CALIBRATION PROCEDURE

NI PXIe-5653

This document contains the verification and adjustment procedures for the National Instruments PXIe-5653 RF synthesizer (NI 5653). Refer to `ni.com/calibration` for more information about calibration solutions.

Contents

NATIONAL INSTRUMENTS

Software

Calibrating the NI 5653 requires you to install one of the following packages on the calibration system.

- NI-RFSA 2.4 or later
- NI-RFSG 1.7 or later

Note NI-RFSG automatically installs when you install NI-RFSA.

You can download all required software from `ni.com/downloads`.

The software supports programming the calibration procedures in the LabVIEW, C, and LabWindows™/CVI™ application development environments (ADE). When you install the software, you need to install support only for the ADE that you intend to use.

Documentation

You might find the following documents helpful as you perform the calibration procedure:

- *NI 5665 RF Vector Signal Analyzer Getting Started Guide*
- *NI RF Signal Generators Help*
- *NI PXIe-5665 Specifications*

The latest versions of these documents are available on `ni.com/manuals`.

Test Equipment

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

Table 1. Required Equipment Specifications for NI 5653 Calibration

Equipment	Recommended Model	Where Used	Minimum Requirements
Signal source analyzer	Rohde & Schwarz (R&S) FSUP Signal Source Analyzer	Verifying 10 MHz Reference Frequency Accuracy Verifying 100 MHz Reference Frequency Accuracy Verifying LO1 Frequency Accuracy Verifying LO1 Phase Noise Verifying LO2 Phase Noise Verifying LO3 Phase Noise Adjusting Reference Accuracy Adjusting YIG Frequency Accuracy	Frequency range: 9 MHz to 10 GHz Frequency accuracy: 1 ppb over the frequency range, 900 MHz to 9 GHz recommended Noise floor: <-152 dBm/Hz Phase noise measurement using cross-correlation Frequency counter marker feature Spectrum analysis capabilities
Frequency reference	Symmetricon 8040C Rubidium Frequency Standard	Verifying 10 MHz Reference Frequency Accuracy Verifying 100 MHz Reference Frequency Accuracy Verifying LO1 Frequency Accuracy Adjusting Reference Accuracy Adjusting YIG Frequency Accuracy	Frequency: 10 MHz Frequency accuracy: $1 * 10^{-9}$ (typically ±5E-11)

Table 1. Required Equipment Specifications for NI 5653 Calibration (Continued)

Equipment	Recommended Model	Where Used	Minimum Requirements
Power meter	Anritsu ML2438A with a MA247xD Series Diode Sensor	Verifying 10 MHz Reference Amplitude Accuracy Verifying 100 MHz Reference Amplitude Accuracy Verifying LO1 Amplitude Accuracy Verifying LO2 Amplitude Accuracy Verifying LO3 Amplitude Accuracy Adjusting LO1, LO2, and LO3 Output Power	Range: 0 dBm to +20 dBm Frequency range: 9 MHz to 8.3 GHz Accuracy: 0.5% Linearity: Up to +15 dBm (MA2475 only)
SMA (m)-to-SMA (m) Cable	—	Verifying 10 MHz Reference Frequency Accuracy Verifying 100 MHz Reference Frequency Accuracy Verifying LO1 Frequency Accuracy Verifying LO1 Phase Noise Verifying LO2 Phase Noise Verifying LO3 Phase Noise Adjusting Reference Accuracy Adjusting YIG Frequency Accuracy Adjusting LO1, LO2, and LO3 Output Power	Length: 36 in.

Test Conditions

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

- Keep cabling as short as possible. Long cables act as antennas, picking up extra noise that can affect measurements.
- Verify that all connections, including front panel connections and screws, are secure.
- Maintain an ambient temperature of 23 °C ±5 °C.
- Keep relative humidity between 10% and 90%, noncondensing.
- Allow a warm-up time of at least 30 minutes after the chassis is powered on. The warm-up time ensures that the NI 5653 is at a stable operating temperature.
- In each verification procedure, insert a delay between configuring all devices and acquiring the measurement. This delay may need to be adjusted depending on the instruments used but should always be at least 1,000 ms for the first iteration, 1,000 ms when the power level changes, and 100 ms for each other iteration.
- Perform self-calibration on the NI 5653.
- Plug the PXI/PXI Express chassis and the calibrator into the same power strip to avoid ground loops.
- Use a torque wrench appropriate for the type of RF connector that you are using. NI recommends a 0.565 N · m (5 lb · in.) wrench for SMA connectors and an 0.90 N · m (8 lb · in.) wrench for 3.5 mm connectors.
- Connect the frequency reference source to the REF IN connector on the back of the PXI Express chassis with a standard BNC (m)-to-BNC (m) cable. This connection replaces the connection from the NI 5653 REF OUT (10 MHz) connector to the PXI Express chassis REF IN connector, if present.
- Ensure that the PXI/PXI Express chassis fan speed is set to HIGH, that the fan filters, if present, 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`.

Initial Setup

Refer to the *NI 5665 RF Vector Signal Analyzer Getting Started Guide* for information about how to install the software and hardware and how to configure the device in Measurement and Automation Explorer (MAX).

Self-Calibrating the NI 5653

Note No signal connections are needed for self-calibration.

You can self-calibrate the NI 5653 using the self-calibration features provided with NI-RFSG.

As-Found and As-Left Limits

The as-found limits are the published specifications for the NI 5653, found in the *NI PXIe-5665 Specifications* document. NI uses these limits to determine whether the NI 5653 meets the device specifications when it is received for calibration.

The as-left limits are equal to the published NI specifications for the NI 5653, less guard bands for measurement uncertainty, temperature drift, and drift over time. NI uses these limits to determine whether the NI 5653 meets the device specifications over its calibration interval.

Verification

The performance verification procedures assume that adequate traceable uncertainties are available for the calibration references.

Verifying 10 MHz Reference Frequency Accuracy

This verification ensures that the internal oven-controlled crystal oscillator (OCXO) is adjusted for correct frequency accuracy. Complete the following procedure to determine the as-found status of the NI 5653.

1. Connect the NI 5653 REF OUT 10 MHz front panel connector to the signal source analyzer RF IN front panel connector.
2. Connect the signal source analyzer REF IN rear panel connector to the rubidium frequency reference output connector.
3. Create a new device session for the NI 5653.
4. Set the RF frequency to 4 GHz and commit the settings to hardware.
5. Check the signal generation status and verify that there are no reported errors or warnings.
6. Configure the signal source analyzer as follows:
   - Center frequency: 110 MHz
   - Reference level: -50 dBm
   - Frequency span: 1 kHz
   - Reference clock source: External
   - Frequency counter mode: 0.1 Hz resolution
7. Use the signal source analyzer frequency counter to measure the frequency of the peak at approximately 110 MHz.

8. Calculate the deviation using the following formula:

$$\Delta f = \left| \frac{f_{measured}(MHz) - 110MHz}{110MHz} \right|$$

9. Ensure that the result in step 8 is less than the result of the following formula:

$$Initial\ Accuracy + Aging + Temperature\ Stability$$

where

$$Initial\ Accuracy = 50 \times 10^{-9}$$

$$Aging = \frac{100 \times 10^{-9}}{Year} \times NumberofYearsSinceLastAdjustment$$

$$Temperature\ Stability = 10 \times 10^{-9}$$

10. Close the device session.

Verifying 10 MHz Reference Amplitude Accuracy

This verification ensures that the internal 10 MHz reference circuitry is adjusted for correct amplitude accuracy. Complete the following procedure to determine the as-found status of the NI 5653.

1. Connect the NI 5653 REF OUT 10 MHz front panel connector to the power meter.
2. Connect the signal source analyzer REF IN rear panel connector to any rubidium frequency reference output connector.
3. Create a new device session for the NI 5653.
4. Set the RF frequency to 4 GHz and commit the settings to hardware.
5. Check the signal generation status and verify that there are no reported errors or warnings.
6. After correcting for the measurement frequency, use the power meter to measure the NI 5653 REF OUT 10 MHz front panel connector power. Ensure that the power is between 1 dBm and 10 dBm.
7. Close the device session.

Verifying 100 MHz Reference Frequency Accuracy

This verification ensures that the internal 100 MHz reference circuitry is adjusted for correct frequency accuracy. Complete the following procedure to determine the as-found status of the NI 5653.

1. Connect the NI 5653 REF OUT 100 MHz front panel connector to the signal source analyzer RF IN front panel connector.
2. Connect the signal source analyzer REF IN rear panel connector to any rubidium frequency reference output connector.
3. Create a new device session for the NI 5653.
4. Set the RF frequency to 4 GHz and commit the settings to hardware.
5. Check the signal generation status and verify that there are no reported errors or warnings.

6. Configure the signal source analyzer as follows:
   - Center frequency: 100 MHz
   - Reference level: 10 dBm
   - Frequency span: 250 kHz
   - Reference clock source: External
   - Frequency counter mode: 0.1 Hz resolution
7. Use the signal source analyzer frequency counter to measure the frequency of the peak at approximately 110 MHz.
8. Calculate the deviation using the following formula:

$$\Delta f = \left| \frac{f_{measured}(MHz) - 100MHz}{100MHz} \right|$$

9. Ensure that the result in step 8 is less than the result of the following formula:

$$Initial\ Accuracy + Aging + Temperature\ Stability$$

   Where:

$$Initial\ Accuracy = 50 \times 10^{-9}$$

$$Aging = \frac{100 \times 10^{-9}}{Year} \times Number of Years Since Last Adjustment$$

$$Temperature\ Stability = 10 \times 10^{-9}$$

10. Close the device session.

Verifying 100 MHz Reference Amplitude Accuracy

This verification ensures that the 100 MHz reference circuitry is adjusted for correct amplitude accuracy. Complete the following procedure to determine the as-found status of the NI 5653.

1. Connect the NI 5653 REF OUT 100 MHz front panel connector to the power meter.
2. Create a new device session for the NI 5653.
3. Set the RF frequency to 4 GHz and commit the settings to hardware.
4. Check the signal generation status and verify that there are no reported errors or warnings.
5. After correcting for the measurement frequency, use the power meter to measure the NI 5653 REF OUT 100 MHz front panel connector power. Ensure that the power is between 1 dBm and 10 dBm.
6. Close the device session.

Verifying LO1 Frequency Accuracy

This verification ensures that the internal local oscillator (LO) circuitry is adjusted for correct frequency accuracy. Complete the following procedure to determine the as-found status of the NI 5653.

1. Connect the NI 5653 LO1 front panel connector to the signal source analyzer RF IN front panel connector.
2. Connect the signal source analyzer REF IN rear panel connector to the rubidium frequency reference output connector.
3. Create a new device session for the NI 5653.
4. Create a list of test frequencies from 3.2 GHz to 8.3 GHz in 100 MHz increments including endpoints.
5. Set the RF frequency to the first value of the frequency array you created in step 4 and commit the settings to hardware.
6. Check the signal generation status and verify that there are no reported errors or warnings.
7. Configure the signal source analyzer as follows:
   - Center frequency: Frequency from the list in step 4
   - Reference level: 20 dBm
   - Frequency span: 1 kHz
   - Reference clock source: External
8. Measure the frequency of the peak that is returned by the signal source analyzer at approximately the corresponding point in the frequency array you created in step 4.
9. Use the following formula to calculate the deviation:

$$\Delta f = \left| \frac{f_{measured}(MHz) - f_{expected}(MHz)}{f_{expected}(MHz)} \right|$$

10. Repeat steps 5 through 9 for each subsequent point in the frequency array created in step 4.
11. Ensure that the results in step 8 are less than the result of the following formula:

$$Initial\ Accuracy + Aging + Temperature\ Stability$$

    Where

$$Initial\ Accuracy = 50 \times 10^{-9}$$

$$Aging = \frac{100 \times 10^{-9}}{Year} \times Number of Years Since Last Adjustment$$

$$Temperature\ Stability = 10 \times 10^{-9}$$

12. Close the device session.

Verifying LO1 Amplitude Accuracy

This verification ensures that the internal LO1 circuitry is adjusted for correct amplitude accuracy. Complete the following procedure to determine the as-found status of the NI 5653.

1. Connect the NI 5653 LO1 front panel connector to the power meter.
2. Create a new device session for the NI 5653.
3. Create a list of test frequencies from 3.2 GHz to 8.3 GHz in 100 MHz increments, including endpoints.
4. Calculate the expected output power, $P_{Expected}$, for each frequency using the following formulas.

   For all frequencies from 3.2 GHz to 8.2 GHz:

   $$P_{Expected} = 10.5 - 3\left(\frac{frequency(GHz) - 3.2GHz}{5.0GHz}\right)(dBm)$$

   For the frequency 8.3 GHz:

   $$P_{Expected} = 6.5 \text{ dBm}$$

5. Set the RF frequency to the first value of the frequency array you created in step 3 and commit the settings to hardware.
6. Check the signal generation status and verify that there are no reported errors or warnings.
7. After correcting for the measurement frequency, use the power meter to measure the NI 5653 LO1 front panel connector power.
8. Calculate the power deviation, $P_{Deviation}$, using the following formula:

   $$P_{Deviation}(dB) = P_{Measured}(dBm) - P_{Expected}(dBm)$$

9. Repeat steps 5 through 8 for each point in the frequency array you created in step 3.
10. Verify that the power deviation results calculated in step 9 for each point are within ±2.5 dB for LO1.
11. Close the device session.

Verifying LO2 Amplitude Accuracy

This verification ensures that the internal LO2 circuitry is adjusted for correct amplitude accuracy. Complete the following procedure to determine the as-found status of the NI 5653.

1. Connect the NI 5653 LO2 front panel connector to the power meter.
2. Create a new device session for the NI 5653.
3. Set the RF frequency to 4 GHz and commit the settings to hardware.
4. Check the signal generation status and verify that there are no reported errors or warnings.
5. After correcting for the measurement frequency, use the power meter to measure the LO2 output power.
6. Ensure that the output power is between 6.5 dBm and 13 dBm.
7. Close the device session.

Verifying LO3 Amplitude Accuracy

This verification ensures that the internal LO3 circuitry is adjusted for correct amplitude accuracy. Complete the following procedure to determine the as-found status of the NI 5653.

1. Connect the NI 5653 LO3 front panel connector to the power meter.
2. Create a new device session for the NI 5653.
3. Set the RF frequency to 4 GHz and commit the settings to hardware.
4. Check the signal generation status and verify that there are no reported errors or warnings.
5. After correcting for the measurement frequency, use the power meter to measure the LO3 output power.
6. Ensure that the output power is between 7 dBm and 13 dBm.
7. Close the device session.

Verifying LO1 Phase Noise

This verification ensures that the internal LO1 circuitry is adjusted for correct phase noise accuracy. Complete the following procedure to determine the as-found status of the NI 5653.

1. Connect the NI 5653 LO1 front panel connector to the signal source analyzer RF IN front panel connector.
2. Create a new device session for the NI 5653.
3. Configure the signal source analyzer as follows:
   - Phase noise measurement using cross-correlation PLLs and internal generators
   - Automatic DUT detection
   - Spur suppression enabled
   - Fast Fourier transform (FFT) mode with Blackman-Harris window
   - Measurement span from 100 Hz to 10 MHz (offset frequencies)
4. Use the signal source analyzer to perform a manual frequency sweep at the settings shown in Table 2.

Table 2. LO1 Manual Sweep Settings

Carrier Frequency Offset	Resolution Bandwidth	Cross Correlation
100 Hz to 300 Hz	10 Hz	100
300 Hz to 1 kHz	30 Hz	1,000
1 kHz to 3 kHz	100 Hz	10,000
3 kHz to 10 kHz	300 Hz	10,000
10 kHz to 30 kHz	1 kHz	10,000
30 kHz to 100 kHz	1 kHz	5,000
100 kHz to 300 kHz	3 kHz	1,000

Table 2. LO1 Manual Sweep Settings (Continued)

Carrier Frequency Offset	Resolution Bandwidth	Cross Correlation
300 kHz to 1 MHz	10 kHz	1,000
1 MHz to 3 MHz	30 kHz	1,000
3 MHz to 10 MHz	100 kHz	1,000

5. Set the RF frequency to 5.4125 GHz and commit the settings to hardware.
6. If your signal source analyzer does not automatically center for phase noise measurements, manually set the signal source analyzer center frequency to 5.4125 GHz.
7. Check the signal generation status and verify that there are no reported errors or warnings.
8. Use the signal source analyzer to measure the phase noise. Record the measurements.
9. Set the RF frequency to 7.8125 GHz and commit the settings to hardware.
10. If your signal source analyzer does not automatically center for phase noise measurements, manually set the signal source analyzer center frequency to 7.8125 GHz.
11. Repeat steps 7 through 8 using the new frequency and record the measurements.
12. Ensure that the recorded measurements are within the limits set in Table 3.

Table 3. LO1 Phase Noise Density (dBc/Hz)

Offset	LO1 at 5.4125 GHz	LO1 at 7.8125 GHz
100 Hz	<-89	<-86
1 kHz	<-118	<-115
10 kHz	<-128	<-127
100 kHz	<-125	<-125
1 MHz	<-141	<-141
5 MHz	<-155	<-155

Verifying LO2 Phase Noise

This verification ensures that the internal LO2 circuitry is adjusted for correct phase noise accuracy. Complete the following procedure to determine the as-found status of the NI 5653.

1. Connect the NI 5653 LO2 front panel connector to the signal source analyzer RF IN front panel connector.
2. Create a new device session for the NI 5653.
3. Configure the signal source analyzer as follows:
   - Phase noise measurement using cross-correlation PLLs and internal generators
   - Automatic DUT detection
   - Spur suppression enabled

- Fast fourier transform (FFT) mode with Blackman-Harris window
- Measurement span from 100 Hz to 10 MHz (offset frequencies)

4. Use the signal source analyzer to perform a manual frequency sweep at the settings in Table 4.

Table 4. LO2 Manual Sweep Settings

Carrier Frequency Offset	Resolution Bandwidth	Cross Correlation
100 Hz to 300 Hz	10 Hz	100
300 Hz to 1 kHz	30 Hz	1,000
1 kHz to 3 kHz	100 Hz	10,000
3 kHz to 10 kHz	300 Hz	10,000
10 kHz to 30 kHz	1 kHz	10,000
30 kHz to 100 kHz	1 kHz	5,000
100 kHz to 300 kHz	3 kHz	1,000
300 kHz to 1 MHz	10 kHz	1,000
1 MHz to 3 MHz	30 kHz	1,000
3 MHz to 10 MHz	100 kHz	1,000

5. Set the RF frequency to 4 GHz and commit the settings to hardware.
6. If your signal source analyzer does not automatically center for phase noise measurements, manually set the signal source analyzer center frequency to 4 GHz.
7. Check the signal generation status and verify that there are no reported errors or warnings.
8. Use the signal source analyzer to measure the phase noise. Record the results.
9. Close the device session.
10. Ensure that the recorded measurements are within the limits set in Table 5.

Table 5. LO2 Phase Noise Density (dBc/Hz)

Offset	LO2
100 Hz	<-92
1 kHz	<-121
10 kHz	<-134
100 kHz	<-134
1 MHz	<-143
5 MHz	<-155

Verifying LO3 Phase Noise

This verification ensures that the internal LO3 circuitry is adjusted for correct phase noise accuracy. Complete the following procedure to determine the as-found status of the NI 5653.

1. Connect the NI 5653 LO2 front panel connector to the signal source analyzer RF IN front panel connector.
2. Create a new device session for the NI 5653.
3. Configure the signal source analyzer as follows:
   - Phase noise measurement using cross-correlation PLLs and internal generators
   - Automatic DUT detection
   - Spur suppression enabled
   - Fast Fourier transform (FFT) mode with Blackman-Harris window
   - Measurement span from 100 Hz to 10 MHz (offset frequencies)
4. Use the signal source analyzer to perform a manual frequency sweep at the settings listed in Table 6.

Table 6. LO3 Phase Noise Frequency Sweep Signal Source Analyzer Settings

Carrier Frequency Offset	Resolution Bandwidth	Cross Correlation
100 Hz to 300 Hz	10 Hz	100
300 Hz to 1 kHz	30 Hz	1,000
1 kHz to 3 kHz	100 Hz	10,000
3 kHz to 10 kHz	300 Hz	10,000
10 kHz to 30 kHz	1 kHz	10,000
30 kHz to 100 kHz	1 kHz	5,000
100 kHz to 300 kHz	3 kHz	1,000
300 kHz to 1 MHz	10 kHz	1,000
1 MHz to 3 MHz	30 kHz	1,000
3 MHz to 10 MHz	100 kHz	1,000

5. Set the RF frequency to 4 GHz and commit the settings to hardware.
6. If your signal source analyzer does not automatically center for phase noise measurements, manually set the signal source analyzer center frequency to 800 MHz.
7. Check the signal generation status and verify that there are no reported errors or warnings.
8. Use the signal source analyzer to measure the phase noise. Record the results.
9. Close the device session.

10. Ensure that the recorded measurements are within the limits set in Table 7.

Table 7. LO3 Phase Noise Density (dBc/Hz)

Offset	LO3
100 Hz	<-104
1 kHz	<-135
10 kHz	<-148
100 kHz	<-149
1 MHz	<-158
5 MHz	<-160

Adjustment

Completing the adjustment procedure automatically updates the calibration date and temperature stored in the NI 5653 EEPROM. The calibration date also updates when you call the niRFSG Initialize External Calibration and the niRFSG Close External Calibration VIs.

Adjusting Reference Accuracy

Complete the following procedure to adjust the NI 5653 frequency accuracy performance using a signal source analyzer. This adjustment yields a more accurately tuned VCO frequency.

1. Connect the NI 5653 REF OUT 10 MHz front panel connector to the signal source analyzer RF IN front panel connector.
2. Connect the signal source analyzer REF IN rear panel connector to the rubidium frequency reference output connector.
3. Configure the signal source analyzer as follows:
   - Center frequency: 10 MHz
   - Reference level: 10 dBm
   - Frequency span: 600 Hz
   - Reference clock source: External
4. Create a new external calibration session using the appropriate password.

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

5. Create a new Reference Clock calibration session.

6. Use the signal source analyzer to measure the peak power and frequency at the peak with the following parameter settings:
    - Set frequency reference level: **Spectrum Analyzer Ref Level** value returned by NI-RFSG
    - Set center frequency: **Spectrum Analyzer Center Frequency** value returned by NI-RFSG
    - Frequency counter mode: 0.1 Hz resolution
    - Measure power level: maximum peak power as measured
7. Adjust the NI 5653 Reference Clock using the measurements taken in step 6 for the **Measured Ref Out Frequency Peak** and **Measured Ref Out Power** parameters.
8. Repeat steps 6 and 7 until the **Reference Clock Calibration Complete** parameter returns a value of TRUE.
9. Close the external calibration session. Store the results to the EEPROM on the device.

Adjusting YIG Frequency

Complete the following procedure to adjust the NI 5653 YIG coarse frequency performance using a signal source analyzer.

1. Connect the NI 5653 LO1 front panel connector to the signal source analyzer RF IN front panel connector.
2. Connect the signal source analyzer REF IN rear panel connector to the rubidium frequency reference output connector.
3. Configure the signal source analyzer as follows:
    - Center frequency: 3 GHz
    - Reference level: 20 dBm
    - Frequency span: 1 GHz
    - Resolution bandwidth: 50 kHz
    - Reference clock source: External
4. Create a new external calibration session using the appropriate password.
5. Create a new YIG frequency calibration session.
6. Use the signal source analyzer to measure the peak power and frequency at the peak with the following parameter settings:
    - Set frequency span: **Spectrum Analyzer Frequency Span** value returned by NI-RFSG
    - Set center frequency: **Spectrum Analyzer Center Frequency** value returned by NI-RFSG
    - Measure frequency: Frequency at peak power as measured
    - Measure power level: Maximum peak power as measured
7. Adjust the YIG frequency using the measurements taken in step 6 for the **Measured LO1 Frequency** and **Measured LO1 Power** parameters.

8. Repeat steps 6 through 7 until the **YIG Frequency Calibration Complete** parameter returns a value of TRUE.
9. Close the external calibration session. Store the results to the EEPROM on the device.

Adjusting LO1, LO2, and LO3 Output Power

Complete the following procedure to adjust the NI 5653 LO power performance using a power meter. This adjustment yields a more accurate output power for the NI 5653 LO front panel connectors.

1. Connect the NI 5653 LO1 front panel connector to the power meter.
2. Create a new external calibration session using the appropriate password.
3. Create a new LO gain calibration session for LO1.
4. Use the power meter to measure the LO1 output power at the frequency specified by the **Calibration Frequency** parameter.
5. Adjust the LO Gain using the power measured in step 4 for the **Measured LO Power** parameter.
6. Repeat steps 4 and 5 until the **LO Gain Calibration Complete** parameter returns a value of TRUE.
7. Close the external calibration session. Store the results to the EEPROM on the device.
8. Disconnect the NI 5653 LO1 front panel connector from the power meter, and connect the NI 5653 LO2 front panel connector to the power meter.
9. Repeat steps 2 through 7 for LO2.
10. Disconnect the NI 5653 LO2 front panel connector from the power meter, and connect the NI 5653 LO3 front panel connector to the power meter.
11. Repeat steps 2 through 7 for LO3.

EEPROM Update

When an adjustment procedure is completed, the NI 5653 internal calibration memory, stored in the 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 performing an external calibration in software.

Reverification

Complete the following sections to determine the as-left status of the device.

Note If any test fails reverification after performing an adjustment, verify that you have met the *Test Conditions* before returning your device to NI. Refer to *Worldwide Support and Services* for information about support resources or service requests.

Reverifying 10 MHz Reference Amplitude Accuracy

This reverification ensures that the internal 10 MHz reference circuitry is adjusted for correct amplitude accuracy following adjustment. Complete the following procedure to determine the as-left status of the NI 5653.

1. Connect the NI 5653 REF OUT 10 MHz front panel connector to the power meter.
2. Connect the signal source analyzer REF IN rear panel connector to any rubidium frequency reference output connector.
3. Create a new device session for the NI 5653.
4. Set the RF frequency to 4 GHz and commit the settings to hardware.
5. Check the signal generation status and verify that there are no reported errors or warnings.
6. After correcting for the measurement frequency, use the power meter to measure the NI 5653 REF OUT 10 MHz front panel connector power. Ensure that the power is between 4 dBm and 7.5 dBm.
7. Close the device session.

Reverifying 100 MHz Reference Amplitude Accuracy

This reverification ensures that the 100 MHz reference circuitry is adjusted for correct amplitude accuracy following adjustment. Complete the following procedure to determine the as-left status of the NI 5653.

1. Connect the NI 5653 REF OUT 100 MHz front panel connector to the power meter.
2. Create a new device session for the NI 5653.
3. Set the RF frequency to 4 GHz and commit the settings to hardware.
4. Check the signal generation status and verify that there are no reported errors or warnings.
5. After correcting for the measurement frequency, use the power meter to measure the NI 5653 REF OUT 100 MHz front panel connector power. Ensure that the power is between 4 dBm and 7.5 dBm.
6. Close the device session.

Reverifying LO1 Amplitude Accuracy

This reverification ensures that the internal LO1 circuitry is adjusted for correct amplitude accuracy following adjustment. Complete the following procedure to determine the as-left status of the NI 5653.

1. Connect the NI 5653 LO1 front panel connector to the power meter.
2. Create a new device session for the NI 5653.
3. Create a list of test frequencies from 3.2 GHz to 8.3 GHz in 100 MHz increments, including endpoints.

4. Calculate the expected output power, $P_{Expected}$, for each frequency using the following formulas.

   For all frequencies from 3.2 GHz to 8.2 GHz:

$$P_{Expected} = 10.5 - 3\left(\frac{frequency(GHz) - 3.2GHz}{5.0GHz}\right)(dBm)$$

   For the frequency 8.3 GHz:

$$P_{Expected} = 6.5 \text{ dBm}$$

5. Set the RF frequency to the first value of the frequency array you created in step 3 and commit the settings to hardware.
6. Check the signal generation status and verify that there are no reported errors or warnings.
7. After correcting for the measurement frequency, use the power meter to measure the NI 5653 LO1 front panel connector power.
8. Calculate the power deviation, $P_{Deviation}$, using the following formula:

$$P_{Deviation}(dB) = P_{Measured}(dBm) - P_{Expected}(dBm)$$

9. Repeat steps 5 through 8 for each point in the frequency array you created in step 3.
10. Verify that the power deviation results calculated in step 9 for each point are within ±1.0 dB for LO1.
11. Close the device session.

Reverifying LO2 Amplitude Accuracy

This reverification ensures that the internal LO2 circuitry is adjusted for correct amplitude accuracy following adjustment. Complete the following procedure to determine the as-left status of the NI 5653.

1. Connect the NI 5653 LO2 front panel connector to the power meter.
2. Create a new device session for the NI 5653.
3. Set the RF frequency to 4 GHz and commit the settings to hardware.
4. Check the signal generation status and verify that there are no reported errors or warnings.
5. After correcting for the measurement frequency, use the power meter to measure the LO2 output power.
6. Ensure that the output power is between 8.25 dBm and 9.75 dBm.
7. Close the device session.

Reverifying LO3 Amplitude Accuracy

This reverification ensures that the internal LO3 circuitry is adjusted for correct amplitude accuracy following adjustment. Complete the following procedure to determine the as-left status of the NI 5653.

1. Connect the NI 5653 LO3 front panel connector to the power meter.
2. Create a new device session for the NI 5653.

3. Set the RF frequency to 4 GHz and commit the settings to hardware.
4. Check the signal generation status and verify that there are no reported errors or warnings.
5. After correcting for the measurement frequency, use the power meter to measure the LO3 output power.
6. Ensure that the output power is between 9 dBm and 11 dBm.
7. Close the device session.

Reverifying Other Device Performance Specifications

For all other device performance specifications, repeat the *Verification* section to determine the as-left status of the device.

Worldwide Support and Services

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.

Visit ni.com/services for NI Factory Installation Services, repairs, extended warranty, and other services.

Visit ni.com/register to register your National Instruments product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

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

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