INDIAN INSTITUTE OF SCIENCE, BENGALURU

DEPARTMENT OF ELECTRONIC SYSTEMS ENGINEERING

DESIGN FOR ANALOG CIRCUITS LABORATORY REPORT

ASSIGNMENT 8

ACTIVE SECOND ORDER FILTERS

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1.1 Aim

To perform transient and frequency domain simulations of KRC low pass filter.

1.2 Schematic

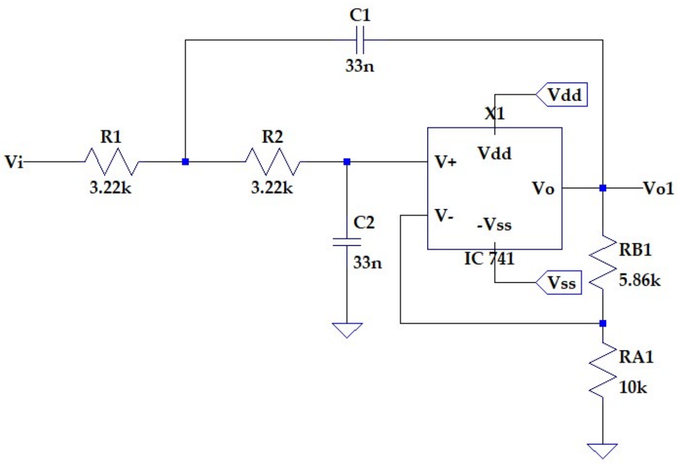

Figure 1: LTSpice schematic of KRC low pass filter

1.3 Component Selection

The transfer function of the filter is given by

$$\frac{V_{o1}(s)}{V_i(s)} = \frac{K}{s^2R_1C_1R_2C_2 + s(C_2R_2 + C_2R_1 + (1-K)C_1R_1) + 1} \tag{1}$$

Where $K = 1 + R_{B1}/R_{A1}$. Choosing $C_1 = C_2, R_1 = R_2$, we have

$$H_{LP} = K, \omega_0 = \frac{1}{R_1C_1}, Q = \frac{1}{3-K}$$

For obtaining $\omega_0 = 2\pi \times 1.5krad/s$ and $Q = 0.707$, the values chosen are $R_1 = R_2 = 3.22k\Omega, C_1 = C_2 = 33nF, R_{A1} = 5.86k\Omega, R_{B1} = 10k\Omega$.

1.4 Frequency Response

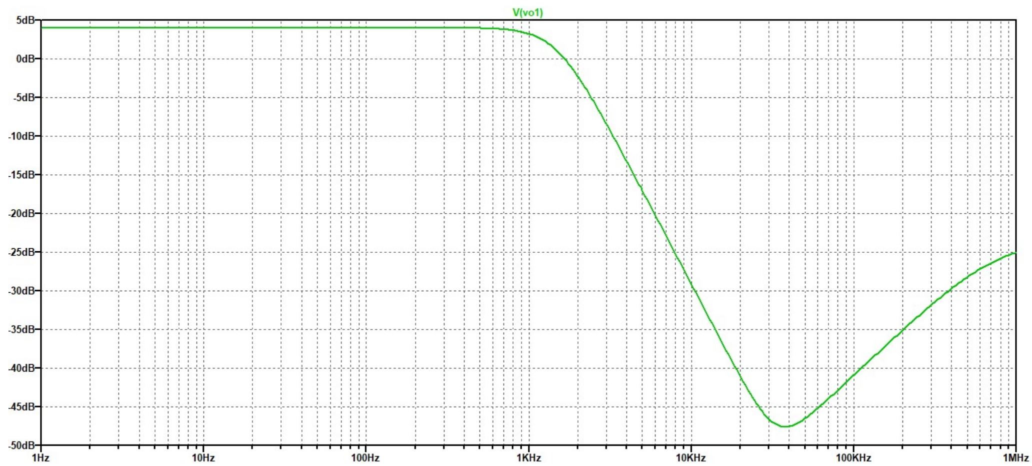

Figure 2: Frequency response of KRC low pass filter

The figure 2 above shows the frequency response of the KRC low pass filter. The cutoff frequency obtained is 1.498 kHz.

1.5 Transient Response

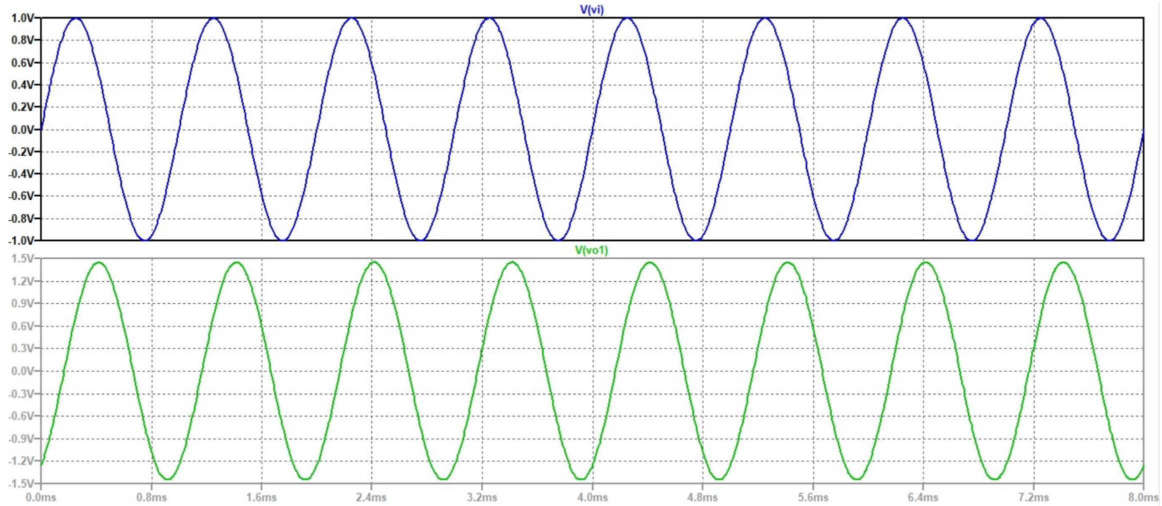

Figure 3: Transient response of KRC low pass filter

The figure 3 above shows the transient response of the KRC low pass filter with 1 V, 1 kHz sinewave input. The output voltage amplitude obtained is 1.45 V.

2 KRC High Pass Filter

2.1 Aim

To perform transient and frequency domain simulations of KRC high pass filter.

2.2 Schematic

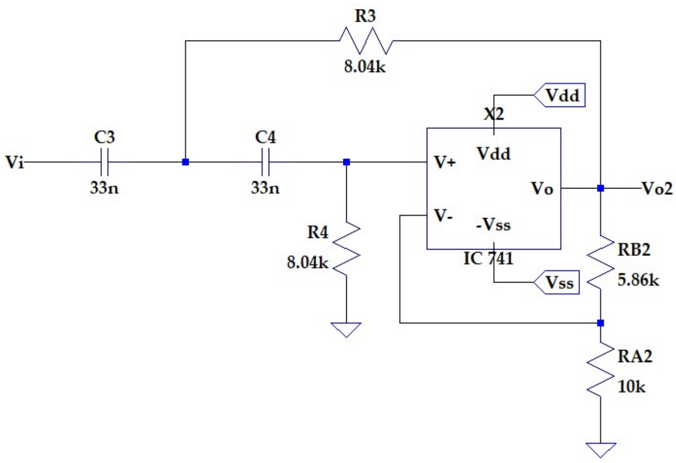

Figure 4: LTSpice schematic of KRC high pass filter

2.3 Component Selection

The transfer function of the filter is given by

$$\frac{V_{o2}(s)}{V_i(s)} = \frac{Ks^2}{s^2R_3C_3R_4C_4 + s(C_4R_4 + C_4R_3 + (1-K)C_3R_3) + 1} \tag{2}$$

Where $K = 1 + R_{B2}/R_{A2}$. Choosing $C_3 = C_4, R_3 = R_4$, we have

$$H_{HP} = K, \omega_0 = \frac{1}{R_3C_3}, Q = \frac{1}{3-K}$$

For obtaining $\omega_0 = 2\pi \times 0.6krad/s$ and $Q = 0.707$, the values chosen are $R_3 = R_4 = 8.04k\Omega, C_3 = C_4 = 33nF, R_{B2} = 5.86k\Omega, R_{A2} = 10k\Omega$.

2.4 Frequency Response

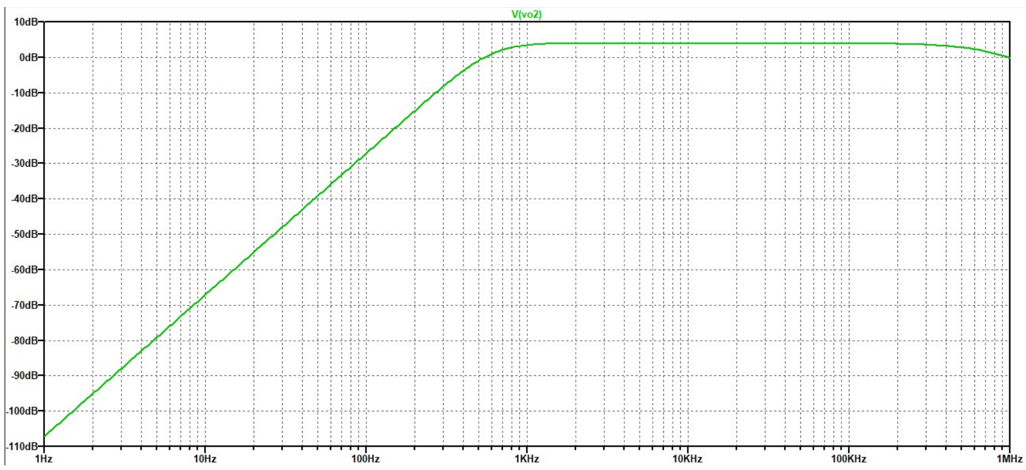

Figure 5: Frequency response of KRC high pass filter

The figure 5 above shows the frequency response of the KRC high pass filter. The cutoff frequency obtained is 599.7 Hz.

2.5 Transient Response

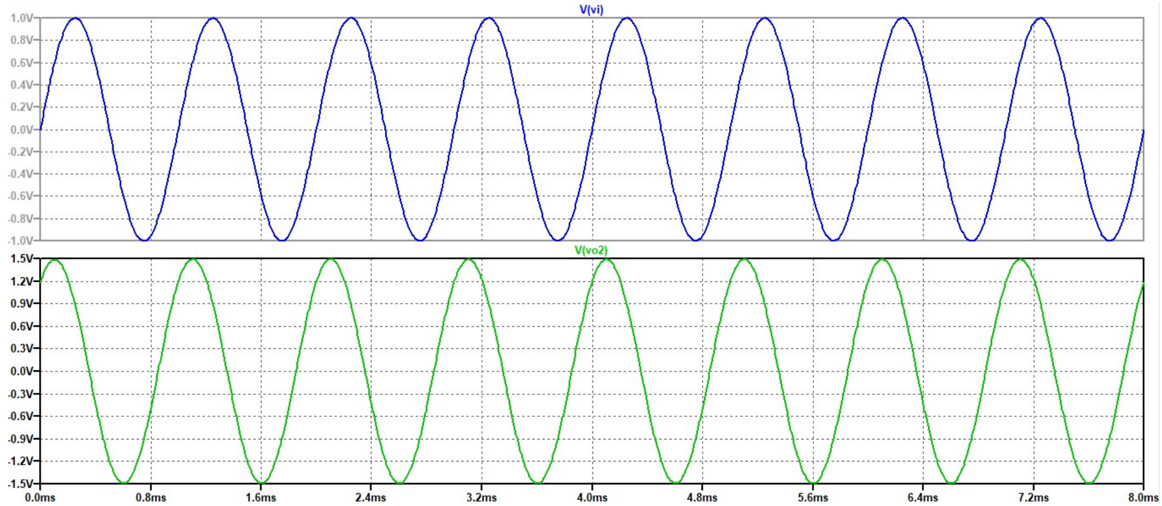

Figure 6: Transient response of KRC high pass filter

The figure 6 above shows the transient response of the KRC high pass filter with 1 V, 1 kHz sinewave input. The output voltage amplitude obtained is 1.49 V.

3 Twin-T Notch Filter

3.1 Aim

To perform transient and frequency domain simulations of Twin-T Notch filter.

3.2 Schematic

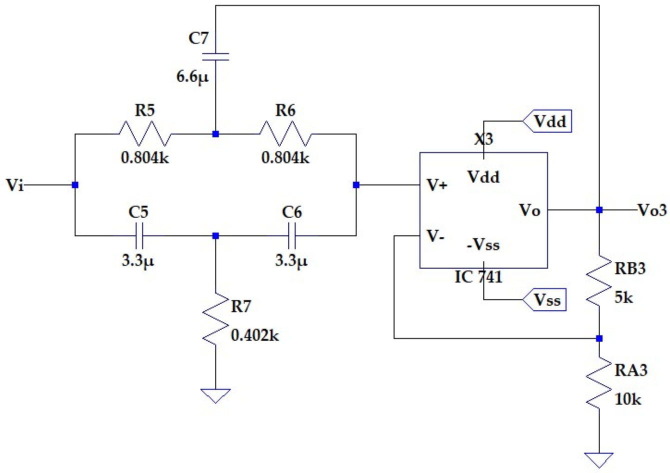

Figure 7: LTSpice schematic of Twin-T notch filter

3.3 Component Selection

Choosing $R_5 = R_6 = 2R_7, C_5 = C_6 = C_7/2$, the transfer function of the filter is given by

$$\frac{V_{o3}(s)}{V_i(s)} = K\frac{(1 + s^2R_5^2C_5^2)}{s^2R_5^2C_5^2 + s(4 - 2K)R_5C_5 + 1} \tag{3}$$

Where $K = 1 + R_{B3}/R_{A3}$. The parameters of the filter are

$$H_{0N} = K, \omega_0 = \frac{1}{R_5C_5}, Q = \frac{1}{4 - 2K}$$

For obtaining $\omega_0 = 2\pi \times 60rad/s$ the values chosen are $C_5 = C_6 = C_7/2 = 3.3\mu F, R_5 = R_6 = 2R_7 = 0.804k\Omega$ and $K = 1.5(R_{B3} = 5k\Omega, R_{A3} = 10k\Omega)$.

3.4 Frequency Response

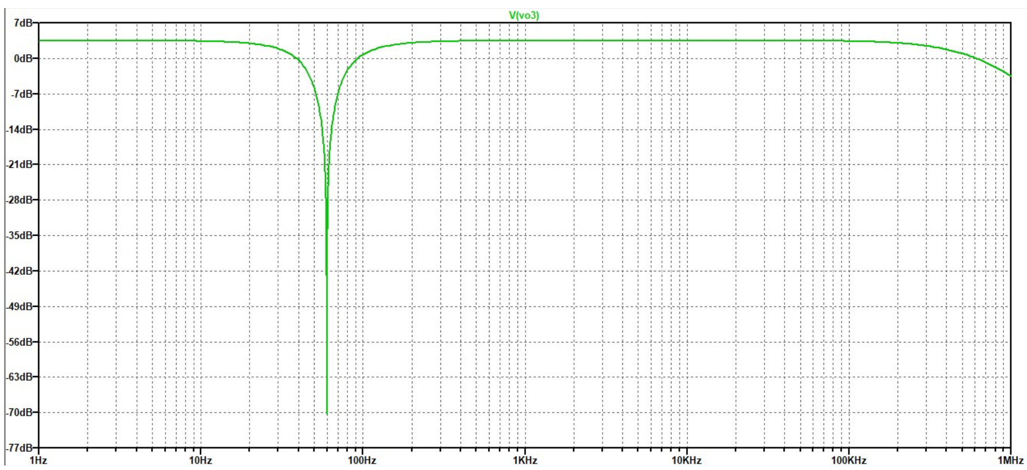

Figure 8: Frequency response of Twin-T notch filter

The figure 8 above shows the frequency response of the Twin-T notch filter. The notch frequency obtained is 59.98 Hz.

3.5 Transient Response

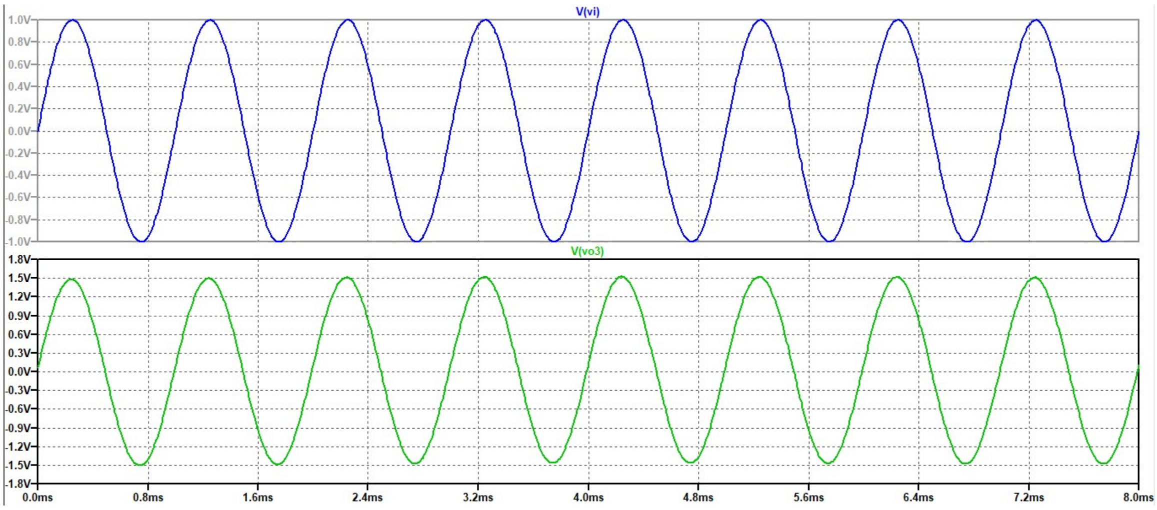

Figure 9: Transient response of Twin-T notch filter

The figure 9 above shows the transient response of the Twin-T notch filter with 1 V, 1 kHz sinewave input. The output voltage amplitude obtained is 1.50 V.

4 Multiple-feedback Band Pass Filter

4.1 Aim

To perform transient and frequency domain simulations of multiple-feedback bandpass filter.

4.2 Schematic

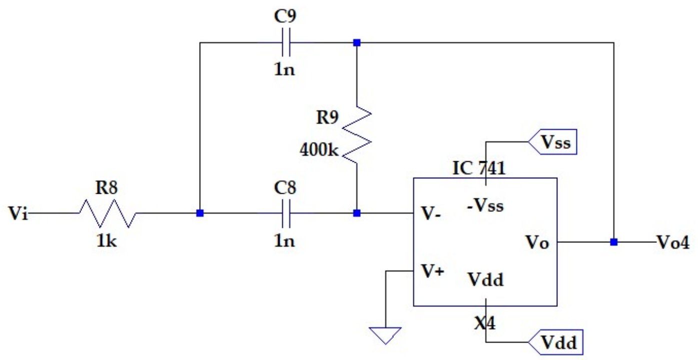

Figure 10: LTSpice schematic of multiple-feedback bandpass filter

4.3 Component Selection

The transfer function of the filter is given by

$$\frac{V_{o4}(s)}{V_i(s)} = \frac{-sC_8R_9}{s^2C_8C_9R_8R_9 + sR_8(C_8 + C_9) + 1} \tag{4}$$

Choosing $C_8 = C_9$ the filter parameters obtained are

$$H_{0BP} = -2Q^2, Q = 0.5\sqrt{\frac{R_9}{R_8}}, \omega_0 = \frac{1}{\sqrt{R_8R_9}C_8}$$

For obtaining $\omega_0 = 2\pi \times 8krad/s, Q = 8000/800 = 10$, the values chosen are $R_8 = 1k\Omega, R_9 = 400k\Omega, C_8 = C_9 = 1nF$.

4.4 Frequency Response

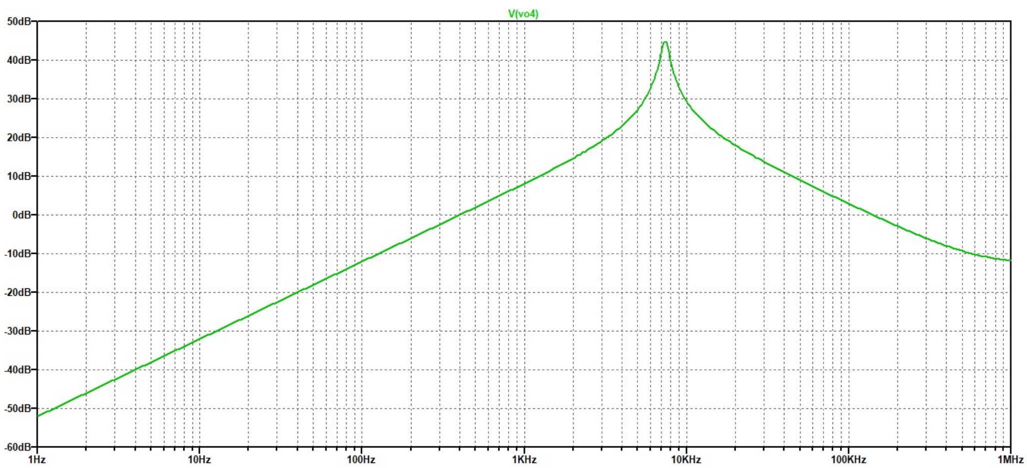

Figure 11: Frequency response of multiple-feedback bandpass filter

The figure 11 above shows the frequency response of the multiple-feedback bandpass filter. The bandwidth obtained is 603.7 Hz and the peak gain is obtained at 7.396 kHz.

4.5 Transient Response

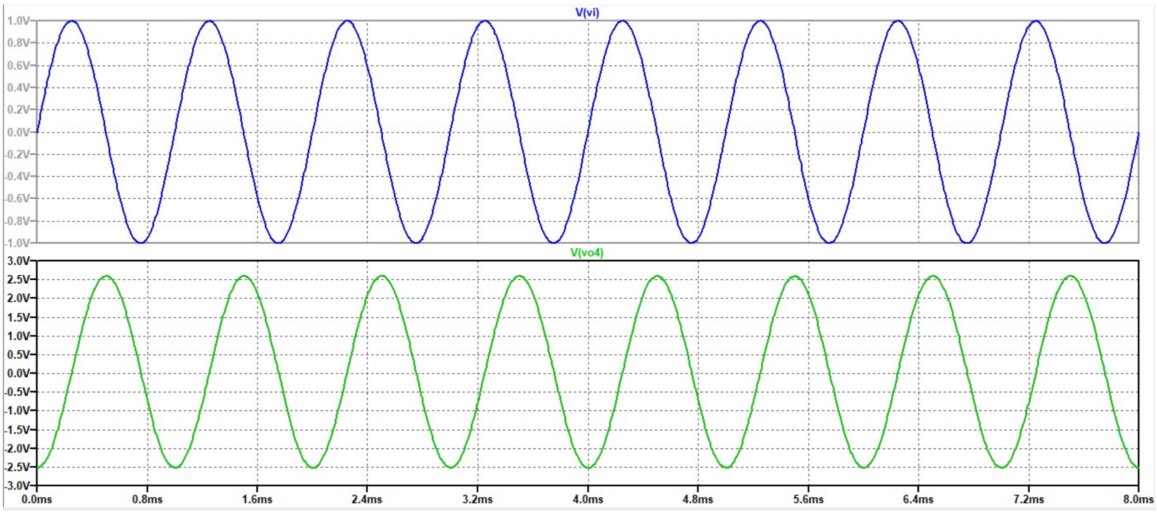

Figure 12: Transient response of multiple-feedback bandpass filter

The figure 12 above shows the transient response of the multiple-feedback bandpass filter with 1 V, 1 kHz sinewave input. The output voltage amplitude obtained is 2.56 V.

5 Conclusion

(1). The second order active filters offer higher selectivity compared to the first order filters as they have higher stop-band attenuation.

(2). The second order filters can be used in cascade to design higher order filters.