CALIBRATION PROCEDURE

NI PXIe-6555/6556

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ni.com/manuals

This document contains the verification and adjustment procedures for the NI PXIe-6555 (NI 6555) and NI PXIe-6556 (NI 6556) 200 MHz digital waveform generator/analyzer with PPMU. For more information about calibration solutions, visit ni.com/calibration.

Contents

Software

To calibrate the NI 6555/6556, you must install NI-HSDIO 2.0 or later on the calibration system. You can download NI-HSDIO from `ni.com/downloads`. NI-HSDIO supports LabVIEW and LabWindows™/CVI™. When you install NI-HSDIO, you only need to install support for the application software that you intend to use.

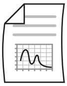
Note NI 6555/6556 calibration is not supported on the LabVIEW Real-Time operating system.

Related Documentation

Consult the following documents for information about the NI 6555/6556, NI-HSDIO, and your application software. All documents are available at `ni.com/manuals` and at **Start» All Programs»National Instruments»NI-HSDIO»Documentation**.

NI Digital Waveform Generator/Analyzer Getting Started Guide

Contains instructions for NI-HSDIO installation, hardware installation, and hardware programming



NI PXIe-6555/6556 Specifications

Contains NI 6555/6556 specifications and calibration interval

NI-HSDIO Readme

Contains operating system and application software support in NI-HSDIO

NI Digital Waveform Generator/Analyzer Help

Contains detailed information about the NI 6555/6556

LabVIEW Help

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

NI-HSDIO C Reference Help

Contains reference information for NI-HSDIO C functions and NI-HSDIO C properties

Test Equipment

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

Table 1. Recommended Equipment

Equipment	Recommended Model	Where Used	Requirements
Digital Multimeter (DMM)	NI PXI-4071	*Verifying DC Generation Voltage Accuracy* *Verifying DC Acquisition Voltage Threshold Accuracy* *Verifying Force Voltage Accuracy and Measure Voltage Accuracy*	DCV Input Range: -3 V to 8 V DCV Accuracy: $\leq$ 93 µV DCV Input Impedance: 10 MΩ Internal switch controller (if your DMM does not have an internal switch controller, you must use an external switch controller).
Source Measurement Unit (SMU)	NI PXI-4132	*Verifying Force Current Accuracy and Measure Current Accuracy* *Verifying Force Current Voltage Clamp Accuracy* Quadrant Boundary (*Verifying Force Current Quadrant Boundary* and *Verifying Force Voltage Quadrant Boundary*)	DCI Accuracy: 0.083% (2 µA range), 0.042% (8 µA range), 0.062%(32 µA range), 0.11%(128 µA range), 0.049% (512 µA range), $\leq$ 0.083% (2 mA range), $\leq$ 0.042% (8 mA range), $\leq$ 0.054% (32 mA range) DCV Input Range: -3 V to 8 V DCV Accuracy: 3.4 mV

Table 1. Recommended Equipment (Continued)

Equipment	Recommended Model	Where Used	Requirements
Digital Oscilloscope	Tektronix DPO7104C or DPO70404C	*Verifying Exported Sample Clock Duty Cycle* (DDC CLK OUT) *Verifying Pin-to-Pin Output Skew Accuracy* *Verifying Pin-to-Pin Input Skew Accuracy*	Timebase accuracy < 25 ppm Analog Bandwidth > 1 GHz with two edge measurement accuracy ≤ 10 ps
Multiplexer	NI PXIe-2593 (×3) or NI SCXI-1193 (×2)	—	500 MHz Bandwidth
Breakout Box (×2)	NI SMB-2163 NI part number 779566-01	—	Single-ended SMB connectors
Shielded Single-ended Cable (×2)	NI SHC68-C68-D4	—	Shielded 50 Ω coaxial cable (68-pin VHDCI connector)
MCX-SMB cable (×29)	NI part number 188376-01	—	50 Ω coaxial cable, 1 m length
MCX-MCX cable (×4)	NI part number 188374-0R3	—	50 Ω coaxial cable, 0.3 m length
MCX-SMA cable (×5)	NI part number 188377-01	—	50 Ω coaxial cable, matched cable length
Digital Sampling Oscilloscope	Tektronix CSA8000 or DSA8300	*TDR Cable Testing*	Time Interval Accuracy: ≤ 8 ps + 0.01% of interval
TDR Sampling Module	Tektronix 80E04	*TDR Cable Testing*	Time Interval Accuracy: ≤ 8 ps + 0.01% of interval

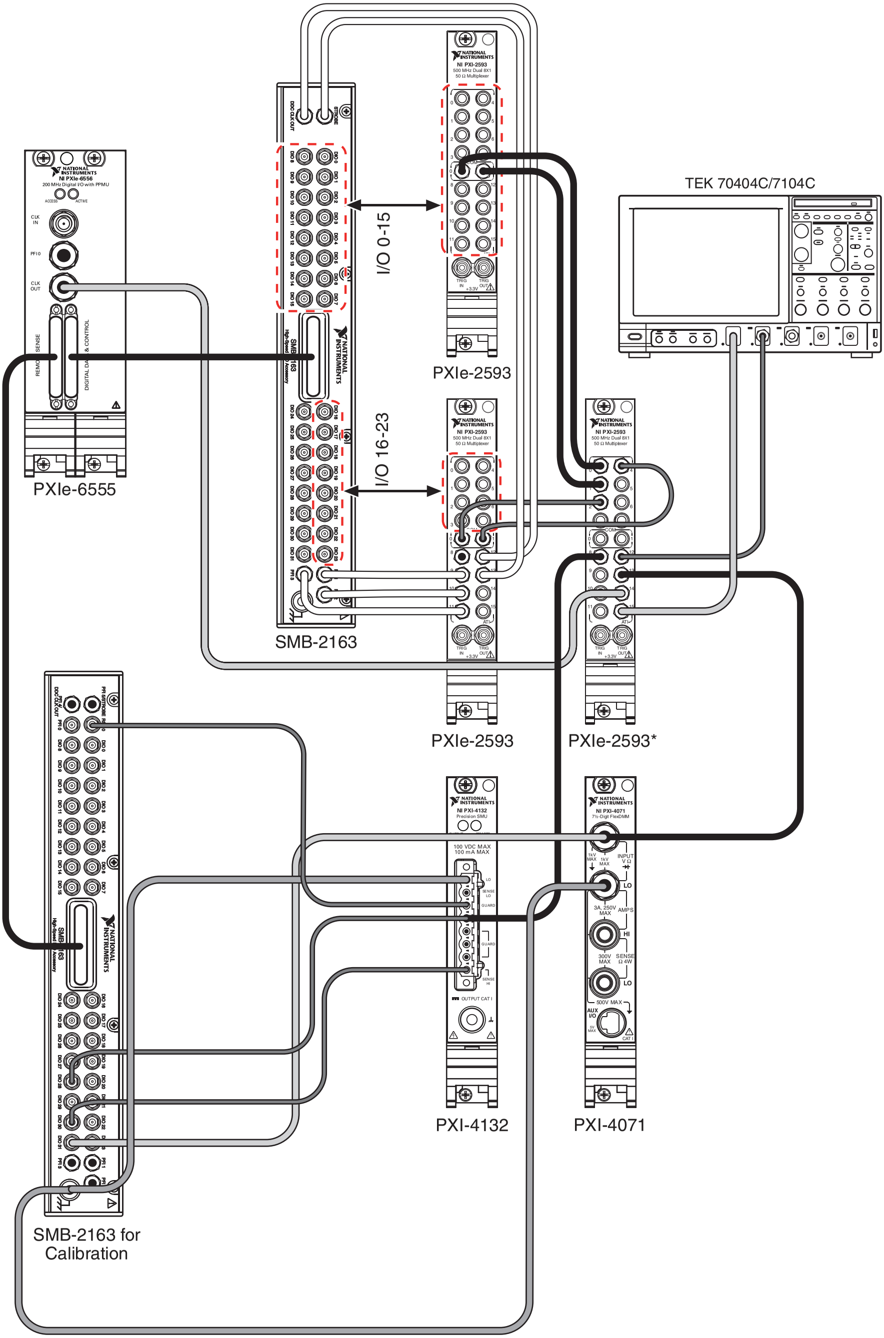
Note Refer to the connection diagram below for NI 6555/6556-specific hardware.

Connecting Calibration Equipment

Connecting the NI 6555

The following figure shows how to connect the recommended test equipment to the NI 6555 to perform verification and adjustment.

Figure 1. NI 6555 Test Equipment Connections



Note For I/O channels 0 through 15, connect the I/O channels to their corresponding switches sequentially. For example, connect I/O 0 to Switch 0, I/0 1 to Switch 1, and so on.

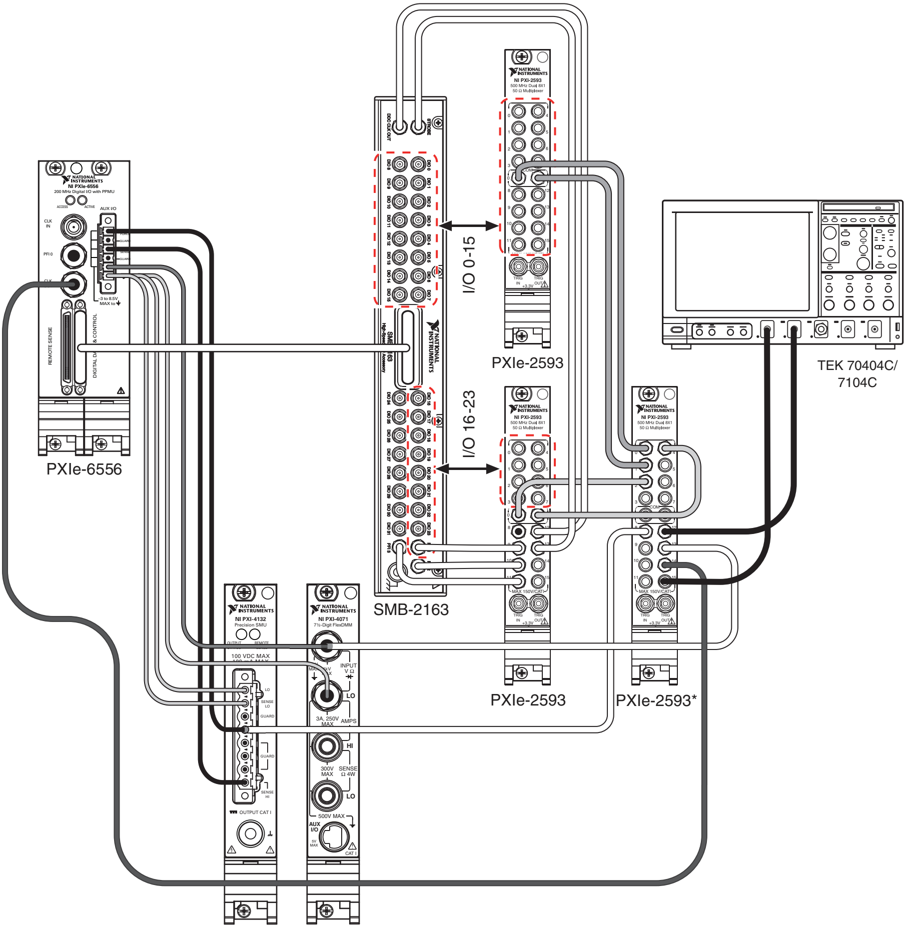
Note For I/O channels 16 through 23, connect the I/O channels to their corresponding switches sequentially. Connect I/O 16 to Switch 0, I/0 17 to Switch 1, and so on.

Note On the NI PXI-2593 marked with an asterisk (*), route the two COM connectors internally.

Connecting the NI 6556

The following figure shows how to connect the recommended test equipment to the NI 6556 to perform verification and adjustment.

Figure 2. NI 6556 Test Equipment Connections



Note For I/O channels 0 through 15, connect the I/O channels to their corresponding switches sequentially. For example, connect I/O 0 to Switch 0, I/0 1 to Switch 1, and so on.

Note For I/O channels 16 through 23, connect the I/O channels to their corresponding switches sequentially. Connect I/O 16 to Switch 0, I/0 17 to Switch 1, and so on.

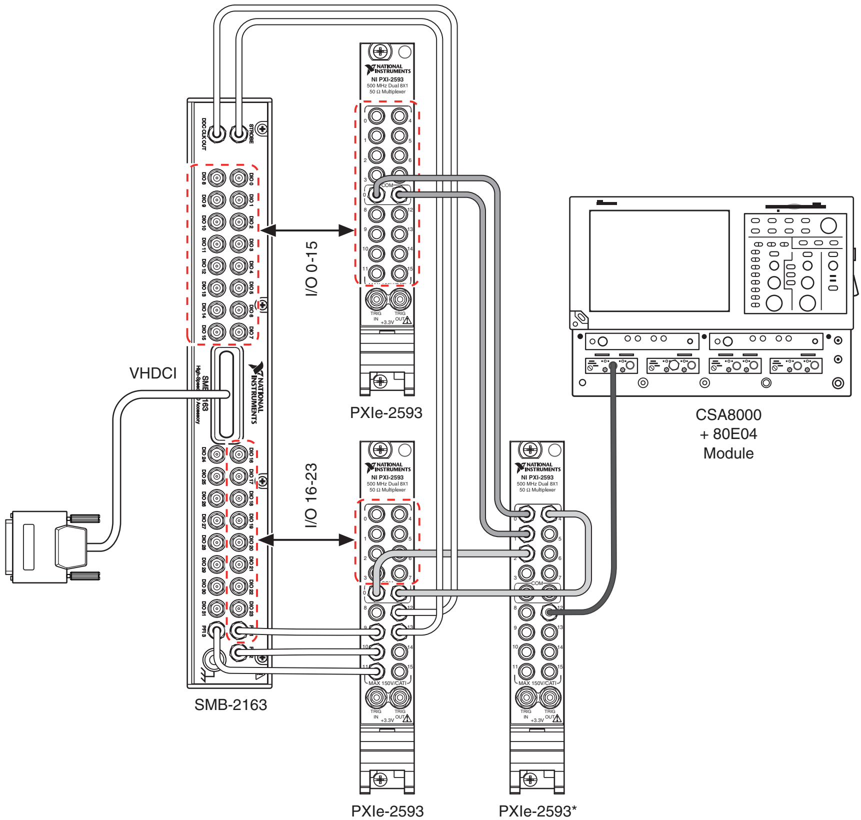
Note On the NI PXI-2593 marked with an asterisk (*), route the two COM connectors internally.

Connecting TDR Cable Testing Equipment

The following figure shows how to connect the recommended test equipment to the switch matrix to perform time-domain reflectometer (TDR) cable testing.

Note You must perform TDR cable testing every time you introduce a new cable, including the VHDCI cable, to the recommended test equipment.

Figure 3. NI 6555/6556 TDR Cable Testing Connections



Note For I/O channels 0 through 15, connect the I/O channels to their corresponding switches sequentially. For example, connect I/O 0 to Switch 0, I/0 1 to Switch 1, and so on.

Note For I/O channels 16 through 23, connect the I/O channels to their corresponding switches sequentially. Connect I/O 16 to Switch 0, I/0 17 to Switch 1, and so on.

Note On the NI PXI-2593 marked with an asterisk (*), route the two COM connectors internally.

Test Conditions

The following setup and environmental conditions are required to ensure the NI 6555/6556 meets published specifications.

- Keep connections to the NI 6555/6556 as short as possible. Long cables and wires act as antennas, picking up extra noise that can affect measurements.
- Verify that all connections to the NI 6555/6556 are secure.
- Use shielded copper wire for all cable connections to the NI 6555/6556. Use twisted-pair wire to eliminate noise and thermal offsets.
- Use 50 Ω BNC coaxial cables for all connections to the NI 6555/6556.
- Maintain an ambient temperature of 23 °C ±5 °C. The NI 6555/6556 temperature will be greater than the ambient temperature.
- The ambient temperature variation during adjustment and final verification must be within ±1 °C.
- Keep relative humidity below 80%.
- Allow adequate warm-up time for all of the instruments and equipment according to the manufacturer instructions.
- Ensure that the PXI/PXI Express chassis fan speed is set to HIGH, that the fan filters are clean, and that the empty slots contain filler panels. For more information, refer to the *Maintain Forced-Air Cooling Note to Users* document available at `ni.com/manuals`.

TDR Cable Testing

Complete the following steps to perform TDR testing on the cables used for device calibration. You must test the TDR cables every time you change a cable or you use a new cable for device calibration.

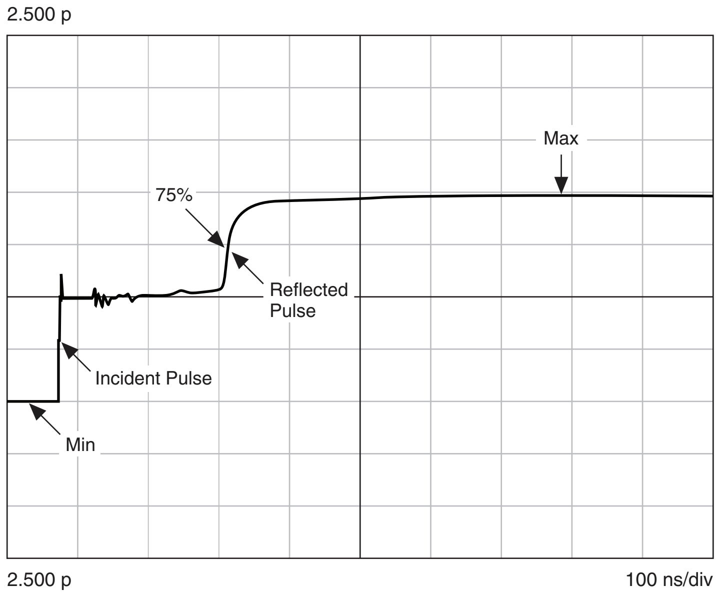
1. Disconnect the VHDCI cable from the NI 6555/6556.
2. Clear all previous TDR oscilloscope measurements.
3. Initialize only CH1 on the TDR oscilloscope.
4. Execute the TDR preset function for CH1 on the TDR oscilloscope.
5. Turn on the TDR state function on the TDR oscilloscope.
6. Configure the TDR oscilloscope according to the following settings:
   a. TDR step polarity: Rising edge
   b. Units: ρ (rho)
   c. Trigger source: internal clock
   d. Internal clock rate: 100 kHz
   e. Acquisition mode: Average
   f. Number of samples to average: 16

g. Timebase: Main TB
h. Horizontal scale: 100 ns/div
i. Record Length: 4000

7. Configure the switch matrix so that CH0 on the NI 2163 is connected to CH1 on the TDR oscilloscope. Use the same cable that is connected to CHB on the digital oscilloscope. Wait 3 seconds for the measurement to settle.

Reflected Pulse Zooming

Figure 4. Full Waveform with Incident and Reflected Pulses



8. Measure the maximum amplitude (Max) and the minimum amplitude (Min) of the waveform. Measure Max and Min in ρ.
9. Calculate the amplitude at the middle of the reflected pulse (MidPulse) using Min and Max with the following equation:

$$MidPulse = 0.75 \times (Max - Min) + Min$$

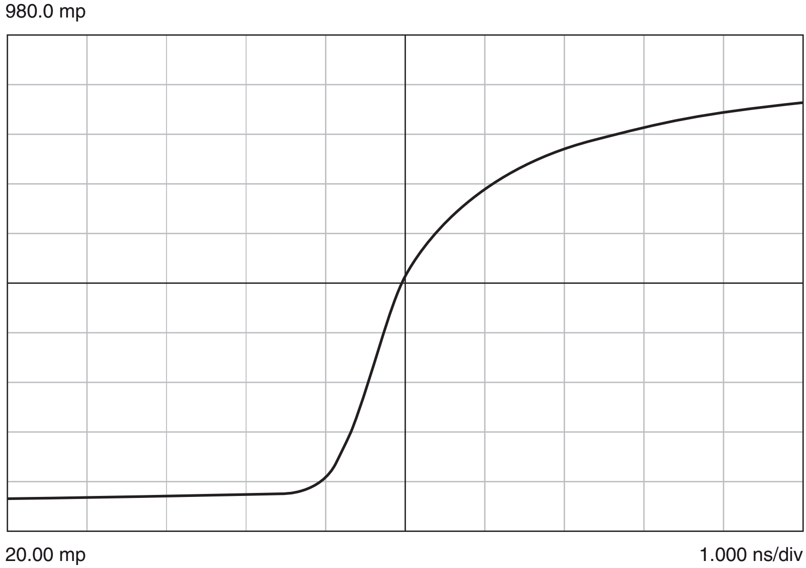
10. Record the time at MidPulse calculated in the previous step as MidTime. MidTime is only calculated for Channel 0. For all other channels, use the time calculated for Channel 0.

Note The channel-to-channel skew through the switch matrix and cables must be <5 ns.

11. Configure the horizontal scale on the oscilloscope to 1 ns/div, and center the reflected pulse using MidTime for only channel 0.

12. Configure the vertical scale to 100 mρ/div and the vertical position to -4.8 div.

Figure 5. Waveform Reflected Pulse After Zooming



Calculating Delay

13. Acquire the waveform from the oscilloscope.
14. Locate the HorizontalIndex for the 250 mρ threshold using linear interpolation.
15. Use the following equation to determine TDRDelay, in seconds:

$$TDRDelay = \frac{HorizontalIndex \times TimeFactor}{2}$$

where *TimeFactor* = (10 divisions × 1 × 10^{-9} s/division) / 4,000 points

= 2.5 × 10^{-12} s/point (0.0025 ns)

16. Clear the data on the oscilloscope.
17. Repeat step 7and steps 13 through 16 for channels 1 to 23 and PFI1, PFI2, PFI4, and PFI5.
18. Save the TDRDelay values for all channels into a system TDR value array for future use.

Self-Calibration

Complete the following steps to self-calibrate the device.

1. Disconnect or disable all connections to the NI 6555/6556.
2. Wait 30 minutes for the device to warm up.
3. Initialize a generation session.
4. Call the self-calibration function.

5. Close the generation session.

Verification

The following performance verification procedures describe the sequence of operation and test limits required to check the NI 6555/6556. This procedure assumes that adequate traceable uncertainties are available for the calibration references.

Verifying DC Generation Voltage Accuracy

Complete the following procedure to determine the as-found and as-left status of the NI 6555/6556 generation voltage high (VOH), generation voltage level low (VOL), and termination voltage (VTT) accuracy.

1. Initialize a generation session, reset the device, and close the generation session.
2. Configure the DMM according to the following settings:
    a. Function: DC volts
    b. Range: 10 V
    c. Digits of resolution: 6.5 digits
    d. Power line frequency: 50 Hz or 60 Hz, depending on your country
    e. Aperture time: 1 PLC
    f. ADC calibration: On
3. Initialize an external calibration session, and initialize a child session with a generation session type.
4. Connect channel 0 of the NI 6555/6556 to the DMM through the switch matrix.
5. Call the configure (channel) calibration state function with the external calibration session handle according to the following settings:
    a. Channel: Channel under test
    b. Calibration type: Output voltage accuracy verify
6. Assign channels 0 to 23 as dynamic channels with the child session handle initialized in step 3.
7. Set the data voltage level range attribute string to the -2 V to 6 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.
8. Write a waveform composed of all 1s (0xFFFFFFFF) for 128 samples to test the VOH.
9. Initiate generation and call the wait until done function.
10. Set the data high voltage level to the first test voltage in Table 2 with the configure voltage function, and call the commit (dynamic) function to commit the change.
11. Wait 1 ms for the output to settle, and measure the output voltage of channel 0 on the NI 6555/6556 with the DMM.
12. Record the output voltage measurement, and calculate the error value by subtracting the measured voltage from the test voltage. Compare the error value to the as-found or as-left test limit in Table 2.
13. Repeat steps 10 through 12 for the remaining test voltages in Table 2.

14. To verify the VOL, repeat steps 8 through 13 with the following modifications:
    a. Step 8—Write a waveform composed of all 0s (0x00000000) for 128 samples.
    b. Step 10—Set the data low voltage level to the first test voltage in Table 2 with the configure voltage function, and call the commit (dynamic) function to commit the change.
15. To verify the VTT, repeat steps 8 through 13 with the following modifications:
    a. Step 8—Set the tristate mode attribute to **drive termination voltage**, then set the supported data states attribute to **0, 1, Z (tristate)**, and write a digital waveform composed of all Zs for 128 samples.
    b. Step 10—Set the data termination voltage level attribute to the first test voltage in Table 2 for the channel under test, and and call the commit (dynamic) function to commit the change.
16. Disconnect the NI 6555/6556 from the DMM through the switch matrix.
17. Repeat steps 4 through 16 for channels 1 to 23, PFI1, PFI2, PFI4, and PFI5.
18. Clear the calibration state with the external calibration session handle.
19. Close the child session with the external calibration. Close the child session handle and the external calibration session with a calibration action input of **Cancel**.
20. Repeat steps 1 through 19 for the -1 V to 7 V voltage level range with the following modifications:
    a. Step 7—Set the data voltage level range attribute string to the -1 V to -7 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.

Table 2. NI 6555/6556 DC Generation Voltage Accuracy Verification Test Limits

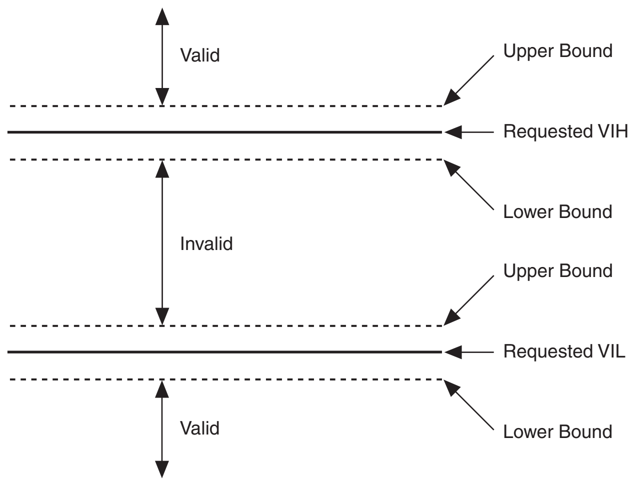
Voltage Level Range	Test Voltage	As-Found Test Limit (mV) ±5 °C of Self-Calibration			As-Left Test Limit (mV) ±1 °C of Self-Calibration		
		VOH	VOL	VTT	VOH	VOL	VTT
-2 V to 6 V	-2 V	±11	±11	±11	±9.07	±9.72	±10.01
	0 V						
	2 V						
	4 V						
	6 V						
-1 V to 7 V	-1 V	±11	±11	±11	±9.07	±9.72	±10.01
	1 V						
	3 V						
	5 V						
	7 V						

Verifying DC Acquisition Voltage Threshold Accuracy

Complete the following procedure to determine the as-found and as-left status of the NI 6555/6556 DC acquisition voltage threshold accuracy.

1. Initialize a generation session, reset the device, and close the generation session.
2. Configure the DMM according to the following settings:
   a. Function: DC volts
   b. Range: 10 V
   c. Digits of resolution: 6.5 Digits
   d. Power line frequency: 50 Hz or 60 Hz, depending on your country
   e. Auto zero: Once
   f. ADC calibration: On
   g. Aperture Time: 1 PLC
3. Initialize an external calibration session.
4. Initialize a child acquisition session and a child generation session from the external calibration session handle.
5. Connect channel 0 of the NI 6555/6556 to the DMM through the switch matrix.
6. Call the configure (channel) calibration state function with an external calibration session handle according to the following settings:
   a. Channel: Channel under test
   b. Calibration type: Input voltage accuracy verify

Figure 6. VIH and VIL Upper and Lower Bounds



Determining the Lower and Upper VIL Bounds

7. Configure a dynamic acquisition session according to the following steps:
   a. Assign channels 0 to 23 as dynamic channels with the child acquisition session handle initialized in step 4.
   b. Configure the Sample Clock rate to 50 MHz using the onboard clock.
   c. Set the data voltage level range attribute string to the -2 V to 6 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.
   d. Set the data interpretation attribute to **valid or invalid**.
   e. Set the VIL to the first test voltage in Table 4.
   f. Set the VIH to the range maximum of 6 V.
   g. Set the acquisition size to `500` samples per record.
   h. Dynamically commit the change.
8. Configure a dynamic generation session.
   a. Assign channels 0 to 23 as dynamic channels with the child generation session handle initialized in step 4.
   b. Set the data voltage level range attribute string to the -2 V to 6 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.
   c. Set the VOH 0.1 V lower than the test voltage.
   d. Write a waveform of only 1s (0xFFFFFFFF) for 128 samples.
9. Initiate generation, and call the wait until done function.
10. Set the PPMU-capable I/O switch attribute to **disconnect**, and wait 1 ms for the switch to settle.
11. Read a waveform of 500 samples. Apply a channel mask to the acquired data by ANDing the acquired data with a channel mask.

Table 3. Channel Mask Values

Channel	Channel Mask (Hexadecimal)	Channel	Channel Mask (Hexadecimal)
0	0x1	14	0x4000
1	0x2	15	0x8000
2	0x4	16	0x10000
3	0x8	17	0x20000
4	0x10	18	0x40000
5	0x20	19	0x80000
6	0x40	20	0x100000
7	0x80	21	0x200000

Table 3. Channel Mask Values (Continued)

Channel	Channel Mask (Hexadecimal)	Channel	Channel Mask (Hexadecimal)
8	0x100	22	0x400000
9	0x200	23	0x800000
10	0x400	PFI1	0x100000
11	0x800	PFI2	0x200000
12	0x1000	PFI4	0x400000
13	0x2000	PFI5	0x800000

Note PFI1, PFI2, PFI4, and PFI5 share the same channel masks as channels 20 to 23. The configure calibration state function maps PFI1, PFI2, PFI4, and PFI5 to channels 20 to 23, so that waveforms acquired from PFI1, PFI2, PFI4, and PFI5 can be stored in the channel 20 to 23 memory. Ensure that you call the configure calibration state function correctly in step 6.

a. If all data points for the channel under test with the mask applied return **`=0 (valid)`**, increase the output voltage by a step size of 0.2 V for the channel under test, and dynamically commit the change.

b. In all other cases, decrease the output voltage by a step size of 0.2 V and commit the change.

12. Repeat the previous step eleven times, and decrease the step size by 1/2 each time. The final output voltage is the Lower VIL Boundary.
13. Set the PPMU-capable I/O switch attribute to **connect** and wait 1 ms. Then measure this boundary voltage using the DMM.
14. Set the PPMU-capable I/O switch attribute to **disconnect**, and wait 1 ms for the switch to settle.
15. Reset the VOH to 0.1 V higher than the test voltage. Read the waveform for 500 samples.
    a. If all data points for the channel under test with the mask applied return ≥**`1 (invalid)`**, decrease the output voltage by a step of 0.2 V for the channel under test, and dynamically commit the change.
    b. In all other cases, increase the output voltage by a step size of 0.2 V, and commit the change.
16. Repeat the previous step eleven times, and decrease the step size by 1/2 each time. The final output voltage is the Upper VIL Boundary.
17. Set the PPMU-capable I/O switch attribute to **connect** and wait 1 ms. Then measure this boundary voltage using the DMM.

Determining the Lower and Upper VIH Bounds

18. Repeat steps 7 through 17 with the following modifications:
    a. Step 7e and 7f—Set the VIH to the first test voltage in Table 4. Set the VIL to the range minimum of -2 V.
    b. Step 11—Read a waveform of 500 samples.
       - If all data points for the channel under test with the mask applied return ≥**`1 (invalid)`**, increase the output voltage by a step size of 0.2 V for the channel under test, and dynamically commit the change.
       - In all other cases, decrease the output voltage by a step size of 0.2 V and commit the change.
    c. Step 12—Repeat the previous step eleven times, halving the step size each time. The final output voltage is the Lower VIH Boundary.
    d. Step 15—Reset the VOH to 0.1 V higher than the test voltage. Read the waveform for 500 samples.
       - If all data points for the channel under test read **`=0 (valid)`**, decrease the output voltage by a step of 0.2 V, and dynamically commit the change.
       - In all other cases, increase the output voltage by a step size of 0.2 V and commit the change.
    e. Step 16—Repeat the previous step eleven more times. Decrease the step size by 1/2 each time. The final output voltage is the Upper VIH Boundary.
19. Subtract the Test Voltage from the Measure Boundary Voltage to derive the Error Value, and compare the Error Value to the as-found or as-left test limit.
20. Repeat steps 7 through 19 for all test voltages in Table 4.
21. Disconnect the NI 6555/6556 channel from the DMM.
22. Repeat steps 5 through 21 for channels 1 to 23 and PFI1, PFI2, PFI4, and PFI5.
23. Clear the calibration state with the external calibration session handle.
24. Close both child sessions with the external calibration session and child session handles.
25. Call the close external calibration function with a calibration action input of **cancel**.
26. Repeat steps 1 through 25 for the -1 V to 7 V range with modifications:
    a. Step 7c—Set the data voltage level range attribute string to the -1 V to 7 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.
    b. Step 7f—Set the VIH to the range maximum of 7 V.
    c. Step 8b—Set the data voltage level range attribute string to the -1 V to 7 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.
    d. Step 7e and 7f—Set the VIH to the first test voltage in Table 4. Set the VIL to the range minimum of -1 V.

Table 4. NI 6555/6556 DC Acquisition Voltage Threshold Accuracy Verification As-Found Test Limits

Voltage Level Range	Test Voltage	As-Found Test Limit (mV) ±5 °C of Self-Calibration	
		VIH	VIL
-2 V to 6 V	-1.500 V	±25	±25
	0.250 V		
	2.000 V		
	3.750 V		
	5.500 V		
-1 V to 7 V	-0.500 V	±25	±25
	1.325 V		
	3.150 V		
	4.975 V		
	6.800 V		

Table 5. NI 6555/6556 DC Acquisition Voltage Threshold Accuracy Verification As-Left Test Limits

Voltage Level Range	Test Voltage	As-Left Test Limit (mV) ±1 °C of Self-Calibration	
		VIH	VIL
-2 V to 6 V	-1.500 V	±20.66	±21.46
	0.250 V		
	2.000 V		
	3.750 V		
	5.500 V		
-1 V to 7 V	-0.500 V	±20.66	±21.46
	1.325 V		
	3.150 V		
	4.975 V		
	6.800 V		

Verifying Force Voltage Accuracy and Measure Voltage Accuracy

Complete the following procedure to determine the as-found and as-left status of the NI 6555/6556 force voltage accuracy and measure voltage accuracy.

1. Initialize a generation session, reset the device, and close the generation session.
2. Configure the DMM according to the following settings:
   a. Function: DC volts
   b. Range: 10 V
   c. Power line frequency: 50 Hz or 60 Hz, depending on your country
   d. Aperture time: 1 PLC
   e. ADC Calibration: On
   f. Digits of resolution: 6.5 digits
3. Connect Channel 0 of the NI 6555/6556 to the DMM through the switch matrix.
4. Initialize a generation session.
5. Set the data voltage level range attribute string to the -2 V to 6 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.
6. Commit (dynamic) the change.

Determining Local Sense Accuracy

7. Call and configure the stPMU source voltage function according to the following settings:
   a. Channel: Channel under test
   b. Voltage level: Test Voltage
   c. Sense location: Local
   d. Current range: 32 mA
8. Allow 1 ms for the NI 6555/6556, DMM, and cabling to settle.

Note Allow 0.5 seconds after you take the first measurement with the NI 6555/6556 for the measurement to settle before you take subsequent measurements.

9. Read the voltage with the DMM.
10. Calculate the Force Voltage Error by subtracting the DMM Reading from the Test Voltage, and compare this value to the local sense test limits in Table 6.
11. Call and configure the stPMU measure voltage function according to the following settings:
    a. Sense location: Local
    b. Aperture time: 1/60 seconds for 60 Hz PLC or 1/50 seconds for 50 Hz PLC
12. Record the PMU Channel Voltage Reading, and subtract the DMM Channel Voltage Reading to find the Measure Voltage Error. Compare the Measure Voltage Error to the local sense measure voltage test limits.
13. Repeat steps 7 through 12 using the remaining test voltages from Table 6.

Determining Remote Sense Accuracy

14. Repeat steps 7 through 13 with the following modifications:
    a. Step 7c—Sense location: Remote sense
    b. Step 10—Calculate the Force Voltage Error by subtracting the DMM Reading from the Test Voltage, and compare this value to the remote sense test limits in Table 6.
    c. Step 11a—Sense location: Remote sense
    d. Step 12—Record the PMU Channel Voltage Reading, and subtract the DMM Channel Voltage Reading to find the Measure Voltage Error. Compare the Measure Voltage Error to the remote measure voltage test limits in Table 6.
15. Disable the PMU and set it to its previous digital state.
16. Close the generation session.
17. Disconnect the NI 6555/6556 channel from DMM.
18. Repeat steps 3 through 17 for channels 1 to 23 and PFI1, PFI2, PFI4, and PFI5.
19. Repeat steps 1 through 18 for voltages in the -1 V to 7 V range with the following modifications:
    a. Step 5—Set the data voltage level range attribute string to the -1 V to 7 V range for channels 0 to 23, PFI1, PFI2, PFI4, PFI5.

Table 6. NI 6555/6556 Force Voltage Accuracy and Measure Voltage Accuracy Verification As-Found Test Limits

<table>
<tr><th rowspan="3">Voltage Level Range</th><th rowspan="3">Test Voltage</th><th colspan="4">As-Found Test Limit (mV) ±5 °C of Self-Calibration</th></tr>
<tr><th colspan="2">Force Voltage</th><th colspan="2">Measure Voltage</th></tr>
<tr><th>Local</th><th>Remote</th><th>Local</th><th>Remote</th></tr>
<tr><td rowspan="5">-2 V to 6 V</td><td>-2 V</td><td rowspan="10">±11</td><td rowspan="10">±11</td><td rowspan="10">±3</td><td rowspan="10">±3</td></tr>
<tr><td>0 V</td></tr>
<tr><td>2 V</td></tr>
<tr><td>4 V</td></tr>
<tr><td>6 V</td></tr>
<tr><td rowspan="5">-1 V to 7 V</td><td>-1 V</td></tr>
<tr><td>1 V</td></tr>
<tr><td>3 V</td></tr>
<tr><td>5 V</td></tr>
<tr><td>7 V</td></tr>
</table>

Table 7. NI 6555/6556 Force Voltage Accuracy and Measure Voltage Accuracy Verification As-Left Test Limits

Voltage Level Range	Test Voltages	As-Left Test Limit (mV) ±1 °C of Self-Calibration			
		Force Voltage		Measure Voltage	
		Local	Remote	Local	Remote
-2 V to 6 V	-2 V	±6.29	±6.58	±1.82	±1.91
	0 V				
	2 V				
	4 V				
	6 V				
-1 V to 7 V	-1 V				
	1 V				
	3 V				
	5 V				
	7 V				

Verifying Force Current Accuracy and Measure Current Accuracy

Complete the following procedure to determine the as-found and as-left status of the NI 6555/6556 force current accuracy and measure current accuracy.

1. Initialize a generation session, reset the device, and close the generation session.
2. Connect Channel 0 of the NI 6555/6556 to the SMU through the switch matrix.
3. Configure the SMU according to the following settings:
   a. Source mode: Single point
   b. Output function: DC voltage
   c. Sense: Local
   d. Voltage range: 10 V
   e. Voltage level: 2.5 V
   f. Current limit autorange: On
4. Initialize a generation session.
5. Set the data voltage level range attribute string to the -2 V to 6 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.
6. Commit (dynamic) the changes.

7. Set the SMU current limit to the appropriate value for the current being measured in Table 8. For example, for the 32 mA PMU range, set the SMU current limit to 100 mA.
8. Initialize generation on the SMU.
9. Call and configure the stPMU source current function according to following settings:
    a. Current level: Test Current from Table 8
    b. Upper voltage limit: 6 V
    c. Lower voltage limit: -2 V
    d. Current range: Current Range from Table 8
10. Allow 1 ms for the NI 6555/6556, SMU, and cabling to settle.

Note Allow 0.5 seconds after you take the first measurement with the NI 6555/6556 for the measurement to settle before you take subsequent measurements.

Read the current generated by the SMU, and calculate the force current percent of range error with the following equation:

$$ForceCurrentPercentageofRange = \frac{TestCurrent - (-SMUReading)}{TestCurrentRange} \times 100\%$$

Note Invert the SMU reading because the SMU and PMU current readings have opposite polarity.

11. Call the stPMU measure current function and configure the aperture time input to 1/60 seconds for 60 Hz PLC or 1/50 seconds for 50 Hz PLC.
12. Record the current reading of the channel under test.
13. Calculate the measure current percent of range error with the following equation, and compare this value to the measure current test limit in Table 8.

$$MeasureCurrentPercentageofRange = \frac{PMUReading - (-SMUReading)}{TestCurrentRange} \times 100\%$$

Note Invert the SMU reading because the SMU and PMU current readings have opposite polarity.

14. Disable the PMU and set it to the previous digital state.
15. Call the abort SMU function to transition the SMU from the running state to the committed state.
16. Repeat steps 7 through 15 using the remaining test currents from Table 8.
17. Disable the SMU output and close the SMU session.
18. Close the generation session.
19. Disconnect the NI 6555/6556 channel from the SMU.
20. Repeat steps 2 through 19 for channels 1 to 23, PFI1, PFI2, PFI4, and PFI5.

Table 8. NI 6555/6556 Force Current Accuracy and Measure Current Accuracy Verification As-Found Test Limits

Current Range	Test Current	As-Found Test Limit ±5 °C of Self-Calibration	
		Force Current Test Limit	Measure Current Test Limit
2 µA	0.5 µA	1% of range	1% of range
	1.0 µA		
	1.5 µA		
	2.0 µA		
	-0.5 µA		
	-1.0 µA		
	-1.5 µA		
	-2.0 µA		
8 µA	2 µA	1% of range	1% of range
	4 µA		
	6 µA		
	8 µA		
	-2 µA		
	-4 µA		
	-6 µA		
	-8 µA		
32 µA	8 µA	1% of range	1% of range
	16 µA		
	24 µA		
	32 µA		
	-8 µA		
	-16 µA		
	-24 µA		
	-32 µA		

Table 8. NI 6555/6556 Force Current Accuracy and Measure Current Accuracy Verification As-Found Test Limits (Continued)

Current Range	Test Current	As-Found Test Limit ±5 °C of Self-Calibration	
		Force Current Test Limit	Measure Current Test Limit
128 µA	32 µA	1% of range	1% of range
	64 µA		
	96 µA		
	128 µA		
	-32 µA		
	-64 µA		
	-96 µA		
	-128 µA		
512 µA	128 µA	1% of range	1% of range
	256 µA		
	384 µA		
	512 µA		
	-128 µA		
	-256 µA		
	-384 µA		
	-512 µA		
2 mA	0.5 mA	1% of range	1% of range
	1.0 mA		
	1.5 mA		
	2.0 mA		
	-0.5 mA		
	-1.0 mA		
	-1.5 mA		
	-2.0 mA		

Table 8. NI 6555/6556 Force Current Accuracy and Measure Current Accuracy Verification As-Found Test Limits (Continued)

Current Range	Test Current	As-Found Test Limit ±5 °C of Self-Calibration	
		Force Current Test Limit	**Measure Current Test Limit**
8 mA	2 mA	1% of range	1% of range
	4 mA		
	6 mA		
	8 mA		
	-2 mA		
	-4 mA		
	-6 mA		
	-8 mA		
32 mA	8 mA	1% of range	1% of range
	16 mA		
	24 mA		
	32 mA		
	-8 mA		
	-16 mA		
	-24 mA		
	-32 mA		

Table 9. NI 6555/6556 Force Current Accuracy and Measure Current Accuracy Verification As-Left Test Limits

Current Range	Test Current	As-Left Test Limit ±1 °C of Self-Calibration	
		Force Current Test Limit	**Measure Current Test Limit**
2 µA	0.5 µA	0.779% of range	0.725% of range
	1.0 µA		
	1.5 µA		
	2.0 µA		
	-0.5 µA		
	-1.0 µA		
	-1.5 µA		
	-2.0 µA		
8 µA	2 µA	0.779% of range	0.725% of range
	4 µA		
	6 µA		
	8 µA		
	-2 µA		
	-4 µA		
	-6 µA		
	-8 µA		
32 µA	8 µA	0.779% of range	0.725% of range
	16 µA		
	24 µA		
	32 µA		
	-8 µA		
	-16 µA		
	-24 µA		
	-32 µA		

Table 9. NI 6555/6556 Force Current Accuracy and Measure Current Accuracy Verification As-Left Test Limits (Continued)

Current Range	Test Current	As-Left Test Limit ±1 °C of Self-Calibration	
		Force Current Test Limit	Measure Current Test Limit
128 μA	32 μA	0.779% of range	0.725% of range
	64 μA		
	96 μA		
	128 μA		
	-32 μA		
	-64 μA		
	-96 μA		
	-128 μA		
512 μA	128 μA	0.779% of range	0.725% of range
	256 μA		
	384 μA		
	512 μA		
	-128 μA		
	-256 μA		
	-384 μA		
	-512 μA		
2 mA	0.5 mA	0.779% of range	0.725% of range
	1.0 mA		
	1.5 mA		
	2.0 mA		
	-0.5 mA		
	-1.0 mA		
	-1.5 mA		
	-2.0 mA		

Table 9. NI 6555/6556 Force Current Accuracy and Measure Current Accuracy Verification As-Left Test Limits (Continued)

Current Range	Test Current	As-Left Test Limit ±1 °C of Self-Calibration	
		Force Current Test Limit	Measure Current Test Limit
8 mA	2 mA	0.894% of range	0.725% of range
	4 mA		
	6 mA		
	8 mA		
	-2 mA		
	-4 mA		
	-6 mA		
	-8 mA		
32 mA	8 mA	0.894% of range	0.825% of range
	16 mA		
	24 mA		
	32 mA		
	-8 mA		
	-16 mA		
	-24 mA		
	-32 mA		

Verifying Force Current Voltage Clamp Accuracy

Complete the following procedure to determine the as-found and as-left status of the NI 6555/6556 force current voltage clamp accuracy.

1. Initialize a generation session, reset the device, and close the generation session.
2. Connect channel 0 of the NI 6555/6556 to the SMU through the switch matrix.
3. Initialize the SMU according to the following settings:
    a. Source mode: Sequence
    b. Output function: DC voltage
    c. Sense: Local
    d. Voltage level autorange: On

e. Current limit autorange: On

f. Source delay: 0.0008 s

g. Power line frequency: 50 Hz or 60 Hz, depending on your country

h. Aperture time: 0.03125 PLC

i. Current limit: 0.001 A

4. Initialize a generation session.
5. Set the data voltage range attribute to the -2 V to 6 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.
6. Commit (dynamic) the changes.

Verifying PMU Current Sourcing Clamp High Voltage Accuracy

7. Set the PMU to source current according to the following settings:
   a. Current level: +256 µA
   b. Upper voltage limit: First voltage clamp high test voltage in Table 10 or Table 11.
   c. Lower voltage limit: First voltage clamp low test limit under test in Table 10 or Table 11.
   d. Current range: 512 µA
8. Configure the SMU to output a series of voltages using the following function:

$$f(n) = TestClampHighVoltage + 100mV - (650mV + 100mV) \times 1.01(e^{-0.159n} - 0.01)$$

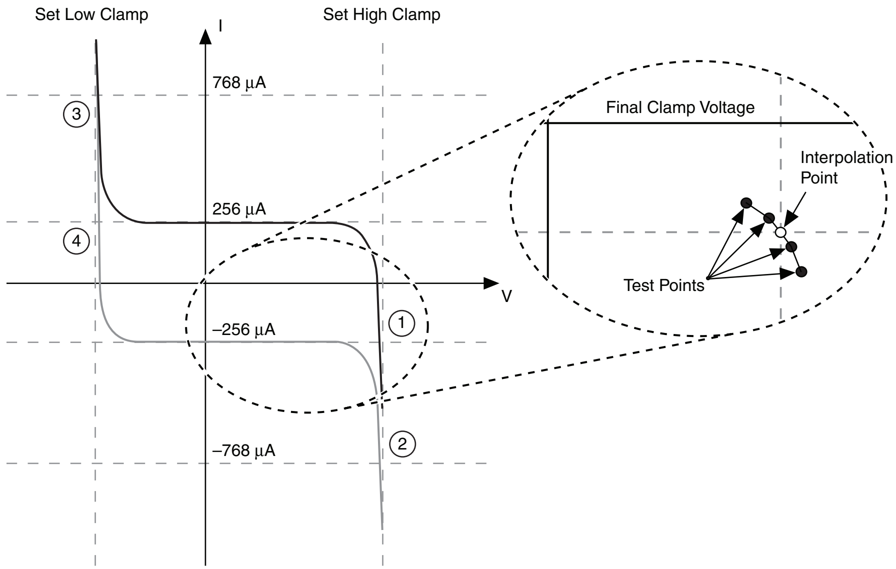
where n is 0 through 29.

9. At each sweeping point, measure the voltage and current sourced by the SMU, and calculate the current difference between the values with the following equation:

CurrentDifference = PMUSetCurrentLevel - (-SMUCurrentReading)

10. Use linear interpolation to find the clamp voltage point where the absolute value of CurrentDifference is twice the absolute value of the PMU set current level. Circle 1 in Figure 7 indicates the location of the final clamp high voltage. Furthermore, the close-up view of the final clamp voltage in Figure 7 indicates how the final clamp voltage is determined with linear interpolation.
11. The difference between the final clamp voltage and the test clamp level is the voltage clamp error. Compare this error to the as-found or as-left test limits in Table 10.

Figure 7. Determining the Final Clamp Voltage



12. Abort the SMU session.
13. Repeat steps 7 to 12 for the remaining test voltages in Table 10.

Verifying PMU Current Sinking Clamp High Voltage Accuracy

14. Repeat steps 7 through 13 with the following modification:
    a. Step 7—Set the PMU to source current according to the following setting:
        - Current level: -256 µA

Note Circle 2 indicates the location of the final clamp voltage in Figure 7.

Verifying PMU Current Sourcing Clamp Low Voltage Accuracy

15. Repeat steps 7 through 13 with the following modification:
    b. Step 8—Configure the SMU to output a series of voltages using the following function:

$$f(n) = TestClampLowVoltage - 100mV + (650mV + 100mV) \times 1.01(e^{-0.159n} - 0.01)$$

where *n* is 0 through 29.

Note Circle 3 indicates the location of the final clamp voltage from step 10 in Figure 7.

Verifying PMU Current Sinking Clamp Low Voltage Accuracy

16. Repeat steps 7 through 12 with the following modifications:
    a. Step 7—Set the PMU to source current according to the following settings:
       - Current level: -256 µA
    b. Step 8—Configure the SMU to output a series of voltages using the following function:

$$f(n) = TestClampLowVoltage - 100mV + (650mV + 100mV) \times 1.01(e^{-0.159n} - 0.01)$$

where n is 0 through 29

Note Circle 4 indicates the location of the final clamp voltage in Figure 7.

17. Disable the PMU and set it to its previous digital state.
18. Disable the SMU output and close the SMU session.
19. Close the generation session.
20. Disconnect channel 0 of the NI 6555/6556 from the SMU.
21. Repeat steps 2 through 20 for channels 1 to 23, PFI1, PFI2, PFI4, and PFI5.
22. Repeat steps 1 through 21 for the -1 V to 7 V range with the following modification:
    a. Step 5—Set the data voltage level range attribute string to the -1 V to 7 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.

Table 10. NI 6555/6556 Force Current Voltage Clamp Accuracy Verification As-Found Test Limits

Voltage Range	PMU Current Level	Parameter Under Test	Voltage Clamp High (V)	Voltage Clamp Low (V)	As-Found Test Limit ±5 °C of Self-Calibration
-2 V to 6 V	± 256 µA	Voltage Clamp High	-1.00	-2.00	100 mV
			0.75	-2.00	
			2.50	-2.00	
			4.25	-2.00	
			6.00	-2.00	
		Voltage Clamp Low	6.00	5.00	100 mV
			6.00	3.25	
			6.00	1.50	
			6.00	-0.25	
			6.00	-2.00	

Table 10. NI 6555/6556 Force Current Voltage Clamp Accuracy Verification As-Found Test Limits (Continued)

Voltage Range	PMU Current Level	Parameter Under Test	Voltage Clamp High (V)	Voltage Clamp Low (V)	As-Found Test Limit ±5 °C of Self-Calibration
-1 V to 7 V	± 256 µA	Voltage Clamp High	0	-1.00	100 mV
			1.75	-1.00	
			3.50	-1.00	
			5.25	-1.00	
			7.00	-1.00	
		Voltage Clamp Low	7.00	6.00	100 mV
			7.00	4.25	
			7.00	2.50	
			7.00	0.75	
			7.00	-1.00	

Table 11. NI 6555/6556 Force Current Voltage Clamp Accuracy Verification As-Left Test Limits

Voltage Range	PMU Current Level	Parameter Under Test	Voltage Clamp High (V)	Voltage Clamp Low (V)	As-Left Test Limit ±1 °C of Self-Calibration
-2 V to 6 V	± 256 µA	Voltage Clamp High	-1.00	-2.00	72.52 mV
			0.75	-2.00	
			2.50	-2.00	
			4.25	-2.00	
			6.00	-2.00	
		Voltage Clamp Low	6.00	5.00	72.52 mV
			6.00	3.25	
			6.00	1.50	
			6.00	-0.25	
			6.00	-2.00	

Table 11. NI 6555/6556 Force Current Voltage Clamp Accuracy Verification As-Left Test Limits (Continued)

Voltage Range	PMU Current Level	Parameter Under Test	Voltage Clamp High (V)	Voltage Clamp Low (V)	As-Left Test Limit ±1 °C of Self-Calibration
-1 V to 7 V	± 256 µA	Voltage Clamp High	0	-1.00	72.52 mV
			1.75	-1.00	
			3.50	-1.00	
			5.25	-1.00	
			7.00	-1.00	
		Voltage Clamp Low	7.00	6.00	72.52 mV
			7.00	4.25	
			7.00	2.50	
			7.00	0.75	
			7.00	-1.00	

Verifying Force Current Quadrant Boundary

Complete the following procedure to determine the as-found and as-left status of the NI 6555/6556 force current quadrant boundary.

1. Initialize a generation session, reset the device, and close the generation session.
2. Connect channel 0 of the NI 6555/6556 to the SMU through the switch matrix.
3. Configure the SMU according to the following settings:
    a. Source mode: Single point
    b. Output function: DC voltage
    c. Sense: Local
    d. Voltage range: 10 V
    e. Current limit autorange: On
4. Initialize a generation session.
5. Set the data voltage range attribute to the -2 V to 6 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.
6. Commit (dynamic) the changes.
7. Set the voltage level of the SMU to the first output voltage in Table 12.
8. Set the current limit of the SMU to the appropriate value for current being measured. For example, for the 32 mA PMU range, set the SMU current limit to 100 mA.
9. Initiate an SMU generation and enable SMU output.

10. Configure the PMU to source current according to the following settings:
    a. Current level: First test current in Table 12
    b. Upper voltage limit: 6 V
    c. Lower voltage limit: -2 V
    d. Current range: First test current range
11. Wait 1 ms for the SMU, cabling, and the NI 6555/6556 to settle.

> **Note** Before taking the first measurement, wait 0.1 seconds for settling. Subsequent measurements require 1 ms for settling.

12. Use the PMU to measure voltage with local sense. Set aperture time to 1 ms.
13. Record the voltage reading of the channel under test.
14. Adjust the SMU output voltage using the difference between the current SMU voltage set-point and the measured PMU voltage reading. Repeat steps 11 through 14 (this step) until the difference between the PMU measured voltage and the SMU set voltage from step 7 is within ±1 mV.
15. Read the current from the SMU.
16. Use the PMU to measure the current. The aperture time should be equal to 1/PLF (power line frequency).
17. Calculate the error and compare it to the as-found and as-left test limits in Table 12.
    a. Calculate the force current percent of range error with the following equation:

$$ForceCurrentPercentofRangeError = \frac{TestCurrent - (-SMUReading)}{TestCurrentRange} \times 100$$

    b. Calculate the measure current percent of range error with the following equation:

$$MeasureCurrentPercentofRangeError = \frac{PMUReading - (-SMUReading)}{TestCurrentRange} \times 100$$

18. Disable the PMU and set it to its previous digital state.
19. Abort the SMU session.
20. Repeat steps 7 through 19 with the remaining test currents and DUT current ranges listed in Table 12 for the -2 V to 6 V range.
21. Disable the SMU output and close the session.
22. Disconnect channel 0 of the NI 6555/6556 from the SMU.
23. Repeat steps 2 through 22 for channels 1 to 22, PFI1, PFI2, PFI4, and PFI5.
24. Repeat steps 1 through 23 for the -1 V to 7 V voltage range with the following modification:
    a. Step 5—Set the data voltage level range attribute string to the -1 V to 7 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.
    b. Step 10b—Upper voltage limit: 7 V
    c. Step 10c—Lower voltage limit: -1 V

Figure 8. Characteristic Quadrant Behavior by Current Range

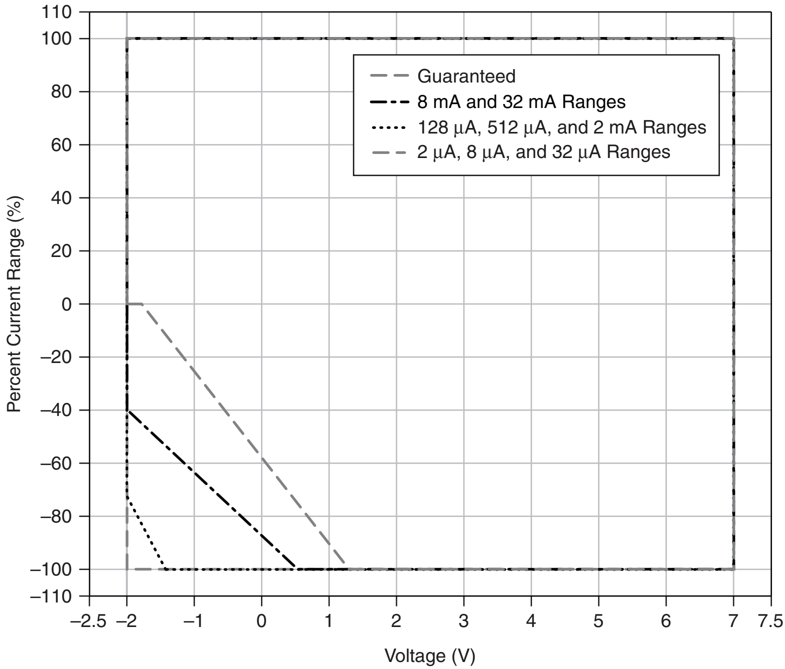


Table 12. NI 6555/6556 Force Current Quadrant Boundary Verification As-Found Test Limits

Voltage Range	PMU Current Range	PMU Output Current	SMU Output Voltage	As-Found Test Limit ±5 °C of Self-Calibration: Force Current (% of Range)	As-Found Test Limit ±5 °C of Self-Calibration: Measure Current (% of Range)
-2 V to 6 V	32 mA	-32.0 mA	5.00 V	1%	1%
		32.0 mA	5.00 V		
		-9.6 mA	-1.00 V		
		-32.0 mA	1.25 V		
		32.0 mA	-1.00 V		
	8 mA	-8.0 mA	5.00 V		
		8.0 mA	5.00 V		
		-2.4 mA	-1.00 V		
		-8.0 mA	1.25 V		
		8.0 mA	-1 V		
	2 mA	-2.0 mA	5.00 V		
		2.0 mA	5.00 V		
		0.6 mA	-1.00 V		
		-2.0 mA	1.25 V		
		2.0 mA	-1.00 V		
	512 µA	-512.0 µA	5.00 V		
		512.0 µA	5.00 V		
		-153.6 µA	-1.00 V		
		-512 µA	1.25 V		
		512 µA	-1.00 V		

Table 12. NI 6555/6556 Force Current Quadrant Boundary Verification As-Found Test Limits (Continued)

Voltage Range	PMU Current Range	PMU Output Current	SMU Output Voltage	As-Found Test Limit ±5 °C of Self-Calibration	
				Force Current (% of Range)	Measure Current (% of Range)
-2 V to 6 V	128 µA	-128.0 µA	5.00 V	1%	1%
		128.0 µA	5.00 V		
		-38.4 µA	-1.00 V		
		-128.0 µA	1.25 V		
		128.0 µA	-1.00 V		
	32 µA	-32.0 µA	5.00 V		
		32.0 µA	5.00 V		
		-9.6 µA	-1.00 V		
		-32.0 µA	1.25 V		
		32.0 µA	-1.00 V		
	8 µA	-8.0 µA	5.00 V		
		8.0 µA	5.00 V		
		-2.6 µA	-1.00 V		
		-8.0 µA	1.25 V		
		8.0 µA	-1.00 V		
	2 µA	-2.0 µA	5.00 V		
		2.0 µA	5.00 V		
		-0.6 µA	-1.00 V		
		-2.0 µA	1.25 V		
		2.0 µA	-1.00 V		

Table 12. NI 6555/6556 Force Current Quadrant Boundary Verification As-Found Test Limits (Continued)

Voltage Range	PMU Current Range	PMU Output Current	SMU Output Voltage	As-Found Test Limit ±5 °C of Self-Calibration	
				Force Current (% of Range)	Measure Current (% of Range)
-1 V to 7 V	32 mA	-32.0 mA	6.00 V	1%	1%
		32.0 mA	6.00 V		
		-19.2 mA	0 V		
		-32.0 mA	1.25 V		
		32.0 mA	0 V		
	8 mA	-8.0 mA	6.00 V		
		8.0 mA	6.00 V		
		-4.8 mA	0 V		
		-8.0 mA	1.25 V		
		8 mA	0 V		
	2 mA	-2.0 mA	6.00 V		
		2.0 mA	6.00 V		
		-1.2 mA	0 V		
		-2.0 mA	1.25 V		
		2.0 mA	0 V		
	512 µA	-512.0 µA	6.00 V		
		512.0 µA	6.00 V		
		-307.2 µA	0 V		
		-512.0 µA	1.25 V		
		512.0 µA	0 V		

Table 12. NI 6555/6556 Force Current Quadrant Boundary Verification As-Found Test Limits (Continued)

Voltage Range	PMU Current Range	PMU Output Current	SMU Output Voltage	As-Found Test Limit ±5 °C of Self-Calibration	
				Force Current (% of Range)	Measure Current (% of Range)
-1 V to 7 V	128 μA	-128.0 μA	6.00 V	1%	1%
		128.0 μA	6.00 V		
		-76.8 μA	0 V		
		-128.0 μA	1.25 V		
		128.0 μA	0 V		
	32 μA	-32.0 μA	6.00 V		
		32.0 μA	6.00 V		
		-19.2 μA	0 V		
		-32.0 μA	1.25 V		
		32.0 μA	0 V		
	8 μA	-8.0 μA	6.00 V		
		8.0 μA	6.00 V		
		-4.8 μA	0 V		
		-8.0 μA	1.25 V		
		8.0 μA	0 V		
	2 μA	-2.0 μA	6.00 V		
		2.0 μA	6.00 V		
		-1.2 μA	0 V		
		-2.0 μA	1.25 V		
		2.0 μA	0 V		

Table 13. NI 6555/6556 Force Current Quadrant Boundary Verification As-Left Test Limits

Voltage Range	PMU Current Range	PMU Output Current	SMU Output Voltage	As-Left Test Limit ±1 °C of Self-Calibration	
				Force Current (% of Range)	Measure Current (% of Range)
-2 V to 6 V	32 mA	-32.0 mA	5.00 V	0.894%	0.825%
		32.0 mA	5.00 V		
		-9.6 mA	-1.00 V		
		-32.0 mA	1.25 V		
		32.0 mA	-1.00 V		
	8 mA	-8.0 mA	5.00 V	0.894%	0.725%
		8.0 mA	5.00 V		
		-2.4 mA	-1.00 V		
		-8.0 mA	1.25 V		
		8.0 mA	-1 V		
	2 mA	-2.0 mA	5.00 V	0.779%	0.725%
		2.0 mA	5.00 V		
		0.6 mA	-1.00 V		
		-2.0 mA	1.25 V		
		2.0 mA	-1.00 V		
	512 µA	-512.0 µA	5.00 V	0.779%	0.725%
		512.0 µA	5.00 V		
		-153.6 µA	-1.00 V		
		-512 µA	1.25 V		
		512 µA	-1.00 V		

Table 13. NI 6555/6556 Force Current Quadrant Boundary Verification As-Left Test Limits (Continued)

Voltage Range	PMU Current Range	PMU Output Current	SMU Output Voltage	As-Left Test Limit ±1 °C of Self-Calibration	
				Force Current (% of Range)	Measure Current (% of Range)
-2 V to 6 V	128 µA	-128.0 µA	5.00 V	0.779%	0.725%
		128.0 µA	5.00 V		
		-38.4 µA	-1.00 V		
		-128.0 µA	1.25 V		
		128.0 µA	-1.00 V		
	32 µA	-32.0 µA	5.00 V	0.779%	0.725%
		32.0 µA	5.00 V		
		-9.6 µA	-1.00 V		
		-32.0 µA	1.25 V		
		32.0 µA	-1.00 V		
	8 µA	-8.0 µA	5.00 V	0.779%	0.725%
		8.0 µA	5.00 V		
		-2.6 µA	-1.00 V		
		-8.0 µA	1.25 V		
		8.0 µA	-1.00 V		
	2 µA	-2.0 µA	5.00 V	0.779%	0.725%
		2.0 µA	5.00 V		
		-0.6 µA	-1.00 V		
		-2.0 µA	1.25 V		
		2.0 µA	-1.00 V		

Table 13. NI 6555/6556 Force Current Quadrant Boundary Verification As-Left Test Limits (Continued)

Voltage Range	PMU Current Range	PMU Output Current	SMU Output Voltage	As-Left Test Limit ±1 °C of Self-Calibration	
				Force Current (% of Range)	Measure Current (% of Range)
-1 V to 7 V	32 mA	-32.0 mA	6.00 V	0.894%	0.825%
		32.0 mA	6.00 V		
		-19.2 mA	0 V		
		-32.0 mA	1.25 V		
		32.0 mA	0 V		
	8 mA	-8.0 mA	6.00 V	0.894%	0.725%
		8.0 mA	6.00 V		
		-4.8 mA	0 V		
		-8.0 mA	1.25 V		
		8 mA	0 V		
	2 mA	-2.0 mA	6.00 V	0.779%	0.725%
		2.0 mA	6.00 V		
		-1.2 mA	0 V		
		-2.0 mA	1.25 V		
		2.0 mA	0 V		
	512 µA	-512.0 µA	6.00 V	0.779%	0.725%
		512.0 µA	6.00 V		
		-307.2 µA	0 V		
		-512.0 µA	1.25 V		
		512.0 µA	0 V		

Table 13. NI 6555/6556 Force Current Quadrant Boundary Verification As-Left Test Limits (Continued)

Voltage Range	PMU Current Range	PMU Output Current	SMU Output Voltage	As-Left Test Limit ±1 °C of Self-Calibration	
				Force Current (% of Range)	Measure Current (% of Range)
-1 V to 7 V	128 µA	-128.0 µA	6.00 V	0.779%	0.725%
		128.0 µA	6.00 V		
		-76.8 µA	0 V		
		-128.0 µA	1.25 V		
		128.0 µA	0 V		
	32 µA	-32.0 µA	6.00 V	0.779%	0.725%
		32.0 µA	6.00 V		
		-19.2 µA	0 V		
		-32.0 µA	1.25 V		
		32.0 µA	0 V		
	8 µA	-8.0 µA	6.00 V	0.779%	0.725%
		8.0 µA	6.00 V		
		-4.8 µA	0 V		
		-8.0 µA	1.25 V		
		8.0 µA	0 V		
	2 µA	-2.0 µA	6.00 V	0.779%	0.725%
		2.0 µA	6.00 V		
		-1.2 µA	0 V		
		-2.0 µA	1.25 V		
		2.0 µA	0 V		

Verifying Force Voltage Quadrant Boundary

Complete the following procedure to determine the as-found and as-left status of the NI 6555/6556 force voltage quadrant boundary.

1. Initialize a generation session, reset the device, and close the generation session.
2. Connect channel 0 of the NI 6555/6556 to the SMU through the switch matrix.
3. Configure the SMU according to the following settings:
   a. Source mode: Single point
   b. Output function: DC voltage
   c. Sense: local
   d. Voltage range: 10 V
   e. Current limit range: 100 mA
   f. Current limit: 2 mA
   g. Voltage level: 0 V
4. Initialize a generation session.
5. Set the data voltage range attribute to the -2 V to 6 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.
6. Commit (dynamic) the changes.
7. Configure the PMU to source voltage according to the following settings:
   a. Voltage level: 0 V
   b. Current range: 32 mA
   c. Sense: Local
8. Initiate the SMU and enable output.
9. Set the voltage level of the SMU to the first output voltage value in Table 14 (for as-found values) or Table 15 (for as-left values).
10. Set the current limit for the SMU to the first value in Table 14 or Table 15.
11. Configure the PMU to source voltage according to the following settings:
    a. Voltage level: First test voltage in Table 14 or Table 15
    b. Current range: First current range in Table 14 or Table 15
    c. Sense: Local
12. Wait 1 ms for the SMU, cabling, and the NI 6555/6556 to settle.
13. Read the current and voltage with the SMU. If the absolute value of the SMU current reading is less than the SMU set current limit, increase the SMU current limit using the following equation. Wait 1 ms for settling each time you increase the SMU current limit. Repeat step 13 (this step) until the SMU current reading is no less than the original SMU current limit in Table 14 or Table 15.

$$NewSMUCurrentLimit = OldSMUCurrentLimit + (OldSMUCurrentLimit - |SMUCurrentReading|) + PMUCurrentRange \times 0.5\%$$

14. Stop the test and fail force voltage quadrant boundary verification if one of the following conditions apply:
    a. You cannot complete Step 13 after 5 iterations.
    b. The following relation is true:

    $$(|SMUCurrentReading| - OldSMUCurrentLimit) \geq PMUCurrentRange \times 1\%$$

15. Set the PMU to measure voltage and current with local sense. The aperture time should be 1/PLF (power line frequency).
16. Calculate the error and compare it to the as-found or as-left test limits in Table 14 or Table 15.
    a. Calculate the force voltage error by subtracting the PMU measured voltage from the PMU set voltage. This error should be less than 14 mV.
    b. Calculate the measure current percent of range error with the following equation, and compare this value to the measure current test limit in Table 14 and Table 15.

    $$MeasureCurrentPercentofRangeError = \frac{PMUReading - (-SMUReading)}{TestCurrentRange} \times 100$$

17. Repeat steps 9 to 16 with remaining test points in Table 14 or Table 15 for the -2 V to 6 V range.
18. Disable the SMU output and close the session.
19. Set the PMU to its previous digital state and close the session.
20. Disconnect channel 0 of the NI 6555/6556 from the SMU.
21. Repeat steps 2 through 20 for channels 1 to 23, PFI1, PFI2, PFI4, and PFI5.
22. Repeat steps 1 to 21 for the -1 V to 7 V range with the following modification:
    a. Step 5—Set the data voltage level range attribute string to the -1 V to 7 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.
    b. Step 17—Repeat steps 9 to 16 with the remaining test points in Table 14 or Table 15 for the -1 V to 7 V range.

Table 14. NI 6555/6556 Force Voltage Quadrant Boundary Verification As-Found Test Limits

Voltage Range	PMU Current Range	PMU Output Voltage	SMU Current Limit Range	SMU Current Limit	SMU Output Voltage	As Found Test Limit ±5 °C of Self-Calibration: Measure Current (% of Range)
-2 V to 6 V	32 mA	-2.00 V	100 mA	2.0 mA	-1.0 V	1%
		1.25 V		32.0 mA	2.0 V	
		-2.00 V		32.0 mA	-3.0 V	
		6.00 V		32.0 mA	5.0 V	
		6.00 V		32.0 mA	6.5 V	
	8 mA	-2.00 V	10 mA	0.4 mA	-1.0 V	1%
		1.25 V		8.0 mA	2.0 V	
		-2.00 V		8.0 mA	-3.0 V	
		6.00 V		8.0 mA	5.0 V	
		6.00 V		8.0 mA	6.5 V	
	2 mA	-2.00 V	10 mA	0.2 mA	-1.0 V	1%
		1.25 V		2.0 mA	2.0 V	
		-2.00 V		2.0 mA	-3.0 V	
		6.00 V		2.0 mA	5.0 V	
		6.00 V		2.0 mA	6.5 V	
	512 µA	-2.00 V	1 mA	25.6 µA	-1.0 V	1%
		1.25 V		512.0 µA	2.0 V	
		-2.00 V		512.0 µA	-3.0 V	
		6.00 V		512.0 µA	5.0 V	
		6.00 V		512.0µA	6.5 V	

Table 14. NI 6555/6556 Force Voltage Quadrant Boundary Verification As-Found Test Limits (Continued)

Voltage Range	PMU Current Range	PMU Output Voltage	SMU Current Limit Range	SMU Current Limit	SMU Output Voltage	As Found Test Limit ±5 °C of Self-Calibration
						Measure Current (% of Range)
-2 V to 6 V	128 µA	-2.00 V	1 mA	20.0 µA	-1.0 V	1%
		1.25 V		128.0 µA	2.0 V	
		-2.00 V		128.0 µA	-3.0 V	
		6.00 V		128.0 µA	5.0 V	
		6.00 V		128.0 µA	6.5 V	
	32 µA	-2.00 V	100 µA	2.0 µA	-1.0 V	1%
		1.25 V		32.0 µA	2.0 V	
		-2.00 V		32.0 µA	-3.0 V	
		6.00 V		32.0 µA	5.0 V	
		6.00 V		32.0 µA	6.5 V	
	8 µA	-2.00 V	10 µA	0.4 µA	-1.0 V	1%
		1.25 V		8.0 µA	2.0 V	
		-2.00 V		8.0 µA	-3.0 V	
		6.00 V		8.0 µA	5.0 V	
		6.00 V		8.0 µA	6.5 V	
	2 µA	-2.00 V	10 µA	0.2 µA	-1.0 V	1%
		1.25 V		2.0 µA	2.0 V	
		-2.00 V		2.0 µA	-3.0 V	
		6.00 V		2.0 µA	5.0 V	
		6.00 V		2.0 µA	6.5 V	

Table 14. NI 6555/6556 Force Voltage Quadrant Boundary Verification As-Found Test Limits (Continued)

Voltage Range	PMU Current Range	PMU Output Voltage	SMU Current Limit Range	SMU Current Limit	SMU Output Voltage	As Found Test Limit ±5 °C of Self-Calibration
						Measure Current (% of Range)
-1 V to 7 V	32 mA	-1.00 V	100 mA	9.6 mA	0 V	1%
		1.25 V		32.0 mA	2.0 V	
		-1.00 V		32.0 mA	-1.5 V	
		7.00 V		32.0 mA	6.0 V	
		7.00 V		32.0 mA	7.5 V	
	8 mA	-1.00 V	10 mA	2.4 mA	0 V	1%
		1.25 V		8.0 mA	2.0 V	
		-1.00 V		8.0 mA	-1.5 V	
		7.00 V		8.0 mA	6.0 V	
		7.00 V		8.0 mA	7.5 V	
	2 mA	-1.00 V	10 mA	0.6 mA	0 V	1%
		1.25 V		2.0 mA	2.0 V	
		-1.00 V		2.0 mA	-1.5 V	
		7.00 V		2.0 mA	6.0 V	
		7.00 V		2.0 mA	7.5 V	
	512 µA	-1.00 V	1 mA	153.6 µA	0 V	1%
		1.25 V		512.0 µA	2.0 V	
		-1.00 V		512.0 µA	-1.5 V	
		7.00 V		512.0 µA	6.0 V	
		7.00 V		512.0 µA	7.5 V	

Table 14. NI 6555/6556 Force Voltage Quadrant Boundary Verification As-Found Test Limits (Continued)

Voltage Range	PMU Current Range	PMU Output Voltage	SMU Current Limit Range	SMU Current Limit	SMU Output Voltage	As Found Test Limit ±5 °C of Self-Calibration: Measure Current (% of Range)
-1 V to 7 V	128 µA	-1.00 V	1 mA	38.4 µA	0 V	1%
		1.25 V		128.0 µA	2.0 V	
		-1.00 V		128.0 µA	-1.5 V	
		7.00 V		128.0 µA	6.0 V	
		7.00 V		128.0 µA	7.5 V	
	32 µA	-1.00 V	100 µA	9.6 µA	0 V	1%
		1.25 V		32.0 µA	2.0 V	
		-1.00 V		32.0 µA	-1.5 V	
		7.00 V		32.0 µA	6.0 V	
		7.00 V		32.0 µA	7.5 V	
	8 µA	-1.00 V	10 µA	2.4 µA	0 V	1%
		1.25 V		8.0 µA	2.0 V	
		-1.00 V		8.0 µA	-1.5 V	
		7.00 V		8.0 µA	6.0 V	
		7.00 V		8.0 µA	7.5 V	
	2 µA	-1.00 V	10 µA	0.6 µA	0 V	1%
		1.25 V		2.0 µA	2.0 V	
		-1.00 V		2.0 µA	-1.5 V	
		7.00 V		2.0 µA	6.0 V	
		7.00 V		2.0 µA	7.5 V	

Table 15. NI 6555/6556 Force Voltage Quadrant Boundary Verification As-Left Test Limits

Voltage Range	PMU Current Range	PMU Output Voltage	SMU Current Limit Range	SMU Current Limit	SMU Output Voltage	As-Left Test Limit ±5 °C of Self-Calibration
						Measure Current (% of Range)
-2 V to 6 V	32 mA	-2.00 V	100 mA	2.0 mA	-1.0 V	0.825%
		1.25 V		32.0 mA	2.0 V	
		-2.00 V		32.0 mA	-3.0 V	
		6.00 V		32.0 mA	5.0 V	
		6.00 V		32.0 mA	6.5 V	
	8 mA	-2.00 V	10 mA	0.4 mA	-1.0 V	0.725%
		1.25 V		8.0 mA	2.0 V	
		-2.00 V		8.0 mA	-3.0 V	
		6.00 V		8.0 mA	5.0 V	
		6.00 V		8.0 mA	6.5 V	
	2 mA	-2.00 V	10 mA	0.2 mA	-1.0 V	0.725%
		1.25 V		2.0 mA	2.0 V	
		-2.00 V		2.0 mA	-3.0 V	
		6.00 V		2.0 mA	5.0 V	
		6.00 V		2.0 mA	6.5 V	
	512 µA	-2.00 V	1 mA	25.6 µA	-1.0 V	0.725%
		1.25 V		512.0 µA	2.0 V	
		-2.00 V		512.0 µA	-3.0 V	
		6.00 V		512.0 µA	5.0 V	
		6.00 V		512.0 µA	6.5 V	

Table 15. NI 6555/6556 Force Voltage Quadrant Boundary Verification As-Left Test Limits (Continued)

Voltage Range	PMU Current Range	PMU Output Voltage	SMU Current Limit Range	SMU Current Limit	SMU Output Voltage	As-Left Test Limit ±5 °C of Self-Calibration
						Measure Current (% of Range)
-2 V to 6 V	128 µA	-2.00 V	1 mA	20.0 µA	-1.0 V	0.725%
		1.25 V		128.0 µA	2.0 V	
		-2.00 V		128.0 µA	-3.0 V	
		6.00 V		128.0 µA	5.0 V	
		6.00 V		128.0 µA	6.5 V	
	32 µA	-2.00 V	100 µA	2.0 µA	-1.0 V	0.725%
		1.25 V		32.0 µA	2.0 V	
		-2.00 V		32.0 µA	-3.0 V	
		6.00 V		32.0 µA	5.0 V	
		6.00 V		32.0 µA	6.5 V	
	8 µA	-2.00 V	10 µA	0.4 µA	-1.0 V	0.725%
		1.25 V		8.0 µA	2.0 V	
		-2.00 V		8.0 µA	-3.0 V	
		6.00 V		8.0 µA	5.0 V	
		6.00 V		8.0 µA	6.5 V	
	2 µA	-2.00 V	10 µA	0.2 µA	-1.0 V	0.725%
		1.25 V		2.0 µA	2.0 V	
		-2.00 V		2.0 µA	-3.0 V	
		6.00 V		2.0 µA	5.0 V	
		6.00 V		2.0 µA	6.5 V	

Table 15. NI 6555/6556 Force Voltage Quadrant Boundary Verification As-Left Test Limits (Continued)

Voltage Range	PMU Current Range	PMU Output Voltage	SMU Current Limit Range	SMU Current Limit	SMU Output Voltage	As-Left Test Limit ±5 °C of Self-Calibration: Measure Current (% of Range)
-1 V to 7 V	32 mA	-1.00 V	100 mA	9.6 mA	0 V	0.825%
		1.25 V		32.0 mA	2.0 V	
		-1.00 V		32.0 mA	-1.5 V	
		7.00 V		32.0 mA	6.0 V	
		7.00 V		32.0 mA	7.5 V	
	8 mA	-1.00 V	10 mA	2.4 mA	0 V	0.725%
		1.25 V		8.0 mA	2.0 V	
		-1.00 V		8.0 mA	-1.5 V	
		7.00 V		8.0 mA	6.0 V	
		7.00 V		8.0 mA	7.5 V	
	2 mA	-1.00 V	10 mA	0.6 mA	0 V	0.725%
		1.25 V		2.0 mA	2.0 V	
		-1.00 V		2.0 mA	-1.5 V	
		7.00 V		2.0 mA	6.0 V	
		7.00 V		2.0 mA	7.5 V	
	512 µA	-1.00 V	1 mA	153.6 µA	0 V	0.725%
		1.25 V		512.0 µA	2.0 V	
		-1.00 V		512.0 µA	-1.5 V	
		7.00 V		512.0 µA	6.0 V	
		7.00 V		512.0 µA	7.5 V	

Table 15. NI 6555/6556 Force Voltage Quadrant Boundary Verification As-Left Test Limits (Continued)

Voltage Range	PMU Current Range	PMU Output Voltage	SMU Current Limit Range	SMU Current Limit	SMU Output Voltage	As-Left Test Limit ±5 °C of Self-Calibration Measure Current (% of Range)
-1 V to 7 V	128 µA	-1.00 V	1 mA	38.4 µA	0 V	0.725%
		1.25 V		128.0 µA	2.0 V	
		-1.00 V		128.0 µA	-1.5 V	
		7.00 V		128.0 µA	6.0 V	
		7.00 V		128.0 µA	7.5 V	
	32 µA	-1.00 V	100 µA	9.6 µA	0 V	0.725%
		1.25 V		32.0 µA	2.0 V	
		-1.00 V		32.0 µA	-1.5 V	
		7.00 V		32.0 µA	6.0 V	
		7.00 V		32.0 µA	7.5 V	
	8 µA	-1.00 V	10 µA	2.4 µA	0 V	0.725%
		1.25 V		8.0 µA	2.0 V	
		-1.00 V		8.0 µA	-1.5 V	
		7.00 V		8.0 µA	6.0 V	
		7.00 V		8.0 µA	7.5 V	
	2 µA	-1.00 V	10 µA	0.6 µA	0 V	0.725%
		1.25 V		2.0 µA	2.0 V	
		-1.00 V		2.0 µA	-1.5 V	
		7.00 V		2.0 µA	6.0 V	
		7.00 V		2.0 µA	7.5 V	

Verifying Exported Sample Clock Duty Cycle

Complete the following procedure to determine the as-found and as-left status of the NI 6555/6556 pin-to-pin output skew accuracy.

1. Initialize a generation session.
2. Configure the Sample Clock according to the following settings:
   a. Clock source: Onboard clock
   b. Clock rate: 200 MHz
3. Assign all channels as dynamic channels.
4. Configure the data voltage level for all channels according to the following settings:
   a. High level: 3.3 V
   b. Low level: 0 V
5. Export the Sample Clock to the digital data and control (DDC) VHDCI connector and commit (dynamic) the change.
6. Clear all previous oscilloscope measurements.
7. Initialize only CHA on the oscilloscope.
8. Initialize the duty cycle measurement on CHA.
9. Configure the oscilloscope according to the following settings:
   a. Trigger source: CHA
   b. Time per record: 5 µs
   c. Edge trigger: Positive
   d. Trigger level: 0.825 V
   e. Sample rate: ≥10 GS/s
   f. Acquisition type: Normal
   g. Input impedance: 50 Ω
   h. Coupling type: DC coupling
   i. Vertical range and offset: Configure to maximize resolution
   j. Duty cycle measurement: CHA
10. Connect PFI4 on the DDC VHDCI connector to CHA of the oscilloscope through the switch matrix.
11. Perform a duty-cycle measurement with the oscilloscope. Average 64 measurements and compare this result to the as-found and as-left test limits.
12. Close the generation session.

Table 16. NI 6555/6556 Exported Sample Clock Duty Cycle Verification Test Limits

As-Found Limit		As-Left Limit	
Min	**Max**	**Min**	**Max**
42.00%	55.00%	43.18%	54.32%

Verifying Pin-to-Pin Output Skew Accuracy

Complete the following procedure to determine the as-found and as-left status of the NI 6555/6556 pin-to-pin output skew accuracy.

1. Initialize a generation session, reset the device, and close the generation session.
2. Initialize an external calibration session, and then call the initialize child session function with a generation session input.
3. Use the child generation session handle created by the initialize child session function to assign channels 0 to 23 as dynamic channels.
4. Configure the data voltage level for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5 according to the following settings:
   a. High level: 1 V
   b. Low level: 0 V
5. Set the data voltage range attribute to the -2 V to 6 V range for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.

Verifying Data Line Rising Edge Delay

6. Write a waveform composed of an alternating pattern of 0xAAAAAAAA and 0x55555555 for 256 samples.
7. Configure a marker event (marker 0) for PFI1.
8. Set the DataActiveEvent.Position property node to Sample Clock Rising Edge.
9. Dynamically commit (do not start) the task.
10. Repeat steps 7 to 9 for PFI2, PFI4, and PFI5. You must commit each PFI line separately.
11. Configure the Sample Clock according to the following settings:
    a. Clock source: Onboard clock
    b. Clock rate: 101 MHz
12. Call the configure generation repeat function to enable continuous generation.
13. Export the Sample Clock to the SMA ClkOut output.
14. Call the initiate function.
15. Clear all previous oscilloscope measurements.
16. Initialize only channels CHA and CHB on the oscilloscope.
17. Configure the oscilloscope according to the following settings:
    a. Trigger source: CHB
    b. Edge trigger: Positive
    c. Trigger level: DataVoltageHighLevel / 4
    d. Sample rate: Maximum real-time rate, ≥10 GS/s
    e. Acquisition type: Continuous
    f. Input impedance: 50 Ω
    g. Coupling type: DC Coupling

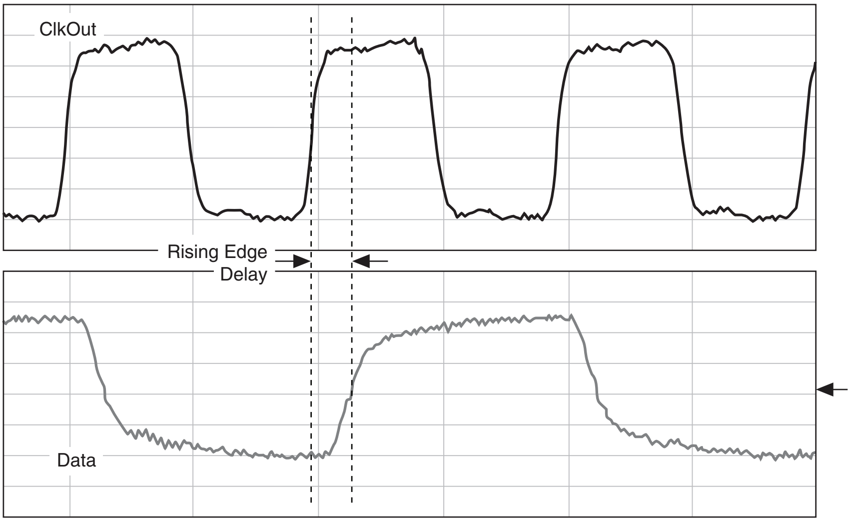
h. Vertical range and offset: Configure to maximize resolution

i. Time per records: 50 ns

j. Setup delay (delta time) measurement: CHA (Clkout) to CHB (Data). You may need to define the measurement window.

- CHA delay measurement slope: Positive
- CHB delay measurement slope: Positive
- CHA delay measurement level: 0.825 V
- CHB delay measurement level: *DataVoltageHighLevel / 4*

Figure 9. Pin-to-pin Data Rising Edge Delay Measurement



18. Connect the NI 6555/6556 Clkout SMA output to CHA of the oscilloscope through the switch matrix.
19. Call the tristate channels function according to the following settings:
    a. Channel: 0 to 23
    b. Tristate: True
20. Call the configure (channel) calibration state function with the external calibration session handle according to the following settings:
    a. Channel: Channel under test
    b. Calibration type: Output channel skew accuracy verification
    c. Reference number: 0
21. Connect channel 0 of the NI 6555/6556 to CHB of the oscilloscope through the switch matrix.

22. Call the tristate channels function to enable only the channel under test according to the following settings:
    a. Channel: Channel under test
    b. Tristate: False

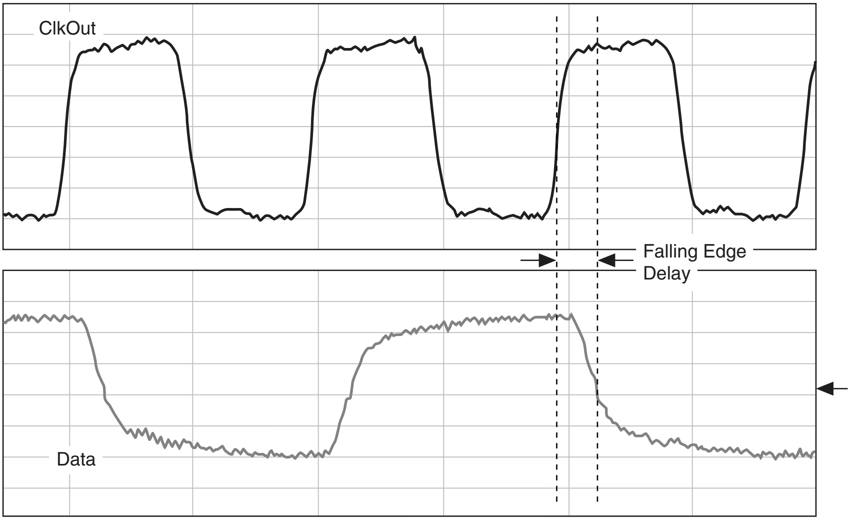
> **Note** Do not perform this step for PFI channels.

23. Clear any previous measurements, and begin data acquisition with the oscilloscope. Acquire data for at least 200 delay measurements.
24. Calculate the average delay value and save this value for the channel under test.
25. Disconnect the channel under test from CHB of the oscilloscope.
26. To obtain the absolute delay, subtract the station TDR value from the average delay value for the channel under test previously measured. This step negates the path length differences between the channels.
27. Repeat steps 19 to 26 for channels 1 to 23, PFI1, PFI2, PFI4, and PFI5.
28. Save the absolute delay for all channels into an array, calculate the mean value of the array, and store this value as MEAN(DataRisingEdge).
29. Clear the calibration state.
30. Call the close child session function and use both the external calibration session and child session handles.
31. Call the close external calibration function and pass the **Cancel** input.

Verifying Data Line Falling Edge

32. Repeat steps 1 through 31 with the following modifications:
    a. Step 17b—Edge trigger: Negative
    b. Step 17j—CHB slope for delay measurement: Negative
    c. Step 28—Save the absolute delay for each channel into an array, and save the average value for all data falling edge measurements as MEAN(DataFallingEdge). Compare this value to MEAN(DataRisingEdge) previously calculated. Ensure that the difference between the two values is less than half of the Sample Clock cycle of the 101 MHz clock. If the difference between the two values is not less than half of the Sample Clock cycle of the 101 MHz clock, then ensure that your test sequence and device connections are correct.

Figure 10. Pin-to-pin Data Falling Edge Delay Measurement



Verifying Enable Line Rising Edge

33. Repeat steps 1 through 31 with the following modifications:
    a. Step 4:
        - Configure the data voltage level for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5 according to the following settings:
            – High level: 0 V
            – Low level: 0 V
        - Set the tristate mode attribute to drive termination voltage, and set the supported data states attribute to 0, 1, and Z (tristate). Next, write a digital waveform composed of a toggle pattern between Z and 0 for 256 samples.
        - Set the data termination voltage level attribute to 1 V for the channel under test.
    b. Step 28—Save the absolute delay for each channel into an array, and save the average for all enable rising edge measurements as MEAN(EnableRisingEdge). Compare this value to MEAN(DataRisingEdge) calculated previously. Ensure that the difference between the two values is less than half of the Sample Clock cycle of the 101 MHz clock.

Verifying Enable Line Falling Edge

34. Repeat steps 1 through 31 with the following modifications:
    a. Step 4:
        - Configure the data voltage level for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5 according to the following settings:
            - High level: 0 V
            - Low level: 0 V
        - Set the tristate mode attribute to drive termination voltage, and set the supported data states attribute to 0, 1, and Z (tristate). Next, write a digital waveform composed of a toggle pattern between Z and 0 for 256 samples.
        - Set the data termination voltage level attribute to 1 V for the channel under test.

    b. Step 17:
        - Step 17b—Edge trigger: Negative
        - Step 17j—CHB slope: Negative

    c. Step 28:
        - Save the mean value as MEAN(EnableFallingEdge). Compare this value to MEAN(DataRisingEdge) previously calculated. Ensure that the difference between the two values is less than half of the Sample Clock cycle.

35. Calculate the relative skew values with following equations, and compare the relative skew values to the as-found and as-left limits listed in Table 17 and Table 18:
    - Calculate *RelativeSkew(DataRisingEdge)* using the following equation:

$$RelativeSkew(DataRisingEdge) = AbsoluteDelay(DataRisingEdge) - \frac{Max(DataRisingEdgeArray) + Min(DataRisingEdgeArray)}{2}$$

    - Calculate *RelativeSkew(DataFallingEdge)* using the following equation:

$$RelativeSkew(DataFallingEdge) = AbsoluteDelay(DataFallingEdge) - \frac{Max(DataFallingEdgeArray) + Min(DataFallingEdgeArray)}{2}$$

    - Calculate *RelativeSkew(EnableRisingEdge)* using the following equation:

$$RelativeSkew(EnableRisingEdge) = AbsoluteDelay(EnableRisingEdge) - \frac{Max(EnableRisingEdgeArray) + Min(EnableRisingEdgeArray)}{2}$$

    - Calculate *RelativeSkew(EnableFallingEdge)* using the following equation:

$$RelativeSkew(EnableFallingEdge) = AbsoluteDelay(EnableFallingEdge) - \frac{Max(EnableFallingEdgeArray) + Min(EnableFallingEdgeArray)}{2}$$

36. Repeat steps 1 through 35 with the following modifications:
    a. Step 4a—Data high: 5 V
    b. Step 17—Update trigger level and CHB level for delay measurement
    c. Step 33—Data termination voltage: 5 V for the channel under test
    d. Step 34—Data termination voltage: 5 V

Table 17. NI 6555 Pin-to-Pin Output Skew Accuracy Verification Test Limits

As-Found Test Limit	As-Left Test Limit (±1 °C From Self-Calibration)
±750 ps	±440 ps

Table 18. NI 6556 Pin-to-Pin Output Skew Accuracy Verification Test Limits

As-Found Test Limit (±5 °C From Self-Calibration)	As-Left Test Limit (±1 °C From Self-Calibration)
±600 ps	±440 ps

Verifying Pin-to-Pin Input Skew Accuracy

Complete the following procedure to determine the as-found and as-left status of the NI 6555/6556 pin-to-pin input skew accuracy.

Verifying Comparator A Rising Edge

1. Initialize a generation session, reset the device, and close the generation session.
2. Initialize an external calibration session, and then call the initiate child session function with a acquisition session input.
3. Assign channels 0 to 23 as dynamic channels with the child session handle initialized in step 2.
4. Configure Refclk to **None**.
5. Export Refclk to the ClkOut output SMA.
6. Call the configure Sample Clock function according to the following settings:
    a. Clock source: Onboard clock
    b. Clock rate: 120 MHz
7. Create a digital Edge Start Trigger for PFI1.
8. Set the StartTrig.DigitalEdge.Position property to Sample Clock Rising Edge and dynamically commit (do not initiate) this change.
9. Disable the Start Trigger and dynamically commit (do not start) this change.
10. Repeat steps 7 to 9 for PFI2, PFI4, and PFI5. You must commit each PFI line separately.

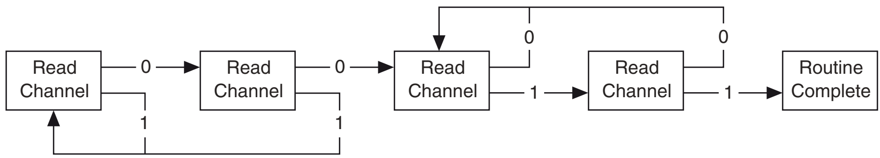
11. Configure the data voltage level for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5 according to the following settings:
    a. High level: 1.65 V
    b. Low level: -1 V
12. Set the data interpretation attribute to **Valid or Invalid** for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5.
13. Call the configure acquisition size function and set the samples per record to `1,002`.
14. Commit (dynamic) the changes.
15. Call the configure (device) calibration state function with the external calibration session handle according to the following settings:
    a. Calibration Type: Input channel skew accuracy verify
    b. Reference number: 0
16. Clear all previous oscilloscope measurements.
17. Initialize only channels CHA and CHB on the oscilloscope.
18. Configure the oscilloscope according to the following settings:
    a. Trigger source: CHA
    b. Edge trigger: Positive
    c. Trigger level: 0.825 V
    d. Sample rate: Maximum real-time rate, ≥10 GS/s
    e. Acquisition type: Continuous
    f. Input impedance: 50 Ω
    g. Coupling type: DC Coupling
    h. Vertical range and offset: Configure to maximize resolution
    i. Time per records: 50 ns
    j. Setup delay (delta time) measurement: CHA (Clkout) to CHB (Data). You may need to define the measurement window.
        - CHA (Clkout) delay measurement slope: Positive
        - CHB (Data) delay measurement slope: Positive
        - CHA (Clkout) delay measurement level: 0.825 V
        - CHB (Data) delay measurement level: 0.825 V
19. Connect the NI 6555/6556 SMA Clkout output to CHA of the oscilloscope through the switch matrix.
20. Connect PFI3 to CHB on the oscilloscope through the switch matrix.
21. Clear any previous measurements and start acquisition on the oscilloscope.
22. Acquire at least 200 delay measurements between PFI3 and ClkOut SMA, and save the average delay value as `M0`.
23. Disconnect the ClkOut SMA and PFI3 from the oscilloscope through the switch matrix.

24. Call the configure (channel) calibration state function with the external calibration session handle according to the following settings:
    a. Channel: Channel under test
    b. Calibration type: Input channel skew accuracy verify
    c. Reference number: 1

Comparator A Coarse Rising Edge Search

25. Connect the SMA ClkOut to channel 0 of the NI 6555/6556 through the switch matrix.
26. Set the oscillator phase DAC value attribute to `100`.
27. Read a single record, and apply a channel mask to only analyze at the channel under test. Refer to the *Verifying DC Acquisition Voltage Threshold Accuracy* test for the appropriate channel mask to apply. If 2/3 of 1,002 samples (668 samples) returned are 0, then output **True**. In all other cases, output **False**.
28. Repeat the previous step 50 times. If 50% or more of the acquisitions return true, record the result of this step as `1`. If fewer than 50% of the acquisitions return true, record the result as `0`.
29. Increase the oscillator phase DAC value property by 100, and repeat starting with step 27 until the oscillator phase DAC value returns two consecutive 0s followed by two consecutive 1s.
30. Save the final oscillator phase DAC value from the previous step as `D0`. The following figure describes this test.

Figure 11. Pin-to-Pin Input Skew Accuracy Edge Searching



Comparator A Fine Rising Edge Search

31. Subtract `800` from `D0`, and set the oscillator phase DAC value to this value.
32. Read a single record, and apply a channel mask to only analyze at the channel under test. Refer to the *Verifying DC Acquisition Voltage Threshold Accuracy* test for the appropriate channel mask to apply. If 2/3 of 1,002 samples (668 samples) returned are 0, then output **True**. In all other cases, output **False**.
33. Repeat the previous step 50 times. If 50% or more of the acquisitions return true, decrease the oscillator phase DAC value attribute by a step size of 400. If fewer than 50% of the acquisitions return true, increase the oscillator phase DAC value attribute by a step size of 400.
34. Repeat the previous two steps 10 more times, and decrease the step size by 1/2 each time.

Note If you read back True or False for all 11 iterations, then an edge was not found. If the oscillator phase DAC value is not between 0 and 16,383, NI-HSDIO returns an error. Check all connections and try the test again.

35. Disconnect SMA Clkout from Channel 0.
36. Call the configure (device) calibration state function with the external calibration session handle according to the following settings:
    a. Calibration type: Input channel skew accuracy verify
    b. Reference number: 0
37. Connect SMA Clkout to CHA of the oscilloscope through the switch matrix.
38. Connect PFI3 to CHB of the oscilloscope through the switch matrix.
39. Clear all previous oscilloscope measurements, and start acquisition. Acquire at least 200 delay measurements from SMA Clkout to PFI3. Save the average delay value as M1_Channel0.
40. Disconnect SMA Clkout and PFI3 from the oscilloscope.
41. Subtract the TDR values for channel 0 from M1_Channel0 to negate the path length differences between channels. Then calculate CompARisingEdgeAbsoluteDelay with the following equation:

    CompARisingEdgeAbsoluteDelay = (M1_Channel0 - M0) - StationTDR_0
42. Repeat steps 24 to 40 for channels 1 to 23, PFI1, PFI2, PFI4, and PFI5. Then calculate CompARisingEdgeAbsoluteDelay with the following equation:

    CompARisingEdgeAbsoluteDelay = (M1_ChannelX - M0) - StationTDR_X

    Save all absolute delay values into an array.
43. Call the reset calibration state function.
44. Close the child acquisition session.
45. Close the external calibration session with an input of **Cancel**.
46. Save the absolute delay for all channels as an array and calculate and save the mean value as MEAN(CompARisingEdge).

Verifying Comparator B Rising Edge

47. Repeat steps 1 through 45 with the following modifications:
    a. Step 11—Configure the data voltage level for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5 according to the following settings:
        - High level: 5.00 V
        - Low level: 1.65 V
    b. Step 27—Read a single record, and apply a channel mask to only analyze at the channel under test. Refer to the *Verifying DC Acquisition Voltage Threshold Accuracy* test for the appropriate channel mask to apply. If 2/3 of 1,002 samples (668 samples) read back from the channel under test are ≥1, output **True**. In all other cases output **False**.

c. Step 32—Read a single record, and apply a channel mask to only analyze at the channel under test. Refer to the *Verifying DC Acquisition Voltage Threshold Accuracy* test for the appropriate channel mask to apply. If 2/3 of 1,002 samples (668 samples) read back from the channel under test are ≥1, output **True**. In all other cases output **False**.

d. Step 41—Subtract the TDR values from M1_Channel0 to negate the path length differences between channels. Then calculate CompBRisingEdgeAbsoluteDelay with the following equation:

CompBRisingEdgeAbsoluteDelay = (M1_Channel0 - M0) - StationTDR_0

e. Step 42—Repeat steps 24 to 40 for channels 1 to 23, PFI1, PFI2, PFI4, and PFI5. Then calculate CompBRisingEdgeAbsoluteDelay with the following equation:

CompBRisingEdgeAbsoluteDelay = (M1_ChannelX - M0) - StationTDR_X

Save all absolute delay values into an array.

Verifying Comparator A Falling Edge

48. Repeat steps 1 through 45 with the following modifications:

a. Step 27—Read a single record, and apply a channel mask to only analyze at the channel under test. Refer to the *Verifying DC Acquisition Voltage Threshold Accuracy* test for the appropriate channel mask to apply. If 1/3 of 1,002 samples (334 samples) returned are 0, then output **True**. In all other cases, output **False**.

b. Step 42—Read a single record, and apply a channel mask to only analyze at the channel under test. Refer to the *Verifying DC Acquisition Voltage Threshold Accuracy* test for the appropriate channel mask to apply. If 1/3 of 1002 samples read back from the channel under test are 0, output a **True**. In all other cases, output **False**.

c. Step 39—Clear all previous oscilloscope measurements, and start an acquisition. Acquire at least 200 delay measurements from SMA Clkout to PFI3. Save the average delay value as M1_Channel0. Measure the duty cycle and frequency of SMA Clkout. Calculate the time error for the falling edge measurement.

$$TimeError = \frac{50 - DutyCycle}{100} \times \frac{1}{Frequency}$$

d. Step 41—Subtract the channel 0 TDR value from M1_Channel0 to negate the path length differences between channels. Then calculate CompAFallingEdgeAbsoluteDelay with the following equation:

CompAFallingEdgeAbsoluteDelay_Temp = (M1_Channel0 + TimeError - M0) - StationTDR_0

e. Step 42—Repeat steps 24 to 40 for channels 1 to 23, PFI1, PFI2, PFI4, and PFI5. Then calculate *CompAFallingEdgeAbsoluteDelay* with the following equation:

CompAFallingEdgeAbsoluteDelay_Temp =
(M1_ChannelX + TimeError - M0) - StationTDR_X

- Save CompAFallingEdgeAbsoluteDelay_Temp for all channels as an array and calculate the mean value of the array. Save this value as MEAN(CompAFallingEdge_temp).

- Then make the following calculations:

$$T_{adjustment} = [(MEAN(CompAFallingEdge\_Temp) - MEAN(CompARisingEdge)) / (SampleClockPeriod/2)] \times (SampleClockPeriod/2)$$

and round the value in [ ] to the nearest integer.

Note SampleClockPeriod = 1/120 MHz.

$$CompAFallingEdgeAbsoluteDelay = CompAFallingEdgeAbsoluteDelay\_Temp - T_{adjustment}$$

Save all absolute delay values into an array.

Verifying Comparator B Falling Edge

49. Repeat steps 1 through 45 with the following modifications:
    a. Step 11—Configure the data voltage level for channels 0 to 23, PFI1, PFI2, PFI4, and PFI5 according to the following settings:
        - High level: 5.00 V
        - Low level: 1.65 V
    b. Step 27—Read a single record, and apply a channel mask to only analyze at the channel under test. If 1/3 of 1,002 samples (334 samples) returned are ≥1, then output **True**. In all other cases, output **False**.
    c. Step 32—Read a single record. If 1/3 of 1,002 samples (334 samples) read back from the channel under test are ≥1, output **True**. In all other cases, output **False**.
    d. Step 39—Clear all previous oscilloscope measurements, and start an acquisition. Acquire the delay measurements from SMA Clkout to PFI3. Save the average delay value as M1_Channel0. Measure the duty cycle and frequency of SMA Clkout. Calculate the time error for the falling edge measurement.

$$TimeError = \frac{50 - DutyCycle}{100} \times \frac{1}{Frequency}$$

    e. Step 41—Subtract the channel 0 TDR value from M1_Channel0 to negate the path length differences between channels. Then calculate CompBFallingEdgeAbsoluteDelay_Temp with the following equation:

$$CompBFallingEdgeAbsoluteDelay\_Temp = (M1\_Channel0 + TimeError - M0) - StationTDR\_0$$

    f. Step 42—Repeat steps 24 to 40 for channels 1 to 23, PFI1, PFI2, PFI4, and PFI5. Then calculate CompBFallingEdgeAbsoluteDelay_Temp with the following equation:

$$CompBFallingEdgeAbsoluteDelay\_Temp = (M1\_ChannelX + TimeError - M0) - StationTDR\_X$$

        - Save the *CompBFallingEdgeAbsoluteDelay_Temp* for all channels as an array and calculate the mean value of the array. Save this value as MEAN(CompBFallingEdge_temp).

- Make the following calculations:

$$T_{adjustment} = [(MEAN(CompBFallingEdge\_Temp) - MEAN(CompARisingEdge)) / (SampleClockCycle/2)] \times (SampleClockCycle/2)$$

and round the value in [ ] to the nearest integer.

$$CompBFallingEdgeAbsoluteDelay = CompBFallingEdgeAbsoluteDelay\_Temp - T_{adjustment}$$

Save all absolute delay values into an array.

50. The following values are calculated by the following equations:

$$Max(AbsoluteDelay) = Max\{CompARisingEdgeAbsoluteDelay, CompAFallingEdgeAbsoluteDelay, CompBRisingEdgeAbsoluteDelay, CompBFallingEdgeAbsoluteDelay\}$$

$$Min(AbsoluteDelay) = Min\{CompARisingEdgeAbsoluteDelay, CompAFallingEdgeAbsoluteDelay, CompBRisingEdgeAbsoluteDelay, CompBFallingEdgeAbsoluteDelay\}$$

$$RelativeSkew(CompARisingEdge) = CompARisingEdgeAbsoluteDelay - \frac{Max(AbsoluteDelay) + Min(AbsoluteDelay)}{2}$$

$$RelativeSkew(CompAFallingEdge) = CompAFallingEdgeAbsoluteDelay - \frac{Max(AbsoluteDelay) + Min(AbsoluteDelay)}{2}$$

$$RelativeSkew(CompBRisingEdge) = CompBRisingEdgeAbsoluteDelay - \frac{Max(AbsoluteDelay) + Min(AbsoluteDelay)}{2}$$

$$RelativeSkew(CompBFallingEdge) = CompBFallingEdgeAbsoluteDelay - \frac{Max(AbsoluteDelay) + Min(AbsoluteDelay)}{2}$$

51. Compare the RelativeSkew values to the following as-found or as-left test limits.

Table 19. NI 6555 Pin-to-Pin Input Skew Accuracy Verification Test Limits

As-Found Test Limit	As-Left Test Limit
±725 ps	±420 ps

Table 20. NI 6556 Pin-to-Pin Input Skew Accuracy Verification Test Limits

As-Found Test Limit (±5 °C from self-calibration)	As-Left Test Limit (±1 °C from self-calibration)
±600 ps	420 ps

Adjustment

The following performance adjustment procedures describe the steps required to adjust the NI 6555/6556.

Adjusting Voltage and Resistor Reference

Complete the following procedure to adjust the voltage and resistor references of the NI 6555/6556.

1. Initialize an external calibration session.
2. Configure the device calibration state with the external calibration session handle according to the following settings:
    a. Calibration type: Voltage reference adjust
    b. Reference number: 0
    c. Connector: Use the remote sense connector for the NI 6555 and the AUX I/O connector for the NI 6556
3. Configure the DMM according to the following settings:
    a. Functions: DC volts
    b. Range: 10 V
    c. Resolution in digits: 6 1/2
    d. Power line frequency: 50 Hz or 60 Hz, depending on your country
    e. Aperture time: 1 PLC
    f. Auto zero: On
    g. ADC calibration: On
4. Wait 100 ms for the measurement voltage to settle.
5. Use the DMM to read and save the measurement as M_0.
6. Call the adjust calibration (DBL) function according to the following settings:
    a. Calibration type: Voltage reference adjust
    b. Reference number: 0
    c. Value: M0
7. Configure the device calibration state according to the following settings:
    a. Calibration type: Voltage reference adjust
    b. Reference number: 1
    c. Connector: Remote sense for the NI 6555 or AUX I/O for the NI 6556
8. Wait 100 ms for the measurement voltage to settle.
9. Use the DMM to read and save the measurement as M1.

10. Call the adjust calibration (DBL) function according to the following settings:
    a. Calibration type: Voltage reference adjust
    b. Reference number: 1
    c. Value: M1
11. Configure the SMU according to the following settings:
    a. Source mode: Single point
    b. Output function: DC current
    c. Sense: Remote
    d. Voltage limit: 8 V
    e. Voltage limit range: 10 V
    f. Auto zero: On
    g. Samples to average: 50
12. Configure the device calibration state according to Table 21 and the following settings:
    a. Calibration type: Sink resistor adjust
    b. Reference number: Iteration number in Table 21
    c. Connector: Use the remote sense connector for the NI 6555 and the AUX I/O connector for the NI 6556
13. Source the first current value for iteration 0 in Table 21 with the SMU, and wait 100 ms to measure voltage (V_1) and current (I_1).
14. Source the second current value for iteration 0 in Table 21 with the SMU, and wait 100 ms to measure voltage (V_2) and current (I_2).
15. Calculate the measured resistance with the following equation:

$$MeasuredResistance = \left|\frac{V_2 - V_1}{I_2 - I_1}\right|$$

16. Call the adjust calibration (DBL) function according to the following settings:
    a. Calibration type: Sink resistor adjust
    b. Reference number: Iteration number in Table 21
    c. Value: Measured resistance
17. Repeat steps 12 through 16 for the rest of the iterations in Table 21.

Table 21. NI 6555/6556 Voltage Sink and Resistor Reference Adjustment Settings

Iteration	Current Range	First Current	Second Current
0	10 mA	10 mA	6 mA
1	1 mA	1 mA	600 µA
2	100 µA	100 µA	60 µA
3	10 µA	5 µA	1 µA

18. Configure the device calibration state according to the following settings:
    a. Calibration type: Source resistor adjust
    b. Reference number: Iteration number in Table 22
    c. Connector: Use the remote sense connector for the NI 6555 and the AUX I/O connector for the NI 6556
19. Source the first current value for iteration 0 in Table 22 with the SMU, and wait 100 ms to measure voltage (V_1') and current (I_1').
20. Source the second current value for iteration 0 in Table 22 with the SMU, and wait 100 ms to measure voltage (V_2') and current (I_2').
21. Calculate the measured resistance with the following equation:

$$MeasuredResistance = \left|\frac{V_2' - V_1'}{I_2' - I_1'}\right|$$

22. Call the adjust calibration (DBL) function according to the following settings:
    a. Calibration type: Source Resistor Adjust
    b. Reference number: Iteration number in Table 22
    c. Value: Measured resistance
23. Repeat steps 18 through 22 for the remaining iterations in Table 22.
24. Clear the calibration state.
25. To continue adjusting the NI 6556, go directly to the next section. To perform only timing adjustment for the NI 6555, or to only perform DC adjustment, call the close ext cal function with the calibration action input **Commit**, and self-calibrate the device.

Table 22. NI 6555/6556 Voltage Source and Resistor Reference Adjustment Settings

Iteration	Current Range	First Current	Second Current
0	10 mA	-10 mA	-9.5 mA
1	1 mA	-1 mA	-800 µA
2	100 µA	-100 µA	-60 µA
3	10 µA	-5 µA	-1 µA

Adjusting the NI 6556 Calibration Pulse

Complete the following procedure to adjust the calibration pulse performance of the NI 6556.

Note Perform voltage and resistor reference adjustment immediately before proceeding with the NI 6556 calibration pulse adjustment.

1. Using the external calibration session handle from the voltage and resistor reference adjustment, initialize a child generation session.

2. Call the configure Sample Clock function according to the following settings:
   a. Clock source: Onboard clock
   b. Clock rate: 101 MHz
3. Export the Sample Clock to ClkOut SMA.
4. Assign all channels as dynamic channels. Dynamically commit (do not start) the task.
5. Tristate all data and PFI channels.
6. Call the configure (device) calibration state function using the ext cal session handle:
   a. Calibration type: Calibration pulse adjust
   b. Reference number: 0
7. Clear all previous oscilloscope measurements.
8. Initialize CHA and CHB.
9. Configure the oscilloscope according to the following settings:
   a. Trigger source: CHB
   b. Edge trigger: Positive
   c. Trigger level: 0.625 V
   d. Sample rate: Maximum real-time rate, ≥10 GS/s
   e. Acquisition type: Continuous acquisition
   f. Input impedance: 50 Ω
   g. Coupling type: DC coupling
   h. Vertical range and offset: Configure to maximize resolution
   i. Time per records: 50 ns
   j. Setup delay (delta time) measurement: CHA (Clkout) to CHB (Data). You may need to define the measurement window.
      - CHA slope: Positive
      - CHB slope: Positive
      - CHA level: 0.825 V
      - CHB level: 0.625 V
10. Connect SMA Clkout on the NI 6556 to CHA on oscilloscope through the switch matrix.
11. Connect channel 0 on the NI 6556 to CHB on the oscilloscope through the switch matrix.
12. Clear all previous measurements, and start an acquisition on the oscilloscope for at least 200 measurements. Save the average delay value for the channel under test. Refer to Figure 9 for more information about the rising to rising edge measured in this step.
13. Disconnect channel 0 from the oscilloscope.
14. Subtract the station TDR value for the channel under test from the delay value to negate the path length differences between the channels. This value is called the *cal pulse skew* for each channel.
15. Repeat steps 11 through 14 for channels 1 to 23 and PFI1, PFI2, PFI4, and PFI5
16. Call the clear calibration state function.

17. Save the cal pulse skew for all channels into an array with channel 0 as element 0 and each subsequent channel sequentially following.
18. Call the adjust calibration (array) function with the external cal session handle according to the following settings:
    a. Calibration type: Calibration pulse adjust
    b. Reference number: 0
    c. Value: Cal pulse skew array
19. Call the close child session function (use ext cal session handle and child session handle).
20. Call the close ext cal function with a calibration action parameter of **Commit**.
21. Close the oscilloscope session.
22. Close switch session.
23. Complete the self-calibration procedure from the beginning of the document.
24. Complete *Verifying Pin-to-Pin Input Skew Accuracy* with the following modifications:
    a. Step 15—Call the configure (device) calibration state function using the ext cal session handle according to the following settings:
        - Calibration type: Input channel skew adjust
        - Reference number: 0
    b. Step 24—Call the configure (channel) calibration state function using the ext cal session handle according to the following settings:
        - Channel: Channel under test
        - Calibration type: Input channel skew adjust
        - Reference number: 1
    c. Step 36—Call the configure (device) calibration state function with the external calibration session handle according to the following settings:
        - Calibration type: Input channel skew adjust
        - Reference number: 0
25. Save RelativeSkew(CompARisingEdge), RelativeSkew(CompBRisingEdge), RelativeSkew(CompAFallingEdge), and RelativeSkew(CompBFallingEdge) for all channels into four arrays.
26. Call the init ext cal function.
27. Call the adjust calibration (array) function to adjust the cal pulse according to the following settings:
    a. Calibration type: Calibration pulse adjust
    b. Reference number: 1
    c. Value: RelativeSkew(CompARisingEdge) array
28. Call the adjust calibration (array) function according to the following settings:
    a. Calibration type: Calibration pulse adjust
    b. Reference number: 2
    c. Value: Relative skew (CompBRisingEdge) array

29. Call the adjust calibration (array) function according to the following settings:
    a. Calibration type: Calibration pulse adjust
    b. Reference number: 3
    c. Value: RelativeSkew(CompAFallingEdge) array
30. Call the adjust calibration (array) function according to the following settings:
    a. Calibration type: Calibration pulse adjust
    b. Reference number: 4
    c. Value: RelativeSkew(CompBFallingEdge) array.
31. Call the close ext cal function with a calibration action parameter of **Commit**.
32. Complete the self-calibration procedure from the beginning of the document.

Adjusting the NI 6555 Pin-to-Pin Input Skew

Complete the following procedure to adjust the calibration performance of the NI 6555.

Note Perform voltage and resistor reference adjustment and self-calibration immediately before preceding with the NI 6555 pin-to-pin input skew adjustment.

1. Perform Pin-to-Pin Input Skew Verification with the following modifications.
    a. Step 15—Call the configure (device) calibration state function using the ext cal session handle according to the following settings:
        - Calibration type: Input channel skew adjust
        - Reference number: 0
    b. Step 24—Call configure (channel) calibration state function using the ext cal session handle according the following settings:
        - Channel: Channel under test
        - Calibration type: Input channel skew adjust
        - Reference number: 1
    c. Step 36—Call the configure (device) calibration state function with the external calibration session handle according to the following settings:
        - Calibration type: Input channel skew adjust
        - Reference number: 0
2. Save RelativeSkew(CompA Rising Edge) for all channels into an array.
3. Save RelativeSkew(CompB Rising Edge) for all channels into an array.
4. Save RelativeSkew(CompA Falling Edge) for all channels into an array.
5. Save RelativeSkew(CompB Falling Edge) for all channels into an array.
6. Call the init ext cal function.

7. Call the adjust calibration (array) function according to the following settings:
   a. Calibration type: Input channel skew adjust
   b. Reference Number: 1
   c. Value: RelativeSkew(CompARisingEdge) array.
8. Call the adjust calibration (array) function according to the following settings:
   a. Calibration type: Input channel skew adjust
   b. Reference number: 2
   c. Value: RelativeSkew(CompBRisingEdge) array
9. Call the adjust calibration (array) function according to the following settings:
   a. Calibration type: Input channel skew adjust
   b. Reference number: 3
   c. Value: RelativeSkew(CompAFallingEdge) array
10. Call the adjust calibration (array) function according to the following settings:
    a. Calibration Type: Input channel skew adjust
    b. Reference number: 4
    c. Value: RelativeSkew(CompBFallingEdge) array
11. Call the close ext cal function with a calibration action parameter of **Commit**.

Adjusting the NI 6555 Pin-to-Pin Output Skew

Complete the following procedure to adjust the calibration performance of the NI 6555.

1. Complete Pin-to-Pin Output Skew Verification with the following modification:
   a. Run the output skew adjustment for a single voltage and set VOH and VTT to 2.5 V. You do not need to run output skew adjust at 1 V or 5 V.
   b. Step 20—Call the configure (channel) calibration state function using the external calibration state handle according to the following settings:
      - Channel: Channel under test
      - Calibration type: Output channel skew adjust
      - Reference number: 0
   c. Step 35—Calculate the relative skew values with following equations:

Max(AbsoluteDelay) = Max{DataRisingEdgeAbsoluteDelay, DataFallingEdgeAbsoluteDelay, EnableRisingEdgeAbsoluteDelay, EnableFallingEdgeAbsoluteDelay}

Min(AbsoluteDelay) = Min{DataRisingEdgeAbsoluteDelay, DataFallingEdgeAbsoluteDelay, EnableRisingEdgeAbsoluteDelay, EnableFallingEdgeAbsoluteDelay}

- Calculate *RelativeSkew(DataRisingEdge)* using the following equation:

$$RelativeSkew(DataRisingEdge) = AbsoluteDelay(DataRisingEdge) - \frac{Max(AbsoluteDelay) + Min(AbsoluteDelay)}{2}$$

- Calculate *RelativeSkew(DataFallingEdge)* using the following equation:

$$RelativeSkew(DataFallingEdge) = AbsoluteDelay(DataFallingEdge) - \frac{Max(AbsoluteDelay) + Min(AbsoluteDelay)}{2}$$

- Calculate *RelativeSkew(EnableRisingEdge)* using the following equation:

$$RelativeSkew(EnableRisingEdge) = AbsoluteDelay(EnableRisingEdge) - \frac{Max(AbsoluteDelay) + Min(AbsoluteDelay)}{2}$$

- Calculate *RelativeSkew(EnableFallingEdge)* using the following equation:

$$RelativeSkew(EnableFallingEdge) = AbsoluteDelay(EnableFallingEdge) - \frac{Max(AbsoluteDelay) + Min(AbsoluteDelay)}{2}$$

2. Save the DataRisingEdgeRelativeSkew for all channels into an array.
3. Save the EnableRisingEdgeRelativeSkew for all channels into an array.
4. Save the DataFallingEdgeRelativeSkew for all channels into an array.
5. Save the EnableFallingEdgeRelative skew for all channels into an array.
6. Call the initialize external calibration function.
7. Call the adjust calibration (array) function according to the following settings:
   a. Calibration type: Output channel skew adjust
   b. Reference Number: 1
   c. Value: RelativeSkew(DataRisingEdge) array
8. Call the adjust calibration (array) function according to the following settings:
   a. Calibration type: Output channel skew adjust
   b. Reference Number: 2
   c. Value: RelativeSkew(DataFallingEdge) array
9. Call the adjust calibration array function according to the following settings:
   a. Calibration type: Output channel skew adjust
   b. Reference Number: 3
   c. Value: RelativeSkew(EnableRisingEdge) array
10. Call the adjust calibration (array) function according to the following settings
    a. Calibration Type: Output channel skew adjust
    b. Reference Number: 4
    c. Value: RelativeSkew(EnableFallingEdge) array
11. Call the close external calibration function with a calibration action parameter of **Commit**.
12. Complete self calibration.

Updating the EEPROM

When you complete an adjustment procedure, the NI 6555/6556 internal calibration memory (EEPROM) is immediately updated.

If you do not want to perform an adjustment, you can update the calibration date and onboard calibration temperature without making any adjustments by initializing an external calibration, setting the calibration temperature, and closing the external calibration.

Re-Verification

Repeat the *Verification* section to determine the as-left status of the device.

Note If any test fails Re-Verification after performing an adjustment, verify that you have met the *Test Conditions* before returning your device to NI. Refer to *Where to Go for Support* for assistance in returning the device to NI.

Where to Go for Support

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

National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world. For telephone support in the United States, create your service request at `ni.com/support` or dial 512 795 8248. For telephone support outside the United States, visit the Worldwide Offices section of `ni.com/niglobal` to access the branch office websites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

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