New Current-Mode Second Order Filter using Current Feedback Amplifiers (CFAS)

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ABSTRACT
A new configuration for realizing current- mode multifunction filter using current feedback amplifiers for a single current input source is presented. The proposed current-mode circuit realizes simultaneously low pass, high pass and band pass filters where as notch and all-pass filter functions can also be realized by addition and/or subtraction of various filter functions without any substantial hardware requirement. The proposed circuit has low active and passive sensitivities and employs generally grounded capacitors. These filters also enjoy grounded-resistance-control of the parameters ω_0 and Q_0.

Keywords
Current Mode, Active Filter, Current Feedback, Operational Amplifiers.

1. Introduction
Analog filters find applications in many areas like communication, measurement, instrumentation and control system engineering. A current feedback amplifier (CFA) [1] is an active building block used to implement voltage as well as current-mode analog signal processing circuits[1 – 11]. The low input impedance at x port and high output impedance at z port of CFA enables easy and simple realization of current-mode circuits. Some of the main advantages of current-mode circuits are small voltage swings at the nodes, excellent high frequency performance and larger dynamic range compared to voltage mode circuits. An added advantage is that filter current responses can be added or subtracted directly without any increase in the hardware. It is very suitable for portable equipment and gadgets where low value of supply voltage is required. The need to propose this new current feedback amplifier (CFA) based filter stems from the fact that single CFA multifunction filter proposed by Horng et al[4] suffers from low Q-values. In the proposed circuit two CFAs are used with all the passive components except one feedback resistor are grounded. Quality factor is conveniently improved by the addition of an active element (CFA) in this circuit. Many other prominent current/voltage mode circuits employing CFAs are given in the literature [2-11].

In this paper, a new circuit configuration is proposed to realize current-mode second order low pass, band pass and high pass filter simultaneously for a single current input. The notch and all pass filter functions are also obtained.

The proposed filter circuit employs in a general sense two CFAs and two grounded capacitors with some grounded/floating resistors. The proposed circuit has been designed and tested on PSpice and results were found to be satisfactory.

2. CURRENT FEEDBACK AMPLIFIER
Fig.1 denotes the symbol of CFA, The terminal relation of the CFA can be characterized by the following set of equations:

$V_x = V_y$, $i_x = i_z$, $V_0 = V_z$, & $i_y = 0$

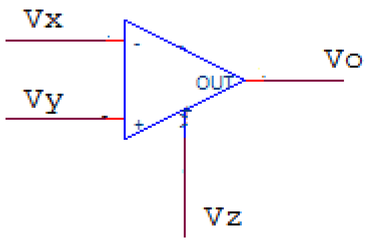

Fig.1 Circuit symbol of CFA

3. PROPOSED CURRENT MODE MULTIFUNCTION BIQUAD FILTER
The proposed CFA based multifunction filter is realized as shown in Fig.2. This circuit realizes current-mode low pass, high pass and band pass filter functions for single current input. The circuit is attractive as it uses very few passive elements with all capacitors grounded. The proposed circuit may also be used to realize notch as well as all pass current mode filter with a little addition of active component in the circuit. The simulation results are given in Fig.4 All the passive components except one feedback resistor are grounded. Although R_1 seems to be floating but it is also virtually grounded as $V_x = V_y = 0$ as shown in the circuit of Fig.2. Low pass response can be obtained using a current from Z port of the second CFA. In Fig.3 the circuit of Fig 2 is modified to obtain all pass and notch filter functions.

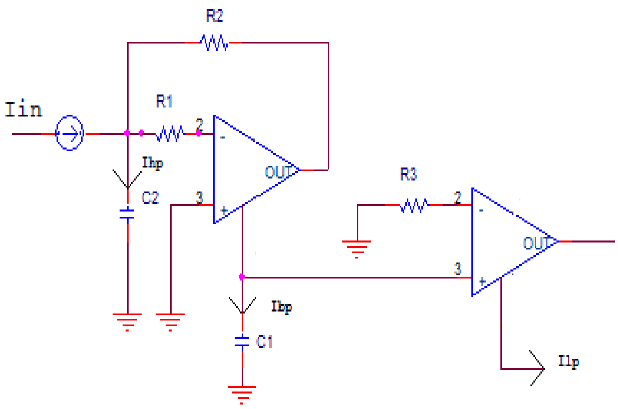

Figure 2 The proposed current-mode biquad filter.

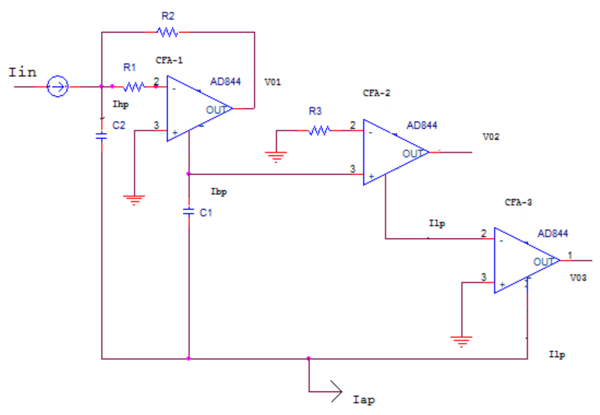

Figure 3 The modified current-mode biquad filter ckt to obtain all pass and notch filter.

The routine analysis yields the transfer functions of the

Fig 2. As shown below

$$\frac{I_{lp}}{I_{in}} = \frac{\frac{G_1G_3}{C_1C_2}}{s^2+\frac{s(G_1+G_2)}{C_2}+\frac{G_1G_2}{C_1C_2}} \qquad (1)$$

$$\frac{I_{hp}}{I_{in}} = \frac{s^2}{s^2+\frac{s(G_1+G_2)}{C_2}+\frac{G_1G_2}{C_1C_2}} \qquad (2)$$

$$\frac{I_{bp}}{I_{in}} = \frac{-\frac{sG_1}{C_2}}{s^2+\frac{s(G_1+G_2)}{C_2}+\frac{G_1G_2}{C_1C_2}} \qquad (3)$$

$$\omega_0 = \sqrt{\frac{G_1G_2}{C_1C_2}}\,. \qquad (4)$$

$$\mathrm{BW} = \frac{G_1+G_2}{c_2} \qquad (5)$$

$$Q = \frac{w_0}{BW} = \frac{1}{G_1+G_2}\sqrt{\frac{C_2G_1G_2}{C_1}} \qquad (6)$$

The filter circuit of Fig.2 is simulated for R_1=R_2 = R_3 =1K and C_1=C_2= 10nF for f_0 = 15.923 kHz & Q = $\frac{1}{2}$.

The simulated frequency response is shown in Fig.4.

The active and passive Sensitivities of the proposed filter have been found to be very small and are

$$S_{G_1}^{\omega_0} = S_{G_2}^{\omega_0} = -S_{C_1}^{\omega_0} = -S_{C_2}^{\omega_0} = S_{\alpha_1}^{\omega_0} = S_{\beta_1}^{\omega_0} = S_{\alpha_2}^{\omega_0} = S_{\gamma}^{\omega_0} = \frac{1}{2} \qquad (7)$$

$$S_{\alpha_1}^{Q} = S_{\beta_1}^{Q} = S_{\alpha_2}^{Q} = S_{\gamma}^{\omega_0} = S_{G_1}^{Q} = S_{G_2}^{Q} = -S_{C_1}^{Q} = 1$$

$$S_{G_1}^{BW} = S_{G_2}^{BW} = -S_{C_2}^{BW} = 1 \qquad (8)$$

4. SIMULATION RESULTS

We perform the simulations by using PSpice software Orcad 16.2 .The proposed circuit in Fig.2 is simulated with the passive element values C_1=C_2=10nF which results in quality factor of Q=0.5. Fig.4 illustrates the simulated frequency response.

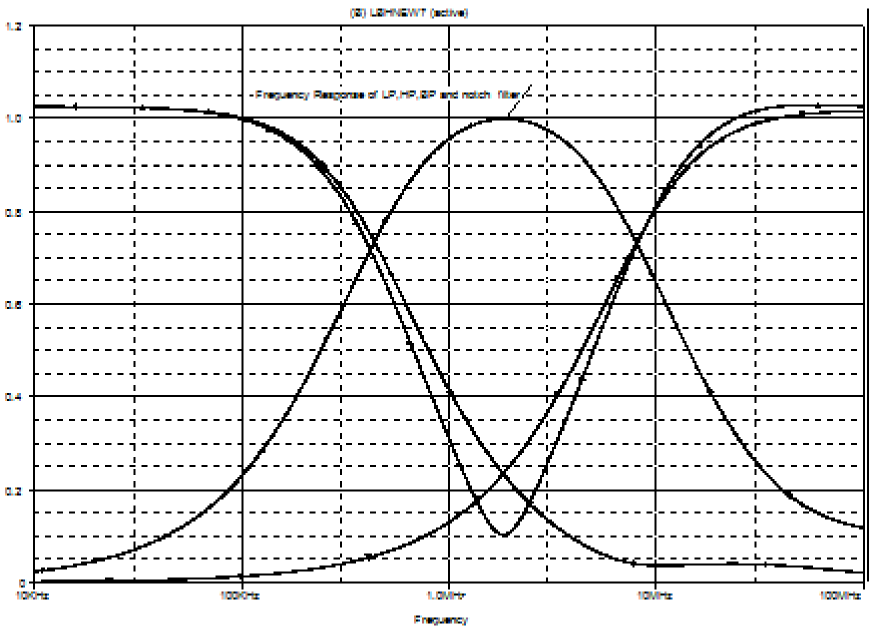

Figure 4 Frequency response of the proposed current-mode biquad filter.

5. CONCLUSIONS

New configuration for realizing current mode filter using two CFAs are presented. The proposed current-mode circuit can simultaneously realize low pass, band pass, high pass and notch filters by using CFAs. The proposed circuits have no requirements for component matching conditions. This circuit can also be used for high frequency applications. The simulation results confirm the theoretical results very well. Pure current outputs can be generated by employing more number of CFAs.

6. REFERENCES

[1] C.Toumazou, F.J.Lidgey and D.G.Haigh(ed.).”Analogue IC Design: The current mode Approach”, London, Peter Peregrinus Ltd.1990.

[2] J.W.Horng,P.Y.Chou and J.Y.Wu,”Voltage/current – mode multifunction filters using current feedback amplifiers and grounded capacitors’, Active and Passive Electronic components,vol.2010,p.1-5,2010.

[3] K.Kumar and K.Pal,”High input impedance voltage mode universal biquad filter, “Indian Journal off Pure and Applied PHYSICS, vol.48, no.4, p.292-296, 2010.

[4] J.W.Horng, C.L.Hou, W.S.Huang, and D.Yang,”Voltage/Current-Mode Multifunction Filters Using One Current Feedback Amplifier and Grounded Capacitors, “Circuits and Systems, vol.2, no.2, p-60-64, April 2011.

[5] A.Fabre,”Insensitive voltage-mode and current-mode filters from commercially available transimpedance op amps,”IEE Proceedings G, vol 140, p.319-321, Oct.1993.

[6] S.I.Liu,”High input impedance filters with low component spread using current-feedback amplifiers.”Electronics Lett, vol.31, no.13, p.1042-1043, 1995

[7] R.K.Sharma and R.Senani,”Universal current mode biquad using a single CFOA”, Int.J.Electronics, Vol.91, No.3, .175-183, March 2004

[8] S.S.Gupta, D.R.Bhaskar and R.Senani,”New Voltage controlled oscillators using CFOAs”, Interational Journal of Electronics and communication AEU.63, 3 p.209-217, 2009.

[9] C. Laoudias and C. Psychalinos, “1.5 V complex filters using current mirrors,” IEEE Transactions on Circuits and Systems II, vol. 59, pp. 575–579, 2011.

[10] X. Zhang, X. Ni, M. Iwahashi, and N. Kambayashi, “Realization of universal active complex filter using CCIIs and CFCCIIs,” Analog Integrated Circuits and Signal Processing, vol. 20, no. 2, pp. 129–137, 2013

[11] S. N. Ahmad, M. R. Khan and Moinuddin, "A new current-mode universal filter", FREQUENZ, Journal of RF-Engineering and Telecommunications, (Germany), Vol. 58, 7/8, pp. 195-196, 2004.