Calibration Procedure

PXIe-5842 with S-Parameters

March 2025

379052A-01

Instructions on how to complete the performance verification and adjustment of your instrument.

NI PXIe-5842 with S-Parameters VST3 Calibration Procedure

This document contains the verification and adjustment procedures for the NI-PXIe-5842 RF PXI Vector Signal Transceiver, NI-PXIe-5633 2-port Vector Network Analyzer and associated NI-PXIe-5655 RF Analog Signal Generator. Use the procedures in this document to automate calibration or to conduct manual calibration.

Review and become familiar with the entire procedure before beginning the calibration process.

Contents

1. Terms and Definitions

DUT	DUT is an acronym for Device Under Test and refers to the NI product being calibrated. For this procedure, DUT refers to the PXIe-5842 with S-Parameters that comprises of a NI-PXIe-5842 RF PXI Vector Signal Transceiver, NI-PXIe-5633 2-port Vector Network Analyzer and associated NI-PXIe-5655 RF Analog Signal Generator.
As-Found Limits	These limits are derived from the published specifications for the DUT. NI uses these limits to determine if the DUT is performing within the recommended calibration interval specifications at the time of calibration and before any adjustment is performed.
As-Left Limits	These limits are derived from the published specifications for the DUT minus guardband to ensure a high probability that the DUT will meet its specifications over the next recommended calibration interval.
Functional Test	Functional Tests determine whether the DUT is operating correctly. Functional tests are not directly related to performance specifications.
Verification	Verification evaluates the measured calibration results against the defined As-Found Limits. The result of the evaluation is expressed as a Pass/Fail condition in the calibration certificate using an established evaluation formula.
Adjustment	Adjustment performs a set of operations on the DUT to optimize the measurement performance and conform it to the assigned calibrated values.
Reverification	Reverification evaluates the measured calibration results against the As-Left limits after adjustment. The As-Left limits may be tighter than the As-Found limits.
Recommended Calibration Interval	This interval indicates the recommended period between each round of verification and adjustment of the DUT. There is a high probability that, within this interval, the DUT will remain within the published warranted performance specifications. Some measurement DUTs have warranted specifications for different calibration intervals, for example: 24 hours, 90 days, 1 year, and 2 years. In this case, the specification depends on the calibration cycle chosen by the user.

2. Calibration Overview

Recommended Calibration Interval
1 year

Password
NI

Note
This is the default password for all password-protected operations. This password is site-specific.

PXIe-5842 & PXIe-5633 (Receiver and Transmitter) Estimated Test Time [hours:minutes]	
Task	26.5 GHz option
Warm Up	0:30
Verify Only 2 GHz BW	5:15
Adjust Only 2GHz BW	5:20

Note
Estimated test times assume the user is conducting an automated calibration.

VST Environmental Conditions	VST Verification	VST Adjustment
Ambient temperature	22.5 °C ± 2.5 °C	22.5 °C ± 2 °C
Internal DUT temperature range[1]	Tcal ± 2.5 °C	Tcal ± 2 °C
Relative humidity	Between 10% and 90%, noncondensing	

[1] The internal temperature of the DUT is greater than the ambient temperature.

VNA Environmental Conditions	VNA Verification Internal DUT temperature range
Ambient temperature	23.0 °C ± 5.0 °C
Relative humidity	Between 10% and 90%, noncondensing
VNA Trace Noise Port 1[2]	NA
VNA Trace Noise Port 2[2]	NA
VNA Uncorrected Error Terms Port 1[3]	X ± 2.0 °C
VNA Noise Floor Port 1[3]	X ± 2.0 °C
VNA Uncorrected Error Terms Port 2[4]	X ± 2.0 °C
VNA Noise Floor Port 2[4]	X ± 2.0 °C
VNA Linearity[5]	Y ± 1.0 °C

Note
Use of microscope is recommended for visual inspection to identify damage to any connectors prior to mating anything to DUT.

Note
Clean all RF connectors using Isopropyl 99.5% alcohol using a lint free swab. Avoid applying any pressure to the center conductor. Always follow all applications of alcohol with compressed air

Note
Gauge all RF connectors prior to ensure that no damage is propagated to other connections. Always use gloves to avoid oils from hands damaging gauges.

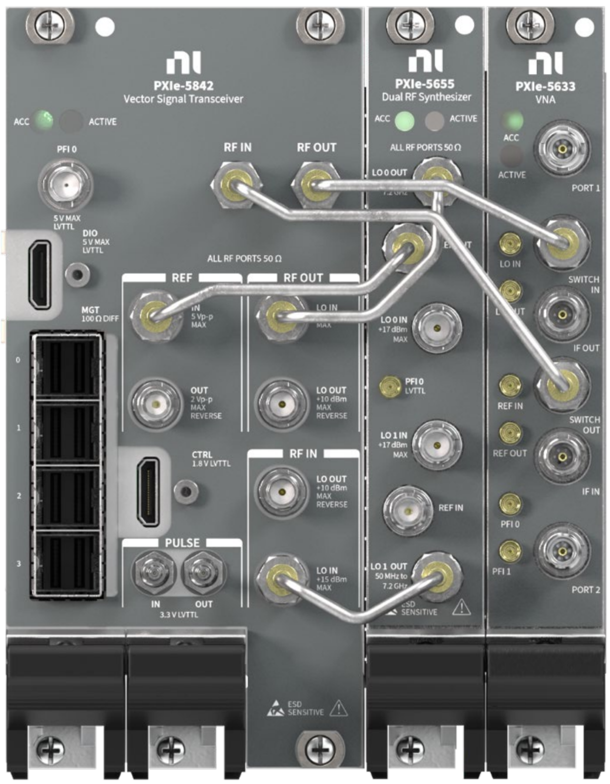
Note
Use proper technique when applying torque to any RF connection. Torque wrenches that fully break are recommended. Ensure that

[2] The temperature of the DUT is not applicable due to the short duration of this test.
[3] X is the temperature of the DUT at the beginning of VNA uncorrected error terms being measured on Port 1.
[4] X is the temperature of the DUT at the beginning of VNA uncorrected error terms being measured on Port 2.
[5] Y is the temperature of the DUT at the beginning of first step attenuator measurement during the Dynamic Accuracy test.

> backing wrench is used to isolate the female connection from moving, while applying torque wrench to male connection.

2.1. Device Under Test Overview

Figure 1 – NI PXIe-5842 VST with S-parameters Multi-Module Instrument

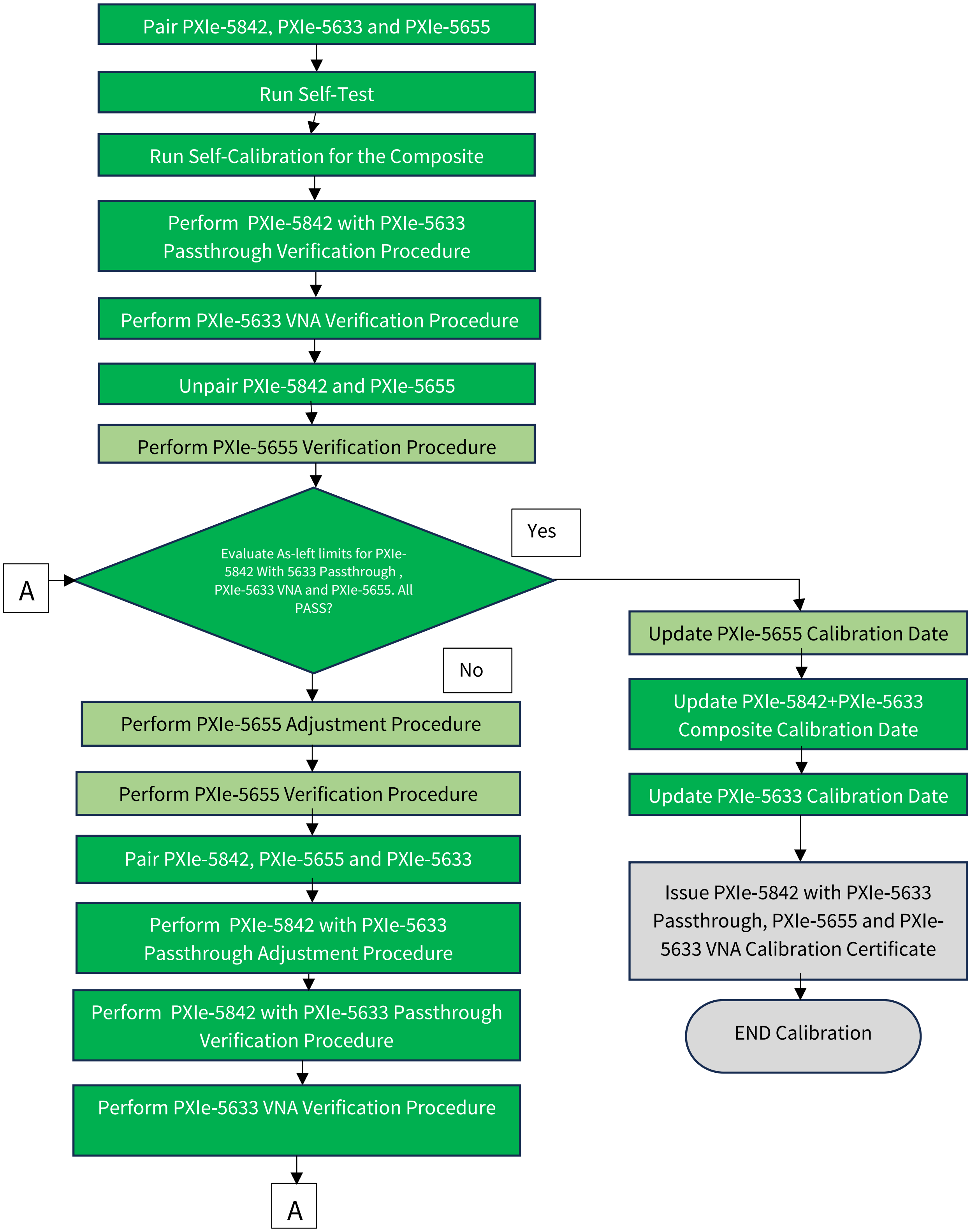


This NI VST with S-Parameters consists of a NI PXIe-5842, a NI PXIe-5655 and a NI PXIe-5633 paired as a multi-module. The calibration certificate will list the three devices.

This instrument must be calibrated as a paired single unit to meet the published specifications. If either the calibrated paired NI PXIe-5842, NI PXIe-5633 and NI PXIe-5655 are replaced the calibration becomes invalid and the “new” instrument must be calibrated.

2.2. Calibration Procedure Overview

This procedure includes the following calibration and adjustment steps:



Note
To **Unpair**: Disconnect all the semi-rigid cables between the PXIe-5842, PXIe-5655 and PXIe-5633 devices. There is no need to unpair in NI MAX.
To Pair: Connect all the semi-rigid cables between the PXIe-, PXIe-5655 and PXIe-5633 devices. Select the Associated LO to the PXIe-5842 device in NI MAX.

The Verification and adjustment of the PXIe-5655 RF Analog Signal Generator is documented in a separate document, PXIe-5655 Calibration Procedure.

Follow the calibration sequence described in the flow chart above to perform the Verification and Adjustment if needed. Follow this procedure for the Verification of the NI PXIe-5842 VST with S-Parameters and follow PXIe-5655 Calibration Procedure when calibrating the PXIe-5655 by itself.

2.3. Calibration Condition Guidelines

- Keep cabling as short as possible. Long cables act as antennas, picking up extra noise that can affect measurements. Cable movement or flexure change can cause vector error in measurements.
- Visually inspect and gauge all connectors prior to mating anything together.
- Keep connectors clean and debris free using lint-free swabs with 99.5% isopropanol alcohol along with HFC-134a compressed air.
- Minimize cable movement or flexure changes throughout the procedure but especially when performing error correction.
- Ensure that all connections to the DUT are secure.
- Allow adequate warm up time for all components of the calibration system.
- Make all connections as shown in diagrams.

- Ensure that the PXI/PXI Express chassis fan speed is set to Auto, 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.
- If a DUT fails reverification after adjustment, ensure that the Test Conditions have been met before returning the DUT to NI.

3. Calibration Resources

3.1. Required Software

Note
Ensure that the most recent version of the required driver software is installed before conducting the calibration.

Install the following software on the calibration system:

- RFSA 23.5
- RFSG 23.5

3.2. Recommended Documentation

Go to `ni.com/docs` to locate the following documentation for more information when performing this calibration:

- PXIe-5655 Calibration Procedure
- PXIe-5842 User Manual(s)
- PXIe-5842 Getting Started Guide(s)

3.3. Verification Prerequisites

To Verify and Adjust PXIe-5842 VST with S-Parameters you must be able to Verify and Adjust the associated RF Signal Generator PXIe-5655. Refer to the PXIe-5655 Calibration Procedure, available at ni.com/manuals for further details.

3.4. Test Equipment

This section details the equipment NI recommends for each test performed as part of this calibration procedure.

NI Calibration Executive Users
Refer to the Calibration Executive Help to find an updated list of test equipment for this calibration procedure.

Table 1: General Test Equipment for PXIe-5842 and PXIe-5655

Standard	Recommended Model	Where Used	Functional Requirement(s)
Chassis	NI PXIe-1095 PN-785971-01	All	Timing Sync Option
Controller	NI PXIe-8881do PN-786636-01	All	16GB RAM/500GB SSD
Phase noise and Spectrum analyzer	R&S FSWP26	6.2 RF Input Third Order Intermodulation Verification 6.7 RF Output Average Noise Density Verification 6.9 RF Output Harmonic Spurs Verification 6.10 RF Output Third Order Intermodulation Verification	Options: B1, B4, B24 and B61

Power Sensor (#1)	R&S NRP33S	5.1 Receiver Fixture Characterization 5.2 Cable loss Characterization 6.5 RF Input Absolute Amplitude Verification 6.6 RF Input Power Linearity Verification 6.7 RF Input Frequency Response Verification 7.2.1 Transmission Port 1 and Receiver on Port 2 Adjustment Connection 7.2.2 RF Transmission External Gain Port 1 Adjustment Procedure 7.2.3 RF Receiver External Gain **Port 2** Adjustment Procedure 7.2.4 Transmission Port 2 and Receiver on **Port 1** Adjustment Connection 7.2.5 RF Transmission External Gain **Port 2** Adjustment Procedure 7.2.6 RF Receiver External Gain **Port 1** Adjustment Procedure	NA
Power Sensor (#2)	R&S NRP33S	5.1 Receiver Fixture Characterization 5.2 Cable loss Characterization 6.3 RF Output Absolute Amplitude Verification 6.4 RF Output Frequency Response Verification 7.2.1 Transmission Port 1 and Receiver on Port 2 Adjustment Connection 7.2.2 RF Transmission External Gain **Port 1** Adjustment Procedure 7.2.3 RF Receiver External Gain **Port 2** Adjustment Procedure 7.2.4 Transmission Port 2 and Receiver on **Port 1** Adjustment Connection 7.2.5 RF Transmission External Gain **Port 2** Adjustment Procedure 7.2.6 RF Receiver External Gain **Port 1** Adjustment Procedure	NA
Signal Generator (x2)	R&S SMA100B 31.8 GHz	5.1 Receiver Fixture Characterization 5.2 Cable loss Characterization 6.2 RF Input Third Order Intermodulation Verification (x2) 6.5 RF Input Absolute Amplitude Verification 6.6 RF Input Power Linearity Verification 6.7 RF Input Frequency Response Verification 7.2.1 Transmission **Port 1** and Receiver on **Port 2** Adjustment Connection	Options: B131, B35, K36, and B86.

		7.2.2 RF Transmission External Gain **Port 1** Adjustment Procedure 7.2.3 RF Receiver External Gain **Port 2** Adjustment Procedure 7.2.4 Transmission Port 2 and Receiver on **Port 1** Adjustment Connection 7.2.5 RF Transmission External Gain **Port 2** Adjustment Procedure 7.2.6 RF Receiver External Gain **Port 1** Adjustment Procedure	
10 MHz Rb Reference standard	Microchip 8040	All	Reference Clock Routing
GPIB to USB Adapter (x3)	NI 783368-01	All	NA
36” SMA (m) to BNC (m) cable	Fairview Microwave FMC0208315-36	All	Reference Clock Routing
36” BNC (m) to BNC (m) cable (x3)	Fairview Microwave FMC0808058-36	All	Reference Clock Routing
36” 3.5 mm cable (m) to (m) (x5)	Maury SP-35-MM-36-LP	5.1 Receiver Fixture Characterization (cable #1) 5.2 Cable loss Characterization(Cable #A) 6.2 RF Input Third Order Intermodulation Verification (x3) 6.5 RF Input Absolute Amplitude Verification (cable #1) 6.6 RF Input Power Linearity Verification (cable #1) 6.7 RF Input Frequency Response Verification (cable #1) 6.8 RF Output Average Noise Density Verification (cable #A) 6.9 RF Output Harmonic Spurs Verification (cable #A) 6.10 RF Output Third Order Intermodulation Verification (cable #A) 7.2.1 Transmission **Port 1** and Receiver on **Port 2** Adjustment Connection	f≥26.5 GHz VSWR ≤1.25

		7.2.2 RF Transmission External Gain **Port 1** Adjustment Procedure 7.2.3 RF Receiver External Gain **Port 2** Adjustment Procedure 7.2.4 Transmission Port 2 and Receiver on **Port 1** Adjustment Connection 7.2.5 RF Transmission External Gain **Port 2** Adjustment Procedure 7.2.6 RF Receiver External Gain **Port 1** Adjustment Procedure	
3.5 mm Power Splitter (2 resistor)	Keysight 11667B	5.1 Receiver Fixture Characterization #1 6.5 RF Input Absolute Amplitude Verification(#1) 6.6 RF Input Power Linearity Verification (#1) 6.7 RF Input Frequency Response Verification (#1) 7.2.1 Transmission **Port 1** and Receiver on **Port 2** Adjustment Connection 7.2.2 RF Transmission External Gain **Port 1** Adjustment Procedure 7.2.3 RF Receiver External Gain **Port 2** Adjustment Procedure 7.2.4 Transmission Port 2 and Receiver on **Port 1** Adjustment Connection 7.2.5 RF Transmission External Gain **Port 2** Adjustment Procedure 7.2.6 RF Receiver External Gain **Port 1** Adjustment Procedure	Max VSWR 1.22
LF Power Combiner	Mini-Circuits ZFRSC-123-S+	6.2 RF Input Third Order Intermodulation Verification	DC to 12 GHz
HF 2.92 mm Power Combiner	Mini-Circuits ZC2PD-K0144+	6.2 RF Input Third Order Intermodulation Verification	1 GHz to 26GHz
45° SMA (m) to (f) Adapter	Centric C3243	5.1 Receiver Fixture Characterization #1 6.5 RF Input Absolute Amplitude Verification(#1) 6.6 RF Input Power Linearity Verification (#1) 6.7 RF Input Frequency Response Verification (#1)	Max VSWR 1.12
3.5 mm (f) to (f)	Maury CC-A-35-FF	5.1 Receiver Fixture Characterization 5.2 Cable loss Characterization 6.8 RF Output Average Noise Density Verification (adapter #A)	Max VSWR 1.12

Adapter (x2)		6.9 RF Output Harmonic Spurs Verification (Adapter #A) 6.10 RF Output Third Order Intermodulation Verification (adapter #A) 7.2.1 Transmission **Port 1** and Receiver on **Port 2** Adjustment Connection 7.2.2 RF Transmission External Gain **Port 1** Adjustment Procedure 7.2.3 RF Receiver External Gain **Port 2** Adjustment Procedure 7.2.4 Transmission Port 2 and Receiver on **Port 1** Adjustment Connection 7.2.5 RF Transmission External Gain **Port 2** Adjustment Procedure 7.2.6 RF Receiver External Gain **Port 1** Adjustment Procedure	
3.5mm (m) to (m) Adapter	Maury CC-A-35-MM	5.1 Receiver Fixture Characterization 6.5 RF Input Absolute Amplitude Verification (#1) 7.2.1 Transmission **Port 1** and Receiver on **Port 2** Adjustment Connection 7.2.2 RF Transmission External Gain **Port 1** Adjustment Procedure 7.2.3 RF Receiver External Gain **Port 2** Adjustment Procedure 7.2.4 Transmission Port 2 and Receiver on **Port 1** Adjustment Connection 7.2.5 RF Transmission External Gain **Port 2** Adjustment Procedure 7.2.6 RF Receiver External Gain **Port 1** Adjustment Procedure	Max VSWR 1.12
3.5 mm (m) 50 Ω Terminator	Pasternack PE6TR1109	6.11 RF Input Average Noise Density Verification	Max VSWR 1.15
Laboratory Mini Scissor Lift Jack	NA	To support Power Sensors	NA

Table 2: Additional Test Equipment for PXIe-5633

<table>
<tr><th>Standard</th><th>Recommended Model</th><th>Where Used</th><th colspan="3">Functional Requirement(s)</th></tr>
<tr><td>ECM #1</td><td>NI Cal-5501</td><td>6.13 VNA Calibration Port 1
6.14 VNA Uncorrected Error Terms Port 1 Functional Procedure
6.15 VNA Noise Floor Port 1 Verification Procedure
6.16 VNA Calibration Port 2
6.17 VNA Uncorrected Error Terms Port 2 Functional Procedure
6.18 VNA Noise Floor Port 2 Verification Procedure</td><td colspan="3">All Standards are Database Characterized</td></tr>
<tr><td>ECM #2</td><td>NI Cal-5501</td><td>6.19 VNA Calibration for Linearity Accuracy</td><td colspan="3">All Standards are Database Characterized</td></tr>
<tr><td rowspan="7">Step Attenuator</td><td rowspan="7">Keysight J7201C</td><td rowspan="7">6.19 VNA Calibration for Linearity Accuracy</td><td colspan="3">Max VSWR 1:15:1

All attenuation states characterized[6]</td></tr>
<tr><td>Atten Value</td><td>100 MHz to 18 GHz</td><td>> 18 GHz to 26.5 GHz</td></tr>
<tr><td>1 dB to 2 dB</td><td>± 0.40 dB</td><td>± 0.60 dB</td></tr>
<tr><td>3 dB to 6 dB</td><td>± 0.55 dB</td><td>± 0.75 dB</td></tr>
<tr><td>7 dB to 10 dB</td><td>± 0.70 dB</td><td>± 0.80 dB</td></tr>
<tr><td>11 dB to 30 dB</td><td>± 0.70 dB</td><td>± 0.80 dB</td></tr>
<tr><td>31 dB to 60 dB</td><td>± 0.80 dB</td><td>± 0.90 dB</td></tr>
<tr><td>36” 3.5 mm cable (m) to (m) (x2)</td><td>Maury Microwave SP-35-MM-36</td><td>6.12 VNA Trace Noise Verification Procedure
6.13 VNA Calibration Port 1
6.14 VNA Uncorrected Error Terms Port 1 Functional Procedure
6.15 VNA Noise Floor Port 1 Verification Procedure
6.16 VNA Calibration Port 2</td><td colspan="3">10 MHz to 26.5 GHz
Max VSWR 1.10:1</td></tr>
</table>

[6] Maximum transmission loss is in reference or normalized to 0 dB state of step attenuator.

		6.17 VNA Uncorrected Error Terms **Port 2** Functional Procedure 6.18 VNA Noise Floor **Port 2** Verification Procedure 6.19 VNA Calibration for Linearity Accuracy		
3.5 mm (m) 50 Ω Precision Short (x2)	Spinner 533762R000	6.12 VNA Trace Noise Verification Procedure		
3.5mm (m) to (m) Adapter	Maury Microwave CC-A-35-MM	6.13 VNA Calibration **Port 1** 6.14 VNA Uncorrected Error Terms **Port 1** Functional Procedure 6.15 VNA Noise Floor **Port 1** Verification Procedure 6.16 VNA Calibration **Port 2** 6.17 VNA Uncorrected Error Terms **Port 2** Functional Procedure 6.18 VNA Noise Floor **Port 2** Verification Procedure	Max VSWR 1.10:1 Max Transmission Loss[7]	
			50 MHz to 2 GHz	-0.012 ln (*freq*) + 0.1777 dB
			> 2 GHz to 10 GHz	-0.037 ln (*freq*) + 0.7095 dB
			> 10 GHz to 26.5 GHz	-4x10^{-12}(*freq*) – 0.1054 dB

4. Preliminary Actions

4.1. Warm Up the DUT

Warm up time starts after the installed DUT is powered on in the chassis. Warm up time resets after the DUT is removed from the chassis. This DUT requires 30 minutes to warm up prior to conducting any tests.

Note
Observe adequate Warm up time for all components of the calibration system.

[7] *Freq* in functional requirements specifications is in units Hz.

4.2. Perform Self-Calibration

Self-calibration should be performed after the DUT has warmed up for the recommended time period. This function measures the onboard reference voltage of the DUT and adjusts the self-calibration constants to account for any errors caused by short-term fluctuations in the environment.

Complete the following steps to conduct self-calibration using Measurement & Automation Explorer (MAX).

Note
Disconnect all external signals before beginning self-calibration.

1. Launch MAX.
2. Select **My System»Devices and Interfaces»*[DUT model name]***.
3. Start self-calibration:
4. Open an RFSA or RFSG session (based on your hardware license) and run AelfCal.vi.

4.3. Zeroing the Power Meter

- Ensure that the power meter is not connected to any signals.
- Zero the power meter using the built-in function, according to the power meter documentation.

Note
Electronic Calibration Module (ECM) or NI Cal-5501 requires at least 30 mins of continuous power to ensure that module is at thermal equilibrium prior to making any measurements.

Note
It is recommended to leave the electronic calibration module (ECM) connected to the system via the USB cable to allow the module to stay at thermal equilibrium. This will avoid further delays.

5. Perform Characterization

5.1. Receiver Fixture Characterization

This procedure determines the correction factors to apply due to power splitter, cables and connectors that are used to generate a known output power at different frequencies.

The Power Meter and Signal Generator are connected to the DUT receiver via a 2-resistor splitter. During external adjust, RF Input Absolute Amplitude Accuracy Verification, and RF Input Frequency Response Verification, a frequency sweep is done with both the Power meter and DUT simultaneously.

If you disassemble this fixture, you must recharacterize it before it is used again.

5.1.1. Test points and limits

Table 3: Receiver Fixture Characterization Test Points

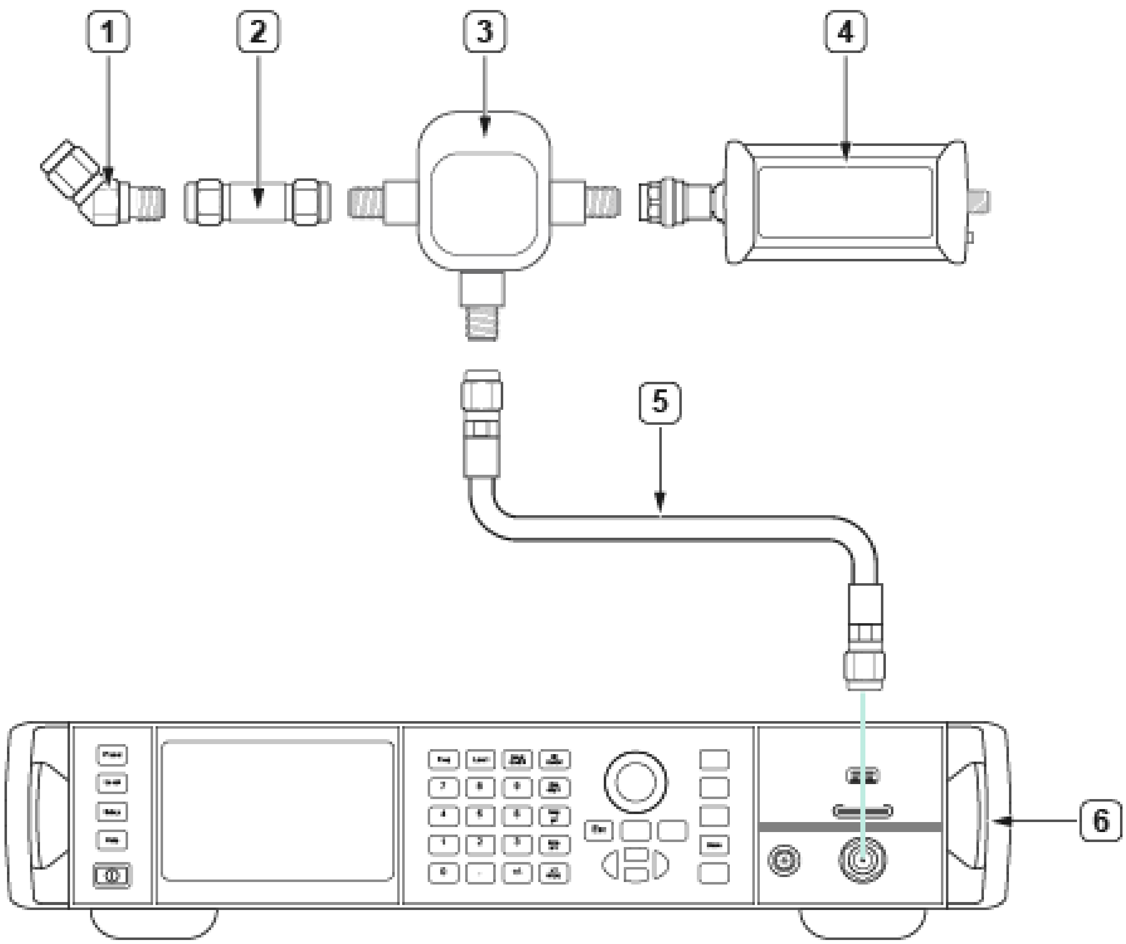
Range	Frequency step	
	Version	Step
30 MHz to 8.0 GHz	F08	5 MHz
30 MHz to 12.0 GHz	F12	5 MHz
30 MHz to 18 GHz	F18	5 MHz

30 MHz to 26.5 GHz	F26	5 MHz

5.1.2. Initial Test Connections

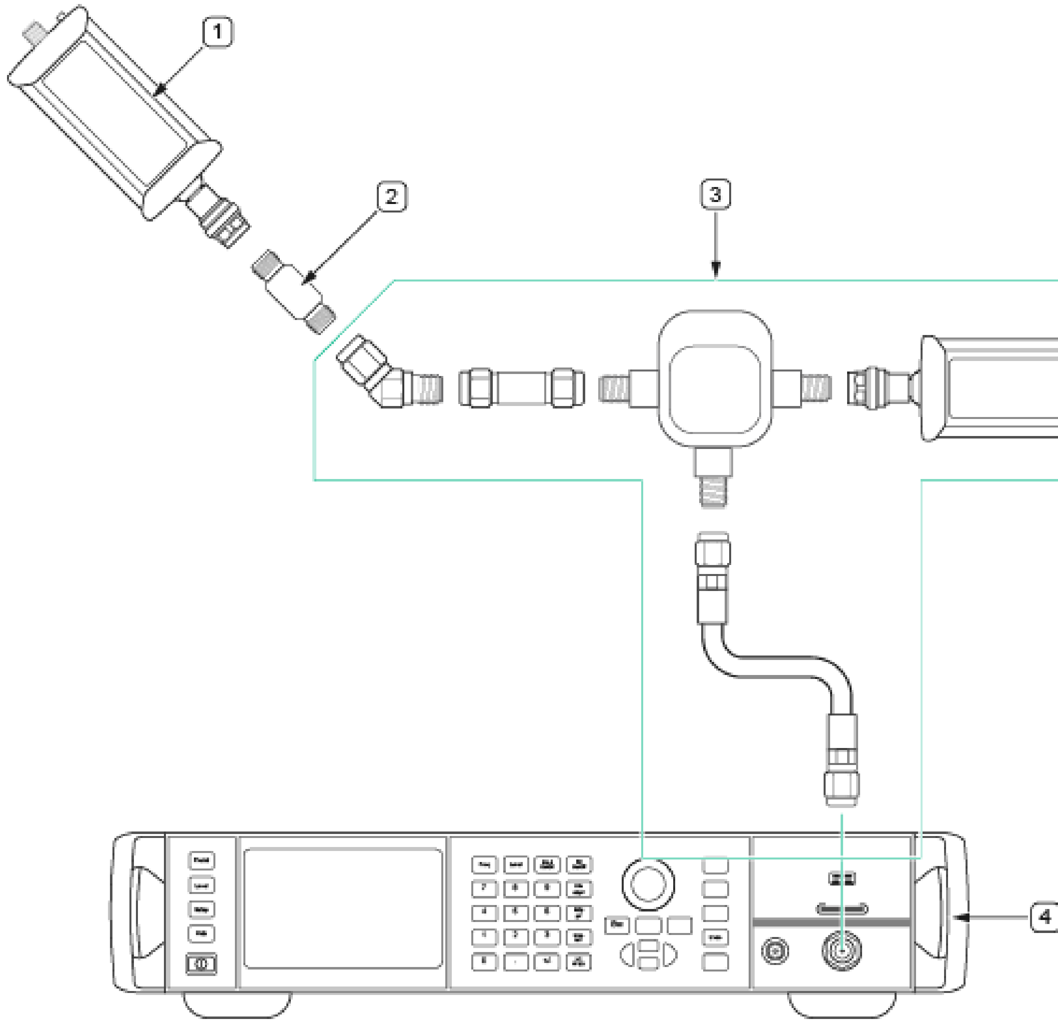
Note
Make the connections indicated in **Figure 2**.

Figure 2. Initial Connection for Receiver Fixture Characterization



1. 45° SMA Male to Female Adapter
2. 3.5 mm Male to Male Adapter
3. 3.5 mm Power Splitter (2 resistor)
4. Power Sensor #1
5. 36” 3.5 mm cable Male to Male #1
6. Signal Generator

Figure 3. Final Measurement Connections for Receiver Fixture Characterization



1. Power Sensor #2
2. 3.5 mm Female to Female Adapter
3. Receiver Fixture from **Figure 2**
4. Signal Generator

5.1.3. Characterization Procedure

1. Assemble the Receiver fixture as per **Figure 2**.

Ensure that the Power Meter has been zeroed according with section 4.3. Perform the zero before making the connection in **Figure 3**.

Make the final measurement connections as per **Figure 3**.

2. Set the following settings on the Signal Generator:
   - Power: 0 dBm
   - RF Frequency: 30 MHz

Repeat, once for each frequency point indicated in **Table 3**.

3. Set the initial power level of the signal generator to 0 dBm, record this value as the $\texttt{Requested\_TX\_Power}_0$.
4. Set the RF Frequency to the next value in the Frequency sweep.
5. Measure the power from the Characterization Power Sensor (#2), record this value as $\texttt{RX\_Path\_Measurement}_i$ (where $\texttt{i}$ is the $\texttt{i}^{th}$ iteration of this measurement), starting at zero.
6. Measure the power from the RX Cal Fixture Power Sensor #1, record this value as $\texttt{PM\_Path\_Measurement}_i$.
7. Evaluate if the following is true:

$$\texttt{Requested\_TX\_Power}_0 - 0.1 \leq \texttt{RX\_Path\_Measurement}_i \leq \texttt{Requested\_TX\_Power}_0 + 0.1$$

8. If the above evaluation is false, set the power level of the signal generator to:

$$\texttt{Requested\_TX\_Power}_i = \texttt{Requested\_TX\_Power}_0 + \texttt{Correction}_i$$

where $\texttt{Correction}_i = \texttt{Requested\_TX\_Power}_0 - \texttt{RX\_Path\_Measurement}_0$

9. Repeat from step 3 until the output of the RX Cal Fixture evaluation is true. If the evaluation is not true after four iterations, check the connections.
10. When the evaluation is true record the following parameters:

$$\texttt{RX\_Fixture\_PM\_to\_RX\_Path\_Response} = \texttt{RX\_Path\_Measurement}_i - \texttt{PM\_Path\_Measurement}_i$$

(***Equation 1***)

$$\texttt{RX\_Fixture\_TX\_to\_RX\_Path\_Response} = \texttt{Requested\_TX\_Power}_i + \texttt{Correction}_i - \texttt{RX\_Path\_Measurement}_i$$

(***Equation 2***)

Note

Do not disassemble Receiver Fixture item #3 from **Figure 3** after characterization. If you disassemble this fixture, you must recharacterize it before it is used again.

5.2. Cable loss Characterization

Perform the following steps to characterize the cable loss for the TX Average Noise Density and Harmonic Spurs tests. This characterization should be run right after section 5.1 Receiver Fixture Characterization. The RX Fixture measurements are reused during these measurements.

5.2.1. Test points

Table 4: Receiver Fixture Characterization Test Points

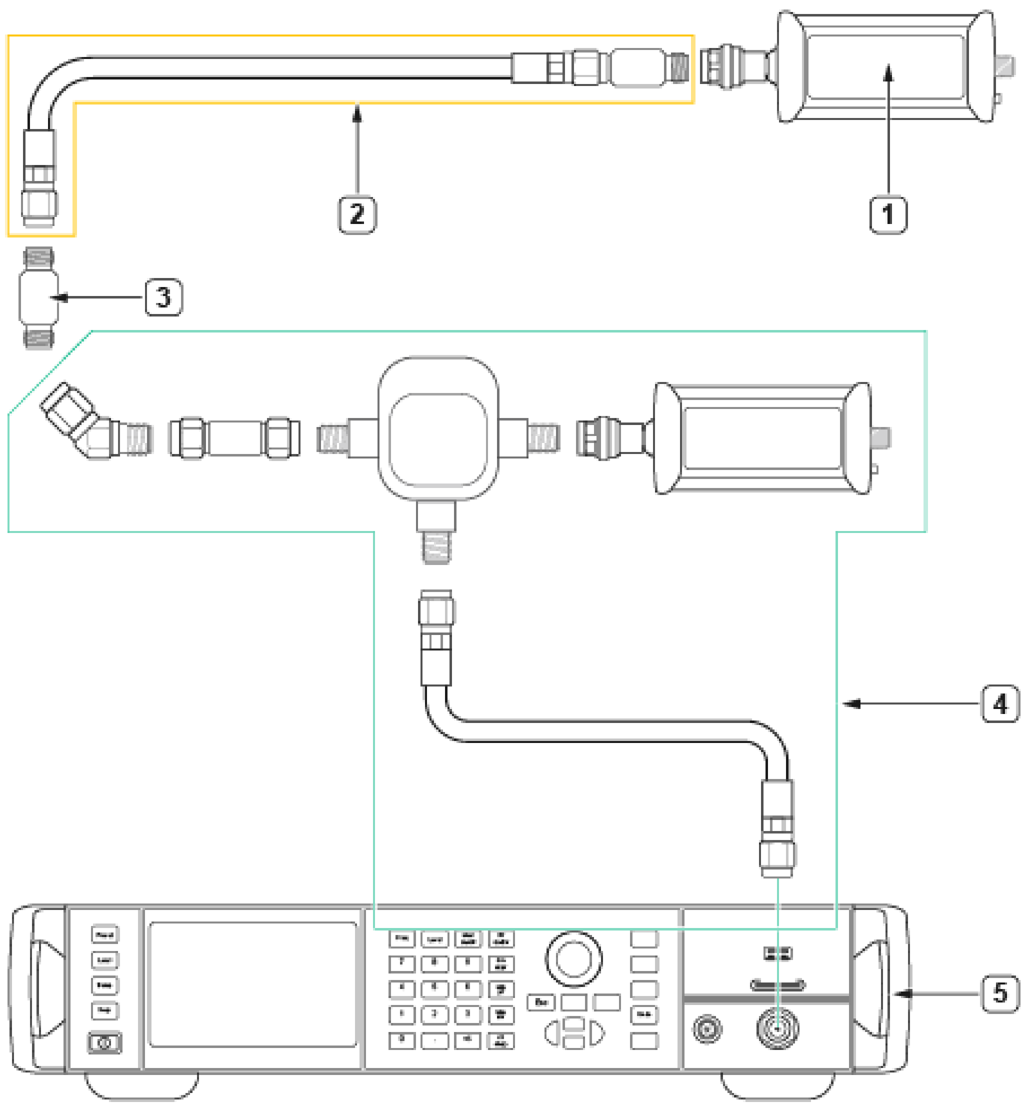
Range	Frequency step	
	Version	Step
30 MHz to 8.0 GHz	F08	5 MHz
30 MHz to 12.0 GHz	F12	5 MHz
30 MHz to 18 GHz	F18	5 MHz
30 MHz to 26.5 GHz	F26	5 MHz

5.2.2. Initial Test Connections

Note

Make the connections indicated in **Figure 4** .

Figure 4. Connection for Transmit Cable Loss Characterization



1. Power Sensor #2
2. Cable Characterization Fixture
3. 3.5 mm (f) to (f) Adapter
4. Receiver Fixture
5. Signal generator

5.2.3. Characterization Procedure

1. Make the cable loss connections as per **Figure 4**.

2. Set the following settings on the Signal Generator:

   - Power: 0 dBm
   - RF Frequency: 30 MHz

Repeat, once for each frequency point in **Table 4**.

3. Measure the power from the Characterization Power Sensor (#2), at the end of the cable (#2) and adapter (Item #2). record this value as:

   $RX\_Path\_Cable\_Power_i$.

4. Measure the power from the RX Cal Fixture Power Sensor #1, record this value as:

   $PM\_Path\_Power_i$.

5. Record the path loss through the Cable (#2) and Adapter (item #2) for each frequency, using:

$$\mathbf{PM\_to\_RX\_Cable\_Path\_Response\ [dB]} = RX\_Path\_Cable\_Power_i - PM\_Path\_Power_i - RX\_Fixture\_PM\_to\_RX\_Path\_Response_i$$

(***Equation 3***)

Where $RX\_Fixture\_PM\_to\_RX\_Path\_Response_i$ value was determined at step 5.1 Receiver Fixture Characterization.

Note
Do not disassemble Receiver Fixture item #5 from **Figure 4** after characterization. If you disassemble this fixture, you must recharacterize it before it is used again.

Note
Cable #2 and adapter #3 characterized in this section, should be kept together, and identified to be used only where “36” 3.5 mm (m) to (f) cable fixture” is required throughout this calibration procedure.

6. Perform Verification

Table 5: DUT Hardware Options Maximum Frequency

Hardware Option	Maximum Frequency / IQ Center Frequency
F08	8.0 GHz
F12	12 GHz
F18	18 GHz
F26	26.5 GHz

Table 6: DUT Hardware Options Maximum Signal Bandwidth and IQ Rate

Hardware Option	Maximum Signal Bandwidth	Maximum IQ Rate
B05	500 MHz	625 MS/s
B10	1 GHz	1.25 GS/s
B20	2 GHz	2.5 GS/s

Table 7: Signal Bandwidth for Enabled Mode

IQCF/RF Frequency	Signal Bandwidth	
1.70 GHz to < 5.25 GHz	B05: 250 MHz B10: 500 MHz B20: 600 MHz The maximum Signal Bandwidth is also limited by IQ Rate * 0.8	
5.25 GHz to 26.5 GHz	B05: 250 MHz B10: 500 MHz B20: 900 MHz The maximum Signal Bandwidth is also limited by IQ Rate * 0.8	

Note
The Signal Bandwidth is based on the device's upconverter / Downconverter value, but because we don't have direct control over it in Enabled mode, **Table 7** gives the signal bandwidth values required in terms of IQCF and RF Frequency.

Table 8: Signal Bandwidth for User Defined Mode

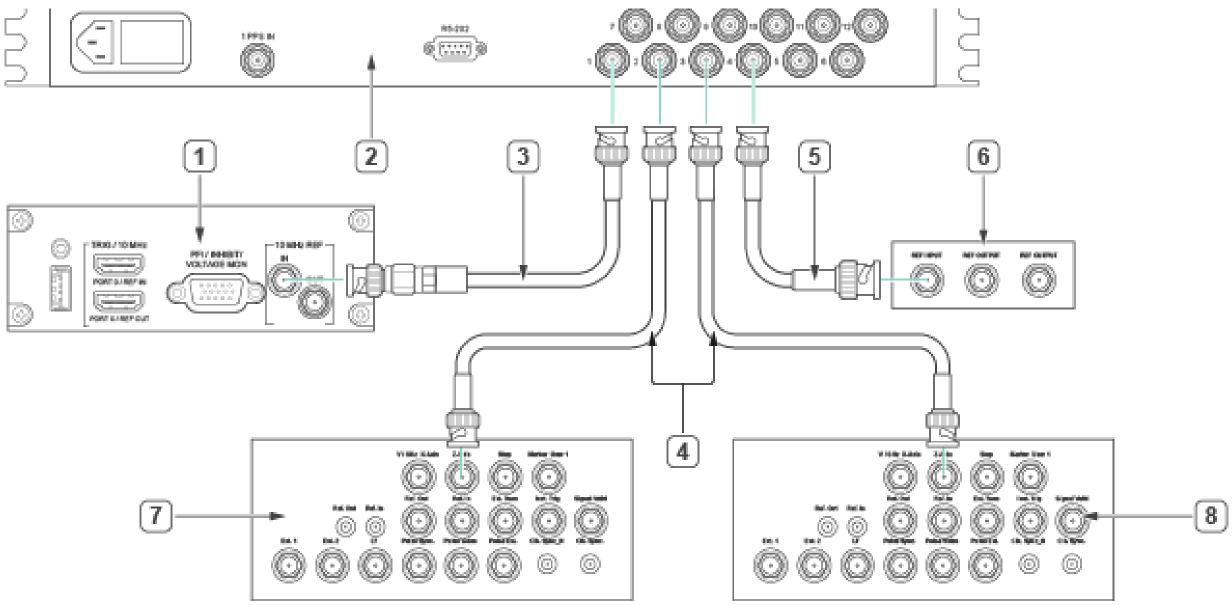
IQCF/RF Frequency	Maximum Settable Signal Bandwidth
30 MHz to < 1.75 GHz	Minimum of the following: ▪ Maximum BW for version: B05: 500 MHz B10: 1 GHz B20: 1.97 GHz ▪ Input: (2GHz – IQCF) * 2 Output: (2GHz – RF Frequency) * 2 ▪ Input:(IQCF – 30MHz) * 2 Output:(RF Frequency – 30MHz) * 2 ▪ IQ Rate * 0.8
1.75 GHz to 2.0 GHz	Minimum of the following: ▪ B05: 1 GHz – 2 * |XCFO|, capped at 500 MHz ▪ B10: 1 GHz – 2 * |XCFO|, capped at 1000 MHz ▪ B20: 1 GHz – 2 * |XCFO| ▪ IQ Rate * 0.8
>2.0 GHz to 5.8 GHz	Minimum of the following: ▪ B05: 1.4 GHz – 2 * |XCFO|, capped at 500 MHz ▪ B10: 1.4 GHz – 2 * |XCFO|, capped at 1000 MHz ▪ B20: 1.4 GHz – 2 * |XCFO| ▪ IQ Rate * 0.8
>5.8 GHz to 26.5 GHz	Minimum of the following: ▪ B05: 2.0 GHz – 2 * |XCFO|, capped at 500 MHz ▪ B10: 2.0 GHz – 2 * |XCFO|, capped at 1000 MHz ▪ B20: 2.0 GHz – 2 * |XCFO|

6.1. Initial Reference Clock Connections

The rubidium source must export its 10 MHz signal to the PXIe-1095 chassis PXI_CLK for all verify and adjust procedures. The Signal Generators (SMA 100B) and Spectrum Analyzer (FSWP) must also be connected to the 10 MHz source.

> **Note**
> These connections must be done before any Verification or Adjustment procedures are performed.

Figure 5. External Reference Clock Connection



1. Timing and Sync Module of PXI Chassis
2. 10 MHz Rb Reference standard
3. SMA (m)-to-BNC (m) Cable
4. BNC (m)-to-BNC (m) Cable
5. BNC (m)-to-BNC (m) Cable
6. Back of Spectrum Analyzer (FSWP)
7. Back of Signal Generator #1 (SMA100B)
8. Back of Signal Generator #2 (SMA100B)

6.2. RF Input Third Order Intermodulation Verification

6.2.1. Standards Characterization and Test workflow

This characterization/measurement sequence was designed to minimize the operator interactions and connections. The RF Input Third Order Intermodulation (TOI) Verification will be performed as follows:

1. RF Input TOI Low Frequency Fixture Characterization
   a. Includes Traceability Measurement for Low Frequency Fixture
2. RF Input TOI Low Frequency Test Execution
3. RF Input TOI High Frequency Fixture Characterization
   a. Includes Traceability Measurement for High Frequency Fixture
4. RF Input TOI High Frequency Test Execution

6.2.2. Characterization Validation Minimum requirements

Table 9. Characterization Validation Acceptance Maximum Limits

IQ Center Frequency	Nominal Power Level	Acceptance Limit
30 MHz to 1.0 GHz	-36.0 dBm	+1.0 dB
>1.0 GHz to 3.0 GHz		-1.0 dB
>3.0 GHz to 8.0 GHz		-3.0 dB
>8.0 GHz to 26.5 GHz		0.0 dB
30 MHz to 1.0 GHz	-6.0 dBm	+27.0 dB
>1.0 GHz to 3.0 GHz		+28.0 dB

>3.0 GHz to 8.0 GHz		+26.0 dB
>8.0 GHz to 26.5 GHz		+28.0 dB
30 MHz to 1.0 GHz	+9.0 dBm	+42.0 dB
>1.0 GHz to 3.0 GHz		+42.0 dB
>3.0 GHz to 8.0 GHz		+41.0 dB
>8.0 GHz to 26.5 GHz		+42.0 dB

6.2.3. Input TOI Low Frequency Characterization points

Table 10. Input TOI Low Frequency Fixture Characterization Configurations

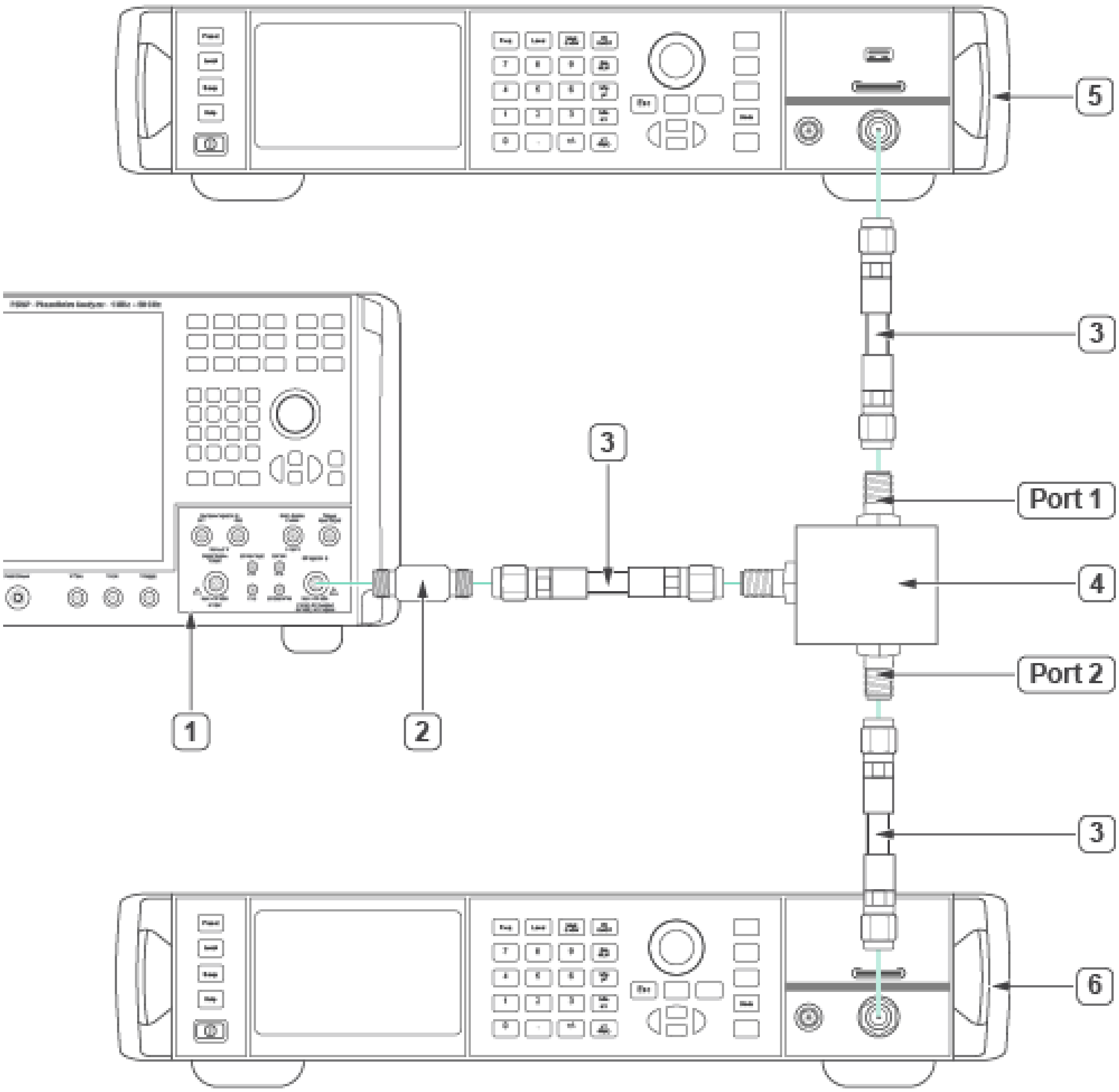
IQ Center Frequency	Nominal Power Level	Spectrum Analyzer Reference Level	Spectrum Analyzer Attenuation
30 MHz to 145 MHz in 5 MHz steps 150 MHz to 190 MHz in 10 MHz steps 300 MHz to 1.0 GHz in 20 MHz steps	-36.0 dBm	-30 dBm	0 dB
	-6.0 dBm	0 dBm	20 dB
	+9.0 dBm	+15 dBm	35 dB

6.2.4. Input TOI Low Frequency Initial Test Connection

Note

Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

Figure 6. RF Input TOI Low Frequency Combiner Characterization Connections



1. Phase noise and Spectrum analyzer
2 3.5mm Male to Female Adapter
3. 36” 3.5 mm cable (m) to (m) (x3)
4. LF Power Combiner
5. Signal Generator #1
6. Signal Generator #2

6.2.5. RF Input TOI LF Power Combiner Characterization

The two tones at the output of the combiner must have the correct amplitude to perform the TOI verification. The combiner response is not linear with frequency and the power delivered by each individual generator also varies.
To ensure that the tones delivered through the combiner to the DUT have adequate power at each frequency the system must be characterized prior to performing the verification.

1. Make the connections indicated in Figure **6**
2. Configure the Signal Generator #1 for the following:
    - Power Level: Initial lower Nominal Power Level from **Table 10**
    - Frequency: (Initial IQ Frequency from Configurations **Table 10** + 10 MHz)
    - ALC: On
3. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency:
    (Initial IQ Frequency from Configurations **Table 10** + 10 MHz)
    - Span: 1 kHz
    - Reference Level: Initial Reference Level from Table 10
    - Attenuation: Initial Attenuation from Table 10
    - RBW: 30 Hz
    - Sweep Count: 10001
    - Mode: Auto Peak
    - Reference Clock: 10 MHz, External
4. Generate an RF signal on Signal Generator #1, with the specified settings. Wait until it settles.
5. Characterizing Port1

Repeat, once for each Signal Generator #1 Nominal Power Level in **Table 10**, starting with the lower power setting.

6. Record this Power Level value as "**Nominal_Power**"

Repeat, once for each Signal Generator #1 IQ Center Frequency setting in Table 10.

7. Servo the RF power from the signal generator #1, until the Spectrum Analyzer measurement is equal to (**Nominal_Power** ± 0.075 dB).

8. Record the power setting from the signal generator #1 as:

Combiner_Port1Low*i* [dBm]

Where "*f(x)i*" is a linear index number to identify each frequency within the sweep from 1 to n.

9. Configure the Signal Generator #1:

   - Power Level: Current Power iteration Nominal Power Level from Table 10
   - Frequency: (Next IQ Frequency from Configurations Table 10 + 10 MHz)

10. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: Same Frequency as the Signal Generator #1
    - Reference Level: Current Power iteration Reference Level from Table 10
    - Attenuation: Current Power iteration Attenuation from Table 10
    -

11. Configure the Signal Generator #1 for the following:

    - Power Level: Next Nominal Power Level from **Table 10**
    - Frequency: (Initial IQ Frequency from Configurations **Table 10** + 10 MHz)

-

12. Disable the power output of Signal Generator #1.
13. Configure the Signal Generator #2 for the following:
    - Power Level: Initial lower Nominal Power Level from **Table 10**
    - Frequency: (Initial IQ Frequency from Configurations **Table 10** + 10.7 MHz)
    - ALC: On
14. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency:
    (Initial Frequency from Configurations **Table 10** + 10.7 MHz)
    - Span: 1 kHz
    - Reference Level: Initial Reference Level from Table 10
    - Attenuation: Initial Attenuation from Table 10
    - RBW: 30 Hz
    - Sweep Count: 10001
    - Mode: Auto Peak
    - Reference Clock: 10 MHz, External
15. Generate an RF signal on Signal Generator #2, with the specified settings. Wait until it settles.
16. Characterizing Port2

Repeat, once for each Signal Generator #2 Nominal Power Level in **Table 10**, starting with the lower power setting.

17. Record this Power Level value as "**Nominal_Power**"

Repeat, once for each Signal Generator #2 IQ Center Frequency setting in Table 10.

18. Servo the RF power from the signal generator #1, until the Spectrum Analyzer measurement is equal to (**Nominal_Power** ± 0.075 dB).

19. Record the power setting from the signal generator #2 as:

$Combiner\_Port2Low_i$ [dBm]

Where "*$f(x)_i$*" is a linear index number to identify each frequency within the sweep from 1 to n.

20. Configure the Signal Generator #2:
    - Power Level: Current Power iteration Nominal Power Level from **Table 10**
    - Frequency: (Next IQ Frequency from Configurations **Table 10** + 10.7 MHz)
21. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: Same Frequency as the Signal Generator #2
    - Reference Level: Current Power iteration Reference Level from **Table 10**
    - Attenuation: Current Power iteration Attenuation from **Table 10**
    -

22. Configure the Signal Generator #2 for the following:

    - Power Level: Next Nominal Power Level from **Table 10**

- Frequency: (Initial IQ Frequency from Configurations **Table 10** + 10.7 MHz)

23. Disable the power output of Signal Generator #2.

6.2.6. RF Input TOI LF Power Combiner Characterization validation

To ensure that the characterized tones delivered through the combiner to the DUT have a significantly lower TOI compared with the DUT specification in order to minimize the impact in the DUT TOI accuracy determination at each frequency and power level.

1. Configure the Signal Generator #1 for the following:
   - Power Level: Initial lower Nominal Power Level from Table 10 as determined in the characterization section:

     $$\textbf{Combiner\_Port1Low}_i\ \textbf{[dBm]}$$

   - Frequency:
     f_1= (Initial IQ Frequency from Configurations **Table 10** + 10 MHz)
   - ALC: On
2. Configure the Signal Generator #2 for the following:
   - Power Level: Initial lower Nominal Power Level from Table 10 as determined in the characterization section:

     $$\textbf{Combiner\_Port2Low}_i\ \textbf{[dBm]}$$

   - Frequency:
     f_2= (Initial IQ Frequency from Configurations **Table 10** + 10.7 MHz)
   - ALC: On
3. Configure the Spectrum Analyzer for the following settings:
   - Center Frequency: Initial Frequency from Configurations Table 10
   - Span: 1 kHz
   - Reference Level: Initial Reference Level from Table 10
   - Attenuation: Initial Attenuation from Table 10
   - RBW: 30 Hz
   - Sweep Count: 10001

- Mode: Auto Peak
- Reference Clock: 10MHz, External

4. Generate RF signals from both Generators simultaneously, with the specified settings. Wait until they settle.

5. Taking the Validation measurements:

Repeat, once for each Signal Generator #1 and #2 (simultaneously) Nominal Power Level in **Table 10**, starting with the lower power setting.

Repeat, once for each Signal Generator #1 and #2 (simultaneously) IQ Center Frequency setting in Table 10.

6. Set Spectrum Analyzer Center Frequency to (f_1)

7. Measure the Power at frequency (f_1) with spectrum Analyzer

8. Record the measured power:

$$f_1 = \textbf{fundamental\_tone}_1 \text{ [dBm]}$$

9. Set Spectrum Analyzer Center Frequency to (f_2)

10. Measure the Power at frequency (f_2) with spectrum Analyzer

11. Record the measured power:

$$f_2 = \textbf{fundamental\_tone}_2 \text{ [dBm]}$$

12. Set Spectrum Analyzer Center Frequency to:

$$(2f_1 - f_2) = \text{Center Frequency} + 9.3 \text{ MHz}$$

13. Measure the Power at frequency ($2f_1 - f_2$) with spectrum Analyzer

14. Record the measured power:

$$(2f_1 - f_2) = \textbf{IMD}_3\textbf{\_tone}_1 \text{ [dBm]}$$

15. Set Spectrum Analyzer Center Frequency to:

$$(2f_2 - f_1) = \text{Center Frequency} + 11.4 \text{ MHz}$$

16. Measure the Power at frequency ($2f_2 - f_1$) with spectrum Analyzer
17. Record the measured power:

$$(2f_2 - f_1) = \mathbf{IMD_3\_tone_2\ [dBm]}$$

18. Calculate IMD_3 using the following equation:

$$IMD_3 = Min(fundamental\_tone_1; fundamental\_tone_2) - Max(IMD_3\_tone_1; IMD_3\_tone_2)$$

19. Calculate TOI using the following equation:

$$TOI = Min(fundamental\_tone_1; fundamental\_tone_2) + IMD_3/2$$

20. Compare the calculated TOI with limits in **Table 9**
21. If the characterization does not meet the limits in **Table 9**, it must be repeated. Ensure that all equipment and accessories are in good condition and all connections are correctly done before repeating the characterization.
22. Configure the Signal Generator #1 for the following:
    - Power Level: Current Iteration of Nominal Power Level from Table 10 as determined in the characterization section:

      f_1: Combiner_Port1Low$_i$ [dBm]

    - Frequency:
      f_1= (Next Frequency from Configurations **Table 10** + 10 MHz)
    - ALC: On

23. Configure the Signal Generator #2 for the following:
    - Power Level: Current Iteration of Nominal Power Level from Table 10 as determined in the characterization section:

      Combiner_Port2Low$_i$ [dBm]

    - Frequency:
      f_2= (Next Frequency from Configurations **Table 10** + 10.7 MHz)
    - ALC: On

24. Configure the Spectrum Analyzer for the following settings:

- Center Frequency: f_1
- Reference Level: Reference Level that corresponds to Signal Generator Power Level setting from **Table 10**
- Attenuation: Attenuation that corresponds to Signal Generator Power Level setting from **Table 10**

25. Configure the Signal Generator #1 for the following:
    - Power Level: Next Iteration of Nominal Power Level from Table 10 as determined in the characterization section:

      Combiner_Port1Low$_i$ [dBm]

    - Frequency:
      f_1= (Initial IQ Frequency from Configurations **Table 10** + 10 MHz)
    - ALC: On
26. Configure the Signal Generator #2 for the following:
    - Power Level: Next Iteration of Nominal Power Level from Table 10 as determined in the characterization section:

      f_2: Combiner_Port2Low$_i$ [dBm]

    - Frequency:
      f_2= (Initial IQ Frequency from Configurations **Table 10** + 10.7 MHz)
    - ALC: On
27. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: f_1
    - Reference Level: Reference Level that corresponds to Signal Generator Power Level setting from Table 10
    - Attenuation: Attenuation that corresponds to Signal Generator Power Level setting from Table 10
28. Disable the power output of Signal Generator #1.
29. Disable the power output of Signal Generator #2.
30. Disconnect the cable connected to the Signal Analyzer without disturbing any of the other connections made according to **Figure 6**.

6.2.7. RF Input TOI Low Frequency Verification

Table 11. RF Input TOI Low Frequency Verification Limits

IQ Center Frequency	Nominal Power Reference Level	Verification Limit
30 MHz to 1.0 GHz	-30.0 dBm	-8.0 dB
30 MHz to 1.0 GHz	0.0 dBm	+21.0 dB
30 MHz to 1.0 GHz	+15.0 dBm	+36.0 dB

Table 12. RF Input TOI Low Frequency Verification Test Points

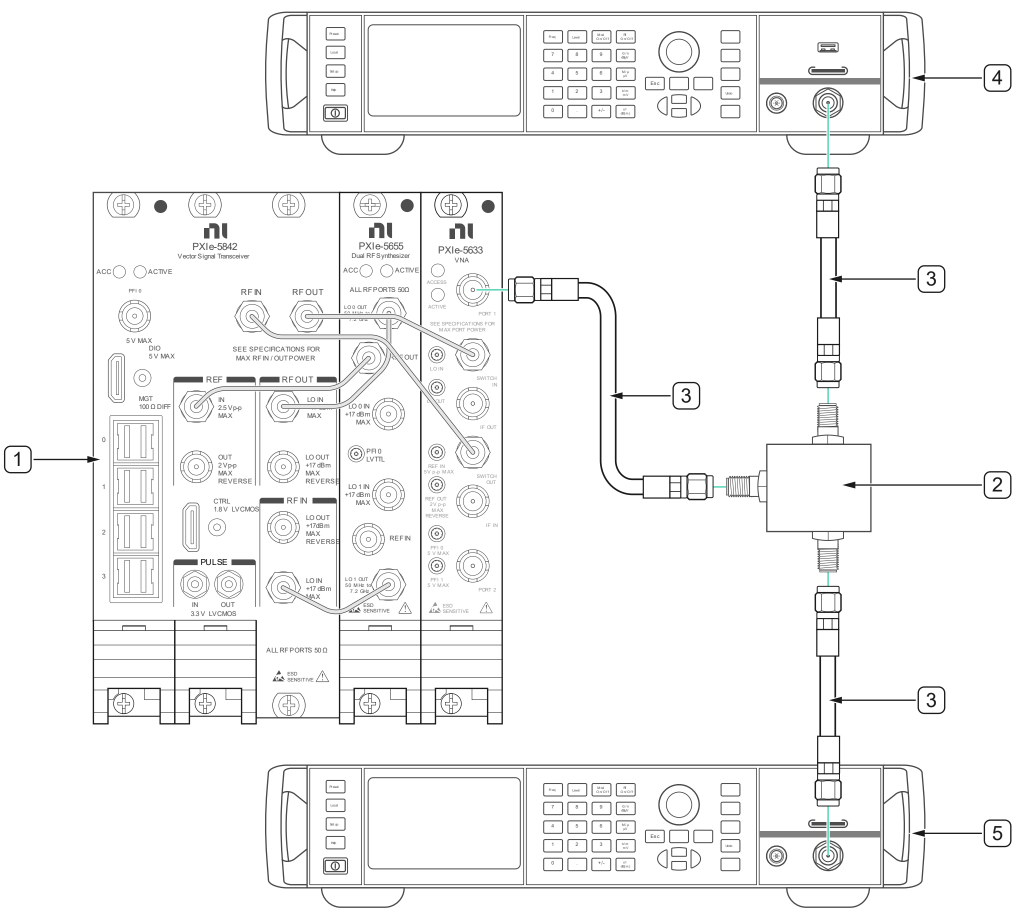
<table>
<tr><th>IQ Center Frequency</th><th>Nominal Power Level</th><th>Spectrum Analyzer Reference Level</th><th>Spectrum Analyzer Attenuation</th></tr>
<tr><td rowspan="3">30 MHz to 145 MHz in 5 MHz steps
150 MHz to 290 MHz in 10 MHz steps
300 MHz to 1.0 GHz in 20 MHz steps</td><td>-36.0 dBm</td><td>-30 dBm</td><td>0 dB</td></tr>
<tr><td>-6.0 dBm</td><td>0 dBm</td><td>20 dB</td></tr>
<tr><td>+9.0 dBm</td><td>+15 dBm</td><td>35 dB</td></tr>
</table>

6.2.8. RF Input TOI Low Frequency Verification Initial Test Connection

Note

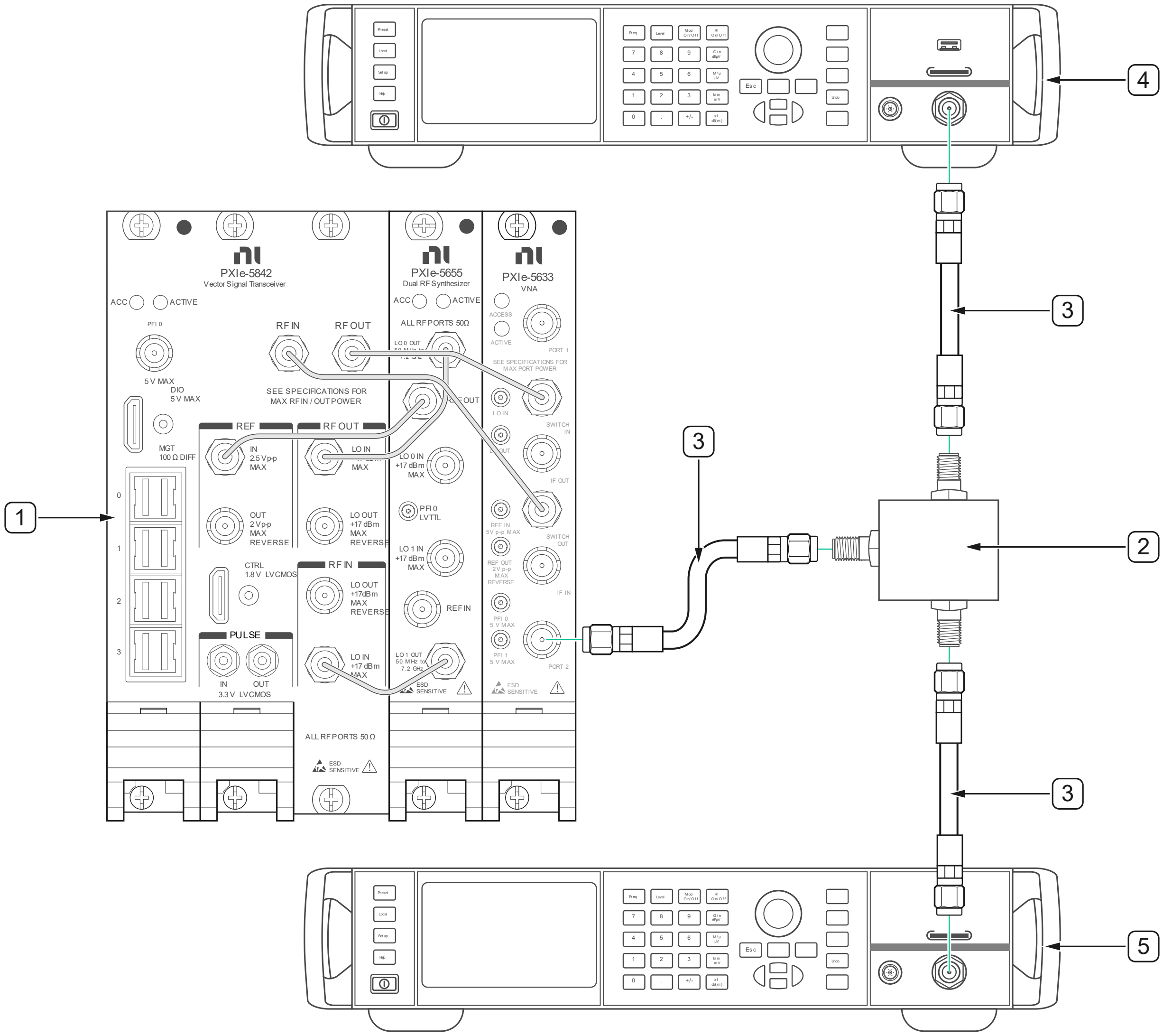
Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

Figure 7. RF Input TOI Verification **Port 1** connections



1. DUT
2 LF Power Combiner
3. 36” 3.5 mm cable (m) to (m) (x3)
4. Signal Generator #1
5. Signal Generator #2

Figure 8. RF Input TOI Verification **Port 2** connections



1. DUT
2. LF Power Combiner
3. 36” 3.5 mm cable (m) to (m) (x3)
4. Signal Generator #1
5. Signal Generator #2

6.2.9. RF Input TOI Low Frequency **Port 1** Verification Procedure (Upconverter Mode = **User Defined**)

This procedure verifies the Third Order Intercept (TOI) Accuracy of the DUT's input channel on Port 1.

Table 13: RF Input LF TOI Accuracy Test points and Configurations

IQ Center Frequency	Reference Power Level	Downconverter Offset Mode	Downconverter Offset	DUT Bandwidth
▪ 30 MHz to 145 MHz in 5 MHz steps ▪ 150 MHz to 290 MHz in 10 MHz steps ▪ 300 MHz to 1.0 GHz in 20 MHz steps	-30 dBm 0 dBm +15 dBm	User Defined	Driver Default	See **Table 8**

1. Make the connections indicated in **Figure 7**
2. Configure the DUT for the following settings for "User Defined" mode:
   - IQ Center Frequency: First IQ Center Frequency from **Table 13**
   - Reference Level: First Reference Level from **Table 13**
   - Downconverter Offset Mode: User Defined
   - Downconverter Offset: Driver Default
   - Signal Bandwidth: Signal Bandwidth from **Table 13**
   - Acquisition Type: IQ
   - FFT Window Type: Flat Top
   - IQ Rate: From **Table 6** based on the HW option
   - Number of Samples: 200 kS
   - Number of Records: 10
   - Reference Clock Source: PXI_Clock (Locked to Rubidium)
   - Reference Clock Frequency: 10 MHz
3. Configure the Signal Generator #1 for the following:
   - Power Level:

(Initial lower Reference Power Level from **Table 10** – 6 dB), as determined in the characterization section for that power level and frequency:

Combiner_Port1Low$_i$ [dBm]

- Frequency:
  f_1= (Initial IQ Frequency from Configurations **Table 13** + 10 MHz)
- ALC: On

4. Configure the Signal Generator #2 for the following:
   - Power Level:
     (Initial lower Reference Power Level from **Table 13** – 6 dB), as determined in the characterization section for that power level and frequency:

     Combiner_Port2Low$_i$ [dBm]

   - Frequency:
     f_2= (Initial IQ Frequency from Configurations **Table 13** + 10.7 MHz)
   - ALC: On

5. Generate RF signals from both Generators simultaneously, with the specified settings. Wait until they settle.

6. Taking the Verification measurements

Repeat, once for each Signal Generator #1 and #2 (simultaneously) Reference Power Level in Table 13, starting with the lower power setting.

Repeat, once for each Signal Generator #1 and #2 (simultaneously) IQ Center Frequency setting in **Table 13**.

7. Acquire a spectrum of the combined signal using the DUT.

8. Measure the power at the expected distortion frequencies using the following settings:
   - See section
     - Frequency Deviation: 15 kHz
     - Search Frequencies: $f1$, $f2$, ($2f1$-$f2$), ($2f2$-$f1$)

9. Record the measured power:

f_1= **fundamental_tone$_1$ [dBm]**

10. Record the measured power:

f_2= **fundamental_tone$_2$ [dBm]**

11. Record the measured power:

$(2 f_1 - f_2)$ = **IMD$_3$_tone$_1$ [dBm]**

12. Record the measured power:

$(2 f_2 - f_1)$ = **IMD$_3$_tone$_2$ [dBm]**

13. Calculate IMD_3 using the following equation:

$$IMD_3 = \text{Min}(\text{fundamental\_tone}_1; \text{fundamental\_tone}_2) - \text{Max}(IMD_3\text{\_tone}_1; IMD_3\text{\_tone}_2)$$

14. Calculate TOI using the following equation:

$$\textbf{TOI} = \text{Min}(\text{fundamental\_tone}_1; \text{fundamental\_tone}_2) + IMD_3/2$$

15. Compare the calculated TOI with limits in **Table 11**

16. Configure the Signal Generator #1 for the following:
    - Power Level: Current Iteration of Reference Power Level from **Table 13** as determined in the characterization section for that power level and frequency:

      Combiner_Port1Low$_i$ [dBm]
    - Frequency:
      $\boldsymbol{f_1}$= (Next IQ Frequency from Configurations **Table 13** + 10 MHz)
    - ALC: On

17. Configure the Signal Generator #2 for the following:
    - Power Level: Current Iteration of Reference Power Level from **Table 13** as determined in the characterization section for that power level and frequency:

      Combiner_Port2Low$_i$ [dBm]

- Frequency:
  f_2= (Next IQ Frequency from Configurations **Table 13** + 10.7 MHz)
- ALC: On

18. Configure the DUT for the following settings:
    - IQ Center Frequency: Next IQ Center Frequency from **Table 13**
    - Signal Bandwidth: Signal Bandwidth from **Table 13**
    - IQ Rate: From **Table 6** based on the HW option

19. Configure the Signal Generator #1 for the following:
    - Power Level:
      (Next iteration of Reference Power Level from **Table 10** – 6 dB), as determined in the characterization section for that power level and frequency:

      Combiner_Port1Low$_i$ [dBm]
    - Frequency:
      f_1= (Initial IQ Frequency from Configurations **Table 13** + 10 MHz)
    - ALC: On

20. Configure the Signal Generator #2 for the following:
    - Power Level:
      (Next iteration of Reference Power Level from **Table 10** – 6 dB), as determined in the characterization section for that power level and frequency:

      Combiner_Port2Low$_i$ [dBm]
    - Frequency:
      f_2= (Initial IQ Frequency from Configurations **Table 13** + 10.7 MHz)
    - ALC: On
21. Configure the Signal Generator #2 for the following:
    - Power Level: Next Iteration of Nominal Power Level from **Table 13** as determined in the characterization section:

      Combiner_Port2Low$_i$ [dBm]
    - Frequency:
      f_2= (Initial IQ Frequency from Configurations **Table 13** + 10.7 MHz)

- ALC: On

22. Configure the DUT for the following settings:
    - IQ Center Frequency: Initial IQ Center Frequency from **Table 13**
    - Reference Level: Next Iteration Reference Level from **Table 13**
    - Signal Bandwidth: Signal Bandwidth from **Table 13**
    - IQ Rate: From **Table 6** based on the HW option

6.2.10. RF Input TOI Low Frequency **Port 2** Verification Procedure (Upconverter Mode = **User Defined**)

1. Repeat procedure 6.2.9 RF Input TOI Low Frequency **Port 1** Verification Procedure (Upconverter Mode = **User Defined**):

   1.1. Replace connections of **Figure 7** with **Figure 8**.

   1.2. Where "Port 1" is mentioned, replace with "Port 2".

6.2.11. Input TOI High Frequency Characterization points

Table 14. Input TOI High Frequency Fixture Characterization Configurations

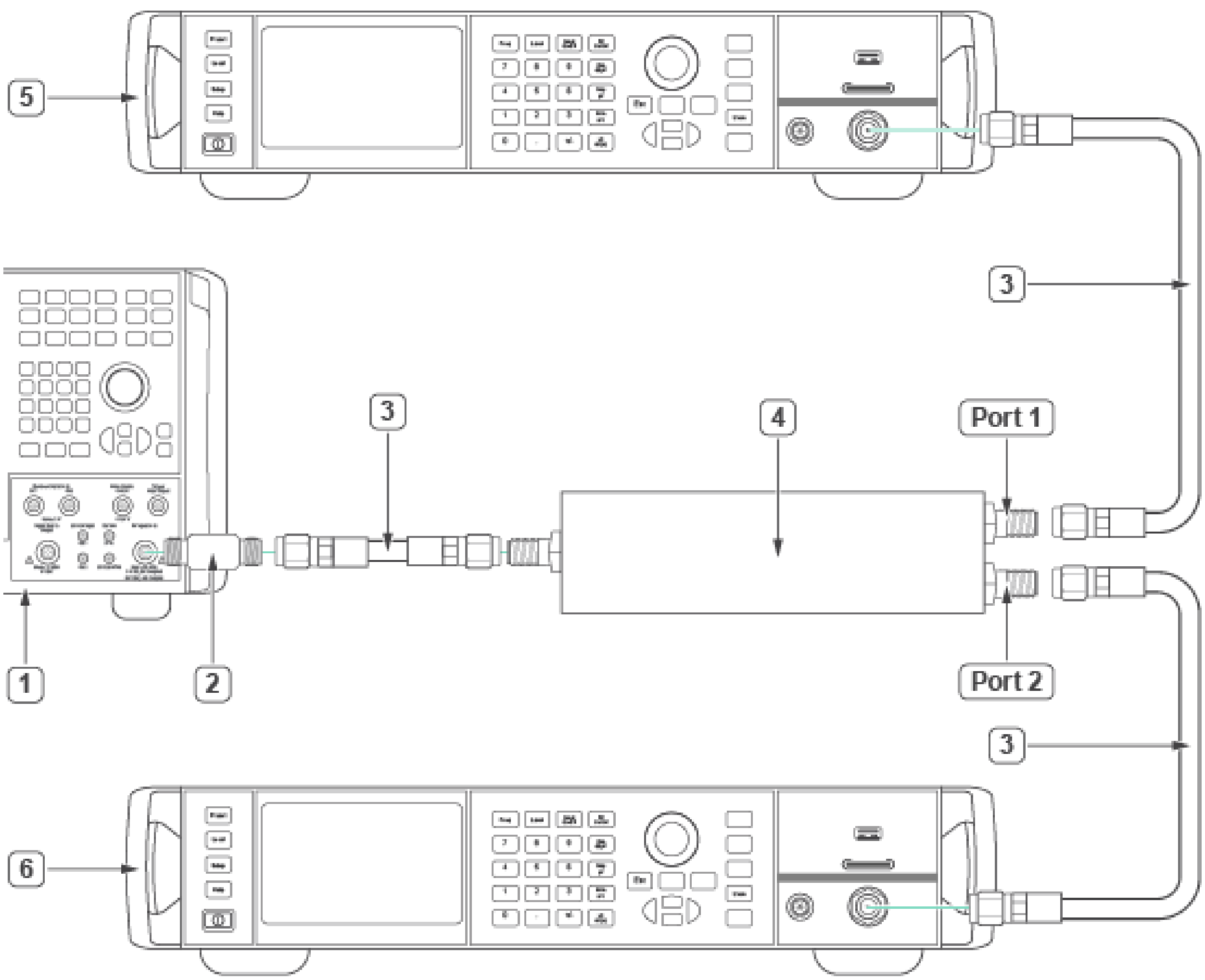
IQ Center Frequency	Nominal Power Level	Spectrum Analyzer Reference Level	Spectrum Analyzer Attenuation
▪ 1.0 GHz to 1.74 MHz in 20 MHz steps	-36.0 dBm	-30 dBm	0 dB
▪ 1.701 GHz; 1.749 GHz	-6.0 dBm	0 dBm	20 dB
▪ 1.75 GHz to 3.95 GHz in 50 MHz steps ▪ 4.0 GHz to 26.3 GHz in 100 MHz steps ▪ 26.38 GHz	+9.0 dBm	+15 dBm	40 dB for 8 GHz ≤ f ≤ 12 GHz, 35 dB otherwise

6.2.12. Input TOI High Frequency Initial Test Connection

Note

Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

Figure 9. RF Input TOI High Frequency Combiner Characterization Connections



1. Phase noise and Spectrum analyzer
4. HF Power Combiner

2 3.5mm Female to Female Adapter
3. 36” 3.5 mm cable (m) to (m) (x3)
5. Signal Generator #1
6. Signal Generator #2

6.2.13. RF Input TOI High Frequency Power Combiner Characterization

The two tones at the output of the combiner must have the correct amplitude to perform the TOI verification. The combiner response is not linear with frequency and the power delivered by each individual generator also varies.
To ensure that the tones delivered through the combiner to the DUT have the adequate power at each frequency the system must be characterized prior to performing the verification.

1. Make the connections indicated in **Figure 9**
2. Configure the Signal Generator #1 for the following:
   - Power Level: Initial lower Nominal Power Level from **Table 14**
   - Frequency: (Initial IQ Center Frequency from Configurations **Table 14** + 95 MHz)
   - ALC: On
3. Configure the Spectrum Analyzer for the following settings:
   - Center Frequency:
   (Initial IQ Center Frequency from Configurations **Table 14** + 95 MHz)
   - Span: 1 kHz
   - Reference Level: Initial Reference Level from **Table 14**
   - Attenuation: Initial Attenuation from **Table 14**
   - RBW: 30 Hz
   - Sweep Count: 10001
   - Mode: Auto Peak
   - Reference Clock: 10 MHz, External

4. Generate an RF signal on Signal Generator #1, with the specified settings. Wait until it settles.

5. Characterizing Port1

Repeat, once for each Signal Generator #1 Nominal Power Level in **Table 14**, starting with the lower power setting.

6. Record this Power Level value as "**Nominal_Power**$_p$"

Where "*f(x)*$_p$" is a linear index number to identify each Power level iteration from 1 to n.

Repeat, once for each Signal Generator #1 IQ Center Frequency setting in **Table 14**.

7. Servo the RF power from the signal generator #1, until the Spectrum Analyzer measurement is equal to (**Nominal_Power**$_{p,f}$ ± 0.075 dB).

8. Record the power setting from the signal generator #1 as:

Combiner_Port1HF$_{p,f}$ **[dBm]**

Where "*f(x)*$_f$" is a linear index number to identify each frequency within the sweep from 1 to n and *f(x)*$_p$" is a linear index number to identify each Power level iteration from 1 to n.

9. Configure the Signal Generator #1:
   - Power Level: Current Power iteration Nominal Power Level from **Table 14**
   - Frequency: (Next IQ Frequency from Configurations **Table 14** + 95 MHz)
10. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: Same Frequency as the Signal Generator #1
    - Reference Level: Current Power iteration Reference Level from **Table 14**
    - Attenuation: Current Power iteration Attenuation from **Table 14**

11. Configure the Signal Generator #1 for the following:
    - Power Level: Next Nominal Power Level from **Table 14**
    - Frequency: (Initial IQ Frequency from Configurations **Table 14** + 95 MHz)
12. Disable the power output of Signal Generator #1.
13. Configure the Signal Generator #2 for the following:
    - Power Level: Initial lower Nominal Power Level from **Table 14**
    - Frequency: (Initial IQ Frequency from Configurations **Table 14** + 105 MHz)
    - ALC: On
14. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency:
    (Initial Frequency from Configurations **Table 14** + 105 MHz)
    - Span: 1 kHz
    - Reference Level: Initial Reference Level from Table 10
    - Attenuation: Initial Attenuation from Table 10
    - RBW: 30 Hz
    - Sweep Count: 10001
    - Mode: Auto Peak
    - Reference Clock: 10MHz, External
15. Generate an RF signal on Signal Generator #2, with the specified settings. Wait until it settles.
16. Characterizing Port2

Repeat, once for each Signal Generator #2 Nominal Power Level in **Table 14**, starting with the lower power setting.

17. Record this Power Level value as "**Nominal_Power$_p$**"

Where "$f(x)_p$" is a linear index number to identify each Power level iteration from 1 to n.

Repeat, once for each Signal Generator #2 IQ Center Frequency setting in **Table 14**.

18. Servo the RF power from the signal generator #1, until the Spectrum Analyzer measurement is equal to (**Nominal_Power**$_{p,d}$ ± 0.075 dB).

19. Record the power setting from the signal generator #2 as:

Combiner_Port2HF$_{p,f}$ **[dBm]**

Where "$f(x)_f$" is a linear index number to identify each frequency within the sweep from 1 to n and $f(x)_p$" is a linear index number to identify each Power level iteration from 1 to n.

20. Configure the Signal Generator #2:
    - Power Level: Current Power iteration Nominal Power Level from **Table 14**
    - Frequency: (Next IQ Frequency from Configurations **Table 14** + 105 MHz)
21. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: Same Frequency as the Signal Generator #2
    - Reference Level: Current Power iteration Reference Level from **Table 14**
    - Attenuation: Current Power iteration Attenuation from **Table 14**

22. Configure the Signal Generator #2 for the following:

    - Power Level: Next Nominal Power Level from **Table 14**
    - Frequency: (Initial IQ Frequency from Configurations **Table 10** + 105 MHz)

23. Disable the power output of Signal Generator #2.

6.2.14. RF Input TOI High Frequency Power Combiner Characterization validation

To ensure that the characterized tones delivered through the combiner to the DUT have a significantly lower TOI compared with the DUT specification in order to minimize the impact in the DUT TOI accuracy determination at each frequency and power level.

1. Configure the Signal Generator #1 for the following:
   - Power Level: Initial lower Nominal Power Level from **Table 14** as determined in the characterization section:

     $\mathbf{Combiner\_Port1HF}_{p,f}$ [dBm]

   - Frequency:
     f_1= (Initial IQ Frequency from Configurations **Table 14** + 95 MHz)
   - ALC: On

2. Configure the Signal Generator #2 for the following:
   - Power Level: Initial lower Nominal Power Level from **Table 14** as determined in the characterization section:

     $\mathbf{Combiner\_Port2HF}_{p,f}$ [dBm]

   - Frequency:
     f_2= (Initial IQ Frequency from Configurations **Table 14** + 105 MHz)
   - ALC: On

3. Configure the Spectrum Analyzer for the following settings:
   - Center Frequency: Initial Frequency from Configurations **Table 14**
   - Span: 1 kHz
   - Reference Level: Initial Reference Level from **Table 14**
   - Attenuation: Initial Attenuation from **Table 14**
   - RBW: 30 Hz
   - Sweep Count: 10001
   - Mode: Auto Peak
   - Reference Clock: 10 MHz, External

4. Generate RF signals from both Generators simultaneously, with the specified settings. Wait until they settle.

5. Taking the Validation measurements:

Repeat, once for each Signal Generator #1 and #2 (simultaneously) Nominal Power Level in **Table 14**, starting with the lower power setting.

Repeat, once for each Signal Generator #1 and #2 (simultaneously) IQ Center Frequency setting in **Table 14**.

6. Set Spectrum Analyzer Center Frequency to (f_1)

7. Measure the Power at frequency (f_1) with spectrum Analyzer

8. Record the measured power:

$$f_1 = \textbf{fundamental\_tone}_1 \textbf{ [dBm]}$$

9. Set Spectrum Analyzer Center Frequency to (f_2)

10. Measure the Power at frequency (f_2) with spectrum Analyzer

11. Record the measured power:

$$f_2 = \textbf{fundamental\_tone}_2 \textbf{ [dBm]}$$

12. Set Spectrum Analyzer Center Frequency to:

$$(2 f_1 - f_2) = \text{Center Frequency} + 85 \text{ MHz}$$

13. Measure the Power at frequency ($2 f_1 - f_2$) with spectrum Analyzer

14. Record the measured power:

$$(2 f_1 - f_2) = \textbf{IMD}_3\textbf{\_tone}_1 \textbf{ [dBm]}$$

15. Set Spectrum Analyzer Center Frequency to:

$$(2 f_2 - f_1) = \text{Center Frequency} + 115 \text{ MHz}$$

16. Measure the Power at frequency ($2 f_2 - f_1$) with spectrum Analyzer

17. Record the measured power:

$$(2f_2 - f_1) = \mathbf{IMD_3\_tone_2\ [dBm]}$$

18. Calculate IMD_3 using the following equation:

$$IMD_3 = Min(fundamental\_tone_1; fundamental\_tone_2) - Max(IMD_3\_tone_1; IMD_3\_tone_2)$$

19. Calculate TOI using the following equation:

$$TOI = Min(fundamental\_tone_1; fundamental\_tone_2) + IMD_3/2$$

20. Compare the calculated TOI with limits in **Table 9**

21. If the characterization does not meet the limits in **Table 9**, it must be repeated. Ensure that all equipment and accessories are in good working condition and all connections are correctly done before repeating the characterization.

22. Configure the Signal Generator #1 for the following:
    - Power Level: Current Iteration of Nominal Power Level from **Table 14** as determined in the characterization section:

      f_1: Combiner_Port1HF$_{pf}$ [dBm]

    - Frequency:
      f_1= (Next Frequency from Configurations **Table 14** + 95 MHz)
    - ALC: On

23. Configure the Signal Generator #2 for the following:
    - Power Level: Current Iteration of Nominal Power Level from Table 10 as determined in the characterization section:

      Combiner_Port2HF$_{pf}$ [dBm]

    - Frequency:
      f_2= (Next Frequency from Configurations **Table 14** + 105 MHz)
    - ALC: On

24. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: f_1

- Reference Level: Reference Level that corresponds to Signal Generator Power Level setting from **Table 14**
- Attenuation: Attenuation that corresponds to Signal Generator Power Level setting from **Table 14**

25. Configure the Signal Generator #1 for the following:
    - Power Level: Next Iteration of Nominal Power Level from **Table 14** as determined in the characterization section:

      $\mathbf{Combiner\_Port1HF}_{pf}$ **[dBm]**

    - Frequency:
      f_1= (Initial IQ Frequency from Configurations **Table 14** + 95 MHz)
    - ALC: On

26. Configure the Signal Generator #2 for the following:
    - Power Level: Next Iteration of Nominal Power Level from **Table 14** as determined in the characterization section:

      f_2**:** $\mathbf{Combiner\_Port2HF}_{pf}$ **[dBm]**

    - Frequency:
      f_2= (Initial IQ Frequency from Configurations **Table 14** + 105 MHz)
    - ALC: On

27. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: f_1
    - Reference Level: Reference Level that corresponds to Signal Generator Power Level setting from **Table 14**
    - Attenuation: Attenuation that corresponds to Signal Generator Power Level setting from **Table 14**
28. Disable the power output of Signal Generator #1.
29. Disable the power output of Signal Generator #2.
30. Disconnect the cable connected to the Signal Analyzer without disturbing any of the other connections made according to **Figure 9**

6.2.15. RF Input TOI High Frequency Verification

Table 15. RF Input TOI High Frequency Verification Limits

IQ Center Frequency	Nominal Power Reference Level	Verification Limit [≥]
>1.0 GHz to 3.0 GHz	-30.0 dBm	-12 dB
>3.0 GHz to 8.0 GHz		-18 dB
>8.0 GHz to 26.5 GHz		-10 dB
>1.0 GHz to 3.0 GHz	0.0 dBm	18 dB
>3.0 GHz to 8.0 GHz		13 dB
>8.0 GHz to 26.5 GHz		13 dB
>1.0 GHz to 3.0 GHz	+15.0 dBm	34 dB
>3.0 GHz to 8.0 GHz		28 dB
>8.0 GHz to 26.5 GHz		28 dB

Table 16. RF Input TOI High Frequency Verification Test Points (Downconverter Mode – User Defined)

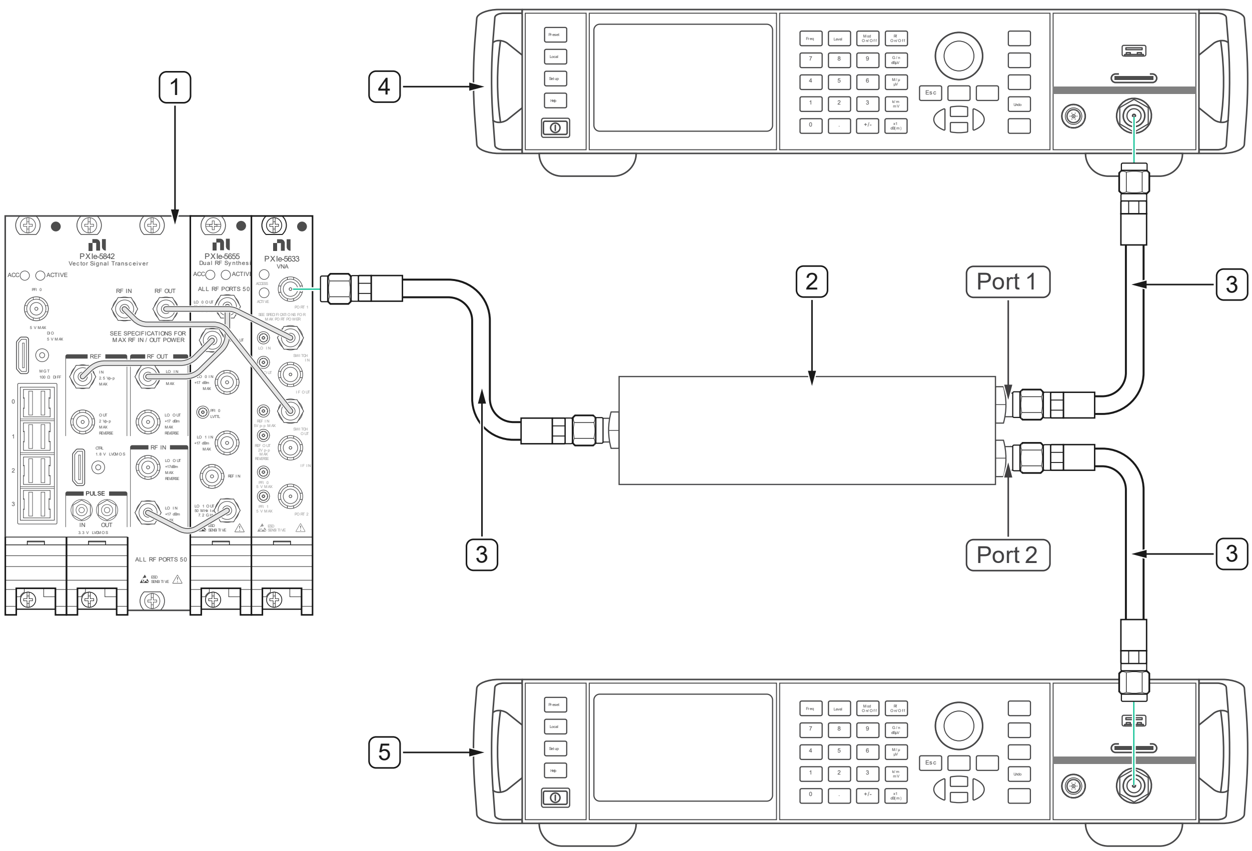
IQ Center Frequency	Nominal Power Level	Spectrum Analyzer Reference Level	Spectrum Analyzer Attenuation
▪ 1.02 GHz to 1.74 MHz in 20 MHz steps ▪ 1.749 GHz ▪ 1.75 GHz to 3.95 GHz in 50 MHz steps ▪ 4.0 GHz to 26.3 GHz in 100 MHz steps ▪ 26.38 GHz Do not test above (Maximum DUT Frequency – 20 MHz), see **Table 5**	-36.0 dBm	-30 dBm	0 dB
	-6.0 dBm	0 dBm	20 dB
	+9.0 dBm	+15 dBm	40 dB for 8 GHz ≤ f ≤ 12 GHz, 35 dB otherwise

6.2.16. Verification Initial Test Connection

Note

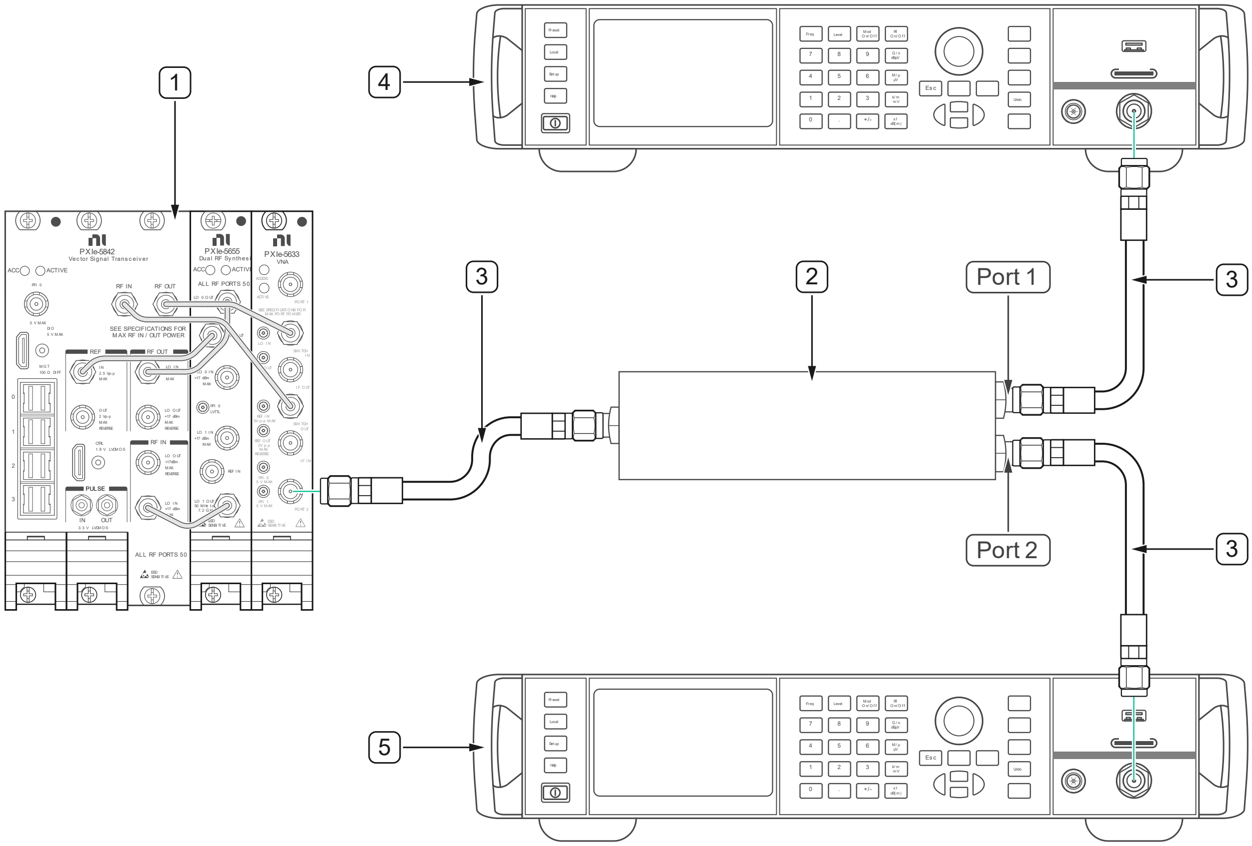
Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

Figure 10. RF Input TOI High Frequency **Port 1** Verification connections



1. DUT
2 HF Power Combiner
3. 36” 3.5 mm cable (m) to (m) (x3)
4. Signal Generator #1
5. Signal Generator #2

Figure 11. RF Input TOI High Frequency **Port 2** Verification connections



1. DUT
2 HF Power Combiner
3. 36” 3.5 mm cable (m) to (m) (x3)
4. Signal Generator #1
5. Signal Generator #2

6.2.17. Verification Procedure

This procedure verifies the Third Order Intercept (TOI) Accuracy of the DUT’s input channel.

Table 17: RF Input TOI High Frequency Accuracy Test points and Configurations (Downconverter Mode = **User Defined**)

IQ Center Frequency	Reference Power Level	Downconverter Offset	DUT Bandwidth
▪ 1.02 GHz to 1.74 MHz in 20 MHz steps ▪ 1.749 GHz ▪ 1.75 GHz to 3.95 GHz in 50 MHz steps ▪ 4.0 GHz to 26.3 GHz in 100 MHz steps ▪ 26.38 GHz Do not test above (Maximum DUT Frequency – 20 MHz), see **Table 5**	-30 dBm, 0 dBm +15 dBm	0	See **Table 8**

6.2.18. RF Input TOI High Frequency Verification Port 1 Procedure (Downconverter Mode = User Defined)

1. Make the connections indicated in **Figure 10**.
2. Configure the DUT for the following settings:
   - IQ Center Frequency: First IQ Center Frequency from **Table 17**
   - Reference Level: First Reference Power Level from **Table 17**
   - Downconverter Offset Mode: User Defined
   - Downconverter Offset: Downconverter Offset from **Table 17**
   - Signal Bandwidth: Signal Bandwidth from **Table 8**
   - Acquisition Type: IQ
   - FFT Window Type: Flat Top
   - IQ Rate: From **Table 6** based on the HW option
   - Number of Samples: 200 kS
   - Number of Records: 10
   - Reference Clock Source: PXI_Clock (Locked to Rubidium)
   - Reference Clock Frequency: 10 MHz

3. Configure the Signal Generator #1 for the following:
   - Power Level:
     (Initial lower Reference Power Level from **Table 17** – 6 dB), as determined in the characterization section for that power level and frequency:

     $Combiner\_Port1HF_{pf}$ [dBm]

   - Frequency:
     f_1= (Initial IQ Frequency from Configurations **Table 17** + 95 MHz)
   - ALC: On

4. Configure the Signal Generator #2 for the following:
   - Power Level:
     (Initial lower Reference Power Level from **Table 17** – 6 dB), as determined in the characterization section for that power level and frequency:

     $Combiner\_Port2HF_{pf}$ [dBm]

   - Frequency:
     f_2= (Initial IQ Frequency from Configurations **Table 17** + 105 MHz)
   - ALC: On

5. Generate RF signals from both Generators simultaneously, with the specified settings. Wait until they settle.

6. Taking the Verification measurements:

Repeat, once for each Signal Generator #1 and #2 (simultaneously) Reference Power Level in Table 17, starting with the lower power setting.

Repeat, once for each Signal Generator #1 and #2 (simultaneously) IQ Center Frequency setting in **Table 17**.

7. Acquire a spectrum of the combined signal using the DUT.

8. Measure the power at the expected distortion frequencies using the following settings:

- See section **9.2 - Acquiring a Spectrum from IQ Data and Measuring the Peak**
  - Frequency Deviation: 15 kHz
  - Search Frequencies: ƒ1, ƒ2, (2ƒ1-ƒ2), (2ƒ2-ƒ1)

9. Record the measured power:

f_1= **fundamental_tone$_1$ [dBm]**

10. Record the measured power:

f_2= **fundamental_tone$_2$ [dBm]**

11. Record the measured power:

$(2f_1 - f_2)$ = **IMD$_3$_tone$_1$ [dBm]**

12. Record the measured power:

$(2f_2 - f_1)$ = **IMD$_3$_tone$_2$ [dBm]**

13. Calculate IMD$_3$ using the following equation:

IMD$_3$ = Min(fundamental_tone$_1$; fundamental_tone$_2$) – Max(IMD$_3$_tone$_1$; IMD$_3$_tone$_2$)

14. Calculate TOI using the following equation:

TOI = Min(fundamental_tone$_1$; fundamental_tone$_2$) + IMD$_3$/2

15. Compare the calculated TOI with limits in **Table 15**

16. Configure the Signal Generator #1 for the following:
    - Power Level: Current Iteration of Reference Power Level from **Table 17** as determined in the characterization section for that power level and frequency:

      Combiner_Port1HF$_{pf}$ [dBm]
    - Frequency:
      ***f*$_1$**= (Next IQ Frequency from Configurations **Table 17** + 95 MHz)
    - ALC: On

17. Configure the Signal Generator #2 for the following:

- Power Level: Current Iteration of Reference Power Level from **Table 17** as determined in the characterization section for that power level and frequency:

  $Combiner\_Port2HF_{pf}$ [dBm]

- Frequency:
  f_2= (Next IQ Frequency from Configurations **Table 17** + 105 MHz)
- ALC: On

18. Configure the DUT for the following settings:

    - IQ Center Frequency: Next IQ Center Frequency from **Table 17**
    - Signal Bandwidth: Signal Bandwidth from **Table 17**
    - IQ Rate: From **Table 6** based on the HW option

19. Configure the Signal Generator #1 for the following:
    - Power Level:
    (Next iteration of Reference Power Level from **Table 17** – 6 dB), as determined in the characterization section for that power level and frequency:

      $Combiner\_Port1HF_{pf}$ [dBm]
    - Frequency:
    f_1= (Initial IQ Frequency from Configurations **Table 17** + 95 MHz)
    - ALC: On

20. Configure the Signal Generator #2 for the following:
    - Power Level:
    (Next iteration of Reference Power Level from **Table 17** – 6 dB), as determined in the characterization section for that power level and frequency:

      $Combiner\_Port2HF_{pf}$ [dBm]
    - Frequency:
    f_2= (Initial IQ Frequency from Configurations **Table 17** + 105 MHz)
    - ALC: On

21. Configure the DUT for the following settings:
    - IQ Center Frequency: Initial IQ Center Frequency from **Table 17**
    - Reference Level: Next Iteration Reference Level from **Table 17**
    - Signal Bandwidth: Signal Bandwidth from **Table 17**
    - IQ Rate: From **Table 6** based on the HW option

6.2.19. Verification Procedure Port 1 (Downconverter Mode = Enabled)

Table 18: RF Input TOI High Frequency Accuracy Test Points and Configurations (Downconverter Mode = **Enabled**)

IQ Center Frequency	Reference Power Level	Downconverter Offset	DUT Bandwidth
▪ 1.701 GHz ▪ 1.75 GHz to 3.95 GHz in 50 MHz steps ▪ 4.0 GHz to 26.3 GHz in 100 MHz steps ▪ 26.38 GHz Do not test above (Maximum DUT Frequency – 20 MHz), see **Table 5**	-30 dBm, 0 dBm +15 dBm	Driver Default	See **Table 7**

1. Make the connections indicated in **Figure 10**.
2. Configure the DUT for the following settings:
    - IQ Center Frequency: First IQ Center Frequency from **Table 18**
    - Reference Level: First Reference Power Level from **Table 18**
    - Downconverter Offset Mode: User Defined
    - Downconverter Offset: Downconverter Offset from **Table 18**
    - Signal Bandwidth: Signal Bandwidth from **Table 18**
    - Acquisition Type: IQ
    - FFT Window Type: Flat Top

- IQ Rate: From **Table 6** based on the HW option
- Number of Samples: 200 kS
- Number of Records: 10
- Reference Clock Source: PXI_Clock (Locked to Rubidium)
- Reference Clock Frequency: 10 MHz

3. Configure the Signal Generator #1 for the following:
    - Power Level:
    (Initial lower Reference Power Level from **Table 18** – 6 dB), as determined in the characterization section for that power level and frequency:

    $$\textbf{Combiner\_Port1HF}_{pf}\ \textbf{[dBm]}$$

    - Frequency:
    f_1= (Initial IQ Frequency from Configurations **Table 18** + 95 MHz)
    - ALC: On

4. Configure the Signal Generator #2 for the following:
    - Power Level:
    (Initial lower Reference Power Level from **Table 18** – 6 dB), as determined in the characterization section for that power level and frequency:

    $$\textbf{Combiner\_Port2HF}_{pf}\ \textbf{[dBm]}$$

    - Frequency:
    f_2= (Initial IQ Frequency from Configurations **Table 18** + 105 MHz)
    - ALC: On

5. Generate RF signals from both Generators simultaneously, with the specified settings. Wait until they settle.

6. Taking the Verification measurements:

> Repeat, once for each Signal Generator #1 and #2 (simultaneously) Reference Power Level in Table 17, starting with the lower power setting.

Repeat, once for each Signal Generator #1 and #2 (simultaneously) IQ Center Frequency setting in **Table 18**.

7. Acquire a spectrum of the combined signal using the DUT.
8. Measure the power at the expected distortion frequencies using the following settings:
   - See section **9.2 - Acquiring a Spectrum from IQ Data and Measuring the Peak**
     - Frequency Deviation: 15 kHz
     - Search Frequencies: $f1$, $f2$, $(2f1\text{-}f2)$, $(2f2\text{-}f1)$
9. Record the measured power:

$$f_1 = \textbf{fundamental\_tone}_\mathbf{1}\ \textbf{[dBm]}$$

10. Record the measured power:

$$f_2 = \textbf{fundamental\_tone}_\mathbf{2}\ \textbf{[dBm]}$$

11. Record the measured power:

$$(2f_1 - f_2) = \textbf{IMD}_\mathbf{3}\textbf{\_tone}_\mathbf{1}\ \textbf{[dBm]}$$

12. Record the measured power:

$$(2f_2 - f_1) = \textbf{IMD}_\mathbf{3}\textbf{\_tone}_\mathbf{2}\ \textbf{[dBm]}$$

13. Calculate IMD_3 using the following equation:

$$IMD_3 = \text{Min}(\text{fundamental\_tone}_1; \text{fundamental\_tone}_2) - \text{Max}(IMD_3\text{\_tone}_1; IMD_3\text{\_tone}_2)$$

14. Calculate TOI using the following equation:

$$\textbf{TOI} = \text{Min}(\text{fundamental\_tone}_1; \text{fundamental\_tone}_2) + IMD_3/2$$

15. Compare the calculated TOI with limits in **Table 15**
16. Configure the Signal Generator #1 for the following:

- Power Level: Current Iteration of Reference Power Level from **Table 18** as determined in the characterization section for that power level and frequency:

  Combiner_Port1HF$_{pf}$ [dBm]
- Frequency:

  f_1= (Next IQ Frequency from Configurations **Table 18** + 95 MHz)
- ALC: On

17. Configure the Signal Generator #2 for the following:
    - Power Level: Current Iteration of Reference Power Level from **Table 18** as determined in the characterization section for that power level and frequency:

      Combiner_Port2HF$_{pf}$ [dBm]
    - Frequency:

      f_2= (Next IQ Frequency from Configurations **Table 18** + 105 MHz)
    - ALC: On

18. Configure the DUT for the following settings:
    - IQ Center Frequency: Next IQ Center Frequency from **Table 18**
    - Signal Bandwidth: Signal Bandwidth from **Table 18**
    - IQ Rate: From **Table 6** based on the HW option

19. Configure the Signal Generator #1 for the following:
    - Power Level:

      (Next iteration of Reference Power Level from **Table 18** – 6 dB), as determined in the characterization section for that power level and frequency:

      Combiner_Port1HF$_{pf}$ [dBm]
    - Frequency:

      f_1= (Initial IQ Frequency from Configurations **Table 18** + 95 MHz)
    - ALC: On

20. Configure the Signal Generator #2 for the following:

- Power Level:
  (Next iteration of Reference Power Level from **Table 18** – 6 dB), as determined in the characterization section for that power level and frequency:

  $Combiner\_Port2HF_{pf}$ [dBm]
- Frequency:
  f_2= (Initial IQ Frequency from Configurations **Table 18** + 105 MHz)
- ALC: On

21. Configure the DUT for the following settings:

- IQ Center Frequency: Initial IQ Center Frequency from **Table 18**
- Reference Level: Next Iteration Reference Level from **Table 18**
- Signal Bandwidth: Signal Bandwidth from **Table 18**
- IQ Rate: From **Table 6** based on the HW option

6.2.20. RF Input TOI High Frequency Verification Port 2 Procedure (Downconverter Mode = User Defined)

1. Repeat procedure 6.2.18 RF Input TOI High Frequency Verification **Port 1** Procedure (Downconverter Mode = **User Defined**):

   1.1 Replace connections of **Figure 10** with **Figure 11**.

   1.2 Where "Port 1" is mentioned, replace with "Port 2".

6.2.21. RF Input TOI High Frequency Verification Port 2 Procedure (Downconverter Mode = Enabled)

1. Repeat procedure 6.2.19 Verification Procedure **Port 1** (Downconverter Mode = **Enabled**):

   1.1 Replace connections of **Figure 10** with **Figure 11**.

   1.2 Where “Port 1” is mentioned, replace with “Port 2”.

6.3. RF Output Absolute Amplitude Verification

6.3.1. Test Limits

Table 19: RF Output Amplitude Accuracy Verification Test Limits, (**User Defined Mode**)

For Power levels from -20 dBm to Maximum Specified Power		
Frequency Range	Verification Test Limit	
	Lower Limit	Upper Limit
30 MHz to 200 MHz	-4.10 dB	+4.10 dB
> 200 MHz to 6.0 GHz	-1.05 dB	+1.05 dB
>6.0 GHz to 8.0 GHz	-1.15 dB	+1.15 dB
>8.0 GHz to 12.0 GHz	-0.85 dB	+1.05 dB
>12.0 GHz to 22.0 GHz	-1.20 dB	+1.20 dB
>22.0 GHz to 25.0 GHz	-1.60 dB	+1.60 dB
>25.0 GHz to 26.5 GHz	-1.95 dB	+1.95 dB

For Power levels from -30 dBm to <-20 dBm Specified Power		
Frequency Range	Verification Test Limit	
	Lower Limit	Upper Limit
30 MHz to 200 MHz	-4.10 dB	+4.10 dB
> 200 MHz to 6.0 GHz	-1.05 dB	+1.05 dB
>6.0 GHz to 8.0 GHz	-1.35 dB	1.35 dB
>8.0 GHz to 12.0 GHz	-1.40 dB	+1.40 dB
>12.0 GHz to 22.0 GHz	-1.35 dB	+1.35 dB
>22.0 GHz to 25.0 GHz	-1.60 dB	+1.60 dB
>25.0 GHz to 26.5 GHz	-1.95 dB	+1.95 dB

Table 20: RF Output Amplitude Accuracy Verification Test Limits (**Enabled Mode**)

For Power levels from -20 dBm to Maximum Specified Power		
Frequency Range	Verification Test Limit	
	Lower Limit	Upper Limit
1.7 GHz to 6.0 GHz	-1.05 dB	+1.05 dB
>6.0 GHz to 8.0 GHz	-1.15 dB	+1.15 dB
>8.0 GHz to 12.0 GHz	-0.85 dB	+1.05 dB
>12.0 GHz to 22.0 GHz	-1.20 dB	+1.20 dB
>22.0 GHz to 25.0 GHz	-1.60 dB	+1.60 dB
>25.0 GHz to 26.5 GHz	-1.95 dB	+1.95 dB
For Power levels from -30 dBm to <-20 dBm Specified Power		
Frequency Range	Verification Test Limit	

	Lower Limit	Upper Limit
1.7 GHz to 6.0 GHz	-1.05 dB	+1.05 dB
>6.0 GHz to 8.0 GHz	-1.50 dB	+1.35 dB
>8.0 GHz to 12.0 GHz	-1.40 dB	+1.40 dB
>12.0 GHz to 22.0 GHz	-1.35 dB	+1.35 dB
>22.0 GHz to 25.0 GHz	-1.60 dB	+1.60 dB
>25.0 GHz to 26.5 GHz	-1.95 dB	+1.95 dB

Table 21: RF Output Maximum Power Level (**User Defined Mode**)

Center Frequency Range	Maximum Power Level
30 MHz to 600 MHz	+9.0 dBm
>600 MHz to 1.75 GHz	+9.0 dBm (+18 dBm*)
>1.75 GHz to 6.0 GHz	+17.0 dBm
>6.0 GHz to 8.0 GHz	+16.0 dBm
>8.0 GHz to 12.0 GHz	+15.0 dBm
>12.0 GHz to 18.0 GHz	+14.0 dBm
>18.0 GHz to 22.0 GHz	+13.0 dBm
>22.0 GHz to 24.0 GHz	+11.0 dBm
>24.0 GHz to 25.0 GHz	+3.0 dBm
>25.0 GHz to 26.5 GHz	-9.0 dBm

*) For Signal Bandwidth = 500 MHz

Table 22: RF Output Maximum Power Level (**Enabled Mode**)

Center Frequency Range	Maximum Power Level
>1.7 GHz to 4.0 GHz	+18.0 dBm
>4.0 GHz to 6.0 GHz	+17.0 dBm
>6.0 GHz to 8.0 GHz	+16.0 dBm
>8.0 GHz to 18.0 GHz	+15.0 dBm
>18.0 GHz to 22.0 GHz	+13.0 dBm
>22.0 GHz to 24.0 GHz	+8.0 dBm
>24.0 GHz to 25.0 GHz	+3.0 dBm
>25.0 GHz to 26.5 GHz	-8.0 dBm

6.3.2. Initial Test Connection

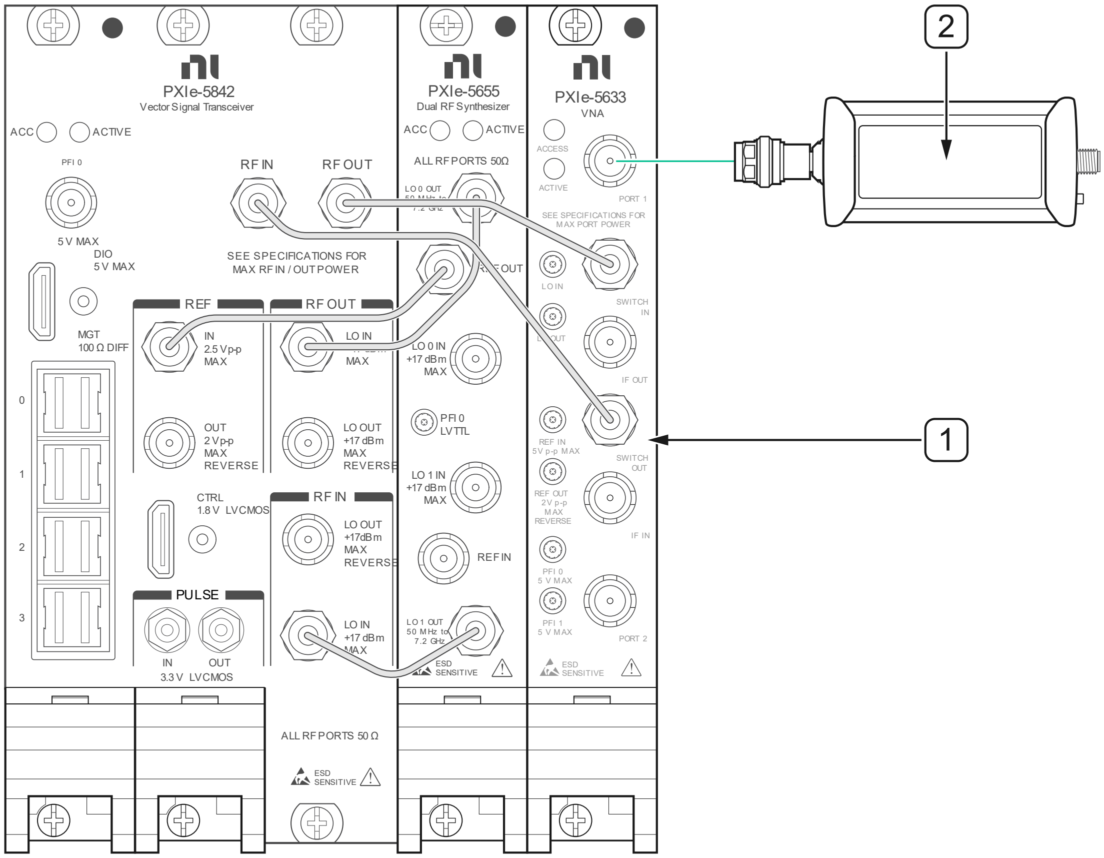
Note

Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

CAUTION

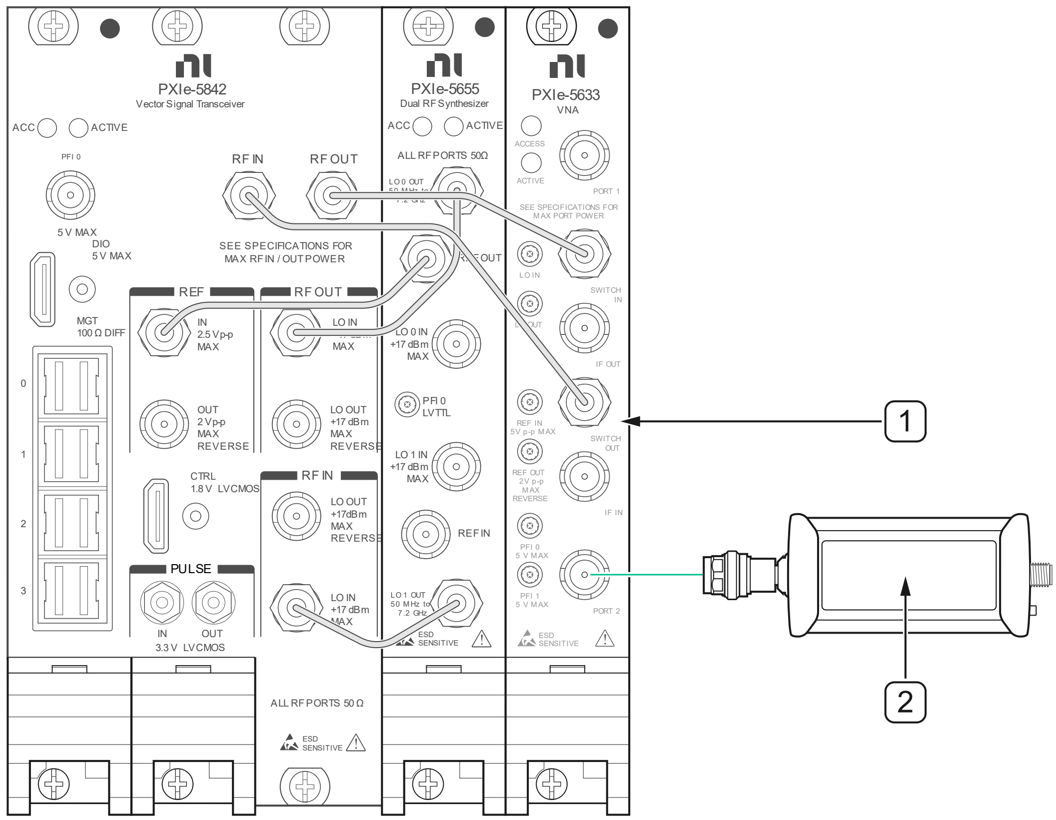
The form factor of the power sensor might cause strain to the DUT test port connector due to tight spacing between the chassis and power sensor. Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Figure 12. Connections for RF Output Amplitude Accuracy **Port 1** Verification



1. DUT
2. Power Sensor #2

Figure 13. Connections for RF Output Amplitude Accuracy **Port 2** Verification



1. DUT

2. Power Sensor #2

6.3.3. Verification Procedure

This procedure verifies the power level accuracy of the DUT's output channel. When the Upconverter Offset Mode is set to User-Defined (DC Coupling) an Upconverter offset is configured. When the Upconverter Offset Mode is set to Enabled (AC-coupled) the Upconverter Frequency is automatically set by the driver.

Table 23: Output Absolute Accuracy Test points and Configurations

<table>
<tr><th>DUT Frequency Range</th><th>DUT Power Level</th><th>DUT Upconverter Mode</th><th>DUT Bandwidth</th></tr>
<tr><td>▪ 201 MHz
▪ 210 MHz to 290 MHz in 10 MHz steps
▪ 300 MHz to 1.74 GHz in 20 MHz steps
▪ 1.749 GHz</td><td>-30 dBm to 5 dBm in 5 dBm steps and +9 dBm</td><td>User Defined</td><td>Default</td></tr>
<tr><td>▪ 601 GHz
▪ 620 MHz to 1.74 GHz in 20 MHz steps
▪ 1.749 GHz</td><td>+10 dBm
+15 dBm to Maximum Power endpoint in 1 dBm steps</td><td>User Defined</td><td>500 MHz</td></tr>
<tr><td>▪ 1.75 GHz to 3.95 GHz in 50 MHz steps
▪ 4.0 GHz to (Maximum Frequency) (See Table 5) in 100 MHz Steps</td><td rowspan="2">-30 dBm to 5 dBm in 5 dBm steps

+10 dBm to Maximum Power endpoint in 1 dB steps)

If the +10 dBm point is above the Max Linear Power endpoint for that frequency measure only the Max Linear Power at that frequency

• See Table 21Table 19 and Table 22 for Maximum Power</td><td>User Defined</td><td>Default</td></tr>
<tr><td>▪ 1.701 GHz
▪ 1.75 GHz to 3.95 GHz in 50 MHz steps
▪ 4.0 GHz to (Maximum Frequency) (See Table 5) in 100 MHz Steps</td><td>Enabled</td><td>See Table 7</td></tr>
</table>

6.3.4. Verification Procedure **Port 1** (Upconverter Mode = **User Defined**)

1. Ensure that the Power Meter has been zeroed according with section 4.3.
2. Power Meter Aperture configuration

The power meter requires that the frequency is configured to perform internal corrections to achieve its warranted specifications. Always configure the frequency of the power meter before making a measurement.

The power meter's accuracy also depends on the power level it is measuring; set the aperture according to **Table 81:** Power Meter Aperture Configuration

3. Make the connections indicated in **Figure 12**

4. Configure the DUT for the following settings for "User Defined" mode:

- Output Port: 1
- Mode: CW
- Upconverter Offset Mode: User Defined
- Upconverter Frequency Offset:
  - User Defined Mode and Frequency <1.75 GHz: Driver Default
  - User Defined Mode and Frequency ≥1.75 GHz: -20 MHz
- Power Level: Initial lower Power Level from Configurations **Table 23**
- Frequency: Initial Frequency from Configurations **Table 23**
- Bandwidth: Signal Bandwidth from Configurations **Table 23**
- Reference Clock Source: PXI_CLK (Locked to Rubidium)
- Reference Clock Frequency: 10 MHz

5. Configure the Power Sensor for the following settings:

- Frequency: Initial Frequency from Configurations **Table 23**
- Power Meter Path Selection: Auto Mode
- Aperture Time: Select from **Table 81** based on the expected input power
- Number of Averages: 1

6. Generate an RF signal on the DUT with the specified settings. Wait until it settles.

7. Taking the measurements:

> Repeat, once for each DUT Power Level in Table 23, starting with the lower power setting.

6. Record this Power Level value as "**Requested_TX_Power**"

Based on your DUT option, repeat once for each DUT Frequency setting in Table 23.

8. Measure the power of the DUT with the Power Meter and record the value as "PM_measured_power".
9. Calculate the absolute power level accuracy using the following equation:

   Output Absolute Amplitude (UDM) = PM_measured_power **-** Requested_TX_Power **[dB]**

10. Configure the DUT:
    a. Frequency: Next Frequency from Configurations **Table 23**
11. Configure the Power Sensor:
    a. Frequency: Same frequency as the DUT

12. Configure the DUT for the following settings for "User Defined" mode:

- Power Level: Next Power Level from Configurations **Table 23**
-

6.3.5. Verification Procedure (Upconverter Mode = Enabled)

1. Power Meter Aperture configuration

The power meter requires that the frequency is configured to perform internal corrections to achieve its warranted specifications. Always configure the frequency of the power meter before making a measurement.

The power meter's accuracy also depends on the power level it is measuring; set the aperture according to **Table 81:** Power Meter Aperture Configuration.

2. Make the connections indicated in **Figure 12.**

3. Configure the DUT for the following settings for "User Defined" mode:
   - Output Port: 1
   - Mode: CW
   - Upconverter Offset Mode: Enabled
   - Upconverter Frequency Offset: Driver Default
   - Power Level: Initial lower Power Level from Configurations **Table 23**
   - Frequency: Initial Frequency from Configurations **Table 23**
   - Bandwidth: Signal Bandwidth from Configurations **Table 23**
   - Reference Clock Source: PXI_CLK (Locked to Rubidium)
   - Reference Clock Frequency: 10 MHz
4. Configure the Power Sensor for the following settings:
   - Frequency: Initial Frequency from Configurations **Table 23**
   - Power Meter Path Selection: Auto Mode
   - Aperture Time: Select from **Table 81** based on the expected input power
   - Number of Averages: 1
5. Generate an RF signal on the DUT with the specified settings. Wait until it settles.
6. Taking the measurements:

Repeat, once for each DUT Power Level in Table 23, starting with the lower power setting.

7. Record this Power Level value as "**Requested_TX_Power**"

Based on your DUT option, repeat once for each DUT Frequency setting in Table 23.

8. Measure the power of the DUT with the Power Meter and record the value as "PM_measured_power".
9. Calculate the absolute power level accuracy using the following equation:

Output Absolute Amplitude (ENM) = PM_measured_power **-** Requested_TX_Power **[dB]**

10. Configure the DUT:
    a. Frequency: Next Frequency from Configurations **Table 23**
11. Configure the Power Sensor:
    a. Frequency: Same frequency as the DUT

12. Configure the DUT for the following settings for "User Defined" mode:

    - Power Level: Next Power Level from Configurations **Table 23**

6.3.6. Verification Procedure Port 2 (Downconverter Mode = User Defined)

1. Repeat procedure 6.3.4 Verification Procedure **Port 1** (Upconverter Mode = **User Defined**) :

   1.1. Make the connections indicated in **Figure 13** for Verification of Port 2.

   1.2. Where "Port 1" is mentioned, replace with "Port 2".

6.3.7. Verification Procedure Port 2 (Downconverter Mode = Enabled)

1. Repeat 6.3.5 Verification Procedure (Upconverter Mode = **Enabled**):

   1.1. Make the connections indicated in **Figure 13** for Verification of Port 2.

   1.2. Where "Port 1" is mentioned, replace with "Port 2".

6.4. RF Output Frequency Response Verification

6.4.1. Test Limits

Table 24: RF Output Frequency Response Accuracy Verification Test Limits (**User Defined Mode**)

Frequency Range	Verification Test Limit	
	Lower Limit	Upper Limit
>200 MHz to 1.02 GHz	-1.35 dB	+1.35 dB
>1.02 GHz to 1.75 GHz	-1.10 dB	+1.10 dB
>1.75 GHz to 12.0 GHz	-1.00 dB	+1.00 dB
>12.0 GHz to 18.0 GHz	-0.90 dB	+0.90 dB
>18.0 GHz to 22.0 GHz	-1.20 dB	+1.20 dB
>22.0 GHz to 25.0 GHz	-1.25 dB	+1.25 dB
>25.0 GHz to 26.5 GHz	-2.35 dB	+2.35 dB

Table 25: RF Output Frequency Response Verification Test Limits (**Enabled Mode)**

Frequency Range	Verification Test Limits	
	Lower Limit	Upper Limit
1.7 GHz to 1.75 GHz	-1.10 dB	+1.10 dB
>1.75 GHz to 12.0 GHz	-1.00 dB	+1.00 dB
>12.0 GHz to 18.0 GHz	-0.90 dB	+0.90 dB
>18.0 GHz to 22.0 GHz	-1.20 dB	+1.20 dB
>22.0 GHz to 25.0 GHz	-1.25 dB	+1.25 dB

>25.0 GHz to 26.5 GHz	-2.35 dB	+2.35 dB

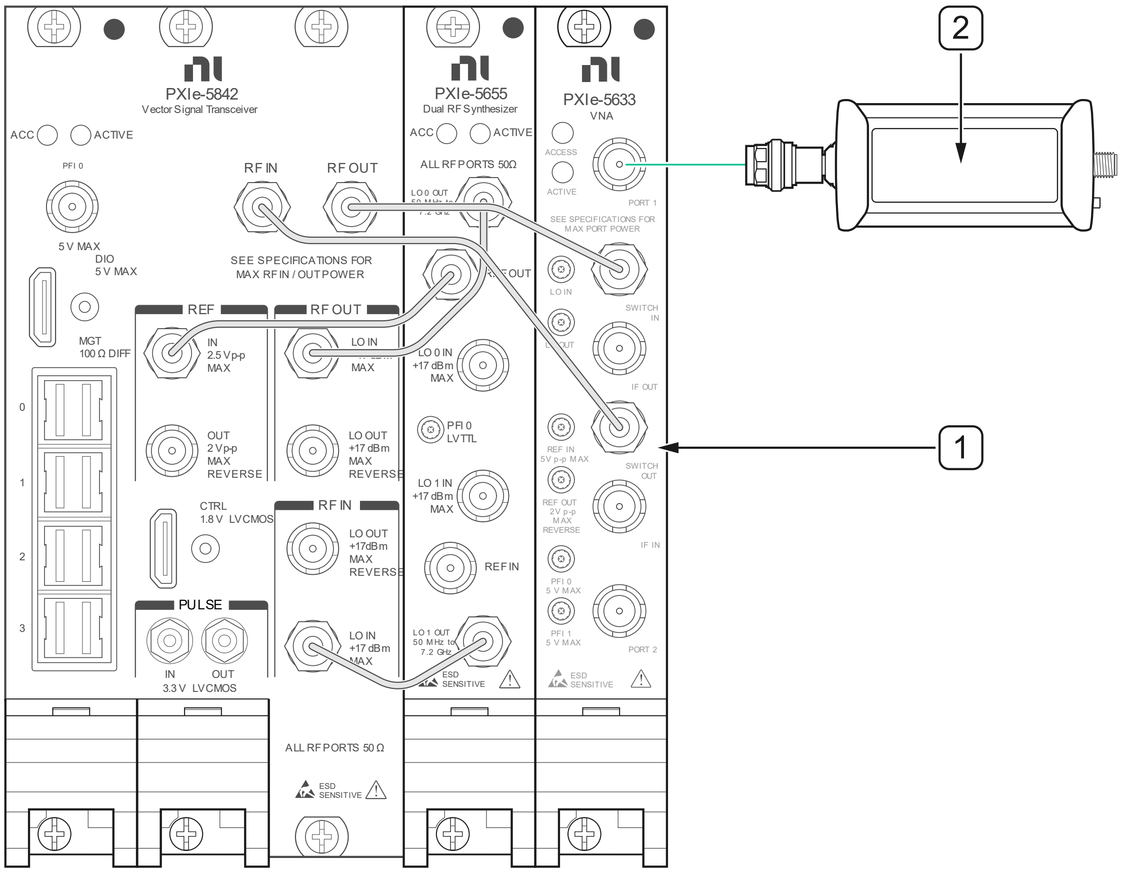
6.4.2. Initial Test Connection

Note

Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

CAUTION
The form factor of the power sensor might cause strain to the DUT test port connector. Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

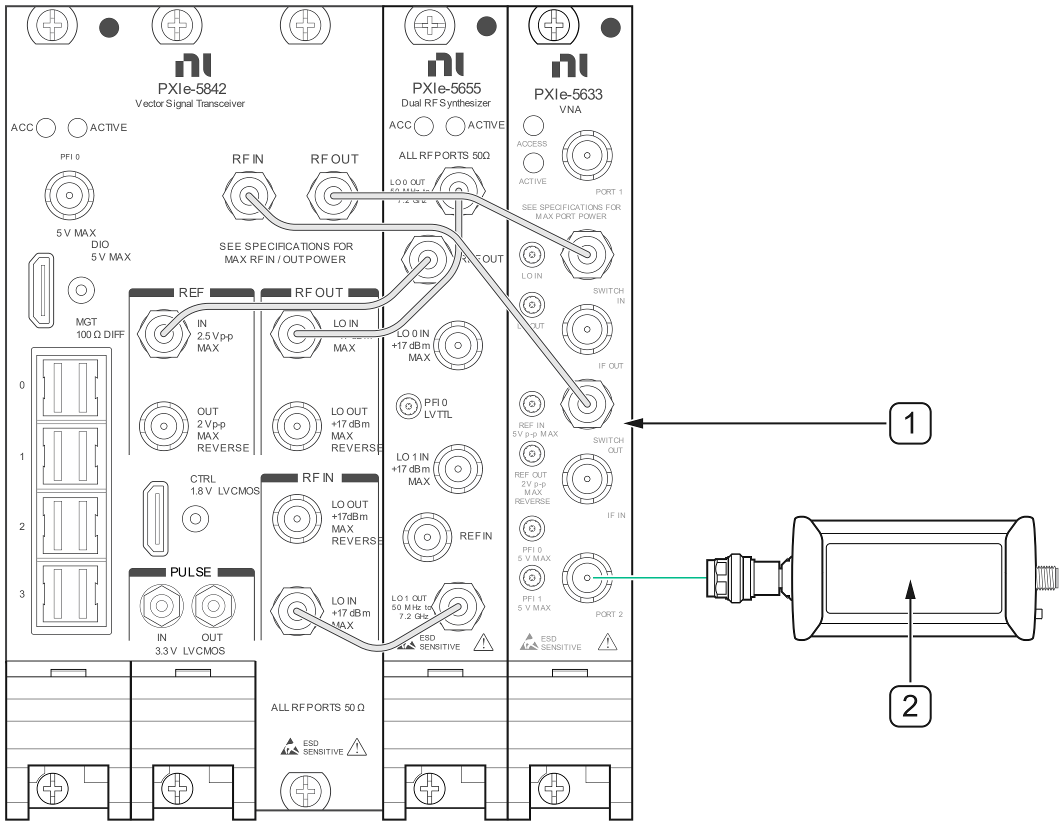
Figure 14. Connections for RF Output Frequency Response Accuracy **Port 1** Verification



1. DUT

2. Power Sensor #2

Figure 15. Connections for RF Output Frequency Response Accuracy **Port 2** Verification



1. DUT
2. Power Sensor #2

6.4.3. Verification Procedure

This procedure verifies the Frequency Response accuracy of the DUT's output channel at a specified upconverter center frequency within the bandwidth selected.

Table 26: RF Output Frequency Response Accuracy Test points and Configurations (**User Defined Mode**)

DUT Center Frequency Range	DUT Power Level	Reference Tone Offset	Additional Sweep Info	DUT Bandwidth
▪ 205 MHz to 275 MHz in 25 MHz steps	▪ -30 dBm ▪ 0 dBm ▪ Max Linear Power point See **Table 21** for Maximum Power	0 Hz	Sweep Step Size: 5 MHz Offsets below 200 MHz absolute frequency should be removed	See **Table 8**
▪ 280 MHz ▪ 300 MHz to 600 MHz in 100 MHz steps			Sweep Step Size: 10 MHz Must include ±250 MHz and ±500 MHz Offsets below 200 MHz absolute frequency should be removed	
▪ 601 MHz ▪ 1015 MHz ▪ 750 MHz to 1.5 GHz in 250 MHz steps			Sweep Step Size: 20 MHz Must include ±250 MHz and ±500 MHz Offsets below 200 MHz absolute frequency should be removed	
▪ 601 MHz ▪ 1015 MHz ▪ 750 MHz to 1.5 GHz in 100 MHz steps ▪ 1.749 GHz	▪ +10 dBm to Max Linear Power endpoint in 5 dBm steps) ▪ Include Max Linear Power point for 500 MHz signal BW	0 Hz	Sweep Step Size: 50 MHz. Must include ±250 MHz and ±500 MHz Offsets below 200 MHz absolute frequency should be removed	500 MHz
▪ 1.749 GHz	▪ -30 dBm ▪ 0 dBm ▪ Include Max Linear Power point	0 Hz	Sweep Step Size: 50 MHz Must include ±250 MHz	See **Table 8**

▪ 1.75 GHz to 11.75 GHz in 250 MHz steps Do not test above Maximum DUT Frequency, see **Table 5**	▪ -30 dBm ▪ 0 dBm ▪ +10 dBm to Max Linear Power endpoint in 5 dBm steps) ▪ Include Max Linear Power point If the +10 dBm point is above the Max Linear Power endpoint for that frequency, measure only the Max Linear Power at that frequency. See **Table 21** for Maximum Power	20 MHz	Sweep Step Size: 50 MHz Must include 100 kHz, ±20 MHz, ±250 MHz and ±500 MHz Remove 0 Hz offset (start your sweep from +20 MHz up, and -20 MHz down)	See **Table 8**
▪ 12 GHz to 26.5 GHz in 250 MHz steps Do not test above Maximum DUT Frequency, see **Table 5**	▪ -30 dBm ▪ 0 dBm ▪ (Max Linear Power – 2 dB) to Maximum Linear Power in 1 dB Steps. (For example, if Maximum Linear power is +4 dBm test: +2 dBm, +3 dBm and +4 dBm) See **Table 21** for Maximum Power		Sweep Step Size: 50 MHz, except for 0 dBm, use 20 MHz Must include 100 kHz, ±20 MHz, ±250 MHz and ±500 MHz Remove 0 Hz offset (start your sweep from +20 MHz up, and -20 MHz down)	See **Table 8**

Table 27: RF Output Frequency Response Accuracy Test Points and Configurations (**Enabled Mode**)

DUT Center Frequency Range	DUT Power Level	Reference Tone Offset	Additional Sweep Info	DUT Bandwidth
▪ 1.701 GHz ▪ 1.75 GHz to 11.75 GHz in 250 MHz steps Do not test above Maximum DUT Frequency, see **Table 5**	▪ -30 dBm ▪ 0 dBm ▪ +10 dBm to Max Linear Power endpoint in 5 dBm steps) ▪ Include Max Linear Power point If the +10 dBm point is above the Max Linear Power endpoint for that frequency, measure only the Max Linear Power at that frequency See **Table 22** See *) For Signal Bandwidth = 500 MHz See **Table 22** for Maximum Power	0 Hz	Sweep Step Size: 50 MHz Must include ±125 MHz and ±250 MHz	See **Table 7**
▪ 12 GHz to 26.5 GHz in 250 MHz steps Do not test above Maximum DUT Frequency, see **Table 5**	▪ -30 dBm ▪ 0 dBm ▪ Maximum Linear Power to (Max Linear Power – 2 dB) in 1 dB Steps. (For example, if Maximum Linear power is +4 dBm test: +2 dBm, +3 dBm and +4 dBm) See **Table 22** for Maximum Power			

	See *) For Signal Bandwidth = 500 MHz See **Table 22** for Maximum Power			

6.4.4. Verification Procedure **Port 1** (Upconverter Mode = **User Defined**)

1. Ensure that the Power Meter has been zeroed according with section 4.3.

2. Power Meter Aperture configuration

The power meter requires that the frequency is configured to perform internal corrections to achieve its warranted specifications. Always configure the frequency of the power meter before making a measurement.

The power meter's accuracy also depends on the power level it is measuring; set the aperture according to **Table 81:** Power Meter Aperture Configuration

3. Make the connections indicated in **Figure 14**.

4. Configure the DUT for the following settings for "User Defined" mode:

   - Output Port: 1
   - Mode: Arb Waveform (IQ)
   - IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 6**
   - Number of Samples: 50 kS
   - Upconverter Offset Mode: User Defined
   - Upconverter Frequency Offset: Driver Default
   - MultiTone VI Cluster Input (see section **Table 26** for more information):
     - Number of Elements = 1

- Tone Frequency = Reference Tone Offset from **Table 26**
    - Tone Phase = [0]
    - Tone Power = [0]
- Power Level: Initial lower Power Level from Configurations **Table 26**
- Frequency: Initial Center Frequency from Configurations **Table 26**
- Bandwidth: Signal Bandwidth from Configurations **Table 26**
- Reference Clock Source: PXI_CLK (Locked to Rubidium)
- Reference Clock Frequency: 10 MHz

5. Configure the Power Sensor for the following settings:
    - Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 26**
    - Power Meter Path Selection: Auto Mode
    - Aperture Time: Select from **Table 81** based on the expected input power
    - Number of Averages: 1
6. Generate an RF signal on the DUT with the specified settings. Wait until it settles.
7. Taking the measurements

Repeat, once for each DUT Power Level in **Table 26**, starting with the lower power setting.

Based on your DUT option, repeat once for each DUT Center Frequency setting in **Table 26**.

8. Measure the power of the DUT with the Power Meter and record the value as "$PM\_measured\_power_{Ref}$".

Repeat, sweeping the Tone Offset Frequency of the DUT through all Tone Offsets.
Start from Center Frequency to –Signal Bandwidth/2 and from Center Frequency to +Signal Bandwidth/2, in step sizes indicated on Table 26.

Note

The test points within a BW should start at the center point zero and expand symmetrically from that at the required step size

For Center Frequencies ≥1.75 GHz, test points should start at (Center Frequency + 20 MHz) and expand up, and (Center Frequency -20MHz) and expand down.

9. MultiTone VI Cluster Input:
   - Tone Frequency = Next Tone Offset based on the step size in **Table 26**.
10. Configure the Power Sensor for the following settings:
    - Frequency: (Current Center Frequency + Reference Tone Offset + Next Sweep Step) from Configurations **Table 26**.
11. Measure the power of the DUT with the Power Meter and record the value as "$PM\_measured\_power_i$". Where "x_i" is a linear index number to identify each new tone offset within the sweep from 1 to n.
12. Calculate the normalized frequency response for each baseband tone offset "x_i" using the following equation:

$$\mathbf{Normalized\_Frequency\_Response_i = PM\_measured\_power_i - PM\_measured\_power_{ref}}$$

13. Calculate the max frequency response error using the following equation:

Output Frequency Response (UDM) = Maximum (|Normalized_Frequency_Response$_i$|,…,|Normalized_Frequency_Response$_n$|) [dB]

14. Configure the DUT:

- MultiTone VI Cluster Input (see section **Table 26** for more information):
- Tone Frequency = Reference Tone Offset from **Table 26**
- Frequency: Next Center Frequency from Configurations **Table 26**
- Bandwidth: Signal Bandwidth from Configurations **Table 26**

15. Configure the Power Sensor:
    a. Frequency: Same frequency as the DUT

16. Configure the DUT for the following settings:

- Power Level: Next Power Level from Configurations **Table 26**
- Frequency: Initial Center Frequency from Configurations **Table 26**
- Bandwidth: Signal Bandwidth from Configurations **Table 26**
- MultiTone VI Cluster Input (see section **Table 26** for more information):
    - Number of Elements = 1
- Tone Frequency = Reference Tone Offset from **Table 26**
    - Tone Phase = [0]
    - Tone Power = [0]

17. Configure the Power Sensor for the following settings:

- Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 26**

- Aperture Time: Select from **Table 81** based on the expected input power

18. Generate an RF signal on the DUT with the specified settings. Wait until it settles.

6.4.5. Verification Procedure Port 1 (Upconverter Mode = Enabled)

1. Ensure that the Power Meter has been zeroed according withto section 4.3.
2. Power Meter Aperture configuration

The power meter requires that the frequency is configured to perform internal corrections to achieve its warranted specifications. Always configure the frequency of the power meter before making a measurement.

The power meter's accuracy also depends on the power level it is measuring; set the aperture according to **Table 81:** Power Meter Aperture Configuration

3. Make the connections indicated in **Figure 14**.

4. Configure the DUT for the following settings for "Enabled" mode:
    - Output Port: 1
    - Mode: Arb Waveform (IQ)
    - IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 6**
    - Number of Samples: 50 kS
    - Upconverter Offset Mode: Enabled
    - Upconverter Frequency Offset: Driver Default
    - MultiTone VI Cluster Input (see section **Table 27** for more information):
        - Number of Elements = 1

- Tone Frequency = Reference Tone Offset from **Table 27**
  - Tone Phase = [0]
  - Tone Power = [0]
- Power Level: Initial lower Power Level from Configurations **Table 27**
- Frequency: Initial Center Frequency from Configurations **Table 27**
- Bandwidth: Signal Bandwidth from Configurations **Table 27**
- Reference Clock Source: PXI_CLK (Locked to Rubidium)
- Reference Clock Frequency: 10 MHz

5. Configure the Power Sensor for the following settings:
   - Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 27**
   - Power Meter Path Selection: Auto Mode
   - Aperture Time: Select from **Table 81** based on the expected input power
   - Number of Averages: 1
6. Generate an RF signal on the DUT with the specified settings. Wait until it settles.
7. Taking the measurements

Repeat, once for each DUT Power Level in Table 27, starting with the lower power setting.

Based on your DUT option, repeat once for each DUT Center Frequency setting in **Table 27.**

8. Measure the power of the DUT with the Power Meter and record the value as “PM_measured_power$_{Ref}$”.

Repeat, sweeping the Tone Offset Frequency of the DUT through all Tone Offsets.

Start from Center Frequency to –Signal Bandwidth/2 and from Center Frequency to +Signal Bandwidth/2, in step sizes indicated on **Table 27.**

Note

The test points within a BW should start at the center point zero and expand symmetrically from that at the required step size.

9. MultiTone VI Cluster Input:

Tone Frequency = Next Tone Offset based on the step size in **Table 27**.

10. Configure the Power Sensor for the following settings:

Frequency: (Current Center Frequency + Reference Tone Offset + Next Sweep Step) from Configurations **Table 27**.

11. Measure the power of the DUT with the Power Meter and record the value as "$PM\_measured\_power_i$". Where "x_i" is a linear index number to identify each new tone offset within the sweep from 1 to n.

12. Calculate the normalized frequency response for each baseband tone offset "x_i" using the following equation:

$$\mathbf{Normalized\_Frequency\_Response_i = PM\_measured\_power_i - PM\_measured\_power_{ref}}$$

13. Calculate the max frequency response error using the following equation:

$$\mathbf{Output\ Frequency\ Response\ (UDM) = Maximum\ (|Normalized\_Frequency\_Response_i|, \ldots, |Normalized\_Frequency\_Response_n|)\ [dB]}$$

14. Configure the DUT:
    - MultiTone VI Cluster Input (see section **Table 27** for more information):
    - Tone Frequency = Reference Tone Offset from **Table 27**
    - Frequency: Next Center Frequency from Configurations **Table 27**
    - Bandwidth: Signal Bandwidth from Configurations **Table 27**

19. Configure the Power Sensor:
    a. Frequency: Same frequency as the DUT

20. Configure the DUT for the following settings:
    - Power Level: Next Power Level from Configurations **Table 27**
    - Frequency: Initial Center Frequency from Configurations **Table 27**
    - Bandwidth: Signal Bandwidth from Configurations **Table 27**
    - MultiTone VI Cluster Input (see section **Table 27** for more information):
        1. Number of Elements = 1

    b. Tone Frequency = Reference Tone Offset from **Table 27**
        1. Tone Phase = [0]
        2. Tone Power = [0]

21. Configure the Power Sensor for the following settings:

    a. Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 27**

    b. Aperture Time: Select from **Table 81** based on the expected input power

22. Generate an RF signal on the DUT with the specified settings. Wait until it settles.

6.4.6. Verification Procedure for *Port 2* (Upconverter Mode = User Defined)

1. Repeat procedure 6.4.4 Verification Procedure **Port 1**(Upconverter Mode = **User Defined**):

   1.1. Replace **Figure 18** with **Figure 15.** Connections for RF Output Frequency Response Accuracy **Port 2** Verification.

   1.2. Where "Port 1" is mentioned, replace with "Port 2".

6.4.7. Verification Procedure for *Port 2* (Upconverter Mode = Enabled)

1. Repeat procedure 6.4.5 Verification Procedure **Port 1** (Upconverter Mode = **Enabled**):

   1.1. Replace **Figure 18** with **Figure 15.** Connections for RF Output Frequency Response Accuracy **Port 2** Verification.

   1.2. Where "Port 1" is mentioned, replace with "Port 2".

6.5. RF Input Absolute Amplitude Verification

Table 28: RF Input Absolute Amplitude Accuracy Verification Test Limits (**User Defined Mode**) Port 1 and Port 2

Frequency Range	As-Found Test Limit	
	Lower Limit	Upper Limit
30 MHz to 1.75 GHz	-1.15 dB	+1.15 dB
>1.75 GHz to 6.0 GHz	-1.45 dB	+1.45 dB
>6.0 GHz to 12.0 GHz	-1.10 dB	+1.10 dB
>12.0 GHz to 18.0 GHz	-1.85 dB	+1.85 dB
>18.0 GHz to 22.0 GHz	-1.50 dB	+1.50 dB
>22.0 GHz to 26.5 GHz	-2.25dB	+2.25 dB

Table 29: RF Input Absolute Amplitude Verification Test Limits (**Enabled Mode**) Port 1 and Port 2

Frequency Range	As-Found Test Limit	
	Lower Limit	Upper Limit
1.7 GHz to 6.0 GHz	-1.45 dB	+1.45 dB
>6.0 GHz to 12.0 GHz	-1.10 dB	+1.10 dB
>12.0 GHz to 18.0 GHz	-1.85dB	+1.85 dB
>18.0 GHz to 22.0 GHz	-1.50 dB	+1.50 dB
>22.0 GHz to 26.5 GHz	-2.25dB	+2.25 dB

6.5.1. Initial Test Connection

Note

Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

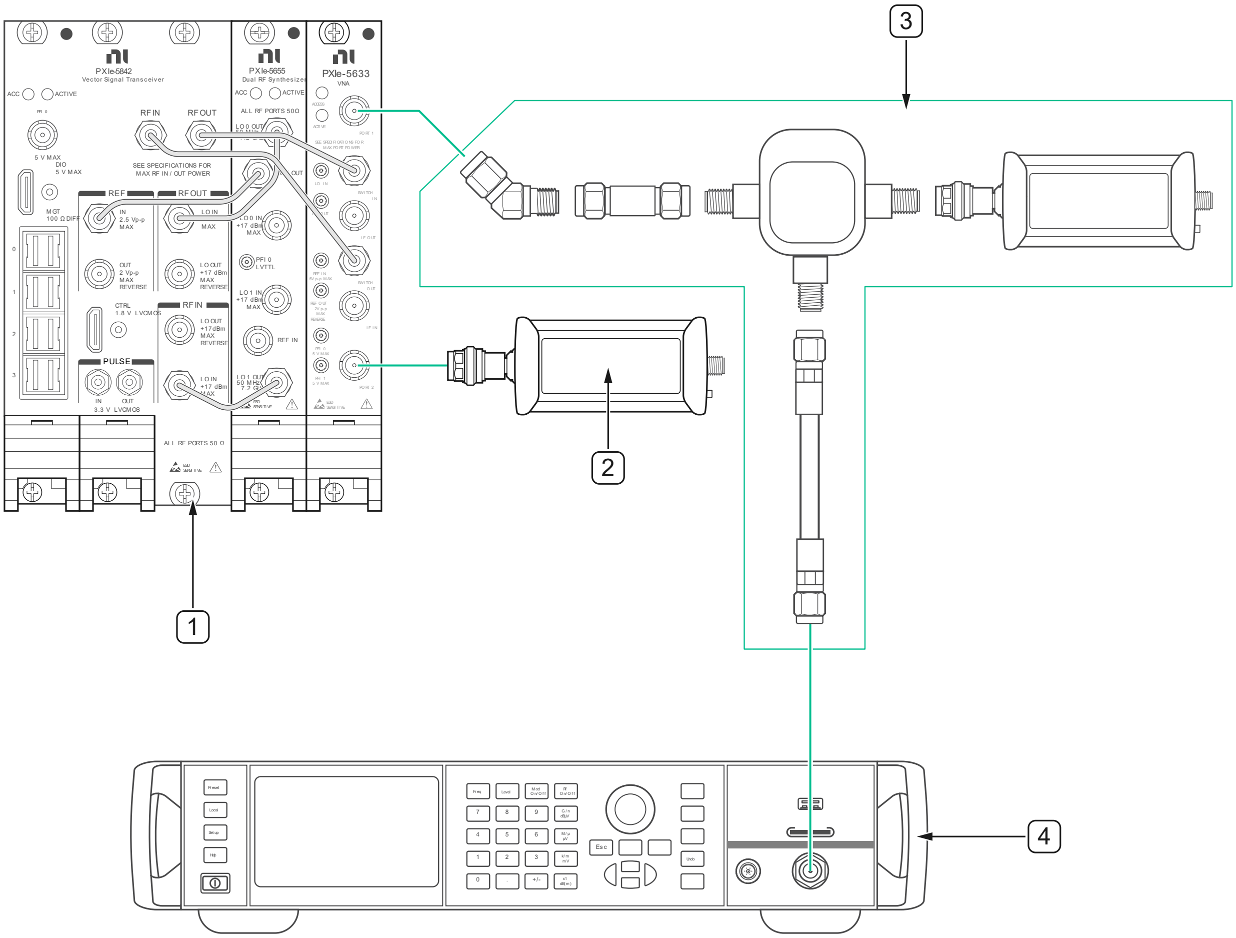
Note

Make sure that you have performed the Input Receiver fixture characterization as per **section 5.1** - Receiver Fixture Characterization before starting this Verification procedure.

CAUTION

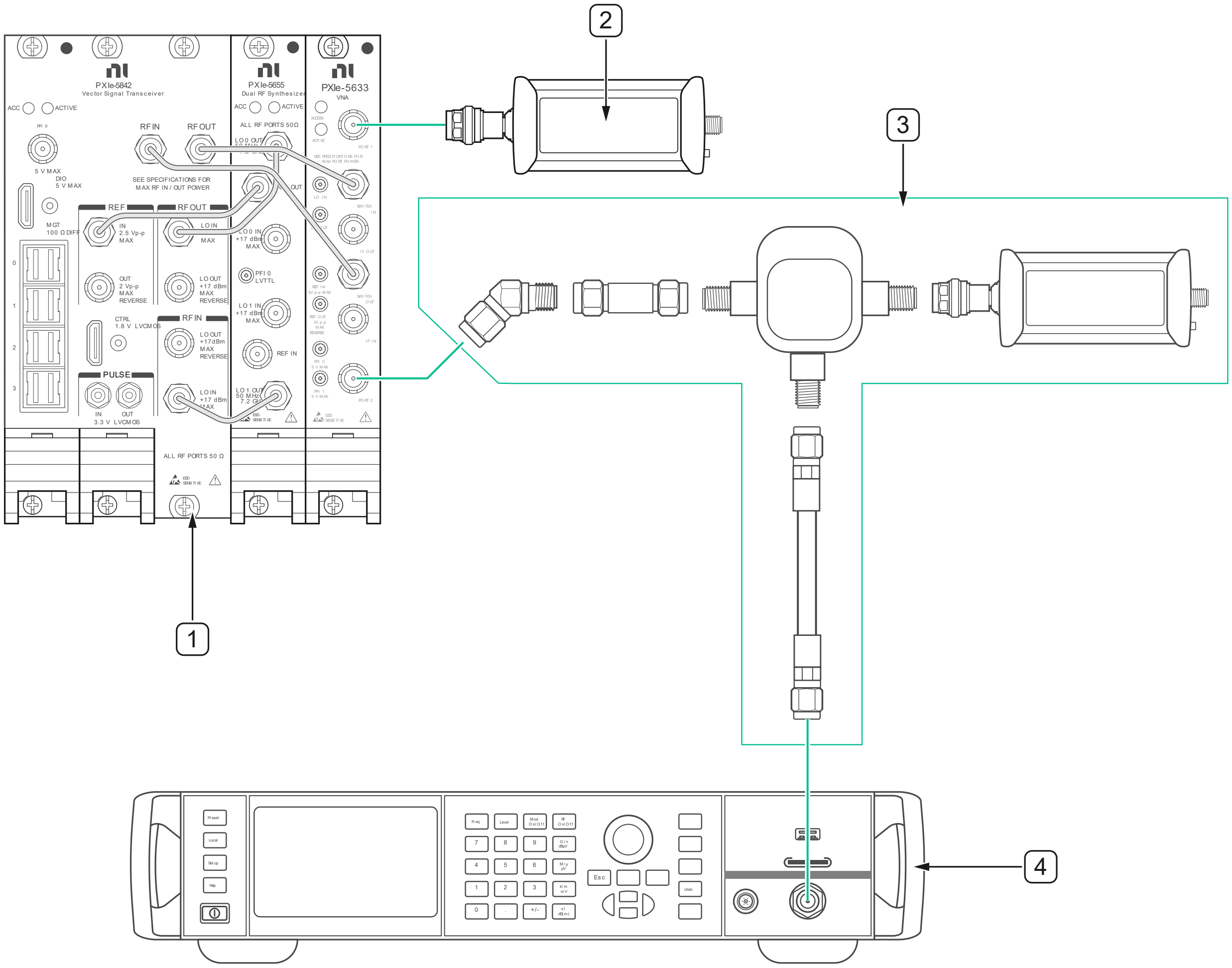
Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Figure 16. Connections for RF Input Absolute Amplitude Accuracy **Port 1** Verification



1. DUT
2. Receiver Fixture from Figure **3**
2. Power Sensor #2
4. Signal Generator

Figure 17. Connections for RF Input Frequency Response Accuracy **Port 2** Verification



1. DUT
2. Power Sensor #2
3. Receiver Fixture from Figure **3**
4. Signal Generator

6.5.2. Verification Procedure

This procedure verifies the Absolute Amplitude accuracy of the DUT's Input channel at a specified center frequencies and power levels for the selected Down Converter Offset Modes.

Table 30: RF Input Amplitude Minimum Reference Power Level

DUT IQ Frequency Range	DUT Minimum Reference Power Level	DUT Upconverter Mode
≤ 13.0 GHz	-45 dBm	User Defined
>13.0GHz to 23.0 GHz	-40 dBm	
>23.0 GHz to Maximum Frequency	-35 dBm	
≤ 4.5 GHz	-45 dBm	Enabled
>4.5 GHz to 6.2 GHz	-40 dBm	
>6.2 GHz to 6.4 GHz	-45 dBm	
>6.4 GHz to 7.3 GHz	-35 dBm	
>7.3 GHz to 15.0 GHz	-40 dBm	
>15.0 GHz to Maximum Frequency	-35 dBm	

Table 31: RF Input Absolute Amplitude Accuracy Test Points and Configurations (**User Defined Mode**)

DUT IQ Center Frequency Range	DUT Reference Power Level	Nominal Power at DUT input	DUT Bandwidth
▪ 30 MHz to 145 MHz in 5 MHz steps ▪ 150 MHz to 290 MHz in 10 MHz steps ▪ 300 MHz to 1.740 GHz in 20 MHz steps ▪ 1.749 GHz ▪ 1.75 GHz to 3.95 GHz in 50 MHz steps ▪ 4.0 GHz to Maximum Frequency in 100 MHz steps Do not test above Maximum DUT Frequency, see **Table 5**	▪ Minimum Reference Power level from **Table 30** to +25 dBm in 5 dB steps.	▪ DUT Reference Power Level ≤10 dBm: Same as the DUT Reference Power Level ▪ DUT Reference Power Level >10 dBm: +10 dBm	Driver Default

Table 32: RF Input Absolute Amplitude Accuracy Test points and Configurations (**Enabled Mode**)

DUT IQ Center Frequency Range	DUT Reference Power Level	Nominal Power at DUT input	DUT Bandwidth
▪ 1.701 GHz ▪ 1.75 GHz to 3.95 GHz in 50 MHz steps ▪ 4.0 GHz to Maximum Frequency in 100 MHz steps Do not test above Maximum DUT Frequency, see **Table 5**	▪ Minimum Reference Power level from **Table 30** to +25 dBm in 5 dB steps.	▪ DUT Reference Power Level ≤10 dBm: Same as the DUT Reference Power Level ▪ DUT Reference Power Level >10 dBm: +10 dBm	See **Table 7**

6.5.3. Verification Procedure (Upconverter Mode = User Defined)

1. Make the connections indicated in **Figure 16.**
2. Configure the DUT for the following settings:
    - Input Port: 1
    - Acquisition type: IQ
    - FFT Window Type: Flat Top
    - IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 6**
    - Number of Samples: 50 kS
    - Downconverter Offset Mode: User Defined
    - Downconverter Frequency Offset: Driver Default
    - Reference Power Level: Initial lower Power Level from Configurations **Table 31**
    - IQ Center Frequency: Initial Center Frequency from Configurations **Table 31**
    - Bandwidth: Signal Bandwidth from Configurations **Table 31**
    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz

3. Configure the Signal Generator for the following settings:
    - RF Frequency: Initial Center Frequency from Configurations **Table 31**
    - Power Level: Power Level such that to achieve the minimum Nominal Power at DUT input from **Table 30**

Note

Nominal Power Level at DUT input should be the:

DUT Reference Power Level (**Table 30**) + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

4. Configure the Power Sensor for the following settings:
    - Frequency: Initial Center Frequency from Configurations **Table 31**
    - Power Meter Path Selection: Auto Mode
    - Aperture Time: Select from **Table 81** based on the expected input power
    - Number of Averages: 1
5. Generate a CW signal on the Signal Generator with the specified settings. Wait until it settles.
6. Taking the measurements:

Repeat, once for each DUT Power Level in Table 31, starting with the lower power setting.

Based on your DUT option, repeat once for each DUT Frequency setting in Table 31 starting with the lower frequency.

7. Measure the power deliver to the DUT with the Power Meter and record the value as “**PM_measured_power**”.
8. Measure the power at the DUT and record the value as “**DUT_measured_power**”.

9. See **Table 31**.
    a. Frequency Deviation: 125 kHz
    b. Search Frequency: Equal to the CW signal on the Signal Generator
10. Calculate the absolute power level accuracy using the following equation:

Input Absolute Amplitude (UD) = DUT_measured_power - **RX_Fixture_PM_to_RX_Path_Response -** PM_measured_power **[dBm]**

Where **"RX_Fixture_PM_to_RX_Path_Response"** is the Receiver Fixture characterized value, at the measurement frequency, calculated by (***Equation 1***) in section **5.1.3 Characterization Procedure**

11. Configure the DUT for the following settings:
    a. IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 6**
    b. IQ Center Frequency: Next Center Frequency from Configurations **Table 31**
    c. Bandwidth: Signal Bandwidth from Configurations **Table 31**
    d. Downconverter Offset:
        1. Frequency <1.75GHz: Driver Default
        2. Frequency ≥1.75 GHz: -20 MHz
12. Configure the Signal Generator for the following settings:
    a. RF Frequency: same as the IQ Center Frequency from previous paragraph
    b. Power Level: Power Level such that to achieve the selected Nominal Power at DUT input at the selected frequency

Note

Nominal Power Level at DUT input should be the:

DUT Reference Power Level selected + RX_Fixture_PM_to_RX_Path_Response

(at the selected frequency (***Equation 1***)).

13. Configure the Power Sensor:

    a. Frequency: Same frequency as the DUT

14. Configure the DUT for the following settings:

    - IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 6**
    - Reference Power Level: Next Power Level from Configurations **Table 31**
    - IQ Center Frequency: Initial Center Frequency from Configurations **Table 31**
    - Bandwidth: Signal Bandwidth from Configurations **Table 31**
    - Downconverter Offset: Driver Default

15. Configure the Signal Generator for the following settings:

    - RF Frequency: Initial Center Frequency from Configurations **Table 31**
    - Power Level: Power Level such that to achieve the selected Nominal Power at DUT input

Note

Nominal Power Level at DUT input should be the:

Selected DUT Reference Power Level + RX_Fixture_PM_to_RX_Path_Response (Equation 1).

16. Configure the Power Sensor for the following settings:
    - Frequency: Initial Center Frequency from Configurations **Table 31**
    - Aperture Time: Select from **Table 81** based on the expected input power
17. Generate a CW signal on the Signal Generator with the specified settings. Wait until it settles.

6.5.4. Verification Procedure (Upconverter Mode = Enabled)

1. Make the connections indicated in **Figure 16.**
2. Configure the DUT for the following settings:
    - Input Port: 1
    - Acquisition type: IQ
    - FFT Window Type: Flat Top
    - IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 6**
    - Number of Samples: 50 kS
    - Downconverter Offset Mode: Enabled
    - Downconverter Frequency Offset: Driver Default

- Reference Power Level: Initial lower Power Level from Configurations **Table 32**
- IQ Center Frequency: Initial Center Frequency from Configurations **Table 32**
- Bandwidth: Signal Bandwidth from Configurations **Table 32**
- Reference Clock Source: PXI_CLK (Locked to Rubidium)
- Reference Clock Frequency: 10 MHz

3. Configure the Signal Generator for the following settings:
   - RF Frequency: Initial Center Frequency from Configurations **Table 32**
   - Power Level: Power Level such that to achieve the minimum Nominal Power at DUT input from **Table 30**.

> **Note**
>
> Nominal Power Level at DUT input should be the:
>
> DUT Reference Power Level (**Table 30**) + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

4. Configure the Power Sensor for the following settings:
   - Frequency: Initial Center Frequency from Configurations **Table 32**.
   - Power Meter Path Selection: Auto Mode
   - Aperture Time: Select from **Table 81** based on the expected input power
   - Number of Averages: 1
5. Generate a CW signal on the Signal Generator with the specified settings. Wait until it settles.
6. Taking the measurements:

Repeat, once for each DUT Power Level in Table 31, starting with the lower power setting.

Based on your DUT option, repeat once for each DUT Frequency setting in Table 32 starting with the lower frequency.

7. Measure the power deliver to the DUT with the Power Meter and record the value as "**PM_measured_power**".

8. Measure the power at the DUT and record the value as "**DUT_measured_power**".

   a. See **Table 32**

      - Frequency Deviation: 125 kHz
      - Search Frequency: Equal to the CW signal on the Signal Generator

9. Calculate the absolute power level accuracy using the following equation:

Input Absolute Amplitude (EN) = DUT_measured_power - **RX_Fixture_PM_to_RX_Path_Response -** PM_measured_power **[dBm]**

Where **"RX_Fixture_PM_to_RX_Path_Response"** is the Receiver Fixture characterized value, at the measurement frequency, calculated by (***Equation 1***) in section **5.1.3 Characterization Procedure**

10. Configure the DUT for the following settings:

    a. IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 6**

    b. IQ Center Frequency: Next Center Frequency from Configurations **Table 32**

    c. Bandwidth: Signal Bandwidth from Configurations **Table 32**

11. Configure the Signal Generator for the following settings:
    a. RF Frequency: same as the IQ Center Frequency from previous paragraph
    b. Power Level: Power Level such that to achieve the selected Nominal Power at DUT input at the selected frequency.

Note

Nominal Power Level at DUT input should be the:

DUT Reference Power Level selected + RX_Fixture_PM_to_RX_Path_Response

(at the selected frequency (***Equation 1***)).

12. Configure the Power Sensor:
    a. Frequency: Same frequency as the DUT

13. Configure the DUT for the following settings:
    a. IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 6**
    b. Reference Power Level: Next Power Level from Configurations **Table 32**
    c. IQ Center Frequency: Initial Center Frequency from Configurations **Table 32**
    d. Bandwidth: Signal Bandwidth from Configurations **Table 32**
14. Configure the Signal Generator for the following settings:
    a. RF Frequency: Initial Center Frequency from Configurations **Table 32**

b. Power Level: Power Level such that to achieve the selected Nominal Power at DUT input

Note

Nominal Power Level at DUT input should be the:

Selected DUT Reference Power Level + RX_Fixture_PM_to_RX_Path_Response (Equation 1).

15. Configure the Power Sensor for the following settings:

    a. Frequency: Initial Center Frequency from Configurations **Table 32**

    b. Aperture Time: Select from **Table 81** based on the expected input power

16. Generate a CW signal on the Signal Generator with the specified settings. Wait until it settles.

6.5.5. Verification Procedure for *Port 2* (Upconverter Mode = User Defined)

1. Repeat procedure 6.5.3 Verification Procedure (Upconverter Mode = **User Defined**) :

   1.1. Replace **Figure 16** with **Figure 17.** Connections for RF Input Frequency Response Accuracy **Port 2** Verification.

   1.2. Where "Port 1" is mentioned, replace with "Port 2".

6.5.6. Verification Procedure for *Port 2* (Upconverter Mode = Enabled)

1. Repeat procedure 6.5.4 Verification Procedure (Upconverter Mode = **Enabled**):

   1.1. Replace **Figure 16** with **Figure 17.** Connections for RF Input Frequency Response Accuracy **Port 2** Verification.

   1.2. Where "Port 1" is mentioned, replace with "Port 2".

6.5.7. RF Input Power Linearity Verification

Table 33: RF Input Linearity Accuracy Verification Test Limits (User Defined and Enabled Modes)

Frequency Range	Verification Test Limits	
	Lower Limit	Upper Limit
30 MHz to 26.5 GHz	-0.50 dB	+0.50 dB

6.5.8. Initial Test Connection

Note

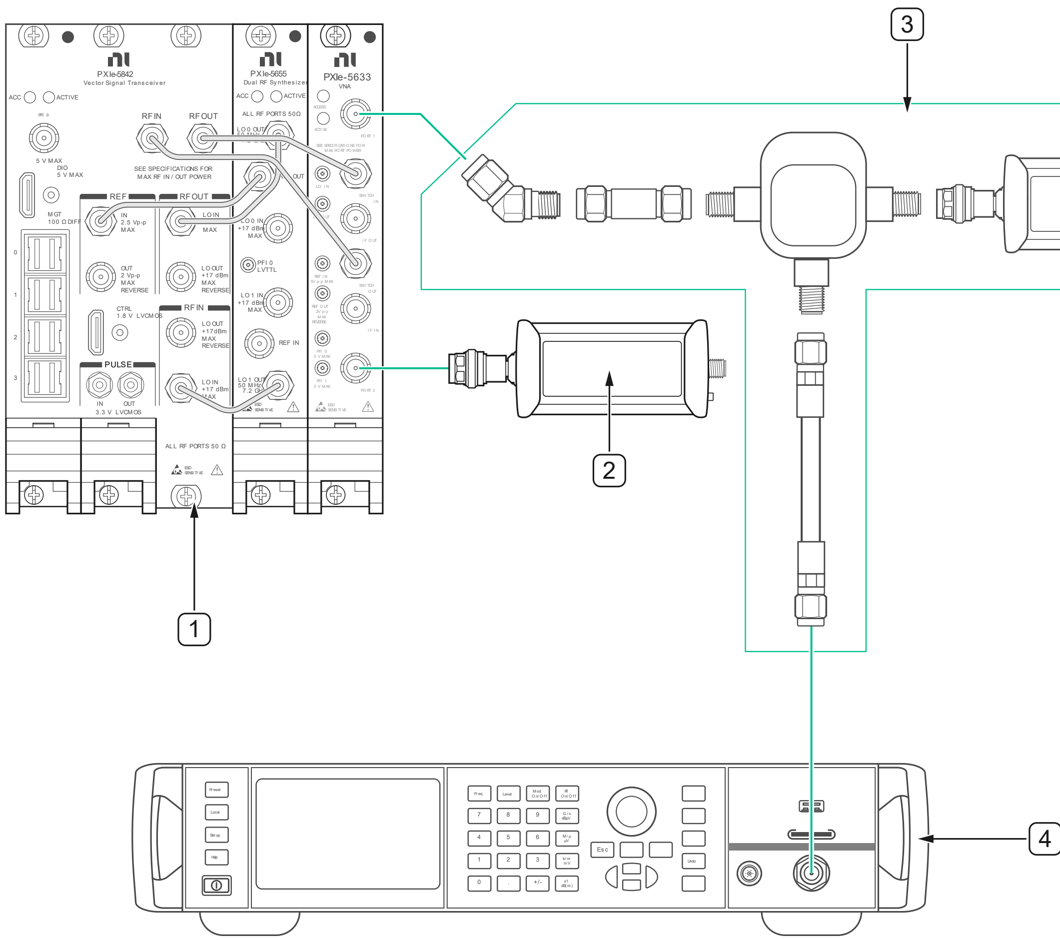
Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

CAUTION
Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Note

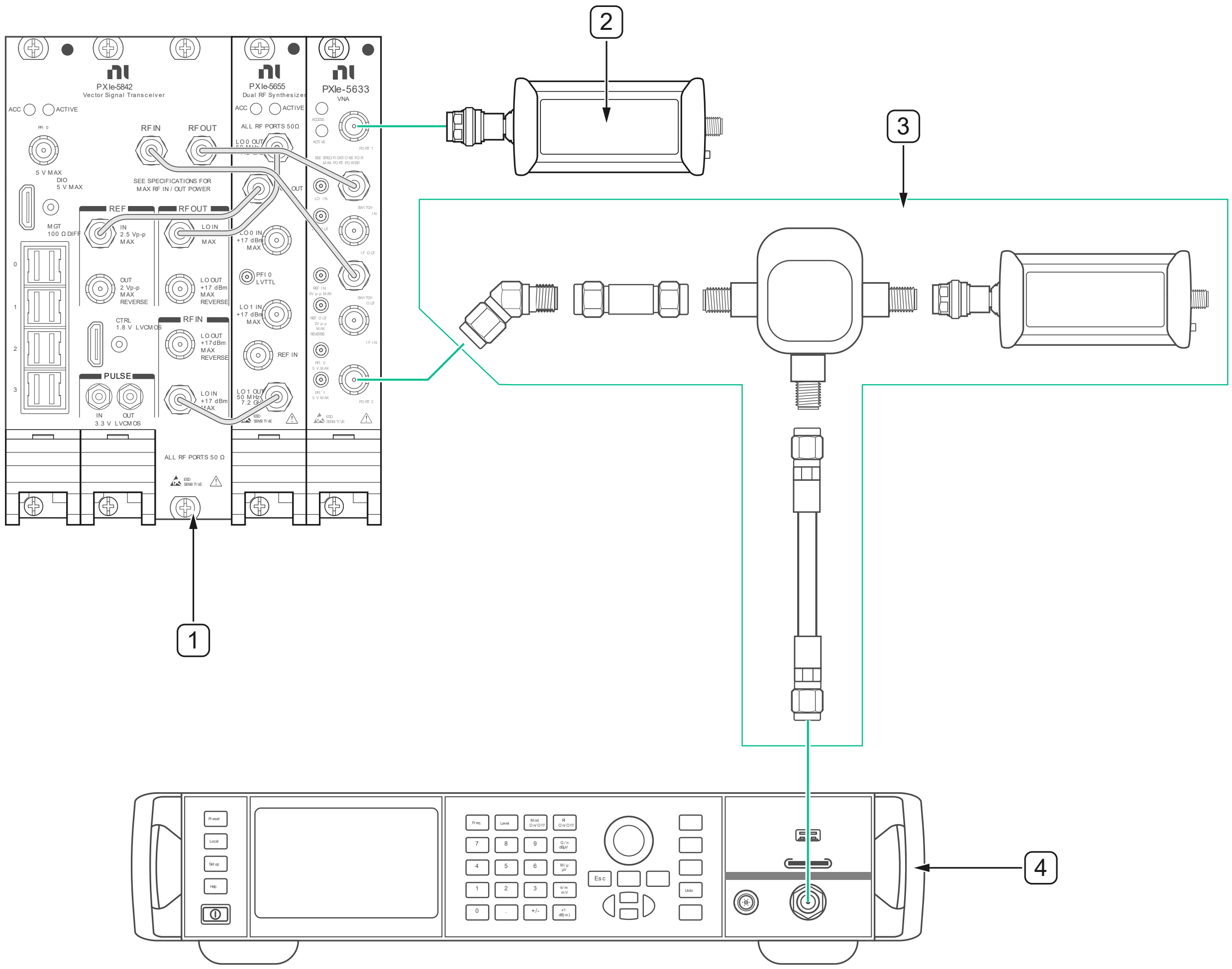
Make sure that you have performed the Input Receiver fixture characterization as per **section 5.1** - Receiver Fixture Characterization before starting this Verification procedure.

Figure 18. Connections for RF Input Power Linearity Accuracy **Port 1** Verification



1. DUT
2. Receiver Fixture from Figure **3**
2. Power Sensor #2
4. Signal Generator

Figure 19. Connections for RF Input Power Linearity Accuracy **Port 2** Verification



1. DUT
2. Power Sensor #2
3. Receiver Fixture from Figure **3**
4. Signal Generator

6.5.9. Verification Procedure

This procedure verifies the input power linearity accuracy of the DUT's Analog to Digital Converter (ADC) Input channel at a specified center frequencies and power levels for the selected Down Converter Offset Modes.

Table 34: RF Input Power Linearity Accuracy Test Points and Configurations (**User Defined Mode**)

DUT IQ Center Frequency Range	DUT Reference Power Level	Nominal Power at DUT input	DUT Bandwidth
▪ 30 MHz, 45 MHz, 50 MHz, 290 MHz, 530 MHz, 770 MHz ▪ 1.010 GHz, 1.490 GHz, 1.730 GHz, 1.749 GHz ▪ 1.75 GHz to Maximum Frequency in 1 GHz steps ▪ 8 GHz, 12 GHz, 18 GHz, and 26.5 GHz Do not test above Maximum DUT Frequency, see **Table 5**	▪ +5 dBm	▪ IQ Center Frequency <10 GHz: -35 dBm to 0 dBm in 1 dB Steps ▪ IQ Center Frequency ≥10 GHz: -40 dBm to 0 dBm in 1 dB steps ▪ Use 0 dBm as the reference power level	Driver Default

Table 35: RF Input Power Linearity Accuracy Test points and Configurations (**Enabled Mode**)

DUT IQ Center Frequency Range	DUT Reference Power Level	Nominal Power at DUT input	DUT Bandwidth
▪ 1.701 GHz ▪ 1.75 GHz to Maximum Frequency in 1 GHz steps ▪ 8 GHz, 12 GHz, 18 GHz, and 26.5 GHz Do not test above Maximum DUT Frequency, see **Table 5**	▪ +5 dBm	▪ IQ Center Frequency <10 GHz: -35 dBm to 0 dBm in 1 dB Steps ▪ IQ Center Frequency ≥10 GHz: -40 dBm to 0 dBm in 1 dB steps ▪ Use 0 dBm as the reference power level	See **Table 7**

6.5.10. Verification Procedure for **Port 1** (Upconverter Mode = **User Defined**)

1. Make the connections indicated in **Figure 18**.
2. Configure the DUT for the following settings:
    - Input Port: 1
    - Acquisition type: IQ
    - FFT Window Type: Flat Top
    - IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 6**
    - Number of Samples: 50 kS
    - Downconverter Offset Mode: User Defined
    - Downconverter Frequency Offset: Driver Default
    - Reference Power Level: Power Level from Configurations **Table 34**
    - IQ Center Frequency: Initial Center Frequency from Configurations **Table 34**
    - Bandwidth: Signal Bandwidth from Configurations **Table 34**
    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz
3. Configure the Signal Generator for the following settings:
    - RF Frequency: Initial Center Frequency from Configurations **Table 34**
    - Power Level: Power Level such that to achieve 0 dBm Power at DUT input.

Note

Nominal Power Level at DUT input should be the:

DUT Reference Power Level (**0 dBm**) + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

4. Configure the Power Sensor for the following settings:
   - Frequency: Initial Center Frequency from Configurations **Table 34**
   - Power Meter Path Selection: Auto Mode
   - Aperture Time: Select from **Table 81** based on the expected input power
   - Number of Averages: 1

5. Generate a CW signal on the Signal Generator with the specified settings. Wait until it settles.

6. Taking the measurements:

Repeat, once for each DUT Power Level in Table 34, starting with the 0 dBm Reference power setting down to the minimum power setting.

Based on your DUT option, repeat once for each DUT Frequency setting in Table 34 starting with the lower frequency.

7. Measure the power deliver to the DUT with the Power Meter and record the value as "**PM_measured_power**".

8. Measure the power at the DUT and record the value as "**DUT_measured_power"**.

   a. See **9.2 - Acquiring a Spectrum from IQ Data and Measuring the Peak**

      1. Frequency Deviation: 125 kHz

      2. Search Frequency: Equal to the CW signal on the Signal Generator

9. Calculate the Input absolute power level accuracy using the following equation:

Input Absolute Amplitude (UDLin) = DUT_measured_power - **RX_Fixture_PM_to_RX_Path_Response -** PM_measured_power **[dBm]**

Where **"RX_Fixture_PM_to_RX_Path_Response"** is the Receiver Fixture characterized value, at the measurement frequency, calculated by (***Equation 1***) in section **5.1.3 Characterization Procedure.**

10. If this power iteration to measure the 0 dBm Reference power setting, skip the next step and save the measurement as "**Absolute Amplitude$_{0dBm}$ (UDLin)"** at the set frequency.

11. Calculate the RF Input Power Linearity Accuracy using the following equation:

Input_Power_Linearity (UD)= Input Absolute Amplitude (UDLin) – Input Absolute Amplitude$_{0dBm}$ (UDLin)

Where "**Input Absolute Amplitude$_{0dBm}$ (UDLin)"** is the power measured previously at 0 dBm reference for the set frequency.

12. Configure the DUT for the following settings:
    a. IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 6**
    b. IQ Center Frequency: Next Center Frequency from Configurations **Table 34**
    c. Bandwidth: Signal Bandwidth from Configurations **Table 34**
    d. Downconverter Offset:
        1. Frequency <1.75GHz: Driver Default
        2. Frequency ≥1.75 GHz: -20 MHz

13. Configure the Signal Generator for the following settings:
    a. RF Frequency: same as the IQ Center Frequency from previous paragraph
    b. Power Level: Power Level such that to achieve the selected Nominal Power at DUT input at the selected frequency

Note

Nominal Power Level at DUT input should be the:

DUT Reference Power Level selected + RX_Fixture_PM_to_RX_Path_Response

(at the selected frequency (***Equation 1***)).

14. Configure the Power Sensor:
    a. Frequency: Same frequency as the DUT

15. Configure the DUT for the following settings:
    a. IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 6**
    b. Reference Power Level: Next Power Level down from Configurations **Table 34**
    c. IQ Center Frequency: Initial Center Frequency from Configurations **Table 34**
    d. Bandwidth: Signal Bandwidth from Configurations **Table 34**
    e. Downconverter Offset: Driver Default

16. Configure the Signal Generator for the following settings:
    a. RF Frequency: Initial Center Frequency from Configurations **Table 31**.
    b. Power Level: Power Level such that to achieve the selected Nominal Power at DUT input

Note

Nominal Power Level at DUT input should be the:

Selected DUT Reference Power Level +
RX_Fixture_PM_to_RX_Path_Response

(Equation 1).

17. Configure the Power Sensor for the following settings:
    a. Frequency: Initial Center Frequency from Configurations **Table 34**
    b. Aperture Time: Select from **Table 81** based on the expected input power
18. Generate a CW signal on the Signal Generator with the specified settings. Wait until it settles.

6.5.11. Verification Procedure for Port 1 (Upconverter Mode = Enabled)

1. Make the connections indicated in **Figure 18**.

2. Configure the DUT for the following settings:
    - Input Port: 1
    - Acquisition type: IQ
    - FFT Window Type: Flat Top
    - IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 6**
    - Number of Samples: 50 kS
    - Downconverter Offset Mode: Enabled
    - Downconverter Frequency Offset: Driver Default
    - Reference Power Level: Power Level from Configurations **Table 35**

- IQ Center Frequency: Initial Center Frequency from Configurations **Table 35**
- Bandwidth: Signal Bandwidth from Configurations **Table 35**
- Reference Clock Source: PXI_CLK (Locked to Rubidium)
- Reference Clock Frequency: 10 MHz

3. Configure the Signal Generator for the following settings:

    - RF Frequency: Initial Center Frequency from Configurations **Table 35**
    - Power Level: Power Level such that to achieve 0 dBm Power at DUT input.

Note

Nominal Power Level at DUT input should be the:

DUT Reference Power Level (**0 dBm**) + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

4. Configure the Power Sensor for the following settings:

    - Frequency: Initial Center Frequency from Configurations **Table 35**
    - Power Meter Path Selection: Auto Mode
    - Aperture Time: Select from **Table 81** based on the expected input power
    - Number of Averages: 1

5. Generate a CW signal on the Signal Generator with the specified settings. Wait until it settles.

6. Taking the measurements:

Repeat, once for each DUT Power Level in Table 35, starting with the 0 dBm Reference power setting down to the minimum power setting.

Based on your DUT option, repeat once for each DUT Frequency setting in Table 35 starting with the lower frequency.

7. Measure the power deliver to the DUT with the Power Meter and record the value as “PM_measured_power”.

8. Measure the power at the DUT and record the value as “**DUT_measured_power”**.

   a. See **9.2 - Acquiring a Spectrum from IQ Data and Measuring the Peak**

      1. Frequency Deviation: 125 kHz

      2. Search Frequency: Equal to the CW signal on the Signal Generator

9. Calculate the Input absolute power level accuracy using the following equation:

Input Absolute Amplitude (ENLin) = DUT_measured_power - **RX_Fixture_PM_to_RX_Path_Response -** PM_measured_power **[dBm]**

Where **“RX_Fixture_PM_to_RX_Path_Response”** is the Receiver Fixture characterized value, at the measurement frequency, calculated by (***Equation 1***) in section **5.1.3 Characterization Procedure**

10. If this power iteration is to measure the 0 dBm Reference power setting, skip the next step and save the measurement as “**Absolute Amplitude$_{0dBm}$ (ENLin)”** at the set frequency.

11. Calculate the RF Input Power Linearity Accuracy using the following equation:

Input_Power_Linearity (EN)= Input Absolute Amplitude (ENLin) – Input Absolute Amplitude$_{0dBm}$ (ENLin)

Where “**Input Absolute Amplitude$_{0dBm}$ (ENLin)”** is the power measured previously at 0 dBm reference for the set frequency.

12. Configure the DUT for the following settings:
    a. IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 6**
    b. IQ Center Frequency: Next Center Frequency from Configurations **Table 35**
    c. Bandwidth: Signal Bandwidth from Configurations **Table 35**
    d. Downconverter Offset: Driver Default
13. Configure the Signal Generator for the following settings:
    a. RF Frequency: same as the IQ Center Frequency from previous paragraph
    b. Power Level: Power Level such that to achieve the selected Nominal Power at DUT input at the selected frequency

Note

Nominal Power Level at DUT input should be the:

DUT Reference Power Level selected + RX_Fixture_PM_to_RX_Path_Response

(at the selected frequency (***Equation 1***)).

14. Configure the Power Sensor:
    a. Frequency: Same frequency as the DUT

15. Configure the DUT for the following settings:
    a. IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 6**

b. Reference Power Level: Next Power Level down from Configurations **Table 35**

c. IQ Center Frequency: Initial Center Frequency from Configurations **Table 35**

d. Bandwidth: Signal Bandwidth from Configurations **Table 35**

e. Downconverter Offset: Driver Default

16. Configure the Signal Generator for the following settings:

    a. RF Frequency: Initial Center Frequency from Configurations **Table 35**.

    b. Power Level: Power Level such that to achieve the selected Nominal Power at DUT input

> **Note**
>
> Nominal Power Level at DUT input should be the:
>
> Selected DUT Reference Power Level + RX_Fixture_PM_to_RX_Path_Response (Equation 1).

17. Configure the Power Sensor for the following settings:

    a. Frequency: Initial Center Frequency from Configurations **Table 35**.

    b. Aperture Time: Select from **Table 81** based on the expected input power.

18. Generate a CW signal on the Signal Generator with the specified settings. Wait until it settles.

6.5.12. Verification Procedure for Port 2 (Upconverter Mode = User Defined)

1. Repeat procedure 6.6.3 Verification Procedure for **Port 1** (Upconverter Mode = **User Defined**):

   1.1. Replace **Figure 18** with **Figure 19.** Connections for RF Input Power Linearity Accuracy **Port 2** Verification.

   1.2. Where “Port 1” is mentioned, replace with “Port 2”.

6.5.13. Verification Procedure for Port 2 (Upconverter Mode = Enabled)

1. Repeat procedure 6.6.4 Verification Procedure for **Port 1** (Upconverter Mode = **Enabled**):

   1.1. Replace **Figure 18** with **Figure 19.** Connections for RF Input Power Linearity Accuracy **Port 2** Verification.

   1.2. Where “Port 1” is mentioned, replace with “Port 2”.

6.6. RF Input Frequency Response Verification

6.6.1. Test Limits

Table 36: RF Input Frequency Response Accuracy Verification Test Limits (**User Defined Mode**)

Frequency Range	Verification Test Limit	
	Lower Limit	Upper Limit
30 MHz to 1.75 GHz	-1.0 dB	+1.0 dB
>1.75 GHz to 6.0 GHz	-0.90 dB	+0.90 dB
>6.0 GHz to 12.0 GHz	-1.25 dB	+1.25 dB
>12.0 GHz to 22.0 GHz	-1.35 dB	+1.35 dB
>22.0 GHz to 26.5 GHz	-2.35 dB	+2.35 dB

Table 37: RF Input Frequency Response Verification Test Limits (**Enabled Mode**)

Frequency Range	Verification Test Limit	
	Lower Limit	Upper Limit
1.7 GHz to 6.0 GHz	-0.90 dB	+0.90 dB
>6.0 GHz to 12.0 GHz	-1.25 dB	+1.25 dB
>12.0 GHz to 22.0 GHz	-1.35 dB	+1.35 dB
>22.0 GHz to 26.5 GHz	-2.35 dB	+2.35 dB

6.6.2. Initial Test Connection

Note

Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

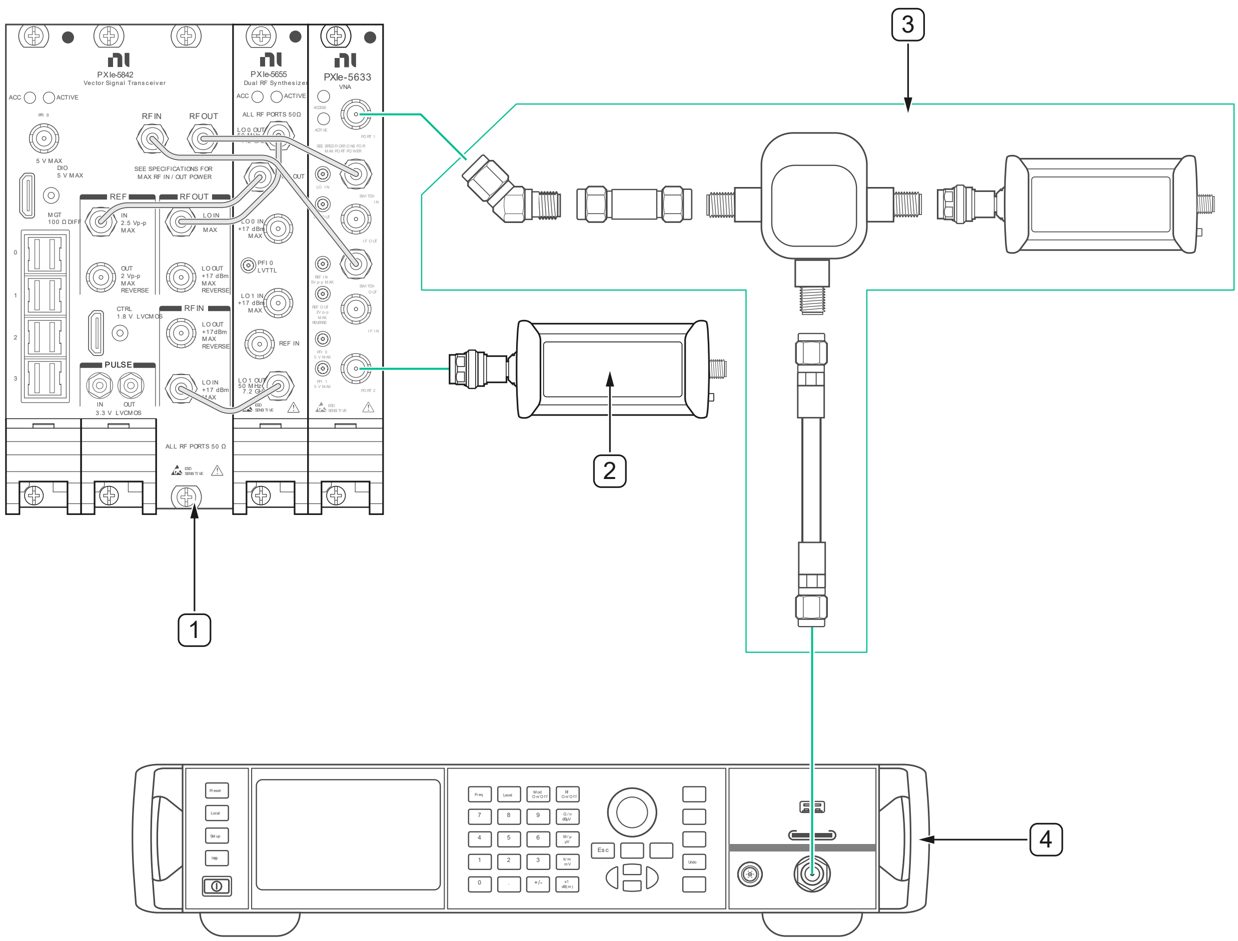
CAUTION

Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Note

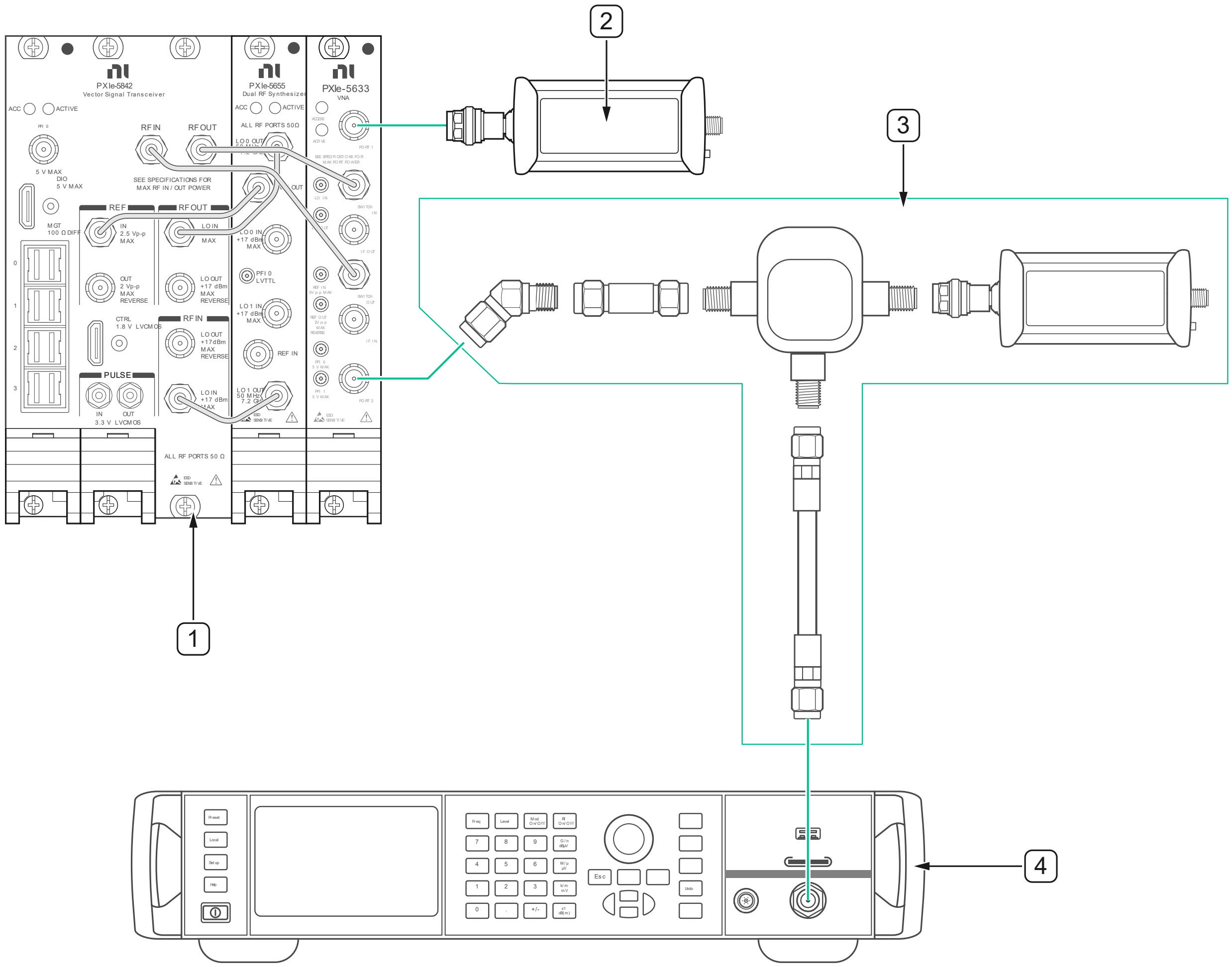
Make sure that you have performed the Input Receiver fixture characterization as per **section 5.1** - Receiver Fixture Characterization before starting this Verification procedure.

Figure 20. Connections for RF Input Frequency Response Accuracy **Port 1** Verification



1. DUT
2. Receiver Fixture from Figure **3**
2. Power Sensor #2
4. Signal Generator

Figure 21. Connections for RF Input Frequency Response Accuracy **Port 2** Verification



1. DUT
2. Power Sensor #2
3. Receiver Fixture from Figure **3**
4. Signal Generator

6.6.3. Verification Procedure

This procedure verifies the Frequency Response accuracy of the DUT's input channel at a specified downconverter center frequency within the bandwidth selected.

Table 38: RF Input Frequency Response Accuracy **Port 1 and Port 2** Test Points and Configurations (**User Defined Mode**)

DUT IQ Center Frequency Range	DUT Reference Power Level	Power Level at DUT input	Reference Tone Offset	Additional Sweep Info	DUT Bandwidth
▪ 31 MHz ▪ 35 MHz to 65 MHz in 5 MHz steps	▪ -30 dBm ▪ 0 dBm ▪ +25 dBm	▪ -30 dBm ▪ 0 dBm ▪ +10 dBm	0 Hz	Sweep Step Size: 1 MHz	See **Table 8**
▪ 75 MHz to 275 MHz in 25 MHz steps				Sweep Step Size: 5 MHz Must include: ±39 MHz and ±41 MHz	
▪ 280 MHz ▪ 300 MHz to 500 MHz in 100 MHz steps				Sweep Step Size: 10 MHz Must include: ±39 MHz, ±41 MHz and ±250 MHz	
▪ 530 MHz ▪ 1015 MHz ▪ 750 MHz to 1.5 GHz in 250 MHz steps ▪ 750 MHz to 1.5 GHz in 125 MHz steps if Reference Power Level is 0 dBm				Sweep Step Size: 20 MHz Must include: ±39 MHz, ±41 MHz, ±250 MHz and ±500 MHz	
▪ 1.749 GHz				Sweep Step Size: 50 MHz	

				Must include: ±20 MHz, ±39 MHz, ±41 MHz and ±250 MHz	
▪ 1.75 GHz to 26.5 GHz in 250 MHz steps ▪ 1.75 GHz to 26.5 GHz in 125 MHz steps if Reference Power Level is 0 dBm Do not test above Maximum DUT Frequency, see **Table 5**			20 MHz	Sweep Step Size: 50 MHz. Must include: ±20 MHz, ±39 MHz, ±41 MHz, ±250 MHz and ±500 MHz Remove 0 Hz offset (start your sweep from +20 MHz up, and -20 MHz down)	

Table 39: RF Input Frequency Response Accuracy **Port 1 and Port 2** Test Points and Configurations (**Enabled Mode**)

DUT IQ Center Frequency Range	DUT Reference Power Level	Power Level at DUT input	Reference Tone Offset	Additional Sweep Info	DUT Bandwidth
▪ 1.701 GHz ▪ 1.75 GHz to 26.5 GHz in 250 MHz steps ▪ 1.75 GHz to 26.5 GHz in 125 MHz steps if Reference Power Level is 0 dBm Do not test above Maximum DUT Frequency, see **Table 5**	▪ -30 dBm ▪ 0 dBm ▪ +25dBm	▪ -30 dBm ▪ 0 dBm ▪ +10 dBm	0 Hz	Sweep Step Size: 50 MHz. Must include: ±125 MHz and ±250 MHz	See **Table 7**

6.6.4. Verification Procedure for *Port 1* (Upconverter Mode = User Defined)

1. Power Meter Aperture configuration

The power meter requires that the frequency is configured to perform internal corrections to achieve its warranted specifications. Always configure the frequency of the power meter before making a measurement.

The power meter's accuracy also depends on the power level it is measuring; set the aperture according to **Table 81:** Power Meter Aperture Configuration

2. Make the connections indicated in **Figure 20** for Verification.

3. Configure the DUT for the following settings for "User Defined" mode:

    - Input Port: 1
    - IQ Center Frequency: Initial Center Frequency from Configurations **Table 38**
    - Reference Power Level: Initial lower Power Level from Configurations **Table 38**
    - Downconverter Offset Mode: User Defined
    - Downconverter Frequency Offset: Driver Default
    - Bandwidth: Signal Bandwidth from Configurations **Table 38**
    - Acquisition Type: IQ
    - FFT Window Type: Flat Top
    - IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 38**
    - Number of Samples: 50 kS
    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz

4. Configure the Signal Generator for the following settings:

    - RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 38**.
    - Power Level: Power Level such that to achieve the lowest Power Level at DUT input indicated in Configurations **Table 38**.

Note

The Power Level at DUT input should be the:

Power Level at DUT input + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

5. Configure the Power Sensor for the following settings:
   - RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 38**
   - Power Meter Path Selection: Auto Mode
   - Aperture Time: Select from **Table 81** based on the expected input power
   - Number of Averages: 1
6. Generate an RF signal on the Signal Generator with the specified settings. Wait until it settles.
7. Taking the measurements:

Repeat, once for each DUT Power Level in Table 38, starting with the lower power setting.

Based on your DUT option, repeat once for each DUT Center Frequency setting in Table 38.

Note

Input Frequency Response$_{Ref}$ is always determined at the (Frequency + Reference Tone Offset) test point.

For example, if the IQ Center frequency is 1.75 GHz and the Reference Tone Offset is 0 Hz, then the reference is measured and calculated at (1.75 GHz + 0) =1.75 GHz.
if the IQ Center frequency is 1.75 GHz and the Reference Tone Offset is 20 MHz, then the reference is measured and calculated at (1.75 GHz + 20 MHz) =1.77 GHz.

8. Measure the power deliver to the DUT with the Power Meter and record the value as "PM_measured_power$_{Ref}$".
9. Measure the power at the DUT and record the value as "**DUT_measured_power$_{Ref}$**".

   a. See **9.2 - Acquiring a Spectrum from IQ Data and Measuring the Peak** Annex for more details on how to make this measurement.

      1. Frequency Deviation: 125 kHz
      2. Search Frequency: Equal to the CW signal on the Signal Generator

10. Calculate the Input absolute power Reference level using the following equation:

Input Frequency Response$_{Ref}$ = DUT_measured_power$_{Ref}$ - RX_Fixture_PM_to_RX_Path_Response - PM_measured_power$_{Ref}$ **[dB]**

Where **"RX_Fixture_PM_to_RX_Path_Response"** is the Receiver Fixture characterized value, at the measurement frequency, calculated by (***Equation 1***) in section **5.1.3 Characterization Procedure**

Repeat, sweeping the Tone Offset Frequency of the DUT through all Tone Offsets.
Start from Center Frequency to –Signal Bandwidth/2 and from Center Frequency to +Signal Bandwidth/2, in step sizes indicated on Table 38.

Note

The test points within a BW should start at the center point zero and expand symmetrically from that, at the required step size, to both ±Bandwidth/2 points.

For Center Frequencies where the reference Tone offset is different than zero, test points should start at (Center Frequency + reference

Tone offset) and expand up, and (Center Frequency - reference Tone offset) and expand down.

11. MultiTone VI Cluster Input:
    a. Tone Frequency = Next Tone Offset based on the step size in **Table 38**.
12. Configure the Power Sensor for the following settings:
13. Frequency: (Current Center Frequency + Reference Tone Offset + Next Sweep Step) from Configurations **Table 38**.
14. Measure the power of the DUT with the Power Meter and record the value as "PM_measured_power$_i$".
    a. Where "x_i" is a linear index number to identify each new tone offset within the sweep from 1 to n.
15. Calculate the Frequency Response Input Frequency Response (UD) for each Tone Offset Frequency:

Input Frequency Response$_i$ = DUT_measured_power$_i$ - RX_Fixture_PM_to_RX_Path_Response - PM_measured_power$_i$ **[dB]**

16. Calculate the normalized frequency response for each baseband tone offset "x_i" using the following equation:

Normalized_Frequency_Response$_i$ = Input Frequency Response$_i$ – Input Frequency Response$_{Ref}$ [dB]

17. Calculate the maximum frequency response error using the following equation:

Max Input Frequency Response (UD) = Maximum (|Normalized_Frequency_Response$_i$|,...,|Normalized_Frequency_Response$_n$|) [dB]

18. Configure the DUT for the following settings for "User Defined" mode:

    - IQ Center Frequency: next Center Frequency from Configurations **Table 38**
    - Bandwidth: Signal Bandwidth from Configurations **Table 38**

- IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 38**

19. Configure the Signal Generator for the following settings:

    - RF Frequency: (Next Frequency + Reference Tone Offset) from Configurations **Table 38**.
    - Power Level: Power Level such that to achieve the set Power Level at DUT input for this step.

Note

The Power Level at DUT input should be the:

Power Level at DUT input + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

20. Configure the Power Sensor for the following settings:

    - RF Frequency: same frequency as the Signal Generator
    - Aperture Time: Select from **Table 81** based on the expected input power

21. Generate an RF signal on the Signal Generator with the specified settings. Wait until it settles.

22. Configure the DUT for the following settings for “User Defined” mode:

    - IQ Center Frequency: Initial Center Frequency from Configurations **Table 38**
    - Reference Power Level: Next lower Power Level from Configurations **Table 38**
    - Bandwidth: Signal Bandwidth from Configurations **Table 38**
    - IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 38**

23. Configure the Signal Generator for the following settings:
    - RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 38**.
    - Power Level: Power Level such that to achieve the next Power Level at DUT input indicated in Configurations **Table 38**.

Note

The Power Level at DUT input should be the:

Power Level at DUT input + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

24. Configure the Power Sensor for the following settings:
    - RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 38**
    - Aperture Time: Select from **Table 81** based on the expected input power
25. Generate an RF signal on the Signal Generator with the specified settings. Wait until it settles.

6.6.5. Verification Procedure *Port 1* (Upconverter Mode = Enabled)

1. Power Meter Aperture configuration.

   The power meter requires that the frequency is configured to perform internal corrections to achieve its warranted specifications. Always configure the frequency of the power meter before making a measurement.

The power meter's accuracy also depends on the power level it is measuring; set the aperture according to **Table 81:** Power Meter Aperture Configuration

2. Make the connections indicated in **Figure 20**.

3. Configure the DUT for the following settings for "User Defined" mode:

   - Input Port: 2
   - IQ Center Frequency: Initial Center Frequency from Configurations **Table 39**
   - Reference Power Level: Initial lower Power Level from Configurations **Table 39**
   - Downconverter Offset Mode: User Defined
   - Downconverter Frequency Offset: Driver Default
   - Bandwidth: Signal Bandwidth from Configurations **Table 39**
   - Acquisition Type: IQ
   - FFT Window Type: Flat Top
   - IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 39**
   - Number of Samples: 50 kS
   - Reference Clock Source: PXI_CLK (Locked to Rubidium)
   - Reference Clock Frequency: 10 MHz

4. Configure the Signal Generator for the following settings:

   - RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 39**.
   - Power Level: Power Level such that to achieve the lowest Power Level at DUT input indicated in Configurations **Table 39**.

Note

The Power Level at DUT input should be the:

Power Level at DUT input + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

5. Configure the Power Sensor for the following settings:
   - RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 38**
   - Power Meter Path Selection: Auto Mode
   - Aperture Time: Select from **Table 81** based on the expected input power
   - Number of Averages: 1

6. Generate an RF signal on the Signal Generator with the specified settings. Wait until it settles.

7. Taking the measurements:

Repeat, once for each DUT Power Level in Table 39, starting with the lower power setting.

Based on the DUT option, repeat once for each DUT Center Frequency setting in Table 39.

Note

Input Frequency Response$_{Ref}$ is always determined at the (Frequency + Reference Tone Offset) test point.

For example, if the IQ Center frequency is 1.75 GHz and the Reference Tone Offset is 0 Hz, then the reference is measured and calculated at (1.75 GHz + 0) =1.75 GHz.
if the IQ Center frequency is 1.75 GHz and the Reference Tone Offset is 20 MHz, then the reference is measured and calculated at (1.75 GHz + 20 MHz) =1.77 GHz.

8. Measure the power deliver to the DUT with the Power Meter and record the value as "PM_measured_power$_{Ref}$".

9. Measure the power at the DUT and record the value as "**DUT_measured_power**$_{Ref}$".

   a. See **9.2 - Acquiring a Spectrum from IQ Data and Measuring the Peak** Annex for more details on how to make this measurement.

      1. Frequency Deviation: 125 kHz

      2. Search Frequency: Equal to the CW signal on the Signal Generator

10. Calculate the Input absolute power Reference level using the following equation:

Input Frequency Response$_{Ref}$ **= DUT_measured_power**$_{Ref}$ **- RX_Fixture_PM_to_RX_Path_Response -** PM_measured_power$_{Ref}$ **[dB]**

Where **"RX_Fixture_PM_to_RX_Path_Response"** is the Receiver Fixture characterized value, at the measurement frequency, calculated by (***Equation 1***) in section **5.1.3 Characterization Procedure**

Repeat, sweeping the Tone Offset Frequency of the DUT through all Tone Offsets.
Start from Center Frequency to –Signal Bandwidth/2 and from Center Frequency to +Signal Bandwidth/2, in step sizes indicated on Table 39.

Note

The test points within a BW should start at the center point zero and expand symmetrically from that, at the required step size, to both ±Bandwidth/2 points.

For Center Frequencies where the reference Tone offset is different than zero, test points should start at (Center Frequency + reference Tone offset) and expand up, and (Center Frequency - reference Tone offset) and expand down.

11. MultiTone VI Cluster Input:

    a. Tone Frequency = Next Tone Offset based on the step size in **Table 39**.

12. Configure the Power Sensor for the following settings:

13. Frequency: (Current Center Frequency + Reference Tone Offset + Next Sweep Step) from Configurations **Table 39**.

14. Measure the power of the DUT with the Power Meter and record the value as "**PM_measured_power$_i$**". Where "x_i" is a linear index number to identify each new tone offset within the sweep from 1 to n.

15. Calculate the Frequency Response Input Frequency Response (UD) for each Tone Offset Frequency:

$$\textbf{Input Frequency Response}_i = \textbf{DUT\_measured\_power}_i - \textbf{RX\_Fixture\_PM\_to\_RX\_Path\_Response} - \text{PM\_measured\_power}_i\ \textbf{[dB]}$$

16. Calculate the normalized frequency response for each baseband tone offset "x_i" using the following equation:

$$\textbf{Normalized\_Frequency\_Response}_i = \textbf{Input Frequency Response}_i - \textbf{Input Frequency Response}_{Ref}\ \textbf{[dB]}$$

17. Calculate the maximum frequency response error using the following equation:

$$\textbf{Max Input Frequency Response (EN) = Maximum } (|\textbf{Normalized\_Frequency\_Response}_i|, \ldots, |\textbf{Normalized\_Frequency\_Response}_n|)\ \textbf{[dB]}$$

18. Configure the DUT for the following settings for "User Defined" mode:

   a. IQ Center Frequency: next Center Frequency from Configurations **Table 39**

   b. Bandwidth: Signal Bandwidth from Configurations **Table 39**

   c. IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 39**

19. Configure the Signal Generator for the following settings:

   a. RF Frequency: (Next Frequency + Reference Tone Offset) from Configurations **Table 39**.

   b. Power Level: Power Level such that to achieve the set Power Level at DUT input for this step.

Note

The Power Level at DUT input should be the:

Power Level at DUT input + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

20. Configure the Power Sensor for the following settings:

   a. RF Frequency: same frequency as the Signal Generator

   b. Aperture Time: Select from **Table 81** based on the expected input power

21. Generate an RF signal on the Signal Generator with the specified settings. Wait until it settles.

22. Configure the DUT for the following settings for “User Defined” mode:

   a. IQ Center Frequency: Initial Center Frequency from Configurations **Table 39**.

b. Reference Power Level: Next lower Power Level from Configurations **Table 39**.

c. Bandwidth: Signal Bandwidth from Configurations **Table 39**.

d. IQ Rate: Maximum IQ rate for the DUT from DUT Hardware Options Maximum Signal Bandwidth **Table 39**.

23. Configure the Signal Generator for the following settings:

a. RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 39**.

b. Power Level: Power Level such that to achieve the next Power Level at DUT input indicated in Configurations **Table 39**.

Note

The Power Level at DUT input should be the:

Power Level at DUT input + RX_Fixture_PM_to_RX_Path_Response (***Equation 1***).

24. Configure the Power Sensor for the following settings:

a. RF Frequency: (Initial Frequency + Reference Tone Offset) from Configurations **Table 39**.

b. Aperture Time: Select from **Table 81** based on the expected input power

25. Generate an RF signal on the Signal Generator with the specified settings. Wait until it settles.

6.6.6. Verification Procedure for *Port 2* (Upconverter Mode = User Defined)

1. Repeat procedure 6.7.4 Verification Procedure for ***Port 1*** (Upconverter Mode = **User Defined**):

   1.1. Replace **Figure 20** with **Figure 21.** Connections for RF Input Frequency Response Accuracy **Port 2** Verification.

   1.2. Where "Port 1" is mentioned, replace with "Port 2".

6.6.7. Verification Procedure for *Port 2* (Upconverter Mode = Enabled)

1. Repeat procedure 6.7.5 Verification Procedure ***Port 1*** (Upconverter Mode = **Enabled**):

   1.1. Replace **Figure 20** with **Figure 21.** Connections for RF Input Frequency Response Accuracy **Port 2** Verification.

   1.2. Where "Port 1" is mentioned, replace with "Port 2".

6.7. RF Output Average Noise Density Verification

6.7.1. Test Limits

Table 40: Test Points/Limits for Verification Test

Frequency Range	Output Power	Verification Test Limits
		High Limit
30 MHz to 600 MHz	+15 dBm If the +15 dBm point is above the Max Linear Power endpoint for that frequency,	-112.0 dBm
>600 MHz to 1.75 GHz		-123.0 dBm
>1.75 GHz to 3.75 GHz		-125.0 dBm

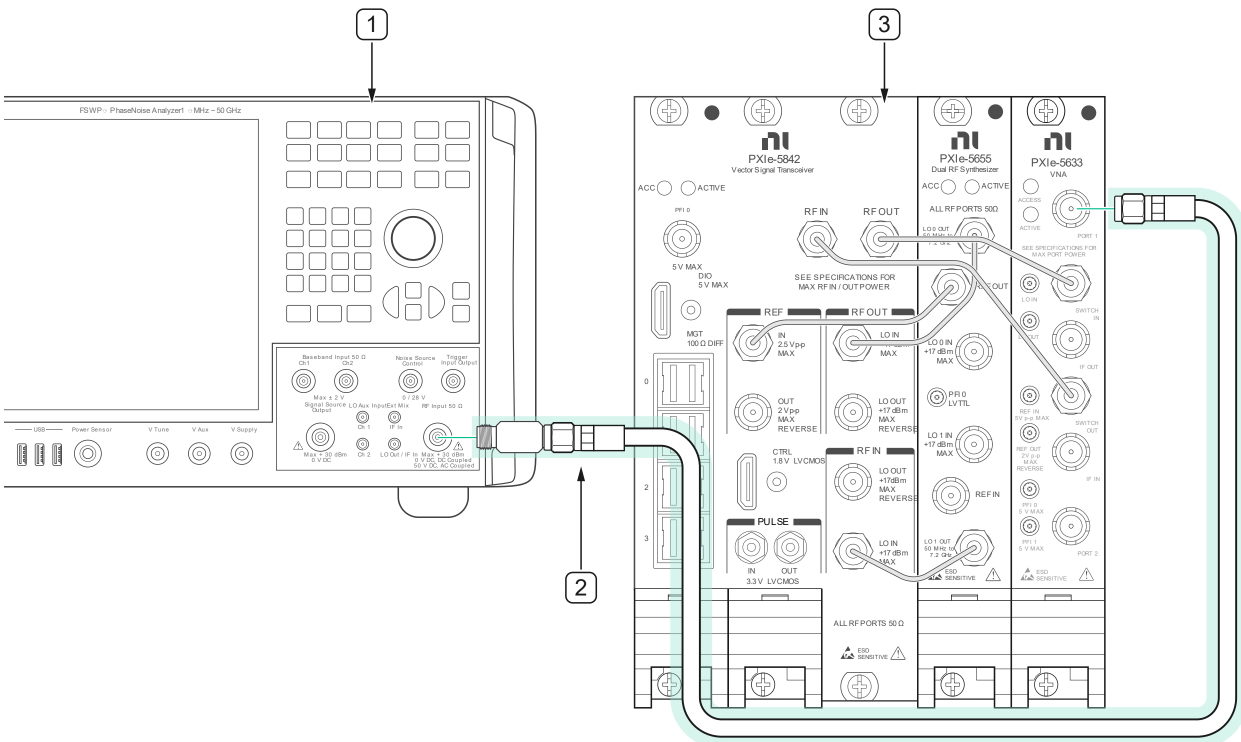
>3.75 GHz to 8.0 GHz	measure only the Max Linear Power at that frequency	-128.0 dBm
>8.0 GHz to 12.0 GHz		-127.0 dBm
>12.0 GHz to 18.0 GHz		-122.0 dBm
>18.0 GHz to 22.0 GHz		-124.0 dBm
>22.0 GHz to 24.0 GHz		-127.0 dBm
>24.0 GHz to 25.0 GHz		-130.0 dBm
30 MHz to 600 MHz	0 dBm	-117.0 dBm
>600 MHz to 3.75 GHz		-142.0 dBm
>3.75 GHz to 6.0 GHz		-144.0 dBm
>6.0 GHz to 8.0 GHz		-144.0 dBm
>8.0 GHz to 12.0 GHz		-140.0 dBm
>12.0 GHz to 22.0 GHz		-138.0 dBm
>22.0 GHz to 25.0 GHz		-133.0 dBm
30 MHz to 600 MHz	-30 dBm	-152.0 dBm
>600 MHz to 1.75 GHz		-165.0 dBm
>1.75 GHz to 3.75 GHz		-164.0 dBm
>3.75 GHz to 6.0 GHz		-165.0 dBm
>6.0 GHz to 8.0 GHz		-164.0 dBm
>8.0 GHz to 12.0 GHz		-161.0 dBm
>12.0 GHz to 18.0 GHz		-160.0 dBm
>18.0 GHz to 22.0 GHz		-157.0 dBm
>22.0 GHz to 25.0 GHz		-153.0 dBm
>25.0 GHz to 26.5.0 GHz		-152.0 dBm

6.7.2. Initial Test Connection

Note

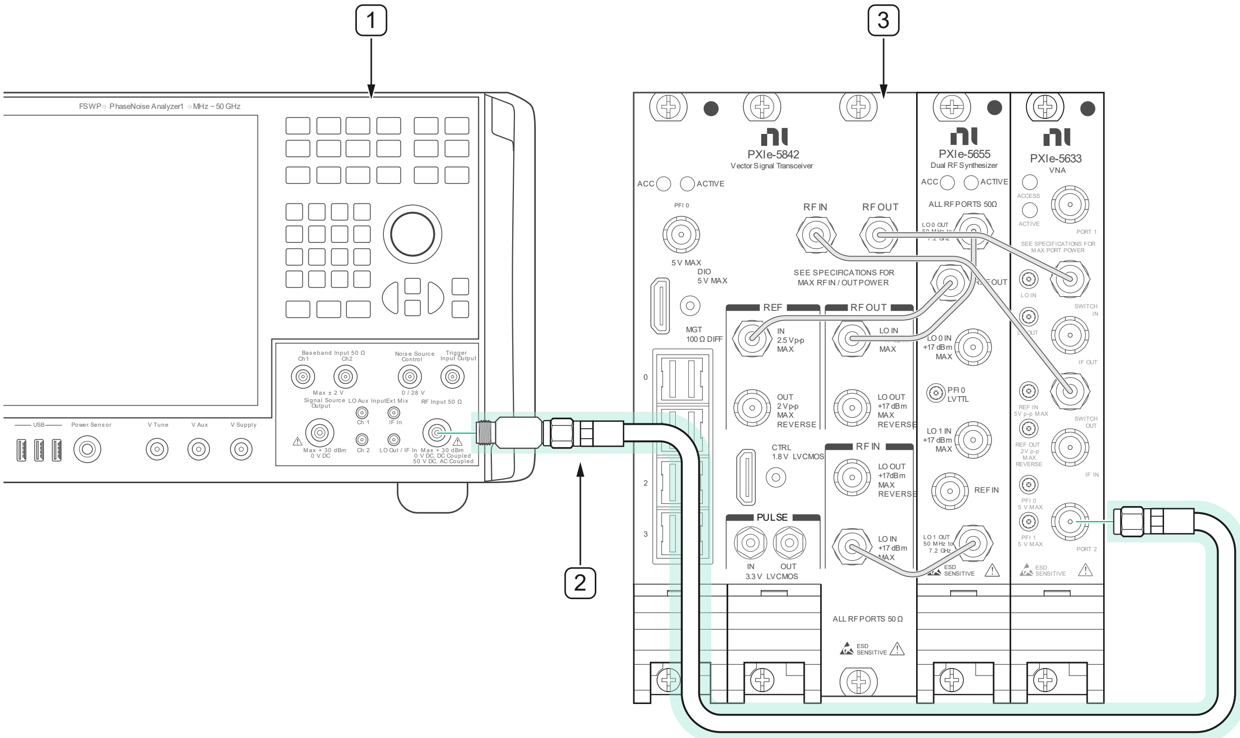
Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

Figure 22. Connections for RF Output Average Noise Density **Port 1** Verification



1. Phase noise and Spectrum analyzer
2. Generator Fixture
3. DUT

Figure 23. Connections for RF Output Average Noise Density **Port 2** Verification



1. Phase noise and Spectrum analyzer
2. Generator Fixture
3. DUT

6.7.3. Verification Procedure

Ensure that the connection fixture between the Spectrum Analyzer and the DUT has been characterized as per section 5.2 Cable loss Characterization.

> **Note**
> Do not disassemble Cable Fixture item #7 from **Figure 4** after characterization. If the fixture is disassembled, it must be recharacterized before it is used again.

Table 41: Output Average Noise Density Configurations

DUT Frequency Range	DUT Power Level	DUT Upconverter Mode	DUT Bandwidth
▪ 30 MHz and 50 MHz ▪ 100 MHz to 550 MHz in 50 MHz steps ▪ 600 MHz to 1.6 GHz in 200 MHz steps ▪ 1.745 GHz	-30 dBm, 0 dBm[1], +15 dBm or Max Linear Power endpoint for that frequency	**User Defined**	≤600 MHz: 0 Hz >600 MHz: 500 MHz
▪ 1.75 GHz ▪ 1.8 GHz to Maximum Frequency (See Table 5) in 200 MHz Steps. For option 26.5 GHz, Maximum Frequency is 26.48 GHz			See **Note** 1 – If DUT maximum Power is less than 0 dBm, only test -30 dBm power level.
▪ 1.701 GHz		**Enabled**	0 Hz
▪ 1.80 GHz to Maximum Frequency (See Table 5) in 200 MHz Steps. For option 26.5 GHz, Maximum Frequency is 26.48 GHz			See **Table 7**

Note 1 – If DUT maximum Power is less than 0 dBm, only test -30 dBm power level.

6.7.4. Verification Procedure **Port 1** (Upconverter Mode = **User Defined**)

17. Make the connections indicated in **Figure 22**.
18. Configure the DUT for the following settings for “User Defined” mode:
    - Output Port: 1
    - Mode: Arb Waveform (IQ)
    - Power Level Type: Peak

- Power Level: Initial lower Power Level from Configurations Table **41**.
- Reference Clock Source: PXI_CLK (Locked to Rubidium)
- Reference Clock Frequency: 10 MHz
- Frequency: Initial lowest Frequency from Configurations **Table 41**
- Upconverter Offset Mode: User Defined
- Upconverter center frequency: Default
- Bandwidth: Signal Bandwidth from Configurations **Table 41**
- IQ Rate:
  - Frequency <1.75GHz: 750 MHz (or maximum for device HW option **Table 6**)
  - Frequency ≥1.75 GHz: 1.25*Signal Bandwidth
- Number of Samples: 250k
- Digital Gain: -40 dB
- MultiTone VI Cluster Input (see section **9.1 - Generating an IQ Signal**):
  - Number of Elements = 1
  - Tone Frequency = [0]
  - Tone Phase = [0]
  - Tone Power = [0]

19. Configure the Spectrum Analyzer for the following settings:

- Mode: Spectrum
- Reference Oscillator Source: External Reference (Locked to Rubidium)
- Averaging Type: RMS Averaging
- Number of averages: 10
- Preamp Level = 30
- Center Frequency: DUT Frequency + 18 MHz
- Noise Marker Frequency: Center Frequency from Configurations (**Table 41**) + 2 MHz)
- Reference Level: (+5 of DUT Power Level + DUT Digital Gain)
- Span: 10 MHz
- RBW: 1 MHz
- VBW: 100 kHz
- Sweep Time: 8.94 ms

- Noise Cancellation: Enabled for -30 dBm power level, otherwise Disabled

20. Generate the Signal with the DUT. Wait for Settling.

21. Taking the measurements:

Repeat, once for each DUT Power Level in Table 37, starting with the lower power setting.

Based on the DUT option, repeat, once for each DUT Frequency in Table 41.

6. Enable the Noise Marker on the Spectrum Analyzer
7. Configure FSWP Noise Marker Frequency.
8. Initiate Spectrum Read.
9. Record the Noise Marker measurement as: Noise_Marker_Measurement
10. Calculate the Corrected Average Noise:

Average Noise Density = Noise_Marker_Measurement + PM_to_RX_Cable_Path_Response [dB] (*Equation 3*)

11. Configure the DUT for the following settings:
    a. Frequency: Next Frequency from Configurations **Table 41**
    b. Bandwidth: Signal Bandwidth from Configurations **Table 8**
    c. IQ Rate:
        1. Frequency <1.75GHz: 750 MHz (or maximum for device HW option **Table 6**)

2. Frequency ≥1.75 GHz: 1.25*Signal Bandwidth

12. Configure the Spectrum Analyzer for the following settings:

d. Center Frequency: DUT Frequency + 18 MHz

e. Noise Marker Frequency: Center Frequency from Configurations (**Table 41**) + 2 MHz)

f. Noise Cancellation: Enabled for -30 dBm power level, otherwise Disabled

13. Configure the DUT for the following settings:

g. Power Level: Next Power Level from Configurations **Table 41**

h. Frequency: Initial lowest Frequency from Configurations **Table 41**

i. Bandwidth: Signal Bandwidth from Configurations **Table 8**

j. IQ Rate: 750 MHz (or maximum for device HW option **Table 6**)

14. Configure the Spectrum Analyzer for the following settings:

k. Reference Level: (+5 of DUT Power Level + DUT Digital Gain)

l. Center Frequency: DUT Frequency + 18 MHz

m. Noise Marker Frequency: (Center Frequency from Configurations (**Table 37**) + 2 MHz)

n. Noise Cancellation: Enabled for -30 dBm power level, otherwise Disabled

6.7.5. Verification Procedure (Upconverter Mode = Enabled)

1. Make the connections indicated in **Figure 22**.

2. Configure the DUT for the following settings:

    - Output Port: 1
    - Mode: Arb Waveform (IQ)
    - Power Level Type: Peak
    - Power Level: Initial lower Power Level from Configurations **Table 41**
    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz
    - Frequency: Initial lowest Frequency from Configurations **Table 41**
    - Upconverter Offset Mode: Enabled
    - Upconverter center frequency: Default
    - Bandwidth: Signal Bandwidth from Configurations **Table 7**
    - IQ Rate: 1.25 * Signal Bandwidth
    - Number of Samples: 125k
    - Digital Gain: -40 dB
    - MultiTone VI Cluster Input (see section **9.1 - Generating an IQ Signal**):
        - Number of Elements = 1
        - Tone Frequency = [0]
        - Tone Phase = [0]
        - Tone Power = [0]

3. Configure the Spectrum Analyzer for the following settings:

    - Mode: Spectrum
    - Reference Oscillator Source: External Reference (Locked to Rubidium)
    - Averaging Type: RMS Averaging
    - Number of averages: 10
    - Preamp Level = 30
    - Center Frequency: DUT Frequency + 18 MHz
    - Noise Marker Frequency: (Center Frequency from Configurations (**Table 41**) + 2 MHz)
    - Reference Level: (+5 of DUT Power Level + DUT Digital Gain)
    - Span: 10 MHz
    - RBW: 1 MHz

- VBW: 100 kHz
- Sweep Time: 8.94 ms
- Noise Cancellation: Enabled for -30 dBm power level, otherwise Disabled

4. Generate the Signal with the DUT. Wait for Settling.

5. Taking the measurements:

Repeat, once for each DUT Power Level in Table 41, starting with the lower power setting.

Based on the DUT option, repeat, once for each DUT Frequency in Table 41.

6. Enable the Noise Marker on the Spectrum Analyzer

7. Configure FSWP Noise Marker Frequency.

8. Initiate Spectrum Read.

9. Record the Noise Marker measurement as: Noise_Marker_Measurement

10. Calculate the Corrected Average Noise:

Average Noise Density = Noise_Marker_Measurement + PM_to_RX_Cable_Path_Response [dB] (*Equation 3*)

11. Configure the DUT for the following settings:

    a. Frequency: Next Frequency from Configurations **Table 41**

    b. Bandwidth: Signal Bandwidth from Configurations **Table 7**

12. Configure the Spectrum Analyzer for the following settings:

    a. Center Frequency: DUT Frequency + 18 MHz

b. Noise Marker Frequency: Center Frequency from Configurations (**Table 41**) + 2 MHz)

c. Noise Cancellation: Enabled for -30 dBm power level, otherwise Disabled

13. Configure the DUT for the following settings:
    a. Power Level: Next Power Level from Configurations **Table 41**
    b. Frequency: Initial lowest Frequency from Configurations **Table 41**
    c. Bandwidth: Signal Bandwidth from Configurations **Table 7**
    d. IQ Rate: 750 MHz (or maximum for device HW option **Table 6**)
14. Configure the Spectrum Analyzer for the following settings:
    a. Reference Level: (+5 of DUT Power Level + DUT Digital Gain)
    b. Center Frequency: DUT Frequency + 18 MHz
    c. Noise Marker Frequency: (Center Frequency from Configurations (**Table 41**) + 2 MHz)
    d. Noise Cancellation: Enabled for -30 dBm power level, otherwise Disabled

6.7.6. Verification Procedure Port 2 (Downconverter Mode = User Defined)

1. Repeat procedure 6.8.4 Verification Procedure **Port 1** (Upconverter Mode = **User Defined**):

   1.1. Replace **Figure 26** with **Figure 27.** Connections for RF Output Third Order Intermodulation Port 2 Verification.

   1.2. Where “Port 1” is mentioned, replace with “Port 2”.

6.7.7. Verification Procedure Port 2 (Downconverter Mode = Enabled)

1. Repeat procedure 6.8.5 Verification Procedure (Upconverter Mode = **Enabled**):

   1.1. Replace **Figure 26** with **Figure 27.** Connections for RF Output Third Order Intermodulation Port 2 Verification.

   1.2. Where "Port 1" is mentioned, replace with "Port 2".

6.8. RF Output Harmonic Spurs Verification

6.8.1. Test Limits

Table 42: Test Points/Limits for Verification Test

Frequency Range	Digital Gain	**Enabled Mode** Test Limits	**User Defined Mode** Test Limits
		Verification Upper Limit [dBc]	Verification Upper Limit [dBc]
30.0 MHz to 1.7 GHz	0 dB	NA	-33
>1.7 GHz to 1.75 GHz		-33	-33
>1.75 GHz to 2.3 GHz		-31	-31
>2.3 GHz to 3.0 GHz		-28	-36
>3.0 GHz to 6.0 GHz		-27	-27
>6.0 GHz to 8.0 GHz		-31	-31
>8.0 GHz to 13.25 GHz		-30	-30
30.0 MHz to 75.0 MHz	-12 dB	NA	-40

>75.0 MHz to 1.7 GHz		NA	-40
>1.7 GHz to 1.75 GHz		-40	-40
>1.75 GHz to 2.3 GHz		-43	-43
>2.3 GHz to 3.0 GHz		-40	-47
>3.0 GHz to 6.0 GHz		-40	-40
>6.0 GHz to 8.0 GHz		-44	-44
>8.0 GHz to 13.25 GHz		-43	-43

Note
Test up to 26.5 GHz only; no harmonics above 26.5 GHz will be measured.

6.8.2. Initial Test Connection

Note
Make sure that you have made the connections described in **Figure 5** Initial Reference Clock Connections before starting this Verification procedure.

Table 43 : Signal Bandwidth for Enabled Mode

IQCF/RF Frequency	Signal Bandwidth	
1.70 GHz to < 5.25 GHz	B05: 250 MHz B10: 500 MHz B20: 600 MHz The maximum Signal Bandwidth is also limited by IQ Rate * 0.8	

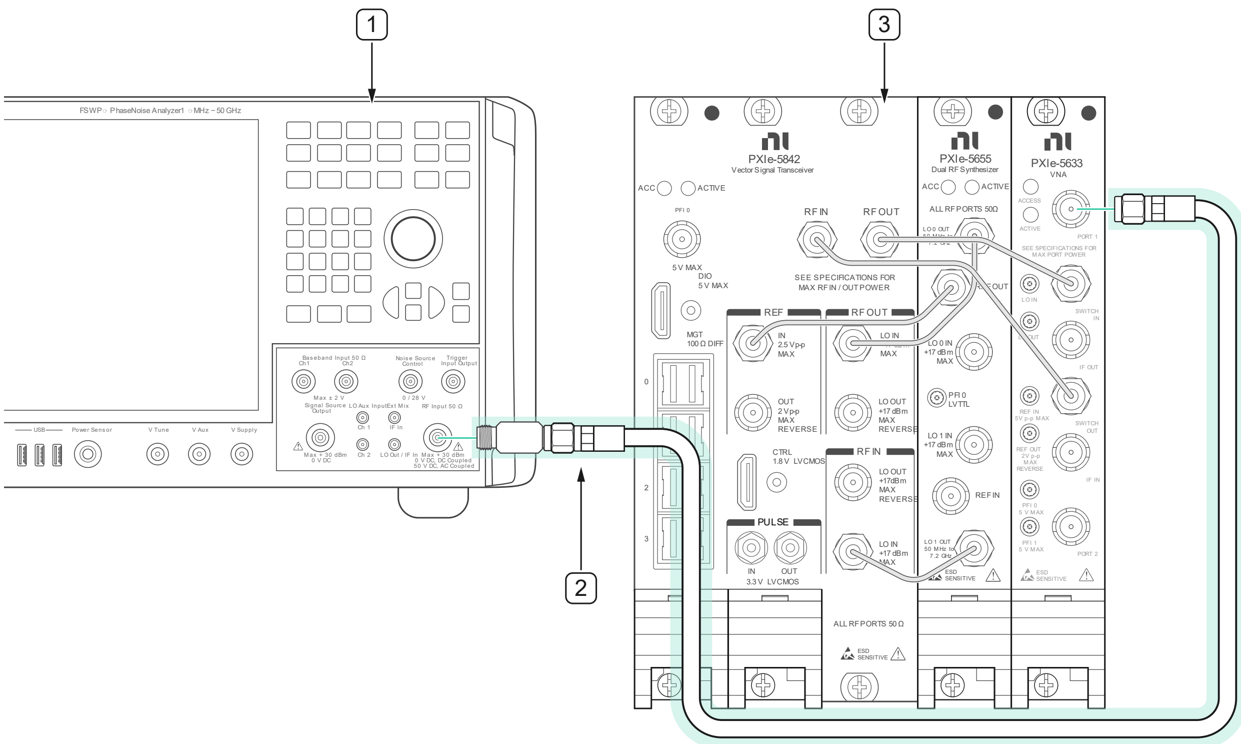
5.25 GHz to 26.5 GHz	B05: 250 MHz B10: 500 MHz B20: 900 MHz The maximum Signal Bandwidth is also limited by IQ Rate * 0.8	

Note
The Signal Bandwidth is based on the device's upconverter / Downconverter value, but because we don't have direct control over it in Enabled mode, **Table 43** gives the signal bandwidth values required in terms of IQCF and RF Frequency.

Table 44: Signal Bandwidth for User Defined Mode

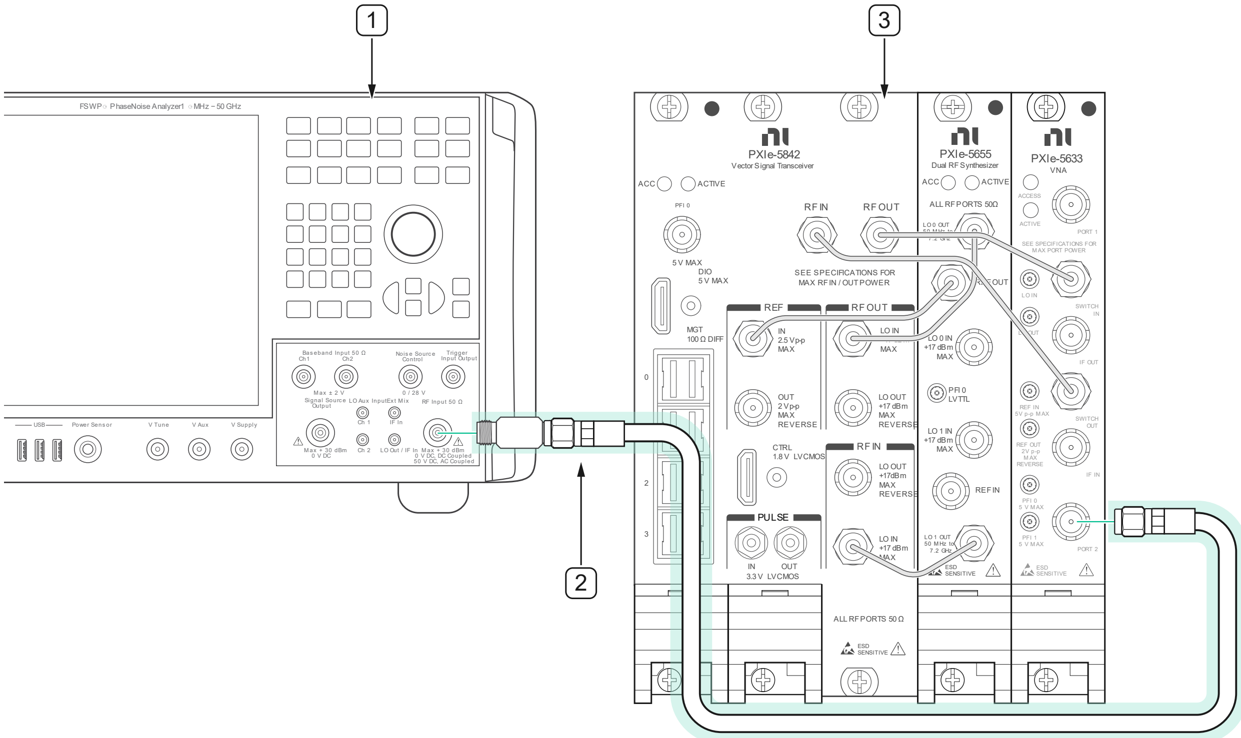
IQCF/RF Frequency	Maximum Settable Signal Bandwidth
30 MHz to < 1.75 GHz	Minimum of the following: ▪ Maximum BW for version: B05: 500 MHz B10: 1 GHz B20: 1.97 GHz ▪ Input: (2GHz – IQCF) * 2 Output: (2GHz – RF Frequency) * 2 ▪ Input:(IQCF – 30MHz) * 2 Output:(RF Frequency – 30MHz) * 2 ▪ IQ Rate * 0.8
1.75 GHz to 2.0 GHz	Minimum of the following: ▪ B05: 1 GHz – 2 * |XCFO|, capped at 500 MHz ▪ B10: 1 GHz – 2 * |XCFO|, capped at 1000 MHz ▪ B20: 1 GHz – 2 * |XCFO| ▪ IQ Rate * 0.8
>2.0 GHz to 5.8 GHz	Minimum of the following: ▪ B05: 1.4 GHz – 2 * |XCFO|, capped at 500 MHz ▪ B10: 1.4 GHz – 2 * |XCFO|, capped at 1000 MHz ▪ B20: 1.4 GHz – 2 * |XCFO| ▪ IQ Rate * 0.8
>5.8 GHz to 26.5 GHz	Minimum of the following: ▪ B05: 2.0 GHz – 2 * |XCFO|, capped at 500 MHz ▪ B10: 2.0 GHz – 2 * |XCFO|, capped at 1000 MHz ▪ B20: 2.0 GHz – 2 * |XCFO|

Figure 24. Connections for Output Harmonic Spurs **Port 1** Verification



1. Phase noise and Spectrum analyzer
2. Generator Fixture
3. DUT

Figure 25. Connections for Output Harmonic Spurs **Port 2** Verification



1. Phase noise and Spectrum analyzer
2. Generator Fixture
3. DUT

6.8.3. Verification Procedure

1. Ensure that the connection fixture between the Spectrum Analyzer and the DUT has been characterized as per section 5.2 Cable loss Characterization.

> **Note**
> Do not disassemble Cable Fixture item #7 from **Figure 4** after characterization. If the fixture is disassembled, it must be recharacterized before it is used again.

Table 45: Output Harmonic Spurs Configurations

<table>
<tr><th>DUT Frequency</th><th>DUT Power Level</th><th>DUT Upconverter Mode</th><th>Digital Gain</th><th>Upconverter Offset</th></tr>
<tr><td>▪ 30 MHz to 45 MHz in 5 MHz steps
▪ 50 MHz to 1.70 GHz in 50 MHz steps
▪ 1.749 MHz</td><td rowspan="2">0 dBm</td><td rowspan="2">User Defined</td><td rowspan="3">0 dB and -12 dB</td><td>Driver default</td></tr>
<tr><td>▪ 1.75 GHz to 13.20 GHz (or Maximum Frequency) (See Table 5) in 50 MHz Steps
▪ Include 8.813 GHz and 13.229 GHz unless above maximum frequency</td><td>0 MHz</td></tr>
<tr><td>▪ 1.701 GHz
▪ 1.75 GHz to 13.20 GHz (or Maximum Frequency) (See Table 5) in 50 MHz Steps
▪ Include 8.833 GHz and 13.249 GHz unless above maximum frequency</td><td>0 dBm</td><td>Enabled</td><td>Driver default</td></tr>
</table>

Table 46: Output Harmonic maximum frequency by Hardware option

Hardware Option	Maximum Frequency	Maximum frequency for 2^{sd} harmonic	Maximum frequency for 3rd harmonic
F08	8.0 GHz	≤8.0 GHz	≤8.0 GHz
F12	12 GHz	≤12.0 GHz	≤8.833 GHz
F18	18 GHz	≤13.249 GHz	≤8.833 GHz
F26	26.5 GHz	≤13.249 GHz	≤8.833 GHz

6.8.4. Verification Procedure Port 1 (Upconverter Mode = User Defined)

1. Make the connections indicated in **Figure 24** for Verification of Port 1
2. Configure the DUT for the following settings:
   - Output Port: 1
   - Mode: Arb Waveform (IQ)
   - IQ Rate: 125 MS/s
   - Number of Samples: 50 kS
   - Reference Clock Source: PXI_CLK (Locked to Rubidium)
   - Reference Clock Frequency: 10 MHz
   - Frequency: First frequency from Configurations **Table 45**
   - Upconverter Offset Mode: User Defined
   - Upconverter Offset from Configurations **Table 45**
   - MultiTone VI Cluster Input (see section **9.1 - Generating an IQ Signal**):
     - Number of Elements = 1
     - Tone Frequency
       - Frequency < 1.75 GHz: [0]
       - Frequency ≥ 1.75 GHz: [20M]
     - Tone Phase = [0]+
     - Tone Power = [-1]
   - Power Level: First Power Level from Configurations **Table 45**
   - Signal Bandwidth:
       - Frequency <1.75GHz: 0 Hz
       - Frequency ≥1.75 GHz: 100 MHz
   - Digital Gain: First Digital Gain from Configurations **Table 45**
3. Configure the Spectrum Analyzer for the following settings:
   - Mode: Spectrum

- Reference Oscillator Source: External Reference (Locked to Rubidium)
- Center Frequency: DUT Frequency + DUT Tone Offset (from Configurations **Table 45**)
- Reference Level: DUT Power Level +5 dB
- Span: 10 kHz
- RBW: 1 kHz
- Number of averages: 1
- Attenuation Mode: Auto

4. Enable the DUT to generate the tone. Wait until it settles.

5. Taking the measurements:

Repeat once for each Digital gain setting.

Repeat, once for each DUT Frequency in Configurations Table 45.

6. Measure the peak power of the tone and save as: Fundamental_Power

7. Save the frequency of the tone as: Fundamental_Frequency

8. Calculate the corrected Fundamental measured power:

Fundamental_Power_Corrected = Fundamental_Power - PM_to_RX_Cable_Path_Response [dB]

9. If the **DUT Frequency + Tone Offset ≤ Maximum frequency for 2nd harmonic** from **Table 46** then reconfigure the Spectrum Analyzer to:

   a. Center Frequency: 2 x the measured Fundamental_Frequency

   b. Reference level: DUT Power Level - 20.

10. Measure the peak power of the tone and save as:

2nd HarmPower

11. Calculate the corrected second harmonic measured power:

2nd HarmPower_Corrected = 2nd HarmPower - PM_to_RX_Cable_Path_Response [dB]

12. If the **DUT Frequency + Tone Offset ≤ Maximum frequency for 3rd harmonic** from **Table 46** then reconfigure the Spectrum Analyzer to:
    - Center Frequency - 3 x the measured Fundamental_Frequency
    - Reference level - DUT Power Level - 30.

13. Measure the peak power of the tone and save as:

3rd HarmPower

14. Calculate the corrected third harmonic measured power:

3rd HarmPower_Corrected = 3rd HarmPower - PM_to_RX_Cable_Path_Response [dB]

15. Calculate the output harmonic distortion:

2nd_HD =
2nd HarmPower Corrected - Fundamental_Power_Corrected [dBc]

3rd_HD =
3rd HarmPower Corrected - Fundamental_Power_Corrected [dBc]

16. Configure the DUT for the following settings:

- Frequency: Next frequency from Configurations **Table 45**
- Upconverter Offset for the selected frequency from configurations **Table 45**
    - MultiTone VI Cluster Input (see section **9.1 - Generating an IQ Signal**):
        - Tone Frequency
            - Frequency < 1.75 GHz: [0]
            - Frequency ≥ 1.75 GHz: [20M]

17. Configure the Spectrum Analyzer for the following settings:
    - Center Frequency: DUT Frequency + DUT Tone Offset (from Configurations **Table 45**)
    - Reference Level: DUT Power Level +5 dB

18. Configure the DUT for the following settings:
    - Digital Gain: next value from Configurations **Table 45**

6.8.5. Verification Procedure Port 1 (Upconverter Mode = Enabled)

1. Make the connections indicated in **Figure 24** for Verification of Port 1
2. Configure the DUT for the following settings:
    - Output Port: 1
    - Mode: Arb Waveform (IQ)
    - IQ Rate: 125 MS/s
    - Number of Samples: 50 kS
    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz
    - Frequency: First frequency from Configurations **Table 45**
    - Upconverter Offset Mode: Enabled
    - Upconverter Offset from configurations **Table 45**
    - MultiTone VI Cluster Input (see section **9.1 - Generating an IQ Signal**):
        - Number of Elements = 1
        - Tone Frequency = [0]
        - Tone Phase = [0]+
        - Tone Power = [-1]

- Power Level: First Power Level from configurations **Table 45**
- Signal Bandwidth: 100 MHz
- Digital Gain: First Digital Gain from Configurations **Table 45**

3. Configure the Spectrum Analyzer for the following settings:
   - Mode: Spectrum
   - Reference Oscillator Source: External Reference (Locked to Rubidium)
   - Center Frequency: DUT Frequency + DUT Tone Offset (from Configurations **Table 45**)
   - Reference Level: DUT Power Level +5 dB
   - Span: 10 kHz
   - RBW: 1 kHz
   - Number of averages: 1
   - Attenuation Mode: Auto
4. Enable the DUT to generate the tone. Wait until it settles.
5. Taking the measurements:

Repeat once for each Digital gain setting.

Repeat, once for each DUT Frequency in Configurations Table 45.

6. Measure the peak power of the tone and save as: Fundamental_Power
7. Save the frequency of the tone as: Fundamental_Frequency
8. Calculate the corrected Fundamental measured power: **Fundamental_Power_Corrected = Fundamental_Power - PM_to_RX_Cable_Path_Response [dB]**

9. If the **DUT Frequency + Tone Offset ≤ Maximum frequency for 2nd harmonic** from **Table 46** then reconfigure the Spectrum Analyzer to:

    a. Center Frequency: 2 x the measured Fundamental_Frequency

    b. Reference level: DUT Power Level - 20.

10. Measure the peak power of the tone and save as: **2nd HarmPower**

11. Calculate the corrected second harmonic measured power:

2nd HarmPower_Corrected = 2nd HarmPower - PM_to_RX_Cable_Path_Response [dB]

12. If the **DUT Frequency + Tone Offset ≤ Maximum frequency for 3rd harmonic** from **Table 46** then reconfigure the Spectrum Analyzer to:

    a. Center Frequency - 3 x the measured Fundamental_Frequency

    b. Reference level - DUT Power Level - 30.

13. Measure the peak power of the tone and save as: **3rd HarmPower**

14. Calculate the corrected third harmonic measured power:

3rd HarmPower_Corrected = 3rd HarmPower - PM_to_RX_Cable_Path_Response [dB]

15. Calculate the output harmonic distortion:

2nd_HD =

2nd HarmPower Corrected - Fundamental_Power_Corrected [dBc]

3rd_HD =
3rd HarmPower Corrected - Fundamental_Power_Corrected [dBc]

16. Configure the DUT for the following settings:

- Frequency: Next frequency from Configurations **Table 45**
- Upconverter Offset for the selected frequency from configurations **Table 45**

17. Configure the Spectrum Analyzer for the following settings:

- Center Frequency: DUT Frequency + DUT Tone Offset (from Configurations **Table 45**)
- Reference Level: DUT Power Level +5 dB

18. Configure the DUT for the following settings:

- Digital Gain: next value from Configurations **Table 45**

6.8.6. Verification Procedure Port 2 (Downconverter Mode = User Defined)

1. Repeat procedure 6.9.4 Verification Procedure **Port 1** (Upconverter Mode = User Defined):

   1.1. Replace **Figure 24** with **Figure 25.** Connections for Output Harmonic Spurs **Port 2** Verification

   1.2. Where “Port 1” is mentioned, replace with “Port 2”.

6.8.7. Verification Procedure Port 2 (Downconverter Mode = Enabled)

1. Repeat procedure 6.9.5 Verification Procedure **Port 1** (Upconverter Mode = Enabled):

   1.1. Replace **Figure 24** with **Figure 25.** Connections for Output Harmonic Spurs Port 2 Verification

   1.2. Where “Port 1” is mentioned, replace with “Port 2”.

6.9. RF Output Third Order Intermodulation Verification

6.9.1. Test Limits

Table 47: RF Output Third Order Intermodulation Test Limits for Verification Test (**Upconverter Mode – User Defined**)

Frequency Range	Output Power	Verification Test Limits
		Upper Limit
30 MHz to 600 MHz	-30 dBm	-54.0 dBm
>600 MHz to 3.0 GHz		-44.0 dBm
>3.0 GHz to 6.0 GHz		-47.0 dBm
>6.0 GHz to 12.0 GHz		-46.0 dBm
>12.0 GHz to 18.0 GHz		-44.0 dBm
>18.0 GHz to 26.5 GHz		-41.0 dBm
30 MHz to 600 MHz	0 dBm	-46.0 dBm
>600 MHz to 3.0 GHz		-46.0 dBm

>3.0 GHz to 6.0 GHz		-49.0 dBm
>6.0 GHz to 12.0 GHz		-49.0 dBm
>12.0 GHz to 18.0 GHz		-46.0 dBm
>18.0 GHz to 25.0 GHz		-44.0 dBm
30 MHz to 3.0 GHz	+15 dBm or DUT Maximum Level, see Table **49Table 49**	-42.0 dBm
>3.0 GHz to 6.0 GHz		-45.0 dBm
>6.0 GHz to 12.0 GHz		-41.0 dBm
>12.0 GHz to 18.0 GHz		-37.0 dBm
>18.0 GHz to 20 GHz		-36.0 dBm
>20.0 GHz to 22 GHz		-35.0 dBm
>22 GHz to 24 GHz		-35.0 dBm
>24 GHz to 26.5 GHz		-38.0 dBm

Table 48: RF Output Third Order Intermodulation Test Limits for Verification Test (**Upconverter Mode – Enabled**)

Frequency Range	Output Power	As-Found Test Limit
		Upper Limit
1.701 GHz to 3.0 GHz	-30 dBm	-54.0 dBm
>3.0 GHz to 6.0 GHz		-47.0 dBm
>6.0 GHz to 12.0 GHz		-51.0 dBm
>12.0 GHz to 18.0 GHz		-48.0 dBm
>18.0 GHz to 26.5 GHz		-46.0 dBm
1.701 GHz to 3.0 GHz	0 dBm	-53.0 dBm
>3.0 GHz to 6.0 GHz		-49.0 dBm

>6.0 GHz to 12.0 GHz		-50.0 dBm
>12.0 GHz to 18.0 GHz		-48.0 dBm
>18.0 GHz to 25.0 GHz		-46.0 dBm
1.701 GHz to 3.0 GHz	+15 dBm Or DUT Maximum Level, see **Table 50**	-48.0 dBm
3.0 GHz to 6.0 GHz		-45.0 dBm
>6.0 GHz to 12.0 GHz		-42.0 dBm
>12.0 GHz to 18.0 GHz		-34.0 dBm
>18.0 GHz to 20.0 GHz		-36.0 dBm
>20.0 GHz to 22.0 GHz		-35.0 dBm
>22.0 GHz to 26.5 GHz		-42.0 dBm

Table 49: DUT Output Maximum Power Level (**Upconverter Mode – User Defined**)

Frequency Range	User Defined
30.0 MHz to 200.0 MHz	+9.0 dBm
>200.0 MHz to 600 MHz	+9.0 dBm
>600 MHz to < 1.75 GHz	+9.0 dBm (+18.0 dBm)[2]
1.75 GHz to <4.0 GHz	+17.0 dBm
>4.0 GHz to 6.0 GHz	+17.0 dBm
>6.0 GHz to 8.0 GHz	+16.0 dBm
>8.0 GHz to 12.0 GHz	+15.0 dBm
>12.0 GHz to 18.0 GHz	+14.0 dBm
>18.0 GHz to 20.0 GHz	+13.0 dBm

>20.0 GHz to 22.0 GHz	+13.0 dBm
>22.0 GHz to 24.0 GHz	+11.0 dBm
>24.0 GHz to 25.0 GHz	+3.0 dBm
>25.0 GHz to 26.5 GHz	-9.0 dBm

Note 2 – Only for Signal Bandwidth = 500 MHz

Table 50: DUT Output Maximum Power Level (**Upconverter Mode – Enabled**)

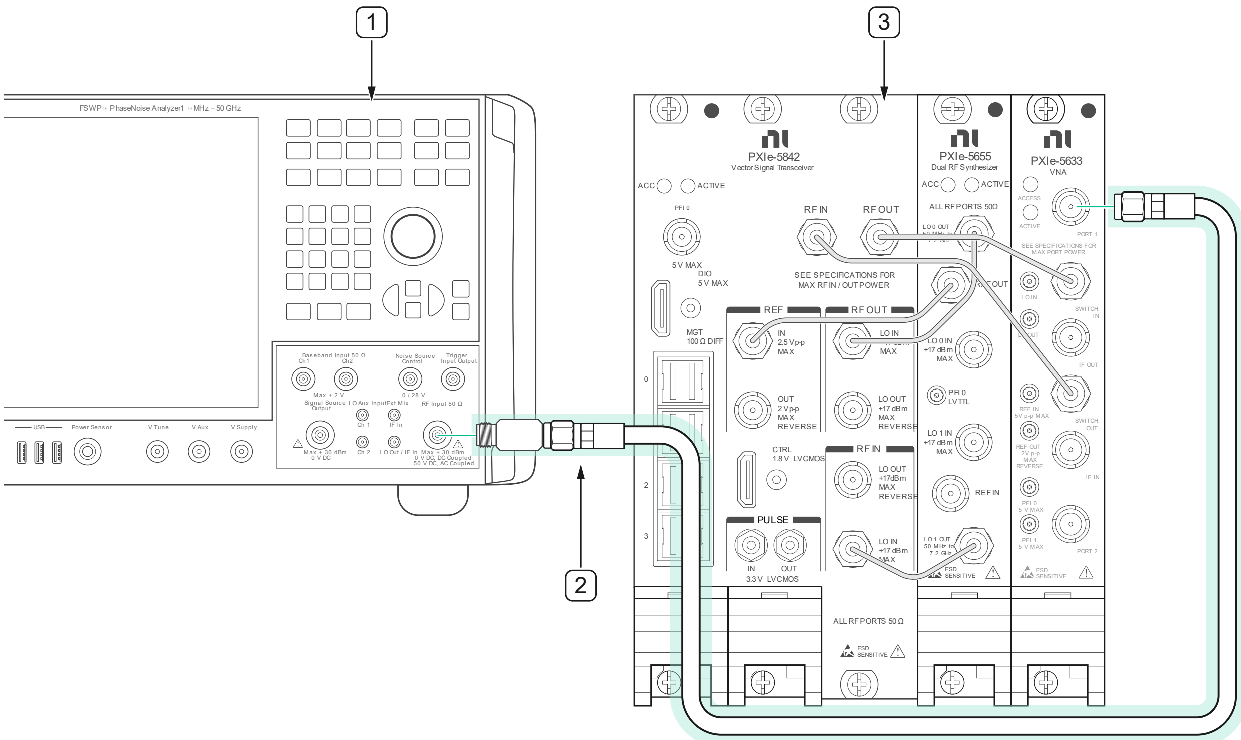
Frequency Range	User Defined
1.7 GHz to 4.0 GHz	+18.0 dBm
>4.0 GHz to 6.0 GHz	+17.0 dBm
>6.0 GHz to 8.0 GHz	+16.0 dBm
>8.0 GHz to 18.0 GHz	+15.0 dBm
>18.0 GHz to 22.0 GHz	+13.0 dBm
>22.0 GHz to 24.0 GHz	+8.0 dBm
>24.0 GHz to 25.0 GHz	+3.0 dBm
>25.0 GHz to 26.5 GHz	-8.0 dBm

6.9.2. Initial Test Connection

Note

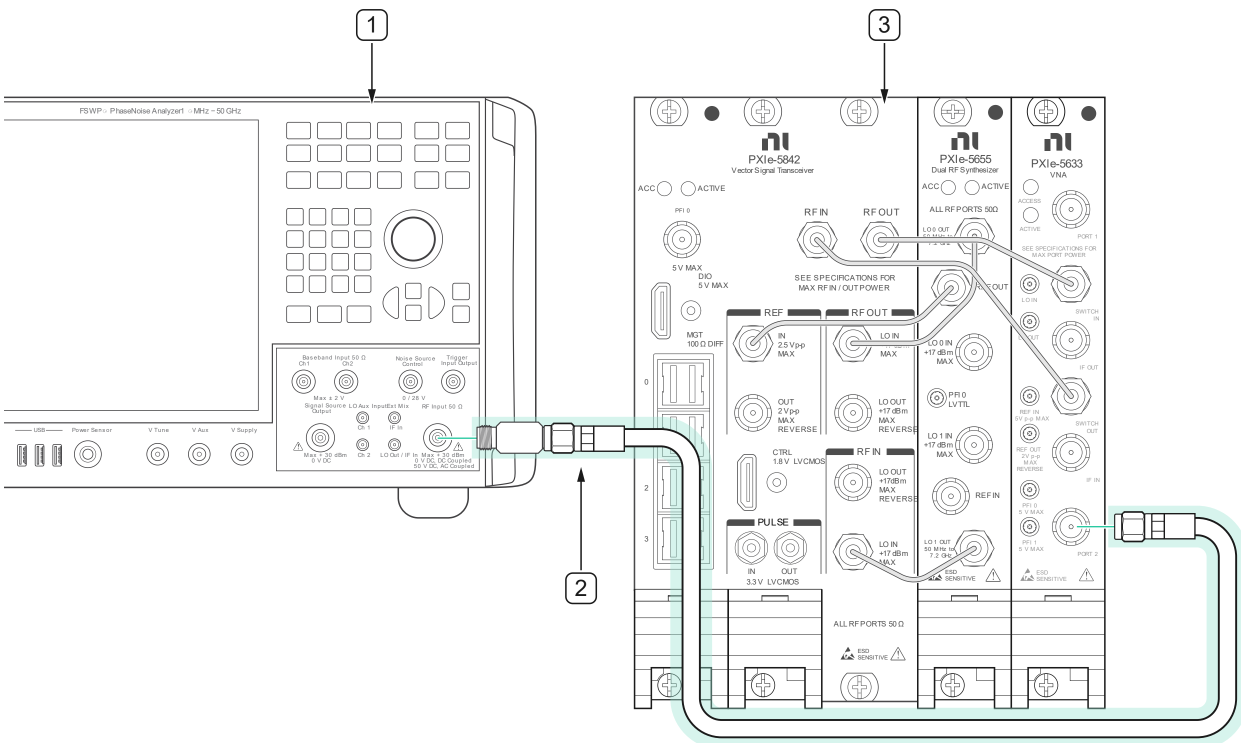
Make sure that you have made the connections described in **Figure 5.** External Reference Clock Connection before starting this Verification procedure.

Figure 26. Connections for RF Output Third Order Intermodulation **Port 1** Verification



1. Phase noise and Spectrum analyzer
2. Generator Fixture
3. DUT

Figure 27. Connections for RF Output Third Order Intermodulation Port 2 Verification



1. Phase noise and Spectrum analyzer
2. Generator Fixture
3. DUT

1. Ensure that the connection fixture between the Spectrum Analyzer and the DUT has been characterized as per section 5.2 Cable loss Characterization.

> **Note**
> Do not disassemble Cable Fixture item #7 from **Figure 4** after characterization. If the fixture is disassembled, it must be recharacterized before it is used again.

6.9.3. Verification Procedure

Table 51: RF Output TOI Configurations (**User Defined**)

DUT IQ Frequency	DUT Power Level	Signal Analyzer Attenuation	DUT Bandwidth	DUT Tone Offsets
▪ 30 MHz to 90 MHz in 10 MHz steps ▪ 100 MHz to 275 MHz in 25 MHz steps ▪ 300 MHz to 950 MHz in 50 MHz steps	-30 dBm	0 dB	≤600 MHz: 0 Hz >600 MHz: 500 MHz	t_1=10 MHz t_2=10.7 MHz
	0 dBm	20 dB		
	Minimum between +15.0 dBm and Maximum DUT Linear Power see **Table 49 Table 49**	35 dB		
▪ 1.0 GHz to 1.7 GHz in 100 MHz steps ▪ 1.749 GHz	-30 dBm	0 dB	500 MHz	t_1=95 MHz t_2=105 MHz
	0 dBm	20 dB		
	Minimum between +15.0 dBm and Maximum DUT Linear Power see **Table 49** **Table 49**	35 dB		

▪ 1.75 GHz ▪ 1.8 GHz to 26.3 GHz (or Maximum Frequency, See **Table 5**) in 100 MHz steps ▪ 26.38 GHz See **Table 5)**	-30 dBm	0 dB	230 MHz	t_1=95 MHz t_2=105 MHz
	0 dBm	20 dB		
	Minimum between +15.0 dBm and Maximum DUT Linear Power see **Table 49 Table 49**	+40 dB for 8 GHz ≤ f ≤ 12 GHz, otherwise 35 dB		

Table 52: RF Output TOI Configurations (Enabled)

DUT IQ Frequency	DUT Power Level	Signal Analyzer Attenuation	DUT Bandwidth	DUT Tone Offsets
▪ 1.701 GHz ▪ 1.8 GHz to 26.3 GHz (or Maximum Frequency, See **Table 5**) in 100 MHz steps ▪ 26.38 GHz See **Table 5)**	-30 dBm	0 dB	230 MHz	t_1=95 MHz t_2=105 MHz
	0 dBm	20 dB		
	Minimum between +15.0 dBm and Maximum DUT Linear Power see **Table 50**	+40 dB for 8 GHz ≤ f ≤ 12 GHz, otherwise +35 dB		

6.9.4. Verification Procedure Port 1 (Upconverter Mode = User Defined)

1. Make the connections indicated in **Figure 26** for Verification of Port 1.

2. Configure the DUT to generate two single sideband tones simultaneously, offset from the carrier:

   - Output Port: 1
   - Mode: Arb Waveform (IQ)
   - Power Level Type: Peak Power
   - Reference Clock Source: PXI_CLK (Locked to Rubidium)
   - Reference Clock Frequency: 10 MHz
   - Frequency: First frequency from Configurations **Table 51** (f_0)
   - Upconverter Offset Mode: User Defined
   - Power Level: First Power Level from configurations **Table 51**
   - Signal Bandwidth: Bandwidth Matching the Power Level from configurations **Table 51**
   - Upconverter Offset:
     - Frequency (f_0) < 1.75 GHz: Driver Default
     - Frequency (f_0) ≥ 1.75 GHz: 0 Hz
   - MultiTone VI Cluster Input (see section **9.1 - Generating an IQ Signal**):
     - Number of Elements = 2
     - Tone Frequency: DUT Tone Offset Frequencies from Configurations **Table 51**
     - Tone Phase = [0, 0]
     - Tone Power = [-7, -7]
   - IQ Rate: Hardware option maximum from **Table 6**
   - Number of Samples: 50 kS
   - Digital Gain: 0 dB

3. Configure the Spectrum Analyzer for the following settings:

   - Mode: Spectrum
   - Reference Oscillator Source: External Reference (Locked to Rubidium)

- Center Frequency: Same as DUT Frequency (f_0)
    - $f_1 = f_0 + t_1$ (***t_1*** Matching the DUT Power Level from configurations **Table 51**)
- Reference Level: DUT Power Level + DUT digital gain
- Span: 1 kHz
- RBW: 30 Hz
- Sweep Count: 10001
- Mode: Auto Peak
- Attenuation: Matching the DUT Power Level from configurations **Table 51**

4. Enable the DUT to generate the tones. Wait until it settles.

5. Taking the Verification measurements:

Repeat, once for each DUT Reference Power Level in **Table 51**, starting with the lower power setting.

Repeat, once for IQ Center Frequency setting in **Table 51**.

6. Measure the Power at frequency f_1.

7. Record the corrected measured power with cable characterization at f_1 frequency:

    Pf_{1c} **= Pf_1 - M_to_RX_Cable_Path_Response$_{(f1)}$ [dBm]**

8. Configure the Spectrum Analyzer for the following settings:

    Center Frequency: Same as DUT Frequency (f_0)

    - $f_2 = f_0 + t_2$ (***t_2*** Matching the DUT Power Level from configurations **Table 51**)

9. Measure the Power at frequency f_2.

10. Record the corrected measured power with cable characterization at f_2 frequency:

    Pf_{2c} **= Pf_2 - M_to_RX_Cable_Path_Response$_{(f2)}$ [dBm]**

11. Configure the Spectrum Analyzer for the following settings:

    Center Frequency: Same as DUT Frequency (f_0)

    - $f(IMD3_{T1}) = (\mathbf{2\ \mathit{f}_2 - \mathit{f}_1})$

12. Measure the Power at frequency $f(IMD3_{T1})$.

13. Record the corrected measured power with cable characterization at $f(IMD3_{T1C})$ frequency:

$$Pf(IMD3_{T1C}) = Pf(IMD3_{T1}) - \mathbf{M\_to\_RX\_Cable\_Path\_Response}_{(f2(IMD3T1))}\ \mathbf{[dBm]}$$

14. Configure the Spectrum Analyzer for the following settings:

    Center Frequency: Same as DUT Frequency (f_0)

    - $f(IMD3_{T2}) = (2\,f_1 - f_2)$

15. Measure the Power at frequency $f(IMD3_{T2})$.

16. Record the corrected measured power with cable characterization at $f(IMD3_{T2C})$ frequency:

$$Pf(IMD3_{T2C}) = Pf(IMD3_{T2}) - \mathbf{M\_to\_RX\_Cable\_Path\_Response}_{(f2(IMD3T2))}\ \mathbf{[dBm]}$$

17. Calculate Output IMD_3 using the following equation:

$$\mathbf{Out(IMD_3)} = Min(Pf_{1C}; Pf_{2C}) - Max[Pf(IMD3_{T1C}); Pf(IMD3_{T2C})]$$

    - Calculate TOI using the following equation:

$$\mathbf{Out(TOI)} = Min(Pf_{1C}; Pf_{2C}) + [Min(Pf_{1C}; Pf_{2C}) - Out(IMD_3)/2]\ [dB]$$

    - Compare the calculated Out(TOI) with limits in **Table 47**

18. Configure the DUT to generate two single sideband tones simultaneously, offset from the carrier:

    - Frequency: Next frequency from Configurations **Table 51** (f_0)

- Upconverter Offset:
  - Frequency (f_0) < 1.75 GHz: Driver Default
  - Frequency (f_0) ≥ 1.75 GHz: 0 Hz
- Power Level: Current Power Level from configurations **Table 51**
- Signal Bandwidth: Bandwidth Matching the current Power Level from configurations **Table 51**
- MultiTone VI Cluster Input (see section **9.1 - Generating an IQ Signal**):
  - Number of Elements = 2
  - Tone Frequency: DUT Tone Offset Frequencies from Configurations **Table 51**
  - Tone Phase = [0, 0]
  - Tone Power = [-7, -7]
- IQ Rate: Hardware option maximum from **Table 6**

19. Configure the Spectrum Analyzer for the following settings:

- Center Frequency: Same as DUT Frequency (f_0)
  - $f_1 = f_0 + \boldsymbol{t_1}$ (***t_1*** Matching the DUT Power Level from configurations **Table 51**)
- Reference Level: DUT Power Level + DUT digital gain
- Attenuation: Matching the DUT Power Level from configurations **Table 51**

20. Configure the DUT to generate two single sideband tones simultaneously, offset from the carrier:

- Frequency: First frequency from Configurations **Table 51** (f_0)
- Upconverter Offset:
  - Frequency (f_0) < 1.75 GHz: Driver Default
  - Frequency (f_0) ≥ 1.75 GHz: 0 Hz
- Power Level: Next Power Level from configurations **Table 51**
- Signal Bandwidth: Bandwidth Matching the Power Level from configurations **Table 51**
- MultiTone VI Cluster Input (see section **9.1 - Generating an IQ Signal**):

- Number of Elements = 2
- Tone Frequency: DUT Tone Offset Frequencies from Configurations **Table 51**
- Tone Phase = [0, 0]
- Tone Power = [-7, -7]

- IQ Rate: Hardware option maximum from **Table 6**

21. Configure the Spectrum Analyzer for the following settings:

    - Center Frequency: Same as DUT Frequency (f_0)
        - $f_1 = f_0 + t_1$ (t_1 Matching the DUT Power Level from configurations **Table 51**)
    - Reference Level: DUT Power Level + DUT digital gain
    - Attenuation: Matching the DUT Power Level from configurations **Table 51**

22. Enable the DUT to generate the tones. Wait until it settles.

6.9.5. Verification Procedure Port 1 (Upconverter Mode = Enabled)

1. Make the connections indicated in **Figure 26** for Verification of Port 1.

2. Configure the DUT to generate two single sideband tones simultaneously, offset from the carrier:

    - Output Port: 1
    - Mode: Arb Waveform (IQ)
    - Power Level Type: Peak Power
    - Reference Clock Source: PXI_CLK (Locked to Rubidium)
    - Reference Clock Frequency: 10 MHz
    - Frequency: First frequency from Configurations **Table 52** (f_0)
    - Upconverter Offset Mode: Enabled
    - Power Level: First Power Level from configurations **Table 52**
    - Signal Bandwidth: Bandwidth Matching the Power Level from configurations **Table 52**
    - Upconverter Offset: Driver Default

- MultiTone VI Cluster Input (see section **9.1 - Generating an IQ Signal**):
  - Number of Elements = 2
- Tone Frequency: DUT Tone Offset Frequencies from Configurations **Table 52**
  - Tone Phase = [0, 0]
  - Tone Power = [-7, -7]
- IQ Rate: Hardware option maximum from **Table 6**
- Number of Samples: 50 kS
- Digital Gain: 0 dB

3. Configure the Spectrum Analyzer for the following settings:

- Mode: Spectrum
- Reference Oscillator Source: External Reference (Locked to Rubidium)
- Center Frequency: Same as DUT Frequency (f_0)

$f_1 = f_0 + \boldsymbol{t_1}$ ($\boldsymbol{t_1}$ Matching the DUT Power Level from configurations **Table 52**)

- Reference Level: DUT Power Level + DUT digital gain
- Span: 1 kHz
- RBW: 30 Hz
- Sweep Count: 10001
- Mode: Auto Peak
- Attenuation: Matching the DUT Power Level from configurations **Table 52**

4. Enable the DUT to generate the tones. Wait until it settles.

5. Taking the Verification measurements:

> Repeat, once for each DUT Reference Power Level in **Table 52**, starting with the lower power setting.
>
> > Repeat, once for IQ Center Frequency setting in **Table 52**.

6. Measure the Power at frequency f_1.

7. Record the corrected measured power with cable characterization at f_1 frequency:

   Pf_{1c} **= P**f_1 **- M_to_RX_Cable_Path_Response**$_{(f1)}$ **[dBm]**

8. Configure the Spectrum Analyzer for the following settings:

   Center Frequency: Same as DUT Frequency (f_0)

$f_2 = f_0 + t_2$ (t_2 Matching the DUT Power Level from configurations **Table 52**)

9. Measure the Power at frequency f_2.

10. Record the corrected measured power with cable characterization at f_2 frequency:

    Pf_{2c} **= P**f_2 **- M_to_RX_Cable_Path_Response**$_{(f2)}$ **[dBm]**

11. Configure the Spectrum Analyzer for the following settings:

    Center Frequency: Same as DUT Frequency (f_0)

    - $f(IMD3_{T1}) = (2 f_2 - f_1)$

12. Measure the Power at frequency $f(IMD3_{T1})$.

13. Record the corrected measured power with cable characterization at $f(IMD3_{T1C})$ frequency:

    $Pf(IMD3_{T1C})$ **=**
    $Pf(IMD3_{T1})$ **- M_to_RX_Cable_Path_Response**$_{(f2(IMD3T1))}$ **[dBm]**

14. Configure the Spectrum Analyzer for the following settings:

    Center Frequency: Same as DUT Frequency (f_0)

    - $f(IMD3_{T2}) = (2 f_1 - f_2)$

15. Measure the Power at frequency $f(IMD3_{T2})$.

16. Record the corrected measured power with cable characterization at $f(IMD3_{T2C})$ frequency:

$Pf(IMD3_{T2C})$ **=**

$Pf(IMD3_{T2})$ **- M_to_RX_Cable_Path_Response**$_{(f2(IMD3T2))}$ **[dBm]**

17. Calculate Output IMD_3 using the following equation:

Out(IMD₃) = $Min(Pf_{1C}; Pf_{2C}) - Max[Pf(IMD3_{T1C}); Pf(IMD3_{T2C})]$

- Calculate TOI using the following equation:

Out(TOI) = $Min(Pf_{1C}; Pf_{2C}) + [Min(Pf_{1C}; Pf_{2C}) - Out(IMD_3)/2]$ [dB]

Compare the calculated Out(TOI) with limits in **Table 48**

18. Configure the DUT to generate two single sideband tones simultaneously, offset from the carrier:

- Frequency: Next frequency from Configurations **Table 52** (f_0)
- Upconverter Offset:
  - Frequency (f_0) < 1.75 GHz: Diver Default
  - Frequency (f_0) ≥ 1.75 GHz: 0 Hz
  - Power Level: Current Power Level from configurations **Table 52**

Signal Bandwidth: Bandwidth Matching the current Power Level from configurations **Table 52**

- MultiTone VI Cluster Input (see section **9.1 - Generating an IQ Signal**):
  - Number of Elements = 2

Tone Frequency: DUT Tone Offset Frequencies from Configurations **Table 52**

  - Tone Phase = [0, 0]
  - Tone Power = [-7, -7]
- IQ Rate: Hardware option maximum from **Table 6**

19. Configure the Spectrum Analyzer for the following settings:

- Center Frequency: Same as DUT Frequency (f_0)

$f_1 = f_0 + \boldsymbol{t_1}$ (***t_1*** Matching the DUT Power Level from configurations **Table 52)**

- Reference Level: DUT Power Level + DUT digital gain

Attenuation: Matching the DUT Power Level from configurations **Table 52**

20. Configure the DUT to generate two single sideband tones simultaneously, offset from the carrier:

- Frequency: First frequency from Configurations **Table 52** (f_0)
- Upconverter Offset:
  - Frequency (f_0) < 1.75 GHz: Diver Default
  - Frequency (f_0) ≥ 1.75 GHz: 0 Hz

Power Level: Next Power Level from configurations **Table 52**

Signal Bandwidth: Bandwidth Matching the Power Level from configurations **Table 52**

- MultiTone VI Cluster Input (see section **9.1 - Generating an IQ Signal**):
  - Number of Elements = 2
  - Tone Frequency: DUT Tone Offset Frequencies from Configurations **Table 52**
  - Tone Phase = [0, 0]
  - Tone Power = [-7, -7]
- IQ Rate: Hardware option maximum from **Table 6**

21. Configure the Spectrum Analyzer for the following settings:

- Center Frequency: Same as DUT Frequency (f_0)

- $f_1 = f_0 + \boldsymbol{t_1}$ (***t₁*** Matching the DUT Power Level from configurations **Table 52**)
- Reference Level: DUT Power Level + DUT digital gain
- Attenuation: Matching the DUT Power Level from configurations **Table 52**

22. Enable the DUT to generate the tones. Wait until it settles.

6.9.6. Verification Procedure Port 2 (Downconverter Mode = User Defined)

1. Repeat procedure 6.10.4 Verification Procedure **Port 1** (Upconverter Mode = **User Defined**):

Replace **Figure 26** with **Figure 27.** Connections for RF Output Third Order Intermodulation Port 2 Verification

Where “Port 1” is mentioned, replace with “Port 2”.

6.9.7. Verification Procedure Port 2 (Downconverter Mode = Enabled)

1. Repeat procedure 6.10.5 Verification Procedure **Port 1** (Upconverter Mode = **Enabled**):

   Replace **Figure 26** with **Figure 27.** Connections for RF Output Third Order Intermodulation Port 2 Verification

   Where “Port 1” is mentioned, replace with “Port 2”.

6.10. RF Input Average Noise Density Verification

6.10.1. Verification Test Limits

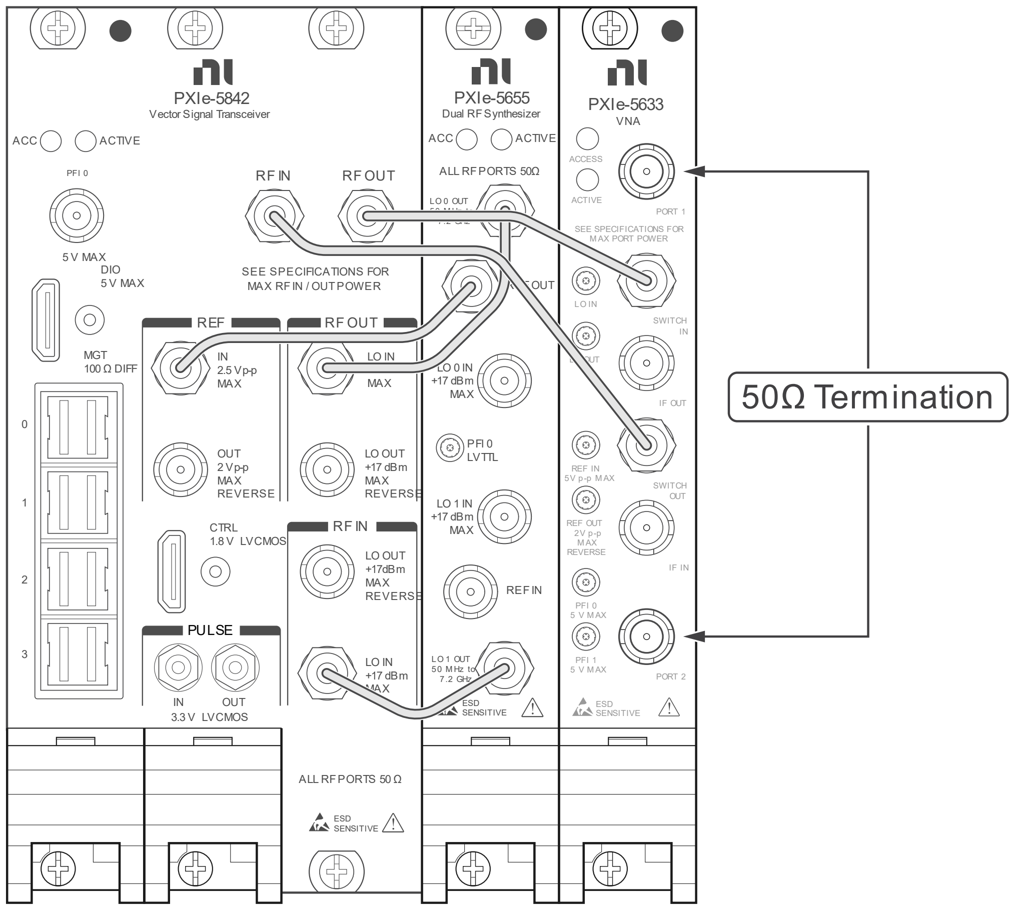
Table 53: RF Input Average Noise Density Test Limits for Verification Test

IQ Frequency	Reference Level	As-Found Upper Limit
30 MHz to <1.75 GHz		-160 dBm
1.75 GHz to 3.0 GHz		-159 dBm
>3.0 GHz to 12.0 GHz		-155 dBm
>12.0 GHz to 18.0 GHz	-30 dBm	-151 dBm
>18.0 GHz to 22.0 GHz		-150 dBm
>22.0 GHz to 25.0 GHz		-148 dBm
>25.0 GHz to 26.5 GHz		-147 dBm
30 MHz to 1.75 GHz		-134 dBm
>1.75 GHz to 22.0 GHz	0 dBm	-133 dBm
>22.0 GHz to 26.5 GHz		-131 dBm

Note
Test up to 26.5 GHz only; no harmonics above 26.5 GHz will be measured.

6.10.2. Initial Test Connection

Figure 28. Connections for Input Average Noise Density Verification



1. 3.5 mm (m) 50 Ω Terminator (x2)
2. DUT

6.10.3. Verification Procedure

Table 54: RF Input Average Noise Density Configurations

DUT IQ Frequency	DUT Downconverter Mode	DUT Reference Power Level	Signal Bandwidth
▪ 30 MHz ▪ 50 MHz ▪ 100 MHz to 26.5 GHz (or Maximum Frequency, See Table 5) in 100 MHz steps	User Defined	▪ -30 dBm ▪ 0 dBm	▪ IQCF <1.75GHz: Driver Default ▪ IQCF ≥ 1.75GHz: 48 MHz
▪ 1.701 GHz ▪ 1.8 GHz to 26.5 GHz (or Maximum Frequency) (See Table 5) in 100 MHz Steps	Enabled	▪ -30 dBm ▪ 0 dBm	48 MHz

6.10.4. Verification Procedure **Port 1** (Downconverter Mode = **User Defined**)

1. Make the connections indicated in **Figure 28**.
2. Configure the DUT for the following settings:
   - Input Port: 1
   - Acquisition Type: IQ Mode
   - FFT Window: Uniform
   - Averaging Mode: RMS
   - Mode: Arb Waveform (IQ)
   - Reference Power Level: First Reference Power Level from configurations **Table 54**
   - IQ Center Frequency: First IQ frequency from Configurations **Table 54**
   - Downconverter Offset Mode: User Defined
   - Downconverter Offset: Driver Default

- Signal Bandwidth: Signal Bandwidth from Configurations **Table 54**
- IQ Rate: 60 MS/s
- Number of Samples: IQ Rate / 1000

3. Taking the measurements:

Repeat once for each DUT Reference Power Level setting from Configurations Table 54

Repeat, once for each DUT IQ Frequency in Configurations Table 54.

4. Initiate a Spectrum read from DUT
5. Measure the Power Spectrum Data with the DUT and name it "**Power_Spectrum_Data**", see **9.2 - Acquiring a Spectrum from IQ Data and Measuring the Peak** annex for more details.
6. The power Spectrum Data has the following parameters:
   - Spectrum_df: Frequency Spacing of the spectrum
   - Spectrum_f_0: Spectrum Initial Frequency
   - Spectrum_Data: An array of spectrum Y values
7. Create a subset array of **Power_Spectrum_Data**, called **Data_Subset**, including only the points within the noise frequency span of interest that is determined by:
   - Noise Offset: 20 MHz (the offset between the center frequency of Spectrum_Data and Data_Subset)
   - Noise Span: 1 MHz (the span of the Data_Subset)
8. Create array **Data_Subset_No_Spurs** from **Data_Subset** array, by removing all spurs of Data_Subset
   - Take the mean of all remaining points, and remove points (spurs) that are 5 dB above the mean
   - Remove all points below the thermal noise floor (< -174 dBm)
9. Determine the equalization noise bandwidth for the filter used, ENBW. This can be determined by calling the Window Properties VI function with following parameter:
   - BW: 1 Hz BW
   - info.window: Rectangle

10. Calculate the Average Noise Density using formulas:

BW Noise Contribution [dBm/Hz]= 10*log(1/(ENBW * Spectrum_df))
Average_Power_of_Noise_Floor [mW]= Mean($10^{Data\_Subset[i]/10}$), for all values "*i*"

Average Power of Noise_Floor [dBm] = 10*log(Average_Power_of_Noise_Floor[mW])

Average Noise Density [dBm/Hz] = Average Power of Noise_Floor + BW Noise Contribution

11. Configure the DUT for the following settings:
    - IQ Center Frequency: Next IQ frequency from Configurations **Table 54**
    - Signal Bandwidth: Signal Bandwidth from Configurations **Table 54**

12. Configure the DUT for the following settings:
    - Reference Power Level: Next Reference Power Level from configurations **Table 54**
    - IQ Center Frequency: First IQ frequency from Configurations **Table 54**
    - Signal Bandwidth: Signal Bandwidth from Configurations **Table 54**

6.10.5. Verification Procedure Port 1 (Downconverter Mode = Enabled)

1. Make the connections indicated in **Figure 28**.

2. Configure the DUT for the following settings:

- Input Port: 1
- Acquisition Type: IQ Mode
- FFT Window: Uniform
- Averaging Mode: RMS
- Mode: Arb Waveform (IQ)
- Reference Power Level: First Reference Power Level from configurations **Table 54**
- IQ Center Frequency: First IQ frequency from Configurations **Table 54**
- Downconverter Offset Mode: Enabled
- Downconverter Offset: Driver Default
- Signal Bandwidth: Signal Bandwidth from Configurations **Table 54**
- IQ Rate: 60 MS/s
- Number of Samples: IQ Rate / 1000

3. Taking the measurements:

Repeat once for each DUT Reference Power Level setting from Configurations Table 54

Repeat, once for each DUT IQ Frequency in Configurations Table 54.

4. Initiate a Spectrum read from DUT
5. Measure the Power Spectrum Data with the DUT and name it "**Power_Spectrum_Data**", see **9.2 - Acquiring a Spectrum from IQ Data and Measuring the Peak** annex for more details.
6. The power Spectrum Data has the following parameters:
   - Spectrum_df: Frequency Spacing of the spectrum
   - Spectrum_f_0: Spectrum Initial Frequency
   - Spectrum_Data: An array of spectrum Y values
7. Create a subset array of **Power_Spectrum_Data**, called **Data_Subset**, including only the points within the noise frequency span of interest that is determined by:
   - Noise Offset: 20 MHz (the offset between the center frequency of Spectrum_Data and Data_Subset)

- Noise Span: 1 MHz (the span of the Data_Subset)

8. Create array **Data_Subset_No_Spurs** from **Data_Subset** array, by removing all spurs of Data_Subset
   - Take the mean of all remaining points, and remove points (spurs) that are 5 dB above the mean
   - Remove all points below the thermal noise floor (< -174 dBm)
9. Determine the equalization noise bandwidth for the filter used, ENBW. This can be determined by calling the Window Properties VI function with following parameter:
   - BW: 1 Hz BW
   - info.window: Rectangle

10. Calculate the Average Noise Density using formulas:

BW Noise Contribution [dBm/Hz]= 10*log(1/(ENBW * Spectrum_df))
Average_Power_of_Noise_Floor [mW]= Mean($10^{Data\_Subset[i]/10}$), for all values "*i*"

Average Power of Noise_Floor [dBm] = 10*log(Average_Power_of_Noise_Floor[mW])

Average Noise Density [dBm/Hz] = Average Power of Noise_Floor + BW Noise Contribution

11. Configure the DUT for the following settings:

   - IQ Center Frequency: Next IQ frequency from Configurations **Table 54**
   - Signal Bandwidth: Signal Bandwidth from Configurations **Table 54**

12. Configure the DUT for the following settings:

   - Reference Power Level: Next Reference Power Level from configurations **Table 54**
   - IQ Center Frequency: First IQ frequency from Configurations **Table 54**

- Signal Bandwidth: Signal Bandwidth from Configurations **Table 54**

6.10.6. Verification Procedure Port 2 (Downconverter Mode = User Defined)

1. Repeat procedure 6.11.4 Verification Procedure **Port 1** (Downconverter Mode = **User Defined**):

   1.1. Where “Port 1” is mentioned, replace with “Port 2”.

6.10.7. Verification Procedure Port 2 (Downconverter Mode = Enabled)

1. Repeat procedure 6.11.5 Verification Procedure **Port 1** (Downconverter Mode = **Enabled**):

   1.1. Where “Port 1” is mentioned, replace with “Port 2”.

6.11. VNA Trace Noise Verification Procedure

6.11.1. VNA Trace Noise Test Points and Limits

Table 55: VNA Trace Noise Verification: Magnitude Test Limits

Frequency Range	As-Found Test Limit
	Upper Limit
50 MHz to < 6 GHz	0.0030 dB RMS
6 GHz to 6.15 GHz	0.0060 dB RMS
> 6.15 GHz to 26.5 GHz	0.0060 dB RMS

Table 56: VNA Trace Noise Verification: Phase Test Limits

Frequency Range	As-Found Test Limit
	Upper Limit
50 MHz to 300 MHz	0.030 degree RMS
> 300 MHz to < 6 GHz	0.030 degree RMS
6 GHz to 8 GHz	0.060 degree RMS
> 8 GHz to 12 GHz	0.060 degree RMS
> 12 GHz to 26.5 GHz	0.060 degree RMS

Table 57: VNA Trace Noise Verification: Frequency Test Points

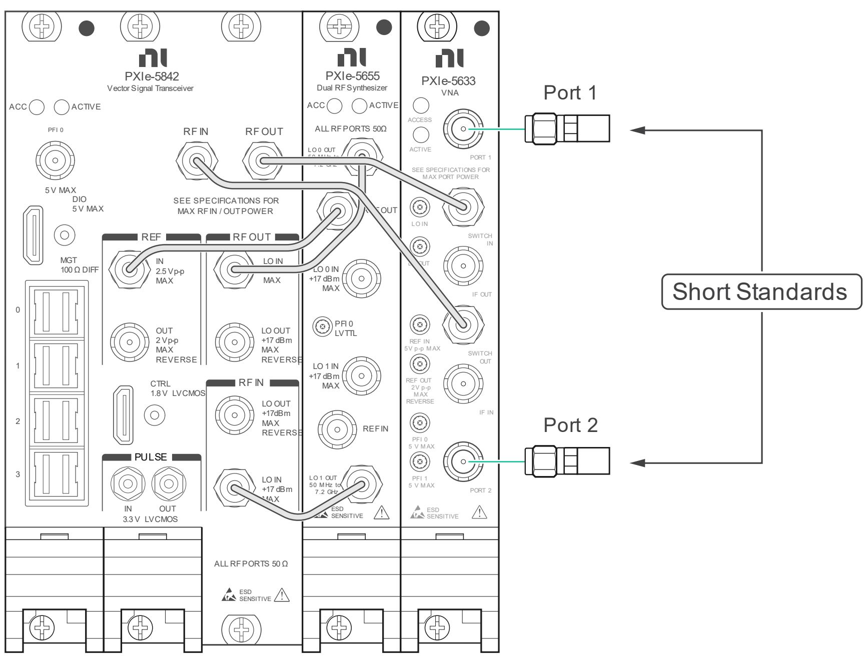
Frequency Test Points
50 MHz to 26.5 GHz in 100 MHz steps, include 26.5 GHz test point

6.11.2. VNA Trace Noise Initial Test Connections

Note

Make sure that you have made the connections described in **Figure 29** - Trace Noise Connections using proper torquing technique.

Figure 29 - Trace Noise Connections



1. DUT
2. 3.5 mm Male Precision Short
3. 3.5 mm Male Precision Short

6.11.3. VNA Trace Noise Verification Procedure

This procedure verifies the trace noise of the DUT's internal receivers then reported as S-Parameters. (S_{ii})

1. Make connections indicated in **Figure 29**.

2. Open session with DUT.

3. Set DUT to use 100 MHz PXI backplane clock signal.

4. Configure the DUT for the following settings:

   - IF Bandwidth: 10 kHz
   - Source Power Mode: Auto
   - Port 1 Source Power Level: 0 dBm
   - Port 1 Test Receiver Attenuation: 0 dB
   - Port 2 Source Power Level: 0 dBm
   - Port 2 Test Receiver Attenuation: 0 dB
   - Averaging Enabled: False

5. Taking the measurements:

Repeat once for each DUT Frequency setting from Table 57.

6. Set DUT to Frequency from **Table 57**.
   a. Set DUT into CW mode by sending an array of a single frequency value into RFMX Config Sweep Settings.vi.
7. Configure DUT to perform single sweep of S-Parameters.
   a. `SParams Num SParmas` setting should be set to `1`.
   b. `Correction Enabled` setting should be set to `False`.
   c. `SParams Format` setting should be set to `Complex`.

Repeat 201 times.

8. Initiate single sweep.
9. Fetch Complex Data from DUT.
10. Store Data to be used in Trace Noise calculation.

11. Calculate standard deviation for each port.

 a. Calculate the standard deviation.

$$stdev_{magnitude_{ii}}(f) = \sqrt{\frac{1}{n-1}\sum_{x=1}^{n}\left(|S_{ii}(x)| - \overline{|S_{ii}(x)|}\right)^2}$$

$$stdev_{phase_{ii}}(f) = \sqrt{\frac{1}{n-1}\sum_{x=1}^{n}\left(\angle S_{ii}(x) - \overline{\angle S_{ii}(x)}\right)^2}$$

$$Where\ i = 1{,}2$$

 b. Calculate the Trace Noise for each port (S_{ii}).

$$|Trace_{Noise_{ii}}(f)| = 20 * log_{10}\left(stdev_{magnitude_{ii}}(f)\right)\ dB\ RMS$$

$$\angle Trace_{Noise_{ii}}(f) = stdev_{phase_{ii}} * \frac{180}{\pi}\ degrees\ RMS$$

$$Where\ i = 1{,}2$$

6.12. VNA Calibration **Port 1**

This portion of the verification procedure will create error terms used in the following procedures: 6.14 VNA Uncorrected Error Terms **Port 1** and 6.15 VNA Noise Floor **Port 1** Verification Procedure.

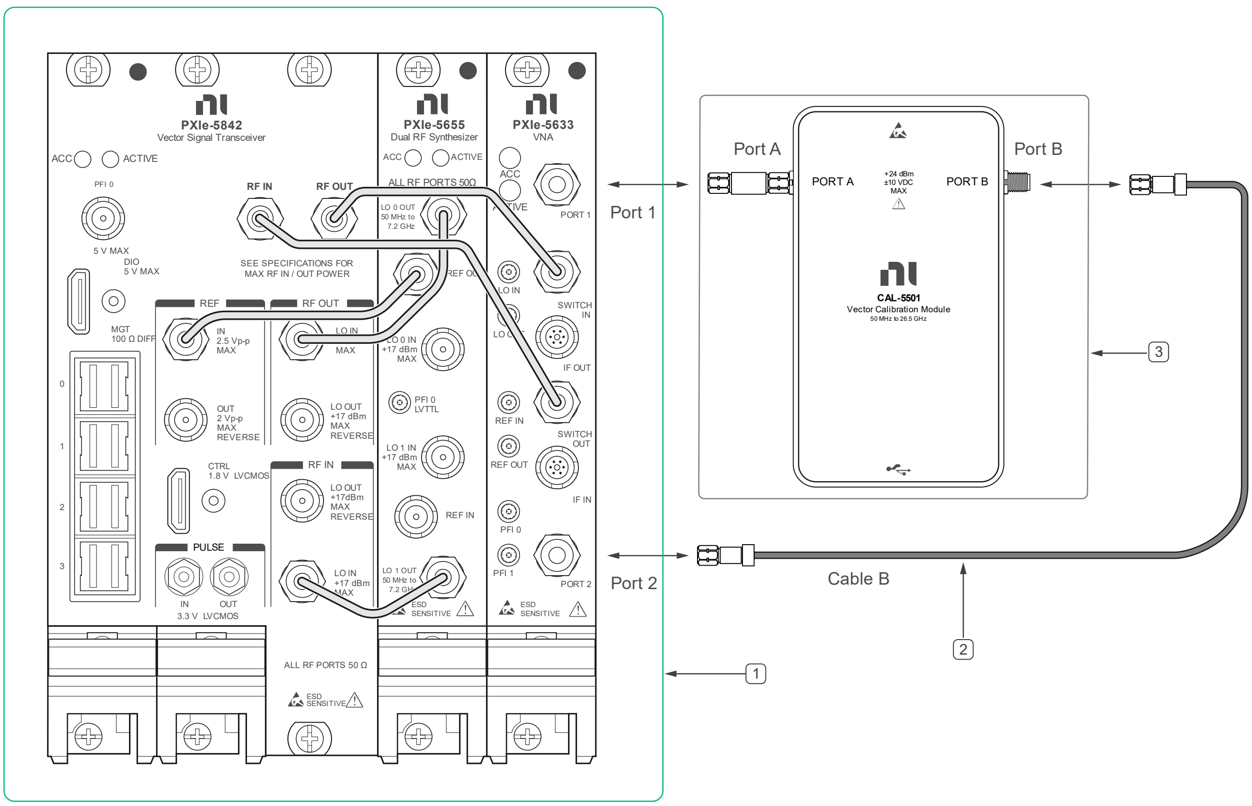
Once VNA calibration on Port 1 procedure starts, the temperature of the DUT cannot change more than ± 2.0 °C. If the DUT temperature fluctuates outside this range, then any procedures using these error terms will be invalid.

6.12.1. VNA Calibration **Port 1** Initial Test Connections

Note

Make sure that you have made the connections described in **Figure 30** using proper torquing technique.

Figure 30 – VNA Calibration **Port 1** Connections



1. DUT
2. 36” 3.5 mm cable (m) to (m)
3. ECM #1 with 3.5mm (m) to (m) Adapter attached to Port A

6.12.2. VNA Calibration Port 1 Procedure

The true value of any measurement can't be known; however, a VNA calibration or vector error correction reduces the effect of systematic errors inherit to the design of the DUT, cables and connectors. Measuring the various impedance states of an Electronic Calibration Module (ECM) will determine the error terms automatically with the least number of connections necessary. The ECM must be fully characterized, and all impedance states must be known.

1. Make the connections indicated in **Figure 30**.

2. Open session with DUT.

3. Set DUT to use 100 MHz PXI backplane clock signal.

4. Configure the DUT for the following settings:

    - IF Bandwidth: 1 kHz
    - Source Power Mode: Auto
    - Port 1 Source Power Level: -10 dBm
    - Port 1 Test Receiver Attenuation: 0 dB
    - Port 2 Source Power Level: -10 dBm
    - Port 2 Test Receiver Attenuation: 0 dB
    - Averaging Enabled: False

5. Configure the DUT to make S-Parameter measurements.

6. Setup frequency list to be measured using **Table 58**.

Table 58: VNA Calibration **Port 1**: Frequency Test Points

Frequency Test Points
50 MHz to 26.5 GHz in 50 MHz steps.

7. Perform a 2-Port SOLT calibration using the ECM.

6.13. VNA Uncorrected Error Terms **Port 1** Functional Procedure

This procedure assumes that the VNA Calibration or error correction calibration was previously executed. Refer to section 6.13 for more information.

6.13.1. VNA Uncorrected Error Terms **Port 1** Functional Procedure Test Points and Limits

Table 59: VNA Uncorrected Error Terms **Port 1**: Frequency Test Points

Frequency Test Points
50 MHz to 26.5 GHz in 50 MHz steps.

Table 60: VNA Uncorrected Error Terms **Port 1** Functional Test Limits: Directivity

Frequency Range	As-Found Test Limit
	Upper Limit
50 MHz to 300 MHz	-19.5 dB
> 300 MHz to 1 GHz	-15.6 dB
> 1 GHz to 3 GHz	-15.0 dB
> 3 GHz to 6 GHz	-14.9 dB
> 6 GHz to 8 GHz	-10.7 dB
> 8 GHz to 12 GHz	-8.7 dB
> 12 GHz to 18 GHz	-7.4 dB
> 18 GHz to 22 GHz	-7.4 dB
> 22 GHz to 26.5 GHz	-5.3 dB

Table 61: VNA Uncorrected Error Terms **Port 1** Functional Test Limits: Source Match

Frequency Range	As-Found Test Limit
	Upper Limit
50 MHz to 300 MHz	-18.6 dB
> 300 MHz to 1 GHz	-13.9 dB
> 1 GHz to 3 GHz	-10.7 dB
> 3 GHz to 6 GHz	-13.2 dB
> 6 GHz to 8 GHz	-12.7 dB
> 8 GHz to 12 GHz	-9.6 dB

> 12 GHz to 18 GHz	-6.5 dB
> 18 GHz to 22 GHz	-6.5 dB
> 22 GHz to 26.5 GHz	-4.8 dB

Table 62: VNA Uncorrected Error Terms **Port 1** Functional Test Limits: Load Match

Frequency Range	As-Found Test Limit
	Upper Limit
50 MHz to 300 MHz	-12.7 dB
> 300 MHz to 1 GHz	-13.3 dB
> 1 GHz to 3 GHz	-9.8 dB
> 3 GHz to 6 GHz	-11.2 dB
> 6 GHz to 8 GHz	-12.0 dB
> 8 GHz to 12 GHz	-8.6 dB
> 12 GHz to 18 GHz	-6.3 dB
> 18 GHz to 22 GHz	-6.2 dB
> 22 GHz to 26.5 GHz	-3.9 dB

Table 63: VNA Uncorrected Error Terms **Port 1** Functional Test Limits: Reflection Tracking

Frequency Range	As-Found Test Limit	
	Lower Limit	Upper Limit
50 MHz to 300 MHz	-3.54 dB	2.23 dB
> 300 MHz to 1 GHz	-3.70 dB	1.84 dB
> 1 GHz to 3 GHz	-4.22 dB	1.42 dB
> 3 GHz to 6 GHz	-5.26 dB	1.00 dB
> 6 GHz to 8 GHz	-4.94 dB	1.08 dB
> 8 GHz to 12 GHz	-5.40 dB	0.20 dB
> 12 GHz to 18 GHz	-6.79 dB	-0.19 dB
> 18 GHz to 22 GHz	-8.79 dB	-0.71 dB
> 22 GHz to 26.5 GHz	-10.46 dB	-1.34 dB

Table 64: VNA Uncorrected Error Terms **Port 1** Functional Test Limits: Transmission Tracking

Frequency Range	As-Found Test Limit	
	Lower Limit	Upper Limit
50 MHz to 300 MHz	-3.45 dB	2.28 dB
> 300 MHz to 1 GHz	-3.71 dB	2.02 dB
> 1 GHz to 3 GHz	-4.08 dB	1.62 dB
> 3 GHz to 6 GHz	-5.02 dB	0.98 dB
> 6 GHz to 8 GHz	-4.66 dB	1.32 dB
> 8 GHz to 12 GHz	-4.93 dB	0.34 dB

> 12 GHz to 18 GHz	-7.00 dB	-0.22 dB
> 18 GHz to 22 GHz	-8.04 dB	-0.39 dB
> 22 GHz to 26.5 GHz	-10.43 dB	-1.37 dB

6.13.2. VNA Uncorrected Error Terms Port 1 Functional Procedure Initial Test Connections

Assumes that connection is made from section 6.13.1 and left connected during this procedure. Refer to **Figure 30** for more details.

6.13.3. VNA Uncorrected Error Terms Port 1 Functional Procedure

This functional procedure uses the 12-term error model calculated during the error corrected calibration procedure, refer to section 6.13 for more information. The directivity, source match, load match, reflection tracking, and transmission tracking are determined from the error corrected calibration.

Note
This procedure does not de-embed the adapter used between the Electronic Calibration Module (ECM) and the DUT; therefore, its uncertainty must be considered when calculating the expanded uncertainty of these error terms.

1. Refer to section 6.13 for more information on creating the 12-term error model error terms: Directivity, Source Match, Load Match, Reflection Tracking, and Transmission Tracking.

2. Read all error terms from 2-Port SOLT calibration using the ECM.

3. Read values from `12 Term Error Model per Port`.

    a. Directivity or e00

    b. Source Match or e11

    c. Load Match or e22

    d. Reflection Tracking or e10e01

    e. Transmission Tracking or e10e32

4. Compare error terms against test limits.

6.14. VNA Noise Floor **Port 1** Verification Procedure

6.14.1. VNA Noise Floor **Port 1** Test Points and Limits

Table 65: VNA Noise Floor **Port 1** Verification: Magnitude Test Limits

Frequency Range	As-Found Test Limit
	Upper Limit
100 MHz to 300 MHz	-107 dBm/Hz
> 300 MHz to 6 GHz	-131 dBm/Hz
> 6 GHz to 12 GHz	-125 dBm/Hz
> 12 GHz to 22 GHz	-127 dBm/Hz
> 22 GHz to 26.5 GHz	-125 dBm/Hz

Table 66: VNA Noise Floor **Port 1** Verification: Frequency Test Points

Frequency Test Points
100 MHz to 26.5 GHz in 50 MHz steps

Table 67: Wave Parameters

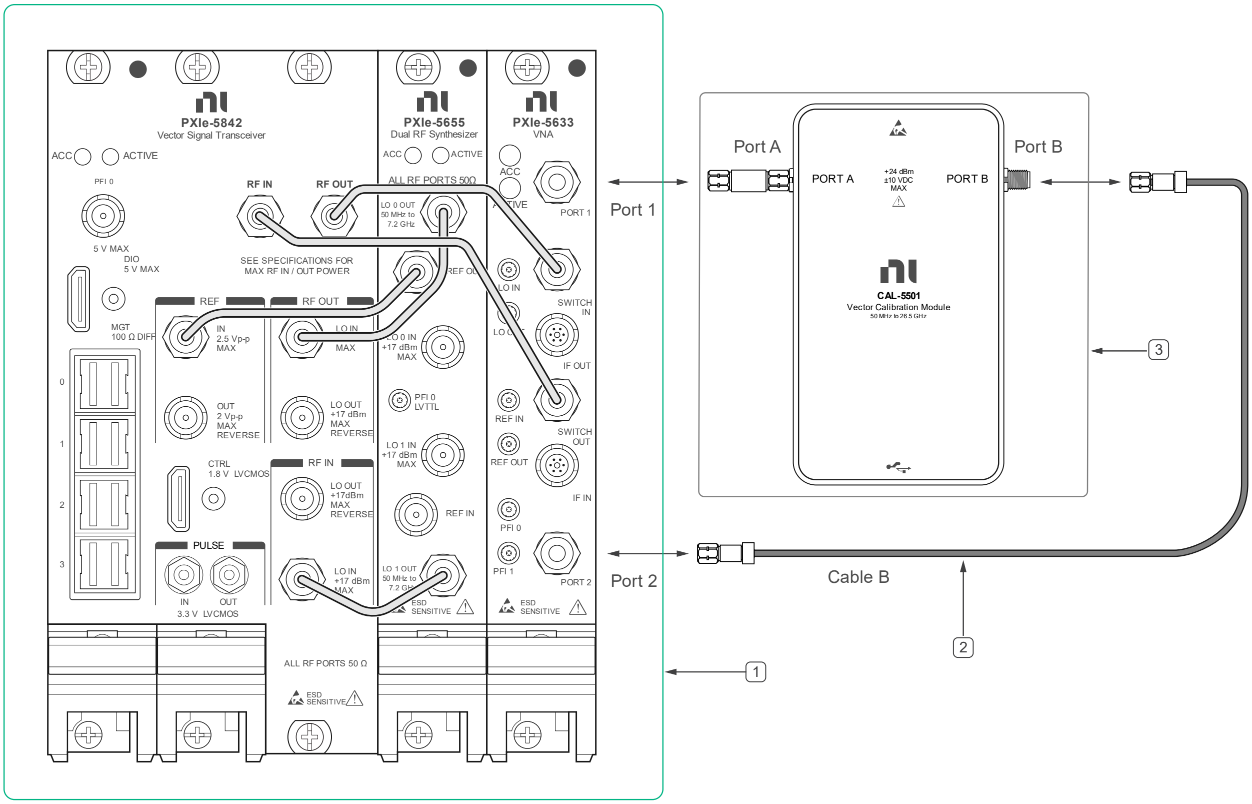
Selector String	Waves Receiver	Waves Receiver Port	Waves Source Port	Waves Format
Wave0	Test	Port1	Port2	Magnitude
Wave1	Test	Port2	Port1	Magnitude
Wave3	Reference	Port1	Port1	Magnitude
Wave4	Reference	Port2	Port2	Magnitude

6.14.2. VNA Noise Floor **Port 1** Initial Test Connections

Note

Make sure that you have made the connections described in **Figure 31** using proper torquing technique.

Figure 31 – Noise Floor Connections



1. DUT
2. 36” 3.5 mm cable (m) to (m)
3. ECM #1 with 3.5mm (m) to (m) Adapter attached to Port A

6.14.3. VNA Noise Floor Port 1 Verification Procedure

This procedure verifies the noise floor of the DUT’s internal receivers on port 1.

1. Make connections indicated in **Figure 31**.

2. Open session with DUT.

3. Set DUT to use 100 MHz PXI backplane clock signal.

4. Configure the DUT for the following settings:

   - IF Bandwidth: 1 kHz
   - Source Power Mode: Auto
   - Port 1 Source Power Level: -10 dBm
   - Port 1 Test Receiver Attenuation: 0 dB
   - Port 2 Source Power Level: -10 dBm
   - Port 2 Test Receiver Attenuation: 0 dB
   - Averaging Enabled: False

5. Setup DUT to take `Waves` measurement.

   a. Set `Source Power Mode` to `Auto`.

   b. Set `Waves Magnitude Units` to `dBm`.

   c. Set `Waves Phase Trace Type` to `Wrapped`.

Repeat once for each Frequency in Table 66.

6. Set `Frequency List (Hz)` property node according to **Table 66**.
   a. Create array of size 1 per frequency point in **Table 66**.
7. Set measurement as `Waves`.
8. Set `Waves Num Waves` property to `1`.
9. Set Wave parameter
   a. Set `Selector String` to `Wave0`.
   b. Set `Waves Receiver` to `Reference`.
   c. Set `Waves Receiver Port` to `Port1`.
   d. Set `Waves Source Port` to `Port1`.
   e. Set `Waves Format` to `Magnitude`.
10. Commit all settings to push all the settings to the DUT.
11. Initiate the Session.

12. Read data from DUT. Save receiver measurements as $a_1(f)$.
13. Save power measurement for each frequency from ECM as $p_{1det}(f)$.

14. Calculate power correction factor.

$$K_{port_1}(f) = p_{1det}(f) - a_1(f)$$

15. Set `Frequency List (Hz)` property node according to **Table 66**.
16. Setup DUT to take `Waves` measurement.

    a. Set `Averaging Enabled` to `True`.

    b. Set `Averaging Count` to `501`.

    c. Ensure `Correction Enabled` is set to `True`.

    d. Set `Waves Num Waves` property is set up to 4.

    e. Setup each wave parameter according to **Table 67** using a unique `selector string`.

    f. Set `Source Power Mode` to `Off`.

    g. Set `Waves Magnitude Units` to `dBm`.

    h. Set `Waves Phase Trace Type` to `Wrapped`.

Repeat 501 times based on Averaging Count Setting.

17. Initiate the Session.

Repeat 4 times, once per Wave Parameter in Table 67.

18. Read data from DUT.

19. Store data to be used in calculation to determine Noise Floor measurement based on Wave Selector string. $Wave_{x\,Meas_{dBm}}$

20. Convert each measurement from dBm to linear units.

$$Wave_{x\,Meas\_lin} = 10^{\frac{Wave_{x\,Meas_{dBm}} - 10}{20}}$$

21. Calculate the mean of each wave parameter and frequency test point using the 501 samples collected.

$$Wave_{x\,Mean_{dBm}} = 20log\left(\frac{1}{n-1}\sum_{i=1}^{n} Wave_{x\,Meas\_lin}(i)\right) + 10$$

22. Calculate the Noise Floor for each receiver.

$$Noise\ Floor(f) = Wave_{x\,Mean_{dBm}}(f) + K_{port_1}(f) - 10 * log(IF\_BW)$$

6.15. VNA Calibration **Port 2**

This portion of the verification procedure will create error terms used in the following procedures: 6.17 VNA Uncorrected Error Terms **Port 2** Functional Procedure and 6.18 VNA Noise Floor **Port 2** Verification Procedure.

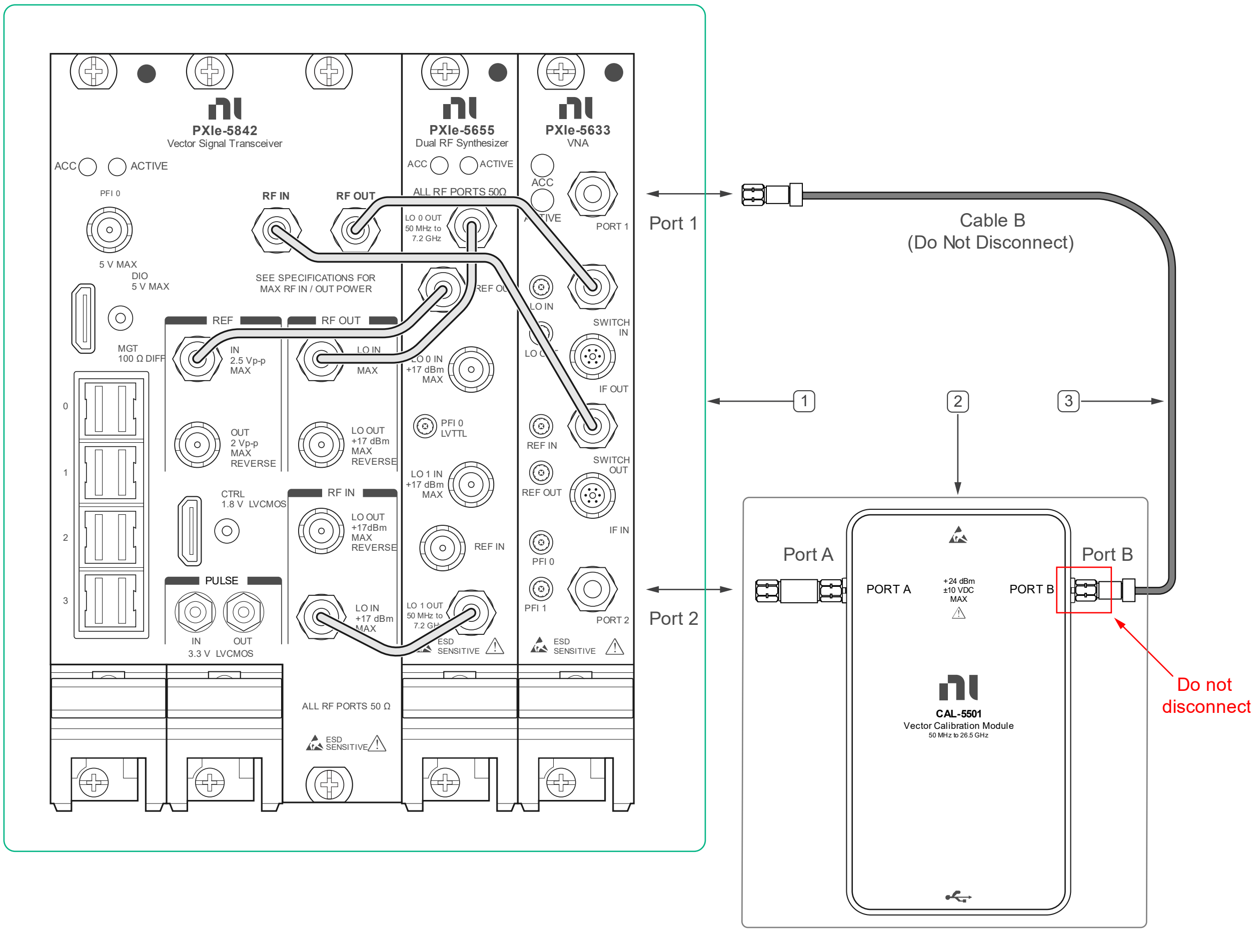
Once VNA calibration on Port 2 procedure starts, the temperature of the DUT cannot change more than ± 2.0 °C. If the DUT temperature fluctuates outside this range, then any procedures using these error terms will be invalid.

6.15.1. VNA Calibration **Port 2** Initial Test Connections

Note

Make sure that you have made the connections described in **Figure 32** using proper torquing technique.

Figure 32 – VNA Calibration Port 2 Connections



1. DUT
2. ECM #1 with 3.5mm (m) to (m) Adapter attached to Port A
3. 36" 3.5 mm cable (m) to (m)

6.15.2. VNA Calibration Port 2 Procedure

The true value of any measurement can't be known; however, a VNA calibration or vector error correction reduces the effect of systematic errors inherit to the design of the DUT, cables and connectors. Measuring the various impedance states of an Electronic Calibration Module (ECM) will determine the error terms automatically with the least number of connections necessary. The ECM must be fully characterized and all impedance states must be known.

1. Make connections indicated in **Figure 32**.

2. Open session with DUT.

3. Set DUT to use 100 MHz PXI backplane clock signal.

4. Configure the DUT for the following settings:

    - IF Bandwidth: 1 kHz
    - Source Power Mode: Auto
    - Port 1 Source Power Level: -10 dBm
    - Port 1 Test Receiver Attenuation: 0 dB
    - Port 2 Source Power Level: -10 dBm
    - Port 2 Test Receiver Attenuation: 0 dB
    - Averaging Enabled: False

5. Configure the DUT to make S-Parameter measurements.

6. Perform a 2-Port SOLT calibration using the ECM.

6.16. VNA Uncorrected Error Terms **Port 2** Functional Procedure

This procedure assumes that the VNA Calibration or error correction calibration was previously executed. Refer to section 6.16 for more information.

6.16.1. VNA Uncorrected Error Terms **Port 2** Functional Procedure Test Points and Limits

Table 68: VNA Uncorrected Error Terms **Port 2** Functional Test Limits: Directivity

Frequency Range	As-Found Test Limit
	Upper Limit
50 MHz to 300 MHz	-19.5 dB
> 300 MHz to 1 GHz	-15.6 dB
> 1 GHz to 3 GHz	-15.0 dB
> 3 GHz to 6 GHz	-14.9 dB
> 6 GHz to 8 GHz	-10.7 dB
> 8 GHz to 12 GHz	-8.7 dB
> 12 GHz to 18 GHz	-7.4 dB
> 18 GHz to 22 GHz	-7.4 dB
> 22 GHz to 26.5 GHz	-5.3 dB

Table 69: VNA Uncorrected Error Terms **Port 2** Functional Test Limits: Source Match

Frequency Range	As-Found Test Limit
	Upper Limit
50 MHz to 300 MHz	-18.6 dB
> 300 MHz to 1 GHz	-13.9 dB
> 1 GHz to 3 GHz	-10.7 dB
> 3 GHz to 6 GHz	-13.2 dB
> 6 GHz to 8 GHz	-12.7 dB
> 8 GHz to 12 GHz	-9.6 dB
> 12 GHz to 18 GHz	-6.5 dB
> 18 GHz to 22 GHz	-6.5 dB
> 22 GHz to 26.5 GHz	-4.8 dB

Table 70: VNA Uncorrected Error Terms **Port 2** Functional Test Limits: Load Match

Frequency Range	As-Found Test Limit
	Upper Limit
50 MHz to 300 MHz	-12.7 dB
> 300 MHz to 1 GHz	-13.3 dB
> 1 GHz to 3 GHz	-9.8 dB
> 3 GHz to 6 GHz	-11.2 dB
> 6 GHz to 8 GHz	-12.0 dB
> 8 GHz to 12 GHz	-8.6 dB

> 12 GHz to 18 GHz	-6.3 dB
> 18 GHz to 22 GHz	-6.2 dB
> 22 GHz to 26.5 GHz	-3.9 dB

Table 71: VNA Uncorrected Error Terms **Port 2** Functional Test Limits: Reflection Tracking

Frequency Range	As-Found Test Limit	
	Lower Limit	Upper Limit
50 MHz to 300 MHz	-3.54 dB	2.23 dB
> 300 MHz to 1 GHz	-3.70 dB	1.84 dB
> 1 GHz to 3 GHz	-4.22 dB	1.42 dB
> 3 GHz to 6 GHz	-5.26 dB	1.00 dB
> 6 GHz to 8 GHz	-4.94 dB	1.08 dB
> 8 GHz to 12 GHz	-5.40 dB	0.20 dB
> 12 GHz to 18 GHz	-6.79 dB	-0.19 dB
> 18 GHz to 22 GHz	-8.79 dB	-0.71 dB
> 22 GHz to 26.5 GHz	-10.46 dB	-1.34 dB

Table 72: VNA Uncorrected Error Terms **Port 2** Functional Test Limits: Transmission Tracking

Frequency Range	As-Found Test Limit	
	Lower Limit	Upper Limit
50 MHz to 300 MHz	-3.45 dB	2.28 dB
> 300 MHz to 1 GHz	-3.71 dB	2.02 dB

> 1 GHz to 3 GHz	-4.08 dB	1.62 dB
> 3 GHz to 6 GHz	-5.02 dB	0.98 dB
> 6 GHz to 8 GHz	-4.66 dB	1.32 dB
> 8 GHz to 12 GHz	-4.93 dB	0.34 dB
> 12 GHz to 18 GHz	-7.00 dB	-0.22 dB
> 18 GHz to 22 GHz	-8.04 dB	-0.39 dB
> 22 GHz to 26.5 GHz	-10.43 dB	-1.37 dB

6.16.2. VNA Uncorrected Error Terms Port 2 Functional Procedure Initial Test Connections

Assumes that connection is made from section 6.16.1 and left connected during this procedure. Refer to **Figure 32** for more details.

6.16.3. VNA Uncorrected Error Terms Port 2 Functional Procedure

This functional procedure uses the 12-term error model calculated during the error corrected calibration procedure, refer to section 6.16 for more information. The directivity, source match, load match, reflection tracking, and transmission tracking are determined from the error corrected calibration.

Note
This procedure does not de-embed the adapter used between the Electronic Calibration Module (ECM) and the DUT; therefore, its uncertainty must be considered when calculating the expanded uncertainty of these error terms.

1. Refer to section 6.16 for more information on creating the 12-term error model error terms: Directivity, Source Match, Load Match, Reflection Tracking, and Transmission Tracking.

2. Read all error terms from 2-Port SOLT calibration using the ECM with the following code.

3. Read values from `12 Term Error Model per Port`.

    a. Directivity or e00

    b. Source Match or e11

    c. Load Match or e22

    d. Reflection Tracking or e10e01

    e. Transmission Tracking or e10e32

4. Compare error terms against test limits.

6.17. VNA Noise Floor **Port 2** Verification Procedure

6.17.1. VNA Noise Floor **Port 2** Test Points and Limits

Table 73: VNA Noise Floor **Port 2** Verification: Magnitude Test Limits

Frequency Range	As-Found Test Limit
	Upper Limit
100 MHz to 300 MHz	-107 dBm/Hz
300 MHz to 6 GHz	-131 dBm/Hz
6 GHz to 12 GHz	-125 dBm/Hz
12 GHz to 22 GHz	-127 dBm/Hz
22 GHz to 26.5 GHz	-125 dBm/Hz

Table 74: VNA Noise Floor **Port 2** Verification: Frequency Test Points

Frequency Test Points
100 MHz to 26.5 GHz in 50 MHz steps

Table 75: Wave Parameters

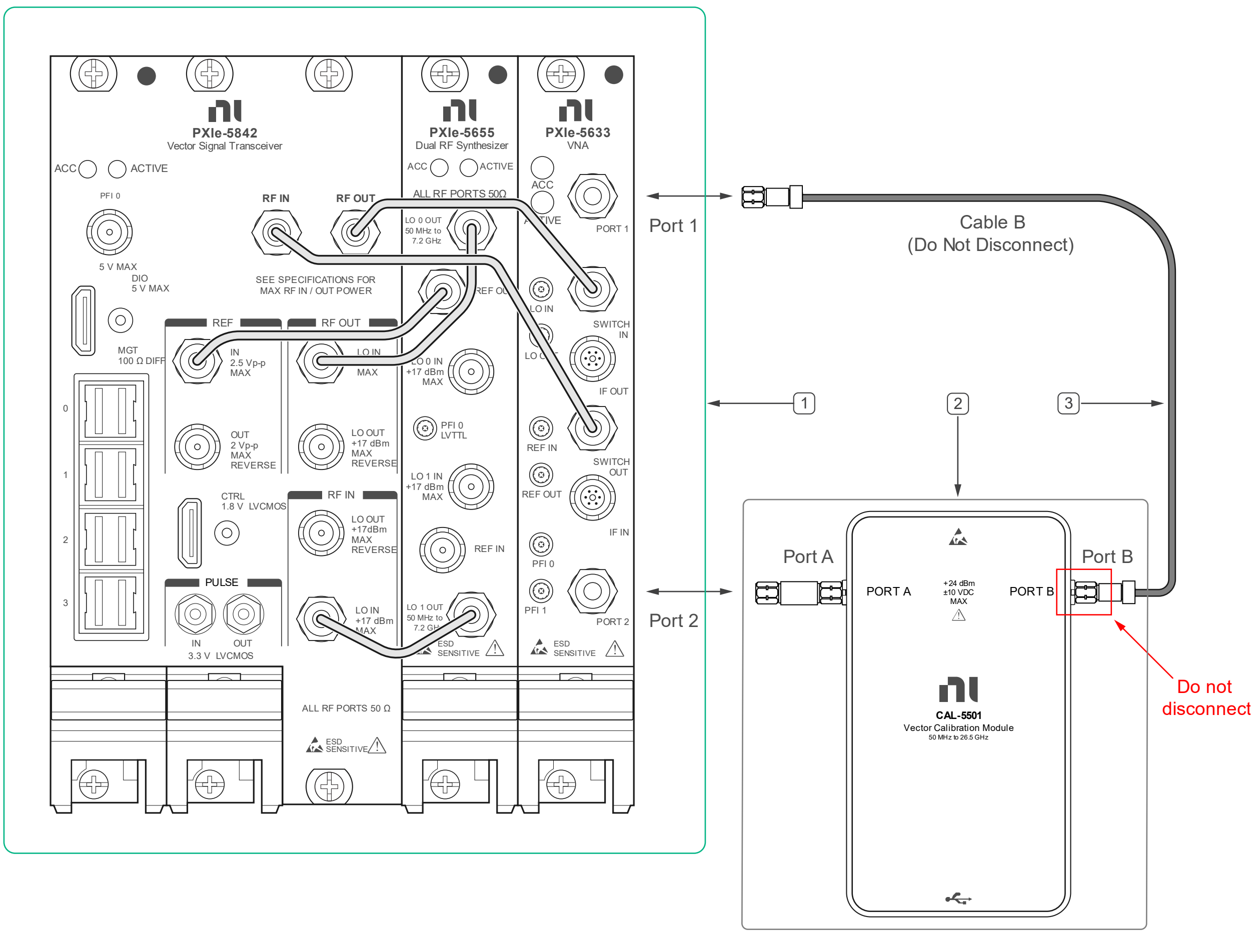
Selector String	Waves Receiver	Waves Receiver Port	Waves Source Port	Waves Format
Wave0	Test	Port1	Port2	Magnitude
Wave1	Test	Port1	Port1	Magnitude
Wave3	Reference	Port1	Port2	Magnitude
Wave4	Reference	Port1	Port1	Magnitude

6.17.2. VNA Noise Floor **Port 2** Initial Test Connections

Note

Make sure that you have made the connections described in **Figure 33** using proper torquing technique.

Figure 33 - Trace Noise Connections



1. DUT
2. ECM #1 with 3.5mm (m) to (m) Adapter attached to Port A
3. 36” 3.5 mm cable (m) to (m)

6.17.3. VNA Noise Floor Port 2 Verification Procedure

This procedure verifies the noise floor of the DUT's internal receivers on port 2.

1. Make the connections indicated in **Figure 33**.

2. Open session with DUT.

3. Set DUT to use 100 MHz PXI backplane clock signal.

4. Configure the DUT for the following settings:

    - IF Bandwidth: 10 kHz
    - Source Power Mode: Auto
    - Port 1 Source Power Level: 0 dBm
    - Port 1 Test Receiver Attenuation: 0 dB
    - Port 2 Source Power Level: 0 dBm
    - Port 2 Test Receiver Attenuation: 0 dB
    - Averaging Enabled: False
    - Averaging Count: 1

5. Set up DUT to take `Waves` measurement.

    a. Set `Source Power Mode` to `Auto`.

    b. Set `Waves Magnitude Units` to `dBm`.

    c. Set `Waves Phase Trace Type` to `Wrapped`.

Repeat once for each Frequency in Table 74.

6. Set `Frequency List (Hz)` property node according to **Table 74**.
    a. Create array of size 1 per frequency point in **Table 74**.
7. Set measurement as `Waves`.
8. Set `Waves Num Waves` property node to `1`.
9. Set Wave parameter
    a. Set `Selector String` to `Wave0`.
    b. Set `Waves Receiver` to `Reference`.
    c. Set `Waves Receiver Port` to `Port2`.
    d. Set `Waves Source Port` to `Port2`.
    e. Set `Waves Format` to `Magnitude`.
10. Commit all the settings to the DUT.
11. Initiate the Session.
12. Read data from DUT. Save receiver measurements as $a_2(f)$.
13. Save power measurement for each frequency from ECM as $p_{2det}(f)$.

14. Calculate power correction factor.

$$K_{port_2}(f) = p_{2det}(f) - a_2(f)$$

15. Set `Frequency List (Hz)` property node according to **Table 74**.
16. Setup DUT to take `Waves` measurement.
    a. Set `Averaging Enabled` to `True`.
    b. Set `Averaging Count` to `501`.
    c. Ensure `Correction Enabled` is set to `True`.
    d. Set `Waves Num Waves` property is set up to 4.
    e. Setup each wave parameter according to **Table 75**: Wave Parameters using the property node assigning each a unique `selector string`.
    f. Set `Source Power Mode` to `Off`.

g. Set `Waves Magnitude Units` to `dBm`.

h. Set `Waves Phase Trace Type` to `Wrapped`.

Repeat 501 times based on Averaging Count Setting.

17. Initiate the Session.

Repeat 4 times, once per Wave Parameter in Table 75.

18. Read data from DUT.
19. Store data to be used in calculation to determine Noise Floor measurement based on Wave Selector string. $Wave_{x_{Meas_{dBm}}}$

20. Convert each measurement from dBm to linear units.

$$Wave_{x_{Meas\_lin}} = 10^{\frac{Wave_{x_{Meas_{dBm}}} - 10}{20}}$$

21. Calculate the mean of each wave parameter and frequency test point using the 501 samples collected.

$$Wave_{x_{Mean_{dBm}}} = 20log\left(\frac{1}{n-1}\sum_{i=1}^{n} Wave_{x_{Meas\_lin}}(i)\right) + 10$$

22. Calculate the Noise Floor for each receiver.

$$Noise\ Floor(f) = Wave_{x_{Mean_{dBm}}}(f) + K_{port_2}(f) - 10 * log(IF\_BW)$$

6.18. VNA Calibration for Linearity Accuracy

Once the VNA calibration procedure starts, the temperature of the DUT cannot change more than ± 2.0 °C. If the DUT temperature fluctuates outside this range, then any procedures using these error terms will be invalid.

The true value of any measurement can't be known; however, a VNA calibration or vector error correction reduces the effect of systematic errors inherit to the design of the DUT, cables and connectors. Measuring the various impedance states of an Electronic Calibration Module (ECM) will determine the error terms automatically with the least number of connections necessary. The ECM must be fully characterized, and all impedance states must be known.

This procedure will determine the non-linearity of the DUT comparing error corrected measurements of various attenuator states against previously characterized attenuator states. The step attenuator used with this procedure ideally should be capable of providing at least 70 dB of attenuation in 1 dB steps. All measurements are made with -5 dBm at the b_i receiver. The source power maxed out for each frequency and the correct attenuation will be determined to achieve -5 dBm at the receivers.

Characterization files should be provided for the step attenuator that include each frequency for all attenuation values used by this procedure. Files should be in sNp format and uniquely labeled for each attenuation state. The prefix of the files should include the serial number of the step attenuator and with the date appended at the end of the file.

Example file format for attenuation value 001 dB:
SN123456_Atten_001dB_20240604.s2p

Note

Automated procedure from CalExec will not allow procedure to run without these files being present.

6.18.1. VNA Calibration for Linearity Accuracy Test Points and Limits

Table 76: VNA Linearity Verification: Magnitude Test Limits

Frequency Range	Nominal Test Port Power Level (dBm)	As-Found Test Limit	
		Lower Limit (dB)	Upper Limit (dB)
100MHz to 1GHz	-5	-0.12	0.12
	-10	-0.12	0.12
	-22.5	-0.12	0.12
	-25	-0.133	0.133
	-30	-0.16	0.16
	-35	-0.20	0.20
	-40	-0.34	0.34
> 1GHz to 12GHz	-5	-0.11	0.11
	-10	-0.11	0.11
	-22.5	-0.11	0.11
	-25	-0.117	0.117
	-30	-0.13	0.13
	-35	-0.23	0.23
	-40	-0.35	0.35
> 12GHz to 20GHz	-5	-0.11	0.11
	-10	-0.11	0.11
	-22.5	-0.11	0.11
	-25	-0.117	0.117

	-30	-0.13	0.13
	-35	-0.23	0.23
	-40	-0.35	0.35
> 20GHz to 23GHz	-10	-0.11	0.11
	-22.5	-0.11	0.11
	-25	-0.12	0.12
	-30	-0.14	0.14
	-35	-0.25	0.25
	-40	-0.38	0.38
> 23GHz to 26.5GHz	-10	-0.12	0.12
	-22.5	-0.12	0.12
	-25	-0.173	0.173
	-30	-0.28	0.28
	-35	-0.50	0.50
	-40	-0.87	0.87

Table 77: VNA Linearity Verification: Phase Test Limits

Frequency Range	Nominal Test Port Power Level (dBm)	As-Found Test Limit	
		Lower Limit (degrees)	Upper Limit (degrees)
100MHz to 1GHz	-5	-0.792	0.792
	-10	-0.792	0.792
	-22.5	-0.792	0.792
	-25	-0.8778	0.8778
	-30	-1.056	1.056
	-35	-1.32	1.32
	-40	-2.244	2.244
> 1GHz to 12GHz	-5	-0.726	0.726
	-10	-0.726	0.726
	-22.5	-0.726	0.726
	-25	-0.7722	0.7722
	-30	-0.858	0.858
	-35	-1.518	1.518
	-40	-2.31	2.31
> 12GHz to 20GHz	-5	-0.726	0.726
	-10	-0.726	0.726
	-22.5	-0.726	0.726
	-25	-0.7722	0.7722
	-30	-0.858	0.858
	-35	-1.518	1.518
	-40	-2.31	2.31

> 20GHz to 23GHz	-10	-0.726	0.726
	-22.5	-0.726	0.726
	-25	-0.792	0.792
	-30	-0.924	0.924
	-35	-1.65	1.65
	-40	-2.508	2.508
> 23GHz to 26.5GHz	-10	-0.792	0.792
	-22.5	-0.792	0.792
	-25	-1.1418	1.1418
	-30	-1.848	1.848
	-35	-3.3	3.3
	-40	-5.742	5.742

Table 78: VNA Linearity Verification: Frequency Test Points

Frequency Test Points
100 MHz, 1 GHz, 4 GHz, 8 GHz, 12 GHz, 18 GHz, 20 GHz, 24 GHz, and 26.5 GHz

Table 79: VNA Linearity Verification: Test Port Power Settings

Frequency	Test Port Power
100 MHz to 20 GHz	-5 dBm to -40 dBm in 5 dB steps
> 20 GHz to 26. 5 GHz	-10 dBm to -40 dBm in 5 dB steps

6.18.2. VNA Calibration for Linearity Accuracy Initial Test Connections

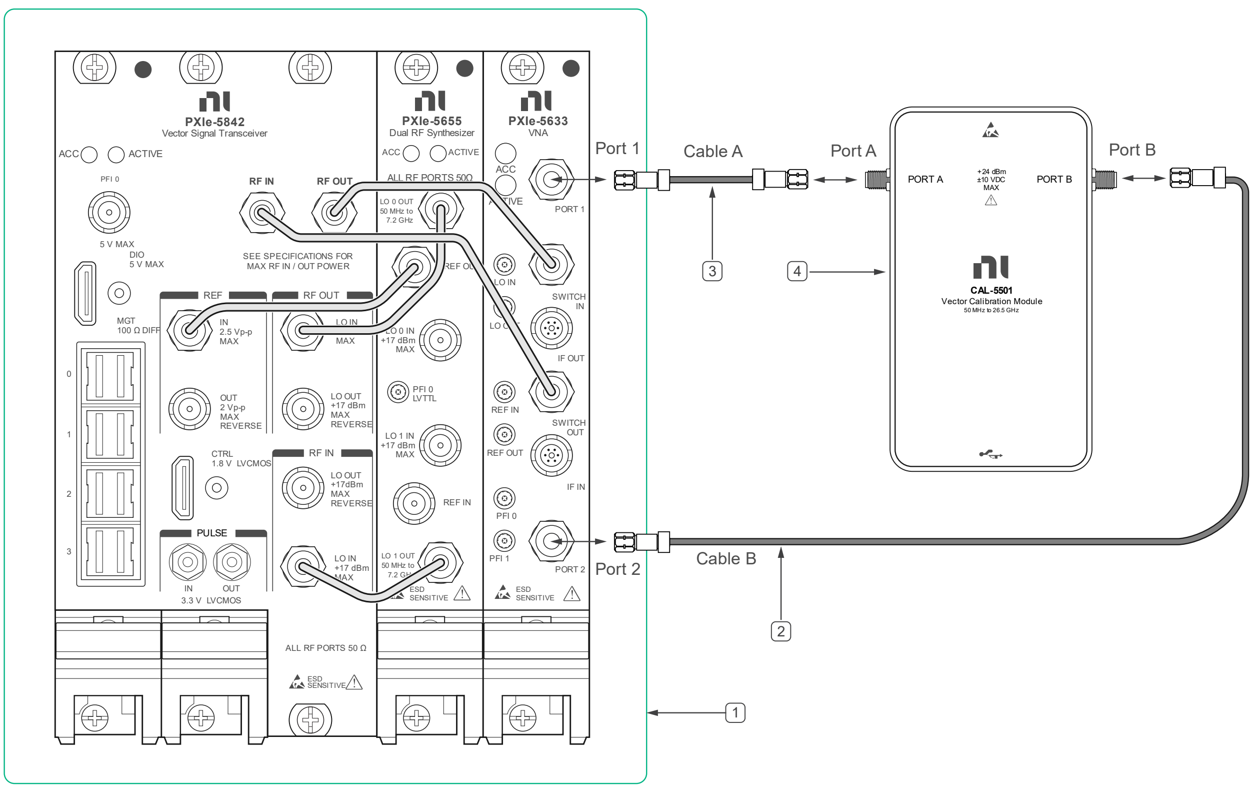
Note

Make sure that you have made the connections described in **Figure 34** using proper torquing technique.

Note

Cables should not be moved and fully supported after being connected to ECM module.

Figure 34 – VNA Calibration for Linearity Accuracy Connections



1. DUT
2. 36” 3.5 mm cable (m) to (m)
3. 36” 3.5 mm cable (m) to (m)
4. ECM #2

6.18.3. VNA Calibration for Linearity Accuracy Procedure

1. Make the connections indicated in **Figure 34**.
2. Open session with DUT.
3. Set DUT to use 100 MHz PXI backplane clock signal.
4. Configure the DUT to make S-Parameter measurements.
5. Commit all configurations to the DUT.
6. Perform a 2-Port SOLT calibration using the ECM using the following code.
7. De-embed cable from VNA Error Correction at both Port 1 and Port 2 using the `5633 deembed cable.vi`.
    a. Obtain newly created VNA Error Correction Terms. Henceforth these terms will be referenced as `Calset Linearity P1-P2 Cable End.`
        1. Obtain saved VNA Error Correction Terms saved from section 6.13 VNA Calibration Port 1 using `5633 fetch 12 error terms model` using `RFmx.vi.` Henceforth these terms will be referenced as `Calset Direct at P1.`
    b. Obtain saved VNA Error Correction Terms saved from section 6.16 VNA Calibration Port 2 using `5633 fetch 12 error terms model` using `RFmx.vi.` Henceforth these terms will be referenced as `Calset Direct at P2.`

c. This will create two new sets of data and identify the insertion loss of the cable connected to each Port of the DUT. Henceforth referred to as `Insertion Loss P1 Cable` and `Insertion Loss P2 Cable` respectively.

8. Ensure that the correct VNA Error Terms are loaded into the DUT using `Calset Linearity P1-P2 Cable End.`

Repeat twice, once for each Port.

Repeat once for each frequency in Table 78.

9. Read the max source power for DUT, then set DUT Power Level for both ports appropriately.

$$DUT_{PowerLevel} = Max_{Power} - 2\ dB$$

10. Set DUT to make `Waves` measurement.
11. Set Number of Waves to `1` using `Waves Num Waves` property.
12. Set Waves properties.
    a. Set `Selector String` to `Wave0.`
    b. Set `Waves Receiver` property to `Reference`.
    c. Set `Waves Format` property to `Magnitude.`
    d. Set `Waves Source Port` to Port being tested.
    e. Set `Waves Magnitude Units` property to `dBm.`
13. Push all the new settings to the DUT.
14. Start an acquisition.
15. Read the DUT receiver information in parallel with the power measurement from the ECM, then determine the K-factor

$$K - factor_i = ECM_{Power} - DUT_{Power}$$

6.18.4. Step Attenuator Connection for Linearity Accuracy

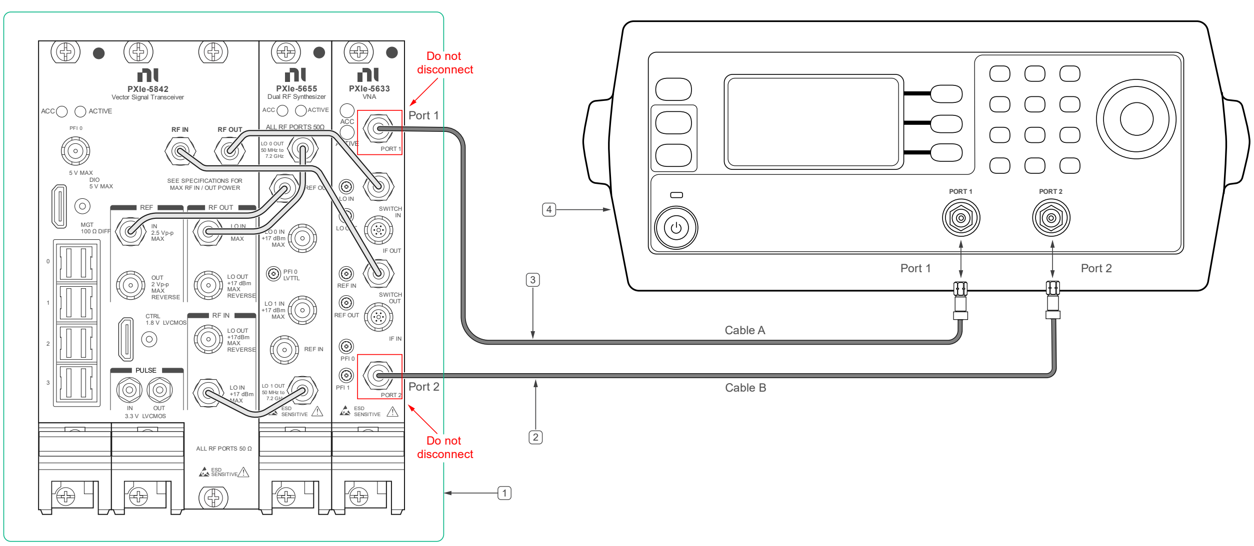
Note

Minimize cable movement between ECM connection for VNA Error Correction Term creation and when connection to step attenuator. Cables should be fully supported and not allowed to move during the duration of the remainder of procedure.

Note

Step Attenuator should be fully characterized and sNp files should be supplied for all attenuation values used. All frequencies used shall be contained within each file as no interpolation shall be used.

Figure 35 – Step Attenuator Connection for Linearity Procedure



1. DUT
2. 36” 3.5 mm cable (m) to (m)
3. 36” 3.5 mm cable (m) to (m)
4. Step Attenuator

6.18.5. Step Attenuator Linearity Accuracy Procedure

1. Make the connections indicated in **Figure 35**.

2. Open session with DUT.

3. Set DUT to use 100 MHz PXI backplane clock signal.

4. Ensure that the correct VNA Error Terms are loaded into the DUT.

Repeat twice, once for each Linearity Measurement.

5. Set Linearity Measurement according to **Table 80**.

Table 80 Linearity Measurement Configurations

Measurement	Receiver	Receiver Port	Source Port	Format
S_{12}	Test	Port1	Port2	Magnitude
S_{21}	Test	Port2	Port1	Magnitude

Repeat once for each frequency in Table 78.

6. Set the DUT to CW mode by sending an array of one element for each frequency according to **Table 78**.

7. Ensure that Correction Enabled is set to `True`.

8. Set Step Attenuator instrument to appropriate attenuation based on frequency loss of cables from both `Insertion Loss P1 Cable` and `Insertion Loss P2 Cable` data previously calculated.

Repeat up to 100 times, until Source Power is within -10 dBm ± 0.01 dB.

9. Set DUT to make `Waves` measurement.

10. Set Number of Waves to `2` using `Waves Num Waves` property.

11. Set Waves properties according to **Table 80** with `Waves Magnitude Units` property set to `dBm`.

12. Push or commit all the new settings to the DUT.

13. Initiate an acquisition.

14. Fetch the DUT receiver information.

15. Read the b_j receiver and adjust level of source power (a_i) until b_j receiver is within -10 dBm ± 0.01 dB.

    a. Save final source power level as a_1 for Port 1.

    b. Save final source power level as a_2 for Port 2.

Note

Monitor the temperature to ensure that it does not drift outside the limits previously identified for this procedure.

Repeat for each attenuator setting in Table 79.

Repeat once for each measure receiver (b_i).

Repeat once for each frequency in Table 78.

16. Set the DUT to CW mode by sending an array of one element for each frequency according to **Table 78**.

17. Set Step Attenuator to attenuation setting for specific iteration of loop.

18. Set DUT Port 1 properties.
    a. Set `Power Level (dBm)` property according to final a_1 power level determined in previous step.
    b. Set `Test Receiver Atten (dB)` property to `0` dB.
19. Set DUT Port 2 properties.
    a. Set `Power Level (dBm)` property according to final a_2 power level determined in previous step.
    b. Set `Test Receiver Atten (dB)` property to `0` dB.
20. Set `Waves Num Waves` property to `4`.
21. Set `Correction Enabled` to `True`.

22. Set Waves properties according to **Table 80** with `Waves Magnitude Units` property set to `dBm`.

23. Enable measurements by sending in an array of two elements: `SParams` and `Waves`.
24. Set S-Parameter settings to DUT.
    a. Set `SParams Receiver Port` and `SParams Source Port` according to measurement.
    b. For S_{12}: Receiver port is set to 1 and source port is set to 2.
    c. For S_{21}: Receiver port is set to 2 and source port is set to 1.
    d. Set `SParms Format` to `dB`.

e. Set `SParms Magnitude Units` to `dB`.
f. Set `SParms Phase Trace Type` to `Wrapped`.

25. Initiate an acquisition.

26. Fetch the DUT receiver information and store the data as b_{meas_1} for Port 1 and b_{meas_2} for Port 2.

27. Determine the linearity of the DUT for Port 1.

$$A_{21_i}(f) = b_{1m,i}(f) + k_1(f) - CableLoss_1(f)$$

$$\left|Linearity_{forward}(f)\right| = \left|S_{21_i}(f) - A_{21_i}(f)\right| - \left|S_{21_{ref}}(f) - A_{21_{ref}}(f)\right|$$

$$\angle Linearity_{forward}(f) = 6.6 * \left|Linearity_{forward}(f)\right|$$

28. Determine the linearity of the DUT for Port 2.

$$A_{12_i}(f) = b_{2m,i}(f) + k_2(f) - CableLoss_2(f)$$

$$|Linearity_{reverse}(f)| = \left|S_{12_i}(f) - A_{12_i}(f)\right| - \left|S_{12_{ref}}(f) - A_{12_{ref}}(f)\right|$$

$$\angle Linearity_{reverse}(f) = 6.6 * |Linearity_{reverse}(f)|$$

29. Compare all linearity values against limits.

7. Perform Adjustment

Adjustment automatically updates the calibration constants, the date, and the temperature in the DUT EEPROM. If the DUT passes the verification procedures within the As-Left test limits, an adjustment is not required. Proceed to the *Update the Onboard Calibration Information* section.

The adjustments are sensitive to temperature variation. The internal device temperature must be maintained within ± 2.0 °C during the following adjustment sections (about 1.5 h):

- 5.9.4 LO Self Cal and Impairments Self Cal
- TX External Gain Adjustment Port1
- RX External Gain Adjustment Port2
- TX External Gain Adjustment Port2
- RX External Gain Adjustment Port1
- TX Gain Internal Cal
- RX Gain Internal Cal
- EXT Cal Date

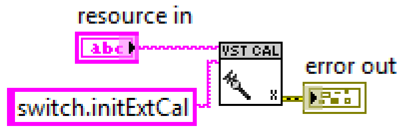
The execution order of the adjust procedure is intentionally setup such that temperature variation is minimized. Only one connection change is required during this time.

To track the module's temperatures, use "rxSig" and "txSig".

7.1. Initialize for adjustment

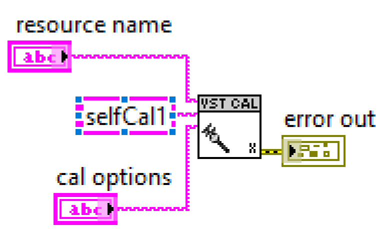
7.1.1. This section initializes the EEPROM in preparation for adjustment.

1. Call procedure "***X.vi***" with string "*switch.initExtCal*" and appropriate resource names. Cal options are not needed.



7.2. LO and Impairments Self Cal

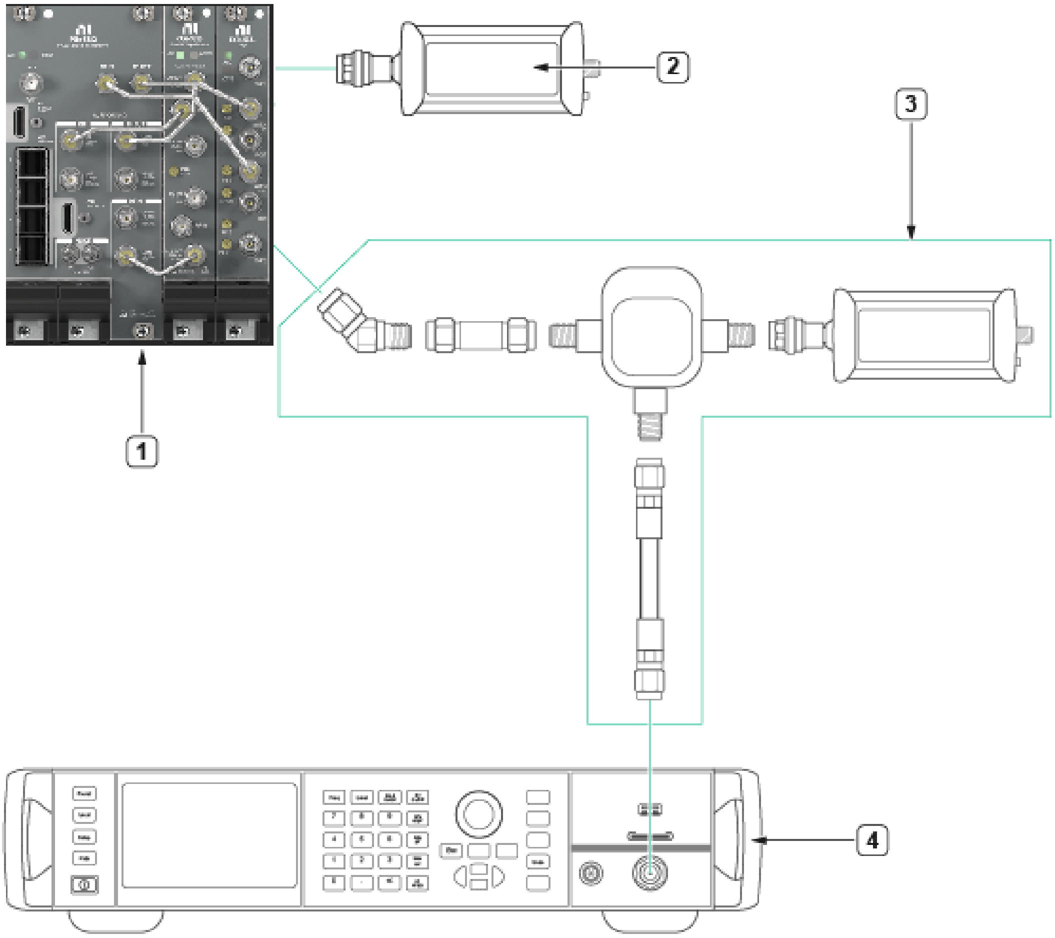
1. No external connections are required for this step specifically, but the system will be connected to the adjustment system, at this point, to minimize the time between adjustment steps.
2. Ensure that the Power Meter has been zeroed according with section 4.3 before connecting it to the DUT.
3. Perform a Power meter zero on the Receiver fixture Power meter before the fixture is connected to the DUT.
4. Make the connections according with Figure 36.
5. Call procedure "***X.vi***" with string "*selfCal1*" and appropriate resource names. Cal options are not needed.



7.2.1. Transmission **Port 1** and Receiver on **Port 2** Adjustment Connection

CAUTION
The form factor of the power sensors might cause strain to the DUT test port connector. Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Figure 36. Connection for RF Transmission Port 1 and Receiver on Port 2 Adjustment



1. DUT
2. Power Sensor #2
3. Receiver Fixture
4. Signal Generator#1

7.2.2. RF Transmission External Gain **Port 1** Adjustment Procedure

1. All previous adjust sections must have been completed prior in sequence, without major time delay or temperature drift.

2. Open a calibration session using "*Initialize External Calibration 2.vi*" with the *initialize RFSA* input Boolean as False.

3. Configure the power meter for the following:
   a. Measurement Mode: Continuos Average Mode (default)
   b. Auto Averaging: Enabled (default)
   c. Aperture Time: 0.001 s
   d. Auto Averaging Resolution: 3 (default)
   e. Auto Range Mode: Enabled (default)

4. Call "*Power Meter Cal Initialize.vi*".
   - Port Type: "*switch_p1.0*"

5. Making the Adjustments

Repeat until the "*Calibration Complete Boolean output*" of the "*Power Meter Cal Adjust.vi*" or the error wire becomes "**TRUE**".

6. Call "*Power Meter Cal Configure.vi*".

7. Use the frequency to measure output from the previous call to configure the external power meter and perform a read from the Power Meter.

8. Return results of Power Meter read to "*Power Meter Cal Adjust.vi*".

9. Call "*Power Meter Cal Initialize.vi*".
   - Port Type: "switch_p1.#" , where "#" is the next increment number up to 6 (for a total 7 instances from #=0 through #=6).

10. Call "*Power Meter Cal Finalize.vi*".

11. Call "***Close External Calibration.vi***" with:

    - Input "write calibration to hardware?" - set to "True".

12. Query the RxSig and TxSig temperature sensors and compare it with the initial query to check for temperature stability. If the RxSig and TXSig temperatures are more than ±2° C from the initial query, then the procedure should be restarted starting from **7.2 LO and Impairments Self Cal**.

7.2.3. RF Receiver External Gain Port 2 Adjustment Procedure

1. All previous adjust sections must have been completed prior in sequence, without major time delay or temperature drift.

2. Open a calibration session using "*Initialize External Calibration 2.vi*" with the *initialize RFSA* input Boolean as False.

3. Configure the power meter for the following:
    a. Measurement Mode: Continuous Average Mode (default)
    b. Auto Averaging: Enabled (default)
    c. Aperture Time: 0.001 s
    d. Auto Averaging Resolution: 3 (default)
    e. Auto Range Mode: Enabled (default)

4. Call "*Power Meter Cal Initialize.vi*".

    - Port Type: "*switch_p2.0*"

5. Making the Adjustments:

Repeat until the "*Calibration Complete Boolean output*" of the "*Input Gain Cal Adjust.vi*" or the error wire becomes "TRUE".

6. Call "*Input Gain Cal Configure.vi*".
7. Use the "*Frequency to measure"* and "*Power to generate"* outputs from the previous function call to configure external power meter and external generator. The *Power to generate* is the desired power at the port, compensate for the loss of the splitter by requesting a higher external generator power. See **5.1 Receiver Fixture Characterization**.
8. Return results of Power Meter read to "*RF Input Gain Cal Adjust.vi*".

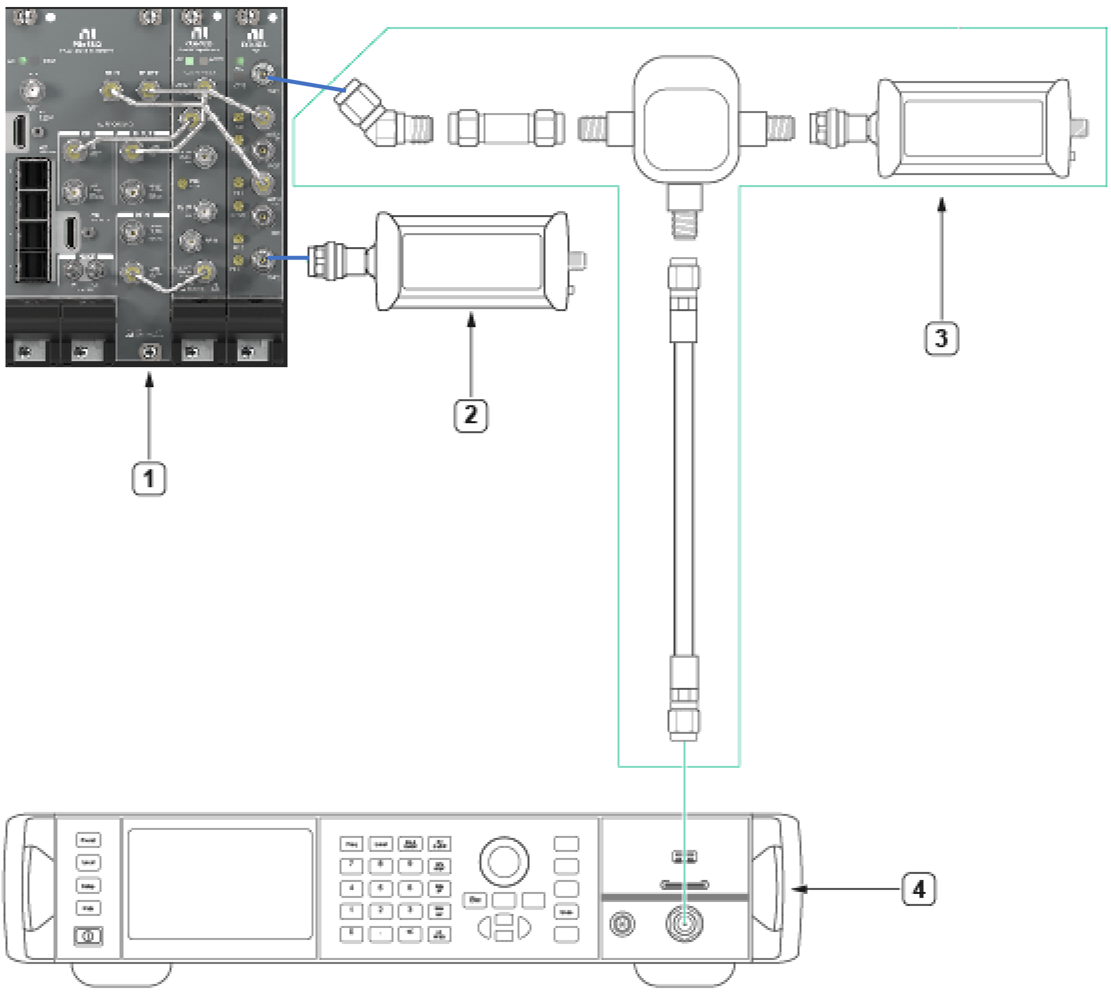
9. Call "*Power Meter Cal Initialize.vi*".
   - Port Type: "switch_p2.#" , where "#" is the next increment number up to 6 (for a total 7 instances from #=0 through #=6).

10. Call "*RF Input Gain Cal Finalize.vi*".
11. Call "***Close External Calibration.vi***" with:
    - Input "write calibration to hardware?" - set to "True".
12. Query the RxSig and TxSig temperature sensors and compare it with the initial query to check for temperature stability. If the RxSig and TXSig temperatures are more than ±2° C from the initial query, then the procedure should be restarted starting from **7.2 LO and Impairments Self Cal**.

7.2.4. Transmission Port 2 and Receiver on Port 1 Adjustment Connection

CAUTION
The form factor of the power sensors might cause strain to the DUT test port connector. Exercise care when making this connection to ensure appropriate means of weight distribution and strain relief are applied to prevent damage of the connectors.

Figure 37. Connection for RF Transmission Port 2 and Receiver on Port 1 Adjustment



1. DUT
2. Power Sensor #2
3. Receiver Fixture
4. Signal Generator#1

7.2.5. RF Transmission External Gain Port 2 Adjustment Procedure

1. All previous adjust sections must have been completed prior in sequence, without major time delay or temperature drift.
2. Make the connections according with **Figure 37**.
3. Open a calibration session using "*Initialize External Calibration 2.vi*" with the *initialize RFSA* input Boolean as False.
4. Configure the power meter for the following:
   a. Measurement Mode: Continuous Average Mode (default)
   b. Auto Averaging: Enabled (default)
   c. Aperture Time: 0.001 s
   d. Auto Averaging Resolution: 3 (default)
   e. Auto Range Mode: Enabled (default)
5. Call "*Power Meter Cal Initialize.vi*".
   - Port Type: "*switch_p2.0*"
6. Making the Adjustments

Repeat until the "*Calibration Complete Boolean output*" of the "*Power Meter Cal Adjust.vi*" or the error wire becomes "TRUE".

7. Call "*Power Meter Cal Configure.vi*".
8. Use the frequency to measure output from the previous call to configure the external power meter and perform a read from the Power Meter.
9. Return results of Power Meter read to "*Power Meter Cal Adjust.vi*".

10. Call "*Power Meter Cal Initialize.vi*".

- Port Type: “switch_p2.#” , where “#” is the next increment number up to 6 (for a total 7 instances from #=0 through #=6).

11. Call “*Power Meter Cal Finalize.vi*”.

12. Call “***Close External Calibration.vi***” with:
    - Input “write calibration to hardware?” - set to “True”.

13. Query the RxSig and TxSig temperature sensors and compare it with the initial query to check for temperature stability. If the RxSig and TXSig temperatures are more than ±2° C from the initial query, then the procedure should be restarted starting from **7.2 LO and Impairments Self Cal**.

7.2.6. RF Receiver External Gain Port 1 Adjustment Procedure

1. All previous adjust sections must have been completed prior in sequence, without major time delay or temperature drift.

2. Open a calibration session using “*Initialize External Calibration 2.vi*” with the *initialize RFSA* input Boolean as False.

3. Configure the power meter for the following:
    a. Measurement Mode: Continuous Average Mode (default)
    b. Auto Averaging: Enabled (default)
    c. Aperture Time: 0.001 s
    d. Auto Averaging Resolution: 3 (default)
    e. Auto Range Mode: Enabled (default)

4. Call “*Power Meter Cal Initialize.vi*”.
    - Port Type: “*switch_p2.0*”

5. Making the Adjustments:

Repeat until the "*Calibration Complete Boolean output*" of the "*Input Gain Cal Adjust.vi*" or the error wire becomes "TRUE".

6. Call "*Input Gain Cal Configure.vi*".

7. Use the "*Frequency to measure"* and "*Power to generate"* outputs from the previous function call to configure external power meter and external generator. The *Power to generate* is the desired power at the port, compensate for the loss of the splitter by requesting a higher external generator power. See **5.1 Receiver Fixture Characterization**.

8. Return results of Power Meter read to "*RF Input Gain Cal Adjust.vi*".

9. Call "*Power Meter Cal Initialize.vi*".

   - Port Type: "switch_p1.#" , where "#" is the next increment number up to 6 (for a total 7 instances from #=0 through #=6).

10. Call "*RF Input Gain Cal Finalize.vi*".

11. Call "***Close External Calibration.vi***" with:

    - Input "write calibration to hardware?" - set to "True".

12. Query the RxSig and TxSig temperature sensors and compare it with the initial query to check for temperature stability. If the RxSig and TXSig temperatures are more than ±2° C from the initial query, then the procedure should be restarted starting from **7.2 LO and Impairments Self Cal**.

7.3. Transmitter Gain Internal Cal

1. RF Transmission External Gain Adjustment Procedure, for all ports, must be completed before this calibration is run.
2. No external equipment is needed to run this procedure, however the previous connections can remain in place as long as the generator is turned off.
3. Call "***X.vi***" and appropriate resource names. Cal options are not needed.
    - With string: "*switch.int2*"
4. Query the "RxSig "and "TxSig" temperature sensors. Compare the respective readings with tRxSigRef and tTxSigRef reference temperatures. If the temperatures changed more than ±2 °C from the reference temperatures, the procedure should be restarted from **7.2 LO and Impairments Self Cal**.

7.4. Receiver Gain Internal Cal

1. RF Receiver External Gain Adjustment Procedure, for all ports, must be completed before this calibration is run.
2. No external equipment is needed to run this procedure; however the previous connections can remain in place as long as the generator is turned off.
3. Call "***X.vi***" and appropriate resource names. Cal options are not needed.
    - With string: "*switch.int1*"
4. Query the "RxSig "and "TxSig" temperature sensors. Compare the respective readings with tRxSigRef and tTxSigRef reference temperatures. If the temperatures changed more than ±2 °C from the reference temperatures, the procedure should be restarted from **7.2 LO and Impairments Self Cal**.

7.5. EXT Cal Date

1. The current time should be saved as the time at which external adjust was completed.
2. No external equipment is needed to run this procedure; however, the previous connections can remain in place as long as the generator is turned off.
3. Call "***X.vi***" and appropriate resource names. Cal options are not needed.
   - With string: "*switch.stampExt*"
4. This stamps the scalar portion of the external cal date, however it may not be reflected in MAX, as it uses the vector calibration date.

7.6. Running Self Cal

1. The final step of adjustment is to run self cal to ensure self cal can run successfully.
2. No external equipment is needed to run this procedure; however, the previous connections can remain in place as long as the generator is turned off.
3. Call "***X.vi***" and appropriate resource names. Cal options are not needed.
   - With string: "*selfCal2*"

8. Perform Reverification

Perform all tests in the Verification section after completing Adjustment. This verification compares the As-Left limits with measurement data collected after the DUT adjustment. The As-Left limits may be tighter than the As-Found limits.

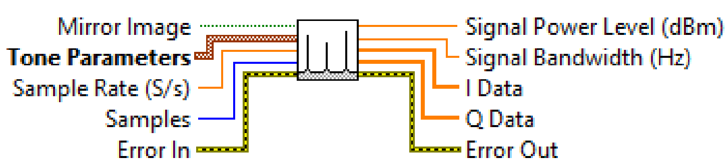
9. Programming Appendix

9.1. Generating an IQ Signal

When generating an RF Signal using the DUT in IQ mode, use the rfsg_Complex Multitone II.vi in conjunction with niRFSG Write Arb Waveform (I-Q).vi.

The rfsg_Complex Multitone II.vi can be found here:
…\<LabVIEW>\instr.lib\niRFSG\niRFSGExamplesSupport.llb\rfsg_Complex Multitone II.vi

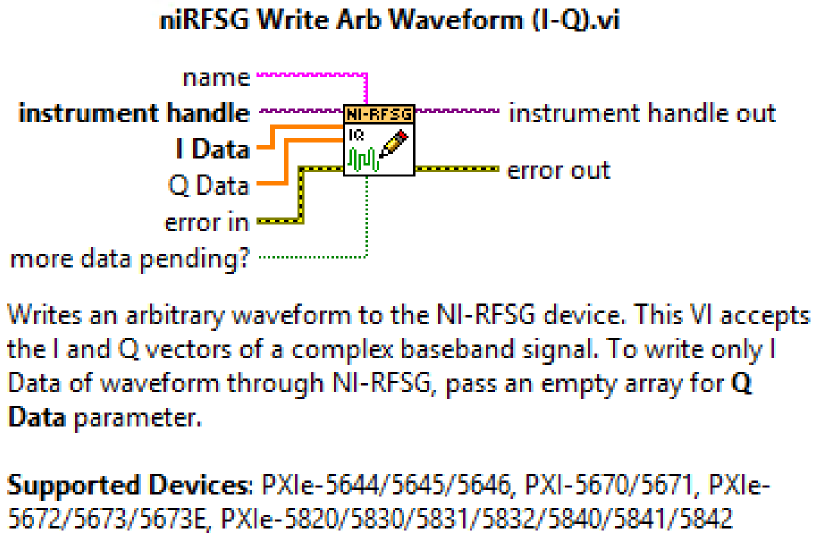
rfsg_Complex Multitone II.vi

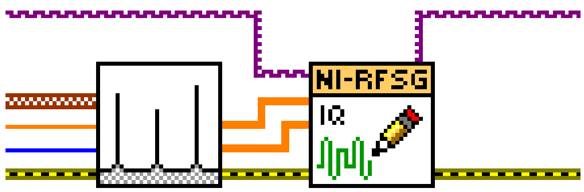


Generates a multitone complex waveform with the specified number of samples and at the specified sample rate.

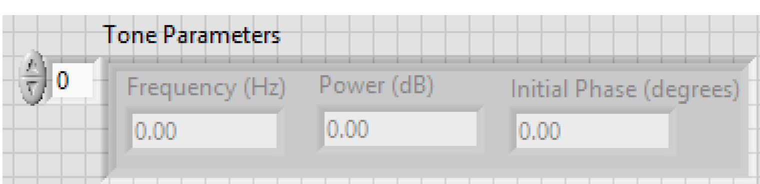
For each element in the Tone Parameters array, a tone with the specified frequency, power, and initial phase will appear in the output waveform.

If Mirror Image is true, additional tones will appear in the output waveform. The additional tones will have the same initial phase and power as the tones specified, but their frequencies will be the negative (-) of the frequencies specified.



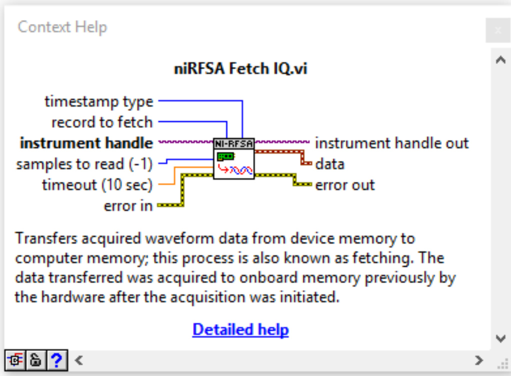


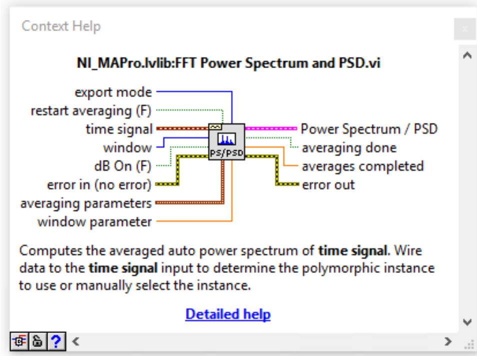
The Tone Parameters input to rfsg_Complex Multitone II.vi is an array of clusters. Each element of the array (a cluster) refers to a tone in your waveform. This allows you to generate IQ data that represents multiple tones. You would need to specify the Frequency Offset of the Tone, the Relative Power of the Tone, and the initial phase; throughout the document these may be referred to as “Tone Frequency”, “Tone Power”, and “Tone Phase” respectively. For most test cases, there will only be 1 element for the Tone Parameters input. This represents only a single tone generation. The exception to this is when multiple tones need to be generated in the RF Output Third Order Interpolation verification test.

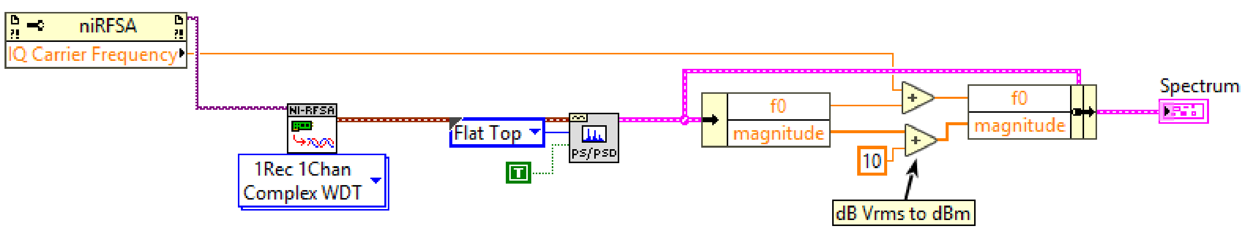


9.2. Acquiring a Spectrum from IQ Data and Measuring the Peak

1. When acquiring an RF Signal using the DUT in IQ mode, use the FFT Power Spectrum and PSD.vi in conjunction with niRFSA Fetch IQ.vi

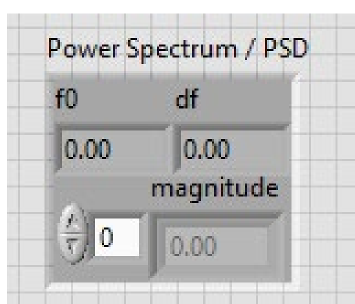






2. The FFT Power Spectrum and PSD.vi is a part of the NI_MAPro.lvlib which can be found here:

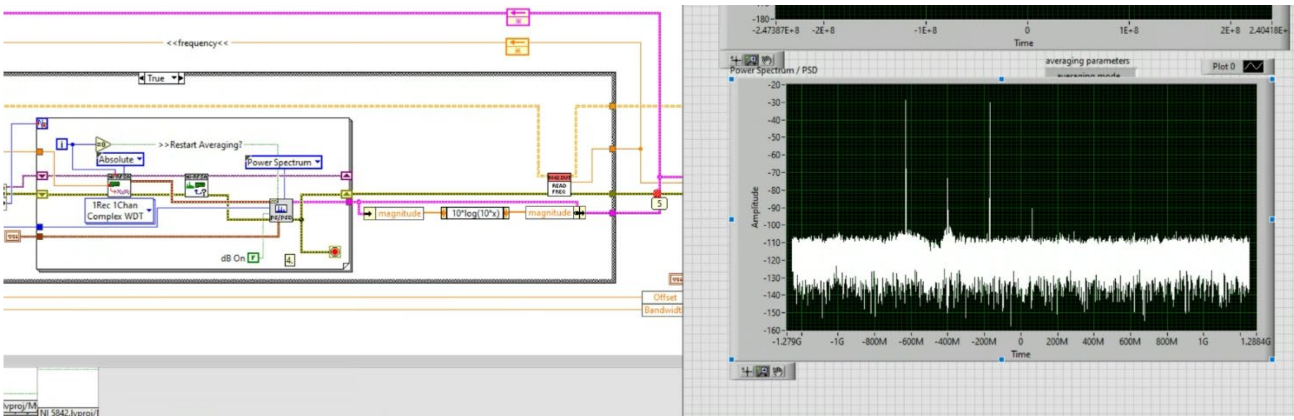
```
C:\Program Files\National Instruments\LabVIEW
2020\vi.lib\measure\NI_MAPro.lvlib
```



3. Create a subarray of the Magnitude array around the frequency of interest. Adjust the magnitude to convert from dBV to dBm.

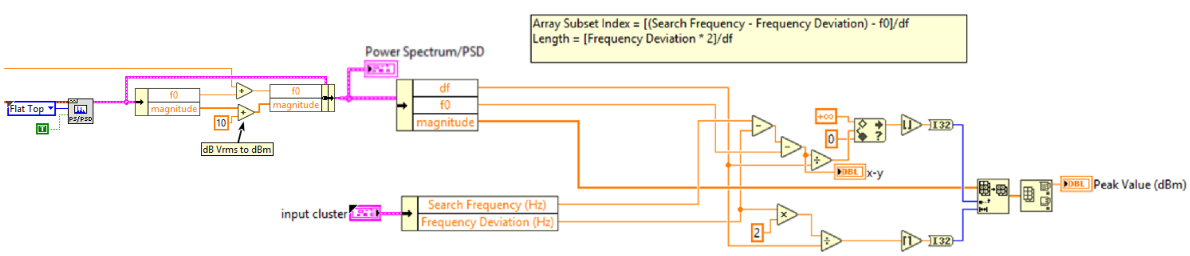
   Example

   There are additional considerations for band 1, Setting 400 MHz as the IQCF and generating a tone at 240Mhz gives this result:

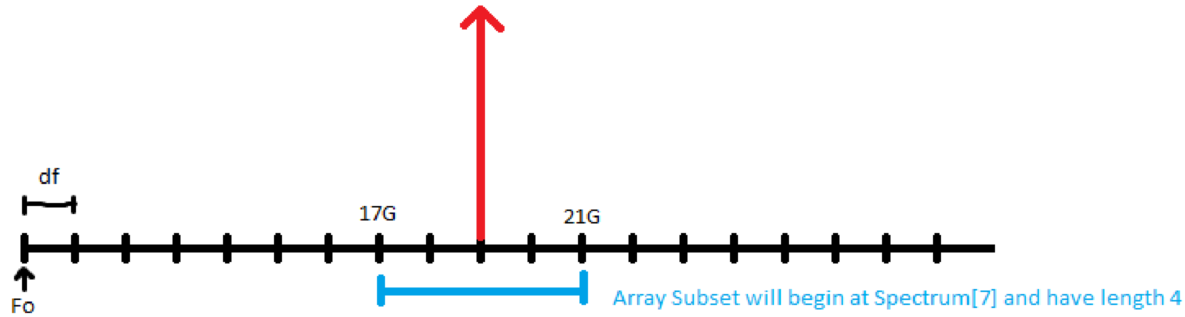


4. 0 offset/Time on the X-axis in this case is 400Mhz. The tone at -400M is baseband and the tone below that is an artifact of direct sampling in band 1. Everything below -400 MHz should be ignored. The tone around -160 MHz offset is the 240 MHz signal generator tone and that is the one we should be measuring.

5. Alternatively, you can look at the subset of the array:



6. Illustrated example:



Spectrum[] has the
following properties:
Fo = 10G
df = 1G

With the following search parameters, find Array Subset
Search Frequency = 19G
Frequency Deviation 2G
Array Subset Index = [(Search Frequency - Frequency Deviation) - f0]/df
= [(19G - 2G) - 10G]/1G
= (17G - 10G)/1G
= 7
Length = [Frequency Deviation * 2]/df
= 4G/1G
= 4

10. Power Meter Aperture Configuration

Table 81: Power Meter Aperture Configuration

Power Level [dBm]	Aperture [s]
-45	0.68
-40 to -35	0.013
-30 to -25	132E-6
-20	10E-6
-15 to +5	25E-6
10 to <20	24E-6
≥20	10E-6

11. Revision History

Revision	Section	Changes
379052A-01 March 2025	All	This is the initial release version of the PXIe-5842 with S-Parameters Calibration Procedure.

12. NI Services

Visit ni.com/support to find support resources including documentation, downloads, and troubleshooting and application development self-help such as tutorials and examples.

Visit ni.com/services to learn about NI service offerings such as calibration options, repair, and replacement.

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

NI corporate headquarters is located at 11500 N Mopac Expwy,
Austin, TX 78759-3504, USA.

379052A-01 March 2025