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An Application of Operative Trans-resistance Amplifier and its Simulation

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Abstract---*This work offers grounding inductor simulation by employing "Operational Transresistance Amplifiers that could be replaced by actual inductor. The variation in the induction values can be varied with in variation of the resistance and capacitance of the passive elements. The passive elements are grounded. The simulation of the inductor is discussed for displaying the compatibility with more complexed circuits. The workability of circuit had been performed into the PSPICE. Every simulating result had been provided.*

Index Terms--- *OPA (operational trans-resistance amplifiers), OTRA, band pass filter, RLC circuit****.***

I. OVERVIEW

In analog signal processing an inductor is employed for performing multiple applications like oscillator, filters etc. due to simple but influential "frequency characteristics". Even so it is rarely used in models just because of its bulky design. Different researchers had proposed their inductor simulation by employing an active device along with passive elements such as capacitor and inductors. This simulation of the inductor can be easily used into the circuits for obtaining more complexed transfer function[1].

According to, the researcher had proposed double technique for identifying grounded inductors by employing two OTRAs and 6 passive elements into each of them. The resistive elements, therefore, satisfies a ground inductor identifying conditions. According to, the researcher had employed OTRA for identifying –ve or +ve inductance in parallel with the –ve and +ve resistances under multiple circumstances[2].

In this work, a new realization way is being offered for realizing grounded inductor by employing two "Operational Trans-resistance Amplifiers" and some passive elements. Passive elements employed into the simulation of the inductor which does not requires fulfilling such conditions according to the resistive elements[3]. In ideal condition, no resistive values are shown by the circuit and thus it acts as purely inductive circuit as proposed in. According to the proposed design, the design had been formed i.e. "RLC band pass filter circuit" by employing the inductor simulation as an application of the offered circui[4]t.

The OTRA brief description had been provided in next section. The offered circuit for inductor grounded and band pass filter is provided in section 3 as per its tenability expressions. All simulating outcome are proposed in section 4. Section 5 provides the final remarks[5].

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II. OVERVIEW OF OTRA

The active model "Operational Trans-resistance Amplifier (OTRA) gives high transresistence gain on the differential input current[6]. In ideal condition the trans-resistance gain is infinite and inverting as well whereas the "non-inverting input currents are equal". Correspondingly, both input terminals are virtually grounded. The device symbol is as shown in Fig. 1.

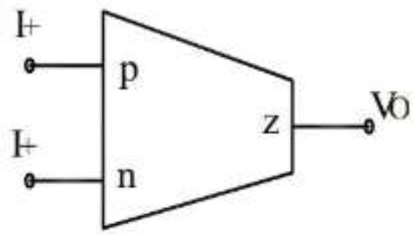

Fig. 1: Symbol of OTRA

The characterisation of the device w.r.to provided equations (1) that also provides the output input relationship. "+ve and –ve are its input terminals of corresponding potentials with input currents I- and I+ whereas Vo is the output terminal potential"[7]. The trans-resistance gain is denoted Rm.

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

The equations contained in (1) can be written individually as shown in (2).

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

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

OTRA can be implemented using two Current Feedback Operational Amplifiers (CFOAs) (see [5] and the references cited therein). Such a realization is shown in Fig. 2. It may also be designed using CMOS technology for VLSI implementation as shown by authors in [6,7]. The implementation of OTRA given by author in [7] is shown in Fig. 3.

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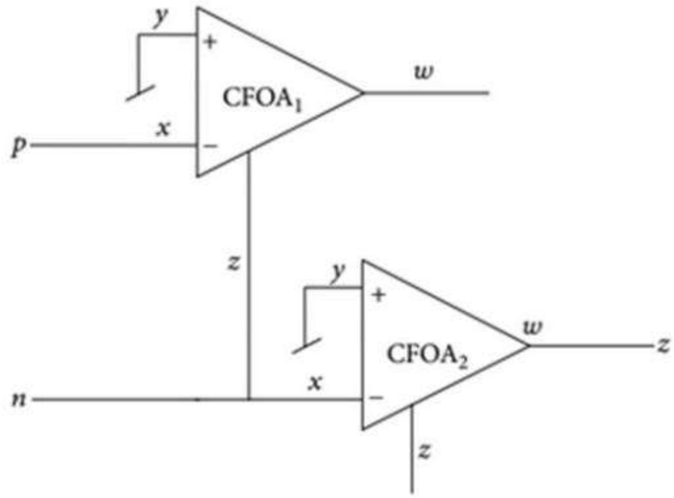

Fig. 2: OTRA implementation using CFOAs

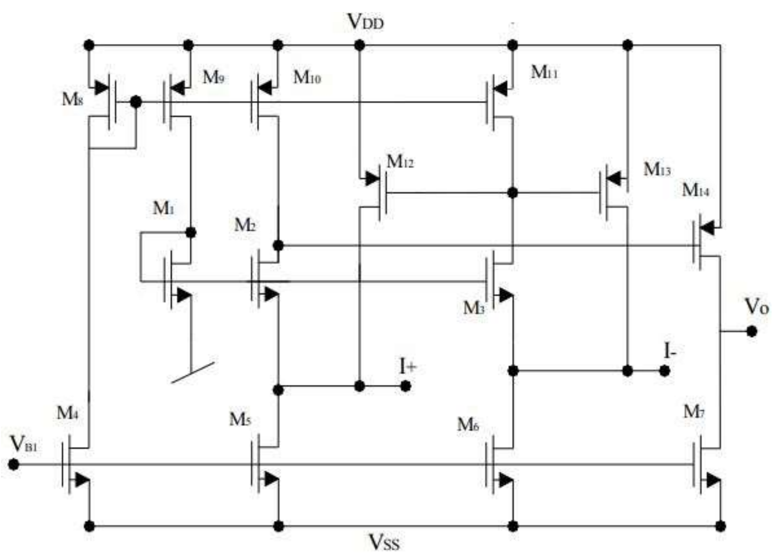

Fig. 3: OTRA implementation using CMOS technology

III. PROPOSED CIRCUITS

According to this paper, the grounded inductor simulation is performed using OTRA as its “active building block”. The configuration illustrated in Fig. 4 that has two OTRA with some passive elements are employed for realizing a circuit with similar input impedance as same as the ground inductor[8]. The input impedance expression of circuit is provided by (3) that can be proved by the equation (1).

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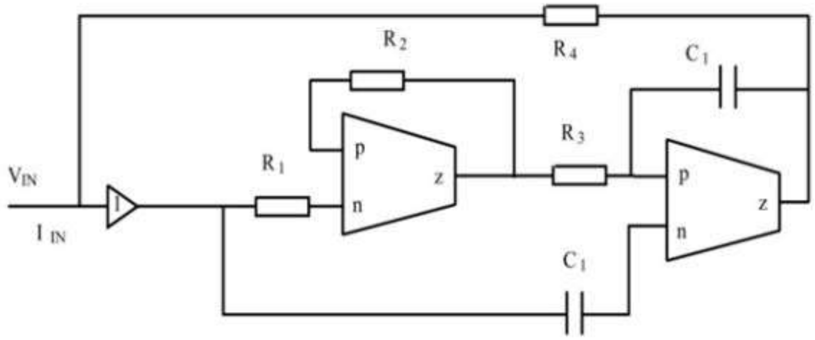

Fig. 4: Simulation of grounded inductor using OTRA

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

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

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

Therefore, in the variation with capacitance and resistance the value of inductance can be varied i.e. stated by equation (4).

One of the important application of the inductor is filter. The "2nd order RLC band pass filter" circuit is employed for simulation at the place of actual one that ensures the working ability of our design and compatibility[9]. Fig. 5 states the "RLC band pass filter" with real inductor and so Fig. 6 states an equivalent circuit wherein the simulated inductor is employed. The filter transfer function is provided by (5). The centre frequency and the bandwidth expressios are provided by (6) & (7) resp[10].

$$\frac{V_o}{V_{in}} = \frac{S(\frac{1}{C_oR_0})}{S^2+s\left(\frac{1}{C_0R_0}\right)+(\frac{1}{L_0C_0})} \qquad (5)$$

$$f_o = \frac{1}{2\pi\sqrt{LC}} \qquad (6)$$

$$\frac{\omega_o}{Q} = \frac{1}{C_0R_0} \qquad (7)$$

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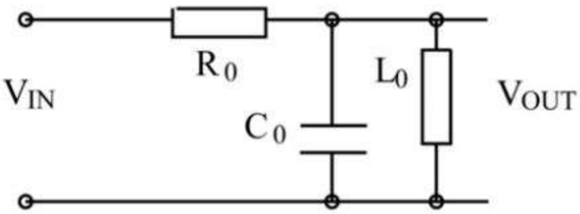

Fig. 5: RLC band pass filter circuit

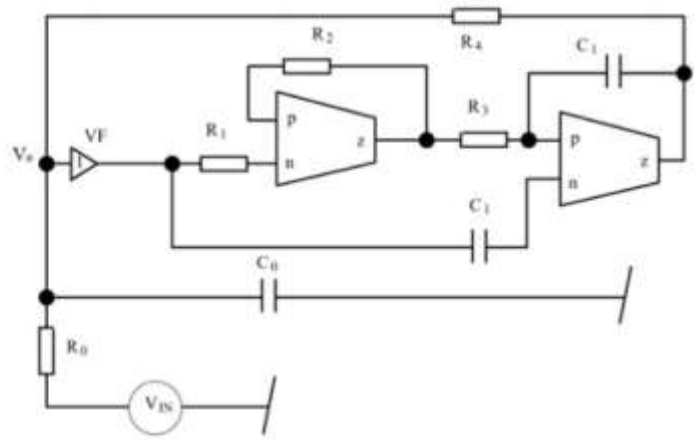

Fig. 6: RLC band pass filter circuit using simulated inductor

IV. SIMULATION RESULTS

The OTRA was designed by employing CFOAs as illustrated in Fig2 for the simulation with 12V power supply. The passive elements employed for the simulation of the inductance are of value: “C1= 0.2nF, R1=R2=R3=R4= 7KΩ. The inducting value for the simulation by employing (4) and further values are 9.8 mH. The tested circuit for response of input impedance frequency. The variation in input impedance with frequency is stated by Fig.7.

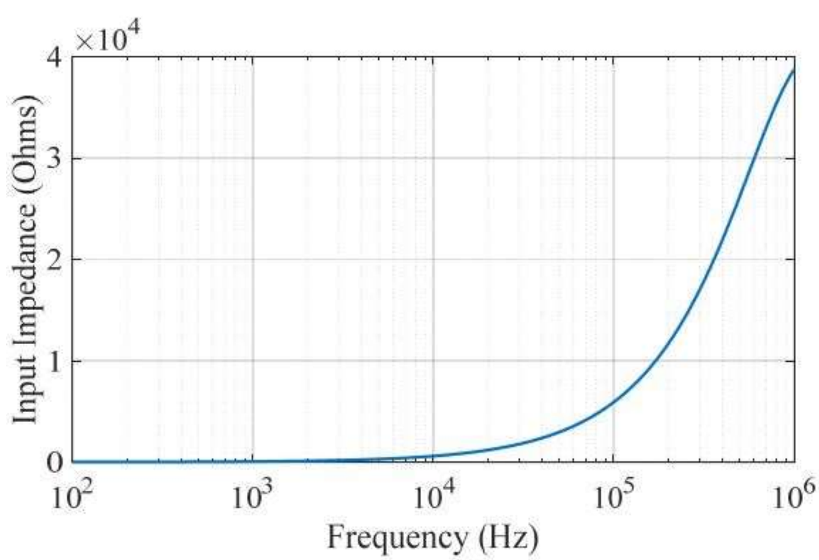

Fig. 7: Variation of input impedance of simulated inductor with frequency

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The Fig.6 states the “band pass filter” that also was verified for the frequency response that is stated in Fig.8. The passive elements values are employed in the inductor simulation designing that is kept as same as prior case (that provides value of inductor simulation, L0= 9.8mH). C0 and R0 is chosen for the value i.e. 12.50pF and 14.0 KΩ correspondingly. Employing these values, the centre frequency values for “band pass filter” comes to be 454.70 KHz ideally. As stated by the response of frequency, the band pass filter centre frequency is approximate to the ideal value by employing inductor.

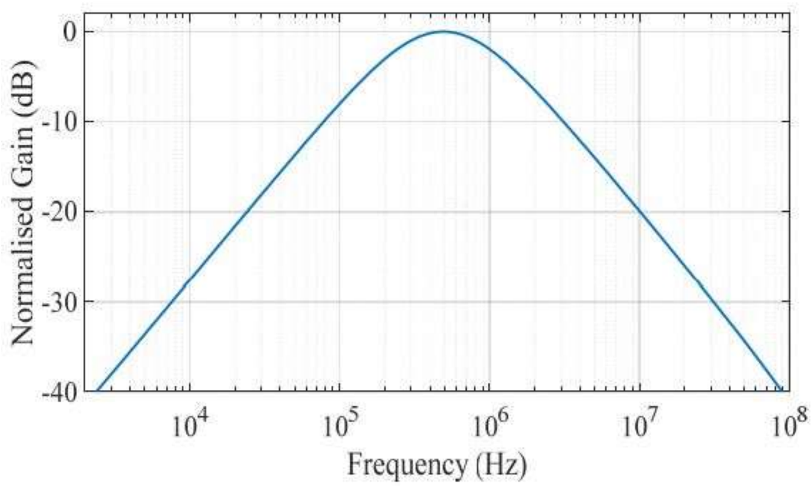

Fig. 8: Band pass filter respone of RLC filter circuit using simulated Inductor

V. CONCLUSIONS

This work offers a novel configuration that realizes a ground inductor by employing “Operational Trans-resistance Amplifiers”. The value of the inductance can be varied in variation with passive elements. A “band pass filter” for the simulation of inductor is built that illustrates the experimented result in arrangement through the results.

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