R&S®mapwiz
Mapping Editor for Rohde&Schwarz Signal and Spectrum Analyzers and Signal Generators

Test and Measurement
Introduction
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ROHDE&SCHWARZ

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

- R&S®FPS-K70.
- R&S®FSQ-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 "mapwiz"

The mapping wizard (mapwiz) is a tool from Rohde & Schwarz designed for editing modulation schemes (e.g. QPSK, 32QAM). Its main purpose is the assignment of logical symbol numbers to constellation points and the selection of modulation specific parameters. Beyond this it supports the creation of nearly any arbitrarily chosen constellation diagram. The output of mapwiz is a mapping file (“`.vam`”) 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 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.

The program 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

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

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

3 Working with “mapwiz"

3.1 Main Window

The screen after starting mapwiz is shown in Figure 3-1. Basically, all white fields may be edited. Grey fields are displayed only, i.e. their values cannot be changed.

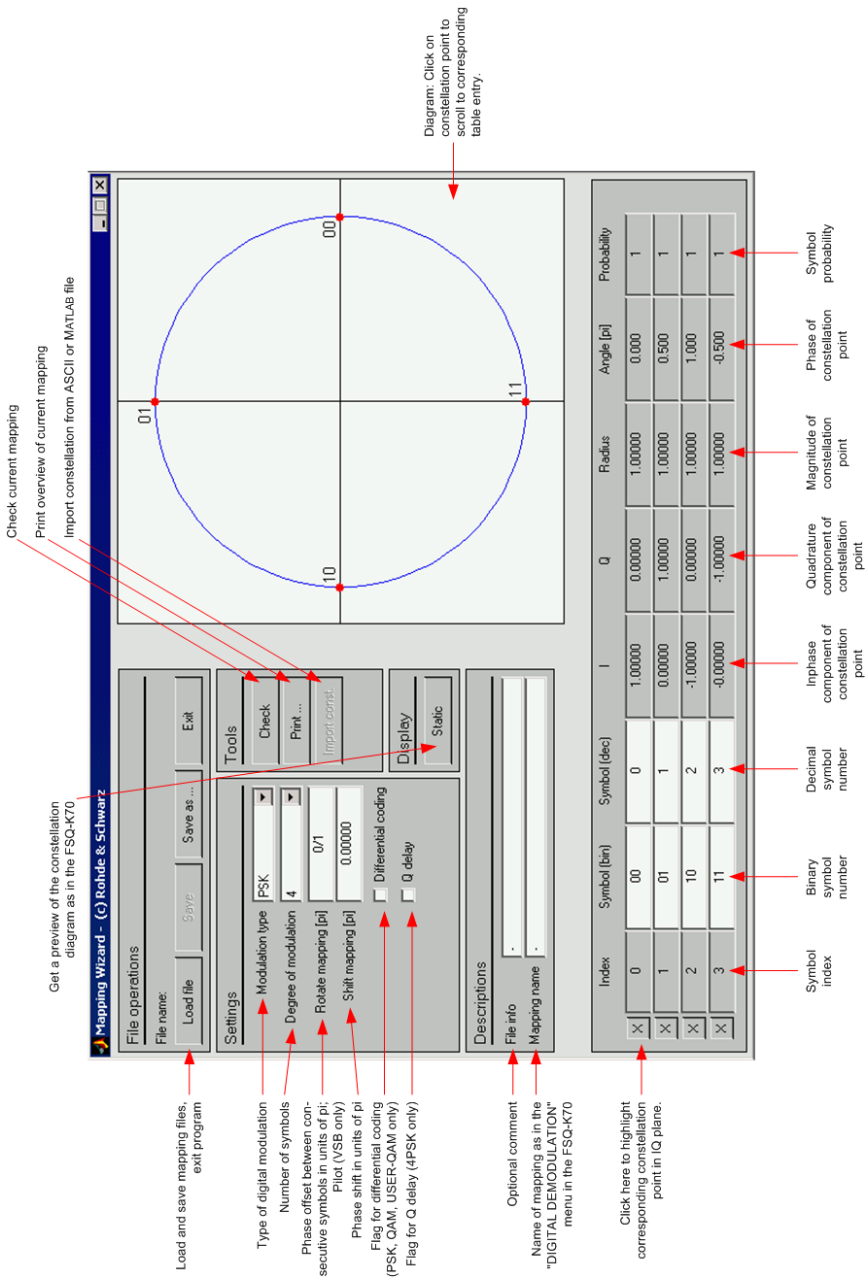


Figure 3-1:mapwiz main window

3.2 Creating a new Mapping File

In order to create a new mapping file, follow the steps below:

1. Choose the desired modulation scheme from the dropdown menu *Modulation type*.

   Available types are:

   – PSK (Phase Shift Keying)
   – MSK (Minimum Shift Keying)
   – FSK (Frequency Shift Keying)
   – VSB (Vestigial Sideband Modulation)
   – QAM (Quadrature Amplitude Modulation)
   – USER-QAM (User definable Quadrature Amplitude Modulation)

2. Select an appropriate number of symbols from *Degree of modulation*.
3. If desired, set additional options:

   – Differential Coding
   – XOR Coding
   – Q delay
   – Rotate Mapping

   These options will be thoroughly discussed below (cf. Modulation specific Options).

4. In the symbol table, symbol numbers from *0* to (*Degree of modulation – 1*) have to be assigned to the constellation points. For USER-QAM the complex constellation points together with their probabilities must also be entered.
5. A phase shift may be entered into the *Shift mapping* field. *Shift mapping* rotates the complex constellation by the given angle.
6. Enter a name for the mapping in the field *Mapping name*. The length is limited to 14 characters.
7. In the field *File info* an optional comment can be given.
8. To save the mapping file, press the *Save as...* button and select VSA mapping as the file format (“`.vam`”). After pressing this button a check of all entered parameters will be performed. A dialog box will pop up if any errors have occurred. It is recommended to choose a file name containing the modulation and the mapping name (e.g. “`16qam my mapping.vam`” or “`4fsk c4fm.vam`”).

Notes:

- You can check the mapping by simply pressing the *Check* button. For example it will be verified if any logical symbol number appears more than once.
- In order to find the corresponding constellation point for a row in the symbol table, click on the **X** button. The point or the transition will then be highlighted on the constellation diagram.
- Similarly, clicking on a point in the constellation diagram will cause the symbol table to scroll to the corresponding line.

- When *Display* is set to *Static* the current logical mapping diagram will be shown. For differential PSK, QAM, USER-QAM and MSK, the phase transitions are represented by arrows. For FSK, the constellation points represent the possible instantaneous frequencies. For VSB only the real parts of the constellation will be shown. With *Display* set to *Preview* you will get the same constellation diagram as shown on the analyzer.

Note: You might see more points than the value of Degree of modulation (e.g. 3π/8-8PSK).

3.3 Importing user defined Constellations

Especially for user defined constellations, i.e. USER-QAM, it might be more convenient to edit constellation data with a text editor. Therefore mapwiz supports the importing of files in MATLAB (“`.mat`”) and ASCII file formats.

If you want to import a static USER-QAM constellation (cf. Static USER-QAM) the file has to contain *M* (=*Degree of modulation*) constellation points. *M* must be a power of two.

For differential USER-QAM (cf. Differential USER-QAM), the file may only contain the points of one sector of the constellation, i. e. *M = (Degree of modulation)/(No. of sectors)*. *Degree of modulation* and *No. of sectors* have to be set before the import. *Degree of modulation* and *No. of sectors* must be a power of two.

MATLAB Files

The file must be created with the same MATLAB version on which mapwiz is run. It should have the following structure:

- *mappingarray0* (mandatory):
  Vector of length *M* containing the complex constellation points.
- *codingarray0* (optional):
  Vector of length *M* holding the symbol numbers (integer) in the range *[0, M-1]* in arbitrary order. If *codingarray0* is missing, the symbols will be numbered in the order of appearance in *mappingarray0*.
- *probabilityarray0* (optional):
  Vector of length *M* holding the probabilities (no normalization required) of the constellation points as positive, real numbers. If probabilityarray0 is missing, equiprobable constellation points will be assumed.

ASCII Files

The data must be arranged in columns. The number of lines corresponds to *M*. Symbol numbers will be assigned in the order of the file. The format within one line is as follows:

```
I Q [probability]
```

- 1st column (mandatory):
  In-phase component of constellation point as real number.

- 2nd column (mandatory):
  Quadrature component of constellation point as real number.
- 3rd column (optional):
  Symbol probability (no normalization required) as positive, real number. If the 3rd column is missing, equiprobable constellation points will be assumed.

3.4 Exporting Mapping Files

Mapping files may be exported to an ASCII data file. Exporting, external editing and subsequent reimporting of data would thus facilitate the handling of large constellation schemes. Just press the *Save as...* button and select *ASCII export*. The created file will contain all the information expected by the import function of mapwiz: In-phase and quadrature components of the constellation points and probabilities (if not equiprobable).

3.5 Printing

To get a printed summary of the current mapping, press the *Print* button. You can choose the number format of the symbols on the print out.

4 Modulation specific Options

The main steps for creating a new mapping file have been described above (cf. Creating a new Mapping File). The following paragraphs will focus on the important steps for each modulation scheme.

4.1 PSK

1. Select a *Degree of modulation*: 2, 4 or 8.
2. In *Rotate mapping* an angle as a fraction of π can be specified. The denominator has to be a power of two. This corresponds to a rotation of the entire constellation between consecutive symbols.
3. For differential PSK set the *Differential coding* checkbox. The diagram will then show the phase transitions.
4. For Offset-QPSK mark the *Q delay* checkbox (only for 4PSK).
5. Logical symbol numbers may be changed.

4.2 MSK

1. Using the *XOR coding* option, the FSQ-K70 or the FSW-K70, respectively, will expect that every received symbol is the result of an XOR precoding of the sent bits (e.g. GSM[3]).
2. Logical symbol numbers may be changed.

4.3 FSK

1. Select a *Degree of modulation*: 2 or 4.
2. Logical symbol numbers may be changed.

Note: The points in the constellation diagram represent instantaneous frequencies.

4.4 VSB

1. *Degree of modulation*: Only 8 is supported.
2. Logical symbol numbers may be changed.

[3] Global System for Mobile Communications

3. Enter the normalized pilot level into the field Pilot (e.g. $\frac{1.25}{8-1} = 0.17857$) for 8VSB as in ATSC5[4]).

4.5 Static QAM

1. Select a *Degree of modulation*: 16, 32, 64, 128 or 256.
2. Logical symbol numbers may be changed.

4.6 Static USER-QAM

1. Select a *Degree of modulation*: 2,4,8,16, 32, 64, 128 or 256.
2. In *Rotate mapping* an angle as a fraction of π can be specified. The denominator has to be a power of two. This corresponds to a rotation of the entire constellation between consecutive symbols.
3. You must define the complex constellation points in the table.
   Note: These points may also be imported by clicking on the *Import const.* button (cf. Importing user defined Constellations).
4. Logical symbol numbers may be changed.
5. Probability values may be given in the last column of the table. Probabilities are represented as positive, real numbers (no normalization required).

4.7 Differential QAM / USER-QAM

In the next section a short introduction to differential QAM and differential USER-QAM will be given. Later on it will be described how to create a differential QAM or a differential USER-QAM mapping file.

What is differential QAM / USER-QAM?

For QAM and USER-QAM, the option *Differential coding* may be activated. Differential QAM is for example used by the DVB-C[5] standard. Using this option, the first bits of the symbol values (MSBs[6]) correspond to the sector in which a received symbol appears, compared to the sector of the previously received symbol. The last bits (LSBs[7]) represent the (static) position of the received symbol within a sector.

[4] Advanced Television Systems Committee

[5] Digital Video Broadcasting for cable systems, cf. ETSI EN 300 429

[6] Most Significant Bits

[7] Least Significant Bits

Figure 4-1 shows the differential and the static mappings as they would appear in mapwiz. The left side of Figure 4-1 visualizes the phase transitions, whereas the right side shows the mapping inside a sector.

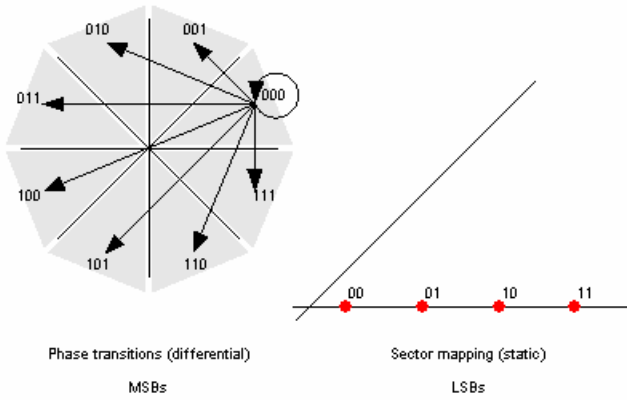


Figure 4-1: Constellation diagram (differential / static)

Figure 4-2 shows the corresponding symbol table of the differential and the static mappings. In the left table the symbols for the phase transitions may be edited. In the right table the constellation points within a sector may be edited.

Index	Symbol MSBs (bin)	Transition [pi]
0	000	0
1	001	0.25
2	010	0.5
3	011	0.75

Index	Symbol LSBs (bin)	I	Q	Probability
0	00	0.14286	0.00000	1
1	01	0.42857	0.00000	1
2	10	0.71429	0.00000	1
3	11	1.00000	0.00000	1

Figure 4-2: Symbol table (differential / static)

Differential USER-QAM

1. Modulation type: USER-QAM
2. Select a *Degree of modulation*: 2, 4, 8, 16, 32, 64, 128 or 256.
   This corresponds to the total number of symbols.
3. In *Rotate mapping* an angle as a fraction of π can be specified. The denominator has to be a power of two. This corresponds to a rotation of the entire constellation between consecutive symbols.
4. Activate the *Differential coding* checkbox.
5. Set *No. of sectors*.
6. Enter the constellation points for one sector (cf. Figure 3, table on the right).
   M = (Degree of modulation)/(No. of sectors) points must be entered.
   Note: These points may also be imported by clicking on the Import const. button (cf. Importing user defined Constellations).
7. If desired change the probabilities of the constellation points.
8. Change the logical symbol numbers in the right table (LSBs).

9. Assign logical symbol numbers to the phase transitions in the left table of Figure 4-2 (MSBs).

Differential QAM

1. *Modulation type*: QAM
2. Select a *Degree of modulation*: 16, 32, 64, 128 or 256.
3. Activate the *Differential coding* checkbox.
4. In the table logical symbol numbers may be changed (MSBs and LSBs).

Note: The tables and diagrams for differential QAM are similar to those of differential USER-QAM. However, No. of sectors is constant and equals 4.

5 Transferring Mapping Files to the FSQ

Follow these steps to load the mapping files with the FSQ-K70:

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 mapping file (e.g. "`4fsk c4fm.vam`") into the FSQ's floppy drive.
5. Press MAPPINGS.
6. Choose your mapping file, e.g. `4fsk_c4fm`, from the list and press ENTER .
7. If the new mapping file was successfully imported an entry will appear in the FSQ-K70's "MODULATION & MAPPING" table (cf. Figure 5-1). Please refer to the FSQ-K70 manual for further details.

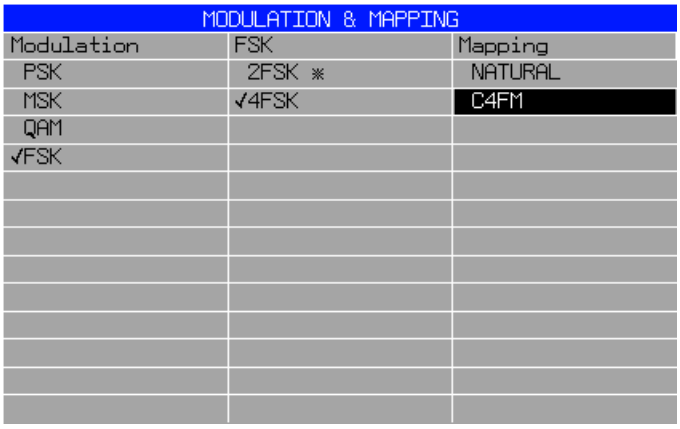
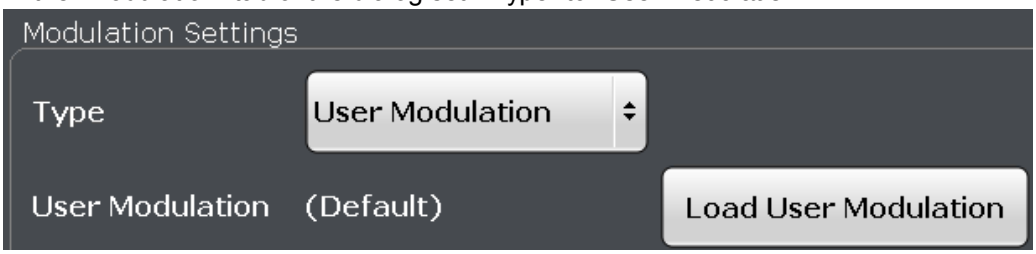


Figure 5-1: FSQ-K70 "MODULATION & MAPPING" table

6 Transferring Mapping Files to the FSW

Follow these steps to load the mapping with the FSW-K70:

1. Copy your .vam mapping file to a USB memory stick and connect the USB 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 the "VSA" button.
3. Press the ”Signal Description” softkey to open the ”Signal Description” dialog.
4. In the ”Modulation” tab of the dialog set ” Type” to ”User Modulation”.

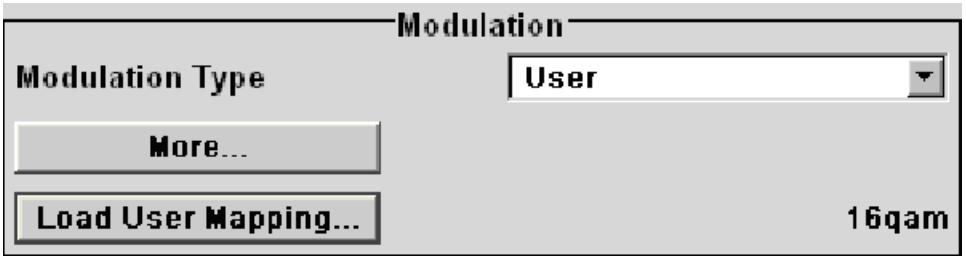


5. Press the "Load User Modulation" button to open the "Load User Modulation" dialog and select your .vam file.

7 Transferring Mapping Files to the Signal Generator

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

1. Copy your .vam mapping file to a USB memory stick and connect the USB stick to the Signal Generator.
2. Select ”Custom Digital Mod. . . ” from the baseband section.
3. Select ”Modulation Type” - ”User”.
4. Select ”Load User Mapping. . . ”.



5. Load your .vam file from the USB stick.