Ameliorated Structure of Current Controlled Conveyor [CCCII] and it's Performance Analysis

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Abstract
This paper deals with multiple output current controlled conveyor [MOCCC] and a new structure of "Second generation Current Controlled Conveyor [CCCII]" is also presented which is known as ameliorated structure of CCCII. This paper also deals with the performance analysis of ameliorated CCCII over conventional Current Conveyor. With new structure of CCCII both static and dynamic performances are improved. Thanks to an objective function which maximizes current bandwidth of new CCCII. The ameliorated structure presents current bandwidth of 46.878MHz as compared to 10.771MHz for conventional CCCII. A Pspice simulation using bipolar technology with Q2N2222 for NPN and Q2N2907 for PNP transistor models is presented which demonstrate the results.

Keyword
MOCCC, Ameliorated structure of CCCII.

1. INTRODUCTION
The second generation current controlled conveyor (CCCII) is the op-amp equivalent in current mode signal processing [1], [5], [6]. Wide band capability, wide dynamic range under low power operation, precise outputs &unity gain over wide band are the key features of CCCII, for these reasons current conveyor as active element received great attention in recent years as an alternative to classical voltage mode operational amplifiers. CCCII is very useful in current mode signal processing than its voltage mode counter parts, such as in Function Generators, Oscillators & Universal Filters etc.

2. CURRENT CONVEYOR
The common representation of a multiple output current controlled conveyor [MOCCC] is depicted in following fig.1-

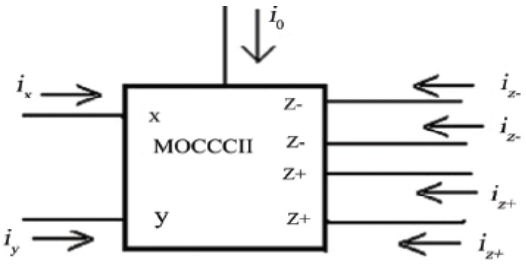

Fig 1 - General representation of multiple output current controlled conveyor.

Where the relation between terminal voltage & current can be given by the following matrix equation.-

$$\begin{bmatrix} i_Y \\ v_X \\ i_Z \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & \pm 1 & 0 \end{bmatrix} \begin{bmatrix} v_Y \\ i_X \\ v_Z \end{bmatrix}$$

Above shows-

$$I_Y=0, \quad V_Y=V_X \quad I_Z=+I_X \text{ or } -I_X \qquad \text{eq.(1)}$$

From above matrix equation (1) it is clear that no current flows into its input terminal Y. In above matrix equation (1) the + sign denotes the positive X-to-Z current transfer of the positive current conveyor CCCII+ and the - sign determines the negative X-to-Z current transfer of the negative current conveyor CCCII-.

3. IMPROVING CURRENT CONTROLLED CONVEYOR
An implementation of conventional current conveyor with multiple outputs [MOCCC] can be shown in following figure.2

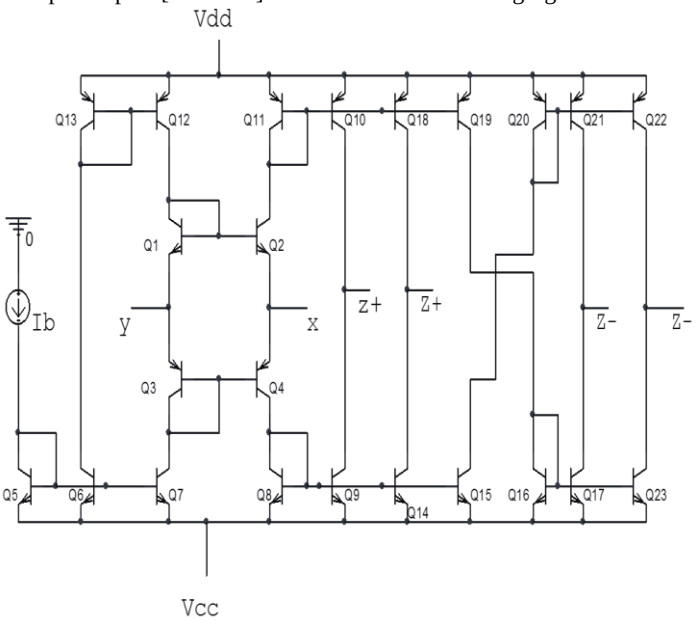

Fig.2-Structure of multiple output conventional current controlled conveyor [MOCCC].

Where in above figure.2 there are two outputs of MOCCCII in the form of Z^+ terminals which can be found after current mirroring from X terminal, and similarly there are two outputs in the form of Z^- terminals which can be found after cross connecting with Z^+ terminal.

So there is another advantage of CCCII is that a number of outputs can be found from a single output using current mirroring property.

Now only the single output (Z^+) will be used [and will show Z in the place of Z^+] of multiple output current controlled conveyor [MOCCC] for simulation as shown below in fig.3-

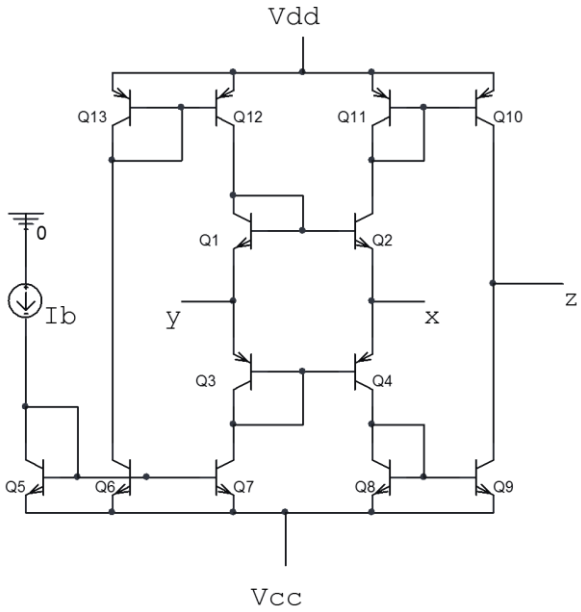

Fig.3-Conventional structure of Current controlled conveyor.

Following Table1 shows the simulation condition, for the analysis of conventional current conveyor.

TABLE-1

TECHNOLOGY	Q2N2222 FOR NPN Q2N2907 FOR PNP
SUPPLY VOLTAGE	+2.5V ON V_{DD} -2.5V ON V_{CC}
BIAS CURRENT [I_B]	1mA

Simulation result-

To prove the performances of the conventional CCCII the Pspice simulation program was used. Following fig4 shows the current i/p & o/p characteristics between terminal X and Z+, which shows an excellent current following action over the wide current range. Again the transfer characteristics between terminal Y&X can be shown in fig5 which exhibits a linear one to one voltage following characteristics. Following two figures also verifies equation (1).

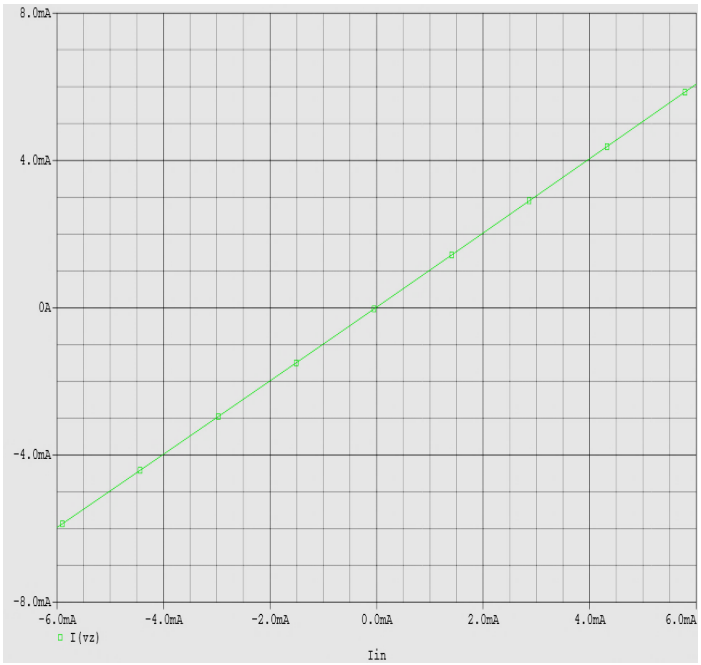

Fig.4-The current i/p &o/p characteristics between terminal X &Z^+

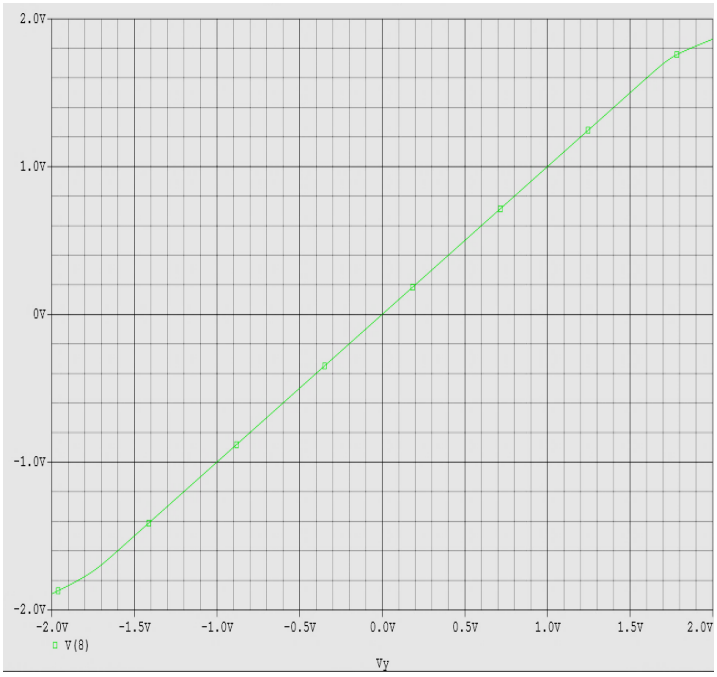

Fig.5-The voltage i/p& o/p characteristics between terminals Y&X

Finally frequency characteristics of the conventional current conveyor can be presented. Small signal current gain characteristics between terminal Z+ and X are simulated, & the result can be shown in following fig.6

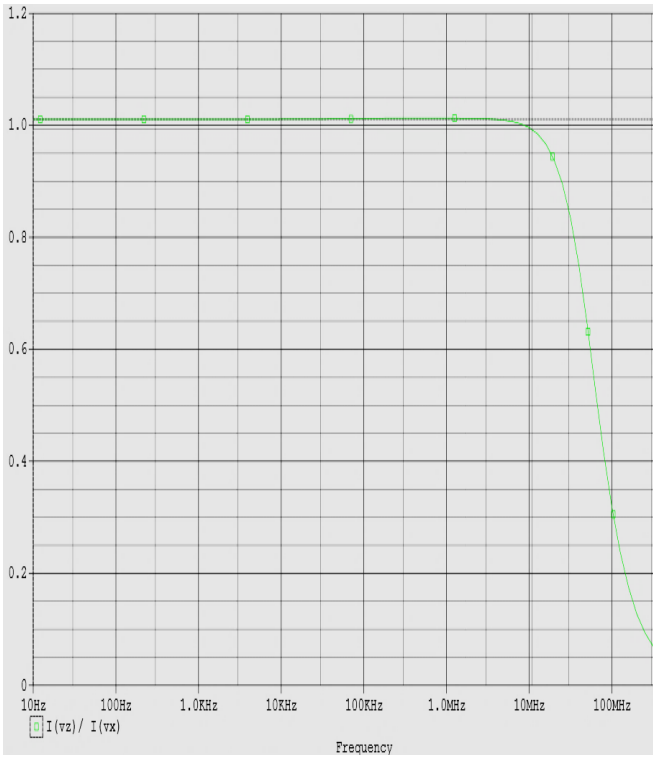

Fig.6-Frequency response of current gain between X & Z^+

From above fig.6 it is clear that, the static current is close to unity. In addition this configuration gives high current cut-off frequency. This is about 10.771MHz.

Following Table2 shows conclusion of conventional CCCII parameters.

TABLE-2

PARAMETERS	OBTAINED RESULT
Supply voltage	+2.5V ON V_{DD} -2.5V ON V_{CC}
Bias Current	1 mA
Current gain between Z&X port	0.992
Current bandwidth	10.771MHz

Now to optimize performances of conventional structure, a Heuristic proposed in [2] can be used. In fact, the Heuristic is an algorithm driven methodology which consists of minimizing X port input resistance value, maximizing Y and Z ports resistance values, maximizing high cut off current frequency and minimizing noise effect. For this purpose, an objective function (OF) is built, It is a weighted sum of error and performance functions [3].The basic idea of the ameliorated structure[4] consists of separating the voltage following path from one of the current follower one. This is done by using a new signal path for the current transfer between X & Z ports.

4. AMELIORATED STRUCTURE OF CCCII

The ameliorated structure is depicted at fig.7 as shown below-

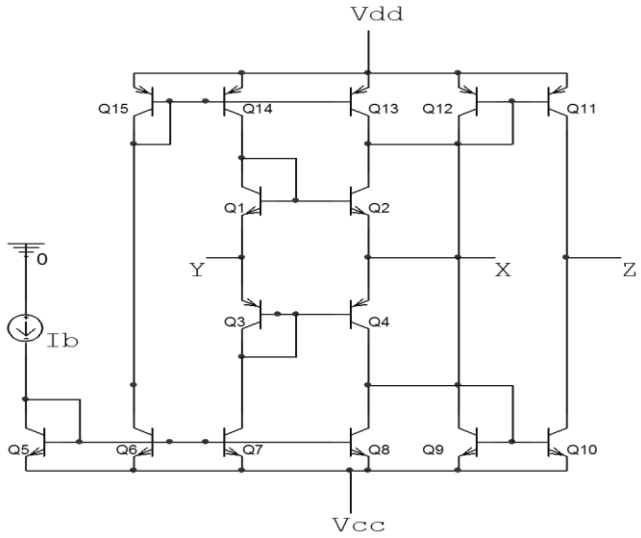

Fig.7-Ameliorated structure of CCCII

Table1 shows the simulation condition for the analysis of ameliorated structure of CCCII.

Simulation result-

Following graphs shows the comparative study of conventional current conveyor & ameliorated structure of current conveyor. In all the following graphs B [green line] shows the result for ameliorated structure and A [red line] for conventional structure of current conveyor. Following fig.8 shows the current i/p & o/p characteristics between terminal X&Z^+ & fig.9 shows transfer characteristics between terminal Y and X.

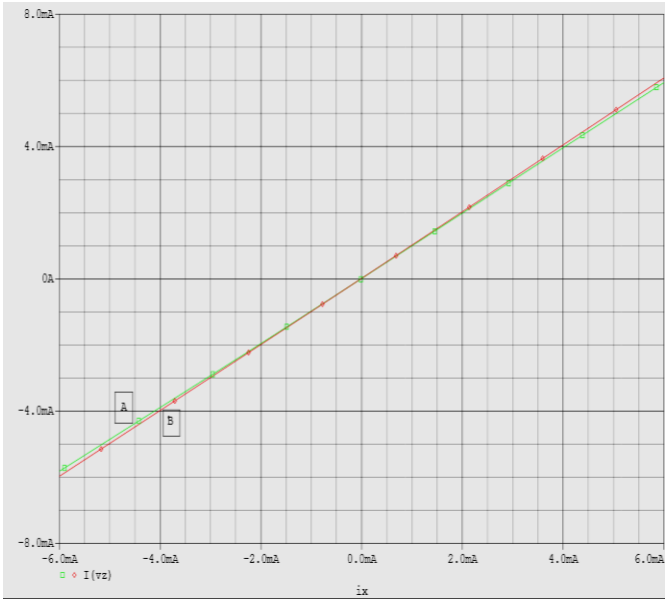

Fig.8-The current i/o & o/p characteristics for both the structures Between terminals X&Z^+

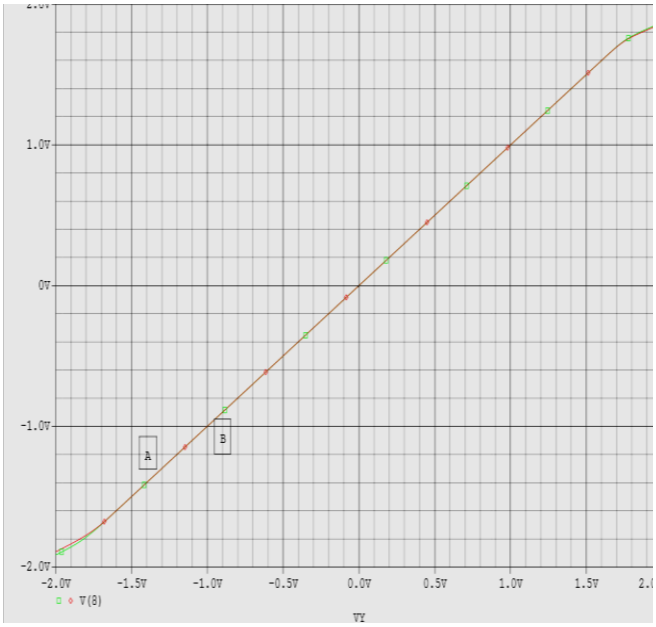

Fig.9-The voltage i/p& o/p characteristics for both the structures Between terminals Y& X.

From above two graphs it is clear that ameliorated structure also follows equation (1), because both lines A& B overlaps on each other.

Finally frequency characteristics for both the structure can be presented & it can be shown in fig.10 that the current bandwidth for the ameliorated structure is increasing, simulated result also verifies Ameliorated structure and shows that current bandwidth for ameliorated structure is about 46.878MHz.

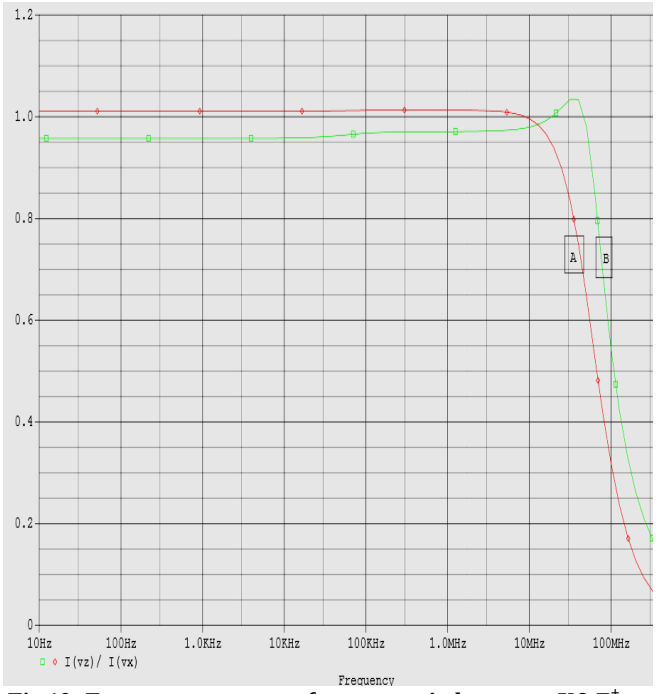

Fig.10 -Frequency response of current gain between X&Z^+ for both structures.

Following Table3 shows comparative conclusion of ameliorated and conventional CCCII structures-

TABLE-3

PARAMETERS	OBTAINED RESULT FOR AMELIORATED STRUCTURE	OBTAINED RESULT FOR CONVENTIONAL STRUCTURE
Supply voltage	+2.5V ON V_{DD} -2.5V ON V_{CC}	+2.5V ON V_{DD} -2.5V ON V_{CC}
Bias Current	1 mA	1 mA
Current gain between Z&X port	0.995	0.992
Current bandwidth	46.878MHz	10.771MHz

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5. CONCLUSION

In this paper multiple output current controlled conveyor [MOCCC] is introduced and the characteristics of CCCII is presented. A new structure of CCCII known as ameliorated structure of CCCII & its improved performance over conventional CCCII is shown and above all results are also verified by PSPICE simulation. The ameliorated structure presents a good building block for design of universal filters, function generators and oscillator etc.

Using conventional structure of current conveyor we solved the drawback of OPAMP and with ameliorated structure we improve the performance of conventional structure now using different transistor parameters or using CMOS technology we can further increase current bandwidth.

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