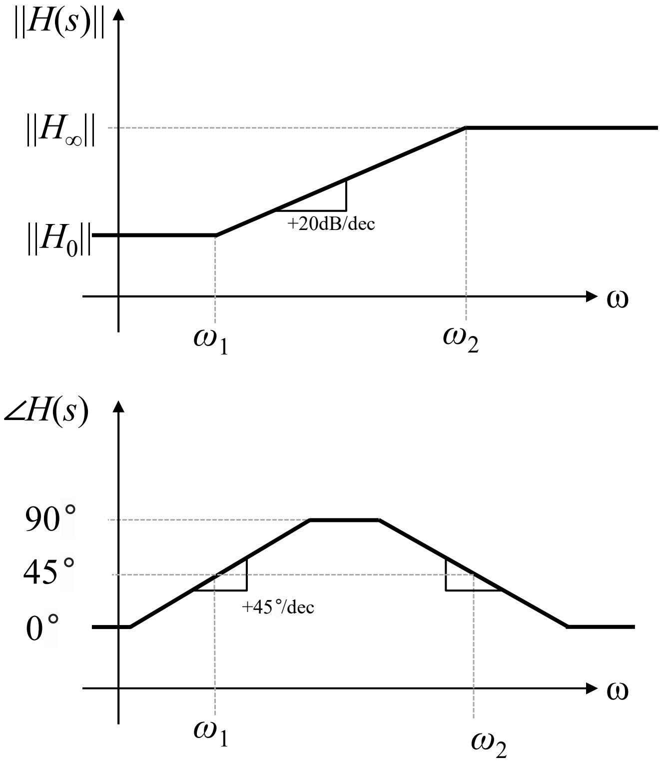
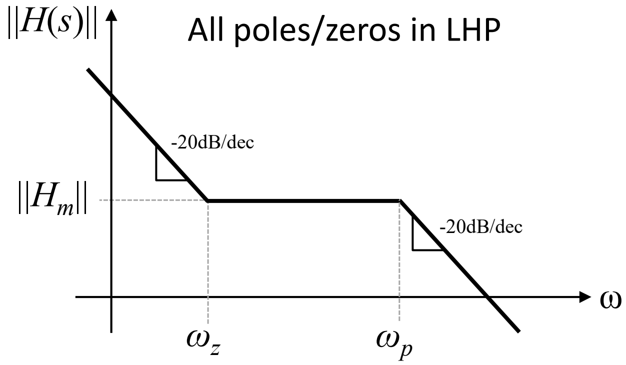
Example 2

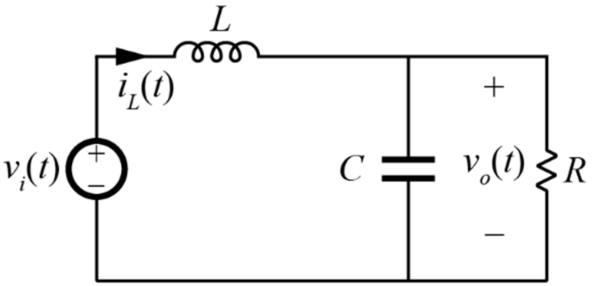


$||H(s)||$
$||H_\infty||$
$||H_0||$
+20dB/dec
ω
ω_1
ω_2
$\angle H(s)$
90°
45°
0°
+45°/dec
ω
ω_1
ω_2

Example 3



Complex Poles



Standard Form for Complex Poles

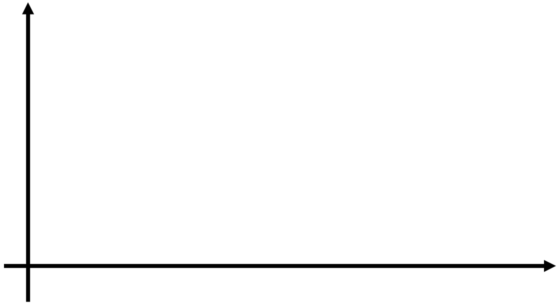
$$H(s) = \frac{1}{\left(\frac{s}{\omega_0}\right)^2 + \frac{s}{Q\omega_0} + 1}$$

$$H(s) = \frac{1}{\left(\frac{s}{\omega_0}\right)^2 + 2\zeta\frac{s}{\omega_0} + 1}$$

- ω_0, Q, and ζ are real for real circuits
  - Found by coefficient matching to solved transfer function
- ω_0 is the angular/resonant frequency
  - Q is the "quality factor"
    - Roots are complex when $Q > \frac{1}{2}$
    - If $Q < \frac{1}{2}$, the polynomial can be factored into two real poles
  - ζ is the "damping factor"
    - Roots are complex when $\zeta > 1$
    - If $\zeta > 1$, the polynomial can be factored into two real poles

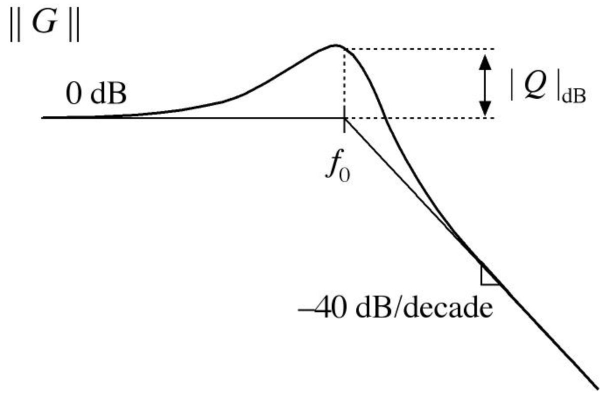
$$\zeta = \frac{1}{2Q}, \qquad Q = \frac{1}{2\zeta}$$

Magnitude Asymptotes

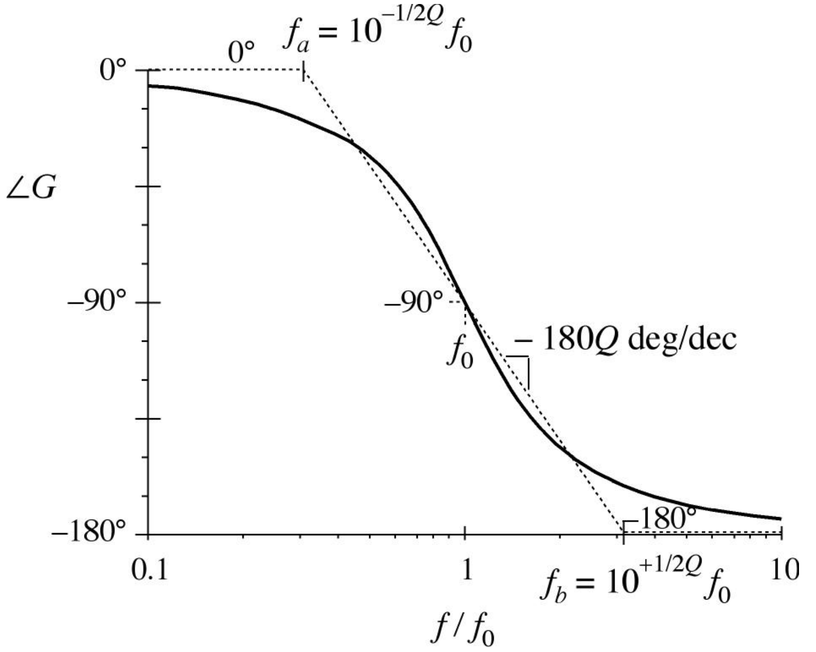


Asymptotes for Complex Poles, Q>0.5

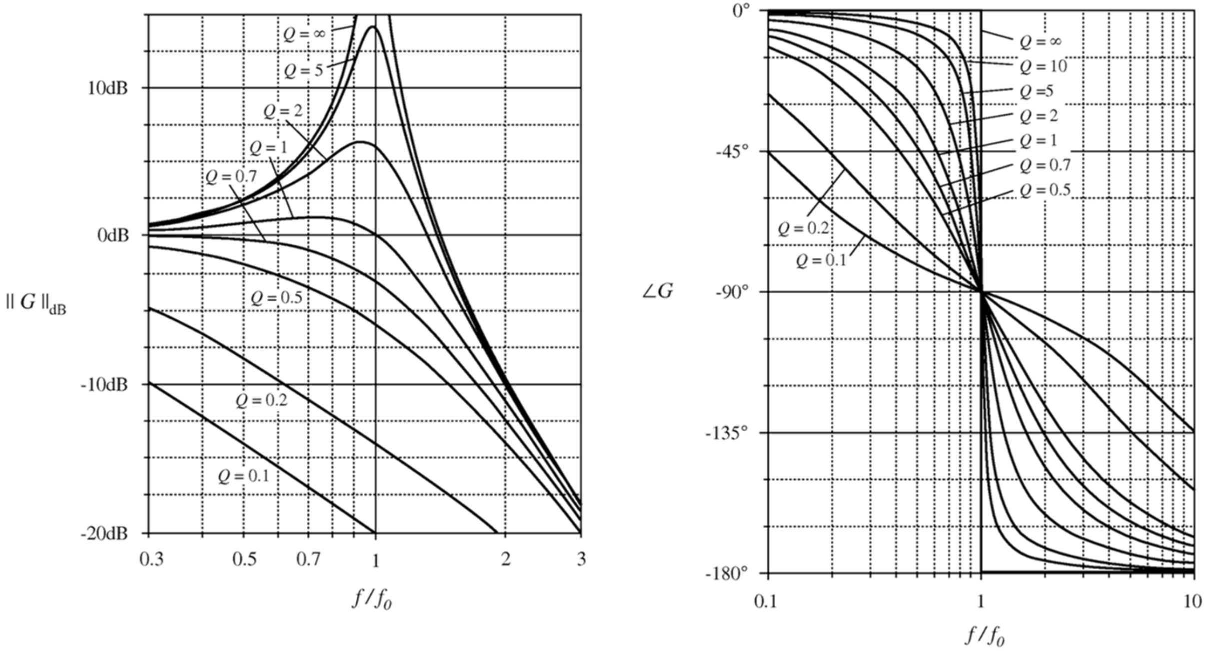
Magnitude



Phase



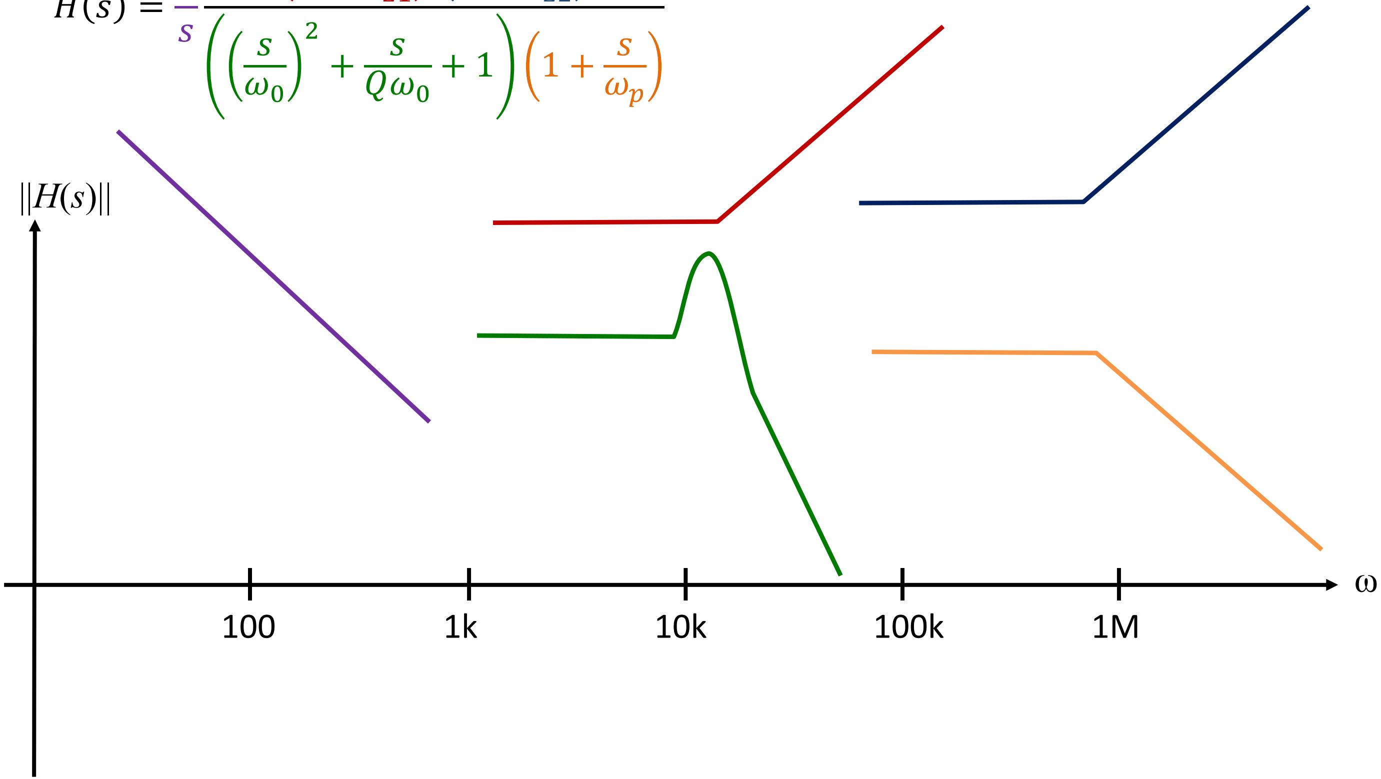
Curves for Varying Q



Example

A	w_{z1}	w_{z2}	ω_0	Q	ω_p
1000	100	10k	1k	10	100k

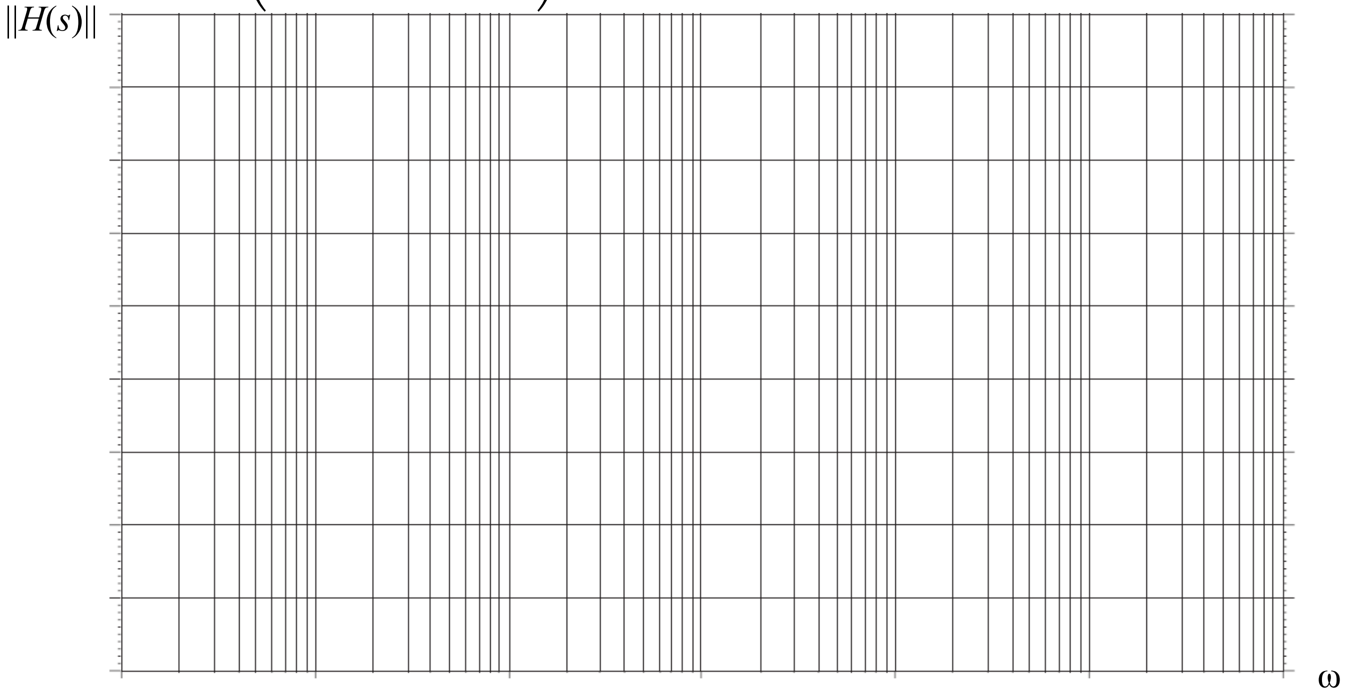
$$H(s) = \frac{A}{s}\frac{\left(1+\frac{s}{w_{z1}}\right)\left(1+\frac{s}{w_{z2}}\right)}{\left(\left(\frac{s}{\omega_0}\right)^2+\frac{s}{Q\omega_0}+1\right)\left(1+\frac{s}{\omega_p}\right)}$$



Example

A	w_{z1}	w_{z2}	ω_0	Q	ω_p
1000	100	10k	1k	10	100k

$$H(s) = A\frac{\left(1+\frac{s}{w_{z1}}\right)\left(1+\frac{s}{w_{z2}}\right)}{s\left(\left(\frac{s}{\omega_0}\right)^2+\frac{s}{Q\omega_0}+1\right)\left(1+\frac{s}{\omega_p}\right)}$$



MATLAB

```
A = 1000;
wz1 = 100;
wz2 = 10e3;
w0 = 1e3;
Q = 10;
wp = 100e3;

s = tf('s');

H = A*(1+s/wz1)*(1+s/wz2)/...
       (s*(1+s/wp)*((s/w0)^2+s/Q/w0+1));

bode(H)
```