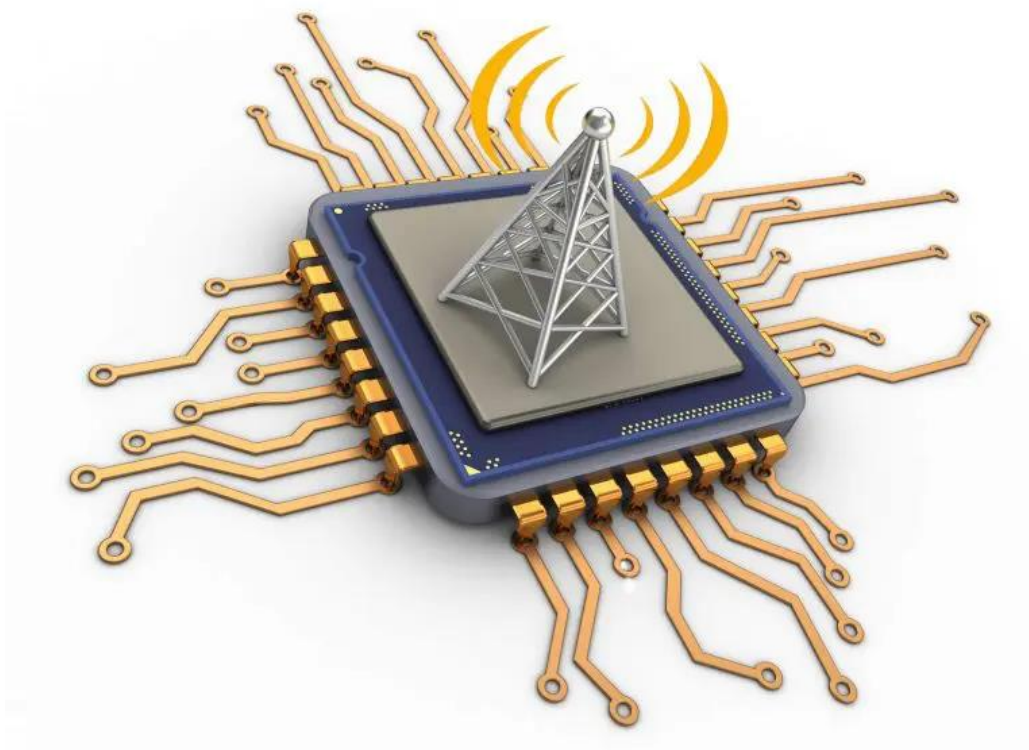


COOK-BOOK OF Two Stage Op-Amp



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1. Motivation:

This Cook-Book present the design conduct that is to be followed for the designing of the Two-Stage Operational amplifier. The need of 2-Stage Opamp over single stage differential amplifier (5-transistor OTA) is caused by the demand for the higher gain. Because of its immunity to environmental noise, it has gain immense popularity in analog circuit.

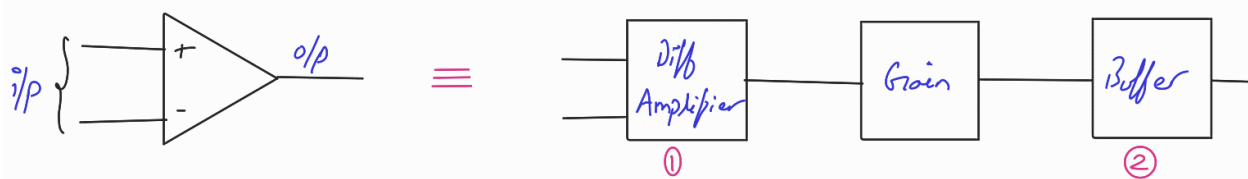


Figure 1: Disintegration of Op-amp

(1) Differential Amplifier of 40dB gain is not suitable to make a negative feedback amplifier so it is followed by the Gain block as a second stage but if we make an Op-Amp without a (2) Buffer stage the it is simply called a Transconductance Amplifier.

Hence, we will be designing the three blocks in stages and analyze it stepwise basis.

2. Design Requirement:

- A) Technology: UMC 180nm process
- B) Supply Voltage (V_{dd}) = 1.8 V
- C) Voltage gain (A_v) = 1000 (60dB)
- D) Load Capacitor (C_L) = 2pF

E) Input Common mode range (ICMR) = Max: +1.6V & Min: -0.8V

F) Slew Rate (SR) = 20V/usec

G) Power Dissipation < 300 uW

H) Gain Bandwidth Product (GBW) = 30 MHz

I) Phase Margin (PM) $\geq 60^\circ$

This project aims to achieve a typical design requirement. Although following the cook-book, any design need similar to this can be achieved with proper tuning.

3. Two Stage Op-Amp Topology:

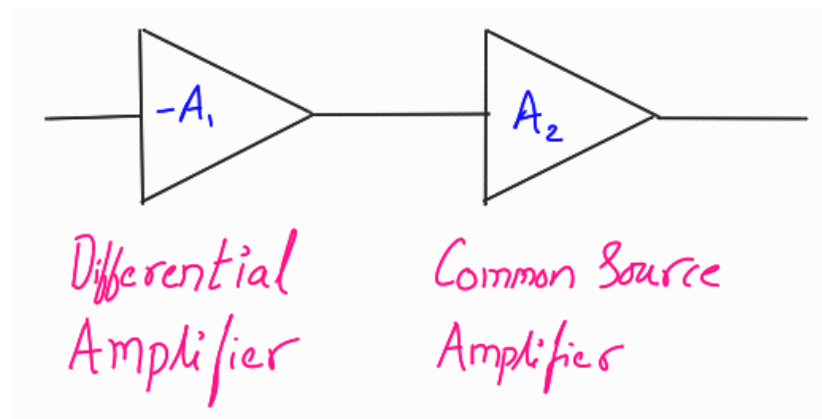


Figure 2: Block diagram of Op-amp topology

Now for the Common source amplifier we have two options to choose from a) NMOS Common Source b) PMOS Common Source

We are using PMOS CS Amplifier as a 2nd stage for a competent headroom [Ref: [Which transistor type to use for the second stage?](#) By Dr. Nagendra Krishnapura, Course: Analog Circuits, IIT Madras]

We can make more stages, having more gain E.g.: 5 stages without any issues of head room but the issue arises because of the increasing poles.

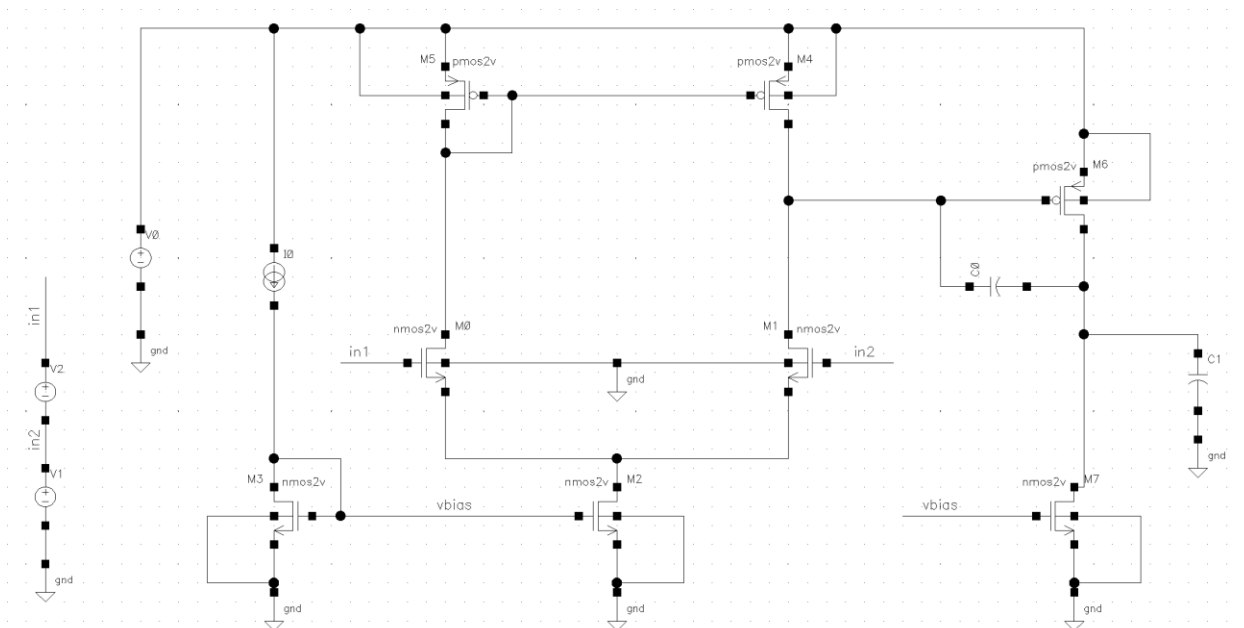


Figure 3: Proposed Two Stage Op-Amp topology

We want to achieve Positive gain out of 2nd stage hence, we switched the sign in 1st stage (in1 = -ve & in2 = +ve) such that negative from 1st stage and one more negative from Common source results in total positive gain.