Realisation of Single-Resistance-Controlled Sinusoidal Oscillator: A new application of the CDTA

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Abstract: - Among various modern active building blocks, the recently introduced 'current differencing transconductance amplifier' (CDTA) is emerging as a very flexible and versatile building block for analog circuit design and has been used earlier for realizing a variety of functions. In this paper, a new application of the CDTA in realising a Single Resistance Controlled Sinusoidal Oscillator has been introduced. The proposed circuit employs only a single CDTA alongwith a bare minimum of only four passive components and yet offers the advantages of (i) independent control of condition of oscillation and frequency of oscillation and (ii) low active and passive sensitivities. The workability of the proposed configuration has been demonstrated by experimental results.

Key-Words: - Current Differencing Transconductance Amplifier, Sinusoidal oscillator, Current-mode circuits.

1 Introduction

Single Resistance Controlled sinusoidal oscillators (SRCOs) find numerous applications in communication, control systems, signal processing, instrumentation and measurement systems, see[1]-[3] and the references cited therein. SRCOs based upon different active building blocks are available in the literature, see [4]-[12] and the references cited therein. The advantages, applications and usefulness of recently introduced new active building block named current differencing transconductance amplifier (CDTA) are now being recognised in literature [13]-[16]. Recently, a current-mode quadrature oscillator using two CDTA and six passive elements has been introduced [16]. However, to the best knowledge and belief of the authors, no SRCO using single CDTA has yet been presented in the open literature so far. The purpose of this paper is, therefore, to propose a new SRCO using a single CDTA along with a minimum possible number of passive components, which offers (i) independent control of oscillation frequency and condition of oscillation, and (ii) low active and passive sensitivities. SRCOs realizable with minimum components have the following advantages (i) minimum power dissipation, (ii) reduced likelihood of the circuit failure and (iii) reduced component cost, noise and parasitic effects [7]. The practicability of the new circuit has been demonstrated by experimental results based upon commercially available AD844 type CFOAs and LM3080 type OTAs.

2 New Oscillator Configuration

The proposed new configuration is shown in Fig.1. Assuming an ideal CDTA characterised by $V_p=V_n=0$, $I_z=I_p-I_n$, $I_{x+}=g_mV_z$, $I_{x-}=-g_mV_z$, where $V_z = I_z.Z_z$ and Z_z is the external impedance connected to the *z*-terminal of the CDTA [13]-[16].

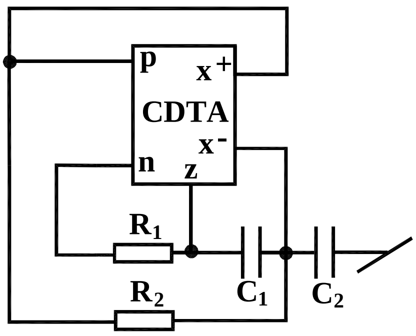

Fig.1: The proposed configuration.

A routine circuit analysis yields the following characteristic equation:

$$s^2C_1C_2 + s\{(C_1 + C_2)2G_1 - C_2g_m\} + 2G_1G_2 = 0 \qquad (1)$$

where $G_1 = \frac{1}{R_1}$ and $G_2 = \frac{1}{R_2}$.

Thus, the condition of oscillation (CO) and frequency of oscillation (FO) are given by:

$$\left\{2\left(1+\frac{C_1}{C_2}\right)-R_1 g_m\right\}\leq 0 \tag{2}$$

and

$$\omega_0=\sqrt{\frac{2}{R_1 R_2 C_1 C_2}} \tag{3}$$

Therefore, it is seen that FO is independently controllable by resistor R_2 whereas CO is independently established by the transconductance (g_m) of the CDTA.

3 Non-ideal Analysis

Taking the non-idealities into account, namely $I_z = (\alpha_p I_p - \alpha_n I_n)$, where $\alpha_p = 1-\varepsilon_p$ ($\varepsilon_p \ll 1$) and $\alpha_n = 1-\varepsilon_n$ ($\varepsilon_n \ll 1$) denote the current tracking errors, respectively, then the CO and FO can be given by:

$$\left(1+\frac{C_1}{C_2}\right)\left\{\frac{1+\alpha_n}{R_1+R_n}\left(1+\frac{R_p}{R_2}\right)\right\}-\alpha_p g_m+\frac{C_1}{C_2}g_m\left(1-\alpha_p\right)\leq 0 \tag{4}$$

$$\omega_0=\sqrt{\frac{(1+\alpha_n)}{C_1 C_2\left(R_1+R_n\right)\left(R_2+R_p\right)}} \tag{5}$$

where R_n and R_p are the input resistances of the n and p terminals of CDTA respectively.

From a comparison of equations (4) and (5) it is seen that influence of R_p and R_n on ω_0 can be compensated by predistorting the value of R_1 and R_2 on the other hand, from the inspection of non-ideal condition of oscillation in equation (4) it is clear that R_n can be accommodated R_1 whereas the impact of R_2 on oscillation condition can be minimised by ensuring R_2 to be taken as much larger than R_p.

Its active and passive sensitivities can be found as:

$$S_{C_1}^{\omega_0}=-\frac{1}{2},\ S_{C_2}^{\omega_0}=-\frac{1}{2},\ S_{R_1}^{\omega_0}=-\frac{1}{2}\left(\frac{R_1}{R_1+R_n}\right),$$

$$S_{R_2}^{\omega_0}=-\frac{1}{2}\left(\frac{R_2}{R_2+R_p}\right),\ S_{R_n}^{\omega_0}=-\frac{1}{2}\left(\frac{R_n}{R_1+R_n}\right),$$

$$S_{\alpha_n}^{\omega_0}=\frac{\alpha_n}{2(1+\alpha_n)},\ S_{R_p}^{\omega_0}=-\frac{1}{2}\left(\frac{R_p}{R_2+R_p}\right),\ S_{\alpha_p}^{\omega_0}=0$$

which are all very low.

4 Experimental Results

To confirm theoretical analysis, the proposed SRCO was experimentally tested by constructing the CDTA with two AD844 ICs current feedback op-amps and two LM3080 ICs operational Transconductance amplifiers. The DC power supply voltages were taken as ±6V. The passive elements of the configuration were selected as $C_1 = C_2 = 1$ nF, $R_1 = 4$ KΩ. The variability of oscillation frequency with resistor R_2 is shown in Fig. 2, and is seen to be in very good agreement with the corresponding theoretical values. The typical waveform generated by this oscillator of Fig. 1 with $R_2 = 5$ KΩ is shown in Fig. 3. These experimental results, thus, prove the workability of the proposed SRCO.

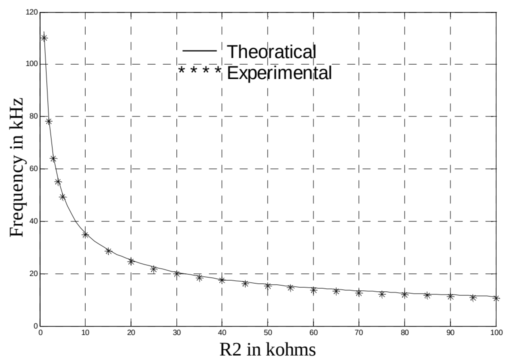

Fig.2: Variation of oscillation frequency with resistance R_2.

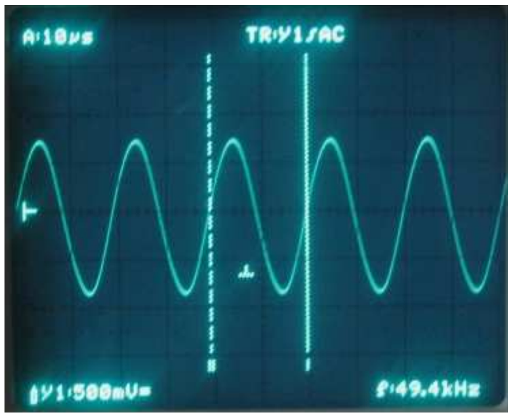

Fig.3: Typical voltage output waveform of the proposed SRCO.

5 Conclusions

Among various modern active building blocks, CDTA is emerging as quite flexible and versatile for analog circuit design and has been used earlier for realizing a variety of functions. However, use of CDTA in the realization of single-element-controlled sinusoidal oscillator had not been known earlier. This paper has filled this void by introducing a novel single CDTA- based configuration which uses a minimum possible number of active buildings (only one) along with a minimum possible number of passive components (namely, only two resistors and two capacitors) and yet offers independent control of both CO and FO (the former through g_m and later through the resistor R_2). This paper thus added a new application circuit to the existing repertoire of CDTA-based application circuits. The work towards generating the complete family of CDTA-based SRCOs, is currently in progress and the results of this work will be forwarded for publication at a later date.

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References:

[1] Senani, R. New types of sine wave oscillators. *IEEE Trans. on Instrumentation and Measurement* (USA), September 1985, 34(3), pp. 461-463.

[2] Senani, R. and Bhaskar, D. R. Single-op-amp Sinusoidal oscillators suitable for generation of Very Low Frequencies. *IEEE Trans. on Instrumentation and Measurement* (USA), August 1991, 40(4), pp. 777-779.

[3] Bhaskar, D. R. and Senani, R. New CFOA-based Single-element- controlled Sinusoidal Oscillators. *IEEE Trans. on Instrumentation and Measurement* (USA), December 2006, 55(6), pp. 2014-2021.

[4] Singh, V. K., Sharma, R. K., Singh, A. K., Bhaskar, D. R. and Senani, R. Two new canonic single-CFOA oscillators with single resistor controls. *IEEE Trans. on Circuits and Systems II: Express Brief* (USA), December 2005, 52(12), pp. 860-864.

[5] Celma, S., Martinez, P.A., and Carlosena, A. Minimal realisation for single resistor controlled sinusoidal oscillator using single CCII. *Electron. Lett.*, 1992, 28(5), pp. 443-444.

[6] Bhaskar, D. R. and Senani, R. New Current-Conveyor-based Single-resistance- controlled/ voltage-controlled oscillator employing grounded capacitors. *Electron. Lett.*, IEE (UK), April 1993, 29(7), pp. 612-614.

[7] Lee, C.T. and Wang, H.Y. Minimum realization for FTFN-based SRCO. *Electron. Lett.*, IEE (UK), September 2001, 37(20), pp. 1207-1208.

[8] Bhaskar, D. R. Grounded -capacitor SRCO using only one PFTFN. *Electron. Lett.*, IEE (UK), September 2002, 38(20), pp. 1156-1157.

[9] Gupta, S. S. and Senani, R. Grounded-capacitor current-mode SRCO: Novel application of DVCCC. *Electron. Let.*, IEE (UK), February 2000, 36(3), pp. 195-196.

[10] Aggarawal, V., Kilinc, S. and Cam, U. Minimum component SRCO and VFO using a single DVCCC. *Analog Integrated Circuits and Signal Processing*, 2006, 49, pp. 181-185.

[11] Ozcan, S., Toker, A., Acar, C., Kuntman, H. and Cicekoglu, O. Single resistance-controlled sinusoidal oscillators employing current differencing buffered amplifier. *Microel. Journal*, 2000, 31, pp.169-174.

[12] Cam, U. A Novel Single-Resistance-Controlled Sinusoidal Oscillator Employing Single Operational Transresistance Amplifier. *Analog Integrated Circuits and Signal Proc.*, 2002, 32, pp.183–186.

[13] Biolek, D. CDTA-Building block for current-mode analog signal processing. *Proc. of the ECCTD'03*, Krakow, Poland, 2003, III, pp. 397-400.

[14] Biolek, D., Hancioglu, E. and Keskin, A.U. High-performance current differencing transconductance amplifier and its application in precision current-mode rectification. *AEU – Int. Journal of Electronics and Communications*, February 2008, 62 (2), pp.92-96.

[15] Keskin, A.U., Biolek, D., Hancioglu, E. and Biolkova, V. Current-mode KHN filter employing current differencing transconductance amplifier. *AEU –Int. Journal of Electronics and Communications*, June 2006, 60 (6), pp.443-446.

[16] Keskin, A.U. and Biolek, D. Current mode quadrature oscillator using current differencing transconductance amplifiers (CDTA). *IEE Proc. Circuits Devices Systs.'* June 2006, 153(3), pp.214-218.