NOVEL GROUNDED CAPACITOR ALL-PASS AND NOTCH FILTERS USING CURRENT CONVEYORS AND DIFFERENTIAL AMPLIFIER

R. SARASWAT^a, K. PAL^{b,*} and S. RANA^c

^aScientific Laboratory Instruments, Post Box. 78, Roorkee – 247 667, India;

^bDepartment of Earthquake Engineering, I.I.T. Roorkee, Roorkee – 247 667, India;

^cDAV Centenary Public School, Hardwar – 249 404, India

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Three circuits each realizing second-order all-pass/notch filter transfer functions are reported. All circuits use grounded capacitors and are suitable for IC implementation. These circuits offer the advantages of high input impedance and low output impedance and are superior to all earlier realisations.

Keywords: Active filters; All-pass filters; Notch filters; Current conveyor

1 INTRODUCTION

The second generation current conveyor (CCII) has received considerable attention in the literature as it can realise various filters, oscillators and inductances superior to operational amplifier versions [1–5]. It has been most successful in the realisation of a desired circuit with grounded capacitors which are preferred from the IC implementation point of view [6, 7]. There exists a number of circuits using current conveyors realising first- and second-order all-pass transfer function [4, 5, 8, 9], however circuits having high input impedance, low output impedance and using grounded capacitors are not available for realisation of second-order all-pass and notch filter functions, having some distinct advantages. In this paper three circuits have been reported which have the above-mentioned features.

2 CIRCUIT DESCRIPTIONS

The proposed circuits are shown in Figures 1–3. The voltage transfer function of the circuit of Figure 1 assuming CCII to be ideal is given by

$$\frac{V_o}{V_i} = \frac{(1 + s^2 C_1 C_2 R_1 R_2) + s(C_1 R_1 + C_2 R_2 - C_1 R_2)}{(1 + s^2 C_1 C_2 R_1 R_2) + s(C_1 R_1 + C_2 R_2)}. \quad (1)$$

* Corresponding author.

FIGURE 3 Another novel second-order all-pass/notch filter realisation.

Eq. (1) becomes

$$\frac{V_o}{V_i} = \frac{1 + 4s^2R^2C^2}{1 + 4s^2R^2C^2 + 4sRC}. \quad (7)$$

Eq. (7) represents a notch transfer function. The circuit has high input impedance, low output impedance and uses grounded capacitors but suffers with the disadvantage of unequal R_1 , R_2 and C_1 , C_2 which makes it difficult to tune at a particular frequency. This disadvantage is rectified in the circuits of Figures 2 and 3. Both the circuits have the same voltage transfer function

$$\frac{V_o}{V_i} = \frac{1 + s^2R^2C^2 + sCR(2 - a)}{1 + s^2R^2C^2 + 2sCR}. \quad (8)$$

If $a = 4$ the circuit behaves as an all-pass function having voltage transfer function

$$\frac{V_o}{V_i} = \frac{1 + s^2R^2C^2 - 2sCR}{1 + s^2R^2C^2 + 2sCR}. \quad (9)$$

For $a = 2$, Eq. (8) represents a notch filter given by

$$\frac{V_o}{V_i} = \frac{1 + s^2R^2C^2}{1 + s^2R^2C^2 + 2sCR}. \quad (10)$$

The circuits have the following advantages

- (i) high input impedance
- (ii) low output impedance
- (iii) easy tuning through resistances R_s as both resistances are of equal values
- (iv) suitability for IC implementation as they use grounded capacitors [6].

The circuits of Figures 2 and 3 are superior to all earlier realisations. As compared to the earlier novel realisation [8] it has low output impedance and easy tunability as the circuit [8] can not be designed for equal values of resistances or capacitances responsible for phase shift control or notch frequency tuning.

3 EXPERIMENTAL RESULTS

The circuits of Figures 2 and 3 were tested as notch filter and all-pass filter for the following component values

$$\begin{aligned} R &= 10 \text{ K}\Omega, & C &= 0.01 \mu\text{F} \\ R_1 &= 10 \text{ K}\Omega, & a &= 2, 4. \end{aligned}$$

The CCII $\oplus$ circuit reported by Huertas [10] was used and in its realisation, operational amplifiers IC-741 were used. The experimental results confirm the theory.

4 CONCLUSIONS

Three circuits realising all-pass/notch filters have been reported. The circuit offers advantages of high input impedance, low output impedance, grounded capacitor and two circuits have easier phase tuning facility than earlier circuits. It has been shown that a combination of operational amplifier and CCII results in better filter realisation than purely CCII-based realisations.

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