
DESIGN AND SIMULATION OF A ANALOG MULTIPLIER CIRCUIT USING ESIM.

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Abstract

Abstract: The project focuses on the design and simulation of an Analog Multiplier using operational amplifiers in eSim. An analog multiplier is a circuit that generates an output proportional to the product of two input signals, which is widely used in modulation, signal processing, and communication systems. The circuit is implemented using a combination of logarithmic and antilogarithmic amplifiers, along with a summing amplifier and an inverting amplifier to obtain the correct polarity of the output. Simulation is performed using Ngspice and further analyzed using Python plots, validating the theoretical design. The results demonstrate accurate multiplication of input signals with the expected waveform characteristics, confirming the effectiveness of the log–antilog approach for analog multiplication in eSim.

KEYWORDS: Analog Multiplier, Operational Amplifier, Log Amplifier, Antilog Amplifier, Summing Amplifier, Inverting Amplifier, eSim, Ngspice Simulation, Python Plot.

INTRODUCTION

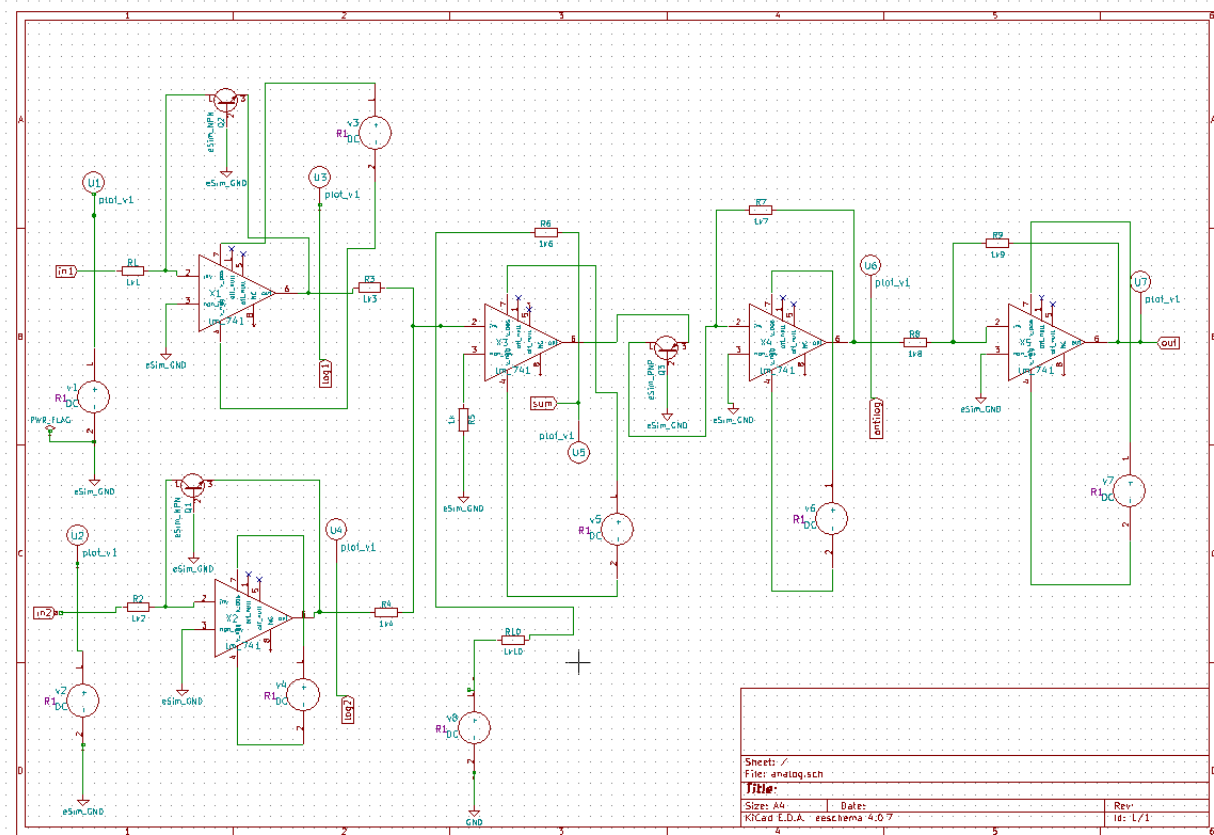
An **Analog Multiplier** is a circuit that produces an output proportional to the product of two input signals, widely used in modulation, frequency conversion, and signal processing. It can be designed using **log and antilog amplifier techniques**, where the inputs are converted to logarithmic form, summed, and then converted back using an antilog amplifier. Additional stages like summing and inverting amplifiers ensure correct polarity and scaling. In this project, the analog multiplier is simulated using **eSim**, with Ngspice for circuit analysis and Python for waveform verification, confirming the accurate multiplication of input signals.

THEORY

An analog multiplier is a device that produces an output voltage or current that is proportional to the product of two or more independent input voltage or current. The analog multiplier is designed using log and antilog amplifier. A log amplifier can be constructed using a bjt in the feedback to the opamp. The output of log amplifier is dependent on the saturation current which varies from transistor to transistor and also with temperature. Antilogarithmic or exponential amplifier does the exact opposite operation of a log amplifier. In analog amplifier the two inputs are given in the form of voltages to log amplifier respectively. The final output is $V_0 = kV_1 \cdot V_2$.

CIRCUIT DIAGRAM

Fig. 1: Circuit Diagram.



EXPECTED OUTPUT:

1. Ngspice plots:

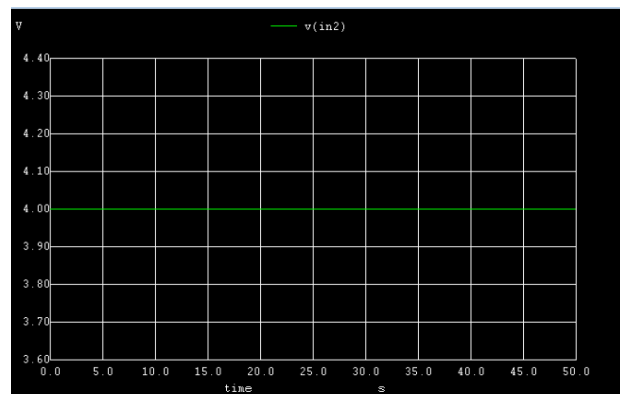
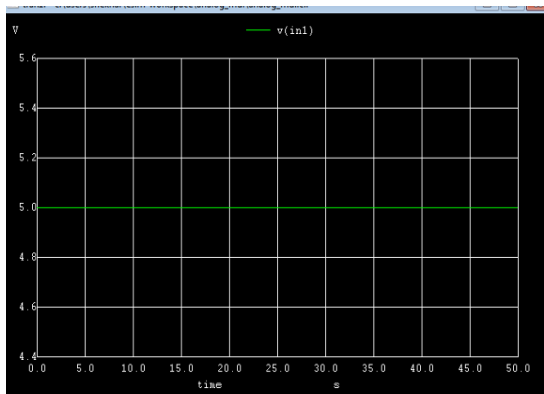


Figure 2: ngspice input 1 plot

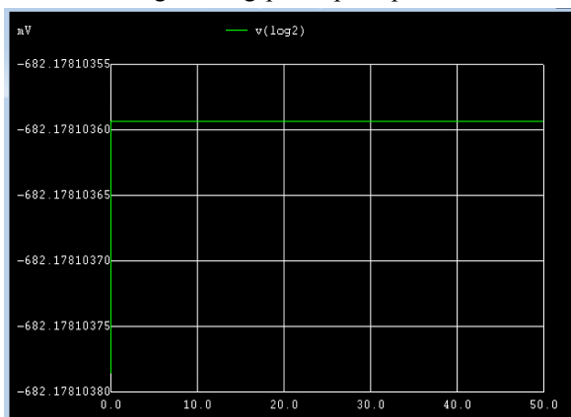
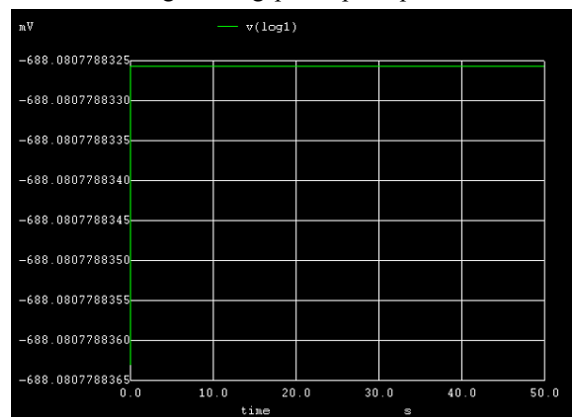


Figure 3: ngspice input 2 plot



OUTPUT WAVEFORM

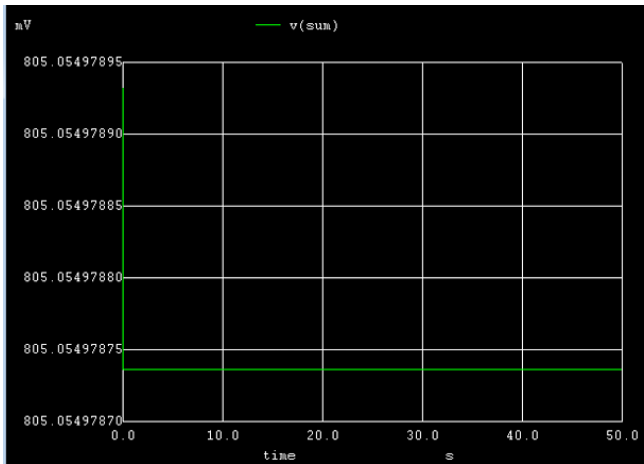


Figure 6: ngspice summing amplifier plot

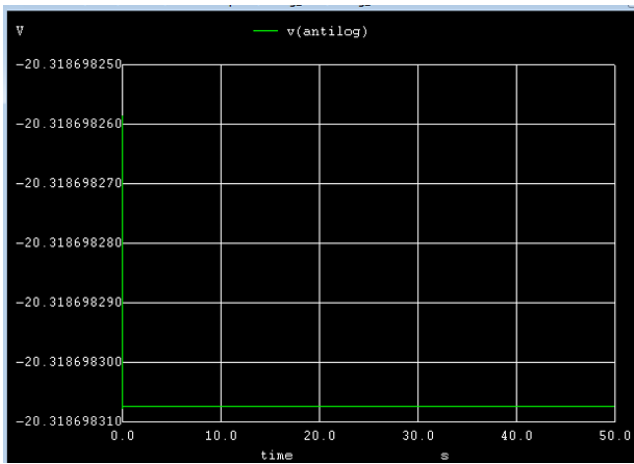


Figure 7: ngspice antilog plot

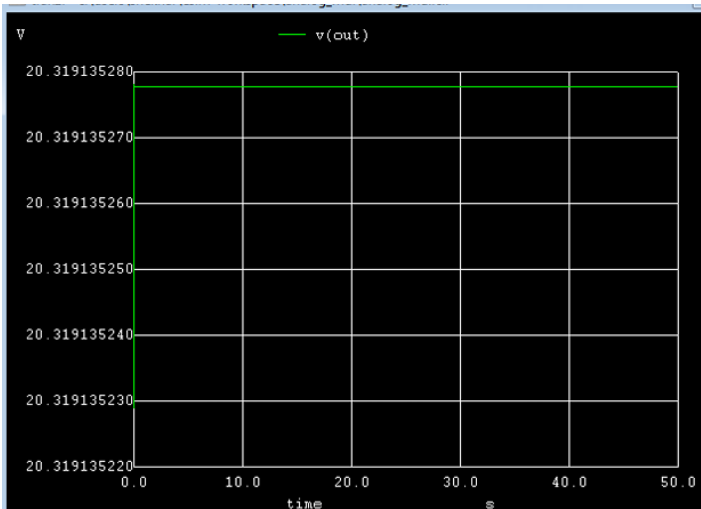


Figure 8: ngspice output plot

2. Python plot :

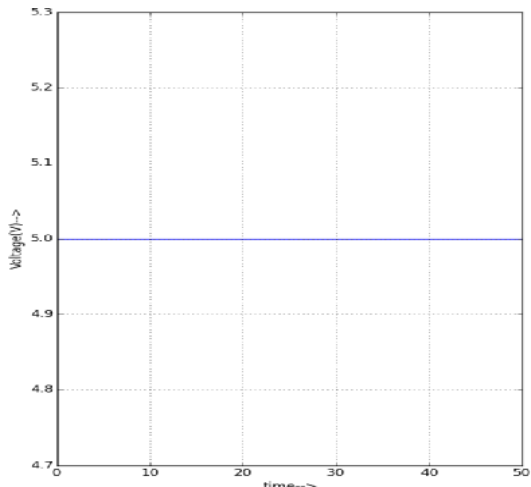


Figure 9: python input 1 plot

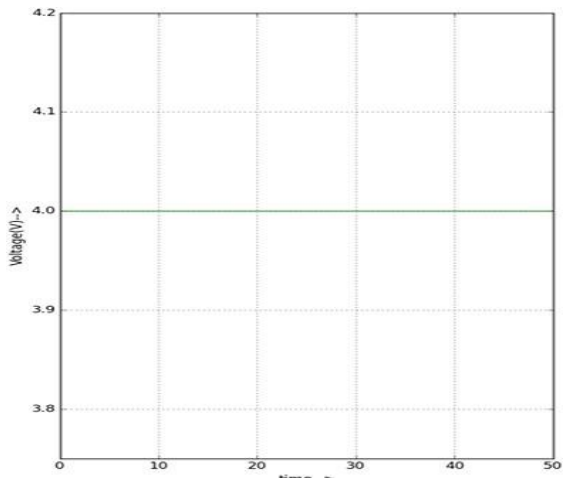


Figure 10: python input 2 plot

Figure 11: python log 1 plot

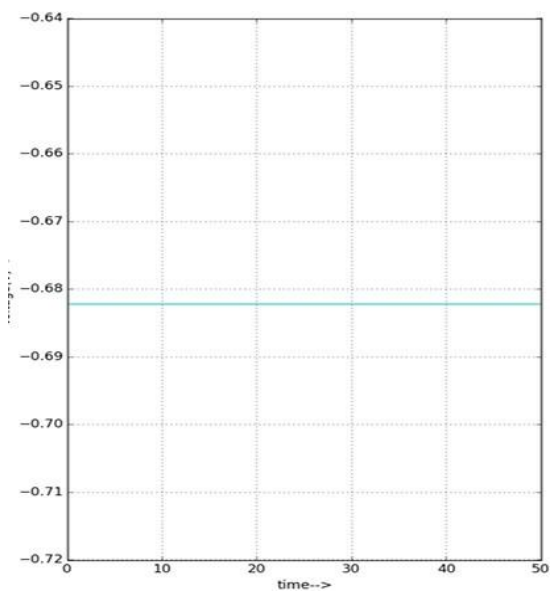
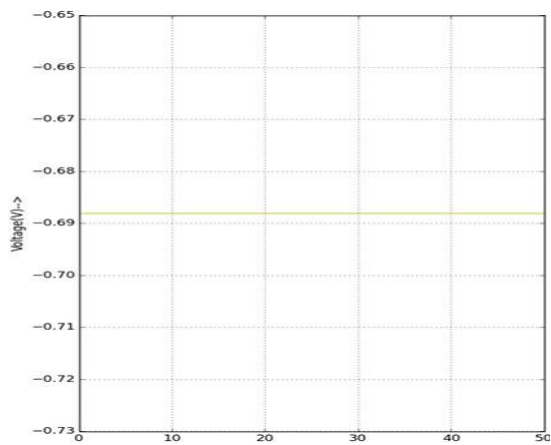


Figure 12: python log 2 plot

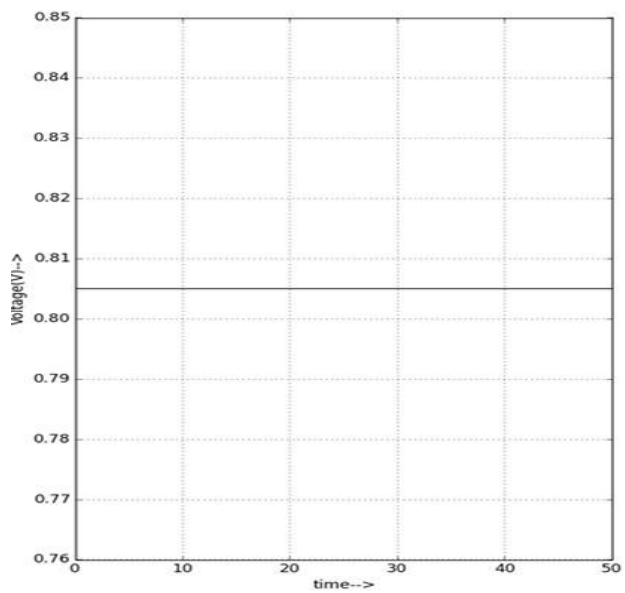


Figure 13: python summing amplifier plot

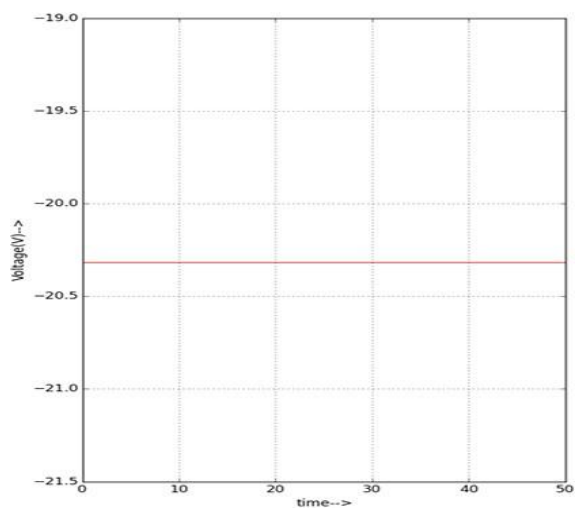


Figure 14: python antilog plot

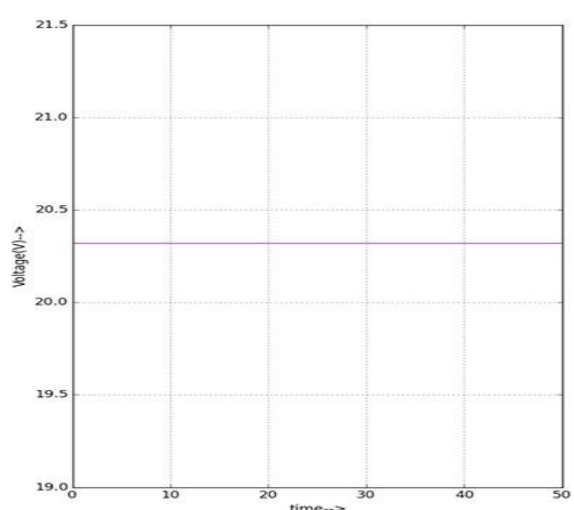


Figure 15: python output plot

CONCLUSION

The Analog Multiplier circuit was successfully designed and simulated using **eSim** with the help of operational amplifiers based on the **log–antilog principle**. The simulation results obtained from **Ngspice** and **Python plots** matched the theoretical expectations, showing that the circuit output is proportional to the product of the input signals. This project demonstrates the practical application of op-amp-based analog multipliers in areas such as modulation, signal processing, and communication systems, while also highlighting the effectiveness of open-source tools like eSim for circuit design and analysis.

REFERENCES

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