A Novel Equi-amplitude Quadrature Oscillator Based on CFOA

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Abstract

This paper presents a single-resistance-controlled sinusoidal equi-amplitude quadrature oscillator based on Current Feedback Operational Amplifier (CFOA) which has potential applications in modulation and detection. Most of the Quadrature Oscillators (QO) available in open literature are suffering with same problem. The ratio of two outputs of those QO is frequency dependent and not equal to unity. So this paper provides condition of equi-amplitude and verifies the results by PSPICE simulation. This circuit employs three CFOAs and all the passive elements are grounded, thus it is suitable for CMOS implementation.

Keywords: Current Feedback Operational Amplifier (CFOA), Quadrature Oscillator (QO), Multiphase Sinusoidal Oscillator (MSO), Single Resistance Controlled Oscillator (SRCO)

1. Introduction

Quadrature oscillator (QO) produces two signals which are equally spaced in phase and same in magnitude. It has potential application in communication, signal processing and power electronics [1-3].Multiphase oscillators are key building blocks for telecommunication and instrumentation application. They are widely used in soil measurement system [4-7]. In modern RF communication system, multiphase techniques in RF transceiver architecture are commonly employed to enhance accuracy of transmitted data [8-9]. RF sinusoidal signals in quadrature are used for modulation detection and image rejection [10]. Due to the potential application of multiphase oscillator and quadrature phase oscillators various methods to design it are described in open literature with some advantages and drawbacks [11]. Study shows that CFOA based oscillators have high noise immunity, low distortion, relatively large slew rate, extended bandwidth, low sensitivity, low power consumption, greater precision and reliability with respect to conventional amplifier.

2. Various Methods to Design MSO/QO

- 1979- Voltage controlled MSO is designed in [3] which exhibit good performance but suffers large number of components and complex circuitry.
- 1982- MSOs with variable frequency are developed in [2].
- 1982-Three phase reference sine wave generator for PWM invertors is designed in [14].
- 1984- Continuous and switched capacitor multiphase oscillator is proposed in [1].
- 1987- Fundamental topologies of three phase LC resonators are proposed in [15].
- 1987-MSOs based on active-R technique are proposed in [18] but they lack electrical tunability.

- 1992- MSO using OTA are proposed in [19] but these MSOs are sensitive to environmental variations and have limited output voltage swing.
- 1994- MSOs using second generation current conveyors (CCII) are proposed in [11]. MSO to generate n number of signals equally spaced in phase require n CCII. But each inverting CCII is equivalent to two CFOAs. So large number of components is required.
- 2003- A system composed of identical subsystems that are cross-coupled in certain manner is capable of generating multi- or quadrature-phase oscillations under specified conditions [10]. On the basis of this theory Jian Wang proposed a quadrature oscillator made by cross coupling of four RC subsystems.
- MSOs incorporating low pass and all pass sections- J. Vosper, R. Deloughry and B. Wilson introduced a generalized odd-phase MSO design producing M output synthesized using a low pass section in cascade with (m-1)/2 dual-output sections that have low pass and all pass outputs[12].
- 2008- A new circuit with only five passive elements is proposed in [13] .In this circuit condition of oscillation can be changed without affecting the oscillation frequency. But the amplitudes of both quadrature outputs are not always equal.
- 2010-Condition of equi-amplitude is presented in [20].

3. Proposed Equi-Amplitude Quadrature Oscillator

The sinusoidal oscillator presented [16] in fig1 has three CFOAs with all capacitors and resistors grounded and produces oscillation. This paper takes two outputs from given SRCO and gives the condition of equal amplitude. So theoretically amplitude of V_1 and V_2 are equal. Condition of equi-amplitude is necessary for the proper functioning of QO.
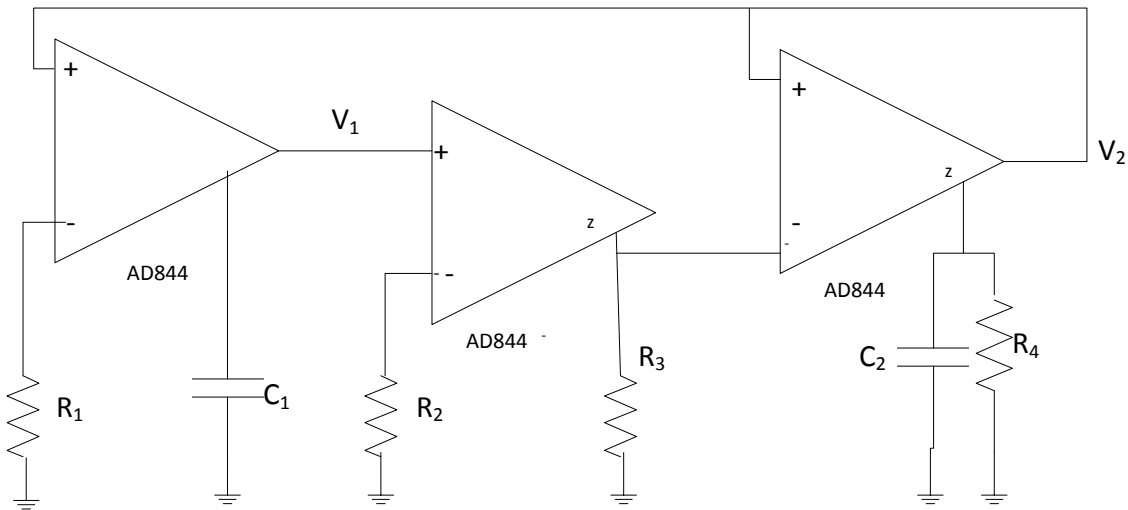

Figure 1

4. Circuit Description

The proposed configuration is based on second-generation current conveyor (CCII) with a voltage buffer which can be characterized by following matrix equation.

$$\begin{bmatrix} i_y \\ v_x \\ i_z \\ v_o \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \cdot \begin{bmatrix} v_y \\ i_x \\ v_z \\ i_o \end{bmatrix}$$
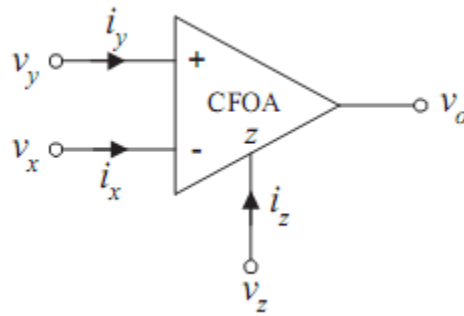

Figure 2

The tuning laws are as follows

$$\text{CO:} \quad R_3 = R_4 \tag{1}$$

$$\text{FO:} \quad \omega_0 = \frac{1}{\sqrt{C1C2R1R2}} \tag{2}$$

The relation between two output voltages is

$$\frac{V1}{V2} = \frac{1}{sC2R2} \tag{3}$$

The condition for output voltages to be equi-amplitude is

$$C_2R_2 = C_1R_1 \tag{4}$$

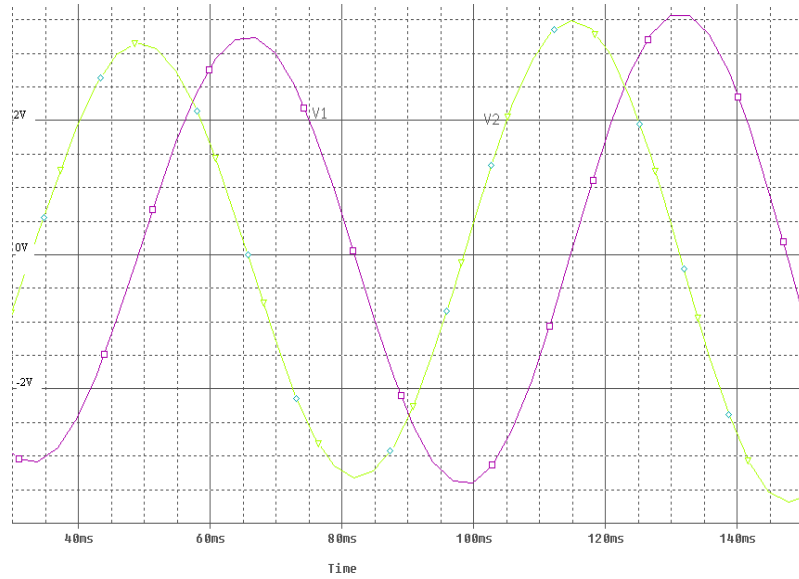## 5. PSPICE Simulation Result

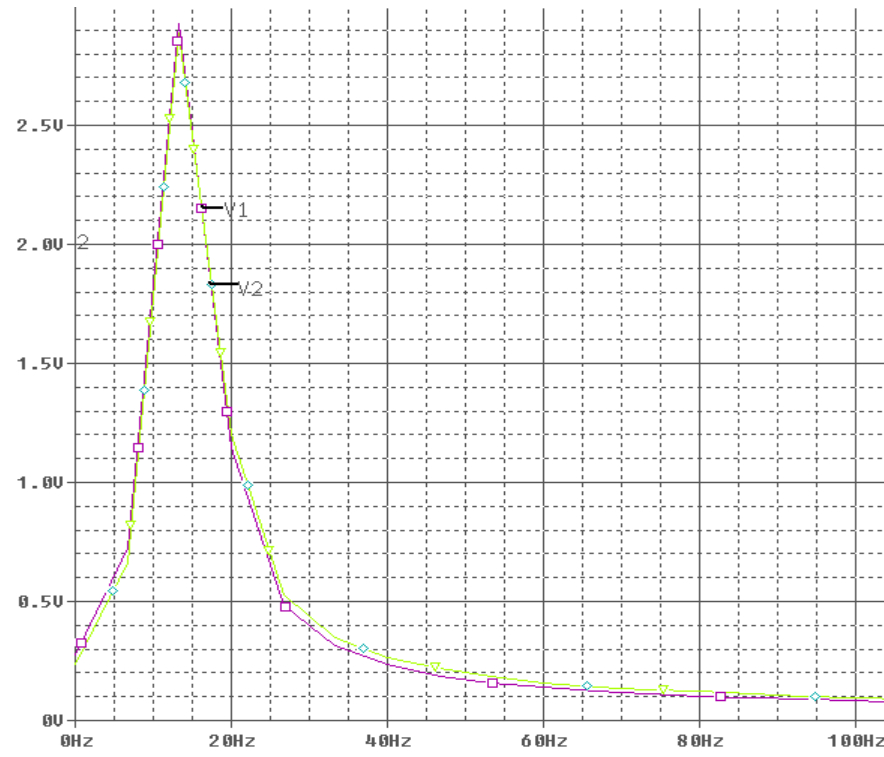**Fig.3: Simulated Waveform of Figure 1**

Figure 4: FFT of Figure 3

In the simulations the model parameters of CFOA were taken from the built in library AD844/AD. The circuit was supplied with symmetrical voltages of $\pm$12 V. The values of passive components were chosen as R_1=500Ω, R_2=1KΩ, R_3=950Ω, R_4 =1KΩ, C_1= 10uF, C_2=10uF. The simulated output waveform frequency is 13.5 KHz. The values of R_1 and R_3 are slightly larger than R_2 to start oscillations. The simulated frequency is 15.6 KHz.

6. Conclusion

The feasibility of the equi-amplitude quadrature sinusoidal oscillator using current feedback operational amplifier has been demonstrated and simulation results confirm very well to the theoretical conclusions. The given circuit enjoys independent control of the frequency, condition of oscillation and condition of equi-amplitude. Moreover, this circuit possesses only six passive components. All passive elements are grounded so this circuit is suitable for VLSI implementation.

Acknowledgment

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