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A New Current-Mode Second Order Universal Filter Employing Current Feedback Amplifiers And Grounded Capacitors

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***Abstract*—A new current-mode second order universal filter employing current feedback amplifier has been realized. The proposed universal filter circuit employs two CFAs, two grounded capacitors and four resistors. The proposed current-mode filter can be used to realize lowpass, bandpass and highpass filter functions simultaneously from the same circuit configuration. All the passive components are either really grounded or virtually grounded except one floating resistor. The active and passive sensitivities of the circuit are quite low. The PSPICE simulation results are also included.**

Keywords—Current feedback amplifier: anlog filter: current-mode

I. INTRODUCTION

The current-mode circuits havebeen suitable in applications such as optical communication, magnetic recording system, high speed bus transceivers, analog to digital data converter, high frequency continuous time filters [1]. There are number of current mode filter circuits presented in literature using active devices such asCCs[2],OTA[3], FTFN[4] ,CDBA[5-6] and CDTA[7-9]. The current feedback amplifier (CFA) is an active building blocks to realize filter circuits [10-16].CFA offers constant gain over fairly large bandwidth, high slew rate and better linearity [10].

In this paper, a new circuit configuration is proposed to realize current-mode second order lowpass, bandpass and high pass filters simultaneously. The notch and allpass filter functions are also obtained, the proposed filter circuit employs two CFAs, three capacitors and four resistors. The active and passive sensitivities are low.

II. CIRCUIT DESCRIPTION

The circuit symbol CFA is shown in Fig.1.The port relations can be characterised by the following equation.

$$V_X = V_Y, \quad I_X = I_Z, \quad I_Y = 0 \text{ and } V_Z = V_O \qquad (1)$$

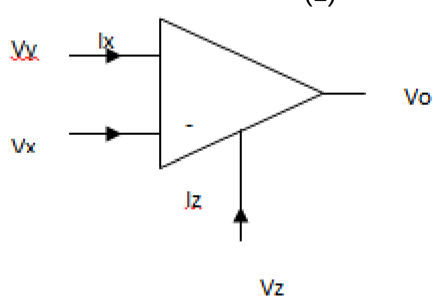

Fig.1 circuit symbol of CFA

The proposed current-mode universal filter is shown in Fig.2. The routine circuit analysis of the proposed fi using port relation of CFA yields the following curre mode transfer functions.

I_{in}

$$\frac{I_{HP}}{I_{in}} = \frac{s^2C_1C_3G_5}{s^2C_1C_3G_5 + sC_3G_5(G_2+G_6) + G_2G_4G_6} \qquad (2)$$

$$\frac{I_{LP}}{I_{in}} = \frac{G_2G_4G_5}{s^2C_1C_3G_5 + sC_3G_5(G_2+G_6) + G_2G_4G_6} \qquad (3)$$

$$\frac{I_{BP}}{I_{in}} = \frac{sC_3G_2G_5}{s^2C_1C_3G_5 + sC_3G_5(G_2+G_6) + G_2G_4G_6} \qquad (4)$$

Thus the circuit realizes a lowpass signal at I_{LP}, a bandpass signal at I_{BP} and a highpass signal at I_{HP} simultneously without changing circuit configuration. The circuit employs two grounded capacitors. The current-mode notch and allpass filters can also be obtained. The natural angular frequency ω_O ,bandwidth and quality factor Q of the proposed current-mode filter can be expressed as

$$\omega_O = \sqrt{\frac{G_2G_4G_6}{C_1C_3G_5}} \qquad (5)$$

$$\frac{\omega_O}{Q} = \frac{G_2+G_6}{C_1} \qquad (6)$$

$$Q = \frac{1}{G_2+G_6}\sqrt{\frac{C_1G_2G_4G_6}{C_3G_5}} \qquad (7)$$

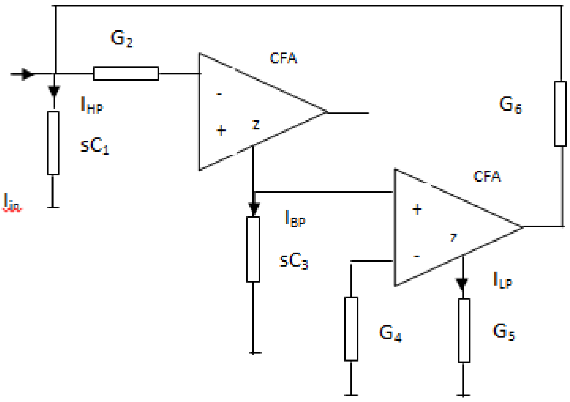

Fig.2 Proposed circuit of current-mode universal filter

III. SENSITIVITY ANALYSIS

Taking account of non-ideal conditions of CFA, the characteristic equations can be modified as

$$I_z = \alpha I_x, \quad V_x = \beta V_y, \quad \text{and} \quad V_O = \gamma V_z \qquad (8)$$

where $\alpha = 1 - \varepsilon_1 (\varepsilon_1 \ll 1)$ denotes the current tracking error, $\beta = 1 - \varepsilon_2 (\varepsilon_2 \ll 1)$ is the input voltage tracking error and $\gamma = 1 - \varepsilon_3 (\varepsilon_3 \ll 1)$ is the output voltage tracking error of the current feedback amplifier. The natural angular frequency ω_O, bandwidth $\frac{\omega_o}{Q}$ and quality factor Q of Fig.2 become

$$\omega_O = \sqrt{\frac{\alpha_1\alpha_2\beta_2\gamma_2 G_2 G_4 G_6}{C_1 C_3 G_5}} \qquad (9)$$

$$\frac{\omega_O}{Q} = \frac{G_2 + G_6}{C_1} \qquad (10)$$

$$Q = \frac{1}{G_2 + G_6}\sqrt{\frac{\alpha_1\alpha_2\beta_2\gamma_2 C_1 G_2 G_4 G_6}{C_3 G_5}} \qquad (11)$$

The active and passive sensitivities of the current-mode universal filter are computed as

$$S^{\omega_O}_{\alpha_1} = S^{\omega_O}_{\alpha_2} = S^{\omega_O}_{\beta_2} = S^{\omega_O}_{\gamma_2} = S^{\omega_O}_{G_2} = S^{\omega_O}_{G_4} = -S^{\omega_O}_{G_5} = S^{\omega_O}_{G_6} = -S^{\omega_O}_{C_1} = -S^{\omega_O}_{C_3} = \frac{1}{2}$$

$$S^{Q}_{\alpha_1} = S^{Q}_{\alpha_2} = S^{Q}_{\beta_2} = S^{Q}_{\gamma_2} = S^{Q}_{C_1} = S^{Q}_{G_2} = -S^{Q}_{C_3} = -S^{Q}_{G_5} = \frac{1}{2}$$

$$S^{Q}_{G_2} = S^{Q}_{G_6} = -1$$

All the active and passive sensitivities of the proposed filter have been found to be fairly small and not more than unity.

IV. SIMULATION RESULT

To test the performance of the proposed filter shown in Fig.2, circuit simulation of the universal circuit has been carried out using PSPICE program. The presented circuit has been designed for f_O =31.85 KHz and $Q = \frac{1}{2}$. The commercially available current feedback amplifier AD844 has been used to realize the CFA. The proposed filter has been designed with R_2=R_4 =R_5= R_6=1KΩ and C_1=C_3=5nF. The frequency response of the second order current-mode universal filter is shown in Fig3. The phase response of allpass filter is shown in Fig.4. The simulation results confirm the theoretical analysis.

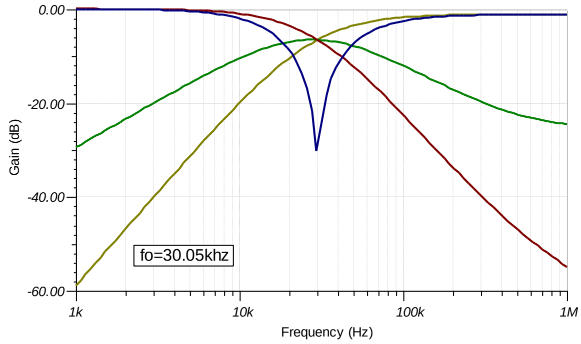

Fig.3 Simulated Frequency response of CM Universal filter

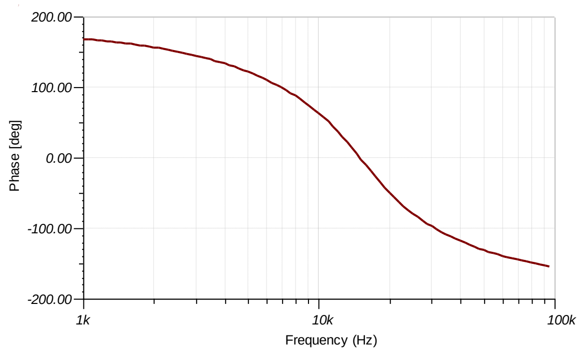

Fig.4 Phase response of All Pass filter

IV CONCLUSION

The circuit for realizing current-mode universal filter using two CFA has been presented. The universal filter has one input and three outputs. The filter circuit provides low pass, bandpass and highpass filter responses .The notch and allpass filter responses are also realized. The proposed circuit uses grounded capacitors. The active and passive sensitivities are very small and less than unity. Simulation results confirm the theoretical analysis.

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