19EE10039
Mansi Uniyal.

Date
Page

Exp 4. Active Low Pass Filter.

Aim: To familarize with 2nd order sallen key low pass filters

Given $R_1 = R_2 = 10\,k\Omega = R_0$

$C_1 = C_2 = 1\,nF = C_0$

case (1). $Q = 1$.

$Q = \frac{1}{3-K} = 1 \therefore K = 2$

where, $K = 1 + \frac{R_f}{R}$ $\therefore R_f = R$

$F_c = \frac{1}{2\pi R_0 C_0}$

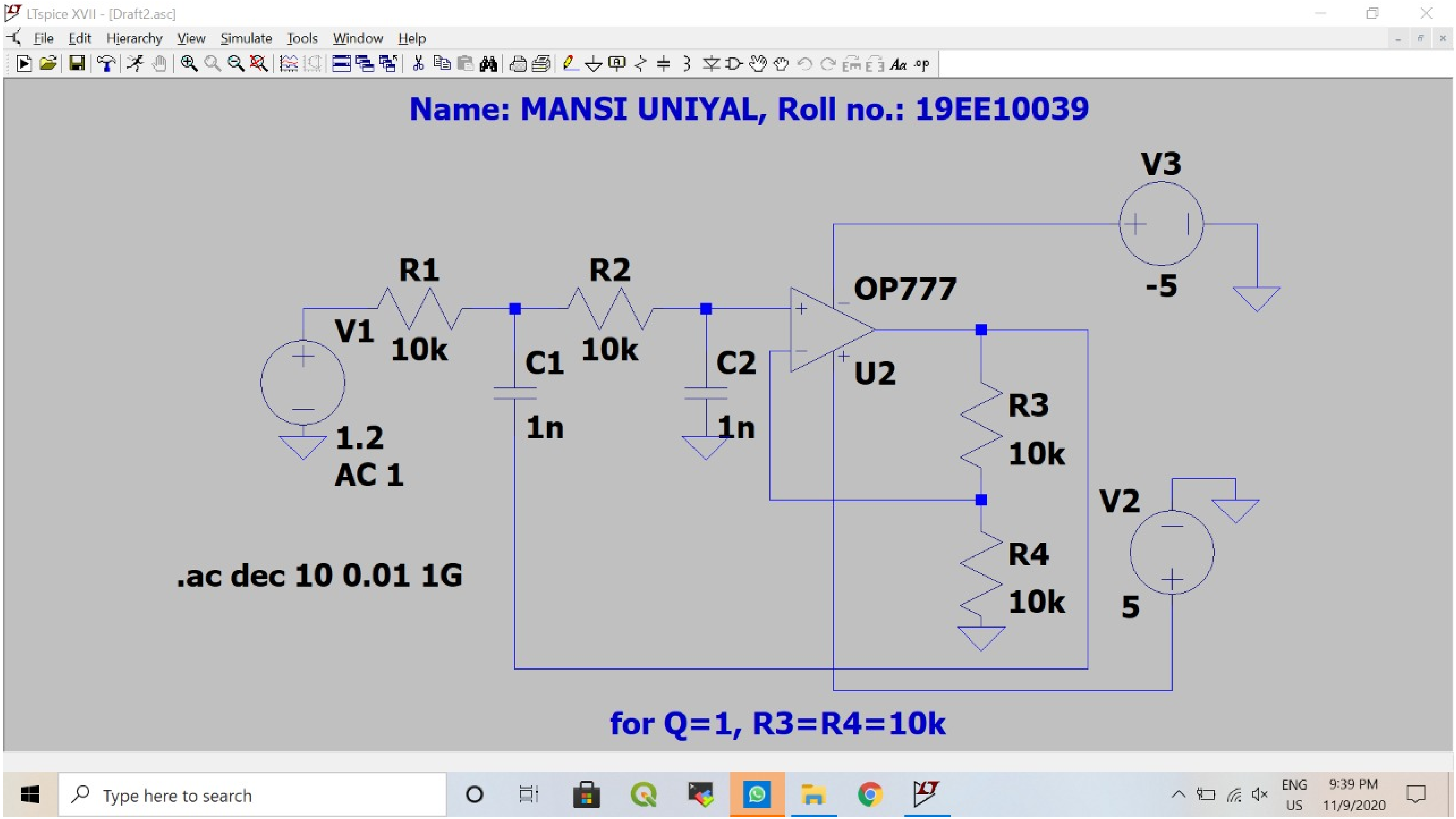
$\therefore R_f = 10K\Omega$

$R = 10K\Omega$

$F_c = 15.92\,KHz$.

Comments:

1. cut off frequency is 15.92 KHz.
2. Damping factor $(z = \frac{1}{2Q}) = 0.5$.
3. At cutoff freq. peek of gain is maximum and then reduces.
4. At this point, filter is undamped and phase shift of $-\pi/2$.


LTspice XVII - [Draft2.asc]
File Edit Hierarchy View Simulate Tools Window Help
Name: MANSI UNIYAL, Roll no.: 19EE10039
V3
-5
R1
10k
R2
10k
OP777
V1
C1
1n
C2
1n
U2
1.2
AC 1
R3
10k
V2
R4
10k
5
.ac dec 10 0.01 1G
for Q=1, R3=R4=10k
Type here to search
ENG
US
9:39 PM
11/9/2020

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$R = 10K\Omega$
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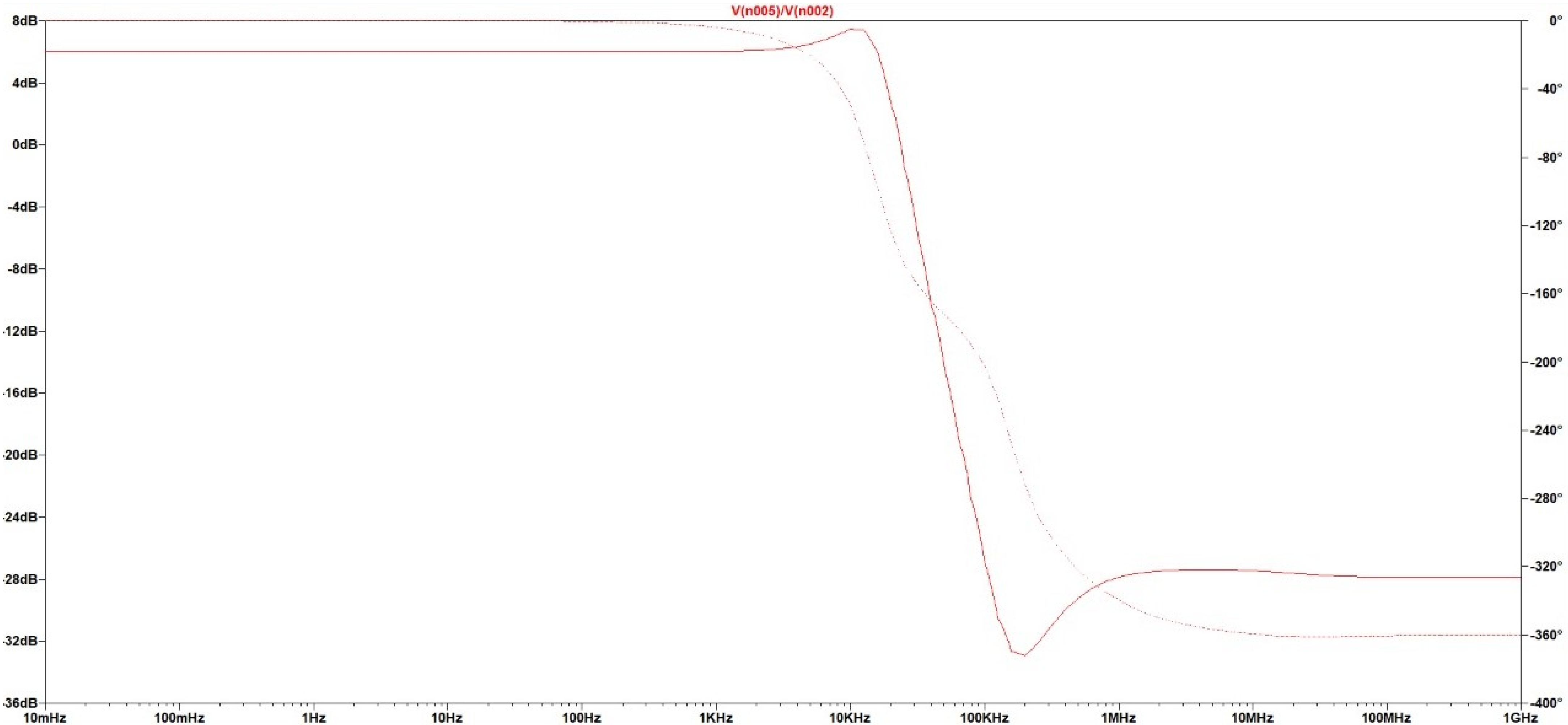
V(n005)/V(n002)
8dB
4dB
0dB
-4dB
-8dB
-12dB
-16dB
-20dB
-24dB
-28dB
-32dB
-36dB
0°
-40°
-80°
-120°
-160°
-200°
-240°
-280°
-320°
-360°
-400°
10mHz
100mHz
1Hz
10Hz
100Hz
1KHz
10KHz
100KHz
1MHz
10MHz
100MHz
1GHz

given $R_1 = R_2 = 10K\Omega = R_0$
$C_1 = C_2 = 1nF = C_0$

Di Case 2 $Q = 1.5$

$$Q = \frac{1}{3-k} = \frac{1}{2-\frac{R_f}{R}}$$

$$\therefore 2-\frac{R_f}{R} = \frac{2}{3} \qquad \therefore \frac{R_f}{R} = \frac{4}{3}$$

let $\boxed{\begin{aligned} R_f &= 40\,k\Omega \\ R &= 30\,K\Omega \end{aligned}}$

$$F_c = \frac{1}{2\pi R_0 C_0} = \boxed{15.92\,kHz.}$$

case 3 $Q = 2.5$

$$Q = 2.5 = \frac{1}{2-\frac{R_f}{R}}$$

$$\therefore \frac{R_f}{R} = 2-\frac{2}{5} = \frac{8}{5}$$

let $\boxed{\begin{aligned} R_f &= 80\,k\Omega \\ R &= 50\,k\Omega \end{aligned}}$

$$F_c = \frac{1}{2\pi R_0 C_0} = \boxed{15.92\,kHz.}$$

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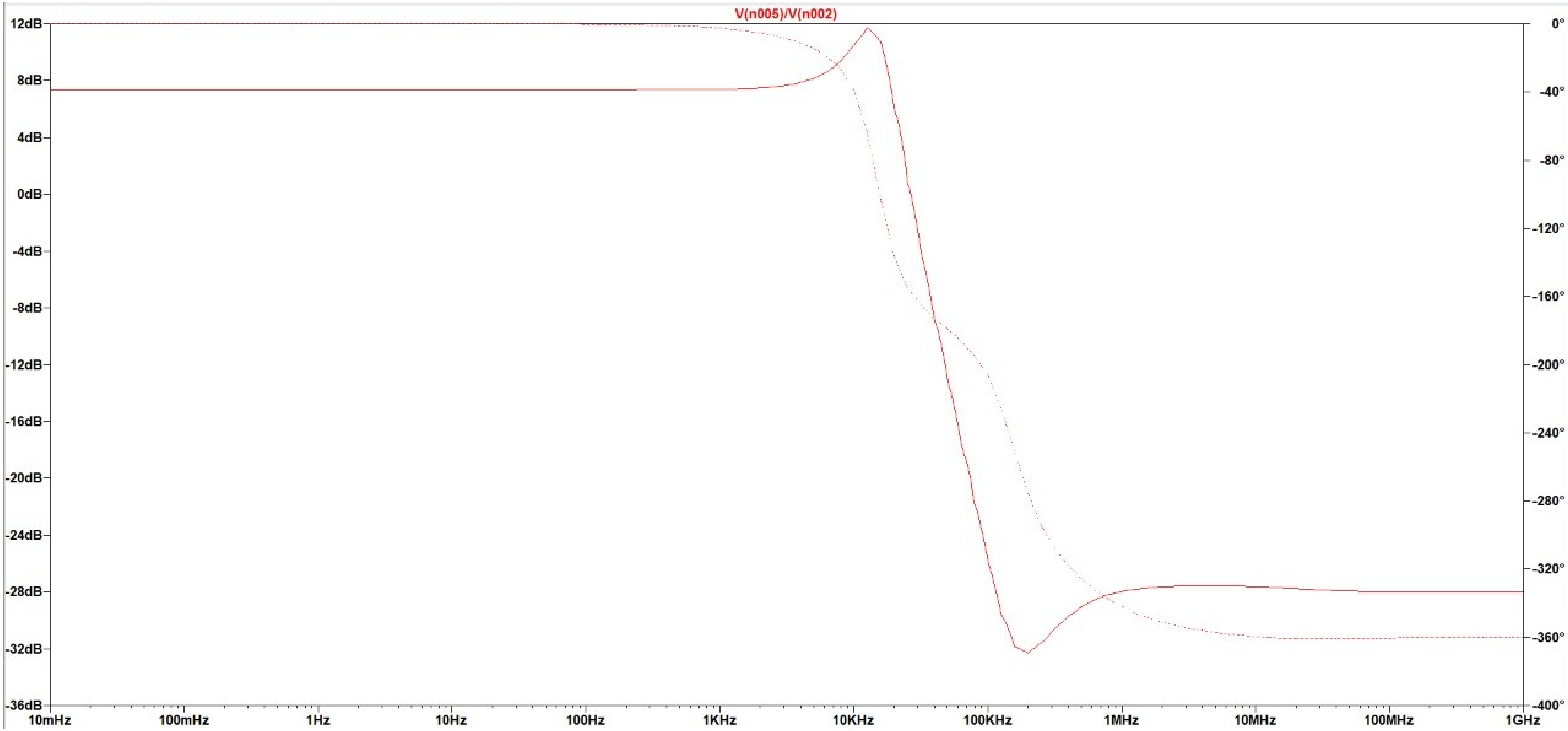
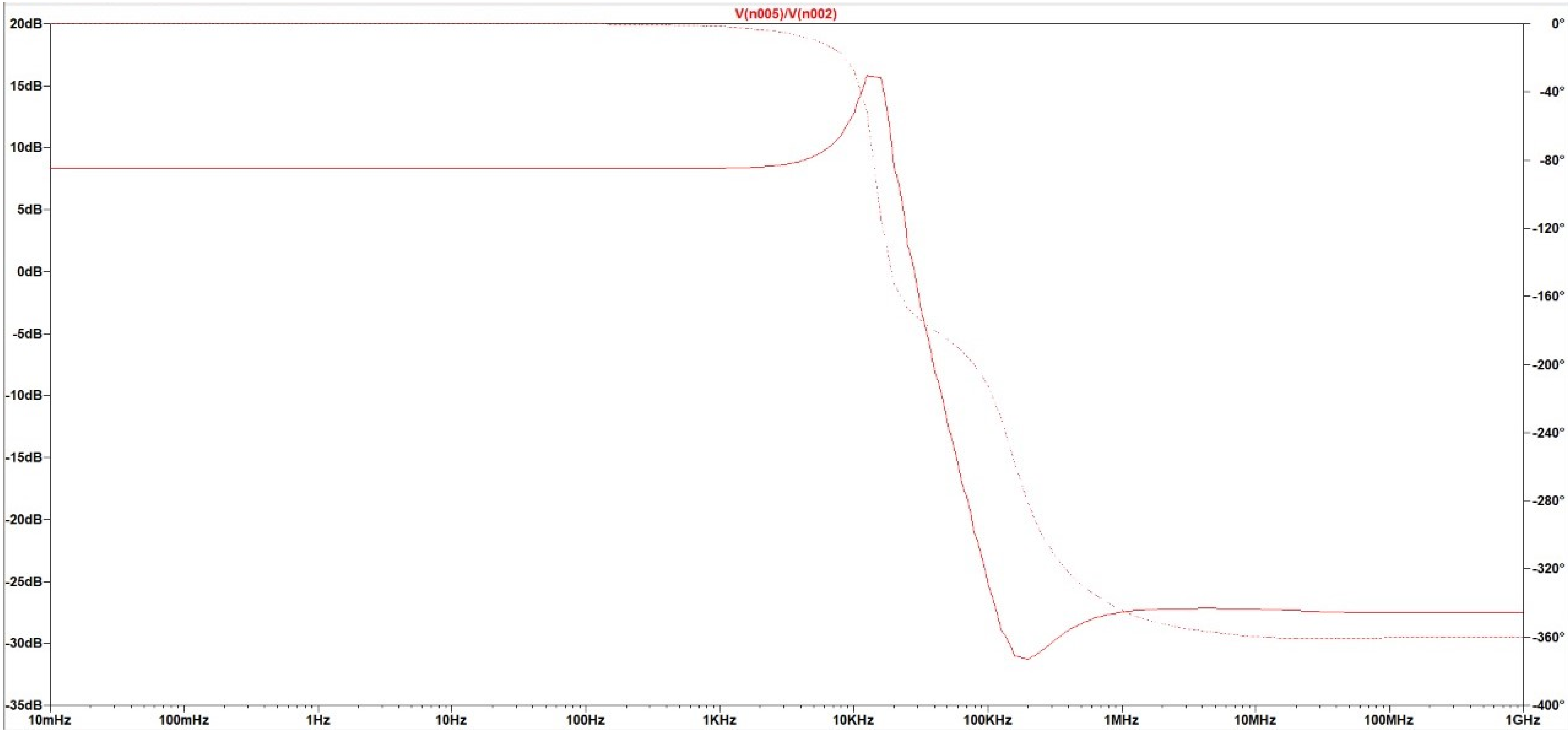
Comments:

1. for $Q = 2.5$, gain is maximum than $Q = 1.5$ bode plot.
2. value of damping factor (ζ) for:
   $Q = 1.5$, $\zeta = 0.33$.
   $Q = 2.5$, $\zeta = 0.2$.
3. The phase shift is $-\pi/2$.
4. cutoff frequency (F_c) for: (observed)
   $Q = 1.5$, $F_c = 23.07$ kHz
   $Q = 2.5$, $F_c = 22.11$ kHz.
5. As (ζ) damping factor increases, overshoot in gain increases near (F_c) & cutoff frequency


V(n005)/V(n002)
12dB
8dB
4dB
0dB
-4dB
-8dB
-12dB
-16dB
-20dB
-24dB
-28dB
-32dB
-36dB
0°
-40°
-80°
-120°
-160°
-200°
-240°
-280°
-320°
-360°
-400°
10mHz
100mHz
1Hz
10Hz
100Hz
1KHz
10KHz
100KHz
1MHz
10MHz
100MHz
1GHz


V(n005)/V(n002)
20dB
15dB
10dB
5dB
0dB
-5dB
-10dB
-15dB
-20dB
-25dB
-30dB
-35dB
0°
-40°
-80°
-120°
-160°
-200°
-240°
-280°
-320°
-360°
-400°
10mHz
100mHz
1Hz
10Hz
100Hz
1KHz
10KHz
100KHz
1MHz
10MHz
100MHz
1GHz

given $R_1 = R_2 = 10K\Omega = R_0$

$C_1 = C_2 = 1pF = C_0.$

case (4) $Q = 2.5$

$$Q = 2.5 = \frac{1}{2 - \frac{R_f}{R}}.$$

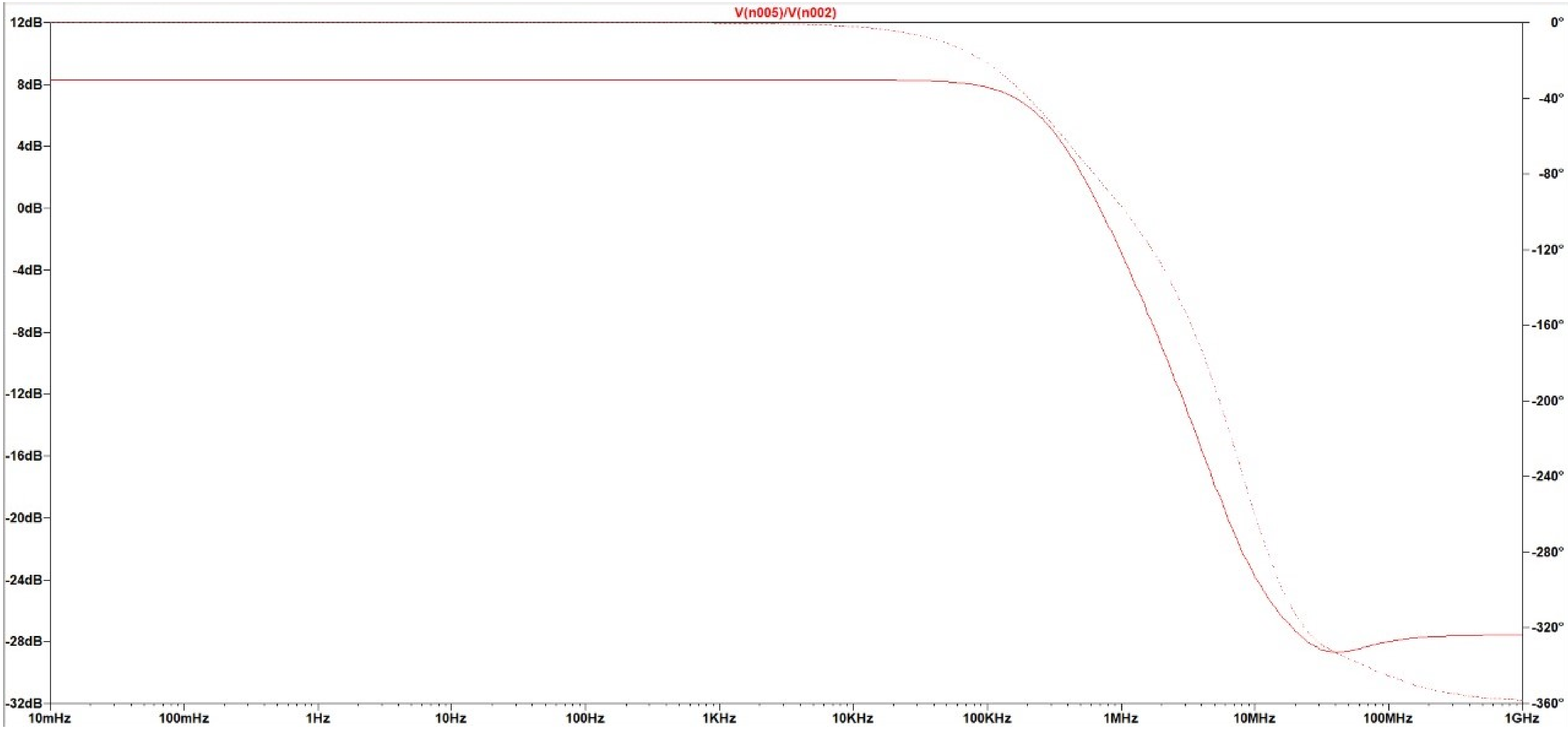
$$\frac{R_f}{R} = \frac{8}{5}$$

let $\boxed{\begin{array}{l} R_f = 80k\Omega \\ R = 50k\Omega \end{array}}$

$$F_c = \frac{1}{2\pi R_0 C_0} = \boxed{15.92 MHz}$$

comments:

1. Drastic change in F_c cutoff frequency
2. F_c observed 289.84 kHz
3. Phase shift of $-\pi/2$.
4. Graph more smooth
5. lesser capacitive value, higher range freq. filter.



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-320°
-360°
10mHz
100mHz
1Hz
10Hz
100Hz
1KHz
10KHz
100KHz
1MHz
10MHz
100MHz
1GHz