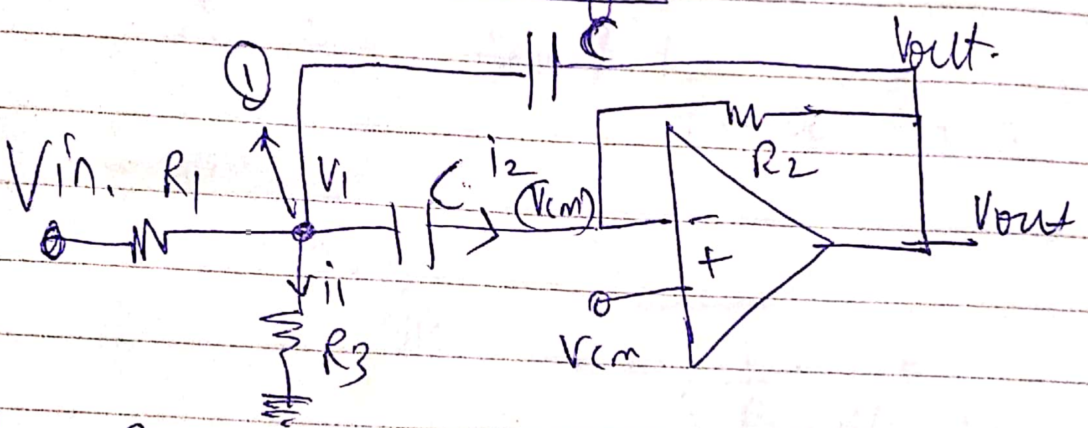
Name- Balasubramaniam M C
Roll - EE18B155.

Pre-lab Exp.-6 - Bandpass filters:-

Ex 1:-

Transfer function of:-



$\frac{V_{out}}{V_{in}} = ?$

At node ①

$$\frac{V_{in} - V_1}{R_1} = \frac{V_1}{R_3} + (V_1 - V_{out})sC + (V_1 - V_{cm})sC$$

$$\frac{V_{in}}{R_1} + V_{out}sC + V_{cm}sC = V_1\left\{ \frac{1}{R_1} + \frac{1}{R_3} + 2sC \right\} \text{ -- Eq.1}$$

$$\frac{V_{cm} - V_{out}}{R_2} = (V_1 - V_{cm})sC \Rightarrow \frac{V_{cm}}{R_2 sC} - \frac{V_{out}}{R_2 sC} + V_{cm} = V_1 \text{ - Eq.2}$$

From Eqn. 1 and Eqn. 2,

$$\left\{ \frac{V_{in}}{R_1} + V_{out}sC + V_{cm}sC \right\} = \left\{ V_{cm}\left\{ \frac{1}{R_2 sC} + 1 \right\} - \frac{V_{out}}{R_2 sC} \right\} \times \left\{ \frac{1}{R_1} + \frac{1}{R_3} + 2sC \right\}.$$

$$\frac{V_{in}}{R_1} + V_{cm}sC - V_{cm}\left\{\frac{1}{R_2 sC}+1\right\}\left\{\frac{1}{R_1}+\frac{1}{R_3}+2sC\right\}$$

$$= -\frac{V_{out}}{R_2 sC}\left\{\frac{1}{R_1}+\frac{1}{R_3}+2sC\right\}$$

$$- V_{out}\, sC$$

(V_{cm} is just a dc offset)

$$\therefore \frac{V_{in}}{R_1} = -V_{out}\left\{+\frac{1}{R_2R_1sC} + \frac{1}{R_3R_2sC} + \frac{2}{R_2} + sC\right\}$$

$$\frac{V_{out}}{V_{in}} = \frac{-1}{R_1\left\{\frac{1}{R_2R_1sC}+\frac{1}{R_3R_2sC}+\frac{2}{R_2}+sC\right\}}$$

$$\frac{V_{out}}{V_{in}} = \frac{-1}{\cancel{R_1}\left\{\frac{R_3 + R_1 + 2R_1R_3sC + R_1R_2R_3(sC)^2}{\cancel{R_1}R_2R_3sC}\right\}}$$

$$\frac{V_{out}}{V_{in}} = \frac{-R_2R_3sC}{\left\{(sC)^2(R_1R_2R_3) + 2R_1R_3sC + R_1 + R_3\right\}}$$

$$\frac{V_{out}}{V_{in}} = \frac{-\frac{s}{R_1C_1}}{\left\{s^2 + \frac{2s}{R_2C} + \frac{(R_1+R_3)}{R_1R_2R_3C^2}\right\}}$$

$$\therefore \boxed{\omega_0 = \sqrt{\frac{R_1+R_3}{R_1R_2R_3}}\cdot\frac{1}{C}}$$

$$\boxed{\frac{\omega_0}{Q_0} = \frac{2}{R_2C}}$$

$$Q_0 = \sqrt{\frac{(R_1+R_3)}{R_1R_2R_3} \cdot \frac{1}{C} \cdot \frac{R_2C}{2}} = \boxed{\sqrt{\frac{(R_1+R_3)\cdot R_2}{R_1R_3} \cdot \frac{1}{2}} = Q_0}$$

$$\cancel{A_0Q} \quad \frac{A_0\omega_0}{Q_0} = +\frac{1}{R_1C} = \frac{A_0 \cdot 2}{R_2C}$$

$$\boxed{A_0 = \frac{R_2}{R_1} \cdot \frac{1}{2}}$$

For BPF 1:-

$f_{01} = 1\,kHz$. $\quad A_{0\,1\text{ and }2} = 1 \quad Q_{1,2} = 10$

$$A_0 = \frac{R_2}{2R_1} = 1$$

$$\therefore \boxed{R_2 = 2R_1}$$

$$\omega_0 = 2\pi \times 1\,kHz$$

$$\sqrt{\frac{(R_1+R_3)R_2}{R_1R_3} \cdot \frac{1}{2}} = 10$$

$$\omega_0 = \sqrt{\frac{R_1+R_3}{R_1R_2R_3} \cdot \frac{1}{C}} = 2\pi \times 10^3$$

$$\therefore 20 = \sqrt{\frac{(R_1+R_3)\cdot 2}{R_3}}$$

$$\omega_0 = \sqrt{\frac{200\cancel{R_3}}{R_1R_2\cancel{R_3}} \cdot \frac{1}{C}} = 2\pi \times 10^3$$

$$\therefore 200R_3 = R_1 + R_3$$

$$\boxed{R_3(199) = R_1}$$

(This is for $BPF_{1,2}$)

$$= \sqrt{\frac{200}{2R_1^2} \cdot \frac{1}{C}} = 2\pi \times 10^3$$

$$\frac{10}{R_1C} = 2\pi \times 10^3 \Rightarrow R_1C = 10^{-2}/2\pi \quad \boxed{= 10^{-3} \times 1.59}$$

(BPF_1)

Scanned with CamScanner

For BPF2 :-

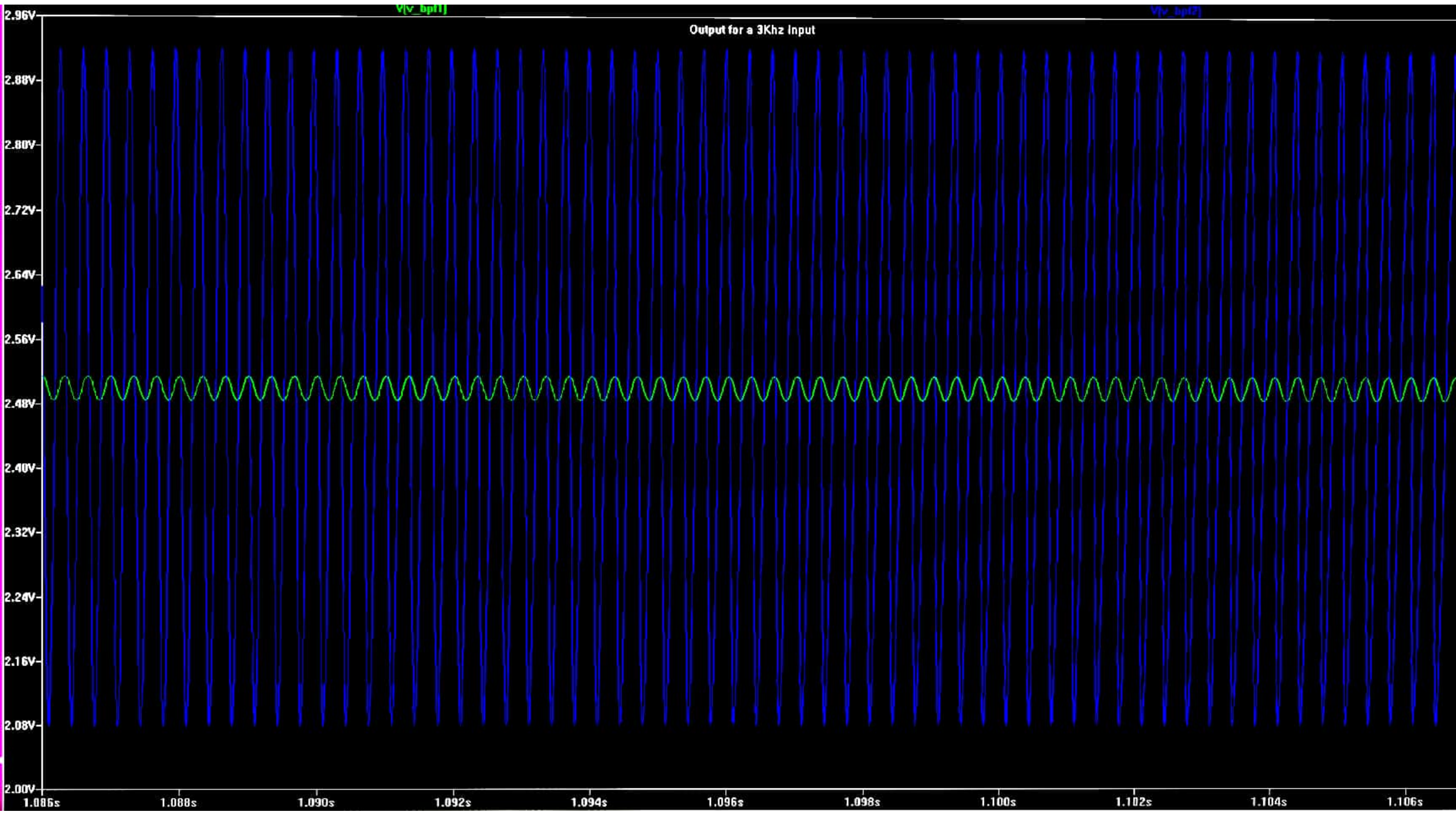
$\omega_0 = 2\pi \times 3 \times 10^3$ rad/s

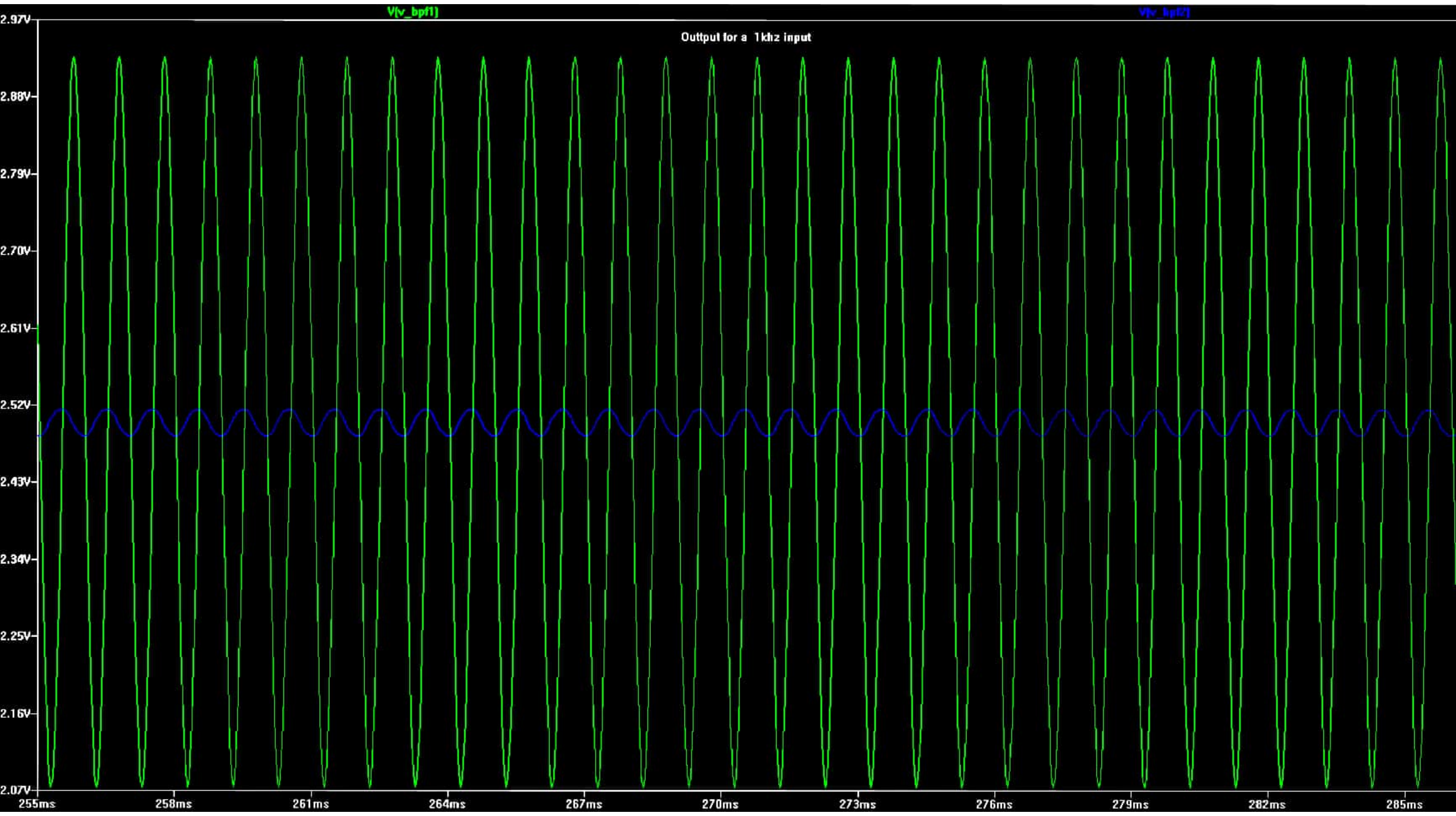
$\therefore \underset{(BPF_2)}{R_1.C} = 10^{-2}/(3\times 2\pi) = \boxed{5.31\times 10^{-4}}$

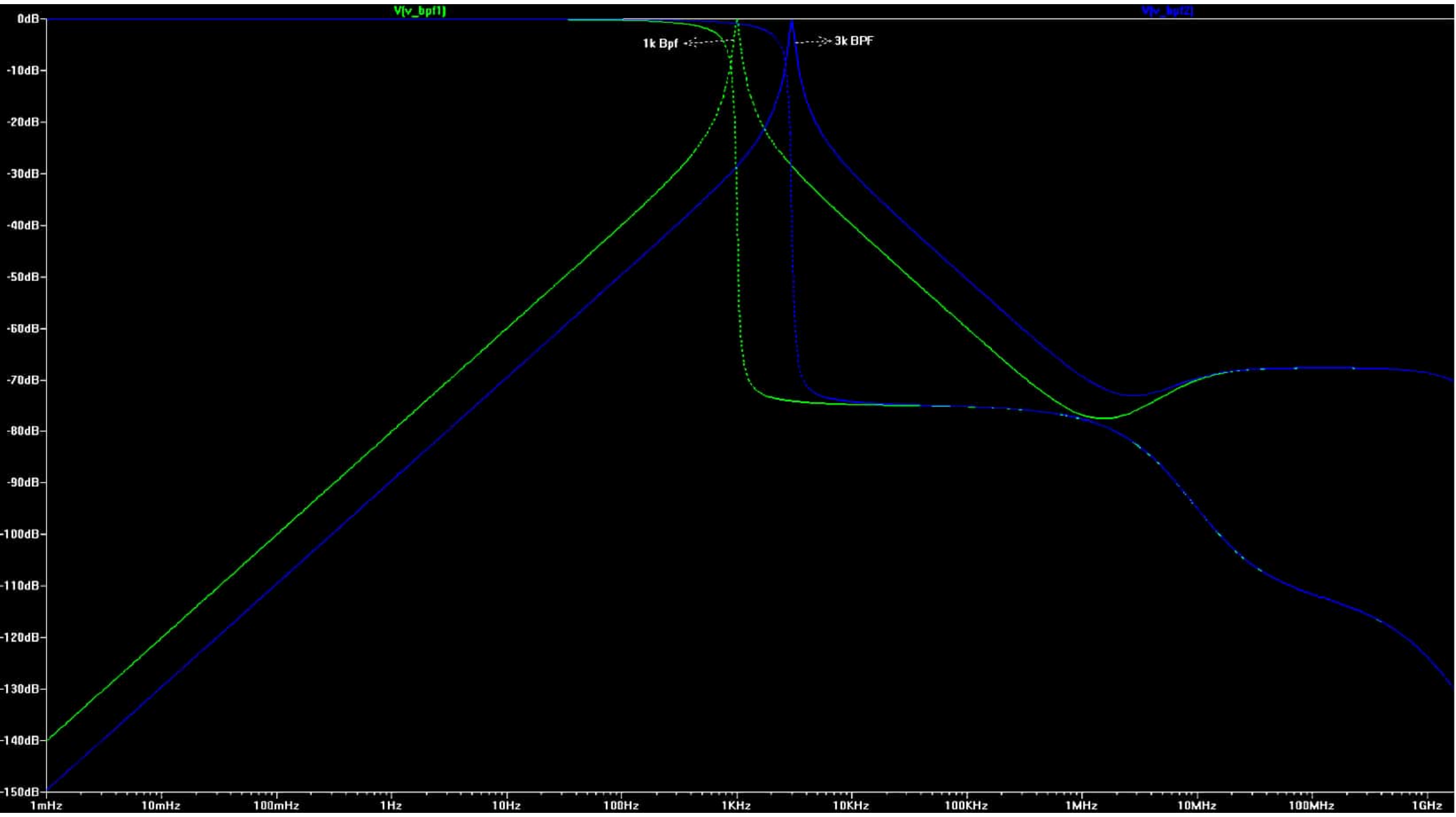
Hence, values taken
for BPF 1 : $R_1 = 100k = R_{1b}$
$R_2 = 200k = R_{2b}$
$R_3 = 0.503k = R_{3b}$
same for BPF2

BPF1 :- $C_a = 15.9nF$

BPF2 :- $C_b = 5.3nF$


V(v_bpf1)
V(v_bpf2)
Output for a 3Khz Input
2.96V
2.88V
2.80V
2.72V
2.64V
2.56V
2.48V
2.40V
2.32V
2.24V
2.16V
2.08V
2.00V
1.086s
1.088s
1.090s
1.092s
1.094s
1.096s
1.098s
1.100s
1.102s
1.104s
1.106s


V[v_bpf1]
Output for a 1khz input
2.97V
2.88V
2.79V
2.70V
2.61V
2.52V
2.43V
2.34V
2.25V
2.16V
2.07V
255ms
258ms
261ms
264ms
267ms
270ms
273ms
276ms
279ms
282ms
285ms


V(v_bpf1)
V(v_bpf2)
1k Bpf
3k BPF
0dB
-10dB
-20dB
-30dB
-40dB
-50dB
-60dB
-70dB
-80dB
-90dB
-100dB
-110dB
-120dB
-130dB
-140dB
-150dB
1mHz
10mHz
100mHz
1Hz
10Hz
100Hz
1KHz
10KHz
100KHz
1MHz
10MHz
100MHz
1GHz