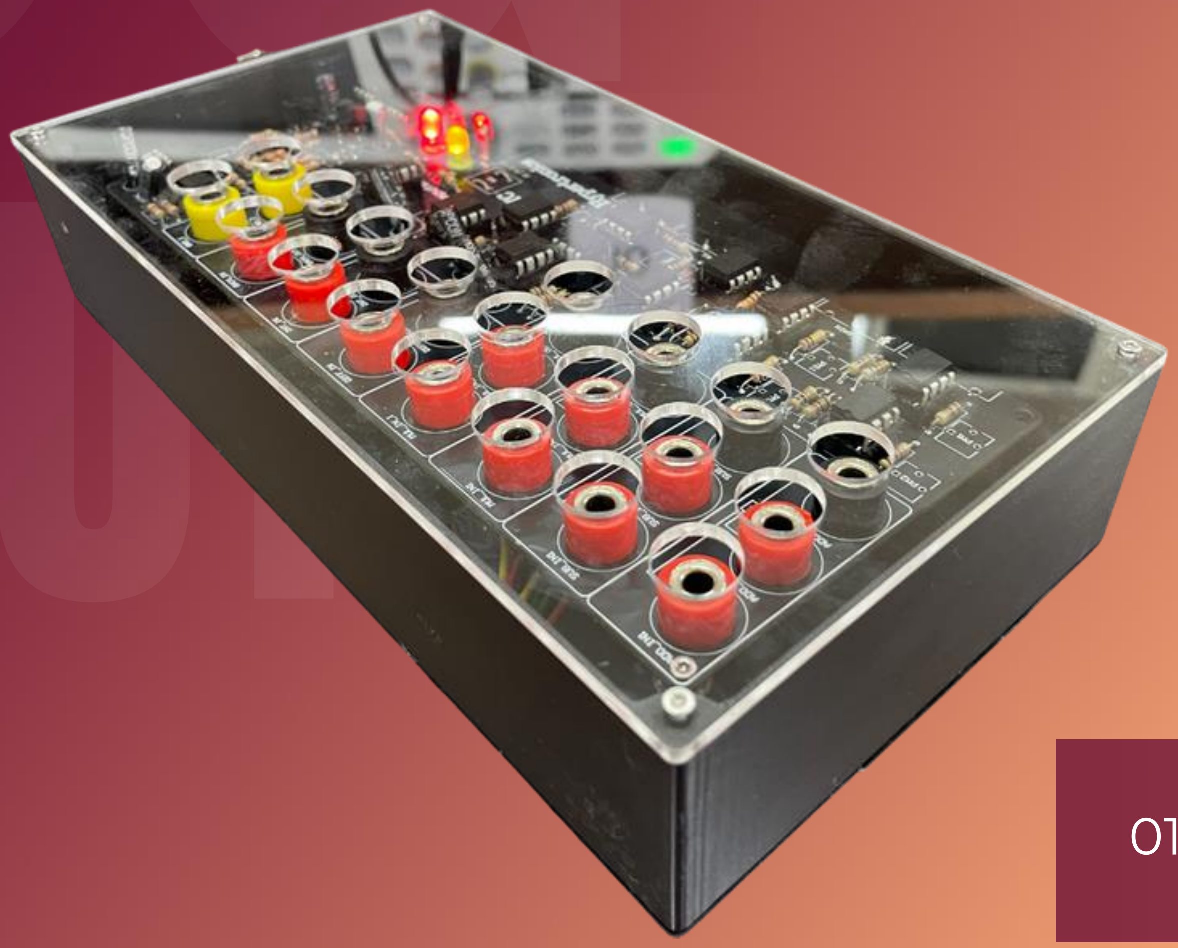
EN2091 - Laboratory Practice and Projects

ANALOG COMPUTER



TEAM HYPERTRONICS

230726L - Wijesinghe.U.G.S.K.D

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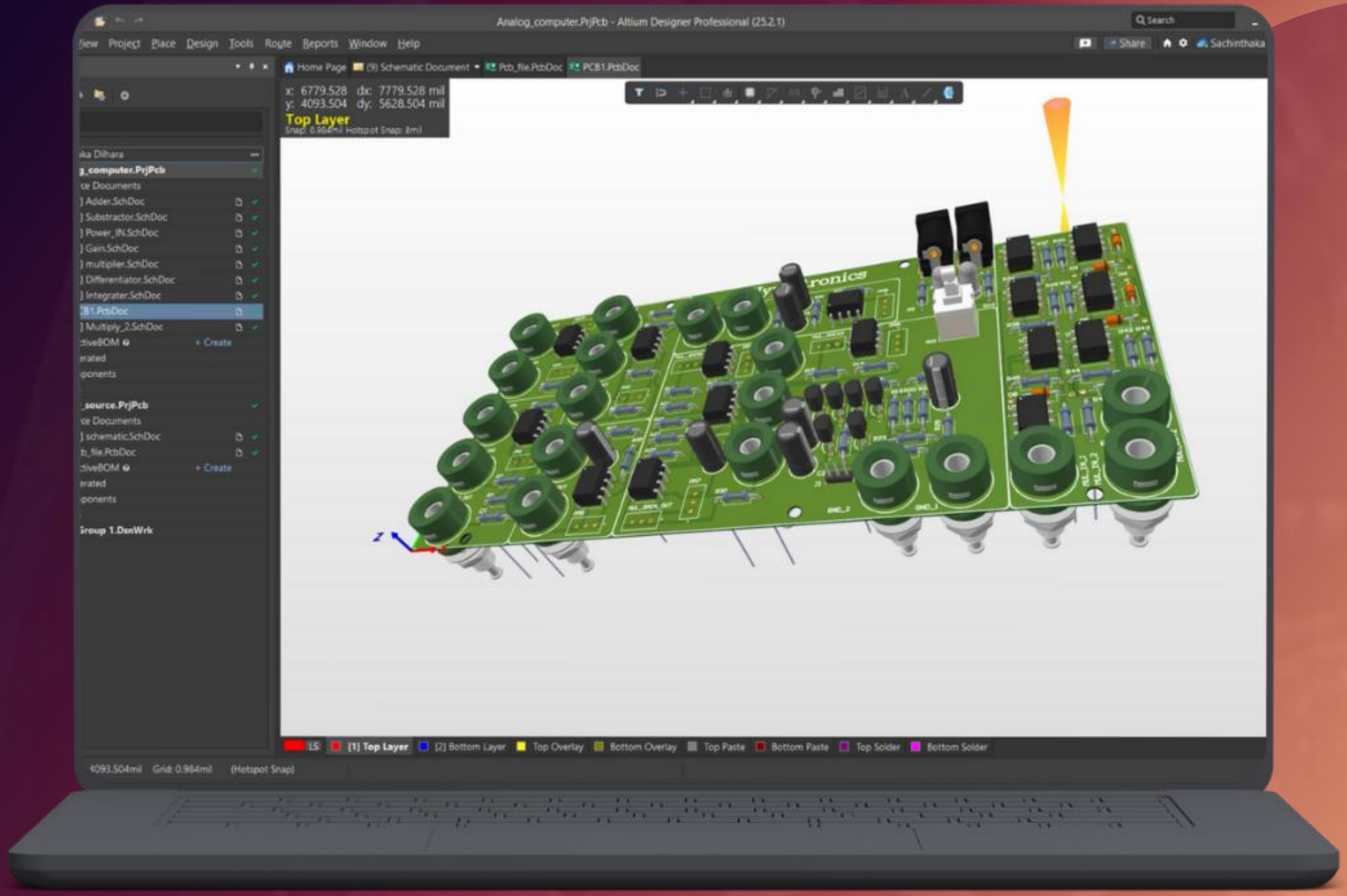
230147L - Dilhara.D.S

PROJECT INTRODUCTION

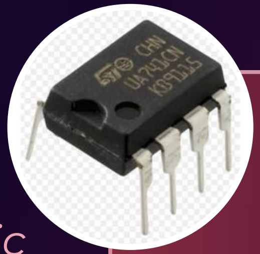
Our project aims to demonstrate the functionality of op-amp circuits in performing fundamental analog computations such as:

- addition
- subtraction
- multiplication
- integration
- differentiation

within the 1 Hz to 10 kHz frequency range. It consists of a dual-channel input interface for each operation with control mechanisms for easily adjustable gain and is powered by a stable and clean power supply system, which acts as a separate module.

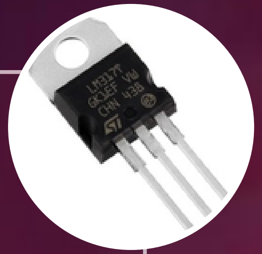


COMPONENTS & WHY?



UA741
General Purpose OP-Amp

- *Widely available and affordable. • Ideal for basic operations like addition, subtraction*
- *Bandwidth (~ 1 MHz) is sufficient for 1 kHz to 10 kHz signals.*
- *Stable and easy to implement without complex compensation.*

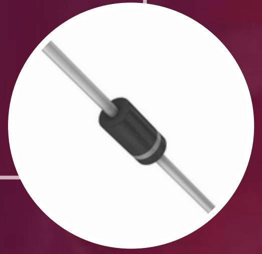


LM7812/LM7912(Option02)
Fixed 12v voltage regulator

- *cheap and widely available*
- *regulator circuit is simple,not complicated like Adjustable regulator*

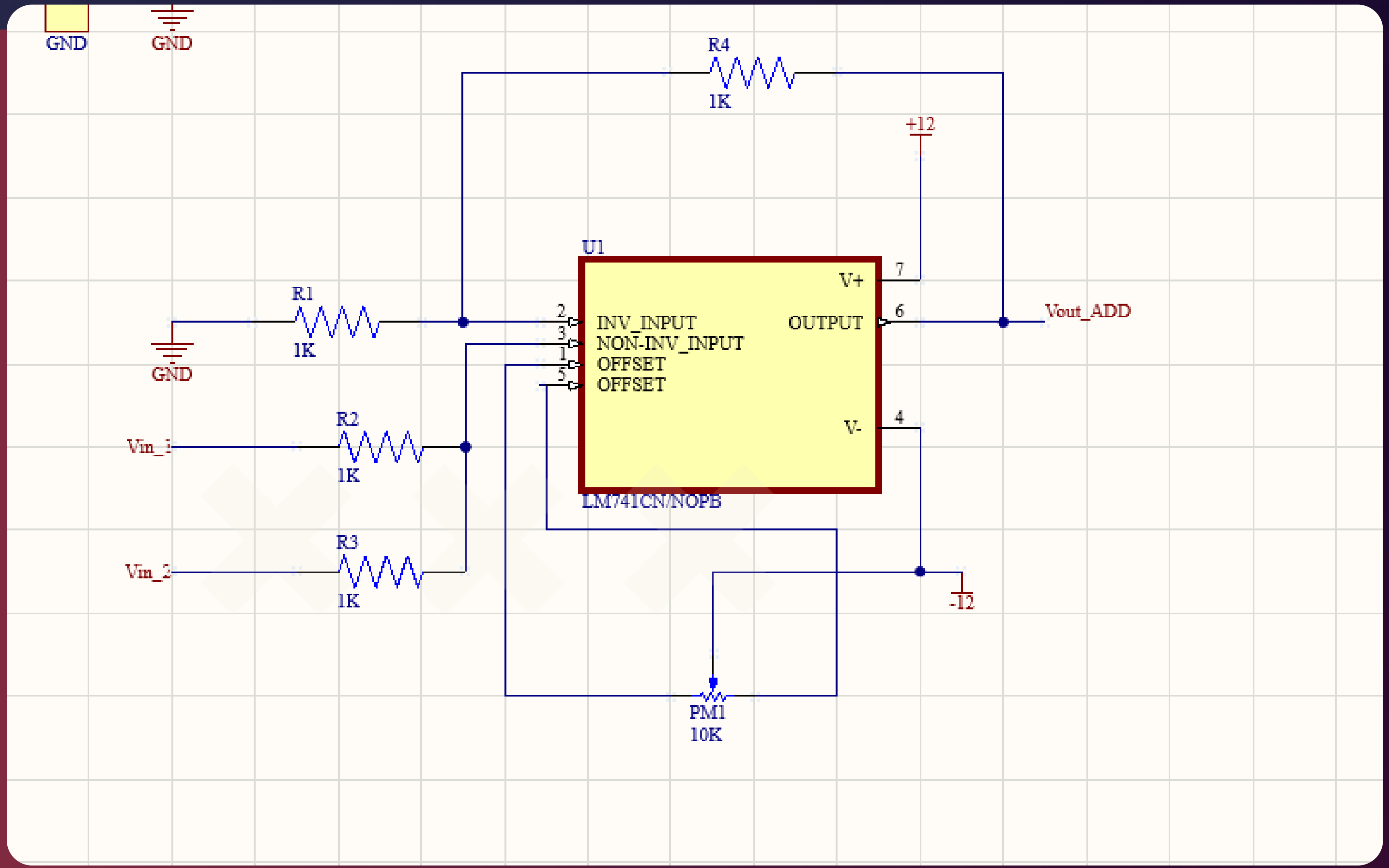
IN4148
Diode

- *Widely available and affordable*
- *IN4148 works linearly at low currents; 1N4007 doesn't.*
- *Faster response: 1N4148 has low junction capacitance and fast switching.*
- *1N4148 has lower leakage and better temperature stability for small signals.*



IN4007
Diode

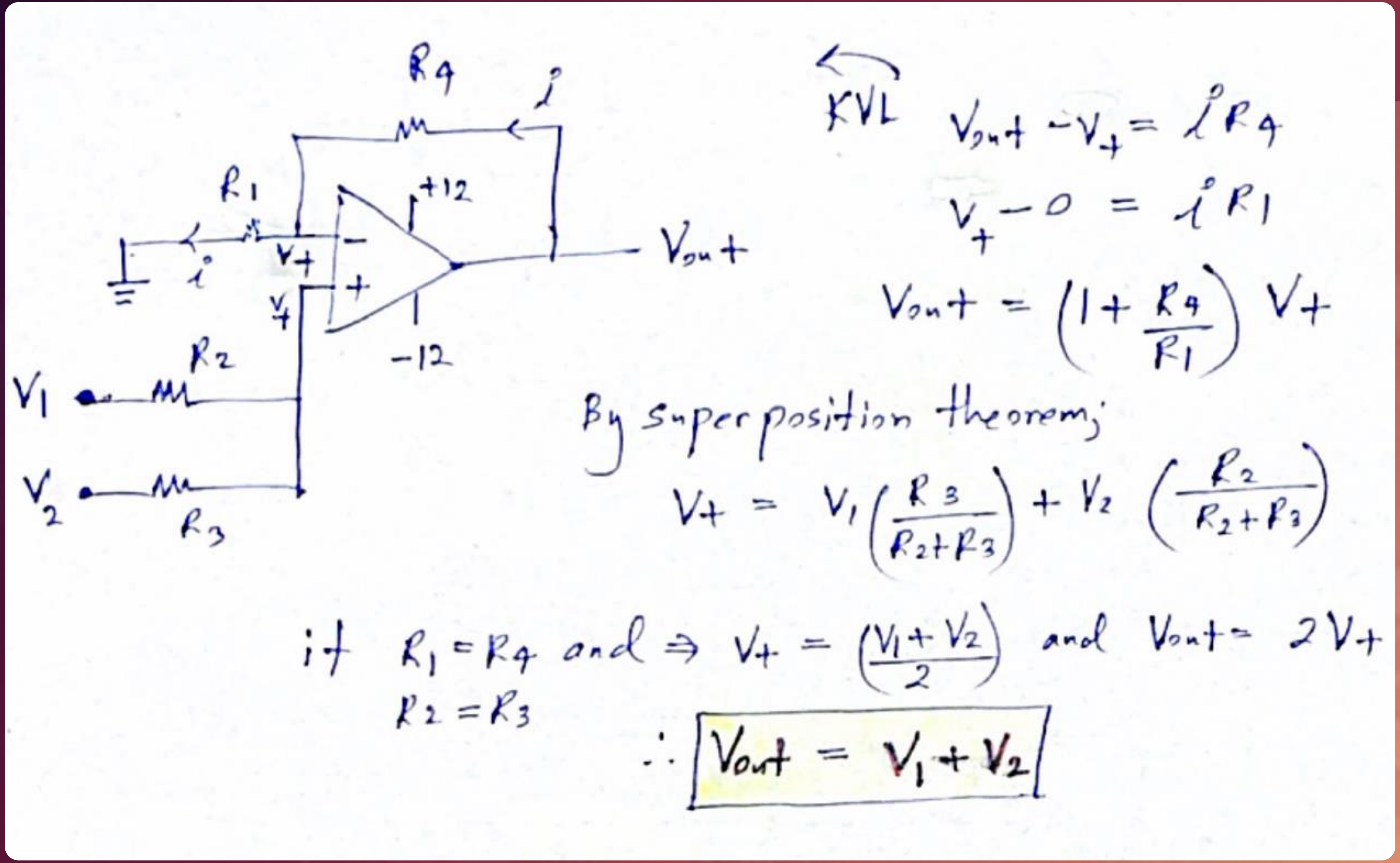
- *cheap and widely available*
- *Withstands up to 1000 V (Peak Reverse Voltage), making it ideal for AC to DC rectifier applications*
- *Can handle 1 A continuous current*

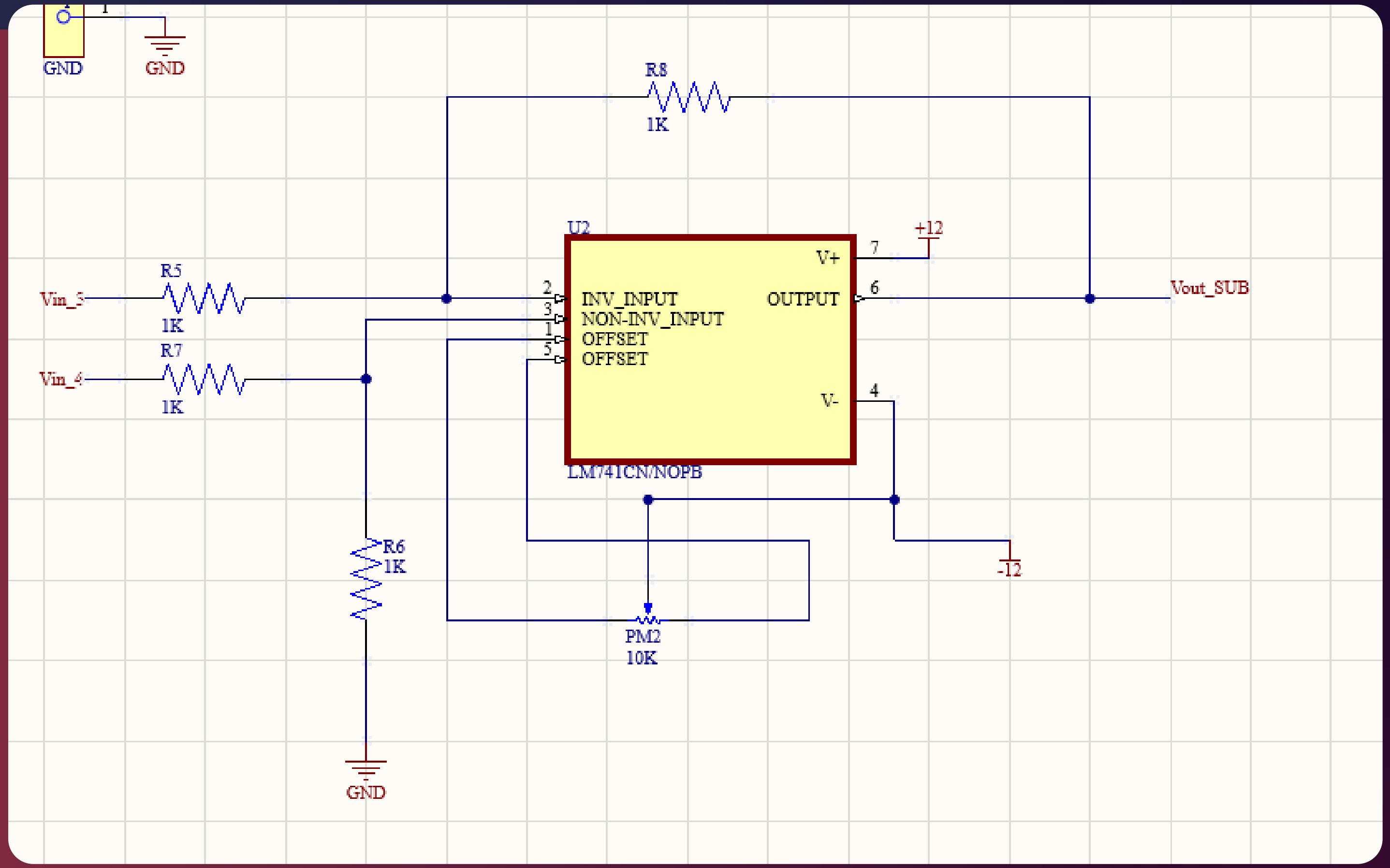


ADDER CIRCUIT

WHY 1KOHM RESISTORS?

Small resistors, such as 100 Ω, draw more current compared to 1 kΩ resistors, leading to increased power consumption. While higher resistances, like 10 kΩ, are permissible, they tend to produce lower bandwidth. Utilizing very high values, such as 100 kΩ, can even filter out portions of the input signal. Consequently, a 1 kΩ resistor serves as an excellent choice in this scenario.

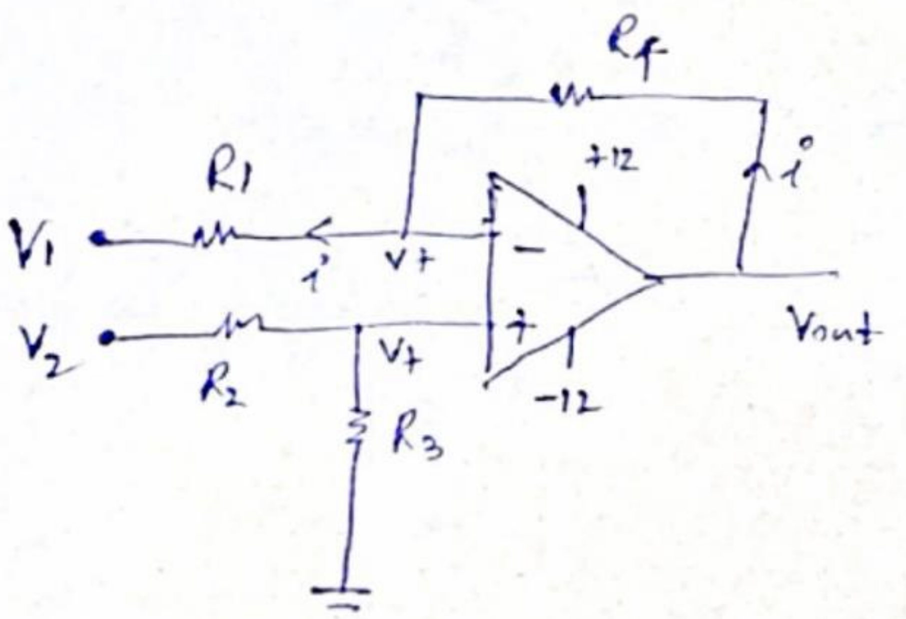




SUBTRACTOR CIRCUIT

WHY 1KOHM RESISTORS?

Small resistors, like 100 Ω, draw more current compared to 1 kΩ, which leads to increased power consumption. While higher resistors, such as 10 kΩ, are permissible, they tend to offer lower bandwidth. If we opt for an excessively high value, like 100 kΩ, it may filter out certain portions of the input signal. Thus, a 1 kΩ resistor is an excellent choice in this scenario.



KVL $\quad V_{out} - V_+ = iR_4$

$V_+ - V_1 = iR_1$

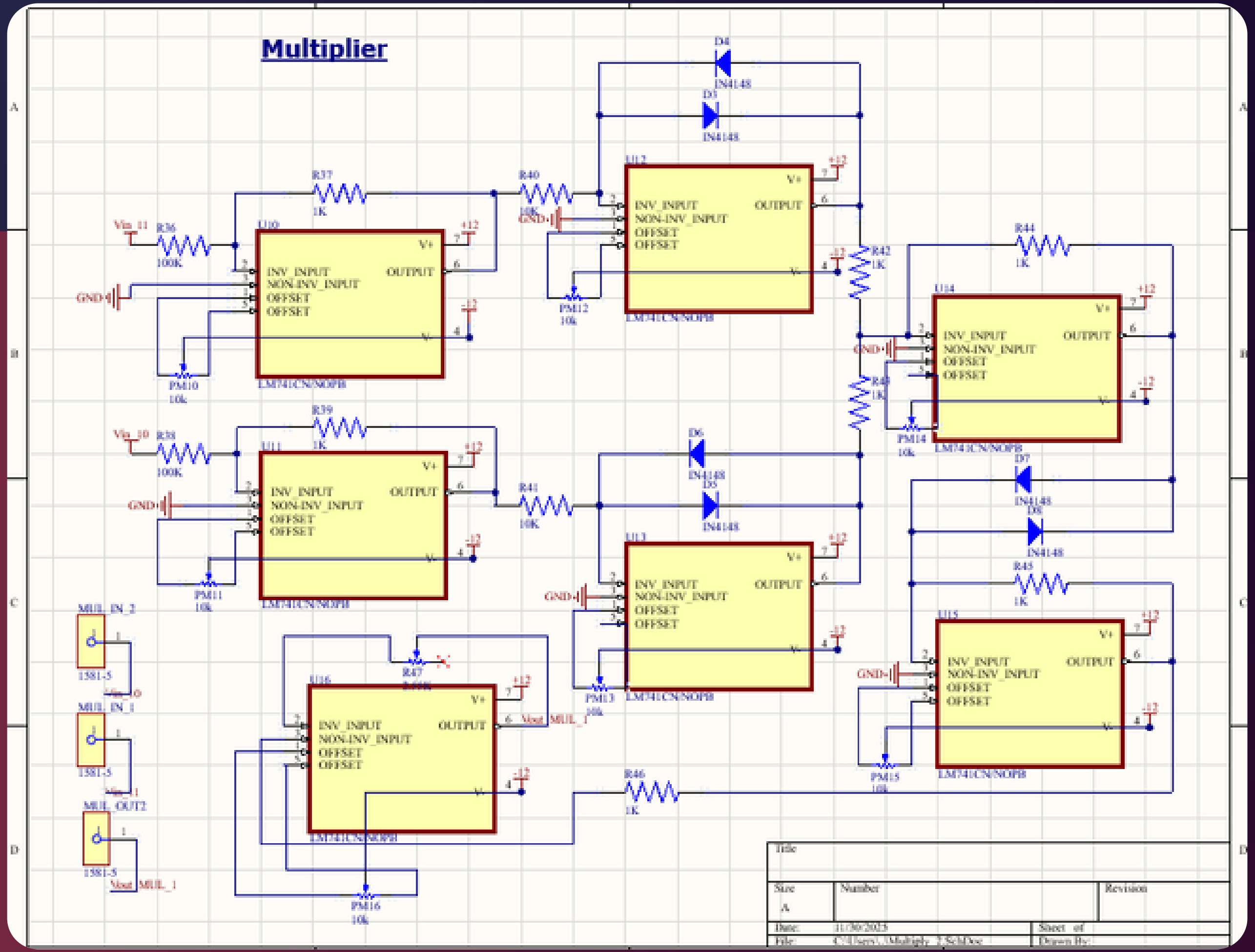
$$\frac{V_{out} - V_+}{V_+ - V_1} = \frac{R_4}{R_1}$$

$$V_+ = \frac{V_2 \cdot R_3}{R_2 + R_3}$$

if $R_1 = R_2 = R_3 = R_4 \Rightarrow \quad V_{out} + V_1 = 2V_+$

and $V_+ = \frac{V_2}{2}$

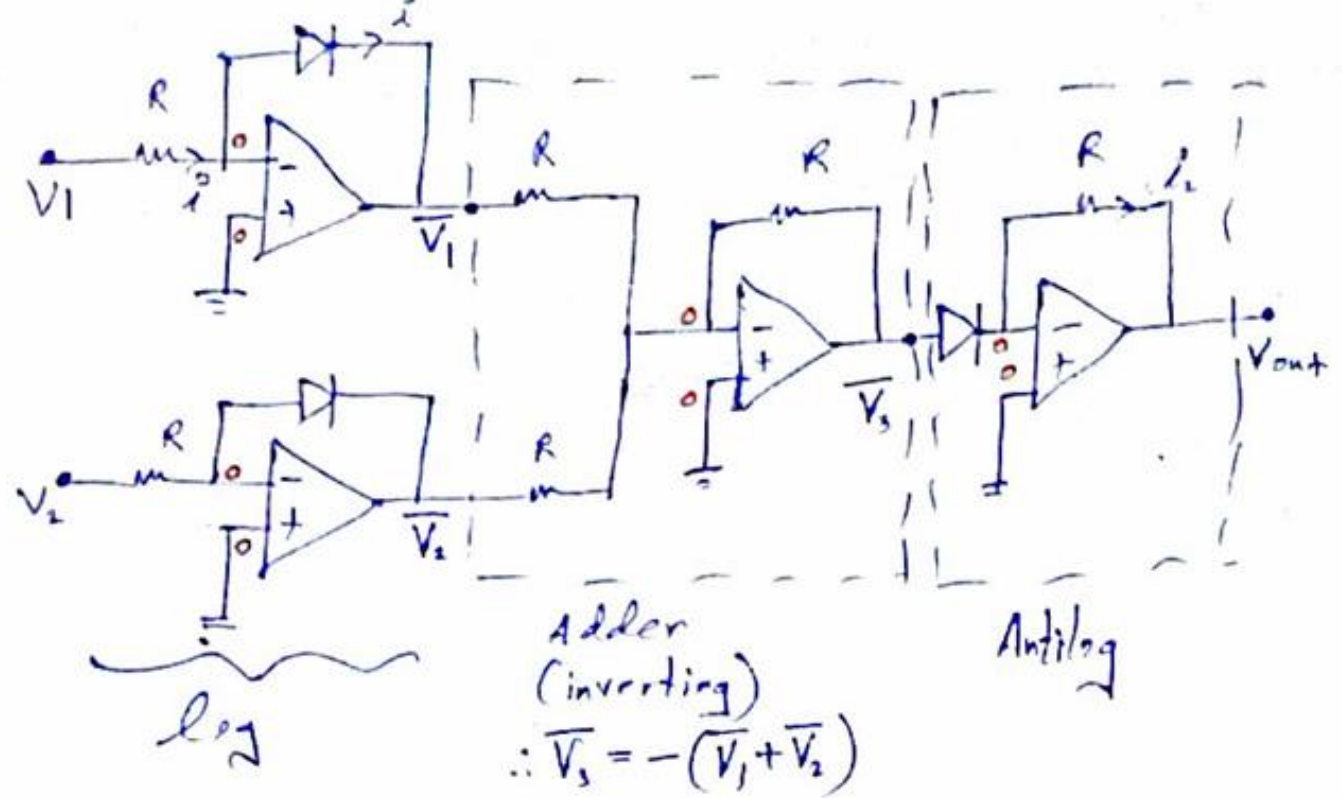
$$\therefore \boxed{V_{out} = V_2 - V_1}$$



MULTIPLIER CIRCUIT

WHY HIGHER INPUT RESISTORS?

In log/antilog multipliers, using large resistors helps ensure that the input voltage generates a small current. This approach maintains a more linear and predictable log function.



Suppose positive half cycle of V_1;

$V_1 = iR \rightarrow i = \frac{V_1}{R}$

$\bar{V}_1 = -\eta V_T \ln\left(\frac{V_1}{R I_s}\right)$ —(1)

Similarly; V_2

$\bar{V}_2 = -\eta V_T \ln\left(\frac{V_2}{R I_s}\right)$ —(2)

$V_3 = (\bar{V}_1 + \bar{V}_2) \times -1$

$= +\eta V_T \left[\ln\left(\frac{V_1}{R I_s}\right) + \ln\left(\frac{V_2}{R I_s}\right)\right]$

$= +\eta V_T \left[\ln\left(\frac{V_1 \cdot V_2}{R I_s}\right)\right]$

$-\frac{V_{out} + 0}{R} = i_2$

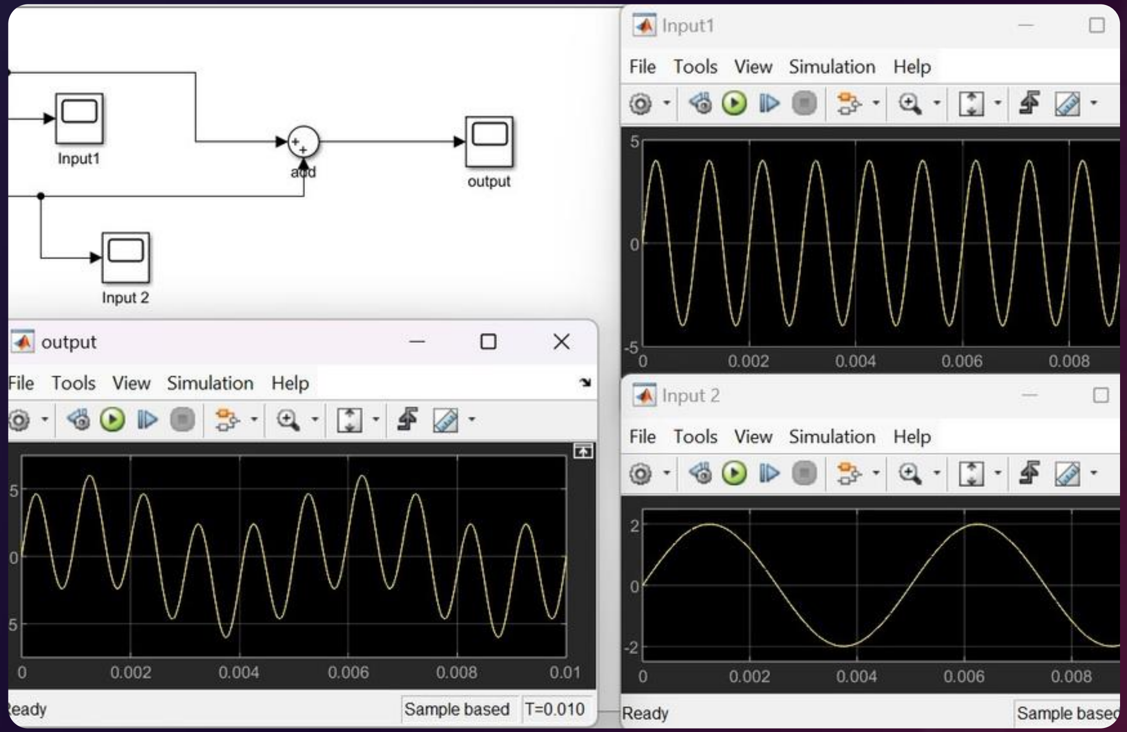
$i_2 = I_s e^{\frac{(\bar{V}_3 - 0)}{\eta V_T}}$

$-\frac{V_{out}}{R I_s} = e^{\frac{\bar{V}_3}{\eta V_T}} = e^{\frac{+\eta V_T \ln\left(\frac{V_1 V_2}{R I_s}\right)}{\eta V_T}} = \left(\frac{V_1 V_2}{R I_s}\right)^{+1}$

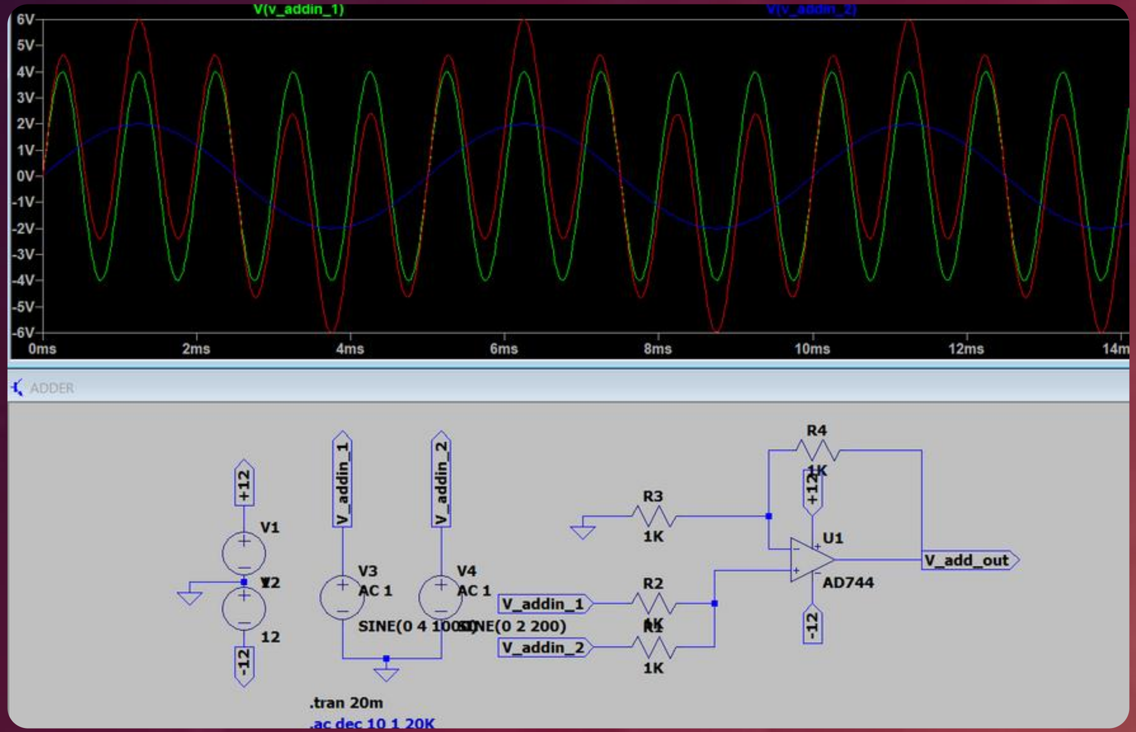
$\therefore \boxed{V_{out} = V_1 \cdot V_2}$

ADDER
SIMULATION RESULTS &
BREADBOARD/FINAL IMPLEMENTATION

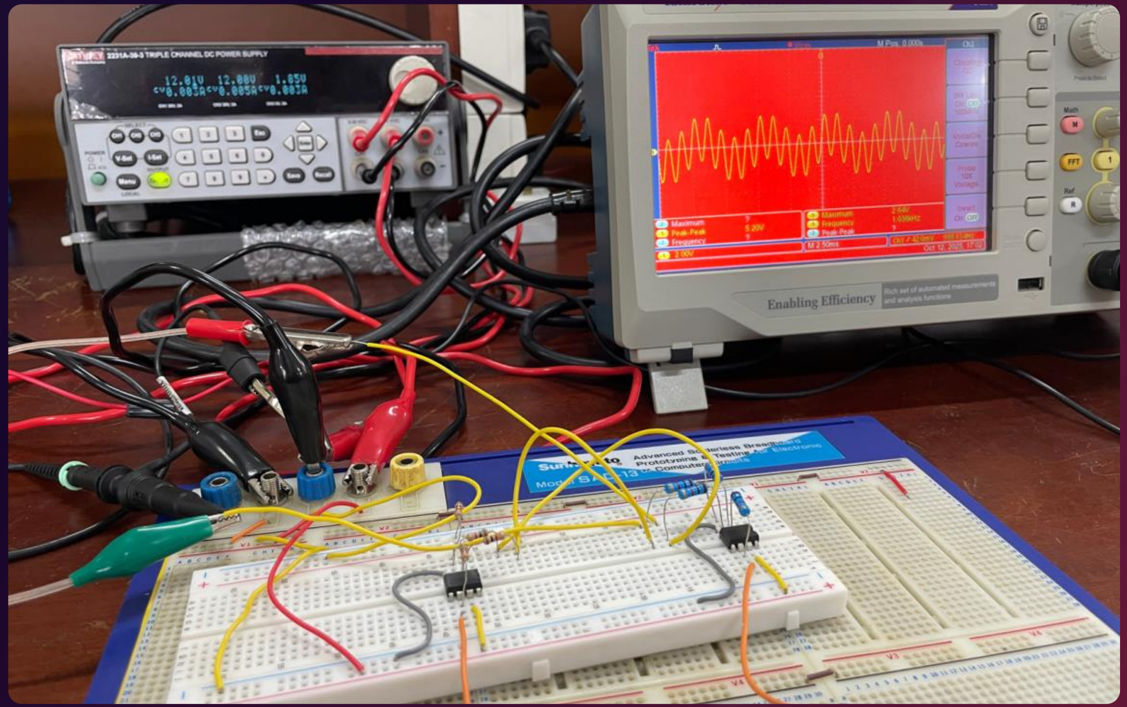
SIMULINK



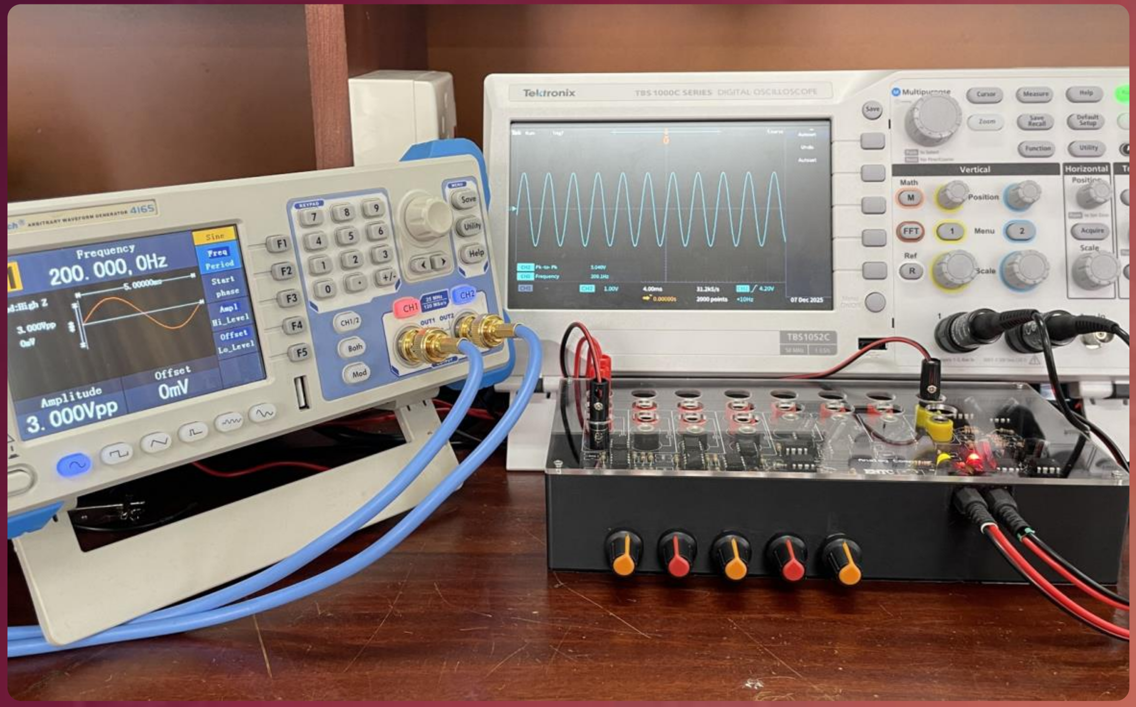
LT-SPICE



BREADBOARD IMPLEMENTATION

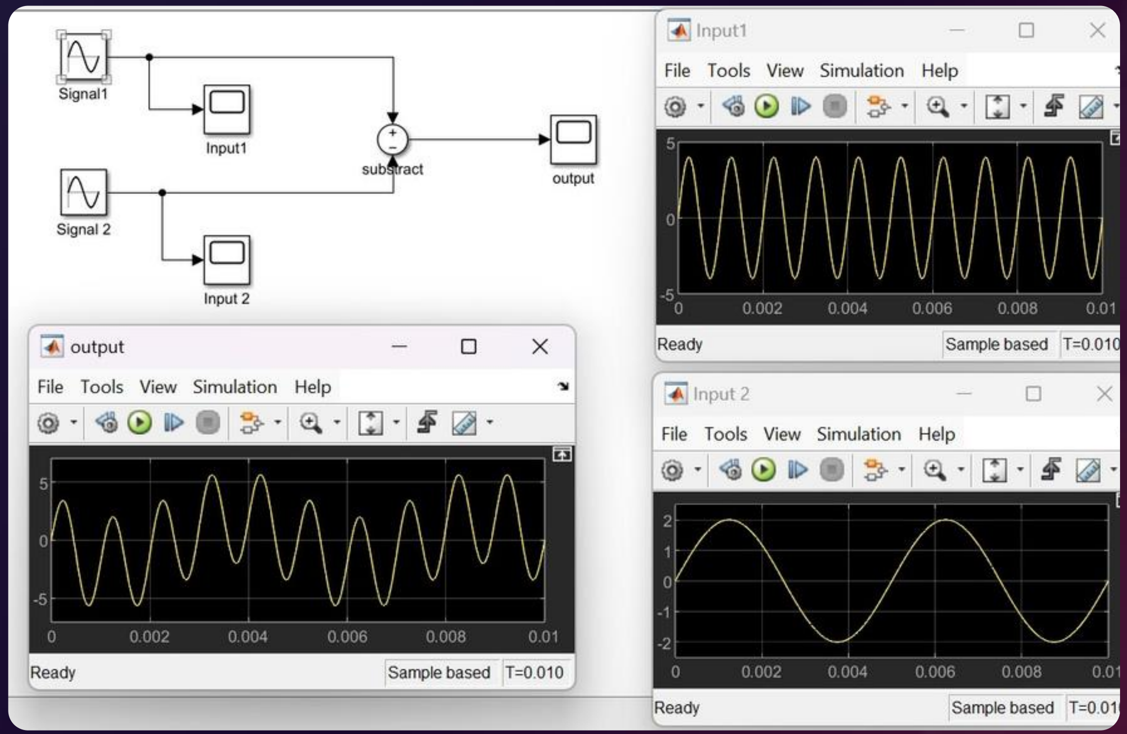


FINAL IMPLEMENTATION

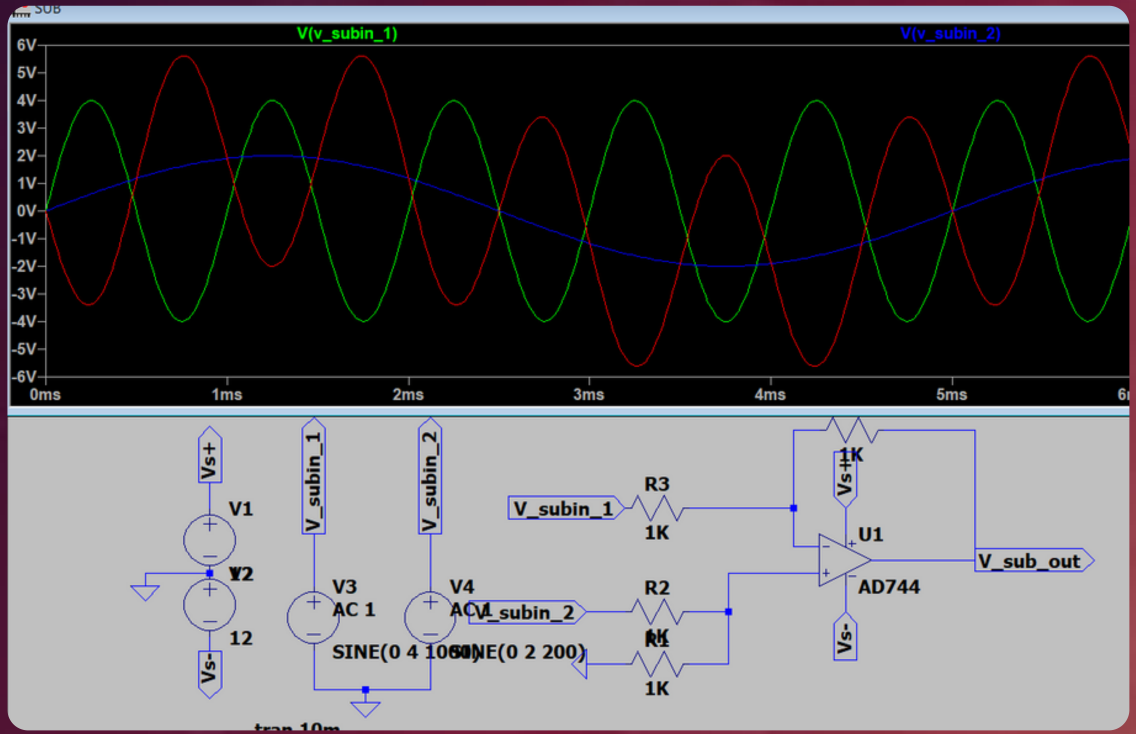


SUBTRACTOR
SIMULATION RESULTS &
BREADBOARD/FINAL IMPLEMENTATION

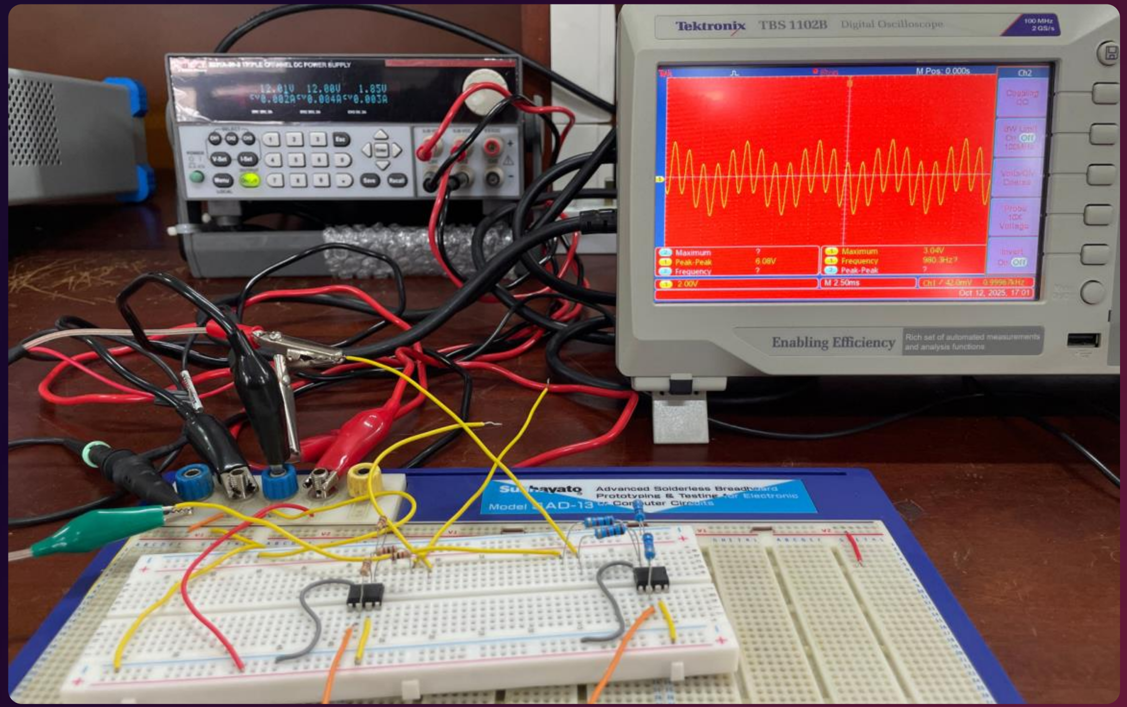
SIMULINK



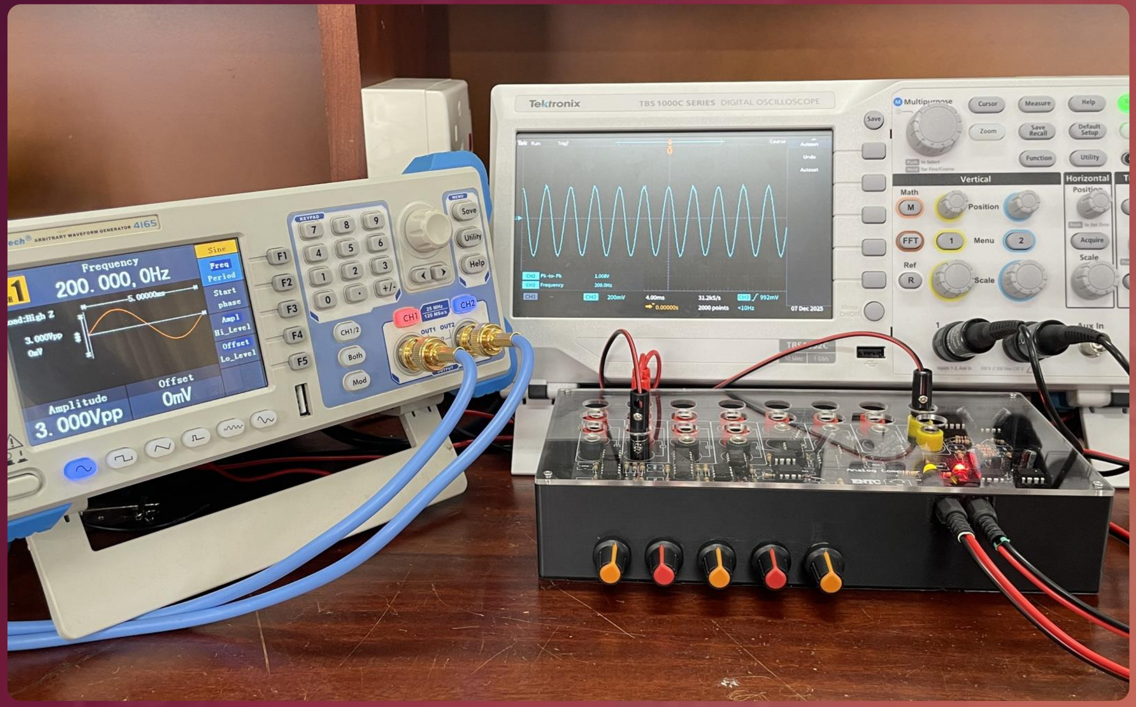
LT-SPICE



BREADBOARD IMPLEMENTATION

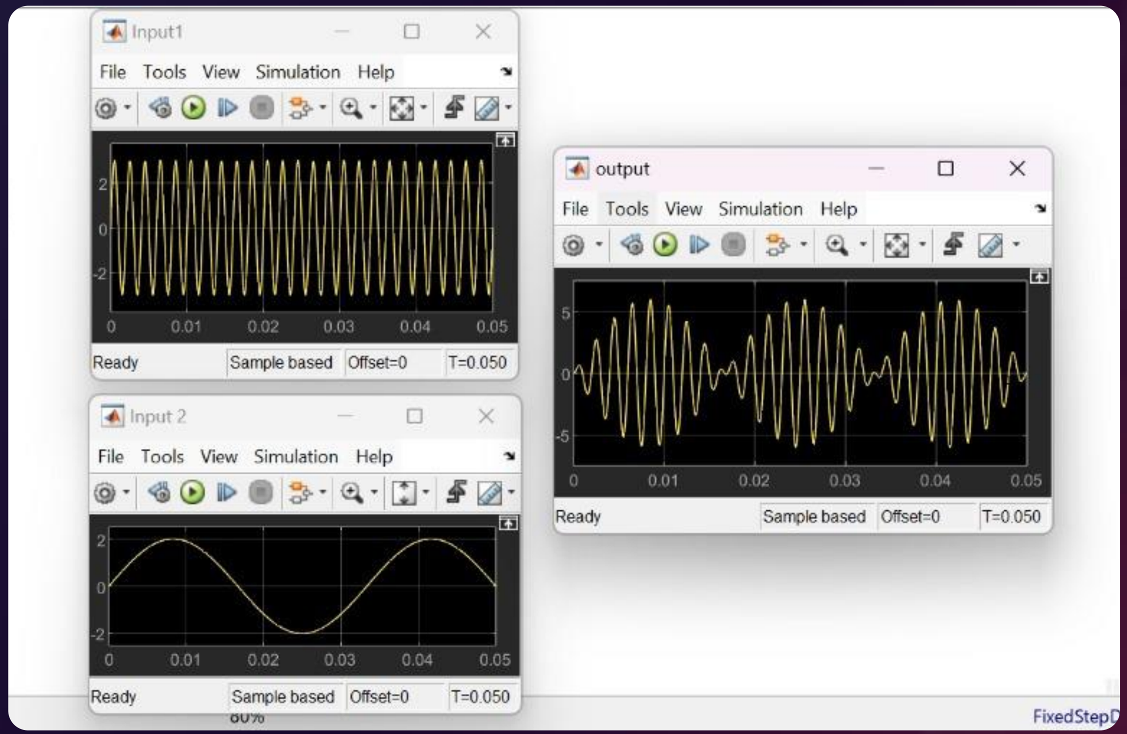


FINAL IMPLEMENTATION



MULTIPLIER
SIMULATION RESULTS &
BREADBOARD/FINAL IMPLEMENTATION

SIMULINK



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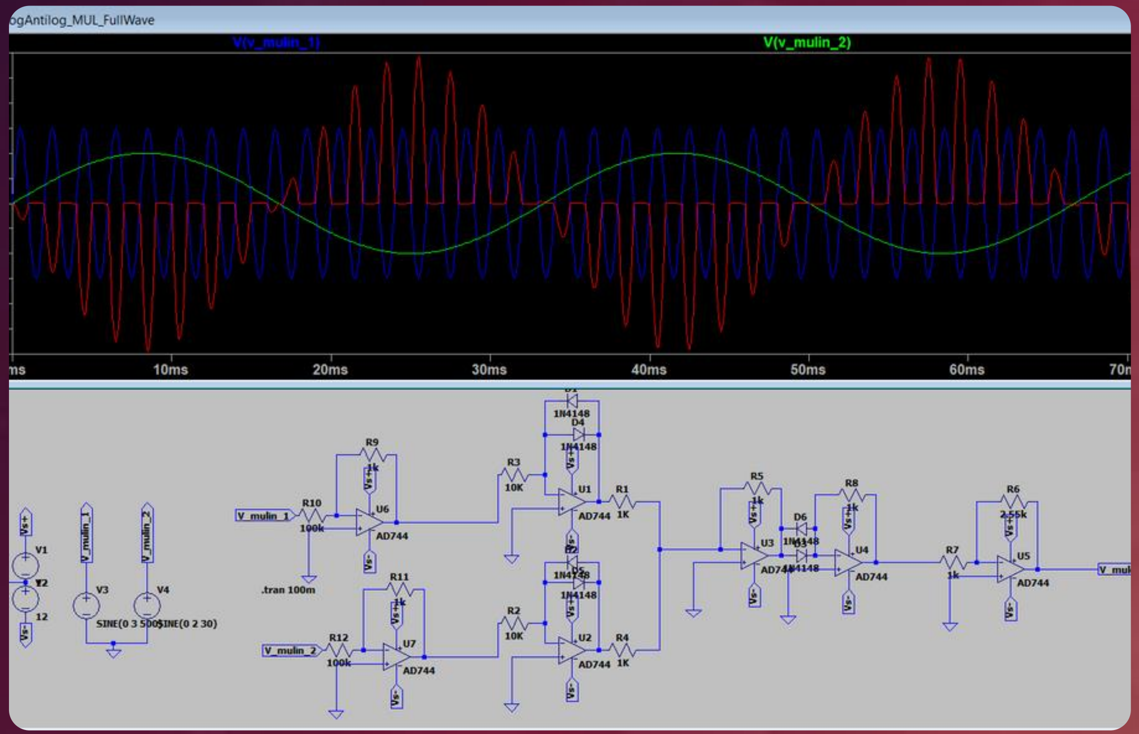
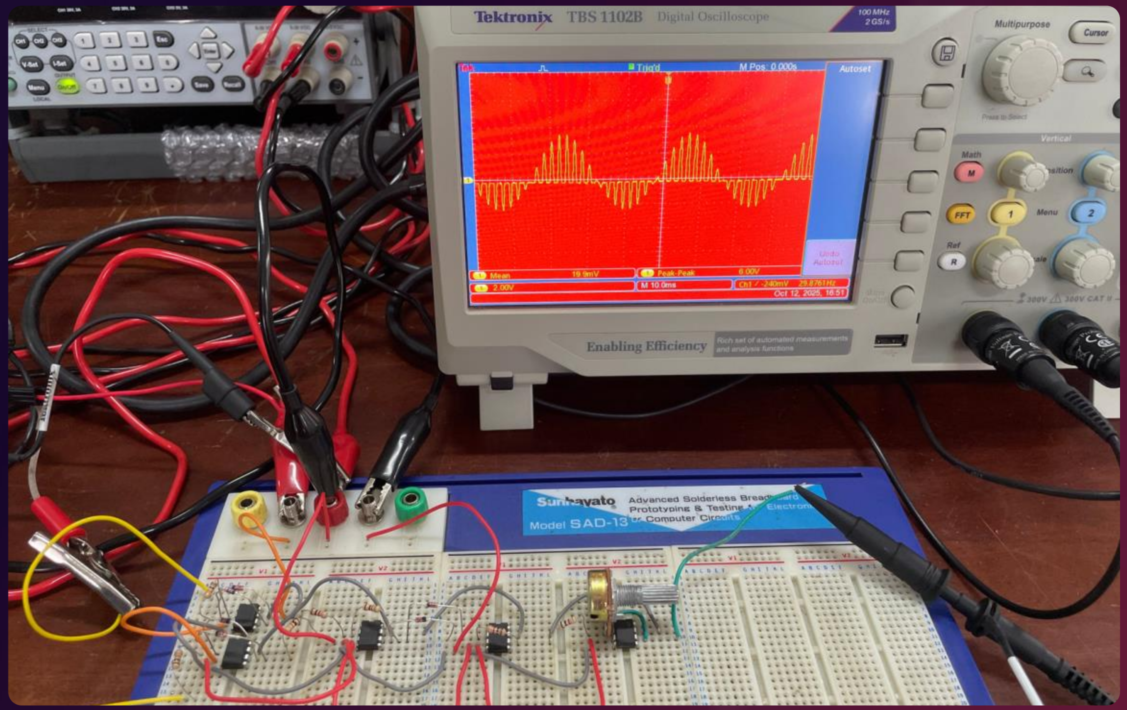
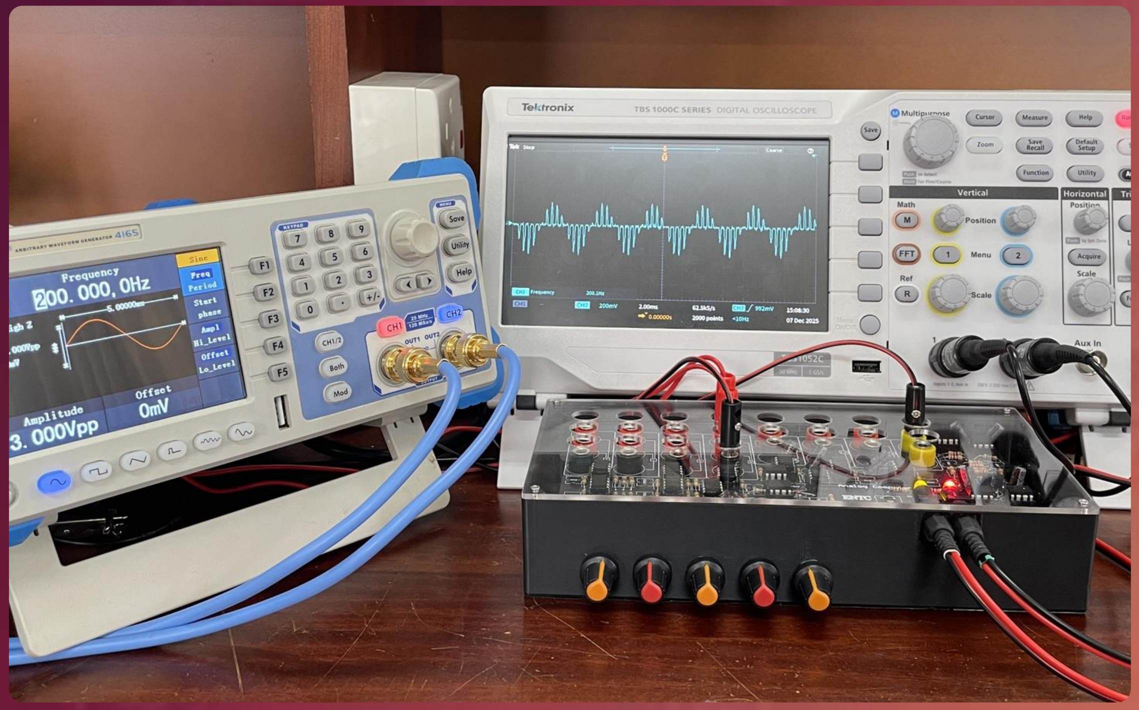


BREADBOARD IMPLEMENTATION

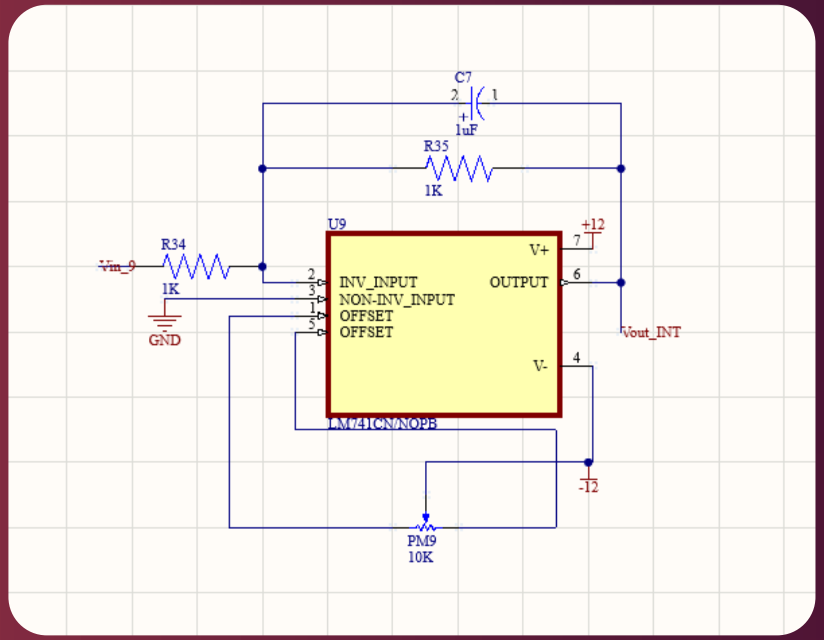


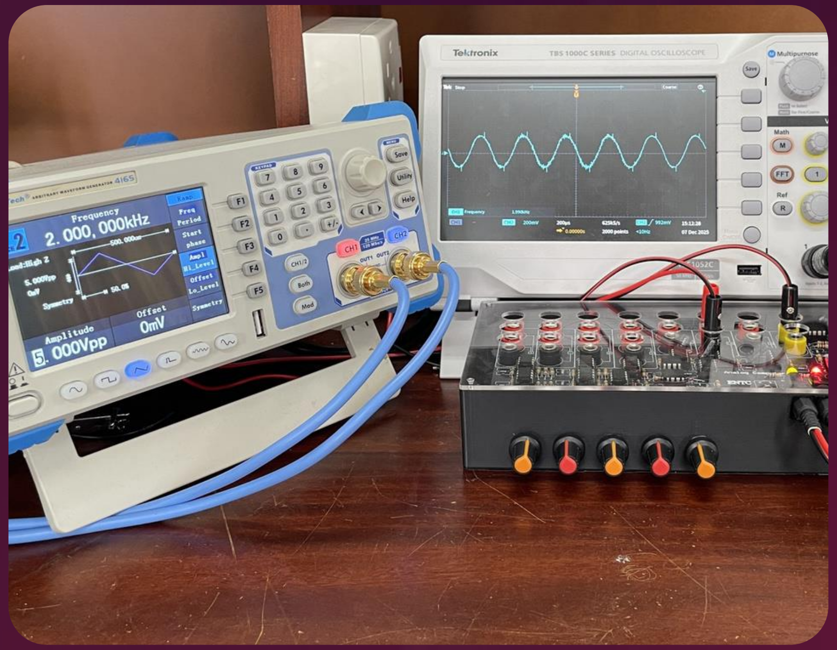
FINAL IMPLEMENTATION



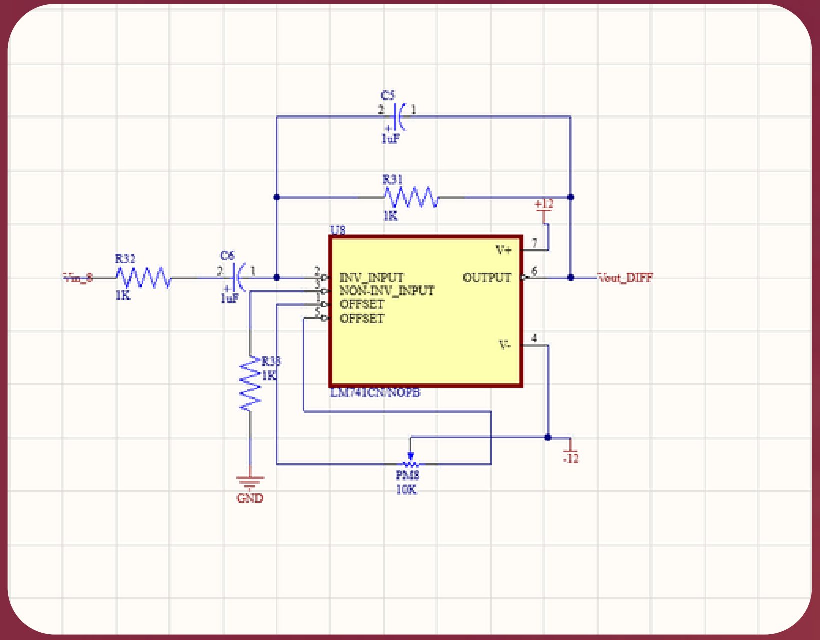
ADDITIONAL CIRCUITS

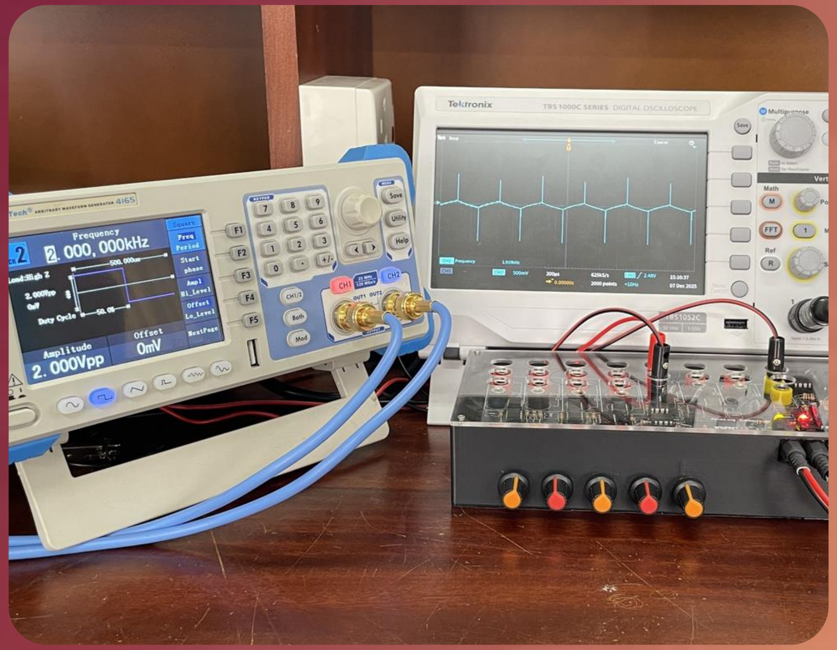
INTEGRATOR



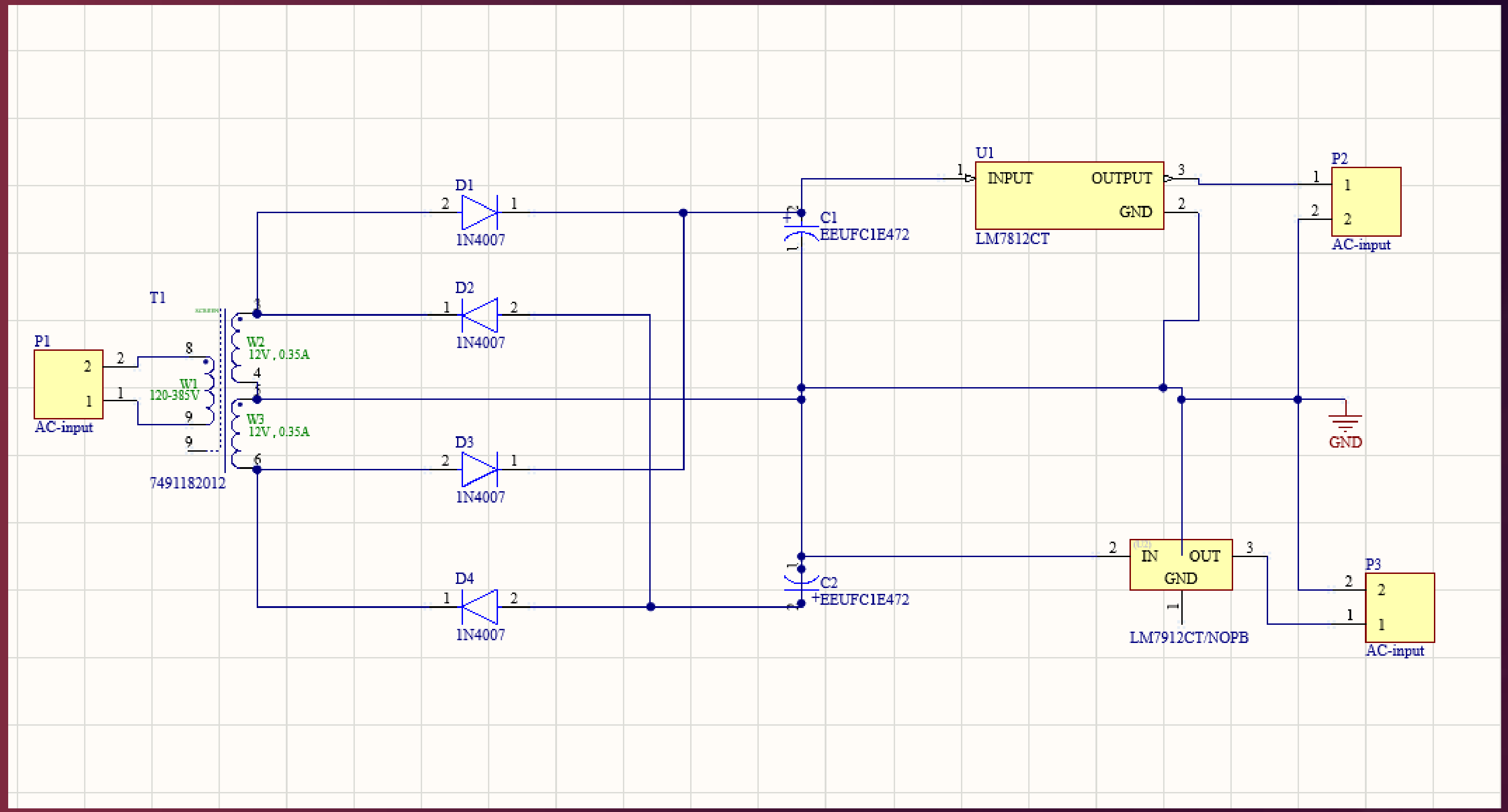


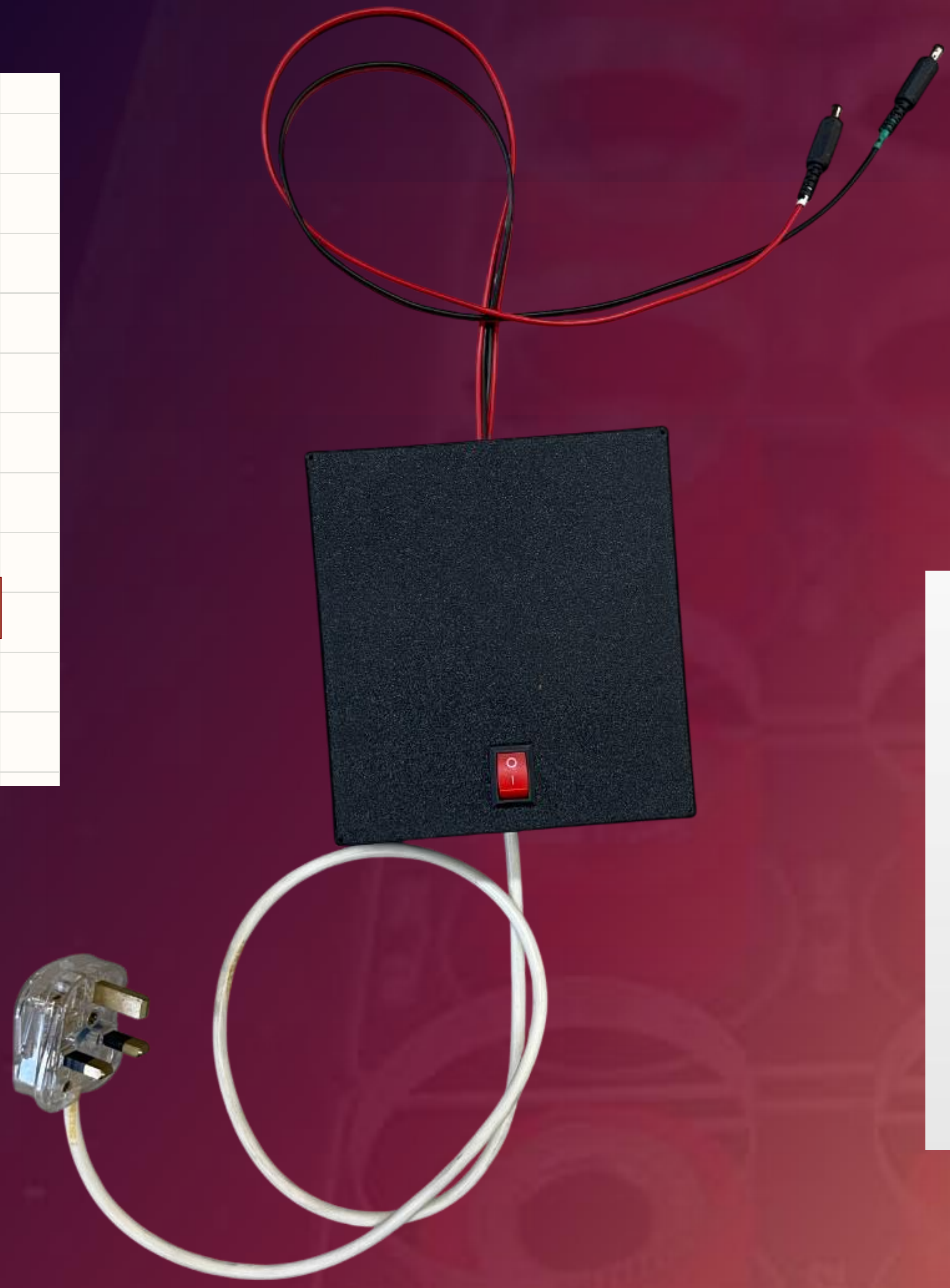
DIFFERENTIATOR

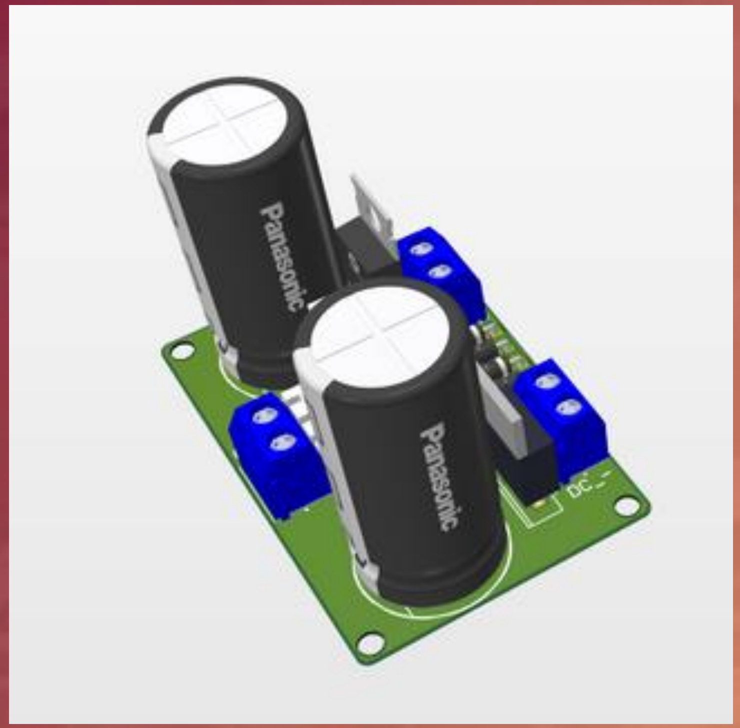




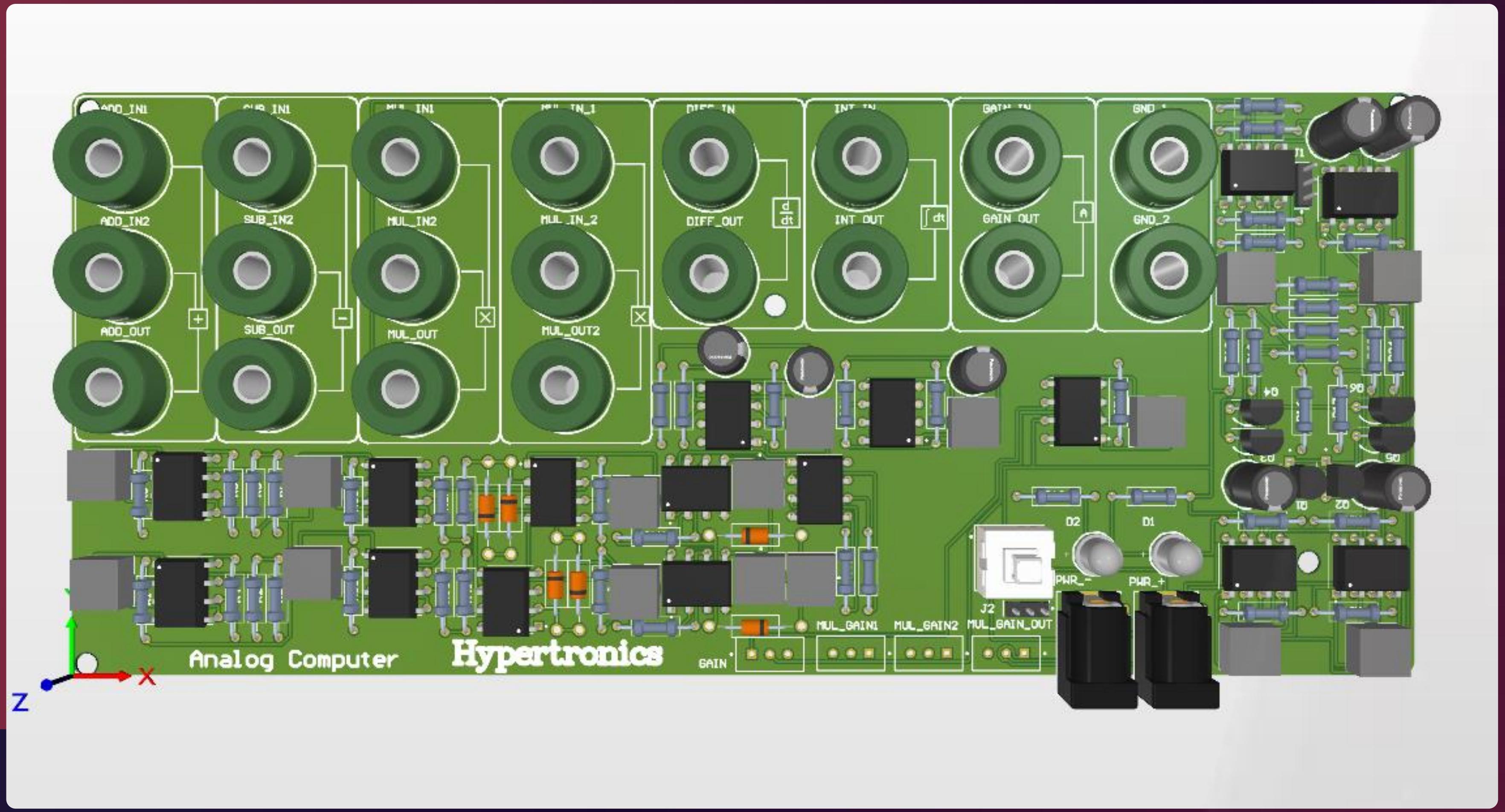
POWER SUPPLY
FIXED ±12V

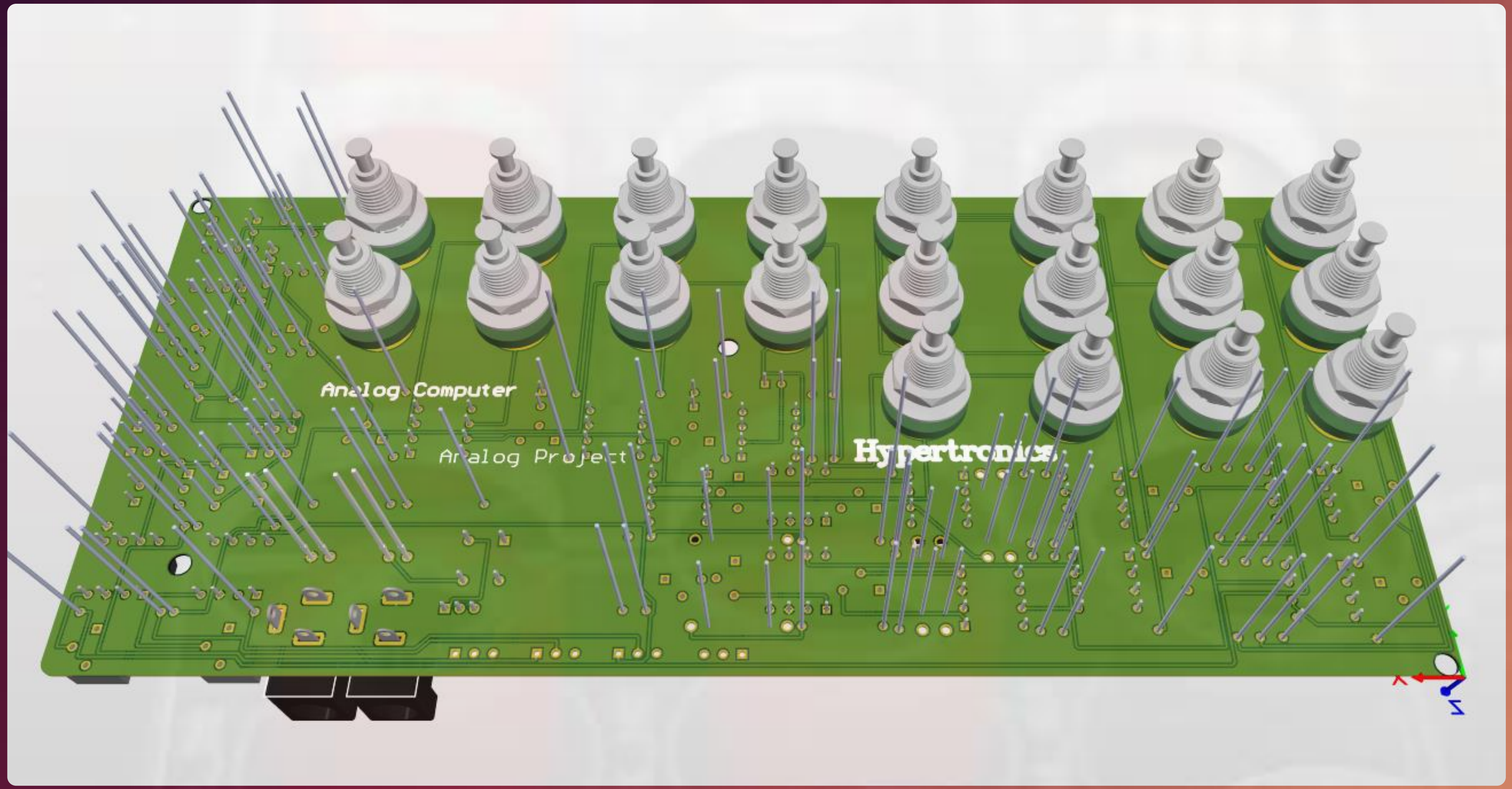




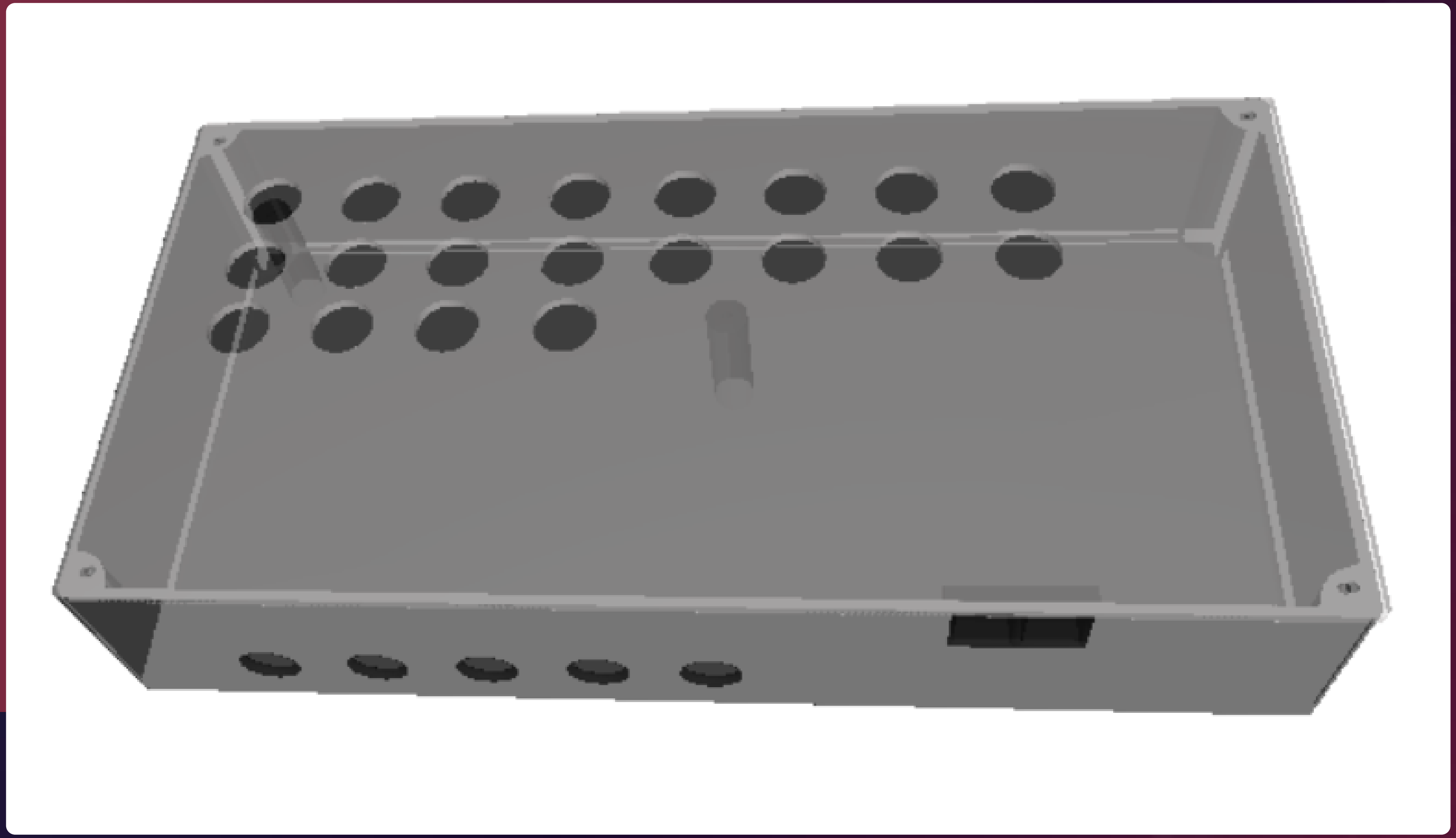


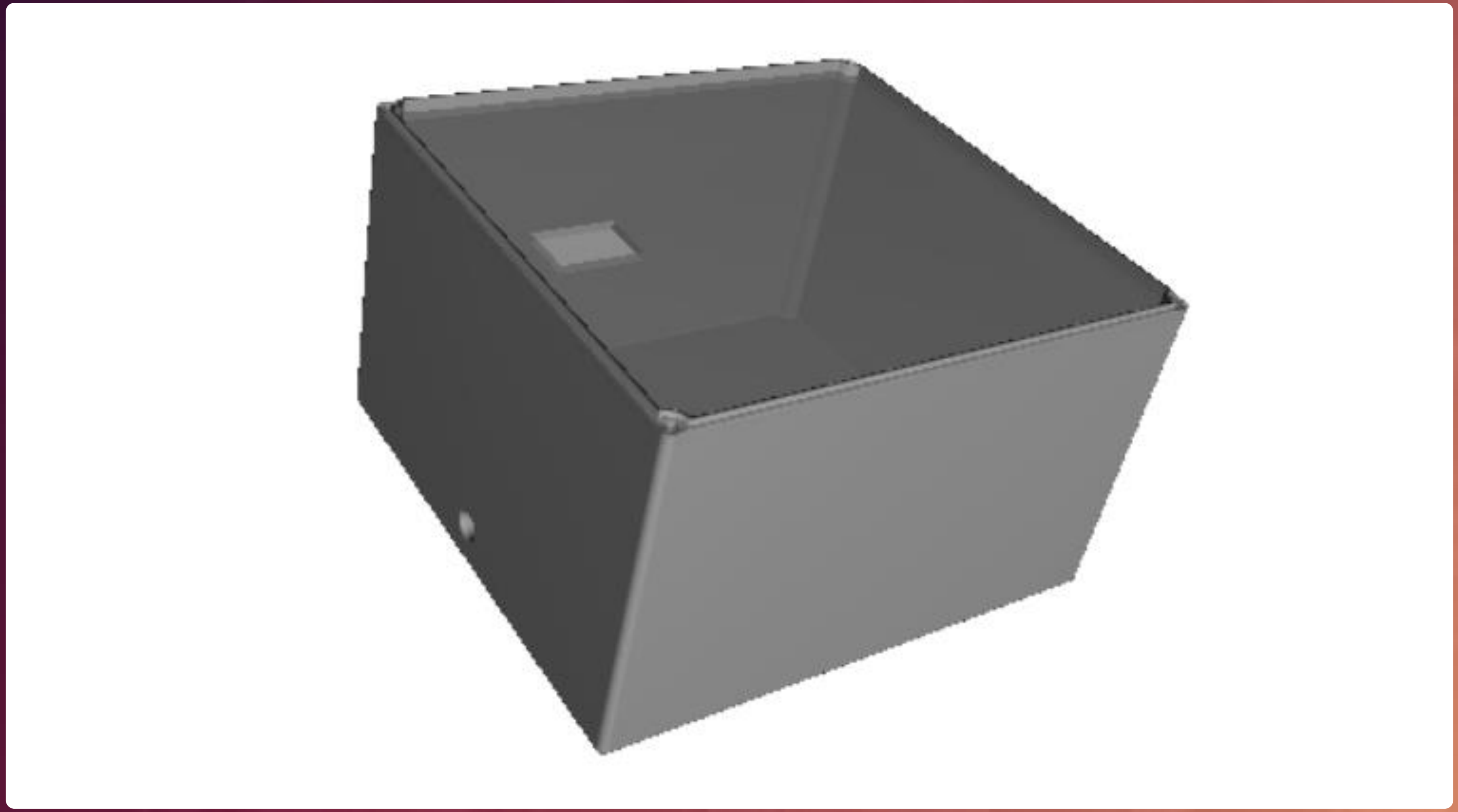
PCB
DESIGN


Analog Computer
Hypertronics


Analog Computer
Analog Project
Hypertronics

ENCLOSURE
DESIGN





CHALLENGES & RESULTS

- We Achieved the expected results with the project.
- Our Main challenge was the mismatch among BJTs in the Gilbert cell led to unexpected non-linear behavior in the multiplier circuit.
- We Overcome that issure by Replacing the Gilbert cell with a Log-Antilog multiplier with some modifications.
- It Improved linearity and allowed the circuit to produce the desired output.

DEVICE PARAMETERS

- Maximum Supply Voltage — ±18v(±12v Recommended)
- Maximum input Current — 10mA
- Max/Min output Voltage — ±12V
- Bandwidth — 1–10kHz
- Maximum Noise Level — 100mV
- Accuracy — ±(1–10)%
- Maximum Gain — x10

TASK ALLOCATION

230726L

Wijesinghe.U.G.S.K.D

Simulation & component selection
PCB schematic design

230147L

DILHARA.D.S

PCB design
breadboard implementation

230724E

Wijesekara.W.A.G.S

powersupply design
soldering

230659H

UPEKSHANI T. S.

Enclosure Design
breadboard implementation

THANK YOU

TEAM HYPERTRONICS