Application Note

MODULATION ACCURACY MEASUREMENTS OF DVB-S2 AND DVB-S2X SIGNALS

Products:

- R&S® FSW-K70
- R&S® FSW-K70M
- R&S® FSV3-K70
- R&S® FSV3-K70M
- R&S® FPS-K70
- R&S® VSE-K70
- R&S® VSE-K70M
- R&S® FPL-K70
- R&S® FPL-K70M

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Note:

Please find the most up-to-date document on our homepage http://www.rohde-schwarz.com/appnote/1EF93.

This document is complemented by software. The software may be updated even if the version of the document remains unchanged

Contents

1 Overview

This Application Note gives a short overview how signals with two different modulation schemes can be analyzed. The Application Note focuses on DVB-S2(X) signals, but the approach may be used for similar signals as well, as e.g. used in microwave backhaul links.

The Application Note also provides a software tool that automates the configuration and provides the variety of different constellations that are used within DVB-S2(X).

The software makes may be used directly with most R&S® Signal- and Spectrum-Analyzers. It also directly connects to the R&S®VSE PC software with its Vector Signal Analysis personality. Through the PC software, any VSE supported instrument can now be used to analyze DVB-S2(X) or similar modulations.

From version 4 on, both application note and software tool may make use of the FSW-K70M option, when available.

2 Introduction

Signals using a high frequency carrier typically share a common challenge: Keeping the phase at the receiver synchronous to the transmitter. Most signal links solve the challenge by introducing pilots or a so called synchronization section. Pilots typically use a robust modulation scheme, such as QPSK. In the payload section, link designers often try to use a high modulation order, e.g. 256APSK, in order to maximize data throughput. So the signal contains sections of QPSK followed by higher order modulations.

Most vector signal analysis software packages require the signal to use a single modulation scheme only. Signals with pilots of a different modulation scheme require either two analysis steps on the same set of I/Q data or an analysis with multiple modulations. The R&S FSW family allows both approaches, as described in this application note.

The approach described in this Application Note is applicable to all signals containing two or more different modulation schemes, however the focus in this document is DVB-S2X, which is backwards compatible to DVB-S2.

DVB-S2(X) signals contain two different modulation schemes: the header and pilot sections of the signal employ a (modified) π/2-BPSK modulation, whereas the payload part uses an M-ary (A)PSK modulation.

Generation of DVB-S2(X) signals is covered in [1].

3 Modulation Accuracy Analysis

DVB-S2(X) is a very flexible standard. It offers a wide variety of constellations, from π/2-BPSK to 256APSK each constellation with different coding rates. The standard always uses a (modified) π/2-BPSK for its header segment. Since the payload uses a different constellation with a higher order, the signal in general has two segments with different constellations.

3.1 Measurement of DVB-S2X with the FSW-K70 or the FPS-K70

The R&S FSW-K70 as well as the R&S FPS-K70 (digital demodulation personalities or VSA) can process only one constellation at a time.

Therefore, a different approach is necessary to analyze DVB-S2(X): the FSW/FPS can operate two (or more) instances (so called channels) of the digital demodulation personality on the same set of data. One channel analyzes the header whereas the other channel demodulates the payload section.

Since the demodulation of DVB-S2(X) requires many settings in two different instances of the digital demodulation personality, this application note comes with a software that does not only set up all necessary channels, but also provides all the different constellation files which exist for DVB-S2(X). The software makes it very convenient for the user, since it decodes all necessary setup information out of the captured signal and automatically configures the channels accordingly.

Setting up the R&S FSW-K70 / FPS-K70

The R&S FSW as well as the R&S FPS provide the Multi Standard Radio Analyzer (MSRA). This mode of operation allows multiple personalities or multiple instances of the same personality to access and analyze the same set of captured data. Each instance of a personality is referred to as a channel.

In the context of DVB-S2(X), we will use this functionality to provide time correlation between the header segment and the following payload section as described above.

Here are the main steps to set up this measurement. These can either be done manually as described below or automatically with the help of the software provided with this Application Note (see 3.3).

1. Configuration of the MSRA master or VSE data recording: use a sampling rate of at least four times the symbol rate, i.e. a sampling rate of 80 MHz or higher for a 20 MSym/s DVB-S2(X) signal. The capture length should be set to 5 ms or longer (see 3.4.1), unless more details of the signal are known. Use single sweep mode.
2. Configuration of the header VSA channel: Set the modulation to QPSK with DVB-S2 mapping and specify the SOF (start of frame) sequence inside the PLS header as a pattern. The pattern can be created with the software provided with this Application Note (see 3.3). The bit sequence of the SOF section is described in [2]. For QPSK with DVB-S2 mapping it is "01320231010232313232020232". Left-align the result range with reference to the pattern and set the result range length to the entire PLS header (90 symbols). The symbols diagram now shows a header line called “Analysis Interval”. These values specify the time segment of the current result range with respect to the start of capture of the MSRA master. E.g. “218.70 µs – 223.20 µs” is a time interval of 4.5 µs starting 218.70 µs after the first sample in the MSRA capture (see Figure 1).

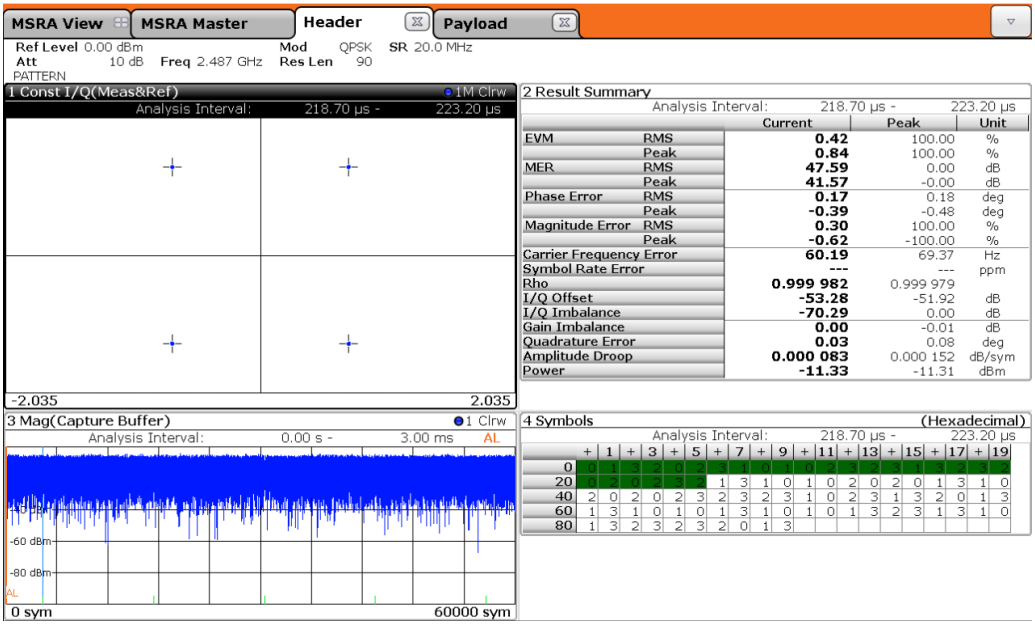

Figure 1: Screenshot of the header channel. The SOF pattern was found, the header symbols are displayed in the symbols trace. The location of the header within the captured data (MSRA Master) is indicated as "Analysis Interval", here 218.70 µs to 223.20 µs.

3. Configuration of a second VSA channel for the payload segment: for M-ary APSK modulations, use “User Modulation”. The user modulation files can be created using the mapwiz Mapping Wizard software available on the R&S website. For DVB-S2(X), all necessary mappings exist and can be downloaded to the R&S FSW using the attached software. The software places all user modulation files into "C:\R_S\Instr\user\VSA\Constellation\DVB-S2X\" on the instrument. As an alternative, they are available as a zip file along with this Application Note. Configure the result range length according to the current frame structure (see 3.4.1), making sure that the subsequent header or pilot section is not included. Configure the “Capture Offset” (in TRIG menu) to the stop value of the analysis interval of the header channel, 223.20 µs in the example above. Use the “Refresh” button to update the results. During manual operation, every new capture requires that the “Capture Offset” is reconfigured according to the pattern search in the header channel, unless an external trigger signals the position of each frame. The attached software however does this automatically.

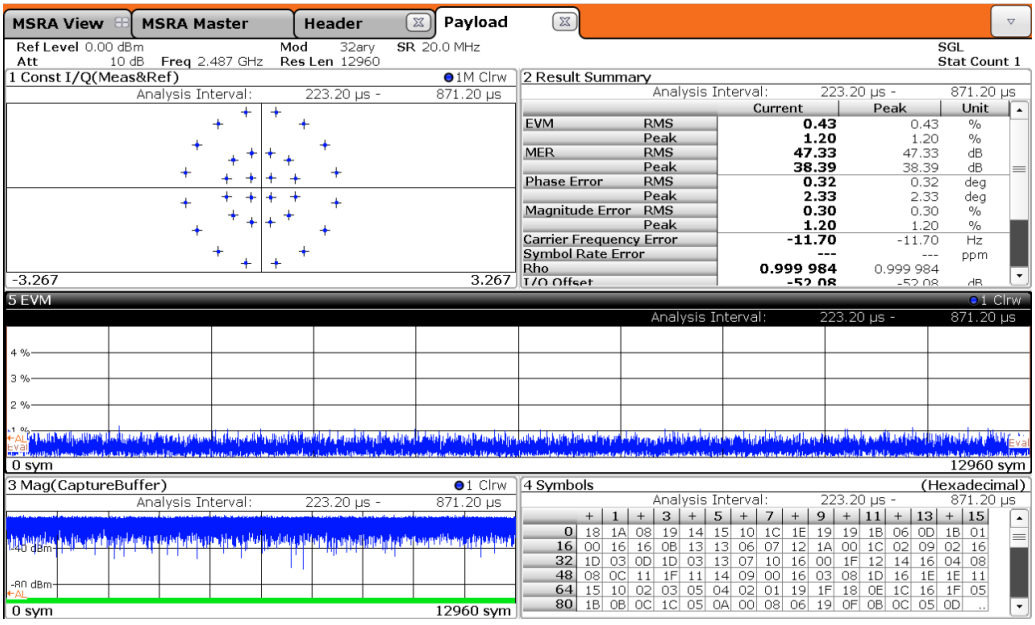

Figure 2: Screenshot of the payload channel. A 32APSK modulation is configured. The frame length is 12960 symbols, which is derived from 64800 bits divided by 5 (5 bits per symbol in 32APSK). Capture offset is set to 223.20 µs.

3.2 Measurement of DVB-S2X with the FSW-K70M application for Multiple Modulations

Starting with FW 3.00, the R&S FSW-K70 also supports signals containing multiple modulations. The add-on option FSW-K70M is required for this measurement.

In contrast to the method described above, the multiple modulation application does not require multiple channels.

In addition, the multiple modulation application will run stand-alone, e.g. in Run Continuous mode, without requiring the external software tool for every individual measurement. However, we still recommend the software tool for initial configuration of K70M, as it automatically decodes the header and configures K70M automatically.

Setting up the R&S FSW-K70M

In contrast to the single modulation application K70, K70M supports multiple modulations within one measurement. For a successful demodulation of a DVB-S2 or S2X signal, the application requires knowledge about the frame structure of the current signal. The frame structure is the allocation of header, pilot, and payload blocks in time. The header block is the time reference. A known pattern, for DVB-S2/S2X the start of frame (SOF), defines the beginning of a new frame. The payload block has a modulation scheme different from that of the header. The optional pilot blocks split the payload into multiple segments and have the same modulation scheme as the header. The frame definition may comprise only a fraction of the real frame, but we recommend in general defining the entire frame within K70M. Figure 5 shows a schematic of the DVB-S2X frame structure.

This approach also allows evaluating the EVM for the entire frame with a single number, whereas the multi-channel approach allows EVM evaluation only for each segment separately.

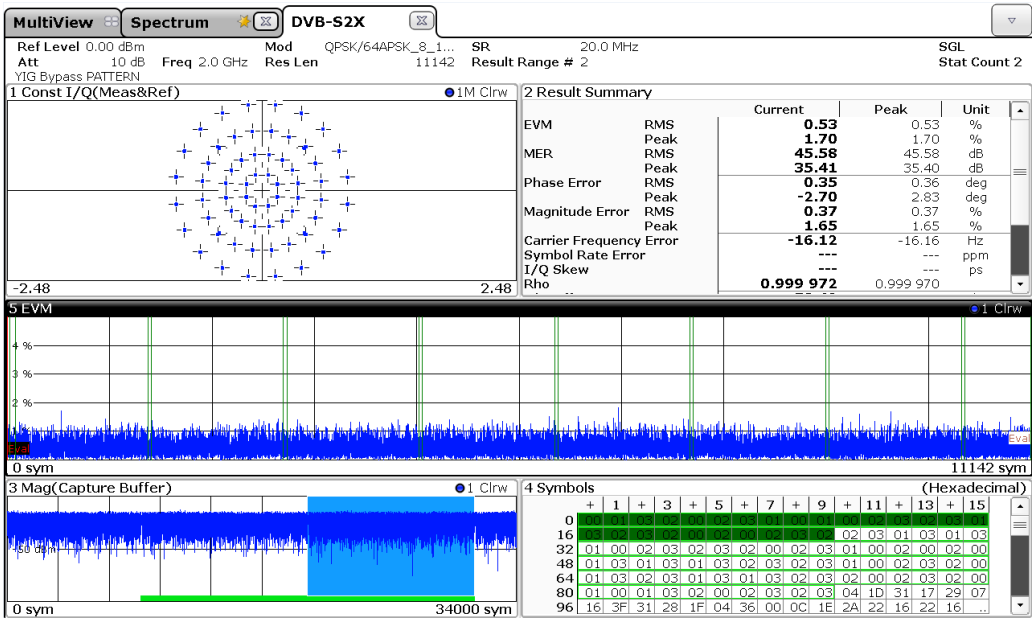

Figure 3: Screenshot of R&S FSW-K70M supporting multiple modulations in a single channel. K70M may run in continuous mode without additional configuration from external tools for signals containing two different modulation schemes.

3.3 Measurement of DVB-S2X with the R&S VSE-K70

The digital demodulation personality (or VSA) of the R&S VSE-K70 can process only one modulation at a time. Therefore, the header and the payload part of the DVB-S2(X) signal need to be analyzed separately, while the time correlation between these two parts needs to be maintained.

The software provided with this application note sets up the VSA automatically for a DVB-S2X signal. For a description of the manual setup, please refer to 0. Keep in mind that the R&S VSE software does not support the MSRA. However, the R&S VSE software provides a data recorder. So when analyzing the signal within VSE, the data is recorded initially, before it is analyzed in two different VSA channels. Since both channels are using the same data recording, time correlation is inherent (see Figure 4).

The position of the start of the payload part can be calculated manually. It is possible to read out the pattern position in the header channel by querying "[SENSe:]DDEMod:SEARch:MBURst:STARt?" over the remote control interface.

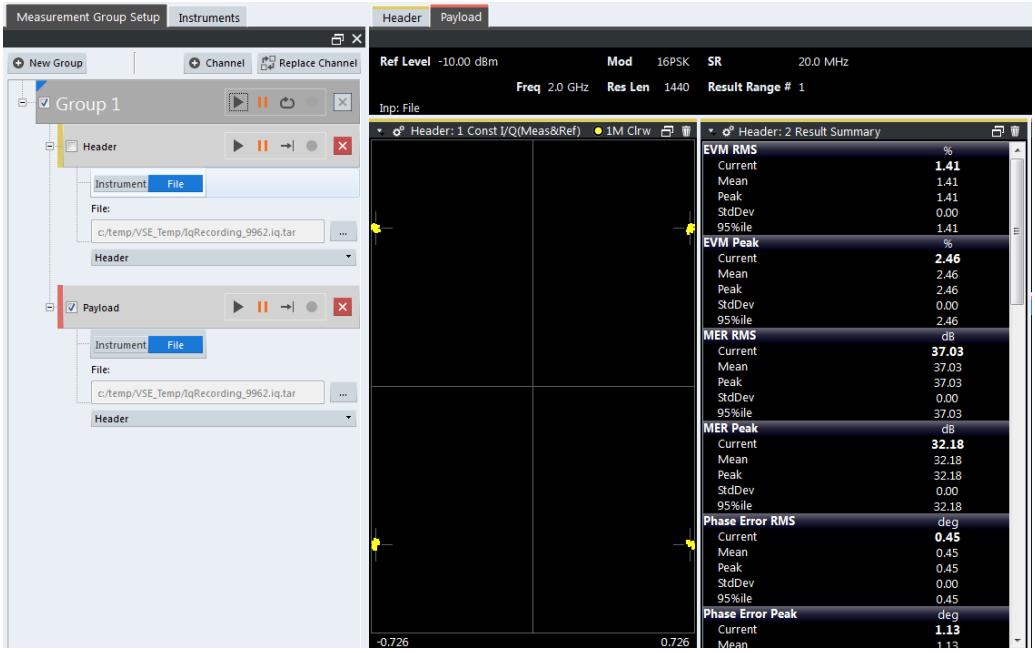

Figure 4: Screenshot of R&S VSE-K70. Two channels (header and payload) both configured to analyze the same file (recording).

3.4 Configuration Side Notes

3.4.1 Frame Length

[2] specifies the frame length to be 64,800 bits for a normal frame and 16,200 bits for a short frame.

A measurement without a trigger corresponding to the start of frame, may begin anywhere in the frame. In the worst case, it starts with a single symbol offset to the frame. Therefore, a minimum of one frame length plus two header length is required so the SOF pattern can always be found within the capture. For payload analysis, another frame length is needed. Doing the math on 64,800 bits, assuming QPSK without inserted pilots and a symbol rate of 20,000 MSyms/s results in a capture time of at least 3.249 ms. See also Figure 5.

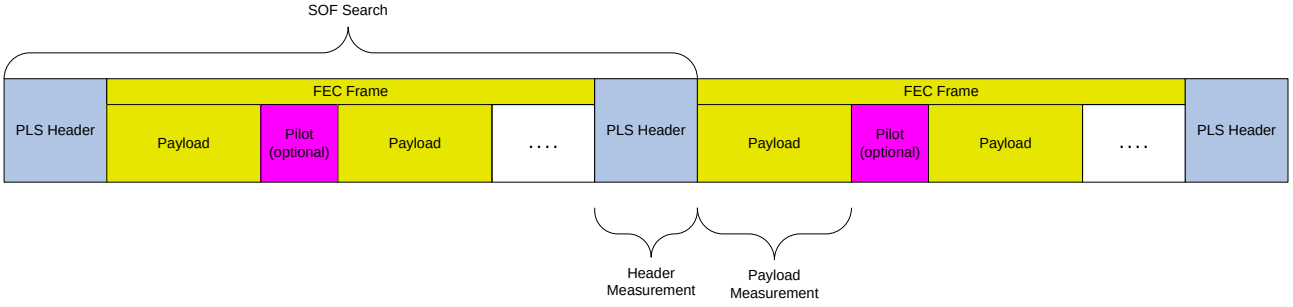

Figure 5: Timing structure of DVB-S2(X) signal. Different segments for SOF search, header measurement and payload measurement are indicated.

3.4.2 Modulation Accuracy (EVM) and Bit stream Result

Both standards, DVB-S2 and DVB-S2X employ a physical layer scrambling. The mapped symbols are scrambled in a way so that the result corresponds to either the original mapping or a mapping that is rotated

n x 90° degree compared to the original mapping. As a result, the bit stream of the payload does not correspond to the sender's bit stream. However, the EVM measurement is not affected.

Within DVB-S2X, there are 4 constellations which do not show rotational symmetry. These are both 8APSK constellations, as well as the 256APSK constellations with code rates 20/30 and 22/30. For these constellations, modified mapping files exist that allow EVM measurements. The modified mapping files consist of the original constellation and an additional 90° rotated version (see Figure 6).

For the 256APSK constellations with code rates 20/30 and 22/30, a number of constellation points is relatively close to each other in the modified constellation file. In order to avoid wrong decisions, a good signal-to-noise ratio is required.

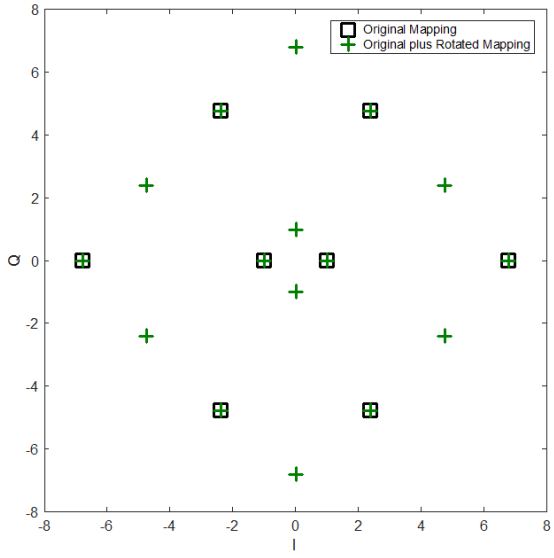

Figure 6: 8APSK 100/180 constellation and the modified version that shows rotational symmetry

4 The Software Package

4.1 Installation

The software does not require any installation. Simply double click on the executable, either on a PC that has a connection to the instrument (GPIB or LAN) or directly on the instrument. When the software runs directly on the instrument, the VISA Analyzer address can be left in its default "TCPIP::localhost", otherwise the VISA resource string specifies the connection and address of the instrument.(Then the VISA address of the analyzer just has to be set to TCPIP::localhost)

4.2 Installing the User Modulation Files

Since the DVB-S2(X) standard uses a variety of dedicated mappings, it is necessary to supply each constellation as a user modulation file (".vam") to the vector signal analysis personality. The software package comes with all mappings defined in the DVB-S2 [2] and DVB-S2X standards [3]. The "Copy Constellations" button copies all constellation files into the appropriate folder. All constellation files need to be copied before the software can run the first measurement. Note: from firmware R&S FSW 3.00 on, the modulation schemes as well as frame configuration files are part of the firmware package and are available on all instruments.

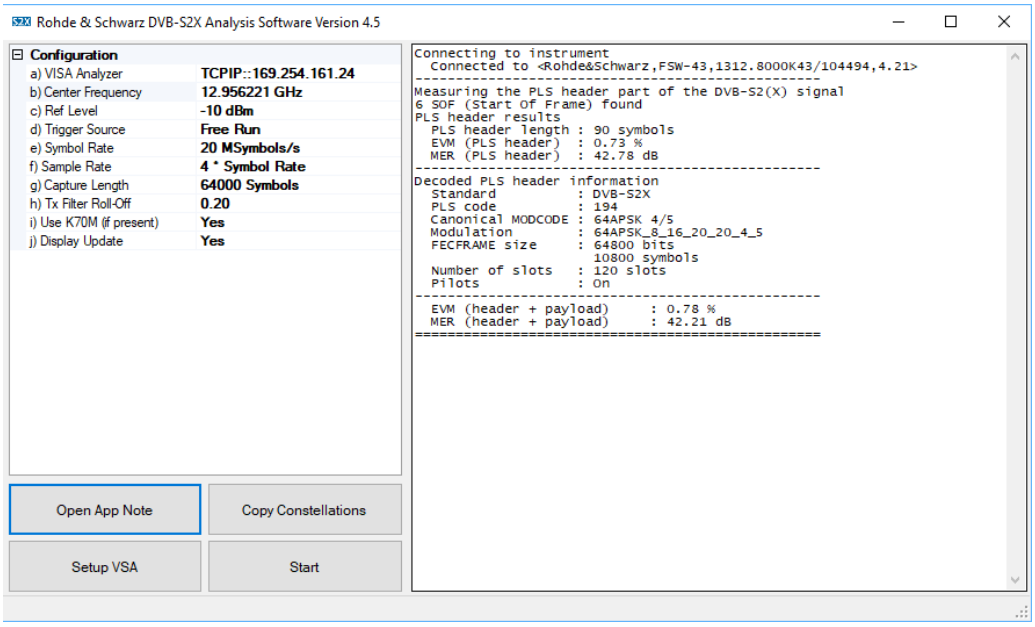

Figure 7: Screenshot of the DVB-S2X Analysis software running on an R&S FSW. "Setup VSA" sets up the MSRA and VSA channels or the multiple modulation application K70M, depending on availability. "Start" initiates the measurement.

4.3 Configuring the Measurement

The measurement is configured automatically by pressing "Setup VSA". The configuration section on the left side of the software specifies all parameters that are not predefined in the standard. The symbol rate is completely open, i.e. it can be adapted to the data throughput needs and the available bandwidth. The transmit filter roll-off coefficient determines the signal's bandwidth at a given symbol rate. [2] specifies coefficients of .20, .25, and .30, whereas [3] adds .05, .10, and .15.

The Capture Length for the header channel defines the search range for the SOF pattern and is given in symbols. This parameter significantly influences the measurement speed. The default setting of 40,000 symbols ensures that the header channel will always find the SOF pattern. 64800 bit per frame result in 32400 symbols with QPSK modulation. Adding 180 symbols for two header sections results in the minimum length that guarantees a successful pattern search. If your signal uses a higher order modulation and you need to increase measurement speed, you may decrease this number.

The Sample Rate is derived from the symbol rate with an oversampling factor. A factor of 4 is sufficient.

When you have adapted the above settings to your signal, the software configures the instrument as soon as you hit "Setup VSA".

"Start" finally initiates the measurement and displays the results in the window on the right hand side.

When using the R&S VSE, please configure only one instrument that the VSE is talking to, i.e. make sure only one instrument is listed under instruments (see Figure 8).

By default, the tool automatically makes use of the multiple modulation analysis application, if available. However, if you prefer the multi-channel approach, the tool can be forced to not use the multi-modulation analysis, when "Use K70M" is set to "No".

Note: the button "Setup VSA" performs a preset on the connected instrument, whereas "Start" only starts a new measurement without going through a preset. If you're intending to do any additional manual settings (e.g. switching to a different front panel connector), perform the manual steps between "Setup VSA" and "Start", as "Setup VSA" will bring all settings back to their default state.

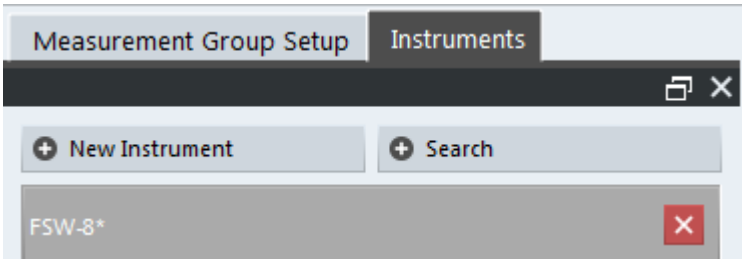

Figure 8: R&S VSE instruments list. Only one instrument shall be connected for the DVB-S2X software to work.

4.4 Remote Control of the Software

The software supports remote control via a raw socket interface. This interface is similar to a standard VXI-11 interface with no additional control channel.

The port for communication with this software is 5026 (Rohde & Schwarz instruments typically use port 5025, so the R&S FSW and the software can be controlled at the same time, even when the software runs on the instrument).

Raw socket connections do not require a VISA interface, however they can be handled by VISA. The VISA resource string for a raw socket connection to port 5026 on localhost (127.0.0.1) is "TCPIP::127.0.0.1::5026::SOCKET".

The following commands are supported by the software:

Remote Control Commands	
Set Up Commands	
DVBS:CONN:ANA	VISA address of connected analyzer [String]
DVBS:FREQ:CENT	Signal center frequency [Hz]
DVBS:TRIG:SOUR:EXT	Set up external trigger [0/1]
DVBS:DISP:TRAC:Y:RLEV	Reference level [dBm]
DVBS:SENS:DDEM:SRAT	Symbol Rate [Hz]
DVBS:SENS:DDEM:PRAT	Oversampling Factor [4/8/16/32]
DVBS:SENS:DDEM:RLEN:VAL	Capture length [Symbols]
DVBS:SENS:DDEM:FILT:ALPH	Tx Filter Roll-Off [1]
DVBS:SYST:DISP:UPD	Analyzer display update [0/1]
DVBS:SENS:DDEM:TWOM	Use K70M if option exists on analyzer in use [0/1]
Action Commands	
DVBS:INIT:LOADVAM	Execute "Copy Constellations"
DVBS:INIT:SETUP	Execute "Setup VSA"
DVBS:INIT:IMM	Execute "Start"
Query Commands	
*IDN?	IDN of the DVB-S2X software
DVBS:FETCH:FSX:IDN?	IDN of the connected analyzer
DVBS:STAT:RUN?	Software busy [0/1]
DVBS:FETCH:EVM:HEADER?	Header EVM RMS [%]
DVBS:FETCH:EVM:HEADER:PEAK?	Header EVM Peak [%]
DVBS:FETCH:EVM:PAYLOAD?	Payload EVM RMS [%]
DVBS:FETCH:EVM:PAYLOAD:PEAK?	Payload EVM Peak [%]
DVBS:FETCH:MER:HEADER?	Header MER [dB]
DVBS:FETCH:MER:PAYLOAD?	Payload MER [dB]
DVBS:FETCH:FRAME:BITS?	FECFRAME size [Bits]
DVBS:FETCH:FRAME:SYMBOLS?	FECFRAME size [Symbols]

Remote Control Commands	
DVBS:FETCH:MOD:MODE?	Used Standard [DVB-S2 or DVB-S2X]
DVBS:FETCH:MOD:NAME?	MODCOD name [String]
DVBS:FETCH:FRAME:SLOTS?	Number of slots [1]
DVBS:FETCH:MOD:PILOTS?	Pilots inserted [0/1]
DVBS:FETCH:ERR:SCPI?	Analyzer SCPI error occurred? [0/1]
SYST:ERR?	Error of the DVB-S2X software itself [String]

The following pseudo code sequence is an example to control the DVB-S2X software through a VISA layer.

Note: "\n" shall be added after each command, where "\n" is the newline character, i.e. 0x0A.

```
viOpen(TCPIP::localhost::5026::SOCKET)

viSetAttribute(TERMCHAR_EN,VI_TRUE)

viSetAttribute(TERMCHAR,10)

viWrite(*IDN?\n)
viRead: Rohde&Schwarz,DVB-S2X Analysis Software,0000.0000K00,1.0.0.0

viWrite(DVBS:CONN:ANA "TCPIP::10.114.10.155"\n)

viWrite(DVBS:FETCH:FSX:IDN? \n)
viRead:
Rohde&Schwarz,FSW-26,1312.8000K26/101447,2.40

viWrite(DVBS:INIT:LOADVAM\n)

<Repeat until a "0" is received>
  <sleep for e.g. 10 ms>
  viWrite(DVBS:STAT:RUN?)

  viRead: <1 for running - 0 for done>

viWrite(DVBS:INIT:SETUP\n)

<Repeat until a "0" is received>
  <sleep for e.g. 10 ms>
  viWrite(DVBS:STAT:RUN?)

  viRead: <1 for running - 0 for done>

viWrite(DVBS:INIT:IMM\n)

<Repeat until a "0" is received>
  <sleep for e.g. 10 ms>
  viWrite(DVBS:STAT:RUN?)

  viRead: <1 for running - 0 for done>

viWrite(DVBS:FETCH:EVM:HEADER? \n)
viRead: 0.054355642

viClose
```

5 Literature

[1] R. &. Schwarz, "DVB-S2 & DVB-S2X Signal Generation in K-Band and Analysis. Application Note 1MA273," [Online]. Available: http://www.rohde-schwarz.com/appnote/1MA273.

[2] ETSI, Digital Video Broadcasting (DVB), ETSI EN 302 307-1 V1.4.1, vol. Part 1, ETSI, 2014-11.

[3] ETSI, Digital Video Broadcasting (DVB), ETSI EN 302 307-2 V1.4.1, vol. Part 2, ETSI, 10-2014.

6 Ordering Information

Designation	Type	Order No.
Signal- and Spectrum Analyzer	R&S®FSW43	1331.5003.43
Vector Signal Analysis Software	R&S®FSW-K70	1313.1416.02
Multi-Modulation Analysis	R&S®FSW-K70M	1338.4177.02
Signal- and Spectrum Analyzer	R&S®FSVA3044	1330.5000.44
Vector Signal Analysis Software	R&S®FSV3-K70	1330.5074.02
Multi-Modulation Analysis	R&S®FSV3-K70M	1346.3376.02
Signal- and Spectrum Analyzer	R&S®FPS40	1319.2008.40
Vector Signal Analysis Software	R&S®FPS-K70	1321.4127.02
Vector Signal Explorer	R&S®VSE, basic edition	1345.1011.06
Vector Signal Analysis Software	R&S®VSE-K70	1320.7522.02
Multi-Modulation Analysis	R&S®VSE-K70M	1345.1211.02

Rohde & Schwarz

The Rohde & Schwarz electronics group offers innovative solutions in the following business fields: test and measurement, broadcast and media, secure communications, cybersecurity, monitoring and network testing. Founded more than 80 years ago, the independent company which is headquartered in Munich, Germany, has an extensive sales and service network with locations in more than 70 countries.

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Rohde & Schwarz customer support

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1EF93 | Version 9e | 11.2022
Application Note | Modulation Accuracy Measurements of DVB-S2 and DVB-S2X Signals
Data without tolerance limits is not binding | Subject to change