

Filter Bank Design

User Manual

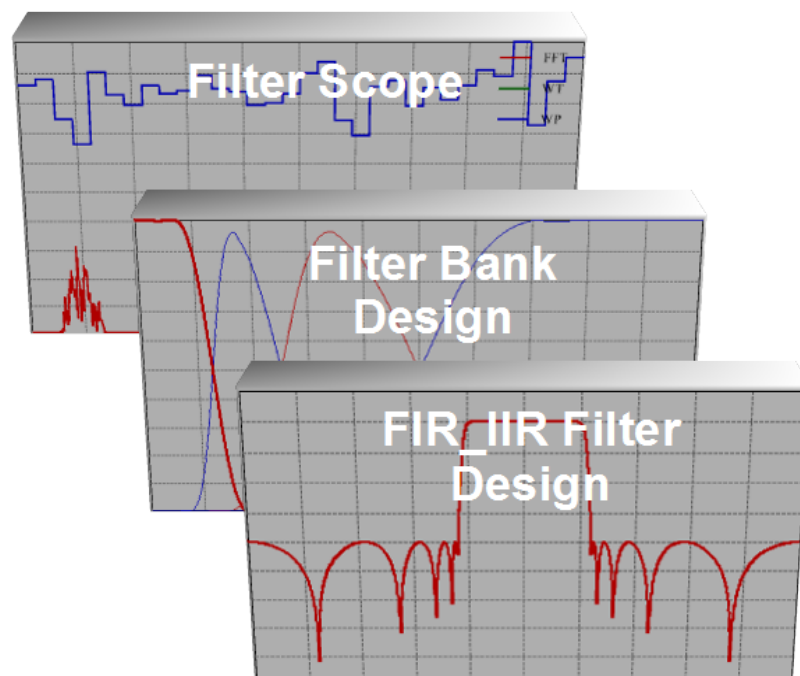


Table of Contents

1./ General introduction of Filter Bank Design software module	3
2./ Freq Resp panel	4
3./ Coefs panel	7
4./ UserDefWaveletBasis panel	8
5./ Menus	9
6./ User Manual	10
7./ Licence	10
8./ Meaning of abbreviations and parameters	10

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1./ General introduction of Filter Bank Design software module

Filter Bank Design software is intended to design digital filter bank with wavelet and wavelet packet transform. Its input can be a wavelet basis file (.wbs) generated by **FIR IIR Filter Design**, or user defined wavelet basis with LP only, or with LP and HP filters.

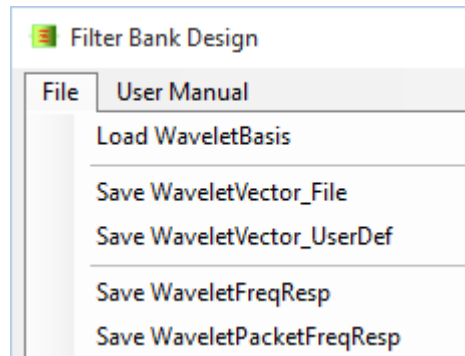
On one hand this software computes the amplitude - frequency response graph of every Wavelet and Wavelet Packet band, on the other hand it provides a Novel design method which is suitable for rejecting the so-called crosstalk distortion.

Environmental conditions

Operation system	MS Windows 7, 8, 10 32 / 64 bit
Display resolution [pixel]	Minimum 1024 x 768
RAM memory	Minimum 1 GByte
Processor	≥ 2 cores

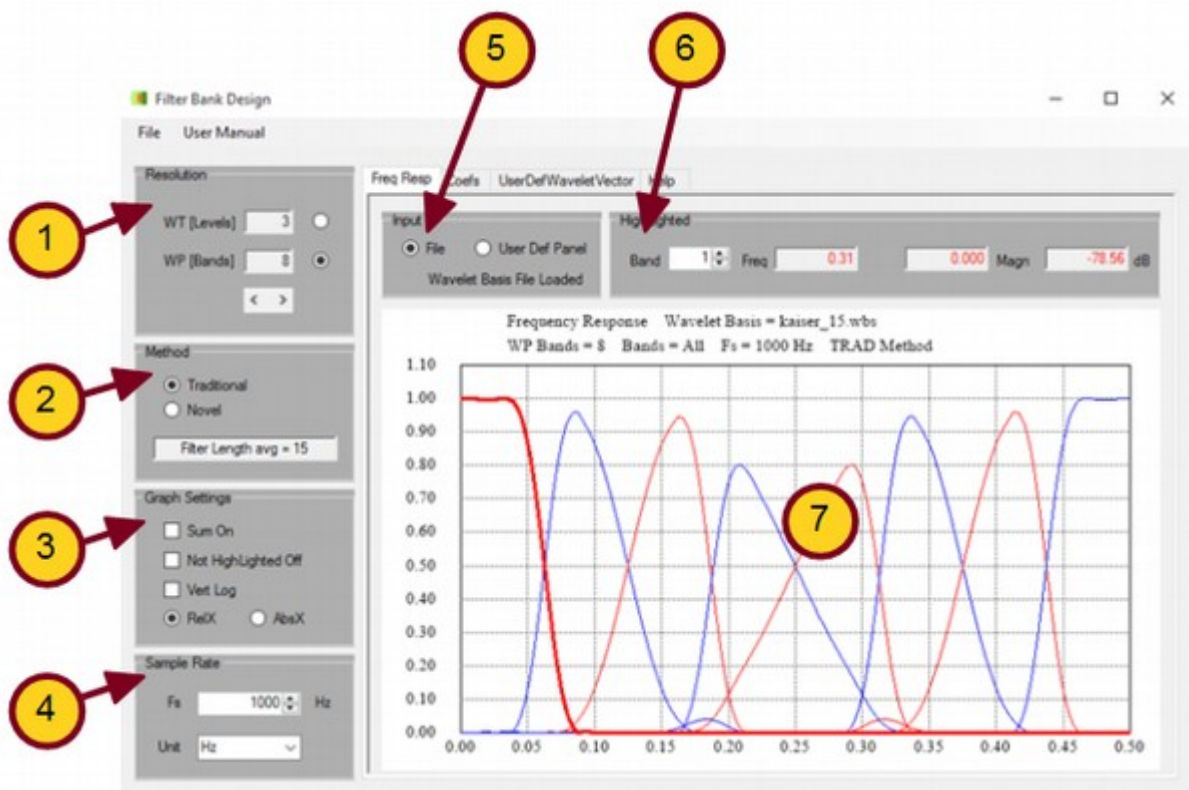
2./ Freq Resp panel

The program is able to compute amplitude – frequency response of two inputs. The first input is a wavelet basis file (*.wbs) which is created by **FIR IIR Filter Design**, the second input is when the user types the wavelet basis filter coefficients (only LP, LP and HP) in the UserDefWaveletBasis window.



To use this panel a wavelet basis file should be loaded. This file includes the wavelet LP filter. Wavelet HP filter is generated during the transform.

Appearance of FreqResp panel



Explanation of marks

1 Resolution

In case of Wavelet (WT radio button on) this number means the number of computed levels. The number of displayed bands are Levels + 1, because at the last level both LP and HP bands are outputs. The output of the HP filters are displayed after every transform step, and the LP output is displayed only after the last step.

In case of Wavelet Packet (WP radio button on) this number means the number of output bands:
Wavelet Packet Bands = $2^{\text{WT Levels}}$

2 Method

Traditional

Both Wavelet and Wavelet Packet use “a trous” algorithm without decimation (downsampling). In Traditional case every wavelet level is computed with the same LP and HP filters with the difference in upsampling. The first level uses filters without upsampling, the second level with one upsampling (one zero inserted after every coefficient), and so on.

Novel

The program creates a wavelet vector from the wavelet basis filter(s). It means that every wavelet level uses different filters in order to keep transition of bands on a constant value.

By choosing adequate filter type and taps the Novel method can eliminate crosstalk distortion caused by weak filter selectivity.

Important notice!

Filter Bank Design wavelet vector designer program is based on the filter design algorithms of **FIR IIR Filter Design**, that is why wavelet vector can be created from wavelet basis designed by **FIR IIR Filter Design**.

Novel method operates only for wavelet basis generated by **FIR IIR Filter Design**, otherwise this method is disabled.

In Novel mode the average filter length is displayed, and next to it the Traditional mode filter length is displayed in brackets. The software uses different length filters in Novel mode, that is why average filter length is used.

3 Graph Settings

Sum On

The program provides the sum of each amplitude – frequency bands for each frequency points, then displays it. If all points of this sum curve equals to 1, it means that the original signal can be

restored by the sum of Bands. This feature allows the user to provide new frequency bands with the sum of any existing bands.

Not Highlighted Off

The program displays that frequency band only which is selected in the HighLighted group (see point 6).

VertLog

Set Vertical axis to logarithmic.

RelX

If switched on, the frequency axis has relative scaling. 0.5 means $F_s / 2$.

AbsX

If switched on, the frequency axis has absolute values.

4 Sample Rate

It affects to the frequency axis if AbsX is switched on. Scaling of the frequency axis follows Sample Rate values.

5 Input

Choosing the input of Wavelet and Wavelet Packet.

File

The program creates wavelet vector from the loaded wavelet basis (*.wbs) file created by **FIR IIR Filter Design**.

User Def Panel

The program creates wavelet vector from the user defined filter coefficients which is on UserDefWaveletBasis panel.

6 HighLighted

The curve of the selected Band will be highlighted with a thicker line. The three indicators display the x and y values of the highlighted curve.

Bands

Choose Band to be highlighted.

7

Graph

Color of bands are red and blue intermittently.

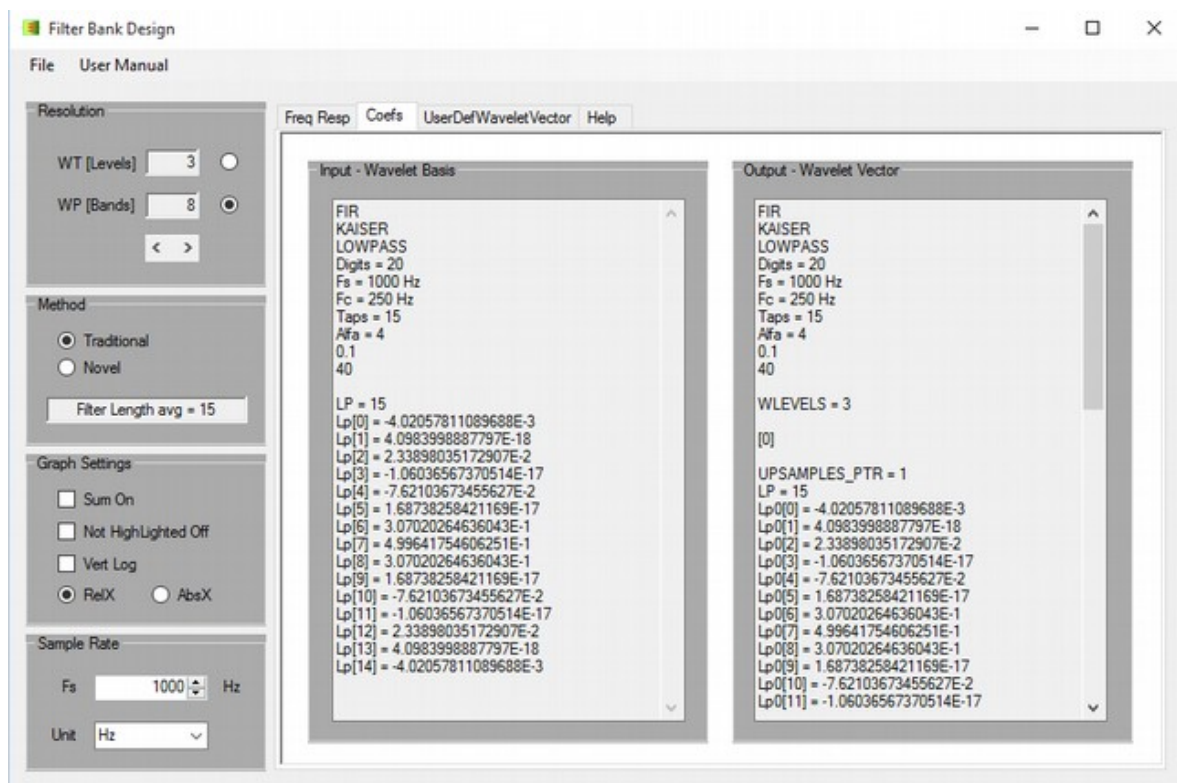
3./ Coefs panel

Input

The program displays the wavelet vector coefficients. The input can come from *.wbs file or UserDefWaveletVector panel depending on the Input switches on FreqResp panel.

Output

Coefficients of the generated wavelet vector can be seen here. In case of Traditional mode Wavelet and Wavelet Packet algorithm use wavelet basis filter at each level, unlike Novel mode where different filters are used at each level (LP0[i], HP0[i] to level 0, LP1[i], HP1[i] to level 1, ..., wavelet basis to the last level).



4./ UserDefWaveletVector panel

Wavelet Name

This name will identify the vector in the saved file. It has no other function.

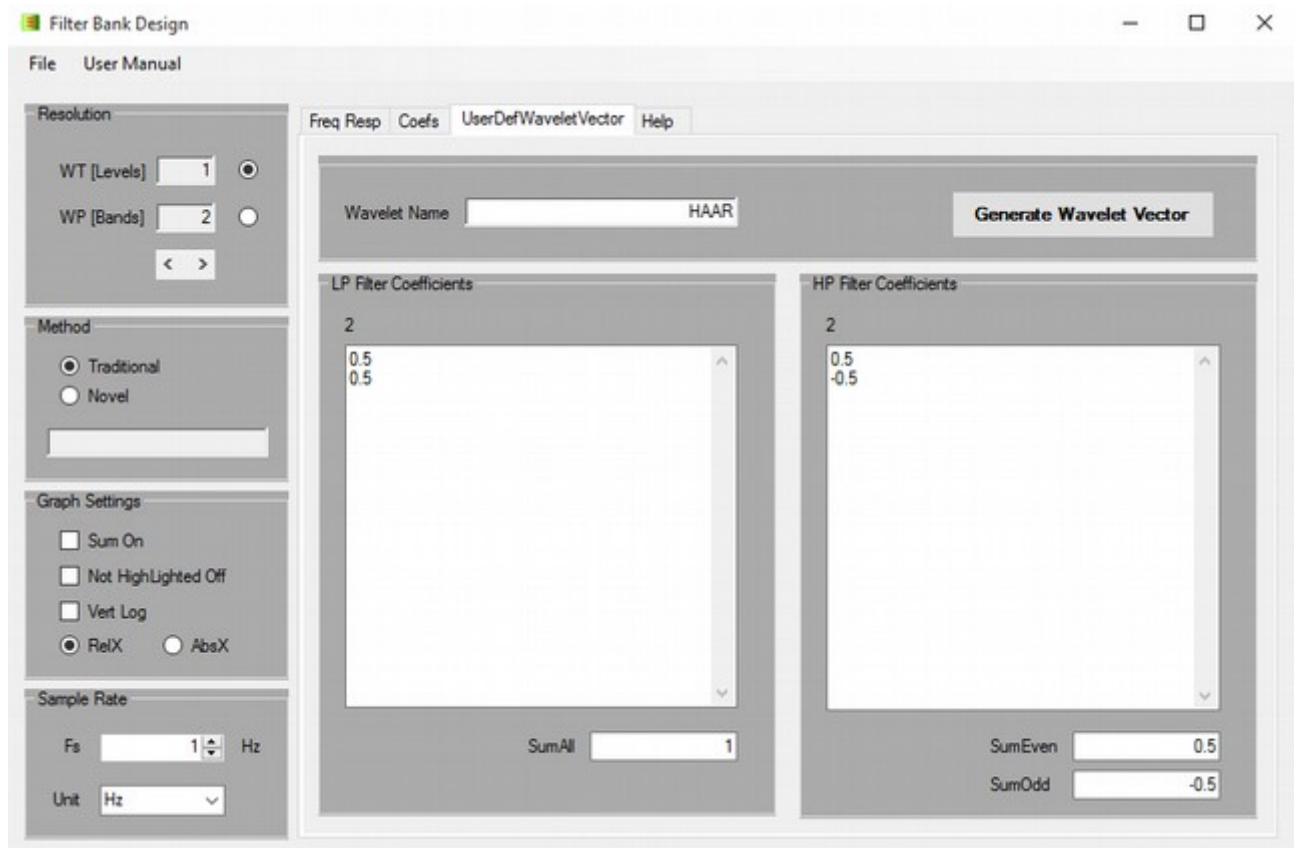
LP Filter Coefficients

Coefficients of the LP filter of the transform can be defined here by typing or inserting coefficients by copy / paste. The program accepts numbers only.

HP Filter Coefficients

Coefficients of the HP filter of the transform can be defined here by typing or inserting coefficients by copy / paste. The program accepts numbers only.

It is allowed to leave this box empty. In this case the wavelet generates orthogonal HP filter.



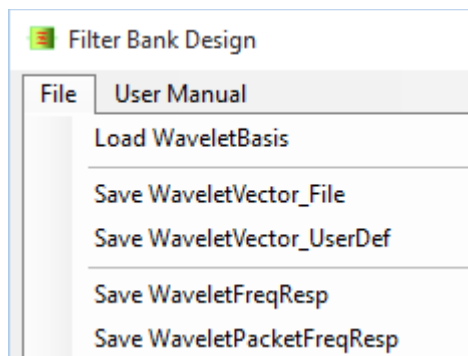
Generate Wavelet Vector

After clicking on this button the program checks the LP and HP coefficients based on list below:

- LP and HP consist of numbers only
- Number of LP coefficients has to be greater than 1
- Sum of LP coefficients has to be in the range of 0.998 – 1.002
- If HP box is not empty, the number of LP and HP coefficients has to be equal to each other
- The absolute value of the sum of the odd index HP coefficients has to be in the range of 0.498 – 0.502
- The absolute value of the sum of the even index HP coefficients has to be in the range of 0.498 – 0.502
- Sign of the sum of odd and even HP coefficients has to be different
- Wavelet Name must not be empty

The successfully generated wavelet vector will be displayed on Coefs panel. It is important to know, that the program disables Novel switch in case of user defined mode.

5./ Menus



Load WaveletBasis

Loads WaveletBasis (*.wbs) file.

Save WaveletFilterVector_File

Saves Wavelet Vector coefficients into file.

Save UserDeWaveletVector_UserDef

Saves user defined wavelet basis into file.

Save WaveletFreqResp

Saves all the amplitude – frequency response curves of wavelet into file.

Save WaveletPacketFreqResp

Saves all the amplitude – frequency response curves of wavelet packet into file.

6./ User Manual

By clicking on the UserManual/English menu the program runs Acrobat Reader to display this UserManual in pdf.

7./ Licence

The **Filter Bank Design** module operates with two licences. One of them is the *Trial version*, the other is the *Licensed version*. In *Trial version* the module operates without time period limit, but with limited functions:

Limitations:

- *File / Load WaveletBasis* function is enabled only for demo files
- Number of Wavelet levels is limited by 3
- *UserDefWaveletVector* tab is not enabled

8./ Meaning of abbreviations and parameters

LP	Low Pass
HP	High Pass
BP	Band Pass
BS	Band Stop
Fs	Sample rate
Ts	Sample time
Fc	Corner frequency. At FIR LP and HP filters the amplitude response is 0.5 at this frequency. At BP and BP filters it means center frequency.
B	Bandwidth at BP and BS filters.
Taps	Number of coefficients at FIR filters.
Order	Order of filter at IIR filter.
Alfa	The value of Kaiser constant at Kaiser filters
Ap	Pass band ripple at IIR Chebyshev I filters in dB
As	Value of minimal attenuation at IIR Chebyshev II filters in dB
FreqUnit	Frequency unit
	uHz = microHertz
	mHz = milliHertz
	Hz = Hertz

kHz = kiloHertz
MHz = megaHertz
GHz = gigaHertz

FFT Fast Fourier transform
WT Wavelet transform
WP Wavelet Packet transform
MRA Multiresolution analysis
AMD Amplitude distortion
PHD Phase distortion
ALD Alias distortion