UNIVERSAL CURRENT-CONVEYOR-BASED CURRENT-MODE FILTER WITH SINGLE INPUT AND FIVE OUTPUTS

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A new universal active current-mode filter with single input and five outputs is presented. The proposed filter avoids the use of external feedback in any part of the circuit and uses grounded resistors. The proposed circuit can simultaneously realize lowpass, highpass, bandpass, allpass, and notch biquadratic filter functions.

INTRODUCTION

At present, there is a growing interest in designing current-mode current-conveyor-based active filters. This is attributed to their higher signal bandwidths, greater linearity and larger dynamic range [1]. Thus, a number of circuit realizations for universal current-mode filters have been proposed [2–11]. A critical study shows that while some of the proposed circuits use grounded resistors and capacitors [2–7], other circuits use floating resistors and/or capacitors [8–11]. The majority of the proposed circuits can realize all the basic biquadratic filter functions, that is, lowpass, highpass, bandpass, allpass, and notch. However, this cannot be achieved simultaneously. Finally, most of the circuits employ external feedback in part of the circuit in order to realize the transfer functions required. This may result in instability problems, especially at high frequencies where the non-idealities of the current-conveyors cannot be ignored.

As an illustrative example, consider the most-recent circuit proposed by Chang [2]. While the circuit can simultaneously realize lowpass, highpass and bandpass functions, to obtain an allpass function it is necessary to connect the three output currents. Similarly, to obtain a notch function it is necessary to connect the highpass and the lowpass output currents. Thus the five basic filter functions cannot be realized simultaneously. While the circuit has the advantage of using grounded resistors and capacitors, it employs external feedback in part of it.

In order to avoid the possible instability problems that may arise due to the employment of external feedback, it is necessary to avoid using external feedback throughout the whole circuit. Also, it would be attractive for integration if a proposed implementation, avoiding the employment of external feedback, can be realized using grounded resistors. It is the purpose of this paper to present such a realization.

PROPOSED CIRCUIT

The proposed circuit is shown in Fig. 1. Using the standard notation, the characteristics of the current conveyors can be described by $i_x = \pm i_z$, $i_y = 0$, $v_x = v_y$ for the CCII $\pm$ and $i_x = i_y = \pm i_z$, $v_x = v_y$ for the CCI $\pm$. Routine analysis of the circuit yields the following transfer functions

$$\frac{I_{01}}{I_i} = \frac{1/C^2 R_1 R_2}{s^2 + s/CR_1 + 1/C^2 R_1 R_2} \quad (1)$$

$$\frac{I_{02}}{I_i} = \frac{s^2}{s^2 + s/CR_1 + 1/C^2 R_1 R_2} \quad (2)$$

$$\frac{I_{03}}{I_i} = \frac{s/CR_1}{s^2 + s/CR_1 + 1/C^2 R_1 R_2} \quad (3)$$

$$\frac{I_{04}}{I_i} = \frac{s^2 - s/CR_1 + 1/C^2 R_1 R_2}{s^2 + s/CR_1 + 1/C^2 R_1 R_2} \quad (4)$$

$$\frac{I_{05}}{I_i} = \frac{s^2 + 1/C^2 R_1 R_2}{s^2 + s/CR_1 + 1/C^2 R_1 R_2} \quad (5)$$

Equation (1) corresponds to the transfer function of a lowpass filter, equation (2) corresponds to the transfer function of a highpass filter, equation (3) corresponds to the transfer function of a bandpass filter, equation (4) corresponds to the transfer function of an allpass filter, and equation (5) corresponds to the transfer function of a notch filter.

From (1)–(5), one can see that the parameters ω_0^2 and $\frac{\omega_0}{Q_0}$ of the proposed current-mode filter realizations are given by

$$\omega_0^2 = 1/C^2 R_1 R_2 \quad (6)$$

and

$$\frac{\omega_0}{Q_0} = 1/CR_1 \quad (7)$$

From (6) and (7), one can see that the parameters ω_0 and $\frac{\omega_0}{Q_0}$ can be adjusted by tuning grounded resistors. Moreover, ω_0 can be adjusted by tuning R_2 without disturbing ω_0/Q_0 .

FIGURE 1 Proposed structure for realizing current-mode lowpass, highpass, bandpass, notch and allpass filters. All current conveyors are CCII $\pm$ except current-conveyor # 1 is CCI $+$ and current-conveyor # 3 is CCII $-$.

SIMULATION RESULTS

To verify the theoretical analysis, the proposed circuit has been simulated using PSPICE. The CCII $\pm$ has been simulated using an operational amplifier together with current mirrors composed of transistor arrays [12] and the CCI $+$ has been simulated using the Fabre translinear CC implementation [13]. With $R_1 = 20k\Omega$, $R_2 = 100\Omega$, $C = 5nF$, that is, $Q_0 \cong 14$ and $\omega_0 \cong 23kHz$, the result obtained from the bandpass filter is shown in Fig. 2. This result is in good agreement with the theory presented.

Date/Time run: 07/27/94 15:05:27

Temperature: 27.0

FIGURE 2 Simulated bandpass characteristic obtained from Fig. 1 with $R_1 = 20k\Omega$, $R_2 = 100\Omega$, $C = 5nF$. The output current is sensed by connecting a load resistance $= 1k\Omega$ at the output of current conveyor # 2.

CONCLUSION

In this paper a novel universal current-mode active filter using current conveyors has been presented. The circuit uses eleven current conveyors and can simultaneously realize all the five standard biquadratic filter sections, the lowpass, the highpass, the bandpass, the allpass, and the notch. Values of ω_0 can be adjusted by tuning grounded resistors without disturbing ω_0/Q_0 .

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