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Design and Simulation of Third order low pass filter using Operational Transconductance Amplifier

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Abstract— **This paper presents designing of third order low pass filter using Operational Transconductance Amplifier (OTA). In this design various techniques are used such as bulk driven technique, current mirrors to facilitate the working of the circuit. Bulk driven technique helps in reducing the power dissipation of the circuit. Simulation is done using 180nm technology on tanner tool and is operating under supply voltages of ±0.5V. From the schematic simulation, the designed filter provides the following results- bandwidth 1.42kHz, total power consumption of 6μW.**

***Index Terms*—- Bulk driven CMOS, current mirror, OTA.**

I. INTRODUCTION

In present era the need for various applications are increasing due to which there is a rapid growth in technology. As the time is passing the devices are becoming more compact and portable which has led to the development of devices which operate on lower power supply and offers low power dissipation. Various techniques are used in order to achieve the said features. The techniques are namely bulk driven technique, use of DC biasing circuitry, current mirrors etc. In this paper a bulk driven Operational Transconductance Amplifier (OTA) has been designed on 180 nm technology and then using the same a third order low pass filter has been designed.

This paper is organised as follows: in section II, basic OTA is discussed, in section III CMOS implementation of the OTA s discussed. In section IV, the designing of third order low pass filter in done using the proposed OTA. In section V, simulation results are discussed finally, in the section VI conclusion.

II. BASIC OTA

An OTA is a voltage controlled current source, more specifically the term "operational" comes from the fact that it takes the difference of two voltages as the input for the current conversion. The ideal transfer characteristic is therefore

$$IOut = gm(VIn+ - VIn-) \ldots\ldots\ldots(1)$$

or, by taking the pre-computed difference as the input,

$$IOut = gmVIn \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

with the ideally constant transconductance gm as the proportionality factor between the two. In reality the transconductance is also a function of the input differential voltage and dependent on temperature.

The term "transconductance" comes about because the ratio of the output current over the input voltage, gm, has the unit of a conductance if looked at "across the amplifier". The proportional factor of output vs. input for an amplifier with current input and voltage output has the unit of a resistance and such an amplifier is called a transresistance amplifier.

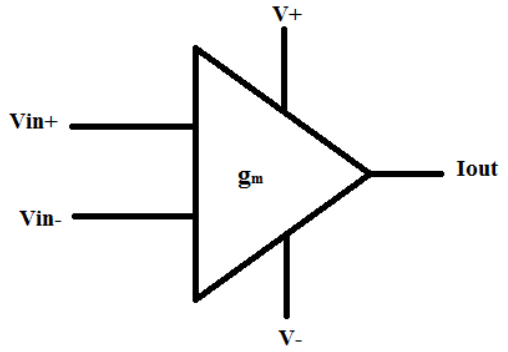

Figure 1 Basic OTA

An ideal OTA has two voltage inputs with infinite impedance (i.e. there is no input current), as shown in fig. 1. The common mode input range is also infinite, while the differential signal between these two inputs is used to control an ideal current source (i.e.the output current does not depend on the output voltage) that functions as an output. The proportionality factor between output current and input differential voltage is called transconductance.

III. CMOS IMPLEMENTATION OF OTA

In Figure 2 DC biasing that is given by two transistors M1, M2, and resistor R, the corresponding transistors forms current mirror that enables to create the same copy current in other branch as well.

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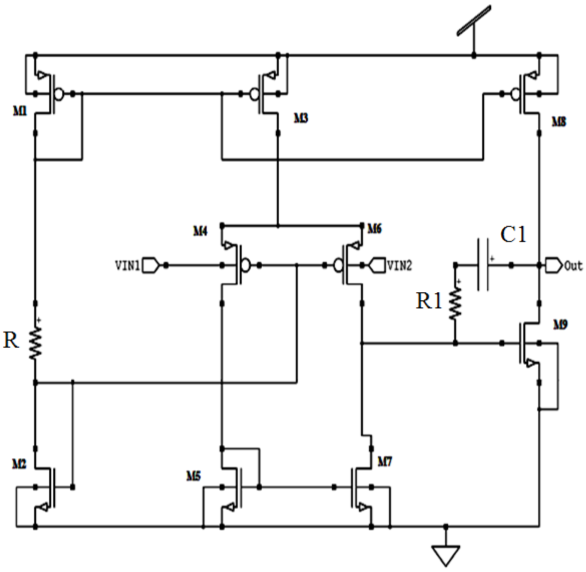

Figure 2 CMOS implementation of OTA

Techniques implemented in the depicted OTA are namely DC biasing technique, current mirror and bulk driven technique. It is a dual input and single output OTA. Inputs VIN1 and VIN2 are provided across transistor M4 and M6 respectively.

The total number of transistors used in the said OTA is 9 and two resistors R and R1 of value 10kΩ and 7.45kΩ respectively. Also a capacitor C1 is used whose value is 0.5pF. The resistor R1 and capacitor C1 forms frequency compensation circuitry for the said operational transconductance amplifier.

IV. PROPOSED FILTER

In this section third order low pass filter using the proposed OTA is implemented. The bandwidth of the filter is 1.42kHz and power dissipation is 6μW. Figure 3 depicts the third order low pass filter using the proposed OTA.

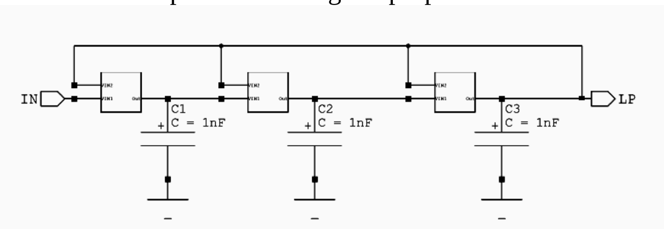

Figure 3 Third order Low Pass Filter

V. SIMULATION RESULTS

The proposed filter provides a bandwidth of 1.42 kHz and power dissipation of 6μW as shown in figure 4.

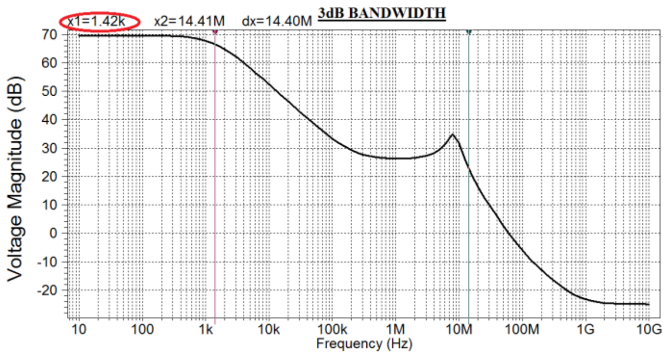

Figure 4 3dB bandwidth of OTA

Various results calculated are tabulated in table 1. Technology used is 0.18 µm, power consumed during simulation is calculated to be 6.0µW. Hence bandwidth is 1.42kHz.

Parameters	**OTA**
Technology	0.18 µm
Power supply	±0.5V
Power consumption	6.0µW
3 dB Bandwidth	1.42kHz

Table 1 Calculated parameters

VI. CONCLUSION

This paper demonstrates an Operational Transconductance Amplifier (OTA) employing bulk driven technique. The main advantage of the designed OTA is that it works on extra low supply voltage and power consumption. The 3dB bandwidth is 1.42kHz . The proposed OTA can be useful in application where extra low supply voltage is required.

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