

ACTIVE-ONLY CURRENT CONTROLLED SUMMING/DIFFERENCE AMPLIFIERS USING CCCII_s

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Novel active-only summing/difference amplifiers employing only current controlled conveyors (CCCII_s) are presented. The circuits possess high input impedance, current controllable gain, good linearity and dynamic range, low THD and are suited for IC implementation. SPICE simulation results are included to verify the circuits.

Keywords: Active-only circuits; Current controlled conveyors

1 INTRODUCTION

Amplification is one of the fundamental signal processing applications. Conventional summing and difference amplifiers employ resistors that need to be varied for obtaining variable gain, which is often impractical especially if the circuit is to be fully integrated. Recently current controlled conveyors (CCCII_s) have gained popularity as these devices provide high performance electronic functions operating either in voltage-mode or current-mode [1, 2]. These conveyors offer a finite current controllable resistance at one of their ports (X) that makes them an ideal choice for resistorless realizations [2]. If these devices are employed in amplifier circuits then active-only circuits with current controllability can be obtained. Such active-only realizations are ideal for monolithic implementation as no resistors are employed.

In this paper, active-only summing amplifier and difference amplifiers are proposed using CCCII_s only. Each circuit uses only three CCCII_s to realize the functions which are current controllable by varying the bias currents of the translinear conveyors [1, 3]. The proposed circuits offer high input impedance, electronic adjustability, low distortions, and are suited for IC implementation. SPICE simulation results are included to confirm the theory.

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2 ACTIVE-ONLY CIRCUITS

The current controlled conveyor (CCCII) is characterized by the following port relationship.

$$i_y = 0, \quad V_x = (V_y + i_x R_x), \quad i_z = p i_x \tag{1}$$

where $p = 1$ for CCCII+ and $p = -1$ for CCCII-. The proposed CCCII based summing/difference amplifier circuit is shown in Figure 1. Routine analysis of the circuit using Eq. (1) yields the following output voltage.

$$V_o = R_{x3} \left(\frac{V_1}{R_{x1}} \pm \frac{V_2}{R_{x2}} \right) \tag{2}$$

where R_{xi} ($i = 1, 2, 3$) is the intrinsic resistance at the terminal X of the i th conveyer and is given as:

$$R_{xi} = \frac{V_T}{2I_{oi}}. \tag{3}$$

I_{oi} is the bias current of the i th current controlled conveyor [1]. In Eq. (2) the '+' sign corresponds to positive conveyor (CCCII2+) and the circuit of Figure 1 realizes a summing amplifier whose gain can be controlled by varying the bias currents of the conveyors. It is evident from Eqs. (2) and (3) that the circuit easily provides a weighted sum of the two input signals. Similarly the '-' sign in Eq. (2) corresponds to negative conveyor (CCCII2-) and the resulting circuit then realizes a difference amplifier with current controllable gain. It is to be noted that the proposed active-only circuit(s) offer high input impedance

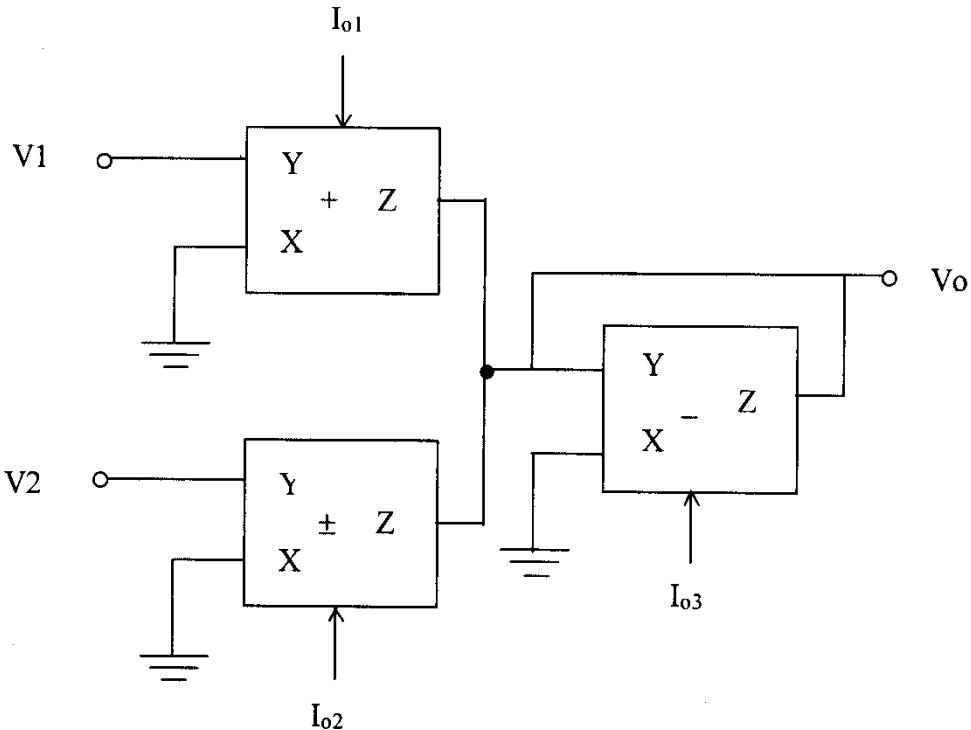


FIGURE 1 Proposed active-only summing/difference amplifier.

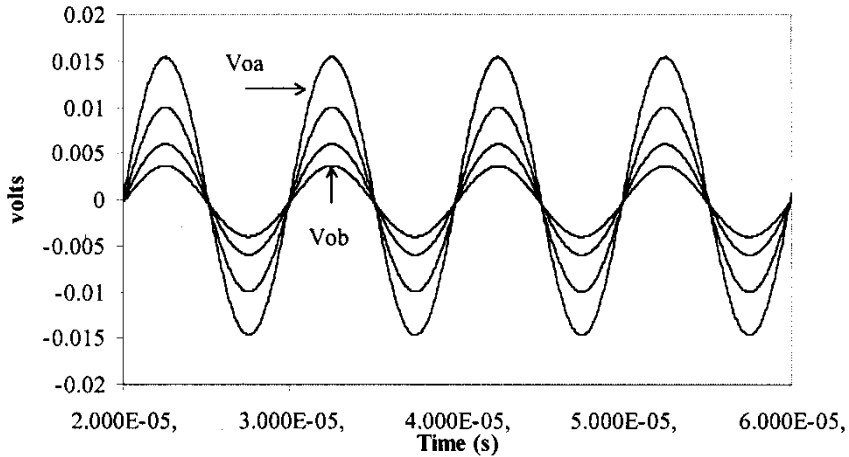


FIGURE 2 Time domain waveforms for summing (V_{oa}) and difference (V_{ob}) amplifier for $V_1 = 10$ mV and $V_2 = 6$ mV.

and are suited for cascading in voltage-mode operation. As the circuit(s) employ no resistors they are also ideal for monolithic implementation.

3 SIMULATION RESULTS

To verify the proposed active-only circuit(s), bipolar implementation of CCCII is used for simulation [1, 2]. Transistor model parameters of NR100N and PR100N with a supply voltage ± 2.5 volts are used for the simulation [4]. The active-only summing amplifier (with CCCII+) of Figure 1 was designed for unity gain with equal bias currents of three conveyors as $100 \mu\text{A}$. The two sinusoidal input signals of amplitudes 10 mV and 6 mV, respectively and a frequency of 100 kHz were used. Next the difference amplifier of Figure 1 (with CCCII-) was simulated using the same values as for the summing amplifier. The time domain waveforms are shown in Figure 2, that shows the output amplitude as 16 mV

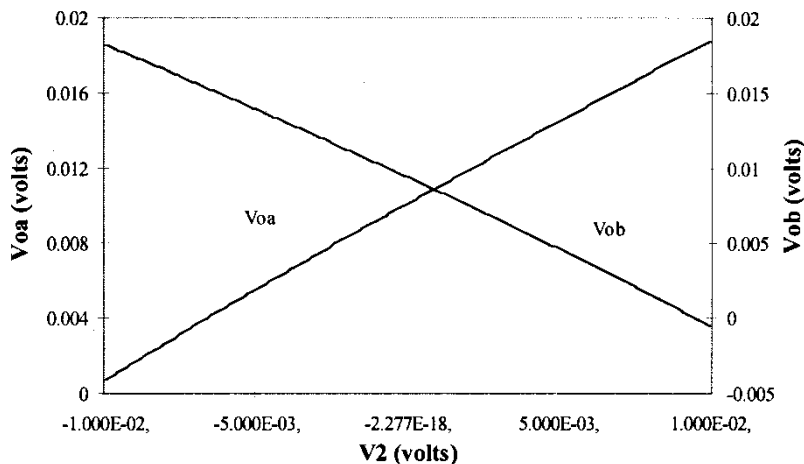


FIGURE 3 DC transfer characteristics for summing (V_{oa}) and difference (V_{ob}) amplifier for $V_1 = 10$ mV.

(V_{oa}) for the summing amplifier and 4 mV (V_{ob}) for the difference amplifier that is in conformity with the design. The output was found to show a total harmonic distortion (THD) of less than 1% for both summing and difference amplifiers that represent a low value. The summing/difference amplifier circuit was next simulated to study its dynamic range by applying a DC input $V_1 = +10$ mV and varying V_2 from -10 mV to $+10$ mV for the same values of bias current as above. The DC transfer characteristics as shown in Figure 3 for both the summing and difference amplifiers confirm a high degree of linearity and good dynamic range.

4 CONCLUSION

A novel active-only circuit using current controlled conveyors realizing summing and difference amplifiers is presented with features like electronic gain control, suitability for IC implementation, low THD, good linearity and dynamic range. Simulation results confirm the utility of the proposed active-only circuits.

References

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