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# Autoranging DC Power Supplies

## E36150 Series


This manual contains service information, performance verification and adjustment procedures for the E36150 Series autoranging DC power supplies.

KEYSIGHT

SERVICE GUIDE

# Notices

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## Warranty



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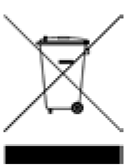


## Declarations of Conformity

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.

# 1 Service and Maintenance



This chapter provides the specifications and service information on cleaning, troubleshooting, repair, and replaceable parts of the E36150 Series. This chapter also explains how to assemble and disassemble the E36150 Series.

## Specifications and Characteristics

**NOTE** For the characteristics and specifications of the E36150 Series Autoranging DC Bench Power Supply, refer to the datasheet at https://www.keysight. com/us/en/assets/3122-1798/data-sheets/E36150-Series.pdf.

## General Information

### Types of service available

If your instrument fails during the warranty period, Keysight Technologies will repair or replace it under the terms of your warranty. After your warranty expires, Keysight offers repair services at competitive prices. You also have the option to purchase a service contract that extends the coverage after the standard warranty expires.

### Obtaining repair service (worldwide)

To obtain service for your instrument, contact your nearest Keysight Technologies Service Center. They will arrange to have your unit repaired or replaced, and can provide warranty or repair–cost information where applicable. Ask the Keysight Technologies Service Center for shipping instructions, including what components to ship. Keysight recommends that you retain the original shipping carton for return shipments.

### Repackaging for shipment

Ensure the following to ship the unit to Keysight for service or repair:

- Attach a tag to the unit identifying the owner and indicating the required service or repair. Include the model number and full serial number.
- Place the unit in its original container with appropriate packaging material.
- Secure the container with strong tape or metal bands.
- If the original shipping container is unavailable, use a container that will ensure at least 10 cm (4 in.) of compressible packaging material around the entire instrument. Use static-free packaging materials.
- Remove the GPIB interface module from the instrument if the instrument is equipped with the GPIB interface module and the module is not having a failure.

Keysight suggests that you always insure your shipments.

### Cleaning and handling

**Cleaning**

To prevent electrical shock, disconnect the instrument from AC mains power and disconnect all test leads before cleaning. Clean the outside of the instrument using a soft, lint-free, cloth slightly dampened with water.

- Do not use detergent or solvents.
- Do not attempt to clean internally.

If required, contact a Keysight Technologies Sales and Service office to arrange for proper cleaning to ensure that safety features and performance are maintained.

**Electrostatic Discharge (ESD) precautions**

Almost all electrical components can be damaged by electrostatic discharge (ESD) during handling. Component damage can occur at electrostatic discharge voltages as low as 50 V.

The following guidelines will help prevent ESD damage during service operations:

- Disassemble instruments only in a static-free work area.
- Use a conductive work area to reduce static charges.
- Use a conductive wrist strap to reduce static charge accumulation.
- Minimize handling.
- Keep replacement parts in original static-free packaging.
- Remove all plastic, foam, vinyl, paper, and other static-generating materials from the immediate work area.

## Troubleshooting

Before troubleshooting or repairing the instrument, make sure the failure is in the instrument rather than any external connections. Also make sure that the instrument was accurately calibrated within the last year (see Calibration Adjustment Procedures > Calibration Interval for details).

Perform the following verifications if the unit is inoperative:

- Verify that the ac power cord is connected to the electronic load.
- Verify that the front-panel power switch is depressed.
- Verify the power-line voltage setting.

## Self-Test Procedures

Refer to *E36150 Series User's Guide* for details.

## User Replaceable Parts

You can find the instrument support part list at Keysight's Test & Measurement Parts Catalog http://www.keysight.com/find/parts.

The

## Battery Replacement

**WARNING**

SHOCK HAZARD

Only qualified, service-trained personnel who are aware of the hazards involved should remove instrument covers. Always disconnect the power cable and any external circuits before removing the instrument cover. Some circuits are active and have power for a short time even when the power switch is turned off.

The internal battery powers the real-time clock. The primary function of the clock it to provide a time stamp for the internal file system. If the battery fails, the clock and time stamp function will not be available. No other instrument functions are affected.

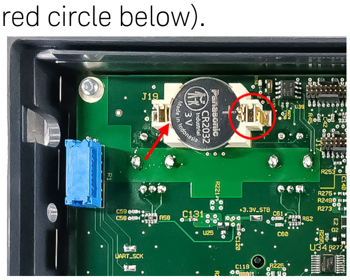
Under normal use at room temperature, the lithium battery has a life expectancy between seven and ten years. Note that battery life will be reduced if the instrument is stored for a prolonged period at temperatures above 40 degrees Celsius.

The battery type is Panasonic CR 2032.

### Replacing the Battery (KPN 1420-0942)

1. Remove the front panel.
2. The battery is located at the front panel PC board.
3. Use a flat-bladed screwdriver and carefully pry up on the side of the battery.


4. Install the new battery. Make sure that the positive side (+) is facing up. Place the battery under the small spring clips closest to the ribbon cable connector, then push down on the opposite end of the battery to seat the battery (see red arrow below). The top of the small spring clips should be visible after the battery is seated (see red circle below).




5. Replace the top cover when finished.
6. Reset the date and time.

**NOTE** Properly dispose of the old battery in accordance with local laws and regulations.

## Disassembly

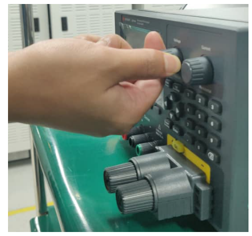
### Tools required

| Items | Torque value |
| --- | --- |
| T20 Torx driver | 21 in.lbs |
| Pozi M4 bit | 9.0 in.lbs |

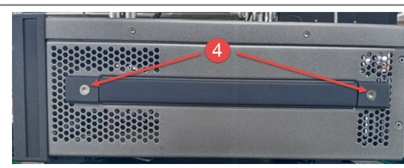
### Removing the front panel

| Steps | Instructions | Visual |
| --- | --- | --- |
| 1. | Remove the side trims (KPN 5190-9105) from the front panel. |   |
| 2. | Remove four Pozi screws (KPN 0515-1055) from the front panel using a Pozi M4 bit. |   |
| 3 | Pull out the front panel |  |
| 4 | To install back the front panel, perform the above steps in reverse order. | |

## Removing/Installing the knob (KPN 54964-47450)

| Steps | Instructions | Visual |
| --- | --- | --- |
| 1. | Pull out the knob to remove the knob from the front panel. |  |
| 2. | To install back the knob, push the knob back in the shaft.<br><br>NOTE: Make sure to follow the shaft orientation before pushing the knob. |   |

## Installing the strap handler

| Steps | Instructions | Visual |
| --- | --- | --- |
| 1. | Insert the stainless steel belt into the PVC strap.<br><br>Note: This step uses the strap handle assembly (KPN E36311-61200). |   |
| 2. | Insert the stainless steel gaskets to both side of the stainless steel belt. | |
| 3. | Cover both side with the plastic cap (KPN 5042-6815). | |
| 4. | Secure both side of the strap handle with 2 (M5*10) screws (KPN 0515-1384) |   |

## Removing/Installing the optional GPIB interface

Refer to the *E36150 Series User's Guide* for details.

# 2 Verification and Adjustments



This chapter contains the performance verification procedures which verify that the E36150 Series is operating within its published specifications. This chapter also provides information on adjustments performed after a performance verification fails.

## Performance Verification

Performance verification ensures that the instrument performs within the specifications stated in the data sheet (https://www.keysight.com/us/en/assets/3122-1798/data-sheets/E36150-Series.pdf)

Verification Test Setups

Constant Current Verification

Constant Voltage Verification

Transient Response Time

CV Ripple and Noise Verification

### Recommended test equipment

The test equipments recommended for the performance verification and adjustment procedures are listed below. If the exact instrument is not available, use the accuracy requirements shown to select substitute calibration standards.

| Type | Specification | Recommended model |
|---|---|---|
| Digital multimeter | Readout: 6 1/2 digits Basic DC<br>Accuracy: 0.0035% | Keysight 34465A or equivalent |
| Current monitor | 10 A (1 Ω), TC = 4 ppm/°C<br>100 A (0.01 Ω), TC = 4 ppm/°C | Guildline 9230A-10<br>Guildline 9230A-100 |
| Electronic Load | 60 V, 80 A minimum, with transient capability | Keysight N3300A / 2 x N3306A (60 V, 120 A) |
| Oscilloscope | Sensitivity: 1 mV<br>Bandwidth Limit: 20 MHz<br>Probe: 1:1 with RF tip | Keysight Infiniium/6054A or equivalent |
| RMS voltmeter | True RMS<br>Bandwidth: 10 MHz<br>Sensitivity: 100 µV | Keysight 3458A or equivalent |
| Differential amplifier | Bandwidth: 20 MHz | LeCroy DA1855A or equivalent |
| Terminations | 1 – 50 Ω BNC termination<br>2 – 50 Ω, ≥ 1/8 W resistor | Not applicable |
| Variable voltage transformer or AC source | Adjustable to highest rated input voltage range.<br>Power: 1500 VA | Keysight AC6803B or equivalent |
| Fixed Load (E36154A) | Wirewound resistor 1000 W and 2000 W, for PARD verification:<br>1. 0.5 Ω (x 4 units in parallel) yields 0.125 Ω for 10 V, 80 A PARD<br>2. 1.125 Ω for 30 V, 26.667 A PARD | MF Power Resistor<br>DSR-1000WR6J-F-V1<br>DSR-2000W1R2J-F-V1 |
| Fixed Load (E36155A) | Wirewound resistor 2000 W, for PARD verification:<br>1. 0.5 Ω for 20 V, 40 A PARD<br>2. 4.5 Ω for 60 V, 13.333 A PARD | MF Power Resistor<br>DSR-2000WR6J-F-V1<br>DSR-2000W5RJ-F-V1 |

## Test considerations

- Ensure that the calibration ambient temperature is stable and between 20 °C and 30 °C.
- Ensure ambient relative humidity is less than 80%.
- Allow a 1-hour warm-up period before verification or calibration.
- Keep cables as short as possible, consistent with the impedance requirements.
- Performance verification and calibration procedure must be performed through rear panel output.

**CAUTION** The tests should be performed by qualified personnel. During performance verification tests, hazardous voltages may be present at the outputs of the power supply.

## Measurement techniques

### Voltmeter

To ensure that the values read by the voltmeter during both the verification procedure and the calibration procedure are not affected by the instantaneous measurement of the AC peaks of the output current ripple, make several DC measurements and average them.

### Current-monitoring resistor

The 4-terminal current shunt is used to eliminate output current measurement error caused by voltage drops in the load leads and connections. It has special current-monitoring terminals inside the load connection terminals. Connect the voltmeter directly to these current-monitoring terminals.

### Electronic load

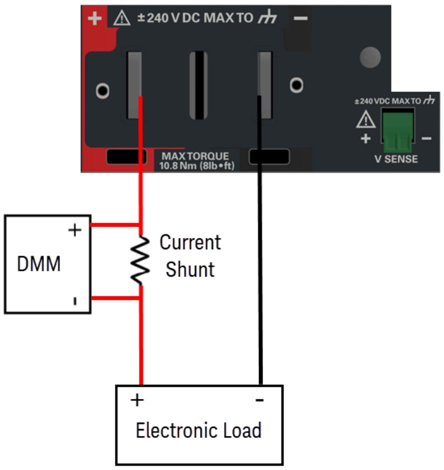
Many of the test procedures require the use of a variable load capable of dissipating the required power. If a variable resistor is used, switches should be used to connect, disconnect, or short the load resistor. For most tests, an electronic load can be used. The electronic load is considerably easier to use than load resistors, but it may not be fast enough to test transient recovery time and may be too noisy for the noise (PARD) tests.

Fixed load resistors may be used in place of a variable load, with minor changes to the test procedures. Also, if computer controlled test setups are used, the relatively slow (compared to computers and system voltmeters) settling times and slew rates of the power system may have to be taken into account. “Wait” statements can be used in the test program if the test system is faster than the power system.

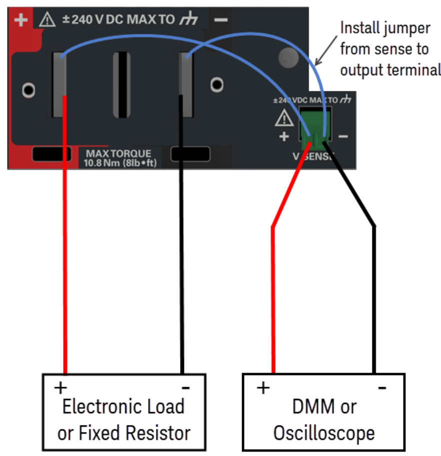
## Verification Test Setups

The following figures show the verification test set-ups. Connect all leads to the output terminal as shown below. A LAN, USB, or GPIB cable is needed for readback data.

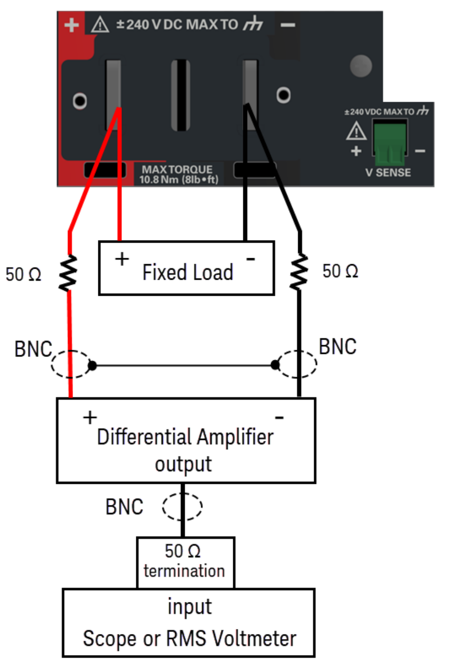
CC Verification Test Setup




CV Verification Test Setup




CV Ripple and Noise Verification Test Setup



## Constant Voltage (CV) verification

### Voltage programming and readback accuracy

*Test category = performance, calibration*

This test verifies that the voltage programming and measurement functions are within specifications.

1. Turn off the power supply.
2. Connect a DMM across the sense terminals (see CV Test Setup). Do not connect the load.
3. Turn on the power supply and program the instrument settings as described in Table 2-1.
4. Turn the output on. The output status should be “CV” and the output current should be close to zero.
5. Record the output voltage reading from the DMM and the voltage measured over the interface. The readings should be within the limits specified in the Test Record Form for the appropriate model under “Voltage Programming” and "Voltage Readback".

Table 2-1 Voltage programming and readback accuracy instrument settings

| Model | DUT settings | |
|---|---|---|
| | Voltage (V) | Current (A) |
| E36154A | 0 | 80 |
| | 30 | 80 |
| E36155A | 0 | 40 |
| | 60 | 40 |

### CV load regulation

*Test category = performance*

This test measures the change in output voltage resulting from a change in output current from full load to no load.

1. Turn off the power supply.
2. Connect a DMM and electronic load to the output terminals (see CV Test Setup).
3. Turn on the power supply and program the instrument settings as described in Table 2-2.
4. Turn the output on.
5. Operate the electronic load in constant current mode and set it's current to the value as described in Table 2-2. The output status of the power supply should be “CV”. If it isn’t, adjust the load so that the output current drops slightly.
6. Record the output voltage reading from the DMM as $V_{load}$.

7. Operate the electronic load in open mode (input off). Record the voltage reading from the DMM again as $V_{noload}$. The difference between the DMM readings in steps 6 and 7 is the CV load regulation ($V_{load}$ - $V_{noload}$), which should not exceed the value listed in the Test Record Form for the appropriate model under "CV Load Regulation".

Table 2-2 CV load regulation instrument settings

| Model | DUT settings | | Eload settings | |
|---|---|---|---|---|
| | Voltage (V) | Current (A) | Mode | Current (A) |
| E36154A | 10 | Max | CC | 80 |
| | 30 | Max | CC | 26.67 |
| E36155A | 20 | Max | CC | 40 |
| | 60 | Max | CC | 13.33 |

### CV line regulation

*Test category = performance*

This test measures the change in output voltage that results from a change in AC line voltage from the minimum to maximum value within the line voltage specifications.

1. Turn off the power supply.
2. Connect a DMM and electronic load to the output terminals (see CV Test Setup).
3. Connect a variable AC Source or Variac to the AC input, and set to an appropriate line voltage for the power supply configuration.
4. Turn on the power supply and program the instrument settings as described in Table 2-3.
5. Turn the output on.
6. Operate the electronic load in constant current mode and set it's current to the value described in Table 2-3. The output status for the power supply should be "CV". If it isn't, adjust the load so that the output current drops slightly.
7. Adjust the AC power source to the low line voltage limit as described in Table 2-3. Record the output reading from the DMM as $V_{lowline}$.
8. Adjust the AC power source to the high line voltage limit as described in Table 2-3. Record the output reading from the DMM as $V_{highline}$.
9. The difference between the DMM readings in steps 7 and 8 is the CV line regulation ($V_{lowline}$ - $V_{highline}$), which should not exceed the value listed in the Test Record Form for the appropriate model under "CV Line Regulation".

Table 2-3 CV line regulation instrument settings

| Model | DUT settings | | AC source settings | | Eload settings | | Line voltage |
|---|---|---|---|---|---|---|---|
| | Voltage (V) | Current (A) | Low | High | Mode | Current (A) | |
| E36154A | 30 | Max | 90 VAC | 110 VAC | CC | 26.67 | 100 VAC |
| | 10 | Max | | | CC | 80 | |
| | 30 | Max | 103.5 VAC | 126.5 VAC | CC | 26.67 | 115 VAC |
| | 10 | Max | | | CC | 80 | |
| | 30 | Max | 207 VAC | 253 VAC | CC | 26.67 | 230 VAC |
| | 10 | Max | | | CC | 80 | |
| E36155A | 60 | Max | 90 VAC | 110 VAC | CC | 13.33 | 100 VAC |
| | 20 | Max | | | CC | 40 | |
| | 60 | Max | 103.5 VAC | 126.5 VAC | CC | 13.33 | 115 VAC |
| | 20 | Max | | | CC | 40 | |
| | 60 | Max | 207 VAC | 253 VAC | CC | 13.33 | 230 VAC |
| | 20 | Max | | | CC | 40 | |

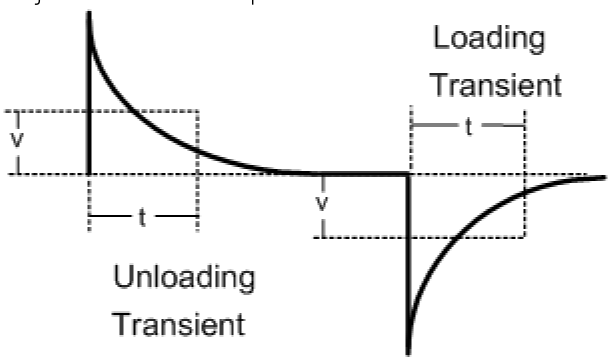
### Transient response time

*Test category = performance*

This test measures the time for the output voltage to recover to within the specified value following a 50% change in the load current.

1. Turn off the power supply.
2. Connect a oscilloscope across the sense terminals (see CV Test Setup). Connect an electronic load to the output terminals.
3. Turn on the power supply and program the instrument settings as described in Table 2-4.
4. Turn the output on.
5. Set the electronic load to operate in constant current mode. Program its load current as described in Table 2-4.
6. Set the transient level to ½ the maximum current. Set the transient duty cycle to 50% and transient frequency to 1 kHz. The output status of the power supply should be “CV”. If it isn’t, adjust the load so that the output current drops slightly.
7. Program the load's transient current level to the higher current value indicated in Table 2-4, and turn the transient generator on.

8. Adjust the oscilloscope for a waveform similar to that shown in the following figure.




9. The output voltage should return to within the specified voltage at the specified time following the 50% load change. Check both loading and unloading transient by triggering on the positive and negative slope. Record the time “t” of the transient at the voltage settling band "v" in the Test Record Form for the appropriate model under “Transient Response”.

10. The transient response specification is met when the voltage recovers within 1 ms.

Table 2-4 Transient response time instrument settings

| Model | DUT settings | | Eload settings | | Voltage settling band |
|---|---|---|---|---|---|
| | Voltage (V) | Current (A) | Current (A) | T-level | |
| E36154A | 30 | Max | 26.67 | 13.333 | 75 mV |
| | 10 | Max | 80 | 40 | 75 mV |
| E36155A | 60 | Max | 13.33 | 6.667 | 150 mV |
| | 20 | Max | 40 | 20 | 150 mV |

### CV ripple and noise verification

*Test category = performance*

Periodic and random output deviations superimpose a residual AC voltage on the DC output. This residual voltage is specified as the rms or peak-to-peak noise in and is specified in the product data sheet.

1. Turn off the power supply.
2. Connect a fixed load, differential amplifier, and an oscilloscope (AC coupled) to the output terminals (see CV Ripple and Noise Test Setup).
3. Use an appropriate load resistor (see the fixed load value in the Recommended Test Equipment list) to keep the power system at instrument settings specified in Table 2-5.

4. As shown in the diagram, use two BNC cables to connect the differential amplifier to the + and – output terminals. Each cable should be terminated by a 50 Ω resistor. The shields of the two BNC cables should be connected together. Connect the output of the differential amplifier to the oscilloscope with a 50 Ω termination at the input of the oscilloscope.
5. Set the differential amplifier to multiply by ten, divide by one, and 1 MΩ input resistance. The positive and negative inputs of the differential amplifier should be set to AC coupling. Set the oscilloscope's time base to 5 ms/div, and the vertical scale to 100 mV/div. Turn the bandwidth limit on (usually 20 or 30 MHz), and set the sampling mode to peak detect.
6. Program the power supply to the settings indicated in Table 2-5 for the appropriate model, and enable the output. Let the oscilloscope run for a few seconds to generate enough measurement points. On the Keysight Infiniium scope, the maximum peak-to-peak voltage measurement is indicated at the bottom of the screen on the right side. Divide this value by 10 to get the CV peak-to-peak noise measurement. The result should not exceed the peak-to-peak limits in the Test Record Form for the appropriate model under "CV Ripple and Noise, peak-to-peak".

**NOTE** If the measurement contains any question marks, clear the measurement and try again. This means that some of the scope data received was questionable.

7. Disconnect the oscilloscope and connect an rms voltmeter in its place. Do not disconnect the 50 ohm termination. Divide the reading of the rms voltmeter by 10. The result should not exceed the rms limits in the Test Record Form for the appropriate model under "CV Ripple and Noise, rms".

Table 2-5 CV ripple and noise verification instrument settings

| Model | DUT settings | | Fixed load |
|---|---|---|---|
| | Voltage (V) | Current (A) | Value |
| E36154A | 30 | Max | 1.125 |
| | 10 | Max | 0.125 |
| E36155A | 60 | Max | 4.5 |
| | 20 | Max | 0.5 |

## Constant Current (CC) verification

### Current programming and readback accuracy

*Test category = performance, calibration*

This test verifies that the current programming and measurement functions are within specifications.

1. Turn off the power supply.
2. Connect the current shunt directly across the output terminals. Connect the DMM directly across the current shunt (see CC Test Setup). Note that the electronic load is not used in this portion of test.
3. Turn on the power supply and program the instrument settings as described in Table 2-6.
4. Turn the output on. The output status should be “CC” and the output voltage should be close to zero.
5. Divide the voltage drop (DMM reading) across the current shunt by the shunt resistance to convert to amps and record this value. Also, record the current measured over the interface.
6. The readings should be within the limits specified in the Test Record Form for the appropriate model under “Current Programming" and "Current Readback (High Range)".

Table 2-6 Current programming and readback accuracy instrument settings

| Model | DUT settings | |
|---|---|---|
| | Voltage (V) | Current (A) |
| E36154A | Max | 0 |
| | Max | 80 |
| E36155A | Max | 0 |
| | Max | 40 |

### Low range current readback accuracy

*Test category = performance, calibration*

This test verifies that the current measurement functions are within specifications.

1. Turn off the power supply.
2. Connect the current shunt directly across the output terminals. Connect the DMM directly across the current shunt (see CC Test Setup). Note that the electronic load is not used in this portion of test.
3. Turn on the power supply and program the instrument settings as described in Table 2-7.
4. Turn the output on. The output status should be "CC" and the output voltage should be close to zero.
5. Divide the voltage drop (DMM reading) across the current shunt by the shunt resistance to convert to amps and record this value. Also, record the current measured over the interface.
6. The readings should be within the limits specified in the Test Record Form for the appropriate model under "Current Readback (Low Range)".

Table 2-7 Low range current readback accuracy instrument settings

| Model | DUT settings | |
|---|---|---|
| | Voltage (V) | Current (A) |
| E36154A | Max | 0 |
| | Max | 0.8 |
| E36155A | Max | 0 |
| | Max | 0.4 |

### CC load regulation

*Test category = performance*

This test measures the change in output current resulting from a change in output voltage from full scale to short circuit.

1. Turn off the power supply.
2. Connect the current shunt, DMM, and electronic load to the output terminals (see CC Test Setup). Connect the DMM directly across the current shunt.
3. Turn on the power supply and program the instrument settings as described in Table 2-8.
4. Turn the output on.
5. Operate the electronic load in constant voltage mode and set its voltage to the value as described in Table 2-8. The output status of the power supply should be "CC". If it isn't, adjust the load so that the output voltage drops slightly.
6. Record the current reading ($I_{load}$), by dividing the voltage reading on the DMM by the resistance of the current monitoring resistor.

7. Operate the electronic load in short (input short) mode. Divide the voltage drop (DMM reading) across the current shunt by the shunt resistance to convert to amps and record this value ($I_{short}$).
8. The difference in the current readings in steps 6 and 7 is the load regulation current, which should should not exceed the value listed in the Test Record Form for the appropriate model under “CC Load Regulation”.

Table 2-8 CC load regulation instrument settings

| Model | DUT settings | | Eload settings | |
|---|---|---|---|---|
| | Voltage (V) | Current (A) | Mode | Voltage (V) |
| E36154A | Max | 80 | CV | 10 |
| | Max | 26.67 | CV | 30 |
| E36155A | Max | 40 | CV | 20 |
| | Max | 13.33 | CV | 60 |

### CC line regulation

*Test category = performance*

This test measures the change in output current that results from a change in AC line voltage from the minimum to maximum value within the line voltage specifications.

1. Turn off the power supply.
2. Connect the current shunt, DMM, and electronic load to the output terminals (see CC Test Setup). Connect the DMM directly across the current shunt.
3. Connect the AC power cord of the power supply to the AC power source.
4. Turn on the power supply and program the instrument settings as described in Table 2-9.
5. Turn the output on.
6. Operate the electronic load in constant voltage mode and set its voltage to the value as described in Table 2-9. The output status of the power supply should be “CC”. If it isn’t, adjust the load so that the output voltage drops slightly.
7. Adjust the AC power source to the low line voltage limit as described in Table 2-9.
8. Divide the voltage drop (DMM reading) across the current shunt by the shunt resistance to convert to amps and record this value ($I_{lowline}$).
9. Adjust the AC power source to the high line voltage limit as described in Table 2-9.
10. Divide the voltage drop (DMM reading) across the current shunt by the shunt resistance to convert to amps and record this value ($I_{highline}$).
11. The difference between the DMM reading in steps 8 and 10 is the CC line regulation, which should not exceed the value listed in the Test Record Form for the appropriate model under “CC Line Regulation”.

Table 2-9 CC line regulation instrument settings

| Model | DUT settings | | AC source settings | | Eload settings | | Line voltage |
|---|---|---|---|---|---|---|---|
| | Voltage (V) | Current (A) | Low | High | Mode | Voltage (V) | |
| E36154A | Max | 26.67 | 90 VAC | 110 VAC | CV | 30 | 100 VAC |
| | Max | 80 | | | CV | 10 | |
| | Max | 26.67 | 103.5 VAC | 126.5 VAC | CV | 30 | 115 VAC |
| | Max | 80 | | | CV | 10 | |
| | Max | 26.67 | 207 VAC | 253 VAC | CV | 30 | 230 VAC |
| | Max | 80 | | | CV | 10 | |
| E36155A | Max | 13.33 | 90 VAC | 110 VAC | CV | 60 | 100 VAC |
| | Max | 40 | | | CV | 20 | |
| | Max | 13.33 | 103.5 VAC | 126.5 VAC | CV | 60 | 115 VAC |
| | Max | 40 | | | CV | 20 | |
| | Max | 13.33 | 207 VAC | 253 VAC | CV | 60 | 230 VAC |
| | Max | 40 | | | CV | 20 | |

## Test Record Forms



### Test record form – Keysight E36154A

| E36154A | Report Number ________ | | Date ________ | |
|---|---|---|---|---|
| **Description** | **DUT Setting** | **Lower limit** | **Result** | **Upper limit** |
| **Constant Voltage Tests** | | | | |
| Voltage Programming | | | | |
| Zero voltage output ($V_0$) | 0 V, 80 A | -0.006 V | ________ | 0.006 V |
| Maximum voltage output ($V_{max}$) | 30 V, 80 A | 29.985 | ________ | 30.015 |
| Voltage Readback | | | | |
| Zero voltage measured over interface | 0 V, 80 A | $V_0$ - 0.006 V | ________ | $V_0$ + 0.006 V |
| Maximum voltage measured over interface | 30 V, 80 A | $V_{max}$ - 0.018 V | ________ | $V_{max}$ + 0.018 V |
| CV Load Regulation ($V_{load}$ - $V_{noload}$) | | | | |
| 30 V at 26.67 A | 30 V, Max A | -5 mV | ________ | 5 mV |
| 10 V at 80 A | 10 V, Max A | -3 mV | ________ | 3 mV |
| CV Line Regulation ($V_{lowline}$ - $V_{highline}$) | | | | |
| 30 V at 26.67 A | 30 V, 80 A | -5 mV | ________ | 5 mV |
| 10 V at 80 A | 10 V, 80 A | -3 mV | ________ | 3 mV |
| CV Ripple and Noise | | | | |
| peak-to-peak | 30 V, Max A | – | ________ | 75 mV |
| | 10 V, Max A | – | ________ | 75 mV |
| rms | 30 V, Max A | – | ________ | 5 mV |
| | 10 V, Max A | – | ________ | 5 mV |
| Transient Response (75 mV) | | | | |
| 30 V at 26.67 A | 30 V, 80 A | – | ________ | 1 ms |
| 10 V at 80 A | 10 V, 80 A | – | ________ | 1 ms |
| **Constant Current Tests** | | | | |
| Current Programming | | | | |
| Zero current output ($I_0$) | Max V, 0 A | -0.02 A | ________ | 0.02 A |
| Maximum current output ($I_{max}$) | Max V, 80 A | 79.9 A | ________ | 80.1 A |
| Current Readback (High Range) | | | | |
| Zero Current measured over interface | Max V, 0 A | $I_0$ - 0.02 A | ________ | $I_0$ + 0.02 A |
| Maximum Current measured over interface | Max V, 80 A | $I_{max}$ - 0.1 A | ________ | $I_{max}$ + 0.1 A |

| E36154A | Report Number ___________ | | Date ____________ | |
|---|---|---|---|---|
| **Description** | **DUT Setting** | **Lower limit** | **Result** | **Upper limit** |
| Current Readback (Low Range) | | | | |
| Zero current measured over interface | Max V, 0 A | $I_0$ - 0.005 A | ____________ | $I_0$ + 0.005 A |
| Maximum current measured over interface | Max V, 0.8 A | $I_{max}$ - 0.0058 A | ____________ | $I_{max}$ + 0.0058 A |
| CC Load Regulation ($I_{load}$ - $I_{short}$) | | | | |
| 26.67 A at 30 V | Max V, 26.67 A | -28.6 mA | ____________ | 28.6 mA |
| 80 A at 10 V | Max V, 80 A | -82 mA | ____________ | 82 mA |
| CC Line Regulation ($I_{lowline}$ - $I_{highline}$) | | | | |
| 26.67 A at 30 V | Max V, 26.67 A | -28.6 mA | ____________ | 28.6 mA |
| 80 A at 10 V | Max V, 80 A | -82 mA | ____________ | 82 mA |

## Test record form – Keysight E36155A

| E36155A | Report Number ________ | | Date __________ | |
|---|---|---|---|---|
| **Description** | **DUT Setting** | **Lower limit** | **Result** | **Upper limit** |
| **Constant Voltage Tests** | | | | |
| Voltage Programming | | | | |
| Zero voltage output ($V_0$) | 0 V, 40 A | -0.01 V | __________ | 0.01 V |
| Maximum voltage output ($V_{max}$) | 60 V, 40 A | 59.972 V | __________ | 60.028 V |
| Voltage Readback | | | | |
| Zero voltage measured over interface | 0 V, 40 A | $V_0$ - 0.01 V | __________ | $V_0$ + 0.01 V |
| Maximum voltage measured over interface | 60 V, 40 A | $V_{max}$ - 0.034 V | __________ | $V_{max}$+ 0.034 V |
| CV Load Regulation ($V_{load}$ - $V_{noload}$) | | | | |
| 60 V at 13.33 A | 60 V, Max A | -8 mV | __________ | 8 mV |
| 20 V at 40 A | 20 V, Max A | -4 mV | __________ | 4 mV |
| CV Line Regulation ($V_{lowline}$ - $V_{highline}$) | | | | |
| 60 V at 13.33 A | 60 V, Max A | -8 mV | __________ | 8 mV |
| 20 V at 40 A | 20 V, Max A | -4 mV | __________ | 4 mV |
| CV Ripple and Noise | | | | |
| peak-to-peak | 60 V, Max A | – | __________ | 75 mV |
| | 20 V, Max A | – | __________ | 75 mV |
| rms | 60 V, Max A | – | __________ | 5 mV |
| | 20 V, Max A | – | __________ | 5 mV |
| Transient Response (150 mV) | | | | |
| 60 V at 13.33 A | 60 V, Max A | – | __________ | 1 ms |
| 20 V at 40 A | 20 V, Max A | – | __________ | 1 ms |
| **Constant Current Tests** | | | | |
| Current Programming | | | | |
| Zero current output ($I_0$) | Max V, 0 A | -0.01 A | __________ | 0.01 A |
| Maximum current output ($I_{max}$) | Max V, 40 A | 39.95 A | __________ | 40.05 A |
| Current Readback (High Range) | | | | |
| Zero current measured over interface | Max V, 0 A | $I_0$ - 0.01 A | __________ | $I_0$ + 0.01 A |
| Maximum current measured over interface | Max V, 40 A | $I_{max}$ - 0.05 A | __________ | $I_{max}$ + 0.05 A |
| Current Readback (Low Range) | | | | |
| Zero current measured over interface | Max V, 0 A | $I_0$ - 0.004 A | __________ | $I_0$ + 0.004 A |
| Maximum current measured over interface | Max V, 0.4 A | $I_{max}$ - 0.0044 A | __________ | $I_{max}$ + 0.0044 A |

| E36155A | Report Number ___________ | | Date ____________ | |
|---|---|---|---|---|
| **Description** | **DUT Setting** | **Lower limit** | **Result** | **Upper limit** |
| CC Load Regulation ($I_{load}$ - $I_{short}$) | | | | |
| 13.33 A at 60 V | Max V, 13.33 A | -15.33 mA | ____________ | 15.33 mA |
| 40 A at 20 V | Max V, 40 A | -42 mA | ____________ | 42 mA |
| CC Line Regulation ($I_{lowline}$ - $I_{highline}$) | | | | |
| 13.33 A at 60 V | Max V, 13.33 A | -15.33 mA | ____________ | 15.33 mA |
| 40 A at 20 V | Max V, 40 A | -42 mA | ____________ | 42 mA |

# Calibration Adjustment Procedures

This chapter includes calibration adjustment procedures for Keysight E36150 Series Autoranging DC Power Supply.

**NOTE** **Perform the verification tests before calibrating your instrument. If the instrument passes the verification tests, the unit is operating within its calibration limits and does not need to be re-calibrated.**

## Closed–case electronic calibration

The instrument uses closed-case electronic calibration; no internal mechanical adjustments are required. The instrument calculates correction factors based on reference signals that you apply and stores the correction factors in non-volatile memory. This data is not changed by cycling power, *RST, or SYSTem:PRESet.

## Calibration interval

The recommended calibration interval for Keysight E36150 series power supply is one year.

## Calibration adjustment process

The following general procedure is recommended to complete a full calibration adjustment.

1. Adhere to the test considerations. See Performance Verification > Test considerations for details.
2. Perform the performance verification tests to characterize the instrument. See Performance Verification for details.
3. Unsecure the instrument for calibration. See Calibration security for details.
4. Perform the calibration procedures. See Calibration procedure for details.
5. Secure the instrument against the calibration. See Calibration security for details.
6. Take note of the security code and calibration count in the instrument's maintenance records.
7. Perform the performance verification tests to verify the calibration.

## Calibration security

The instrument has a calibration passcode to prevent accidental or unauthorized calibration. When you receive your power supply, it is secured by a default passcode. The default passcode is 0. The security code cannot be changed by a power cycle or *RST.

You can enter a passcode of up to 9 digits.

You can change the passcode from both front panel and remote interface.

**From the front panel:**

1. Press **Utilities** > **Test / Setup** > **Calibration** > **Change Passcode**

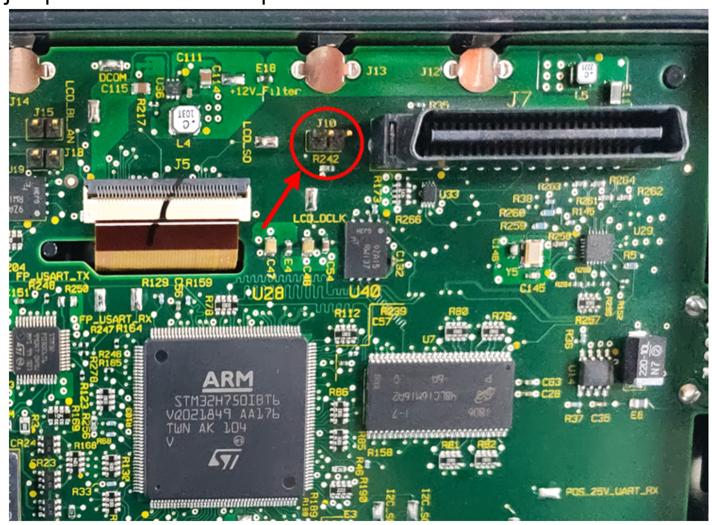
2. Enter your desired passcode and press **Done**.

**From the remote interface:**

To change a new passcode to 12345:

CAL:SEC:CODE 12345

**NOTE** To change a forgotten passcode to a new passcode, you can turn on the instrument after shorting CAL SECURE jumper J10 on the front panel board as shown below and send CAL:SEC:CODE <code> to change the passcode.




## Calibration count

The instrument counts the number of times it has saved calibration data. Your instrument was calibrated at the factory; when you receive your instrument, read and record the initial count. You can only read the calibration count by sending the CAL:COUNt? query, and the calibration count is not change by a power cycle or *RST.

If Auto Save is enabled, the count increments when you exit the calibration state. To avoid double counting, do not manually save the count with Auto Save enabled.

## Calibration message

You can use the CALibration:STRing command to store a message of up to 40 characters in calibration memory. For example, you could store the last calibration date, the calibration due date, or contact information for the person responsible for calibration. The calibration message is not affected by a power cycle or *RST.

You can only store the calibration message when the instrument is unsecured, but you can execute the CALibration:STRing? query regardless of whether the instrument is secured. A new calibration message overwrites the previous message, and messages over 40 characters are truncated.

## Saving calibration data

You must always save new calibration data before cycling instrument power or leaving the calibration state with the Auto Save feature off. To save calibration data, send CAL:SAVE or save the calibration data from the front panel.

## Calibration auto save

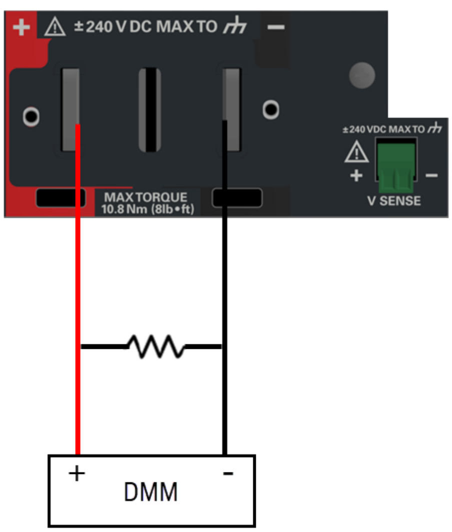
The instrument includes a calibration Auto Save feature. This feature automatically saves the calibration data to non-volatile memory and increments the calibration count when you exit the calibration state.

To enable or disable the CAL auto Save feature, send CAL:ASAV ON or CAL:ASAV OFF. To query the CAL auto Save state, send CAL:ASAV?

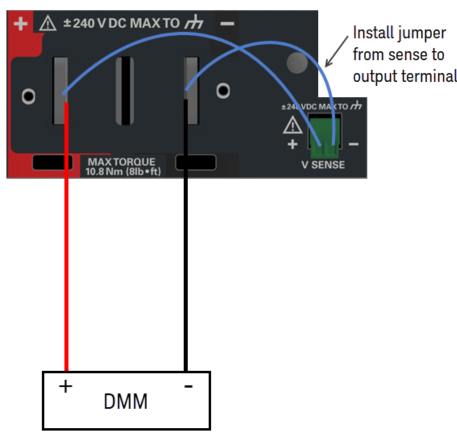
## Calibration Test Setup

The following figures show the verification test set-ups. Connect all leads to the output terminal as shown below.

CC CalibrationTest Setup




CV Calibration Test Setup



## Calibration procedure

### Enter the calibration state

To begin the calibration procedure, you must enter the calibration state.

| Step | Front Panel | SCPI |
|---|---|---|
| 1 | Press **Utilities** > **Test / Setup** > **Calibration**. | |
| | Enter the default passcode (default passcode is 0). Press **Login** to enter the calibration page. | CAL:SEC:STAT 0, <*code*> |
| 2 | To change a forgotten passcode to a new passcode, you can turn on the instrument after shorting CAL SECURE jumper J10 on the front panel board and send scpi command to change the passcode. | CAL:SEC:CODE <code> |

### Calibrate voltage

Let the unit sit with output ON for one minute, then connect the DMM voltage input to the power supply (See CV Cal Setup).

1. Press **Perform Calibration** > **Cal Volt**.
2. Measure the output voltage (low point) with the DMM.
   Note: Wait 2 minutes for the voltage to stabilize before measuring the voltage with DMM.
3. Enter the measured value, and press **Next**.
4. Measure the output voltage (high point) with the DMM.
   Note: Wait 2 minutes for the voltage to stabilize before measuring the voltage with DMM.
5. Enter the measured value, and press **Next**.
6. Read DONE or FAIL on the display.
7. Press **Cal Save**.

### Calibrate current

Allow the unit to sit with output turned ON for one minute, then connect a current monitoring resistor across the output terminals to be calibrated and then connect a DMM across the terminals of the monitoring resistor (See Cal CC Setup).

1. Press **Perform Calibration** > **Cal Curr**.
2. Measure the output current (low point) with the DMM.
   Note: Wait 7 minutes for the current to stabilize before measuring the current with DMM.
3. Enter the measured value, and press **Next**.
4. Measure the output current (mid point) with the DMM.
   Note: Wait 7 minutes for the current to stabilize before measuring the current with DMM.
5. Enter the measured value, and press **Next**.
6. Measure the output current (high point) with the DMM.
   Note: Wait 7 minutes for the current to stabilize before measuring the current with DMM.
7. Enter the measured value, and press **Next**.
8. Read DONE or FAIL on the display.
9. Press **Cal Save**.

### Calibrate low range current

Allow the unit to sit with output ON for one minute before continuing.

1. Press **Perform Calibration** > **Cal Low Curr**.
2. Measure the output low range current (low point) with the DMM.
   Note: Wait 3 minutes for the current to stabilize before measuring the current with DMM.
3. Enter the measured value, and press **Next**.
4. Wait approximately 10 seconds.
5. Measure the output low range current (high point) with the DMM.
   Note: Wait 3 minutes for the current to stabilize before measuring the current with DMM.
6. Enter the measured value, and press **Next**.
7. Read DONE or FAIL on the display.
8. Press **Cal Save**.

## Save the calibration data

To save calibration data, press **Cal Save** or enable the 'Auto Save' feature. With Auto Save, calibration data will be saved when the user exits the calibration menu.

After completing the voltage, current and low range current calibrations, save the calibration data before exiting the calibration state, or simply exit the calibration state if Auto Save is on.

- To save the Cal data: CAL:SAVE
- To enable the Cal Auto Save: CAL:ASAVE ON
- To exit Cal State: CAL:SEC:STAT 1 <code>

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