Transistor-Level Implementation and Simulation of CA3140 BiMOS Operational Amplifier in eSim

eSim Research Migration Project

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Abstract

This work presents the transistor-level implementation and simulation of the **CA3140 BiMOS operational amplifier** using eSim. The circuit combines a MOSFET input stage with a bipolar output stage to achieve high input impedance and efficient output drive capability. The designed circuit is tested in a voltage follower configuration, and its performance is analyzed in terms of gain, slew rate, and transient response. Simulation results are compared with datasheet characteristics to validate correct operation.

1 Introduction

Operational amplifiers are fundamental building blocks in analog electronics, widely used in signal processing, filtering, and amplification. The CA3140 is a **BiMOS op-amp** that integrates MOSFET and bipolar technologies to provide both high input impedance and high-speed performance. Unlike conventional op-amps, it allows operation close to the negative supply rail, making it suitable for single-supply applications. This project focuses on understanding its internal design and reproducing it at the transistor level using eSim.

2 Circuit Description and Working Principle

The CA3140 consists of three main stages: a **differential input stage**, a **high-gain intermediate stage**, and a **class AB output stage**. The input stage uses PMOS transistors to provide very high input impedance and low input current. The second stage provides most of the voltage gain and includes internal compensation for stability. The output stage uses bipolar transistors to deliver sufficient current to the load.

A biasing network ensures constant current operation across all stages, improving linearity and stability. In the voltage follower configuration, the output is fed back to

the inverting input, resulting in unity gain. The circuit accurately follows the input signal while maintaining high bandwidth and fast response.

3 Implementation Methodology in eSim

- Recreated the **transistor-level schematic of CA3140** in eSim using:

i MOSFETs (for input stage)

ii BJTs (for gain and output stages)

iii Resistors, capacitors, and diodes

- Designed and connected **biasing circuits and current mirrors** to ensure proper current flow and stable operation

- Implemented the **three main stages**:

i Differential input stage
ii High-gain second stage
iii Class AB output stage

- Applied a **split power supply (±15V)** to match datasheet operating conditions

- Configured the circuit in **voltage follower mode** (output fed back to inverting input)

- Used **transient analysis** for simulation with a pulse input signal

- Ensured proper **grounding and node connections** to avoid simulation errors

- Adjusted simulation settings to resolve **convergence issues** and obtain stable results

4 Results and Discussion

The simulation results show that the circuit operates correctly as a **voltage follower**, with the output closely tracking the input signal. The waveform exhibits minimal distortion and confirms unity gain behavior.

Key parameters such as **slew rate (~9 V/µs), fast rise time, and stable settling response** are observed, which are consistent with datasheet specifications. Minor deviations may occur due to idealized component models and simulation conditions. Overall, the results validate the proper functioning of the implemented circuit.

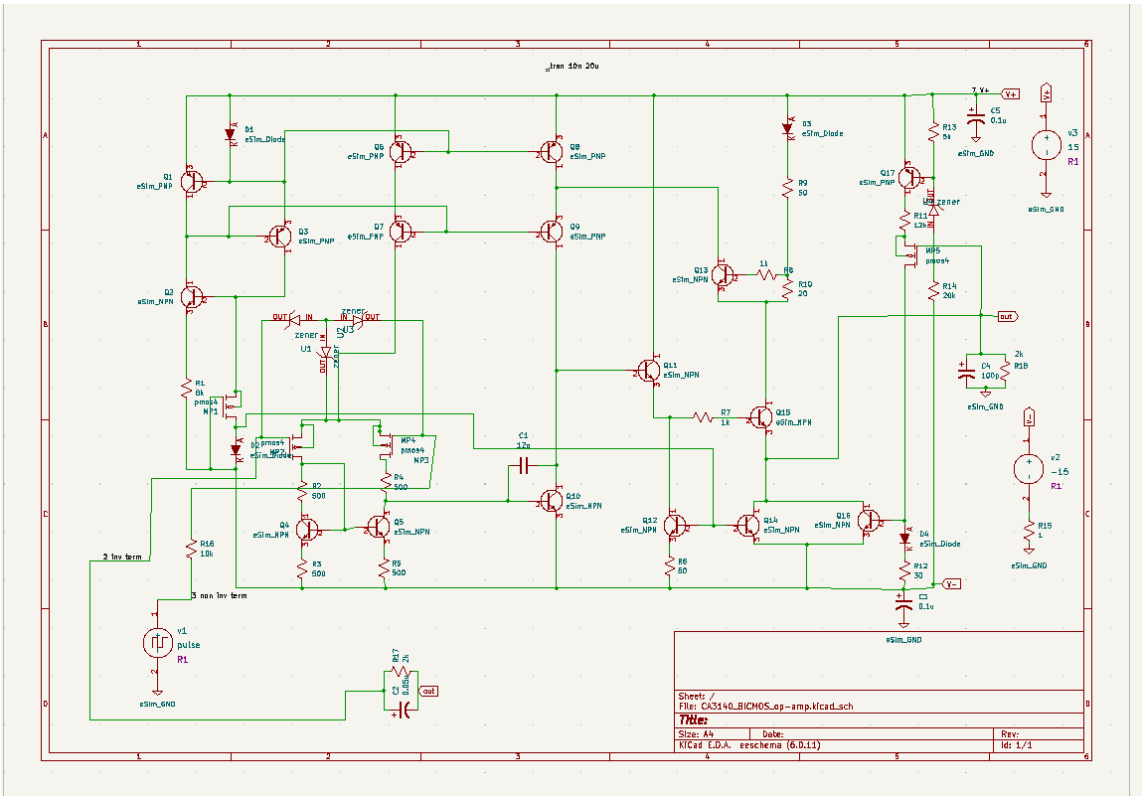

Figure 1: Schematic

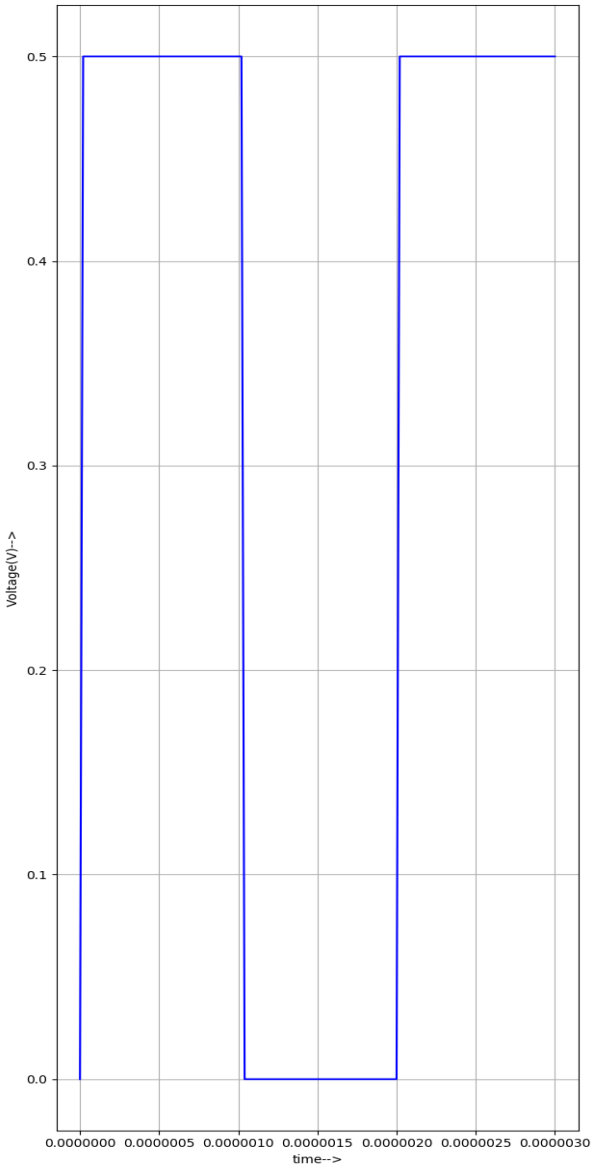

Figure 2: Input

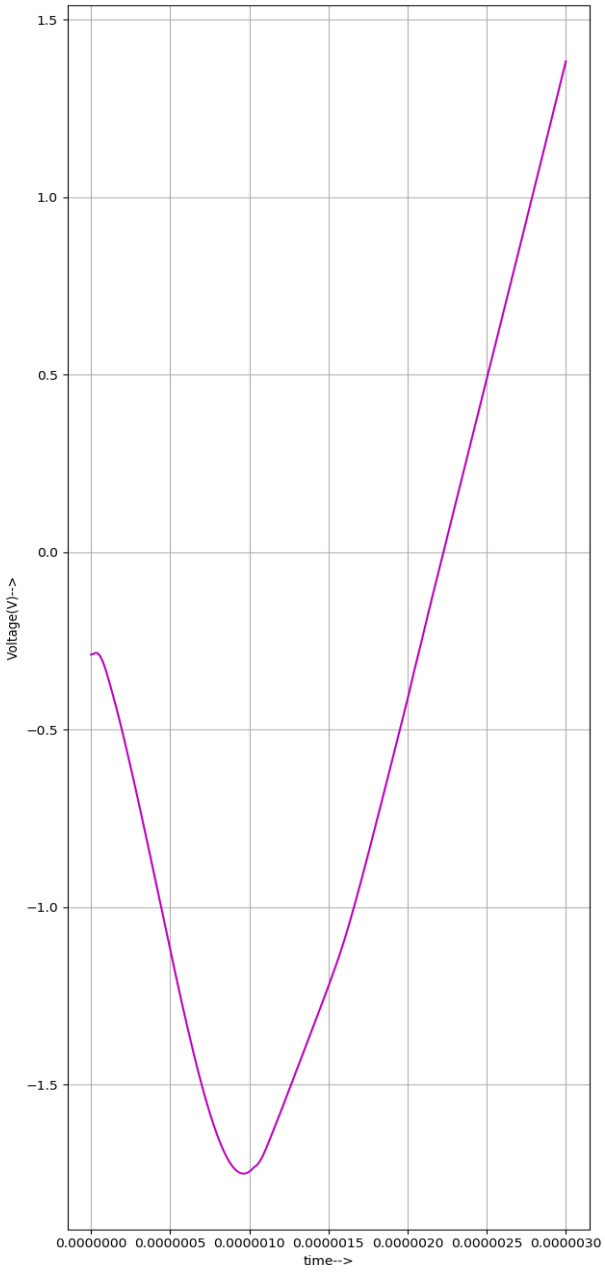

Figure 2: Output

5 Conclusion

The CA3140 operational amplifier was successfully implemented and simulated in eSim at the transistor level. The circuit demonstrates expected behavior, including high input impedance, unity gain operation, and fast transient response. The results closely match datasheet characteristics, confirming the accuracy of the design. This work provides a deeper understanding of op-amp internal architecture and highlights the effectiveness of eSim for analog circuit analysis.

References

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