VXG Signal Generator

M9383B VXG-m and M9484B VXG Microwave Signal Generator

This manual provides documentation for the M9484C running the Microsoft Windows 10 operating system.

KEYSIGHT

MEASUREMENT GUIDE

Notices

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CAUTION

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Where to Find the Latest Information

Documentation is updated periodically. For the latest information about this product, including instrument software upgrades, application information, and product information, browse to the following URL:

https://www.keysight.com/find/m9384b

To receive the latest updates by email, subscribe to Keysight Email Updates at the following URL:

http://www.keysight.com/find/MyKeysight

Information on preventing instrument damage can be found at:

http://keysight.com/find/PreventingInstrumentRepair

Is your product software up-to-date?

Periodically, Keysight releases software updates to fix known defects and incorporate product enhancements. To search for software updates for your product, go to the Keysight Technical Support website at:

http://www.keysight.com/find/techsupport

1 Basic Measurements

KEYSIGHT TECHNOLOGIES

Overview

The M9383B/M9384B signal generators provides frequency coverage from 1 MHz to 44 GHz, with up to 2 GHz RF modulation bandwidth with an internal baseband generator, and over 2 GHz RF modulation bandwidth with external I/Q inputs.

The measurement examples use an X-Series Signal Analyzer to view the results. A few measurement examples require an N9040B/42B signal analyzer and is called out in those specific measurement examples. For information on using the X-Series Signal Analyzer multi-touch user interface, refer to the Online Help.

CAUTION

Please refer to the VXG data sheet and X-Series Signal Analyzer data sheet to ensure your measurement setup has adequate power.

http://literature.cdn.keysight.com/litweb/pdf/5992-4260EN.pdf

and

http://literature.cdn.keysight.com/litweb/pdf/5992-0090EN.pdf

NOTE

The software versions used in this measurement guide are:

– VXG: A.11.01
– X-Series Spectrum Analyzers/N9085EM0E: A.34.xx or later
– 89601 VSA: Version 2023 or later

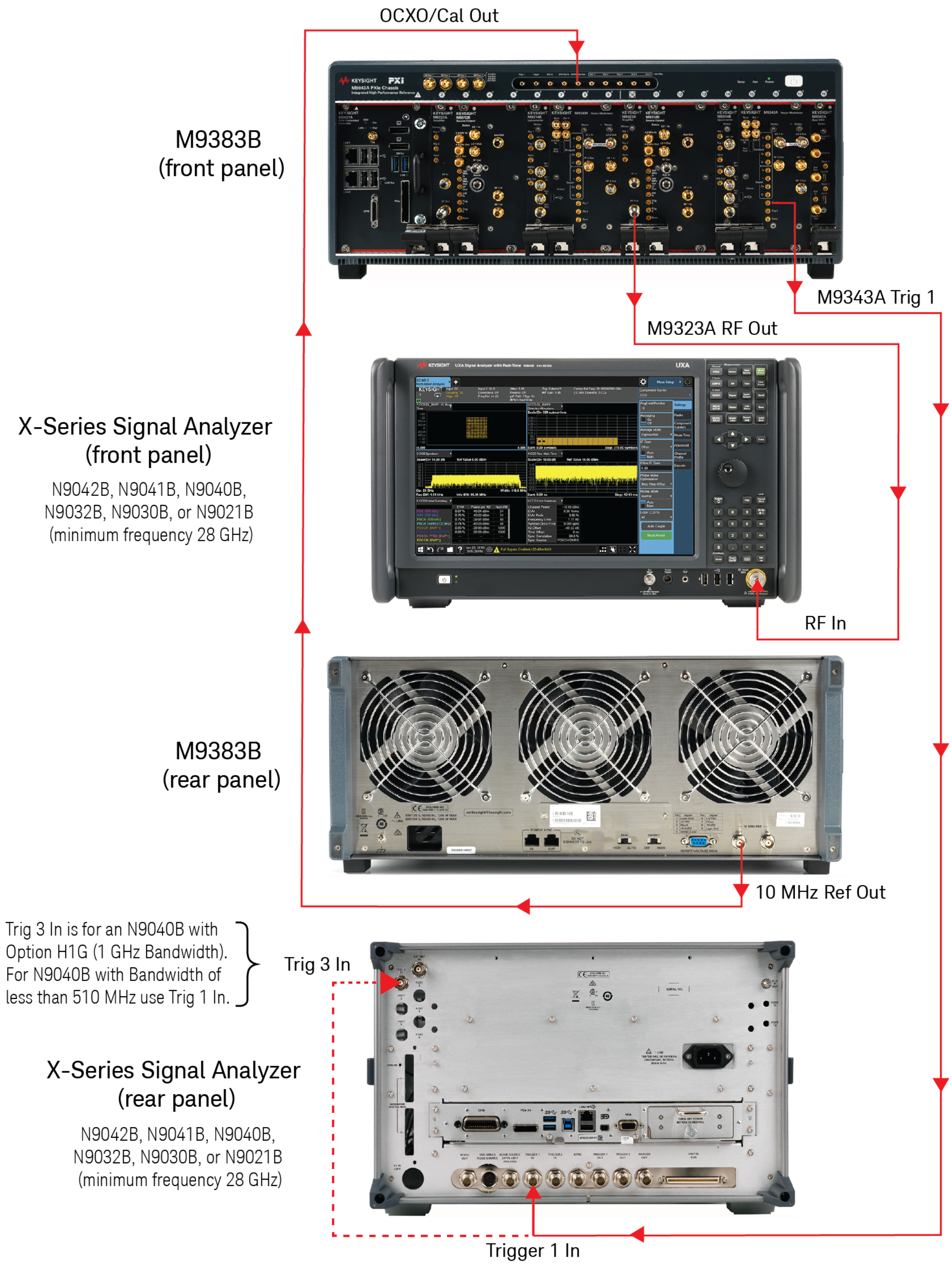
Configuring the Equipment Setup

Cables and Connections for the M9383B

- M9323A front panel RF Out to X-Series Signal Analyzer front panel RF In
- M9343A front panel Trig 1 to X-Series Signal Analyzer rear panel Trig 3 In

  Trig 3 In is for an N9040B with Option H1G (1 GHz Bandwidth). For X-Series Signal Analyzer with Bandwidth of less than 510 MHz, use Trig 1 In.
- M9383B rear panel 10 MHz Ref Out to X-Series Signal Analyzer rear panel Ext Ref In

Equipment Setup



Cables and Connections for the M9384B

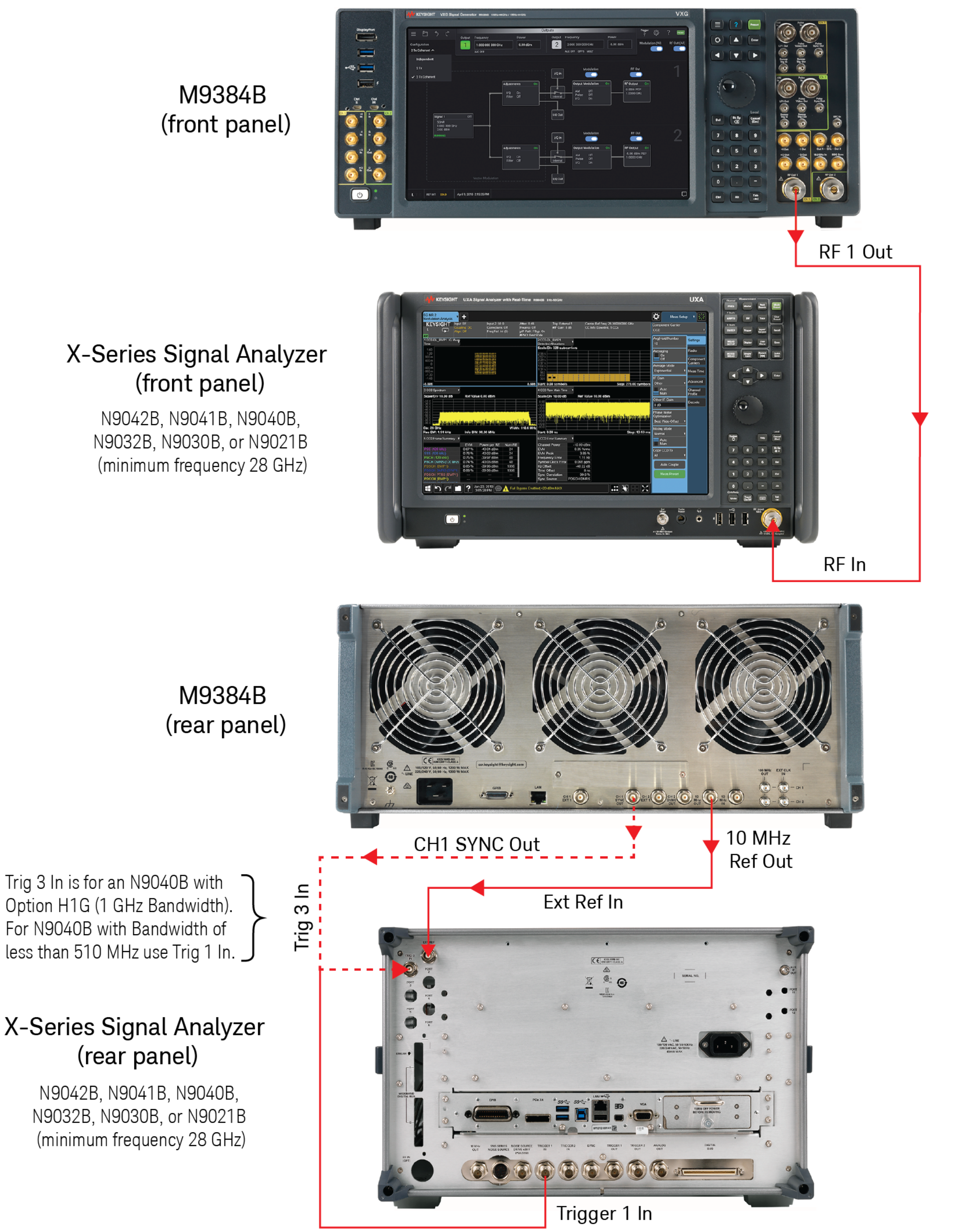
– M9384B front panel RF 1 Out to X-Series Signal Analyzer front panel RF In

– M9384B rear panel SYNC Out to X-Series Signal Analyzer rear panel Trig 3 In

  Trig 3 In is for anN9040B with Option H1G (1 GHz Bandwidth). For X-Series Signal Analyzer with Bandwidth of less than 510 MHz, use Trig 1 In.

– M9384B rear panel 10 MHz Ref Out to X-Series Signal Analyzer rear panel Ext Ref In

Equipment Setup



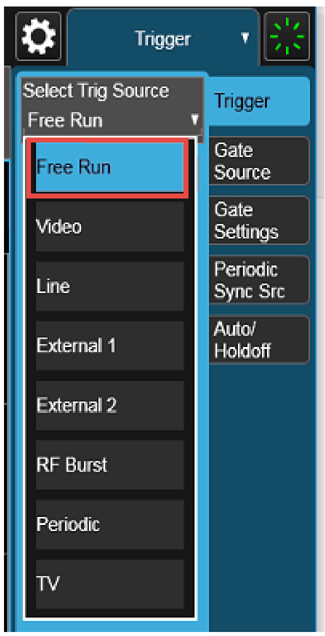
m9384b2x_series.png

Setting Up Triggers on the X-Series Signal Analyzer

1. From the X-Series Signal Analyzer Menu Panel (on the top right of the display), select **Mode/Meas** > **Spectrum Analyzer** mode.

NOTE If accessing the instrument via a Remote Desktop connection, select the Screen tab (at the top of the display) to open the Mode/Measurement/View Selector window.

2. Select **Mode Preset** to set Spectrum Analyzer mode to a known state.
3. From the dropdown on the top right, select **Trigger** and set Trigger Source to **Free Run.**



Making Measurements

Creating a Continuous Waveform (CW)

This procedure will demonstrate the amplitude and frequency accuracy of the VXG at RF and µW frequencies.

NOTE

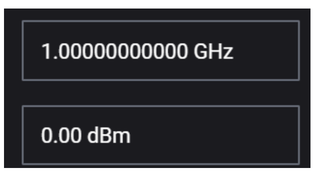
Ensure the equipment and triggers are properly configured. Refer to “Configuring the Equipment Setup” on page 9 and “Setting Up Triggers on the X-Series Signal Analyzer” on page 13.

Using the graphical user interface

On the VXG:

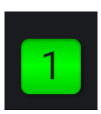
1. Select **Preset** > **Preset** to set the instrument to a known state.
2. In the Output area, set Frequency to **1 GHz** and Power to **0 dBm**.

   These values are coupled to CW Frequency and Total Power (RMS) in the corresponding RF Output Block.

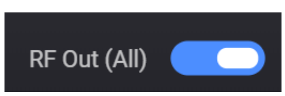


3. Set RF Out to **On** by selecting the numbered channel indicator switch.

   This enables the RF Out for the indicated channels, in this case Channel 1 if using a multi-channel VXG.



4. **For multi-channel instruments only:** In the top right corner of the display, set RF Out (All) to **On** by selecting the switch.



NOTE

In order to turn on RF for any channel, both the RF Out for the specific channel (for example, Channel 1 or Channel 2), and RF Out All must be turned on.

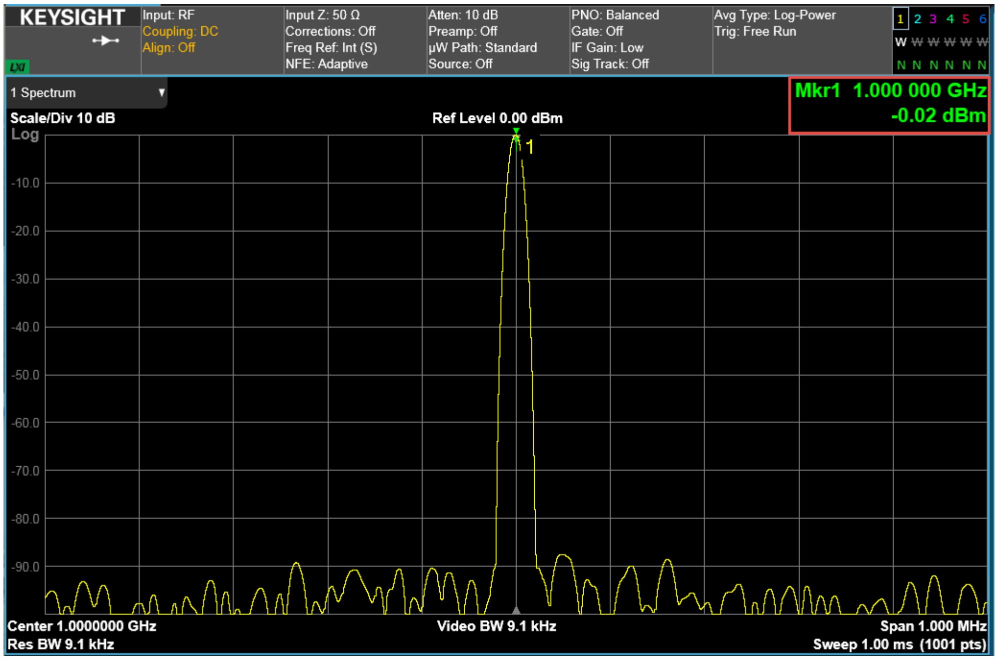
On the X-Series Signal Analyzer:

1. Select **Mode Preset** to set Spectrum Analyzer mode to a known state.

2. From the Menu Panel, select **Frequency** and set Center Frequency to **1 GHz** and Span to **1 MHz**.

3. Select **Peak Search**.

   Observe the accuracy of the amplitude and frequency of the signal.



On the VXG:

1. Set Output 1 Power to **–90 dBm.**

2. Ensure that **RF Out** is On.

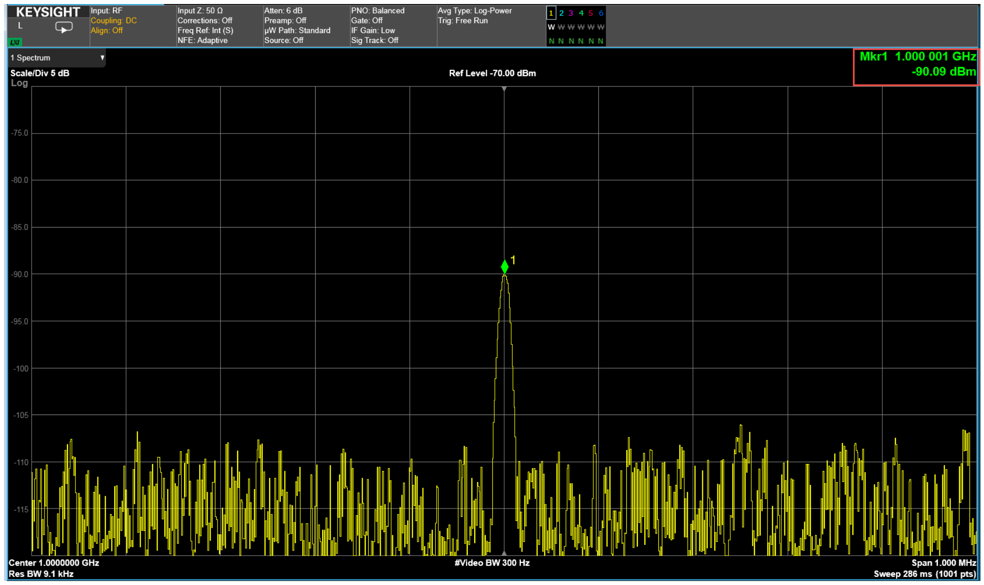
On the X-Series Signal Analyzer:

1. Select **Amplitude** and set Ref Level to **–70 dBm** and Scale/Div **5 dB**.

2. Select **BW** and set Video BW to **300 Hz**.

3. Select **Peak Search**.

Observe the frequency and amplitude accuracy of the VXG at low power levels.

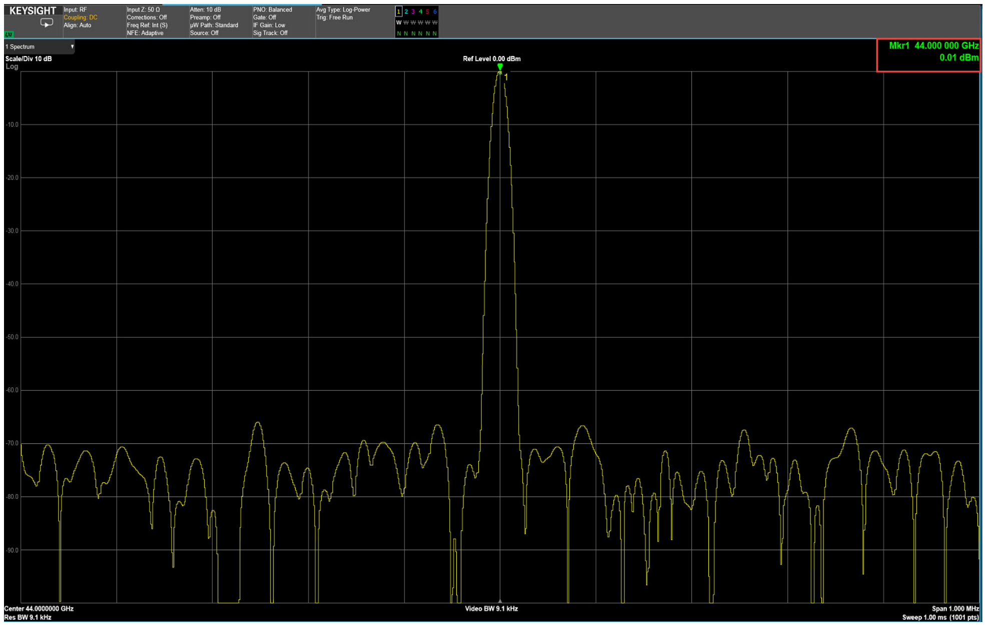


On the VXG:

1. Set Frequency to **44 GHz** and Power to **0 dBm**.

On the X-Series Signal Analyzer:

1. Select **Frequency** and set Center Frequency to **44 GHz**.
2. Select **Amplitude** and set Ref Level to **0 dBm** and Scale/Div to **10 dB**.
3. Select **BW** > **Video BW** and set to **Auto**.
4. Select **Peak Search**.



Observe the frequency and amplitude accuracy at high frequency levels.

Using the equivalent SCPI commands

Creating a CW signal on Channel 1.

On the VXG:

```
SYSTem:PRESet
RF1:FREQuency:CW 1GHZ
RF1:POWer:AMPLitude 0dBm
RF1:OUTPut:STATe ON
```

For multi-channel instruments, set RF Out (all) to On.

```
RFALl:OUTPut ON
```

On the X-Series Signal Analyzer:

```
SYSTem:PRESet
FREQuency:CENTer 1GHZ
FREQuency:SPAN 1MHZ
CALCulate:MARKer1:MAXimum
```

On the VXG:

```
RF1:FREQuency:CW 1GHZ
RF1:POWer:AMPLitude -90dBm
RF1:OUTPut:STATe ON
```

On the X-Series Signal Analyzer:

```
DISPlay:WINDow1:TRACe:Y:RLEVel -70
DISPlay:WINDow1:TRACe:Y:PDIVision 5
BWIDth:VIDeo 300Hz
CALCulate:MARKer1:MAXimum
```

On the VXG:

```
RF1:FREQuency:CW 44GHZ
RF1:POWer:AMPLitude 0dBm
```

On the X-Series Signal Analyzer:

```
FREQuency:CENTer 44GHZ
DISPlay:WINDow1:TRACe:Y:RLEVel 0
DISPlay:WINDow1:TRACe:Y:PDIVision 10
BANDwidth:VIDeo:AUTO ON
```

```
CALCulate:MARKer1:MAXimum
```

Setting Up Amplitude Modulation

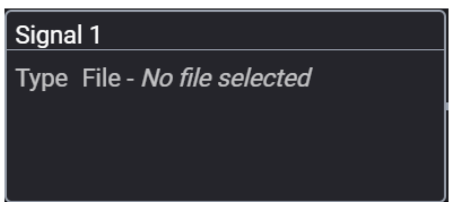
NOTE Ensure the equipment and triggers are properly configured. Refer to “Configuring the Equipment Setup” on page 9 and “Setting Up Triggers on the X-Series Signal Analyzer” on page 13.

Follow the steps below for AM analog modulation using the internal or an external I/Q modulation source.

Using the graphical user interface

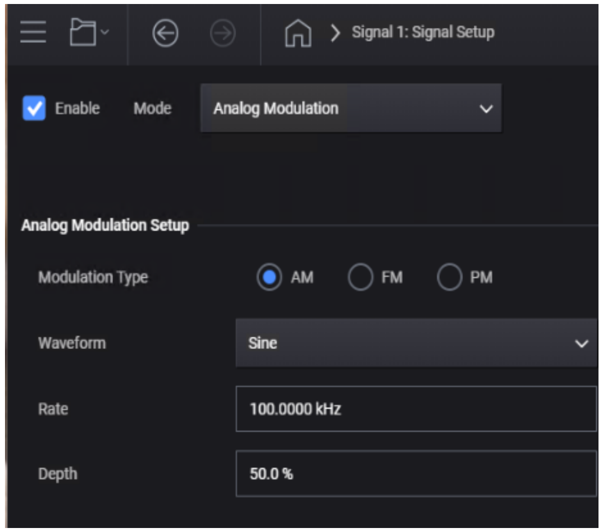
On the VXG:

1. Select **Preset** > **Preset** to set the instrument to a known state.
2. Set Frequency to **20 GHz** and Amplitude to **0 dBm**.
3. Select the **Signal** block.

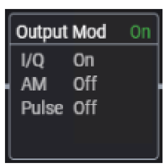


4. From the **Mode** dropdown, select **Analog Modulation**.
5. In the Analog Modulation Signal Setup:
    a. Set Modulation Type to **AM**.
    b. Set Waveform to **Sine**.
    c. Set Rate to **100 kHz**.
    d. Set Depth to **50%**.

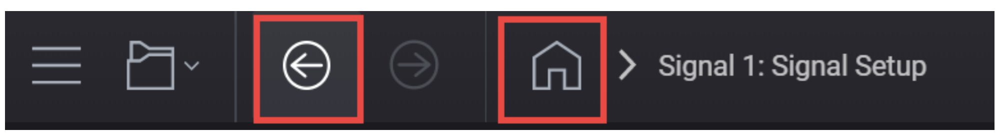
e. Select **Enable** Vector Modulation Signal.



Selecting Enable automatically turns on both Output Modulation and Internal I/Q Modulation as displayed in the Output Modulation block.

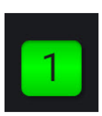


6. Close the Vector Modulation Signal Setup by either selecting the Back button or the Home icon at the top of the display.



7. Set RF Out to **On** by selecting the numbered channel indicator switch.

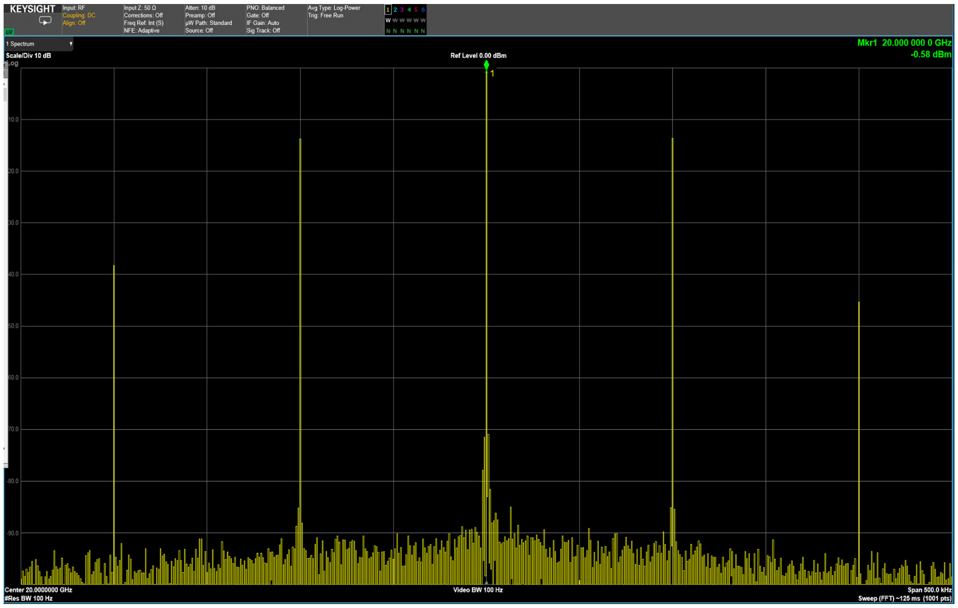
   This enables the RF Out for the indicated channels, in this case Channel 1 if using a multi-channel VXG.



On the X-Series Signal Analyzer:

1. Select **Mode Preset** to set Spectrum Analyzer mode to a known state.
2. Select **Frequency** and set Center Frequency to **20 GHz** and Span to **500 kHz**.

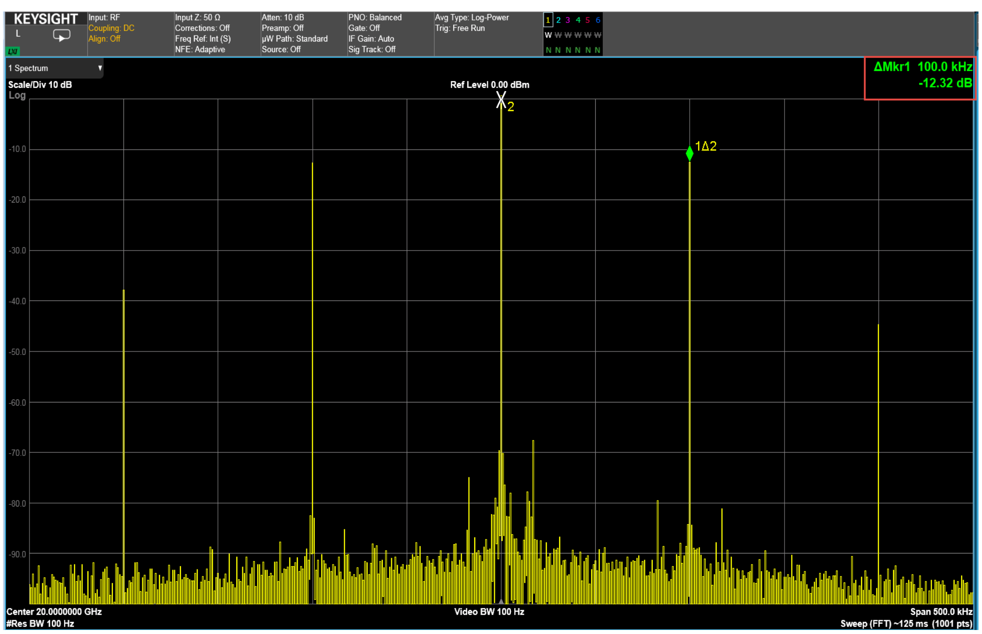
3. Select **BW** and set Res BW to **100 Hz**.



4. Select **Peak Search**.

5. Use markers to measure sideband power relative to the center frequency by selecting **Marker Delta**. Select **Next Pk Right** until the second marker is at the next highest peak.

The Delta Marker should be approximately –12 dB for 50% AM.



Using the equivalent SCPI commands

On The VXG:

```
SYSTem:PRESet
RF1:FREQuency:CW 20GHZ
RF1:POWer:AMPLitude 0dBm
SIGNal:MODE AMODulation
SIGNal1:AMODulation:TYPE AM
SIGNal1:AM:SHAPe SINE
SIGNal1:AM:FREQuency 100KHZ
SIGNal1:AM 50
SIGNal1 ON
RF1:OUTPut:STATe ON
```

For multi-channel instruments, set RF Out (all) to On.

```
RFALl:OUTPut ON
```

On the X-Series Signal Analyzer:

```
SYSTem:PRESet
FREQuency:CENTer 20GHZ
FREQuency:SPAN 500KHZ
BANDwidth 100 Hz
CALCulate:MARKer1:MODE DELTa
CALCulate:MARKer1:MAXimum:RIGHt
```

Repeat the above command until the marker is at the next highest peak.

To retrieve the delta marker:

```
CALCulate:MARKer1:Y?
```

Setting Up Frequency Modulation

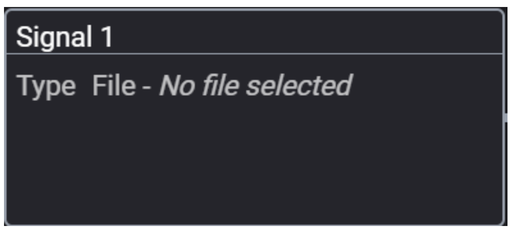
NOTE Ensure the equipment and triggers are properly configured. Refer to "Configuring the Equipment Setup" on page 9 and "Setting Up Triggers on the X-Series Signal Analyzer" on page 13.

Follow the steps below for FM analog modulation using the internal or an external I/Q modulation source.

Using the graphical user interface

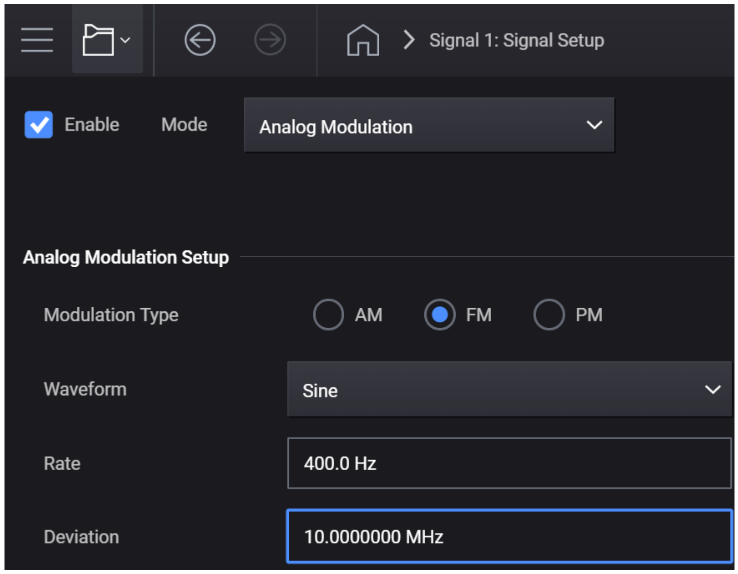
On the VXG:

1. Select **Preset** > **Preset** to set the instrument to a known state.
2. Set Frequency to **20 GHz** and Amplitude to **0 dBm**.
3. Select the **Signal** block.

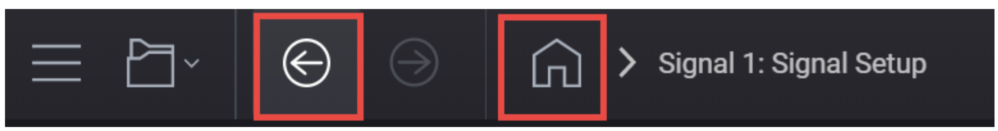


4. Select the **Mode** dropdown and select **Analog Modulation.**
5. In the Analog Modulation Signal Setup:
   a. Set Modulation Type to **FM.**
   b. Set Waveform to **Sine.**
   c. Set Rate to **400 Hz.**
   d. Set Deviation to **10 MHz.**

e. Select **Enable** Vector Modulation Signal

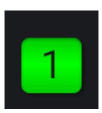


6. Close the Vector Modulation Signal Setup by either selecting the Back button or the Home icon at the top of the display.



7. Set RF Out to **On** by selecting the numbered channel indicator switch.

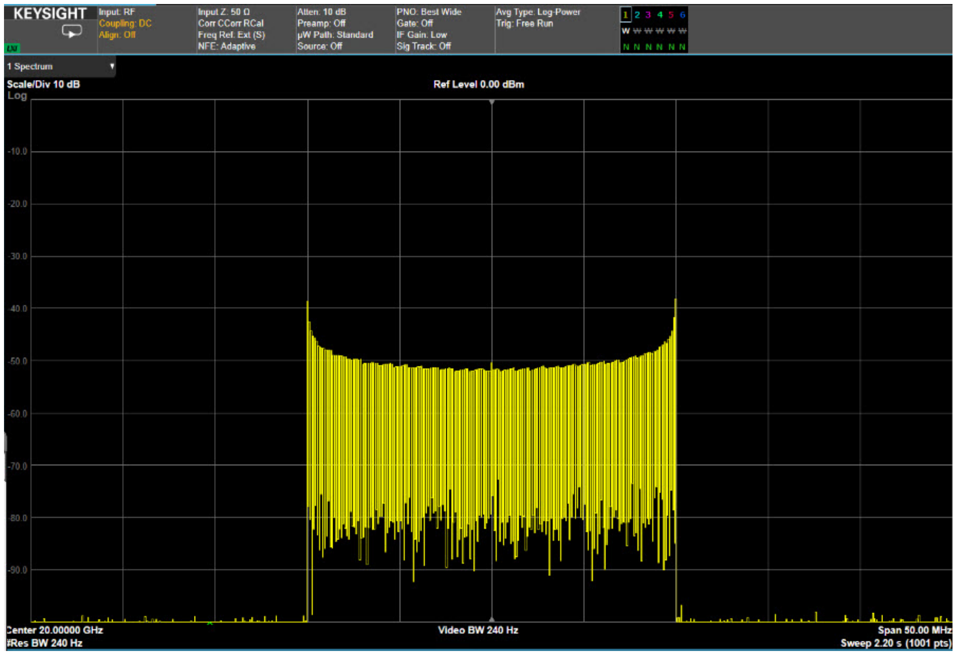
   This enables the RF Out for the indicated channels, in this case Channel 1 if using a multi-channel VXG.



On the X-Series Signal Analyzer:

1. Select **Mode Preset** to set Spectrum Analyzer mode to a known state.
2. Select **Frequency** and set Center Frequency to **20 GHz** and Span to **50 MHz**.

3. Select **BW** and set Res BW to **240 Hz**.



Using the equivalent SCPI commands

On the VXG:

```
SYSTem:PRESet
RF1:FREQuency:CW 20GHZ
RF1:POWer:AMPLitude 0dBm
SIGNal:MODE AMODulation
SIGNal1:AMODulation:TYPE FM
SIGNal1:FM:SHAPe SINE
SIGNal1:FM:FREQuency 400HZ
SIGNal1:FM 10MHZ
SIGNal1 ON
RF1:OUTPut:STATe ON
```

For multi-channel instruments, set RF Out (all) to On.

```
RFALl:OUTPut ON
```

On the X-Series Signal Analyzer:

```
SYSTem:PRESet
FREQuency:CENTer 20GHZ
FREQuency:SPAN 50MHZ
BANDwidth 240 Hz
```

Setting Up Phase Modulation

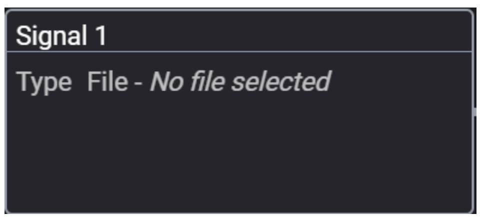
NOTE Ensure the equipment and triggers are properly configured. Refer to "Configuring the Equipment Setup" on page 9 and "Setting Up Triggers on the X-Series Signal Analyzer" on page 13.

Follow the steps below for PM analog modulation using the internal or an external I/Q modulation source.

Using the graphical user interface

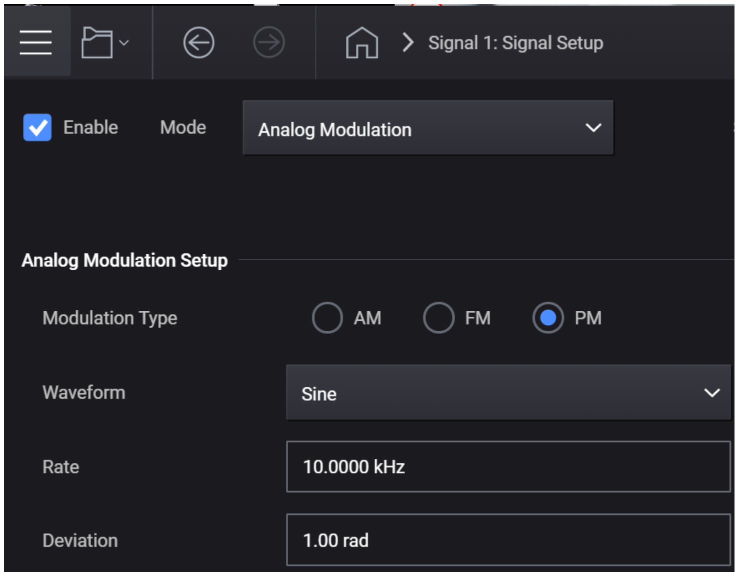
On the VXG:

1. Select **Preset** > **Preset** to set the instrument to a known state.
2. Set Frequency to **20 GHz** and Amplitude to **0 dBm**.
3. Select the **Signal** block to open.

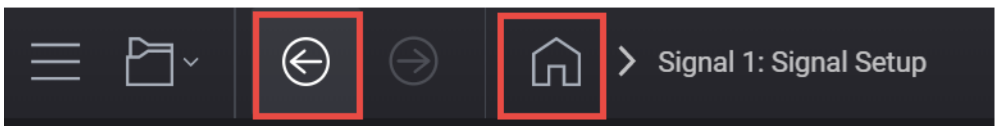


4. Select the Mode dropdown and select **Analog Modulation**.
5. In the Analog Modulation Signal Setup:
   a. Set Modulation Type to **PM**.
   b. Set Waveform to **Sine**.
   c. Set Rate to **10 kHz**.
   d. Set Deviation to **1 rad**.

e. Select **Enable** Vector Modulation Signal.

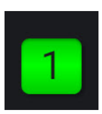


6. Close the Signal Setup by either selecting the Back icon or Home icon at the top of the display.



7. Set RF Out to **On** by selecting the numbered channel indicator switch.

   This enables the RF Out for the indicated channels, in this case Channel 1 if using a multi-channel VXG.

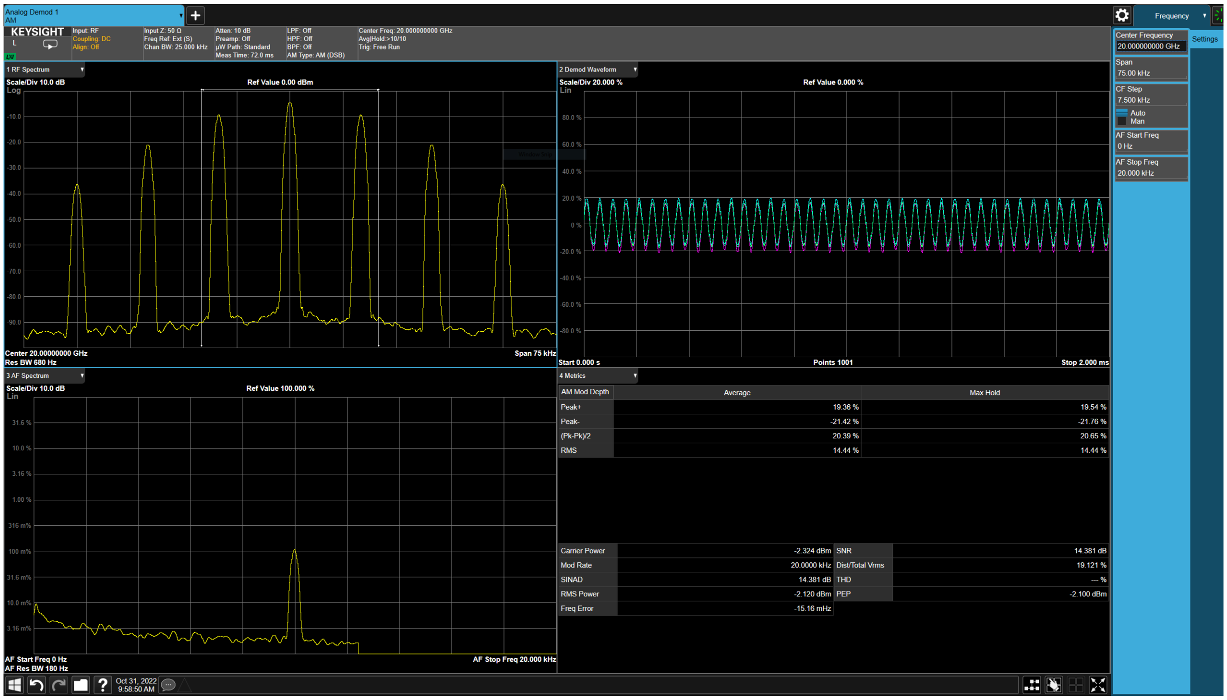


On the X-Series Signal Analyzer:

1. From the Menu Panel (on the top right of the display), select **Mode/Meas** > **Analog Demod** mode > **PM** Measurement > **Quad** View.

NOTE If accessing the instrument via a Remote Desktop connection, select the Screen tab (at the top of the display) to open the Mode/Measurement/View Selector window.

2. Select **Mode Preset** to set Spectrum Analyzer mode to a known state.
3. Select **Frequency** and set Center Frequency to **20 GHz**.



Using the equivalent SCPI commands

On the VXG:

```
SYSTem:PRESet
RF1:FREQuency:CW 20GHZ
RF1:POWer:AMPLitude 0dBm
SIGNal:MODE AMODulation
SIGNal1:AMODulation:TYPE PM
SIGNal1:PM:SHAPe SINE
SIGNal1:PM:FREQuency 10KHZ
SIGNal1:PM 1
SIGNal1 ON
RF1:OUTPut:STATe ON
```

For multi-channel instruments, set RF Out (all) to On.

```
RFALl:OUTPut ON
```

On the X-Series Signal Analyzer:

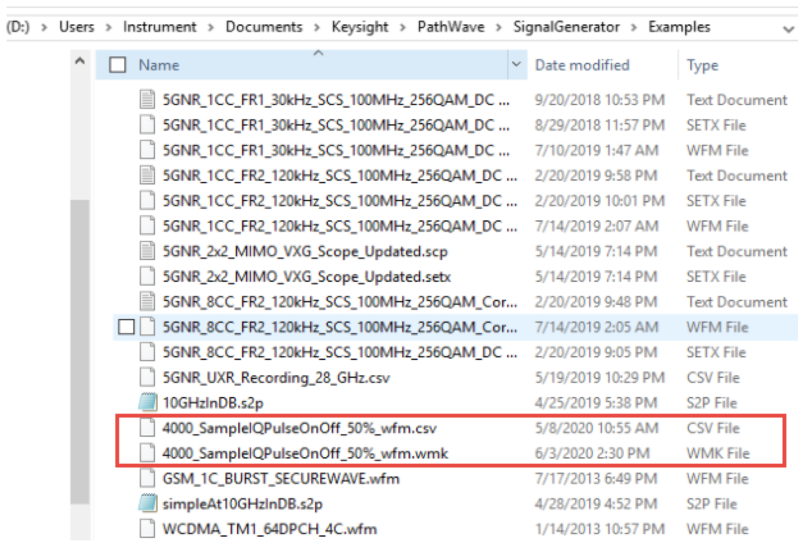
```
INSTrument:CONFigure:ADEMOD:PM
SYSTem:PRESet
DISPlay:VIEW:ADVanced:SELect "QUAD"
FREQuency:CENTer 20GHZ
```

Setting Up Synchronized Pulse (IQ + Analog) Modulation

NOTE

Ensure the equipment and triggers are properly configured. Refer to "Configuring the Equipment Setup" on page 9 and "Setting Up Triggers on the X-Series Signal Analyzer" on page 13.

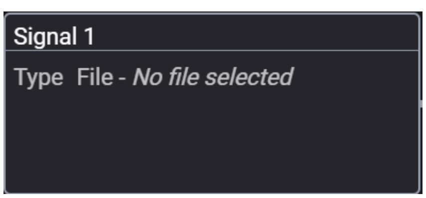
You will need to create your own ASCII text marker file and a binary file with the exact same name. Both files must be stored in the same file folder. For this example, we will use example files that have been stored on the VXG.



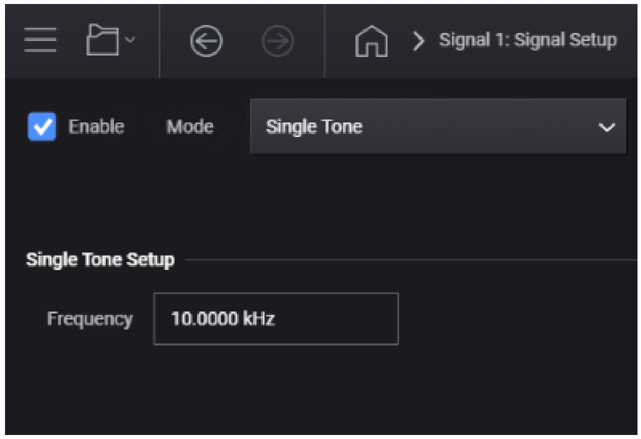
Using the graphical user interface

On the VXG:

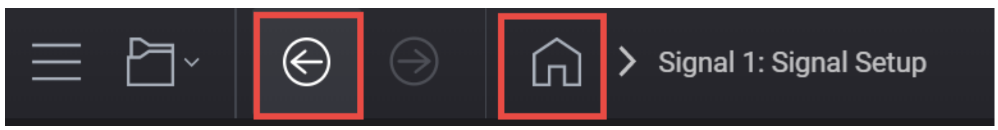
1. Select **Preset** > **Preset** to set the instrument to a known state.
2. Set the Frequency to **1 GHz** and Power to **0.0 dBm**.
3. Select the **Signal** block to open.



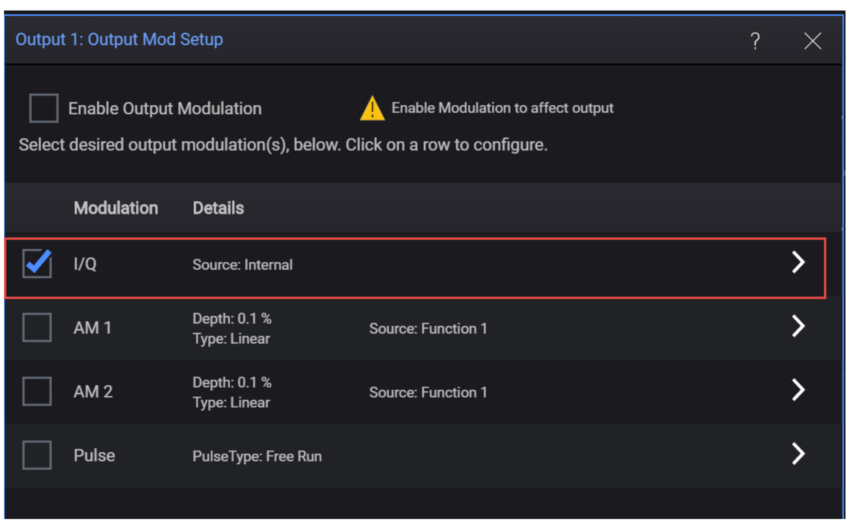
4. Set the **Mode** to **Single Tone**.



5. Close the Signal Setup by either selecting the Back or Home icon at the top of the display.



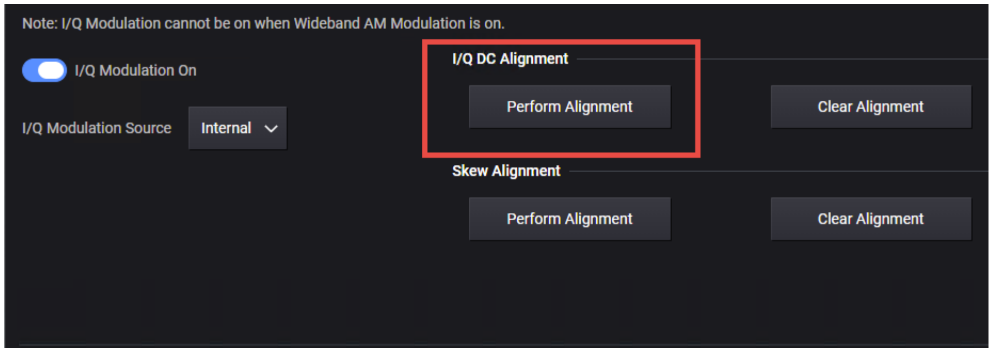
6. Open the **Output Modulation** block and select **I/Q** modulation and open the setup dialog.



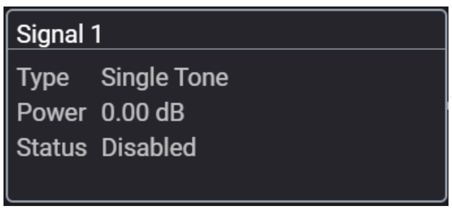
7. Under I/Q DC Alignment, select **Perform Alignment**.

   The I/Q DC alignment will take just a moment to run. When done, `IQ DC Alignment done` is displayed in the Notifications area at the bottom of the display.

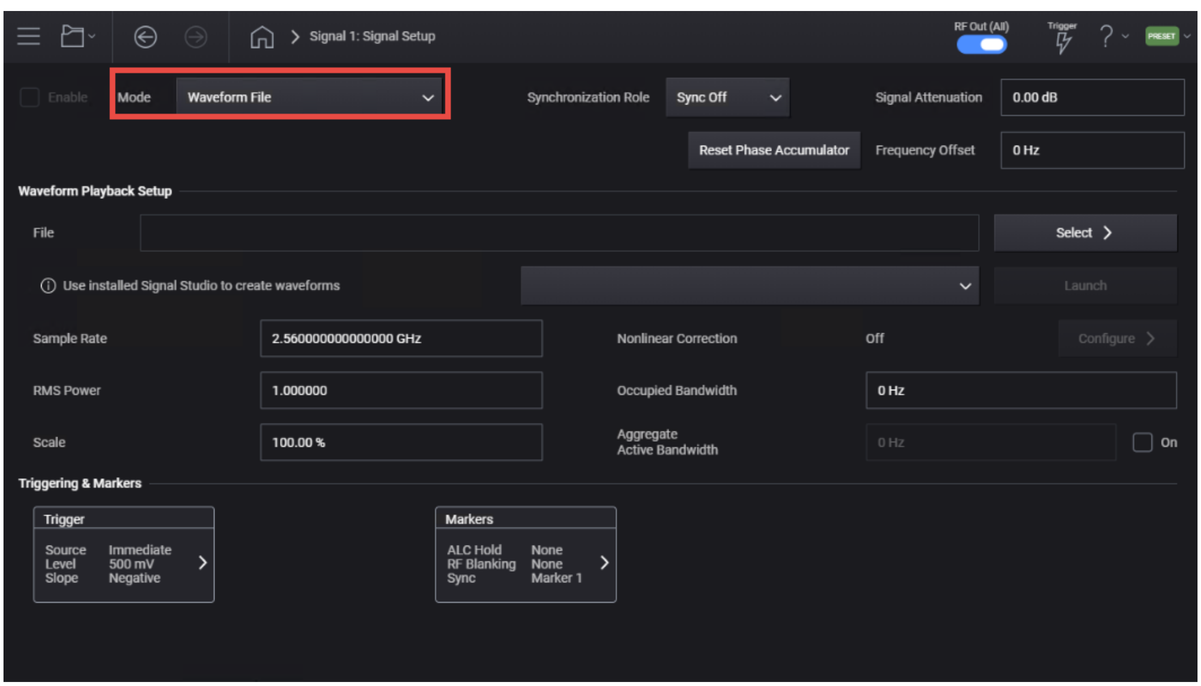
Performing an I/Q DC alignment helps optimize the depth of modulation of the IQ pulse. This needs to be done at every frequency change.



8. Close the **Output Modulation** block by selecting the **Home** icon.
9. Select the **Signal** block to open.



10. Select the Vector Modulation Signal **Mode** dropdown and select **Waveform File.**

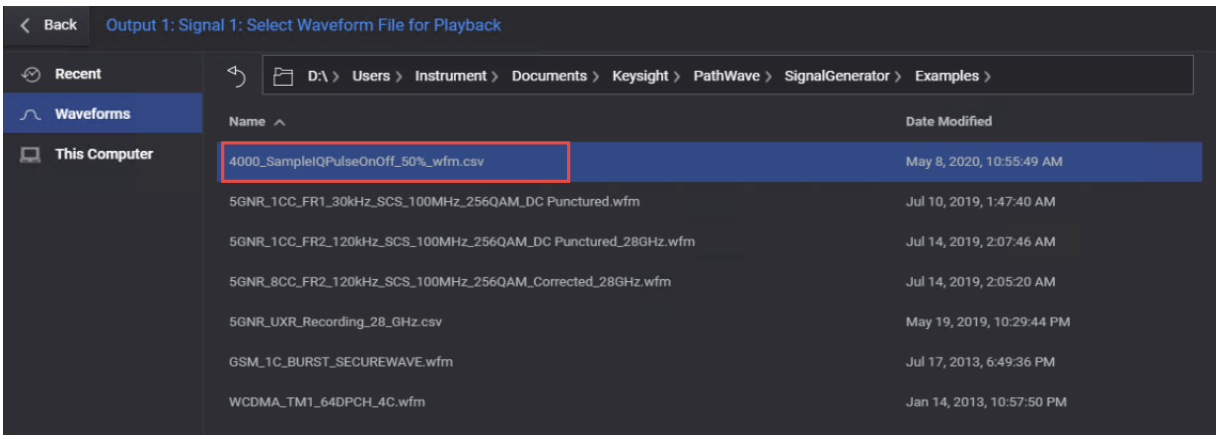


11. In the Waveform Playback Setup area, use File **Select** to navigate to:

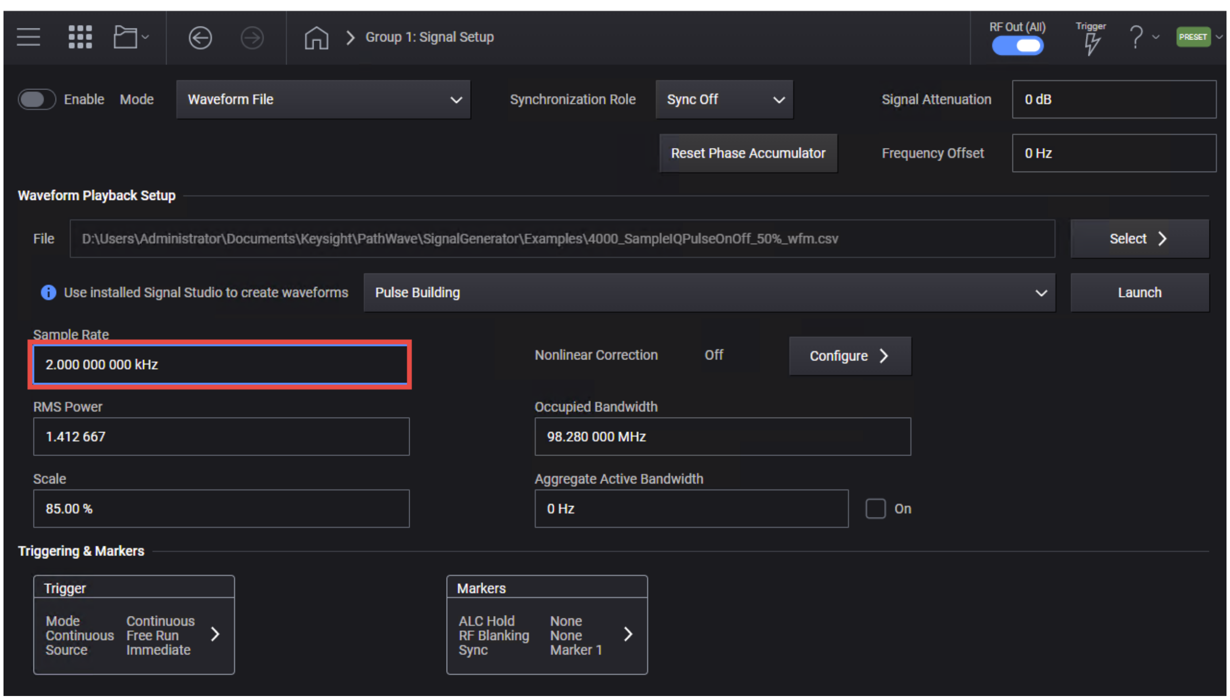
```
D:\Users\Instrument\Documents\Keysight\PathWave
\SignalGenerator\Examples
```

and choose
`4000_SampleQPulseOnOff_50%_wfm.csv`

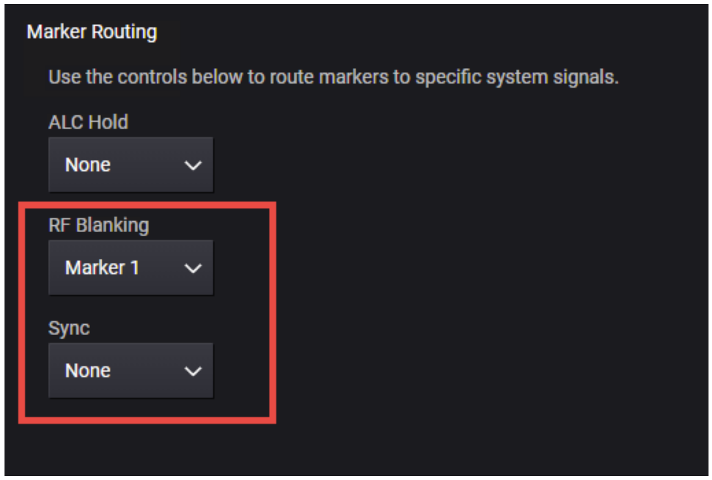
then **Select**.



12. Set the Sample Rate to **2 kHz**.



13. Select the **Markers** block and set Sync to **None** and RF Blanking to **Marker 1**. Select the **Back** icon (<-to close the Markers Setup.



14. Select **Enable** Vector Modulation Signal.
15. Ensure that **RF Out** is on for channel 1.

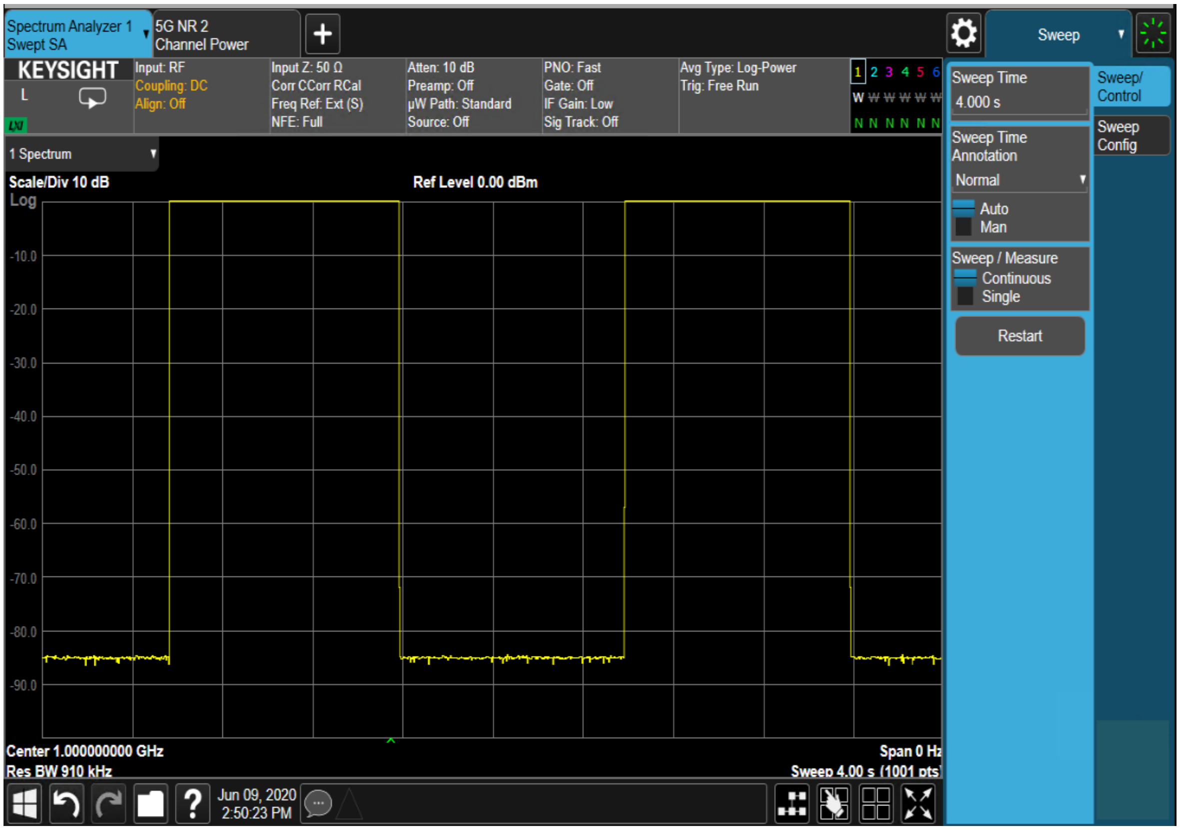
On the X-Series Signal Analyzer:

1. From the Menu Panel (on the top right of the display), select **Mode/Meas** > **Spectrum Analyzer** mode > **Swept SA** Measurement > **Normal** View.

NOTE

If accessing the instrument via a Remote Desktop connection, select the Screen tab (at the top of the display) to open the Mode/Measurement/View Selector window.

2. Select **Mode Preset** to set Spectrum Analyzer mode to a known state.
3. Select **Frequency** and set Center Frequency to **1.0 GHz** and Span to **0 Hz**.
4. Select **BW** and set the Video BW to **300 Hz**.
5. Select **Sweep** and set the Sweep Time to **4.0 s**.


Spectrum Analyzer 1
Swept SA
5G NR 2
Channel Power
Sweep
KEYSIGHT
Input: RF
Coupling: DC
Align: Off
Input Z: 50 Ω
Corr CCorr RCal
Freq Ref: Ext (S)
NFE: Full
Atten: 10 dB
Preamp: Off
µW Path: Standard
Source: Off
PNO: Fast
Gate: Off
IF Gain: Low
Sig Track: Off
Avg Type: Log-Power
Trig: Free Run
1 Spectrum
Scale/Div 10 dB
Log
Ref Level 0.00 dBm
Center 1.000000000 GHz
Res BW 910 kHz
Span 0 Hz
Sweep 4.00 s (1001 pts)
Sweep Time
4.000 s
Sweep Time Annotation
Normal
Auto
Man
Sweep / Measure
Continuous
Single
Restart
Sweep/ Control
Sweep Config
Jun 09, 2020
2:50:23 PM

Setting Up an Multitone Signal

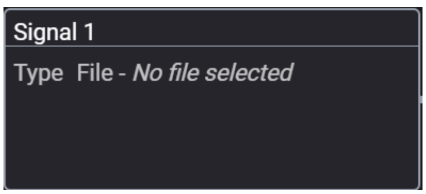
This example shows you how to create a multitone signal, which allows you to separate the usable frequency band into multiple channels. This can make a signal that is difficult to characterize in the time domain more readable.

NOTE Ensure the equipment and triggers are properly configured. Refer to "Configuring the Equipment Setup" on page 9 and "Setting Up Triggers on the X-Series Signal Analyzer" on page 13.

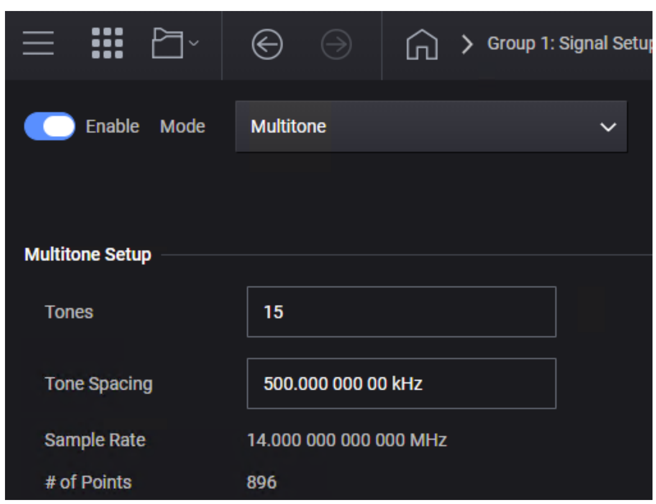
Using the graphical user interface

On the VXG:

1. Select **Preset** > **Preset** to set the instrument to a known state.
2. Set Frequency to **20 GHz** and Amplitude to **-10 dBm**.
3. Select the **Signal** block to open.



4. Set the **Mode** to **Multitone**.
5. In the Analog Modulation Signal Setup:
   a. Set Tones to **15**
   b. Set Tone Spacing to **500 kHz**.
   c. Select **Enable** Vector Modulation Signal

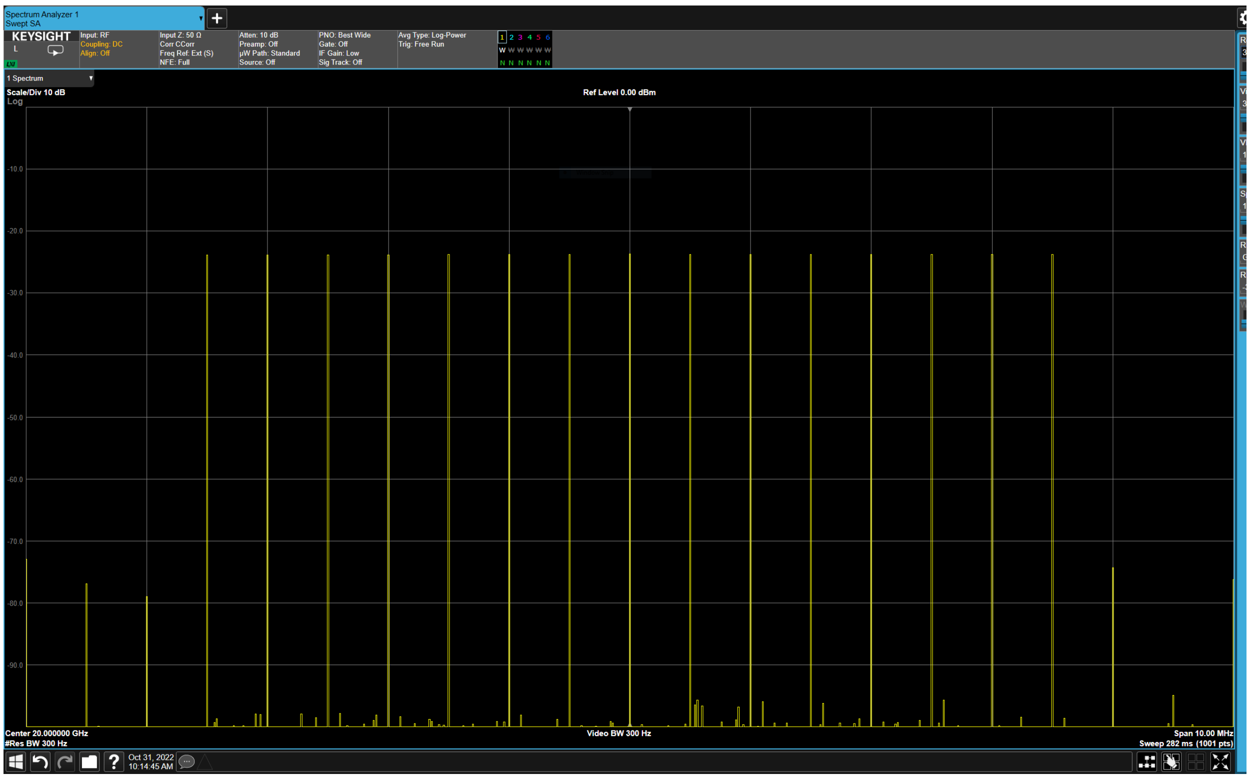


6. Ensure that **RF Out** is On for channel 1.

On the X-Series Signal Analyzer:

1. Select **Mode Preset** to set Spectrum Analyzer mode to a known state.
2. Select **Frequency** and set Center Frequency to **20 GHz** and Span to **10 MHz**.
3. Select **BW** and set Res BW to **300 Hz**.

   Observe the 15 tones.



Using the equivalent SCPI commands

On the VXG:

```
SYSTem:PRESet
RF1:FREQuency:CW 20GHZ
RF1:POWer:AMPLitude -10dBm
SIGNal1:MODE MTONes
SIGNal1:MTONe:ARB:NTON 15
SIGNal1:MTONe:ARB:FSP 500KHZ
SIGNal1 ON
RF1:OUTPut:STATe ON
```

For multi-channel instruments, set RF Out (all) to On.

```
RFALl:OUTPut ON
```

On the X-Series Signal Analyzer:

```
INSTrument:CONFigure:SA:SAN
SYSTem:PRESet
DISPlay:VIEW:ADVanced:SELect “NORMAL”
FREQuency:CENTer 20GHZ
FREQuency:SPAN 10MHZ
BANDwidth 300 Hz
```

Setting Up Waveform File Vector Modulation

In this section, we will load a GSM and a LTE waveform into the VXG to demonstrate the accuracy of the VXG's vector modulation using error vector magnitude (EVM) measurement applications available on the X-Series Signal Analyzer.

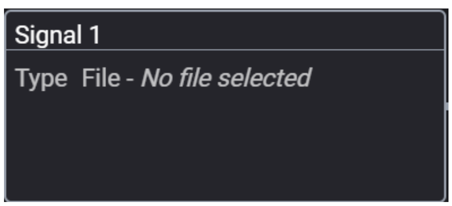
The VXG supports all ARB waveforms that are provided on the X-Series sources. This section will use a few of the ARB files that come with the X-Series sources.

NOTE Ensure the equipment and triggers are properly configured. Refer to "Configuring the Equipment Setup" on page 9 and "Setting Up Triggers on the X-Series Signal Analyzer" on page 13.

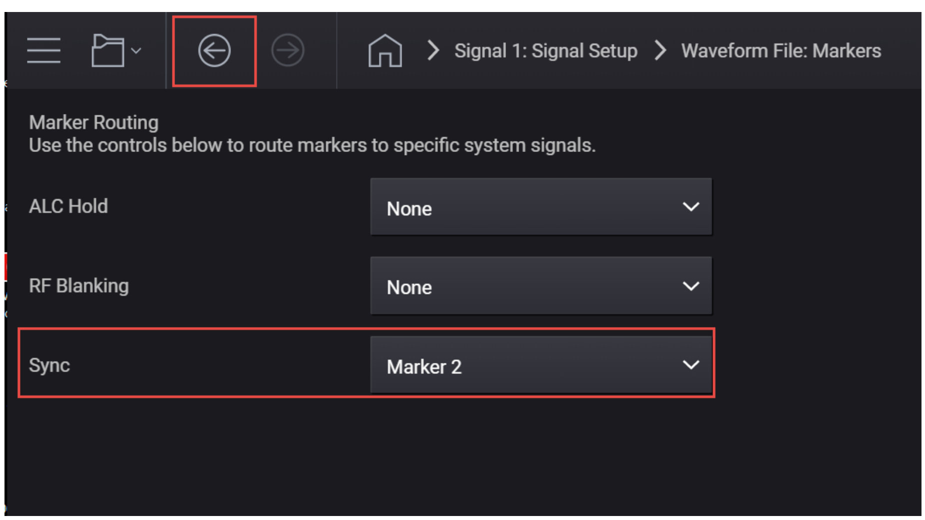
Using the graphical user interface

On the VXG:

1. Select **Preset** > **Preset** to set the instrument to a known state.
2. Set Frequency to **20 GHz** and Amplitude to **0 dBm**.
3. Select the **Signal** block to open.



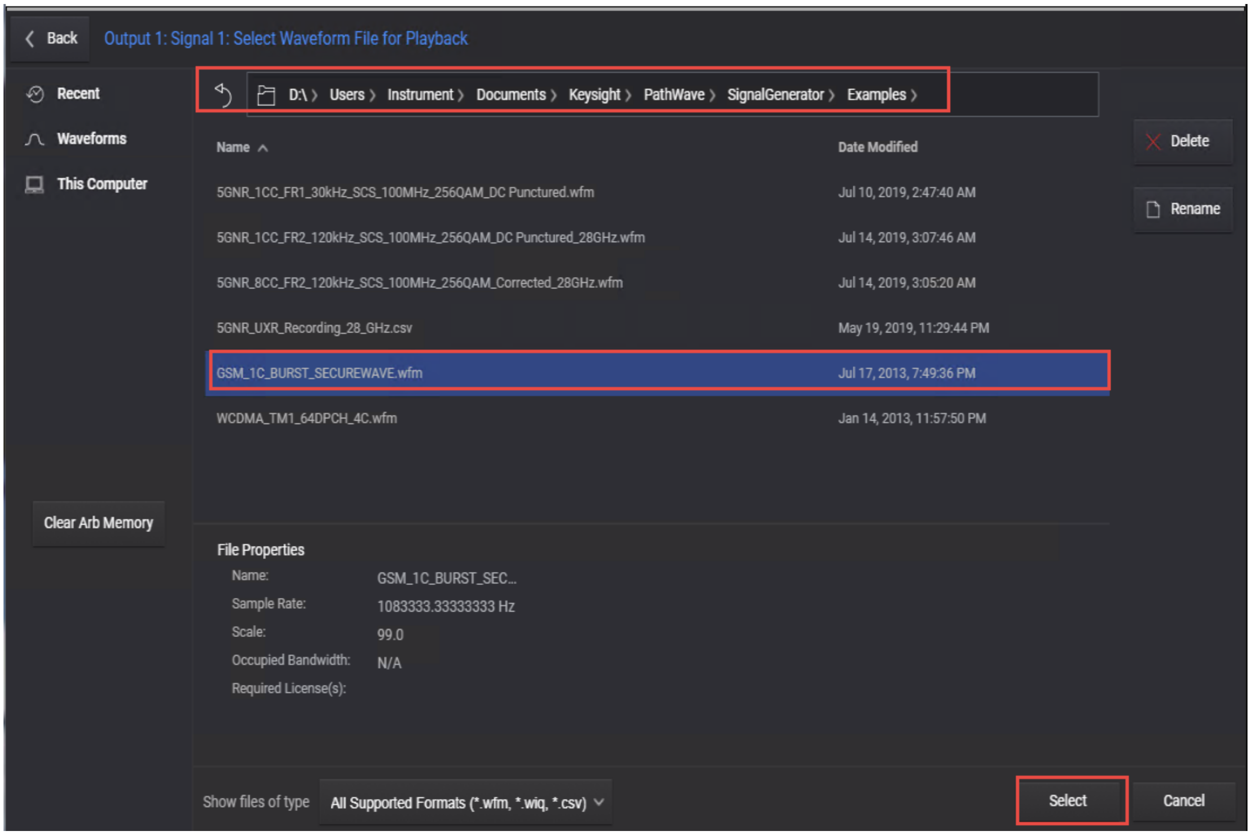
4. Set the **Mode** to **Waveform File**.
5. Select the **Markers** block and set Sync to **Marker 2** and then select **Back** to close the Markers Setup.



6. Use File **Select** to navigate to:

   `D:\Users\Instrument\Documents\Keysight\PathWave \SignalGenerator\Examples`

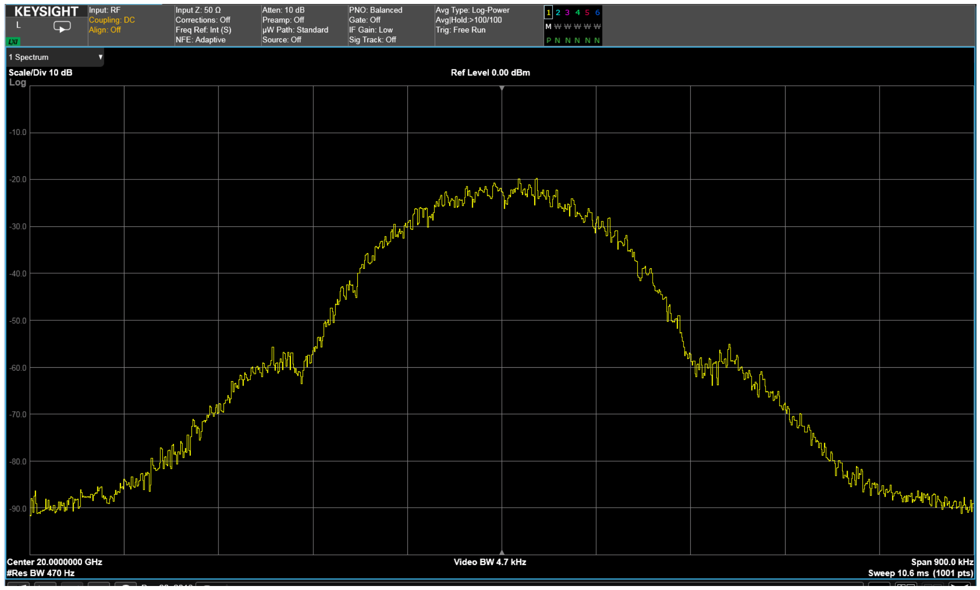
7. Highlight `GSM_1C_Burst.WFM`, then **Select**.



8. Select **Enable** Vector Modulation Signal.
9. Ensure that **RF Out** is on for channel 1.

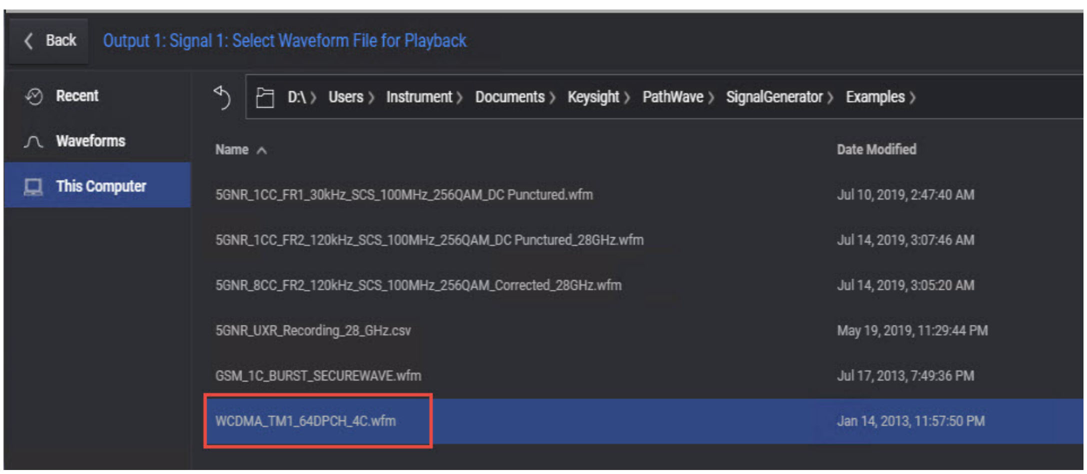
On the X-Series Signal Analyzer:

1. Select **Mode Preset** to set Spectrum Analyzer mode to a known state.
2. Select **Frequency** and set Center Frequency to **20 GHz** and Span to **900 kHz**.
3. Select **BW** and set Res BW to **470 Hz**.
4. Select **Trace** and set Trace Type to **Max Hold**.
5. Observe the GSM signal.



On the VXG:

1. Select the **Signal** block to open.
2. Use File **Select** to navigate to:
   `D:\Users\Instrument\Documents\Keysight\PathWave`
   `\SignalGenerator\Examples`



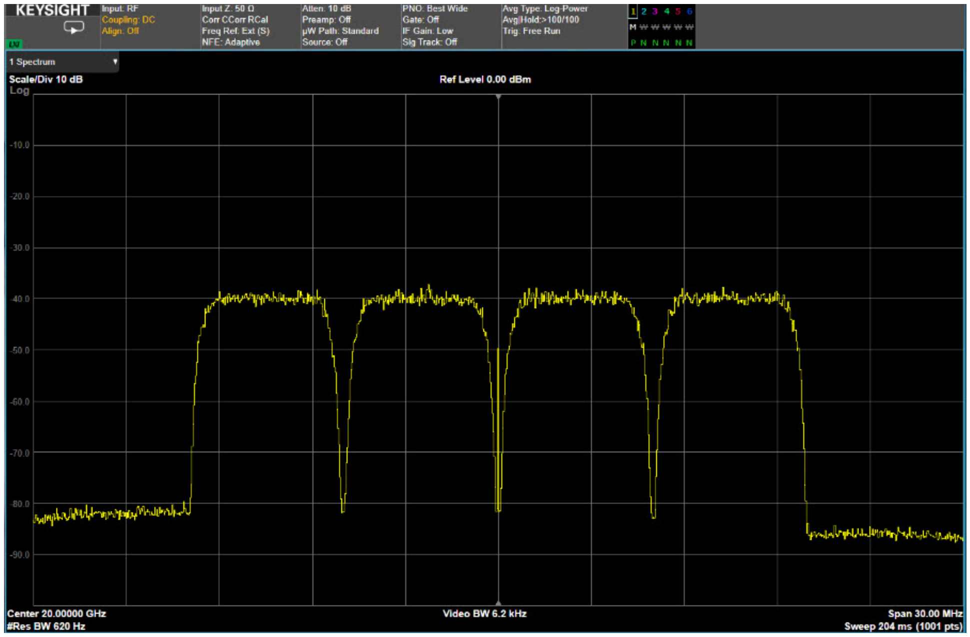
3. Set the file extension to All Files (*.*), highlight `WDCMA_TM1_64DPCH_4C.WFM`, then **Select**.
4. Ensure that **Enable** Vector Modulation Signal is selected.
5. Ensure that **RF Out** is on for channel 1.

On the X-Series Signal Analyzer:

1. Select **BW** and set Res BW to **620 Hz**.

2. Select **Frequency** and set Span to **30 MHz.**

3. Observe the LTE signal.



Using the equivalent SCPI commands

On the VXG:

```
SYSTem:PRESet

RF1:FREQuency:CW 20GHZ

RF1:POWer:AMPLitude 0dBm

SIGNal1:MODE WAVeform

SIGNal1:WAVeform:TRIGger:SYNC:MARKer M2

SIGNal1:WAV
"D:\Users\Instrument\Documents\Keysight\PathWave\SignalGener
ator\Examples\GSM_1C_BURST_SECUREWAVE.wfm"

SIGNal1 ON

RF1:OUTPut:STATe ON
```

For multi-channel instruments, set RF Out (all) to On.

```
RFALl:OUTPut ON
```

On the X-Series Signal Analyzer:

```
FREQuency:CENTer 20GHZ

FREQuency:SPAN 900KHZ

BANDwidth 470 Hz

DISPlay:TXPower:WINDow1:TRACe:MAXHold ON
```

On the VXG:

```
SIGN1:WAV
"D:\Users\Instrument\Documents\Keysight\PathWave\SignalGener
ator\Examples\WCDMA_TM1_64DPCH_4C.wfm"

SIGNal1 ON

RF1:OUTPut:STATe ON
```

On the X-Series Signal Analyzer:

```
BANDwidth 620 Hz

FREQuency:SPAN 30MHZ
```

Corrections/De-embedding Using PathWave N7653APPC Software

De-embedding is used to remove the effects of the test fixtures and cables from the measurement results. De-embedding uses a model of the test fixture and mathematically removes the fixture characteristics (cables, connectors and other passive components) between the source and the device under test (DUT). Once the desired topology has been characterized, its effects can be removed from the output signal, moving the effective reference plane to the point at which the power sensor was connected.

Blocks can be added from supported file formats (.s2p, .csv, .uflat) or by direct measurement, using one of the supported power sensors (power meter, spectrum analyzer, or a network analyzer).

NOTE The VXG must have the N7653APPC PathWave Automatic Channel Response Correction and S-parameter De-embedding license installed.

Adding Fixture Blocks using s2p Files

Amplitude and phase can be corrected by adding multiple s2p files as Fixture Blocks.

An s2p file (also known as a Touchstone file) is an ASCII text file used for documenting the n-port network parameter data and noise data of linear active devices, passive filters, passive devices, or interconnect networks. Each record contains 1 stimulus value and 4 S-parameters (total of 9 values)

The first line in the figure below (# GHz DB R 50) designates:

- (GHz) designates the frequency in Hz, kHz, MHz, or GHz
- (S) the measurements are in S parameters (rather than Y or Z)
- (DB) the values are given in decibel/angle. Instead of DB, you can have RI (real/imaginary) or MA (magnitude/angle)
- (50) the characteristic impedance is 50 ohms

```
!S2P File: Measurements: S11,S21,S12,S22:
# GHz S DB R 50
   9.0 -100 -100  10.0 -100  10.0 -100 -100 -100
   9.5 -100 -100   5.0 -100   5.0 -100 -100 -100
  10.0 -100 -100   0.0 -100   0.0 -100 -100 -100
  10.5 -100 -100  -5.0 -100  -5.0 -100 -100 -100
  11.0 -100 -100 -10.0 -100 -10.0 -100 -100 -100
```

NOTE If there is not a first line header, the default format is GHz, S-parameters, and magnitude/angle.

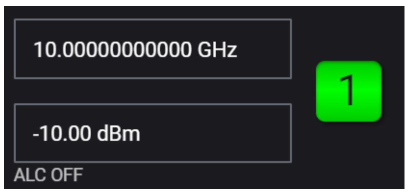
1. Create s2p files in Notepad in the format shown above.

TIP

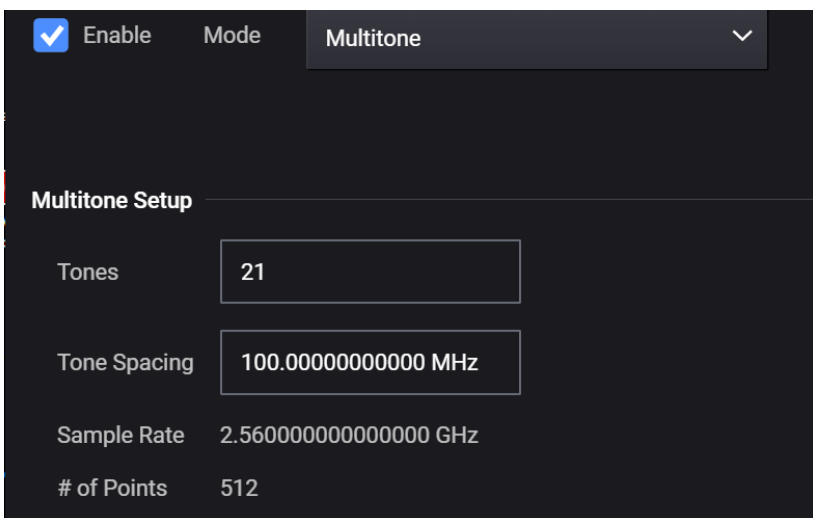
An s2p example file is included on the VXG. Go to

`D:\Users\Instrument\Documents\Keysight\PathWave\SignalGenerator\Examples\simpleAt10GHzInDB.s2p`

2. Select **Preset** > **Preset** to set the instrument to a known state.
3. In the VXG Output area, set the Frequency to **10 GHz** and **Power** to −10 dBm.

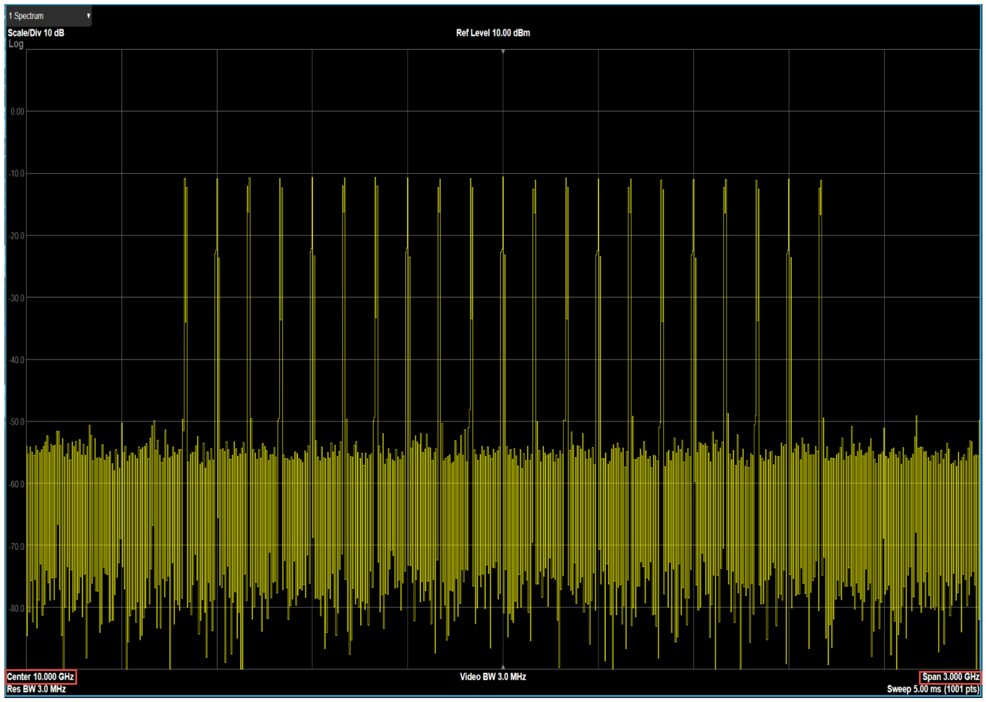


4. Select the Signal Block and set:
   - Mode to **Multitone**
   - Tones to **21**
   - Tone Spacing to **100 MHz**
   - Select **Enable** Vector Modulation Signal

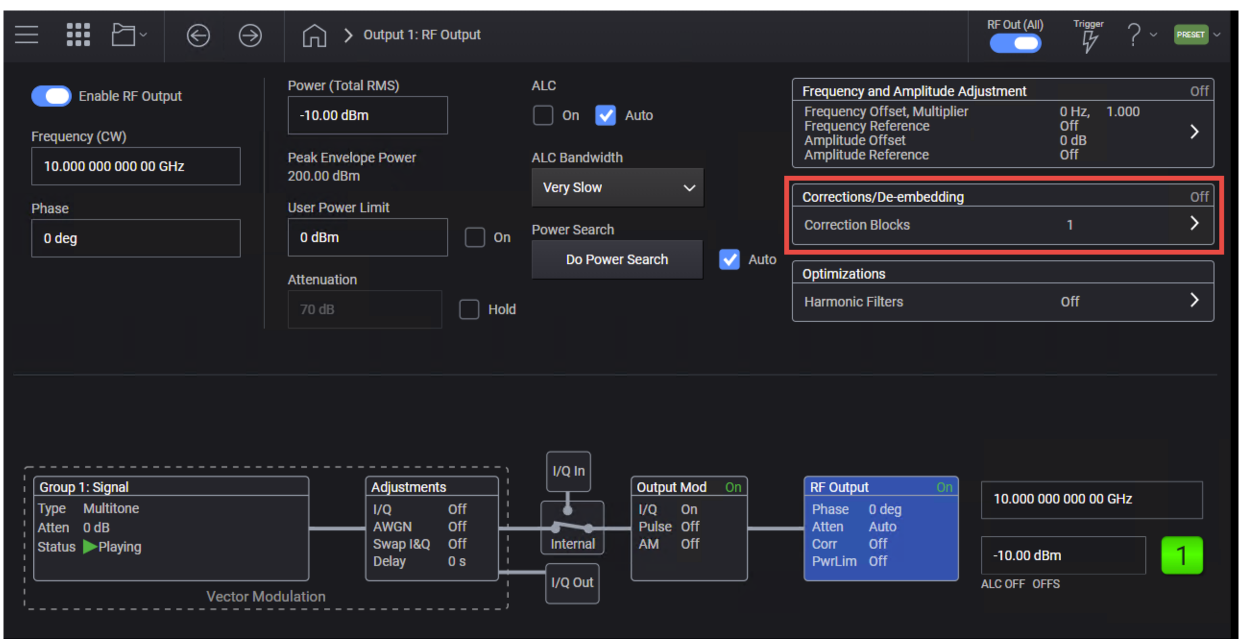


5. Close the Signal block by selecting the Back (<-) icon, and then select **RF Out** to turn on for channel 1.
6. On the X-Series Signal Analyzer spectrum analyzer in Spectrum Analyzer Mode:
   - Preset the spectrum analyzer
   - Set the Center to **10 GHz**

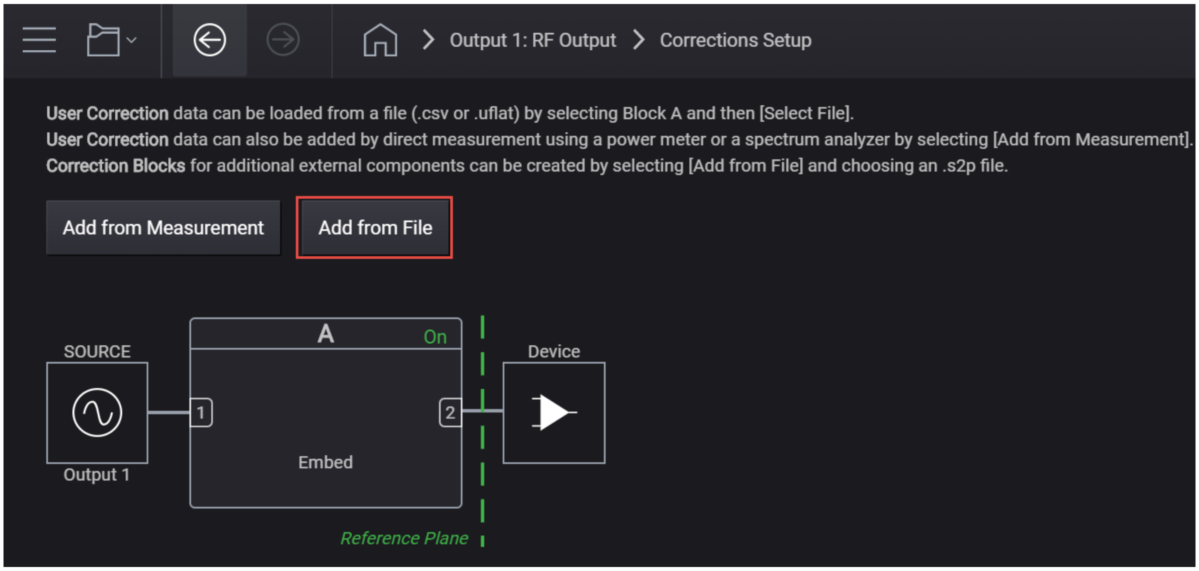
– Set the Span to **3 GHz**



7. On the VXG, select the **RF Output** block > **Corrections De-embedding.**

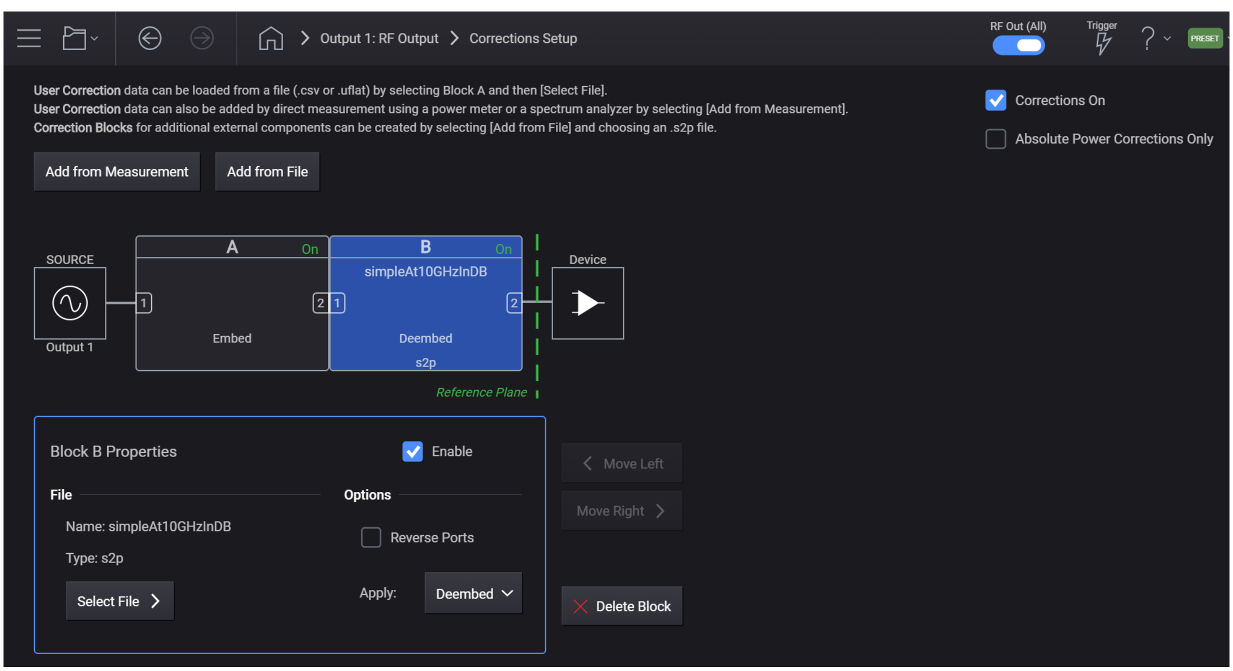


8. In the Corrections Setup dialog, select **Add from File**.

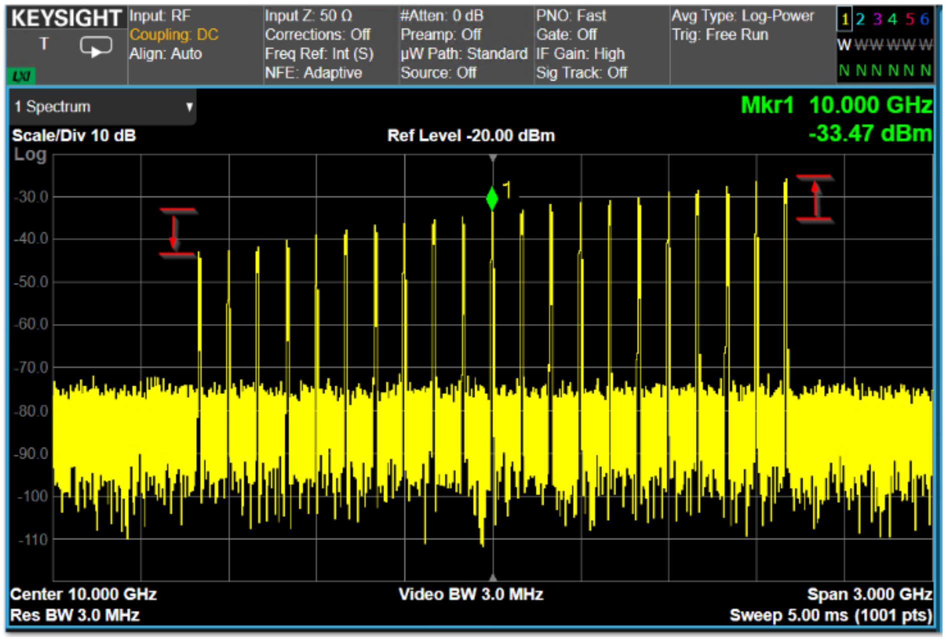


9. Navigate and select the s2p file and then **Select**.
`D:\Users\Instrument\Documents\Keysight\PathWave\SignalGenerator\Examples\simpleAt10GHzInDB.s2p`

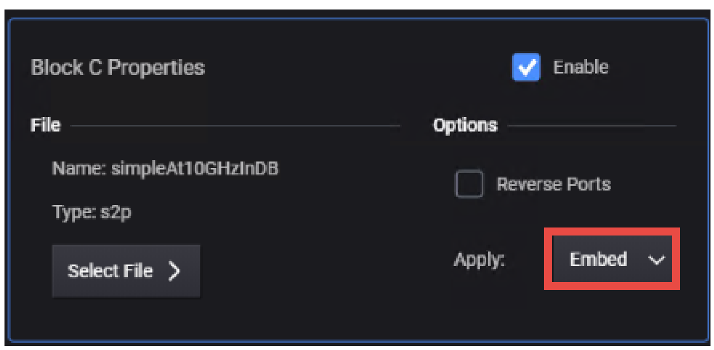
Notice that Block B is added in the Correction Setup diagram.



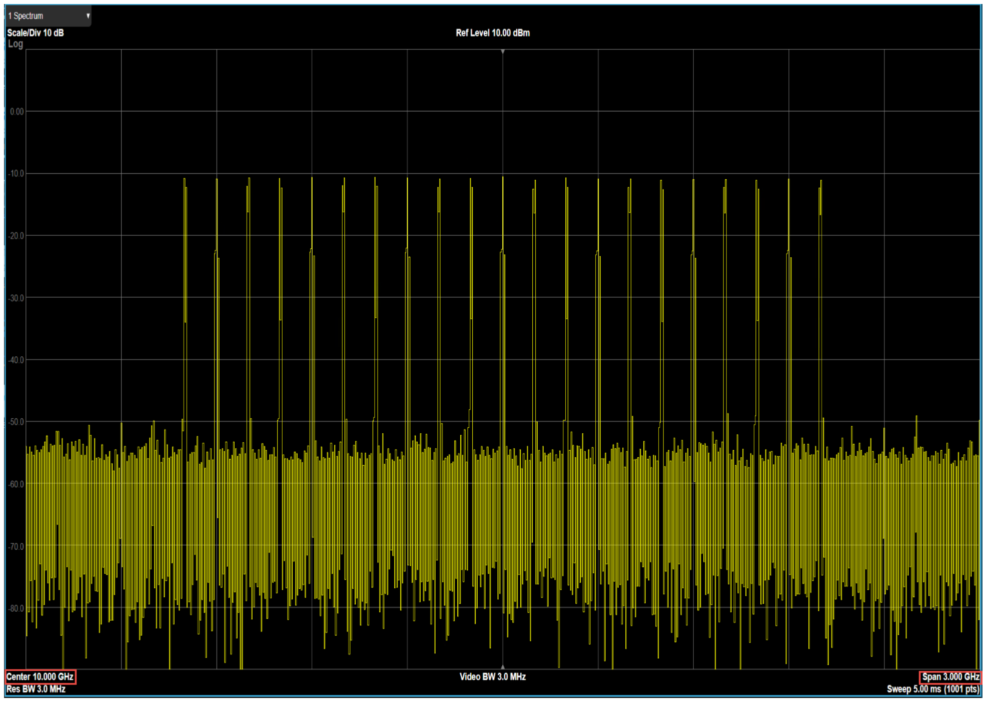
10. Turn **Corrections On**. View the results on the signal analyzer and observe how the .s2p file has impacted the signal.



11. Add a third block using the same file name as shown in the steps above. V Select Embed from the Apply drop down menu to set Block C Properties to **Embed.**



View the results on the X-Series spectrum analyzer. Notice that the corrections are no longer shown. This is because the de-embedded corrections applied in Block B cancel the embedded corrections applied in Block C.



Using a Spectrum Analyzer to Make the Corrections Measurement

When using a spectrum analyzer, it must be locked to the VXG Frequency Reference. This is important because the power measurement can be inaccurate due to a narrow resolution bandwidth (RBW) used in the spectrum analyzer. Supported Keysight X-Series signal analyzers are:

– N9000A/B CXA

– N9010A/B EXA

– N9020A/B MXA

– N9030A/B PXA

– X-Series Signal Analyzer and N9041B UXA

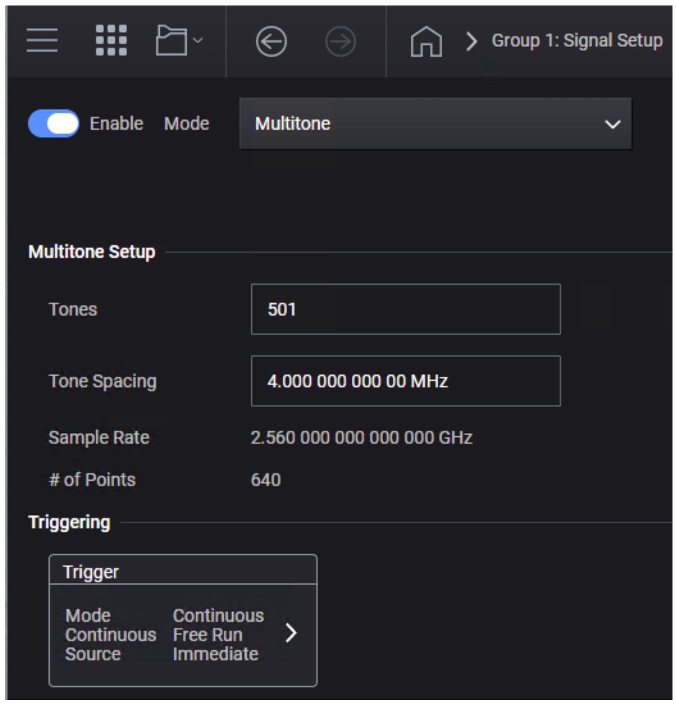
– M90XA

Using the Graphical User Interface

On the VXG:

1. Connect the VXG 10 MHz Out to the N90x0A/B Ext Reference In.
2. Connect cable or DUT between the VXG RF Out and the signal analyzer RF in.

3. Select **Preset** > **Preset** to set the instrument to a known state.
4. Set the Frequency to **12 GHz** and Amplitude to **–10 dBm**.
5. Select the **Signal** block and change the Mode from Waveform File to **Multitone**.
6. Configure the signal to have **501 Tones** with **4 MHz Tone Spacing**, then select **Enable**.



7. Close the Signal block and select 

 to turn on Channel 1’s RF Out.

On the signal analyzer:

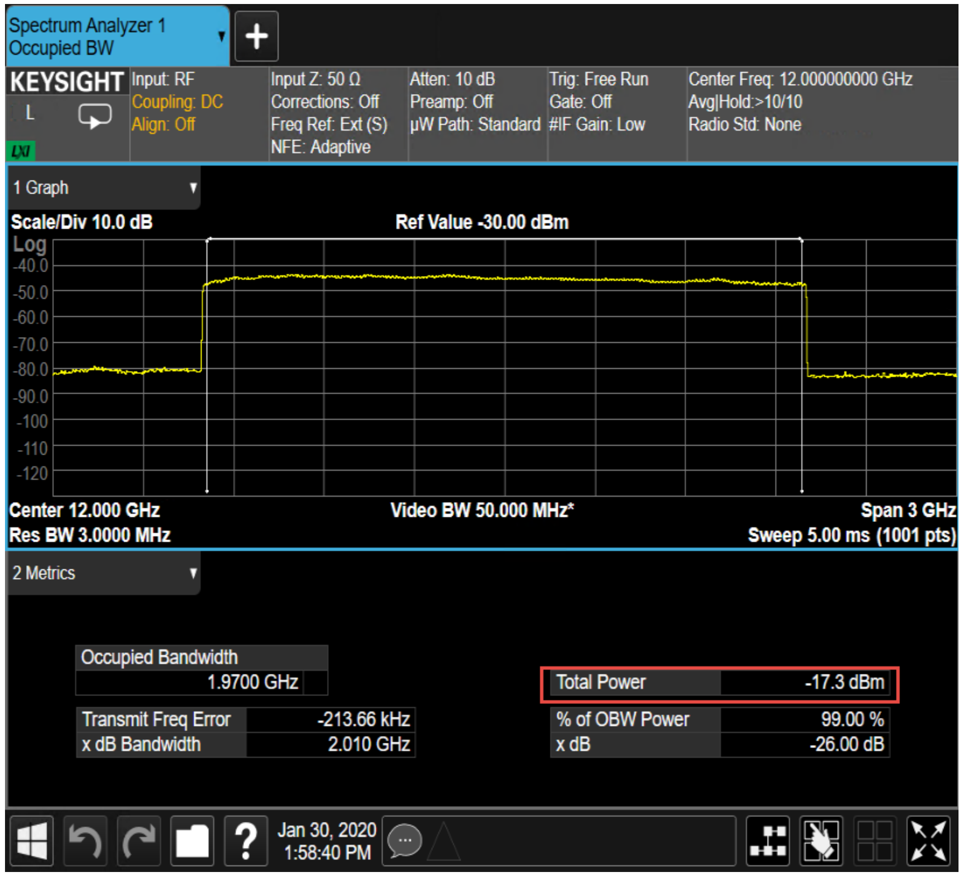
1. From the Menu Panel (on the top right of the display), select **Mode/Meas** > **Spectrum Analyzer** mode > **Occupied BW** Measurement > **OBW Results** View.

NOTE

If accessing the instrument via a Remote Desktop connection, select the Screen tab (at the top of the display) to open the Mode/Measurement/View Selector window.

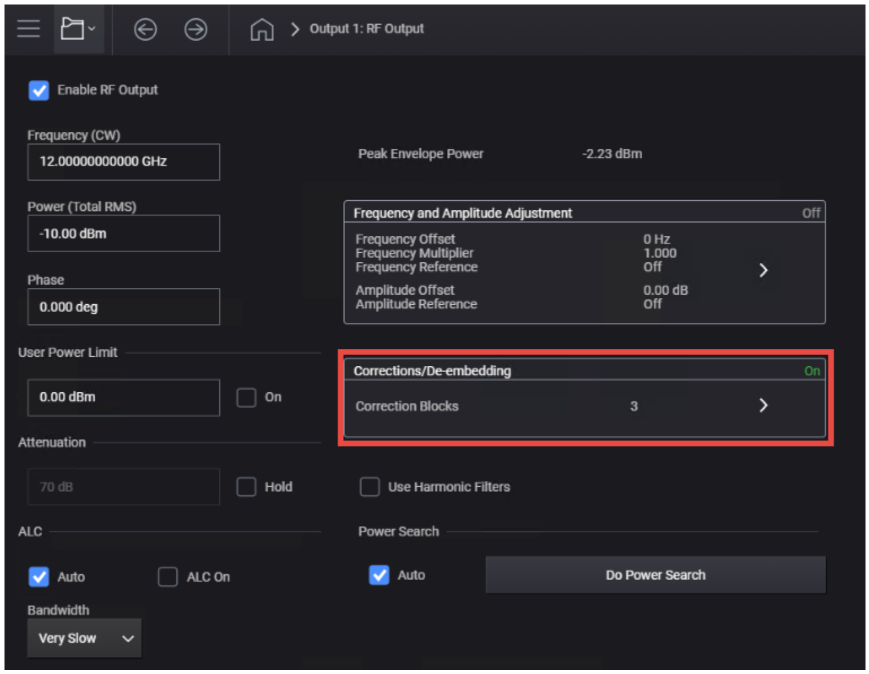
2. Set the Center Frequency to **12 GHz** and the Span to **3 GHz**.

Observe how the fixturing is impacting this signal, including the flatness and the total power.

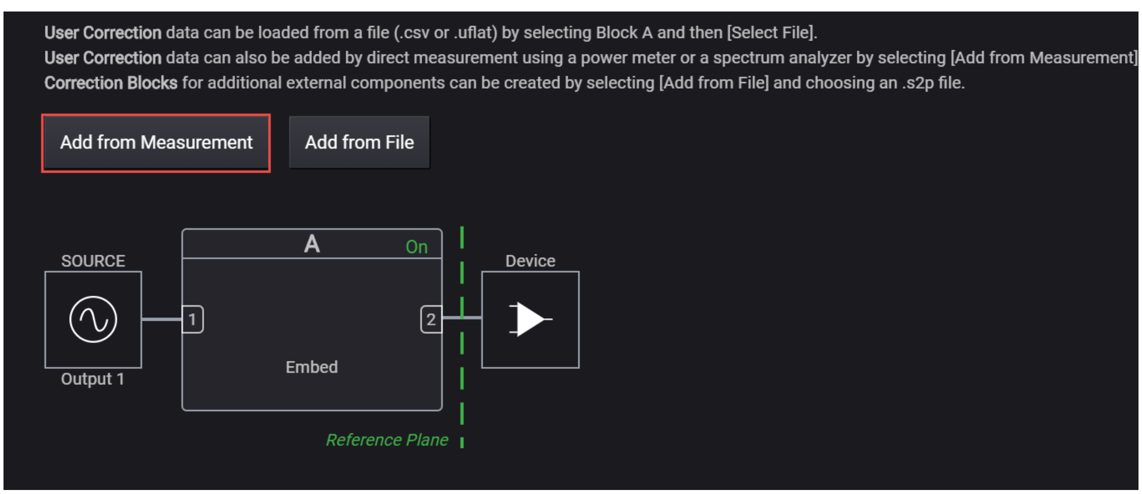


On the VXG:

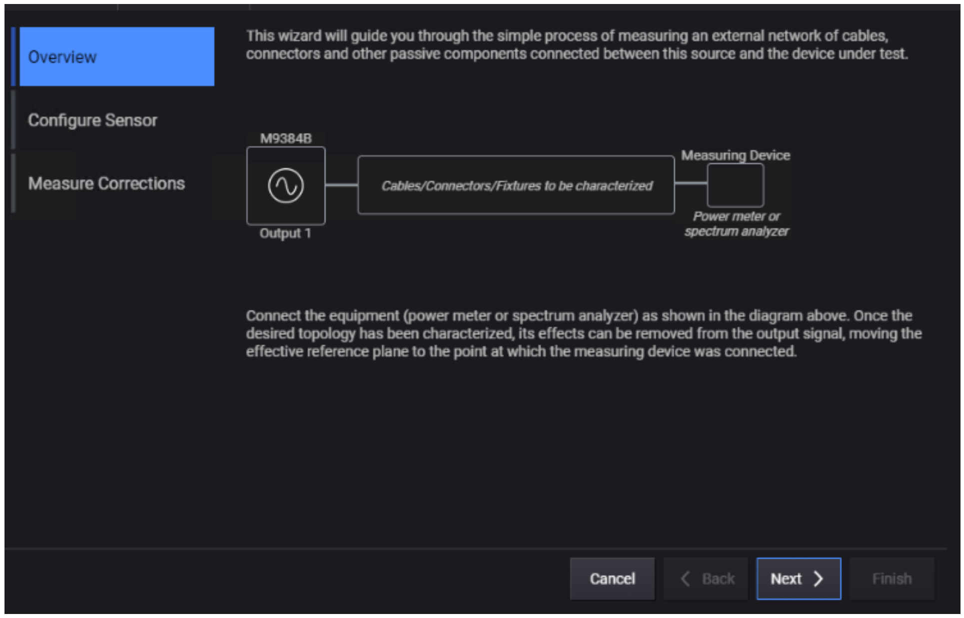
1. Select the **RF Output** block > **Corrections/De-embedding** block to open the Correction Setup.



2. Select **Add from Measurement** to open the Measure Corrections Block Wizard.

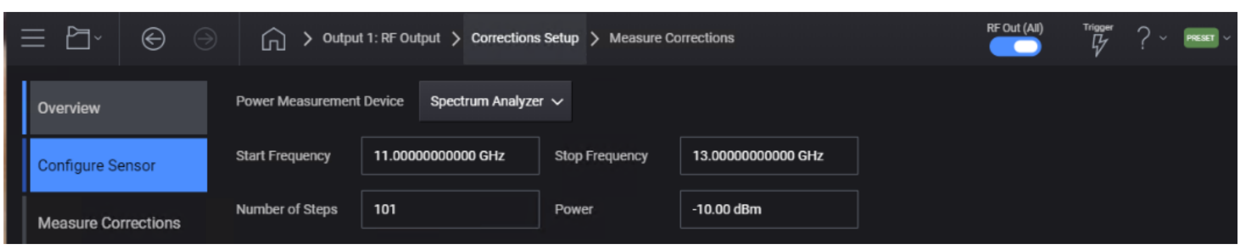


3. Connect the power sensor (in this case, the X-Series signal analyzer) as shown in the diagram below. After reading the overview, select **Next** to move to the Configure Sensor setup.

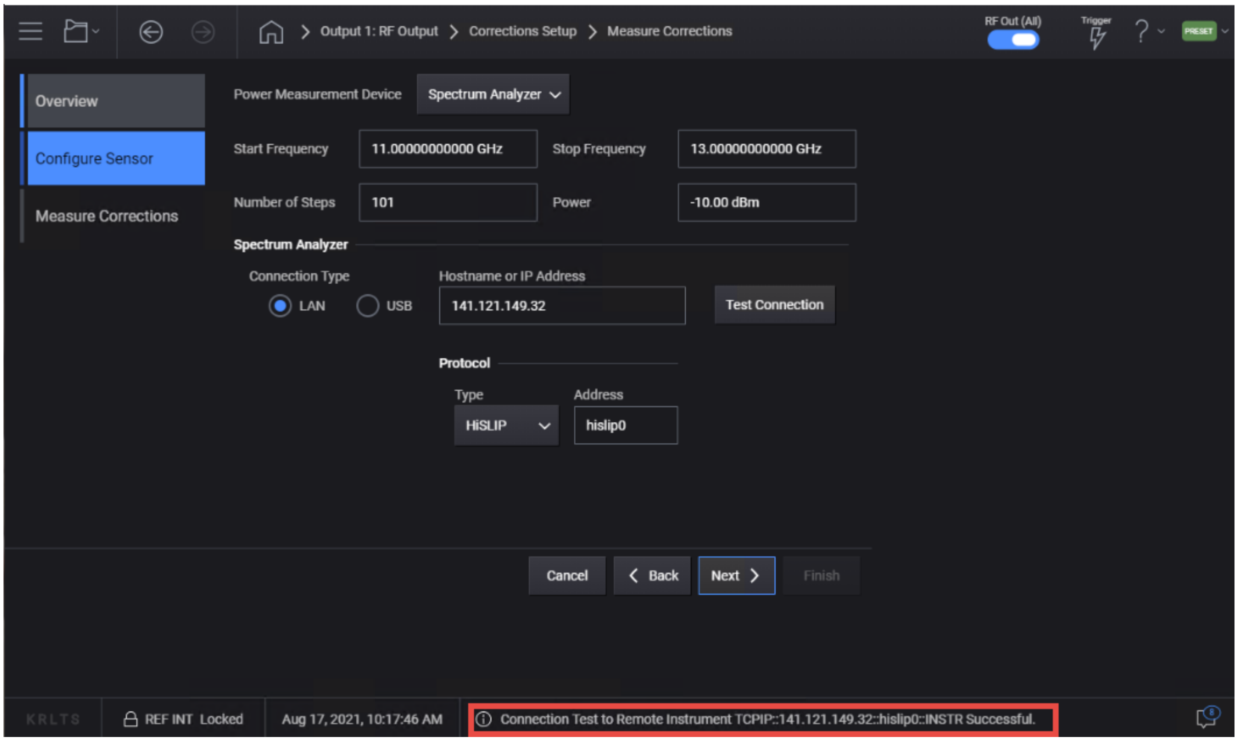


4. In the Configure Sensor setup, select the **Power Measurement Device** dropdown and select **Spectrum Analyzer**.

5. Set the Start and Stop Freq, Amplitude, and the Num Steps. For this example Start Freq **11 GHz**, Stop Freq **13 GHz**, Amplitude to the highest power used in your measurement (For this example, **-10 dBm**, which we already set in the main window. If you change the value here, it will update the value in the main measurement window.) and Num Steps to **101**.



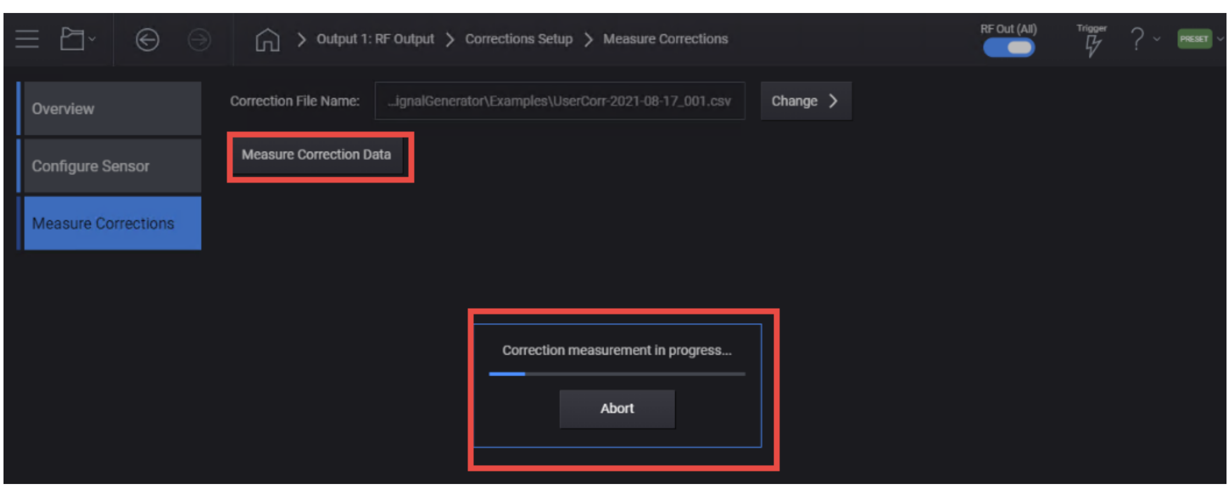
6. Set Connection Type to **LAN**, enter the LAN Address and set the Protocol parameters to **HiSLIP,** and then select **Test Connection**.



7. Once you are successfully connected, select **Next** to move to the Measure Corrections step.

8. Select **Measure Correction Data**.

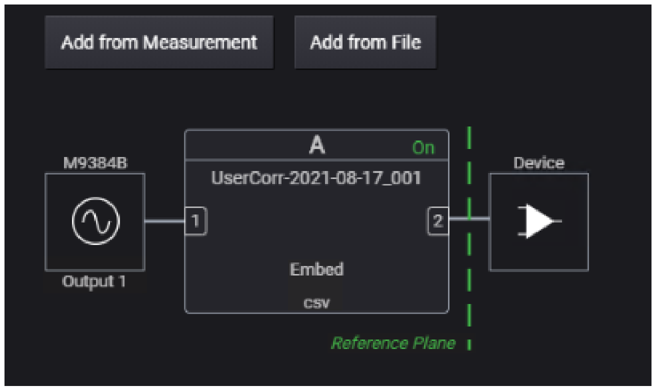
   During the measurement, the VXG outputs a CW between the Start and Stop Frequencies for the specified number of steps and output power. It will take some time to measure all 101 points, and the progress is indicated by the blue bar. You can watch the signal analyzer as it steps through this process.



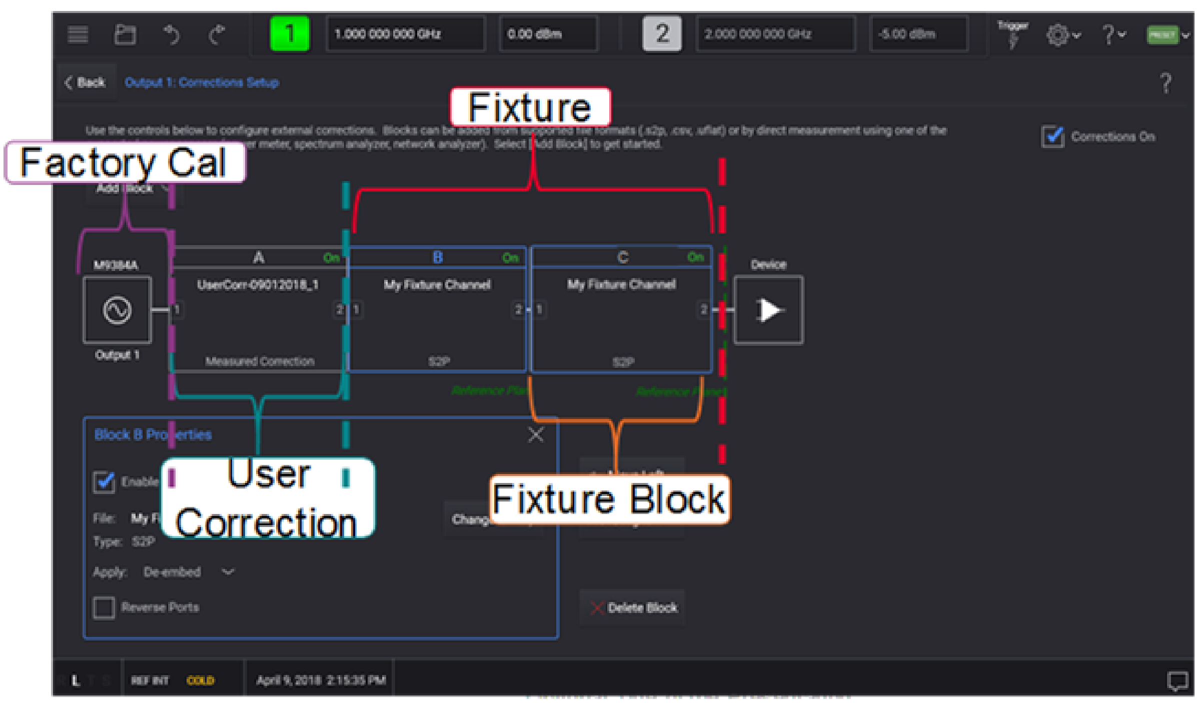
The measurement results are saved to a csv file using an automatically generated file name.

9. When the measurement is complete, select **Finish**, then select **Corrections On**.

The output csv file is set to Block A.



Block A is dedicated for User Correction. The image below shows how blocks are assigned in the User Correction and Fixture block.



10. On the signal analyzer, select **Restart** from the top left of the UI to **Restart** the measurement (because it is applying averaging). Observe how the measured corrections impacted the signal. You can easily toggle Corrections on and off on the VXG to see the difference.

Using a Power Meter to Make the Corrections Measurement

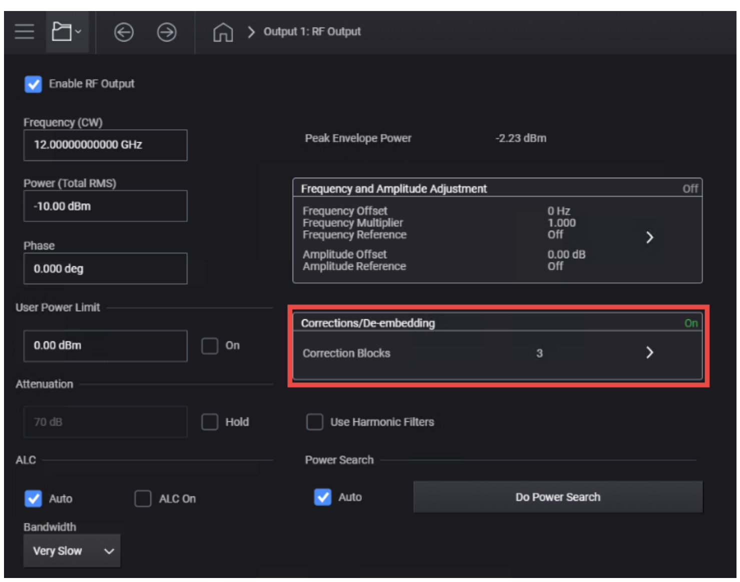
A power meter can also be used at the power measurement device. The following USB power sensors are supported:

- U8487A-CFG007
- U8485A-CFG006
- U2000A
- U2001A
- U2002A
- U2004A
- U2000B
- U2001B
- U2000H
- U2001H
- U2002H

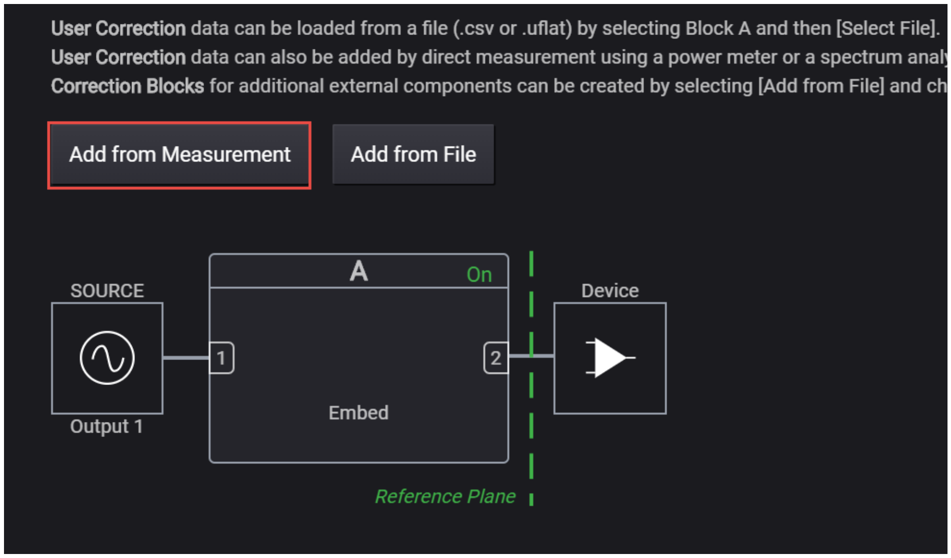
Using the graphical user interface

On the VXG:

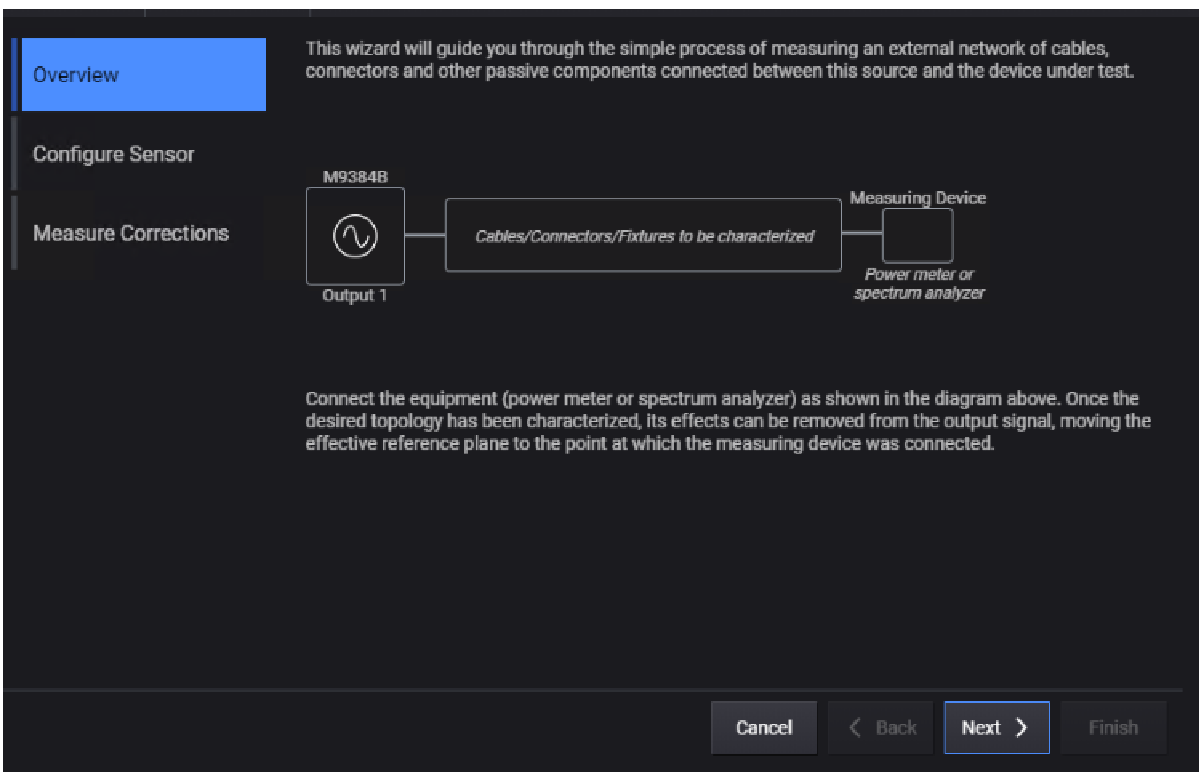
1. Connect the VXG 10 MHz Out to the N90x0A/B Ext Reference In.
2. Select the **RF Output** block > **Corrections/De-embedding** block to open the Correction Setup.



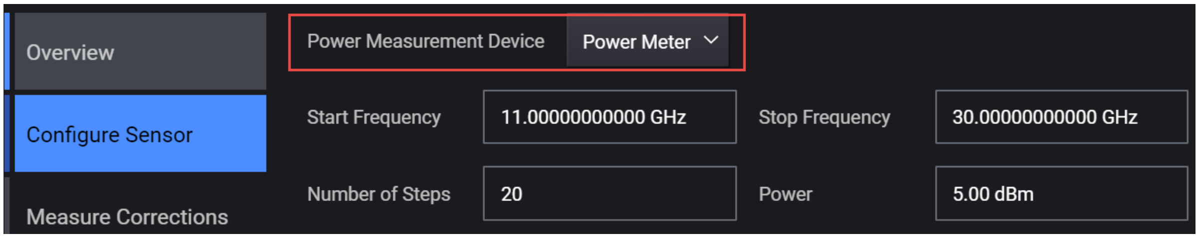
3. Select **Add from Measurement** to open the Measure Corrections Block Wizard.



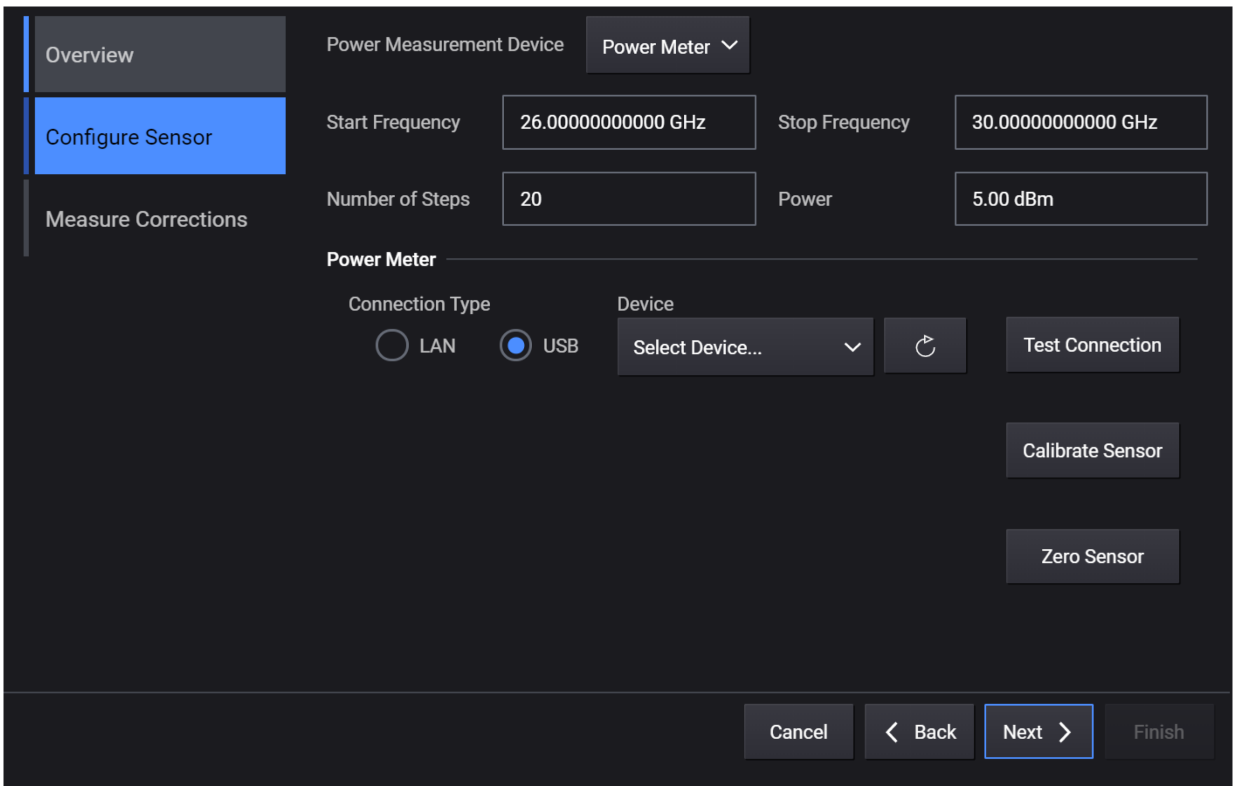
4. Connect the power sensor as shown in the diagram below then select **Next**.



5. Select **Next** to go to Configure Sensor dialog and select the **Power Measurement Device** dropdown > **Power Meter**.



6. Set the Start and Stop Freq, Amplitude, and the Num Steps. For this example Start Freq **26 GHz**, Stop Freq **30 GHz**, Amplitude to the highest power used in your measurement **5 dBm**, and Num Steps to **20**.

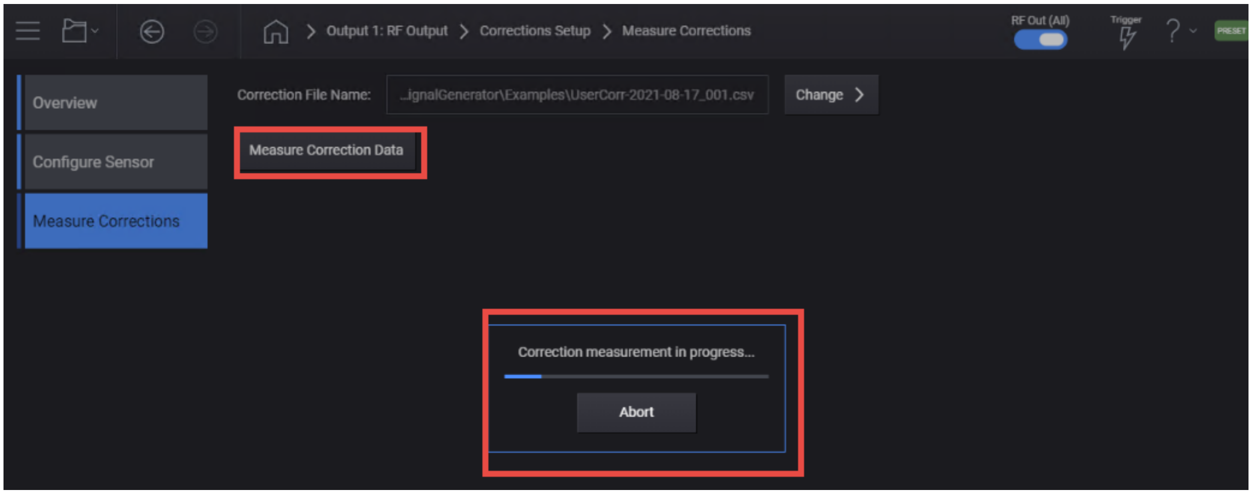


7. Select the Connection Type to **USB**, and then specify the Device and VISA Address.

8. Select **Test Connection** to verify connectivity, and then select **OK** then **Next** to continue.

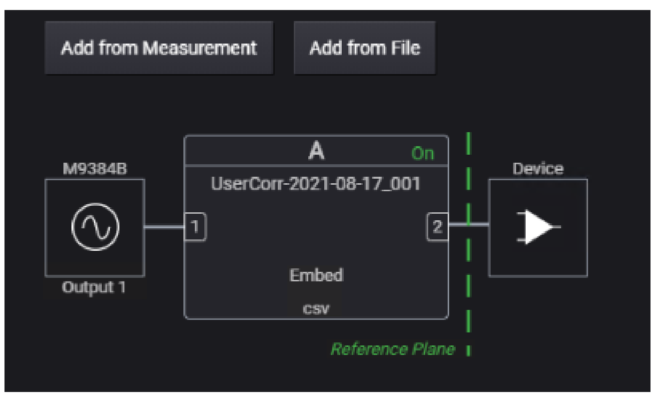
   You can also calibrate and zero out the power sensor before measuring corrections.

9. Select **Next** to go to the Measure Corrections dialog and select **Measure Correction Data**.

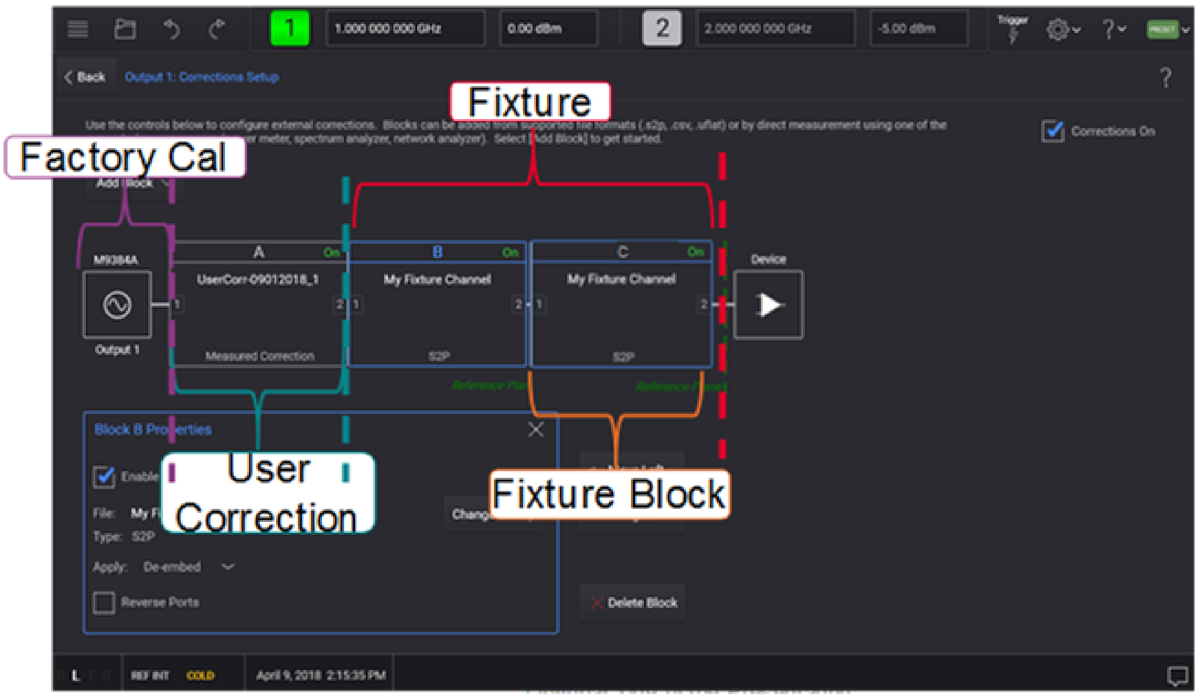


During the measurement, the VXG outputs a CW between the Start and Stop Frequencies for the specified number of steps and output power. The measurement results are saved to a csv file using an automatically generated file name.

10. Select **Finish**. The output csv file is set to Block A.



Block A is dedicated for User Correction. The image below shows how blocks are assigned in the User Correction and Fixture block.



11. Select **Corrections On** to apply.

Using the equivalent SCPI commands

Using a spectrum analyzer to make the corrections measurement

On the VXG:

```
SYSTem:PRESet
```

`Set the power level to the highest level used in your measurement.`

```
RF1:POWer:AMPLitude 5dBm
```

```
CORRection:PMDevice SANalyzer
```

```
CORRection:FLATness:STEP:STARt 26GHZ
```

```
CORRection:FLATness:STEP:STOP 30GHZ
```

```
CORRection:FLATness:STEP:POINts 20
```

```
CORRection:SANalyzer:COMMunicate:TYPE SOCKets
```

Set the LAN address and protocol parameters for your spectrum analyzer.

```
CORRection:SANalyzer:COMMunicate:LAN:IP "192.168.1.5"
```

```
CORRection:SANalyzer:COMMunicate:LAN:PORT 5025
```

```
CORRection:FLATness:CALibrate
```

Wait for the measurement to complete.

```
CORRection ON
```

Using a power meter to make the corrections measurement.

On the VXG:

```
SYSTem:PRESet
RF1:POWer:AMPLitude 5dBm
CORRection:PMDevice PMETer
CORRection:FLATness:STEP:STARt 26GHZ
CORRection:FLATness:STEP:STOP 30GHZ
CORRection:FLATness:STEP:POINts 20
CORRection:SANalyzer:COMMunicate:TYPE USB
```

NOTE

Use query CORRection:PMETer:COMMunicate:USB:LIST? for a list of all connected USB devices.

`CORRection:PMETer:COMMunicate:USB:DEVice “instr0”`

[Optional] `CORRection:PMETer:CALibrate`

[Optional] `CORRection:PMETer:ZERO`

`CORRection:FLATness:CALibrate`

`CORRection ON`

Adding fixture blocks using s2P files

On the VXG:

```
SYSTem:PRESet
RF1:FREQuency:CW 10GHZ
RF1:POWer:AMPLitude -20dBm
SIGNal1:MODE MTONe
SIGNal1:MTONe:ARB:NTON 21
SIGNal1:MTONe:ARB:FSP 100MHZ
SIGNal1 ON
RF1:OUTPut:STATe ON
```

For multi-channel instruments, set RF Out (all) to On.

```
RFALl:OUTPut ON
```

On the X-Series Signal Analyzer:

```
SYSTem:PRESet
FREQuency:CENTer 10GHZ
FREQuency:SPAN 3GHZ
```

On the VXG:

Set the path to the s2p data as block 2 (you can use 1 through 4).

```
CORRection:BLOCk2:FILE "FixtureChannel2"
CORRection:BLOCk2 ON
```

Add block C with the same file.

```
CORRection:BLOCk3:FILE "FixtureChannel2"
```

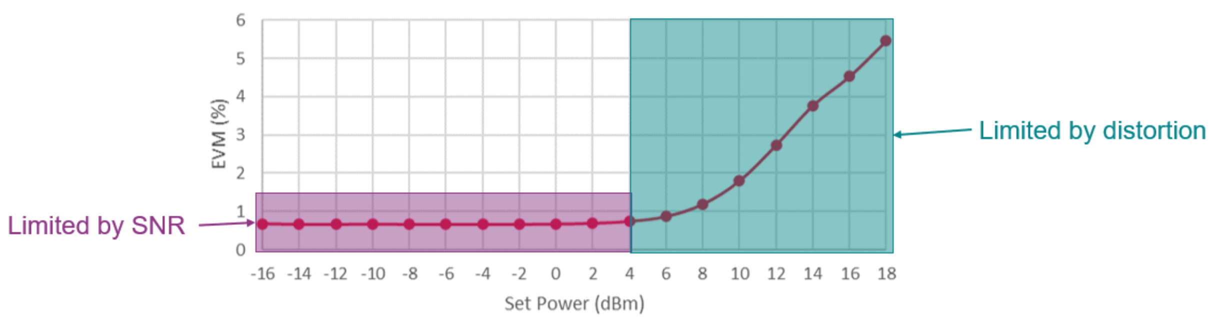
Change Block C to Embed.

```
CORRection:BLOCk3:APPLy EMBedding
CORRection:BLOCk3 ON
```

Instrument Nonlinear Correction

Instrument Nonlinear Correction (INC) is a digital pre-distortion (DPD) based correction using a Keysight signal analyzer (N9042B, N9040B, or N9030B) to compensate for nonlinearities in the VXG. INC is useful in reducing EVM (and other metrics impacted distortion) at high power levels and extending the range of the power with linear output of the VXG. INC is a point correction valid for a given frequency/power/waveform combination and can be used for EVM and ACP measurements at high power levels (>5 dB). The VXG must have the N7653APPC PathWave automatic channel response correction and S-parameter de-embedding license installed. You must have firmware version A.07.01 or greater to use this feature.

Instrument nonlinear corrections compensate for nonlinearities in the VXG. Improvement to EVM will only be seen at power levels where distortion is the limiting factor. INC will not improve EVM in the area where signal to noise ratio (SNR) is the limiting factor.

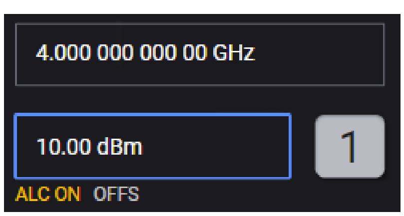


Setting Up an INC 1CC 4 GHz, 10 dBm EVM Measurement

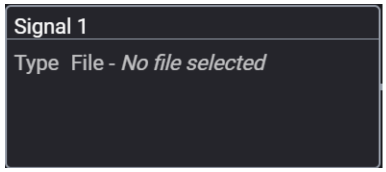
On the VXG:

In order to compare before and after correction results, we will start by making an EVM measurement without applying corrections.

1. Select **Preset** > **Preset** to set the instrument to a know state.
2. In the Output area, set Frequency to **4 GHz** and Power to **10 dBm**.



3. Select the **Signal** block to open the Vector Modulation Signal Setup panel.

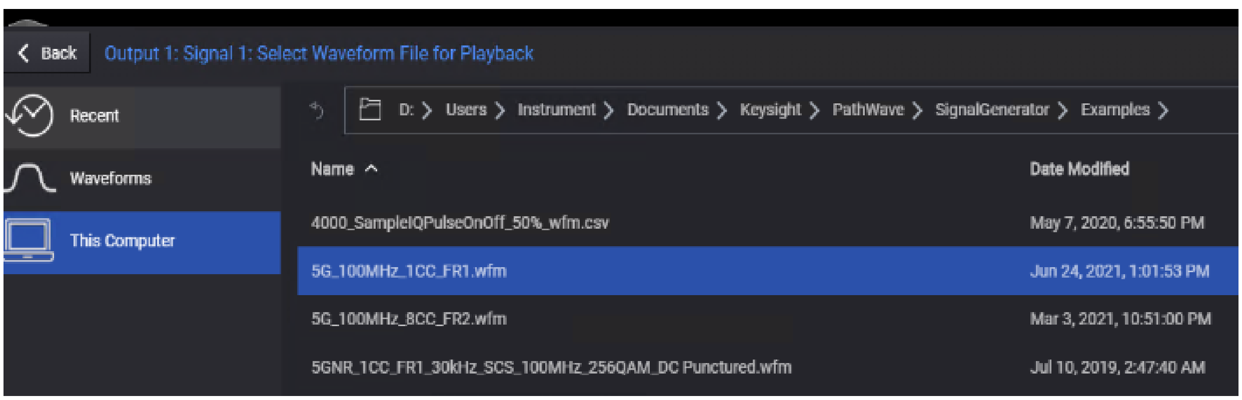


4. In the Vector Modulation Setup, set Mode to **Waveform File**.
5. In the Waveform Playback Setup area, use File **Select** to navigate to:

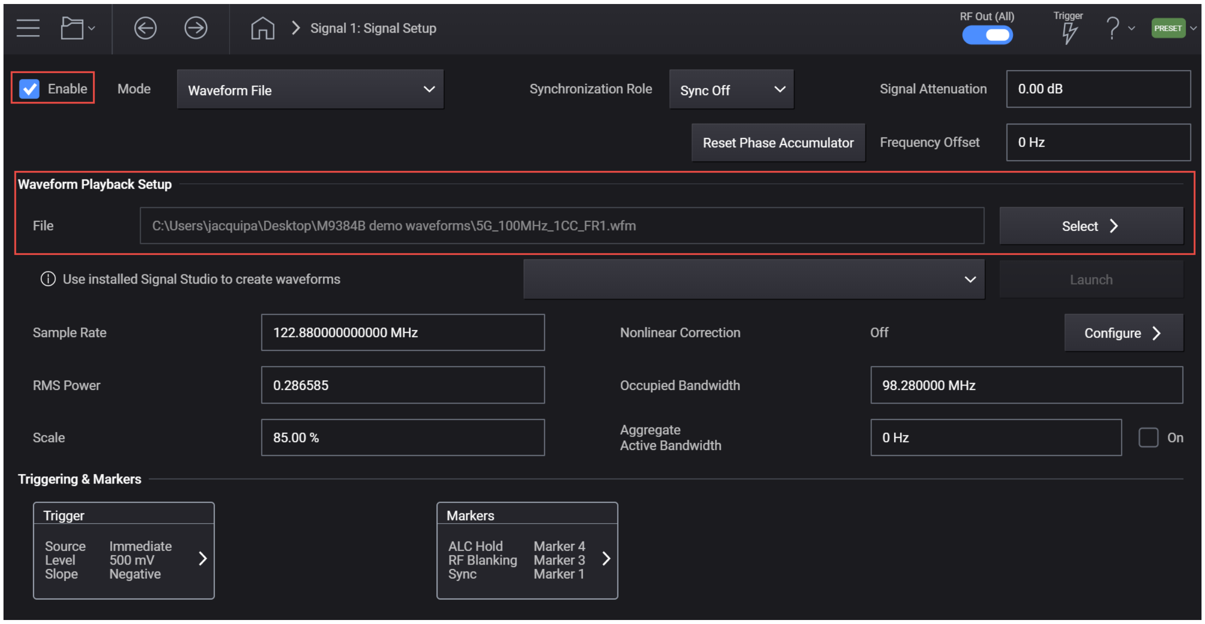
```
D:\Users\Instrument\Documents\Keysight\PathWave
\SignalGenerator\Examples
```

```
and choose
5G_100MHz_1cc_FR1.wfm
```

then **Select**.



6. Select **Enable** Vector Modulation Signal.



7. Set RF Out to **On** for channel 1.

On the UXA:

1. From the X-Series Signal Analyzer Menu Panel (on the top right of the display), select **Mode/Meas** > **5GNR** Mode > **Modulation Analysis Measurement** > **OK**.

NOTE

If accessing the instrument via a Remote Desktop connection, select the Screen tab (at the top of the display) to open the Mode/Measurement/View Selector window.

2. Select **Mode Preset** to set Spectrum Analyzer 5GNR mode to a known state.
3. From the X-Series Signal Analyzer Menu Panel (on the top right of the display), select **Mode/Meas** > **5GNR** Mode > **Modulation Analysis** Measurement > **OK**.

NOTE

All example waveforms and setup files are located on the VXG at:

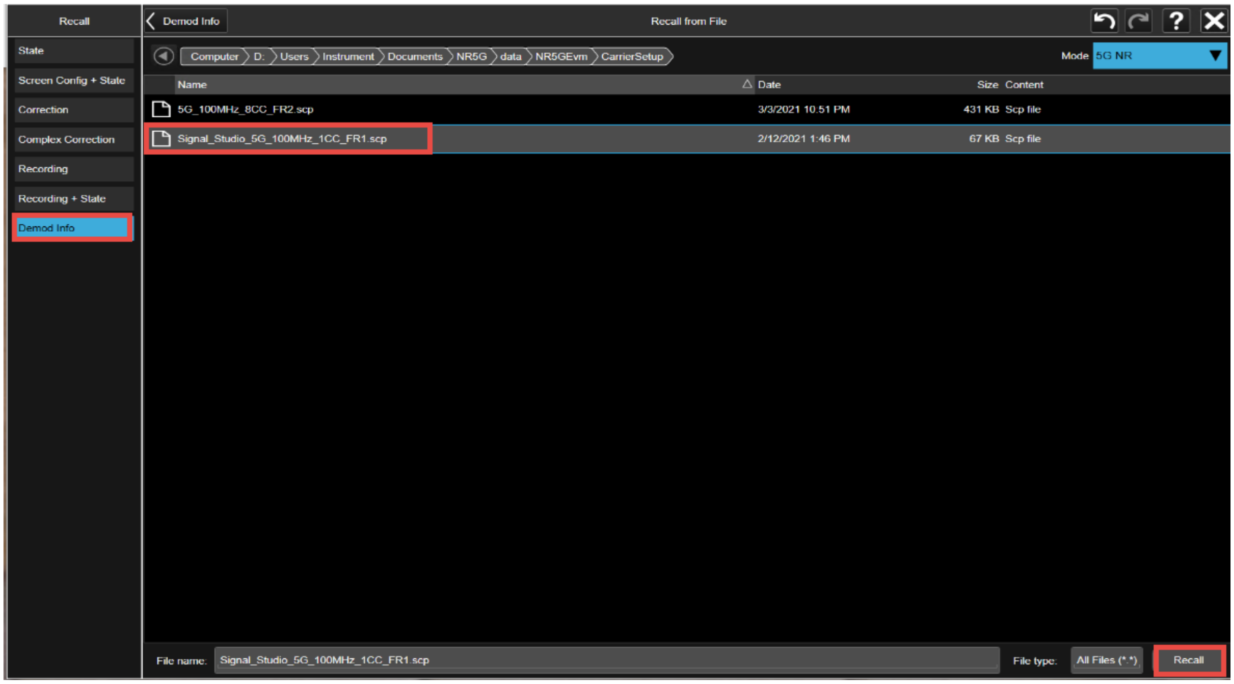
`D:\Users\Instrument\Documents\Keysight\PathWave \SignalGenerator\Examples`

You will need to copy over the setup files to the X-Series Signal Analyzer or the PC running the VSA application.

4. Select **Recall** (If accessing the X-Series Signal Analyzer remotely, select the Folder icon at the bottom of the display) **Demod Info** > Data Type set to **CC Setup** > **Recall From** >

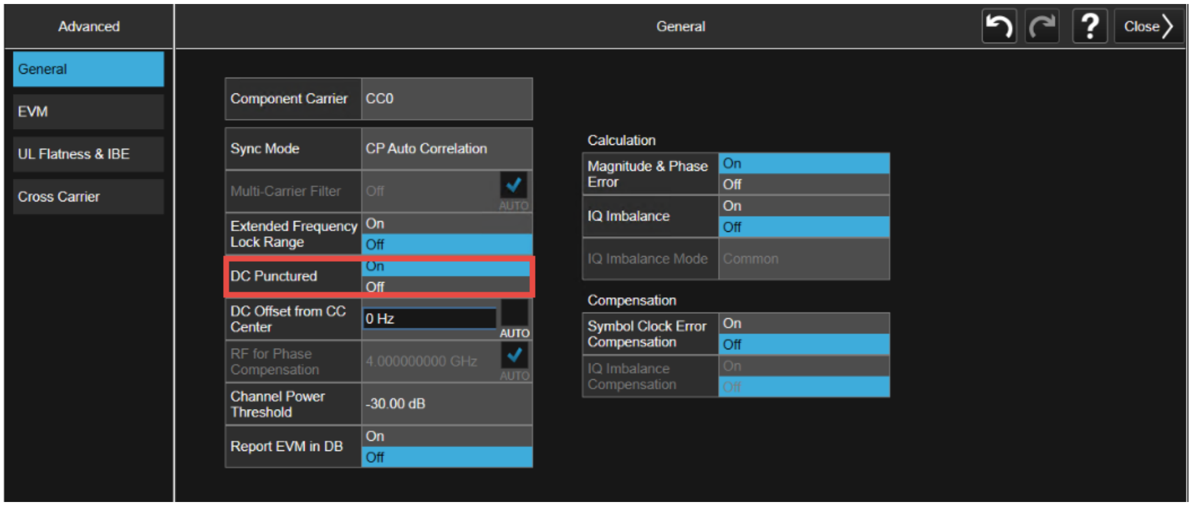
   `Signal Studio_5G_100 MHz_1CC_FR1.scp`

   Recall



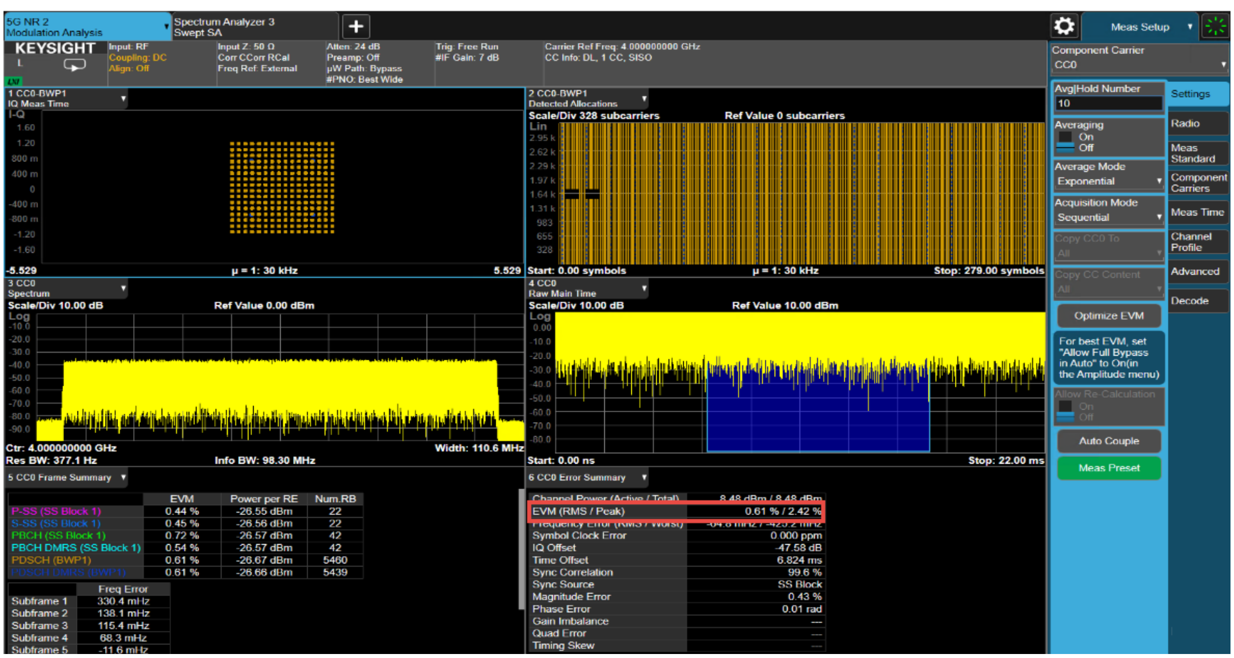
5. The Signal Stuidio_5G_100 MHz_1CC_FR1.scp file should automatically set the Carrier Frequency to 4 GHz. If not, got to Frequency > Carrier Reference Frequency > 4 GHz.

6. From the Main menu, select **Meas Setup** > **Advanced** tab > **Advanced Demod Setup** and set DC Punctured to **On**, then **Close** the Advanced Demod Setup window.



7. In the Meas Setup window, select the **Settings** tab > **Optimize EVM**.

   Record the results. For this example EVM is 0.61% and EVM Peak is 2.42%

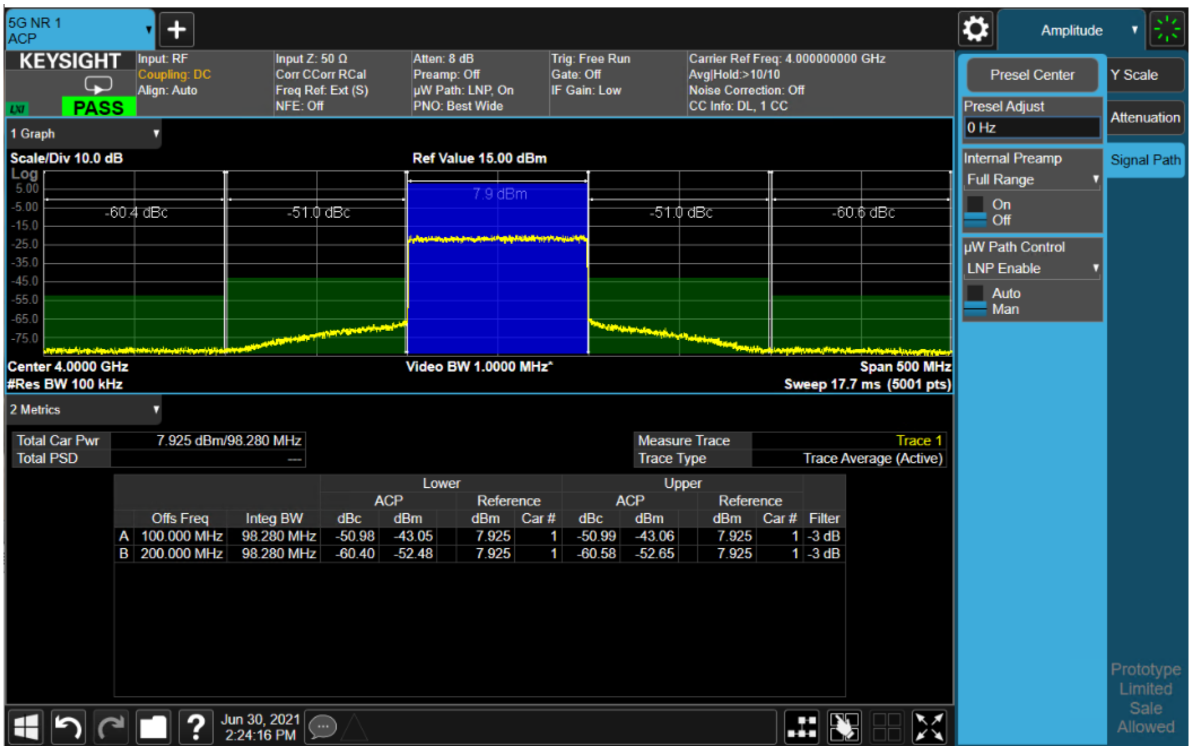


To Measure ACP:

a. Select **Mode/Meas** > **5GNR** Mode > **ACP** > **OK.**

b. Select **Amplitude** > **Signal Path** tab > and set µW Path Control to **Low Noise Path Enable.**

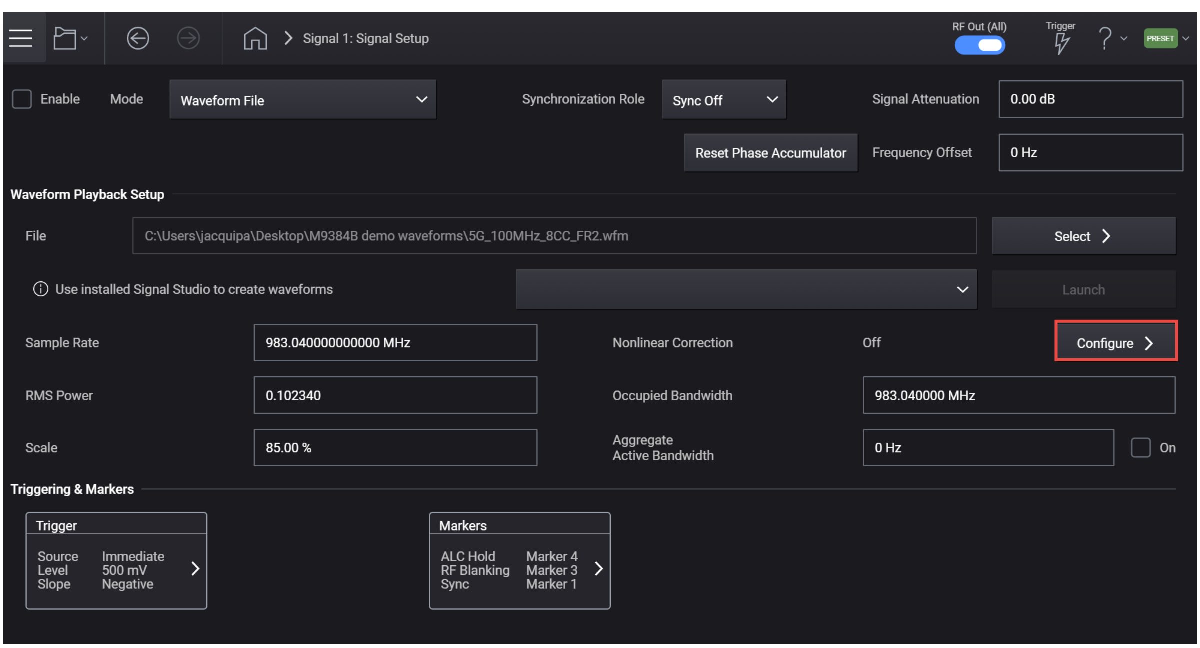
Record the results for the Lower and Upper ACP results. For this example -50.9 dBc (lower) and -50.9 (upper).



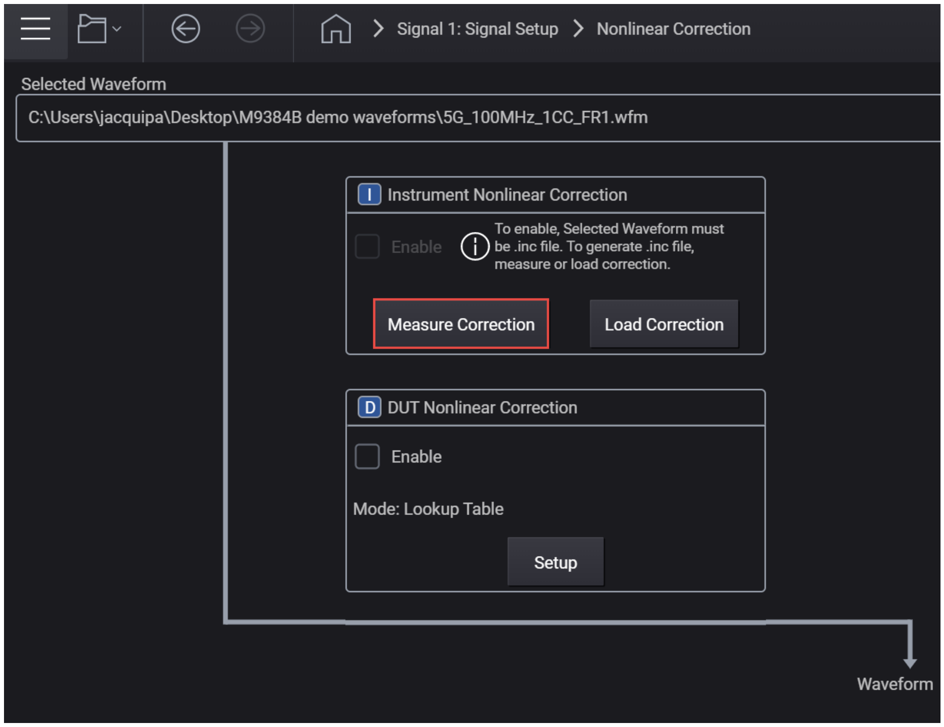
c. Select **Mode/Meas** > **5GNR** Mode > **Modulation Analysis** > **OK**.

On the VXG:

1. Open the Signal block and select **Configure** to open the Nonlinear Correction Setup.

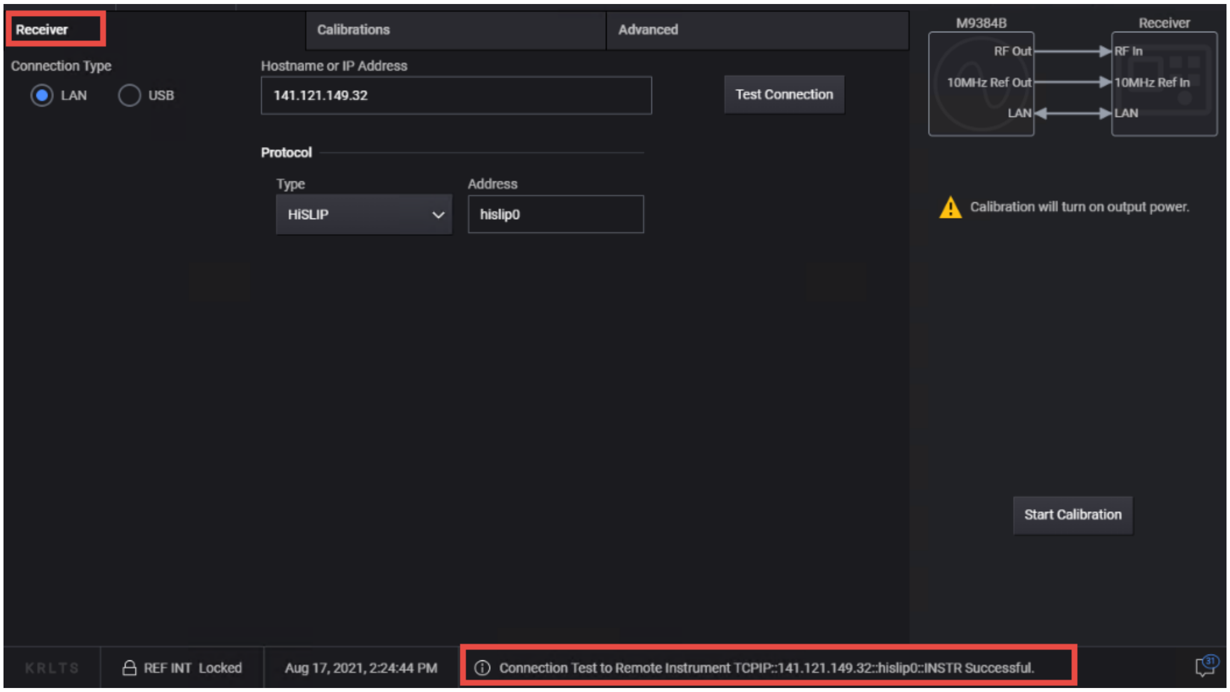


2. In the Instrument Nonlinear Correction area, select **Measure Correction** to open the Instrument Nonlinear Calibration screen.

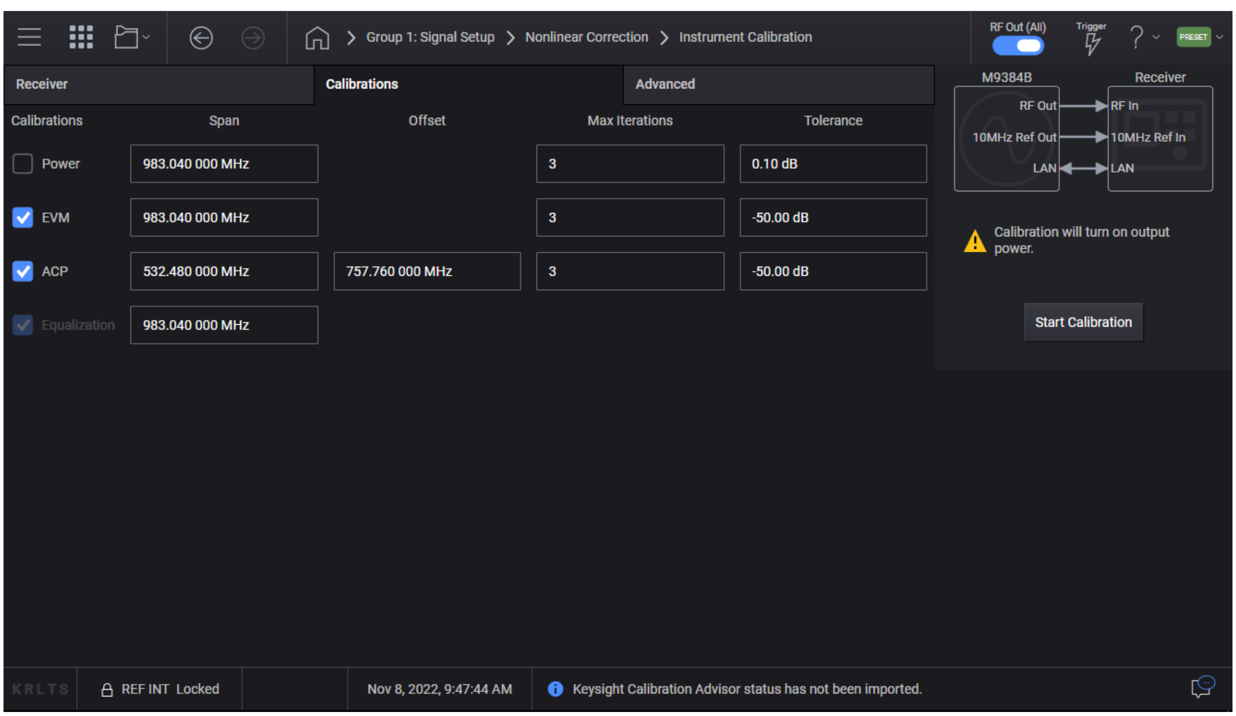


3. Under the Receiver tab (opened by default), enter your connection information and test the connection. For this example, select **LAN** as the Connection Type > Enter the IP address for you signal analyzer (for this example, 141.121.149.32) as the Hostname > **Test Connection**.

The Connection status will be displayed in the Notifications area at the bottom of the main window.



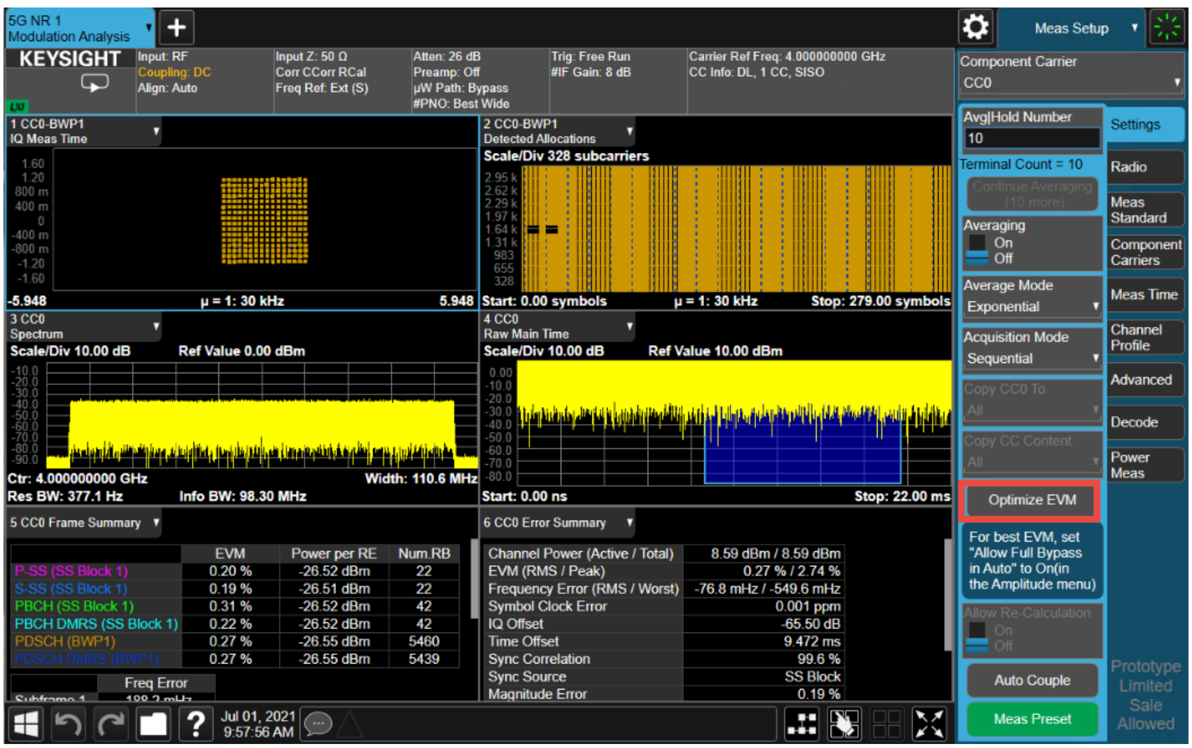
4. Select the **Calibrations** tab and select **EVM** and **ACP** for the Calibrations, then **Start Calibration**.



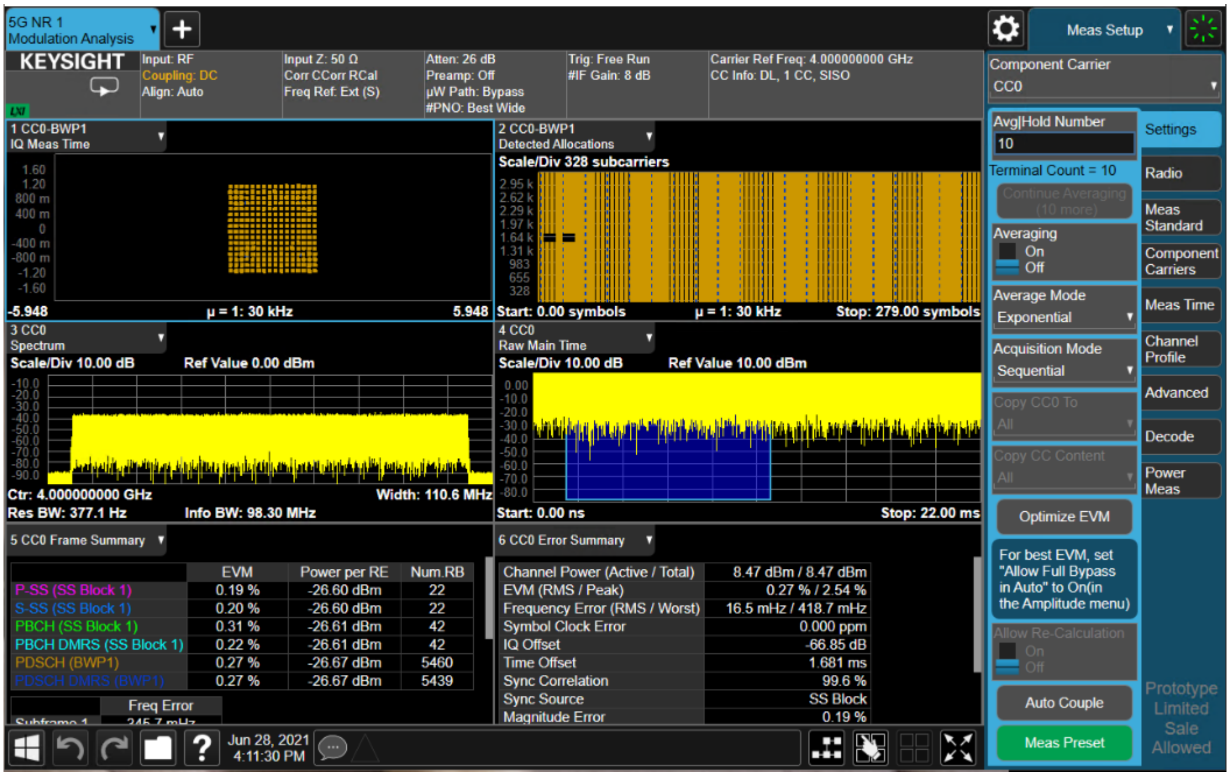
The calibration will take a few minutes to complete. Once done, the INC file will be created and it will automatically be used in place of the .wfm file originally loaded. An "I" will be displayed in the Signal block indicating this status.

On the UXA:

1. Select **Optimize EVM**.



Note the changes to EVM RMS and EVM Peak values. For this example EVM RMS is 0.27% (before 0.61%) and EVM Peak is 2.64% (before 2.42%).

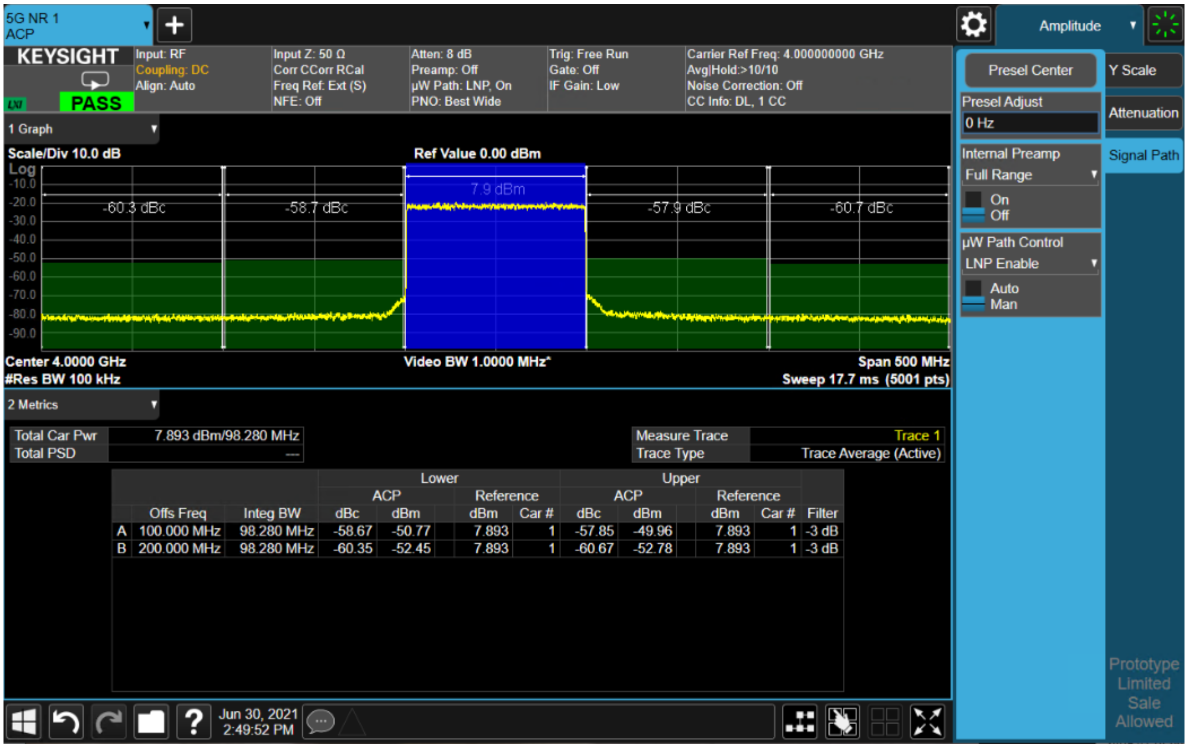


To Measure ACP:

a. Select **Mode/Meas** > **5GNR** Mode > **ACP** > **OK**.

b. Select **Amplitude** > **Signal Path** tab > and set µW Path Control to **LNP (Low Noise Path) Enable.**

Note the changes to the Lower and Upper ACP values. For this example Lower -58.67 dBc (before -50.9 dBc) and Upper -57.85 dBc (before -50.9).

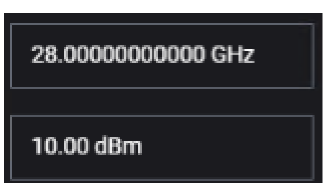


Setting Up an INC 8CC 28 GHz, 10 dBm EVM Measurement

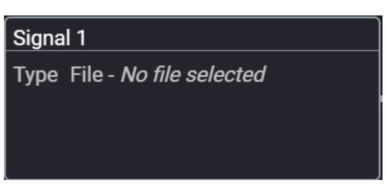
On the VXG:

In order to compare before and after correction results, we will start by making an EVM measurement without applying corrections.

1. Select **Preset** > **Preset** to set the instrument to a know state.
2. In the Output area, set Frequency to **28 GHz** and Power to **10 dBm**.



3. Select the **Signal** block to open the Vector Modulation Signal Setup panel.



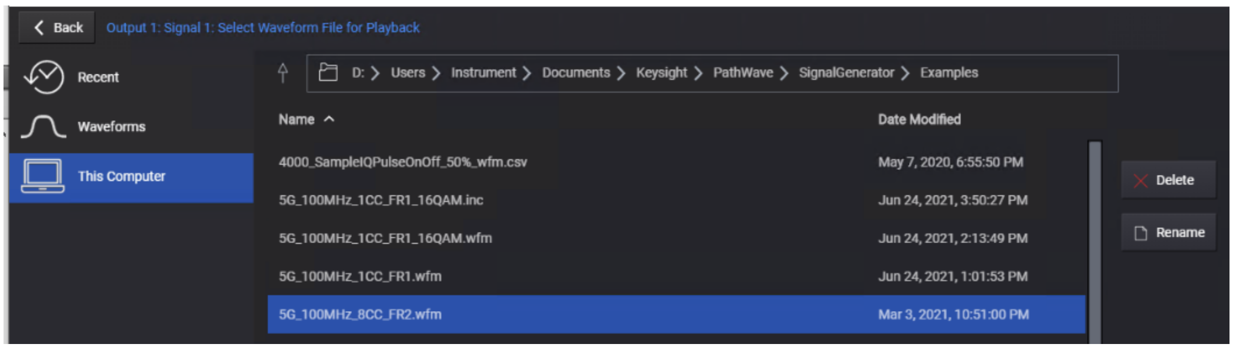
4. In the Vector Modulation Setup, set Mode to **Waveform File**.

5. In the Waveform Playback Setup area, use File **Select** to navigate to:

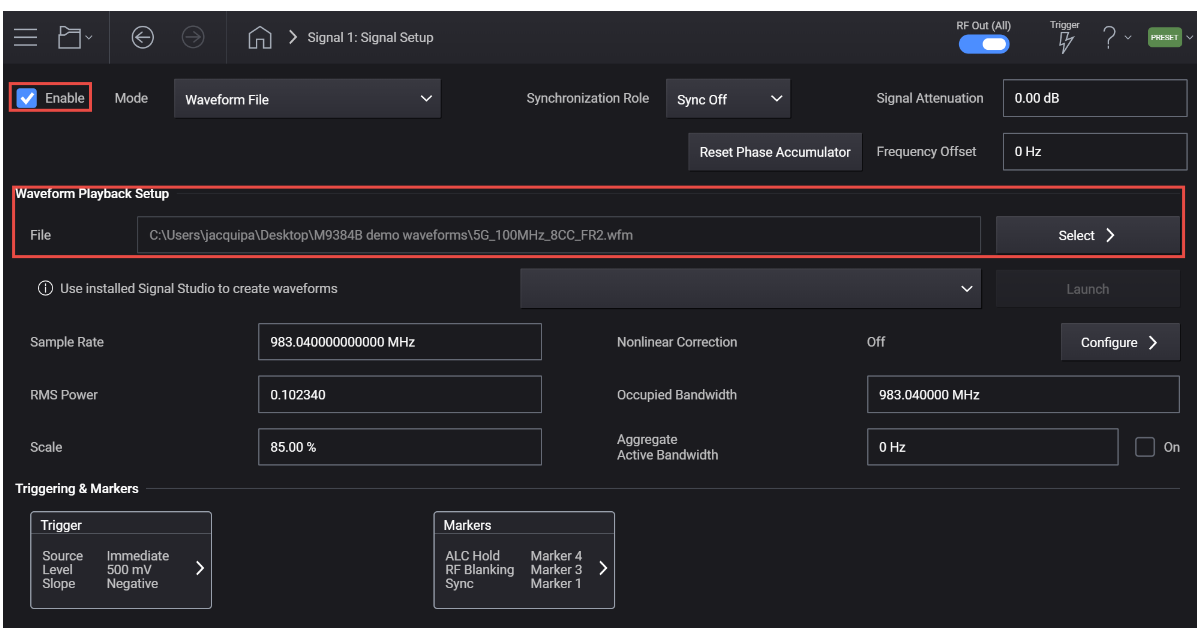
   D:\Users\Instrument\Documents\Keysight\PathWave\SignalGenerator\Examples

   and choose
   5G_100MHz_8cc_FR2.wfm

   then **Select**.



6. Select **Enable** Vector Modulation Signal and close the Signal block.



7. Set RF Out to **On**.

On the UXA:

1. From the X-Series Signal Analyzer Menu Panel (on the top right of the display), select **Mode/Meas** > **5GNR** Mode > **OK**.

NOTE

If accessing the instrument via a Remote Desktop connection, select the Screen tab (at the top of the display) to open the Mode/Measurement/View Selector window.

2. Select **Mode Preset** to set Spectrum Analyzer 5GNR mode to a known state.
3. From the X-Series Signal Analyzer Menu Panel (on the top right of the display), select **Mode/Meas** > **5GNR** Mode > **Modulation Analysis** Measurement > **OK**.

NOTE

All example waveforms and setup files are located on the VXG at:

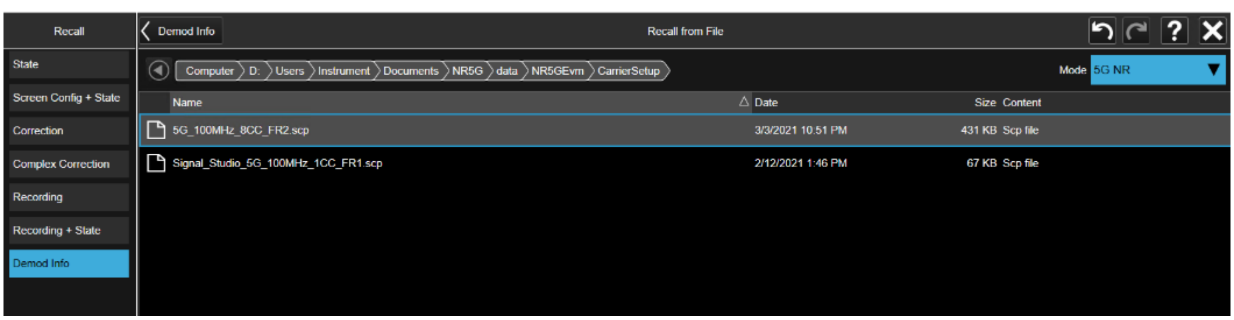
`D:\Users\Instrument\Documents\Keysight\PathWave \SignalGenerator\Examples`

You will need to copy over the setup files to the X-Series Signal Analyzer or the PC running the VSA application.

4. Select **Recall** (If accessing the X-Series Signal Analyzer remotely, select the Folder icon at the bottom of the display) **Demod Info** > Set Data Type to **CC Setup** > **Recall From** >

   `5G_100 MHz_8CC_FR2.scp`

   Recall



5. The .scp file should automatically set the Carrier Frequency to 28 GHz. If not, got to Frequency > Carrier Reference Frequency > 28 GHz.
6. Select **Meas Setup** > **Advanced** tab > **Advanced Demod Setup** and set DC Punctured to **On**, then **Close** the Advanced Demod Setup window.
7. Select the **Sweep** > **Single Sweep**.
8. Select **Meas Setup** > **Settings** tab > **Optimize EVM**.

It will take a couple of minutes for the UXA to measure all 8 carriers.

Record the results.

For this example CC0 EVM RMS is 6.21%, EVM Peak is 27.33% and for CC7 EVM RMS is 4.51% and EVM Peak is 15.75%

To Measure ACP:

a. Select **Mode/Meas** > **5GNR** Mode > **ACP** > **OK**.

b. Select **Amplitude** > **Signal Path** tab > and set µW Path Control to **LNP (Low Noise Path) Enable**.

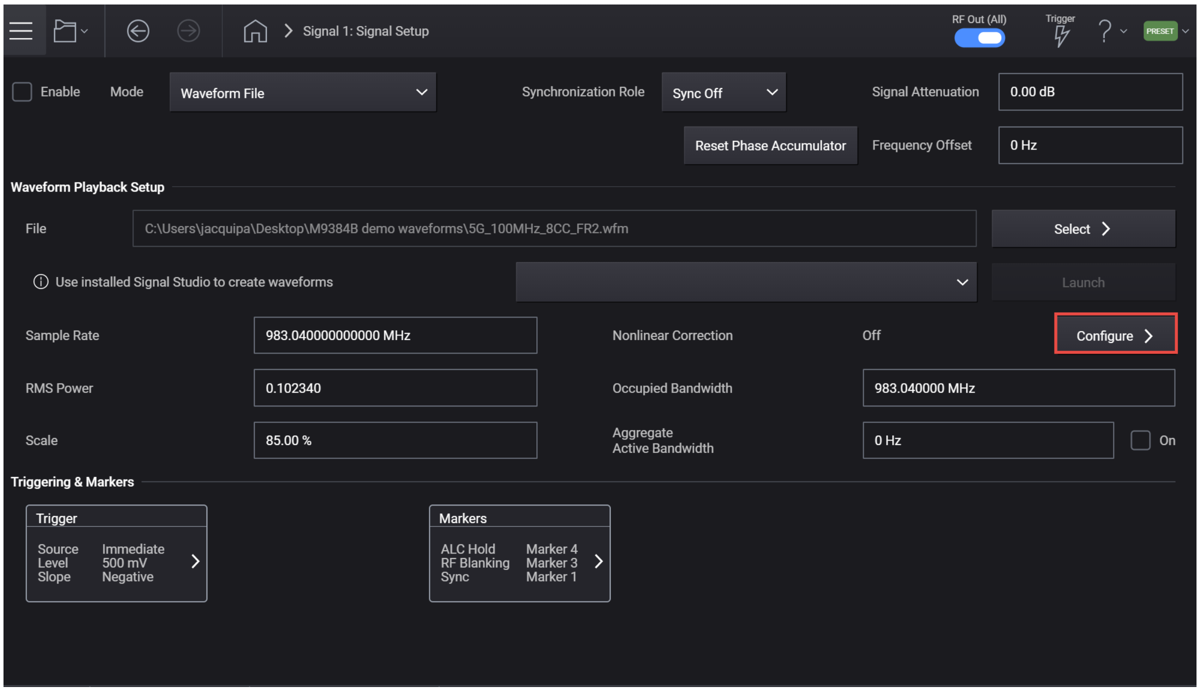
c. Select **Sweep** > **Restart** to take a new sweep.

Note the values of the Lower and Upper ACP. For this example Lower, at 100 MHz offset is -26.7 dBc and Upper -27.06 dBc.

d. Select **Mode/Meas** > **5GNR** Mode > **Modulation Analysis** > **OK.**

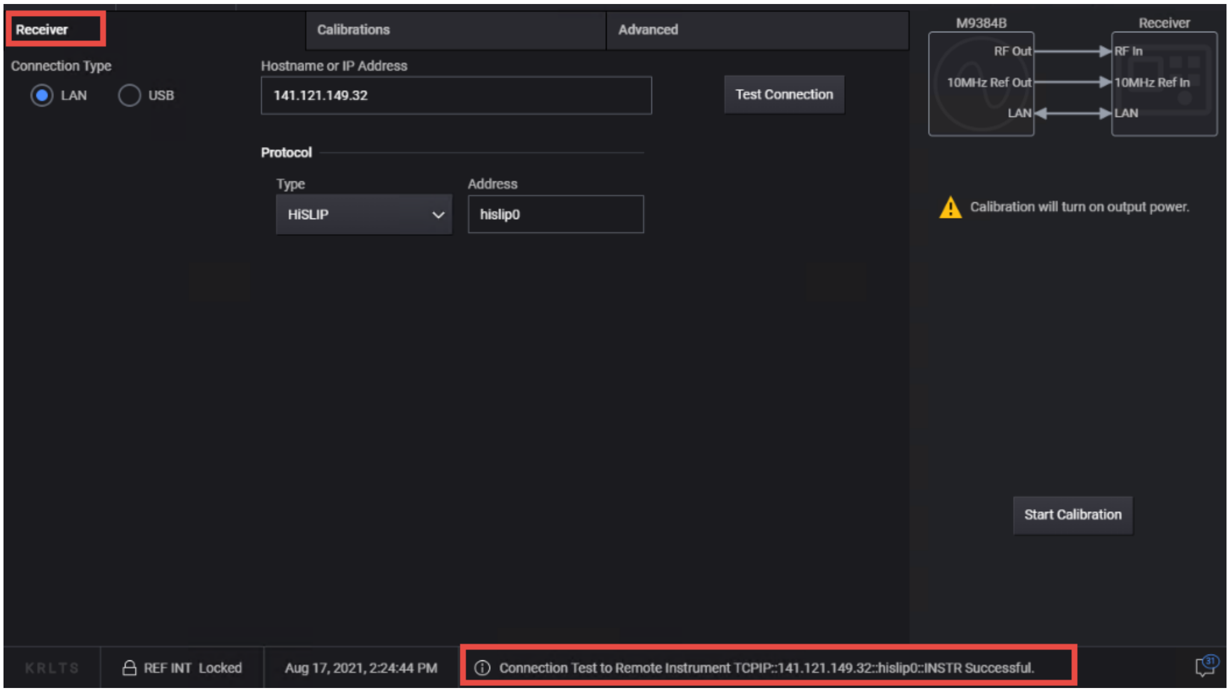
On the VXG:

1. In the Signal block and select **Configure** to open the Nonlinear Correction Setup.

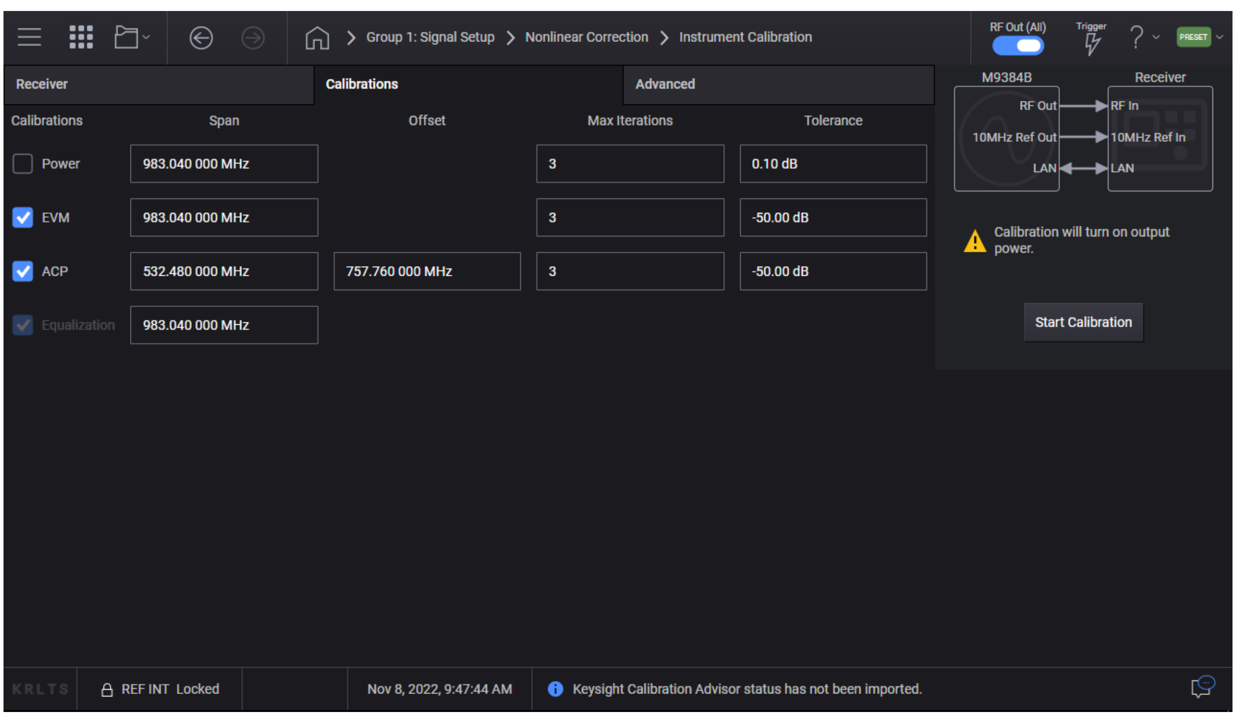


2. In the Instrument Nonlinear Correction area, select **Measure Correction** to open the Instrument Nonlinear Calibration screen.
3. Under the Receiver tab (opened by default), enter your connection information and test the connection. For this example, select **LAN** as the Connection Type > Enter the IP address for you signal analyzer (for this example, 141.121.149.32) as the Hostname > **Test Connection**.

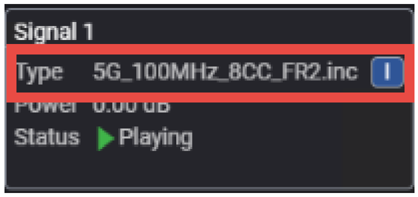
The Connection status will be displayed in the Notifications area at the bottom of the main window.



4. Select the **Calibrations** tab and select **EVM** and **ACP** for the Calibrations, then **Start Calibration**.



The calibration will take a few minutes to complete. Once done, the INC file will be created and it will automatically be used in place of the .wfm file originally loaded. An "I" will be displayed in the Signal block indicating this status.



On the UXA:

1. Select the **Sweep** > **Restart**.
2. Select **Optimize EVM**.

   Note the changes to EVM RMS and EVM Peak values..

   For this example CC0 EVM RMS went from 6.21% to 3.13%, EVM Peak went from 27.33% to 11.68% and for CC7 EVM RMS went from 4.51% to 2.87% and EVM Peak went from 15.75% to 10.55%.

To Measure ACP:

a. Select **Mode/Meas** > **5GNR** Mode > **ACP** > **OK**.

b. Select **Amplitude** > **Signal Path** tab > and set µW Path Control to **LNP (Low Noise Path) Enable.**

c. Select **Sweep** > **Restart** to take a new sweep.

Note the changes to the Lower and Upper ACP values. For this example Lower, at 100 MHz offset is -32.27 (before -26.7 dBc) and Upper -31.15 (before -27.06 dBc).

2 5G New Radio (NR) Measurements using X-Apps

This section includes the following topics:

5G Waveform, EVM, and ACP Analysis Using X-Applications

The VXG enables 5G testing with a low error vector magnitude (EVM) at high frequencies. The VXG has extremely good EVM at high power levels. However, not all signal analyzers can capture this low value. We will use the X-Series Signal Analyzer UXA signal analyzer with the 5G NR X-Series application to observe EVM and adjacent channel power (ACP).

Setting Up Triggers on the Signal Analyzer using 5G NR Mode

NOTE Refer to "Configuring the Equipment Setup" on page 9 for connecting the instruments and accessing the VXG SFP.

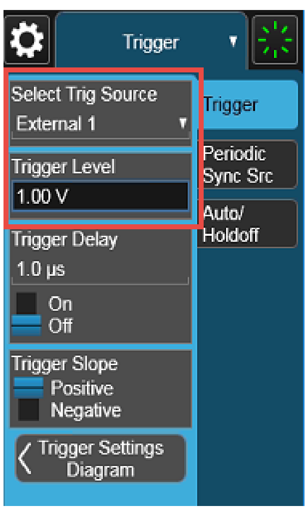
Setting Up Triggers on the X-Series Signal Analyzer

Using the graphical user interface

1. From the X-Series Signal Analyzer, select **Mode/Meas** > **5G NR** mode.

NOTE If accessing the instrument via a Remote Desktop connection, select the Screen tab (at the top of the display) to open the Mode/Measurement/View Selector window.

2. Select **Mode Preset** to set 5G NR mode to a known state.
3. Select **Mode/Meas** > **5G NR** Mode > **Modulation Analysis** Measurement.
4. From the Menu Panel (on the top right of the display), select **Trigger** and set Select Trigger Source to **External 1** and Trigger Level to **1 V**.



Using the equivalent SCPI commands

On the X-Series Signal Analyzer:

`INSTrument:CONFigure:NR`

`SYSTem:PRESet`

Change the current window to 5G NR Modulation Analysis Measurement Mode

`INSTrument:CONFigure:NR5G:EVM`

`TRIGger:EVM:SOURce EXTernal1`

`TRIGger:EXTernal1:LEVel 1V`

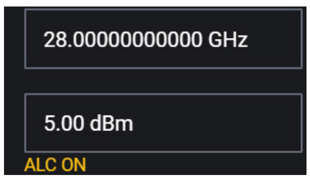
Setting Up a 1 CC 28 GHz EVM Measurement

NOTE Ensure the equipment and triggers are properly configured. Refer to "Configuring the Equipment Setup" on page 9 and "Setting Up Triggers on the Signal Analyzer using 5G NR Mode" on page 86.

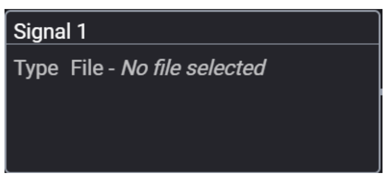
Using the graphical user interface

On the VXG:

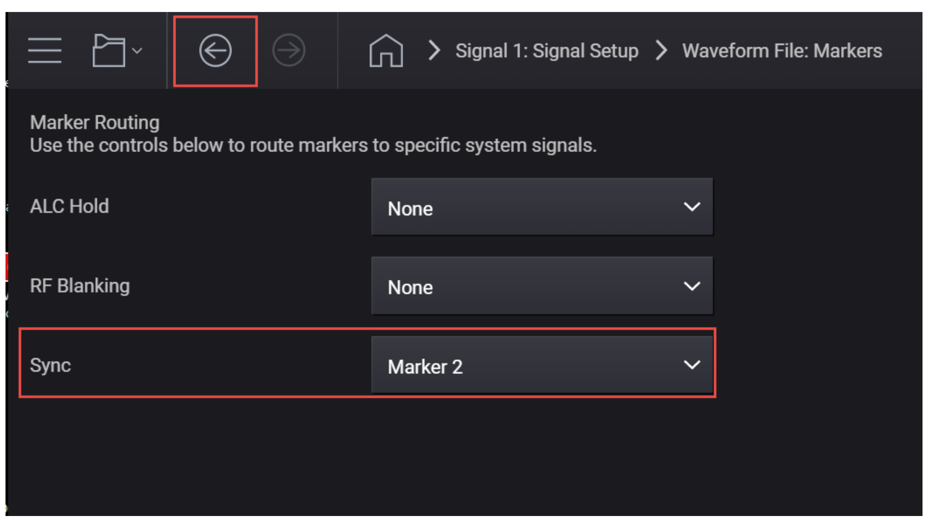
1. Select **Preset** > **Preset** to set the instrument to a known state.
2. In the Output 1 area, set Frequency to **28 GHz** and Power to **5 dBm**.



3. Select **Signal** block to open.



4. Select the **Markers** block and set Sync to **Marker 2** and then select **Back (<-)** to close the Markers Setup.



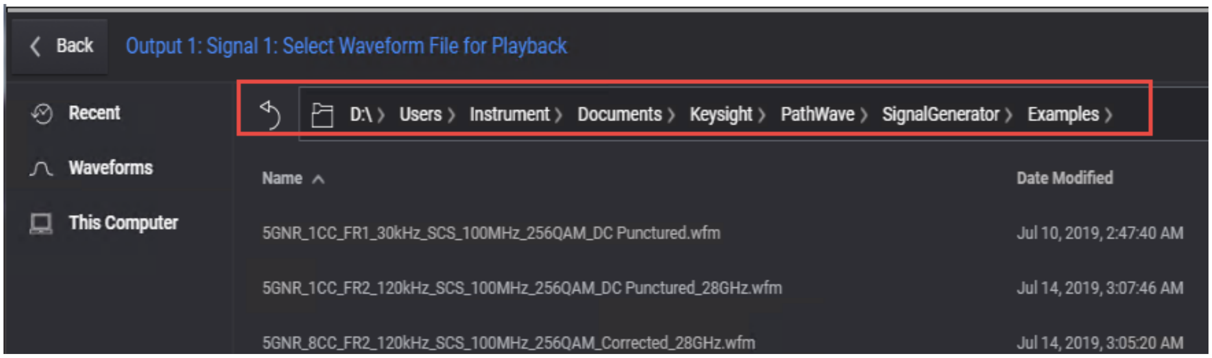
5. In the Waveform Playback Setup area, use File **Select** to navigate to:

```
D:\Users\Instrument\Documents\Keysight\PathWave
```

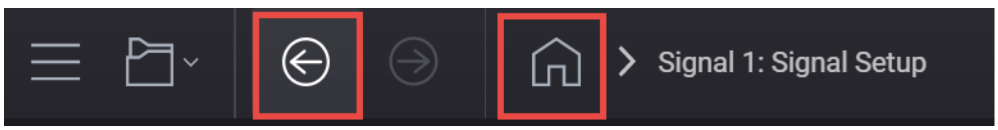
`\SignalGenerator\Examples`

and choose
`5GNR_1CC_FR2_120kHz_SCS_100MHz_256QAM_DCPunctured_28GHz.wfm`

then **Select**.



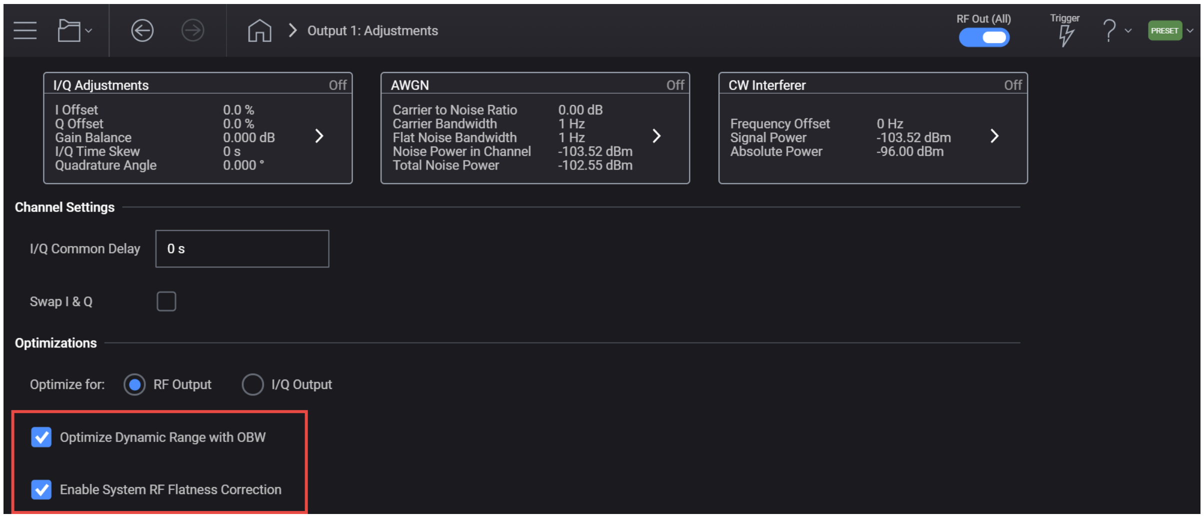
6. Select **Enable** to turn on the Vector Modulation Signal.
7. Close the Vector Modulation Signal Setup by either selecting the Back button or the Home icon at the top of the display.



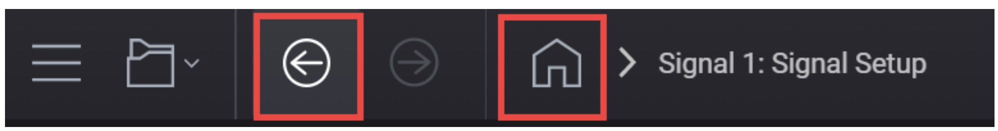
8. Select the **Adjustments** block and select **Optimize Dynamic Range with OBW** and **Enable System RF Flatness Correction.**

   Optimize Dynamic Range with OBW This setting filters the system RF flatness correction coefficients over the instantaneous bandwidth indicated in the waveform header (or in the “Occupied Bandwidth” settings area under the Signal block > Occupied Bandwidth setting). This has the potential to improve EVM performance by not having to correct for flatness errors outside the requested bandwidth. For example, if RF flatness correction was done at 2 GHz, but you are only interested in an 800 MHz section, then applying the correction flatness to that portion only can improve signal to noise ratio, and therefore EVM when there is a lot of hardware roll off.

   Enable System RF Flatness Correction - Disabling this function disables the factory calibrated RF channel flatness equalizer. Depending on the hardware channel response, this may hurt or improve the EVM. This is due to the dynamic range implications as it relates to signal to noise ratio. The greater the RF hardware variations in flatness, the greater the amount of correction is required, the greater the correction effectively reduces the number of resolution DAC bits that can be used, which degrades the signal to noise ratio and therefore potentially EVM. The trade-off is to balance between flatness and signal to noise ratio.

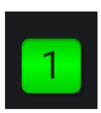


9. Close the Adjustments Setup by either selecting the Back button or the Home icon at the top of the display.

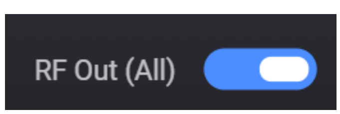


10. Set RF Out to **On** by selecting the numbered channel indicator switch.

    This enables the RF Out for the indicated channels, in this case Channel 1 if using a multi-channel VXG.



11. **For two channel instruments only:** In the top right corner of the display, set RF Out (All) to **On** by selecting the switch.



NOTE

In order to turn on RF for any channel, both the RF Out for the specific channel (for example, Channel 1 or Channel 2), and RF Out All must be turned on.

On the X-Series Signal Analyzer:

NOTE

All example waveforms and setup files are located on the VXG at:

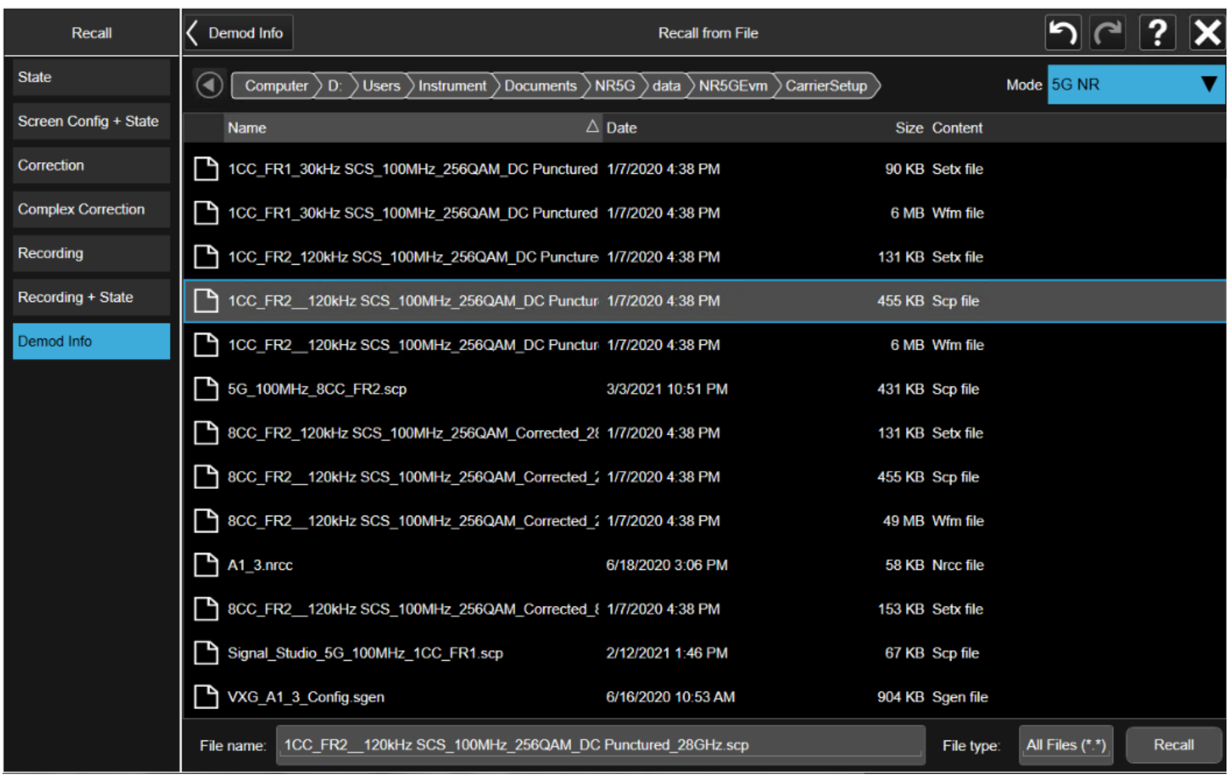
`D:\Users\Instrument\Documents\Keysight\PathWave \SignalGenerator\Examples`

You will need to copy over the setup files to the X-Series Signal Analyzer or the PC running the VSA application.

1. Select **Recall** (If accessing the X-Series Signal Analyzer remotely, select the Folder icon at the bottom of the display) **Demod Info** > Set Data Type to **CC Setup** > **Recall From** >

   `1CC_FR2_120kHz_SCS_100MHz_256QAM_DCpunctured_28GHz_34.scp`

   Recall



2. Select **Meas Setup** > **Meas Time** and set:
   - Search Length to **10 ms**
   - Result Length to **2 Sub Frame**
   - Frame Trigger to **On**

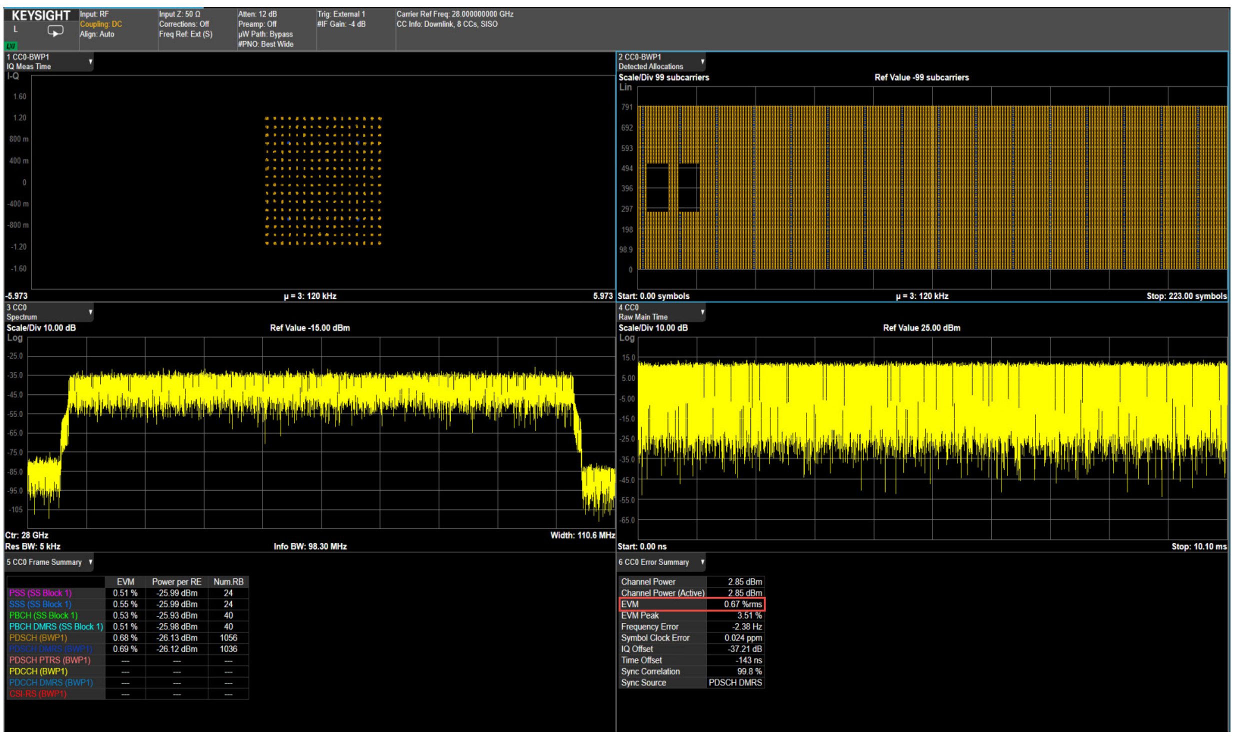
3. Select **Advanced** tab > **Advanced Demod Setup** and set **DC Punctured to On**, (highlighted in blue).

4. Ensure that RF for Phase Compensation Auto is *not* selected and the value is **0 Hz**. **Close** the Advanced Settings table.

5. Select the **Settings** tab > **Optimize EVM**.

   The Optimize EVM function automatically sets the combination of preamplification, mechanical and electronic attenuation, and IF gain based on the measured signal peak level.

   EVM should be less than 1%.



Using the equivalent SCPI commands

On the VXG:

```
SYSTem:PRESet
```

```
RF1:FREQuency:CW 28GHZ
```

```
RF1:POWer:AMPLitude 5dBm
```

```
SIGNal1:MODE WAVeform
```

```
SIGNal1:WAVeform:TRIGger:SYNC:MARKer M2
```

Navigate to the desired waveform file.

```
SIGNal1:WAVeform “D:\Users\Instrument\Documents\demo
waveforms
5GNR_1CC_FR2_120kHz_SCS_100MHz_256QAM_DCPunctured_28GHz.
wfm”
```

```
SIGNal1 ON
```

```
IQO:CORR:OPT:DYN:RANG:OBW ON
```

```
RF1:OUTPut ON
```

For multi-channel instruments, set RF Out (all) to On.

```
RFALl:OUTPut ON
```

On the X-Series Signal Analyzer:

Navigate to the desired waveform file.

NOTE

All example waveforms and setup files are located on the VXG at:

```
D:\Users\Instrument\Documents\Keysight\PathWave
\SignalGenerator\Examples
```

You will need to copy over the setup files to the X-Series Signal Analyzer or the PC running the VSA application.

```
MMEMory:LOAD:EVM:SETup CC0,
“D:\Users\Instrument\Documents\NR5G\data\NR5GEvm\CarrierSetu
p\5GNR_1CC_FR2_120kHz
SCS_100MHz_256QAM_DCpunctured_28GHz.scp”
```

```
EVM:CCARrier0:TIME:LENGth:SEARch 10ms
```

```
EVM:CCARrier0:TIME:LENGth:RESult 2
```

```
EVM:CCARrier0:FRAMe:TRIGger ON
```

```
EVM:CCARrier0:DC:PUNCture ON
```

```
EVM:CCARrier0:PHASe:COMPensation:AUTO OFF
```

```
EVM:CCARrier0:PHASe:COMPensation:FREQuency 0 Hz
```

```
EVM:OPTimize
```

Setting up an 8 CC 28 GHz EVM Measurement

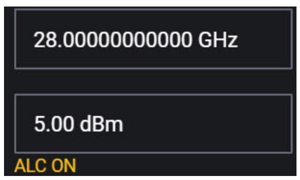
This procedure shows you how to USE the X-Series Signal Analyzer signal analysis 5G NR X-Series application to observe EVM on an eight-carrier waveform.

NOTE Ensure the equipment and triggers are properly configured. Refer to “Configuring the Equipment Setup” on page 9 and “Setting Up Triggers on the Signal Analyzer using 5G NR Mode” on page 86.

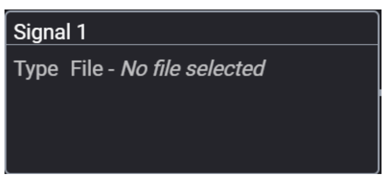
Using the graphical user interface

On the VXG:

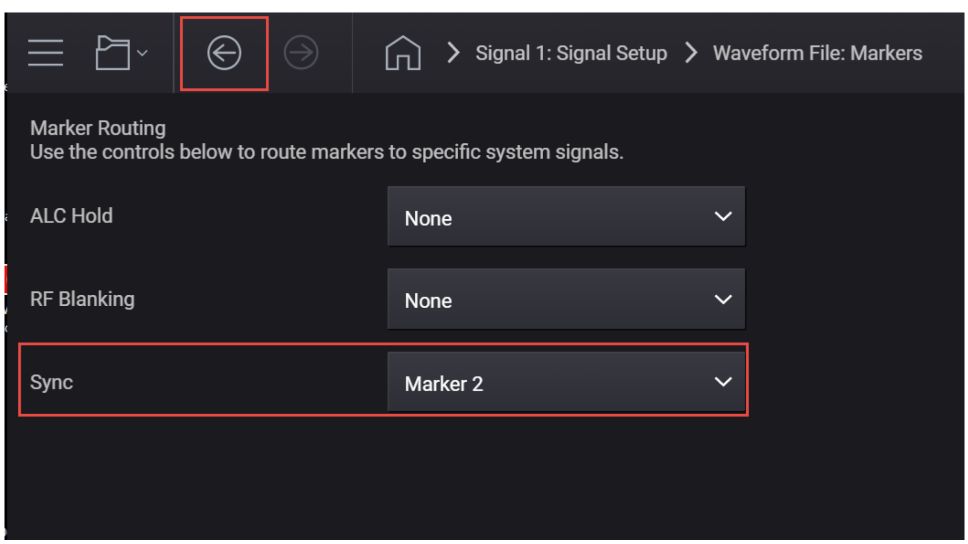
1. Select **Preset** > **Preset** to set the VXG to a known state.
2. Set Frequency to **28 GHz** and Amplitude to **5 dBm**.



3. Select the **Signal** block to open.



4. Select the **Markers** block and set Sync to **Marker 2** and then select **Back** to close the Markers Setup.



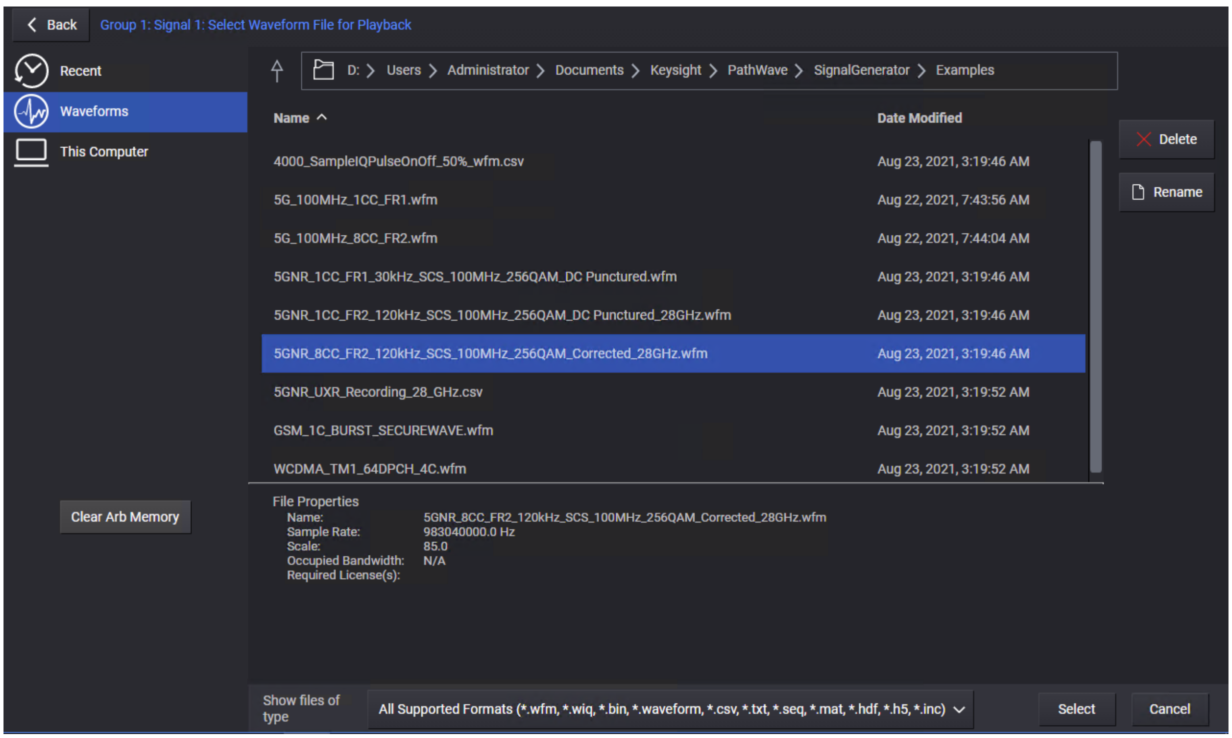
Use File **Select** to navigate to:

D:\Users\Instrument\Documents\Keysight\PathWave\SignalGenerator\Examples

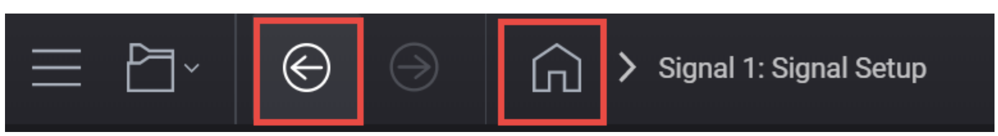
and choose

`5GNR_8CC_FR2_120kHz_SCS_100MHz_256QAM_Corrected_28GHz.wfm`

then **Select**.



5. Select **Enable** Vector Modulation Signal.
6. Close the Signal Setup by either selecting the Back button or the Home icon at the top of the display.

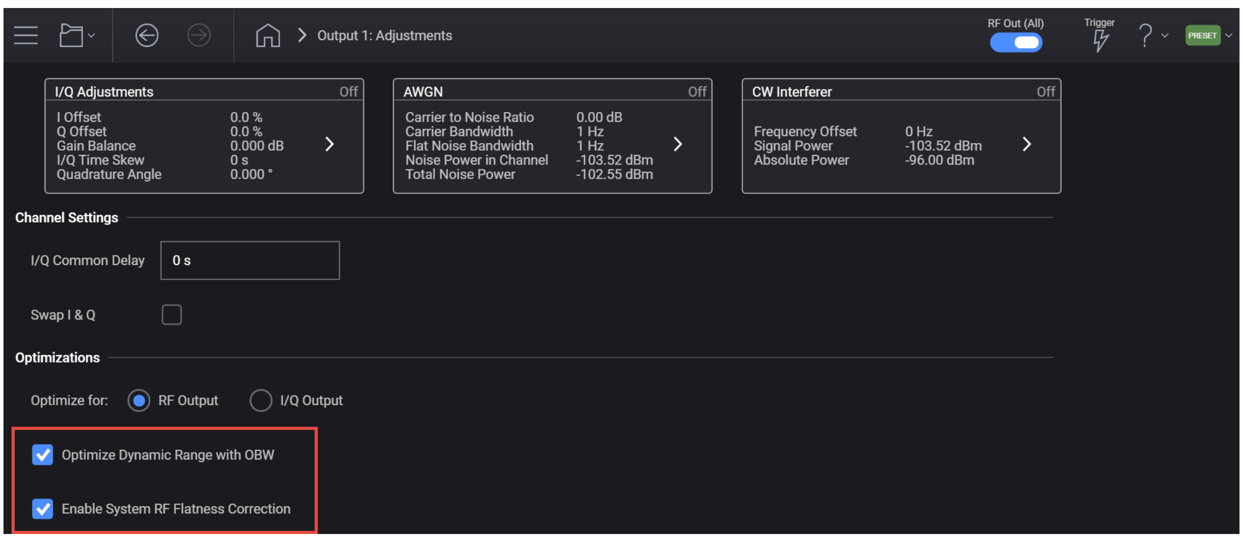


7. Select the **Adjustments** block and select **Optimize Dynamic Range with OBW** and **Enable System RF Flatness Correction.**

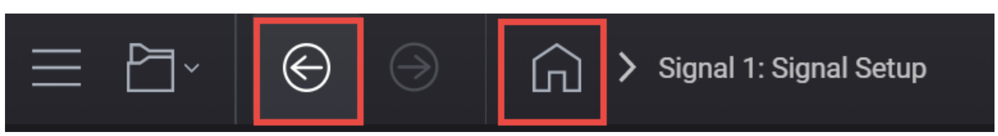
   Optimize Dynamic Range with OBW This setting filters the system RF flatness correction coefficients over the instantaneous bandwidth indicated in the waveform header (or in the “Occupied Bandwidth” settings area under the Signal block > Occupied Bandwidth setting).

This has the potential to improve EVM performance by not having to correct for flatness errors outside the requested bandwidth. For example, if RF flatness correction was done at 2 GHz, but you are only interested in an 800 MHz section, then applying the correction flatness to that portion only can improve signal to noise ratio, and therefore EVM when there is a lot of hardware roll off.

Enable System RF Flatness Correction - Disabling this function disables the factory calibrated RF channel flatness equalizer. Depending on the hardware channel response, this may hurt or improve the EVM. This is due to the dynamic range implications as it relates to signal to noise ratio. The greater the RF hardware variations in flatness, the greater the amount of correction is required, the greater the correction effectively reduces the number of resolution DAC bits that can be used, which degrades the signal to noise ratio and therefore potentially EVM. The trade-off is to balance between flatness and signal to noise ratio.

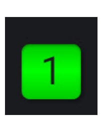


8. Close the Adjustments Setup by either selecting the Back button or the Home icon at the top of the display.

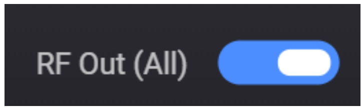


9. Set RF Out to **On** by selecting the numbered channel indicator switch.

   This enables the RF Out for the indicated channels, in this case Channel 1 if using a multi-channel VXG.



10. **For multi-channel instruments only:** In the top right corner of the display, set RF Out (All) to **On** by selecting the switch.



NOTE

In order to turn on RF for any channel, both the RF Out for the specific channel (for example, Channel 1 or Channel 2), and RF Out All must be turned on.

On the X-Series Signal Analyzer:

NOTE

All example waveforms and setup files are located on the VXG at:

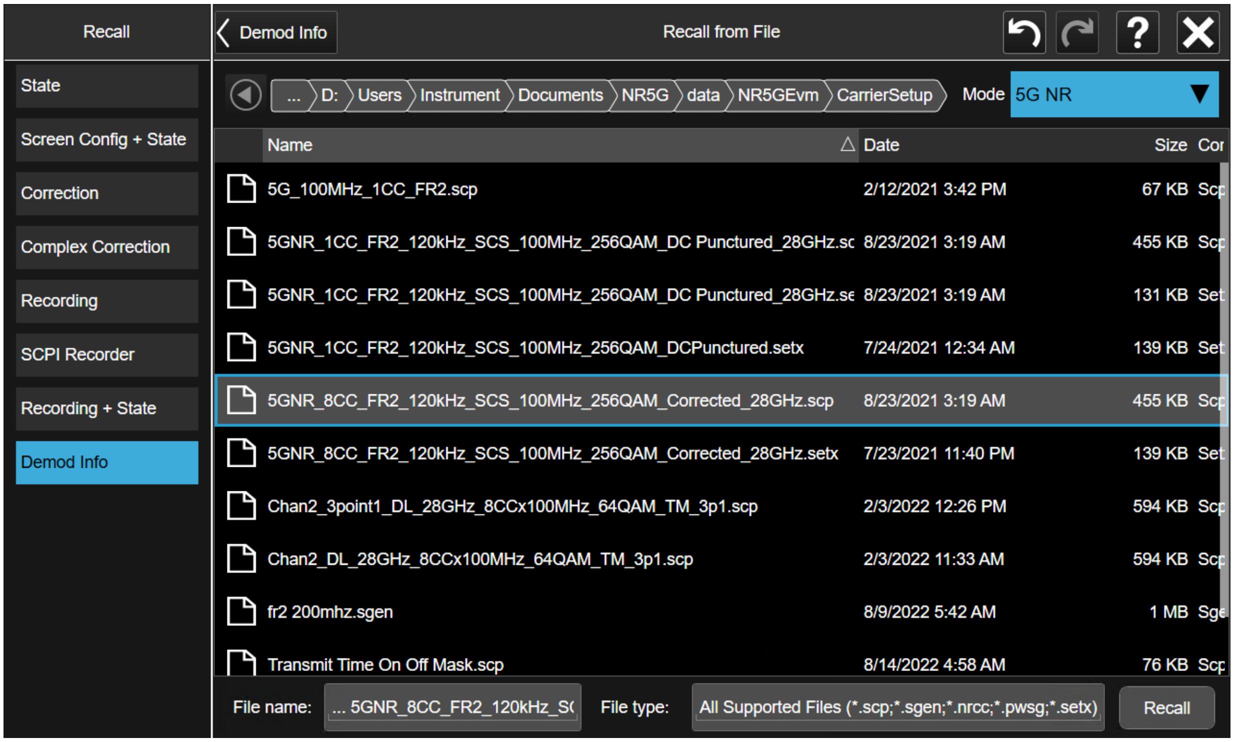
`D:\Users\Instrument\Documents\Keysight\PathWave \SignalGenerator\Examples`

You will need to copy over the setup files to the X-Series Signal Analyzer or the PC running the VSA application.

---

1. Select **Recall** (If accessing the X-Series Signal Analyzer remotely, select the Folder icon at the bottom of the display) > **Demod Info** > set Data Type to **CC Setup** > **Recall From** > `5GNR_8CC_FR2_120kHz_SCS_100MHz_256QAM_Corrected_28GHz_34.scp` **Recall**.

   You must be in the correct analysis mode to recall the .scp file.



2. Select **Meas Setup** > **Meas Time** tab and set:

   – Search Length to **10 ms**

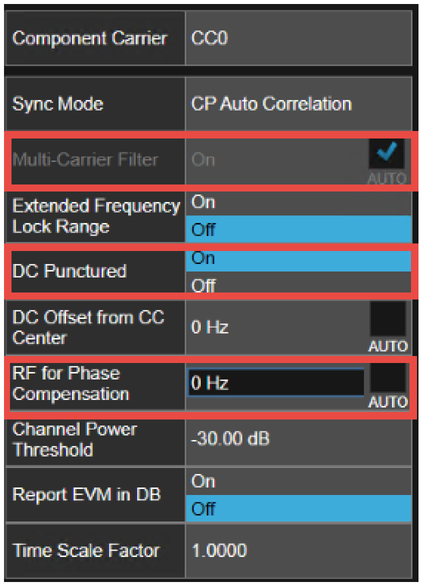
   – Result Length to **2 Sub Frame**

   – Frame Trigger to **On**

3. Select **Meas Setup** > **Advanced** tab > **Advanced Demod Setup** and select both **Multi-Carrier Filter** and **DC Punctured** to turn on.

   The multi-carrier filter is used to filter out the unwanted carriers and minimize leakage into the component carrier of interest.

4. Ensure that RF for Phase Compensation is *not* selected and the value is **0 Hz**, then **Close** the Advanced Settings table.



5. Select the **Sweep** > **Single Sweep**.

6. Select **Meas Setup** > **Settings** tab > **Optimize EVM**.

   It will take a couple of minutes for the UXA to measure all 8 carriers.

Using the equivalent SCPI commands

On the VXG:

```
SYSTem:PRESet
```

```
RF1:FREQuency:CW 28GHZ
```

```
RF1:POWer:AMPLitude 5dBm
```

```
SIGNal1:MODE WAVeform
```

```
SIGNal1:WAVeform:TRIGger:SYNC:MARKer M2
```

Navigate to the desired waveform file.

```
SIGNal1:WAVeform “D:\Users\Instrument\Documents\demo
waveforms\5GNR_8CC_FR2_120kHz_SCS_100MHz_Corrected_28GHz.wfm
”
```

```
SIGNal1 ON
```

```
IQO:CORR:OPT:DYN:RANG:OBW ON
```

```
IQO:CORR:CHANNel:FLATness ON
```

```
RF1:OUTPut ON
```

For multi-channel instruments, set RF Out (all) to On.

```
RFALl:OUTPut ON
```

On the X-Series Signal Analyzer:

NOTE

All example waveforms and setup files are located on the VXG at:

`D:\Users\Instrument\Documents\Keysight\PathWave\SignalGenerator\Examples`

You will need to copy over the setup files to the X-Series Signal Analyzer or the PC running the VSA application.

Navigate to the desired waveform file.

```
MMEMory:LOAD:EVM:SETup CC0,
“D:\Users\Instrument\Documents\NR5G\data\NR5GEvm\CarrierSetu
p\5GNR_8CC_FR2_120kHz_SCS_100MHz_256QAM_Corrected_28GHz.scp”
```

```
EVM:CCARrier0:TIME:LENGth:SEARch 10ms
```

```
EVM:CCARrier0:TIME:LENGth:RESult 2
```

```
EVM:CCARrier0:FRAMe:TRIGger ON
```

```
EVM:CCARrier0:MCFilter ON
```

```
EVM:CCARrier0:DC:PUNCture ON
```

```
EVM:CCARrier0:PHASe:COMPensation:AUTO OFF
```

```
EVM:CCARrier0:PHASe:COMPensation:FREQuency 0 Hz
```

To Optimize EVM for Multi-Carrier Waveforms

```
POWer:ATTenuation 0dB
[POWer:ATTenuation 2dB], …
EVM:IF:GAIN:LEVel 0dB
```

To View the Results of Two Carriers

Set the top right window (Window 2) to display IQ Meas Time

```
DISPlay:EVM:WINDow2:DATA MTIM
```

Set the top right window to display Component Carrier 1

```
DISPlay:EVM:WINDow2:CCARrier CC1
```

Set the middle right window to display the FFT of the Raw Main Time waveform

```
DISPlay:EVM:WINDow4:DATA SPEC
DISPlay:EVM:WINDow4:CCARrier CC1
```

Set the bottom right window to display a table of general measurement numeric results

```
DISPlay:EVM:WINDow6:DATA DRES
DISPlay:EVM:WINDow6:CCARrier CC1
```

Set the bottom left window to display the error summary for CC0

```
DISPlay:EVM:WINDow5:DATA DRES
```

Setting Up a 1 CC 3.5 GHz ACP Measurement

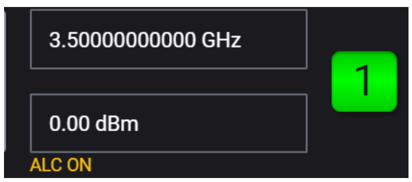
NOTE

Ensure the equipment and triggers are properly configured. Refer to "Configuring the Equipment Setup" on page 9 and "Setting Up Triggers on the Signal Analyzer using 5G NR Mode" on page 86.

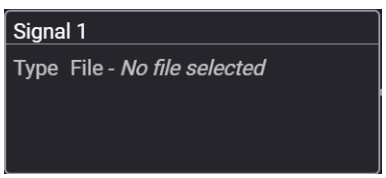
Using the graphical user interface

On the VXG:

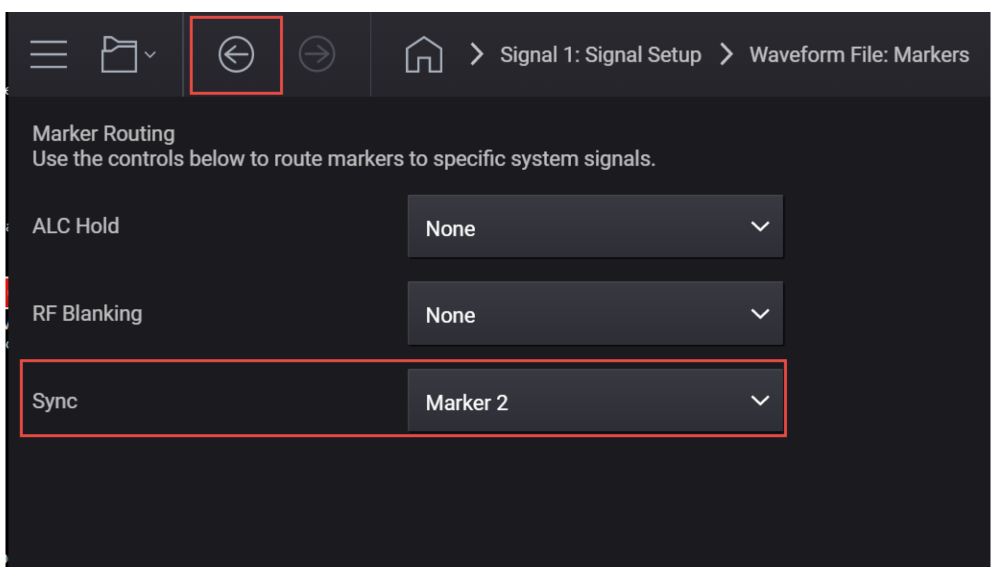
1. Select **Preset** > **Preset** to set the VXG to a known state.
2. Set Frequency to **3.5 GHz** and Amplitude to **0 dBm**.



3. Select the **Signal** block to open the Vector Modulation Signal Setup panel.



4. Select the **Markers** block and set Sync to **Marker 2** and then select **Back** to close the Marker Setup.



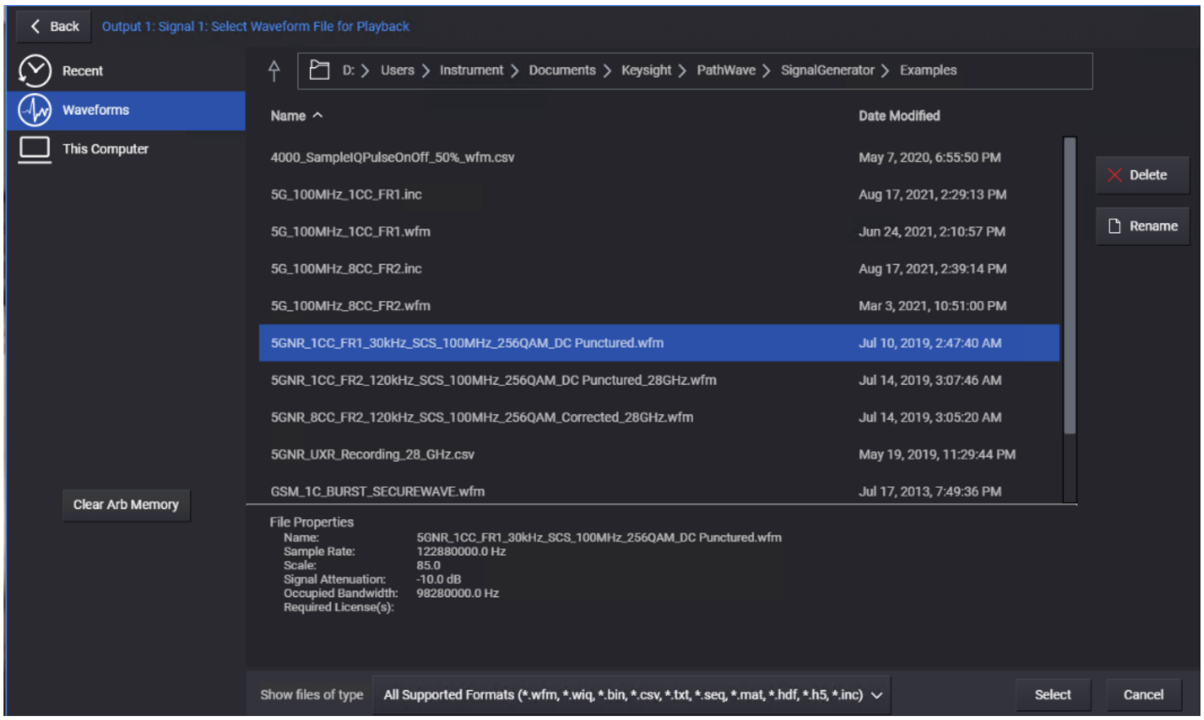
5. Use File **Select** to navigate to:

   `D:\Users\Instrument\Documents\Keysight\PathWave \SignalGenerator\Examples`

   and choose

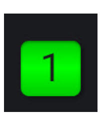
   `5GNR_1CC_FR1_30kHz_SCS_100MHz_256QAM_DCPunctured.wfm`

   then **Select**.

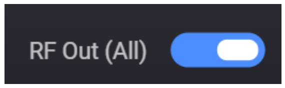


6. In the Vector Modulation Signal Setup, ensure that **Enable** Vector Modulation Signal is selected, then close the Signal block.
7. Set RF Out to **On** by selecting the numbered channel indicator switch.

   This enables the RF Out for the indicated channels, in this case Channel 1 if using a multi-channel VXG.



8. **For multi-channel instruments only:** In the top right corner of the display, set RF Out (All) to **On** by selecting the switch.



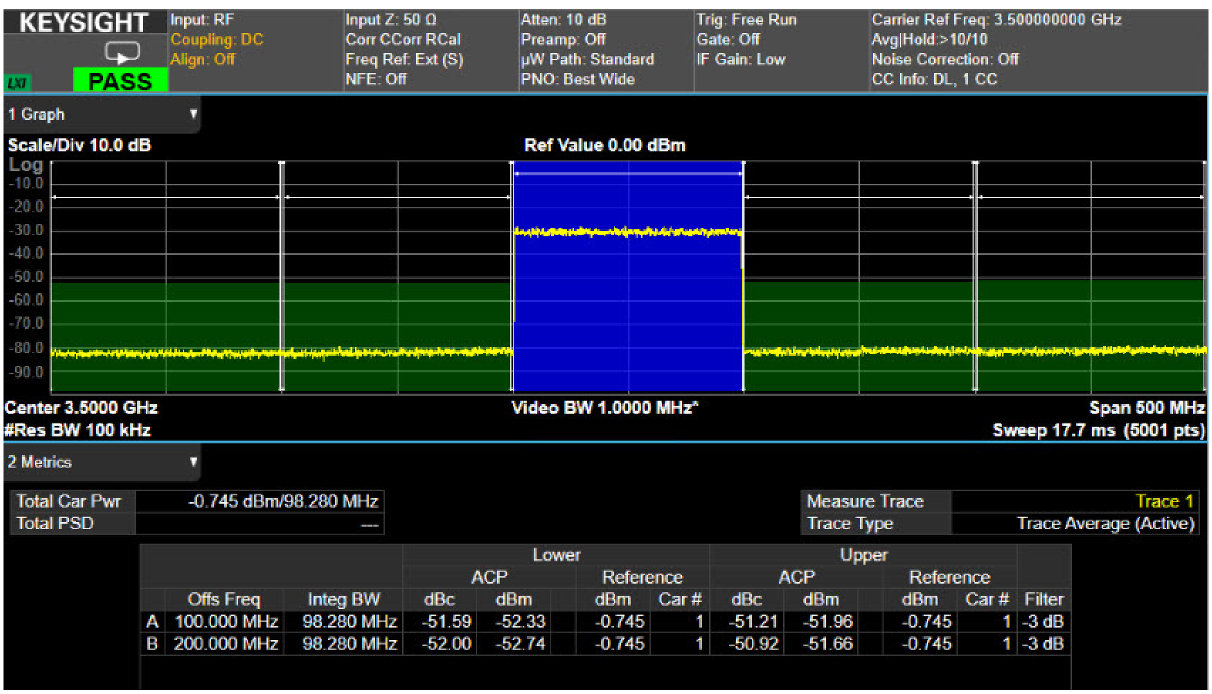
NOTE In order to turn on RF for any channel, both the RF Out for the specific channel (for example, Channel 1 or Channel 2), and RF Out All must be turned on.

On the X-Series Signal Analyzer:

1. Select **Mode Preset** to set 5G NR mode to a known state.
2. Select **Mode/Meas** > **5G NR** Mode > **ACP** Measurement.

NOTE If accessing the instrument via a Remote Desktop connection, select the Screen tab (at the top of the display) to open the Mode/Measurement/View Selector window.

3. Select **Frequency** and set Carrier Reference Frequency to **3.5 GHz**.



Using the equivalent SCPI commands

On the VXG:

```
SYSTem:PRESet

RF1:FREQuency:CW 3.5GHZ

RF1:POWer:AMPLitude 0dBm

SIGNal1:MODE WAVeform

SIGNal1:WAVeform:TRIGger:SYNC:MARKer M2

SIGNal1:WAVeform "D:\Users\Instrument\Documents\MCS demo
waveforms\5GNR_1CC_FR1_30kHz_SCS_100MHz_256QAM_DCPunctured.w
fm"

SIGNal1 ON

DM:OPTimization:CHANnel ACP

RF1:OUTPut ON
```

For multi-channel instruments, set RF Out (all) to On.

```
RFALl:OUTPut ON
```

On the X-Series Signal Analyzer:

```
SYSTem:PRESet

INSTrument:CONFigure: NR5G:ACP

CCARrier:REFerence 3.5GHZ

ACPower:CORRection:NOISe ON
```

Using PathWave N7631APPC to Create a Waveform File then Automatically Configure the Analyzer to View the Results

PathWave software tools can be used to create, download, and playback waveforms through the VXG.

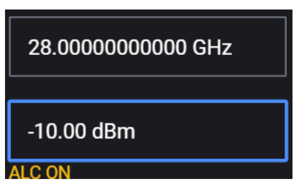
This example shows you how to create and analyze a 5G NR signal using the embedded PathWave software and then automatically configure the analyzer to make the measurement.

NOTE The VXG must have the N7631APPC Signal Generation for 5G NR license installed.

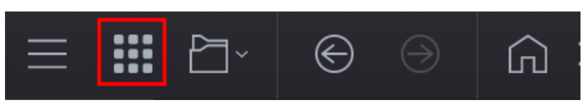
Using the graphical user interface

On the VXG:

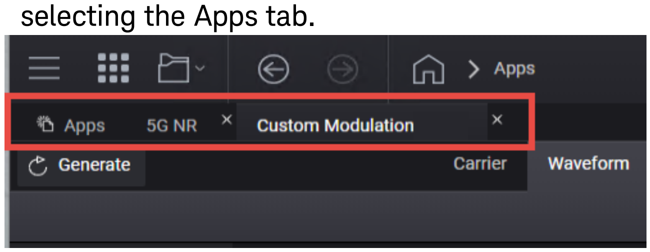
1. Select **Preset** > **Preset** to set the VXG to a known state.
2. In the Output area, set Frequency to **28 GHz** and Power to **-10 dBm**.



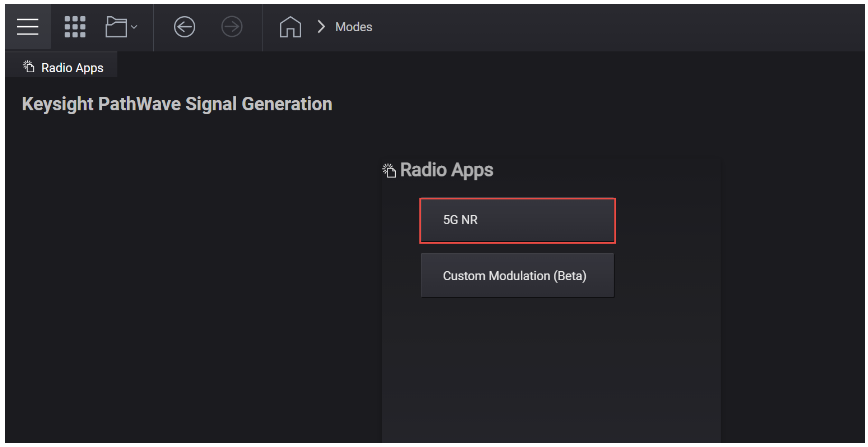
3. Select the **Radio Apps** block to open the mode selection panel.



NOTE If you have previously opened any of your available applications, the dialog box will not be displayed. Instead, you will see tabs of the applications that have already been used. You can view all of your available applications by selecting the Apps tab.

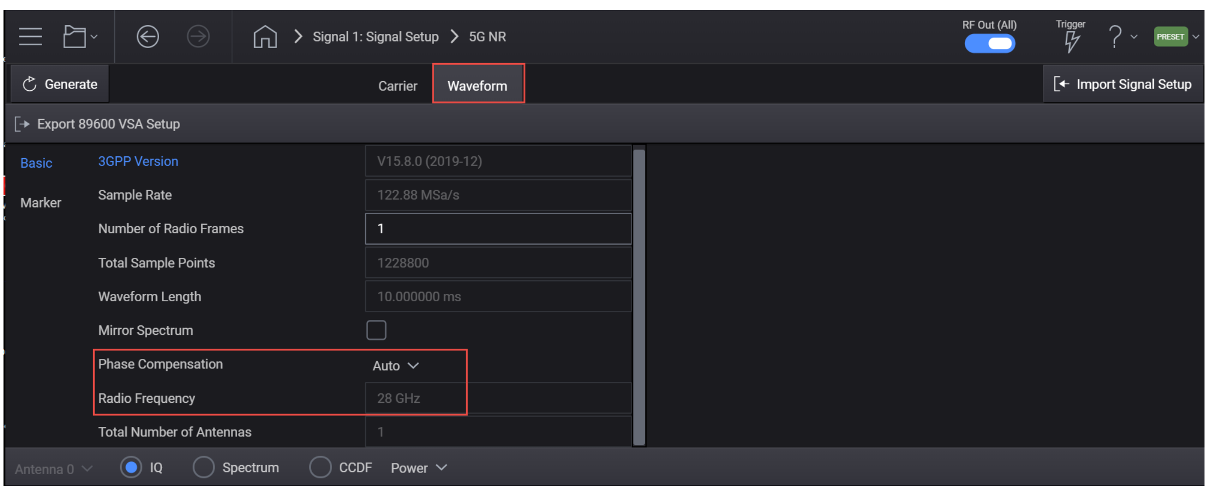


4. Select **5G NR** to enter the 5G NR signal mode.



5. In the 5G NR setup, select the **Waveform** tab and observe the Phase Compensation and Radio Frequency settings.

   Phase Compensation is applied by default at baseband for RF up-conversion. This means it depends on the carrier frequency, and the waveform should only be played at the carrier frequency it was generated for, unlike conventional Signal Studio waveforms, which are independent from carrier frequency. Phase Compensation is set to Auto by default. The frequency is coupled with the VXG frequency setting. You can select Manual to specify a different frequency, or turn it off.



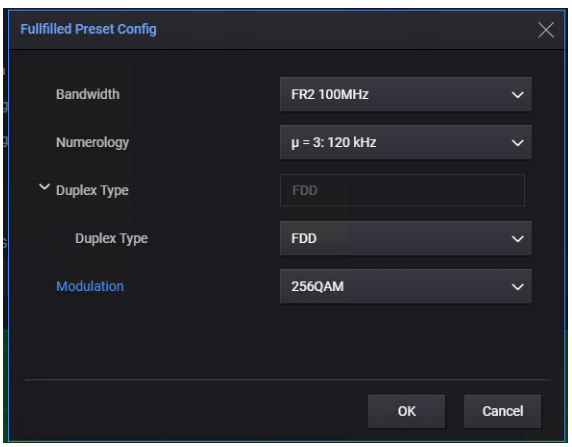
TIP Some applications, like power amplifier measurements use the same waveform at different frequencies and can be time consuming to generate a separate waveform for each frequency. In this case, you would turn Phase

Compensation Off, so the waveform becomes independent from the carrier frequency. You need to do the same on the analysis side, or the demodulation will fail.

6. Select the **Carrier** tab.
7. Select **Full-Filled Config** and set Bandwidth to **FR2 100 MHz**, Numerology to **μ= 3:120 kHz**, Duplex Type to **FDD**. Modulation to **256 QAM**.

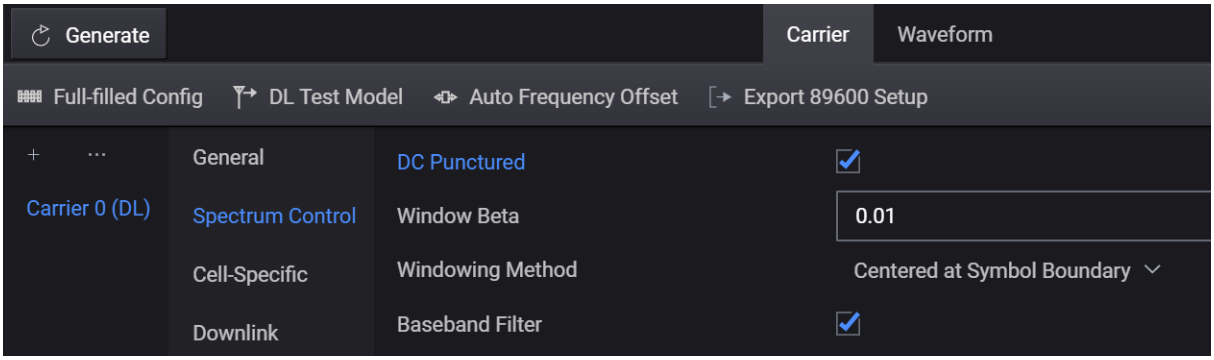
NOTE If you have a signal analyzer with demodulation bandwidth that is wide enough to cover the other FR2 bandwidths, 200 MHz or 400 MHz, you can choose to use a wider bandwidth.

Full Filled Configurations is a great place to start creating your waveform. You can select FR, bandwidth, and modulation format with a fully allocated PDSCH data channel. This would represent a spectrally correct signal that is typically used in power amplifier measurements. You can modify the RB allocations and Slot allocations if fully allocated data channels are not desired.



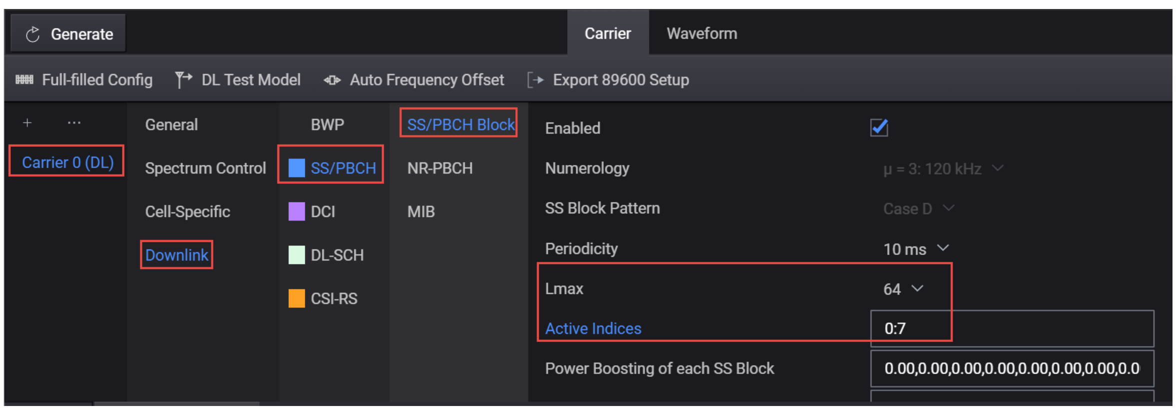
8. Select **OK** to exit the Full Filled Config setup.
9. From the Carrier panel (in the left pane), select **Spectrum Control** > **DC Punctured On**.

When DC Punctured is enabled, the DC subcarrier is excluded from the measurement results. This is often helpful to avoid obscuring measurement results with artifacts of LO feedthrough.



10.From the Carrier panel (in the left pane), select **Downlink** > **SS PBCH** > **SS PBCH Block** and set Lmax to **64** and Active Indices to = **0:7**.

Instead of transmitting all 64 beams, we enable only 8 of them by setting Active Indices to 0:7.

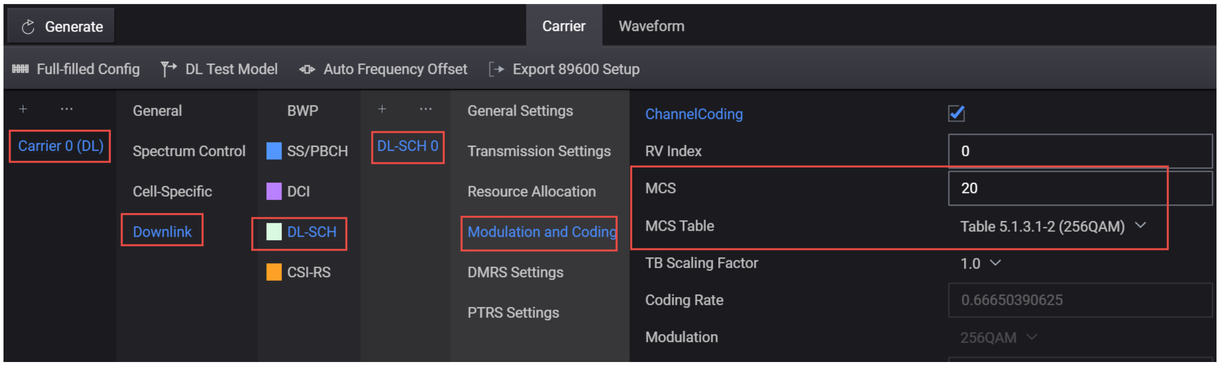


NOTE

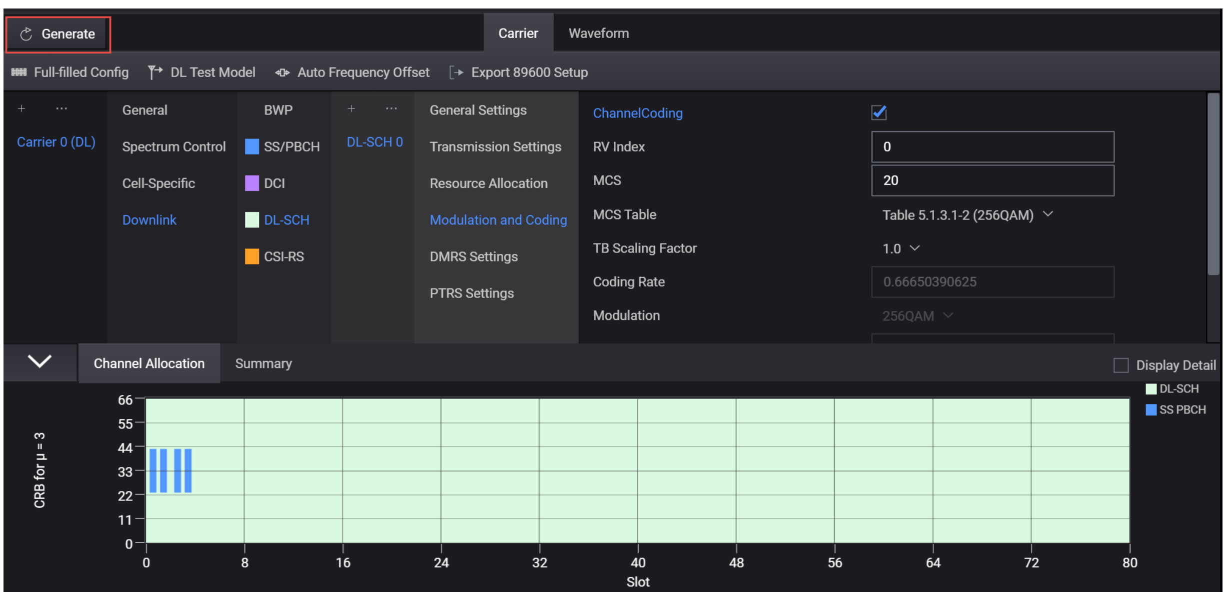
Lmax sets the maximum number of possible SS/PBCH blocks in a transmission opportunity. This value is fixed for a given carrier bandwidth. Typically, higher frequency and bandwidth carriers use a larger set of SS/PBCH opportunities to support a larger set of antenna beams.Lmax is either 4 or 8 for FR1 and 64 for FR2.

11. From the **Carrier** panel (in the left pane), select **Downlink** > **DL-SCH** > **DL-SCH0** > **Modulation and Coding** and set MCS Table to **Table 5.1.3.1-2 (256QAM)** and MCS to **20**.

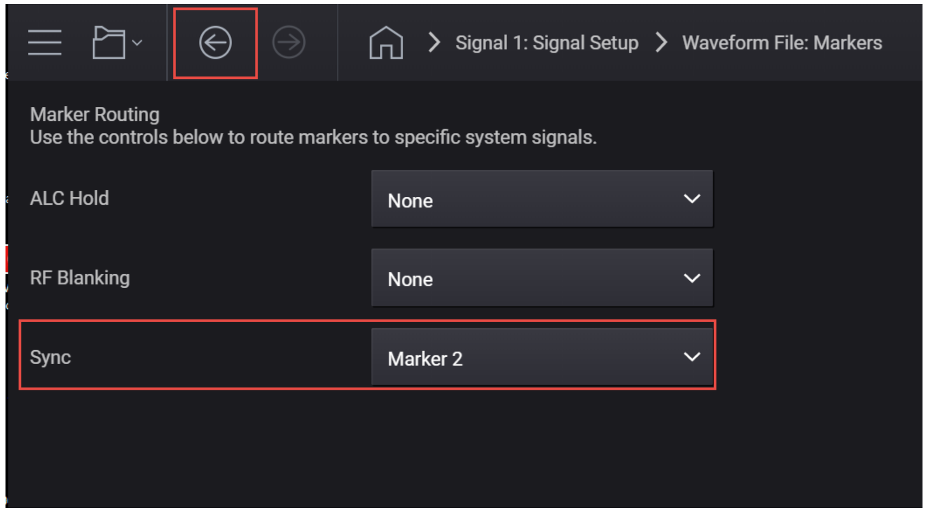
The Modulation Coding Scheme (MCS) specifies the modulation, coding and overall spectral efficiency of the PDSCH as specified in 3GPP Table 5.1.3.1.



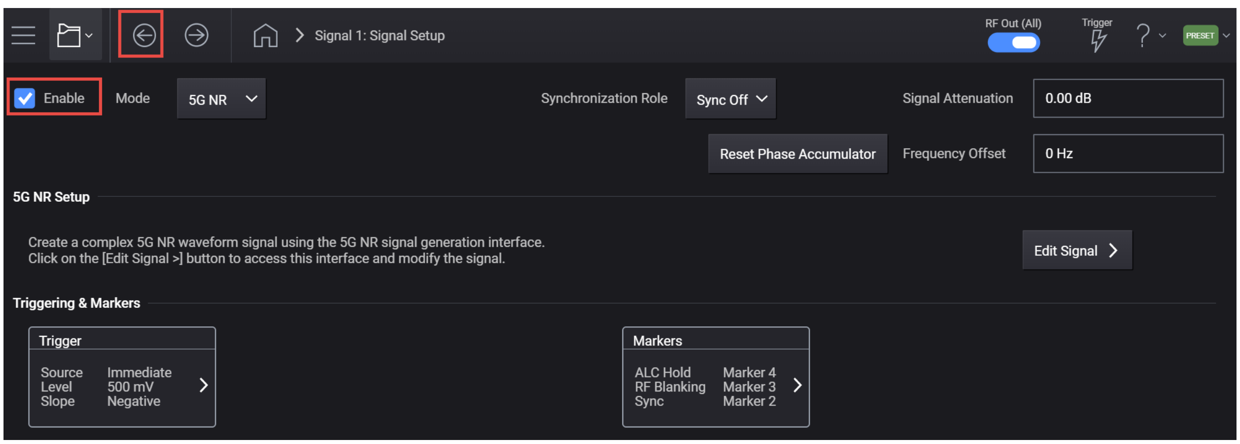
12. Select **Generate** to generate the Waveform, and then select Home to return to the main window.



13. Select the **Markers** block and set Sync to **Marker 2**, then select **Back**.

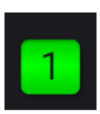


14. Select **Enable** Vector Modulation Signal.



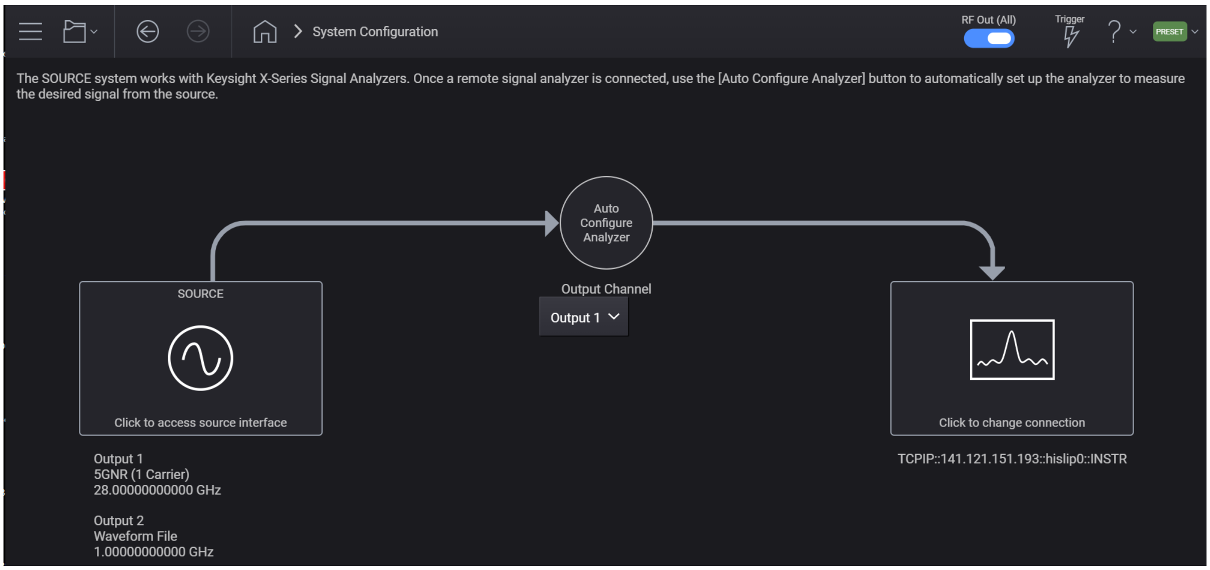
15. Return to the window and turn RF Out to **On** by selecting the numbered channel indicator switch.

This enables the RF Out for the indicated channels, in this case Channel 1 if using a multi-channel VXG.



Setup Auto Configure Analyzer

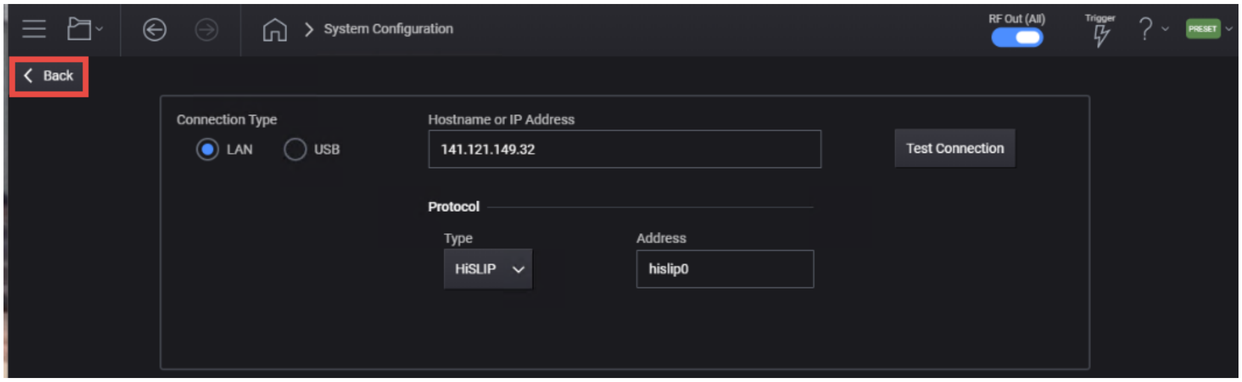
1. Select the System menu (triple bar tab at the top left of the window) to open the System Menu and then select **Configure Analyzer**.



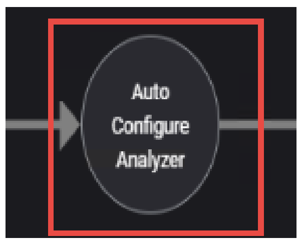
2. In the System Configuration setup, click on the Remote Signal Analyzer block (on far right) to setup the communication channel to the Keysight X-Series Signal Analyzer.

3. Set Connection Type to **LAN**.
4. In the Connect Remote X-Series Signal Analyzer setup, enter the Hostname or IP Address for the signal analyzer.
5. Under Set Protocol, select **HiSLIP** and use the Remote name **hislip0**.

6. Select **Test Connection** to verify, then **Back.**



7. Select **Auto Configure Analyzer** to send the VXG settings to the analyzer.

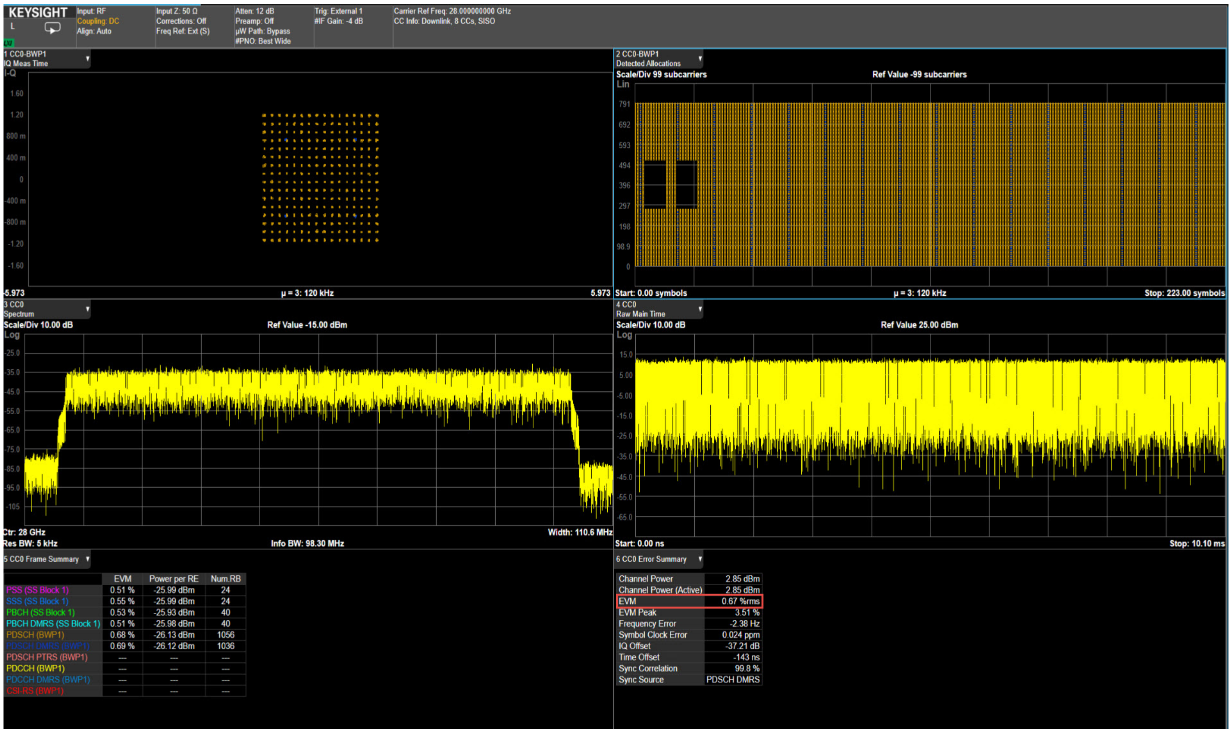


The System Configuration selection brings up a screen that lets you perform a Generation-to-Analysis work flow. The “Auto Configure Analyzer” button will automatically transfer the setup from the source to a Keysight X-Series signal analyzer, in order to measure the desired signal from the source. If you are generating a 3GPP 5G New Radio signal, and the 5G New Radio application is licensed on the analyzer, the analyzer will perform demodulation of the signal. Otherwise, the analyzer will auto-tune on the signal being generated. The Keysight X-Series Signal Analyzer requires firmware version x.24.00 or greater.

On the X-Series Signal Analyzer

1. Set up triggers, refer to “Setting Up Triggers on the Signal Analyzer using 5G NR Mode” on page 86.
2. From the menu panel, select **Meas Setup** > **Advanced** > **Advanced Demod Setup** > **DC Punctured On.**

3. View the results on the signal analyzer.



More About the 5G NR Traces

- Trace 1: shows the composite constellation diagram showing different modulation formats for the different channels/signals present in the transmitted signal. See Trace 6 (Frame Summary) for the list of channels. Again, when enabling BWP, SS Block is grayed out. When enabling SS Block, channels withing BWP are grayed out.
- Trace 2: shows the envelope of the captured raw data. This data is unprocessed and includes additional points acquired for settling of the filters involved in subsequent processing, such as the demodulation filtering.
- Trace 3: shows the FTT of the Raw Main Time waveform.
- Trace 4: shows the general measurement numeric results.
- Trace 5: shows the detected allocations of all channels/signals within the measurement interval (2 Subframes in this example).
- Trace 6: shows EVM, Power, and Number of RB of the individual channels/signals.

TIP

The Frame Summary table shows Num. RB for PDSCH of 1056 and 1016 for PDSCH-DMRS. The signal configuration has only 66 RBs. The RB result in the Frame Summary Table is per Slot. In this example procedure, we changed the

measurement interval to 2 Subframes, which is 16 slots for 120 kHz numerology (8 slots/subframe). 66 * 16 = 1056. For PDSCH-DMRS, the value is 1016 because two of the 16 slots overlap with the SS Block which occupies 20 RBs resulting in 20 RBs being punctured from DMRS in these two slots. Therefore, the total RB Number for DMRS is 1056 - 20 * 2 = 1016.

Using the equivalent SCPI commands

On the VXG:

`SYSTem:PRESet`

`RF1:FREQuency:CW 28GHZ`

`RF1:POWer:AMPLitude -10dBm`

`SIGNal1:MODE NR`

`SIGNal1:NR5G:CCARrier:BWIDth FR2BW100M`

Select μ = 3: 120kHz:

`SIGNal1:NR5G:CCARrier:SNUMerology MU3`

`SIGNal1:NR5G:CCARrier:DLINk:SSBLock:LMAX 64`

`SIGNal1:NR5G:CCARrier:DLINk:SSBLock:ACTive:INDices "0:7"`

`SIGNal1:NR5G:CCARrier:DLINk:SCH0:MCS 20`

`SIGNal1:NR5G:CCARrier:DLINk:SCH0:MCS:TABLe TABL52`

`SIGNal1:NR5G:WAVeform:GENerate`

`SIGNal1:NR5G:TRIGger:SYNC:MARKer M2`

`SIGNal1 ON`

`RF1:OUTPut ON`

For multi-channel instruments, set RF Out (all) to On.

`RFALl:OUTPut ON`

3 5G NR Measurements Using the VSA Software

This section includes the following topics:

KEYSIGHT TECHNOLOGIES

5G Waveform and EVM Analysis Using VSA Software

The VXG enables 5G testing with a low error vector magnitude (EVM) at high frequencies. The VXG has extremely good EVM at high power levels. However, not all signal analyzers can capture this low value. We will use the X-Series Signal Analyzer with the Vector Signal Analysis (VSA) software to observe EVM.

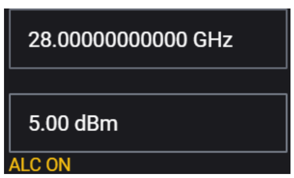
Setting Up a 1 CC 28 GHz EVM Measurement

NOTE Ensure the equipment and triggers are properly configured. Refer to "Equipment Setup" on page 10.

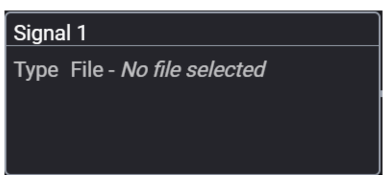
Using the graphical user interface

On the VXG:

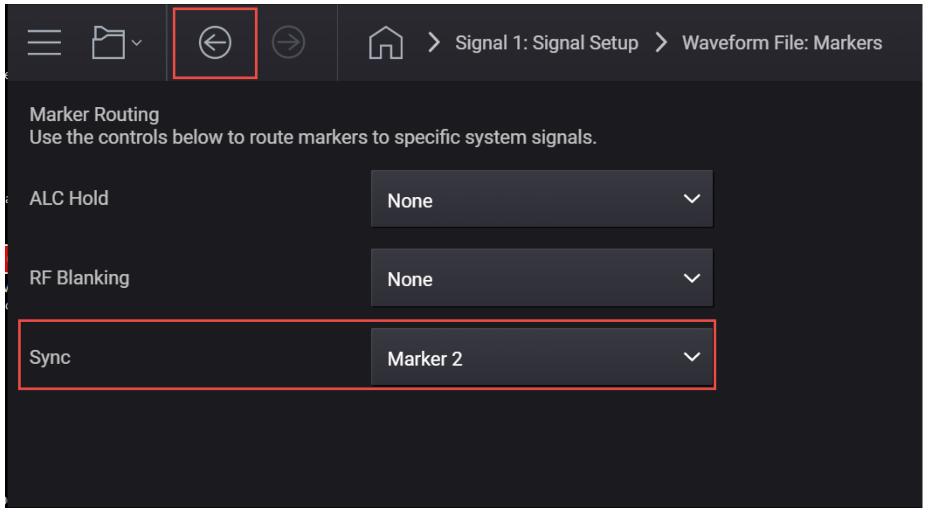
1. Select **Preset** > **Preset** to set the VXG to a known state.
2. In the Output 1 area, set Frequency to **28 GHz** and Power to **5 dBm**.



3. Select the **Signal** block to open the Vector Modulation Signal Setup panel.



4. Select the **Markers** block and set Sync to **Marker 2**, then select **Back**.



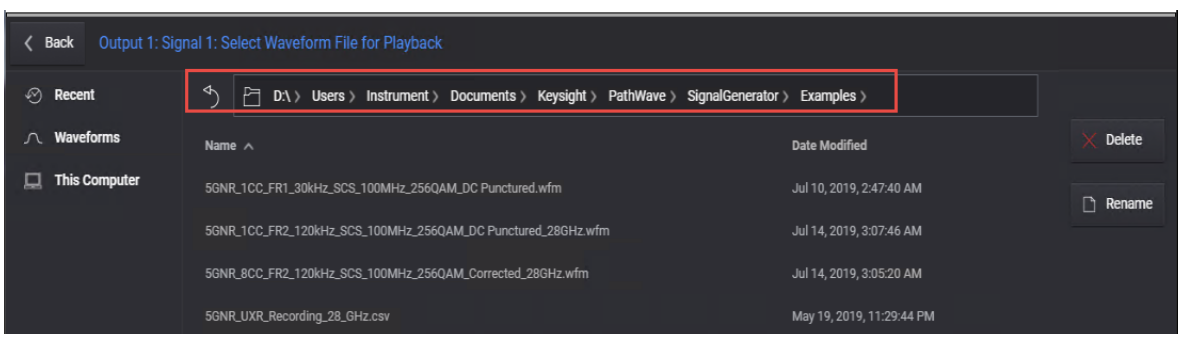
5. Use File **Select** to navigate to:

   `D:\Users\Instrument\Documents\Keysight\PathWave\SignalGenerator\Examples`

   and choose

   `5GNR_1CC_FR2_120kHz_SCS_100MHz_256QAM_DCPunctured_28GHz.wfm`

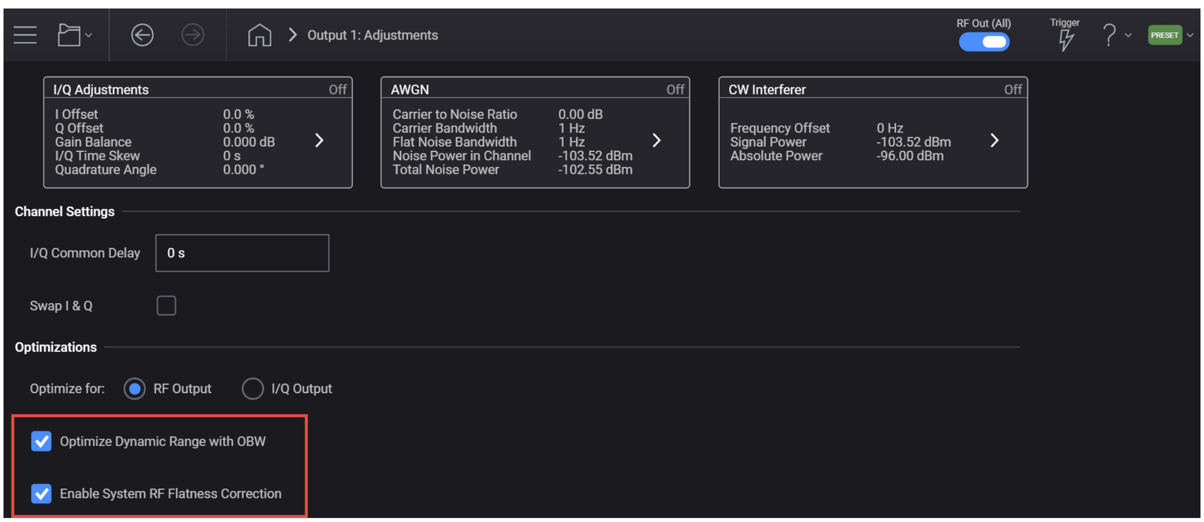
   then **Select**.



6. Select **Enable** Vector Modulation Signal.
7. Close the Vector Modulation Signal Setup window by selecting the Back or Home icon (<-).
8. Select the **Adjustments** block and select **Optimize Dynamic Range with OBW** and **Enable System RF Flatness Correction**. Close the Adjustments block by selecting the Back icon (<-).

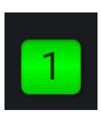
   Optimize Dynamic Range with OBW This setting filters the system RF flatness correction coefficients over the instantaneous bandwidth indicated in the waveform header (or in the “Occupied Bandwidth” settings area under the Signal block > Occupied Bandwidth setting). This has the potential to improve EVM performance by not having to correct for flatness errors outside the requested bandwidth. For example, if RF flatness correction was done at 2 GHz, but you are only interested in an 800 MHz section, then applying the correction flatness to that portion only can improve signal to noise ratio, and therefore EVM when there is a lot of hardware roll off.

Enable System RF Flatness Correction - Disabling this function disables the factory calibrated RF channel flatness equalizer. Depending on the hardware channel response, this may hurt or improve the EVM. This is due to the dynamic range implications as it relates to signal to noise ratio. The greater the RF hardware variations in flatness, the greater the amount of correction is required, the greater the correction effectively reduces the number of resolution DAC bits that can be used, which degrades the signal to noise ratio and therefore potentially EVM. The trade-off is to balance between flatness and signal to noise ratio.

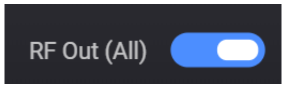


9. Set RF Out to **On** by selecting the numbered channel indicator switch.

   This enables the RF Out for the indicated channels, in this case Channel 1 if using a multi-channel VXG.



10. **For multi-channel instruments only:** In the top right corner of the display, set RF Out (All) to **On** by selecting the switch.



NOTE In order to turn on RF for any channel, both the RF Out for the specific channel (for example, Channel 1 or Channel 2), and RF Out All must be turned on.

On the X-Series Signal Analyzer:

– Open the VSA software by selecting **Mode Meas** > **Launch VSA**.

NOTE If accessing the instrument via a Remote Desktop connection, select the Screen tab (at the top of the display) to open the Mode/Measurement/View Selector window.

In the VSA software:

1. From the menu bar, select **File** > Preset > **All** to set the VSA to a known state.

NOTE All example waveforms and setup files are located on the VXG at:

`D:\Users\Instrument\Documents\Keysight\PathWave \SignalGenerator\Examples`

You will need to copy over the setup files to the X-Series Signal Analyzer or the PC running the VSA application.

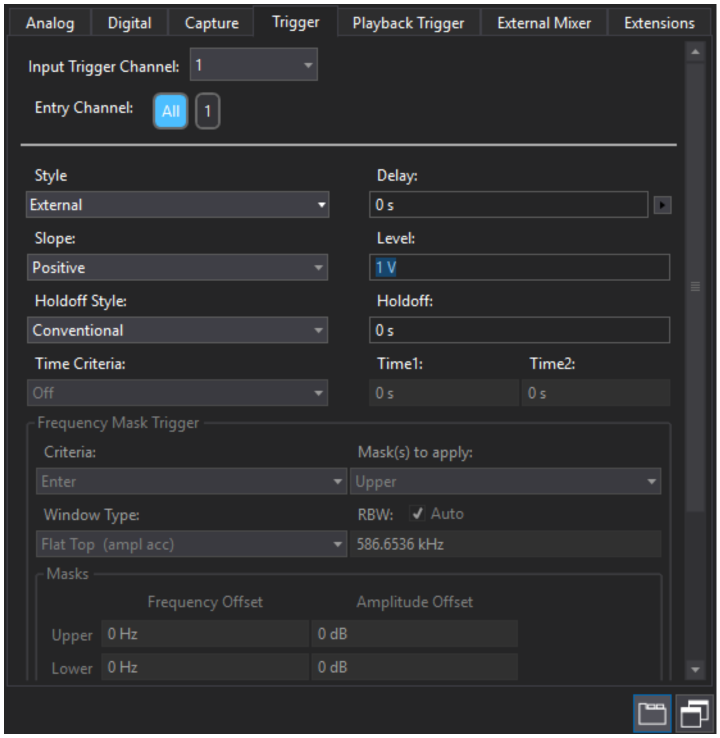
---

2. Select **File** > **Recall** > **Recall Setup** and navigate to D:Users\Instrument\Documents\NR5G\data\NR5GEvm\Carrier Setup, then open `5GNR_1CC_FR2_120kHz SCS_100MHz_256QAM_DC Punctured_28GHz.setx`

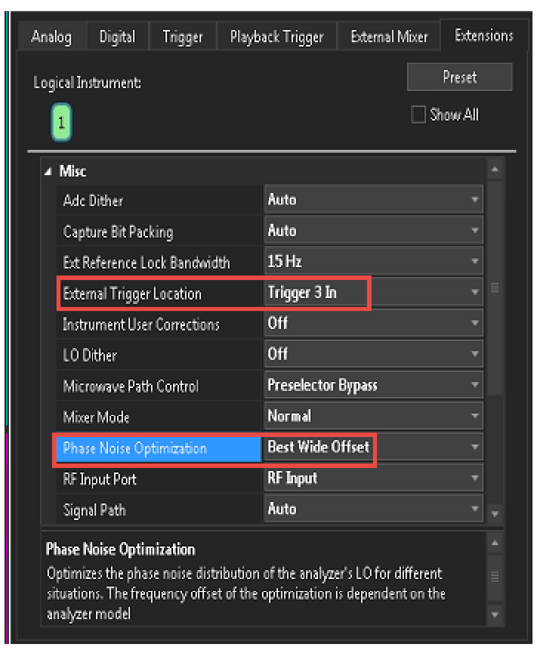
3. From the toolbar, select the **Pause** Icon. 

   Pausing the measurement will help to speed up the setup time.

4. From the menu bar, select **Input** > **Trigger** and set Style to **External** and Level to **1.0 V**.



5. Select the **Extensions** tab and change the External Trigger location to **Trigger 3 In** (if using an N9040B with Option H1G) and Phase Noise Optimization to **Best Wide Offset**, then close the window.



6. From the menu bar, select **MeasSetup** > **5G NR Demod Properties** > **Time** tab.

   – Set Result Length to **10 Subframes**

   – Set Meas Interval to **2 Subframes**

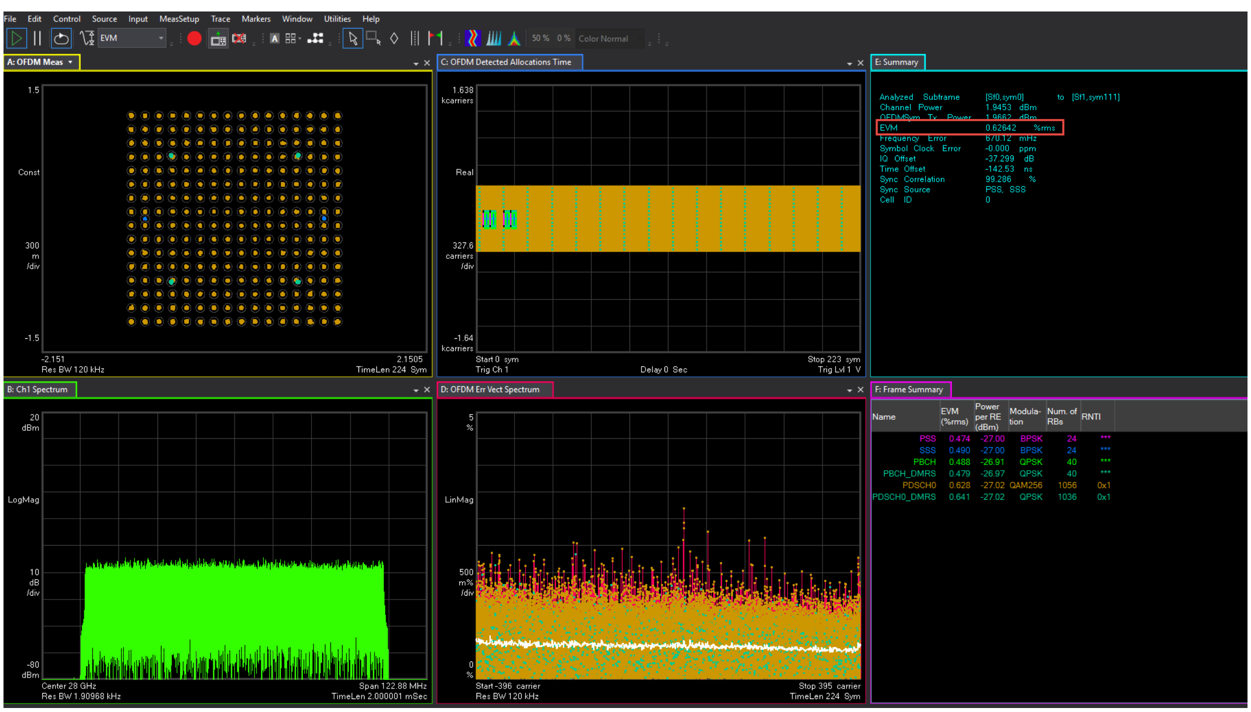
   – Select **Frame Trigger is Present**

7. From the toolbar, select the **Auto-Rang**e dropdown and select **EVM-Table or Algorithm Based**.

   – EVM - Table or Algorithm Based performs EVM optimization based on prescribed table/algorithm instead of using EVM in the feedback loop. This method of EVM auto-range is normally faster than Meas Based Iteration, but may not achieve the most optimal setup for minimized EVM).

   – EVM - Meas Based Iteration has a feedback loop around the entire measurement, uses the measured EVM in the feedback loop, and tries to adjust hardware parameters to minimize the EVM. It is the slowest EVM auto-range method, but it should achieve the most optimal setup for good EVM.

8. Select the **Auto-Range** icon to run the measurement for EVM optimization. This may take a few minutes to complete.



Using the equivalent SCPI commands

On the VXG:

```
SYSTem:PRESet

RF1:FREQuency:CW 28GHZ

RF1:POWer:AMPLitude 5dBm

SIGNal1:MODE WAVeform

SIGNal1:WAVeform:TRIGger:SYNC:MARKer M2

SIGNal1:WAVeform “D:\Users\Instrument\Documents\MCS demo
waveforms
5GNR_1CC_FR2_120kHz_SCS_100MHz_256QAM_DCPunctured_28GHz.wfm”

SIGNal1 ON

IQO:CORR:OPT:DYN:RANG:OBW ON

IQO:CORR:CHAN:FLAT ON

RF1:OUTPut ON
```

For multi-channel instruments, set RF Out (all) to On.

```
RFALl:OUTPut ON
```

On the X-Series Signal Analyzer:

```
INSTrument:SELect VSA89601
```

NOTE

All example waveforms and setup files are located on the VXG at:

```
D:\Users\Instrument\Documents\Keysight\PathWave
\SignalGenerator\Examples
```

You will need to copy over the setup files to the X-Series Signal Analyzer or the PC running the VSA application.

```
SYSTem:PRESet

MMEMory:LOAD
“D:Users\Instrument\Documents\NR5G\data\NR5GEvm\Carrier
Setup\5GNR_1CC_FR2_120kHz
SCS_100MHz_256QAM_DCPunctured_28GHz.setx”

INITiate:PAUSe

INPut:TRIGger:STYle "EXTERNAL"

INPut:TRIGger:LEVel:EXTernal 1V

INPut:EXTension:PARameters:SET "ExtTriggerLoc", 2

INPut:EXTension:PARameters:SET "PhaseNoiseOptDualLoop", 1
```

Set the 5G NR Demod Result Length to 10 Subframes:

```
NR5G:RLENgth 10
```

```
NR5G:SUBFrame:INTerval 2
```

Set the Acquisition Mode to “Frame Trigger is Present”

```
nr5g:FRAMe:TRIGger:ENABled 1
```

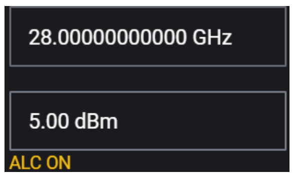
Setting Up an 8 CC 28 GHz EVM Measurement

NOTE Ensure the equipment and triggers are properly configured. Refer to "Equipment Setup" on page 10.

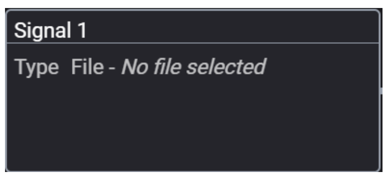
Using the graphical user interface

On the VXG:

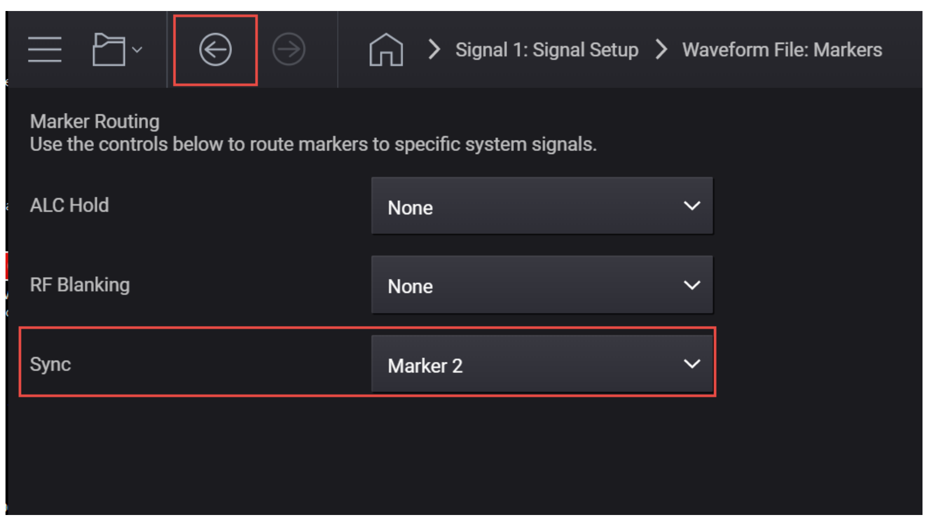
1. Select **Preset > Preset** to set the VXG to a known state.
2. In the Output 1 area, set Frequency to **28 GHz** and Power to **5 dBm**.



3. Select the **Signal** block to open the Vector Modulation Signal Setup panel.



4. Set Vector Modulation Signal Mode to **Waveform File**.
5. Select the **Markers** block and set Sync to **Marker 2**, then select **Back (<-)**.



6. Use File **Select** to navigate to:

```
D:\Users\Instrument\Documents\Keysight\PathWave
\SignalGenerator\Examples
```

and choose

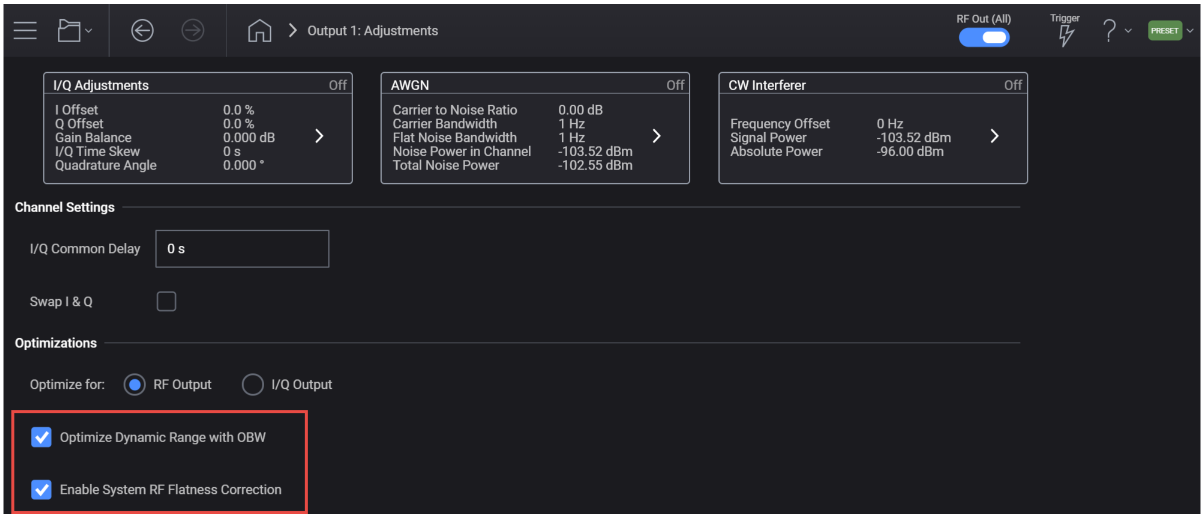
`5GNR_8CC_FR2_120kHz_SCS_100MHz_256QAM_Corrected_1.wfm`

then **Select**.

7. Select **Enable** Vector Modulation Signal.
8. Close the Vector Modulation Signal Setup window by selecting the Back (<-) button.
9. Select the **Adjustments** block and select **Optimize Dynamic Range with OBW** and **Enable System RF Flatness Correction**. Close the Adjustments window by selecting the Back (<-) button.

   Optimize Dynamic Range with OBW This setting filters the system RF flatness correction coefficients over the instantaneous bandwidth indicated in the waveform header (or in the "Occupied Bandwidth" settings area under the Signal block > Occupied Bandwidth setting). This has the potential to improve EVM performance by not having to correct for flatness errors outside the requested bandwidth. For example, if RF flatness correction was done at 2 GHz, but you are only interested in an 800 MHz section, then applying the correction flatness to that portion only can improve signal to noise ratio, and therefore EVM when there is a lot of hardware roll off.

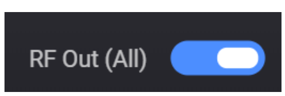
   Enable System RF Flatness Correction - Disabling this function disables the factory calibrated RF channel flatness equalizer. Depending on the hardware channel response, this may hurt or improve the EVM. This is due to the dynamic range implications as it relates to signal to noise ratio. The greater the RF hardware variations in flatness, the greater the amount of correction is required, the greater the correction effectively reduces the number of resolution DAC bits that can be used, which degrades the signal to noise ratio and therefore potentially EVM. The trade-off is to balance between flatness and signal to noise ratio.



10. Set RF Out to **On** by selecting the numbered channel indicator switch.

This enables the RF Out for the indicated channels, in this case Channel 1 if using a multi-channel VXG.

11. For multi-channel instruments only: In the top right corner of the display, set RF Out (All) to **On** by selecting the switch.



NOTE In order to turn on RF for any channel, both the RF Out for the specific channel (for example, Channel 1 or Channel 2), and RF Out All must be turned on.

On the X-Series Signal Analyzer:

— Open the VSA software by selecting **Mode Meas** > **Launch VSA**.

NOTE If accessing the instrument via a Remote Desktop connection, select the Screen tab (at the top of the display) to open the Mode/Measurement/View Selector window.

In the VSA software:

1. From the menu bar, select **File** > **Preset** > **All** to set the VSA to a known state.

NOTE

All example waveforms and setup files are located on the VXG at:

`D:\Users\Instrument\Documents\Keysight\PathWave \SignalGenerator\Examples`

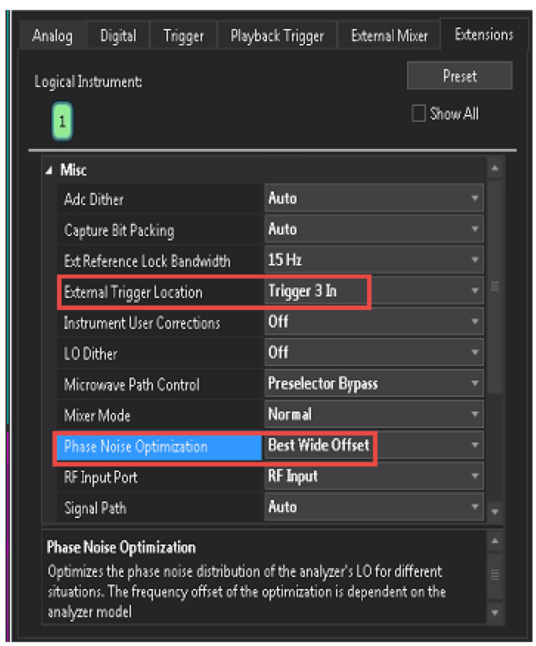
You will need to copy over the setup files to the X-Series Signal Analyzer or the PC running the VSA application.

2. Select **File** > **Recall** > **Recall Setup** and navigate to D:Users\Instrument\Documents\NR5G\data\NR5GEvm\Carrier Setup, then open `5GNR_8CC_FR2_120kHz_SCS_100MHz_256QAM_Corrected_1.setx`

3. From the toolbar, select the **Pause** Icon. 

   Pausing the measurement will help to speed up the setup time.

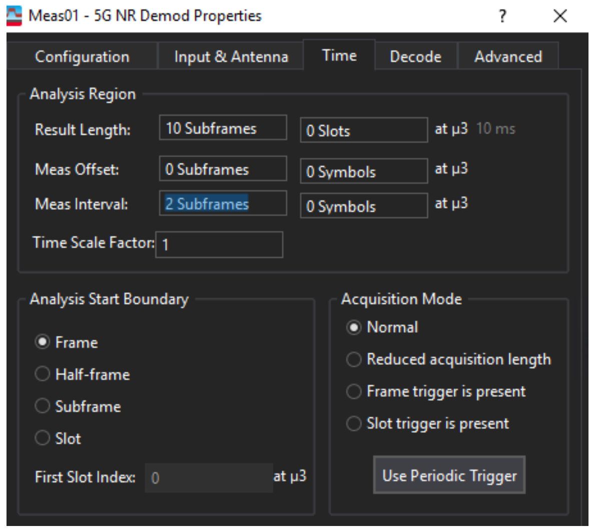
4. Select the **Extensions** tab and change the External Trigger location to **Trigger 3 In** and Phase Noise Optimization to **Best Wide Offset**.



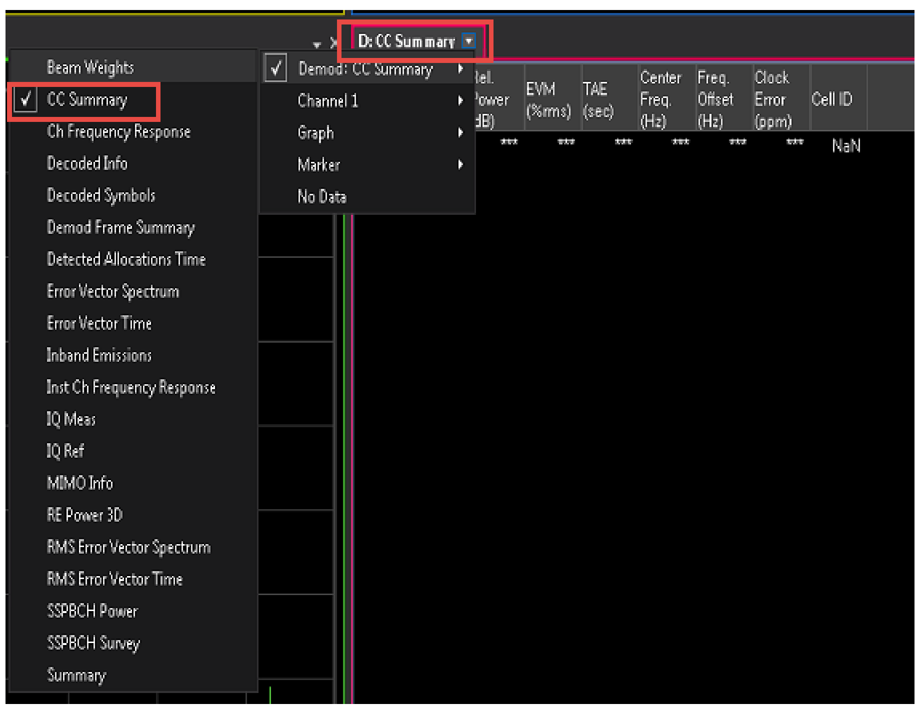
5. From the menu bar, select **MeasSetup** > **5G NR Demod Properties** > **Time** tab.

   – Set Result Length to **10 Subframes**.

– Set Meas Interval to **2 Subframes**.



6. In the bottom center trace window, select the Trace Data menu and select **Demod: > CC Summary**.

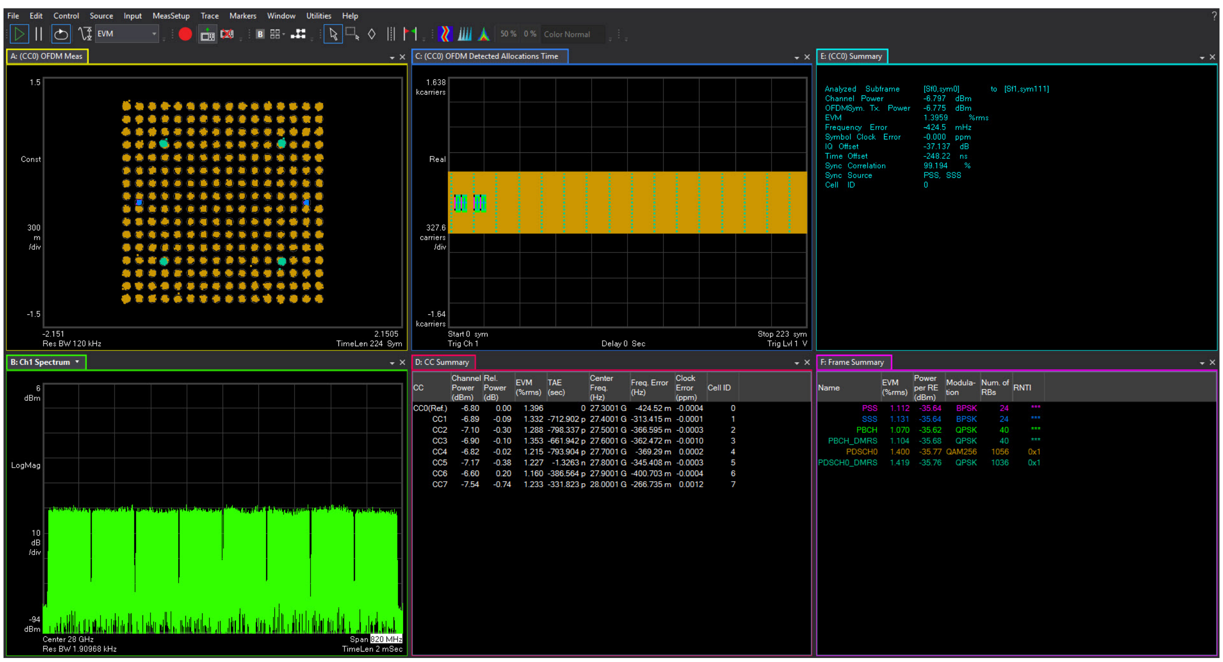


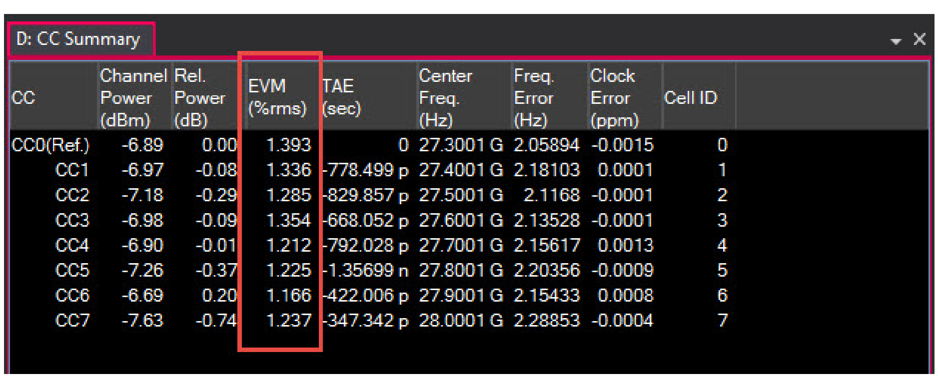
7. In the Spectrum trace window (bottom left window), select **Center** and change the frequency to **28 GHz**.

8. From the toolbar, select the Auto-Range dropdown and select **EVM-Table or Algorithm Based**.

- EVM - Table or Algorithm Based performs EVM optimization based on prescribed table/algorithm instead of using EVM in the feedback loop. This method of EVM auto-range is normally faster than Meas Based Iteration, but may not achieve the most optimal setup for minimized EVM).
- EVM - Meas Based Iteration has a feedback loop around the entire measurement, uses the measured EVM in the feedback loop, and tries to adjust hardware parameters to minimize the EVM. It is the slowest EVM auto-range method, but it should achieve the most optimal setup for good EVM.

9. Select the **Auto-Range** icon to run the measurement for EVM optimization on all eight channels. This may take a few minutes to complete.





D: CC Summary

CC	Channel Power (dBm)	Rel. Power (dB)	EVM (%rms)	TAE (sec)	Center Freq. (Hz)	Freq. Error (Hz)	Clock Error (ppm)	Cell ID
CC0(Ref.)	-6.89	0.00	1.393	0	27.3001 G	2.05894	-0.0015	0
CC1	-6.97	-0.08	1.336	-778.499 p	27.4001 G	2.18103	0.0001	1
CC2	-7.18	-0.29	1.285	-829.857 p	27.5001 G	2.1168	-0.0001	2
CC3	-6.98	-0.09	1.354	-668.052 p	27.6001 G	2.13528	-0.0001	3
CC4	-6.90	-0.01	1.212	-792.028 p	27.7001 G	2.15617	0.0013	4
CC5	-7.26	-0.37	1.225	-1.35699 n	27.8001 G	2.20356	-0.0009	5
CC6	-6.69	0.20	1.166	-422.006 p	27.9001 G	2.15433	0.0008	6
CC7	-7.63	-0.74	1.237	-347.342 p	28.0001 G	2.28853	-0.0004	7

Using the equivalent SCPI commands

On the VXG:

```
SYSTem:PRESet
RF1:FREQuency:CW 28GHZ
RF1:POWer:AMPLitude 5dBm
SIGNal1:MODE WAVeform
SIGNal1:WAVeform:TRIGger:SYNC:MARKer M2
SIGNal1:WAVeform “D:\Users\Instrument\Documents\MCS demo waveforms\5GNR_8CC_FR2_120kHz_SCS_100MHz_Corrected_28GHz.wfm”
SIGNal1 ON
```

IQO:CORR:OPT:DYN:RANG:OBW ON

```
IQO:CORR:CHAN:FLAT ON
RF1:OUTPut ON
```

For multi-channel instruments, set RF Out (all) to On.

```
RFALl:OUTPut ON
```

On the X-Series Signal Analyzer

```
INSTrument:SELect VSA89601
MMEMory:LOAD:DEMO "D:\Users\Instrument\Documents\NR5G\data\NR5GEvm\CarrierSetup\1CC_FR2_120kHz SCS_100MHz_256QAM_DC Punctured_28GHz.setx"
INITiate:PAUSe
INPut:TRIGger:STYLe "External"
INPut:TRIGger:LEVel:EXTernal 1V
INPut:EXTension:PARameters:SET "ExtTriggerLoc", 2
INPut:EXTension:PARameters:SET "PhaseNoiseOptDualLoop", 1
NR5G:RLENgth 10
NR5G:SUBFrame:INTerval 2
NR5G:FRAMe:TRIGger:ENABled 1
NR5G:CAGGregation:CONFigure "Contiguous8CC"
NR5G:DC:PUNCtured 1
NR5G:MCFilter:ENABled 1
```

```
FREQuency:CENTer 28 GHz
```

```
INPut:ANALog:CRITeria:RANGe:AUTO "EVM", -1
```

NOTE

All example waveforms and setup files are located on the VXG at:

```
D:\Users\Instrument\Documents\Keysight\PathWave
\SignalGenerator\Examples
```

You will need to copy over the setup files to the X-Series Signal Analyzer or the PC running the VSA application.

Creating a Basic 5G NR Signal Using PathWave N7631APPC Embedded Software

PathWave software tools can be used to create, download, and playback waveforms through the VXG.

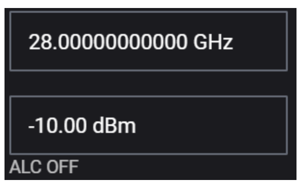
This example shows you how to create and analyze a 5G NR signal using the embedded PathWave software. Your VXG must include the N7631APPC license.

NOTE The VXG must have the N7631APPC Signal Generation for 5G NR license installed.

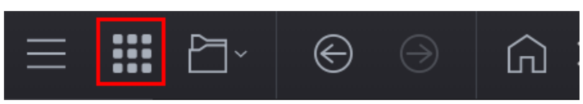
Using the graphical user interface

On the VXG:

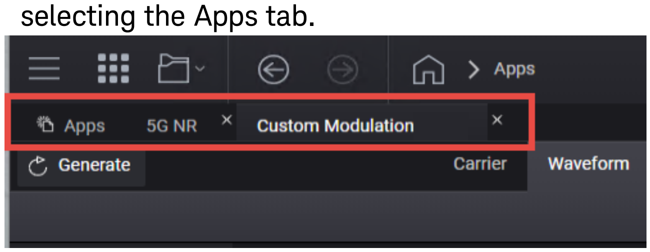
1. Select **Preset** > **Preset** to set the VXG to a known state.
2. In the Output area, set Frequency to **28 GHz** and Power to **-10 dBm**.



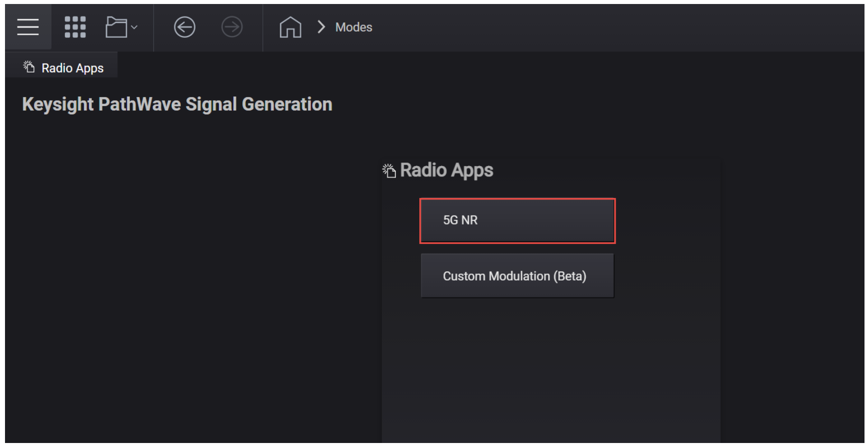
3. Select the **Radio Apps** block to open the mode selection panel.



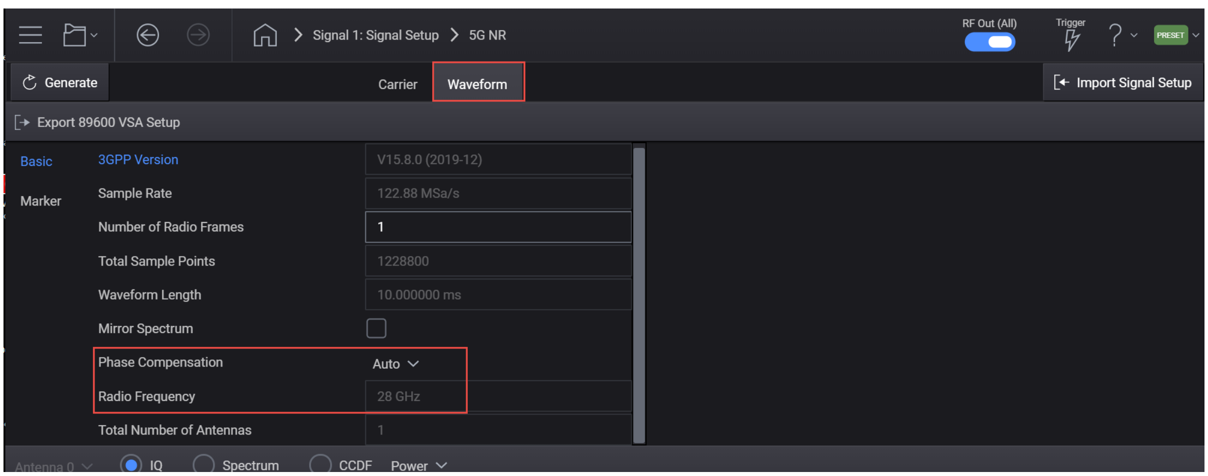
NOTE If you have previously opened any of your available applications, the dialog box will not be displayed. Instead, you will see tabs of the applications that have already been used. You can view all of your available applications by selecting the Apps tab.



4. Select **5G NR** to enter the 5G NR signal mode.



5. In the 5G NR setup, select the **Waveform** tab and observe the Phase Compensation and Radio Frequency settings.



TIP

Phase Compensation is applied by default at baseband for RF up-conversion. This means the waveform generation is per the carrier frequency, unlike conventional Signal Studio waveforms, which are independent from carrier frequency. Phase Compensation is set to Auto by default. The frequency is coupled with the VXG frequency setting under the Instrument node. You can select Manual to specify a different frequency, or turn it off.

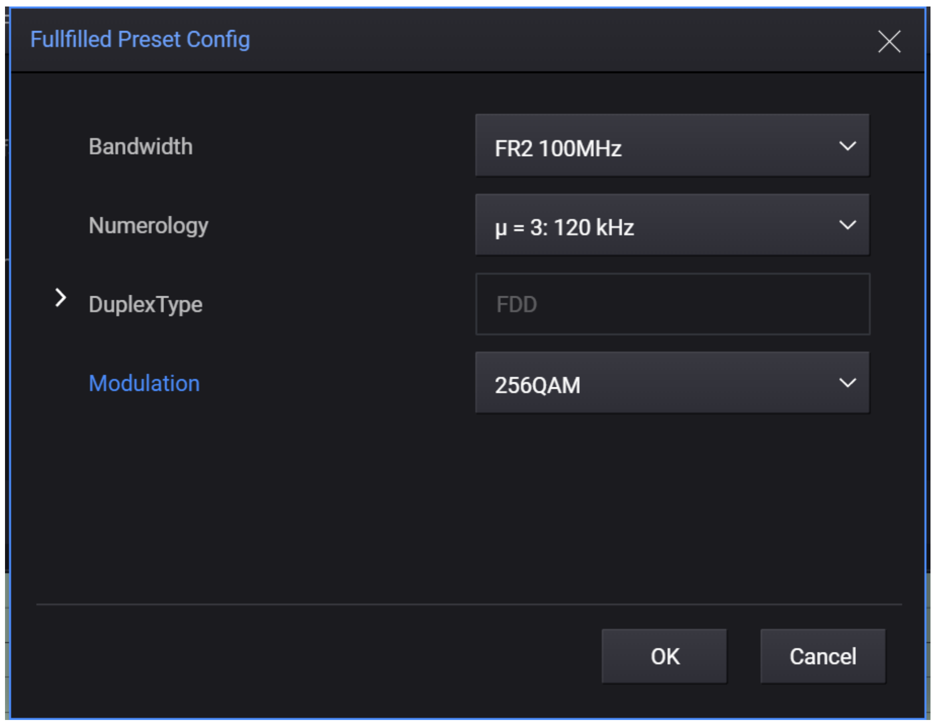
Some applications, like power amplifier measurements use the same waveform at different frequencies and can be time consuming to generate a separate waveform for each frequency. In this case, you would turn Phase Compensation Off, so the waveform becomes independent from the carrier frequency. You need to do the same on the analysis side, or the demodulation will fail.

6. Select the **Carriers** tab and then select the **Full-Filled Config** tab.

7. Select the **Full-Filled Config** tab and set Bandwidth to **FR2 100 MHz**, Numerology to **μ = 3: 120 kHz**, Modulation to **256QAM** and then select **OK**.

NOTE If you have a signal analyzer with demodulation bandwidth that is wide enough to cover the other FR2 bandwidths, 200 MHz or 400 MHz, you can choose to use a wider bandwidth.

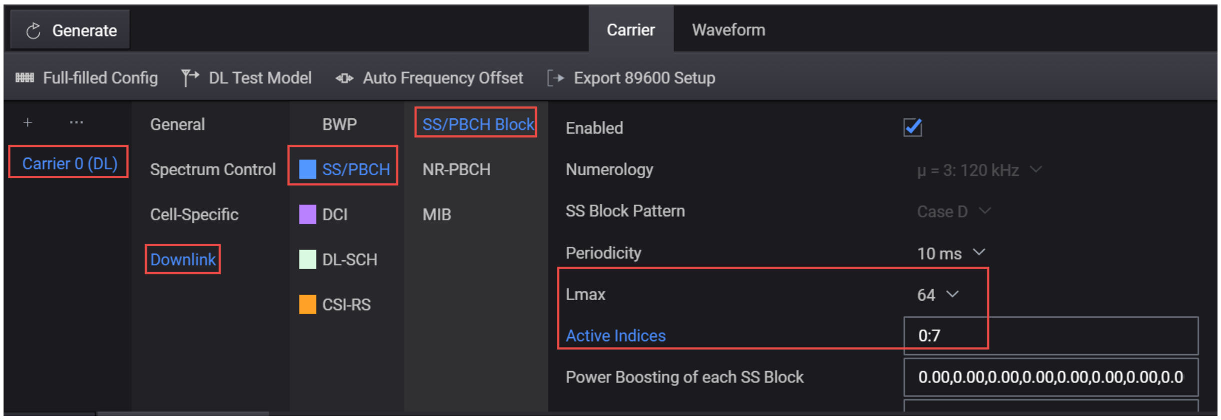
Full Filled Configurations is a great place to start creating your waveform. You can select FR, bandwidth, and modulation format with a fully allocated PDSCH data channel. This would represent a spectrally correct signal that is typically used in power amplifier measurements. You can modify the RB allocations and Slot allocations if fully allocated data channels are not desired.



8. Select **OK** to exit the Full Filled Config setup.

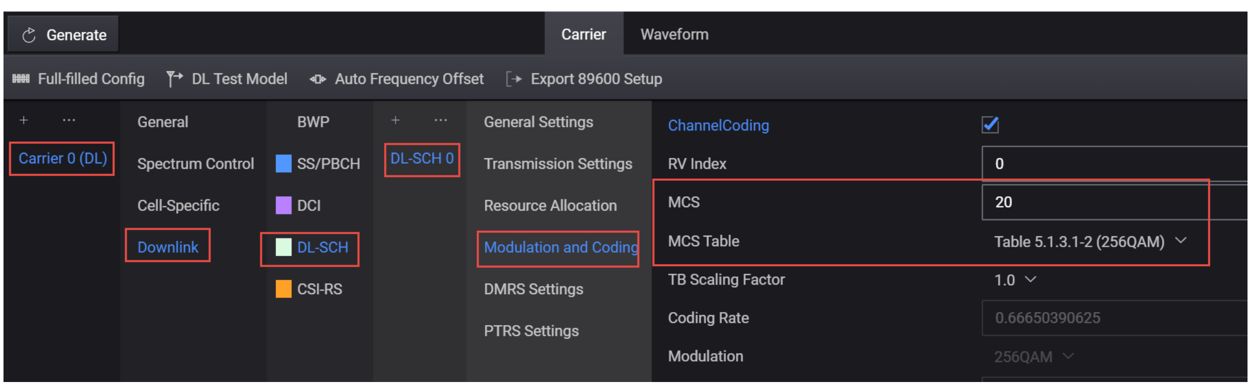
9. From the Carrier panel (in the left pane), select **Downlink** > **SS PBCH** > **SS PBCH Block** and change Lmax to **64** and Active Indices to = **0:7**.

Instead of transmitting all 64 beams, we enable only 8 of them be setting Active Indices to 0:7.

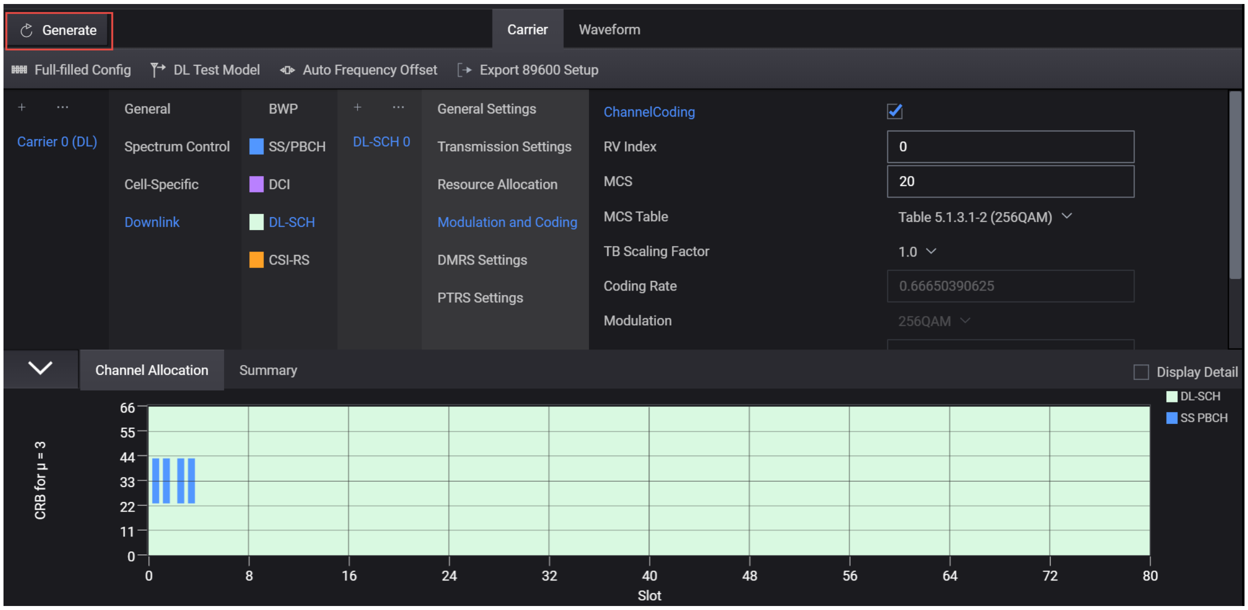


NOTE Lmax sets the maximum number of possible SS/PBCH blocks in a transmission opportunity. This value is fixed for a given carrier bandwidth. Typically, higher frequency and bandwidth carriers use a larger set of SS/PBCH opportunities to support a larger set of antenna beams.Lmax is either 4 or 8 for FR1 and 64 for FR2.

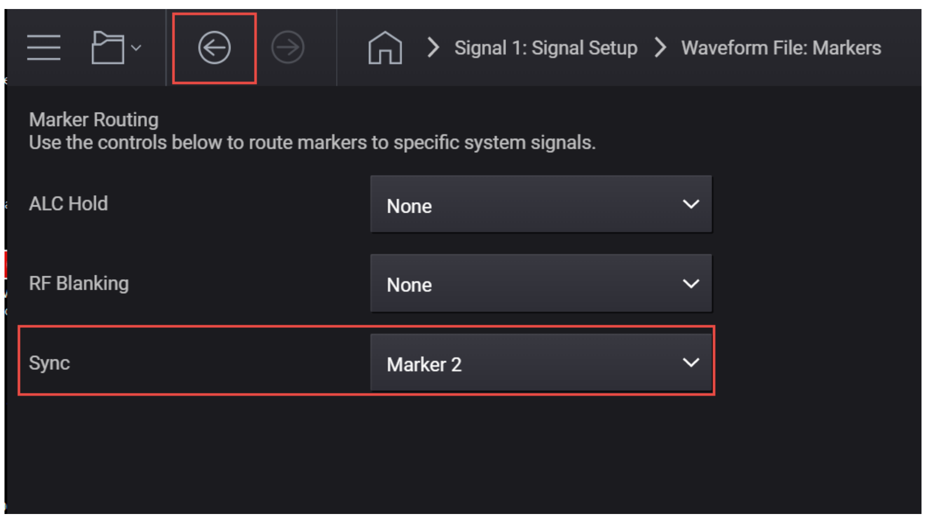
10. From the Carrier panel (in the left pane), select **Downlink** > **DL-SCHs** > **DL-SCH0** > **Modulation and Coding** and set MCS Table to **Table 5.1.3.1-2 (256QAM)** and MCS to **20**.



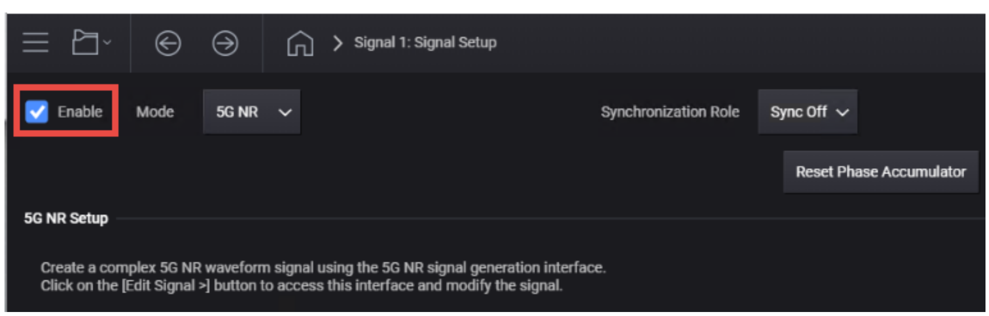
11. Select **Generate** to generate the Waveform, and then select **Back**.



12. Select the **Markers** block and set Sync to **Marker 2**, set ALC Hold and RF Blanking to **None** and then select **Back**.



13. Select **Enable** Vector Modulation Signal, then close the Signal block.



14. Set RF Out to **On** by selecting the numbered channel indicator switch.

This enables the RF Out for the indicated channels, in this case Channel 1 if using a multi-channel VXG.

On the X-Series Signal Analyzer:

– Open the VSA software by selecting **Mode Meas** > **Launch VSA**.

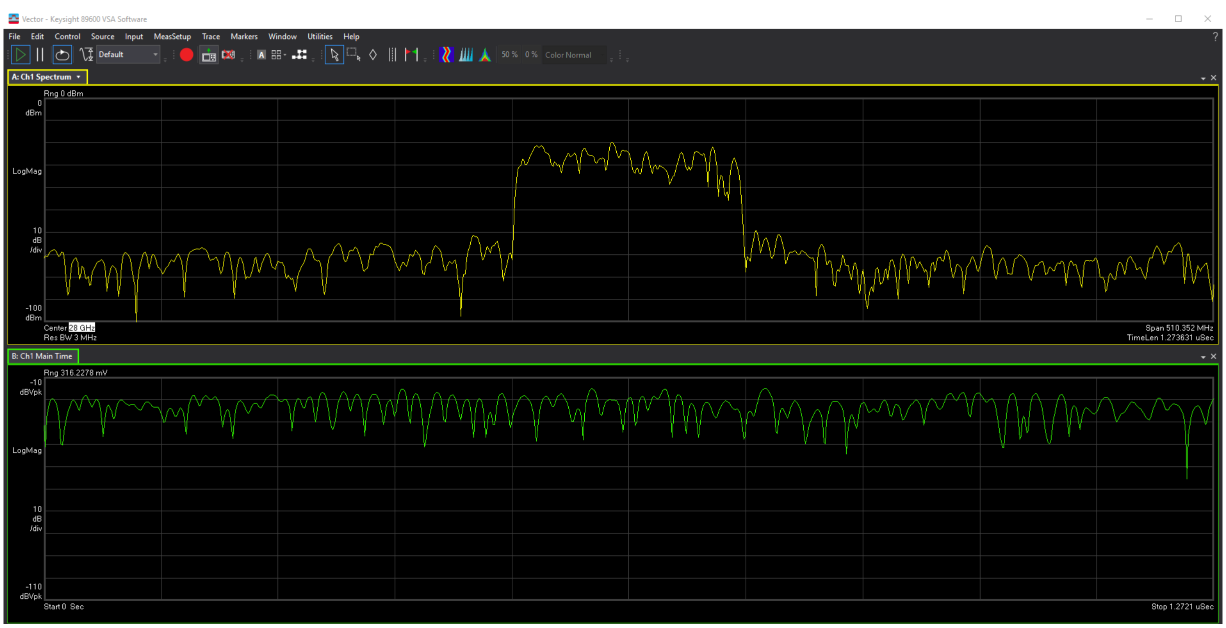
NOTE If accessing the instrument via a Remote Desktop connection, select the Screen tab (at the top of the display) to open the Mode/Measurement/View Selector window.

In the VSA software:

1. From the menu bar, select **File** > **Preset** > **All** to set the VSA to a known state.

2. Set the Center Frequency to **28 GHz**, then select **Auto Range**. 

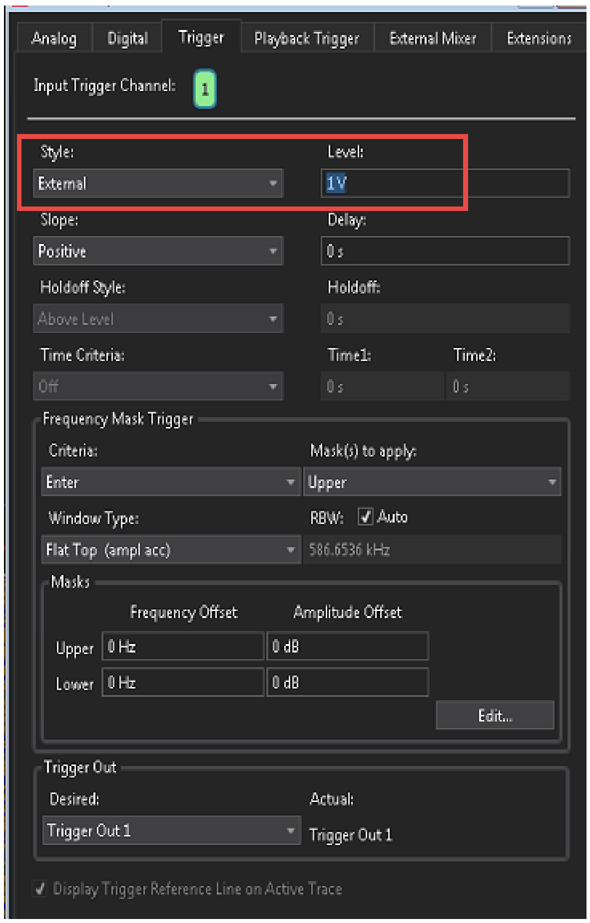
   Auto Range samples the current input signal and then sets the full scale input range to the minimum range that includes the peak voltage sample of the input signal.



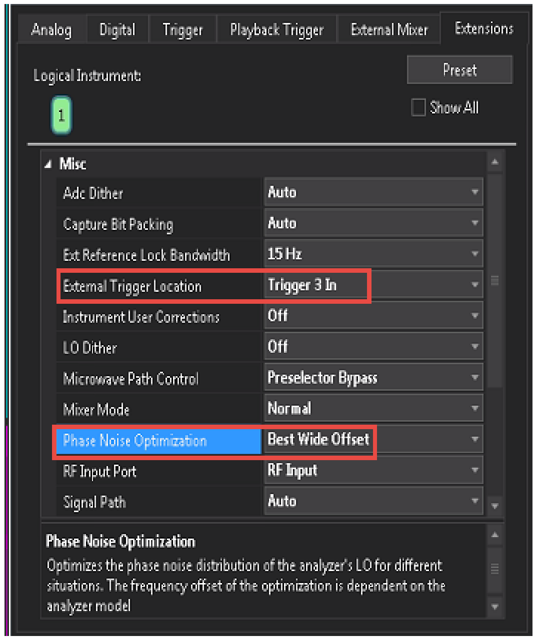
3. From the toolbar, select the **Pause** Icon. 

TIP Pausing the measurement will help to speed up the setup time.

4. From the menu bar, select **Input** > **Trigger** and set Style to **External** and Level to **1.0 V**.

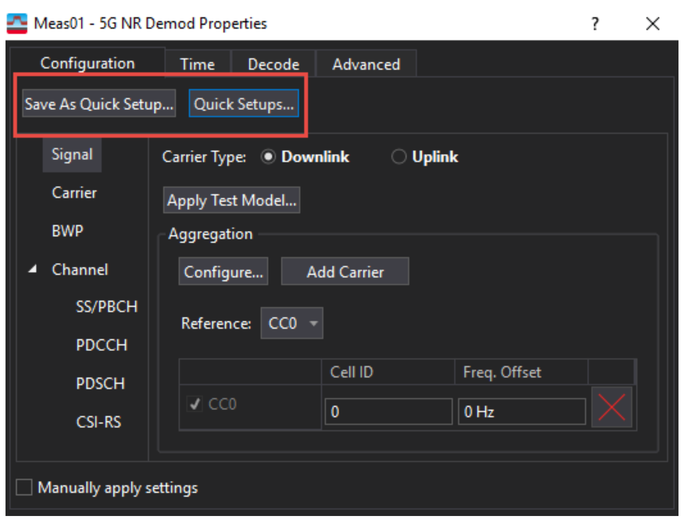


5. Select the **Extensions** tab and change the External Trigger location to **Trigger 1 In** or **Trigger 3 In** (Use Trigger 3 if your N9040B has Option H1G, 1 GHz BW) and set Phase Noise Optimization to **Best Wide Offset**.



6. From the menu bar, select **MeasSetup** > **Measurement Type** > **Cellular** > **5G NR**.

7. From the menu bar, select **MeasSetup** > **5G NR Demod Properties** > **Configuration** tab.

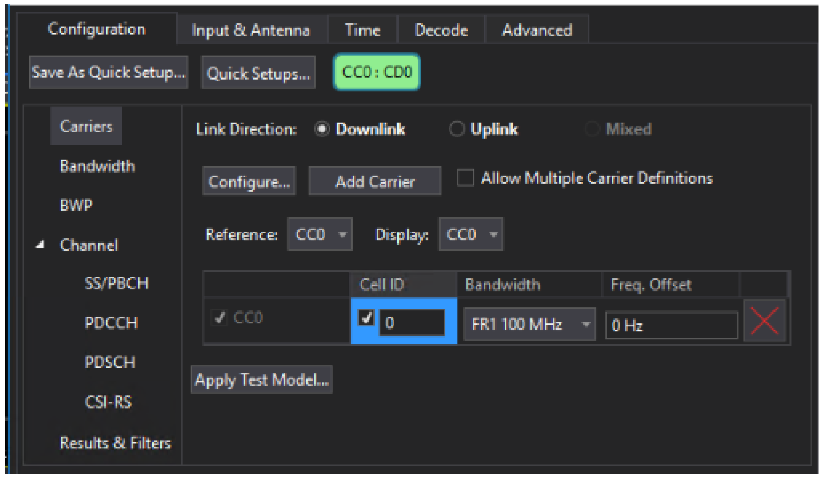


TIP Use Quick Setups for convenient saving and loading of common configurations. Quick Setups are factory supplied configurations and cannot be deleted by users. (This includes Signal Studio Downlink and Uplink defaults.)

Save As Quick Setup (saved by the user) can be specific to the current user or can be made available to others users. These setups can also be deleted.

8. Select the **Carrier** panel.

   The Carrier dialog is used to configure component carrier level parameters: Cell ID, Bandwidth, and Resource Grid for each Numerology.



   – Set Cell ID to **0**

     When the checkbox is selected, Cell ID auto-detection is enabled for the carrier.

NOTE

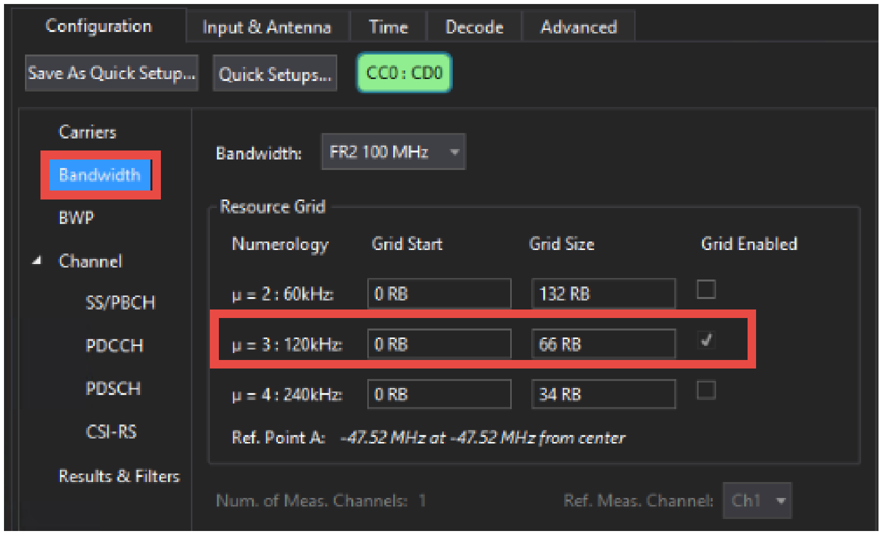
Cell ID is carried on PSS and SSS so the SS/PBCH must be transmitted and enabled for Auto Cell ID to work. It must also be a downlink since SS/PBCH is only transmitted on a downlink.

   – Set Bandwidth to **FR2 100 MHz**

9. Select the Bandwidth panel and set Numerology to **μ = 3: 120 kHz**

   For FR2 100 MHz, the Max RB for 120 kHz numerology is 66 RB. This value will be used when we configure BWP, SS/PBCH, and PDSCH.

FR2 only uses 60, 120, or 240 kHz numerologies. This is why 15 and 30 kHz numerologies do not show under the Resource Grid.

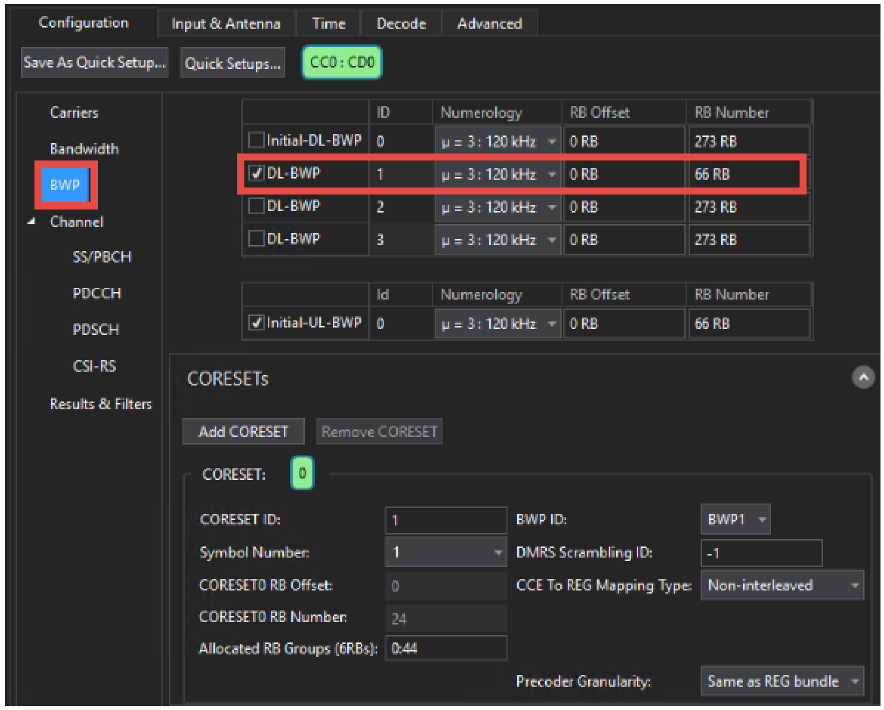


10. Select the **BWP** pane, then enable **DL-BWP**.

This section is used to configure the Downlink BWP allocation within the component carrier and the control resource set (CORESET). CORESET is used for PDCCH configuration and will not be used in this example. We will use the default values of:

- Numerology μ= 3: **120 kHz**
- RB offset **0 RB**
- RB Number **66 RB**

A component carrier with 100 MHz at FR2 has a maximum RB of 66 for 120 kHz numerology. In this example, DL-BWP uses the full carrier bandwidth of 66 RBs as shown below.



TIP VSA supports a single BWP within a component carrier (CC). Signal Studio and X-Apps support multiple BWPs within a CC. You can use VSA multi-measurement to analyze multiple BWPs simultaneously.

11. Select the **Channel** pane > **SS/PBCH**, enable **SS/PBCH** and set the following parameters:

    – Lmax to **L64**

      Lmax specifies the maximum number of SS/PBCH Blocks (that is, beams) in an SS Block period.

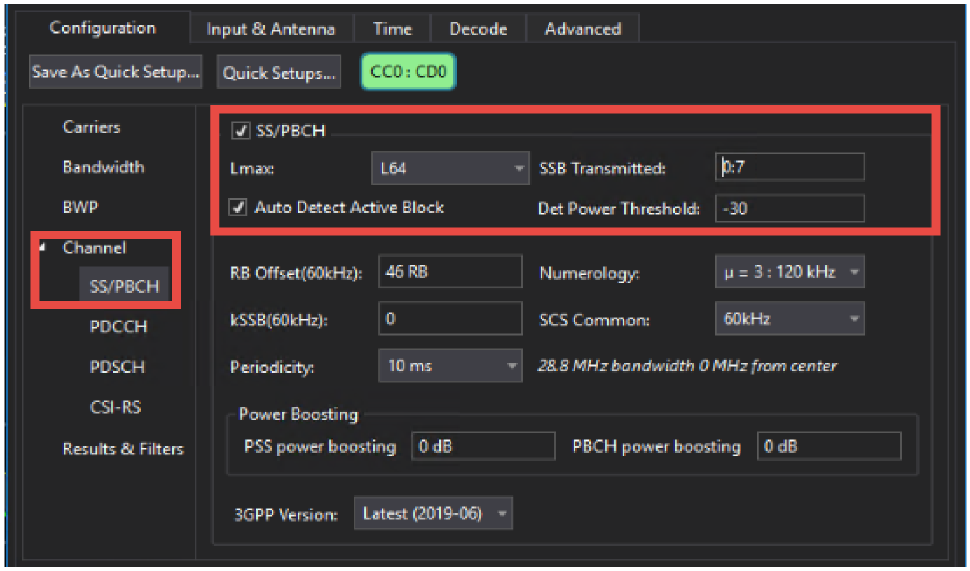
      – FR1 up to 3 GHz, Lmax = 4

      – FR1 3 to 6 GHz, Lmax = 8

      – FR2 6 to 52.6 GHz, Lmax = 64

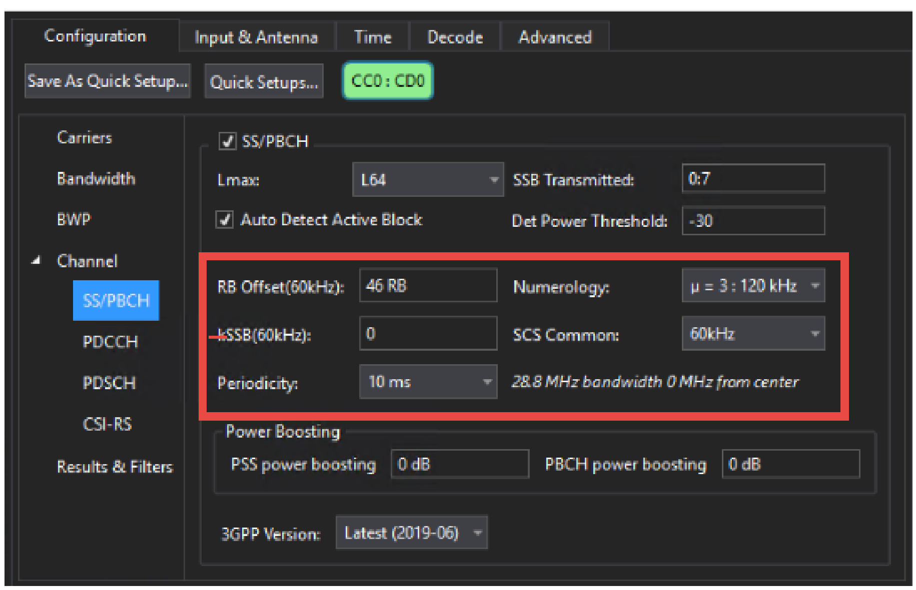
    – SSB Transmitted to **0:7**

For this example, we will not use all 64 SS Blocks; we will activate only 8 of them. You can also select the **Auto Detect Active Block** and set the **Det Power Threshold** to auto detect the active SS Blocks.



These following settings use the default values.

– RB Offset(60kHz) = **46 RB**
– kSSB(60kHz) = **0**
– Periodicity = **10 ms**
– Numerology = **μ= 3 = 120 kHz**



The frequency location of an SS Block is not fixed. The default value of 46 RB and kSSB of 0 subcarriers places it in the center of the carrier bandwidth. This value is calculated based on the 60 kHz numerology as defined by 3GPP (15 and 30 kHz sub-carrier spacing uses 15 kHz numerology, 120 and 240 kHz spacing uses 60 kHz numerology.)

For example, to calculate the 120 kHz sub-carrier spacing, the value would be

66RB/2 = 33 RB

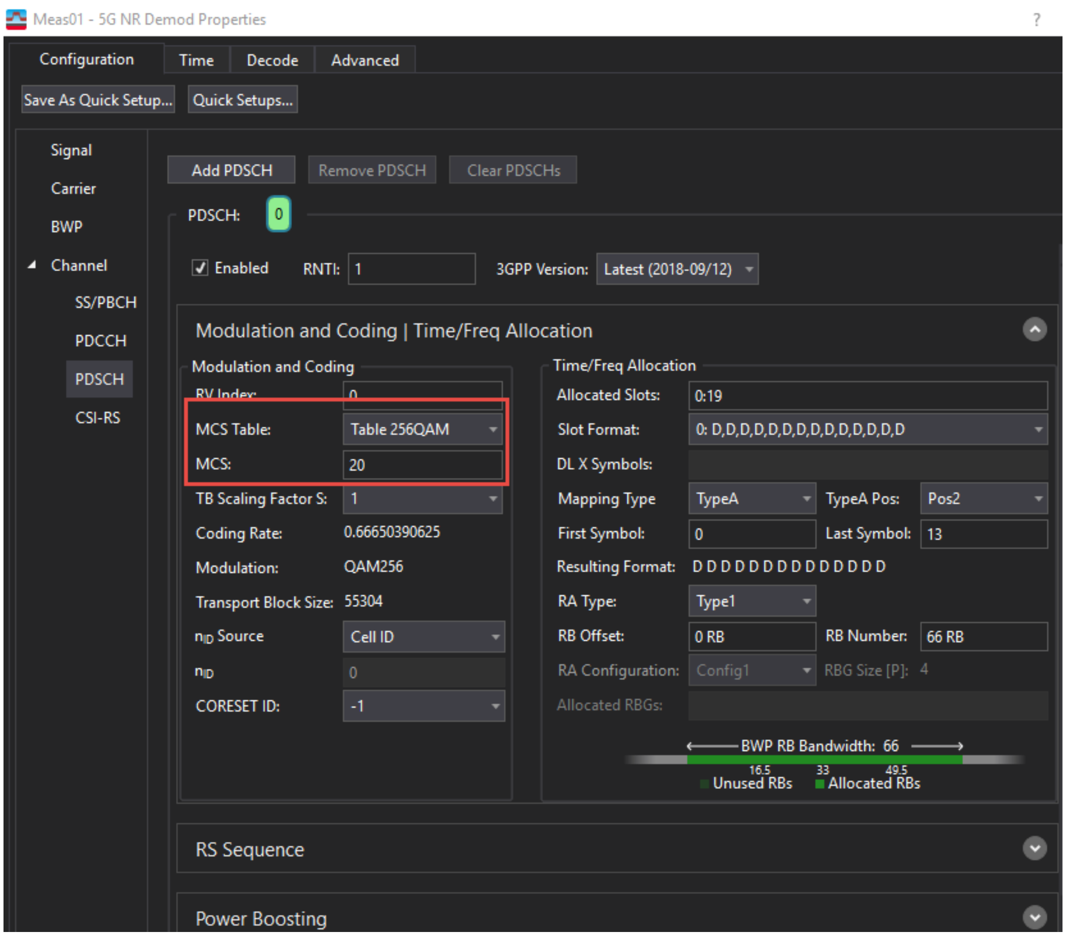
This is the center of the carrier bandwidth. However, the SS Block is 20 RB wide, so the start of the SS Block is 23 RB.

23 RB in 120 kHz is 23 * 2 = 46 RB in 60 kHz

This is the default value used in the VSA software for 120 kHz numerology.

12. From the Channel pane, select **PDSCH** and then set the following parameters:

– Under Modulation and Config section, set MCS Table to **Table 256QAM** and MCS to **20**.



TIP 3GPP has different Tables for PDSCH MCS.

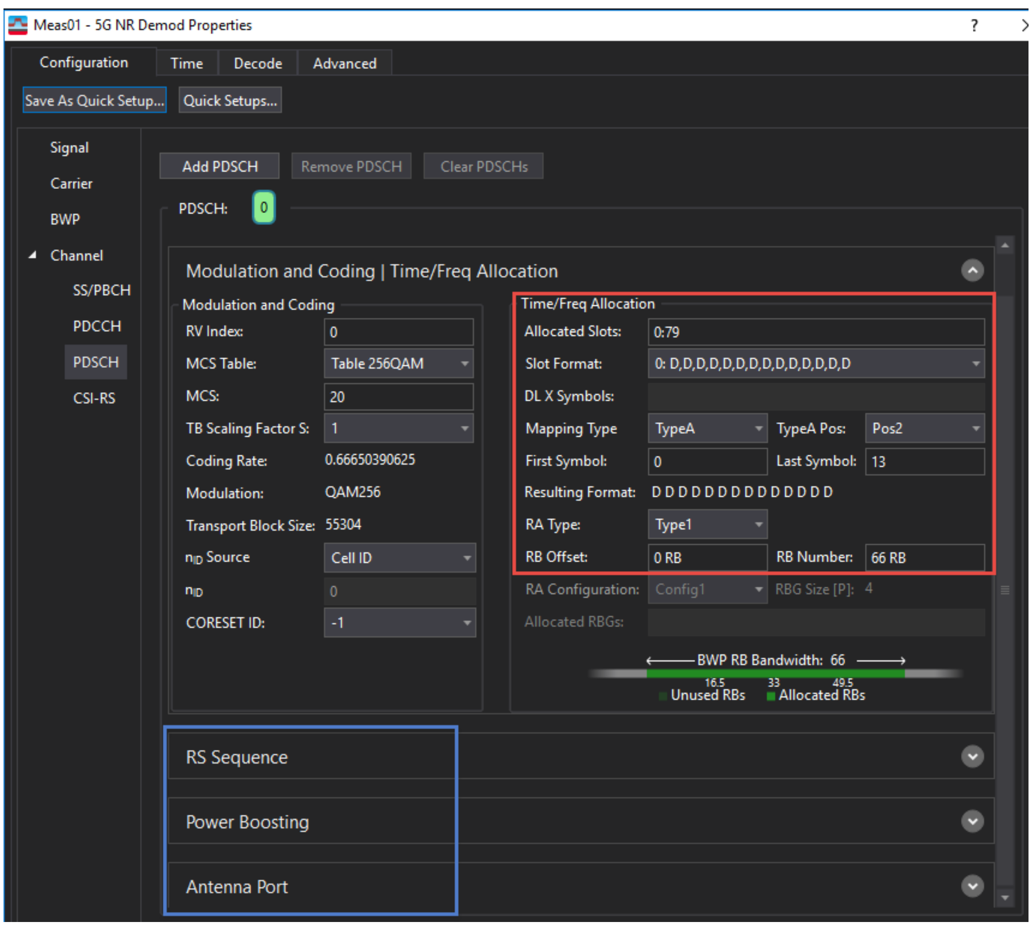
Table 5.1.3.1-2 has 256 QAM as maximum modulation

Table 5.1.3.1-3 has 64 QAM as maximum modulation

Table 5.1.3.1-1 has 64 QAM as maximum modulation, and is for low spectrum efficiency (LowSE).

See 3GPP TS38.214 for more information.

– Under the Time/Freq Allocation section, set
  – Allocated Slots to **0:79**
  – Slot Format to **0**
  – First Symbol to **0**
  – Last Symbol to **13**
  – RB Offset to **0 RB**
  – RB Number to **66 RB**



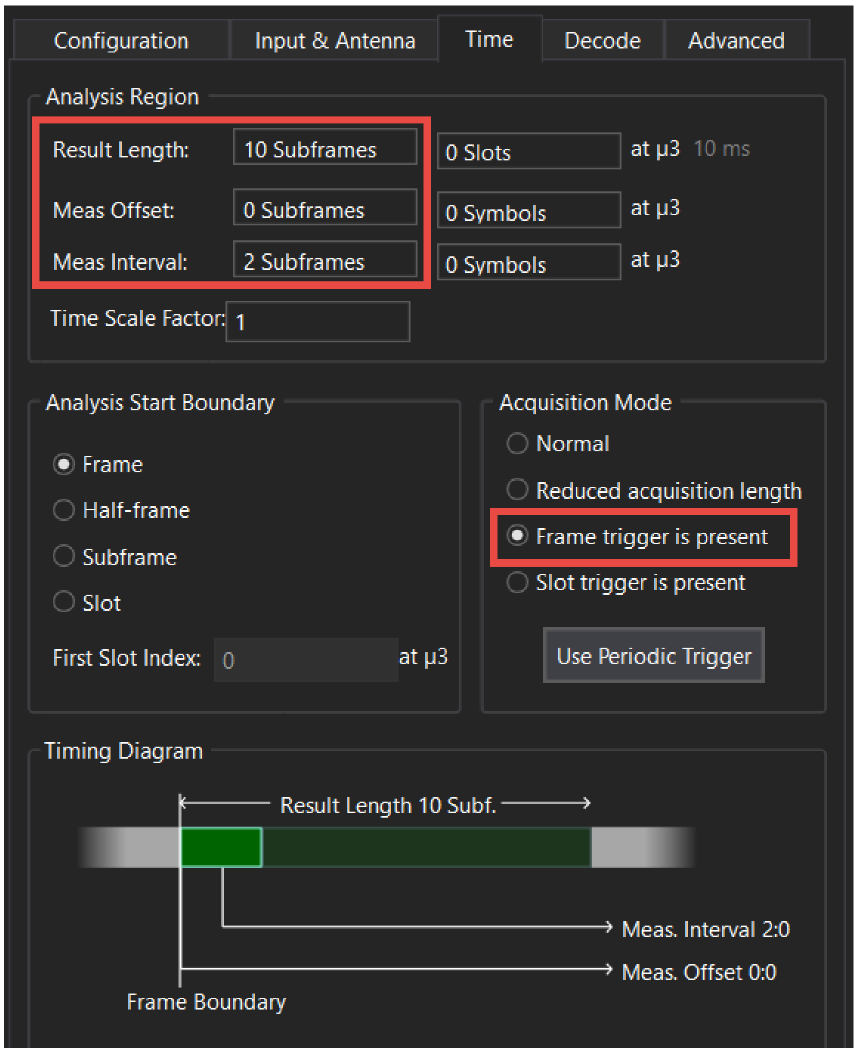
We will use the default values for RS Sequence, Power Boosting, and Antenna Port. Power s would not change the DMRS sequences, but they might be interested in modifying Power Boosting.

13. Select the **Time** tab and set:

– Result Length to **10 Subframes**.

– Meas Interval to **2 Subframes**.

– Select **Frame Trigger is Present**.



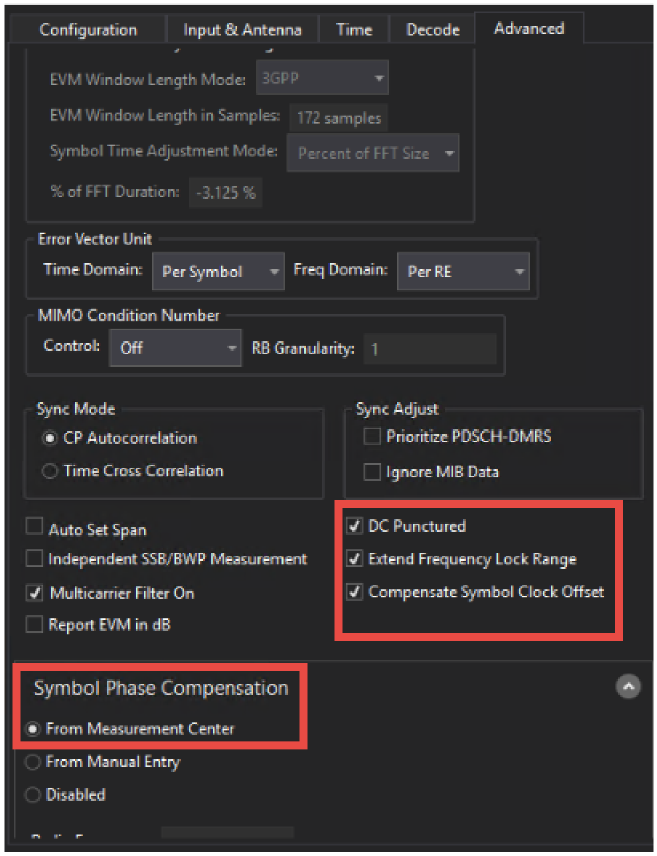
14. Select the **Advanced Settings** tab and select **DC Punctured**.

5G NR counts the DC subcarrier as a valid subcarrier for rate-matching purposes. The network decides if the DC subcarrier is modulated or not. High LO feedthrough will impact demodulation and EVM performance of the input signal. This setting is off by default.

Use **Extend Frequency Lock Range** if you cannot lock to the input signal.

Compensate Symbol Clock Offset is used along with timing track to compensate for clock error in the input signal. The Symbol Clock Error result is reported in the Summary trace.

Symbol Phase Compensation > **From Measurement Center** is enabled by default. It is specified in the 3GPP requirement and is used to compensate for phase differences between symbols caused by up conversion or down conversion. Getting this setting wrong will cause demod issues.



15. From the menu bar, select **Window** > **Trace Layout** > **Tile Visible**.

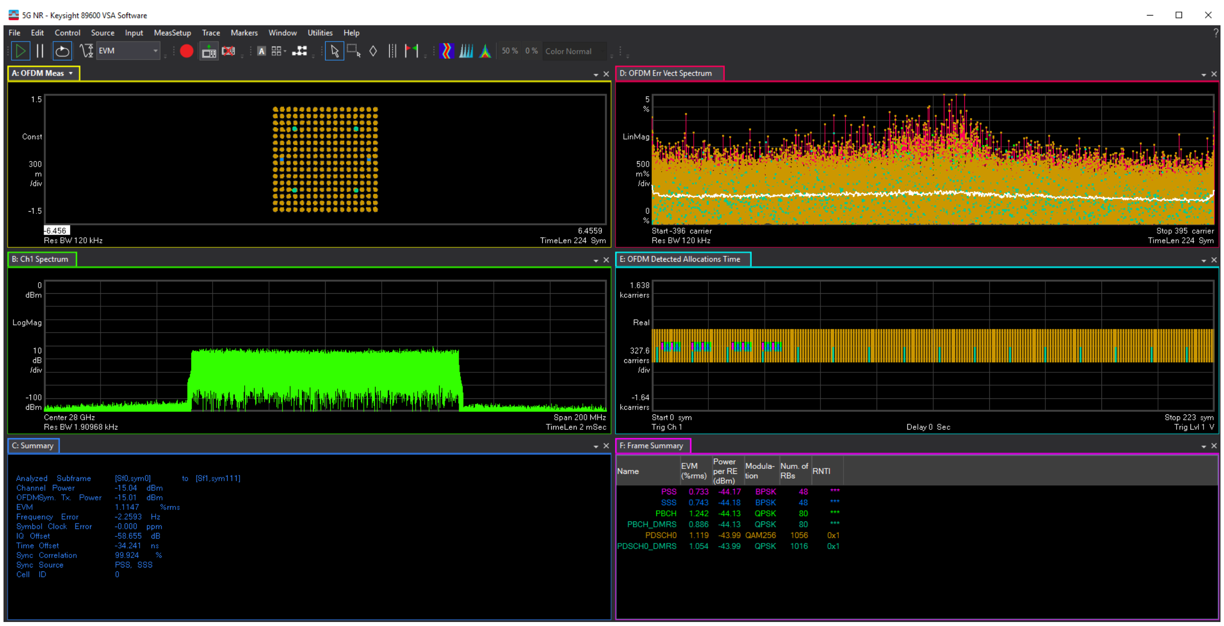
This will display all six 5G NR traces on the display.

16. Select the **Auto-Range** icon to run the measurement for **EVM-Table or Algorithm Based.**

– EVM - Table or Algorithm Based performs EVM optimization based on prescribed table/algorithm instead of using EVM in the feedback loop. This method of EVM auto-range is normally faster than Meas Based Iteration, but may not achieve the most optimal setup for minimized EVM).

– EVM - Meas Based Iteration has a feedback loop around the entire measurement, uses the measured EVM in the feedback loop, and tries to adjust hardware parameters to minimize the EVM. It is the slowest EVM auto-range method, but it should achieve the most optimal setup for good EVM.

TIP The VSA has color coding based on channel type, marker coupling to pinpoint error, symbol level analysis (by changing the measurement interval, and measurement offset into a single symbol).



More About the 5G NR Traces

– Trace A: shows the composite constellation diagram showing different modulation formats for the different channels/signals present in the transmitted signal.

– Trace B: shows the frequency spectrum.

– Trace C: shows the composite error metrics. You can also see the automatically detected Cell ID value and the Channel Power.

– Trace D: shows the EVM versus subcarrier and symbol.

– Trace E: shows the detected allocations of all channels/signals within the measurement interval. (For this example, 2 Subframes) You can see the 8 active SS Blocks in the first four slots.

– Trace F: shows the frame summary: EVM Power per RE, Modulation format, Number of RB and RTNI of the individual channels/signals.

For more information on these traces, see the Online help.

Trace Filtering

The VSA has per-trace filtering to filter by subsegments and channels. Subsegment refers to Layers, (in case of MIMO), BWP, and SS Block. In the downlink, Layers in DL-BWP and SS Block are presented as subsegments. In the uplink, Layers in UL-BWP are presented as subsegments.

The following traces can be filtered by subsegments and channel types.

– OFDM Meas

– OFDM Ref

– Error Vector Spectrum

– Error Vector Time

– Detected Allocations Time trace can be filtered per channel only

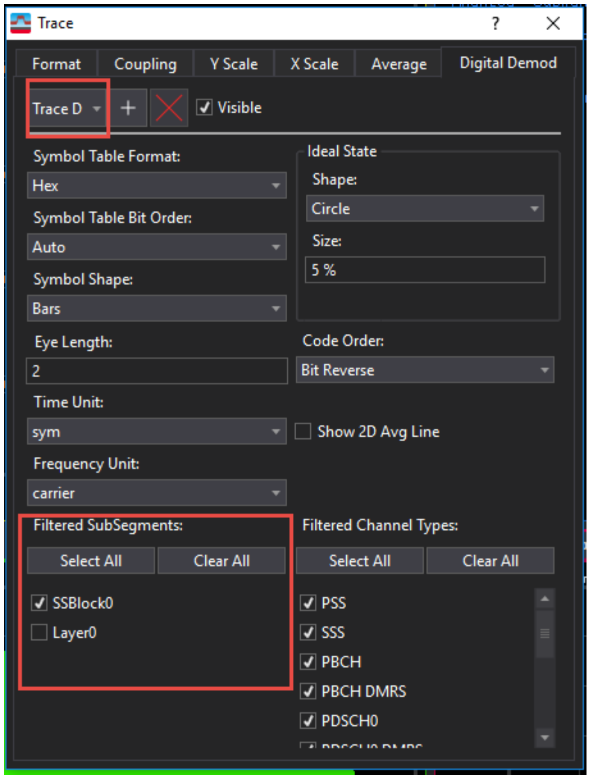
The rest of the traces do not support per-trace filtering.

A Simple Example

We will apply per-trace filtering to Error Vector Spectrum (Trace D) and Detected Allocations Time (Trace E) traces.

1. From the menu bar, select **Trace** > **Digital Demod**.
2. In the Trace Dialog, select **Trace D** (OFDM Error Vector Spectrum) from the dropdown.
3. In the Filtered SubSegments area, clear the **Layer0** check box.

This allows you to take a look at SS Block. You can also filter with SS Block Channels/Signals you want to see by using the Filtered Channel Type.



4. Select Trace E (OFDM Detected Allocations Time) from the Trace dialog.
5. In the Filtered SubSegments area, clear the **SS Block0** check box.

   This alloys you to look at Layer 0 information, which is the DL-BWP information.

6. In the Filter Channel Types area, **Clear All** selections, then select just **PDSCH-DMRS**.

   You now see a gap in two of the DMRS symbols. Why is this?

   Notice that the Frame Summary table shows Num. of RBs for PDSCH of 1056 and 1016 for PDSCH-DMRS. The signal configuration only had 66 RBs. Why the change in the measurement result?

   The RB result in the Frame Summary table is per Slot. In this example, we changed the measurement interval to 2 Subframes, which is 16 slots for 120 kHz numerology (8slots/subframe). 66*16=1056. For PDSCH-DMRS, the value is 1016 because of the 16 slots overlap with the SS Block, which occupies 20 RBs. This results in 20 RBs being punctured from DMRS in these two slots, so the total RB Number for DMRS is 1056-20*2 = 1016.

Using the equivalent SCPI commands

On the VXG:

```
SYSTem:PRESet
RF1:FREQuency:CW 28GHZ
RF1:POWer:AMPLitude -10dBm
SIGNal1:MODE NR
SIGNal1:NR5G:CCARrier:BWIDth FR2BW100M
SIGNal1:NR5G:CCARrier:SNUMerology MU3
SIGNal1:NR5G:CCARrier:DLINk:SSBLock:LMAX 64
SIGNal1:NR5G:CCARrier:DLINk:SSBLock:ACTive:INDices "0:7"
SIGNal1:NR5G:CCARrier:DLINk:SCH0:MCS 20
SIGNal1:NR5G:WAVeform:GENerate
SIGNal1:NR5G:TRIGger:SYNC:MARKer M2
SIGNal1 ON
RF1:OUTPut ON
```

For multi-channel instruments, set RF Out (all) to On.

```
RFALl:OUTPut ON
```

On the X-Series Signal Analyzer:

```
INSTrument:SELect VSA89601
SYSTem:PRESet
FREQuency:CENTer 28 GHz
INPut:ANALog:RANGe:AUTO
INITiate:PAUSe
INPut:TRIGger:STYLe "External"
INPut:TRIGger:LEVel:EXTernal 1V
INPut:EXTension:PARameters:SET "ExtTriggerLoc", 2 (This will set it to Trigger 3)
NR5G:FRAMe:TRIGger:ENABled 1
INPut:EXTension:PARameters:SET "PhaseNoiseOptDualLoop", 1
MEASure:CONFigure NR5G
NR5G:CCARrier:CIDentity:AUTO 1 |OR| NR5G:CCARrier:CIDentity 0
```

```
NR5G:CCARrier:TBANdwidth "FRTwo100MHz"
NR5G:DBWP:ENABled 1
NR5G:DBWP:NUMerology "Mu3"
NR5G:DBWP:ROFFset 0
NR5G:DBWP:RNUMber 66
NR5G:SSBLock:ENABled 1
NR5G:SSBLock:LMAX "L64"
NR5G:SSBLock:AINDexes "0:7"
NR5G:DBWP:PDSCh1:MCS:TABLe "Table2"
NR5G:DBWP:PDSCh1:MCS 20
NR5G:DBWP:PDSCh1:SLOT:ALLocated "0:79"
NR5G:CCAR:PDSCH1:SFI 0
NR5G:CCAR:PDSCH1:SINDex:FIRSt 0
NR5G:CCAR:PDSCH1:SINDex:LAST 13
NR5G:CCAR:PDSCH1:ROFFset 0
NR5G:CCAR:PDSCH1:RNUMber 66
NR5G:RLENgth 10
NR5G:SUBFrame:INTerval 2
NR5G:FRAMe:TRIGger:ENABled 1
NR5G:DC:PUNCtured 1
NR5G:MCFilter:ENABled 1
NR5G:FREQuency:LOCK:EXTended 1
NR5G:COMPensate:SYMBol:CLOCk:OFFset 1
DISPlay:LAYout 3,2
INPut:ANALog:CRITeria:RANGe:AUTO "EVM", -1
```

Creating a DL MIMO Signal Using PathWave N7631APPC Signal Generation

NOTE The VXG must have the N7631APPC Signal Generation for 5G NR license installed.

This procedure will show you how to configure and analyze a downlink (DL) multiple input, multiple output (MIMO) signal using PathWave Signal Generation and the 89600 VSA software. The hardware setup below includes a 2-channel VXG signal generator and a 2+ channel, 33 GHz or higher Infiniium UXR-Series Oscilloscope.

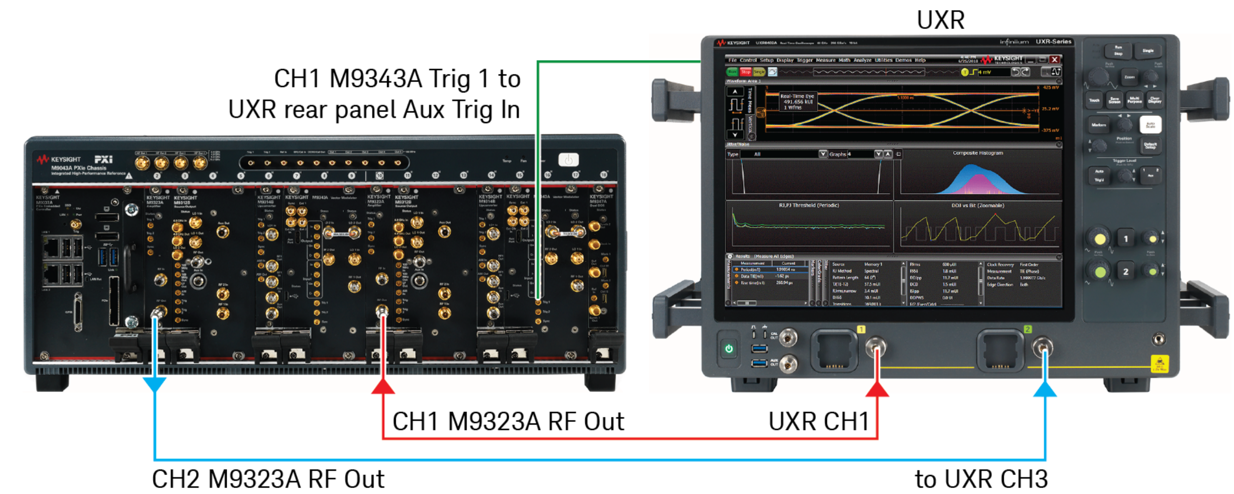
TIP If you do not have access to a Keysight Infiniium UXR Real-Time Oscilloscope, a UXR recording waveform file has been included in the Example waveform file folder:

```
D:\Users\Instrument\Documents\Keysight\PathWave
\SignalGenerator\Examples
```

You will need to copy the **5GNR_UXR_Recording_28GHz.csv** file to the X-Series Signal Analyzer or the PC running the VSA application. Steps have been included below to successfully run the recording.

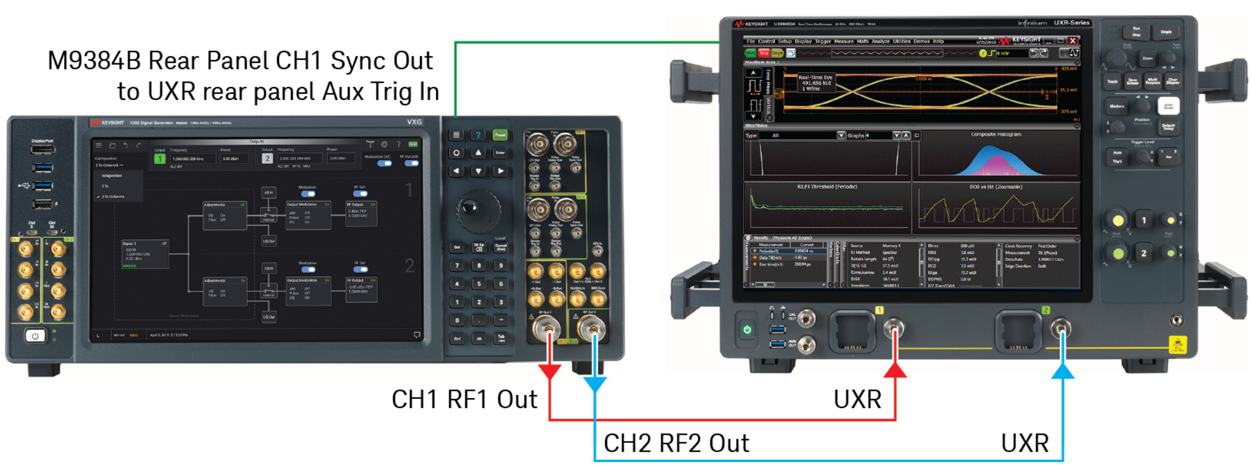
Equipment Setup for the M9383B

- CH1 M9323A front panel RF Out to UXR front panel CH1
- CH2 M9323A front panel RF Out to UXR front panel CH3
- CH1 M9343A front panel Trig 1 to UXR rear panel Aux Trig In



Equipment Setup for the M9384B

- M9384B CH1 front panel RF Out to UXR front panel CH1
- M9384B CH2 front panel RF Out to UXR front panel CH3
- M9384B rear panel TCH1 Sync Out to UXR rear panel Aux Trig In

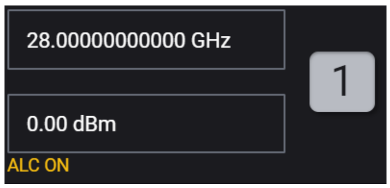


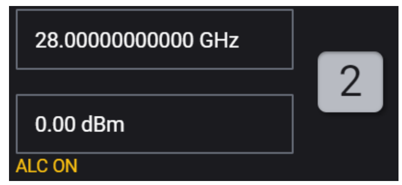
Using the graphical user interface

To generate the waveform in PathWave:

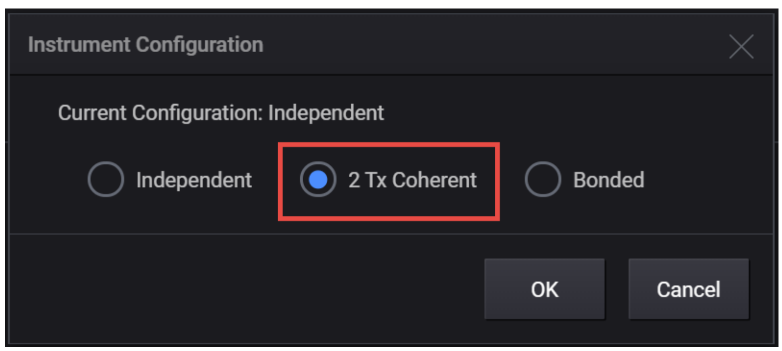
On the VXG:

1. Select **Preset** > **Preset** to set the VXG to a known state:
2. In the Output area for both Channel 1 and Channel 2, set Frequency to **28 GHz** and Power to **0 dBm**.

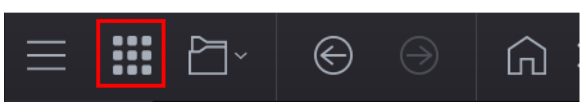




3. In the Menu/Tool Bar, select the Triple Bar icon (top left corner of the display, and then select Configure Channels. Change the signal configuration from Independent to **2 Tx Coherent**.

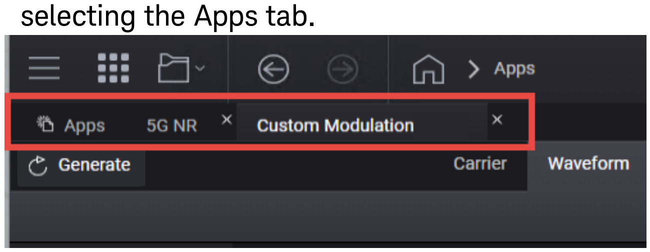


4. Select the **Radio Apps** block to open the mode selection panel.

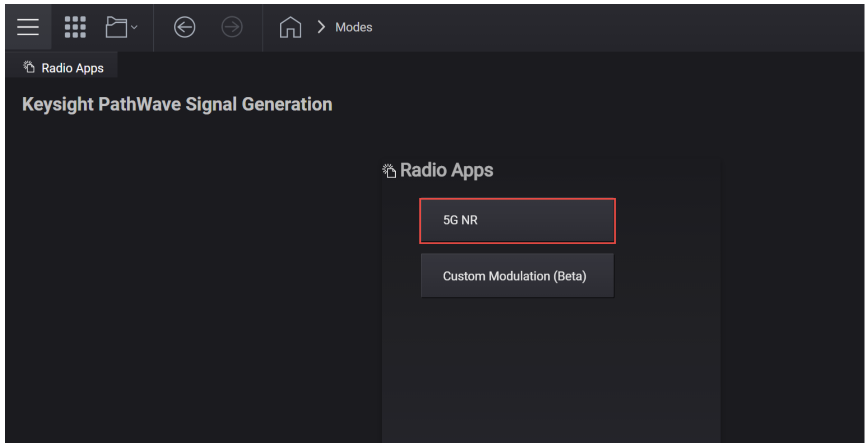


NOTE

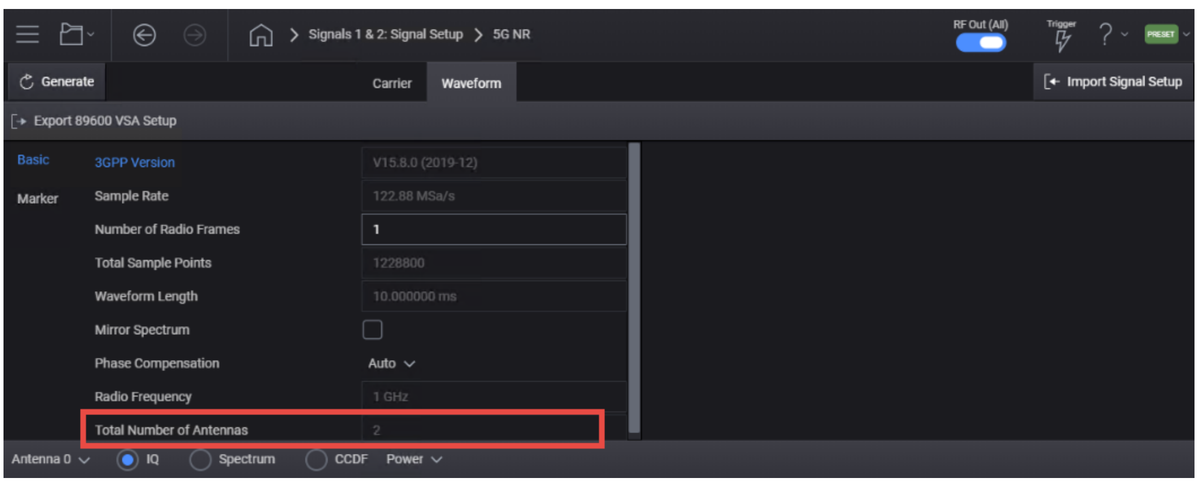
If you have previously opened any of your available applications, the dialog box will not be displayed. Instead, you will see tabs of the applications that have already been used. You can view all of your available applications by selecting the Apps tab.



5. Select **5G NR** to enter the 5G NR signal mode.



6. Select the **Waveform** tab and observe that Total Number of Antennas has been automatically set to 2. This means that two antenna port signals will be generated.



7. Select the **Carriers** tab > **Cell Specific** node, and confirm the following settings:

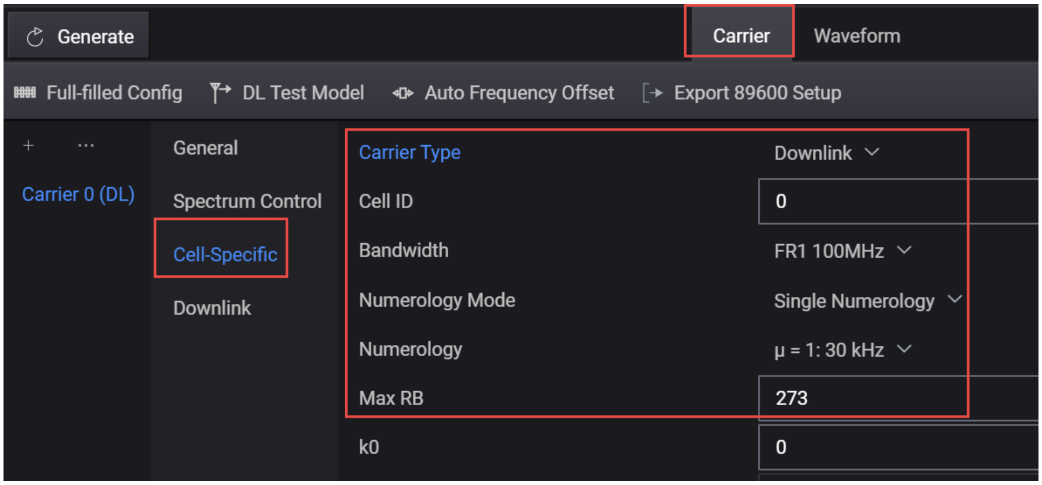
   – Carrier Type = **Downlink**

   – Cell ID = **0**

   – Bandwidth **FR1 100 MHz**

   – Numerology = μ= **1:30 kHz**

– Max RB = **273**

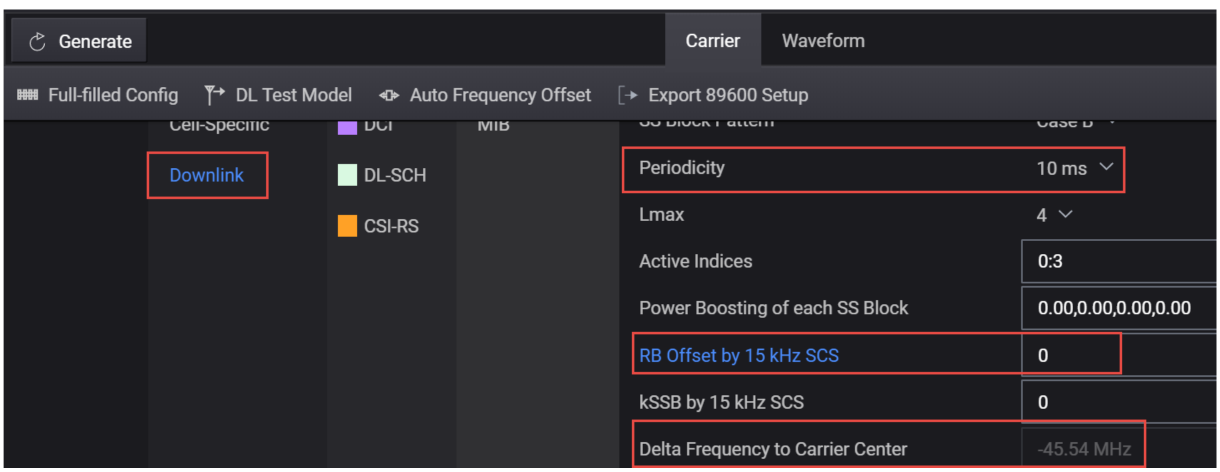


8. Select the **Downlink** node > **SS PPCH** > **SS PBCH Block** and set:

   – Periodicity to **10 ms**

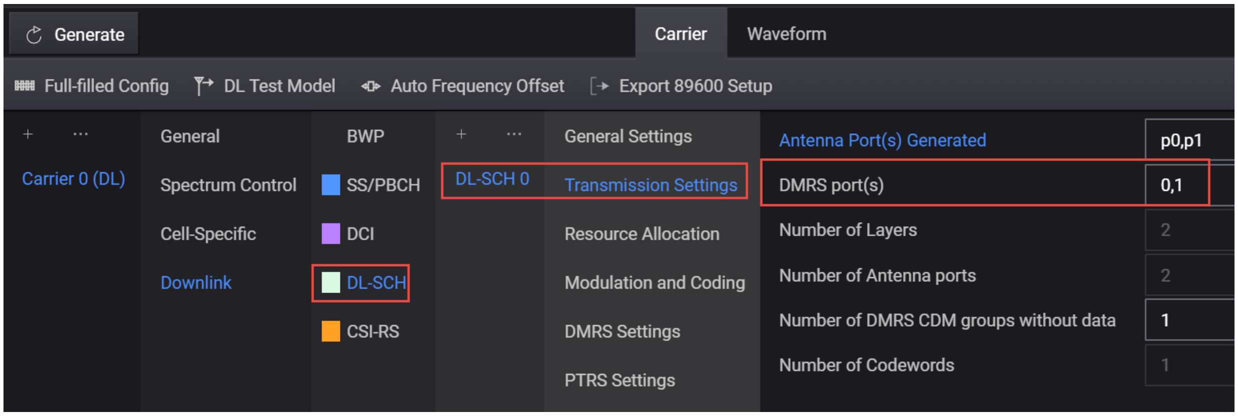
   – RB Offset by 15 kHz SCS to **0**

   Notice that this automatically changes the Delta Frequency to Carrier Center to –45.54 MHz.



9. Select the **DL-SCH** node > **Transmission Settings** and verify that DMRS port(s) is set to **0,1**.

The Number of Layers is updated to 2 and each layer is assigned with a particular DMRS port. Also, Antenna Ports Generated is automatically set to p0,p1. This will map generated multiple antenna port signals to different antennas (instruments).



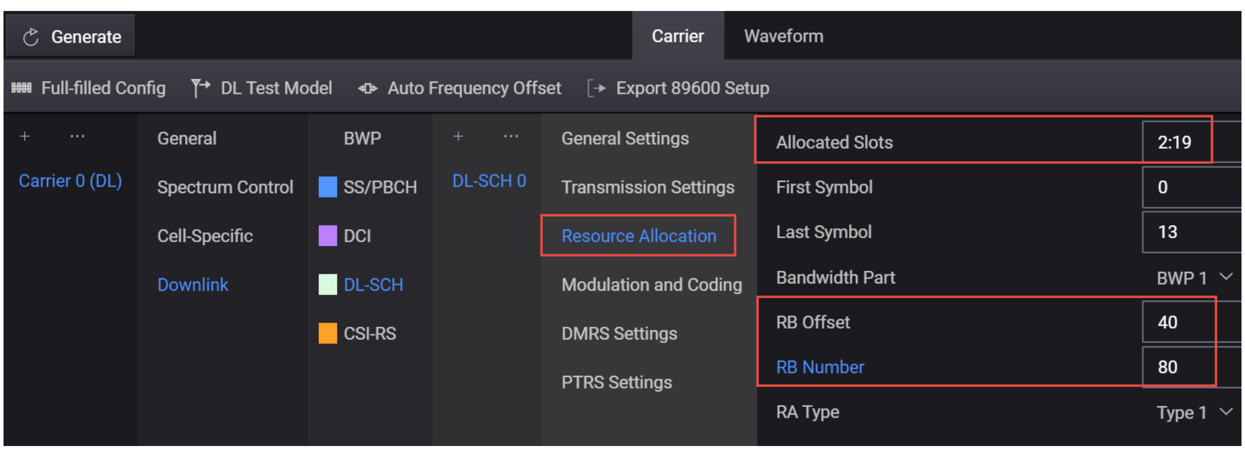
10. Select the **Resource Allocation** node and set:

   – Allocated Slots to **2:19**

   – RB Offset to **40**

   – RB Number to **80**

   DL-SCH0 will occupy the RBs 40-80 and DL-SCH1 will occupy the rest of the resources.

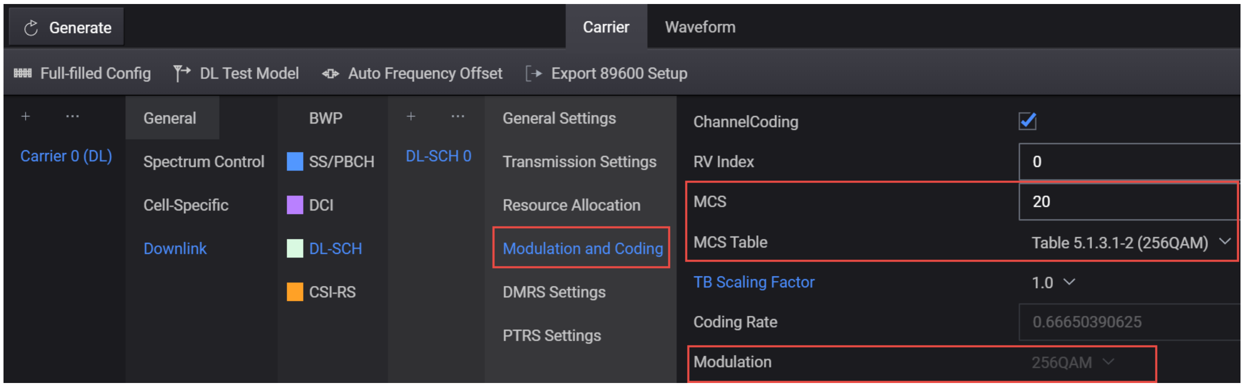


11. Select the **Modulation and Coding** node and set:

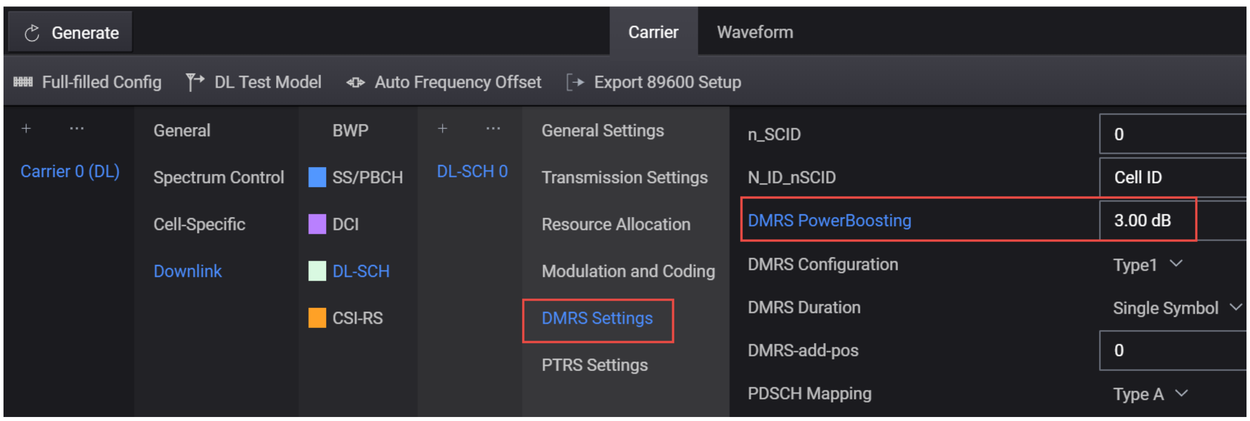
   – MCS to **20**

   – MCS Table to **5.1.3.1-2 (256 QAM)**

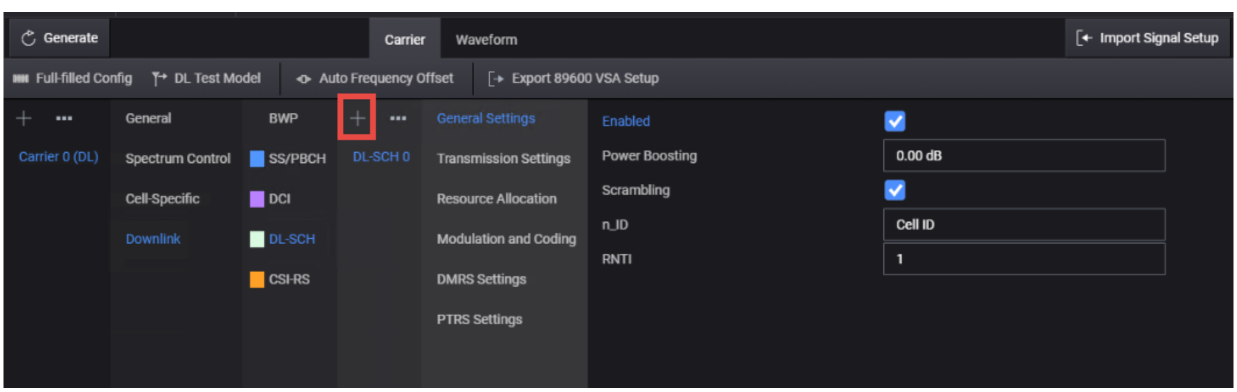
Notice that modulation is updated to 256 QAM.



12. Select the **DMRS Settings** node and set DMRS Power Boosting to **3 dB**.

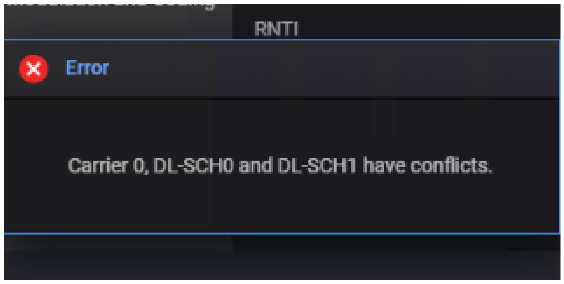


13. Under the DL-SCH 0 node, select the + icon to add a new DL-SCH (DL-SCH1).



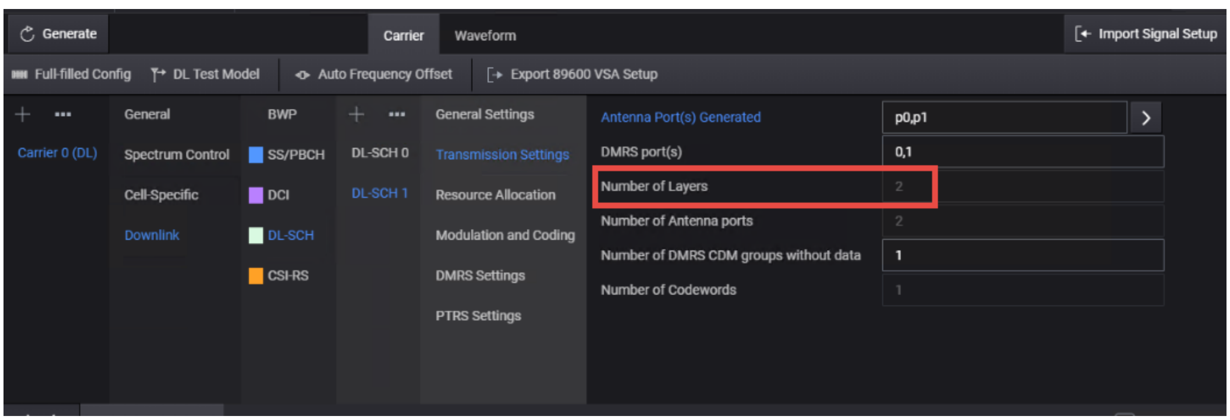
NOTE

This will create a conflict between DL-SCH0 and DL-SCH1. This will be resolved in a later step.



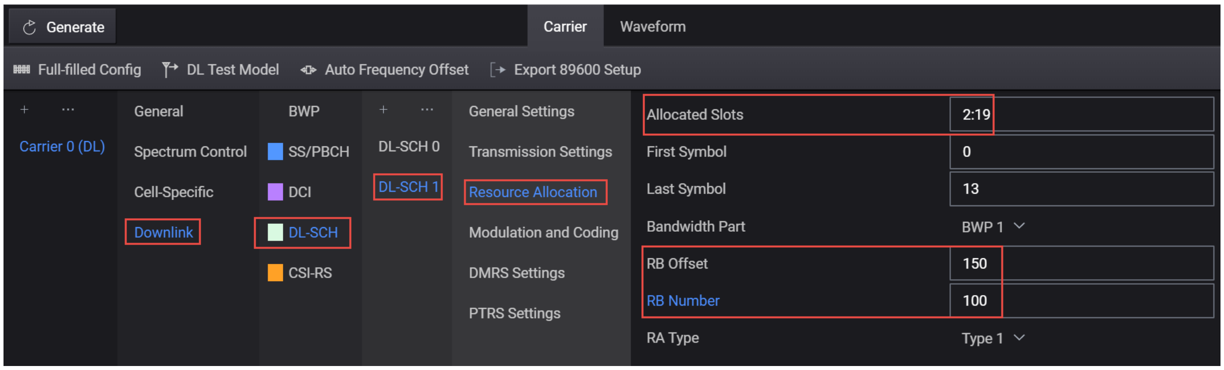
14. From the Channels node, select **DL-SCH** > **DL-SCH1** > **Transmission Settings** and verify that DMRS port(s) is set to **0,1.**

    Notice that Number of Layers is updated to 2 and each layer is assigned with a particular DMRS port. Antenna Ports Generated is automatically assigned P0,P1, which will map generated multiple antenna port signals to different antennas (instruments).



15. Select the **Resource Allocation** node and set:
    - Allocated Slots to **2:19**
    - RB Offset to **150**
    - RB Number to **100**

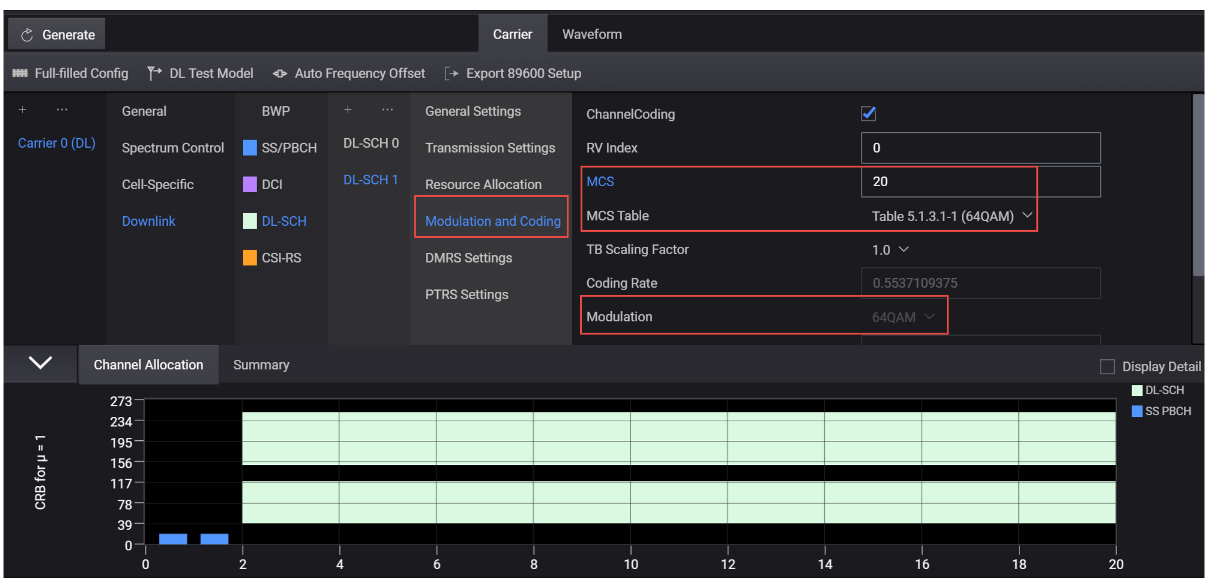
Notice that this resolves the conflict between DL-SCH channels. (The pink shading is removed from the Channel Allocation graph. To clear the conflict error message at the bottom of the display, select the Message icon (bottom, right corner) and select **Clear**.



16. Select the **Modulation and Coding** node, and set:

– MCS to **20**

– MCS Table to **Table 5.1.3.1-1 (64 QAM)**



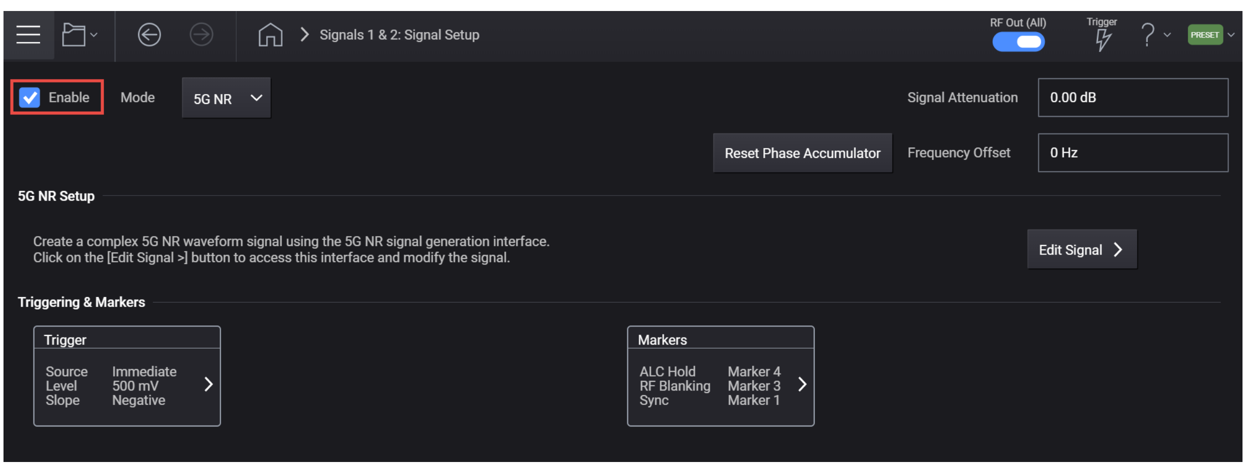
17. Select the Waveform Tab and select **Generate**.

18. In the bottom panel, select **Spectrum**.

You should see a spectrum like the one below.

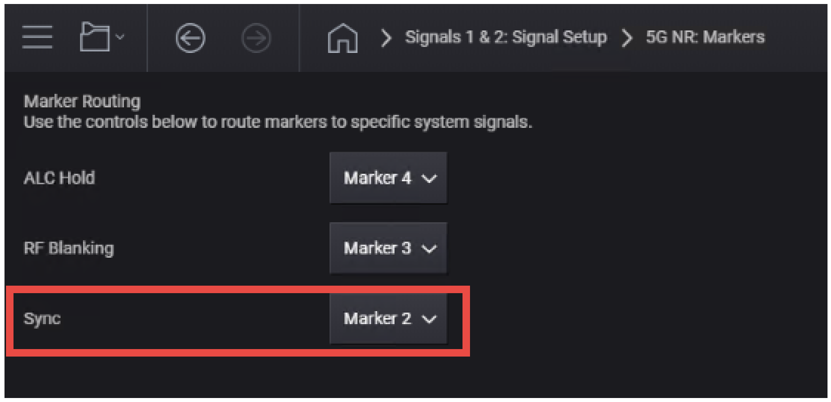
19. Return to the **Carriers** tab and select **Export 89600 VSA Setup**. Save the .setx file to a USB drive to transfer to the VSA.

20. Select the **Back** (<-) button to return to the Signal Setup dialog, then select the **Enable** Vector Modulation Signal check box.

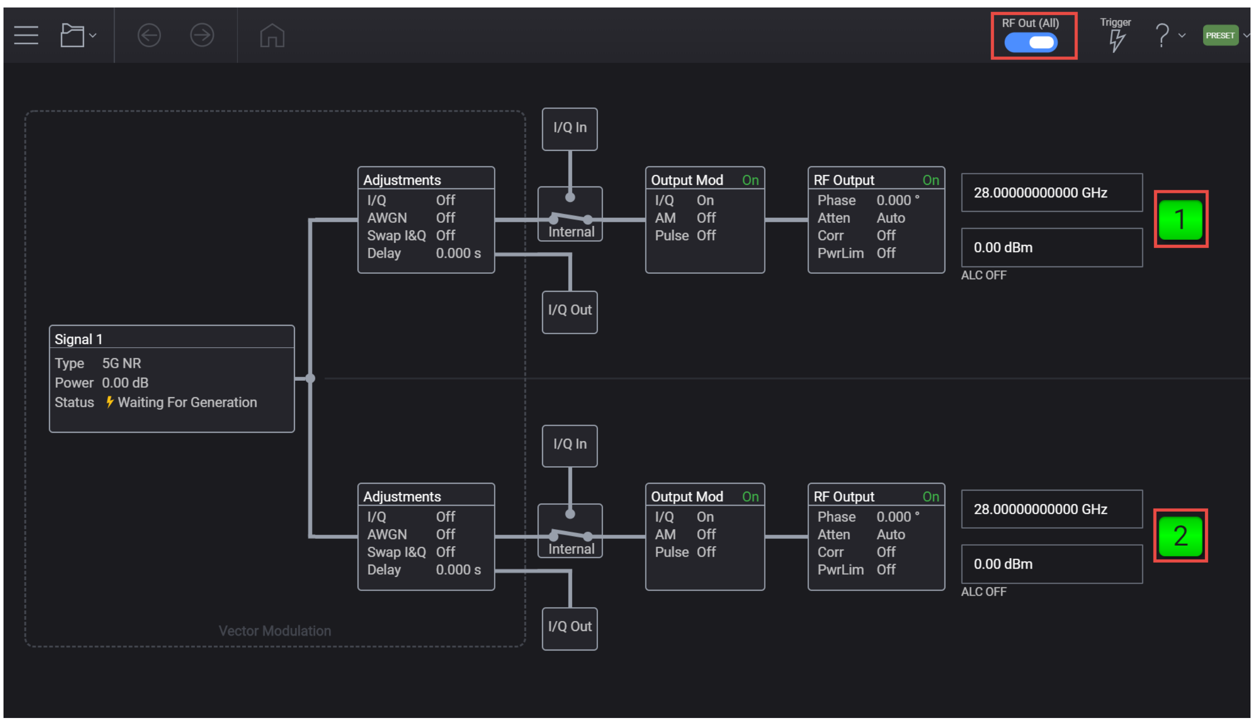


21. Select the **Markers** block, and set the Sync marker to **Marker 2**.

Marker 2 is the Frame Trigger.



22. Close the Signal Setup block and set RF Out to **On** by selecting the numbered channel indicator switches, and then select **RF Out (All)** master control switch to turn the RF output On for both channels or off for both channels.



On the UXR Oscilloscope (or X-Series Signal Analyzer with VSA):

To analyze the signal using the VXS on the UXR

— Open the VSA software by selecting **Mode Meas** > **Launch VSA**.

NOTE If accessing the instrument via a Remote Desktop connection, select the Screen tab (at the top of the display) to open the Mode/Measurement/View Selector window.

In the VSA software:

1. From the VSA menu bar, select **File** > **Preset** > **All** to set the VSA to a known state.

   – If you have access to a Keysight Infiniium UXR Real Time Scope, Continue with step 2 below.

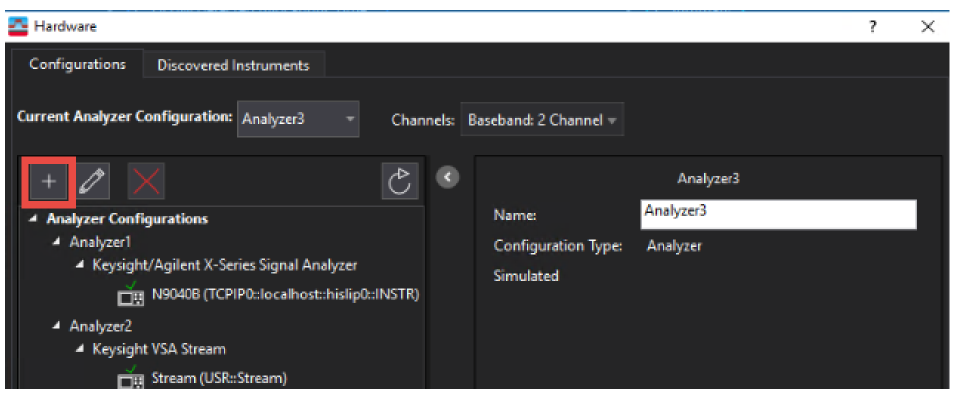
   – If you do not have access to a Keysight Infiniium UXR Real-Time Oscilloscope, a UXR recorded waveform file has been included in the Example waveform file folder of the VXG:

      a. Go to:
      `D:\Users\Instrument\Documents\Keysight\PathWave`
      `\SignalGenerator\Examples`

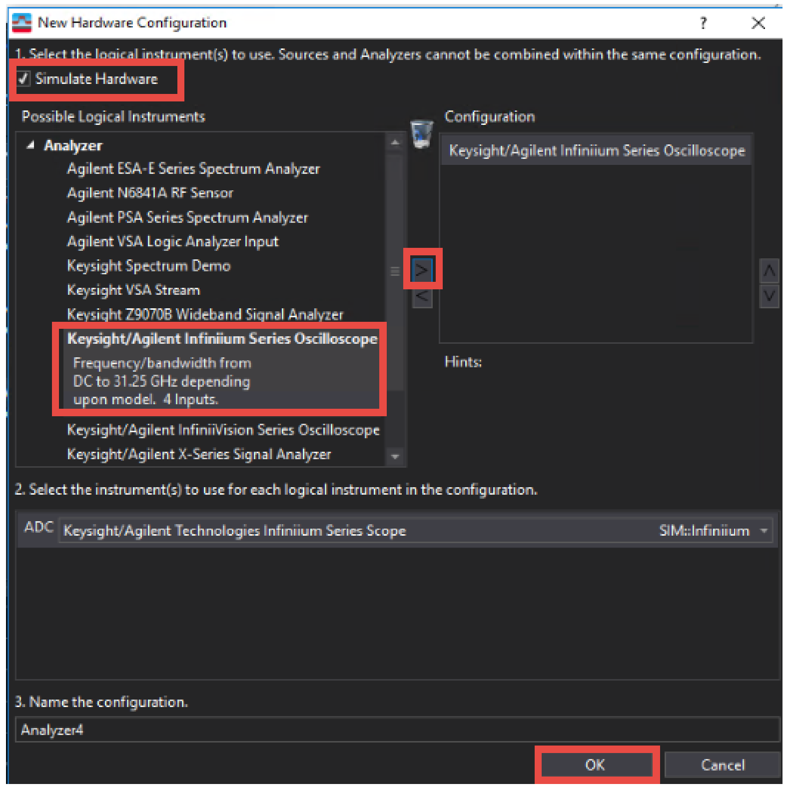
      Copy the **5GNR_UXR_Recording_28GHz.csv** file to the X-Series Signal Analyzer or the PC running the VSA application.

      b. To simulate the UXR, select **Utilities** > **Hardware** > **Configurations**.

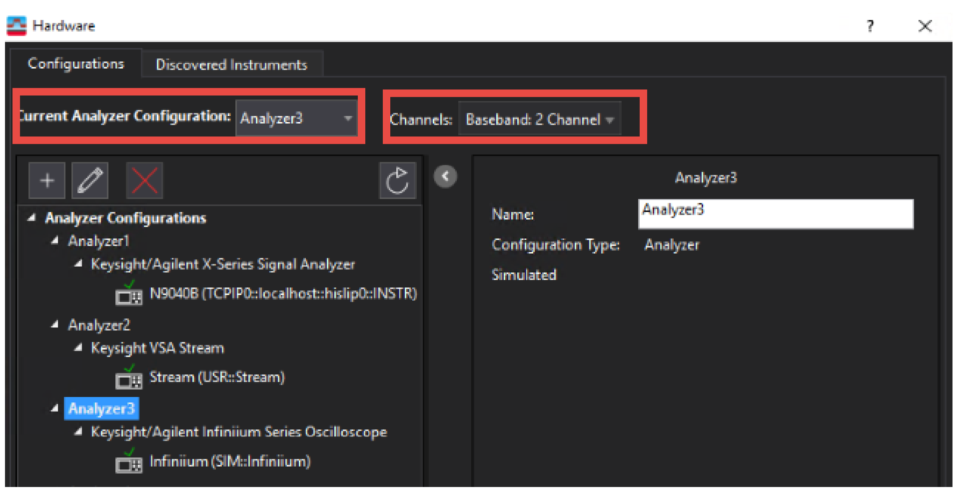
      c. Select the + icon, then in the New Hardware Configuration dialog, select **Simulate Hardware**.



d. Scroll down the Possible Logical Instruments and select **Keysight/Agilent Infiniium Series Oscilloscope** and select the right arrow to move it under Configuration.

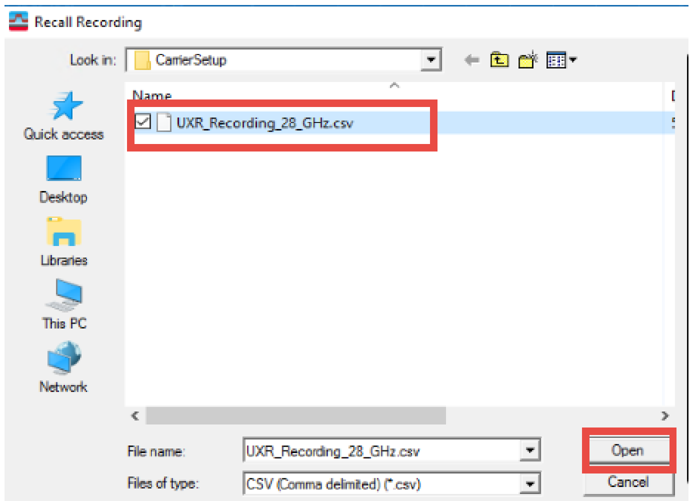


e. In the Hardware dialog, select **Analyzer 3** (or the associated analyzer number for the new configuration.) as the Current Analyzer Configuration. In the Channels dropdown menu, select Baseband 2 Channel, then close the dialog box.



f. Select **File** > **Recall** > **Recall Setup** and load the .setx file created in PathWave.

g. Select **File** > **Recall** > **Recall Recording**, select `UXR_Recording_28_GHz.csv`, then **Open**.



h. Continue with Step 4.

2. From the menu bar, select **Input** > **Channels** > **User** > **2 Channels**.

3. If you are using a UXR, Select Autorange .

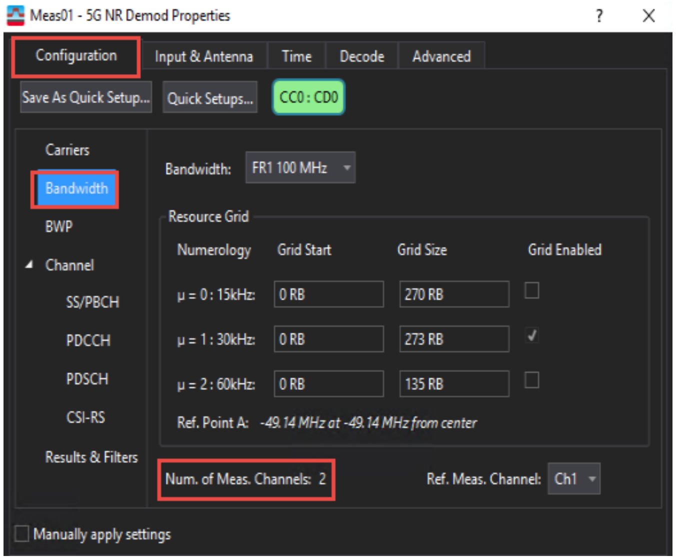
NOTE

Autorange does not work if you are simulating the waveform with the UXR recording. Continue with the next step.

Auto Range samples the current input signal and then sets the full scale input range to the minimum range that includes the peak voltage sample of the input signal.

4. From the menu bar, select **MeasSetup** > **Measurement Type** > **Cellular** > **5G NR**.

5. Select **MeasSetup** > **5G NR Demod Properties** > **Configuration** tab > **Bandwidth** pane and note that the Num of Meas. Channels is set to **2**.

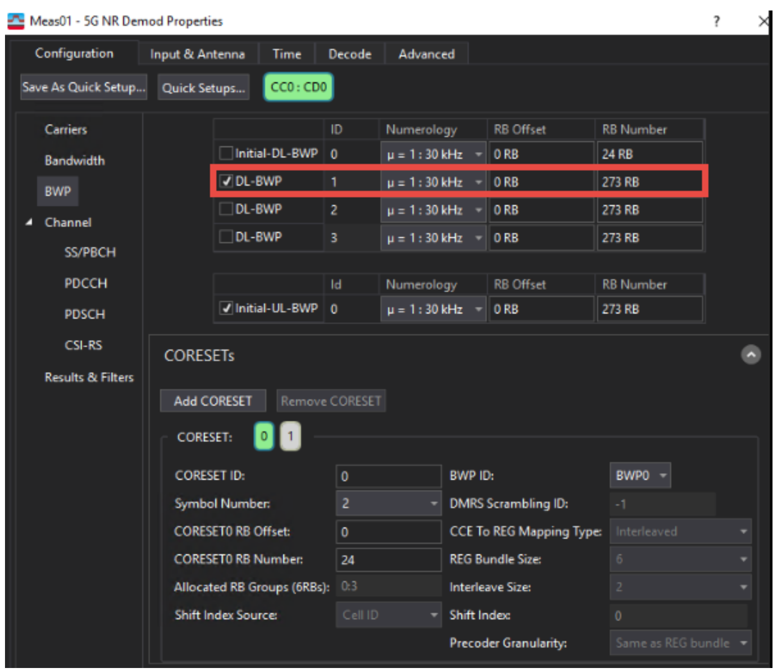


6. Select the **BWP** pane and confirm that DL-BWP is enabled. We will use the default settings of:

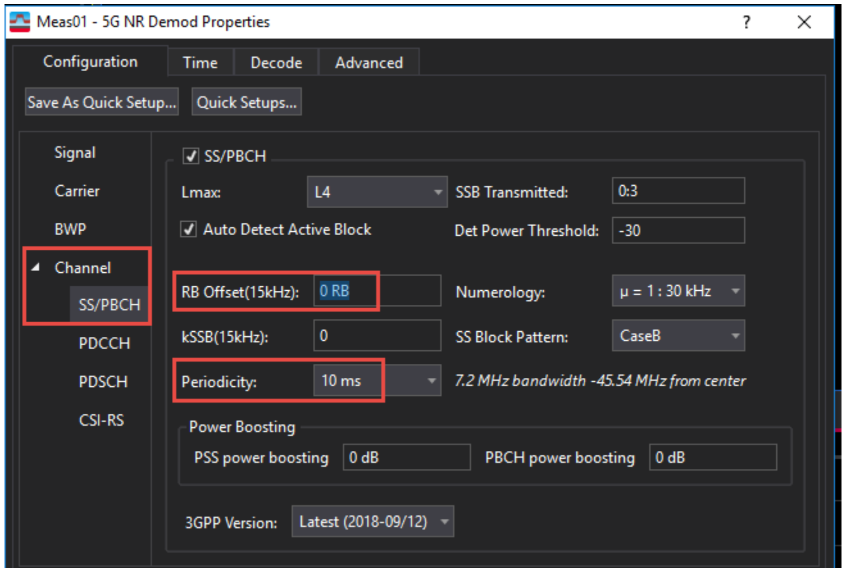
   – Numerology = **μ= 1:30 kHz**

   – RB Offset = **0 RB**

   – RB Number = **273 RB**



7. Select the **Channel** pane > **SS/PBCH** and verify RB Offset (15 kHz) is set to **0 RB** and Periodicity to **10 ms**.



8. Select the **PDSCH** pane and for PDSCH 0, set:

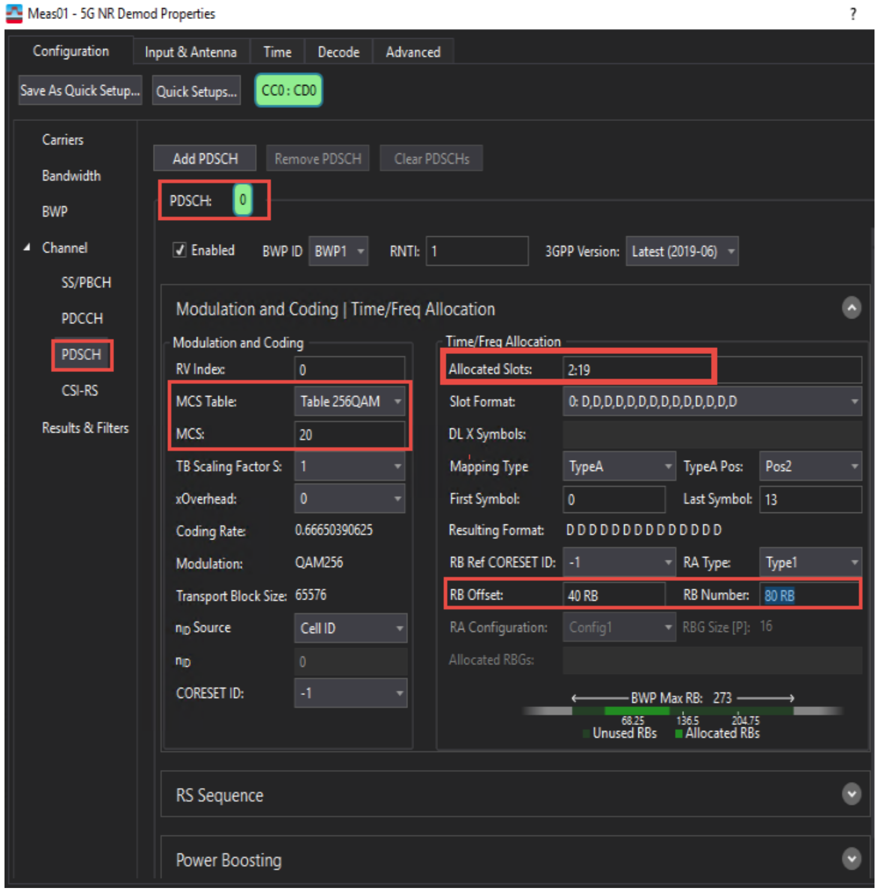
   – MCS Table to **Table 256 QAM**

   – MCS to **20**

   – Allocated Slots to **2:19**

   – RB Offset to **40 RB**

– RB Number to **80 RB**



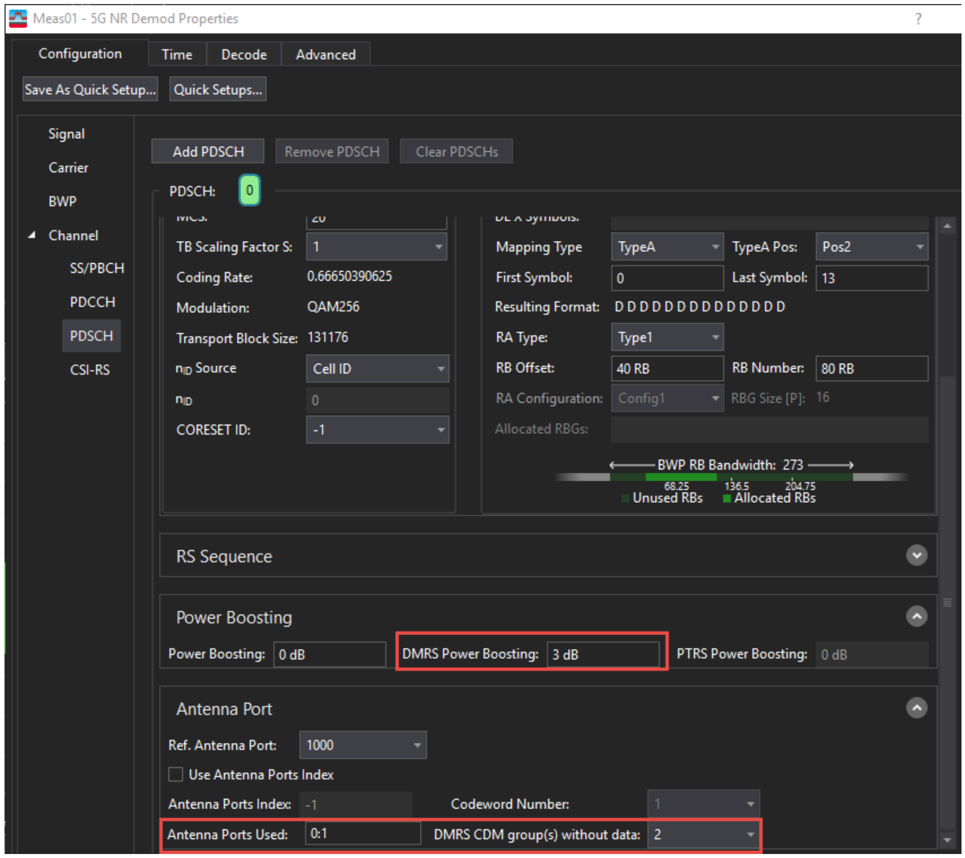
9. Scroll down and select the Antenna Port dropdown and set:

   – Antenna Ports Used,1 to **0,1**

   – DMRS CDM Group(s) without data to **2** (to match the PathWave setup)

10. Select the **Power Boosting** dropdown and verify that DMRS Power Boosting has automatically been set to **3 dB.**

According to the 3GPP definition, DMRS power boosting is 3 dB for CDM Group Number = 2 and VSA, similar to PathWave, changes the DMRS power boosting to 3 dB.



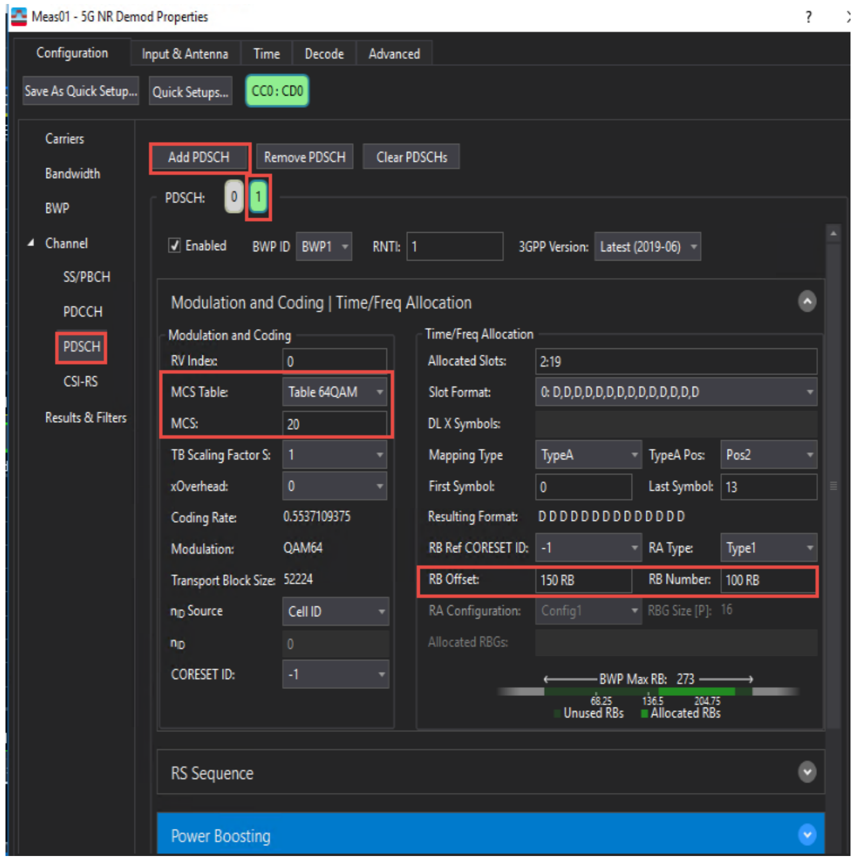
Now you should see the demodulated 256 QAM constellation and EVM results per layer in frame summary for PDSCHO.

11. To add and configure PDSCH1, select **Add PDSCH**.

12. Select PDSCH1 and set:

- MCS Table to T**able 64 QAM**
- MCS to **20**
- Allocated Slots to **2:19**
- RB Offset to **150 RB**

– RB Number to **100 RB**

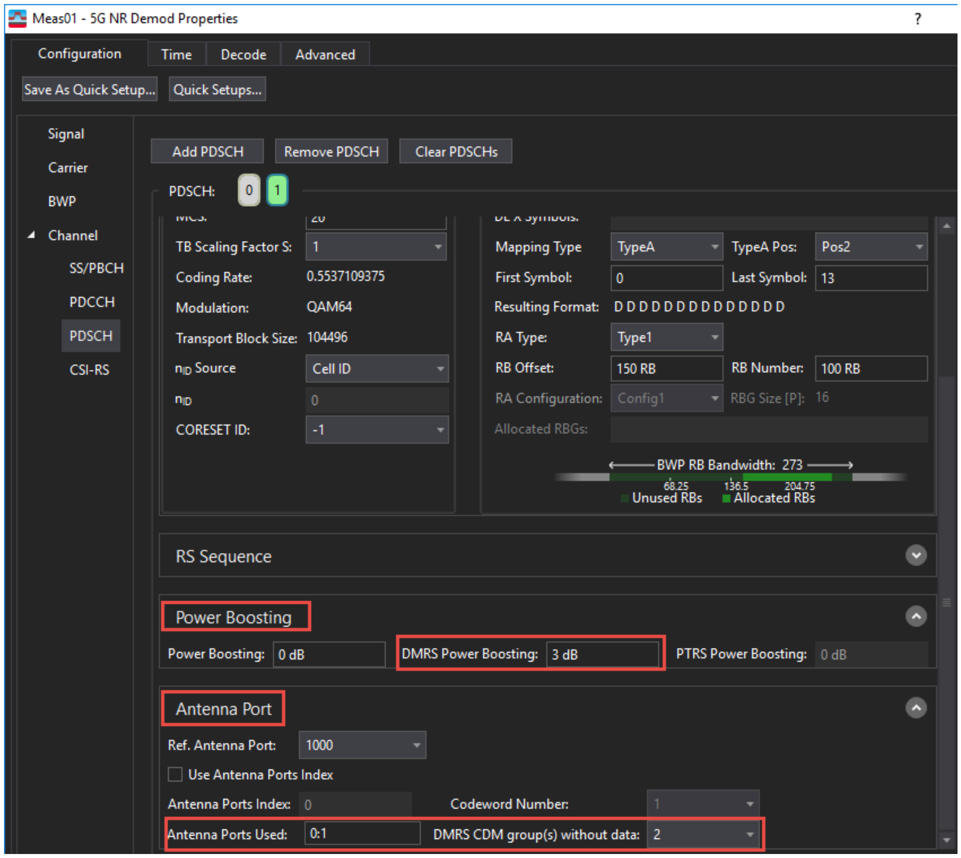


13. Scroll down and open the **Antenna Port** dropdown and set:

– Antenna Ports Used to **0:1**

– DMRS CDM group(s) without data to **2**.

14. Select the **Power Boosting** dropdown and verify that DMRS Power Boosting is set to **3 dB**.

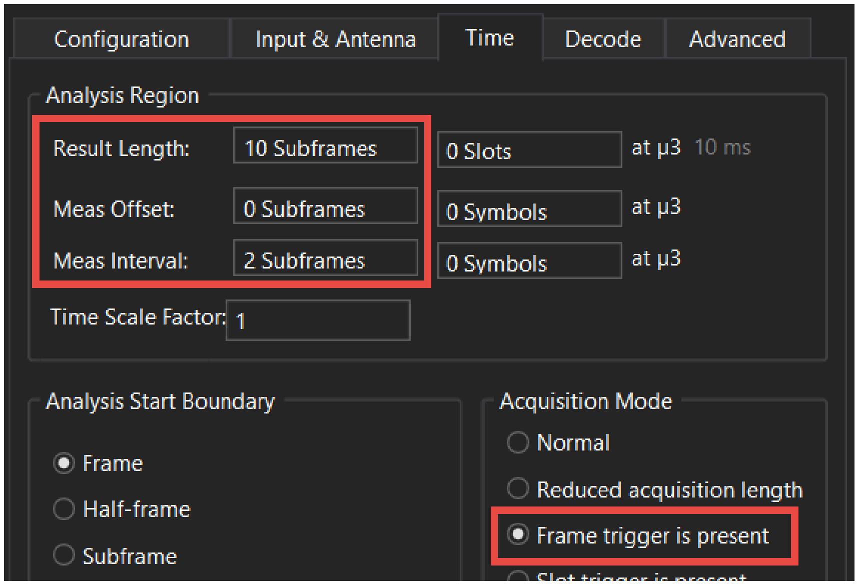


15. To configure the time settings, select the **Time** tab and set:

– Result Length to **10 Subframes**

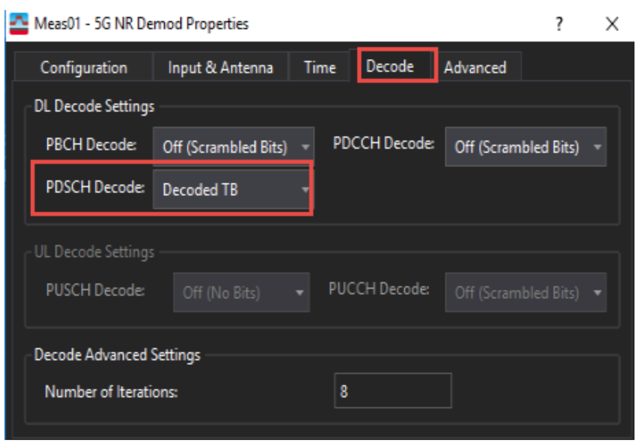
– Meas Interval to **2 Subframes**

– Enable **Frame Trigger is present. NOTE:** if using the UXR recording, leave Frame Trigger set to **Normal**.



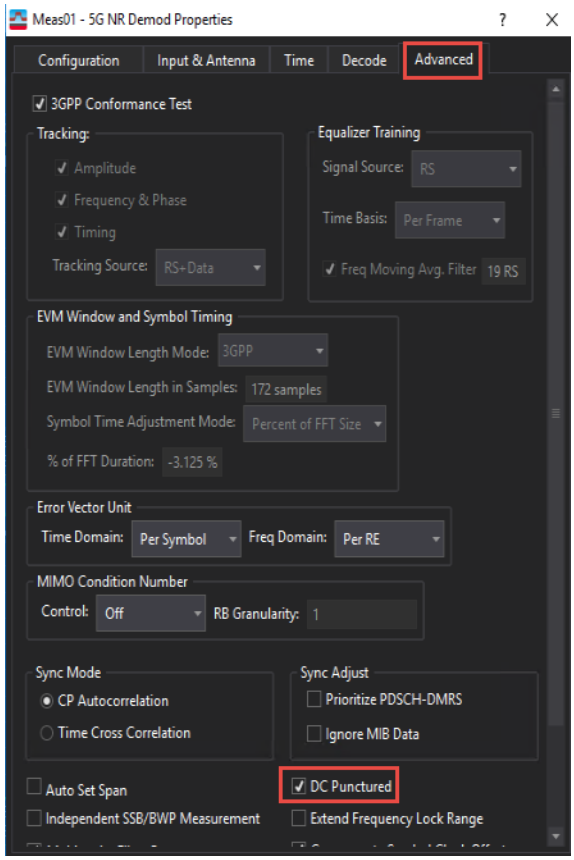
16. To configure the PDSCH decoding, select the **Decode** tab and set PDSCH Decode to **Decoded TB**.

This will decode PDSCH to the transport block, which is exactly the payload bits we configured in PathWave. Ensue that the Transport Block Size (TBS) 901344 is the same as in PathWave as this is the criteria to check the parameter alignment for channel decoding. TBS is auto calculated with MCS, Time/Frequency allocation, DMRS settings and Antenna Port settings.



NOTE Different decode levels are supported. This allows advanced users to be able to check into the intermediate step data for algorithm or troubleshooting.

17. Select the Advanced tab and select the **DC Punctured** check box then close the 5G NR Demod Properties dialog box.

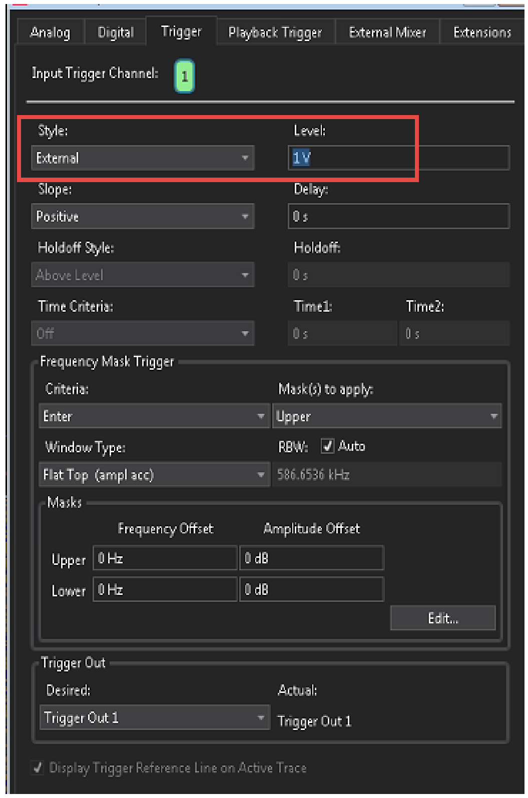


18. From the menu bar, select **Input** > **Trigger** and set:

– Style to **External**

– Level to **1 V**

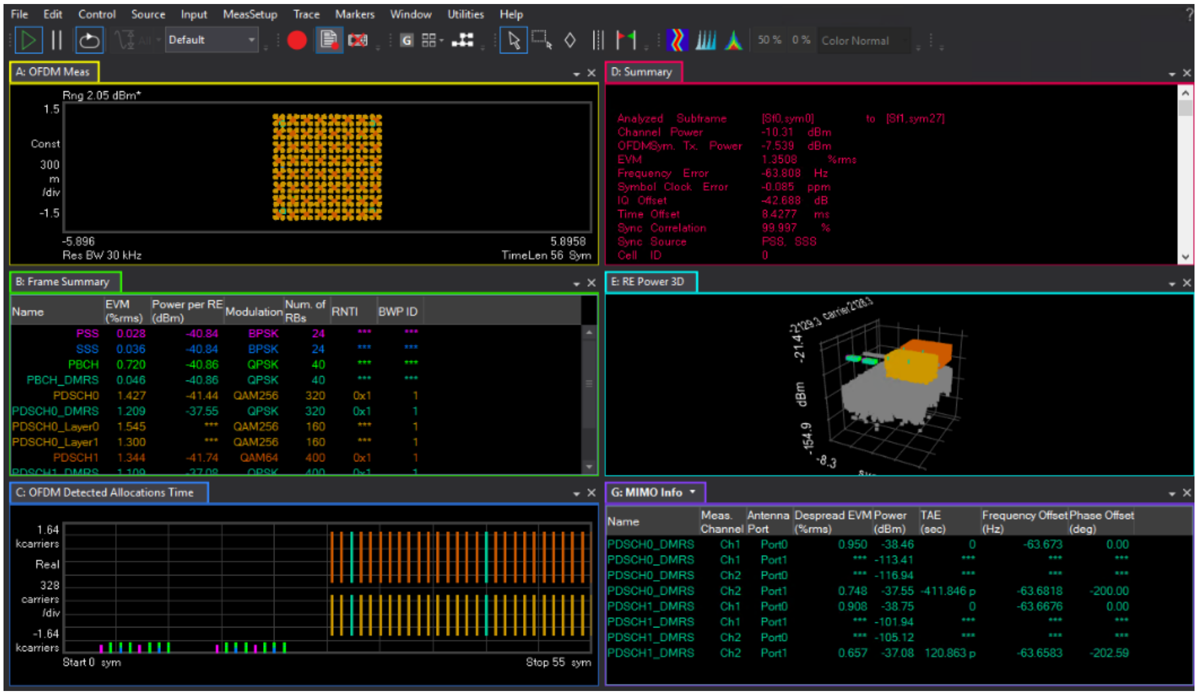
NOTE: if using the UXR recording, skip this step as you cannot set up an external trigger.



19. Change the traces so you can see the following traces, plus any additional traces.

- Demod: IQ Meas/OFDM Meas Trace (Constellation diagram)
- Demod: Summary
- Demod: Frame Summery
- Demod: RE Power 3D
- Demod: OFDM Detected Allocations Time

– MIMO Info



Using the equivalent SCPI commands

On the VXG:

```
SYSTem:PRESet
RF1:FREQuency:CW 28GHz
RF1:POWer:AMPLitude 0dBm
RF2:FREQuency:CW 28GHz
RF2:POWer:AMPLitude 0dBm
CONFigure TX2
SIGNal:MODE NR
SIGNal:NR5G:CCARrier0:TYPE DL
SIGNal:NR5G:CCARrier0:CIDentity 0
SIGNal:NR5G:CCARrier0:NUM:MODE SINGLE
SIGNal:NR5G:CCARrier0:BWID FR1BW100M
SIGNal:NR5G:CCARrier0:SNUM MU1
SIGNal:NR5G:CCARrier0:SNUM:RB:NUMB 273
SIGNal:NR5G:CCARrier0:DLINk:SSBL:PERiodicity P10MS
SIGNal:NR5G:CCARrier0:DLINk:SSBL:RB:OFFSet 0
```

```
SIGNal:NR5G:CCARrier0:DLINk:SCH0:DMRS:PORT '0,1'
SIGNal:NR5G:CCARrier0:DLINk:SCH0:SLOT "2:19"
SIGNal:NR5G:CCARrier0:DLINk:SCH0:RB:OFFSet 2
SIGNal:NR5G:CCARrier0:DLINk:SCH0:RB:NUMBer 80
SIGNal:NR5G:CCARrier0:DLINk:SCH0:MCS:TABL TABL52
SIGNal:NR5G:CCARrier0:DLINk:SCH0:MCS 20
SIGNal:NR5G:CCARrier0:DLINk:SCH0:DMRS:POWer 3
SIGNal:NR5G:CCARrier0:DLINk:SCH0:ADD
SIGNal:NR5G:CCARrier0:DLINk:SCH1:DMRS:PORT '0,1'
SIGNal:NR5G:CCARrier0:DLINk:SCH1:DMRS:CGWD:COUN 2
SIGNal:NR5G:CCARrier0:DLINk:SCH1:SLOT "2:19"
SIGNal:NR5G:CCARrier0:DLINk:SCH1:RB:OFFSet 150
SIGNal:NR5G:CCARrier0:DLINk:SCH1:RB:NUMBer 100
SIGNal:NR5G:CCARrier0:DLINk:SCH1:MCS:TABL TABL51
SIGNal:NR5G:CCARrier0:DLINk:SCH1:MCS 20
SIGNal:NR5G:WAVeform:GENerate
SIGNal ON
SIGNal:NR5G:TRIGger:SYNC:MARKer M2
RF1:OUTPut ON
RF2:OUTPut ON
RFAL1:OUTPut ON
```

On the X-Series Signal Analyzer:

```
INSTrument:SELect VSA89601
SYSTem:PRESet
FREQuency:CENTer 28 GHz
FREQuency:SPAN 122.88 MHz
INPut:ANALog:RANGe:AUTO
INITiate:PAUSe
INP:CHAN:CONF RF,RF
MEASure:CONFigure NR5G
NR5G:DBWP:ENABled 1
```

```
NR5G:SSBLock:ENABled 1

NR5G:SSBLock:ROFFset 0

NR5G:SSBLock:PERiodicity "Period10Milliseconds"

NR5G:DBWP:PDSCh1:MCS:TABLe "Table2"

NR5G:DBWP:PDSCh1:MCS 20

NR5G:DBWP:PDSCh1:SLOT:ALLocated "2:19"

NR5G:CCARrier:PDSCh1:ROFFset 40

NR5G:CCARrier:PDSCh1:RNUMber 80

NR5G:CCARrier:PDSCh1:ANTenna:PORT:USED 3

NR5G:CCARrier:PDSCh1:RCGNumber "Two"

NR5G:DBWP:PDSCh1:BPOWer:DMRS 3

NR5G:DBWP:PDSCh2:MCS:TABLe "Table1"

NR5G:DBWP:PDSCh2:MCS 20

NR5G:DBWP:PDSCh2:SLOT:ALLocated "2:19"

NR5G:CCARrier:PDSCh2:ROFFset 150

NR5G:CCARrier:PDSCh2:RNUMber 100

NR5G:CCARrier:PDSCh2:ANTenna:PORT:USED 3

NR5G:CCARrier:PDSCh2:RCGNumber "Two"

NR5G:DBWP:PDSCh2:BPOWer:DMRS 2

NR5G:RLENgth 10

NR5G:SUBFrame:INTerval 2

NR5G:FRAMe:TRIGger:ENABled 1

NR5G:DC:PUNCtured 1

NR5G:MCFilter:ENABled 1

NR5G:COMPensate:SYMBol:CLOCk:OFFset 1

INPut:TRIGger:STYLe "External"

INPut:TRIGger:LEVel:EXTernal 1V

INPut:EXTension:PARameters:SET "ExtTriggerLoc", 2

INPut:EXTension:PARameters:SET "PhaseNoiseOptDualLoop", 1

NR5G:FRAMe:TRIGger:ENABled 1
```

```
NR5G:DECode:MODE "DecodedTB"

DISPlay:LAYout 3,2
```

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