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New Grounded Capacitor Single Resistance Controlled Sinusoidal Oscillator Using Two CFOAs

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A new canonic grounded capacitor sinusoidal oscillator using two CFOAs is introduced. The frequency of oscillation is controlled by varying a grounded resistor without affecting the condition of oscillation. Simulation results to confirm theoretical analysis are included.

Keywords: Oscillators, Current feedback Op Amp.

1 INTRODUCTION

Several oscillators are available in the literature using the classical Operational Amplifier (Op Amp) or the Current Conveyor (CCII) or the Current Feedback Operational Amplifier (CFOA) or the Four Terminal Floating Nullor (FTFN) or the Current Amplifier as the active elements [1–12].

The oscillator reported in [3] employs grounded capacitors but is not canonic as it uses three capacitors. It is always preferable to have canonic and grounded capacitor oscillators [13].

In this paper a new grounded capacitor canonic oscillator using two CFOAs is introduced.

2 PROPOSED OSCILLATOR

Figure 1 represents the proposed grounded capacitor canonic oscillator which uses two CFOAs. The circuit employs one CFOA as a Negative Impedance

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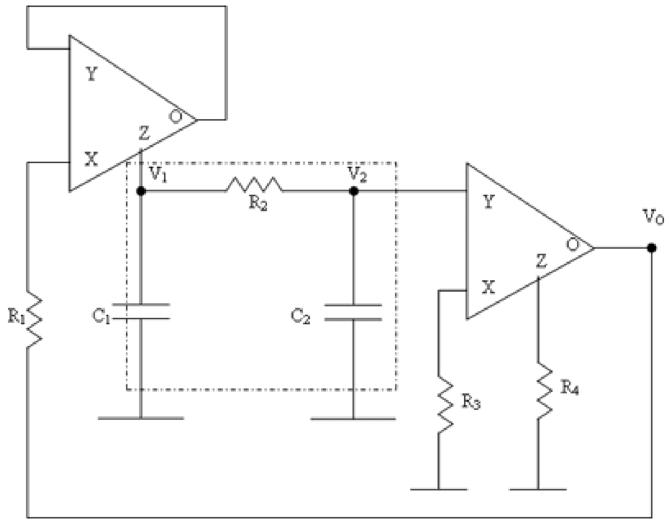

FIGURE 1
The proposed canonic grounded capacitor oscillator.

Converter (NIC), and the second CFOA as a Voltage Controlled Voltage Source (VCVS). The two capacitors together with the floating resistor R_2 form a π circuit. The oscillator circuit can be easily compensated for the parasitic resistances R_{X1} and R_{X2} which are absorbed in R_1 and R_3 respectively. The circuit is also easily compensated for the parasitic capacitance C_{Z1} by subtracting its values from the value of C_1. On the other hand the parasitic capacitance C_{Z2} is affecting the circuit at high frequencies as will be explained in the following section.

The state equation of the circuit of Fig. 1 in matrix form is given by:

$$\begin{bmatrix} \frac{dv_1}{dt} \\ \frac{dv_2}{dt} \end{bmatrix} = \begin{bmatrix} \frac{1}{C_1}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) & \frac{1}{C_1}\left(\frac{1}{R_2} - \frac{R_4}{R_1 R_3}\right) \\ \frac{1}{C_2 R_2} & -\frac{1}{C_2 R_2} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \tag{1}$$

The condition of oscillation is given by:

$$\frac{R_2}{R_1} = 1 + \frac{C_1}{C_2} \tag{2}$$

The radian frequency of oscillation is given by:

$$\omega_0 = \sqrt{\frac{1}{C_1 C_2 R_1 R_2}\left(\frac{R_4}{R_3} - 1\right)} \tag{3}$$

The ratio of the grounded resistor R_3 or R_4 controls the frequency of oscillation without affecting the condition of oscillation.

Several grounded capacitor canonic oscillators using two CFOAs are included in [2, 14, 15] the reported oscillator however is not among the collection of oscillators in [2, 14, 15] and is slightly different from the circuit in Fig 6(a) given in [2]. As pointed out in [2] it is not possible to realize a two CFOA oscillator with independent control on the condition of oscillation and frequency of oscillation using two grounded capacitors and grounded resistors only. On the other hand with two CCII having two outputs, two grounded capacitors and three grounded resistors oscillators with independent control on the condition of oscillation and frequency of oscillation were introduced in [1]. The two CFOA family of oscillators reported in [14] and [15] with independent control on the condition of oscillation and frequency of oscillation and two grounded capacitors employ three resistors (which is the minimum) with one or two or all the three resistors being floating. Three of the circuits reported in [15] use a π− RC circuit two of them with three floating resistors and the third with two floating resistors. The reported circuit uses one more resistor than those reported in [14] and [15] and has no independent control on the oscillation condition and is given to complete the family of two CFOA using a π− RC.

The oscillator reported in [3] although uses three capacitors but has independent control on the condition of oscillation and on the frequency of oscillation.

3 EFFECT OF C_Z

The parasitic capacitance C_Z of the second CFOA results in increasing the circuit order to three and the state matrix equation becomes:

$$\begin{bmatrix} \frac{dv_1}{dt} \\ \frac{dv_2}{dt} \\ \frac{dv_o}{dt} \end{bmatrix} = \begin{bmatrix} \frac{1}{C_1R_1} - \frac{1}{C_1R_2} & \frac{1}{C_1R_2} & -\frac{1}{C_1R_1} \\ \frac{1}{C_2R_2} & -\frac{1}{C_2R_2} & 0 \\ 0 & \frac{1}{C_ZR_3} & -\frac{1}{C_ZR_4} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_o \end{bmatrix} \tag{4}$$

The characteristic equation is obtained as:

$$\begin{aligned} &s^3 C_1C_2C_zR_1R_2R_4 + s^2\left[C_1C_2R_1R_2 + (C_1R_1 + C_2R_1 - C_2R_2)C_zR_4\right] + \\ &s\left[C_1R_1 + C_2R_1 - C_2R_2 - C_zR_4\right] + \left[\frac{R_4}{R_3} - 1\right] = 0 \end{aligned} \tag{5}$$

The actual radian frequency is obtained as:

$$\omega_{0a} = \omega_0 \left[1 - \frac{\tau}{2}\left(\frac{1}{C_2 R_2} + \frac{1}{C_1 R_2} - \frac{1}{C_1 R_1}\right)\right] \tag{6}$$

The effect of the parasitic capacitance C_Z can be minimized by taking R_4 much less than R_1 and R_2.

The condition of oscillation is affected by C_Z and is obtained as:

$$\frac{R_2}{R_1} = 1 + \frac{C_1}{C_2} - \frac{\tau . R_4}{R_3 R_1 C_2} \tag{7}$$

where $\tau = C_Z R_4$

4 SIMULATION RESULTS

The active building block used in the simulation included in this paper is the CFOA from Analog Devices AD-844 biased with $\pm$ 10V.

Figure 2 represents the output waveform of the proposed oscillator designed for fo = 230 kHz by taking $C_1 = 20\,\text{pF}$, $C_2 = 40\,\text{pF}$, $R_1 = 20\,\text{k}\Omega$ $R_2 = 30\,\text{k}\Omega$, $R_3 = 100\,\text{k}\Omega$ and $R_4 = 200\,\text{k}\Omega$.

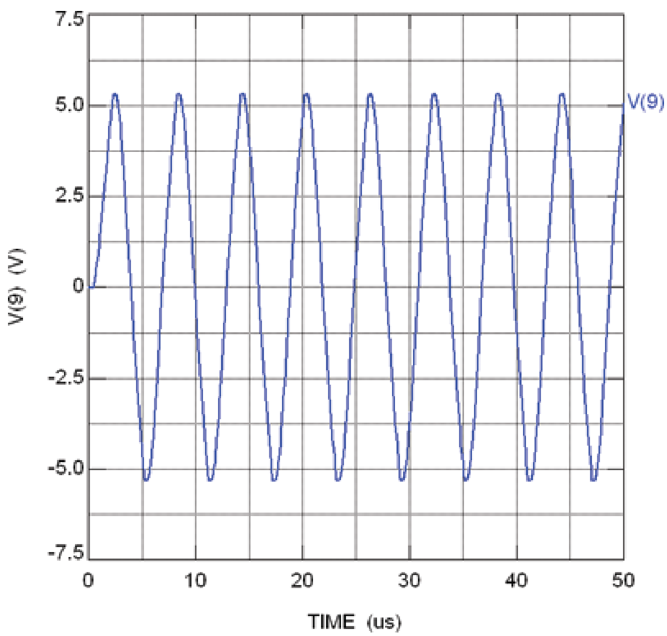

FIGURE 2
Simulated output waveform with 10V supply.

5 CONCLUSIONS

A new canonic grounded capacitor oscillator using two CFOAs is introduced. The frequency of oscillation is controlled by varying a grounded resistor without affecting the condition of oscillation. The circuit can be compensated for the two parasitic resistances R_x and the parasitic capacitance C_{Z1}. The effect of the parasitic capacitance of the second CFOA however affects the circuit and has been considered in details. Simulation results are included. It is emphasized that most of the oscillator circuits available in the literature can be realized with CFOAs or classical Op Amps.

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