

Obtaining PSRR for a CMOS differential amplifier with active load

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Abstract

for three modes: 27 °C temperature and TT process corner, -40 °C temperature and FF process, 85 °C temperature and SS process corner, we get the parameters for this amplifier in 90 nm CMOS technology. The differential amplifier is one of the most important circuit inventions and dates back to the time of electronic lamps. Differential operation is one of the main options in analog and mixed-signal circuits due to its many advantages. An amplifier is an electronic device or circuit used to increase the size of the signal applied to its input. In this simulation, we use the Hspice program, this circuit will have 6 MOSFETs, and as a result, there will be 12 MOSFET channel lengths and thicknesses. In this simulation, We will check PSRR, in three cases with different temperatures. Likewise, Excel and MATLAB programs were used to obtain more accurate values and graph shapes. With HSPICE software, analog circuits can be fully checked. PSRR stands for Power Supply Rejection Ratio, which measures the amplifier's ability to reject changes or fluctuations in the power supply voltage.

Keywords: PSRR, Differential Amplifier, Hspice, CMOS.

Introduction

Humans have always wanted to make things as easy and fast as possible. Today, most human needs are met with several times the speed compared to three decades ago, for example, a transistor reacts with a speed of 1 nanosecond, and this speed is much faster than the human brain. However, they are not superior to the human brain. What has made the human brain superior to all man-made creatures is a very complex system of brain neurons. One of the important features of the synthesis of advanced circuits is the efficiency and, if possible, automatic analog tool design. It has always tried to provide a method to determine the size of devices in analog integrated circuits (IC) based on specific relationships. For this purpose, to estimate We must simulate the best characteristic of each circuit for each value in the variables of the problem. In addition, we must consider the way of biasing and the working area and input sources. The result of the simulation changes by changing the variables and it is as if we are facing another problem. Here we will simulate a CMOS differential amplifier with active load with an Hspice simulation tool in 90 nm CMOS technology. Electrical engineering students get acquainted with the analysis of analog circuits, from simple and low frequency to advanced and high frequency, and the simulation of these circuits. With this software, analog circuits can be fully checked. Spice is a program that simulates electrical circuits on a home computer. You can see any voltage with the current waveform of the circuit. SPICE calculates these voltages and currents against transient analysis time or DC frequency analysis. Many Spice programs also perform other studies such as the following.

- sensitivity analysis
- Distortion analysis
- Noise analysis
- Analysis A

SPICE stands for program simulation with an emphasis on integrated circuits. Researchers at UC Berkeley developed this computer program in the mid-70s. The emergence of integrated circuits required a method to test the circuit design before the expensive manufacturing process. It was necessary to write software that could make the circuit design and simulation process easier and integrated circuit engineers could create their designs in a similar computer environment. Build and troubleshoot. Today, SPICE provides graphical tools (waveforms) and graphic processors for drawing graphs and waveforms. SPICE simulators and applications are extended to analog and digital circuits, microwave instruments, and electromechanical systems. Spice is a great tool for electronics education. As you work with programs and perform operations. Experiment and modify the circuit and see what happens. How does this action happen? Change the value of resistance and see its effect on the circuit in a few seconds. You can increase your understanding of circuits, [1, 2].

Spice works like this:

1. The circuit is added in a CIR text file that describes it, which is called a netlist. Or you design the circuit using graphic symbols on a visual diagram board.
2. Activate the simulator, Spice Net reads the list and then performs the required analysis such as AC and DC or transient responses. The result is added to a text output file OUT.
3. You can see the simulation result in the output text file (OUT). Many SPICE programs provide a graphical display of the waveforms in the binary data files it displays saved.

Circuit simulation steps in HSpice software:

1. Draw the circuit and name each node
2. Label each component and assign a value to it.
3. Create a text file (netlist) and enter all components and connections of nodes in a list.
4. Decide on the sample analysis you want to perform AC, and DC transient noise, and write a suitable description for the circuit.
5. Run the simulation and see the result, [1, 2].

An amplifier is a general term used to describe a circuit that produces and amplifies a version of its input signal. However, all amplifier circuits are not the same and they are classified according to their circuit configuration and mode of operation.

In "electronics", small signal amplifiers are generally used devices that have the relative ability to amplify a small input signal, for example in a sensor such as an optical component, a much larger output signal to operate a relay, lamp, or speaker. have created There are many types of circuits classified as amplifiers, from small-signal operational amplifiers to large-signal power amplifiers. The classification of an amplifier depends on the size of the signal, its magnitude and magnitude, its physical configuration, and the way it transmits the input signal, it is a relationship between the input signal and the current in the load. Amplifiers can be a simple box or block that includes an amplifier component such as a bipolar transistor, field effect transistor, or operational amplifier that has two input terminals and two output terminals connected to ground with an output signal that is much larger than the input signal. As it happens in "enhanced", considered. As an explanation for the gain of the amplifier, the relationship between the signal measured at the output and the signal measured at the input can be expressed. The differential amplifier amplifies the voltage difference between the input pins. As a result, if there is a common voltage such as noise in both pins, it will not affect its output voltage. For this reason, differential amplifiers are widely used in industrial applications to amplify the output signal of sensors. In operational amplifiers, one of the two input terminals of the inverting negative input

(or non-inverting) positive input is usually used to amplify a single input signal. The other legs are connected to the ground. So, in this arrangement, signal amplification is not differential and actually the signal is amplified relative to the ground. But because standard operational amplifiers have two inverting and non-inverting bases, as a result, the input signal can be connected to both input terminals at the same time and produce another common type of circuit based on operational amplifiers, which are called differential amplifiers. All operational amplifiers, abbreviated Op-Amps, are essentially differential amplifiers due to their input configuration. To design a differential amplifier with limited and controlled gain, it is necessary to create negative feedback by adding other peripheral circuits to the IC of the operational amplifier. The differential operational amplifier amplifies the difference between two input voltages, and for this reason, unlike the adder amplifier that adds the input voltages together, this circuit is a subtractive operational amplifier. Using the principle of the sum of works, the output voltage can be obtained easily. It is enough to consider one of the sources and zero the other at any moment, [3, 4, 5, 6, 7].

Equations

PSRR stands for Power Supply Rejection Ratio, which measures the amplifier's ability to reject changes or fluctuations in the power supply voltage. A negative PSRR indicates that the output voltage of an amplifier changes in the opposite direction to changes in the supply voltage. In general, a negative PSRR can indicate an instability or a design problem in the amplifier circuit. It may be caused by improper biasing, inadequate isolation or filtering of the power supply, or a mismatch between circuit components, [8, 9, 10, 11, 12, 13].

To address a negative PSRR, several steps can be taken:

1. Check Bias: Make sure the amplifier is properly biased to operate in its linear region. Improper biasing can lead to undesirable variations in the output voltage with changes in the power supply.
2. Improved power supply filtering: Use better filtering techniques to reduce noise and fluctuations in the power supply. This may include adding decoupling capacitors, using a low-pass filter, or using voltage regulators to provide a stable and clean power supply.
3. Check for component mismatches: Check if there are any mismatches in component values or attributes exists which can cause negative PSRR. Check for changes in resistor or capacitor values, transistor characteristics, or other amplifier circuit components.
4. Reevaluating Circuit Design: Review the overall circuit design, including gain stages, feedback mechanisms, and coupling techniques. Make sure the amplifier is designed to minimize the effect of power supply variations on the output voltage.
5. Simulation and testing: from simulation tools or taking measurements for analysis Use amplifier behavior under different power supply conditions. This can help identify specific areas of the dermis that contribute to negative PSRR.

By addressing these considerations and taking the necessary corrective measures, the negative PSRR in the amplifier circuit can be reduced or eliminated and a stable and accurate output voltage can be ensured even in the presence of power supply fluctuations.

To achieve a positive PSRR power supply rejection ratio, you want the output voltage of the amplifier to remain constant and not be affected by changes or fluctuations in the supply voltage. A positive PSRR indicates that the amplifier effectively rejects changes in supply voltage, [14, 15, 16, 17, 18, 19, 20, 21, 22, 23].

Here are some steps to improve or achieve a positive PSRR:

1. Power Supply Filtering: Implement effective power supply filtering techniques to reduce noise and fluctuations. This can include the use of decoupling capacitors or voltage regulators to provide a stable and clean power supply.
2. Power Supply Isolation: Place isolation capacitors across the power supply pins of the amplifier. These capacitors can help filter out high-frequency noise and stabilize the power supply voltage, improving the rejection of amplifier power supply variations.
3. Landing techniques: Landing techniques are appropriate to minimize land loops and reduce Performance noise coupling due to improper ground connection. This can include using a star or dedicated ground, separating analog and digital grounds, and minimizing ground surface disturbances.
4. Component Selection: Select components with good linearity, low thermal sensitivity, and quality specifications. Look for parts that are specifically designed for low noise and high stability.
5. Feedback Mechanisms: Include appropriate feedback mechanisms in the amplifier circuit. Techniques such as negative feedback can help stabilize the output voltage and reduce the dependence on the power supply voltage.
6. PCB layout: Pay attention to the layout of the amplifier circuit on the PCB. Proper placement and routing of traces can minimize noise coupling and improve the rejection of power supply changes.
7. Simulation and testing: tools for simulating or taking measurements to analyze behavior Use the amplifier under different power supply conditions. This can help identify areas for improvement and validate the positive PSRR.

By implementing these measures and carefully designing the amplifier circuit, a positive PSRR can be achieved, which indicates that the amplifier effectively rejects changes in the power supply voltage and provides a stable output voltage, [24, 25, 26, 27, 28, 29, 30, 31, 32, 33].

Mode voltage gain ratio - differential over power supply voltage gain = PSRR (1)

[34]

AC source in series with V_{dd} = power supply gain (2)

[35]

Excel and MATLAB were used to obtain PSRR.

Tables, Figures and Photographs

Simulation of a CMOS differential amplifier with active load with Hspice simulation tool in 90 nm technology CMOS.

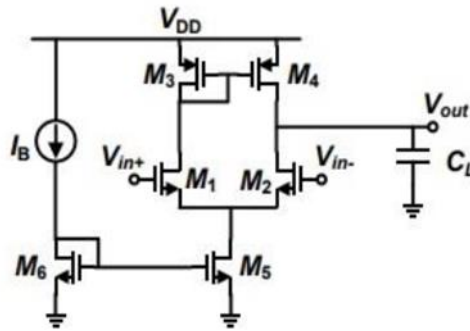


Figure 1: CMOS differential amplifier with active load

Table 1: Values of the elements of this amplifier

Parameter	Value
(W/L)1,2	4*4μm/0.15μm
(W/L)3,4	8*8μm/0.25μm
(W/L)5	10*4μm/0.25μm
(W/L)6	1*4μm/0.25μm
I_B	100μA
C_L	2pF
V_{cmi}	0.8v
Power supply voltage	1.2v

Simulation Setup:

The simulation utilizes Hspice to analyze a differential amplifier designed in 90 nm CMOS technology. The simulations are performed for three temperature conditions:

- 27 °C with TT process corner (typical conditions)
- -40 °C with FF process corner (fast-fast corner, representing worst-case low temperature)
- 85 °C with SS process corner (slow-slow corner, representing worst-case high temperature)

The simulation likely involves injecting an AC signal into the amplifier while sweeping the power supply voltage to determine the PSRR.

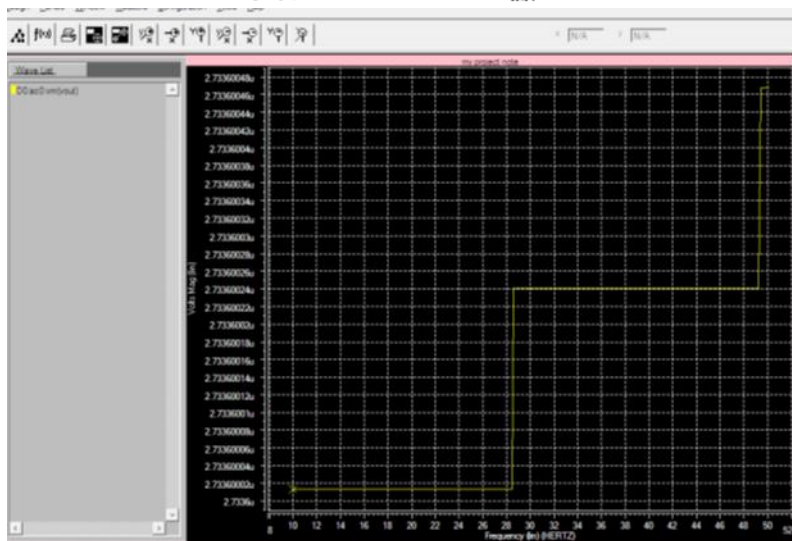


Diagram 1: Command and profit code of the power supply at a temperature of 27°C for the T process

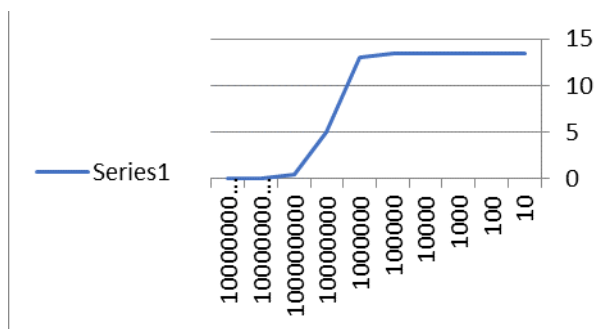


Diagram 2: Mode voltage gain – differential

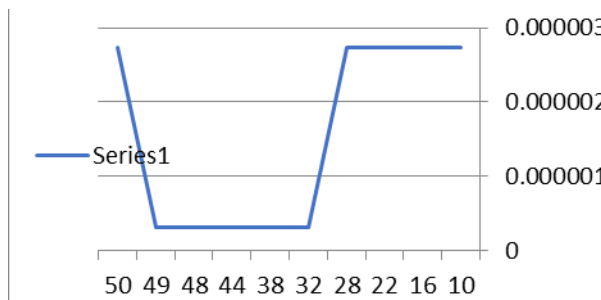


Diagram 3: Power supply voltage gain

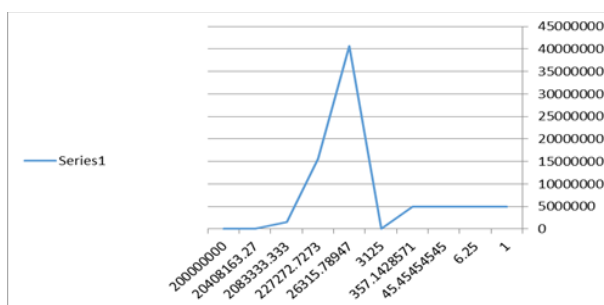


Diagram 4: PSRR temperature of 27°C TT process



Photograph 1: PSRR temperature 27°C process TT "MATLAB software"

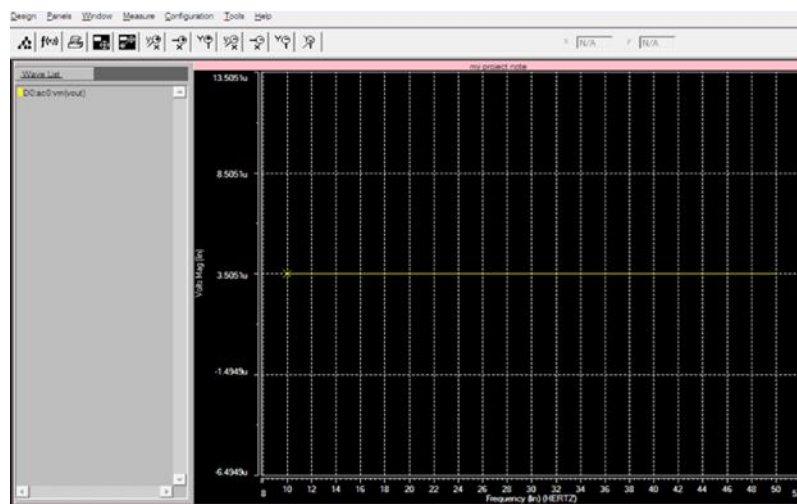


Diagram 5: Power supply voltage gain, -40°C temperature, and FF process corner

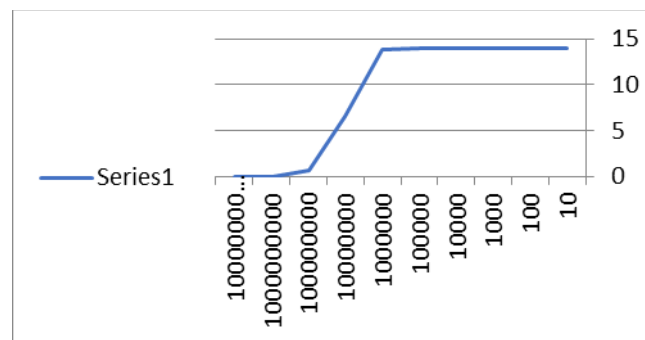


Diagram 6: Differential mode voltage gain

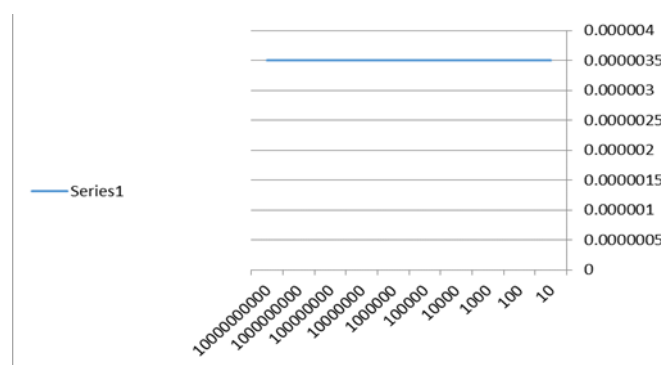


Diagram 7: Power supply voltage gain

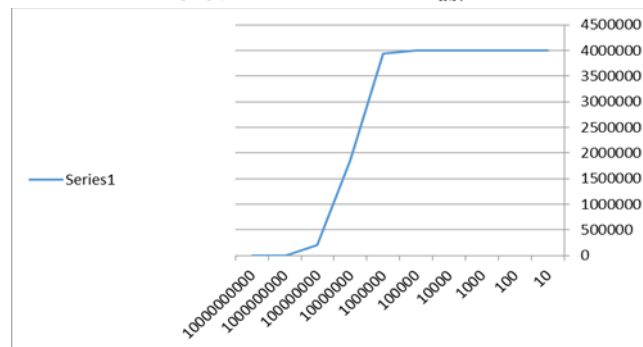


Diagram 8: PSRR temperature -40°C and FF process corner



Photograph 2: PSRR temperature -40°C and FF process corner "MATLAB software"

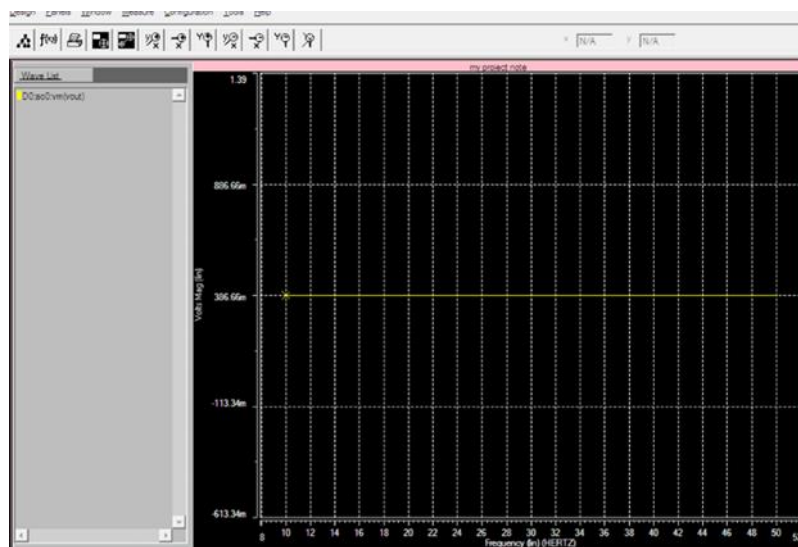


Diagram 9: Power supply voltage gain, 85°C temperature, and SS process corner

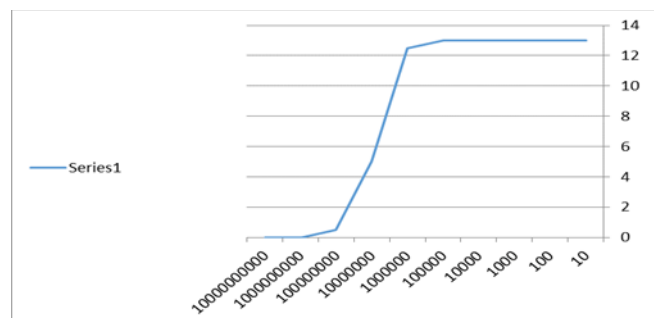


Diagram 10: Mode voltage gain – differential

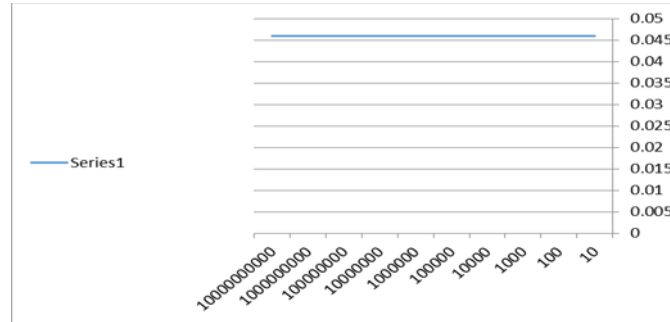


Diagram 11: Power supply voltage gain

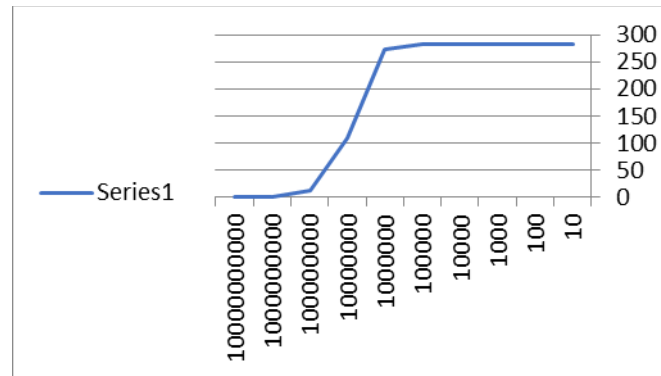


Diagram 12: PSRR temperature of 85°C and SS process corner



Photograph 3: PSRR temperature 85°C and SS process corner "MATLAB software"

Results Discussion

This section analyzes the concepts of PSRR, how to address negative PSRR, and techniques to achieve positive PSRR.

- The article effectively defines PSRR and its impact on amplifier output voltage stability.
- It outlines clear steps to troubleshoot and rectify negative PSRR issues in amplifier circuits.
- The article provides valuable methods to improve or achieve a positive PSRR for optimal amplifier performance.

Discussion:

- The negative PSRR section emphasizes the importance of proper biasing, power supply filtering, and component selection for amplifier stability.
- It highlights how mismatches and design flaws can contribute to negative PSRR, requiring corrective measures like circuit reevaluation and simulations.
- The positive PSRR section underscores the effectiveness of filtering, isolation techniques, proper grounding, and feedback mechanisms in achieving a stable output.
- It emphasizes the role of component selection, PCB layout, and simulations in optimizing PSRR.

Strengths:

- The article offers a practical approach to understanding and addressing PSRR in amplifier circuits.
- It provides clear and actionable steps for troubleshooting and design considerations.

Conclusions

With advanced integrated circuit technology and aggressive scaling into the nanometer regime, statistical variability in device electrical characteristics caused by the discreteness of charge and fabrication process variations has significantly increased. These variations in turn result in fluctuations in output characteristics of important analog building blocks and in particular, amplifiers.

By definition, a single-ended signal is a signal that is measured concerning a fixed potential, usually ground. According to the definition, the differential signal is a signal that is measured between two nodes with changes of the same magnitude and opposite sign (relative to a constant potential). These two nodes must have the same impedances

concerning that fixed potential. The potential to which the signal is measured is called the "common mode" (CM) level. It is better to think of the CM level as the bias value of the voltages, that is, the value that exists without a signal. By examining the circuit in three states with different temperatures, we saw that the amount of gain changes, but generally, the changes are in the same range, [36, 37, 38].

Overall, this article provides a valuable foundation for understanding PSRR and its importance in amplifier design. By incorporating the suggested improvements, you can create an even more comprehensive and informative resource.

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