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The Differential Voltage Current Controlled Conveyor Tranconductance Amplifier: A Novel Active Block Prevailing Op-Amp Limitations

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Abstract— The differential difference current controlled current conveyor transconductance amplifier (DVCCCTA) is a novel active building block which can substitute the widely used operational amplifier in analog circuit design. The operation of differential difference current controlled current conveyor transconductance amplifier is different from the operation of operational amplifier. The DVCCCTA can be used to design various circuits like integrator, differentiator, adder, substractor etc. The advantages of DVCCCTA are it has high slew rate, wide bandwidth, and also current processing capabilities at input terminals. Since DVCCCTA is not slew limited in the same fashion of OPAMP, it can provide amplification of high frequency signals with a constant bandwidth virtually independent of gain.

Keywords- *DVCCCTA, OPAMP, Signal processing.*

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I. INTRODUCTION

The Differential Voltage Current Controlled Conveyor Transconductance Amplifier (DVCCCTA) is an attractive active building block for analog signal processing. The applications based on DVCCCTA are resistorless as it has one parasitic resistance and transconductance element each which can be tuned electronically by adjusting the input bias current of DVCCCTA. The DVCCCTA consists of Differential Voltage Current Conveyor (DVCC), Translinear loop and Transconductance amplifier (TA).

Differential voltage current conveyor

The differential voltage current conveyor (DVCC) is an extension of the second-generation current conveyor (CCII). The second-generation current conveyor (CCII) is a versatile analog building block that can be used to implement various high frequency analog signal applications, like filters and current-mode oscillators. But for the application which requires two high input impedance terminals like impedance converters and current-mode instrumentation amplifiers, a single CCII block is not sufficient. In addition, most of these applications employ floating elements in order to minimize the number of used CCII blocks. For this reason and in order to provide two high input impedance terminals, the differential voltage current conveyor (DVCC) is used. The CCII has a disadvantage that only one of the input terminals has high input impedance (the Y terminal). This disadvantage becomes evident when the CCII is required to handle differential signals, as in the case of an instrumentation amplifier. The block diagram of the DVCC is shown in Fig.1.

The voltage at X terminal is equal to the voltage difference of terminals Y1 and Y2; a current injected at the X terminal is being replicated to the Z terminal. An ideal DVCC exhibits zero input resistance at terminal X, and infinite resistance at both Y terminals as well as the Z terminal. Since the DVCC has two high input impedance terminals, it is suitable for handling differential input signals. The CMOS implementation of DVCC is shown in Fig. 2.2. The differential voltage conveying action of the circuit is based on the differential pairs M1-M2 and M3-M4. The current mirror formed by transistors M5 and M6 forces the sum of the drain currents of M1 and M4 to be equal to the sum of the drain currents of M2 and M3.

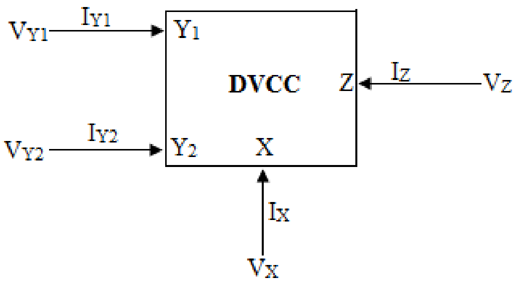

Fig.1 Block diagram of DVCC

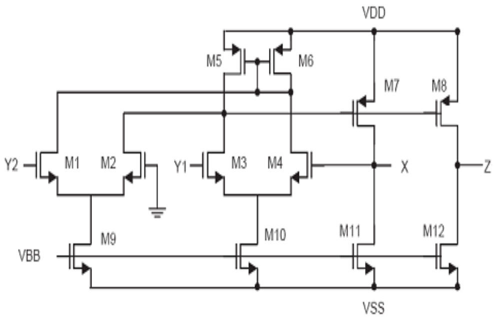

Fig.2. CMOS Implementation of DVCC

And its terminal relations are given by following matrix

$$\begin{bmatrix} I_{Y1} \\ I_{Y2} \\ V_X \\ I_Z \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} V_{Y1} \\ V_{Y2} \\ I_X \\ V_Z \end{bmatrix}$$

Translinear loop

This block is used to provide parasitic resistance in DVCCCTA and is shown in Fig.3. The parasitic resistance is controlled by bias current.

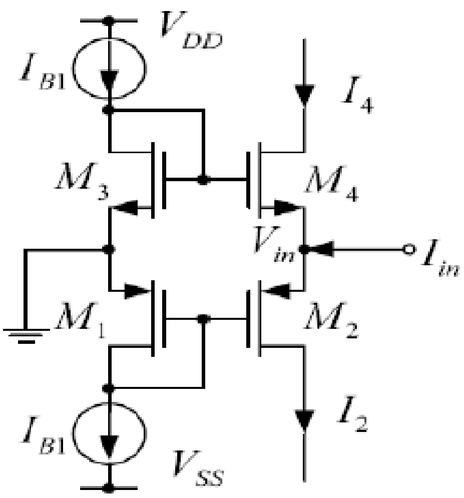

Fig.3 Class AB Translinear loop

Transconductance amplifier

The operational transconductance amplifier is a differential amplifier whose differential input voltage produces an output current. Thus, it is a voltage controlled current source (VCCS). The transconductance of the amplifier is proportional to the square root of bias current. This feature makes it useful for electronic control of amplifier gain. The block diagram and CMOS implementation of transconductance amplifier is shown in Fig. 4 and Fig. 5.

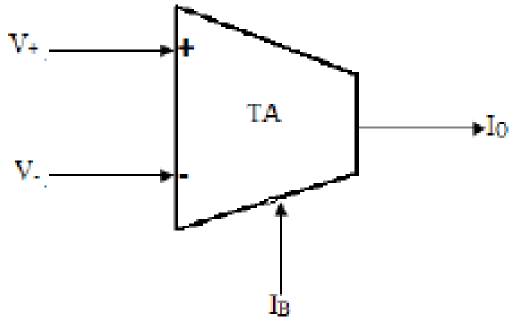

Fig. 4 Block diagram of Transconductance Amplifier

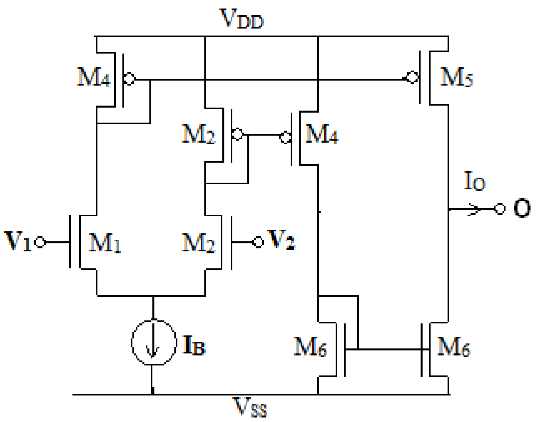

Fig. 5 CMOS Implementation of Transconductance Amplifier

The output current IO may be given as

$$I_O = g_m (V_1 - V_2)$$

$$\text{Where} \quad g_m = \sqrt{\mu_n C_{OX} \left(\frac{W}{L}\right)_{1,2} I_B}$$

II. DVCCCTA

Since DVCCCTA is consist of DVCC, translinear loop and Transconductance amplifier, so on combining the circuit diagram of Fig. 2, Fig.3 and Fig.5, the block diagram and CMOS implementation of DVCCCTA is shown in Fig.6 and Fig.7

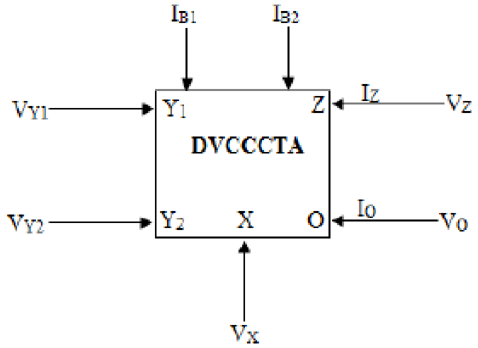

Fig.6 Block diagram of DVCCCTA

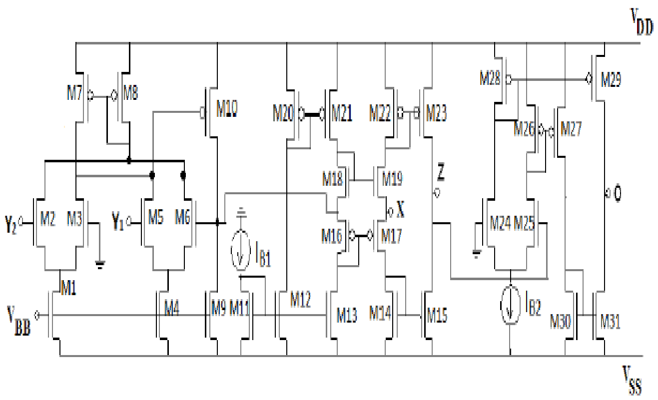

Fig.7 CMOS Implementation of DVCCCTA

In the Fig.7, the transistors from M1 to M10 forms DVCC, the transistors from M11 to M23 form translinear loop, while transistors from M24 to M31 form transconductance amplifier. The port relationships of the DVCCCTA can be characterized by the following matrix:

$$\begin{bmatrix} I_{Y1} \\ I_{Y2} \\ V_X \\ I_Z \\ I_O \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 1 & -1 & R_x & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & -g_m & 0 \end{bmatrix} \begin{bmatrix} V_{Y1} \\ V_{Y2} \\ I_X \\ V_Z \\ V_O \end{bmatrix}$$

And in equation form

$$I_{Y1} = I_{Y2} = 0, \quad V_X = V_{Y1} - V_{Y2} + I_X R_X, \quad I_Z = I_X, \quad I_O = -g_m V_Z$$

Where Rx is the intrinsic resistance at X terminal and gm is the transconductance from Z terminal to O terminal of the DVCCCTA. The values of Rx and gm depend on bias currents IB1 and IB2 respectively, which may be expressed as:

$$R_x = 1/(\sqrt{2\mu_n C_{ox}(W/L)_{18,19} I_{B1}} + \sqrt{2\mu_p C_{ox}(W/L)_{16,17} I_{B1}})$$

And

$$g_m = \sqrt{2\mu_n C_{ox}(W/L)_{24,25} I_{B2}}$$

III. COMPARISON WITH CONVENTIONAL OPAMP

The DVCCCTA is getting substantial consideration as they compromise analog designers some momentous advantages over the convention OPAMP. Some advantages are enumerated underneath:

i) It is a appropriate current and voltage mode device.

ii)This DVCCCTA building block is engaged in low sensitivity design.

iii)The supply voltage of integrated circuits can be reduced comparatively.

iv) Better ac performance with better linearity.

v)Smaller number of passive components to perform a specific function.

vi) Suitable for relatively higher frequencies.

IV. DVCCCTA APPLICATION

In the field of analog signal processing DVCCCTA can be applied through various method s such as filters [1-4], oscillators [5], mutual inductance [6] etc. DVCCCTA are extensively used as basic analog building blocks to realize current mode active filters. The universal filter is among the most popular analog filters as it can provide several standard functions like low pass, high pass, all pass, band pass, and notch. DVCCCTA is also helpful in the active network synthesis. They can be applied in various components realizations.

V. CONCLUSION

In this paper an over view of DVCCCTA has been revealed in terms of their configuration. Due to versatile characteristics and compatibility with several circuits we observe that DVCCCTA offers advantages over the conventional OPAMP such as gain bandwidth limitation, improved slew rate etc. Due to its low voltage low power characteristics the DVCCCTA is going to define an era in the field of electronics.

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