Calibration Procedure

TS-15100

October 2022

378821A-01

ni.com

TS-15100 Calibration Procedure

This document contains the verification and adjustment procedures for the TS-15100. Use the procedures in this document to automate calibration or to conduct manual calibration. Review and become familiar with the entire procedure before beginning the calibration process.

Contents

Terms and Definitions

DUT	DUT is an acronym for Device Under Test and refers to the NI product being calibrated. For this procedure, DUT refers to the TS-15100.
As-Found Limits	These limits are derived from the published specifications for the DUT. NI uses these limits to determine if the DUT is performing within the recommended calibration interval specifications at the time of calibration and before any adjustment is performed.
As-Left Limits	These limits are derived from the published specifications for the DUT minus guardband to ensure a high probability that the DUT will meet its specifications over the next recommended calibration interval.
Functional Test	Functional Tests determine whether the DUT is operating correctly. Functional tests are not directly related to performance specifications.
Verification	Verification evaluates the measured calibration results against the defined As-Found Limits. The result of the evaluation is expressed as a Pass/Fail condition in the calibration certificate using an established evaluation formula.
Adjustment	Adjustment performs a set of operations on the DUT to optimize the measurement performance and conform it to the assigned calibrated values.
Reverification	Reverification evaluates the measured calibration results against the As-Left limits after adjustment. The As-Left limits may be tighter than the As-Found limits.
Recommended Calibration Interval	This interval indicates the recommended period between each round of verification and adjustment of the DUT. There is a high probability that, within this interval, the DUT will remain within the published warranted performance specifications. Some measurement DUTs have warranted specifications for different calibration intervals, for example: 24 hours, 90 days, 1 year, and 2 years. In this case, the specification depends on the calibration cycle chosen by the user.

Calibration Overview

Recommended Calibration Interval
2 years

Password
NI

Note
This is the default password for all password-protected operations. This password is site-specific.

Task	Estimated Test Time	Operator Connections	Test Points
Setup	10 minutes		—
Warm Up	10 minutes	—	—
Performance Check	20 minutes	64	32
Verify, Adjust, and Reverify	11 minutes	8	25
Verify Only	5 minutes	8	12
Adjust Only	1 minutes	8	1

Note
Estimated test times assume the user is conducting a manual calibration. For most procedures, automating the calibration significantly reduces test times.

Environmental Conditions	Verification	Adjustment
Ambient temperature	23°C ± 5 °C	23 °C ± 1 °C
Relative humidity	Below 80%, noncondensing	

Calibration Condition Guidelines

- Keep cabling as short as possible. Long cables act as antennas, picking up extra noise that can affect measurements.
- Ensure that all connections to the DUT are secure.
- Allow adequate warm up time for all components of the calibration system.
- Make all connections as shown in diagrams.
- Use shielded copper wire for all cable connections to the DUT.
- Use twisted-pair wires to eliminate noise and thermal offsets.
- If a DUT fails reverification after adjustment, ensure that the Test Conditions have been met before returning the DUT to NI.

Calibration Resources

Required Software

Note
Ensure that the most recent version of the required driver software is installed before conducting the calibration.

Install the following software on the calibration system:

- NI-DAQmx
- Supported application development environment (ADE) — LabVIEW or LabWindows™/CVI™
- Supported operating system — Windows

Recommended Documentation

Go to ni.com/docs to locate the following documentation for more information when performing this calibration:

- TS-15100 Feature Guide
- NI-DAQmx Readme
- NI-DAQmx Help
- LabVIEW Help
- NI-DAQmx C Reference Help
- NI-DAQmx .NET Help Support for Visual Studio

Test Equipment

This section details the equipment NI recommends for each test performed as part of this calibration procedure.

NI Calibration Executive Users
Refer to the Calibration Executive Help to find an updated list of test equipment for this calibration procedure.

Standard	Recommended Model	Where Used	Functional Requirement(s)
Calibrator	Fluke 5730A	All Tests	DC Voltage Output Voltage Range: up to 10 V
TestScale Backplane and Core Module Calibration Kit	NI 788650-02	All Tests	
37-Pin DSUB Terminal Block	NI-9923	All Tests	
37-Pin DSUB to 37-Pin DSUB cable	778621-01	All Tests	
Banana Plugs (x2)	Multicomp Pro PE000038 (Red) Multicomp Pro PE000037 (Black)	All Tests	
Twisted-pair wire			

Warm Up the DUT

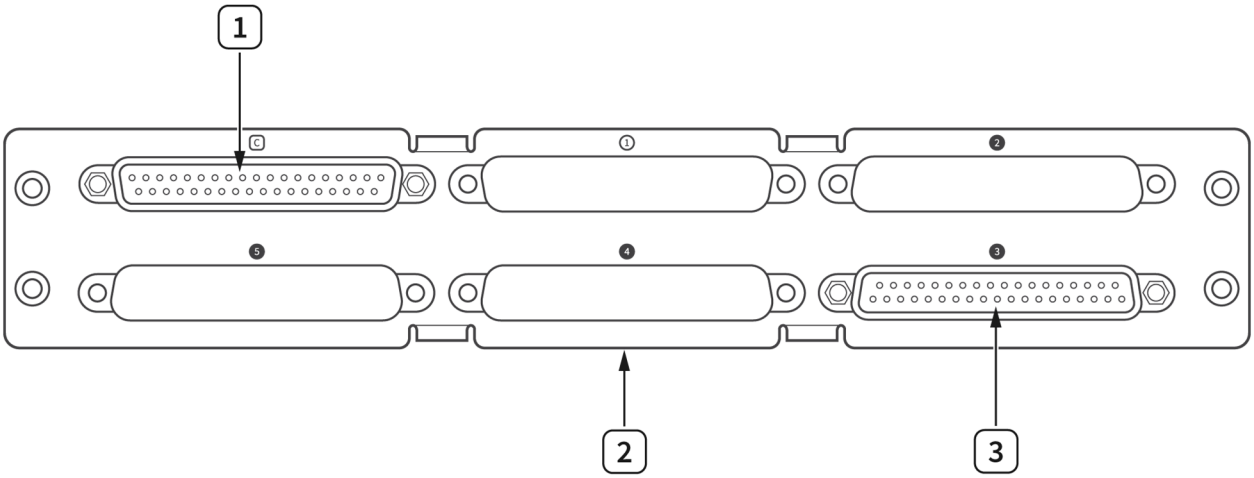
Warm up time starts after the installed DUT is powered on in the chassis. Warm up time resets after the DUT is removed from the chassis. This DUT requires 10 minutes to warm up prior to conducting any tests.

Note
Observe adequate warm up time for all components of the calibration system.

Initial Setup

Note
The core module (TS-15050) will be installed in slot labeled “C”. Ensure that the DUT is installed in slot 3 of the TS-15000/15010.

Figure 1. Initial Setup



1. TS-15050 (Core Module)
2. TS-15000/15010 Backplane
3. DUT

Perform Self-Calibration

Self-calibration should be performed after the DUT has warmed up for the recommended time period. This function measures the onboard reference voltage of the DUT and adjusts the self-calibration constants to account for any errors caused by short-term fluctuations in the environment.

Complete the following steps to conduct self-calibration using Measurement & Automation Explorer (MAX).

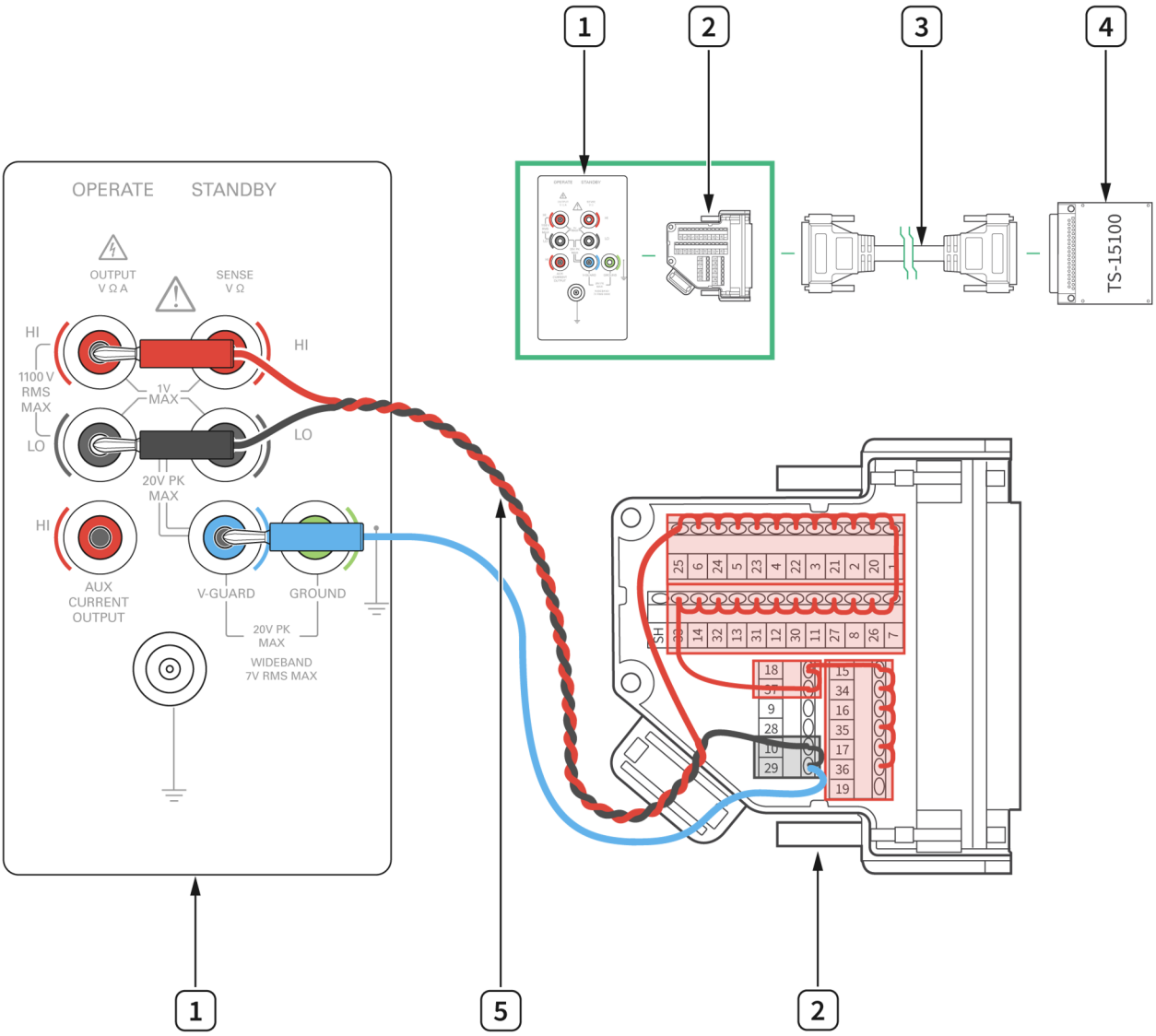
Note
Disconnect all external signals before beginning self-calibration.

1. Launch MAX.
2. Select **My System»Devices and Interfaces»<TS-15000 *or* TS-15010>“TSx”»NI TS-15100 “TSxMod3”**.
3. Start self-calibration using one of the following methods:
4. Click **Self-Calibrate** in the upper right corner of MAX.
5. Right-click the name of the DUT in the MAX configuration tree and select **Self-Calibrate** from the drop-down menu.

Optional Functional Check

The purpose of the functional check is to verify that all channels are working properly. This procedure does not verify the accuracy of each channel, only the functionality.

Figure 2. Initial Connection for this Test



1. Calibrator
2. NI-9923
3. 37-Pin DSUB to 37-Pin DSUB Cable
4. TS-15100
5. Twisted-Pair Wire

Repeat 32 times, once for each channel.

1. Connect the channel under test to the calibrator as shown in **Figure 3**.
2. Configure the calibrator to output 5 V, with GND engaged.
3. Create and configure an AI voltage task on the DUT as shown in **Table 1**.

Table 1: AI Voltage Channel Configuration

Parameter	Value
Physical channels	*TSxMod3/aix*
Terminal Configuration	Differential
Scaled Units	Volts
Input Range	5 V

4. Configure the timing properties for the voltage acquisition as shown in **Table 2**.

Table 2: AI Voltage Channel Timing Configuration

Parameter	Value
Rate	100000
Samples per Channel	10000
Sample Mode	Finite Samples

5. Start the task.
6. Acquire readings with the DUT as shown in **Table 3**.

Table 3: AI Voltage Channel Read Configuration

Parameter	Value
Number of Samples per Channel	-1
Timeout	10.0

7. Stop and clear the task. If the channel is not functioning properly, return the DUT to NI for repair.

Perform Verification

AI Voltage Verification

Test Limits

Note
The limits in **Table 4** are derived using the values in **Table 9** and **Table 10** using the following equation:

$$Accuracy = Gain\ Error * Reading + Offset\ Error + INL * Range + (Noise * 3)/\sqrt{Number\ of\ Samples}$$

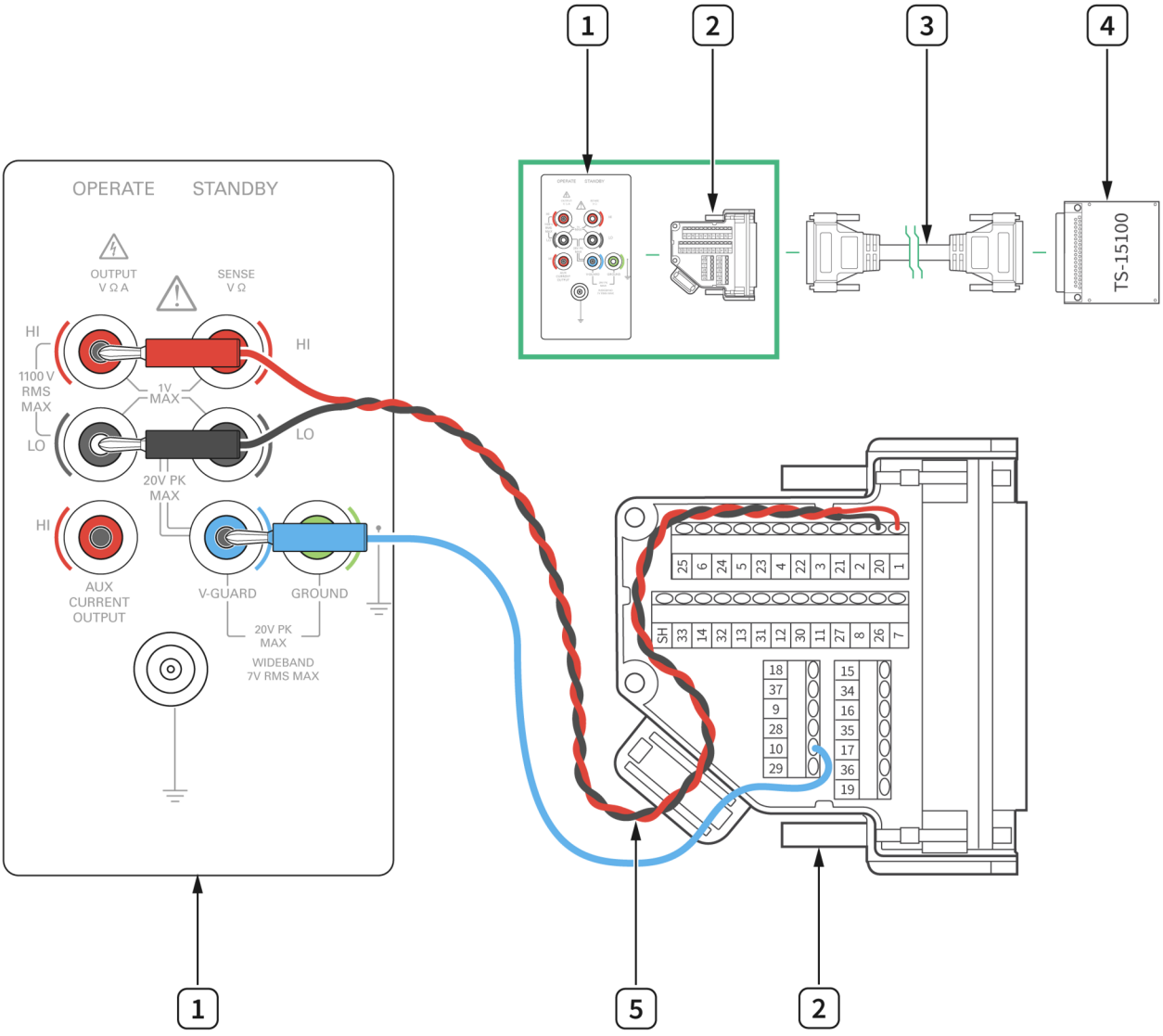
Table 4: AI Voltage Verification Limits

Range	Test Point (V)	As-Found Test Limit		As-Left Test Limit	
		Lower Limit (V)	Upper Limit (V)	Lower Limit (V)	Upper Limit (V)
±10	9.980000	9.971420	9.988580	9.976335	9.983665
±10	0.000000	-0.005127	0.005127	-0.002667	0.002667
±10	-9.980000	-9.988580	-9.971420	-9.983665	-9.976335
±5	4.990000	4.985560	4.994440	4.988017	4.991983
±5	0.000000	-0.002614	0.002614	-0.001384	0.001384
±5	-4.990000	-4.994440	-4.985560	-4.991983	-4.988017
±1	0.998000	0.997038	0.998962	0.997533	0.998467
±1	0.000000	-0.000577	0.000577	-0.000327	0.000327
±1	-0.998000	-0.998962	-0.997038	-0.998467	-0.997533
±0.2	0.199600	0.199335	0.199865	0.199434	0.199766
±0.2	0.000000	-0.000176	0.000176	-0.000126	0.000126
±0.2	-0.199600	-0.199865	-0.199335	-0.199766	-0.199434

Initial Test Connection

Note
Connect the positive output of the calibrator to AI 0 (pin 1) and connect the negative output of the calibrator to AI 8 (pin 20) and COM (pin 10). If the calibrator has a guard connection, connect that terminal to COM instead of connecting COM to the negative output. For the connection, solder each end of the twisted-pair wires to their respective banana plugs; and on the other end, insert each wire from the twisted-pair to the screw terminal on the NI-9923.

Figure 3. Initial Connection for this Test



1. Calibrator
2. NI-9923
3. 37-Pin DSUB to 37-Pin DSUB Cable
4. TS-15100
5. Twisted-Pair Wire

Verification Procedure

Complete the following procedure to verify the AI accuracy.

1. Connect the AI 0 channel to the calibrator as shown in **Figure 3**.

Repeat 12 times, once for each test point.

2. Configure the calibrator to output the Test Point value from **Table 4**, with GND engaged.

3. Create and configure an AI voltage task on the DUT as shown in **Table 5**.

Table 5: AI Voltage Channel Configuration

Parameter	Value
Physical channels	*TSxMod3/ai0*
Terminal Configuration	Differential
Scaled Units	Volts
Input Range	Range from **Table 4**

5. Configure the timing properties for the voltage acquisition as shown in **Table 6**.

Table 6: AI Voltage Channel Timing Configuration

Parameter	Value
Rate	100000
Samples per Channel	10000
Sample Mode	Finite Samples

6. Start the task.

7. Acquire readings with the DUT as shown in **Table 7**.

Table 7: AI Voltage Channel Read Configuration

Parameter	Value
Number of Samples per Channel	-1
Timeout	10.0

8. Stop and clear the task.

9. Set the calibrator to Standby mode (STBY).

Perform Adjustment

AI Voltage Adjustment

Perform an adjustment at least once within the calibration interval. Adjustment automatically updates the calibration constants, the date, and the temperature in the DUT EEPROM. If the DUT passes the verification procedures within the As-Left test limits, an adjustment is not required. Proceed to the *Update the Onboard Calibration Information* section.

Note
Initial test connection is the same as the connection for AI Voltage Verification, as shown in **Figure 3**.

Adjustment Procedure

1. Open a calibration session.
   - Call DAQmxInitExtCal to initialize the adjustment.
2. Configure the calibrator to output 4 V. Set the calibrator to operate (OPR).
3. Perform an external adjustment using DAQmxTSSeriesCalAdjust, as shown in **Table 8**.

Table 8: Adjustment Configuration

Parameter	Value
Reference Value	4.0
Model Number	15100

4. Save the adjustment to the EEPROM using DAQmxCloseExtCal by choosing the “commit” action. This function also saves the date, time, and temperature of the adjustment to the onboard memory.
5. Set the calibrator to Standby (STBY) and disconnect the DUT.

Perform Reverification

Perform all tests in the Verification section after completing Adjustment. This verification compares the As-Left limits with measurement data collected after the DUT adjustment. The As-Left limits are tighter than the As-Found limits.

Update the Onboard Calibration Information

When the adjustment procedure is completed, the DUT internal calibration memory (EEPROM) is immediately updated.

If an adjustment is not needed, update the calibration date and onboard calibration temperature without making any adjustments by initializing an external calibration session, setting the calibration temperature, and closing the external calibration session.

Accuracy Under Calibration Conditions

The following accuracy tables are valid for calibration under the following conditions:

- Ambient temperature 23°C ± 5 °C
- DUT installed in slot 3 of the TS-15000/15010 backplane
- Slots 1, 2, 4, and 5 are empty

Note

The test limits in **Table 4** are derived using the values in **Table 9** and **Table 10** using the following equation:

$$Accuracy = Gain\ Error * Reading + Offset\ Error + INL * Range + (Noise * 3)/\sqrt{Number\ of\ Samples}$$

Table 9: TS-15100 Accuracy Under Calibration Conditions

Range	As-Found		As-Left	
	Gain Error (%)	Offset Error (mV)	Gain Error (%)	Offset Error (mV)
±10	0.0346	4.36	0.0100	1.90
±5	0.0366	2.23	0.0120	1.00
±1	0.0486	0.50	0.0140	0.25
±0.2	0.0446	0.16	0.0200	0.11

Table 10: Additional Accuracy Information

Range	Noise (µV RMS)	INL (ppm)
10V	240	76
5V	130	76
1V	30	76
0.2V	20	76

Revision History

Revision	Section	Changes
378821A-01 October 2022	—	This is the initial release version of the TS-15100 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.

NI corporate headquarters is located at 11500 N Mopac Expwy, Austin, TX 78759-3504, USA.

378821A-01 October 2022