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Practical Realization of Current Mode Active Elements Using AD844 and some Applications

KEYWORDS Current Mode active elements, Current conveyor, Commercially available chip AD844, Circuit simulation

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ABSTRACT *In this paper various Current Mode active elements like first generation current conveyor (CCI)), third generation current conveyor (CCIII), Differential voltage Current Conveyor (DVCC) and Dual-X-CCII (DXCCII) have been realized using commercially available chip AD844. The DXCCII is used as a building block to show its application as Amplifier, Integrator and All-pass filter. The proposed circuits are composed of only grounded passive components, which is suitable for designing in the Integrated circuits. PSPICE simulation has been done to verify the results.*

1. Introduction

The operational amplifiers (opamps) suffer from the finite gain-bandwidth product which limits accuracy and reduces the frequency range of operation.[1-6] Therefore, many circuits such as oscillators, current-mode and voltage mode filters, simulated inductors, rectifiers etc. are constructed employing different types of current conveyors (CC) such as second-generation positive-type current conveyor(CCII+), second-generation negative-type current conveyor(CCII-), dual-output second-generation current conveyor (DOCCII), first-generation current conveyor (CCI), third-generation current conveyor(CCIII), differential voltage current conveyor(DVCC), dual X current conveyor (DXCC), positive-type current gain variable CCII(CGVCCII+), positive-type voltage gain variable CCII(VGVCCII+). Current conveyors (CCI, CCII and CCIII) have received considerable attention since their introduction mainly due to their wider bandwidth and their capability to give current as well as voltage output. But one of the disadvantages of this current mode circuits is that there is only one commercially available chip in the market that is AD844 [7]. In fact, the AD844 is a current feedback Operational amplifier (CFOA) which can be used also as a positive type second generation current conveyor (CCII+). In this paper the CCII+ is not realized because the AD844 verifies its port characteristics. For practical purposes, it is very important to realize different types of CCs and other active devices using AD844 or CCII+s.

2. Current Mode Active elements

2.1 Positive-type first-generation Current Conveyor (CCI+)

The port characteristics of CCI+ are shown as matrix equation (1)

$$\begin{bmatrix} Iy \\ Iz^{+} \\ Vx \end{bmatrix} = \begin{bmatrix} \gamma & 0 & 0 \\ \alpha & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} Ix \\ 0 \\ Vy \end{bmatrix}$$

(1)

It can be realized with three CCII+s and three resistors as shown in fig.1. The current gains of the Z+ and Y terminals are equal to

$\alpha = R_1 / R_2$ and $\gamma = R_1 / R_3$

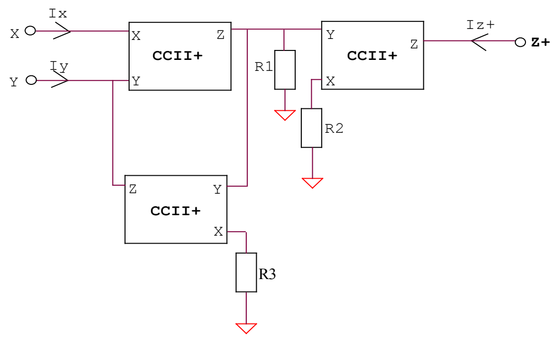

Fig.1 Positive-type first-generation current conveyor

2.2 Positive-type third-generation Current conveyor (CCIII+)

The Port relation of CCIII+ can be described as:

$$\begin{bmatrix} Iy \\ Iz^{+} \\ Vx \end{bmatrix} = \begin{bmatrix} -1 & 0 & 0 \\ \alpha & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} Ix \\ 0 \\ Vy \end{bmatrix} \quad (2)$$

It can be realized with three CCII+s and two resistors as shown in fig.2. The current gains of the Z+ terminal is equal to $\alpha = R_1 / R_2$

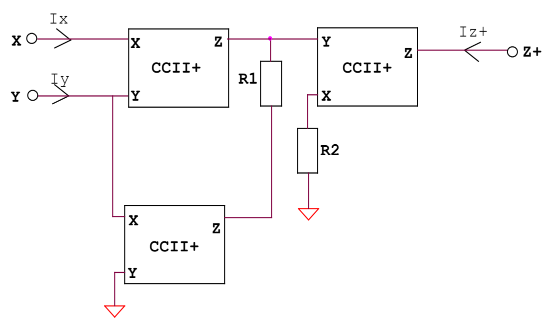

Fig.2 Positive-type third-generation current conveyor

2.3 Differential voltage Current conveyor (DVCC)

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The DVCC is a four port active element described by:

$$\begin{bmatrix} Iy_1 \\ Iy_2 \\ Iz^+ \\ Vx \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & \beta & -\beta \end{bmatrix} \begin{bmatrix} Ix \\ Vy_1 \\ Vy_2 \end{bmatrix} \quad (3)$$

It can be realized with three CCII+s and two resistors as shown in fig.3. The voltage gain of the DVCC is equal to $\beta = R_2 / R_1$

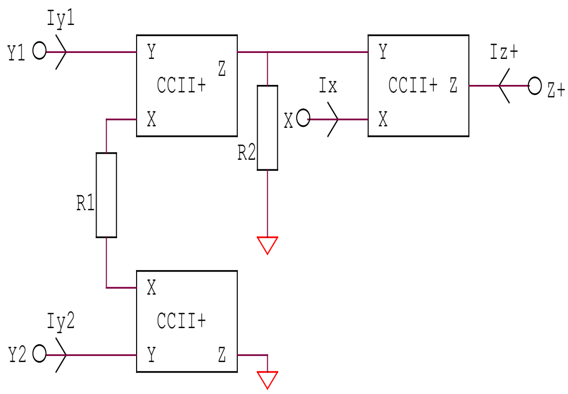

Fig.3 Differential voltage current conveyor (DVCC)

2.4 Dual X Current conveyor (DXCCII)
A DXCCII can be implemented with two CCII+s, one CCII- (CCII- is formed by two CCII+) and two resistors as shown in fig.4 and symbol of DXCCII is shown in fig.5

The DXCCII is a five port active element with

One high impedance, voltage input terminals:Y

Two low impedence, current input terminal: Xp, Xn

Two high impedence, current output terminals: Zp, Zn

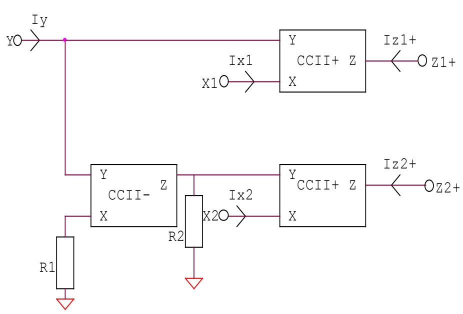

Fig.4 Dual X current conveyor (DXCCII)

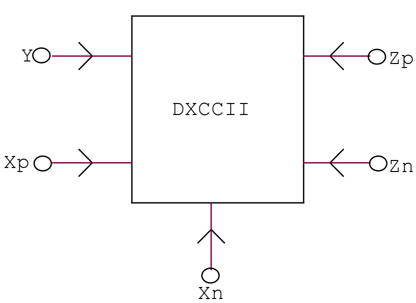

Fig.5 Symbol of DXCCII

The input – output characteristic of DXCCII is defined as:

$$\begin{bmatrix} Iy \\ Izp \\ Izn \\ Vxp \\ Vxn \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} Ixp \\ Ixn \\ Vy \end{bmatrix} \quad (4)$$

3. Simulation Results
PSPICE simulation using AD844 Model has been done. This simulation has been done at supply voltage of ± 10 volt and $R_1 = R_2 = 1K$.

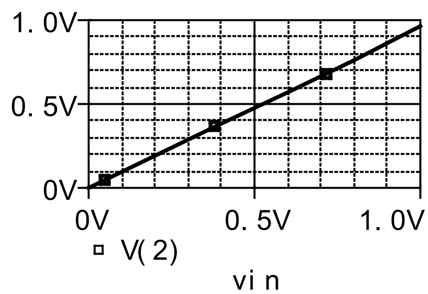

Fig. 6(a) Verification of Voltage Relation

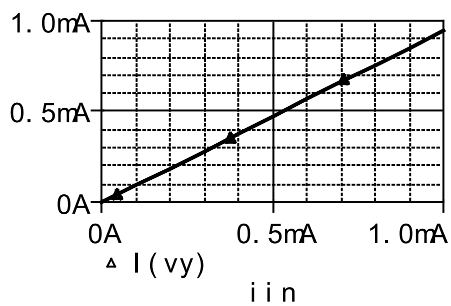

Fig. 6(b) Verification of Current Relation

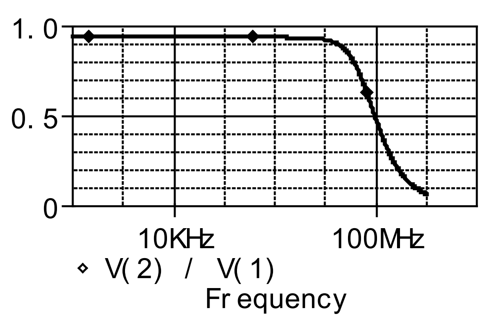

Fig. 6(c) Verification of Voltage Relation in Frequency Domain

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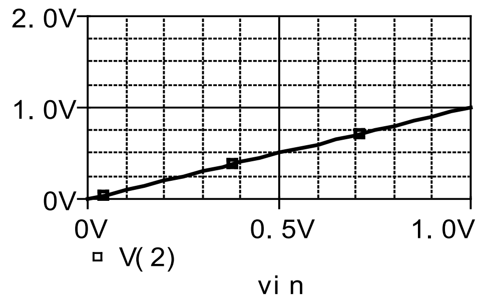

Fig. 7(a) Verification of Voltage Relation

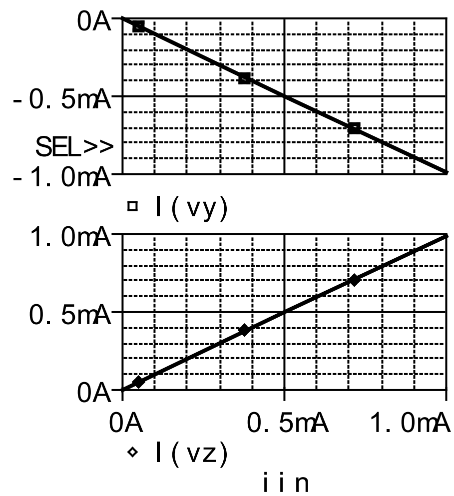

Fig. 7(b) Verification of Current Relation

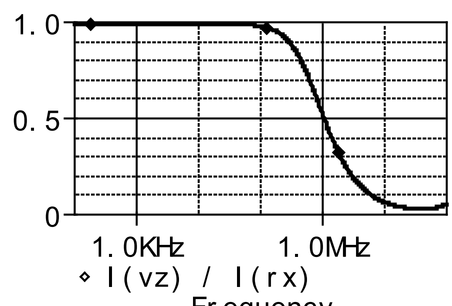

Fig. 7(c) Verification of current Relation in Frequency Domain

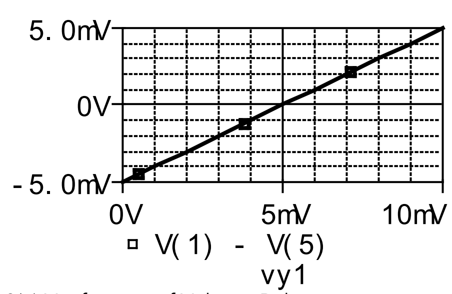

Fig. 8(a) Verification of Voltage Relation

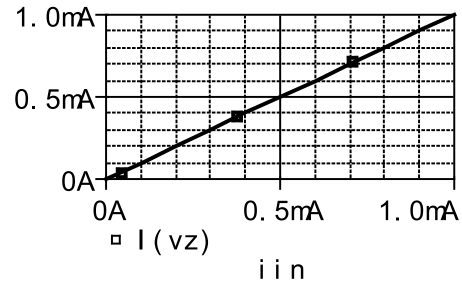

Fig. 8(b) Verification of Current Relation

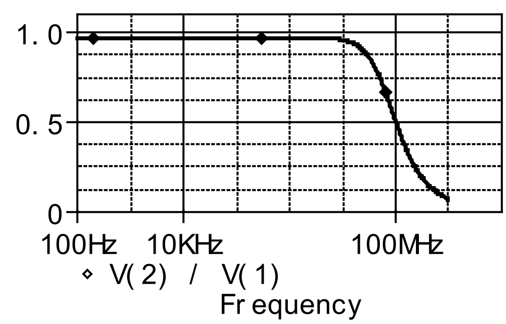

Fig. 8(c) Verification of Voltage Relation in Frequency Domain

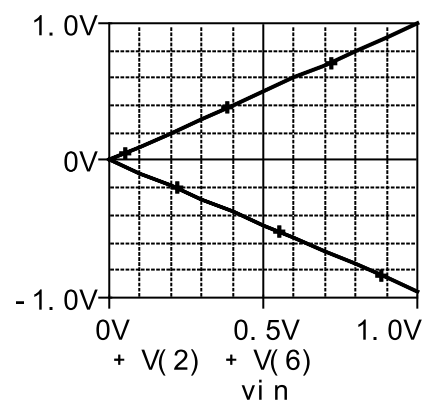

Fig. 9(a) Verification of Voltage Relation

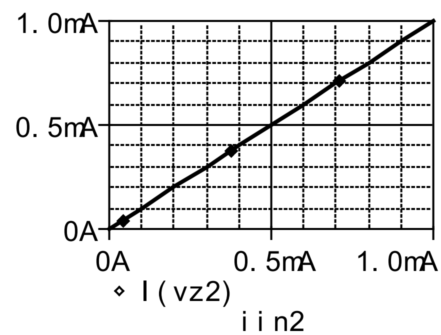

Fig. 9(b) Verification of Current Relation

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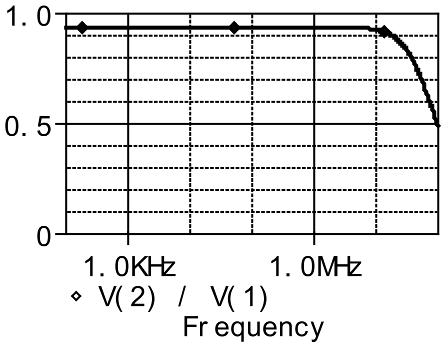

Fig. 9(c) Verification of current Relation in Frequency Domain

The simulated results which are shown in fig.6(a), 6(b) and 6(c) show the port characteristics verification of the CCI+. Fig. 7(a), 7(b) and 7(c) show the practical realization of CCIII+, fig.8 (a),8(b) and 8(c) is of DVCC and fig.9(a), 9(b) and 9(c) is of DXCCII. All the above result verified its port relations.

4. Applications of DXCCII
4.1Amplifier

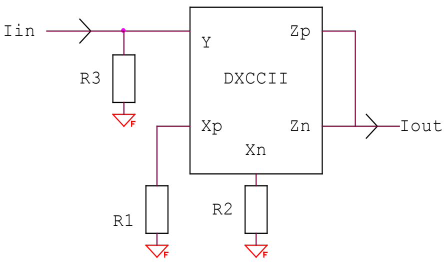

Fig.10 proposed circuit for current mode Amplifier

The transfer function of the proposed amplifier is given by:

$$Iout/Iin = R_3[R_2 - R_1] \ / \ R_1R_2 \qquad (5)$$

4.2 Integrators

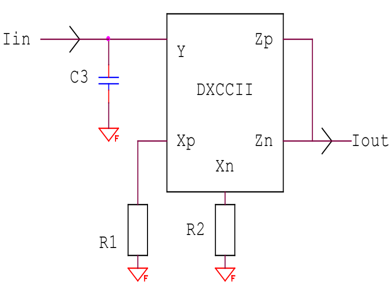

Fig. 11(a) Proposed CM Loss-less Integrator

The transfer function of the proposed current mode loss-less Integrator is given by:

$$Iout/Iin = [R_2 - R_1]/sC_3 R_1R_2 \qquad (6)$$

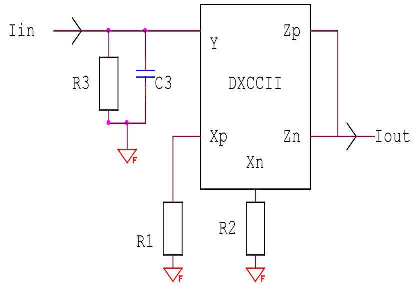

Fig. 11(b) Proposed CM Lossy Integrator

The transfer function of the proposed current mode lossy Integrator (Low pass filter) is given by:

$$Iout/Iin = k/(s + 1/C_3R_3) \qquad (7)$$

Where, $k = R_3(R_2 - R_1)/C_3R_1R_2R_3$

$$\omega_o = 1/C_3R_3$$

4.3 All pass filter
The transfer function of the proposed current mode All pass filter is given by:

$$Iout/Iin = -C_2(s - 1/C_2R_1)/C_3(s + 1/C_3R_3) \qquad (8)$$

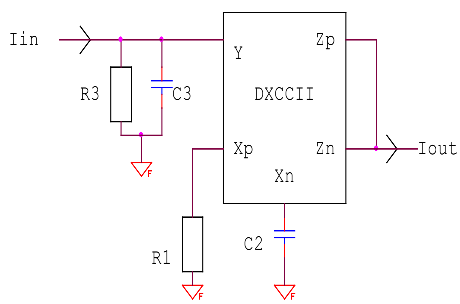

Fig.12 Proposed CM All-pass filter

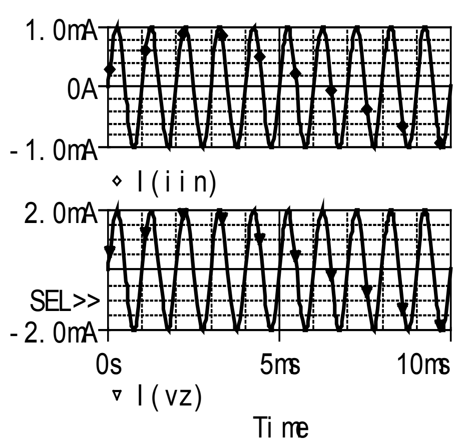

Fig. 13 Input / Output current Waveform

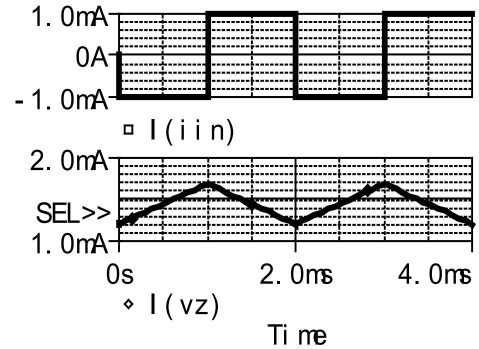

Fig. 14(a) Input / Output current Waveform

5. Simulation Results

PSPICE simulation using AD844 Model has been done. This simulation has been done at supply voltage of ± 10 volt. Taking R_1= 0.5k, R_2=1k, R_3=2k, and Iin=2mAp-p, the relation given by eqn.(5) shows non-inverting Amplifier with no error in Fig.13 of the CM integrated circuit.

Taking R_1= 2k, R_2=1k C_3=7.96nf, Iin=1mA,and fo=10khz then the relation given by eqn.(6) shows the loss-less integrator for square wave input and output is shown in fig14(a). Taking R_1= 0.5k, R_2=1k, R_3=1k, fo =100kz, C_3 =1.59nf and Iin =1mA, the relation of eqn.(7) shows CM LPF in fig.14 (b) with cut-off frequency of 85.943kHz and with gain error of 0.105.

Taking R_1= R_3=5k Iin=1mV, design frequency fo=10khz, then after calculation C_2= C_3=3.184nf, the response of eqn.(8) shows CM APF as shown in fig. 15

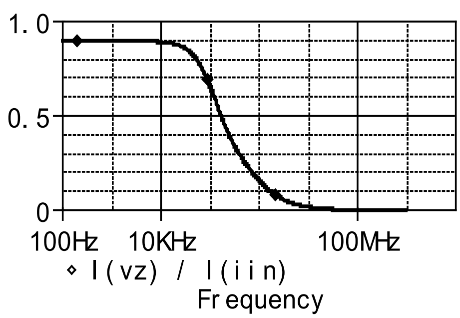

Fig. 14 (b) CM Gain Plot of LPF

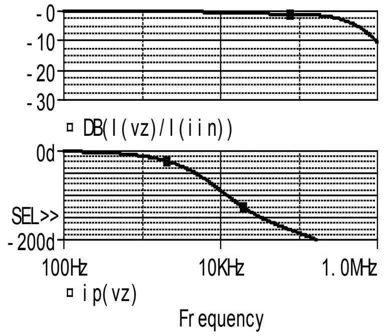

Fig. 15 CM Gain Plot and phase plot of APF

6. Conclusion

The Current mode active elements have been realized using commercially available chip AD844. CCI+, CCIII+, DVCC and DXCCII port relations are verified. The DXCCII is used as a building block to show its applications as Amplifiers, Integrators and All-pass filters in the current mode topology. All the proposed circuits are composed of only grounded passive components, which are suitable for designing them in the integrated circuits.

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