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Current Conveyor Simulation Circuits Using Operational Amplifiers

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ABSTRACT

In this paper one circuit simulating a second generation current conveyor (CCII) is reported. The circuit uses four operational amplifier and gives low tracking error. This circuit realises both positive and negative polarity second generation current conveyor. Based on this circuit a simulation circuit for dual output current conveyor (DOCCII) is also described. Finally a generalized CCII circuit is proposed which by control of logic 0 or 1 at a control terminal of analog multiplexer gives CCII+ or CCII- simulation. These simulations are used in verifying the CCII and DOCCII based circuits experimentally, and are economical.

1. Introduction

The second generation current conveyor CCII introduced by Sedra and Smith [1] is widely used in realisation of filters and oscillators [2-7]. It is available with both polarity as CCII+ and CCII-. By connecting CCII+ and CCII- together a dual output CCII (DOCCII) is formed which has got its importance in current mode filter realisations [8-9]. To experimentally test the circuit based on these elements several discrete or spice models are available in literature [10-16]. In this work two circuits of simulating CCII and DOCCII are given which purely uses IC741 operational amplifier, available at very low cost. These simulations are most attractive in research laboratory to practically test the performance of CCII and DOCCII based realizations.

2. Circuit Description

The first proposed circuit is shown in fig.1. This circuit has been obtained by modifying the circuit of Huertas [10] shown in fig.2

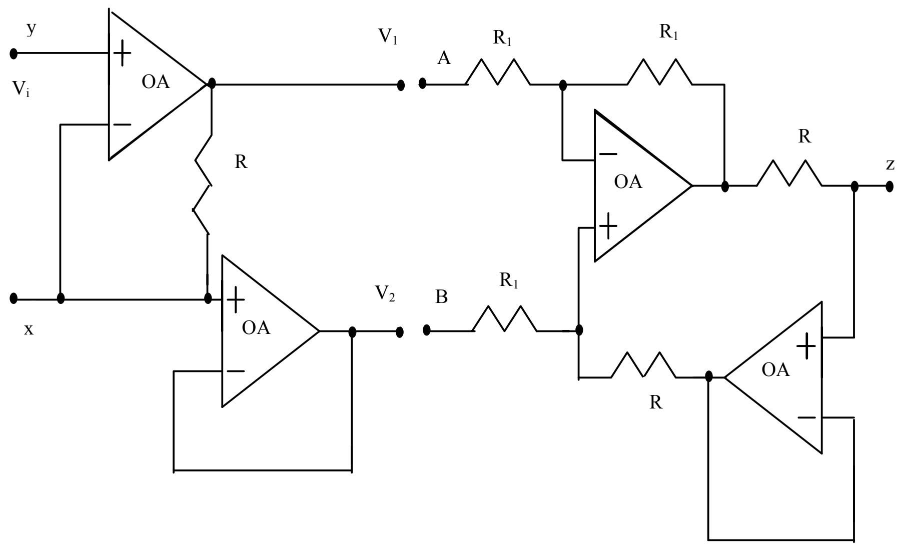


Fig.1 A modified configuration of second generation current conveyor [CCII]

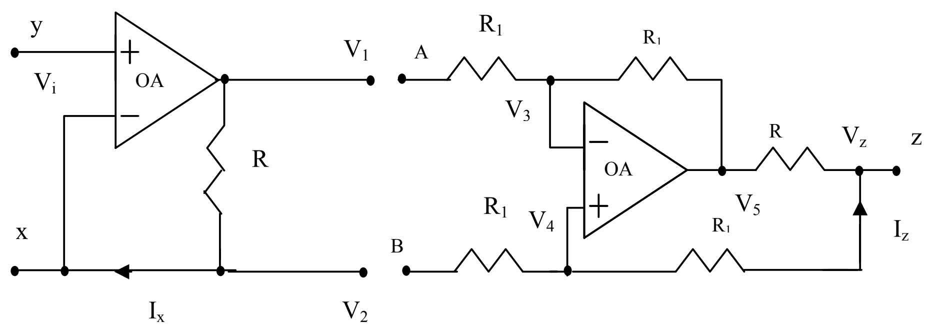


Fig. 2.Circuit reported by Huertas [10]

The characteristics of second generation current conveyor (CCII) for which this circuit is proposed is as follows:

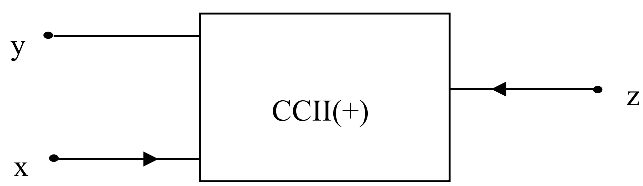
CCII (+):

$i_y = 0,$
$v_x = v_{y,}$
$i_z = i_x$

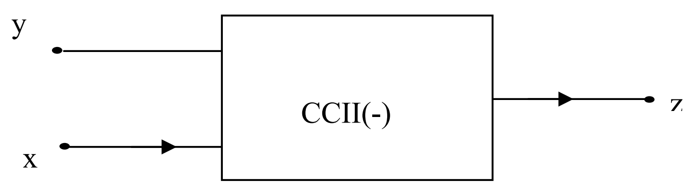
CCII (-):

$i_y = 0,$
$v_x = v_{y,}$
$i_z = -i_x$

symbolic representations of CCII (+) and CCII (-) are given in fig. 3.



(a)



(b)

Fig.3 : Symbolic representations of CCII (+) and CCII (-)[a & b]

For a non ideal CCII:

$i_y = 0,$
$v_x = v_y(1+\varepsilon_1),$
$i_z = i_x(1+\varepsilon_2)$

where ε_1 and ε_2 are non idealities

2.1 Analysis

In this circuit y terminal is the non inverting terminal of operational amplifier (OA 1), which has high input impedance, thus $i_y = 0$, Also in an operational amplifier inverting terminal follows the non inverting terminal, therefore $v_x = v_y$.

To prove third condition $i_z = i_x$ for CCII (+) connect V_1 to A and V_2 to B. Assume I_x current flows through x terminal towards ground.

$$i_x = \frac{V_1 - V_2}{R} \qquad (1)$$

Now $$i_1 = \frac{V_1 - V_3}{R_1} = \frac{V_3 - V_5}{R_1} \qquad (2)$$

which gives $V_5 = 2V_3 - V_1$ (3)

Similarly $V_z = 2V_4 - V_2$ (4)

as inverting terminal voltage of an operational amplifier is equal to non inverting terminal voltage

$V_4 = V_3$

and eqn. (3) and (4) gives

$$V_5 - V_z = V_1 - V_2$$

or $$\frac{V_5 - V_z}{R} = \frac{V_1 - V_2}{R}$$

or $$- i_z = i_x$$

Hence this circuit simulates a CCII (-).

Since no current is drawn by non inverting terminals of operational amplifiers in unity gain ,i_x and i_z flows through respective resistance R only, thus tracking error is practically zero. In case of circuit of Huertas [10] it is not zero. Also the circuit of Huertas uses high valued resistances for R_1, the present circuit can use low value and it can be equal to R also. Thus all six resistances of equal values makes circuit realisation simple.

By connecting V_1 to B and V_2 to A, a CCII (-) is realised.

The another active element dual output current conveyor (DOCCII) is also used in the realisation of filters etc. Based on the circuit of fig.1 one can easily realise a circuit simulating DOCCII as shown in fig.5. It uses six operational amplifiers and has the following terminal properties

$i_y = 0,$

$v_x = v_y,$

$i_z = i_x$

$i_{\bar{z}} = -x$

This circuit also offers low tracking error.

Fig.4 : Symbolic representations of DOCCII

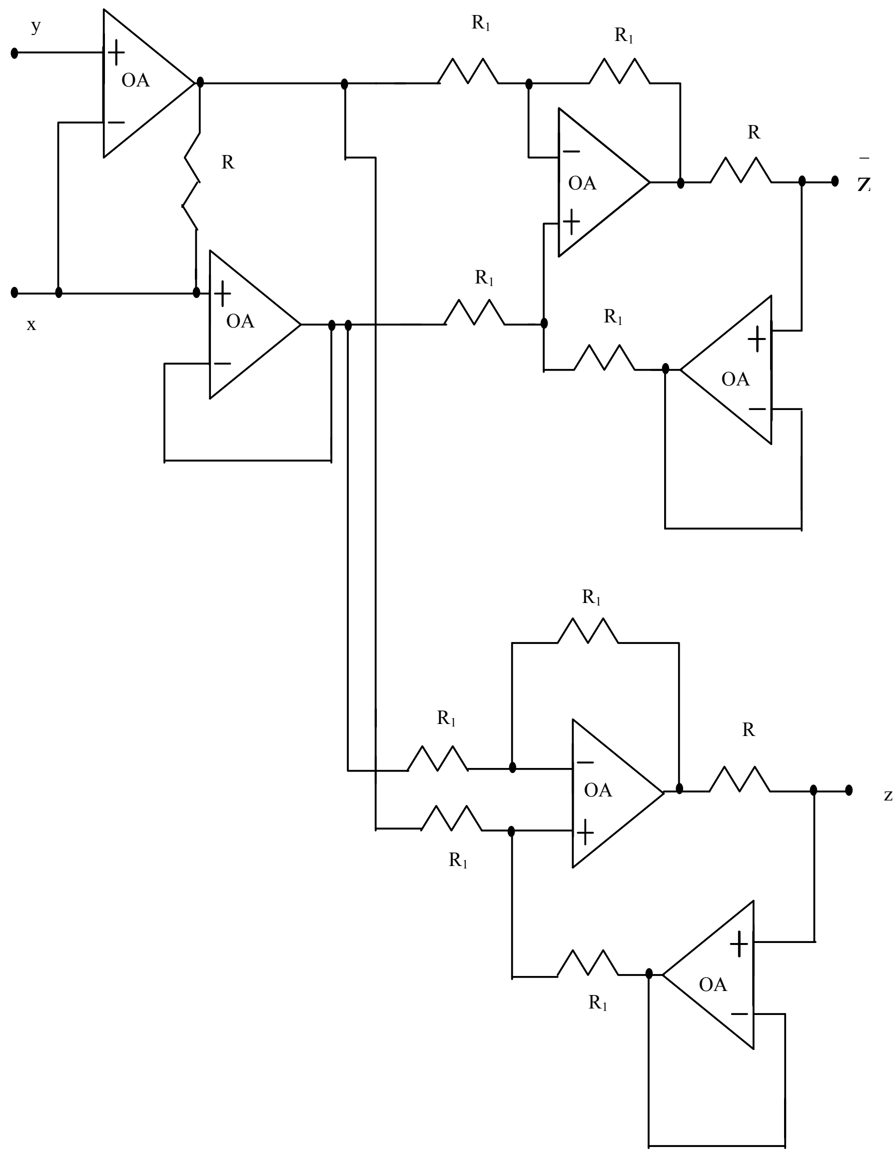


Fig.5 : A practical DOCCII implementation circuit.

Finally a generalised current conveyor simulation (GCCII) as shown in fig.6 is proposed. The circuit uses a analog multiplexer IC-4502 which through logic 0 or 1 at control terminal C gives CCII+ or CCII- respectively.

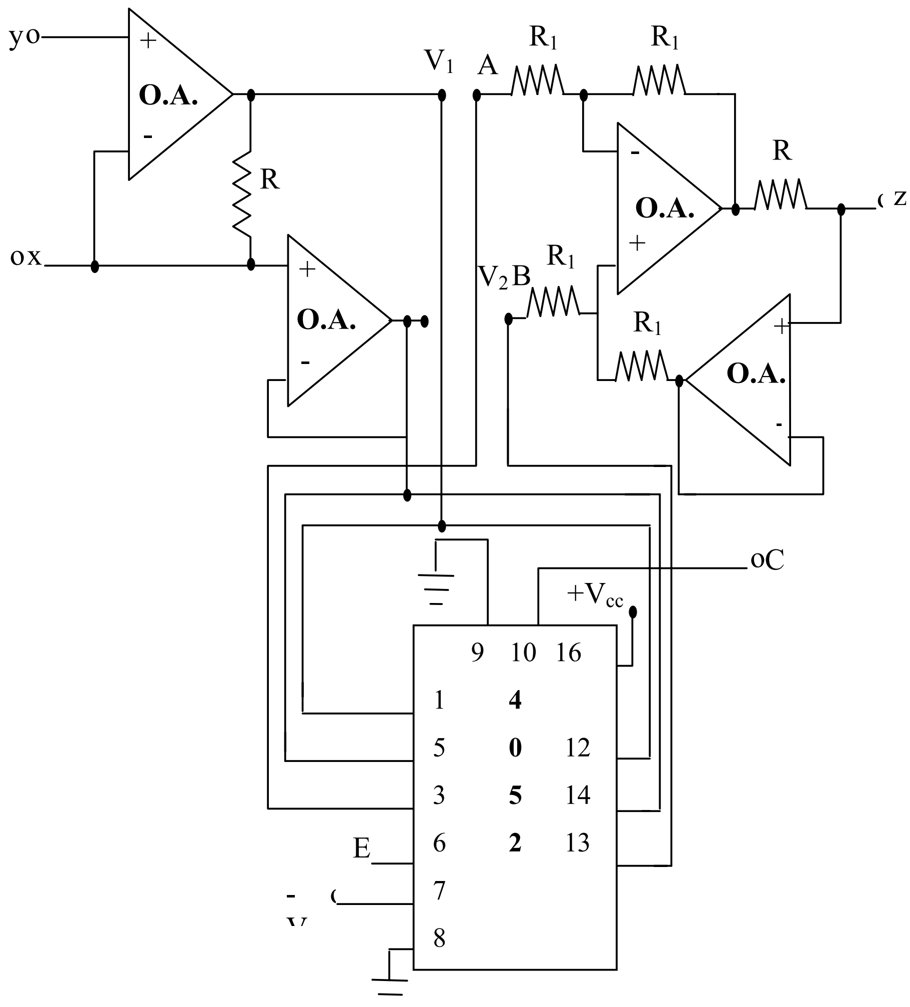


Fig.6 : A GCCII Circuit.

3. Experimental Results

All these circuits were tested for a.c. input at $1KH_z$ as an amplifier configuration shown in fig.7. The voltage gain $\frac{V_0}{V_i}$ is given as

$$\frac{V_0}{V_i} = \pm\frac{R_2}{R_1}$$

where + sign stand for CCII (+) and – sign stand for CC (-).

Choosing $R_1 = 10K\Omega$ and $R_2 = 10K\Omega$, $20K\Omega$, $30K\Omega$, $100K\Omega$,

The circuit were tested for different gain and experimental results were found in good agreement with the theory. In another experiment the circuit of DOCCII was tested as amplifier configuration with resistance $10K\Omega$ at x w.r.t. ground and resistances of $20K\Omega$ at z and $10K\Omega$ at $\bar{z}$ terminal w.r.t. ground. The waveforms for an input of 100mv at $1KH_z$ and output for a gain of 2.0 and 1.0 are shown in fig.8. The voltage waveform at terminal z has a gain of 2.0 and is in phase with voltage at x , while same at $\bar{z}$ is out of phase and has unity gain as designed. In the realisation of CCII+ and DOCCII the IC-741 were used and value of resistances $R= 1.0K\Omega$ and $R_1 =10K\Omega$.

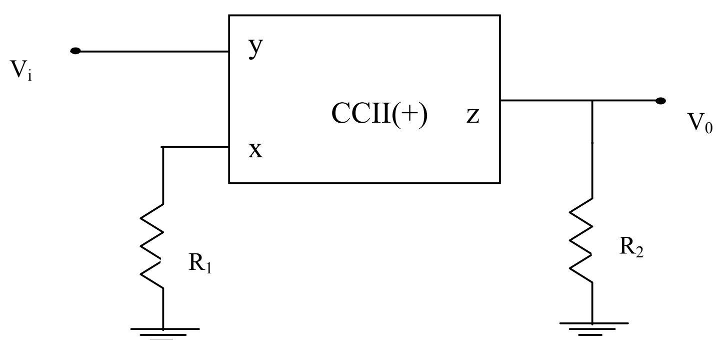


Fig.7. An amplifier circuit using CCII

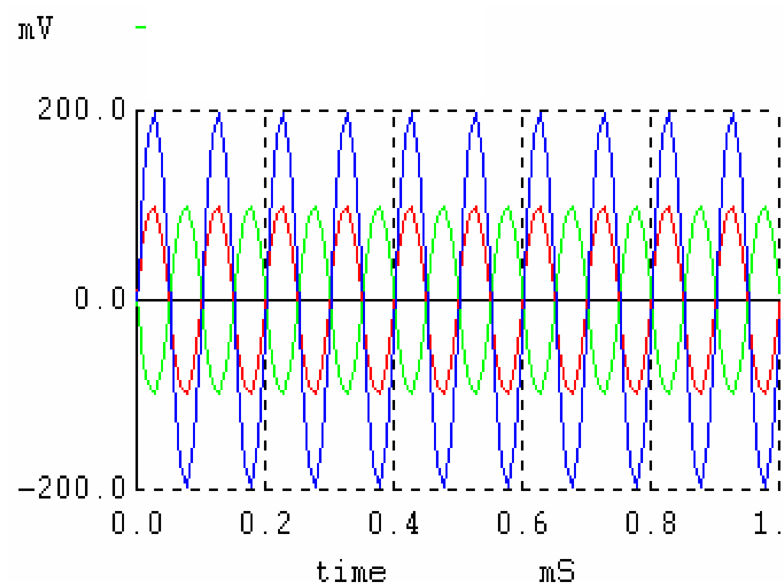


Fig. 8. Input and output waveforms of DOCCII.

Using CCII simulated circuit of fig.1 the all pass filter circuits of Khan & Maheshwari [17] and Pal [18] were tested and result were found very satisfactory.

4. Conclusions

A circuit simulating a second generation current conveyor (CCII) is reported. The circuit uses four operational amplifier and gives low tracking error. This circuit realises both positive and negative polarity second generation current conveyor. Based on this circuit a simulation circuit for dual output current conveyor (DOCCII) is also described. Finally a generalized CCII circuit is proposed which by control of logic 0 or 1 at a control terminal of analog multiplexer gives CCII+ or CCII- simulation These simulations are used in verifying the CCII and DOCCII based circuits experimentally, and are economical.

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