Plotting the Frequency Response of a Digital Filter

Introduction

This application provides a procedure *FilterFrequencyResponse* that plots the magnitude and phase response of an IIR or FIR filter. This procedure is used to illustrate the frequency response of several filters.

For an

- IIR filter, *FilterFrequencyResponse* expects two lists of taps of equal length (the coefficients of the numerator and denominator of the transfer function)
- FIR filter, *FilterFrequencyResponse* expects a single list of taps

Maple has three functions for generating filter taps (that is, the coefficients of the filter transfer function): GenerateButterworthTaps, GenerateChebyshev1Taps and GenerateFIRFilterTaps.

GenerateButterworthTaps and GenerateChebyshev1Taps give a single array that contains the coefficients of the numerator and denominator of the transfer function. The first half are the coefficients of the numerator, while the latter half are the coefficients of the denominator; these must be provided to *FilterFrequencyResponse* separately, and not as a single list.

Procedure

```
> restart:
```

```
Digital Filter Frequency Response
```

Frequency Response of a Chebyshev Type 1 Filter

Order

```
> ord := 5:
```

Sampling frequency

```
> sampling_freq := 2000.0:
```

Cutoff frequency

```
> filt_freq := 800 / sampling_freq
```

$$filt\_freq := 0.4000000000 \tag{3.1}$$

Passband ripple

```
> ripple := 29:
```

Here we returns transfer function coefficients of a lowpass digital Chebyshev Type I filter

```
> taps := SignalProcessing:-GenerateChebyshev1Taps( ord,
  filt_freq, ripple, filtertype = lowpass);
```

$$taps := [0.0145256222951223, 0.0726281114756114, 0.145256222951223, 0.145256222951223, 0.0726281114756114, 0.0145256222951223, 1., 1.67764328574172, 1.12542851668154, -0.885659875792075, -1.51371985423053, -0.938872158956746] \tag{3.2}$$

Assign the coefficients of the numerator and denominator to separate names

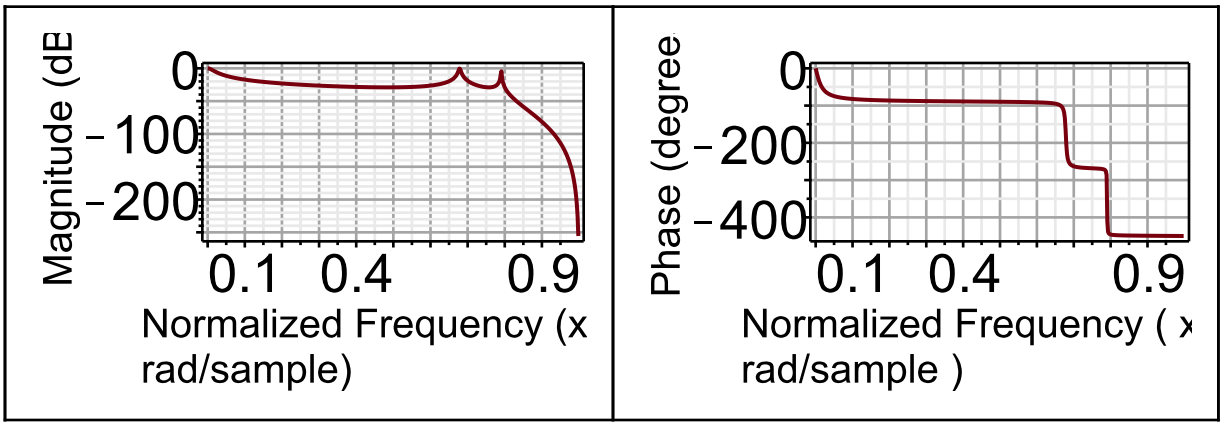
```
> taps := convert( taps, list ):
  num_taps := numelems( taps ):
  b := taps[ 1..num_taps / 2 ];
  a := taps[ num_taps / 2 + 1 .. -1 ];
```

$$b := [0.0145256222951223, 0.0726281114756114, 0.145256222951223, 0.145256222951223, 0.0726281114756114, 0.0145256222951223]$$

$$a := [1., 1.67764328574172, 1.12542851668154, -0.885659875792075, -1.51371985423053, -0.938872158956746] \tag{3.3}$$

Now plot the magnitude and phase of the filter

```
> FilterFrequencyResponse(b,a)
```



Frequency Response of an FIR Filter

```
> taps := SignalProcessing:-GenerateFIRFilterTaps( 48, 0.25,
  window = Hamming, normalize = false, filtertype = lowpass)
```

$$taps := [\ -0.000766226652048602,\ -0.000841339149671470,\ 0.00100860740404767,\ 0.00127911948879349,\ -0.00166460722830032,\ -0.00217769827899556,\ 0.00283228559132624,\ 0.00364406190199566,\ -0.00463129091647615,\ -0.00581592581011653,\ 0.00722525069301681,\ 0.00889433259851163,\ -0.0108697711579715,\ -0.0132156039368307,\ 0.0160229476557357,\ 0.0194264426666097,\ -0.0236338399613289,\ -0.0289828724473002,\ 0.0360601225851508,\ 0.0459783098573302,\ -0.0611288196507035,\ -0.0877401269135040,\ 0.148669591060247,\ 0.449695739487900,\ 0.449695739487900,\ 0.148669591060247,\ -0.0877401269135040,\ -0.0611288196507035,\ 0.0459783098573302,\ 0.0360601225851508,\ -0.0289828724473002,\ -0.0236338399613289,\ 0.0194264426666097,\ 0.0160229476557357,\ -0.0132156039368307,\ -0.0108697711579715,\ 0.00889433259851163,\ 0.00722525069301681,\ -0.00581592581011653,\ -0.00463129091647615,\ 0.00364406190199566,\ 0.00283228559132624,\ -0.00217769827899556,\ -0.00166460722830032,\ 0.00127911948879349,\ 0.00100860740404767,\ -0.000841339149671470,\ -0.000766226652048602\ ] \quad (4.1)$$

Now plot the magnitude and phase of the filter

```
> taps := convert(taps, list):
  FilterFrequencyResponse(taps)
```