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A Temperature-insensitive Current-mode Multiplier/Divider Using Only Double-output VDTA

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Abstract

This paper presents analog current-mode four-quadrant multiplier/two-quadrant divider based on only double output voltage differencing transconductance amplifier (DO-VDTA), without any external passive element. The proposed circuit is ideally temperature-insensitive. The PSpice simulation program is used to investigate the performance of circuit. The given results agree well with the theoretical anticipation. The power consumption is approximately 2.21mW at ±1.5V power supply voltages.

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Keywords: Temperature-sensitive, Multiplier/divider, Current-mode, DO-VDTA

1. Introduction

Multiplier and divider are mathematically important function, widely applied in the field of electronic engineering, for example in communication systems, instrumentation, and analog signal processing applications. Thus, the multiplier/divider were successively developed by different active blocks such as current conveyors (CCII) [1], OTAs [2], CDBA [3]. Anyway, there are any disadvantages in the presented circuits such as using of

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many active/passive elements [1-2] which is inappropriate to further fabricate in IC and output depending on ambient temperature [1, 3].

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 [9], which it is consequently seems to be a versatile component in the realization of a class of analog signal processing circuits. In addition, it can be adjusted of the output current gain.

In the last decade, because of requirement using with portable accessories and wireless technology which need battery power supply, we need to reduce supply voltage in electronic technology apparatuses. Therefore, current-mode technique is used since more their potential advantages such as larger dynamic range, higher signal bandwidth, greater linearity, simpler circuitry, and lower power consumption [10-11].

Therefore, this article presents a simple architecture of a current mode multiplier/divider using only double-output VDTA without any external passive element. The proposed circuit can function as a four-quadrant analog multiplier and a two-quadrant analog divider, theoretically insensitive to temperature variation. The output amplitude can be electronically adjusted by bias current, it can work also as an amplifier. Hence, it is appropriate to be directly applied with microcontroller and to further develop becoming integrated circuit (IC). The performances of circuit proved by PSpice simulation, the results show correspondence with the theoretical analysis.

2. Basic concept of DO-VDTA

The DO-VDTA 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)

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

where g_{m1}, g_{m2} and g_{m3} are transconductances of the DO-VDTA, they are shown in Eq. (2)

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

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

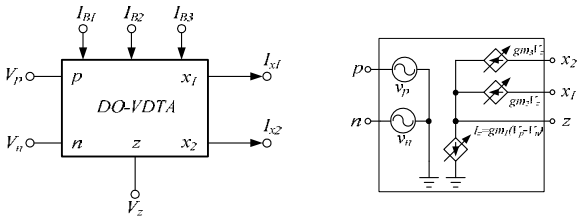

Fig. 1. The DO-VDTA (a) symbol (b) equivalent circuit

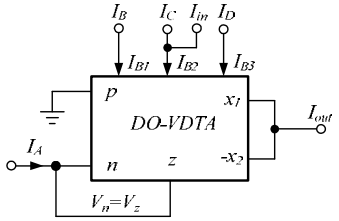

Fig. 2. The proposed current-mode multiplier/divider