Realization of Grounded Inductor Based Band Pass Filter Design to Achieve Optimum Linearity with Bandwidth using Single VDVTA

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ABSTRACT

The main objective of this papers an electronically tuneable grounded inductor using single VDVTA as a newly active element. The VDVTA replace spiral passive inductors for all Analogue Signal Processing and data communications operations. The temperature variation on its resonant frequency is investigated using 45-nm CMOS technology. This paper employed CMOS realization of Voltage Differencing Voltage Transconductance Amplifier (VDVTA) and its application as a grounded inductor. A Band pass filter circuit is presented using single VDVTA based grounded inductor. Furthermore, the impact of temperature variation on the response of the band pass filter is analyzed and presented. The proposed circuit presents only single VDVTA newly active elements and one grounded capacitor. The circuit finds applications in all integrated circuit implementations.

Keywords:**Voltage Differencing Voltage Transconductance Amplifier (VDVTA), Grounded Inductor, Band Pass Filter.**

I.INTRODUCTION

In this paper, a new active element namely voltage differencing voltage transconductance amplifier (VDVTA) is used as a building block for employing grounded inductor [1,2,10,11,12,13]. VDVTA consists of a current source controlled by the different of two input voltages and a multiple output which provides electronically tuneable by varying its transconductance. A wide range of applications of CMOS grounded inductors in high speed Analogue Signal Processing and data communications. The limitations of these grounded inductors include a low-quality factor, very small and non-tuneable inductance, a very small self-resonant frequency and the need for a large silicon area. The passive grounded inductors also cannot scale with the process technology. However, the grounded inductors have a large electronically tuneable quality factor, large electronically tunable inductance and high self-resonant frequency. The cost of production of grounded inductors are also too less and they are fully compatible[7,8,12]. With CMOS technology. Hence, realization of grounded inductor has become a popular research topic for the research scholar in the research community to aid design engineer. Various active elements such as Operational Amplifiers [2,4], Current Feedback Operational Amplifier (CFOA) [5,6], Therefore, the major purpose of this communication is to present a novel grounded inductor simulator configuration with following advantageous features: (i) low active and passive elements requirement (only one VDVTA, one capacitor and one resistor) (ii) employment of all grounded passive components (iii) electronically controllable inductance and (iv) low non ideal effects[6,7,9,15].Voltage Differencing Buffered Amplifiers (VDBA)[7], Current Conveyor (CCI)[8], Current Differencing Transconductance Amplifier (CDTA)[9] were proposed in the literature for realizing grounded inductor circuits. But these circuits have one or more problems use of external passive resistors, need of some floating passive components, cannot be tuned electronically. VLSI circuits often operate at high temperature due to heat generation [2,13,14]. The temperature in the VLSI technology does not same thought the entire chips are to observe due to variation in activities during chip implantation.

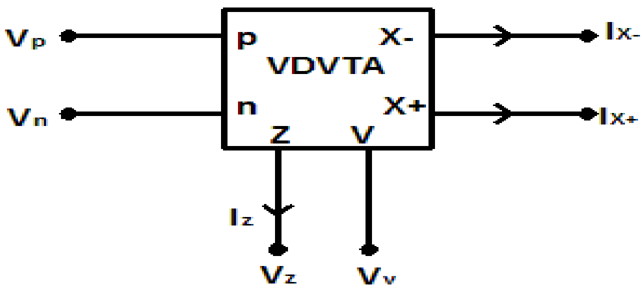

Fig. 1: Symbolic Notation of VDVTA

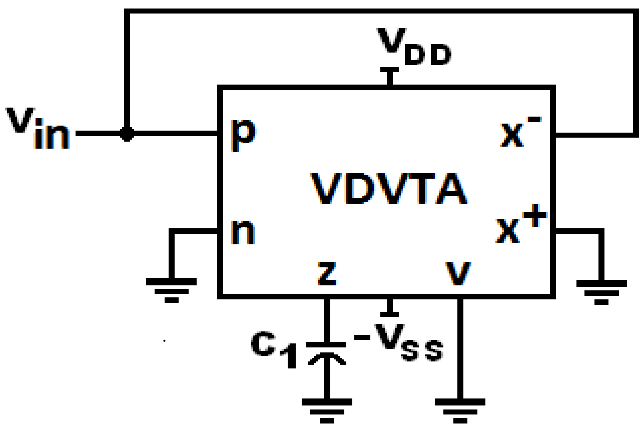

Fig. 2: Proposed Grounded Inductor circuit employing single VDVTA

The variation in temperature depends upon the circuit behavior. In an integrated circuit, billions of chips exist. If the performance of chip varies, then the entire integrated circuit performs poorly. This paper investigates the impact of temperature variation on circuit response when VDVTA is used as grounded inductor for realizing band pass filter.

2. CMOS REALIZATION OF VOLTAGE DIFFERENCING VOLTAGE TRANSCONDUCTANCE AMPLIFIER

A symbolic notation of VDVTA is shown in Figure 1. VDVTA contains p, n, v as high impedance input terminals and z, x+, x− as high impedance output terminals. VDVTA is characterized by the following matrix:
Characteristics Equations are:

$$\begin{bmatrix} Iz \\ I_{X+} \\ I_{X-} \end{bmatrix} \Rightarrow \begin{bmatrix} gm_1 & -gm_1 & 0 \\ 0 & 0 & gm_2 \\ 0 & 0 & -gm_2 \end{bmatrix} \begin{bmatrix} V_p \\ V_n \\ V_z - V_v \end{bmatrix} \qquad (1)$$

$$Iz = gm(Vp - Vn) \qquad (2)$$

$$I_{X+} = gm_2(V_z - V_v) \qquad (3)$$

$$I_{X-} = -gm_2(V_z - V_v) \qquad (4)$$

3. APPLICATION OF VDVTA AS GROUNDED INDUCTOR

The Major application of grounded inductor is shown using VDVTA based grounded inductor circuit is shown in Figure 2. It consists of one VDVTA and a grounded capacitor (C1). Based on equations obtained from [2,4] and approximating we get the Input Impedance (Zin) of the circuit as:
Input Impedance of the proposed Grounded Inductor

$$Z_{in} = \frac{Sc_1}{gm_1 gm_2} \qquad (5)$$

Equivalent Input Impedance of the proposed Grounded Inductor

$$Z_{in} = sL_{eq} \qquad (6)$$

Equivalent Inductance of the proposed Grounded Inductor from equation (5) and Equation (6)

$$L_{eq} = \frac{C_1}{gm_1 gm_2} \qquad (7)$$

The proposed grounded Inductor is electronically controllable with the help of $gm_1 gm_2$.

4. MAJOR APPLICATION OF VDVTA AS BAND PASS FILTER

The proposed inductor was verified by presenting it in a band pass filter. The band pass filter presented which is shown in Figure 4. Let the equivalent inductance of the VDVTA configuration is given by ‘L’.

The expression of resonant frequency of the band pass filter circuit is given by The resonant frequency of the design band pass filter

$$\omega^2 = \frac{gm_1 gm_2}{C_1 C_2} \qquad (8)$$

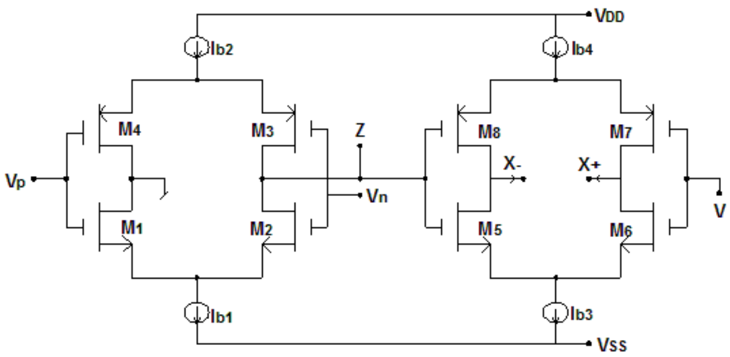

Fig.3: C MOS Realization of circuit of proposed Grounded Inductor Circuit using Single VDVTA

5. CMOS SIMULATION RESULT

All the simulation results in this work are performed using 45-nm industrial CMOS technology with dual supply of ±0.9 V. Analog Design Environment of Cadence is used as a simulation tool. Figure 5 shows the input impedance versus frequency plot of the presented grounded inductor circuit using single VDVTA configuration.

The simulated inductance value is found to be 8.49-8.79µH. According to the simulation results the input impedance of the inductor varies to achieve linearly with frequency.

The simulation result presents the AC analysis of band pass filter which is designed using grounded inductor employing Voltage Differencing Voltage Transconductance Amplifier (VDVTA). The analysis is carried out at different temperature ranges.

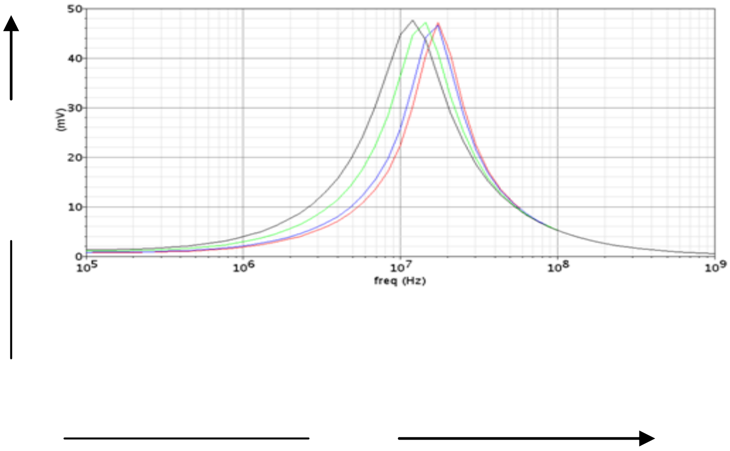

Fig.4: AC analysis of Band Pass Filter

Threshold voltage V_T dependant on Temperature. Therefore

$$V_T = V_T(T_0) \pm \alpha_{VT}(T_H - T_0) \qquad (9)$$

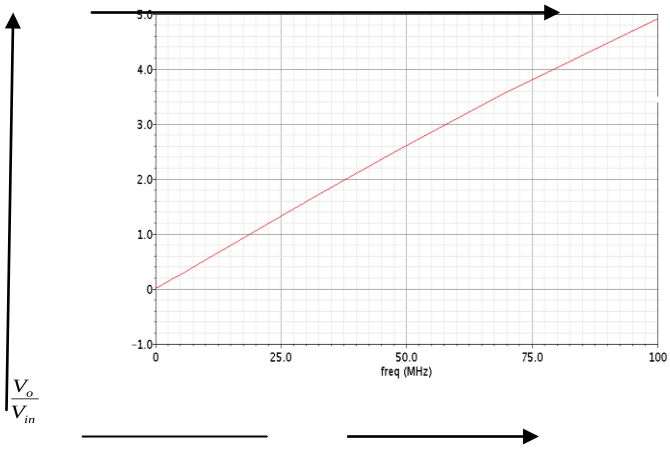

Fig.5: AC Response of Band Pass Filter with Temperature Variation.

Whereas T_0 is the initial room temperature, T_H is the highest temperature range and α_{VT} is the mobility of charge

Carriers.The typical values of temperatures are 20^0C, 30^0C, 40^0C, 60^0C, 80^0C, 100^0C, 120^0C.

The AC response of the band pass filter is presented at different temperatures to obtain the temperature dependant resonant frequency from the theoretical values.

They are 27°C (at room temperature), 40°C, 80°C and 120°C shown in Figure 6. It is presented that the resonant frequency decreases with the temperature increases.

6. CONCLUSION

An electronically tunable grounded inductor circuit is employed with single Voltage Differencing Voltage Transconductance Amplifier (VDVTA) configuration using Analogue Design Environment of Cadence. Temperature variation analysis is presented to observe the temperature dependent resonant frequency of the band pass filter designed using single VDVTA based grounded inductor. The resonant frequency of grounded inductor can be electronically tunable. At higher frequencies, the grounded inductor which is shown various parasitic effects. The grounded inductor circuit finds many applications in high-speed analogue signal processing and data communication systems.

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