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Resistor Controlled Voltage-Mode Eight-Phase Sinusoidal Oscillator Using MOCCIs

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***Abstract*— A simple scheme is given for the realization of a voltage mode three-output sinusoidal oscillator (VMTOSO). Using this scheme a negative type second generation current conveyor, [CCII(-)]-based VMTOSO is realized. The [CCII(-)]-based VMTOSO is then transformed into a multioutput current conveyor [MOCCII]-based voltage mode eight-phase sinusoidal oscillator (VMEPSO) by replacing all the CCII(-) by MOCCIIs and some additional grounded passive components. The proposed circuit enjoys attractive features such as independent control of frequency and condition of oscillation, almost equal magnitude and equally spaced in phase voltage outputs, grounded passive components and low sensitivity figures. The use of grounded passive components makes the circuit suitable for IC implementation. The proposed oscillator circuit is designed and verified using Pspice simulation.**

***Index Terms*— Current conveyors, Sinusoidal oscillators, Active networks.**

I. INTRODUCTION

The second generation current conveyors, CCIIs, have proved to be effective building blocks for active filters, oscillators, amplifiers and immittance simulators because of their higher bandwidth, greater linearity and wider dynamic range[1-12].

Multiphase sinusoidal oscillators (MSOs) have wide applications in communication, signal processing and power controllers. For this reason a number of MSOs have been realized by using different active devices and reported in the technical literature [13-16]. Most of these circuits suffer complex circuitry using a large number of component counts. For example, an eight phase sinusoidal oscillator is realized by using eight CCIIs, four grounded capacitors, eight grounded resistors, eight floating resistors and eight unity gain buffers[14]. In another case, a six-phase sinusoidal oscillator is realized by using six operational amplifiers, twelve floating resistors, three grounded resistors and three grounded capacitors[16.]

In this paper, a [MOCCII]-based eight-phase sinusoidal oscillator with all grounded passive components is realized. As all the outputs are equally spaced in phase at the oscillating frequency, an eight-phase oscillator can generate two-phase signals and four-phase signals by selecting the proper output terminals.

II. CIRCUIT DESCRIPTION

For the realization of a voltage mode eight-phase sinosoidal oscillator, eight consecutive outputs at 45^o apart are required. For this purpose, first a [CCII (-)]-based three output oscillator is realized from the scheme given in Fig.1 The basic building blocks (BBBs) for this scheme are an oscillator with two outputs -135^o apart and an inverting non-ideal integrator. The basic building block oscillator is realized with two CCII (-), three grounded resistors and three grounded capacitors as shown in Fig. 2(a). The routine analysis results the characteristic equation as follows:

$$s^2 + s\left[\frac{1}{R_1C_1} + \frac{1}{R_3C_3} - \frac{C_2}{C_1C_3R_4}\right] + \frac{1}{R_1R_3C_1C_3} = 0 \qquad (1)$$

which gives the condition of oscillation as

$$\frac{C_1}{R_3} + \frac{C_3}{R_1} = \frac{C_2}{R_4} \qquad (2a)$$

and frequency of oscillation is

$$\omega_o = \left[\frac{1}{R_1R_3C_1C_3}\right]^{1/2} \qquad (2b)$$

For $R_1 = R_3 = R_4 = R$, $C_1 = C_3 = C$
the condition of oscillation becomes

$$C_2 = \frac{C}{2} \qquad (3a)$$

and the frequency of oscillation is given by

$$\omega_o = \frac{1}{RC} \qquad (3b)$$

From Fig.2(a), at oscillating frequency, ω_o, the phase relationship between two output voltages V_1 and V_4 can be obtained as follows:

$$V_4 = -\frac{(sC_3R_3 + 1)R_4}{R_3}V_1\Big|_{s\,=\,j\omega_0}$$

$$V_4 = V_1 \angle -\frac{3\pi}{4} \qquad (4)$$

Equation (4) shows that the two output voltages of basic building block oscillator of Fig.2(a) are -135^o apart as shown in Fig.2(b).The implementation of Fig.1(a) is shown in Fig.3(a), The inverting non-ideal integrator's, output voltage, V_6, leads the input voltage, V_1, by 135°. It is given by

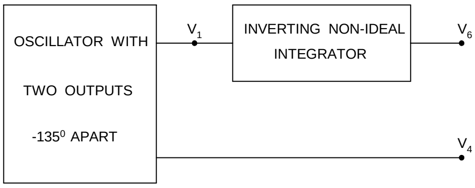
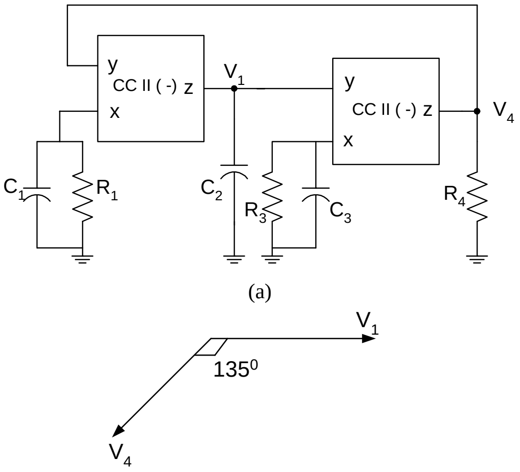


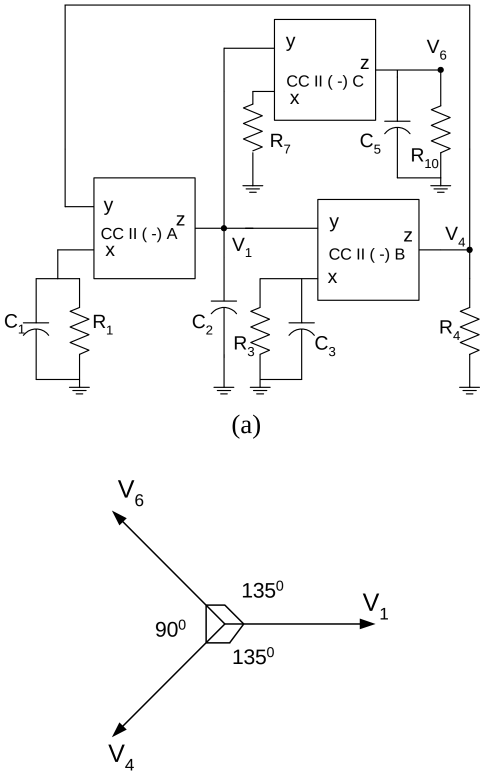
Fig.1. The scheme for the realization of three-output oscillator.



(a)

(b)

Fig. 2(a) BBB oscillator with two outputs –135° apart and
(b) Phasor diagram
(c)



(a)

(b)

Fig.3(a). [CCII(-)] –based three-output oscillator and (b) Phasor diagram

$$V_6 = -\frac{R_{10}}{(sC_5R_{10}+1)R_7}V_1\Big|_{s=j\omega_0}$$

$$V_6 = V_1\angle\frac{3\pi}{4} \tag{5}$$

The phasor diagram of Fig.3(a) is shown in Fig.3(b). Now, the CCII(-) A, CCII(-) B and CCII(-) C in Fig.3(a) are replaced by three output MOCCIIA, two output MOCCIIB and three output MOCCIIC respectively. At one negative terminal of each MOCCII, components used are same as those in all CCII(-) of Fig.3(a). Appropriate grounded components are connected at the additional output nodes of MOCCIIA, MOCCIIB and MOCCIIC for obtaining V_2, V_3, V_5, V_7 and V_8.

The phasor diagram of Fig.3(b) shows that the two output voltages V_4 and V_6 have 90° phase shift. The inversion of V_4 is provided by connecting a grounded resistor R_6 at the positive output terminal of MOCCIIB in the same way as V_4 is obtained from a negative output terminal of the same MOCCIIB through a grounded resistor R_4. Thus, the inversion of V_4, i.e., V_8 is obtained.

The phase relationship is given by

$$V_8 = -\frac{(sC_3R_3+1)R_6}{R_3}V_1\Big|_{s=j\omega_0}$$

$$V_8 = V_1\angle\frac{\pi}{4} \tag{6a}$$

Using eqn.4 and 6(a),

$$V_8 = -V_4 \tag{6b}$$

The inversion of V_6 i.e. V_2 is obtained by connecting identical grounded parallel combination of C_4 and R_9 at the positive output terminal of MOCCIIC as a grounded parallel combination of C_5 and R_{10} is connected to the negative output terminal of MOCCIIC to generate V_6, The phase relationship is given by

$$V_2 = \frac{R_9}{(sC_4R_9+1)R_9}V_1\Big|_{s=j\omega_0}$$

$$V_2 = V_1\angle-\frac{\pi}{4} \tag{7a}$$

Using Eqns.5 and 7(a)

$$V_2 = -V_6 \tag{7b}$$

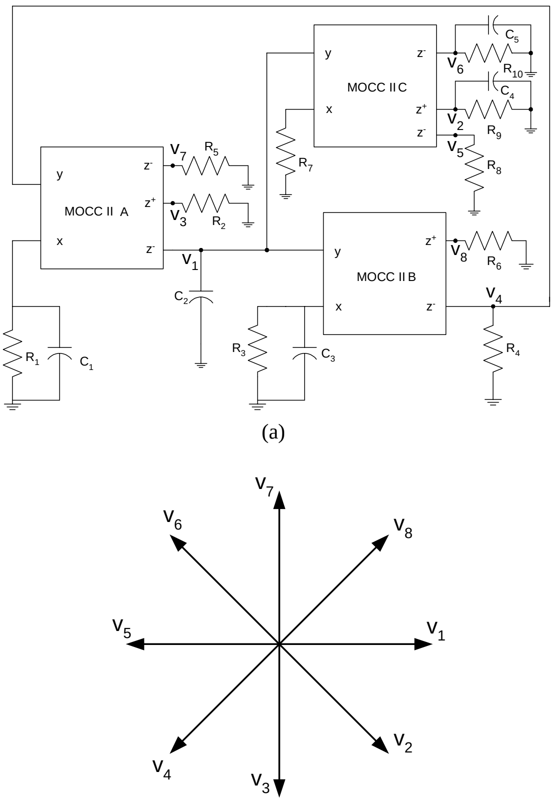
A grounded resistor R_8 at one of the negative type output terminals of MOCCIIC gives the inversion of V_1 as V_5. The phase relationship can be obtained as

$$V_5 = -\frac{R_8}{R_7}V_1\Big|_{s=j\omega_0}$$

$$V_5 = -V_1 \tag{8}$$

Output voltage V_1 is available at one of the negative output terminals of MOCCIIA across the capacitor C_2. By connecting two grounded resistors R_2 and R_5 at positive and negative terminals of MOCCIIA respectively, $\pm 90^o$ phase shifted outputs V_3 and V_7 from V_1 are produced. The phase relationship can be obtained by substituting the value of V_4 from eqn. 4.

$$V_3 = \frac{(sC_1R_1+1)R_2}{R_1}V_4\Big|_{s=j\omega_0}$$



(a)

(b)

Fig.4(a) [MOCCII]-based voltage mode eight-phase sinusoidal oscillator (VMEPSO) and (b) Phasor diagram.

$$V_3 = V_1\angle -\frac{\pi}{2} = -jV_1 \tag{9}$$

and
$$V_7 = -\frac{(sC_1R_1+1)R_5}{R_1}V_4\Big|_{s\,=\,j\omega_0}$$

$$V_7 = V_1\angle\frac{\pi}{2} = jV_1 \tag{10}$$

Thus, voltage outputs V_1, V_3, V_5 and V_7 is produced. The complete circuit for [MOCCII]-based VMEPSO and phasor diagram are shown in Fig. 4(a), 4(b) respectively.

Taking output voltage, V_1, as the reference voltage the phase relationship between eight output voltages of oscillator of fig. 4(a) can be summarized as,

$$V_2 = V_1\angle -\frac{\pi}{4} \qquad V_6 = V_1\angle\frac{3\pi}{4}$$
$$V_3 = -jV_1 \qquad V_7 = jV_1$$
$$V_4 = V_1\angle -\frac{3\pi}{4} \qquad V_8 = V_1\angle\frac{\pi}{4}$$
$$V_5 = -V_1 \tag{11}$$

Figure 4(b) shows the special features of eight-phase oscillator of fig.4(a). It can provide:

1) Eight consecutive outputs with 45° phase shift, i.e. , V_1, V_2, V_3, V_4, V_5, V_6, V_7 and V_8,
2) Four sets of quadrature outputs i.e., (V_1, V_3), (V_2, V_4), (V_5, V_7), and (V_6, V_8)
3) Two sets of four-phase quadrature outputs. The first set consists of V_1, V_3, V_5 and V_7. The second set consists of V_2, V_4, V_6 and V_8.
4) Three sets of outputs with 135° phase shift, i.e., (V_1, V_4), (V_2, V_5) and (V_3, V_6),
5) Four sets of outputs with 180° phase shift, i.e., (V_1, V_5), (V_2, V_6), (V_3, V_7) and (V_4, V_8).

III. SENSITIVITY STUDY

The incremental sensitivity measure on the oscillator's frequency of oscillations gives

$$S^{\omega_o}_{R_1R_3C_1C_3} = -\frac{1}{2} \tag{12}$$

Equation (12) shows that the proposed oscillator exhibits low sensitivities properties, i.e., less than unity in magnitude.

IV. SIMULATION RESULTS

The [MOCCII]-based oscillator of Fig.4(a), is verified by simulation using Spice model of CCII[1]. The circuit of Fig.4(a) is designed for an oscillating frequency, f_o = 100 KHz using Eq. (3). The values are taken as $R_1 = R_2 = R_3 = R_4 = R_5 = R_6 = R_7 = R_8 = R_9 = R_{10} = 10K$, $C_1 = C_3 = C_4 = C_5 = 0.159$ nF and $C_2 = .0799$nF. Output waveforms obtained through Pspice simulation are shown in Fig.5. The oscillator is then tuned by varying the resistance, R. The variation of frequency with R is shown in fig.6.

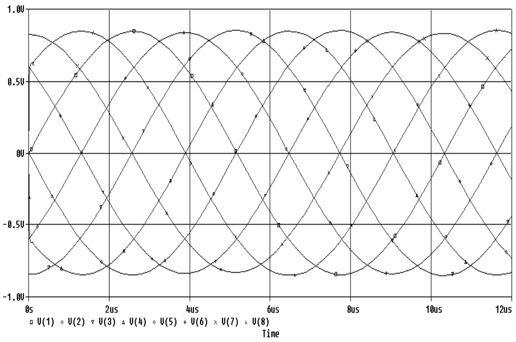


Fig. 5. Simulation results of [MOCCII]-based eight-phase sinusoidal oscillator of Fig.4(a).

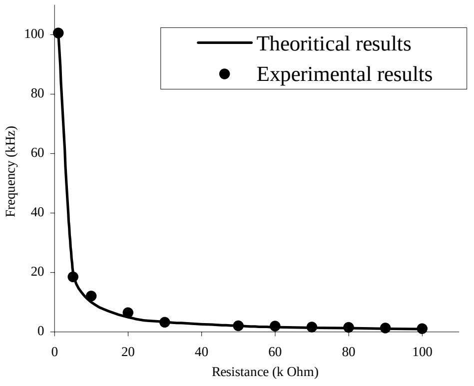


Fig.6 Frequency tuningof [MOCCII]-based eight-phase sinusoidal oscillator of with resistance R.

V. CONCLUSION

A [MOCCII]-based voltage mode eight-phase sinusoidal oscillator is realized, which has the following attractive features.

a) Independent control of frequency and condition of oscillation.
b) Almost equal magnitude and equally spaced in phase voltage outputs.
c) Can generate either eight consecutive outputs with 45^{o} phase shift or four sets of four-phase quadrature outputs or three sets of outputs with 135^{o} apart or four sets of outputs with 180^{o} phase shift.
d) Low sensitivity figures,
e) Grounded passive components, which make the circuit suitable for IC implementation.

The simulation results of the proposed oscillator verify the theory with attractive results.

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