Finding the frequency response using MATLAB

Finding Frequency Response Using MATLAB

- There are several MATLAB functions that are very useful for finding the impulse, frequency and step responses of a filter
  - impz, freqz and stepz
- Consider the z-transform of the response

$$H(z) = \frac{b_0 + b_1 z^{-1} + b_2 z^{-2} + \cdots}{a_0 + a_1 z^{-1} + a_2 z^{-2} + \cdots}$$

- Express the numerator and denominator as vectors

Finding Frequency Response Using MATLAB

- Express the numerator and denominator as vectors

$$b = [b_0, b_1, b_2, \ldots]$$

$$a = [a_0, a_1, a_2, \ldots]$$

- Then to find the impulse response for a N points use impz

$$\text{impResp} = \text{impz}(b, a, N)$$

Finding Frequency Response Using MATLAB

- Then to find the frequency response for a N points use freqz

$$[\mathrm{h}, \mathrm{w}] = \mathrm{freqz}(b, a, N)$$

- h is the complex frequency response (N-points)
- w is the frequency from 0 to Nyquist (N-points) normalized to π.
  - The Nyquist frequency is π.

Plotting the Frequency Response Using MATLAB

- The linear magnitude of the frequency response can be found using the abs() command in MATLAB

$$magnitude = abs(h)$$

- The magnitude in decibels of the frequency response can be found using the abs() command in MATLAB and taking $20\log_{10}(magnitude)$

$$dB = 20\log_{10} abs(h)$$

Plotting the Frequency Response Using MATLAB

- The phase (in radians) of the frequency response can be found using the angle() command in MATLAB

$$\theta_{rad} = angle(h)$$

- The phase (in degrees) of the frequency response can be found using the angle() command in MATLAB and converting to degrees using the “rad2deg” command

$$\theta_{deg} = rad2\mathrm{deg}(angle(h))$$

Plotting the Frequency Response Using MATLAB

- The frequency vector is radian frequency from 0 to the Nyquist frequency or $0 \; to \; \pi$

- Convert to absolute frequency by dividing by 2π and multiplying by the sampling frequency

$$f_{abs} = \frac{w}{2\pi} \times f_{sample}$$

MATLAB Example

Filter Plotting Example

Define the filter impulse response. Use simple 1 pole IIR filter.

```
%

% Define the impulse response.  An FIR filter has all zeros and no poles so
% there are only coefficients in the numberato and no coefficients
% in the denominator
%

b = [0.001692, 0.001768, 0.001462, -0.000000, -0.003349, -0.008518, -0.014026, -0.016897, -0.013
0.157053, 0.166136, 0.157053, 0.131929, 0.096474, 0.058241, 0.024432, 0.000000, -0.013328, -0.01
0.001462, 0.001768, 0.001692];  %  Numerator Coefficients

a = 1;  %  Denominator coefficient

%  Use the freqz command to compute the frequency response of the filter.
%  Use 1000 points

[h,w] = freqz(b, a, 1000);

%  Plot the magnitude in decibels of the frequency response assuming the
%  sampling rate is 10 kHz

freqSample = 10e3;  %  Sampling frequency
freqHz = w/(2*pi) * freqSample;  %  Conver the frequency sweep to absolute Hz
magdb = 20*log10(abs(h));  %  Compute the magnitude in decibels
phaseDeg = rad2deg(angle(h));


figure
plot(freqHz, magdb, 'LineWidth',2)
grid on
title('Filter Magnitude Response (dB)')
xlabel('Frequency (Hz)')
ylabel('Amplitude (dB)')
```

MATLAB Example

```
figure
plot(freqHz, magdb, 'LineWidth',2)
grid on
title('Filter Magnitude Response (dB)')
xlabel('Frequency (Hz)')
ylabel('Amplitude (dB)')
```

```
figure
plot(freqHz, phaseDeg, 'LineWidth',2)
grid on
title('Filter Phase Response (deg)','Wrapped')
xlabel('Frequency (Hz)')
ylabel('Phase (deg)')
```