CALIBRATION PROCEDURE

NI PXI/PCI-5122

Contents

Conventions

The following conventions are used in this manual:

» — 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.

♦ — The ♦ symbol indicates that the following text applies only to a specific product, a specific operating system, or a specific software version.

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

This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash. When this symbol is marked on a product, refer to the Safety and Radio-Frequency Interference Read Me First document for information about precautions to take.

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. This font 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, and code excerpts.

`monospace italic` — Italic text in this font denotes text that is a placeholder for a word or value that you must supply.

Introduction

This document contains instructions for calibrating the NI PXI/PCI-5122 digitizer (NI 5122). This calibration procedure is intended for metrology labs. It describes specific programming steps for writing an external calibration procedure for the NI 5122.

What Is Calibration?

Calibration consists of verifying the measurement accuracy of a device and correcting for any measurement error. Verification is measuring the performance of a device and comparing the results to the specifications of the device. NI calibrates every NI 5122 digitizer at the factory. During the factory calibration process, the calibration constants are stored in an onboard EEPROM. These values are loaded from this EEPROM and used as needed by the digitizer.

The NI 5122 supports two types of calibration: self-calibration (or internal calibration) and external calibration.

Self-Calibration

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

External Calibration

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

Why Should You Calibrate?

The accuracy of electronic components drifts with time and temperature, which can affect measurement accuracy as a device ages. Calibration verifies that the digitizer still meets its specified accuracy and NI standards. If adjustments are necessary, calibration makes the adjustments to restore the accuracy of the digitizer.

How Often Should You Calibrate?

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

Caution Although you can use self-calibration repeatedly, self-calibrating the NI 5122 more than a few times a day may cause excessive wear on the relays over time.

The measurement accuracy requirements of your application determine how often you should externally calibrate the NI 5122. 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. Refer to the *External Calibration Options* section for more information.

Software and Documentation Requirements

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

Software

Calibrating the NI 5122 requires installing NI-SCOPE version 2.6 or later on the calibration system. You can download NI-SCOPE from the Instrument Driver Network at `ni.com/idnet`. NI-SCOPE supports programming the *Self-Calibration Procedures* in a number of programming languages. However, only LabVIEW and C are supported for the *External Calibration Procedures*.

NI-SCOPE 2.6 or later includes all the functions and attributes necessary for calibrating the NI 5122. For LabWindows™/CVI™, the NI-SCOPE function panel `niScopeCal.fp` provides further help on the functions available in CVI. LabVIEW support is installed in `niScopeCal.llb`, and all calibration functions appear in the function palette. Refer to Table 1 for file locations.

Calibration functions are C function calls or LabVIEW VIs in the NI-SCOPE driver. In this document, the C function call is shown first, followed by the corresponding LabVIEW VI in parentheses. 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 functions and VIs, refer to the *NI-SCOPE Function Reference Help* or the *NI-SCOPE VI Reference Help*. These references can be found in the *NI High-Speed Digitizers Help*. To access this help file, go to **Start»Programs»National Instruments» NI-SCOPE»Documentation»NI High-Speed Digitizers Help**.

Table 1. Calibration File Locations after Installing NI-SCOPE 2.6 or Later

File Name and Location	Description
`IVI\Bin\niscope_32.dll`	NI-SCOPE driver containing the entire NI-SCOPE API, including calibration functions
`IVI\Lib\msc\niscope.lib`	NI-SCOPE library for Microsoft C containing the entire NI-SCOPE API, including calibration functions
`LabVIEW (`*`version`*`)\examples\instr\niScope`	Directory of LabVIEW NI-SCOPE example VIs, including self-calibration; access the calibration example from the LabVIEW function palette
`LabVIEW (`*`version`*`)\instr.lib\niScope Calibrate\niScopeCal.llb`	LabVIEW VI library containing VIs for calling the NI-SCOPE calibration API; access calibration functions from the NI-SCOPE calibration section of the LabVIEW function palette
`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

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

- *NI High-Speed Digitizers Getting Started Guide*
- *NI High-Speed Digitizers Help*
- *NI PXI/PCI-5122 Specifications*
- *NI-SCOPE Function Reference Help* or *NI-SCOPE VI Reference Help*

These documents are installed when you install NI-SCOPE. You can also download them from the NI Web site at `ni.com/manuals`.

Self-Calibration Procedures

The NI 5122 includes precise internal circuits and references it uses during self-calibration to adjust for time and temperature drift. The digitizer 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 digitizer before you perform verification. NI-SCOPE includes self-calibration example programs for LabVIEW, CVI, and Microsoft Visual C.

You can initiate self-calibration using Measurement & Automation Explorer (MAX), using the Scope Soft Front Panel (SFP), or programmatically using NI-SCOPE.

MAX

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

1. Disconnect or disable any AC inputs to the digitizer.
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 on the device and select **Self-Calibrate** from the drop-down menu.

Scope SFP

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

1. Launch the Scope SFP (**Start»Programs»National Instruments» NI-SCOPE»Scope Soft Front Panel**).
2. Select the device you want to calibrate using the Device Configuration dialog box (**Edit»Device Configuration**).
3. Launch the Calibration dialog (**Utility»Self Calibration**).
4. Disconnect or disable any AC inputs to the digitizer.
5. Click **OK** to begin self-calibration.

NI-SCOPE

To self-calibrate the NI 5122 programmatically using NI-SCOPE, complete the following steps:

1. Disconnect or disable any AC inputs to the digitizer.
2. Call `niScope_init` (niScope Initialize VI) to obtain an instrument session handle. Set the following parameters:
   - **resourceName**: The device name assigned by MAX
   - **IDQuery**: `NISCOPE_VAL_VI_FALSE`
   - **resetDevice**: `NISCOPE_VAL_VI_FALSE`
   - **vi**: The returned session handle that you use to identify the instrument in all subsequent instrument driver function calls
3. Call `niScope_calSelfCalibrate` (niScope Cal Self Calibrate VI) with the following parameters:
   - **sessionHandle**: The instrument handle that you obtain from `niScope_init` (niScope Initialize VI)
   - **channelList**: `VI_NULL`
   - **option**: `VI_NULL`

   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 digitizer.
4. Call `niScope_close` (niScope Close VI) to close the session handle. Set the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`

External Calibration Options

External calibration involves both adjustment and verification. 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 limits given in Tables 4 through 8.

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. However, the device will not necessarily remain within these specifications for an additional two years. The device 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. The *Optional Calibration* section describes alternate procedures that allow you to skip adjustment if the device already meets its calibration test limits or published specifications.

Complete Calibration

Performing a complete calibration is the recommended way to guarantee that the NI 5122 will meet or exceed its published specifications for a two-year calibration interval. At the end of the complete calibration procedure, you verify that the measurement error falls within the calibration test limits. Figure 1 shows the programming flow for complete calibration.

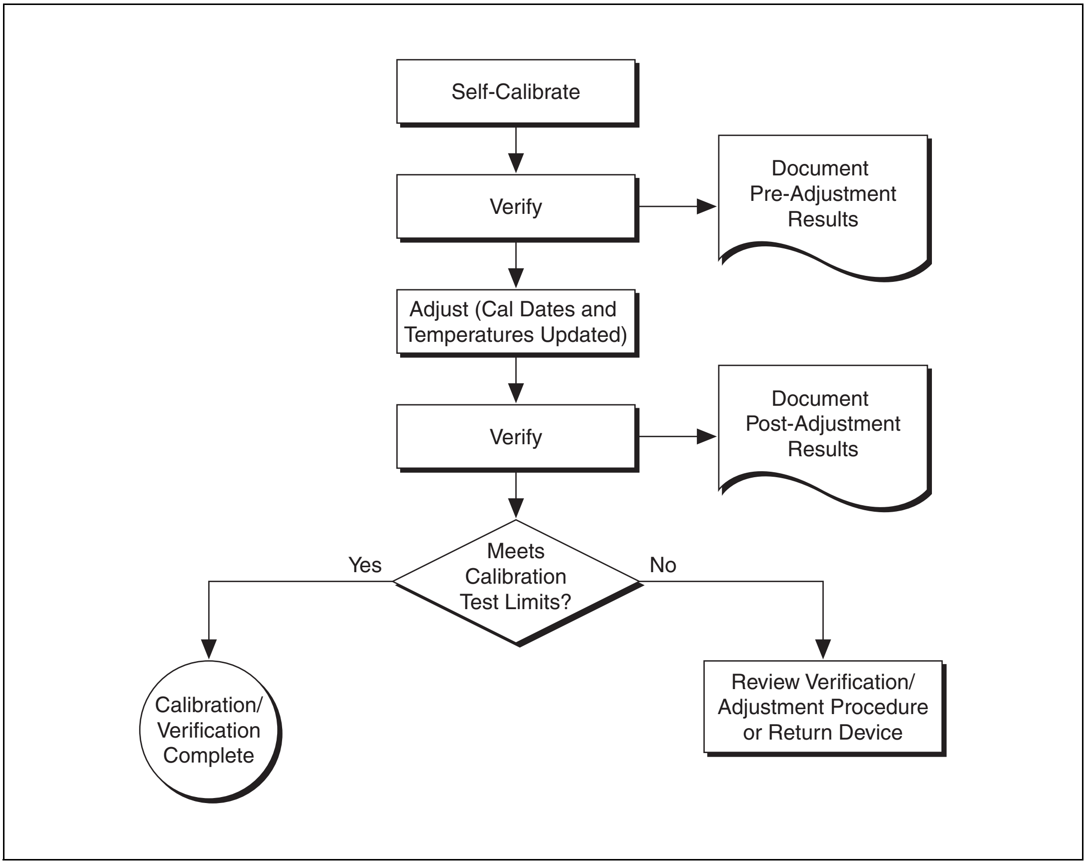

Figure 1. Complete Calibration Programming Flow

Optional Calibration

You can choose to skip the adjustment steps of the calibration procedure if the measurement error is within the calibration test limits or the published specifications during the first verification. If all of the measurement errors determined during the first verification fall within the calibration test limits, the device is guaranteed to meet or exceed its published specifications for a full calibration interval. In this case, you can update the calibration date, effectively resetting the calibration interval, without actually performing an adjustment. Refer to the *Adjusting the NI 5122* section for more information.

If all of the measurement errors determined during the first verification fall within the published specifications, but not within the calibration test limits, adjustment is also optional. However, you cannot update the calibration date, because the device will not necessarily operate within the published specifications for an additional two years.

Note Regardless of the results of the first verification, if you choose to perform an adjustment, you must verify that the measurement error falls within the calibration test limits at the end of the calibration procedure.

Figure 2 shows the programming flow for the optional calibration.

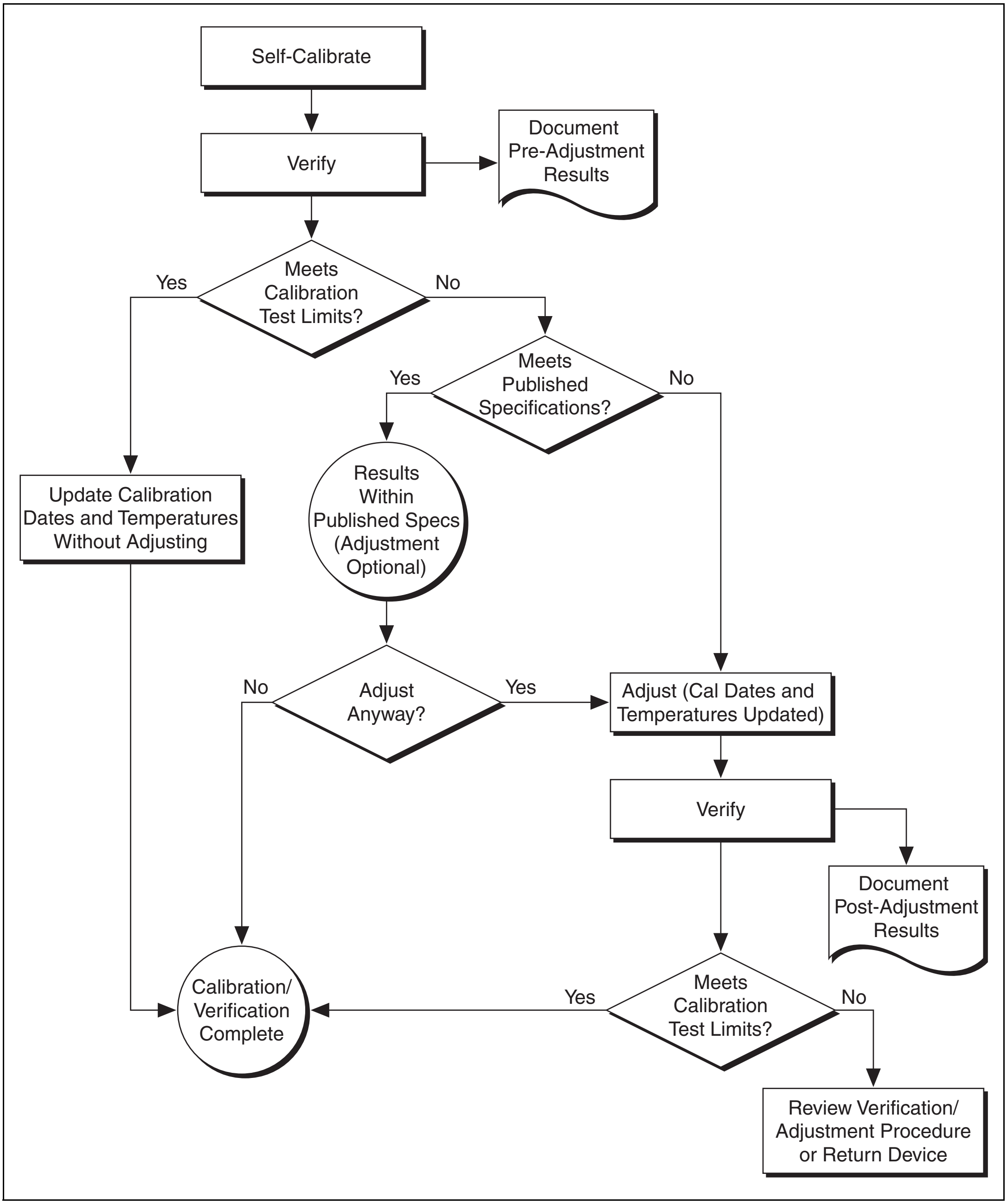

Figure 2. Optional Calibration Programming Flow

External Calibration Requirements

Test Equipment

Table 2 lists the equipment required for externally calibrating the NI 5122. If you do not have the recommended instruments, use these specifications to select a substitute calibration standard.

Table 2. Required Equipment Specifications for NI 5122 External Calibration

Required Equipment	Recommended Equipment	Parameter Measured	Specification
Signal Generator	Fluke 9500B oscilloscope calibrator (Wavetek 9500 with high-stability reference option) 9510 Test Head	Vertical Gain	DC ±(0.025% + 25 µV) into 1 MΩ or 50 Ω
		Bandwidth	±1.5% output amplitude flatness for leveled sine wave up to 100 MHz relative to 50 kHz into 1 MΩ or 50 Ω
		Timing	2 ppm frequency accuracy
BNC cable	—	—	50 Ω

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 digitizer, or use a short 50 Ω BNC coaxial cable if necessary. Long cables and wires act as antennae, picking up extra noise that can affect measurements.
- Keep relative humidity between 10 and 90% non-condensing, or consult the digitizer hardware documentation for the optimum relative humidity.
- Maintain an ambient temperature of 23 ±5 °C.
- 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 5122 is at a stable operating temperature.

- For PXI digitizers:
  - Ensure that the PXI chassis fan speed is set to HI, that the fan filters are clean, and that the empty slots contain filler panels.
  - Plug the PXI chassis and the calibrator into the same power strip to avoid ground loops.
- For PCI digitizers:
  - Plug the PC and the calibrator into the same power strip to avoid ground loops.

External Calibration Procedures

The complete external calibration procedure consists of self-calibrating, verifying the performance of the digitizer, adjusting the calibration constants, and verifying again after the adjustments. In some cases, the complete calibration procedure may not be required. Refer to the *External Calibration Options* section for more information.

The external calibration procedure automatically stores the calibration date to allow traceability.

Verifying NI 5122 Specifications

Note Always self-calibrate the NI 5122 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 5122. Refer to the *External Calibration Options* section to determine which limits to use in these procedures.

All verification procedures described in this section begin with `niScope_init` (niScope Initialize VI) with **resetDevice** set to `NISCOPE_VAL_TRUE`, and end with `niScope_close` (niScope Close VI).

Note If any of these tests fail immediately after you perform an external adjustment, verify that you have met the required test conditions before you return the digitizer to NI for repair.

Vertical Offset and Vertical Gain Accuracy

Table 3 contains the input parameters for verifying both vertical offset accuracy and vertical gain accuracy of the NI 5122.

To verify vertical offset accuracy, complete the procedures described in the *Vertical Offset Accuracy* section for each of the 39 iterations listed in

Table 3, then repeat the procedure for channel 1. The calibration test limits and published specifications are shown in Table 4.

To verify vertical gain accuracy, complete the procedures described in the *Vertical Gain Accuracy* section for each of the 39 iterations listed in Table 3, then repeat the procedure for channel 1. The calibration test limits and published specifications are shown in Table 5.

Table 3. Input Parameters for Vertical Offset Accuracy and Vertical Gain Accuracy Verification

Iteration	Input Impedance	Max Input Frequency (Hz)	Range (V)
1	50 Ω	100,000,000	0.2
2	50 Ω	100,000,000	0.4
3	50 Ω	100,000,000	1
4	50 Ω	100,000,000	2
5	50 Ω	100,000,000	4
6	50 Ω	100,000,000	10
7	50 Ω	35,000,000	0.2
8	50 Ω	35,000,000	0.4
9	50 Ω	35,000,000	1
10	50 Ω	35,000,000	2
11	50 Ω	35,000,000	4
12	50 Ω	35,000,000	10
13	50 Ω	20,000,000	0.2
14	50 Ω	20,000,000	0.4
15	50 Ω	20,000,000	1
16	50 Ω	20,000,000	2
17	50 Ω	20,000,000	4
18	50 Ω	20,000,000	10
19	1 MΩ	100,000,000	0.2
20	1 MΩ	100,000,000	0.4
21	1 MΩ	100,000,000	1
22	1 MΩ	100,000,000	2

Table 3. Input Parameters for Vertical Offset Accuracy and Vertical Gain Accuracy Verification (Continued)

Iteration	Input Impedance	Max Input Frequency (Hz)	Range (V)
23	1 MΩ	100,000,000	4
24	1 MΩ	100,000,000	10
25	1 MΩ	100,000,000	20
26	1 MΩ	35,000,000	0.2
27	1 MΩ	35,000,000	0.4
28	1 MΩ	35,000,000	1
29	1 MΩ	35,000,000	2
30	1 MΩ	35,000,000	4
31	1 MΩ	35,000,000	10
32	1 MΩ	35,000,000	20
33	1 MΩ	20,000,000	0.2
34	1 MΩ	20,000,000	0.4
35	1 MΩ	20,000,000	1
36	1 MΩ	20,000,000	2
37	1 MΩ	20,000,000	4
38	1 MΩ	20,000,000	10
39	1 MΩ	20,000,000	20

Vertical Offset Accuracy

To verify vertical offset accuracy, complete steps 1 through 8 for each of the 39 configuration iterations listed in Table 3.

1. Call `niScope_ConfigureChanCharacteristics` (niScope Configure Chan Characteristics VI) with the following parameters:
   - **channelList**: `"0"`
   - **inputImpedance**: The Input Impedance value for the current iteration from Table 3
   - **maxInputFrequency**: The Max Input Frequency value for the current iteration from Table 3

2. Call `niScope_ConfigureVertical` (niScope Configure Vertical VI) with the following parameters:
   - **channelList**: `"0"`
   - **range**: The Range value for the current iteration from Table 3
   - **offset**: `0.0`
   - **coupling**: `NISCOPE_VAL_DC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `NISCOPE_VAL_TRUE`
3. Call `niScope_ConfigureHorizontalTiming` (niScope Configure Horizontal Timing VI) with the following parameters:
   - **minSampleRate**: `10,000,000`
   - **minNumPts**: `100,000`
   - **refPosition**: `50.0`
   - **numRecords**: `1`
   - **enforceRealtime**: `NISCOPE_VAL_TRUE`
4. Call `niScope_Commit` (niScope Commit VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`
5. Short-circuit the channel 0 input of the digitizer by connecting the calibrator test head directly to the digitizer and grounding the output of the calibrator.
6. Wait 50 ms for calibrator's impedance matching to settle.
7. Call `niScope_InitiateAcquisition`. (niScope Initiate Acquisition VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`
8. Call `niScope_FetchMeasurement` (niScope Fetch Measurement VI) with the following parameters:
   - **channelList**: `"0"`
   - **timeout**: `1.0`
   - **scalarMeasFunction**: `NISCOPE_VAL_VOLTAGE_AVERAGE`

   Compare the resulting average voltage to the value in the Calibration Test Limits column or the Published Specifications column in Table 4 that corresponds to the vertical range used. The **inputImpedance** and **maxInputFrequency** do not affect the test limit value. If the result is within the selected test limit, the device has passed this portion of the verification.

Note 50 Ω input impedance with 20 V range is not a valid configuration.

Move the calibrator test head to the digitizer input channel 1 and repeat steps 1 through 8 for every configuration in Table 3, replacing `"0"` with `"1"` for the **channelList** parameter.

Table 4. NI 5122 Vertical Offset Calibration Test Limits and Published Specifications

Range (V)	Calibration Test Limits (V)	Published Specifications (V)
0.2	±0.00057	±0.001
0.4	±0.00057	±0.001
1	±0.00057	±0.001
2	±0.00057	±0.001
4	±0.0033	±0.008
10	±0.0033	±0.008
20	±0.0039	±0.01

You have finished verifying the vertical offset accuracy of the NI 5122.

Vertical Gain Accuracy

To verify vertical gain accuracy, complete steps 1 through 11 for each of the 39 configuration iterations in Table 3.

1. Call `niScope_ConfigureChanCharacteristics` (niScope Configure Chan Characteristics VI) with the following parameters:
   - **channelList**: `"0"`
   - **inputImpedance**: The Input Impedance value for the current iteration from Table 3
   - **maxInputFrequency**: The Max Input Frequency value for the current iteration from Table 3
2. Call `niScope_ConfigureVertical` (niScope Configure Vertical VI) with the following parameters:
   - **channelList**: `"0"`
   - **range**: The Range value for the current iteration from Table 3
   - **offset**: `0.0`
   - **coupling**: `NISCOPE_VAL_DC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `NISCOPE_VAL_TRUE`

3. Call `niScope_ConfigureHorizontalTiming` (niScope Configure Horizontal Timing VI) with the following parameters:
   - **minSampleRate**: `10,000,000`
   - **minNumPts**: `100,000`
   - **refPosition**: `50.0`
   - **numRecords**: `1`
   - **enforceRealtime**: `NISCOPE_VAL_TRUE`
4. Call `niScope_Commit` (niScope Commit VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`
5. Connect the calibrator test head directly to the channel 0 input of the digitizer and output the positive voltage from Table 5 that corresponds to the vertical range used. Be sure to configure the load impedance of the calibrator to match the input impedance of the digitizer.
6. Wait 2,500 ms for the calibrator's impedance matching to settle.
7. Call `niScope_InitiateAcquisition` (niScope Initiate Acquisition VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`
8. Call `niScope_FetchMeasurement` (niScope Fetch Measurement VI) with the following parameters:
   - **channelList**: `"0"`
   - **timeout**: `1.0`
   - **scalarMeasFunction**: `NISCOPE_VAL_VOLTAGE_AVERAGE`
9. Output the negative voltage listed in Table 5 with the calibrator.
10. Call `niScope_FetchMeasurement` (niScope Fetch Measurement VI) with the following parameters:
    - **channelList**: `"0"`
    - **timeout**: `1.0`
    - **scalarMeasFunction**: `NISCOPE_VAL_VOLTAGE_AVERAGE`
11. Compute the error in the vertical gain as a percentage of input using the formula:

    $$\text{error} = (((a - b) / (c - d)) - 1) * 100$$

    where a is the measured positive voltage, b is the measured negative voltage, c is the applied positive voltage, and d is the applied negative voltage.

    Compare the resulting percent error to the Calibration Test Limits or the Published Specifications listed in Table 5. If the result is within the selected test limit, the device has passed this portion of the verification.

Table 5. Vertical Gain Stimuli, Calibration Test Limits, and Published Specifications

Range (V)	Positive Input (V)	Negative Input (V)	Calibration Test Limits	Published Specifications
0.2	0.09	–0.09	±0.37%	±0.65%
0.4	0.18	–0.18	±0.37%	±0.65%
1	0.45	–0.45	±0.37%	±0.65%
2	0.9	–0.9	±0.37%	±0.65%
4	1.8	–1.8	±0.37%	±0.65%
10	4.5	–4.5	±0.37%	±0.65%
20	9	–9	±0.37%	±0.65%

Move the calibrator test head to the digitizer input channel 1 and repeat steps 1 through 11 for every configuration in Table 3, replacing `"0"` with `"1"` for the **channelList** parameter.

You have finished verifying the vertical gain accuracy of the NI 5122.

Programmable Vertical Offset Accuracy

Complete the following steps to verify the programmable vertical offset accuracy for each digitizer channel:

1. Call `niScope_ConfigureChanCharacteristics` (niScope Configure Chan Characteristics VI) with the following parameters:
   - **channelList**: `"0"`
   - **inputImpedance**: `NISCOPE_VAL_50_OHM`
   - **maxInputFrequency**: `100,000,000`
2. Call `niScope_ConfigureVertical` (niScope Configure Vertical VI) with the following parameters:
   - **channelList**: `"0"`
   - **range**: `2.0`
   - **offset**: `0.75`
   - **coupling**: `NISCOPE_VAL_DC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `NISCOPE_VAL_TRUE`

3. Call niScope_ConfigureHorizontalTiming (niScope Configure Horizontal Timing VI) with the following parameters:
   - **minSampleRate**: 10,000,000
   - **minNumPts**: 100,000
   - **refPosition**: 50.0
   - **numRecords**: 1
   - **enforceRealtime**: NISCOPE_VAL_TRUE
4. Call niScope_Commit (niScope Commit VI) with the following parameter:
   - **vi**: The instrument handle you obtained from niScope_init
5. Connect the calibrator test head directly to the channel 0 input of the digitizer and output 0.75 V with a 50 Ω load impedance.
6. Wait 2,500 ms for the calibrator's impedance matching to settle.
7. Call niScope_InitiateAcquisition (niScope Initiate Acquisition VI) with the following parameter:
   - **vi**: The instrument handle you obtained from niScope_init
8. Call niScope_FetchMeasurement (niScope Fetch Measurement VI) with the following parameters:
   - **channelList**: "0"
   - **timeout**: 1.0
   - **scalarMeasFunction**: NISCOPE_VAL_VOLTAGE_AVERAGE
9. Output –0.75 V with the calibrator.
10. Call niScope_ConfigureVertical (niScope Configure Vertical VI) with the following parameters:
    - **channelList**: "0"
    - **range**: 2.0
    - **offset**: –0.75
    - **coupling**: NISCOPE_VAL_DC
    - **probeAttenuation**: 1.0
    - **enabled**: NISCOPE_VAL_TRUE
11. Call niScope_InitiateAcquisition (niScope Initiate Acquisition VI) with the following parameter:
    - **vi**: The instrument handle you obtained from niScope_init
12. Call niScope_FetchMeasurement (niScope Fetch Measurement VI) with the following parameters:
    - **channelList**: "0"
    - **timeout**: 1.0
    - **scalarMeasFunction**: NISCOPE_VAL_VOLTAGE_AVERAGE

13. Compute the error in the programmable vertical offset as a percentage of input using the formula:

$$\text{error} = (((a - b) / 1.5) - 1) * 100$$

where a is the measured positive voltage and b is the measured negative voltage.

Compare the resulting percent to the Calibration Test Limits or the Published Specifications listed in Table 6. If the result is within the selected test limit, the device has passed this portion of the verification.

Table 6. NI 5122 Programmable Vertical Offset Accuracy

Calibration Test Limits	Published Specifications
±0.36%	±0.4%

14. Move the calibrator test head to the digitizer input channel 1 and repeat steps 1 through 13, replacing `"0"` with `"1"` for the **channelList** parameter.

You have finished verifying the programmable vertical offset accuracy of the NI 5122.

Timing Accuracy

Complete the following steps to verify the timing accuracy for the NI 5122:

1. Call `niScope_ConfigureChanCharacteristics` (niScope Configure Chan Characteristics VI) with the following parameters:
   - **channelList**: `"0"`
   - **inputImpedance**: `NISCOPE_VAL_50_OHM`
   - **maxInputFrequency**: `20,000,000`
2. Call `niScope_ConfigureVertical` (niScope Configure Vertical VI) with the following parameters:
   - **channelList**: `"0"`
   - **range**: `2.0`
   - **offset**: `0.0`
   - **coupling**: `NISCOPE_VAL_DC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `NISCOPE_VAL_TRUE`

3. Call `niScope_ConfigureHorizontalTiming` (niScope Configure Horizontal Timing VI) with the following parameters:
   - **minSampleRate**: `100,000,000`
   - **minNumPts**: `1,000,000`
   - **refPosition**: `50.0`
   - **numRecords**: `1`
   - **enforceRealtime**: `NISCOPE_VAL_TRUE`
4. Call `niScope_Commit` (niScope Commit VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`
5. Connect the calibrator test head directly to the channel 0 input of the digitizer. Configure the calibrator to output an exact 11 MHz sine wave with 1 V peak-to-peak amplitude and 50 Ω load impedance.
6. Wait 250 ms for calibrator impedance matching and frequency to settle.
7. Call `niScope_InitiateAcquisition` (niScope Initiate Acquisition VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`
8. Call `niScope_FetchMeasurement` (niScope Fetch Measurement VI) with the following parameters:
   - **channelList**: `"0"`
   - **timeout**: `1.0`
   - **scalarMeasFunction**: `NISCOPE_VAL_FFT_FREQUENCY`
9. Compute the error in timing as parts per million (ppm) using the formula:

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

   where a is the measured frequency.

   Compare the result to the Calibration Test Limits or the Published Specifications listed in Table 7. If the result is within the selected test limit, the device has passed this portion of the verification.

Table 7. Timing Accuracy

Calibration Test Limits	Published Specifications
±5.3 ppm	±25 ppm

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.

You have finished verifying the timing accuracy of the NI 5122.

Bandwidth and Flatness

Complete the following steps for each of the six configurations listed in Table 8 to verify the bandwidth and flatness for each digitizer channel:

1. Call `niScope_ConfigureChanCharacteristics` (niScope Configure Chan Characteristics VI) with the following parameters:
   - **channelList**: `"0"`
   - **inputImpedance**: The Input Impedance value for the current iteration in Table 8
   - **maxInputFrequency**: The Max Input Frequency for the current iteration in Table 8
2. Call `niScope_ConfigureVertical` (niScope Configure Vertical VI) with the following parameters:
   - **channelList**: `"0"`
   - **range**: The Range value for the current iteration in Table 8
   - **offset**: `0.0`
   - **coupling**: `NISCOPE_VAL_DC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `NISCOPE_VAL_TRUE`
3. Call `niScope_ConfigureHorizontalTiming` (niScope Configure Horizontal Timing VI) with the following parameters:
   - **minSampleRate**: `10,000,000`
   - **minNumPts**: `30,000`
   - **refPosition**: `50.0`
   - **numRecords**: `1`
   - **enforceRealtime**: `NISCOPE_VAL_TRUE`
4. Call `niScope_Commit` (niScope Commit VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`
5. Connect the calibrator test head directly to the channel 0 input of the digitizer. Configure the calibrator to output a 50 kHz sine wave with peak-to-peak voltage amplitude set to half the vertical range of the digitizer. Configure the load impedance of the calibrator to match the input impedance of the digitizer.
6. Wait 250 ms for calibrator’s impedance matching to settle.

7. Call `niScope_InitiateAcquisition` (niScope Initiate Acquisition VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`
8. Call `niScope_FetchMeasurement` (niScope Fetch Measurement VI) with the following parameters:
   - **channelList**: `"0"`
   - **timeout**: `1.0`
   - **scalarMeasFunction**: `NISCOPE_VAL_VOLTAGE_RMS`
9. Call `niScope_ConfigureHorizontalTiming` (niScope Configure Horizontal Timing VI) with the following parameters:
   - **minSampleRate**: `100,000,000`
   - **minNumPts**: `300,000`
   - **refPosition**: `50.0`
   - **numRecords**: `1`
   - **enforceRealtime**: `NISCOPE_VAL_TRUE`
10. Repeat steps 10a through 10d for each Input Frequency listed for the current iteration in Table 8.
    a. Configure the calibrator to output the Input Frequency for the current iteration from Table 8.
    b. Call `niScope_InitiateAcquisition` (niScope Initiate Acquisition VI) with the following parameter:
       - **vi**: The instrument handle you obtained from `niScope_init`
    c. Call `niScope_FetchMeasurement` (niScope Fetch Measurement VI) with the following parameters:
       - **channelList**: `"0"`
       - **timeout**: `1.0`
       - **scalarMeasFunction**: `NISCOPE_VAL_VOLTAGE_RMS`
    d. Compute the power difference using the formula:

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

       where *a* is the measured RMS voltage in step 12 and *b* is the measured RMS voltage in step 8.

       If the result is within the test limits from Table 8, the device has passed this portion of the verification.

Move the calibrator test head to the digitizer input channel 1 and repeat steps 1 through 10, replacing `"0"` with `"1"` for the **channelList** parameter.

Table 8. NI 5122 Bandwidth and Flatness Stimuli and Limits

Iteration	Max Input Frequency	Input Impedance	Range (V)	Input Frequency (Hz)	Calibration Test Limits Max Level (dB)	Calibration Test Limits Min Level (dB)	Published Specifications Max Level (dB)	Published Specifications Min Level (dB)
1	100 MHz	50 Ω	0.2	20,100,000	0.27	–0.27	0.4	–0.4
				40,100,000	0.77	–0.77	1	–1
				84,400,000	3	–3	3 at 80 MHz	–3 at 80 MHz
2	100 MHz	50 Ω	0.4	20,100,000	0.27	–0.27	0.4	–0.4
				50,100,000	0.77	–0.77	1	–1
				103,700,000	3	–3	3 at 100 MHz	–3 at 100 MHz
3	100 MHz	1 MΩ	0.2	20,100,000	0.27	–0.27	0.4	–0.4
				40,100,000	0.77	–0.77	1	–1
				84,400,000	3	–3	3 at 80 MHz	–3 at 80 MHz
4	100 MHz	1 MΩ	0.4	20,100,000	0.27	–0.27	0.4	–0.4
				50,100,000	0.77	–0.77	1	–1
				103,700,000	3	–3	3 at 100 MHz	–3 at 100 MHz
5	35 MHz	50 Ω	0.4	16,100,000	1.05	–1.05	1.2	–1.2
				32,100,000	1.27	–1.27	1.6	–1.6
				36,100,000	3	–3	3 at 35 MHz	–3 at 35 MHz
6	20 MHz	50 Ω	0.4	15,100,000	–0.68	–2.72	–0.4	–3
				20,100,000	–1.65	–4.35	–1.3	–4.7

You have finished verifying the bandwidth and flatness of the NI 5122.

Adjusting the NI 5122

If the NI 5122 successfully passed each of the verification procedures within the calibration test limits, then an adjustment is recommended but not required to guarantee its published specifications for the next two years. If the digitizer 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 digitizer. Refer to the *External Calibration Options* 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 digitizer.

Note If the digitizer passed the entire verification procedure within the calibration test limits and you do not want to perform an adjustment, you can update the calibration date and onboard calibration temperature without making any adjustments by completing *only* steps 3 and 9 in this section.

Complete all of the following steps to externally adjust the NI 5122:

1. Using a BNC cable, connect REF FREQUENCY OUTPUT on the back of the calibrator to the channel 0 input of the digitizer. Make sure the output of the reference frequency is enabled on the calibrator. Connect the calibrator test head directly to the channel 1 input of the digitizer. Configure the calibrator to output an exact 4 V DC signal into a 1 MΩ load impedance.
2. Wait 250 ms for the calibrator impedance matching to settle.
3. Call `niScope_CalStart` (niScope Cal Start VI) using the user password. The factory default password for the NI 5122 is `NI`.
4. Call `niScope_CalAdjustVCXO` (niScope Cal Adjust VCXO VI) with the following parameter:
   - **stimulusFreq**: `10,000,000`

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

5. Call `niScope_CalAdjustRange` (niScope Cal Adjust Range VI) with the following parameters:
   - **channelName**: `"1"`
   - **range**: `0`
   - **stimulus**: `4.0`
6. Configure the calibrator to ground its output.

7. Call `niScope_CalAdjustRange` (niScope Cal Adjust Range VI) with the following parameters:
   - **channelName**: `"1"`
   - **range**: `0`
   - **stimulus**: `0.0`
8. Call `niScope_CalSelfCalibrate` (niScope Cal Self Calibrate VI) with the following parameters:
   - **channelList**: `VI_NULL`
   - **option**: `VI_NULL`
9. Call `niScope_CalEnd` with the following parameters:
   - **sessionHandle**: The instrument handle you obtained from `niScope_CalStart`
   - **action**: `NISCOPE_VAL_ACTION_STORE` to save the results of the calibration

You have finished adjusting the NI 5122. It is not necessary to adjust each channel individually. However, you should repeat the entire verification procedure to verify a successful adjustment.

Calibration Utilities

NI-SCOPE supports several calibration utilities that allow you to retrieve information about adjustments performed on the NI 5122, change the external calibration password, and store small amounts of information in the onboard EEPROM. You can retrieve some data using MAX, however, 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 wish to retrieve information from **My System»Devices and Interfaces»NI-DAQmx Devices**.
2. Select the **Calibration** tab in the lower right 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)

Calibration Function References

The functions used in this procedure, including all calibration functions, are documented in the *NI-SCOPE Function Reference Help* and the *NI-SCOPE VI Reference Help*, both of which you can access from the *NI High-Speed Digitizers Help* (**Start»Programs»National Instruments»NI-SCOPE»Documentation**).

Technical Support Resources

NI Web Support

National Instruments Web support is your first stop for help in solving installation, configuration, and application problems and questions. Online problem-solving and diagnostic resources include frequently asked questions, knowledge bases, product-specific troubleshooting wizards, manuals, drivers, software updates, and more. Web support is available through the Technical Support section of `ni.com`.

A Declaration of Conformity (DoC) is our claim of compliance with the Council of the European Communities using the manufacturer's declaration of conformity. This system affords the user protection for electronic compatibility (EMC) and product safety. You can obtain the DoC for your product by visiting `ni.com/hardref.nsf`. If your product supports calibration, you can obtain the calibration certificate for your product at `ni.com/calibration`.

Worldwide Support

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. You can access our branch office Web sites from the Worldwide Offices section of `ni.com`. Branch office Web sites provide up-to-date contact information, support phone numbers, email addresses, and current events.

If you have searched the technical support resources on our Web site and still cannot find the answers you need, contact your local office or National Instruments corporate. For telephone support in the United States, dial 512 795 8248. For telephone support outside the United States, contact your local branch office:

Australia 1800 300 800, Austria 43 0 662 45 79 90 0, Belgium 32 0 2 757 00 20, Brazil 55 11 3262 3599, Canada (Calgary) 403 274 9391, Canada (Ottawa) 613 233 5949, Canada (Québec) 450 510 3055, Canada (Toronto) 905 785 0085, Canada (Vancouver) 514 685 7530, China 86 21 6555 7838, Czech Republic 420 224 235 774, Denmark 45 45 76 26 00, Finland 385 0 9 725 725 11, France 33 0 1 48 14 24 24, Germany 49 0 89 741 31 30, Greece 30 2 10 42 96 427, India 91 80 51190000, Israel 972 0 3 6393737, Italy 39 02 413091, Japan 81 3 5472 2970, Korea 82 02 3451 3400, Malaysia 603 9131 0918, Mexico 001 800 010 0793, Netherlands 31 0 348 433 466, New Zealand 0800 553 322, Norway 47 0 66 90 76 60, Poland 48 22 3390150, Portugal 351 210 311 210, Russia 7 095 783 68 51, Singapore 65 6226 5886, Slovenia 386 3 425 4200, South Africa 27 0 11 805 8197, Spain 34 91 640 0085, Sweden 46 0 8 587 895 00, Switzerland 41 56 200 51 51, Taiwan 886 2 2528 7227, Thailand 662 992 7519, United Kingdom 44 0 1635 523545

370529A-01 Jan04