PROGRAMMABLE VOLTAGE-MODE MULTIFUNCTION FILTER USING TWO CURRENT CONVEYORS AND ONE OPERATIONAL TRANSCONDUCTANCE AMPLIFIER

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A new voltage-mode active-filter with single input and three outputs is presented. The parameters of the proposed filter are programmable and the filter uses grounded capacitors. The proposed circuit can simultaneously realize lowpass, highpass, and bandpass biquadratic filter functions and enjoys low temperature sensitivities.

INTRODUCTION

At present there is a growing interest in designing multifunction current-mode and voltage-mode active filters. Thus, a number of circuit realizations for multifunction current-mode and voltage-mode filters, using current-conveyors or operational-transconductance-amplifiers (OTAs) were proposed [1-17]. A critical study shows that while some of the proposed circuits use grounded resistors and capacitors [1-6,11-13], other circuits use floating resistors and/or capacitors [7-10,15-17]. The majority of the proposed circuits can realize all the basic biquadratic filter functions, that is, lowpass, highpass, bandpass, allpass, and notch. However, in most of the circuits this can not be achieved simultaneously. Moreover, while the filter parameters in current-conveyor-based circuits are not programmable, in OTA-based circuits these parameters are programmable. This is attributed to the dependence of the OTA-transconductance (g_m) on the auxiliary bias-current I_{ABC} . However, because the auxiliary-bias-current is temperature-dependent, the parameters of the resulting active-filter structures suffer from relatively high temperature sensitivities.

It is the major intention of this paper to explore the feasibility of designing programmable multifunction filters with relatively low temperature sensitivities. Also it would be attractive for integration if a proposed implementation can be realized using grounded capacitors while enjoying high input impedance and independent control of the filter parameters.

and

$$\frac{\omega_o}{Q_o} = 1/C_1 R_1 \quad (5)$$

From (4) and (5), one can see that the parameters ω_o and ω_o/Q_o can be adjusted by tuning the resistor R_1 . Moreover, ω_o can be adjusted by tuning g_m without disturbing ω_o/Q_o . And since g_m is a function of I_{ABC} this opens the way for current/voltage control of the parameter ω_o .

SENSITIVITY ANALYSIS

By defining the passive sensitivity of a parameter F to the element of variation x_i by

$$S_{x_i}^F = \frac{dF}{dx_i} \frac{x_i}{F}$$

it is easy to show that the sensitivity of the parameters ω_o and ω_o/Q_o to the variations in passive elements are given by

$$S_{C_1}^{\omega_o} = S_{C_2}^{\omega_o} = S_{R_1}^{\omega_o} = -\frac{1}{2}$$

$$S_{C_1}^{\omega_o/Q_o} = S_{R_1}^{\omega_o/Q_o} = -\frac{1}{2}$$

Similarly, the temperature-sensitivity of ω_o can be expressed by

$$S_T^{\omega_o} = -\frac{1}{2}$$

Thus, the ω_o and ω_o/Q_o sensitivities to passive-elements and temperature are low.

SIMULATION RESULTS

To verify the theoretical analysis, the proposed circuit has been simulated using Pspice. The CCII± has been simulated using the simplified nonideal model shown in Fig. 2(a) [18] with $C_y = 1pF, C_z = 1.5pF, R_y = 20M\Omega, R_z = 2M\Omega, R_{xy} = 50\Omega, h_1 = h_2 = 1.0$. The OTA has been simulated using the simplified model shown in Fig. 2(b)

(a)

(b)

FIGURE 2 (a) Nonideal model for the current conveyor CCII+ and (b) Nonideal model for the OTA.

with $R_{input} = 5M\Omega$, $R_{output} = 10M\Omega$, $C_{output} = 1pF$, $g_m = 1mA/V$. The results obtained from the LPF, HPF and BPF, for different values of Q_o , are shown in Fig. 3. These results are in good agreement with the theory presented.

CONCLUSION

In this paper a novel multifunction programmable voltage-mode active filter has been presented. The circuit uses two second-generation current conveyors and one operational transconductance amplifier (OTA) and can simultaneously realize the standard lowpass, highpass, and bandpass biquadratic filter sections. Values of ω_o can be adjusted by tuning the transconductance of the OTA without disturbing ω_o/Q_o . This opens the way to programmable voltage(current)-control of the parameter ω_o .

FIGURE 3 (a) Simulated bandpass characteristic obtained from the circuit of Fig. 1 with $C_1 = 1.0\mu F$, $C_2 = 1.0nF$, $C_3 = 10nF$, $R_1 = 1.0k\Omega$, $R_3 = 10.0k\Omega$, $g_m = 5mA/V$ (b) Simulated bandpass, lowpass and highpass characteristics obtained from the circuit of Fig. 1 with $C_1 = 10nF$, $C_2 = 10nF$, $C_3 = 1nF$, $R_1 = 1.0k\Omega$, $R_3 = 10.0k\Omega$, $g_m = 1mA/V$ (c) Simulated bandpass, lowpass and highpass characteristics obtained from the circuit of Fig. 1 with $C_1 = 10nF$, $C_2 = 0.1\mu F$, $C_3 = 1nF$, $R_1 = 1.0k\Omega$, $R_3 = 10.0k\Omega$, $g_m = 1mA/V$.

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