OTA-C Realization of Electronically Tunable Current-Mode Biquadratic Filters

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Abstract

An active-C biquadratic filter structure is proposed which consists of only seven OTAs and two grounded capacitors. The proposed circuit can simultaneously realize lowpass, bandpass and highpass transfer functions without changing circuit topology. This technique provides many advantages which include low passive and active sensitivities and, moreover, its Q-factor is electronically tunable and separately from the tuning of the natural angular frequency ω_o. PSPICE simulation results are obtained that confirm the theoretical analysis.

1. Introduction

During the past few years, the development of electronically tunable filtering networks is of great importance for the implementation of many communication and instrumentation systems [1]. Recently, filtering networks have been rapidly developed and used to construct many high performance circuits, such as operational transconductance amplifiers OTAs [2-4], second-generation current conveyors (CCIIs) [5-6] and an four-terminal floating nullor (FTFN) [7-8]. Normally, OTA is only the active device that its transconductance gain can be linearly and electronically tuned over a wide adjustable range. Furthermore, the OTA-based structures are very attractive in the sense that they can be realized with the employment of grounding capacitors, reducing the number of components, and require no resistors [9]. It is well known that the grounding capacitor can be implemented on a smaller area and can absorb equivalent shunt capacitive practices. Therefore, the OTA-based structures are more suitable for implemented in monolithic integrated circuit form than CCII-based and FTFN-based structures. Although the realizations of the tunable current-mode biquadratic filters based on an OTA-C technique have been widely investigated [2-4, 9-10], the tuning process of Q-factor are affecting the natural angular frequency ω_o. The synthesis structure which expected to remarkably attractive for the filter implementations should be independently tuned of the ω_o and Q-factor by electronic means.

The goal of this paper is to present a design variant for realizing electronically tunable biquadratic filter configuration, which is based on the use of the OTA-C technique. The method is general and suitable for monolithic integration and electronic frequency tuning. The proposed technique offers the following advantageous features : (i) can be realized the most frequently used filtering functions, namely, lowpass, highpass and bandpass transfer functions simultaneously without changing circuit topology and elements, (ii) can be independently and electronically tuned their ω_o and Q-factor, (iii) can be found to be insensitive to the passive components and the non-idealities of the active components. The simulation results using PSPICE are used to confirm the performance of the proposed configuration.

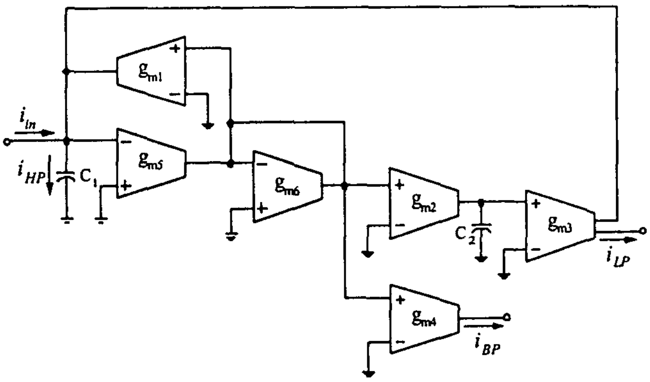

Figure 1 : The proposed circuit configuration

2. Proposed scheme

The proposed scheme to generate current-mode biquadratic filtering functions based on OTA-grounded capacitor is shown in Fig. 1, where g_{mi} is the transconductance gain of the i-th OTA. From routine circuit analysis, the current transfer functions of the configuration in Fig. 1 can be expressed by the following equations :

$$T_{LP}(s)=\frac{I_{LP}(s)}{I_{in}(s)}=-\frac{\left(\frac{g_{m2}g_{m3}g_{m5}}{g_{m6}C_1C_2}\right)}{D(s)} \quad (1)$$

$$T_{BP}(s)=\frac{I_{BP}(s)}{I_{in}(s)}=-\frac{s\left(\frac{g_{m4}g_{m5}}{g_{m6}C_1}\right)}{D(s)} \quad (2)$$

and

$$T_{HP}(s)=\frac{I_{HP}(s)}{I_{in}(s)}=\frac{s^2}{D(s)} \quad (3)$$

where

$$D(s)=s^2+s\left(\frac{g_{m1}g_{m5}}{g_{m6}C_1}\right)+\left(\frac{g_{m2}g_{m3}g_{m5}}{g_{m6}C_1C_2}\right)$$