

Novel Techniques for Implementing Low Voltage Low Power and High Bandwidth Current Conveyors

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Abstract - This paper gives an overview of current conveyor and its various generations in terms of its historical evolution along with possible techniques for improvements in their performance. The techniques for designing low voltage and low power configuration are discussed in brief which can be utilized in performance improvement of several current conveyor based devices. Some techniques for bandwidth enhancement and for high frequency operation are also mentioned which will be boom in the field of filter designing.

Keywords — Current Conveyor (CC II), Current Mirror (CM), Operational Amplifiers (OA), Differential voltage current conveyor (DVCC), CMOS realization.

I. INTRODUCTION

The first work that came into light in the field of current conveyor took place in 1966. Basically that research work was oriented towards design of programmable instruments for merging in a system for computer controlled experiments. At the time of introduction of current conveyor (in 1968), it was not clearly mentioned that what advantages it can offer over conventional building blocks. After so many research works on performance improvement of current conveyor in terms of their low voltage, low power and high frequency operation, these novel building blocks have proven their usefulness. There has been remarkable progress in the circuit implementation of current conveyors as a key element because of its low voltage low power characteristics and wide dynamic operating range. We can achieve these low voltage and low power operation characteristics by negotiating between different parameters of the current conveyor. The high frequency operation can be obtained by making small modification in existing circuit configuration. These compromises may vary in various configurations of the different generation's current conveyors. The current conveyors have also been extremely successful in the development of an instrumentation amplifier which does not depend critically on the matching of external components, instead depends only on the absolute value of a single component. It can also provide better common mode rejection ratio in instrumentation amplifiers than op-amps. The current conveyor offers an alternative way of abstracting complex circuit functions, thus aiding in the creation of new and useful implementations. The current conveyor is categorized into three generations namely first generation current conveyor (CCI), second generation current conveyor (CCII), and third generation current conveyor

(CCIII) based on their circuit configuration and characteristics.

II. GENERATIONS OF CURRENT CONVEYOR

The first generation current conveyor (CCI) was a 3-port device. In the figure shown below these ports can be identified as port Y, port X, and port Z respectively.

If a voltage is applied to terminal Y, same potential will appear on the input terminal X. An input current I being forced into terminal X will result the same amount of current flowing into terminal Y.

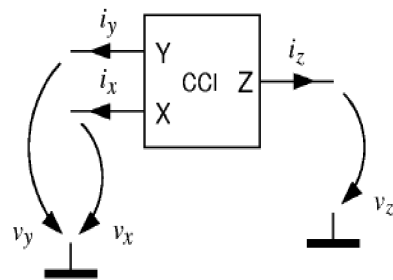


Fig.2.1. Block diagram representation of CCI

The current I will be conveyed to output terminal Z such that terminal Z has the characteristics of a current source, of value I , having high output impedance. Potential of X being set by that of Y, is independent of the current being forced into port X. Current through port Y being fixed by X is independent of the voltage applied to Y [4]. Nullator-norator representation of first generation current conveyor is shown in the following fig.

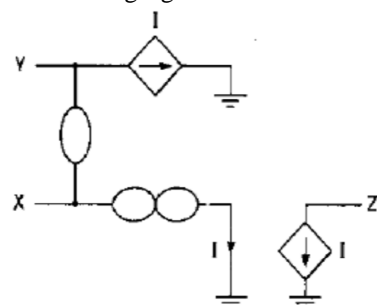


Fig.2.2. Nullator- norator representation of CCI

To enhance the versatility of the first generation current conveyor, a second version was introduced in 1970. The block diagram for the second generation current conveyor was almost similar to the first generation current conveyor except having the change, there was no current flow in

terminal Y. Thus, terminal Y exhibits infinite input impedance. The voltage at X follows that applied to Y, thus X exhibits zero input impedance. The current supplied to X is conveyed to the high impedance output terminal Z where it is supplied with either positive polarity (in CCII+) or negative polarity (in CCII-).

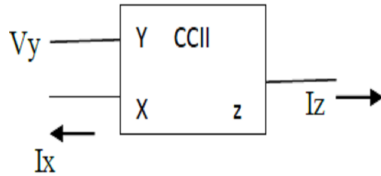


Fig.2.3. Block diagram of CCII

When the currents flowing in the terminals Z and X are in the opposite direction then current conveyor is denoted as negative current conveyor. If the currents flowing in the terminals Z and X are same in the direction then the current conveyor is denoted as positive current conveyor [2,4].

Third generation current conveyor (CCIII) has been proposed by Fabre in 1995. Third generation current conveyors (CCIIIs) can be considered as current controlled current sources with a unity gain consisting of four ports. This type of current conveyor is useful to take out the current flowing through a floating branch of a circuit and can be utilized in various multifunction filters, inductance simulation and active filters. The main features of the CCIII are low gain errors (high accuracy), high linearity and wide frequency response [3].

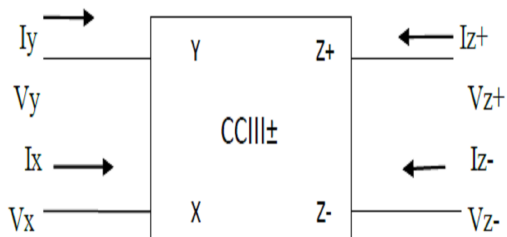


Fig.2.4. Block diagram representation of CCIII

III. DESIGN METHODOLOGIES FOR LOW VOLTAGE LOW POWER CONFIGURATIONS

The explosive growth of portable battery oriented devices in electronics industry has enhanced the demand for low power techniques which can operate at decreased supplies so that battery lifetime can be improved. Low voltage low power techniques are very useful in various applications such as pace-makers, blood flow-meters, hearing instruments, pagers, cellular phones etc.

The term 'low voltage' is applied for the circuits that can operate at a supply voltage of $2V_{TH} + 2V_{DSAT}$. On other hand the very low voltage circuits have to operate at supply voltage of $V_{TH} + V_{DSAT}$. While designing the low voltage configurations we should take care of following aspects

(1) Current consumption in CMOS circuits is directly proportional to the square of the supply voltage. (2) In low

voltage design there should be an efficient use of the supply voltage range.

In analog circuits, it is not compulsory that decrease in the supply voltage must reduce the power consumption. For this particular case the 'folding' technique should be used in place of conventional 'stacking' of transistors. Low power configuration is characterized by an efficient use of the supply current. By keeping the biasing current in the μA range, we can generally obtain reduced power consumption [6].

IV. BANDWIDTH IMPROVEMENT IN CURRENT CONVEYOR

In first generation current conveyors if we keep the transistors size smaller then we can achieve wider bandwidth of operation [7]. Another important aspect is a small decrease of biasing currents can reduce circuit dissipation, which demotes circuit performance, bandwidth and dynamic range [8]. If we increase the polarization current in traditional class AB CCII, the bandwidth also increases. Although, on other hand the input impedance decreases with this increase, which can result in oscillatory behaviors.

In second generation current conveyors for bandwidth enhancement there is an optimum value for the dimensions of the transistors. The parasitic capacitances limit the bandwidth for the values beyond an optimum width of transistors in the translinear loop (M1 to M4 in traditional class AB CCII).

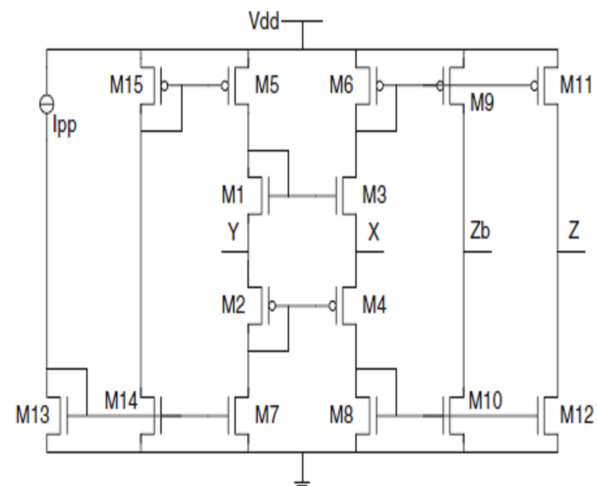


Fig.4.1. Traditional second-generation current conveyor

These transistors sizes should be greater than the transistors used in current mirror (in the traditional class AB CCII) [9].

Another method to achieve wide bandwidth is reducing the compensating capacitors. If implementation of current conveyor with current mirrors is done with smaller number of transistors, circuit operation is allowed at higher frequencies [10]. Use of cascode configurations also helps in improving bandwidth and gain.

V .CONCLUSION

In this paper, we have presented the various techniques to design a novel current conveyor configuration. The mentioned methodologies discussed here, are to achieve low voltage, low power and high bandwidth operation. A brief introduction of current conveyors has also been mentioned in terms of their different generations as their historical development from their time of introduction. The above ideas can be tested on PSPICE/HSPICE and can be used in designing of improved current conveyor based devices.

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