International Journal of Scientific and Technical Advancements

ISSN: 2454-1532

Performance of Current Controlled Current Conveyor based on Complementary Source Follower

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Abstract— Current mode circuits have found wide applications in low voltage analog circuits due to their inherent advantages over voltage mode circuits. The response of current mode circuits is completely determined by signal processing in current form with both input and output signals being in current form. Current conveyor is a current mode circuit that has gained importance in the past and has been extensively used for low voltage signal processing. However, it lacks in tunability and there is a voltage tracking error between input and output ports. These shortcomings have been removed in its improved version namely Current Controlled Current Conveyor. In this paper, we have presented a Current Controlled Current Conveyor based on complimentary source follower and its results have been obtained with PSpice simulations in 0.18nm Technology.

Keywords— Voltage mode; current mode; current controlled current conveyor.

I. INTRODUCTION

In In recent years designing of electronic circuits that can operate from low supply voltages has been gaining an increasing interests due to the fact that the battery operated portable devices require low power dissipation to increase battery life and minimum number of cells to reduce the volume and weight. For this reason the current mode technique is more suitable rather than the voltage mode technique. Also the current mode structures are more favorable because of their advantages such as, larger dynamic range, greater linearity, higher signal bandwidth and simple circuitry [1–2]. Current conveyors can be classified into three generations. First generation current conveyor, second generation current conveyor, CCII and third generation current conveyor, CCIII

First generation current conveyor CCI:**-** In 1968 a French Scholar A. S. Sedra and K. C. Smith presented the first generation current conveyor in which they showed that signal processing in current mode is much faster than in voltage mode[3]. The current conveyor circuit is basically an inner part of the op-amp, works in open loop mode, so as to provide higher frequency range of operation than the conventional op-amp and high input output impedance for cascading of the circuits. Basically a current conveyor (CC) is a three terminal device which are denoted by X, Y and Z as shown in fig.1. The terminals X and Y are the input signal terminals and Z is the output signal terminal. Port X is a hybrid port which acts as current signal input port and voltage signal output port. Port Y is a voltage signal input and current output port and port Z is a current signal output port which can sink or source current equal to the input current fed into port X. An ideal current conveyor must have zero input impedance at port X , infinite input impedance at port Y and infinite output impedance at port Z. Beside this it must have unity voltage transfer ratio between port Y and X and unity current transfer ratio between port X and Z, which shows the presence of current buffer between these terminals. The bandwidth for both voltage and current transfers should be ideally infinite which means the processing of signals do not depend on their frequency.

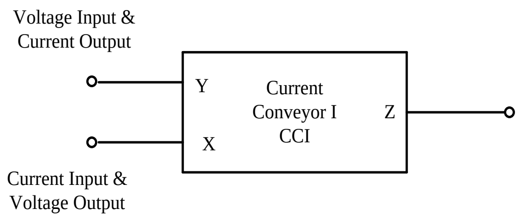

Fig. 1. Block diagram of CCI.

The terminal characteristics of CCI can be best represented by the following hybrid matrix giving the outputs of the three ports in terms of their corresponding inputs

$$\begin{bmatrix} I_Y \\ V_X \\ I_z \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & \pm 1 & 0 \end{bmatrix} \begin{bmatrix} V_Y \\ I_X \\ V_Z \end{bmatrix}$$

This gives the following results

$$I_X = I_Y = \pm I_Z$$

$$V_X = V_Y$$

Second generation current conveyor CCII**:-** In the year 1970, the improved version of the current conveyor was introduced by A.S Sedra and K.C Smith which was named as second generation current conveyor CCII [4] in which no current flows in terminal Y i.e $I_y = 0$ It consists of an operational amplifier and external PNP transistors. In 1996, A. Fabre et al proposed another improved version of second generation current conveyor (CCII) was presented in 1990 using an operational amplifier and external CMOS transistors [5]. But again the circuits have transistor mismatching and the performance is similar to that of operational amplifiers. This shows that the voltage mode operational amplifier is not necessarily the solution of all analog circuit design problems. All the analog circuit applications were being replaced by

Vinod Kumar, Rockey Gupta, Roshani Gupta, and Susheel Sharma, "Performance of current controlled current conveyor based on complementary source follower in 0.18nm technology," *International Journal of Scientific and Technical Advancements*, Volume 2, Issue 4, pp. 95-98, 2016.

current mode signal processing method using current conveyors. Further, due to high slew rate and wide bandwidth, these devices received popularity in video applications too. Nowadays Current conveyors are available in MOS technology is used for developing current conveyors ICs.

Third generation current conveyor (CCIII):- Third generation current conveyor was published by Sedra in 1995. It is similar to the CCI except that the current in X port and Y port flows in opposite directions. In this paper we have studied the performance of a complementary source follower of current controlled current conveyor in 0.18nm technology and found that these results agree well with the theoretical results.

II. CCCC Based on Complementary Source Follower

Number of circuit topologies for second generation current controlled current conveyor (CCCC) has been reported in literature like CCCC based on translinear loop, differential pair etc [8-11]. Here, we are presenting the simulation results of CCCC based on complementary source follower. The circuit of complementary source follower is shown in Fig. 2, where M1-M4 forms the core of the circuit and remaining MOSFETs are used for biasing purpose [8]. The circuit has small input impedance at port X, high input impedance at port Y and provides good linearity for voltage and current transfer characteristics. The resistance at port X of the circuit can be controlled by varying the bias current (I_b) applied to MOSFET M5. As evident from the Fig. 2, X is the input current port and output voltage port, Y is the input voltage port and Z is the output current port.

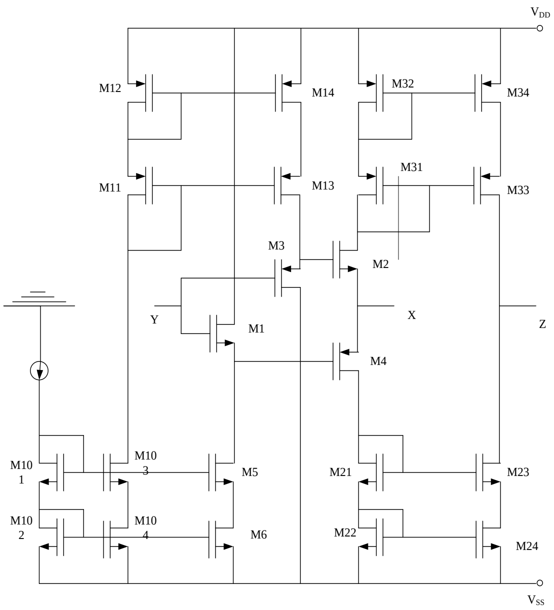

Fig. 2. CCCC based on complementary source follower.

III. Simulation Results

The circuit of CCCC based on complementary source follower shown in fig. 2 has been simulated by using level 3 PSpice parameters of 0.18 µm technology with supply voltages of ±0.5V by selecting W/L of M_{101}-M_{104} and M_5-M_6 as 0.54µm/0.18 µm, M_{11}-M_{14} and M_{31}-M_{34} as 5.4µm/0.18 µm, M_3-M_4 and M_{21}-M_{24} as 7.2µm/0.18 µm and M_1-M_2 as 0.9µm/0.18 µm. The current transfer characteristics are shown in figs. 3 and 4 while the voltage transfer characteristics are shown in figs. 5 and 6.

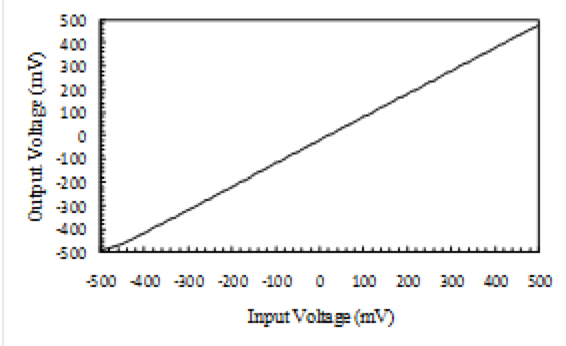

Fig. 3. Voltage Transfer ratio of CCCC.

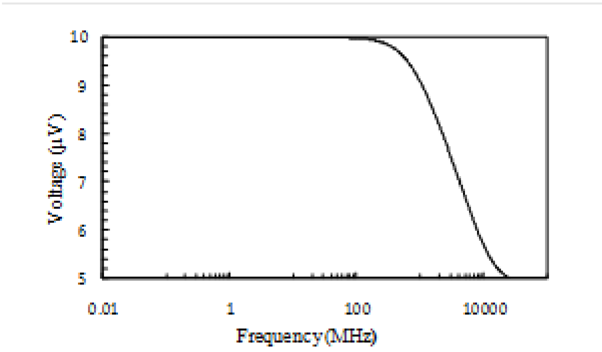

Fig. 4 Frequency response of voltage transfer of CCCC

From Fig. 3 and 4, the voltage transfer ratio has been found to be 0.9997. The input resistance at port Y has been found to be 10^{11}GΩ and the output resistance at port X has been found to be 3.8 K Ω with a bandwidth of 3.96 GHz.

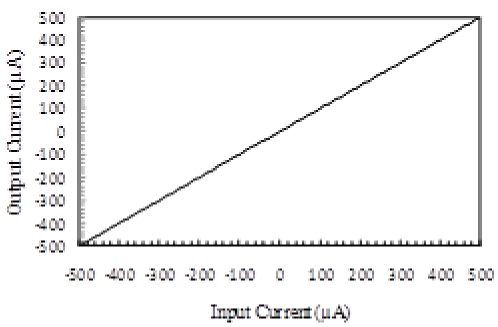

Fig. 5. Current transfer ratio of CCCC.

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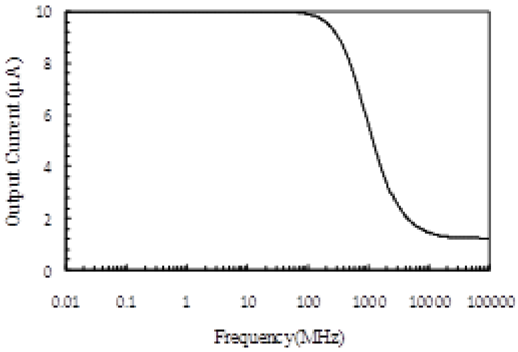

Fig. 6. Frequency response of current transfer of CCCC.

From Fig. 5 and 6, the current transfer ratio has been found to be 1. The input resistance at port X has been found to be 3.8 KΩ and the output resistance at port Z has been found to be 500 G Ω with a bandwidth of 681.29 MHz.

IV. Conclusion

In this paper, we have designed a current controlled current conveyor (CCCC) based on complimentary source follower. . The voltage transfer ratio of the given circuit has been found to be 0.9997 with a bandwidth of 3.96 GHz.The current transfer ratio has been found to be 1 with a bandwidth of 681.29 MHz. The simulation results have been obtained using PSpice simulations in 0.18nm Technology with the supply voltage of ±0.5 V.

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