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Voltage Mode Two-Phase and Four-Phase Sinusoidal Oscillator Using VDCC

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Abstract- In this work the application of a new active building block, Voltage Differencing Current Conveyor, VDCC, as a voltage mode sinusoidal oscillator is proposed. The VDCC block is implemented using a MOSFET model which has been proposed previously. A systematic approach has been employed in this work to synthesize sinusoidal oscillator, where a Bandpass filter is used as a basic building block to synthesize the two-phase sinusoidal oscillator, which in turn is used to synthesize a four-phase sinusoidal oscillator. The four-phase sinusoidal oscillator has four outputs equally spaced in phase, at 45° to each other. The proposed multi-phase sinusoidal oscillator (MSO) circuits also enjoy attractive features such as the use of grounded passive components and low sensitivity figures. The workability of the circuit is confirmed by the PSPICE simulations of the circuits using TSMC 0.18µm model parameters.

Keywords: VDCC, MOSFET, MSO, CCII±.

I. INTRODUCTION

The Voltage Differencing Current Conveyor, VDCC, can be used in both current mode and voltage mode thus it has become very popular in analog circuit design. Its high performance coupled with functional versatility has led to its wide application implementation of high performance electronic functions.

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 in the past years [4-9]. Most of these circuits suffer from complex circuitry as they use a large number of components. For example, in [6] an eight phase sinusoidal oscillator is realized by using eight positive output second generation Current Conveyors{CCII(+)}, four grounded capacitors, eight grounded resistors, eight floating resistors and eight unity gain buffers. In another case, a six-phase sinusoidal oscillator [7] is realized by using six operational amplifiers, eleven floating resistors, three grounded resistors and three grounded capacitors. [1]

In the present work one two-phase sinusoidal oscillator and one four-phase sinusoidal oscillator have been proposed using VDCC as the active element, which employ lesser number of components. The basic scheme of the oscillator was proposed in [1] using CCII±. The circuit gives the following desirable features:

1. Equally spaced in phase voltage outputs.
2. Low sensitivity figures.
3. Use of grounded passive components.
4. Suitable for modern IC technologies.

II. CIRCUIT DESCRIPTION

The circuit symbol of the active element,VDCC, is shown in Fig. 1, where P and N are input terminals andZ, X, $W_P$and $W_N$are output terminals.

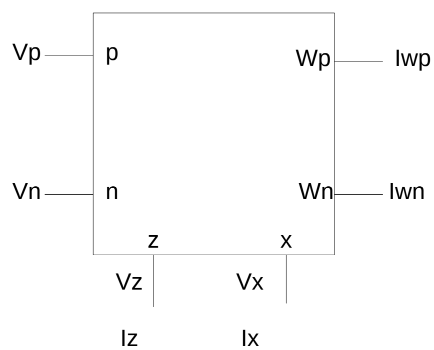

Fig.1 Symbol of VDCC

The input output equations of an ideal VDCCshown in Fig. 1 are given in [2] and reproduced below:

$$\begin{bmatrix} I_n \\ I_p \\ I_z \\ V_x \\ I_{Wp} \\ I_{Wn} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ g_m & -g_m & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} V_p \\ V_n \\ V_z \\ I_x \end{bmatrix}$$

In the VDCC block [10] in the input stage we have a trans-conductance amplifier and in the output stage we have a second generation current conveyor.

The scheme for realization of the four-phase sinusoidal oscillator is shown in fig. 2. The basic building block for this scheme comprise of an oscillator with two outputs which are 135° apart in phase (φ) (two-φ oscillator), along with one non-inverting non-ideal integrator and one non-inverting non-ideal differentiator. The oscillator with the two 135° apart outputs (two-φ oscillator) is realized using a band-pass filter (BPF) shown in fig. 3. This BPF uses two active VDCC blocks and some passive elements.
The transfer gain of this BPF is given as:

$$\frac{V_4}{V_{in}} = \frac{s\left[\frac{C_1}{C_2C_4R_3}\right]}{s^2 + s\left[\frac{1}{R_2C_4} + \frac{1}{R_4C_4}\right] + \frac{1}{C_2C_4R_2R_4}} \quad (1)$$

Using this BPF the two-φ oscillator is realized by providing a direct feedback from output terminal V_4 to the input V_{in}.
The characteristic equation of this circuit is given as:

$$s^2 + s\left[\frac{1}{R_2C_4} + \frac{1}{R_4C_4} - \frac{C_1}{C_2C_4R_3}\right] + \frac{1}{C_2C_4R_2R_4} = 0 \quad (2)$$

Hence, the condition of oscillation is given as:

$$\frac{1}{R_2C_4} + \frac{1}{R_4C_4} = \frac{C_1}{C_2C_4R_3} \quad (3)$$

and the frequency of oscillation is given as:

$$w_0 = \sqrt{\frac{1}{C_2C_4R_2R_4}} \quad (4)$$

For $R_2 = R_4 = R \; and \; C_1 = C_2 = C_4 = C$
the oscillation condition and frequency of oscillation respectively becomes:

$$R_3 = \frac{R}{2}$$

$$w_0 = \frac{1}{RC} \quad (5)$$

From fig. 4, the phase relationship between output voltages V_1 and V_2, at oscillation frequency is obtained as:

$$V_4 = -\frac{R_4}{(sC_4R_4 + 1)R_3}V_1 \;\; for \; s = jw_0$$

$$V_4 = V_1\angle 135° \quad (6)$$

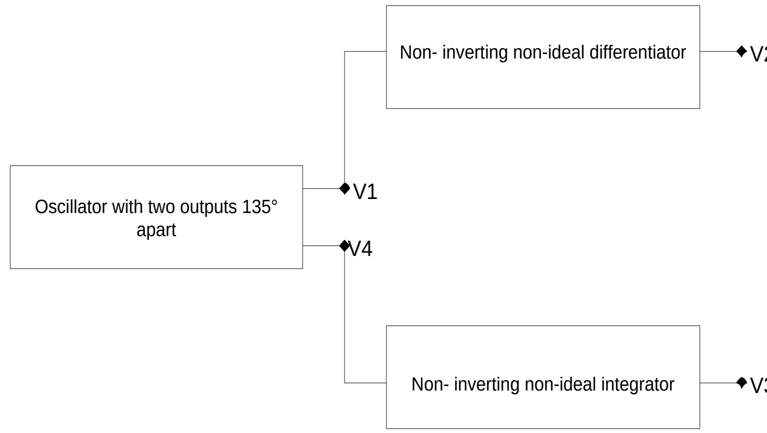

Fig.2: Scheme for realization of oscillators

Equation (6) shows that the two output voltages are 135° apart. From fig. 7(a), for a non-inverting non-ideal differentiator, the output voltage V_2 leads the input voltage V_1 by 45°, which is obtained as:

$$V_2 = \frac{(sC_3R_6 + 1)R_7}{R_6}V_1 \;\; for \; s = jw_0$$

$$V_2 = V_1\angle 45° \quad (7)$$

For non-inverting integrator, the output voltage V_3lags behind the input voltage V_4 by 45°. The phase relationship between V_4 and V_3 is obtained as:

$$V_3 = -\frac{R_5}{(sC_5R_5 + 1)R_1}V_4 \;\; for \; s = jw_0$$

$$V_3 = V_4\angle -45° \quad (8)$$

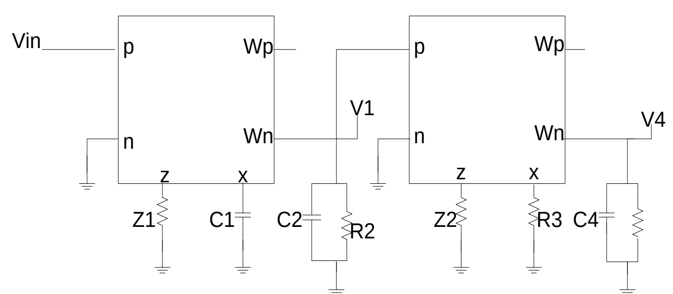

Fig. 3:Band-pass filter, the basic building block

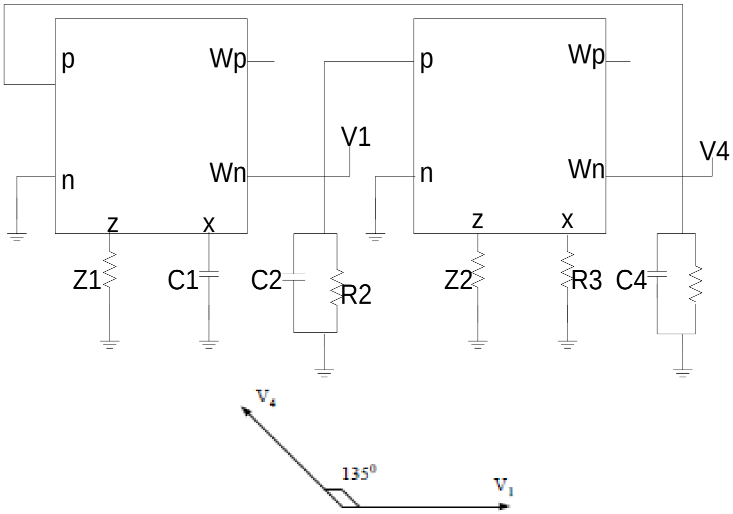

Fig. 4 Proposed VDCC based 2-φ sinusoidal oscillator with its phasor diagram

The phasor diagrams of the 2-φ sinusoidal oscillator and 4-φ sinusoidal oscillatorare shown in fig. 4 and fig. 7(b), respectively. It is evident from fig. 4, that the 2-φ sinusoidal oscillator gives two consecutive outputs with a phase shift of 135°. Similarly, fig. 7(a) shows that the 4-φ sinusoidal oscillator can provide four consecutive outputs with phase shift of 45°.

III. SENSITIVITY ANALYSIS

The passive sensitivities of the oscillators are obtained to be as follows:

$$S_{R_2}^{w_0} = S_{R_4}^{w_0} = S_{C_2}^{w_0} = S_{C_4}^{w_0} = -\frac{1}{2} \quad (9)$$

$$S_{R_3}^{w_0} = S_{C_1}^{w_0} = 0 \quad (10)$$

IV. SIMULATIONS

The VDCC block was simulated using the MOSFET model of VDCC given in [2]. The PSPICE simulations were done using TSMC 0.18µm parameters. The VDCC based voltage mode2-φ sinusoidal oscillator and 4-φ sinusoidal oscillator were designed for an oscillating frequency 1MHz using equation (4).

The values of passive components are as follows: $R_1 = R_2 = R_4 = R_5 = R_6 = R_7 = 10K, R_3 = 4.4K$ And $C_1 = C_2 = C_3 = C_4 = C_5 = 1.59nF$.

The value of Z_1, Z_2, Z_3 is determined by the transconductance gain of the VDCC, g_m, which is equal to 277µA/V [2], and from this value we get

$$Z_1 = Z_2 = Z_3 = 3.6K$$

The output waveform of the 2-φ sinusoidal oscillator is shown in fig. 5, where the two sinusoidal outputs are in 135° phase difference. The output waveform of the 4-φ sinusoidal oscillator is shown in fig. 6, wherethe four sinusoidal outputs are in 45° phase difference.

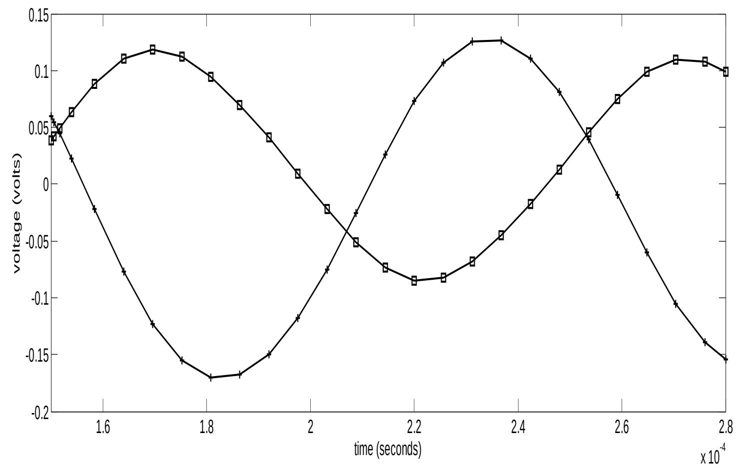

Fig. 5: Output of the proposed VDCC based 2-φ sinusoidal oscillator

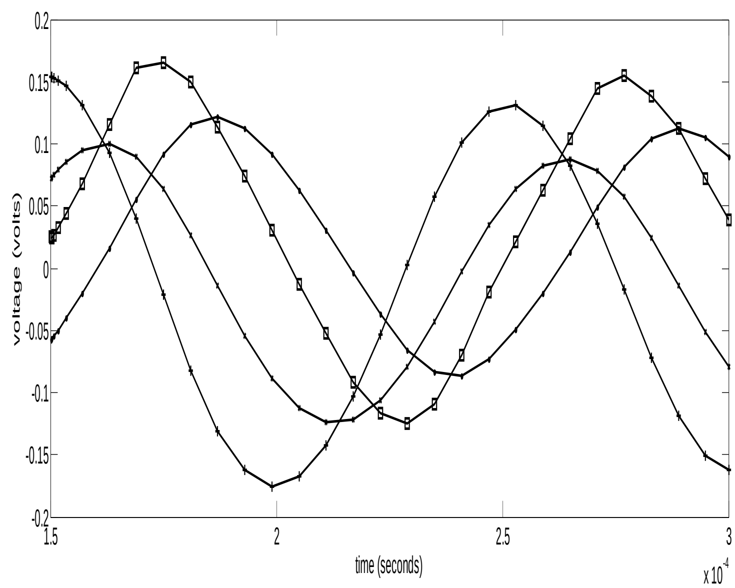

Fig. 6: output of the proposed VDCC based 4-φ sinusoidal oscillator

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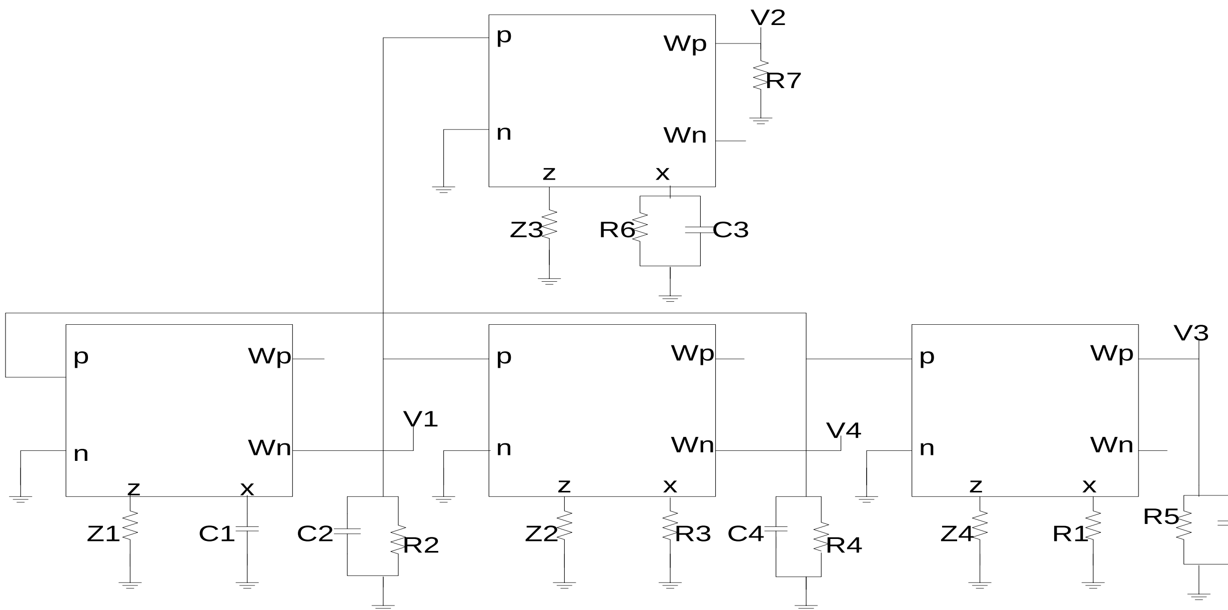

Fig. 7(a): Proposed VDCC based 4-φ sinusoidal oscillator

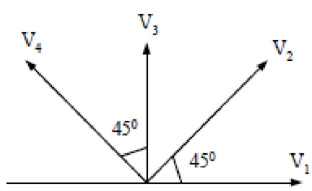

Fig. 7(b):Phasor diagram of proposed VDCC based 4-φ sinusoidal oscillator

V. CONCLUSIONS

The realization of VDCC active block using MOSFET model, as proposed scheme [1] has been utilized for the realization of VDCC- based Voltage mode 2-phase sinusoidal oscillator. The VDCC-based Voltage mode 2-phase sinusoidal oscillator is then transformed into a VDCC- based Voltage mode 4-phase sinusoidal oscillator. All the realized oscillators provide the voltages of almost equal magnitude and equal phase shift. The circuits have attractive sensitivity performance, use of grounded passive components and are suitable for modern IC technologies. The simulation results of the proposed oscillators verify the proposed theory.

VI. BIBLIOGRAPHY

[1.] Firat Kacar, Abdullah Yesil, Shahram Minaei, Hakan Kuntman, “Positive/negative lossy/lossless grounded inductance simulators employing single VDCC and only two passive elements”, International Journal of Electronics and Communications, 68(2014), page- 73-78.

[2.] Dinesh Prasad, Javed Ahmad, “New electronically controllable lossless synthetic floating inductance circuit using single VDCC”, Scientific Research Journal on Circuits and Systems, 2014, 5, page no: 13-17.

[3.] NigarMinhaj, “Multi-output Second Generation Current Conveyor Based Voltage-mode Eight-phase Sinusoidal oscillator”, International Conference on Advances in Recent Technologies in Communication and computing, 2009, page- 236-239.

[4.] A.A. Khan, S. Bimal, K.K. Dey, and S.S. Roy, “Novel RC sinusoidal oscillator using second generation current conveyor”, IEEE Transactions On Instrumentation and Measurement, 54, pp. 2402-2406, 2005.

[5.] N. Minhaj, “Current conveyor-based voltage mode two-phase and four-phase quadrature oscillators”, Int. J. Elect., 94, pp. 663-669, 2007.

[6.] G. Ferri, N. Guerrini, E. Silverii, A. Tatone, “Vibration Damping Using CCII-Based Inductance

Simulators", IEEE Transactions on Instrumentation and Measurement,Digital Object Identifier 10.1109/TIM.2007.913762, 57(5),907-914,2008.

[7.] N. Minhaj,"CCII-based single-element controlled quadrature oscillators employing grounded passive components", International Journal of Recent Trends in Engineering, 1(3), 294-296, 2009.

[8.] I.A. Khan, M..T.Ahmed and N. Minhaj, "Tunable OTA-based multiphase Sinusoidal oscillators", Int. J. Elect., 72 , pp. 443-450, 1992.

[9.] D.-S. Wu, S. I. Liu, Y. S. Hwang and Y. P. Wu, "Multiphase sinusoidal oscillator using second-generation current conveyors", Int. Journal of Electronics, 78 , pp. 645-651, 1995.

[10.] Biolek D, Senani R, Biolkova V, Kolka Z., "Active elements for analog signal processing: classification, review, and new proposals". Radio-engineering2008;17(4):15–32.