Implementation of Monostable Multivibrator Using Low Voltage Current Differencing Transconductance Amplifier

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Abstract- In this paper, a CMOS realization of the current differencing transconductance amplifier in the low voltage is presented. CDTA circuit can operate in supply rails down to ±0.75V. The low voltage CDTA performs low power consumption and tuning over a wide current range. The proposed circuit is employed in monostable multivibrator using single CDTA with a few external components. The proposed circuit provides the advantageous feature of shortening the recovery time required for applying the consecutive triggering pulse. To verify the correctness of the realization, PSPICE simulation results will also supplied.

Keywords – ***CDTA, Monostable Multivibrator***

I. INTRODUCTION

Monostable multivibrators (one-shot timers) are widely used in various modern electronic applications, such as communication systems, phase-locked loop circuits, instrumentation measurement systems, and power conversion control circuits [1]. A monostable circuit can provide an adjustable pulse waveform with specified width and height in response to a triggering signal. Typically, monostable circuits are implemented using an operational amplifier (OPA), which is performed as a voltage comparator, together with a timing capacitor and three resistors [2]. The main disadvantage of this OPA-based construction is that more external passive components are required. Apart from the conventional circuit design manner, current-mode circuit techniques for signal processing have been received considerable attention in the past few years due to their potential advantages like wider bandwidth, higher slew rate, and functional versatility [3–4]. The literature review reveals that the monostable multivibrator using various analog building blocks have already been presented [15-20].The main disadvantages of these circuit which are given in literature [5-6] is that excessive active devices are required. Hence, this point of view, several designs with single active device were constructed [7-10].An OTRA based scheme, which features dual triggering modes, was presented in [7].Its main disadvantage is used more passive components. To reduce these components and shorten the recovery time, a modified version is reported [8]. Another monostable multivibrator were developed with DVCC in [10].The main problem with this circuit is not respond to retriggerble mode and the recovery time is not too shorted.

Low-voltage signal processing is one of the main goals of today's analog designers because of the trend of low supply voltages in technology and the need for low power consumption in portable devices. On the other hand, analog signal processing in very low supply voltages can be best accomplished in the current-mode [4]. Therefore, low voltage analog building blocks operating in the current-mode are important need of today's analog signal processing applications. Current differencing transconductance amplifier (CDTA), recently reported current-mode active building block, appears to be very useful for current-mode signal processing. Its advantages have been already shown in the literature [11-14]. Using the CDTA element, it is possible to obtain circuit solutions with less number of passive elements than its counterparts and it also leads to compact circuit structures requiring a few active building blocks in some applications [15].

The paper is organized as follows: Section II gives a review of the CDTA device in low voltage ±0.75V operation. In section III we discuss the proposed circuit of monostable multivibrator. The simulation result is presented in Section IV and concluding remarks are made in section V.

II. CDTA AND ITS REALIZATION

CDTA is a current-mode active device which offers a very low input parasitic capacitance, wide frequency range and wide dynamic range [16]. The CDTA element constitutes of an input current substractor which takes the difference of input signals and transfers to the z terminal and a dual output transconductance stage which is used to convert the voltage at the z terminal to dual output currents with a transconductance parameter g for the positive output and –g for the negative output. The circuit symbol for CDTA is shown in Figure 1. Its terminal relationship is given by the following matrix and defining equations [17].

$$\begin{bmatrix} Vp \\ Vn \\ Iz \\ Ix \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 \\ 0 & 0 & \pm gm & 0 \end{bmatrix} \begin{bmatrix} Ip \\ In \\ Vz \\ 0 \end{bmatrix}$$

$$Vp = 0, \quad Vn = 0, \quad Iz = Ip - In, \quad Ix_{+} = g_m Vz, \quad Ix_{-} = -g_m Vz \tag{1}$$

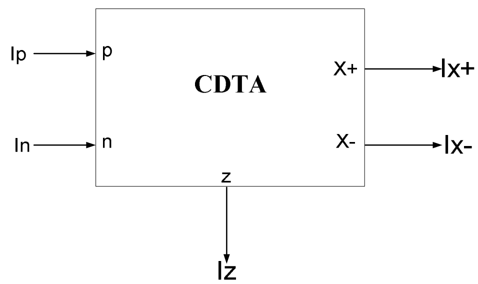

Fig.1 CDTA element symbol

Intermediate z terminal of current differencing transconductance amplifier is usually loaded by a grounded impedance. This sometimes results in circuits that consist of only grounded elements. This is required for process dependent realization issues [17]. CMOS realization of the CDTA element is in Fig. 2.

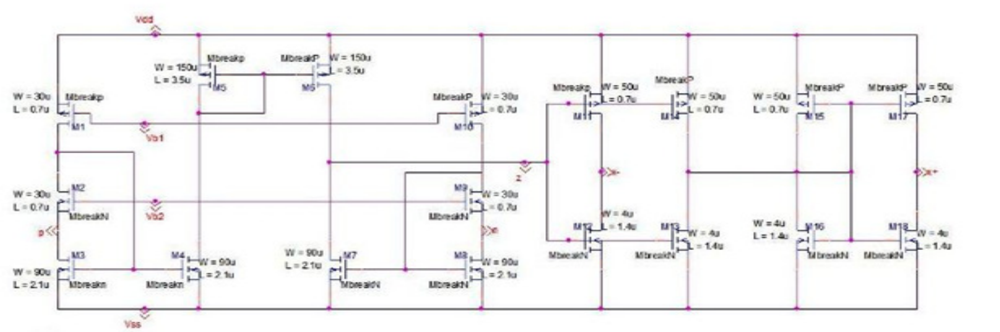

Figure 2. Low Voltage CMOS CDTA

The transistors M1 to M10 form the input stage of the CDTA element. In the current mirrors of the input stage, flipped voltage followers (FVF) [18] are used. Feedback in FVF results in very low input resistances at the input terminals. Input resistance of the p and n terminals can be given using the output resistance of FVF. In the circuit, to construct the current mirrors, outputs of FVF are used as inputs of CDTA. M2, M3 and M8, M9 are FVF transistors. Input resistances of the p and n terminals or, output resistance of FVF can be calculated approximately using the following equation [18], which is in the order of a few tens of ohms. SPICE simulation results give this value as 24.5 Ω at 1MHz as shown in Fig. 3. After this frequency, it starts to increase as expected but still in acceptable limits till 100MHz.

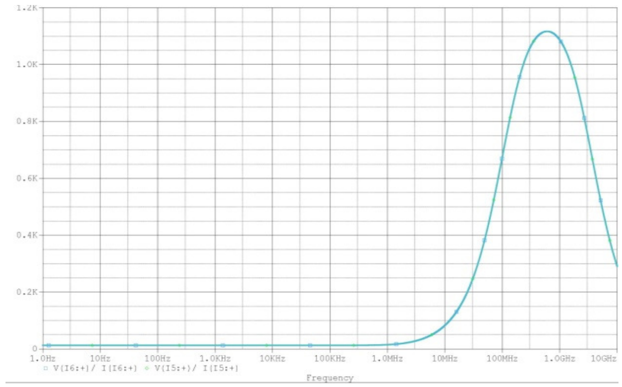

Figure 3.Variation of input resistance of CDTA with frequency

Aspects of transistors are given in Table 1. As seen from the table, channel lengths of current mirror transistors are chosen larger to compensate the channel length modulation effect which causes DC offset at the input stage. However, this shortens available bandwidth of current transfer from the input to the z terminal, so offset [17] here trades off bandwidth. One solution is to use more accurate current mirrors but this time higher supply voltages are needed to bias those current mirror topologies. Variation of the z terminal current with respect to input currents is given in Fig. 4 and Fig.5.

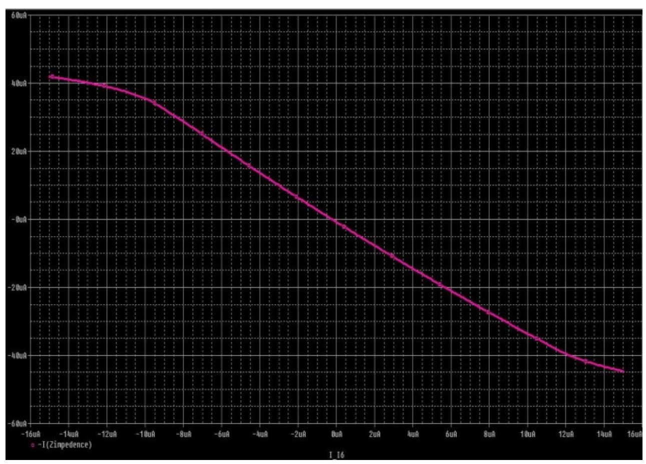

Figure 4: Variation of the z terminal current with respect to n(input) terminal current

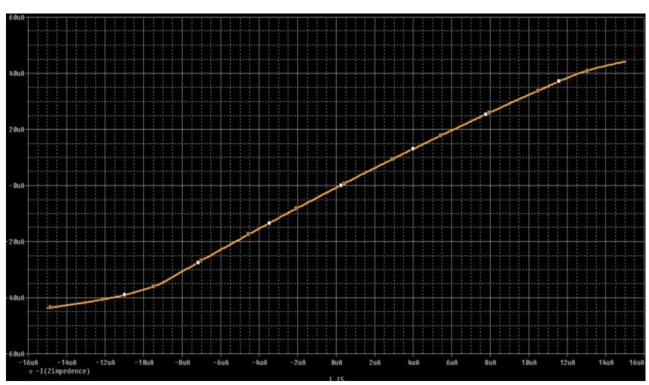

Figure 5: Variation of the z terminal current with respect to p(input) terminal current

Variation of current transfer from the n terminal and p terminal to the z terminal with frequency is given in Fig.6. Bandwidths can be extended if small sized current mirror transistors are used, trading off current mirror accuracy because of the channel length modulation.

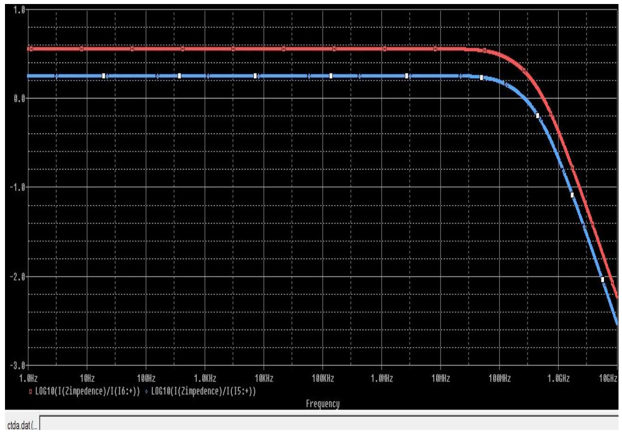

Figure 6: Variation of the input terminal currents with frequency

Almost 70MHz bandwidth difference between n and p terminal currents is caused by the current mirror high frequency poles because input signal follows the path through these current mirror transistors from p to z. In fact, it is the choice of the designer to determine the size of these current mirror transistors. It is also sensible to choose transistor dimensions small to extend the bandwidth, and use other offset compensation techniques.

Output stage consists of inverters that are used for analog signal processing. Negative output is taken at the output of the first inverter and using another inverter, signal is mirrored at the input of the third inverter which is connected in a unity gain topology. The last one inverts the negative signal, and produces positive output currents [14]. Transconductance of this inverter stages, also the transconductance of CDTA, is given by the sum of transconductances of the inverter transistors.

$$g = g_{m11} + g_{m22} \tag{4}$$

Transconductance of both positive and negative output is given in Fig.7. Thanks to the simple topology of the output transconductors, transconductance of CDTA has large bandwidth which makes it suitable for high frequency operation. Transconductance is a very important feature of CDTA because it directly affects circuit equations. Any nonideality, especially, in the frequency range of operation, can severely alters the performance of the circuit that use CDTAs, so proper care must be taken on transconductance in design of CDTA circuits.

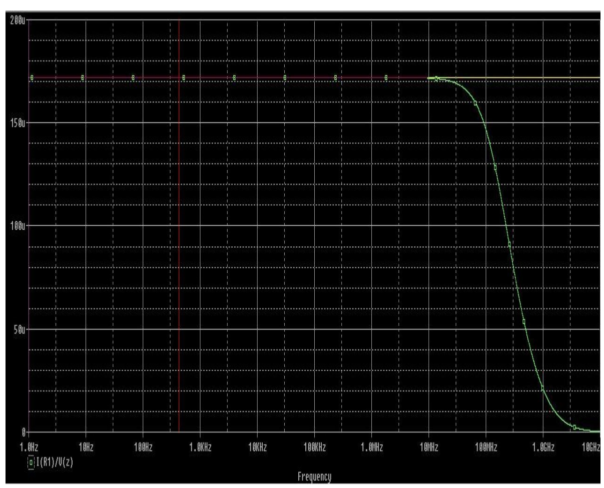

Figure 7: Transconductance of CDTA

TABLE I. ASPECTS OF TRANSISTOR

M1W=30µ L=0.7 µ	M10 W=30µ L=0.7 µ
M2 W=30µ L=0.7µ	M11 W=50µ L=0.7 µ
M3 W=90µ L=2.1µ	M12 W=4µ L=1.4 µ
M4 W=90µ L=2.1µ	M13 W=4µ L=1.4 µ
M5 W=150µ L=3.5 µ	M14 W=50µ L=0.7 µ
M6 W=150µ L=3.5 µ	M15 W=50µ L=0.7 µ
M7 W=90µL=2.1µ	M16 W=4µ L=1.4 µ
M8 W=90µ L=2.1µ	M17 W=50µ L=0.7 µ
M9 W=30µ L=0.7µ	M18 W=4µ L=1.2 µ

III. MONOSTABLE MULTIVIBRATOR CIRCUIT DESCRIPTION

The circuit diagram of proposed CDTA based monostable multivibrator are shown in fig 8. The circuit is design with one CDTA one diode, two capacitors & two registers. All the passive components are grounded. The circuit is negative edge triggered to produce the output pulse as shown in figure 9. The pulse width T is adjustable by the passive components. The trigger circuit is composed of one capacitor, one resistor & a diode for generating the negative edge triggered pulse. The multivibrator operates as follows: In the stable state, which prevails in absence of the triggering signal, the output of cdta is at –V. It also means that there is no current to charge the capacitor through the feedback loop.

The negative edge triggering signal is added .The diode is turned on to provide the path. The capacitor C_f begins to charge linearly upon +V & the circuit enters in quasi stable state. After this voltage capacitor again discharge and the circuit switch back into stable state. The duration of pulse is determined by the value of capacitor C_{in} & resistor Rin.

$$T = Rin\ Cin\ \ln (Rin/R19)$$

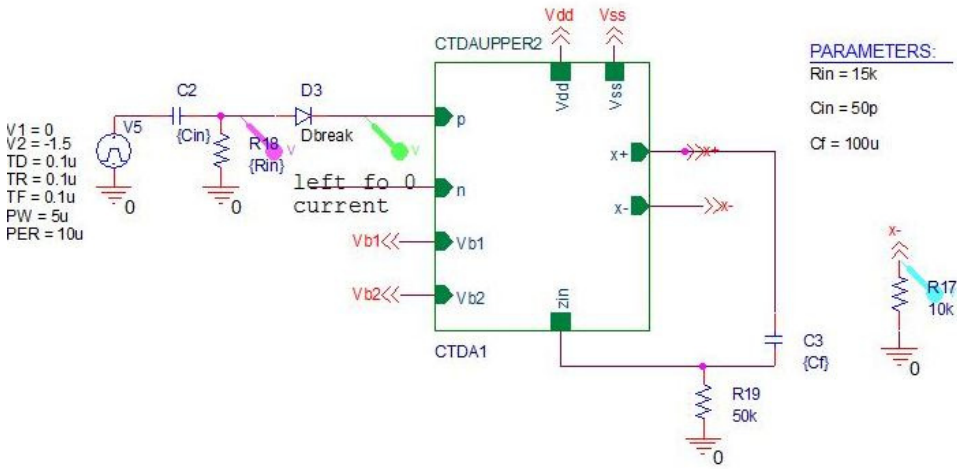

Figure 8 : Monostable Multivibrator

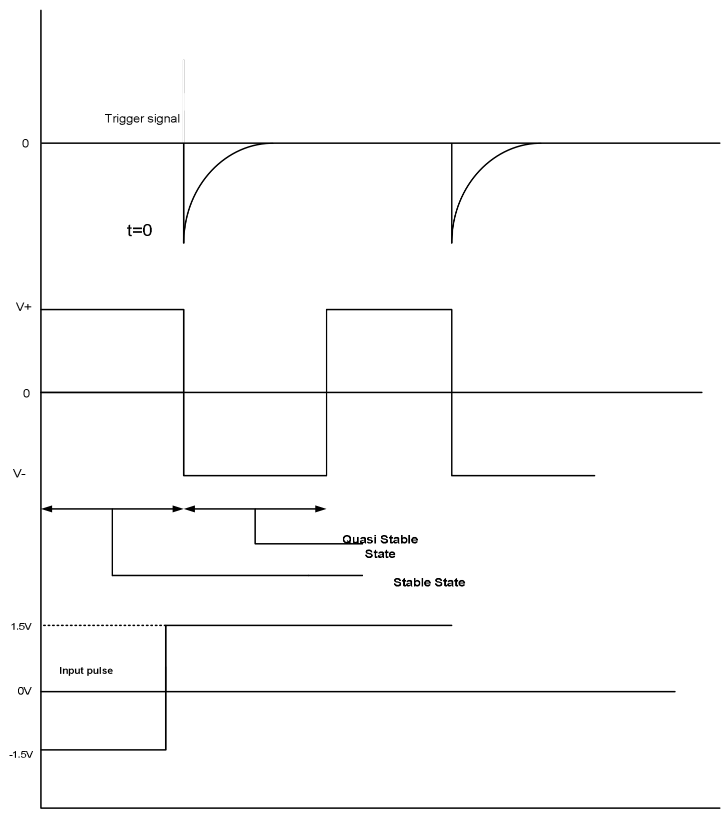

Figure 9: Proposed waveform of monostable multivibrator

IV. EXPERIMENTAL RESULTS

Simulation of the low voltage CDTA block and monostable multivibrator are made using the PSPICE with AMIS 0.35µm technology. Power supplies are selected as ±0.75V.Performance data of low voltage CDTA are given in Table 2. The proposed CDTA works near the GHz range.

The SPICE simulations of the proposed monostable multivibrator with the following experimental parameters are specified: +V= -V = 1.5v and Rin = 15kΩ, Rf (R19) = 50kΩ, Cin = 50pf and calculate the pulse width is T= 2μs.The simulated results are displayed in fig. 11. It can be seen when the triggering pulse is applied than we got the pulse at output node X+ of CDTA block with the pulse width of 2μs.The measured pulse width time is very less than the previous design in [5-10].From the above experimental results, it is concluded that the proposed monostable multivibrator indeed can speed up the recovery process when leaving the quasi stable state. Thus the triggering signals can be applied consecutively with nearly zero intervals between them after the 10μs period.

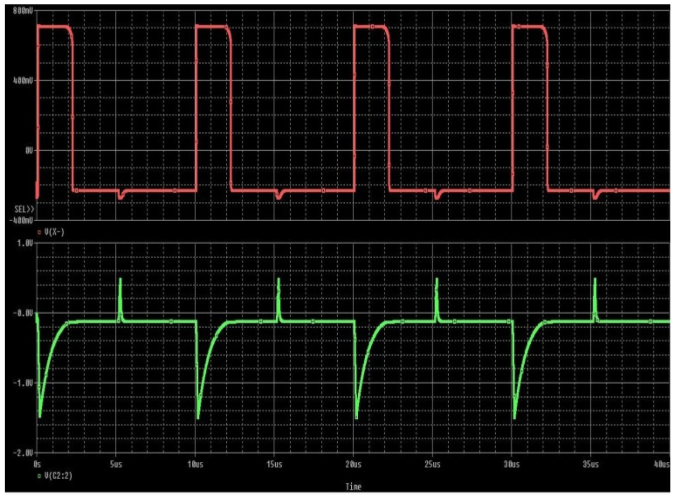

Figure 10: Simulated result of monostable multivibrator

TABLE II. SUMMARY OF SIMULATION RESULTS

Supply Voltages	±0.75V
Bias Current	54μA
Technology	0.35μm AMIS
Iz/Ip(-3dB) bandwidth	87MHz
Iz/In(-3dB) bandwidth	20MHz
Power Consumption	0.37mW
Biasing Voltage	Vb1=-0.2V,Vb2= 0.3V
Transconductance	210μA/V

V. CONCLUSIONS

In this study, a novel monostable multivibrator using low voltage CDTA structure is presented. The low voltage CDTA takes the advantage of the large bandwidth and very low input resistances. The proposed circuit topology is simpler since only one CDTA and a few components are used. The effectiveness of proposed schemes has been verified through experimental results. The pulse width is reduced than the previous designs [5-10]. The proposed circuit provide brand-new applications for the CDTA device. They could be expected to find wide applications in the instrumentation, measurement, and communication system.

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