APPLICATION NOTE

DVB-S2/S2X Modulation Analysis 89600 VSA Software

Option 89601DVBC

KEYSIGHT

Table of Contents

Introduction

Digital Video Broadcasting Satellite Communication Analysis (Option 89601DVBC) enriches the 89600 VSA software capabilities to demodulate and analyze DVB-S2 and DVB-S2X signals based on ETSI specification (www.etsi.org).

89601DVBC supports DVB-S2/S2X modulation analysis measurements according to ETSI EN 302 307-1(DVB-S2) and 302 307-2 (DVB-S2X) specifications. In addition to the conventional demodulation analysis results like EVM, 89601DVBC also provides Bit Error Rate (BER) results. This allows you to verify the accuracy of the transmitted signal's CRC and payload decoding.

Supported features include:

- PLFrame signal analysis for each frame part: SOF, PLSCODE, Pilot, and Data
- all standard-defined MODCOD formats, QPSK, Pi / 2-BPSK, 8PQSK, 16 / 32 / 64 / 128 / 256 APSK
- Options for standard-defined roll-off factors from 0.05 to 0.35 or customized roll-off factors

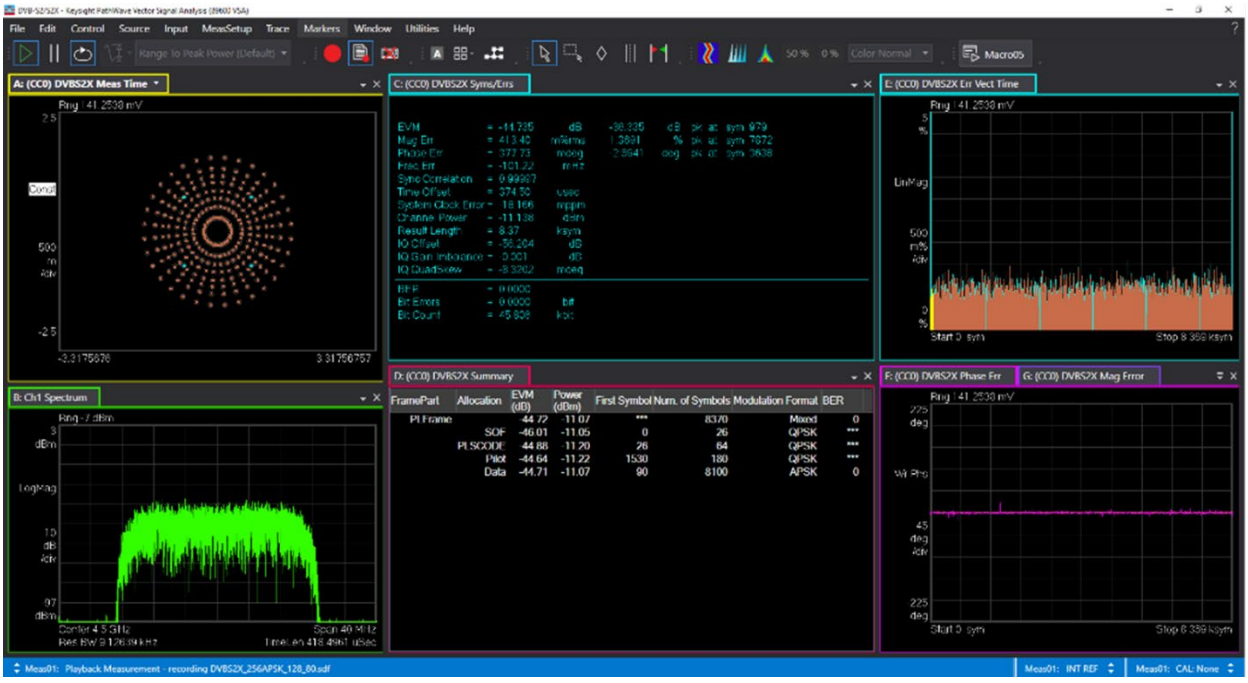
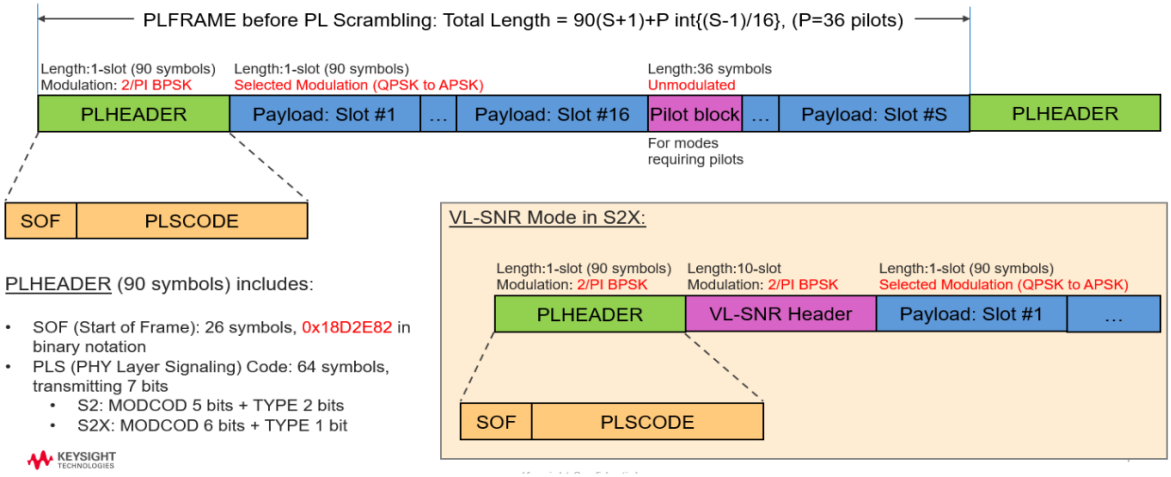


Figure 1. DVB-S2/S2X measurement user interface

DVB-S2/S2X PHY layer framing



PLHEADER (90 symbols) includes:

- SOF (Start of Frame): 26 symbols, 0x18D2E82 in binary notation
- PLS (PHY Layer Signaling) Code: 64 symbols, transmitting 7 bits
  - S2: MODCOD 5 bits + TYPE 2 bits
  - S2X: MODCOD 6 bits + TYPE 1 bit

ETSI EN 302 307-2 (DVB-S2X) specifications define a combination of code rate and modulation. See Table 17a of the ETSI EN 302 307-2 V1.3.1 (2021-04).

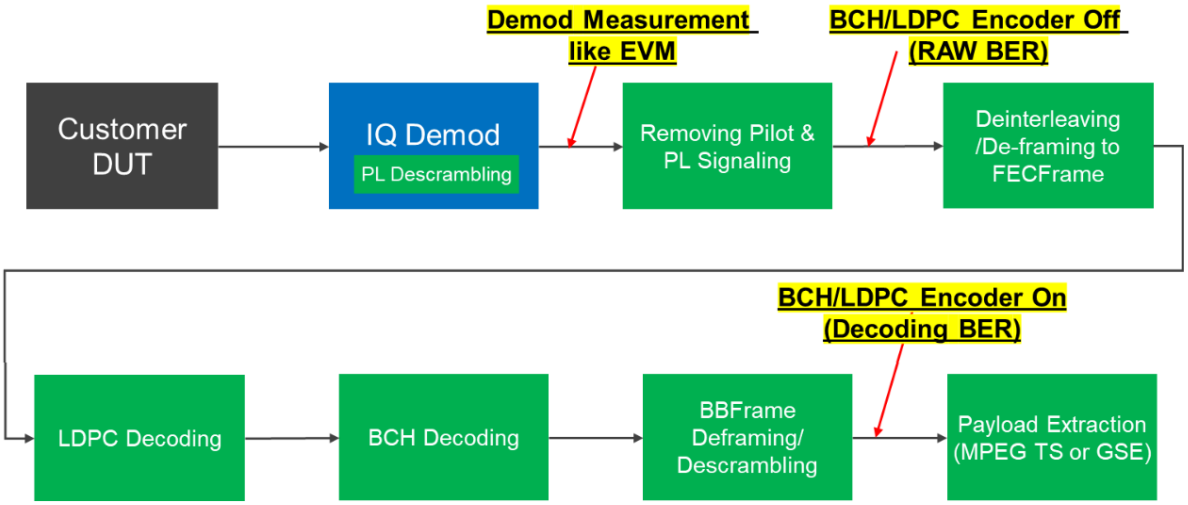
Table 17a: S2X MODCOD Coding

PLS code decimal value	Canonical MODCOD name	Implementation MODCOD name	Code Type
129	VL SNR set1 See Table 18a		
131	VL SNR set2 See Table 18a		
132	QPSK 13/45	QPSK 13/45	Normal
134	QPSK 9/20	QPSK 9/20	Normal
136	QPSK 11/20	QPSK 11/20	Normal
138	8APSK 5/9-L	2+4+2APSK 100/180	Normal
140	8APSK 26/45-L	2+4+2APSK 104/180	Normal
142	8PSK 23/36	8PSK 23/36	Normal
144	8PSK 25/36	8PSK 25/36	Normal
146	8PSK 13/18	8PSK 13/18	Normal
148	16APSK 1/2-L	8+8APSK 90/180	Normal
150	16APSK 8/15-L	8+8APSK 96/180	Normal
152	16APSK 5/9-L	8+8APSK 100/180	Normal
154	16APSK 26/45	4+12APSK 26/45	Normal
156	16APSK 3/5	4+12APSK 3/5	Normal
158	16APSK 3/5-L	8+8APSK 18/30	Normal
160	16APSK 28/45	4+12APSK 28/45	Normal
162	16APSK 23/36	4+12APSK 23/36	Normal
164	16APSK 2/3-L	8+8APSK 20/30	Normal
166	16APSK 25/36	4+12APSK 25/36	Normal
168	16APSK 13/18	4+12APSK 13/18	Normal
170	16APSK 7/9	4+12APSK 140/180	Normal
172	16APSK 77/90	4+12APSK 154/180	Normal
174	32APSK 2/3-L	4+12+16rbAPSK 2/3	Normal
178	32APSK 32/45	4+8+4+16APSK 128/180	Normal
180	32APSK 11/15	4+8+4+16APSK 132/180	Normal
182	32APSK 7/9	4+8+4+16APSK 140/180	Normal
184	64APSK 32/45-L	16+16+16+16APSK 128/180	Normal
186	64APSK 11/15	4+12+20+28APSK 132/180	Normal
190	64APSK 7/9	8+16+20+20APSK 7/9	Normal
194	64APSK 4/5	8+16+20+20APSK 4/5	Normal
198	64APSK 5/6	8+16+20+20APSK 5/6	Normal
200	128APSK 3/4	128APSK 135/180	Normal
202	128APSK 7/9	128APSK 140/180	Normal
204	256APSK 29/45-L	256APSK 116/180	Normal
206	256APSK 2/3-L	256APSK 20/30	Normal
208	256APSK 31/45-L	256APSK 124/180	Normal
210	256APSK 32/45	256APSK 128/180	Normal
212	256APSK 11/15-L	256APSK 22/30	Normal
214	256APSK 3/4	256APSK 135/180	Normal

Table 17a of the ETSI EN 302 307-2 V1.3.1 (2021-04)

DVB-S2X measurement

DVB-S2/S2X demodulation and decoding diagram is shown below.



Using 89600 VSA DVB-S2/S2X (89601DVBC) with N7623C Signal Studio for Digital Video (N7623EMBC), and PWSG Advanced Waveform Utilities (N7618APPC) for multi-carrier combination, you can perform signal analysis for satellite DVB-S2X signals.

Figure 2. DVB-S2/S2X measurement system

Software configuration requirements

The following table lists the required software and licenses.

Product	Licensing	Software release
N7623C Signal Studio for Digital Video	N7623EMBC	2020 Update 1.0 or the latest on K.com
89600 DVB-S2/S2X Satellite Measurement Application	89601DVBC (89601200C is required)	VSA2024 or the latest on K.com
PathWave Signal Generation Advanced Waveform Utility (PWSG AWU)	N7618APPC	2023 Update 1.0 or the latest on K.com

DVB-S2X Signal Generation and Analysis – Single Carrier

DVB-S2X specification uses both Canonical and Implementation MODCOD (modulation/coding) name. Signal Studio uses Canonical name and VSA uses both (Canonical name with Implementation name in parenthesis). In this demo, we will use 256APSK 32/45 (256APSK128/180).

Table 17a: S2X MODCOD Coding

PLS code decimal value	Canonical MODCOD name	Implementation MODCOD name	Code Type
129	VL SNR set1 See Table 18a		
131	VL SNR set2 See Table 18a		
132	QPSK 13/45	QPSK 13/45	Normal
134	QPSK 9/20	QPSK 9/20	Normal
136	QPSK 11/20	QPSK 11/20	Normal
198	64APSK 5/6	8+16+20+20APSK 5/6	Normal
200	128APSK 3/4	128APSK 135/180	Normal
202	128APSK 7/9	128APSK 140/180	Normal
204	256APSK 29/45-L	256APSK 116/180	Normal
206	256APSK 2/3-L	256APSK 20/30	Normal
208	256APSK 31/45-L	256APSK 124/180	Normal
210	256APSK 32/45	256APSK 128/180	Normal
212	256APSK 11/15-L	256APSK 22/30	Normal
214	256APSK 3/4	256APSK 135/180	Normal

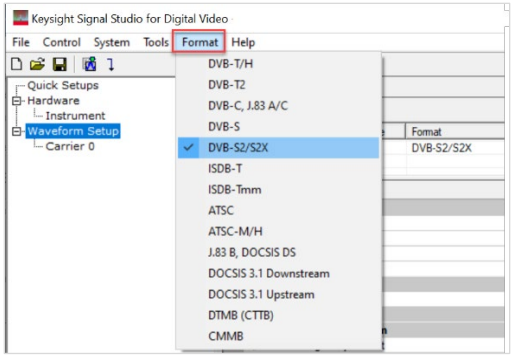
Note: It's assumed the DVB-S2X measurement system has been connected and set up.

DVB-S2X signal generation

Generate DVB-S2X Waveform using N7623C Signal Studio for Digital Video.

1. Start N7623C Signal Studio for Digital Video and select the signal generator to be connected.

2. Select **Format** as **DVB-S2/S2X**



1. On the **Instrument** page, set **Frequency** and **Amplitude**.

2. Basic	
Frequency	**4.500 000 000 000 GHz**
Amplitude	**-10.00 dBm**
RF Output	On

NOTE: DVB-S2 and DVB-S2X operate in Ku band (10-14 GHz) and Ka band (18-30 GHz). This demo guide is using a center frequency of 4.5 GHz.

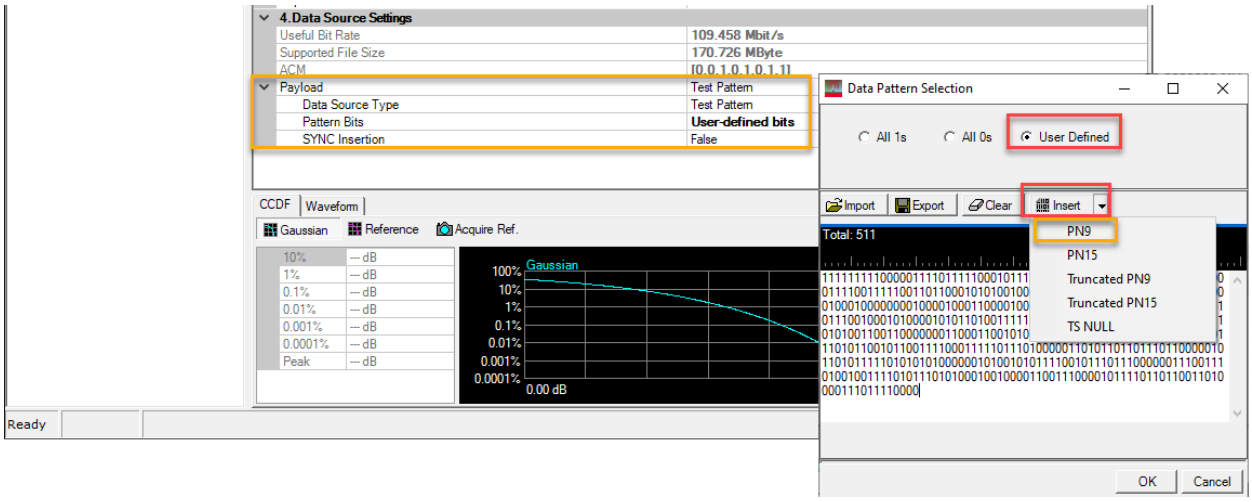
2. On the **Carrier** page, set **DVB-S2/S2X Settings** as follows.

*Note: **CRC-8 Encoder** is set to **False** because VSA2024 doesn't support it.*

2. DVB-S2/S2X Settings	
Filter Type	Root Nyquist
Roll-off Factor	**0.25**
Symbol Rate	**20.0000000 MHz**
Support DVB-S2X	**True**
VL-SNR Header	False
FEC Frame	Normal
Modulation Type	**256 APSK**
Code Rate	**32/45**
Insert Pilot	True
CRC-8 Encoder	**False**
Number of LDPC Blocks	188
Multi-path Channel	OFF

3. On the **Carrier** page, set **Data Source Settings** as follows.

*Note: **Payload** is set to **PN9** for BER test.*

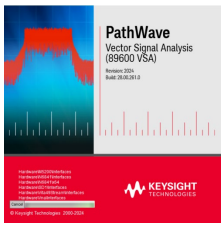


4. Select Generate and Download the waveform to the signal generator.

DVB-S2X signal analysis

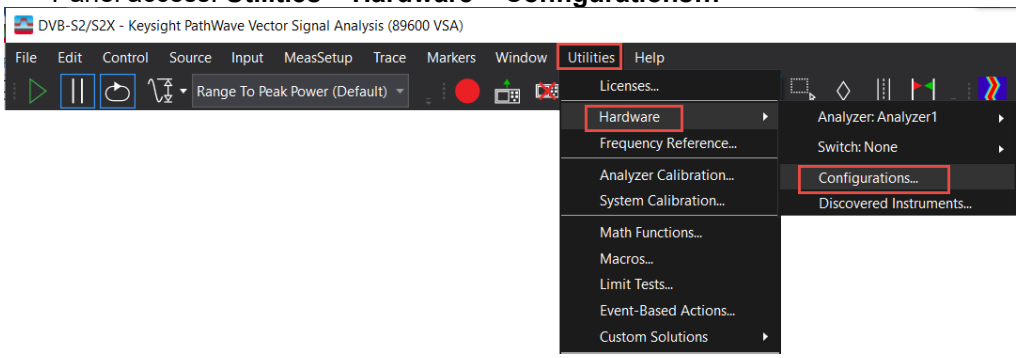
Analyze the signal using VSA DVB-S2/S2X measurement application.

1. Launch 89600 VSA 2024 application.

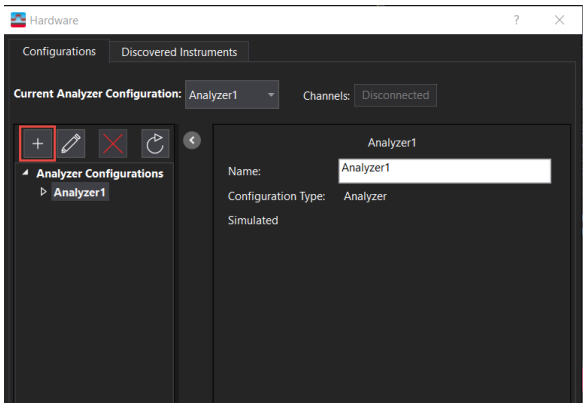


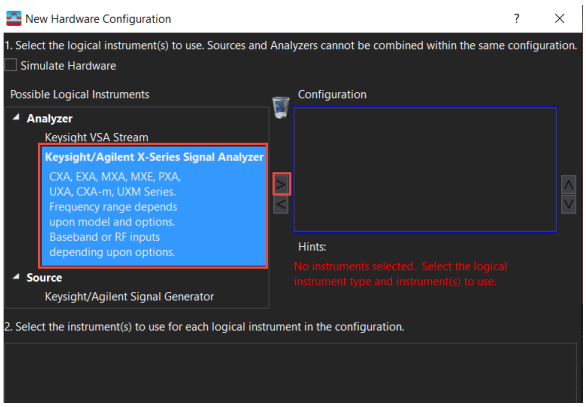
2. Configure the signal analyzer hardware.

   Panel access: **Utilities** > **Hardware** > **Configurations…**

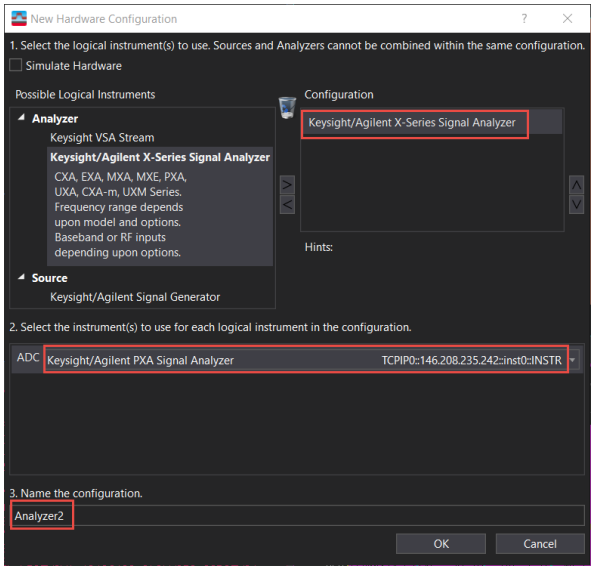


2.1 Click “+” icon, select Keysight/Agilent X-Series Signal Analyzer and click “>” icon to add a new instrument.



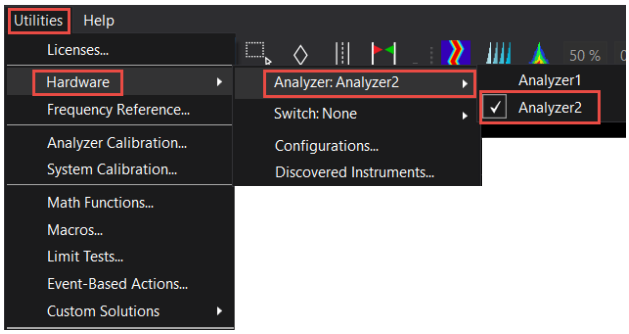


2.2 Select the instrument, type in a name and click OK to continue.



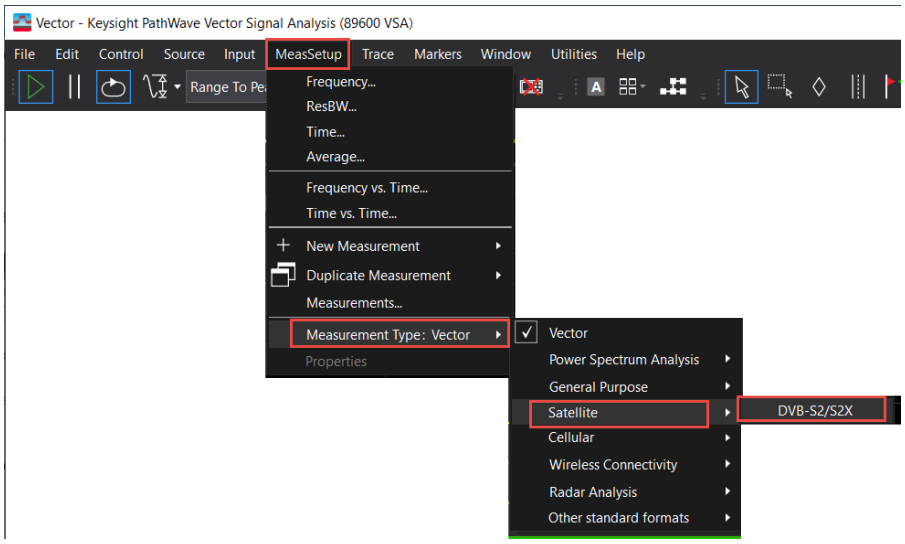
2.3 Connect to Analyzer2.

Panel access: **Utilities** > **Hardware** > **Analyzer** > **Analyzer2**



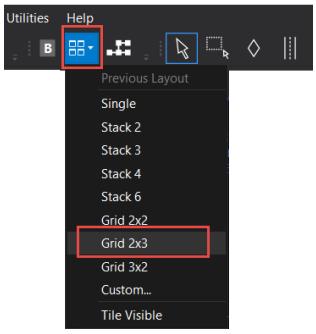
3. Select DVB-S2/S2X measurement.

Panel access: **MeasSetup** > **Measurement Type** > **Satellite** > **DVB-S2/S2X**



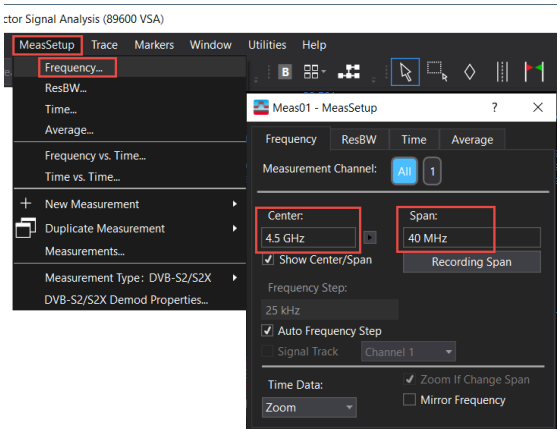
4. Set the display layout as **Grid 2x3**

   Panel access: Trace Layout icon > **Grid 2x3**

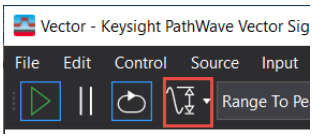


5. Set the frequency and span.

   Panel access: **MeasSetup** > **Frequency…** > **Center** = 4.5 GHz, **Span** = 40 MHz

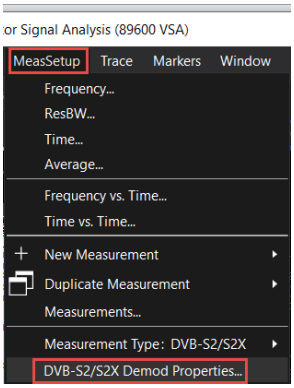


6. Click **Auto-range** icon.

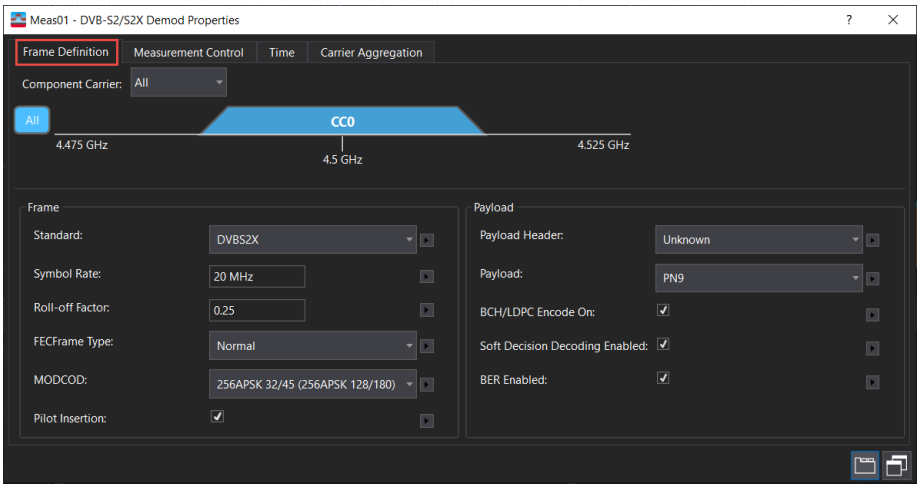


7. Configure the parameters for **DVB-S2/S2X Demod Properties**.

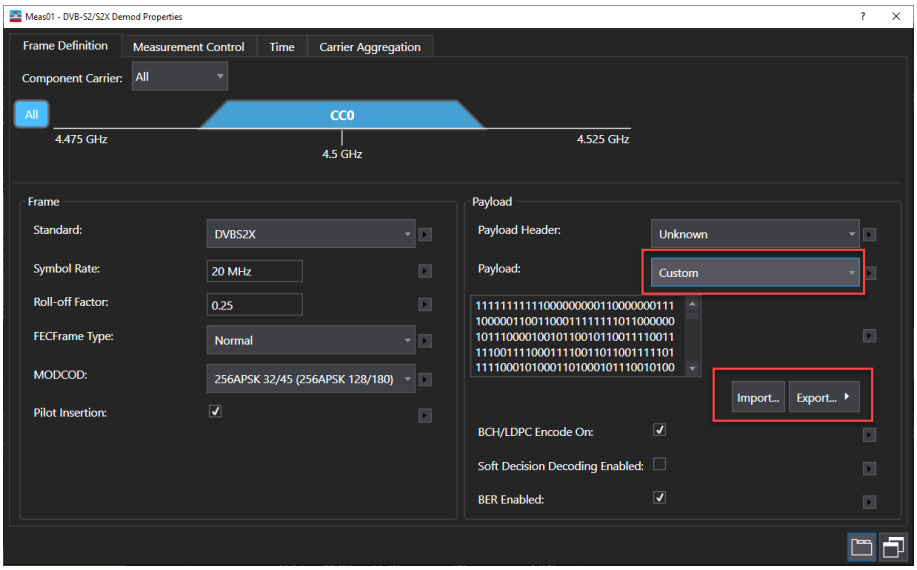
   Panel access: **MeasSetup** -> **DVB-S2/S2X Demod Properties…**



   7.1. Select **Frame Definition** tab and set the parameters as follows.



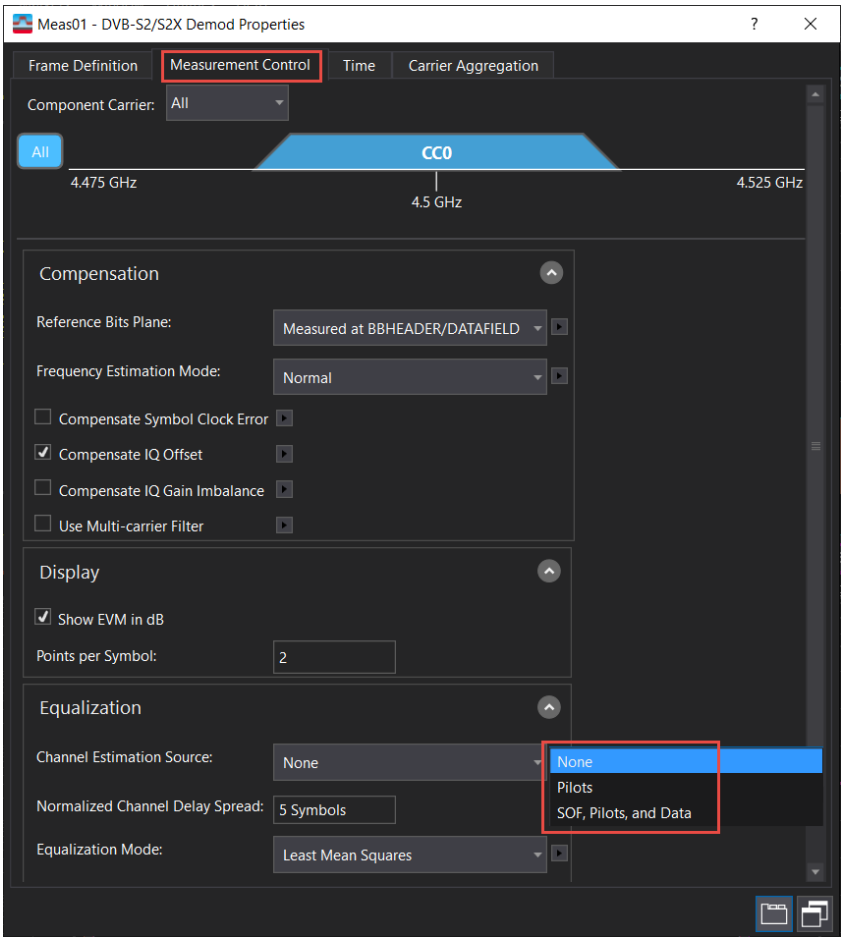
*Note: **PN9** is used for this demo for BER calculation. BER calculations are supported if the payload sequence is either AllOnes, AllZeros, a PN type or a custom bit sequence. You can also import or export custom sequences.*



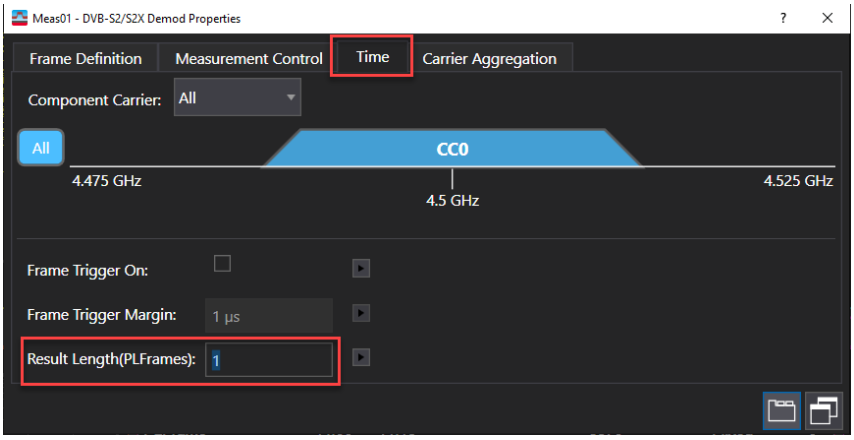
7.2. Select **Measurement Control** tab and set the parameters as follows.

Note:

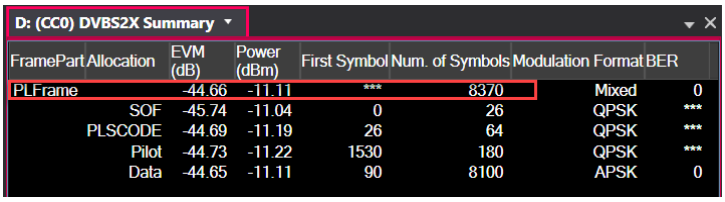
- *The Reference Bits Plane is set to BBHeader/Datafield plane by default, which is used to create reference symbols for EVM calculation.*
- *Channel Estimation Source is set to None by default, which means no equalization is applied. You can also select the fields to estimate the frequency response of the channel for equalization.*



7.3. Select **Time** tab and set the parameters as follows.



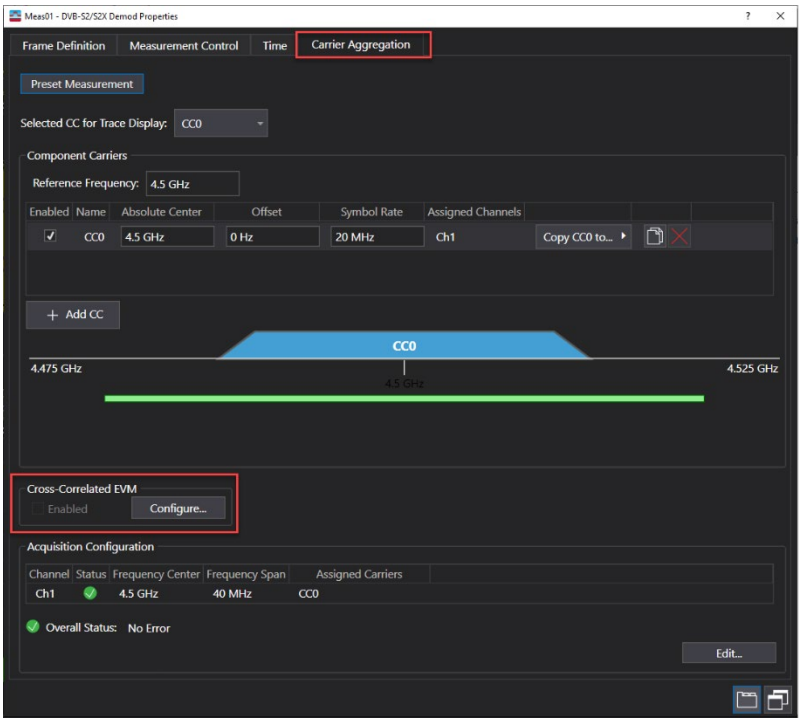
When **Result Length(PLFrames)** is set to **1**, the Frame Summary table (including SOF, PLSCODE, PILOT, DATA) is shown as below.



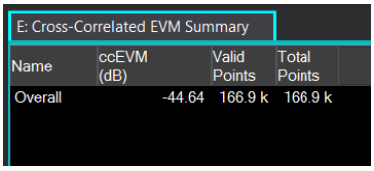
7.4. Select **Carrier Aggregation** tab.

Note: No adjustment is required for this tab.

- *Up to 16 component carriers can be combined into a single signal, each with different allocations, measurement parameters, symbol rate etc.*
- *Cross-Correlated EVM (ccEVM) can be used with Option 89601EVMC.*

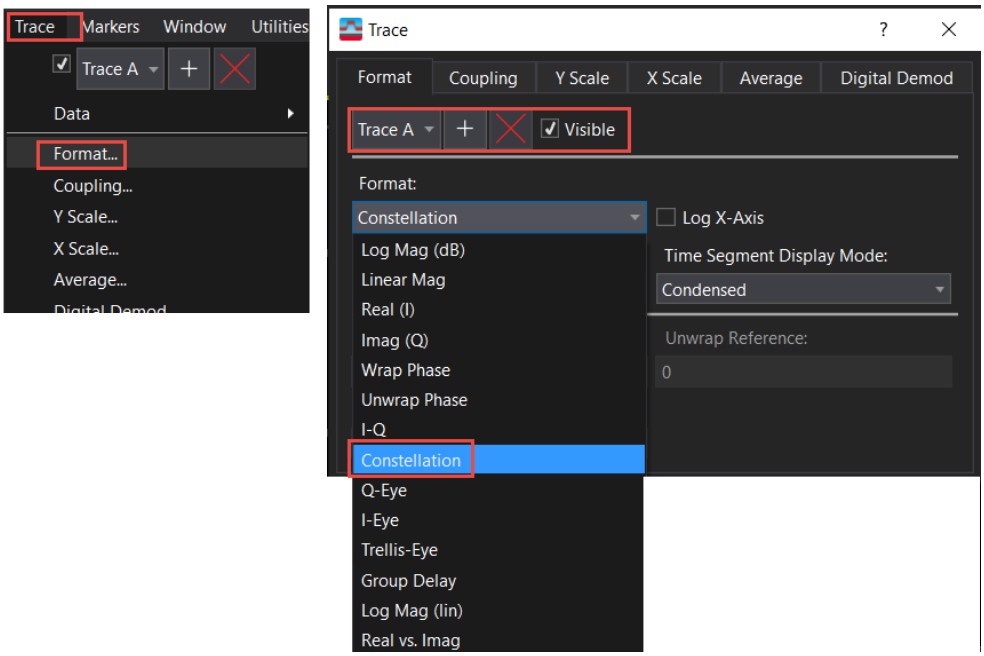


With setting **Cross-Correlated EVM** to **Enabled**, you can get ccEVM result as below.

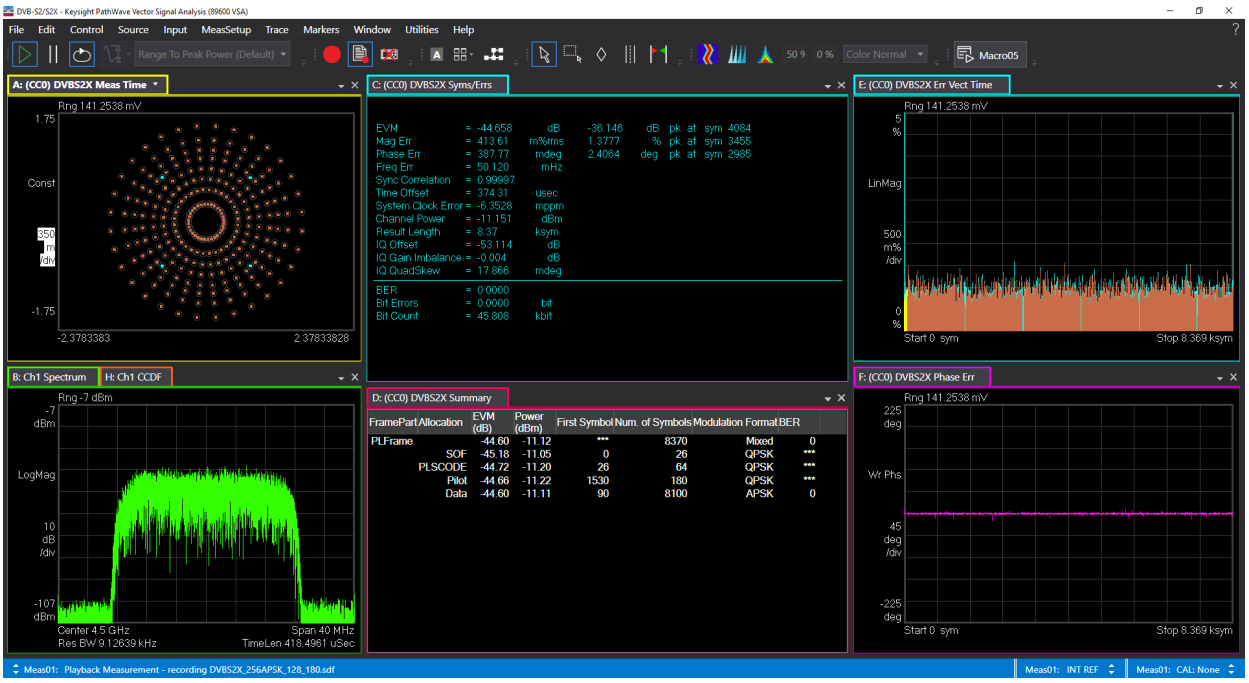


8. Change Trace A to a Constellation Diagram.

Panel access: **Trace** > **Format** > select **Trace A** as **Visible** > select **Constellation** format

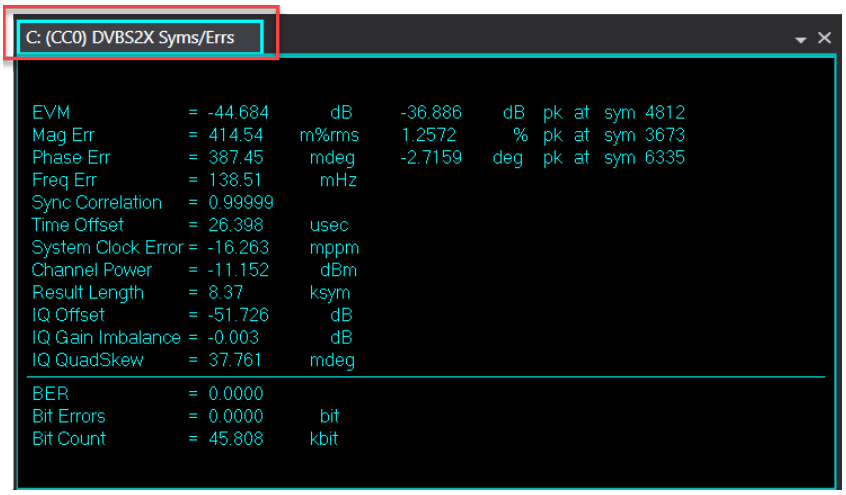


You should see successful demodulation results and a very low EVM.



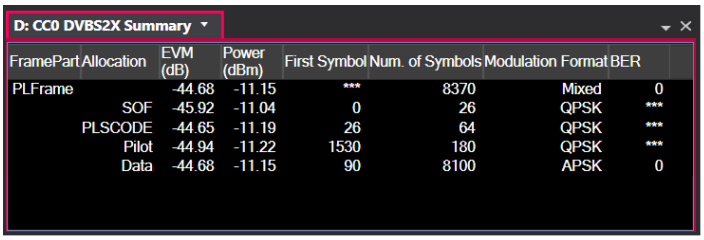
There are more traces and tables available to be displayed, for example, Error Vector Spectrum, Decoded Info and BER bits and so on. For more information, you can search Available Error Summary Data (DVB-S2/S2X) and Available Trace Data (DVB-S2/S2X) in the 89600 VSA Help.

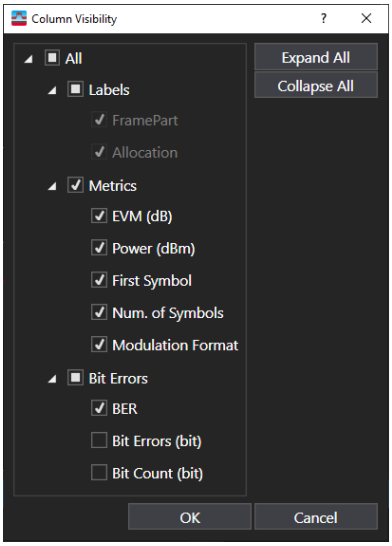
The **Syms/Errs** table show the composite EVM of all segments. The upper section show the error information and the lower section shows the binary bits for each symbol.



Summary table is a type of Matrix Table that provides sortable rows by column, selectable column visibility, and copy/paste and export functionality to share rows of content or complete tables to applications like email, text editing or spreadsheet programs.

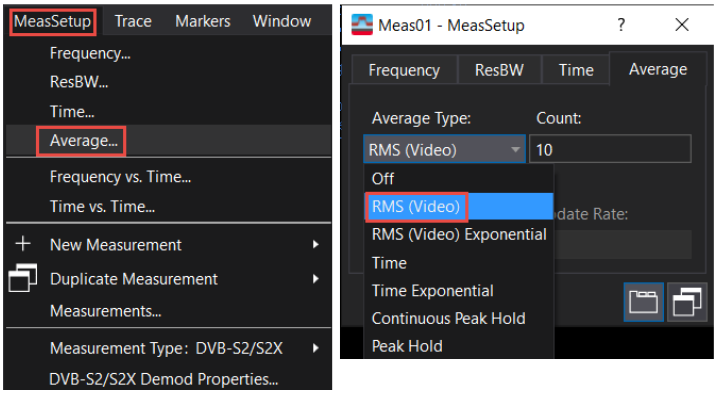
DVBS2X Summary displays EVM/Power/Mod format/BER of the entire Frame and each active segment within the Frame. Right click the header row to display the menu and select **Column Visibility**. You can configure the columns to be displayed.

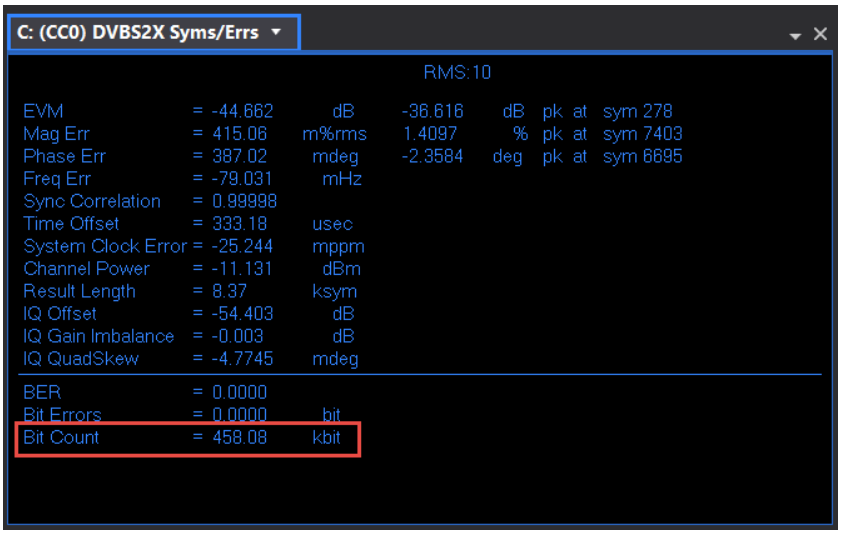




9. To increase the number of Bit Count for the BER calculation, use averaging.

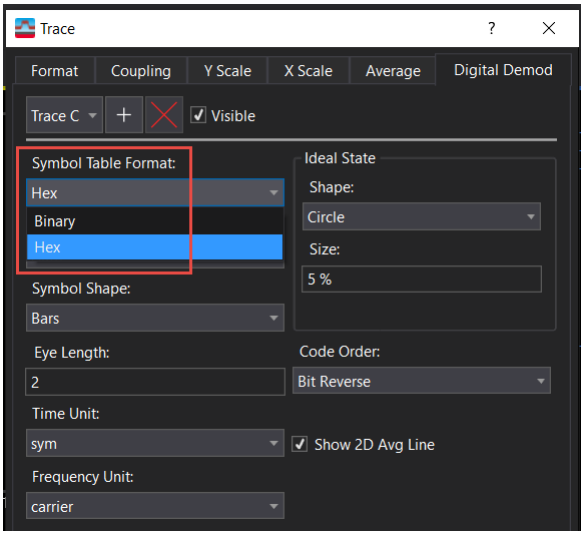
   Panel access: **Meas Setup** -> **Average** -> **Average Type** = **RMS (Video)**





10. The Demod bits are displayed in **Hex** by default. You can change it to **Binary**.

    Panel access: **Trace** -> **Digital Demod** > **Symbol Table Format** > **Binary**



DVB-S2X Signal Generation and Analysis – Multi-Carrier

In this demo, we will use 16APSK 3/5 .

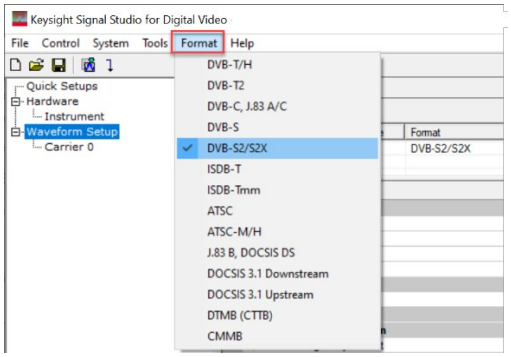
Note: It's assumed the DVB-S2X measurement system has been connected and set up.

DVB-S2X multi-carrier signal generation

We will generate three DVB-S2X single carrier waveforms separately using **N7623 Signal Studio for Digital Video** and combine the three waveforms into a multi-carrier signal.

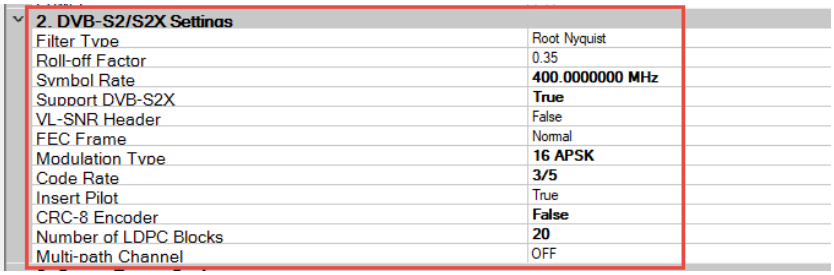
1. Launch **N7623C Signal Studio for Digital Video** and select the simulation mode.

2. Select **Format** as **DVB-S2/S2X**



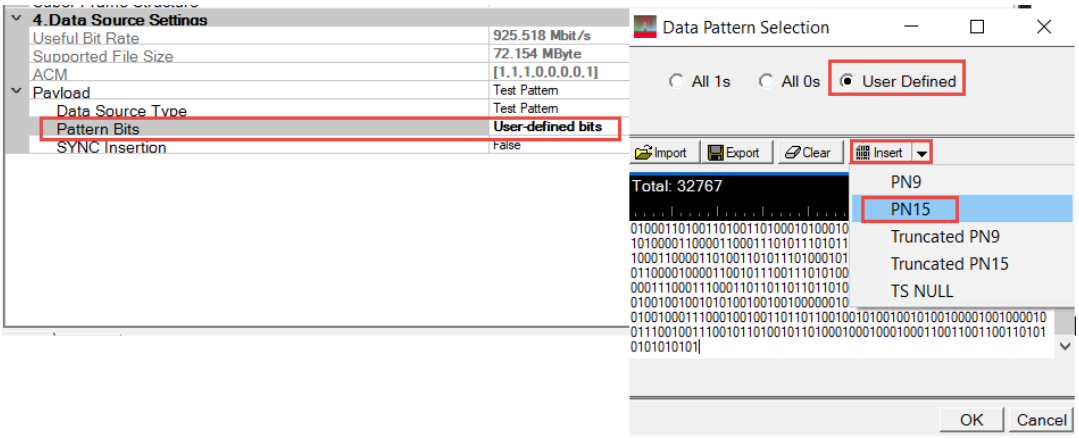
*Note: **CRC-8 Encoder** is set to **False** because VSA2024 doesn't support it.*

3. On the **Carrier** page, set **DVB-S2/S2X Settings** as follows.

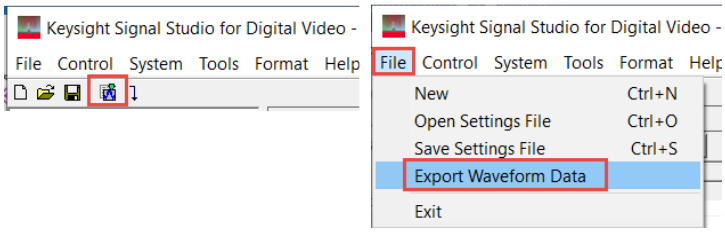


4. On the **Carrier** page, set **Data Source Settings** as follows.

Note: Select the payload as PN15. It's recommended to use different PN sequences for three waveforms, so the combined multi-carrier CCDF can be improved compared with the same PN sequence for all carriers.



5. Generate the waveform and save the waveform file as DVBS2X 16APSK 400MHz_1.wfm.



Change the PN sequence as appropriate, and generate and save the waveform file “DVBS2X 16APSK 400MHz_2.wfm”.

Change the PN sequence as appropriate, and generate and save the waveform file “DVBS2X 16APSK 400MHz_3.wfm”.

Note: The three waveform files need to be saved in a USB disk where the VXG-C and the AWU application can access and load the files.

6. You can select one of the following two options to combine the three waveforms to a multi-carrier signal.

Note: M9484C VXG Signal Generator with frequency up to 14 GHz or above and bandwidth 2.5 GHz is used in this demo. The instrument is connected successfully in the DVB-S2X measurement system.

Option 1: Using option M9484C-8SG

Combine three waveforms of DVB-S2X single carrier using M9484C VXG with Option M9484C-8SG.

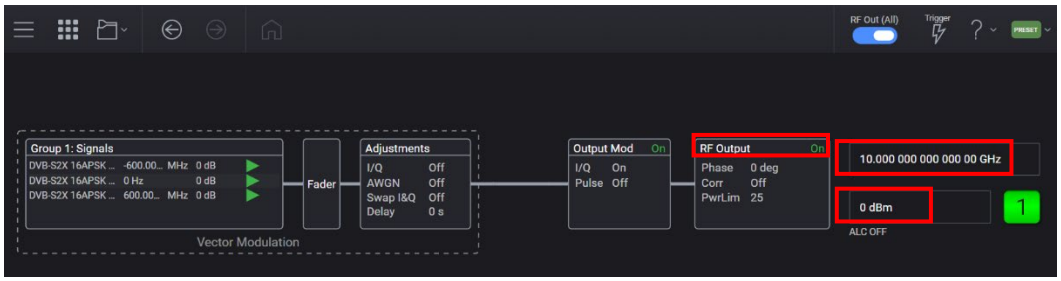
1. Load and enable three waveforms. Set the **Frequency Offset** as follows.

DVBS2X 16APSK 400MHz_1.wfm Frequency Offset = -600 MHz, Attenuation = 0 dB

DVBS2X 16APSK 400MHz_2.wfm Frequency Offset = 0 MHz, Attenuation = 0 dB

DVBS2X 16APSK 400MHz_3.wfm Frequency Offset = 600 MHz, Attenuation = 0 dB

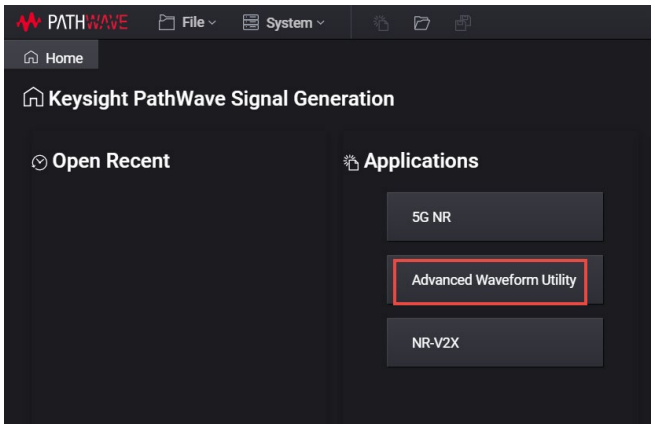
2. Set Center Frequency = 10 GHz, Amplitude = 0 dBm, RF Output = On, as shown below.



Option 2: Using the PWSG AWU application

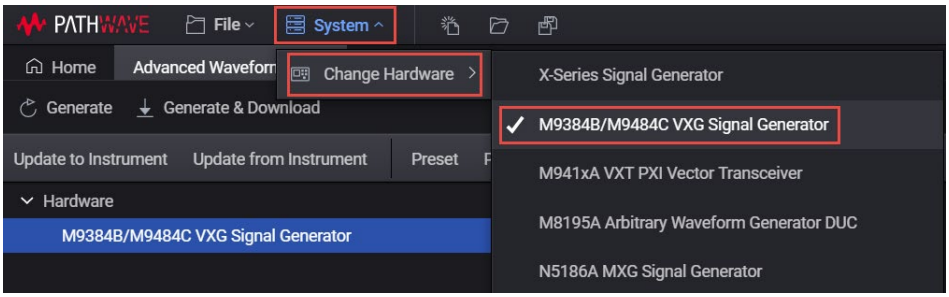
Combine three waveforms of DVB-S2X single carrier using the PWSG AWU application.

1. Launch the PathWave Signal Generation Desktop 2024 and start the application Advanced Waveform Utility (AWU).



2. Connect to the instrument.

Panel access: **System** > **Change Hardware** > **M9384B/M9484C VXG Signal Generator**



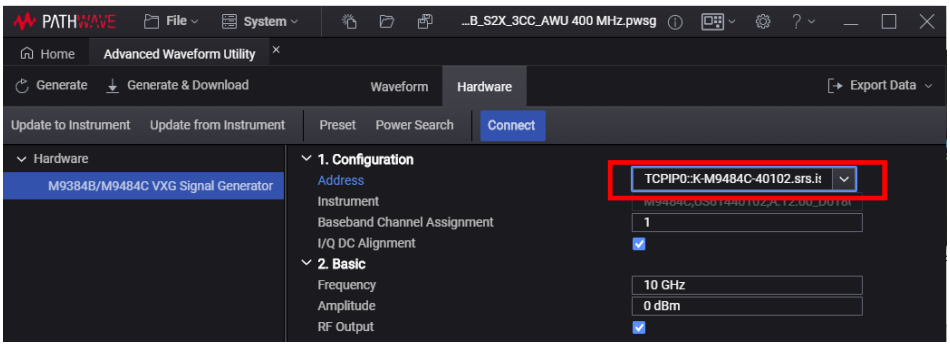
3. Select **Hardware** tab.

In **Address**, input the IP address of the VXG and click **Connect**.

Set **Baseband Channel Assignment** = 1

Set **Frequency** = 10 GHz

Set **Amplitude** = 0 dBm



4. Select **Waveform** tab.

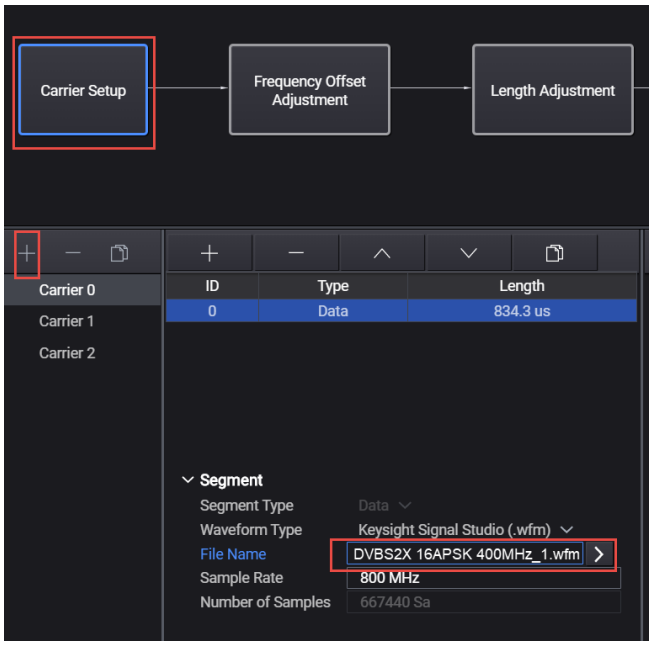
Select **Carrier Setup**.

Click “+” icon to add two carriers CC1, CC2.

Select Carrier0 and load the waveform “DVBS2X 16ASPK 400 MHz_1.wfm”

Select Carrier1 and load the waveform “DVBS2X 16ASPK 400 MHz_2.wfm”

Select Carrier2 and load the waveform “DVBS2X 16ASPK 400 MHz_3.wfm”

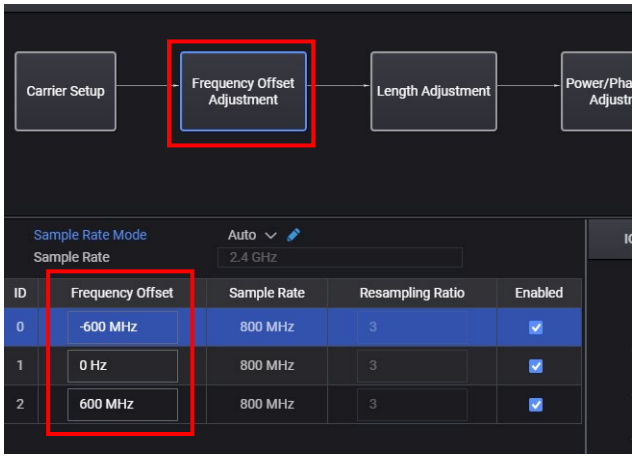


Select **Frequency Offset Adjustment** and set parameter as follows.

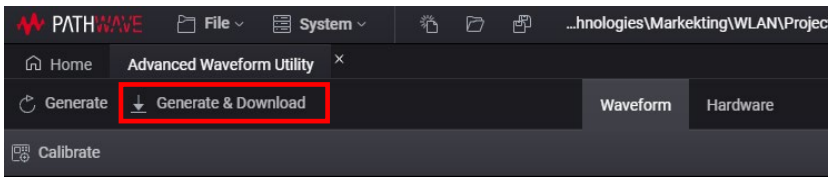
Carrier0 Frequency Offset = -600 MHz

Carrier1 Frequency Offset = 0 MHz

Carrier2 Frequency Offset = 600 MHz



5. Click **Generate & Download**



You can select the Spectrum window to check the combined DVB-S2X 3 Carriers Spectrum.

You can select the CCDF window to check the combined DVB-S2X 3 Carriers CCDF trace compared to Gaussian reference.

DVB-S2X multi-carrier signal analysis

Analyze the signal using VSA DVB-S2/S2X application.

Note: the signal analyzer need to have 2 GHz bandwidth in order to analyze the three-carrier signal in this demo.

3. Refer to DVB-S2X Signal Analysis step 1 ~ step 4 to set up the VSA DVB-S2/S2X application.

4. Set the frequency and span.

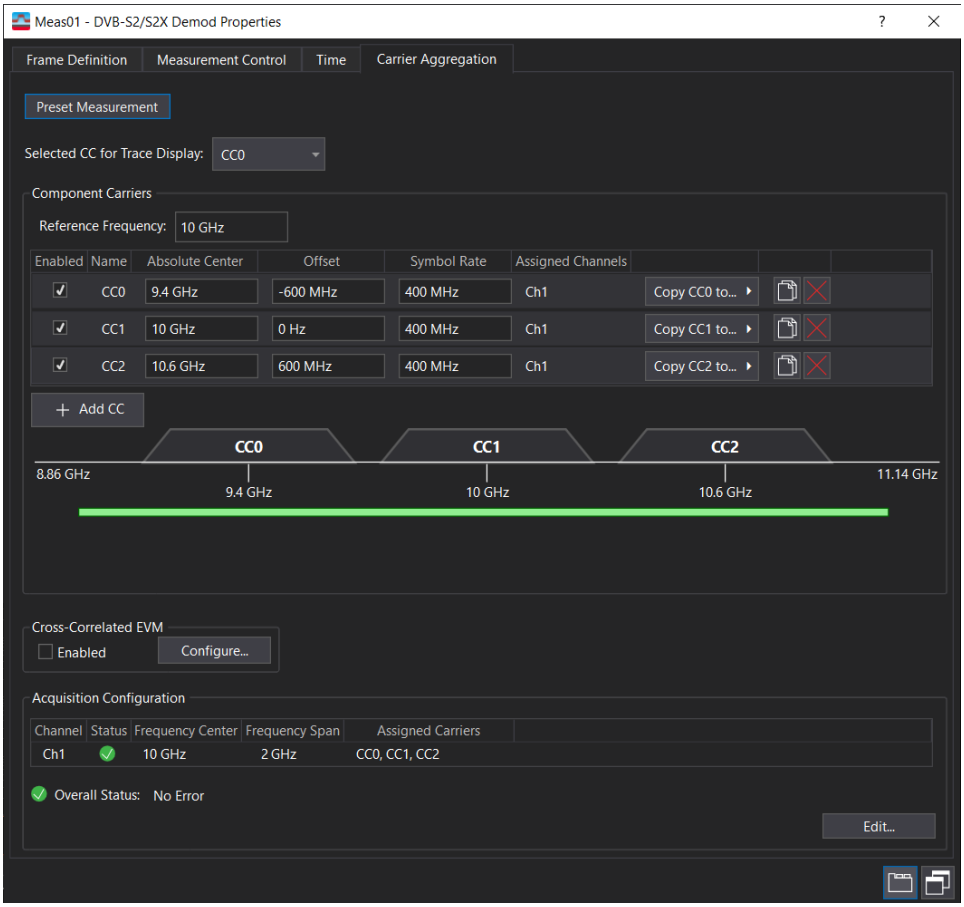
   Panel access: **MeasSetup** > **Frequency…** > **Center** = 10 GHz, **Span** = 2 GHz

Note: If you cannot set the span to 2 GHz, check the analyzer bandwidth option.

5. Configure the 89600 VSA with Multi-carrier Configuration.

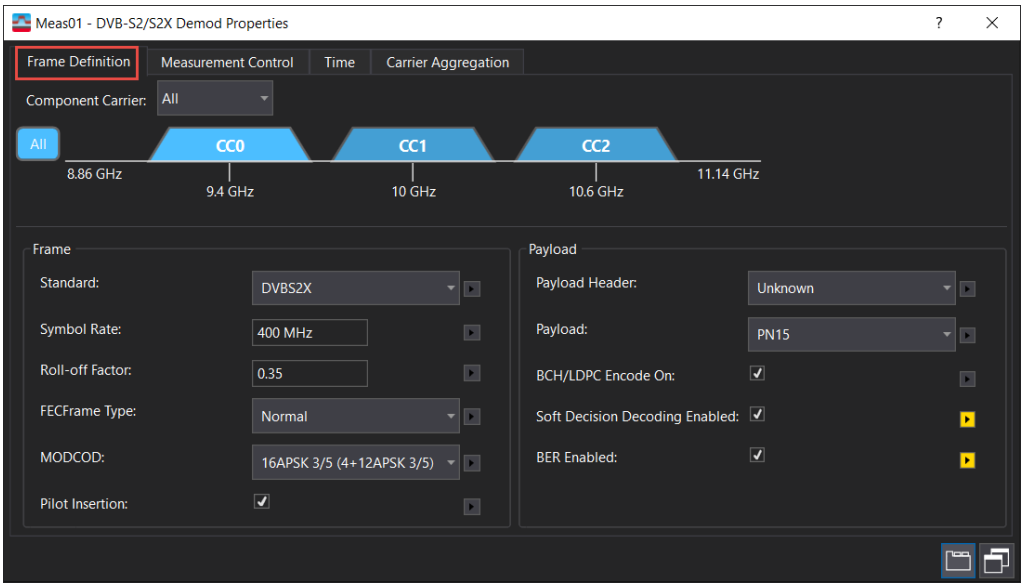
   Panel access: **MeasSetup** > **DVB-S2/S2X Demod Properties…**

   2.1 Select **Carrier Aggregation** tab and click "+ Add CC" to add CC1 and CC2. Set carrier parameters as below.



   2.2 Select Frame Definition tab and set parameters for each carrier as below.

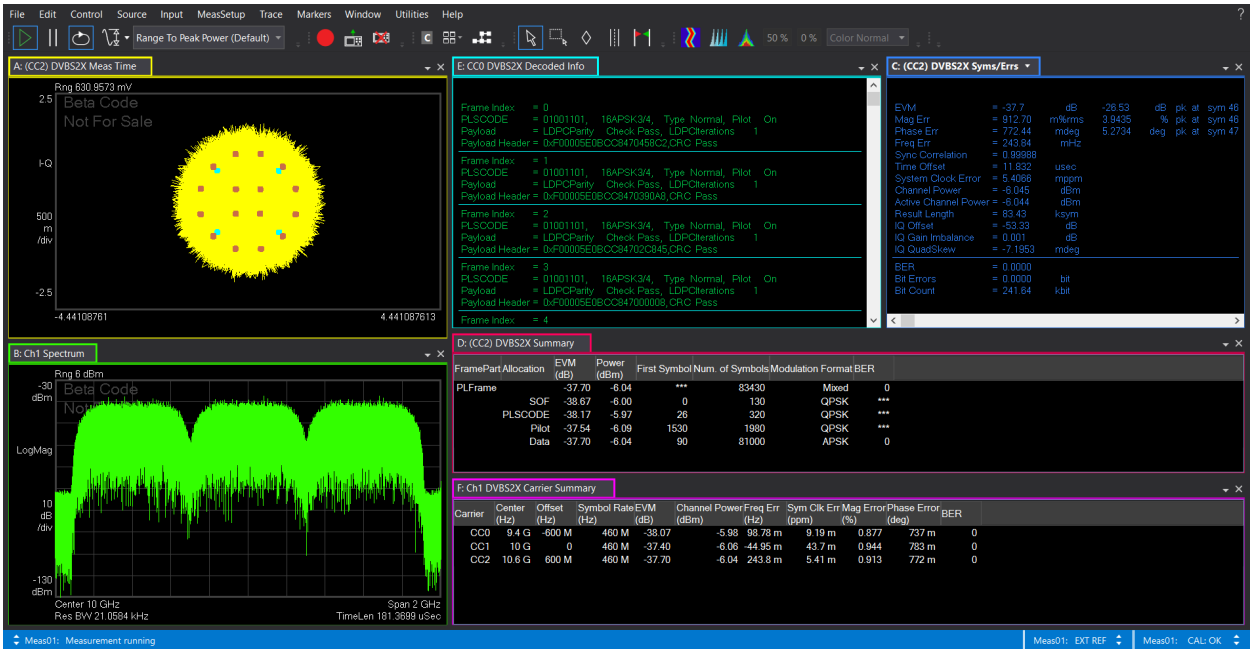
Note: MODCOD=16APSK 3/5



6. Adjust the Range without Overload.

7. You will get the measurement result as the following if you make all of the configuration correctly.

   - Trace A: Constellation for the DVB-S2X as 16APSK
   - Trace B: Spectrum with 3 DVB-S2X carrier, each with 400 MHz
   - Trace E: DVB-S2X Decoded Info
   - Trace C: DVB-S2X Syms/Errors
   - Trace D: DVB-S2X Summary (Each Frame Part with SOF, PLSCODE, Pilot, and Data are shown with EVM, Power, First Symbol Location, Num. of Symbol, Modulation Format, and BER)
   - Trace F: DVB-S2X Carrier Summary (CF, Offset, Symbol Rate, EVM, Channel Power, Frequency Error, Symbol clock error, Mag Error, Phase Error, BER Error are all shown here for all of the selected carriers)



Conclusion

The 89600 VSA software's DVB-S2/S2X Satellite Modulation Analysis measurement extension, Option 89601DVBC, supports BER metrics with full channel decoding and multi-carrier configuration within a single measurement for DVB-S2 and DVB-S2X signals.

By configuring result traces for spectrum, acquisition time, and DVB-S2 / S2X specific modulation quality traces and tables, engineers can easily identify signal characteristics and troubleshoot issues such as intermittent errors or recurring synchronization failures.

Additional Information

Literature

PathWave Vector Signal Analysis (89600 VSA) Software - Brochure, 5990-6553EN

PathWave Vector Signal Analysis (89600 VSA) Software - Configuration Guide, 5990-6386EN

Digital Video Broadcasting (DVB) Satellite Communication Analysis – Technical Overview, 3123-1507.EN

Signal Studio for Digital Video N7623C – Technical Overview, 5992-2786EN

PathWave Signal Generation Advanced Waveform Utility (AWU) – Technical Overview, 3122 -1430.EN

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