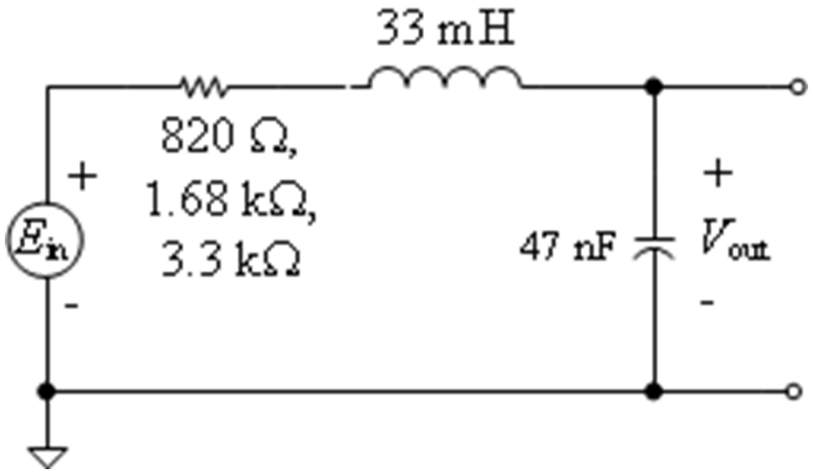
Low Pass – Quick Look



1. V_{out} at DC ?

   cap is _____

   inductor is _____

2. V_{out} at high f ?

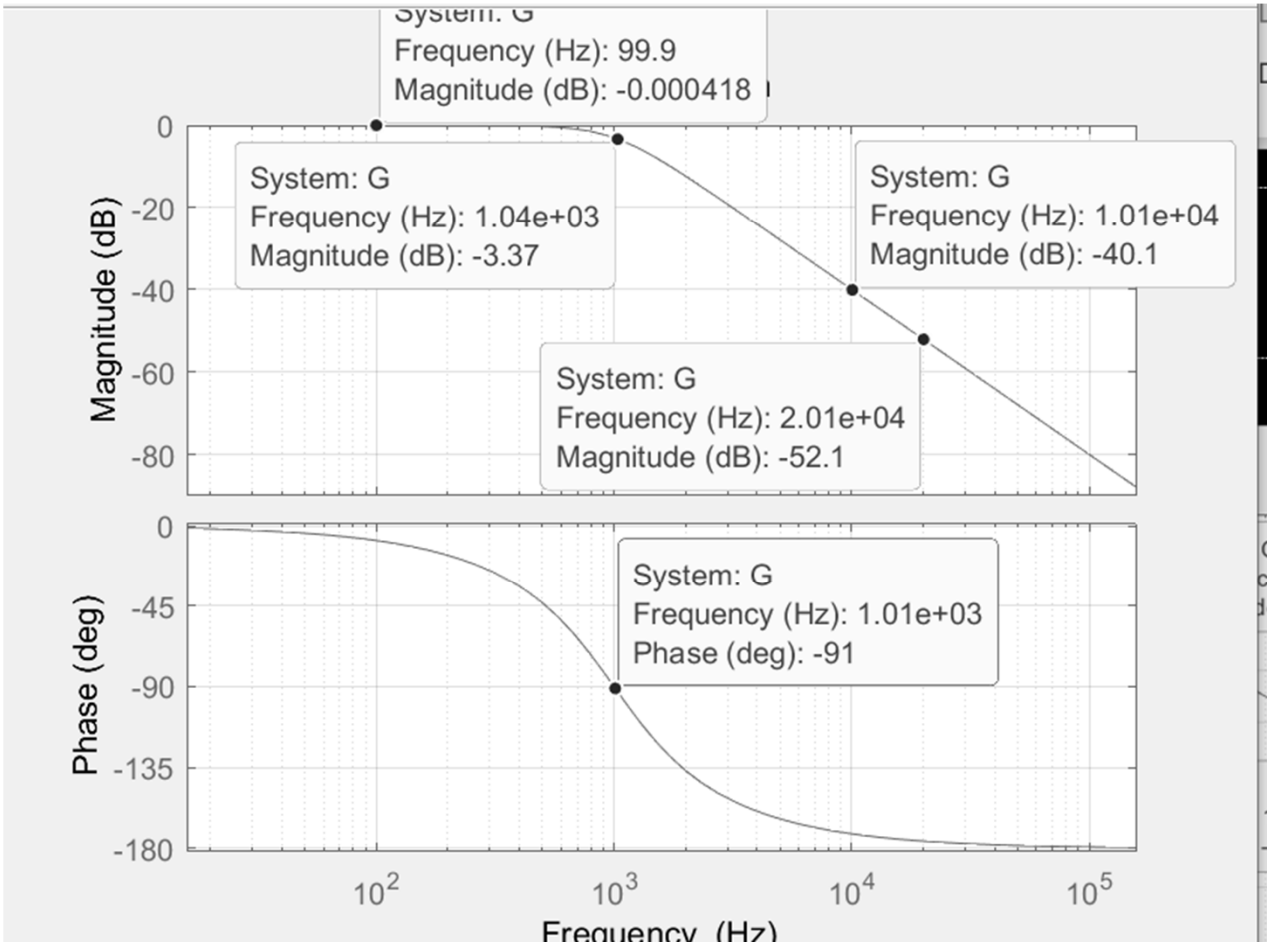
   cap is _____

   inductor is _____

$$\frac{\frac{1}{LC}}{s^2 + \frac{R}{L}s + \frac{1}{LC}}$$

$$\frac{\frac{1}{LC}}{s^2 + \frac{R}{L}s + \frac{1}{LC}} \Longleftrightarrow \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

```
clear
format short G
s=tf('s')

Ao=1;
fo=1e3;
wo=2*pi*fo;
zeta=0.707;

G=Ao*wo^2/(s^2+2*zeta*wo*s+wo^2)

opts = bodeoptions('cstprefs');
opts.FreqUnits = 'Hz';
opts.grid = 'on';
opts.PhaseWrapping = 'on';
opts.MagLowerLimMode = 'manual';
opts.MagLowerLim = -90;

bodeplot(G,{1e2,1e6},opts);
```



$$s^2 + 2\zeta\omega_n s + \omega_n{}^2 \quad = \quad s^2 + \frac{R}{L}s + \frac{1}{LC}$$

$\omega_n{}^2$ =

$2\zeta\omega_n$ =

ζ =

ω_n =

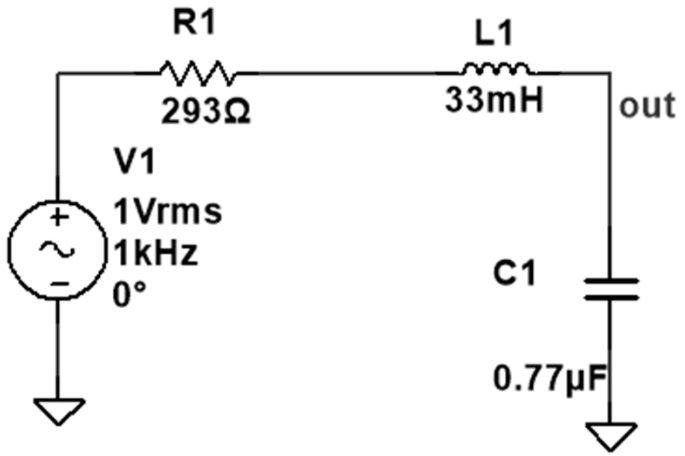
f_o $\frac{1}{2*\pi\sqrt{LC}}$

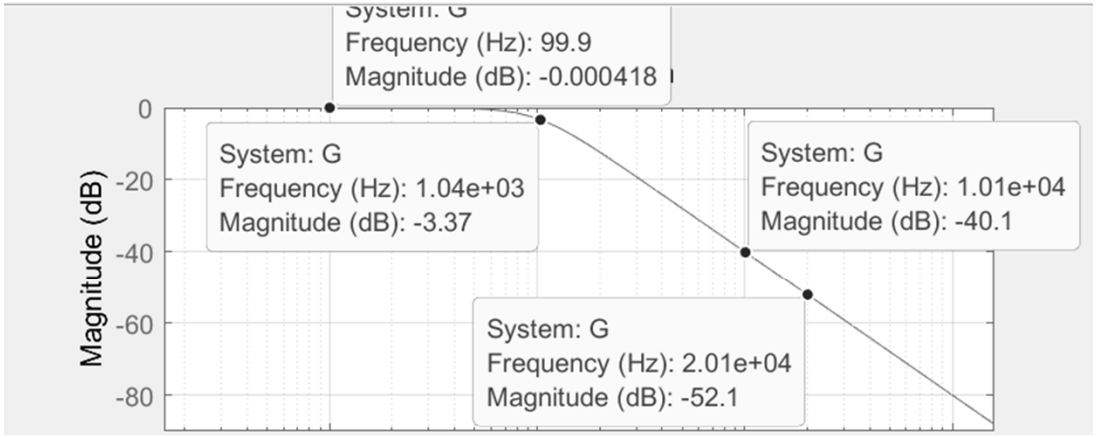
ζ =

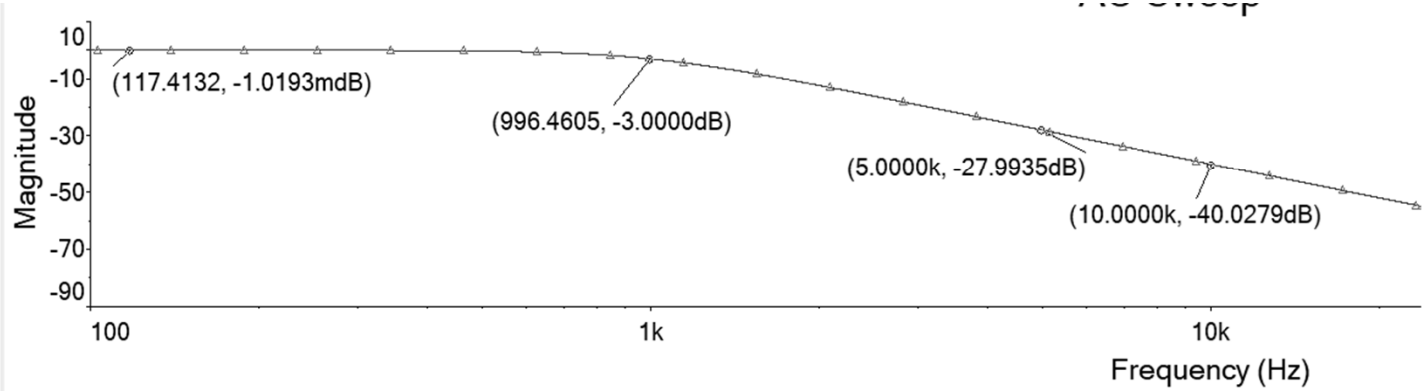
Butterworth low pass design

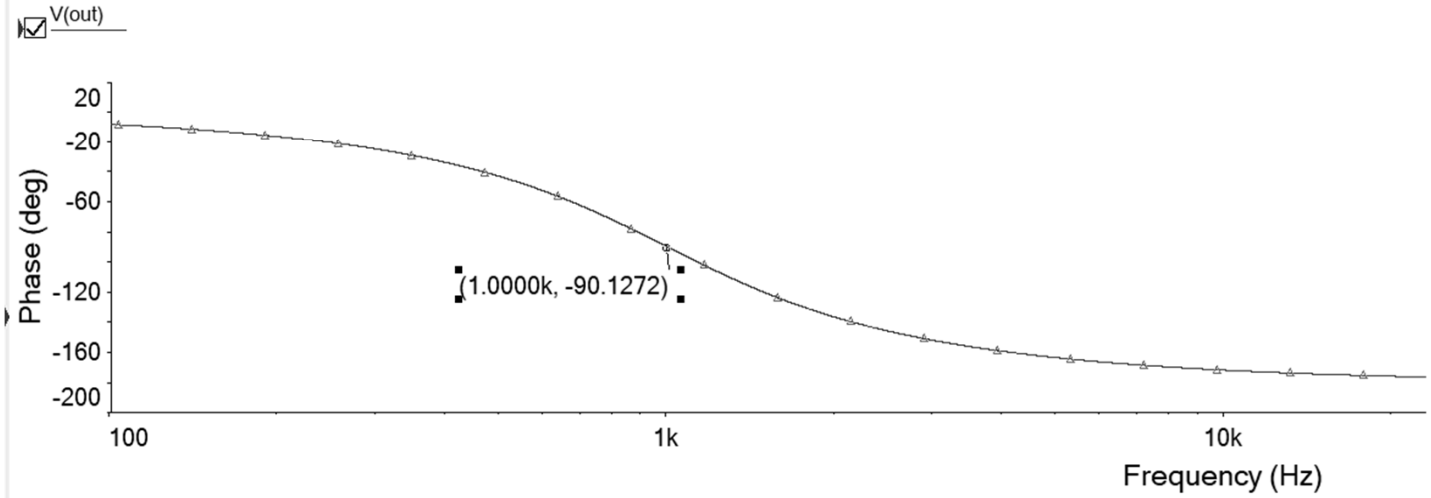
- Given: ζ= $A_o = 1$ $f_o = 1$ kHz
- Pick L = 33 mH
- Calculate C = _____ $f_o = \frac{1}{2*\pi\sqrt{LC}}$

- Calculate R = _____ $\zeta = \frac{1}{2} R \sqrt{\frac{C}{L}}$

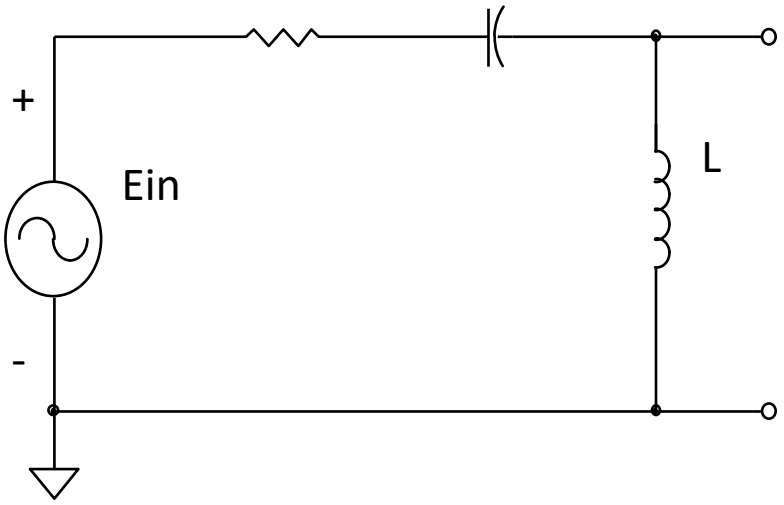

R1
293Ω
L1
33mH
out
V1
1Vrms
1kHz
0°
C1
0.77µF


Frequency (Hz): 99.9
Magnitude (dB): -0.000418
System: G
Frequency (Hz): 1.04e+03
Magnitude (dB): -3.37
System: G
Frequency (Hz): 1.01e+04
Magnitude (dB): -40.1
System: G
Frequency (Hz): 2.01e+04
Magnitude (dB): -52.1
Magnitude (dB)
0
-20
-40
-60
-80


(117.4132, -1.0193mdB)
(996.4605, -3.0000dB)
(5.0000k, -27.9935dB)
(10.0000k, -40.0279dB)
Magnitude
10
-10
-30
-50
-70
-90
100
1k
10k
Frequency (Hz)


V(out)
(1.0000k, -90.1272)
Phase (deg)
20
-20
-60
-120
-160
-200
100
1k
10k
Frequency (Hz)

High Pass – Quick Look



1. V_{out} at DC ?

   cap is _____

   inductor is _____

2. V_{out} at high f ?

   cap is _____

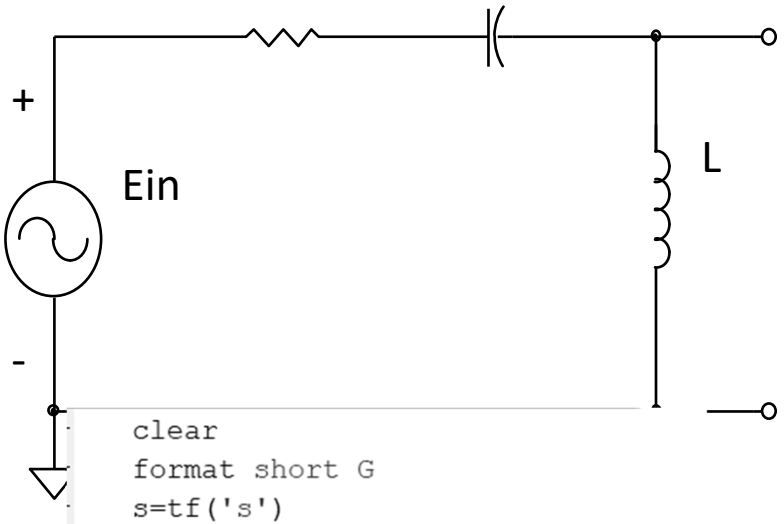
   inductor is _____

$$\frac{s^2}{s^2 + \frac{R}{L}s + \frac{1}{LC}}$$

$\omega_n{}^2 =$ $\qquad\qquad$ $2\zeta\omega_n =$

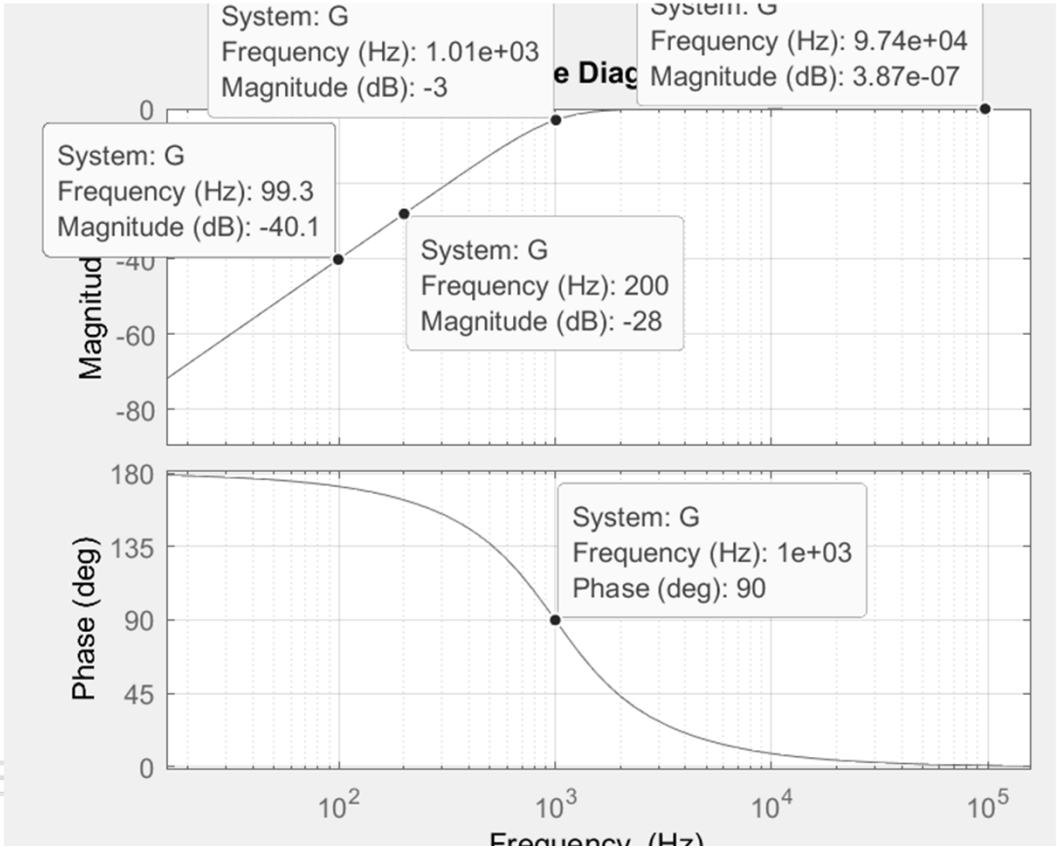
$$\frac{s^2}{s^2 + \frac{R}{L}s + \frac{1}{LC}} \quad \Leftrightarrow \quad \frac{s^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

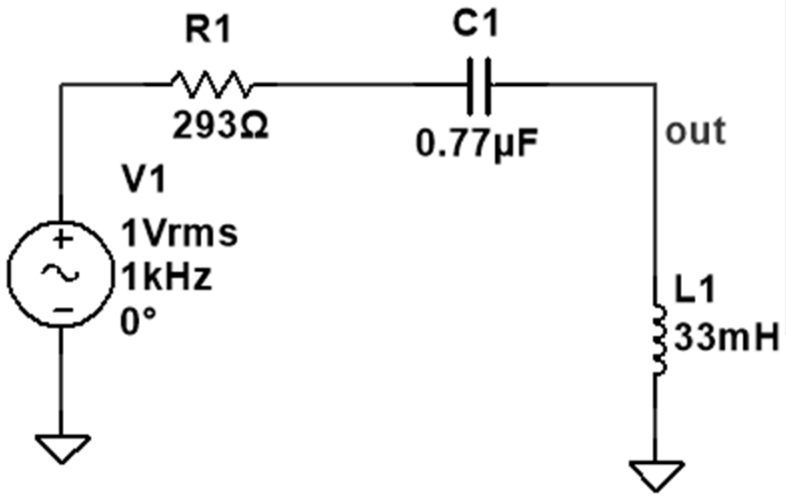
High Pass – transfer function

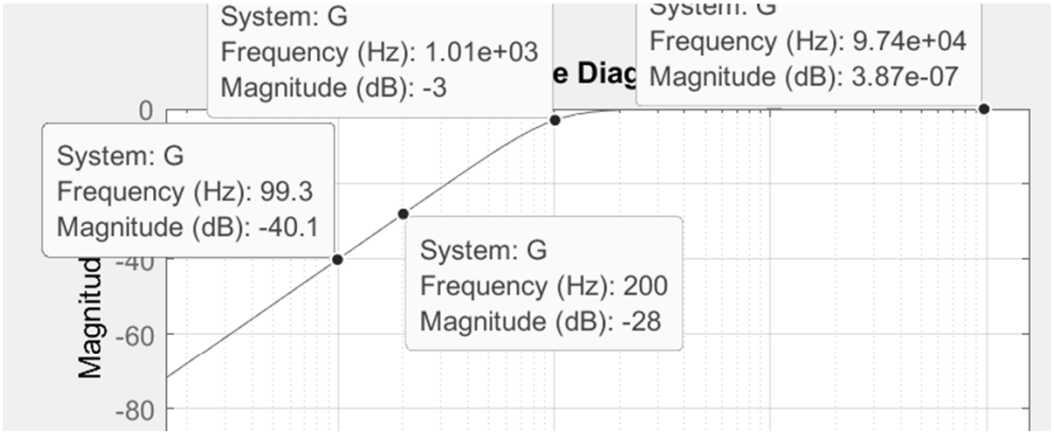


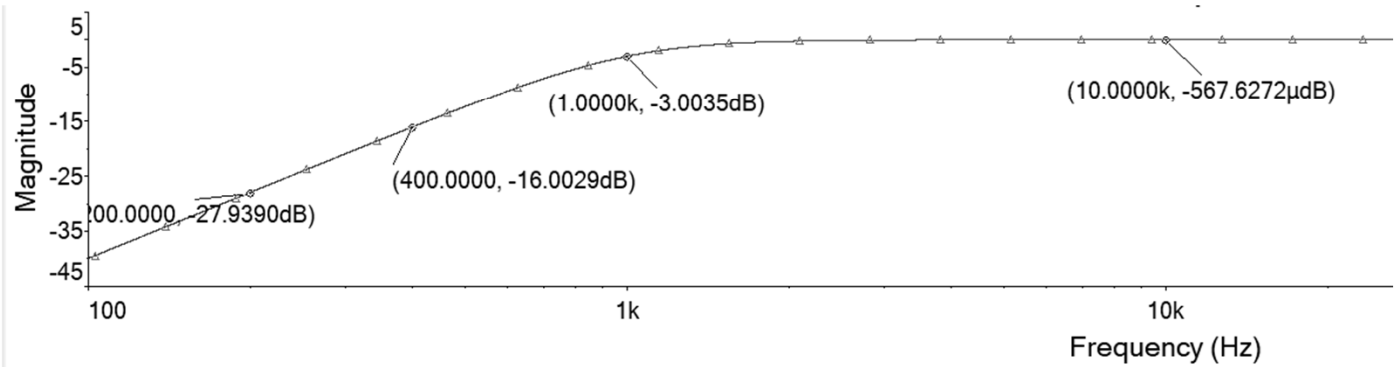
$$\frac{s^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

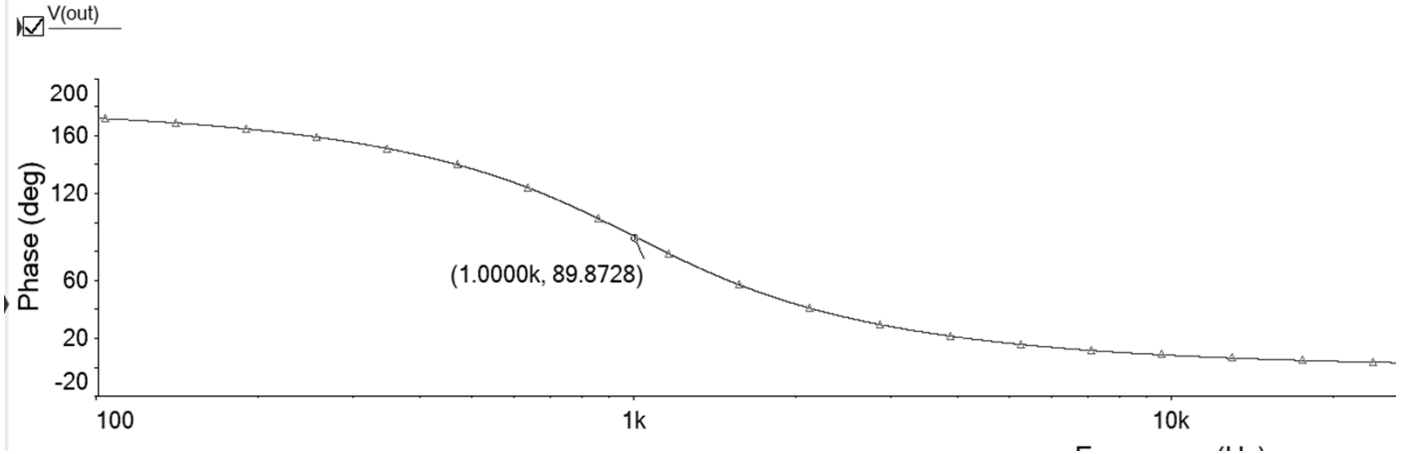
```
clear
format short G
s=tf('s')

Ao=1;
fo=1e3;
wo=2*pi*fo;
zeta=0.707;

G=Ao*s^2/(s^2+2*zeta*wo*s+wo^2)

opts = bodeoptions('cstprefs');
opts.FreqUnits = 'Hz';
opts.grid = 'on';
opts.PhaseWrapping = 'on';
opts.MagLowerLimMode = 'manual';
opts.MagLowerLim = -90;

bodeplot(G,{1e2,1e6},opts);
```



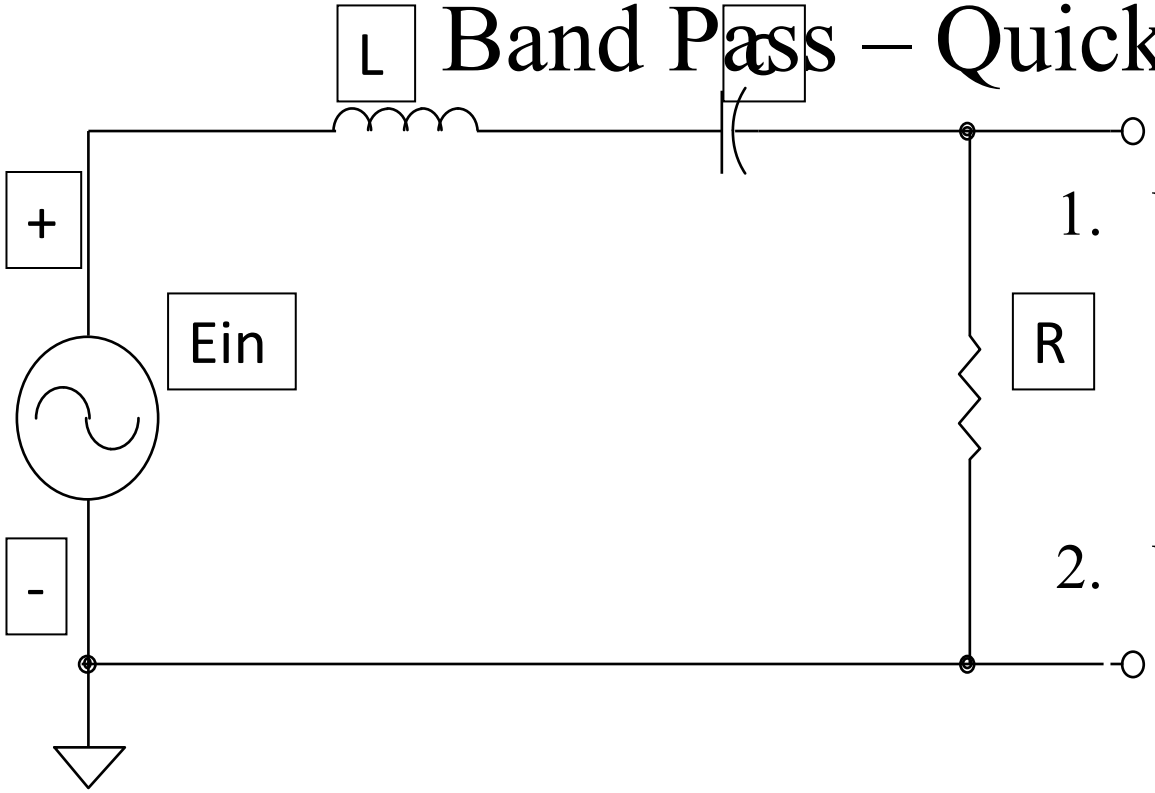

R1
293Ω
C1
0.77µF
out
V1
1Vrms
1kHz
0°
L1
33mH


System: G
Frequency (Hz): 1.01e+03
Magnitude (dB): -3
System: G
Frequency (Hz): 9.74e+04
Magnitude (dB): 3.87e-07
System: G
Frequency (Hz): 99.3
Magnitude (dB): -40.1
System: G
Frequency (Hz): 200
Magnitude (dB): -28
0
-60
-80


Magnitude
5
-5
-15
-25
-35
-45
(1.0000k, -3.0035dB)
(10.0000k, -567.6272µdB)
(400.0000, -16.0029dB)
00.0000, -27.9390dB)
100
1k
10k
Frequency (Hz)


V(out)
Phase (deg)
200
160
120
60
20
-20
(1.0000k, 89.8728)
100
1k
10k

Band Pass – Quick Look



1. V_{out} at DC ?

   cap is _____

   inductor is _____

2. V_{out} at high f ?

   cap is _____

   inductor is _____

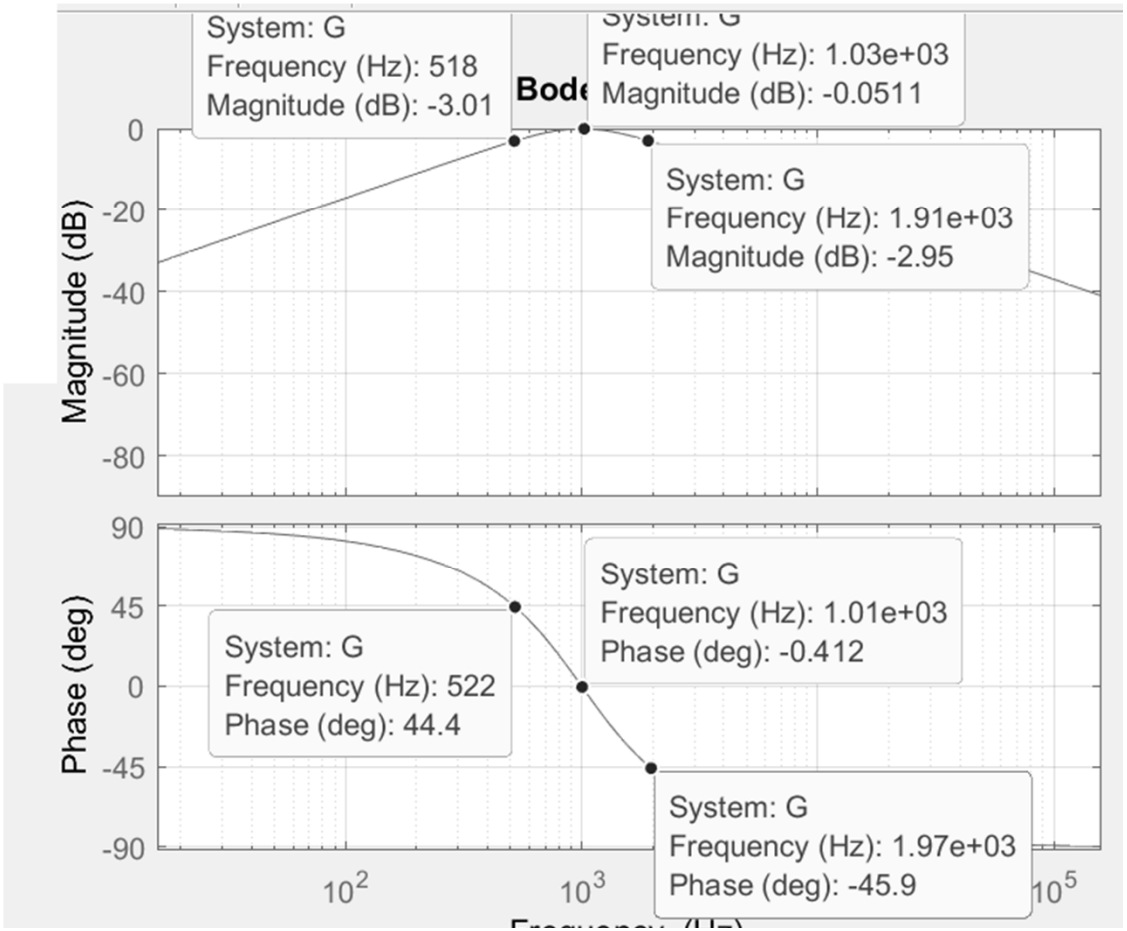
$$\frac{\frac{R}{L}s}{s^2 + \frac{R}{L}s + \frac{1}{LC}}$$

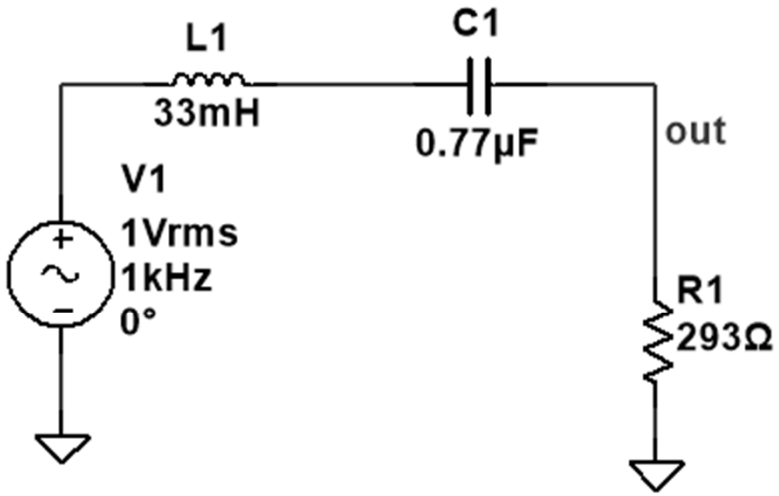
$\omega_n{}^2 =$ $\qquad\qquad$ $2\zeta\omega_n =$

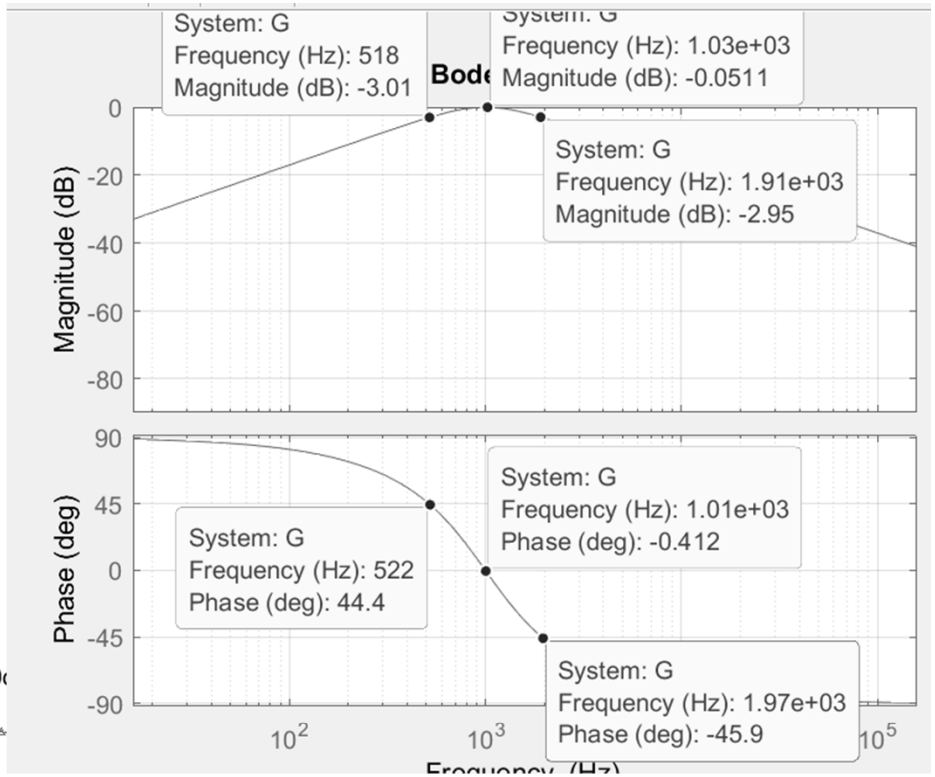
$$\frac{\frac{R}{L}s}{s^2 + \frac{R}{L}s + \frac{1}{LC}} \Longleftrightarrow \frac{2\zeta\omega_n s}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

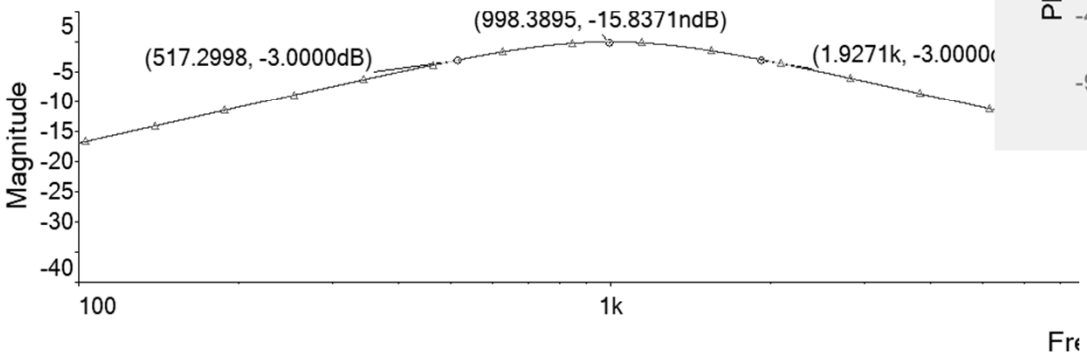
```
clear
format short G
s=tf('s')

Ao=1;
fo=1e3;
wo=2*pi*fo;
zeta=0.707;

G=Ao*2*zeta*wo*s/(s^2+2*zeta*wo*s+wo^2)

opts = bodeoptions('cstprefs');
opts.FreqUnits = 'Hz';
opts.grid = 'on';
opts.PhaseWrapping = 'on';
opts.MagLowerLimMode = 'manual';
opts.MagLowerLim = -90;

bodeplot(G,{1e2,1e6},opts);
```

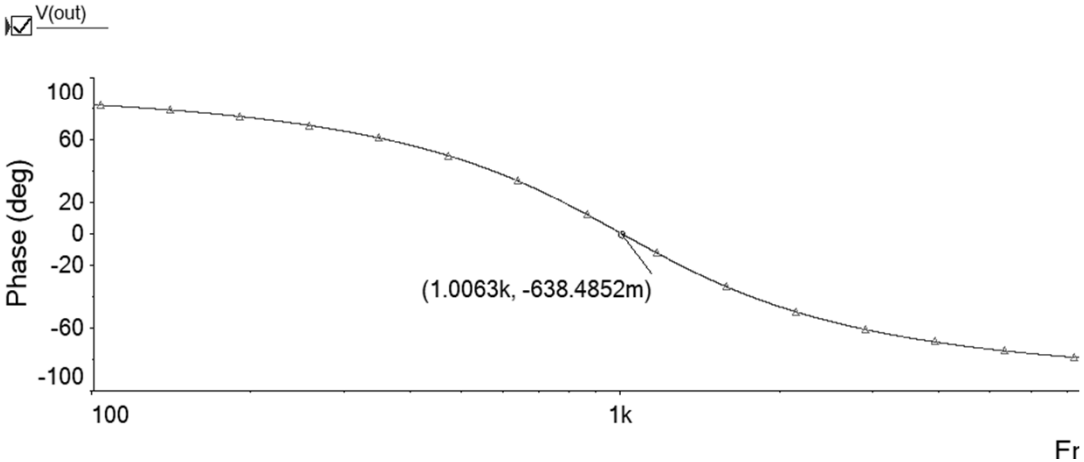
$$\frac{2\zeta\omega_n s}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$



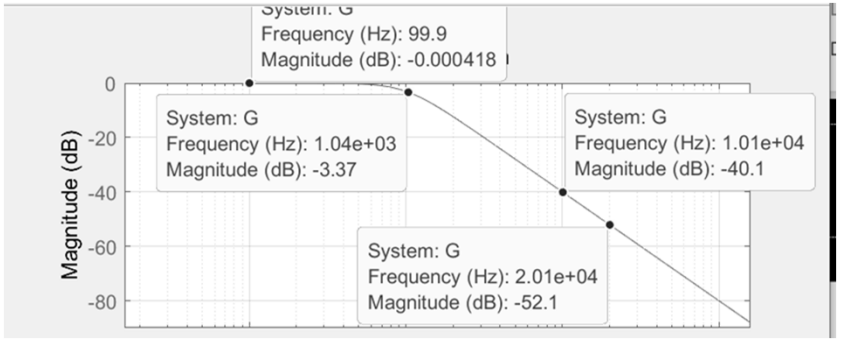

L1
33mH
C1
0.77µF
out
V1
1Vrms
1kHz
0°
R1
293Ω


System: G
Frequency (Hz): 518
Magnitude (dB): -3.01
Bode
System: G
Frequency (Hz): 1.03e+03
Magnitude (dB): -0.0511
System: G
Frequency (Hz): 1.91e+03
Magnitude (dB): -2.95
Magnitude (dB)
0
-20
-40
-60
-80
System: G
Frequency (Hz): 1.01e+03
Phase (deg): -0.412
System: G
Frequency (Hz): 522
Phase (deg): 44.4
System: G
Frequency (Hz): 1.97e+03
Phase (deg): -45.9
Phase (deg)
90
45
0
-45
-90
10^2
10^3
10^5

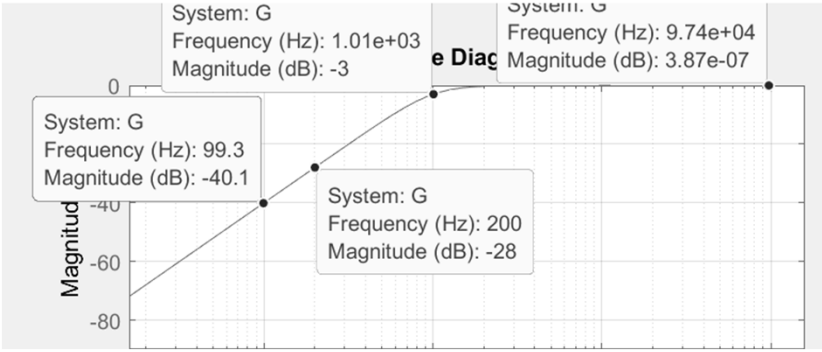

(998.3895, -15.8371ndB)
(517.2998, -3.0000dB)
(1.9271k, -3.0000
Magnitude
5
-5
-10
-15
-20
-25
-30
-40
100
1k
Fre


V(out)
Phase (deg)
100
60
20
0
-20
-60
-100
(1.0063k, -638.4852m)
100
1k
Fr

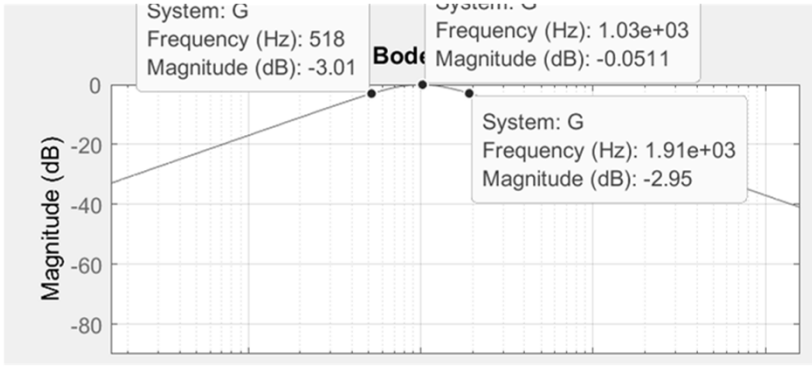
$$\frac{}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$



$$\frac{}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

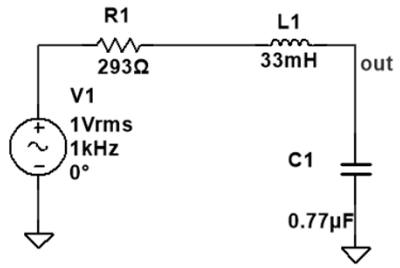


$$\frac{}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

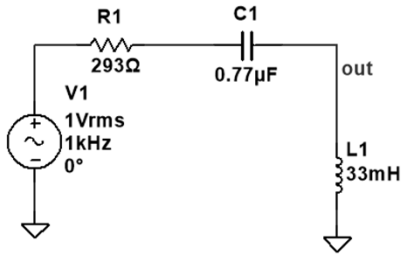


$$\omega_n = \frac{1}{\sqrt{LC}} \qquad f_o = \frac{1}{2*\pi\sqrt{LC}} \qquad \zeta = \frac{1}{2} R \sqrt{\frac{C}{L}}$$

$$\frac{}{s^2 + \frac{R}{L}s + \frac{1}{LC}}$$



$$\frac{}{s^2 + \frac{R}{L}s + \frac{1}{LC}}$$



$$\frac{}{s^2 + \frac{R}{L}s + \frac{1}{LC}}$$