Signal Processing – Analog Part

<u>Submitted To:</u>

Prof. Ulf Witkowski

South Westphalia University of Applied Sciences

Soest Campus

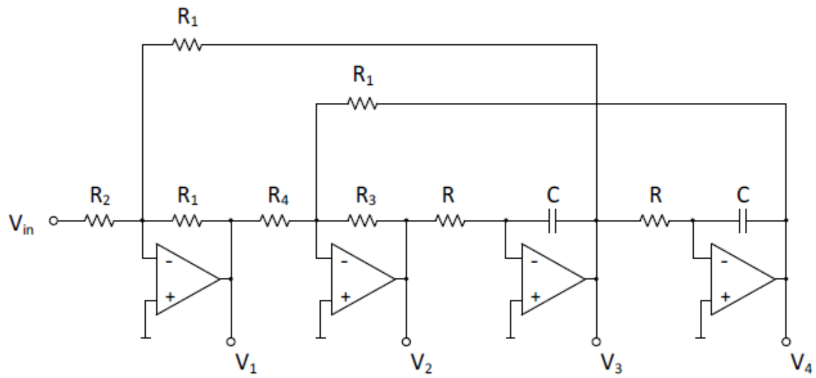
Presented by,

Md. Saiful Islam Sajol

Matriculation no. 30042836

Task 1

Filter Characteristics



$$\frac{V1}{Vin} = - \frac{R_1 R_3 R_4 + R^2 R_1{}^2 R_4 s^2 C^2}{R_2 R_3 R_4 + R^2 R_1 R_2 R_4 s^2 C^2 + R R_1 R_2 R_3 s C}$$

Notch (Band Reject Filter)

$$\frac{V2}{Vin} = \frac{R^2 R_1{}^2 R_3 s^2 C^2}{R R_1 R_2 R_3\, sC + R_2\, R_3 R_4 + R^2 R_1 R_2 R_4\, s^2 C^2}$$

High Pass Filter

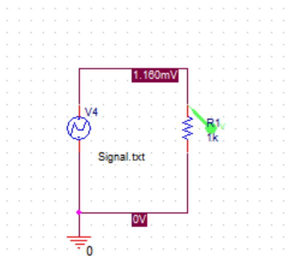
$$\frac{V3}{Vin} = \frac{-R R_1{}^2\, R_3\, s\, C}{R R_1 R_2 R_3\, sC + R_2\, R_3\, R_4 + R^2\, R_1\, R_2\, R_4\, s^2\, C^2}$$

Band Pass Filter

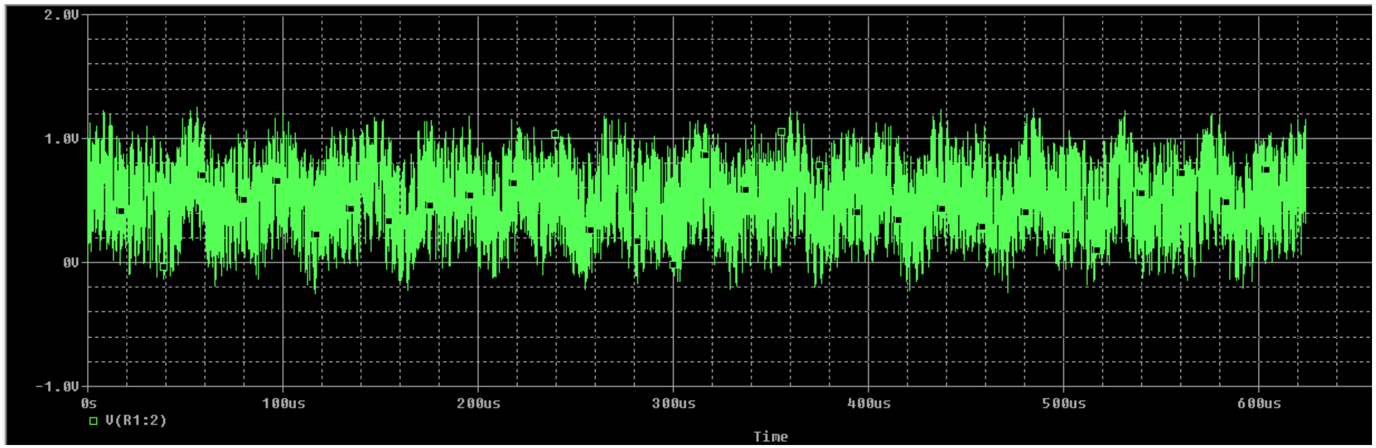
$$\frac{V4}{Vin} = \frac{R_1{}^2\, R_3}{R\, R_1\, R_2\, R_3\, s\, C + R_2\, R_3\, R_4 + R^2\, R_1\, R_2\, R_4\, s^2\, C^2}$$

Low Pass Filter

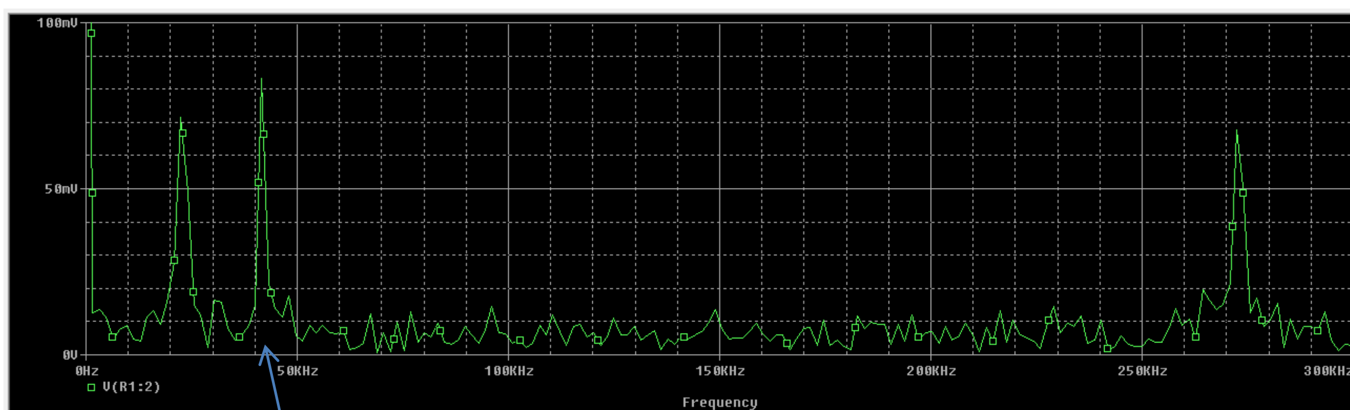
Task 2



voltage source generating the noisy signal.

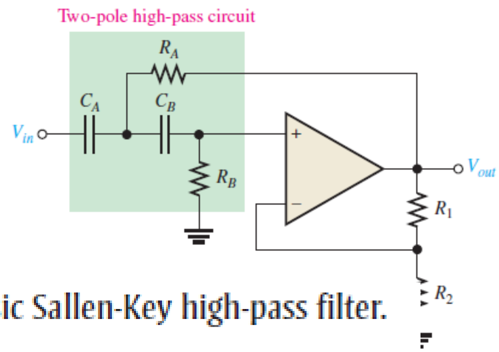


FFT

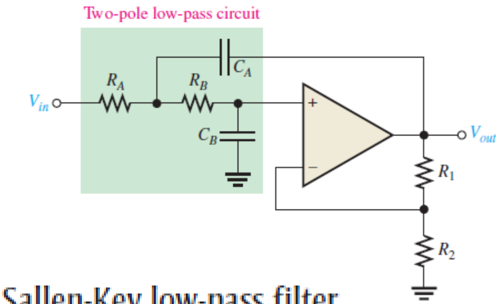


frequency of the wanted signal, it is ftarget = 42KHz

Solution :



Basic Sallen-Key high-pass filter.

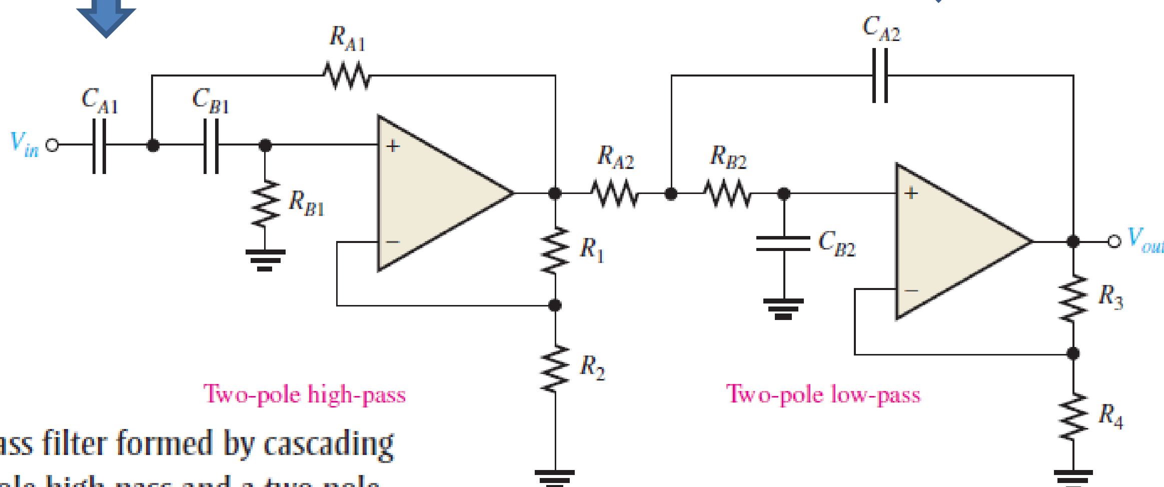


Basic Sallen-Key low-pass filter.

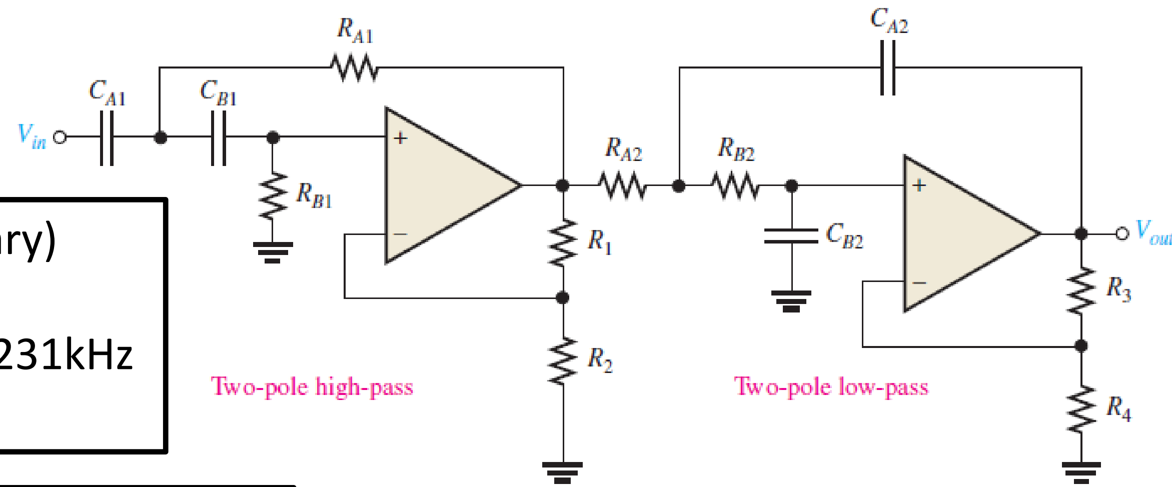
$$f_{c1} = \frac{1}{2\pi\sqrt{R_{A1}R_{B1}C_{A1}C_{B1}}}$$

$$f_{c2} = \frac{1}{2\pi\sqrt{R_{A2}R_{B2}C_{A2}C_{B2}}}$$

$$f_0 = \sqrt{f_{c1}f_{c2}}$$



Band-pass filter formed by cascading a two-pole high-pass and a two-pole low-pass filter (it does not matter in which order the filters are cascaded).



f_c=42kHz   and f_{c1}=39kHz(arbitrary)
$f_{c2}=f_c^2/f_{c1}=42^2/39=45.23$kHz
Bandwidth,B=(45.23-39)kHz=6.231kHz

Finding parameters of High pass Filter Side

For simplicity,
We select $R_{B1}=R_{A1}=R_2=3.9k\Omega$ (arbitrary)
F_{c1}=1/(2*pie*RC)
C=1046pF ~1000pF (E-24 sequence)
$C_{A1}= C_{B1} = C_{1} =$ 1000pF
R1/R2=0.586 (from chart)
R1=0.586*3.9k=2.285kΩ

Finding parameters of Low pass Filter Side

For simplicity,
We select $R_{B2}=R_{A2}=R_4=3.9k\Omega$ (arbitrary)
F_{c2}=1/(2*pie*RC)
C=902.25pF ~910pF (E-24 sequence)
$C_{A2}= C_{B2}$ = 910pF
R3/R4=1 (from chart)
R3=R4=3.9kΩ

Values for the Butterworth response.

ORDER	ROLL-OFF DB/DECADE	1ST STAGE POLES	1ST STAGE DF	1ST STAGE R_1/R_2	2ND STAGE POLES	2ND STAGE DF	2ND STAGE R_3/R_4	3RD STAGE POLES	3RD STAGE DF	3RD STAGE R_5/R_6
1	−20	1	Optional							
2	−40	2	1.414	0.586						
3	−60	2	1.00	1	1	1.00	1			
4	−80	2	1.848	0.152	2	0.765	1.235			
5	−100	2	1.00	1	2	1.618	0.382	1	0.618	1.382
6	−120	2	1.932	0.068	2	1.414	0.586	2	0.518	1.482

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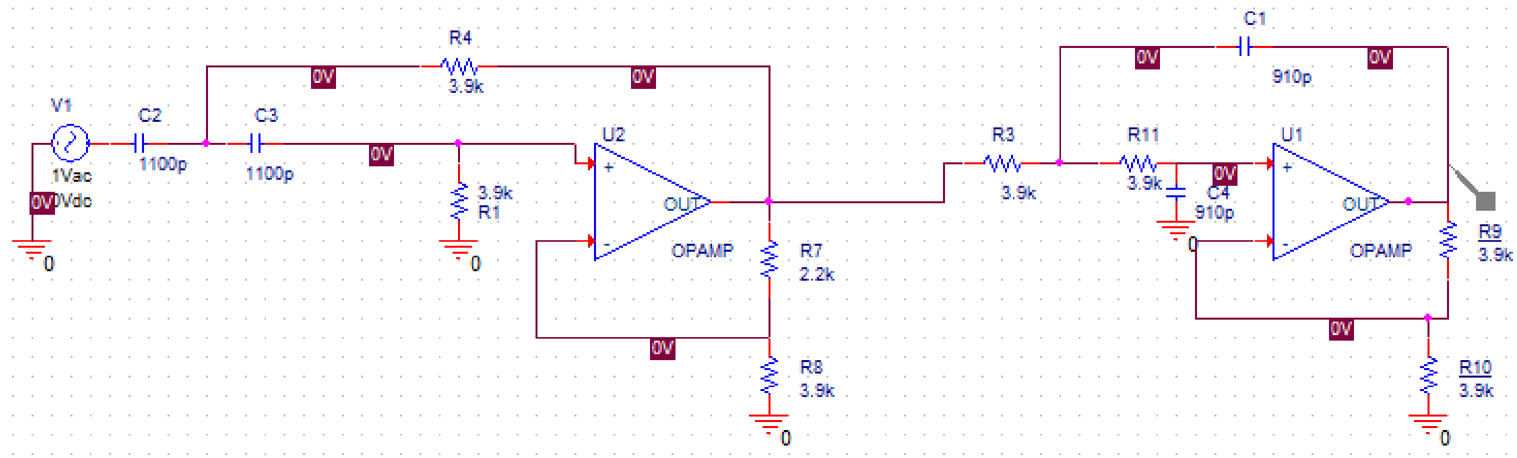
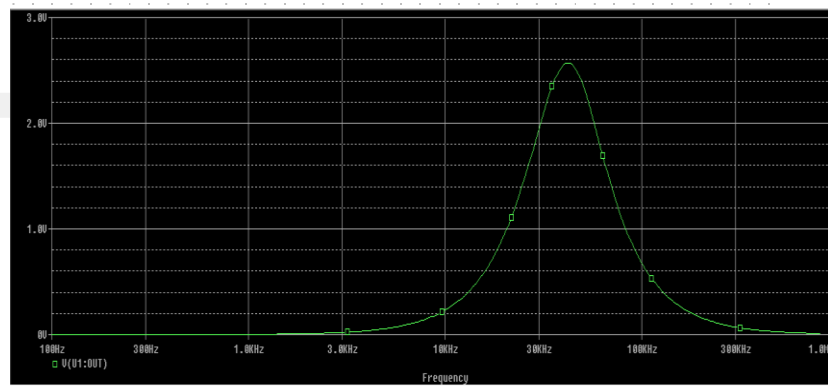
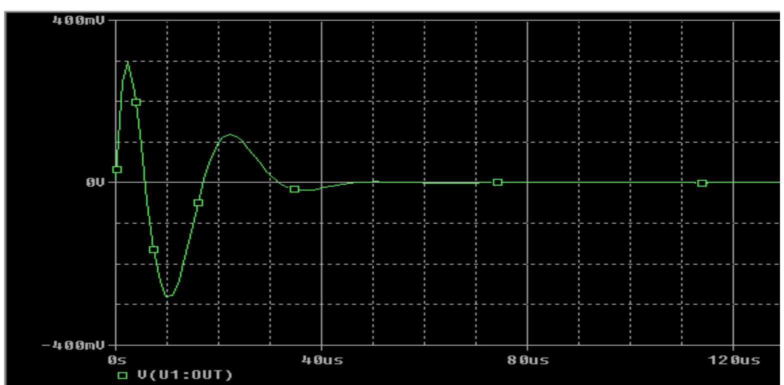
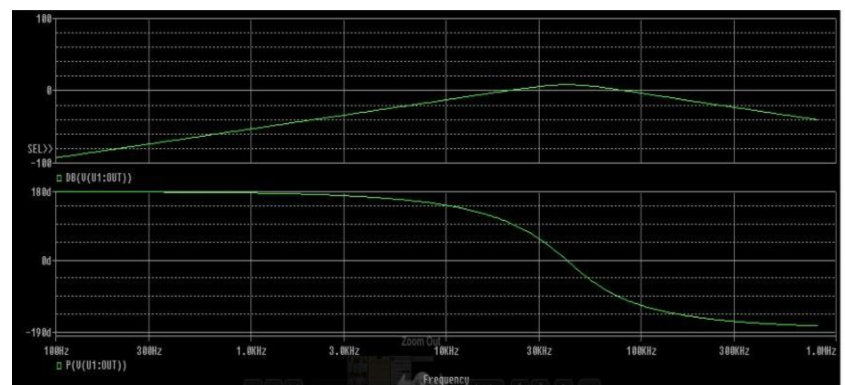

R4
3.9k
C1
910p
V1
C2
C3
U2
R3
R11
U1
1Vac
0Vdc
1100p
1100p
3.9k
R1
OUT
OPAMP
R7
2.2k
R8
3.9k
3.9k
3.9k
C4
910p
R9
3.9k
R10
3.9k
0V
0


3.0V
2.0V
1.0V
0V
100Hz
300Hz
1.0KHz
3.0KHz
10KHz
30KHz
100KHz
300KHz
1.0MHz
V(U1:OUT)
Frequency

Time Domain


400mV
0V
-400mV
0s
40us
80us
120us
V(U1:OUT)


100
0
SEL>>
-100
DB(V(U1:OUT))
180d
0d
-180d
100Hz
300Hz
1.0KHz
3.0KHz
10KHz
30KHz
100KHz
300KHz
1.0MHz
P(V(U1:OUT))
Frequency