Design for Analog Circuits - Laboratory Report

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Assignment 3

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1 Negative Impedance Converter

1.1 Aim

To perform DC sweep analysis of the Negative Impedance Converter Circuit provided and observe its performance.

1.2 Circuit Diagram

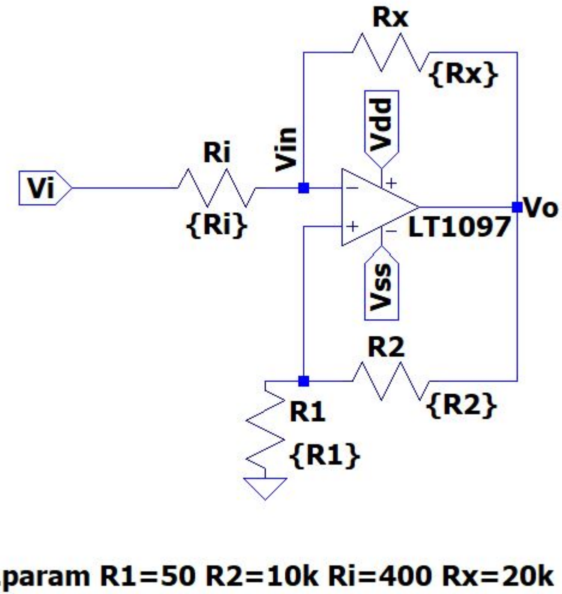

Figure 1: LTSpice Schematic of Negative Impedance Converter

1.3 Theory

Assuming ideal op-amp, the voltage at both input nodes of the op-amp is V_{in}. Writing the KCL equation at the non-inverting terminal of the op-amp, we have:

$$\frac{V_o - V_{in}}{R_2} = \frac{V_{in}}{R_1}$$

$$\text{or, } V_o = V_{in}(1 + \frac{R_2}{R_1})$$

Current through R_i (and R_x) is given by:

$$I_{R_1} = -V_{in}(\frac{R_2}{R_1 R_x})$$

So, looking at node Vin we should see an impedance of $-R_x R_1/R_2 = -100\Omega$.

1.4 DC Sweep Simulation Results

The Figures 2 and 3 below show the DC sweep simulation plots of I_{R_i} versus V_i and V_{in} respectively. The slope of I_{R_i} versus V_{in} comes out to be -99.99Ω.

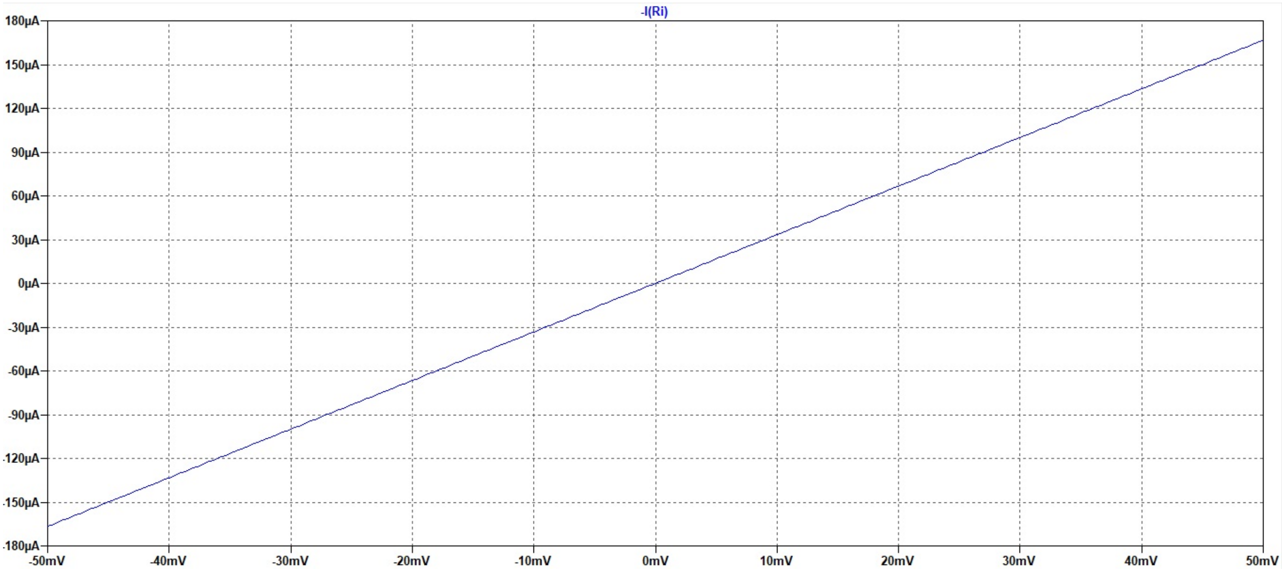

Figure 2: I_{R_i} vs V_i for negative impedance converter

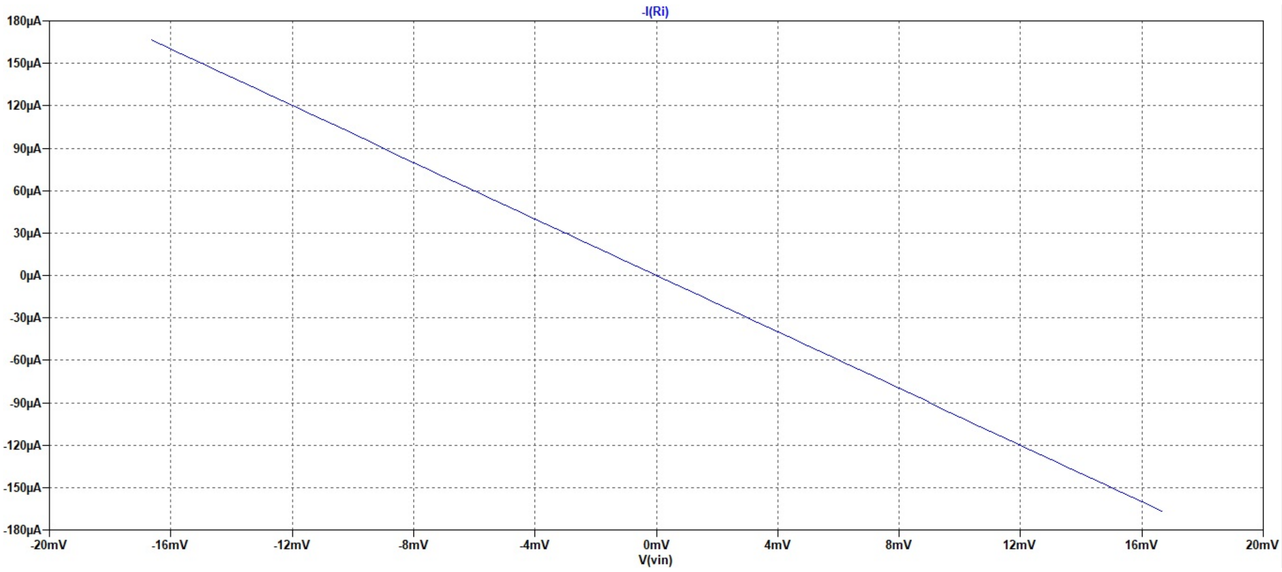

Figure 3: I_{R_i} vs V_{in} for negative impedance converter

2 Instrumentation Amplifier

2.1 Aim

To perform transient simulation of the Instrumentation Amplifier circuit provided and observe its differential and common mode response. ‘

2.2 Schematic

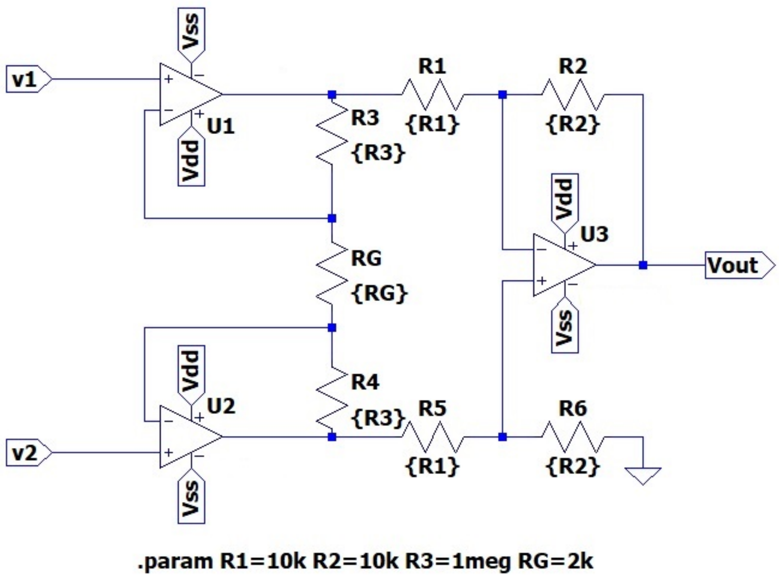

Figure 4: LTSpice Schematic of Instumentation Amplifier

2.3 Theory

The gain of the instrumentation amplifier should be

$$\frac{V_{out}}{V_2 - V_1} = (1 + \frac{2R_3}{R_G})\frac{R_2}{R_1}$$

For the parameters provided we get a value of 1001 for the gain.

2.4 Transient Simulation Results

The figure 5 shows the transient simulation results of the instrumentation amplifier with a 10 mV 1 kHz sinewave differential input and 5 V DC common mode input. The output sinewave amplitude is 9.95 V and the DC amplitude is 2×10^{-5} V. The differential gain is 995 and the common mode gain is 4×10^{-6} .

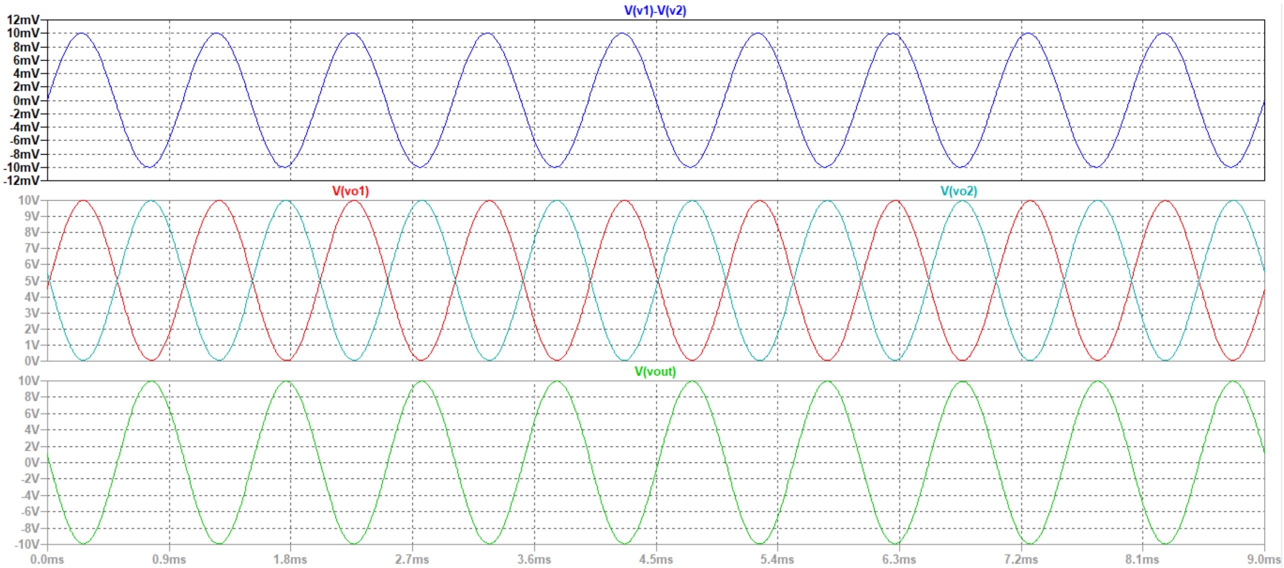

Figure 5: Transient Simulation of Instrumentation amplifier

3 Conclusion

1. The negative impedance converter reduces the effective resistance of the voltage source Vi from 400Ω to 300Ω. But the problem with the circuit is that it will not work for values of R_i below 100Ω. The reason is as follows:
   The positive and negative feedback factors for the circuit are

$$\text{Positive feedback factor} = \frac{R_1}{R_1 + R_2} \simeq \frac{50}{10000}$$
$$\text{Negative feedback factor} = \frac{R_i}{R_i + R_x} \simeq \frac{200}{10000}$$

   If the value of R_i is less than 100Ω, the circuit will be in positive feedback and hence will not function as negative impedance converter.

2. The instrumentation amplifier gain is not evenly distributed between the two stages. The input stage has a gain of 1001 whereas the output stage has a gain of 1. In the simulation results referred above the universal op-amp block of LTSpice has been used, and a good gain is obtained ($\simeq$ 995); but with a practical op-amp model there will be loss of gain (gain observed with LT 1097 op-amp is $\simeq$ 558).