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# **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

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

- Express the numerator and denominator as vectors

# Finding Frequency Response Using MATLAB

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- Express the numerator and denominator as vectors

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

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

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

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

# Finding Frequency Response Using MATLAB

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

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

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

# Plotting the Frequency Response Using MATLAB

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- 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

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

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

- 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

$$\theta_{deg} = \text{rad2deg}(\text{angle}(h))$$

# Plotting the Frequency Response Using MATLAB

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- The frequency vector is radian frequency from 0 to the Nyquist frequency or 0 to  $\pi$
- Convert to absolute frequency by dividing by  $2\pi$  and multiplying by the sampling frequency

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

# MATLAB Example

## Filter Plotting Example

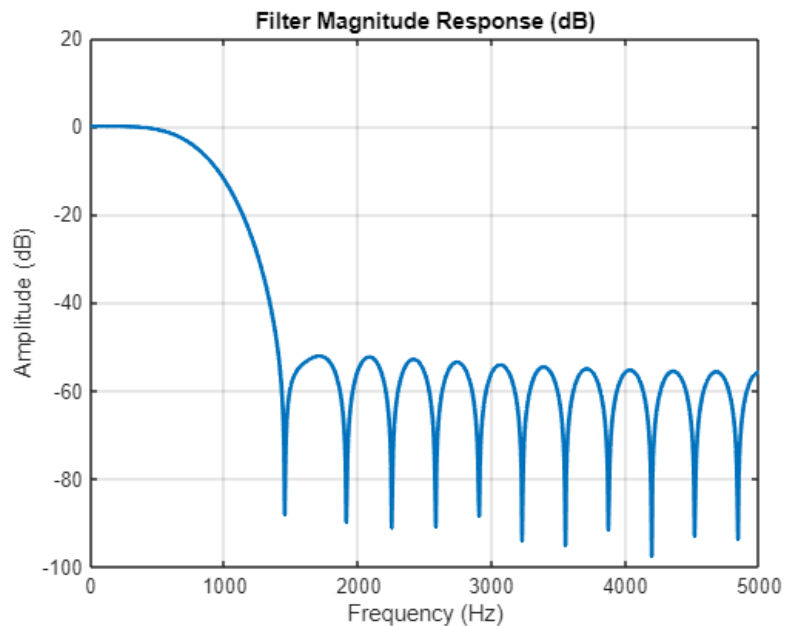
Define the filter impulse response. Use simple 1 pole IIR filter.

```
%  
  
% Define the impulse response. An FIR filter has all zeros and no poles so  
% there are only coefficients in the numerator and no coefficients  
% in the denominator  
%  
  
b = [0.001692, 0.001768, 0.001462, -0.000000, -0.003349, -0.008518, -0.014026, -0.016897, -0.013328, 0.157053, 0.166136, 0.157053, 0.131929, 0.096474, 0.058241, 0.024432, 0.000000, -0.013328, -0.016897, -0.014026, -0.008518, -0.003349, -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; % Convert 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)')
```

