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以運算轉阻放大器之主極點設計之正交振盪器
A Quadrature Oscillator Employing the Dominant Poles of the OTRAs

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摘要

本篇文章提出以兩個運算轉阻放大器(OTRA)及電阻器所設計之正交振盪器。此振盪器可以產生兩個相位差為 90˚之弦波，而且在本文所設計之振盪器電路，不需再外加電容器，只需兩個運算轉阻放大器以及兩個電阻器即可產生振盪。本文我們用運算轉阻放大器之主極點的觀念分析此電路。

關鍵詞：運算轉阻放大器(OTRA)，正交振盪器

Abstract

In this paper, the authors use two operational transresistance amplifiers (OTRAs) and two resistors to design a quadrature oscillator. The quadrature oscillator can produce two sinusoidal waves with 90˚ phase difference. The circuit can oscillate without external capacitor. We analyze the circuit employing the dominant pole of OTRA.

Keywords: operational transresistance amplifier (OTRA), quadrature oscillator

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].

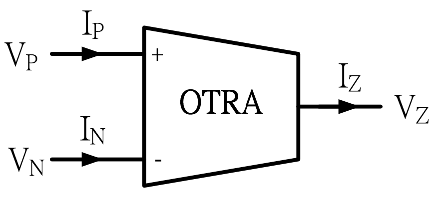
A quadrature oscillator can provides two sinusoids with 90˚ phase difference, and it constitute an important unit in many communication and instrumentation systems [2-3].

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 for 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 oscillators. The circuit symbol and the port characteristics of the OTRA is shown in Fig. 1, where Rm is the transresistance gain. And assume that Rm 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 Rm as



$$\begin{bmatrix} Vp \\ Vn \\ Vz \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ Rm & -Rm & 0 \end{bmatrix} \begin{bmatrix} Ip \\ In \\ Iz \end{bmatrix}$$

Fig. 1 Circuit symbol and port characteristics of an OTRA

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$$Rm = \frac{Rm_0}{1 + \frac{s}{\omega_p}} \tag{1}$$

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

$$\frac{V_{O2}'}{V_{O2}} = \frac{V_{O2}'}{V_{O1}}\frac{V_{O1}}{V_{O2}} = -\frac{Rm}{R_2}\frac{Rm}{R_1} = -\frac{Rm_0^{\,2}}{R_1 R_2 (1+\frac{s}{\omega_p})^2} \tag{2}$$

Then, $s = j\omega$, if $\omega >> \omega_P$

$$\frac{V_{O2}'}{V_{O2}} = -\frac{Rm_0^{\,2}\omega_p^{\,2}}{R_1 R_2 s^2}\bigg|_{s=j\omega_0} = 1 \tag{3}$$

so $$s^2 + \frac{Rm_0^{\,2}\omega_p^{\,2}}{R_1 R_2} = 0 \tag{4}$$

$$s = \pm\frac{jRm_0\omega_p}{\sqrt{R_1 R_2}} \tag{5}$$

So, the oscillation angular frequency is given by

$$\omega_0 = \frac{Rm_0\omega_p}{\sqrt{R_1 R_2}} \tag{6}$$

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 Rm_0 and ω_P of AD844ANs are 4.45MΩ and 59.5krad/s. The transresistance of the OTRA is infinite and we choose R_1=R_2=30kΩ, supply voltages of ±15V. The output waveforms of the OTRA-based oscillator are shown in Fig. 6. Two sinusoidal waves with 90˚phace defference 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 frequency spectrum in different temperatures (-40℃, 25 ℃、100℃) of the OTRA-based oscillator is shown in Fig. 7. The relationship between the noise and frequency of the circuit is shown in Fig. 8.

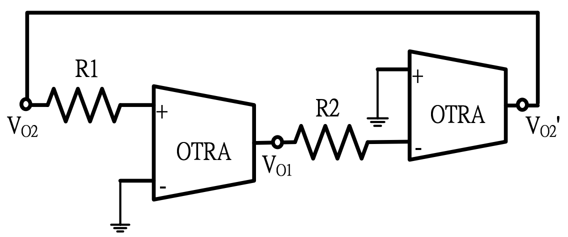

Fig. 2 The quadrature oscillator using OTRAs

IV. CONCLUSIONS

An OTRA-based quadrature oscillator topology is presented in this paper. The proposed circuit uses two OTRAs

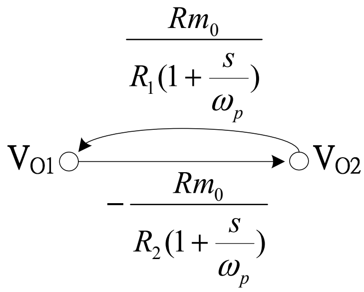

Fig. 3 The signal flow graph for Fig. 2

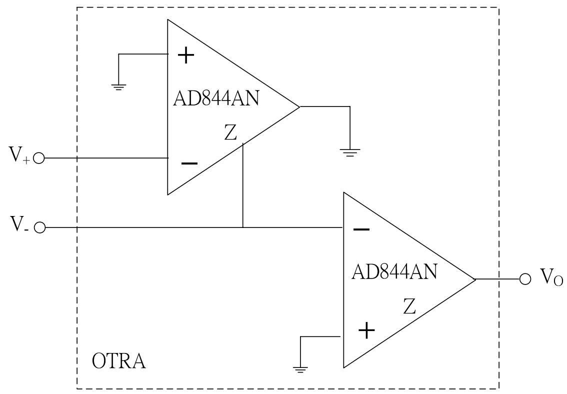

Fig. 4 An OTRA constructed with AD844AN

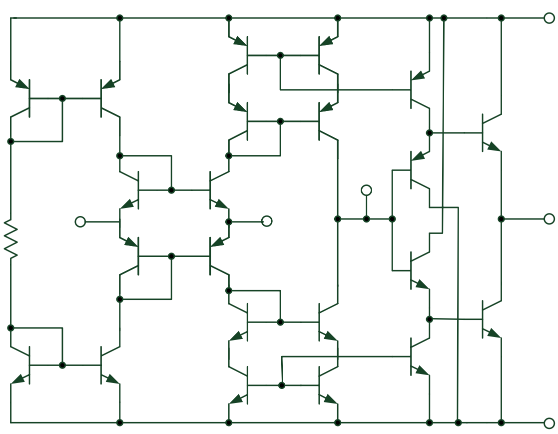

Fig. 5 The equivalent circuit of AD844A

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.

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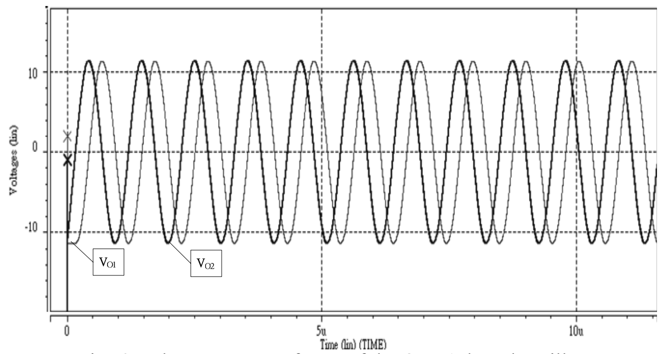

Fig. 6 The output wavefroms of the OTRA-based oscillator.

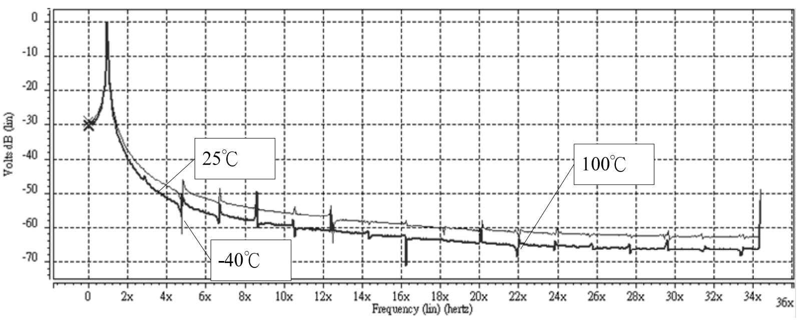

Fig. 7 The frequency spectrum in different temperatures of the OTRA-based oscillator

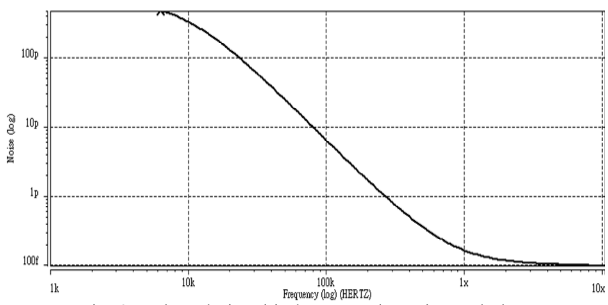

Fig. 8 The relationship between the noise and phase