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Operational Trans-resistance Amplifier based Inductor Simulation

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Abstract--- *The present paper relates to "Simulation of an inductor based on Operational Trans-resistance Amplifiers". This implantation can be used in place of an actual inductor. In this values of passive elements like resistors and capacitors are varied to vary the values of inductor correspondingly. Virtual grounding is used for passive components. Later in the paper simulated inductor application is deliberated for showing chemistry with extra complicated circuits. Different simulation results are obtained by the experimentation.*

Index Terms— *Analog Signal Processing, Inductor, Capacitor, Resistor.*

I. INTRODUCTION

Many applications's such as oscillators, filters utilizes inductors in case of "ASP (analog signal processing) because of its frequency characteristics that have powerful nature. There direct use is not easy to implement in any circuit. In papers [1-5] many authors have projected different methods of simulation of inductors employing an active device in combination with passive apparatuses like capacitors and resistors [1-5]. After simulating, the inductor is utilized in different circuits to get more complicated T.F. (transfer functions). There are 2 techniques to construct the realization of grounded-inductor as explained in paper [3], in that realization it uses "OTRAs" and 6 numbers of passive apparatuses in each realization. All the circumstances should be satisfied by the resistive components before realization of grounded inductor. Under various circumstances as described in paper [4] a realization based on "OTRA" for +ve and –ve inductance in shunt connection with +ve or –ve resistance. In present paper an "RLC band pass filter" circuit has been implemented by employing simulated inductor.

The 2nd part of the paper provides an elaborated overview to "OTRA". The projected circuitry of the "grounded inductor" and the "Band pass filter" circuit is explained in part 3 of the paper. Results got by the simulation are discussed in part 4. Part 5 is followed by the conclusion.

II. OPERATIONAL TRANSRESISTANCE AMPLIFIER (OTRA)

The gain of "Operational Trans-resistance Amplifier (OTRA)" is preferably infinite as it delivers high value of trans-resistance gain. "Both input terminals are virtual grounds". This is represented in Figure 1.

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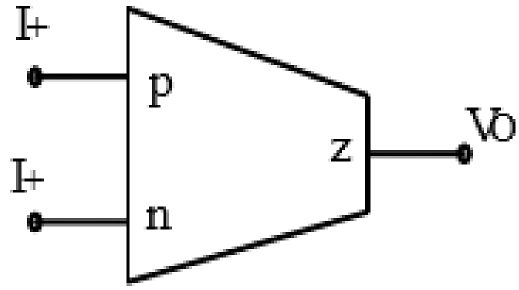

Fig. 1: Symbol of OTRA

Relation between input and output can be seen from equation 1. ‘V positive’ and ‘V negative’ are potentials at input side terminal potentials related to currents at the terminal of input i.e. ‘I positive’ and ‘I negative’ while in equation 1 ‘Vo’ is potential at the terminal of output side. Rm represents the gain of Trans-resistance.

$$\begin{bmatrix} V_+ \\ V_- \\ V_o \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ R_m & -R_m & 0 \end{bmatrix} \begin{bmatrix} I_+ \\ I_- \\ I_o \end{bmatrix} \qquad (1)$$

The equation 1 can be modified as:

$$V_+ = V_- = 0 \quad \& \quad V_o = R_m(I_+ - I_-) \qquad (2)$$

Ideally, $R_m \rightarrow \infty$. Thus, $I_+ = I_-$

For the realization of “OTRA” 2, current Feedback “Operational Amplifiers” are used. This can be seen by the Figure 2. It could also be intended with the help of “CMOS” technology for “VLSI” execution as represented in paper [6,7]. Figure 3 illustrates a diagram for the execution of “OTRA” demonstrated in paper [7].

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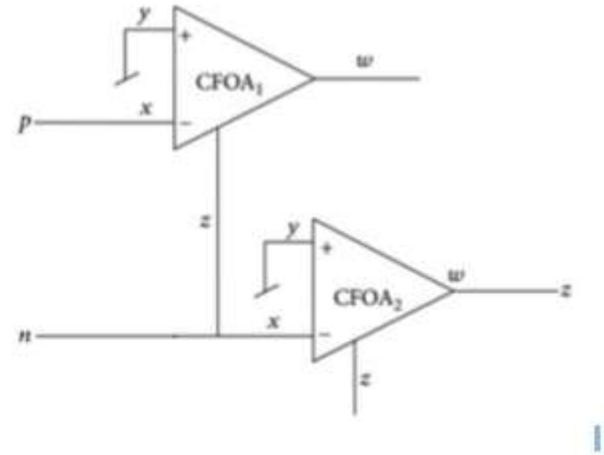

Fig. 2: OTRA implementation using CFOAs

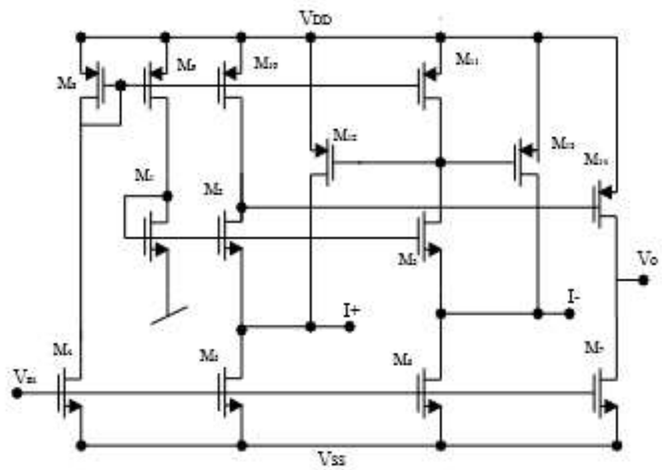

Fig. 3: OTRA implementation using CMOS technology

III. PROPOSED CIRCUITS

In the proposed paper, grounded inductor has been simulated with the help of "OTRA" as an active device. From figure 4 one can see, for realization of a circuit '2' "OTRAs" and some passive elements are used whose input impedance is similar to grounded-inductor. Equation 3 represents the input impedance derived with the help of equation 1.

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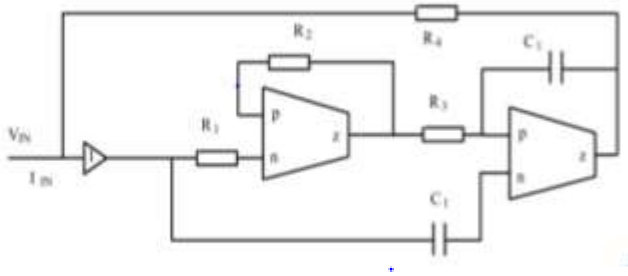

Fig. 4: Simulation of grounded inductor using OTRA

$$Zin = \frac{sC_1R_1R_3R_4}{R_2} \quad (3)$$

Impedance of an inductor is sL, where L is the inductance
Thus, the simulated inductance is found to be:

$$L = \frac{C_1R_1R_3R_4}{R_2} \quad (4)$$

From equation 4 it can be seen that inductance calue depends upon the values of resistance and capacitance. The main application of an inductor is in realization of electrical filter. To confirm the functioning of present project and its chemistry with filters, a second order “RLC band pass filter” circuit is implemented by employing simulated inductor rather than using an actual one. An “RLC band pass filter” circuit is shown in Figure 5 in case of actual inductor however in Figure 6 simulated inductor is employed. Filter’s T.F. is represented by the equation 5. Equations 6 and 7 are for center frequency and bandwidth expressions correspondingly.

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$$\frac{V_o}{V_{in}} = \frac{S\left(\frac{1}{C_0 R_0}\right)}{S^2 + S\left(\frac{1}{C_0 R_0}\right) + \left(\frac{1}{L_0 C_0}\right)} \tag{5}$$

$$f_o = \frac{1}{2\pi\sqrt{LC}} \tag{6}$$

$$\frac{\omega_o}{Q} = \frac{1}{C_0 R_0} \tag{7}$$

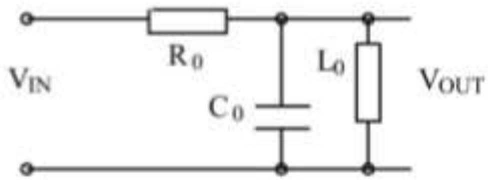

Fig. 5: RLC band pass filter circuit

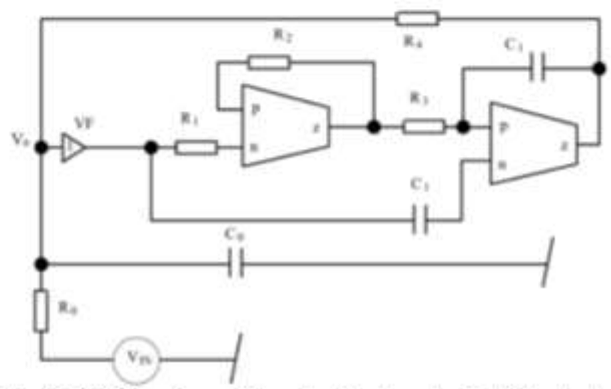

Fig. 6: RLC band pass filter circuit using simulated inductor

IV. SIMULATION RESULTS

Specification in designing “OTRA” with the help of “CFOAs” are given as:

1) Supply Power : ±12V
2) passive components :

C1 = 00.20nF

R1 = R2 = R3 = R4 = 07.00KΩ.

L= 9.8mH.

Figure 7 represents deviation in impedence at input side with related frequency.

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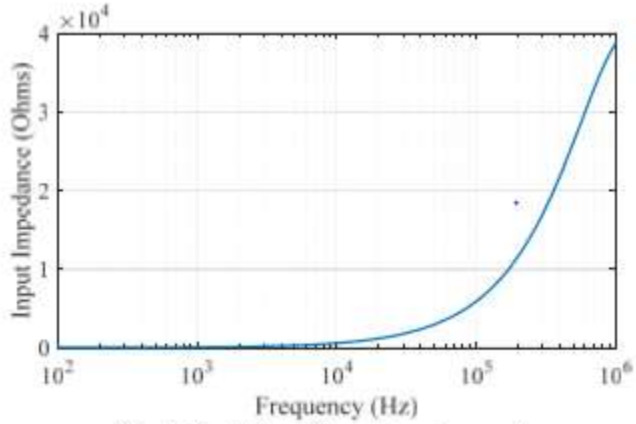

Fig. 7: Variation of input impedance of simulated inductor with frequency

Figure 6 illustrates a "band pass filter" circuit has been verified corresponding to the frequency response as in Figure 8.

Passive components has same values as in previous case for simulating inductor i.e. L0 = 9.8mH. But,

R0 = 14KΩ and,

Co= 12.5pF, hence

Frequency= 0454.70 KHz

This value of frequency comes out in ideal case.

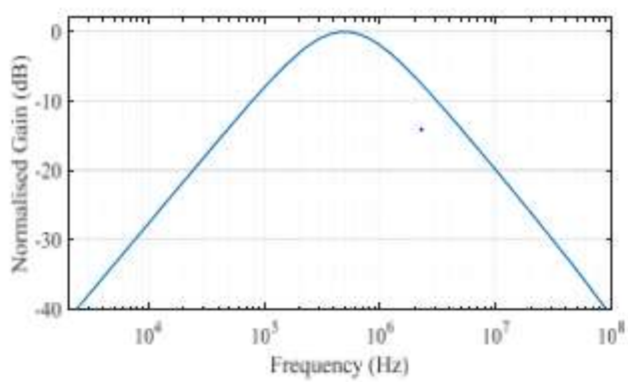

Fig. 8: Band pass filter respone of RLC filter circuit using simulated Inductor

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V. CONCLUSION

The goal of the paper "Realization of a grounded inductor that employes an Operational Transresistance Amplifiers" has be realized in a sucessful manner. By changing the values of passive type components associated with system value of the inductance can be varied. The implented circuit can be used in place an actual inductor for several circuitry projects. Theory of this implementation agrees with the results obtaied by the experiment.

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