

Two Stage CMOS Operational Amplifier Using Cadence 180nm Technology.

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ABSTRACT: In this paper we have presented a method for designing an Operational Amplifier using Differential Amplifier and Common Source Amplifier (CMOS-Two stage Op-Amp) using Cadence Virtuoso 180nm Technology. An Operational Amplifier is a DC- coupled High -gain electronic voltage Amplifier with a differential Input and usually a Single-ended output. Op-Amps are one of the widely used electronic devices at the present time, being used in a wide range of industries, consumers and scientific devices. Op-Amps are mainly used as a voltage follower, active rectifier, current to voltage converter, Mathematical operations and in different types of voltage filter. Here we are discussing about different operational parameters of Op-Amp such as Gain Band width, Gain, Phase Margin, Power dissipation etc. We are Designing the Op-Amp circuit with specifications and completing the design flow and verifying the DC analysis, AC analysis and Transient analysis

KEYWORDS: Op-Amp, Differential Amplifier, Cadence, 180nm Technology.

I. INTRODUCTION

An operational amplifier is an integrated circuit that acts as Voltage amplifier. It has a differential input which consists of a Non- inverting input with positive voltage and an inverting input with negative voltage, ideally the Op-Amp amplifies only the difference in voltage between the two which is called as the differential input voltage and output voltage of the Op-Amp is typically greater than the potential difference between the input voltages. At present time, the Op-amp has been used widely since it consists of low power and low voltage silicon chip system and it is in greater demand because of portability, low battery consumption and its nature of versatility.

Since, Op-Amps have tremendous amount of gain and with differential inputs it is easy to design many types of circuits. The tremendous amount of gain means that the circuit can make use of high amount of negative feedback making the unparallel linearity and Bandwidth possible. Op-Amps are widely used in different applications such as Differential Amplifier, Inverting Amplifier, Non-Inverting Amplifier, Voltage followers, Summing Amplifiers, Instrumentation Amplifiers etc.

II. BLOCK DIAGRAM

Figure 1 shows the block diagram of Two stage Op-Amp which consist of two blocks i.e., Differential amplifier in the first stage and common source amplifier in the second stage. Differential amplifier will provide the needed high gain and the Common Source Amplifier provides high output voltage and also further increases the gain.

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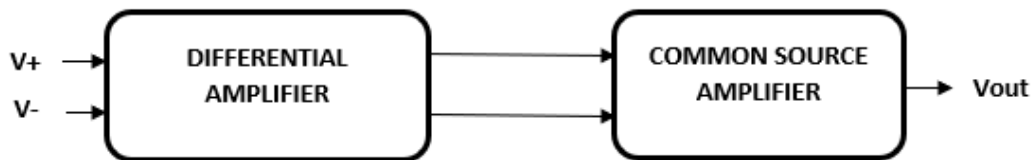


Fig 1: Block Diagram of Two Stage Op-Amp

The first stage of the block diagram is Differential Amplifier, which is a type of electronic amplifier that amplifies the difference between two input voltages but suppresses any voltage common to the two inputs. It has two inputs Non-inverting voltage (V+) and inverting voltage (V-). The output can be either a differential voltage or single ended voltage depending on the input voltages.

The output of this is given as the input of common source amplifier, Since the gain provided by the differential amplifier is not sufficient. The second stage of the block diagram which is Common Source Amplifier provides the additional amplification that's necessary. Common Source Amplifier is a one of three basic single stage field effect transistor (FET) amplifier topologies, typically used as voltage amplifier.

III. SCHEMATIC DESIGN

Differential amplifier is constructed using PM0, PM1 (pmos) and NM0, NM1 (nmos) Field effect transistors. Common source amplifier circuit is constructed using PM2 and NM4 FETs as shown in the circuit. Biasing is provided by NM2 and NM3. We bias an amplifier to a particular value in order to keep the Op-Amp from Saturation and also to allow the signals to have a much higher range. These two circuits are connected to get the CMOS two stage amplifier as shown in the below circuit.

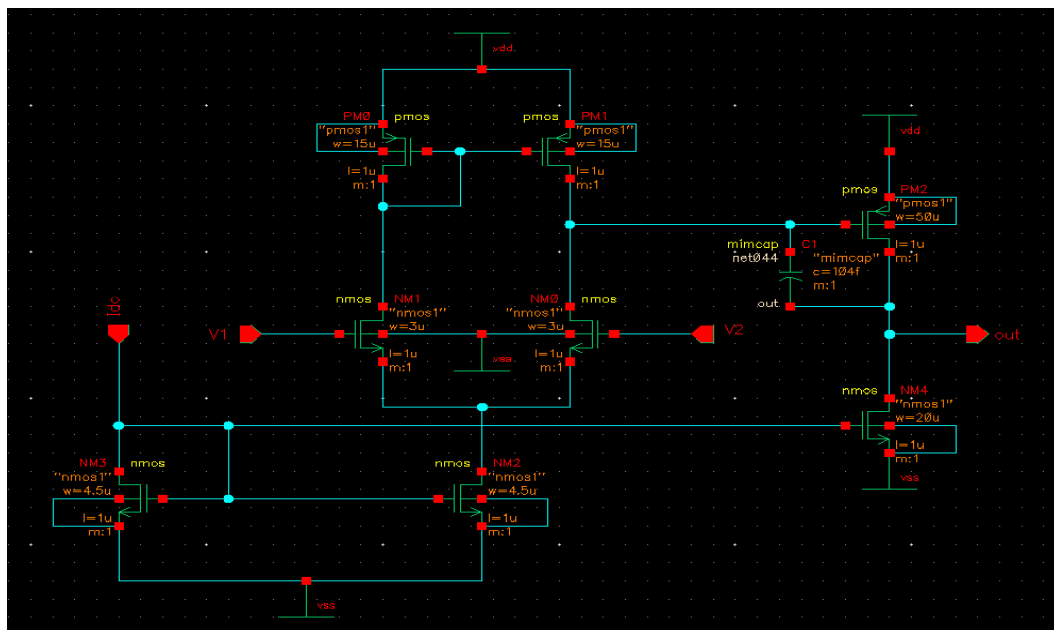


Fig 2. Schematic design of two stage Op-Amp

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In order to design a two stage CMOS Op-Amp several design steps must be considered. This is done to achieve proper transistor size that is necessary for the Op-Amp. Assume all the transistors are in saturation state. The steps to design a Two stage Op-Amp is given below.

- 1) The first step is to choose the device length which is used throughout the circuit.
- 2) The minimum required value of the compensation capacitor C_c must be 0.22 times greater than CL to achieve phase margin 60° . Here, assume $z \geq 10GB$.
- 3) Depending on requirements of the slew rate, the tail current I_o value is determined by

$$\text{Slew Rate (SR)} = \frac{I_o}{C_c} \dots\dots\dots[1]$$

4) The gain of first stage of the circuit can be obtained by

$$A_{v1} = \frac{-g_{m1}}{g_{ds2} + g_{m4}} = \frac{-2g_{ml}}{I5(\lambda2 + \lambda4)} \dots\dots\dots[2]$$

5) The gain of second stage of the circuit can be obtained by

$$A_{v2} = \frac{g_{m6}}{g_{m6} + g_{m7}} = \frac{-g_{m6}}{I6(\lambda6 + \lambda7)} \dots\dots\dots[3]$$

6) Bandwidth is given by

$$BW = \frac{g_{m1}}{C_c} \dots\dots\dots[4]$$

7) The Negative Input Common Mode Ratio Range is given by

$$ICMR (-) = \left[\sqrt{\frac{2ID1}{\beta1}} + V_{t1} \right]_{max} + V_{dsat} \dots\dots\dots[5]$$

8) The positive Input Common Mode Ratio Range is given by

$$ICMR (+) = \left[V_{DD} - \sqrt{\frac{2ID1}{\beta3}} + |V_{t3}| \right]_{min} + V_{t1min} \dots\dots\dots[6]$$

9) The saturation voltage negative input common mode ratio is given by

$$V_{dsat} \geq ICMR (-) - \left[\sqrt{\frac{2ID1}{\beta1}} + V_{t1} \right]_{max} \dots\dots\dots[7]$$

IV. SIMULATION AND ANALYSIS

1. AC ANALYSIS
2. DC ANALYSIS
3. TRANSIENT ANALYSIS

1. AC ANALYSIS

AC Analysis is used to find out the small signal response of the circuit. In AC analysis AC signals is applied to the input stage and change in output is obtained. With the help of this several performance parameters can be estimated such as Gain, Gain Bandwidth, Phase Margin etc. Frequency Response can be estimated by using DC operating point and AC analysis.

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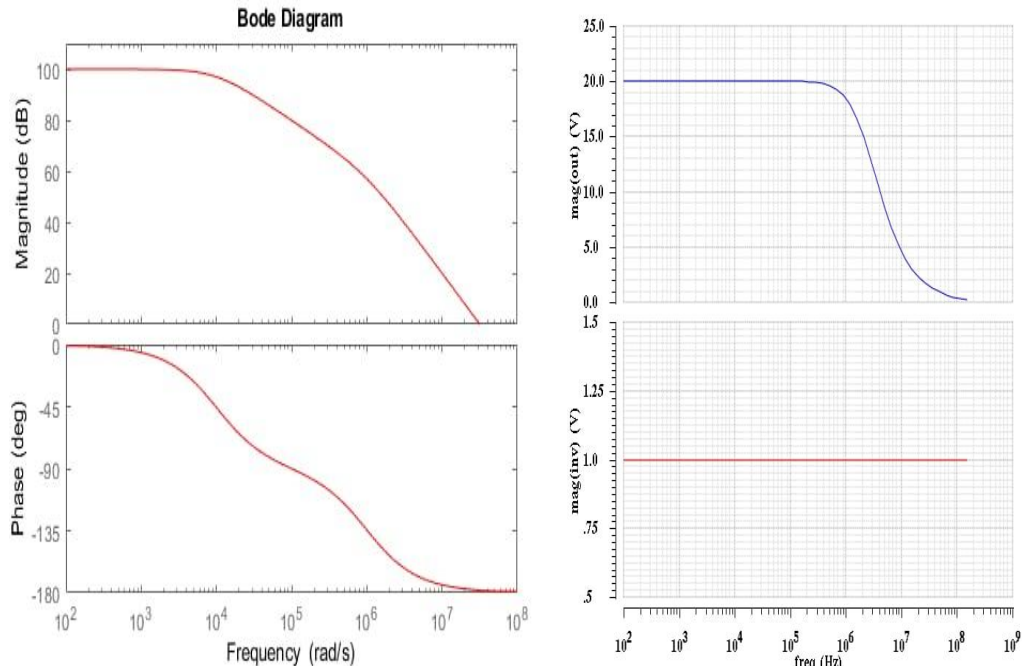


Fig 3. AC analysis of two stage Op-Amp

PARAMETERS

SPECIFIC PARAMETERS	DESIGNED VALUE
Technology (nm)	180nm
Bias Voltage (V)	2.5V
DC Voltage (V)	1.8V
DC Current (uA)	30u
Gain Bandwidth (MHz)	34MHz
Gain (db)	72.56db
Phase Margin (deg)	60
Slew Rate (V/us)	20V/us

Table1. Performance parameters of two-stage Operational Amplifier

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2. DC ANALYSIS

DC Analysis calculates the behaviour of the circuit when DC voltage or current is applied to it. It is used in determining operating point known as Bias point or Quiescent Point (Q-point).

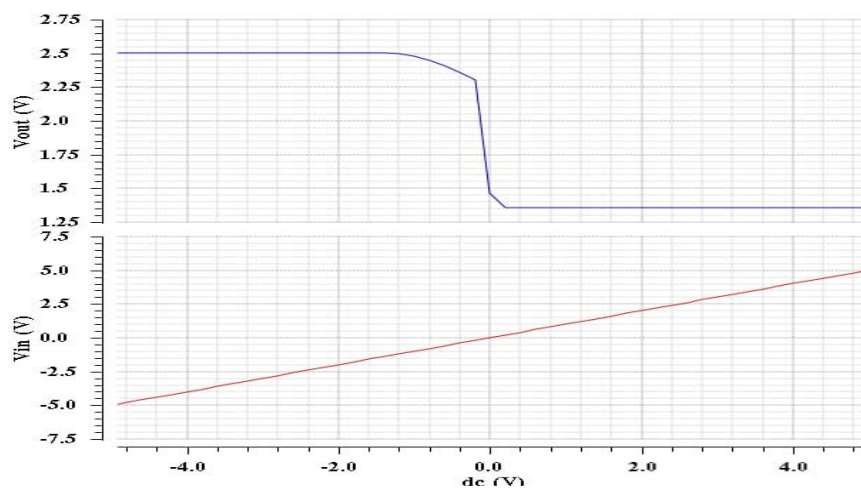


Fig 4. DC analysis of two stage Op-Amp

3. TRANSIENT ANALYSIS

Transient Response gives information about how the Op-Amp works for a pulse input. It gives time domain waveforms which are plots of voltage or current v/s time. In a small amount of time the current or voltage may rapidly change. Therefore, in order to check the fluctuations transient analysis is done.

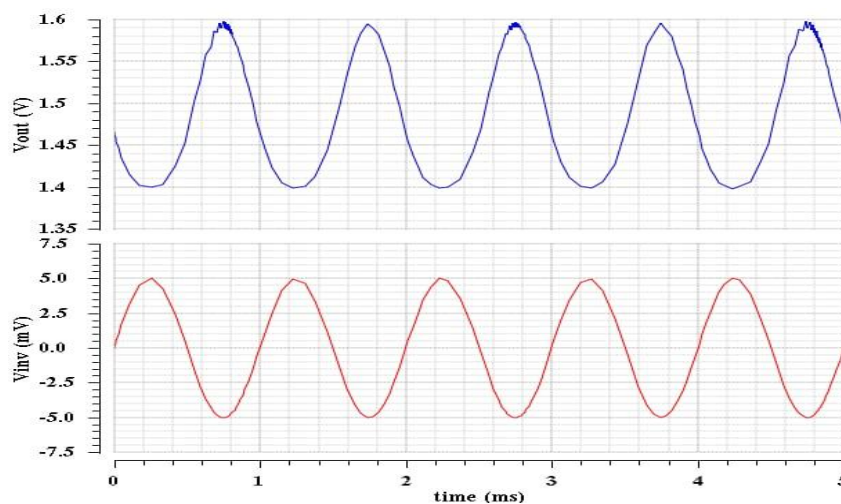


Fig 5. Transient analysis of two stage Op-Amp

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V. CONCLUSION

CMOS two stage op-amp using Differential amplifier and common source amplifier is designed, simulated and analysed using 180nm technology. It provides high performance with gain of 72.56db, bandwidth of 34MHz, phase margin of 60 degree. The main purpose of designing two stage Op-Amp is to obtain high gain, low power consumption, high output swing, greater bandwidth and low noise.

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