Design of High Gain Differential Amplifier using Various Topologies - A Review

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Abstract— The objective of this paper is to design differential amplifier using various topologies. The characteristics of differential amplifier is measured by gain, CMRR and gain bandwidth product. In this paper a new high performance differential amplifier is designed using different approaches and a comparison is made between them. A low pass filter is designed using differential amplifier.

Key words: Differential Amplifier, Low Voltage and High Voltage Gain, CMOS Process, CMRR

I. Introduction

Over the past few years, the electronic has made tremendous changes in the era of VLSI technology. The major changes came through in the market are due to invention of MOS transistors.

CMOS technology mainly involves in satisfying all design constraints like power, area and speed by minimizing feature size and using the optimization techniques by lowering the supply voltage using VTCMOS and MTCMOS etc. CMOS technology has more advantage over the NMOS technology because of design flexibility and easily configurable. Hence CMOS has a rapid acceptance in the upcoming technology in the field of analog, digital and mixed signal circuits, like RF communication field, signal processing and biomedical applications.

II. Differential Amplifier

The differential amplifiers are designed using bipolar transistors and MOS transistors. The differential amplifier circuit amplifies the difference between two input signals and rejects any two common signals. The ideal characteristics of differential amplifier are infinite gain, infinite bandwidth and CMRR, high input impedance, low output admittance, low distortion and sensitivity.

A differential amplifier can be designed in many ways where output can be single ended and double ended. The most commonly used amplifier is double ended means which has two inputs and two outputs commonly known as fully differential amplifier. The advantages of fully differential amplifier over single ended are simple biasing, high immunity to noise and high linearity. But the disadvantage is large area.

The fully differential amplifier amplifies the difference between two input signals which are out of phase and rejects the signals which have common phase due to noise induced. This is termed as CMRR. An ideal amplifier circuit has an infinite CMRR.

A. Differential amplifier with passive load

Different types of differential amplifier are studied, designed and analyzed based on its high performance.

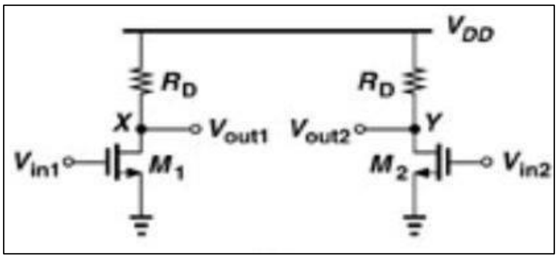

Fig. 1: Basic differential amplifier with passive load

The basic differential amplifier is shown. It is designed using two n channel MOSFETs M1 and M2 to form differential pair. The resistors RD are used as load to drive the transistors into saturation. The two input voltages Vin1 and Vin2 are applied at the gate terminal of MOS transistors, which are equal in magnitude and opposite in phase. The major advantage of this circuit it has greater output voltage swing.

When two inputs Vin1 and Vin2 are applied with same magnitude and same phase i.e Vin, CM does the effect on the trans conductance of the MOS transistors and which in turn effects the bias current and leads to change the output voltage gain and also further decreases the output voltage swing. If suppose the value of Vin, CM is low then it may turn off M1 and M2, hence no amplification but the output will be clipped off. Hence a minimum bias current is required to maintain the common mode level.

B. Differential Amplifier with active load

Here the circuit is designed using different load using active components like diode connected and current source loads.

In this circuit we use PMOS transistors as load by selecting proper dimensions and proper bias current. To achieve high gain, the aspect ratio of PMOS must decrease, and VGS- VTH must be increased to compensate the common mode level at X and Y nodes.

If Vin, CM is increased positively then M1 and M2 will be ON only if Vin, CM ≥ VTH. Further ID1 and ID2 proceed to increment and VP additionally rises. If Vin, CM is further increased then output voltages will remain constant but at some point M1 and M2 enters into triode region when Vin, CM > Vout1 + VTH = VDD – RDIss/2+VTH.

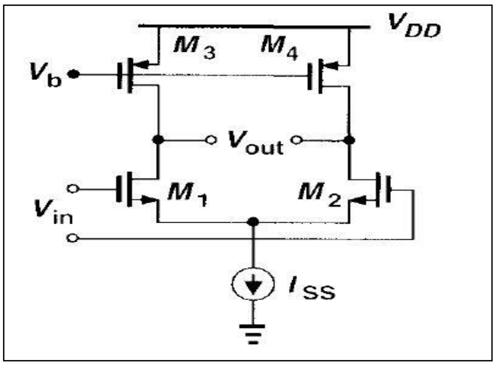

Fig. 2: Differential amplifier with active load

In this circuit we replace the resistors by active devices (NMOS) M3 and M4 and driven by external source to be in saturation. The external bias affects the trans conductance of M1 and M2, so to avoid this effect the tail current by Iss is set properly. If Vin1=Vin2=Vin,CM then ID1=ID2=0 so, both M1 and M2 are OFF and at the same time M3 will be in triode region, hence there will be no amplification and leads to Vout1=Vout2=VDD.

C. Differential Amplifier with active load (current mirror)

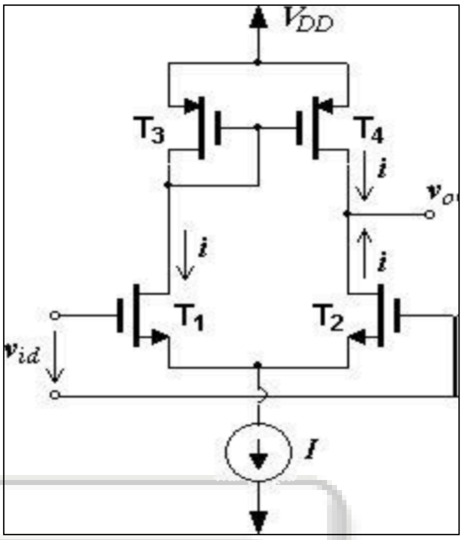

Fig. 3: Differential Amplifier with Active Current Mirror configuration

In this circuit external biasing is removed and a differential pair with current mirror is configured as active load. The main purpose of this configuration is it converts the fully differential input to single ended output. Here the transistors T3 and T4 are similar to each other. The transistor T3 is used to enhance the gain, for example if V_{GS} is increased by a little amount, then I_{D1} increases by ΔI_{D1} and I_{D2} decreases by ΔI_{D2}.

Similarly ID3 and ID4 and also increases by ΔI, thereby increasing the output voltage and leads to high gain. This is done due to the reduced drain current of T2 and increased drain current of T4. The T4 and T2 are paired such that T4 helps T2 for a change in output voltage.

III. COMPARISONS

Topology	Voltage gain (dB)	Power dissipation (mW)
Differential Amplifier with passive load	16.01	6.04
Differential Amplifier with active load	21.19	2.13
Differential Amplifier with diode connected topology	35.43	1.83

Table 1: Comparison between different topologies

IV. CONCLUSION

In this paper the different topologies of differential amplifier are designed and analyzed in terms of gain, gain bandwidth product and CMRR.

V. FUTURE WORK

In future work we will design and analyze the different topologies of differential amplifier using different technologies and after that made a comparison between them in terms of voltage gain and power dissipation.

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