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PCI-5114

CALIBRATION PROCEDURE

NI 5114

This document contains instructions for writing an external calibration procedure for the NI PXI/PXIe/PCI-5114. For more information about calibration, visit ni.com/calibration.

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Software

To calibrate the NI 5114, install the following versions of NI-SCOPE.

Table 1. Required Software for NI 5114 Calibration

Device	NI-SCOPE Version
NI PXI-5114	2.9 or later
NI PCI-5114	3.1 or later
NI PXIe-5114	14.1 or later

You can download NI-SCOPE from the Instrument Driver Network at ni.com/idnet. NI-SCOPE supports programming the [Self-Calibration](#) and [Verification](#) sections in a number of programming languages. However, only LabVIEW and C are supported for the [Adjustment](#) section.

NI-SCOPE includes all the functions and attributes necessary for calibrating the NI 5114. LabVIEW support is installed in `niScopeCal.llb`, and all calibration functions appear in the function palette. For LabWindows™/CVI™, the NI-SCOPE function panel `niScopeCal.fpf` provides further help on the functions available in CVI. Refer to Table 2 for installed file locations.

Calibration functions are LabVIEW VIs or C function calls in the NI-SCOPE driver. The C function calls are valid for any compiler capable of calling a 32-bit DLL. Many of the functions use constants defined in the `niScopeCal.h` file. To use these constants in C, you must include `niScopeCal.h` in your code when you write the calibration procedure.

For more information on the calibration VIs and functions, refer to the *NI-SCOPE Function Reference Help* or the *NI-SCOPE LabVIEW Reference Help*. These references can be found in the *NI High-Speed Digitizers Help*. Refer to the *NI-SCOPE Readme* for the installed locations of these documents.

Table 2. Calibration File Locations after Installing NI-SCOPE

File Name and Location	Description
<code>IVI\Bin\niscope_32.dll</code>	NI-SCOPE driver containing the entire NI-SCOPE API, including calibration functions.
<code>IVI\Lib\msc\niscope.lib</code>	NI-SCOPE library for Microsoft C containing the entire NI-SCOPE API, including calibration functions.
<code>LabVIEW (version)\examples\instr\niScope</code>	Directory of LabVIEW NI-SCOPE example VIs, including self-calibration.
<code>LabVIEW (version)\instr.lib\niScopeCalibrate\niScopeCal.llb</code>	LabVIEW VI library containing VIs for calling the NI-SCOPE calibration API.

Table 2. Calibration File Locations after Installing NI-SCOPE (Continued)

File Name and Location	Description
IVI\Drivers\niScope\ niScopeCal.fp	CVI function panel file that includes external calibration function prototypes and help on using NI-SCOPE in the CVI environment.
IVI\Include\niScopeCal.h	Calibration header file, which you must include in any C program accessing calibration functions. This file automatically includes niScope.h, which defines the rest of the NI-SCOPE interface.
IVI\Drivers\niScope\ Examples	Directory of NI-SCOPE examples for CVI, C, Visual C++, and Visual Basic.

Documentation

Consult the following documents for information about the NI PXI/PXIe/PCI-5114, NI-SCOPE, and your application software. All documents are available on ni.com, and the Help files install with the software.



NI High-Speed Digitizers Getting Started Guide

Contains: NI-SCOPE installation, hardware installation, and hardware programming



NI 5114 Specifications

Contains: NI PXI/PXIe/PCI-5114 specifications and calibration interval



NI-SCOPE Readme

Contains: Operating system and application software support in NI-SCOPE



NI High-Speed Digitizers Help

Contains: Detailed information about NI PXI/PXIe/PCI-5114



NI-SCOPE LabVIEW Reference Help

Contains: LabVIEW programming concepts and reference information about NI-SCOPE VIs and functions



NI-SCOPE Function Reference Help

Contains: Reference information for NI-SCOPE C functions and NI-SCOPE C properties

Password

The default calibration password is NI.

Calibration Interval

External Calibration

The measurement accuracy requirements of your application determine how often you should externally calibrate the NI 5114. NI recommends that you perform a complete external calibration at least once every two years. You can shorten this interval based on the accuracy demands of your application or the requirements of your processes. Refer to [Appendix A: Calibration](#) for more information.

Self-Calibration

Self-calibration can be performed as necessary to compensate for environmental changes.



Caution Although you can use self-calibration repeatedly, self-calibrating the NI 5114 more than a few times a day may cause excessive wear on the relays over time.

Test Equipment

Table 3 lists the equipment required for externally calibrating the NI 5114. If you do not have the recommended instruments, use these specifications to select a substitute calibration standard.

Table 3. Required Equipment Specifications for the NI 5114 External Calibration

Required Equipment	Recommended Equipment	Parameter Measured	Specification
Signal Generator	Fluke 9500B Oscilloscope Calibrator	DC Accuracy	DC $\pm(0.025\% + 25 \mu\text{V})$ into 1 M Ω
	or Wavetek 9500 (with high-stability reference option)	Bandwidth, Trigger Sensitivity	$\pm 2\%$ output amplitude flatness for leveled sine wave up to 125 MHz relative to 50 kHz into 50 Ω
	Fluke 9510 Test Head	Timing	± 2 ppm frequency accuracy
BNC cable	—	—	50 Ω



Note The delay times indicated in this procedure apply specifically to the Fluke 9500B calibrator. If you use a different calibrator, you may need to adjust these delay times.

Calibration Procedures

The calibration process includes the following steps:

1. *Initial Setup*—Install the device and configure it in Measurement & Automation Explorer (MAX).
2. *Self-Calibration*—Adjust the self-calibration constants of the device.
3. *Verification*—Verify the existing operation of the device. This step confirms whether the device is operating within its specified range prior to calibration.
4. *Adjustment*—Perform an external adjustment of the device that adjusts the calibration constants with respect to a known voltage source. The adjustment procedure automatically stores the calibration date on the EEPROM to allow traceability.
5. *Reverification*—Repeat the verification procedure to ensure that the device is operating within its specifications after adjustment.

These steps are described in more detail in the following sections.

Initial Setup

Refer to the *NI High-Speed Digitizers Getting Started Guide* for information about how to install the software and hardware, and how to configure the device in MAX.

Test Conditions

Follow these guidelines to optimize the connections and the environment during calibration:

- Always connect the calibrator test head directly to the input BNC of the device, or use a short 50 Ω BNC coaxial cable if necessary. Long cables and wires act as antennas, picking up extra noise that can affect measurements.
- Keep relative humidity between 10 and 90% non-condensing, or consult the device hardware documentation for the optimum relative humidity.
- Maintain an ambient temperature of 23 ± 5 °C. The device temperature will be greater than the ambient temperature.
- Allow a warm-up time of at least 15 minutes after the NI-SCOPE driver is loaded. Unless manually disabled, the NI-SCOPE driver automatically loads with the operating system and enables the device. The warm-up time ensures that the measurement circuitry of the NI 5114 is at a stable operating temperature.
- Plug the PXI/PXI Express chassis or PC and the calibrator into the same power strip to avoid ground loops.
- **(PXI/PXIe)** Ensure that the PXI/PXI Express chassis fan speed is set to HIGH, the fan filters are removed, and the empty slots contain PXI chassis slot blockers and filler panels. For more information refer to the *Maintain Forced-Air Cooling Note to Users* document available at ni.com/manuals.
- Verify that all connections to the device, including front panel connections, are secure.
- Use shielded copper wire for all cable connections to the device. Use twisted-pair wire to eliminate noise and thermal offsets.

Self-Calibration

The NI 5114 includes precise internal circuits and references used during self-calibration to adjust for time and temperature drift. The device gain, offset, flatness, and trigger timing are all corrected in self-calibration. Measuring the accuracy of these internal calibration circuits with another instrument during external calibration provides traceability for the verification procedure. Absolute accuracy is ensured by compensating for any error measured in the internal references.



Note Self-calibrate the device before you perform *Verification*. NI-SCOPE includes self-calibration example programs for LabVIEW, CVI, and Microsoft Visual C.

You can initiate self-calibration using the following methods:

- MAX
- NI-SCOPE Soft Front Panel (SFP)
- NI-SCOPE



Note The device must be installed in MAX before it can be used in another program.

MAX

To initiate self-calibration from MAX, complete the following steps:

1. Disconnect or disable any AC inputs to the device.
2. Launch MAX.
3. Select **My System»Devices and Interfaces»NI-DAQmx Devices**.
4. Select the device that you want to calibrate.
5. Initiate self-calibration using one of the following methods:
 - Click **Self-Calibrate** in the upper right corner of MAX.
 - Right-click the name of the device in the MAX configuration tree and select **Self-Calibrate** from the drop-down menu.

NI-SCOPE Soft Front Panel

To initiate self-calibration from the NI-SCOPE Soft Front Panel (SFP), complete the following steps:

1. Disconnect or disable any AC inputs to the device.
2. Launch the NI-SCOPE SFP, which is available at **Start»All Programs»National Instruments»NI-SCOPE»NI-SCOPE Soft Front Panel**.
3. Select the device you want to calibrate from the Select Device dialog box. The Select Device dialog box automatically opens when you launch the NI-SCOPE SFP.



Note To change the device, select **Edit»Change Device**, and select the new device that you want to calibrate.

4. Launch the Calibration dialog box by selecting **Utility»Self Calibration**.
5. Click **OK** to begin self-calibration.

NI-SCOPE

To self-calibrate the NI 5114 programmatically using NI-SCOPE, complete the following steps:

1. Disconnect or disable any AC inputs to the device.
2. Open a session and obtain a session handle using the niScope Initialize VI.



Note Throughout the procedure, refer to the C/C++ function call parameters for the LabVIEW input values.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_init</code> with the following parameters:</p> <p>vi: The returned session handle that you use to identify the instrument in all subsequent NI-SCOPE driver function calls</p> <p>resourceName: The device name assigned by MAX</p> <p>idQuery: <code>VI_FALSE</code></p> <p>resetDevice: <code>VI_TRUE</code></p>

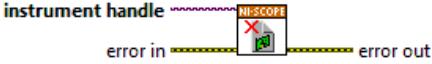
3. Self-calibrate the device using niScope Cal Self Calibrate VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_CalSelfCalibrate</code> with the following parameters:</p> <p>sessionHandle: The instrument handle from <code>niScope_init</code></p> <p>channelList: <code>VI_NULL</code></p> <p>option: <code>VI_NULL</code></p>



Note Because the session is a standard session rather than an external calibration session, the new calibration constants are immediately stored in the EEPROM. Therefore, you can include this procedure in any application that uses the device.

4. End the session using the niScope Close VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_close</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

Verification



Note After the 15-minute warm-up time, always self-calibrate the NI 5114 before beginning a verification procedure.

This section describes the program you must write to verify either the calibration test limits or the published specifications for the NI 5114.



Note If any of these tests fail after you perform an external adjustment, make sure that you have met the requirements listed in the [Test Equipment](#) and [Calibration Procedures](#) sections before you return the device to National Instruments for repair.

Vertical Offset and Vertical Gain Accuracy

Table 4 contains the input parameters for verifying both vertical offset accuracy and vertical gain accuracy of the NI 5114.

To verify vertical offset accuracy, complete the procedures described in the [Vertical Offset Accuracy](#) section for each of the 20 iterations listed in Table 4 for channel 0, then repeat the procedures for channel 1. The *Calibration Test Limits* and *Published Specifications* for vertical offset accuracy are shown in Table 5.

To verify vertical gain accuracy, complete the procedures described in the [Vertical Gain Accuracy](#) section for each of the 20 iterations listed in Table 7 for channel 0; then repeat the procedures for channel 1. The *Calibration Test Limits* and *Published Specifications* for vertical gain accuracy are shown in Table 6.

Table 4. NI 5114 Input Parameters for Vertical Offset Accuracy and Vertical Gain Accuracy Verification

Iteration	Max Input Frequency (MHz)	Range
1	125	0.04
2	125	0.1
3	125	0.2
4	125	0.4

Table 4. NI 5114 Input Parameters for Vertical Offset Accuracy and Vertical Gain Accuracy Verification (Continued)

Iteration	Max Input Frequency (MHz)	Range
5	125	1
6	125	2
7	125	4
8	125	10
9	125	20
10	125	40
11	20	0.04
12	20	0.1
13	20	0.2
14	20	0.4
15	20	1
16	20	2
17	20	4
18	20	10
19	20	20
20	20	40

Vertical Offset Accuracy

Complete the following steps to verify vertical offset accuracy of the NI 5114. You must verify both channels with each iteration listed in Table 5.

1. Open a session and obtain a session handle using the niScope Initialize VI.



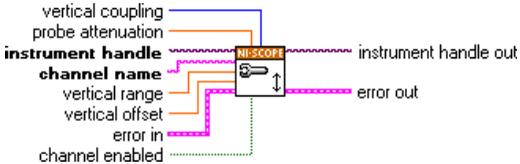
Note Throughout the procedure, refer to the C/C++ function call parameters for the LabVIEW input values.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_init</code> with the following parameters:</p> <p>resourceName: The device name assigned by MAX</p> <p>idQuery: <code>VI_FALSE</code></p> <p>resetDevice: <code>VI_TRUE</code></p>

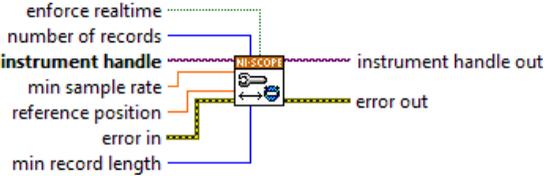
2. Configure the input impedance and the maximum input frequency using the niScope Configure Chan Characteristics VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureChanCharacteristics</code> with the following parameters:</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>channelList: "0"</p> <p>inputImpedance: <code>NISCOPE_VAL_1_MEG_OHM</code></p> <p>maxInputFrequency: The <i>Maximum Input Frequency</i> value in Table 5 for the current iteration</p>

3. Configure the common vertical properties using the niScope Configure Vertical VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureVertical</code> with the following parameters:</p> <p>coupling: <code>NISCOPE_VAL_DC</code> probeAttenuation: <code>1.0</code> vi: The instrument handle from <code>niScope_init</code> channelList: <code>"0"</code> range: The <i>Range</i> value in Table 4 for the current iteration offset: <code>0.0</code> enabled: <code>NISCOPE_VAL_TRUE</code></p>

4. Configure the horizontal properties using the niScope Configure Horizontal Timing VI.

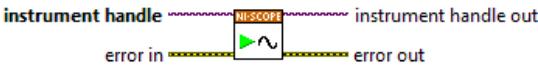
LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureHorizontalTiming</code> with the following parameters:</p> <p>enforceRealtime: <code>NISCOPE_VAL_TRUE</code> numRecords: <code>1</code> vi: The instrument handle from <code>niScope_init</code> minSampleRate: <code>10,000,000</code> refPosition: <code>50.0</code> minNumPts: <code>100,000</code></p>

5. Commit all the parameter settings to hardware using the niScope Commit VI.

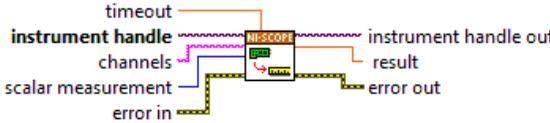
LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Commit</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

6. Short-circuit the channel 0 input of the device by connecting the calibrator test head directly to the device and grounding the output of the calibrator.

7. Wait 500 ms for the calibrator to ground its output.
8. Initiate a waveform acquisition using the niScope Initiate Acquisition VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Initiate Acquisition</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

9. Fetch a waveform from the device and perform a voltage average measurement using the niScope Fetch Measurement (poly) VI. Select the Measurement Scalar DBL instance of the VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Fetch Measurement</code> with the following parameters:</p> <p>timeout: 1.0</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>channelList: "0"</p> <p>scalarMeasFunction: <code>NISCOPE_VAL_VOLTAGE_AVERAGE</code></p>

Compare the resulting average voltage to the value listed in the *Published Specifications* column in Table 5 that corresponds to the settings used. If the result is within the selected test limit, the device has passed this portion of the verification.

10. Repeat steps 2 through 9 for each iteration in Table 4.
11. Move the calibrator test head to device input channel 1 and repeat steps 2 through 10 for every configuration in Table 4, changing the value of the **channelList** parameter from "0" to "1".
12. End the session using the niScope Close VI.

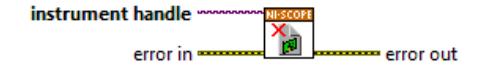
LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_close</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

Table 5. NI 5114 Vertical Offset Limits

Range	Calibration Test Limits (V)		Published Specifications (V)	
	PXI/PXIe	PCI	PXI/PXIe	PCI
0.04	±0.00024	±0.00032	±0.00032	±0.0004
0.1	±0.0002	±0.00048	±0.0005	±0.00058
0.2	±0.0004	±0.00068	±0.0008	±0.00088
0.4	±0.0008	±0.0008	±0.0014	±0.00148
1	±0.002	±0.002	±0.0032	±0.00328
2	±0.004	±0.004	±0.0062	±0.00628
4	±0.008	±.008	±0.0122	±0.01228
10	±0.02	±0.02	±0.0302	±0.03028
20	±0.04	±0.04	±0.0602	±0.06028
40	±0.08	±0.08	±0.1202	±0.12028

Vertical Gain Accuracy

Complete the following steps to verify the vertical gain accuracy of the NI 5114. You must verify both channels with each iteration listed in Table 4.

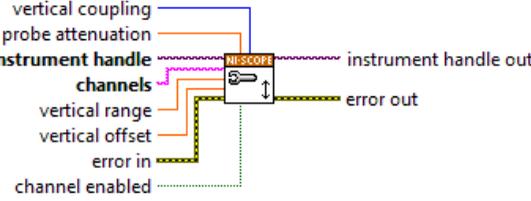
1. Open a session and obtain a session handle using the niScope Initialize VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_init</code> with the following parameters:</p> <p>resourceName: The device name assigned by MAX</p> <p>idQuery: <code>VI_FALSE</code></p> <p>resetDevice: <code>VI_TRUE</code></p>

- Configure the input impedance and the maximum input frequency using the niScope Configure Chan Characteristics VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureChanCharacteristics</code> with the following parameters:</p> <p>channelList: "0"</p> <p>inputImpedance: <code>NISCOPE_VAL_1_MEG_OHM</code></p> <p>maxInputFrequency: The <i>Maximum Input Frequency</i> value in Table 4 for the current iteration</p>

- Configure the common vertical properties using the niScope Configure Vertical VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureVertical</code> with the following parameters:</p> <p>coupling: <code>NISCOPE_VAL_DC</code></p> <p>probeAttenuation: 1.0</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>channelList: "0"</p> <p>range: The <i>Range</i> value in Table 4 for the current iteration</p> <p>offset: 0.0</p> <p>enabled: <code>NISCOPE_VAL_TRUE</code></p>

4. Configure the horizontal properties using the niScope Configure Horizontal Timing VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureHorizontalTiming</code> with the following parameters:</p> <p>enforceRealtime: <code>NISCOPE_VAL_TRUE</code></p> <p>numRecords: 1</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>minSampleRate: 10,000,000</p> <p>refPosition: 50.0</p> <p>minNumPts: 100,000</p>

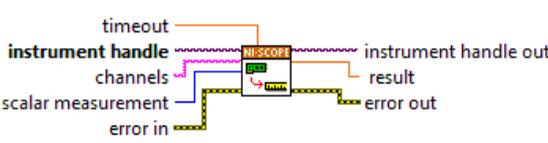
5. Commit all the parameter settings to hardware using the niScope Commit VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Commit</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

6. Connect the calibrator test head directly to the channel 0 input of the device and output the *Positive Input* voltage in Table 6 that corresponds to the vertical range used with a 1 MΩ load impedance.
7. Wait 2,500 ms for the impedance matching and frequency of the calibrator to settle.
8. Initiate a waveform acquisition using the niScope Initiate Acquisition VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_InitiateAcquisition</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

9. Fetch a waveform from the device and perform a voltage average measurement using the niScope Fetch Measurement (poly) VI. Select the Measurement Scalar DBL instance of the VI. This value is the *Measured Positive Voltage* used in step 14.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Fetch Measurement</code> with the following parameters:</p> <p>timeout: 1.0</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>channelList: "0"</p> <p>scalarMeasFunction: <code>NISCOPE_VAL_VOLTAGE_AVERAGE</code></p>

10. Using the calibrator, output the *Negative Input* voltage listed in Table 6 that corresponds to the vertical range used.
11. Wait 2,500 ms for the impedance matching and frequency of the calibrator to settle.
12. Initiate a waveform acquisition using the niScope Initiate Acquisition VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Initiate Acquisition</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

13. Fetch a waveform from the device and perform a voltage average measurement using the niScope Fetch Measurement (poly) VI. Select the Measurement Scalar DBL instance of the VI. This value is the *Measured Negative Voltage* used in step 14.

LabVIEW VI	C/C++ Function Call
	<p>Call niScope_Fetch Measurement with the following parameters:</p> <p>timeout: 1.0</p> <p>vi: The instrument handle from niScope_init</p> <p>channelList: "0"</p> <p>scalarMeasFunction: NISCOPE_VAL_VOLTAGE_AVERAGE</p>

14. Calculate the error in the vertical gain as a percentage of input using the following formula:

$$error = \left(\left(\frac{a-b}{c-d} \right) - 1 \right) \times 100$$

where

- a* = the *Measured Positive Voltage*
- b* = the *Measured Negative Voltage*
- c* = the applied *Positive Voltage*
- d* = the applied *Negative Voltage*

Compare the resulting percent error to the *Published Specifications* column listed in Table 6. If the result is within the selected test limit, the device has passed this portion of the verification.

15. Repeat steps 2 through 14 for each iteration in Table 5.
16. Move the calibrator test head to the device input channel 1 and repeat steps 2 through 15 for every iteration in Table 6, changing the value of the **channelList** parameter from "0" to "1".
17. End the session using the niScope Close VI.

LabVIEW VI	C/C++ Function Call
	<p>Call niScope_close with the following parameter:</p> <p>vi: The instrument handle from niScope_init</p>

Table 6. NI 5114 Vertical Gain Stimuli, Calibration Test Limits, and Published Specifications

Range (V)	Positive Input (V)	Negative Input (V)	Calibration Test Limits	Published Specifications
0.04	0.018	-0.018	±1.3975%	±1.5%
0.1	0.045	-0.045	±1.3975%	±1.5%
0.2	0.09	-0.09	±1.3975%	±1.5%
0.4	0.18	-0.18	±1.3975%	±1.5%
1	0.45	-0.45	±1.3975%	±1.5%
2	0.9	-0.9	±1.3975%	±1.5%
4	1.8	-1.8	±1.3975%	±1.5%
10	4.5	-4.5	±1.3975%	±1.5%
20	9	-9	±1.3975%	±1.5%
40	18	-18	±1.3975%	±1.5%

Programmable Vertical Offset Accuracy

Complete the following steps to verify the programmable vertical offset accuracy for each device channel.

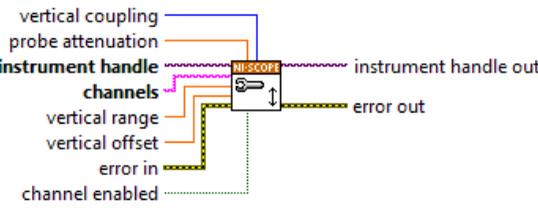
1. Open a session and obtain a session handle using the niScope Initialize VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_init</code> with the following parameters:</p> <p>resourceName: The device name assigned by MAX</p> <p>idQuery: <code>VI_FALSE</code></p> <p>resetDevice: <code>VI_TRUE</code></p>

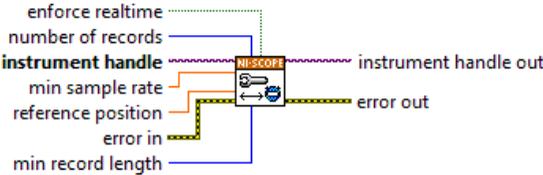
- Configure the input impedance and the maximum input frequency using the niScope Configure Chan Characteristics VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureChanCharacteristics</code> with the following parameters:</p> <p>vi: The instrument handle from <code>niScope_init</code> channelList: "0" inputImpedance: <code>NISCOPE_VAL_1_MEG_OHM</code> maxInputFrequency: 20,000,000</p>

- Configure the common vertical properties using the niScope Configure Vertical VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureVertical</code> with the following parameters:</p> <p>coupling: <code>NISCOPE_VAL_DC</code> probeAttenuation: 1.0 vi: The instrument handle from <code>niScope_init</code> channelList: "0" range: The <i>Range</i> value in Table 7 for the current iteration offset: The <i>Positive Offset</i> setting value in Table 7 for the current iteration enabled: <code>NISCOPE_VAL_TRUE</code></p>

4. Configure the horizontal properties using the niScope Configure Horizontal Timing VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureHorizontalTiming</code> with the following parameters:</p> <p>enforceRealtime: <code>NISCOPE_VAL_TRUE</code></p> <p>numRecords: 1</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>minSampleRate: 10,000,000</p> <p>refPosition: 50.0</p> <p>minNumPts: 100,000</p>

5. Commit all the parameter settings to hardware using the niScope Commit VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Commit</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

6. Connect the calibrator test head directly to the channel 0 input of the device.
7. Output the *Positive Output* voltage listed in Table 7 for the current iteration with a 1 M Ω load impedance.
8. Wait 2,500 ms for the impedance matching and frequency of the calibrator to settle.
9. Initiate a waveform acquisition using the niScope Initiate Acquisition VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_InitiateAcquisition</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

10. Fetch a waveform from the device and perform a voltage average measurement using the niScope Fetch Measurement (poly) VI. Select the Measurement Scalar DBL instance of the VI. This value is the *Measured Positive Voltage* used in step 17.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_FetchMeasurement</code> with the following parameters:</p> <p>timeout: 1.0</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>channelList: "0"</p> <p>scalarMeasFunction: <code>NISCOPE_VAL_VOLTAGE_AVERAGE</code></p>

11. Configure the common vertical properties using the niScope Configure Vertical VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureVertical</code> with the following parameters:</p> <p>coupling: <code>NISCOPE_VAL_DC</code></p> <p>probeAttenuation: 1.0</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>channelList: "0"</p> <p>range: The <i>Range</i> value in Table 7 for the current iteration</p> <p>offset: The <i>Negative Offset</i> setting in Table 7 for the current iteration</p> <p>enabled: <code>NISCOPE_VAL_TRUE</code></p>

12. Commit all the parameter settings to hardware using the niScope Commit VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Commit</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

13. Connect the calibrator test head directly to the channel 0 input of the device and output the *Negative Offset* voltage listed in Table 7 for the current iteration with a 1 MΩ load impedance.
14. Wait 2,500 ms for the impedance matching and frequency of the calibrator to settle.
15. Initiate a waveform acquisition using the niScope Initiate Acquisition VI.

LabVIEW VI	C/C++ Function Call
	Call <code>niScope_InitiateAcquisition</code> with the following parameter: vi: The instrument handle from <code>niScope_init</code>

16. Fetch a waveform from the device and perform a voltage average measurement using the niScope Fetch Measurement (poly) VI. Select the Measurement Scalar DBL instance of the VI. This value is the *Measured Negative Voltage* used in step 17.

LabVIEW VI	C/C++ Function Call
	Call <code>niScope_FetchMeasurement</code> with the following parameters: timeout: 1.0 vi: The instrument handle from <code>niScope_init</code> channelList: "0" scalarMeasFunction: <code>NISCOPE_VAL_VOLTAGE</code> <code>_AVERAGE</code>

17. Calculate the error in the programmable vertical offset as a percentage of input using the following formula:

$$error = \left(\left(\frac{a-b}{c-d} \right) - 1 \right) \times 100$$

where

- a* is the *Measured Positive Voltage*
- b* is the *Measured Negative Voltage*
- c* is the applied *Positive Voltage*
- d* is the applied *Negative Voltage*

Compare the resulting percent to the *Published Specifications* column listed in Table 7. If the result is within the selected test limit, the device has passed this portion of the verification.

18. Repeat steps 2 through 17 for each iteration in Table 7.
19. Move the calibrator test head to the device input channel 1 and repeat steps 2 through 18, changing the value of the **channelList** parameter from "0" to "1".
20. End the session using the niScope Close VI.

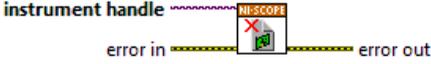
LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_close</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

Table 7. NI 5114 Programmable Vertical Offset Accuracy Stimuli, Calibration Test Limits, and Published Specifications

Iteration	Range (V)	Positive Offset (V)	Negative Offset (V)	Calibration Test Limits	Published Specifications
1	0.04	0.8	-0.8	±1.95%	±2%
2	0.1	0.8	-0.8	±1.95%	±2%
3	0.2	0.8	-0.8	±1.95%	±2%
4	0.4	0.8	-0.8	±1.95%	±2%
5	1	8	-8	±1.95%	±2%
6	2	8	-8	±1.95%	±2%
7	4	8	-8	±1.95%	±2%
8	10	30	-30	±1.95%	±2%
9	20	25	-25	±1.95%	±2%
10	40	15	-15	±1.95%	±2%

Timing Accuracy

Complete the following steps to verify the timing accuracy for the NI 5114.

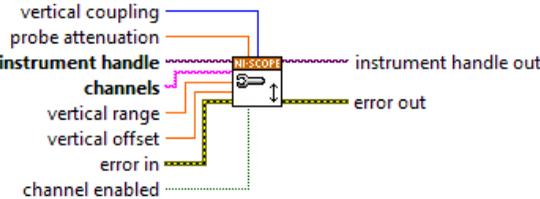
1. Open a session and obtain a session handle using the niScope Initialize VI.

LabVIEW VI	C/C++ Function Call
 <p>resource name id query reset device error in</p> <p>instrument handle error out</p>	<p>Call <code>niScope_init</code> with the following parameters:</p> <p>resourceName: The device name assigned by MAX idQuery: <code>VI_FALSE</code> resetDevice: <code>VI_TRUE</code></p>

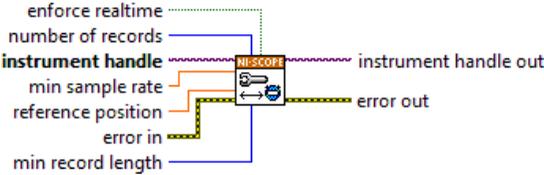
2. Configure the input impedance and the maximum input frequency using the niScope Configure Chan Characteristics VI.

LabVIEW VI	C/C++ Function Call
 <p>instrument handle channel name input impedance max input frequency error in</p> <p>instrument handle out error out</p>	<p>Call <code>niScope_ConfigureChanCharacteristics</code> with the following parameters:</p> <p>channelList: "0" inputImpedance: <code>NISCOPE_VAL_50_OHM</code> maxInputFrequency: <code>20,000,000</code></p>

3. Configure the common vertical properties using the niScope Configure Vertical VI.

LabVIEW VI	C/C++ Function Call
 <p>vertical coupling probe attenuation instrument handle channels vertical range vertical offset error in channel enabled</p> <p>instrument handle out error out</p>	<p>Call <code>niScope_ConfigureVertical</code> with the following parameters:</p> <p>coupling: <code>NISCOPE_VAL_DC</code> probeAttenuation: <code>1.0</code> vi: The instrument handle from <code>niScope_init</code> channelList: "0" range: <code>2.0</code> offset: <code>0.0</code> enabled: <code>NISCOPE_VAL_TRUE</code></p>

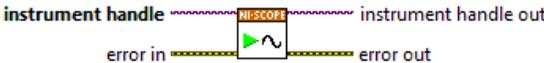
4. Configure the horizontal properties using the niScope Configure Horizontal Timing VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureHorizontalTiming</code> with the following parameters:</p> <p>enforceRealtime: <code>NISCOPE_VAL_TRUE</code></p> <p>numRecords: 1</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>minSampleRate: 250,000,000</p> <p>refPosition: 50.0</p> <p>minNumPts: 2,500,000</p>

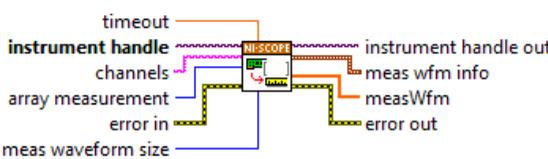
5. Commit all the parameter settings to hardware using the niScope Commit VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Commit</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

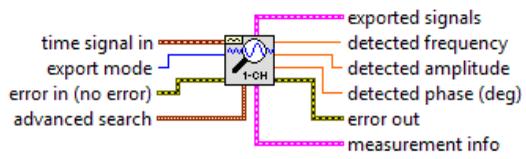
6. Connect the scope calibrator test head directly to the channel 0 input of the device. Configure the calibrator to output an exact 11 MHz sine wave with 1 V_{pk-pk} amplitude and 50 Ω load impedance.
7. Wait 2,500 ms for the impedance matching and frequency of the calibrator to settle.
8. Initiate a waveform acquisition using the niScope Initiate Acquisition VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_InitiateAcquisition</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

9. Retrieve a waveform using the niScope Fetch (poly) VI. Select the Array Measurement 1D DBL instance of the VI. Use the default value for the **timestamp Type** parameter.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Fetch Measurement</code> with the following parameters:</p> <p>timeout: 5.0 vi: The instrument handle from <code>niScope_init</code> channelList: "0" numSamples: -1</p>

10. Measure the exact frequency of the peak around 11 MHz using the Extract Single Tone Information VI with the following inputs.
- **advanced search»approx freq.:** -1
 - **advanced search»search:** 5
 - **export signals:** 0 (none)

LabVIEW VI	C/C++ Function Call
	<p>Perform an FFT on the array of data from step 9.</p>

11. Calculate the error in timing as parts per million (ppm) using the following formula:

$$\text{error} = (a - 11,000,000) / 11$$

where *a* is the measured frequency.

Compare the result to the *Published Specifications* column listed in Table 8. If the result is within the selected test limit, the device has passed this portion of the verification.



Note The same time source is used for both channel 0 and channel 1, so you only need to verify the timing accuracy on one channel.

12. End the session using the niScope Close VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_close</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

Table 8. NI 5114 Timing Accuracy Limits and Published Specifications

Calibration Test Limits	Published Specifications
±5.3 ppm	±25 ppm

Bandwidth and Flatness

Complete the following steps to verify the bandwidth and flatness of the NI 5114. You must verify both channels with each iteration listed in Table 9.



Note Verification of bandwidth is optional.

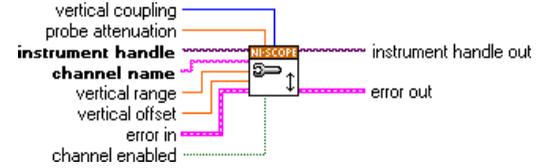
1. Open a session and obtain a session handle using the niScope Initialize VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_init</code> with the following parameters:</p> <p>resourceName: The device name assigned by MAX</p> <p>idQuery: <code>VI_FALSE</code></p> <p>resetDevice: <code>VI_TRUE</code></p>

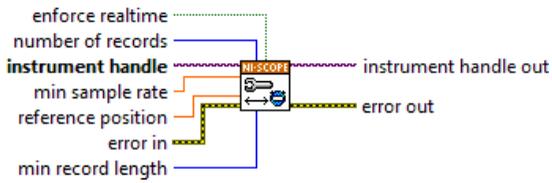
- Configure the input impedance and the maximum input frequency using the niScope Configure Chan Characteristics VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureChanCharacteristics</code> with the following parameters:</p> <ul style="list-style-type: none"> vi: The instrument handle from <code>niScope_init</code> channelList: " 0 " inputImpedance: <code>NISCOPE_VAL_50_OHM</code> maxInputFrequency: The <i>Maximum Input Frequency</i> value in Table 9 for the current iteration

- Configure the common vertical properties using the niScope Configure Vertical VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureVertical</code> with the following parameters:</p> <ul style="list-style-type: none"> coupling: <code>NISCOPE_VAL_DC</code> probeAttenuation: 1.0 vi: The instrument handle from <code>niScope_init</code> channelList: " 0 " range: The <i>Range</i> value in Table 9 for the current iteration offset: 0.0 enabled: <code>NISCOPE_VAL_TRUE</code>

4. Configure the horizontal properties using the niScope Configure Horizontal Timing VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureHorizontalTiming</code> with the following parameters:</p> <p>enforceRealtime: <code>NISCOPE_VAL_TRUE</code></p> <p>numRecords: 1</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>minSampleRate: 10,000,000</p> <p>refPosition: 50.0</p> <p>minNumPts: 30,000</p>

5. Commit all the parameter settings to hardware using the niScope Commit VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Commit</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

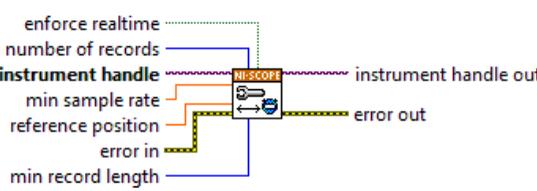
6. Connect the calibrator test head directly to the channel 0 input of the device. Configure the calibrator to output a 50 kHz sine wave with peak-to-peak voltage amplitude set to half the vertical range of the device. Configure the load impedance of the calibrator to match the input impedance of the device.
7. Wait 2,500 ms for the impedance matching and frequency of the calibrator to settle.
8. Initiate a waveform acquisition using the niScope Initiate Acquisition VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_InitiateAcquisition</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

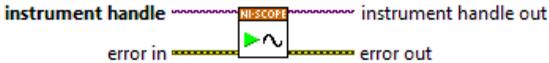
9. Fetch a waveform from the device and perform a voltage RMS measurement using the niScope Fetch (poly) Measurement VI. Select the Measurement Scalar DBL instance of the VI. This value is the *Measured RMS Voltage of 50 kHz Sine Wave* used in step 11.e.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_FetchMeasurement</code> with the following parameters:</p> <p>timeout: 1.0</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>channelList: "0"</p> <p>scalarMeasFunction: <code>NISCOPE_VAL_VOLTAGE_RMS</code></p>

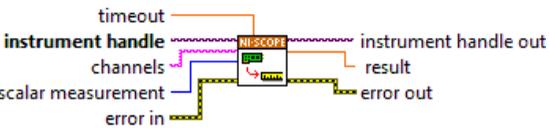
10. Configure the horizontal properties using the niScope Configure Horizontal Timing VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureHorizontalTiming</code> with the following parameters:</p> <p>enforceRealtime: <code>NISCOPE_VAL_TRUE</code></p> <p>numRecords: 1</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>minSampleRate: 250,000,000</p> <p>refPosition: 50.0</p> <p>minNumPts: 300,000</p>

11. Repeat steps 11. a through 11. e for each *Input Frequency* in the current iteration.
 - a. Configure the calibrator to output the *Input Frequency* listed in Table 9 for the current iteration.
 - b. Wait 2,500 ms for the impedance matching and frequency of the calibrator to settle.
 - c. Initiate a waveform acquisition using the niScope Initiate Acquisition VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_InitiateAcquisition</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

- d. Fetch a waveform from the device and perform a voltage RMS measurement using the niScope Fetch Measurement (poly) VI. Select the Measurement Scalar DBL instance of the VI. This value is the *Measured RMS Voltage of Generated Sine Wave* used in step 11. e.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_FetchMeasurement</code> with the following parameters:</p> <p>timeout: 1.0</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>channelList: "0"</p> <p>scalarMeasFunction: NISCOPE_VAL_VOLTAGE_RMS</p>

- e. Calculate the power difference using the following formula:

$$\text{power} = (20\log_{10} a) - (20\log_{10} b)$$

where

a is the *Measured RMS Voltage of Generated Sine Wave*

b is the *Measured RMS Voltage of 50 kHz Sine Wave*

If the result is within the test limits in Table 9, the device has passed this portion of the verification.

12. Repeat steps 2 through 11 for each iteration in Table 9.
13. Move the calibrator test head to the device input channel 1 and repeat steps 2 through 12, changing the value of the **channelList** parameter from "0" to "1".

14. End the session using the niScope Close VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_close</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

Table 9. NI 5114 Bandwidth and Flatness Stimuli and Published Specifications

Iteration	Max Input Frequency (MHz)	Range (V)	Input Frequency (MHz)	Published Specifications	
				Max Level (dB)	Min Level (dB)
1	125	0.04	50.1	1	-1
			100.1	3	-3
2	125	0.4	50.1	1	-1
			125.1	3	-3
3	125	2	50.1	1	-1
			125.1	3	-3
4	125	10	50.1	1	-1
			125.1	3	-3
5	20	1	20.1	N/A	-3*
			25.1	-3*	N/A

* Published specification value listed for validation of noise filter only. The specification is not included in the *NI PXIe-5114 Specifications* document. Verification of these limits is optional.

Trigger Sensitivity

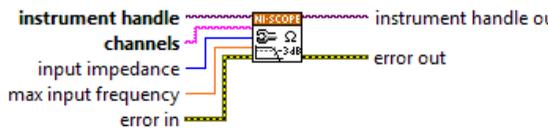
Complete the following steps to verify the trigger sensitivity of the NI 5114. You must verify channel 0, channel 1, and the external trigger channel using the corresponding iterations listed in Table 10. Use the following inputs:

- For channel 0, use the entries for iterations 1 and 2.
- For channel 1, use the entries for iterations 3 and 4.
- For the external trigger channel, use the entries for iterations 5 and 6.

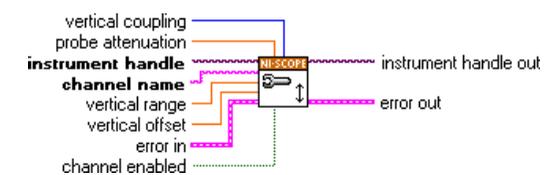
1. Open a session and obtain a session handle using the niScope Initialize VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_init</code> with the following parameters:</p> <p>resourceName: The device name assigned by MAX</p> <p>idQuery: <code>VI_FALSE</code></p> <p>resetDevice: <code>VI_TRUE</code></p>

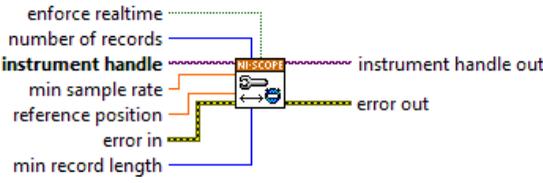
2. Configure the input impedance and the maximum input frequency using the niScope Configure Chan Characteristics VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureChanCharacteristics</code> with the following parameters:</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>channelList: <code>"0"</code></p> <p>inputImpedance: <code>NISCOPE_VAL_50_OHM</code></p> <p>maxInputFrequency: <code>125,000,000</code></p>

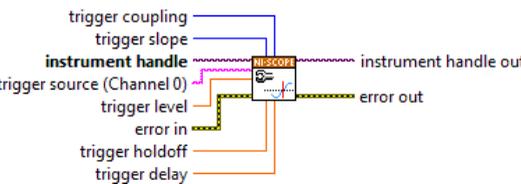
3. Configure the common vertical properties using the niScope Configure Vertical VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureVertical</code> with the following parameters:</p> <p>coupling: <code>NISCOPE_VAL_DC</code></p> <p>probeAttenuation: <code>1.0</code></p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>channelList: <code>"0"</code></p> <p>range: <code>0.2</code></p> <p>offset: <code>0.0</code></p> <p>enabled: <code>NISCOPE_VAL_TRUE</code></p>

4. Configure the horizontal properties using the niScope Configure Horizontal Timing VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureHorizontalTiming</code> with the following parameters:</p> <p>enforceRealtime: <code>NISCOPE_VAL_TRUE</code></p> <p>numRecords: 50</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>minSampleRate: 250,000,000</p> <p>refPosition: 50.0</p> <p>minNumPts: 1,000</p>

5. Configure an edge trigger using the niScope Configure Trigger (poly) VI. Select the Analog Edge Ref Trigger instance of the VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_ConfigureTriggerEdge</code> with the following parameters:</p> <p>triggerCoupling: <code>NISCOPE_VAL_DC</code></p> <p>slope: The <i>Slope</i> value in Table 10 for the current iteration</p> <p>vi: The instrument handle from <code>niScope_init</code></p> <p>triggerSource: The <i>Trigger Source</i> value in Table 10 for the current iteration</p> <p>level: The <i>Level</i> value in Table 10 for the current iteration</p> <p>holdoff: 0</p> <p>delay: 0</p>



Note The trigger level is set to center the trigger hysteresis window at 0.0 V.

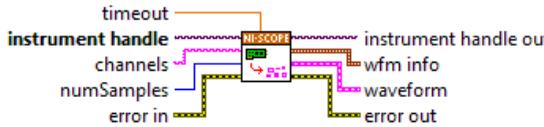
6. Commit all the parameter settings to hardware using the niScope Commit VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Commit</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

7. Connect the scope calibrator test head directly to the device input for the channel you are testing. Configure the calibrator to output the appropriate signal in Table 10.
8. Wait 2,500 ms for the impedance matching and frequency of the calibrator to settle.
9. Initiate a waveform acquisition using the niScope Initiate Acquisition VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Initiate Acquisition</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

10. Acquire a waveform using the niScope Fetch (poly) VI. Select the Cluster instance of the VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Fetch</code> with the following parameter:</p> <p>timeout: 2.0 vi: The instrument handle from <code>niScope_init</code> channelList: "0" numSamples: -1</p>

11. If the device does not time out, the device has passed this portion of the verification. If the device does time out, you must call the niScope Abort VI to end the acquisition. If your device fails and you end the acquisition, you must re-run the verification.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_Abort</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

12. To verify the trigger sensitivity on channel 1, repeat steps 2 through 11 using the values in Table 10, iterations 3 and 4. Make the following changes:
- Change **channelList** to "1" in steps 2, 3, and 10.
 - Connect the calibrator test head to channel 1 in step 7.
13. To verify the trigger sensitivity on the external trigger channel, repeat steps 2 through 11 using the values in Table 10, iterations 5 and 6. Make the following changes:
- Change **channelList** to "0" in steps 2, 3, and 10.
 - Connect the calibrator test head to the external trigger channel (TRIG) in step 7.
14. End the session using the niScope Close VI.

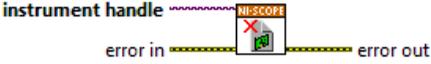
LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_close</code> with the following parameter:</p> <p>vi: The instrument handle from <code>niScope_init</code></p>

Table 10. NI 5114 Trigger Sensitivity Inputs

Iteration	Trigger Source	Level	Slope	Calibrator Signal
1	0	1 mV	NISCOPE_VAL_POSITIVE	9.7 mV _{pk-pk} 100 MHz sine wave with 50 Ω load impedance
2	0	-1 mV	NISCOPE_VAL_NEGATIVE	
3	1	1 mV	NISCOPE_VAL_POSITIVE	9.7 mV _{pk-pk} 100 MHz sine wave with 50 Ω load impedance
4	1	-1 mV	NISCOPE_VAL_NEGATIVE	
5	VAL_EXTERNAL	50 mV	NISCOPE_VAL_POSITIVE	485 mV _{pk-pk} 125 MHz sine wave with 1 MΩ load impedance
6	VAL_EXTERNAL	-50 mV	NISCOPE_VAL_NEGATIVE	

Adjustment

If the NI 5114 successfully passed each of the verification procedures within the calibration test limits, then an adjustment is recommended but not required to guarantee the published specifications for the next two years. You can update the calibration date and onboard calibration temperature without making any adjustments by completing only steps 1 and 13.f in this section. If the device was not within the calibration test limits for each of the verification procedures, you can perform the adjustment procedure to improve the accuracy of the device. Refer to the [Appendix A: Calibration](#) section to determine which procedures to perform.

An adjustment is required only once every two years. Following the adjustment procedure automatically updates the calibration date and temperature in the EEPROM of the device.

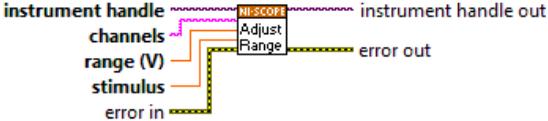
Complete all of the following steps to externally adjust the NI 5114:

1. Obtain an instrument session handle using the niScope Cal Start VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_CalStart</code> with the following parameters:</p> <p>resourceName: The name of the device to calibrate. You can find this name under Devices and Interfaces in MAX.</p> <p>password: The password required to open an external calibration session. If this password has not been changed since manufacturing, the password is "NI".</p>

2. Short-circuit the channel 0 input of the device by connecting the calibrator test head directly to the device and grounding the output of the calibrator.
3. Wait 2,500 ms for the impedance matching and frequency of the calibrator to settle.

- Adjust the vertical range using the niScope Cal Adjust Range VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_CalAdjustRange</code> with the following parameters:</p> <p>sessionHandle: The instrument handle from <code>niScope_CalStart</code></p> <p>channelName: "0"</p> <p>range: 10</p> <p>stimulus: 0</p>

- Configure the calibrator to output the voltage listed under the *Input (V)* column in Table 11. Configure the load impedance of the calibrator to 1 M Ω .
- Wait 2,500 ms for the impedance matching and frequency of the calibrator to settle.
- Adjust the vertical range using the niScope Cal Adjust Range VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_CalAdjustRange</code> with the following parameters:</p> <p>sessionHandle: The instrument handle from <code>niScope_CalStart</code></p> <p>channelName: "0"</p> <p>range: The <i>Range</i> value in Table 11 for the current iteration</p> <p>stimulus: The <i>Input voltage</i> in Table 11 for the current iteration</p>

- Repeat steps 5 through 7 for each iteration in Table 11.
- Move the calibrator test head to the device input channel 1 and repeat steps 2 through 8, changing the value of the **channelList** parameter from "0" to "1".
- Using a BNC cable, connect REF FREQUENCY OUTPUT on the back of the calibrator to the channel 0 input of the device. Make sure the output of the reference frequency is enabled and set to 10 MHz. If you are not using a Fluke 9500B/Wavetek 9500 calibrator, connect a precise 10 MHz, 1 V_{pk-pk} sine or square wave source to channel 0.

11. Adjust the sample rate using the niScope Cal Adjust VCXO VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_CalAdjustVCXO</code> with the following parameters:</p> <p>sessionHandle: The instrument handle from <code>niScope_CalStart</code></p> <p>stimulusFreq: 10,000,000</p>



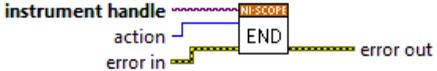
Note The 10 MHz stimulus is automatically taken from channel 0.

12. Disconnect or disable all inputs to the device.

13. Self-calibrate the device using niScope Cal Self Calibrate VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_CalSelfCalibrate</code> with the following parameters:</p> <p>sessionHandle: The instrument handle from <code>niScope_CalStart</code></p> <p>channelList: <code>VI_NULL</code></p> <p>option: <code>VI_NULL</code></p>

f. End the session and save the results using the niScope Cal End VI.

LabVIEW VI	C/C++ Function Call
	<p>Call <code>niScope_CalEnd</code> with the following parameters:</p> <p>sessionHandle: The instrument handle from <code>niScope_CalStart</code></p> <p>action: <code>NISCOPE_VAL_ACTION_STORE</code></p>

You have finished adjusting the NI 5114. Repeat the steps listed in the *Verification* section to reverify the performance of the NI 5114 after adjustments.

Table 11. NI 5114 Input Parameters for External Adjustment

Iteration	Range (V)	Input (V)
1	40	18
2	20	9
3	10	4.5
4	4	1.8
5	2	0.9
6	1	0.45
7	0.4	0.18
8	0.2	0.09
9	0.1	0.045
10	0.04	0.018
11	40	-18
12	20	-9
13	10	-4.5
14	4	-1.8
15	2	-0.9
16	1	-0.45
17	0.4	-0.18
18	0.2	-0.09
19	0.1	-0.045
20	0.04	-0.018

Appendix A: Calibration

External calibration involves verification and, if necessary, adjustment and reverification. Adjustment is the process of measuring and compensating for device performance to improve the measurement accuracy. Performing an adjustment updates the calibration date, effectively resetting the calibration interval. The device is guaranteed to meet or exceed its published specifications for the duration of the calibration interval. Verification is the process of testing the device to ensure that the measurement accuracy is within certain specifications. Verification can be used to ensure that the adjustment process was successful or to determine if the adjustment process needs to be performed at all. During verification, you must compare the measurement error to the limits given in each section.

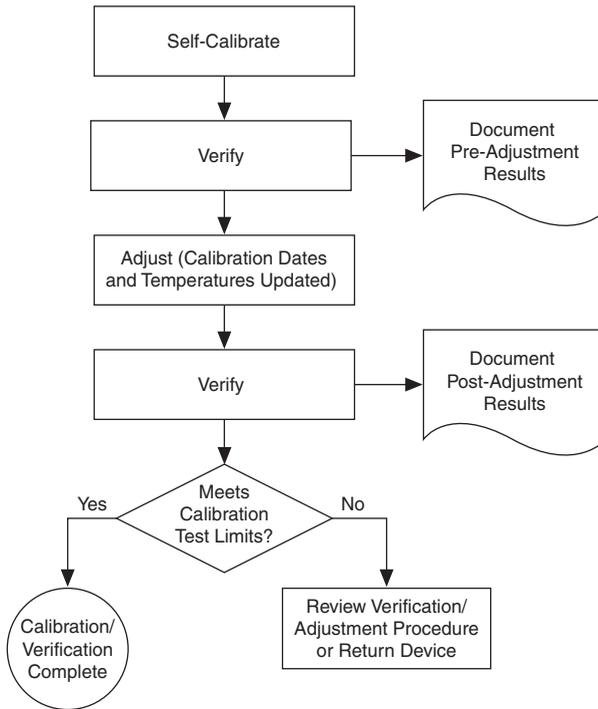
This document provides two sets of test limits for most verification stages—the *calibration test limits* and the *published specifications*. The calibration test limits are more restrictive than the published specifications. If all of the measurement errors determined during verification fall within the calibration test limits, the device is guaranteed to meet or exceed its published specifications for a full calibration interval (two years). For this reason, you must verify against the calibration test limits when performing verification after adjustment. If all of the measurement errors determined during verification fall within the published specifications, but not within the calibration test limits, the device is meeting its published specifications. While the device does not necessarily remain within these specifications for an additional two years, it will meet published specifications for the remainder of the current calibration interval. In this case, you can perform an adjustment if you want to further improve the measurement accuracy or reset the calibration interval. If some measurement errors determined during verification do not fall within the published specifications, you must perform an adjustment to restore the device operation to its published specifications.

The *Complete Calibration* section describes the recommended calibration procedure.

Complete Calibration

Perform a complete calibration to guarantee that the NI 5114 meets or exceeds its published specifications for a two-year calibration interval. At the end of the complete calibration procedure, verify that the measurement error falls within the calibration test limits. Figure 1 shows the programming flow for a complete calibration.

Figure 1. Complete Calibration Programming Flow



Appendix B: Calibration Utilities

NI-SCOPE supports several calibration utilities you can use to retrieve information about adjustments performed on the NI 5114, change the external calibration password, and store small amounts of information in the onboard EEPROM. Although you can retrieve some data using MAX, you can retrieve all the data programmatically using NI-SCOPE functions.

MAX

To retrieve data using MAX, complete the following steps:

1. Select the device from which you want to retrieve information from **My System»Devices and Interfaces**.
2. Select the **Settings** tab in the lower left corner.

You should see information about the last date and temperature for both external and self-calibration.

NI-SCOPE

NI-SCOPE provides a full complement of calibration utility functions and VIs. Refer to the *NI High-Speed Digitizers Help* for the complete function reference and VI reference. The utility functions include:

- `niScope_CalChangePassword` (niScope Cal Change Password VI)
- `niScope_CalFetchCount` (niScope Cal Fetch Count VI)
- `niScope_CalFetchDate` (niScope Cal Fetch Date VI)
- `niScope_CalFetchMiscInfo` (niScope Cal Fetch Misc Info VI)
- `niScope_CalFetchTemperature` (niScope Cal Fetch Temperature VI)
- `niScope_CalStoreMiscInfo` (niScope Cal Store Misc Info VI)

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