On various generations and different applications of Current Conveyors

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Abstract — many of electronic systems uses active devices like operational amplifiers, operational Transconductance amplifier uses voltage mode of operations, which have their own advantages and disadvantages. Now a day, current mode of operation is playing a vital role as compared to voltage mode of operation. In this paper, a survey on various generations of the current conveyor is conducted. It has been observed that second generation current conveyor is the most widely used one. The mathematical analysis of the second generation current conveyor is performed. Some of the applications of the current conveyor are explained with illustrations. It has been observed that using second generation current conveyors low power applications can be designed. The simulations are carried out using MULTISIM.

Index Terms — Current mode, Current conveyor, Bandwidth, Second generation Current conveyor, Applications, Low Power.

1. INTRODUCTION

Many of the analog circuits uses voltage mode of operation. They suffer from the disadvantage of Lower Bandwidth [1], [2], [3]. So many of the signal processing operations will be carried out at Lower Frequencies. But many of the applications like Bio-medical, cellular phones need low-voltage, low-power operation. It is very difficult to design a circuit to have wide dynamic range and high linearity [4], [5].

Recently, current mode circuits have become an alternative to voltage mode circuits because of their advantages. The main advantage of using current mode technique is for a fixed supply voltage, the dynamic range of a current mode circuit is much large than that of a voltage mode circuit. A second advantage of current mode circuits is their fastness. In a current mode circuit, the parasitic capacitances do not affect the circuit [7].

Keeping the advantages of current conveyors into account in this paper a survey is carried out. The paper concentrates on the various generations of current conveyors, which is discussed in Section 2. The mathematical analysis of current conveyor is discussed in section 3. Some of the applications of the current conveyor are discussed in section 4. Conclusions are presented in section 5.

2. GENERATIONS OF CURRENT CONVEYORS

2.1 First current conveyor: CCI

The current conveyor is a 3-port device whose black-box representation is show in figure 1.

2.2 The Second Generation Current Conveyor: CCII

The second generation current conveyor is as shown in Fig.2. It is defined by the following matrix [8], [9].

\[
\begin{bmatrix}
I_x \\
V_x \\
I_z
\end{bmatrix} =
\begin{bmatrix}
0 & 1 & 0 \\
1 & 0 & 0 \\
0 & 1 & 0
\end{bmatrix}
\begin{bmatrix}
V_x \\
I_x \\
V_z
\end{bmatrix}
\]

(1)

It is very expensive to fabricate first generation of current conveyors.

In current conveyor the voltage and current at terminal X and Y will be same. The current I will be conveyed to the output terminal Z such that terminal Z has the characteristics of a current source, of value I, With high output impedance. So, it can be noticed that there is a virtual short circuit between X and Y terminals. The input-output characteristics of CCI can be described by the following equitation.

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\end{bmatrix}
\]

(1)

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\[
\begin{pmatrix}
    I_Y \\
    V_X \\
    I_Z \\
\end{pmatrix} = \begin{pmatrix}
    0 & 0 & 0 \\
    1 & 0 & 0 \\
    0 & \pm1 & 0
\end{pmatrix} \begin{pmatrix}
    V_Y \\
    I_X \\
    V_Z
\end{pmatrix}
\] (2)

Figure 2. Second generation Current Conveyor

2.3 The Third Generation Current Conveyor: CCIII

The third generation current conveyor is introduced in the year 1995. It is similar to CCI in structure. It is defined as,

\[
\begin{pmatrix}
    I_Y \\
    V_X \\
    I_Z \\
\end{pmatrix} = \begin{pmatrix}
    0 & -1 & 0 \\
    1 & 0 & 0 \\
    0 & \pm1 & 0
\end{pmatrix} \begin{pmatrix}
    V_Y \\
    I_X \\
    V_Z
\end{pmatrix}
\] (3)

3. ANALYSIS OF CMOS CCII

The Schematic diagram of the second generation Current conveyor is as shown in Fig.3.

Let voltages at Y be \( V_Y \) and at X be \( V_X \).

Apply KVL from terminal Y, \( M_2, M_2 \) and Terminal X. Then

\[
V_Y + V_{G_{S1}} - V_{G_{S2}} - V_X = 0
\] (4)

Assume \( M_1, M_2 \) are equal

\[V_{G_{S1}} = V_{G_{S2}}\]

Therefore equation 1 is

\[V_Y - V_X = 0\]

\[V_Y = V_X\] (5)

Assume Current at X terminal is \( I_X \). Section \( M_2, M_5, M_7 \) and section \( M_6, M_{12}, M_{13} \) are equal and same current will flow each section. That current is \( \frac{I_X}{2} \). Section \( M_4, M_5 \) and section \( M_6, M_7 \) are cascode sections. So,

\[
\frac{I_X}{2} = \frac{(W/L)_5}{(W/L)_4} \quad \text{or} \quad \frac{I_X}{2} = \frac{(W/L)_7}{(W/L)_6}
\]

Hence

\[I_{M_6} = \frac{(W/L)_5}{(W/L)_4} \cdot \frac{I_X}{2}\]

Similarly,

\[I_{M_{13}} = \frac{(W/L)_7}{(W/L)_6} \cdot \frac{I_X}{2}\] (6)

Apply KCL at node Z

\[I_Z = I_{M_6} + I_{M_{13}}\]

\[I_Z = \frac{(W/L)_5}{(W/L)_4} \cdot \frac{I_X}{2} + \frac{(W/L)_7}{(W/L)_6} \cdot \frac{I_X}{2}\]

If \( (W/L)_5 = (W/L)_{10} \) and \( (W/L)_6 = (W/L)_5 \)

Then

\[I_Z = \frac{I_X}{2} + \frac{I_X}{2}\]

(8)

\[I_Z = I_X\]

(9)

At this point, a full SPICE can be undertaken to trim the design to the desired performance.

4. CURRENT CONVEYOR APPLICATIONS

Current conveyor finds applications in many applications such as Analog to Digital converters, oscillators, etc. Some of the applications of the Current conveyors like Low Pass Filter, High Pass, Band Pass and Band stop filter, Current adder, Voltage adder etc. are illustrated in this section. All simulations are carried out using Multisim Software and are shown in Fig.4-10.
Figure 4. Low Pass Filter

Figure 5. High Pass Filter
Figure 6. Bandpass Filter

Figure 7. Bandreject Filter
5. CONCLUSIONS

In this paper the basic principle of operation of the current conveyor and its merits over operational amplifier is discussed. The advantages and disadvantages of various generations of current conveyor are studied. Mathematical derivations of the current conveyor are carried out. Various applications of current conveyor are explained with necessary simulations.

REFERENCES


