

New current-controlled current-mode sinusoidal quadrature oscillators using CDTAs

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ABSTRACT

This article presents new current-mode oscillator circuits using CDTAs which is designed from block diagram. The proposed circuits consist of three CDTAs and two grounded capacitors. The condition of oscillation can be adjusted electronically/orthogonally from the oscillation frequency by adjusting bias current of the CDTAs. The proposed quadrature oscillators have high output impedance and use only grounded capacitors without any external resistor which is very appropriate for future development into an integrated circuit. The PSPICE simulation and experimental results are corresponding to the theoretical analysis.

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1. Introduction

The current design of the active building block (ABB) devices begins the role as being used in analog technology and analog signal processing. Therefore, ABB has been developed to be used as a pawn in the designed circuit, which is suitable for a class of analog signal processing for voltage-mode and current-mode technique. In the last decade, a lot of papers in electronic circuit design have been presented in current-mode technique using the current-mode building block. It is stated that the circuit designed from current-mode technique can provide the advantages such as larger dynamic range, inherently wide bandwidth, higher slew-rate, greater linearity and low power consumption [1]. The oscillator circuit is important in electrical and electronic engineering. This circuit has been widely implemented such as, telecommunication system, measuring tool systems, and signal processing for instance. Consequently, oscillator circuit is needed to be introduced with modern active building blocks. According to recent research reviews on designing current-mode oscillator circuit using active building block, it is found that the most recommended qualifications for an appropriate circuit design: the circuit uses grounded capacitor which is convenient for further fabrication in integrated circuit [2,3], the circuit has high outputs impedance appropriate for cascade connection application in current mode technique which is

capable to directly drive load without using buffering device [5], and the block diagram/signal flow graph has been introduced to design the circuit which is easy and convenient for designing [6], etc.

Quadrature oscillator (QO) is one of oscillator which providing two sinusoidal signals with 90° phase difference. Some applications for quadrature signal are used in telecommunications for single-sideband modulators and quadrature mixers [7]. From literature survey, it is found that several implementations of oscillators and quadrature oscillators using current differencing transconductance amplifier (CDTA) and current-controlled current differencing transconductance amplifier (CCCDTA), have been reported [12–43]. Unfortunately, these reported circuits suffer from one more of weaknesses. For example, many of these applications are the condition of oscillation and the frequency of oscillation cannot be electronically controlled for both by adjusting the bias current [14–16,20,21,24–29,31,37,38,42]. The proposed circuits use floating capacitor [14,16,20,21,28,29,31,36,37,41], which is not convenient to future fabricate in integrated circuits [8]. There is excessive use of the passive elements, especially external resistors [14–16,20,21,24–29,31,35,37,38,42] and the circuits consist of large number (more than five components) of passive components [14,16]. Output impedances are not high, that make the circuit cannot directly drive load in current-mode technique [22–24,31,40]. Moreover, the condition of oscillation cannot be adjusted independently from the frequency of oscillation [12,21,25,29–31,33,37,39] and the proposed circuits do not present in current-mode oscillator [20,41]. In addition, some proposed circuits presented quadrature oscillator with the condition of oscillation and the frequency

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of oscillation are independently controllable [13,17–19,32,34,43]. However, it is found that the proposed circuits have weak points from reported and the proposed circuits are not designed based on block diagram/signal flow graph or not present new technique for designing oscillator circuit. As mentioned above, to analyze and design current-mode oscillator and quadrature oscillator circuits to meet all requirements is difficult and experience is needed. This case, infra structure diagram could help to analyze and design more convenient, especially for the beginner and non-expert in this field.

The purpose of this paper is to present the current-mode quadrature oscillator circuits based on CDTA which is designed from block diagram. The proposed block diagram developed from current-mode quadrature oscillator based on all-pass filter, to be approved appropriate for designing current-mode quadrature oscillator circuit. The proposed current-mode quadrature oscillator circuits consist of three CDTAs and two grounded capacitors. Moreover, the proposed circuits have high output impedance appropriate for cascade connection application in current mode technique which is capable to directly drive load. The circuits use only grounded capacitors without the addition of external resistors. Additionally, the condition of oscillation can be adjusted electronically/independently from the oscillation frequency. Moreover, the proposed oscillators design based on g_m -C oscillator, it is designed by implicating active device which can be controlled by electronic method. This case, g_m could be controlled by adjusting the bias current. Advantage of the designed oscillator is that the condition of oscillation and frequency of oscillation can be adjusted by adjusting the bias current of active device. In addition, adjusting by electronic method is more popular than adjusting value of passive devices [45]. Accordingly, the PSPICE simulation program results are in correspondence with the theoretical analysis.

2. Basic concept of CDTA

In 2003, there was a new active building block namely current differencing transconductance amplifier (CDTA) presented for analog signal processing suitable for voltage-mode and current-mode techniques [9]. The characteristics of the ideal CDTA are represented by the following hybrid matrix:

$$\begin{bmatrix} V_p \\ V_n \\ I_z \\ I_x \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 \\ 0 & 0 & 0 & \pm g_m \end{bmatrix} \begin{bmatrix} I_p \\ I_n \\ V_x \\ V_z \end{bmatrix}. \quad (1)$$

The difference of the input currents (I_p and I_n) flows from port z . In some applications, the terminal of CDTA can be extended to utilize the current through terminal which is called z_c (z-copy) [10]. For CMOS CDTA, the transconductance (g_m) can be written in Eq. (2). This g_m can be tuned by external input bias current I_B . The symbol and equivalent circuit of the CDTA are illustrated in Fig. 1(a) and (b), respectively. The CMOS internal construction of CDTA is shown in Fig. 2.

$$g_m = \sqrt{kI_B} \quad (2)$$

and

$$k = \mu_n C_{ox} \left(\frac{W}{L} \right)_{11,12}, \quad (3)$$

where k is the physical parameter of CMOS transistor, μ_n is the average electron mobility, C_{ox} is the gate-oxide capacitance per unit area, W is the effective channel width and L is the effective channel length. According to Eq. (2), g_m will be changed depending on the transconductance parameter ($\mu_n C_{ox}$) of transistor. In practice,

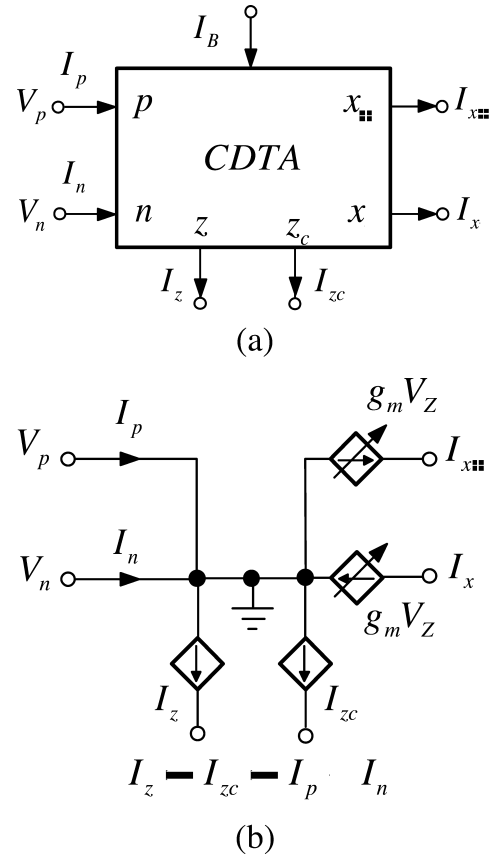


Fig. 1. CDTA: (a) symbol and (b) equivalent circuit.

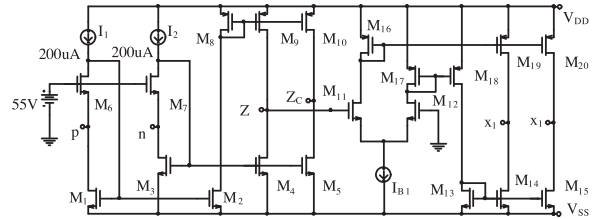


Fig. 2. Internal construction of CDTA [11].

the average electron mobility is dependent on temperature and the doping level but is almost constant for a wide range of normally used doping level. Also, the transconductance parameter is proportional to mobility, and since mobility falls with increasing temperature, the overdrive rises with temperature.

3. Proposed current-mode quadrature oscillators

The designs of current-mode quadrature oscillator circuit based on first order all-pass filter have been introduced. It is easy and convenient for designing; the circuit consists of two sections which are current-mode first order and lossless integrator. The block diagram

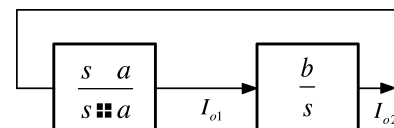


Fig. 3. Block diagrams for quadrature oscillator based on all-pass filter.

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