Design and Simulation of CMOS OTA With 700mv, 60db GAIN and 10PF Load

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***Abstract*—The OTA is popular for implementing voltage controlled oscillators (VCO) and filters (VCF) for analog music synthesizers, because it can act as a two-quadrant multiplier as we'll see later. For this application the control input has to have a wide dynamic range of at least 60 dB, while the OTA should behave sensibly when overdriven from the signal input (in particular, it should not lock up or phase reverse). Viewed from a slightly different angle an OTA can be used to implement an electrically tunable resistor that is referenced to ground, with extra circuitry floating resistors are possible as well.**

***Index Terms*— Tarnscoductance, slew rate, common mode rejection ratio (CMRR), Power supply rejection ratio (PSRR), Voltage gain ,ADEL**

I. INTRODUCTION

Operational Transconductance Amplifiers are important building block in many analog systems. These analog systems often require low power, fast settling time and high dynamic range. The CMOS Operational Transconductance Amplifier (OTA) is a unique device with characteristics particularly suited to applications viz. multiplexing, amplitude modulation, analog multiplication, gain control, switching circuitry and comparators.

DESIGN OF OTA

Low voltage and low power amplifier design in low-voltage design, the main consideration is to maintain the output swing as higher as possible. This can be achieved when no cascading transistors can be used in the output stage. For minimum power consumption, the number of current branches should be minimized. So the current mirror amplifier is best suited for low-power low-voltage amplifier. Current Mirror Amplifier The circuit in which output current is forced to equal the input current is said to be a current mirror circuit. It is special case of constant current bias. An advantage of current mirror circuits is that it takes fewer components, simple to design and easy to fabricate.

Principle of Operation: 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

$$IOut = gm(VIn+ - VIn-) \quad \text{………(1)}$$

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

$$, IOut = gmVIn \quad \text{.. …… (2)}$$

with the ideally constant transconductance gm as the proportionality factor between the two. In reality the transconductance1 is also a function of the input differential voltage and dependent on temperature, as we will later see. To summarize, an ideal OTA has two voltage inputs with infinite impedance (i.e. there is no input current). 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.

Parameter require for designing CMOS OTA

(1) Slew rate
(2) Common-mode input range (ICMR)
(3) Common-mode rejection ratio (CMRR)
(4) Power supply rejection ratio (PSRR)
(5) Voltage Gain

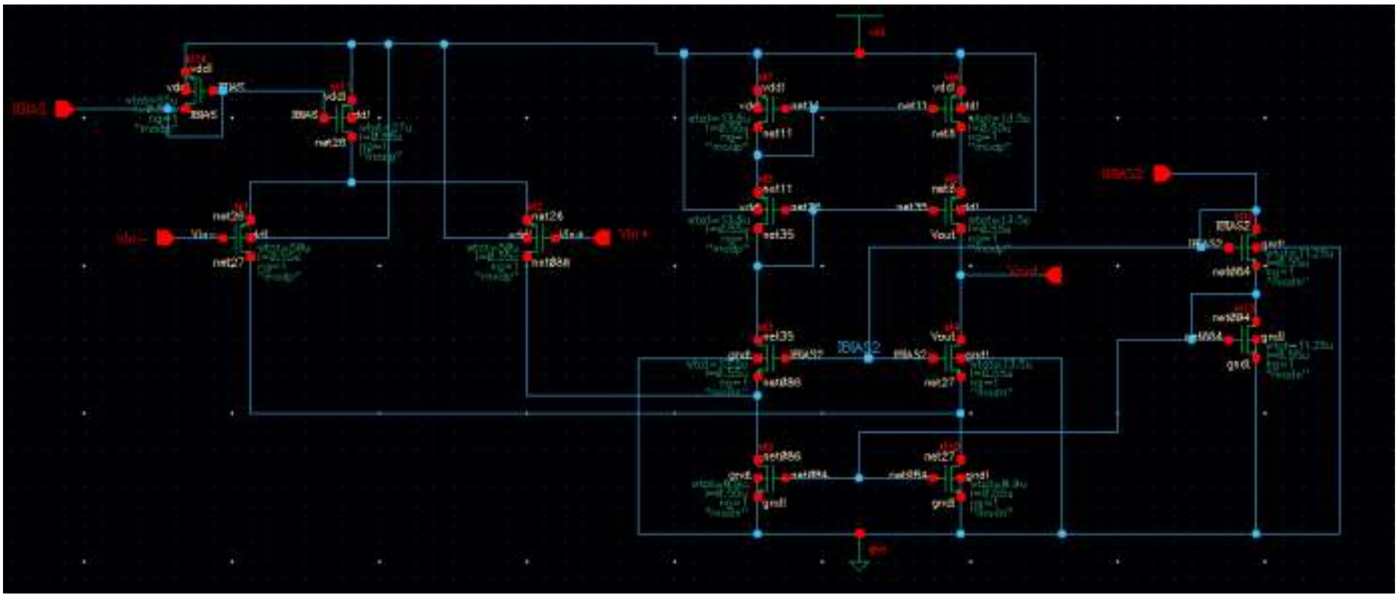


Fig: Implemented OTA Circuit on 90nm

Specification:

(1). gain 60 db

(2).phase 45degree

(3).bias cirrent 100uA

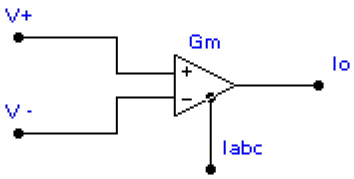
(4).common mode voltage 700mv

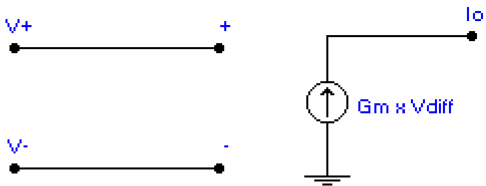
(5).slew rate 87v/us

(6) unity gain bandwidth (ugb) 60mhz

(7). power dissipation 712uW

Fast, High- Gain, Operational Transconductance Ampler (OTAs) are an integral part of switched-capacitor (SC) circuits. The symbol the OTA is similar to the operational amplifier as shown in below fig. It has two input terminal one is inverting Vin- and other is non-inverting terminal Vin+, finally it has one output terminal that has current at the output Iout. OTA works as voltage controlled current source, its takes the difference of the two voltages as the input for the current conversion. OTAs are versatile analog building blocks that allow the amplification and filtering of signals with minimum power consumption. The OTA is similar to a standard operational amplifier in that it has a high impedance differential input stage. The negative feedback provides the gain control mechanism, it stabilizes the gain. Fig shows the equivalent circuit of the operational transoconductance amplifier, where output current depends on voltage of the inverting and noninverting terminal. Fig. Schematic Symbol for OTA Fig Equivalent Circuit Iabc input bias current is used to control the transconductance of the amplifier. Iabc is called bias current of the amplifier. Amplifier gain can be controlled with the help of bias current. Iabc is directly proportional to the amplifier's transconductance





Application of OTA : The OTA is used for implementation of voltage controlled oscillators (VCO) and filters (VCF) for analog music synthesizers. Another application of OTA includes in the implementation of an electrically tunable resistor that can be used as reference to ground. The primary application for an OTA is to drive low-impedance sinks such as coaxial cable with low distortion at high bandwidth. It is used in designing of active filters, portable devices, sensor implementation, and hearing aid implementation.

OTAs (operational transconductance amplifiers) are versatile building blocks used for many applications such as filters, oscillators Examples of low-power applications that can benefit from the reduced supply voltage include portable products, biomedical and sensor implementations, hearing-aid devices, and energy harvesting applications

OTA is also used in designing of Active filter. Transconductance – capacitor (Gm-C) filter have been used at hearing aids, pacemakers other low applications. Some Applications of the OTA is given as follows-

• Voltage Amplifiers The basic voltage amplifier can be realized with the help of OTA circuit

. The input signal is applied at the inverting terminal of the amplifier with the negative feedback. The negative feedback is used to provide the controllable gain to the amplifier. The expression of the voltage gain and output impedance is given

As in equation

V0/ Vi = 1−gm R2/ 1+gm R1………………….(1)

Zo = R1+R2 /1+gm R1 ………………. (2)

Advantages :

The cascode arrangement offers high gain, high bandwidth, high slew rate, high stability, and high input impedance.

Disadvantages

The cascode circuit requires two transistors and requires a relatively high supply voltage. For the two-FET cascode, both transistors must be biased with ample VDS in operation, imposing a lower limit on the supply voltage.

Parameters	**Operational Transcoductance**
Supply Voltage	**1.1v**
Power(uW)	**712uW**
Gain(dB)	**60 db**
Unity Gain frequency (MHZ)	**60 mhz**
Slew Rate (V/us)	**87v/us**

CONCLUSION

Simulation of the design is done on the 90nm CMOS technology. This work reveals that operational transconductance amplifier circuit using cascading technique to reduce the power consumption. Multi stage OTA has better performance comparing the two stage OTA. In this paper, three Stage Operational transoconductance amplifier has designed with the bulk drive technology that allows it to operate at low voltage. The Proposed circuit uses the cascoding technique to stack the transistors in the second stage of the three stage OTA. This reduces the power consumption of the three stage OTA, increases gain and bandwidth, also improves the slew rate. The proposed OTA circuit requires the power consumption of 712µW and slew rate of 87v/us V/us.

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