CALIBRATION PROCEDURE

NI VirtualBench™

VB-8012, VB-8034, and VB-8054 All-In-One Instrument

This document contains the verification and adjustment procedures for the National Instruments VirtualBench VB-8012, VB-8034, and VB-8054. For more information about calibration solutions, visit ni.com/calibration.

Contents

Software and Firmware

Calibrating the NI VirtualBench requires the installation of NI VirtualBench application development support and NI LabVIEW 2013 or later on the Windows calibration system. You can download the software and driver from ni.com/downloads.

Table 1 lists the earliest required firmware support for VirtualBench calibration. You can update the firmware through the VirtualBench application.

Table 1. VirtualBench Calibration Firmware Support

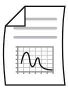
VirtualBench	Earliest Firmware Support
VB-8012	Version 1.1.2
VB-8034	Version 15.1
VB-8054	Version 16.1

Documentation

Consult the following documents for information about the NI VirtualBench and your application software. All documents are available on `ni.com` and help files install with the software.

NI VirtualBench VB-8012 Quick Start or
NI VirtualBench VB-8034/8054 Quick Start

Contains: NI VirtualBench hardware installation, software launching



NI VirtualBench VB-8012 Specifications, *NI VirtualBench VB-8034 Specifications*, or *NI VirtualBench VB-8054 Specifications*

Contains: specifications and calibration interval for your VirtualBench

NI VirtualBench VI Reference Help

Contains: LabVIEW programming concepts and reference information about NI VirtualBench VIs and functions

Test Equipment

Table 2 lists all recommended equipment for the performance verification and adjustment procedures for all VirtualBench instruments. If the recommended equipment is not available, select a substitute using the requirements listed in the table.

Table 2. VirtualBench Calibration Recommended Equipment

Equipment	Recommended Model	Instrument Calibration	Minimum Requirements
Multifunction calibrator	Fluke 5700A/5720A/5730A	*Digital Multimeter (DMM) Calibration Procedure*	Must be calibrated within the last year.
Low thermal electromotive force (EMF) copper cable	Fluke 5440A-7002	*Digital Multimeter (DMM) Calibration Procedure*	Low thermal electromotive force (EMF) copper cable with 4 mm banana connectors.
Amplifier	Fluke 5725A	*Digital Multimeter (DMM) Calibration Procedure*	Must be calibrated within the last year.
Shielded interface cable for the amplifier	Fluke 842901	*Digital Multimeter (DMM) Calibration Procedure*	—

Table 2. VirtualBench Calibration Recommended Equipment (Continued)

Equipment	Recommended Model	Instrument Calibration	Minimum Requirements
50 Ω terminator	Amphenol 000-46650-51RFX	*Oscilloscope Calibration Procedure*	VB-8012 only.
Oscilloscope calibrator	Fluke 9500B calibrator	*Oscilloscope Calibration Procedure*	Vertical gain: DC ±(0.025% + 25 µV) into 1 MΩ
Oscilloscope calibrator active head	Fluke 9530	*Oscilloscope Calibration Procedure*	DC operation
Function generator	NI 5421	*Oscilloscope Calibration Procedure* (adjustment section)	Must be able to generate a 1 kHz square wave between 36 mV_{pp} and 18 V_{pp} with less than 200 ns rise time and less than 5% overshoot.
SMB to BNC cable	NI part number 778827-01	*Oscilloscope Calibration Procedure*	Cable needed to connect from the function generator to the VirtualBench BNC connectors.
Digital multimeter (DMM)	NI PXI-4071	*Function Generator (FGEN) Calibration Procedure*, *DC Power Supply Calibration Procedure*	DC V accuracy: 21 ppm at 25 V DC input impedance: ≥1 GΩ DC A accuracy: 310 ppm at 1 A, 460 ppm at 2 A
Banana plug-to-BNC cable	Pomona 4530-C	*Function Generator (FGEN) Calibration Procedure*	—
Cabling wire	—	*DC Power Supply Calibration Procedure*	18 AWG to 22 AWG. Twisted pair, shielded cabling wire is recommended

Test Conditions

Follow these guidelines to optimize the equipment and the environment during calibration:

- Keep connections to the device as short as possible. Long cables and wires act as antennae, picking up noise that can affect measurements.
- Use a USB connection between the PC and VirtualBench.
- Verify that all connections to the device, including front panel connections, are secure.
- Keep relative humidity between 10% and 80% noncondensing.
- Allow a warm up time of at least 30 minutes to ensure that the VirtualBench is at a stable operating temperature.
- Plug the VirtualBench, PC, and the test equipment into the same power strip to avoid ground loops.
- Verification limits are defined assuming the same test equipment is used during verification and adjustment.
- **(Oscilloscope, FGEN, and DC Power Supply Procedures)** Maintain an ambient temperature of 23 ±5 °C. The device temperature will be greater than the ambient temperature.
- **(DMM Procedure)** Maintain an ambient temperature of 23 ±1 °C. The device temperature will be greater than the ambient temperature.
- **(DMM Procedure)** Clean any oxidation from the banana plugs on the Fluke 5440 cables before plugging them into the binding posts of the calibrator or the banana plug connectors on the VirtualBench. Oxidation tarnishes the copper banana plugs so that they appear dull rather than shiny and leads to greater thermal EMF.
- **(DMM Procedure)** Keep the blue banana plugs on the Fluke 5440 cables connected to the V GUARD binding post of the calibrator at all times.
- **(DMM Procedure)** Prevent the cables from moving or vibrating by taping or strapping them to a nonvibrating surface. Movement or vibration causes triboelectric effects that can result in measurement errors.
- **(DC Power Supply Procedure)** Use shielded copper wire for all cable connections. Use twisted-pair, shielded wire to reduce measurement error in noisy environments.

Digital Multimeter (DMM) Calibration Procedure

This section contains the verification and adjustment procedures for the DMM on the VirtualBench. The calibration process includes the following steps:

1. *DMM Initial Setup*—Set up the test equipment.
2. *DMM Verification*—Verify the existing operation of the instrument. This step confirms whether the instrument is operating within its specified range prior to adjustment.
3. *DMM Adjustment*—Perform an external adjustment of the instrument that adjusts the calibration constants with respect to standards of known values.
4. *DMM Re-Verification*—Repeat the verification procedure to ensure that the instrument is operating within its specifications after adjustment.

These steps are described in more detail in the following sections.

Note If you are calibrating both the DMM and the DC power supply, the DMM must be calibrated first.

DMM Test Equipment

Table 3 lists the equipment recommended for the DMM performance verification and adjustment procedures. If the recommended equipment is not available, select a substitute using the requirements listed in the table.

Table 3. Recommended Equipment

Equipment	Recommended Model	Minimum Requirements
Multifunction calibrator	Fluke 5700A/ 5720A/5730A	Must be calibrated within the last year.
Low thermal electromotive force (EMF) copper cable	Fluke 5440A-7002	Low thermal electromotive force (EMF) copper cable with 4 mm banana connectors.
Amplifier	Fluke 5725A	Must be calibrated within the last year.
Shielded interface cable for the amplifier	Fluke 842901	—

DMM Test Conditions

Follow these guidelines to optimize the equipment and the environment during calibration:

- Keep connections to the device as short as possible. Long cables and wires act as antennae, picking up noise that can affect measurements.
- Use a USB connection between the PC and VirtualBench.
- Verify that all connections to the device, including front panel connections, are secure.
- Keep relative humidity between 10% and 80% noncondensing.
- Allow a warm up time of at least 30 minutes to ensure that the VirtualBench is at a stable operating temperature.
- Plug the VirtualBench, PC, and the test equipment into the same power strip to avoid ground loops.
- Verification limits are defined assuming the same test equipment is used during verification and adjustment.
- Maintain an ambient temperature of 23 ±1 °C. The device temperature will be greater than the ambient temperature.

- Clean any oxidation from the banana plugs on the Fluke 5440 cables before plugging them into the binding posts of the calibrator or the banana plug connectors on the VirtualBench. Oxidation tarnishes the copper banana plugs so that they appear dull rather than shiny and leads to greater thermal EMF.
- Keep the blue banana plugs on the Fluke 5440 cables connected to the V GUARD binding post of the calibrator at all times.
- Prevent the cables from moving or vibrating by taping or strapping them to a nonvibrating surface. Movement or vibration causes triboelectric effects that can result in measurement errors.

DMM Initial Setup

Note This section is necessary for pre-adjustment verifications only. If you are performing a post-adjustment verification, skip the setup and go directly to the *DMM Verification* section.

To set up the test equipment, complete the following steps:

1. If VirtualBench is running, shut down all instruments on the VirtualBench, and close the VirtualBench software. Remove all signal connections.
2. Verify that the calibrator has been calibrated within the time limits specified in the *DMM Test Equipment* section, and that DC zeros calibration has been performed within the last 30 days. Consult the Fluke user documentation for instructions on calibrating these devices.

Note Ensure that the VirtualBench is warmed up for at least 30 minutes.

3. Call `DMM Initialize` to create a session. For more information on using `DMM Initialize`, refer to the *NI VirtualBench VI Reference Help*.

Note You use this session in all subsequent function calls throughout the verification procedures.

DMM Verification

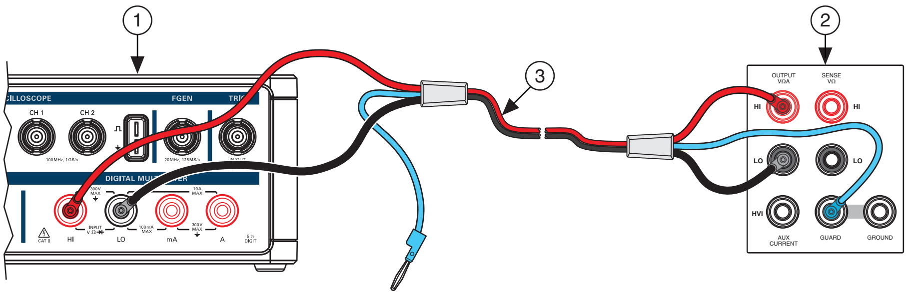
You can use the verification procedures described in this section for both pre-adjustment and post-adjustment verification. The steps of each verification procedure must be performed in the order listed; however, you can omit entire sections (for example, the entire *Verifying AC Current* section), if necessary.

Verifying DC Voltage

To verify the DC voltage function of the VirtualBench DMM, complete the following steps:

1. Reset the calibrator.
2. Connect the red connectors on one end of the low thermal electromotive force (EMF) copper cable to the banana plug connectors of the VirtualBench, and connect the connectors on the other end of the cable to the appropriate calibrator binding posts. Figure 1 shows the correct connections.

Figure 1. Cable Connections for DC Voltage



1	VirtualBench DMM	2	Multifunction Calibrator	3	Low EMF Copper Cable

3. Wait 2 minutes for the thermal EMF to stabilize.
4. Null the points by completing the following steps:
   a. For the 100 mV range, set the calibrator to 0 V.

> **Note** When outputting less than 220 mV, range lock the calibrator to 2.2 V so it prevents creating a voltage divider with the internal resistance of the VirtualBench.

   b. Call `DMM Configure Measurement` with the following parameters:
      - **Function** = `DC Volts`
      - **Auto Range** = `FALSE`
      - **Manual Range** = `0.1`
   c. Set the input resistance of the VirtualBench to 10 GΩ by calling `DMM Configure DC Voltage` with the following parameter:
      - **Input Resistance** = `10 GOhm`
   d. Call `DMM Read`. Record this measurement.
5. Generate 0.101 V verification point on the calibrator.
6. Call `DMM Configure Measurement` with the following parameters:
   - **Function** = `DC Volts`
   - **Auto Range** = `FALSE`
   - **Manual Range** = `0.1`
7. Set the input resistance of the VirtualBench to 10 GΩ by calling `DMM Configure DC Voltage` with the following parameter:
   - **Input Resistance** = `10 GOhm`

8. Call `DMM Read`. Subtract the saved value from step 4 and compare to the limits listed in Table 4.

Table 4. VirtualBench DC Voltage Verification Limits

Range (V)	Verification Point (V)	Input Resistance	1 Year Limits (V)		24 Hour Limits (V)	
			Lower	Upper	Lower	Upper
0.1	0.101	10 GΩ	0.100980	0.101020	0.100996	0.101004
	0		-0.000005	0.000005	-0.000003	0.000003
	-0.101		-0.101020	-0.100980	-0.101004	-0.100996
1	1.01	10 GΩ	1.009800	1.010200	1.009960	1.010040
	0		-0.00005	0.00005	-0.00002	0.00002
	-1.01		-1.010200	-1.009800	-1.010040	-1.009960
10	10.1	10 GΩ	10.0980	10.1020	10.0997	10.1003
	0		-0.0005	0.0005	-0.0002	0.0002
	-10.1		-10.1020	-10.0980	-10.1003	-10.0997
100	101	10 MΩ	100.960	101.040	100.993	101.007
	0		-0.005	0.005	-0.002	0.002
	-101		-101.040	-100.960	-101.007	-100.993
300	150	10 MΩ	149.933	150.068	149.979	150.021
	0		-0.015	0.015	-0.014	0.014
	-150		-150.068	-149.933	-150.021	-149.979

Note Use the values in the *24 Hour Limits* column for a post-adjustment verification *only*. Otherwise, use the values in the *1 Year Limits* column.

9. Repeat steps 5 through 8 for each verification point listed for the 100 mV range in Table 4.
10. Generate 1.01 V verification point on the calibrator.
11. Call `DMM Configure Measurement` with the following parameters:
    - **Function** = `DC Volts`
    - **Auto Range** = `FALSE`
    - **Manual Range** = `1`
12. Set the input resistance of the VirtualBench by calling `DMM Configure DC Voltage` with the following parameter:
    - **Input Resistance** = `10 GOhm`
13. Call `DMM Read`. Compare to the limits listed in Table 4.

14. Repeat steps 10 through 13 for each verification point in the remaining ranges listed in Table 4.
15. Reset the calibrator for safety reasons.
16. Disconnect all cables from the calibrator and VirtualBench.

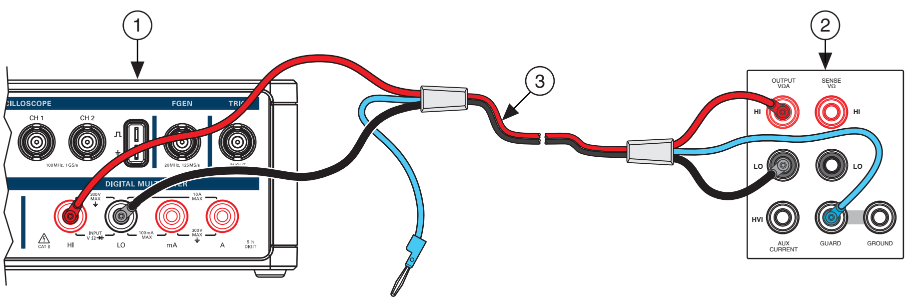
You have completed verifying the DC voltage function of the VirtualBench.

Verifying AC Voltage

To verify the AC voltage function of the VirtualBench DMM, complete the following steps:

1. Reset the calibrator.
2. Connect the red connectors on one end of the low EMF copper cable to the banana plug connectors of the VirtualBench, and connect the connectors on the other end of the cable to the appropriate calibrator binding posts. Figure 2 shows the correct connections.

Figure 2. Cable Connections for AC Voltage



1	VirtualBench DMM	2	Multifunction Calibrator	3	Low EMF Copper Cable

3. Wait 2 minutes for the thermal EMF to stabilize.

Note Thermal EMF stabilization time is not needed if the cables have not been connected/reconnected.

4. Generate 0.006 V_{rms} verification point on the calibrator.
5. Call `DMM Configure Measurement` with the following parameters:
   - **Function** = `AC Volts`
   - **Auto Range** = `FALSE`
   - **Manual Range** = `0.1`

6. Call `DMM Read`. Compare to the limits listed in Table 5.

Table 5. VirtualBench AC Voltage Verification Limits

Range (V_{rms})	Verification Point Frequency (kHz)	Verification Point (V_{rms})	1 Year Limits (V_{rms})		24 Hour Limits (V_{rms})	
			Lower	Upper	Lower	Upper
0.1	1	0.006	0.005943	0.006057	0.005988	0.006012
		0.05	0.049890	0.050110	0.049984	0.050016
		0.101	0.100829	0.101171	0.100979	0.101021
1	1	0.06	0.05943	0.06057	0.05988	0.06012
		0.5	0.49890	0.50110	0.49984	0.50016
		1.01	1.00829	1.01171	1.00979	1.01021
10	1	0.6	0.5943	0.6057	0.5988	0.6012
		5	4.9890	5.0110	4.9984	5.0016
		10.1	10.0829	10.1171	10.0979	10.1021
100	1	6	5.943	6.057	5.988	6.012
		50	49.890	50.110	49.984	50.016
		101	100.829	101.171	100.979	101.021
265	1	15.9	15.748	16.052	15.868	15.932
		66.25	66.038	66.462	66.213	66.287
		135.15	134.855	135.445	135.107	135.193

Note Use the values in the *24 Hour Limits* column for a post-adjustment verification *only.* Otherwise, use the values in the *1 Year Limits* column.

7. Repeat steps 4 through 6 for each verification point listed in Table 5 for all ranges.
8. Reset the calibrator for safety reasons.
9. Disconnect all cables from the calibrator and VirtualBench.

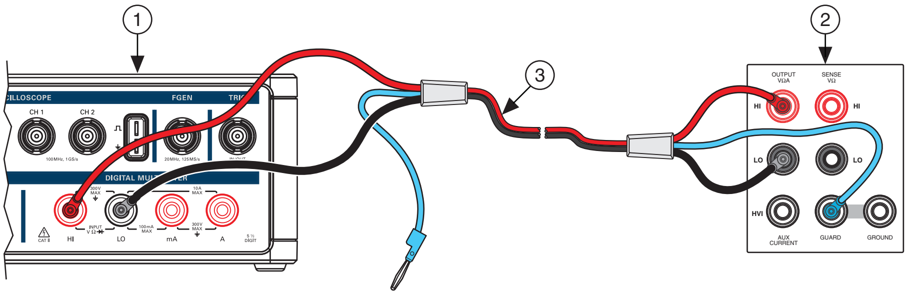
You have completed verifying the AC voltage function of the VirtualBench.

Verifying Resistance

To verify the resistance function of the VirtualBench, complete the following steps:

1. To verify resistance ≤19 kΩ, connect the red connectors on one end of the low EMF copper cable to the banana plug connectors of the VirtualBench, and connect the connectors on the other end of the cable to the appropriate calibrator binding posts. Figure 3 shows the correct connections.

Figure 3. Cable Connections for Resistance ≤19 kΩ



1	VirtualBench DMM	2	Multifunction Calibrator	3	Low EMF Copper Cable

2. Wait 2 minutes for the thermal EMF to stabilize.

Note Thermal EMF stabilization time is not needed if the cables have not been connected/reconnected.

3. Call `DMM Configure Measurement` with the following parameters:
   - **Function** = `Resistance`
   - **Auto Range** = `FALSE`
   - **Manual Range** = `100`
4. Set the calibrator to output 0 Ω with 2-wire compensation turned on.
5. Call `DMM Read` to allow the calibrator to properly settle.
6. Wait 5 seconds for settling.
7. Call `DMM Read` 20 times. Calculate and record the average value.
8. Output 1 Ω verification point on the calibrator.
9. Call `DMM Configure Measurement` with the following parameters:
   - **Function** = `Resistance`
   - **Auto Range** = `FALSE`
   - **Manual Range** = `100`

10. Call `DMM Read` 20 times. Calculate and record the average value. Subtract the average value measured in step 7. Verify that the result falls between the limits listed in Table 6.

Table 6. VirtualBench Resistance ≤19 kΩ Verification Limits

Range	Verification Point	1 Year Limits ± (% of Calibrator Output + % of Range)	24 Hour Limits ± (Deviation from Calibrator Output)
100 Ω	1 Ω	0.018 + 0.05	48.7 mΩ
	100 Ω	0.018 + 0.05	49.3 mΩ
1 kΩ	10 Ω	0.018 + 0.005	48.0 mΩ
	190 Ω	0.018 + 0.005	70.0 mΩ
	1 kΩ	0.018 + 0.005	67.0 mΩ
10 kΩ	100 Ω	0.018 + 0.005	130 mΩ
	1.9 kΩ	0.018 + 0.005	310 mΩ
	10 kΩ	0.018 + 0.005	350 mΩ
100 kΩ	1 kΩ	0.018 + 0.005	1.1 Ω
	19 kΩ	0.018 + 0.005	2.0 Ω
1 MΩ	10 kΩ	0.035 + 0.005	28 Ω

Note Use the values in the *24 Hour Limits* column for a post-adjustment verification *only.* Otherwise, use the values in the *1 Year Limits* column.

Note Limits are provided for resistance instead of absolute limits because the limits depend on the actual resistance value output by your calibrator.

11. Repeat steps 8 through 10 for each verification point of the 100 Ω range listed in Table 6.
12. Repeat steps 3 through 11 for every range in Table 6.
13. To verify resistance >19 kΩ, call `DMM Configure Measurement` with the following parameters:
    - **Function** = `Resistance`
    - **Auto Range** = `FALSE`
    - **Manual Range** = `100 kΩ`
14. Set the calibrator to output 0 Ω with 2-wire compensation turned off.
15. Call `DMM Read` to allow the calibrator to properly settle.
16. Wait 5 seconds for settling.
17. Call `DMM Read` 20 times. Calculate and record the average value.

18. Output 100 kΩ verification point on the calibrator.
19. Call `DMM Configure Measurement` with the following parameters:
    - **Function** = `Resistance`
    - **Auto Range** = `FALSE`
    - **Manual Range** = `100 kΩ`
20. Call `DMM Read` 20 times. Calculate and record the average value. Subtract the average value measured in step 17. Verify that the result falls between the limits listed in Table 7.

Table 7. VirtualBench Resistance >19 kΩ Verification Limits

Range	Verification Point	1 Year Limits ± (% of Calibrator Output + % of Range)	24 Hour Limits ± (Deviation from Calibrator Output)
100 kΩ	100 kΩ	0.018 + 0.005	3.8 Ω
1 MΩ	1 MΩ	0.035 + 0.005	100 Ω
10 MΩ	100 kΩ	0.150 + 0.005	120 Ω
	10 MΩ	0.150 + 0.005	10 kΩ
100 MΩ	1 MΩ	1.3 + 0.005	1.5 kΩ
	100 MΩ	1.3 + 0.005	190.3 kΩ

Note Use the values in the *24 Hour Limits* column for a post-adjustment verification *only*. Otherwise, use the values in the *1 Year Limits* column.

Note Limits are provided for resistance instead of absolute limits because the limits depend on the actual resistance value output by your calibrator.

21. Repeat steps 18 through 20 for each verification point on that range listed in Table 7.
22. Repeat steps 13 through 21 for each range listed in Table 7.
23. Reset the calibrator for safety reasons.
24. Disconnect all cables from the calibrator and VirtualBench.

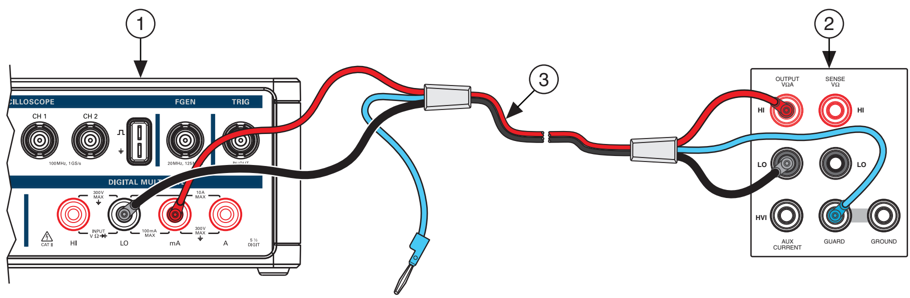
You have completed verifying the resistance function of the VirtualBench.

Verifying DC Current

To verify the DC current function of the VirtualBench, complete the following steps:

1. Reset the calibrator.
2. To verify DC current ranges <1 A, connect the connectors on one end of the low EMF copper cable to the VirtualBench mA and LO banana plug connectors, and connect the connectors on the other end of the cable to the HI and LO calibrator binding posts. Figure 4 shows the correct connections.

Figure 4. Cable Connections for Current Ranges <1 A



1	VirtualBench DMM	2	Multifunction Calibrator	3	Low EMF Copper Cable

3. Wait 2 minutes for the thermal EMF to stabilize.
4. Generate 0.0101 A verification point on the calibrator.
5. Call `DMM Configure Measurement` with the following parameters:
   - **Function** = `DC Current`
   - **Auto Range** = `FALSE`
   - **Manual Range** = `0.01`
6. Call `DMM Read`. Compare to the limits listed in Table 8.

Table 8. VirtualBench DC Current Verification Limits <1 A

Range (A)	Verification Point (A)	1 Year Limits (A)		24 Hour Limits (A)	
		Lower	Upper	Lower	Upper
0.01	0.0101	0.0100909	0.0101091	0.0100976	0.0101024
	0	-0.0000020	0.0000020	-0.0000020	0.0000020
	-0.0101	-0.0101091	-0.0100909	-0.0101024	-0.0100976
0.1	0.101	0.100926	0.101074	0.100995	0.101005
	0	-0.000003	0.000003	-0.000003	0.000003
	-0.101	-0.101074	-0.100926	-0.101005	-0.100995

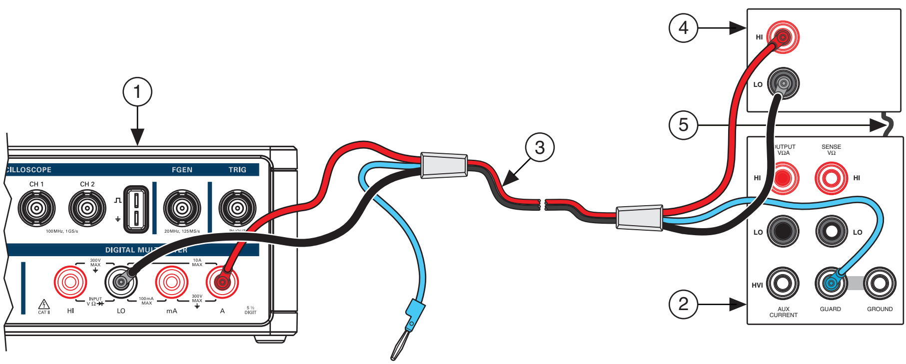
Note Use the values in the *24 Hour Limits* column for a post-adjustment verification *only*. Otherwise, use the values in the *1 Year Limits* column.

7. Repeat steps 4 through 6 for each verification point listed in Table 8.
8. Reset the calibrator for safety reasons.
9. Disconnect all cables from the calibrator and VirtualBench.

Note Consult the user documentation for the amplifier used in step 10 for the recommended warm up time (at least 30 minutes) to ensure that the amplifier circuitry is at a stable operating temperature.

10. To verify DC current ranges ≥1 A, connect an amplifier to the calibrator, connect the connectors on one end of the low EMF copper cable to the VirtualBench A and LO banana plug connectors, and connect the connectors on the other end of the cable to the HI and LO binding posts on the amplifier. Figure 5 shows the correct connections.

Figure 5. Cable Connections for DC Current Ranges ≥1 A



1	VirtualBench DMM	4	Amplifier
2	Multifunction Calibrator	5	Shielded Interface Cable
3	Low EMF Copper Cable		

11. Wait 2 minutes for the thermal EMF to stabilize.
12. Generate 1.01 A verification point on the calibrator.
13. Call `DMM Configure Measurement` with the following parameters:
    - **Function** = `DC Current`
    - **Auto Range** = `FALSE`
    - **Manual Range** = `1`

14. Call `DMM Read`. Compare to the limits listed in Table 9.

Table 9. VirtualBench DC Current Verification Limits ≥1 A

Range (A)	Verification Point (A)	1 Year Limits (A)		24 Hour Limits (A)	
		Lower	Upper	Lower	Upper
1	1.01	1.00844	1.01156	1.00968	1.01032
	0	-0.00025	0.00025	-0.00025	0.00025
	-1.01	-1.01156	-1.00844	-1.01032	-1.00968
10	2.2	2.1967	2.2033	2.1995	2.2005
	0	-0.0004	0.0004	-0.0004	0.0004
	-2.2	-2.2033	-2.1967	-2.2005	-2.1995

Note Use the values in the *24 Hour Limits* column for a post-adjustment verification *only*. Otherwise, use the values in the *1 Year Limits* column.

15. Repeat steps 12 through 14 for each verification point listed in Table 9.
16. Reset the calibrator for safety reasons.
17. Disconnect all cables from the calibrator and VirtualBench.

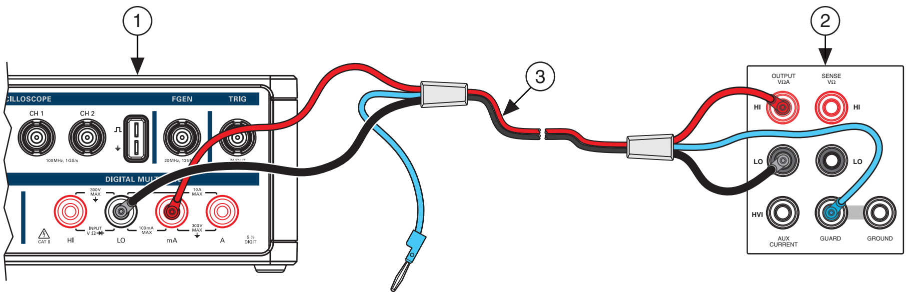
You have completed verifying the DC current function of the VirtualBench.

Verifying AC Current

To verify the AC current function of the VirtualBench DMM, complete the following steps:

1. Reset the calibrator.
2. To verify AC current ranges ≤50 mA, connect the connectors on one end of the low EMF copper cable to the VirtualBench mA and LO banana plug connectors, and connect the connectors on the other end of the cable to the HI and LO calibrator binding posts. Figure 6 shows the correct connections.

Figure 6. Cable Connections for AC Current Ranges ≤50 mA



1	VirtualBench DMM
2	Multifunction Calibrator
3	Low EMF Copper Cable

3. Wait 2 minutes for the thermal EMF to stabilize.
4. Generate 0.0003 A verification point on the calibrator.
5. Call `DMM Configure Measurement` with the following parameters:
   - **Function** = `AC Current`
   - **Auto Range** = `FALSE`
   - **Manual Range** = `0.005`
6. Call `DMM Read`. Compare to the limits listed in Table 10.

Table 10. VirtualBench AC Current Verification Limits ≤50 mA

Range (A_{rms})	Verification Point (A_{rms})	Frequency (Hz)	1 Year Limits (A_{rms})		24 Hour Limits (A_{rms})	
			Lower	Upper	Lower	Upper
0.005	0.0003	40	0.0002969	0.0003031	0.0002995	0.0003005
	0.0025	40	0.0024925	0.0025075	0.0024989	0.0025011
	0.00505	40	0.0050374	0.0050626	0.0050481	0.0050519
0.05	0.003	40	0.002969	0.003031	0.002995	0.003005
	0.025	40	0.024925	0.025075	0.024988	0.025012
	0.0505	40	0.050374	0.050626	0.050480	0.050520

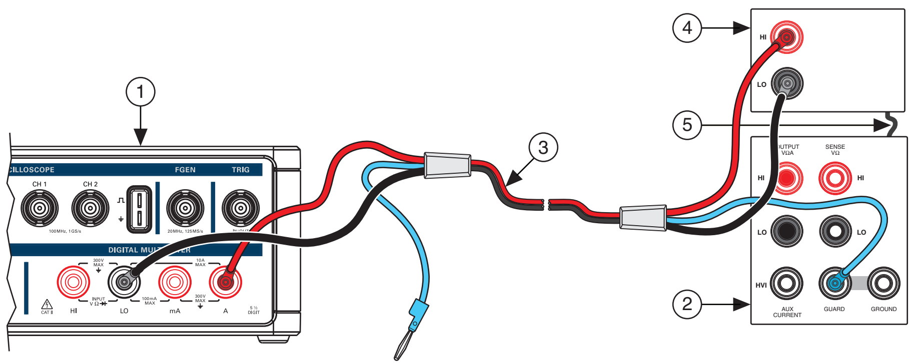
Note Use the values in the *24 Hour Limits* column for a post-adjustment verification *only*. Otherwise, use the values in the *1 Year Limits* column.

7. Repeat steps 4 through 6 for each verification point listed in Table 10.
8. Reset the calibrator for safety reasons.
9. Disconnect all cables from the calibrator and VirtualBench.

Note Consult the user documentation for the amplifier used in step 10 for the recommended warm up time (at least 30 minutes) to ensure that the amplifier circuitry is at a stable operating temperature.

10. To verify AC current ranges ≥500 mA, connect an amplifier to the calibrator, connect the connectors on one end of the low EMF copper cable to the VirtualBench A and LO banana plug connectors, and connect the connectors on the other end of the cable to the HI and LO binding posts on the amplifier. Figure 7 shows the correct connections.

Figure 7. Cable Connections for AC Current Ranges ≥500 mA



1 VirtualBench DMM	4 Amplifier
2 Multifunction Calibrator	5 Shielded Interface Cable
3 Low EMF Copper Cable	

11. Wait 2 minutes for the thermal EMF to stabilize.
12. Generate 30 mA verification point on the calibrator.
13. Call `DMM Configure Measurement` with the following parameters:
    - **Function** = `AC Current`
    - **Auto Range** = `FALSE`
    - **Manual Range** = `0.5`

14. Call `DMM Read`. Compare to the limits listed in Table 11.

Table 11. VirtualBench AC Current Verification Limits ≥500 mA

Range (A_{rms})	Verification Point (A_{rms})	Frequency (Hz)	1 Year Limits (A_{rms})		24 Hour Limits (A_{rms})	
			Lower	Upper	Lower	Upper
0.5	0.03	40	0.02971	0.03030	0.02992	0.03008
	0.25	40	0.24938	0.25063	0.24982	0.25018
	0.505	40	0.50399	0.50601	0.50471	0.50529
5	0.3	40	0.2968	0.3033	0.2969	0.3031
	2.5	40	2.4913	2.5088	2.4928	2.5072
	5.05	40	5.0349	5.0651	5.0380	5.0620

Note Use the values in the *24 Hour Limits* column for a post-adjustment verification *only.* Otherwise, use the values in the *1 Year Limits* column.

15. Repeat steps 12 through 14 for each verification point listed in Table 11.
16. Reset the calibrator for safety reasons.
17. Disconnect all cables from the calibrator and VirtualBench.

You have completed verifying the AC current function of the VirtualBench.

DMM Adjustment

This section explains how to adjust the VirtualBench DMM. You can choose to perform these adjustment procedures with or without performing the verification procedures first.

Caution If you skip any of the steps within a section of the adjustment procedures, NI VirtualBench does *not* allow you to store your new calibration coefficients. Instead, NI VirtualBench restores the original coefficients to the EEPROM.

Note If verification was successful and you do not want to go through the adjustment procedure, you can update the calibration date by calling `Cal Set Calibration Information`.

Note NI recommends repeating the verification procedures after you perform these adjustment procedures. Re-verification ensures that the instrument you have calibrated is operating within specifications after adjustments.

Setting Up the Test Equipment

If you have not already set up the test equipment, complete the following steps:

1. Remove all connections from the input banana plug connectors on the VirtualBench.
2. Verify that the calibrator has been calibrated within the time limits specified in Table 3, and that DC zeros calibration has been performed within the last 30 days. Consult the Fluke user documentation for instructions on calibrating these devices.

> **Note** Ensure that the calibrator is warmed up for at least 60 minutes before you begin this procedure.

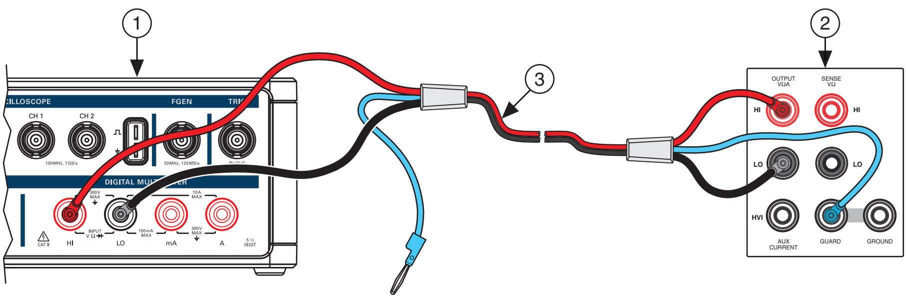
3. Reset the calibrator.
4. If you have not already done so, allow the VirtualBench to warm up for 30 minutes.

Adjusting DC Voltage

To adjust the DC voltage function of the VirtualBench, complete the following steps:

1. Reset the calibrator.
2. Connect the red connectors on one end of the low EMF copper cable to the banana plug connectors of the VirtualBench, and connect the connectors on the other end of the cable to the appropriate calibrator binding posts. Figure 8 shows the correct connections.

Figure 8. Cable Connections for DC Voltage



1 VirtualBench DMM   2 Multifunction Calibrator   3 Low EMF Copper Cable

3. Wait 2 minutes for the thermal EMF to stabilize.
4. Call `DMM Initialize Calibration` with the following parameter:
   - **Password** = `NI` (default)
5. Call `DMM Get DC Voltage Calibration Adjustment Points`. This will return two arrays:
   - **Range**—A numerical array specifying the range being calibrated
   - **Adjustment Point**—A numerical array specifying the DC voltage required to perform the adjustment
6. Output the adjustment point on the calibrator.

7. Call `DMM Adjust DC Voltage Calibration` with the following parameters:
   - **Range**—Supplied from the output of DMM Get DC Voltage Calibration Adjustment Points
   - **Adjustment Point**—Supplied from the output of DMM Get DC Voltage Calibration Adjustment Points
8. Repeat steps 6 through 7 for all adjustment points.
9. Call `DMM Close Calibration` with the following parameter:
   - **Action Input** = `Commit`
10. Reset the calibrator for safety reasons.
11. Disconnect all cables from the calibrator and VirtualBench.

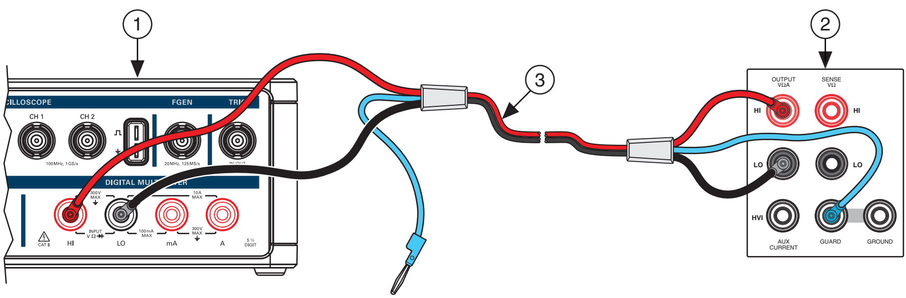
You have completed adjusting the DC voltage function of the VirtualBench.

Adjusting AC Voltage

To adjust the AC voltage function of the VirtualBench, complete the following steps:

1. Reset the calibrator.
2. Connect the red connectors on one end of the low EMF copper cable to the banana plug connectors of the VirtualBench, and connect the connectors on the other end of the cable to the appropriate calibrator binding posts. Figure 9 shows the correct connections.

Figure 9. Cable Connections for AC Voltage



1	VirtualBench DMM	2	Multifunction Calibrator	3	Low EMF Copper Cable

3. Wait 2 minutes for the thermal EMF to stabilize.

Note Thermal EMF stabilization time is not needed if the cables have not been connected/reconnected.

4. `Call DMM Initialize Calibration` with the following parameter:
   - **Password** = `NI` (default)

5. `Call DMM Get AC Voltage Calibration Adjustment Points`. This will return three arrays:
   - **Range**—A numerical array specifying the range being calibrated
   - **Adjustment Point**—A numerical array specifying the voltage required to perform the adjustment
   - **Frequency**—A numerical array specifying the frequency of the calibration signal
6. Output the adjustment point on the calibrator.
7. Call `DMM Adjust AC Voltage Calibration` with the following parameters:
   - **Range**—Supplied from the output of DMM Get AC Voltage Calibration Adjustment Points
   - **Adjustment Point**—Supplied from the output of DMM Get AC Voltage Calibration Adjustment Points
   - **Frequency**—Supplied from the output of DMM Get AC Voltage Calibration Adjustment Points
8. Repeat steps 6 through 7 for all adjustment points.
9. Call `DMM Close Calibration` with the following parameter:
   - **Action Input** = `Commit`
10. Reset the calibrator for safety reasons.
11. Disconnect all cables from the calibrator and VirtualBench.

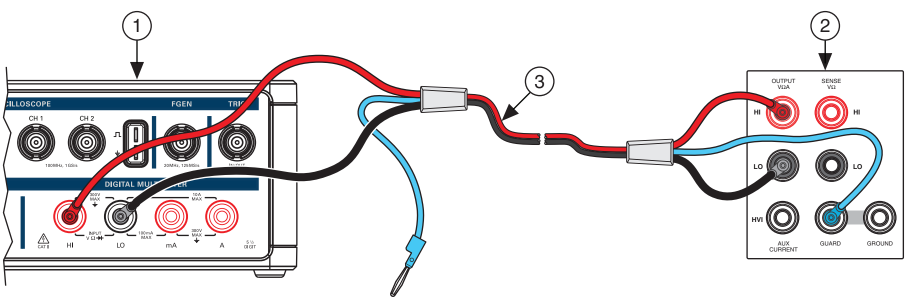
You have completed adjusting the AC voltage function of the VirtualBench.

Adjusting Resistance

To adjust the resistance function of the VirtualBench, complete the following steps:

1. Reset the calibrator.
2. To adjust resistance ≤19 kΩ, connect the red connectors on one end of the low EMF copper cable to the banana plug connectors of the VirtualBench, and connect the connectors on the other end of the cable to the appropriate calibrator binding posts. Figure 10 shows the correct connections.

Figure 10. Cable Connections for Resistance ≤19 kΩ



1	VirtualBench DMM	2	Multifunction Calibrator	3	Low EMF Copper Cable

3. Wait 2 minutes for the thermal EMF to stabilize.
4. Call `DMM Initialize Calibration` with the following parameter:
   - **Password** = `NI` (default)
5. Call `DMM Get Resistance Calibration Adjustment Points`. This will return two arrays:
   - **Range**—A numerical array specifying the range being calibrated
   - **Adjustment Point**—A numerical array specifying the resistance values required to perform the adjustment
6. Output the adjustment point on the calibrator with 2-wire compensation turned on.
7. Call `DMM Setup Resistance Calibration` with the following parameter:
   - **Range**—Supplied from DMM Get Resistance Calibration Adjustment Points
8. Wait 5 seconds for settling.
9. Call `DMM Adjust Resistance Calibration` with the following parameter:
   - **Adjustment Point**—Resistance value returned by the calibrator
10. Repeat steps 6 through 9 for the first four adjustment points.
11. To adjust resistance >19 kΩ, output the adjustment point on the calibrator with 2-wire compensation turned off.
12. Call `DMM Setup Resistance Calibration` with the following parameter:
    - **Range**—Supplied from DMM Get Resistance Calibration Adjustment Points
13. Wait 5 seconds for settling.
14. Call `DMM Adjust Resistance Calibration` with the following parameter:
    - **Adjustment Point**—Resistance value returned by the calibrator
15. Repeat steps 11 through 14 for the last eight adjustment points.
16. Call `DMM Close Calibration` with the following parameter:
    - **Action Input** = `Commit`
17. Reset the calibrator for safety reasons.
18. Disconnect all cables from the calibrator and VirtualBench.

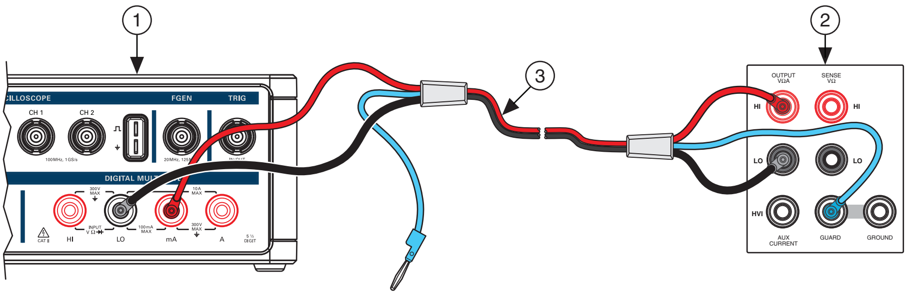
You have completed adjusting the resistance function of the VirtualBench.

Adjusting AC and DC Current

To adjust the AC and DC current functions of the VirtualBench, complete the following steps:

1. Reset the calibrator.
2. To adjust current ranges <1 A, connect the connectors on one end of the low EMF copper cable to the VirtualBench mA and LO banana plug connectors, and connect the connectors on the other end of the cable to the HI and LO calibrator binding posts. Figure 11 shows the correct connections.

Figure 11. Cable Connections for Current Ranges <1 A

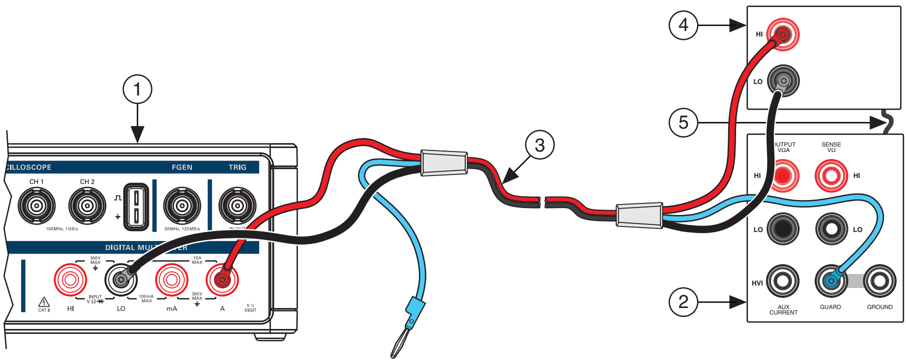


1	VirtualBench DMM	2	Multifunction Calibrator	3	Low EMF Copper Cable

3. Wait 2 minutes for the thermal EMF to stabilize.
4. `Call DMM Initialize Calibration` with the following parameter:
   - **Password** = `NI` (default)
5. `Call DMM Get Current Calibration Adjustment Points`. This will return two arrays:
   - **Range**—A numerical array specifying the range being calibrated
   - **Adjustment Point**—A numerical array specifying the current required to perform the adjustment
6. Output the adjustment point on the calibrator.
7. Call `DMM Adjust Current Calibration` with the following parameters:
   - **Range**—Supplied from the output of DMM Get Current Calibration Adjustment Points
   - **Adjustment Point**—Supplied from the output of DMM Get Current Calibration Adjustment Points
8. Repeat steps 6 through 7 for the first six adjustment points.

9. To adjust current ranges ≥1 A, connect an amplifier to the calibrator, connect the connectors on one end of the low EMF copper cable to the VirtualBench A and LO banana plug connectors, and connect the connectors on the other end of the cable to the HI and LO binding posts on the amplifier. Figure 12 shows the correct connections.

Figure 12. Cable Connections for Current Ranges ≥1 A



1 VirtualBench DMM	4 Amplifier
2 Multifunction Calibrator	5 Shielded Interface Cable
3 Low EMF Copper Cable	

10. Wait 2 minutes for the thermal EMF to stabilize.
11. Repeat steps 6 through 7 for the last six adjustment points.
12. Call `DMM Close Calibration` with the following parameter:
    - **Action Input** = `Commit`.
13. Reset the calibrator for safety reasons.
14. Disconnect all cables from the calibrator and VirtualBench.

You have completed adjusting the current functions of the VirtualBench.

DMM EEPROM Update

When an adjustment procedure for the DMM is completed, the VirtualBench internal calibration memory (EEPROM) is immediately updated.

If you do not want to perform an adjustment, you can update the calibration date and onboard calibration temperature without making any adjustments by calling `Cal Set Calibration Information`.

DMM Re-Verification

Repeat the *DMM Verification* section to determine the As-Left status of the instrument.

Note If any test fails re-verification after performing an adjustment, verify that you have met the conditions listed in the *DMM Test Conditions* section before returning your device to NI. Refer to *Where to Go for Support* for assistance in returning the device to NI.

Oscilloscope Calibration Procedure

This section contains the verification and adjustment procedures for the oscilloscope on the VirtualBench. The calibration process includes the following steps:

1. *Oscilloscope Initial Setup*—Set up the test equipment.
2. *Oscilloscope Verification*—Verify the existing operation of the instrument. This step confirms whether the instrument is operating within its specified range prior to adjustment.
3. *Oscilloscope Adjustment*—Perform an external adjustment of the instrument that adjusts the calibration constants with respect to standards of known values.
4. *Oscilloscope Re-Verification*—Repeat the verification procedure to ensure that the instrument is operating within its specifications after adjustment.

These steps are described in more detail in the following sections.

Oscilloscope Test Equipment

Table 12 lists the equipment recommended for the oscilloscope performance verification and adjustment procedures. If the recommended equipment is not available, select a substitute using the requirements listed in the table.

Table 12. Recommended Equipment

Equipment	Recommended Model	Minimum Requirements
50 Ω terminator	Amphenol 000-46650-51RFX	VB-8012 only.
Oscilloscope calibrator	Fluke 9500B calibrator	Vertical gain: DC ±(0.025% + 25 μV) into 1 MΩ
Oscilloscope calibrator active head	Fluke 9530	DC operation

Table 12. Recommended Equipment (Continued)

Equipment	Recommended Model	Minimum Requirements
Function generator	NI 5421	Must be able to generate a 1 kHz square wave between 36 mV_{pp} and 18 V_{pp} with less than 200 ns rise time and less than 5% overshoot.
SMB to BNC cable	NI part number 778827-01	Cable needed to connect from the function generator to the VirtualBench BNC connectors.

Oscilloscope Test Conditions

Follow these guidelines to optimize the equipment and the environment during calibration:

- Keep connections to the device as short as possible. Long cables and wires act as antennae, picking up noise that can affect measurements.
- Use a USB connection between the PC and VirtualBench.
- Verify that all connections to the device, including front panel connections, are secure.
- Keep relative humidity between 10% and 80% noncondensing.
- Allow a warm up time of at least 30 minutes to ensure that the VirtualBench is at a stable operating temperature.
- Plug the VirtualBench, PC, and the test equipment into the same power strip to avoid ground loops.
- Verification limits are defined assuming the same test equipment is used during verification and adjustment.
- Maintain an ambient temperature of 23 ±5 °C. The device temperature will be greater than the ambient temperature.

Oscilloscope Initial Setup

Note This section is necessary for pre-adjustment verifications only. If you are performing a post-adjustment verification, skip the setup and go directly to the *Oscilloscope Verification* section.

To set up the test equipment, complete the following steps.

1. If VirtualBench is running, shut down all instruments on the VirtualBench, and close the VirtualBench software. Remove all signal connections.
2. Verify that the oscilloscope calibrator has been calibrated within the time limits specified in its specifications, and that a self-calibration has been performed before VirtualBench calibration. Consult the oscilloscope calibrator user documentation for instructions on calibrating these devices.

Note Ensure that the VirtualBench is warmed up for at least 30 minutes and the calibrator is warmed up for the minimum time required as specified in its user documentation.

3. Verify that a self-calibration has been performed on the function generator before VirtualBench calibration.

Oscilloscope Verification

You can use the verification procedure described in this section for both pre-adjustment and post-adjustment verification.

Verifying the Oscilloscope Offset

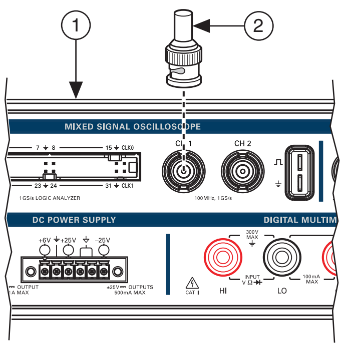
Complete the following steps to verify the VirtualBench oscilloscope offset.

Note In this procedure, the 50 Ω BNC terminator is only needed for the VB-8012. The VB-8034 and VB-8054 use an internal 50 Ω BNC terminator during calibration.

1. **(VB-8012)** Connect a 50 Ω BNC terminator to oscilloscope channel 1, as shown in Figure 13.

   (VB-8034/8054) Ensure there are no cables connected to any oscilloscope channels.

Figure 13. VB-8012 Oscilloscope Offset Channel 1 Connection Diagram



1	VB-8012 Oscilloscope	2	50 Ω Terminator

2. Call `MSO Initialize`.
3. Call `MSO Configure Timing` with the following parameter:
   - **Sample Rate** = `1M`
   - **Acquisition Time (s)** = `0.1`
   - **Pretrigger Time (s)** = `1e-9`
   - **Sampling Mode** = `Sample`

4. Call `MSO Configure Analog Channel` with the following parameters:
   - **Enable Channel** = `TRUE`
   - **Channel** = `mso/1`
   - **Vertical Coupling** = `DC`
   - **Probe Attenuation** = `1x`
   - **Vertical Range** = `20`
   - **Vertical Offset** = `0`
5. Call `MSO Run`.
6. Call `MSO Read`. Calculate and record the average analog waveform. Verify that this measurement falls within the limits in Table 13.

Table 13. Oscilloscope Offset Verification Limits

Range (V)	Verification Point (V)	1 Year Limits (mV)		24 Hour Limits (mV)	
		Lower	Upper	Lower	Upper
20	0	-400	400	-100	100
10		-200	200	-50	50
5		-100	100	-30	30
2		-40	40	-12	12
1		-20	20	-6	6
0.5		-10	10	-3	3
0.2		-4	4	-1.2	1.2
0.1		-2	2	-0.8	0.8
0.05		-1	1	-0.6	0.6
0.02*		-0.4	0.4	-0.3	0.3
* VB-8034 and VB-8054 only.					

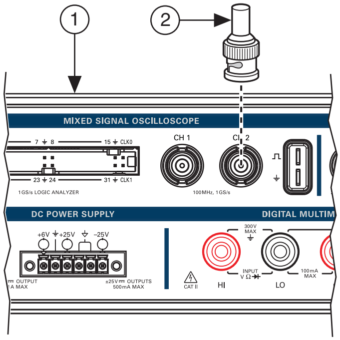
7. Call `MSO Stop`.
8. Repeat steps 4 to 7 for all of the ranges in Table 13.

Note The 0.02 V range only applies to the VB-8034 and VB-8054.

9. Call `MSO Close`.

10. **(VB-8012)** Remove the 50 Ω BNC terminator from channel 1 and connect it to channel 2, as shown in Figure 14.

Figure 14. VB-8012 Oscilloscope Offset Channel 2 Connection Diagram



1	VB-8012 Oscilloscope	2	50 Ω Terminator

11. Repeat steps 2 to 9 for all ranges on channel 2.

Note When calling `MSO Configure Analog Channel` in step 4, change the **Channel** input to `mso/2`.

12. **(VB-8012)** Remove the 50 Ω BNC terminator from channel 2.
13. **(VB-8034/8054)** Repeat steps 2 to 9 for all ranges on channel 3.

Note When calling `MSO Configure Analog Channel` in step 4, change the **Channel** input to `mso/3`.

14. **(VB-8034/8054)** Repeat steps 2 to 9 for all ranges on channel 4.

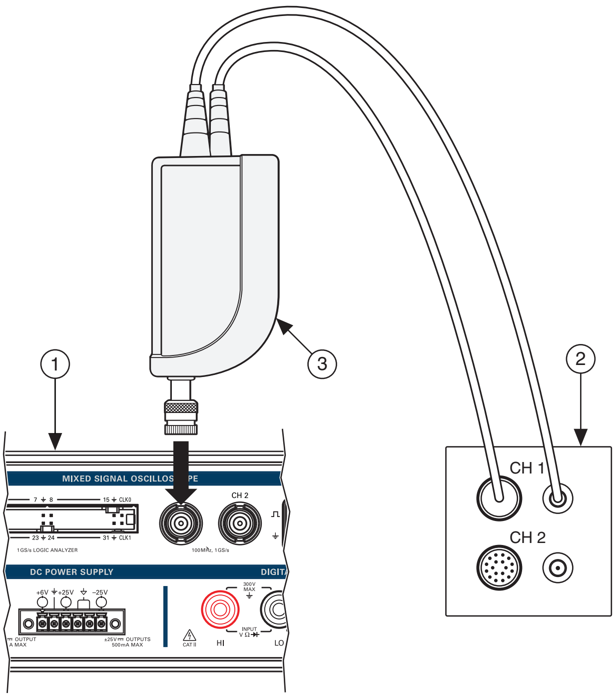
Note When calling `MSO Configure Analog Channel` in step 4, change the **Channel** input to `mso/4`.

Verifying the Oscilloscope Gain

Complete the following steps to verify the VirtualBench oscilloscope gain.

1. Connect VirtualBench channel 1 to the oscilloscope calibrator active head, as shown in Figure 15.

Figure 15. Oscilloscope Gain Channel 1 Connection Diagram



1	VirtualBench Oscilloscope	3	Oscilloscope Calibrator Active Head
2	Oscilloscope Calibrator		

2. Call `MSO Initialize`.
3. Call `MSO Configure Timing` with the following parameters:
   - **Sample Rate** = `1M`
   - **Acquisition Time (s)** = `0.1`
   - **Pretrigger Time (s)** = `1e-9`
   - **Sampling Mode** = `Sample`
4. Call `MSO Configure Analog Channel` with the following parameters:
   - **Enable Channel** = `TRUE`
   - **Channel** = `mso/1`
   - **Vertical Coupling** = `DC`

- **Probe Attenuation** = `1x`
- **Vertical Range** = `20`
- **Vertical Offset** = `0`

Note Configure the oscilloscope calibrator for high impedance loads.

5. Set the oscilloscope calibrator DC voltage output to -90% of the range, or -18 V.
6. Wait at least 5 seconds for the oscilloscope calibrator to settle.
7. Call `MSO Run`.
8. Call `MSO Read`. Calculate and record the average analog waveform. Save this value as V_{meas_neg}.
9. Set the oscilloscope calibrator DC voltage output to +90% of the range, or +18 V.
10. Wait at least 5 seconds for the oscilloscope calibrator to settle.
11. Call `MSO Run`.
12. Call `MSO Read`. Calculate and record the average analog waveform. Save this value as V_{meas_pos}.
13. Call `MSO Stop`.
14. Calculate the gain error as follows:

$$\left[\frac{(V_{meas\_pos} - V_{meas\_neg})}{(V_{pos} - V_{neg})} - 1\right] \times 100\%$$

Where V_{pos} and V_{neg} are listed in Table 14.
Verify that this calculation falls within the limits in Table 14.

Table 14. Oscilloscope Gain Verification Limits

Range (V)	V_{pos} (V)	V_{neg} (V)	1 Year Limits (%)		24 Hour Limits (%)	
			Lower	Upper	Lower	Upper
20	18	-18	-2	2	-0.8	0.8
10	9	-9	-2	2	-0.8	0.8
5	4.5	-4.5	-2	2	-0.8	0.8
2	1.8	-1.8	-2	2	-0.8	0.8
1	0.9	-0.9	-2	2	-0.8	0.8
0.5	0.45	-0.45	-2	2	-0.9	0.9
0.2	0.18	-0.18	-2	2	-0.9	0.9
0.1	0.09	-0.09	-2	2	-1	1

Table 14. Oscilloscope Gain Verification Limits (Continued)

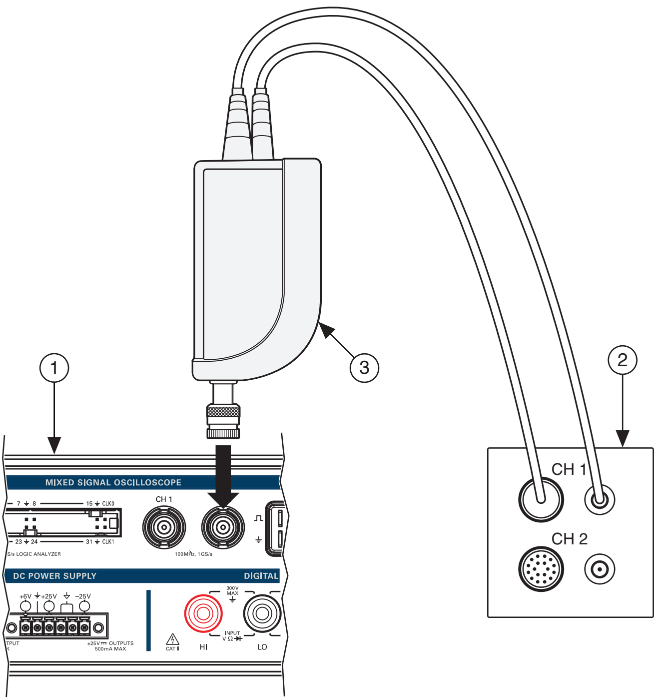
Range (V)	V_{pos} (V)	V_{neg} (V)	1 Year Limits (%)		24 Hour Limits (%)	
			Lower	Upper	Lower	Upper
0.05	0.045	-0.045	-2	2	-1	1
0.02*	0.018	-0.018	-2	2	-1.2	1.2
* VB-8034 and VB-8054 only.						

15. Repeat steps 4 to 14 for all of the ranges with the values for V_{pos} and V_{neg} in Table 14.

Note The 0.02 V range only applies to the VB-8034 and VB-8054.

16. Call `MSO Close`.
17. Remove the connections from channel 1. Connect VirtualBench channel 2 to the oscilloscope calibrator active head, as shown in Figure 16.

Figure 16. Oscilloscope Gain Channel 2 Connection Diagram



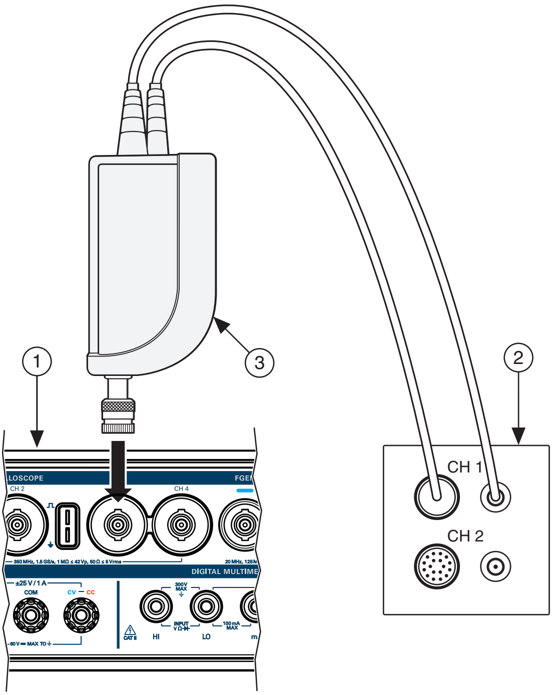
1	VirtualBench Oscilloscope	2	Oscilloscope Calibrator	3	Oscilloscope Calibrator Active Head

18. Repeat steps 2 to 16 for all ranges on channel 2.

Note When calling `MSO Configure Analog Channel` in step 4, change the **Channel** input to `mso/2`.

19. Remove the connections from channel 2.
20. **(VB-8034/8054)** Connect VirtualBench channel 3 to the oscilloscope calibrator active head, as shown in Figure 17.

Figure 17. VB-8034/8054 Oscilloscope Gain Channel 3 Connection Diagram



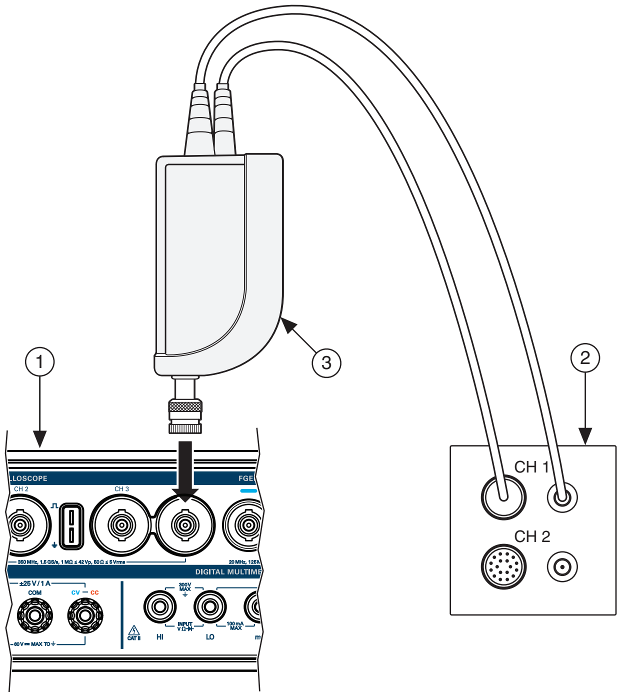
1	VirtualBench Oscilloscope	2	Oscilloscope Calibrator	3	Oscilloscope Calibrator Active Head

21. **(VB-8034/8054)** Repeat steps 2 to 16 for all ranges on channel 3.

Note **(VB-8034/8054)** When calling `MSO Configure Analog Channel` in step 4, change the **Channel** input to `mso/3`.

22. **(VB-8034/8054)** Remove the connections from channel 3. Connect VirtualBench channel 4 to the oscilloscope calibrator active head, as shown in Figure 18.

Figure 18. VB-8034/8054 Oscilloscope Gain Channel 4 Connection Diagram



1	VirtualBench Oscilloscope	2	Oscilloscope Calibrator	3	Oscilloscope Calibrator Active Head

23. **(VB-8034/8054)** Repeat steps 2 to 16 for all ranges on channel 4.

Note **(VB-8034/8054)** When calling `MSO Configure Analog Channel` in step 4, change the **Channel** input to `mso/4`.

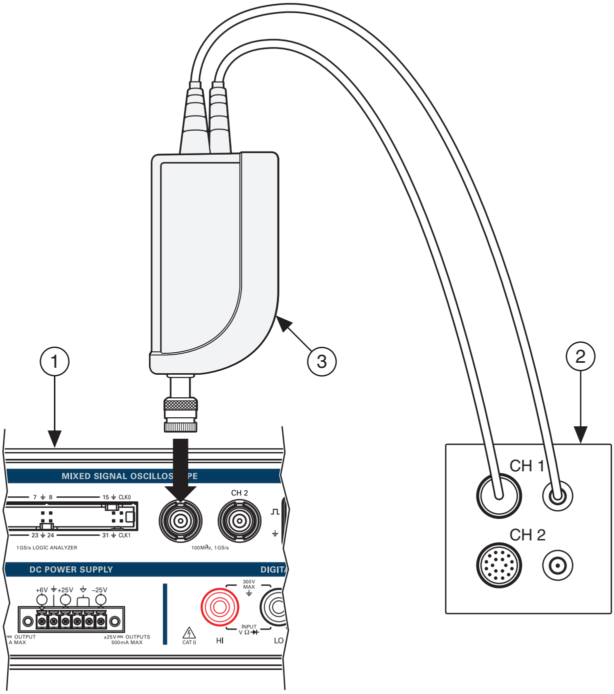
24. **(VB-8034/8054)** Remove the connections from channel 4.

Verifying the Oscilloscope Offset DAC Gain

Complete the following steps to verify the VirtualBench Oscilloscope Offset DAC Gain.

1. Connect VirtualBench channel 1 to the oscilloscope calibrator active head, as shown in Figure 19.

Figure 19. Oscilloscope Gain Channel 1 Connection Diagram



1	VirtualBench Oscilloscope	2	Oscilloscope Calibrator	3	Oscilloscope Calibrator Active Head

2. Call `MSO Initialize`.
3. Call `MSO Configure Timing` with the following parameters:
   - **Sample Rate** = `1M`
   - **Acquisition Time (s)** = `0.1`
   - **Pretrigger Time (s)** = `1e-9`
   - **Sampling Mode** = `Sample`

4. Call `MSO Configure Analog Channel` with the following parameters:
   - **Enable Channel** = `TRUE`
   - **Channel** = `mso/1`
   - **Vertical Coupling** = `DC`
   - **Probe Attenuation** = `1x`
   - **Vertical Range** = `20`
   - **Vertical Offset** = `-18`
5. Set the oscilloscope calibrator DC voltage output to the programmed vertical offset, or -18 V for this iteration.
6. Wait at least 5 seconds for the oscilloscope calibrator and DUT to settle.
7. Call `MSO Run`.
8. Call `MSO Read`. Calculate and record the average analog waveform. Save this value as V_{meas_neg}.
9. Call `MSO Stop`.
10. Call `MSO Configure Analog Channel` with the following parameters:
    - **Enable Channel** = `TRUE`
    - **Channel** = `mso/1`
    - **Vertical Coupling** = `DC`
    - **Probe Attenuation** = `1x`
    - **Vertical Range** = `20`
    - **Vertical Offset** = `18`
11. Set the oscilloscope calibrator DC voltage output to the programmed vertical offset, or +18 V for this iteration.
12. Wait at least 5 seconds for the oscilloscope calibrator and DUT to settle.
13. Call `MSO Run`.
14. Call `MSO Read`. Calculate and record the average analog waveform. Save this value as V_{meas_pos}.
15. Call `MSO Stop`.
16. Calculate the gain error as follows:

$$\left[\frac{(V_{meas\_pos} - V_{meas\_neg})}{(V_{pos} - V_{neg})} - 1\right] \times 100\%$$

    Where V_{pos} and V_{neg} are listed in Table 15.
    Verify that this calculation falls within the limits in Table 15.

Table 15. Oscilloscope Offset DAC Gain Verification Limits

Vertical Range (V)	Vertical Offset (V)		1 Year Limits (%)		24 Hour Limits (%)	
	V_{pos}	V_{neg}	Lower	Upper	Lower	Upper
20	18	-18	-2	2	-1	1
10			-2	2	-0.7	0.7
5			-2	2	-0.5	0.5
2			-2	2	-0.5	0.5
1			-2	2	-0.5	0.5
0.5			-2	2	-0.5	0.5
0.2	4.5	-4.5	-2	2	-0.5	0.5
0.1			-2	2	-0.5	0.5
0.05			-2	2	-0.5	0.5
0.02*			-2	2	-0.5	0.5

* VB-8034 and VB-8054 only.

17. Repeat steps 4 to 16 for all of the ranges with the values for V_{pos} and V_{neg} in Table 15.

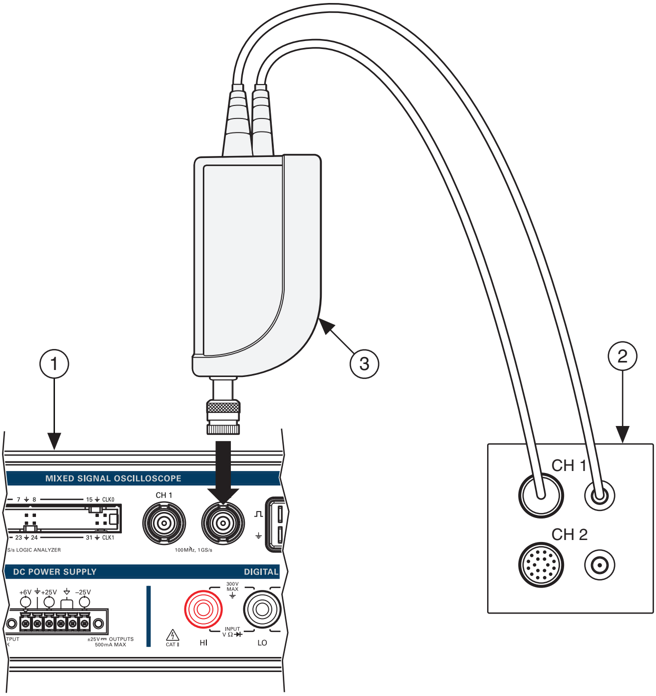
Note When calling `MSO Configure Analog Channel` the Vertical Range input must match the range value in Table 15.

Note The 0.02 V vertical range only applies to the VB-8034 and VB-8054.

18. Call `MSO Close`.

19. Remove the connections from channel 1. Connect VirtualBench channel 2 to the oscilloscope calibrator active head, as shown in Figure 20.

Figure 20. Oscilloscope Gain Channel 2 Connection Diagram



1	VirtualBench Oscilloscope	2	Oscilloscope Calibrator	3	Oscilloscope Calibrator Active Head

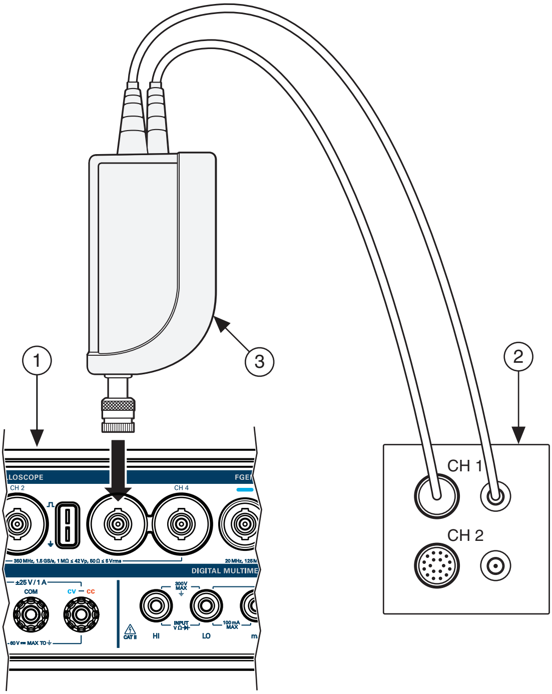
20. Repeat steps 2 to 18 for all ranges on channel 2.

Note When calling `MSO Configure Analog Channel` in step 4, change the **Channel** input to `mso/2`.

21. Remove the connections from channel 2.

22. **(VB-8034/8054)** Connect VirtualBench channel 3 to the oscilloscope calibrator active head, as shown in Figure 21.

Figure 21. VB-8034/8054 Oscilloscope Gain Channel 3 Connection Diagram



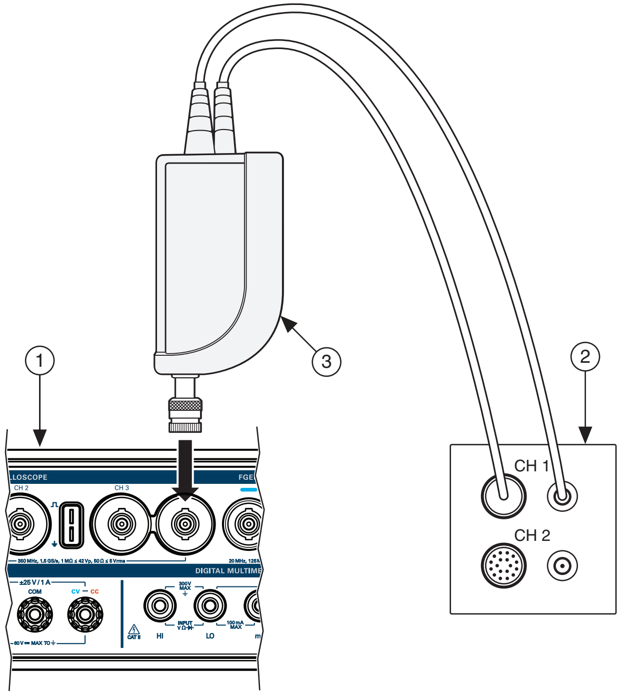
1	VirtualBench Oscilloscope	2	Oscilloscope Calibrator	3	Oscilloscope Calibrator Active Head

23. **(VB-8034/8054)** Repeat steps 2 to 18 for all ranges on channel 3.

Note **(VB-8034/8054)** When calling `MSO Configure Analog Channel` in step 4, change the **Channel** input to `mso/3`.

24. **(VB-8034/8054)** Remove the connections from channel 3. Connect VirtualBench channel 4 to the oscilloscope calibrator active head, as shown in Figure 22.

Figure 22. VB-8034/8054 Oscilloscope Gain Channel 4 Connection Diagram



1	VirtualBench Oscilloscope	2	Oscilloscope Calibrator	3	Oscilloscope Calibrator Active Head

25. **(VB-8034/8054)** Repeat steps 2 to 18 for all ranges on channel 4.

Note **(VB-8034/8054)** When calling `MSO Configure Analog Channel` in step 4, change the **Channel** input to `mso/4`.

26. **(VB-8034/8054)** Remove the connections from channel 4.

Oscilloscope Adjustment

This section explains how to adjust the VirtualBench oscilloscope. You can choose to perform these adjustment procedures with or without performing the verification procedures first.

Note NI recommends repeating the verification procedures after you perform these adjustment procedures. Re-verification ensures that the instrument you have calibrated is operating within specifications after adjustments.

Note Allow the VirtualBench to warm up for at least 30 minutes before adjusting.

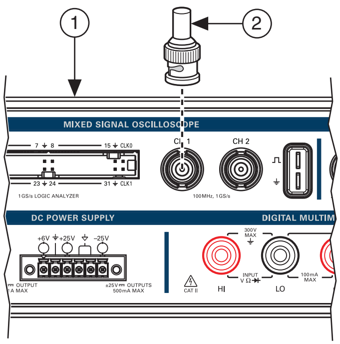
To adjust the Oscilloscope accuracy perform the following steps:

Note In this procedure, the 50 Ω BNC terminator is only needed for the VB-8012. The VB-8034 and VB-8054 use an internal 50 Ω BNC terminator during calibration.

1. **(VB-8012)** Connect a 50 Ω BNC terminator to Oscilloscope channel 1, as shown in Figure 23.

   (VB-8034/8054) Ensure there are no cables connected to any oscilloscope channels.

Figure 23. VB-8012 Oscilloscope Adjustment Channel 1 Connection Diagram

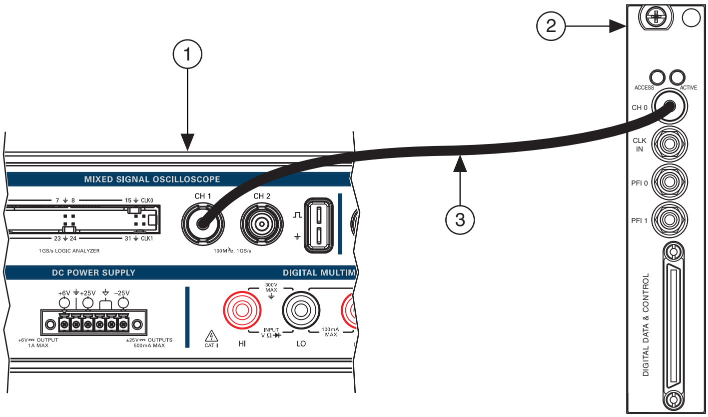


1	VB-8012 Oscilloscope	2	50 Ω Terminator

2. Call `MSO Initialize Calibration` with the following parameter:
   - **Password** = `NI` (default)
3. Call `MSO Adjust Offset Calibration` with the following parameter:
   - **Channel** = `mso/1`

4. **(VB-8012)** Disconnect the 50 Ω terminator
5. Connect Channel 1 of the oscilloscope to Channel 0 of the function generator with the BNC-to-SMB cable, as shown in Figure 24.

Figure 24. Oscilloscope Channel 1-to-Function Generator Connection Diagram



1	VirtualBench Oscilloscope	2	Function Generator	3	BNC-to-SMB Cable

6. Call `MSO Get Compensator Attenuation Calibration Adjustment Points`. This will return three arrays:
   - **Range**—A numerical array specifying the range being calibrated
   - **Amplitude**—A numerical array specifying the square wave amplitude required for calibration (V_{pk-pk})
   - **Frequency**—A numerical array specifying the frequency of the calibration square wave

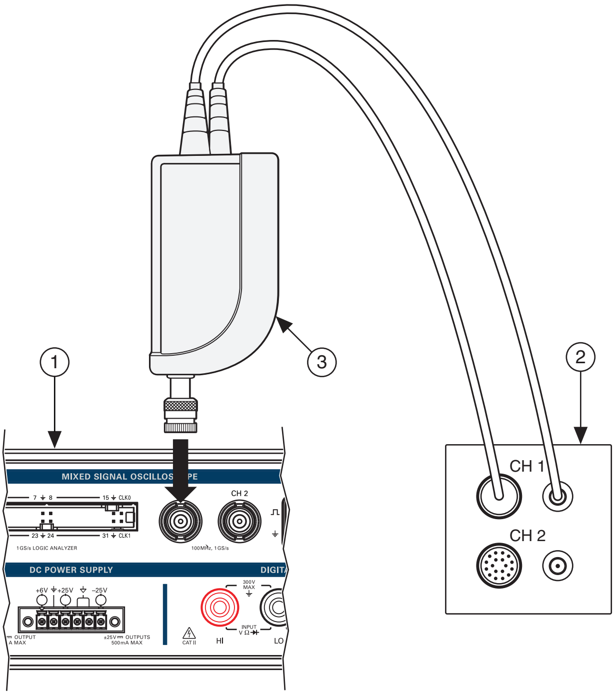
Note Configure the function generator for high impedance loads.

7. Use the function generator to generate a square wave with the offset set to zero and duty cycle set to 50%; the frequency and amplitude are supplied from the output of MSO Get Compensator Attenuation Calibration Adjustment Points.
8. Wait 100 milliseconds.
9. Call `MSO Adjust Compensator Attenuation Calibration` with the following parameters:
   - **Channel**—`mso/1`
   - **Range**—Supplied from the output of MSO Get Compensator Attenuation Calibration Adjustment Points

- **Amplitude**—Supplied from the output of MSO Get Compensator Attenuation Calibration Adjustment Points
- **Frequency**—Supplied from the output of MSO Get Compensator Attenuation Calibration Adjustment Points

10. Repeat steps 7 to 9 for each adjustment point.
11. Disconnect the function generator. Connect VirtualBench channel 1 to the oscilloscope calibrator active head, as shown in Figure 25.

Figure 25. Oscilloscope Gain Channel 1 Connection Diagram

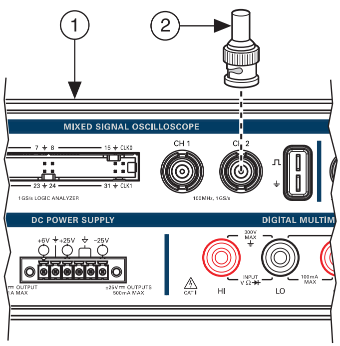


1	VirtualBench Oscilloscope	2	Oscilloscope Calibrator	3	Oscilloscope Calibrator Active Head

12. Call `MSO Get Range Calibration Adjustment Points`. This will return two arrays:
    - **Range**—A numerical array specifying the range being calibrated
    - **Adjustment Point**—A numerical array specifying the DC voltage required to perform the adjustment
13. Use the oscilloscope calibrator to generate a DC voltage with the adjustment point supplied from the output of MSO Get Range Calibration Adjustment Points.
14. Wait 5 seconds.

15. Call `MSO Adjust Range Calibration` with the following parameters:
    - **Channel**—`mso/1`
    - **Range**—Supplied from the output of MSO Get Range Calibration Adjustment Points
    - **Adjustment Point**—Supplied from the output of MSO Get Range Calibration Adjustment Points
16. Repeat steps 13 to 15 for each adjustment point.
17. Call `MSO Get Offset DAC Calibration Adjustment Points`. This will return two arrays:
    - **Range**—A numerical array specifying the range being calibrated
    - **Adjustment Point**—A numerical array specifying the DC voltage required to perform the adjustment
18. Use the oscilloscope calibrator to generate a DC voltage with the adjustment point supplied from the output of MSO Get Offset DAC Calibration Adjustment Points.
19. Wait 5 seconds.
20. Call `MSO Adjust Offset DAC Calibration` with the following parameters:
    - **Channel**—`mso/1`
    - **Range**—A numerical array specifying the range being calibrated
    - **Adjustment Point**—A numerical array specifying the DC voltage required to perform the adjustment
21. Repeat steps 18 to 20 for each adjustment point.
22. Remove the connections from channel 1.
23. **(VB-8012)** Connect a 50 Ω BNC terminator to oscilloscope channel 2, as shown in Figure 26.

Figure 26. VB-8012 Oscilloscope Offset Channel 2 Connection Diagram



1	VB-8012 Oscilloscope	2	50 Ω Terminator

24. Repeat steps 3 to 21 for MSO channel 2.

Note For all inputs, change the **Channel** input to `mso/2`.

25. **(VB-8012)** Skip to step 28.
26. **(VB-8034/8054)** Repeat steps 3 to 21 for MSO channel 3.

Note **(VB-8034/8054)** For all inputs, change the **Channel** input to `mso/3`.

27. **(VB-8034/8054)** Repeat steps 3 to 21 for MSO channel 4.

Note **(VB-8034/8054)** For all inputs, change the **Channel** input to `mso/4`.

28. Call `MSO Close Calibration` with the following parameter:
    - **Action** = `Commit`

You have completed adjusting the VirtualBench oscilloscope. It is recommended that a post-adjustment verification be performed.

Oscilloscope EEPROM Update

When an adjustment procedure for the oscilloscope is completed, the VirtualBench internal calibration memory (EEPROM) is immediately updated.

If you do not want to perform an adjustment, you can update the calibration date and onboard calibration temperature without making any adjustments by calling `Cal Set Calibration Information`.

Oscilloscope Re-Verification

Repeat the *Oscilloscope Verification* section to determine the As-Left status of the instrument.

Note If any test fails re-verification after performing an adjustment, verify that you have met the conditions listed in the *Oscilloscope Test Conditions* section before returning your device to NI. Refer to *Where to Go for Support* for assistance in returning the device to NI.

Function Generator (FGEN) Calibration Procedure

This section contains the verification and adjustment procedures for the FGEN on the VirtualBench. The calibration process includes the following steps:

1. *FGEN Initial Setup*—Set up the test equipment.
2. *FGEN Verification*—Verify the existing operation of the instrument. This step confirms whether the instrument is operating within its specified range prior to adjustment.

3. *FGEN Adjustment*—Perform an external adjustment of the instrument that adjusts the calibration constants with respect to standards of known values.
4. *FGEN Re-Verification*—Repeat the verification procedure to ensure that the instrument is operating within its specifications after adjustment.

These steps are described in more detail in the following sections.

FGEN Test Equipment

Table 16 lists the equipment recommended for the FGEN performance verification and adjustment procedures. If the recommended equipment is not available, select a substitute using the requirements listed in the table.

Table 16. Recommended Equipment

Equipment	Recommended Model	Minimum Requirements
Digital multimeter (DMM)	NI PXI-4071	DC V accuracy: 21 ppm DC input impedance: ≥1 GΩ DC A accuracy: 310 ppm
Banana plug-to-BNC cable	Pomona 4530-C	—

FGEN Test Conditions

Follow these guidelines to optimize the equipment and the environment during calibration:

- Keep connections to the device as short as possible. Long cables and wires act as antennae, picking up noise that can affect measurements.
- Use a USB connection between the PC and VirtualBench.
- Verify that all connections to the device, including front panel connections, are secure.
- Keep relative humidity between 10% and 80% noncondensing.
- Allow a warmup time of at least 30 minutes to ensure that the VirtualBench is at a stable operating temperature.
- Plug the VirtualBench, PC, and the test equipment into the same power strip to avoid ground loops.
- Verification limits are defined assuming the same test equipment is used during verification and adjustment.
- Maintain an ambient temperature of 23 ±5 °C. The device temperature will be greater than the ambient temperature.

FGEN Initial Setup

Note This section is necessary for pre-adjustment verifications only. If you are performing a post-adjustment verification, skip the setup and go directly to the *Verifying the FGEN Offset* section.

To set up the test equipment, complete the following steps.

1. If VirtualBench is running, shut down all instruments on the VirtualBench, and close the VirtualBench software. Remove all signal connections.
2. Verify that the DMM has been calibrated within the proper calibration interval specified in its specifications, and a self-calibration is performed.

Note Ensure that the VirtualBench is warmed up for at least 30 minutes and the DMM is warmed up for the minimum time required as specified in its user documentation.

FGEN Verification

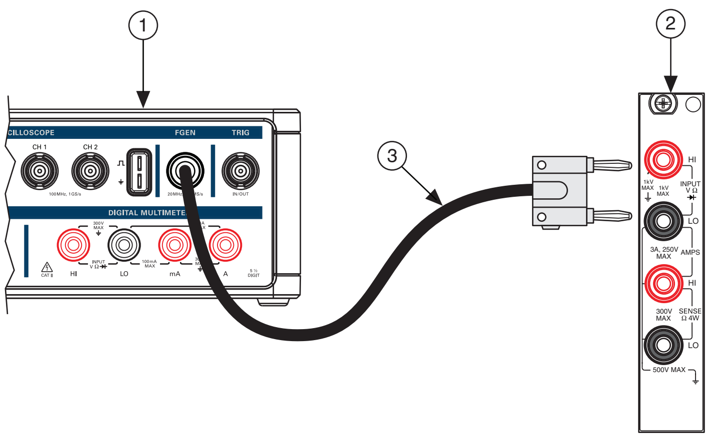
You can use the verification procedure described in this section for both pre-adjustment and post-adjustment verification.

Verifying the FGEN Offset

Complete the following steps to verify the VirtualBench FGEN offset.

1. Connect the voltage input HI and LO terminals of the DMM to the FGEN BNC using a banana plug-to-BNC cable—observing the polarity of the banana plugs—as shown in Figure 27.

Figure 27. Cable Connections for FGEN Verification and Adjustment



1 VirtualBench FGEN	2 DMM	3 Banana Plug-to-BNC Cable

2. Call `FGEN Initialize`.
3. Call `FGEN Configure Standard Waveform` with the following parameters:
   - **Waveform Function** = `DC`
   - **DC Offset** = `0`
4. Call `FGEN Enable Filter` with the following parameter:
   - **Enable Filter** = `TRUE`
5. Call `FGEN Run` to enable the output.
6. Wait at least 100 milliseconds for settling.
7. Perform a measurement with the DMM in the 100 mV range. Compare to the limits listed in Table 17.

Table 17. FGEN Offset Calibration Limits

Verification Point (V)	FGEN Enable Filter Setting	1 Year Limits (V)		24 Hour Limits (V)	
		Lower	Upper	Lower	Upper
0	TRUE (On)	-0.008	0.008	-0.003	0.003
0	FALSE (Off)	-0.008	0.008	-0.003	0.003

8. Call `FGEN Enable Filter` with the following parameter:
   - **Enable Filter** = `FALSE`
9. Wait at least 100 milliseconds for settling.
10. Perform a measurement with the DMM in the 100 mV range. Compare to the limits listed in Table 17.
11. Call `FGEN Close`.

Verifying the FGEN Gain

Complete the following steps to verify the VirtualBench FGEN gain.

1. Connect the voltage input HI and LO terminals of the DMM to the FGEN BNC using a banana plug-to-BNC cable—observing the polarity of the banana plugs—as shown in Figure 27.
2. Call `FGEN Initialize`.
3. Call `FGEN Configure Standard Waveform` with the following parameters:
   - **Waveform Function** = `DC`
   - **DC Offset** = `12`
4. Call `FGEN Enable Filter` with the following parameter:
   - **Enable Filter** = `TRUE`

5. Wait at least 100 milliseconds for settling.
6. Call `FGEN Run`.
7. Perform a measurement with the DMM in the best available range greater than 12 V. Compare to the limits listed in Table 18.

Table 18. FGEN Gain Calibration Limits

Verification Point (V)	FGEN Enable Filter Setting	1 Year Limits (V)		24 Hour Limits (V)	
		Lower	Upper	Lower	Upper
+12	TRUE (On)	11.88	12.12	11.98	12.02
	FALSE (Off)	11.88	12.12	11.98	12.02
-12	TRUE (On)	-12.12	-11.88	-12.02	-11.98
	FALSE (Off)	-12.12	-11.88	-12.02	-11.98

8. Call `FGEN Enable Filter` with the following parameter:
   - **Enable Filter** = `FALSE`
9. Wait at least 100 milliseconds for settling.
10. Perform a measurement with the DMM in the best available range greater than 12 V. Compare to the limits listed in Table 18.
11. Repeat steps 3 through 10 for all verification points in Table 18.
12. Call `FGEN Close`.

FGEN Adjustment

This section explains how to adjust the VirtualBench FGEN. You can choose to perform these adjustment procedures with or without performing the verification procedures first.

Note NI recommends repeating the verification procedures after you perform these adjustment procedures. Re-verification ensures that the instrument you have calibrated is operating within specifications after adjustments.

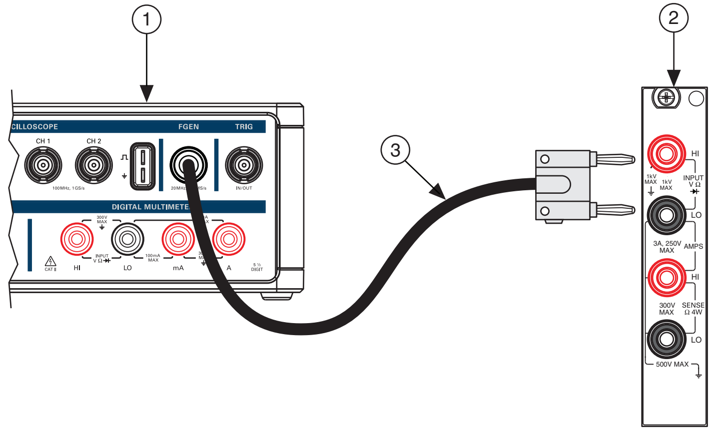
Note Before adjustment perform a self-calibration on the DMM performing the adjustment.

Note Allow the VirtualBench to warm up for at least 30 minutes before adjusting.

To adjust the FGEN accuracy complete the following steps.

1. Connect the voltage input HI and LO terminals of the DMM to the FGEN BNC using a banana plug-to-BNC cable—observing the polarity of the banana plugs—as shown in Figure 28.

Figure 28. Cable Connections for FGEN Verification and Adjustment



1	VirtualBench FGEN	2	DMM	3	Banana Plug-to-BNC Cable

2. Call `FGEN Initialize Calibration` with the following parameter:
   - **Password** = `NI` (default)
3. Call `FGEN Setup Offset Calibration` with the following parameter:
   - **Enable Filter** = `TRUE`
4. Wait 100 milliseconds.
5. Perform a measurement with the DMM in the 1 V range. Record the reference value measurement.
6. Call `FGEN Adjust Offset Calibration` with the following parameter:
   - **Reference Value**—Supplied from measurement in step 5
7. Repeat steps 3 through 6 until `FGEN Adjust Offset Calibration` returns `TRUE` from its Calibration Done output.
8. Repeat steps 3 through 7 with the following parameter:
   - **Enable Filter** = `FALSE`
9. Call `FGEN Get Gain Calibration Adjustment Points`. This will return two arrays:
   - **Enable Filter**—A Boolean array of filter settings
   - **Adjustment Point**—An array of voltage points used in the gain adjustment steps

10. Call `FGEN Setup Gain Calibration` with the following parameters:
    - **Enable Filter**—Supplied from the output of FGEN Get Gain Calibration Adjustment Points
    - **Adjustment Point**—Supplied from the output of FGEN Get Gain Calibration Adjustment Points
11. Wait 100 milliseconds.
12. Perform a measurement with the DMM in a range greater than 12 V. Record the reference value measurement.
13. Call `FGEN Adjust Gain Calibration` with the following parameter:
    - **Reference Value**—Supplied from measurement in step 12
14. Repeat steps 10 through 13 for all adjustment points.
15. Call `FGEN Close Calibration` with the following parameter:
    - **Action** = `Commit`

You have completed adjusting the VirtualBench FGEN. It is recommended that you perform a post-adjustment verification.

FGEN EEPROM Update

When an adjustment procedure for the FGEN is completed, the VirtualBench internal calibration memory (EEPROM) is immediately updated.

If you do not want to perform an adjustment, you can update the calibration date and onboard calibration temperature without making any adjustments by calling `Cal Set Calibration Information`.

FGEN Re-Verification

Repeat the *FGEN Verification* section to determine the As-Left status of the instrument.

Note If any test fails re-verification after performing an adjustment, verify that you have met the conditions listed in the *FGEN Test Conditions* section before returning your device to NI. Refer to *Where to Go for Support* for assistance in returning the device to NI.

DC Power Supply Calibration Procedure

This section contains the verification and adjustment procedures for the DC power supply on the VirtualBench. The calibration process includes the following steps:

1. *DC Power Supply Initial Setup*—Set up the test equipment.
2. *DC Power Supply Verification*—Verify the existing operation of the instrument. This step confirms whether the instrument is operating within its specified range prior to adjustment.

3. *DC Power Supply Adjustment*—Perform an external adjustment of the instrument that adjusts the calibration constants with respect to standards of known values.
4. *DC Power Supply Re-Verification*—Repeat the verification procedure to ensure that the instrument is operating within its specifications after adjustment.

These steps are described in more detail in the following sections.

Note If you are calibrating both the DMM and the DC power supply, the DMM must be calibrated first.

DC Power Supply Test Equipment

Table 19 lists the equipment recommended for the DC power supply performance verification and adjustment procedures. If the recommended equipment is not available, select a substitute using the requirements listed in the table.

Table 19. Recommended Equipment

Equipment	Recommended Model	Minimum Requirements
Digital multimeter (DMM)	NI PXI-4071	DC V accuracy: 21 ppm at 25 V DC input impedance: ≥1 GΩ DC A accuracy: 310 ppm at 1 A, 460 ppm at 2 A
Cabling wire	—	18 AWG to 22 AWG. Twisted pair, shielded cabling wire is recommended

DC Power Supply Test Conditions

Follow these guidelines to optimize the equipment and the environment during calibration:

- Keep connections to the device as short as possible. Long cables and wires act as antennae, picking up noise that can affect measurements.
- Use a USB connection between the PC and VirtualBench.
- Verify that all connections to the device, including front panel connections, are secure.
- Use shielded copper wire for all cable connections. Use twisted-pair, shielded wire to reduce measurement error in noisy environments.
- Keep relative humidity between 10% and 80% noncondensing.
- Allow a warm up time of at least 30 minutes to ensure that the VirtualBench is at a stable operating temperature.

- Plug the VirtualBench, PC, and the test equipment into the same power strip to avoid ground loops.
- Verification limits are defined assuming the same test equipment is used during verification and adjustment.
- Maintain an ambient temperature of 23 ±5 °C. The device temperature will be greater than the ambient temperature.

DC Power Supply Initial Setup

Note This section is necessary for pre-adjustment verifications only. If you are performing a post-adjustment verification, skip the setup and go directly to the *DC Power Supply Verification* section.

To set up the test equipment, complete the following steps:

1. If VirtualBench is running, shut down all instruments on the VirtualBench, and close the VirtualBench software. Remove all signal connections.
2. Verify that the DMM has been calibrated within the proper calibration interval specified in its specifications, and a self-calibration is performed.

Note Ensure that the VirtualBench is warmed up for at least 30 minutes and the DMM is warmed up for the minimum time required as specified in its user documentation.

Note Before verifying or adjusting the DC power supply, you must enable and set the output voltages at full scale for a minimum of 15 minutes.

Note If you are calibrating both the DMM and the DC power supply, the DMM must be calibrated first.

DC Power Supply Verification

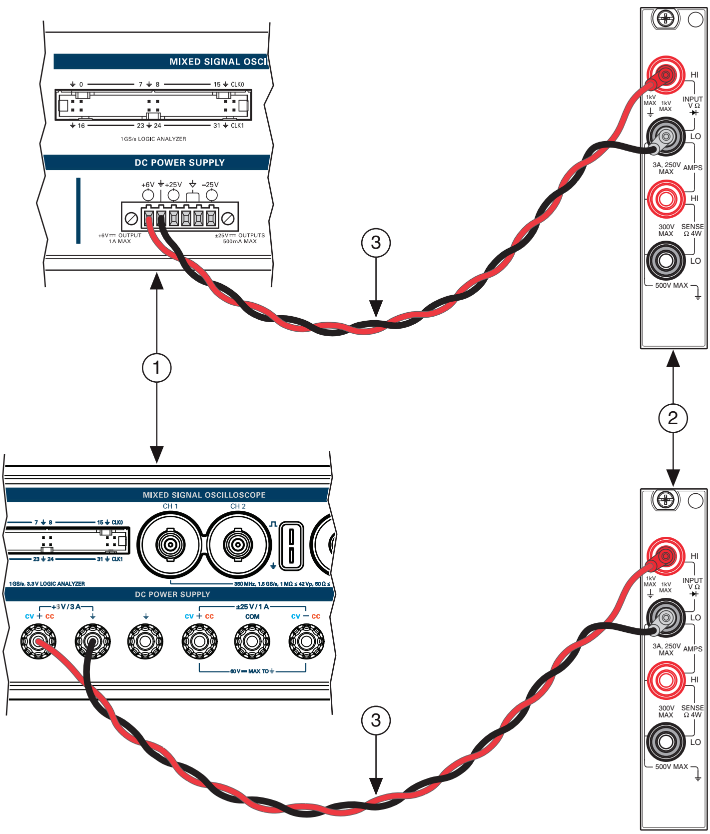
You can use the verification procedure described in this section for both pre-adjustment and post-adjustment verification.

Verifying Voltage Programming and Measurement Accuracy

To verify the voltage programming and measurement accuracy on the +6 V, +25 V, and -25 V channels, complete the following steps.

1. Reset the DMM and configure it for the 10 V range.
2. Connect Channel +6 V to Volts HI, and GND to Volts LO with cabling wire, as shown in Figure 29.

Figure 29. Cable Connections For +6 V Voltage Programming Accuracy Verification



1	VirtualBench DC Power Supply	2	DMM	3	Cabling Wire

3. Call `PS Initialize`.
4. Call `PS Enable All Outputs` with the following parameter:
   - **Enable Outputs** = `TRUE`

5. Call `PS Configure Voltage Output` with the following parameters:
   - **Channel** = `ps/+6V`
   - **Voltage Level** = `0`, as listed in the first row of the *Verification Point* column of Table 20 or 21
   - **Current Limit** = `1` or `3`, as listed in the first row of the *Current Limit* column of Table 20 or 21
6. Wait at least 150 milliseconds for the DC power supply to settle.
7. Measure the output voltage with the DMM and record the reading. Subtract the DMM reading from the verification point. Verify that the calculation falls between the limits in Table 20 or 21.

Table 20. VB-8012 DC Power Supply Voltage Programming and Measurement Accuracy

Channel	Verification Point (V)	Current Limit (A)	1 Year Limits ±(V)	24 Hour Limits ±(V)
+6 V	0	1	0.0050	0.0020
	1.5		0.0065	0.0024
	3		0.0080	0.0028
	4.5		0.0095	0.0031
	6		0.0110	0.0035
+25 V	0	0.5	0.0200	0.0080
	6.5		0.0265	0.0096
	12.5		0.0325	0.0111
	18.75		0.0388	0.0127
	25		0.0450	0.0143
-25 V	0	0.5	0.0200	0.0080
	-6.5		0.0265	0.0096
	-12.5		0.0325	0.0111
	-18.75		0.0388	0.0127
	-25		0.0450	0.0143

Table 21. VB-8034/8054 DC Power Supply Voltage Programming and Measurement Accuracy

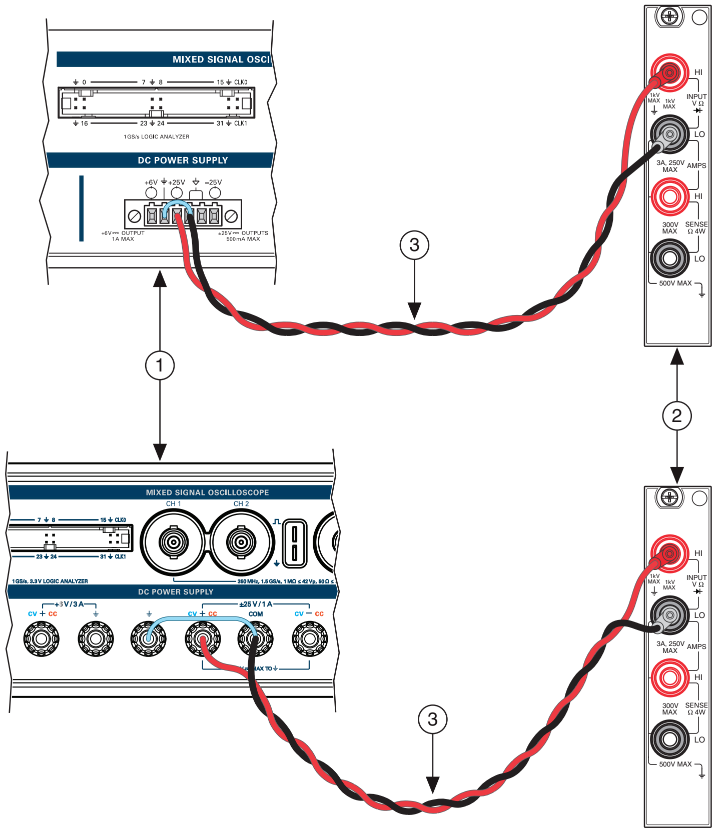
Channel	Verification Point (V)	Current Limit (A)	1 Year Limits ±(V)	24 Hour Limits ±(V)
+6 V	0	3	0.0050	0.0020
	1.5		0.0065	0.0024
	3		0.0080	0.0028
	4.5		0.0095	0.0031
	6		0.0110	0.0035
+25 V	0	1	0.0200	0.0080
	6.5		0.0265	0.0096
	12.5		0.0325	0.0111
	18.75		0.0388	0.0127
	25		0.0450	0.0143
-25 V	0	1	0.0200	0.0080
	-6.5		0.0265	0.0096
	-12.5		0.0325	0.0111
	-18.75		0.0388	0.0127
	-25		0.0450	0.0143

Note Use the values in the *1 Year Limits* column. The values in the *24 Hour Limits* column are for a post-adjustment verification only.

8. Call `PS Read Output` with the following parameter:
   - **Channel** = `ps/+6V`
9. Subtract the DMM reading from step 7 from the DC power supply Actual Voltage Level reading in step 8. Verify that calculation falls between the limits in Table 20 or 21.
10. Repeat steps 5 through 9 for each verification point on this channel.
11. Call `PS Reset Instrument`.

12. Disconnect all connections and connect Channel +25 V to Volts HI and GND and Common Floating GND to Volts LO as shown in Figure 30.

Figure 30. Cable Connections For +25 V Voltage Programming Accuracy Verification

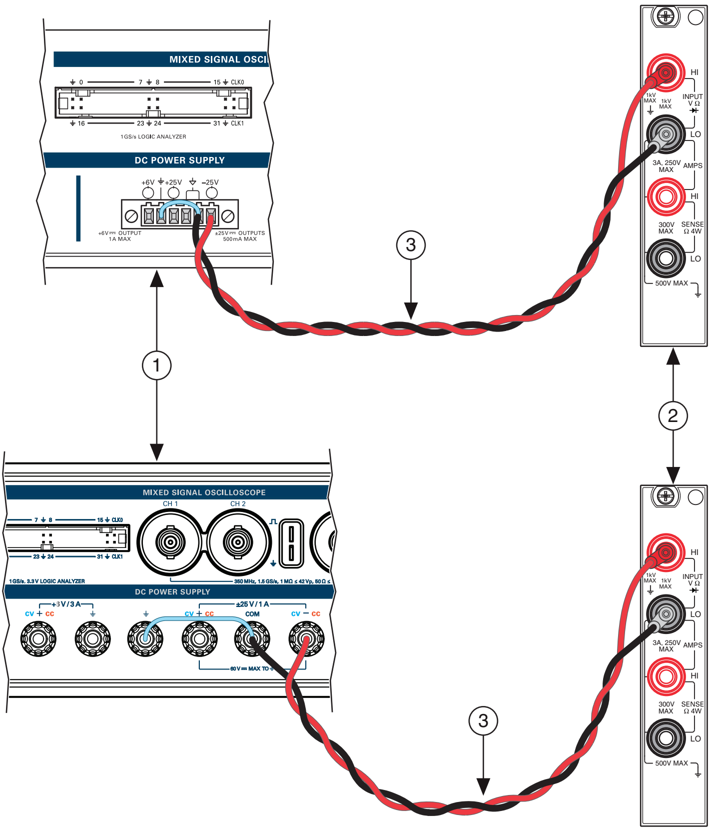


1	VirtualBench DC Power Supply	2	DMM	3	Cabling Wire

13. Configure the DMM for the 100 V range.
14. Repeat steps 4 through 11 for the `ps/+25V` channel

15. Disconnect all connections and connect Channel -25 V to Volts HI, and GND to Volts LO as shown in Figure 31. Connect GND and Common Floating GND with a jumper.

Figure 31. Cable Connections For -25 V Voltage Programming Accuracy Verification



1	VirtualBench DC Power Supply	2	DMM	3	Cabling Wire

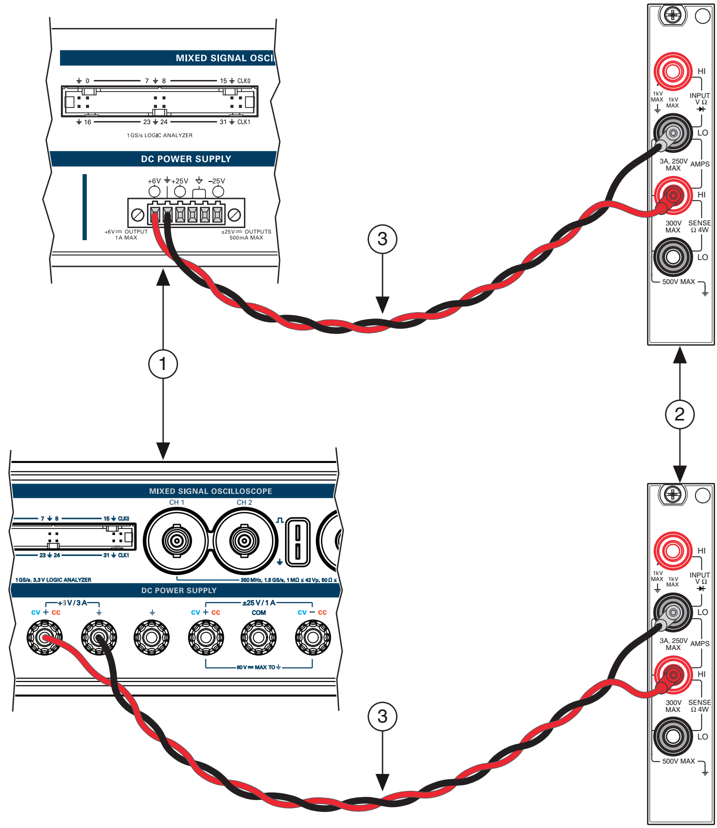
16. Repeat steps 4 through 11 for the `ps/-25V` channel.
17. Disconnect all connections.
18. Call `PS Close`.

Verifying Current Programming and Measurement Accuracy

To verify the current programming and measurement accuracy of the DC power supply, complete the following steps.

1. Reset the DMM and configure it for the 1 A range for the VB-8012 or the 3 A range for the VB-8034/8054.
2. Connect Channel +6 V to Amps HI, and GND to Amps LO as shown in Figure 32.

Figure 32. Cable Connections For +6 V Current Programming Accuracy Verification



1	VirtualBench DC Power Supply	2	DMM	3	Cabling Wire

3. Call `PS Initialize`.
4. Call `PS Enable All Outputs` with the following parameter:
   - **Enable Outputs** = `TRUE`

5. Call `PS Configure Current Output` with the following parameters:
   - **Channel** = `ps/+6V`
   - **Current Level** = `0.01` or `0.03`, as listed in the first row of the *Verification Point* column of Table 22 or 23
   - **Voltage Limit** = `6`, as listed in the first row of the *Voltage Limit* column of Table 22 or 23
6. Wait for the DC power supply to settle. The VB-8012 requires at least 60 seconds of settling time. The VB-8034/8054 requires at least 5 seconds of settling time.
7. Measure the output voltage with the DMM and record the reading. Subtract the DMM reading from the verification point. Verify that the calculation falls between the limits in Table 22 or 23.

Table 22. VB-8012 DC Power Supply Current Programming and Measurement Accuracy

Channel	Verification Point (A)	Voltage Limit (V)	1 Year Limits ±(A)	24 Hour Limits ±(A)
+6 V	0.01	6	0.01002	0.00201
	1		0.01200	0.00300
+25 V	0.005	25	0.00401	0.00101
	0.5		0.00475	0.00150
-25 V	0.005	-25	0.00401	0.00101
	0.5		0.00475	0.00150

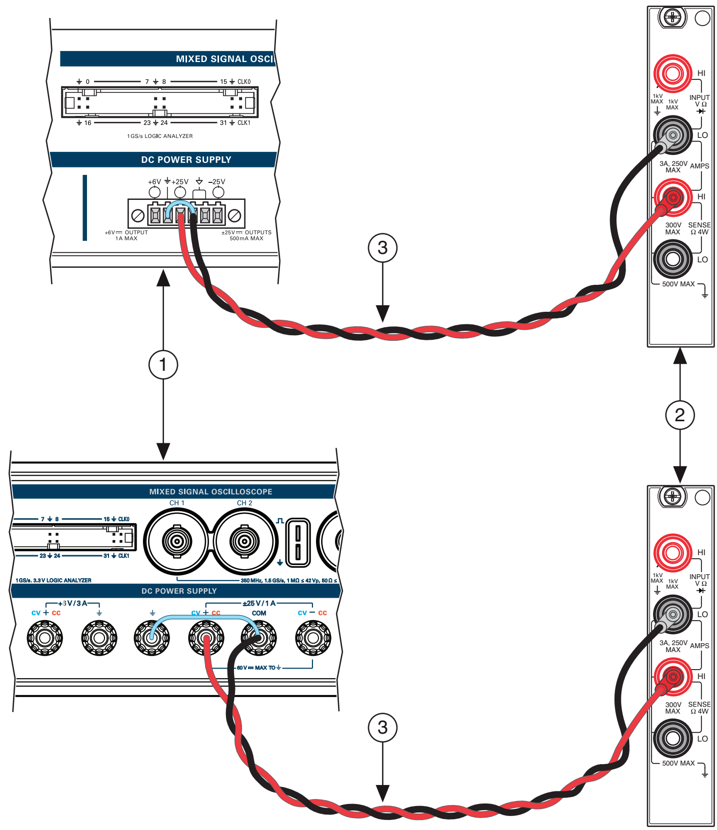
Table 23. VB-8034/8054 DC Power Supply Current Programming and Measurement Accuracy

Channel	Verification Point (A)	Voltage Limit (V)	1 Year Limits ±(A)	24 Hour Limits ±(A)
+6 V	0.03	6	0.01006	0.001058
	2		0.01400	0.001550
+25 V	0.01	25	0.00402	0.000323
	1		0.00550	0.000570
-25 V	0.01	-25	0.00402	0.000323
	1		0.00550	0.000570

Note Use the values in the *1 Year Limits* column. The values in the *24 Hour Limits* column are for a post-adjustment verification only.

8. Call `PS Read Output` with the following parameter:
   - **Channel** = `ps/+6V`
9. Subtract the DMM reading from step 7 from the DC power supply Actual Current Level reading in step 8. Verify that calculation falls between the limits in Table 22 or 23.
10. Repeat steps 5 through 9 for each verification point on this channel.
11. Call `PS Reset Instrument`.
12. Disconnect all connections and connect Channel +25 V to Amps HI, and Common Floating GND to Amps LO as shown in Figure 33. Connect GND and Common Floating GND with a jumper.

Figure 33. Cable Connections For +25 V Current Programming Accuracy Verification

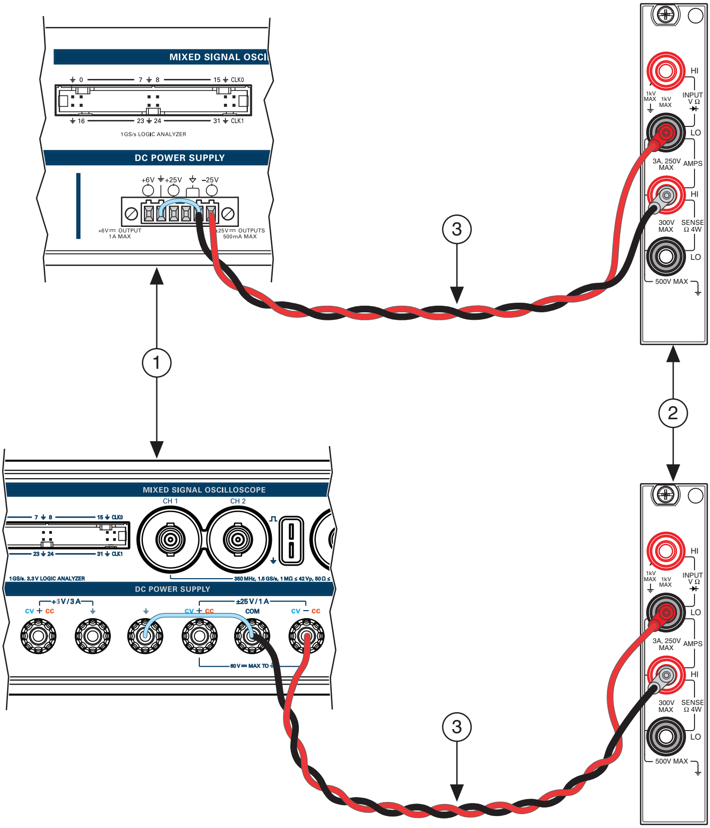


1	VirtualBench DC Power Supply	2	DMM	3	Cabling Wire

13. Repeat steps 5 through 11 for the `ps/+25V` channel.

14. Disconnect all connections and connect Channel -25 V to Amps LO, and Common Floating GND to Amps HI as shown in Figure 34. Connect GND and Common Floating GND with a jumper.

Figure 34. Cable Connections For -25 V Current Programming Accuracy Verification



1	VirtualBench DC Power Supply	2	DMM	3	Cabling Wire

15. Repeat steps 5 through 11 for the `ps/-25V` channel.
16. Disconnect all connections.
17. Call `PS Close`.

If the instrument has successfully passed all verification tests, the DC power supply is within the published specifications, and adjustment is optional.

DC Power Supply Adjustment

This section explains how to adjust the VirtualBench DC power supply. You can choose to perform these adjustment procedures with or without performing the verification procedures first.

Note NI recommends repeating the verification procedures after you perform these adjustment procedures. Re-verification ensures that the instrument you have calibrated is operating within specifications after adjustments.

Note Before adjustment perform a self-calibration on the DMM performing the adjustment.

Note Allow the VirtualBench to warm up for at least 30 minutes before adjusting.

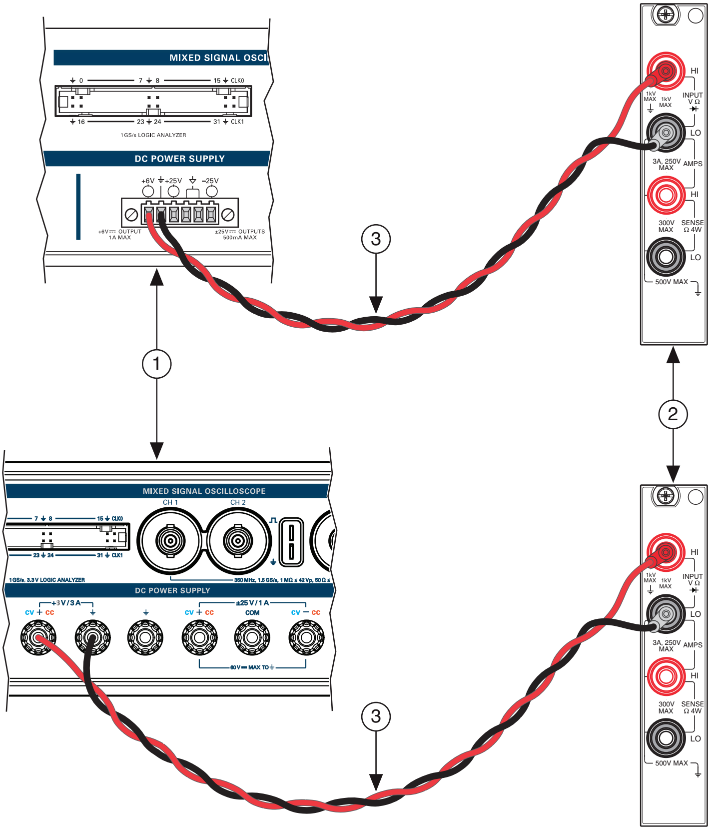
Note Before adjusting the DC power supply, you must enable and set the output voltages at full scale for a minimum of 15 minutes.

Adjusting Voltage Programming and Measurement Accuracy

Complete the following steps to adjust voltage programming and measurement accuracy of VirtualBench.

1. Reset the DMM.
2. Call `PS Initialize Calibration` with the following parameters:
   - **Cal Type** = `Voltage`
   - **Password** = `NI` (default)
3. Connect Channel +6 V to Volts HI, and GND to Volts LO as shown in Figure 35.

Figure 35. Cable Connections For +6 V Voltage Programming and Measurement Accuracy Adjustment



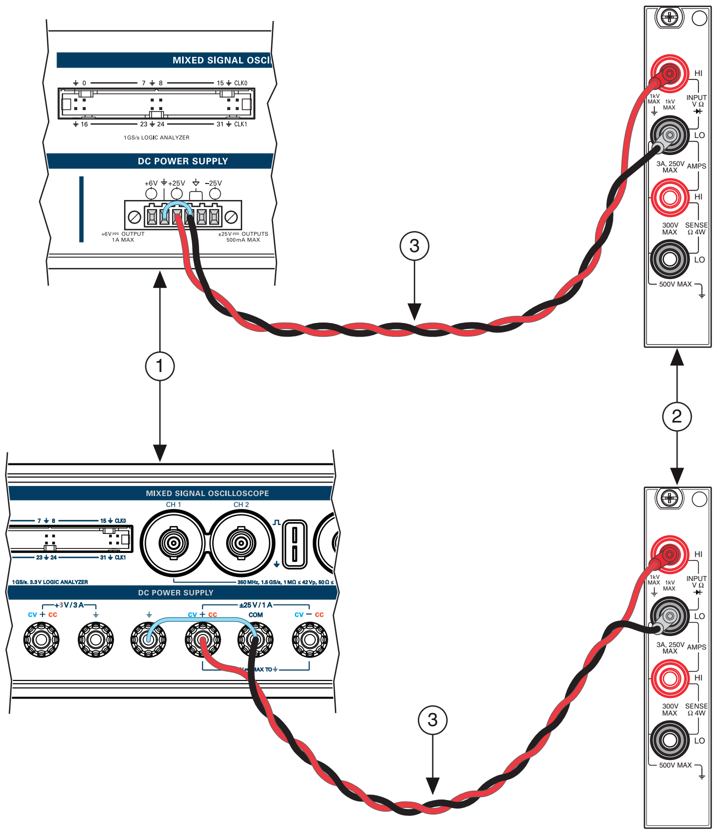
1	VirtualBench DC Power Supply	2	DMM	3	Cabling Wire

4. Call `PS Get Adjustment Points` with the following parameter:
   - **Channel** = `ps/+6V`

   This will return an array:
   - **Adjustment Points**—An array of voltage points used in the adjustment steps
5. Call `PS Set Adjustment Point` with the following parameters:
   - **Channel** = `ps/+6V`
   - **Adjustment Point**—Supplied from the output of PS Get Adjustment Points
6. Wait at least 150 milliseconds for the DC power supply to settle.
7. Measure the output voltage with the DMM.

8. Call `PS Measure Adjustment Point` with the following parameters:
   - **Channel** = `ps/+6V`
   - **Reference Value**—Supplied from the DMM measurement in step 7
9. Repeat steps 5 through 8 for each adjustment point on this channel.
10. Disconnect all connections and connect Channel +25 V to Volts HI, and Common Floating GND to Volts LO as shown in Figure 36. Connect GND and Common Floating GND with a jumper.

Figure 36. Cable Connections For +25 V Voltage Programming and Measurement Accuracy Adjustment

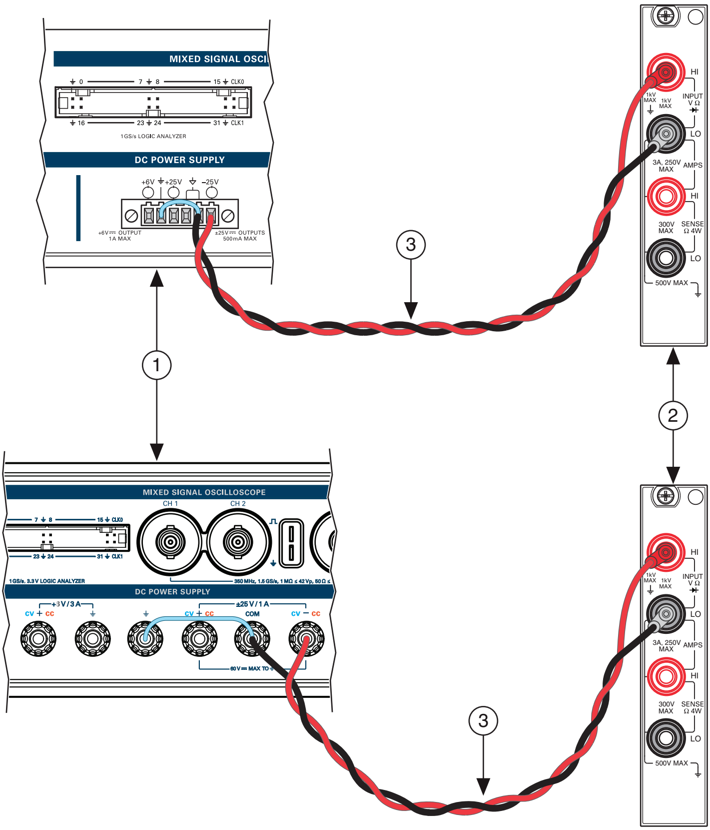


1	VirtualBench DC Power Supply	2	DMM	3	Cabling Wire

11. Repeat steps 4 through 9 for the `ps/+25V` channel.

12. Disconnect all connections and connect Channel -25 V to Volts HI, and Common Floating GND to Volts LO as shown in Figure 37. Connect GND and Common Floating GND with a jumper.

Figure 37. Cable Connections For -25 V Voltage Programming and Measurement Accuracy Adjustment



1	VirtualBench DC Power Supply	2	DMM	3	Cabling Wire

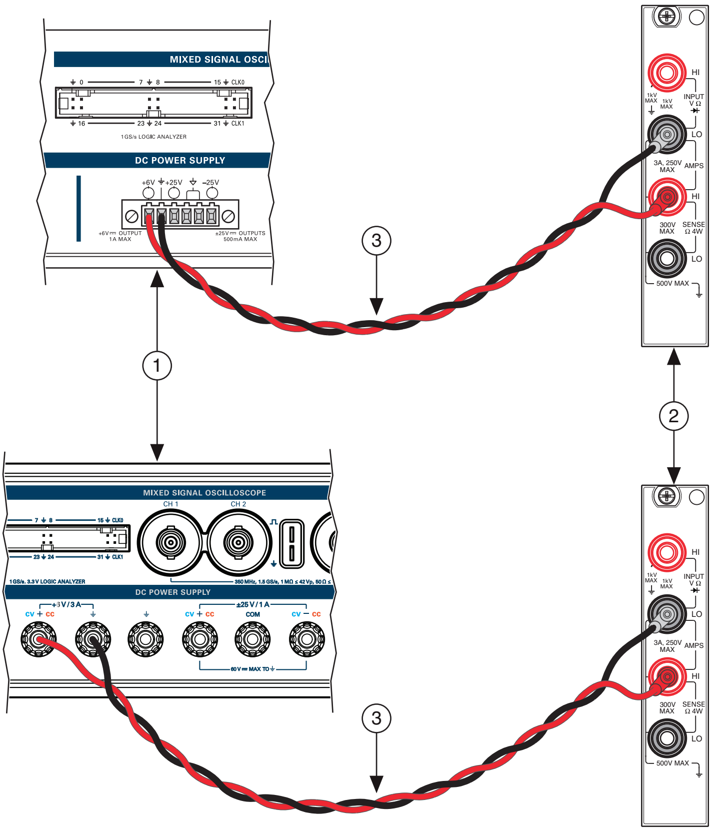
13. Repeat steps 4 through 9 for the `ps/-25V` channel.
14. Call `PS Close Calibration` with the following parameter:
    - **Action** = `Commit`
15. Disconnect all connections.

Adjusting Current Programming and Measurement Accuracy

Complete the following steps to adjust voltage programming and measurement accuracy of VirtualBench.

1. Reset the DMM.
2. Call `PS Initialize Calibration` with the following parameters:
   - **Cal Type** = `Current`
   - **Password** = `NI` (default)
3. Connect Channel +6 V to Amps HI, and GND to Amps LO as shown in Figure 38.

Figure 38. Cable Connections For +6 V Current Programming and Measurement Accuracy Adjustment



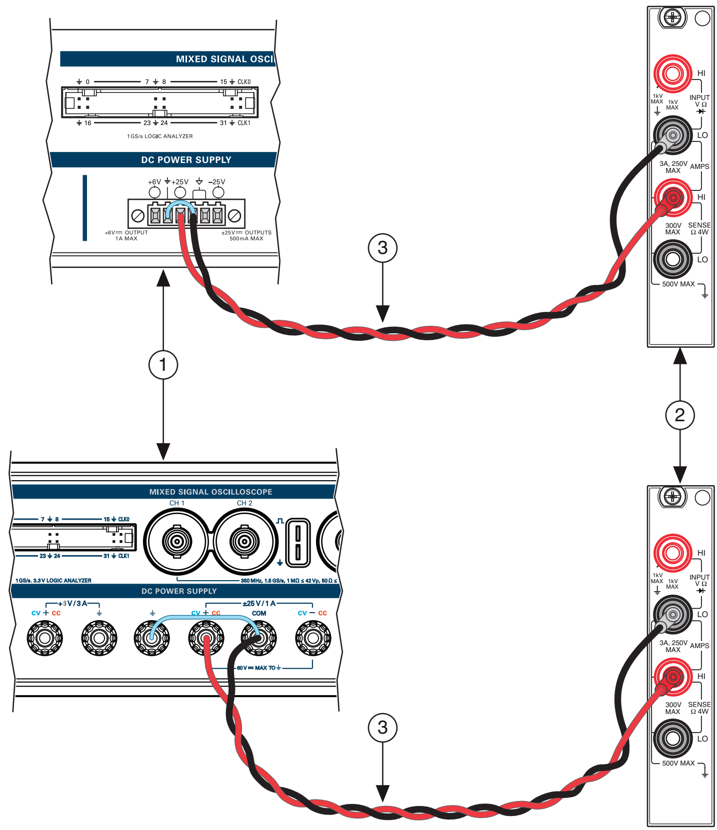
1	VirtualBench DC Power Supply	2	DMM	3	Cabling Wire

4. Call `PS Get Adjustment Points` with the following parameter:
   - **Channel** = `ps/+6V`

   This will return an array:
   - **Adjustment Points**—An array of current points used in the adjustment steps
5. Call `PS Set Adjustment Point` with the following parameters:
   - **Channel** = `ps/+6V`
   - **Adjustment Point**—Supplied from the output of PS Get Adjustment Points
6. Wait for the DC power supply to settle. The VB-8012 requires at least 60 seconds of settling time. The VB-8034/8054 requires at least 5 seconds of settling time.
7. Measure the output current with the DMM.
8. Call `PS Measure Adjustment Point` with the following parameters:
   - **Channel** = `ps/+6V`
   - **Reference Value**—Supplied from the DMM measurement in step 7
9. Repeat steps 5 through 8 for each adjustment point on this channel.

10. Disconnect all connections and connect Channel +25 V to Amps HI, and Common Floating GND to Amps LO as shown in Figure 39. Connect GND and Common Floating GND with a jumper.

Figure 39. Cable Connections For +25 V Current Programming and Measurement Accuracy Adjustment

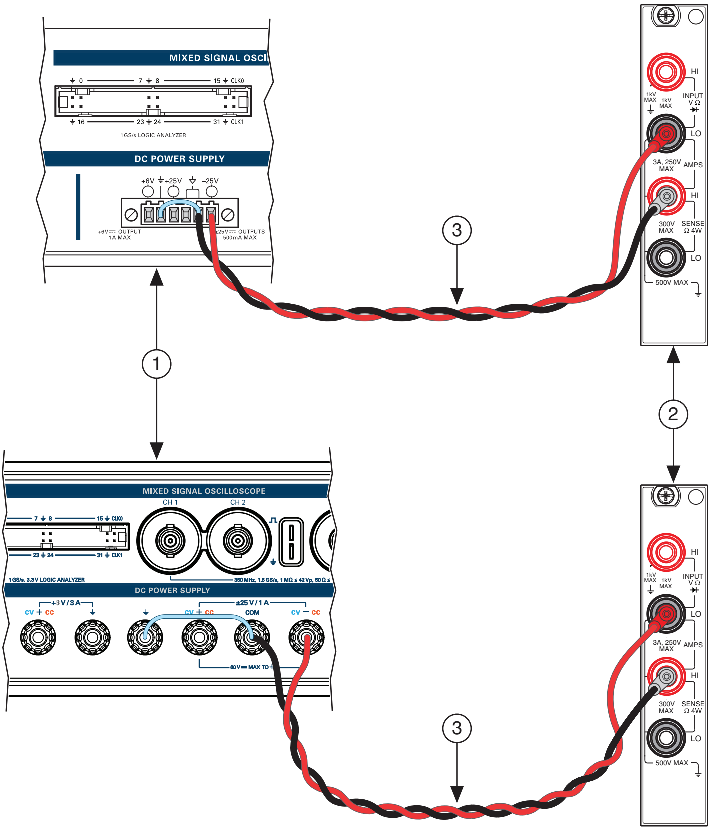


1	VirtualBench DC Power Supply	2	DMM	3	Cabling Wire

11. Repeat steps 4 through 9 for the `ps/+25V` channel.

12. Disconnect all connections and connect Channel -25 V to Amps LO, and Common Floating GND to Amps HI as shown in Figure 40. Connect GND and Common Floating GND with a jumper.

Figure 40. Cable Connections For -25 V Current Programming and Measurement Accuracy Adjustment



1	VirtualBench DC Power Supply	2	DMM	3	Cabling Wire

13. Repeat steps 4 through 9 for the `ps/-25V` channel.
14. Call `PS Close Calibration` with the following parameter:
    - **Action** = `Commit`
15. Disconnect all connections.

DC Power Supply EEPROM Update

When an adjustment procedure for the DC power supply is completed, the VirtualBench internal calibration memory (EEPROM) is immediately updated.

If you do not want to perform an adjustment, you can update the calibration date and onboard calibration temperature without making any adjustments by calling `Cal Set Calibration Information`.

DC Power Supply Re-Verification

Repeat the *DC Power Supply Verification* section to determine the As-Left status of the instrument. Use the values in the *24 Hour Limits* column of Tables 20 through 23 for a post-adjustment verification.

Note If any test fails Re-Verification after performing an adjustment, verify that you have met the *DC Power Supply Test Conditions* before returning your device to NI. Refer to *Where to Go for Support* for assistance in returning the device to NI.

Where to Go for Support

The National Instruments website is your complete resource for technical support. At `ni.com/support` you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

Visit `ni.com/services` for NI Factory Installation Services, repairs, extended warranty, and other services.

Visit `ni.com/register` to register your National Instruments product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

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