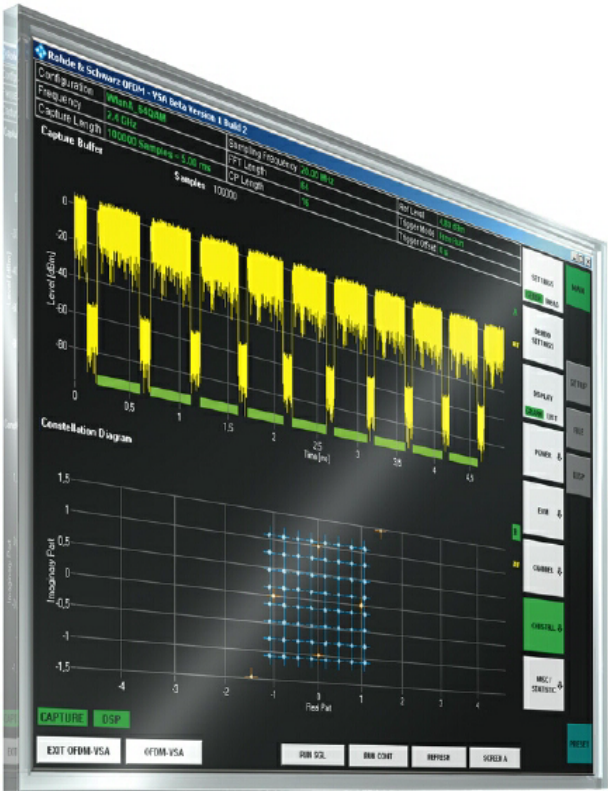


R&S®FS-K96/-K96PC OFDM Vector Signal Analysis Software User Manual



1310.0331.02 – 04

The User Manual describes the following R&S®FS-K96/-K96PC models:

- R&S®FS-K96 and R&S®FS-K96PC

The firmware of the instrument makes use of a valuable open source software package. The verbatim license texts are provided on the user documentation CD-ROM (included in delivery).

Package	Link	License
NSIS	http://nsis.sourceforge.net/Main_Page	2.46

Rohde&Schwarz would like to thank the open source community for their valuable contribution to embedded computing.

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The following abbreviations are used throughout this manual:

R&S®FS-K96/-K96PC is abbreviated as R&S FS-K96/-K96PC .

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Conventions Used in the Documentation

The following conventions are used throughout the R&S FS-K96 User Manual:

Typographical conventions

Convention	Description
"Graphical user interface elements"	All names of graphical user interface elements both on the screen and on the front and rear panels, such as dialog boxes, softkeys, menus, options, buttons etc., are enclosed by quotation marks.
"KEYS"	Key names are written in capital letters and enclosed by quotation marks.
<i>Input</i>	Input to be entered by the user is displayed in italics.
File names, commands, program code	File names, commands, coding samples and screen output are distinguished by their font.
"Links"	Links that you can click are displayed in blue font.
"References"	References to other parts of the documentation are enclosed by quotation marks.

Other conventions

- **Remote commands:** Remote commands may include abbreviations to simplify input. In the description of such commands, all parts that have to be entered are written in capital letters. Additional text in lower-case characters is for information only.
- **Procedure descriptions:** When describing how to operate the device, several alternative methods may be available to perform the same task. In this case, the procedure using the touchscreen is described, where available. Any elements that can be activated by touching can also be clicked using an additionally connected mouse. The alternative procedure using the keys on the device or the on-screen keyboard is only described if it deviates from the standard operating procedures as described in the Quick Start Guide under "Basic Operations".

The terms "**select**" and "**press**" may refer to any of the described methods, i.e. using a finger on the touchscreen, a mouse pointer in the display, or a key on the device or on a keyboard.

1 General Information

The R&S FS-K96 OFDM Vector Signal Analysis PC software uses the I/Q capture functionality of the R&S spectrum analyzer to enable generic OFDM measurements using a PC-based software.

This manual supports the user in working with this software. It describes how to prepare, execute, and evaluate a measurement and gives many helpful hints and examples.

1.1 License Types

The OFDM Vector Signal Analysis PC Software enables to:

- capture and analyze I/Q data from an R&S FSW, R&S FSV, R&S FSVR, R&S FSQ, R&S FSG or R&S FSUP
- read and analyze I/Q data from file

Two different license types of the software can be purchased:

- **FS-K96PC**: This license enables software operation with and without an R&S signal analyzer. It is e.g. possible to read data from file without a connection to an analyzer.
- **FS-K96**: This license requires a connection to an R&S FSW, R&S FSV, R&S FSVR, R&S FSQ, R&S FSG or R&S FSUP. No license needs to be installed on the analyzer.



It is also possible to operate the software with the provided example I/Q data files without any license.

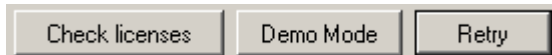
In order to do this, just click “Demo Mode” when a pop-up window asks you to insert a smartcard with a valid license. The following signals that are provided with the software in the subfolder `%Application path%\SIGNALS\` can be analyzed:

- DVBT_Mode2k_Ng1_32_QPSK.iqw
 - WimaxOfdm_DL_G1_16_16QAM.iqw
 - WlanA_64QAM.iqw
 - WlanN_64QAM.iqw
-

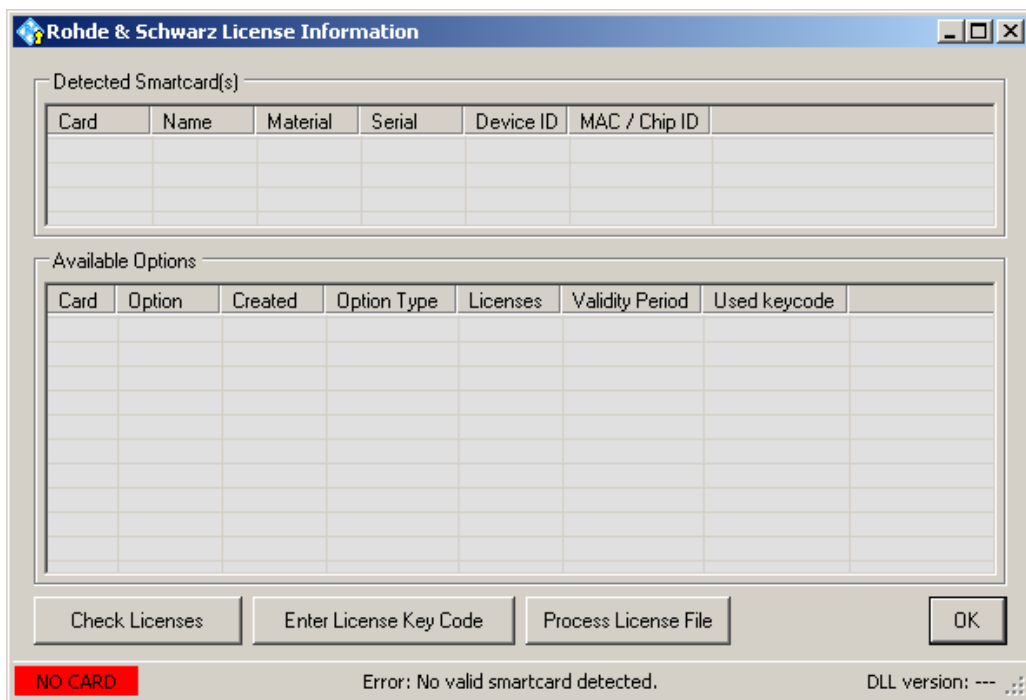
1.1.1 Ordering a New License

New license types, such as the FS-K96U that upgrades the FS-K96 to the FS-K96PC can be ordered as *registered* license. This means that the license key code is based on the unique serial number of the R&S FSPC smartcard serial number. The serial number (that is necessary for ordering the license) can be obtained as follows:

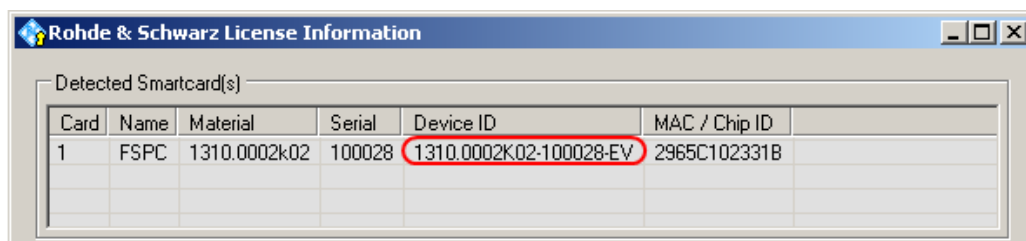
1. Start the software **without** inserting the smartcard / dongle.
2. A window will open that gives you the choice between “Check licenses”, “Demo Mode” and “Retry”.



3. Click “Check licenses”. The following window will open:



4. Insert the smartcard / dongle.
5. Click on “Check Licenses” and read out Device ID that appears in the column “Device ID”:



1.2 Introduction – OFDM

In an OFDM (Orthogonal Frequency Division Multiplexing) system, the available spectrum is divided into multiple carriers, called subcarriers, which are orthogonal to each other. Each of these subcarriers is independently modulated by a low rate data stream.

OFDM is used as well in WLAN, WiMAX and broadcast technologies like DVB. OFDM has several benefits including its robustness against multipath fading and its efficient

receiver architecture.

Fig. 1 shows a representation of an OFDM signal taken from [1]. Data symbols are independently modulated and transmitted over a high number of closely spaced orthogonal subcarriers. In the OFDM-VSA common modulation schemes as QPSK, 16QAM, and 64QAM can be defined as well as arbitrary distributed constellation points.

In the time domain, a guard interval may be added to each symbol to combat inter-OFDM-symbol-interference due to channel delay spread. The OFDM-VSA requires a cyclic prefix as guard interval which is inserted prior to each OFDM symbol.

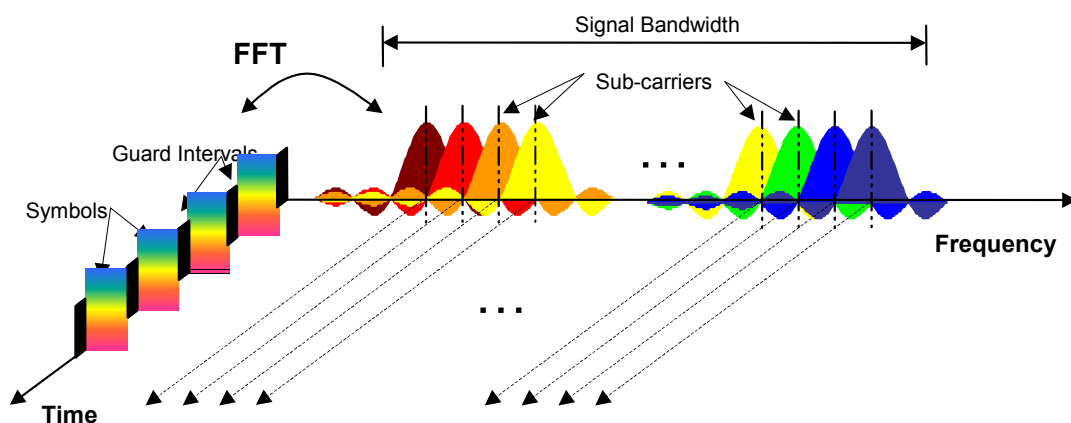


Fig. 1 Frequency-time representation of an OFDM signal

In practice, the OFDM signal can be generated using the inverse fast Fourier transform (IFFT) digital signal processing. The IFFT converts a number N of complex data symbols used as frequency domain bins into the time domain signal. Such an N -point IFFT is illustrated in Fig. 2, where $a(mN+n)$ refers to the n^{th} subchannel modulated data symbol, during the time period $mT_u < t \leq (m+1)T_u$.

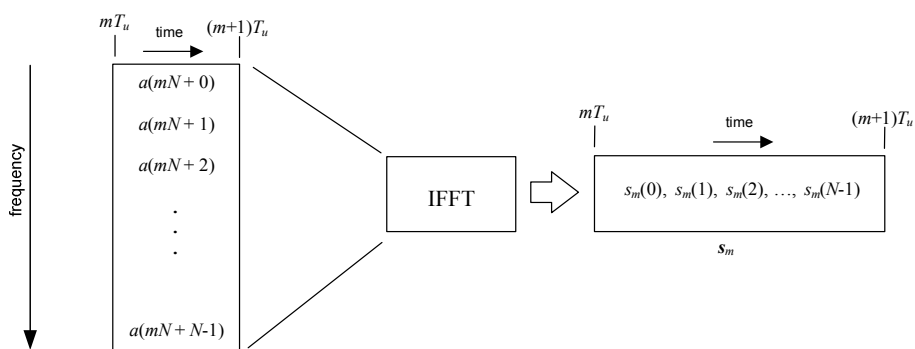


Fig. 2 OFDM Useful Symbol Generation Using an IFFT

The vector \mathbf{s}_m is defined as the useful OFDM symbol. It is the time superposition of the N narrowband modulated subcarriers. Therefore, from a parallel stream of N sources of data, each one independently modulated, a waveform composed of N orthogonal subcarriers is obtained, with each subcarrier having the shape of a frequency *sinc* function (see Fig. 1).

Fig. 3 illustrates the mapping from a serial stream of QAM symbols to N parallel streams, used as frequency domain bins for the IFFT. The N -point time domain blocks obtained from the IFFT are then serialized to create a time domain signal. Not shown in Fig. 3 is the process of cyclic prefix insertion.

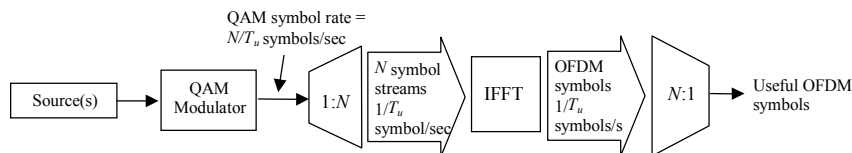


Fig. 3 OFDM Signal Generation Chain

[1] 3GPP TR 25.892: Feasibility Study for Orthogonal Frequency Division Multiplexing (OFDM) for UTRAN enhancement (Release 6)

1.3 OFDM Parameterization

A generic OFDM analyzer supports various OFDM standards. Therefore a common parameterization of OFDM systems has to be defined.

1.3.1 Time Domain Description

The fundamental unit of an OFDM signal in time domain is a 'Sample'. An 'OFDM-Symbol' with a length of N_s samples consists of a 'Guard Interval' of length N_G and an 'FFT Interval' of length N_{FFT} .

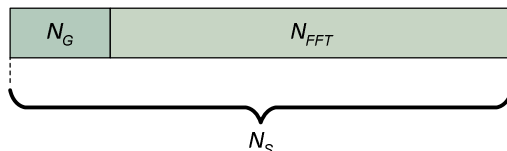


Fig. 4 OFDM Symbol in Time Domain

1.3.2 Frequency Domain Description

The FFT intervals of the OFDM symbols are transformed into the frequency domain using a discrete Fourier transform. The successive symbols of the OFDM signal are displayed in time-frequency matrices. The fundamental unit of an OFDM signal in frequency domain is a 'Cell'. A column of cells at the same frequency is called 'Carrier'. A row of cells at the same time is called 'Symbol'. The carrier number is the column index of a time-frequency matrix. The number '0' is assigned to the so called 'DC-Carrier', which lies at the transmitter center frequency. The total number of carriers is N_{FFT} . The 'DC-Carrier Offset' determines the position of the DC carrier relative to the lowermost carrier and is an inherent attribute of the FFT algorithm.

FFT Length N_{FFT}	DC-Carrier Offset	Range
even	$\frac{N_{FFT}}{2}$	$\left[-\frac{N_{FFT}}{2}, \frac{N_{FFT}}{2} - 1 \right]$
odd	$\frac{N_{FFT} - 1}{2}$	$\left[-\frac{N_{FFT} - 1}{2}, \frac{N_{FFT} - 1}{2} \right]$

The symbol number is the row index of a time frequency matrix. The first symbol gets the number '0'. The total area of a time frequency matrix is called 'Frame'. A frame is the highest level unit used in the OFDM-VSA.

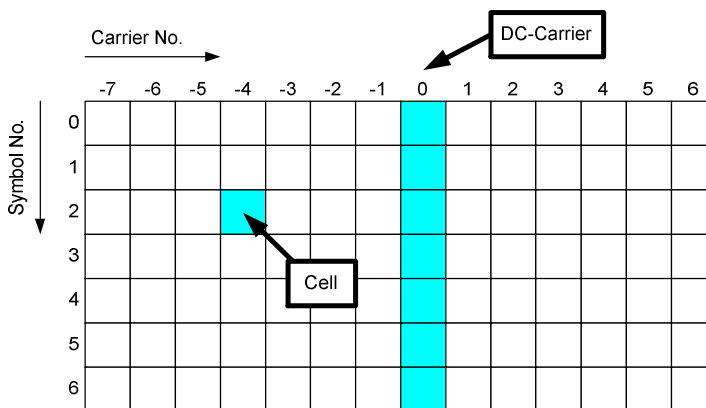


Fig. 5 Time-Frequency Matrix

1.3.2.1 Allocation Matrix

The allocation matrix defines the complete frame and subclassifies the OFDM system into:

- Pilot cells,
- Data cells,
- Don't Care cells,
- Zero cells.

Pilot cells contain known values and are used for various synchronization and parameter estimation purposes. Data cells contain the user data or "payload" of the transmission. The modulation format of the data cells must be known or can be estimated in a modulation estimation block. "Don't care" regions are cells that aren't evaluated for EVM measurement, but contain signal power. Finally, zero cells contain no signal power at all. Typically these are guard carriers around DC or at the edges of the carrier axis.

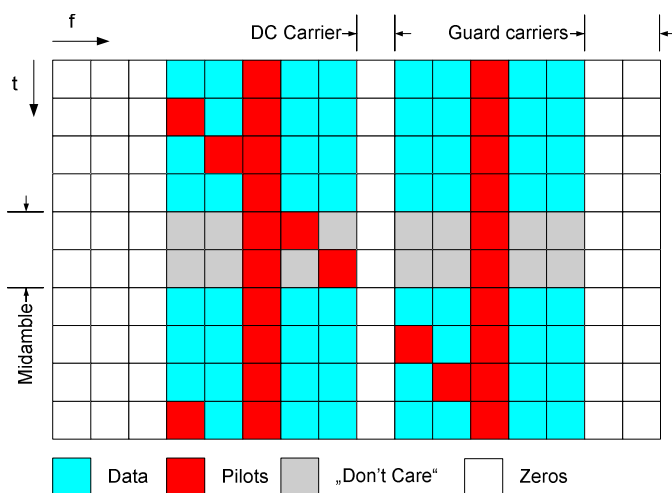


Fig. 6 Example of an Allocation Matrix

1.3.2.2 Pilot Matrix

A pilot matrix contains known complex numbers in the matrix cells, which are defined as pilot cells in the allocation matrix. Within the analyzer, the pilot matrix is correlated with the received time frequency matrix to get the frame start and the frequency offset of the received signal relative to the given allocation matrix.

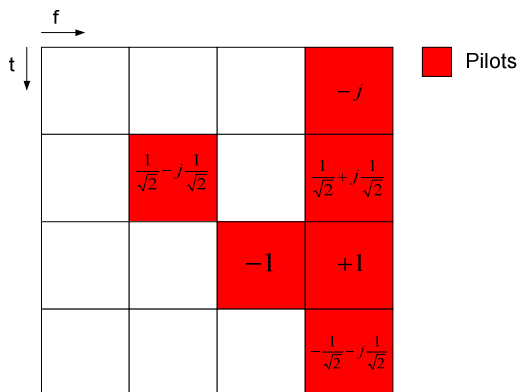


Fig. 7 Example of a Pilot Matrix

1.3.2.3 Constellation Vector

A constellation vector contains all possible numbers in the complex plane that belong to a specific modulation format. Constellation vectors must be defined for each possible data modulation format. The magnitude within the constellation vectors must be scaled according to the pilot matrix. One entry in the constellation vector is called 'constellation point'.

Differential modulation is not supported. The respective absolute modulation scheme must be used instead (e.g. QPSK instead of DQPSK). Periodically rotated constellations are not supported. The set union of all constellations must be used instead (e.g. 8PSK instead of PI/4-DQPSK).

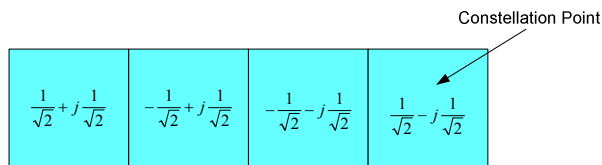


Fig. 8 QPSK Constellation Vector

1.3.2.4 Modulation Matrix

A modulation matrix contains numbers to the underlying constellation vector for each cell, which is defined as data cell in the allocation matrix. Clusters of data cells with the same modulation therefore share the same number. A data cell can also contain an unused number, that is a number for which no constellation vector is defined. In this case, all data cells sharing that number are assumed to use one and only one of the valid constellation vectors. This method can be used within the OFDM-VSA to allow automatic modulation detection.

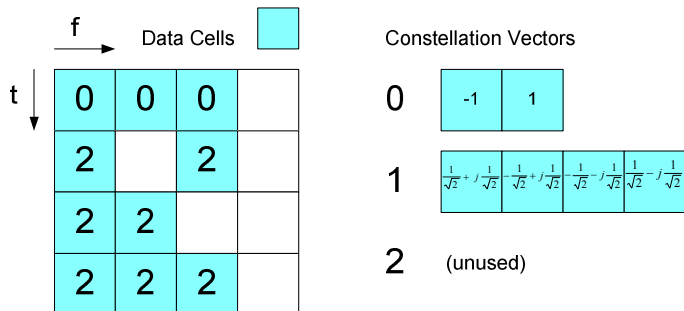


Fig. 9 Example of a Modulation Matrix

1.3.3 Preamble Description

The OFDM demodulator shall support synchronization on repetitive preamble symbols. A repetitive preamble contains several repetitions of one time domain block. Fig. 10 shows exemplarily the parameterization of a repetitive preamble symbol, which contains a five times repetition of block T. The allocation matrix can have an arbitrary offset to the begin of the preamble symbol. If the offset is zero or negative, the preamble is also contained within the frame and is used for further estimation processes.

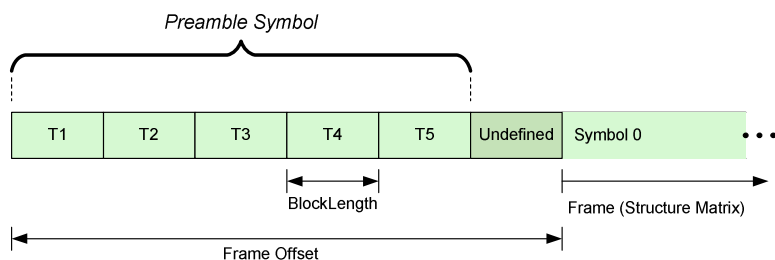


Fig. 10 Description of a Repetitive Preamble Symbol

2 Installation and Test Setup

2.1 Minimum System Requirements

The following minimum system configuration is recommended for the use of the R&S FS-K96 / R&S FS-K96PC Software:

- Operating System: Microsoft Windows XP Professional (+ SP2)
- Free Hard Disk Space: 1 GB
- Free RAM: ≥ 1 GB
- Graphics Resolution: \geq XGA (800x600 pixel)
- USB: one free USB port to connect the smartcard reader (if no PC-built-in smartcard reader is used)
- Measuring instrument connection:
 - Hardware: IEC/IEEE bus or LAN connection
 - Software: VISA driver, National Instruments VISA version ≥ 4.2



Windows 7 32-bit and 64-bit systems are supported.

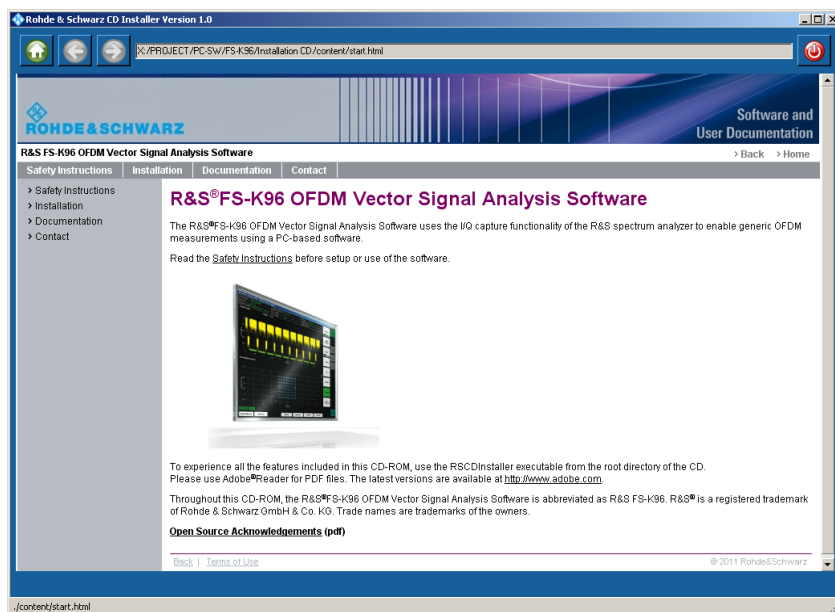
2.2 Software Installation

For successful installation of the R&S FS-K96 Software you need to

1. prepare your PC
2. install the R&S FS-K96 Software

In order to complete both steps, execute the `AutoStart.exe` file in the main directory of the installation CD. In the case that you have download the installation package from the Rohde&Schwarz homepage, please unzip the directory and go to the main directory.

The following screen will appear and the browser will guide you through the installation process.



2.2.1 Preparing the PC

The R&S FS-K96 Software needs some additional software components to run properly. All necessary components are delivered with the software itself. You can install them from the CD-ROM (or your downloaded install directory) prior to installing the R&S FS-K96 Software.

They are located in the category “Installation” and then “Required Components”



Prepare the PC as follows (a detailed explanation follows after the list):

1. Check if Microsoft .NET Framework 2.0 is installed on your computer by clicking on the link “Check for .NET installed”. Start the installation if it is not already installed.
2. Install all required components using the R&S Framework Installer.
3. Install VISA for remote operation of the used instruments.

Installing Microsoft .NET Framework Version 2.0

You need to install Microsoft .NET Framework 2.0 or a later version in order to use the R&S FS-K96 Software. Therefore, you need to check whether the .NET Framework is already installed.

1. Click on “Check for .NET Installed.exe”.
2. A message box tells you, if the .NET Framework is installed or not.

- If the .NET Framework is not installed on your PC, click on the link to the installer.

Install the required components

A number of software components are required to use the R&S FS-K96 Software. It is recommended to use the R&S Framework Installer available on the CD-ROM to install all required components.

- Start the R&S Framework Installer by clicking on the link.

The screenshot shows the 'Required Components' section of the R&S FS-K96 OFDM Vector Signal Analysis Software website. The page title is 'Required Components'. The text states: 'The R&S FS-K96 OFDM Vector Signal Analysis Software needs some additional software components to run properly. Follow the steps below.'

Installing Microsoft .NET Framework Version 2.0

- Start [Check for .NET Installed \(exe\)](#).
 - A message box tells you if the .NET Framework is installed or not.
 - If .NET is not installed, start the [.NET Framework Installer \(exe\)](#) and follow the instructions.

Installing required components:

- Start the installation of all required components by using the [R&S Framework Installer \(exe\)](#).
 - A dialog box lists all required components. Check the "Installation State" of the components you want to install.
 - If the component is "Ready to install", it can be installed by just selecting the component with the checkbox in the first column and clicking "Install selected components" afterwards.
 - If the component is "Ready to download", the Framework installer cannot find the installation file on a local hard drive. You need to download the component and install it manually.
- Install the missing components with the "Install selected components" button.

- The installer opens the following dialog box:

The screenshot shows the 'Rohde & Schwarz OFDM Vector Signal Analysis Software Framework Installer, Version 2.0' dialog box. It contains a table with the following data:

Install?	Component	Required Version	Installation State	Installation Source Path	Download Path	Detailed Information
<input checked="" type="checkbox"/>	Microsoft Visual C++ Runtime Library	2005 SP1 ATL Security Update x86	Ready to install	C:\Documents a...	http://www.rohde-s...	...
<input checked="" type="checkbox"/>	MATLAB Component Runtime	2009b (Version 7.9, Runtime V7.11)	Ready to install	C:\Documents a...	http://www.rohde-s...	...
<input type="checkbox"/>	MATLAB .NET Interfacing	2009b (Version 7.9, Runtime V7.11)	Installed by FS-K96 installer	Installed by FS-K96 i...	Installed by FS-K96 i...	...
<input checked="" type="checkbox"/>	Intel IPP Library	4.1	Ready to install	C:\Documents a...	http://www.rohde-s...	...
<input type="checkbox"/>	VISA	... (ANY)	Not installed		Not available for do...	Click here to get mor...
<input type="checkbox"/>	Port Mapper (for Remote Control)	2.8	Ready to install	C:\Documents a...	http://www.rohde-s...	...

Summary Status: Some mandatory components are not installed and their installation sources are missing. Check the manual on how to obtain these sources.

Buttons: Install selected components, Refresh, Exit



Mandatory Components

- Microsoft Visual C++ Runtime Library
- MATLAB Component Runtime
- MATLAB .NET Interfacing
- Intel IPP Library
- VISA

Optional Components

- Port Mapper
(necessary for remote control of the R&S FS-K96 Software)

3. The mandatory components need to be installed in order to operate the software. Check the "Installation State" of the components you want to install.
 - a. If the component is "**Ready to install**", it can be installed by just selecting the component with the checkbox in the first column and clicking "Install selected components" afterwards.
 - b. If the component is "**Ready to download**", the R&S Framework Installer cannot find the installation file on a local hard drive. You need to download the component and install it manually. Afterwards, you can use the R&S Framework Installer to check, whether the installation has been successful.
 - c. If you do not have the VISA component already installed on your PC, it is recommended to install the component from the additional CD that is supplied together with the R&S FS-K96 Software package.
4. Start the installation by pressing the "Install selected components" button. All selected components will be installed.

Note that the Matlab .NET Interfacing is installed with the Matlab Component Runtime. There is no separate installation routine for it.



You can also install all components manually. All files necessary are on the CD-ROM in the corresponding directories in the `\install\Framework` folder.

Install VISA

It is necessary to install VISA (Virtual Instrument Software Architecture) to access instruments connected to the PC via IEEE or LAN bus.

Please use the National Instruments VISA:

- The National Instrument VISA driver CD is supplied together with the R&S FS-K96 Software package. You can also visit <http://www.ni.com/visa> to get the latest version for your operating system.

2.2.2 Installing the R&S FS-K96 Software

After installing all required components, you can install the R&S FS-K96 Software.

You can start the installer either by using your browser to navigate there or directly from the CD (`\install\OFDM Vector Signal Analysis Software.exe`).



The installer will do the following:

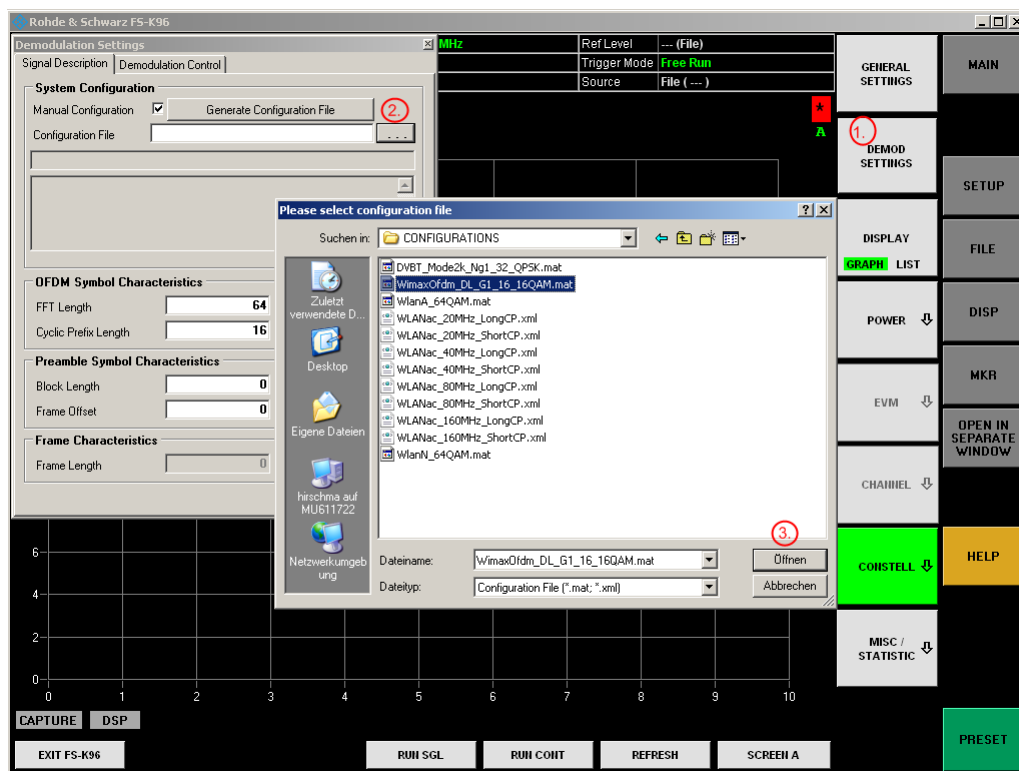
- Install the R&S FS-K96 Software including an uninstall tool
- Create a Windows Start Menu entry (Programs → R&S OFDM Vector Analysis Software)
- Create a shortcut on the desktop (optional)

Start the software via the start menu entry or the shortcut on the desktop.

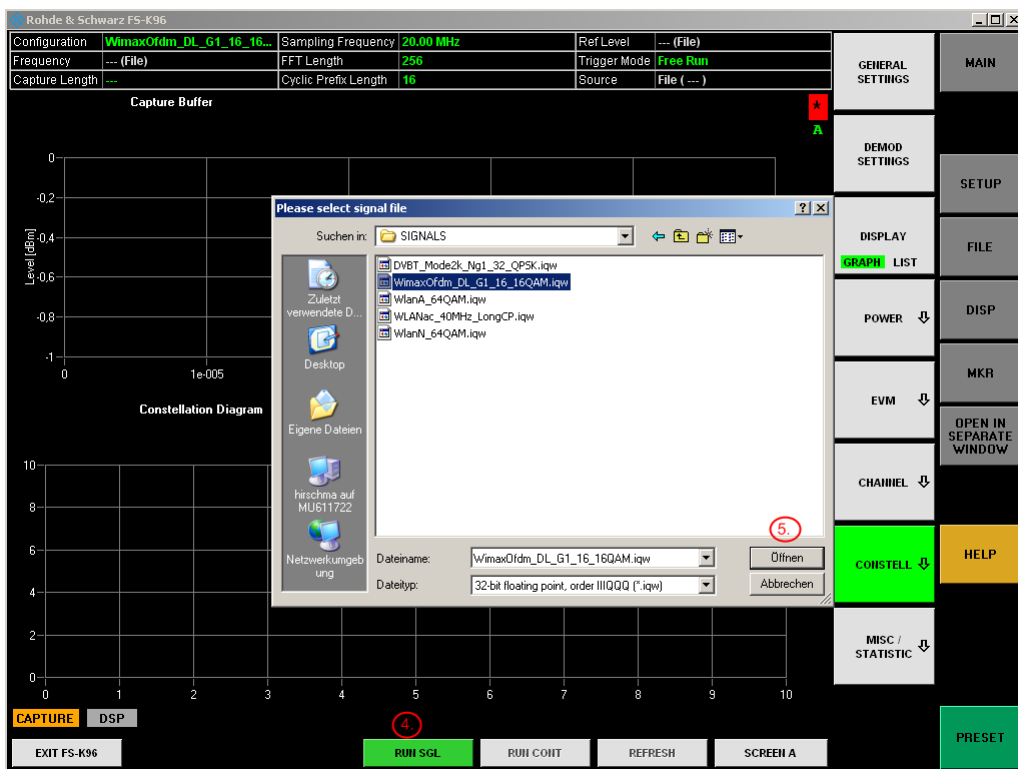
2.2.3 Checking for Successful Installation

After a successful installation, please start the R&S FS-K96 Software. Run the following sequence in order to check the functionality:

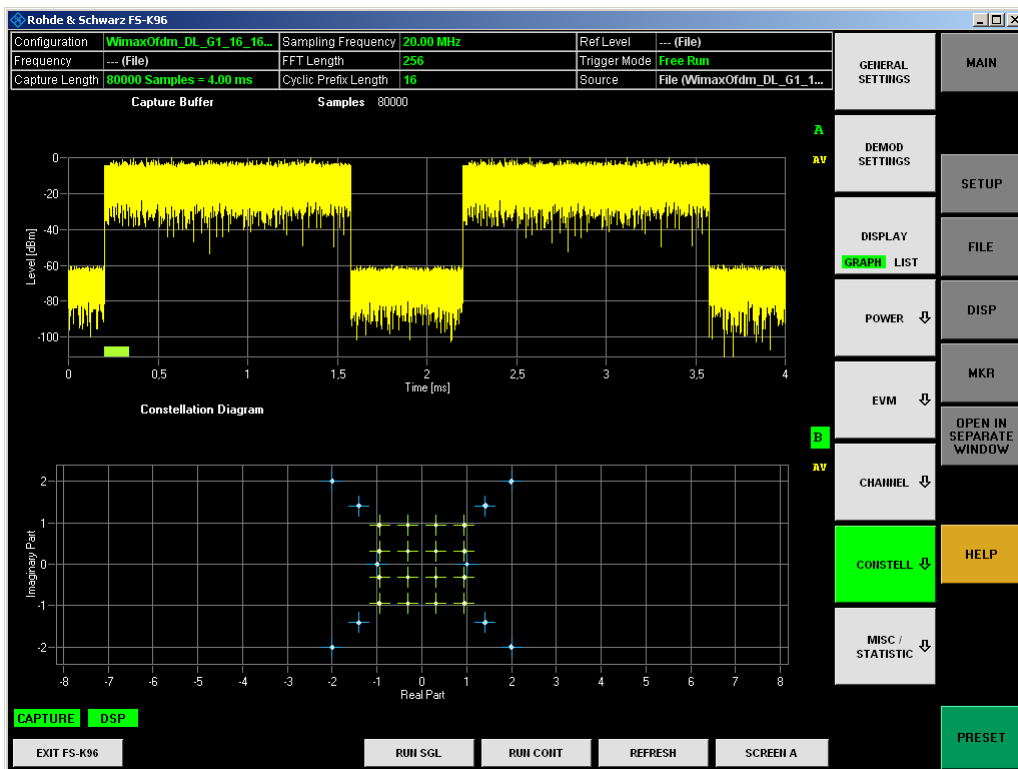
- ▶ If you do not have the license smartcard (cf. [Using the Smartcard Reader](#)) at hand, click “Demo Mode” in the dialog that prompts you to insert your smartcard.
- ▶ The R&S FS-K96 Software opens. Click on the hardkey <DEMOM SETTINGS> on the right hand side and select the file `WimaxOfdm_DL_G1_16_16.mat` as Configuration File. You can find this file in your install directory in the folder `\CONFIGURATIONS`.



- ▶ Press the hotkey <RUN SGL> and select the file `WimaxOfdm_DL_G1_16_16QAM.iqw`. You can find this file in your install directory in the folder `\SIGNALS`.



► You should get a valid measurement as shown in the following screenshot.



2.2.4 Uninstalling the R&S FS-K96 Software

The OFDM Vector Signal Analysis Software can be uninstalled using the Uninstall tool in “%Program folder%\Rohde-Schwarz\OFDM Vector Signal Analysis Software\Uninstall” or via "Add or Remove Software" in the Windows Control Panel. The framework components have to be uninstalled manually via "Add or Remove Software" in the Windows Control Panel.



Before uninstalling the components, ensure that no other software uses one of the components.

The following programs have been installed:

- Intel Integrated Performance Primitives RTI4.1 for Windows on Intel Pentium processors
- Matlab Component Runtime 7.11
- Rohde & Schwarz OFDM Vector Analysis Software (FS-K96)
- Microsoft .NET Framework 2.0 (see following note)
- Microsoft Visual C++ 2005 Redistributable (see following note)
- Rohde & Schwarz Portmap 2.8.3 (optional)



It is not recommended to uninstall the two Microsoft components:

- Microsoft .NET Framework 2.0
- Microsoft Visual C++ 2005 Redistributable

They are most probably also used by other software components on your PC.

2.3 Using the Smartcard Reader

To enable the FS-K96 software via smartcard (dongle), you have to load the FS-K96PC or FS-K96 license on an existing smartcard or order a new smartcard (FSPC license dongle PC software).

You can use the smartcard together with the USB smartcard reader (for SIM format) supplied with the software or insert the smartcard (full format) in a reader already connected to your PC or built in your PC. Instructions on how to insert the card into the reader is also supplied together with the CD package.

Note that support for problems with the smartcard licensing can only be guaranteed, if the supplied USB smartcard reader (for SIM format) is used.

1. With the delivery of the FSPC you got a smartcard and a USB smartcard reader.



2. Remove the smartcard.



3. Insert the smartcard into the USB smartcard reader.
With the USB smartcard reader such that the LED or "OMNIKEY" label is facing upward, insert the smartcard with the chip facing downward and the angled corner facing away from the USB smartcard reader.



4. After pushing the smartcard completely inside the USB smartcard reader, you can use it together with the software.

If you insert the USB smartcard reader into the PC, the drivers will be loaded. If your PC does not already have drivers installed for this reader, the hardware will not be detected and the R&S FS-K96 Software will not work.

In this case, please install the required driver manually. You will find it in the folder `\install\USB SmartCard Reader Driver Files`, named according to the processor architecture (OMNIKEY3x21_x86... or OMNIKEY3x21_x64). Detailed information on the file content and the download location for updated drivers can be found in the `ReadMe.txt` file in the same folder.



You may have problems locking your PC while the card is inserted, as Windows will try to get log-in information from the card immediate after you lock your PC.

You can overcome this problem by editing one registry entry. Either execute the registry file `DisableCAD.reg` in the same folder the USB Smartcard reader installation files are located. Or manually change the entry:

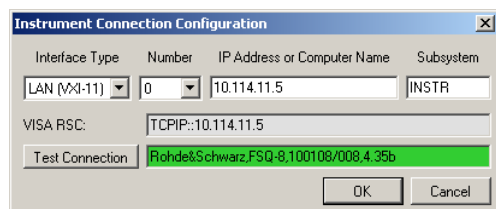
- ▶ Open the Windows Start Menu and select the "Run" item.
- ▶ Enter "regedit" in the dialog to open the system registry.
- ▶ Navigate to `HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows\CurrentVersion\policies\system`.
- ▶ Set the value of `DisableCAD` to 0.

Note that security policies may prevent you from editing the value. Contact your IT administration if you have problems with editing the value or installing the drivers.

2.4 Connection to the Instrument

In order to be able to communicate with the instruments, the PC must be connected to the R&S FSQ/FSG/FSUP/FSV/FSVR/FSW using either an IEEE bus or LAN connection. The type of connection and the address can be selected inside the software. The R&S FSQ/FSG/FSUP/FSV/FSVR/FSW address (either GPIB or LAN address) has to be set in the R&S FS-K96 Software.

1. Start the FS-K96 Software and press [**PRESET**].
2. Press [**SETUP**] and set the data source to instrument via the <DATA SOURCE> softkey.
3. Press <CONFIGURE ANALYZER CONNECTION> and set up the instrument connection. Use the *Test Connection* button to verify the connection settings.



FSQ/FSG/FSUP/FSV/FSVR/FSW requirement

Any

- R&S FSQ with firmware version 4.35 or higher,
 - R&S FSG with firmware version 4.39 or higher,
 - R&S FSUP with firmware version 4.37 or higher
 - R&S FSV with firmware version 1.10 or higher,
 - R&S FSVR with firmware version 1.51 or higher
 - R&S FSW
- can be used.

In the following, it is exemplarily explained for the R&S FSQ and the R&S FSV how to option the GPIB and LAN Address.

2.4.1 How to Obtain the GPIB or LAN Address in the R&S FSQ Instrument

In this section it is described how to obtain the GPIB or LAN address of the R&S FSQ instrument.

GPIB address

1. Press the [**SETUP**] hardkey.
2. The *SETUP* menu opens.
3. Press the <GPIB> softkey.

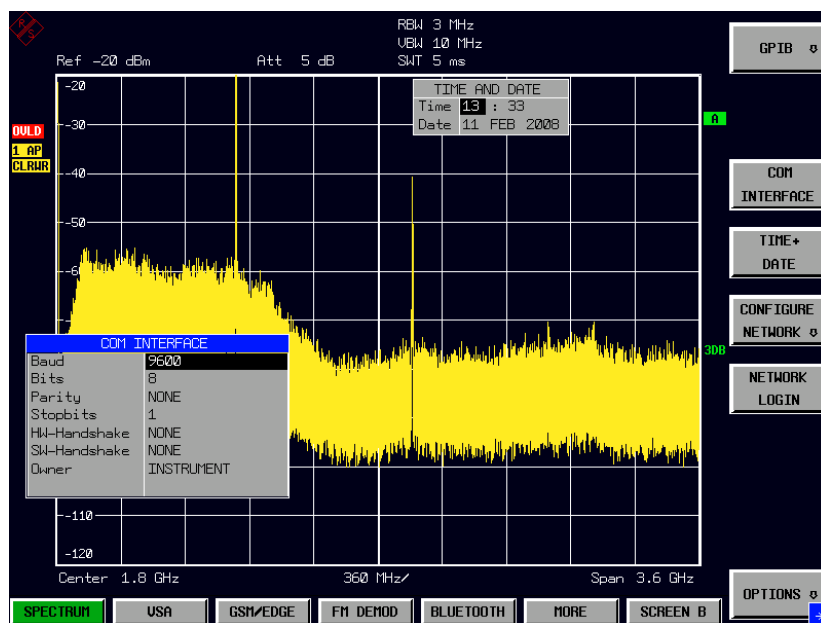


Fig. 11 Softkey: GPIB Address

LAN address

1. Press the [SETUP] hardkey.
2. The *SETUP* menu opens.
3. Press the <CONFIGURE NETWORK> softkey.

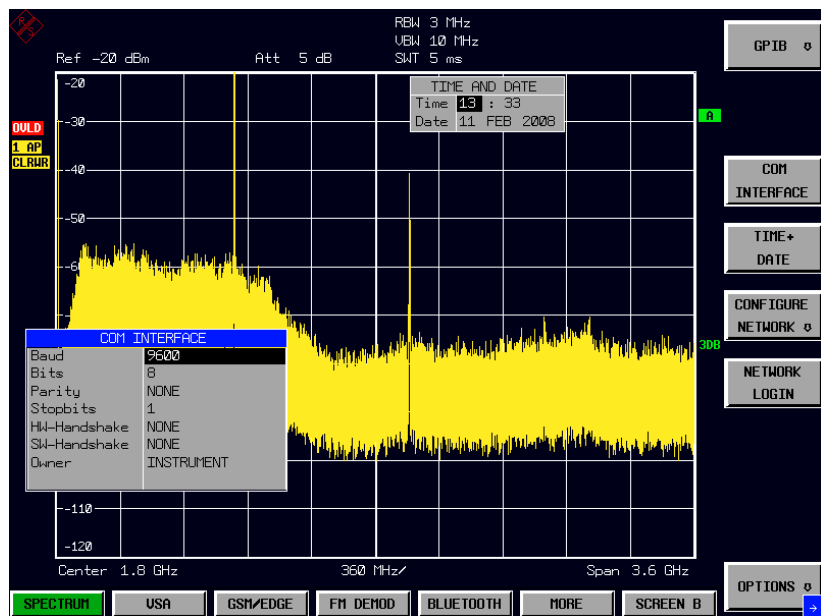


Fig. 12 Softkey: Configure Network

4. Select *Local Area Connection* and press Enter.

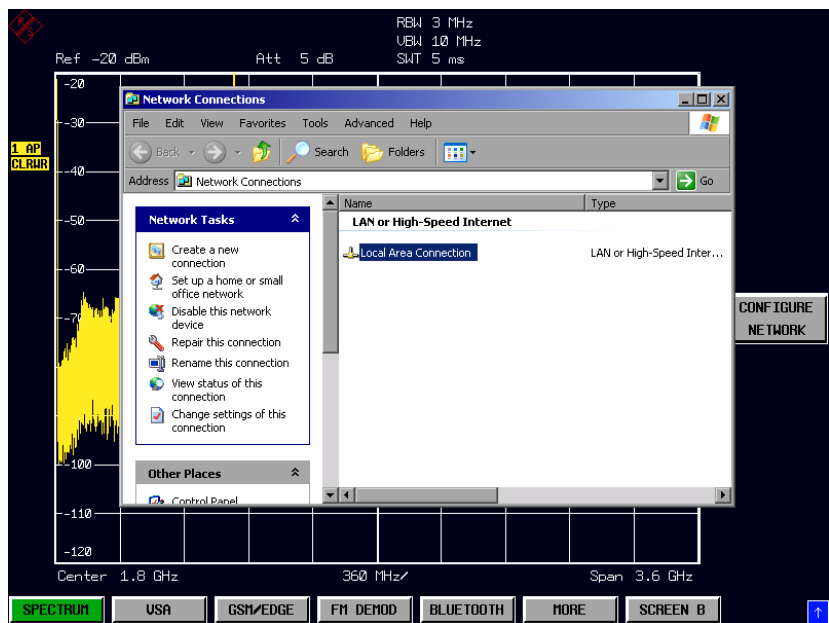


Fig. 13 Local Area Connection

5. Click on the *Support* tab of the *Local Area Connection Status* dialog.

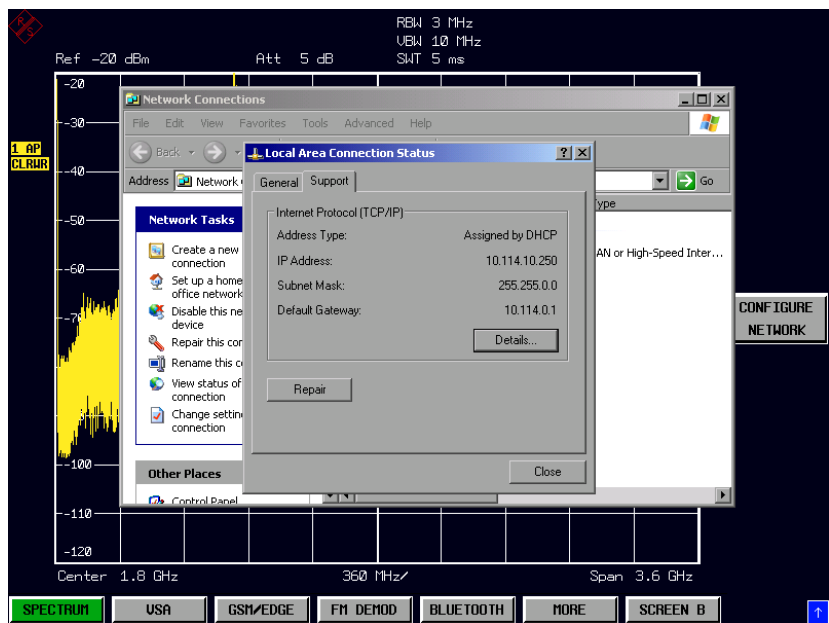


Fig. 14 Local Area Connection: Support Tab

2.4.2 How to Obtain the GPIB or LAN Address in the R&S FSV Instrument

In this section it is described how to obtain the GPIB or LAN address of the R&S FSV instrument.

GPIB address of R&S FSV

1. Press the [**SETUP**] hardkey.
2. The *SETUP* menu opens.
3. Press the < *GENERAL SETUP* > softkey.

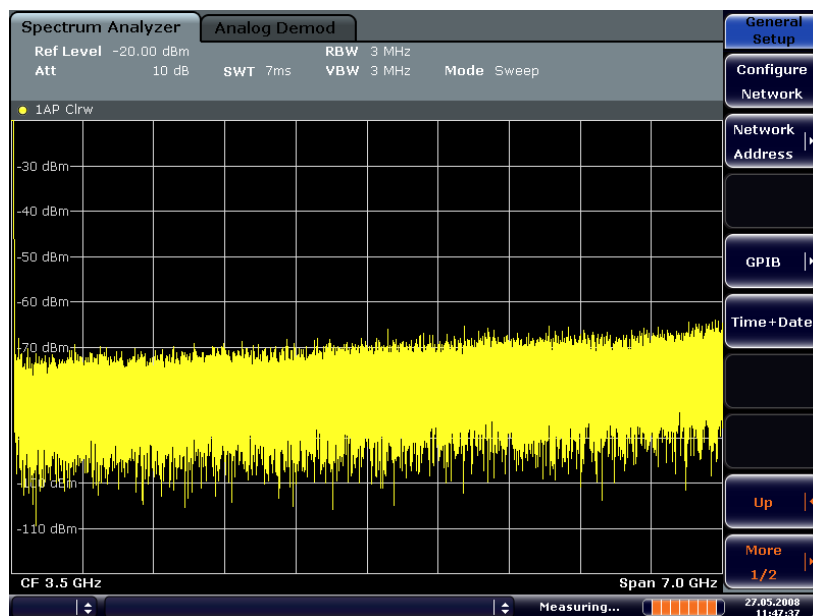


Fig. 15 The General Setup Menu

4. Press the <GPIB> softkey.
5. Press the <GPIB Address> softkey.
6. The GPIB dialog input box opens. Query or change the GPIB address.



Fig. 16 Input Dialog Box: GPIB Address

LAN address of the R&S FSV

1. Press the [**SETUP**] hardkey.
2. The *SETUP* menu opens.
3. Press the < *GENERAL SETUP* > softkey.

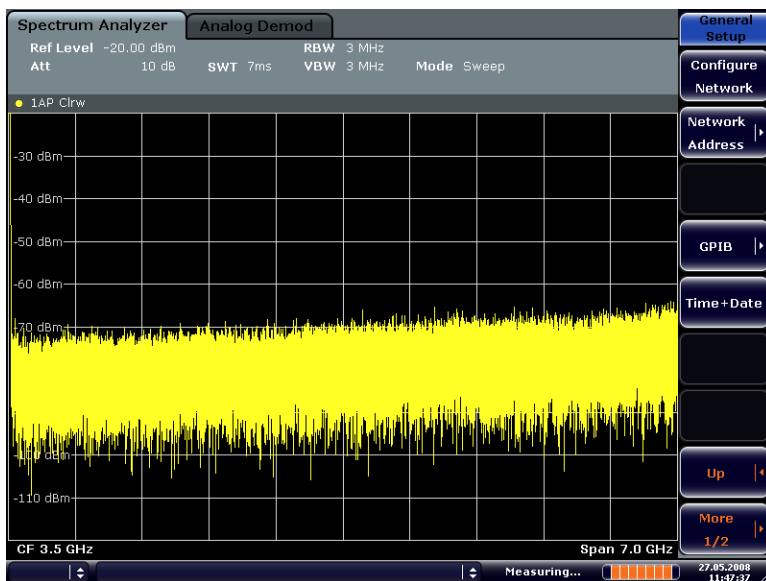


Fig. 17 The General Setup Menu

4. Press the <Network Address> softkey.

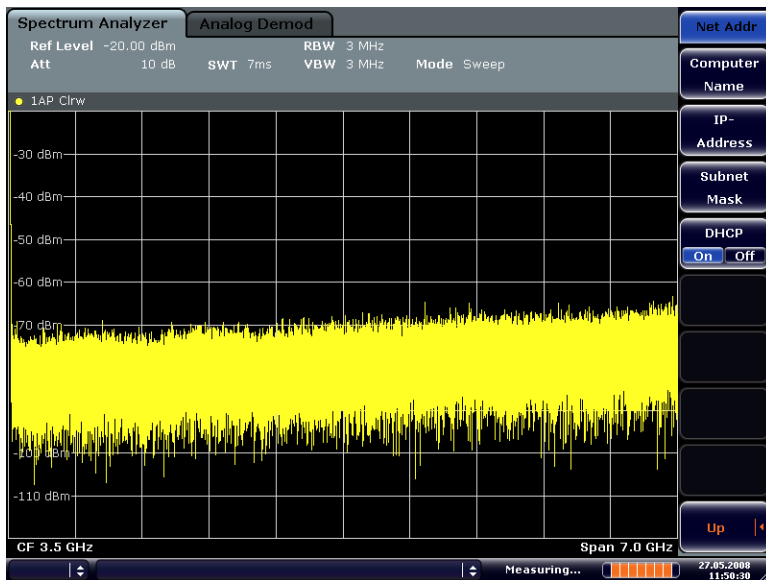


Fig. 18 The Network Address Menu

5. Press the <IP-Address> softkey to query the IP-address.

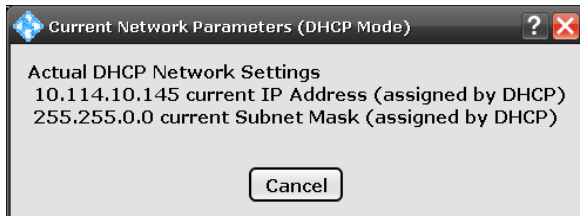


Fig. 19 Current Network Parameters (DHCP Mode)

2.5 Quick Start Guide

This section will help you to quickly become familiar with the FS-K96 Software (refer to section 3 for detailed operating instructions). As an exemplary signal WLAN 802.11a is used. The analyzer must be connected to the external PC via LAN or IEEE bus.

2.5.1 Setting up the Generator

This example requires an 802.11a or 802.11g-OFDM signal with 64-QAM data modulation. Fig. 20 shows the exemplary settings of an R&S SMU Vector signal generator.

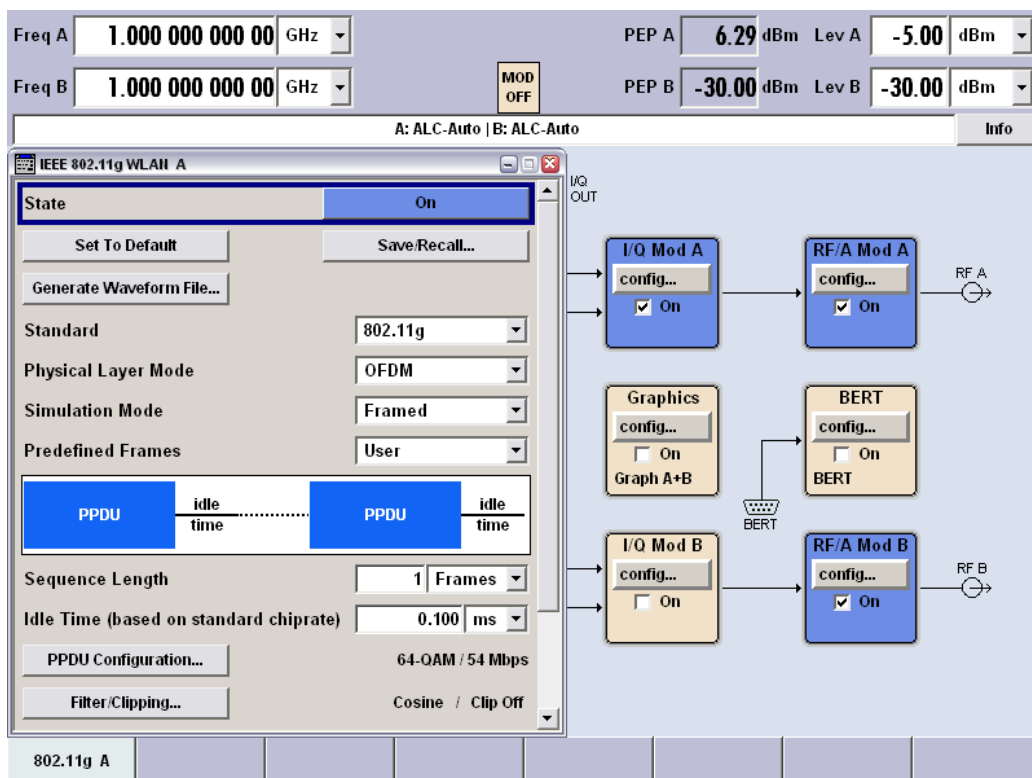


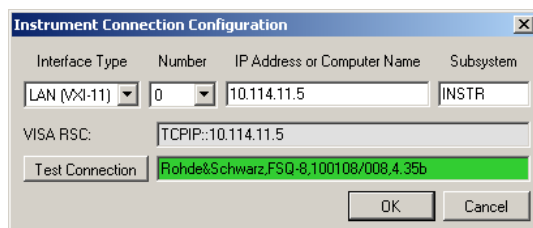
Fig. 20: WLAN Settings Menu of the R&S SMU Vector Signal Generator

2.5.2 Setting up the Measurement

1. Start the FS-K96 Software and press [**PRESET**].
2. Press [**SETUP**] and set the data source to instrument via the <DATA SOURCE> softkey.

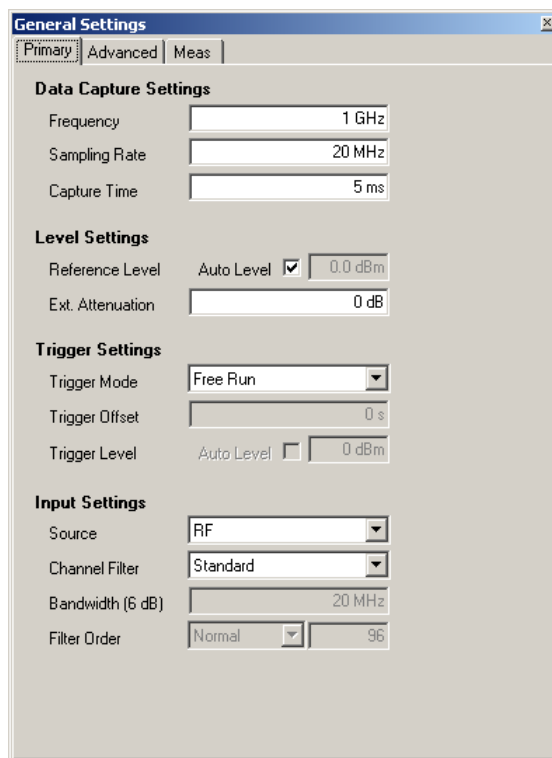


3. Press <CONFIGURE ANALYZER CONNECTION> and set up the instrument connection. Use the 'Test Connection' button to verify the connection settings.



2.5.2.1 General Setup (frequency, level, etc)

1. Press <GENERAL SETTINGS> to open the General Settings panel.

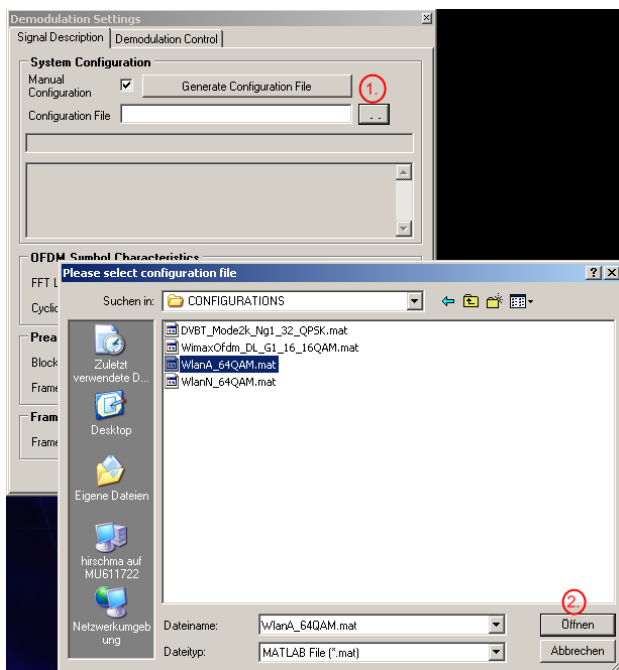


2. Enter the desired frequency to measure in the *Frequency* field.
3. Enter the 802.11a sample rate of 20 MHz in the *Sampling Rate* field.
4. Enter a capture length of 5 ms in the *Capture Time* field.

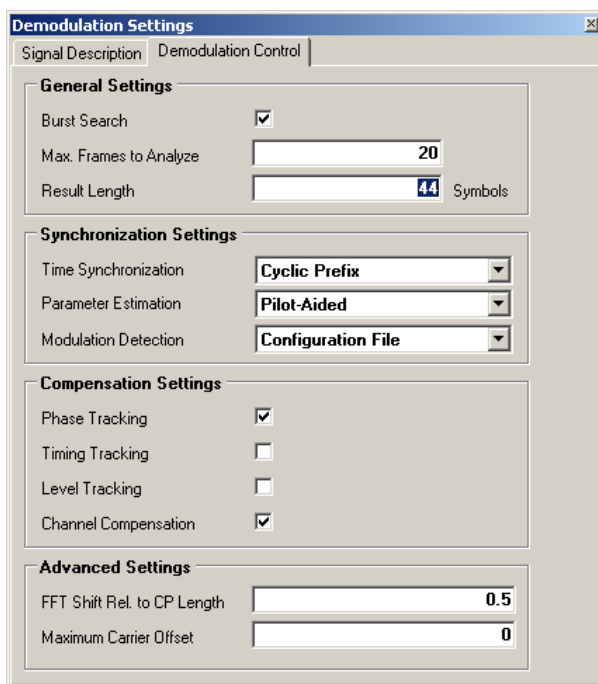
All other settings in this panel are sufficient for this example.

2.5.2.2 Demodulation Setup (System configuration and demodulation control)

1. Press <DEMOD SETTINGS> to open the Demodulation Settings panel, and select the *Signal Description* tab.
2. Load the system configuration file 'wlanA_64QAM.mat'.



3. Select the *Demodulation Control* tab.



4. Set the number of symbols per frame to the number of data symbols per OFDM burst plus 5 (4 preamble symbols + 1 signal field).

2.5.3 Performing the Measurement

- ▶ Start the measurement by pressing **<RUN SGL>**.

Measurement results are updated once the measurement has been completed. The results are displayed in graphical form. The display can be toggled to a tabular list of measurement points by pressing **<DISPLAY>**.



Fig. 21: Successful WLAN Measurement with the FS-K96 Software

3 Operating the Software

This section contains a detailed description of all measurement modes, settings and results.

3.1 Starting the Software

Use the desktop shortcut or the shortcut from the Start menu to start the FS-K96 Software. The following window appears:



Fig. 22 Six Main Elements of the FS-K96 Software

The software user interface consists of six main elements:

- **Header table (1)**
Showing basic information such as measurement frequency or capture length.
- **Results display (2)**
Here, all measurement results are displayed in full or split screen style. Results displays are always separated into
 - Header (showing title, etc) and
 - Display (showing data) section.
- **Status bar (3)**
The status bar shows "live" information on the measurement progress and displays software messages and errors.

- **Hotkeys (4)**
The hotkeys control the measurement process (e.g. running a measurement). Pressing a hotkey will be referred to as **<HOTKEY CAPTION>** in this manual, e.g. **<RUN SGL>**.
- **Softkeys (5)**
The softkeys are used to open configuration windows and to select the desired measurement result style. The softkeys may change when operating the software (e.g. clicking a hardkey). Pressing a softkey will be referred to as **<SOFTKEY CAPTION>** in this manual, e.g. **<SPECTRUM>**.
- **Hardkeys (6)**
The hardkeys provide the same functions as those known from the R&S Analyzer (load/store data, configure the display, etc). Pressing a hardkey will be referred to as **[HARDKEY CAPTION]** in this manual, e.g. **[MAIN]**.

3.2 Hotkey Menu



- <EXIT FS-K96>** Closes the software.
- <RUN SGL>** If the data source is set to “File”, a file dialog with I/Q data files is opened.
- Remote: `MMEM:LOAD:IQ:STAT 'C:\MyCapture.iqw'`



Drag-and-Drop

You can also load an I/Q data file by drag-and-drop.

- If the data source is set to “Instrument”, the FS-K96 captures I/Q data once from the connected instrument.
- Remote: `INIT:IMM`
- <RUN CONT>** If the data source is set to “File”, a file dialog with I/Q data files is opened. The FS-K96 then continuously analyzes the selected I/Q data file until the button is pressed again.
- If the data source is set to “Instrument”, the FS-K96 captures I/Q data from the connected instrument until the button is pressed again.
- <REFRESH>** Starts a new measurement sequence based on the I/Q data that has already been captured.
- Remote: `INIT:REFR`
- <SCREEN A/B>** Activates screen A or B, respectively.
- Remote: `DISP:WIND1:SEL`

3.3 Hardkey Menu

MAIN	Opens the main softkey menu (cf. 3.4 Softkey Menu)
SETUP	<p>Opens the software setup softkey menu. There, it is possible to</p> <ul style="list-style-type: none"> • Configure the analyzer connection • Specify the data source (instrument/file) • Enable the remote control • Show logging results • Show system information.
FILE	Opens the file management menu. See 5.3 File Management for more details.
DISP	Opens the display softkey menu and controls the display settings. See 5.4 Display Settings for more details.
MKR	Has the same functionality as the "Marker" entry in the context menu of the graph display. For an explanation how to use the "MARKER" hardkey, see 3.7.1.1 Evaluating the Results - Marker.. The [MARKER] hardkey acts on the actual selected graph.
OPEN IN SEPARATE WINDOW	Creates a copy of the currently selected screen and displays it in additional windows. See 5.5 Open in Separate Window for more details.
HELP	<p>Opens the help softkey menu. There, it is possible to</p> <ul style="list-style-type: none"> • Watch tutorial videos in English or German • Open the user manual. • Send an email to the R&S support team.
PRESET	<p>When the PRESET hardkey is pressed the OFDM Vector Signal Analysis Software is preset. If the input source is not set to "File" and a valid R&S FSQ/FSG/FSUP/FSV/FSVR or FSW address is configured, this instrument is also preset.</p> <p>→ Remote: *RST</p>

3.4 Softkey Menu

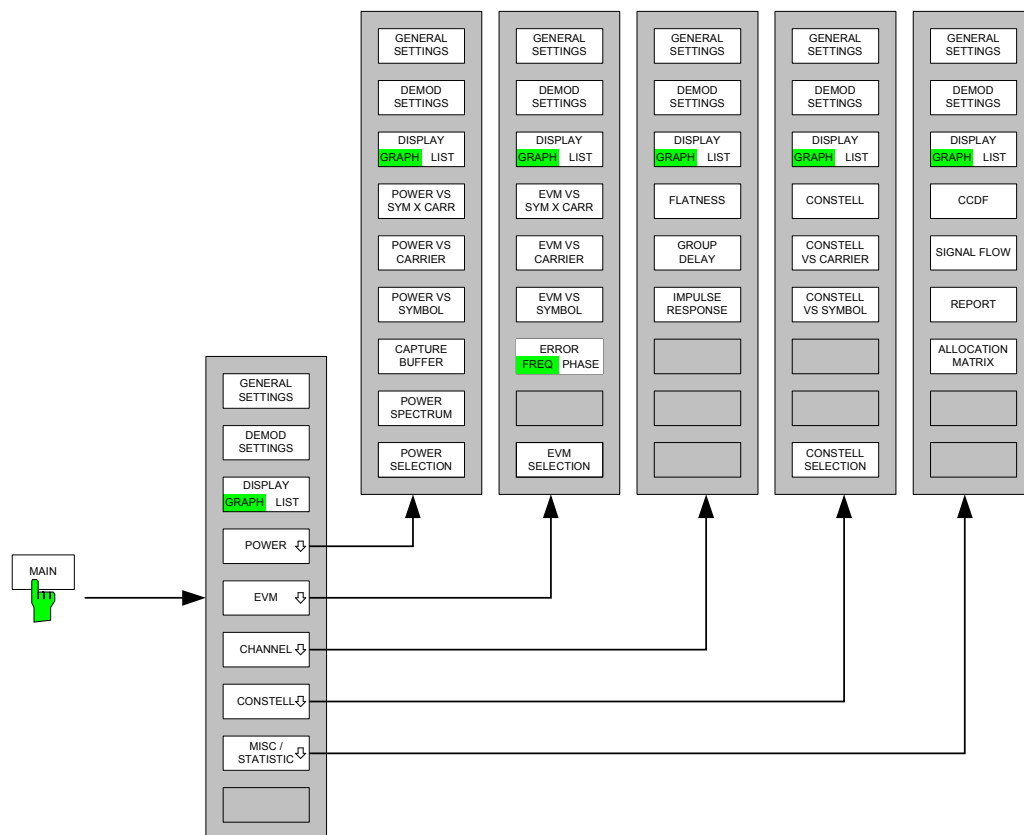
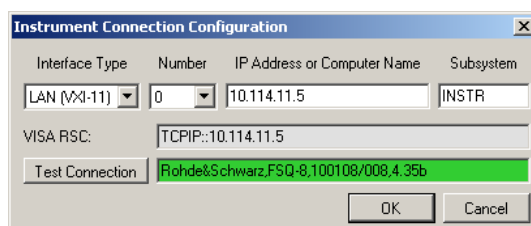


Fig. 23 FS-K96 Softkey Menu Structure

3.5 Preparing for Instrument Connection

In order to be able to communicate with the instruments, the R&S FSQ/FSG/FSUP/FSV/FSVR/FSW must be connected with the PC using either an IEEE bus or LAN connection. The type of connection and the address can be selected inside the software.

1. Start the FS-K96 Software and press [PRESET].
2. Press [SETUP] and set the data source to instrument via the <DATA SOURCE> softkey.
3. Press <CONFIGURE ANALYZER CONNECTION> and set up the instrument connection. Use the 'Test Connection' button to verify the connection settings.

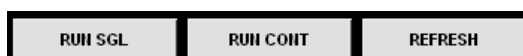


3.6 Performing Measurements

You can either use the R&S analyzer hardware to capture I/Q data or load the I/Q data from a file. The data source can be switched by using the [SETUP] <DATA SOURCE> keys. Please refer to section [Import and Export of Data](#) for details on the file format.

3.6.1 Running the Measurement

Use the hotkeys of the FS-K96 Software displayed at the bottom of the screen to start a single or continuous measurement with newly acquired data or the already captured I/Q data.



<RUN SGL> Executes a single measurement with data capturing and signal processing and stops after it has finished.

→ Remote: INIT:IMM

<RUN CONT> Executes subsequent measurements with data capturing and signal processing until you press <RUN CONT> again.

<REFRESH> Executes a single measurement as with <RUN SGL>, but using already captured I/Q data for processing. This can be used to e.g. observe the changes of different demodulation settings to the results.

→ Remote: INIT:REFR

3.6.2 Events During a Measurement

While running the measurement, certain events may cause the measurement execution to fail. The corresponding error message is displayed in the status bar and stored in the error log.

3.6.3 Measurement Header Table

The tabular section below the title bar shows the overall measurement settings and specific results used to obtain the current measurement results.

Configuration	Manual	Sampling Frequency	20.00 MHz	Ref Level	-2.90 dBm
Frequency	1 GHz	FFT Length	64	Trigger Mode	Free Run
Capture Length	100000 Samples = 5.00 ms	CP Length	16	Source	RF (FSG)

Fig. 24 Overall Measurement Settings Summary

The settings summary includes the following information:

- Configuration Name of the loaded configuration or 'Manual'.
- Frequency The analyzer RF frequency.
- Capture Length Capture length in number of samples and time.
- Sampling Frequency System sample rate.
- FFT Length Length of the FFT interval in number of samples.

- CP Length Length of Cyclic prefix interval in number of samples.
- Ref Level Reference level of the analyzer.
- Trigger Mode Trigger condition of the analyzer.
- Source Input source of the I/Q data.

3.7 Evaluating the Results

3.7.1 Context Menu (Marker, Zoom, Pan, Copy Image to Clipboard, Show Data Points)

Using the right mouse button on the graphical displays, you can select several options to perform a more detailed measurement on the displayed graphics.

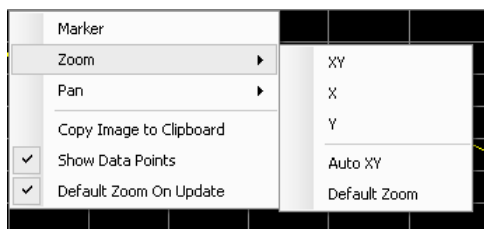


Fig. 25 Context Menu: Zoom

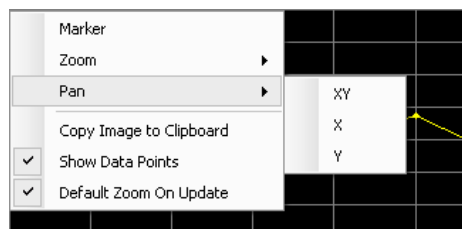


Fig. 26 Context Menu: Pan

3.7.1.1 Marker

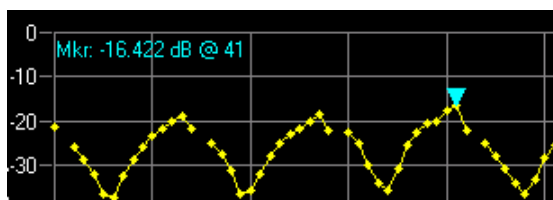


Fig. 27 Example: Marker

- The marker is activated via the context menu. If activated it is set on the absolute maximum of the trace menu.



Setting the marker to the trace maximum

If you have shifted the marker and want to put it back on the absolute maximum, click "Marker" twice in the context menu (deactivates and activates the marker again).

- The text which appears in the upper left corner of the screen consists of: Mkr: [y value] [unit of y axis] @ [x value] [unit of x axis]
- If the marker is moved with the mouse, it jumps to the point closest to the cursor.



Move the mouse above the curve to hop between the local maxima or below the curve to hop between the local minima.

3.7.1.2 Zoom

XY

Click and hold the left mouse button in the graph to select an X and Y area to zoom in on.

X

Click and hold the left mouse button in the graph to select a range on the X area to zoom in on.

Y

Click and hold the left mouse button in the graph to select a range on the Y area to zoom in on.

Auto XY

Scales the X and Y axes automatically to display the complete trace data.

Alternatively double-click on the display area.

Default Zoom

Scales the X and Y axes to the default axis values.

3.7.1.3 Pan

XY

Click and hold the left mouse button in the graph to move the graph in the X and Y direction.

X

Click and hold the left mouse button in the graph to move the graph in the X direction.

Y

Click and hold the left mouse button in the graph to move the graph in the Y direction.

3.7.1.4 Copy Image to Clipboard

Copies the displayed image to the operating system clipboard.

3.7.1.5 Show Data Points

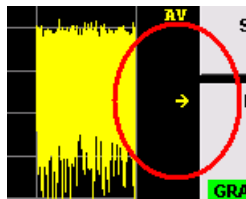
Displays small dots at each data point of the linear interpolated trace.

3.7.1.6 Default Zoom On Update

Resets the Zoom to the default zoom on each display update.

3.7.2 Arrows Indicating Data Out of Display Range

Parts or all of the data may be out of the display range. For this purpose, arrow indicators on the right side of the graph show a status in each direction (up, down, left, right). The arrow is displayed in yellow if only parts of the data are outside the visual area. If all data is outside the visual area, the arrow turns red.



This yellow arrow indicates that parts of the data are outside to the right of the visible area (arrow points to the right).

4 Measurements

4.1 Numerical results

EVM measurements

- *EVM All*
EVM for all data and all pilot cells of the analyzed frame
- *EVM Data*
EVM for all data cells of the analyzed frame
- *EVM Pilot*
EVM for all pilot cells of the analyzed frame.

I/Q constellation measurements

- *I/Q Offset*
Power at spectral line 0 normalized to the total transmitted power.
- *Gain Imbalance*
Logarithm of the 'Q-Channel to I-Channel gain ratio'.
- *Quadrature Error*
Measure of the 'phase angle between Q-Channel and I-Channel' deviating from the ideal 90 degrees.

Frequency measurements

- *Frequency Error*
Difference between measured and reference center frequency.
- *Sample Clock Error*
Difference between measured and reference sample clock relative to the system sampling rate.

Power measurements

- *Frame Power*
Average time domain power of the analyzed frame.
- *Crest Factor*
Peak-to-average power ratio of the analyzed frame.

4.2 Graphical Results

Power measurements

- *Power vs. Symbol X Carrier*
Power profile of all cells in the analyzed frame.
- *Power vs. Carrier*
Power of all carriers in the analyzed frame averaged over the symbols.

- *Power vs. Symbol*
Power of all symbols in the analyzed frame averaged over the carriers.
- *Capture Buffer*
Power profile of the capture buffer data being analyzed.
- *Power Spectrum*
Power density spectrum of the complete capture buffer.

EVM measurements

- *EVM vs. Symbol X Carrier*
EVM of all cells in the analyzed frame.
- *EVM vs. Carrier*
EVM of all carriers in the analyzed frame averaged over the symbols.
- *EVM vs. Symbol*
EVM of all symbols in the analyzed frame averaged over the carriers.
- *Error Freq / Phase*
Sample wise Frequency and phase error vs. time.

Channel measurements

- *Flatness*
Magnitude of the channel transfer function.
- *Group Delay*
Relative group delay of each single carrier averaged over all OFDM symbols.
- *Impulse Response*
Magnitude of the channel impulse response and position within the guard interval.

Constellation measurements

- *Constellation Diagram*
Complex constellation diagram of the modulation symbols. The different cell types are assigned to unique colors. With the <CONSTELL SELECTION> softkey it is possible to suppress unwanted information.
- *Constellation vs. Carrier*
Real and imaginary part of the modulation symbols over all carriers.
- *Constellation vs. Symbol*
Real and imaginary part of the modulation symbols over all symbols.

Miscellaneous and Statistic

- *CCDF (complementary cumulative distribution function)*
Complementary cumulative probability distribution for the capture buffer samples relative to the average power.
- *Signal Flow*
Detailed description of the current measurement status.
- *Report*
Detailed list of the demodulation steps.
- *Allocation Matrix*
Graphical representation of the allocation matrix (i.e. structure matrix) defined in the configuration file.

4.3 I/Q Measurements

This section contains a detailed description of the measurements.

4.3.1 Power vs Symbol x Carrier

The Power vs Symbol x Carrier results are selected by pressing the <POWER> softkey in the main measurement softkey menu followed by the <POWER VS SYM X CARR> softkey.

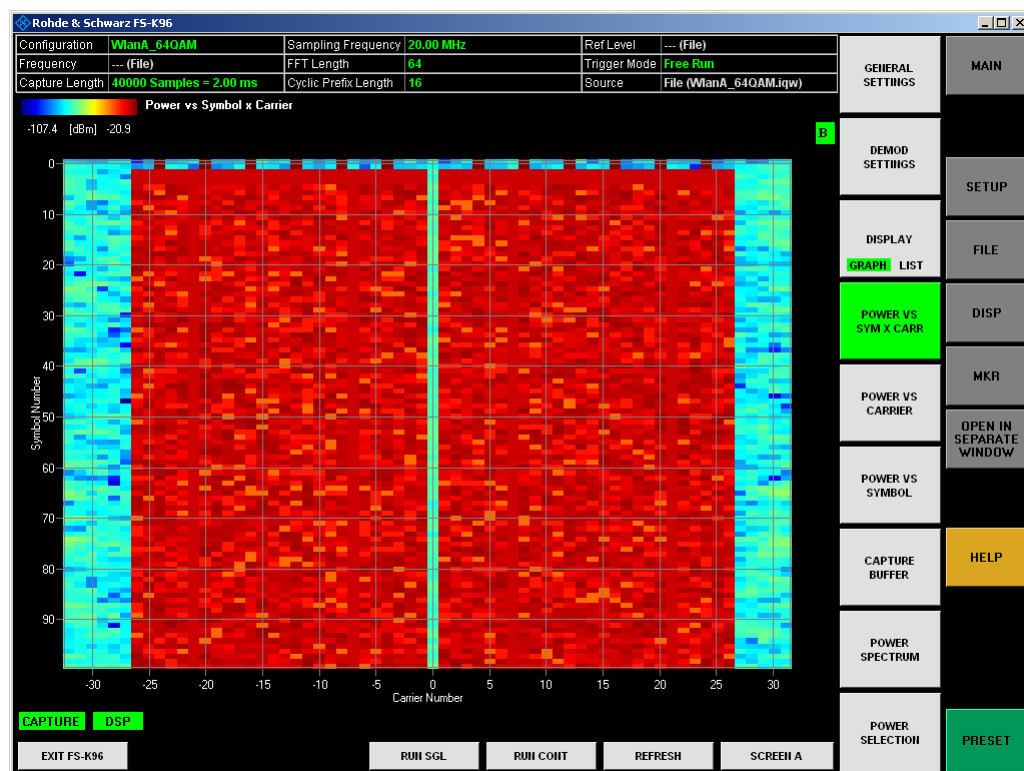


Fig. 28 Power vs. Symbol x Carrier Display

The Power vs Symbol x Carrier display shows the power of each carrier in each symbol of the received signal frames in dBm. The unit dBm is here relative to the carrier spacing, i.e. the resolution bandwidth is the carrier spacing. The values are color-coded using a colormap which is displayed on the top of the measurement window. All analyzed frames are concatenated in symbol direction.

→ Remote: CALC1:FEED 'POW:PVSC'

4.3.2 Power vs Carrier

The Power vs Carrier results are selected by pressing the <POWER> softkey in the main measurement softkey menu followed by the <POWER VS CARRIER> softkey.



Fig. 29 Power vs Carrier Display

The Power vs. Carrier display shows the power of each carrier of the received signal frames in dBm with statistics in symbol direction. The unit dBm is here relative to the carrier spacing, i.e. the resolution bandwidth is the carrier spacing.

It is also possible to see the Power vs. Carrier at a specific symbol. The selection can be made by the softkey <POWER SELECTION>.

➔ Remote: CALC1:FEED 'POW:PVCA'

4.3.3 Power vs Symbol

The Power vs Symbol results are selected by pressing the <POWER> softkey in the main measurement softkey menu followed by the <POWER VS SYMBOL> softkey.



Fig. 30 Power vs Symbol Display

The Power vs Symbol display shows the power of each symbol of the received signal frames in dBm with statistics in carrier direction. The unit dBm is here relative to the carrier spacing, i.e. the resolution bandwidth is the carrier spacing. All analyzed frames are concatenated in symbol direction with blue lines marking the frame borders. Carriers which contain 'Zero'-cells over the complete symbol range (e.g. guard carriers or DC carrier) are excluded from the statistic.

It is also possible to see the Power vs Symbol at a specific carrier. The selection can be made by the softkey <POWER SELECTION>.

→ Remote: CALC1:FEED 'POW:PVSY'

4.3.4 Capture Buffer

The Capture Buffer PVT (power versus time) results are selected by pressing the <POWER> softkey in the main measurement softkey menu followed by the <CAPTURE BUFFER> softkey.



Fig. 31 Capture Buffer Display

The capture buffer shows the complete range of captured data for the last sweep. The Capture Buffer display shows the power of the captured I/Q data versus time in dBm. The analyzed frames are identified with a green bar at the bottom of the Capture Buffer display.

All I/Q measurements process the same signal data. Therefore, all I/Q measurement results are available after a single I/Q measurement has been executed. I/Q measurements may be performed for RF or baseband input.

→ Remote: CALC1:FEED 'POW:CBUF'

4.3.5 Power Spectrum

The Power Spectrum is selected by pressing the <POWER> softkey in the main measurement softkey menu followed by the <POWER SPECTRUM> softkey.

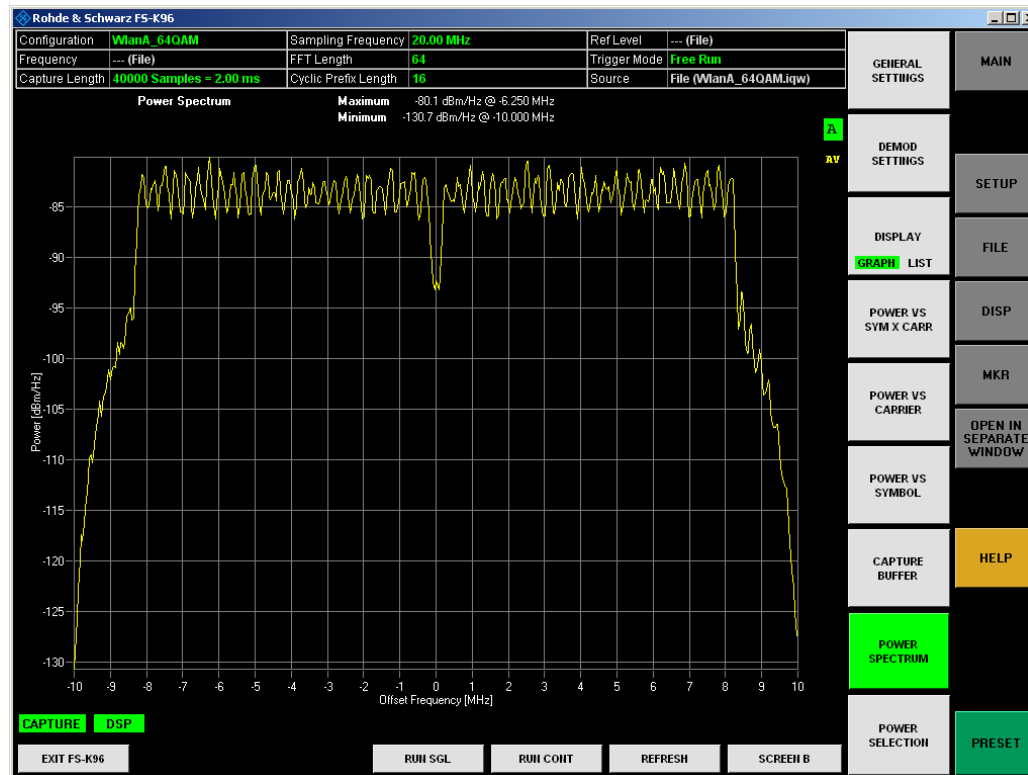


Fig. 32 Power Spectrum Display

The Power Spectrum display shows the power density spectrum of the complete capture buffer in dBm/Hz.

➔ Remote: CALC1 : FEED ' POW : PSPE '

4.3.6 Power Selection

The <POWER SELECTION> softkey displays a pop-up dialog that allows the displayed results of the Power vs. Symbol measurement and Power vs. Carrier measurement to be filtered.

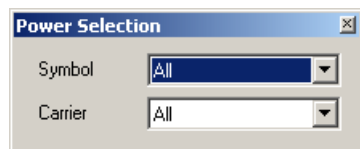


Fig. 33 Power Evaluation Filter panel

Please note that if you use several screens, it is not possible to have two different filters for the different screens.

➔ Remote: Not supported yet.

4.3.7 EVM vs Symbol x Carrier

The EVM vs Symbol x Carrier results are selected by pressing the <EVM> softkey in the main measurement softkey menu followed by the <EVM VS SYM X CARR> softkey.

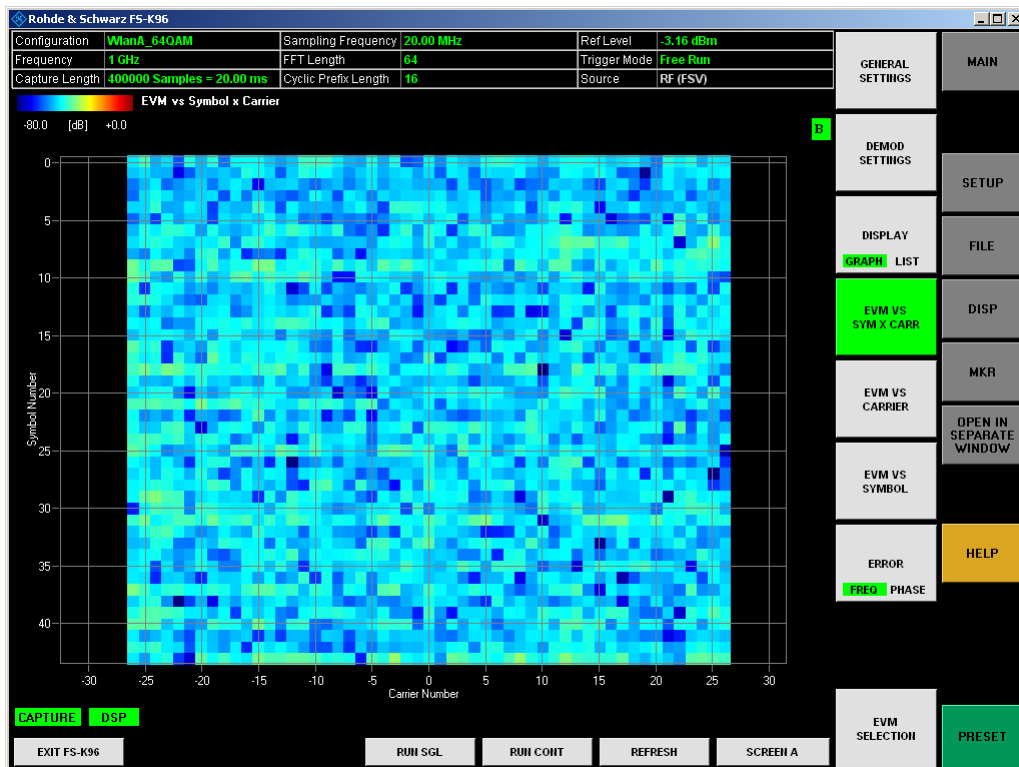


Fig. 34 EVM vs Symbol x Carrier Display

The EVM vs Symbol x Carrier display shows the EVM of each carrier in each symbol of the received signal frames in dB or %, depending on the unit settings. The values are color-coded using a colormap which is displayed on the top of the measurement window. All analyzed frames are concatenated in symbol direction.

➔ Remote: CALC1:FEED 'EVM:EVSC'

4.3.8 EVM vs Carrier

The EVM vs Carrier results are selected by pressing the <EVM> softkey in the main measurement softkey menu followed by the <EVM VS CARRIER> softkey.

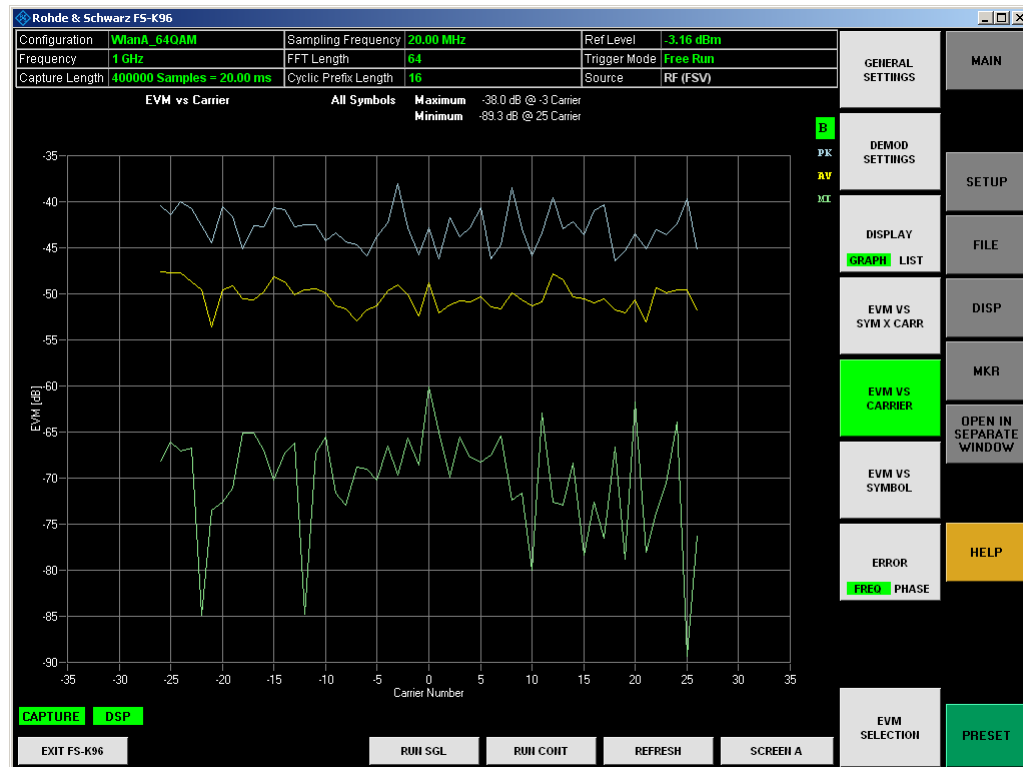


Fig. 35 EVM vs Carrier Display

The EVM vs Carrier display shows the EVM of each carrier of the received signal frames in dB or %, depending on the unit settings, with statistics in symbol direction.

It is also possible to see the EVM vs Carrier at a specific symbol. The selection can be made by the softkey <EVM SELECTION>.

➔ Remote: CALC1:FEED 'EVM:EVCA'

4.3.9 EVM vs Symbol

The EVM vs Symbol results are selected by pressing the <EVM> softkey in the main measurement softkey menu followed by the <EVM VS SYMBOL> softkey.

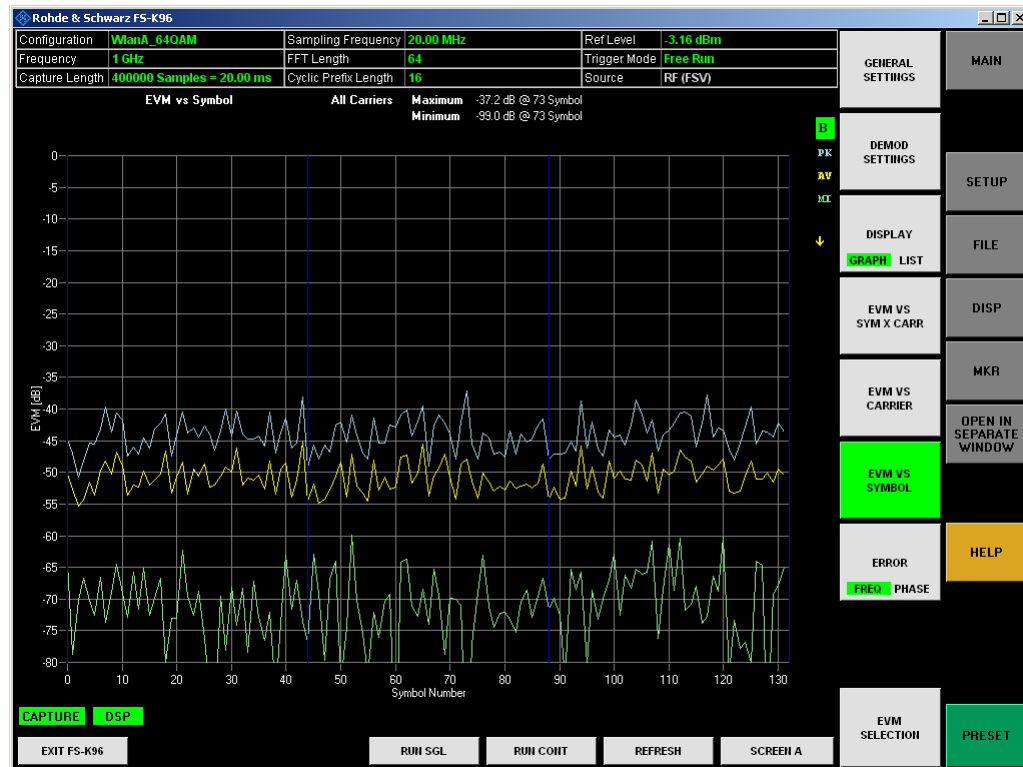


Fig. 36 EVM vs Symbol Display

The EVM vs. Symbol display shows the EVM of each symbol of the received signal frames in dB or %, depending on the unit settings, with statistics in carrier direction. All analyzed frames are concatenated in symbol direction with blue lines marking the frame borders. Carriers which contain 'Zero'-cells over the complete symbol range (e.g. guard carriers or DC carrier) are excluded from the statistic.

It is also possible to see the EVM vs. Symbol at a specific carrier. The selection can be made by the softkey <EVM SELECTION>.

➔ Remote: CALC1:FEED 'EVM:EVSY'

4.3.10 EVM Selection

The <EVM SELECTION> softkey displays a pop-up dialog that allows the displayed results of the EVM vs. Symbol measurement and EVM vs. Carrier measurement to be filtered.

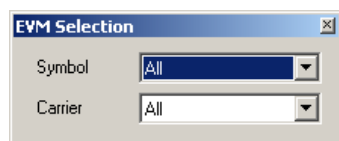


Fig. 37 EVM Evaluation Filter panel

Please note that if you use several screens, it is not possible to have two different filters for the different screens.

➔ Remote: Not supported yet.

4.3.11 Error Freq. / Phase

The Error Freq. / Phase results are selected by pressing the <EVM> softkey in the main measurement softkey menu followed by the <ERROR FREQ PHASE> softkey. Successive pressing of the softkey toggles between Frequency and Phase Error.



Fig. 38 Frequency Error Display

The Error Frequency display shows the frequency deviations in Hz versus time. The Error Phase display shows the phase deviations in Degree versus time. The evaluation length of this measurement can be set in the measurement setup menu (<GENERAL SETTINGS>, Meas Tab).

All analyzed frames are concatenated in time direction with blue lines marking the frame borders.

➔ Remote: CALC1:FEED 'EVM:FERR'

➔ Remote: CALC1:FEED 'EVM:PERR'

4.3.12 Channel Flatness

The Channel Flatness measurement results are selected by pressing the <CHANNEL> softkey in the main measurement softkey menu followed by the <FLATNESS> softkey.



Fig. 39 Channel Flatness Display

The Channel Flatness display shows the amplitude of the channel transfer function vs. carrier. The statistic is performed over all analyzed frames.

→ Remote: CALC1:FEED 'CHAN:FLAT'

4.3.13 Group Delay

The Group Delay measurement results are selected by pressing the <CHANNEL> softkey in the main measurement softkey menu followed by the <GROUP DELAY> softkey.

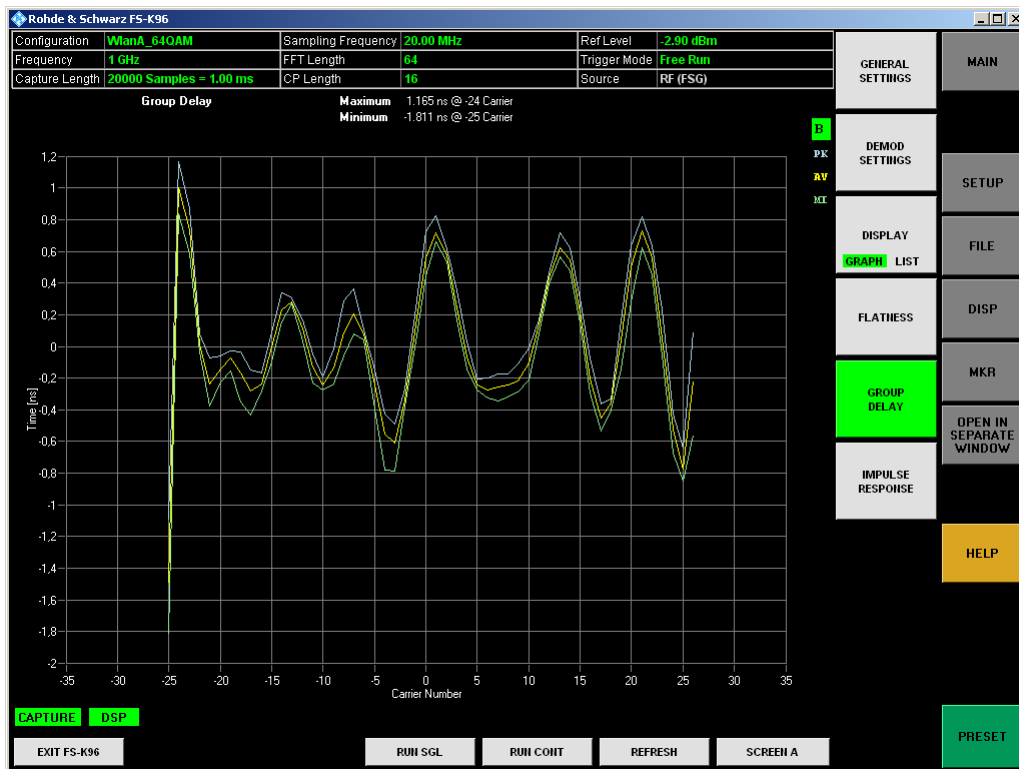


Fig. 40 Group Delay Display

The Group Delay display shows the group delay of each single subcarrier. The statistic is performed over all analyzed frames.

→ Remote: CALC1:FEED 'CHAN:GDEL'

4.3.14 Channel Impulse Response

The Channel Impulse Response is selected by pressing the <CHANNEL> softkey in the main measurement softkey menu followed by the <IMPULSE RESPONSE> softkey.

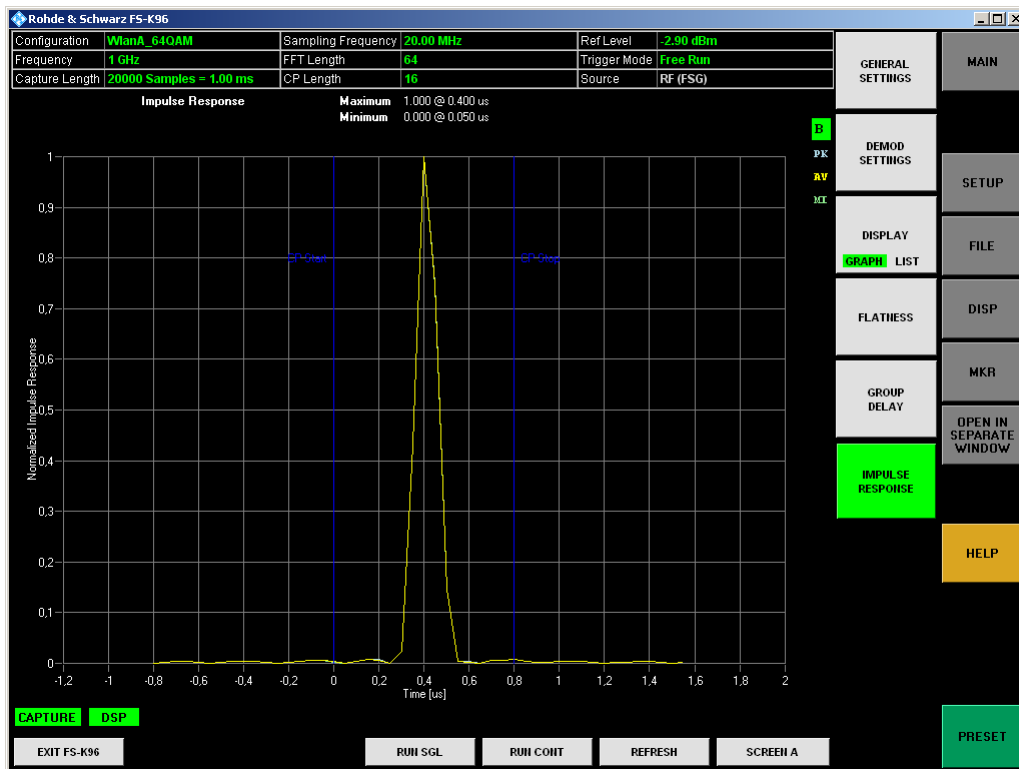


Fig. 41 Channel Impulse Response Display

The Channel Impulse Response display shows the impulse response of the channel and its position within the guard interval. The start and the end of the guard interval are marked with blue lines. The statistic is performed over all analyzed frames.

➔ Remote: CALC1:FEED 'CHAN:IRES'

4.3.15 Constellation Diagram

The Constellation Diagram is selected by pressing the <CONSTELL> softkey in the main measurement softkey menu followed by the <CONSTELL> softkey.



Fig. 42 Constellation Diagram Display

The Constellation Diagram display shows the inphase and quadrature phase results over the full range of the measured input data. The ideal points for the selected cell types are displayed for reference purposes.

➔ Remote: CALC1:FEED 'CONS:CONS'

4.3.16 Constellation vs. Carrier

The Constellation vs. Carrier diagram is selected by pressing the <CONSTELL> softkey in the main measurement softkey menu followed by the <CONSTELL VS CARRIER> softkey.

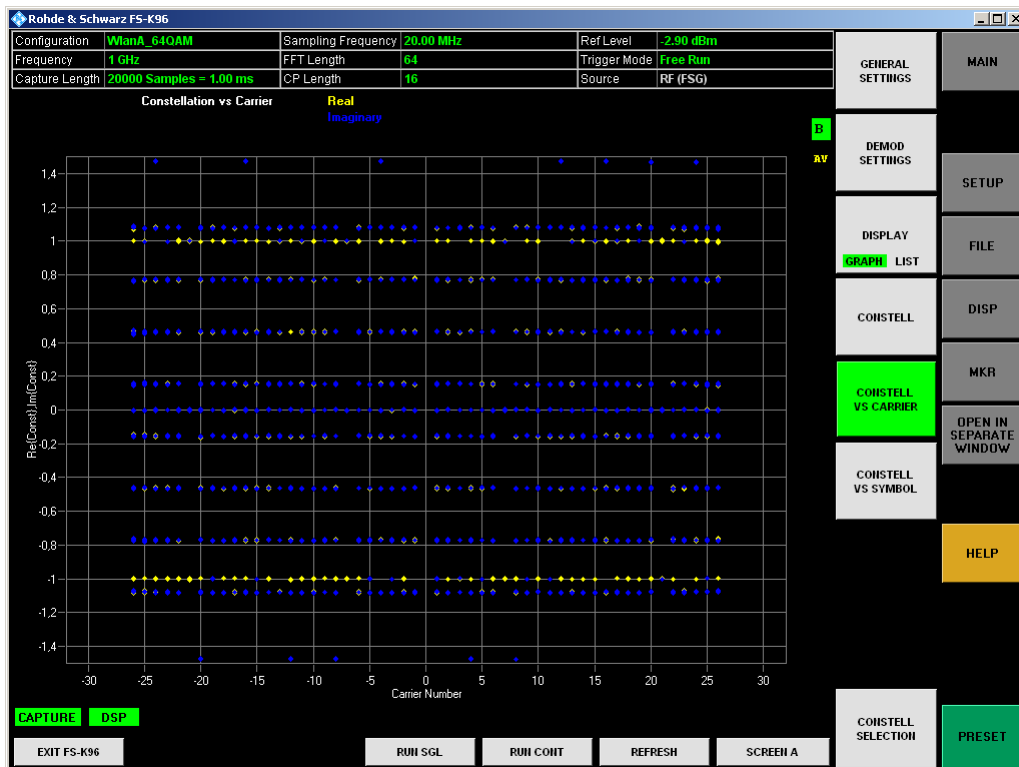


Fig. 43 Constellation vs. Carrier Display

The Constellation vs. Carrier display shows the inphase and quadrature magnitude results of all symbols over the respective carriers. The inphase-values are displayed as yellow dots; the quadrature-values are displayed as blue dots.

➔ Remote: CALC1:FEED 'CONS:CVCA'

4.3.17 Constellation vs. Symbol

The Constellation vs. Symbol diagram is selected by pressing the <CONSTELL> softkey in the main measurement softkey menu followed by the <CONSTELL VS SYMBOL> softkey.

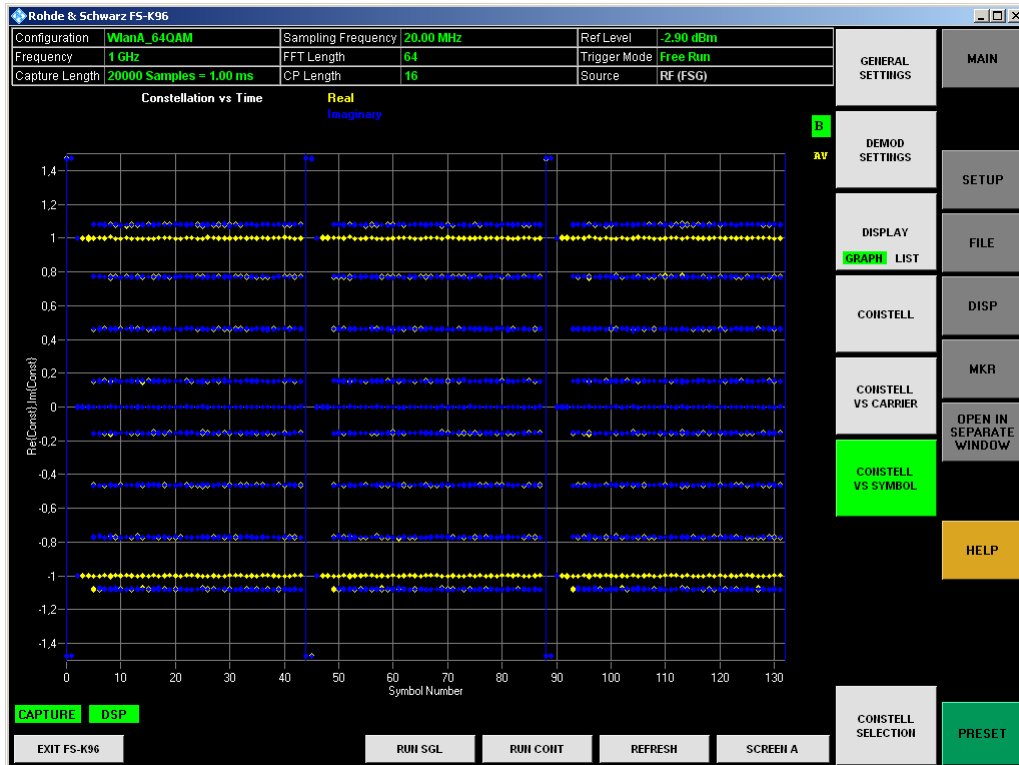


Fig. 44 Constellation vs. Symbol Display

The Constellation vs. Symbol display shows the inphase and quadrature magnitude results of all carriers over the respective symbols. The inphase-values are displayed as yellow dots; the quadrature-values are displayed as blue dots. All analyzed frames are concatenated in symbol direction with blue lines marking the frame borders.

➔ Remote: CALC1:FEED 'CONS:CVSY'

4.3.18 Constellation Selection

The <CONSTELL SELECTION> softkey displays a pop-up dialog that allows the displayed results to be filtered. The results may be filtered by any combination of cell type, modulation, symbol, or carrier. The results are updated as soon as any change to the constellation selection parameters is made.

Please note that if you use several screen and have the constellation display on each of these screens, it is not possible to have two different filters for the different screens.

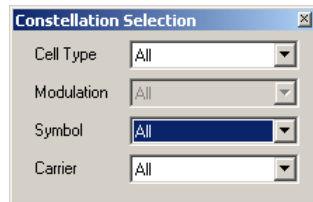


Fig. 45 Constellation Evaluation Filter Panel

→ Remote: Not supported yet.

4.3.19 CCDF (complementary cumulative distribution function)

The CCDF measurement results are selected by pressing the <MISC / STATISTIC> softkey in the main measurement softkey menu followed by the <CCDF> softkey.

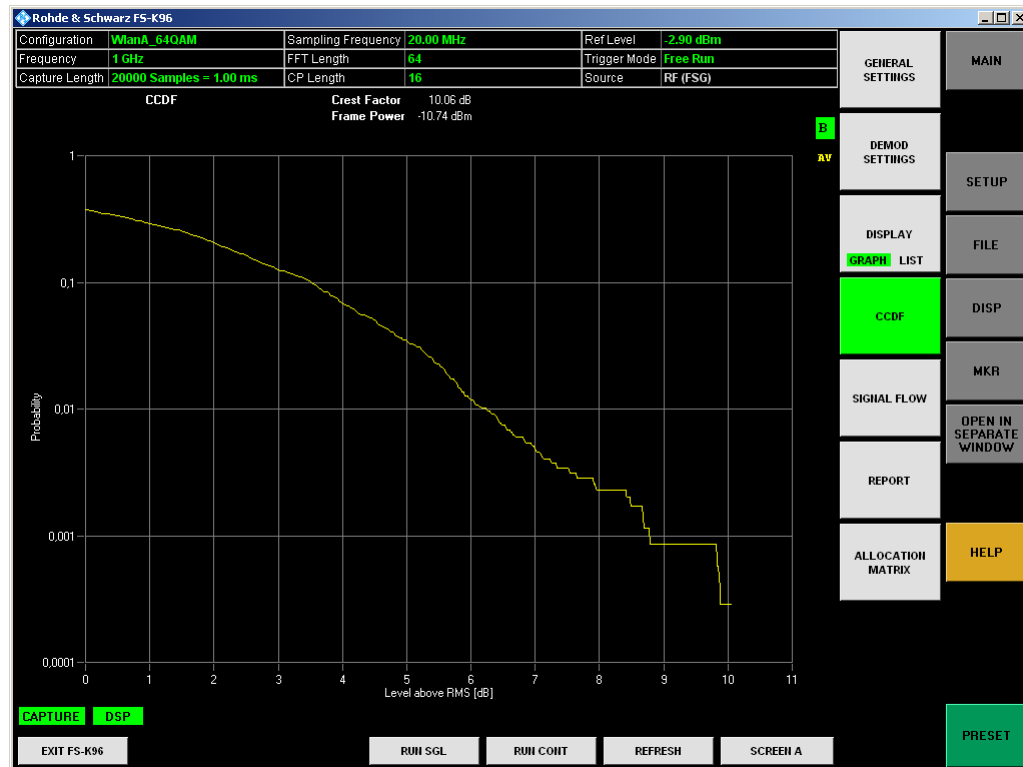


Fig. 46 CCDF Display

The CCDF results display shows the probability of an amplitude exceeding the mean power. The X axis displays power relative to the measured mean power.

→ Remote: CALC1:FEED 'STAT:CCDF'

4.3.20 Signal Flow

The Signal Flow display is selected by pressing the <MISC / STATISTIC> softkey in the main measurement softkey menu followed by the <SIGNAL FLOW> softkey.

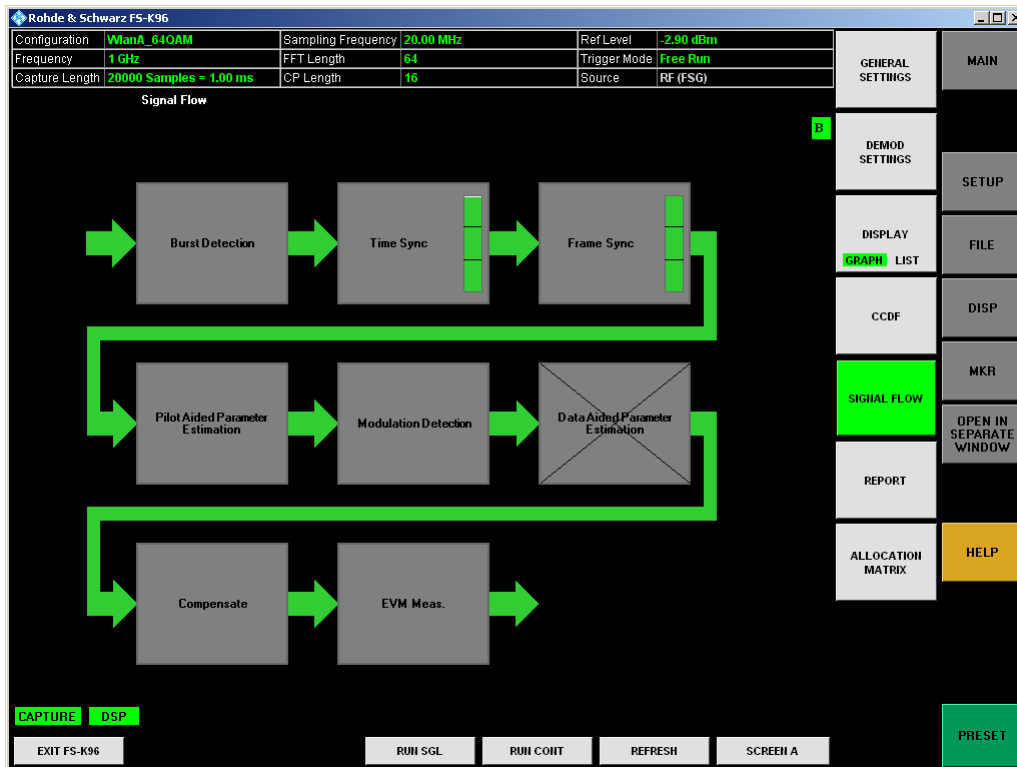


Fig. 47 Signal Flow Display

The Signal Flow display shows a detailed description of the current measurement status. It provides additional hints on what is going wrong within the signal analysis. Unused blocks are crossed out.

For the synchronization blocks, a bar is shown giving information about the reliability of the synchronization result. If the level in the bar falls below the thresholds indicated by the horizontal line, the color of the bar changes from green to yellow and finally to red. When the synchronization of the block fails, the complete block changes its color and all succeeding arrows change their color too.

For detailed information about the complete synchronization process, please refer to section 7.2.2.

→ Remote: CALC1:FEED 'STAT:SFLO'

4.3.21 Demodulation Report

The demodulation report is selected pressing the *<MISC / STATISTIC>* softkey in the main measurement softkey menu followed by the *<REPORT>* softkey.

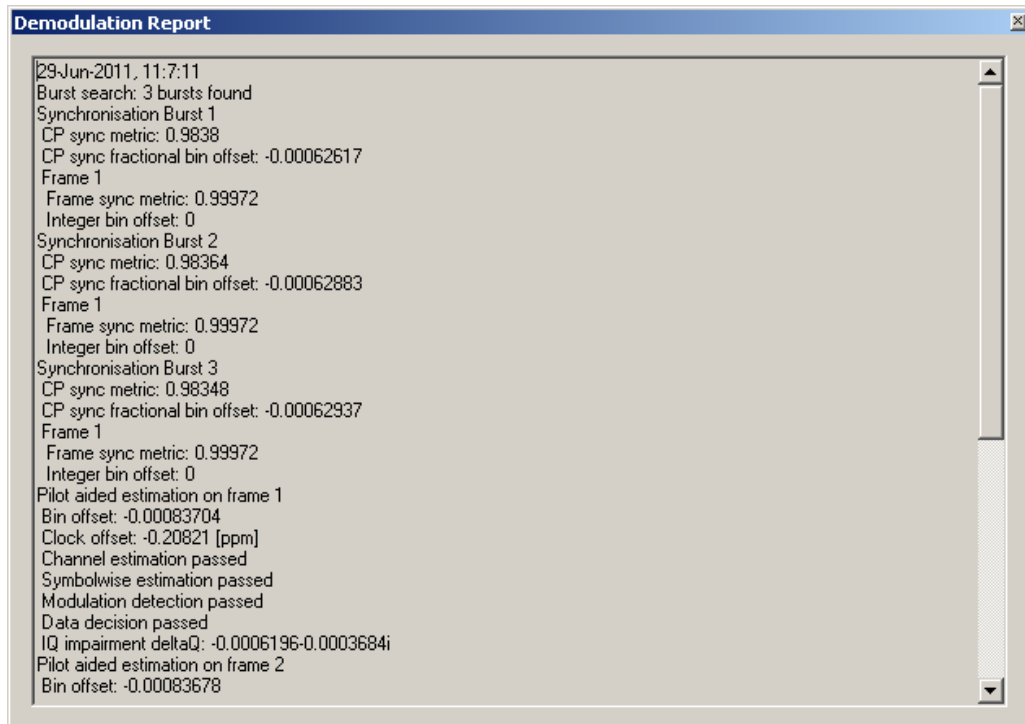


Fig. 48 Demodulation Report

The demodulation report lists messages generated by the signal processing kernel. It can give additional hints about the signal processing chain.

➔ Remote: CALC1:FEED 'STAT:REPT'

4.3.22 Allocation Matrix

The Allocation Matrix display is selected pressing the <MISC / STATISTIC> softkey in the main measurement softkey menu followed by the <ALLOCATION MATRIX> softkey.



Fig. 49 Allocation Matrix

The Allocation Matrix display is a graphical representation of the allocation matrix (i.e. structure matrix) defined in the configuration file. It is possible to use the marker in order to get more detailed information on the individual cells.

➔ Remote: Not supported yet.

4.4 Result Summary

The Result Summary table is displayed for I/Q measurements when the display mode is set to LIST. This table shows the overall scalar measurement results. The statistic is performed over all analyzed frames within the capture buffer.



Fig. 50 Result Summary Display

The Result Summary display is selected by pressing the <DISPLAY – LIST> softkey, which is available in all main measurement menus and submenus.

- ➔ Remote: Use the “FETCh Subsystem” to get the results of the Result Summary via remote control.

5 Settings

This section describes the "General Settings" dialog box, where all settings related to the overall measurement (i.e. Data Capture Settings, Input, Level, Trigger, Input Settings) can be modified.

5.1 General Settings

This section describes the General Settings panel, where all settings related to the overall measurement (i.e. Data Capture, Trigger and Input settings) can be modified.

The "General Settings" softkey opens the "General Settings" dialog box with three tabs: *Primary*, *Advanced* and *Meas*. To see the content of the tabs as shown below click on one of the tabs.



Fig. 51 Tabs in General Settings Dialog

For a detailed description of the primary, advanced and measurement settings see below.

5.1.1 Primary Settings

The <GENERAL SETTINGS> softkey opens the General Settings panel on the Primary tab.

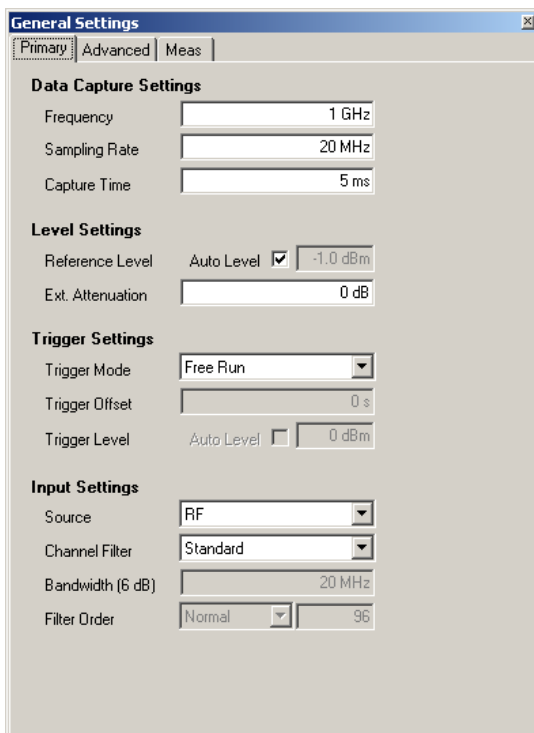


Fig. 52 Primary Tab of the General Settings Menu

5.1.1.1 Data Capture Settings

The Data Capture Settings are the general settings concerning the physical attributes of the signals to be measured.

Frequency

Frequency

Specifies the *Center Frequency* of the signal to be measured.
The maximum frequency depends on the hardware configuration of the R&S analyzer.

→ Remote: SENS:FREQ:CENT 1GHz

Sampling Rate

Sampling Rate

Specifies the *System Sampling Rate* of the OFDM signal to be measured.
The maximum sampling rate depends on the hardware configuration of the R&S analyzer.

→ Remote: TRAC:IQ:SRAT 16MHz

Capture Time

Capture Time

Specifies the *Capture Time* which is stored in the capture buffer and analyzed within one sweep.

The maximum capture time depends on the hardware configuration of the R&S analyzer and the memory of the external PC.

→ Remote: SENS:SWEep:TIME 5ms

5.1.1.2 Level Settings

The Level Settings are the general settings concerning the power leveling of the R&S analyzer.

Automatic level detection

Automatic level detection allows the Signal Level and Reference Level settings to be adjusted to the input signal. Automatic level detection can be performed by setting *Auto Level* in the General Settings panel to ON. Running the automatic level detection means that an automatic level detection measurement is executed before each measurement sweep.

→ Remote: CONF:POW:AUTO 1

Reference Level

Reference Level Auto Level

Specifies the *Reference Level* to use when running measurements, or displays the reference level when *Auto Level* is enabled.

The *Reference Level* parameter is editable only when RF input is selected and *Auto Level* is disabled.

When Auto Level is set to ON, the FS-K96 Software will measure the reference level automatically at the start of each measurement sweep. This ensures that the reference level is always set at the optimal level for obtaining accurate results but will lead to slightly increased measurement times.

The *Auto Level* setting is only available for RF input.

→ Remote: `DISP:TRAC:Y:RLEV -20`

External Attenuation

Ext. Attenuation

Specifies an *External Attenuation* to be considered in the power results of the R&S FS-K96 Software.

→ Remote: `DISP:TRAC:Y:RLEV:OFFS 0`

5.1.1.3 Trigger Settings

The Trigger Settings group contains all the settings related to the triggering of a measurement sweep.

Trigger Mode

Trigger Mode

Trigger Mode is the source of the trigger for the measurement sweep.

The possible values for the *Trigger Mode* are:

- Free Run** – The measurement sweep starts immediately.
- External** – The measurement sweep starts when the external trigger signal meets or exceeds the specified external trigger level at the input connector *EXT TRIGGER/GATE* on the rear panel.
- IF-Power** – The measurement sweep starts when the IF power meets or exceeds the specified trigger level.

→ Remote: `TRIG:MODE IMM`

Trigger Offset

Trigger Offset

Trigger Offset specifies the time offset between the trigger signal and the start of the sweep. A negative value indicates a pre-trigger.

The *Trigger Offset* parameter is not editable when *Trigger Mode* is set to Free Run because this indicates that the measurement sweep should trigger immediately and as such a trigger delay or pre-trigger would not be appropriate.

→ Remote: `TRIG:HOLD 1ms`

Trigger Level



Trigger Level specifies the threshold of the External- or the IF-Power trigger.

If Auto Level is selected, this trigger threshold is determined automatically by the R&S FS-K96 Software before each sweep.

→ Remote: TRIG:LEV 1 V

5.1.1.4 Input Settings

The Input settings group contains settings related to the input source of the signal to be measured.

Input Path



Selects the data source of the OFDM demodulator. The input can be *RF*, *Analog Baseband*, *Digital I/Q* or *File*.

→ Remote: INP:SEL RF

Channel Filter



Channel Filter selects the input filter preceding the OFDM demodulator. The *Standard* setting uses the default filter of the connected instrument. *Adjustable* allows the design of a lowpass filter with adjustable bandwidth and filter order.

→ Remote: INP:FILT:CHAN OFF

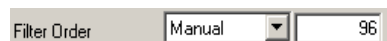
Bandwidth 6 dB



The *Bandwidth* of the channel filter is defined as two times the 6 dB cutoff frequency. It can be chosen between 0 Hz and the sample rate. Choosing a bandwidth near the sample rate can lead to backfolding of higher frequency signal parts.

→ Remote: INP:FILT:CHAN:BAND 20MHz

Filter Order



The *Filter Order* determines the slope characteristics of the channel filter. Three predefined filter orders, *Low*, *Normal* and *High* are available. Additionally, the filter order can be set manually. Odd filter orders are rounded to the next higher even number.

→ Remote: INP:FILT:CHAN:ORD 96

5.1.2 Advanced Settings

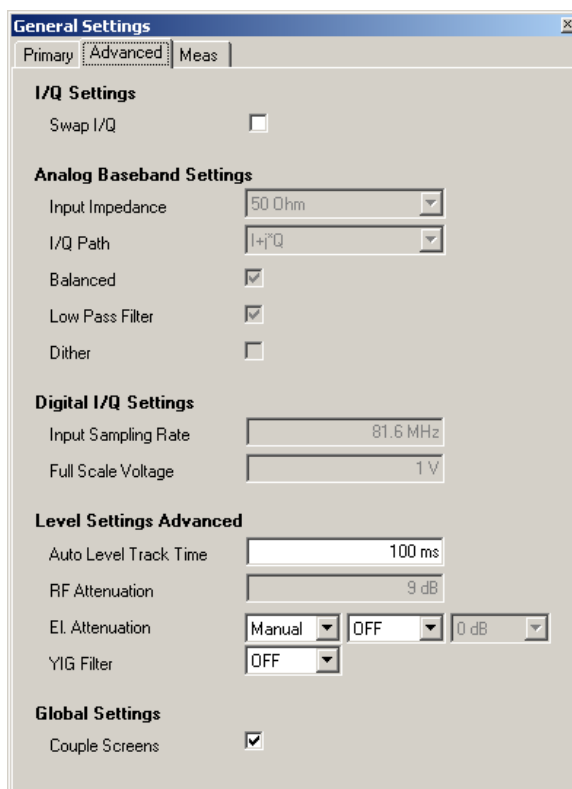


Fig. 53 Advanced Tab of the General Settings Menu

5.1.2.1 I/Q Settings

Swap I/Q

Swap I/Q

Swap I/Q interchanges the I channel and the Q channel.

→ Remote: SENS:SWAP OFF

5.1.2.2 Analog Baseband Settings

The Analog Baseband Settings group contains settings related to the baseband input source.

Input Impedance

Input Impedance

Input Impedance allows the selection of the impedance of the Baseband inputs. The selection depends on the instrument configuration.

The *Input Impedance* parameter is editable only when Baseband input is selected.

→ Remote: INP:IQ:IMP HIGH

Balanced

Balanced

Balanced switches the Baseband inputs between symmetrical (balanced) and asymmetrical (unbalanced).

The *Balanced* parameter is editable only when Baseband input is selected.

→ Remote: INP:IQ:BAL ON

Lowpass

Low Pass Filter

When enabled, the *Lowpass* parameter inserts a 36 MHz lowpass filter into the I and Q parts of the baseband input.

→ Remote: SENS:IQ:LPAS 0

Dither

Dither

When enabled, the *Dither* parameter specifies that a 2 MHz-wide noise signal at 42.67 MHz is injected into the signal path of the Baseband input. It appears in the spectrum at 38.92 MHz. The *Dither* parameter is editable only when Baseband input is selected.

→ Remote: SENS:IQ:DITH 0

5.1.2.3 Digital I/Q Settings

The Digital IQ Settings group contains settings related to the digital IQ input source.

Digital Input Sampling Rate

Digital Input Sampling Rate

Digital Input Sampling Rate defines the sampling rate of the data signal at the digital IQ input. The *Digital Input Sampling Rate* parameter is editable only when Baseband input is selected.

→ Remote: SENS:IQ:DITH 0

Full Scale Voltage

Full Scale Voltage

Full Scale Voltage defines the voltage corresponding to the maximum input value of the digital baseband input (value 7FFF hex).

The *Full Scale Voltage* parameter is editable only when Baseband input is selected.

→ Remote: INP:DIQ:RANG 1V

5.1.2.4 Level Settings Advanced

The Level Settings Advanced group contains settings related to the leveling of the R&S analyzer.

Auto Level Track Time


Auto Level Track Time specifies the sweep time used for the auto level measurements.

This parameter is editable only when RF input is selected and *Auto Level* is enabled.

➔ Remote: `CONF:POW:AUTO:SWE:TIME 100MS`

RF Attenuation



RF Attenuation specifies the mechanical attenuation to be applied to the input RF signal.

Available values:

0 dB to 75 dB in steps of 5 dB.

The *RF Attenuation* parameter is editable only when RF input is selected and *Auto Level* is disabled.

➔ Remote: `INP:ATT 10`

El. Attenuation


EL Attenuation specifies the electrical attenuation to be applied to the input RF signal.

Available values:

0 dB to 30 dB in steps of 5 dB.

The electrical attenuator can be switched off completely.

➔ Remote: `INP:EATT:STAT ON`

➔ Remote: `INP:EATT 5`

YIG Filter


YIG Filter specifies the state of the YIG filter in the R&S Analyzer.

➔ Remote: `INP:FILT:YIG OFF`

5.1.2.5 Global Settings

The Global Settings group contains settings related to the settings which apply in a global scope.



If Couple Screens is enabled, the markers on the top and bottom screen which have the same unit (e.g., frequency or symbol index) are coupled.

➔ Remote: Not supported yet.

5.1.3 Measurement Settings

This section describes the Measurement Settings panel, where all settings related to the measurement result displays can be modified. It allows to specify units of the result axes and offers specific settings for the different measurements.

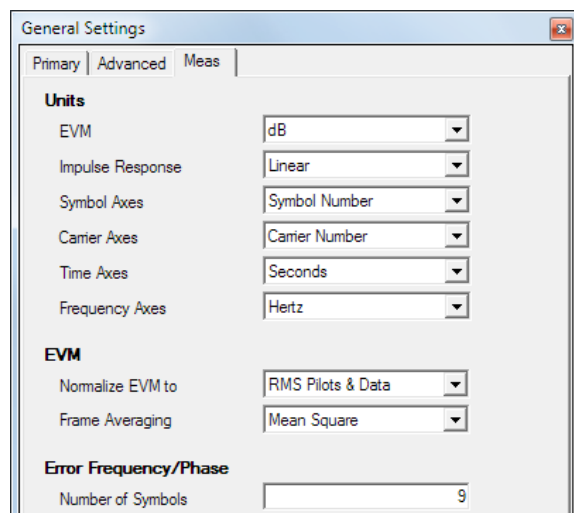


Fig. 54 Measurement Tab of the General Settings Menu

5.1.3.1 Units

The Units group contains settings regarding the axes units of the different result displays.

EVM

EVM

EVM specifies the unit of EVM results.

Available values: *dB* or *%*

→ Remote: UNIT:EVM DB

Impulse Response

Impulse Response

Impulse Response specifies whether the channel impulse response is to be displayed linearly or logarithmically

Available values: *Linear* or *dB*

→ Remote: UNIT:IRES LIN

Symbol Axes

Symbol Axes

Symbol Axes specifies the unit of time axes representing symbol numbers.

Available values: *Symbol Number* or *Seconds*

➔ Remote: UNIT:SAX SYM

Carrier Axes

Carrier Axes

Carrier Axes specifies the unit of frequency axes representing carrier numbers.

Available values: *Carrier Number* or *Hertz*

➔ Remote: UNIT:CAX CARR

Time Axes

Time Axes

Time Axes specifies the unit of general time axes

Available values: *Seconds*, *Sample Time* or *Symbol Time*

➔ Remote: UNIT:TAX S

Frequency Axes

Frequency Axes

Frequency Axes specifies the unit of general frequency axes

Available values:

Hertz, Sample Rate or Subcarrier Spacing

➔ Remote: UNIT:FAX Hz

5.1.3.2 EVM

The EVM group contains settings regarding the calculation of the error vector magnitude results.

Normalize EVM to

Normalize EVM to

Normalize EVM to specifies the OFDM cells which are averaged to get the reference magnitude for EVM normalization (see chapter 8.2.1 for details).

Available values:

RMS Pilots & Data, RMS Data, RMS Pilots, None

➔ Remote: SENS:DEM:EVMC:NORM RMSPD

Frame Averaging

Frame Averaging

Frame Averaging specifies the method of averaging over multiple OFDM frames used to get the mean EVM values in the result list.

Frame Averaging	Averaged EVM over <i>N</i> frames
Mean Square	$\sqrt{\frac{1}{N} \sum_{i=0}^{N-1} EVM_i^2}$
RMS	$\frac{1}{N} \sum_{i=0}^{N-1} EVM_i$

Mean square averaging is consistent with the EVM calculation within one frame. However, some standards, e.g. 802.11a, require RMS averaging.

Available values:

Mean Square, RMS

➔ Remote: SENS : DEM : EVMC : FAV RMS

5.1.3.3 Error Freq. / Phase

The Error Freq. / Phase group contains settings regarding the Error Freq. / Phase measurement within the EVM measurement group.

Number of Symbols

Number of Symbols

Number of Symbols specifies the number of symbols per frame used for the evaluation of the sample wise frequency and phase error calculation. The upper limit is the Result Length minus one (Result Length – 1).

➔ Remote: Not supported yet.

5.2 Demodulation Settings

This section describes the demodulation settings of the software for running a correct measurement by means of OFDM system configuration and demodulation control options.

5.2.1 Signal Description

The <DEMODO SETTINGS> softkey opens the Demodulation Settings panel on the *Signal Description* tab.

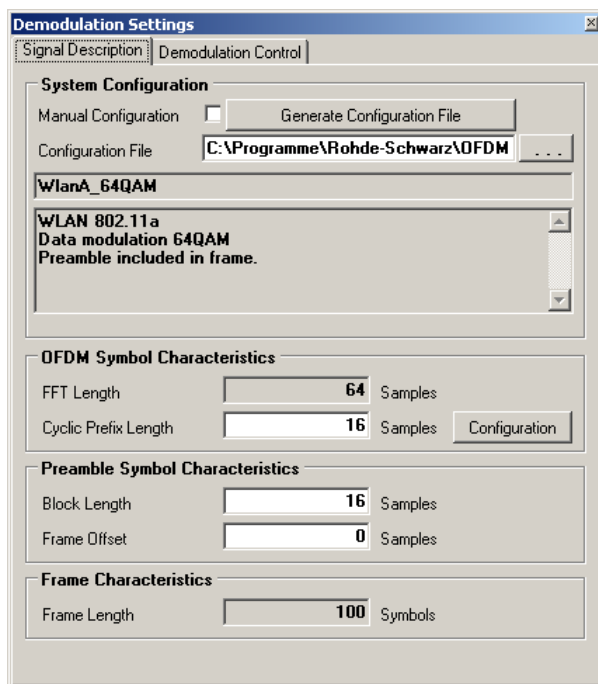


Fig. 55 System Description Tab of the Demodulation Settings Menu

5.2.1.1 System Configuration

The System Configuration group contains general settings to specify the OFDM system.

Manual Configuration

Manual Configuration

Manual Configuration allows to specify an OFDM system without using a system configuration file. The basic OFDM parameters can be entered manually. If manual configuration is enabled, no frame synchronization can be performed. EVM or Channel measurements are not available. The constellation diagram will still show a rotation.

→ Remote: CONF:SYST:MAN

Configuration File



Configuration File allows loading a configuration file which defines the specific OFDM system. Pressing ‘...’ opens a file manager. The configuration file contains the system name and a system description, which are displayed within the text fields.

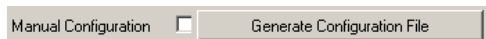
➔ Remote: MMEM:LOAD:CFGF 'C:\TEMP\K96Test.mat'



Drag-and-Drop

You can also load a configuration file by drag-and-drop.

Configuration with Wizard



“Generate Configuration File” opens a dialog that displays the necessary settings for a burst detection and a coarse timing synchronization. Based on these results, it is then possible to start the “R&S FS-K96 Configuration File Wizard” (cf. Fig. 68) and to generate a configuration file.

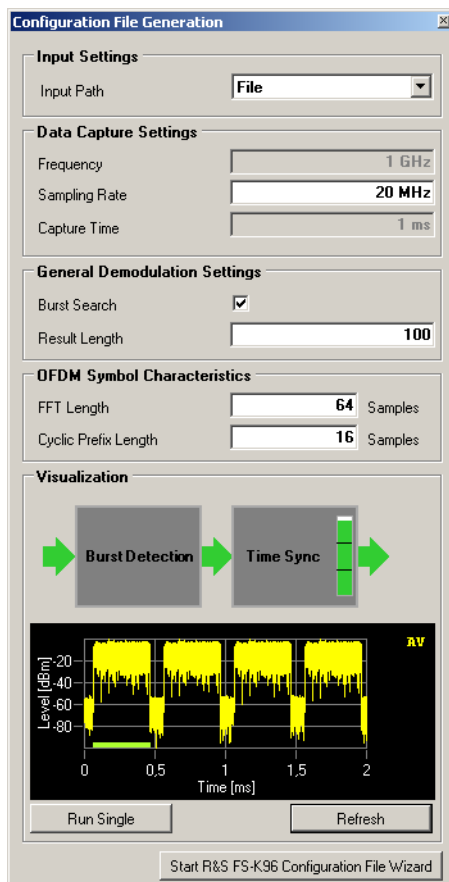


Fig. 56 Configuration File Generation Dialog

5.2.1.2 OFDM Symbol Characteristics

The OFDM Symbol Characteristics group contains settings to specify the OFDM symbol in time domain.

FFT Length

FFT Length Samples

FFT Length specifies the length of the FFT area of an OFDM symbol in time domain in number of samples.

This parameter is editable only when manual configuration is selected.

➔ Remote: `CONF:SYMB:NFFT 256`

Cyclic Prefix Configuration

Cyclic Prefix Length Samples

Cyclic Prefix Length specifies the length of the Cyclic Prefix area of an OFDM symbol in time domain in number of samples.

➔ Remote: `CONF:SYMB:NGU 16`

“Configuration” opens a dialog that allows for the configuration of the non-conventional cyclic prefix mode (cf. Fig. 57).

➔ Remote: `CONF:SYMB:GUAR:MODE GU2`

In the conventional cyclic prefix mode, all OFDM symbols have the same cyclic prefix length. In the non-conventional cyclic prefix mode, some OFDM symbols have different cyclic prefix lengths than others. One well-known OFDM system, where different cyclic prefix lengths can occur in one frame is e.g. LTE.

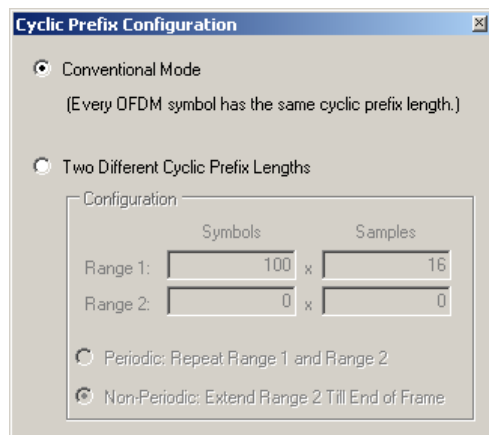


Fig. 57 Cyclic Prefix Configuration Dialog

In the non-conventional case, we distinguish between the periodic mode and the non-periodic mode.

➔ Remote: `CONF:SYMB:GUAR:PER ON`

In the periodic mode (cf. Fig. 58), one “Slot” that consists of the two ranges that can be defined in this dialog is repeated over and over until the number of symbols specified by the result range parameter is reached (e.g. LTE).

	Symbols		Samples
Range 1:	1	x	80
Range 2:	3	x	72

- **Number of Symbols (Range 1) (1)**
Specifies the length of the first range in symbols.
Remote: `CONF:SYMB:GUAR1:NSYM 1`
- **First Cyclic Prefix Length (2)**
Specifies the length of the first cyclic prefix in samples.
Remote: `CONF:SYMB:NGU1 80`
- **Number of Symbols (Range 2) (3)**
Specifies the length of the second range in symbols.
Remote: `CONF:SYMB:GUAR2:NSYM 6`
- **Second Cyclic Prefix Length (4)**
Specifies the length of the second cyclic prefix in samples.
Remote: `CONF:SYMB:NGU2 72`

In the non-periodic case (cf. Fig. 59), a fixed preamble has a different cyclic prefix length than the rest of the frame (e.g. 802.11ac). In this case, the length of the second range is extended till the end of the demodulated frame. Therefore, the length of the second range cannot be specified in this case.



Fig. 58 Non-Conventional Cyclic Prefix Case: Periodic Mode

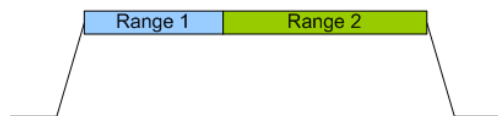


Fig. 59 Non-Conventional Cyclic Prefix Case: Non-Periodic Mode

5.2.1.3 Preamble Symbol Characteristics

The Preamble Symbol Characteristics group contains settings to specify the preamble symbol in time domain. These parameters are used only if 'Preamble Synchronization' is selected in the *Demodulation Control* settings tab.

Block Length

Block Length Samples

Block Length specifies the length of one data block within the repetitive preamble in number of samples.

→ Remote: `CONF:PRE:BLEN 64`

Frame Offset

Frame Offset Samples

Frame Offset specifies the time offset from the preamble start to the actual frame start in number of samples.

→ Remote: `CONF:PRE:FOFF -16`

5.2.1.4 Frame Characteristics

The Frame Characteristics group contains settings to specify the complete OFDM frame.

Frame Length

Frame Length Symbols

Frame Length displays the length of the configured OFDM frame. This is the maximum evaluation length for which a configuration exists. The parameter has no meaning in manual mode.

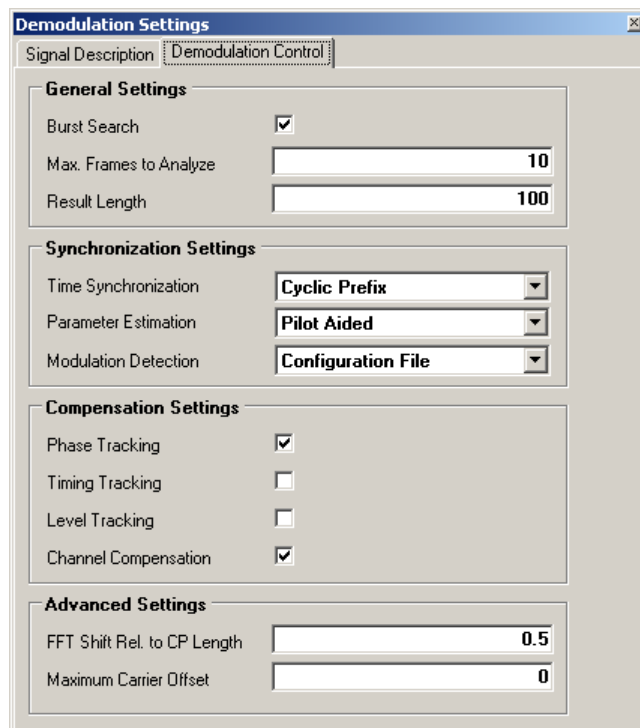


Fig. 60 Demodulation Control Tab of the Demodulation Setup Menu

5.2.1.5 General Settings

The General Settings group contains basic settings about the position and length of the OFDM frame within the capture buffer.

Burst Search

Burst Search

Burst Search specifies whether the demodulator shall search for power bursts before time synchronization. If enabled, the successive demodulation steps are restricted to the signal areas which contain significant power. For continuous signals this parameter has to be disabled.

→ Remote: SENS:DEM:FORM:BURS ON

Maximum Frames to Analyze

Max. Frames to Analyze

Max. Frames to Analyze specifies the maximum number of frames which are analyzed within one capture buffer.

→ Remote: SENS:DEM:FORM:MAXF 5

Result Length

Result Length

Result Length specifies the number of analyzed symbols in one frame. This number must be equal or lower than the Frame Length specified in the *System Description* menu. In order to guarantee stable demodulation, its lower limit is 4.

→ Remote: SENS:DEM:FORM:NOFS 100

5.2.1.6 Synchronization Settings

The Synchronization Settings group contains settings which control the synchronization steps of the demodulation.

Time Synchronization

Time Synchronization

Time Synchronization specifies the synchronization method in time domain. The *cyclic prefix* method performs a correlation of the cyclic prefix with the end of the FFT interval. The *preamble* method searches for the repetitive preamble blocks.

→ Remote: SENS:DEM:TSYN CP

Parameter Estimation

Parameter Estimation

Parameter Estimation specifies the mode of synchronization in the frequency domain. In the manual configuration mode without a configuration file, the parameter estimation is forcefully switched off. If a configuration file is loaded, *Pilot Aided* synchronization or *Pilot And Data Aided* synchronization can be selected. *Pilot Aided* synchronization uses only the predefined pilot cells as reference signal. The *Pilot And Data Aided* synchronization uses both pilots and decided data cells for an additional synchronization step.

→ Remote: SENS:DEM:FSYN PIL

Modulation Detection

Modulation Detection

Modulation Detection specifies the operation mode of the automatic modulation detection for the data cells. If *Configuration File* is selected, the modulation matrix within the system configuration file is evaluated. The *symbolwise* modulation detection determines a common modulation format for all data cells within one OFDM symbol. The *carrierwise* modulation detection determines a common modulation format for all data cells within one OFDM carrier.

→ Remote: SENS:DEM:MDET CFG

5.2.1.7 Compensation Settings

The Compensation Settings group allows a detailed choice of channel and synchronization parameters to be compensated before the EVM measurement.

Phase Tracking

Phase Tracking

Phase Tracking specifies whether or not the measurement results should be compensated for common phase error.

The compensation is done on a per-symbol basis.

→ Remote: SENS:TRAC:PHAS ON

Timing Tracking

Timing Tracking

Timing Tracking specifies whether or not the measurement results should be compensated for sample clock deviations.

The compensation is done on a per-symbol basis.

→ Remote: SENS:TRAC:TIME OFF

Level Tracking

Level Tracking

Level Tracking specifies whether or not the measurement results should be compensated for power level deviations.

The compensation is done on a per-symbol basis.

→ Remote: SENS:TRAC:LEV OFF

Channel Compensation

Channel Compensation

Channel Compensation specifies whether or not the measurement results should be compensated for the channel transfer function. The compensation is done on a per-carrier basis.

→ Remote: SENS:COMP:CHAN ON

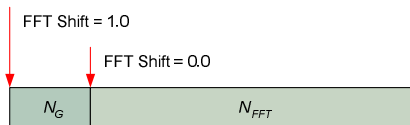
5.2.1.8 Advanced Settings

The Advanced Settings group contains settings which control certain signal processing steps within the FS-K96 Software.

FFT Shift relative to Cyclic Prefix Length

FFT Shift rel. to CP Length

FFT Shift rel. to CP length allows for shifting the FFT start sample within the guard interval. This is useful if relevant parts of the channel impulse response fall outside the cyclic prefix interval.



→ Remote: SENS:DEM:FFTS 0.5

Maximum Carrier Offset

Maximum Carrier Offset

Maximum Carrier Offset defines the search range of the frame synchronization in frequency direction. If set to zero, the center frequency offset must be less than half the carrier distance. Higher values allow higher frequency offsets, but slow down the measurement time.

→ Remote: SENS:DEM:COFF 0

5.3 File Management

This section describes the file management of demodulation settings, global settings and I/Q data.

The [FILE] hardkey opens the file management softkey menu.

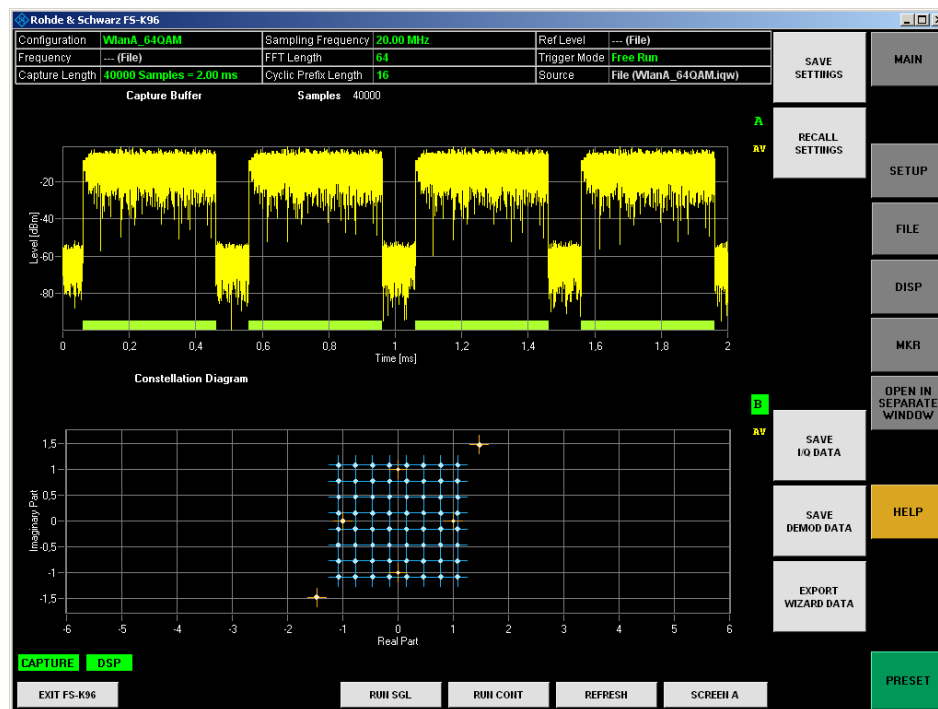


Fig. 61 File Management Menu

Use **<SAVE SETTINGS>** to open a standard file dialog to save the current settings of the FS-K96 Software.

→ Remote: `M MEM:STOR:STAT 'C:\TEMP\K96Test.ovsa'`

Use **<RECALL SETTINGS>** to open a standard file dialog to load and apply a previously saved setting file.



Drag-and-Drop

You can also load a setup by drag-and-drop.

→ Remote: `M MEM:LOAD:STAT 'C:\TEMP\K96Test.ovsa'`

Use **<SAVE I/Q DATA>** to open a standard file dialog to save the current I/Q data in the capture buffer.

→ Remote: `M MEM:STOR:IQ:STAT 'C:\TEMP\MyCapture.iqw'`

Use **<SAVE DEMOD DATA>** to open a standard file dialog to save the processed and demodulated data in a time-frequency matrix.

→ Remote: Not supported yet.

Please refer to section 6 [“Import and Export of Data”](#) for details on the file format.

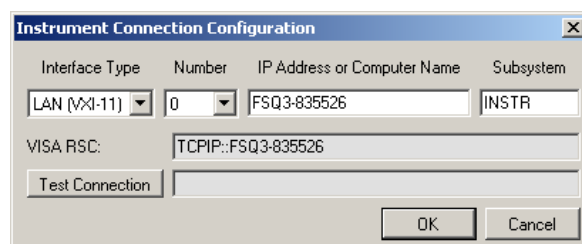
Use **<EXPORT WIZARD DATA>** to export the demodulated data for the R&S FS-K96 Configuration File Wizard.

→ Remote: Not supported yet.

Please refer to section 7.2.1 [“Overview of the R&S FS-K96 Configuration File Wizard”](#) for details on the R&S FS-K96 Configuration File Wizard.

5.3.1 Configure Analyzer Connection

In order to be able to communicate with the instruments, the R&S analyzer must be connected with the PC using either an IEEE bus or LAN connection. The type of connection and the address can be selected by the **<CONFIGURE ANALYZER CONNECTION>** softkey:



If more than one interface is available on the PC (e.g. because two LAN cards are installed), please select the appropriate interface *Number*. The *Subsystem* does not need to be changed.

Depending on the *Interface Type*, different types of addresses must be entered:

Interface	Description	Address equivalent to ...
GPIB Instrument	IEEE bus system using the IEEE 488 protocol	Instrument primary GPIB address (0...31). Default value is 20 for the R&S FSQ.
LAN <i>VXI-11 protocol</i>	LAN bus system using the VXI-11 protocol (supported with FSQ firmware version 3.65 or later)	Host address as TC/IP address or computer name. Contact your local IT support if you are not sure what to enter here.
LAN <i>RSIB protocol</i>	LAN bus system using a Rohde & Schwarz-specific protocol (supported with all R&S FSQ firmware versions)	Host address as TC/IP address or computer name. Contact your local IT support if you are not sure what to enter here.

→ Remote: CONF:ADDR `TCPIP::192.168.1.1::INSTR`

5.3.2 Data Source (Instrument or File)

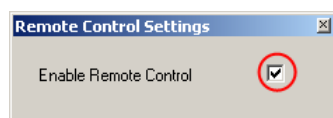
The **<DATA SOURCE>** softkey is used to specify the I/Q data source. Data can either be captured from the R&S analyzer (*INSTR* is selected) or read from file (*FILE* is selected). If *FILE* is selected, each time the user presses the **<RUN SGL>** or **<RUN CONT>** hotkey, a dialog is shown where the user can specify the full name and path of the I/Q data file to be used. Pressing ENTER loads the specified I/Q data file and displays the results.

If the specified file cannot be found or is not a valid I/Q data file, an error message will be displayed indicating that the I/Q data could not be imported.

→ Remote: INP:SEL FILE

5.3.3 Remote Control Settings

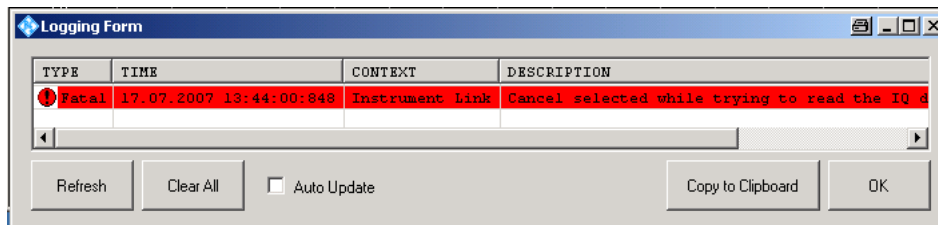
Pressing the **<REMOTE CONTROL SETTINGS>** softkey opens the following pop-up dialog:



The dialog allows for enabling or disabling the remote control functionality of the OFDM-VSA. Disabling of the remote control needs a restart of the software.

5.3.4 Show Logging

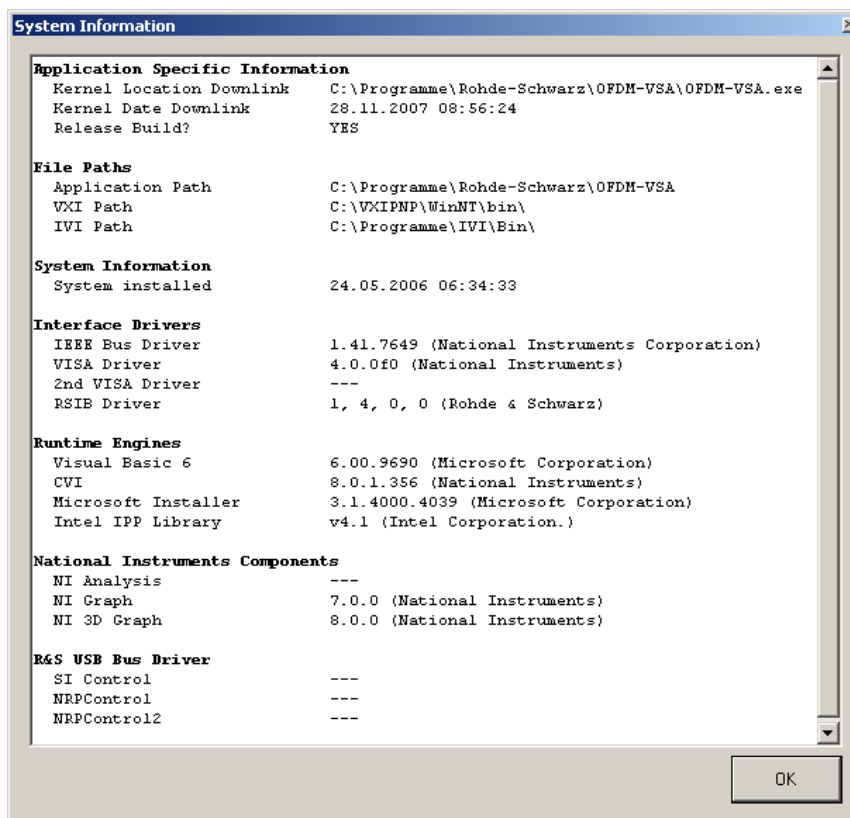
The *<SHOW LOGGING>* softkey is used to display an error messages history.



The message history can be refreshed and cleared, and the contents can be copied to the operating system clipboard.

5.3.5 System Info

The *<SYSTEM INFO>* softkey opens a dialog containing system information about the version numbers of used drivers and utility software. This information can be useful in case the analyzer software does not work properly.



5.4 Display Settings

The layout of the display can be controlled using the display menu.

The **[DISP]** hardkey opens the display softkey menu. It also closes any settings panels that are open.

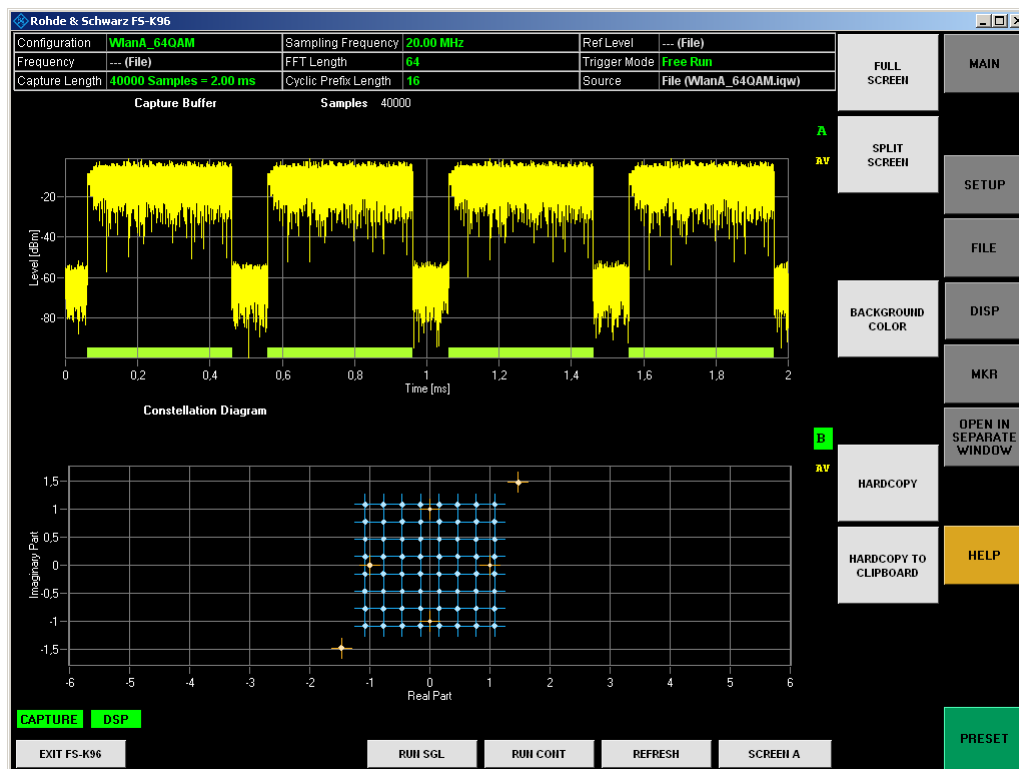


Fig. 62 Display Menu

The display menu allows the display to be changed between split and full screen for I/Q measurement results.

→ Remote: `DISPlay:FORMat SPL`

I/Q measurements can be run in split screen or in full screen mode.

The active screen can be selected by

- clicking on the screen.
- pressing the **<SCREEN A / SCREEN B>** hotkey. In full screen mode the **<SCREEN A / SCREEN B>** hotkey also toggles which screen is displayed.

→ Remote: `DISP:WIND1:SEL`

The background color of the software can be changed by pressing the **<BACKGROUND COLOR>** softkey and selecting a color in the color selection dialog.

The **<HARDCOPY>** softkey saves a screenshot of the software window in the following formats:

- **BMP**: Uncompressed pixel format
- **GIF**: Color compressed pixel format with 256 colors (platform independent)

- *JPEG*: Compressed pixel format
 - *PNG*: Lossless compressed pixel format
 - *TIFF*: Format for high color depth images
- Remote: MMEM:NAME 'C:\TEMP\Screenshot.bmp' "
- Remote: HCOF

The <*HARDCOPY TO CLIPBOARD*> softkey sends a screenshot of the software window to the operating system clipboard.

5.5 Open in Separate Window

The [*OPEN IN SEPARATE WINDOW*] hardkey creates a copy of the currently selected screen and displays it in additional windows. This functionality makes it possible to watch more than two results simultaneously.



Fig. 63 FS-K96 Software with Several Result Windows

6 Import and Export of Data

This section describes how to import and export data from and to the FS-K96 Software.

The software will process the following types of data files the user may manipulate:

- I/Q data
- Demodulation data
- Limits

6.1 I/Q Data

Purpose

The FS-K96 Software is able to process I/Q data from a file rather than from the R&S signal analyzer hardware. Captured I/Q data can also be stored in various formats for e.g. processing with other external tools or for support purposes.

Format

I/Q data can be formatted either in binary form or as ASCII files. The data is linearly scaled using the unit Volt (if a correct display of e.g. Capture Buffer power is required).

- For **binary format**, data is expected as 32-bit floating point data, Little Endian format (also known as LSB Order or Intel format).
(EXAMPLE: 0x1D86E7BB in hexadecimal notation will be decoded to - 7.0655481E-3.)
The data order can be either IQIQIQ or II..IQQ..Q.
- For **ASCII format**, data is expected as I and Q values in alternating rows, separated by new lines:

```
<I value 1>
<Q value 1>
<I value 2>
<Q value 2>
...
```
- For waveform format (*.wav), data is encrypted. The format complies with the waveform format that is e.g. used by the R&S Signal Generators and R&S® WinIQSIM Software.

Usage – Import

To use externally stored data, switch to the data source file using [**SETUP**] <DATA SOURCE FILE>. Each time you start a new measurement, you will be prompted for the file name.

Usage – Export

To export captured I/Q data, select [**FILE**] <SAVE IQ DATA>.

6.2 Demodulation Data

Purpose

The demodulated data at the end of the signal processing chain can be saved for further evaluation in Matlab. The data is stored in a time frequency matrix representing the analyzed OFDM frames.

Format

The demodulation data is stored in a Matlab *.mat file. This file contains two matrices named 'mfcRlk' and 'mfcAlk'. The matrix size is 'Number of Symbols' X 'FFT Length'. The matrix 'mfcRlk' contains the demodulated and corrected OFDM symbols while 'mfcAlk' contains the associated reference symbols.

The following example code shows how to load the demodulation data in Matlab and plot the constellation diagram:

```
% load file
s = load('mydata.mat', '-mat');
% show constellation
plot(real(s.mfcRlk), imag(s.mfcRlk), 'bo');
hold on;
plot(real(s.mfcAlk), imag(s.mfcAlk), 'rx');
hold off;
```

Usage – Export

To export the demodulation data, select **[FILE]** <SAVE DEMOD DATA>.



The demodulation data can also be read out via remote control commands. The demodulated symbols and the reference symbols are available as traces 3 and 4 of the constellation diagram. This allows a seamless integration of the FS-K96 within larger OFDM software projects.

6.3 Limits

Purpose

The limit definition is used to specify user-defined limits. Currently, limits are only used in the Result Table (**[MAIN]** <DISPLAY LIST>).

Format

The limit definition can be provided as XML. An example, including comments on how to use the definition, is shown below:

```
<Limits>
  <EVMA11/><!--Unit: dB-->
  <EVMDATA/><!--Unit: dB-->
  <EVMPilot/><!--Unit: dB-->
  <IQOffset/><!--Unit: dB-->
  <IQGainImbalance/><!--Unit: dB-->
  <IQQuadratureError/><!--Unit: deg-->
  <FrequencyError/><!--Unit: Hz-->
  <SampleClockError/><!--Unit: ppm-->
  <FramePower/><!--Unit: dBm-->
  <CrestFactor/><!--Unit: dB-->
</Limits>

<!--Example
<Limits>
  <EVMA11 Mean="-40" Max="-30"/>
</Limits>
-->
```

Limit definitions which are not required may be skipped by making no entries or by deleting the complete tag.

Usage – IMPORT

The limit definition file must be placed in the same folder as the FS-K96 Software binary (“%Program folder%\Rohde-Schwarz\ OFDM Vector Signal Analysis Software” by default). The file name must be limits.xml. The file is read once during the start-up process of the software.

7 System Configuration File

The R&S FS-K96 Software has to know the structure of the OFDM system in order to be able to demodulate an OFDM signal correctly. By “structure”, we refer to the complete description of the OFDM system:

- the number of subcarriers (i.e. the FFT size)
- the number of symbols
- the number of samples in the cyclic prefix (also referred to as guard length)
- the position (carrier number, symbol number) of the
 - pilot symbols
 - data symbols
 - zero symbols
 - don't care symbols
- the modulation format of the data symbols (e.g. QPSK, 16QAM etc.)
- the value of the pilot symbols
- (optional: the definition of the preamble)

This section describes the format and generation of the OFDM system configuration file which can be loaded within the system configuration tab of the demodulation setup window.

The OFDM configuration file can be either stored in Matlab *.mat format (cf. [Matlab Configuration File Format](#)) or in an XML *.xml format (cf. [XML Configuration File Format](#)).

7.1 Matlab Configuration File Format

The OFDM configuration can be stored in a Matlab *.mat format which contains the structure 'stOfdmCfg'. The following table lists the elements of the structure and the sub-structures.

Instead of manual generation of the configuration structure it is recommended to use the additionally provided OFDM system class and its methods.

Structure: stOfdmCfg			
Parameter	Type	Meaning	Example
sVersion	string	Version identifier of the interface format.	'R&S_OVSA_IFC_V0.1'
sSystem	string	Identifier of the OFDM system.	'Wimax IEEE 802.16-2004'
sDescription	string	Additional information about the OFDM system.	'Uplink with subchannelisation 8, 20 symbols, special 17QAM modulation'
stPreamble	structure	Optional definition of a repetitive preamble symbol for time synchronization.	
iNfft	int32	Number of samples in one FFT block.	256
iNg	int32	Number of samples in the cyclic prefix block.	16
iNOFSymbols	int32	Number of symbols described by this system definition. This is also the maximum result range.	100
meStructure	[iNOFSymbols X iNfft] matrix of int8	Time-Frequency matrix containing the type of each cell in the OFDM system. 0: Zero 1: Pilot 2: Data 3: Don't Care	[0,0,1,1,1,1,1,1,1,1,0,0; 0,0,2,2,1,2,2,1,2,2,0,0]
vstDataConst	Array of stConstellation	Array of constellation structures; one constellation structure for each data constellation.	
viDataConstPtr	Vector of uint8	For each 'Data' entry in meStructure this vector contains the number of the constellation used for the data cell. meStructure is evaluated row wise.	[0,0,1,1,2,2]
vfcPilot	Vector of complex float32	For each 'Pilot' entry in meStructure this vector contains the complex pilot value. meStructure is evaluated row wise.	[1+j,-1-j,-1+j,1-j,1+j,-1-j,-1+j,1-j,1+3j,-1-j]

Structure: stPreamble			
Parameter	Type	Meaning	Example
iBlockLength	int32	Length of the repetitive block.	16
iFrameOffset	int32	Offset of the first sample of the preamble symbol to the first sample of the first symbol defined in the allocation matrix.	0

Structure: stConstellation			
Parameter	Type	Meaning	Example
sName	string	Constellation name.	'QPSK'
vfcValue	Vector of complex float32	Vector of complex valued constellation points.	$[-1-j, -1+j, 1+j, 1-j]$



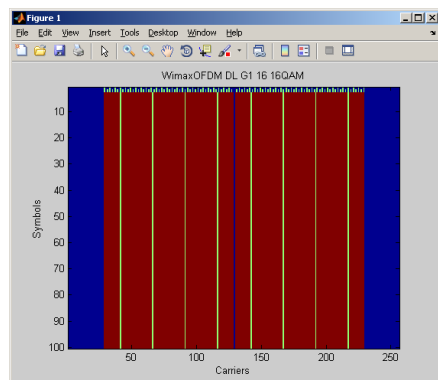
Debugging the system configuration file

An easy way to take a quick look at your allocation matrix (meStructure) in your system configuration file is via the Matlab function `imagesc()`.

Example:

```
MyConfigFile = load(<Configfilename>);
imagesc(MyConfigFile.stOfdmCfg.meStructure);
```

The plot for the exemplary Wimax Configuration file that is included in your software then looks as follows:



7.1.1 OFDM System Class

The R&S FS-K96 provides a Matlab class which supports the user in creating the configuration file, so that he does not need to generate the configuration structure manually. It is recommended to use this class. The Matlab class `@OfdmSys` is stored in the installation directory `@OfdmSys`

- OFDM Vector Signal Analysis Software
 - CONFIGURATIONS
 - RS.CompassStandalone
 - SIGNALS
 - TOOLS
 - MATLAB
 - @OfdmSys**
 - VIDEOS

and contains the following functions:

Table 1: Overview of the Member Functions of the Matlab Class @OfdmSys

Member Function	Description
<code>c = OfdmSys()</code> <code>c = OfdmSys(iNOFSymbols, iNfft, iNg)</code>	Default Constructor and parameterized constructor
<code>c = Init (iNOFSymbols, iNfft, iNg)</code>	Initialize a new system configuration
<code>c = SetSystem (sSystem)</code> <code>c = SetDescription (sDescription)</code>	Describe the OFDM system
<code>c = SetConstellation (vfcValue, sName)</code>	Define a constellation vector
<code>c = SetCell (iSymbol, iCarrier, 'Zero')</code> <code>c = SetCell (iSymbol, iCarrier, 'Pilot', fcValue)</code> <code>c = SetCell (iSymbol, iCarrier, 'Data', sConstName)</code> <code>c = SetCell (iSymbol, iCarrier, 'DontCare')</code>	Define a specific cell of the OFDM system
<code>c = SetPreamble (iBlockLength, iFrameOffset)</code>	Define a repetitive preamble symbol
<code>c = LoadConfigFile (sFileName)</code> <code>c = SaveConfigFile (sFileName)</code>	Load or save a system configuration file

The following part describes the functions and the input parameters of the Matlab Class @OfdmSys in detail. Furthermore a short example is given for all of the functions.

With the information provided below, the user can write his own *.m file. Running the *.m file creates the custom *.mat OFDM configuration file. This *.mat file contains the configuration data and can be loaded into the R&S FS-K96 OFDM Vector Signal Analysis Software.

INIT	This function initializes the System Configuration Class	
	<code>c = Init(c, iNOFSymbols, iNfft, iNg);</code>	
Input parameter	<code>c</code>	Input object
	<code>iNOFSymbols</code>	Number of OFDM symbols in one frame included in the configuration file. This is the maximum frame length to be analyzed.
	<code>iNfft</code>	FFT length in number of samples
	<code>iNg</code>	Cyclix prefix length in number of samples
Output parameter	<code>c</code>	Modified object
Example 1	<code>cOfdmSys = OfdmSys();</code> <code>cOfdmSys = Init(cOfdmSys, 100, 64, 16);</code>	
Example 2	<code>cOfdmSys = OfdmSys(100, 64, 16);</code>	



Support for cyclic prefix configuration

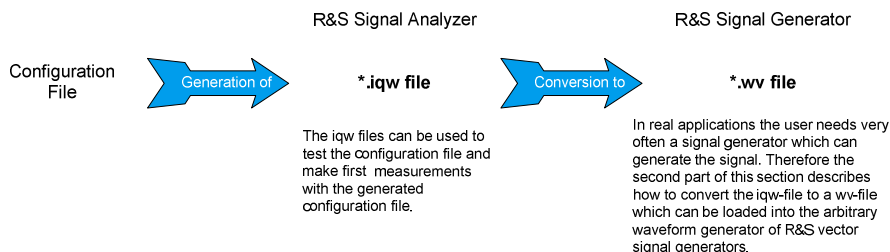
At the moment, only the conventional cyclic prefix mode is supported in the *.mat configuration file format. That means, that OFDM systems with symbols of different cyclic prefix length (e.g. LTE) are currently not supported in the *.mat configuration file format. It is recommended to either use the *.xml configuration file format for these setups or to enter the cyclic prefix configuration manually after the *.mat configuration file has been loaded.

SET_SYSTEM	This function sets the system name string.	
	<code>c = SetSystem(c, sSystem);</code>	
Input parameter	c	Input object
	sSystem	String containing the name of the system
Output parameter	c	Modified class
Example	<code>cOfdmSys = SetSystem(cOfdmSys, 'WiMAX_802_16');</code>	
SET_DESCRIPTION	This function sets the system description string	
	<code>c = SetDescription(c, sDescription);</code>	
Input parameter	c	Input object
	sDescription	String containing the description of the system
Output parameter	c	Modified class
Example	<code>cOfdmSys = SetDescription(cOfdmSys, 'WiMAX 802.16');</code>	
SET_CONSTELLATION	This function sets a constellation vector	
	<code>c = SetConstellation(c, sName)</code> <code>c = SetConstellation(c, sName, vfcValue)</code>	
Input parameter	c	Input object
	sName	Name of the constellation
	vfcValue	Complex value with the constellation symbols. Can be omitted for unknown modulation areas
Output parameter	c	Modified object
Example	<code>cOfdmSys = SetConstellation(cOfdmSys, 'QPSK', 1/sqrt(2) * [1+j, -1+j, -1-j, 1-j]);</code>	
SET_CELL	This function defines one cell in the time frequency matrix (a specific cell of the OFDM system)	
	<code>c = SetCell(c, viSymbol, viCarrier, 'Zero')</code> <code>c = SetCell(c, viSymbol, viCarrier, 'Pilot', vfcValue)</code> <code>c = SetCell(c, viSymbol, viCarrier, 'Data', sConstName)</code> <code>c = SetCell(c, viSymbol, viCarrier, 'DontCare')</code>	
Input parameter	c	Input object
	viSymbol	Symbol numbers of cells
	viCarrier	Carrier numbers of cells
	'Pilot', vfcValue	Complex pilot values
	'Data', sConstName	Name of the data constellation
Output parameter	c	Modified object
Example	<code>cOfdmSys = SetCell(cOfdmSys, 4, [-26:-22, -20:-8, -6:-1, 1:6, 8:20, 22:26], 'Data', 'BPSK');</code>	
Special requirements	The Generic OFDM analyzer has a minimum requirement about the number and the location of the pilot cells: <ol style="list-style-type: none"> 1. The number of pilot cells must be at least 4 2. At least two different symbols must contain pilot cells 3. At least two different carriers must contain pilot cells 	

SET_PREAMBLE	This function sets the repetitive preamble parameters (optional parameter needed for time synchronization on preamble)	
	<code>c = SetPreamble(c, iBlockLength, iFrameOffset)</code>	
Input parameter	<code>c</code>	Input object
	<code>iBlockLength</code>	Length of one repetitive block in number of samples
	<code>iFrameOffset</code>	Offset of preamble start to frame start
Output parameter	<code>c</code>	Modified object
Example	<code>cOfdmSys = SetPreamble(cOfdmSys, 16, 0);</code>	
Special requirements	The definition of a repetitive preamble is optional and not necessary if cyclic prefix synchronisation is used. If the offset is zero or negative, the preamble is also contained within the frame and is used for further estimation processes.	
SAVE_CONFIG_FILE	This function generates and saves a configuration file from the current system configuration to be used within R&S FS-K96 Software.	
	<code>c = SaveConfigFile(c, sFileName)</code>	
Input parameter	<code>c</code>	Input object
	<code>sFileName</code>	File name of the configuration file
Output parameter	<code>c</code>	Modified object
Example	<code>SaveConfigFile(cOfdmSys, 'example.mat');</code>	
LOAD_CONFIG_FILE	This function configures the OfdmSys object from a configuration file.	
	<code>c = LoadConfigFile(c, sFileName)</code>	
Input parameter	<code>c</code>	Input object
	<code>sFileName</code>	File name of the configuration file
Output parameter	<code>c</code>	Modified object

7.1.2 Generate I/Q Data Files

The following part describes how to generate *.iqw-files (data format of R&S Signal Analyzers) and how to convert these files to *.wv-files (data format for arbitrary waveform generator of R&S Signal Generators). With this description the user obtains a complete R&S test solution for signal generation and analysis of generic OFDM signals.



7.1.2.1 I/Q data files for R&S Signal Analyzers (*.iqw-file) – ofdmsys_generator.m

The Matlab tools directory of R&S FS-K96 contains the file `ofdmsys_generator.m`. This file generates a test signal from a given configuration file and saves the signal as '*.iqw' (iiii,qqqq...) file for use in R&S FS-K96. This iqw-file is stored in the same directory as the `ofdmsys_generator.m` file and the filename equals the configuration file name with 'iqw' as file extension.

<code>Ofdmsys_generator.m</code>	This function generates an I/Q data file (iqw-file), which can be loaded into R&S FS-K96, from any configuration file	
	<code>vfcSignal = ofdmsys_generator(sConfigFileName, iNOFrames, iNOIdleSymbols)</code>	
Input parameter	<code>sConfigFileName</code>	Configuration file name
	<code>iNOFrames</code>	Number of frames to be generated
	<code>iNOIdleSymbols</code>	Number of idle symbols between bursts and at start and end of signal
Output parameter	<code>vfcSignal</code>	Generated signal vector
Examples	<pre>% Generation of a continuous signal ofdmsys_generator('example.mat', 2, 0); % Generation of a bursted signal ofdmsys_generator('example.mat', 2, 1);</pre>	

7.1.2.2 I/Q data files for R&S Signal Generators (*.wv-file) – mat2wv.m

R&S FS-K96 offers another helpful file within the Matlab tools directory: `mat2wv.m`. This file automatically converts the *.mat file into a *.wv file which can be used with R&S signal generators. This wv-file is stored in the same directory as the `mat2wv.m` file and the filename equals the mat file name with 'wv' as file extension.

To use this tool two steps have to be performed:

1. Execute `ofdmsys_generator.m` to obtain the generated signal vector `vfcSignal` out of the configuration file. This signal vector is needed in the second step.
2. Execute `mat2wv.m` to obtain the wanted *.wv file.

<code>mat2wv.m</code>	This function generates an I/Q data file (wv-file), which can be loaded into the arbitrary waveform generator of R&S Signal Generators, from a Matlab vector	
	<code>mat2wv(vfcSignal, sFilename, fSampleRate, bNormalize)</code>	
Input parameter	<code>vfcSignal</code>	Input data vector
	<code>sFilename</code>	Filename of the generated waveform file
	<code>fSampleRate</code>	Sample rate of the signal in Hz
	<code>bNormalize</code>	True: The signal is normalized by the max. magnitude False: The signal is not normalized. The maximum magnitude of the signal shall not exceed 1.0.
Examples	<pre>vfcSignal = ofdmsys_generator('example.mat', 2, 0); mat2wv(vfcSignal, 'example.wv', 11.2e6, True);</pre>	

Afterwards the signal can be loaded into the arbitrary waveform generator.

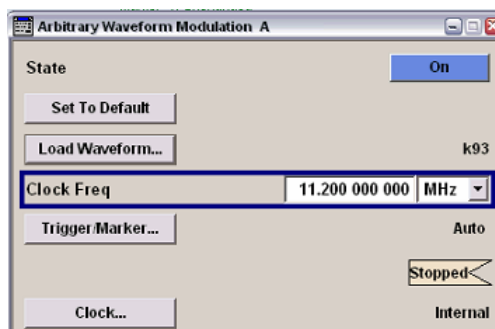


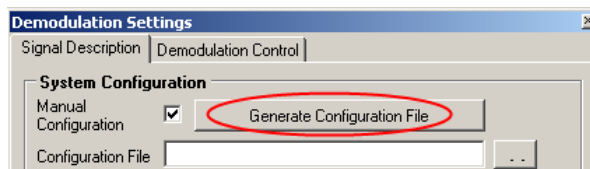
Fig. 64 Arbitrary Waveform Generator of R&S SMU200A

7.2 XML Configuration File Format

The OFDM configuration can be stored in an *.xml format which contains all the necessary information about the OFDM signal, e.g. number of carriers, used modulations, pilot symbol positions, etc..

In order to generate such a configuration file, Rohde&Schwarz provides the R&S FS-K96 Configuration File Wizard. Provided that you already have a signal that you want to measure, you can do a coarse timing synchronization of your signal. Using this sample signal, the R&S FS-K96 Configuration File Wizard helps you to extract the necessary OFDM system parameters.

First, capture the signal you want to measure and then go to **[MAIN] <DEMODO SETTINGS>** and select the “System Description” tab. Then, click on “Generate Configuration File”.



The following dialog will be shown, which displays all necessary settings for a burst detection and coarse timing synchronization:

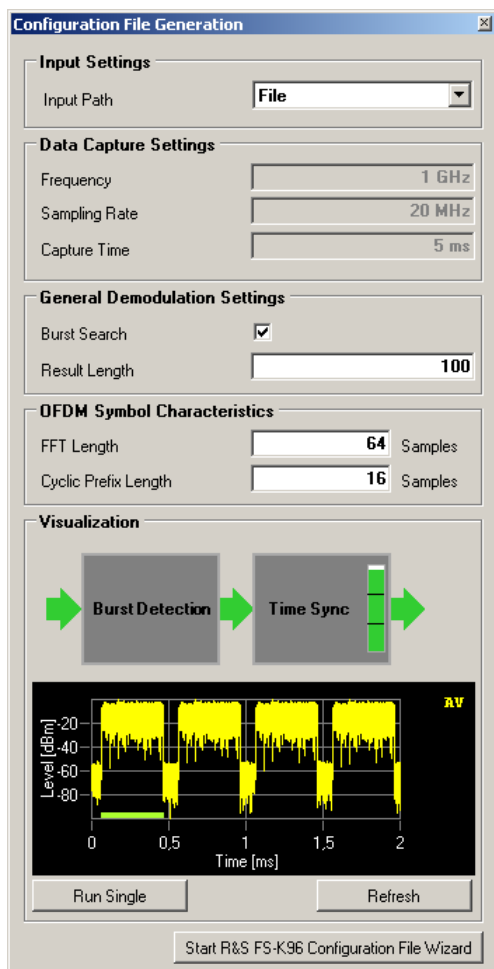


Fig. 65 Necessary Settings to Prepare the Data for the R&S FS-K96 Configuration File Wizard

Enter the necessary settings and use the Refresh button to check whether your *Time Sync* is accurate. Furthermore, if your signal is bursted, enter the correct number of symbols per frame, i.e. ensure that the green bar in the capture buffer preview covers the whole burst.



Fig. 66 Correct



Fig. 67 Incorrect

Subsequently, you can start the R&S FS-K96 Configuration File Wizard by clicking on the lower button. It will then start, preconfigured with your current signal and settings.

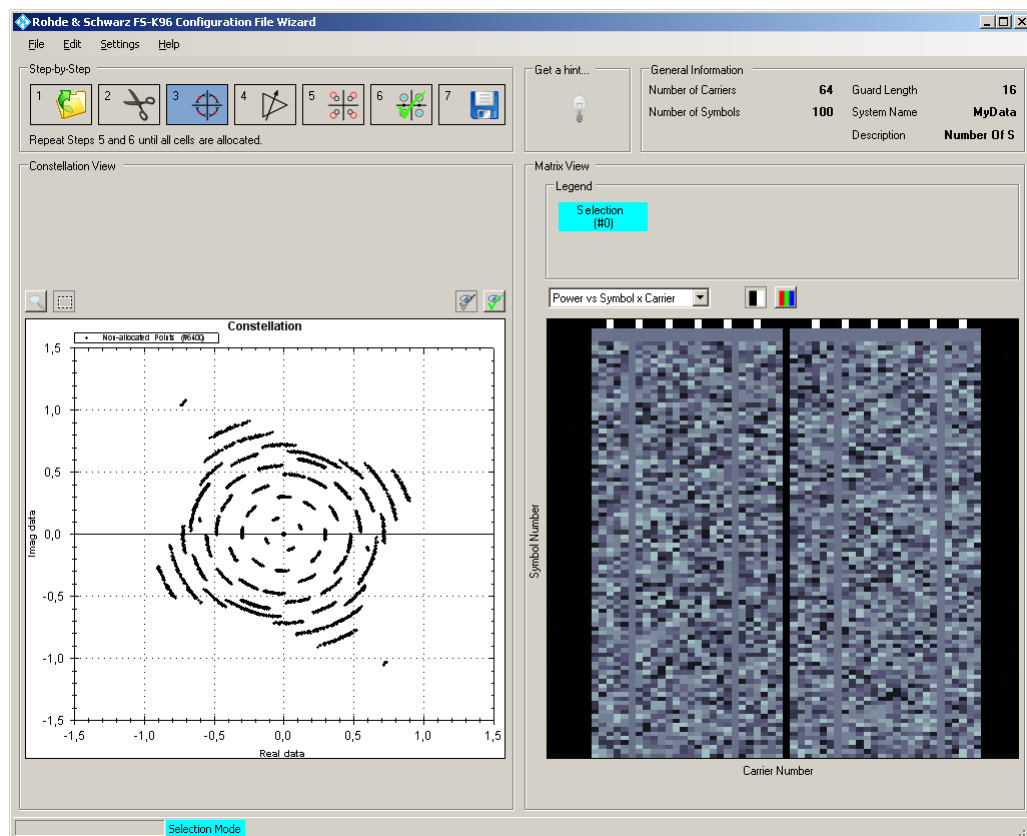


Fig. 68 R&S FS-K96 Configuration File Wizard.

7.2.1 Overview of the R&S FS-K96 Configuration File Wizard

The goal of the R&S FS-K96 Configuration File Wizard is to help you describe your signal. It enables allocation of pilot symbols and data symbols with a chosen modulation. After you have allocated all your cells, the R&S FS-K96 Configuration File Wizard can export an *.xml file that can later be loaded as configuration file into the R&S FS-K96 Software.

The GUI of the R&S FS-K96 Configuration File Wizard consists of five main areas:

1. **Step-by-Step:** The step-by-step bar guides the user through the necessary steps in generating a configuration file. Please note that steps 5 and 6 need to be repeated until all cells are allocated.
2. **Constellation View:** The constellation diagram on the left hand side visualizes the loaded signal in the I/Q plane. It is possible to zoom in and/or to select points that are then highlighted in the Matrix View area. Pressing the Ctrl-key on your keyboard, allows you to add further cells to your selection. The Constellation View area contains a toolbar. On the left hand side, you can toggle between zoom and selection mode. On the right hand side, you can choose which constellation points should be visible:



- Enabling the icon with the eye and the non-filled check displays all the constellation points that are not yet allocated.
 - Enabling the icon with the eye and the green filled check displays all the constellation points that are already allocated.
3. **Matrix View:** The matrix view area displays the 2D representation of the signal. The y-axis represents the time direction (unit: symbols), the x-axis represents the subcarriers. The matrix view can be toggled between “Frame Power” and “Allocation Matrix”. It is possible to select an area either by clicking the mouse or with the context menu. Pressing the Ctrl-key on your keyboard, allows you to add further cells to your selection. The cells within the selected area will then be highlighted in the Constellation View. The Frame Power matrix view contains a toolbar where you can choose between a black and white colormap and a jet colormap.



The Allocation Matrix view contains a toolbar where you can choose whether to show the highlighted constellation points in the allocation matrix



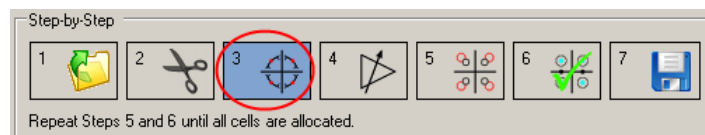
4. **General Information:** This area displays the general information on your system configuration. It is possible to choose a custom system name and system description by clicking on the entries. Both will later be stored in your configuration file.
5. **Hint Area:** Clicking on the “Light Bulb” icon, the software will give useful hints about the next steps that are necessary to generate a configuration file.

7.2.1.1 Quick Start Guide for the R&S FS-K96 Configuration File Wizard

This section will help you to quickly become familiar with the R&S FS-K96 Configuration File Wizard. A WLAN 802.11a signal is used as an example.

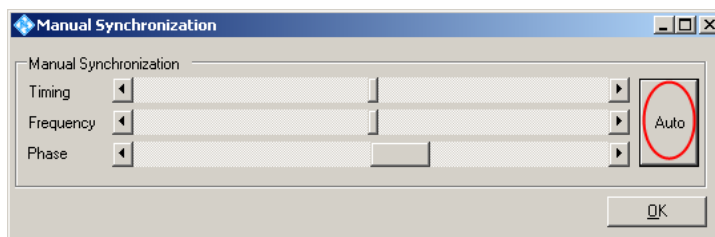
Start from Preset in the R&S FS-K96 Software and load the file `WlanA_64QAM.iqw` (you can find this file in your install directory in the folder `\SIGNALS`). Follow the steps as described in [XML Configuration File Format](#) and ensure that the settings in the R&S FS-K96 Software are according to the screenshot in [Fig. 65](#). Open the R&S FS-K96 Configuration File Wizard directly from the R&S FS-K96 Software.

Let us now focus on the step-by-step bar. Since you have started the R&S FS-K96 Configuration File Wizard directly from the R&S FS-K96 Software, it is already preconfigured with your signal. Hence, you can skip step 1. As the WLAN signal is a burst signal, you can assume that one frame is defined by one burst. Therefore, you can also skip step 2 and proceed straight to step 3.



Synchronization of the Signal (Step 3)

Click on the “Synchronization” icon, and subsequently on the *Auto* button of the shown dialog. The signal will automatically synchronize.



In the case that you work with a signal where the automatic synchronization fails, try to use the sliders to get a clear view of the constellation diagram:

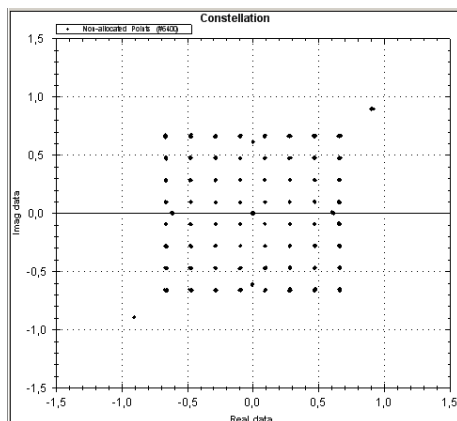
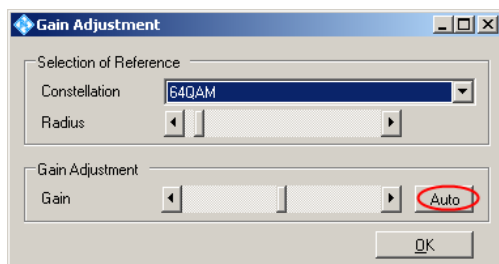


Fig. 69 Example of a constellation diagram for a synchronized WLAN signal.

Gain Adjustment (Step 4)

Click on the “Gain Adjustment” icon. The following dialog will be shown:



The goal of this step is to provide an overall scaling estimation for your signal. First, you have to decide on a reference constellation. By reference constellation, we refer to a constellation that occurs in several cells of your signal. It is recommended to decide on the constellation that occurs in *most* cells. You can easily find this constellation by making use of the selection mode and checking the number of highlighted cells in the Matrix View. For the current WLAN sample signal, the best reference constellation is 64QAM. After you have selected 64QAM as reference constellation, press the *Auto* button to perform automatic gain estimation. The result of this step is that all constellation points belonging to the reference constellation are approximately in the center of the constellation markers.

In the case that you work with a signal where the automatic gain correction fails, try to adjust the radius and click on the *Auto* button again. If the automatic gain correction still fails, try another reference constellation or use the *Gain* slider to center the points in the constellation markers manually.

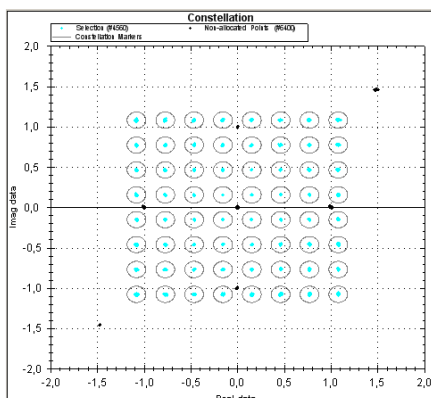
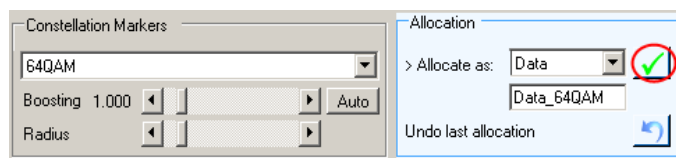



Fig. 70 Example of a Constellation Diagram for a Synchronized WLAN Signal after the Gain Synchronization.

Cell Selection and Allocation (Step 5 and 6)

Your next goal is to allocate selected points as pilot symbols, data symbols, “zeros” or “Don’t care” symbols. You should already have selected constellation points from the gain synchronization procedure. Check their position in the “Frame Power” matrix and decide whether they are pilot symbols or data symbols. Go to step 6, and look at the colored area of the GUI. There, you can choose your allocation type. For the WLAN sample signal, you should allocate the 64QAM cells as data symbols. Optionally, you can assign a name to this specific allocation by typing into the text box. Then, click on the “Check” icon to actually do the allocation.



The constellation cells that have just been allocated will now disappear from the Constellation View. You can toggle their visibility by using the  icon. Note that you can also overwrite already allocated cells with another allocation.

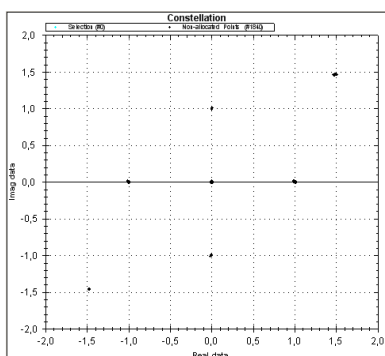


Fig. 71 Example of a Constellation Diagram for a Synchronized WLAN Signal after the Allocation of the 64QAM Cells as Data Symbols.

Now go back to step 5 and proceed with the allocation of the residual points, e.g. choose “Zero” as “Constellation Marker” and allocate the constellation points in the center of the diagram as “Zero” symbols (step 6).

Go back again to step 5 and investigate the remaining points shown in the Constellation View. For the WLAN sample signal, you can select the BPSK symbols with the mouse. When taking a look at the Allocation Matrix, you will see that these BPSK symbols are used at the very beginning of the frame and at certain carriers. From this information, you can conclude that these symbols are probably pilot symbols.

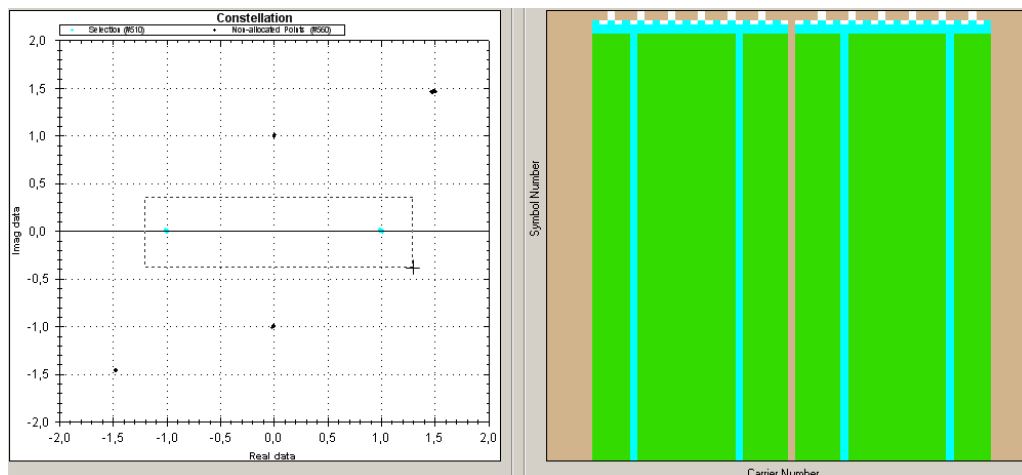


Fig. 72 Selection of the BPSK Symbols with the Mouse.

Hence, you can select BPSK constellation markers and allocate these cells as pilot symbols.

If you have worked with the WLAN sample signal, you will now have very few cells left for allocation. Go back to step 5, select all residual cells with the mouse in the Constellation View and allocate these cells as “Don’t Care” symbols (step 6). For “Don’t Care” symbol, no EVM will be calculated in the R&S FS-K96 Software.

The R&S FS-K96 Configuration File Wizard will now prompt that you have allocated all your cells.

Saving the Configuration File (Step 7)

Click on the “Save” icon. Choose a filename for your configuration file and save your file. If you have started the R&S FS-K96 Configuration File Wizard directly from the R&S FS-K96 Software, the software will ask you whether you want to immediately import your newly generated configuration file into the R&S FS-K96 Software. The R&S FS-K96 Software will then do an automatic refresh.



Boosting

In the case that you do not find a constellation marker type that matches the constellation points (step 5), you may try to use the boosting slider to scale the constellation markers or manually enter the boosting factor of the constellation by double-clicking on the boosting value.

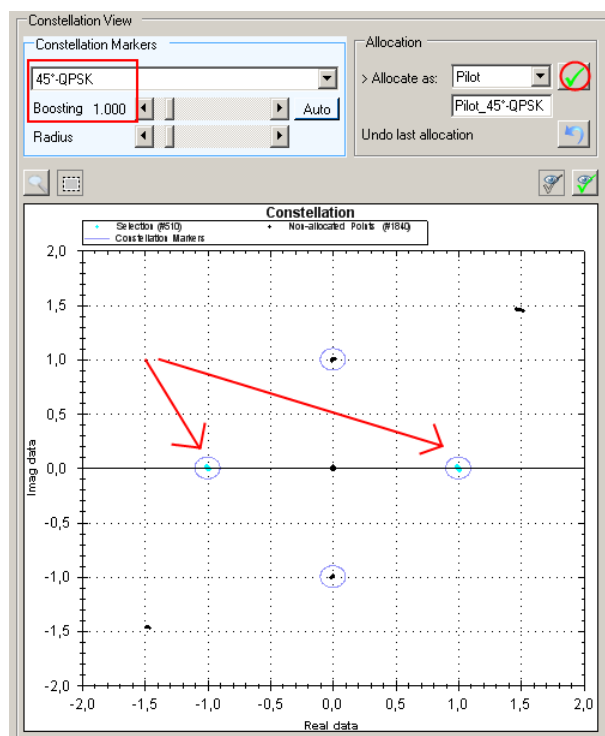


Selecting cells with the mouse

You can manually select cells with the mouse. Press the Ctrl-key to add further cells to the selection.

Selecting cells with the mouse is not only useful for the allocation of “Don't Care” symbols (cf. Step 5 and 6 in the Quick Start Guide). You can also use the mouse to select cells and later allocate them as “Data Symbols” or “Pilot Symbols”. Then, the current modulation type and boosting factor will be stored for these cells.

Example: Clicking on the “Check” icon will allocate only the highlighted cells as 45°-QPSK pilot symbols with boosting factor 1.



7.2.2 Generate I/Q Data Files

The following part describes how to generate *.iqw-files (data format of R&S Signal Analyzers) and *.wv-files (data format for arbitrary waveform generator of R&S Signal Generators). With this description the user obtains a complete R&S test solution for signal generation and analysis of generic OFDM signals.

The R&S FS-K96 Configuration File Wizard offers the possibility to generate an ideal OFDM signal based on a loaded xml configuration file or based on the allocation of a loaded input signal.

Start the signal generation over the file menu and choose “Generate Test Signal”.

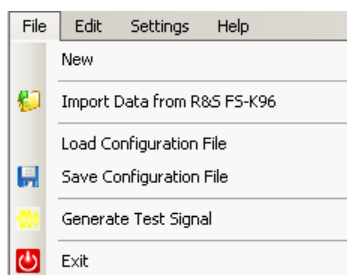


Fig. 73 File Menu of the R&S FS-K96 Configuration File Wizard

For an example WLAN signal, the dialog could then look like displayed in Fig. 74.

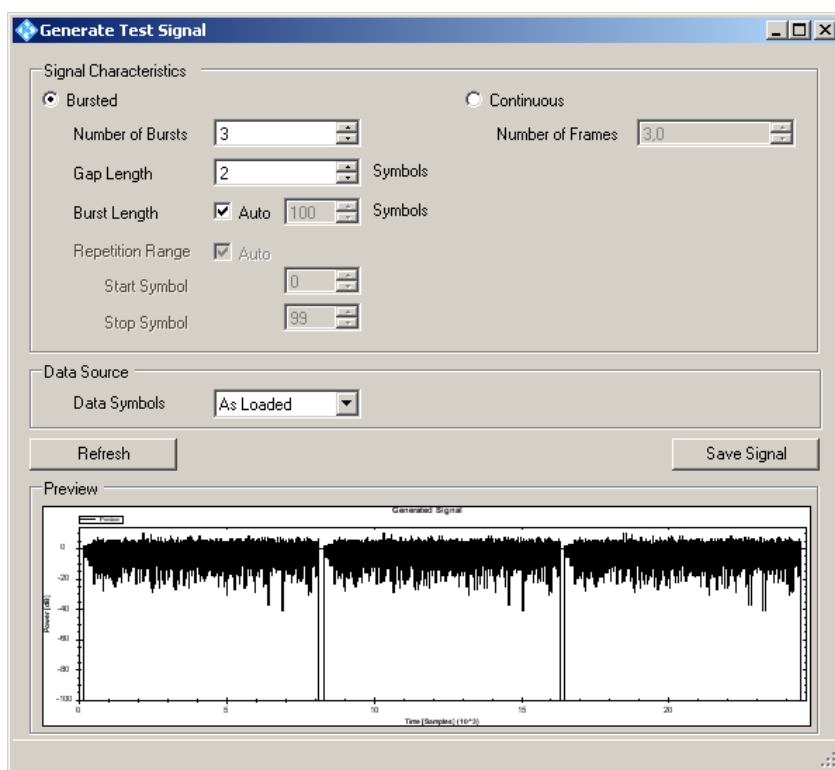


Fig. 74 Signal Generation Dialog of the R&S FS-K96 Configuration File Wizard

In the dialog, contains the following parameters for the generation of bursted signals:
Number of Bursts: Specifies how many bursts are to be generated for the I/Q data file. The file always starts with the ramp of the first burst.

Gap Length: Specifies how many idle symbols are supposed to be between adjacent bursts.

Burst Length: Specifies the length of one single burst. If the burst length is set to automatic, it will coincide with the length of one frame in the configuration file. If the burst length is shorter than the frame length, the last symbols of the frame will be ignored for signal generation. If the burst length is to be larger then the frame length, it is recommended to specify a so-called repetition range.

Repetition Range: The repetition range can only be set if the burst length is larger than the specified frame length. In this case, the signal to be generated contains more data symbols then specified in the configuration file. If the repetition range is set to automatic, it will start with the first data symbol and end with the last symbol of the frame. This functionality is especially important for signals that start with a preamble, e.g. WLAN. Please refer to Fig. 75 and Fig. 76 for an example.

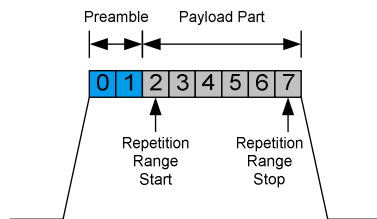


Fig. 75 Original Signal

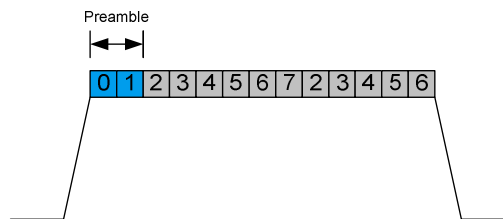


Fig. 76 Signal to Be Generated (Burst Length is 13 symbols)

For a continuous signal, only one parameter needs to be set.

Number of Frames: Specifies the number of OFDM frames that are to be generated. The signal always starts with the first symbol of one frame.

Both, bursted and continuous signals require that the data source is specified.

Data Source: Can be set to “Random” or “As Loaded”. If it is set to “Random”, new random data is loaded for the data symbols, if refresh is clicked. If it is set to “As Loaded”, the signal generation function maintains the data symbols that have been initially loaded. These data symbols can come from an original signal that has been loaded into the R&S FS-K96 Configuration File Generator and where all the cells have been allocated.

Use the “Save Signal” button to generate the OFDM signal and save it to file. Be aware that the I/Q data is stored with an oversampling of one. In the case you want to play the signal with an R&S Signal Generator, it is recommended to upsample it in Matlab. Please refer to [I/Q data files for R&S Signal Generators \(*.wv-file\) – mat2wv.m](#) for details on the required I/Q data format.

8 Measurements in Detail

This section provides a detailed explanation of the measurements provided by the OFDM-VSA and provides help to measure the characteristics of specific types of DUT.

8.1 Signal Processing

8.1.1 Data Capturing

The analyzer software runs on an external PC and operates a signal analyzer by remote control via LAN or GPIB. Several mixer stages convert the RF signal to an intermediate frequency (IF), which is digitized by an A/D converter. The signal processing following the A/D converter is implemented in digital hardware with ASICs and FPGAs. A numerically controlled oscillator shifts the signal from IF to complex baseband, followed by a halfband filter and a fractional resampler. Arbitrary output sample rates can be set by programming the resampler combined with a subsequent decimation filter.

Alternatively to the use of the RF input, analog baseband signals can be digitized directly (R&S FSQ-B71). Additionally, a digital I/Q interface R&S FSQ-B17 or R&S FSV-B17 is available to analyze digital baseband signals without having to make use of analog components. The block diagrams in Fig. 77 shows the R&S FSQ analyzer hardware from the IF section to the processor running the OFDM-VSA downlink measurement.

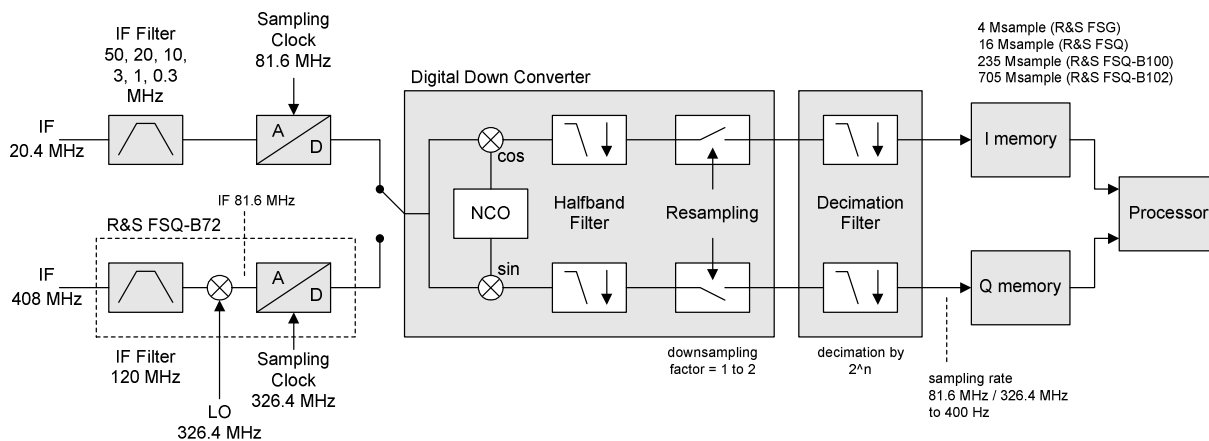


Fig. 77 Data Capturing Mechanism of the R&S FSQ

8.1.2 Channel Filter

The FS-K96 can use the internal channel filter of the instrument or apply an adjustable lowpass filter. Table 2 lists the filter bandwidths of the internal channel filter, which are fully equalized within the digital hardware.

Table 2 Internal analyzer bandwidth depending on the target sampling rate

	sampling rate	bandwidth	max. bandwidth
R&S FSQ	400 Hz to 81.6 MHz	0.8 x sampling rate	28 MHz w/o R&S FSQ B72
	81.6 MHz to 326.4 MHz with R&S FSQ B72	0.68 x sampling rate	120 MHz with R&S FSQ B72
R&S FSG	400 Hz to 81.6 MHz	0.8 x sampling rate	28 MHz w/o R&S FSQ B72
R&S FSV	100 Hz to 32 MHz	0.8 x sampling rate	
	32 MHz to 45 MHz	0.625 x sampling rate	28 MHz w/o R&S FSV B70
	45 MHz to 128 MHz with R&S FSV B70	0.625 x sampling rate	40 MHz with R&S FSV B70
R&S FSVR	100 Hz to 32 MHz	0.8 x sampling rate	
	32 MHz to 128 MHz	0.625 x sampling rate	40 MHz
R&S FSW	100 Hz to 200 MHz	0.8 x sampling rate (for 100 Hz < sampling rate <= max. bandwidth / 0.8) max. bandwidth (for sampling rate > max. bandwidth / 0.8)	10 MHz
			28 MHz with R&S FSW B28
			40 MHz with R&S FSW B40
			80 MHz with R&S FSW B80
			160 MHz with R&S FSW B160

Alternatively to the internal filters, a lowpass filter with adjustable bandwidth and slope characteristics can be applied to the input signal. A window-based finite impulse response filter is designed. The bandwidth is defined as two times the 6 dB cutoff frequency and the filter order determines the slope characteristics. Three predefined filter slopes and a manual input of the filter order are available.

Choosing the correct filter order is a trade-off between selectivity and filter impulse response length. A high filter order leads to superior selectivity between adjacent channels. On the other hand, such a filter has a long channel impulse response, which can produce intersymbol interference if used in systems with small guard intervals. Low filter orders require a higher distance between channels and will possibly attenuate the outer carriers of the signal. In contrast, the channel impulse response is short and suited for systems with short guard intervals.

The adjustable lowpass filter performs a decimation at its output. So the maximum output sample rate, which can be set in the General Settings menu, is reduced compared to the internal filter setting.

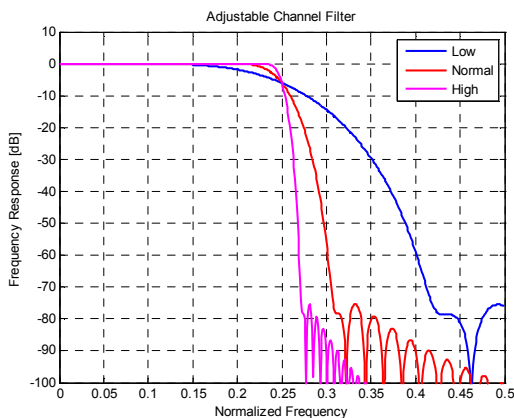


Fig. 78 Channel Filter Frequency Responses Depending on the Filter Order

8.1.3 OFDM Measurement

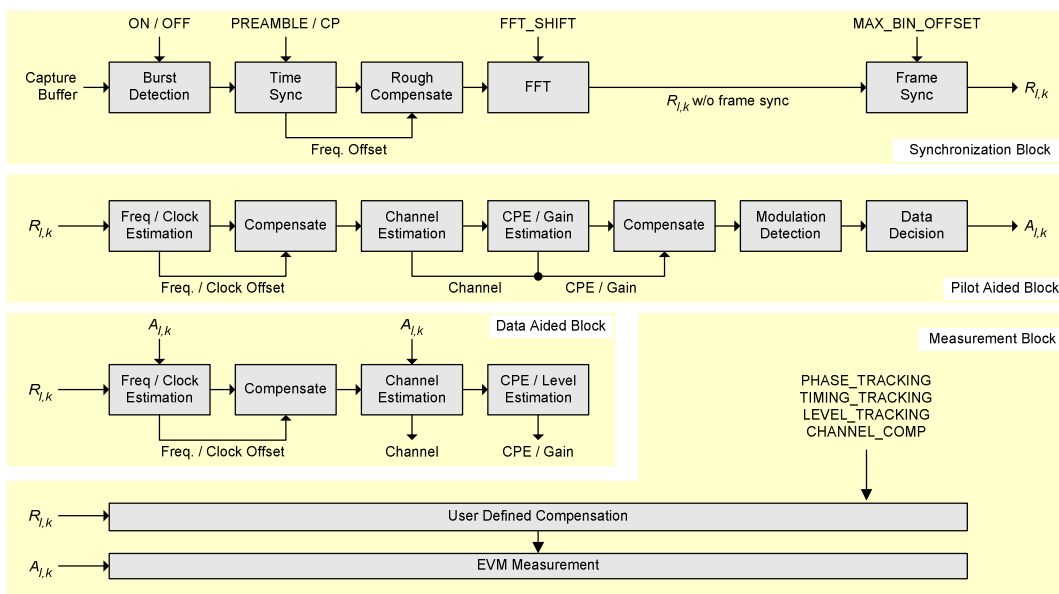


Fig. 79 Block Diagram of the FS-K96 OFDM Measurement

The block diagram in Fig. 79 shows the OFDM-VSA measurement from the capture buffer containing the I/Q data to the actual analysis block. The signal processing chain can be divided in four major blocks:

- Synchronization Block
- Pilot Aided Block
- Data Aided Block
- Measurement Block

8.1.3.1 Synchronization Block

The synchronization starts with a burst detection that extracts transmission areas within a burst signal by a power threshold. For seamless transmission, as is the case in most broadcast systems, it is possible to bypass this block. The following time synchronization uses either the preamble or the cyclic prefix of each OFDM symbol to find the optimum starting point for the FFT by a correlation metric. If preamble synchronization is selected, the correlation is done between successive blocks of a repetitive preamble structure. Alternatively, the cyclic prefix synchronization correlates the guard interval of each symbol with the end of the FFT part. Both methods additionally return an estimation of the fractional frequency offset by evaluating the phase of the correlation maximum. This frequency offset has to be compensated before the FFT to avoid intercarrier interference.

By default, the FFT starting point is put in the center of the guard interval assuming a symmetric impulse response, but it can optionally be shifted within the guard interval. After performing the FFT for each available OFDM symbol, a time-frequency matrix $R_{l,k}$ with symbol index l and subcarrier index k is available.

The following frame synchronization determines the frame start within this matrix and

the integer carrier frequency offset. This is done by a two dimensional correlation of $R_{l,k}$ with the known pilot matrix from the configuration file. To avoid unnecessary computing time for signals with low frequency offset, the search length in the frequency direction can be limited by a control parameter.

8.1.3.2 Pilot Aided Block

The pilot aided block within the signal processing chain uses the predefined pilot cells for parameter estimation and subsequent compensation of the signal impairments. It starts with maximum likelihood estimation of the remaining frequency error and sample clock offset. While a frequency error leads to a phase offset linearly increasing with time, the clock offset introduces an additional phase error linearly increasing with frequency. The estimator determines the most probable parameters that lead to the phase offsets observed on the pilot cells. The resulting offset values are compensated in the frequency domain by re-rotating the phase of the $R_{l,k}$ matrix. However, for severe clock offsets it can be necessary to resample the received signal in the time domain and repeat the FFT stage.

The subsequent channel estimator determines the channel transfer function at the known pilot positions and uses interpolation to get a complete frequency response vector for all subcarriers. Since the presented measurement system is intended for stationary channels, the interpolation is performed along the frequency direction only. The node values on the frequency axis are determined by averaging all available pilots of each subcarrier over time. Depending on the layout of the pilots on the frequency axis, an interpolation filter bank with optimum Wiener filter coefficients is calculated in advance. The Wiener filter is designed under the assumption that the maximum impulse response length does not exceed the cyclic prefix length.

Although the channel is assumed to be stationary, common phase error and power level variations are estimated symbol by symbol over the complete frame. This takes settling effects of oscillators and power amplifiers into account. All estimated impairments are fully compensated to get an optimum signal for the subsequent modulation-detection and data decision stage.

The modulation-detection block determines the modulation type of the data cells. Either each carrier or each symbol can be assigned to one specific constellation. Alternatively, the modulation information provided in the configuration file is evaluated to extract clusters of data cells with consistent modulation. The estimator uses a maximum likelihood approach, where each cluster of data cells is compared with all possible modulation hypotheses and the most probable constellation for each cluster is used for the subsequent data decision. The data decision block finally outputs a reference signal matrix $A_{l,k}$ which is an optimum estimate of the actual transmitted OFDM frame.

8.1.3.3 Data Aided Block

The data aided block can be activated optionally to refine the parameter estimations with the help of the reference signal. Whereas the previous stages could only include pilot cells for the estimation algorithms, the data aided part can treat data cells as additional pilots. This increases the accuracy of the estimates in good signal to noise environments without data decision errors. However, if the reference signal matrix $A_{l,k}$

contains falsely decided data cells, the data aided estimation part can corrupt the results and should be omitted.

8.1.3.4 Measurement Block

The last part of the signal processing chain comprises the user defined compensation and the measurement of modulation quality. The measurement block takes the received OFDM symbols $R_{l,k}$ and the previously determined reference OFDM symbols $A_{l,k}$ to calculate the error vector magnitude (EVM). The received OFDM symbols can optionally be compensated by means of phase, timing and level deviations as well as the channel transfer function.

8.2 Measurement Result Definitions

8.2.1 Error Vector Magnitude (EVM)

The EVM of a cell (symbol number l , carrier number k) is defined as

$$EVM_{l,k} = \sqrt{\frac{|r_{l,k} - a_{l,k}|^2}{P_{norm}}}$$

where

- $r_{l,k}$ is the received symbol point in the complex plane of symbol number l and carrier number k .
The received symbol point is compensated by phase and clock errors as well as channel transfer function according to the user settings.
- $a_{l,k}$ is the ideal symbol point in the complex plane of symbol number l and carrier number k .
 P_{norm} is a normalization value that can be set in four different ways

Normalize EVM to	P_{norm}
RMS Pilots & Data	$\frac{1}{N_{pilot} + N_{data}} \sum_{\substack{l,k \in \\ Pilot, \\ Data}} a_{l,k} ^2$
RMS Data	$\frac{1}{N_{data}} \sum_{\substack{l,k \in \\ Data}} a_{l,k} ^2$
RMS Pilots	$\frac{1}{N_{pilot}} \sum_{\substack{l,k \in \\ Pilot}} a_{l,k} ^2$
None	1.0

- N_{pilot} is the number of pilot cells
- N_{data} is the number of data cells

8.2.2 I/Q Impairments

The I/Q imbalance can be written as

$$r(t) = G_I \cdot \Re\{s(t)\} + j \cdot G_Q \cdot \Im\{s(t)\}$$

where $s(t)$ is the transmit signal, $r(t)$ is the received signal, and G_I and G_Q are the weighting factors.

Variable	Meaning	Definition from Transmitter Model
G_I	Gain I-branch	1
G_Q	Gain Q-branch	$1 + \Delta Q$ (complex)

$$\text{Gain-Imbalance} = 20 \log \left(\frac{|G_Q|}{|G_I|} \right) \text{ dB}$$

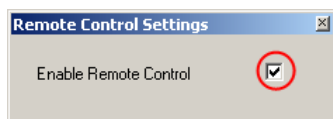
$$\text{Quadrature-Error} = \arctan \left(\frac{\text{Im}\{G_Q\}}{\text{Re}\{G_Q\}} \right) \cdot 180^\circ / \pi$$

9 Remote Control

9.1 Enabling Remote Control

The remote control functionality of the FS-K96 Software is disabled after installing the software. It has to be enabled once by the following sequence:

1. Start the FS-K96 Software and press [**SETUP**]
2. Enable the remote control functionality via the `<REMOTE CONTROL SETTINGS>` softkey.



9.2 General Setup

In order to remote control the FS-K96 Software, you need to establish a connection between your remote scripting tool and the software. Since the FS-K96 Software runs directly on your PC and not on an R&S instrument, you need to connect your remote scripting tool to your PC and not to the instrument.

1. Start the FS-K96 Software on your PC.
2. If you want to capture I/Q data from an instrument, connect the FS-K96 Software to this instrument.
3. Start the remote scripting tool (e.g. Matlab) on your PC.
4. Connect your remote scripting tool to the local host, e.g. "TCPIP::localhost".

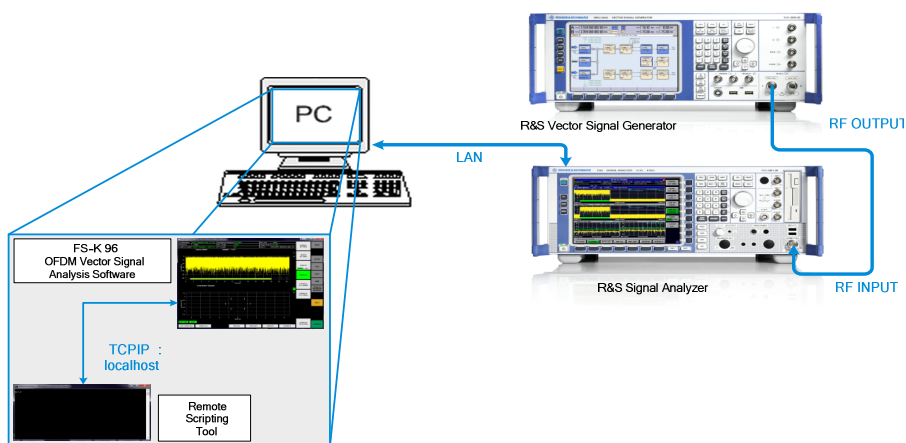


Fig. 80 Example Setup for Remote Controlling the FS-K96 Software



Remote Control Example

In the subfolder `%Application path%\TOOLS\MATLAB`, you can find an example Matlab script (`remote_example.m`) for remote controlling the FS-K96 Software.

9.3 Description of Commands

This section specifies all the remote control commands specific to the OFDM-VSA option. Only those commands provided for this option are specified. For details of remote control commands provided by the host analyzer please refer to the analyzer user manual.

9.3.1 Notation

In the following sections, all commands implemented in the software are first listed in tables and then described in detail, arranged according to the command subsystems. The notation is adapted to the SCPI standard. The SCPI conformity information is included in the individual description of the commands.

Table of Command

Command:	In the command column, the table provides an overview of the commands and their hierarchical arrangement (see indentations).
Parameter:	The parameter column indicates the requested parameters together with their specified range.
Unit:	The unit column indicates the basic unit of the physical parameters.
Comment:	In the comment column an indication is made on: <ul style="list-style-type: none"> – whether the command does not have a query form, – whether the command has only one query form – whether the command is implemented only with a certain option of the instrument

Indentations

The different levels of the SCPI command hierarchy are represented in the table by means of indentations to the right. The lower the level, the further the indentation to the right. Please note that the complete notation of the command always includes the higher levels as well.

Example: `SENSe:FREQuency:CENTer` is represented in the table as follows:

<code>SENSe</code>	first level
<code> :FREQuency</code>	second level
<code> :CENTer</code>	third level

Individual description

The individual description contains the complete notation of the command. An example for each command, the *RST value and the SCPI information are included as well.

Upper/lower case notation

Upper/lower case letters are used to mark the long or short form of the key words of a command in the description. The instrument itself does not distinguish between upper and lower case letters.

Special characters

A selection of key words with an identical effect exists for several commands. These keywords are indicated in the same line; they are separated by a vertical stroke.

Only one of these keywords needs to be included in the header of the command. The effect of the command is independent of which of the keywords is used.

Example: `SENSe:FREQuency:CW|:FIXed`

The two following commands with identical meaning can be created. They set the frequency of the fixed frequency signal to 1kHz:

```
SENSe:FREQuency:CW 1E3 =
SENSe:FREQuency:FIXed 1E3
```

A vertical stroke in parameter indications marks alternative possibilities in the sense of "or". The effect of the command is different, depending on which parameter is used.

Example: Selection of the parameters for the command

```
DISPlay:FORMat FULL | SPLit
```

If parameter FULL is selected, full screen is displayed, in the case of SPLit, split screen is displayed.

[] Key words in square brackets can be omitted when composing the header (cf. Section 3.5.2, Optional Keywords). The full command length must be accepted by the instrument for reasons of compatibility with the SCPI standards. Parameters in square brackets can be incorporated optionally in the command or omitted as well.

{ } Parameters in braces can be incorporated optionally in the command, either not at all, once or several times.

Description of parameters Due to the standardisation, the parameter section of SCPI commands consists always of the same syntactical elements. SCPI has therefore specified a series of definitions, which are used in the tables of commands. In the tables, these established definitions are indicated in angled brackets (<...>) and will be briefly explained in the following.

<boolean> This keyword refers to parameters which can adopt two states, "on" and "off". The "off" state may either be indicated by the keyword OFF or by the numeric value 0, the "on" state is indicated by ON or any numeric value other than zero. Parameter queries are always returned the numeric value 0 or 1.

<numeric value> These keywords mark parameters which may be entered as numeric values

9.4 Common Commands

*RST

RESET sets the FS-K96 Software and the connected instrument to a defined default status. The command essentially corresponds to pressing the *PRESET* key. The default setting is indicated in the description of the commands.

Example

```
*RST
'Resets the FS-K96 Software and the connected instrument.'
```

***IDN?**

IDENTIFICATION QUERY queries the OFDM-VSA identification.

Example:

```
*IDN?
'Returns 'Rohde&Schwarz,K96,000000/000,Version x.x''
```

9.5 CALCulate Subsystem

CALCulate<1|2>:FEED

This command can be used to set or get the measurement-data currently displayed on the selected screen A or B.

Parameters

Parameter-String	Measurement-Data-Type
POW:PVSC	Power versus Symbol X Carrier
POW:PVCA	Power versus Carrier
POW:PVSY	Power versus Symbol
POW:CBUF	Capture Buffer
POW:PSPE	Power Spectrum
EVM:EVSC	EVM versus Symbol X Carrier
EVM:EVCA	EVM versus Carrier
EVM:EVSY	EVM versus Symbol
EVM:FERR	Frequency Error
EVM:PERR	Phase Error
CHAN:FLAT	Channel Flatness
CHAN:GDEL	Group Delay
CHAN:IRES	Channel Impulse Response
CONS:CONS	Constellation Diagram
CONS:CVCA	Constellation versus Carrier
CONS:CVSY	Constellation versus Symbol
STAT:CCDF	CCDF
STAT:SFLO	Signal Flow
STAT:REPT	Report

Example

```
CALC2:FEED 'POW:CBUF'
'Select Capture-Buffer to be displayed on screen B.
```

9.6 CONFigure Subsystem

The CONFigure subsystem contains commands for configuring complex measurement tasks. The CONFigure subsystem is closely linked to the functions of the FETCH subsystem, where the measurement results of the measurements are queried.

```
CONFigure:ADDRess <string>
CONFigure:POWer:AUTO ON | OFF | ONCE
CONFigure:POWer:AUTO:SWEEP:TIME <numeric value>
CONFigure:PREamble:BLENGTH <numeric value>
CONFigure:PREamble:FOFFset <numeric value>
CONFigure[:SYMBOL]:GUARD:MODE CONV | GU2
CONFigure[:SYMBOL]:GUARD<1|2>: NSYMBOLS <numeric value>
CONFigure[:SYMBOL]:GUARD: PERiodic <boolean>
CONFigure[:SYMBOL]:NFFT <numeric value>
CONFigure[:SYMBOL]:NGUARD<1|2> <numeric value>
CONFigure:SYSTEM:MANual
```

CONFigure:ADDRess <string>

This remote control command defines the network address of the signal analyzer. The string specifies a VISA resource descriptor.

Interface	Descriptor	Descriptor parameters
GPIB Instrument	GPIB[board]:: primary address [:INSTR]	GPIB board number (optional – typically skipped) Instrument primary GPIB address (0...31)
LAN VXI-11 protocol	TCPIP[board]:: host address [:LAN device name] [:INSTR]	TCP/IP board number (optional – typically skipped) Host address as TCP/IP address or computer name Device name (optional, default: inst0)
LAN RSIB protocol	RSIB:: host address [:INSTR]	RSIB protocol Host address as TCP/IP address or computer name

Example

```
CONF:ADDR 'TCPIP::192.168.1.1::INSTR'
```

Characteristics

*RST value -

CONFigure:POWer:AUTO ON | OFF | ONCE

This remote control command is used to switch on or off automatic power level detection. When switched on, power level detection is performed at the start of each measurement sweep. If this command is issued with the ONCE parameter, the auto level routine is immediately performed one time regardless of the current state of this parameter (ON or OFF).

Example

```
CONF:POW:AUTO 1
'Automatic detection of the input power level.
```

Characteristics

*RST value: ON

CONFigure:POWer:AUTO:SWEep:TIME <numeric value>

This remote control command is used to specify the sweep time for the automatic power level detection.

Example

```
CONF:POW:AUTO:SWE:TIME 200MS
'The auto power detect measurement will use a sweep time of 200 ms
```

Characteristics

*RST value: 100 ms

CONFigure:PREamble:BLENght <numeric value>

This command specifies the length of one block within a repetitive preamble symbol.

Example

```
CONF:PRE:BLEN 32
'Specifies the block length to 32 samples.
```

Characteristics

*RST value: 0

CONFigure:PREamble:FOFFset <numeric value>

This command defines the distance from the first preamble sample to the first sample of the frame.

Example

```
CONF:PRE:FOFF 0
'The frame starts with the first preamble sample.
```

Characteristics

*RST value: 0

CONFigure[:SYMBOL]:GUARd:MODE CONV | GU2

This command selects the cyclic prefix configuration of the OFDM demodulation. The cyclic prefix mode is either conventional (CONV) or considers two different cyclic prefix lengths (GU2).

Example

```
CONF:GUAR:MODE CONV
```

Characteristics

*RST value: CONV

CONFigure[:SYMBOL]:GUARd<1|2>: NSYMBOLs <numeric value>

This command defines the number of symbols in the first and second cyclic prefix range. The command can only be used if the cyclic prefix mode is non-conventional. Furthermore, the command can only be used with the suffix "2", if the cyclic prefix ranges are periodic.

Example

```
CONF:SYMB:GUAR2:NSYM 6
```

Characteristics

*RST value: -

CONFigure[:SYMBOL]:GUARd: PERiodic <boolean>

This command switches between the periodic and non-periodic cyclic prefix ranges. The command can only be used if the cyclic prefix mode is non-conventional.

Example

```
CONF:SYMB:GUAR:PER ON
```

Characteristics

*RST value: OFF

CONFigure[:SYMBOL]:NFFT <numeric value>

This command specifies the FFT length of an OFDM symbol.

Example

```
CONF:SYMB:NFFT 1024
```

'Specifies the FFT length to 1024 samples.

Characteristics

*RST value 64

CONFigure[:SYMBOL]:NGUard<1|2> <numeric value>

This command specifies the guard length of the OFDM symbol. The guard interval contains the cyclic prefix. In the non-conventional cyclic prefix mode, the second guard lengths is defined with the suffix 2.

Example

```
CONF:SYMB:NGU 128
'Specifies the guard length to 128 samples.
```

Characteristics

*RST value: 16

CONFigure:SYSTEM:MANual

This command switches the OFDM system configuration to manual mode, if a configuration file was previously loaded.

Example

```
CONF:SYST:MAN
```

Characteristics

*RST value: ON

9.7 DISPlay Subsystem

```
DISPlay:FORMat SPL | SING
```

```
DISPlay[:WINDow<1|2>]:SElect
```

```
DISPlay[:WINDow<1|2>]:SSElect
```

```
DISPlay[:WINDow<1|2>]:TABLe <boolean>
```

```
DISPlay[:WINDow<1|2>]:TRACe<1...3>:Y[:SCALe]:RLEVel[:RF] <numeric value>
```

```
DISPlay[:WINDow<1|2>]:TRACe<1...3>:Y[:SCALe]:RLEVel:OFFSet <numeric value>
```

DISPlay:FORMat SPL | SING

This command sets the visible screen display type to full or split screen.

Example

```
DISP:FORM SING
'Sets the display to full screen.
```

Characteristics

*RST value: SPL

DISPlay[:WINDow<1|2>]:SElect

This command selects whether screen A or screen B is active.

Example

```
DISP:WIND1:SEL
'Sets the screen A active.
```

Characteristics

*RST value: -

DISPlay[:WINDow<1|2>]:SSElect

This is an alias for DISPlay:WINDow[1|2]:SElect. SSElect means Screen SElect.

Example

```
DISP:WIND1:SSEL
'Sets the screen A active.
```

Characteristics

*RST value: 1

DISPlay[:WINDow<1|2>]:TABLe <boolean>

This command selects whether the results summary table is displayed

Example

```
"DISP:WIND1:TABL 0
'Hides the results table
```

Characteristics

*RST value: 0

DISPlay[:WINDow<1|2>]:TRACe<1...3>:Y[:SCALE]:RLEVel[:RF] <numeric value>

This remote control command can be used to retrieve or set the current internal instrument reference level for RF input used when performing measurements. The numeric suffix at WINDow<1|2> and TRACe<1 to 3> are irrelevant.

Example

```
"DISP:TRAC:Y:RLEV?
'Returns the current RF reference level in use

DISP:TRAC:Y:RLEV -20
'Sets the instrument reference level to -20 dBm
```

Characteristics

*RST value: 0 dBm

DISP:WINDow<1|2>:TRACe<1...3>:Y[:SCALe]:RLEVel:OFFSet <numeric value>

This remote control command specifies the external attenuation/gain applied to measurements. The value corresponds to the reference level offset in the spectrum analyzer mode. The numeric suffix at WINDow<1|2> and TRACe<1 to 3> are irrelevant.

Example

```
DISP:TRAC:Y:RLEV:OFFS 10
External attenuation (level offset) of the analyzer is 10 dB

DISP:TRAC:Y:RLEV:OFFS -10
'External attenuation of the analyzer is -10 dB. i.e. a gain
of 10 dB
```

Characteristics

*RST value: dB

9.8 FETCh Subsystem

```
FETCh:SUMMARY:EVM[:ALL][:AVERAGE]?
FETCh:SUMMARY:EVM[:ALL]:MINimum?
FETCh:SUMMARY:EVM[:ALL]:MAXimum?
FETCh:SUMMARY:EVM:DATA[:AVERAGE]?
FETCh:SUMMARY:EVM:DATA:MINimum?
FETCh:SUMMARY:EVM:DATA:MAXimum?
FETCh:SUMMARY:EVM:PILOt[:AVERAGE]?
FETCh:SUMMARY:EVM:PILOt:MINimum?
FETCh:SUMMARY:EVM:PILOt:MAXimum?
FETCh:SUMMARY:FERRor[:AVERAGE]?
FETCh:SUMMARY:FERRor:MINimum?
FETCh:SUMMARY:FERRor:MAXimum?
FETCh:SUMMARY:SERRor[:AVERAGE]?
FETCh:SUMMARY:SERRor:MINimum?
FETCh:SUMMARY:SERRor:MAXimum?
FETCh:SUMMARY:IQOFFset[:AVERAGE]?
FETCh:SUMMARY:IQOFFset:MINimum?
FETCh:SUMMARY:IQOFFset:MAXimum?
FETCh:SUMMARY:GIMBalance[:AVERAGE]?
FETCh:SUMMARY:GIMBalance:MINimum?
FETCh:SUMMARY:GIMBalance:MAXimum?
FETCh:SUMMARY:QUADerror[:AVERAGE]?
FETCh:SUMMARY:QUADerror:MINimum?
FETCh:SUMMARY:QUADerror:MAXimum?
FETCh:SUMMARY:POWER[:AVERAGE]?
FETCh:SUMMARY:POWER:MINimum?
```

FETCh:SUMMary:POWer:MAXimum?
 FETCh:SUMMary:CRESt[:AVERAge]?
 FETCh:SUMMary:CRESt:MINimum?
 FETCh:SUMMary:CRESt:MAXimum?

FETCh:SUMMary:EVM[:ALL][:AVERAge]?
FETCh:SUMMary:EVM[:ALL]:MINimum?
FETCh:SUMMary:EVM[:ALL]:MAXimum?

This command returns the “EVM All”-value from the result summary list.
 Depending on the EVM unit selected in the “General Settings”-Menu the value will be either in dB or in percent.

Example

```
FETC:SUMM:EVM:MAX?
'Returns maximum value.
FETC:SUMM:EVM:MIN?
'Returns minimum value.
FETC:SUMM:EVM?
'Returns mean value.
```

Characteristics

*RST value: -

FETCh:SUMMary:EVM:DATA[:AVERAge]?
FETCh:SUMMary:EVM:DATA:MINimum?
FETCh:SUMMary:EVM:DATA:MAXimum?

This command returns the “DATA EVM”-value from the result summary list.
 Depending on the EVM unit selected in the “General Settings”-Menu the value will be either in dB or in percent.

Example

```
FETC:SUMM:EVM:DATA?
'Returns mean data EVM value.
```

Characteristics

*RST value: -

FETCh:SUMMary:EVM:PILOt[:AVERAge]?
FETCh:SUMMary:EVM:PILOt:MINimum?
FETCh:SUMMary:EVM:PILOt:MAXimum?

This command returns the “PILOT EVM”-value from the result summary list.
 Depending on the EVM unit selected in the “General Settings”-Menu the value will be either in dB or in percent.

Example

```
FETC:SUMM:EVM:PIL?
'Returns mean pilot EVM value.
```

Characteristics

*RST value: -

FETCh:SUMMary:FERRor[:AVERage]?
FETCh:SUMMary:FERRor:MINimum?
FETCh:SUMMary:FERRor:MAXimum?

This command returns the “Center Frequency Error”-value from the result summary list in Hz.

Example

```
FETC:SUMM:FERR?
'Returns average frequency error in Hz.
```

Characteristics

*RST value: -

FETCh:SUMMary:SERRor[:AVERage]?
FETCh:SUMMary:SERRor:MINimum?
FETCh:SUMMary:SERRor:MAXimum?

This command returns the “Sample Clock Error”-value from the result summary list in parts per million (ppm).

Example

```
FETC:SUMM:SERR?
'Returns average sample clock error in ppm.
```

Characteristics

*RST value: -

FETCh:SUMMary:IQOFfset[:AVERage]?
FETCh:SUMMary:IQOFfset:MINimum?
FETCh:SUMMary:IQOFfset:MAXimum?

This command returns the “IQ-Offset”-value from the result summary list in dB.

Example

```
``FETC:SUMM:IQOF?
'Returns average IQ Offset in dB.
```

Characteristics

*RST value:-

FETCh:SUMMary:GIMBalance[:AVERage]?
FETCh:SUMMary:GIMBalance:MINimum?
FETCh:SUMMary:GIMBalance:MAXimum?

This command returns the “IQ-Gain-Imbalance”-value from the result summary list in dB.

Example

```
FETC:SUMM:GIMB?
'Returns average Gain Imbalance in dB.
```

Characteristics

*RST value: -

FETCh:SUMMary:QUADerror[:AVERage]?
FETCh:SUMMary:QUADerror:MINimum?
FETCh:SUMMary:QUADerror:MAXimum?

This command returns the “Quadrature Error”-value from the result summary list in degree.

Example

```
FETC:SUMM:QUAD?
'Returns average Quadrature Error in degree.
```

Characteristics

*RST value: -

FETCh:SUMMary:POWER[:AVERage]?
FETCh:SUMMary:POWER:MINimum?
FETCh:SUMMary:POWER:MAXimum?

This command returns the “Frame Power”-value from the result summary list in dBm.

Example

```
“FETC:SUMM:POW? “ Returns average Frame Power in dBm.
```

Characteristics

*RST value: -

FETCh:SUMMary:CRESt[:AVERage]?
FETCh:SUMMary:CRESt:MINimum?
FETCh:SUMMary:CRESt:MAXimum?

This command returns the “Crest Factor”-value from the result summary list in dBm.

Example

```
FETC:SUMM:CRES?
'Returns Crest Factor in dB.
```

Characteristics

*RST value: -

9.9 FORMat Subsystem

FORMat[:DATA]

This command specifies the data format for the data transmitted from the OFDM-VSA-Software to the control PC.

Example

```
FORM REAL
'The FS-K96 Software will send binary data in Real32 data format.
```

Parameters

ASCIi | PACKed | REAL

Characteristics

*RST value: ASCii

9.10 HCOPy Subsystem

HCOPy[:IMMediate]

This command starts a hardcopy output to the file specified by MMEMory:NAME. The graphic file format is determined by the file extension (*.bmp, *.gif, *.jpg, *.png or *.tif).

Example

```
MMEM:NAME 'C:\TEMP\Screenshot.bmp'
HCOP
'A screenshot of the FS-K96 Software is stored in the file
C:\TEMP\Screenshot.bmp.
```

Characteristics

RST value: -

9.11 INITiate Subsystem

INITiate[:IMMediate]

INITiate:REFResh

INITiate[:IMMediate]

This remote control command requests the FS-K96 Software to start a new measurement sequence. If a measurement sequence is already in progress, then the command will be ignored.

Example

```
INIT
'The FS-K96 Software will start a new measurement.
```

Characteristics

*RST value: -

INITiate:REFResh

This remote control command requests the FS-K96 Software to start a new measurement sequence based on the I/Q data that has already been captured.

Example

```
INIT:REFR
'The FS-K96 Software will start a new measurement based on
the stored I/Q data.
```

Characteristics

*RST value: -

9.12 INPut Subsystem

INPut:ATTenuation <numeric value>

INPut:DIQ:RANGe[:UPPer] <numeric value>

INPut:DIQ:SRATe <numeric value>

INPut:EATT <numeric value>

INPut:EATT:STATe <boolean>

INPut:FILTer:CHANnel[:STATe] <boolean>

INPut:FILTer:CHANnel:BANDwidth <numeric value>

INPut:FILTer:CHANnel:ORDer <numeric value>

INPut:FILTer:YIG[:STATe] <boolean>

INPut:SElect AIQ | RF | DIQ | FILE

INPut:IQ:BALanced[:STATe] <boolean>

INPut:IQ:IMPedance LOW | HIGH

INPut:ATTenuation <numeric value>

This command specifies the current input mechanical attenuator. The step width is 10 dB without the electronic attenuator option, and the range is 0 dB to 70 dB. The input attenuation can be set in 5 dB steps between 0 dB and 75 dB with the electronic attenuator option.

Example

```
INP:ATT?  
'Returns the current mechanical attenuator setting in use
```

Characteristics

*RST value: 10 dB

INPut:DIQ:RANGe[:UPPer] <numeric value>

This remote control command specifies the full scale level of the digital base band input. Note that this command requires option FSQ-B17 or FSV-B17.

Example

```
INP:DIQ:RANG?  
'Returns the full scale level of the digital baseband input
```

Characteristics

*RST value: 1 V

INPut:DIQ:SRATe <numeric value>

This remote control command specifies the sampling rate for the digital base band input. Note that this command requires option FSQ-B17 or FSV-B17, respectively.

Example

```
"INP:DIQ:SRAT"
```

Characteristics

*RST value: 81.6 MHz

INPut:EATT <numeric value>

This command specifies the attenuation of the current input electronic input attenuator. The attenuation setting can only be varied in 5 dB steps from 0 to 30 dB. Other entries are rounded to the next lower integer value. The electronic attenuator is switched off in the default state.

Example

```
INP:EATT?  
'Returns the current electronic attenuator setting in use.
```

Characteristic

*RST value: 0 dB

The command is only available with the electronic attenuator option (FSU-B25).

INPut:EATT:STATe <boolean>

This command switches the electronic input attenuation into the signal path (state ON) or removes it from the signal path (state OFF).

Example

```
INP:EATT:STAT ON
'Switches the electronic attenuator into the signal path.
```

Characteristics

*RST value: OFF

The command is only available with the electronic attenuator option (FSU-B25).

INPut:FILTer:CHANnel[:STATe] <boolean>

This command switches an adjustable channel filter into the signal path (condition ON) or removes it from the signal path (condition OFF).

Example

```
INP:FILT:CHAN ON
'Selects the adjustable channel filter.
```

Characteristics

*RST value: OFF

INPut:FILTer:CHANnel:BANDwidth <numeric value>

The 6 dB bandwidth of the channel filter is specified by this command.

Example

```
INP:FILT:CHAN:BAND 14MHZ
'Sets the filter bandwidth to 14 MHz.
```

Characteristics

*RST value: 20 MHz

INPut:FILTer:CHANnel:ORDer <numeric value>

This command sets the filter order of the lowpass channel filter. Odd orders are rounded to the next higher even number. The number of filter taps is the filter order plus 1.

Example

```
INP:FILT:CHAN:ORD 256
'Selects a filter order of 256.
```

Characteristics

*RST value: 96

INPut:FILTer:YIG[:STATe] <boolean>

This command switches the YIG filter for image frequency suppression into the signal path (condition ON) or removes it from the signal path (condition OFF).

Example

```
INP:FILT:YIG OFF
'Switches the YIG filter off.
```

Characteristics

*RST value: OFF

INPut:SElect AIQ | RF | DIQ | FILE

This remote control command specifies whether the Analog baseband Inputs, Digital Baseband input, RF input or File input is the currently selected signal input. Note that Analog baseband input requires option R&S FSQ-B71. Digital Baseband Input requires option R&S FSQ-B17 or R&S FSV-B17.

Example

```
INP:SEL AIQ
'Select analog baseband input.
```

Characteristics

*RST value: FILE

INPut:IQ:BALanced[:STATe] <boolean>

This remote control command specifies whether the IQ inputs are symmetrical (balanced) or asymmetrical (unbalanced). Note that this command requires option FSQ-B71.

Example

```
INP:IQ:BAL ON
'Specifies symmetrical (balanced) IQ inputs.
```

Characteristics

*RST value: OFF

INPut:IQ:IMPedance LOW | HIGH

This remote control command specifies the input impedance for the IQ inputs. Note that this command requires option FSQ-B71.

Example

```
INP:IQ:IMP LOW
'Specifies low input impedance for IQ inputs.
```

Characteristics

*RST value: LOW

9.13 MMEMory Subsystem

MMEMory:LOAD:CFGFile <file_name>
 MMEMory:LOAD:STATe <file_name>
 MMEMory:LOAD:IQ:STATe <file_name>
 MMEMory:LOAD:IQ:STATe <file_name>
 MMEMory:NAME <file_name>
 MMEMory:STORE:DEMod:STATe <file_name>
 MMEMory:STORE:IQ:STATe <file_name>
 MMEMory:STORE:STATe <file_name>

MMEMory:LOAD:CFGFile <file_name>

This command loads a configuration file which describes the OFDM system. The file must be of type "*.mat".

Example

```
MMEM:LOAD:CFGF 'C:\TEMP\K96Test.mat'
```

Characteristics

*RST value: –

MMEMory:LOAD:STATe <file_name>

This command restores previously saved settings. The file must be of type "*.ovsa".

Example

```
MMEM:LOAD:STAT 'C:\TEMP\K96Test.ovsa'
```

Characteristics

*RST value: –

MMEMory:LOAD:IQ:STATe <file_name>

Perform a single sweep using a file as input.

Example

```
MMEM:LOAD:IQ:STAT 'C:\TEMP\MyCapture.iqw'
```

Characteristics

*RST value: –

MMEMory:NAME <file_name>

This command defines a destination file for the printout started with the command HCOPY:IMMEDIATE. The graphic file format is determined by the file extension (*.bmp, *.gif, *.jpg, *.png or *.tif).

Example

```
MMEM:NAME 'C:\TEMP\Screenshot.bmp'
```

Characteristics

*RST value: –

MMEMory:STORe:DEMod:STATe <file_name>

This command stores the current demodulation data to a binary MAT-file which can be loaded within Matlab.

Example

```
MMEM:STOR:DEM:STAT 'C:\TEMP\MyDemod.mat'
```

Characteristics

*RST value: –

MMEMory:STORe:IQ:STATe <file_name>

This command stores the current IQ data to a file with the extension “.iqw”. The data format is 32 bit floating point and the data order is I.IQQ.Q. Existing files will be overwritten.

Example

```
MMEM:STOR:IQ:STAT 'C:\TEMP\MyCapture.iqw'
```

Characteristics

*RST value: –

MMEMory:STORe:STATe <file_name>

This command stores the current settings to a file. The resulting filetype is “.ovsa”. Existing files will be overwritten.

Example

```
MMEM:STOR:STAT 'C:\TEMP\K96Test.ovsa'
```

Characteristics

*RST value: –

9.14 SENSE Subsystem

The SENSE command is used to set and get the values of parameters in the remote software. The "get" variant of the SENSE command differs from "set" in that it takes no parameter values (unless otherwise stated) but is followed by the character '?' and will return the parameter's value in the same format as it is set.

e.g SENS:FREQ:CENT 10GHZ - sets the center frequency to 10 GHz
 SENS:FREQ:CENT? - response 10 GHZ - returns the current center frequency

```
[SENSe:]COMPensate:CHANnel <boolean>
[SENSe:]DEMod:COFFset <numeric value>
[SENSe:]DEMod:EVMCalc:NORMALize RMSPD | RMSDAT | RMSPIL | NONE
[SENSe:]DEMod:EVMCalc:FAverage MS | RMS
[SENSe:]DEMod:EVMCalc:NORMALize RMSPD | RMSDAT | RMSPIL | NONE
```

This command defines the normalization of the EVM results. The EVM values are normalized to the RMS value of all pilot and data cells (RMSPD), to the RMS value of the data cells only (RMSDAT) or to the RMS value of the pilot cells (RMSPIL) only. Additionally the normalization can be switched off at all (NONE).

Example

```
SENS:DEM:EVMC:NORM RMSDAT
```

Characteristics

*RST value: RMSPD

```
[SENSe:]DEMod:EVMCalc:FAverage MS | RMS
```

This command defines the averaging method to calculate the mean EVM over multiple frames for the result list. The average can be either done on the squared EVM values (MS) or on the EVM values directly (RMS).

Example

```
SENS:DEM:EVMC:FAV MS
```

Characteristics

*RST value: MS

```
[SENSe:]DEMod:FFTShift <numeric value>
[SENSe:]DEMod:FORMat:BURSt <boolean>
[SENSe:]DEMod:FORMat:MAXFrames <numeric value>
[SENSe:]DEMod:FORMat:NOFSymbols <numeric value>
[SENSe:]DEMod:FSYNc NONE | PIL | DAT
[SENSe:]DEMod:MDETECT CFG | SYM | CARR
[SENSe:]DEMod:TSYNc PREAM | CP
[SENSe:]FREQUENCY:CENTer <numeric value>
[SENSe:]IQ:DITHer[:STATe] <boolean>
[SENSe:]IQ:LPASs[:STATe] <boolean>
```

```
[SENSe:]SWAPiq <boolean>
[SENSe:]SWEep:TIME <numeric value>
[SENSe:]TRACking:PHASe <boolean>
[SENSe:]TRACking:TIME <boolean>
[SENSe:]TRACking:LEVel <boolean>
[SENSe:]VOLTage:IQ:RANGe <numeric value>
[SENSe:]VOLTage:IQ:RANGe <numeric value>
```

[SENSe:]COMPensate:CHANnel <boolean>

This command defines whether the estimated channel transfer function shall be compensated before EVM measurements.

Example

```
SENS:COMP:CHAN ON
'Activate channel compensation
```

Characteristics

*RST value: ON

[SENSe:]DEMod:COFFset <numeric value>

This command defines the maximum carrier offset allowed for frame synchronization.

Example

```
SENS:DEM:COFF 2
'Freq. Offset of max. two subcarriers is allowed
```

Characteristics

*RST value: 0

[SENSe:]DEMod:EVMCalc:NORMalize RMSPD | RMSDAT | RMSPIL | NONE

This command defines the normalization of the EVM results. The EVM values are normalized to the RMS value of all pilot and data cells (RMSPD), to the RMS value of the data cells only (RMSDAT) or to the RMS value of the pilot cells (RMSPIL) only. Additionally the normalization can be switched off at all (NONE).

Example

```
SENS:DEM:EVMCalc:NORM RMSDAT
```

Characteristics

*RST value: RMSPD

[SENSe:]DEMod:EVMCalc:FAverage MS | RMS

This command defines the averaging method to calculate the mean EVM over multiple frames for the result list. The average can be either done on the squared EVM values (MS) or on the EVM values directly (RMS).

Example

```
SENS:DEM:EVMC:FAV MS
```

Characteristics

*RST value: MS

[SENSe:]DEMod:FFTShift <numeric value>

This command shifts the FFT start sample within the guard interval. The value is normalized to the guard interval length.

Example

```
SENS:DEM:FFTS 0.6
```

Characteristics

*RST value: 0.5

[SENSe:]DEMod:FORMat:BURSt <boolean>

The burst search is controlled by this command. It should be switched on for bursted OFDM signals.

Example

```
SENS:DEM:FORM:BURS ON  
'Switches on burst search.'
```

Characteristics

*RST value: ON

[SENSe:]DEMod:FORMat:MAXFrames <numeric value>

This command sets the maximum number of frames to be demodulated.

Example

```
SENS:DEM:FORM:MAXF 10  
'At most 10 frames are analyzed.'
```

Characteristics

*RST value: 1

[SENSe:]DEMod:FORMat:NOFSymbols <numeric value>

This command sets the number of symbols per frame to be analyzed. Frames with less symbols are discarded.

Example

```
SENS:DEM:FORM:NOFS 44
'44 symbols per frame are analyzed.
```

Characteristics

*RST value: 10

[SENSe:]DEMod:FSYNc NONE | PIL | DAT

This command selects the frequency synchronization and parameter estimation mode of the OFDM demodulator. The synchronization either uses pilot cells only (PIL) or includes a second stage, where also the decided data cells are accounted for (DAT). If 'NONE' is selected, the demodulator stops after the rough time synchronization.

Example

```
SENS:DEM:FSYN PIL
'The frequency sync. is done on pilots
```

Characteristics

*RST value: PIL

[SENSe:]DEMod:MDETect CFG | SYM | CARR

This command configures the auto demodulation functionality. If 'CFG' is selected, the modulation matrix within the configuration file is evaluated. 'SYM' assigns the data cells of each symbol to one constellation, 'CARR' assumes one constellation for all data cells in each carrier.

Example

```
SENS:DEM:MDET SYM
'The modulation type is detected symbolwise
```

Characteristics

*RST value: CFG

[SENSe:]DEMod:TSYNc PREAM | CP

The time synchronization can be performed by correlating the repetitive preamble structure or the cyclic prefix.

Example

```
SENS:DEM:TSYN CP
'Cyclic prefix time synchronization is selected
```

Characteristics

*RST value: CP

[SENSe:]FREQuency:CENTer <numeric value>

The remote control command is used to specify the frequency that the analyzer will use to make measurements against the input signal.

Example

```
SENS:FREQ:CENT 5GHZ
'A center frequency of 5 GHz is selected
```

Characteristics

*RST value: 1 GHz

[SENSe:]IQ:DITHer[:STATe] <boolean>

This instruction links a 2 MHz-wide dither signal at 42.67 MHz into the signal path of the baseband inputs. Note that this command requires option FSQ-B71.

Example

```
SENS:IQ:DITH 1
'Switches on the 2 MHz broad dither signal
```

Characteristics

*RST value: OFF

[SENSe:]IQ:LPASs[:STATe] <boolean>

This instruction switches a 36 MHz filter into the I and Q branch of the baseband inputs. Note that this command requires option FSQ-B71.

Example

```
SENS:IQ:LPAS 1
'Switches on the lowpass filter for the IQ inputs.
```

Characteristics

*RST value: ON

*RST value: 1 V

[SENSe:]SWAPiq <boolean>

This remote control command can be used to specify if the IQ data shall be swapped.

Example

```
SENS:SWAP ON
'SWAP IQ data
```

Characteristics

*RST value: OFF

[SENSe:]SWEep:TIME <numeric value>

The remote control command is used to specify the sweep acquisition period (capture time) for which the input signal is to be measured.

Example

```
SENS:SWEep:TIME 20ms  
'A capture time of 20 ms is specified.
```

Characteristics

*RST value: 20 ms

[SENSe:]TRACking:PHASe <boolean>

This command activates or deactivates the phase tracking within the demodulator.

Note:

[SENSe] is not optional for this command when using the short form "TRAC" as it conflicts with the "TRACe" command.

Example

```
SENS:TRAC:PHASe ON  
'Activate phase tracking
```

Characteristics

*RST value: ON

[SENSe:]TRACking:TIME <boolean>

This command activates or deactivates the sample clock deviation tracking within the demodulator.

Note:

[SENSe] is not optional for this command when using the short form "TRAC" as it conflicts with the "TRACe" command

Example

```
SENS:TRAC:TIME ON  
'Activate tracking of sample clock deviations
```

Characteristics

*RST value: OFF

[SENSe:]TRACking:LEVel <boolean>

This command activates or deactivates the power level tracking within the demodulator.

Note:

[SENSe] is not optional for this command when using the short form "TRAC" as it conflicts with the "TRACe" command.

Example

```
SENS:TRAC:LEV ON
'Activate power level tracking
```

Characteristics

*RST value: OFF

[SENSe:]VOLTage:IQ:RANGe <numeric value>

This command defines the measurement range of the analog baseband input. The value range depends on the input impedance. The measurement range defines the measurable peak voltage (positive and negative). Note that this command requires option FSQ-B71.

Input Impedance	Range of values / Volt (5 dB steps)
Low (50 Ω)	0.0316; 0.0562; 0.1; 0.178 ; 0.316; 0.562; 1; 1.78; 3.16; 5.62
High (1 k Ω)	0.0316; 0.0562; 0.1; 0.178 ; 0.316; 0.562; 1; 1.78

Example

```
SENS:VOLT:IQ:RANGE 0.1
'Sets the IQ input range to 0.1 V.
```

Characteristics

*RST value: 1 V

9.15 TRACe Subsystem

The TRACe subsystem controls access to the software's internal trace memory.

TRACe[:DATA]? TRACE1 | TRACE2 | TRACE3

TRACe:IQ:SRATe <numeric value>

TRACe[:DATA]? TRACE1 | TRACE2 | TRACE3

This command returns all the measured data that relates to the currently selected measurement type. The data format returned is particular to the currently selected measurement type and is specified below.

Example

TRACe? TRACE1

Return values:

The returned values are scaled in the current measurement unit. For some measurements the unit may change depending on the unit-settings specified in the General Setup menu (or set by the UNIT:EVM-command).

ASCII format (FORMat ASCii):

In ASCII format, a list of values separated by commas is returned (Comma Separated Values = CSV). Empty fields will return *NaN*.

Binary format (FORMat REAL,32):

If the transmission takes place using the binary format (REAL,32), the data are transferred in block format (Definite Length Block Data according to IEEE 488.2). They are arranged in lists of 32 Bit IEEE 754 floating point numbers.

Power vs Symbol X Carrier

Returns the power values of all evaluated OFDM cells. The result matrix is written symbol-wise, i.e. all subcarriers of one symbol are written before the next symbol begins. All detected frames are transferred.

Trace1: Power values [dBm/Carrier]

Power vs Carrier

Returns the power values as list over all carriers. The statistic is performed in symbol direction.

Trace1: Mean values (averaged over all symbols) [dBm/Carrier]

Trace2: Minimum values [dBm/Carrier]

Trace3: Maximum values [dBm/Carrier]

Power vs Symbol

Returns the power values as list over all symbols. The statistic is performed in carrier direction.

Trace1: Mean values (averaged over all carriers) [dBm/Carrier]
Trace2: Minimum values [dBm/Carrier]
Trace3: Maximum values [dBm/Carrier]

Capture Buffer

Returns the power values of all IQ samples within the capture buffer.

Trace1: Power values [dBm]

Power Spectrum

Returns the power density spectrum of the capture buffer. The result values span the frequency range of $-\text{SampleRate} / 2$ to $+\text{SampleRate} / 2 - \text{SampleRate}/\text{NOfResultValues}$.

Trace1: Power density values [dBm/Hz]

EVM vs Symbol X Carrier

Returns the EVM values of all evaluated OFDM cells. The result matrix is written symbol-wise, i.e. all subcarriers of one symbol are written before the next symbol begins. All detected frames are transferred.

Trace1: EVM values [dB | Percent]

EVM vs Carrier

Returns the EVM values as list over all carriers. The statistic is performed in symbol direction.

Trace1: Mean values (averaged over all symbols) [dB | Percent]
Trace2: Minimum values [dB | Percent]
Trace3: Maximum values [dB | Percent]

EVM vs Symbol

Returns the EVM values as list over all symbols. The statistic is performed in carrier direction.

Trace1: Mean values (averaged over all carriers) [dB | Percent]
Trace2: Minimum values [dB | Percent]
Trace3: Maximum values [dB | Percent]

Frequency Error

Returns the frequency error versus time. The length of the time axis is specified as number of settling symbols in the EVM measurement setup menu.

Trace1: Frequency error vs time [Hz]

Phase Error

Returns the phase error versus time. The length of the time axis is specified as number of settling symbols in the EVM measurement setup menu.

Trace1: Phase error vs time [deg]

Channel Flatness

Returns the spectrum flatness in dB as list over all subcarriers.

Trace1: Mean values (averaged over all frames) [dB]

Trace2: Minimum values [dB]

Trace3: Maximum values [dB]

Channel Group Delay

Returns the channel group delay in ns as list over all subcarriers.

Trace1: Mean values (averaged over all frames) [ns]

Trace2: Minimum values [ns]

Trace3: Maximum values [ns]

Channel Impulse Response

Returns the channel impulse response versus time. This is the inverse FFT of the estimated channel transfer function. The time axis spans one FFT interval.

Trace1: Normalized channel impulse response (averaged over all frames)

Trace2: Minimum values

Trace3: Maximum values

Constellation

Returns the constellation points of the OFDM cells. The result matrix is written symbol-wise, i.e. all subcarriers of one symbol are written before the next symbol begins. All detected frames are transferred. The IQ data is interleaved, i.e. each constellation point comprises of an I value followed immediately by the associated Q value.

Trace1 and Trace2 contain the evaluated cells with the constellation selection settings applied. Trace3 and Trace4 contain all cells of the OFDM frames, which are Number Of Symbols x FFT Length complex numbers.

Trace1: Received Constellation points with applied constellation selection

Trace2: Ideal Constellation points with applied constellation selection

Trace3: All received Constellation points

Trace4: All ideal Constellation points

**Remote Control Example**

In the subfolder `%Application path%\TOOLS\MATLAB`, you can find an example Matlab script (`remote_example_TraceIQ.m`) that demonstrates how to read the I/Q samples of the constellation diagram per remote control.

CCDF

Returns the complementary cumulative distribution function of the analyzed frames. The power values are normalized to the mean power.

Trace1: Normalized power values [dB]

Trace2: Probability values associated with the power values of trace 1

TRACe:IQ:SRATe <numeric value>

This command sets the sample rate for IQ measurements.

Example

```
TRAC:IQ:SRAT 16MHz
'Specifies a sample rate of 16 MHz.
```

Characteristics

*RST value:-

9.16 TRIGger Subsystem

The trigger subsystem is used to synchronize device action(s) with events.

TRIGger[:SEQuence]:HOLDoff <numeric value>

TRIGger[:SEQuence]:LEVel[:EXTernal] <numeric value>

TRIGger[:SEQuence]:LEVel:POWer <numeric value>

TRIGger[:SEQuence]:LEVel:POWer:AUTO <boolean>

TRIGger[:SEQuence]:MODE IMMEDIATE | EXTernal | POWer

TRIGger[:SEQuence]:HOLDoff <numeric value>

This command defines the length of the trigger delay. A negative delay time (pretrigger) can be set.

Example

```
TRIG:HOLD 500us
'A trigger offset of 500 μs is set.
```

Characteristics

*RST value: 0 μs

TRIGger[:SEQuence]:LEVel[:EXTernal] <numeric value>

This command accepts the level of the external trigger input for which triggering will occur.

Example

```
TRIG:LEV 1 V" Sets the external trigger level to 1 V.
```

Characteristics

*RST value: 1.4 V

TRIGger[:SEQuence]:LEVel:POWer <numeric value>

This command accepts the level of the input signal for which triggering will occur. The value is specified in dBm for RF input and V for baseband inputs.

Example

```
TRIG:LEV:POW 10
'Set to 10 dBm for RF measurement.
TRIG:LEV:POW 1
'Set to 1 V for baseband measurement.
```

Characteristics

*RST value: 0 dBm

TRIGger[:SEQuence]:LEVel:POWer:AUTO <boolean>

This command specifies whether or not an automatic power trigger level calculation is performed before each main measurement. The setting of this command is ignored if the setting for TRIGger[:SEQuence]:MODE is not POWER.

Example

```
TRIG:LEV:POW:AUTO 1
'Specifies that an automatic power trigger level calculation
should be performed before the start of each main measurement.
```

Characteristics

*RST value: OFF

TRIGger[:SEQuence]:MODE IMMEDIATE | EXTERNAL | POWER

This command configures how triggering is to be performed.

Parameter

IMMEDIATE	Automatically triggers the next measurement at the end of the previous measurement. This corresponds to the FREE RUN setting.
EXTERNAL	The next measurement is triggered by the signal at the external trigger input, e.g. a gated trigger
POWER	The next measurement is triggered by the detection of a signal with sufficient power.

Example

```
TRIG:MODE IMM
'The measurement will be done in free run mode
```

Characteristics

*RST value: IMMEDIATE

9.17 UNIT Subsystem

The unit subsystem specifies the units for specific result types.

```
UNIT:CAXes CARR | HZ
```

UNIT:EVM DB | PCT
UNIT:FAXes HZ | SRAT | CSP
UNIT:IRES DB | LIN
UNIT:SAXes SYM | S
UNIT:TAXes S | SAM | SYM

UNIT:CAXes CARR | HZ

This command specifies the units for carrier axes, e.g. EVM vs. carrier.

Parameter:

CARR Subcarrier numbers
HZ Hertz

Example

```
UNIT:CAX CARR  
'Subcarrier numbers as axis unit.
```

Characteristics

*RST value: CARR

UNIT:EVM DB | PCT

This command specifies the units for EVM results.

Parameter

DB EVM results returned in dB
PCT EVM results returned in %

Example:

```
UNIT:EVM PCT  
'EVM results to be returned in %.
```

Characteristics

*RST value: dB

UNIT:FAXes HZ | SRAT | CSP

This command specifies the units for frequency axes, e.g. power spectrum.

Parameter

HZ Seconds
SRAT Sample rate
CSP Subcarrier spacing

Example

```
UNIT:FAX Hz  
'Hertz as axis unit.
```

Characteristics

*RST value: Hz

UNIT:IRES DB | LIN

This command specifies the units for impulse response results.

Parameter

DB Impulse response results returned in dB
LIN Impulse response result normalized to one

Example

```
UNIT:IRES DB
```

Characteristics

*RST value: LIN

UNIT:SAXes SYM | S

This command specifies the units for symbol axes, e.g. EVM vs symbol.

Parameter

SYM Symbol numbers
S Seconds

Example

```
UNIT:SAX SYM  
'Symbol numbers as axis unit.
```

Characteristics

*RST value: SYM

UNIT:TAXes S | SAM | SYM

This command specifies the units for time axes, e.g. channel impulse response.

Parameter

S Seconds
SAM Sample numbers
SYM Symbol numbers

Example

```
UNIT:TAX S  
'Seconds as axis unit.
```

Characteristics

*RST value: s

9.18 Softkeys With Assignment of IEC/IEEE Bus Commands

9.18.1 Hardkey MAIN

GENERAL SETTINGS

Primary

```
[SENSe]:FREQuency:CENTer
TRACe:IQ:SRATe
[SENSe]:SWEep:TIME
```

```
DISPlay:TRACe:Y:RLEVel:RF
SENSe:VOLTage:IQ:RANGe
CONFIgure:POWer:AUTO
DISPlay:TRACe:Y:RLEVel:OFFSet
```

```
TRIGger[:SEQuence]:MODE
TRIGger[:SEQuence]:HOLDoff
TRIGger[:SEQuence]:LEVel:POWer
TRIGger[:SEQuence]:LEVel:POWer:AUTO
```

```
INPut:SElect
INPut:FILTer:CHANnel:STATe
INPut:FILTer:CHANnel:BANDwidth
INPut:FILTer:CHANnel:ORDer
```

Advanced

```
[SENSe]:SWAPiq
```

```
INPut:IQ:IMPedance
INPut:IQ:BALanced[:STATe]
[SENSe]:IQ:LPASs[:STATe]
[SENSe]:IQ:DITHer[:STATe]
```

```
INPut:DIQ:SRATe
INPut:DIQ:RANGe[:UPPer]
```

```
CONFIgure:POWer:AUTO:SWEep:TIME
INPut:ATTenuation
INPut:EATT
INPut:EATT:AUTO
INPut:EATT:STATe
INPut:FILTer:YIG[:STATe]
```

Meas

```
UNIT:EVM
UNIT:SAXes
UNIT:CAXes
UNIT:TAXes
UNIT:FAXes
UNIT:IRES
```

```
[SENSe]:DEMod:EVMCalc:NORMALize
[SENSe]:DEMod:EVMCalc:FAverage
```

DEMOD
SETTINGS

System Description

CONFigure:SYStem:MANual
MMEMory:LOAD:CFGFile
CONFigure:SYMB:NFFT
CONFigure:SYMB:NGU1
CONFigure:SYMB:NGU2
CONFigure:SYMB:GUAR:MODE
CONFigure:SYMB:GUAR:PER
CONF:SYMB:GUAR1:NSYM
CONF:SYMB:GUAR2:NSYM
CONFigure:PREAmble:BLENgth
CONFigure:PREAmble:FOFFset

Demodulation Control

[SENSe]:DEMod:FORMat:BURSt
[SENSe]:DEMod:FORMat:MAXFrames
[SENSe]:DEMod:FORMat:NOFSymbols

[SENSe]:DEMod:TSYnc
[SENSe]:DEMod:FSYnc
[SENSe]:DEMod:MDETect

[SENSe]:TRACking:PHASe
[SENSe]:TRACking:TIME
[SENSe]:TRACking:LEVel
[SENSe]:COMPensate:CHANnel

[SENSe]:DEMod:FFTShift
[SENSe]:DEMod:COFFset

DISPLAY
GRAPH LIST

DISP:TABLE

POWER

CALCulate<1|2>:FEED `POW:PVSC`
CALCulate<1|2>:FEED `POW:PVCA`
CALCulate<1|2>:FEED `POW:PVSY`
CALCulate<1|2>:FEED `POW:CBUF`
CALCulate<1|2>:FEED `POW:PSPE`

EVM

CALCulate<1|2>:FEED `EVM:EVSC`
CALCulate<1|2>:FEED `EVM:EVCA`
CALCulate<1|2>:FEED `EVM:EVSY`
CALCulate<1|2>:FEED `EVM:FERR`
CALCulate<1|2>:FEED `EVM:PERR`

CHANNEL

CALCulate<1|2>:FEED `CHAN:FLAT`
CALCulate<1|2>:FEED `CHAN:GDEL`
CALCulate<1|2>:FEED `CHAN:IRES`

CONSTELL

CALCulate<1|2>:FEED `CONS:CONS`
CALCulate<1|2>:FEED `CONS:CVCA`
CALCulate<1|2>:FEED `CONS:CVSY`

MISC /
STATISTIC

CALCulate<1|2>:FEED `STAT:CCFD`
CALCulate<1|2>:FEED `STAT:SFLO`
CALCulate<1|2>:FEED `STAT:REPT`

9.18.2 Hardkey SETUP

CONFIGURE
ANALYZER
CONNECTION

CONF:ADDR

9.18.3 Hardkey FILE

SAVE	MMEMemory:STORe:STATe
RECALL	MMEMemory:LOAD:STATe
SAVE IQ DATA	MMEMemory:STORe:IQ:STATe
SAVE DEMOD DATA	MMEMemory:STORe:DEMod:STATe

9.18.4 Hardkey DISPLAY

SINGLE SCREEN	DISPlay:FORMat SING
SPLIT SCREEN	DISPlay:FORMat SPL
HARDCOPY	MMEMemory:NAME HCOP

9.18.5 Hardkey PRESET

	*RST
--	------

10 Troubleshooting


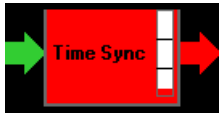
This section shows the most common problems that occur when using the FS-K96 Software.

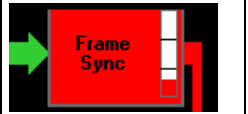
10.1 General Errors

Error	Remedy
The software does not start up – only an error message occurs.	The graphical display component may not be installed correctly. Check if the file cwui.ocx is present in the System Root folder. If yes, re-register the component by opening a command prompt in the System Root folder and typing in "regsvr32 cwui.ocx".
The software shows the start-up screen but crashes during that state.	Delete the file Default.ovsa from the Application Path Delete the folder "mcrCache7.11" from the temporary directory and re-start the software.
When trying to run a measurement with the analyzer, the error message "Instrument not found @ ..." occurs.	The software cannot connect to the measurement instrument. Check the connection setup ([SETUP] <CONFIGURE ANALYZER CONNECTION>). Ensure the instrument is connected to the specified bus and has the stated address assigned. If you are using a firewall, ensure that the firewall does not block the connection to the instrument.
When trying to run a measurement with the analyzer, the error message "Auto level FAILED: NO SIGNAL" occurs.	The measured signal level during the auto-level process is too low. Increase the signal level at the analyzer input.

10.2 Using the Signal Flow Diagram

The signal flow diagram can be a powerful tool to find and remedy demodulation problems. The following table lists some hints how to interpret failures at the different blocks.

Block	Hints
	Burst Search ON but signal is not bursted Bursts are shorter than required by the setting 'Result Length' in the <i>Demodulation Control</i> menu.
	The time domain structure of the signal doesn't match the settings. Check the following parameters: Sampling Rate FFT Length Cyclic Prefix Length (If 'Time Sync' = 'Cyclic Prefix') Preamble Block Length (If 'Time Sync' = 'Preamble')

	<p>Frames are shorter than required by the setting 'Result Length' in '<i>Demodulation Control</i>'</p> <p>The pilot cells of the signal doesn't match the configuration</p> <p>Check the pilot matrix in the configuration file</p> <p>Increase 'Maximum bin offset' in the <i>Demodulation Control</i> menu if a frequency offset of more than one subcarrier spacing could occur</p> <p>Try 'Swap I/Q' to interchange I and Q parts of the signal</p> <p>The channel transfer function varies over the frame</p> <p>Decrease 'Result Length' in the <i>Demodulation Control</i> menu</p>
---	---

Glossary

A

Application path The path where the setup software installed the R&S FS-K96 Software (“%Program folder%\Rohde-Schwarz\ OFDM Vector Signal Analysis Software” by default)

C

Cell Basic unit of an OFDM time frequency matrix. A cell is identified by a symbol number and a subcarrier number.

Cyclic Prefix Guard interval at the begin of the OFDM symbol to prevent intersymbol interference. It contains a copy of the OFDM symbol's end.

F

FFT Fast Fourier Transform

Frame Total area of a time frequency matrix which is evaluated by the OFDMA analysis software

O

OFDM Orthogonal Frequency Division Multiplexing

OFDM-VSA R&S FS-K96 / FS-K96PC OFDM Vector Signal Analysis Software

S

Subcarrier Basic unit in frequency domain. Each subcarrier can be modulated independently.

Symbol Block in time domain consisting of the cyclic prefix and FFT interval

System root The path where Microsoft Windows is installed; by default, this is C:\WINNT

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