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BNC-2121

CALIBRATION PROCEDURE

NI PXIe-6614

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This document contains the performance verification and adjustment procedures for the National Instruments NI PXIe-6614. For more information about calibration, visit ni.com/calibration.

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Software

Calibrating the NI PXIe-6614 requires NI-DAQmx version 9.8 or later on the calibration system. You can download NI-DAQmx from ni.com/downloads. NI-DAQmx supports a number of application development environments (ADEs) and programming languages, including LabVIEW, LabWindows™/CVI™, Microsoft Visual C++, Microsoft Visual Basic. Please refer to NI-DAQ Readme file for more details by selecting **Start»All Programs»National Instruments»NI-DAQ**. When you install NI-DAQmx, you only need to install support for the ADE or programming language you intend to use.

Documentation

Consult the following documents for information about the NI PXIe-6614, NI-DAQmx, and your application software. All documents are available on ni.com and help files install with the software.



DAQ Getting Started Guide, Read Me First: NI-DAQmx, and DAQ Device Installation Guide

Instructions for installation, hardware setup, and configuration of NI-DAQ devices.



NI 6614 User Manual

NI 6614 specific information.



NI 6614 Specifications

NI 6614 specifications and calibration interval



NI-DAQmx Readme

Operating system and application software support in NI-DAQmx



NI DAQmx Help

Information about creating applications that use the NI-DAQmx driver



LabVIEW Help

LabVIEW programming concepts and reference information about NI-DAQmx VIs and functions



NI-DAQmx C Reference Help

Reference information for NI-DAQmx C functions and NI-DAQmx C properties



NI-DAQmx .NET Help Support for Visual Studio

Reference information for NI-DAQmx .NET methods and NI-DAQmx .NET properties, key concepts, and a C enum to .NET enum mapping table

Test Equipment

Table 1 lists the equipment recommended for the performance verification and adjustment procedures. If the recommended equipment is not available, select a substitute using the requirements listed in Table 1.

Table 1. Test Equipment

Equipment	Recommended Models	Requirements
10 MHz rubidium frequency standard clock or better*	Symmetricom 8040C or Datum 8040	± 0.75 ppb [†] accuracy or better
Shielded 68-conductor cable	SH68-68-D1	Terminated with 68-pin female 0.050 series D-type connector
I/O connector block	BNC-2121, SCB-68A, or any 68-pin breakout box	—
BNC Male-to-BNC Male cable	—	50 Ω
75 Ω BNC Male to 50 Ω BNC Female Adaptor	—	50 to 75 Ω
* Allow adequate time for the clock to warm up prior to calibration. [†] 1 ppb = 1/1000,000,000		

Connecting the Clock Source to the NI PXIe-6614

1. Connect the NI PXIe-6614 to the I/O connector block using the shielded 68-conductor cable.
2. Connect the stable clock to PFI 39 on the NI PXIe-6614:
 - If you are using the BNC-2121, attach the BNC adapter to PFI 39 on the BNC-2121 and then connect the stable clock source to it with the BNC cable.
 - If you are using the SCB-68A, connect the stable clock to pin 2 (PFI 39) and then connect the ground of the stable clock to pin 36 (GND).

Test Conditions

The following setup and environmental conditions are required to ensure the NI PXIe-6614 meets published specifications.

- Keep connections to the NI PXIe-6614 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 NI PXIe-6614 are secure.
- Use shielded coaxial cables or shielded copper wire for all cable connections to the NI PXIe-6614. Use twisted-pair wire to eliminate noise and thermal offsets.

- Maintain an ambient temperature of $23\text{ }^{\circ}\text{C} \pm 5^{\circ}\text{C}$.
- Keep relative humidity between 5% to 95%, non-condensing.
- Allow a warm-up time of at least two hours to ensure the NI PXIe-6614 measurement circuitry is at a stable operating temperature.

Initial Setup

Refer to the *DAQ Getting Started Guide, Read Me First: NI-DAQmx, and DAQ Device Installation Guide* for information about how to install the software and hardware and how to configure the device in Measurement & Automation Explorer (MAX).



Note When a device is configured in MAX, it is assigned a device name. Each function call uses this device name to determine which 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.

Complete the following steps to set up the NI PXIe-6614.

1. Install NI-DAQmx.
2. Power off the PXI Express chassis.
3. Install the NI PXIe-6614 into a PXIe compatible slot of the PXI Express chassis and then turn the chassis on.



Note Installing the NI PXIe-6614 into the system timing slot automatically overdrives the PXI backplane clock. Therefore, performing adjustments in the system timing slot will cause the PXI backplane clock to change during the adjustment process. Refer to the *Using the OXCO to Overdrive the PXI Backplane Clock* section in the *NI 6614 User Manual* for more information.

4. Reboot the host computer and launch **Measurement & Automation Explorer (MAX)**.
5. Right-click the device name and select **Self-Test** to ensure that the module is working properly.
6. Connect the Clock source to the NI PXIe-6614. Refer to the [Connecting the Clock Source to the NI PXIe-6614](#) sections for instructions.

Verification

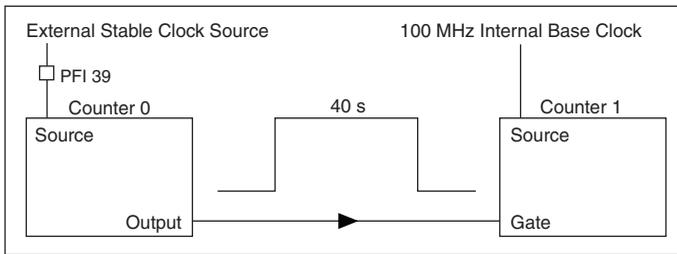
The following performance verification procedure describes measuring the 100 MHz base clock on the NI PXIe-6614.

Clock Accuracy Verification

Verifying the performance of the oscillator on an NI PXIe-6614 requires a pair of counters, which are Counters 0 and 1.

Counter 0 generates an accurate 40 second pulse using the external clock source. The pulse is then routed to Counter 1, which counts the number of edges of the internal timebase. The number of clock edges is then used to compute the internal timebase frequency.

Figure 1. NI PXIe-6614 Verification Process



To conduct the measurement, configure the counters as stated below:

1. Use the DAQmx Create Channel (CO - Pulse Generation - Time) VI and configure Counter 0 as follows:
 - a. Set the counter to generate a continuous time pulse high time of 40 seconds, with 1 second low time.
 - b. Set the initial delay to 0, idle state to Low, and the pulse unit to Seconds.
2. Configure the CO channel properties as indicated in Table 2 using a DAQmx Channel property node.

Table 2. Configuration Settings for CO Channel

Property	Value
CO.Ctr.TimebaseSrc	PFI39
CO.Ctr.TimebaseRate	10000000
CO.Pulse.Term	Ctr0InternalOutput

3. Configure Counter 1 using DAQmx Create Channel (CI - Count Edges) VI. Set the count direction as Count Up, clock edge type as Rising, and initialize the initial count to 0.
4. Set the CI.CountEdges.Term to 100MHzTimeBase using a DAQmx Channel property node.

- Configure the CI trigger properties as indicated in Table 3 using a DAQmx Trigger property node.

Table 3. Configuration Settings for CI Trigger

Property	Value
Pause.TrigType	Digital Level
Pause.DigLvl.Src	Ctr0InternalOutput
Pause.DigLvl.When	Low

- Use DAQmx Read VI to count the number of clock edges within the 40 seconds pulse.
- Calculate the frequency accuracy of the base clock using the following equation:

$$\text{Measured Clock Frequency (Hz)} = \frac{\text{Number of clock edges counted}}{40 \text{ s}}$$

The frequency measurement has an uncertainty that is equal to the sum of the stable clock error and the quantization error caused by the counter. The stable clock accuracy must meet the specifications listed in the [Test Equipment](#) section of this document. The quantization error, which is the inherent uncertainty in digitizing an analog value, is 10 ns (equivalent to 1 clock edge miscount). Using a measurement duration of 40 seconds gives a quantization error as follows:

$$\frac{10 \text{ ns}}{40 \text{ s}} = 0.25 \text{ ppb}$$

The sum of the stable clock error 0.75 ppb and the quantization error 0.25 ppb gives a total measurement uncertainty of 1 ppb. You can reduce the measurement uncertainty by using a more stable clock source, increasing the measurement duration, or both.



Note The NI PXIe-6614 counters are of 32-bits resolution. Counter overflow can occur when the generated pulse is more than 42.9 seconds.



Note The time needed for verification is slightly more than the gate pulse duration.

Compare the measured clock frequency obtained with the acceptable frequency range shown in Table 4.

Table 4. Initial Performance Verification Test Limits

Device	Test Limit (Typical*)
NI PXIe-6614	± 85 ppb [†]
<p>* This test limit is a typical specification; NI does not warrant that your initial measurements are in accordance with this limit. To ensure the performance of the equipment, NI recommends that you perform the adjustment procedure and reverify the equipment using the specifications in Table 5.</p> <p>[†] ± 85 ppb covers the ± 75 ppb limit per year and the ± 10 ppb OCXO retrace error.</p>	

Adjustment is necessary if the measured value is not within the calibration measurement target frequency range listed in Table 5.



Note Test limits in Tables 4 and 5 are based upon the 374078A-01 edition of the *NI 6614 Specifications*. Refer to the most recent *NI 6614 Specifications* online at ni.com/manuals.

Adjustment

The following performance adjustment procedures describes the sequence of operation required to adjust the NI PXIe-6614. The adjustment process for the NI PXIe-6614 takes approximately 8 minutes or less to complete.

Clock Accuracy Adjustment

The adjustment process iteratively measures the 100 MHz timebase and adjusts the hardware until the measured frequency is within the target limits listed in Table 5.

Table 5. Adjustment Target Frequency Range

Device	Calibration Measurement Accuracy	Calibration Measurement Target Frequency Range—As Left	
		Low Limit	High Limit
NI PXIe-6614	± 4.25 ppb	99,999,999.575 Hz	100,000,000.425 Hz

To adjust the frequency accuracy of the 100 MHz Clock, do the following:



Note Throughout the procedure, refer to the NI-DAQmx function call parameters for the LabVIEW input values.

Refer to the *NI-DAQmx Help* or the *NI-DAQmx C Reference Help* for more information on NI-DAQmx function calls.

1. Open a calibration session on your device using the DAQmx Initialize External Calibration VI.

LabVIEW Block Diagram	NI-DAQmx Function Call
	<p>Call DAQmxInitExtCal with the following parameters:</p> <p>deviceName: dev1 password: The password required to open an external calibration session. The default password is NI. calHandle: A reference to the calibration session</p>

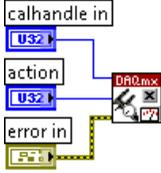
2. Perform an external calibration adjustment using the DAQmx Adjust TIO Timebase Calibration VI.

LabVIEW Block Diagram	NI-DAQmx Function Call
	<p>Call DAQmxAdjustTIOTimebaseCal with the following parameters:</p> <p>calHandle: The session handle returned from DAQmxInitExtCal referenceFrequency: 10000000.00</p>



Note An error message is returned if DAQmx is unable to perform the adjustment. In this situation, verify that the external stable clock source is operating normally and is properly connected to the NI PXIe-6614, and repeat the adjustment process. If the error persists, contact National Instruments. Refer to the [Worldwide Support and Services](#) section for contact information.

- Close the calibration session using the DAQmx Close External Calibration VI. This VI writes the calibration constants, date, time, and temperature to the internal calibration memory.

LabVIEW Block Diagram	NI-DAQmx Function Call
	<p>Call <code>DAQmxCloseExtCal</code> with the following parameters:</p> <p>calHandle: The session handle returned from <code>DAQmxAdjustTIOTimebaseCal</code></p> <p>action: Use <code>DAQmx_VAL_EXT_CAL_COMMIT</code> to update the internal calibration memory. If you want to abort the operation without updating the calibration memory, use <code>DAQmx_VAL_EXT_CAL_CANCEL</code>.</p>



Note In LabVIEW, if the **error in** indicates that an error has occurred during adjustment, DAQmx does not update the internal calibration memory.

EEPROM Update

When an adjustment procedure successfully completes, the NI PXIe-6614 internal calibration memory (EEPROM) is immediately updated.

Reverification

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



Note The reverification must be done immediately after adjustment without power-cycling the device to ensure that no retrace error from OCXO is added to the clock accuracy.



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 *Worldwide Support and Services* for assistance in returning the device to NI.

Worldwide Support and Services

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

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

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