

User's Guide

EDU34450A 5½ Digit Digital Multimeter

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Notices

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Waste Electrical and Electronic Equipment (WEEE)

This product complies with the WEEE Directive marking requirement. The affixed product label (see below) indicates that you must not discard this electrical/electronic product in domestic household waste.

Product category: With reference to the equipment types in the WEEE directive Annex 1, this product is classified as “Monitoring and Control instrumentation” product. Do not dispose in domestic household waste.

To return unwanted products, contact your local Keysight office, or see

about.keysight.com/en/companyinfo/environment/takeback.shtml for more information.



Declarations of Conformity

Declarations of Conformity for this product and for other Keysight products may be downloaded from the Web. Go to <https://regulations.about.keysight.com/DoC/default.htm>. You can then search by product number to find the latest Declaration of Conformity.

Safety Information

CAUTION

A CAUTION notice denotes a hazard. It calls attention to an operating 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 CAUTION notice until the indicated conditions are fully understood and met.

WARNING

A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Safety and Regulatory Information

Safety Considerations

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Keysight Technologies assumes no liability for the customer's failure to comply with these requirements.

WARNING**BEFORE APPLYING POWER**

- Verify that the correct fuse is installed.
 - Ensure the mains supply voltage fluctuation do not exceed $\pm 10\%$ of the nominal supply voltage.
-

GROUND THE INSTRUMENT

This product is a Safety Class I instrument (provided with a protective earth terminal). To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument must be connected to the AC power supply mains through a three-conductor power cable, with the third wire firmly connected to an electrical ground (safety ground) at the power outlet. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury. If the instrument is to be energized via an external autotransformer for voltage reduction, be certain that the autotransformer common terminal is connected to the neutral (earthed pole) of the AC power lines (supply mains).

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE OR WET ENVIRONMENTS

Do not operate the device around flammable gases or fumes, vapor, or wet environments.

DO NOT OPERATE DAMAGED OR DEFECTIVE INSTRUMENTS

Instruments that appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Keysight Technologies Sales and Service Office for service and repair to ensure that safety features are maintained. To contact Keysight for sales and technical support, refer to the support links on the following Keysight website: www.keysight.com/find/assist (worldwide contact information for repair and service).

USE THE POWER CORD PROVIDED

Use the device with the power cord provided with the shipment.

USE THE DEVICE AS SPECIFIED

If the device is used in a manner not specified by manufacturer, the device protection may be impaired.

IEC MEASUREMENT CATEGORY II

The HI and LO input terminals may be connected to mains in IEC Category II installations for line voltages up to 300 VAC rms. To avoid the danger of electric shock, do not connect the inputs to mains for line voltages above 300 VAC rms. See "IEC Measurement Category II Overvoltage Protection" on the following page for further information.

OBSERVE ALL DEVICE MARKINGS BEFORE CONNECTING TO DEVICE

Observe all markings on the device before connecting any wiring to the device.

LINE AND CURRENT PROTECTION FUSES

For continued protection against fire, replace the line fuse and the current-protection fuse only with fuses of the specified type and rating.

ENSURE COVER IS SECURED IN PLACE

Do not operate the device with the cover removed or loosened. Only qualified, service-trained personnel should remove the cover from the instrument.

PROTECTION LIMITS

To avoid instrument damage and the risk of electric shock, do not exceed any of the Protection Limits defined in the following section.

ENSURE TEST LEAD IS USED AS SPECIFIED

If the Test Leads are used in a manner not specified by Keysight Technologies, the protection provided by the Test Leads may be impaired. Also, do not use a damaged or worn Test Lead. Instrument damage or personal injury may result.

MEASURING VOLTAGES GREATER THAN 30 VRMS, 42 VPK, OR 60VDC

Measuring voltages greater than 30 Vrms, 42 Vpk, or 60 Vdc is always hazardous. ALL multimeter terminals must be considered as hazardous whenever inputs are greater than 30 Vrms, 42 Vpk, or 60 Vdc are connected to ANY input terminal. Regard all terminals as being at the same potential as the highest voltage applied to any terminal.

AC POWER CORD

Removal of the AC power cord is the disconnect method to remove power from the instrument. Be sure to allow for adequate access to the power cord to permit disconnection from AC power. Use only the Keysight specified power cord for the country of use or one with equivalent ratings.

DO NOT EXCEED MEASUREMENT LIMIT

Do not exceed any measurement limits defined in the specifications to avoid instrument damage and the risk of electric shock.

OPERATING IN REMOTE MODE

When operating in remote mode, measurements will be triggered by remote computer and will not be updated continuously on the instrument display. Always refer to the remote computer for actual measurement.

CAUTION CLEAN WITH SLIGHTLY DAMPENED CLOTH

Clean the outside of the instrument with a soft, lint-free, slightly dampened cloth. Do not use detergent, volatile liquids, or chemical solvents.

PRESENCE OF AMBIENT ELECTROMAGNETIC (EM) FIELDS AND NOISE

Degradation of some product specifications can occur in the presence of ambient electromagnetic (EM) fields and noise that are coupled to the power line or I/O cables of the instrument. The instrument will self-recover and operate to all specifications when the source of ambient EM field and noise are removed or when the instrument is protected from the ambient EM field or when the instrument cabling is shielded from the ambient EM noise.

CAUTION WHEN WORKING WITH VOLTAGES ABOVE 30 VRMS, 42 VPK, OR 60 VDC

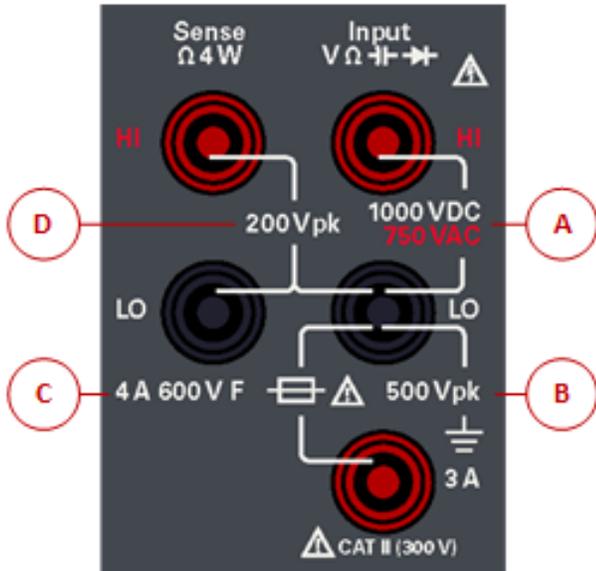
Use with caution when working with voltages above 30 Vrms, 42 Vpk or 60 Vdc. These voltages pose a shock hazard.

CAUTION WHEN CONNECTING OPEN LEADS TO THE HI SENSE AND LO SENSE TERMINALS

When not in use, the Hi sense and Lo sense terminals will not be connected. Do not connect open leads to these terminals or disconnect these terminals with an external device.

Protection Limits

The Keysight EDU34450A 5½ Digital Multimeter provides protection circuitry to prevent damage to the instrument and to protect against the danger of electric shock, provided that the Protection Limits are not exceeded. To ensure safe operation of the instrument, do not exceed the Protection Limits shown on the front panel, as defined below:



Input Terminal Protection Limits

Protection Limits are defined for the input terminals:

Main Input (HI and LO) Terminals. The HI and LO input terminals are used for voltage, resistance, capacitance, and diode test measurements. Two Protection Limits are defined for these terminals:

- **HI to LO Protection Limit.** The Protection Limit from HI to LO ("A" in the figure above) is 1000 VDC or 750 VAC, which is also the maximum voltage measurement. This limit can also be expressed as 1000 Vpk maximum.
- **LO to Ground Protection Limit.** The LO input terminal can safely "float" a maximum of 500 Vpk relative to ground. This is Protection Limit "B" in the figure above.

Although not shown on the figure, the Protection Limit for the HI terminal is a maximum of 1000 Vpk relative to the ground. Therefore, the sum of the "float" voltage and the measured voltage must not exceed 1000 Vpk.

Current Input Terminal. The current input ("I") terminal has a Protection Limit of 3 A (rms) maximum current flowing from the LO input terminal. This is Protection Limit "C" in the figure above. Note that the current input terminal will be at approximately the same voltage as the LO terminal.

NOTE

The current-protection circuitry includes a fuse on the front panel. To maintain protection, replace this fuse only with a fuse of the specified type and rating.

Sense Terminal Protection Limits

The HI and LO sense terminals are used only for four-wire resistance measurements (" Ω 4W"). The Protection Limit is 200 Vpk for all of the terminal pairings ("D" in the figure above):

- LO sense to LO input.
- HI sense to LO input.
- HI sense to LO sense.

NOTE

The 200 Vpk limit on the sense terminals is the Protection Limit. Operational voltages in resistance measurements are much lower - less than 5 V in normal operation.

IEC Measurement Category II Overvoltage Protection

To protect against the danger of electric shock, the Keysight EDU34450A 5½ Digit Multimeter provides overvoltage protection for line-voltage mains connections meeting both of the following conditions:

- The HI and LO input terminals are connected to the mains under Measurement Category II conditions, defined below, and
- The mains are limited to a maximum line voltage of 300 VAC rms.

IEC Measurement Category II includes electrical devices connected to mains at an outlet on a branch circuit. Such devices include most small appliances, test equipment, and other devices that plug into a branch outlet or socket. The EDU34450A may be used to make measurements with the HI and LO inputs connected to mains in such devices, or to the branch outlet itself (up to 300 VAC rms). However, the EDU34450A may not be used with its HI

and LO inputs connected to mains in permanently installed electrical devices such as the main circuit-breaker panel, sub-panel disconnect boxes, or permanently wired motors. Such devices and circuits are subject to overvoltages that may exceed the protection limits of the EDU34450A.

Voltages above 300 VAC rms may be measured only in circuits that are isolated from mains. However, transient overvoltages are also present on circuits that are isolated from mains. The EDU34450A is designed to safely withstand occasional transient overvoltages up to 2500 Vpk. Do not use this multimeter to measure circuits where transient overvoltages could exceed this level.

Safety Symbols

Symbol	Description
	Caution, risk of danger (refer to the manual for specific Warning or Caution information)
	Protective earth (ground) terminal.
	Earth ground
CAT II 300 V	IEC Measurement Category II. Inputs may be connected to mains (up to 300 VAC rms) under Category II overvoltage conditions.
WARNING	The WARNING sign denotes a hazard. It 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	The CAUTION sign denotes a hazard. It calls attention to an operating procedure, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond CAUTION sign until the indicated conditions are fully understood and met.
NOTE	The NOTE sign denotes important information. It calls attention to a procedure, practice, condition or the like, which is essential to highlight.

Regulatory Markings

Symbol	Description
	The RCM mark is a registered trademark of the Australian Communications and Media Authority.
	The CE mark is a registered trademark of the European Community. This CE mark shows that the product complies with all the relevant European Legal Directives. ICES/NMB-001 indicates that this ISM device complies with the Canadian ICES-001. Cet appareil ISM est conforme a la norme NMB-001 du Canada. ISM GRP.1 Class A indicates that this is an Industrial Scientific and Medical Group 1 Class A product.
	This symbol indicates the time period during which no hazardous or toxic substance elements are expected to leak or deteriorate during normal use. Forty years is the expected useful life of the product.
	This symbol is a South Korean Class A EMC Declaration. This is a Class A instrument suitable for professional use and in electromagnetic environment outside of the home.
	The CSA mark is a registered trademark of the Canadian Standards Association.
	This instrument complies with the WEEE Directive marking requirement. This affixed product label indicates that you must not discard this electrical or electronic product in domestic household waste.

South Korean Class A EMC declaration:

Information to the user:

This equipment has been conformity assessed for use in business environments. In a residential environment this equipment may cause radio interference.

- This EMC statement applies to the equipment only for use in business environment.

사용자 안내문

이 기기는 업무용 환경에서 사용할 목적으로 적합성평가를 받은 기기로서 가정용 환경에서 사용하는 경우 전파간섭의 우려가 있습니다.

- 사용자 안내문은 “업무용 방송통신기자재”에만 적용한다.

Safety and EMC Requirements

This power supply is designed to comply with the following safety and EMC (Electromagnetic Compatibility) requirements:

- Low Voltage Directive 2014/35/EU
- EMC Directive 2014/30/EU

Environmental Conditions

This instrument is designed for indoor use and in an area with low condensation. The table below shows the general environmental requirements for this instrument.

Environmental Condition	Requirement
Temperature	Operating condition: 0 °C to 55 °C Storage condition: -40 °C to 70 °C
Humidity	Full accuracy to 80% RH at 0 °C to 30 °C (non-condensing) Full accuracy to 40% RH at 30 °C to 55 °C (non-condensing)
Altitude	3000 m
Pollution degree	2
Power supply and line frequency	100, 120, 220 , 240 V 50/60 Hz
Power consumption	13 VA max

1 Introduction to the Instrument

[Instrument at a Glance](#)

[Front Panel at a Glance](#)

[Front Panel Display at a Glance](#)

[Front Panel Buttons at a Glance](#)

[Rear Panel at a Glance](#)

[Fuse Information](#)

[Instrument Dimensions](#)

The Keysight EDU34450A 5½ Digit Multimeter is capable of providing a wide range of measurement functions such as DC voltage, DC current, True RMS AC voltage and AC current, 2-wire and 4-wire resistance, frequency, diode test, continuity, capacitance, and temperature measurements.

Instrument at a Glance

The Keysight EDU34450A 5½ Digit Digital Multimeter offers full range of measurement capabilities with class-leading display and user interface.

Key features:

- Eleven measurement functions; DCV, DCI, True RMS ACV, ACI, 2- and 4-wire resistance, frequency, continuity, diode test, capacitance, and temperature
- Intuitive 7-inch WVGA dual-measurement color display
- Basic DCV accuracy of 0.015% for 1 V
 - 100 mV: 0.018%
 - 1 V: 0.015%
 - 10 V: 0.025%
 - 100 V: 0.025%
 - 1000 V: 0.027%
- Up to 5,000 points data-logging memory
- USB and LAN PC connectivity
- PathWave BenchVue software included

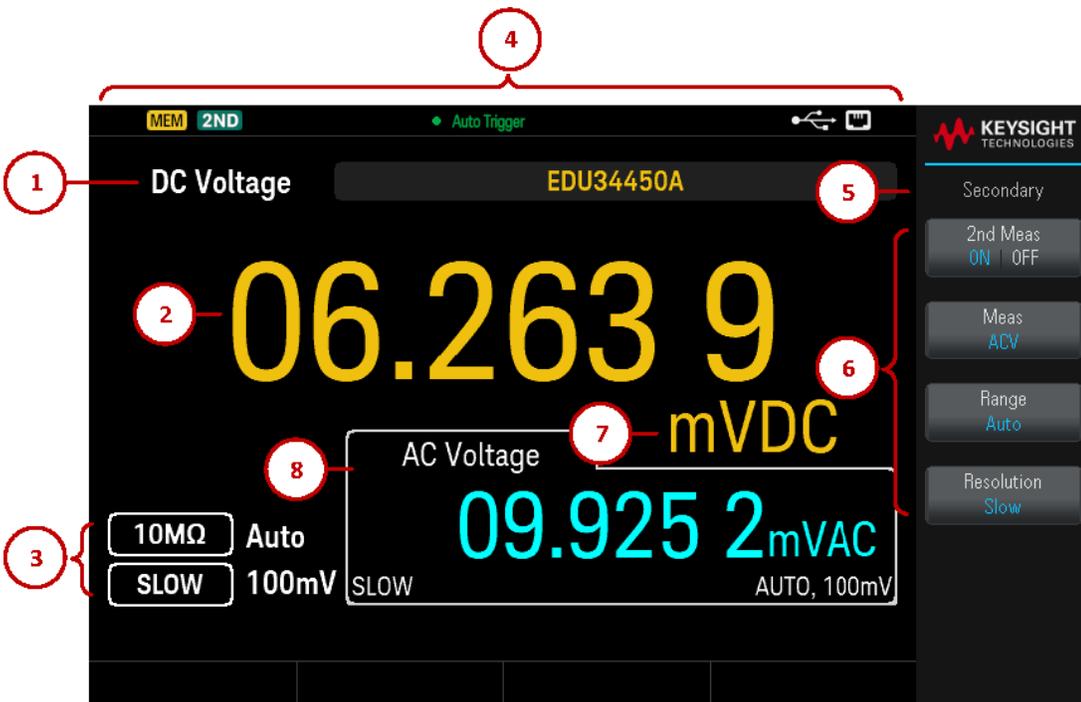
Front Panel at a Glance



Legend	Description
1	7-inch WVGA display

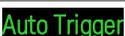
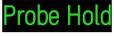
Legend	Description
2	[ON/OFF] switch
3	USB port – allows an external USB flash drive to be connected to the instrument
	<p>NOTE The EDU34450A supports USB flash drives with the following specification: USB 2.0, FAT32 format, up to 32 GB. We recommend using a SanDisk Cruzer Blade flash drive for the front panel USB port.</p>
4	[Back] button
	<p>NOTE Press and hold [Back] button for more than 3 seconds with an external USB flash drive connected to automatically capture the instrument screen. The captured image will be saved to the connected USB flash drive.</p>
5	Menu softkeys
6	[Enter] button and arrow keys
7	Measurement buttons
8	Primary: [Display], [Acquire], [Run/Stop], [Store/Recall], and [Null] buttons Secondary: 2nd (secondary display), Probe Hold, Utility, and Math buttons
9	[-], Range, and [+] buttons
10	[Shift] Local button
11	Input terminals
12	Fuse holder

Front Panel Display at a Glance

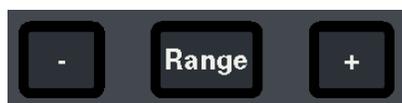


Legend	Description
1	Primary measurement function name
2	Primary measurement value
3	Primary measurement parameters
4	Instrument status indicators
5	Softkey menu name
6	Softkey labels
7	Measurement unit
8	Secondary measurement function, value, and parameters (when turned ON)

Instrument Status Indicators

Legend	Description
	USB flash drive is connected
	LAN is connected
	Instrument in remote mode
	Secondary measurement is turned on.
	Data is logged through data log operation.
	Shift is enabled.
	Instrument is running in continuous mode.
	Probe hold is turned on.
	Data log have been turned on; instrument is waiting for data log trigger.
	Data log is running.
	Only available for remote mode, shown when READ? is sent to the instrument.  is shown after the instrument has captured a reading.
	Only available for remote mode, shown when bus trigger is selected.  is shown after INIT command is sent to the instrument and the instrument has captured a reading.
	Only available in remote mode, shown when bus trigger is selected and INIT command is sent to the instrument.
	Only available when trigger delay is set more than 0 s with data log enabled, shown after Run/Stop is pressed.

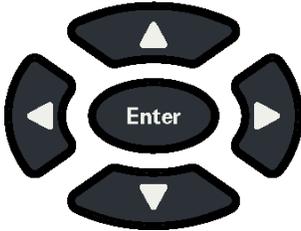
Front Panel Buttons at a Glance



Legend	Description
[DCV]	Press to enable DC voltage measurement.
[ACV]	Press to enable AC voltage measurement.
[Ω2W]	Press to enable 2-wire resistance measurement.
Ω4W	Press [Shift] then press [Ω2W] to enable 4-wire resistance measurement.
[Cont]	Press to enable continuity tests.
→+	Press [Shift] then press [Cont] to enable diode measurements.
[DCI]	Press to enable DC current measurement.
[ACI]	Press to enable AC current measurement.
[Freq]	Press to enable frequency measurement.
[Temp]	Press to enable temperature measurement.
⇄	Press [Shift] then press [Temp] to enable capacitance measurement.
[Display]	Press to access the Display menu.
2nd	Press [Shift] then press [Display] to access the Secondary menu.
[Acquire]	Press to acquire a measurement.
Probe Hold	Press [Shift] then press [Acquire] to access the Probe Hold menu.
[Run/Stop]	Press to access the Run/Stop menu.
[Store/Recall]	Press to access the Store/Recall menu.
Utility	Press [Shift] then press [Store/Recall] to access the Utility menu.
[Null]	Press to trigger the null function.
Math	Press [Shift] then press [Null] to enable the Math menu.
[Shift]	Press to access a button's secondary function.

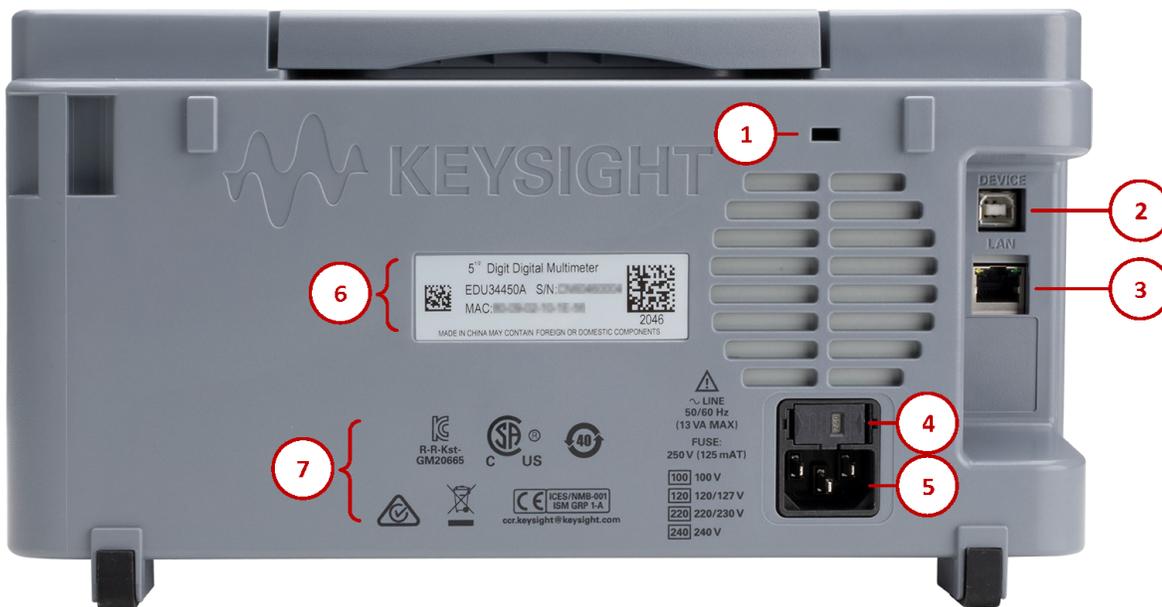
Legend	Description
Local	Press during remote control to regain access to the front panel buttons.
[-] and [+]	Press to decrease or increase the measurement range. This will set the instrument to manual range.
[Range]	Press to enable auto range.

Front Panel Navigation



Use the arrow keys to navigate menus and adjust values. Use **[Enter]** to confirm your selection.

Rear Panel at a Glance



Legend	Description
1	Kensington lock
2	Universal Serial Bus (USB-B) interface connector
3	Local Area Network (LAN) interface connector
4	AC line fuse
5	AC power connector
6	Instrument serial number and MAC address

Legend	Description
7	Instrument safety and regulatory labels

WARNING This is a Protection Class 1 equipment (chassis must be connected to a protective earth ground). The mains plug shall only be inserted in an outlet provided with a Protective Earth Terminal.

Fuse Information

Current Input Fuse Replacement

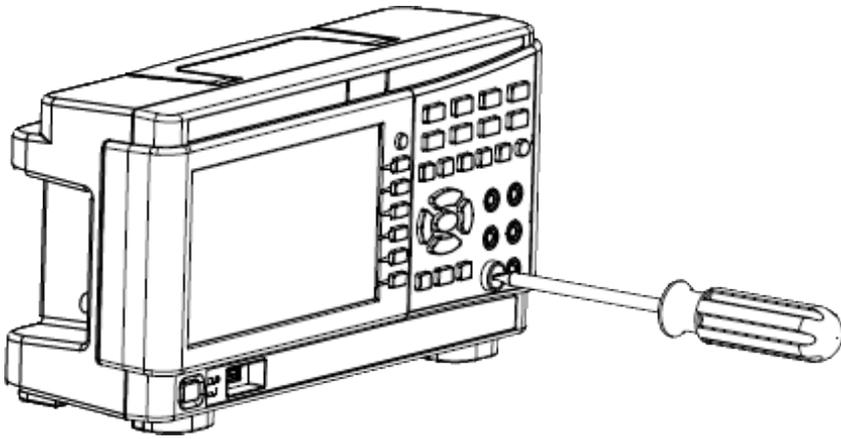
The following table describes the fuse that you should use.

Fuse Part Number	Description	Fuse Type
EDU34450-36202	Fuse 4 A, 600 V, 6 x 32 mm, Ceramic Fast-Acting	Cartridge

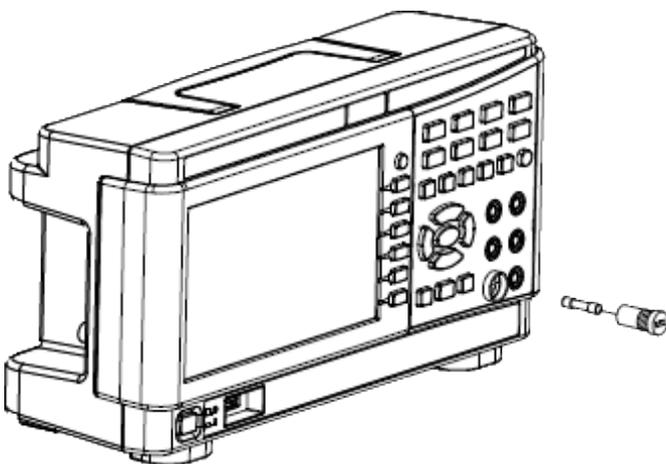
If you have determined that the current input fuse is faulty, replace it with one of the same size and rating.

To replace a blown fuse, follow the three steps shown below:

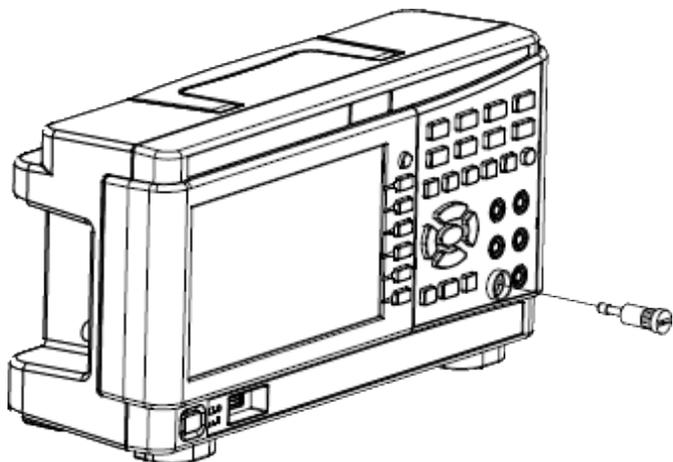
1. The current input fuse can be found in the instrument's front panel. Using a slotted (flat head) screwdriver, turn the fuse holder clockwise to remove it from the instrument.



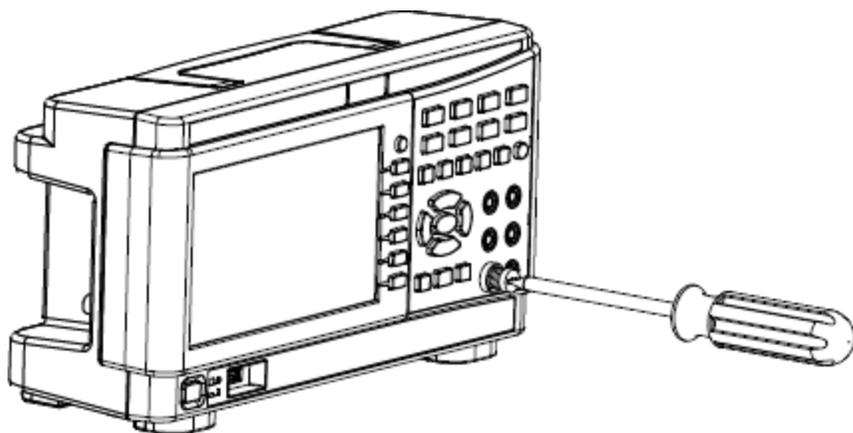
2. Remove the blown fuse from the fuse holder and insert the proper replacement fuse into the fuse holder.



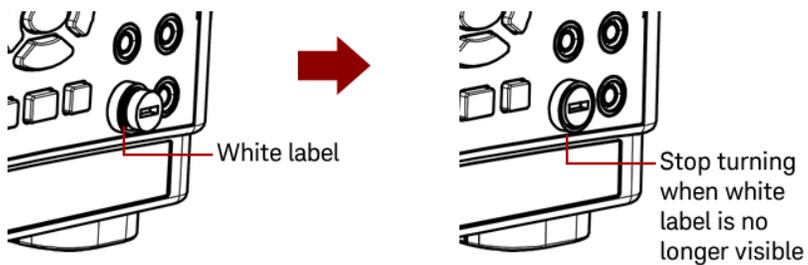
3. Re-insert the fuse holder into the instrument.



4. Use a slotted (flat head) screwdriver to turn the fuse holder anti-clockwise to secure it into the instrument.



(Turn the fuse holder until the white label is no longer visible.)



CAUTION Stop turning the fuse holder when the white label is no longer visible. Do not over-tighten as the plastic fuse holder may crack if it is over-tightened.

Power Line Fuse Replacement

The power line fuse is located within the instrument's fuse-holder assembly on the rear panel. The multimeter is shipped from the factory with a power-line fuse installed.

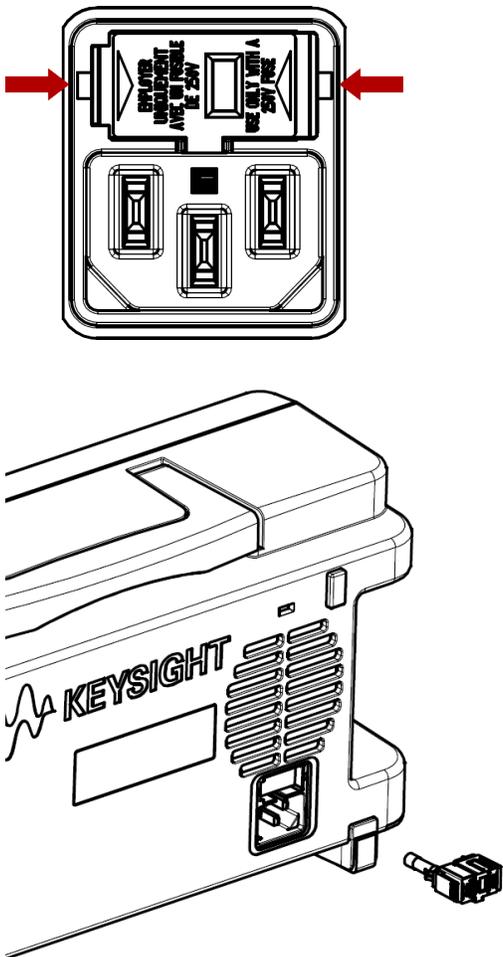
The following table describes the fuse that you should use.

Fuse Part Number	Fuse Description	Fuse Type
EDU34450-36200	Fuse 125 mA, Glass, 5 x 20 mm Slow Blow	Cartridge

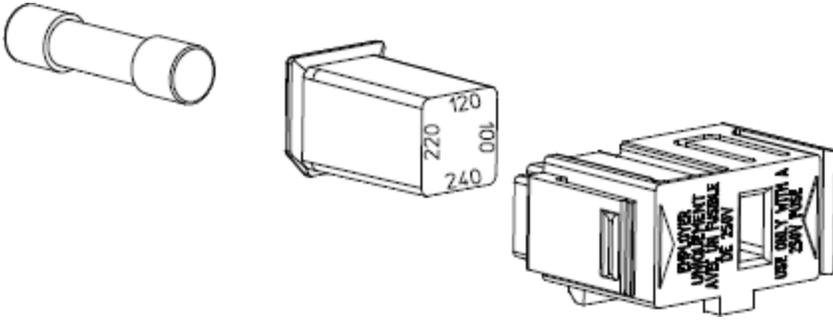
If you have determined that the power line fuse is faulty, replace it with one of the same size and rating.

To replace a blown fuse, follow the four steps shown below:

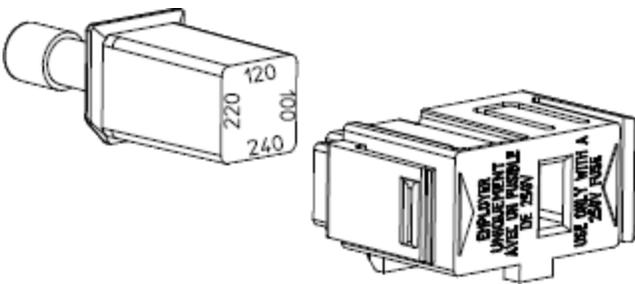
1. The power line fuse can be found in the instrument's rear panel. Disconnect the power cord. Use your fingertips to depress the left and right tabs, and then remove the fuse holder by pulling it out.



- Remove the line voltage selector from the fuse holder and remove the blown fuse from the line voltage selector.



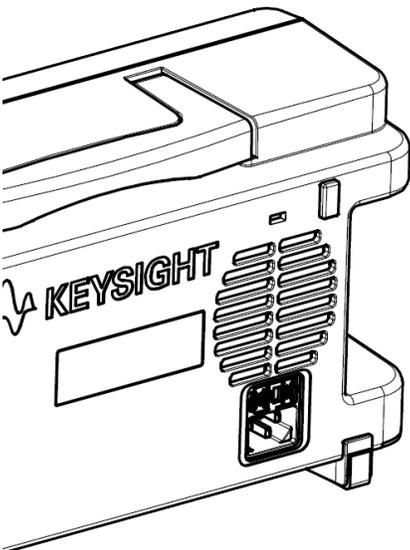
- Insert the proper replacement fuse into the line voltage selector and reinstall so that the correct voltage appears in the fuse holder window.



NOTE

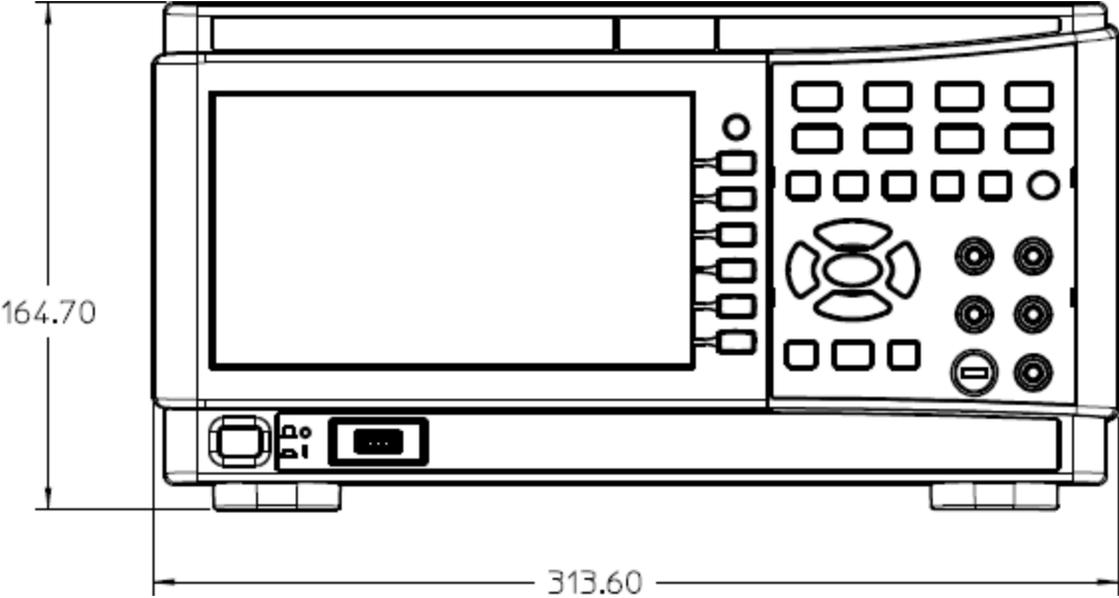
To change the instrument's line voltage rating (100 V, 120 V, 220 V, or 240 V), rotate the line voltage selector so that the desired voltage appears in the fuse holder window.

- Re-insert the fuse holder into the instrument. Ensure that you hear a "click" when securing the fuse holder to the instrument.

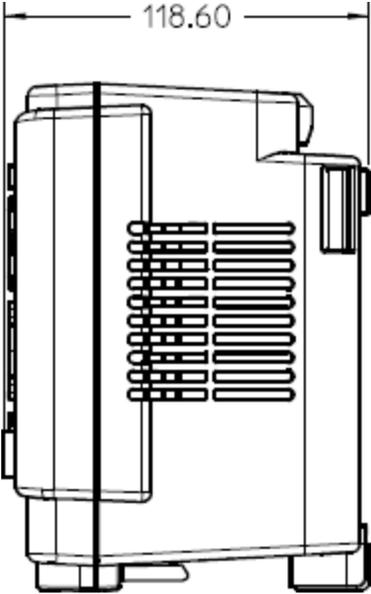


Instrument Dimensions

Height: 164.70 mm x Width: 313.60 mm



Length: 118.60 mm



2 Getting Started

[Prepare the Instrument for Use](#)

[Take a Measurement](#)

[Select a Range](#)

[Use the Built-in Help System](#)

[Remote Interface Connections](#)

[Remote Interface Configurations](#)

This section describes basic procedures to help you get started quickly with the instrument.

Prepare the Instrument for Use

When you receive your instrument, inspect it for any obvious damage that may have occurred during shipment. If there is damage, notify the shipping carrier and nearest Keysight Sales and Support Office immediately. Refer to www.keysight.com/find/assist.

Until you have checked out the instrument, save the shipping carton and packing materials in case the unit has to be returned. Check the list below and verify that you have received these items with your instrument. If anything is missing, please contact your nearest Keysight Sales and Support Office.

- Quick Start Guide
- AC power cord (for country of destination)
- A set of test leads (EDU34450-62100)
- Certificate of Calibration and Shelf Life Notice
- Keysight Safety Leaflet (9320-6797)
- RoHS Addendum for Digital Multimeters (China) (9320-6661)

Documentation and Firmware Revisions

The documentation listed below can be downloaded for free through our website at www.keysight.com/find/EDU34450A-manual

- Keysight EDU34450A 5½ Digit Digital Multimeter Quick Start Guide. Printed copy, included with your instrument.
- Keysight EDU34450A 5½ Digit Digital Multimeter User's Guide. This manual.
- Keysight EDU34450A 5½ Digit Digital Multimeter Programmer's Reference.
- Keysight EDU34450A 5½ Digit Digital Multimeter Service Guide.

For the latest firmware revision and firmware update instruction, go to www.keysight.com/find/EDU34450A-sw.

Recommended Calibration Interval

Keysight Technologies recommends a one-year calibration cycle for this instrument.

Set Up the Instrument

Place the instrument's feet on a flat, smooth horizontal surface. Attach the power cable to the rear panel, then plug it into main power. Connect the LAN or USB cables as desired, and you may also secure the instrument with a security lock cable. Finally, turn the instrument on using the front-panel **[On/Off]** button.

WARNING Do not apply any voltage to the instrument inputs until all terminals are properly connected. Plugging or unplugging the test lead while high voltage is applied can cause instrument damage, and may increase the risk of electric shock.

DC Voltage Parameters

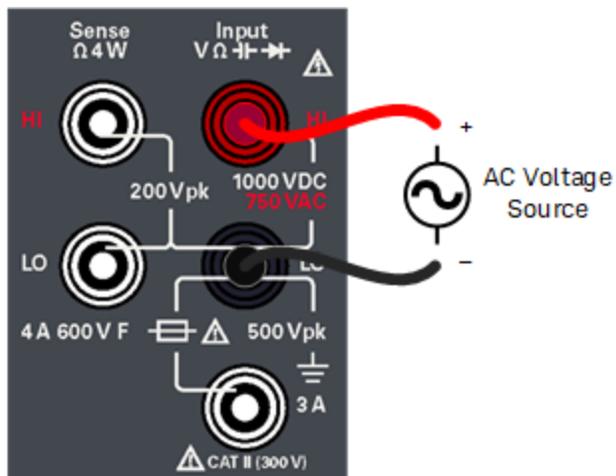
- Measurement Range: 100.000 mV, 1.00000 V, 10.0000 V, 100.000 V, 1000.00 V
- Speed: Slow, Medium, Fast
- Default Setting: Autoranging, Slow measurement speed
- Measurement Method: Sigma Delta A-to-D converter
- Input Impedance: >10 G Ω selected range (0.1 V and 1 V only) or ~10 M Ω all ranges (typical)
- Input Protection: 1000 V on all ranges (HI terminal)

Measuring AC (RMS) Voltage

1. Press [ACV].



2. Connect the terminals as shown below.



3. Read the display.

Press **Resolution** to change the reading speed to either **Slow**, **Medium**, or **Fast**.

WARNING Do not apply any voltage to the instrument inputs until all terminals are properly connected. Plugging or unplugging the test lead while high voltage is applied can cause instrument damage, and may increase the risk of electric shock.

AC Voltage Parameters

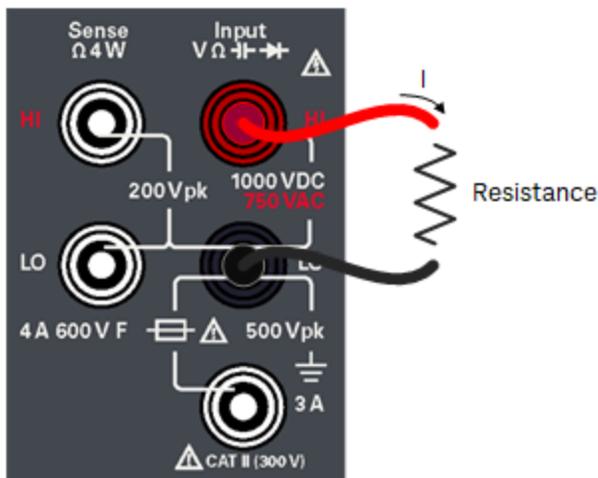
- Measurement Range: 100.000 mV, 1.00000 V, 10.0000 V, 100.000 V, 750.00 V
- Speed: Slow-2 Hz High Pass Filter (HPF), Medium-20 Hz HPF, Fast-200 Hz HPF
- Default Setting: Autoranging, Slow measurement speed
- Measurement Method: AC coupled true RMS - measures the AC component with up to 400 VDC bias on any range
- Crest Factor: Maximum 3:1 at full scale
- Input Impedance: $>1.1 \text{ M}\Omega$ in parallel with $<100 \text{ pF}$ on all ranges
- Input Protection: 750 V rms on all ranges (HI terminal)

Measuring 2-Wire Resistance

1. Press [**Ω2W**].



2. Connect the terminals as shown below.



3. Read the display.
 - Press **Resolution** to change the reading speed to either **Slow**, **Medium**, or **Fast**.
 - Press **OCOMP** to enable (**ON**) or disable (**OFF**) the offset compensation.

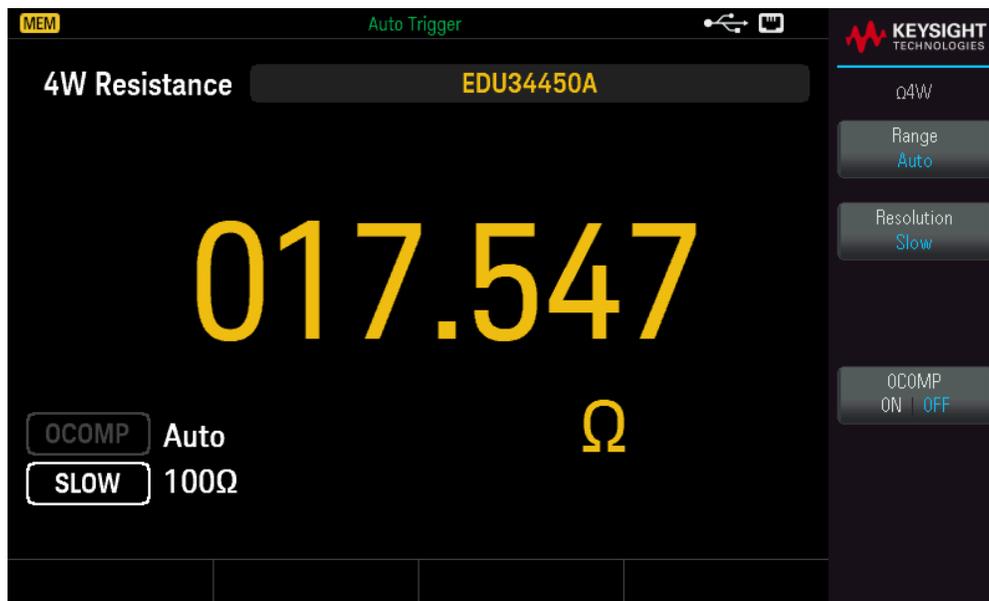
2-Wire Resistance Parameters

- Measurement Range: 100.000 Ω, 1.00000 kΩ, 10.0000 kΩ, 100.000 kΩ, 1.00000 MΩ, 10.0000 MΩ, 100.000 MΩ.
- Speed: Slow, Medium, Fast

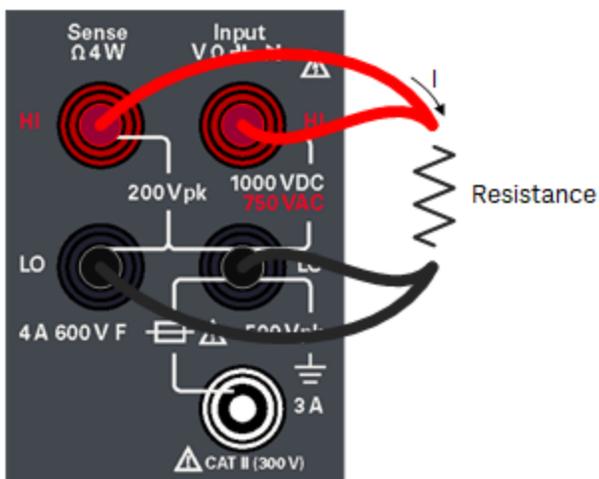
- Default Setting: Autoranging, Slow measurement speed
- Measurement Method: 2-wire ohms
- Input protection: 1000 V on all ranges (HI terminal)

Measuring 4-Wire Resistance

1. Press **[Shift]** > **[Ω2W]** | **Ω4W**.



2. Connect the terminals as shown below.



3. Read the display.
 - Press **Resolution** to change the reading speed to either **Slow**, **Medium**, or **Fast**.
 - Press **OCOMP** to enable (**ON**) or disable (**OFF**) the offset compensation.

4-Wire Resistance Parameters

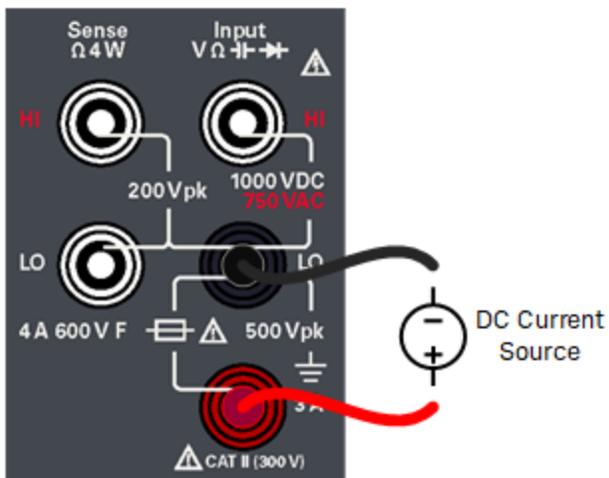
- Measurement Range: 100.000 Ω , 1.00000 k Ω , 10.0000 k Ω , 100.000 k Ω , 1.00000 M Ω , 10.0000 M Ω , 100.000 M Ω .
- Speed: Slow, Medium, Fast
- Default Setting: Autoranging, Slow measurement speed
- Measurement Method: 4-wire ohms
- Input protection: 1000 V on all ranges (across HI-LO terminals), 200 V (across HI Sense-LO Sense terminals).

Measuring DC Current

1. Press [DCI].



2. Connect the terminals as shown below.



3. Read the display.

Press **Resolution** to change the reading speed to either **Slow**, **Medium**, or **Fast**.

DC Current Parameters

- Measurement Range: 10.0000 mA, 100.000 mA, 1.00000 A, 3.0000 A
- Speed: Slow, Medium, Fast
- Default Setting: Autoranging, Slow measurement speed
- Shunt Resistance: 1 Ω for 10 mA and 100 mA, and 0.1 Ω for 1 A and 3 A ranges

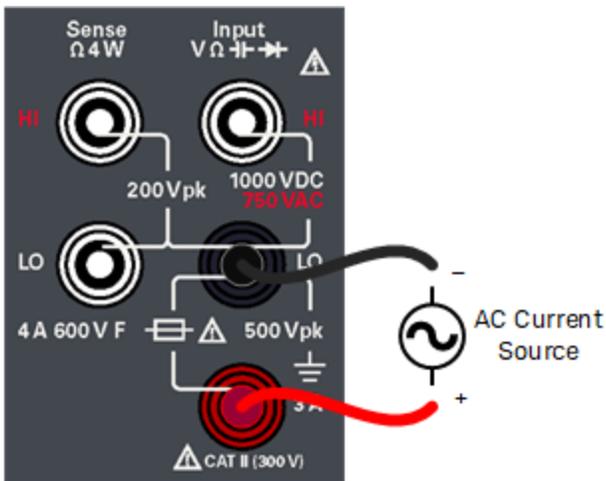
- Input Protection: Front panel, 4 A 600 V ceramic fast-acting fuse

Measuring AC Current

1. Press [ACI].



2. Connect the terminals as shown below.



3. Read the display.

Press **Resolution** to change the reading speed to either **Slow**, **Medium**, or **Fast**.

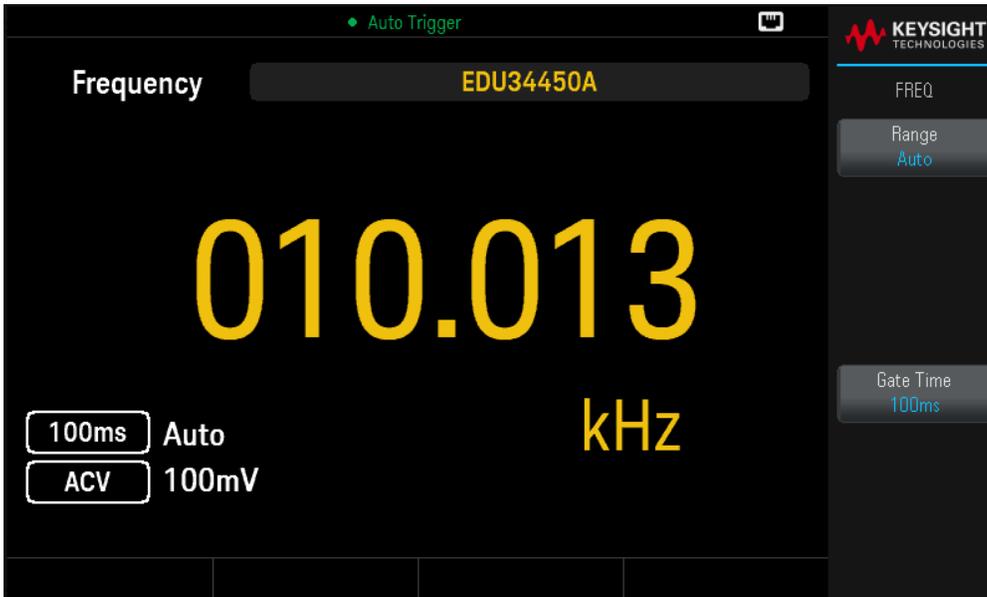
AC Current Parameters

- Measurement Range: 10.0000 mA, 100.000 mA, 1.00000 A, 3.0000 A
- Speed: Slow-2 Hz High Pass Filter (HPF), Medium-20 Hz HPF, Fast-200 Hz HPF

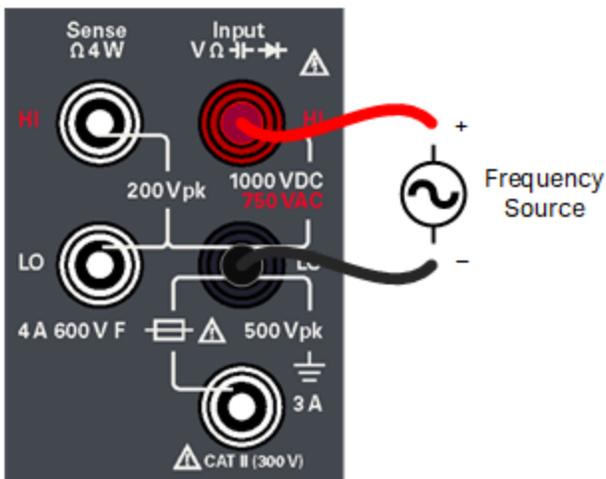
- Default Setting: Autoranging, Slow measurement speed
- Shunt Resistance: 1 Ω for 10 mA and 100 mA, and 0.1 Ω for 1 A and 3 A ranges
- Input Protection: Front panel, 4 A 600 V ceramic fast-acting fuse

Measuring Frequency for Voltage

1. Press [ACV] > [Freq].



2. Connect the terminals as shown below.



3. Read the display.

Press **Gate Time** to change the gate time to either **100ms** or **1s**.

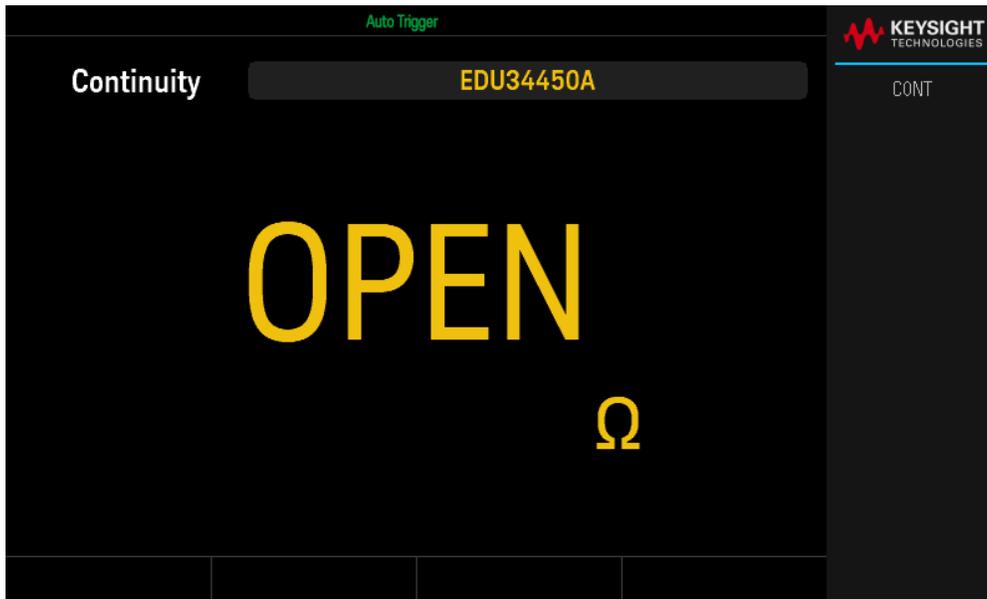
Frequency for Voltage Parameters

- Measurement Range: 100.000 mV, 1.00000 V, 10.0000 V, 100.000 V, 750.00 V (Range is based on the voltage level of the signal, not frequency.)
- Measurement Method: Reciprocal counting technique
- Signal Level: 10% of range to full scale input on all ranges except where noted. 100 mV range specifications are for full scale or greater inputs. For inputs from 10 mV to 100 mV (in the 100 mV range), multiply the total % of reading error by 10.
- Gate Time: 1 second (slow mode) or 0.1 second (medium mode)
- Input Protection: 750 V rms on all ranges (HI terminal)

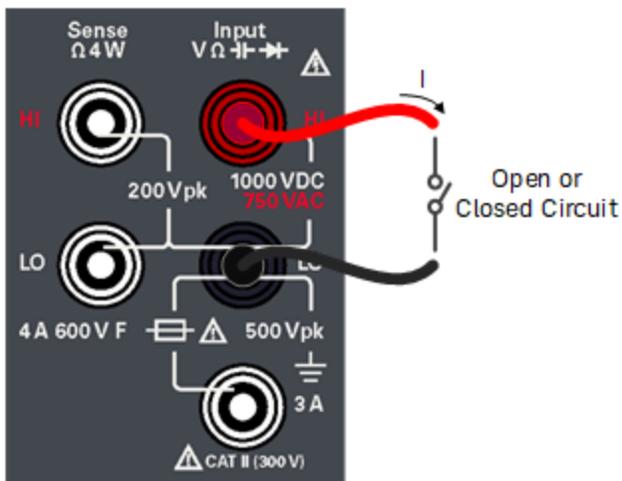
- Signal Level: 10% of range to full scale input on all ranges except where noted. 10 mA range specifications are for full scale or greater inputs. For inputs from 1 mA to 10 mA (in the 10 mA range), multiply the total % of reading error by 10.
- Gate Time: 1 second (slow mode) or 0.1 second (medium mode)
- Input Protection: Front panel, 4 A 600 V ceramic fast-acting fuse

Testing Continuity

1. Press [Cont].



2. Connect the terminals as shown below.



3. Read the display.

A resistance value is observed if the circuit is closed, and OPEN is observed if the circuit is open.

Continuity Parameters

- Measurement Method: 0.5 mA (typical) constant current source
- Response Time: 100 samples/second with audible tone
- Continuity Threshold: 10 Ω fixed

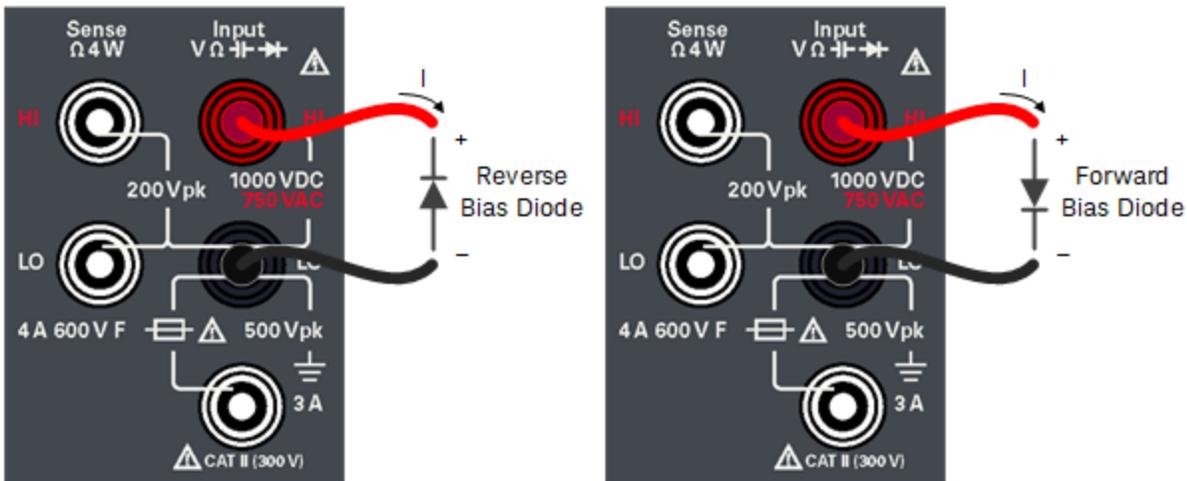
- Input Protection: 1000 V (HI terminal)

Testing Diodes

1. Press **[Shift]** > **[Cont]** | **↔**.



2. Connect the terminals as shown below (either to test the reverse bias diode position or the forward bias diode position).



3. Read the display.

- For the reverse bias diode position: OPEN is observed if the diode is good.
- For the forward bias diode position: A value ranging from 0.3 to 0.8 V is observed if the diode is good (for most silicon diodes).
- If OPEN is observed on both directions, the diode is bad.
- If a 0 V to 0.4 V drop is observed on both directions, the diode is shorted.

Press **Beeper** to enable (ON) or disable (OFF) the beeper.

Diode Parameters

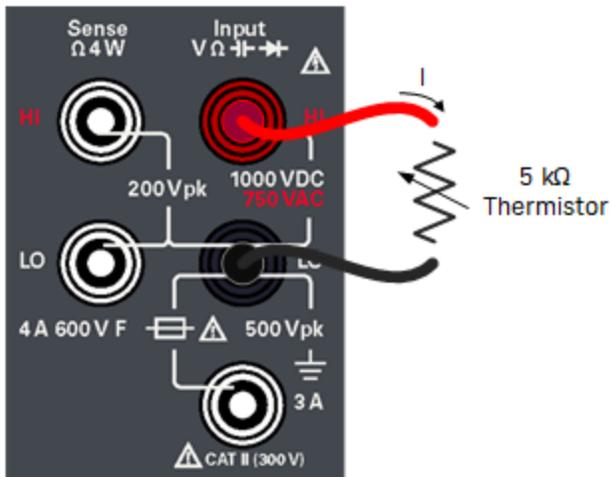
- Measurement Method: 0.5 mA (typical) constant current source
- Response Time: 100 samples/second with audible tone
- Input Protection: 1000 V (HI terminal)

Measuring Temperature

1. Press [Temp].



2. Connect the terminals as shown below.



3. Read the display.

Press **Units** to switch the temperature units between degree Celsius (°C) or degree Fahrenheit (°F).

Temperature Parameters

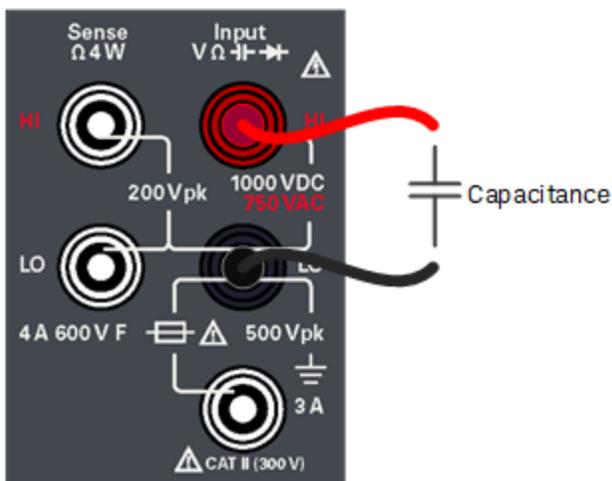
- Measurement Range: -80.0 °C to 150.0 °C, -110.0 °F to 300.0 °F
- Measurement Method: 2-wire Ohms measurement of 5 kΩ thermistor sensor (E2308A) with computed conversion
- Input Protection: 1000 V (HI terminal)
- Optional Accessory: E2308A Thermistor Temperature Probe

Measuring Capacitance

1. Press **[Shift]** > **[Temp]** | **⇄**.



2. Connect the terminals as shown below.



3. Read the display.

Capacitance Parameters

- Measurement Range: 1.000 nF, 10.00 nF, 100.0 nF, 1.000 μ F, 10.00 μ F, 100.0 μ F, 1.000 mF, 10.00 mF
- Default Setting: Autoranging
- Measurement Method: Computed from constant current source charge time. Typical 0.12 V to 1.0 V AC signal level
- Input Protection: 1000 V (HI terminal)

Select a Range

You can let the multimeter automatically select the range using autoranging, or you can select a fixed range manually. Autoranging is convenient because the multimeter automatically senses and selects the appropriate range for each measurement. However, manually selecting the range results in better performance, since the multimeter does not have to determine which range to use for each measurement.

The default setting for all measurement functions is autoranging.

Press [+] to disable autoranging and manually select an upper range, or

Press [-] to disable autoranging and manually select a lower range.

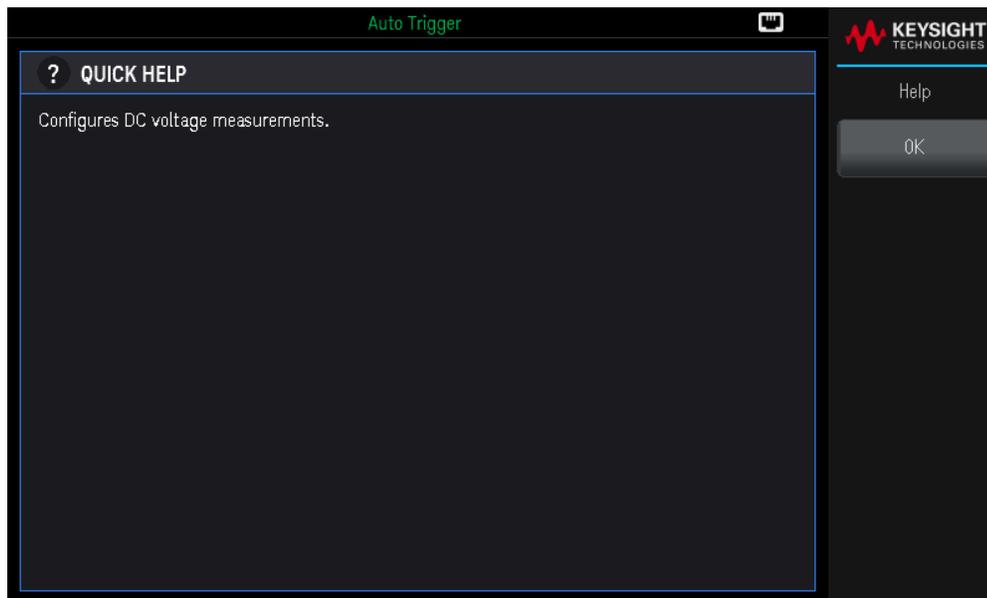
Press [Range] to enable autoranging again.

Use the Built-in Help System

The built-in help system provides context-sensitive help on any front panel key or menu softkey. A list of help topics is also available to assist you with several front panel operations.

View the Help Information for a Button or Softkey

Press and hold any softkey or front panel button, such as [DCV].



If the message contains more information than will fit on the display, press the down arrow softkey to view the remaining information.

Press **OK** to exit Help.

NOTE**Local Language Help**

All messages, context-sensitive help, and help topics are available in English, French, German, Spanish, Simplified Chinese, Traditional Chinese, Japanese, Korean, and Russian. All messages, context-sensitive help, and help topics appear in the selected language. The softkey labels and status line messages are not translated and are always in English. To select the language, press **[Shift] > [Store/Recall] | Utility > User Settings > Language**. Then select the desired language.

Remote Interface Connections

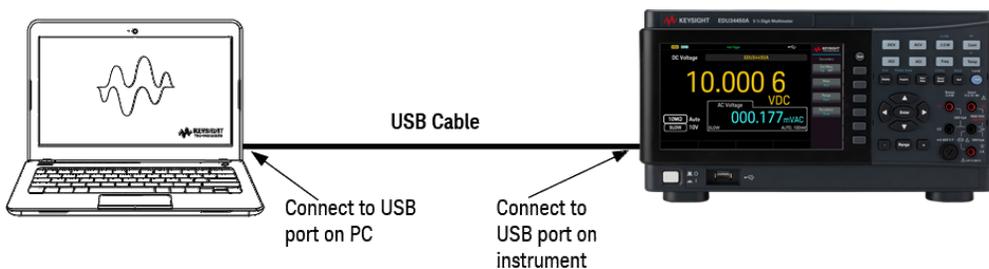
This section describes how to connect to the various communication interfaces to your instrument. For further information about configuring the remote interfaces, refer to **Remote Interface Configuration**.

NOTE

If you have not already done so, install the Keysight IO Libraries Suite, which can be found at www.keysight.com/find/iolib. For detailed information about interface connections, refer to the *Keysight Technologies USB/LAN/GPIB Interfaces Connectivity Guide* included with the Keysight IO Libraries Suite.

Connect to the Instrument via USB

The following figure illustrates a typical USB interface system.



1. Connect your instrument to the rear USB port on your computer using a USB cable.
2. With the Connection Expert Utility of the Keysight IO Libraries Suite running, the computer will automatically recognize the instrument. This may take several seconds. When the instrument is recognized, your computer will display the VISA alias, IDN string, and VISA address. You can also view the instrument's VISA address from the front panel menu.
3. You can now use Interactive IO within the Connection Expert to communicate with your instrument, or you can program your instrument using the various programming environments.

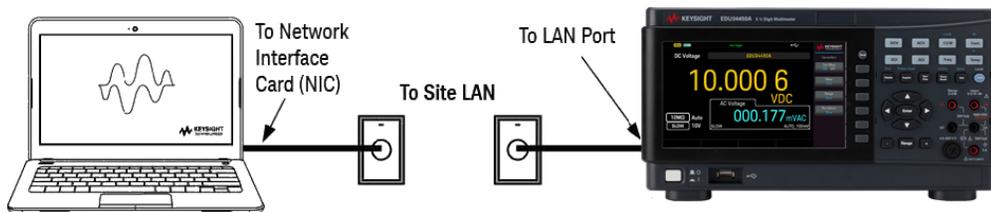
NOTE

The USB cable is not recommended to be longer than 3 meters.

Connect to the Instrument via LAN (Site and Private)

Site LAN

A **site LAN** is a local area network in which LAN-enabled instruments and computers are connected to the network through routers, hubs, and/or switches. They are typically large, centrally-managed networks with services such as DHCP and DNS servers. The following figure illustrates a typical site LAN system.



1. Connect the instrument to the site LAN or to your computer using a LAN cable. The as-shipped instrument LAN settings are configured to automatically obtain an IP address from the network using a DHCP server (DHCP is ON by default). The DHCP server will register the instrument's hostname with the dynamic DNS server. The hostname as well as the IP address can then be used to communicate with the instrument. The front panel LAN indicator will come on when the LAN port has been configured.

NOTE If you need to manually configure any instrument LAN settings, refer to [Remote Interface Configuration](#) for information about configuring the LAN settings from the front panel of the instrument.

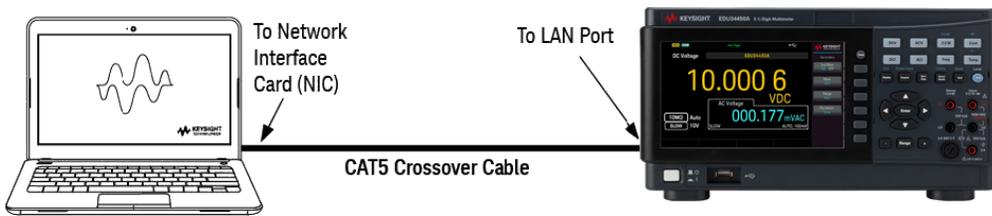
2. Use the Connection Expert utility of the Keysight IO Libraries Suite to add the instrument and verify a connection. To add the instrument, you can request the Connection Expert to discover the instrument. If the instrument cannot be found, add the instrument using its hostname or IP address.

NOTE If this does not work, refer to "Troubleshooting Guidelines" in the *Keysight Technologies USB/LAN/GPIB Interfaces Connectivity Guide* included with the Keysight IO Libraries Suite.

3. You can now use Interactive IO within the Connection Expert to communicate with your instrument, or you can program your instrument using the various programming environments. You can also use the Web browser on your computer to communicate with the instrument as described under Remote Control.

Private LAN

A **private LAN** is a network in which LAN-enabled instruments and computers are directly connected, and not connected to a site LAN. They are typically small, with no centrally-managed resources. The following figure illustrates a typical private LAN system.



1. Connect the instrument to the computer using a LAN crossover cable. Alternatively, connect the computer and the instrument to a standalone hub or switch using regular LAN cables.

NOTE

Make sure your computer is configured to obtain its address from DHCP and that NetBIOS over TCP/IP is enabled. Note that if the computer had been connected to a site LAN, it may still retain previous network settings from the site LAN. Wait one minute after disconnecting it from the site LAN before connecting it to the private LAN. This allows Windows to sense that it is on a different network and restart the network configuration.

2. The factory-shipped instrument LAN settings are configured to automatically obtain an IP address from a site network using a DHCP server. You can leave these settings as they are. Most Keysight products and most computers will automatically choose an IP address using auto-IP if a DHCP server is not present. Each assigns itself an IP address from the block 169.254.nnn. Note that this may take up to one minute. The front panel LAN indicator will come on when the LAN port has been configured.

NOTE

Turning off DHCP reduces the time required to fully configure a network connection when the power supply is turned on. To manually configure the instrument LAN settings, refer to [Remote Interface Configuration](#) for information about configuring the LAN settings from the front panel of the instrument.

3. Use the Connection Expert utility of the Keysight IO Libraries Suite to add the power supply and verify a connection. To add the instrument, you can request the Connection Expert to discover the instrument. If the instrument cannot be found, add the instrument using its hostname or IP address.

NOTE

If this does not work, refer to “Troubleshooting Guidelines” in the *Keysight Technologies USB/LAN/GPIB Interfaces Connectivity Guide* included with the Keysight IO Libraries Suite.

4. You can now use Interactive IO within the Connection Expert to communicate with your instrument, or you can program your instrument using the various programming environments. You can also use the Web browser on your computer to communicate with the instrument as described under Remote Control.

Remote Interface Configuration

The instrument supports remote interface communication over two interfaces: USB and LAN. Both are "live" at power up.

- USB Interface: Use the rear-panel USB port to communicate with your PC. There is no configuration required for the USB interface. Simply connect the instrument to your PC with a USB cable.
- LAN Interface: Use the rear-panel LAN port to communicate with your PC. By default, DHCP is on, which may enable communication over LAN. The acronym DHCP stands for Dynamic Host Configuration Protocol, a protocol for assigning dynamic IP addresses to networked devices. With dynamic addressing, a device can have a different IP address every time it connects to the network.

Keysight IO Libraries Suite

NOTE

Ensure that the Keysight IO Libraries Suite is installed before you proceed for the remote interface configuration.

Keysight IO Libraries Suite is a collection of free instrument control software that automatically discovers instruments and allows you to control instruments over LAN, USB, GPIB, RS-232, and other interfaces. For more information, or to download IO Libraries, go to www.keysight.com/find/iosuite.

LAN Configuration

The following sections describe the LAN configuration functions on the front-panel menu.

When shipped, DHCP is on, which may enable communication over LAN. The acronym DHCP stands for Dynamic Host Configuration Protocol, a protocol for assigning dynamic IP addresses to devices on a network. With dynamic addressing, a device can have a different IP address every time it connects to the network.

Some LAN settings require you to cycle instrument power to activate them. The instrument briefly displays a message when this is the case, so watch the screen closely as you change LAN settings.

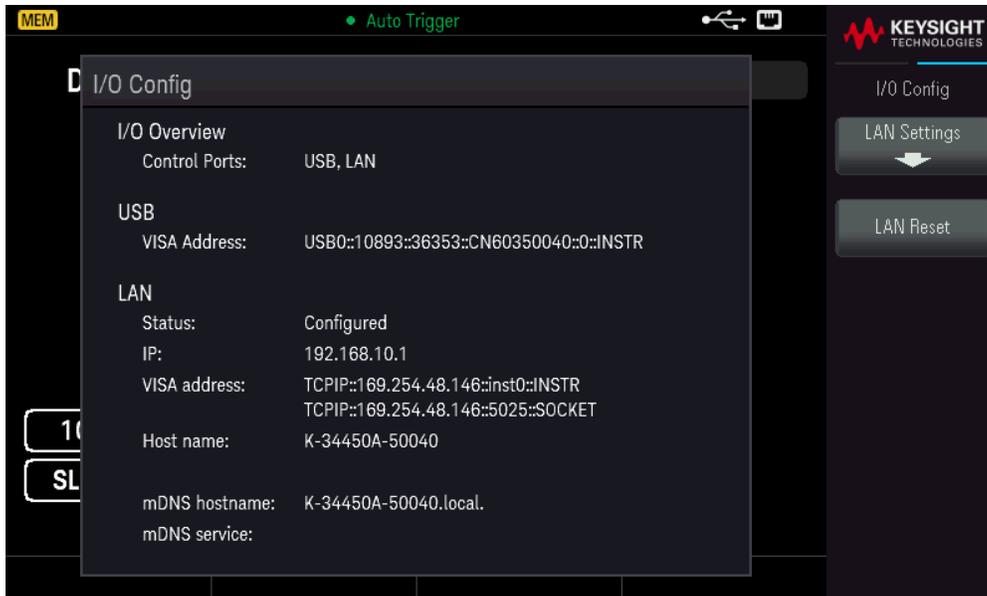
NOTE

After changing the LAN settings, you must save the changes. Press **Apply** to save the setting. If you do not save the setting, exiting the I/O Config menu will also prompt you to press **Yes** to save the LAN setting or **No** to exit without saving. Selecting **Yes** cycles power to the instrument and activates the settings. LAN settings are non-volatile; they will not be changed by power cycling or *RST. If you do not want to save your changes, press **No** to cancel all changes.

View the LAN Settings

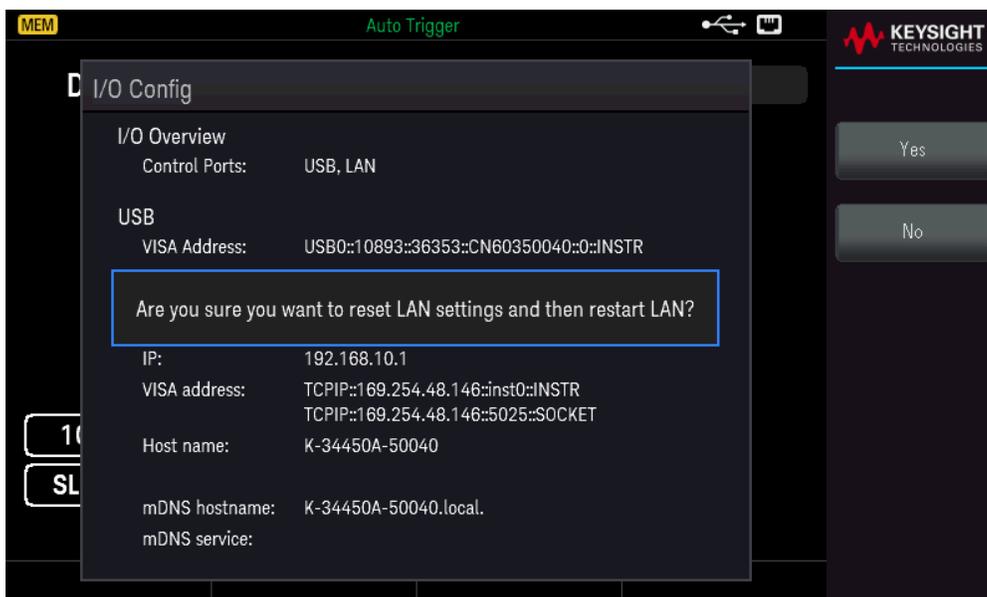
Press **[Shift]** > **[Store/Recall]** | **Utility** > **I/O Config** to view the LAN Settings.

The LAN status may be different from the front panel configuration menu settings - depending on the configuration of the network. If the settings are different, it is because the network has automatically assigned its own settings.



Press **LAN Settings** to access the LAN Settings Menu. See **Modify the LAN Settings** for more details.

Press **LAN Reset** restore the LAN settings to default values.



Modify the LAN Settings

As shipped from the factory, the instrument pre-configured settings should work in most LAN environments. Refer to the "Non-Volatile Settings" in the *Programming Guide* for information on the factory-shipped LAN settings.

1. Access the LAN Settings menu.

Press the **LAN Settings** softkey.



Select **Services** to turn the various LAN services on or off.



With DHCP on, an IP address will automatically be set by the DHCP (Dynamic Host Configuration Protocol) when you connect the instrument to the network, provided the DHCP server is found and is able to do so. DHCP also automatically deals with the subnet mask and gateway address, if required. This is typically the easiest way to establish LAN communication for your instrument. All you need to do is leave DHCP on. Contact your LAN administrator for details.

2. Establish an "IP Setup."

If you are not using DHCP (use the **Services** softkey to set **DHCP** to **OFF**), you must establish an IP setup, including an IP address, and possibly a subnet mask and gateway address.



Press **[Back]** > **Addresses** > **Modify** to configure the IP address, subnet mask, and gateway address.



Contact your network administrator for the IP address, subnet mask, and gateway to use.

IP Address: All IP addresses take the dot-notation form "nnn.nnn.nnn.nnn" where "nnn" in each case is a byte value in the range 0 through 255. You can enter a new IP address using the arrow keys. Press **Previous** or **Next** to move the cursor to the next field or previous field. **Do not enter leading zeros.**

Subnet Mask: Subnetting allows the LAN administrator to subdivide a network to simplify administration and

minimize network traffic. The subnet mask indicates the portion of the host address used to indicate the subnet. Use the arrow keys to enter a new subnet mask address. Press **Previous** or **Next** to move the cursor to the next field or previous field.

Gateway: A gateway is a network device that connects networks. The default gateway setting is the IP address of such a device. Use the arrow keys to enter a new gateway address. Press **Previous** or **Next** to move the cursor to the next field or previous field.

Press **Apply** to save your changes.

3. Configure the "DNS Setup" (optional)

DNS (Domain Name Service) is an Internet service that translates domain names into IP addresses. Ask your network administrator whether DNS is in use, and if it is, for the host name, domain name, and DNS server address to use.

Normally, DHCP discovers DNS address information; you only need to change this if DHCP is unused or not functional. To manually configure the addressing of the instrument, use the **Services** softkey to set **Auto DNS** to **OFF**.



a. Set the "hostname." Press **[Back]** > **Host Name** and enter the hostname. A hostname is the host portion of the domain name, which is translated into an IP address. The hostname is entered as a string using the softkeys provided. The hostname may include letters, numbers, and dashes ("-"). Press **Apply** to save your changes.



The instrument is shipped with a default hostname with the following format: K-{modelnumber}-{serialnumber},

where {modelnumber} is the instrument's 6-character model number (e.g. 33212A) and {serialnumber} is the last five characters of the instrument's serial number (e.g. 45678 if the serial number is CN12345678).

b. Set the "DNS Server" addresses. Press **[Back]**. Press **Addresses > Modify** to configure the DNS server addresses.

Enter the Primary DNS (**DNS1**) and Second DNS (**DNS2**). Use the arrow keys to enter a new DNS server address. Press **Previous** or **Next** to move the cursor to the next field or previous field. See your network administrator for details.



4. Configure the mDNS Service (optional).

Your instrument receives a unique mDNS service name at the factory, but you may change it. The mDNS service name must be unique on the LAN.

To manually configure the service name of the instrument, use the **Services** softkey to set mDNS to **ON**.



Press **mDNS Service**.



Use the softkeys provided to set a desired service name. The name must start with letter; other characters can be an upper or lower case letters, numeric digits, or dashes ("-"). Press **Apply** to save your changes.

SCPI Socket Services

This instrument allow any combination of up to two simultaneous data socket, control socket, and telnet connections to be made.

Keysight instruments have standardized on using port 5025 for SCPI socket services. A data socket on this port can be used to send and receive ASCII/SCPI commands, queries, and query responses. All commands must be terminated with a newline for the message to be parsed. All query responses will also be terminated with a newline.

The socket programming interface also allows a control socket connection. The control socket can be used by a client to send device clear and to receive service requests. Unlike the data socket, which uses a fixed port number, the port number for a control socket varies and must be obtained by sending the following SCPI query to the data socket: `SYSTem:COMMunicate:TCPIP:CONTRol?`

After the port number is obtained, a control socket connection can be opened. As with the data socket, all commands to the control socket must be terminated with a newline, and all query responses returned on the control socket will be terminated with a newline.

To send a device clear, send the string "DCL" to the control socket. When the power system has finished performing the device clear it echoes the string "DCL" back to the control socket.

Service requests are enabled for control sockets using the Service Request Enable register. Once service requests have been enabled, the client program listens on the control connection. When SRQ goes true the instrument will send the string "SRQ +nn" to the client. The "nn" is the status byte value, which the client can use to determine the source of the service request.

More About IP Addresses and Dot Notation

Dot-notation addresses ("nnn.nnn.nnn.nnn" where "nnn" is a byte value from 0 to 255) must be expressed with care, as most PC web software interprets byte values with leading zeros as octal (base 8) numbers. For example, "192.168.020.011" is actually equivalent to decimal "192.168.16.9" because ".020" is interpreted as "16" expressed in octal, and ".011" as "9". To avoid confusion, use only decimal values from 0 to 255, with no leading zeros.

3 Features and Functions

Secondary Display

Math Operations

Acquire

Probe Hold

Run/Stop

Utility Menu

Store/Recall

This chapter contains details on instrument features, including front panel and remote interface operation. You may want to read Front Panel Menu Operation first. See the *EDU34450A Programming Guide* for details on SCPI commands and queries.

Secondary Display

Most measurement functions have predefined range or measurement capabilities that can be displayed in the secondary measurement mode. All math operations have predefined operations that are displayed on the secondary display.

The table below shows the measurement functions which are available in the secondary display.

Primary Display	Secondary Display				
	DCV	ACV	DCI	ACI	FREQ
DCV	-	●	●	●	-
ACV	●	-	●	●	●
DCI	●	●	-	-	-
ACI	●	●	-	-	●
FREQ	-	●	-	●	-

- All specifications are ensured only under a single display.
- For ACI-ACV (primary or secondary) measurement, the ACV input signal is limited to 500,000 V×Hz.
- For DCI-ACV (primary or secondary) measurement, the ACV input signal is limited to 6,000,000 V×Hz.
- For DCV-ACV (primary or secondary) measurement, the DCV input signal is limited to 500 V when ACV input signal is in 100 mV range. The ACV input signal must be greater than 50 mV.
- For ACI-DCV (primary or secondary) measurement operation frequencies, refer to the table below.

ACI-DCV	Measurement Operation Frequency
Slow/Medium	>500 Hz (600 Hz) / n × 50 Hz (60 Hz) for <500 Hz
Fast	>10 kHz / n × 1 kHz for <10 kHz

- For more information, please refer to [Measurement Speed Consideration](#).
- For remote operation, refer to the DISPLAY:WINDow2 commands in the *Keysight EDU34450A Programming Guide*.

Front Panel Operations

Press **[Shift]** > **[Display]** > **2nd Meas ON | OFF**.



- To change the secondary measurement, press **Meas** to switch between the available options.
- To change the range of the secondary measurement, press **Range** to switch between the available options.
- To change the resolution of the secondary measurement, press **Resolution** to switch between the available options.
- To disable the secondary measurement, press **2nd Meas ON | OFF**.

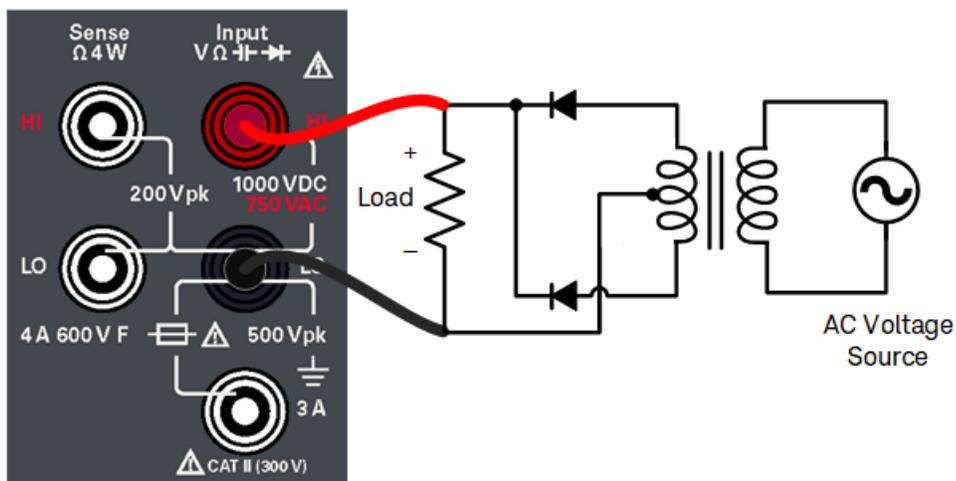
Dual Display Operation Examples

This section describes some practical operations when using dual display feature.

Measure DC Voltage and AC Ripple on a Rectification Circuit

A single measurement for both DC voltage and AC ripple can be displayed through both displays while testing a rectifier circuit.

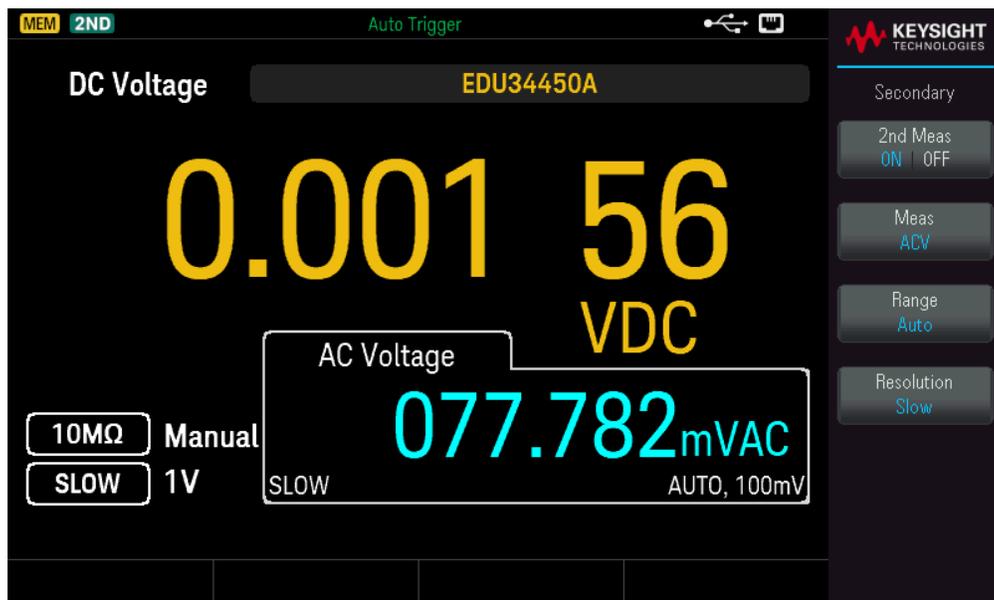
1. Connect the red and black test leads to the input terminal and probe the test points.



2. Press [DCV] to select DC voltage as the primary measurement.



3. Press [Shift] > [Display] > 2nd Meas ON | OFF to enable the secondary measurement.
4. Press Meas > ACV to select AC voltage as the secondary measurement.



5. Press Range and Resolution to adjust the measurement range and speed accordingly.

Math Operations

The table below shows the various math operations that can be used with each measurement function:

Math Operation	Measurement Function										
	DCV	ACV	DCI	ACI	2RES	4RES	FREQ	DIODE	CONT	TEMP	CAP
Null	●	●	●	●	●	●	●	-	-	●	●
Scaling	●	●	-	-	-	-	-	-	-	-	-
Statistics	●	●	●	●	●	●	●	-	-	●	●
Limits	●	●	●	●	●	●	●	●	-	●	●

- Only one math operation can be enabled at a time.
- When the secondary display is enabled, selecting a math operation will turn off the secondary display.
- Changing the range and resolution is allowed for all math operations.
- You can edit the reference/offset/limit values used for the Null, Scaling, and Limits math operations.
- For remote operation, refer to the CALCulate Subsystem in the *EDU34450A Programming Guide*.

Null

When making null measurements, also called relative, each reading is the difference between a stored null offset value and the input signal. One possible application is to increase the accuracy of a 2-wire resistance measurement by nulling the test lead resistance. Nulling the leads is also particularly important prior to making capacitance measurements. The formula used for calculating null measurements is:

$$\text{Null Measurement Display} = \text{Reading} - \text{Null Offset Value}$$

- The null offset value is adjustable. You can set it to any value between 0 and $\pm 120\%$ of the highest range, for the present function.
- For resistance measurements, the instrument will read a non-zero value even when the two test leads are in direct contact because of the resistance of these leads. Short the test leads and press **[Null]** once the displayed value is stable to zero-adjust the display.
- For DC voltage measurements, the thermal effect will influence the accuracy. Short the test leads and press **[Null]** once the displayed value is stable to zero-adjust the display.

Front Panel Operations

Press **[Null]** to enable the Null operation. The reading is captured as the null offset value.



The reading before the math formula is applied is shown in the secondary display.

To change the Null offset value, press **[Shift]** > **[Null]** | **Math** > **Null Offset Value**. Use the arrow keys to set a desired value. Press **[Enter]** when done.



To disable the Null operation, press **Null ON** | **OFF**.

Scaling

There are two Scaling operations available: dB Scaling and dBm Scaling. The scaling operation applies to voltage measurements only.

dB Scaling

Each dB measurement is the difference between the input signal and a stored relative value, with both values converted to dBm. When enabled, the dB operation computes the dBm value for the next reading, stores the dBm result into the relative value register, and immediately produces the dB calculation. The formula used for calculating dB measurements is:

$$dB = \text{Reading in dBm} - \text{Relative Value in dBm}$$

The relative value can take any value between 0 dBm and ± 120.000 dBm. The default relative value is 0 dBm. You can either let the instrument automatically measure this value, or you can enter a specific value.

The first displayed reading is always precisely 000.00 dB.

Front Panel Operations

Press **[Shift]** > **[Null]** | **Math** > **Function Scaling** > **Scaling ON** | **OFF**. Then press **Scaling Function** and select **dB** to enable the dB Scaling operation.



The reading before the math formula is applied is shown in the secondary display.

To change the dB reference value, press **dB Reference Value**. Use the arrow keys to set a desired value. Press **[Enter]** when done.



To disable the dB Scaling operation, press **Scaling ON | OFF**.

dBm Scaling

The logarithmic dBm (decibels relative to one milliwatt) scale is often used in RF signal measurements. The instrument takes a measurement and calculates the power delivered to a reference resistance (typically 50 Ω, 75 Ω, or 600 Ω). The voltage measurement is then converted to dBm. The formula used for calculating dBm measurements is:

$$dBm = 10 \times \log_{10} [(Reading^2 / R_{REF}) / 0.001 W]$$

You can choose from several reference resistance values:

$R_{REF} = 2 \Omega, 4 \Omega, 8 \Omega, 16 \Omega, 50 \Omega, 75 \Omega, 93 \Omega, 110 \Omega, 124 \Omega, 125 \Omega, 135 \Omega, 150 \Omega, 250 \Omega, 300 \Omega, 500 \Omega, 600 \Omega, 800 \Omega, 900 \Omega, 1000 \Omega, 1200 \Omega, \text{ or } 8000 \Omega.$

Front Panel Operations

Press **[Shift] > [Null] | Math > Function Scaling > Scaling ON | OFF**. Then press **Scaling Function** and select **dBm** to enable the dBm Scaling operation.



The reading before the math formula is applied is shown in the secondary display.

To change the dBm reference value, press **dBm Reference Value**. Use the arrow keys to select a desired value.



To disable the dBm Scaling operation, press **Scaling ON | OFF**.

Limits

The Limit operation enables you to perform pass or fail testing to the upper and lower limits that you specify. The upper limit value you select must be larger than the lower limit value. The initial factory settings for both values is zero.

- This math operation applies to all measurement functions except continuity test.
- The instrument clears all limits after a Factory Reset (*RST command), an Instrument Preset (SYSTEM:PRESet command), or when a measurement function is changed.

Front Panel Operations

Press **[Shift]** > **[Null]** | **Math** > **Function Limits** > **Limits ON | OFF**.

The limit values and state is shown on the bottom of the display.

- PASS: The readings are within the specified limits.
- FAIL-HI: The reading is above the high limit.
- FAIL-LO: The reading is below the low limit.





To change the high limit value, press **High Limit**. Use the arrow keys to set a desired value. Press **[Enter]** when done. The high limit value must always be greater than the lower limit.

To change the low limit value, press **Low Limit**. Use the arrow keys to set a desired value. Press **[Enter]** when done.

To enable the beeper, press **Beeper ON | OFF**. Each time the input value transitions from PASS to HIGH or from PASS to LOW, or when transitioning directly from HIGH to LOW or LOW to HIGH, the instrument beeps once.

To disable the Limit operation, press **Limits ON | OFF**.

Statistics

The Statistics operation stores the minimum and maximum values, the average, and the number of readings during a series of measurements.

- This math operation applies to all measurement functions except continuity and diode test.
- The stored statistical data are cleared when statistics are enabled, when the CALCulate:FUNction command is sent while the CALCulate:STATe is ON, when the power is turned off, after a Factory Reset (*RST command), after an Instrument Preset (SYSTem:PRESet command), or after a measurement function change.

Front Panel Operations

Press **[Shift]** > **[Null]** | **Math** > **Function Statistics** > **Statistics ON | OFF**.



The minimum, maximum, and average readings together with the number of samples taken are shown on the bottom of the display.

To disable the readings, press **Statistics ON | OFF**.

Acquire

The EDU34450A can operate in **Continuous** or **Data Log** measurement mode.

Continuous

At power-on, the default measurement mode is **Continuous**. Continuous readings are taken at the fastest rate possible for the selected measurement configuration. To set the trigger source for the Continuous mode, follow the steps below:

1. Configure the multimeter for the measurement by selecting the function, range, resolution, and so on.
2. Specify the multimeter's measurement mode. Choices are as below:
 - An **Immediate** internal trigger (default).
 - A manual or software (**Bus**) trigger from the remote interface.
3. Ensure that the multimeter is ready to accept a trigger from the specified source (called the wait-for-trigger state).

Immediate Triggering



In the continuous triggering mode, the trigger signal is always present. When you place the multimeter in the wait-for-trigger state, the trigger is issued immediately. This is the default trigger source for remote interface operation.

Remote Interface Operation

The following command selects the immediate trigger source: TRIGger:SOURce IMMEDIATE

The CONFigure and MEASure? commands automatically set the trigger source to IMMEDIATE.

Refer to the *Keysight EDU34450A Programming Guide* for complete description and syntax for these commands.

Software (Bus) Triggering

The Software (Bus) trigger source can only be enabled via SCPI.

The instrument automatically triggers immediately when you send a bus trigger command.

- The TRIGger:SOURce BUS command selects the bus trigger source.
- The MEASure? command overwrites the BUS trigger and triggers the DMM and returns a measurement.
- The READ? command does not overwrite the BUS trigger, and if selected, generates an error. It will only trigger the instrument and return a measurement when the IMMEDIATE trigger is selected.

– The INITiate command only initiates the measurement and needs a trigger (BUS or IMMEDIATE) to make the actual measurement.

Refer to the *Keysight EDU34450A Programming Guide* for the complete description and syntax for these commands.

Data Log

The **Data Log** measurement mode, is available only from the multimeter's front panel. Data Log mode provides a front-panel user interface that allows you to set up data logging into the instrument's non-volatile memory, without programming, and without a connection to a computer. Once you have finished collecting data, you can view it from the front panel or you can view the data from your computer (DATA:DATA? NVMEM).

Front Panel Operations

To select the Data Log measurement mode, press [Acquire] > Acquire **Continuous** > Acquire **Data Log**.



You can then select the sample interval (time between measurements - for example, 500 ms), duration as either an amount of time or a number of readings, and whether to start after a delay.

- Press **Trigger Delay** to set the delay time (0 to 3600 seconds) between a trigger is initiated and first reading is taken by the data log function. The smallest delay time resolution is 100 μ s.
- Press **Trigger Count** to set the total triggers that will be received. It can be configured from 1 to 5000 triggers for single display measurement and 2500 triggers for dual display measurement.
- Press **Sample Interval** to set the delay time (maximum 3600 seconds) between subsequent readings. The smallest resolution is 100 μ s. The minimum interval is configuration dependent and may be lower than 1 s.
- Press **Sample Count** to specify the number of readings (samples) the instrument will take per trigger. The total number of readings returned will be the product of the sample count and trigger count. (Number of Readings = Sample Count x Trigger Count).

After configuring the data logging parameters, press **Data Log ON | OFF** to enable data logging.

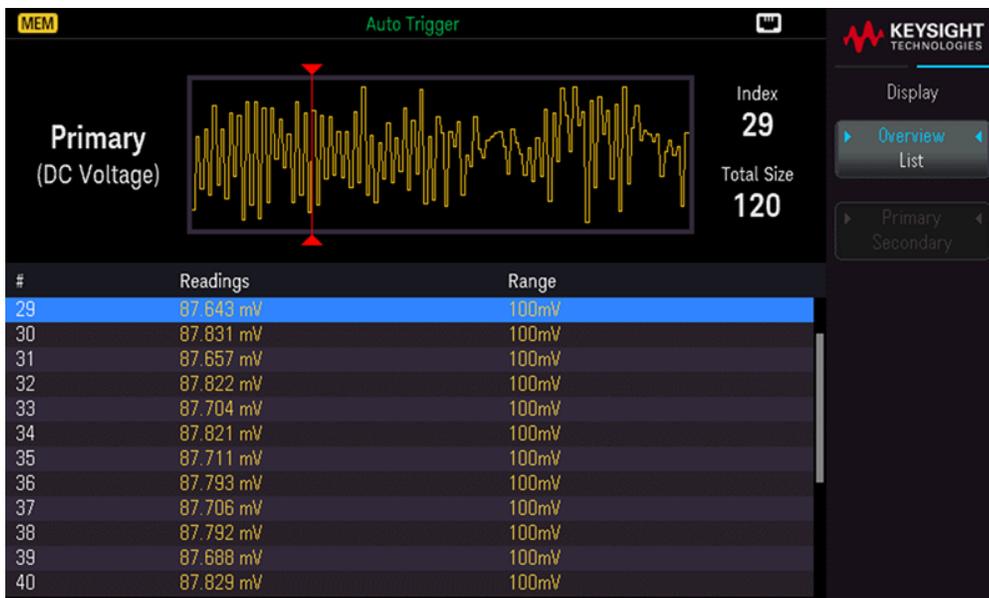


Press **[Run/Stop]**. Data logging will begin immediately or following the specified Trigger Delay (if Trigger Count is > 1).

Data logging will stop after the specified number of readings (Sample Count) has been collected.

Viewing the Data Logged Readings

Press **[Display]** > **View Log** to view the data logged readings. 12 data points are shown at any one time.



Use the **[Down]** or **[Up]** arrow keys to highlight the next or previous data point. The **[Right]** or **[Left]** arrow keys to display the next or previous page.

- **Overview** always displays the next 12 data points.



– List allows you to step through the data points shown.



You can log data from both primary and secondary measurements if **Secondary Display** is enabled.



Press **Primary** | **Secondary** to toggle between the readings from the primary (shown in yellow) or secondary display (shown in blue).





Probe Hold

The Probe Hold feature allows you to capture and hold a reading on the front panel display. This is useful in situations when you want to take a reading, remove the test probes, and have the reading remain on the display.

- When a stable reading is detected, the instrument beeps once (if the beeper is enabled), and holds the reading on the primary display. The preset variation is 10% of the full scale.
- A new reading value is captured when the variation of the measured value exceeds the preset variation. The instrument beeps once (if the beeper is enabled) when a captured reading is updated.
- If the reading value is unable to reach a stable state (when exceeding the preset variation), the reading value will not be updated.

When enabled, the instrument begins evaluating readings using the rules described below:

$$\text{Primary Display} = \text{Reading}_N \text{ IF } \text{Max}() - \text{Min}() \leq 0.1\% \times \text{Reading}_N$$

The decision to update a new reading value in the primary display is based upon the box-car moving statistics of the present reading and the three previous readings:

$$\text{Max} (\text{Reading}_N \text{ Reading}_{N-1} \text{ Reading}_{N-2} \text{ Reading}_{N-3})$$

$$\text{Min} (\text{Reading}_N \text{ Reading}_{N-1} \text{ Reading}_{N-2} \text{ Reading}_{N-3})$$

Front Panel Operation

Press **[Shift]** > **[Acquire]** | **Probe Hold**.



The captured reading is shown on the bottom of the display. The live reading is shown at the top left of the display.

- Press **[–]** or **[+]** to decrease or increase the measurement range manually. Press **[Range]** to enable autoranging.
- Press **Resolution** to toggle the resolution between **Slow** or **Medium**.
- Press **Remove Last** to remove the last captured reading.

- Press **Clear Readings** to clear all captured readings.
- To enable the beeper, press **Beeper ON | OFF**. When a stable reading is detected or when the captured reading is updated, the instrument beeps once.

Run/Stop

- Pressing **[Run/Stop]** when in **Data Log** measurement mode starts the data logging when the specified delay has elapsed.
- Data logging will stop after the specified duration (time or number of readings) has occurred or after you long press **[Run/Stop]**.

Utility Menu

Press **[Shift]** > **[Store/Recall]** | **Utility**.



The **Utility** menu provides the following features:

Configures the I/O parameters for remote operations

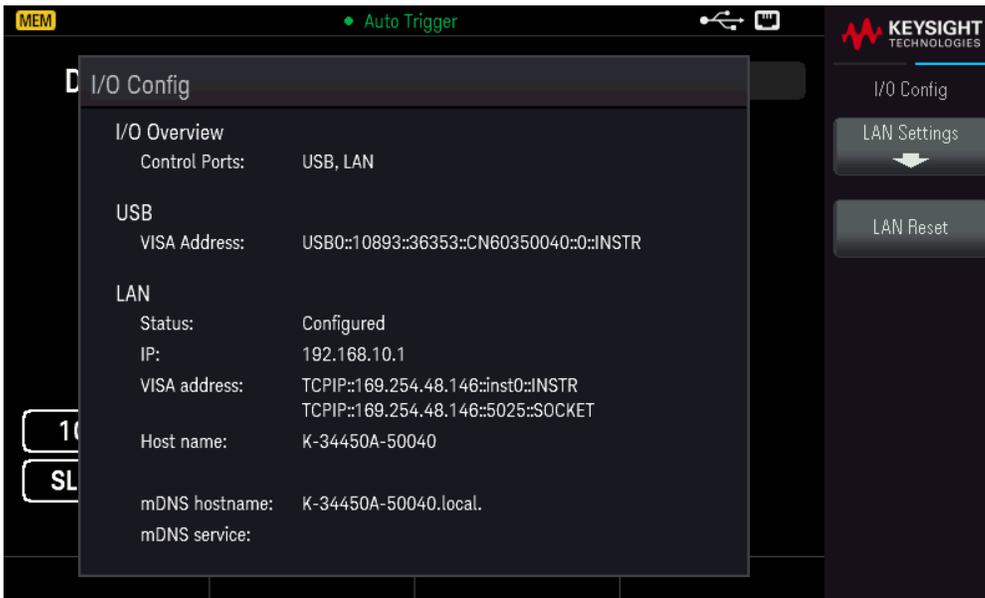
Provides access to self-test, calibration, and security functions

Specifies the user preferences that control how you interact with the instrument

Displays information related the instrument and allows you to view all recorded errors

I/O Config Menu

I/O Config configures the I/O parameters for remote operations over the LAN interface.



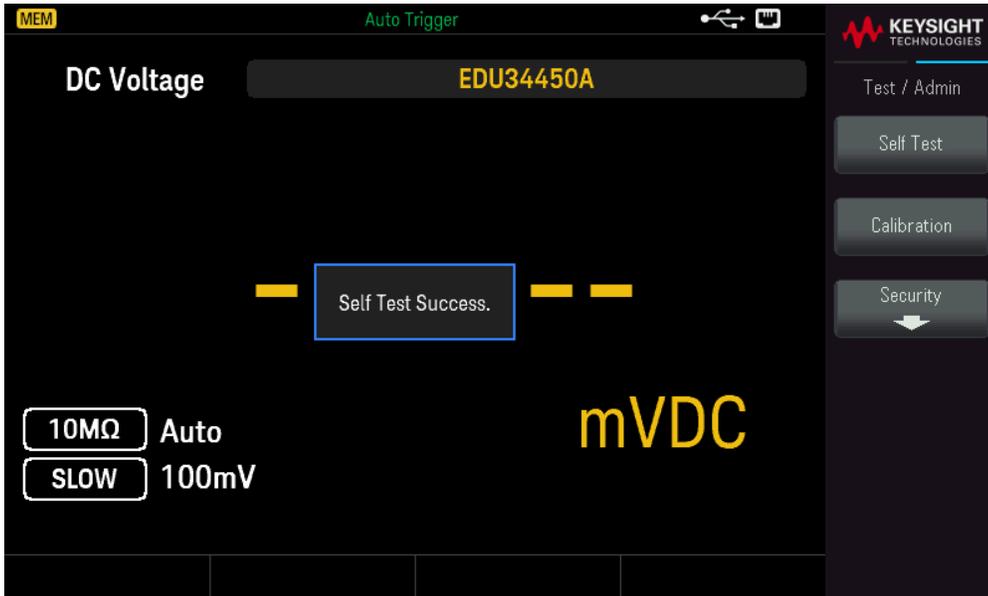
See [Remote Interface Connections](#) and [Remote Interface Configurations](#) for more details.

Instrument Setup Menu

Instr. Setup provides access to self-test, calibration, and security functions.



Self Test verifies proper instrument operation. This self-test is equivalent to the *TST? SCPI query, and you do not need to remove inputs to the instrument to run the test.



Calibration accesses the instrument's calibration procedures. See "Calibration Adjustment Procedures" in the *EDU34450A Service Guide* for more details.



Security manages the passcode and allows you to lock or unlock the instrument against unauthorized calibration.

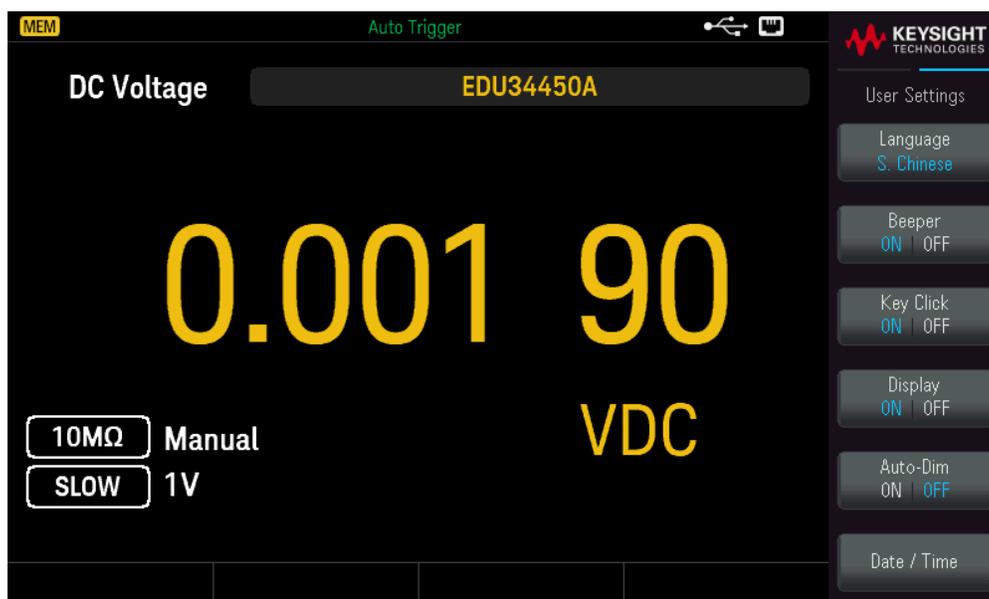


Press **Lock** to secure the instrument against accidental or unauthorized instrument calibration. When shipped from the factory, the instrument is secured, with the security code (calibration password) set to **EDU34450A**. The same security code must be used for front panel and remote operation. If you secure the instrument from the front panel, use that same code to unsecure it from the remote interface.

Press **Change Passcode** to set a new passcode. The passcode is an unquoted string up to 12 characters, must start with letter (A-Z), and may contain letters, numbers (0-9) and underscores. Press **Confirm** to save your changes when you are done.

User Settings Menu

User Settings specifies user preferences that control how you interact with the instrument. These settings are stored in non-volatile memory.



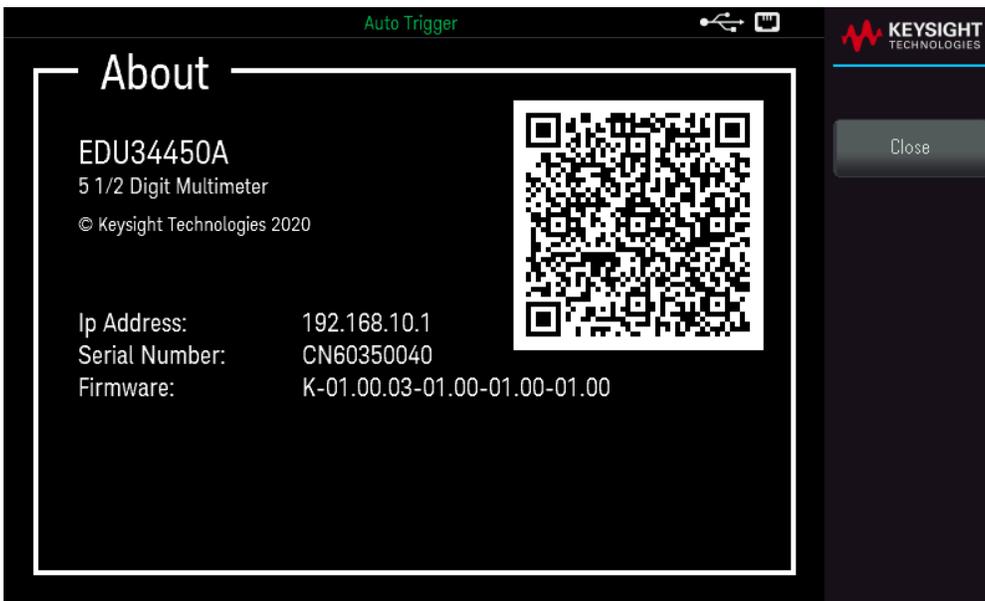
- **Language** selects the help language for front panel use: English, French, German, Spanish, Simplified Chinese, Traditional Chinese, Japanese, Korean, or Russian. All messages, context-sensitive help, and help topics appear in the selected language. The softkey labels and status line messages are not translated and are always in English.
- **Beeper** enables or disables the audible tone (**ON** or **OFF**) associated with the following features:
 - Limits – a measurement limit is exceeded (if limits are enabled)
 - Probe Hold – the measured signal records a stable reading
 - Diode – the forward bias voltage is between 0.3 and 0.8 V
 - Error – an error is generated from the front panel or remote interface
- **Key Click** disables or enables the click heard when a front panel key or softkey is pressed.
- **Display** turns off the display. Press any front panel key to turn it on again.
- **Auto-Dim** dims the screen after 2 minutes of inactivity.
- **Date / Time** sets the instrument's real-time clock, which always uses a 24-hour format (00:00:00 to 23:59:59). There is no automatic setting of the date and time, such as to adjust for daylight savings time. Use the front panel arrow keys to set the year, month, day, hour, minute, and second.

Help Menu

Help displays information related to your instrument and allows you to view all the errors in the error queue.



About shows the instrument IP address, serial number, and firmware revision. Scan the QR code shown to view the documentation related to this instrument.



Error View displays all the errors in the error queue. See "SYSTEM:ERRor?" in the *EDU34450A Programming Guide* for more details.



Store/Recall

You can save and recall complete instrument states.

- There are five internal user storage registers; numbered 1 through 5.
- The present instrument state, including all settings for measurement configuration, math operations, and system operations, can be saved in one of the five non-volatile memory location and later recalled.
- For remote operation, refer to the MEMory Subsystem, the *SAV, and *RCL commands in the *Keysight EDU34450A Programming Guide*.

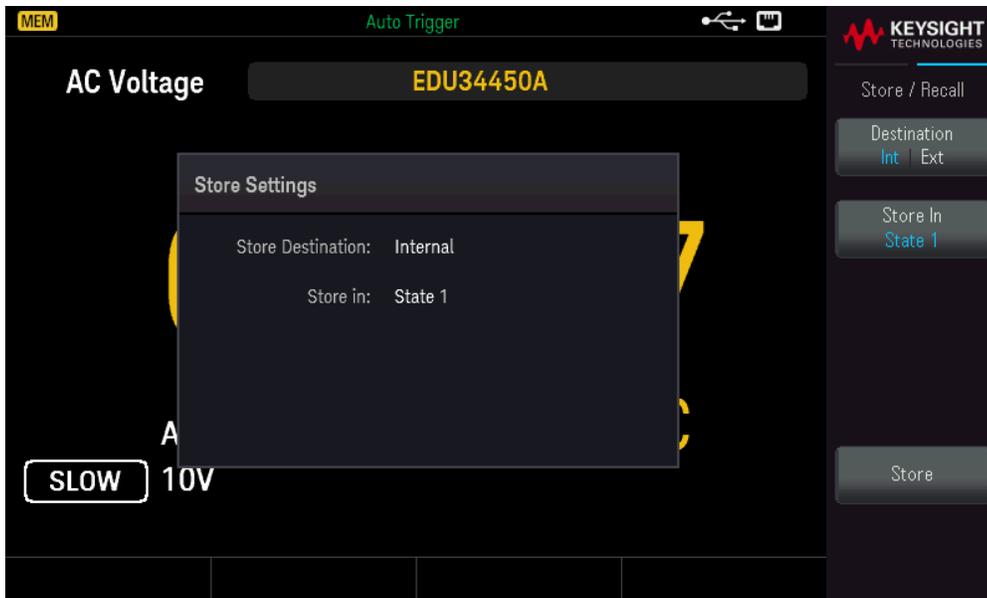
Front Panel Operations

Press [Store/Recall].



Store Settings

Store Settings allows you to browse to a directory and specify a file name, and to choose whether you want to store a state file internally or to an external USB drive.



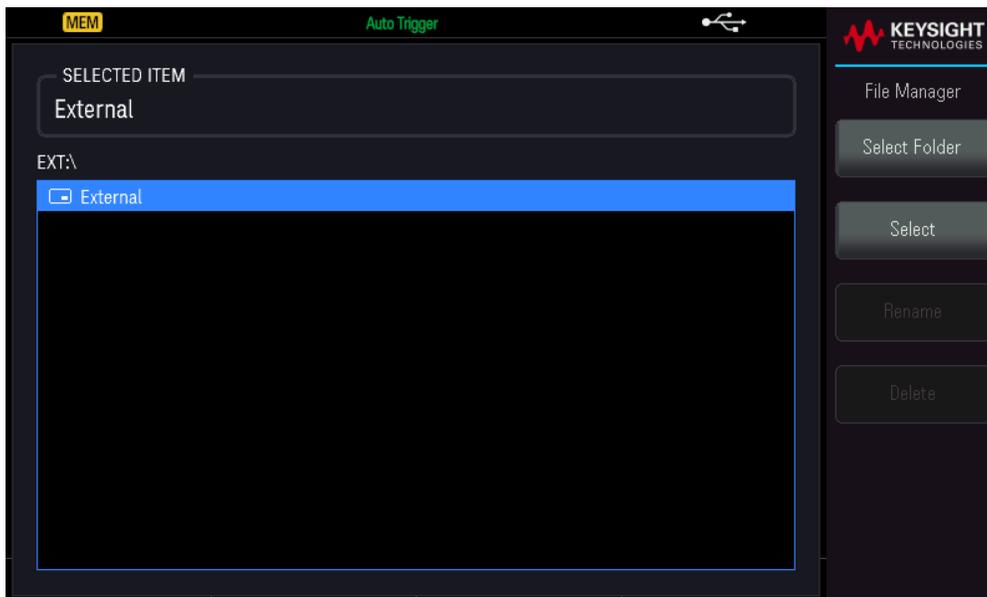
To Store an Instrument State Internally

- Select **Destination Int | Ext** to store the instrument state internally within the instrument non-volatile memory.
- Select **Store In** to choose between the available options: **Last**, **State 1**, **State 2**, **State 3**, **State 4**, or **State 5**.
- Press **Store** to save the current instrument state into the selected storage location.

To Store an Instrument State Externally

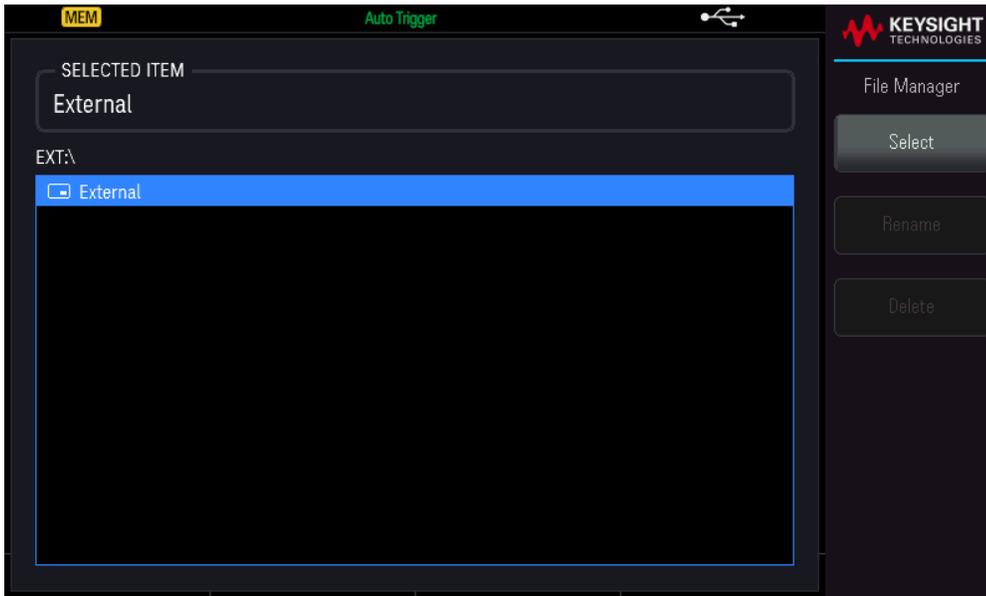


- Press **Destination Int | Ext** to store the instrument state in a connected external USB device.
- Press **Select File | Path**. Press **Browse** to browse the directory of the connected external USB device. Use the arrow keys to navigate.



- Press **Select Folder** to select a folder in the directory of the connected external USB device
- Press **Rename** to rename the file.
- Press **Delete** to delete the selected file.
- Press **Select** to confirm your selection.

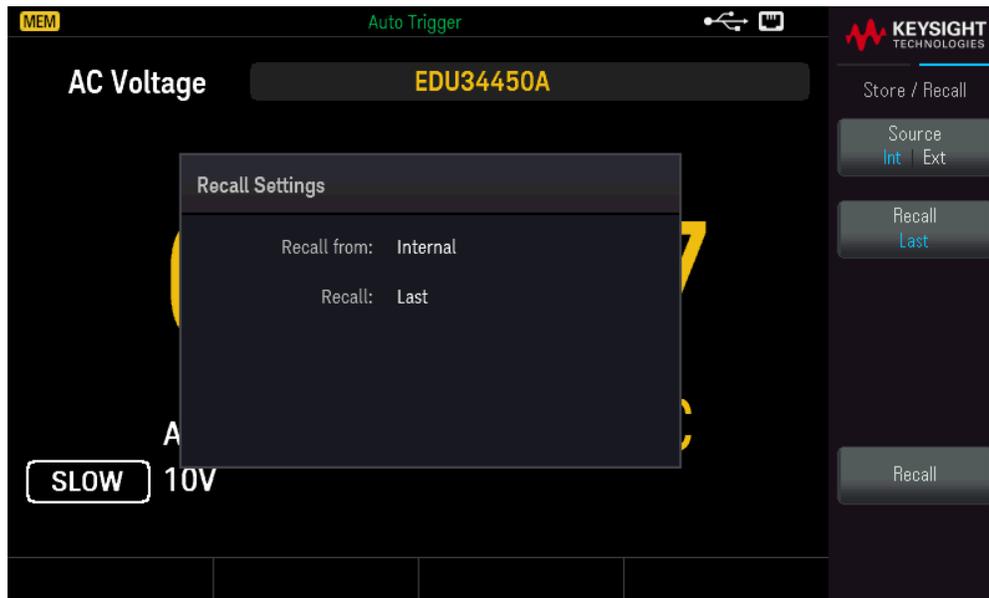
- Press **Select File | Path**. Press **Browse** browse the directory of the connected external USB device. Use the arrow keys to navigate.



- Press **Rename** to rename the file.
- Press **Delete** to delete the selected file.
- Press **Select** to confirm your selection.
- Select **File Name** to specify a file name.
- Press **Store** to save the current instrument state into the selected storage location.

Recall Settings

Recall Settings allows you to browse to the file to be recalled. Use the arrow keys to navigate to the desired state file (*.sta).



To Recall an Instrument State Stored Internally

- Select **Source** [Int](#) | [Ext](#) to recall an instrument state that is stored internally within the instrument non-volatile memory.
- Select **Recall** to choose between the available options: [Last](#), [State 1](#), [State 2](#), [State 3](#), [State 4](#), or [State 5](#).
- Press **Recall** to recall the instrument state from the selected storage location.

To Recall an Instrument State Stored Externally

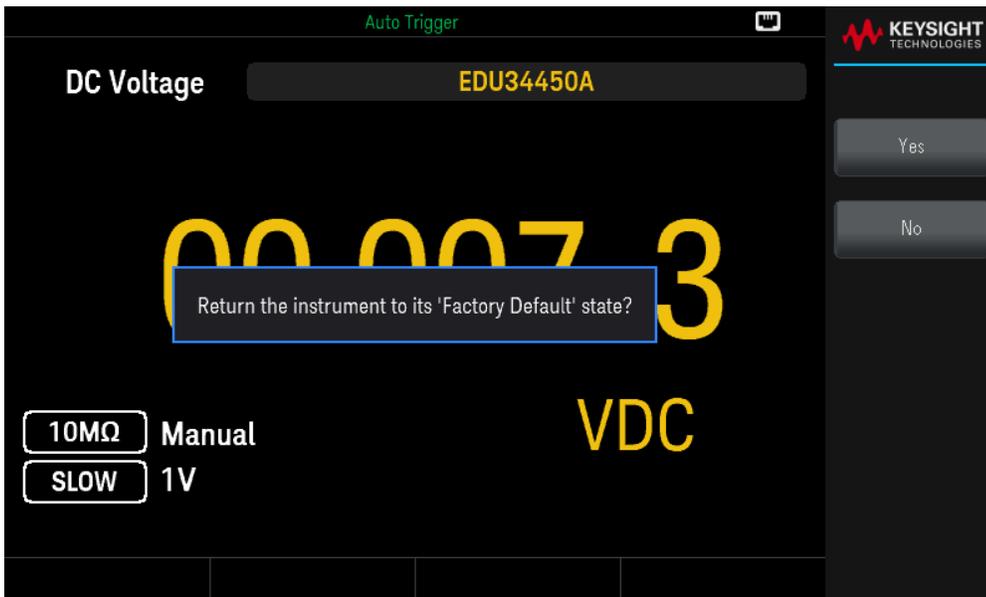
- Select **Source** [Int](#) | [Ext](#) to store the instrument state in a connected external USB device.
- Select **Browse** to browse the directory of the connected external USB device. Use the arrow keys to navigate.
- Press **Recall** to recall the instrument state from the selected storage location.

Power On Setting

Power On selects the state that is loaded at power-up. This can be either the state when the instrument was powered down with the power switch ([Last](#)) or the factory default state ([Factory Default](#)).



Press **Set Power On** to confirm your power-on selection ([Last](#) or [Factory Default](#)).

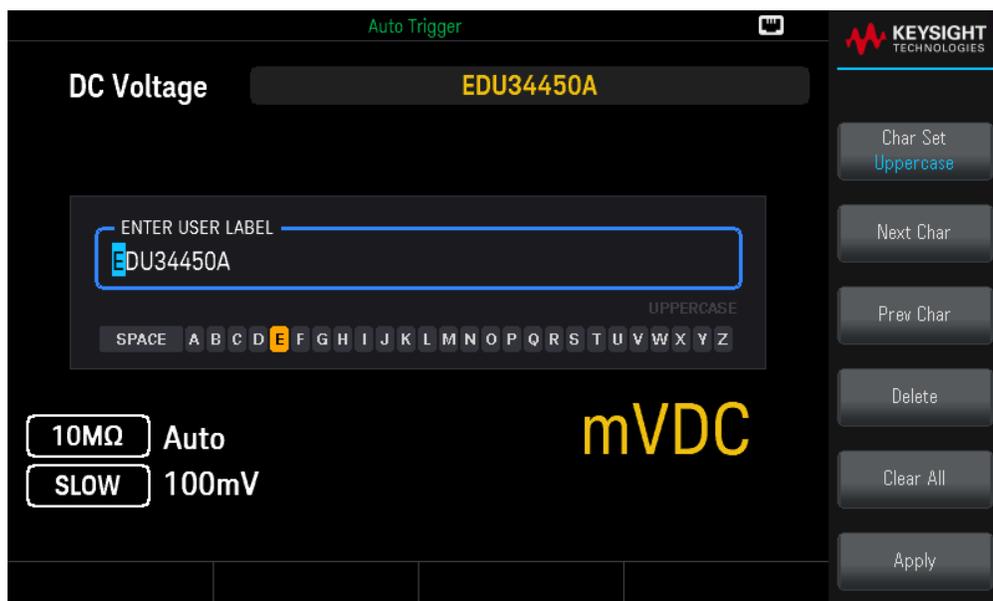


User Label

Press [Display] > User Label to change the label shown on the user interface.



The user label is entered as a string using the softkeys provided. The user label may include letters, numbers, and symbols (_ - + = # % @ \$ () [] { } ~ .).



Press **Apply** to save your changes.



4 Characteristics and Specifications

NOTE

For the characteristics and specifications of the EDU34450A 5½ Digit Digital Multimeter, refer to the data sheet at: <https://www.keysight.com/us/en/assets/3120-1002/data-sheets/EDU34450A-5-5-Digit-Dual-Display-Digital-Multimeter.pdf>.

5 Measurement Tutorial

DC Measurement Considerations

Noise Rejection

Measurement Speed Consideration

Secondary Measurement Considerations

Resistance Measurement Considerations

True RMS AC Measurements

Other Primary Measurement Functions

Other Sources of Measurement Error

The Keysight EDU34450A 5½ Digital Multimeter is capable of making very accurate measurements. In order to achieve the greatest degree of accuracy, you must take the necessary steps to eliminate potential measurement errors. This chapter describes the common errors found in measurements and gives suggestions on what you can do to avoid these errors.

DC Measurement Considerations

Thermal EMF Errors

Thermoelectric voltages are the most common source of error in low-level DC voltage measurements. Thermoelectric voltages are generated when you make circuit connections using dissimilar metals at different temperatures. Each metal-to-metal junction forms a thermocouple, which generates a voltage proportional to the junction temperature. You should take the necessary precautions to minimize thermocouple voltages and temperature variations in low-level voltage measurements. The best connections are formed using copper-to-copper crimped connections, as the instrument's input terminals are a copper alloy. The table below shows common thermoelectric voltages for connections between dissimilar metals.

Copper-to-	Approx. mV / °C
Cadmium-Tin Solder	0.2
Copper	<0.3
Gold	0.5
Silver	0.5
Brass	3
Beryllium Copper	5
Aluminum	5
Tin-Lead Solder	5
Kovar or Alloy 42	40
Silicon	500
Copper-Oxide	1000

Noise Rejection

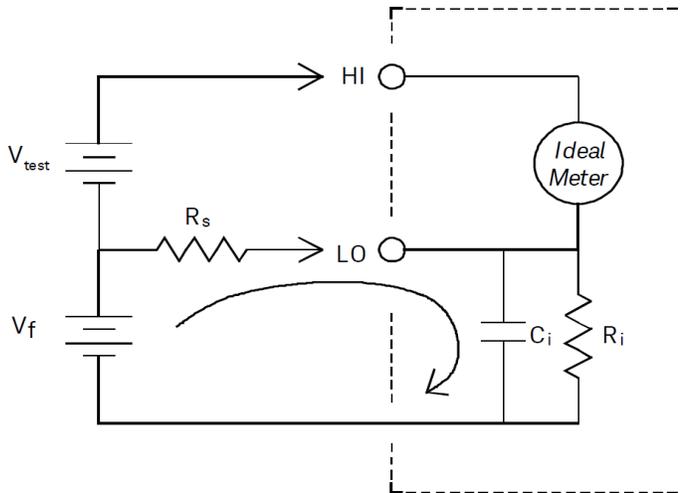
Rejecting Power-Line Noise Voltages

A desirable characteristic of integrating analog-to-digital (A/D) converters is their ability to reject power-line related noise present with DC input signals. This is called normal mode noise rejection, or NMR. The instrument achieves NMR by measuring the average DC input by “integrating” it over a fixed period.

Common Mode Rejection (CMR)

Ideally, a multimeter is completely isolated from earth-referenced circuits. However, there is finite resistance between the instrument's input LO terminal and earth ground, as shown below. This can cause errors when measuring low voltages which are floating relative to earth ground.

The figure below shows a Common Mode Rejection (CMR) circuit:



V_f = Float Voltage
 R_s = DUT Source Resistance
 Imbalance
 R_i = Multimeter Isolation Resistance
 (LO-Earth)
 C_i = Multimeter Input Capacitance:

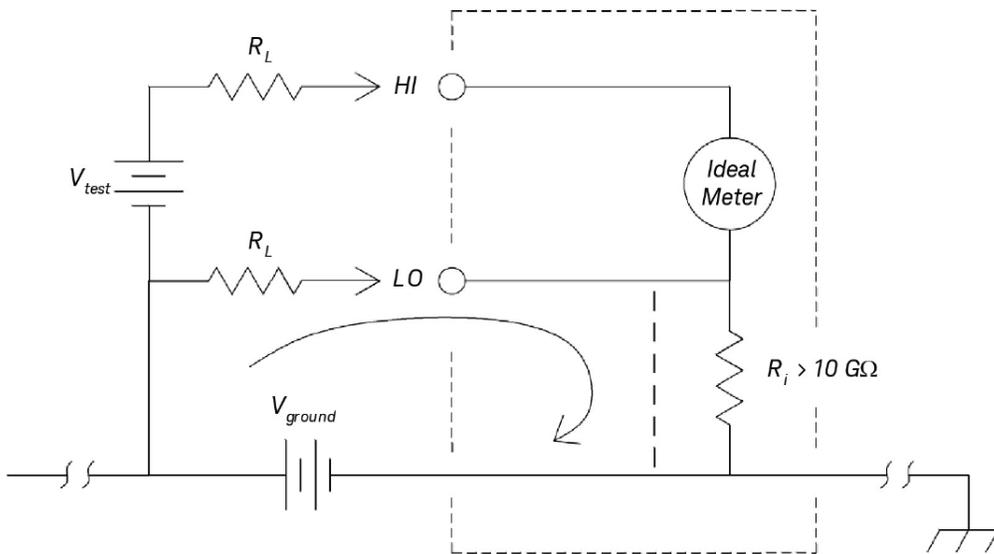
$$\text{Error (v)} = \frac{V_f \times R_s}{R_s + R_i}$$

Noise Caused by Magnetic Loops

If you are making measurements near magnetic fields, take caution to avoid inducing voltages in the measurement connections. You should be especially careful when working near conductors carrying large currents. Use twisted-pair connections to the instrument to reduce the noise pickup loop area, or dress the test leads as close together as possible. Loose or vibrating test leads will also induce error voltages. Tie down test leads securely when operating near magnetic fields. Whenever possible, utilize magnetic shielding materials or increase the distance from magnetic sources.

Noise Caused by Ground Loops

When measuring voltages in circuits where the instrument and the device-under-test are both referenced to a common earth ground, a ground loop is formed. As shown in figure below any voltage difference between the two ground reference points (V_{ground}) causes a current to flow through the measurement leads. This causes noise and offset voltage (usually power-line related), which are added to the measured voltage.



R_L = Lead Resistance
 R_i = Multimeter Isolation Resistance
 V_{ground} = Voltage Drop on Ground Bus

The best way to eliminate ground loops is to isolate the instrument from earth by *not* grounding the input terminals. If the instrument must be earth-referenced, connect it and the device-under-test to the same common ground point. Also connect the instrument and the device-under-test to the same electrical outlet whenever possible.

Measurement Speed Consideration

There are two methods of integrating the sampled data taken in the measurement, slow/medium (NPLC) and fast (Aperture).

When you set the resolution to slow or medium, you can achieve improved accuracy associated with time averaging, as well as also improve the rejection of power-line interference (normal mode rejection, or NMR).

Aperture is the period, measured in seconds, during which the instrument's analog-to-digital (A/D) converter samples the input signal for a measurement. A longer aperture yields better resolution; a shorter aperture provides faster measurements. For example, the fast mode for DC Voltage measurements set a specific 1 ms measurement period and is not based on power line frequency. No normal mode rejection is provided in aperture mode.

Secondary Measurement Considerations

The secondary measurements mode allows users to make two measurements in one display. During secondary measurement mode, the display will show two separate measurements and there is a switching delay between both measurements.

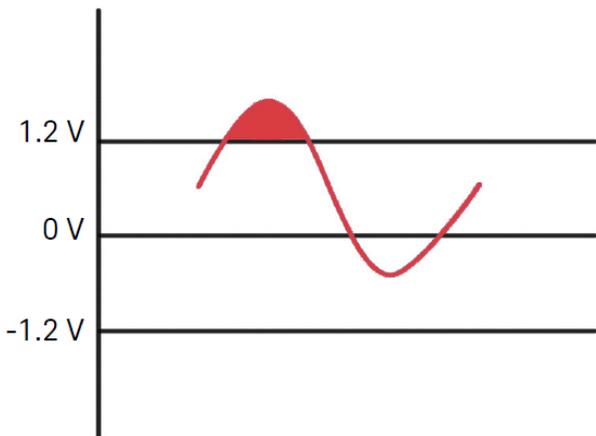
The table below shows some of the applications that can be measured using secondary measurement mode:

Secondary Function Combinations	Application
DCV and ACV	Measure AC signal with DC offset from an amplifier output Measure AC ripple noise and DC output voltage from a power supply
DCV and DCI	Measure DC voltage and DC current on a electronic circuit
DCV and ACI	Inverter application
ACV and DCI	Inverter application
ACV and ACI	Measure primary and secondary signal of a transformer circuit
ACV/ACI and Freq	Measure frequency of the line voltage

DC Voltage Dynamic Range in Secondary Measurement

When measuring DC and AC in dual measurement mode, make sure the DC + AC components do not exceed the instrument's ADC dynamic range. The instrument has a dynamic range of ± 1.2 V or 120% of full scale for each DCV ranges.

For example, the DC offset of the signal as shown in the figure below causes the input to exceed the upper limit ADC dynamic range. This may cause errors in DC component measurement.



Consider an AC component of 1 V_{rms} signal with a DC offset of 100 mV. When measuring at DCV 1 V range, V_{peak} of the signal is 1.514 V which exceeds the ADC dynamic range of 1.2 V, causing an error in DC measurement.

Select a higher range DCV 10 V range for better accuracy.

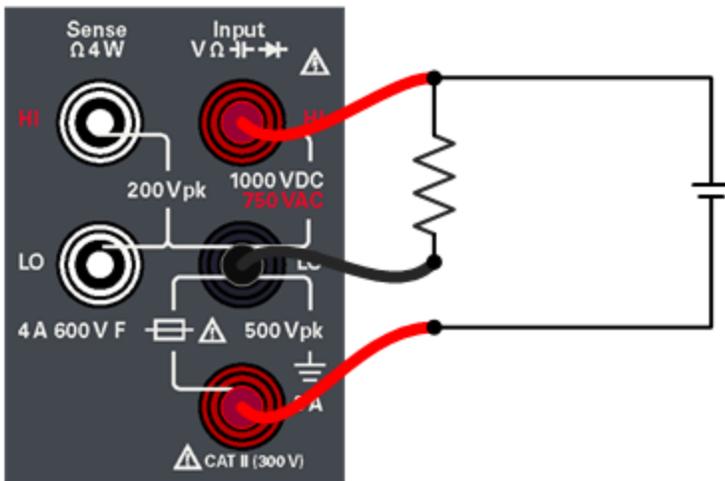
The same error of measurement applies to DCV and ACI dual mode caused by the instrument's series burden voltage.

Voltage and Current in Dual Measurement

When measuring DC voltage and DC current in dual measurement mode, take into account the resistance of the test lead and internal measuring circuitry. The instrument shares the same common ground both in DC voltage and DC current measurement. When a current flow through the LO terminal, a voltage drop will occur in the circuit and will affect the accuracy of the voltage reading.

Considering the internal resistance and external lead resistance total is 0.0125 ohm. If applying a 1 A DC current, an error of $(0.0125 \Omega \times 1 \text{ A})$ 0.0125 V or 12.5 mV will occur. This error will be relative by range with the ADC dynamic range of 1.2 V.

The figure below shows an example of measuring voltage and current in secondary measurement mode.



The error in measurement will be significant when applying a higher current.

Resistance Measurement Considerations

When measuring resistance, the test current flows from the input HI terminal through the resistor being measured. The voltage drop across the resistor being measured is sensed internal to the instrument. Therefore, test lead resistance is also measured.

The errors mentioned earlier in this chapter for DC voltage measurements also apply to resistance measurements. Additional error sources unique to resistance measurements are discussed here.

Removing Test Lead Resistance Errors

To eliminate offset errors associated with test lead resistance, refer to **Null**.

Minimizing Power Dissipation Effects

When measuring resistors designed for temperature measurements (or other resistive devices with large temperature coefficients), be aware that the instrument will dissipate some power in the device-under-test (DUT).

If power dissipation is a problem, you should select the instrument's next higher measurement range to reduce the errors to acceptable levels. The following table shows several examples.

Range	Test Current	DUT Power at Full Scale
100 Ω	1 mA	100 μ W
1 k Ω	0.5 mA	250 μ W
10 k Ω	100 μ A	100 μ W
100 k Ω	10 μ A	10 μ W
1 M Ω	1 μ A	1 μ W
10 M Ω	100 nA	100 nW
100 M Ω	100 nA/10 M Ω	1 μ W

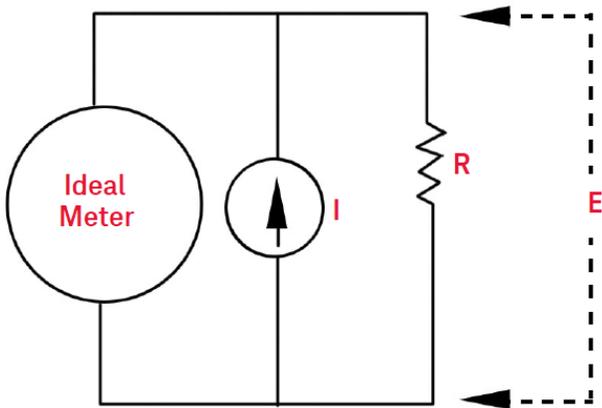
Errors in High Resistance Measurements

When you are measuring large resistances, significant errors can occur due to resistance insulation and surface cleanliness. You should take the necessary precautions to maintain a “clean” high-resistance system. Test leads and fixtures are susceptible to leakage due to moisture absorption in insulating materials and “dirty” surface films. Nylon and PVC are relatively poor insulators ($10^9 \Omega$) when compared to PTFE insulators ($10^{13} \Omega$).

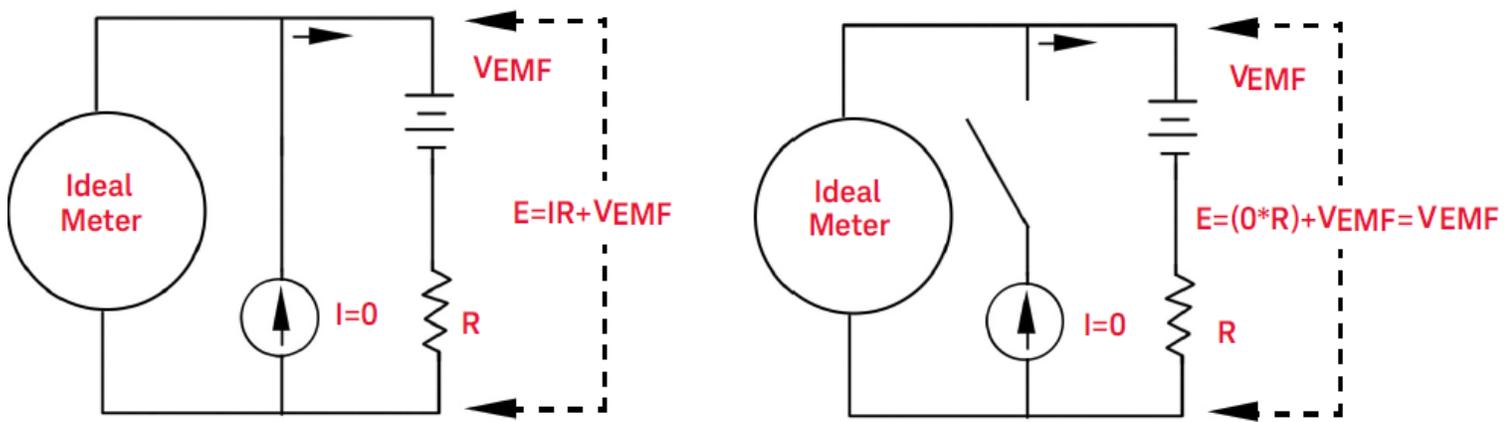
Leakage from nylon or PVC insulators can easily contribute a 0.1% error when measuring a 1 M Ω resistance in humid conditions.

Offset Compensation

A resistance measurement involves measuring a voltage (E) induced across the resistance by a known current source.



Thermal EMF caused by dissimilar metals can create a parasitic voltage in the measurement circuit (V_{EMF}). The thermal EMF can be caused by the input lead connections or internally in resistor R. In general, this voltage will not change with the current applied to the resistor.



The voltage measured, and so the resistance calculated, is in error by V_{EMF} . Using offset compensation can reduce the errors caused by V_{EMF} . To make an offset compensated measurement, the meter makes two voltage measurements, one with the current source on and one with the current source off, and subtracts the two measurements. The actual voltage drop across the resistor, and the calculated resistance are obtained by:

$$\text{First Reading} - \text{Second Reading} = (I * R + V_{EMF}) - V_{EMF} = I * R$$

Offset compensation can be used in 2-Wire or 4-Wire ohms measurements (only available on 100 Ω , 1 k Ω , and 10 k Ω).

True RMS AC Measurements

True RMS responding multimeters, like the EDU34450A, measure the “heating” potential of an applied voltage. Power dissipated in a resistor is proportional to the square root of an applied voltage, independent of the waveshape of the signal. This instrument accurately measures true RMS voltage or current, as long as the wave shape contains negligible energy above the instrument’s effective bandwidth. Note that the instrument uses the same techniques to measure true RMS voltage and true RMS current.

Waveform Shape	Crest Factor	AC RMS	AC + DC RMS
	$\sqrt{2}$	$\frac{V}{\sqrt{2}}$	$\frac{V}{\sqrt{2}}$
	$\sqrt{3}$	$\frac{V}{\sqrt{3}}$	$\frac{V}{\sqrt{3}}$
	$\sqrt{\frac{T}{t_p}}$	$\frac{V}{CF} \times \sqrt{1 - \frac{1}{CF^2}}$	$\frac{V}{CF}$
	1	V	V

The instrument's AC voltage and AC current functions measure the AC-coupled true RMS value. In this Keysight instrument, the "heating value" of only the AC components of the input waveform are measured (DC is rejected). As seen in the figure above; for sinewaves, triangle waves, and square waves, the AC-coupled and AC+DC values are equal since these waveforms do not contain a DC offset. However, for non-symmetrical waveforms, such as pulse trains, there is a DC voltage content, which is rejected by Keysight's AC-coupled true rms measurements. This can provide a significant benefit.

An AC-coupled true rms measurement is desirable when you are measuring small AC signals in the presence of large DC offsets. For example, this situation is common when measuring AC ripple present on DC power supplies. There are situations, however, where you might want to know the AC+DC true RMS value. You can determine this value by combining results from DC and AC measurements, as shown below:

$$ac + dc = \sqrt{ac^2 + dc^2}$$

For the best AC noise rejection, you should perform the DC measurement at s-mode.

True RMS Accuracy and High-Frequency Signal Content

A common misconception is that "since an AC multimeter is true RMS, its sinewave accuracy specifications apply to all waveforms." Actually, the shape of the input signal can dramatically affect measurement accuracy, for any multimeter, especially when that input signal contains high-frequency components which exceed the instrument's bandwidth. Error in RMS measurements arise when there is significant input signal energy at frequencies above the instrument's bandwidth.

Estimating High-Frequency (Out-of-Band) Error

A common way to describe signal waveshapes is to refer to their "Crest Factor". Crest factor is the ratio of the peak value to RMS value of a waveform. For a pulse train, for example, the crest factor is approximately equal to the square root of the inverse of the duty cycle.

$$CF = \frac{1}{\sqrt{d}} = \frac{1}{\sqrt{\frac{t_p}{T}}} = \frac{1}{\sqrt{prf \times t_p}}$$

Notice that crest factor is a composite parameter, dependent upon the pulse-width and repetition frequency; crest factor alone is not enough to characterize the frequency content of a signal.

Traditionally, digital multimeters include a crest factor derating table that applies at all frequencies. The measurement algorithm used in the EDU34450A is not inherently sensitive to crest factor, so no such derating is necessary. With this instrument, as discussed in the previous section, the focal issue is high-frequency signal content which exceeds the instrument's bandwidth.

For periodic signals, the combination of crest factor and repetition rate can suggest the amount of high-frequency content and associated measurement error. The first zero crossing of a simple pulse occurs at

$$f_1 = \frac{1}{t_p}$$

This gives an immediate impression of the high-frequency content by identifying where this crossing occurs as a function of crest factor:

$$f_1 = CF^2 \cdot prf$$

The table below shows the typical errors for various pulse waveforms as a function of input pulse frequency:

prf	Typical Error for Square Wave, Triangular Wave, and Pulse Trains of CF = 3, 5, or 10				
	Square Wave	Triangle Wave	CF = 3	CF = 5	CF = 10
200	-0.02%	0.00%	-0.04%	-0.09%	-0.34%
1000	-0.07%	0.00%	-0.18%	-0.44%	-1.71%
2000	-0.14%	0.00%	-0.34%	-0.88%	-3.52%
5000	-0.34%	0.00%	-0.84%	-2.29%	-8.34%
10000	-0.68%	0.00%	-1.75%	-4.94%	-26.00%
20000	-1.28%	0.00%	-3.07%	-8.20%	-45.70%
50000	-3.41%	-0.04%	-6.75%	-32.2%	-65.30%
100000	-5.10%	-0.12%	-21.8%	-50.6%	-75.40%

The table above gives an additional error for each waveform, to be added to the value from the accuracy table provided in the *Keysight EDU34450A Datasheet*.

Example: A pulse train with level 1 Vrms, is measured on the 1 V range. It has pulse heights of 3 V (that is, a Crest Factor of 3) and duration 111 μs. The prf can be calculated to be 1000 Hz, as follows:

$$prf = \frac{1}{CF^2 \times t_p}$$

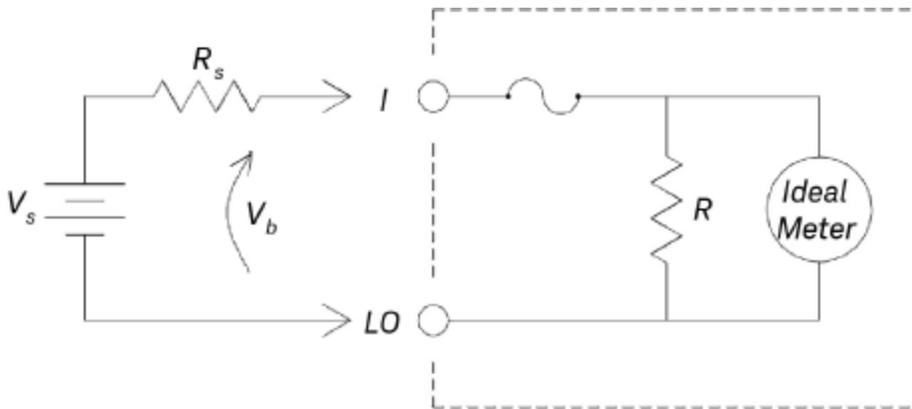
Thus, from the table above, this AC waveform can be measured with 0.18 percent additional error.

AC Filter

The instrument's AC voltage and AC current functions implement three low-frequency comb filters. These filters allow you to trade-off minimum measured frequency for faster reading speed. The "SLOW" mode filter cut-off at 2 Hz and useful for frequencies above 20 Hz. The "MEDIUM" filter cut-off at 20 Hz and useful for frequencies above 200 Hz. The "FAST" filter cut-off at 200 Hz and useful for frequencies above 1 kHz.

DC current measurements

When you connect the instrument in series with a test circuit to measure current, a measurement error is introduced. The error is caused by the instrument's series burden voltage. A voltage is developed across the wiring resistance and current shunt resistance of the instrument, as shown below.



V_s = Source Voltage
 R_s = DUT Source Resistance
 V_b = Multimeter Burden Voltage
 R = Multimeter Current Shunt

$$\text{Error (\%)} = \frac{-100\% \times V_b}{V_s}$$

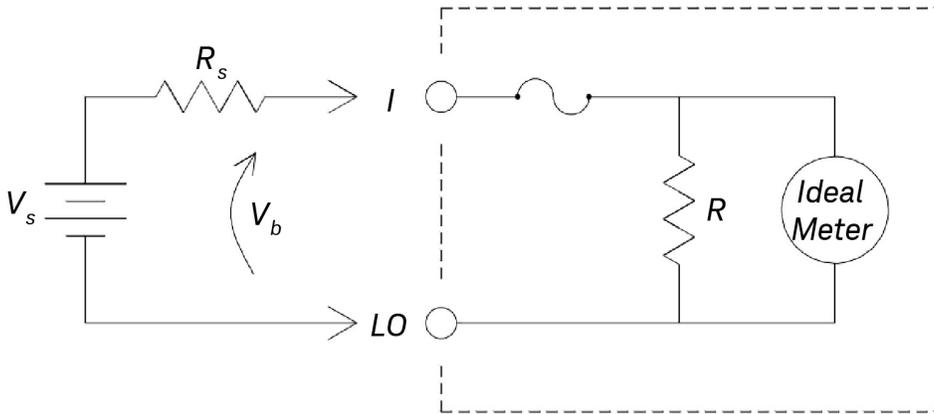
Other Primary Measurement Functions

Frequency Measurement Errors

The instrument uses a reciprocal counting technique to measure frequency. This method generates constant measurement resolution for any input frequency. All frequency counters are susceptible to errors when measuring low-voltage, low-frequency signals. The effects of both internal noise and external noise pickup are critical when measuring "slow" signals. The error is inversely proportional to frequency. Measurement errors also occur if you attempt to measure the frequency of an input following a DC offset voltage change. You must allow the instrument's input to fully settle before making frequency measurements.

DC Current Measurements

When you connect the instrument in series with a test circuit to measure current, a measurement error is introduced. The error is caused by the instrument's series burden voltage. A voltage is developed across the wiring resistance and current shunt resistance of the instrument, as shown below.



V_s = Source Voltage

R_s = DUT Source Resistance

V_b = Multimeter Burden Voltage

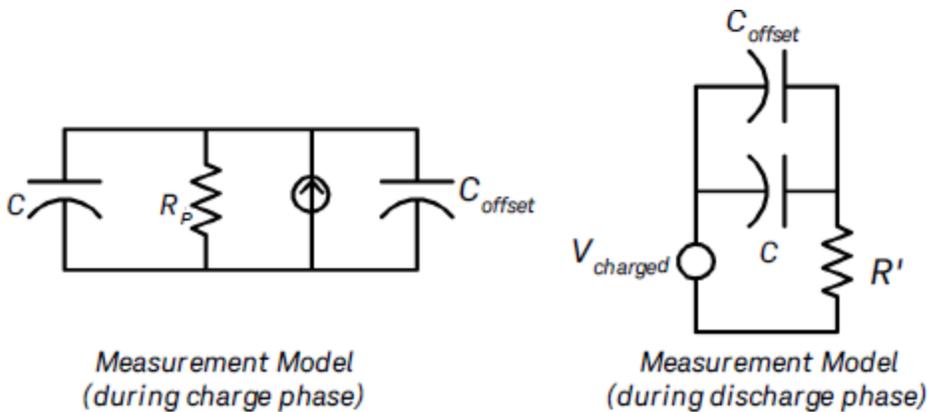
R = Multimeter Current Shunt

$$\text{Error (\%)} = \frac{-100\% \times V_b}{V_s}$$

If you apply more than 1 A during current measurement, self-heating occurs in the instrument record's 3 A shunt resistor and internal signal-conditioning component. Do allow few minutes stabling time for better accuracy for current measurement. After applying more than 1 A current measurement, do allow a few minutes for heat dissipation to ensure better accuracy for other measurement.

Capacitance Measurements

The instrument implements capacitance measurements by applying a known current to the capacitor as shown below:



Capacitance is calculated by measuring the change in voltage (ΔV) that occurs over a “short aperture” time, (Δt). The measurement cycle consists of two parts: a charge phase and a discharge phase.

The change in voltage (ΔV) and “short aperture” time (Δt), vary by range, in order to minimize noise and increase reading accuracy. The following table lists the current source and reading rate at full scale during the measurement.

Range	Current Source	Reading Rate at Full Scale
1 nF	100 nA	1.0/second
10 nF	100 nA	0.5/second
100 nF	1 μ A	1.5/second
1 μ F	1 μ A	0.25/second
10 μ F	10 μ A	0.25/second
100 μ F	100 μ A	0.25/second
1 mF	500 μ A	0.25/second
10 mF	1 mA	0.15/second

The values of capacitance and loss resistance measured with the instrument may differ from the values measured using an LCR meter. This is to be expected, since this is essentially a DC measurement method, while LCR measurement uses applied frequencies anywhere from 100 Hz to 100 kHz. In most cases, neither method measures the capacitor at its exact frequency of application.

For the best accuracy, take a zero null measurement with open probes, to null out the test lead capacitance, before connecting the probes across the capacitor to be measured.

Temperature Measurements

The instrument measures temperature by measuring the temperature sensitive resistance of 5 k Ω thermistors.

Thermistors consist of semiconductor materials and provide roughly 10 times the sensitivity of an RTD. Because they are semiconductors, their temperature range is more limited, commonly to -80 $^{\circ}$ C to 150 $^{\circ}$ C. Thermistors have highly non-linear, temperature-resistance relationships; therefore their conversion algorithms are more complex. Keysight instruments use the standard Hart-Steinhart Approximation to provide accurate conversions.

Other Sources of Measurement Error

Loading Errors (AC Volts)

In the AC voltage function, the input of the instrument appears as a (at least) 1.1 M Ω resistance in parallel with <100 pF of capacitance. The cabling that you use to connect signals to the instrument also adds capacitance and loading.

For low frequencies, the loading error is:

$$\text{Error (\%)} = \frac{-100 \times R_s}{R_s + 1.1 \text{ M}\Omega}$$

At high frequencies, the additional loading error is:

$$\text{Error (\%)} = 100 \times \left[\frac{1}{\sqrt{1 + (2\pi \times F \times R_s \times C_{in})^2}} - 1 \right]$$

R_s = Source Resistance

F = Input Frequency

C_{in} = Input Capacitance (100 pF) Plus Cable Capacitance

Measurements Below Full Scale

You can make the most accurate AC measurements when the instrument is at or near the full scale of the selected range. Autoranging occurs at 10% (down-range) and 120% (up-range) of full scale. This enables you to measure some inputs at full scale on one range and 10% of full scale on the next higher range. In general, the accuracy is better on the lower range; for the highest accuracy, select the lowest manual range possible for the measurement.

High-Voltage Self-Heating Errors

If you apply more than 300 Vrms, self-heating occurs in the instrument's internal signal-conditioning components. These errors are included in the instrument's specifications.

Temperature changes inside the instrument due to self-heating may cause additional error on other AC voltage ranges.

AC Current Measurement Errors (Burden Voltage)

Burden voltage errors, which apply to DC current, also apply to AC current measurements. However, the burden voltage for AC current is larger due to the instrument's series inductance and your measurement connections. The burden voltage increases as the input frequency increases. Some circuits may oscillate when performing current measurements due to the instrument's series inductance and your measurement connections.

Low-Level Measurement Errors

When measuring AC voltages less than 100 mV, be aware that these measurements are especially susceptible to errors introduced by extraneous noise sources. An exposed test lead acts as an antenna and a properly functioning multimeter will measure the signals received. The entire measurement path, including the power line, acts as a loop antenna. Circulating currents in the loop create error voltages across any impedances in series with the instrument's input. For this reason, you should apply low-level AC voltages to the instrument through shielded cables. You should connect the shield to the input LO terminal.

Make sure the instrument and the AC source are connected to the same electrical outlet whenever possible. You should also minimize the area of any ground loops that cannot be avoided. A high-impedance source is more susceptible to noise pickup than a low-impedance source. You can reduce the high-frequency impedance of a source by placing a capacitor in parallel with the instrument's input terminals. You may have to experiment to determine the correct capacitor value for your application.

Most extraneous noise is not correlated with the input signal. You can determine the error as shown below.

$$\text{Voltage Measured} = \sqrt{V_{in}^2 + \text{Noise}^2}$$

Correlated noise, while rare, is especially detrimental. Correlated noise always adds directly to the input signal. Measuring a low-level signal with the same frequency as the local power line is a common situation that is prone to this error.

Pulse Measurement Error

You can use the DC measurement function to measure a pulse signal and obtain its relevant average measurement quickly. The formula of the equivalent DC average of a pulse signal is provided below.

$$\frac{1}{T} \int_T f(x) dx$$

where $f(x)$ is the function representing the signal waveform over a period of T .

Errors may occur when the pulse signal is measured at low voltage range due to saturation of the instrument's analog-to-digital (ADC) rail voltage.



This information is subject to change without notice.

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