Second order OTA-C filters with three inputs and single output

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Abstract

A three input and single output second order OTA-C filter is presented in this paper. The circuit employs two OTAs and two capacitors in its realization. The new circuit offers some standard second order filters such as high-pass, band-pass, and all-pass.

1. Introduction

The operational transconductance amplifier has come to play an important role in the realization of active filters due to the tunability of the circuit through the transconductance. The transconductance represents the ratio of the output current to the input voltage. It is adjustable over several decades by a supplied bias current. An OTA provides a highly linear electronic tunability. Furthermore, OTA based filters require no resistors, hence they are more suitable for monolithic integration compared to other active element.

A number of circuits of universal biquad including second order OTA-C filters have been reported in the literature [1-14]. Nawrocki et al [1] proposed a two integrator loop voltage mode universal biquad filters with single input and single output using eight OTA and two grounded capacitors. In 1992 Khan et al [2] presented two configurations for realizing voltage-mode universal biquadratic filters with three input and single output using three OTAs, one voltage follower and two capacitors. Sanchez-sinencio et al [3] persposed a generation of continuous-time two integrator loop OTA filter structures. Sun and Fiddler [4] presented a universal biquadric filter using six OTA and two grounded capacitors. The contribution by J.W Horng [5] belongs to a voltage –mode biquadric filter with one input and five outputs using five OTAs and two grounded capacitors. In 1993 J.Wu. and Xie [6] proposed a five input and three output voltage mode multifunction filters using four OTAs and two capacitores. However, these configurations [1-6] employ too many active elements. In 1998 Y. Sun [7] presented a second order OTA-C filter derived from Nawroki-Klein biquad using eight OTA and two grounded capacitor. In the recent work of the year 2003, J.W. Horng [8] proposed high input impedance voltage-mode universal filter using two dual output OTA and one CCII. In this paper a new voltage mode OTA-C filter circuit using two single output OTAs and two capacitors is presented. The circuit offers some standard second order filters named high-pass, band-pass, and all-pass from the same configuration.

2. Circuit description

The proposed circuit of second order OTA-C filter is shown in fig (1).

![Fig. 1](image-url)
The voltage transfer functions of the proposed circuit is given by

\[ V_{01} = \frac{s^2C_1C_2V_i + sC_i[V_i(g_2 - V_{g1})] + V_{g1}g_2}{s^2C_1C_2 + sC_i(g_2 - g_1) + g_1g_2} \] (1)

2.1 High pass filter

The realization conditions are

\[ V_1 = V_2 = 0, V_3 = V_i, g_2 = 2g_1 \]

The eqn. (1) becomes

\[ \frac{V_{01}}{V_i} = \frac{s^2C_1C_2}{s^2C_1C_2 + sC_i(g_2 - g_1) + g_1g_2} \] (2)

which represents a high pass filter.

2.2 Band pass filter

The realization conditions are

\[ V_1 = V_3 = 0, V_2 = V_i, g_2 = 2g_1 \]

The eqn. (1) becomes

\[ \frac{V_{01}}{V_i} = \frac{sC_1g_2}{s^2C_1C_2 + sC_i(g_2 - g_1) + g_1g_2} \] (3)

which represents a band-pass filter.

2.3 All-pass filter

The realization conditions are

\[ V_2 = 0, V_3 = V_i, g_2 = 2g_1 \]

The eqn. (1) becomes

\[ \frac{V_{01}}{V_i} = \frac{s^2C_1C_2 - sC_1g_1 + g_1g_2}{s^2C_1C_2 + sC_1g_1 + g_1g_2} \] (4)

which represents an all pass filter.

3. Experimental results

The second order OTA-C filter circuit of fig (1) was tested for following component values.

\[ g_1 = .0001 \text{ mho} \]
\[ g_2 = .0002 \text{ mho} \]

\[ C_1 = .01 \mu \text{F} \]
\[ C_2 = .01 \mu \text{F} \]

The IC AD844 was used as CFA for the OTA model as shown in the fig (2). The results were obtained using spice simulation.

![Fig (2) An OTA model using CFA](image)

The results of study for all pass filter are shown in graph (fig 3(a)), for high-pass and band-pass are shown in graph (fig 3(b)(c)).

![Fig 3(a) Phase Vs Frequency response of all-pass filter](image)
Fig. 3 (b) Gain Vs frequency response of the high pass filter

Fig. 3 (b) Gain Vs frequency response of the band-pass filter

The experimental results when compared with theoretical results was found in good agreement (deviation not more than ± 6%).

4. Conclusions

A new circuit of voltage mode OTA-C filter circuit using two single output OTAs and two capacitors is presented. The circuit offers some standard second order filters such as high-pass, band-pass, and all-pass from the same configuration.

References.


