

Products: R&S FSQ-K96, R&S FSQ, R&S SMU, R&S SMBV, R&S AMU, R&S SMATE, R&S AFQ

## Measurement on generic OFDM Signals

### Application Note 1EF65

This application note illustrates the operation of the OFDM measurement software R&S FSQ-K96. It describes applications, setup, features, settings and results. Further it concentrates on generating the configuration file for R&S FSQ-K96, the appropriate IQ data files for Signal Analyzer R&S FSQ and waveform files for 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.



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# 1 Introduction

OFDM modulation schemes are used in many communication systems. The information is distributed over a large number of carriers, thus providing high resistance against signal interference. To measure the quality of an OFDM signal it is necessary to demodulate the OFDM signal.

Up to now OFDM measurement solutions for commercial signal analyzers were standard specific and required the device under test stick to the standardized system. R&S developed a generic measurement system, the new OFDM Vector Signal Analysis R&S FSQ-K96, which allows comprehensive variations of the OFDM parameters and which therefore supports modulation measurements on generic OFDM signals.

The OFDM demodulator provides high flexibility in the development as it is not determined for specific standards such as WLAN or WiMAX. Instead the OFDM demodulator is freely configurable. Besides center frequency or level general OFDM parameters such as guard interval or FFT length are adjustable. Furthermore the structure of the preamble, the position and value of the pilots as well as position and modulation type of the data carriers can be user-defined. To ensure ease of operation and to simplify the analysis of devices the R&S FSQ-K96 offers many graphical and numerical results such as EVM vs. carrier or constellation diagram.

# 2 R&S FSQ-K96

## Applications

R&S FSQ-K96 is a flexible solution for transmitter tests on generic OFDM signals. As the OFDM demodulator is freely configurable it is a very good tool for wireless communication applications. It measures the modulation parameters of standard compliant signals such as WLAN or WiMAX as well as signals not following a standard. The user interface of the R&S FSQ-K96 allows the user to set all OFDM parameters freely. Thus it supports design engineers with the analysis of proprietary standards and in early stages of upcoming OFDM-standards. Furthermore design engineers who test modules as e.g. amplifiers can now use their own OFDM signals and do not have to use e.g. complex WiMAX signals.

A wide field for applications is the A&D market. OFDM and OFDMA modulation schemes are often used in military communications. Most OFDM signals in this environment differ from existing digital standards and are often proprietary. The R&S FSQ-K96 allows the user to demodulate non-standard OFDM signals and is therefore ideal for the analysis of military OFDM signals.

The generic OFDM demodulator also supports demodulation of broadcast OFDM signals, as e.g. DVB-T, DVB-H or ISDB-T, and is a good tool for research institutes and universities.

## Hardware Setup

To perform a measurement with the analyzer software R&S FSQ-K96 you need an R&S signal analyzer R&S FSQ and a PC. The R&S FSQ-K96 runs on the external PC and operates a signal analyzer by remote control via LAN or GPIB. Dependent on spectrum analyzer model used RF signals up to 50 GHz can be analyzed. Adding the respective options also analysis in the analog or digital baseband is possible. The maximum demodulation bandwidth in RF domain is 120 MHz. The captured IQ data is stored within

## Software Installation

the instrument and transferred blockwise to the external PC which runs the OFDM measurement software.

### Software Installation

The R&S FSQ-K96 software requires a number of software components to be installed to execute the application. A software tool, referred to as application framework installer, will perform the installation of the required components.

Select FSQ\_OFDM\_VSA\_FRAMEWORK\_INSTALLER\_VERS\_x.x.exe and execute it. When the required framework for the R&S FSQ-K96 is available on the PC, the application software itself can be installed. Select the installer, named FSQ\_OFDM\_VSA\_PC\_SW\_VERS\_x.x.exe, and start the process.

### First Measurements

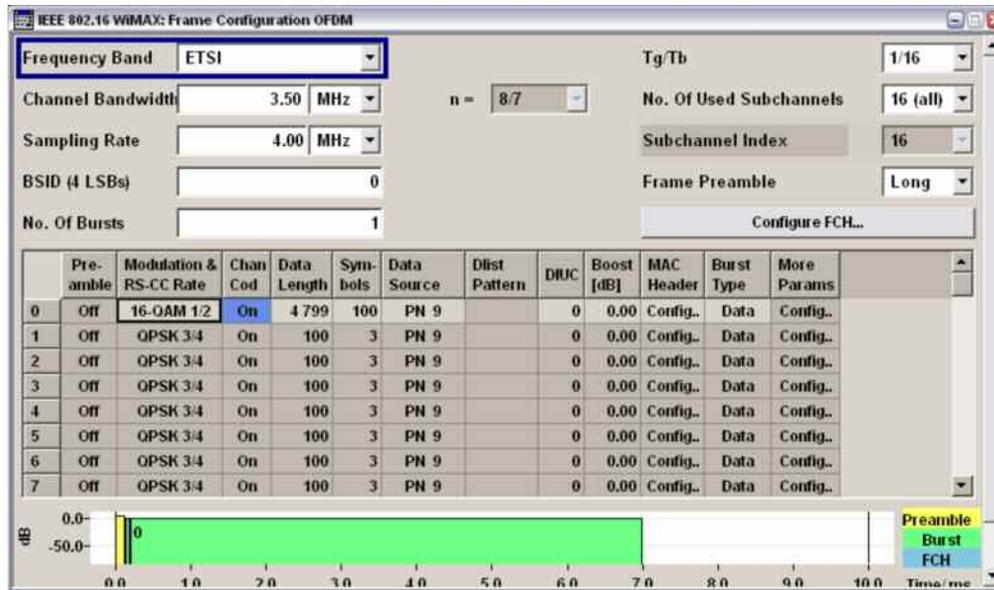
The following part describes in detail how to perform a first measurement with R&S FSQ-K96. The operating concept, general program settings, software features, and available results are described subsequently. For a more detailed explanation please refer to the R&S FSQ-K96 manual.

The R&S SMU200A is used for signal generation and the R&S FSQ with the external PC software R&S FSQ-K96 is used on the analysis side.

### Generating a WiMAX OFDM signal with R&S SMU200A

In order to setup a WiMAX OFDM signal with R&S SMU200A the following steps have to be performed:

1. Preset SMU, set frequency to 1 GHz, level to -10 dBm and select "Baseband A" block in the SMU diagram area.
2. Open baseband configuration by pressing "Config..." button
3. Select "IEEE 802.16 WiMAX..." => WiMAX software menu opens
4. Configure WiMAX frame by pressing "Frame configuration..." and setup a WiMAX OFDM signal as follows:



5. Go back to the WiMAX menu, set state to "on" and enable RF in the SMU diagram area.

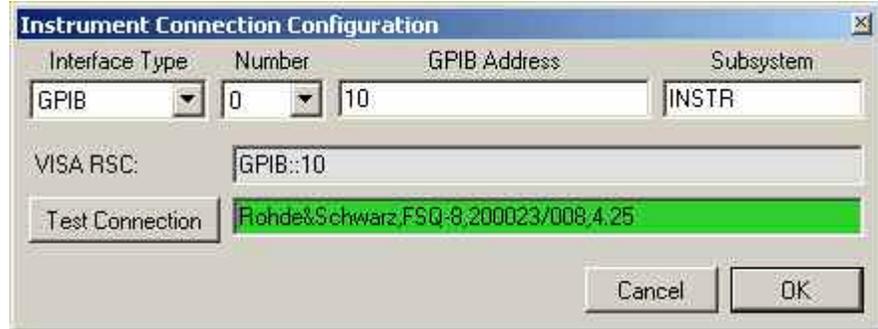
## First Measurements

### Analyzing the WiMAX OFDM signal with R&S FSQ and R&S FSQ-K96

In order to analyze the WiMAX OFDM signal with R&S FSQ-K96 the following steps have to be performed:

#### Hardware setup

6. Start R&S FSQ-K96 external PC Software and press "Preset"
7. Connect external PC with the R&S FSQ (via GPIB or LAN).
8. Go to "Setup", "Configure Analyzer Connection", configure the R&S spectrum analyzer and test the instrument connection



9. Go to "Setup" and set "Data Source" to INSTR

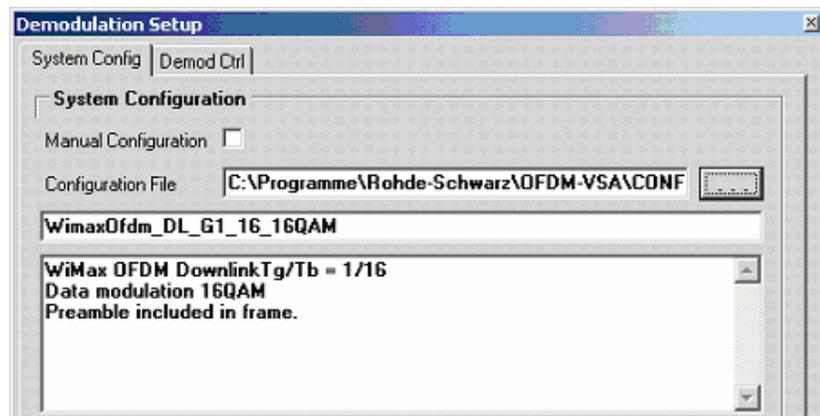
#### General Settings

10. Afterwards go to "Main", "General Settings" and set frequency to 1 GHz, sampling rate to 4 MHz and trigger to free run

#### Demodulation Settings

In "Demod Settings" 2 different modes are available, manual configuration mode and configuration file mode. In order to demodulate the signal a configuration file is needed.

11. Load the WiMAX OFDM configuration file "WimaxOfdm\_DL\_G1\_16\_16QAM.mat" in demod settings



You can find these files in the installation directory of the R&S FSQ-K96 software under "configurations".



## ***First Measurements***

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12. Make sure that burst search is enabled in “Demod settings”, “Demod Ctrl”
13. Increase the “number of symbols per frame” to 100 to analyze the whole frame including preamble and signal field
14. Start measurement by pressing “RUN SGL”

### Results

15. After setting up the R&S FSQ-K96 for WiMAX OFDM signals and performing a single measurement the result display shows “Capture Buffer” (power versus time) on screen A and “Constellation diagram” on screen B (illustrated in figure 1).

R&S FSQ-K96 displays the following measurement results as graphs

#### Power measurement

- Power vs. symbol and carrier
- Power vs. carrier
- Power vs. symbol
- Capture buffer
- Power spectrum

#### Error vector magnitude (EVM measurements)

- EVM vs. symbol and carrier
- EVM vs. carrier
- EVM vs. symbol
- Frequency and phase error

#### Channel measurements

- Spectrum flatness
- Group delay
- Impulse response

#### Constellation measurements

- Constellation diagram (color-coded by modulation mode)
- Constellation vs. carrier
- Constellation vs. symbols

#### Other measurements

- CCDF
- Signal flow diagram (detailed description of the current measurement status)

Furthermore a numeric table lists the main results of the measurement.

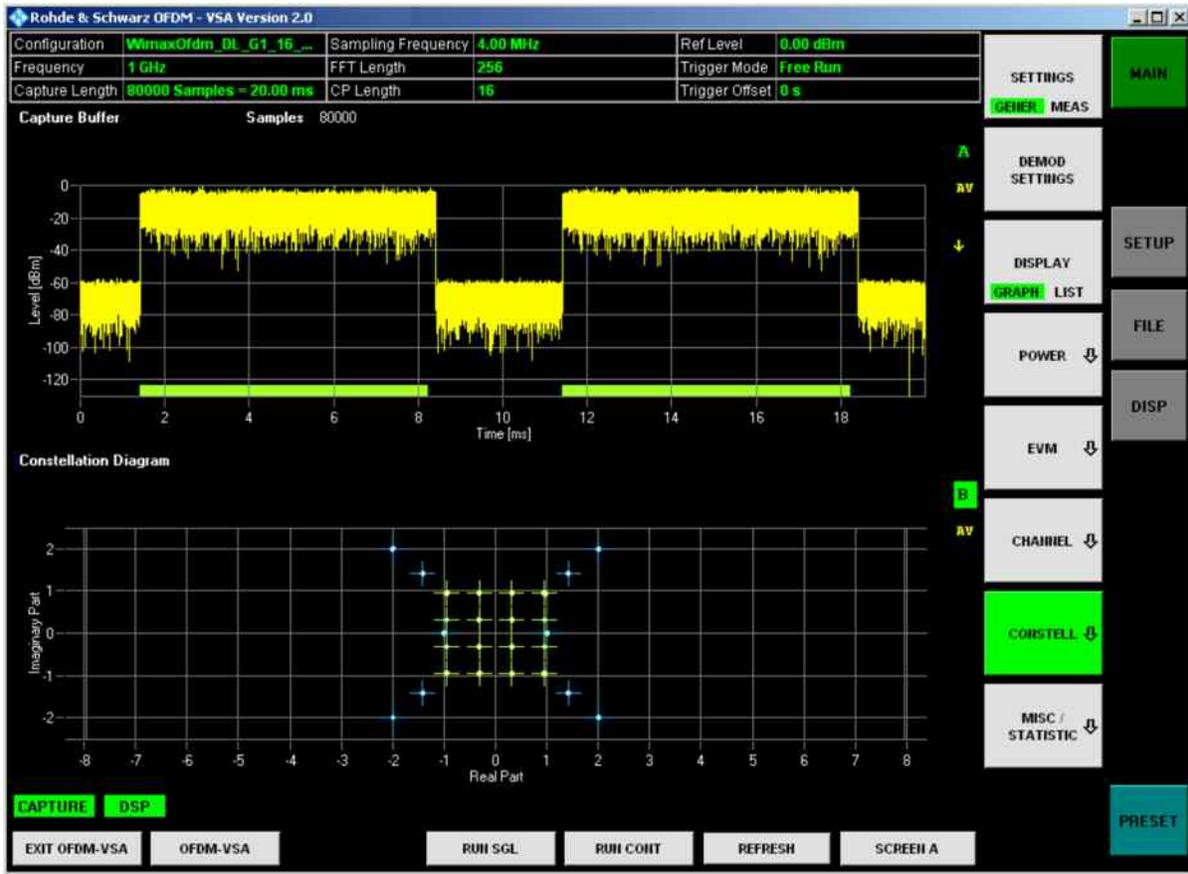


Figure 1: Screenshot of R&S FSQ-K96

## 3 Parameterizing OFDM Systems

R&S FSQ-K96 has to know the structure of the OFDM system to demodulate any OFDM signal correctly. The following part introduces a way to parameterize OFDM systems. Using this parameterization the user can generate a configuration file which allows to represent a broad range of OFDM and OFDMA systems. The parameters explained in this part are necessary for the configuration file and will be used in this file.

The document is not intended to give an OFDM technology introduction. For more detailed information about OFDM please refer to AN 1MA96\_0E (page 8 ff).

### Basics OFDM Signals

The fundamental unit of an OFDM system in time domain is a “Sample”.  $N_S$  samples build one “OFDM Symbol”. The OFDM symbol consists of a Cyclic Prefix interval of length  $N_G$  and a FFT interval of length  $N_{FFT}$ . (The sample rate  $f_s$  must be set to the FFT clock:  $f_s = N_{FFT} \cdot \text{SubcarrierSpacing}$ )

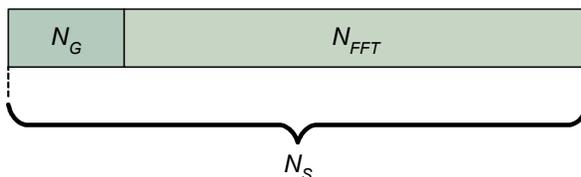


Figure 2: OFDM symbol in time domain

## R&S FSQ-K96 OFDM Structure Matrix

The fundamental unit of an OFDM system in frequency domain is a “Cell” (see figure 3). A column of cells at the same frequency is called “Carrier”. A row of cells at the same time is called “Symbol”. The total area of a time-frequency matrix is called “Frame”.

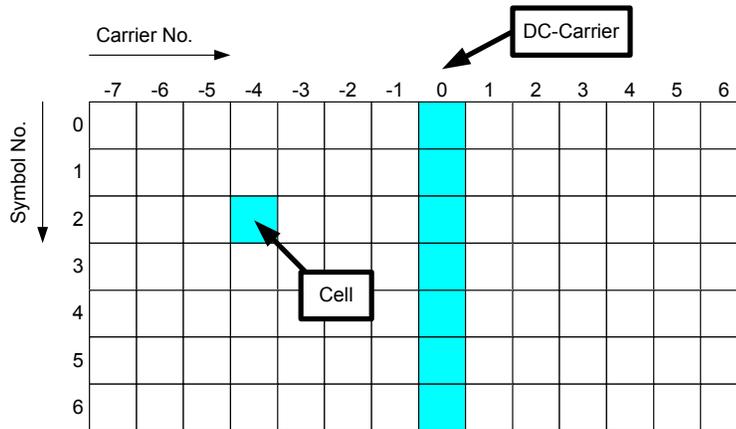


Figure 3: OFDM time-frequency matrix (OFDM system in frequency and time domain)

## R&S FSQ-K96 OFDM Structure Matrix

Each OFDM cell, addressed by symbol number and carrier number, can be assigned to one of the following cell types: Pilot Cells, Data Cells, Zero Cells, Don't Care Cells. Preamble cells are defined as Pilot cells.

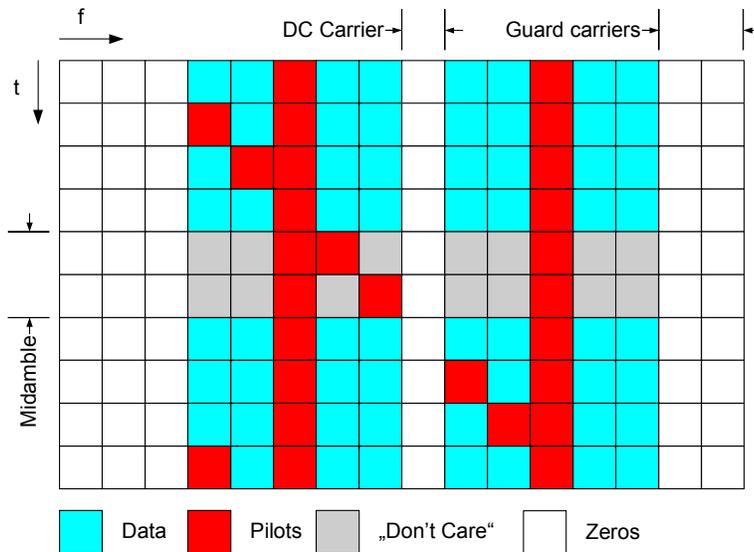


Figure 4: R&S FSQ-K96 OFDM structure matrix : The structure matrix assigns all cells of a frame to a specific type.

In case of pilot cells the user must also specify the pilot value. The Pilot Matrix contains the values of all pilot cells.

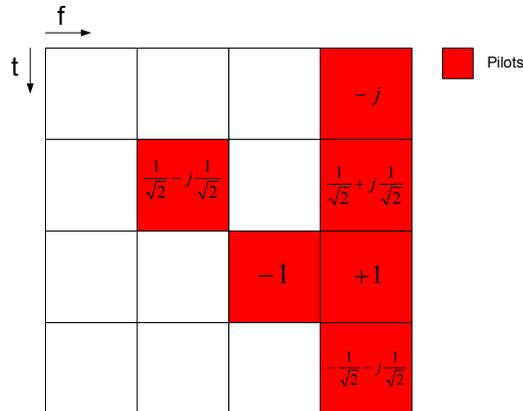


Figure 5: Pilot Matrix

In case of data cells the user must specify the modulation format of every data cell.

The first step is to define a constellation vector which contains all possible constellation points belonging to a specific modulation format.

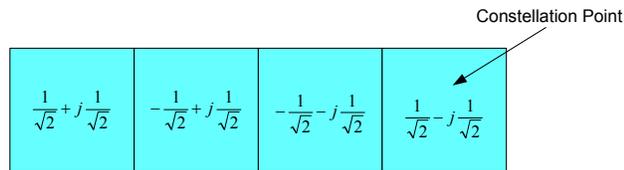


Figure 6: QPSK constellation vector

In the second step every data cell is assigned to a specific modulation format in a so called modulation matrix. This modulation matrix contains pointers to the underlying constellations for all data cells (figure 7).

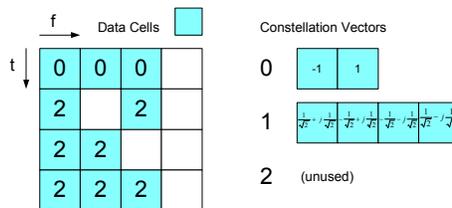


Figure 7: Modulation matrix

If automatic demodulation is set to *auto* (see figure 8), the unused constellations are automatically mapped to one of the defined constellation vectors. 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.

## Preamble for time synchronization

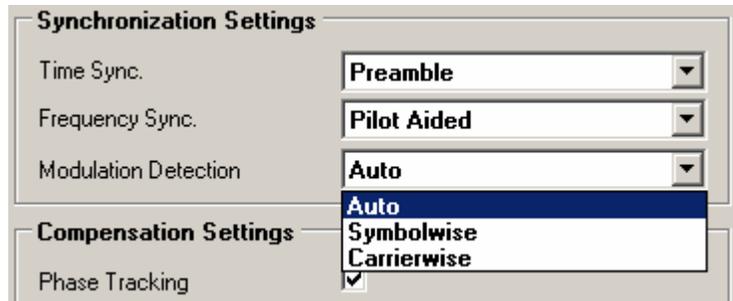


Figure 8: Modulation Detection

### Preamble for time synchronization

In the R&S FSQ-K96 the user can choose between time synchronization on cyclic prefix or preamble (see demod settings R&S FSQ-K96 – figure 9). 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. Thus the R&S FSQ-K96 only needs the optional preamble definition if time synchronization is set to preamble method.

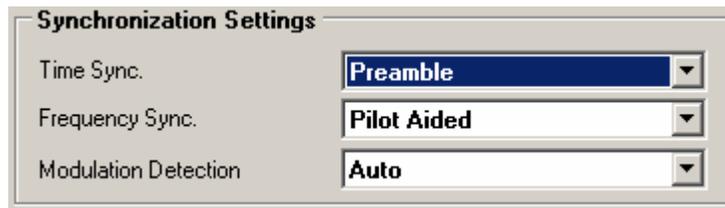


Figure 9: Time sync. Preamble – only in this case the preamble definition in time domain is needed

### Parameterization of a repetitive preamble symbol

A repetitive preamble contains several repetitions of one time domain block. Figure 10 shows exemplarily the parameterization of a repetitive preamble symbol, which contains a five times repetition of block T. The R&S FSQ-K96 OFDM structure matrix can have an arbitrary offset to the beginning of the preamble symbol.

The user must set the block length, which specifies the length of one repetitive block in number of samples, and the frame offset, which specifies the time offset from the preamble start to the actual frame start in number of samples. If the offset is zero or negative, the preamble is also contained within the frame and has to be defined as pilot cells in the structure matrix (see figure 4).

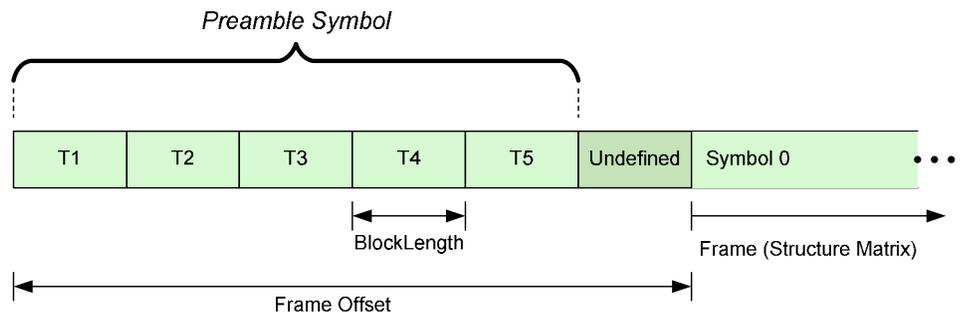


Figure 10: Preamble structure used for time synchronization

## 4 Configuration File Concept

The basic OFDM parameters like FFT length and cyclic prefix length can be set manually in the R&S FSQ-K96 'demod settings'. A configuration file is used to describe the OFDM signal regarding preamble structure, position of pilots and data carriers, and the modulation format of the data carriers.

### **Manual configuration (Analysis without configuration file)**

Measurements, which require exact frequency and phase recovery such as EVM or channel flatness, always require a configuration file. Nevertheless it is possible to run the software without this file to show basic measurement results like CCDF and various power measurements as well as an unsynchronized constellation diagram. The manual configuration mode also offers the possibility to check the correctness of the fundamental OFDM timing settings. Just go to 'demod settings' 'system configuration' and activate 'Manual Configuration'.

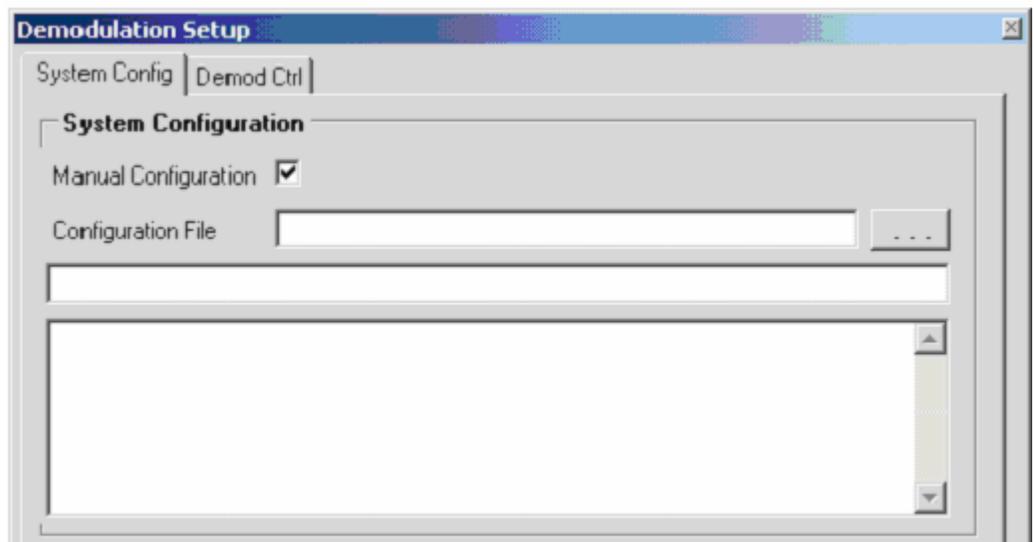


Figure 11: Manual Configuration

### **Configuration file mode (Analysis with configuration file)**

The configuration file defines all OFDM parameters necessary for the demodulation of OFDM signals. It contains user-defined information about

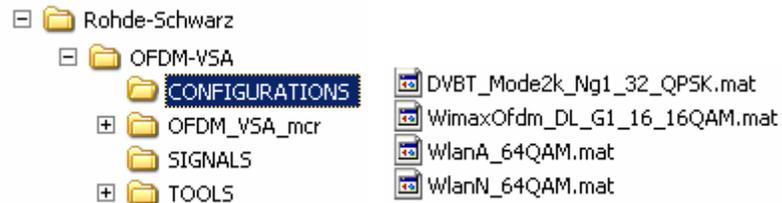
- Position and value of the pilot carriers
- Position and modulation format of the data carriers
- Preamble structure

The configuration file has to be developed from the OFDM standard specification and is generated with Matlab (see chapter 5). Rohde & Schwarz provides sample system configuration files for the following standards

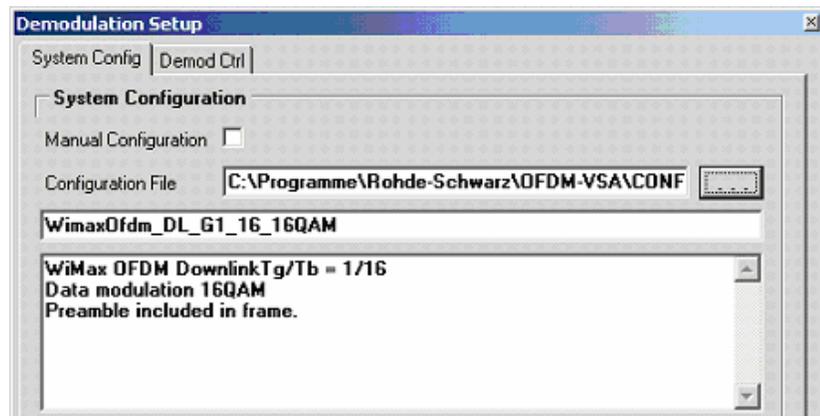
- WLAN 802.11a, 802.11g OFDM
- WiMAX 802.16 OFDM
- DVB-T, DVB-H

These files are delivered with the software in the installation directory of the R&S FSQ-K96 under 'configurations'.

## Configuration file mode (Analysis with configuration file)

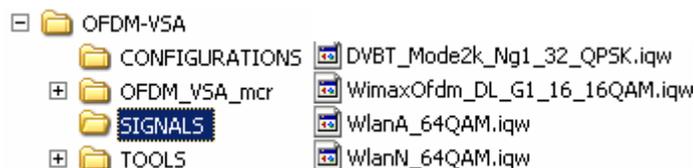


The user can load a configuration file into R&S FSQ-K96 in 'demod settings':



Afterwards the R&S FSQ-K96 has all information which is necessary to demodulate the OFDM signal and thus all results of the R&S FSQ-K96 are available, including EVM results, channel measurement results,...

For first tests of the sample system configuration files Rohde & Schwarz also provides IQ data of the signals in the 'signals' directory (iqw-files).



These iqw-files belong to the configuration files and can be loaded in R&S FSQ-K96 by setting data source to file, pressing RUN SGL and choosing the iqw-file. In the dialog that opens the user can also specify the format of the iqw files. All of the files delivered with R&S FSQ-K96 are III...QQQ files.

## 5 Generation of the configuration file with Matlab

This section describes the generation of the configuration file. The configuration file contains the complete description of the OFDM demodulator and can be loaded in R&S FSQ-K96 'demod settings'.

If a 'non standard compliant signal' should be analyzed or if the properties of the signal change as e.g. modulation format or position of pilots, it is necessary to generate a new configuration file by adjusting an existing file. Matlab should be used to make these changes.

The OFDM configuration is stored in a Matlab \*.mat format which contains the structure 'stOfdmCfg'. The exact format of the configuration file is defined in the manual, where a table lists the elements of the structure and the sub-structures.

## Matlab Class @OfdmSys

The R&S FSQ-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



and contains the following functions:

Member Function	Description
Init (iNOofSymbols, iNfft, iNg)	Initialize a new system configuration
SetSystem (sSystem) SetDescription (sDescription)	Describe the OFDM system
SetConstellation (vfcValue, sName)	Define a constellation vector
SetCell (iSymbol, iCarrier, 'Zero') SetCell (iSymbol, iCarrier, 'Pilot', fcValue) SetCell (iSymbol, iCarrier, 'Data', sConstName) SetCell (iSymbol, iCarrier, 'DontCare')	Define a specific cell of the OFDM system
SetPreamble (iBlockLength, iFrameOffset)	Define a repetitive preamble symbol
LoadConfigFile (sFileName) SaveConfigFile (sFileName)	Load or save a system configuration file

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

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 its 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 Generic OFDM analysis personality.

INIT	This function initializes the System Configuration Class	
	<code>c = Init(c, iNOofSymbols, iNfft, iNg);</code>	
Input parameter	c	Input object
	iNOofSymbols	Number of OFDM symbols in one frame included in the configuration file. This is the maximum frame length to be analyzed.
	iNfft	FFT length in number of samples
	iNg	Cyclix prefix length in number of samples
Output parameter	c	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>
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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, 'BPSK', [-1,1]);</code> <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

## Matlab Class @OfdmSys

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	'Data', sConstName	Name of the data constellation
Output parameter	c	Modified object
Example	cOfdmSys = SetCell(cOfdmSys, 4, [-26:-22,-20:-8,-6:-1,1:6,8:20,22:26], 'Data', 'BPSK');	
Special requirements	<p>The Generic OFDM analyzer has a minimum requirement about the number and the location of the pilot cells:</p> <ol style="list-style-type: none"> <li>1. The number of pilot cells must be at least 4</li> <li>2. At least two different symbols must contain pilot cells</li> <li>3. At least two different carriers must contain pilot cells</li> </ol>	

SET_PREAMBLE	This function sets the repetitive preamble parameters (optional parameter needed for time synchronization on preamble)	
	c = SetPreamble(c, iBlockLength, iFrameOffset)	
Input parameter	c	Input object
	iBlockLength	Length of one repetitive block in number of samples
	iFrameOffset	Offset of preamble start to frame start
Output parameter	c	Modified object
Example	cOfdmSys = SetPreamble(cOfdmSys, 16, 0);	
Special requirements	<p>The definition of a repetitive preamble is optional and not necessary if cyclic prefix synchronisation is used.</p> <p>If the offset is zero or negative, the preamble is also contained within the frame and is used for further estimation processes.</p>	

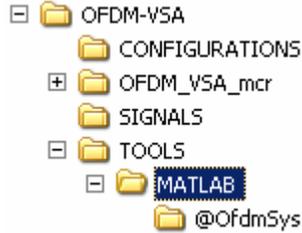
SAVE_CONFIG_FILE	This function generates and saves a configuration file from the current system configuration to be used within OFDM-VSA.	
	c = SaveConfigFile(c, sFileName)	
Input parameter	c	Input object
	sFileName	File name of the configuration file
Output parameter	c	Modified object
Example	SaveConfigFile(cOfdmSys, 'example.mat');	

LOAD_CONFIG_FILE	This function configures the OfdmSys object from a configuration file.	
	c = LoadConfigFile(c, sFileName)	
Input parameter	c	Input object
	sFileName	File name of the configuration file
Output parameter	c	Modified object
Example	SaveConfigFile(cOfdmSys, 'example.mat');	

**Example WLAN 802.11a**

This section demonstrates how to generate a configuration file for IEEE 802.11a out of the IEEE standard document.

Open a copy of the Matlab generator script “gen\_wlan\_a.m”:



and reconstruct the generation of this Matlab script.

**802.11a Standard (Table 79)**

The 802.11a standard defines in table 79 the following parameters:

$\Delta_F$ : Subcarrier frequency spacing	0.3125 MHz (=20 MHz/64)
$T_{GI}$ : GI duration	0.8 $\mu$ s ( $T_{FFT}/4$ )

**Matlab Script (gen\_wlan\_a.m)**

```

iNOFSymbols = 100;
iNfft = 64;
iNg = 16;
% Generate OFDMSYS class object
cOfdmSys = OfdmSys(iNOFSymbols, iNfft, iNg);
    
```

**802.11a Standard (Section 17.3.5.7)**

**Table 81 – Modulation-dependent normalization factor  $K_{MOD}$**

Modulation	$K_{MOD}$
BPSK	1
QPSK	1/√2
16-QAM	1/√10
64-QAM	1/√42

**Matlab Script (gen\_wlan\_a.m)**

```

% Modulation of the Data Cells
% {'BPSK', 'QPSK', '16QAM', '64QAM'}
sDataConstName = '64QAM';
sSystemName = sprintf('WlanA_%s', sDataConstName);
cOfdmSys = SetSystem(cOfdmSys, sSystemName);
sDescription = sprintf(['WLAN 802.11a\n', ...
    'Data modulation %s\n', ...
    'Preamble included in frame.'], sDataConstName);
cOfdmSys = SetDescription(cOfdmSys, sDescription);
    
```

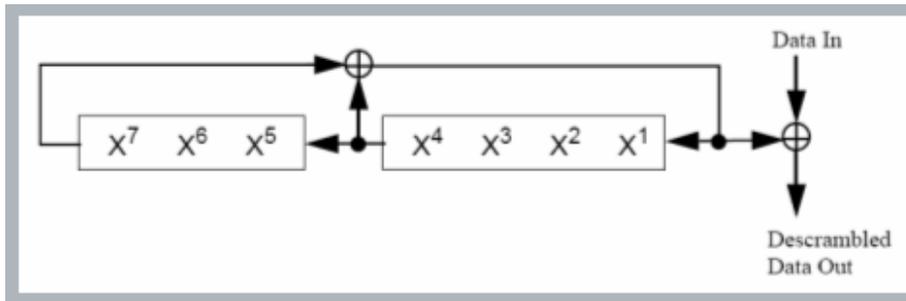


## Example WLAN 802.11a

### Matlab Script (gen\_wlan\_a.m)

```
% Pilot sequence consisting of 4 subcarriers
P = [1,1,1,-1];
% Carrier positions
kP = [-21,-7,7,21];
```

### 802.11a Standard (Pilot Subcarrier Modulation)



### Matlab Script (gen\_wlan\_a.m)

```
% Pilot modulating sequence p_0..126v
% 17.3.5.9 (25) generated with shift register from
% 17.3.5.4 (Fig. 113) by replacing all 1 with -1
% and all 0 with 1
% The modulation sequence starts with the signal symbol
vPRBS = ones(1,7);
lSignal = 4;
for l = lSignal:iNofSymbols-1
    DataOut = xor(vPRBS(4),vPRBS(7));
    vPRBS = [DataOut,vPRBS(1:end-1)];
    cOfdmSys = SetCell(cOfdmSys, l, kP, 'Pilot', (1-2*
DataOut)*P);
end
```

### 802.11a Standard (Section 17.3.3)

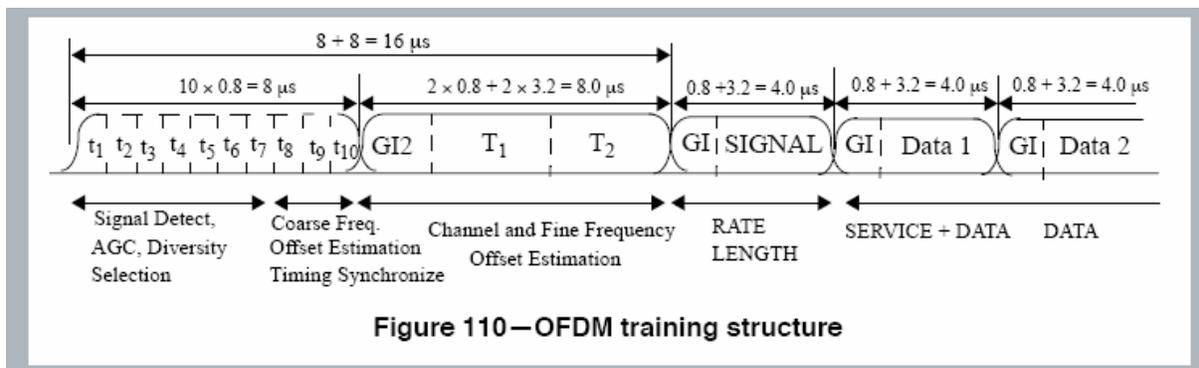


Figure 110—OFDM training structure

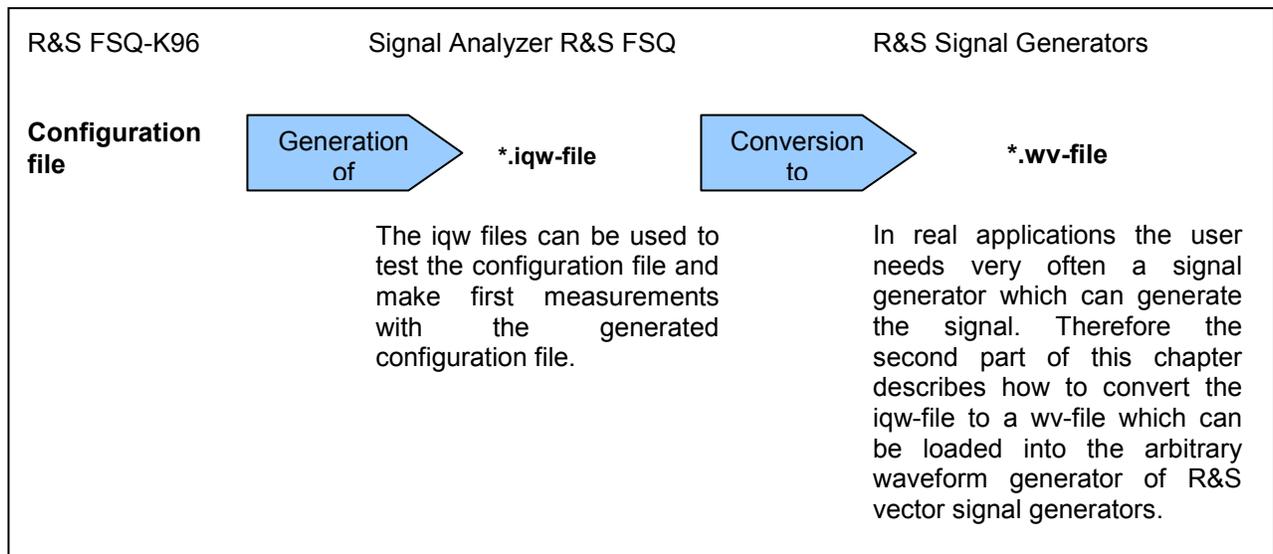
OFDM-VSA expects constant symbol and guard interval lengths. The 802.11a preamble can be interpreted as standard OFDM symbols with  $N_{FFT} = 64$  and  $N_G = 16$ . This requires some transforms of the description in the standard document.



```
% Save configuration file
sFileName = [sSystemName, '.mat'];
fprintf('Save Config File ''%s''\n', sFileName);
SaveConfigFile(cOfdmSys, sFileName);
```

## 6 Tools to generate IQ data files for Signal Analyzer R&S FSQ and waveform files for R&S Signal Generators

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.



### ***IQ data files for Signal Analyzer R&S FSQ (\*.iqw-file) – ofdmsys\_generator.m***

The Matlab tools directory of R&S FSQ-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 FSQ-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.

<i>ofdmsys_generator.m</i>	This function generates an IQ data file (iqw-file), which can be loaded into R&S FSQ-K96, from any configuration file	
	<pre>vfcSignal = ofdmsys_generator(sConfigFileName, iNOOfFrames, iNOOfIdleSymbols)</pre>	
Input parameter	<i>sConfigFileName</i>	Configuration file name
	<i>iNOOfFrames</i>	Number of frames to be generated
	<i>iNOOfIdleSymbols</i>	Number of idle symbols between bursts and at start and end of signal

## Waveform files for R&S Signal Generators (\*.wv-file) –

Output parameter	vfcSignal	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>	

### Waveform files for R&S Signal Generators (\*.wv-file) – *mat2wv.m*

R&S FSQ-K96 (release version 2.0 or higher) 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.

mat2wv.m	This function generates an IQ 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	vfcSignal	Input data vector
	sFilename	Filename of the generated waveform file
	fSampleRate	Sample rate of the signal in Hz
	bNormalize	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.
Example	<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 (see figure 12).

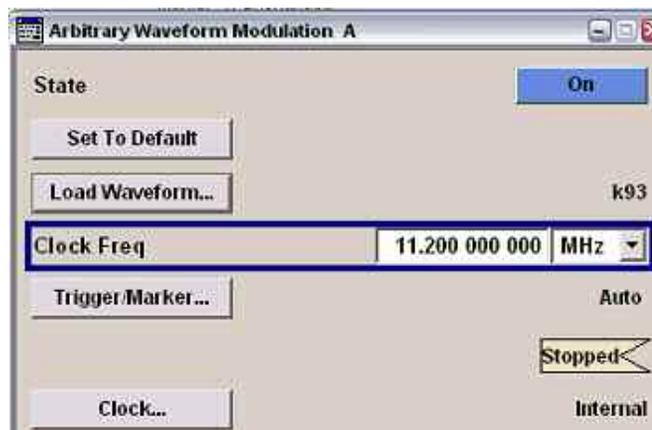


Figure 12: Arbitrary Waveform Generator of R&S SMU200A

## 7 Additional Information

This application note and the associated program R&S FSQ-K96 OFDM Vector Signal Analysis are updated from time to time. Please visit the website in order to download new versions.

Please send any comments or suggestions about this application note to [TM-Applications@rsd.rohde-schwarz.com](mailto:TM-Applications@rsd.rohde-schwarz.com).

## 8 Ordering information

### OFDM Vector Signal Analysis

R&S FSQ-K96	OFDM VSA PC Software	1308.9570.02
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### Signal Analyzer R&S FSQ

R&S FSQ3	20 Hz ... 3.6 GHz	1155.5001.03
R&S FSQ8	20 Hz ... 8 GHz	1155.5001.08
R&S FSQ26	20 Hz ... 26,5 GHz	1155.5001.26
R&S FSQ40	20 Hz ... 40 GHz	1155.5001.40

### Hardware Options for R&S FSQ

R&S FSQ-B71	Baseband Inputs DC to 36 MHz	1157.0113.02
R&S FSQ-B72	I/Q Bandwidth Extension to 120 MHz	1157.0336.02

Please note, that complete solutions for generic OFDM measurements for various applications are available from Rohde & Schwarz.

For additional information about R&S FSQ-K96, R&S signal and spectrum analyzers and R&S signal generators, see the Rohde & Schwarz website [www.rohde-schwarz.com](http://www.rohde-schwarz.com).



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*This application note and the supplied programs may only be used subject to the conditions of use set forth in the download area of the Rohde & Schwarz website.*