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Application of VDVTA as Grounded Lossy Series and Parallel RL Circuit

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ABSTRACT

This paper presents two simple topologies of novel grounded lossy series and parallel RL circuit employing VDVTA. Inductor and resistor are simulated employing one VDVTA and one passive component. Both the proposed topologies for the immittance simulation have been realized using a simple circuit. There is little deviation in the values of theoretically calculated and practically simulated series and parallel RL circuit. To study the performance of the realized grounded lossy series and parallel RL circuit, a second order high pass filter has been constructed using one of the circuits. To verify the presented theoretical analysis, the PSPICE simulation results are given using CMOS technology.

Keywords: Grounded RL circuit, lossy, electronically tunable, VDVTA (voltage differencing voltage transconductance amplifier)

INTRODUCTION

With the recent advancement in the integrated circuit technology, the state of art is pushing towards the solution of chip with higher density of integration, reduced power consumption, cost cutting and above all to support the standard of communication, we require technology having different data rates as well as different frequency band [1]. Due to these requirements active simulations of RC filters and inductors are having increased demand. There are vast numbers of active RC filter and simulated lossy inductors are reported in literature using different active building blocks [2-11].

Several topologies for simulated inductors and high pass filters have been proposed till date [12-18], each of them has their own advantages and disadvantages. Few filters available in literature are active RC filters, transmission line filters, switched capacitor filters, LC filters, g_mC filters, mosfet-c filters etc. By going through the literature review we can find that active filters like RC as well as mosfet-c suffer from the problem of limited range of operation due to finite gain-BW product as feedback is provided by op-amp. With the ongoing advancement in the communication and signal processing technologies, filters requirement is growing day by day with different features. Filters make an essential component in modulation and demodulation devices as well as transreceivers. Filters have the ability of a huge impact on the overall function and performance of any communication systems, whether it is sensitivity, sensibility or image rejection ratio.

Few filters possess the ability to operate at several GHz but they lack the tunability and higher density requirements on-chip. To overcome this advantage, we need to have actively simulated tunable inductors that can overcome the problem of large die area and increased power consumption. Simulated inductors possess the quality to overcome several problems of the spiral coil inductors that are difficult to be integrated on chip.

ACTIVE BUILDING BLOCK VDVTA

The symbolic representation of VDVTA as shown below in fig 1 has three input terminals namely p, n, v and four output terminals as x+, x-, z [19-20]. It was first presented in [21] and employed in the realization of 1st order all pass filter in [22]. Each terminal of VDVTA possesses high value of impedance.

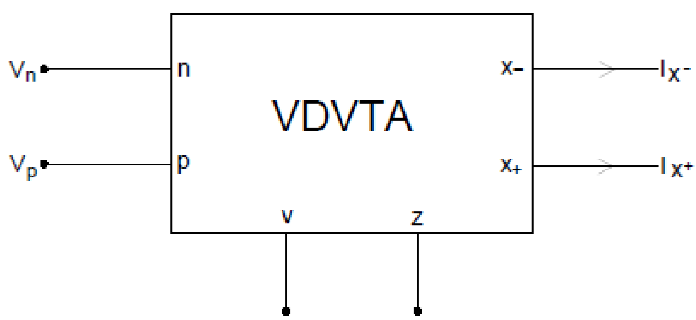

Fig 1: Symbolic diagram depicting VDVTA

The characteristic equations of above shown VDVTA can be given as under:

- $I_Z = g_{m1} (V_p - V_n)$
- $I_{x+} = g_{m2} (V_z - V_v)$
- $I_{x-} = -g_{m2} (V_z - V_v)$

PROPOSED GROUNDED LOSSY RL CIRCUIT (SERIES)

The proposed grounded lossy RL circuit (series) is given in the fig 2. The circuit has been realized using one active building block and one passive element that are VDVTA and a capacitor respectively.

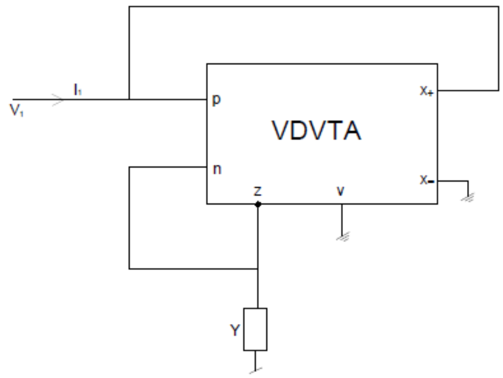

Fig 2: Proposed grounded lossy series RL circuit simulator

With the help of characteristics equation, solving the circuit presented in fig.2, we can obtain the value of L_{eq} and R_{eq}.

$$I_Z = g_{m1} (V_p - V_n)$$

$$I_Z = g_{m1} (V_1 - V_z) \tag{1}$$

$$I_Z = V_Z Y_1 \tag{2}$$

$$I_{x+} = g_{m2} (V_Z - 0) = I_1$$

$$I_1 = g_{m2} V_Z \tag{3}$$

From equation (1) and (2)

$$g_{m1} V_1 = (Y_1 + g_{m1}) V_Z \tag{4}$$

Putting the value of V_Z from equation (4) in equation (3)

$$I_1 = \frac{g_{m1} g_{m2} V_1}{Y_1 + g_{m1}}$$

If Y_1 = SC

$$\frac{V_1}{I_1} = \frac{SC}{g_{m1} g_{m2}} + \frac{1}{g_{m2}}$$

$$\frac{V_1}{I_1} = S\,L_{eq} + R_{eq}$$

Hence,

$$L_{eq} = \frac{C}{g_{m1}g_{m2}} \text{ and } R_{eq} = \frac{1}{g_{m2}} \quad (5)$$

Clearly equation (5) shows the circuit in fig.2 can simulate grounded series R-L circuit, with the equivalent inductance and resistance given in above equation.

PROPOSED GROUNDED LOSSY RL CIRCUIT (PARALLEL)

The proposed grounded lossy RL circuit (parallel) is given in fig 3. Similarly, as in the case of RL circuit (series), here also the parallel R-L circuit is realized using one active building block and one passive element that are VDVTA and a capacitor respectively.

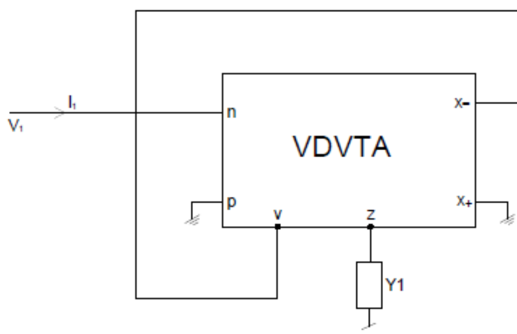

Fig 3: Proposed grounded lossy parallel RL circuit simulator

Using the characteristics equation of VDVTA, Solving the circuit presented in fig.3

$$I_Z = g_{m1} (V_p - V_n)$$

$$I_Z = g_{m1} (0 - V_z)$$

$$I_Z = -g_{m1} V_1 \quad (6)$$

From circuit shown in fig.3,

$$I_Z = V_Z Y_1 \quad (7)$$

$$I_{x-} = -g_{m2} (V_Z - V_1) = I_1 \quad (8)$$

From (7) and (8)

$$I_1 = -g_{m2} \left[\frac{-g_{m1}V_1}{Y_1} - V_1\right] \quad (9)$$

If $Y_1 = SC$

$$\frac{I_1}{V_1} = \frac{g_{m1}g_{m2}}{SC} + g_{m2}$$

Hence,

$$L_{eq} = \frac{C}{g_{m1}g_{m2}} \text{ and } R_{eq} = \frac{1}{g_{m2}}$$

APPLICATION OF THE PROPOSED CIRCUIT

The proposed grounded lossy parallel RL circuit can be employed to simulate second order HPF as depicted in fig. 4

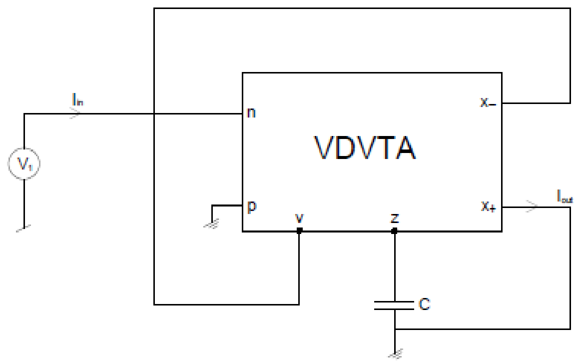

Fig 4: 2nd order HPF using proposed lossy grounded parallel RL circuit

The virtue of the presented filter is that, it has wider bandwidth and high gain. It is basically a parallel RLC filter, where the parallel RL circuit has been replaced by our proposed grounded lossy parallel RL circuit employing VDVTA, with a capacitor connected at the output.

The transfer function can be given as:

$$\frac{I_{HP}}{I_{in}} = \frac{I_{out}}{I_{in}} = \frac{S^2}{S^2 + \frac{S}{R_{eq}C} + \frac{1}{L_{eq}C}}$$

SIMULATION RESULTS

The performance of all the above proposed circuits can be demonstrated by the help of PSpice simulation results. The circuit components are taken as C = 1nF, R_{eq} = 1.59 kΩ, L_{eq} = 2.53 mH, g_{m1} = 631.881 µA/V, g_{m2} = 626.3 µA/V and I_B = 125 µA. The value of transconductance of VDVTA can be adjusted using bias current.

The theoretical and simulated values are given as below:

	Calculated Value	Simulated parallel RL	Simulated series RL
L_{eq}	2.53 mH	2.59 mH	2.531 mH
R_{eq}	1.59 kΩ	1.59 kΩ	1.61 kΩ

The Pspice simulation results obtained using TSMC CMOS 0.18µm for proposed grounded lossy series and parallel RL circuit simulator and the application as 2nd order HPF are given as under.

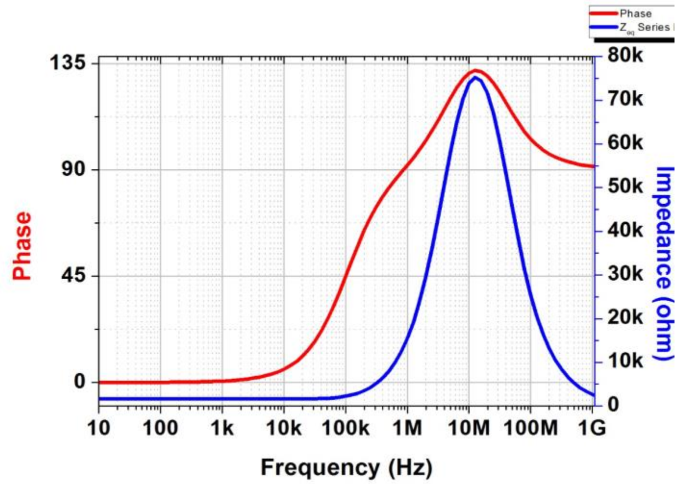

Fig 5: Simulated frequency response of proposed grounded series RL circuit

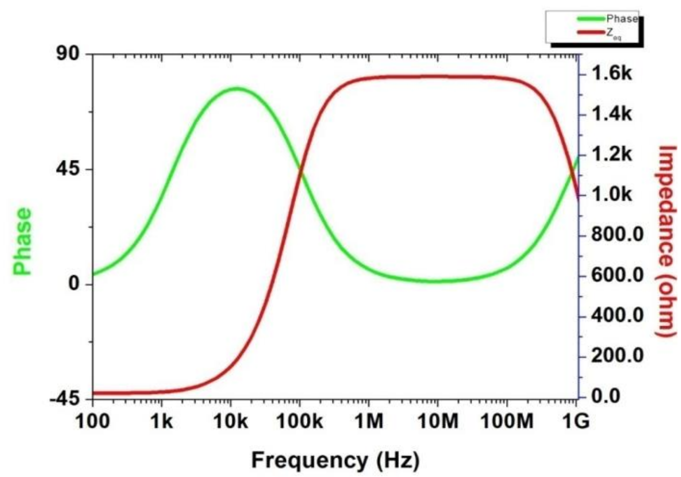

Fig 6: Simulated frequency response of proposed grounded parallel RL circuit

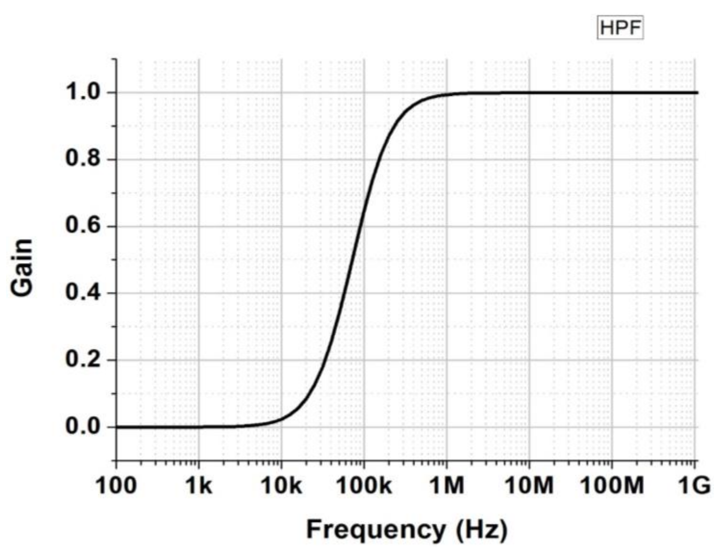

Fig 7: Simulated frequency response of proposed HPF realized in fig.4

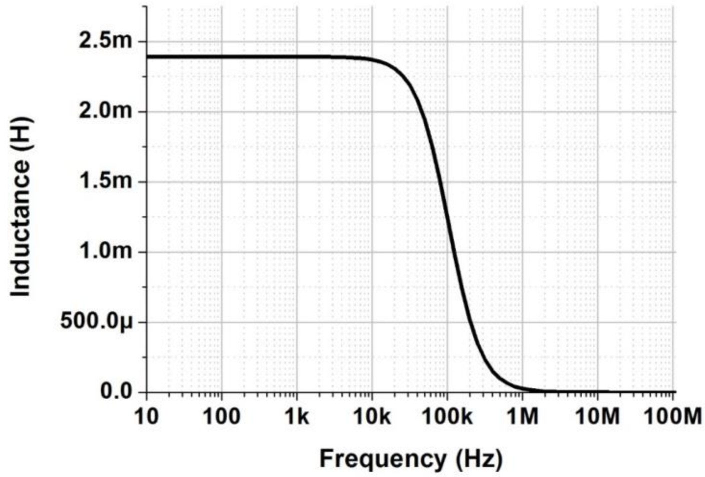

Fig 8: Simulated frequency response of parallel L_{eq}

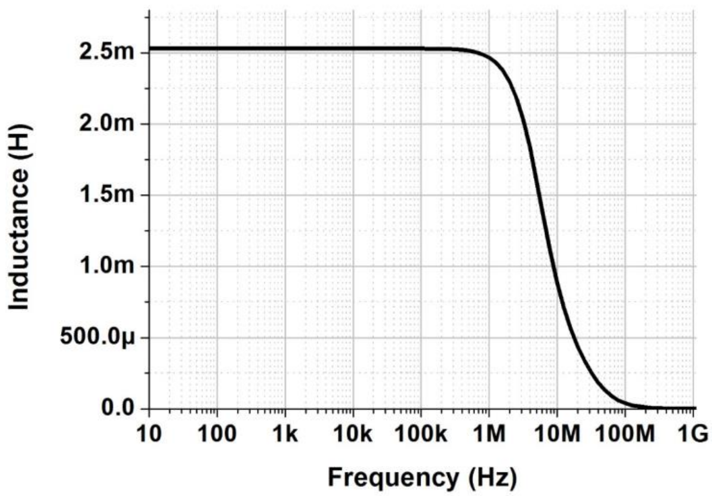

Fig 9: Simulated frequency response of series L_{eq}

CONCLUSIONS

The paper concludes the realization of grounded series and parallel RC circuits that are lossy and adjustable in characteristics. The realized second order high pass filter has been simulated and verifies the application of proposed circuit. Simulated frequency response of equivalent parallel and series inductance also verifies the workability of proposed circuit. To confirm the claimed characteristics of proposed circuit the comparison has been done between theoretical and simulated values, that shows very little deviation and hence performance and the workability of proposed circuit is well investigated and demonstrated.

Declaration

- The authors have no relevant financial or non-financial interests to disclose.
- The authors have no conflicts of interest to declare that are relevant to the content of this article.

- The authors have no financial or proprietary interests in any material discussed in this article.
- The authors are responsible for correctness of the statements provided in the manuscript.

References

[1]. Worapong Tangsrirat, “Actively Floating Lossy Inductance Simulators Using Voltage Differencing Buffered Amplifiers” IETE Journal of Research, DOI: 10.1080/03772063.2018.1433082

[2]. S. Minaei and E. Yuce, “Realization of tunable active floating inductance simulators,” Int. J. Electron., Vol. 95, no. 1, pp. 27–37, Jan. 2008.

[3]. R. Senani, “New single-capacitor simulation of floating inductors,” Electro compon. Sci. Technol., Vol. 10, pp. 7–12, Mar. 1982.

[4]. R. Senani and D. R. Bhaskar, “New lossy/loss-less synthetic floating inductance configuration realized with only two CFOAs,” Analog Integr. Circ. Sig. Process., Vol. 73, pp. 981–7, Jun. 2012.

[5]. R. Senani, “New tunable synthetic floating inductors,” Electronics Letter, Vol. 16, no. 10, pp. 382–3, May 1980.

[6]. D. R. Bhaskar and R. Senani, “Synthetic floating inductors realized with only two current feedback op-amps,” Am. J. Electrical and Electronics Eng., Vol. 3, no. 4, pp. 88–92, Sep. 2015.

[7]. E. Yuce, “New low component count floating inductor simulators consisting of a single DDCC,” Analog Integr. Circ. Sig. Process., Vol. 58, pp. 61–66, Jan. 2009.

[8]. M. A. Ibrahim, S. Minaei, E. Yuce, N. Herencsar, and J. Koton, “Lossy/lossless floating/grounded inductance simulation using one DDCC,” Radioengineering, Vol. 21, no.1, pp. 3–10, Apr. 2012.

[9]. R. Senani, “Network transformations for incorporating non ideal simulated immittances in the design of active filters and oscillators,” IEEE Proceedings, Pt. G., Vol. 134, no. 4, pp. 158–66, Aug. 1987.

[10]. R. Senani, “Floating immittance realization: Nullor approach,” Electronics Letter, Vol. 24, no.7, pp.403–5, Mar. 1988.

[11]. W. Tangsrirat, “Synthetic grounded lossy inductance simulators using single VDIBA,” IETE Journal of Research, Vol. 63, no. 1,pp. 134–41, Jan–Feb 2017.

[12]. Keskin, A.U. (2006) Multi-Function Biquad Using Single CDBA. Electrical Engineering, 88, 353-356. http://dx.doi.org/10.1007/s00202-004-0289-4

[13]. Herencsar, N., Koton, J., Vrba, K. and Lattenberg, I. (2010) New Voltage-Mode Universal Filter and Sinusoidal Oscillator Using Only Single DBTA. International Journal of Electronics, 97, 365-369. http://dx.doi.org/10.1080/00207210903325229

[14]. Tangsrirat, W. and Channumsin, O. (2011) Voltage-Mode Multifunctional Biquadratic Filters Using Single DVCC and Minimum Number of Passive Elements. Indian Journal of Pure and Applied Physics, 49, 703-707.

[15]. Kumar, P. and Pal, K. (2008) Universal Biquadratic Filter Using a Single Current Conveyor. Journal of Active and Passive Electronic Devices, 3, 7-16.

[16]. Shah, N.A., Rather, M.F. and Iqbal, S.Z. (2005) A Novel Voltage-Mode Universal Filter Using a Single CFA. Journal of Active and Passive Electronic Devices, 1, 183-188.

[17]. Chen, H.P. (2010) Single CCII-Based Voltage-Mode Universal Filter. Analog Integrated Circuits and Signal Processing (USA), 62, 259-262. http://dx.doi.org/10.1007/s10470-009-9345-3

[18]. Chang, C.M. and Chen, H.P. (2005) Single FDCCII-Based Tunable Universal Voltage-Mode Filter. Circuits, Systems and Signal Processing, 24, 221-227. http://dx.doi.org/10.1007/s00034-004-0422-7

[19]. G. Singh, D. Prasad and D.R. Bhaskar, Single VDVTA-based voltage-mode biquad filter, Circuits and Systems, 6 (2015), no.3, 55-59. http://dx.doi.org/10.4236/cs.2015.63006

[20]. Ghanshyam Singh, “CMOS Realization of VDVTA and OTA Based Fully Electronically Tunable First Order All Pass Filter with Optimum Linearity at Low Supply Voltage ± 0.85 V” Circuits and Systems, 2020, 11, 39-49 https://www.scirp.org/journal/cs

[21]. Biolek, D., Senani, R., Biolkova, V. and Kolka, Z. (2008) Active Elements for Analog Signal Processing; Classification, Review and New Proposals. Radioengineering, 17, 15-32.

[22]. Shaktour, I.M. (2011) Unconventional Circuit Elements for Ladder Filter Design. Ph.D. Thesis.https://www.vutbr.cz/www_base/zav_prace_soubor_verejne.php?file_i=35975