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SIMULATION AND ANALYSIS OF CDTA

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***Abstract*- CDTA (Current Differencing Transconductance Amplifier) is a device that processes information in the form of electric currents. It is a current input and current output device, which has two stages namely CDU (Current Differencing Unit) and an OTA (Operational Transconductance Amplifier). In this paper, a low voltage low power bulk driven CDTA has been employed. Demands for low voltage low power integrated circuit design are growing with technology advancement. Designs in the 0.18µm CMOS technology have been verified via Tanner tool simulation. The supply voltages are only ±0.5V. This CDTA provides 22.29MHz, 41.35MHz bandwidth for respective inputs and power dissipation of 33.25µW.**

Index Terms— **Bulk driven CMOS, CDTA, OTA, Tanner Tool**

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I. INTRODUCTION

As the technology is advancing the scale of integration is improving, more transistors faster and smaller than their predecessors are packed into the chip, Because of the improving scale of integration the operating frequency and processing capacity per chip are undergoing steady growth, resulting into increased power dissipation.

In order to meet the demands for the electronic circuits working on extremely low supply voltages and power consumption, signals representing the information in the form of electric currents are used for processing. Such signals offer higher bandwidth and better signal linearity. In other words, it can be quoted that current mode approach helps in designing circuits with lower voltage swings and smaller voltage supply.

There are number of advantages of current mode approach This approach provides higher frequency range of operation, better accuracy rates, improved linearity and better accuracy.

In this paper, a bulk driven Current Differencing Transconductance Amplifier (CDTA) has been employed. Bulk driven technique supports low threshold voltage devices and proper scaling of supply voltage [9]. In this technique the value of gate -to-source voltage is set to a sufficient level that is appropriate to form an inversion layer while input signal is applied to the bulk terminal.

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In bulk driven MOS [5][9], the input is applied at the bulk of the MOS transistor while in gate driven MOS the input is given at the gate terminal of the MOS transistor. In bulk driven MOS, the threshold voltage is the function of bulk-to-source voltage and controls the drain current. Using this technique, even at zero input bias voltage, the transistor can remain in active mode.

The paper covers the implementation of bulk driven technique in designing a low voltage low power CDTA (Current Differencing Transconductance Amplifier). The designed CDTA consumes extra low power and supply voltages in contrast to gate driven structures.

II. CURRENT DIFFERENCING TRANSCONDUCTANCE AMPLIFIER (CDTA)

Current Differencing Transconductance Amplifier (CDTA)[1][2] is a new active element with two current inputs and two current outputs. This element has two stages CDU (Current Differencing Unit) and OTA (Operational Transconductance Amplifier).CDU is formed via two OTAs namely OTA 1 and OTA 2. Each OTA works as a separate current conveyor of opposite types. Input to OTA 1 is I_P and that to OTA 2 is I_N. The input to the first stage i.e. CDU are two currents I_P and I_N and output is the difference current I_Z. And voltages at terminals P and N are taken to be zero (0) as terminals P and N are internally grounded.

$$I_Z = I_P - I_N \quad (1)$$

$$V_P = V_N = 0 \quad (2)$$

The voltage drop across the Z terminal is transformed into X terminal currents via second stage of CDTA i.e. OTA (Operational Transconductance Amplifier). The number of X- terminals can be arbitrary. The figure 1 shows two bidirectional X+ and X- outputs from stage second OTA i.e. OTA3.

$$I_X = g_m V_Z \quad (3)$$

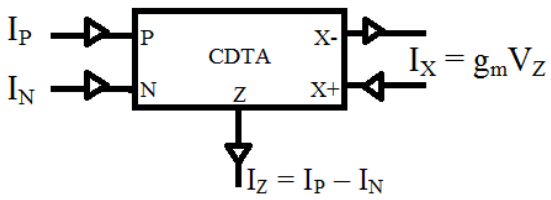

Figure 1 Schematic of CDTA

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A CMOS BD-CDTA is designed using 0.18µm technology. In comparison to the conventional gate driven methods, this bulk driven configuration works on lower power supply of ±0.5V, which also results in low power dissipation of 33.25µW.

III. CMOS IMPLEMENTATION OF CDTA

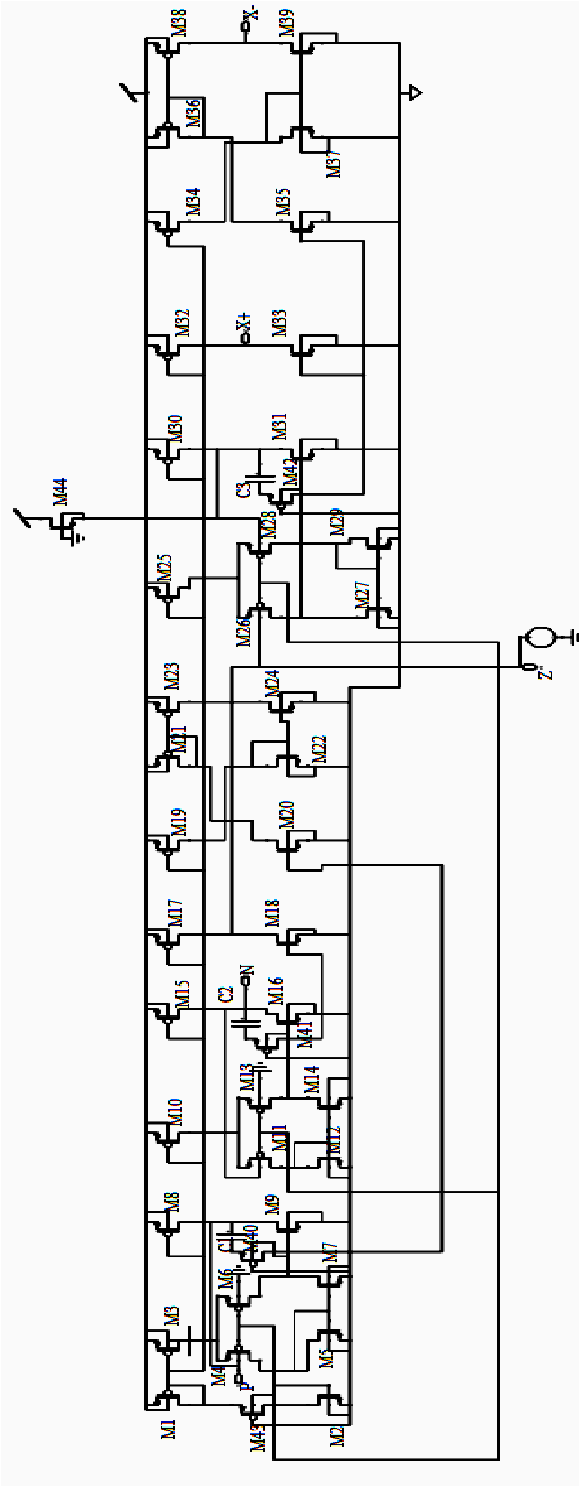

Figure 2 CMOS implementation of CDTA

Figure 2 depicts the CMOS implementation of bulk driven Current Differencing Transconductance Amplifier (CDTA). Transistors M1, M2 and M43 provide the DC biasing topology and corresponding transistors form the current mirror. CDTA is implemented using three OTAs of classical two stage topology with the bulk driven differential input stage employing a p-channel MOS transistor pair and current mirror acting as an active load, and with current inverters and circuits for providing copies of output current.

There are three OTAs in figure 2, OTA 1 is implemented via transistors M3-M9 and M19-M24 whereas OTA 2 is implemented via transistors M10-M18 and M19-M24. The remaining transistors M25-M39 form the OTA 3.
In order to split the parasitic poles of two adjacent OTAs, negative feedback from the drain of transistor M9 to the bulk of transistor M4 is accompanied by the M40 – C1 circuit. M40 is operating in linear region, thus behaving as a resistor (same compensation is provided to OTA2 via M41-C2 circuit). C1 here is the compensation capacitor which is used to split the parasitic poles of two adjacent OTA stages. This splitting is done to make the pole of first stage dominant and push the pole of second stage at high frequency. The value of capacitor and aspect ratios of the transistors are taken such that the phase margin of the respective OTA is approximately equal to 80.

IV. SIMULATION RESULTS

The simulation results for CDTA according to figure 2 are given in figure 3 and 4, and the parameters of the designed bulk driven CDTA are tabulated in table 1.

Figure 3 shows the I_Z/I_P curve of CDU (Current Differencing Unit) and figure 4 shows the I_Z/I_N curve of CDU (Current Differencing Unit) both simulated on assumption $V_Z=0$. The cutoff frequency of I_Z/I_P and I_Z/I_N are 22.29MHz and 41.35MHz respectively.

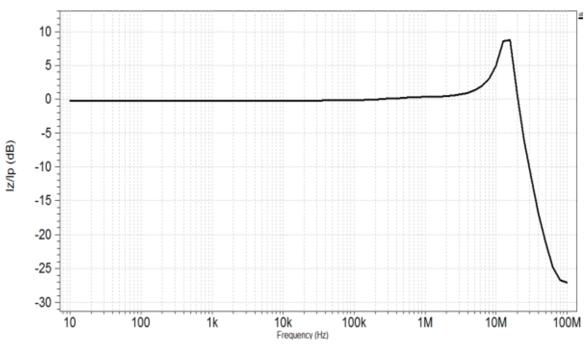

Figure 3 Frequency response for I_Z/I_P

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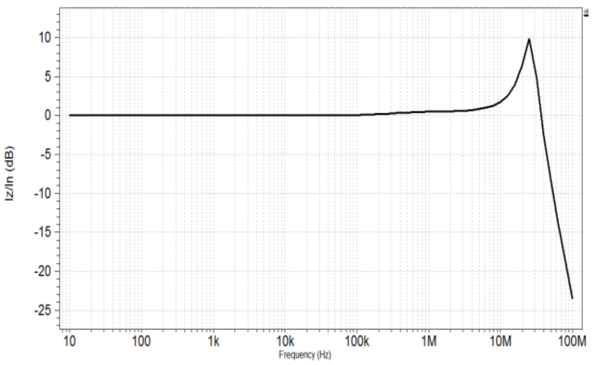

Figure 4 Frequency response of I_Z/I_N

Parameters	CDTA
Technology	0.18µm
Supply voltage	±0.5V
Power consumption	33.25µW
3 dB bandwidth of I_Z/I_P	22.29MHz
3 dB bandwidth of I_Z/I_N	41.35MHz

Table 1 Simulated results for bulk driven CDTA

V. CONCLUSION

This paper demonstrates a Current Differencing Transconductance Amplifier (CDTA) employing bulk driven technique. The main advantage of the designed CDTA is that it works on extra low supply voltage and power consumption. The 3dB bandwidth of I_Z/I_P and I_Z/I_N are 22.29MHz and 41.35MHz respectively. The proposed CDTA can be useful in application where extra low supply voltage is required.

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