INDIAN INSTITUTE OF SCIENCE, BENGALURU

DEPARTMENT OF ELECTRONIC SYSTEMS ENGINEERING

DESIGN FOR ANALOG CIRCUITS LABORATORY REPORT

ASSIGNMENT 10

SENSOR AMPLIFIERS AND PHASE TRIPLER

SOUMYA KANTA RANA

S.R. No. : 04-01-00-10-51-21-1-19261

October 17, 2021

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1 Negative Impedance Converter

1.1 Aim

To perform DC operating point simulation of the negative impedance converter.

1.2 Schematic

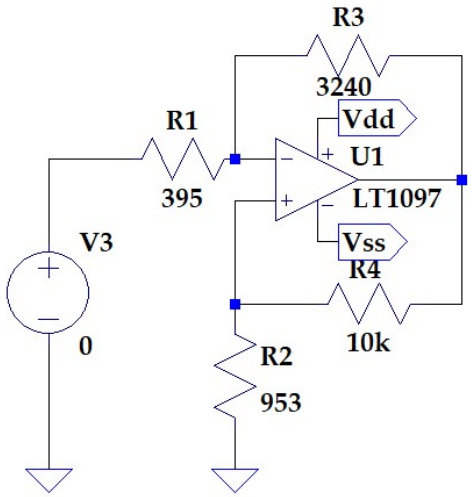

Figure 1: LTSpice schematic of negative impedance converter.

1.3 DC operating point simulation

The figure 2 shows the dc sweep simulation results (output voltage and input current) of the negative impedance converter versus input voltage. The negative impedance seen by the voltage source is -308.78Ω, making the effective source impedance 86.22Ω.

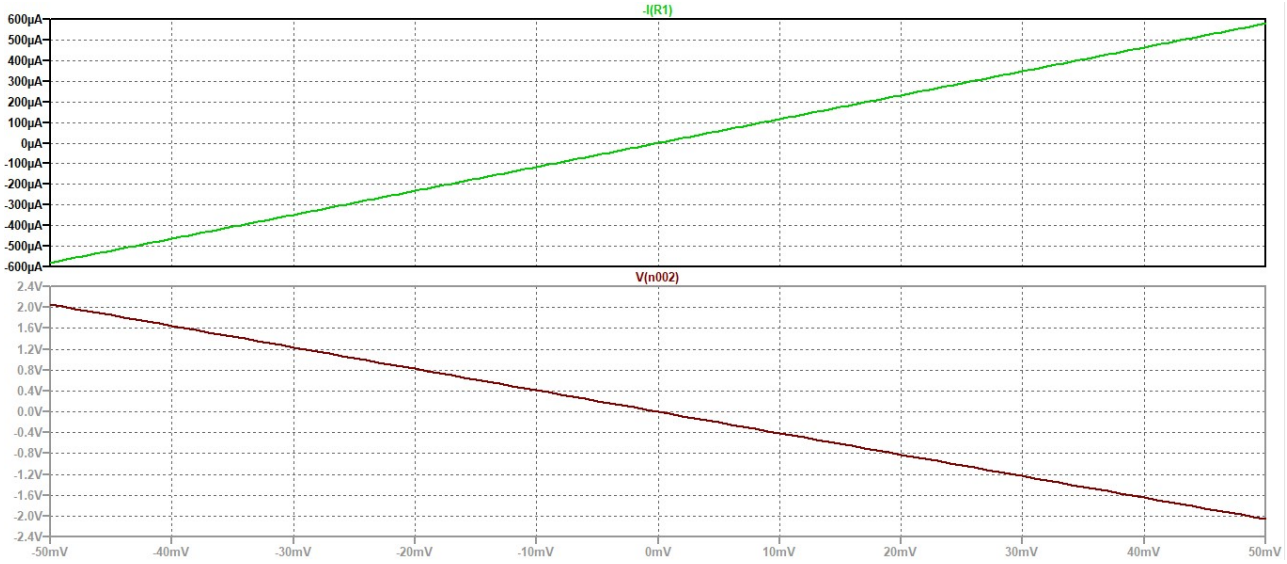

Figure 2: DC operating point simulation of negative impedance converter

2 Sensor Amplifier (0.2-140 Hz)

2.1 Aim

To perform frequency response simulation of the Sensor Amplifier.

2.2 Schematic

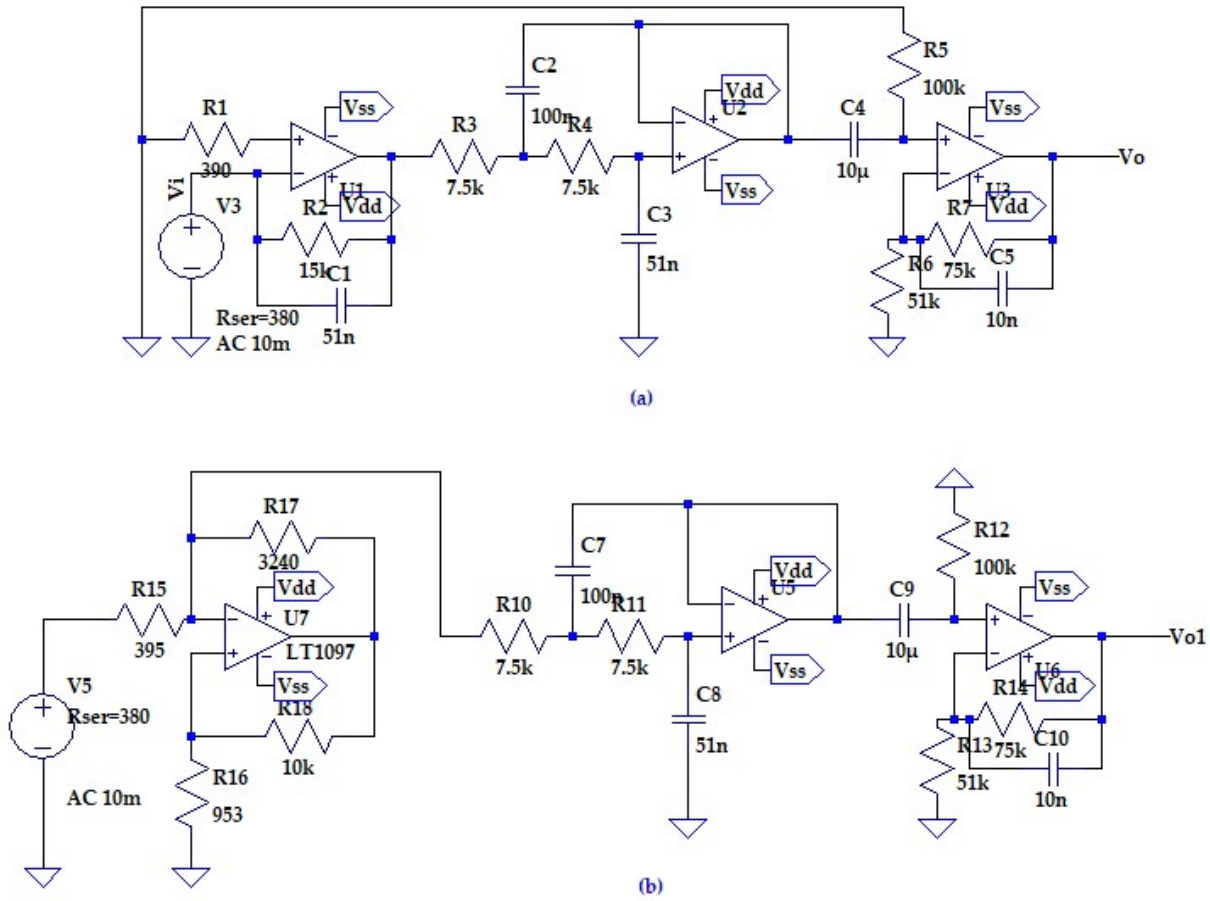

Figure 3: LTSpice schematic of (a) Sensor Amplifier(0.2-140 Hz), (b) With negative impedance converter.

2.3 Frequency Response

The figure 4 shows the frequency response of the sensor amplifier. The gain in the frequency range of interest is **97.3**. The gain rolls off at **-60 dB/decade** after 140 Hz. There is also a low frequency zero as the gain rises at **20dB/decade** till 0.16 Hz. The Negative impedance converter reduces the gain to **1.6**.

2.4 Summary

1. The first stage (op-amp U1) is a low pass filter with its pole at 208.04 Hz .
2. The second stage (op-amp U2) is a sallen key low pass filter with $\omega_0 = 297.14Hz$ (two poles).
3. The third stage (C_4 & R_5) is a high pass filter with its pole at 0.16 Hz.
4. The fourth stage (op-amp U3) is a low pass filter with its pole at 212.2 Hz.

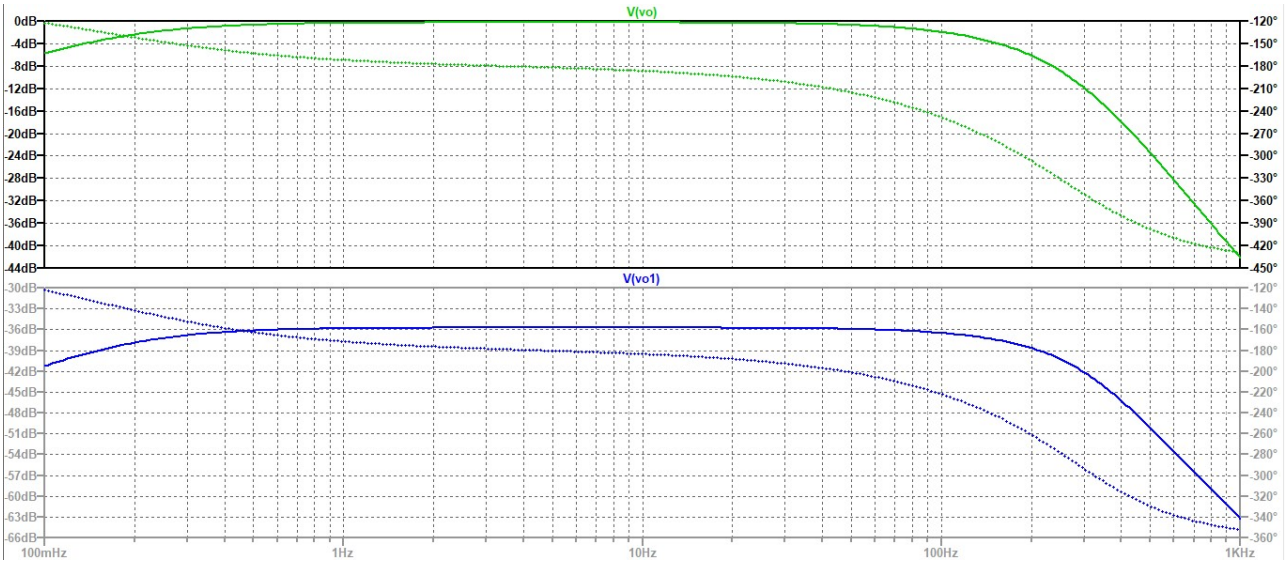

Figure 4: Frequency Response of Sensor Amplifier (0.2-140 Hz)

3 Sensor Amplifier (0-20 Hz)

3.1 Aim

To perform frequency response simulation of the Sensor Amplifier.

3.2 Schematic

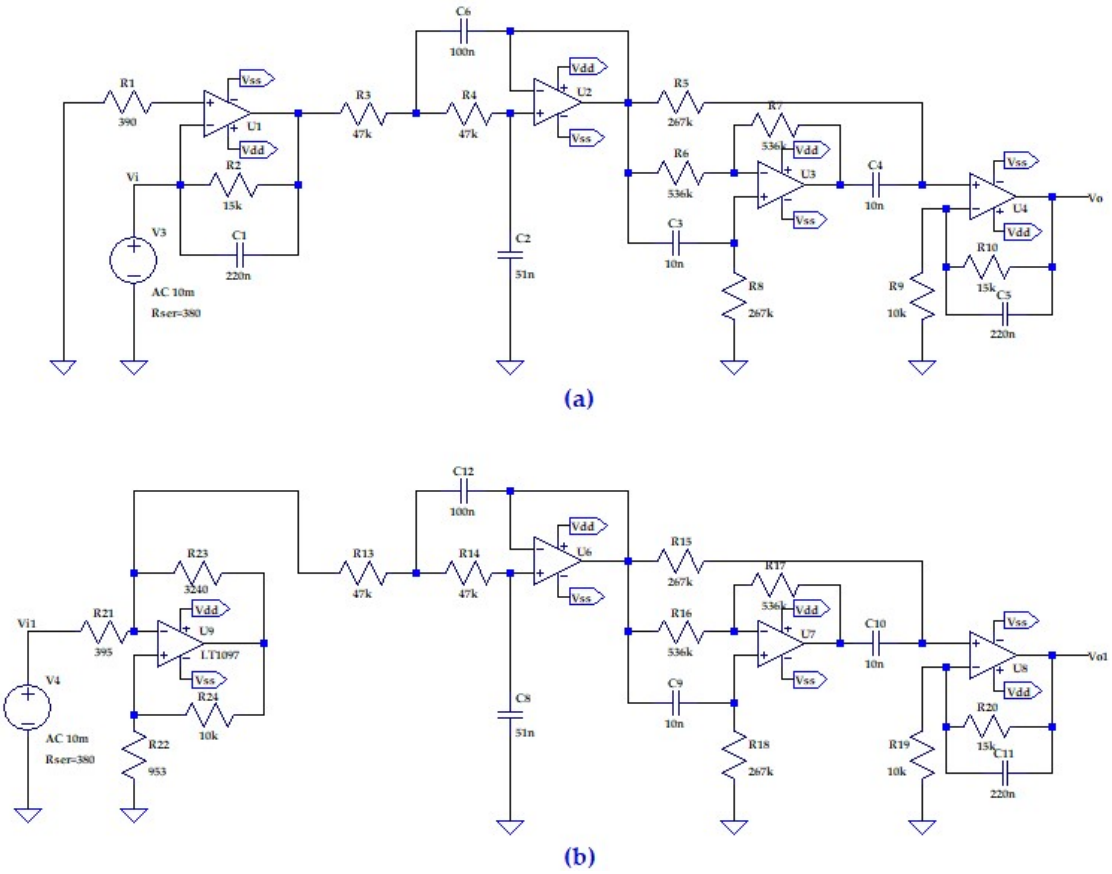

Figure 5: LTSpice schematic of (a) Sensor Amplifier(0-20 Hz), (b) With negative impedance converter.

3.3 Frequency Response

The figure 6 shows the frequency response of the sensor amplifier. The gain in the frequency range of interest is **97.39** and the high frequency gain roll-off is **-40dB/decade**. The notch at 60Hz helps in reducing the 60Hz power supply noise. The notch also comprises of a RHP zero. The Negative impedance converter reduces the gain to **1.62**.

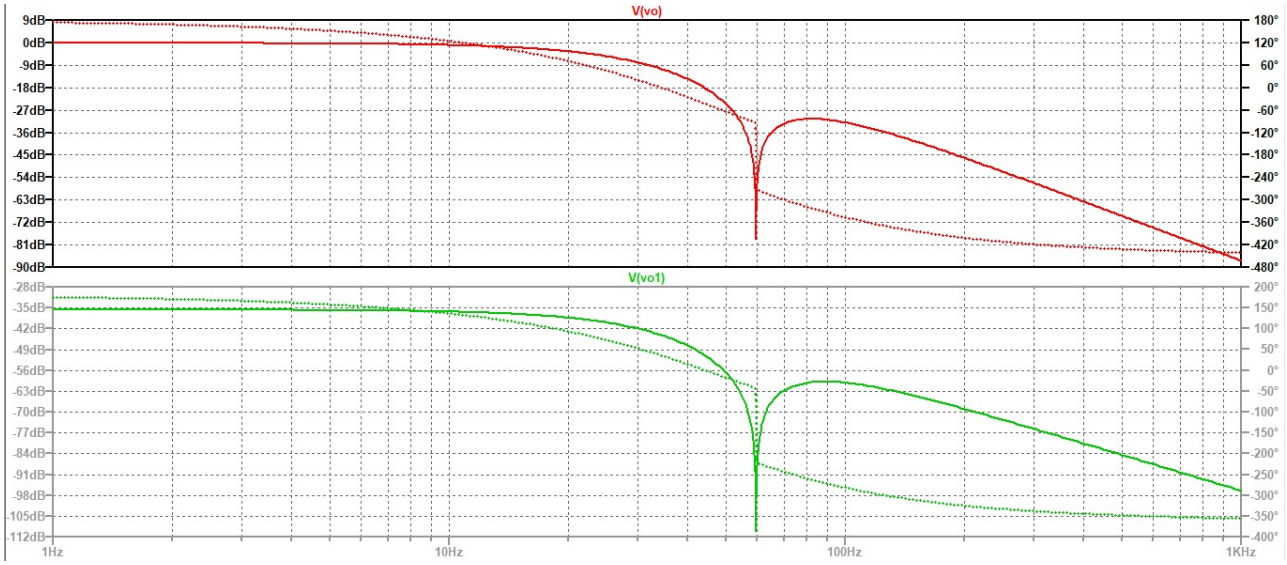

Figure 6: Frequency Response of Sensor Amplifier (0-20 Hz)

3.4 Summary

1. The first stage (op-amp U1) is a low pass filter with its pole at 48.23 Hz .
2. The second stage (op-amp U2) is a sallen key low pass filter with $\omega_0 = 47.41Hz$ (two poles).
3. The third stage (op-amp U3) is a notch filter with its zeroes at 60 Hz.
4. The fourth stage (op-amp U4) is a low pass filter with its pole at 48.23 Hz.

4 Phase Tripler

4.1 Aim

To perform transient simulation of the Phase Tripler.

4.2 Schematic

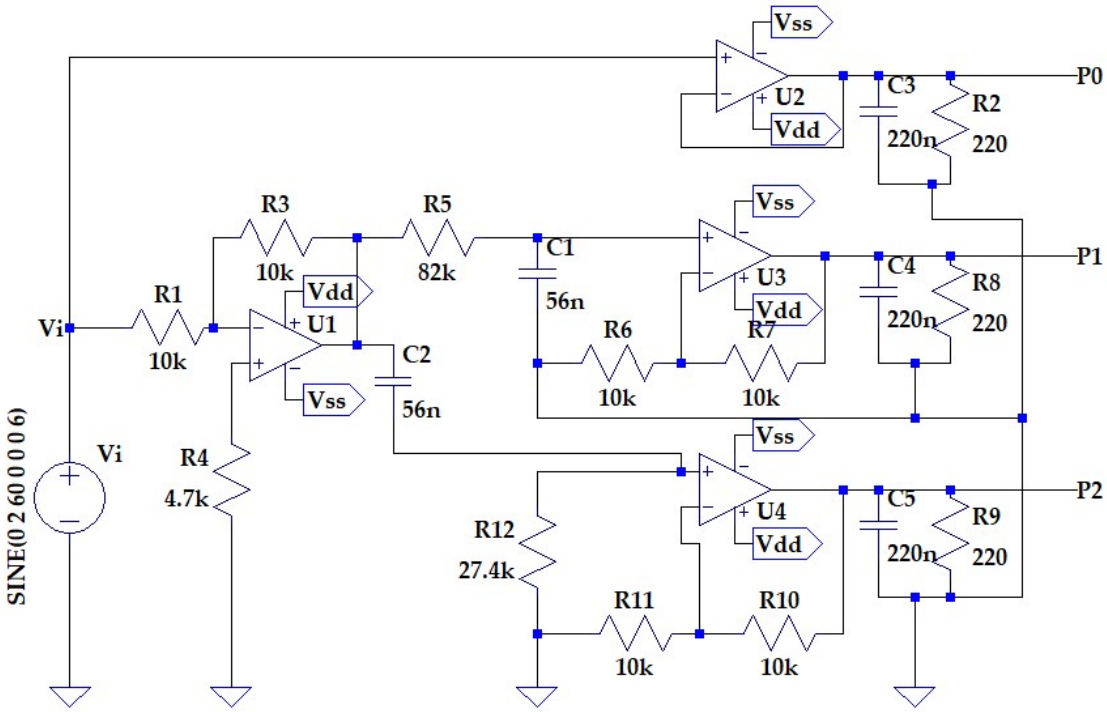

Figure 7: LTSpice schematic of Phase Tripler

4.3 Transient Response

The figure 8 shows the transient simulation waveforms of the phase tripler. The output P0 is same as the input, whereas P1 lags P0 by 120^o and P2 lags P1 by 120^o.

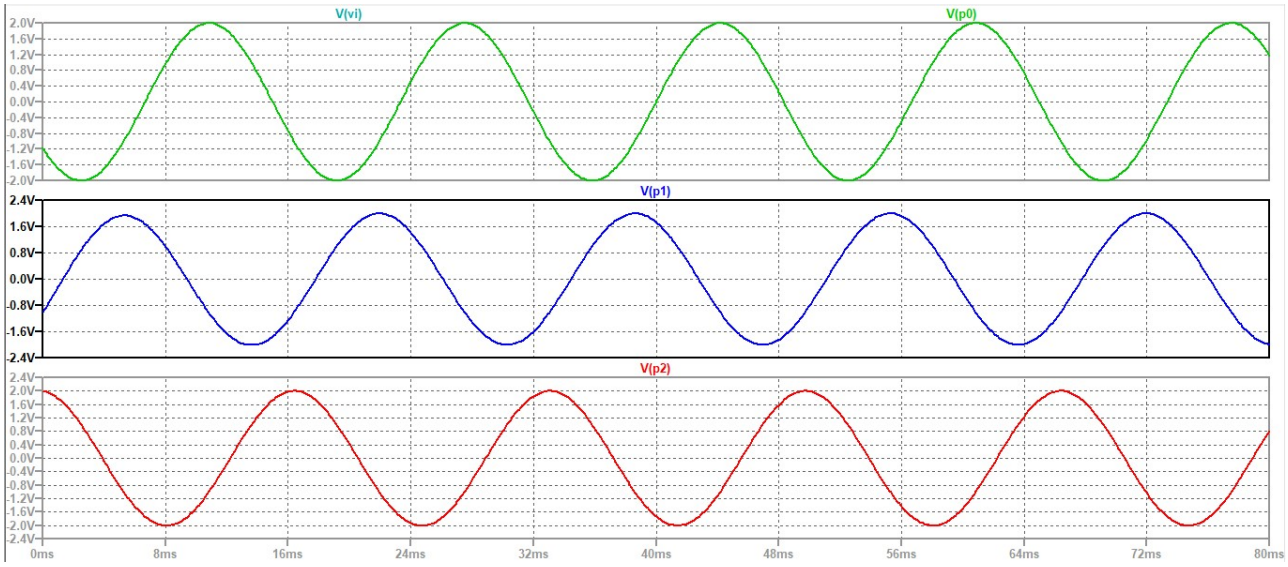

Figure 8: Transient response of Phase Tripler