Design and Characterization of Analog Blocks

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***Abstract*— In this paper, we designed basic CMOS analog blocks such as Miller CMOS OTA and two stage comparator .These basic analog blocks are used to design other analog blocks, which can be used as analog library components. Some examples are filters, analog to digital and digital to analog converters, differentiator, integrator etc.**

***Keywords*—OTA, Miller compensation, differential amplifier,bias circuitry,comparator,resolution**

I. INTRODUCTION

Circuit design is a creative process of developing a circuit that solves a particular problem. Integrated circuit design and discrete circuit designs are the two categories of electronic circuit design. In integrated circuit design, all components are on the same substrate. But in discrete circuit design, active and passive components are not on the same substrate. Two classification of integrated circuit design are analog circuit design and digital circuit design.

Circuit design can cover systems ranging from complex electronic systems to the individual transistors within an integrated circuit. For simple circuits the design process can be done by one person without a planned or structured design process. But for complex designs, teams of designers following a systematic approach with intelligently guided computer simulation are necessary.

CMOS technology is the base in mixed signal implementations. Mixed signal relates circuits with both digital and analog circuitry on the same substrate. It provides density and power savings for digital circuitry and for analog systems; it is a good mix of components. CMOS technology is the dominant semiconductor technology for microprocessors, memories and application specific integrated circuits (ASICs). The main advantage of CMOS over NMOS and bipolar technology is the much smaller power dissipation.

II. OPAMP and Comparator

A. OP-AMP

The operational amplifier, often referred to as an op-amp, is a circuit that provides extremely high gain amplification of the difference in voltage between two inputs. One input is known as the inverting input and the other is known as the non-inverting input. There is only a single output. The input impedance of the inverting and non-inverting input is extremely high. The output impedance of the op-amp is very low. Modern op-amps are integrated circuits.

Op-amps are prototypes of analog integrated circuits. Op-amps are one of the important building blocks in analog circuit design. Op-amps are classified into two groups according to output resistance: buffered and unbuffered. Output resistance will be very high for unbuffered. These are also called operational transconductances amplifier (OTA). Buffered op-amps are low resistance amplifiers and they are also referred as voltage operational amplifiers.

An operational transconductances amplifier (OTA) has a large open loop output resistance at low frequencies. An op-amp provides large voltage gain. Its open loop resistance at low frequencies is very low.

Block diagram of general two stage op amp is shown in fig 1.

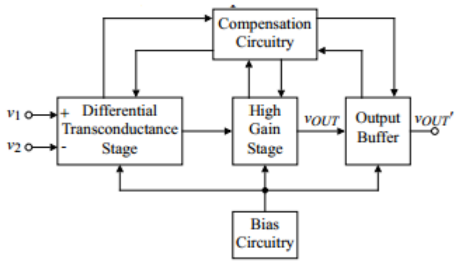

Fig 1. Two stage op amp [1]

Ideal op-amp characteristics are: Infinite differential voltage gain, Infinite input resistance, Zero output resistance etc. Practical op-amp only approaches these values. The characteristics of practical Op amp are: Offset voltage, CMRR, ICMR, PSRR, Slew rate etc

B. COMPARATOR

In many signal processing applications the ability to compare two signals and identify which is larger is very important. A comparator is a circuit that compares one analog signal with another. The output of comparator depends on which input signal is larger.

Static Characteristics of comparator are: Gain, Output high and low states, Input resolution, Offset, Noise etc and dynamic characteristics are Propagation Delay Time, Propagation delay time, slew rate, etc.

The most basic issue in selecting a comparator topology is to determine the minimum required gain. If high gain is required, it requires multiple gain stages. There are several issues involved in selecting number of gain stages.

III. PROPOSED DESIGN

A. Miller CMOS OP-AMP

Most analog electronic appliances are constructed from combinations of a few types of basic circuits. Analog circuits use a continuous range of voltage as opposed to discrete levels as in digital circuits.

Objective of compensation is to achieve stable operation when negative feedback is applied around the op amp. Types of Compensations are Miller compensation and self compensating - Load capacitor compensates the op amp.

In this proposed design a miller capacitor is used for compensation.

Design Specifications

Slew rate	>10v/us
Gain band width	7MHz
Power dissipation	≤ 1mW
Output voltage swing	±2V
Gain	>5000V
Load capacitance	10pF
Input common mode range	-1 to 2V
Positive supply voltage, vdd	+ 2.5V
Negative supply voltage, vss	-2.5V

B. Comparator

A comparator is a device that compares two voltages or currents and outputs a digital signal indicating which is larger. They are commonly used in devices that measure and digitize analog signals, such as analog to digital converters (ADCs), as well as relaxation oscillators.

Design specifications

Resolution	1mv
Positive input common mode range	2 v
Negative input common mode range	-1.25v
Propagation delay	50ns
Positive supply voltage	2.5v
Negative supply voltage	-2.5v
Output high voltage	2v
Output low voltage	-2v

IV.SIMULATION RESULTS

The op amp and comparator is analyzed and verified with the given specifications.

A. Miller CMOS OP-AM

Gain

A sine input of peak to peak amplitude of 800uv is applied at the non-inverting input. Then we get output as 4.23volt.It is shown in fig (2) and the gain response obtained is shown in fig (3).

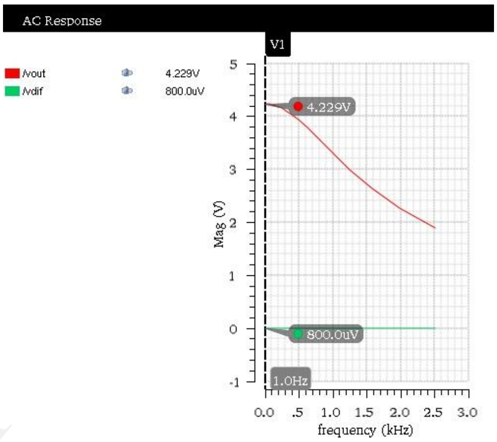

Fig 2 Vout vs. frequency

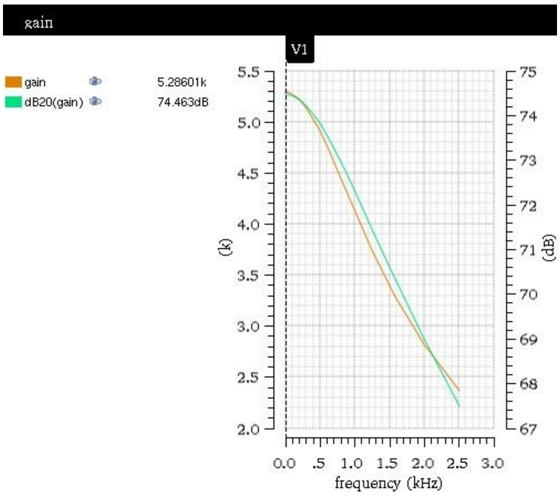

Fig 3. Gain vs. frequency

From this gain response we can see that, gain is 5.26K or 74.46 dB. The gain value 5.26K is greater than the given value 5000or 5K, which is desirable.

CMRR

CMRR, the common mode rejection ratio is the ratio of differential mode gain to the common mode gain. For this characterization, find out the differential mode gain and common mode gain separately. Differential mode gain is obtained by applying a sine input to any of the input of op amp. For the common mode gain, same input is given to both inverting and non inverting input or both inputs are tied together and give a common input to it.

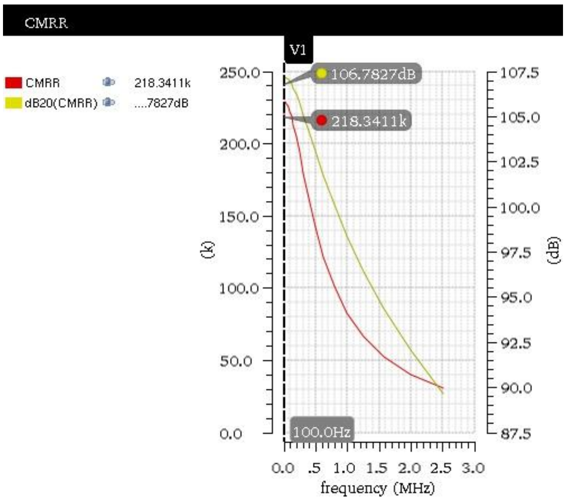

Fig 3. CMRR vs. frequency plot

Slew Rate

Slew rate is the maximum rate of change of output voltage per unit time. For finding slew rate, transient analysis is performed. Given slew rate is greater than 10v/us and obtained is 13.67 v/us.

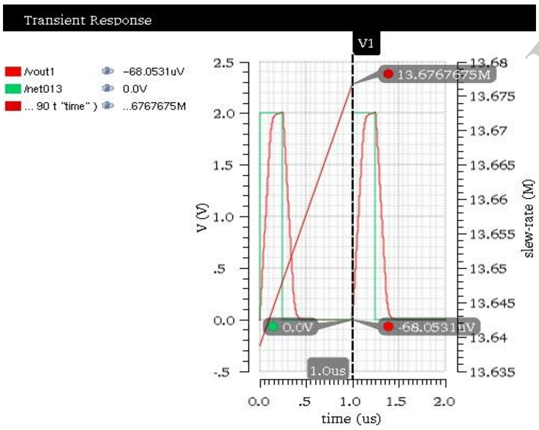

Fig 4.transient response

PSRR

Power supply rejection ratio, PSRR is a result of changes in the power rail voltages. It is the ratio of differential gain, Av to the gain from the power supply ripple to the output with the differential input set to zero.

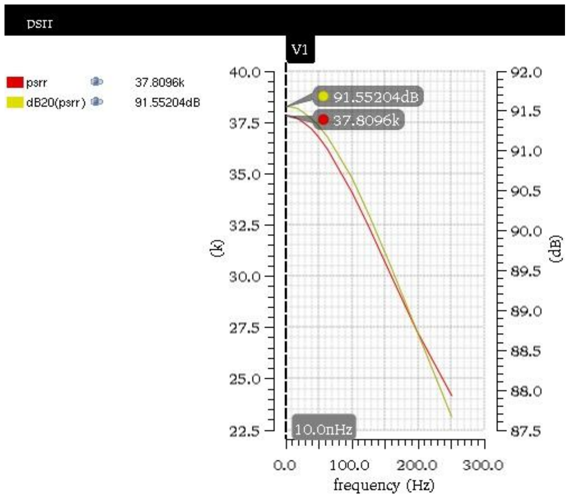

Fig 5. The PSRR vs. frequency plot\

ICMR

Input common mode range, ICMR specifies over what range of common mode voltages the differential amplifier continues to sense and amplify the difference signal with the same gain

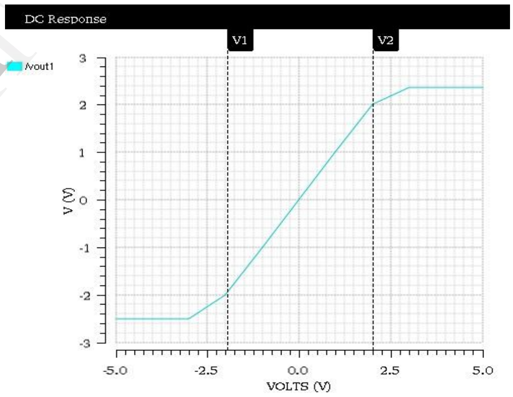

Figure 6.The ICMR characteristic

B. Two Stage Comparator

Propagation Delay

The propagation time of a comparator is a measure of how quickly the output changes states after the input threshold has been reached.

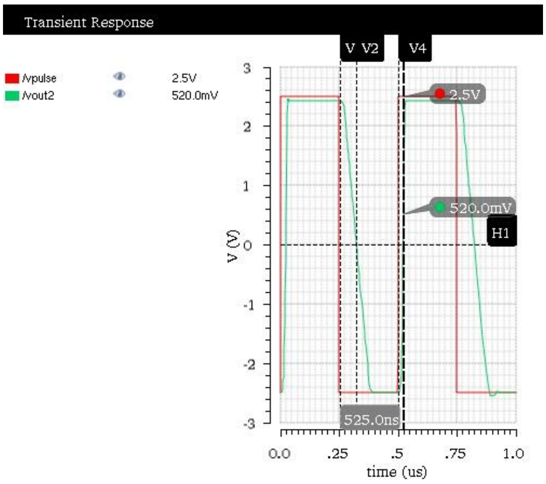

Figure 7. propagation delay

From this response we can see that rising propagation delay is 73 n second and falling propagation delay is 23 n seconds. So the propagation delay is average of this, which is 48 nano seconds.

Transient response when a sine input is applied to the non –inverting terminal is shown below fig 8

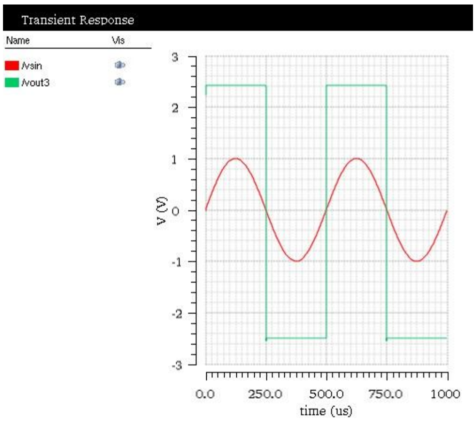

Fig 8.Transient response

RESOLUTION

Resolution or resolving capability is the ratio of, difference between output high and output low to the gain of the comparator. As gain increases, resolving capability approaches ideal.

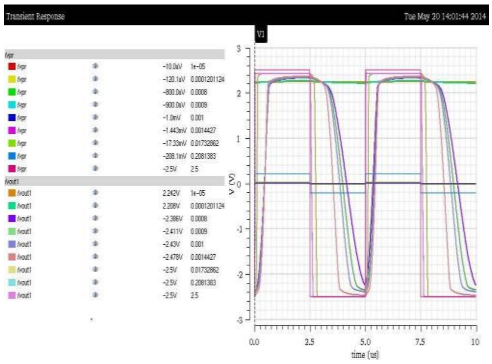

Fig 9. Resolution

V. CONCLUSION

The design and characterization of miller CMOS operational transconductance amplifier and two stage comparator is carried out successfully. The results obtained during simulation were verified against the specifications.

VI. ACKNOWLEDGEMENT

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