevada representative for details.

The Model 232D additionally simplifies the electrical safety testing of more sophisticated electrically operated equipment with up to 10 direct–patient electrodes, such as a diagnostic 12–lead electrocardiograph or recorder. The test receptacle wiring can be set to simulate a wide range of power system faults (as listed earlier).

The Model 232D conducts these added tests:

- Leakage current tests referenced to power ground
  - on all patient electrodes;
  - on individual patient electrodes—RL, RA, LA, LL, and the V1–6 set; and
  - between specified patient electrode pairs:

    right arm and left arm (RA–LA),

    right arm and right leg (RA–RL), and

    left arm and right leg (LA–RL).
- Isolation of all patient electrodes from ground with 120 VAC applied by the analyzer. (The current–limited test voltage is applied to the patient electrodes only when a front panel push–button is depressed and held by the operator.)
- A wide range of ECG simulations and performance testing waveforms.

Specifications

Meter

- Measurements displayed on a 3½-digit LED display.
- Overrange indicated by a flashing 1999.
- The appropriate range selected automatically with the units of measure shown on the mode switch.
- During resistance measurements, a separate LED illuminates when the current source has been activated.

Current

Refer to the *AAMI Load* section later in this chapter for measurement accuracies.

Equipment Current

- One range: 0.1 to 15.0 amps.
- Accuracy: 5% of range.

Resistance

Refer to the *AAMI Load* section later in this chapter for measurement accuracies.

Voltage

- Three voltage ranges:

  0.0 to 199.9 mV

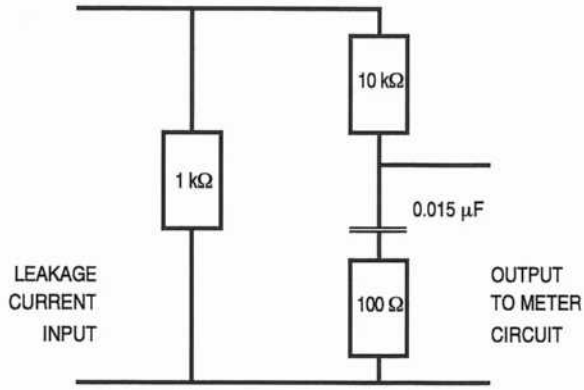
  0 to 1999 mV

  0.0 to 199.9 V

- AAMI Load used for these measurements.
- Millivolt (mV) ranges autoranging.
- Voltage (V) ranges used for line voltage measurements of the test receptacle powering the analyzer.
- Millivolt (mV) ranges usable for external meter jack measurements.

AAMI Load

- Simulated patient load recommended by the Association for the Advancement of Medical Instrumentation (AAMI), Safe Current Limits Standard (ANSI/AAMI ES1-1993) (revision of the earlier ANSI/AAMI ES1-1985 and SCL-12/78).
- AAMI Load drawing:



Full Scale Ranges (TRMS):	Low: 0.1 to 199.9 µA/mV High: 200 to 1999 µA/mV
Frequency Response:	ANSI/AAMI ES1-1993
Accuracy:	+/– (5% or reading +1 µA) @ DC and from 48 Hz to 100 kHz.
Test Load Impedance:	1000 ohms +/– 0.5% @ DC (ANSI/AAMI ES1-1993)

Test Receptacle

- Supplies power to the equipment under test
- 120 VAC at 15 amps maximum
- Push-button switches on front panel select

  NEUTRAL — OPEN and **CLOSED**

  GROUND — OPEN and **CLOSED**

  POLARITY — NORMAL, REVERSE, and **OFF/RESET**

Ground Fault Interrupter

- Detects a **TEST RECEPTACLE** ground fault of >10 mA ±10%.
- Disconnects the hot and neutral lines to the **TEST RECEPTACLE** when a fault is detected.
- Resets by setting the **POLARITY** switch to the **OFF/RESET** (center) position.

Test Lead Jacks

- Four standard banana jacks.
- Two for the **METER** input and two for the **CURRENT SOURCE.**
- Arranged to allow a set of Kelvin cables to be connected to the four terminals and left in for all tests without damaging the analyzer.
- The **CURRENT SOURCE** connected only internally for resistance measurements, so that it will not interfere with leakage measurements even though the cables are connected to the **CURRENT SOURCE** jacks.
- All protected against accidental application of line voltage.

ECG Leads Binding Posts

- Ten universal binding posts.
- Accept 3.2-mm or 4-mm pins or disposable snap electrocardiograph electrodes.

Power Requirements

- 117 VAC at 15 amps 50 to 60 Hz
- Detachable hospital-grade power cord (supplied)
- Uses very little power by itself (<100 mA)
- 15-amp rating for equipment under test plugged into the test receptacle

Physical Characteristics

Size 22.9–cm L × 22.9–cm W × 10.2–cm H
(9–in L × 9–in W × 4–in H)

Weight 2.07 kg (4.5 lb)

Temperature Range

Operating 15° to 35°C (59° to 95°F)

Storage 0° to 50°C (32° to 122°F)

Accessories

Standard

	DNI Part #
• Soft vinyl carrying case	9530-0044
• Power cord*	3010-0012
• Kelvin cable test leads (2)	9501-0032
• Ground pin adapter (2)	9503-0004
• 231D/232D Operating Manual	9508-0173

***Note**

The supplied power cord is 14-gauge wire rated at 15 amps. ***Do not use a smaller size.***

Optional

• 231D/232D Service Manual	9508-0271

Chapter 2

Installation

This chapter contains information for inspecting the instrument, processing a claim, repackaging for shipment, and preparing for use.

Unpacking and Inspection

Follow standard receiving practices upon receipt of the instrument. Check the shipping carton for damage. If damage is found, stop unpacking the instrument. Notify the carrier and ask for an agent to be present while the instrument is unpacked. There are no special unpacking instructions, but be careful not to damage the instrument when unpacking it. Inspect the instrument for physical damage such as bent or broken parts, dents, or scratches.

Claims

Our routine method of shipment is via common carrier, FOB origin. Upon delivery, if physical damage is found, retain all packing materials in their original condition and contact the carrier immediately to file a claim.

If the instrument is delivered in good physical condition but does not operate within specifications, or if there are any other problems not caused by shipping damage, please contact DNI Nevada or your local sales representative.

Warranty Repair

The warranty statement for this product is at the front of this manual.

When shipping an instrument to DNI Nevada for repair, complete the Service Return Form and attach to the instrument. Completing this form will help to ensure timely repair of your instrument.

Use the original carton and packaging material for shipment. If they are not available, we recommend the following guide for repackaging:

- Use a double–walled carton of sufficient strength for the weight being shipped.
- Use heavy paper or cardboard to protect all instrument surfaces. Use nonabrasive material around all projecting parts.
- Use at least four inches of tightly packed, industrial–approved shock–absorbent material around the instrument.

Preparing for Use

The Models 231D/232D are portable instruments designed for use on three-wire 115V 50-60 Hz power.

No cables or wires other than those supplied need be used. No cables need to be fabricated.

Note

To do a performance check on the instrument, follow the procedure outlined in the *Performance Check* chapter of this manual.

Chapter 3

Operating Instructions

Use this chapter to learn about operating the 231D/232D Safety Analyzers.

Instrument Familiarity

In this section you will find the names and descriptions of the controls, displays, and connectors on the top and rear panels of the 231D and 232D Safety Analyzers. The numbers in the list refer to the locations illustrated in Figure 3-1.

Top Panel Controls, Displays, and Connectors

1 Display — A 3½-digit LED display that indicates the results of the measurement being made. Decimal points are placed automatically. The units of measure are shown on the **MODE** switch.

2 **MODE** Switch — Sets the type of measurement to be made. *Model 232D only:* The **ECG** position enables the **LEADS** selector switch.

3 **DC ONLY** Switch — Changes the measurement mode from AC+DC to DC only.

4 **CURRENT SOURCE ACTIVE** Lamp — Lights up in resistance tests indicating when the current source is connected properly.

5 **POLARITY** Switch — A three-position switch. Selects **NORMAL** or **REVERSE** polarity of the hot and neutral lines to the **TEST RECEPTACLE**. In the center position, shuts power **OFF** to the **TEST RECEPTACLE** and **RESETS** the ground fault circuit.

6 **GROUND OPEN** Switch — Momentarily **OPEN**s the ground connection to the **TEST RECEPTACLE**.

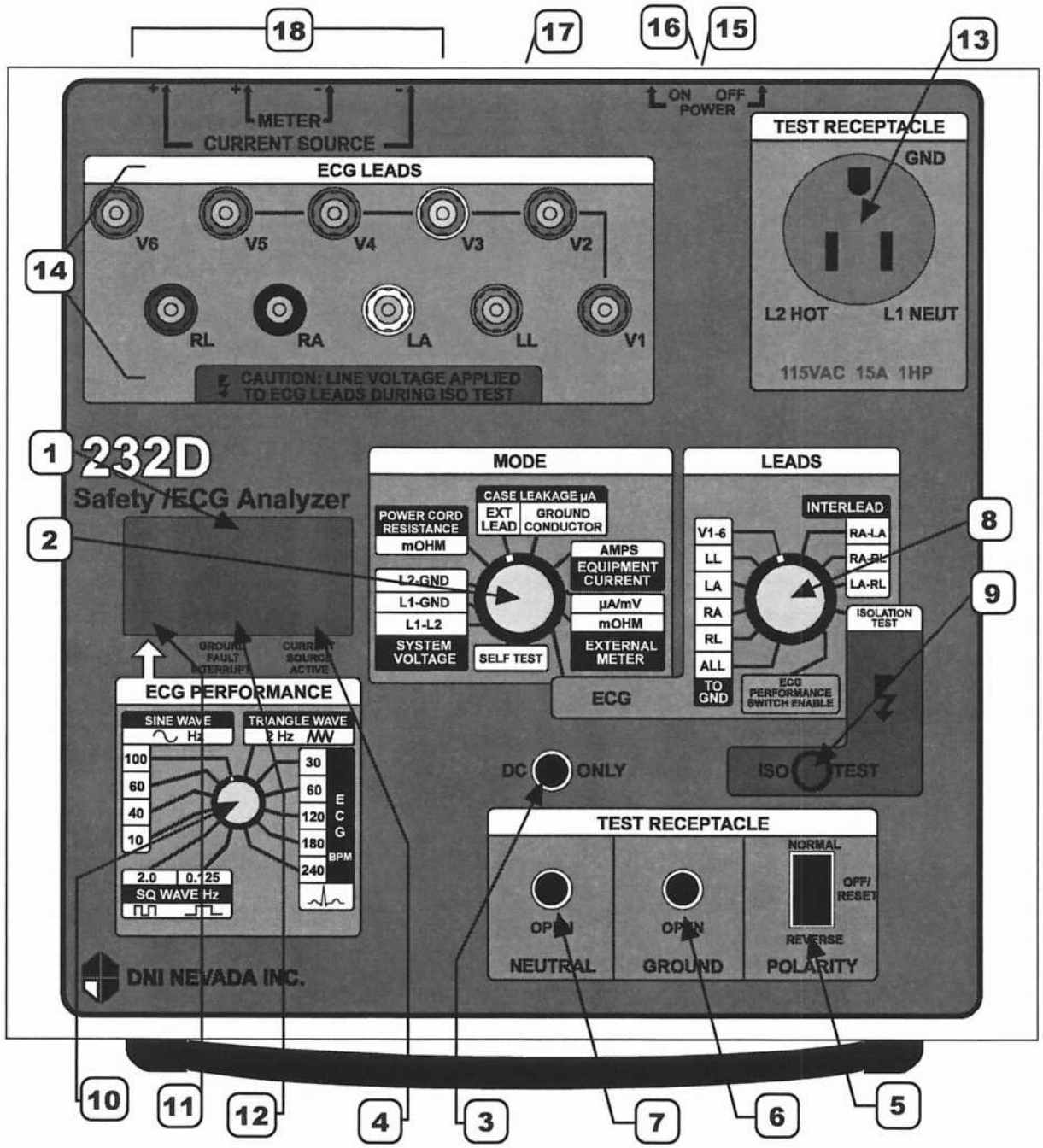


Figure 3-1. *232D Top and Rear Panel Locator*

7 NEUTRAL OPEN Switch — Momentarily OPENs the neutral line to the TEST RECEPTACLE.

8 LEADS Selector Switch *(Model 232D only)* — Selects the ECG lead test to be made. The MODE switch must be in the ECG position to activate these tests.

9 ISO TEST *(Model 232D only)* — Connects the ECG isolation voltage to the ECG LEADS.

CAUTION

This voltage is 117 VAC and, although it is limited to 1 mA, **it is potentially lethal.**

Patient Safety Precaution

Since the test method injects potentially hazardous current levels into the electrocardiograph and the related power system, **do not conduct tests in an occupied patient location or while the patient is connected to a related power system branch circuit**. (Reference: ANSI/AMII ES1-1993)

10 ECG PERFORMANCE Switch *(Model 232D only)* — Selects the ECG Performance Waveform to be applied to the ECG LEADS. The MODE switch must be in the ECG position, and the LEADS switch must be in the ECG PERFORMANCE SWITCH ENABLE position to enable this mode.

11 ECG PERFORMANCE Indicator Lamp *(Model 232D only)* — In the ECG PERFORMANCE waveform mode, this lights up and the display blanks.

12 GROUND FAULT INTERRUPT Lamp — Lights up after a ground fault has been detected.

13 TEST RECEPTACLE — Power receptacle for the equipment under test.

14 ECG LEADS Binding Posts *(Model 232D only)* — Accept all styles of electrocardiograph connectors—disposable snaps, 3.2-mm pins, and 4.0-mm pins.

Rear Panel Connectors and Controls

15 POWER ON/OFF Switch — Turns on the power.

16 POWER CORD Plug — Power cord plugs in here.

> Remove the power cord when storing instrument in the supplied carrying case.

17 FUSE Holder — 15-amp 3AG slow-blow fuse protects the instrument and the equipment under test.

18 External Probe Connections

CURRENT SOURCE — The current source for measuring resistance is internally connected to these jacks when the MODE switch is in the mOHM measuring position.

EXTERNAL METER — The metering circuit is internally connected to these jacks when the MODE switch is in any position requiring external connections.

> Both Kelvin cables can be left connected for all measurements because the MODE switch only connects the CURRENT SOURCE to the rear panel jacks in the resistance measuring positions. Only one Kelvin cable is needed for external lead leakage and power cord resistance measurements.

Testing Procedures

This section describes the types of electrical safety and ECG performance tests that can be performed using the Models 231D/232D.

While these analyzers perform a wide range of tests on both general and critical medical devices, refer to the particular equipment under test (EUT) service manual for the required checkout procedure and testing protocol.

WARNING!

The ground fault interrupter protects the equipment under test from damage in the event of a ground fault of greater than 10 mA. Under most conditions, this protects the operator from electrical shocks. But **a current of less than 10 mA can be fatal.**

The operator is advised to use the same precautions as if there were no ground fault protection.

CAUTION

If any System Voltage or Power Cord Resistance tests fail, do not continue. Stop immediately and fix the problem before continuing. Otherwise **the operator is in danger of receiving a lethal electrical shock.**

Since the integrity of the grounding conductor can be violated during testing, **do not touch the equipment under test (EUT) during testing.**

Start-Up and Self-Test

Before plugging in the analyzer or turning the power on, ensure that no equipment is plugged into the TEST RECEPTACLE and that the POLARITY switch is set to OFF (the center position).

Before using the analyzer to test any other equipment, we recommend that you do the following self-test:

1. Plug the analyzer into the wall socket.
2. Turn the power ON.
3. Set the MODE switch to SELF TEST.

   The display should read 1000 +/-20, and the CURRENT SOURCE ACTIVE lamp should be illuminating. If this is not the case, the instrument is not functioning properly, and it should be repaired before using.

The self-test is not intended to be a complete checkout of the instrument but rather a quick method of determining if it is operational. To do a complete performance check, see the *Performance Test* chapter for instructions.

CAUTION

If any System Voltage or Power Cord Resistance tests fail, do not continue. Stop immediately and fix the problem before continuing. Otherwise **the operator is in danger of receiving a lethal electrical shock.**

System Voltage

The system voltages from either a **grounded** or an **isolated** power outlet can be easily measured without using external test leads.

Grounded Power Systems

For a grounded power outlet, the **neutral** conductor is referred to as the **line one** (L1) and the **hot** conductor is referred to as the **line two** (L2). With a properly wired 120-VAC grounded power outlet, the following values should be read:

1. With the MODE switch in the L1-L2 position, the display reads the **hot** to **neutral** or **line** voltage.

2. With the MODE switch in the L1-GND position, the display reads the **neutral** to **ground** voltage which should be no more than 6 VAC or 5% of the previously measured **line** voltage.

3. With the MODE switch in the L2-GND position, the display reads the **hot** to **ground** voltage which should be approximately equal to the previously measured **line** voltage.

   If the power outlet is wired backward (reverse polarity), **line** voltage (L1-L2) reads the same. However, L1-GND and L2-GND readings are reversed. If ground (GND) wire is open, both the L1-GND and L2-GND read low and of equal value.

CAUTION

If the correct System Voltage readings are not measured, do not continue. Stop and immediately repair (or report) this problem. Otherwise **the operator is in danger of receiving an electrical shock.**

Isolated Power Systems

When testing balanced-line isolation power systems, the **line** voltage (L1-L2) measurement remains the same as above. However, the L1-GND and L2-GND measurements read low and of equal value.

Note

To properly measure leakage current, use a grounded power outlet for the voltage source. (Reference: ANSI/AAMI ES1-1993).

Power Cord Resistance

See **Figure 3-2.** *Power Cord Resistance and Case Leakage.*

To test power cord resistance:

1. Set the MODE switch to POWER CORD RESISTANCE.
2. Set the TEST RECEPTACLE POLARITY switch to the OFF (center) position.
3. Plug the equipment under test into the TEST RECEPTACLE located on the top of the Model 232D.
4. Connect the dual banana plug end of a Kelvin cable to the two **red** rear panel jacks.
5. Connect the alligator end of the Kelvin cable to a grounded point on the case of the equipment under test.

   The CURRENT SOURCE ACTIVE lamp lights up to indicate that the connection is made. The display reads the resistance (in mOHMs) from the case to the power receptacle of the equipment under test.

   This is a four-terminal resistance measurement. The Kelvin cable connects one end of the current source and the positive input of the measuring circuit through separate wires. Thus, the voltage drop in the test leads does not affect the meter reading.

   The same scheme is used inside the Model 232D at the receptacle ground pin, so the resistance of the wiring in the instrument does not affect the reading. The resistance of the test receptacle adds to the reading (<2 mΩ).

CAUTION

If the Power Cord Resistance test fails, do not continue. Stop immediately and fix the problem before continuing. Otherwise **the operator is in danger of receiving a lethal electrical shock.**

Exception: Devices with double-power circuit insulation and a three-prong power plug with ground pin connected to the electrostatic shield (i.e., Cambridge VSIV electrocardiograph).

Case Leakage, External Lead

See **Figure 3-2.** *Power Cord Resistance and Case Leakage, External Lead.*

To make case leakage measurements:

1. Set the MODE switch to CASE LEAKAGE μA, EXT LEAD.
2. Connect a Kelvin cable to the **red** rear panel jacks.
3. Connect the other end of the cable to the case of the equipment under test.
4. Case leakage measurements can now be made for various line conditions:
   - power on
   - power off
   - normal polarity
   - reverse polarity
   - closed or open ground
   - closed or open neutral
5. If a ground fault is detected when the POLARITY switch is placed in either the NORMAL or REVERSE position, the TEST RECEPTACLE is automatically shut off again.

   To reset it, return the POLARITY switch to OFF/RESET, then back on again.

CAUTION

If the instrument fails this test, stop and repair it. **Continuing to use it may result in the operator receiving a lethal electrical shock.**

Case Leakage, Ground Conductor

See **Figure 3-3.** *Case Leakage, Ground Conductor.*

To measure case leakage through the ground wire:

1. Set the MODE switch to CASE LEAKAGE μA, GROUND CONDUCTOR.

2. Without using any test leads, leakage through the ground wire of the power cord can be measured with the TEST RECEPTACLE, GROUND switch OPEN. This test configuration facilitates the measurement of leakage current for double-insulated devices utilizing a three-conductor power plug.

3. If a ground fault is detected when the POLARITY switch is placed in either the NORMAL or REVERSE position, the TEST RECEPTACLE is automatically shut off again. To reset it, return the POLARITY switch to OFF/RESET, then back on again.

CAUTION

If the instrument fails this test, stop and repair it. **Continuing to use it may result in the operator receiving a lethal electrical shock.**

External Meter, μA/mV

See **Figure 3-4.** *External Meter Connections for μA, mV, and mΩ.*

To measure a current of up to 2000 μA or a voltage up to 2000 mV:

1. Set the MODE switch to EXT METER, μA/mV.
2. Connect one Kelvin cable to the two **red** jacks and the other Kelvin cable to the two **black** jacks. If you are using single test leads, connect one single lead to the **red** EXTERNAL jack and the other single lead to the **black** EXTERNAL jack.
3. A current of up to 2000 μA or a voltage up to 2000 mV can now be measured between the cables. The AAMI Load is connected, which may load down voltage measurements where the impedance of the voltage source is high.

Equipment Current

To measure the operating current of the equipment under test:

1. Set the MODE switch to EQUIPMENT CURRENT.
2. Set TEST RECEPTACLE switch to NORMAL POLARITY.

External Meter, mOHMs

See **Figure 3-4.** *External Meter Connections for μA, mV, and mΩ.*

To measure low value resistances:

1. Set the MODE switch to EXT METER, mOHM. In this mode, the current source and measurement circuits are both connected to the rear panel jacks.

2. Connect one Kelvin cable to the **red** jacks and the other Kelvin cable to the **black** jacks.

3. Connect the resistance to be measured between the alligator clips. Be sure the CURRENT SOURCE ACTIVE lamp lights up when the connections are made.

   This is a four-terminal technique used to accurately measure low value resistances (i.e., less than 2 Ω). This is also the only measurement requiring two Kelvin cables.

DC Only

To filter out the AC portion of the measured signal and get a separate reading of DC only (rather than AC+DC) for volts and current:

- Press the DC ONLY button.

ECG Tests *(232D only)*

Note

The **MODE** switch must be in the **ECG** position for all ECG tests.

For all ECG tests:

1. Set the **MODE** switch to **ECG**.
2. Connect the equipment under test to the **TEST RECEPTACLE**.
3. Connect the ECG leads to the **ECG LEADS** posts.

   The leakage tests that follow can be made for:

   - normal/reverse polarity
   - closed/open ground
   - closed/open neutral

Leakage to Ground *(232D only)*

See **Figure 3-5.** *ECG Lead Test Connections.*

To measure the leakage of all leads to ground:

1. Set the **LEADS** selector switch to **ALL**.
2. The next five **LEADS** switch positions—**RL**, **RA**, **LA**, **LL**, and **V1-6**—measure the leakage of individual leads to ground.
3. Patient lead leakage measurements can be made for:

   - power on/off
   - normal/reverse polarity
   - closed/open ground
   - closed/open neutral

Interlead Leakage *(232D only)*

See **Figure 3-5.** *ECG Lead Test Connections.*

To measure leakage between the specified leads:

1. Set the LEADS, INTERLEAD selector switch to positions RA-LA, RA-RL, and LA-RL.
2. Patient interlead leakage measurements can be made for:
   - normal/reverse polarity.
   - closed/open ground.
   - closed/open neutral.
   - power on/off.

Isolation Test *(232D only)*

See **Figure 3-5.** *ECG Lead Test Connections.*

CAUTION

This test applies line voltage to the ECG posts. The current is internally limited to 1 mA.

To measure the leakage that would result if line voltage were to be applied to the ECG terminals:

1. Set the LEADS selector switch to ISO TEST.
2. Press the ISO TEST button.

Note

During isolation test, select only the properly wired test receptacle condition (**normal** POLARITY and **closed** GROUND). Additionally, place the electrocardiograph patient cable at least 20 cm from any grounded/conductive surfaces. (Reference: ANSI/AAMI ES1-1993 4.4)

Performance Waveforms *(232D only)*

To select a performance waveform to be applied to the ECG LEADS:

1. Set the LEADS selector switch to the ECG PERFORMANCE SWITCH ENABLE position.

2. The ECG PERFORMANCE SWITCH ENABLE switch now selects any of the waveforms listed below. All amplitudes are for Lead I.

   - SQUARE WAVE - 0.125 Hz (at 1 mV)
     To check low-end -3db cutoff frequency of the ECG monitor.

   - SQUARE WAVE - 2 Hz (at 1 mV)
     To check amplitude accuracy and damping of the ECG monitor.

   - SINE WAVEs - 10, 40, 60, 100 Hz (at 1 mV)
     To check frequency response of monitor and to check line frequency rejection.

   - TRIANGLE WAVE - 2 Hz (at 3 mV)
     To check linearity of monitor.

   - ECG waves - 30, 60, 120, 180, 240 BPM (at 1 mV)
     To check monitor ECG rate indicator and rate alarm limits.

Power-Down

After completing the tests:

1. Set the POLARITY switch to OFF.

2. Turn the 231D/232D POWER OFF.

3. Disconnect equipment under test from the TEST RECEPTACLE.

4. Unplug the 231D/232D.

   We recommend that the instrument be stored in the storage case provided.

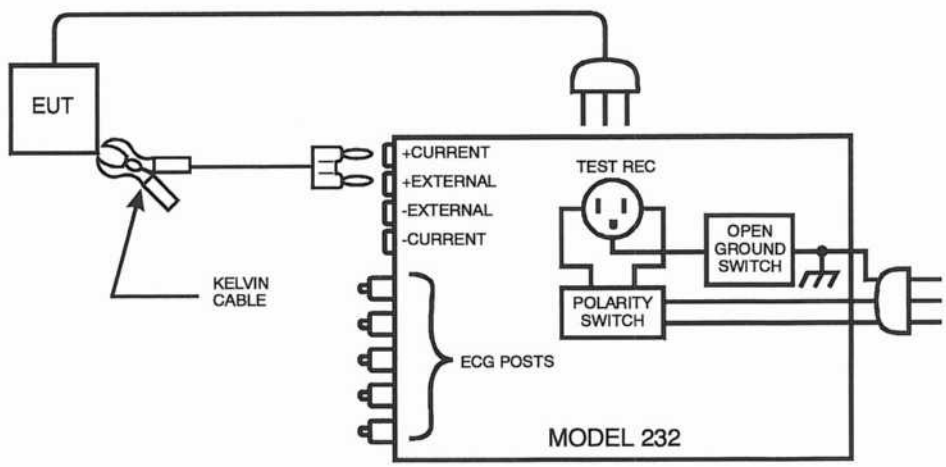


Figure 3-2. *Power Cord Resistance and Case Leakage, External Lead*

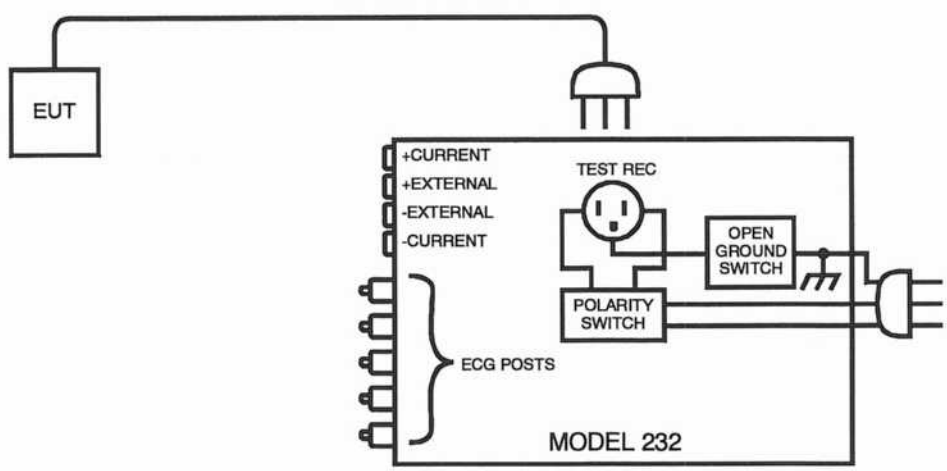


Figure 3-3. *Case Leakage, Ground Conductor*

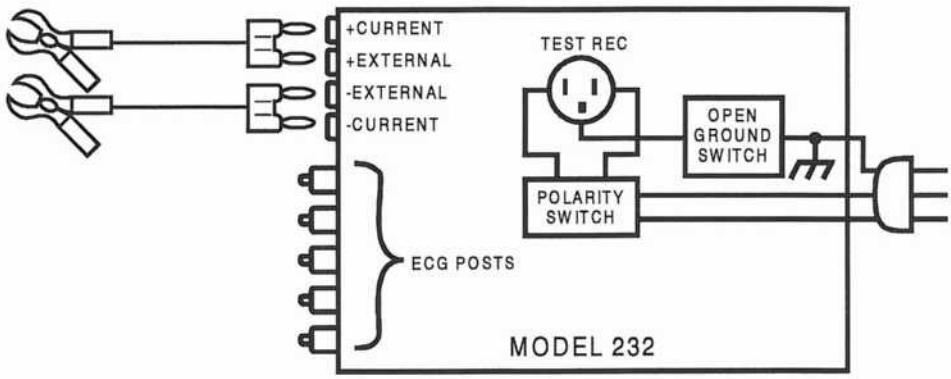


Figure 3-4. *External Meter Connections for μA, mV, and mΩ*

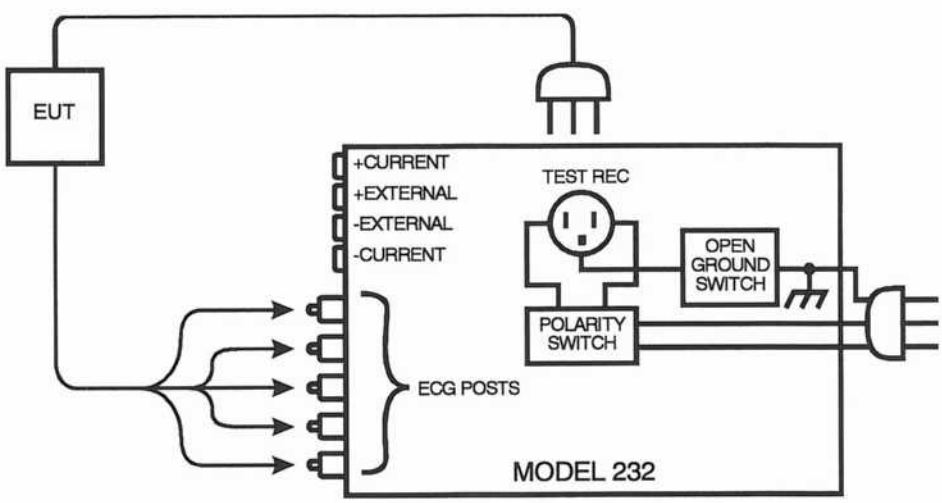


Figure 3-5. *ECG Lead Test Connections*

Chapter 4

Performance Test

The performance test in this chapter checks the operation of the 232D Safety Analyzer. This performance check is usually performed upon the initial receipt of the instrument.

Required Equipment

- **Digital Multimeter (DMM)** — 4½ digits
- **DC Current Source** — 1000 ±10 μA
- **Sine Wave Generator** — 60 Hz to 1 MHz
  10 mV to 1000 mV RMS
- **10-12A 60-Hz Load** — portable electric heater
- **15-A 60-Hz Current Meter** — 1% accuracy
- **Power Receptacle Tester** — Woodhead Model 755P or equivalent
- **Resistors** — 9.31 kΩ, 2 W, 1.0%
  13.0 kΩ, 2 W, 1.0%
  0.1 Ω, 1/8 W, 0.1%

Test Procedure

1. Connect the instrument to an appropriate power source and turn it on.

2. Set **MODE** switch to **SELF TEST**.

   The display should read 1000 ±20, and the **CURRENT SOURCE ACTIVE** LED should illuminate.

3. Set the **MODE** switch to **L1–L2**. Monitor the line voltage.

   The display should read the line voltage ±2 V.

4. Press **DC ONLY**.

   The display should go to .0 or .1.

5. Set the **MODE** switch to **L1–GND**.

   The display should read <5% of the measured value for **L1–L2**.

6. Set the **MODE** switch to **L2–GND**.

   The display should read -0/+5% of the measured value of **L1–L2**.

7. Set the **MODE** switch to **POWER CORD RESISTANCE**.

   The display should be flashing **1999**.

8. Connect a Kelvin cable to the **red EXT** and **red CUR** jacks. Connect the other end of the Kelvin cable to the **GND** pin of the **TEST RECEPTACLE**.

   The display should read <2.0.

9. Set the **MODE** switch to **CASE LEAKAGE μA, EXT LEAD**. Connect a 1000–μA DC current source between the **TEST RECEPTACLE, GND** pin and the Kelvin cable.

   The display should read 1000 ±20 μA.

10. Set the **MODE** switch to **CASE LEAKAGE μA, GROUND CONDUCTOR**. Connect a 1000–μA DC current source between the **TEST RECEPTACLE, GND** pin and chassis ground (front panel screw). Set the **OPEN GROUND** switch to **OPEN**.

    The display should read 1000 ±20 μA.

11. Set the **MODE** switch to **EXTERNAL METER, μA/mV**. Measure the resistance between the **EXT METER** jacks.

The resistance should be between 995 and 1005 Ω.

12. Connect a 1000–mV, 60–Hz sine wave, decoupled through a 100–μF nonpolarized capacitor, to the **EXT METER** jacks. (Decouple the **red** jack; the **black** jack should be ground.)

The display should read 1000 ±20 mV. (The AAMI load will cause a 2.4% error if the sine wave generator has a 50–Ω output resistance and is terminated in 50 Ω.)

13. Switch the sine wave to 100 mV.

The meter should read 100.0 ±2.0 mV.

14. Switch to 10 mV.

The reading should be 10.0 ±2.0 mV.

15. Set the signal generator to 1000 mV at 1000 Hz.

The display should read 724 ±20 mV.

16. Set the signal generator to 1000 mV at 10 kHz.

The display should read 105.0 ±4.0 mV.

17. Set the signal generator to 1000 mV at 100 kHz.

The display should read 14.4 ±4.0 mV.

18. Set the **MODE** switch to **EXT METER, mOHM**. Connect two Kelvin cables to the **EXT METER** and **CURRENT** jacks.

The display should be flashing **1999**.

19. Short the cables together. Move them around to get the minimum reading on the display.

The meter should read <004.

20. Connect the 0.1–Ω resistor to the cables.

The proper reading should be 0.1 ±.002 Ω.

21. Set the MODE switch to ECG. Set the LEADS switch to ALL. Connect a 1000–μA DC current source between any ECG post and the TEST RECEPTACLE, GND pin.

The display should read 1000 ±20.

Check all ECG posts.

22. Set the LEADS switch to RL. Connect the DC current source to the RL binding post.

The display should read 1000 ±20.

Repeat for RA, LA, LL, and V1 binding posts.

23. Set the LEADS switch to the INTERLEAD position of RA–LA. Connect the DC current source to the RA and LA binding posts.

The display should read 1000 ±20.

With the DC current source still connected to the RA and LA posts, ensure that the display reads less than 5.0 μA in the RA–RL and LA–RL switch positions.

Repeat this test with the DC current source connected to the other two INTERLEAD selections of RA–RL and LA–RL. Ensure that the readings are less than 5.0 μA in the other two untested INTERLEAD switch positions.

24. **CAUTION**

Line voltage is applied to the ECG posts when ISO TEST is depressed. Be sure nothing is connected to the ECG POSTS.

Set LEADS switch to ISOLATION TEST. Press ISO TEST.

The display should read <2 μA.

25. Connect any ECG post to ground with ISO TEST depressed.

The display should read 1000 ±100.

26. Set the LEADS switch to ECG PERFORMANCE TEST ENABLE.

The ECG PERFORMANCE Indicator Lamp should light up, and the display should blank.

27. Connect the **ECG LEADS** Binding Posts to an electrocardiograph and check all waveforms.

28. Connect a Power Receptacle Tester to the **TEST RECEPTACLE** and check for proper operation of the **OPEN NEUTRAL, OPEN GROUND,** and **POLARITY** switches.

29. Set the **MODE** switch to **EQUIPMENT CURRENT**. Connect the 10-A 60-Hz load to the **TEST RECEPTACLE**. Monitor the current with the 15-A current meter. Set the **POLARITY** switch to **NORMAL.**

The display should match the current meter within 5%.

Remove the test load.

30. Connect the 13.0–kΩ resistor from **HOT** to **GND** of the **TEST RECEPTACLE**. While not touching the resistor, set the **POLARITY** switch to **NORMAL.** The **GROUND FAULT INTERRUPT** Lamp should not be lighted.

Repeat with the 9.31–kΩ resistor, and the **GROUND FAULT INTERRUPT** Lamp should light up.