EE203 Project

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***Abstract*—The purpose of this experiment was to analyse and simulate a operational amplifier based circuit on SPICE. For this purpose, we selected a gyrator. Gyrator circuit consisting of dual operational amplifier and four resistors inverts impedence of capacitor to simulate inductor.**

***Index Terms*—Gyrator,Simulate,Operational amplifier,SPICE**

I. Theory

A gyrator is a passive, non-reciprocal current element. We can realize two port networks with the help of gyrator despite of changing reliability of one-port networks. We can built gyrator with the help of op-amp and feedbacks. An inverted current-voltage characteristics can be obtained with gyrator.
A gyrator in ideal conditions can be used to couple current from one port to the voltage at another port.

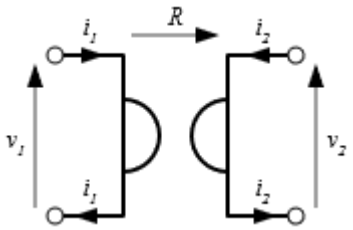

Fig. 1.

$$V_1 = RI_2 \tag{1}$$

$$V_2 = RI_1 \tag{2}$$

where, R = Gyrator resistance represented by arrow.Tail at current and head represents voltage in a two port network

$$Z = \begin{bmatrix} 0 & -R \\ R & 0 \end{bmatrix}$$

Where Z represents the impedence of gyrator

A gyrator has topology to transformer in ideal conditions. As the transformer couples the currents and voltages of different ports, similarly a gyrator couples the current of one port to voltage of another port and vice-versa.

An op-amp can regenerate the effects of gyrator at low frequency of inputs.
One port of this gyrator is completed by capacitor while the other port is between ground and Z_in . The op-amp antagonize the voltage across the resistor and provide it back to R_L.

$$Z = (R + 1/jwc)||(R_L + jwR_LR_C) \tag{3}$$

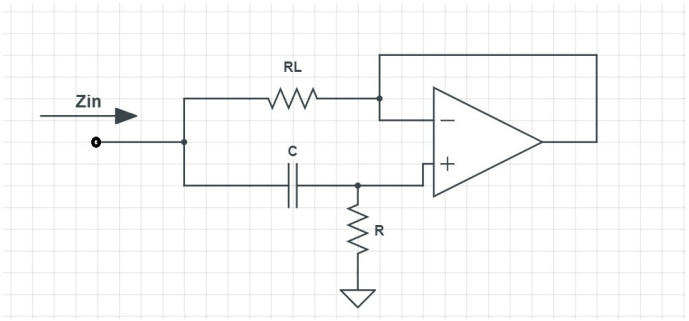

Fig. 2. A Gyrator Circuit

The value of R is such choosen that

$$Z = R_L + jwR_LR_C \tag{4}$$

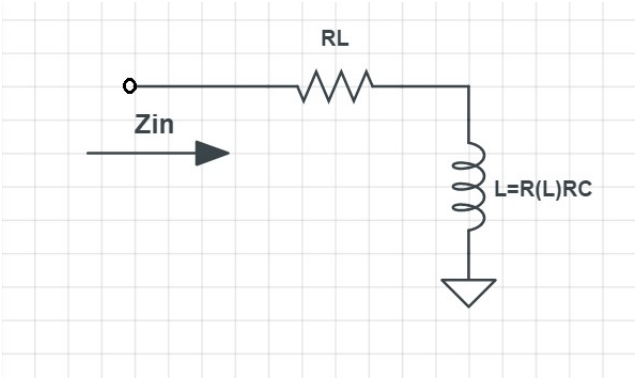

Fig. 3. Equivalent Circuit

The inductor in effective circuit cannot replace an actual inductor in terms of storing energy. Inductors of high range can be constructed with gyrator.
Unlike the inductors and capacitors, the gyrator inductor doesn't have the properties to store energy and power. The voltage response of a gyrator has been limited by power supply. The gyrator only functions in range of power supply of active elements.
The gyrator inductor don't have properties unlike of real inductors to create magnetic and electric fields.

II. Simulation Results

This is how SPICE stimulates the circuits-

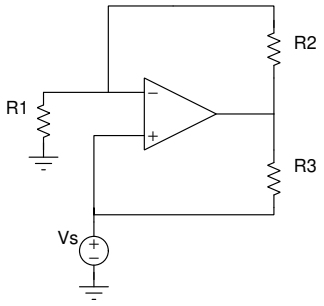

Fig. 4. Simulation Circuit

- It generates a text netlist describing the connections as well circuit elements.
- It applies the information collected into equations which are of the form of non-linear differential algebraic equations.
- Then it solves those equations using integration methods and sparse matrix techniques.

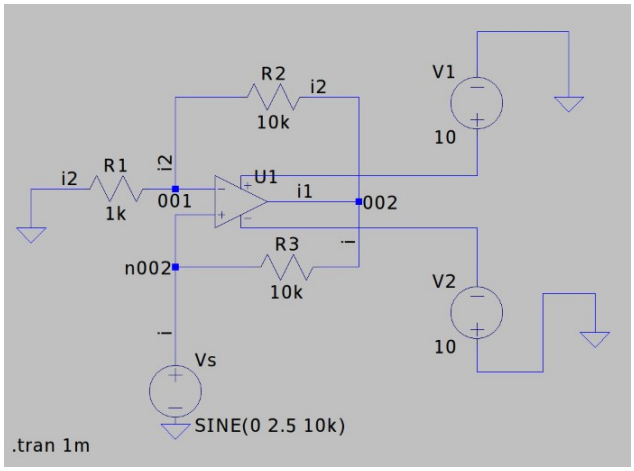

Fig. 5. SPICE Circuit with AC Voltage input

We know that

$$V_{001} = V_S$$

Therefore

$$i_2 = V_S/R_1$$

Applying KVL Between Nodes 001 and 002 and substituting value of i_2, we get

$$V_{002} = V_S(1 + R_2/R_1)$$

Now, applying KVL between Nodes n002 and 002 and substituting value of V_{002}, we get

$$i = -V_S(R_2/R_1R_3)$$

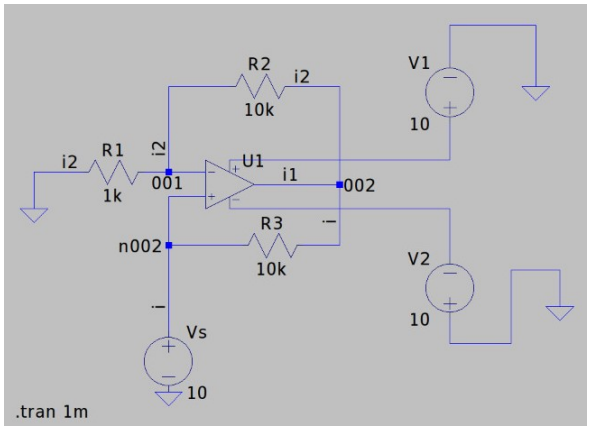

Fig. 6. SPICE Circuit with DC Voltage input

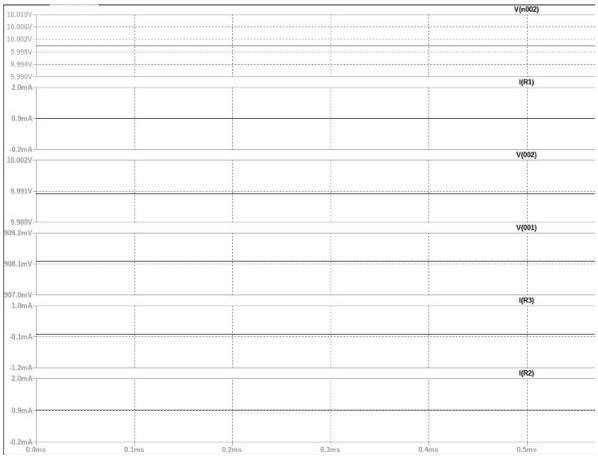

Fig. 7. Waveform for DC Voltage input

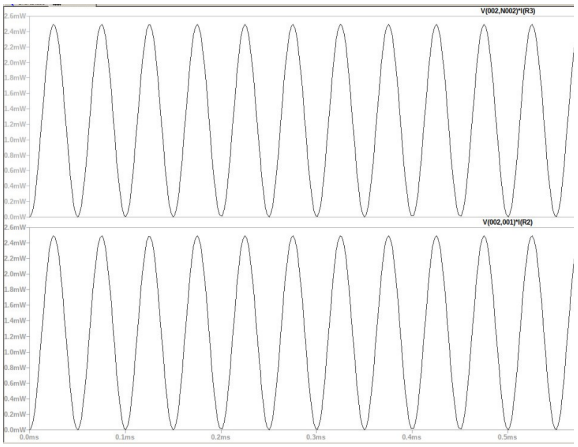

Fig. 8. Power Waveform for AC Voltage input

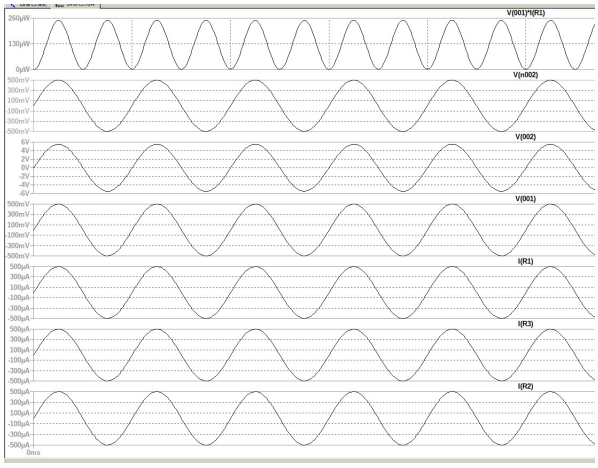

Fig. 9. Waveform for AC Voltage input

A. *Observation*

As we can see that no frequency change in elements,therefore no change occurs for the shape in the waveform for current, voltage or power.
We also observed that voltage values and waveform for Node n002 and 001 are same i.e virtual ground property is satisfied.

B. *Application*

Generally we avoid using inductors in real circuits because the size of inductors are huge. The properties of inductors are almost same as of gyrator. In other words gyrator is an effective alternative of inductors in terms of cost and size.
Practical applications is in graphic equalizer and RLC band pass filters that consists of resistor, capacitors and gyrator(in place of inductors).
Another very useful application of gyrator is in POTS system. The use of gyrator had reduced the size of telephones very effectively. The gyrator eliminates DC current through transformer

III. Conclusion

We simulated a gyrator circuit on SPICE for both AC and DC input signals
We also checked the result for variable values of circuit elements.

References

[1] Gyrator
https://en.wikipedia.org/wiki/Gyrator
[2] The Gyrator, new electric element
https://web.archive.org/web/20140423045739/http://techpreservation.dyndns.org/beitman/abpr/newfiles/TheGyrator.pdf