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.



MEASUREMENT GUIDE

Notices

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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

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Measurement Guide

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Basic Measurements Overview

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

Basic Measurements Configuring the Equipment Setup

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 Basic Measurements Configuring the Equipment Setup

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 Basic Measurements Configuring the Equipment Setup

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.

1.00000000000 GHz	
0.00 dBm	

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.

L L	Ysight F	Input: RF Coupling: DC Align: Off	Input Z: 50 Ω Corrections: O Freq Ref: Int (\$ NFE: Adaptive	Atten: 6 dB ff Preamp: Off 5) µW Path: Stand Source: Off	PNO: Balanced Gate: Off IF Gain: Low Sig Track: Off	Avg Type: Log-Pov Trig: Free Run	ver 1 2 3 4 5 W W W W W N N N N N	6 W N			
1 Spec	trum Div 5 dB	T				Ref Level -70	.00 dBm			Mkr	1 1.000 001 GHz -90.09 dBm
LOIJ											
-76.0											
-80.0											
96.0											
-00.0							1				
-90.0							·				
-96.0											
-100											
-105		L							·		. h
-110		i	ik i li di l		1.1.					. I MAA	
-115	l (h										
			110 (11)	71 7 			1 M.W		117 Y /	AVI V	
Center Res B	1.0000000 0 W 9.1 kHz	3Hz				#Video BW	300 Hz			S	Span 1.000 MHz weep 286 ms (1001 pts)

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.

RFAL1: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 $\ensuremath{\mathsf{I/Q}}$ 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.

KEYS	ight	rput: RF Coupling: DC Vigs: Off	Input Z. 50 D At Connections: Off Pr Freq Ref. Int (S) pV NFE: Adaptive Sc	en: 10 dB samp: Off I Path: Standard urce: Off	PND Balanced Gate: Off IF Gain: Auto Sig Track: Off	Avg Type: Log Power 1 Trig: Pree Run W	23456 www.ww NNNNN				
1 Spectrum Scale/D/V	10 dB	*					Ref Level 0.	00 dBm			Mkr1 20.000 000 0 GHz -0.58 dBm
								1			
10.0											
0.00											
30.0											
e0.0											
50.0											
0.0											
20.0											
-80.0											
-50.0							, lut				
	к. Ц	n la il			an ha dha an	AN NY			n date di basti di) Na an a su bainn a	Alexandrik na st
Center 20 #Res BW	.0000000 Gi 100 Hz	Hz					Video BW 1	to Hz			Span 503.0 kHz Sweep (FFT) ~128 ms (1001 pts)

- 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

SIGNall ON

RF1:OUTPut:STATe ON

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

RFAL1: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 $\ensuremath{\mathsf{I/Q}}$ 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.

Signal 1								
Type File - No file selected								

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

SIGNall ON

RF1:OUTPut:STATe ON

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

RFAL1: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.

Signal 1								
Туре	File - No file selected							

- 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

SIGNall ON

RF1:OUTPut:STATe ON

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

RFAL1: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.

(D:) > Users > Instrument > Documents > Keysight > PathWave > Si	gnalGenerator > Exar	nples 🗸 🗸
↑ Name ^ ~	Date modified	Туре
5GNR_1CC_FR1_30kHz_SCS_100MHz_256QAM_DC	9/20/2018 10:53 PM	Text Document
5GNR_1CC_FR1_30kHz_SCS_100MHz_256QAM_DC	8/29/2018 11:57 PM	SETX File
5GNR_1CC_FR1_30kHz_SCS_100MHz_256QAM_DC	7/10/2019 1:47 AM	WFM File
5GNR_1CC_FR2_120kHz_SCS_100MHz_256QAM_DC	2/20/2019 9:58 PM	Text Document
5GNR_1CC_FR2_120kHz_SCS_100MHz_256QAM_DC	2/20/2019 10:01 PM	SETX File
5GNR_1CC_FR2_120kHz_SCS_100MHz_256QAM_DC	7/14/2019 2:07 AM	WFM File
5GNR_2x2_MIMO_VXG_Scope_Updated.scp	5/14/2019 7:14 PM	Text Document
5GNR_2x2_MIMO_VXG_Scope_Updated.setx	5/14/2019 7:14 PM	SETX File
5GNR_8CC_FR2_120kHz_SCS_100MHz_256QAM_Cor	2/20/2019 9:48 PM	Text Document
5GNR_8CC_FR2_120kHz_SCS_100MHz_256QAM_Cor	7/14/2019 2:05 AM	WFM File
5GNR_8CC_FR2_120kHz_SCS_100MHz_256QAM_DC	2/20/2019 9:05 PM	SETX File
5GNR_UXR_Recording_28_GHz.csv	5/19/2019 10:29 PM	CSV File
10GHzInDB.s2p	4/25/2019 5:38 PM	S2P File
4000_SamplelQPulseOnOff_50%_wfm.csv	5/8/2020 10:55 AM	CSV File
4000_SampleIQPulseOnOff_50%_wfm.wmk	6/3/2020 2:30 PM	WMK File
GSM_1C_BURST_SECUREWAVE.wfm	7/17/2013 6:49 PM	WFM File
simpleAt10GHzInDB.s2p	4/28/2019 4:52 PM	S2P File
WCDMA_TM1_64DPCH_4C.wfm	1/14/2013 10:57 PM	WFM File

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.

Output	Output 1: Output Mod Setup ?									
Enable Output Modulation Enable Modulation to affect output Select desired output modulation(s), below. Click on a row to configure.										
	Modulation	Details								
	I/Q	Source: Internal			>					
	AM 1	Depth: 0.1 % Type: Linear	Source: Function 1		>					
	AM 2	Depth: 0.1 % Type: Linear	Source: Function 1		>					
	Pulse	PulseType: Free Run			>					

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.

Note: I/Q Modulation cannot be on when Wideband AM Modulation is on.									
I/Q Modulation C	'n	I/Q DC Alignment							
I/Q Modulation Source	Internal 🗸	Perform Alignment	Clear Alignment						
		Skew Alignment							
		Perform Alignment	Clear Alignment						

- 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**.

≡ ₽`	€	\ominus	G) > Signal 1	: Signal Setup						RF Out	(All) Trigger	? ~ Preset \
Enable	Mode	Wave	Waveform File 🗸 🗸 🗸]	Synchroniz	ation Role	Sync Off	~	Signal Attenuation	0.00 dB		
									Reset F	Phase Accumulator	Frequency Offset	0 Hz	
Waveform Play	back Setup												
File												Sele	ct >
(i) Use inst	alled Signal	Studio	to creat	e waveforms							~		
Sample Rate	Sample Rate 2.5600000000000 GHz					Nonlinear Correction			Off Configure >				
RMS Power				1.000000				Occupied Bandwidth			0 Hz		
Scale				100.00 %			Aggregate Active Bandwidth				On		
Triggering & Ma	arkers												
Trigger						Markers							
Source Level Slope	urce Immediate vel 500 mV > RF Blanking Sync				None None > Marker 1								
													un de la constante de la const

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.





\equiv	:::		\bigcirc	\ominus	<u>ن</u> ک	Group 1: S	ignal Setup	p								RF Out (All)		Trigger ?	V PRESET
	Enable	Mode	Wavefor	rm File			~	Sync	hronization	Role	Sync Off	~		Sig	nal Attenuatio	on Ode	3		
											Reset P	hase Accur	nulator	Fre	quency Offse	t O Hz	z		
Wavef	orm Playba	ack Setup																	
File D:\Users\Administrator\Documents\Keysight\PathWav				PathWave\	\SignalGenerator\Examples\4000_SampleIQPulseOnOff_50%_wfm.csv											Select	>		
6	Use insta	lled Signa	l Studio to	o create w	aveforms	Pulse Bu	iilding									~		Laun	ch
San	n <mark>ple</mark> Rate																		
2	000 000 0	00 kHz						I	Nonlinear Co	orrectior	ı Of	f	Con	figure >					
RM	RMS Power				Occupied Bandwidth														
1.412 667				98.280 000 MHz															
Scale					Aggregate Active Bandwidth														
85.00 %					0 Hz 🗌 0n														
Trigge	ring & Mar	kers																	
Т	igger						Marke	ers											
N C S	lode ontinuous ource	Continuc Free Run Immedia	ous i > ite				ALC I RF BI Sync	Hold anking	None None Marker 1	>									

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.

Marker Routing									
Use the controls below to route markers to specific system signals.									
ALC Hold	ALC Hold								
None	~								
RF Blanking		7							
Marker 1	\sim								
Sync									
None	~								

- 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.


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

SIGNall ON

RF1:OUTPut:STATe ON

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

RFAL1: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.

	nal 1: Select Waveform File for Playback		
🕙 Recent	う Dへ〉Users〉Instrument〉Documents〉Keysight〉PathWave〉SignalGenerator	> Examples >	
∧ Waveforms	Name A	Date Modified	🗙 Delete
This Computer	5GNR_1CC_FR1_30kHz_SCS_100MHz_256QAM_DC Punctured.wfm	Jul 10, 2019, 2:47:40 AM	☐ Rename
	5GNR_1CC_FR2_120kHz_SCS_100MHz_256QAM_DC Punctured_28GHz.wfm	Jul 14, 2019, 3:07:46 AM	
	5GNR_8CC_FR2_120kHz_SCS_100MHz_256QAM_Corrected_28GHz.wfm	Jul 14, 2019, 3:05:20 AM	
	5GNR_UXR_Recording_28_GHz.csv	May 19, 2019, 11:29:44 PM	
	GSM_1C_BURST_SECUREWAVE.wfm	Jul 17, 2013, 7:49:36 PM	
	WCDMA_TM1_64DPCH_4C.wfm	Jan 14, 2013, 11:57:50 PM	
Clear Arb Memory			
	File Properties Name: GSM_1C_BURST_SEC Sample Rate: 1083333.33333333 Hz Scale: 99.0 Occupied Bandwidth: N/A Required License(s): V/A		
	Show files of type All Supported Formats (*.wfm, *.wiq, *.csv) >	Select	Cancel

- 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

Back Output 1: Signal 1: Select Waveform File for Playback								
🖉 Recent	♦ ☐ D.\ > Users > Instrument > Documents > Keysight > PathWave > SignalGenerato	e 〉 SignalGenerator 〉 Examples 〉						
.∧ Waveforms	Name A	Date Modified						
🛄 This Computer	5GNR_1CC_FR1_30kHz_SCS_100MHz_256QAM_DC Punctured.wfm	Jul 10, 2019, 2:47:40 AM						
	5GNR_1CC_FR2_120kHz_SCS_100MHz_256QAM_DC Punctured_28GHz.wfm	Jul 14, 2019, 3:07:46 AM						
	5GNR_8CC_FR2_120kHz_SCS_100MHz_256QAM_Corrected_28GHz.wfm	Jul 14, 2019, 3:05:20 AM						
	5GNR_UXR_Recording_28_GHz.csv	May 19, 2019, 11:29:44 PM						
	GSM_1C_BURST_SECUREWAVE.wfm	Jul 17, 2013, 7:49:36 PM						
	WCDMA_TM1_64DPCH_4C.wfm	Jan 14, 2013, 11:57:50 PM						

- **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"

SIGNall ON

RF1:OUTPut:STATe ON

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

RFAL1: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"

SIGNall 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

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.

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

	🗸 Enable	Mode	Multitone	\sim	
N	Iultitone Setup				
	Tones	21			
	Tones				
	Tone Spacing	100.00	0000000000 MHz		
	Sample Rate	2.56000	0000000000 GHz		
	# of Points	512			

- 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

TIP

- Set the Span to **3 GHz**



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

Frequency (CW) Peak Envelope Power ALC Image: Comparison of the comparison of t		Output 1: RF Output		RF Out ((All) Trigger ? ~ PRESET ~
Phase User Power Limit Power Search Corrections/De-embedding off 0 deg 0 dBm 0 n Power Search Auto Image: Correction Blocks 1 Attenuation Do Power Search Image: Correction Blocks 1 Image: Correction Blocks 1 70 dB Hold Hold Image: Correction Blocks 1 Image: Correction Blocks 1 1 70 dB Hold Image: Correction Blocks 1 Image: Correction Blocks 1 1 70 dB Hold Image: Correction Blocks 1 Image: Correction Blocks 1 1 70 dB Hold Image: Correction Blocks 1 Image: Correction Blocks 1 1 70 dB Hold Image: Correction Blocks 1 Image: Correction Blocks 1 1 70 dB Hold Image: Correction Blocks 1 Image: Correction Blocks 1 1 70 dB Hold Image: Correction Blocks 1 1 1 1 70 dB Hold Image: Correction Blocks 1 1 1	Enable RF Output Frequency (CW) 10.000 000 000 00 GHz	Power (Total RMS) -10.00 dBm Peak Envelope Power 200.00 dBm	ALC On Z Auto ALC Bandwidth	Frequency and Amplitude Adjustment Frequency Offset, Multiplier Frequency Reference Amplitude Offset Amplitude Reference	0 Hz, 1.000 0 Hz, 1.000 0 dB 0 dB 0 ff
Attenuation Optimizations 70 dB Hold Harmonic Filters Off Harmonic Filters Off YQ n Output Mod On Type Multitone JVQ Off JVQ off Image: Odeg Status ▶Playing Off Delay 0 s Image: Odeg Off JVQ Off Image: Odeg Atten ode Atten Auto Corr Off Pulse Off Atten Auto Corr Off Pulse Off Atten Off Auto Off Delay 0 s Image:	Phase 0 deg	User Power Limit	Very Slow ~ Power Search	Corrections/De-embedding Correction Blocks	0ff 1 >
Group 1: Signal Adjustments I/Q In Output Mod On RF Output Off In In Type Multitone I/Q Off Internal I/Q On Phase 0 deg In In </td <td></td> <td>Attenuation 70 dB Hold</td> <td>Do Power Search 🗸 Auto</td> <td>Optimizations Harmonic Filters</td> <td>off ></td>		Attenuation 70 dB Hold	Do Power Search 🗸 Auto	Optimizations Harmonic Filters	off >
Group 1: Signal Adjustments V/Q In Output Mod On RF Output Off Off Type Multitone V/Q Off V/Q On Phase 0 deg Odg Atten 0 dB Swap I&Q Off Internal Off Pulse Off Atten Auto Status Playing Delay 0 s U/Q Out Off Off Purcling Off -10.00 dBm -10.00 dBm					
Atten 0 dB Status ▶Playing AWGN Off Internal Delay 0 s Internal V0 Out Atten Auto Pulse Off PwrLim Off Internal Auto Pulse Off PwrLim Off Internal Auto Pulse Off PwrLim Off Internal Auto ALC OFF OFFS	Group 1: Signal Type Multitone	Adjustments	U/Q In Output Mod On U/Q On	RF Output On Phase 0 deg	0 000 000 00 GHz
Vector Modulation	Atten 0 dB Status Playing	AWGN Off Swap I&Q Off Delay 0 s	Internal I/Q Out	Atten Auto Corr Off PwrLim Off ALC OFF	O dBm

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

	S	\supset	Output 1: RF Output > Corrections Setup
User Correctio User Correctio Correction Blo	n data can n data can cks for add	be loaded f also be ado litional exte	rom a file (.csv or .uflat) by selecting Block A and then [Select File]. led by direct measurement using a power meter or a spectrum analyzer by selecting [Add from Measurement]. mal components can be created by selecting [Add from File] and choosing an .s2p file.
Add from M	leasureme	ent A	dd from File
SOURCE	1	Emb	ed On I Device
			Reference Plane

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.

\equiv $\square_{}$ Θ Θ \square \rangle	Output 1: RF Output > Corrections	Setup	RF Out (All) Trigger ? Y PRESET
User Correction data can be loaded from a file (.cs User Correction data can also be added by direct r Correction Blocks for additional external compone	v or .uflat) by selecting Block A and then neasurement using a power meter or a s nts can be created by selecting [Add fror 	[Select File]. bectrum analyzer by selecting [Add from Measurement]. n File] and choosing an .s2p file.	Corrections On Absolute Power Corrections Only
Add from Measurement Add from File			
SOURCE SOURCE 1 Output 1 Embed	n B On simpleAt10GHzInDB 2 1 2 Deembed s2p Reference Plane	Device	
Block B Properties	V Enable		
File	Options		
Type: s2p	Reverse Ports		
Select File >	Apply: Deembed ~	X Delete Block	

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.

Block C Properties	🛃 Enable
File	Options
Name: simpleAt10GHzInDB Type: s2p	Reverse Ports
Select File 📏	Apply: 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 1 to turn on Channel 1's RF Out.

On the signal analyzer:

 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.

Spectrum A Occupied B	Analyzer 1 BW	+									
KEYSIG	HT Input: RF Coupling: DC Align: Off	Input Z: Correctio Freq Re NFE: Ac	50 Ω ons: Off f: Ext (S) laptive	Atten: 10 dB Preamp: Off µW Path: Star	ndard	Trig: Free Gate: Off #IF Gain:	Run Low	Center Freq: Avg Hold:>1 Radio Std: N	12.0 0/10 Ione	000000000000000000000000000000000000000) GHz
1 Graph											
Scale/Div	10.0 dB		R	ef Value -30	00 di	3m					
-40.0											
-50.0					armonad dore da		uninorgangerenerer		~		
-60.0											
-80.0										materia	a J. Sandy Jacobian South
-90.0											
-100											
-120											
Center 12.	.000 GHz		Vi	ideo BW 50.0	000 M	Hz*				S	pan 3 GHz
Res BW 3.	.0000 MHz							Sw	eep	5.00 ms	(1001 pts)
2 Metrics	•										
C	ocupied Bandwidt	'n									
	1.9	700 GHz				Total Po	ower			-17.3 dBr	n
Т	ransmit Freq Erro	r	213.66 kHz	z		% of O	3W Powe	r		99.00 %	%
x	dB Bandwidth		2.010 GHz	Z		x dB				-26.00 d	В
۲ ا		? Jan 30), 2020 40 PM								

On the VXG:

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

	G > Outp	ut 1: RF Output				
🛃 Enable RF Output						
Frequency (CW) 12.0000000000 GHz		Peak Envelope Power		-2.23 dBm		
Power (Total RMS)		Frequency and Amplit	ude Adiustment			Off
-10.00 dBm		Frequency Offset Frequency Multiplier Frequency Reference		0 Hz 1.000 Off	````	
Phase 0.000 deg		Amplitude Offset Amplitude Reference		0.00 dB Off		
User Power Limit						
		Corrections/De-embed	lding			On
0.00 dBm	On	Correction Blocks			>	
Attenuation						
	Hold	Use Harmonic F	ilters			
ALC		Power Search				
🛃 Auto 🗌 ALC (Dn	🛃 Auto		Do Power Search		
Bandwidth						
Very Slow 🗸						

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.

Overview	This wizard will guide you through the simple process of measuring an external network of cables, connectors and other passive components connected between this source and the device under test.
Configure Sensor Measure Corrections	M9384B Cables/Connectors/Fixtures to be characterized Output 1 Cables/Connectors/Fixtures to be characterized Power meter or spectrum analyzer
	Connect the equipment (power meter or spectrum analyzer) as shown in the diagram above. 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 measuring device was connected.
	Cancel < Back Next > Finish

- 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.

1	≡ ₽ĭ ⊕ ⊝) Outpu	t 1: RF Output > Corrections	s Setup > Measure Co	prrections	RF Out (All)	Trigger 67	? ~ Preset ~
	Overview	Power Measurement	Device Spectrum Analyze	r ~				
	Configure Sensor	Start Frequency	11.0000000000 GHz	Stop Frequency	13.0000000000 GHz			
	Measure Corrections	Number of Steps	101	Power	-10.00 dBm			

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

≡≌√⊛	Output 1: RF Output >	Corrections Setup > Measure Co	prrections	RF Out (All) Trigger) ~ Preset ~
Overview	Power Measurement Device Spec	trum Analyzer 🗸			
Configure Sensor	Start Frequency 11.00000000	00 GHz Stop Frequency	13.0000000000 GHz		
Measure Corrections	Number of Steps 101	Power	-10.00 dBm		
	Spectrum Analyzer				
	Connection Type Ho	stname or IP Address			
			Test Germanites		
		41.121.149.32	Test connection		
	Pro	tocol			
		Type Address			
		HiSLIP 🗸 hislip0			
		Cancel < Back	K Next > Finish		
KRLTS A REF IN	T Locked Aug 17, 2021, 10:17:46 AM	Connection Test to Remote In	strument TCPIP::141.121.149.32::hislip0	INSTR Successful.	Ç.

- **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.

≡≞∽	Corrections Setup > Measure Corrections	RF Out (All)	Trigger ?~	PRESET
Overview	Correction File Name:ignalGenerator\Examples\UserCorr-2021-08-17_001.csv Change >			
Configure Sensor	Measure Correction Data			
Measure Corrections				
	Correction measurement in progress			
	Abort			

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.

≡ ₽ĭ ⊕ ⊛	G > Outp	out 1: RF Output		
Enable RF Output				
Frequency (CW) 12.0000000000 GHz		Peak Envelope Power	-2.23 dBm	
Power (Total RMS)		Frequency and Amplitude Ac	ljustment	Off
-10.00 dBm		Frequency Offset Frequency Multiplier Frequency Reference	0 Hz 1.000 Off	,
Phase 0.000 deg		Amplitude Offset Amplitude Reference	0.00 dB Off	
User Power Limit		Corrections/De-embedding		On
User Power Limit	On On	Corrections/De-embedding Correction Blocks	3	On >
User Power Limit 0.00 dBm Attenuation	On On	Corrections/De embedding Correction Blocks	3	0n >
User Power Limit 0.00 dBm Attenuation 70 dB	On On Hold	Corrections/De-embedding Correction Blocks	3	0n >
User Power Limit 0.00 dBm Attenuetion 70 dB ALC	On On	Corrections/De-embedding Correction Blocks	3	On >
User Power Limit 0.00 dBm Attenuation 70 dB ALC ALC ALC	on on	Corrections/De-embedding Correction Blocks	3 Do Power Search	0n
User Power Limit 0.00 dBm Attenuation 70 dB ALC ALC Bandwidth	On Ноіd	Corrections/De-embedding Correction Blocks	3 Do Power Search	0n >

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.

Overview	This wizard will guide you through the simple process of measuring an external network of cables, connectors and other passive components connected between this source and the device under test.
Configure Sensor	M93848
Measure Corrections	Cables/Connectors/Fixtures to be characterized
	oupur i
	Connect the equipment (power meter or spectrum analyzer) as shown in the diagram above. 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 measuring device was connected.
	Cancel < Back Next > Finish

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

Overview	Power Measurement	t Device	Power Meter \vee]	
Configure Sensor	Start Frequency	11.000	00000000 GHz	Stop Frequency	30.0000000000 GHz
Measure Corrections	Number of Steps	20		Power	5.00 dBm

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.

Overview	Power Measurement	t Device	Power Meter 🗸				
Configure Sensor	Start Frequency	26.000000	00000 GHz	Stop Frequer	ю	30.000	00000000 GHz
Measure Corrections	Number of Steps	20		Power		5.00 dB	łm
	Power Meter						
	Connection Type		Device				
		O USB	Select Device	. ~	Ċ	т	est Connection
						С	alibrate Sensor
							Zero Sensor
				Cancel	🗸 Back	Nex	tt > Finish

- **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.

\equiv	£1.	€	G > Output 1:	RF Output 📏 C	orrections Setup 📏 Measure Correc	tions		RF Out (All)	Trigger V	PRESET
01	verview		Correction File Name:				Change >			
C	onfigure S	ensor	Measure Correction Da	ata						
м	easure Co	prrections								
				_						
					Correction measurement in prog	ress]			
					Abort					

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

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

NOTE

CORRection:PMETer:COMMunicate:USB:DEVice "instro" [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

SIGNall ON

RF1:OUTPut:STATe ON

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

RFAL1: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.

4.000 000 000 00 GHz	
10.00 dBm	1
ALC ON OFFS	

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.

$\equiv \Box$	€	\ominus	Signal 1: Signa	al Setup				RF Out	(All) Trigger	V PRESET V
Enable	Mode	Waveform F	ile		Synchronization Role	Sync Off		Signal Attenuation	0.00 dB	
						Reset	Phase Accumulator	Frequency Offset	0 Hz	
Waveform Play	back Setup									
File		lsers\jacquipa	\Desktop\M9384B dem	no waveforms\5G_100	MHz_1CC_FR1.wfm				Select >	
(i) Use inst	talled Signal	Studio to crea	ite waveforms					~	Launch	
Sample Rate			122.880000000000	MHz	Nonl	near Correction		Off	Config	ure
RMS Power			0.286585		Осси	pied Bandwidth		98.280000 MHz		
Scale			85.00 %		Aggr Activ	egate e Bandwidth		0 Hz		🗌 On
Triggering & Ma	arkers									
Trigger				Markers						
Source Level Slope	Immediate 500 mV Negative	>		ALC Hold RF Blanking Sync	Marker 4 Marker 3 > Marker 1					

7. Set RF Out to On for channel 1.

On the UXA:

 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.
- 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.

Advanced				General		
General						
EVM	Component Carrier	CC0				
UL Flatness & IBE	Sync Mode	CP Auto Correlation		Calculation	0-	
Cross Carrier	Multi-Carrier Filter		~	Magnitude & Phase Error	Off	
	Extended Frequency	On Off	<u>AUTO</u>	IQ Imbalance	On Off	
	DC Punctured	On Off			Common	
	DC Offset from CC Center	0 Hz	AUTO	Compensation Symbol Clock Error	On	
	RF for Phase Compensation			Compensation IQ Imbalance	Off On	
	Channel Power Threshold	-30.00 dB			Off	
	Report EVM in DB	On Off				

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).

5G NR 1 ACP		• +												\$	Amplitude	• *
	T C	Input: RF Coupling: DC Align: Auto	Input Z Corr CO Freq Ro	: 50 Ω Corr RCal ef: Ext (S) ef	Atten: 8 (Preamp: µW Path	1B Off :LNP,On stWide	Tr Gi I IF	ig: Free R ate: Off Gain: Lov	tun w	Carrier Ref F Avg Hold:>1 Noise Corre	Freq: 4.0 0/10 ction: Of	0000000 f	0 GHz	Pre	sel Center	Y Scale
1 Graph	3	•	NI E. O	"	1110.06	St Mide				00 mil. DL,	100			0 Hz	ທ່ານ	Attenuation
Scale/Div 10.0 d	в				Ref Val	ue 15.00	dBm							Internal	Preamp	Signal Path
5.00					ŀ	7.9 dF	m							Full Ra	nge 🔻	
-5.00	60.4	4 dBc	-51.0) dBc					-51.0) dBc		-60).6 dBc	On Off		
-25.0					j _e tan ^{wan} ana kata									µW Patt LNP En	n Control able ▼	
-45.0														Aut Ma	o n	
-75.0		and the second second second second							Marginal Constitution	· Valatively findered						
Center 4.0000 G	Hz	and the second secon	and and a second se		+ Video B\	V 1.0000) MHz*						Span 500 MHz			
#Res BW 100 kF	iz										Sw	eep 17.	7 ms (5001 pts)			
Total Car Pwr		7 925 dBm/	98 280 MHz						Measu	re Trace			Trace 1			
Total PSD		1.020 0011							Trace	Туре		Trace A	verage (Active)			
					Lower	2.6			Up	oper						
		Offs Freq	Integ BW	dBc d	Bm	dBm	ence Car#	dBc	dBm	dBm	ence Car#	Filter				
	Α	100.000 MHz	98.280 MHz	-50.98 -4	43.05	7.925	1	-50.99	-43.06	7.925	1	-3 dB				
	в	200.000 MHz	98.280 MHz	-60.40 -	52.48	7.925	1	-60.58	-52.65	7.925	1	-3 dB				
																Prototype Limited
15	k		lun 30, 2021 2:24:16 PM										6 🔀			Allowed

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.

\equiv	۲Ţ	€	\ominus	Signal 1: Sign	nal Setup					RI	Out (All)	Trigger ?	~ Preset ~
	Enable	Mode	Waveform	File	~	Synchronization	Role Sync	Off 🗸		Signal Attenuat	ion 0	.00 dB	
							R	eset Phase A	ccumulator	Frequency Offs	et O	Hz	
Wav	eform Play	back Setup											
Fi	le		sers\jacquip	a\Desktop\M9384B de	mo waveforms\5G_100	MHz_8CC_FR2.wf						Select 〉	
(Use ins 	talled Signal	Studio to cre	eate waveforms						`	-		
Si	ample Rate			983.04000000000	MHz	1	Nonlinear Corre	ction		Off		Config	ure
R	MS Power			0.102340			Occupied Band	width		983.040000 MI	Hz		
S	cale			85.00 %			Aggregate Active Bandwid	th		0 Hz			On
Trig	gering & M	arkers											
	Trigger				Markers								
	Source Level Slope	Immediate 500 mV Negative	>		ALC Hold RF Blanking Sync	Marker 4 Marker 3 > Marker 1							

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

$\equiv \Box \cdot \otimes$	∋ 6) 🖒 Signal 1: Signal Setu	p > Nonlinear Correction	
Selected Waveform				
C:\Users\jacquipa\Deskto	op∖M9384B demo	waveforms\5G_100MHz_1	ICC_FR1.wfm	
		Instrument Nonlinear	Correction]
		Enable De inc fi measure	le, Selected Waveform must ile. To generate .inc file, e or load correction.	
		Measure Correction	Load Correction	
		DUT Nonlinear Correc	tion	-
		Enable		
		Mode: Lookup Table		
		S	etup	
				Ļ
				Waveform

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.

Receiver		Calibrations		Advanced		M9384B	Receiver
Connection Typ	e	Hostname or IP Address				10MHz Ref Out	10MHz Ref In
🔵 LAN		141.121.149.32			Test Connection		
		Protocol Type HISLIP ~	Address histip0			Calibration will I	urn on output power.
KRLTS	REF INT Locked	Aug 17, 2021, 2:24:44 PM	 Connection Test to 	Remote Instrumen	t TCPIP::141.121.149.32::hislip	0::INSTR Successful.	(ª

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

≡ ₩	₽~ ⊖ ∋	Group 1: Signal Setup 🗲	Nonlinear Correction > Instrum	nent Calibration	RF Out (All) Trigger ? ~ PRSSET ~
Receiver		Calibrations	Advanced		M9384B Receiver
Calibrations	Span	Offset	Max Iterations	Tolerance	RF Out
Power	983.040 000 MHz		3	0.10 dB	
VM EVM	983.040 000 MHz		3	-50.00 dB	Calibration will turn on output
V ACP	532.480 000 MHz	757.760 000 MHz	3	-50.00 dB	power.
Equalization	983.040 000 MHz				Start Calibration
KRLTS A	REF INT Locked	Nov 8, 2022, 9:47:44 AM	(i) Keysight Calibration Adv	isor status has not been imported	. 💬
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.

Back Output 1: Signal 1: Select Waveform File for Playback									
Recent	D: > Users > Instrument > Documents > Keysight > PathWave > SignalGenerator > Examples								
Waveforms	Name A	Date Modified							
This Computer	4000_SampleIQPulseOnOff_50%_wfm.csv	May 7, 2020, 6:55:50 PM							
	5G_100MHz_1CC_FR1_16QAM.inc	Jun 24, 2021, 3:50:27 PM	X Delete						
	5G_100MHz_1CC_FR1_16QAM.wfm	Jun 24, 2021, 2:13:49 PM	🗋 Rename						
	5G_100MHz_1CC_FR1.wfm	Jun 24, 2021, 1:01:53 PM							
	5G_100MHz_8CC_FR2.wfm	Mar 3, 2021, 10:51:00 PM							

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

≡ ₽`	€	\ominus	Signal 1: Signal	Setup					RF	Out (All)	Trigger ?	V PRESET V
Enable	Mode	Waveform F	ile	~	Synchronization	Role Sync	off ∽		Signal Attenuati	on 0.00) dB	
						F	Reset Phase A	ccumulator	Frequency Offse	et OH;	z	
Waveform Play	back Setup											
File C:\Users\jacquipa\Desktop\M9384B demo waveforms\5G_100MHz_8CC_FR2.wfm											Select >	
(i) Use inst	talled Signa	l Studio to crea	ate waveforms						~			
Sample Rate			983.04000000000 M	IHz		Nonlinear Corre	ection		Off		Config	gure 🗲
RMS Power			0.102340		Occupied Bandwidth 983.040000 MH) MHz		
Scale			85.00 %			Aggregate Active Bandwic	lth		0 Hz] 🗌 On
Triggering & Ma	arkers											
Trigger				Markers								
Source Level Slope	Immediate 500 mV Negative	>		ALC Hold RF Blanking Sync	Marker 4 Marker 3 > Marker 1							

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.

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.
- 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

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

Recall	C Demod Info	Recall from File									
State	Computer D: U	Users \rangle Instrument \rangle Documents \rangle NR5G \rangle o	data 〉NR5GEvm 〉CarrierSetup	>		Mode 5G NR	▼				
Screen Config + State	Name			∆ Date	Size Content						
Correction	5G_100MHz_8CC_FF	ł2.scp		3/3/2021 10:51 PM	431 KB Scp file						
Complex Correction	Signal_Studio_5G_10	0MHz_1CC_FR1.scp		2/12/2021 1:46 PM	67 KB Scp file						
Recording											
Recording + Slate											
Demod Info											

- 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%

5G NR 1 Modulation Analysis						Amplitude	· · · 🛞
KEYSIGHT Input: RF Coupling: DC Align: Auto	Input Ζ: 50 Ω Corr CCorr RCal Freq Ref: Ext (S)	Atten: 28 dB Preamp: Off μW Path: Bypass #PNO: Best Wide	Trig: Free Run #IF Gain: 5 dB	Carrier Ref Freq: 28.00000000 CC Info: DL, 8 CCs, SISO	GHz	Mech Atten 28 dB	Y Scale
1 CC0-BWP1 IQ Meas Time		2 CC7-BI	WP1 v Time			Elec Atten 0 dB	Attenuation
1.60 1.20 800 m 400 m -400 m -400 m -800 m -1.20 -1.60		1.60 1.20 800 m 400 m -400 m -800 m -1.20 -1.60				Enabled Disabled Adjust Atten for Min Clipping Adjust Atten Mech + Elec Elec Only	Signal Path
-5.948 μ = 2	2: 60 kHz NCP	5.948 -5.948	μ = 2	: 60 kHz NCP	5.948	Pre-Adjust for Min	1
Spectrum		4 CC7 Spectrum	•				
Scale/Div 10.00 dB Ref V	/alue 0.00 dBm	Scale/D	v 10.00 dB Ref V	alue 0.00 dBm		<u>, On</u>	
-100 -200 -400 -400 -400 -400 -400 -400 -4	d na sciedingo de pola en el parte Widti BW: 98.30 MHz	-100 -200 -300 -400 -600 -700 -700 -700 -700 -700 -700 -7	<mark>ส์ (()) 50100000 GHz</mark> 5377.1 Hz Info E	ingen and a state of the second state Wild SW: 98.30 MHz	մություն h: 110.6 MHz	Mech Atten Step 2 dB 10 dB	
5 CC0 Error Summary V		6 CC7 Er	ror Summary				
Channel Power (Active / Total) EVM (RMS / Peak) Frequency Error (RMS / Worst) Symbol Clock Error IQ Offset Time Offset Sync Correlation Sync Source Magnitude Error	-1.73 dBm / -1.73 dBm 6.21 % / 27.23 % -3.83 Hz / 6.97 Hz 0.012 ppm -50.82 dB 1.1626 ms 99.9 % PDSCH DMRS 4.58 %	Channe EVM (R Frequee Symbol IQ Offs Time O Sync S Magnitu	t Power (Active / Total) MS / Peak) noy Error (RMS / Worst) Clock Error st ffset orrelation purce de Error	-1.47 dBm / -1.47 dBm 4.51 % / 15.75 % 2593 mHz / 2.66 Hz 0.003 ppm -52.71 dB 7.101 ms 99.9 % PDSCH DMRS 3.22 %			Prototype Limited Sale

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.

≡ Þì`	©	\ominus	Ŵ	> Signal 1: Signal S	Setup					RF Ou	t (All) Trigger		
Enable	Mode	Wavefor	m File		~	Synchroniz	ation Role	Sync Off	~	Signal Attenuation	nal Attenuation 0.00 dB		
								Reset Ph	nase Accumulator	Frequency Offset	0 Hz		
Waveform Playb	ack Setup												
File		lsers\jacqı	ıipa∖Desk	top\M9384B demo ه	waveforms\5G_100	MHz_8CC_FF	R2.wfm				Select >		
(i) Use insta	alled Signal	Studio to	create wa	aveforms									
Sample Rate			98	3.04000000000 MH	łz		Nonline	ar Correction		Off	Configure 🗲		
RMS Power			0.1	02340			Occupie	d Bandwidth		983.040000 MHz			
Scale			85	.00 %			Aggrega Active E	ate andwidth		0 Hz	On		
Triggering & Mar	rkers —												
Trigger					Markers								
Source In Level 5 Slope N	mmediate 500 mV Negative	>			ALC Hold RF Blanking Sync	Marker 4 Marker 3 Marker 1	>						

- 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.

Receiver			Calibrations		Advanced		M9384B	_	Receiver
Connection Typ)e	Hostna	me or IP Address				RF	Out	—▶ RF In
🔵 LAN	USB	141.1	21.149.32			Test Connection	10MHz Ref	Out	● 10MHz Ref In
		Protoco	DI						
		Туре		Address					
		His	SLIP 🗸	hislip0			🔥 Calibra	tion will tur	n on output power.
								Start Cal	ibration
KRLTS		Aug	g 17, 2021, 2:24:44 PM	 Connection Test t 	o Remote Instrumer	nt TCPIP::141.121.149.32::hislip	0::INSTR Succes	sful.	P

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

≡ Ⅲ	۲ ۲	Θ \supset	ĥ	> Group 1: Signal Setup > №	RF Out (All) Trigger ? PRESET ~			
Receiver			Ca	alibrations		Advanced		M9384B Receiver
Calibrations		Span		Offset	Max I	terations	Tolerance	RF Out RF In
Power	983	.040 000 MHz			3		0.10 dB	
VM EVM	983	.040 000 MHz			3		-50.00 dB	Calibration will turn on output
🛃 АСР	532	.480 000 MHz		757.760 000 MHz	3		-50.00 dB	power.
V Equalizat	tion 983	.040 000 MHz						Start Calibration
KRLTS		[Locked		Nov 8, 2022, 9:47:44 AM	🔒 Keysigh	t Calibration Advi	isor status has not been importe	ed.

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).



Measurement Guide

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

This section includes the following topics:

- "5G Waveform, EVM, and ACP Analysis Using X-Applications" on page 86
 - "Setting Up Triggers on the Signal Analyzer using 5G NR Mode" on page 86
 - "Setting Up a 1 CC 28 GHz EVM Measurement" on page 88
 - "Setting up an 8 CC 28 GHz EVM Measurement" on page 95
 - "Setting Up a 1 CC 3.5 GHz ACP Measurement" on page 103
 - "Using PathWave N7631APPC to Create a Waveform File then Automatically Configure the Analyzer to View the Results" on page 107



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

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.

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.



NOTE

NOTE

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.
- 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.

	Signal 1: Signal Setup 🗲	Waveform File: Markers
Marker Routing Use the controls below to route markers	to specific system signals.	
ALC Hold	None	~
RF Blanking	None	~
Sync	Marker 2	~

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.

≡	₽` ©		<u>ہ</u> ک	Output 1	: Ad	justments					F	RF Out (All)	Trigger 6	? ~	PRESET ~
	I/Q Adjustments I Offset Q Offset Gain Balance I/Q Time Skew Quadrature Angle).0 %).0 %).000 dB) s).000 °	Off >		AWGN Carrier to Noise Ratio Carrier Bandwidth Flat Noise Bandwidth Noise Power in Channel Total Noise Power	0.00 dB 1 Hz 1 Hz -103.52 dBm -102.55 dBm	Off	CW Interfere Frequency (Signal Pow Absolute Po	er Offset er ower	0 Hz -103.52 dBm -96.00 dBm	Off >			
Char I/(Sv	nnel Settings	0 s													
Optii	mizations														
	Optimize for: () Rf	- Output	—) //Q с h овw	Putput											
	Enable System RF	Flatness C	Correction												

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:

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.

 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

NOTE

Recall	C Demod Info	Recall from File		50	? 🗙
State	Computer D: Users	Instrument Documents NR5G data NR5GEvm	CarrierSetup	ode 5G NR	•
Screen Config + State	Name	\triangle Date	Size Content		
Correction	1CC_FR1_30kHz SCS_100M	Hz_256QAM_DC Punctured 1/7/2020 4:38 PM	90 KB Setx file		
Complex Correction	1CC_FR1_30kHz SCS_100M	Hz_256QAM_DC Punctured 1/7/2020 4:38 PM	6 MB Wfm file		
Recording	1CC_FR2_120kHz SCS_100	MHz_256QAM_DC Puncture 1/7/2020 4:38 PM	131 KB Setx file		
Recording + State	1CC_FR2_120kHz SCS_100	0MHz_256QAM_DC Punctur 1/7/2020 4:38 PM	455 KB Scp file		
Demod Info	1CC_FR2_120kHz SCS_100	0MHz_256QAM_DC Punctur 1/7/2020 4:38 PM	6 MB Wfm file		
	5G_100MHz_8CC_FR2.scp	3/3/2021 10:51 PM	431 KB Scp file		
	8CC_FR2_120kHz SCS_100	MHz_256QAM_Corrected_2{ 1/7/2020 4:38 PM	131 KB Setx file		
	8CC_FR2_120kHz SCS_100	0MHz_256QAM_Corrected_2 1/7/2020 4:38 PM	455 KB Scp file		
	8CC_FR2_120kHz SCS_100	0MHz_256QAM_Corrected_2 1/7/2020 4:38 PM	49 MB Wfm file		
	A1_3.nrcc	6/18/2020 3:06 PM	58 KB Nrcc file		
	8CC_FR2_120kHz SCS_100	DMHz_256QAM_Corrected_{ 1/7/2020 4:38 PM	153 KB Setx file		
	Signal_Studio_5G_100MHz_1	ICC_FR1.scp 2/12/2021 1:46 PM	67 KB Scp file		
	VXG_A1_3_Config.sgen	6/16/2020 10:53 AM	904 KB Sgen file		
	File name: 1CC_FR2_120kHz	SCS_100MHz_256QAM_DC Punctured_28GHz.scp	File type:	All Files (*.*)	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"

SIGNall 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.

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

NOTE

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.

	Signal 1: Signal Setup 义	Waveform File: Markers
Marker Routing Use the controls below to route markers	to specific system signals.	
ALC Hold	None	~
RF Blanking	None	\sim
Sync	Marker 2	~

Use File **Select** to navigate to:

$\label{eq:lister} D: Users \\ Instrument \\ Documents \\ Keysight \\ PathWave \\ \\ Signal Generator \\ Examples \\$

and choose

 $\label{eq:scs_loom} \begin{array}{l} {\rm 5GNR_8CC_FR2_120\,kHz_SCS_100MHz_256QAM_Corrected_28GHz.} \\ {\rm wfm} \end{array}$



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.

$\equiv \Box$	Θ \Rightarrow	<u>ن</u> ک	Output 1:	Adjustments					Dut (All)	Trigger V	? ~	PRESET
I/Q Adjus I Offset Q Offset Gain Bal I/Q Time Quadrati	stments ance Skew ure Angle	0.0 % 0.0 % 0.000 dB 0 s 0.000 °	Off >	AWGN Carrier to Noise Ratio Carrier Bandwidth Flat Noise Bandwidth Noise Power in Channel Total Noise Power	0.00 dB 1 Hz 1 Hz -103.52 dBm -102.55 dBm	Off >	CW Interferer Frequency Offset Signal Power Absolute Power	0 Hz -103.52 dBm -96.00 dBm	Off >			
Channel Setting I/Q Common Swap I & Q	Delay 0 s											
Optimizations Optimize for:	RF Output		Dutput									
✓ Optimiz ✓ Enable \$	e Dynamic Range v System RF Flatnes:	vith OBW s Correction										

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.

 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.

Recall	C Demod Info Recall fro	m File	? 🗙
State	D: Users Instrument Documents NR5G data	NR5GEvm CarrierSetup Mode 5G NR	▼
Screen Config + State	Name	∆ Date	Size Cor
Correction	5G_100MHz_1CC_FR2.scp	2/12/2021 3:42 PM	67 KB Scp
Complex Correction	5GNR_1CC_FR2_120kHz_SCS_100MHz_256QAM_DC Punc	tured_28GHz.sc 8/23/2021 3:19 AM	455 KB Scp
Recording	5GNR_1CC_FR2_120kHz_SCS_100MHz_256QAM_DC Punc	tured_28GHz.se 8/23/2021 3:19 AM	131 KB Set
SCPI Recorder	5GNR_1CC_FR2_120kHz_SCS_100MHz_256QAM_DCPunct	tured.setx 7/24/2021 12:34 AM	139 KB Set
Recording + State	5GNR_8CC_FR2_120kHz_SCS_100MHz_256QAM_Corrected	d_28GHz.scp 8/23/2021 3:19 AM	455 KB Scp
Demod Info	5GNR_8CC_FR2_120kHz_SCS_100MHz_256QAM_Corrected	d_28GHz.setx 7/23/2021 11:40 PM	139 KB Set
	Chan2_3point1_DL_28GHz_8CCx100MHz_64QAM_TM_3p1.	scp 2/3/2022 12:26 PM	594 KB Scp
	Chan2_DL_28GHz_8CCx100MHz_64QAM_TM_3p1.scp	2/3/2022 11:33 AM	594 KB Scp
	fr2 200mhz.sgen	8/9/2022 5:42 AM	1 MB Sg€
	Transmit Time On Off Mask.scp	8/14/2022 4:58 AM	76 KB Scp
	File name: 5GNR_8CC_FR2_120kHz_S(File type: All S	supported Files (*.scp;*.sgen;*.nrcc;*.pwsg;*.setx) Recall

- 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.

Component Carrier	CC0				
Sync Mode	CP Auto Correlation				
Multi-Carrier Filter	On 🖌				
Extended Frequency	On				
Lock Range	Off				
DC Punctured	On				
	Off				
DC Offset from CC Center	0 Hz				
RF for Phase	0 Hz				
Compensation	AUTO				
Channel Power Threshold	-30.00 dB				
Report EVM in DB	On				
	Off				
Time Scale Factor	1.0000				

- 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.

15G NR 1583 The second se								
KEYSIGHT	Input: RF	RF Input Z: 50 Ω Atten: 14 dE		3	Trig: Externa	11	Carrier Ref Freq: 28	000000000 GHz
	Coupling: DC	Corr CCorr	Preamp: Of	f	#IF Gain: 5 d	IB	CC Info: DL, 8 CCs,	SISO
	Align: Off	Freq Ref: Ext (S)	µW Path: B	ypass				
			#PNU: Desi			_		
1 CC0-BWP1	v			2 CC0-BWI	21 locations	•		
				Scale/Div 328 subcarriers				
1.60					020 Subcar			
800 m				2.95 k				
400 m				2.29 k				
0 400 m		at data		1.97 k				
-400 m	1. L. 11.	11111		1.31 k				
-1.20	1.111.11			655				
-1.60				328				
-6.361	μ = 3: 120 k	Hz	6.361	Start: 0.00	symbols			Stop: 223.00 symbols
3 CC0	•			4 CC0	-	•		
Spectrum	D-61/-1 0.00	-ID		Raw Main	ime	D-41		
Scale/Div 10.00 dB	Ret value 0.00	dBm		Scale/DIV	10.00 aB	Ret	value 10.00 dBm	
-10.0				0.00				
-30.0				-20.0				
-50.0				-30.0	dahara data ing pana	ana an tao an ta	tel at an instant de la de la constant	at hat hat a the contract of the second section
-70.0	and a state of a state of the second lar	والمتحدية والمتحد المتحدين المتحد	tala sakan 🔽 t	-50.0	add d tota the day a	Prr -		
-90.0		e se taleri dell'h		-60.0				
Ctr: 27.650140000 G	θHz	Wid	th: 110.6 MHz	-80.0				
Res BW: 1.885 kHz	Info BW: 98.3) MHz		Start: 0.00	ns			Stop: 10.10 ms
5 CC0 Frame Summar	у 🔻			6 Error Sun	nmary	۲		
	EVM	Power per RE	Num.RB				CC0	CC1
P-SS (SS Block 1)	1.06 %	-34.75 dBm	24	Channel I	Power (Activ	e / Total)	-5.80 dBm / -5.8	0 dBm6.00 dBm / -
S-SS (SS Block 1)	1.06 %	-34.75 dBm	24	EVM (RM	IS / Peak)		1.50 % /	5.33 % 1.38 %
PBCH (SS Block 1)	1.69 %	-34.71 dBm	40	Frequenc	y Error (RMS	S / Worst)	3.16 Hz / 3	.16 Hz 247.4 mHz
PBCH DMRS (SS B	Block 1) 1.25 %	-34.78 dBm	40	Symbol C	lock Error		0.00	07 ppm 0
PDSCH (BWP1)	1.50 %	-34.77 dBm	1056	IQ Offset	(SISO)		-37	.19 dB
PDSCH DMRS (BW	/P1) 1.49 %	-34.77 dBm	1036	Time Offs	et		-2	26.0 ns
F		Sync Cor	relation			99.6 %		

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

SIGNall 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.

RFAL1: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 CCO

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

Gack Output 1: Signal 1: Select Waveform File for Playback (\bigcirc) A D: > Users > Instrument > Documents > Keysight > PathWave > SignalGenerator > Examples Recent -1~) Waveforms Date Modified Name ^ This Computer 4000_SampleIQPulseOnOff_50%_wfm.csv May 7, 2020, 6:55:50 PM Delete 5G_100MHz_1CC_FR1.inc Aug 17, 2021, 2:29:13 PM 🗋 Rename 5G_100MHz_1CC_FR1.wfm Jun 24, 2021, 2:10:57 PM 5G_100MHz_8CC_FR2.inc Aug 17, 2021, 2:39:14 PM 5G_100MHz_8CC_FR2.wfm Mar 3, 2021, 10:51:00 PM 5GNR 1CC FR1 30kHz SCS 100MHz 2560AM DC Punctured.wfm Jul 10, 2019, 2:47:40 AM 5GNR_1CC_FR2_120kHz_SCS_100MHz_256QAM_DC Punctured_28GHz.wfm 5GNR_8CC_FR2_120kHz_SCS_100MHz_256QAM_Corrected_28GHz.wfm Jul 14, 2019, 3:05:20 AM 5GNR_UXR_Recording_28_GHz.csv May 19, 2019, 11:29:44 PM Jul 17, 2013, 7:49:36 PM Clear Arb Memory File Properties Sample Rate: Scale: 122880000.0 Hz 85.0 -10.0 dB 98280000.0 Hz Show files of type All Supported Formats (*.wfm, *.wiq, *.bin, *.csv, *.txt, *.seq, *.mat, *.hdf, *.h5, *.inc) 🗸 Select Cancel

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"

SIGNall ON

DM:OPTimization:CHANnel ACP

RF1:OUTPut ON

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

RFAL1: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.

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

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.

\equiv		₽~	©	\supset	Ŵ	> Mode	S			
ΰR	adio App	IS								
Key	sight	PathW	ave Si	gnal Ge	nerat	ion				
	沿 Radio Apps									
								50 10		
								DG NK		
								Custom Modulation (Beta)		

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.

	~ 🕞 💮 îgnal 1:	Signal Setup > 5G NR	I) Trigger ? ~ PRESET ~						
🖒 Generate	e	Carrier Waveform	[← Import Signal Setup						
[+ Export 89600 VSA Setup									
Basic	3GPP Version	V15.8.0 (2019-12)							
Marker	Sample Rate	122.88 MSa/s							
	Number of Radio Frames	1							
	Total Sample Points	1228800							
	Waveform Length	10.000000 ms							
	Mirror Spectrum								
	Phase Compensation	Auto 🗸							
	Radio Frequency	28 GHz							
	Total Number of Antennas	1							
Antenna 0 V 🔘 IQ 🔷 Spectrum 🔷 CCDF Power V									

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.

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.

Fullfilled Preset Config		×
Bandwidth	FR2 100MHz	~
Numerology	μ = 3: 120 kHz	~
∽ Duplex Type		
S Duplex Type	FDD	~
Modulation	256QAM	~
	OK	Cancel
	OK	Galicci

- 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**.

NOTE

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.

👌 Generate		Carrier	Waveform					
‱ Full-filled Config 🍯 DL Test Model 🛛 ⊲D Auto Frequency Offset [→ Export 89600 Setup								
+ …	General	DC Punctured						
Carrier 0 (DL)	Spectrum Control	Window Beta	0	.01				
	Cell-Specific	Windowing Method	C	entered at Symbol Boundary $ arsigma$				
	Downlink	Baseband Filter						

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.

👌 Generate				Carrier Waveform						
🗰 Full-filled Co	🗰 Full-filled Config 🍸 DL Test Model 🐠 Auto Frequency Offset 🛛 Export 89600 Setup									
+	General	BWP	SS/PBCH Block	Enabled						
Carrier 0 (DL)	Spectrum Control	SS/PBCH	NR-PBCH	Numerology						
	Cell-Specific	DCI	МІВ	SS Block Pattern						
	Downlink	DL-SCH		Periodicity	10 ms 🗸					
		CSI-RS		Lmax	64 ×					
				Active Indices	0:7					
				Power Boosting of each SS Block	0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.0					

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.

🖒 Generate				Carrier W	Vaveform	
🗰 Full-filled Cor	nfig 🍸 DL Test Mo	odel 🖘 Auto I	Frequency Offs	set [→ Export 89600 Setu	qu	
+	General	BWP		General Settings	ChannelCoding	
Carrier 0 (DL)	Spectrum Control	SS/PBCH	DL-SCH 0	Transmission Settings	RV Index	0
	Cell-Specific	DCI		Resource Allocation	MCS	20
	Downlink	DL-SCH			MCS Table	Table 5.1.3.1-2 (256QAM)
		CSI-RS		DMRS Settings	TB Scaling Factor	1.0 ~
				PTRS Settings	Coding Rate	
					Modulation	

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

్రి Generate				Carrier	Waveform					
🗰 Full-filled C	onfig 🌱 DL Test Mo	odel ∢o⊳ Auto F	Frequency Offs	et [→ Export 89600 S	etup					
+	General	BWP		General Settings	ChannelCoding					
Carrier 0 (DL)	Spectrum Control	SS/PBCH		Transmission Settings	RV Index		0	0		
	Cell-Specific	DCI		Resource Allocation	MCS		20			
		DL-SCH			g MCS Table		Table 5.1	.3.1-2 (256QAM)		
		CSI-RS		DMRS Settings	TB Scaling Factor	TB Scaling Factor		1.0 ~		
				PTRS Settings	Coding Rate					
					Modulation					
✓ c	Channel Allocation	Summary								Display Detail
CRB for µ = 3	66- 55- 44- 33- 22- 11- 0- 0	8	1 	24 32	40	48 56	64	4 7	2	DL-SCH SS PBCH
					Slot					

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

	🕥 🖒 Signal 1: Signal Setup 🖒	Waveform File: Markers
Marker Routing Use the controls below to route markers	to specific system signals.	
ALC Hold	None	~
RF Blanking	None	\checkmark
Sync	Marker 2	~

14. Select Enable Vector Modulation Signal.

≡ ₽`	©	\ominus	G	> Signal 1: Signal Setup				RF Out (#	All) Trigger	? ~ Preset ~
Enable	Mode	5G NR	~		Synchronization Role	Sy	ync Off 🗸	Signal Attenuation	0.00 dB	
							Reset Phase Accumulator	Frequency Offset	0 Hz	
5G NR Setup										
Create a complex 5G NR waveform signal using the 5G NR signal generation interface. Click on the [Edit Signal >] button to access this interface and modify the signal. Edit Signal >										
Triggering & N	larkers									
Trigger					Marke	rs				
Source Level Slope	Immediate 500 mV Negative	>			ALC H RF Bla Sync	old Inking	Marker 4 Marker 3 > Marker 2			

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.

≡≌∼	Θ	⇒ System Configuration								
< Back										
	Connection	n Type	Hostname or IP Address							
	O L4	N USB	141.121.149.32		Test Connection					
			Protocol							
			Туре	Address						

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.
- TIPThe 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 SIGNall ON RF1:OUTPut ON For multi-channel instruments, set RF Out (all) to On. RFAL1:OUTPut ON

Measurement Guide

3 5G NR Measurements Using the VSA Software

This section includes the following topics:

- "5G Waveform and EVM Analysis Using VSA Software" on page 120
 - "Setting Up a 1 CC 28 GHz EVM Measurement" on page 120
 - "Setting Up an 8 CC 28 GHz EVM Measurement" on page 128
 - "Creating a Basic 5G NR Signal Using PathWave N7631APPC Embedded Software" on page 136
 - "Creating a DL MIMO Signal Using PathWave N7631APPC Signal Generation" on page 157



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

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

Using the graphical user interface

On the VXG:

NOTE

- 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.

	Signal 1: Signal Setup 🖒	Waveform File: Markers
Marker Routing Use the controls below to route markers	to specific system signals.	
ALC Hold	None	~
RF Blanking	None	\checkmark
Sync	Marker 2	~

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.

K Back Output 1: Signal 1: Select Waveform File for Playback										
🖉 Recent	Dへ、Users、Instrument、Documents、Keysight、PathWave、SignalGenerate	r 〉 Examples 〉								
∧ Waveforms	Name A	Date Modified X Delete								
🛄 This Computer	5GNR_1CC_FR1_30kHz_SCS_100MHz_256QAM_DC Punctured.wfm	Jul 10, 2019, 2:47:40 AM								
	5GNR_1CC_FR2_120kHz_SCS_100MHz_256QAM_DC Punctured_28GHz wfm	Jul 14, 2019, 3:07:46 AM								
	5GNR_8CC_FR2_120kHz_SCS_100MHz_256QAM_Corrected_28GHz.wfm	Jul 14, 2019, 3:05:20 AM								
	5GNR_UXR_Recording_28_GHz.csv	May 19, 2019, 11:29:44 PM								

- 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.

\equiv	₽` ⊕ ⊝	<u>ن</u> ک	Output 1: Ac	ljustments				RF	Out (All)	Trigger G	? ~	PRESET ~
	I/Q Adjustments I Offset Q Offset Gain Balance I/Q Time Skew Quadrature Angle	0.0 % 0.0 % 0.000 dB 0 s 0.000 °	Off >	AWGN Carrier Bandwidth Flat Noise Bandwidth Noise Power in Channel Total Noise Power	0.00 dB 1 Hz 1 Hz -103.52 dBm -102.55 dBm	Off >	CW Interferer Frequency Offset Signal Power Absolute Power	0 Hz -103.52 dBm -96.00 dBm	Off >			
Chanr I/Q Sw	nel Settings I Common Delay 0 s ap I & Q											
Optim Opt	izations timize for: RF Output Optimize Dynamic Range v Enable System RF Flatness	I/Q O vith OBW	utput									

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.

Analog	Digital	Capture	Trigger	Playback Trigger	Exte	rnal Mixer	Extensio	ons
Input Trigg	jer Chann	el: 1						
Entry Cha	nnel:	All 1						
Style				Delay:				
External				0 s				
Slope:				Level:				
Positive				1 V				
Holdoff S	tyle:			Holdoff:				
Conventio	nal			0 s				
Time Crite	eria:			Time1:		Time2:		
Criteria:				Mask(s) to apply:				
Window	Туре:			RBW: 🗹 Auto				
				586.6536 kHz				
				Amplitude Offset				
	0 Hz							
								Ð

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.

Anaio Logic	al Instrument:	ingger	Playo	ack i rigger	Date	mairvitxer	Preset	sion	
1						<u> </u>	how All		
4 N	Misc							٠	
	Adc Dither			Auto					
	Capture Bit Pack	ing		Auto					
	Ext Reference Lo	ck Bandwid	lth	15 Hz					
	External Trigger	Location		Trigger 3 In					
	Instrument User	Corrections	5	Off	_				
	LO Dither			Off					
	Microwave Path	Control		Preselector	reselector Bypass 🔹 👻				
	Mixer Mode			Normal					
	Phase Noise Op	timization		Best Wide (Offset				
	RF Input Port			RF Input					
	Signal Path			Auto					
Pha	se Noise Optin	ization							
Op!	timizes the phas ations. The freq	e noise disti uency offse	ribution t of the	of the analyz	er's LO is dene	for differen ndent on th	t		
ana	alyzer model	activy of the	cor uic	opunization	is ucpe	inacine off ci			

- 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-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.



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



5G NR Measurements Using the VSA Software 5G Waveform and EVM Analysis Using VSA Software

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"

SIGNall 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.

RFAL1:OUTPut ON

On the X-Series Signal Analyzer:

INSTrument:SELect VSA89601

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

NOTE

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

5G NR Measurements Using the VSA Software 5G Waveform and EVM Analysis Using VSA Software

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.
- 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.

\equiv	₽~ €		G	> Output 1	: Ac	ljustments					RF Out (All)	Trigger V	? ~	PRESET
	I/Q Adjustments I Offset Q Offset Gain Balance I/Q Time Skew Quadrature Ang	le	0.0 % 0.0 % 0.000 dB 0 s 0.000 °	Off		AWGN Carrier to Noise Ratio Carrier Bandwidth Flat Noise Bandwidth Noise Power in Channel Total Noise Power	0.00 dB 1 Hz 1 Hz -103.52 dBm -102.55 dBm	Off >	CW Interferer Frequency Offset Signal Power Absolute Power	0 Hz -103.52 dBm -96.00 dBm	off			
Char I/C Sv	nnel Settings	0 s												
Optir Op	nizations	RF Output	<u> </u>	Output										
	Optimize Dynai	nic Range v RF Flatnes	with OBW s Correction											

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.

RF Out (All)

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:

NOTE

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

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.

Log	iiog iical Ir	strument	Ingger	Playb	ack rngger	External	vitxer	Preset	sion
	1						_ \$	iow All	
4	Misc								•
	Adc	Dither			Auto				
	Cap	ture Bit Pac	king		Auto				
	Ext P	Reference L	ock Bandwid	ith	15 Hz				
	Exte	mal Trigger	Location		Trigger 3 In				
	Inst	rument Use	r Correction	5	Off				
	L0 (Dither			Off				
	Mic	rowave Patl	h Control		Preselector	Bypass			
	Mix	er Mode			Normal				
	Pha	se Noise Op	otimization		Best Wide (Offset			
	RF I	nput Port			RF Input				
	Sigr	al Path			Auto				
PI O si ar	hase l)ptimi ituatio nalyze	Noise Optin zes the pha ons. The free er model	nization se noise dist quency offse	ribution t of the	of the analyz optimization	er's LO for d is dependen	ifferent It on th	:	

- 5. From the menu bar, select MeasSetup > 5G NR Demod Properties > Time tab.
 - Set Result Length to **10 Subframes**.

5G NR Measurements Using the VSA Software 5G Waveform and EVM Analysis Using VSA Software

- 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 Sun	D: CC Summary 🗸 🗸										
сс	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			

5G NR Measurements Using the VSA Software 5G Waveform and EVM Analysis Using VSA Software

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

SIGNall 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\CarrierSetu p\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

5G NR Measurements Using the VSA Software 5G Waveform and EVM Analysis Using VSA Software

FREQuency:CENTer 28 GHz

NOTE

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

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.

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

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.

∃ III ▷· ⓒ ○ □ > Modes	
h Radio Apps	
Keysight PathWave Signal Generation	
	å Radio Apps
	5G NR
	Custom Modulation (Beta)

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

	~ 🕞 💮 🏠 Signal 1:	Signal Setup > 5G NR	RF Out (All) Trigger
🖒 Generat	e	Carrier Waveform	[← Import Signal Setup
[→ Export 89	9600 VSA Setup		
Basic	3GPP Version	V15.8.0 (2019-12)	
Marker	Sample Rate	122.88 MSa/s	
¢	Number of Radio Frames	1	
	Total Sample Points	1228800	
	Waveform Length	10.000000 ms	
	Mirror Spectrum		
	Phase Compensation	Auto 🗸	
	Radio Frequency	28 GHz	
	Total Number of Antennas	1	
Antenna 0 🗸	IQ Spectrum CCC	F Power V	

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 $\mu = 3$: 120 kHz, Modulation to 256QAM and then select OK.

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.

Fullfilled Preset Config		×
Bandwidth	FR2 100MHz	\sim
Numerology	μ = 3: 120 kHz	~
> DuplexType	FDD	
Modulation	256QAM	~
	OKCano	cel

- 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**.

NOTE

5G NR Measurements Using the VSA Software 5G Waveform and EVM Analysis Using VSA Software

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

🖒 Generate				Carrier	Waveform		
🗯 Full-filled Co	nfig 🍸 → DL Test Mo	odel 🖘 Auto F	requency Offset	► Export 89600	Setup		
+	General	BWP	SS/PBCH Block	Enabled			
Carrier 0 (DL)	Spectrum Control	SS/PBCH	NR-PBCH	Numerology			
	Cell-Specific	DCI	МІВ	SS Block Patte	m		
	Downlink	DL-SCH		Periodicity		10 ms 🗸	
		CSI-RS		Lmax		64 ~	
				Active Indices		0:7	
				Power Boostin	g of each SS Block	0.00,0.00,	0.00,0.00,0.00,0.00,0.00,0.0

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.

💍 Generate				Carrier V	Vaveform	
🗯 Full-filled Co	nfig 🖣→ DL Test Mo	odel 🖘 Auto I	Frequency Offs	set [→ Export 89600 Set	up	
+	General	BWP		General Settings	ChannelCoding	
Carrier 0 (DL)	Spectrum Control	SS/PBCH	DL-SCH 0	Transmission Settings	RV Index	0
	Cell-Specific	DCI		Resource Allocation	MCS	20
	Downlink	DL-SCH		Modulation and Coding	MCS Table	Table 5.1.3.1-2 (256QAM) 🗡
		CSI-RS		DMRS Settings	TB Scaling Factor	1.0 ~
				PTRS Settings	Coding Rate	
					Modulation	

🖒 Generate				Carrier	Waveform						
🗰 Full-filled Config 🔭 DL Test Model 🔹 Auto Frequency Offset [+ Export 89600 Setup											
	General	BWP		General Settings	ChannelCoding						
Carrier 0 (DL)	Spectrum Control	SS/PBCH		Transmission Settings	RV Index		0				
	Cell-Specific	DCI		Resource Allocation	MCS		20				
		DL-SCH			MCS Table		Table 5.	1.3.1-2 (256QAM			
		CSI-RS		DMRS Settings	TB Scaling Factor		1.0 ~				
				PTRS Settings	Coding Rate						
					Modulation						
\sim	Channel Allocation	Summary								Display Detail	
	66-									DL-SCH	
	55-									SS PBCH	
л = 3	44-									-	
for I	33-										
CRB	22-										
	11-										
	0	8	16	24 32	40	48 56	6	i 54 7	i 72	80	
					Slot						

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**.

	🕥 🖒 Signal 1: Signal Setup 🖒	Waveform File: Markers
Marker Routing Use the controls below to route markers	to specific system signals.	
ALC Hold	None	~
RF Blanking	None	~
Sync	Marker 2	~

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

≡₽ŗ	€	€	۵ >	Signal 1: Signal Setu	qı				
🔽 Enable	Mode	5G NR	~			Synchronization Role	Syı	nc Off 🗸	
								Reset Phas	se Accumulator
5G NR Setup									
Create a com Click on the [plex 5G NR Edit Signal :	waveforn >] button t	n signal usin o access thi	ig the 5G NR signal ge is interface and modif	eneration interfac y the signal.	e.			

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.



NOTE

On the X-Series Signal Analyzer:

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

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.

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.

Analog	Digital	Trigger	Playba	ack Trigger	External N	Aixer	Extension
Input Trigg	ger Chann	el: 🚺					
Style:				Level:		7	
External				11			
Slope:				Delay:			
Positive				0 s			
Holdoff Style:				Holdof	f:		
Time Criteria:				Time1:		Time2:	
Frequenc	y Mask Tr	igger —					
Criteria:				Mask(s) to	apply:		
Enter	Enter			Upper			
Window Type:				RB₩: 🗸	Auto		
Flat Top (ampl acc)				7 586.6536 k	:Hz		
Masks							
	Frequ	aency Offset		Amplitude C	Offset		
Upper	0 Hz		0 d	0 dB			
Lower	0 Hz		0 d	8			
						Ed	it
Trigger C	lut						
Desired:				Actual:			
Trigger Out 1				Trigger Ou	ut 1		
🗸 Display							

 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.

Analog	Digital	Trigger	Playb	ack Trigger	External N	Aixer	Exten	sions
Logical In	strument:	Preset						
1						🗌 Sh	iow All	
⊿ Misc								•
Adc	Adc Dither			Auto 🚽				
Capt	Capture Bit Packing			Auto 👻				
Ext R	Ext Reference Lock Bandwidth			15 Hz				
Exter	External Trigger Location			Trigger 3 In				
Instr	Instrument User Corrections			Off				
LOD	LO Dither			Off -				
Micr	Microwave Path Control			Preselector Bypass 🔹 👻				
Mixe	Mixer Mode		Normal 👻					
Phas	Phase Noise Optimization		Best Wide Offset					
RF In	RF Input Port		RF Input					
Sign	al Path			Auto				
Phase Noise Optimization								
Optimiz situatio analyze	tes the phas ns. The freq r model	e noise dist uency offse	ribution t of the	of the analyz optimization	er's LO for d is dependen	ifferent t on th	8	

- 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.

Configuration	Input & Antenna Time Decode Advanced
Save As Quick Setup.	Quick Setups CC0: CD0
Carriers	Link Direction: Downlink Uplink Mixed
Bandwidth BWP	Configure Add Carrier Allow Multiple Carrier Definitions
 Channel 	Reference: CC0 × Display: CC0 ×
SS/PBCH	Cell ID Bandwidth Freq. Offset
PDCCH	🗹 CC0 🔽 0 FR1 100 MHz 👻 0 Hz
PDSCH	Annly Tert Model
CSI-RS	Apply ICLINOCCI.
Results & Filters	

- Set Cell ID to 0

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

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 $\mu = 3:120 \text{ kHz}$

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.

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

Configuration	Input & Antenna	Time Decode	Advanced				
Save As Quick Setup	Quick Setups	CC0:CD0					
Carriers Bandwidth	Bandwidth: FR2	100 MHz 👻					
BWP	Resource Grid						
▲ Channel	Numerology	Grid Start	Grid Size	Grid Enabled			
SS/PBCH	μ = 2 : 60kHz:	0 RB	132 RB				
PDCCH	μ = 3 : 120kHz:	0 RB	66 RB	•			
PDSCH	μ = 4:240kHz:	0 RB	34 RB				
CSI-RS	Ref. Point A: -4	7.52 MHz at -47.52 M	Hz from center				
Results & Filters	Num. of Meas. Cha		Ref. Meas. Channel: Ch1 💌				

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.

Configuration	Input & Ar	out & Antenna Time Decode Ad				ced							
Save As Quick Setup	Quick So	k Setups CC0 : CD0											
Carriers					Numerolog	зу	RB Offset	RB Number					
Bandwidth		🗌 Initia	I-DL-BWP	0	μ = 3 : 120	kHz ≖	0 RB	273 RB					
BWP		∎DL-B	BWP	1	μ = 3 : 120	kHz ≁	0 RB	66 RB					
4 Channel		DL-E	BWP	2	μ = 3 : 120	kHz ⊤	0 RB	273 RB					
SE/DP/CH		DL-E	3WP		μ = 3 : 120	kHz ⊤	0 RB	273 RB					
SS/PBCH													
PDCCH				ld	Numerolo	ЭУ	RB Offset	RB Number					
PDSCH		√ Initia	al-UL-BWP	0	μ = 3 : 120	kHz ▼	0 RB	66 RB					
CSI-RS	CORES		•										
Results & Filters													
	Add C	ORESET											
	CORESET: 0												
	CORE	SET ID:				BWP ID):	BWP1 -					
	Symbo	ol Numb	en			DMRS	Scrambling ID:						
	CORES	SETO RB O	Offset:			CCE To	REG Mapping Type	Non-interleaved	-				
	CORES	SETO RB N	Number:										
	Alloca	ted RB G	roups (6RBs): 0:44									
						Precod	er Granularity:	Same as REG bu	ndle 👻				

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

TIP

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.

ick Setups C	CO: CD0		
SS/PBCH	L64 -		
nax:	L64 -		
		SSB Transmitted:	þ:7
Auto Detect Acti	ve Block	Det Power Threshold:	-30
3 Offset(60kHz): ISB(60kHz): Priodicity: Power Boosting PSS power boosting	46 RB 0 10 ms ~	Numerology: SCS Common: 28.8 MHz bandwidth 0 PBCH power boost	μ = 3 : 120 kHz × 60kHz × MHz from center ting 0 dB
	Goffset (60kHz): SB (60kHz): riodicity: ower Boosting PSS power boostin GPP Version: La	Addo Detect Active Diote Offset(60kHz): 46 RB SB(60kHz): 0 riodicity: 10 ms wer Boosting PSS power boosting 0 dB SPP Version: Latest (2019-06) *	Addo Decet Acare block Dec Power Inteshold # Offset(60kHz): 46 RB Numerology: SB(60kHz): 0 SCS Common: riodicity: 10 ms 28.8 MHz bandwidth 0 ower Boosting 0 dB PBCH power boost SPP Version: Latest (2019-06) =

These following settings use the default values.

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

Configuration	Input & Antenna	Time Decode	Advanced						
Save As Quick Setup	Quick Setups	CC0: CD0							
Carriers	SS/PBCH								
Bandwidth	Lmax:	L64 -	SSB Transmitted:	0:7					
BWP	Auto Detect Act	ive Block	Det Power Threshold:	-30					
Channel SS/PBCH PDCCH	RB Offset(60kHz): -kSSB(60kHz): Basiadisiba	RB Offset(60kHz): 46 RB Numerology: µ = 3 : 120 -hsSSB(60kHz): 0 SCS Common: 60kHz							
CSI-RS Results & Filters	Power Boosting PSS power boosti	ing 0 dB	PBCH power boos	ting 0 dB					
	3GPP Version: La	atest (2019-06) 🔻							

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.

Meas01 - 5G NR Demo	od Properties						?							
Configuration	Time Decode A	Advanced												
Save As Quick Setup	Quick Setups													
Signal Carrier	Add PDSCH Rei	move PDSCH Clear P	PDSCHs											
BWP	PDSCH:													
✓ Channel SS/PBCH	I 3GPP Version: Latest (2018-09/12) ▼													
РДССН	Modulation and	Coding Time/Freq A	Allocation											
PDSCH	Modulation and Codi	ng	Time/Freq Allocatio	on										
CCL DC	RV Index:	<u>0</u>	Allocated Slots:	0:19										
CSI-RS	MCS Table:	Table 256QAM 🚽	Slot Format:	0: D,D,D,D,D,D,D,I	D,D,D,D,D,D,D,D									
	MCS:	20	DL X Symbols:											
	TB Scaling Factor S: 1 🔹	Mapping Type	ТуреА –	TypeA Pos:	Pos2									
	Coding Rate:	0.66650390625	First Symbol:	0	Last Symbol:	13								
	Modulation:	QAM256	Resulting Format:											
	Transport Block Size:	55304	RA Type:	Type1 –										
	n _{ID} Source	Cell ID 🚽	RB Offset:	0 RB	RB Number:	66 RB								
	n _{ID}		RA Configuration:											
	CORESET ID:		Allocated RBGs:											
				← BWP RB Ba	ndwidth: 66 –	<u>→</u>								
				16.5 Unused RBs	Allocated RBs									
	RS Sequence													
	Power Boosting													

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**

🚰 Meas01 - 5G NR Der	mod Properties							?						
Configuration	Time Decode A	dvanced												
Save As Quick Setup	Quick Setups													
Signal Carrier BWP	Add PDSCH Remove PDSCH Clear PDSCHs PDSCH: 0													
 Channel 	Modulation and Coding Time/Freq Allocation													
SS/PBCH	Modulation and Codi	ng		Time/Freq Allocation										
PDCCH	RV Index:	0		Allocated Slots:	0:79									
PDSCH	MCS Table:	Table 256QAM		Slot Format:	0: D,D,D,D,D,D,D,	-								
CSI-RS	MCS:	20		DL X Symbols:										
	TB Scaling Factor S:			Mapping Type	ТуреА	TypeA Pos:	Pos2	-						
	Coding Rate:	0.66650390625		First Symbol:	0	Last Symbol:	13							
	Modulation:	QAM256		Resulting Format:	DDDDDDD									
	Transport Block Size:	55304		RA Туре:	Type1 🔻									
	n _{ID} Source	Cell ID		RB Offset:	0 RB	RB Number:	66 RB							
	n _{ID}			RA Configuration:										
	CORESET ID:													
					← BWP RB B	andwidth: 66 –	_							
					Unused RBs	Allocated RBs	5							
	RS Sequence							•						
	Power Boosting							•						
	Antenna Port							•						

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.

Configuration	Input & Antenna	Ti	me	Deco	de	Advanced						
Analysis Region												
Result Length:	10 Subframes	0 SI	ots		at µ	at µ3 10 ms						
Meas Offset:	0 Subframes	0 Sy	mbols	;	at µ3							
Meas Interval:	2 Subframes	0 Sy	mbols	;	at µ	13						
Time Scale Factor:	1											
Analysis Start Bour	dary		Acqu	uisition I	Mode	•						
Frame Reduced acquisition length												
O Half-frame												
O Subframe			r is present									
⊖ Slot			 Slot trigger is present 									
First Slot Index: () at	μ3	ic Trigger									
Timing Diagram	Timing Diagram											
← Result Length 10 Subf. — →												
						- 1-1						
				`	Mea	s. Offset 0:0						
Frame Bou	indary				mea	51 51 50 0.0						

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.

Configuration	Input & Antenna	Time	Decode	Advanced							
EVM Window Ler	igth Mode: 3GPP										
EVM Window Ler	igth in Samples: 17										
Symbol Time Adj	ustment Mode: p										
% of FFT Duration	n: -3.125 %										
Error Vector Unit											
Time Domain: p	er Symbol 🚽 Fr	eq Domain:	Per RE								
MIMO Condition N	lumber										
Control: Off	- RB Gran	ularity: 1									
Sync Mode		Sync	Adjust								
CP Autocorrela	tion		Prioritize PDSCH-DMRS								
O Time Cross Cor	relation		Ignore MIB Data								
Auto Set Span		√ DC	✓ DC Punctured								
Independent SSB	BWP Measurement	✓ Extended	✓ Extend Frequency Lock Range								
Multicarrier Filter	On	🖌 Cor	Compensate Symbol Clock Offset								
Report EVM in dB											
Symbol Phase C	ompensation				۲						
From Measureme	nt Center										
From Manual Entre	y										
 Disabled 											

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.

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.

	^
Format Coupling Y Scale X Scale Average Digital Demo	od
Trace D 🔻 🕂 🗹 Visible	
Symbol Table Format: Ideal State	
Hex Shape:	
Symbol Table Bit Order:	
Auto Size:	
Symbol Shape: 5 %	
Bars 👻	
Eye Length: Code Order:	
2 Bit Reverse	
Time Unit:	
sym 🚽 🗌 Show 2D Avg Line	
Frequency Unit:	
carrier 👻	
Filtered SubSegments: Filtered Channel Types:	
Select All Clear All Select All Clear All	
SSBlock0	
Laver0	
✓ ✓ PBCH	
PBCH DMRS	
✓ PDSCH0	

- 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

SIGNall ON

RF1:OUTPut ON

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

RFAL1: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

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.

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.

NOTE

TIP

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.

28.0000000000 GHz	28.0000000000 GHz	
0.00 dBm	0.00 dBm	2
ALC ON	ALC ON	

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**.

Current Configuration: Independent Independent 2 Tx Coherent Bonded 	Instrument Configuration											
Independent 2 Tx Coherent Bonded	Current Configuration: Independent											
	Independent	O Bond	led									
OK Cancel			ОК	Cancel								

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.

≡		P]~	\bigotimes			G	> м	lodes											
ΰR	adio Apj	ps																		
Key	sight	: Pat	thWa	ive Si	igna	l Gei	nerat	tion												
										ň Ra	adi	dio A	\pps	;						
												5G	NR							
												Cu	stom N	Modula	ation (B	eta)				

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.

	× 🕞 ⊖ ि > Signals 1	& 2: Signal Setup > 5G NR	RF Out (All)	Trigger ? ~ Preset ~
🖒 General	te	Carrier Waveform		[← Import Signal Setup
[→ Export 8	9600 VSA Setup			
		V15.8.0 (2019-12)		
Marker	Sample Rate	122.88 MSa/s		
	Number of Radio Frames	1		
	Total Sample Points	1228800		
	Waveform Length	10.000000 ms		
	Mirror Spectrum			
	Phase Compensation	Auto 🗸		
	Radio Frequency	1 GHz		
	Total Number of Antennas	2		
Antenna 0 🥆	/ 💽 IQ 📄 Spectrum 📄 CCD	F Power ∨		

- 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

Carrier Waveform								
🎟 Full-filled Config 🎽 DL Test Model 🔹 Auto Frequency Offset [→ Export 89600 Setup								
+	General	Carrier Type	Downlink 🗸					
Carrier 0 (DL)	Spectrum Control	Cell ID	0					
	Cell-Specific	Bandwidth	FR1 100MHz \vee					
	Downlink	Numerology Mode	Single Numerology 🗠					
		Numerology	µ = 1: 30 kHz ╰					
		Max RB	273					
		k0	0					

- 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 $-45.54\ \text{MHz}.$

👌 Generate				Carrier	Waveform		
🗯 Full-filled Co	onfig 🏾 🖣 → DL Test Mo	odel ⊲t Auto∣	Frequency Offset	[→ Export 89600	Setup		
	Cell-Specific	DCI	МІВ			Case D .	
	Downlink	DL-SCH		Periodicity	10 ms 🗡		
'	CSI-RS		L	Lmax	Lmax		
				Active Indices	0:3		
				Power Boosting	g of each SS Block	0.00,0.00,0	0.00,0.00
				RB Offset by 15	5 kHz SCS	0	
				kSSB by 15 kH:	z SCS	0	
				Delta Frequenc	cy to Carrier Center	-45.54 MH	z

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).

🖒 Generate	Carrier Waveform								
‱ Full-filled Config 🍯 DL Test Model ৰ⊳ Auto Frequency Offset [→ Export 89600 Setup									
+	General	BWP		General Settings	Antenna Port(s) Generated	p0,p1			
Carrier 0 (DL)	Spectrum Control	SS/PBCH	DL-SCH 0	Transmission Settings	DMRS port(s)	0,1			
	Cell-Specific	DCI		Resource Allocation	Number of Layers				
	Downlink	DL-SCH		Modulation and Coding	Number of Antenna ports				
		CSI-RS		DMRS Settings	Number of DMRS CDM groups without data	1			
				PTRS Settings	Number of Codewords				

- 10. Select the Resource Allocation node and set:
 - Allocated Slots to 2:19
 - RB Offset to 40
 - RB Number to 80

 $\mathsf{DL}\text{-}\mathsf{SCH0}$ will occupy the RBs 40-80 and $\mathsf{DL}\text{-}\mathsf{SCH1}$ will occupy the rest of the resources.

Waveform									
🇱 Full-filled Config 🍯 DL Test Model 📣 Auto Frequency Offset [→ Export 89600 Setup									
2:19									
0									
13									
BWP 1 🗡									
40									
80									
Туре 1 🗸									

- 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.

🖒 Generate	Carrier Waveform									
₩₩ Full-filled Config T → DL Test Model ৰ> Auto Frequency Offset [→ Export 89600 Setup										
+	General	BWP		General Settings	ChannelCoding					
Carrier 0 (DL)	Spectrum Control	SS/PBCH	DL-SCH 0	Transmission Settings	RV Index	0				
	Cell-Specific DCI Resource Allocatio Downlink DL-SCH Modulation and Co CSI-RS DMRS Settings		Resource Allocation	MCS	20					
					MCS Table	Table 5.1.3.1-2 (256QAM) $ imes $				
			CSI-RS		TB Scaling Factor	1.0 ~				
				PTRS Settings	Coding Rate	0.66650390625				
					Modulation	256QAM \sim				

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

🖒 Generate				Carrier W	Carrier Waveform				
₩₩ Full-filled Config 🎽 DL Test Model 🖘 Auto Frequency Offset [→ Export 89600 Setup									
	General	BWP		General Settings	n_SCID	0			
Carrier 0 (DL)	Spectrum Control	SS/PBCH	DL-SCH 0	Transmission Settings	N_ID_nSCID	Cell ID			
	Cell-Specific	DCI		Resource Allocation	DMRS PowerBoosting	3.00 dB			
	Downlink	DL-SCH		Modulation and Coding	DMRS Configuration	Туре1 🗡			
		CSI-RS		DMRS Settings	DMRS Duration	Single Symbol $$			
				PTRS Settings	DMRS-add-pos	0			
					PDSCH Mapping	Туре А 🗡			

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

🖒 Generate Waveform Carrier 🎟 Full-filled Config 🍯 DL Test Model 👒 Auto Frequency Offset [→ Export 89600 Setup General BWP General Settings Allocated Slots 2:19 DL-SCH 0 Spectrum Control SS/PBCH Transmission Settings First Symbol 13 Last Symbol Cell-Specific DCI Resource Allocation Bandwidth Part BWP1 ∽ Downlink DL-SCH Modulation and Coding 150 RB Offset CSI-RS DMRS Settings 100 PTRS Settings RA Type

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)

👌 Generate	Carrier Waveform											
🗰 Full-filled (### Full-filled Config 🎽 DL Test Model 🔹 Auto Frequency Offset [→ Export 89600 Setup											
+	General	BWP		General Settings	Char	nelCoding						
Carrier 0 (DL)	Spectrum Control	SS/PBCH	DL-SCH 0	Transmission Settings	s RV Ir	ıdex			0			
	Cell-Specific	DCI		Resource Allocation	MCS				20			
Downlink DL-SCH		DL-SCH			ng MCS	Table			Table 5.1.3.1-1 (64QAM)			
				DMRS Settings	TB Scaling Factor				1.0 ~			
				DTD0 0-#:	Codi	Coding Rate						
				PTRS Settings	Mod	ulation				~		
\sim	Channel Allocation	Summary										Display Detail
	273-											DL-SCH
	234											SS PBCH
-	195-											<u> </u>
ъгµ	156-											
R fe	117-											
ō	78-											
	0-											
	0	2	4	6 8		10	12	14	1	6 18		20

- 17. Select the Waveform Tab and select Generate.
- 18. In the bottom panel, select Spectrum.

You should see a spectrum like the one below.

🖒 General	te	Carrier Waveform	[← Import Signal Setup
[→ Export 8	9600 VSA Setup		
Basic		V15.8.0 (2019-12)	
Marker	Sample Rate	122.88 MSa/s	
	Number of Radio Frames	1	
	Total Sample Points	1228800	
	Waveform Length	10.000000 ms	
	Mirror Spectrum		
	Phase Compensation	Auto V	
	Radio Frequency	1 GHz	
	Total Number of Antennas	2	
Antenna 0 🥆	V IQ OSpectrum CCD		
	O dB 30 dB -300 dB center: O Hz	Nilograuf hje estimutite sur sester blander Nilograuf hje estimutite sur sester blander	span: 122.88 MHz

- **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.

		Θ (i	<u>ن</u> ک	· Signals 1 &	2: Signal Setup					RF Out (All) Trigger	? ~	PRESET
🔽 En:	able Mod	le 5	5G NR	~							Signal Attenuation	0.00 dB		
									Reset Phase Ac	ccumulator	Frequency Offset	0 Hz		
5G NR S	Setup													
Creat Click	e a complex 5 on the [Edit S	5G NR wa iignal >] b	aveform outton to	signal usir access th	ng the 5G NR is interface a	signal generation nd modify the sig	n interface. gnal.					Edit Signal 〉		
Triggeri	ng & Markers													
Trig	iger							Markers						
Sou Lev Slo	urce Imme rel 500 n pe Negat	ediate nV tive	>					ALC Hold RF Blanking Sync	Marker 4 Marker 3 > Marker 1					
			_											

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 Infinium Series Oscilloscope** and select the right arrow to move it under Configuration.

	A New Hardware Configuration	?	×
	1. Select the logical instrument(s) to use. Sources and Analyzers cannot be combined within the same Simulate Hardware	configuratio	n.
ĺ	Possible Logical Instruments Configuration		
	Analyzer Agilent ESA-E Series Spectrum Analyzer Agilent N6841A RF Sensor Agilent N6841A RF Sensor Agilent PSA Series Spectrum Analyzer Agilent PSA Series Spectrum Demo Keysight VSA Logic Analyzer Input Keysight XSA Stream Keysight Z90708 Wideband Signal Analyzer Keysight/Agilent Infinitium Series Oscilloscope Frequency/bandwidth from DC to 31.25 GHz depending upon model. 4 Inputs. Keysight/Agilent Infinitivision Series Oscilloscope Keysight/Agilent Infinitivision Series Oscilloscope Keysight/Agilent X-Series Signal Analyzer 2. Select the instrument(s) to use for each logical instrument in the configuration.	Dscilioscope	
	ADC Keysight/Agilent Technologies Infiniium Series Scope SI	M::Infiniium	•
	3. Name the configuration.		
	Analyzer4		
	ОК	Cancel	

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 > UXR_Record:	Recall ing_28	> Recall 3_GHz.c	Record sv, the	ing , select n Open .
🕿 Recall Recordi	ing					
Look in:	CarrierSetup		• +	🗈 💣 💷 -		
Quick access	Name	^ ording_28_GHz.csv			1	
Desktop						
Libraries						
This PC						
Network						
	File name:	UXR Recording 28 GHz	SV.	-	> Open	
	Files of type:	CSV (Comma delimited) (*.c	sv)	•	Cancel	

- 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.

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

Arrow Meas01 - 5G NR Der	nod Propertie	es						? >
Configuration	Input & An	tenna Time	Decode	Advance	d			
Save As Quick Setup	Quick Set	tups CC0 : CD0						
Carriers Bandwidth BWP Channel SS/PBCH PDCCH PDSCH CSLBS		□ Initial-DL-BWP □ DL-BWP □ DL-BWP □ DL-BWP □ Initial-UL-BWP	ID 0 1 2 3 Id 0	Numerolo $\mu = 1 : 30 I$ $\mu = 1 : 30 I$ $\mu = 1 : 30 I$ $\mu = 1 : 30 I$ Numerolo $\mu = 1 : 30 I$	gy dHz v dHz v dHz v dHz v gy dHz v	RB Offset 0 RB 0 RB 0 RB 0 RB 0 RB RB Offset 0 RB	RB Number 24 RB 273 RB 273 RB 273 RB 273 RB RB Number 273 RB	
Results & Filters	CORES Add CC CORES CORES Symbo CORES CORES Allocat Shift In	E IS RESET Remove SET: 0 1	0 2 0 24 E 0:3 Cell ID		BWP IE DMRS CCE To REG Bu Interles Shift In Precod); Scrambling ID; > REG Mapping Type undle Size; ave Size; hdex ler Granularity;	BWP0 -1 Interleaved 6 2 0 Same as REG bu	v v v

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

🔁 Meas01 - 5G NR Der	nod Properties				?	×			
Configuration	Time Decode	Advanced							
Save As Quick Setup	. Quick Setups								
Signal	SS/PBCH								
Carrier	Lmax:	L4 -	SSB Transmitted:	0:3	:3				
BWP	✓ Auto Detect Acti	ve Block	Det Power Threshold:	Power Threshold: -30					
▲ Channel									
SS/PBCH	RB Offset(15kHz):	0 RB	Numerology:	μ = 1:30 kHz					
PDCCH	kSSB(15kHz):	0	SS Block Pattern:	CaseB					
PDSCH	Periodicity:	10 ms 🔹 👻	7.2 MHz bandwidth -45	5.54 MHz from cen	ter				
CSI-RS	Power Boosting —								
	PSS power boosting 0 dB PBCH power boosting 0 dB								
	3GPP Version: La	test (2018-09/12) 🔹							

- 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

Meas01 - 5G NR Demod	Properties							?				
Configuration In	put & Antenna Time	Decode A	dvance	i								
Save As Quick Setup	Quick Setups	CDO										
Carriers Bandwidth BWP	Add PDSCH Ren	nove PDSCH)SCHs								
▲ Channel SS/PBCH	Enabled BWP ID BWP1 RNTI: 1 GPP Version: Latest (2019-06)											
РОССН	Modulation and Coding Time/Freq Allocation											
- Decin	- Modulation and Codir	1g		Time/Freq Allocation								
PDSCH	RV Index:	0		Allocated Slots: 2:19								
CSI-RS	MCS Table:	Table 256QAM	•	Slot Format:	0: D,D,D,D,D,D,D,D,	D,D,D,D,D,D,D,D		-				
Results & Filters	MCS:	20		DL X Symbols:								
	TB Scaling Factor S:	1	-	Mapping Type	ТуреА	 TypeA Pos: 	Pos2	-				
	xOverhead:			First Symbol:	0	Last Symbol:	13					
	Coding Rate:	0.66650390625		Resulting Format: D D D D D D D D D D D D D D D D D D D								
	Modulation:	QAM256		RB Ref CORESET ID:		 RA Type: 	Type1	-				
	Transport Block Size:	65576		RB Offset:	40 RB	RB Number:	80 RB					
	n _{ID} Source	Cell ID		RA Configuration:								
	nD											
	CORESET ID:			-	← BWP 1	Max RB: 273	,	-				
					Unused RBs	Allocated KBs						
	RS Sequence											
	Power Boosting											

- 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.

🜁 Meas01 - 5G NR De	emod Properties	?								
Configuration	Time Decode Advanced									
Save As Quick Setup	o Quick Setups									
Signal Carrier	Add PDSCH Clear PDSCH Clear PDSCHs									
BWP	PDSCH: 0									
A Channel	TR Scaling Easter St. 1 Manning Tung Tung A Tung A Dec.	· · ·								
SS/PBCH	Coding Pater 0.66650300625 Eirst Sumbol: 0. Last Sumbol: 12									
РДССН	Modulation: OAM256 Resulting Format: DDDDDDDDDDDDDDD									
PDSCH	Transport Block Size: 131176 RA Type: Type1									
CSI-RS	nin Source Cell ID RB Offset: 40 RB RB Number: 20 RB									
	np 0 RA Configuration: Config1									
	CORESET ID: -1 Allocated RBGs:									
	← BWP RB Bandwidth: 273 →									
	68.25 136.5 204.75 Unused RBs Allocated RBs									
	RS Sequence									
	Power Boosting									
	Power Boosting: 0 dB DMRS Power Boosting: 3 dB PTRS Power Boosting: 0 dB									
	Antenna Port									
	Ref. Antenna Port: 1000 👻									
	Use Antenna Ports Index									
	Antenna Ports Index: -1 Codeword Number: 1 -									
	Antenna Ports Used: 0:1 DMRS CDM group(s) without data: 2 🔹									

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

- RB Number to 100 RB

🔤 Meas01 - 5G NR De	mod Properties							?				
Configuration	Input & Antenna Time	e Decode	Advance	ed								
Save As Quick Setup	Quick Setups CCO	: CD0										
Carriers Bandwidth	Add PDSCH Re	emove PDSCH	Clear P	DSCHs								
▲ Channel SS/PBCH	✓ Enabled BWP	Enabled BWP ID BWP1 RNTE 1 3GPP Version: Latest (2019-06)										
РДССН	Modulation and	Coding Tim	e/Freq A	Allocation								
DDSCH	Modulation and Coding											
rosen a	RV Index:	RV Index: 0 Allocated Slots: 2:19										
CSI-RS	MCS Table:	able: Table 64QAM 🔻 Slot F			0: D,D,D,D,D,D,D,D),D,D,D,D,D,D,D						
Results & Filters	MCS:	20		DL X Symbols:								
	TB Scaling Factor S:			Mapping Type	ТуреА	 TypeA Pos: 	Pos2					
	xOverhead:			First Symbol:		Last Symbol:	13					
	Coding Rate:	0.5537109375		Resulting Format:	DDDDDDDD	DDDDD						
	Modulation:	QAM64		RB Ref CORESET ID:		• RA Type:	Type1					
	Transport Block Size:	52224		RB Offset:	150 RB	RB Number:	100 RB					
	n _D Source	Cell ID		RA Configuration:	Config1 ·	 RBG Size [P]: 	16					
	np											
	CORESET ID:	CORESET ID: -1 → BWP Max RB: 273 → BWP Max RB: 273 → BWP Max RB: 273 → BMP Max RB:										
	RS Sequence	RS Sequence										
	Power Boosting							•				

- 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.

🚰 Meas01 - 5G NR 🛛	Demod Properties	?
Configuration	Time Decode Advanced	
Save As Quick Setu	up Quick Setups	
Signal Carrier	Add PDSCH Remove PDSCH Clear PDSCHs	
BWP	PDSCH: 0 1	
▲ Channel	I I I I I I I I I I I I I I I I I I I	
SS/PBCH	TB Scaling Factor S: 1 • Mapping Type TypeA • TypeA Pos: Pos	2 -
РОССН	Coding Rate: 0.553/1093/5 First Symbol: 0 Last Symbol: 13	
PDCCH	Modulation: QAM64 Resulting Format: DDDDDDDDDDDDDDDD	
PDSCH	Transport Block Size: 104496 RA Type: Type1 v	
CSI-RS	n _{ID} Source Cell ID • RB Offset: 150 RB RB Number: 100	RB
	n₀ 0 RA Configuration: Config1 ▼ RBG Size [P]: 16	
	CORESET ID: -1 Allocated RBGs:	
	← BWP RB Bandwidth: 273 —	→
	Unused RBs Allocated RBs	
	RS Sequence	•
	Power Boosting	
	Power Boosting: 0 dB DMRS Power Boosting: 3 dB PTRS Power Boosting: 0 dB	
	Antenna Port	۲
	Ref. Antenna Port: 1000 🔹	
	Use Antenna Ports Index	
	Antenna Ports Index: 0 Codeword Number: 1 -	
	Antenna Ports Used: 0:1 DMRS CDM group(s) without data: 2 🔹	

- **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.

Configuration	Input & Antenna	Time	Deco	Advanced				
Analysis Region								
Result Length:	10 Subframes	0 Slots	3 10 ms					
Meas Offset:	0 Subframes	0 Symt	ools	at µ	3			
Meas Interval:	2 Subframes	0 Symt	ols	at µ	μ3			
Time Scale Factor:	1							
Analysis Start Boun	dary							
Frame				lacou	visition longth			
O Half-frame			Reduced acquisition length Erama triagar is present					
O Subframe		Clat triager is present						

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.

Meas01 - 5G NR Demod Properties												
Configuration	Input & Antenna	Tim	e Decode	Advanced	1							
✓ 3GPP Conform	✔ 3GPP Conformance Test											
Tracking:			Equalizer Train	ning								
✓ Amplitud			Signal Source									
✓ Frequence			Time Pacies									
✓ Timing			TIME Dasis:									
Tracking Sou	Tracking Source: RS+Data - Freq Moving Avg. Filter											
EVM Window ar	nd Symbol Timing											
EVM Window	Length Mode: 3GPP											
EVM Window	Length in Samples: 1											
Symbol Time	Adjustment Mode:											
% of FFT Dura	tion: -3.125 %											
Error Vector Uni	i											
Time Domain:	Per Symbol 👻 F	req Dom	ain: Per RE									
- MIMO Conditio	n Number											
Control: Off	✓ RB Grar	nularity:										
Sync Mode	alatia a	S	ync Adjust — Drioritize DD									
Time Cross	Correlation)								
	conciación		Ignore MIB Data									
Auto Set Span			DC Punctured									
🗌 Independent S	SB/BWP Measuremen	t 🗌	Extend Frequer	icy Lock Range	e							
	-	-	- · ·	1.101.10	<i></i> .	- M						

- 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.

			Level:					
		- 12						
			Delay:					
			0 s					
/le:			Holdoff					
ia:			Time1:		Time2:			
lype: ampl acc)		Mask(s) to apply: Upper RBW: Auto 586.6536 kHz						
Frequency	Offset	Am	olitude O	ffset				
0 Hz	0	dB						
0 Hz	0	dB						
					Ed	it		
ıt —								
		А	ctual:					
	/le: I Mask Trigger Fype: (ampl acc) Frequency 0 Hz 0 Hz t	 v v<	/le: 		IV Delay: 0 s Holdoff: I <td>Image: Second secon</td>	Image: Second secon		

- **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

File Edit (Contro	ol Sou	rce Input	MeasSetup	Trace	Markers	Windo	w Utilities H	lelp										?
: 🕞 II [Ċ		- Default			1	. i G	88 - 📲 💡 🗌	₽ □, ◊	• -	1 <mark>8</mark> 1	لللا							
A: OFDM Me	as								- ×	D: Sumr	nary								+ ×
Bng	2.05	dBm*																	^
1.5					exxx	XXXI	2			Analyz									
Const						33X	6			OFDM									
300					XXX					EVM									
m										Freque Symbo			-63.80						
Jdiv					++++	***				IQ Off			-42.68						
-1.5						888.	5			Sync									
-5.8	96								5.8958	Sync									
Hes	s BW a	IU KHZ							imeLen 55 Sym	Gell	U		U						~
B: Frame Sum	nmary	L.,							- ×	E: RE Po	wer 3D								÷ ×
Name	E	VM %rms)	Power per RE (dBm)	Modulation	Num. of RBs	RNTI	BWP ID							and carrier 200	>				
				BPSK					-					4.					
PR	SSS RCH	0.036	-40.84	OPSK	24 40									Ñ 📃 📻					
PBCH_DM	IRS	0.046	-40.86	QPSK	40				_					- KL					
PDSC	сно			QAM256										dBn					
PDSCH0_DM	IRS	1.209	-37.55	QPSK	320	0x1									a.s.				
PDSCH0_Lay	ver0	1.300		QAM256	160									54.5	-				
PDSC														-8.3					
PD90U1 DM	ine i	1 100	-27.09	OPSK	400	01								2	-				
C: OFDM Det	ected	Allocati	ons Time						~ ×	G: MIM	0 Info ▼	<u> </u>							+ ×
1.64										Name		Meas. Channel	Antenna	Despread EVN (%rms)	(dBm)	TAE (RRC)	Frequency Offset	Phase Offset (dea)	
kcarriers										PDSCH	DMRS	Ch1	Port0	0.950	-38.46	0	-63.673	0.00	
Real										PDSCH	_DMRS								
328							11111	1111111111		PDSCHO	DMRS	Ch2	Port0 Port1	0.749	-116.94	-411.946 -	-62 6010		
carriers										PDSCH1	_DMRS	Ch1	Port0	0.908	-38.75	0	-63.6676	0.00	
										PDSCH1	_DMRS								
-1.64 kcarriers				11111	1					PDSCH1	DMRS	Ch2	Port0	0.057	-105.12		-6239 63-		
Star	rt0 sy	m							Stop 55 sym	POSCHI	LOMKS	Ch2	Porti	0.657		120,863 p	-03.0583	-202.59	

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
5G NR Measurements Using the VSA Software 5G Waveform and EVM Analysis Using VSA Software

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 5G NR Measurements Using the VSA Software 5G Waveform and EVM Analysis Using VSA Software

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

5G NR Measurements Using the VSA Software 5G Waveform and EVM Analysis Using VSA Software

NR5G:DECode:MODE "DecodedTB"

DISPlay:LAYout 3,2



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