Available online at www.scholarsresearchlibrary.com

Scholars Research Library

Archives of Applied Science Research, 2010, 2 (3): 248-252

(http://scholarsresearchlibrary.com/archive.html)

ISSN 0975-508X
CODEN (USA) AASRC9

Frequency response of electronically tunable current-mode third order high pass filter with central frequency f_o = 10 k with variable Circuit merit factor Q

G. N. Shinde[1] and D. D. Mulajkar[2]

[1]Indira Gandhi (SR) College, Nanded-431603, Maharashtra, India.
[2]Dnyanasadhana College, Thane-400604, Maharashtra, India.

Abstract

Current mode filters have many advantages compared with their voltage mode counterparts. Current mode filters have large dynamic range, higher bandwidth, greater linearity, simple circuitry, low power consumption etc. In this paper, a realization of a current mode third order high pass filter is described. The proposed circuit employs operational amplifier as the basic building unit. The filter circuit realizes quadratic work function. It provides electronically tuning capability of the filter characteristics. The proposed circuit works ideal for Center frequency fo = 10 k and Circuit merit factor Q > 1. The gain roll-off this configuration is 18dB/octave. The circuit is suitable for monolithic integration and high frequency operation. The filters developed were successful in obtaining passive sensitivities less than unity in magnitude and active sensitivities are half in magnitude, which is a noteworthy achievement. The circuit is suitable for high frequency operation and monolithic integration.

Key Words: Current mode filter, third order, high pass, center frequency.

INTRODUCTION

High performance active filters have received much attention. In filter circuit designs, current mode filters are becoming popular since they have many advantages compared with their voltage mode counter parts. Current mode filters have large dynamic range, higher bandwidth, greater linearity, simple circuitry, low power consumption etc. Designs of current mode filters employing active devices such as Operational Amplifiers (OA), Operational Trans-conductance Amplifiers (OTA) and second generation current conveyors (CCIIS) have been reported in the literature [1-5]. The realization of current transfer function is a topic considerable interest for researchers [3-8]. These filters do not need to employ additional passive elements and are therefore sometimes called active only filters. The major advantages of these circuits are the elimination of passive elements that may result in reduction of chip area for integrated circuit implementation.

Filter circuits utilizing the finite and complex nature of OA gain are suitable for high frequency operation. Such filter circuits would facilitate its integrability and programmability. A growing number of publications exist in the literature on OA and OTA only filters (2, 9-12).

Current mode filter theoretically should exhibit high output impedance (Ideally infinite) and low input impedance (Ideally Zero). Several filter designs based on active-R, active-C and active-RC synthesis have been discussed using active devices and passive elements. The circuit using active devices and resistors is more suitable for monolithic integration.

The purpose of this paper is to focus on realization of current mode filter with quadratic transfer function. The proposed circuit is solely designed with Operational Amplifiers and resistors. The circuit has low passive sensitivities and provides electronically tuning capability of the filter characteristics.

Circuit analysis and analytical treatment

Figure 1 shows proposed circuit diagram of third order high pass filter. It consists of three op-amps (LF 356N) having gain bandwidth ratio of 6.392 X 10^6. The resistors g_{1a}, g_{1b}, g_{2a}, g_{2b}, g_{3a} and g_{3b} serves voltage divider for op-amps.

The analysis gives the current transfer function $T_H = [I_{out} / I_{in}]$

$$T_H = \frac{g_0 s^3}{(g_0+g_2+g_3+g_{1b}k_1+g_1)s^3+(g_1\beta_1+g_3\beta_3)k_1 s^2+g_2\beta_1\beta_2 k_1 k_2 s^1+g_3\beta_1\beta_2\beta_3 k_1 k_2 k_3}$$

Where

$$k_1 = \frac{g_{1a}}{g_{1a}+g_{1b}}$$

$$k_2 = \frac{g_{2a}}{g_{2a}+g_{2b}}$$

$$k_3 = \frac{g_{3a}}{g_{3a}+g_{3b}}$$

If $g_{1b}k_1 << (g_0+g_1+g_2+g_3)$ then ,

$$T_H = \frac{g_0 s^3}{(g_0+g_1+g_2+g_3)s^3+(g_1\beta_1+g_3\beta_3)k_1 s^2+g_2\beta_1\beta_2 k_1 k_2 s^1+g_3\beta_1\beta_2\beta_3 k_1 k_2 k_3}$$

Where,

$$\omega_0 = (g_3\beta_1\beta_2\beta_3k_1k_2k_3)^{\frac{1}{3}}$$

RESULTS AND DISCUSSION

We have proposed the circuit with $k_1 = k_2 = 0.5$ mS; $\beta_1 = \beta_2 = 6 \cdot 392 \times 10^6$ for op.amp. LF 356 N.

Table gives analysis of the frequency response of the filter for $F_0 = 10$ kHz for different values of Q. Figure 2 shows the frequency response of the circuit. It is observed that gain roll-off is 18 dB/octave for center frequency $F_0 = 10$ kHz and circuit works ideal for this frequency.

Sensitivities

The practical solution is to design a network that has low sensitivity to element changes. Thus sensitivity must be less than limit i.e. unity [2, 3, and 12]

The equation of the o and Q sensitivities of the filter transfer functions with respective the parameter k_1, k_2, β_1, β_2, g_1, g_2, g_o are as follows:

$$S_{k_1}^{\omega_0} = S_{k_2}^{\omega_0} = S_{k_3}^{\omega_0} = \frac{1}{3}$$

$$S_{\beta_1}^{\omega_0} = S_{\beta_2}^{\omega_0} = S_{\beta_3}^{\omega_0} = \frac{1}{3}$$

$$S_{g_0}^{\omega_0} = -\frac{1}{3}\left[\frac{g_0}{g_0 + g_1 + g_2 + g_3}\right]$$

$$S_{g_0}^{\omega_0} = -\frac{1}{3}\left[\frac{g_0}{g_0 + g_1 + g_2 + g_3}\right]$$

$$S_{g_2}^{\omega_0} = -\frac{1}{3}\left[\frac{g_2}{g_0 + g_1 + g_2 + g_3}\right]$$

$$S_{g_3}^{\omega_0} = \left(\frac{1 - g_3}{3}\right)$$

CONCLUSION

In this paper, a realization of a current mode third order high pass filter is described. The proposed circuit employs operational amplifier as the basic building unit. The filter circuit can realize transfer function and circuit characteristics can be electronically tuned. The circuit has passive sensitivities no more than unity. The proposed circuit works ideal for Q > 1 at central frequency f_0 = 10 kHz. The gain roll-off is 18dB/octave. The circuit is suitable for high frequency operation and monolithic integration.

Circuit Diagram:

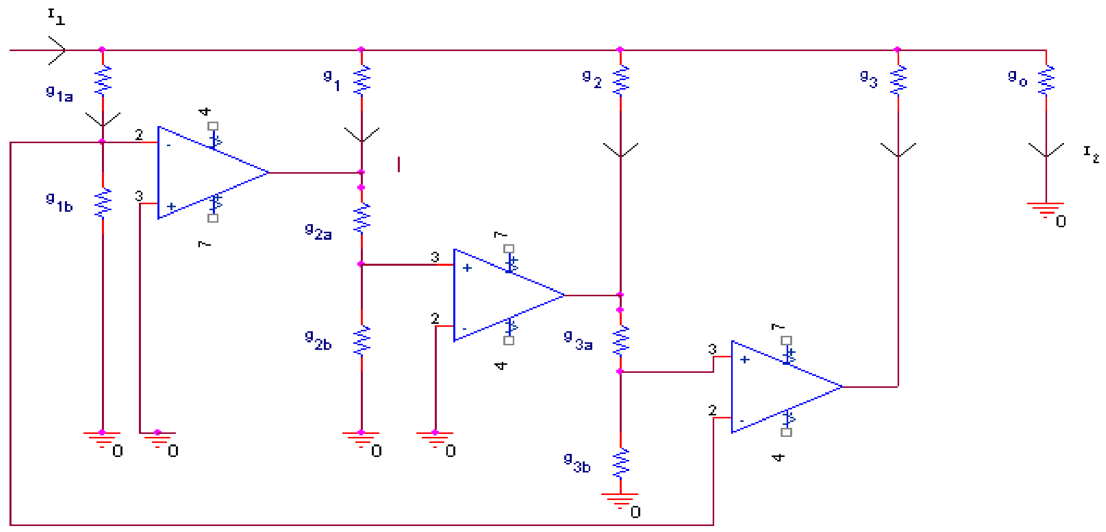

Figure 1. Circuit diagram for electronically tunable current mode Third order high pass filter

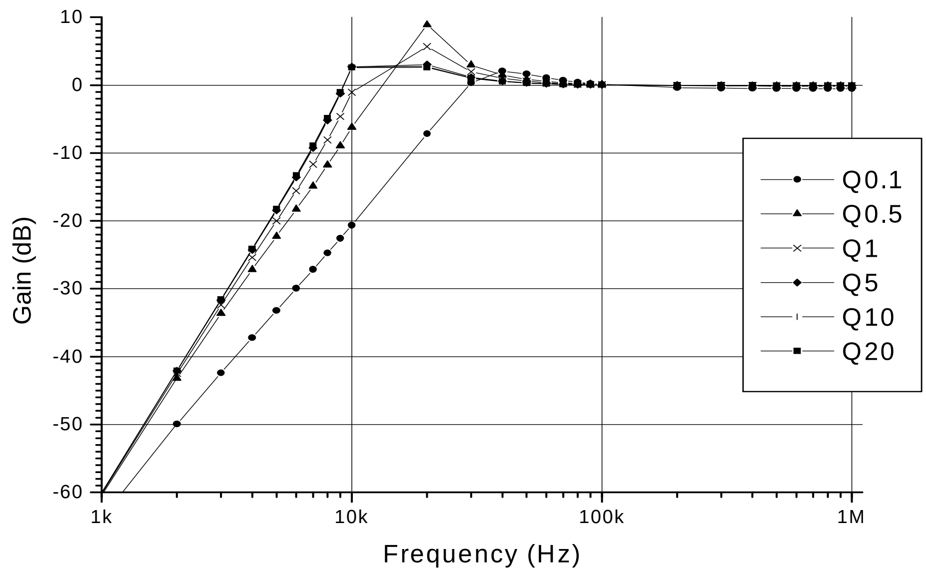

Fig. 2. Frequency Response of Third order Current mode High pass Filter for F_0 = 10 kHz with variable Q

Table1: Analysis of High pass response for third order current mode filter with variable Q

Q	F_{0H} (kHz)	$F_0 \sim F_{0H}$ (kHz)	Gain Roll-off / octave in stop band		Gain Stabilization at pass band	
			dB/ octave	Octave starting at	dB	F_S (kHz)
0·1	25·2	15·2	12·6	10	– 0·5	400
0·5	11·6	1·6	15·4	6	– 0·1	300
1	9·4	0·6	17·1	4	0	200
5	8·6	1·4	17·9	4	0	200
10	8·5	1·5	17·9	4	0	200
20	8·5	1·5	17·9	4	0	200

REFERENCES

[1] Takao Tsukutani, Masami Higashimura, Yasuaki Sumi and Yutaka Fukui, *Int. J Electronics*, **2000**, VOL 87 NO 3, 307-314
[2] Shinde G. N., Achole P. D. *Indian J Physics* 80 (2), 187-190, **2006**
[3] Trkutani T, Ishida M. and Fuksui Y., "Cancellation technique of parasitic poles for active-R high pass filter." . Transaction of the Institute of Electronics and Communication Engineering of Japan, **1991**, Pt. E 75, 1083-1085
[4] Cheng Chung Hsu and Wu-shiung feng *Int. J Electronics*, **2001**, 88, 1, 41-51
[5] Masami Higashimura, *Int J Electronics*, **1992**, 6, 1279-1283
[6] Mitra A. K. and Aatre V. K., *I.E.E.E. Transactions on Circuits and Systems*, **1976**, 23, 670-676
[7] N. A. Shah, M.F. Rather, M. A. Malik, S. Z. Iqbal "Cascadable electronically tunable SITO current-mode active-only universal filter"
[8] Shinde G. N. and Patil P. B. *Sadhana. J. Eng. Sci.* 28 (6), 1919-1926, **2003**.
[9] Takao Tsukutani, Masami Higashimura, Yasuaki Sumi and Yutaka Fukui, *Int. J. Electronics*, **2000**, l 87, 3, 307-314
[10] Cheng-Chung Hsu and Wu-Shiung Feng, *Int. J. Electronics*, **2001**, l, 88, 1, 41-51
[11] Nandi R. "Active R realization of bilinear RL impedances and their applications in a high-Q parallel resonator and external oscillator." Proceeding of the Institute of Electrical and Electronics Engineering, **1978**
[12] G. N. Shinde and D. D. Mulajkar, *International Journal of Physical Sciences*, 3 (6), 148-151, **2008**