

NI 446X Calibration Procedure

This document contains information about calibrating National Instruments PCI/PXI-4461 and PCI/PXI-4462 (NI 446X) devices.

This document does not discuss programming techniques or compiler configuration. The National Instruments DAQmx driver includes help files that have compiler-specific instructions and detailed function explanations. You can install these help files when you install NI-DAQmx on the calibration computer.

NI 446X devices should be externally calibrated at a regular interval as defined by the measurement accuracy requirements of your application. NI recommends that you perform a complete calibration at least once every year. Based on your measurement accuracy needs, you can shorten this interval to 90 days or six months. Self-calibration can be performed as needed or when the temperature varies by 5 °C or more from the last external calibration.

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Conventions

The following conventions appear in this document:

» The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.



This icon denotes a note, which alerts you to important information.

bold

Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names and hardware labels.

italic

Italic text denotes variables, emphasis, a cross-reference, or an introduction to a key concept. Italic text also denotes text that is a placeholder for a word or value that you must supply.

monospace

Monospace text denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.

Return Value

A parameter which points to data that is modified by a function call has a variable name in the form <variableTypeReturnValue>, for example, `uInt32PointerReturnValue`. All function calls return a status integer that you must verify. Because all the functions return this status integer, the function descriptions in this document omit the status integer.

Number Variable Types

The integer variable type used in this document is represented as a whole number. Any floating point variable type is represented as a number with a decimal point. For example, the number 1,024 is written as 1024 if it is an integer, and as 1024.0 if it is a floating point value.

NI 446X

NI 446X refers to the NI PCI-4461, NI PXI-4461, NI PCI-4462, and NI PXI-4462 unless otherwise noted.

Calibration Options

NI 446X devices support two types of calibration: self-calibration and external calibration.

Self-Calibration

Self-calibration, also known as internal calibration, uses a software command and requires no external connections. Self-calibration improves measurement accuracy by compensating for variables such as temperature that might have changed since the last external calibration. Self-calibration retains the traceability of the external calibration.

External Calibration

External calibration is generally performed with high-precision instruments at either NI or a metrology lab. This procedure replaces all calibration constants in the EEPROM and is equivalent to a factory calibration at NI. Because the external calibration procedure changes all EEPROM constants, it invalidates the original calibration certificate. If an external calibration is done with traceable instruments, a new calibration certificate can be issued.

Software and Documentation Requirements

This section describes the software and documentation required for both self-calibration and external calibration.

Software

Install NI-DAQmx 8.1 or later on the calibration computer. You must have the proper device driver installed on the calibration system before calibrating the device.



Note NI recommends that you install the NI-DAQmx driver software before physically installing the NI 446X device. NI-DAQmx, available at ni.com/downloads, configures and controls the NI 446X.

NI-DAQmx supports a number of programming languages, including LabVIEW, LabWindows™/CVI™, Microsoft Visual C++ 6.0, Microsoft Visual Basic 6.0, Microsoft .NET, and Borland C++.

If you want to write the calibration procedure using LabVIEW, NI recommends that you use the Full or Professional Development System or the Developer Suite Professional Edition. These editions include

frequency-domain analysis tools not included in the Base Development System.

You can access the NI-DAQmx header file, `DAQmx.h`, like any standard library. You can find examples of how to use the NI-DAQmx driver in the `Program Files\National Instruments\NI-DAQ\Examples` directory.

Documentation

You might find the following documentation helpful as you write your calibration procedure:

- *NI-DAQmx Help*—This help file contains general information about measurement concepts, key NI-DAQmx concepts, and common applications that are applicable to all programming environments. Select **Start»All Programs»National Instruments»NI-DAQ»NI-DAQmx Help**.
- *NI-DAQmx C Reference Help*—This help file contains C reference and general information about measurement concepts. Select **Start»All Programs»National Instruments»NI-DAQmx Base»Documentation»C Function Reference Manual**.
- *DAQ Getting Started Guide* for NI-DAQ 8.1 or later—This guide describes how to install your NI-DAQmx for Windows software, your NI-DAQmx-supported DAQ device, and how to confirm that your device is operating properly. Select **Start»All Programs»National Instruments»NI-DAQ»DAQ Getting Started Guide**.
- *NI 446X Specifications*—This document contains information about specific device features. The limits you use to verify the accuracy of the devices are based on the specifications found in this document. Select **Start»All Programs»National Instruments»NI-DAQ»Browse Device Documentation** to launch the Device Documentation Browser. You then can select the **Dynamic Signal Acquisition** book to browse the list of DSA devices. Select your device to find a link to the *NI 446X Specifications*.

These documents are installed with NI-DAQmx. You can also download the latest versions from the NI Web site at ni.com/manuals.

Password and User Information

For password-protected operations on most NI 446X devices, the default password is `NI`. On certain devices, however, the default password is `NI\0`. The password is stored in the device EEPROM. You can change the password using the following NI-DAQmx function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call <code>DAQmxChangeExtCalPassword</code> with the following parameters: Device Name: <code>dev1</code> Password: <code>NI</code> or <code>NI\0</code> New Password: <code>myNewPassword</code> (maximum four characters)	



Note Depending on which programming language you use, you can write the `\` character into a string several different ways. Refer to the standard of that language for information about how to write the `\` character into a string.

You can write user-defined information into or read from the EEPROM using the following NI-DAQmx functions.

NI-DAQmx Function Call
Call <code>DAQmxSetCalUserDefinedInfo</code> with the following parameters: deviceName: <code>dev1</code> data: <code>anyUserData</code>
Call <code>DAQmxGetCalUserDefinedInfoMaxSize</code> with the following parameters: deviceName: <code>dev1</code> data: <code>uInt32PointerReturnValue</code>

NI-DAQmx Function Call (Continued)

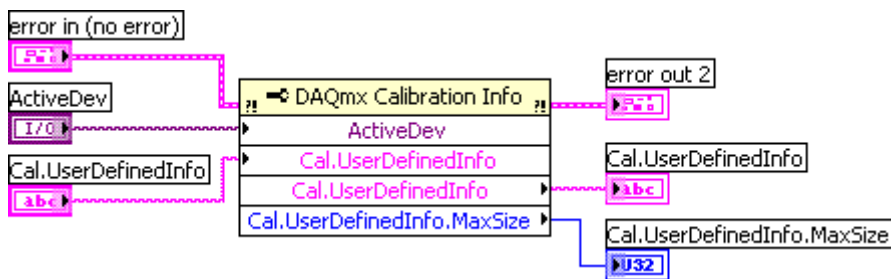
Call DAQmxGetCalUserDefinedInfo with the following parameters:

deviceName: dev1

data: charPointerReturnValue

bufferSize: anyNumberBelowMax

LabVIEW Block Diagram



Both password and user-defined information have a maximum of four ASCII-standard characters and are null-terminated strings. The user information is empty by default and can contain any information you find useful.

Getting Calibration Information

The NI 446X devices contain the current device temperature read directly from the device and the following calibration information stored in the EEPROM:

- Whether the device supports self-calibration
- Date and time of the last self-calibration
- Temperature during the last self-calibration
- Recommended interval for external calibration
- Date and time of the last external calibration
- Temperature during the last external calibration

You can access this information in the Measurement & Automation Explorer (MAX) or by using the following NI-DAQmx functions.

NI-DAQmx Function Call
Call DAQmxGetSelfCalSupported with the following parameters: deviceName: dev1 data: bool32PointerReturnValue
Call DAQmxGetSelfCalLastDateAndTime with the following parameters: deviceName: dev1 year: uInt32PointerReturnValue month: uInt32PointerReturnValue day: uInt32PointerReturnValue hour: uInt32PointerReturnValue minute: uInt32PointerReturnValue
Call DAQmxGetSelfCalLastTemp with the following parameters: deviceName: dev1 data: float64PointerReturnValue
Call DAQmxGetExtCalRecommendedInterval with the following parameters: deviceName: dev1 data: uInt32PointerReturnValue
Call DAQmxGetExtCalLastDateAndTime with the following parameters: deviceName: dev1 year: uInt32PointerReturnValue month: uInt32PointerReturnValue day: uInt32PointerReturnValue hour: uInt32PointerReturnValue minute: uInt32PointerReturnValue

NI-DAQmx Function Call (Continued)

Call DAQmxGetExtCalLastTemp with the following parameters:

deviceName: dev1

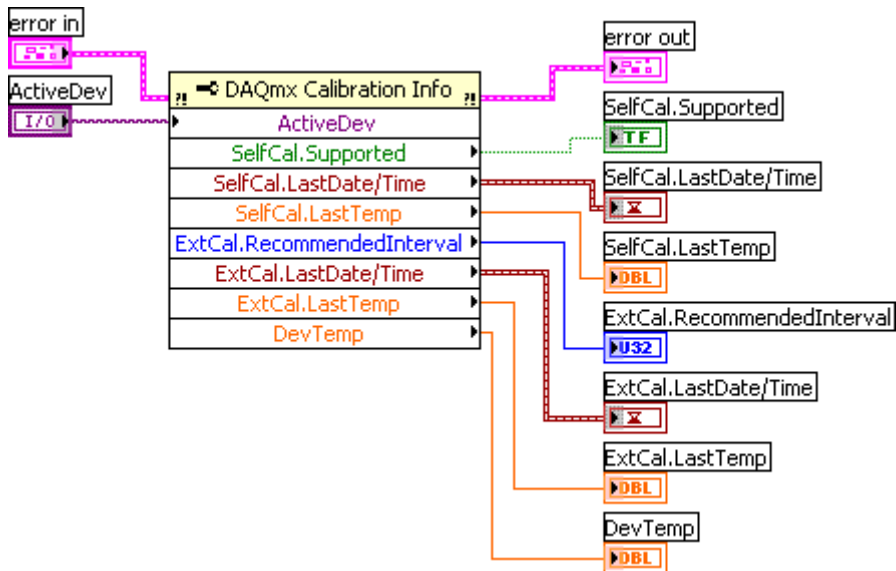
data: float64PointerReturnValue

Call DAQmxGetCalDevTemp with the following parameters:

deviceName: dev1

data: float64PointerReturnValue

LabVIEW Block Diagram



Test Equipment

Table 1 lists the instruments NI recommends for calibrating the NI 446X.

Table 1. NI 446X Calibration Equipment Specifications

Instrument	Critical Specifications	Suggested Model
Calibrator	DC Voltage Range: 1 V, 10 V DC Accuracy: $\pm 300 \mu\text{V}^*$, $\pm 3 \text{ mV}^*$, †	Fluke 5700A
Function Generator	Frequency Range: 1 kHz–10 kHz Frequency Accuracy: $\pm 2 \text{ ppm}^\dagger$ Voltage Range: up to 9 V _{pp}	HP/Agilent 33250A
Digital Multimeter	DC Voltage Range: 100 mV, 1 V, 10 V DC Accuracy: $\pm 100 \text{ ppm}^\dagger$	NI 4070
* $\pm 300 \mu\text{V}$ on 1 V range, $\pm 3 \text{ mV}$ on 10 V range. † This specification contains the initial accuracy and any drift due to temperature and time.		

If the recommended instrument is not available, select a substitute calibration standard that meets the given specifications.

Test Conditions

Follow these guidelines to optimize the connections and the environment during verification and adjustment:

- Keep connections to the NI 446X short. Long cables and wires act as antennae, picking up extra noise that can affect measurements.
- Use a 50 Ω BNC coaxial cable for all connections to the device.
- Keep relative humidity between 10 and 80%, noncondensing, or consult the device documentation for the optimum relative humidity.
- Maintain the temperature between 18 and 28 °C, or refer to the device specifications for the optimum temperature range.
- Allow a warm-up time of at least 15 minutes to ensure that the measurement circuitry of the NI 446X is at a stable operating temperature.
- Allow a warm-up time for all the instruments and equipment, according to the manufacturers' instructions.

Calibration Process

This section provides instructions for verifying and calibrating the NI 446X device.

Calibration Process Overview

The calibration process consists of the following steps:

1. **Initial Setup**—Configure the device in NI-DAQmx.
2. **Self-Calibration**—Measure the onboard reference voltage of the device and adjust the self-calibration constants.
3. **NI 446X Verification Procedure**—Verify the accuracy of the device prior to calibration.
4. **NI 446X Adjustment Procedure**—Perform an external calibration that adjusts the device calibration constants with respect to known voltage and frequency sources.
5. Perform another verification to ensure that the device operates with the specifications after adjustment.

The self-calibration, verification, and adjustment procedures are explained in the following sections.



Note You must compare the verification limits provided in this procedure with the most recent specifications. Refer to the latest NI 446X device specifications at ni.com/manuals.

Initial Setup

NI-DAQmx automatically detects all NI 446X devices. However, for the driver to communicate with the device, you must configure the device in NI-DAQmx.

Complete the following steps to configure a device in NI-DAQmx:

1. Install the NI-DAQmx driver software.
2. Power off the computer that will hold the device and install the device in an available slot.
3. Power on the computer and launch MAX.
4. Right-click the device name and select **Self-Test** to ensure that the device is working properly.



Note When a device is configured with MAX, it is assigned a device name. Each function call uses this device name to determine which DAQ device to calibrate. This document uses `dev1` to refer to the device name. In the following procedures, use the device name as it appears in MAX.

Self-Calibration

Call self-calibration before completing the first verification. This function measures the onboard reference voltage of the device and adjusts the self-calibration constants to account for any errors caused by short-term fluctuations in the operating environment. When you self-calibrate a device, no external signal connections are necessary.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call <code>DAQmxSelfCal</code> with the following parameters: deviceName: dev1	

NI 446X Verification Procedure

Verification determines how well the NI 446X device is meeting specifications. By completing this procedure, you can see how the device has drifted over time, which helps you determine the appropriate calibration interval for your application.

Verifying Analog Input Performance

This section verifies the analog input (AI) performance of all NI 446X devices. Refer to the *NI 446X Specifications* for the number of channels, gain settings, and performance specifications.

Verifying AI DC Offset

Complete the following steps to verify the AI DC offset:

1. Connect a 50 Ω terminator to the analog input channel 0 of the device. The terminator grounds the input channel when it is in pseudodifferential configuration.
2. If you use C function calls, create a task using the following function. If you use LabVIEW, skip this step. The task is created in step 3 in LabVIEW.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxCreateTask with the following parameter: taskHandle: mytaskHandleReturnValue	LabVIEW does not require this step.

You use the object myTaskHandle in all subsequent NI-DAQmx function calls.

3. Create an AI voltage channel through NI-DAQmx using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxCreateAIVoltageChan with the following parameters: taskHandle: myTaskHandle physicalChannel: dev1/ai0 nameToAssignToChannel: " terminalConfig: DAQmx_Val_PseudoDiff minVal: -10.0 maxVal: 10.0 units: DAQmx_Val_Volts CustomScaleName: NULL	

- Modify the AI voltage channel property using the following functions.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxSetAIGain with the following parameters: taskHandle: myTaskHandle channel: dev1/ai0 data: -20.0	
Call DAQmxSetAICoupling with the following parameters: taskHandle: myTaskHandle channel: dev1/ai0 data: DAQmx_Val_DC	

- Configure the timing properties of the acquisition using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxCfgSampClkTiming with the following parameters: taskHandle: myTaskHandle source: NULL rate: 204800.0 activeEdge: DAQmx_Val_Rising sampleMode: DAQmx_Val_FiniteSamps sampsPerChanToAcquire: 102400	

- Start the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxStartTask with the following parameters: taskHandle: myTaskHandle	

7. Acquire data using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxReadAnalogF64 with the following parameters: taskHandle: myTaskHandle numSampsPerChan: -1 timeout: 10.0 fillMode: DAQmx_Val_GroupByChannel arraySizeInSamps: 102400 reserved: NULL readArray: float64ArrayReturnValue sampsPerChanRead: int32PointerReturnValue	

8. Stop the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxStopTask with the following parameters: taskHandle: myTaskHandle	

9. Clear the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxClearTask with the following parameters: taskHandle: myTaskHandle	

10. Average all the values in the array returned from the acquisition. The average is the resulting offset for AI 0 at –20 dB device gain setting. Compare this value to the limits in Table 2.

Table 2. AI Offset Limits

Device Gain	Device Input Offset	
	Min (mV)	Max (mV)
–20	–7.0	7.0
–10	–5.0	5.0
0	–0.7	0.7
10	–0.5	0.5
20	–0.2	0.2
30	–0.1	0.1

11. Repeat steps 2 through 10 for each different gain value that is set in step 4, using the device gain values in Table 2.
12. Repeat steps 1 through 11 for all remaining analog input channels of the device. Replace `ai0` with the appropriate channel name in function call parameters `physicalChannel` and `channel`.

Verifying AI Gain Accuracy

Complete the following steps to verify AI gain accuracy:

1. Connect the output of the calibrator to the analog input channel 0 of the device.
2. Output 9.0 VDC using the calibrator.
3. If you use C function calls, create a task using the following function. If you use LabVIEW, skip this step. The task is created in step 4 in LabVIEW.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call <code>DAQmxCreateTask</code> with the following parameter: taskHandle: <code>mytaskHandleReturnValue</code>	LabVIEW does not require this step.

You use the object `myTaskHandle` in all subsequent NI-DAQmx function calls.

4. Create an AI voltage channel through NI-DAQmx using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxCreateAIVoltageChan with the following parameters: taskHandle: myTaskHandle physicalChannel: dev1/ai0 nameToAssignToChannel: " " terminalConfig: DAQmx_Val_PseudoDiff minVal: -10.0 maxVal: 10.0 units: DAQmx_Val_Volts CustomScaleName: NULL	

5. Modify the AI voltage channel property using the following functions.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxSetAIGain with the following parameters: taskHandle: myTaskHandle channel: dev1/ai0 data: -20.0	
Call DAQmxSetAICoupling with the following parameters: taskHandle: myTaskHandle channel: dev1/ai0 data: DAQmx_Val_DC	

6. Configure the timing properties of the acquisition using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxCfgSampClkTiming with the following parameters: taskHandle: myTaskHandle source: NULL rate: 204800.0 activeEdge: DAQmx_Val_Rising sampleMode: DAQmx_Val_FiniteSamps sampsPerChanToAcquire: 102400	

7. Start the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxStartTask with the following parameters: taskHandle: myTaskHandle	

8. Acquire data using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxReadAnalogF64 with the following parameters: taskHandle: myTaskHandle numSampsPerChan: -1 timeout: 10.0 fillMode: DAQmx_Val_GroupByChannel arraySizeInSamps: 102400 reserved: NULL readArray: float64ArrayReturnValue sampsPerChanRead: int32PointerReturnValue	

9. Stop the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxStopTask with the following parameters: taskHandle: myTaskHandle	

10. Clear the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxClearTask with the following parameters: taskHandle: myTaskHandle	

11. Average all the values in the array returned from the acquisition. This average is used to calculate the gain accuracy for AI 0 at -20 dB device gain setting. Compare this value to the limits (V) in Table 3.

Table 3. AI Gain Accuracy Limits

Device Gain	Calibrator Output Amplitude (VDC)	Device Input Amplitude Accuracy			
		Min (dB)	Max (dB)	Min (V)	Max (V)
-20	9.0	-0.03	0.03	8.9690	9.0311
-10	9.0	-0.03	0.03	8.9690	9.0311
0	9.0	-0.03	0.03	8.9690	9.0311
10	3.0	-0.03	0.03	2.9897	3.0104
20	0.9	-0.03	0.03	0.8969	0.9031
30	0.3	-0.03	0.03	0.2990	0.3010

12. Repeat steps 2 through 11 for all remaining gain values used in step 5. Modify the calibrator output amplitude in step 2. Refer to Table 3 for the calibrator output amplitude and the device gain value.
13. Repeat steps 1 through 12 for all remaining analog input channels of the device. Replace `ai0` with the appropriate channel name in function call parameters `physicalChannel` and `channel`.

Verifying Analog Output Performance

This section verifies the analog output (AO) performance on the NI 4461 devices. Refer to the *NI 446X Specifications* for the number of channels, gain settings, and performance specifications.

Verifying AO DC Offset

Complete the following steps to verify AO DC offset:

1. Connect the analog output channel 0 of the device to the input of the multimeter.
2. Create an array of double float of size 1024. Initialize all the values in the array to 0.0. You use this array to output 0 V using the device analog output channel 0.
3. If you use C function calls, create a task using the following function. If you use LabVIEW, skip this step. The task is created in step 4 in LabVIEW.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call <code>DAQmxCreateTask</code> with the following parameter: taskHandle: <code>mytaskHandleReturnValue</code>	LabVIEW does not require this step.

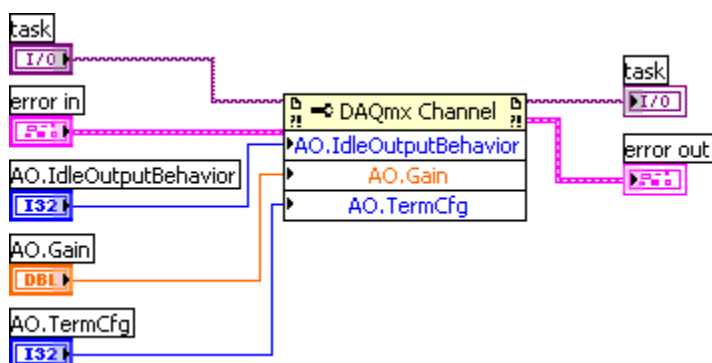
You use the object `myTaskHandle` in all subsequent NI-DAQmx function calls.

4. Create an AO Voltage channel through NI-DAQmx using the following function.

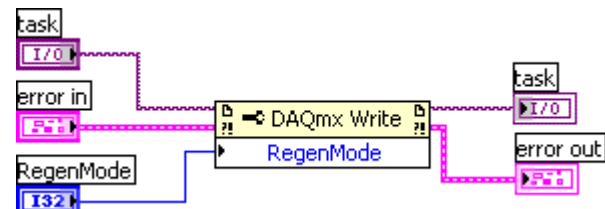
NI-DAQmx Function Call	LabVIEW Block Diagram
Call <code>DAQmxCreateAOVoltageChan</code> with the following parameters: taskHandle: <code>myTaskHandle</code> physicalChannel: <code>dev1/ao0</code> nameToAssignToChannel: <code>" "</code> minVal: <code>-10.0</code> maxVal: <code>10.0</code> units: <code>DAQmx_Val_Volts</code> customScaleName: <code>NULL</code>	

5. Modify the AO voltage channel property using the following functions.

NI-DAQmx Function Call
Call <code>DAQmxSetAOIdleOutputBehavior</code> with the following parameters: taskHandle: <code>myTaskHandle</code> channel: <code>dev1/ao0</code> data: <code>DAQmx_Val_HighImpedance</code>
Call <code>DAQmxSetAOGain</code> with the following parameters: taskHandle: <code>myTaskHandle</code> channel: <code>dev1/ao0</code> data: <code>-40.0</code>

NI-DAQmx Function Call (Continued)	
Call DAQmxSetAOTermCfg with the following parameters: taskHandle: myTaskHandle channel: dev1/ao0 data: DAQmx_Val_PseudoDiff	
LabVIEW Block Diagram	
	

6. Modify the NI-DAQmx write property using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxSetWriteRegenMode with the following parameters: taskHandle: myTaskHandle data: DAQmx_Val_AllowRegen	

7. Configure the timing properties of the generation using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxCfgSampClkTiming with the following parameters: taskHandle: myTaskHandle source: NULL rate: 204800.0 activeEdge: DAQmx_Val_Rising SampleMode: DAQmx_Val_ContSamps sampsPerChanToAcquire: 1024	

8. Configure the onboard memory of the device using the following function and the array created in step 2.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxWriteAnalogF64 with the following parameters: taskHandle: myTaskHandle numSampsPerChan: 1024 autoStart: FALSE timeout: 10.0 dataLayout: DAQmx_Val_GroupByChannel writeArray: myDataArray reserved: NULL sampsPerChanWritten: int32PointerReturnValue	

9. Start the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxStartTask with the following parameters: taskHandle: myTaskHandle	

10. Measure the DC Volts of the analog output channel using the multimeter in its most sensitive range. Compare this value to the limits in Table 4 for –40 dB device gain.

11. Stop the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxStopTask with the following parameters: taskHandle: myTaskHandle	

12. Clear the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxClearTask with the following parameters: taskHandle: myTaskHandle	

13. Repeat steps 3 through 12 for all remaining gain values used in step 5. Refer to Table 4 for all the device gain values.

Table 4. AO Offset Limits

Device Gain	Multimeter Reading	
	Min (mV)	Max (mV)
–40	–1.0	1.0
–20	–1.0	1.0
0	–1.0	1.0

14. Repeat steps 1 through 13 for analog output channel 1 of the device.
Replace `ao0` with `ao1` in the function call parameters
`physicalChannel` and `channel`.

Verifying AO Gain Accuracy

Complete the following steps to verify AO gain accuracy:

1. Connect analog output channel 0 to the input of the multimeter.
2. Create an array of double float of size 1024. Initialize this array with the value 1.0.
3. Multiply each value in the array by 0.09. Use this array to output 0.09 VDC using the device AO 0.
4. If you use C function calls, create a task using the following function.
If you use LabVIEW, skip this step. The task is created in step 5 in LabVIEW.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call <code>DAQmxCreateTask</code> with the following parameter: taskHandle: <code>myTaskHandleReturnValue</code>	LabVIEW does not require this step.

You use the object `myTaskHandle` in all subsequent NI-DAQmx function calls.

5. Create an AO Voltage channel through NI-DAQmx using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call <code>DAQmxCreateAOVoltageChan</code> with the following parameters: taskHandle: <code>myTaskHandle</code> physicalChannel: <code>dev1/ao0</code> nameToAssignToChannel: <code>" "</code> minVal: <code>-10.0</code> maxVal: <code>10.0</code> units: <code>DAQmx_Val_Volts</code> customScaleName: <code>NULL</code>	

6. Modify the AO voltage channel property using the following functions.

NI-DAQmx Function Call
Call DAQmxSetAOIdleOutputBehavior with the following parameters: taskHandle: myTaskHandle channel: dev1/ao0 data: DAQmx_Val_HighImpedance
Call DAQmxSetAOGain with the following parameters: taskHandle: myTaskHandle channel: dev1/ao0 data: -40.0
Call DAQmxSetAOTermCfg with the following parameters: taskHandle: myTaskHandle channel: dev1/ao0 data: DAQmx_Val_PseudoDiff
LabVIEW Block Diagram

7. Modify the NI-DAQmx write property using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxSetWriteRegenMode with the following parameters: taskHandle: myTaskHandle data: DAQmx_Val_AllowRegen	

8. Configure the timing properties of the generation using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxCfgSampClkTiming with the following parameters: taskHandle: myTaskHandle source: NULL rate: 204800.0 activeEdge: DAQmx_Val_Rising SampleMode: DAQmx_Val_ContSamps sampsPerChanToAcquire: 1024	

9. Configure the onboard memory of the device using the following function and the array modified in step 3.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxWriteAnalogF64 with the following parameters: taskHandle: myTaskHandle numSampsPerChan: 1024 autoStart: FALSE timeout: 10.0 dataLayout: DAQmx_Val_GroupByChannel writeArray: myDataArray reserved: NULL sampsPerChanWritten: int32PointerReturnValue	

10. Start the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxStartTask with the following parameters: taskHandle: myTaskHandle	

11. Measure the DC voltage of the analog output channel using the multimeter in the appropriate range. Compare this value to the limits (V) in Table 5 for –40 dB device gain

Table 5. AO Gain Accuracy Limits

Device Gain	Device Output Amplitude (VDC)	Output Amplitude Accuracy			
		Min (dB)	Max (dB)	Min (V)	Max (V)
–40	0.09	–0.04	0.04	0.089587	0.090415
–20	0.9	–0.04	0.04	0.89587	0.90415
0	9.0	–0.04	0.04	8.9587	9.0415

12. Stop the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxStopTask with the following parameters: taskHandle: myTaskHandle	

13. Clear the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxClearTask with the following parameters: taskHandle: myTaskHandle	

14. Repeat steps 3 through 13 for all remaining gain values used in step 6. Also modify the device output amplitude used in step 3. For all values, refer to Table 5.
15. Repeat steps 1 through 14 for analog output channel 1 of the device. Replace ao0 with ao1 in the function call parameters `physicalChannel` and `channel`.

Verifying Timebase Frequency Accuracy

This section describes the verification process for the timebase frequency accuracy on all the NI 446X devices. All analog inputs use a single circuit on each device. The NI 4461 analog output channels also use the same timebase frequency circuit. Therefore, you need to verify only the analog input frequency accuracy on a single channel to verify this circuit accuracy.

Complete the following steps to verify the timebase:

1. Connect the function generator to the analog input channel 0 of the device.
2. Output a sine wave using the function generator. The sine wave should have an amplitude of $9 V_{p-p}$ with no DC offset and a frequency of 10,000.00 Hz.

3. If you use C function calls, create a task using the following function. If you use LabVIEW, skip this step. The task is created in step 4 in LabVIEW.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxCreateTask with the following parameter: taskHandle: mytaskHandleReturnValue	LabVIEW does not require this step.

You use the object `myTaskHandle` in all subsequent NI-DAQmx function calls.

4. Create an AI voltage channel through NI-DAQmx using the following function.

[illegible]

5. Modify the AI voltage channel property using the following functions.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxSetAIGain with the following parameters: taskHandle: myTaskHandle channel: dev1/ai0 data: 0.0	
Call DAQmxSetAICoupling with the following parameters: taskHandle: myTaskHandle channel: dev1/ai0 data: DAQmx_Val_DC	

6. Configure the timing properties of the acquisition using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxCfgSampClkTiming with the following parameters: taskHandle: myTaskHandle source: NULL rate: 40000.0 activeEdge: DAQmx_Val_Rising sampleMode: DAQmx_Val_FiniteSamps sampsPerChanToAcquire: 2560000	

7. Start the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxStartTask with the following parameters: taskHandle: myTaskHandle	

8. Create an array of double float of size 2560000 that will be filled with data. Acquire data using the following function. The acquisition takes over 1 minute.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxReadAnalogF64 with the following parameters: taskHandle: myTaskHandle numSampsPerChan: -1 timeout: 100.0 fillMode: DAQmx_Val_GroupByChannel arraySizeInSamps: 2560000 reserved: NULL readArray: float64ArrayReturnValue sampsPerChanRead: int32PointerReturnValue	

9. Stop the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxStopTask with the following parameters: taskHandle: myTaskHandle	

10. Clear the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxClearTask with the following parameters: taskHandle: myTaskHandle	

11. If you use C function calls, perform an FFT on the array of data. If you use LabVIEW, use the Analog 1D Wfm 1chan Nsamp polymorphic VI to acquire data in step 8. Measure the exact frequency of the peak around 10 kHz using the Extract Single Tone Information VI with the following inputs:
 - **advanced search»approx freq.** : 10000
 - **advanced search»search** : 1
 - **export signals** : 0 (none)
12. Compare the detected frequency to the limits in Table 6.

Table 6. Timebase Frequency Accuracy Limits

Function Generator Output		Device Input Frequency	
Amplitude (V _{p-p})	Frequency (Hz)	Min (Hz)	Max (Hz)
9.0	10,000.00	9,999.8	10,000.2

NI 446X Adjustment Procedure

The NI 446X adjustment procedure adjusts the analog input, analog output, and timebase frequency calibration constants. At the end of each adjustment procedure, the new constants are stored in the external calibration area of the device EEPROM, which ensures that you do not accidentally access or modify any calibration constants adjusted by the metrology laboratory while performing a self-calibration procedure. You can adjust the NI 446X AI, AO, and timebase frequency independently. The following sections describe the AI, AO, and timebase frequency adjustment procedures.

Adjusting the Analog Input

Complete the following steps to adjust the analog input:

1. Connect the output of the calibrator to all the analog input channels of the device, using the BNC T-connectors to split the signal in a tree formation to all the inputs.
2. Use the calibrator to output 5.00 VDC.

- Initialize the AI calibration using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxInitExtCal with the following parameters: deviceName: dev1 password: userPassword calHandle: myCalHandle	

You use the object myCalHandle in all subsequent NI-DAQmx function calls.

- Perform the AI calibration using the following function call. The reference voltage parameter is the voltage value output by the calibrator.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxAdjustDSAAICal with the following parameters: calHandle: myCalHandle referenceVoltage: 5.0	

- Finish the AI calibration with the following function call. Use the action cancel if there has been any error during the AI calibration or if you do not want to save the new AI calibration constants in the device EEPROM. Use the action commit if you want to save the new AI calibration constants in the device EEPROM.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxCloseExtCal with the following parameters: calHandle: myCalHandle action: DAQmx_Val_Action_Commit or DAQmx_Val_Action_Cancel	

Adjusting the Analog Output

Complete the following steps to adjust the analog output:

1. Connect the input of the multimeter to the analog output channel 0 of the device.
2. Initialize the AO Calibration using the following function call.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxInitExtCal with the following parameters: deviceName: dev1 password: userPassword calHandle: myCalHandle	

You use the object myCalHandle in all subsequent NI-DAQmx calibration function calls.

3. Create an array of double float of size 1024. Initialize all the values in the array to 1.0.
4. Multiply each value in the array by 0.09. This is the Device Output Voltage, Requested High Voltage listed in Table 7 for –40 dB device gain. Use this array to output a DC voltage using the device analog output channel 0.
5. If you use C function calls, create a task using the following function. If you use LabVIEW, skip this step. The task is created in step 6 in LabVIEW.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxCreateTask with the following parameter: taskHandle: mytaskHandleReturnValue	LabVIEW does not require this step.

You use the object myTaskHandle in all subsequent NI-DAQmx function calls.

6. Create an AO Voltage channel through NI-DAQmx using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxCreateAOVoltageChan with the following parameters: taskHandle: myTaskHandle physicalChannel: dev1/ao0 nameToAssignToChannel: " " minVal: -10.0 maxVal: 10.0 units: DAQmx_Val_Volts customScaleName: NULL	

7. Modify the AO voltage channel property using the following function.

NI-DAQmx Function Call
Call DAQmxSetAOIdleOutputBehavior with the following parameters: taskHandle: myTaskHandle channel: dev1/ao0 data: DAQmx_Val_HighImpedance
Call DAQmxSetAOGain with the following parameters: taskHandle: myTaskHandle channel: dev1/ao0 data: -40.0

NI-DAQmx Function Call (Continued)

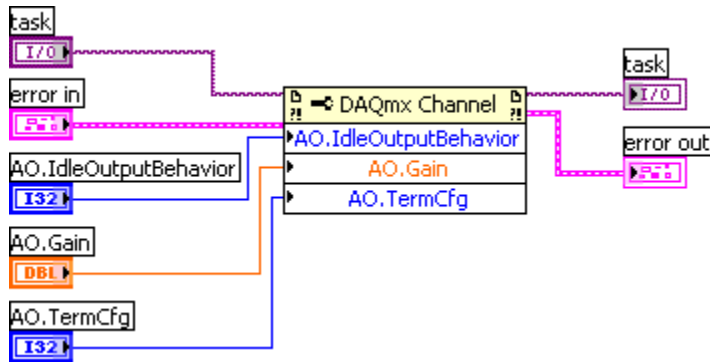
Call DAQmxSetAOTermCfg with the following parameters:

taskHandle: myTaskHandle

channel: dev1/ao0

data: DAQmx_Val_PseudoDiff

LabVIEW Block Diagram



8. Modify the NI-DAQmx write property using the following function.

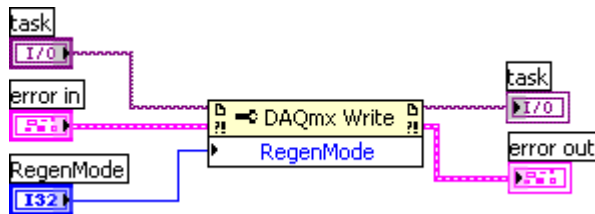
NI-DAQmx Function Call

Call DAQmxSetWriteRegenMode with the following parameters:

taskHandle: myTaskHandle

data: DAQmx_Val_AllowRegen

LabVIEW Block Diagram



9. Configure the timing properties of the generation using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxCfgSampClkTiming with the following parameters: taskHandle: myTaskHandle source: NULL rate: 204800.0 activeEdge: DAQmx_Val_Rising SampleMode: DAQmx_Val_ContSamps sampsPerChanToAcquire: 1024	

10. Configure the onboard memory of the device using the following function and the array you modified in step 4.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxWriteAnalogF64 with the following parameters: taskHandle: myTaskHandle numSampsPerChan: 1024 autoStart: FALSE timeout: 10.0 dataLayout: DAQmx_Val_GroupByChannel writeArray: myDataArray reserved: NULL sampsPerChanWritten: int32PointerReturnValue	

11. Start the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxStartTask with the following parameters: taskHandle: myTaskHandle	

12. Measure the DC voltage of the analog output channel using the multimeter in the appropriate range. Record this value as actualHighVoltage.

13. Stop the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxStopTask with the following parameters: taskHandle: myTaskHandle	

14. Clear the task using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxClearTask with the following parameters: taskHandle: myTaskHandle	

15. Repeat steps 4 to 14 using the Requested Low Voltage for –40 dB device gain from Table 7. Record the multimeter DC voltage measurement as actualLowVoltage.

16. Perform the AO calibration for this gain setting using the following function.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call DAQmxAdjustDSAAOCal with the following parameters: calHandle: myCalHandle channel: 0 requestLowVoltage: -0.09 actualLowVoltage: actualLowVoltage requestedHighVoltage: 0.09 actualHighVoltage: actualHighVoltage gainSetting: -40.0	

17. Repeat steps 4 through 16 for all remaining gain values used in steps 4 and 16. Also modify the device requested high and low voltages used in steps 4 and 16. You can find the values in Table 7.

Table 7. Device Output Voltages for AO Calibration

Device Gain (dB)	Device Output Voltage (V)
-40	0.09 (Requested High Voltage)
	-0.09 (Requested Low Voltage)
-20	0.90 (Requested High Voltage)
	-0.90 (Requested Low Voltage)
0	9.00 (Requested High Voltage)
	-9.00 (Requested Low Voltage)

18. Repeat steps 1 and 4 through 17 for analog output channel 1 of the device. Replace ao0 with ao1 in the function call parameters physicalChannel and channel.

19. Finish the AO calibration with the following function call. Use the action `cancel` if an error occurs during the AO calibration or if you do not want to save the new AO calibration constants in the device EEPROM. Use the action `commit` if you want to save the new AO calibration constants in the device EEPROM.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call <code>DAQmxCloseExtCal</code> with the following parameters: calHandle: <code>myCalHandle</code> action: <code>DAQmx_Val_Action_Commit</code> or <code>DAQmx_Val_Action_Cancel</code>	

Adjusting the Timebase

Complete the following steps to adjust the timebase:

1. Connect the output of the function generator to the analog input 0 of the device.
2. Output a sine wave using the function generator. The sine wave should have an amplitude of $9\text{ V}_{\text{p-p}}$, no offset, and a frequency of 1,000.000 Hz.
3. Initialize the timebase calibration using the following function call.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call <code>DAQmxInitExtCal</code> with the following parameters: deviceName: <code>dev1</code> password: <code>userPassword</code> calHandle: <code>myCalHandle</code>	

You use the object `myCalHandle` in all subsequent NI-DAQmx function calls.

4. Perform the timebase calibration using the following function call. The parameter `referenceFrequency` is the frequency output by the function generator.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call <code>DAQmxAdjustDSATimebaseCal</code> with the following parameters: calHandle: <code>myCalHandle</code> referenceFrequency: <code>1000.0</code>	

5. Finish the timebase calibration with the following function call. Use the action `cancel` if an error occurs during the timebase calibration or if you do not want to save the new timebase calibration constants in the device EEPROM. Use the action `commit` if you want to save the new timebase calibration constants in the device EEPROM.

NI-DAQmx Function Call	LabVIEW Block Diagram
Call <code>DAQmxCloseExtCal</code> with the following parameters: calHandle: <code>myCalHandle</code> action: <code>DAQmx_Val_Action_Commit</code> or <code>DAQmx_Val_Action_Cancel</code>	

Where to Go for Support

The National Instruments Web site 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.

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