APPLICATION NOTE

Using Vector Modulation Analysis

to analyze complex signals

KEYSIGHT

Introduction

To address your dynamic measurement needs, Keysight offers dedicated signal analysis applications for 5G NR, LTE-Advanced Pro (including NB-IoT/eMTC), WLAN 802.11ax along with general-purpose measurement applications for analysis of both standards-based signals and customized propriety signals.

The N9054EM0E Vector Modulation Analysis (VMA) is a general-purpose measurement application.

With the latest release of VMA application version 22.08 or above, a new feature is introduced to allow customers configure the signal with two segments (for example, header and data) for analyzing complex signals like DVB-S2/S2X. In some transmission systems, the frame structure consists of sections for synchronization or carrying signaling; and a section for payload data (header and data sections). Usually, different modulation schemes are necessary for these two sections because a robust reception is a requirement for the header section, while high throughput is essential for the data section.

In the header section, there are pre-defined preamble or pilot sequences with low order modulation for better synchronization of a receiver under a low SNR scenario. In the data section, the actual payload with higher order modulation achieves higher data throughput.

Previously, the digital modulation analysis application could not demodulate and analyze the signals because there were two different kinds of modulation schemes. The ability to disable the header or pilot segment and select the data segment to perform the analysis did not give you the completed signal analysis.

To address this test requirement, Keysight's VMA measurement application (Version 22.08 or above) can easily:

- Configure two segments of the signal, so the VMA application interprets the signal configuration
- Support the synchronization and modulation analysis with two segments separately within one data capture

Key features

- Performs digital modulation analysis of single carrier signals
- Supports a wide range of modulation formats including FSK, PSK, QAM, MSK, ASK, APSK, VSB and customized signals with user-defined IQ constellation
- Insightful modulation quality metrics as EVM or MER; includes measurement traces for raw main time, spectrum, EVM time spectrum, and demodulation results
- Provides convenient standard presets of popular formats, including NADC, EDGE, PDC, PHS, DVB-QAM, DVB-S2/S2X, TETRA, WiSUN, DECT, and SOQPSK-TG
- Supports IQ recording/playback for offline analysis without hardware
- Configurable signal with two segments with Version 22.08

Example: The DVB-S2X is an extension of DVB-S2 for higher efficiency and throughput over a satellite. Figure 1 shows the physical layer frame of the DVB-S2X. The header section may include different parts depending on the system configuration, but π/2-BPSK is used for the whole section. This section carries synchronization bits and physical layer signaling for the receiver. For data section, higher modulation, from QPSK, 8APSK up to 256APSK, is used for high data throughput and spectrum efficiency.

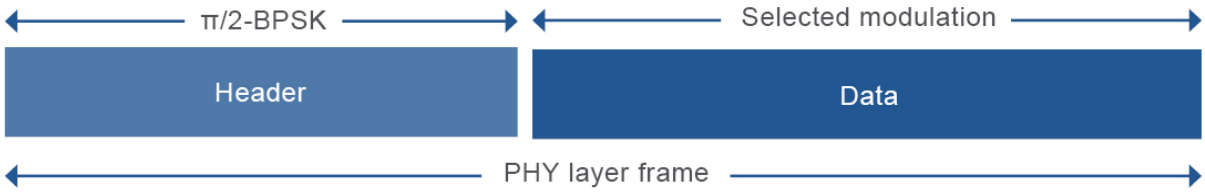

Figure 1. DVB-S2X physical layer frame

Dual-Segment Signal Analysis

Dual segment signal analysis is applicable to the acquisition of IQ pairs from the instrument. Modulation analysis is a measure of the difference between a measured signal and an ideal reference signal. When applying different modulation schemes in the measurement signal, it is measured separately for modulation quality. The signal is divided into segments corresponding to the modulation schemes. Dual segments, called primary and data are setup in the application for demodulation, and the position of each segment is identifiable.

There are usually two options for the start point of the measurement:

- At the beginning of the acquisition data
- Searching for sync pattern

The primary segment is always from the start point — while the data segment is with the offset from the start point.

For the measurement setup, the data segment is set to on or off. When the data segment is turned on, the parameters related to demodulation are set for the primary and data segments.

Figures 2 and 3 are parameters related to the measurement time and demodulation.

There are some common parameters such as capture, search, and synchronization length. These are created for the primary segment. Some parameters such as measurement interval are ready for each activity. Demodulation related parameters work independently — considerable flexibility is available for the modulation schemes with the two segments.

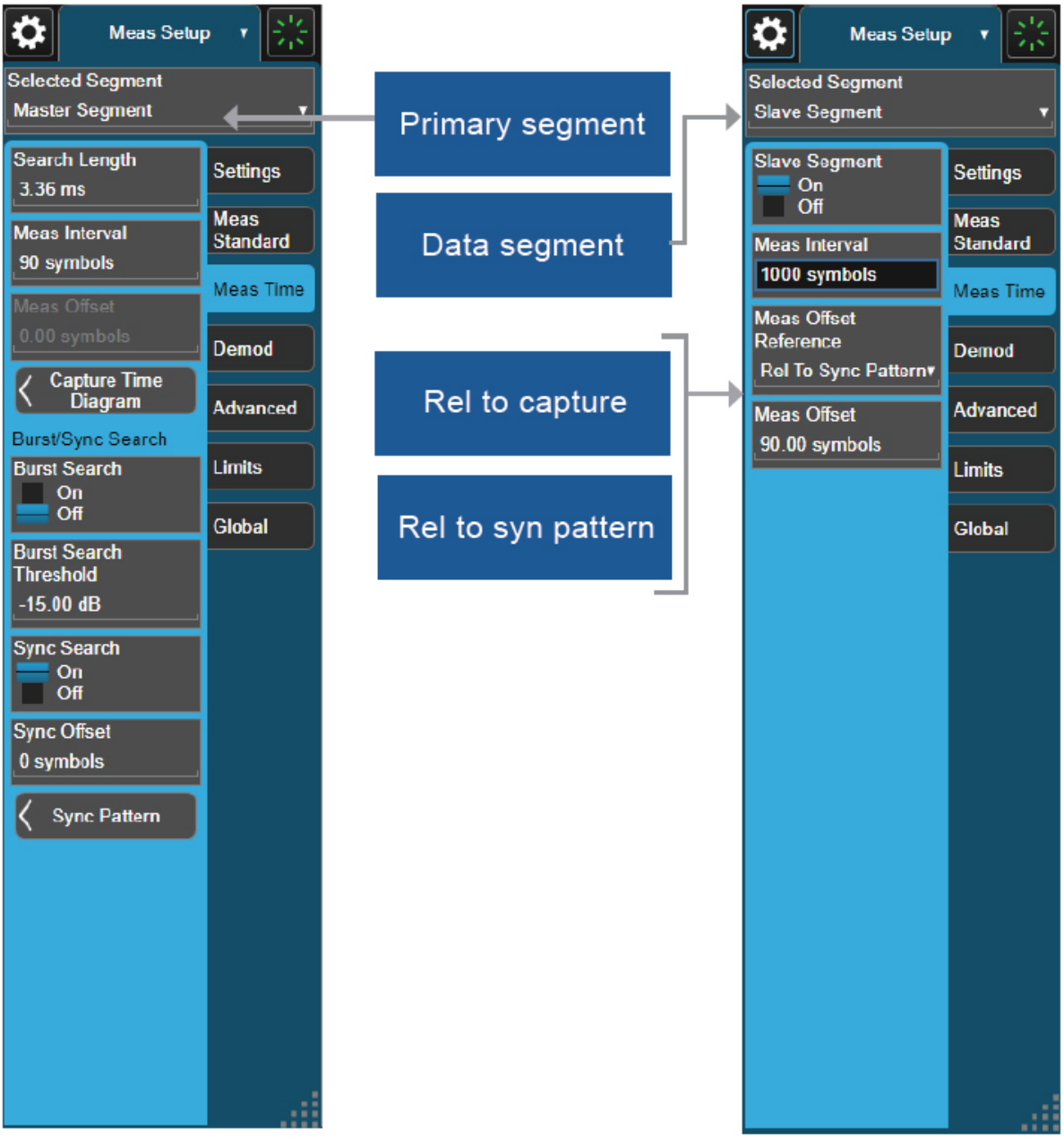

Figure 2. Parameter setup for primary and data segments for measurement time

For the measurement results display, the primary and data segments are displayed separately — power spectrum, time domain trace, IQ constellation, EVM, and error summary.

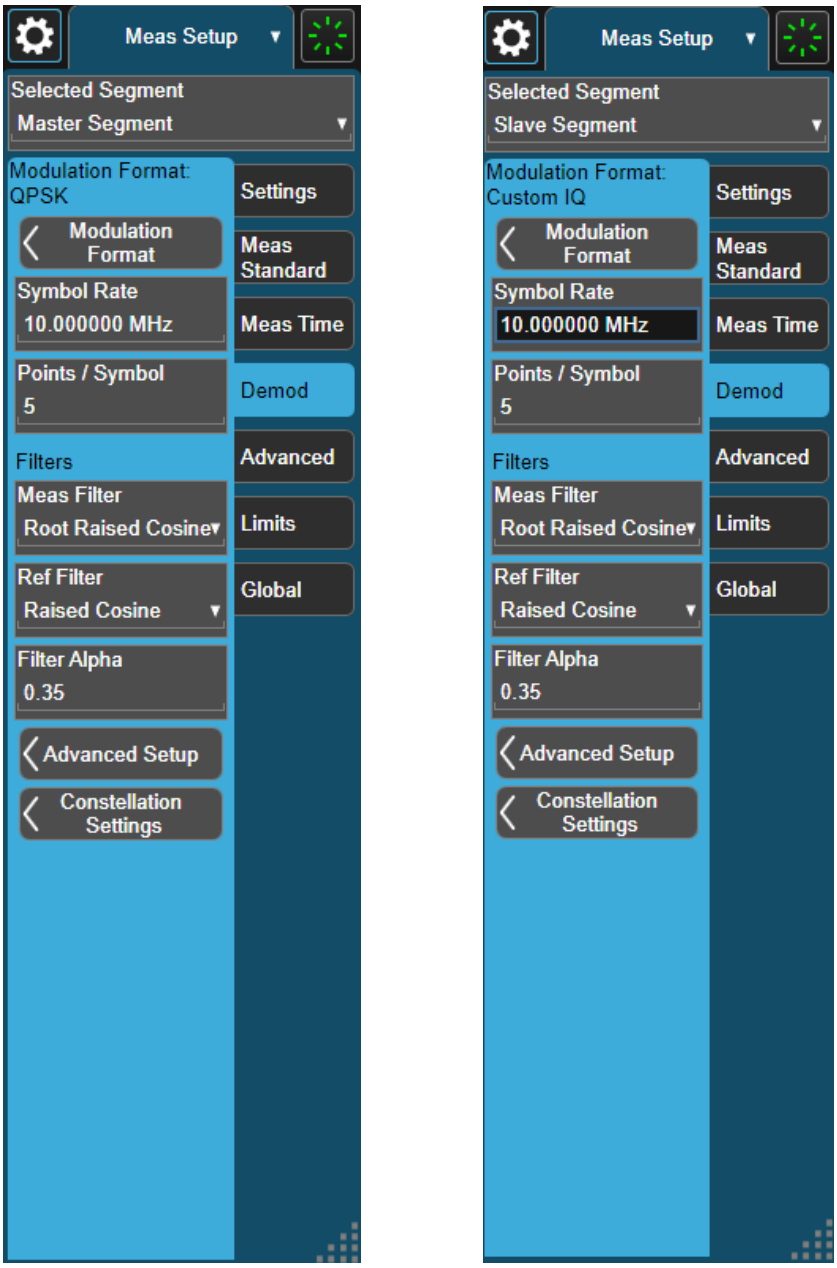

Figure 3. Parameter setup for primary and data segments for demodulation

Similarly, the N7608C Signal Studio Pro software for custom modulation gives you a general-purpose tool for signal creation. It also supports multiple segments configurations with its customizing IQ constellation. N7623C Signal Studio for Digital Video software can generate the fully standard compliant DVB-S/S2/S2X signal with channel coding and TS file payload, which can be used for receiver testing.

Measurement of DVB-S2X Signal

Then we still use DVB-S2X as the example to describe the measurement with dual segments. DVB-S2X adopted Adaptive coding and Modulation (ACM) scheme and multiple modulation schemes for data part are defined. VMA includes some of these schemes in the “Preset to Standard”, which is easy for users to demodulate the signal, but does not prevent users from making adjustment to the measurement parameters afterwards.

Synchronization sequence is in the DVB-S2X frame header, so “sync search” is on. This enables you to define a bit pattern for the sync word search. The analyzer searches through the demodulated data to find the sync pattern and then initiates “meas interval” to determine how much data to display and “search offset” to display data relative to the sync pattern. The position of the primary segment and data segment aligns with the sync word.

The “preset to standard” in the VMA includes DVB-S2X 64APSK.

Parameter	Preset to standard	
	DVB-S2X 64-APSK Code rate 4/5	
Segments	**Primary**	**Data**
Modulation format	QPSK	64-APSK (custom IQ)
Info BW	25 MHz	25 MHz
Symbol rate	10 MHz	10 MHz
Meas filter	Root-raised cosine	Root-raised cosine
Sync search	ON	N/A

Table 1. Setup parameters

You can change the setup from the preset. For example, “Info BW” and “Symbol Rate” are variable for different systems.

VMA gives you the constellation definitions for numerous standard modulations; such as QAM, PSK, VSB, and APSK. For unique constellations, you can define these by selecting “custom IQ” for “modulation format.”

The header portion in a DVB-S2X frame is set as a primary segment to modulate by π/2-BPSK. The constellation is the same as QPSK, so the modulation format is set as QPSK for the demodulation measurement.

The data portion is setup as a data segment; you can use “custom IQ” to edit the constellation of 64-APSK as defined in the DVB-S2X specification as shown in Figure 4. The same way is possible for 128-APSK and 256-APSK DVB-S2X signal demodulation.

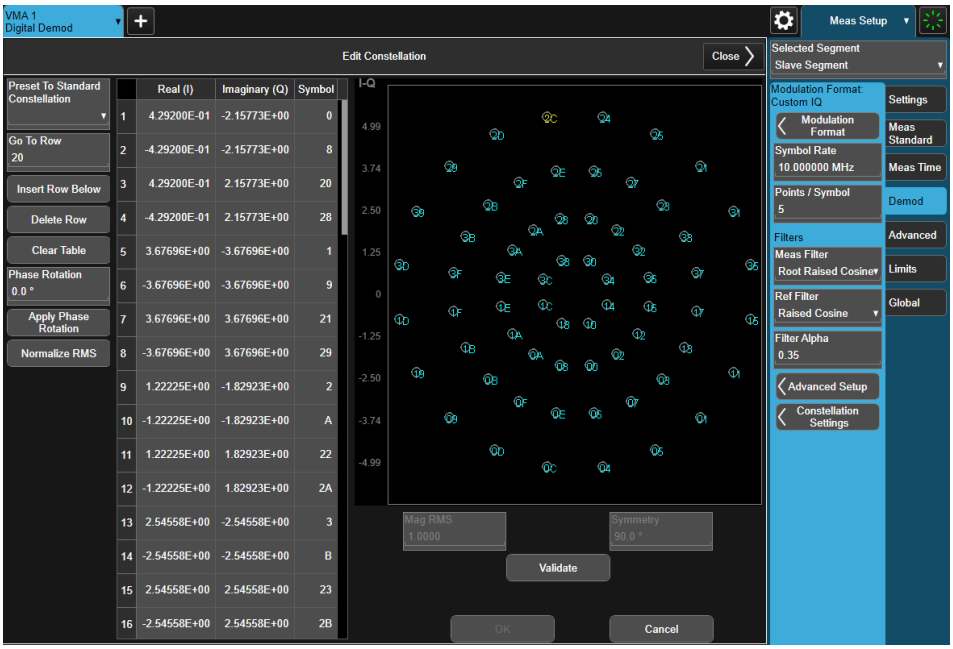

Figure 4. Constellation definition for DVB-S2X

Be noted, a physical layer scrambling is applied in DVB-S2X. The mapped symbols are scrambled with a scrambling code sequence, which would cause the rotation of the constellations or even change the shape of constellation diagram. So the constellations defined here as the reference for EVM measurement are the ones after scrambling instead of the ones provided in the standard and the corresponding bits are not meaningful. N9054EM0E VMA measurement application Version A.27.0x or above is needed to test DVB-S2X signal with scrambling.

Figure 5 displays the measurement results.

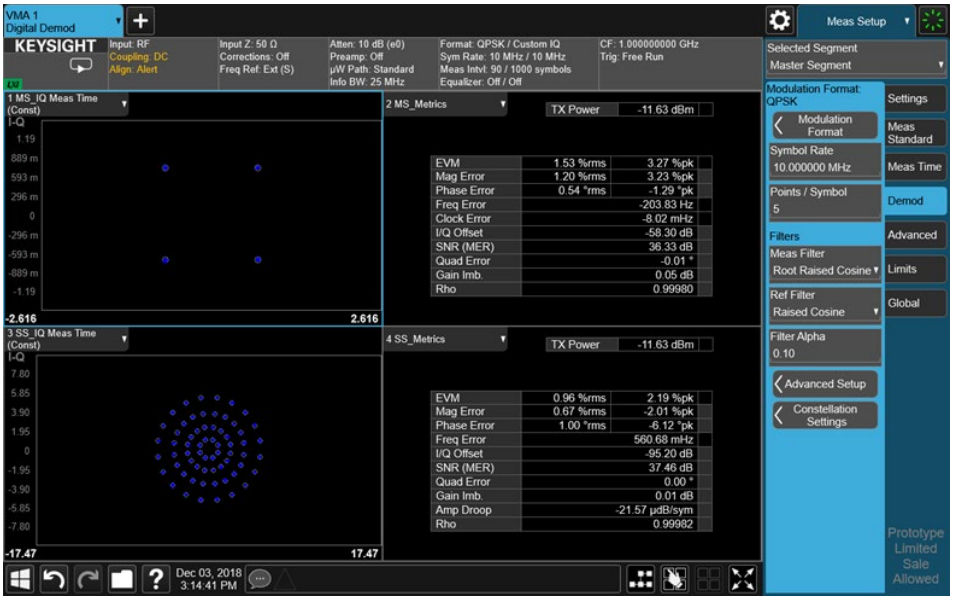

Figure 5. Measurement results for 64-APSK DVB-S2X signal

Summary

Keysight N9054EM0E VMA Vector Modulation Analysis measurement application is a general-purpose analysis application which supports a wide range of signal analysis platforms. The N9054EM0E is cost-effective for high-performance HW platforms; and supports a broad range of requirements — from R&D, design verification, and high-volume manufacturing. The features and flexibility in the VMA dual-segment measurement application keep you current with new standards and emerging technologies. To learn more, please visit www.keysight.com/find/N9054E.

N7608C Signal Studio Pro for Custom Modulation can generate DVB-S2X signals with data section. To learn more, please visit www.keysight.com/find/N7608C.

N7623C Signal Studio for Digital Video can generate fully standard-compliant DVB-S/S2/S2X signals with data and header sections. It also supports the channel coding, scrambling and TS file payload, which can be used for receiver testing. To learn more, please visit www.keysight.com/find/N7623C.

Keysight N9032B PXA X-Series signal analyzer is preselected up to 55 GHz, offering full specifications, up to 2 GHz of analysis bandwidth, and an optional preamplifier to 55 GHz. Industry-leading EVM and DANL deliver quick time-to-insight multitone and DVB-S/S2/S2X measurements. N9056EM0E Channel Quality/Group Delay Measurement Application running on X-Series allows the signal analyzer to take control of the M9484C VXG vector signal generator, enabling the user to set up all the tones from a single user interface to eliminate measurement setup error. Real Time Spectrum Analysis (RTSA) up to 2 GHz bandwidth enables users to monitor signals in real-time and spot spurious signals with 100% probability of intercept on signals with duration as short as 227 ns. To learn more, please visit www.keysight.com/find/N9032B.

Model	N9042B	N9041B	N9040B	N9032B	N9030B	N9021B
Frequency (GHz)	26.5, 44, 50	90, 110	8.4, 13.6, 26.5, 44, 50	8.4, 13.6, 26.5, 44, 50, 55	3.6, 8.4, 13.6, 26.5, 44, 50	8.4, 13.6, 26.5, 32, 44, 50
Max. analysis bandwidth	4 GHz	1 GHz	1 GHz	2 GHz	510 MHz	510 MHz

Table 2. Keysight wideband signal analyzers