CALIBRATION PROCEDURE

NI 5922

This document describes specific programming steps for writing a calibration utility for the National Instruments PXI-5922 flexible-resolution digitizer. This calibration procedure is intended for metrology labs.

Contents

NATIONAL INSTRUMENTS™

Introduction

The NI 5922 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. The external calibration 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.

Calibration Intervals

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

Caution Although you can use self-calibration repeatedly, self-calibrating the NI 5922 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 5922. 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 the *External Calibration Options* section for more information.

Software and Documentation

Calibrating the NI 5922 requires installing NI-SCOPE version 2.8 or later on the calibration system. You can download NI-SCOPE from `ni.com/downloads`. 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 2.8 or later includes all the functions and attributes necessary for calibrating the NI 5922. 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 NI-SCOPE. 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 2.8 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

Table 1. Calibration File Locations after Installing NI-SCOPE 2.8 or Later (Continued)

File Name and Location	Description
`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

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-5922 Specifications*
- *NI-SCOPE Function Reference Help*
- *NI-SCOPE VI Reference Help*

You can download the latest versions of all documentation from the NI Web site at `ni.com/manuals`.

Self-Calibration Procedures

The NI 5922 includes precise internal circuits and references used during self-calibration to adjust for time and temperature drift. The digitizer gain, offset, and flatness 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 the name of the device in the MAX configuration tree and select **Self-Calibrate** from the drop-down menu.

Scope SFP

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

1. Disconnect or disable any AC inputs to the digitizer.
2. Launch the Scope SFP by selecting **Start»Programs»National Instruments»NI-SCOPE»Scope Soft Front Panel**.
3. Select the device you want to calibrate using the Device Configuration dialog box by selecting **Edit»Device Configuration**.
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 5922 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 must be performed. During verification, you must compare the measurement error to limits given in Tables 3 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 alternative 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 5922 meets or exceeds 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.

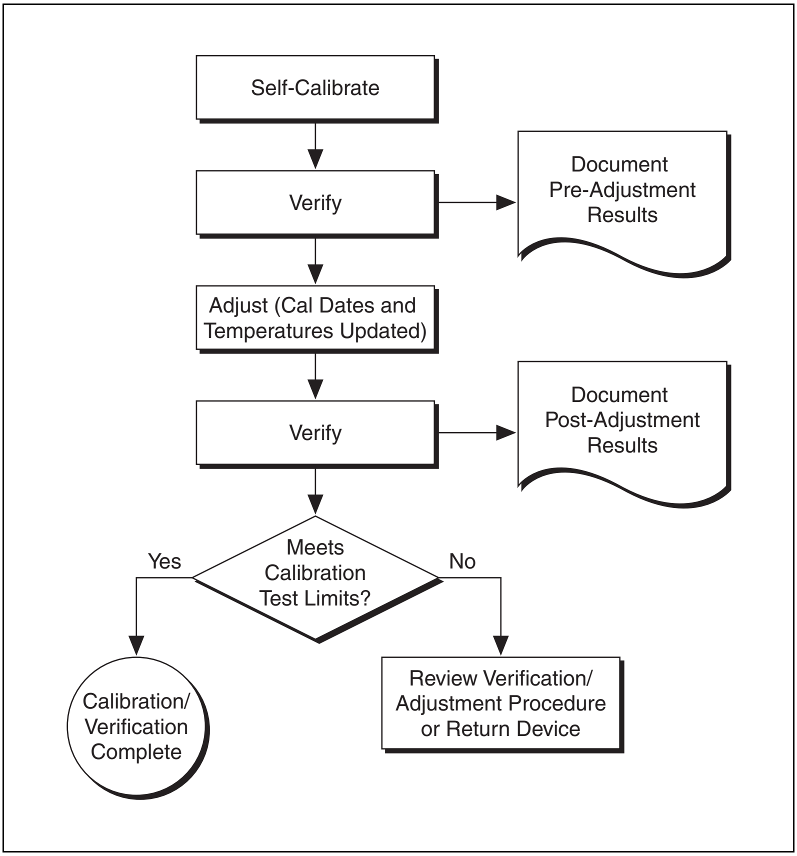

Figure 1. Complete Calibration Programming Flow

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 5922* 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 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.

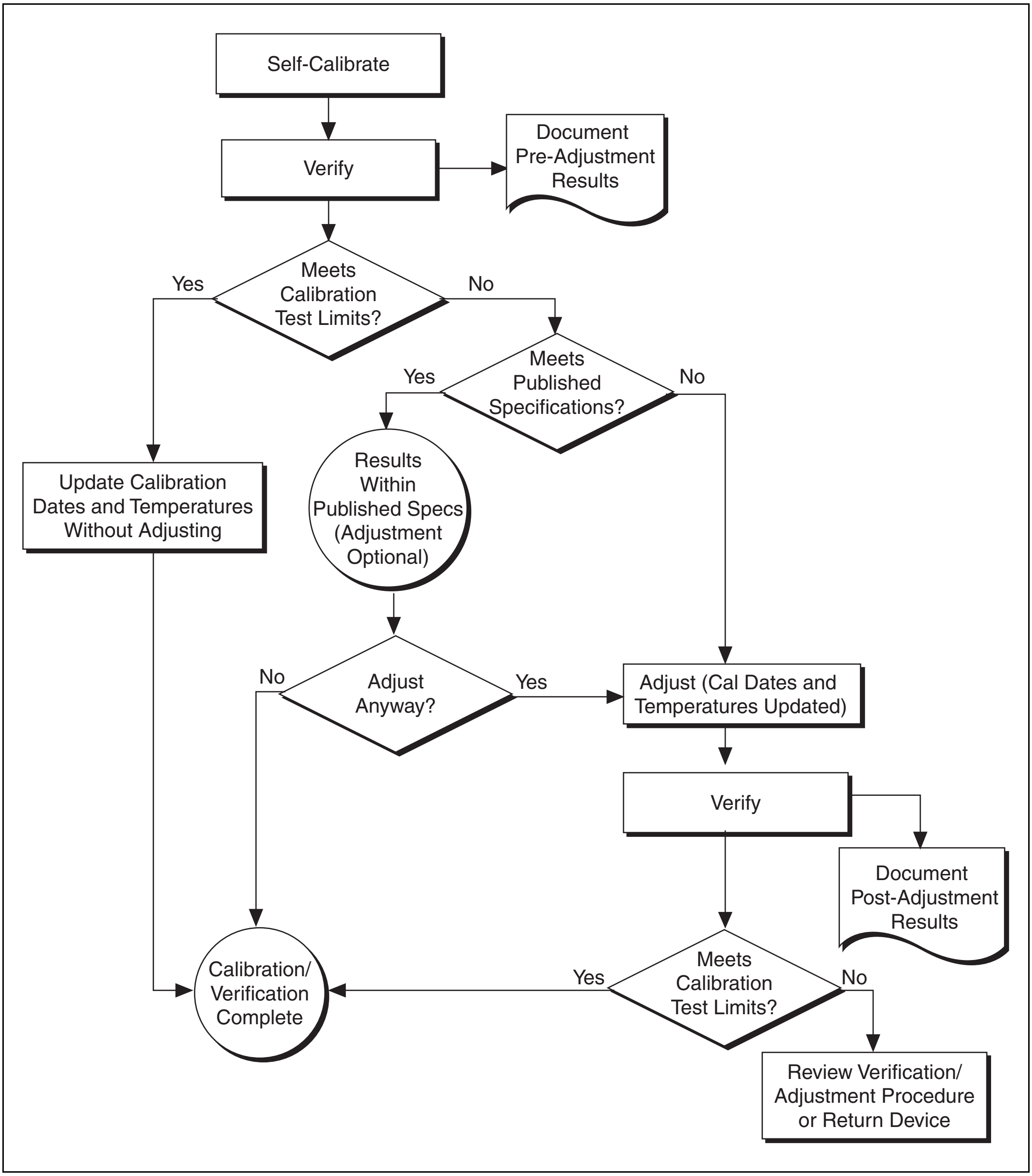

Figure 2. Optional Calibration Programming Flow

External Calibration Requirements

Test Equipment

Table 2 lists the equipment required for externally calibrating the NI 5922. If you do not have the recommended instruments, use these specifications to select a substitute calibration standard.

Table 2. Required Equipment for NI 5922 External Calibration

Required Equipment	Recommended Equipment	Parameter Measured	Specification
Signal Generator	Fluke 9500B oscilloscope calibrator 9510 Test Head (or Wavetek 9500 with high-stability reference option)	Trigger Sensitivity	±3.5% absolute output amplitude accuracy for leveled sine wave up to 1 MHz into 1 MΩ
		Timing	2 ppm frequency accuracy
		Flatness	500 ps fall time pulse edge aberrations: < ±1.5% peak first 10 ns < ±0.5% 10 ns to 1 µs < ±0.1% peak beyond 1 µs
DC Source	Fluke 5700	Vertical Gain	DC ±50 ppm into 1 MΩ
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 increase these delay times. This increase varies between calibrator models.

Test Conditions

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

- Always connect the scope calibrator 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.
- Maintain an ambient temperature of 23 ±5 °C.

- Allow a warm-up time of at least 15 minutes after NI-SCOPE loads. Unless manually disabled, NI-SCOPE automatically loads with the operating system and enables the device. The warm-up time ensures that the measurement circuitry of the NI 5922 is at a stable operating temperature.
- 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.

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 5922 Specifications

Note After the 15-minute warm-up time, always self-calibrate the NI 5922 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 5922. 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).

If any of these tests fail immediately after you perform an external adjustment, verify that you have met the required test conditions listed in the *External Calibration Requirements* section before you return the digitizer to NI for repair.

Vertical Offset Accuracy

Complete the following steps to verify vertical offset accuracy of the NI 5922. You must verify both channels and each iteration listed in Table 3.

1. Disconnect all cabling from the BNC inputs of the NI 5922. No input signal is needed because the NI 5922 internal 50 Ω resistor connects the input to ground.
2. Call `niScope_ConfigureChanCharacteristics` (niScope Configure Chan Characteristics VI) with the following parameters:
   - **channelList**: `"0"`
   - **inputImpedance**: `NISCOPE_VAL_50_OHM`
   - **maxInputFrequency**: `0`
3. 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`
4. 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`
5. Call `niScope_InitiateAcquisition`. (niScope Initiate Acquisition VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`
6. 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 listed in the *Calibration Test Limits* column or the *Published Specifications* column in Table 3 that corresponds to the vertical range used. If the result is within the selected test limit, the device has passed this portion of the verification.

7. Repeat steps 1 through 6 for each iteration in Table 3.
8. Repeat steps 1 through 7 for channel 1, changing the value of the **channelList** parameter from `"0"` to `"1"`.

Table 3. NI 5922 Vertical Offset Calibration

Iteration	Range (V)	Calibration Test Limits (V)	Published Specifications (V)
1	2	±26 μV	±50 μV
2	10	±48 μV	±100 μV

Noise

Complete the following steps to verify noise performance of the NI 5922. You must verify both channels and each iteration listed in Table 4.

1. Disconnect all cabling from the BNC inputs of the NI 5922. No input signal is needed because the NI 5922 internal 50 Ω resistor connects the input to ground.
2. Call `niScope_ConfigureChanCharacteristics` (niScope Configure Chan Characteristics VI) with the following parameters:
   - **channelList**: `"0"`
   - **inputImpedance**: `NISCOPE_VAL_50_OHM`
   - **maxInputFrequency**: `0`
3. Call `niScope_ConfigureVertical` (niScope Configure Vertical VI) with the following parameters:
   - **channelList**: `"0"`
   - **Range**: The *Range* value for the current iteration from Table 4
   - **Offset**: `0.0`
   - **Coupling**: `NISCOPE_VAL_DC`
   - **ProbeAttenuation**: `1.0`
   - **Enabled**: `NISCOPE_VAL_TRUE`
4. Call `niScope_ConfigureHorizontalTiming` (niScope Configure Horizontal Timing VI) with the following parameters:
   - **minSampleRate**: The *Sample Rate* value for the current iteration
   - **minNumPts**: `65536`

- **refPosition**: `50.0`
- **numRecords**: `1`
- **enforceRealtime**: `NISCOPE_VAL_TRUE`

5. Call `niScope_InitiateAcquisition` (niScope Initiate Acquisition VI) with the following parameter:
   - **vi:** The instrument handle you obtained from `niScope_init`
6. Call `niScope_FetchArrayMeasurement` (niScope Fetch Array Measurement VI) with the following parameters:
   - **channelList**: `"0"`
   - **timeout:** `5.0`
   - **arrayMeasFunction:** `NISCOPE_VAL_FFT_AMP_SPECTRUM_VOLTS_RMS`
   - **measWfmSize**: `-1`
7. Calculate the noise value from the returned voltage array V[*n*] using the following formula:

$$Noise\ RMS = \sqrt{\sum_{n=i}^{26215} (V[n])^2}$$

   where *i* is obtained from Table 4.

   a. Add up the squares of each element in the returned array starting with element *i* and ending with element 26,215. The first element in the array is element 0.

   b. Take the square root of the resulting sum. The result is the RMS noise between 100 Hz and 0.4 × *Sample Rate*.

   Compare the result from this step to the value listed in the *Published Specifications* column in Table 4.
8. Repeat steps 1 through 7 for each iteration in Table 4.
9. Repeat steps 1 through 8 for channel 1, changing the value of the **channelList** parameter from `"0"` to `"1"`.

Table 4. NI 5922 Noise Performance

Iteration	Range (V)	Sample Rate (S/s)	*i*	Calibration Test Limits	Published Specifications
1	2	50 k	132	0.95 µV	1 µV
2	2	100 k	66	1.12 µV	1.2 µV
3	2	1 M	7	4.05 µV	4.2 µV

Table 4. NI 5922 Noise Performance (Continued)

Iteration	Range (V)	Sample Rate (S/s)	*i*	Calibration Test Limits	Published Specifications
4	2	5 M	2	8.5 µV	8.7 µV
5	2	10 M	1	19.1 µV	20 µV
6	2	15 M	1	77 µV	80 µV
7	10	50 k	132	3.23 µV	3.4 µV
8	10	100 k	66	4.11 µV	4.3 µV
9	10	1 M	7	12.7 µV	13 µV
10	10	5 M	2	29.5 µV	31 µV
11	10	10 M	1	88 µV	92 µV
12	10	15 M	1	384 µV	401 µV

Input Bias Current

Complete the following steps to verify input bias current of the NI 5922. You must verify both channels.

1. Disconnect all cabling from the BNC inputs of the NI 5922.
2. Call `niScope_ConfigureChanCharacteristics` (niScope Configure Chan Characteristics VI) with the following parameters:
   - **channelList**: `"0"`
   - **inputImpedance**: `NISCOPE_VAL_50_OHM`
   - **maxInputFrequency**: `0`
3. Call `niScope_ConfigureVertical` (niScope Configure Vertical VI) with the following parameters:
   - **channelList**: `"0"`
   - **range**: `2`
   - **offset**: `0.0`
   - **coupling**: `NISCOPE_VAL_DC`
   - **probeAttenuation**: `1.0`
   - **enabled**: `NISCOPE_VAL_TRUE`
4. Call `niScope_ConfigureHorizontalTiming` (niScope Configure Horizontal Timing VI) with the following parameters:
   - **minSampleRate**: `1,000,000`
   - **minNumPts**: `100,000`

- **refPosition**: `50.0`
- **numRecords**: `1`
- **enforceRealtime**: `NISCOPE_VAL_TRUE`

5. Call `niScope_InitiateAcquisition`. (niScope Initiate Acquisition VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`
6. Call `niScope_FetchMeasurement` (niScope Fetch Measurement VI) with the following parameters:
   - **channelList**: `"0"`
   - **timeout**: `1.0`
   - **scalarMeasFunction**: `NISCOPE_VAL_DC_ESTIMATE`
7. Call `niScope_ConfigureChanCharacteristics` (niScope Configure Chan Characteristics VI) with the following parameters:
   - **channelList**: `"0"`
   - **inputImpedance**: `NISCOPE_VAL_1_MEG_OHM`
   - **maxInputFrequency**: `0`
8. Call `niScope_InitiateAcquisition` (niScope Initiate Acquisition VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`
9. Call `niScope_FetchMeasurement` (niScope Fetch Measurement VI) with the following parameters:
   - **channelList**: `"0"`
   - **timeout**: `1.0`
   - **scalarMeasFunction**: `NISCOPE_VAL_DC_ESTIMATE`
10. Calculate the bias current using the following formula:

$$Bias\ Current = \frac{a - b}{1{,}000{,}000}$$

where

a = the voltage measured in step 6

b = the voltage measured in step 9

1,000,000 is the NI 5922 impedance in ohms

Compare the resulting bias current to the value listed in the *Calibration Test Limits* column or the *Published Specifications* column in Table 5. If the result is less than the selected test limit, the device has passed this portion of the verification.

11. Repeat steps 1 through 10 for channel 1, changing the value of the **channelList** parameter from `"0"` to `"1"`.

Table 5. NI 5922 Input Bias Current

Calibration Test Limit	Published Specification
±350 nA	±500 nA

Vertical Gain Accuracy

Complete the following steps to verify vertical gain accuracy of the NI 5922. You must verify both channels and each iteration listed in Table 6.

1. Call `niScope_ConfigureChanCharacteristics` (niScope Configure Chan Characteristics VI) with the following parameters:
   - **channelList**: `"0"`
   - **inputImpedance**: `NISCOPE_VAL_1_MEG_OHM`
   - **maxInputFrequency**: `0`
2. Call `niScope_ConfigureVertical` (niScope Configure Vertical VI) with the following parameters:
   - **channelList**: `"0"`
   - **range**: The *Range* value for the current iteration from Table 6
   - **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 DC voltage calibrator source to the channel 0 input of the digitizer and output the positive voltage from Table 6 that corresponds to the vertical range used.

6. Wait 2,500 ms for the calibrator 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. Generate the negative voltage listed in Table 6 with the calibrator.
10. Wait 2,500 ms for the output of the calibrator to settle.
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. Calculate the error in the vertical gain as a percentage of input using the following formula:

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

    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 *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.
14. Repeat steps 1 through 13 for each iteration listed in Table 6, changing the *Range*, *Positive Input*, and *Negative Input* values accordingly.
15. Move the calibrator to the digitizer input channel 1 and repeat steps 1 through 14, changing the value of the **channelList** parameter from `"0"` to `"1"`.

Table 6. NI 5922 Vertical Gain Stimuli

Iteration	Range (V)	Positive Input (V)	Negative Input (V)	Calibration Test Limits	Published Specifications
1	2	0.9	–0.9	±0.0293%	±0.05%
2	10	4.5	–4.5	±0.0293%	±0.05%

Timing Accuracy

Complete the following steps to verify the timing accuracy for the NI 5922.

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.

1. Call `niScope_ConfigureChanCharacteristics` (niScope Configure Chan Characteristics VI) with the following parameters:
   - **channelList**: `"0"`
   - **inputImpedance**: `NISCOPE_VAL_50_OHM`
   - **maxInputFrequency**: `0`
2. Call `niScope_ConfigureVertical` (niScope Configure Vertical VI) with the following parameters:
   - **channelList**: `"0"`
   - **range**: `10`
   - **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**: `15,000,000`
   - **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 scope calibrator to the channel 0 input of the digitizer. Configure the calibrator to output an exact 2 MHz sine wave with 1 V peak-to-peak amplitude and 50 Ω load impedance.
6. Wait 1,000 ms for the impedance matching and frequency of the calibrator 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. Calculate the error in timing as parts per million (ppm) using the following formula:

$$error = \frac{(a - 2{,}000{,}000)}{2}$$

   where

   a = 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. NI 5922 Timing Accuracy

Calibration Test Limi	Published Specification
±5.3 ppm	±50 ppm

Flatness

Complete the following steps to verify the flatness of the NI 5922. You must verify both channels and each iteration listed in Table 8.

1. Call `niScope_ConfigureChanCharacteristics` (niScope Configure Chan Characteristics VI) with the following parameters:
   - **channelList**: `"0"`
   - **inputImpedance**: `NISCOPE_VAL_50_OHM`
   - **maxInputFrequency**: `0`

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**: The *Sample Rate* value for the current iteration in Table 8
   - **minNumPts**: `500`
   - **refPosition**: `50.0`
   - **numRecords**: `400`
   - **enforceRealtime**: `NISCOPE_VAL_TRUE`
4. Call `niScope_ConfigureTriggerEdge` (niScope Configure Trigger Edge VI) with the following parameters:
   - **triggerSource**: `"0"`
   - **level**: `-0.1`
   - **slope**: `NISCOPE_VAL_POSITIVE`
   - **triggerCoupling**: `NISCOPE_VAL_DC`
   - **holdoff**: `0`
   - **delay**: `0`
5. Call `niScope_Commit` (niScope Commit VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`
6. Connect the scope calibrator to the channel 0 input of the digitizer. Configure the calibrator as follows:
   a. Set the calibrator to rising edge (500 ps) output mode.
   b. Set the frequency to 500 Hz.
   c. Set the peak-to-peak voltage amplitude to one tenth of the vertical range used in step 2.
   d. Set the load impedance of the calibrator to 50 Ω
7. Wait 1,000 ms for the impedance matching of the calibrator to settle.

8. Call `niScope_InitiateAcquisition` (niScope Initiate Acquisition VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`
9. Call `niScope_Fetch` (niScope Multi Fetch VI) with the following parameters:
   - **channelList**: `"0"`
   - **timeout**: `5.0`
   - **numSamples:** `-1`
10. The Fetch function returns a two-dimensional array, with one row corresponding to each of the 400 triggered records. For this array, complete the following steps:
    a. Perform a mathematical convolution on the first record with the array (+1, –1). Denote the result as X1, which contains 501 elements.

    b. Discard the first 150 elements and the last 151 elements from X1. Denote the resulting array as X2, which contains 200 elements.

    c. Perform a circular rotation of the elements within array X2 so that index 0 of the array contains the element with the largest value. Denote the result as X3.

    A circular rotation takes the first element of the array, makes it the last element and shifts all the other elements over one space. The second element now becomes the first. Repeat this process until you reach the desired result.

    d. Perform a complex FFT on the array X3. The result is an array of complex numbers with 200 elements. Discard the last 119 elements. Take the magnitude of the complex number to obtain a real number for each element. Denote this array as X4.

    e. Denote the last element of array X4 as R. Perform the following calculation on the complex number R:

    $$e = \left(\frac{R}{|R|}\right)^{1/80}$$

    The absolute value notation implies calculating the real magnitude (or radius) of the complex number.

    f. The vector X4 has 81 elements. Index this vector from $i = 0$ to 80. Calculate a new complex vector X5 by calculating on all the elements within X4:

    $$X5[i] = \frac{(X4[i])/\ e^{i}}{\sin(\pi \times i/\ 200)}$$

g. Repeat steps 10a through 10f for the next data record, and repeat until you have calculated a result for each of the 400 data records.

11. Calculate the sum of all 400 arrays resulting from step 10. Denote this sum as X6. X6[0] contains the sum of the first elements in each X5, X6[1] contains the sum of the second elements in each X5, and so on.
12. For all elements of X6 (indexed from 0 to 80) calculate a new real array X7:

$$X7[i] = 20\log|X6[i]| - 20\log|X6[0]|$$

The absolute value notation implies calculating the real magnitude (or radius) of the complex number.

Compare the absolute value of each element in X7 to the value listed in the *Calibration Test Limits* column or the *Published Specifications* column in Table 8. If the result is less than the selected test limit, the device has passed this portion of the verification.

13. Repeat steps 1 through 12 for each iteration listed in Table 8.
14. Move the scope calibrator to the digitizer input channel 1 and repeat steps 1 through 13, changing the values of the **channelList** and **triggerSource** parameters from `"0"` to `"1"`.

Table 8. NI 5922 Flatness Settings and Limits

Iteration	Range (V)	Sample Rate (S/s)	Calibration Test Limits	Published Specifications
1	2	5 M	0.06 dB	0.06 dB
2	2	10 M	0.15 dB	0.15 dB
3	2	15 M	0.3 dB	0.3 dB
4	10	5 M	0.06 dB	0.06 dB
5	10	10 M	0.15 dB	0.15 dB
6	10	15 M	0.3 dB	0.3 dB

Note The –3 dB bandwidth of the NI 5922 is set by its digital filters and does not need to be verified.

Trigger Sensitivity

Complete the following steps to verify trigger sensitivity for the external trigger channel of the NI 5922.

1. Call `niScope_ConfigureChanCharacteristics` (niScope Configure Chan Characteristics VI) with the following parameters:
   - **channelList**: `"0"`
   - **inputImpedance**: `NISCOPE_VAL_1_MEG_OHM`
   - **maxInputFrequency**: `0`
2. Call `niScope_ConfigureVertical` (niScope Configure Vertical VI) with the following parameters:
   - **channelList**: `"0"`
   - **range**: `10`
   - **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**: `15,000,000`
   - **minNumPts**: `1,000`
   - **refPosition**: `50.0`
   - **numRecords**: `50`
   - **enforceRealtime**: `NISCOPE_VAL_TRUE`
4. Call `niScope_ConfigureTriggerEdge` with the following parameters:
   - **triggerSource**: `VAL_EXTERNAL`
   - **level**: `0.03125`
   - **slope**: `NISCOPE_VAL_POSITIVE`
   - **triggerCoupling**: `NISCOPE_VAL_DC`
   - **holdoff**: `0`
   - **delay**: `0`

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

5. Call `niScope_Commit` (niScope Commit VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`

6. Connect the scope calibrator to the external trigger channel of the digitizer. Configure the calibrator to output an exact 1 MHz sine wave with 0.3 V peak-to-peak amplitude and 1 MΩ load impedance.
7. Wait 1,500 ms for the calibrator impedance matching and frequency to settle.
8. Call `niScope_InitiateAcquisition` (niScope Initiate Acquisition VI) with the following parameter:
   - **vi**: The instrument handle you obtained from `niScope_init`
9. Call `niScope_Fetch` (niScope Multi Fetch VI) with the following parameters:
   - **channelList**: `"0"`
   - **timeout**: `2.0`
   - **numSamples**: `-1`

   If the digitizer does not time out, the digitizer has passed this portion of the verification. If the digitizer has a timeout error, call `niScope_Abort` (niScope Abort VI) to end the acquisition.
10. Repeat steps 1 through 9, changing the value of the the **slope** parameter from `"NISCOPE_VAL_POSITIVE"` to `"NISCOPE_VAL_NEGATIVE"`.

Note The NI 5922 uses the digitized data from the input channel ADC when performing an analog trigger on CH 0 or CH 1. Verifying the trigger sensitivity for the input channels is not necessary.

Adjusting the NI 5922

If the NI 5922 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 4 and 13 in this section.

Complete all of the following steps to externally adjust the NI 5922.

1. Connect the scope calibrator to the channel 0 input of the digitizer. Configure the calibrator to output an exact 1 MHz sine wave with 1 V peak-to-peak amplitude and 1 MΩ load impedance.
2. Connect the DC source calibrator to the channel 1 input of the digitizer. Configure the DC source calibrator to output an exact 4 V DC signal into a 1 MΩ load impedance (channel 1).
3. Wait 3,000 ms for the calibrator to settle.
4. Call `niScope_CalStart` (niScope Cal Start VI) using the user password. The factory default password for the NI 5922 is `NI`.
5. Call `niScope_CalSelfCalibrate` (niScope Cal Self Calibrate VI) with the following parameters:
   - **channelList**: `VI_NULL`
   - **option**: `VI_NULL`
6. Call `niScope_CalAdjustVCXO` (niScope Cal Adjust VCXO VI) with the following parameter:
   - **stimulusFreq**: `1,000,000`

Note The 1 MHz stimulus is automatically taken from channel 0.

7. Call `niScope_CalAdjustRange` (niScope Cal Adjust Range VI) with the following parameters:
   - **channelName**: `"1"`
   - **range**: `0`
   - **stimulus**: `4.0`
8. Configure the DC source calibrator to output an exact –4 V DC signal into a 1 MΩ load impedance (channel 1).
9. Wait 3,000 ms for the calibrator to settle.
10. Call `niScope_CalAdjustRange` (niScope Cal Adjust Range VI) with the following parameters:
    - **channelName**: `"1"`
    - **range**: `0`
    - **stimulus**: `-4.0`
11. Disconnect or disable all inputs to the digitizer.
12. Call `niScope_CalSelfCalibrate` (niScope Cal Self Calibrate VI) with the following parameters:
    - **channelList**: `VI_NULL`
    - **option**: `VI_NULL`

13. 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 5922. 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 5922, 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 want 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 for the following utility functions:

- `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)

Where to Go for Support

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

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