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Current Conveyor: A New Building Block

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ABSTRACT

Sedra and Smith first introduced the current conveyor in 1968. It is an abstraction for a three-terminal analog electronic device. It is a form of electronic amplifier with unity gain. When configured with other circuit elements, real current conveyors can perform many analog signal processing functions, in a manner operational amplifiers do. This paper presents the basics of current conveyors with some of its applications ina very simple way.

Keywords: Current conveyor, VCVS, VCCS, CCCS.

1. INTRODUCTION

Current-mode circuits[1] may be considered as those circuits in which current is used as an active variable in preference to voltage either through the complete circuit, or in certain restricted areas. Such circuits range from current and transconductance amplifiers through translinear circuits to the new architecture of current conveyor. All share the common feature that manipulation of current provides significant operational benefits compared to their voltage-mode counterparts.

The current-mode approach of circuit design has proved to be functionally flexible and versatile, rapidly gaining acceptance, both as a theoretical and a practical building block. However, it is only in the past few decades that high performance implementations have emerged to enable current-mode modules to successfully challenge voltage operational amplifiers.

The current-mode circuits have the following advantages over their voltage-mode counterparts:

- Wider dynamic range with lower voltage supply
- Wider bandwidth
- Bandwidth, independent of gain
- Higher operating speed
- Simpler circuitry
- Lower power consumption

2. DIFFERENT TYPES OF CURRENT CONVEYOR

There are mainly versions of current conveyors: First generation current conveyor and second-generation current conveyor. The first generation current conveyor, shown in Figure 1 and abbreviated as CCI, is a threeport device. The operation of this device is such that if a voltage is applied at the input terminal Y, an equal potential will appear on the input terminal X. In a similar fashion, an input current forced into the terminal X will result in an equal amount of current flowing into the terminal Y. This current will also be conveyed to the terminal Z such that the terminal Z has the characteristics of a current source. Thus, the device exhibits a virtual short-circuit input characteristic at port X and a dual virtual open-circuit input characteristic at port Y.

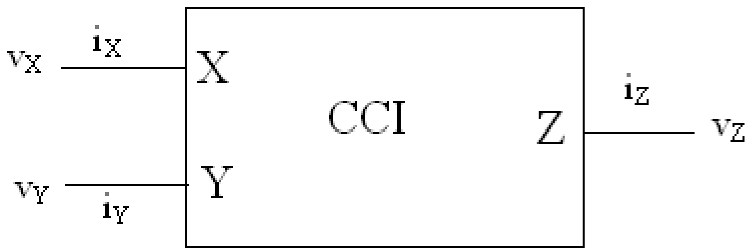

Figure 1: First generation current conveyor

In mathematical terms, the input-output characteristics of CCI can be described by a hybrid matrix which yields:
$i_Y = i_X$, $v_X = v_Y$ and $i_Z = \pm i_X$

Note that positive sign applies for the CCI in which both i_Z and i_X either flow into the conveyor or out of it, whereas negative sign applies when one of the currents flows into the conveyor and the other flows out of it.

To increase the versatility of current conveyor, a second generation current conveyor, shown in Figure 2 and abbreviated as CCII, was introduced, in which no current flows in the terminal Y.

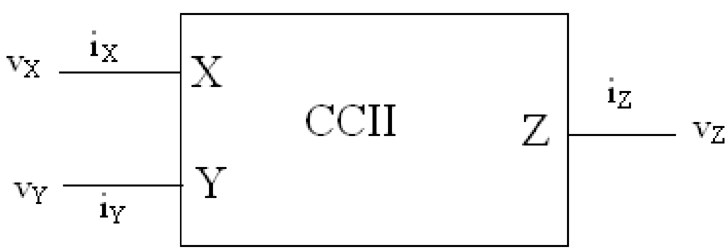

Figure 2. second generation current conveyor

In mathematical terms, the input-output characteristics of CCII can be described by a hybrid matrix which yields:
$i_Y = 0$, $v_X = v_Y$ and $i_Z = \pm i_X$.

The terminal Y, therefore, exhibits an infinite input impedance. The voltage at X follows that applied to Y and thus, X exhibits zero input impedance.

The first widely available paper on CCII[2] illustrated its application in the realization of controlled sources, impedance converters, impedance inverters and various analog computation elements. A comparison paper[3] gave realization for a number of non-linear building blocks that has been postulated by Chua. A large number of applications involving CCII have been reported in the literature[4-6].

3. APPLICATIONS OF CCII

Different types of controlled sources can be designed using CCII. Some of them are given below:

(a) Voltage-controlled voltage source (VCVS)

The practical VCVS using CCII is shown in Figure 3.

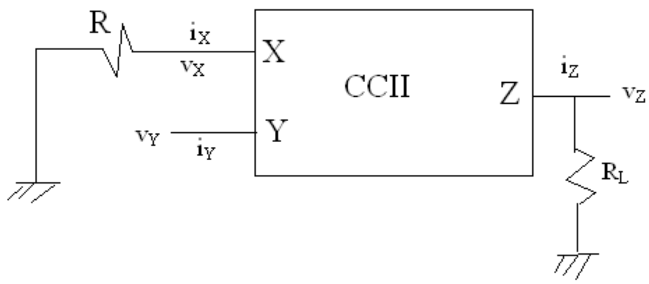

Figure 3: VCVS using CCII+

For an ideal CCII+, we have

$$v_X = v_Y \text{ and } i_Z = i_X .$$

We have,

$$i_X = v_X/R = i_Z.$$

Hence,

$$v_Z = i_Z R_L = (R_L/R)\, v_X$$

which gives

$$v_Z = (R_L/R)\, v_Y.$$

(b) Voltage-controlled current source (VCCS)

The practical VCVS using CCII is shown in Figure 4.

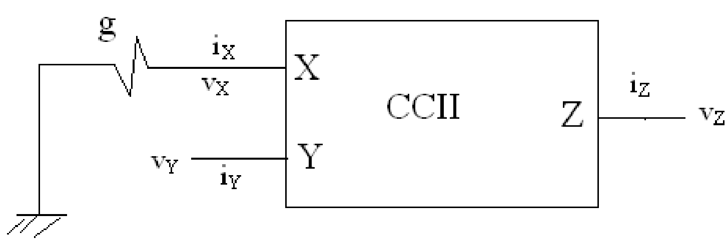

Figure 4: VCCS using CCII+

For an ideal CCII+, we have

$$v_X = v_Y \text{ and } i_Z = i_X .$$

We have,

$$i_X = v_X\, g = v_Y\, g .$$

which gives

$$i_Z = g\, v_Y$$

(c) Current-controlled current source (CCCS)

The practical VCVS using CCII is shown in Figure 5.

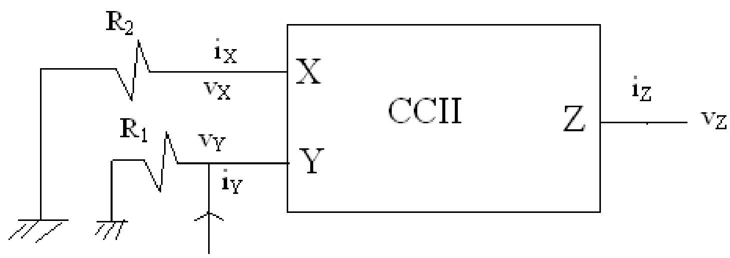

Figure 5: CCCS using CCII+

For an ideal CCII+, we have

$$v_X = v_Y \text{ and } i_Z = i_X .$$

We have,

$$i_Y = v_Y/R_1 = v_X/R_1 = i_X\, R_2/R_1$$

which gives

$$i_Y = i_Z\, (R_2/R_1)$$

which finally gives

$$i_Z = i_Y\, (R_1/R_2) .$$

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