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SIMULATED INDUCTOR-ITS RELEVANCE IN ANALOG TRACK

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ABSTRACT

In the current state of affairs where nano is a well-known topic in the electronics world, smallness of components is in the front. Inductor, the passive component is one of the important elements in most of the circuit. But the application of inductor at low and very low frequencies is very much constricted due to large number of turns required. This stops its realization in integrated circuits and is not comfortable with newest IC technology. In this paper a different way of simulating L is presented. It is called simulated inductor or synthetic inductor. It uses two op-amps and few passive components. The application of this simulated L in analog filters and the frequency response of those filters are presented. The simulation is done in PSPICE. The experimental results are also shown to validate the use of this simulated inductor.

Keywords: inductor, filter, op-amp, simulated inductor.

1. INTRODUCTION

One of the fundamental element inductor uncovers its application in different areas. The main shortcoming of inductor is its application at down to ground frequencies. Thus the application is streamed down to a great extent. Synthetic inductor or simulated inductor gives a different method of realizing the inductor at low frequencies. There are various methods of simulating the inductor making use of OTA's, differential amplifier, current conveyor and so on[1-6]. In this paper the synthetic inductor makes use of two op-amps and a combination of resistors and capacitors. It provides good response at all frequencies. The quality factor is good.

2. SIMULATED INDUCTOR OR SYNTHETIC INDUCTOR

a) Synthetic inductor circuit

The synthetic inductor (or simulated inductor) circuit is shown in Figure-1 and makes use of active and passive components. The impedance of the circuit is given by $Z = Z_1Z_2Z_3/(Z_4Z_5)$. By properly choosing the components, the circuit can be made to act as an inductor.

b) RLC resonator circuit

The basic RLC resonator circuit is used to implement the various filters [7]. By giving input to any one of the terminal any one filter can be realized. The inductor in the RLC resonator is substituted by the synthetic inductor. Many papers are there in realizing the inductor [8, 9]. Simulated inductor is also called as synthetic inductor or synthetic L.

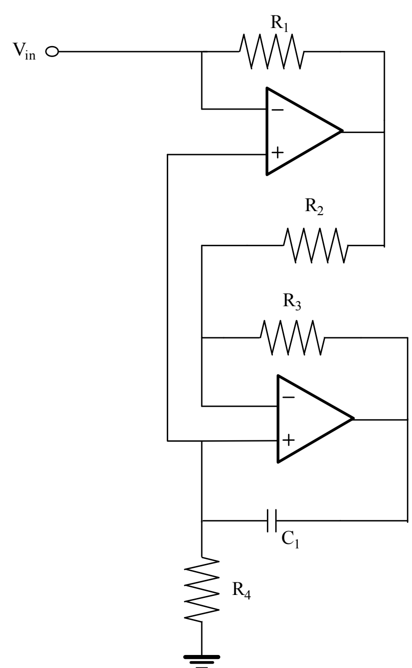

Figure-1. Synthetic inductor.

3. REALIZATION OF LOW PASS FILTER USING SYNTHETIC INDUCTOR

Filters are widely required in communication and other processing systems. It can be used to reject or accept a range of frequencies or a particular frequency. The basic passive filter circuit is constructed using the three basic passive elements namely the resistor, inductor and capacitor. When certain amount of gain is required active components can be used. The realization of various filters at low and very low frequencies is difficult. This is mainly due to large quantity of turns required in the formation of inductor. The disadvantage can be overcome by using synthetic L (synthetic inductor).Inductor can also be simulated using the concept of FDNR [10].

a) Circuit diagram of low pass filter using synthetic L

The Figure-2 below gives the circuit of low pass filter using synthetic L.

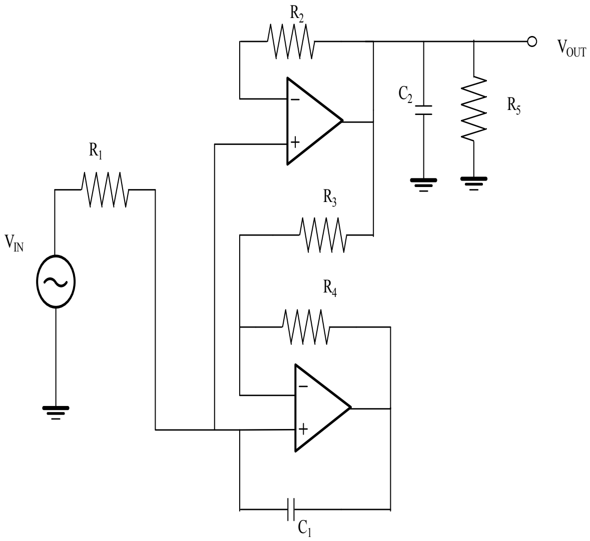

Figure-2. Circuit diagram of low pass filter using Synthetic inductor.

b) Design of low pass filter using synthetic L

Low pass filter

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

Given $f_0 = 100Hz$ Let $C = 1\mu f$

$$L = 2.536H$$

Simulated L

$L = CR^2$ $L = 2.536H$ Let $C = 1\mu f$

$$R = \sqrt{\frac{L}{C}} = 1.592\text{K}\Omega$$

c) Simulation result of low pass filter using synthetic L

The simulation result of low pass filter using the synthetic L is shown in Figure-3. The cut off frequency is found to be 100Hz. The filter realized is a Butterworth filter which gives a flat response.

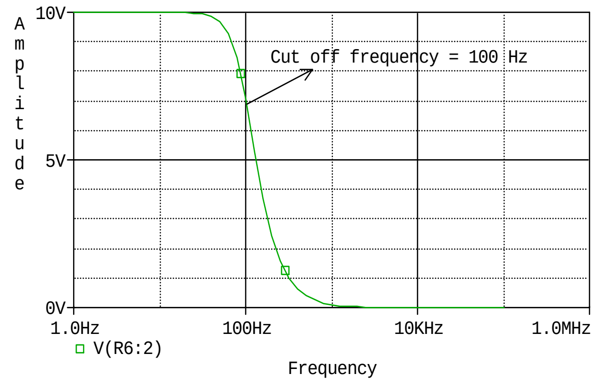

Figure-3. Frequency response of low pass filter using Synthetic inductor.

4. REALIZATION OF HIGH PASS FILTER USING SYNTHETIC L

High pass filter is used in communication and in audio cross over system. Certain applications require high signals to be passed grounding all the low frequency signals. There are cases where filter is to be operated at low frequencies. In such cases synthetic inductor can be used.

a) Circuit diagram of high pass filter using synthetic L

Figure-4 gives the circuit of high pass filter. The circuit can be designed for any frequency.

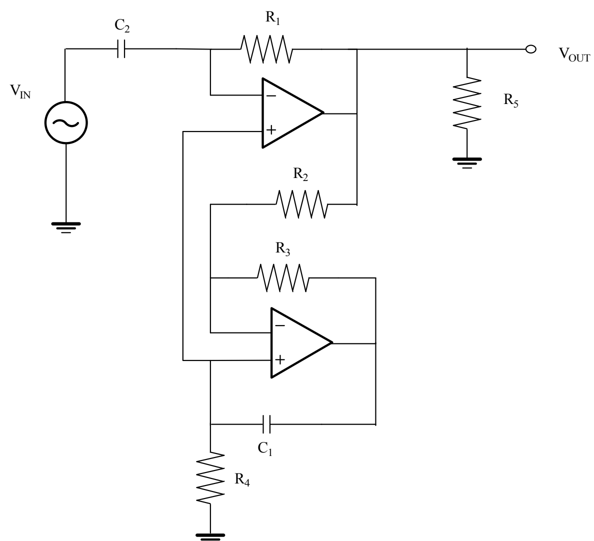

Figure-4. Circuit diagram of high pass filter using Synthetic inductor.

b) Simulation result of high pass filter using synthetic L

The simulation result in Figure 5 shows the cut off frequency to be around 100Hz which is useful for bio-medical applications.

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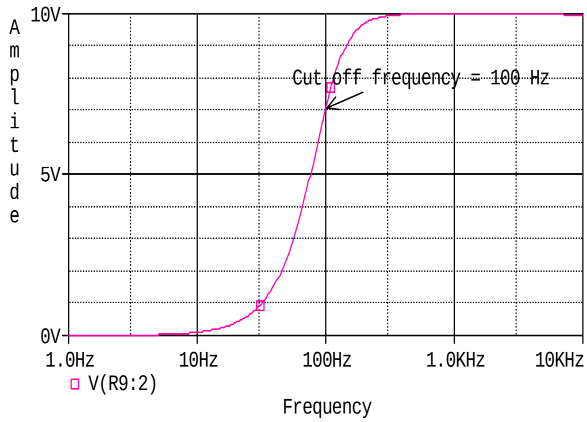

Figure-5. Frequency response of high pass filters using Synthetic inductor.

5. REALIZATION OF BAND PASS FILTER USING SYNTHETIC L

Band pass filter passes a band of frequencies and discards all other frequencies outside the band [11]. As bandwidth is narrow Q is high. It is used in communication.

a) Circuit diagram of band pass filter using synthetic L

The Figure-6 offers the circuit of band pass filter which is used for picking up the desired range of signals for transmission.

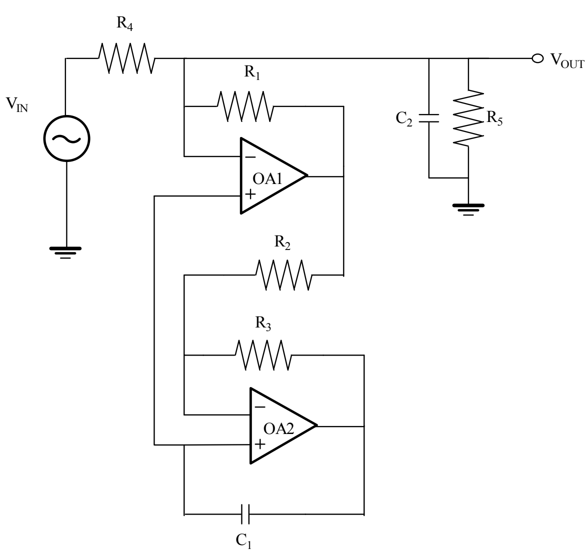

Figure-6. Circuit diagram of band pass filter using Synthetic inductor.

b) Simulation result of band pass filter using synthetic L

The sharp response of band pass filter aids in selecting a narrow band or particular frequency. The response is shown in Figure-7.

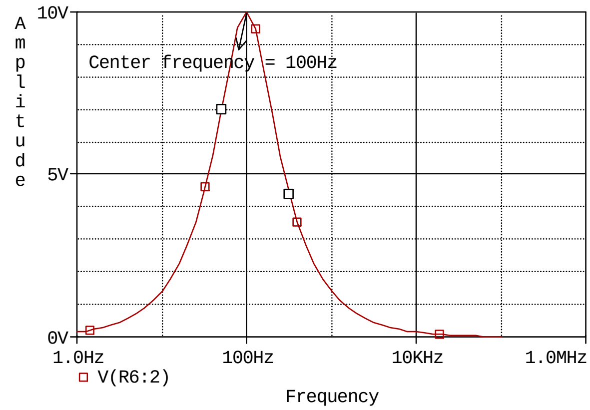

Figure-7. Frequency response of band pass filter using Synthetic inductor.

6. REALIZATION OF NOTCH FILTER USING SYNTHETIC L

Notch filter notches out a particular frequency [12].Using the synthetic inductor, elimination of a single frequency is made possible with the circuit given in Figure-8. It helps to reject power line hum in the transmission line.

a) Circuit diagram of notch filter using synthetic L

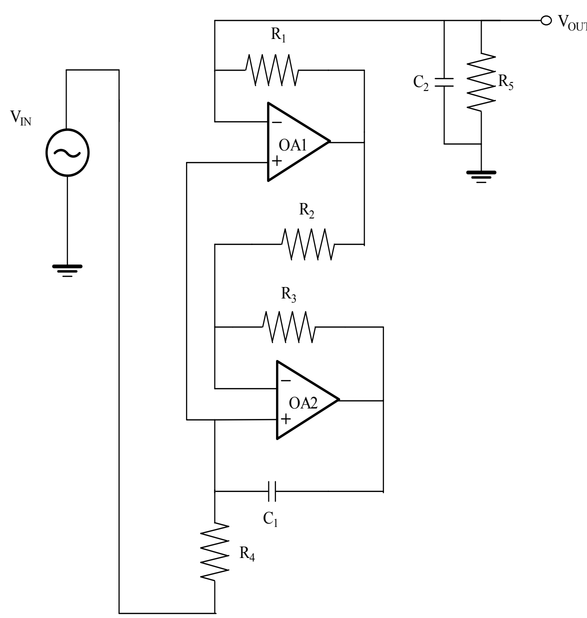

Figure-8. Circuit diagram of notch filter using Synthetic inductor.

b) Simulation result of notch filter using synthetic L

The frequency response of notch filter designed for 100Hz is revealed in Figure-9. The rejection is good at any frequency.

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7. EXPERIMENTAL RESULTS

The implementation of high pass filter for a cut off frequency of 2 KHz using simulated inductor practically is shown in Figure-10. The corresponding tabulation is given in Table-1. The graph given in Figure-11, tallies with the ideal graph designed for 2 KHz.

a) Hardware circuit of high pass filter using synthetic L

The Figure-10 shows the practical implementation of high pass filter. A 100mV sine wave input is given, using the function generator. The corresponding output is seen in the CRO and the readings are tabulated.

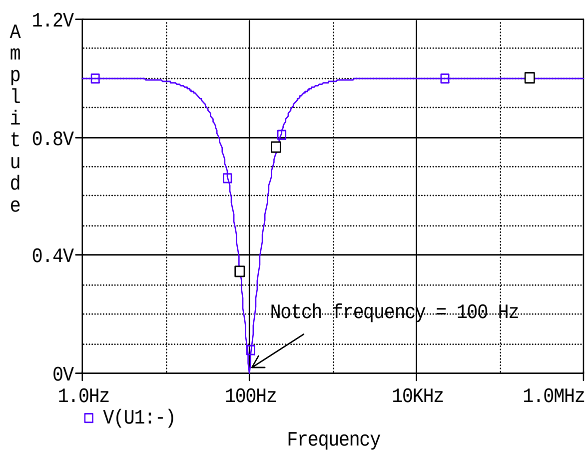

Figure-9. Frequency response of notch filters using Synthetic inductor.

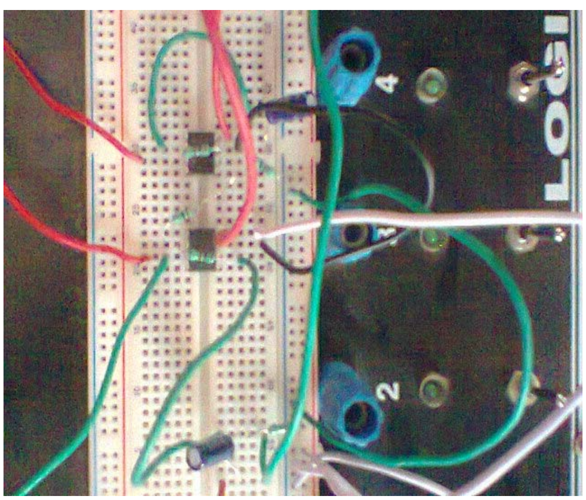

Figure-10. Experimental set up high pass filter using Synthetic inductor.

Table-1. Experimental readings of High pass filter using synthetic L Vin =1V.

S. No.	Frequency in Hz	Output voltage in volts
1	1	0.5
2	1.3	1
3	1.5	1.5
4	1.6	2
5	1.7	2.5
6	2	4
7	2.17	5.4
8	2.2	6.4
9	2.4	7
10	2.6	7.9
11	2.7	8
12	2.9	9
13	3	9
14	3.3	9
15	3.5	9
16	3.6	9
17	4	9
18	4.3	9
19	4.6	9
20	5	9
21	5.6	9
22	6	9

b) Practical response of high pass filter using synthetic L

The practical response of high pass filter is given in Figure-11. The cut off frequency is around 2.2 KHz. Likewise all other filters are implemented practically and the cut off frequency obtained is almost near to the desired frequency.

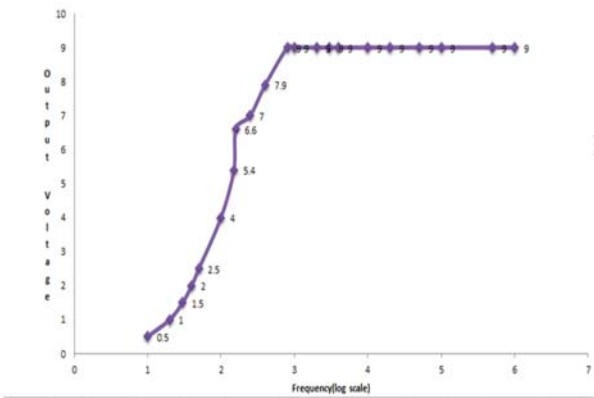

Figure-11. Practical frequency response of high pass filter using Synthetic inductor.

8. CONCLUSIONS

It is a well known fact that inductors cannot be used at low and very low frequencies due to the need for large value of inductor. This paper gives an alternate way of realizing an inductor for use at low frequencies. Using this inductor, any applications at low frequencies can be realized. Validation of one filter gives an opening to design any circuit using this simulated inductor. The experimental results of other filters are also shown to substantiate the use of this simulated inductor for other applications.

REFERENCES

[1] R. Senani. 1985. Novel higher order active filter design using Current Conveyors. Electronics Letters. IEE (UK). 21(22): 1055-1057.

[2] R.H.S. Riordan. 1967. Simulated inductors using differential amplifier. Electrons Letter. l. 3: 50-51.

[3] D. F. Sheahan and H. J. Orchard. 1967. Bandpass-filter realization using gyrators. Electronic Letters. 3: 40-42.

[4] Erkan Yuce. 2008. Grounded Inductor Simulators with Improved Low-Frequency Performances. IEEE Transactions on instrumentation and measurement. 57(5).

[5] Abdullah Yesil,Firat Kacar, Koray Gürkan. 2014. Lossless grounded inductance simulator employing single VDBA and its experimental band-pass filter application. International Journal of Electronics and communications. 68: 143-150.

[6] Umesh Kumar and Sushil Kumar Shukla. 1989. Analytical study of inductor simulation circuit. Active and Passive Electronic components. 13: 211-227.

[7] D. Susan and S. Jayalalitha. 2010. Analog filters using Simulated Inductors. IEEE International Conference on Mechanical and Electrical Technology, ICMET: 659-662.

[8] L.T Bruton. 1978. Multiple-Amplifier RC-Active filter design with emphasis on GIC realizations. IEEE Transaction on Circuits and systems. 25(10).

[9] L.T. Bruton and D. Treleaven. 1975. Active filter design using generalised impedance convertor. EDN: 68-75.

[10] D. Susan and S. Jayalalitha. 2010. Synthesis of low pass filters using FDNR. International Journal of Electronic and Electrical Engineering (IJEEE). 3(3): 263-269.

[11] H.J. Orchard and Desmond F. Sheahan. Inductorless band pass filters. IEEE Journal of solid state circuits. 5(3).

[12] D. Susan and S. Jayalalitha. 2011. Notch filter using simulated inductor. International Journal of Engineering Science and Technology. 3(6): 5126-5131.