High Output Impedance Current-Mode First-Order Allpass Filter Employing One DXCCII

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Abstract-- **A high output impedance current-mode first-order allpass filter is presented. The proposed circuit uses one dual-X second-generation current conveyor (DXCCII), two resistors and one grounded capacitor. The frequency response simulation results of the proposed filter confirm the theoretical analysis.**

I. INTRODUCTION

All-pass filters are widely used in analogue signal processing in order to shift the phase of an electrical signal while keeping the amplitude constant [1]. Current conveyors (CCs) are receiving much attention for their potential advantages such as inherent wider signal bandwidth, simpler circuitry and larger dynamic range [2, 3]. Current-mode active filters with high output impedance are of great interest because they can be directly connected in cascade to implement higher order filters [4, 5]. Besides, the use of only grounded capacitor are beneficial from the point of view of integrated circuit fabrications [6].

Several current-mode first-order allpass filters using various active components have been reported [4, 7-13]. The circuit in [7] uses second-generation current-controlled conveyor (CCCII) to realize such a current-mode first-order allpass filter function. However, the circuit doesn't have the advantage of high output impedance. Several current-mode first-order allpass circuits are presented [8] by using inverting-type second-generation current conveyors (ICCIIs). However, the capacitors they used are floating. In circuit [9], the current-mode first-order allpass function is obtained by employing a current differencing buffered amplifier (CDBA). However, this circuit cannot be directly connected in cascade because it has not the advantage of high output impedance. Some current-mode first-order allpass filters [10, 11] were presented each uses one four terminal floating nullor (FTFN) or one third generation current conveyor (CCIII), one capacitor and three resistors with high output impedance. The first-order allpass filter with high output impedance is realized by using one current operational amplifier (COA), one capacitor and one resistor [12]. However, the capacitors of these circuits are not grounded [10-12]. The first-order allpass filters in [4, 13] each uses two second-generation current conveyors (CCIIs) or two current differencing transconductance amplifiers (CDTAs), one capacitor and one resistor. However, the active components they used are not minimum.

In this paper, a new current-mode first-order allpass filter

using one dual-X second-generation current conveyor (DXCCII) [14], two resistors and one grounded capacitor is presented. The proposed circuit has the advantages of employing only one active device, high output impedance and using grounded capacitor.

II. DXCCII AND PROPOSED CIRCUIT

The DXCCII is a versatile building block for analogue signal processing applications. Much of the versatility of DXCCII-based circuits is attributed to the presence of both the "normal" and the "inverting" X-terminals thereby resulting in two unique outputs at the Z_p and Z_n terminals. The electrical symbol of the DXCCII is shown in Fig. 1. The DXCCII has the advantages of both of the CCII (such as large signal bandwidth, great linearity, wide dynamic range) and the ICCII.

Using standard notation, the port relations of an ideal DXCCII can be characterized in the following matrix form:

$$\begin{bmatrix} I_Y \\ V_{Xp} \\ V_{Xn} \\ I_{Zp} \\ I_{Zn} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} V_Y \\ I_{Xp} \\ I_{Xn} \end{bmatrix} \tag{1}$$

Considering the proposed current-mode circuit in Fig. 2, the current transfer function can be expressed as
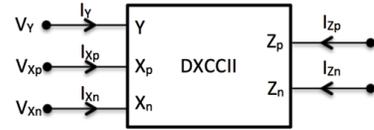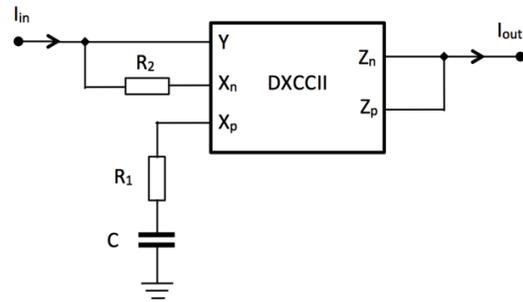

Fig. 1 DXCCII circuit symbolic.

Fig. 2 The proposed current-mode first-order filter.

$$\frac{I_{out}}{I_{in}} = \frac{sCR_2 - 2sCR_1 - 2}{2(sCR_1 + 1)} \qquad (2)$$

With $R_2 = 4R_1$, equation (2) reduces to

$$\frac{I_{out}}{I_{in}} = \frac{sCR_1 - 1}{sCR_1 + 1} \qquad (3)$$

From (3) it can be seen that a first-order allpass response is obtained from I_{out}. Because the I_{out} output terminal is taken out directly from the Z_p and Z_n terminals of the DXCCII, the I_{out} output terminal has the advantage of high output impedance. The cutoff frequency is obtained by

$$\omega_c = \frac{1}{CR_1} \qquad (4)$$

The passive sensitivities are low and obtained as $S_{C,R_1}^{\omega_c} = -1$.

III. SIMULATION RESULTS

HSPICE simulations were carried out to demonstrate the feasibility of the proposed circuit in Fig. 2 using 0.18 μm, level 49 MOSFET from TSMC. The DXCCII was realized by the CMOS implementation in Fig. 3 [14] with the NMOS and PMOS transistor aspect ratios W/L = 4.5 u/0.9 u and W/L = 9 u/0.9 u, respectively.

Fig. 4 represents the magnitude and phase responses of the first-order allpass filters, designed with fc = 1.59 MHz: C = 10 pF, R_1 = 10 kΩ and R_2 = 40 kΩ. The power supply was ±0.9V. The bias voltages are V_b = –0.38 V.
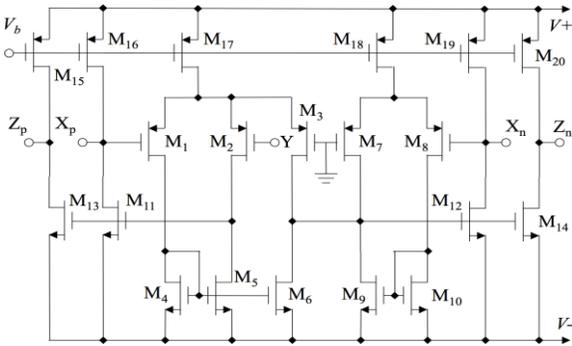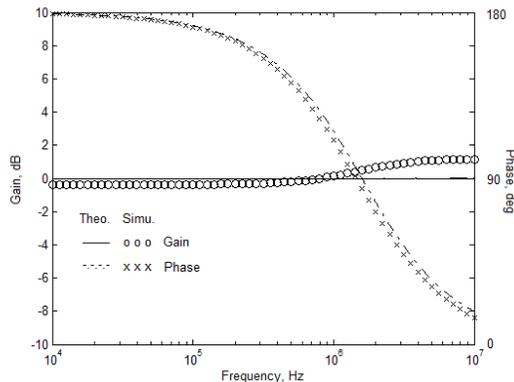

Fig. 3 CMOS realization of the DXCCII.

Fig. 4 Simulated frequency responses for the allpass filter.

IV. CONCLUSIONS

In this paper, a new current-mode first-order allpass filter configuration using one DXCCII, one grounded capacitor and two resistors is presented. The proposed circuit has the advantages of employing only one active device, high output impedance and using only grounded capacitor.

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