International Journal of Physical Sciences Vol. 3 (6), pp. 148-151, June 2008
Available online at http://www.academicjournals.org/IJPS
ISSN 1992 - 1950 © 2008 Academic Journals

Full Length Research Paper

Electronically tunable current mode second order high pass filter for different value of 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.

Accepted 13 June, 2008

This paper presents realization of current-mode active-R filter in order to increase the speed of circuits for analog signal processing and to decrease the supply voltages of integrated circuits. The proposed filter is constructed using operational amplifiers [OA] and resistors. The circuit capable of realizing quadratic transfer function .The proposed second order high pass filter circuit works ideal for Q >=1 at center Frequency F_0 = 50 KHz .The gain roll-off of this configuration is 40dB/decade. Since the circuit is composed only of resistances, it is suitable for high frequency operation and monolithic implementation. 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.

Key words: Current mode filter, second order, high pass, center frequency.

INTRODUCTION

In order to increase the speed of circuits for analog signal processing and to reduce the supply voltages of integrated circuits, designers devote their attention to the so-called current mode (Higashimura, 1992; Tsukutani et al., 2000; Hsu et al., 2001; Nandi, 1978). It means the individual circuit elements should interact by means of currents, not by voltages (Mitra et al., 1976; Trkutani et al., 1991; Tsukutani et al., 2000). In practice, we can only approach the current mode because a current flowing through circuit element necessarily causes a voltage drop. Choosing proper impedance levels, sufficiently small voltages can be achieved with the aim to eliminate the influence of Miller's capacitances and other nonidealities(Hsu et al., 2001).

Current - mode active filters have received significant attention. They are becoming popular because of many advantages over voltage-mode filters. Some of the advantages of the Current-mode filters are larger dynamic range, higher bandwidth, greater linearity, simple circuitry, low power consumption etc. Filters employing operational transconductance amplifiers (OTAs) provide high electronic tunability, integrability, programmability and simplicity in design. Extensive work has been done on filters employing using OA and OTA (Shinde and Patil, 2003; Shinde and Achole, 2006).Present group of author's have done pioneering work in this area. Designs of current mode filters employing active devices such as OAs, OTAs and second generation current conveyors [CCI I s] have been reported in the literature (Shah et al., 2005; Biolek and Gubek, 2004).

Significant work on quadratic filter has been done by Misami Higashimura using basic second order functional block for realizing high order filter functions. However, the uniqueness of the present communication is realization of current mode active R filter suitable for monolithic integration. The circuit designed herein solely uses Op-Amps and few resistors and thus suits the high frequency operation in addition to the ease of IC realization.

Current amplifiers

The summation or difference of signals, multiplying a signal by a constant (which is either frequency independent or dependent), and signal distribution into more places in the circuit belong to the basic operations in linear networks. For currents, these operations can be provided by current amplifiers with zero-input and infinity-output resistances, with a possibility to associate input currents with different signs (amplifiers with difference current inputs), and to distribute the output current into more branches in the circuit (amplifiers with multiple outputs). Current

*Corresponding author. E-mail: shindegn@yahoo.co.in.

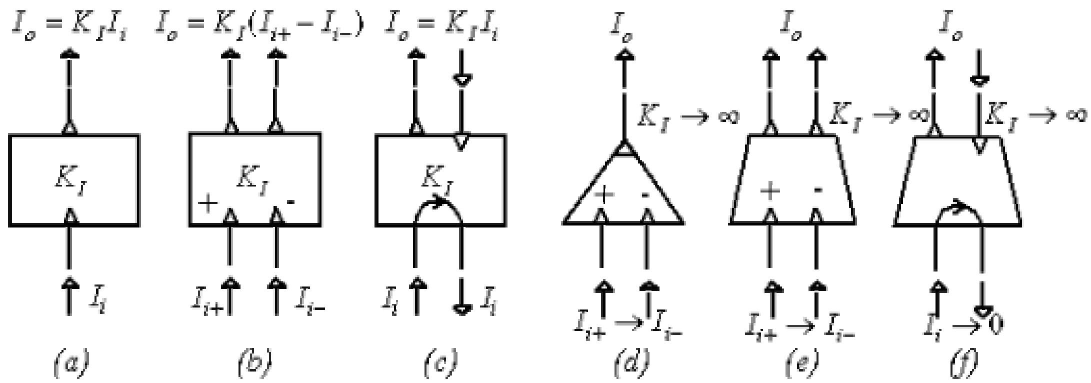

Figure 1. Current amplifiers, (a) single-input single-output, (b) difference-input common-output, (c) through-input difference-output, (d) COA, (e) COA with Common Output, (f) COA with through-input and difference-output.

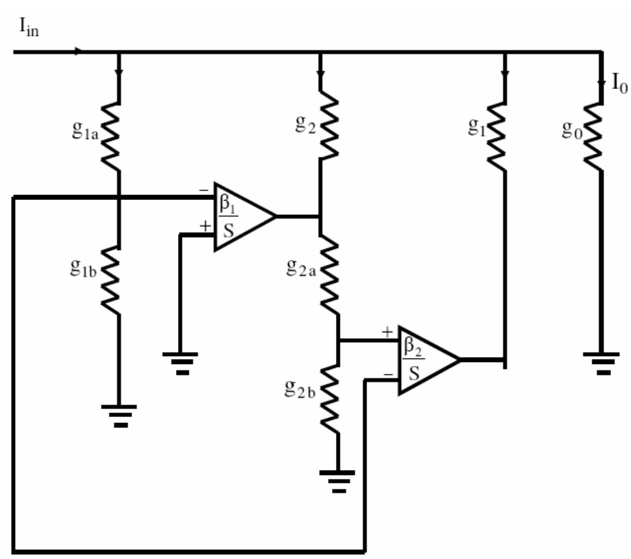

Figure 2. Circuit diagram for electronically tunable current mode second order high pass filter.

weighting can be accomplished by controlling the current gains of amplifiers and by active or passive current dividers.

In terms of inputs, the current amplifiers can be classified as amplifiers with a single input (one low-impedance input with the possibility to sum input currents), amplifiers with a difference input (couple of low-impedance difference inputs), and amplifiers with a through-input (“floating“ couple typical of the input gate of a current-controlled source) (Biolek and Gubek, 2004). The proposed notations of given inputs are obvious in Figure 1. The arrows near the individual outlets denote both the fact that these terminals are current, not voltage terminals, and they show the direction of the currents considered with respect to a defined sign of current transfer K_I. In terms of outputs, let us classify the current amplifiers as single-output and multiple-output amplifiers. The arrows again show the directions of the output currents with respect to the directions of input currents and a defined current transfer (Biolek and Gubek, 2004).

Current amplifiers can have either a finite or infinite current gain K_I. In the case of unity gain, it is not necessary to inscribe it into the schematic symbol. For infinite gain, current amplifiers verge on special operational amplifiers. It is useful to demark them with different schematic symbols: triangular for single-output amplifiers (Figure 1d) and trapezoidal for multiple-output amplifiers (Figure 1e and 1f). The single-output and common-output COA is in Figur 1d and 1e. The through-input COA is another variant with more possible types of outputs. The difference output is given in Figure 1f.

The COA is described in two variants: DISO (Differential-Input-Single-Output) and SIDO (Single-Input-Differential-Output) (Hsu et al., 2001).Since this terminology is widely used (Shah et al., 2005), it is advisable to respect it and to extend it to all the variants in Figure 1.

Circuit analysis and analytical treatment

Figure 2 shows proposed circuit diagram of second order high pass filter. It consists of two op-amps (LF 356N) having gain bandwidth ratio of $6 \cdot 392 \times 10^6$., as gain bandwidth product of this current op. amp is large. The resistors g_{1a}, g_{1b}, g_{2a} and g_{2b} serve the voltage divider for op. amps.

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

$T_H[S] =$

$$\frac{g_0 S^2}{(g_0 + g_1 + g_2 + g_{1b}k_1)S^2 + (g_1\beta_1 + g_2\beta_2)S + g_2\beta_1\beta_2 k_1 k_2}$$

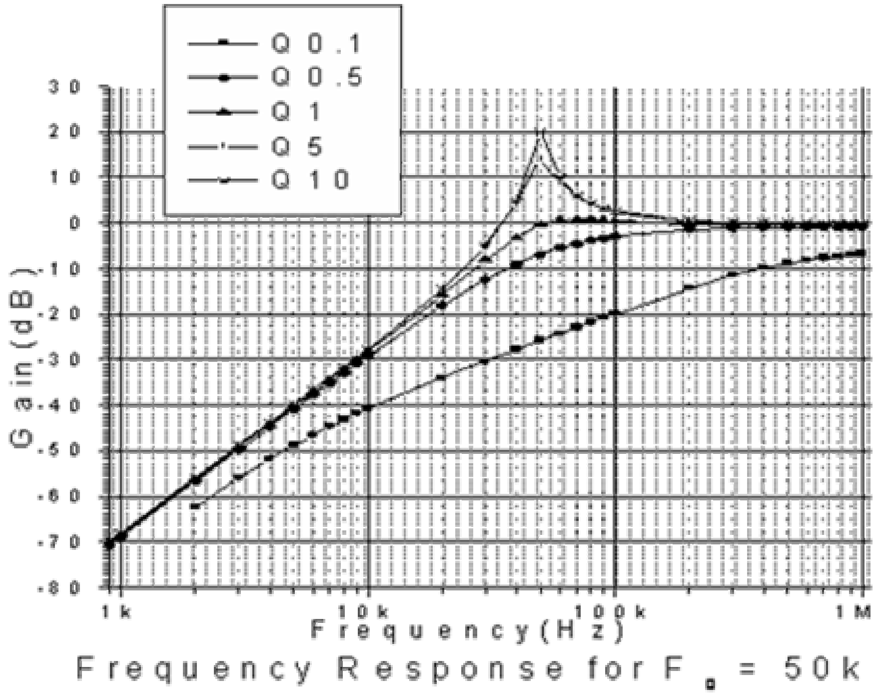

Figure 3. High pass response for electronically tunable current mode second order filter.

Table 1. Analysis of the frequency response of the filter for cutoff frequency 50 K for different values of Q. F_0 = 50 KHz, Q variable

Q	F_{OH} (KHz)	$F_0 \sim F_{OH}$ (KHz)	Gain Roll-off in stop band		Gain Stabilization		Peak Gain of overshoot dB	F_{OSH} (KHz)
			dB/decade	Decade Starting at (KHz)	dB	F_S (KHz)		
0·5	100	50	39	3	− 2	110		
1	32	18	44	3·2	0	50		
5	22	28	41	2	0	110	13	50
10	22	28	40	2	0	110	20	50

F_{OH}: − 3dB Frequency; F_{OSH}: Frequency at which overshoot occurs; F_{OSH}: Frequency at which overshoot occurs; F_S: Frequency at which gain stabilizes.

$$\frac{g_0 S^2}{(g_0+g_1+g_2+g_{1b}k_1)S^2+(g_1\beta_1+g_2\beta_2)S+g_2\beta_1\beta_2k_1k_2}$$
.. (1)

Where $k_1 = \frac{g_{1a}}{g_{1a}+g_{1b}}$ and $k_2 = \frac{g_{2a}}{g_{2a}+g_{2b}}$

If $g_{1b}k_1 \ll [g_0 + g_1 + g_2]$,equation (1) becomes,

$T_H[S]$ =

$$\frac{g_0 S^2}{(g_0+g_1+g_2)S^2+(g_1\beta_1+g_2\beta_2)S+g_2\beta_1\beta_2k_1k_2}$$

RESULT S AND DISCUSSION

We have proposed the circuit with $k_1 = k_2$ = 0.5ms; $\beta_1 = \beta_2 = 6.392 \times 10^6$ for LF 356 N

The frequency response for center frequency 50 kHz for different values of Q is as shown in the Figure 3.This second order high pass filter circuit works ideal for Q >= 1 at center frequency F_0 = 50 KHz. The gain roll-off of this configuration is 40dB/decad for Q = 10. It is also observed that overshoot in gain appears for Q >=1 and gain stabilized at 0 dB.

Table 1 gives the analysis of the frequency response of the filter for cutoff frequency 50 K for different values of Q.

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 (Tsukutani, 2000; Shinde and Achole, 2006).

The equation of the ωo 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:

$$S^{\omega_0}_{k_1} = S^{\omega_0}_{k_2} = S^{\omega_0}_{\beta_1} = S^{\omega_0}_{\beta_2} = \frac{1}{2}$$

$$S^{\omega_0}_{g_0} = -\frac{g_0}{2(g_0+g_1+g_2)}\omega$$

$$S^{\omega_0}_{g_1} = -\frac{g_1}{2(g_0+g_1+g_2)}$$

$$S^{\omega_0}_{g_2} = \frac{(g_0+g_1)}{2(g_0+g_1+g_2)}$$

$$-S^{Q}_{k_1} = S^{Q}_{k_2} = \frac{1}{2}$$

$$S^{Q}_{g_0} = -\frac{g_0}{2(g_0+g_1+g_2)}$$

From these equations, 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.

Conclusion

The current-mode active-R filter circuit can realize quadratic transfer function. The proposed filter is constructed using operational amplifiers [OA] and resistors. The proposed second order high pass filter circuit works ideal for Q >=1 at center frequency F_0 = 50 KHz .The gain roll-off of this configuration is 40 dB/decade. Since the circuit is composed only of resistances, it is suitable for high frequency operation and monolithic implementation. The passive sensitivities are less than unity in magnitude and active sensitivities are half in magnitude, which is a noteworthy achievement.

REFERENCES

Biolek D, Gubek T (2004). New Circuit Elements for Current-Mode Signal Processing, Elektrorevue, Pp: 28-35.

Higashimura M (1992).Active-R realization of current-mode high pass filter, Intl. J. Electron. 6: 1279-1283.

Hsu C, feng W (2001). Structural design of current-mode biquad filters, Intl. J. Electron. 88(1): 41-51.

Mitra AK, Aatre VK (1976). Low sensitivity high frequency active R filters, I.E.E.E. Transactions on Circuits and Systems, 23: 670-676.

Nandi R (1978). 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.

Shah NA, Rather MF, Malik MA, Iqbal SZ (2005). Cascadable electronically tunable SITO current-mode active-only universal filter" Intl. J. Electron. 8(1): 141-151.

Shinde GN, Achole PD (2006). Multiple feedback third order active-R filter with varying tapping ratio B, Indian J. Physics, 80(2): 187-190.

Shinde GN,.Patil PB (2003). A third order active-R filter with feed forward input signal, Sadhana, J.Eng.Sci. 28(6): 1919-1926.

Trkutani T, Ishida M, Fuksui Y (1991). Cancellation technique of parasitic poles for active-R high pass filter, Transaction of the Institute of Electronics and Communication Engineering of Japan, Pt. E 75: 1083-1085.

Tsukutani T, Higashimura M, Sumi Y, Fukui Y (2000). Electronically tunable current mode active-only biquadratic filter, Intl. J. Electron. 87(3): 307-314.