R&S®filtwiz
Filter Editor for Rohde&Schwarz Signal and Spectrum Analyzers and Signal Generators

ROHDE&SCHWARZ

Introduction

PAD-T-M: 3574.3259.02/01.00/CI/1/EN

With the R&S®filtwiz editor, it is possible to design and create filter files that can be imported within the following software options:

- R&S®FPS-K70.
- R&S®FSQ-K70.
- R&S®FSV-K70.
- R&S®FSW-K70.
- R&S®VSE-K70.
- R&S®SMW-B10.
- R&S®SMBV-B10.
- R&S®SMU-B9/B10/B11.
- R&S®SMJ-B9/B10/B11.
- R&S®SMATE-B9/B10/B11.
- R&S®AMU-B9/B10/B11.

Contents

1 What is "filtwiz"

The filter wizard (filtwiz) is a tool from Rohde&Schwarz designed for creating filter files that can be imported on:

- a R&S Signal and Spectrum Analyzer FPS with option R&S®FPS-K70.
- a R&S Signal and Spectrum Analyzer FSQ with option R&S®FSQ-K70.
- a R&S Signal and Spectrum Analyzer FSV with option R&S®FSV-K70.
- a R&S Signal and Spectrum Analyzer FSW with option R&S®FSW-K70.
- a R&S VSE Vector Signal Explorer Software with option R&S®VSE-K70.
- a R&S Signal Generator SMW with option R&S®SMW-B10.
- a R&S Signal Generator SMBV with option R&S®SMBV-B10.
- a R&S Signal Generator SMU with option R&S®SMU-B9/B10/B11.
- a R&S Signal Generator SMJ with option R&S®SMJ-B9/B10/B11.
- a R&S Signal Generator SMATE with option R&S®SMATE-B9/B10/B11.
- a R&S Signal Generator AMU with option R&S®AMU-B9/B10/B11.

Its main purpose is the conversion of user-defined finite impulse response (FIR) filters into the FSx-K70 filter format (“.vaf”). Beyond this filtwiz provides designs for standard filters (e.g. Root Raised Cosine, Gaussian).

filtwiz was developed on a Microsoft Windows[1] platform under MATLAB[2].

[1] Microsoft Windows is © and ™ by Microsoft Corporation, www.microsoft.com

[2] MATLAB is © and ™ by The MathWorks, Inc, www.mathworks.com

2 Installation

filtwiz should preferably be executed on a standard MATLAB installation, version 8.5 (R2015a) or higher on a Microsoft Windows platform.

- Copy the file `filtwiz.p` to a directory in the MATLAB search path (e.g. `.\matlab\work`).
- Start MATLAB.
- Type `close all` on the MATLAB command line.
- Type `filtwiz` on the MATLAB command line to start the wizard.

3 Working with filtwiz

3.1 Main Window

The main screen is shown below. It consists of five boxes:

- File operations
- Descriptions
- Tools
- Display
- Filter Diagram (i.e. a plot of the current filter)

In the following chapters all functions of these boxes will be explained in detail.

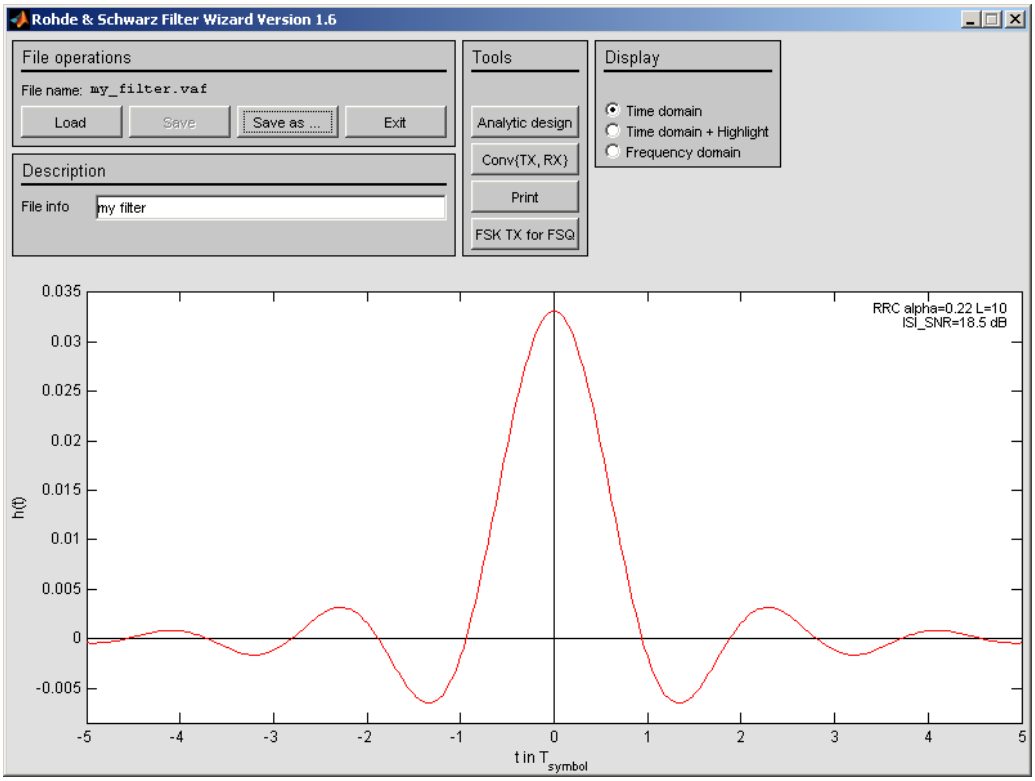


Figure 3-1: filtwiz main window

3.1.1 File operations

filtwiz supports two file formats for loading / saving and importing / exporting respectively:

- FSx-K70 (FSQ-K70, FSV-K70 and FSW-K70) filter files (“`.vaf`”)
- ASCII files

The main purpose of filtwiz is to create FSx-K70 filter files whereas the ASCII file format is aimed to import or export filter coefficients.

Load

Clicking the *Load* button enables you to load or import a user filter. The filter will be displayed in the diagram after loading.

You can select an FSx-K70 filter file ("`.vaf`") for loading. If the file extension differs from "`.vaf`", filtwiz expects an ASCII file containing the coefficients of an FIR filter.

ASCII file import: The file must contain the real filter coefficients with one coefficient per line. It must contain at least three filter coefficients. The imported filter has to contain an odd number of coefficients, and its length is limited to 60 symbols (number of coefficients < 60 · ov + 1). Otherwise the filter will be cut. For importing ASCII files the oversampling factor (ov), i.e. the ratio between the sampling frequency and the symbol frequency, must be entered by the user. filtwiz accepts an ov of 4 or 32. If you import a filter with an ov of 4, the impulse response will be interpolated to an ov of 32. Please note that interpolation results in a longer filter and that it might affect the filters characteristics.

Supported number formats are:

- `1.2345`
- `12345`
- `1.23e-45`
- `1.23E-45`

Save

Clicking the *Save* button saves the current filter in the FSx-K70 filter format ("`.vaf`"). The filter is saved under the file name given in the *File operations* box.

Save As

The *Save as* button is for saving the filter under a different file name or for exporting the filter to an ASCII file. Selecting *".vaf" file* saves the filter using the FSx-K70 specific file format ("`.vaf`").

Selecting *ASCII Export* writes the filter coefficients to an ASCII file. The file contains one coefficient per line (number format: `1.234E+56`).

Exit

Exit terminates the program.

3.1.2 Description

Use the *File info* text field to enter a comment (optional). This text is only saved inside FSx-K70 filter files ("`.vaf`").

3.1.3 Tools

Analytic Design

This tool provides standard filter designs for commonly used filters:

- GAUSS Gaussian lowpass
- GMSK Gaussian Minimum Shift Keying pulse
- RC Raised Cosine
- RRC Root Raised Cosine

For these “analytic filters” there do exist formulae describing their impulse responses (cf. FSQ-K70 manual, chapter 9, “*Analytically Calculated Filters*”). To get a finite discrete time domain representation the analytic impulse response will be sampled and windowed with a rectangular window.

Press the *Analytic design* button to start the design process. In the dialog window you have to specify the filter type, the filter parameter (e.g. roll-off factor) and the filter length in symbols.

Press *OK* to calculate the finite impulse response. The resulting filter is shown in the diagram.

For GAUSS and GMSK the bandwidth time product *BT* ($0 < BT \leq 1$) has to be specified. The GMSK pulse is the convolution of a Gaussian lowpass filter with a rectangular pulse of one symbol in length.

For RC and RRC the roll-off factor alpha ($0 < alpha \leq 1$) has to be specified.

Please note that these filters cannot be used within the VSB (Vestigial Sideband Modulation) demodulator of the FSQ-K70, as in VSB only filters with half of the bandwidth are used.

Conv{TX,RX}

The intention of the *Conv{TX,RX}* tool is to verify if the total impulse response of the transmission system (i.e. the convolution of the TX filter with the RX filter) fulfills the Nyquist condition for zero ISI. This is crucial for pairs of filters used in linear modulation schemes such as PSK and QAM knowing the fact that the FSx-K70’s symbol decision assumes an ISI free signal.

When pressing the *Conv{TX,RX}* button you have to select two filter files, one for the TX and one for the RX filter. Their impulse responses are convolved and the resulting filter is shown in the diagram.

Select *Time domain + Highlight* in the *Display box* to highlight the symbol instants of the total impulse response. For an ISI free system all filter coefficients at symbol instants (except *t = 0*) must equal zero. The ISI_SNR value shown in the diagram is equal to `+Inf dB` if there is no ISI at all, otherwise it gives you a hint about the amount of ISI (see below).

Print

Press the *Print* button to get a print-out of the current filter.

FSK TX for FSQ

Press the *FSK TX for FSQ* button to automatically derive a FSK TX filter from the current filter for use with the FSQ-K70.

Note:

- The FSW-K70 and the FSV-K70 use the set *TRANSMIT FILTER* as the frequency pulse of the FSK and MSK modulators.
- In the FSQ-K70 the frequency pulse of the FSK and MSK modulators results from the convolution of the set *TRANSMIT FILTER* with a rectangular pulse of one symbol duration.
- To get correct and comparable results with FSV-K70 and FSQ-K70, or FSW-K70 and FSQ-K70, different TX filters must be set. See Example below.

Example: How to create the FSK TX Filter for FSQ-K70 for a RRC frequency pulse with “filtwiz”:

1. Start filtwiz from MATLAB.
2. Press the *Analytic design* button.
3. Set the filter parameters (RRC, 10 symbols, Alpha 0.22) and press *OK*.
4. The impulse response of the RRC filter is displayed (Note: This filter could be used in FSV-K70).
5. To design the FSK TX Filter for the FSQ-K70 press the *FSK TX for FSQ* button.
6. The impulse response of the TX Filter for the FSK modulator of the FSQ-K70 will be calculated, displayed and the top right of the diagram will indicate *FSK TX filter for FSQ-K70 {RRC alpha=0.22 L=10}*.
7. Press *Save as...*, and save the filter as `RRC022_FSQ.vaf`.
8. This filter file can be used in FSQ-K70 (see section 4 for details).

3.1.4 Display

In the *Display* box you can select the type of the diagram:

- *Time domain*
  The impulse response of the current filter is displayed (ov=32).
- *Time domain + Highlight*
  The impulse response is displayed and symbol instants are highlighted. This is useful especially for verifying if the impulse response satisfies the Nyquist condition for zero ISI, i.e. if all symbol instants of the impulse response are zero, except for *t=0*.
- *Frequency domain*
  The magnitude and the phase of the frequency response are displayed for frequencies in the range from zero to two times the symbol frequency.

The upper right corner of the diagram shows the source of the current filter:

- *abc.vaf*
  indicates that the current filter has been loaded from the file `abc.vaf`.
- *RRC alpha=0.22 L = 20*
  indicates that a Root Raised Cosine filter with a roll-off factor of 0.22 and a length of 20 symbols was designed using the *Analytic design* tool.
- *Conv{tx.vaf,rx.vaf}*
  indicates that the current filter is the result of the Conv{TX,RX} tool. The TX filter was loaded from the file `tx.vaf` and the RX filter from the file `rx.vaf`.

Additionally the ISI_SNR value is displayed. It is a measure of the intersymbol interference caused by the current impulse response and is quite similar to a signal-to-noise ratio. Its value tends to `+Inf dB` if there is no ISI at all. The smaller the value, the more ISI is present. The *ISI_SNR* value is calculated according to the formula below, given the symbol time T and the real valued finite impulse response *h(t)*.

$$ISI\_SNR = 10 \cdot \log_{10} \frac{h^2(0)}{\sum_{v=-\infty, v\neq 0}^{v=+\infty} h^2(vT)} dB$$

4 Configuring User Filters in the FSQ-K70

This section describes how the filter can be transferred to the FSQ.

1. Enter the option FSQ-K70 by pressing VSA (or press HOME VSA) on the analyzer.
2. Press NEXT.
3. Press IMPORT.
4. Insert a floppy disc containing your filter file, e.g. `c4fm_tx.vaf`, into the FSQ's floppy drive.
5. Press FILTERS.
6. Choose your filter, e.g. `c4fm_tx` from the list and press ENTER.

If the new filter was successfully imported a user set using this filter has to be created. The sequence is given below. Figure 2 shows an example. Please refer to the FSQ-K70 manual for further details.

1. Press HOME VSA.
2. Press MODULATION SETTINGS.
3. Press MODULATION FILTER.
4. Press NEXT.
5. Press NEW USER SET.
6. Select a TRANSMIT FILTER, e.g. `C4FM_TX`.
7. Select a RECEIVE FILTER, e.g. `NONE`.
8. Select a MEAS FILTER, e.g. `NONE`.
9. Press SAVE USER SET.
10. Select the user set from the "MODULATION FILTER SET" table.

MODULATION FILTER SET			
TRANSMIT FILTER	RECEIVE FILTER	MEAS FILTER	SET
RC	NONE	NONE	RC
RRC	RRC	RRC	RRC
GAUSS	NONE	NONE	GAUSS
GAUSS_LINEARIZED	EDGE_ISI	EDGE_MEAS	EDGE
CDMA2K_1X_FWD_TX	CDMA2K_1X_FWD_ISI	CDMA2K_1X_FWD_ISI	CDMA2K 1F
CDMA2K_1X_REV_TX	CDMA2K_1X_REV_ISI	CDMA2K_1X_REV_ISI	CDMA2K 1R
C4FM_TX	NONE	NONE	USER1

Figure 4-1: FSQ-K70 "MODULATION FILTER SET" table

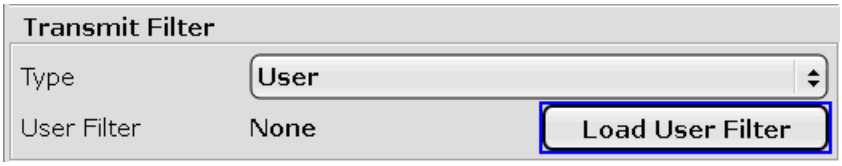
5 Configuring User Filters in the FSV-K70

Follow these steps to load the filter files with the R&S®FSV-K70:

1. Copy your .vaf filter file to a USB memory stick and connect the USB memory stick to the FSV. If you do not want to load the files directly from the USB memory stick, you can copy the .vaf filter file somewhere to the instrument (e.g. `C:\R_S\instr\user\vsa`).
2. Enter the option FSV-K70 by pressing the ”MODE” key and then the ”VSA” softkey.

5.1 Loading a User Transmit Filter

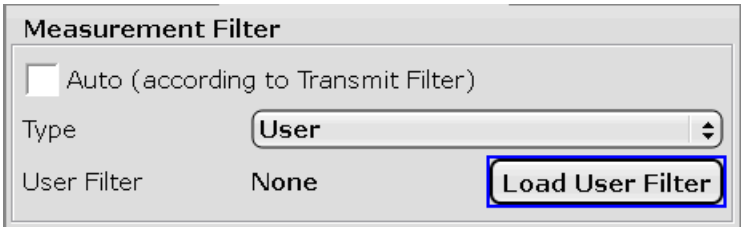
1. Press the ”MEAS CONFIG” key and then the ”Modulation / Signal Description” softkey to open the ”Modulation & Signal Description” dialog.
2. In the ”Modulation” tab of the dialog set ”Transmit Filter Type” to ”User”.



3. Press the ”Load User Filter” button to open the ”Load Tx User Filter” dialog.
4. Select your .vaf filter file.

5.2 Loading a User Measurement Filter

1. Press the ”MEAS CONFIG” key and then the ”Demod / Meas Filter” softkey to open the ”Demodulation & Measurement Filter” dialog.
2. In the ”Measurement Filter” tab of the dialog set ”Measuremet Filter Type” to ”User”.



3. Press the ”Load User Filter” button to open the ”Load Meas User Filter” dialog.
4. Select your .vaf filter file.

6 Configuring User Filters in the FSW-K70

Follow these steps to load the filter files with with the R&S FSW-K70:

1. Copy your .vaf filter file to a USB memory stick and connect the USB memory stick to the FSW. If you do not want to load the files directly from the USB memory stick, you can copy the .vaf filter file somewhere to the instrument (e.g. `C:\R_S\instr\user\vsa`).
2. Enter the option FSW-K70 by pressing the ”MODE” key and then ”VSA” button.

6.1 Loading a User Transmit Filter

1. Press the ”Signal Description” softkey to open the ”Signal Description” dialog.
2. In the ”Modulation” tab of the dialog set ”Transmit Filter Type” to ”User”.

3. Press the ”Load User Filter” button to open the ”Load Tx User Filter” dialog.
4. Select your .vaf filter file.

6.2 Loading a User Measurement Filter

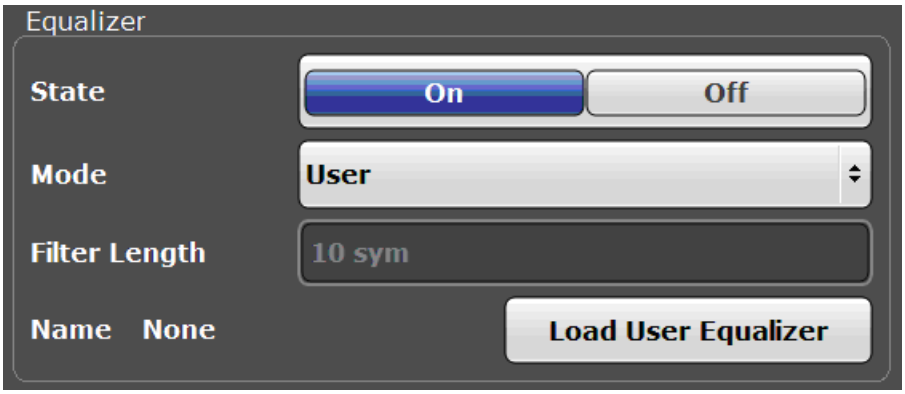
1. Press the ”Demod / Meas Filter” softkey to open the ”Demodulation & Measurement Filter” dialog.
2. In the ”Meas Filter” tab of the dialog set ”Measuremet Filter Type” to ”User”.

3. Press the ”Load User Filter” button to open the ”Load Meas User Filter” dialog.
4. Select your .vaf filter file.

6.3 Loading a User Equalizer Filter

In the FSW-K70 .vaf filter files can also be used as an equalizer filter.

1. Press the ”Demod / Meas Filter” softkey to open the ”Demodulation & Measurement Filter” dialog.
2. In the ”Demodulation” tab of the dialog set the ”Equalizer State” to ”On”.
3. Set the ”Equalizer Mode” to ”User”.

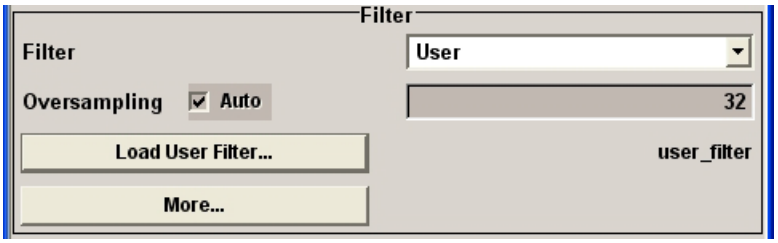


4. Press the ”Load User Equalizer” button to open the ”Load Equalizer Filter File” dialog.
5. Select your .vaf filter file.

7 Configuring User Filters in a Signal Generator

Follow these steps to load the filter files with with an R&S Signal Generator:

1. Copy your .vaf filter file to a USB memory stick.
2. Connect the USB memory stick to the Signal Generator.
3. Select ”Custom Digital Mod. . . ” from the baseband section.
4. Select ”Filter Type” - ”User”.
5. Select ”Load User Filter. . . ”.



6. Load your .vaf file from the USB memory stick.