Current Mode Oscillator Using Current Feedback Amplifier

Abdul Qadir

***Abstract*—In this paper, a novel current mode sinusoidal oscillator is presented. It uses current feedback amplifiers (CFA). One of the CFA is used to simulate negative capacitor. It is suitable for use for low and high frequency applications. The structure is simple and canonic. It uses all grounded capacitors which makes it suitable for CMOS technology.**

***Index Terms*—Current mode, electronic tenability, CMOS technology, active-c current feedback amplifier.**

I. Introduction

In these days current mode circuits are getting more popular because of (i) increased bandwidth (ii) large dynamic range (iii) ease of mathematical operation and (iv) precision [1-3], [11]. Oscillator circuits have extensive applications in Communication, Instrumentation, Geophysics, Biomedical application, Automatic Control systems and various laboratory applications. High frequency oscillators are used in Communication [4], [12], whereas low frequency oscillators are used in Biomedical Engineering, Geophysics and Control system applications [5]. Many investigators have reported oscillator circuits using FTFNs and current conveyors [6-10]. An oscillator using two CFA's and four passive components is presented here. The peculiar aspect of this design is that *negative impedance* (negative capacitance) is realized with the help of a CFA. The circuit is capable of producing two sinusoidal waveforms, which are 90 degree out of phase. Thus it is suitable for such application where two 90 degree out of phase signals are required e.g. single side band generation, quadrature phase shift keying (QPSK) in communication and stereo systems.

II. Proposed Oscillator Circuit

Fig.3 shows the proposed circuit.. It is actually the circuit of Fig.1 with generalized admittance Y1 replaced with simulated negative impedance (capacitive reactance). CFA1 is the main building block whereas CFA2 realizes negative capacitance, which is actually needed to satisfy the condition of oscillation. Negative capacitance is realized as shown in Fig. 2.

Straight forward analysis of circuit of Fig. 1 yields the following current mode transfer function,

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$$\frac{I_1}{I_i}=\frac{\left\{1+\dfrac{Y_4}{Y_3}\right\}}{\left\{1-\dfrac{Y_4}{Y_3}\dfrac{Y_2}{Y_1}+\dfrac{Y_4}{Y_3}+\dfrac{Y_4}{Y_1}\right\}} \qquad (1)$$

Selecting $Y1 = sC1$, $Y2 = G2$, $Y3 = sC3$ and $Y4 = G4$, Eqn. (1); it gives:

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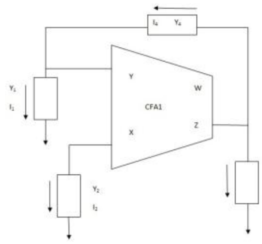
$$\frac{I_1}{I_i}=\frac{\left\{1+\dfrac{G_4}{sC_3}\right\}}{\left\{1-\dfrac{G_2}{sC_3}\dfrac{G_4}{sC_1}+\dfrac{G_4}{sC_3}+\dfrac{G_4}{sC_1}\right\}} \qquad (2)$$

Which simplifies to:

$$\frac{I_1}{I_i}=\frac{\left\{s^2+s\dfrac{G_4}{C_3}\right\}}{\left\{s^2+s\left(\dfrac{1}{C_3}+\dfrac{1}{C_1}\right)G_4-\dfrac{G_2}{C_3}\dfrac{G_4}{C_1}\right\}} \qquad (3)$$

The characteristic equation obtained from this transfer function is,

$$\left\{s^2+s\left(\frac{1}{C_3}+\frac{1}{C_1}\right)G_4-\frac{G_4}{C_3}\frac{G_2}{C_1}\right\}=0 \qquad (4)$$



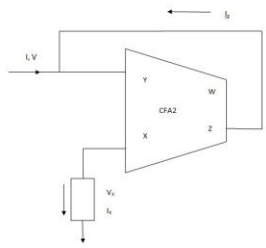


Fig. 1. CFA Building Block Fig. 2. Realizing Simulated negative impedance.

If this characteristic function is free form 's' term (i.e. second term in characteristic equation) and the constant term is positive, the circuit acts as oscillator. These conditions are met with if either of C1 or C3 is converted into negative capacitance. In this paper this is done using a negative impedance conversion. How a CFA can simulate a negative capacitance, is illustrated in Fig.2. A closer look at this (Fig.2) gives,

$$\frac{V_x}{I_z} = -\frac{1}{Y_a} \tag{5}$$

If the element Ya is a capacitance then looking at Fig.2 the Eqn.(5) gives,

$$\frac{V_x}{I_z} = -sC \tag{6}$$

This expression gives the realization of a *negative* grounded capacitance.

Replacing C_1 in Eqn.(3) with a capacitance C of same magnitude yields, sC_1= -sC and Eq.(3) reduces to,

$$\frac{I_1}{I_i} = \frac{\left\{s^2 + s\dfrac{G_4}{C_3}\right\}}{\left\{s^2 + s\left(\dfrac{1}{C_3} - \dfrac{1}{C}\right)G_4 + \dfrac{G_4}{C_3}\dfrac{G_2}{C}\right\}} \tag{7}$$

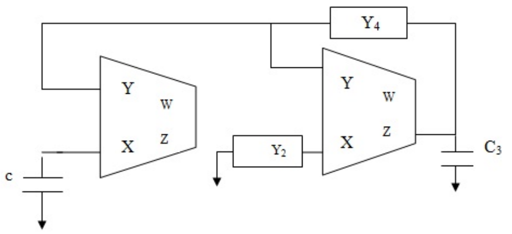


Fig. 3. Proposed circuit

A. Cond • Ition of Oscillation

As s-term in the characteristic equation is zero, the circuit acts • as oscillator This yields the condition of oscillation to be :

$$C_3 = C \tag{8}$$

Looking at Eqn. (9) it is found that the frequency of oscillation can be controlled via R4 (or R2) without disturbing the condition of oscillation (where R*i* = 1/G*i*). The 90 degree phase shifted current waveform is obtainable at R1 as it is resistor and has the signal phase 90 degree shifted compared to the one at simulated capacitor C. Hence two output current waveforms are available which are 90 degree apart.

B. Frequency of Oscillation

The frequency of oscillation is given by:

$$f_o = \frac{1}{2\pi}\sqrt{\frac{G_4}{C_3}\frac{G_2}{C}} \tag{9}$$

The sensitivities of the oscillator circuit are:

$$S_{G_2}^{\omega_0} = S_{G_1}^{\omega_0} = \frac{1}{2};...and...S_{C_3}^{\omega_0} = S_{C}^{\omega_0} = -\frac{1}{2}$$

Which shows low sensitivities.

Simulation results

Circuit was simulated using AD844 as active device. The voltage levels were ± 15V . The supply voltage of ± 15V was used for biasing the active devices. The simulation results are shown in Fig.4. The component values used selected were G_4 = G_2 = 0.0025 mho and C_3 = C = 1 microfarad. The theoretical frequency agrees with the simulation result. It can be seen that two sinusoids are 90 degree apart, one collected at capacitor and the other at resistor.

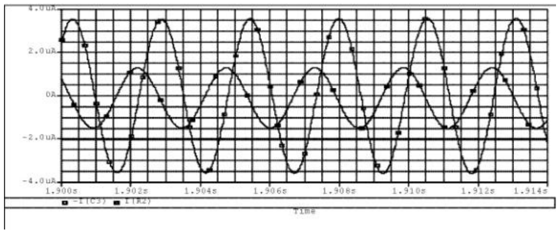


Fig..4. The current waveforms from oscillator

III.CONCLUSION

A novel oscillator circuit using current feedback amplifiers has been presented. The concept behind this design is negative impedance realized using CFA. The circuit belongs to the class of Active-RC type oscillators using grounded capacitors.

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