Dual Mode Quadarature Oscillator Based on VD-DVCC for Signal Processing Applications

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Abstract: In this research presents a dual-mode quadrature oscillator with a minimal component count. The design employs a single Voltage Differencing Differential Voltage Current Conveyor (VD-DVCC), along with two grounded capacitors and two grounded resistors. The oscillator simultaneously provides both current and voltage outputs. Importantly, the frequency of oscillation (FO) and the condition of oscillation (CO) can be adjusted independently. The circuit is validated through simulation at a designed frequency of 2.6971 MHz using 0.18 µm CMOS technology in Cadence design software, operating with a supply voltage of ±0.9 V.

Keywords: *Current Mode, Oscillator, Signal Processing, Tunability*.

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I. INTRODUCTION

Oscillators form an essential part of nearly all electronic circuits, whether digital or analog. They are extensively used as carrier generators in radio communication systems and as clock generators in digital devices, where timing information is critical. By generating periodic signals, oscillators fulfill diverse timing and frequency requirements across systems. Over time, the demand for oscillators per system has significantly increased due to their wide-ranging applications.

One key function of oscillators is frequency synthesis, where a range of frequencies can be generated from a single oscillator. This feature is especially useful in cellular communication, where multiple users require precise frequency allocation to maximize bandwidth efficiency. Additionally, oscillators are often applied as interface circuits for resistive and capacitive sensors, where the output period is proportional to the sensor values.

For oscillator design, current-mode (CM) active building blocks (ABBs) are preferred due to advantages such as higher linearity, wider dynamic range, and improved bandwidth [2]. Various CM-ABBs have been used in oscillator implementations, including the Second-Generation Current Conveyor (CCII) [2–4], Fully Differential Current Conveyor (FDCCII) [5], Current Backward Transconductance Amplifier (CBTA) [6], and Current Conveyor Transconductance Amplifier (CCTA) [7].

However, many existing designs [8–15] require more than two active blocks or rely on a large number of passive elements. In particular, designs in [8–9, 12] lack independent control of oscillation condition and frequency, while others suffer from poor tunability and excessive component requirements.

To address these limitations, this work proposes a minimum-component dual-mode quadrature oscillator using the recently introduced Voltage Differencing Differential Voltage Current Conveyor (VD-DVCC) [1]. The design provides both current and voltage outputs while ensuring independent tunability of FO and CO.

II. PROPOSED DUAL MODE QUADARATURE OSCILLATOR

The proposed oscillator utilizes a single VD-DVCC, two grounded capacitors, and two grounded resistors. It generates two quadrature voltage outputs and two current outputs. Since the current outputs are obtained across capacitors, a current follower is required for sensing them.

The characteristic equation of the oscillator is derived (Equation 9), while the expressions for the condition of oscillation (CO) and frequency of oscillation (FO) are provided in Equations 10–11. Independent tuning is achieved, as FO can be controlled by adjusting the bias current of the VD-DVCC without affecting CO.

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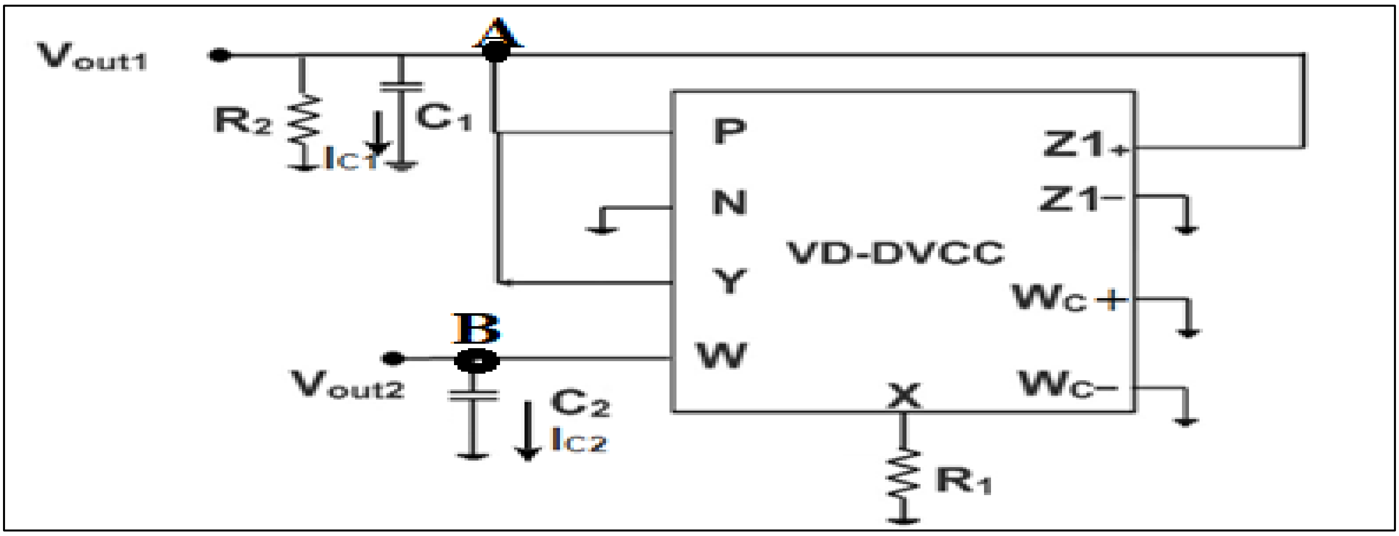

Fig 1 The Proposed Mixed Mode Oscillator Based on VD-DVCC

The analysis procedure for obtaining the characteristic equation of the oscillator, frequency of oscillation (FO) and condition of oscillation (CO) is given below.

$$V_X = V_Y - V_W = V_{out1} - V_{out2} \tag{1}$$

$$I_X = \frac{V_X}{R_1} = \frac{V_{out1} - V_{out2}}{R_1} \tag{2}$$

Applying KCL at node A

$$I_{Z+} = \frac{V_{out1}}{R_2} + V_{out1} sC_1 \tag{3}$$

$$\frac{V_{out1} - V_{out2}}{R_1} = \frac{V_{out1}}{R_2} + V_{out1} sC_1 \tag{4}$$

$$V_{out2} = \frac{V_{out1}[(R_2 - R_1 - sC_1R_1R_2)]}{R_2} \tag{5}$$

Applying KCL at node B

$$g_1 * V_{out1} = V_{out2}\ sC_2 \tag{6}$$

$$V_{out2} = \frac{g_1 * V_{out1}}{sC_2} \tag{7}$$

Equating Equations 5 and Equation 7 we get the oscillator equation

$$\frac{[(R_2 - R_1 - sC_1R_1R_2)]}{R_2} = \frac{g_1}{sC_2} \tag{8}$$

$$S^2C_1C_2R_1R_2 + SC_2R_1 - SC_2R_2 + R_2g_1 = 0 \tag{9}$$

$$\text{C.O.: } C_2R_2 \geq C_2R_1 \tag{10}$$

$$\omega_o = \sqrt{\frac{R_2g_1}{C_1C_2R_1R_2}} \tag{11}$$

III. SIMULATON RESULTS

The proposed oscillator, illustrated in Figure 1, was tested through CMOS implementation of the VD-DVCC (Figures 2–3). The current and voltage relationships are given in Equations 6–7.

- ➢ The circuit was designed for an oscillation frequency of 2.6971 MHz using component values: C1=50 pF, C2=50 pFC_1 = 50\ \text{pF}, \ C_2 = 50\ \text{pF}C1=50 pF, C2=50 pF
- ➢ R1=1 kΩ, R2=1.05 kΩR_1 = 1\ \text{kΩ}, \ R_2 = 1.05\ \text{kΩ} R1=1 kΩ, R2=1.05 Kω

Here, R2R_2R2 is chosen slightly higher than R1R_1R1 to satisfy the oscillation condition, with transconductance set at gm=718 µSg_m = 718\ \mu Sgm=718 µS.

The simulated frequency was found to be 2.582 MHz, showing a 4.08% deviation due to non-idealities and parasitic effects. The startup response of the oscillations is shown in Figure 4, while Figures 5(a–b) depict the quadrature voltage and current outputs. The Fourier spectrum of voltage outputs is presented in Figure 6.

For a bias current of 120 µA, the power dissipation was measured at 2.63 mW. These simulation results confirm the accurate operation of the proposed design.

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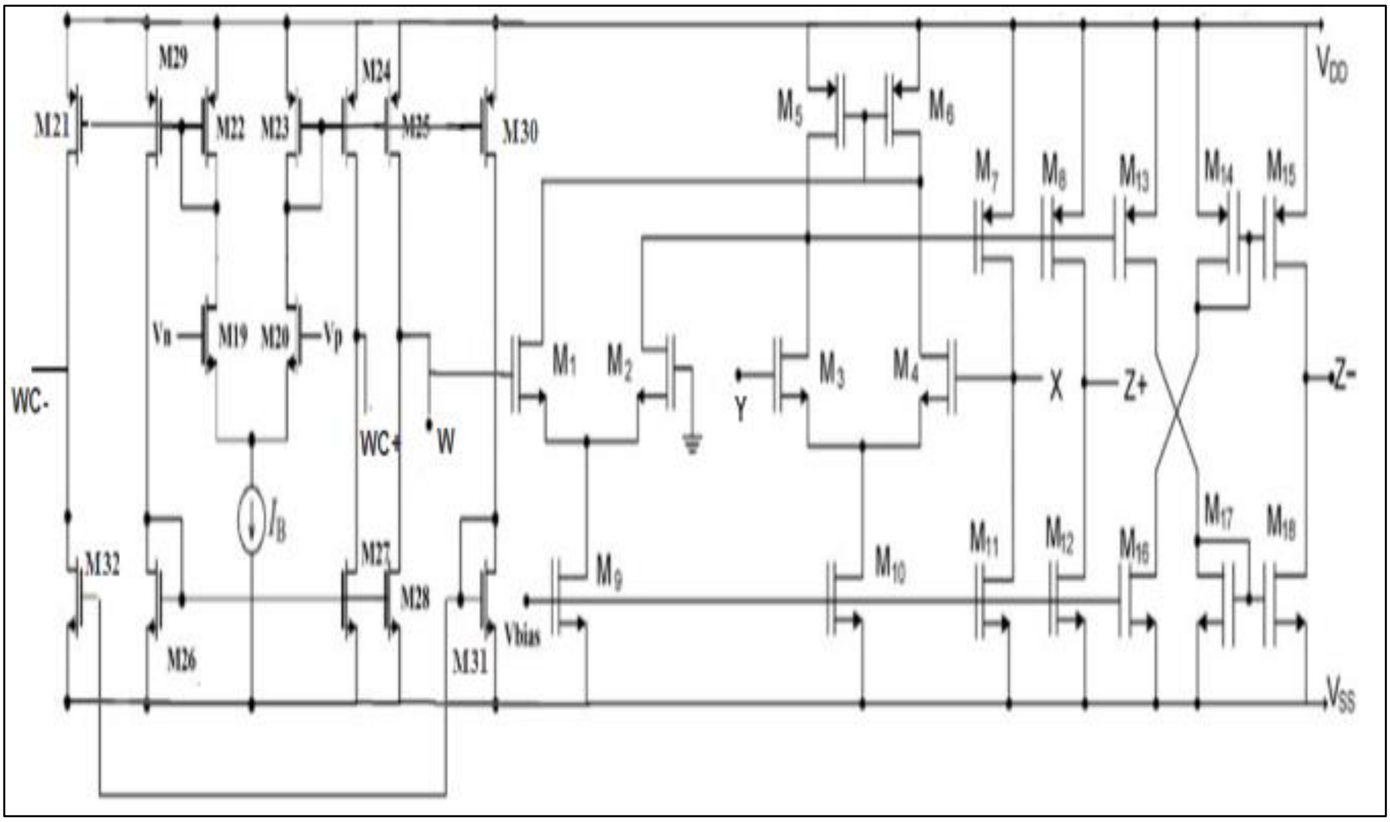


Fig 2 CMOS Implementation of VD-DVCC

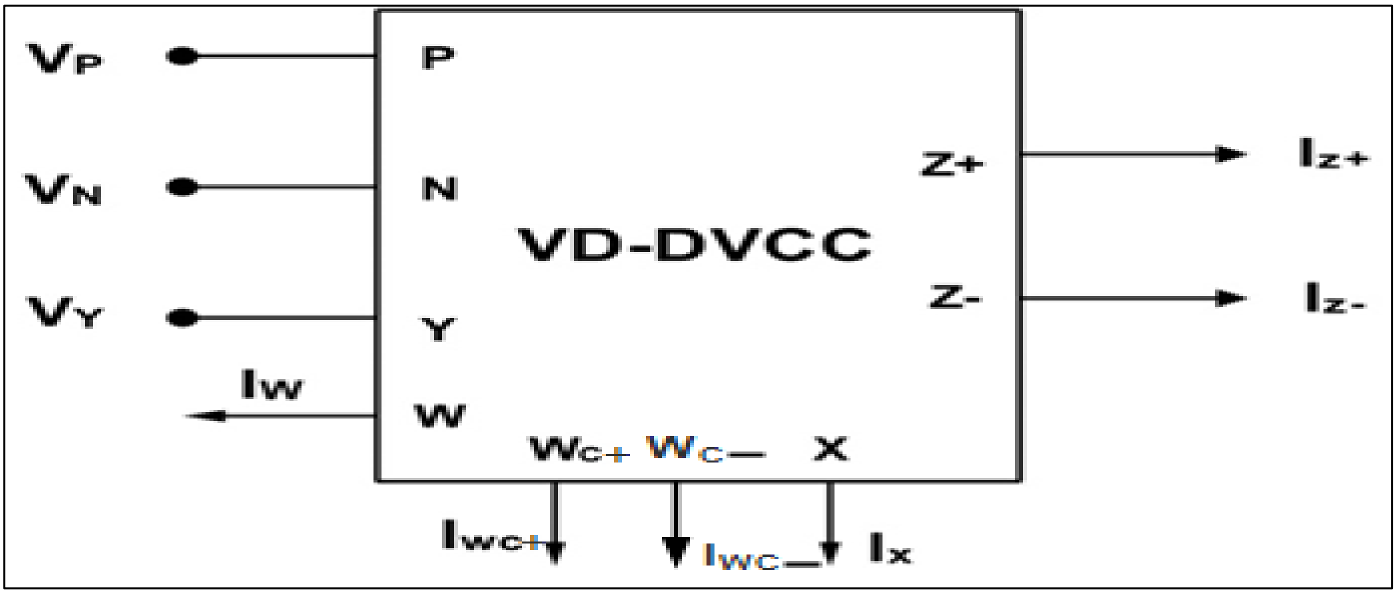


Fig 3 Block Diagram of VD-DVCC

$$\begin{bmatrix} I_N \\ I_P \\ I_W \\ I_{WC} \\ V_X \\ I_{Z+} \\ I_{Z-} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & g_m & -g_m & 0 & 0 \\ 0 & g_m & -g_m & 0 & 0 \\ 0 & 0 & 1 & -1 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} V_P \\ V_N \\ V_Y \\ V_W \\ I_X \end{bmatrix} \tag{12}$$

$$I_{W\pm} = \pm g_m (V_{ZP1} - V_{ZN1}) = \left(\sqrt{2 I_{Bias} k}\right)(V_{ZP1} - V_{ZN1}) \tag{13}$$

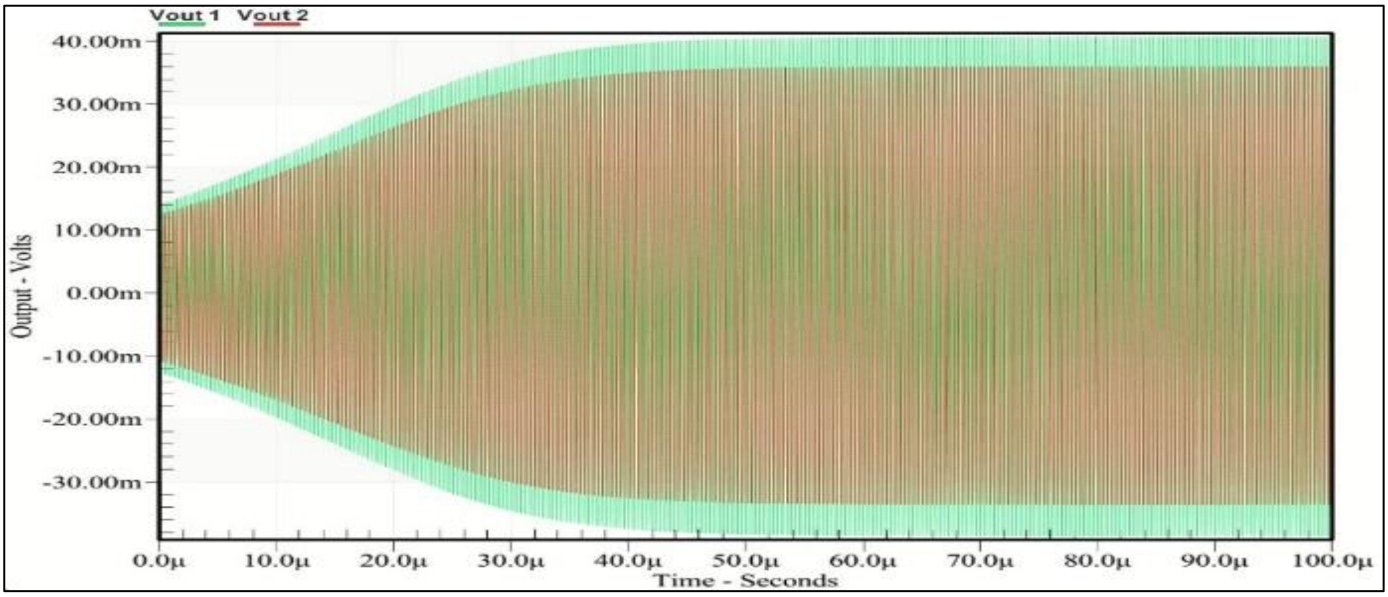
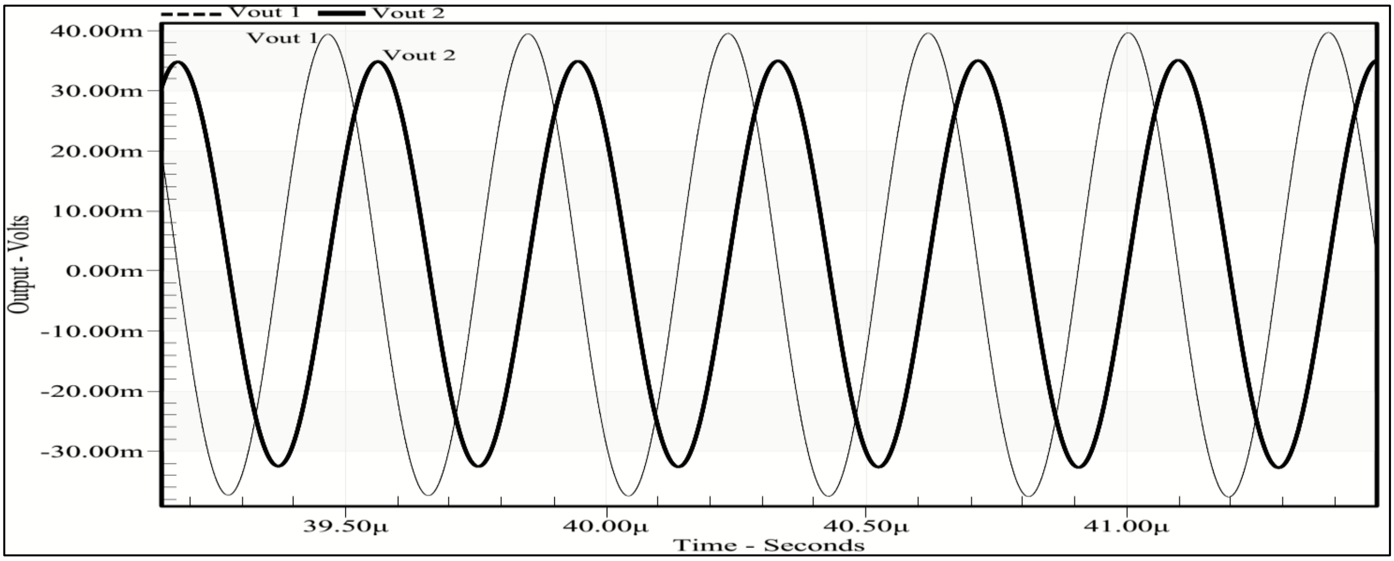
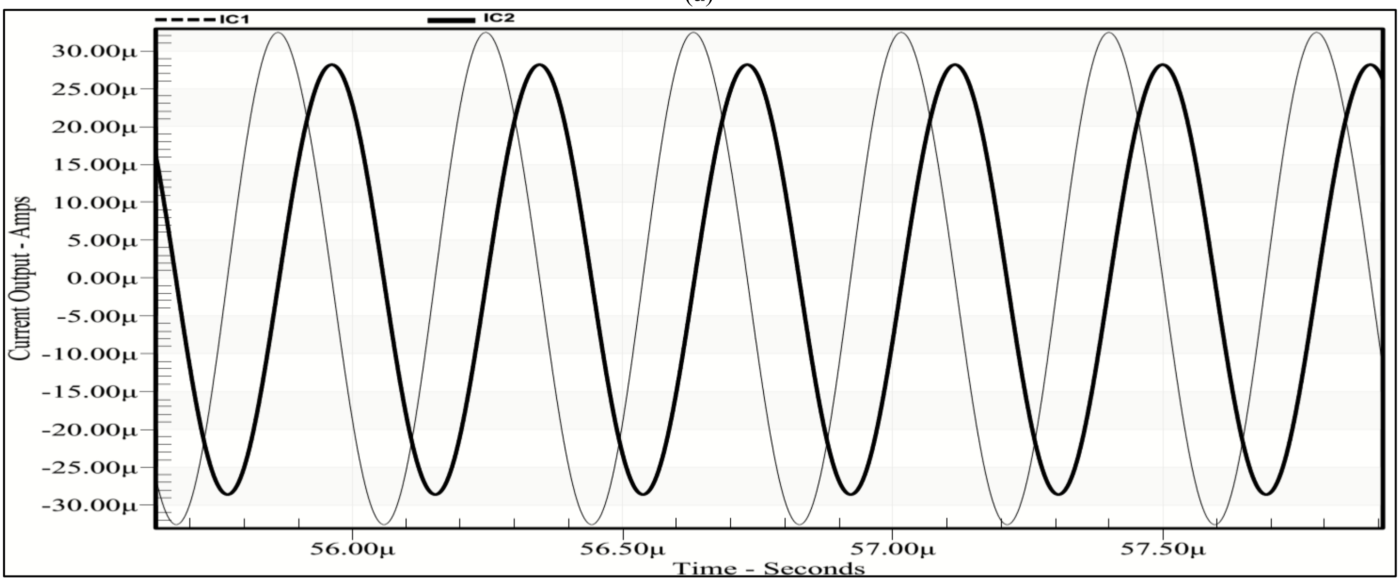


Fig 4 Build-Up of Oscillations



(a)



(b)

Fig 5 Steady State Response of the Oscillator (a) Voltage Mode (b) Current Mode

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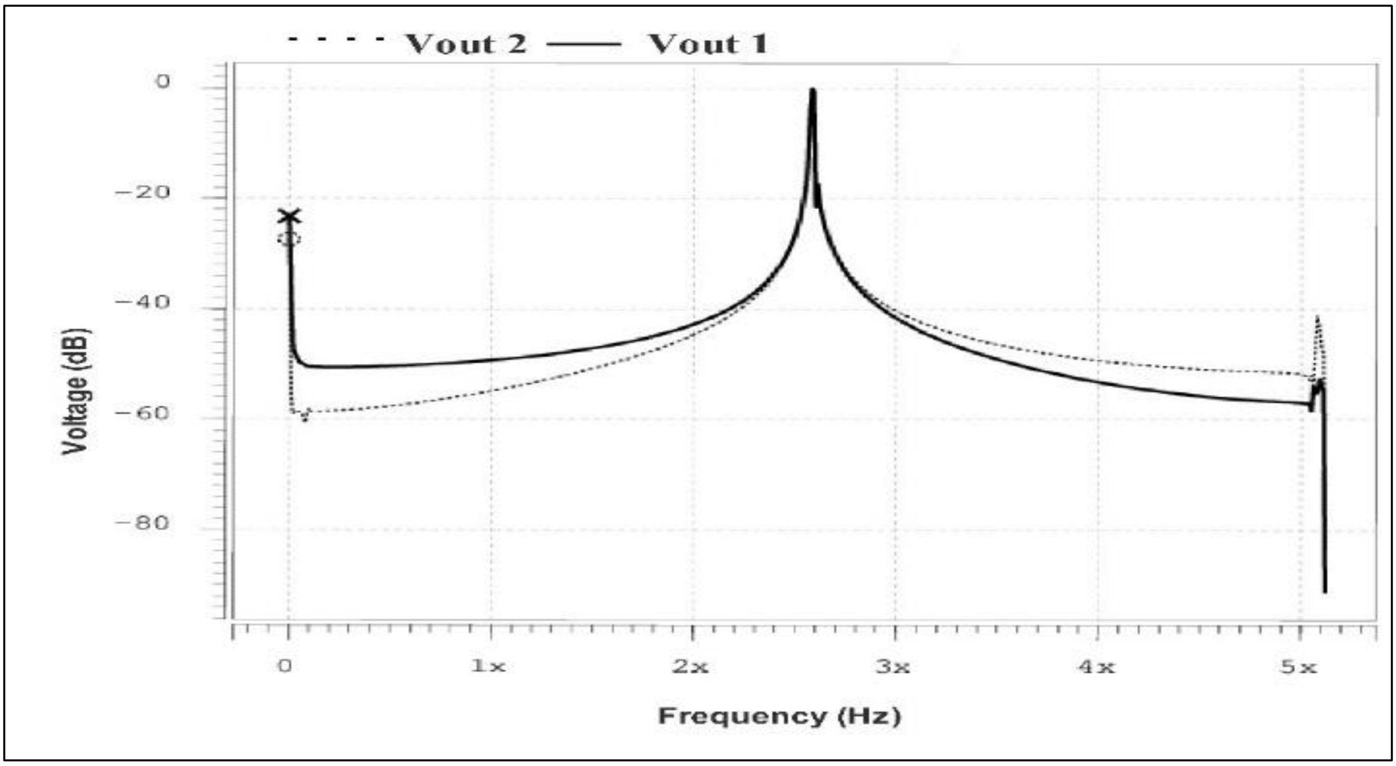

Fig 6 Fourier Spectrum of the Voltage Outputs

IV. CONCLUSION

This paper presents a compact dual-mode quadrature oscillator based on a single VD-DVCC and four grounded passive components. The design enables independent control of frequency and condition of oscillation. Simulation at 2.6971 MHz using ±0.9 V supply demonstrates correct functionality with low power dissipation. The proposed oscillator is thus validated as an efficient and tunable solution for current-mode and voltage-mode signal generation.

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