A Quadrature Oscillator Employing the Dominant Poles of the OTRAs

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I. INTRODUCTION

Recently current-mode circuits have been receiving much attention because of their potential advantages: the wider bandwidth, the higher slew-rate, the greater linearity, the wider dynamic range, the simpler circuitry and the lower power consumption [1].

A quadrature oscillator can provide two sinusoidal waves with 90° phase difference, and it constitutes an important unit in many communication and instrumentation systems [2-3].

The operational transresistance amplifier (OTRA) is one of the current-mode analog active devices. It was proposed by Chen et al. [4]. The OTRA has received considerable attention from analog circuit designers. There are many designs of active filters using OTRAs in [5]. But few oscillator circuit was designed using OTRAs [6]. In this paper, an active oscillator using two resistors and two OTRAs is presented.

II. CIRCUIT DESCRIPTION

Many researchers used dominant poles to design oscillators with CFAs etc [6-7]. In the paper, the OTRAs are used to design a quadrature oscillator. The circuit symbol and the port characteristics of the OTRA is shown in Fig. 1, where $R_m$ is the transresistance gain. And assume that $R_m$ approaches infinity. The input terminals of OTRA are virtually grounded, and the output impedance is so low that parasitic capacitances have little effect.

The proposed quadrature oscillator using two OTRAs and two resistors is presented in Fig. 2. We can express $R_m$ as

$$[V_p] = \begin{bmatrix} 0 & 0 & 0 \end{bmatrix}^T [I_p]$$

$$[V_n] = \begin{bmatrix} 0 & 0 & 0 \end{bmatrix}$$

$$[V_z] = \begin{bmatrix} R_m & -R_m & 0 \end{bmatrix} [I_z]$$

Fig. 1 Circuit symbol and port characteristics of an OTRA
\[ R_m = \frac{R_m}{1 + \frac{s}{\omega_p}} \]  

(1)

The signal flow graph of Fig. 2 is shown in Fig. 3. Then, we disconnect terminals of \( V_{O2} \) and \( V_{O2}' \) in the circuit and find that

\[ \frac{V_{O2}'}{V_{O2}} \frac{V_{O2}'}{V_{O2}} = \frac{R_m R_m}{R_1 R_1} = \frac{R_m^2}{R_1 R_1 (1 + \frac{s}{\omega_p})^2} \]  

(2)

Then, \( s = j\omega \), if \( \omega >> \omega_p \)

\[ \frac{V_{O2}'}{V_{O2}} = \frac{R_m \omega_p^2}{R_1 R_1 s^2} \quad s = j\omega = 1 \]  

(3)

so 

\[ s^2 + \frac{R_m \omega_p^2}{R_1 R_1} = 0 \]  

(4)

\[ s = \pm \frac{jR_m \omega_p}{\sqrt{R_1 R_1}} \]  

(5)

So, the oscillation angular frequency is given by

\[ \omega_o = \frac{R_m \omega_p}{\sqrt{R_1 R_1}} \]  

(6)

III. SIMULATION

Two AD844ANs [8] were used to compose an OTRA as shown in Fig. 4 [9]. The output terminal of AD844 is the Z terminal of CCII attaching a buffer, so the output voltage is the same as the Z terminal.

The BJT circuit of AD844AN is shown in Fig. 5 [9]. The \( R_m \) and \( \omega_p \) of AD844ANs are 4.45M \( \Omega \) and 59.5krad/s. The transresistance of the OTRA is infinite and we choose \( R_1 = R_2 = 30k \, \Omega \), supply voltages of ±15V. The output waveforms of the OTRA-based oscillator are shown in Fig. 6. Two sinusoidal waves with 90° phase difference were obtained in the figure. The theoretical oscillation frequency is 1.405MHz. The simulated oscillator frequency is 1.46MHz. The error is 3.9%. Moreover, the

IV. CONCLUSIONS

An OTRA-based quadrature oscillator topology is presented in this paper. The proposed circuit uses two OTRAs
and two resistors. The dominant poles of the OTRAs were used to obtain oscillation condition. Although replacing the OTRA in the circuits by OPAMP elements, the oscillator still can operate at be obtained. However, using OTRAs make it perform a higher oscillation frequency. The performances of the proposed oscillator are verified through Hspice simulation.

REFERENCES


[9] Analogue Devices AD844 data sheet