Scientific Journal of Impact Factor(SJIF): 3.134

e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 4, April -2015

Simulation and Analysis of First and Second Generations of Current Conveyor using 90nm CMOS Technology

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Abstract —*Current conveyors are unity gain analog building block having high linearity, provide higher gain-bandwidth product and wide dynamic range. The current conveyor is a combination of voltage as well as current follower. The current conveyors operate at low voltage supplies and consume less power. Current Conveyor structure is very simple. The First and Second Generation current conveyors are simulated using 90nm CMOS technology. The main features of these current conveyors are low voltage, less power dissipation, high linearity and wide bandwidth for voltage transfer (Vy to Vx) and current transfer (Ix to Iz) which make them suitable for high frequency and low power applications.*

Keywords- CCI, CCII, current conveyor, current mirrors, current mode circuit

I. INTRODUCTION

If supply voltage and device threshold voltage reduced in CMOS technology, the performance of CMOS voltage mode circuits has greatly affected which results in a reduced dynamic range and an increased power dissipation. Current Conveyors represent the emerging class of high performance analog circuit design based on current mode approach and have simpler architecture, provides better dynamic ranges and operate at lower voltages than their voltage mode circuits. In Current Conveyors, the use of current rather than voltage as the active parameter.

Current Conveyor was introduced by Sedra and Smith in 1968 and 1970. The Current Conveyors have simple architecture, capability to operate at low voltage, and wide bandwidth. It also have unity current and voltage gain, better good frequency performance, higher linearity and wider dynamic rang.

The current conveyor is a grounded three-port network represented by the block representation. with the three ports denoted by X, Y, and Z.

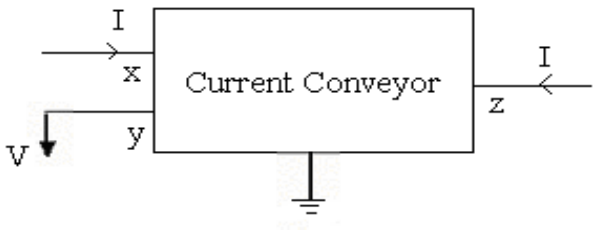

Figure.1 Block Representation of the Basic Current Conveyor [8]

The current conveyors can be classified into three generations.
1. First Generation Current conveyor (CCI)
2. Second Generation Current conveyor (CCII)
3. Third Generation Current conveyor (CCIII)

II. FIRST GENERATION CURRENT CONVEYOR

First Generation Current Conveyor are denoted by CCI±, where "±" specify the direction of the output current. It is basically a three terminal device as shown in figure 2. The relation between the terminal voltage and current of CCI can be given by the following matrix relation,

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

From the above matrix, applied potential at port Y then same voltage will appear at port X and this voltage is independent of current supplied to port X. Also, the current flows through port Y is equal to the current supplied to port X and this current is independent of voltage at port Y, the current supplied to X is also conveyed to the output port Z, port Z has a high impedance level. The impedance level at different ports of first generation current conveyor is listed in table 1.

Table 1: Impedance level at ports of CCI

CCI Ports	Impedance Level
X	Low (ideally zero)
Y	Low (ideally zero)
Z	High (ideally infinite)

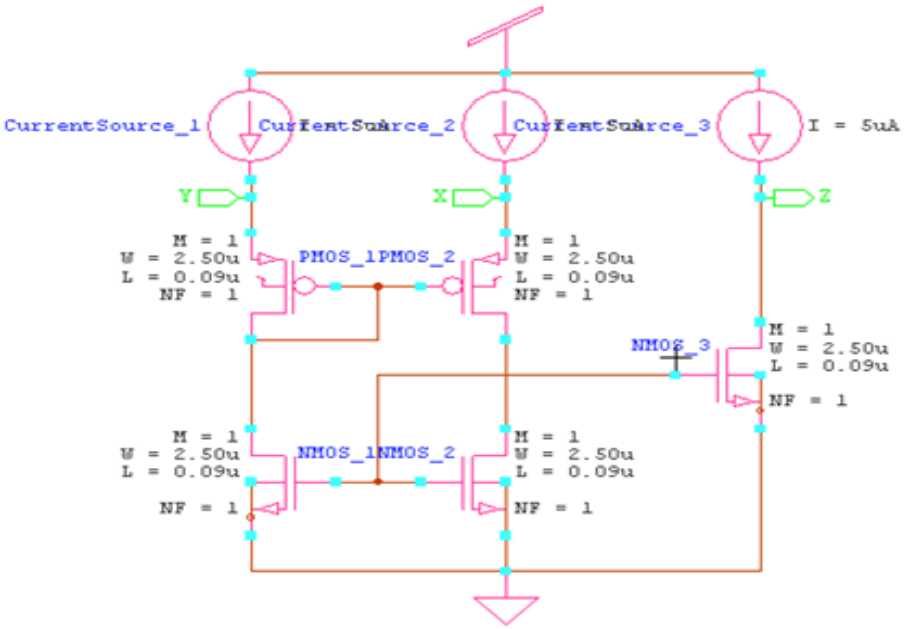

Figure 2 CMOS implementation of the CCI

- NMOS transistors NMOS_1 and NMOS_2 form a current mirror that forces the drain currents of the PMOS transistors PMOS_1 and PMOS_2 to be equal and hence the voltages at the terminals X and Y are forced to be equal.
- The biasing current of the circuit plays an important role in determining the power consumption and the resistance at port X. So it is set to 10μA in order to meet the desired specifications

Simulation Results of CCI:

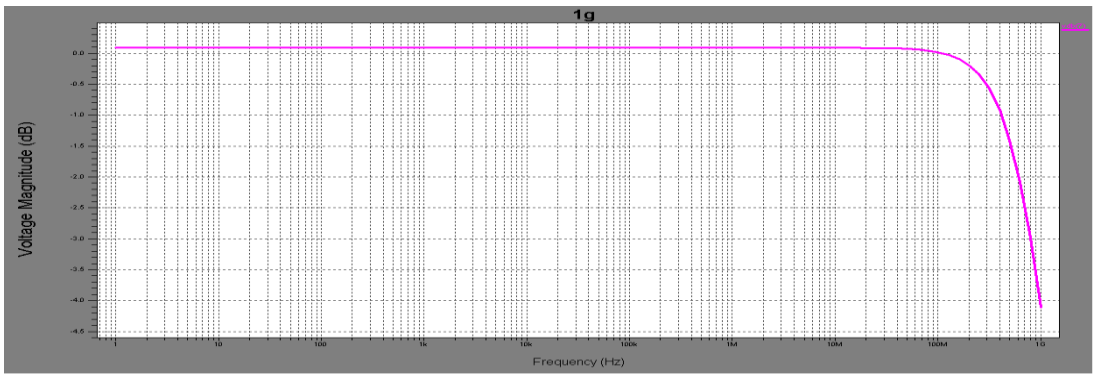

Figure 3 voltage gain of CCI

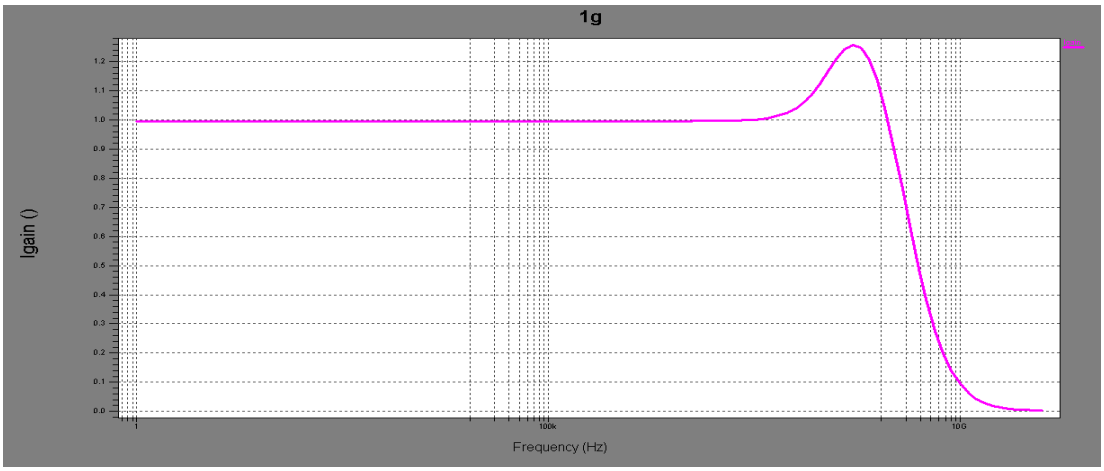

Figure 4 current gain of CCI

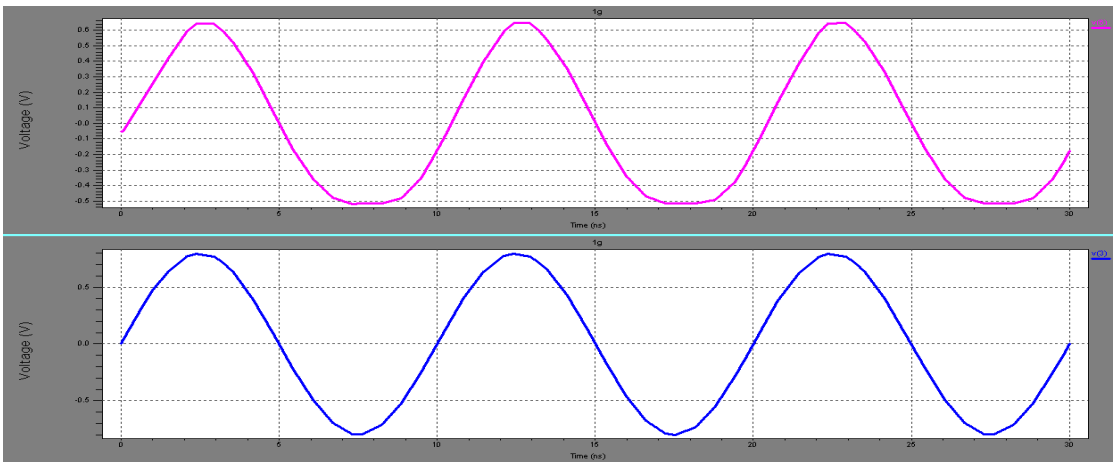

Figure 5 Voltage transfer characteristics by applying a sine wave of CCI

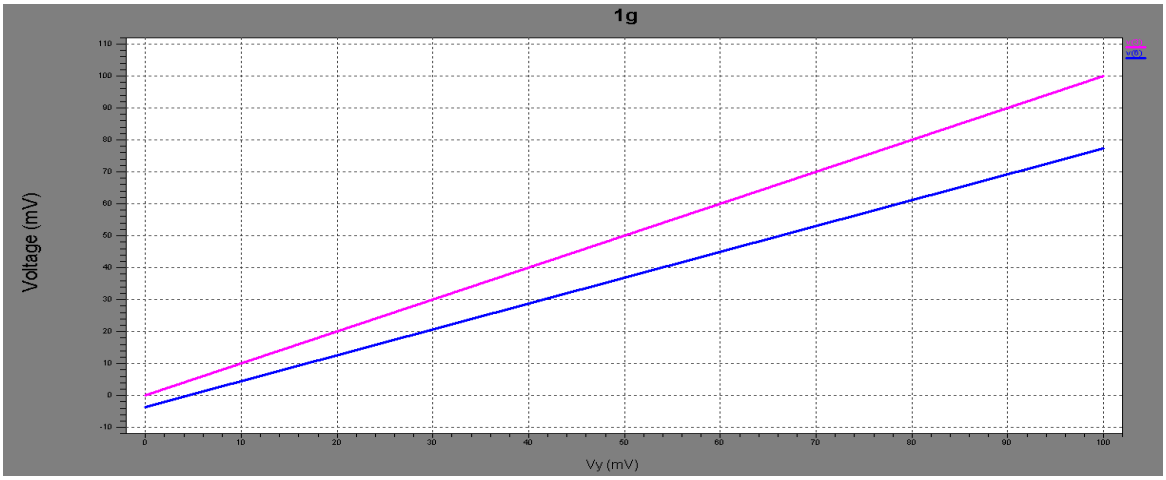

Figure 6 Linearity between Vx and Vy of CCI

Both the port X and Y have zero input impedance in order to sink currents so, the application of CCI becomes difficult. The port Y needs to control a current which has zero impedance, which is usually difficult to obtain in practical designs. This is the greater limit of the CCI structure and this reduces its flexibility and versatility.

III. SECOND GENERATION CURRENT CONVEYOR

The second generation current conveyor (CCII) is one of the most versatile current-mode building blocks. For many applications, in oreder to avoid loading effect a high impedance input port is preferable. So, second generation current conveyor developed to fulfill this requirement. It has one high and one low impedance at input port rather than the two low impedance at input ports of CCI. The CCII can be considered as the basic analog circuit design block because all the active devices can be made of a suitable connection of one or two CCIIs. The relation between the terminal voltage and current of CCII can be given by the following matrix relation,

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

Second Generation current conveyor different from the first generation Current conveyor because of the port Y is a high Impedance port i.e. there is no current flowing into Port Y. The port Y of the second generation current Conveyor is used as a voltage input and port Z is used as a current output port. Whereas, the port X can be used as a voltage output or as a current input port. Therefore, this current conveyor can be used to process both voltage and current signals. There are two types of second generation current conveyors:

1. CCII+ (Positive current conveyor) in which the Currents ix and iz have the same direction as in a current mirror.
2. CCII- (Negative current conveyor) in which currents ix and iz have the different direction as in a current buffer.

The impedance level at different ports of Second generation current conveyor is listed in table 2.

Table 2: Impedance level at ports of CCII

CCII Ports	Impedance Level
X	Low (ideally zero)
Y	High (ideally infinite)
Z	High (ideally infinite)

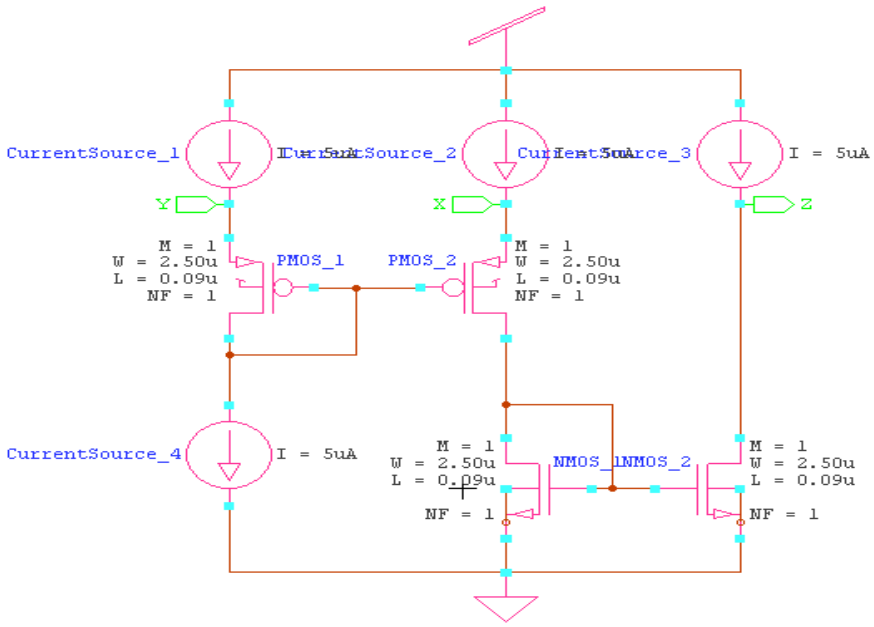

Figure 7 CMOS implementation of the CCII

Simulation Results of CCII:

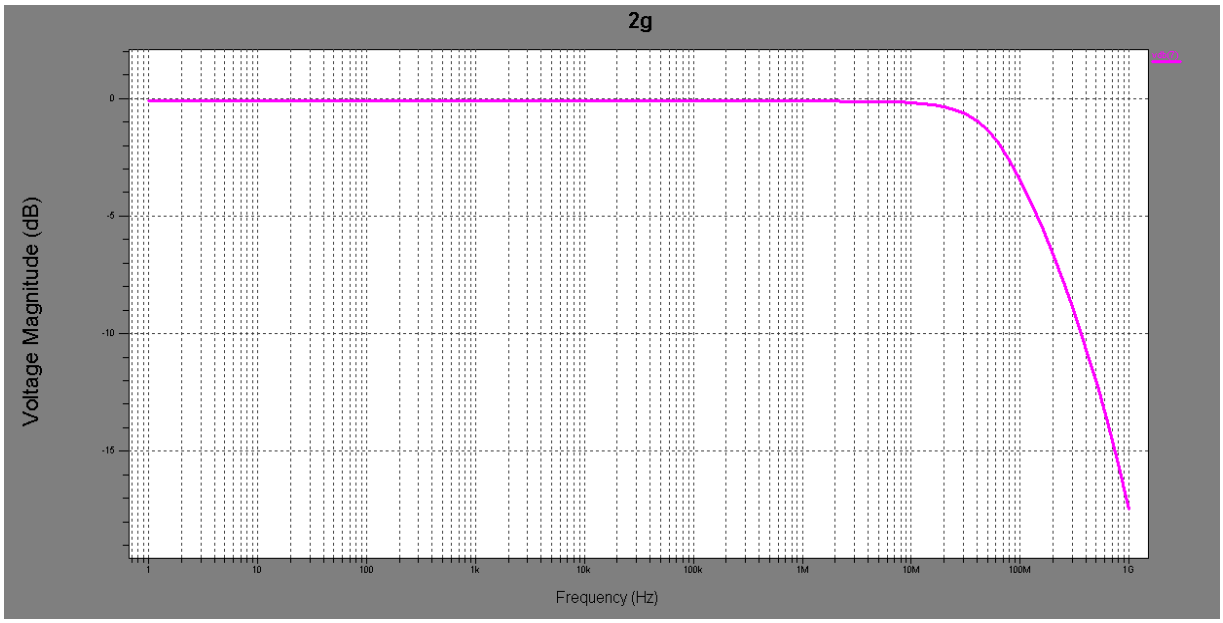

Figure 8 voltage gain of CCII

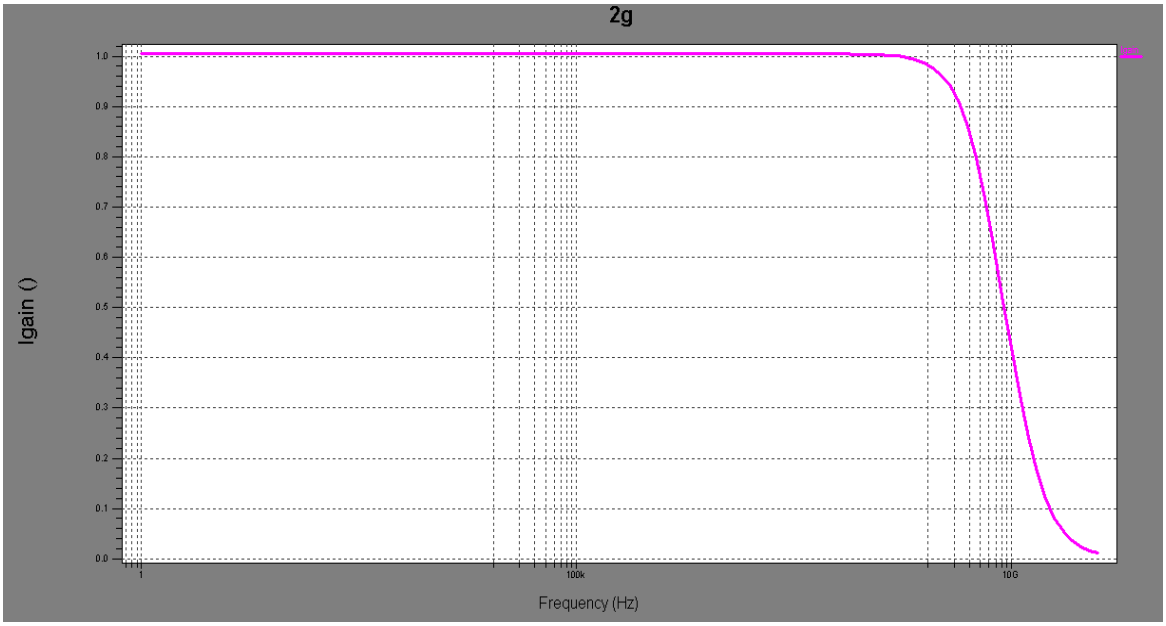

Figure 9 current gain of CCII

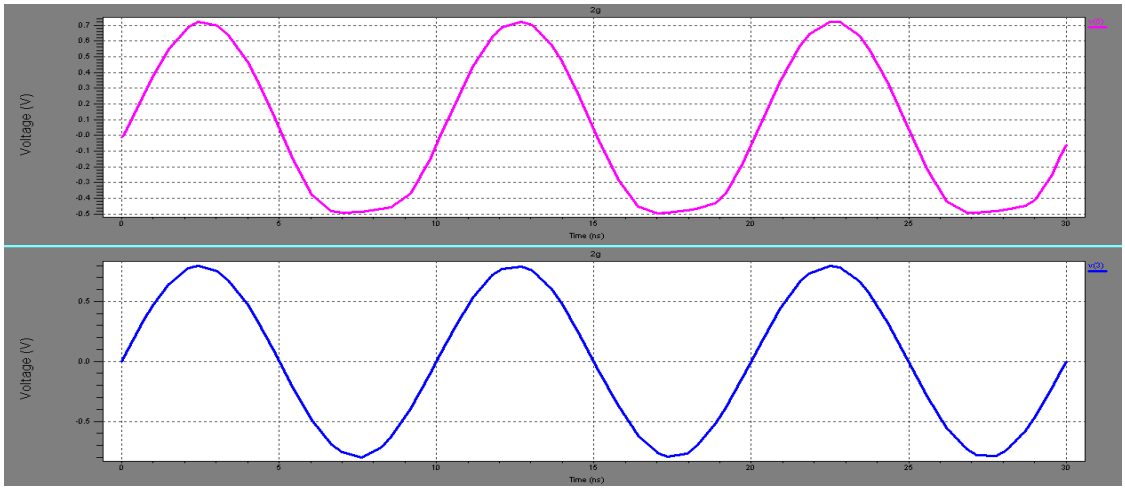

Figure 10 Voltage transfer characteristics by applying a sine wave of CCII

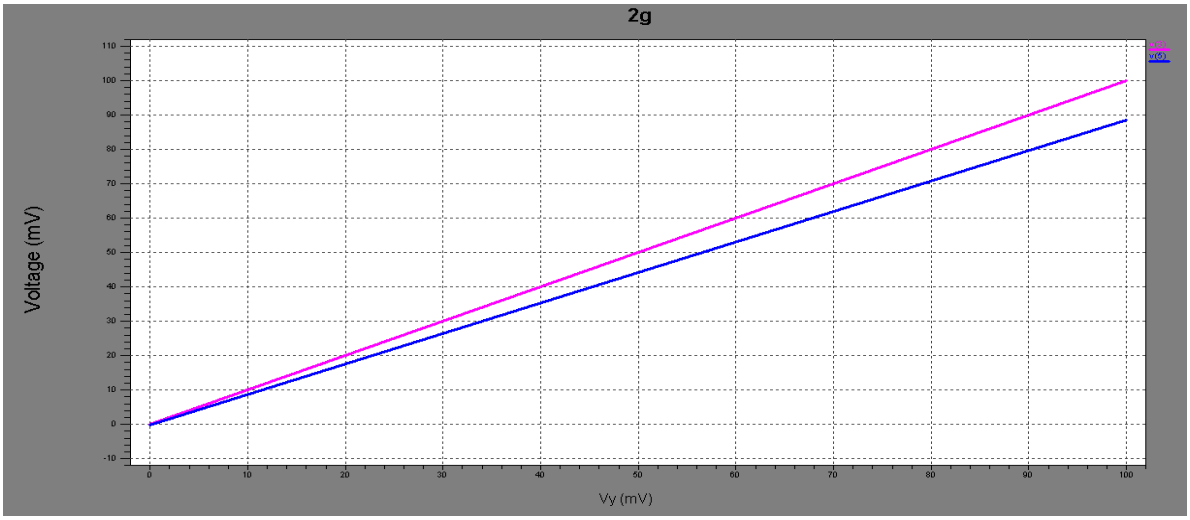

Figure 11 Linearity between Vx and Vy of CCII

IV. SUMMARY OF MEASUREMENT RESULTS

Table 3: Output Results

Parameters	CCI	CCII
Technology	90nm	90nm
Supply Voltage	1V	1V
Bias Current	10µA	10µA
Current Gain	1.02	0.9
Voltage Gain	0.09dB	0.05dB
Current Bandwidth	2.2GHz	5GHz
Voltage Bandwidth	552MHz	710MHz
Delay	125Ps	80.5Ps

CONCLUSION

CMOS Current Conveyors for high frequency applications have been presented. Current conveyor, namely, First and Second Generation Current Conveyor has been analyzed using 90nm CMOS technology process parameters. the circuit First and Second provides the current bandwidth of 2.2GHz and 5GHz respectively, These current conveyors provide unity current gain and unity voltage gain over a wide range of frequency hence this circuit can be used for high frequency applications. The excellent current following action is also achieved from input port to the output port.

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