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Voltage Mode Quadrature Oscillator Employing Single VDTA and Grounded Passive Elements

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Abstract

A new voltage mode quadrature oscillator (VMQO) employing single Voltage differencing transconductance amplifier (VDTA), two grounded capacitors and one grounded resistor has been proposed. The proposed circuit enjoys following advantageous features: i) use of all grounded passive elements, ii) availability of electronic tuning, iii) independent control of frequency of oscillation (FO) and condition of oscillation (CO), iv) low parasitic effects and v) low active and passive sensitivities.

Keywords: Quadrature oscillator, voltage mode, electronic control

1 Introduction

Quadrature oscillators simultaneously provides two 90^0 phase shifted sinusoidal outputs hence, find applications in single sideband generators, quadrature mixers and selective voltmeters [1] - [3]. Numerous VMQO employing different active elements have been reported in literature [2] - [9], [11] - [14]. Unfortunately, these reported oscillator circuits suffer from one or more of following drawbacks:

i) excessive (more than one) use of the active components, ii) excessive (more than three) use of the passive components, iii) presence of floating passive component(s), iv) lack of electronic control and v) lack of independent control of FO and CO. Therefore, the purpose of this communication is to propose a VDTA based VMQO which is free from all the above mentioned weaknesses.
The schematic symbol of new generation active element VDTA [10] is shown in Fig.1, where V_P and V_N are input terminals and Z, X^+ and X^- are output terminals.

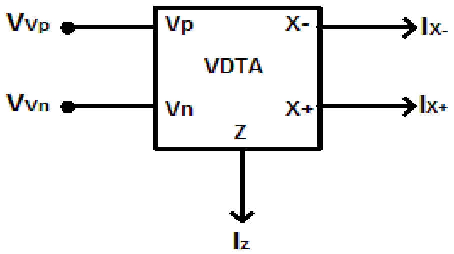

Figure 1: symbolic notation of VDTA

The VDTA can be described by the following set of equations;

$$\begin{bmatrix} I_Z \\ I_{X^+} \\ I_{X^-} \end{bmatrix} = \begin{bmatrix} g_{m_1} & -g_{m_1} & 0 \\ 0 & 0 & g_{m_2} \\ 0 & 0 & -g_{m_2} \end{bmatrix} \begin{bmatrix} V_{V_P} \\ V_{V_N} \\ V_Z \end{bmatrix} \quad (1)$$

2 Proposed Oscillator Configuration

Fig. 2 shows the proposed oscillator configuration. The routine circuit analysis gives the characteristics equation as follows:

$$s^2 + s\frac{1}{C_2}\left(\frac{1}{R_1} - g_{m_2}\right) + \frac{g_{m_1} g_{m_2}}{C_1 C_2} = 0 \quad (2)$$

From equation (2), FO and CO are found to be;

$$\text{FO:} \quad \omega_0 = \sqrt{\frac{g_{m_1} g_{m_2}}{C_1 C_2}} \quad (3)$$

$$\text{CO:} \quad \frac{1}{R_1} - g_{m_2} \le 0 \quad (4)$$

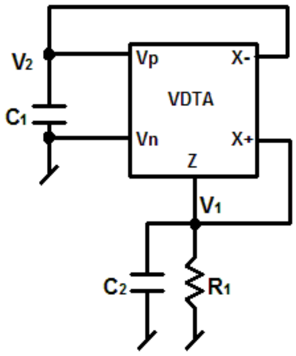

Figure 2: Proposed VMQO

From equations (3) and (4) it is clear that FO is independently adjustable by g_{m_1} and CO by R_1. Control of FO by g_{m_1} provides an opportunity of electronic tuning. The voltage relationships obtained from Fig.2 is:

$$\frac{V_2(s)}{V_1(s)} = -\frac{g_{m_2}}{sC_1} \tag{5}$$

Thus, the phase difference between V_1 and V_2 is 90^0. Hence, the proposed circuit provides two quadrature voltage mode (VM) outputs simultaneously.

3 Non Ideal and Sensitivity Analysis

Fig. 3 shows the non ideal equivalent circuit of proposed oscillator under the influence of VDTA parasitics [15].

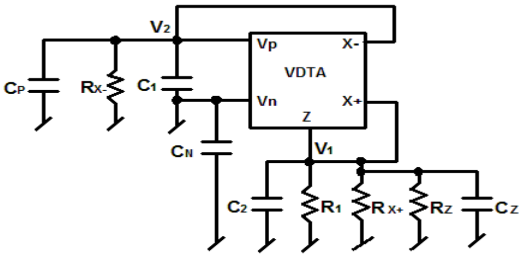

Figure 3: Non ideal equivalent circuit of proposed oscillator.

The FO and CO for the circuit shown in Fig. 3 are given as:

FO: $$\omega_0 = \sqrt{\frac{\frac{1}{R_{X-}}\left(\frac{1}{R_1}+\frac{1}{R_{X+}}+\frac{1}{R_Z}\right)+g_{m_1}g_{m_2}-g_{m_2}\left(\frac{1}{R_{X-}}\right)}{(C_1+C_P)(C_2+C_Z)}} \quad (6)$$

CO: $$\left[(C_1+C_P)\left(\frac{1}{R_1}+\frac{1}{R_{X+}}+\frac{1}{R_Z}\right)+\frac{1}{R_{X-}}(C_2+C_Z)-g_{m_2}(C_1+C_P)\right]\leq 0 \quad (7)$$

Fig.3 shows that parasitic capacitances C_P and C_Z, are in parallel with the external capacitances C_1 and C_2 respectively. Thus, the influence of the parasitic capacitances can be eliminate easily by reducing the values of external capacitances. From equation (6) and (7) it is clear that if $R_{X-} = \infty$, the FO and CO are independently tunable even under the influence of VDTA parasitics.
The sensitivities of FO with respect to various active and passive elements are $S^{\omega_0}_{g_{m_1}} = 0.5$, $S^{\omega_0}_{g_{m_2}} = 0.5$, $S^{\omega_0}_{R_1} = 0$, $S^{\omega_0}_{C_1} = -0.5$ and $S^{\omega_0}_{C_2} = -0.5$

Thus, all the active and passive sensitivities of ω_0 are low.

4 Simulation Results

The proposed VMQO circuit has been simulated by SPICE simulator with CMOS VDTA [26] and R_1 = 1.68 KΩ, $C_1 = C_2$ = .01 nF, $g_{m_1} = g_{m_2} = 631.702 \mu A/V$.

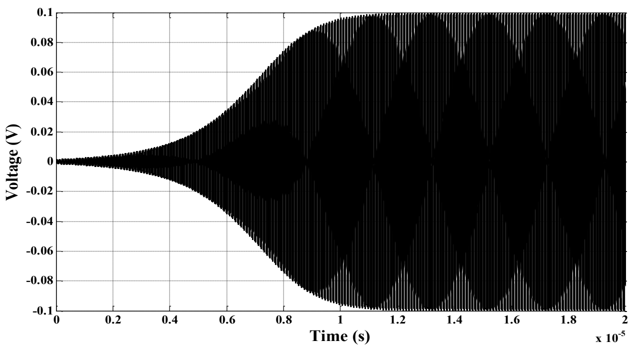

Figure 4: Simulated transient response

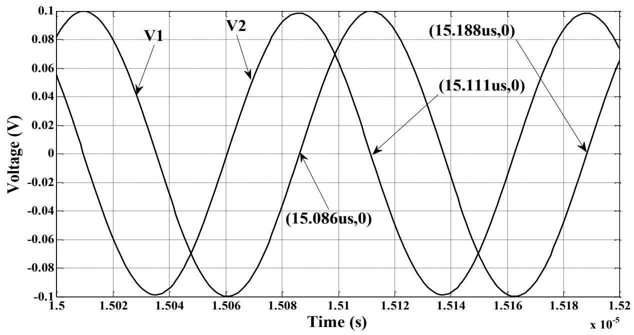

Figure 5: Simulated steady state response

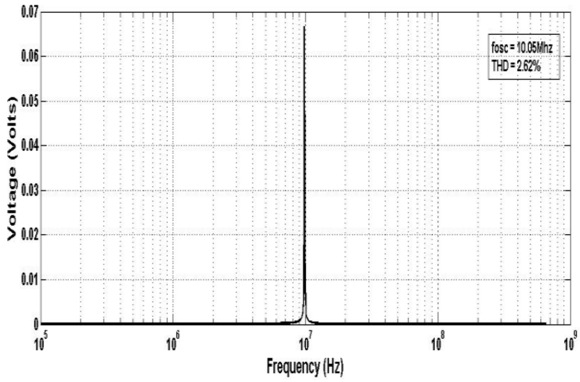

Figure 6: Output spectrum

The Simulated quadrature output voltages responses in transient state and steady state are shown in Fig.4 and Fig.5. From output spectrum shown in Fig.6, frequency of oscillation (fosc) is found 10.05MHz with total harmonic distortion (THD) of 2.62%. These results, thus confirm the validity of proposed configuration.

5 Conclusion

A new VMQO employing single VDTA and three grounded passive components has been proposed which offers non interactive control of FO and CO, electronic tunability, reduced parasitic effects and low active and passive sensitivities. The SPICE simulation results confirmed the theoretical predictions.

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