© 2017 IJEDR | Volume 5, Issue 4 | ISSN: 2321-9939

Current Mode Sinusoidal Quadrature Oscillator Using Current Differencing Tranconductance Amplifier (CDTA)

[1]Rupam Das, [2]Biplab Bhowmick

[1,2]Department Of Electronics & Communication Engineering,
Asansol Engineering College, Asansol, India

Abstract— In this paper a new current mode sinusoidal quadrature oscillator using current differencing transconductance amplifier (CDTA) is presented. The proposed circuit consists of two CDTA, two capacitors and two resisters. In the proposed circuit the frequency of oscillation and condition of oscillation is independently controlled. The operation of the circuit is verified with PSPICE simulation results.

IndexTerms— Quadrature oscillator, CDTA , Current mode signal processing.

I. INTRODUCTION

Current mode building blocks have received considerable attention due to their wider bandwidth and large dynamic range with respect to OPAMP circuits and these blocks can operate in current and voltage mode. CDTA is a recently introduced analog building block (ABB) which has two current inputs and two current outputs and provides electronic tenability through transconductance gain (g_m). CDTA was first introduced by Bioleck [1] and it is found to be very useful building block for circuit design.

The circuit which provides two sinusoidal wave form with 90^0 phase difference is known as quadrature oscillator. Quadrature oscillator can be used as a quadrature mixer,single side band modulator, selective voltmeter or measurement purpose in vector generator etc. From the literature survey we have found a number of quadrature oscillator using CDTA [3-17]. Most of the previous work suffer from the use of a large number of CDTA, and does not provide an independent control of oscillation condition and oscillation frequency.

In this paper a quadrature oscillator circuit is designed using two CDTA , two resistors and two capacitors. The proposed circuit offers the following advantages : (1)the oscillation frequency and oscillation condition is independently controlled (2) low swnsitivity (3) simulation results agree well with theoretical analysis, The paper is organized as follows : the CDTA fundamentals and proposed design are presented in section 2 and section 3 respectively. Non ideal analysis is included in section 4, finally PSPICE simulation results and conclusion are given in section 5 and section 6.

II. CDTA FUNDAMENTAL

CDTA basic block diagram and its equivalent circuit is shown in Fig.1(a) and Fig.1(b) respectively.

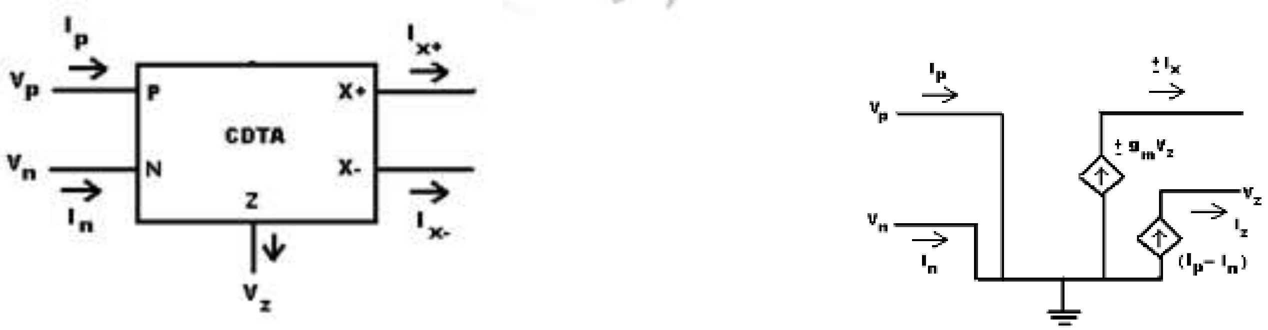

Fig.1: CDTA (a) symbol (b) Equivalent circuit

The port relationship of the CDTA can be characterized by the following matrix:

$$\begin{bmatrix} V_p \\ V_n \\ I_p \\ I_n \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 \\ 0 & 0 & 0 & g_m \end{bmatrix} \begin{bmatrix} I_p \\ I_n \\ V_x \\ V_z \end{bmatrix} \quad (1)$$

Port relationship in (1) may also be represented as:

$$V_p = V_n = 0 \quad (2)$$

$$I_z = I_p - I_n \quad (3)$$

$$I_x = g_m V_z \quad (4)$$

Internal structure of this device is shown in Fig.2.Transconductance gain (g_m) can be expressed as:

$$g_m = \sqrt{\mu Cox\left(\frac{W}{L}\right) I_b} \quad (5)$$

Where μ and C_{ox} are the mobility and gate oxide capacitance per unit area, W is effective width and L is the effective channel length. By adjusting the bias current I_b the transconductance gain can be electronically controlled.

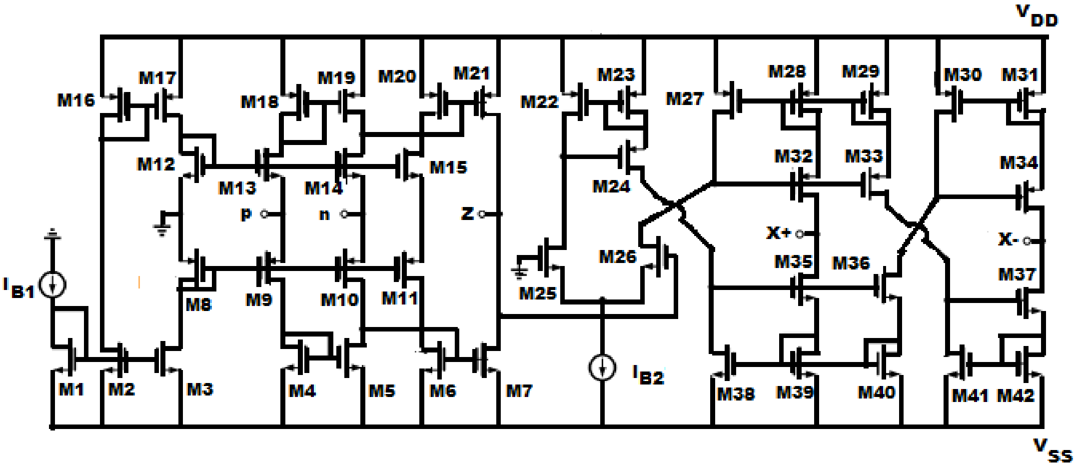

Fig.2: Internal structure of CDTA

III. PROPOSED CURRENT MODE QUADRATURE OSCILLATOR

All pass filters (AP) are very important circuit in analog signal processing. In the literature various all pass filters are available but very few of them are suitable for the design of quadrature oscillator, such types of all pass filter [6] used for quadrature oscillator is shown in Fig.3.

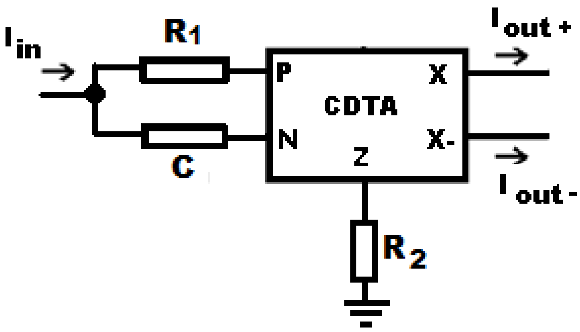

Fig.3: CDTA based current mode AP filter

By cascading the first order all pass filter and non inverting lossless integrator the proposed current mode quadrature oscillator is designed. Block diagram of the proposed quadrature oscillator is shown in Fig.4 and the circuit diagram of the proposed circuit is shown in Fig.5.

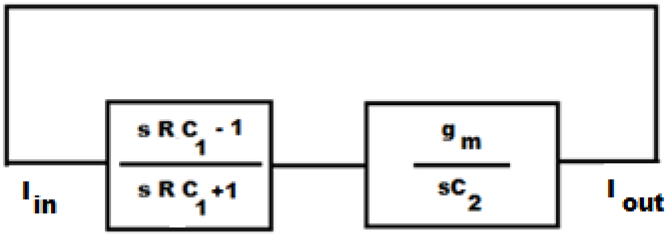

Fig.4: Block diagram of quadrature oscillator

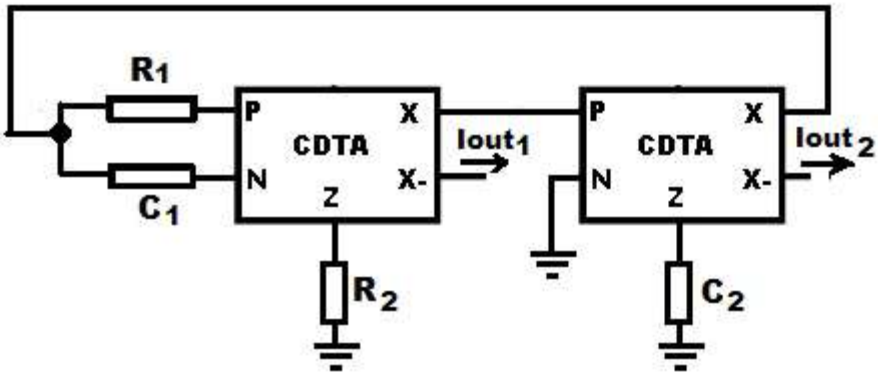

Fig.5: Proposed current mode quadrature oscillator

Routine analysis shows the characteristics equation of the proposed circuit as

$$s^2C_1C_2R_1+s(C_2-g_{m_1}g_{m_2}R_1R_2C_1)+g_{m_1}g_{m_2}=0 \quad (6)$$

For $C_1=C_2=C$ and $R_1=R_2=R$ and $g_{m1}= g_{m2}=g_m$ the condition of oscillation of the proposed circuit is as follows:

CO:

$$g_{m1}g_{m2}\ \text{x}\ R^2=1 \quad (7)$$

$$g_m=\frac{1}{R}$$

the frequency of oscillation of the proposed circuit becomes

FO:

$$\omega_{osc}=\sqrt{\frac{g_{m1}g_{m2}}{C_1C_2R_1}} \quad (8)$$

$$\omega_{osc}=\frac{1}{RC}$$

The quadratic current output relationship is

$$\frac{I_{02}(s)}{I_{01}(s)}=\frac{g_{m2}}{sC_2} \quad (9)$$

For sinusoidal steady state

$$\frac{I_{02}(j\omega)}{I_{01}(j\omega)}=\frac{g_{m2}}{\omega C_2}e^{-j90^0} \quad (10)$$

It shows that phase difference between output current I_{01} and I_{02} is 90^0 thus the oscillator can be used as quadrature oscillator.

IV. EFFECT OF NONIDEALITY

Considering the non ideality current voltage relationship of CDTA the port relationship can be rewritten as **:**

$$\begin{bmatrix} v_p \\ v_n \\ i_z \\ i_x \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ \alpha_p & -\alpha_n & 0 & 0 \\ 0 & 0 & \beta g_m & 0 \end{bmatrix} \begin{bmatrix} i_p \\ i_n \\ v_z \\ v_x \end{bmatrix} \quad (11)$$

Where $\alpha_p = 1-\varepsilon_p, |\varepsilon_p| << 1$ the current transfer error from p to z terminals is, $\alpha_n = 1-\varepsilon_n, |\varepsilon_n| << 1$ is the current transfer error from n to z terminals and β is the transconductance inaccuracy factor from z to x terminals. Using eq^n (16) the proposed oscillator circuit in Fig.5 yields the modified characteristics equation as follows:

$$s^2 C_1 C_2 R_1 + s[C_2 - \alpha_n \beta g_{m1} g_{m2} C_1 R_1 R_2] + \alpha_p \beta g_{m1} g_{m2} = 0 \quad (12)$$

CO:

$$\frac{C_2}{C_1} = \alpha_n \beta g_{m1} g_{m2} R_1 R_2 \quad (13)$$

$$g_m = \frac{1}{R}$$

FO:

$$\omega_{osc} = \sqrt{\frac{\alpha_p \beta g_{m1} g_{m2}}{C_1 C_2 R_2}} \quad (14)$$

$$\omega_{osc} = \frac{1}{RC}$$

sensitivity analysis of the proposed oscillator in non ideal case are expressed as:All the passive and active sensitivities are low and it is shown in equation (15) and equation (16)

$$S_{C_1}^{\omega_{OSC}} = S_{C_2}^{\omega_{OSC}} = S_R^{\omega_{OSC}} = -\frac{1}{2} \quad (15)$$

$$S_{g_{m1}}^{\omega_{OSC}} = S_{g_{m2}}^{\omega_{OSC}} = S_{R_2}^{\omega_{OSC}} = -\frac{1}{2} \quad (16)$$

V. SIMULATION RESULT

The CDTA based all pass filter has been simulated in PSPICE using CMOS based CDTA shown in Fig.3. The model parameter of TSMC 0.18 µm CMOS process and supply voltage of Vdd = -Vss = 2V are used. The aspect ratio of various transistors is shown in Table-2. Simulation is performed with passive component values selected as C=1.21 nf R=1.1KΩ and I_{b1}=200µA and I_{b2}=150µA. The gain and phase response of the all pass filter is shown in Fig.6. The time response of the input and output signals for an input sinusoidal signal 5 KHz is shown in Fig.7. The Fourier spectrum of the output signals at Iout+ are showing at a high selectivity for the applied signal frequency 5 KHz as shown in Fig.8. Simulation result of oscillator output from the initial sate is shown in Fig.9 and for this we are using R=1.1 kΩ and $C_1 = C_2 =$ 1.21nf. The quadrature output is also shown in Fig.10. The Fourier spectrum of the output signals at I_{out_1} & I_{out_2} are showing shown in Fig.11 and Fig.12 respectively. Theoretical frequency of oscillation value calculated from equation (8) is 100.53 KHz while simulated value is 100 KHz. Lissagous fig is shown in Fig.13 which verifies the quadrature relationship between output waveforms.

Table-2: Aspect ratio of various transistor:

Transistor	W(µm)	L(µm)
M1-M21,M24,M27-M42	20	1
M22,M23	45	1
M25,M26	35	0.7

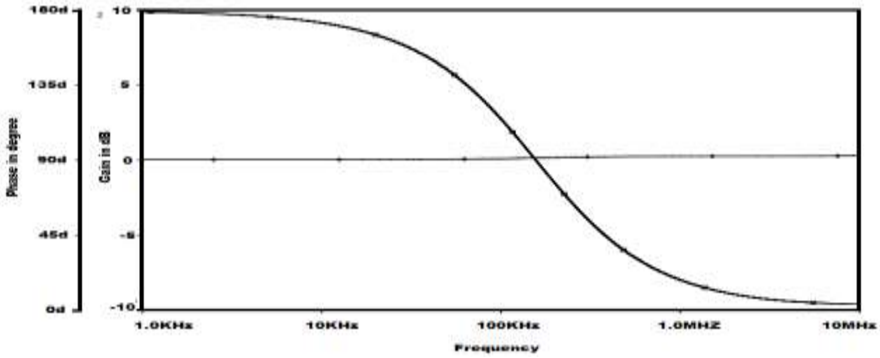

Fig.6: Gain and phase response of the all pass filter at I_{out+}

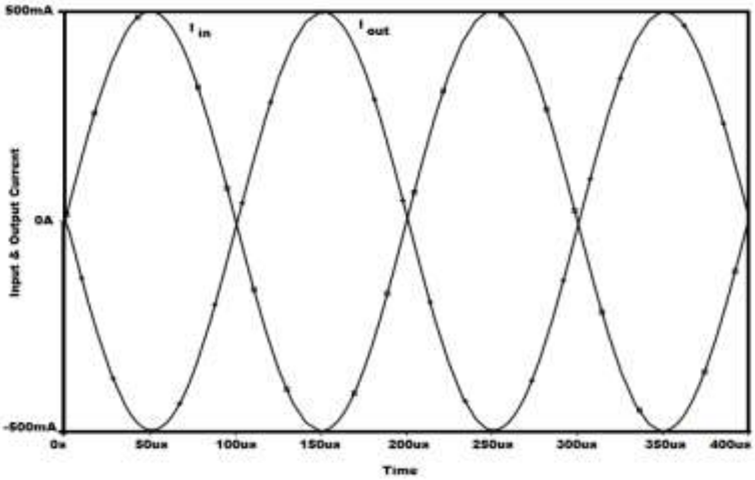

Fig.7: Simulated sinusoidal input and output waveform of Fig.3.

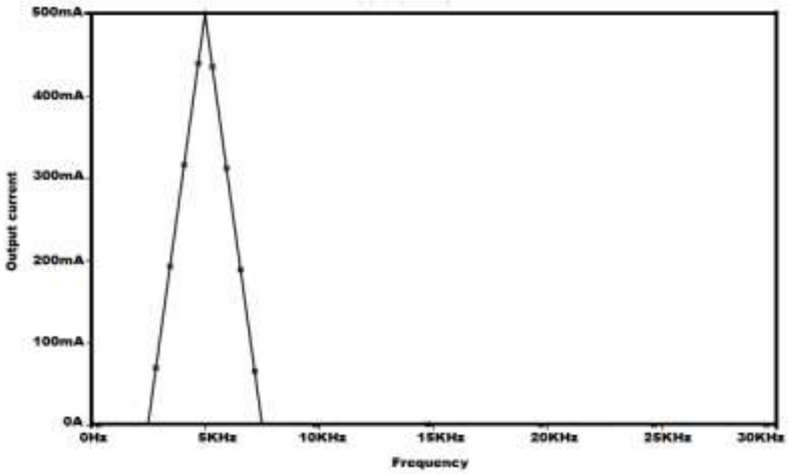

Fig.8: The simulated frequency spectrum I_{out+} of Fig.3.

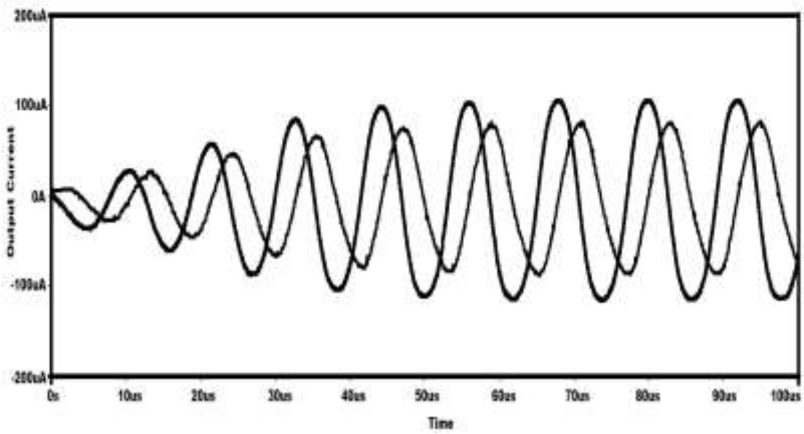

Fig.9: The simulated result of output waveforms from initial state of Fig,5

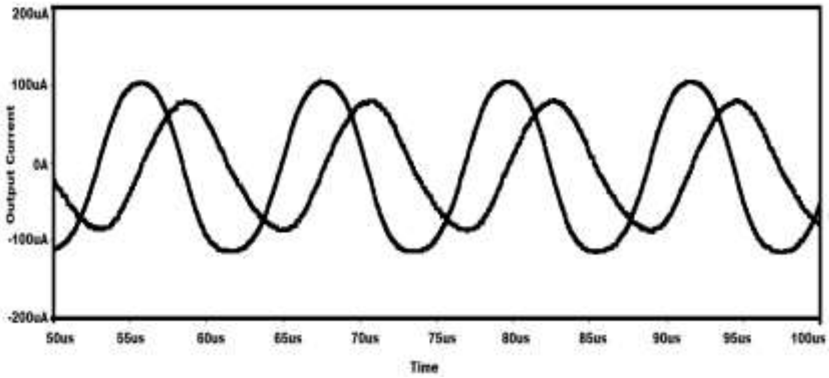

Fig.10: The simulated result of quadrature outputs of Fig.5.

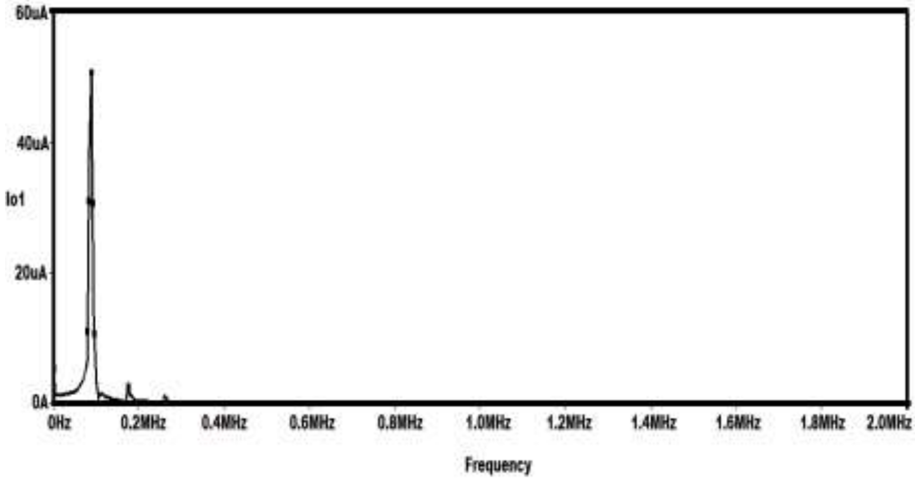

Fig.11: The simulated result of output spectrum at I_{out1} of Fig.5

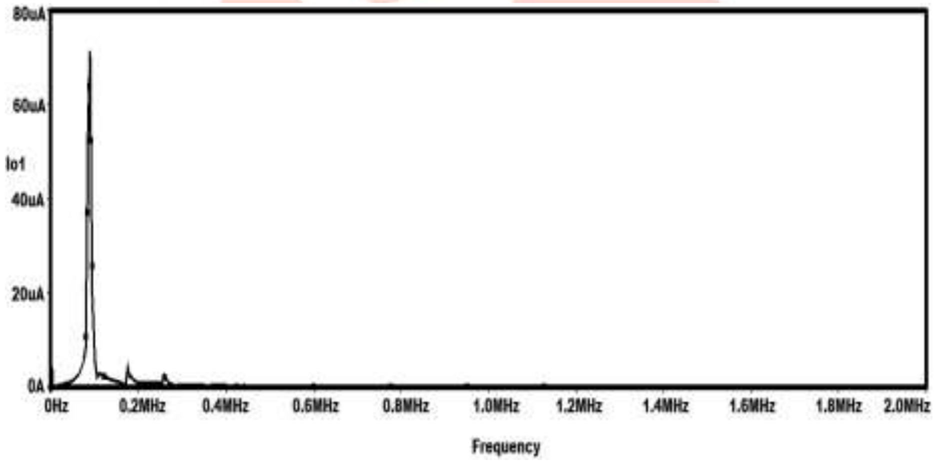

Fig.12: The simulated result of output spectrum at I_{out2} of Fig.5

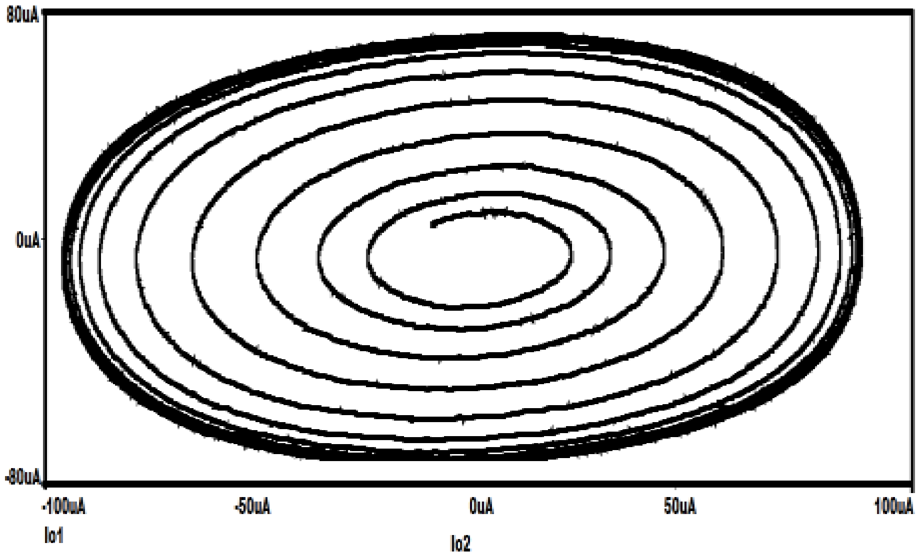

Fig.13: Lissagous figure

VI. CONCLUSION

A new current mode quadrature oscillator using CDTA analog building block is presented here. In the proposed circuit the condition of oscillation and frequency of oscillation can be independently controlled. The circuit uses two CDTA building block, two resistors and two capacitors. The pspice simulation agree well in the theoretical results.

REFERENCES

[1] D.Biolek,"CDTA –building block for current mode analog signal processing", in proceedings of the European conference on circuit theory and design, Krakow,Poland,pp.397-400,2003.

[2] D.Biolek,V.Biokova,"universal biquard using CDTA elements for cascading filter design," in proceedings of the 13th international multiconference on circuits , systems, communications and computers(CSCC-2003) ,Greece,pp.8-12,2003.

[3] J.Jin, C. Wang,"Current-mode four-phase quadrature oscillator using current differencing transconductance amplifier based first-order allpass filter", Rev. Roum. Sci. Techn. – Électrotechn. et Énerg., 57: 291-300, 2012.

[4] W. Tangsrirat,W. Tanjareon,"Current-mode sinusoidal quadrature oscillator with independent control of oscillation frequency and condition using CDTAs", Indian Journal of Pure and Applied Physics, Vol. 48, pp. 363-366, 2010.

[5] W. Tanjaroen, W. Tangsrirat, "Resistorless current-mode quadrature sinusoidal oscillator using CDTAs", Proceedings of the Asia-Pacific Signal and Information Processing Association Annual Summit and Conference, pp. 307-310, 2009.

[6] A.U. Keskin, and D. Biolek,"Current mode quadrature oscillator using current differencing transconductance amplifiers (CDTA)", IEE Proc.-Circuits Devices Syst., 153: 214-218, 2006

[7] A.Uygur, and H. Kuntman, "CDTA-based quadrature oscillator design", 14th European Signal Processing Conference, 2006.

[8] A. Lahiri, "New current-mode quadrature oscillator using CDTA", IEICE Electronics Express, Vol. 6, pp. 135-140, 2009.

[9] N.pandey, Sajal K paul ,"Single CDTA based current mode allpass filter and its applications", Journal of electrical and computer engineering, ID:897631, 2011.

[10] Md.Hasan, Sajal K Paul,"a noval current mode quadrature oscillator usinf current differencing transconductance amplifier", Journal of VLSI Design Tools & Technology 4 (1), 39-42.,2014

[11] F.Kaçar,H.Kuntman,"Design Of Quadrature Oscillator Using Current Differencing (CDTA) Transconductance Amplifier ", pp:399-403.

[12] S. Summart, C. Saetiaw, T. Thosdeekoraphat, C. Thongsopa ,” First Order Filter Based Current-Mode Sinusoidal Oscillators Using Current Differencing Transconductance Amplifiers (CDTAs)” World Academy of Science, Engineering and Technology,International Journal of Electrical, Robotics, Electronics and Communications Engineering Vol:8 No:7, 2014.

[13] M.Kumngern and K.Dejhan,”Electronically Tunable Current-Mode Quadrature Oscillator Using Current Differencing Transconductance Amplifiers “,978-1-4244-4547-9/09/2009 IEEE, TENCON 2009.

[14] Jie Jin and Chunhua Wang,”CDTA-based electronically tunable current-mode quadrature oscillator “ , International Journal of Electronics, 2013.

[15] Jie JIN, ChunHua WANG,” Current-mode universal filter and quadrature oscillator using CDTAs”, Turkish Journal of Electrical Engineering & Computer Sciences, 22: 276 – 286, (2014)

[16] D. Prasad, D.R. Bhaskar, A.K. Singh, “Realisation of single-resistance-controlled sinusoidal oscillator: a new application of the CDTA", WSEAS Transactions on Electronics, Vol. 5, pp. 257-259, 2008.

[17] W. Tanjaroen, W. Tangsrirat, “Resistorless current-mode quadrature sinusoidal oscillator using CDTAs", Proceedings of the Asia-Pacific Signal and Information Processing Association Annual Summit and Conference, 2009.