High Output-impedance Current-mode Oscillator Based-on CCIIs

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Abstract

This article presents a current-mode oscillator using current conveyors (CCIIs) as active elements. The proposed circuit is realized from a lossy integrator and a lossy differentiator. The oscillation condition and oscillation frequency can be independently controlled. The circuit description consists of 2 CCIIs, 4 resistors and 2 grounded capacitors. Using only grounded capacitors, the proposed circuit is then suitable for IC architecture. The proposed circuit, due to high output impedances, enabling easy cascading in current-mode signal processing. The PSPICE simulation results are depicted, and the given results agree well with the theoretical anticipation. The power consumption is approximately 706μW at ±1.5V supply voltages.

INTRODUCTION

It is well accepted that an oscillator is a basic important building circuit, which is frequently employed in electrical engineering works. Among several kinds of the oscillators, a quadrature oscillator is mostly/widely used because the quadrature oscillator can offer sinusoidal signals with 90° phase difference, as for example in telecommunications for quadrature mixers and single-sideband [1]. From our survey, we found that several implementations of oscillators employing different high-performance active building blocks, such as, OTAs [2-3], four terminal floating nullors (FTFNs) [4-5], current follower [6], current controlled current differencing buffered amplifiers (CCCDBAs) [7], current controlled current differencing transconductance amplifiers (CCCDTAs) [8-9], fully-differential second-generation current conveyor (FDCCII) [10], and differencing voltage current conveyor (DVCCs) [11], have been reported. Unfortunately, these reported circuits suffer from one or more of following weaknesses:

- Excessive use of the passive elements, especially external resistors [3-5, 7, 8, 11].
- The oscillation conditions and oscillation frequencies cannot be independently controllable [2, 6].

Presently, a current-mode technique has being been more popular than voltage-mode one. This is due to operating in low-voltage environment as in portable and battery-powered equipments. Since a low-voltage operating circuit becomes necessary, the current–mode technique is ideally suited for this purpose more than the voltage-mode one. Presently, there is a growing interest in synthesizing the current-mode circuits because of more their potential advantages such as larger dynamic range, higher signal bandwidth, greater linearity, simpler circuitry and lower power consumption [12-15].

The CCII has received considerable attention as active component. The flexibility of the device to operate in both current and voltage-modes allows for a variety of circuit designs [16]. Also, the applications of dual-output current conveyor (DO-CCII) have been useful for constructing current-mode circuits from a reduced number of active components [17].

The purpose of this paper is to introduce a simple oscillator, based on CCIIs. The oscillation condition can be adjusted independently from the oscillation frequency. The circuit construction consists of 2 CCIIs, 4 resistors and 2 grounded capacitors. The PSPICE simulation results are also shown, which are in correspondence with the theoretical analysis.

Circuit Configuration

1) Basic Concept of CCII

Since the proposed circuit is based on CCII, a brief review of CCII is given in this section. The characteristics of the ideal CCII are represented by the following hybrid matrix

$$\begin{bmatrix} I_Y \\ V_X \\ I_{Z1,Z2} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & \pm 1 & 0 \end{bmatrix} \begin{bmatrix} V_Y \\ I_X \\ V_Z \end{bmatrix}, \tag{1}$$

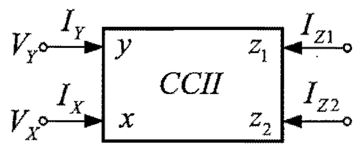
where the ±sign refers to the plus type or minus type current conveyor, respectively. The symbol and the equivalent circuit of the CCII are illustrated in Fig. 1(a) and (b), respectively.

2) Principle of Oscillator

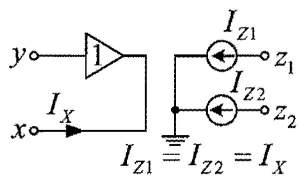
Fig. 2 depicts the diagram oscillator. It consists of lossy integrator and lossy differentiator. The following system characteristic equation is obtained

$$s^2 + s\omega_c(2-k) + \omega_c^2 = 0. \tag{2}$$

From Eq. (2), the condition of oscillation and the oscillation frequency of this system can be obtained as



(a)



(b)

Figure 1. The CCII (a) schematic symbol (b) equivalent circuit.

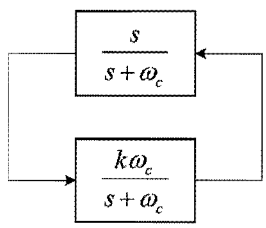


Figure 2. Systematic diagram of oscillator.

$$k = 2 \tag{3}$$

and

$$\omega_{osc} = \omega_c . \tag{4}$$

From Eqs. (3) and (4), there can be seen that the oscillation condition can be controlled by *k*, while the oscillation frequency can be controlled by ω_c. It does not affect each other. This property is an appropriately important factor in the synthesis of the modern oscillators.

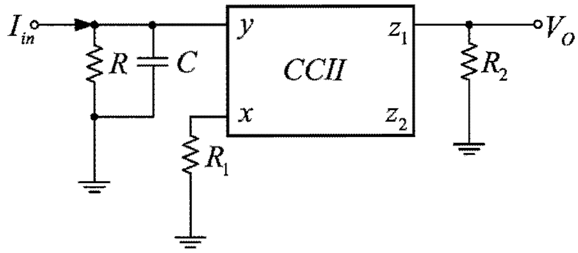


Figure 3. Circuit diagram of the CCII based lossy integrator.

3) Proposed Oscillator

From Fig. 2, the lossy integrator and lossy differentiator using CCII is shown in Figs. 3 and 4 respectively. The transfer functions can be found to be

$$\frac{V_{out}}{I_{in}} = \frac{R_2}{R_1}\left(\frac{1/C}{s+1/RC}\right), \tag{5}$$

and

$$\frac{I_{out}}{V_{in}} = \frac{s/R}{s+1/RC}. \tag{6}$$

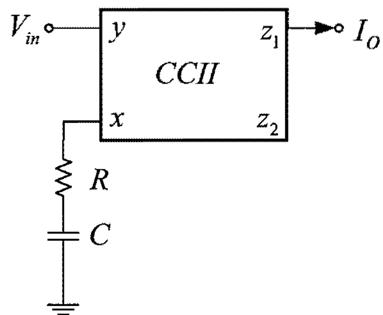


Figure 4. Circuit diagram of the CCII based lossy differentiator.

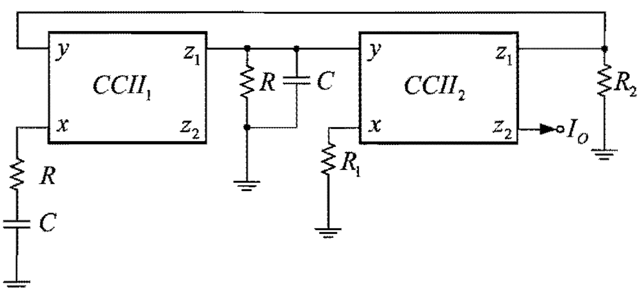


Figure 5. Circuit diagram of the proposed circuit.

The completed proposed circuit employing lossy integrator and lossy differentiator is displayed in Fig. 5. The routine analysis, the following system characteristic equation can be obtained

$$s^2 + \frac{s}{R_x C}(2-k) + \frac{1}{R_x^2 C^2} = 0. \tag{7}$$

From Eq. (8), the oscillation condition and oscillation frequency of this system can be obtained as

$$\frac{R_2}{R_1} = 2 \quad (8)$$

and

$$\omega_{osc} = \frac{1}{RC}. \quad (9)$$

From Eqs. (8) and (9), there can be seen that the oscillation condition can be controlled by R_1 and R_2, while the oscillation frequency can be controlled by R and C.

SIMULATION RESULTS

To prove the performances of the proposed circuit, a PSPICE simulation was performed for examination. This work employs a CCII realized by a CMOS technology. The PMOS and NMOS transistors were simulated by using the parameters of a 0.35μm TSMC CMOS technology [18]. Internal construction of CCII is shown in Fig. 6. The circuit was bias with ±1.5V supply voltages, V_B=0.45V. The aspect transistor ratios of PMOS and NMOS are listed in Table I. R=1kΩ, C=0.1nF, R_1=1kΩ and R_2=2.64kΩ are chosen. It yields the oscillation frequency of 1.44MHz, while calculated value of this parameter from Eq. (9) is 1.59MHz (deviated by 9.43%). Figs. 8 and 9 show simulated output waveforms in transient responses. Fig. 10 shows the simulated output spectrum, it is found that the total harmonic distortion (THD) is about 2.147%.

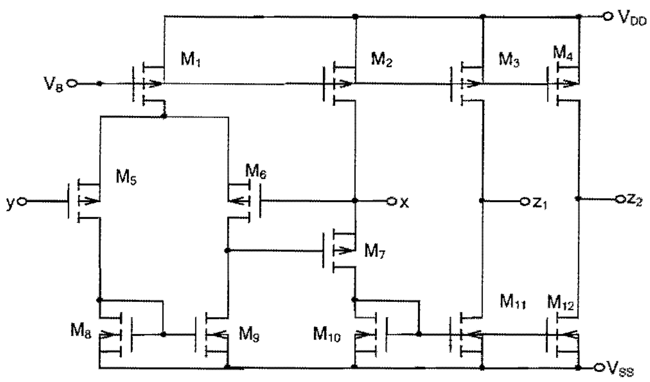


Figure 7. Internal construction of CCII.

TABLE 1 DIMENSION OF CMOS TRANSISTORS

CMOS Transistors	$W(\mu m)/L(\mu m)$
M1, M5-M6	1.4/0.35
M2-M4	2.8/0.35
M7	5.6/0.35
M8-M12	0.7/0.35

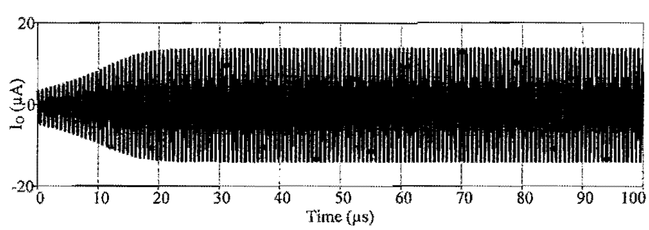


Figure 8. The simulation result of output waveforms during initial state.

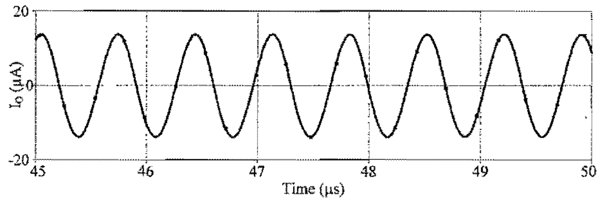


Figure 9. The simulation result of quadrature outputs during a steady state.

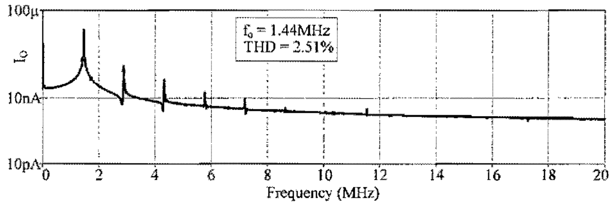


Figure 10. The simulation result of output spectrum.

CONCLUSIONS

The oscillator based on CCIIs has been presented. The features of proposed oscillator are that: the adjustments of oscillation frequency do not affect the oscillation condition: it consists of 2 CCIIs, 4 resistors and 2 grounded capacitors, which is suitable to fabricate in integrated circuit. The PSPICE simulation results are well agreed with the theoretical anticipation where the power consumption is approximately 706μW at ±1.5V supply voltages.

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