DSP Notes: Filter Analysis
Dr. Fred DePiero, CalPoly State University

Downloading SciLab and Related Files

SciLab may be downloaded for free, from DePiero's web site. (Follow 'Notes on Signals & Systems…' link). This SciLab bundle is in the form of a self-extracting file. Extract to the default location. The bundle contains the various functions '`xxx_fwd()`' described below. It also contains a shortcut (C:\Program Files\scilab-3.0\SciLab) which is useful for starting SciLab. Place shortcut on desktop or other convenient location.

Using SciLab to Examine a Frequency Response

The function `freqz_fwd()` may be used to examine a frequency response. The system function H(z) = B(z)/A(z) is described by the coefficients of the B(z) and A(z) polynomials.

$$H(z) = \frac{B(z)}{A(z)} = \frac{B_0 + B_1 z^{-1} + B_2 z^{-2} + B_3 z^{-3} + \cdots}{1 + A_1 z^{-1} + A_2 z^{-2} + A_3 z^{-3} + \cdots}$$

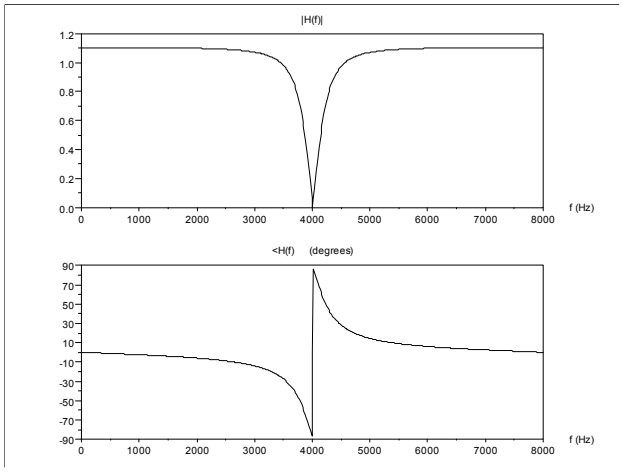
To use SciLab to find the response of a filter described by B(z)/A(z), define vectors, a and b, containing the ordered A_k and B_k coefficients. For example:

$$H(z) = \frac{B(z)}{A(z)} = \frac{1 + z^{-2}}{1 + 0.81\, z^{-2}}$$

```
--> b = [ 1  0   1 ];
--> a = [ 1  0 .81 ];
--> N = 1024;
--> S = 16000;
--> freqz_fwd(b,a,N,S);
```

Where the parameter N is the number of points computed in the frequency spectrum and S is the sampling rate. Note that the parameter A_0 is always one. When defining a system in this fashion, a constant should appear (minimally) in the numerator or denominator of H(z). Hence the vector 'a' should be assigned as a=1 for an FIR system. A system with trivial zeros would assign the vector 'b' to a constant.

The `freqz_fwd()` function plots both the magnitude and phase of H(z), in this example the system is a notch filter.



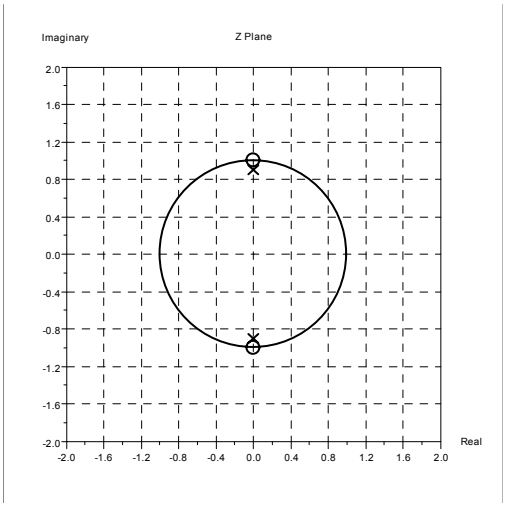
Another function `freqzdb_fwd()` produces magnitude plots with a dB scale, and uses the same input parameters.

Using SciLab to Examine Pole/Zero Plots

The poles and zeros of a system function H(z) = B(z)/A(z) can be plotted using the function `zplane_fwd()`. The system function is described using 'a' and 'b' vectors, as described previously for frequency response. Continuing with the same example system:

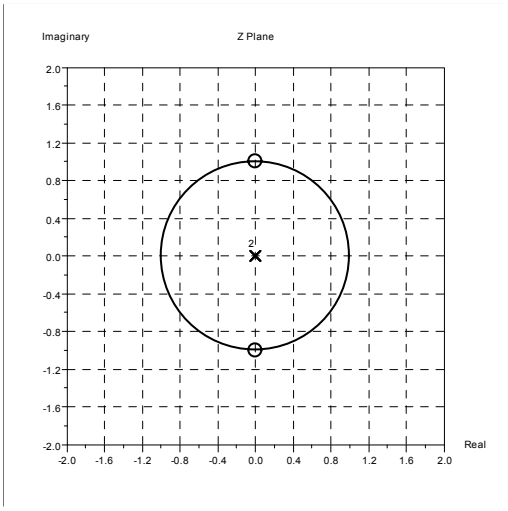
```
--> b = [ 1  0   1 ];
--> a = [ 1  0 .81 ];
--> zplane_fwd(b,a)
```

Yields the following plot:



Higher order poles and zeros are indicated by numeric values on the plot. For example, the following FIR system has a pair of trivial poles at the origin:

```
--> zplane_fwd( [ 1 0 1 ],  1 )
```

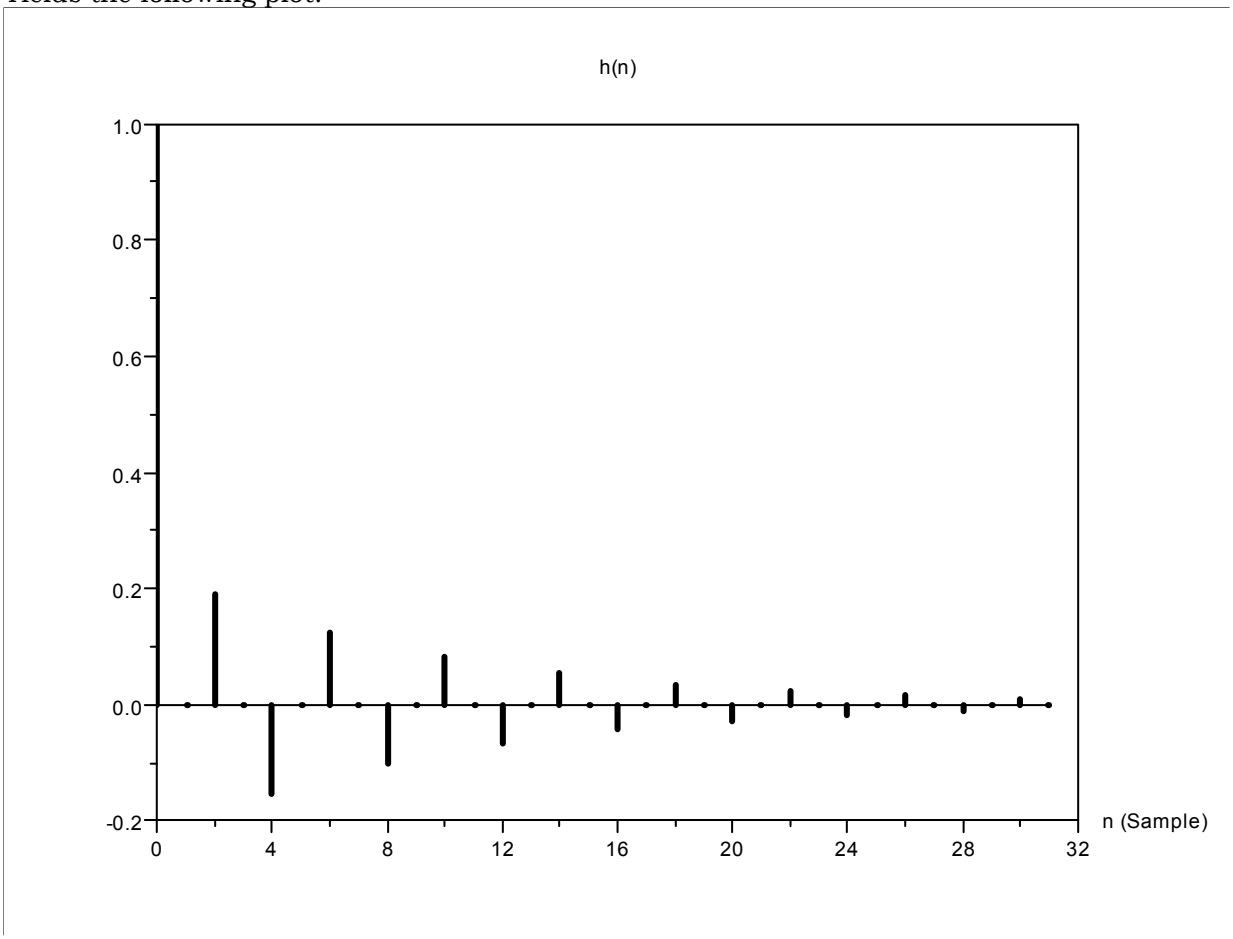


Using SciLab to Plot an Impulse Response

The impulse response, h(n), of a system function H(*z*) can be plotted using the function `dimpulse_fwd()`. The system function is described using 'a' and 'b' vectors, as described previously. An additional parameter, M, specifies the number of samples to be plotted. For example:

```
--> b = [ 1  0   1 ];
--> a = [ 1  0 .81 ];
--> M = 32;
--> dimpulse_fwd(b,a,M);
```

Yields the following plot:



The function `dstep_fwd(b,a,M)` is similar, providing a step response.

Writing SciLab Procedure Files

Procedure files are quite helpful when a series of SciLab commands need to be run, or run repeatedly. To create and edit a procedure file, click on the 'Open SciPad' toolbar button. Then enter commands as needed. Note that lines ending with a semicolon provide a 'quiet mode', of assignment, suppressing displayed values.

Save the procedure file with the extension '.sci', in the default directory.
To run the procedure file, first save (Ctrl-S), and then load into SciLab (Ctrl-L). The output from your procedure file will immediately appear in the main SciLab window.
Functions may also be defined – see examples in default directory.