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A Current-mode Square/Triangular ware Generator based on Multiple-output VDTAs

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Abstract

This article presents the square/triangular wave generator based on multiple output voltage differencing transconductance amplifiers (MO-VDTAs). The circuit topology is simple, consists of only two MO-VDTAs and a few grounded passive components. The features of the proposed circuit are that, its amplitude and frequency can be independently controlled by bias current of the MO-VDTAs, which is not dependent on power supply level. The PSpice simulation results are depicted that they agree well with the theoretical analysis. The total power consumption is approximately 14.3mW at ±1.5V power supply voltages.

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Keywords: Square/triangular wave generator, MO-VDTA

1. Introduction

A square/triangular wave generator is extensively used in communication systems, instrumentation and analog signal processing applications. Hence, the square/triangular wave generator was successively developed by different active blocks such as current conveyors [1], CFOAs [2], OTRA [3]. However, these reported circuits suffer from some weaknesses, such as using of a floating resistor which is inappropriate to further fabricate in IC and lacking of electronic controllability of output magnitude and frequency [1-3].

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VDTA is an active building block. This element was derived from the previously introduced current differencing transconductance amplifier (CDTA) [4]. This means that the VDTA is composed of the current source controlled by the difference of two input voltages and a multiple-output transconductance amplifier. The VDTA is very useful in electronic circuits such as oscillator [5], filters [4, 6-7], Schmitt trigger [8] and etc. Recently, the MO-VDTA was employed in a simple square wave generator circuit [9]. Unfortunately, it works in voltage-mode. The voltage-mode circuits also suffer due to the poor slew rate of the used active building blocks.

Presently, there is a growing interest in synthesizing 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 [10-11]. In the point of view, the current–mode technique is ideally suited to this purpose more than the voltage-mode type.

Therefore, this paper presents a simple architecture of a current-mode square/triangular wave generator which is very simple by using only two MO-VDTAs with single grounded capacitor and two grounded resistors. The output frequency and amplitudes can be independently/electronically adjusted. Hence, it can be directly applied in an automatic control system via a microprocessor. The performance of circuit was proved by PSpice simulation and the results were correspondent in the theoretical analysis.

2. Basic concept of MO-VDTA

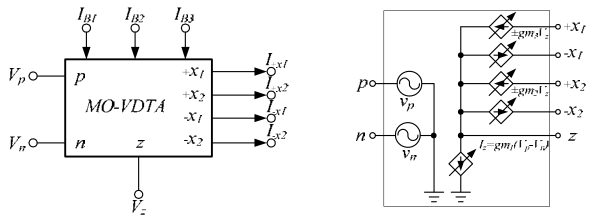
The MO-VDTA element is a simple active building block comprising transconductances section, as shown in Fig. 1. The characteristic and relationship of voltage and current are shown in Eq. (1)

$$\begin{bmatrix} I_z \\ I_{x1} \\ I_{x2} \\ I_{x3} \end{bmatrix} = \begin{bmatrix} g_{m1} & -g_{m1} & 0 \\ 0 & 0 & \pm g_{m2} \\ 0 & 0 & \pm g_{m3} \\ 0 & 0 & \pm g_{m4} \end{bmatrix} \begin{bmatrix} V_p \\ V_n \\ V_z \end{bmatrix}, \tag{1}$$

where g_{m1}, g_{m2}, g_{m3} and g_{m4} are transconductances of the MO-VDTA, which equal

$$g_{m1} = \frac{I_{B1}}{2V_T},\ g_{m2} = \frac{I_{B2}}{2V_T},\ g_{m3} = \frac{I_{B3}}{2V_T},\ g_{m4} = \frac{I_{B4}}{2V_T}. \tag{2}$$

V_T is the thermal voltage. The symbol and the equivalent circuit of the MO-VDTA are shown in Fig. 1(a) and Fig. 1(b), respectively.



(a) (b)

Fig. 1. The MO-VDTA (a) symbol (b) equivalent circuit

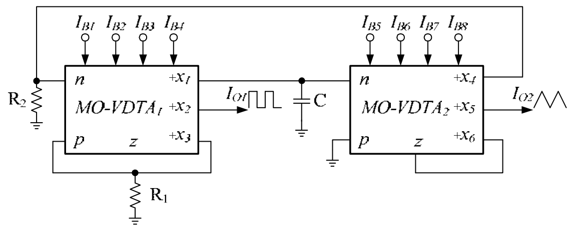


Fig. 2. The proposed square/triangular wave generator

3. Principle of the proposed square/triangular wave generator

A square/triangular wave generator must be based on the Schmitt trigger which was presented in [8]. The proposed current-mode square/triangular wave generator is shown in Fig. 2, it comprises merely 2 MO-VDTAs with 1 grounded capacitor and 2 grounded resistors. The first MO-VDTA functions as the current-mode schmitt trigger and the second MO-VDTA functions as a current-mode integrator circuit. The peak to peak output currents, I_{O1} and I_{O2} are shown in Eq. (3) and (4), respectively, where

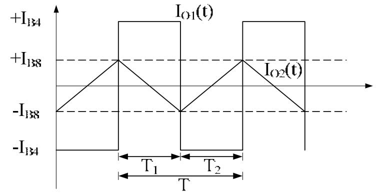


Fig. 3. Output waveform of the current-mode square/triangular wave generator

$$I_{o1(p\text{-}p)}=I_{B4}\,, \tag{3}$$

and $I_{o2(p\text{-}p)}=I_{B8}\,.$ (4)

Time period of proposed circuit is

$$T=\frac{8CV_T I_{B6} I_{B2}}{I_{B3} I_{B5} I_{B7}}\,, \tag{5}$$

$$\text{thus,}\quad f=\frac{1}{T}=\frac{I_{B3} I_{B5} I_{B7}}{8CV_T I_{B6} I_{B2}}\,. \tag{6}$$

Obviously, from Eqs.(3)-(6), square and triangular wave amplitudes and frequency can be independently adjusted via input bias current.

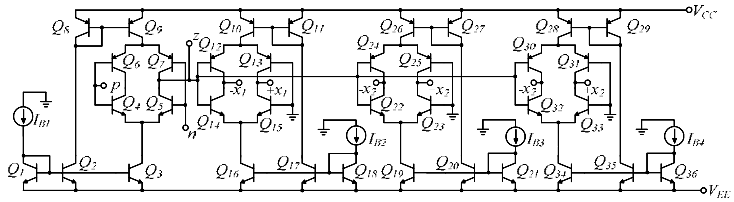


Fig. 4. Internal construction of MO-VDTA used in the simulation

4. Simulation Results

To prove the performance of the proposed square/triangular wave generator, the PSpice simulation program was used. The PNP and NPN transistor employed in the proposed circuit were simulated by respectively using the parameter of the NR200N and PR200N bipolar transistors of ALA400 transistor array from AT&T company [12]. Fig. 4 depicts schematic description of the MO-VDTA. The proposed circuit was supplied at ±1.5V.

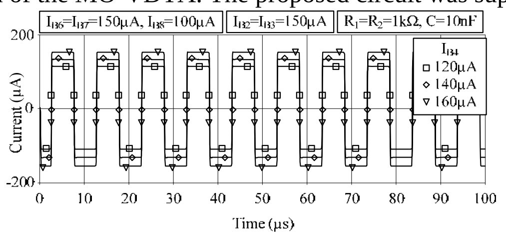


Fig. 5. The square wave amplitude variations for different I_{B4}

When I_{B4} was changed, the square wave amplitude variations of the proposed circuit are shown in Fig. 5.

Similarly, the triangular wave amplitude can be electronically controlled by I_{B8}, as shown in Fig. 6.Additonally, electronically adjustable frequency by IB3 can be shown in Fig. 7 for different capacitances.

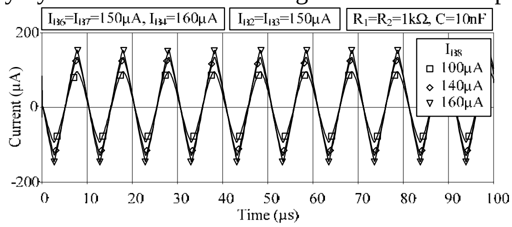


Fig. 6. The triangular wave amplitude variations for different I_{B8}

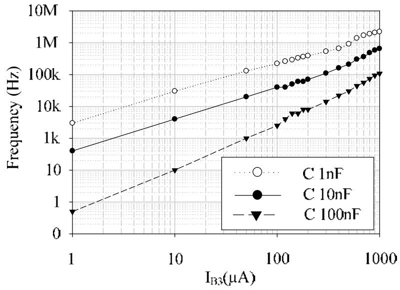


Fig. 7. The frequency of the output signal relative to I_{B3} for various capacitances

5. Summary

The current-mode square/triangular wave generator based on MO-VDTAs has been presented. The proposed circuit comprises only two MO-VDTAs, one capacitor and two resistors, all in grounded, whose output frequency and amplitudes can be independently/electronically controlled via bias current. The total power consumption is approximately 14.3mW at ±1.5V power supply.

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