First Order Current Mode Filters and Multiphase Sinusoidal Oscillators Using MOCCIIs

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Abstract-**An insensitive current mode versatile first order filter section with single input and multiple outputs is realized. The realization uses two multi outputs current conveyors, only one grounded resistor and one grounded capacitor. The realized current mode section provides low-pass, high-pass and all-pass responses at different outputs without any component matching constraint. The all-pass section is then cascaded with the current mode non-inverting integrator to realize a current mode multi-phase sinusoidal oscillator. Thus the realized current mode oscillator provides eight phase sinusoidal outputs with equal magnitudes. The current mode outputs are loaded with same valued resistive load to achieve the eight phase voltage mode sinusoidal outputs with equal magnitudes. All the realization were designed and simulated using PSPICE. The simulation results thus obtained, verify the theory.**

Index Terms- **Current Conveyors, Filters, Oscillators**

1. INTRODUCTION

Current conveyors have become very popular as these devices provide high performance and greater functional versatility in the realization of analog building blocks [1-16]. Several first order voltage-mode all pass sections (APSs) using current conveyors are available in technical literature [3,5,8,9]. However, current-mode (CM) circuits are also receiving much attention for their potential advantage such as inherent wider bandwidth, wide dynamic range and better noise immunity [6,10,15,16]. Considering these advantages of CM circuits, recently several first-order all-pass filters using different active components have been reported [12,13]. Among these topologies, some require element-matching conditions even though with minimum component count while others require large component count and complex circuitry.

In this paper, a new current mode versatile first-order filter section is realized which provides load insensitive low-pass, high-pass and all-pass outputs with single current input. The versatile filter section uses only one grounded resistor and one grounded capacitor along with two multi-output second generation current conveyors (MOCCIIs). This filter section is then utilized to realize a current mode eight-phase sinusoidal oscillator (CM-EOSC) with equal amplitudes. This CM-EOSC current outputs are loaded with same valued resistors to realize voltage mode eight-phase sinusoidal oscillator (VM-EOSC). All the realizations are designed and simulated using PSPICE and the results thus obtained verify the theory.

II. FIRST ORDER FILTER REALIZATION

The electrical symbol of MOCCII is shown in Fig. 1.

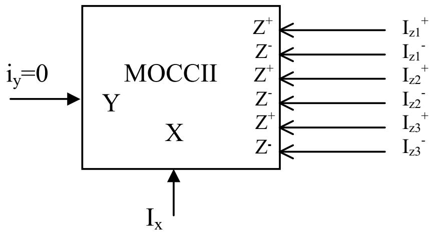

Fig. 1 Symbol of MOCCII

It can be characterized by

$$\begin{bmatrix} I_y \\ V_x \\ I_{zi}^{+} \\ I_{zi}^{-} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & +1 & 0 \\ 0 & -1 & 0 \end{bmatrix} \begin{bmatrix} V_y \\ I_x \\ V_z \end{bmatrix} \qquad (1)$$

where, i = 1, 2, 3. The proposed filter is constructed with two MOCCIIs, one grounded capacitor and resistor as shown in Fig. 2.

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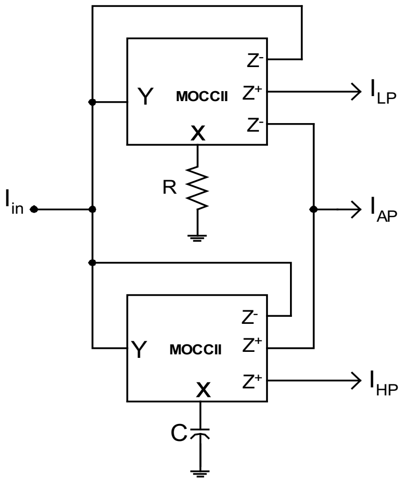

Fig. 2 The versatile first order filter section

The transfer function of the proposed filter can be given by:

$$\frac{I_{LP}}{I_{in}} = \frac{1/RC}{s + 1/RC} \qquad (2)$$

$$\frac{I_{HP}}{I_{in}} = \frac{s}{s + 1/RC} \qquad (3)$$

$$\frac{I_{AP}}{I_{in}} = \frac{s - 1/RC}{s + 1/RC} \qquad (4)$$

Thus the filter realizes the current mode low-pass, high-pass and all-pass sections as exhibited from equations (2), (3) and (4) respectively with pole frequency,

$$\omega_0 = \frac{1}{RC} \qquad (5)$$

The pole-ω_0 sensitivities can be expressed as

$$S^{\omega_0}_{R,C} = -1 \qquad (6)$$

From equation (6), it is clear that pole-ω_0 sensitivities are small i.e. unity in magnitude. It is to be noted that the versatile current mode filter is having low-pass gain, high-pass gain and all-pass gain of unity, which is a desirable feature for cascading applications.

III. MULTI-PHASE SINUSOIDAL OSCILLATOR REALIZATION

The current mode first order filter section of Fig. 2 is used to realize a current mode multi-phase sinusoidal oscillator by cascading the all pass output with MOCCII based non-inverting current mode integrator as shown in Fig. 3.

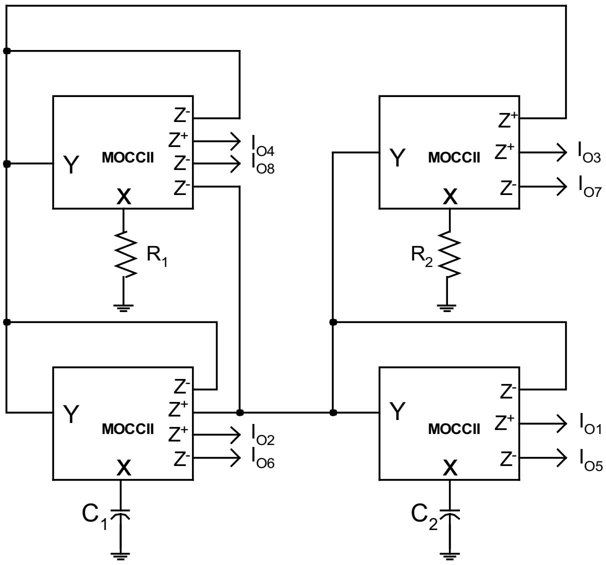

Fig. 3 The MOCCII based CM-EOSC circuit

The routine analysis yields the characteristic equation of the proposed oscillator as

$$s^2 + s\left[\frac{1}{R_1C_1} - \frac{1}{R_2C_2}\right] + \frac{1}{R_1R_2C_1C_2} = 0 \qquad (7)$$

which results in the condition of oscillation as

$$R_1C_1 = R_2C_2 \qquad (8)$$

and the frequency of oscillation as

$$\omega_0 = \left(\frac{1}{R_1R_2C_1C_2}\right)^{1/2} \qquad (9)$$

Assuming R_1=R_2=R and C_1=C_2 =C, equation (9) reduces to

$$\omega_0 = \frac{1}{RC} \qquad (10)$$

From Fig. 3, the various current outputs can be expressed as

$$\begin{aligned} &Io_2 = -\frac{\pi}{4}Io_1,\ Io_3 = -jI_{O1}, \\ &Io_4 = -\frac{3\pi}{4}Io_1,\ Io_5 = -Io_1, \\ &Io_6 = \frac{3\pi}{4}Io_1,\ Io_7 = jIo_1, \\ &Io_8 = \frac{\pi}{4}Io_1 \end{aligned} \qquad (11)$$

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Thus it is evident from equation (11) that the oscillator of Fig. 3 realizes a current mode eight-phase sinusoidal oscillator (CM-EOSC), with equal magnitude. Its phaser diagram is shown in Fig. 4. It is to be noted that just by loading the current outputs of CM-EOSC with single valued resistor, a voltage mode eight phase sinusoidal oscillator (VM-EOSC) with equal magnitudes is realized.

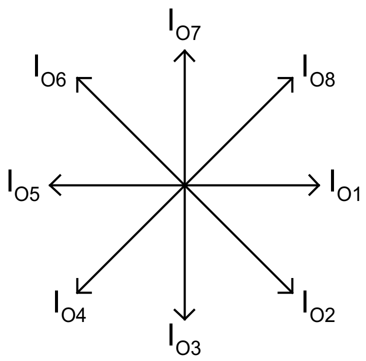

Fig. 4 The phaser diagram of CM-EOSC

The pole-ω_0 sensitivities for the realized CM-EOSC and VM-EOSC with respect to passive components can be expressed as follows

$$S^{\omega_0}_{R_i,C_i} = -1 \quad where \;\; i = 1,2 \qquad \textbf{(12)}$$

Again it is evident from equation (12) the realized oscillator exhibits attractive sensitivity properties

IV. DESIGN AND VERIFICATION

To verify the proposed theory, the first order filter section of Fig. 2 realizing low-pass, high-pass and all-pass responses was designed for a pole frequency f_0=318 KHz. Assuming R=1KΩ, equation (5) results C=0.5nF. The filter was simulated using PSPICE with micromodel of CCII[1]. The observed responses are shown in Fig. 5, which are in close conformity with the design.

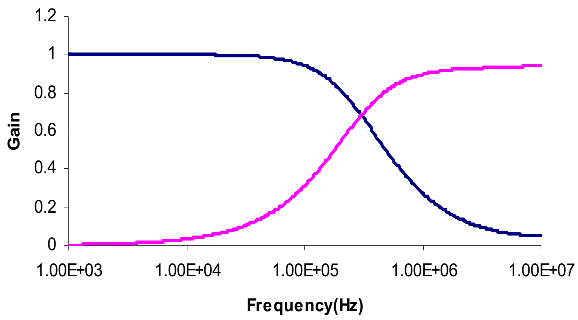

Fig. 5(a) Frequency responses of low-pass and high-pass filter sections

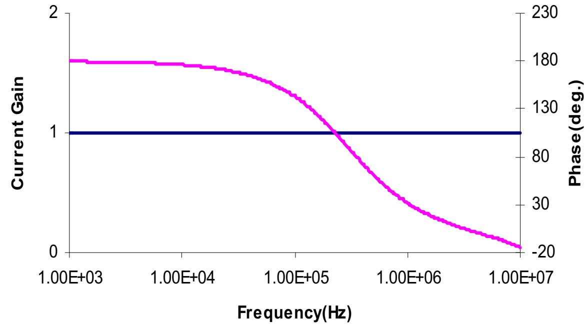

Fig. 5(b) Frequency responses of all-pass filter section

The realized multi-phase oscillator of Fig. 3 was also designed and simulated using PSPICE model of CCII. The oscillator was designed for an oscillating frequency f_0=318 KHz. Assuming R_1=R_2=R=1KΩ, equation (10) results C=0.5nF. It is to be noted that the oscillations were set by trimming the resistor R_1. The observed waveshapes of CM-EOSC are shown in Fig.6. Now the current outputs of the designed CM-EOSC were loaded with equal valued resistor R_L=0.2KΩ and thus the observed waveshapes of the VM-EOSC are shown in Fig.7. It is to be noted that the magnitude of the outputs in current mode as well as voltage mode of the multi-phase oscillator are almost constant, which confirms the theory.

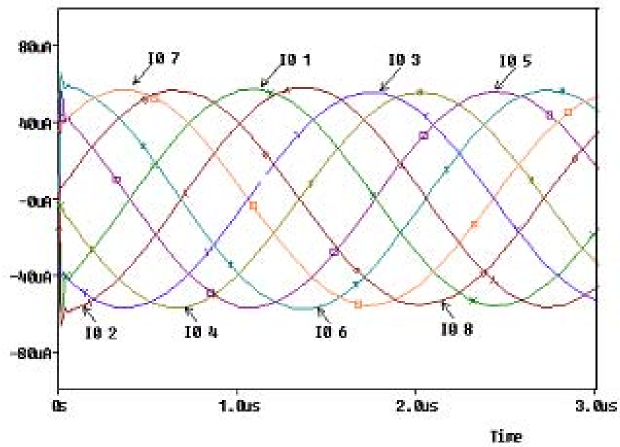

Fig.6 The waveshapes of the designed CM-EOSC of Fig.3

V. CONCLUSION

A novel current mode versatile first order filters section is realized which provides load insensitive low-pass, high-pass and all-pass outputs with single current input. The versatile filter section uses only one grounded resistor and one grounded capacitor along with two multi-outputs second generation current conveyors. The versatile filter section is utilized to realize current mode eight-phase

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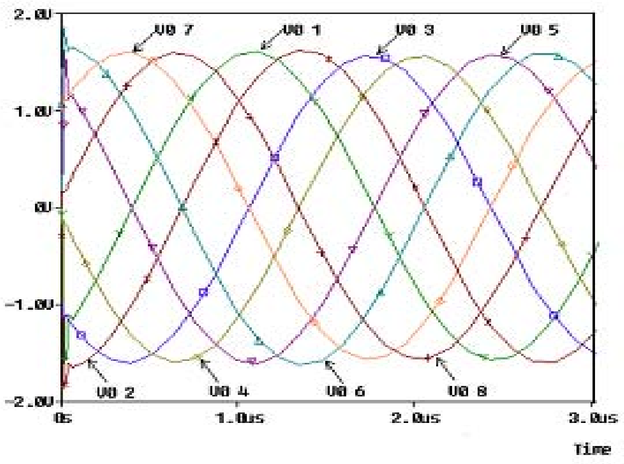

Fig. 7 The waveshapes of VM-EOSC

sinusoidal oscillator with equal magnitudes. This current mode multi-phase sinusoidal oscillator outputs are loaded with equal valued resistors to realize voltage mode eight-phase sinusoidal oscillator. All the realizations use grounded capacitors and hence attractive for monolithic implementation. The sensitivities of the realizations are also analyzed and found to be unity in magnitude. All the realizations were designed and simulated using PSPICE and the results thus found verify the theory.

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