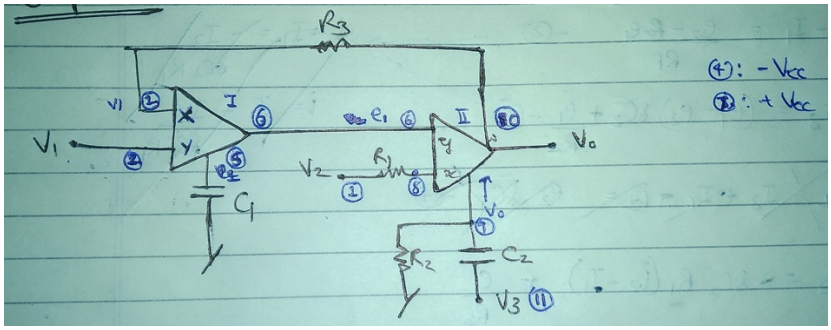
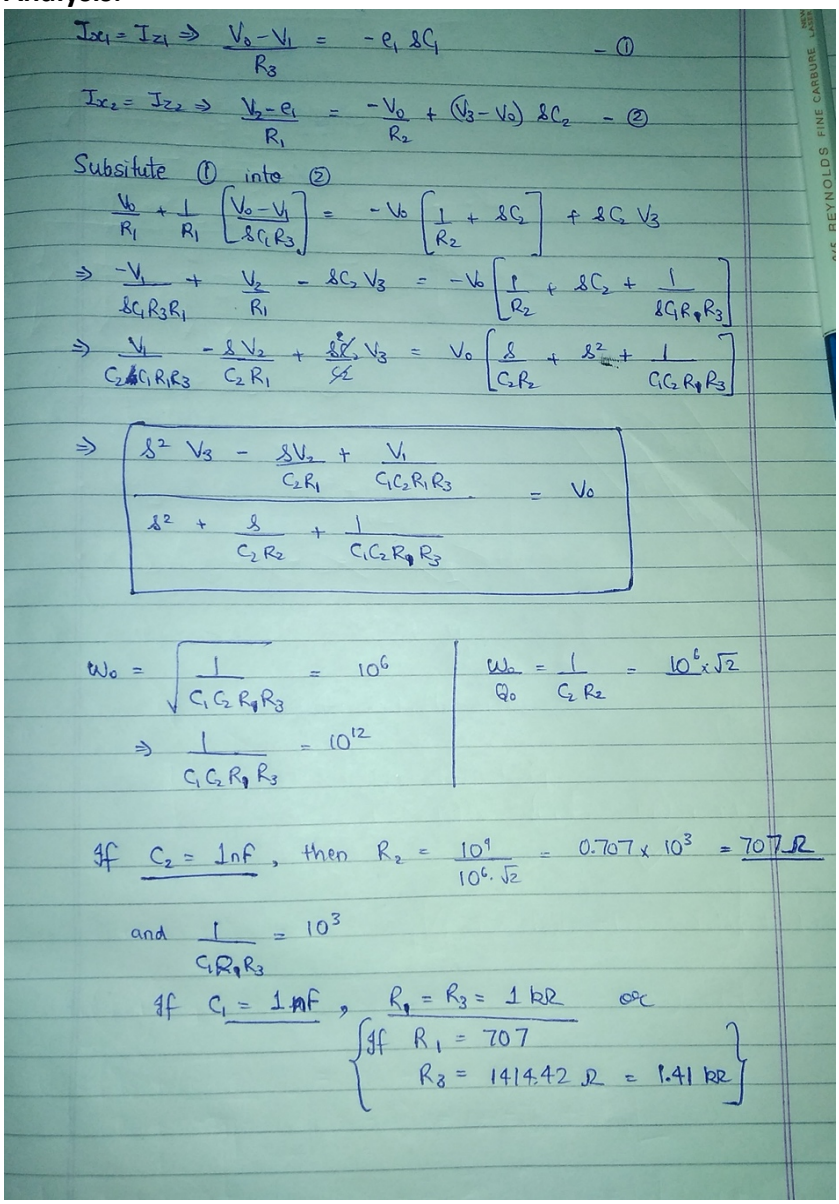
EXPERIMENT 8: Universal biquad using CFOA

1. Analize the circuit shown below.
2. Choose the values of resistors and capacitors to have
   wo = 10^6 rad/s , Qo = $\frac{1}{\sqrt{2}}$, Ho = 1
3. Verify the workability of the circuit by determining magnitude and phase response all the 5 types of filters.

CIRCUIT:



Analysis:

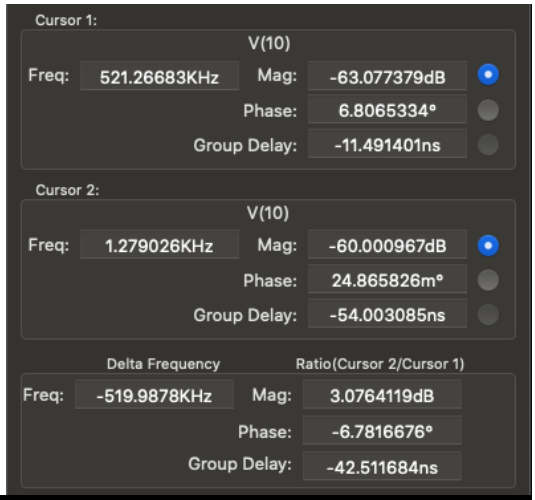


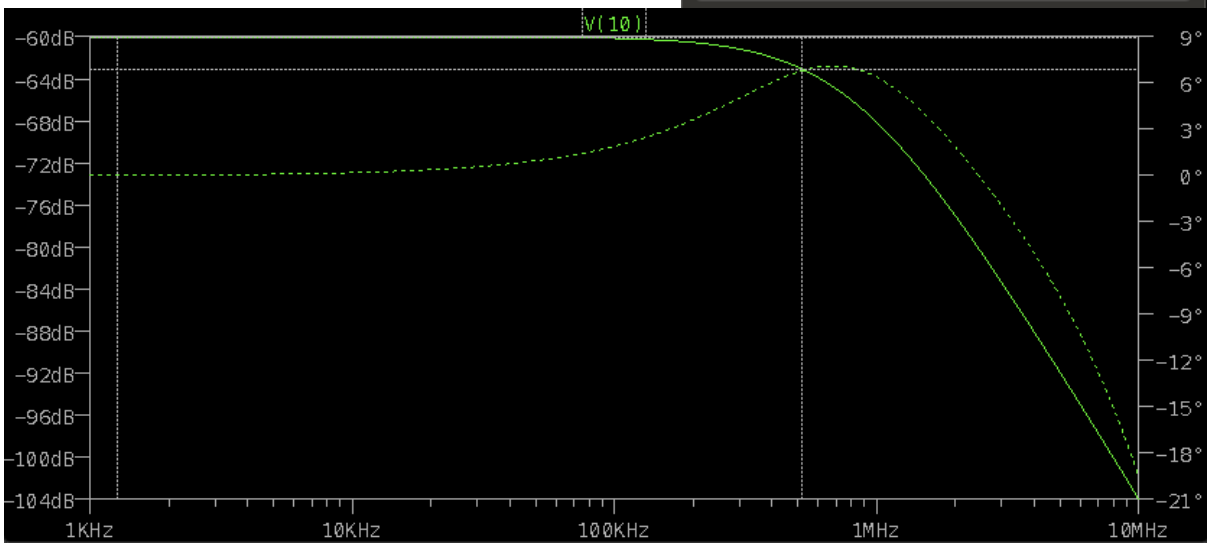
1. Low Pass

```
.include /Users/sanujkul/Documents/LTspice/libraries/ad844.cir
*i. CFOAs:
*Xn Y X +V -V W Z MODELNAME
X1 3 2 7 4 6 5 AD844
X2 6 8 7 4 10 9 AD844

*ii. Passive Componets
R1 1 8 707
R2 9 0 707
R3 3 10 1.41k
C1 5 0 1n
C2 9 11 1n

*iii. Power supplies:
VccPositive 7 0 DC 12V
VccNegative 4 0 DC -12V

*iv. Voltage inputs:
*LP: V2=V3=0, BP: V1=V3=0, HP:V2=V1=0
*AP: V1=V2=V3, R1=R2
V1 2 0 AC 1mV
V2 1 0 AC 0mv
V3 11 0 AC 0mV

***** OUTPUT CODES **********
*AC ANALYSIS
.AC DEC 50 1K 10MEG
```

Observation:

1. At DC, Mag = -60.00 dB
2. At freq = 521 KHz, Mag = -63.08dB
3. Therefore, 3 db BW = 521 KHz
4. At 1 MHz, Magnitude is equal to -66dB, hence there is drop of 6 dB from that of voltage at DC.



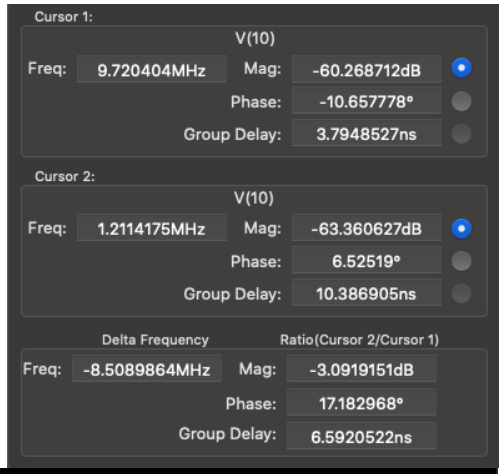


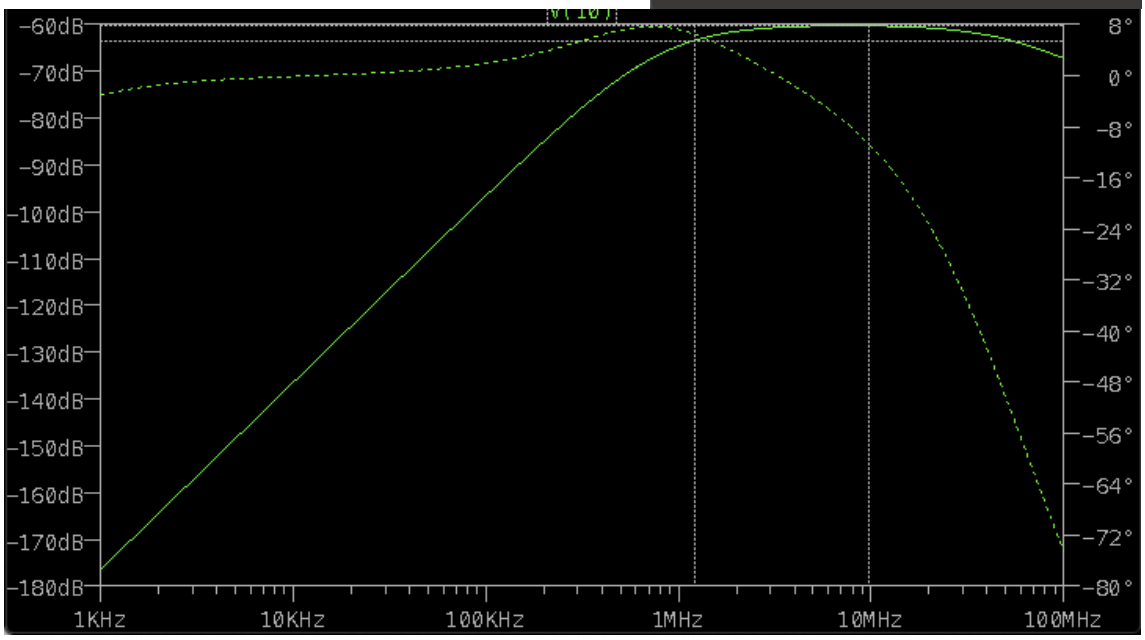
2. HIGH PASS

```
.include /Users/sanujkul/Documents/LTspice/libraries/ad844.cir
*i. CFOAs:
*Xn Y X +V -V W Z MODELNAME
X1 3 2 7 4 6 5 AD844
X2 6 8 7 4 10 9 AD844

*ii. Passive Componets
R1 1 8 707
R2 9 0 707
R3 3 10 1.41k
C1 5 0 1n
C2 9 11 1n

*iii. Power supplies:
VccPositive 7 0 DC 12V
VccNegative 4 0 DC -12V

*iv. Voltage inputs:
*LP: V2=V3=0, BP: V1=V3=0, HP:V2=V1=0
*AP: V1=V2=V3, R1=R2
V1 2 0 AC 0mV
V2 1 0 AC 0mv
V3 11 0 AC 1mV

***** OUTPUT CODES **********
*AC ANALYSIS
.AC DEC 50 1K 100MEG
```

Observations:

1. 3dB cut off frequency = 1.21 MHz



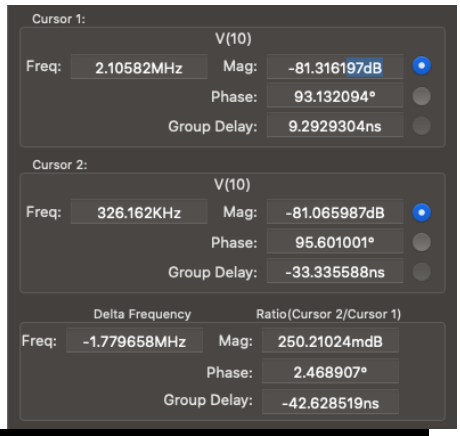


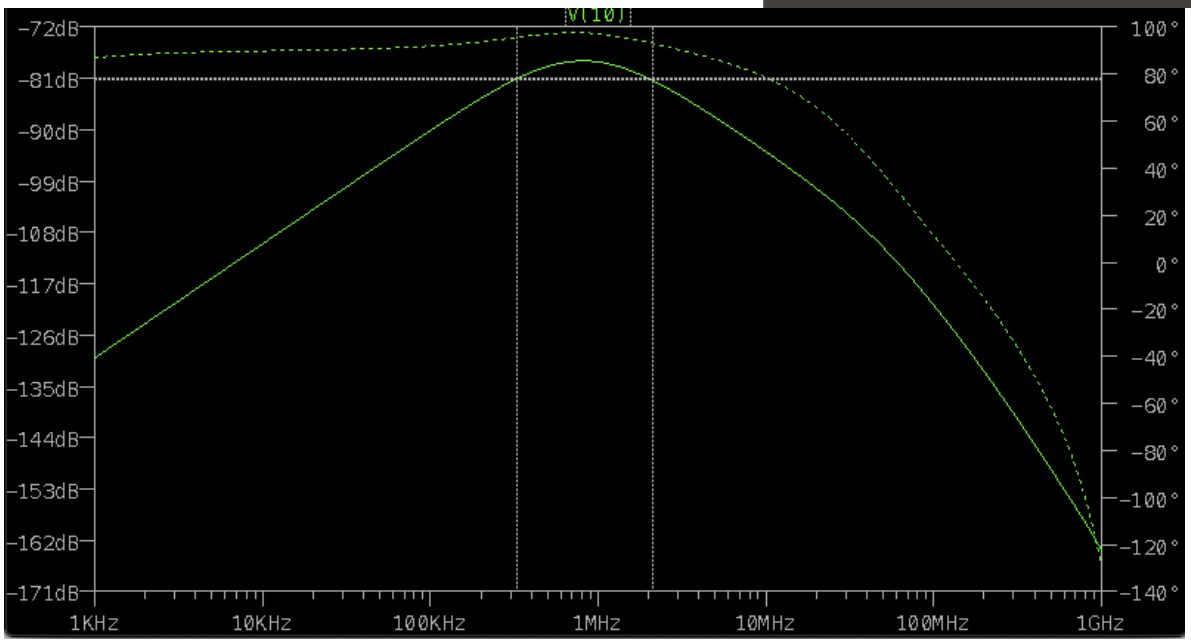
3. Band Pass

```
.include /Users/sanujkul/Documents/LTspice/libraries/ad844.cir
*i. CFOAs:
*Xn Y X +V -V W Z MODELNAME
X1 3 2 7 4 6 5 AD844
X2 6 8 7 4 10 9 AD844

*ii. Passive Componets
R1 1 8 707
R2 9 0 707
R3 3 10 1.41k
C1 5 0 1n
C2 9 11 1n

*iii. Power supplies:
VccPositive 7 0 DC 12V
VccNegative 4 0 DC -12V

*iv. Voltage inputs:
*LP: V2=V3=0, BP: V1=V3=0, HP:V2=V1=0
*AP: V1=V2=V3, R1=R2
V1 2 0 AC 0mV
V2 1 0 AC 1mv
V3 11 0 AC 0mV

***** OUTPUT CODES **********
*AC ANALYSIS
.AC DEC 50 1K 1G
```

Observations

1. Centre frequency = 1 MHz
2. Left -3dB freq = 326 kHz
3. Right -3db freq = 2.105 MHz
4. BW = 1.779 MHz



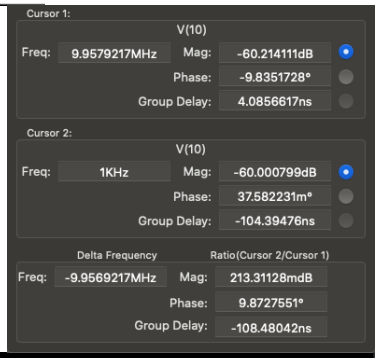


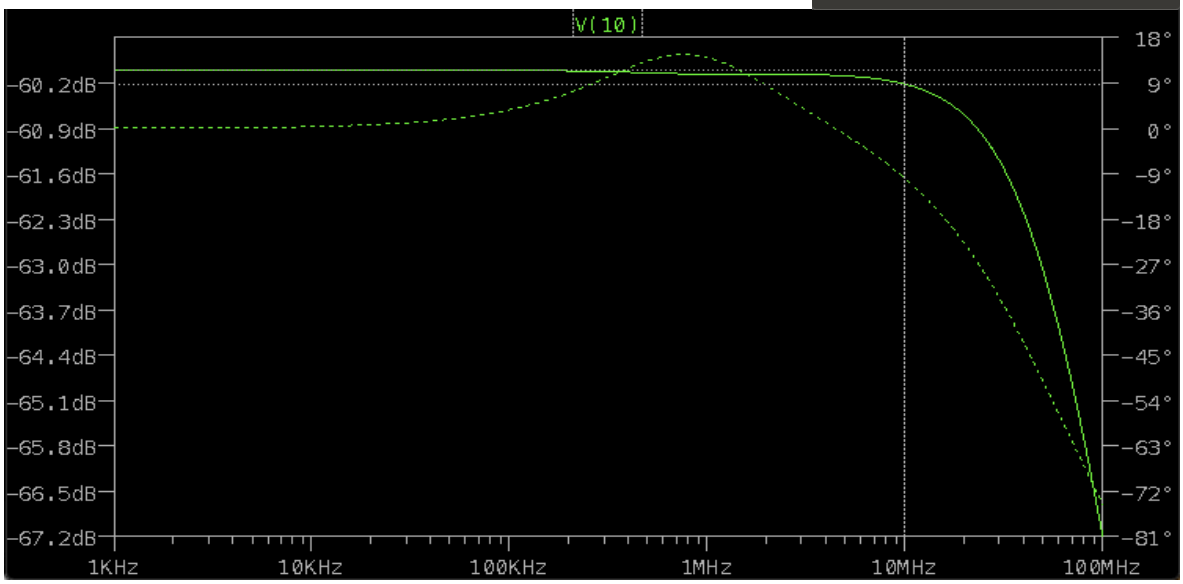
4. ALL Pass

```
.include /Users/sanujkul/Documents/LTspice/libraries/ad844.cir
*i. CFOAs:
*Xn Y X +V -V W Z MODELNAME
X1 3 2 7 4 6 5 AD844
X2 6 8 7 4 10 9 AD844

*ii. Passive Componets
R1 1 8 707
R2 9 0 707
R3 3 10 1.41k
C1 5 0 1n
C2 9 11 1n

*iii. Power supplies:
VccPositive 7 0 DC 12V
VccNegative 4 0 DC -12V

*iv. Voltage inputs:
*LP: V2=V3=0, BP: V1=V3=0, HP:V2=V1=0
*AP: V1=V2=V3, R1=R2, BR: V2=0
V1 2 0 AC 1mV
V2 1 0 AC 1mv
V3 11 0 AC 1mV

***** OUTPUT CODES **********
*AC ANALYSIS
.AC DEC 50 1K 100MEG
```

Observations:

1. Curve has output signal of value -60dB (or the gain 0 db) until 10 MHz and then starts to deteriorate because of parasitic capacitances.



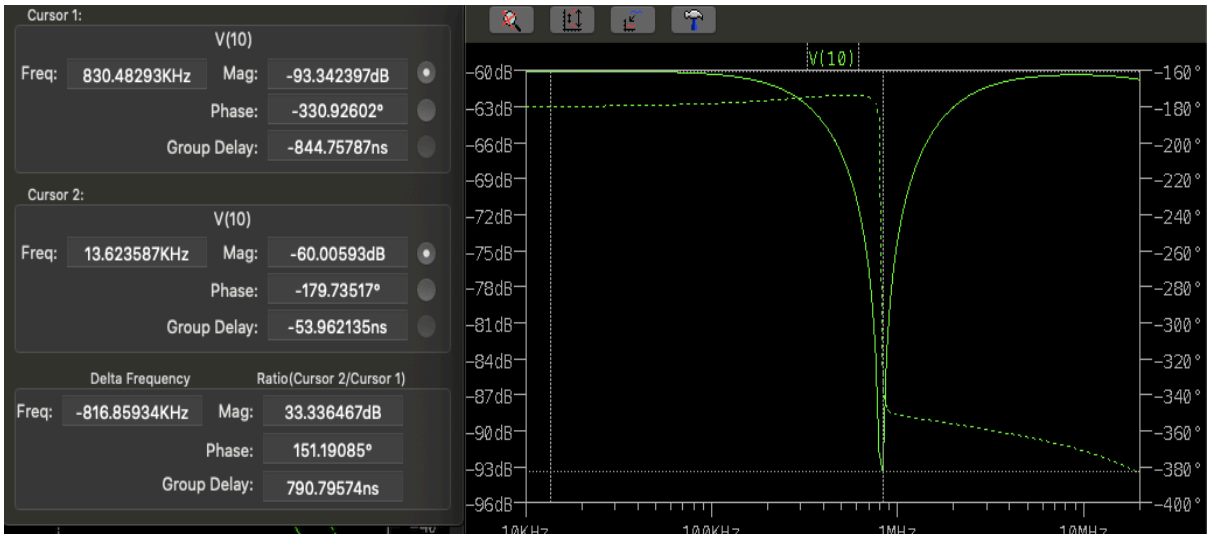


5. Band reject

```
.include /Users/sanujkul/Documents/LTspice/libraries/ad844.cir
*i. CFOAs:
*Xn Y X +V -V W Z MODELNAME
X1 3 2 7 4 6 5 AD844
X2 6 8 7 4 10 9 AD844

*ii. Passive Componets
R1 1 8 707
R2 9 0 707
R3 3 10 1.41k
C1 5 0 1n
C2 9 11 1n

*iii. Power supplies:
VccPositive 7 0 DC 12V
VccNegative 4 0 DC -12V

*iv. Voltage inputs:
*LP: V2=V3=0, BP: V1=V3=0, HP:V2=V1=0
*AP: V1=V2=V3, R1=R2, BR: V2=0
V1 2 0 AC -1mV
V2 1 0 AC 0mv
V3 11 0 AC 1mV

***** OUTPUT CODES **********
*AC ANALYSIS
.AC DEC 50 10K 20MEG
```

Observations:

1. The minima of notch is at 830.4 KHz.
2. In LTSpice, V1 = V3 didn't give the desired result, but V1 = - V3 did. Though mathematically this will make zeros imaginary. Trying to find the reason why this worked.



Conclusions

1. This is a voltage mode **universal filter using 2 CFOAs**.
2. This circuit has a **current feedback.**
3. The circuit can **realize all the 5 filters**.
4. DC gain cant be varied by keeping bandwidth constant. They are interdependent.