ELG3125 Signal and System Analysis Lab

- **Lab8: Bode Plots**

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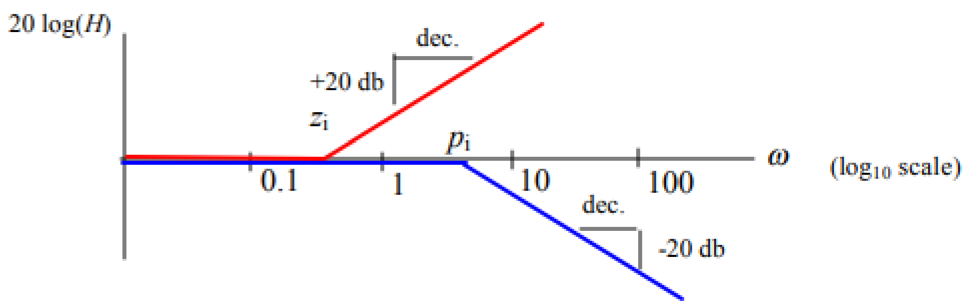
Effect of Individual Zeros and Poles Not at the Origin

The values zi and pi are called a critical frequency (or break frequency). They represent a ramp function of 20 db per decade. Zeros give a positive slope. Poles produce a negative slope.



$$H = \frac{\left|1 + \frac{j\omega}{z_i}\right|}{\left|1 + \frac{j\omega}{p_i}\right|}$$

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Plotting Bode Diagram with Matlab

The command bode computes magnitudes and phase angle of the frequency response of continuous-time, linear, time-invariant systems.

bode(sys)	Creates a Bode plot of the frequency response of a dynamic system model.
bode(sys,w)	Plots system response at frequencies determine by *w*
[mag,phase,w]=bode(sys)	Returns magnitudes, phase values, and frequency value *w* corresponding to bode(sys)

The matrices *mag* and *phase* contain, respectively magnitudes and phase angles of the frequency response of the system, evaluated at user-specified frequency point.

The Phase angle is returned in degrees, the magnitude can be converted to decibels with the statement

*mag_dB=20*log10(mag)*

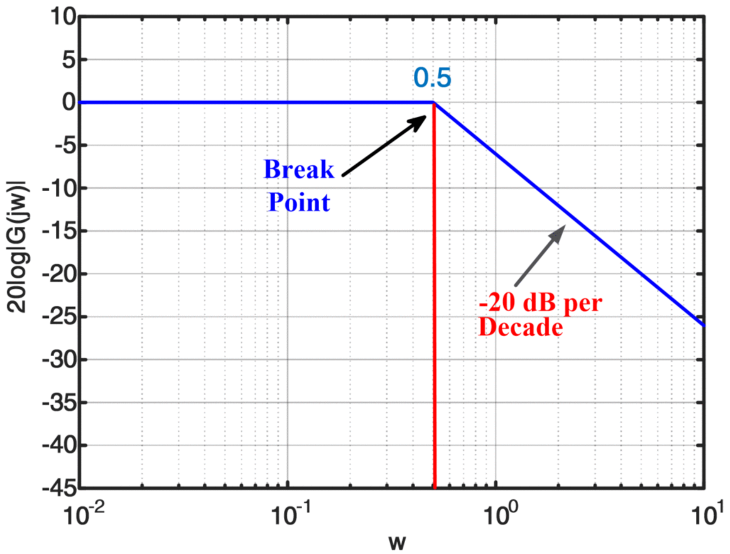
Example

$$H(j\omega) = \frac{1}{2jw+1} = \frac{1}{\frac{jw}{0.5}+1}$$

From above expression, we can deduce the corner frequency or break point as: ω=1/2

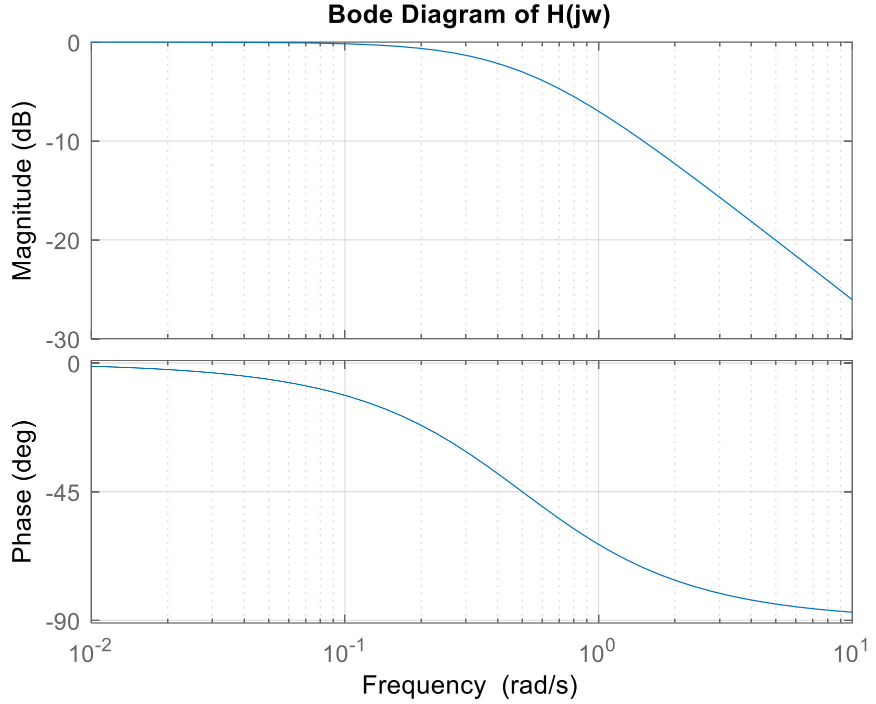
At ω= (very very small value):

|G(jω)|dB=20 log|G(jω)|=20 log(1)=0



```
b = [0 1]; a = [1/0.5 1];
bode(b, a); grid
title('Bode Diagram of H(jw)')
```

$$H(j\omega) = \frac{1}{\frac{jw}{0.5} + 1}$$



The frequency response is given below. What are the nature frequency and the damping factor? Obtain the Bode plot.

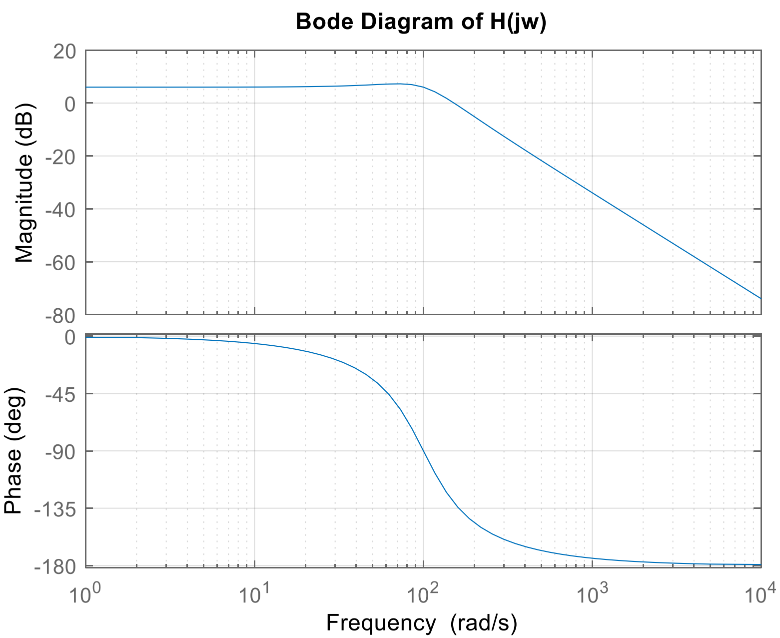
$$H(j\omega)=\frac{2\times10^4}{(j\omega)^2+100(j\omega)+10^4}$$

(Standard form) $H(j\omega)=\frac{\omega_n^2}{(j\omega)^2+2\xi\omega_n(j\omega)+\omega_n^2}$)

Solution:

the nature frequency is $\omega_n=100$, and the damping factor is

$2\xi\omega_n=100 \Rightarrow \xi=\frac{100}{2\omega_n}=\frac{100}{2\times100}=\frac{1}{2}$, which $\angle$ 1, the system is underdamped



Theoretical Approximation

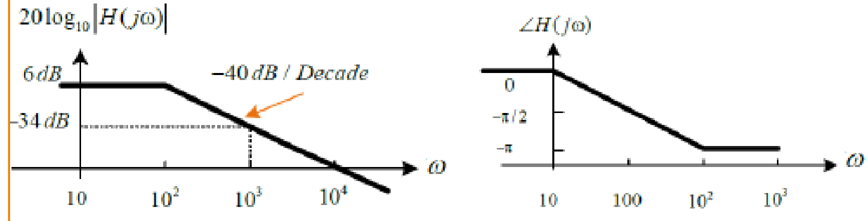
To obtain its Bode plot, we change the expression

$$H(j\omega)=\frac{2\times10^4}{(j\omega)^2+100(j\omega)+10^4}=\frac{2\times10^4}{10^4\left[\left(\frac{j\omega}{10^2}\right)^2+\left(\frac{j\omega}{10^2}\right)+1\right]}=\frac{2\times1}{\left(\frac{j\omega}{10^2}\right)^2+\left(\frac{j\omega}{10^2}\right)+1}$$

Since $20\log_{10}H(j\omega)=20\log_{10}2+20\log_{10}\frac{1}{\left(\frac{j\omega}{10}\right)^2+\left(\frac{j\omega}{10}\right)+1}$

and $20\log_{10}2=6dB$, the magnitude Bode plot would be the one of

$20\log_{10}\frac{1}{\left(\frac{j\omega}{10}\right)^2+\left(\frac{j\omega}{10}\right)+1}$ shifted up by 6 dB, shown below



(a) magnitude Bode plot (b) phase Bode plot

MATLAB implementation

```
b = [0 0 2e4];
a = [1 100 1e4];
bode(b, a); grid
title('Bode Diagram of H(jw)')
```

Exercise 1

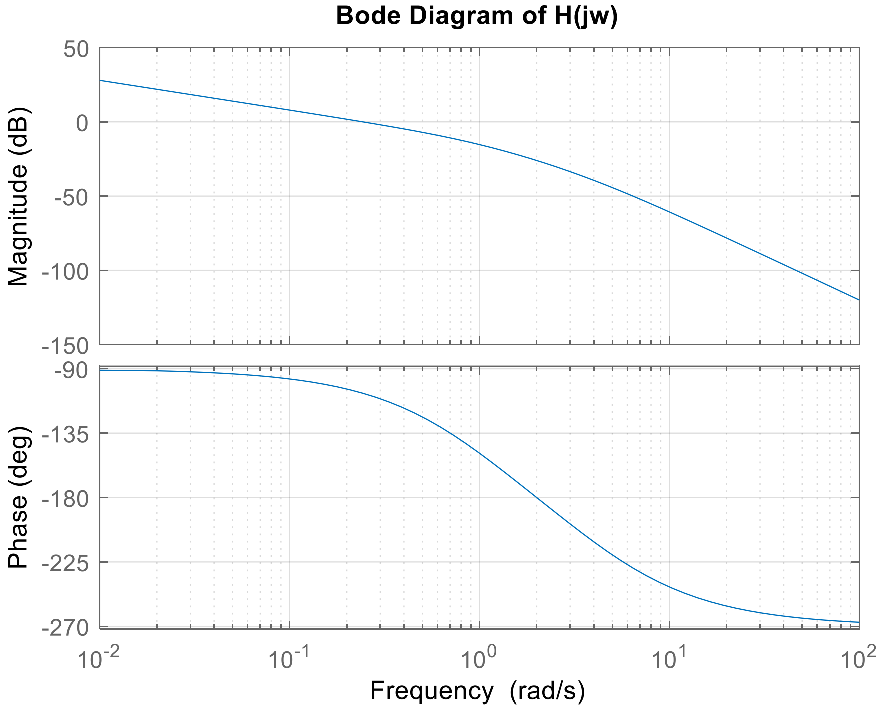
Use MATLAB to draw the bode diagram for the following transfer function:

$$H(s) = \frac{s+2}{s(s+1)(s^2+6s+8)}$$

Replace: $s = j\omega$

Solution

```
% H(s)=[ s+2 ]/[s(s+1)(s^2+6s+8)]
%% Denominator
% s(s+1)(s^2+6s+8) = (s^2+s)(S^2+6s+8)
% (s^4 +7s^3 +14 s^2 +8s)
% a =[1  7  14  8  0]
% OR use distribution properties
a=conv([1 1 0],[1 6 8]);
%% Numerator
b=[1 2];
%% bode plot
bode(b, a); grid
title('Bode Diagram of H(jw)')
```



Note: calculate it and compare your result with MATLAB simulation

The END