CALIBRATION PROCEDURE

FD-11637

8-Channel Strain/Bridge Input Device for FieldDAQ

This document contains information for calibrating the FD-11637. For more information about calibration, visit *ni.com/calibration*.

Contents

Software Requirements

Calibrating the FD-11637 requires the installation of NI-DAQmx on the calibration system. NI recommends using the latest NI-DAQmx driver. Earliest driver support version for calibrating the FD-11637 is listed in the following table.

Table 1. FD-11637 Driver Support

Driver	Earliest Version Support for Device Calibration
NI-DAQmx	18.5

You can download NI-DAQmx from *ni.com/downloads*. NI-DAQmx supports many programming languages, including LabVIEW, LabWindows™/CVI™, C/C++, C#, and Visual Basic .NET. When you install NI-DAQmx, you only need to install support for the application software that you intend to use.

Documentation

Consult the following documents for information about the FieldDAQ device and the NI-DAQmx driver. All documents are available on *ni.com/manuals*; help files install with the software.

FD-11637 Quick Start— Provides instructions for installing and configuring your FieldDAQ device.

FD-11637 User Guide—Provides information about your FieldDAQ device.

FD-11637 Specifications—Provides detailed specifications for your FieldDAQ device.

NI-DAQmx Readme—Provides operating system and application software support in NI-DAQmx.

NI-DAQmx Help—Provides information about creating applications that use the NI-DAQmx driver.

NI-DAQmx C Reference Help—Provides reference information for NI-DAQmx C functions and NI-DAQmx C properties.

Test Equipment

The following table lists the equipment required for calibrating the FD-11637. If the recommended instruments are not available, use the minimum requirements to select substitute equipment.

Table 2. Recommended Test Equipment

Equipment	Recommended Model	Minimum Requirements
Digital multimeter (DMM) (x2)	PXIe-4081	For *Full-Bridge and Half-Bridge Verification* In a range capable of reading at least ±200 mV: • Reading (gain error): ≤20 ppm • Combined offset and noise error: ≤3 µV In a range capable of reading at least 10 V: • Reading (gain error): ≤15 ppm • Combined offset and noise error: ≤10 µV
SHM128M-Pigtail, TP I/O Cable, 0.3 m (x3)	NI part number 786325-0R3	For *Full-Bridge and Half-Bridge Verification* Less than 0.1 Ω mismatch between FD-11637 EX+ and EX- terminals and the resistors For *Quarter-Bridge Verification* Less than 0.1 Ω resistance and less than 5 mΩ mismatch between FD-11637 EX+ and EX- terminals and the resistors
700 Ω discrete resistor (x4)	—	For *Full-Bridge and Half-Bridge Verification* ≤0.15% tolerance, ≥50 mW power rating
10 kΩ discrete resistor	—	For *Full-Bridge and Half-Bridge Verification* ≤0.5% tolerance, ≥5 mW power rating
350 Ω discrete resistor	—	For *Quarter-Bridge Verification* 350 Ω exact values known to within ±60 ppm
120 Ω discrete resistor	—	For *Quarter-Bridge Verification* 120 Ω exact values known to within ±60 ppm

Test Conditions

The following setup and environmental conditions are required to ensure the FD-11637 meets published specifications:

- Keep connections to the device as short as possible. Long cables and wires act as antennas, picking up extra noise that can affect measurements.
- Verify that all connections to the device are secure.
- Use shielded copper wire for all cable connections to the device. Use twisted-pairs wire to eliminate noise and thermal offsets.
- Maintain an ambient temperature of 23 ±5 °C. The device temperature will be greater than the ambient temperature.
- Keep relative humidity below 80%.
- Allow a warm-up time of at least 10 minutes to ensure that the FieldDAQ device measurement circuitry is at a stable operating temperature.

Calibration Procedure

The calibration process includes the following steps:

1. *Initial Setup* on page 4
2. *Full-Bridge and Half-Bridge Verification* on page 5
3. *Quarter-Bridge Verification* on page 10
4. *EEPROM Update (Adjustment)* on page 12
5. *Reverification* on page 12

Note You must complete the full-bridge calibration procedure before calibrating the half- and quarter-bridges because their procedures require a calibrated gain error.

Initial Setup

Complete the following steps to set up the FieldDAQ device.

1. Install the software and NI-DAQmx driver as outlined in the *FD-11637 Quick Start*.

   Note You must install NI-DAQmx 18.5 or later for device calibration support.

2. Set up the FieldDAQ device as outlined in the *FD-11637 Quick Start*.
3. Configure the FieldDAQ device in Measurement & Automation Explorer (NI MAX) as outlined in the *FD-11637 Quick Start*.
4. If the FieldDAQ device is not reserved automatically, select the device and click the **Reserve Network Device** button. Refer to *Reserving the Device in MAX* for more information.

   Note A network connection must be maintained with the DUT for the full duration of the procedure.

5. Self-test your device in MAX by expanding **Devices and Interfaces** »**Network Devices** , right-clicking your FieldDAQ device, and selecting **Self-Test**. Self-test performs a brief test to determine successful device installation. When the self-test finishes, a message indicates successful verification or if an error occurred. If an error occurs, refer to *ni.com/support/daqmx*.

Reserving the Device in MAX

When the FieldDAQ device is connected to a network, multiple users can access the device. To perform any DAQ functionality on the device, including reset and self-test, you must reserve the device in MAX. In MAX, an unreserved device or device reserved by another host appears with an X and a reserved device appears as dark grey. Only one user at a time can reserve the FieldDAQ device.

If the device was not reserved automatically after it was added (**Add Device**), you can reserve the device in MAX by expanding **Devices and Interfaces**»**Network Devices**, selecting the device, and clicking the **Reserve Network Device** button. The Override Reservation dialog box opens when you attempt to explicitly reserve a device. Agreeing to override the reservation forces the FieldDAQ device to be reserved by the current user.

Full-Bridge and Half-Bridge Verification

The FD-11637 has eight independent input channels, each of which can measure full- and half-bridge inputs with excitation voltages of 3 V, 5 V and 10 V.

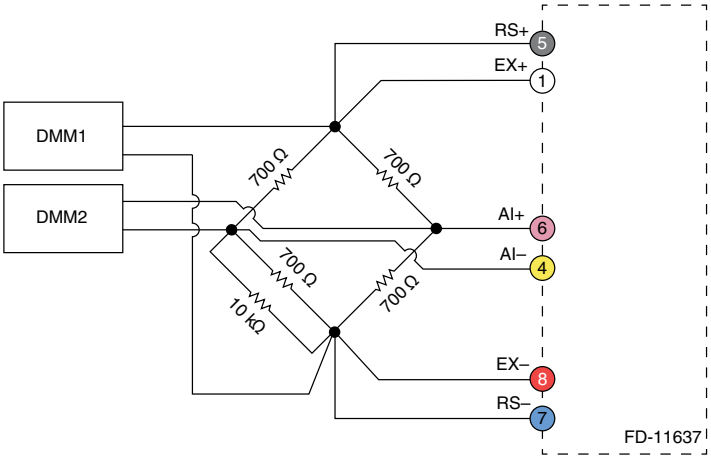
- **Full-bridge**—First applies a full-bridge input that presents an imbalance of approximately half of full-scale to the channel. The channel is configured to excite the bridge, and the actual imbalance is measured by both the FD-11637 and two DMMs. The FD-11637 then internally switches to a zero-imbalance input and makes an additional measurement. Gain (slope) and offset errors are calculated from these measurements. This is repeated for all three excitation voltages.
- **Half-bridge**—Applies a balanced half-bridge input that presents a signal of approximately zero-scale to the channel. The channel is configured to excite the bridge, and the actual imbalance is measured by both the FD-11637 and two DMMs. Offset error is calculated from these measurements. This is repeated for all three excitation voltages.

Note You must complete the full-bridge calibration procedure before calibrating the half- and quarter-bridges because their procedures require a calibrated gain error.

Complete the following procedure to determine the As-Found status of the FD-11637 full- and half-bridge accuracy.

1. Connect a resistor network to the FD-11637 and two DMMs to the channel to be calibrated on the FD-11637, as shown in the following figure. This set of resistances should nominally provide a reading of approximately +16.9 mV/V.

Figure 1. Full-Bridge Connections



Observe the following conditions when connecting the equipment to the FD-11637:

- Connect the leads of the DMM1 either at the "star configuration" points as shown *or* on the RS+ and RS- leads connected to this connection point.
- Connect the leads of the DMM2 either at the "star configuration" points as shown *or* on the AI+ and AI- leads connected to this connection point.
- Ensure that the lead wire resistance from the EX+ pin to the bridge network of resistors is matched to within 0.1 Ω of the resistance from the EX- pin to the bridge network.
- Ensure that a single point in the test system (preferably EX+) is connected to ground to prevent the entire system from floating. The analog inputs on the FD-11637 are not grounded (floating).

2. Call the DAQmx Initialize External Calibration function to start a calibration session on the FieldDAQ device for Bank 1. The default password is NI.

Note Throughout the procedure, two calibration sessions will be open (one for Bank 1 and one for Bank 2). These should remain open until the verification procedure is complete and both banks are ready to commit the adjustment values.

3. Call the DAQmx Set Temperature FieldDAQ Calibration function to input the external temperature in degrees Celsius.
4. Call and configure the DAQmx Setup 11637 Calibration function for 3 V excitation and Full Bridge configuration.

Table 3. Setup Configuration for Full-Bridge Mode

Physical Channel	Bridge Configuration	Voltage Excitation Value
FD-11637-Bank*x*/AI*x*	Full Bridge	3

5. Configure DMM1 for a voltage measurement in the 10 V range.

6. Enable autozero on DMM1.
7. Configure DMM2 for a voltage measurement in the 1 V range.
8. Enable autozero on DMM2.
9. Wait a sufficient amount of time for the bridge resistors' self-heating to stabilize. The required time depends on the resistive temperature coefficient and thermal time constant of the resistors being used.
10. Measure the actual input signal that the full bridge applies to the FD-11637 with the two DMMs. Measure the voltage between AI+ and AI-, and the voltage between RS+ and RS-. Perform the DMM measurements as close to simultaneously as possible in order to reduce error from drift in the resistors.
    – Record the DMM1 measurements as V_{DMM1}.
    – Record the DMM2 measurements as V_{DMM2}.
11. Perform the following calculation using the two DMM measurements to find the actual full-bridge input:

$$Ratio_{ref} = \frac{V_{DMM2}}{V_{DMM1}}$$

12. Call the DAQmx Adjust 11637 Calibration function.

Table 4. Adjustment Configuration for Full-Bridge Mode

Physical Channel	Reference Value
FD-11637-Bank*x*/AI*x*	Reference value ($Ratio_{ref}$) from step 11

DAQmx Adjust 11637 Calibration outputs the following:
- **As-found Gain Error**—Compare to limits in the following table
- **As-found Offset Error**—Compare to limits in the following table
- **Actual Reading** (the measurement taken from the FD-11637 of the reference input)—The expected reading from a perfectly adjusted FD-11637 is the same as the reference value ($Ratio_{ref}$) from step 11

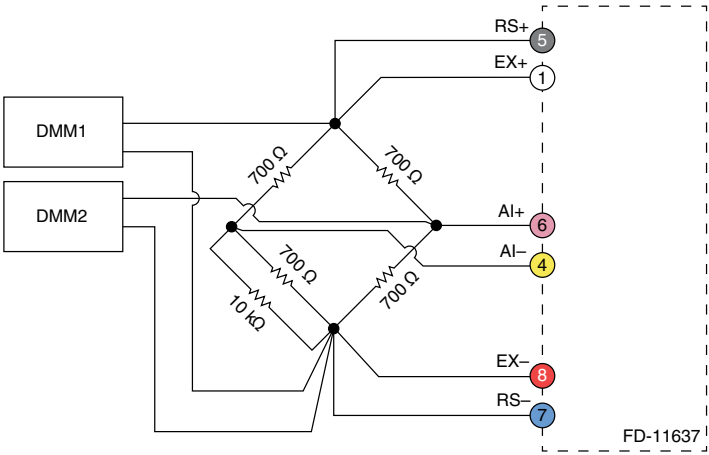
Table 5. Full-Bridge Test Limits

Excitation	Offset Error		Gain Error	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
3 V	-12 µV/V	+12 µV/V	-0.15%	+0.15%
5 V	-8 µV/V	+8 µV/V	-0.15%	+0.15%
10 V	-6 µV/V	+6 µV/V	-0.15%	+0.15%

13. Compare the outputs from step 12 to the limits in Table 5.
14. Repeat steps 4 through 13 for each excitation value specified in Table 5.
15. Repeat steps 4 through 14 for Channels 1 through 3 on Bank 1. Keep the calibration session open.

16. Repeat steps 2 through 15 for Bank 2, opening a new session for Bank 2. Keep the calibration session open.
17. Change the negative connection of DMM2 from AI- to the EX- and RS- connection point for half-bridge verification, as shown in following figure. This set of resistances should nominally provide a balanced input on the AI+ in half-bridge mode.

Figure 2. Half-Bridge Connections



Observe the following conditions when connecting the equipment to the FD-11637:

- Connect the leads of the DMM1 either at the “star configuration” points as shown *or* on the RS+ and RS- leads connected to this connection point.
- Connect the leads of the DMM2 either at the “star configuration” points as shown *or* on the AI+ and RS- leads connected to this connection point.
- Ensure that the lead wire resistance from the EX+ pin to the bridge network of resistors is matched to within 0.1 Ω of the resistance from the EX- pin to the bridge network.
- Ensure that a single point in the test system (preferably EX+) is connected to ground to prevent the entire system from floating because the analog inputs on the FD-11637 are not grounded (floating).

18. Configure both DMM1 and DMM2 for a voltage measurement in the 10 V range.
19. Enable autozero on both DMM1 and DMM2.
20. Call and configure the DAQmx Setup 11637 Calibration function for 3 V excitation and Half Bridge configuration.

Table 6. Setup Configuration for Full-Bridge Mode

Physical Channel	Bridge Configuration	Voltage Excitation Value
FD-11637-Bank*x*/AI*x*	Half Bridge	3

21. Measure the actual input signal that the half bridge applies to the FD-11637 with the two DMMs. Measure the voltage between AI+ and RS-with DMM2, and the voltage between

RS+ and RS- with DMM1. Perform the DMM measurements as close to simultaneously as possible in order to reduce error from drift in the resistors.

– Record the DMM1 measurements as V_{DMM1}.
– Record the DMM2 measurements as V_{DMM2}.

22. Perform the following calculation using the two DMM measurements to find the actual half-bridge input:

$$Ratio_{ref} = \frac{V_{DMM2}}{V_{DMM1}}$$

23. Call the DAQmx Adjust 11637 Calibration function.

Table 7. Adjustment Configuration for Half-Bridge Mode

Physical Channel	Reference Value
FD-11637-Bank*x*/AI*x*	Reference value (*$Ratio_{ref}$*) from step 22

DAQmx Adjust 11637 Calibration outputs the following:

– **As-found Gain Error**—The value from the full-bridge verification
– **As-found Offset Error**—Compare to limits in the following table
– **Actual Reading** (the measurement taken from the FD-11637 of the reference input)—The expected reading from a perfectly adjusted FD-11637:
Ideal Actual Reading = *$Ratio_{ref}$* – 0.5

Table 8. Half-Bridge Test Limits

Excitation	Offset Error	
	Lower Limit	Upper Limit
3 V	-1200 µV/V	+1200 µV/V
5 V	-1200 µV/V	+1200 µV/V
10 V	-1200 µV/V	+1200 µV/V

24. Compare the outputs from step 23 to the limits in Table 8.
25. Repeat steps 18 through 24 for each excitation value specified in Table 8.
26. Repeat steps 18 through 25 for each channel on Bank 1.
27. Repeat steps 18 through 25 for Bank 2.

28. Disconnect the DMMs and resistors from the FD-11637.
29. Do one of the following before ending the session:
    - **Complete quarter-bridge verification and adjustment of all bridges in the same task** (NI recommended)—Move to *Quarter-Bridge Verification* before ending the session.
    - **Correct only the as-found gain and offset errors for full- and half-bridges in the same task**—Move to *EEPROM Update (Adjustment)* (skipping quarter-bridge verification) before ending the session.
    - **Verify full- and half-bridges only with no adjustment**—Call the DAQmx Close External Calibration function to end the session. Set the Action input to Cancel.

Quarter-Bridge Verification

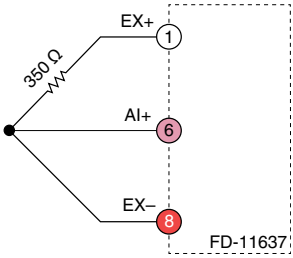
The FD-11637 has eight independent input channels, each of which can measure quarter-bridge inputs of 120 Ω and 350 Ω with excitation voltages of 3 V and 5 V. The quarter-bridge calibration procedure applies a quarter-bridge input of both precisely known and approximate resistance (120 Ω and 350 Ω) to the input. This is repeated for both excitation voltages.

Note *Full-Bridge and Half-Bridge Verification* must be completed before calibrating the quarter-bridge because this procedure requires a calibrated gain error.

Complete the following procedure to determine the As-Found status the FD-11637 quarter-bridge accuracy.

1. Connect a 350 Ω resistor to the FD-11637 as shown in the following figure.

Figure 3. Quarter-Bridge Connections (350 Ω)



Observe the following conditions when connecting the equipment to the FD-11637:

- Ensure that the wiring between the resistor and the FD-11637 terminals are short enough to have less than 0.1 Ω of resistance each, and that the wiring to the EX+ and EX- terminals are matched to within ±5 mΩ.
- Ensure that a single point in the test system (preferably EX+) is connected to ground to prevent the entire system from floating because the analog inputs on the FD-11637 are not grounded (floating).

2. Call and configure the DAQmx Setup 11637 Calibration function for 3 V excitation.

Table 9. Setup Configuration for Quarter-Bridge Mode (350 Ω)

Physical Channel	Bridge Configuration	Voltage Excitation Value
FD-11637-Bank*x*/AI*x*	Quarter Bridge 350 Ohm Completion Resistor	3

3. Call the DAQmx Adjust 11637 Calibration function.

Table 10. Adjustment Configuration for Quarter-Bridge Mode

Physical Channel	Reference Value
FD-11637-Bank*x*/AI*x*	Exact value of the resistor ($Resistance_{Actual}$)

DAQmx Adjust 11637 Calibration outputs the following:

- **As-found Gain Error**—The value from the full-bridge verification
- **As-found Offset Error**—Compare to limits in the following table
- **Actual Reading** (the measurement taken from the FD-11637 of the quarter-bridge input)—The expected reading from a perfectly adjusted FD-11637:

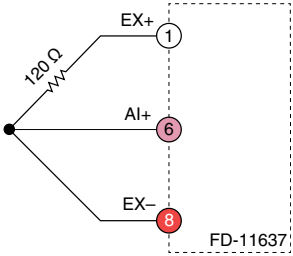
$$IdealActualReading = 0.5 \times \frac{350\Omega - Resistance_{Actual}}{350\Omega + Resistance_{Actual}}$$

Table 11. Quarter-Bridge Test Limits

Excitation	Quarter Bridge Mode	Offset Error	
		Lower Limit	Upper Limit
3 V	350 Ω	-175 µV/V	+175 µV/V
5 V		-175 µV/V	+175 µV/V
3 V	120 Ω	-230 µV/V	+230 µV/V
5 V		-230 µV/V	+230 µV/V

4. Compare the outputs from step 3 to the limits in Table 11.
5. Repeat steps 2 through 4 for the 5 V excitation value.
6. Repeat steps 2 through 5 for each channel on Bank 1.
7. Repeat steps 2 through 5 for each channel on Bank 2.
8. Disconnect the resistor from the FD-11637.
9. Connect a 120 Ω resistor to the FD-11637 as shown in the following figure.

Figure 4. Quarter-Bridge Connections (120 Ω)



Observe the following conditions when connecting the equipment to the FD-11637:

- Ensure that the wiring between the resistor and the FD-11637 terminals are short enough to have less than 0.1 Ω of resistance each, and that the wiring to the EX+ and EX- terminals are matched to within ±5 mΩ.
- Ensure that a single point in the test system (preferably EX+) is connected to ground to prevent the entire system from floating because the analog inputs on the FD-11637 are not grounded (floating).

10. Repeat steps 2 through 5 to calibrate the 120 Ω quarter-bridge mode. The Bridge Configuration input in Table 9 is Quarter Bridge 120 Ohm Completion Resistor.
11. Repeat step 10 for each channel on Bank 1.
12. Repeat step 10 for each channel on Bank 2.
13. Disconnect the resistor from the FD-11637.
14. Do one of the following before ending the session:
    - **Complete adjustment of all verified bridges in the same task** (NI recommended)—Move to *EEPROM Update (Adjustment)* before ending the session.
    - **Verify only with no adjustment**—Call the DAQmx Close External Calibration function to end the session. Set the Action input to Cancel.

EEPROM Update (Adjustment)

Update the FieldDAQ device internal calibration memory (EEPROM) with the new calibration constants for full-, half-, and quarter-bridge modes.

1. Call the DAQmx Close External Calibration function to end the session.
2. Set the Action input to Commit to override the As-Found status.

Reverification

After the *EEPROM Update (Adjustment)*, you may repeat the full-, half- and quarter-bridge verification to determine the As-Left status of the FD-11637. To verify the calibration:

1. Repeat all the steps of *Full-Bridge and Half-Bridge Verification* and *Quarter-Bridge Verification*.
2. Compare the gain and offset errors against the following table. If a verification is performed immediately after a calibration and adjustment and uses the same input signals and test equipment, then the reported gain and offset errors should be within the ranges listed in the following table.

Table 12. Acceptable Reverification Gain and Offset Error Ranges

Error	Full-Bridge	Half-Bridge	Quarter-Bridge	
			350 Ω	120 Ω
Gain Error	±0.002 %	—	—	—
Offset Error	±0.2 µV/V	±3.8 µV/V	±1.0 µV/V	±1.5 µV/V

3. Call the DAQmx Close External Calibration function to end the session.
4. Set the Action input to Cancel.

Note If any test fails reverification after performing an adjustment, verify that you have met the test conditions before returning your device to NI. Refer to *NI Services* for assistance in returning the device to NI.

Signal Connector Pinout

Figure 5. FD-11637 Pinout

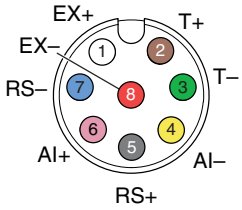


Table 13. Signal Descriptions

Pin Number	Wire Color*	Signal	Description
1	White	EX+	Positive sensor excitation
2	Brown	T+	TEDS data
3	Green	T-	TEDS return
4	Yellow	AI-	Negative analog input signal
5	Gray	RS+	Positive remote sense
6	Pink	AI+	Positive analog input signal
7	Blue	RS-	Negative remote sense

Table 13. Signal Descriptions (Continued)

Pin Number	Wire Color*	Signal	Description
8	Red	EX-	Negative sensor excitation
* Wire color pertains to SHM128M I/O cables sold through NI. Other manufacturers' cable wire colors may vary.			

Revision History

Table 14. Revision History for the *FD-11637 Calibration Procedure*

Revision	Affected Section	Change(s)
377482A-01 (April 2021)	—	This is the initial release of the *FD-11637 Calibration Procedure*.

NI Services

Visit *ni.com/support* to find support resources including documentation, downloads, and troubleshooting and application development self-help such as tutorials and examples.

Visit *ni.com/services* to learn about NI service offerings such as calibration options, repair, and replacement.

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

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