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CALIBRATION PROCEDURE

NI PXI-665*x*

This document describes how to write a calibration procedure for the 10 MHz oscillator frequency of the NI PXI-6653 and NI PXI-6652 timing and synchronization modules.

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Conventions

The following conventions apply to 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.

When symbol is marked on a product, it denotes a warning advising you to take precautions to avoid electrical shock.

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When symbol is marked on a product, it denotes a component that may be hot. Touching this component may result in bodily injury.

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.

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` — Text in this font 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.

Software

This calibration procedure requires NI-Sync and NI-VISA. NI-Sync and NI-VISA support a number of application development environments (ADEs) and programming languages, including LabVIEW, LabWindows™/CVI™, and Microsoft Visual C++. When you install the drivers, you need to install support for only the ADE or programming language you are using. The illustrations in this document show the LabVIEW code for implementing calibration steps using NI-Sync and NI-VISA.

Documentation

You need the *NI-Sync User Manual* to calibrate the NI PXI-665*x*.

The *NI-Sync User Manual* contains detailed information about using the NI-Sync driver, including information about installing NI-Sync and creating applications that use the NI-Sync driver. These sources, along with this document, are your primary references for writing your calibration utility. You also can refer to the documentation for the programming language or application development environment you are using. For further information about the device you are calibrating, refer to the *NI PXI-665x User Manual*.

Calibration Interval

The measurement requirements of the application determine how often you should calibrate the device to ensure its accuracy. National Instruments recommends that you calibrate the NI PXI-6653 and NI PXI-6652 *yearly*. You may want to shorten this interval based on the application demands.

Password

The default password for password-protected operations is `NI`.

Test Equipment

Calibrating the NI PXI-665*x* requires the following equipment.

Equipment	Recommended Model	Requirements
10 MHz clock source	Symmetricom/Datum 8040	Accurate to within 0.75 parts-per-billion (ppb) for the NI PXI-6653, or 150 ppb for the NI PXI-6652.
BNC-SMB cable	—	—
SMB-SMB cable	—	—

Test Conditions

Follow these guidelines to optimize connections and test conditions during the calibration procedure:

- Install the NI PXI-665*x* in Slot 2 of the PXI chassis. The calibration procedure requires features of PXI that are accessible only in slot 2. Use of an NI PXI-1044 or NI PXI-1045 chassis is recommended to reduce error associated in variance in the 5 V chassis supply.
- Maintain a temperature of approximately 25 °C.
- Keep relative humidity below 80 percent.
- Use shielded copper wire for all cable connections to the device.
- Allow a warm up time of at least 15 minutes for the NI PXI-6652 and three hours for the NI PXI-6653 to ensure the measurement circuitry is at a stable operating temperature.
- Keep PXI chassis filters clean and fan speed set to High.

Calibration Procedure

The steps used in the calibration procedure are as follows:

1. Initial setup.
2. Verification.
3. Adjustment.
4. Reverification.

Initial Setup

Complete the following steps to set up the NI PXI-665*x* for calibration.

1. Make sure all components involved in the calibration procedure are powered off.
2. Install the NI PXI-665*x* board into slot 2 of your chassis.

Note The module *must* be installed in slot 2 of the chassis.

3. Power on the PXI chassis first, and then the external equipment.
4. Make sure that all the appropriate driver and application software is installed on the host computer.
5. Configure the hardware properly with Measurement & Automation Explorer (MAX). Refer to the *NI PXI-665x Installation Guide* for details about configuring the PXI equipment.

Verification

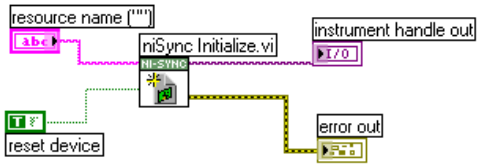
The following steps outline the procedure for measuring the 10 MHz oscillator frequency on the NI PXI-665*x* and determining whether the device requires adjustment to meet the published specifications.

Connecting the Clock Source

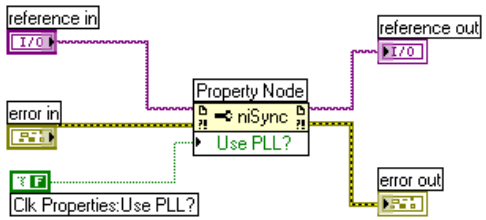
1. Connect the accurate 10 MHz source to the ClkIn connector on the NI PXI-665*x*.
2. Program the NI PXI-665*x* to route the ClkIn signal to PXI_Clk10In without using its 10 MHz PLL by completing steps a–d.

Note Use the data in the C function call reference as inputs to your LabVIEW VI where applicable.

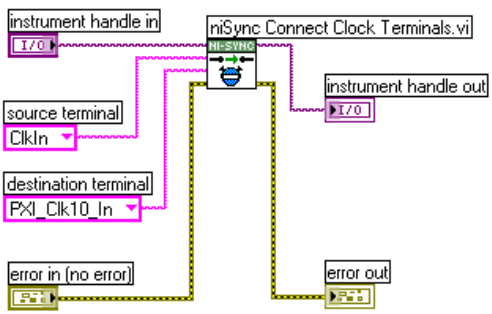
a. Call niSync Initialize VI to set up a handle for the device.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_init` with the following parameters: **resourceName**: `Dev1` **idQuery**: `NULL` **resetDevice**: `VI_TRUE` **vi**: `*SessionHandle`

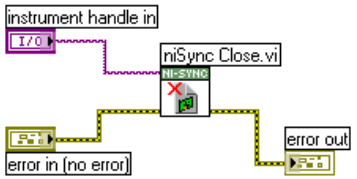
b. Set a writable NI-Sync property node to pass FALSE to the **Use PLL?** attribute.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_SetAttributeViBoolean` with the following parameters: **vi**: `"<SessionHandle>"` **terminalName**: `""` **attributeID**: `NISYNC_ATTR_CLKIN_USE_PLL` **attributeValue**: `VI_FALSE`

c. Call niSync Connect Clock Terminals VI to connect ClkIn to PXI_Clk10_In.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_ConnectClkTerminals` with the following parameters: **vi**: `"<SessionHandle>"` **sourceTerminal**: `NISYNC_VAL_CLKIN` **destinationTerminal**: `NISYNC_VAL_CLK10`

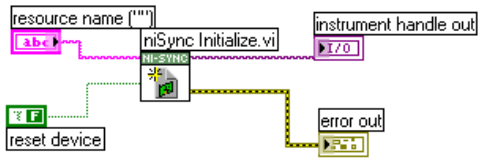
d. Call niSync Close VI to close the handle.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_close` with the following parameter: **vi**: `"<SessionHandle>"`

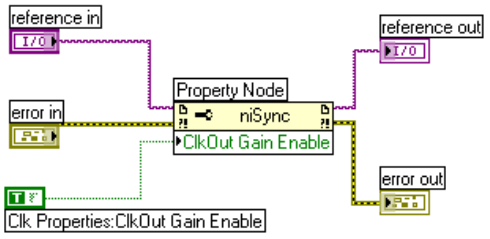
Measuring the Frequency

Complete the following procedure to measure the frequency of the onboard clock source.

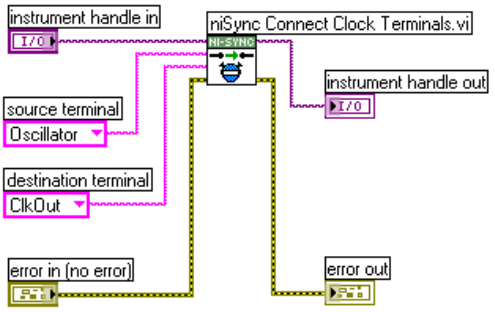
1. Connect the **ClkOut** terminal to the PFI 0 terminal by using an SMB-to-SMB cable.
2. Complete steps a–d to program the board to connect the onboard oscillator to ClkOut. Be sure to use the high-gain setting for clock out.
   a. Call niSync Initialize VI to set up a handle for the device.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_init` with the following parameters: **resourceName**: `Dev1` **idQuery**: `NULL` (ignored) **resetDevice**: `VI_FALSE` **vi**: `*SessionHandle`

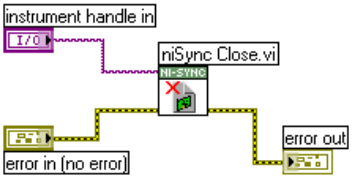
b. Set a writable NI-Sync property node to pass TRUE to the **ClkOut Gain Enable** attribute.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_SetAttributeViBoolean` with the following parameters: **vi**: `"<SessionHandle>"` **terminalName**: `""` **attributeID**: `NISYNC_ATTR_CLKOUT_GAIN_ENABLE` **attributeValue**: `VI_TRUE`

c. Call niSync Connect Clock Terminals VI to connect the oscillator to **ClkOut**.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_ConnectClkTerminals` with the following parameters: **vi**: "<SessionHandle>" **sourceTerminal**: `NISYNC_VAL_OSCILLATOR` **destinationTerminal**: `NISYNC_VAL_CLKOUT`

d. Call niSync Close VI to close the session handle.

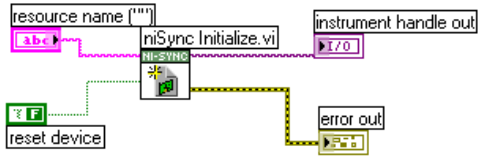
LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_close` with the following parameter: **vi**: "<SessionHandle>"

3. Complete steps a–c to measure the oscillator frequency through PFI 0. To obtain an accurate measurement for calibration, the measurement duration must be made sufficiently long. Refer to Table 1 for the measurement duration to use.

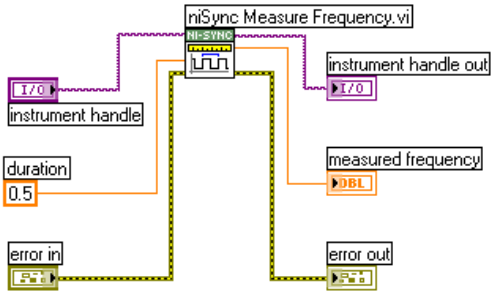
Table 1. Measurement Duration

Device	Measure Accuracy	Required Measurement Duration
NI PXI-6652	200 ppb	0.5 seconds
NI PXI-6653	1 ppb	100 seconds

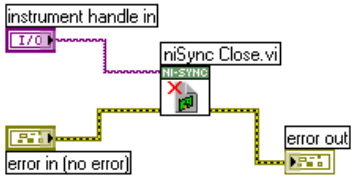
a. Call niSync Initialize VI to set up a handle for the device.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_init` with the following parameters: **resourceName**: `Dev1` **idQuery**: `NULL` **resetDevice**: `VI_FALSE` **vi**: `*SessionHandle`

b. Call niSync Measure Frequency VI to measure the frequency of the oscillator.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_MeasureFrequency` with the following parameters: **vi**: `"<SessionHandle>"` **sourceTerminal**: `NISYNC_VAL_OSCILLATOR` **duration**: `0.5` or `100` **actualDuration**: `*actualDuration` **measuredFrequency**: `*measuredFrequency` **error**: `*error`

c. Call niSync Close VI to close the session handle.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_close` with the following parameter: **vi**: `"<SessionHandle>"`

4. Compare the measured frequency to the device specifications.

To determine if the device under test meets its specifications, you must compare the measured frequency obtained in step 3 of *Measuring the Frequency* with the specified accuracy. Table 2 shows the frequency range that is acceptable according to the published specifications for the NI PXI-665*x*.

Table 2. One Year Test Limits

Device	Specified Accuracy + Aging	Acceptable Frequency Range—As Found	
		Low Limit	High Limit
NI PXI-6652 (TCXO)	± 3.5 ppm	9,999,965 Hz	10,000,035 Hz
NI PXI-6653 (OCXO)	± 57.6 ppb	9,999,999.424 Hz	10,000,000.576 Hz

Table 3. 24 Hour Test Limits

Device	Specified Initial Accuracy	Acceptable Frequency Range—As Left	
		Low Limit	High Limit
NI PXI-6652 (TCXO)	± 2.5 ppm	9,999,975 Hz	10,000,025 Hz
NI PXI-6653 (OCXO)	± 6.1 ppb	9,999,999.939 Hz	10,000,000.061 Hz

If the measured value is within the low-limit and high-limit range listed under the *Acceptable Frequency Range—As Left* in Table 3, the board is meeting published specifications for the 24 hour period following a calibration.

Table 4. Calibration Target Frequency Ranges

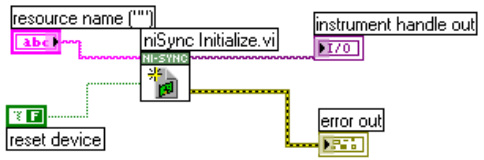
Device	Calibration Measurement Accuracy	Calibration Measurement Target Frequency Range	
		Low Limit	High Limit
NI PXI-6652 (TCXO)	200 ppb	9,999,998 Hz	10,000,002 Hz
NI PXI-6653 (OCXO)	1 ppb	9,999,999.99 Hz	10,000,000.01 Hz

If the measured value is within the low-limit and high-limit range listed under the *Calibration Measurement Target Frequency Range* in Table 4, the board is considered to be calibrated and no adjustment is needed.

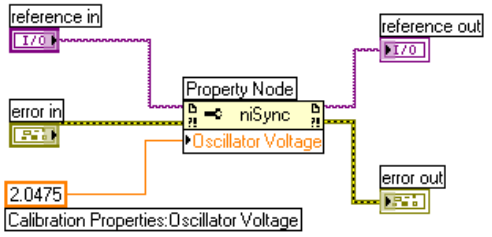
Adjustment

If the accuracy of the 10 MHz oscillator is outside the specified range for the product, the device is out of calibration. A programmable voltage controls the oscillator frequency. By varying this voltage and precisely measuring the frequency, you can find a voltage that gives a frequency as close as possible to 10 MHz.

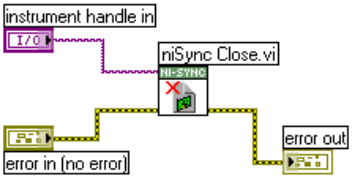
1. Complete steps a–c to set the oscillator control voltage. The range of acceptable voltage values is 0.0 V to 4.095 V with frequency increasing as voltage increases. Use a control voltage of 2.0475 V, which is in the middle of the valid range, as a starting point.
   a. Call niSync Initialize VI to set up a handle for the device.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_init` with the following parameters: **resourceName**: `Dev1` **idQuery**: `NULL` **resetDevice**: `VI_FALSE` **vi**: `*SessionHandle`

   b. Set a writable NI-Sync property node to pass the constant **2.0475** to the **Oscillator Voltage** attribute.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_SetAttributeViBoolean` with the following parameters: **vi**: `"<SessionHandle>"` **terminalName**: `""` **attributeID**: `NISYNC_ATTR_OSCILLATOR_VOLTAGE` **attributeValue**: `2.0475`

c. Call niSync Close VI to close the session handle.

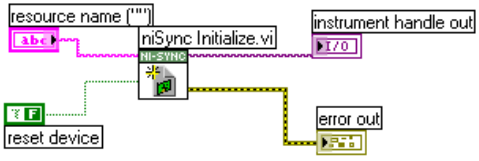
LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_close` with the following parameter: **vi**: "<SessionHandle>"

Proceed with the following steps to find the correct oscillator control voltage.

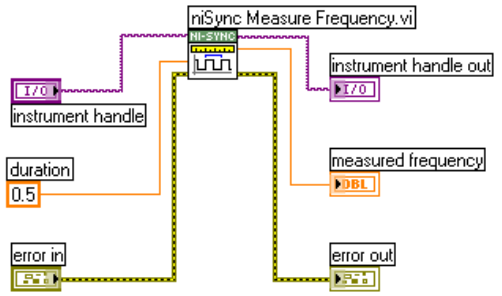
2. After setting the control voltage, measure the frequency again with the NI-Sync Measure Frequency VI to measure PFI 0, as shown in step 3 of the *Measuring the Frequency* section. To obtain an accurate measurement for calibration, the measurement duration must be made sufficiently long. Refer to Table 1, *Measurement Duration*, for the measurement duration to use.

   Complete steps a–c to measure PFI 0.

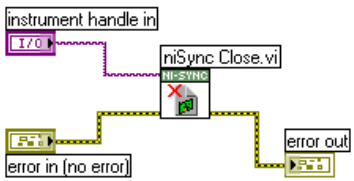
   a. Call niSync Initialize VI to set up a handle for the device.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_init` with the following parameters: **resourceName**: `Dev1` **idQuery**: `NULL` **resetDevice**: `VI_FALSE` **vi**: `*SessionHandle`

b. Call niSync Measure Frequency VI to measure the frequency of the oscillator.

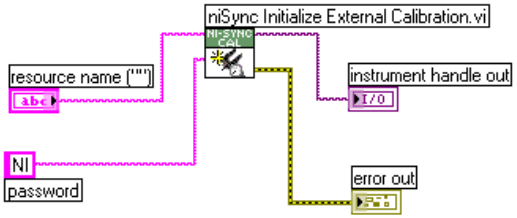
LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_MeasureFrequency` with the following parameters: **vi**: `"<SessionHandle>"` **sourceTerminal**: `NISYNC_VAL_OSCILLATOR` **duration**: `0.5` or `100` **actualDuration**: `*actualDuration` **measuredFrequency**: `*measuredFrequency` **error**: `*error`

c. Call niSync Close VI to close the session handle.

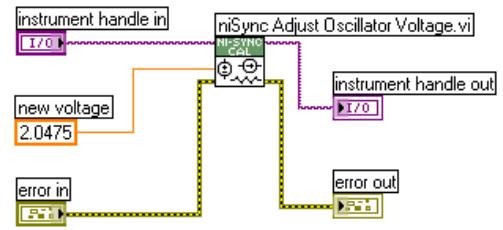
LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_close` with the following parameter: **vi**: `"<SessionHandle>"`

3. Compare the measured frequency to the device specifications.
4. If the measured frequency is still outside of the specified limit, repeat steps 1–3 of the *Adjustment* section until the measured value falls within the acceptable frequency range for your module, as shown in Table 4, *Calibration Target Frequency Ranges*.
5. Commit the calibration values to the Calibration EEPROM using the following procedure.
   a. Call niSync Initialize External Calibration VI to initialize the process.

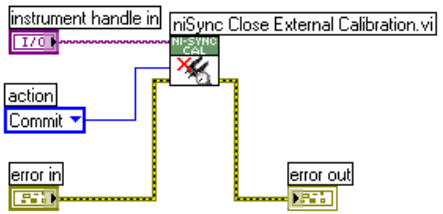
Note `NI` is the default user password. If you have changed the calibration password, use your user-selected calibration password in place of NI.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_InitExtCal` with the following parameters: **resourceName**: `"<MAX ID>"` **password**: `NI` **calibrationInstrumentHandle**: `*SessionHandle`

b. Call niSync Adjust Oscillator Voltage VI to adjust the voltage of the oscillator.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_CalAdjustOscillatorVoltage` with the following parameters: **vi**: `"<SessionHandle>"` **newVoltage**: <new control voltage> **oldVoltage**: `*oldVoltage`

c. Call niSync Close External Calibration VI to commit the settings and close the session.

LabVIEW Block Diagram	NI-SYNC C Function Call
	Call `niSync_CloseExtCal` with the following parameter: **vi**: `"<SessionHandle>"` **action**: `NISYNC_VAL_EXT_CAL_COMMIT`

Reverification

After completing the adjustments to the NI PXI-665*x*, it is important that you verify the oscillator frequency operation by repeating the steps listed in the *Verification* section. Re-verifying after making the adjustments ensures that the NI PXI-665*x* is operating within its test limits.

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.

National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world to help address your support needs. For telephone support in the United States, create your service request at `ni.com/support` and follow the calling instructions or dial 512 795 8248. For telephone support outside the United States, contact your local branch office:

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Poland 48 22 328 90 10, Portugal 351 210 311 210,
Russia 7 495 783 6851, Singapore 1800 226 5886,
Slovenia 386 3 425 42 00, South Africa 27 0 11 805 8197,
Spain 34 91 640 0085, Sweden 46 (0) 8 587 895 00,
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