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NI 6110/6111/6115/6120 Calibration Procedure

This document describes the procedure for verifying and adjusting a National Instruments 6110/6111/6115/6120 data acquisition (DAQ) device. This document contains four main sections:

- *Introduction*—This section tells you what calibration is, why you should calibrate devices, and how often you should calibrate.
- *Equipment and Other Test Requirements*—This section describes what you must do before calibrating the device, including an overview of the test equipment, software, calibration functions, and environment needed for calibration.
- *Calibration Process*—This section provides step-by-step instructions for verifying and calibrating your device.
- *NI 6110/6111/6115/6120 Specifications*—This section provides specification tables for the NI 6110/6111/6115/6120.

This document is intended for metrology labs. It does not cover programming technique or compiler configuration because of the number of programming languages and styles you can use to calibrate the device. However, NI-DAQ has many online help files that contain compiler-specific instructions and function explanations. You can install these help files when you install NI-DAQ.

Introduction

What Is Calibration?

Calibration is a set of operations that compares the values indicated by a measuring instrument or measuring system to the corresponding values realized by external standards. The result of a calibration can be used to determine the measurement error and can correct for it in the adjustment process.

The calibration process consists of verifying, adjusting, and reverifying a device. During verification, you compare the measured performance to an

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external standard of known accuracy to confirm that the product meets or exceeds specifications. During adjustment, you correct the measurement error of the device by adjusting the calibration constants and storing the new calibration constants in the EEPROM. The host computer reads the calibration constants, and the software uses them to compensate for errors in the data and to present calibrated data to the user.

Why Should You Calibrate?

The accuracy of electronic components drifts with time and temperature, which can affect measurement accuracy. Calibration restores these components to the specified accuracy and ensures that the device still meets NI standards.

How Often Should You Calibrate?

The measurement requirements of your measurement application determine how often you should calibrate the device. NI recommends performing a complete calibration at least once every year. You can shorten this interval based on the demands of your application.

Equipment and Other Test Requirements

This section describes the equipment, software, documentation, and test conditions needed for calibration.

Equipment

When calibrating an NI 6110/6111/6115/6120, NI recommends that you use the following instruments:

- Calibrator—Fluke 5700A
- Digital Multimeter (DMM)—NI 4070
- Counter—Agilent (HP) 53131A

If these exact instruments are not available, use the following accuracy requirements to select substitute calibration standards:

- A high-precision voltage source that is at least 50 ppm accurate
- A multiranging 5 1/2-digit DMM accurate to within 15 ppm
- A counter accurate to 0.01%



Note If you do not have custom connection hardware available, you may need a connector block, such as the NI TBX-68, and a shielded 68-pin connector cable. These components give easy access to the individual pins on the 68-pin I/O connector.

Documentation and Software

The following documentation and software are required to calibrate the NI 6110/6111/6115/6120:

- The latest version of NI-DAQ. You can download this from `ni.com` by clicking **Download Software**.
- `niECal.dll`, `niECal.lib`, and `niECal.h` files, available from `ni.com/calibration` by clicking **Manual Calibration Procedures**.
- *NI-DAQ User Manual for PC Compatibles,* available from `ni.com/manuals`.

You also need the *NI-DAQ Function Reference Help*, which is installed with NI-DAQ. To access this file, go to **Start»Programs»National Instruments»NI-DAQ»NI-DAQ Help**.

Documentation

The *NI-DAQ Function Reference Help* and the *NI-DAQ User Manual for PC Compatibles* contain information on using NI-DAQ. The function reference file includes detailed information on the functions in the driver. The user manual provides instructions on installing and configuring National Instruments DAQ devices and describes how to create applications that use NI-DAQ. These documents are your primary references for writing a calibration utility. For more information on the products you are calibrating, refer to the device user manuals.

Software

NI-DAQ supports a number of programming languages, including LabVIEW, Measurement Studio, Microsoft Visual C++, Microsoft Visual Basic, and Borland C++. When you install NI-DAQ, install support for the programming language you are using.

The `niECal.dll`, `niECal.lib`, and `niECal.h` files provide calibration functions that are not provided by NI-DAQ. These functions include protecting the calibration constants and updating the calibration date. You can access the functions in this `.dll` through any 32-bit compiler.

Writing Your Calibration Procedure

The calibration process is described in the *Calibration Process* section. The description includes step-by-step instructions on calling the appropriate calibration functions. Unless otherwise specified, the calibration functions are C function calls in NI-DAQ. These function calls are also valid for Visual Basic programs. While LabVIEW virtual instruments (VIs) are not discussed, the translation from NI-DAQ function calls to LabVIEW VIs is

straightforward, as many of the VIs have the same names as the listed function calls. Refer to the *Creating Verification and Calibration Code* section for flowcharts detailing the code used at each step of the calibration procedure.

You must follow a number of compiler-specific steps to create an application using NI-DAQ. The *NI-DAQ User Manual for PC Compatibles* details the required steps for each of the supported compilers.

Many of the functions listed in the calibration procedure use variables that are defined in the `nidaqcns.h` file. To use these variables, you must include the `nidaqcns.h` file in your code. If you do not wish to use these variable definitions, you can examine the function call listings in NI-DAQ documentation and the `nidaqcns.h` file to determine what input values are required.

Test Conditions

To optimize connections and test conditions during calibration, use the following guidelines:

- Keep connections to the device as short as possible. Long cables and wires can act as antennae, picking up extra noise that can affect calibration.
- Use shielded copper wire for all cable connections to the device. Use twisted-pair wire to eliminate noise and thermal offsets.
- Maintain a temperature between 18 and 28 °C. To operate the device at a specific temperature outside this range, calibrate the module at that temperature.
- Keep relative humidity below 80%.
- Allow a warm-up time of at least 15 minutes for PXI/PCI/AT bus devices and 30 minutes for PCMCIA devices to ensure that the measurement circuitry is at a stable operating temperature.

Calibration Process

The calibration process consists of four main steps.

1. *Creating Verification and Calibration Code*
2. *Verifying the Performance of the NI 6110/6111/6115/6120*—This step determines whether the device is in specification prior to calibration.
3. *Adjusting the Device*—This step adjusts the calibration constants with respect to a known voltage source.

4. *Reverifying the Device*—This step verifies the performance of the device after adjusting, to ensure the device operates within specifications after calibration.

These steps are described in the following sections.

Creating Verification and Calibration Code

This section shows the basic flowcharts for creating the verification and adjustment code for the NI 6110/6111/6115/6120 calibration procedure. These flowcharts only refer to the appropriate NI-DAQ function calls. You may want to refer to the *Calibration Process* section, to the *NI-DAQ Function Reference Help*, and to the *NI-DAQ User Manual for PC Compatibles* for additional information on the software structure and for function explanations.

Verifying Analog Input

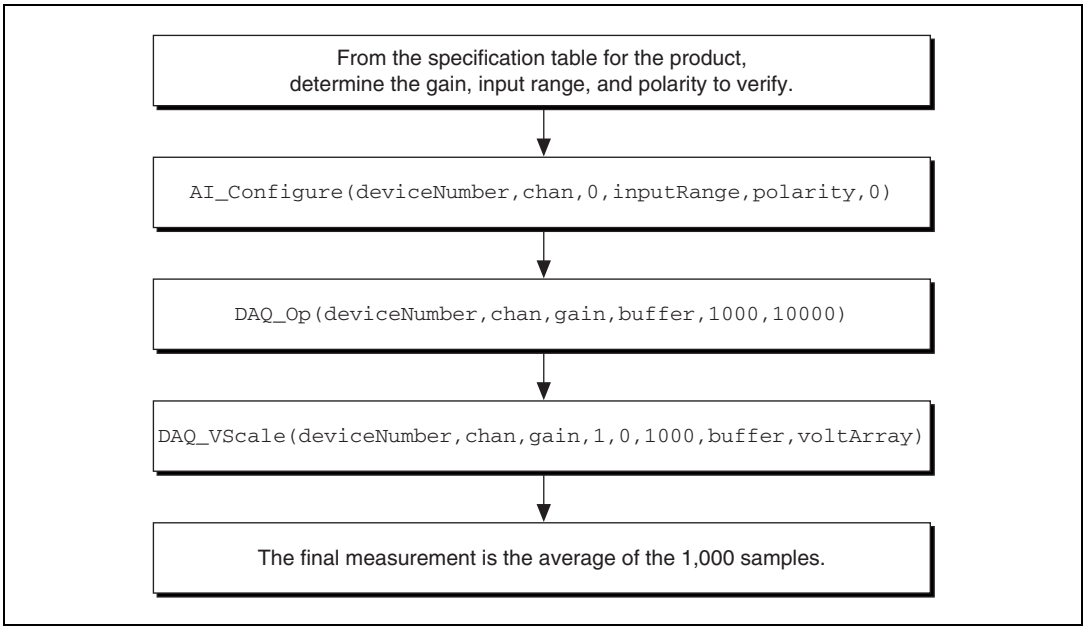


Figure 1. Analog Input Verification

Verifying Analog Output

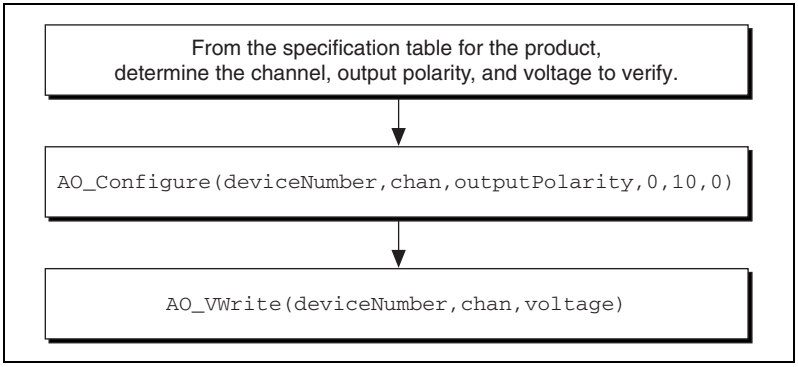


Figure 2. Analog Output Verification

Verifying the Counter

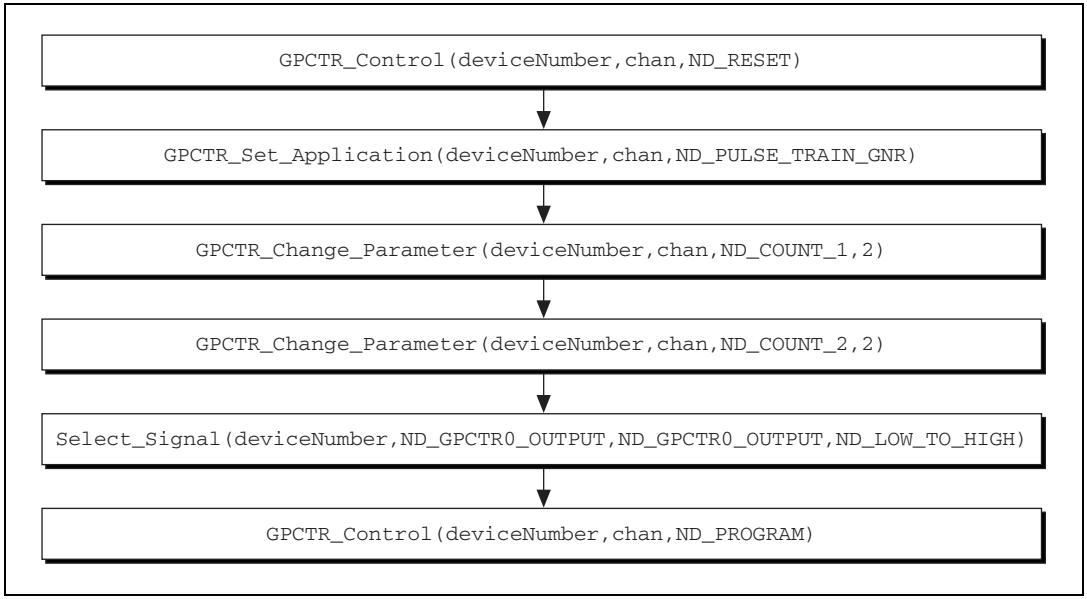


Figure 3. Counter Verification

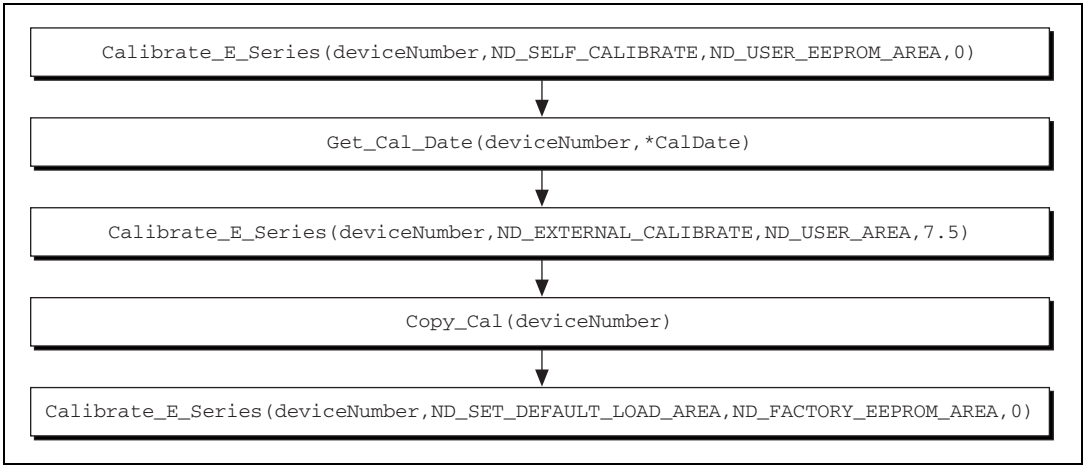


Figure 4. Device Adjustment

Configuring the Device for Calibration

Measurement & Automation Explorer (MAX) ships with NI-DAQ and automatically detects the NI 6110/6111/6115/6120. However, for NI-DAQ to communicate with the device, you must configure the device in MAX.

For information on configuring an NI 6110/6111 refer to Chapter 2, *Installing and Configuring the NI PCI-6110/6111*, of the *NI PCI-6110E/6111E User Manual*. For information on configuring an NI 6115/6120, refer to Chapter 2, *Installing and Configuring the NI 6115/6120*, of the *NI 6115/6120 User Manual.*

The following procedure describes how to configure a device with NI-DAQ.

1. Install NI-DAQ. The latest version is available at `ni.com`.
2. Power off the computer and install the device in an available slot.
3. Power on the computer and launch MAX.
4. Configure the device number and click **Test Resources** to ensure the device is working properly.

You have completed configuring the device for calibration.

Note When MAX configures a device, it assigns a device number. Each function call uses this number to identify which DAQ device to calibrate. Make note of this number so that you have it when you make function calls.

Verifying the Performance of the NI 6110/6111/6115/6120

This section describes the verification procedures for calibrating the NI 6110/6111/6115/6120. You must verify analog input, analog output, and the counter performance.

Verifying Analog Input

To verify the performance of the analog input of the device, complete the following steps:

1. Read the *Equipment and Other Test Requirements* section.

Note Calibrator connections depend on the channel you are verifying. The verification process requires you to individually test each channel.

2. Use the following guide to determine the connections between the calibrator and the device pins for analog input verification.
   a. Starting with channel 0, connect the positive output of the calibrator to the analog input specified in Table 1.

Table 1. Positive Output Connections

Device Channel	Analog Input
0	68
1	33
2	65
3	30

   b. Connect the negative output of the calibrator to the analog input specified in Table 2.

Table 2. Negative Output Connections

Device Channel	Analog Input
0	34
1	66
2	31
3	63

3. If the calibrator and computer are floating with respect to each other, connect the negative output of the calibrator to the analog input channel ground, as listed in Table 3.

Table 3. Channel Ground Connections

Channel Ground	Analog Input
ACH0GND	67
ACH1GND	32
ACH2GND	64
ACH3GND	29

4. Refer to the *NI 6110/6111/6115/6120 Specifications* section for all acceptable settings for the device. Although NI recommends that you verify all ranges, you can save time by checking only the ranges your application uses.
5. Set the calibrator voltage to the test point value indicated in Table 5 for the NI 6110/6111, Table 8 for the NI 6115, or Table 11 for the NI 6120.
6. Call `AI_Configure` to inform NI-DAQ of the input mode, input range, and input polarity selected for the device. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX
   - **chan**—The channel currently being verified
   - **inputMode**—`0`
   - **inputRange**—The range for calibration from Table 5 for the NI 6110/6111, Table 8 for the NI 6115, or Table 11 for the NI 6120
   - **polarity**—`0`
   - **driveAIS**—`0`
7. Call `DAQ_Op` to acquire 1,000 points of voltage data. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX
   - **chan**—The channel currently being verified
   - **gain**—The value specified by Table 5 for the NI 6110/6111, Table 8 for the NI 6115, or Table 11 for the NI 6120
   - **buffer**—Array of conversion samples returned
   - **count**—`1,000`
   - **sampleRate**—`20,000`

8. Call `DAQ_VScale` to convert the buffer of acquired binary values into voltage values. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX
   - **chan**—The channel currently being verified
   - **gain**—The value specified by the appropriate analog input value table
   - **gainAdjust**—`1`
   - **offset**—`0`
   - **count**—`1,000`
   - **binArray**—Binary data returned from DAQ-OP
   - **voltArray**—Double precision array of voltage values
9. Average the 1,000 voltage values. Compare the resulting average to the upper and lower limits listed in the appropriate table. If the result is between these values, the device has passed this test.
10. Repeat steps 4–9 to verify all values.
11. Make the appropriate connections to verify the next channel by repeating steps 2 and 3, and proceed from step 4.

You have completed verifying the analog input levels on the device.

Verifying Analog Output

This procedure verifies the performance of the analog output. Check measurements using the following procedure:

1. Read the *Equipment and Other Test Requirements* section.



Note The NI 6110/6111/6115/6120 has two analog outputs: DAC0OUT and DAC1OUT. This test verifies the performance of both analog output channels.

2. Connect the DMM to DAC0OUT as shown in Table 4.

Table 4. Connections to Analog Outputs

Analog Output	DMM Positive Input	DMM Negative Input
DAC0OUT	DAC0OUT (pin 22)	AOGND (pin 54)
DAC1OUT	DAC1OUT (pin 21)	AOGND (pin 55)

3. Refer to the analog output value tables in the *NI 6110/6111/6115/6120 Specifications* section. These tables show acceptable settings for the device.

4. Call the AO_Configure function to configure the device for the appropriate device number, channel, and output polarity. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX
   - **chan**—The analog output channel currently being verified
   - **outputPolarity**—0
   - **intOrExtRef**—0
   - **refVoltage**—10
   - **updateMode**—0
5. Call AO_VWrite to update the analog output channel with the appropriate voltage. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX
   - **chan**—The analog output channel currently being verified
   - **voltage**—The voltage value you are testing, as shown in Table 6 for the NI 6110/6111, Table 9 for the NI 6115, and Table 12 for the NI 6120
6. Compare the resulting value shown by the DMM to the upper and lower limits on the data sheet. If the value falls between these limits, the device has passed this test.
7. Repeat steps 4–6 to test all values.
8. Disconnect the DMM from DAC0OUT and reconnect it to DAC1OUT, making the connections as shown in Table 4.
9. Repeat steps 4–6, changing the channel from 0 to 1.
10. Disconnect the DMM from the device.

You have now completed verifying analog output levels on the device.

Verifying the Performance of the Counter

This procedure verifies the performance of the counter. The NI 6110/6111/6115/6120 has only one timebase to verify, so you only need to verify counter 0. The timebase is not user-adjustable, so you only can verify the counter performance. To verify counter performance, complete the following steps:

1. Connect the positive input of the counter to GPCTR0_OUT (pin 2) and the negative input of the counter to DGND (pin 35).
2. Call GPCTR_Control to place the counter in a default state. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX

- **gpctrNum**—0
- **action**—ND_RESET

3. Call GPCTR_Set_Application to configure the counter for pulse-train generation. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX
   - **gpctrNum**—0
   - **application**—ND_PULSE_TRAIN_GNR
4. Call GPCTR_Change_Parameter to configure the counter to output a pulse with an off time of 100 ns. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX
   - **gpctrNum**—0
   - **paramID**—ND_COUNT_1
   - **paramValue**—2
5. Call GPCTR_Change_Parameter to configure the counter to output a pulse with an on time of 100 ns. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX
   - **gpctrNum**—0
   - **paramID**—ND_COUNT_2
   - **paramValue**—2
6. Call Select_Signal to route the counter signal to the GPCTR0_OUT pin on the device connector. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX
   - **signal**—ND_GPCTR0_OUTPUT
   - **source**—ND_GPCTR0_OUTPUT
   - **sourceSpec**—ND_LOW_TO_HIGH
7. Call GPCTR_Control to start the generation of a square wave. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX
   - **gpctrNum**—0
   - **action**—ND_PROGRAM
8. The device begins to generate a 5 MHz square wave when the GPCTR_Control function completes execution. Compare the value read by the counter to the test limits in the appropriate table. If the value falls between these limits, the device has passed the test.
9. Disconnect the counter from the device.

You have now verified the counter on the device.

Adjusting the Device

Use the NI 6110/6111/6115/6120 calibration procedure to adjust the analog input and output calibration constants. At the end of each calibration procedure, these new constants are stored in the factory area of the device EEPROM. The user cannot modify these values. This limitation provides a level of security that ensures users cannot accidentally modify any calibration constants adjusted by the metrology laboratory.

This portion of the calibration process calls functions from NI-DAQ as well as functions from the `niECal.dll`. For further information on the functions in the `niECal.dll`, refer to the comments in the `niECal.h` file.

To adjust the analog inputs with a calibrator, complete the following steps:

1. Read the *Equipment and Other Test Requirements* section.
2. Connect the positive output of the calibrator to analog input channel 0+ (pin 68).
3. Connect the negative output of the calibrator to analog input channel 0– (pin 34) and to ACH0GND (pin 67).
4. Call `Get_Cal_Date` to obtain the date of the last calibration. The function is included in the `niECal.dll`. After running, CalDate contains the date that the device was last calibrated.
5. Call `Calibrate_E_Series` to internally calibrate the device. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX
   - **calOP**—`ND_SELF_CALIBRATE`
   - **setOfCalConst**—`ND_USER_EEPROM_AREA`
   - **calRefVolts**—`0`

Note It may take as long as 60 seconds to complete this function call for the NI 6110/6111/6115 and as long as five minutes for the NI 6120.

6. Set the calibrator to output a voltage of 7.50 V for the NI 6110/6111/6115 and 5.0 V for the NI 6120.
7. Call `Calibrate_E_Series`. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX
   - **calOP**—`ND_EXTERNAL_CALIBRATE`
   - **setOfCalConst**—`ND_USER_EEPROM_AREA`
   - **calRefVolts**—7.50 V for the NI 6110/6111/6115 and 5.0 V for the NI 6120

   If the voltage supplied by the source does not maintain a steady 7.50 V for the NI 6110/6111/6115 or 5.0 V for the NI 6120, you receive an

error. If the voltage source is floating with respect to the computer and you have not connected the calibrator GND to ACH0GND, you receive an error.

8. Call `Copy_Const` to enable and copy the new calibration constants to the protected factory portion of the EEPROM and to update the calibration date. This function is also included in the `niECal.dll`.
9. Call `Calibrate_E_Series` to set the factory-calibration constants as the default constants. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX
   - **calOP**—`ND_SET_DEFAULT_LOAD_AREA`
   - **setOfCalConst**—`ND_FACTORY_EEPROM_AREA`
   - **calRefVolts**—`0`
10. Disconnect the calibrator from the device.

The device is now calibrated with respect to the external source.

Reverifying the Device

After the device is calibrated, you may want to reverify the analog input and output operation. To do this, repeat the procedure in the *Verifying the Performance of the NI 6110/6111/6115/6120* section.

NI 6110/6111/6115/6120 Specifications

The tables in this section contain the specifications for the NI 6110/6111/6115/6120. The specifications include analog input, analog output, and counter/timer values. NI 6110/6111 devices share one set of tables. The NI 6115 and NI 6120 each have a set of tables.

The tables display the specifications for 1-year and 24-hour calibration intervals. The 1-year ranges display the specifications that the device should meet if it has been one year since it was calibrated, but after a device has been calibrated with an external source, the values shown in the 24-hour tables are the valid specifications.

Using the Tables

The following sections describe how to use the specification information.

Range

Range refers to the maximum allowable voltage range of an input or output signal. For example, if a device is configured in bipolar mode with a range of 20 V, the device can read signals between +10 and –10 V.

Polarity

Polarity refers to the polarity of the input signal that can be read. In bipolar configuration, the device reads both positive and negative voltages. In unipolar mode, the device reads only positive voltages.

Gain

The Gain value is applied to an input voltage prior to sending the voltage to the A/D converter, which requires a 10 V signal. The input voltage level multiplied by the gain should not exceed the voltage range of the device. For example, for a gain of two with the device configured in bipolar mode, the maximum input voltage can be 4.995 V, because
$4.995 \times 2.0 = 9.990$ V.

Note There are no gain settings for analog output because the output gain is fixed at `1`.

Test Point

The Test Point is the voltage value that you input or output to verify performance. This value is divided into two columns: Location and Value. Location refers to where the test value fits within the test range. Pos FS is positive full-scale and Neg FS is negative full-scale. Value refers to the voltage value you are verifying.

24-Hour Ranges

The 24-Hour Ranges column contains the Upper Limits and Lower Limits for the test point value. When the device is within its 24-hour calibration interval, the test point value should fall between the upper and lower limit values. Upper and lower limits are expressed in volts.

1-Year Ranges

The 1-Year Ranges column contains the Upper Limits and Lower Limits for the test point value. When the device is within its 1-year calibration interval, the test point value should fall between the upper and lower limit values. Upper and lower limits are expressed in volts.

Counters

Counter/timers are not user-adjustable. The test point and upper and lower limits are listed in Table 7, Table 10, and Table 13, for verification purposes only.

Table 5. Analog Input Values for the NI 6110/6111

Range	Polarity	Gain	Test Point		24-Hour Ranges		1-Year Ranges	
			Location	Value (V)	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)	Upper Limit (V)
±42	Bipolar	0.2	PosFS	41.5800	41.5063	41.6537	41.5056	41.6544
±42	Bipolar	0.2	Zero	0.0000	–0.0083	0.0083	–0.0083	0.0083
±42	Bipolar	0.2	NegFS	–41.5800	–41.6537	–41.5063	–41.6544	–41.5056
±20	Bipolar	0.5	PosFS	19.8000	19.7692	19.8308	19.7688	19.8312
±20	Bipolar	0.5	Zero	0.0000	–0.0033	0.0033	–0.0033	0.0033
±20	Bipolar	0.5	NegFS	–19.8000	–19.8308	–19.7692	–19.8312	–19.7688
±10	Bipolar	1	PosFS	9.9000	9.8951	9.9049	9.8950	9.9050
±10	Bipolar	1	Zero	0.0000	–0.0017	0.0017	–0.0017	0.0017
±10	Bipolar	1	NegFS	–9.9000	–9.9049	–9.8951	–9.9050	–9.8950
±5	Bipolar	2	PosFS	4.95000	4.94741	4.95259	4.94734	4.95266
±5	Bipolar	2	Zero	0.0000	–0.00083	0.00083	–0.00083	0.00083
±5	Bipolar	2	NegFS	–4.95000	–4.95259	–4.94741	–4.95266	–4.94734
±2	Bipolar	5	PosFS	1.95000	1.94888	1.95112	1.94885	1.95115
±2	Bipolar	5	Zero	0.00000	–0.00035	0.00035	–0.00035	0.00035
±2	Bipolar	5	NegFS	–1.95000	–1.95112	–1.94888	–1.95115	–1.94885
±1	Bipolar	10	PosFS	0.99000	0.98896	0.99104	0.98894	0.99106
±1	Bipolar	10	Zero	0.00000	–0.00028	0.00028	–0.00028	0.00028
±1	Bipolar	10	NegFS	–0.99000	–0.99104	–0.98896	–0.99106	–0.98894
±0.5	Bipolar	20	PosFS	0.495000	0.494312	0.495688	0.494302	0.495698
±0.5	Bipolar	20	Zero	0.000000	–0.000193	0.000193	–0.000193	0.000193
±0.5	Bipolar	20	NegFS	–0.495000	–0.495688	–0.494312	–0.495698	–0.494302
±0.2	Bipolar	50	PosFS	0.198000	0.197655	0.198345	0.197651	0.198349
±0.2	Bipolar	50	Zero	0.000000	–0.000102	0.000102	–0.000102	0.000102
±0.2	Bipolar	50	NegFS	–0.198000	–0.198345	–0.197655	–0.198349	–0.197651

Table 6. Analog Output Values for the NI 6110/6111

Range	Polarity	Test Point		24-Hour Ranges		1-Year Ranges	
		Location	Value (V)	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)	Upper Limit (V)
20	Bipolar	PosFS	9.990000	9.982299	9.997701	9.982812	9.997188
20	Bipolar	Zero	0.000000	–0.005933	0.005933	–0.001902	0.001902
20	Bipolar	NegFS	–9.990000	–9.997701	–9.982299	–9.997188	–9.982812

Table 7. Counter Values for the NI 6110/6111

Set Point (MHz)	Lower Limit (MHz)	Upper Limit (MHz)
5	4.9995	5.0005

Table 8. Analog Input Values for the NI 6115

Range	Polarity	Gain	Test Point		24-Hour Ranges		1-Year Ranges	
			Location	Value (V)	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)	Upper Limit (V)
±42	Bipolar	0.2	PosFS	41.5800	41.3995	41.7605	41.3987	41.7613
±42	Bipolar	0.2	Zero	0.0000	–0.0366	0.0366	–0.0366	0.0366
±42	Bipolar	0.2	NegFS	–41.5800	–41.7605	–41.3995	–41.7613	–41.3987
±20	Bipolar	0.5	PosFS	19.8000	19.7319	19.8681	19.7315	19.8685
±20	Bipolar	0.5	Zero	0.0000	–0.0144	0.0144	–0.0144	0.0144
±20	Bipolar	0.5	NegFS	–19.8000	–19.8681	–19.7319	–19.8685	–19.7315
±10	Bipolar	1	PosFS	9.9000	9.8900	9.9100	9.8898	9.9102
±10	Bipolar	1	Zero	0.0000	–0.0074	0.0074	–0.0074	0.0074
±10	Bipolar	1	NegFS	–9.9000	–9.9100	–9.8900	–9.9102	–9.8898
±5	Bipolar	2	PosFS	4.95000	4.94545	4.95455	4.94535	4.95465
±5	Bipolar	2	Zero	0.00000	–0.00376	0.00376	–0.00376	0.00376
±5	Bipolar	2	NegFS	–4.95000	–4.95455	–4.94545	–4.95465	–4.94535
±2	Bipolar	5	Pos FS	1.95000	1.94784	1.95216	1.94780	1.95220
±2	Bipolar	5	Zero	0.00000	–0.00146	0.00146	–0.00146	0.00146
±2	Bipolar	5	NegFS	–1.95000	–1.95216	–1.94784	–1.95220	–1.94780
±1	Bipolar	10	PosFS	0.99000	0.98880	0.99120	0.98878	0.99122
±1	Bipolar	10	Zero	0.00000	–0.00077	0.00077	–0.00077	0.00077

Table 8. Analog Input Values for the NI 6115 (Continued)

Range	Polarity	Gain	Test Point		24-Hour Ranges		1-Year Ranges	
			Location	Value (V)	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)	Upper Limit (V)
±1	Bipolar	10	NegFS	–0.99000	–0.99120	–0.98880	–0.99122	–0.98878
±0.5	Bipolar	20	PosFS	0.495000	0.494302	0.495698	0.494292	0.495708
±0.5	Bipolar	20	Zero	0.000000	–0.000411	0.000411	–0.000411	0.000411
±0.5	Bipolar	20	NegFS	–0.495000	–0.495698	–0.494302	–0.495704	–0.494292
±0.2	Bipolar	50	PosFS	0.198000	0.197607	0.198393	0.197603	0.198397
±0.2	Bipolar	50	Zero	0.000000	–0.000189	0.000189	–0.000189	0.000189
±0.2	Bipolar	50	NegFS	–0.198000	–0.198393	–0.197607	–0.198397	–0.197603

Table 9. Analog Output Values for the NI 6115

Range	Polarity	Test Point		24-Hour Ranges		1-Year Ranges	
		Location	Value (V)	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)	Upper Limit (V)
20	Bipolar	PosFS	9.990000	9.976734	10.003266	9.976565	10.003435
20	Bipolar	Zero	0.000000	–0.008900	0.008900	–0.008900	0.008900
20	Bipolar	NegFS	–9.990000	–10.003266	–9.976734	–10.003435	–9.976565

Table 10. Counter Values for the NI 6115

Counter Values	Set Point (MHz)	Lower Limit (MHz)	Upper Limit (MHz)
—	5	5.0005	4.9995

Table 11. Analog Input Values for the NI 6120

Range	Polarity	Gain	Test Point		24-Hour Ranges		1-Year Ranges	
			Location	Value (V)	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)	Upper Limit (V)
±42	Bipolar	0.20	PosFS	41.5800	41.506321	41.653679	41.505621	41.654379
±42	Bipolar	0.20	Zero	0.00000	–0.008303	0.008303	–0.008303	0.008303
±42	Bipolar	0.20	NegFS	–41.5800	–41.653679	–41.506321	–41.654379	–41.505621
±20	Bipolar	0.50	PosFS	19.8000000	19.769172	19.830828	19.768839	19.831161
±20	Bipolar	0.50	Zero	0.00000000	–0.003322	0.003322	–0.003322	0.003322

Table 11. Analog Input Values for the NI 6120 (Continued)

Range	Polarity	Gain	Test Point		24-Hour Ranges		1-Year Ranges	
			Location	Value (V)	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)	Upper Limit (V)
±20	Bipolar	0.50	NegFS	–19.800000	–19.830828	–19.769172	–19.831161	–19.768839
±10	Bipolar	1	PosFS	9.9000000	9.876131	9.923869	9.875965	9.924035
±10	Bipolar	1	Zero	0.0000000	–0.008303	0.008303	–0.008303	0.008303
±10	Bipolar	1	NegFS	–9.9000000	–9.923869	–9.876131	–9.924035	–9.875965
±5	Bipolar	2	PosFS	4.9500000	4.933914	4.966086	4.933831	4.966169
±5	Bipolar	2	Zero	0.000000	–0.008303	0.008303	–0.008303	0.008303
±5	Bipolar	2	NegFS	–4.9500000	–4.966086	–4.933914	–4.966169	–4.933831
±2	Bipolar	5	PosFS	1.950000	1.938631	1.961369	1.938598	1.961402
±2	Bipolar	5	Zero	0.000000	–0.008303	0.008303	–0.008303	0.008303
±2	Bipolar	5	NegFS	–1.950000	–1.961369	–1.938631	–1.961402	–1.938598
±1	Bipolar	10	PosFS	0.990000	0.980141	0.999859	0.980124	0.999876
±1	Bipolar	10	Zero	0.000000	–0.008303	0.008303	–0.008303	0.008303
±1	Bipolar	10	NegFS	–0.990000	–0.999859	–0.980141	–0.999876	–0.980124
±0.5	Bipolar	20	PosFS	0.4950000	0.485919	0.504081	0.485911	0.504089
±0.5	Bipolar	20	Zero	0.000000	–0.008303	0.008303	–0.008303	0.008303
±0.5	Bipolar	20	NegFS	–0.4950000	–0.504081	–0.485919	–0.504089	–0.485911
±0.2	Bipolar	50	PosFS	0.1980000	0.197655	0.198345	0.197651	0.198349
±0.2	Bipolar	50	Zero	0.000000	–0.000102	0.000102	–0.000102	0.000102
±0.2	Bipolar	50	NegFS	–0.1980000	–0.198345	–0.197655	–0.198349	–0.197651

Table 12. Analog Output Values for the NI 6120

Range	Polarity	Test Point		24-Hour Ranges		1-Year Ranges	
		Location	Value (V)	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)	Upper Limit (V)
±10	Bipolar	PosFS	9.9900000	9.982980	9.997020	9.982812	9.997188
±10	Bipolar	Zero	0.000000	–0.001902	0.001902	–0.001902	0.001902
±10	Bipolar	NegFS	–9.9900000	–9.997020	–9.982980	–9.997188	–9.982812

Table 13. Counter Values for the NI 6120

Counter Values	Set Point (MHz)	Upper Limit (MHz)	Lower Limit (MHz)
—	5	4.9995	5.0005

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