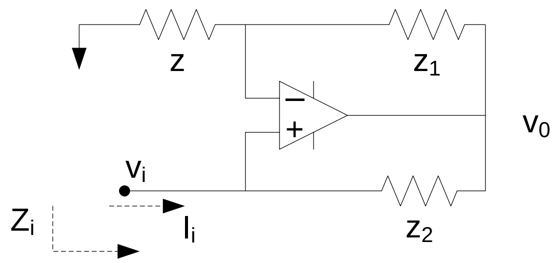
Electrical Engineering Department
Network Lab.

Objective: - Experiment on 1-port Network: Negative Impedance Converter
To find the frequency response of a simple Negative Impedance Converter

Theory:

Negative Impedance conversion is a function yielding (normally grounded) impedance that is proportional to the negative of given impedance (grounded or floating). The figure shows a Negative Impedance Converter (NIC).



Assuming ideal opamps

$$V_0 = V_1 \left(1 + \frac{Z_1}{Z_2}\right)$$

$$V_i - V_0 = I_i Z_2$$

$$\therefore Z_i = \frac{V_i}{I_i} = -Z\frac{Z_2}{Z_1}$$

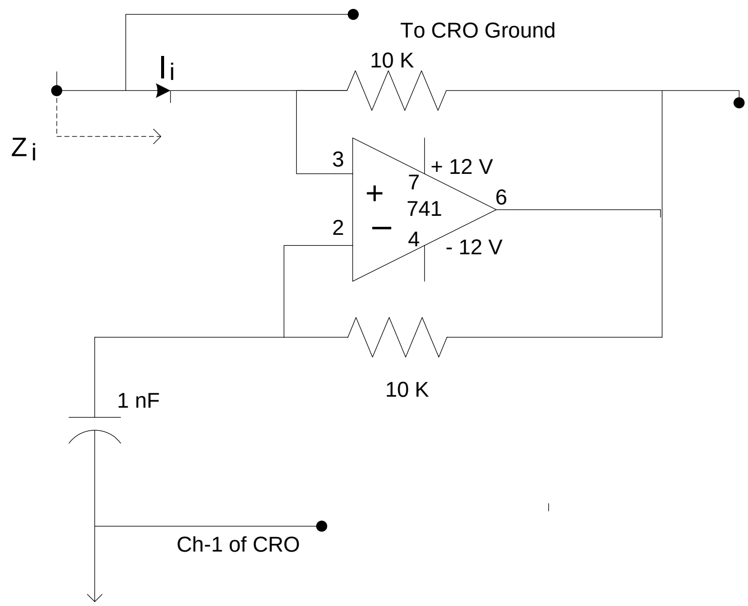
If $Z_2 = Z_1$ then $Z_i = -Z$

For proper inversion there must be a bias path for each opamp input and more negative than positive feedback which requires

$Z / Z_1 > Z_S / Z_2$, Where Z_S is the source impedance

The circuit inverts impedances only at frequencies.
Where the op amp open-loop gain can be considered infinite

Circuit Diagram



Procedure

1. Connect the circuit as shown on a bread-board

2. Apply Sinusoidal Voltage with Frequency varying from 1 KHz on wards with a peak-to-peak amplitude of 1 V (adjust for undistorted output)

3. Measure the phase as well magnitude of the input and output

4. Plot Z_{input} on a Semi-Log graph paper

5. Take the tracing for 3 cases

Discussion Questions

1. Why the negative impedance characteristics are not possible in all frequency range ?

2. Can you synthesize an inductor from a capacitor using this circuit ? Justify your answer.

3. What could be the reasons for distortion of in the output voltage ?

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Objective: - Study of the Gyrator circuit and its application in synthesizing Inductors

To find the frequency response of a Gyrator Circuit

A Gyrator is an ideal two-port element defined by the following equations

$$i_1 = G.V_2$$
$$i_2 = -G.V_1$$

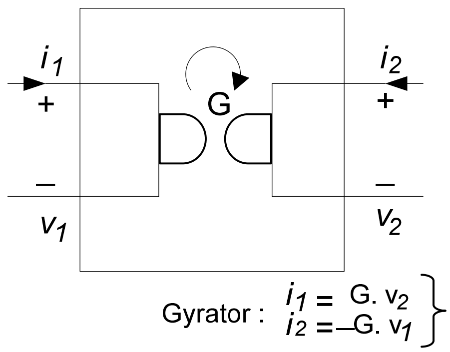


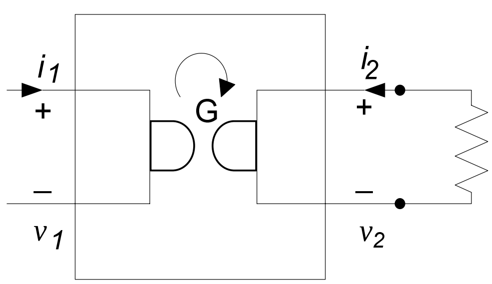
Fig. 1 the Gyrator Representation

Properties of the ideal gyrator circuit:

The ideal gyrator is a non-energetic element, i.e. at all times the power delivered to the two-port identically zero:

Another interesting property is the impedance gyration given by.

$$\frac{V_1}{i_1} = -\frac{1}{G^2} \cdot \frac{i_2}{V_2}$$



$$\frac{v_1}{i_1} = \frac{1}{G^2} \cdot \frac{1}{R_L}$$

$$R_L = \frac{v_2}{-i_2}$$

Fig.2 A gyrator terminated at the output port with a resistor

Capacitor-to-Inductor Mutation property: An interesting property is the following: if the output port of an ideal gyrator is terminated with a capacitor as shown in fig.3, the input port behaves like an inductor. Thus a gyrator is a useful element in the design of inductor less filters.

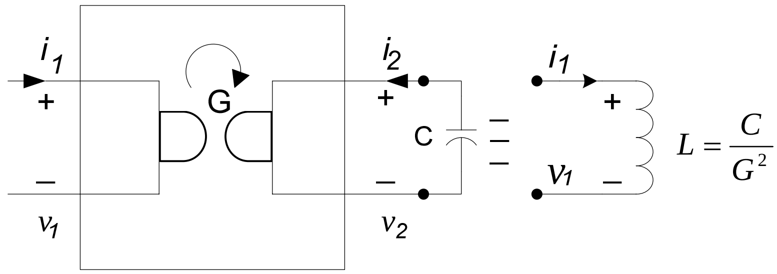


Fig.- Capacitor to Inductor Mutation Property

$$v_1 = L\frac{di_1}{dt} = (\frac{C}{G^2})\frac{di_1}{dt} \qquad \text{--------------------------} \quad (3)$$

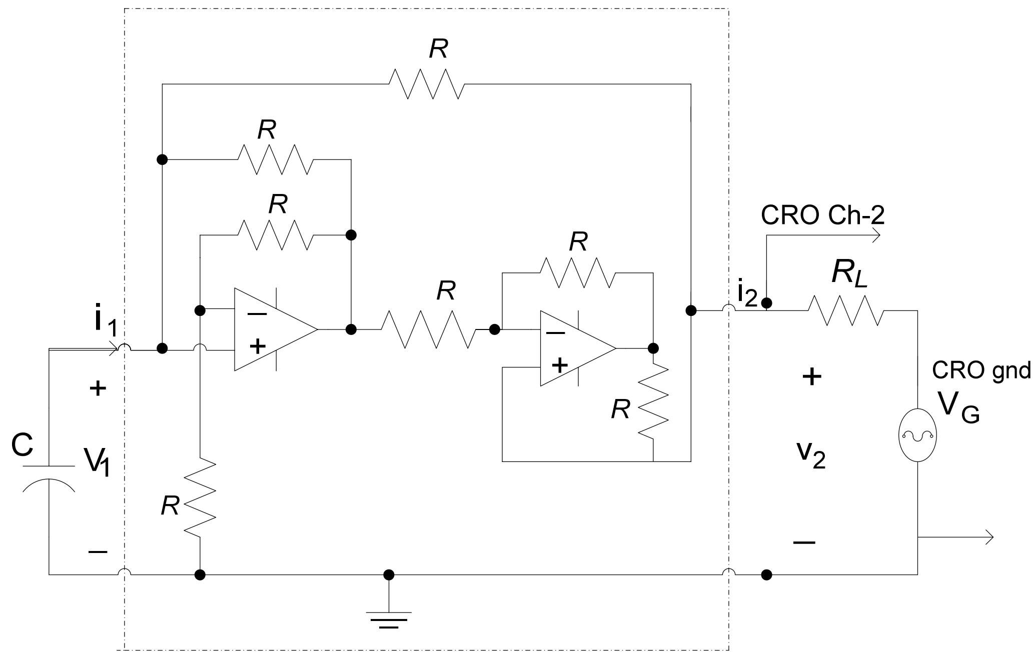


Fig.-4 The experimental circuit

$$\begin{pmatrix} i_1 \\ i_2 \end{pmatrix} = \begin{pmatrix} 0 & -\frac{1}{R} \\ \frac{1}{R} & 0 \end{pmatrix} \begin{pmatrix} v_1 \\ v_2 \end{pmatrix} \quad Gyrtor: G = \frac{1}{R} \qquad L = \frac{C}{G^2} = R^2 C \quad \text{----------} \ (4)$$

C=10nF, 200 nF, 1µF *R=10K* *R_L=1K*

Build the circuit as shown in Fig.4 ($V_{DD} = 12V$ and $V_{SS} = -12V$). Let C is 10nF, 220nF, or 1uF. (You need to measure only one case). Let R_l be 1K. Verify that the circuit works as an inductor (i.e., whether the input impedance is inductive, in the sense that the current lags the voltage by 90^0). Set the output of the function generator to a $1V_{PP,}$ 1 KHz sine wave 0 DC offset. Using the scope, display and measure both the voltage and the current of the *"inductor"*. Check whether the current of the "inductor" lags its voltage. You can use the X/Y mode of the scope as well. Set different sine wave frequencies (from 100Hz, to 10 kHz), and repeat the previous measurement.

Procedure

1. Connect the circuit as shown on a bread-board

2. Apply Sinusoidal Voltage with Frequency varying from 1 kHz on wards with a peak-to-peak amplitude of 1V (adjust for to get undistorted output)

3. Measure the phase as well magnitude of the input and output

4. Plot Z_{input} on Semi-log graph paper

Discussion Questions

Q 1. Why this circuit is named as a Gyrator circuit?

Q 2. Derive the expression (4) pertaining to Fig.4

Q 3. What is the frequency when there is an exact 90° phase shift ? Explain the reason of this behavior.

Q4. Name few commercially available Gyrator chips state the applications