CMOS Technology Differential Amplifier

Monika Mehra, R P Singh
RIMT University, Mandi Gobindgarh, Punjab
Email id- monika.mehra@rimt.ac.in

ABSTRACT: ***This study will show how to construct a Complementary Metal Oxide Semiconductor (CMOS) technology differential amplifier. The model is examined with an active load in this article. N-type Metal Oxide Semiconductor (NMOS) and P-type Metal Oxide Semiconductor (PMOS) were used for simulations via the Advance Design System (ADS). The differential amplifier, as stated in electronic settings, is a popular and essential element in the creation of the analogue circuit. Its features are assessed by gain, bandwidth results and Common Mode Rejection Rate (CMRR). We have a circuit that includes bipolar and MOS. It employs NMOS and PMOS devices to create differential pairs, using the N channel and applying the current P-channel mirror load. This article presents an amplifier design utilizing 0.18μm with a 1.8V CMOS supply voltage. In order to accomplish the parameters and purpose of the circuit we utilize NMOS current meter loads from different topologies. The optimal architecture of this device with 0.18 μm and a supply voltage of 1.8V, is illustrated using an ADS tool.***

KEYWORDS: Circuit, Common Mode, CMOS, Current, Differential Amplifier, Voltage.

1. INTRODUCTION

In the last several decades Very Large Scale Integration (VLSI) has been influenced by the huge transformation in the electronics industry in the era of high integration (VLSI) technology. Due to the advent of MOS transistors, most major modifications have been launched on the market. The integration of integrated circuits into ultra-scale integration on a small, medium and large scale has transformed and revolutionized the electronic world [1]. The differential amplifier is an amplifier type to reinforce the difference of two voltages in a system. We utilize a differential amplifier in electrical circuits to provide high voltage gain and high CMRR. Its major features are very low input current bias, very high input impedance and very low offset voltage. The main advantage of the common mode differential mode is its increased noise tolerance. Furthermore, differential amplifiers enhance ambient noise immunity, linearity and higher signal swing [2].

It may work in two modes: common and differential. The usual technique results in a zero voltage rating and a high voltage rating is achieved in differential mode. In view of such, the differential amplifier has high CMRR in general. The amp generates an output voltage value near zero when the two input voltages are of equal value. The amplifier provides a high voltage output if the two input voltages are uneven. The significant benefit of differential operation over common mode is its greater noise tolerance. Another benefit is that the voltage is increased by the maximum to the highest voltage of 2 (V_{DD}-(V_{GS}-V_{TH})). This is the result of the voltage swing [3].

The MOS transistor improves CMOS technology's strength. By reducing feature dimensions and applying optimization methods, CMOS technology meets all design limitations, such power, speed and area. These technology are applied to decrease the voltage of supply, VTCMOS, MTCMOS, etc. In comparison with single-ended amplifiers, CMOS differential amplifiers are more often utilized for varied purposes. There are two inputs and two outputs in a completely differential amplifier circuit. Sensitivity is a fundamental need for the design of differential amplifiers. When the component matches, its drift drives the processed signal to produce a distinct output differential voltage. The minimal, predictable difference voltage levels are controlled by this voltage. Such a flaw may transform the common input mode signal into the differential output, where the desired signal is handled [4].

1.1 The Role of Differential Amplifier and its Basics:

The difference amplifier increases the difference between V+ and V- shown input signals and eliminates any common signals from both sources. Its ideal qualities are a high input impedance, lower distortion and low output allowance and an infinite bandwidth and gain and a Common Mode Rejection Ratio (CMRR). It also has reduced harmonic distortion and a high voltage fluctuation. Its properties test the circuit's efficient performance [5]. In linear amplification circuits, these amplifiers are employed in order to get minimal distortion of the output. They can be constructed in several ways to achieve a single or double-end output. The most often used amplifier design is the dual-ended one, whereby two inputs have two outputs, called a completely differential amplifier. Its benefit over single ends is easy bias, good linearity and great noise immunity. However, it's got a wide area [6].

At the output of the amplifier a feedback circuit resembling a common mode is utilized to modify the distortion current, thereby denying the common mode indicators. The latter is defined as the difference from the final output voltage to the ideal output voltage when the common signal is delivered to both end inputs in the two types of offset voltages, the input offset and output offset voltage. The same applies when the difference tension gain separates the output offset tension, named the input offset tension. The circuit shown in Figure 1 implies that the output response has distortion when Vin1 and Vin2 have an immense common level of dc mode which is uneven. The M1 and M2 bias currents likewise change as Vin.cm changes. Therefore, the trans-conductivity of the devices and their dc level output are modified. This causes a modest signal gain for amplifiers, which is the problem.

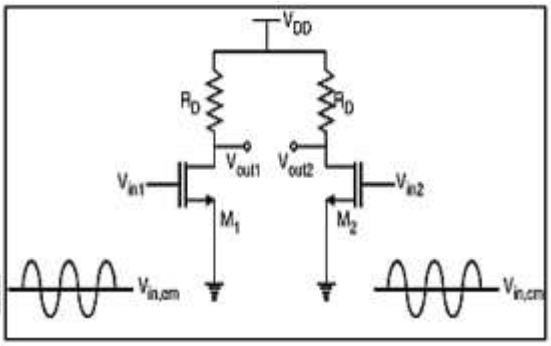

Figure 1: Simple Differential Amplifier.

In order to overcome this problem the circuit is changed to make the ID1 and the ID2 independent of Vin.cm using a current source (I_{ss}). The next updated figure is the circuit with the source Issue. The biasing current of the single transistor is the same when the two inputs Vin1 and Vin2 is the same and the common output mode is VDD. For maintaining the common mode level, a minimum bias current is required. The active MOSFET load differential amplifier is shown in Figure 2. M1 and M2 are a DA pair, whereas M5 is a falling current with an amplifier bias. The current mirror is M3 and M4. Because every transistor is treated as a bulk of every transistor linked to its respective sources in the saturation area, the current flows from M5 into two equal portions which flow through M1, M3, M2 and M4. As a result, M3 and M4 transistors are connected to VDD during connection to VSS.

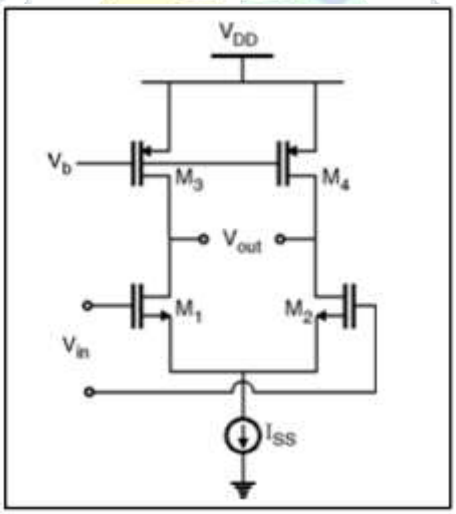

Figure 2: Differential Amplifier with Current Source Load.

Figure 3 is meant to create a differential pair using two n-channel MOSFETs (M1 and M2). RD resistors are used for saturation as a load for driving transistors. At the MOS transistors' door terminal, Vin1 and Vin2, are inducted where they are equal in size and in phase opposite. Nodes X and Y measure the output voltage and the differential signal is measured between these nodes with an equal size and opposite phase to the inputs. Its main benefit is a higher voltage swing.

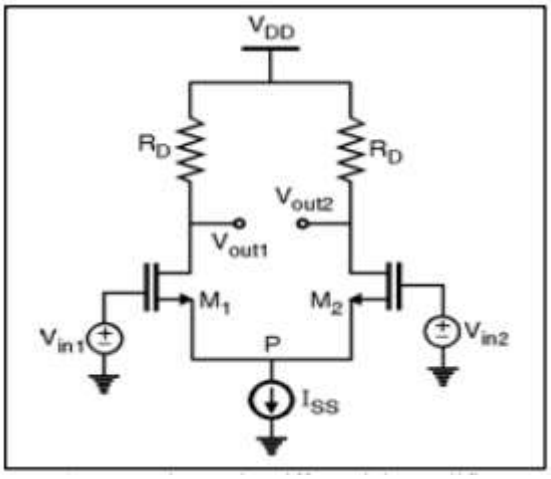

Figure 3: The Basic Differential Amplifier.

By the constant current source, that is shown as I_{ssin} the system, biasing problems are overcome. Figure 4(a) depicts a continuous current source used to keep the minimum current bias in order to prevent the effects of variations in common mode level at the output level. The optimal current source in that circuit is superseded by a transistor, which supplies a constant voltage source in the saturation area. This is an ongoing source of current information.

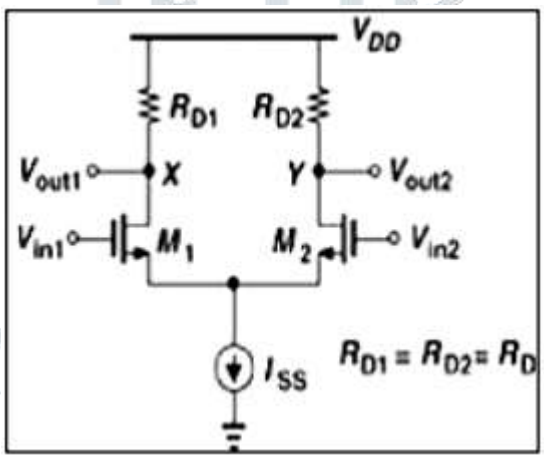

Figure 4(a): Differential Amplifier with Passive Load and Current Source.

1.2 DA with Active Load:

The following circuit employs diverse loads, such as the current source load, through active components. It helps to solve the problem of the reduction of the voltage swing and its influence on gain due to the common mode if a diode is attached. PMOS transistors were utilized as a load for selecting the right measurements and bias current. W/L of PMOS is expected to decrease in terms of high gains (see Figure 4(b)).

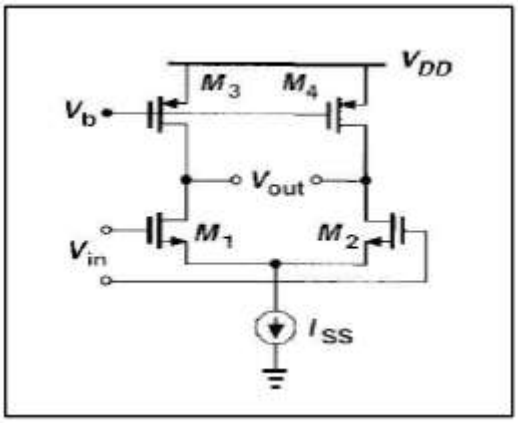

Figure 4(b): Differential Amplifier with Active Load.

1.3 NMOS:

The NMOS transistor body is connected to the source voltage by means of the positive gate V_{gs}=1,8V and draining to the source voltage V_{ds}=1,5V. The resulting I-V characteristics between Id and V_{ds} are shown. If the source voltage is gateway, the current Id only fluctuates as long as V_{gsis} exceeds the threshold voltage. The BSIM-3 model is used for the simulation of the NMOS transistor, with all parameter values coming from the 0.18μm technology file for the TSMC model. Length of NMOS for 1 μm and breadth 10 μm should be regarded. And then the voltage β threshold is calculated and utilized for additional computations. The current Id does not exist when the positive gate voltages apply to NMOS with V_{gs}=0, even if some positive V_{ds} have been used. A sufficiently high positive gate V_{gs} must be used to achieve a considerable quantity of Id. The minimal voltage gate producing the reverse N-type layer that drains the stream voltage becomes the threshold voltage when the V_{gs} is equal to V_t. If Vgs is below V_t, it's the Id=0. Only when $V_{gs}>V_t$ starts the I_d. Virtual channel grows in some V_{ds} with more V_{gs}.

1.4 PMOS:

The PMOS transistor body is connected with a source with a negative gate at the source voltage V_{gs}=1.8V, and a drain at the source V_{ds}= -1.5V. The I-V characteristics show the results of different V_{gs} and I_d and V_{gs} values between Id and V_{ds}. If there is a negative voltage gate, the current Id will only fluctuate if the V_{gs} is higher than the threshold voltage. The PMOS transistor simulation is decided on the BSIM-3 model, whilst the TSMC model file with technology 0.18 μm is used to obtain all parameter values. For 1μm and 10μm width, PMOS lengths are considered. The threshold voltage β is then calculated and further calculations are made. The current Id does not exist when the negative gate voltage supplied to V_{gs}=0 NMOS even if certain negative V_{ds} were applied. A sufficiently high negative V_{gs} gate is required in order to achieve a considerable amount of Id. If V_{gs} is equal to V_t, the minimal gate at the source voltage generates the inversion layer of type P, which drains the current flow. If V_{gs} is below V_t, it's the Id=0. Only when $V_{gs}>V_t$ starts the Id. Virtual channel grows in some V_{ds} with more V_{gs}.

2. LITERATURE SURVEY

K. N. Salama *et al.* presented in the article that a novel operational CMOS amplifier (OTRA) implementation is introduced. The features of the OTRA have been demonstrated to be suited to VLSI applications which use the Ohmic MOS transistors. The OTRA applications are provided for the manufacturing of voltage amplifiers, multipliers, integration devices, continuous time filters and squares. Voltage mode filters are given on the OTRA input terminals which benefit from the existing processing capabilities. A thorough study is presented which takes into account the effect of the limited trans-resistance gain. The suggested circuits are given with both passive compensation and self-compensation. PSpice simulations are based on the AMI 1.2 μm N-well level 3 parameters for the efficacy of the proposed circuits [7].

M. J. S. Smith *et al.* presented in the article that in an undergraduate course on analogue VLSI design, we discuss the application of software developed as part of an analogue CMOS integrated circuit design research program. This method involves a few unconventional applications of programs available on microcomputers such as Macintosh or IBM PC-clones which are easily accessible, cheap and simple to use. The approach is rather generic and additional possible applications are presented, but it should be used in the design of CMOs operating amplifiers at the outset. The versatility of the programs, including circuit simulators and programs for schematic entering and layout, allows them to be utilized with other CAD software. The tools allow undergraduates, without being overwhelmed or losing their grip on the underlying ideas, to construct integrated CMOS analogue circuit designs utilizing state-of-the-art CAD approaches. The details of programs and their use and the analogue IC designs produced by NSF are provided (MOS Implementation Service) [8].

H. Alzaher *et al.* presented in the article that this brief describes the completely balanced version of the DDA as the key component for the implementation of fully differential CMOS analogue circuit designs (ICs). We prove that FBDDA is the answer to systematically construct completely differential versions of every single finite op-amp based circuit. It gives an excellent and effective solution to the differentiation. We also show that the FBDDA shows a wide variety of inputs without requiring complicated circuits, unlike the DDA. A low-power class AB CMOS developed and constructed on a 1.2-μm technology for the suggested circuit is now being implemented. The experimental verification of all suggested design approaches and circuits [9].

E. Vittoz *et al.* presented in the article that on the basis of earlier works, there is a simple model to describe the de behavior of MOS transistors that work in the weak reverse. This model has just 2 parameters and may be designed for a circuit. It is experimentally checked for a Si-gate low voltage CMOS technology, both p- and n-channel test transistors. Several circuit designs are presented and evaluated using a weak reverse operation: The amplitude detestation technique, performed on a quartz oscillator with a very low power consumption result (>0.1 microwatts at 32 kHz), and the low-frequency amplifier are two alternative current references based on existing bipolar circuits. These circuits are resistant to threshold and mobility changes and compatible with the digital low-power circuit CMOS technology [10].

3. DISCUSSION

3.1 Differential Amplifier Design:

NMOS and PMOS transistors are included in the DA design. NMOS current mirror is utilized to provide the differential amplifier with a steady current, where entire transistor body is linked to the transistor source. The voltage of the VDD is 1.8V. Vin1 and Vin2 input terminals connect to a 0.8V V_{dc} sinus wave, with an amplitude of 1mv and V_{dc} 0.5V, respectively with a phased shift of 180. The 10pf load is connected from the V_{out} Terminal. The differential amplifier is simulated using BSIM3, NMOS and PMOS models here. Because we take MOS into account in the saturation area, $V_{outover}$ time is demonstrated by temporary analysis and simulation. Also provided is the computation of the AC gain analysis. We suppose that the slew rate is 10V/µsec, and from that slew rate and capacity we can calculate the current flowing across the transistor.

Slew Rate = $(dV/dt) = I/C_L$.

An input signal amplifier amplifying the difference between the two input voltages is the prime function. The input signal amplifying. In order to boot an entry signal, such as bipolar or unipolar transistors, such as MOSFET, FET, and BJTs, you require active elements (components). A difference amplifier cannot be constructed using simply passive components and active components. For differential amplifiers, certain circuits may be utilized. But it provides a wide range of answers. Ideally, differential amplifiers with zero output impedance should have an endless gain and impedance, while all frequencies are arithmetically perfect, and so far are not passive. A functioning and fair device might generally be easy when creating discrete elements: at least two transistors and a driver with two or more transistors with a few passives. Because the resistance to the current almost negligible, MOSFETs are ideal for driving.

4. CONCLUSION

In order to amplify two input signals and establish the difference, a differential amplifier is constructed. A design is necessary to do this. In this paper, the model is analyzed using an active load. NMOS and PMOS were employed, and their simulations are presented via the Advance Design System (ADS). ADS also shows the architecture of the amplifier. The circuit parameters are for operating amplifier applications and the W/L ratios are established. In addition, ADS improves the accuracy of the outcomes. This article presents an amplifier design utilizing 0,18µm with a 1.8V CMOS supply voltage. In order to accomplish the parameters and purpose of the circuit we utilize NMOS current meter loads from different topologies.

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