

Filtering Toolkit 1 - IIR Filtering Form

Description

IIR Filtering Form enables design and analysis of IIR filters. IIR filter design is performed by analog prototyping based on classical IIR filters such as Butterworth, Chebyshev types I and II, and elliptic filter. IIR Filtering Form can be used to filter an input signal as well.

Initiate IIR Filtering Form

In order to use the form, one has to create the form using function `f:=iirfilteringform(0,"form1")`. Here, the first argument is the widget parent or 0, and the second argument is the string form name. The function returns identification of the widget form. The created IIR Filtering Form is placed in Canvas at the position where function `embed widget(f)` is called with the appropriate widget identity.

```
f:=iirfilteringform(0 , "FormIIR")    Creates IIR filtering form of the name "FormIIR"
```

Preparation of test signal

A test signal is not part of the IIR filtering form. However, we need it in order to test the filtering operation, as created form can filter signal at the same time. We generate a simple test signal as a sum of two sinusoidal signals of different frequencies. The sampling frequency is also defined for overall example which is used later for filter design within IIR filtering form.

```
Fs:=24000    Sampling frequency
Ts1:=1/Fs    Sampling period
dt:=ynodes(x , 0 , 99 Ts1 , 100)    Time axis, 100 samples
f1:=1000     Frequency of the first sinusoidal
f2:=6000     Frequency of the second sinusoidal
x:=5 sin(2 π · f1 dt) + 5 sin(2 π · f2 dt)    Input signal
```

Choosing filter design method

The IIR filtering form is created in Canvas at the position where the function `embed widget(f)` is called. The user can choose the filter design method from the drop-down menu of the same name. There are four options Butterworth, Chebyshev types I and II, and elliptic filter.

Choosing a response type

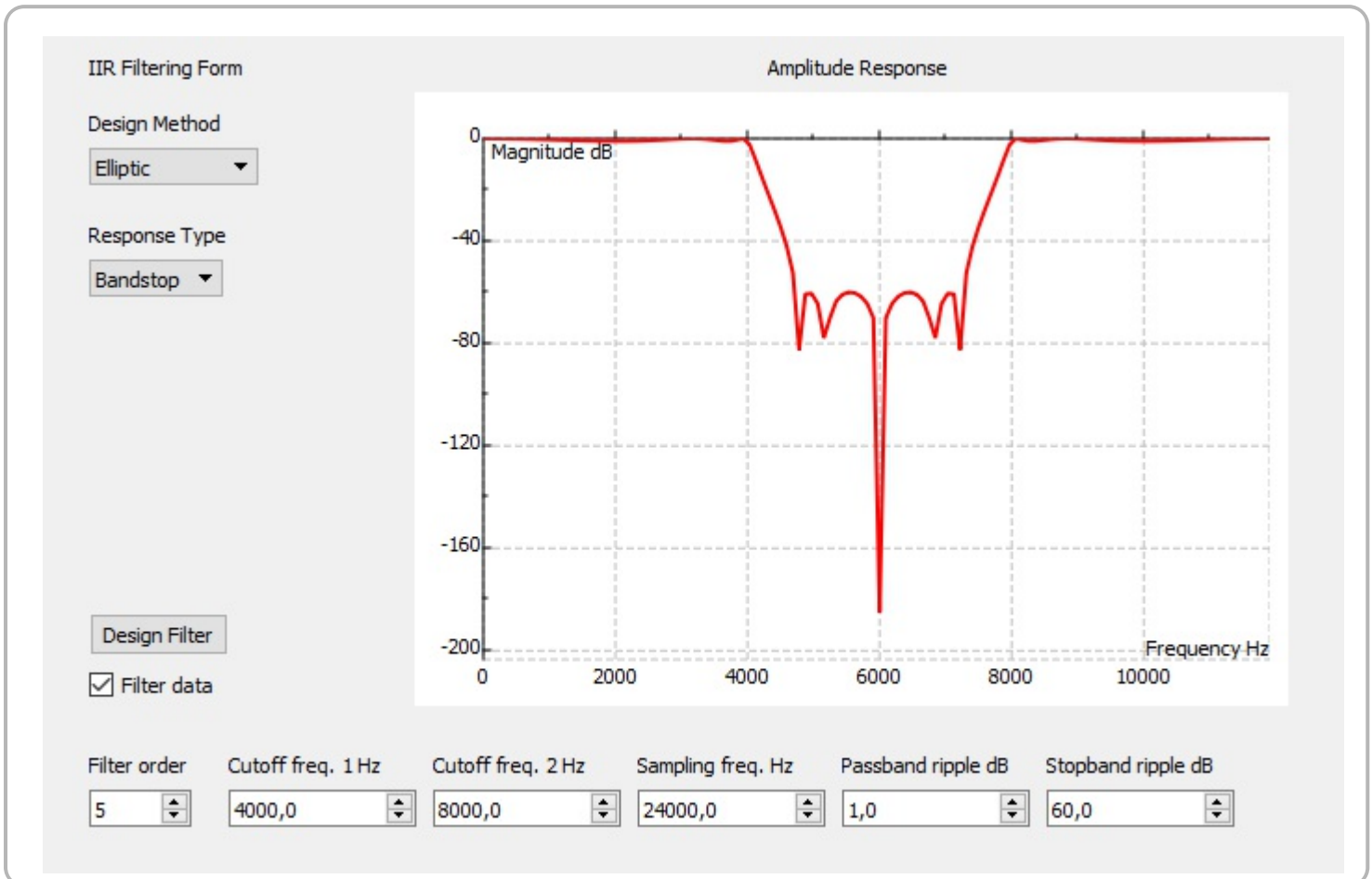
A response type is selected from the drop-down menu of the same name. There are four different response types: lowpass, highpass, bandpass and bandstop frequency response.

Setting the filter design specifications

The filter design specifications, which can be set, vary according to design method and response type. There are 16 different combinations of design method and response type. For all 16 options there two

common filter design specifications: filter order and sampling frequency. Other filter design specifications include: single cutoff frequency for all lowpass and highpass cases, two cutoff frequencies, lower and upper, for all bandpass and bandstop cases. According to selected design method, filter specifications can be passband ripple for Chebyshev type I and elliptic cases, and stopband ripple for Chebyshev type II and elliptic cases. In the IIR filtering form all frequencies are in Hz and ripples in dB.

After all filter design specifications are set the tab Design Filter enables the filter design, and filtering if the Filter data box is checked. The amplitude response of the filter is shown in graph which is included in the IIR filtering form.



Filtering input signal

As explained, the IIR filtering form can be used to filter input signal. In order, to perform filtering the Filter data check box has to be checked. The results are derived by calling functions `iirfilteringresult(f,x)`, where `f` is the identification of widget, `x` is input signal and `y` is output signal.

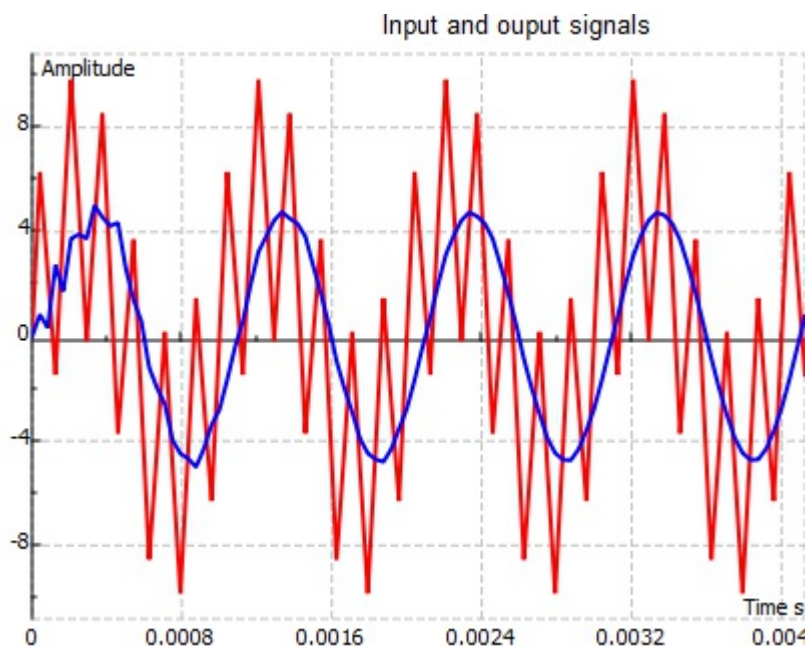
```
y:=iirfilteringresult(f , x)
```

Plotting results

The output signal after filtering can be displayed together with input signal in the same graph. We prepare variables for graph using standard MatDeck approach.

`graf1 := join mat cols(dt , x)` Input signal

`graf2 := join mat cols(dt , y)` Output signal



Filter design specifications

In following table filter design specifications are given with recommended values to see all effects of the IIR filtering form. A cell in table is empty if that specification does not exist in the IIR filtering form. The table contains examples for all 16 options.

Design Method	Response Type	Filter order	Cutoff frequency 1	Cutoff frequency 2	Sampling frequency	Passband ripple	Stopband ripple
Butterworth	lowpass	5	4000Hz		24000Hz		
Butterworth	highpass	5	4000Hz		24000Hz		
Butterworth	bandpass	5	4000Hz	8000Hz	24000Hz		
Butterworth	bandstop	5	4000Hz	8000Hz	24000Hz		
Cheby. I	lowpass	5	4000Hz		24000Hz	1dB	
Cheby. I	highpass	5	4000Hz		24000Hz	1dB	
Cheby. I	bandpass	5	4000Hz	8000Hz	24000Hz	1dB	
Cheby. I	bandstop	5	4000Hz	8000Hz	24000Hz	1dB	
Cheby. II	lowpass	5	4000Hz		24000Hz		60dB
Cheby. II	highpass	5	4000Hz		24000Hz		60dB
Cheby. II	bandpass	5	4000Hz	8000Hz	24000Hz		60dB
Cheby. II	bandstop	5	4000Hz	8000Hz	24000Hz		60dB
Elliptic	lowpass	5	4000Hz		24000Hz	1dB	60dB
Elliptic	highpass	5	4000Hz		24000Hz	1dB	60dB
Elliptic	bandpass	5	4000Hz	8000Hz	24000Hz	1dB	60dB
Elliptic	bandstop	5	4000Hz	8000Hz	24000Hz	1dB	60dB