KKU ENGINEERING JOURNAL 2016;43(S1):29-31 Research Article

KKU Engineering Journal

https://www.tci-thaijo.org/index.php/kkuenj/index

New amplitude controllable current-mode quadrature oscillator using DO-CDTAs

Charinsak Saetiaw*[1)], Phatsagul Thitimahatthanagusol[2)] and Saksit Summart[3)]

[1)]Rajamangala University of Technology Isan, Khon Kean Campus, Thailand.
[2)]Rajamangala University of Technology Isan, Nakorn Ratchasima, Thailand.
[3)]North Eastern Technological College, Thailand.

Received April 2016
Accepted June 2016

Abstract

This article presents new amplitude controllable sinusoidal quadrature oscillator circuit using dual-output CDTAs which able to give four quadrature output current signals. The condition of oscillation (CO) is able to be orthogonally tuned from the frequency of oscillation (FO) by handling the external current biasing. The output ports of proposed circuit have high impedance reasonable for connecting with current-mode circuit and use only grounded component very neat for development into an integrated circuit (IC). Moreover, the QO can adjust amplitude of signals without effect from the CO and FO. The PSPICE simulation program uses for proving the theoretical analysis.

Keywords: Current-mode, Quadrature oscillator, Amplitude controllable, DO-CDTA

1. Introduction

The quadrature oscillator (QO) is an oscillator circuit that provides two sine wave signals with 90 degree phased difference. A quadrature signal was occasionally implemented for quadrature mixers and the modulator with single-sideband modulators in electronic telecommunications [1]. In the last decade, papers concerning the designs of oscillator circuits providing quadrature signals have been suggested as current-mode technique. It is stated that the circuit designed from current-mode technique can be advantageous for designing; larger dynamic range, spontaneously wide bandwidth, higher slew-rate, higher linearity and lower rate of power consumption [2-5].

A lot of research found that the designs of current-mode oscillator using CDTA [6-11] have been introduced. The proposed oscillators have some week points of circuit designing current-mode circuit. For example, the proposed circuits are connected by a floating capacitor [6-8] which is not reasonable for IC fabrication. The external resistors are added (using a number of passive components) [6-8]. In addition, the CO cannot be orthogonally tuned from the FO [9-11]. Moreover, the proposed circuits cannot adjust the current signals amplitude [6-11].

The purpose of this research is to present the quadrature oscillator circuit which is designed in current-mode technique based on DO-CDTA. The CO can be adjusted by electronic method and orthogonally controlled form the FO. The grounded capacitors are used for designing circuit, the external resisters are not employed and output ports of DO-CDTA were applied to output of proposed oscillator. This qualification is appropriate for the fabrication in IC [12-13]. For the signal of outputs, moreover, its amplitude can be adapted by controlling bias current.

2. Basic concept of DO-CDTA

The dual-output current differencing transconductance amplifier or DO-CDTA is an application form CDTA [14]. The characteristics of the ideal DO-CDTA are represented by Eq. (1).

$$\begin{bmatrix} V_p \\ V_n \\ I_z, I_{zc} \\ I_{x1} \\ I_{x2} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & g_{m1} & 0 \\ 0 & 0 & 0 & 0 & g_{m2} \end{bmatrix} \begin{bmatrix} I_p \\ I_n \\ V_{x1}, V_{x2} \\ V_z \\ V_z \end{bmatrix}. \tag{1}$$

The CMOS DO-CDTA, the transconductance (g_m) is written in Eq. (2). The symbol and equivalent circuit are indicated in Figure 1. The circuit construction of DO-CDTA is demonstrated by Figure 2.

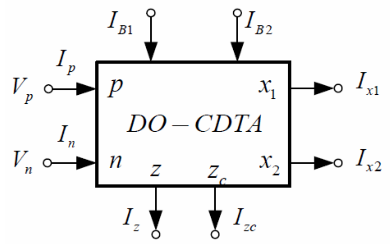
$$g_{m1} = \sqrt{k_1 I_{B1}}, \quad g_{m2} = \sqrt{k_2 I_{B2}}, \tag{2}$$

$$k_1 = m_n C_{ox} \left(W/L \right)_{11,12}, \quad k_2 = m_n C_{ox} \left(W/L \right)_{23,24}. \tag{3}$$

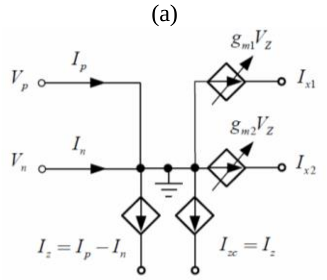
---

*Corresponding author. Tel.: +66 4333 6371
Email address: charinsak.sa@rmuti.ac.th
doi: 10.14456/kkuenj.2016.62

where k is the physical parameter of CMOS transistor. m_n is the average electron mobility in the channel, C_{ox} is the gate-oxide capacitance per unit area, W is the effective channel width and L is the effective channel length.



(a)



(b)

Figure 1 DO-CDTA; (a) symbol (b) equivalent circuit

3. Proposed quadrature oscillator

The quadrature oscillator consists of two DO-CDTAs and two capacitors, presented in Figure 3. The characteristic equation of the proposed oscillator is

$$s^2 + s\frac{g_{m1} - g_{m2}}{C_1} + \frac{g_{m1}g_{m3}}{C_1C_2} = 0 . \quad (4)$$

where g_{m1}, g_{m2} and g_{m3}, g_{m4} are the transconductance of the first and the second DO-CDTAs, respectively. From Eq. (4), the CO and FO are display as

$$CO: \quad g_{m1} = g_{m2} , \quad (5)$$

$$FO = \frac{1}{2\pi}\sqrt{\frac{g_{m1}g_{m3}}{C_1C_2}} . \quad (6)$$

by substitution g_m and k=k_1=k_2=k_3=k_4 from Eq. (2), the CO and FO becomes

$$CO: \quad I_{B1} = I_{B2} , \quad (7)$$

$$FO = \frac{1}{2\pi}\sqrt{k\frac{(I_{B1}I_{B3})^{\frac{1}{2}}}{C_1C_2}} . \quad (8)$$

The ratio of output signals i_{o1}, i_{o2}, i_{o3} and i_{o4} are

$$\frac{i_{o3}(j\omega_{osc})}{i_{o1}(j\omega_{osc})} = \frac{g_{m4}}{\omega_{osc}C_2}e^{j90^0}, \frac{i_{o3}(j\omega_{osc})}{i_{o2}(j\omega_{osc})} = \frac{g_{m4}}{\omega_{osc}C_2}e^{-j90^0},$$
$$\frac{i_{o4}(j\omega_{osc})}{i_{o1}(j\omega_{osc})} = \frac{g_{m4}}{\omega_{osc}C_2}e^{-j90^0}, \frac{i_{o4}(j\omega_{osc})}{i_{o2}(j\omega_{osc})} = \frac{g_{m4}}{\omega_{osc}C_2}e^{j90^0} . \quad (9)$$

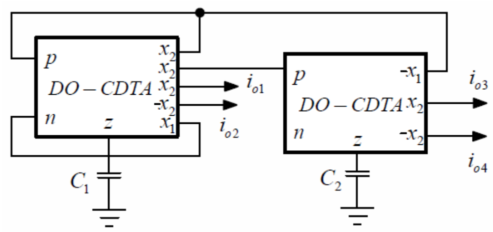


Figure 3 Four phases current-mode QO

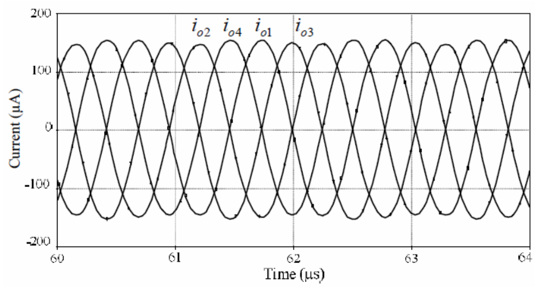


Figure 4 Output waveforms in steady state

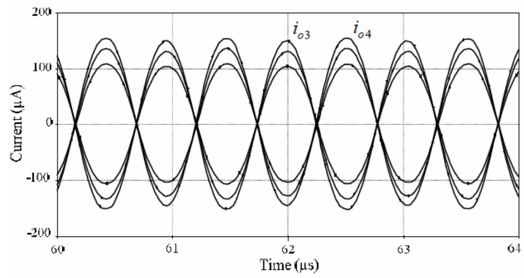


Figure 5 Adjusting of amplitude

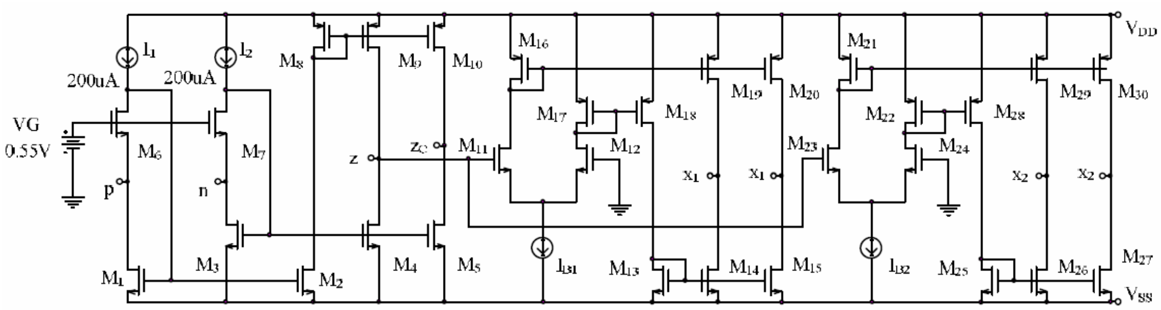


Figure 2 The circuit construction of DO-CDTA

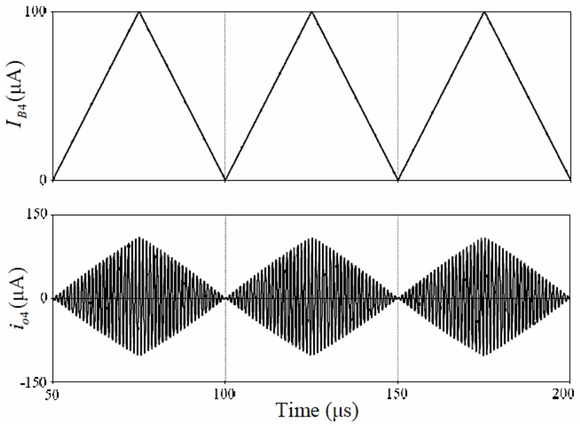


Figure 6 The result of AM operation

4. Simulation results

The PSPICE program is used for examining the theoretical discrimination of the oscillator. The parameters are set ± $1.5V$ supply voltages, $C_1 = C_2 = 0.2\text{nF}$, $I_{B1} = I_{B3} = 200\mu\text{A}$ and $I_B = 207\mu A$. The CMOS circuit construction of DO-CDTA is revealed in Figure 2. The parameters of 0.35 μm TSMC CMOS technology [15] and dimension of the transistors in [16] are employed in the simulation. Figure 4 shows the simulated quadrature output waveforms, the output frequency is 906.961kHz at the total harmonic distortion (THD) about 2.06%. To prove that the amplitude is adjustable, I_{B4} is set 100μA, 150 μA, and 200 μA, respectively. The result is mentioned in Figure 5. Figure 6 presents results of AM operation with 20kH of triangular signal,

5. Conclusions

This paper proposes the four phase current-mode sinusoidal QO. The CO and FO can be orthogonally tuned by finding the bias currents. Additionally, the proposed quadrature circuit can provide high impedance at output terminals and its amplitude is able to be adjusted. The operation of AM demonstrates the constancy of quadrature oscillator. PSPICE simulations are able to testify the theoretical discrimination.

6. Acknowledgements

This work was supported by the Faculty of Engineering, Rajamangala University of Technology Isan, Khon Kaen Campus, Thailand.

7. References

[1] Khan IA, Khawaja S. An integrable gm-C quadrature oscillator. International journal of electronics 2000;87:1353-1357.
[2] Toumazou C, Lidgey FJ. Universal active filter using current conveyors. Electronics Letters 1986;22:662-664.
[3] Abuelma'atti NT, Al-zaher HA. Current-mode sinusoidal oscillators using single FTFN. IEEE Trans. Circuits and Systems-II: Analog and Digital Signal Processing 1999;46:69-74.
[4] Cam U, Toker A, Cicekoglu O, Kuntmam H. Current-mode high output-impedance sinusoidal oscillator configuration employing single FTFN. Analog Integrated Circuits and Signal Processing 2000;24:231-238.
[5] Gupta SS, Senani R. Realization of current-mode SRCOs using all grounded passive elements. Frequenz 2003;57:25-36.
[6] Keskin AU. Biolek D. Current mode quadrature oscillator using current differencing transconductance amplifiers (CDTA). IEE Proc.-Circuits Devices Syst 2006;153:214-218.
[7] Uygur A. Kuntman H. CDTA-Based quadrature oscillator design. Proceedings of the 14th European Signal processing conference; 2006 Sep 4-8; Florence, Italy. EUSIPCO; 2006. p. 4-8.
[8] Prasad D, Bhaskar DR, Singh AK. Realisation of singleresistance-controlled sinusoidal oscillator: a new application of the CDTA. WSEAS Transactions on Electronics 2008;5:257-259.
[9] Horng JW. Current-mode third-order quadrature oscillator using CDTAs. Active and Passive Electronic Components 2009;2009:1-5.
[10] Jaikla W, Siripruchyanun M, Bajer J, Biolek D. A simple current-mode quadrature oscillator using single CDTA. Radioengineering 2008;17:33-39.
[11] Bumrongchoke T, Duangmalai D, Jaikla W. Current differencing transconductance amplifier based current-mode quadrature oscillator using grounded capacitors. Proceedings of the International Symposium on Communications and Information Technologies (ISCIT); 2010 Oct 26-29; Tokyo, Japan. IEEE; 2010. p. 192-195.
[12] Bhusan M, Newcomb RW. Grounding of capacitors in integrated circuits. Electronics Letters 1969;3:148-149.
[13] Soliman AM. New grounded capacitor current mode bandpass low-pass filters using two balanced output ICCII. Journal of Active and Passive Electronic Devices 2008;3:175-184.
[14] Biolek D. CDTA-building block for current-mode analog signal processing. Proceedings of the 16th European Conference on Circuit Theory and Design; 2003 Sep 1-4; Cracow, Poland. p. 397-400.
[15] Yuce E. On the implementation of the floating simulators employing a single active device. International Journal of Electronics and Communications (AEU) 2007;61:453-458.
[16] Thosdeekoraphat T, Summart S, Thongsopa C. A Simple Current-mode Sinusoidal Quadrature Oscillators Using Single DO-CDTA Based-on All-pass Filter. Australian Journal of Basic and Applied Sciences 2013;7:120-127