CMOS Realization Low Voltage CDTA And Its Monostable Multivibrator Application

Harsh Kumar Vatsh[1], Owais Ahmad[2]

[1]*M. Tech. Student, Noida International University*

[2]*Assistant Professor, Department of VLSI, Noida International University*

Abstract - In this paper, a CMOS realization low voltage current differencing transconductance amplifier is presented. CDTA is a current-mode active device which offers a very low input parasitic capacitance, wide frequency range, wide dynamic range and at low voltage offers low power consumption. CDTA operate in supply rails down to ±0.7 V. The proposed circuit is then 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. Correctness of the realization verified through PSPICE simulation results.

Keywords - CDTA, Monostable Multivibrator.

I. INTRODUCTION

Multivibrators are Sequential regenerative circuits either synchronous or asynchronous and are used extensively in electronic timing applications. Multivibrators produce an output wave shape resembling that of a symmetrical or asymmetrical square wave and as such are the most commonly used of all the square wave generators. Multivibrators belong to a family of oscillators commonly called “Relaxation Oscillators“.

Some common types of multivibrator circuits are:

- Astable, in which the circuit is not stable in either state —it continually switches from one state to the other. It functions as a relaxation oscillator.
- Monostable, in which one of the states is stable, but the other state is unstable (transient). A trigger pulse causes the circuit to enter the unstable state. After entering the unstable state, the circuit will return to the stable state after a set time. Such a circuit is useful for creating a timing period of fixed duration in response to some external event. This circuit is also known as a one shot.
- Bistable, in which the circuit is stable in either state. It can be flipped from one state to the other by an external trigger pulse. This circuit is also known as a flip-flop. It can be used to store one bit of information.

On the other hand low-voltage signal processing is one of the main goal 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. Analog signal processing in very low supply voltages can be best accomplished in the current-mode.

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) reported current-mode active building block, appears to be very useful for current-mode signal processing.

This template, modified in MS Word 2007 and saved as a “Word 97-2003 Document” for the PC, provides authors with most of the formatting specifications needed for preparing electronic versions of their papers. All standard paper components have been specified for three reasons: (1) ease of use when formatting individual papers, (2) automatic compliance to electronic requirements that facilitate the concurrent or later production of electronic products, and (3) conformity of style throughout a conference proceedings. Margins, column widths, line spacing, and type styles are built-in; examples of the type styles are provided throughout this document and are identified in italic type, within parentheses, following the example. Some components, such as multi-leveled equations, graphics, and tables are not prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow[1].

Monostable Multivibrators have only ONE stable state (hence their name: “Mono”), and produce a single output pulse when it is triggered externally. Monostable Multivibrators only return back to their first original and stable state after a period of time determined by the time constant of the RC coupled circuit. 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. A monostable circuit can provide an adjustable pulse waveform with specified width and height in response to a triggering signal.

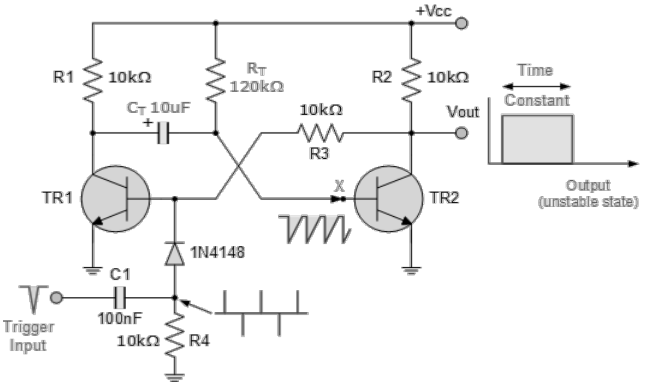

Figure 1.1: Monostable Multivibrators Circuit

CDTA is a current-mode active device which offers a very low input parasitic capacitance, wide frequency range and wide dynamic range.

The active circuit component CDTA (Current Differencing Transconductance Amplifier) is particularly useful for the current-mode applications, because its input and output signals are currents . CDTA consists of the input current-differencing unit and of multiple-output OTA (Operational Transconductance Amplifier). Its block oriented structure is similar to the CDBA element (Current Differencing Buffered Amplifier), in which the voltage unity gain buffer is used instead of the OTA.

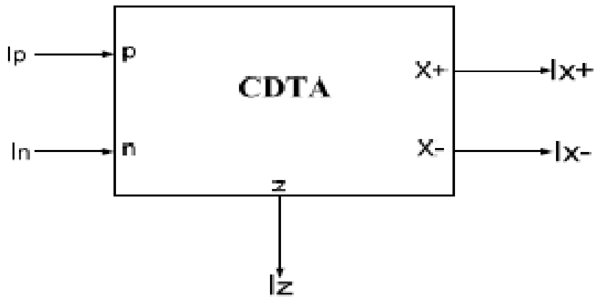

Figure 1.2: The circuit symbol

II. CDTA AND ITS REALIZATION

The Current Differencing Transconductance Amplifier (CDTA) is the active element operating in current-mode. A CDTA is consists of an input current difference and a dual output transconductance stage. The input stage takes the difference of input signals and transfers this difference current to the intermediate Z terminal, where this current is converted to voltage via external impedance[7].

A CDTA is a 5-terminal current-mode active building block. It can be also considered as a current operational amplifier as in figure-2.1 and its defining equation.

$$V_p = V_n = 0 \qquad \text{...... 2-(1)}$$

$$I_z = I_p - I_n \qquad \text{.........2- (2)}$$

$$I_x+ = g_m V_z \qquad \text{.......2- (3)}$$

$$I_x- = -g_m V_z \qquad \text{.......4- (4)}$$

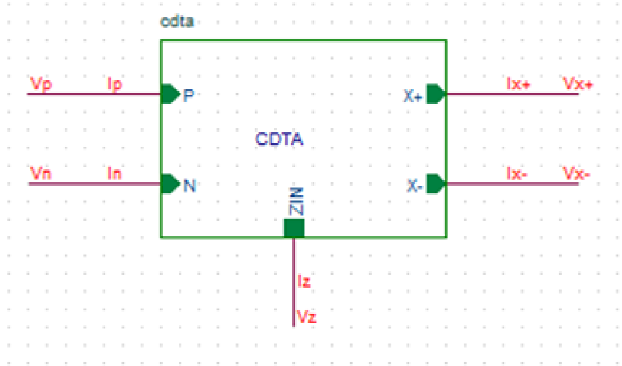

Figure 2.1: The circuit symbol

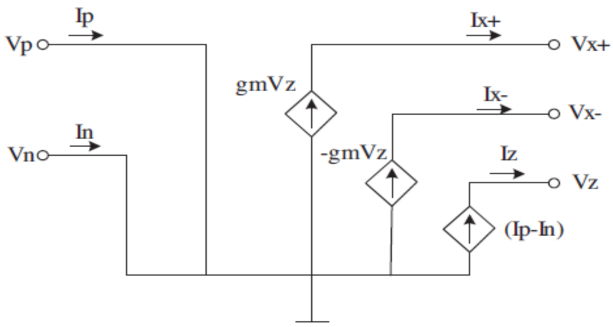

Figure 2.2: Equivalent circuit of the CDTA

The defining equation matrix is given.

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

Considering the deviation of the voltage and current gains from their ideal values, the defining equation of the CDTA in Figure-2.2 becomes:

$$= \begin{bmatrix} V_p \\ V_n \\ I_z \\ I_x \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ \alpha_p & -\alpha_n & 0 & 0 \\ 0 & 0 & 0 & \pm g_m \end{bmatrix} \begin{bmatrix} I_p \\ I_n \\ V_x \\ V_z \end{bmatrix}$$

Where α_p and α_n are current gains α_p= 1 - ε_p, and α_n= 1 - ε_n. Here, α_p and α_n are the current tracking errors and their absolute values much less than the unit value. The differential input current flow over the Z terminal .An external impedance is usually connected to this node and the voltage over this impedance is converted to the output current by the output transconductors with transconductance g_m for the positive output and -g_m for the negative output.

According to above equation and the circuit of figure 5-(b) the current through terminal z follows the difference of the currents through the terminal p and n (i_p-i_n) and flows from terminal z into impedance Z_z[3].

The (CDTA) is composed of a unity-gain current source controlled by the difference of two input currents and a multi-output transconductance amplifier providing electronic tuning ability through its transconductance gain (g_m). Therefore, this device is quite suitable for the synthesis of current-mode filters with electronically tenability properties. Moreover, the use of the CDTA as an active element provides the circuit implementations with a reduced number of passive elements, thereby leading to compact structures in some applications. All these advantages together with its current-mode operation nature make the CDTA a promising choice for implementing the current-mode continuous-time signal processing circuit consecutively.

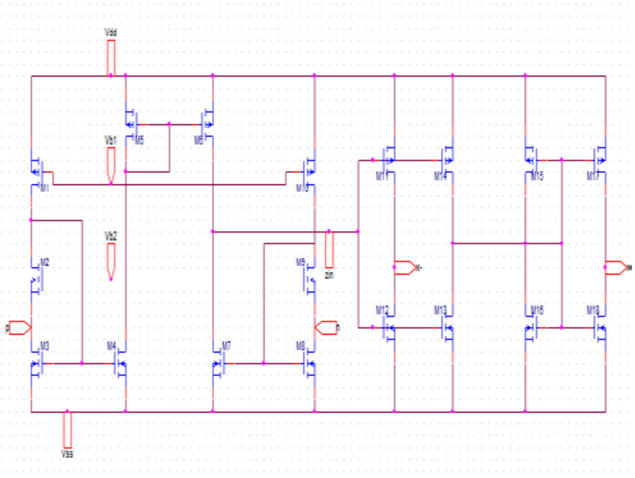

Figure 2.3: CMOS BASED CDTA

The transistors to form the input stage of CDTA element. In the current mirrors of the input stage flipped voltage follower are used. Feedback in FVF results in very low input resistance at the input terminals. Input resistance of the P and N terminal can be given using the output Resistance of FVF are used as input of CDTA. M2, M3 and M8, M9 are FVF transistors.[6]

A. Simulation analysis and results of CDTA

The performance of the proposed CDTA was verified using the PSpice simulation program. The MOS transistors were simulated using TSMC CMOS 0.35- process module parameters. The aspect ratios of the transistors are given in Table 2.1. The supply voltages and biasing current are given by = ±0.7V respectively. SPICE simulation results Input Resistances of the P and N terminals as 15.55Ω shown in figure 2.3.

Table 2.1 -Aspect ratios of the transistors (W/L) in micrometer

M1 w=15µ,L=0.35µ	M10 W=15µ,L=0.35µ
M2 W=15µ, L=0.35µ	M11 W=25µ,L=0.35µ
M3 W=45µ,L=01.05µ	M12 W=2µ, L=.7µ
M4 W=45µ, L=1.05µ	M13 W=2µ,L=.7µ
M5 W=75µ,L=1.75µ	M14 W=25µ,L=0.35µ
M6 W=75µ,L=1.75µ	M15 W=25µ,L=0.35µ
M7 W=45µ,L=1.05µ	M16 W=2µ,L=.35µ
M8 W=45µ,L=1.05µ	M17 W=25µ,L=0.35µ
M9 W=15µ,L=0.35µ	M18 W=2µ,L=0.35µ

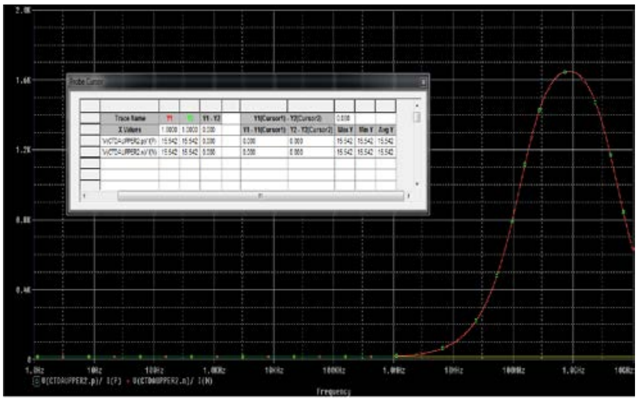

Figure 2.4: Variation of input resistance of CDTA with frequency

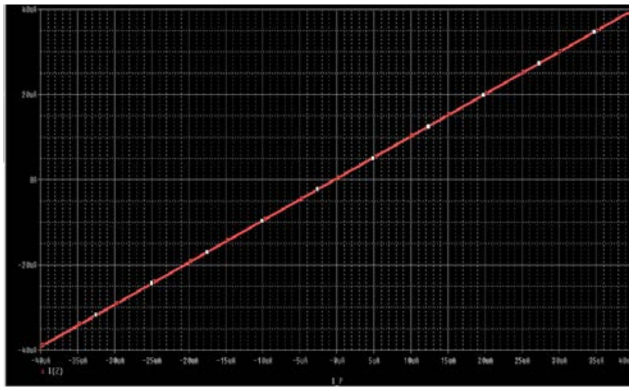

Figure 2. 5: Variation of the Z terminal current with respect to P (input) terminal current

The input terminal current transfer characteristics are given in Figure: 2.5 and 2.6 obtained when one input is open-circuited. The input stage transfers the difference of the input currents to the Z terminal with good accuracy as demonstrated in the Figures. Since few internal nodes exist over the signal path from the input to stage a high frequency operation is satisfied exploiting the high frequency capability of current mode signal processing.

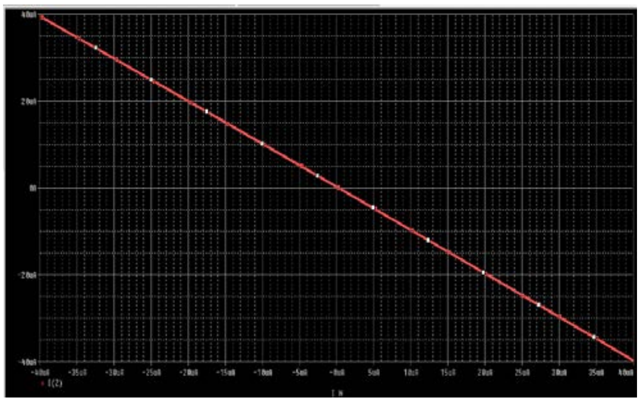

Figure 2.6: Variation of the Z terminal current with respect to N (input) terminal current

In figure 2.6 and 2.7 variation of current transfer from the N terminal and P terminal to Z terminal with frequency is given. 3 dB bandwidths of those characteristics are quite large, 46.419MHz for I_z/I_p and 68.139MHZ for I_z/I_n

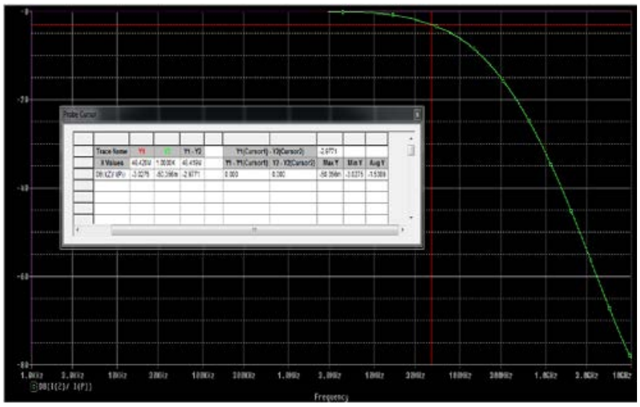

Figure 2.6: Frequency response of Iz/ Ip

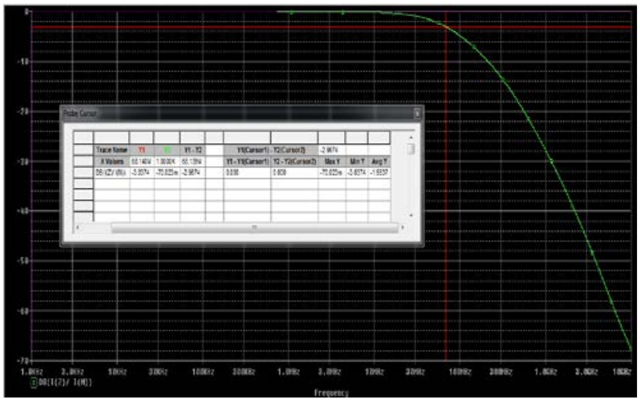

Figure 2.7: Frequency response of Iz/In

Transconductance of this inverter stages also the transconductance of CDTA is given by the sum of transconductance of the inverter transistor

$$g_m = g_{m11} + g_{m22}$$

Transconductance of both positive and negative output is given in figure 2.8.

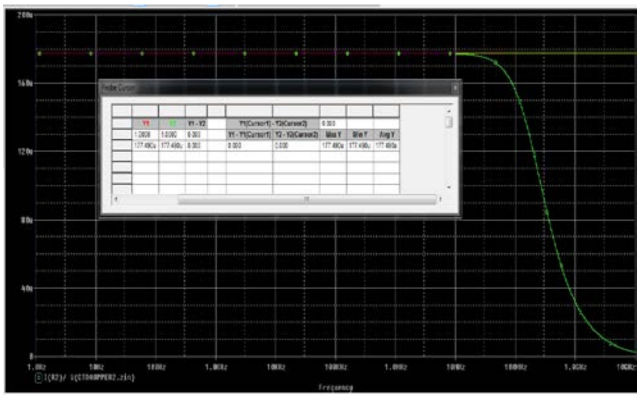

Figure 2.8: Transconductance of CDTA

Table 2.2- Simulation results of CDTA.

Supply Voltages	±0.7V
I_Z/I_P (-3dB Bandwidth)	46.419MHZ
I_z/I_n (-3dB Bandwidth)	68.139MHZ
Power Consumption	336.175μW
Input resistance at P and N	15.549Ω
Transconductance	177.487μA/V

III. MONOSTABLE MULTIVIBRATOR USING CDTA

The circuit diagram of proposed CDTA based Monostable Multivibrator are shown in fig 6.a. The circuit is design with one CDTA one diode, two capacitors & two registers. All the passive components are grounded.

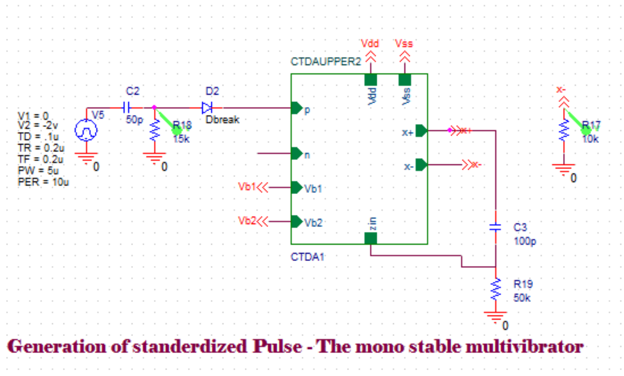

Figure 3.1: CDTA based Monostable Multibrator

The circuit is negative edge triggered to produce the output pulse as shown in figure 6.b. 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} & ResistorR_{in}.

$$T = R_{in}\, C_{in} \ln (R_{in}/R_{19})$$

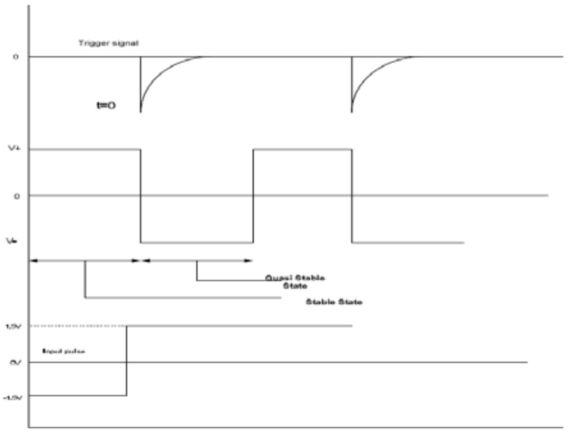

Figure 3.2: Proposed waveform of Monostable multivibrator

IV. SIMULATION 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 ±0.7V.

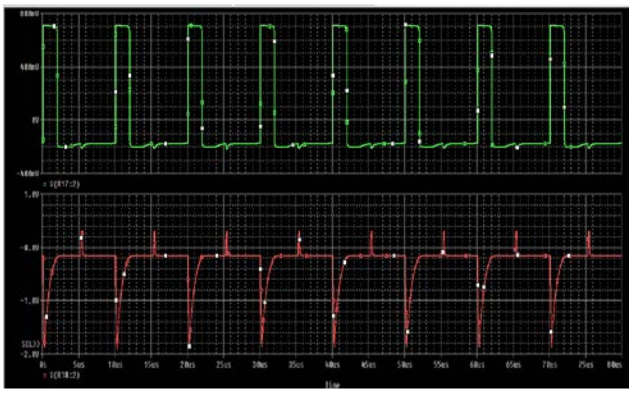

Figure 4.1: Simulated result of Monostable multivibrator

The SPICE simulations of the proposed Monostable Multivibrator with the following experimental parameters are specified: +V= -V = 2v, TD = .1u, TR = .2µ, TF = .2µ, PW = 5µ, PER =10µ and R_{in} = 15k, R_f (R_{19}) = 50k, C_{in} = 50pf and calculate the pulse width is T= 5µs.The simulated results are displayed in fig. 4.1. 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. 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. The overall average power of Monostable Multivibrator .34mW shown in figure 4.2.

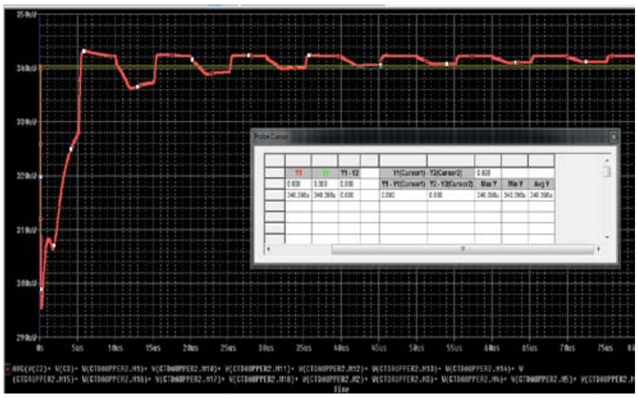

Figure 4.2: Power Consumption of Monostable multivibrator

COMPARISON OF RESULTS

A. EXISTING CDTA BASED MONOSTABLE MULTIVIBRATOR HAVING HIGH POWER CONSUMPTION.

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=3.5µ	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

SUMMARY OF SIMULATION RESULTS

Supply Voltages	±0.75V
Iz/Ip(-3dB) bandwidth	87MHz
Iz/In(-3dB) bandwidth	20MHz
Power Consumption	370.162µW
Input resistance at P and N	15.549Ω
Transconductance	210µA/V
Technology	0.35µm AMIS

B. PROPOSED CDTA BASED MONOSTABLE MULTIVIBRATOR WITH LESS POWER CONSUMPTION

ASPECTS OF TRANSISTOR

M1 W=15µ,L=0.35µ	M10 W=15µ,L=0.35µ
M2 W=15µ, L=0.35µ	M11 W=25µ,L=0.35µ
M3 W=45µ,L=01.05µ	M12 W=2µ, L=.7µ
M4 W=45µ, L=1.05µ	M13 W=2µ,L=.7µ
M5 W=75µ,L=1.75µ	M14 W=25µ,L=0.35µ
M6 W=75µ,L=1.75µ	M15 W=25µ,L=0.35µ
M7 W=45µ,L=1.05µ	M16 W=2µ,L=.35µ
M8 W=45µ,L=1.05µ	M17 W=25µ,L=0.35µ
M9 W=15µ,L=0.35µ	M18 W=2µ,L=0.35µ

SUMMARY OF SIMULATION RESULTS

Supply Voltages	±0.7V
Iz/Ip(-3dB) bandwidth	46.419MHZ
Iz/In(-3dB) bandwidth	68.139MHZ
Power Consumption	340.398µW
Input resistance at P and N	15.549Ω
Transconductance	177.487µA/V
Technology	0.18µm AMIS

V. CONCLUSION

A high performance CMOS implementation of current differencing transconductance is presented. Simulated device characteristics shows the proposed circuit exhibits a very good performance. The simulation results confirmed the high performance provided by the circuit in terms of low input, high output resistances, and a wide linearity range for both the voltage and current operations. The performance of the proposed circuit was tested with an application example of 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. 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.

REFERENCES

[1] J. M. JACOB, ANALOG INTEGRATED CIRCUIT APPLICATIONS, PRENTICE-HALL, NEW JERSEY, 2000.

[2] A. S. Sedra, K.C. Smith, Microelectronic Circuits, 5th ed., Oxford University Press, New York, 2004.

[3] A.S. Sedra, G.W. Roberts, F. Gohh, The current conveyor: history, progress and new results, IET Proc.-Circuits Devices Syst. 137 (2) (1990), 78–87.

[4] C. Toumazou, F.J. Lidegy, D. Haigh, Analog IC Design: The Current-Mode Approach, Peter Peregrinus Press, UK, 1990.

[5] W.S. Chung, H.W. Cha, H.J. Kim, Current-controllable monostable multi- vibrator using OTAs, IEEE Trans. Circuits Syst. I 49 (5) (2002) 703–705.

[6] P. Tuwanut, J. Koseeyaporn, P. Wardkein, A novel monostable multivibrator circuit, IEEE Tencon (2005) 1–4.

[7] Y.K. Lo, H.C. Chien, Current-mode monostable multivibrators using OTRAs, IEEE Trans. Circuits Syst. II 53 (11) (2006) 1274–1278.

[8] Y.K. Lo, H.C. Chien, Single OTRA-based current-mode monostable multi- vibrator with two triggering modes and a reduced recovery time, IET Proc.- Circuits Devices Syst. 1 (3) (2007) 257–261.

[9] Y.K. Lo, H.C. Chien, Current-controllable monostable multivibrator with retriggerable function, Microelectron. J. 40 (8) (2009) 1184–1191.

[10] Hung-Chun Chien,Yu-Kang Lo, Design and implementation of monostable multivibrators employing differential voltage current conveyors, Microelectronics Journal 42 (2011) 1107–1115

[11] Biolek, D., “CDTA-Building block for current-mode analog signal processing”, Proc. ECCTD’03, Cracow, Poland, 2003, Vol. III, pp.397-400.

[12] Uygur, A. and Kuntman, H., “Novel current-mode biquad using a current differencing transconductance amplifier”, Proceedings of Applied Electronics 2005, pp. 349-352, Pilsen, Czech Republic, September 2005.

[13] Uygur, A. “The CDTA element and its applications”, Master Thesis, Istanbul Technical University, Institute of Science and Technology, 2005.

[14] Uygur, A. Kuntman H. and Zeki, A. “Multi-input multi-output CDTA-based KHN filter, Proc. of ELECO 2005: The 4th International Conference on Electrical and Electronics, pp.46-50, December 2005, Bursa, Turkey.

[15] D. Biolek, E. Hanciouglu, A.U. Keskin, “High-performance current differencing trans-conductance amplifier and its application in precision current-mode rectification”, Int. J. Electron. Commun, 62, 2008, pp-92-96.

[16] A. Uygur, H. Kuntman “Low -Voltage Current Differencing Transconductance Amplifier in a Novel Allpass Configuration”, IEEEMELECON 2006, May 16-19, Benalmadena (Malaga), Spain

[17] Carvajal, R.G. et al, “The flipped voltage follower: a useful cell for low-voltage low-power circuit design”, IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications, Regular Papers Vol. 52, Issue 7, July 2005 pp.1276 - 1291.