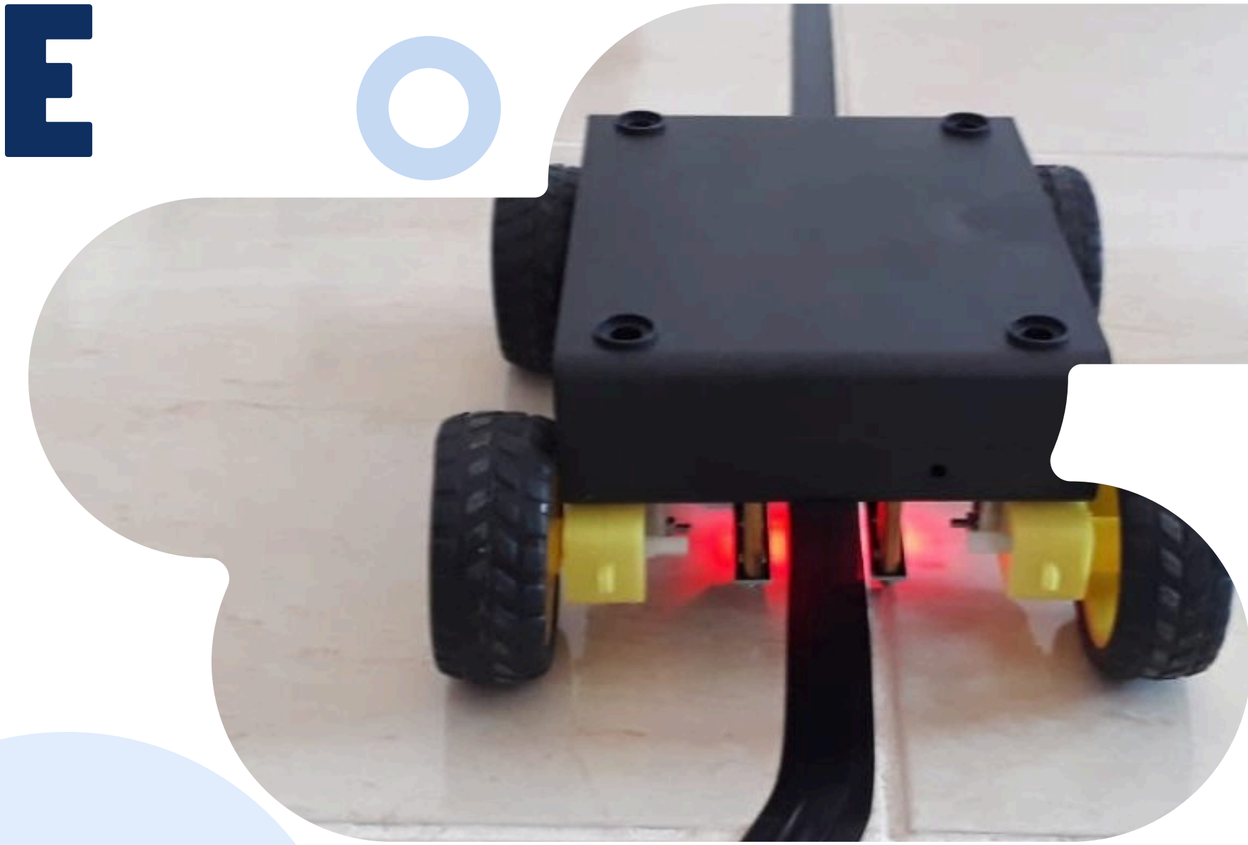
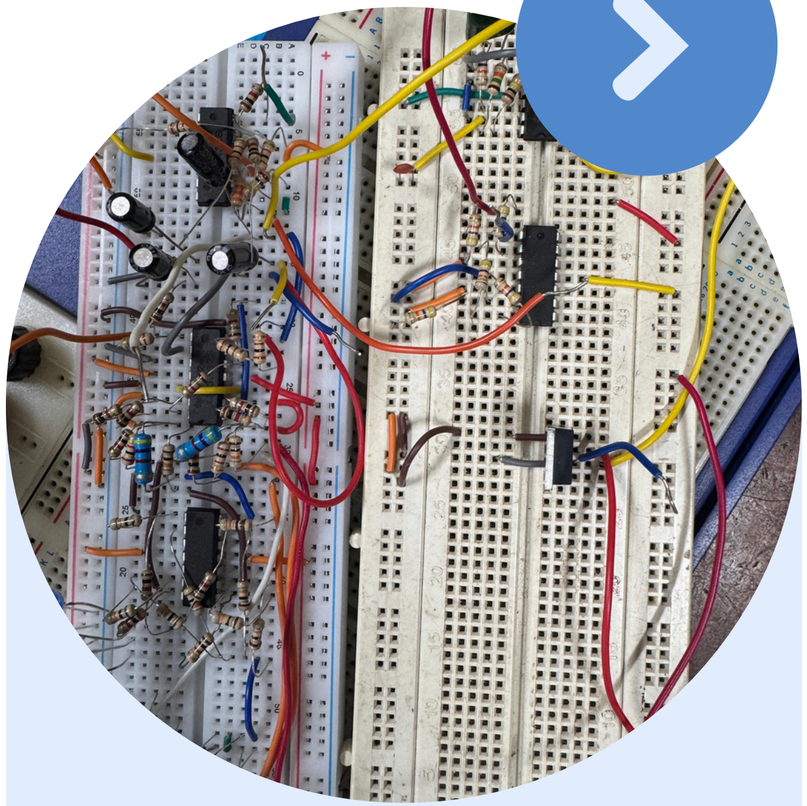
ANALOG LINE FOLLOWING ROBOT

Presented by Outlaws





Project Overview

- Fully analog line-following robot using PID control.
- IR sensor array detects line position.
- Analog circuits generate error and implement PID.
- Comparator with triangular wave produce PWM for motor control.
- Transistors drive motors for smooth, real-time line tracking.

Components and Selection

LM324N Op-Amp IC

Contains 4 op-amps in total. Ideal for implementing P, I, D circuits and signal conditioning.

IR Sensors

Provides accurate line position detection. Analog output simplifies processing.

Resistors & Variable resistors

Used for setting PID gains (Kp, Ki, Kd) and voltage division.

Capacitors

Used for filtering, integration, and differentiation circuits.

DC Motors

Provide motion to the robot and respond effectively to PWM control signals.

Voltage Regulators

Used to create a regulated ±5 V dual power supply for stable analog operation.

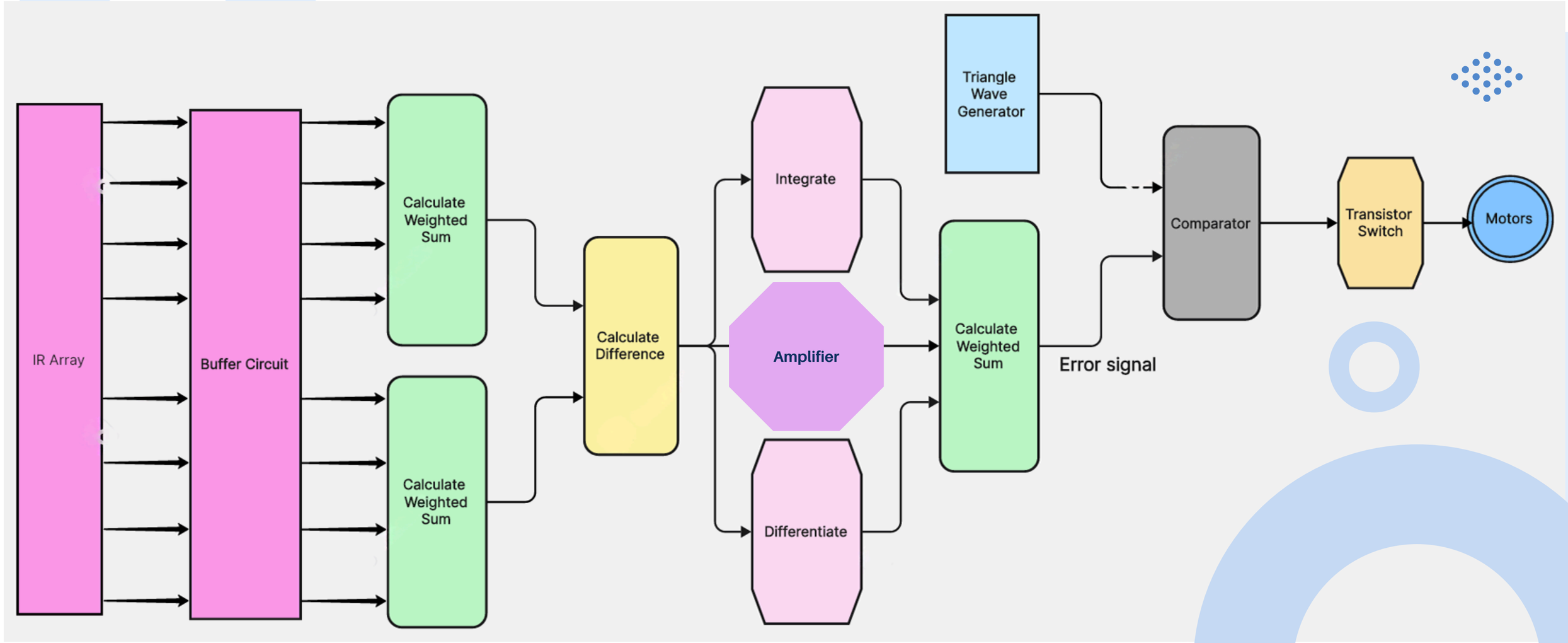
3.7 V Li-ion Batteries

Used as the main power source. Two batteries connected in series supply sufficient voltage for both regulators to produce ±5 V.

MOSFETs

Used as efficient electronic switches for driving DC motors with PWM signals. Offer fast switching speed and low power loss compared to BJTs.

System Block Diagram



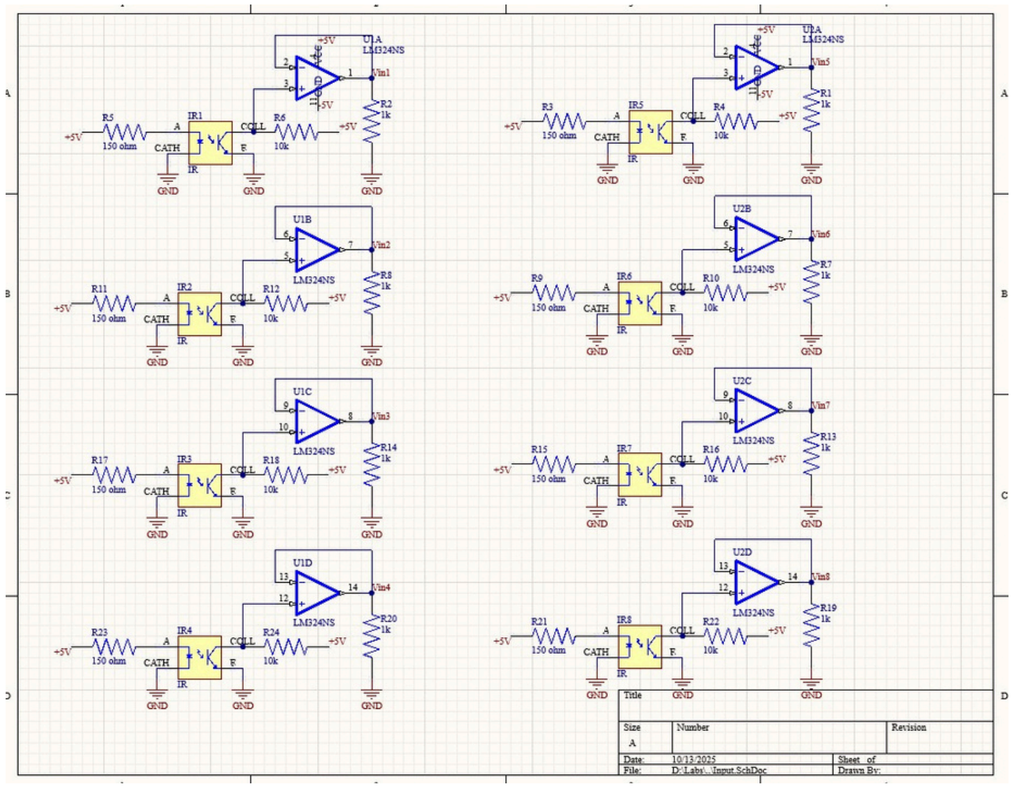
Functionality

IR Sensor Array

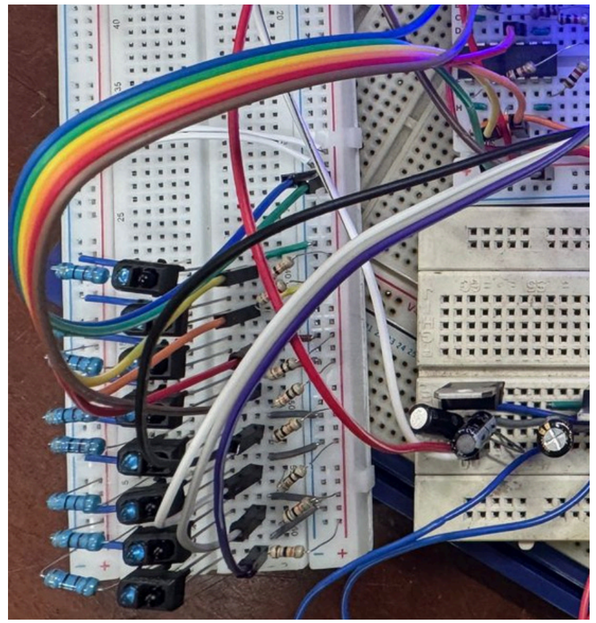
Function: Detects the position of the black line on a white surface.Provides analog voltage proportional to reflected light intensity.
Component: 8 IR emitter–receiver pairs.

Buffer Circuit

Function: Isolates the sensor array from the next stage and prevents signal interference.
Component: Op-amps from LM324 in voltage follower mode.



Input IR sensors and buffers



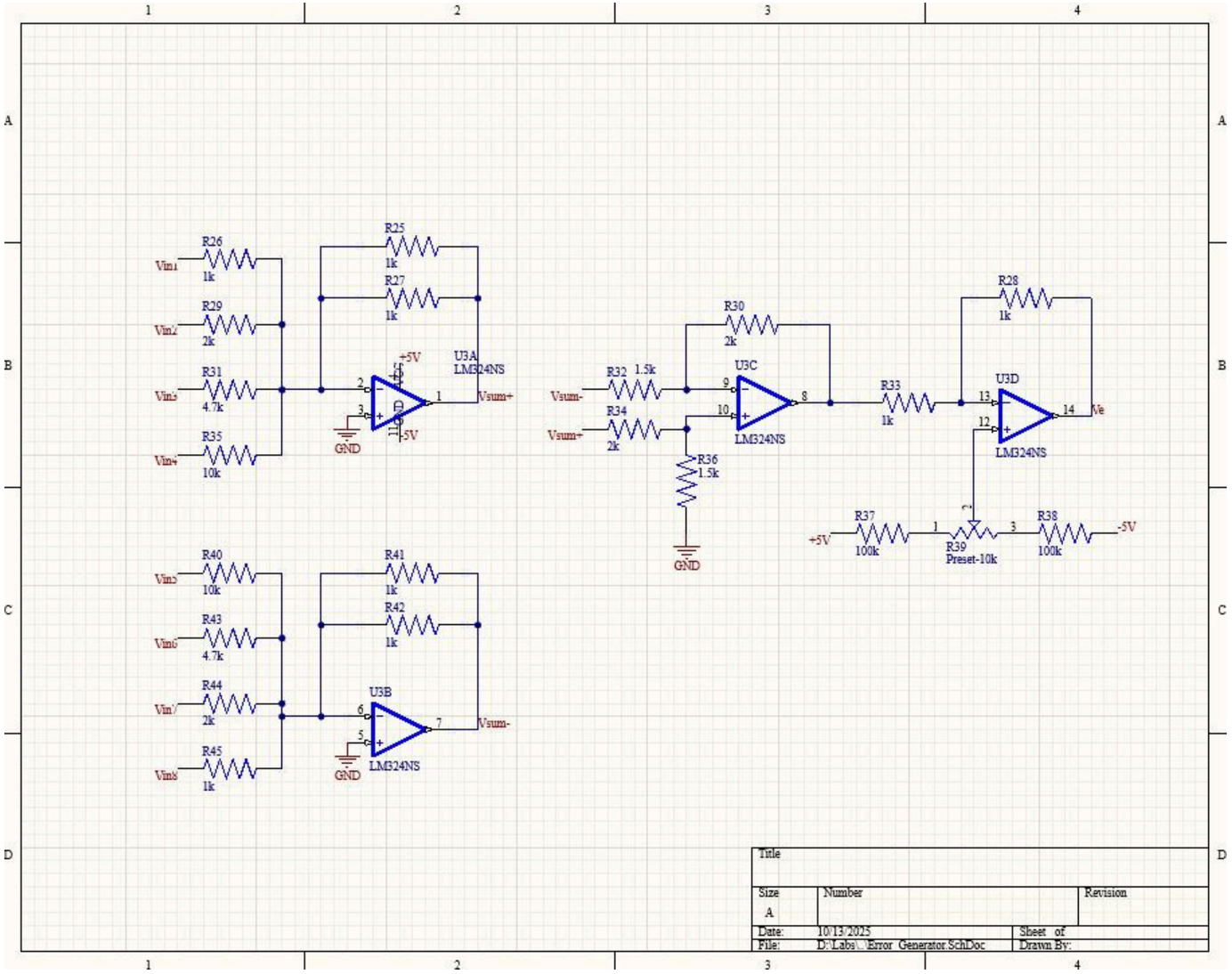
Functionality

Weighted Sum Calculation

Function: Computes position information by giving different weights to each sensor.
Component: Scaling adder circuit using op-amps and resistors.

Calculate Difference

Function: Produces the error signal by comparing left and right sums.
Component: Differential amplifier

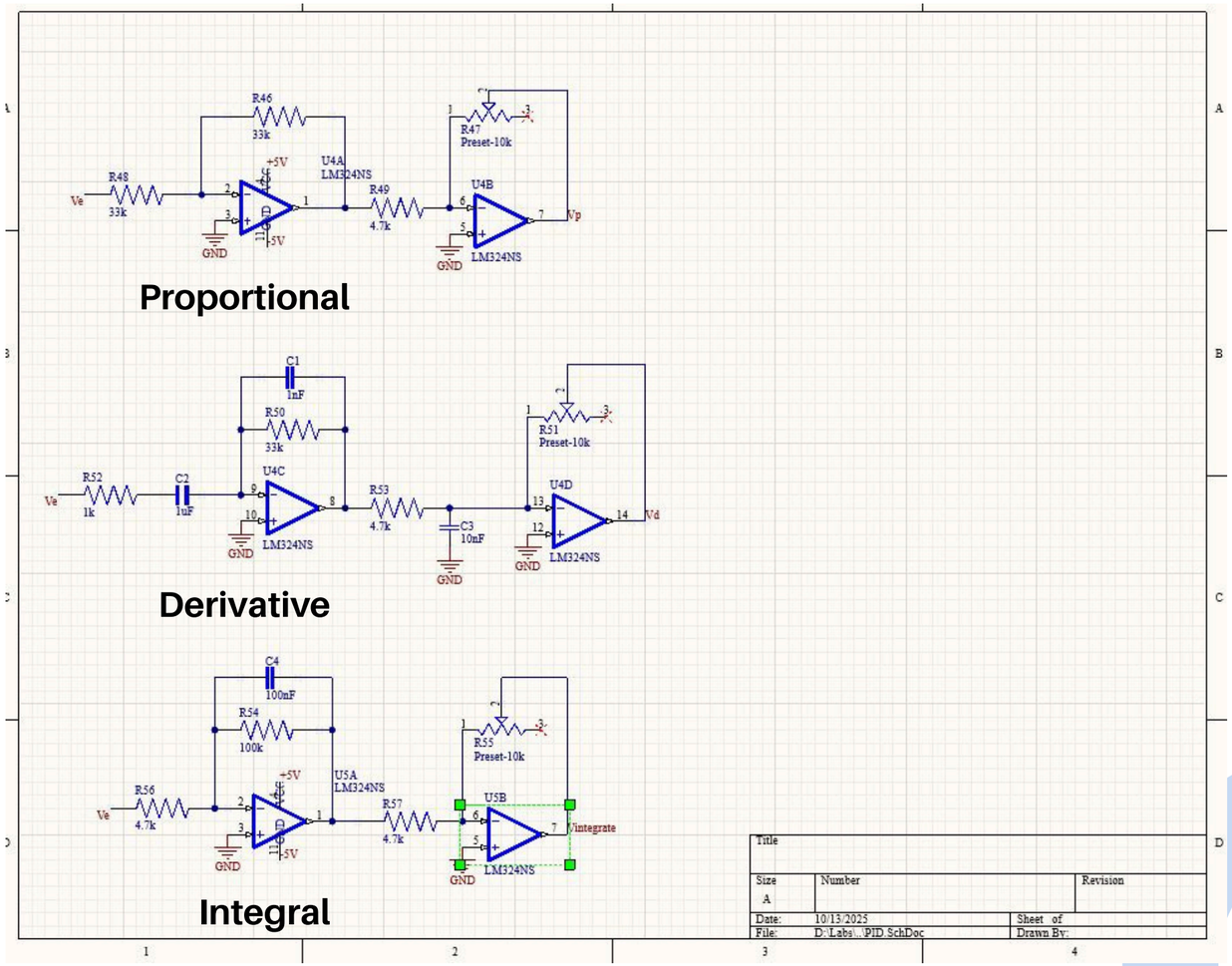


Scaling adders and Subtractor

Functionality

PID Control

- **Proportional (P):** Directly amplifies error signal.
  - Provides immediate correction proportional to error.
- **Integral (I):** Integrates error over time using an op-amp integrator.
  - Eliminates steady-state error.
- **Derivative (D):** Differentiates error signal using an op-amp differentiator.
  - Predicts and reduces overshoot.



PID controller

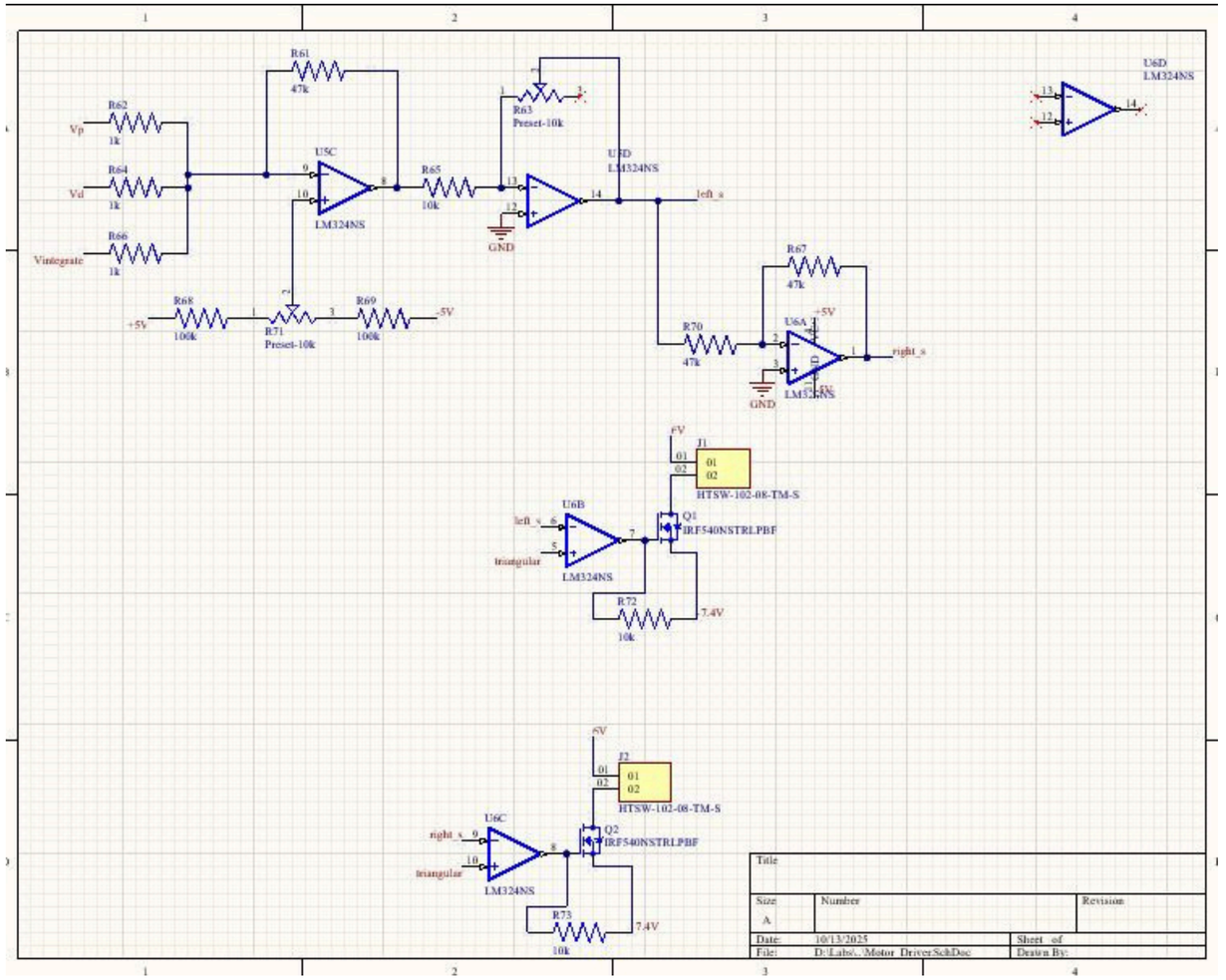
Functionality

Transistor Switch

Function: Drives DC motors based on PWM signal.
Component: Power transistors

Motors

Function: Execute movement and correction.
Component: Two DC gear motors.



Motor controlling circuit

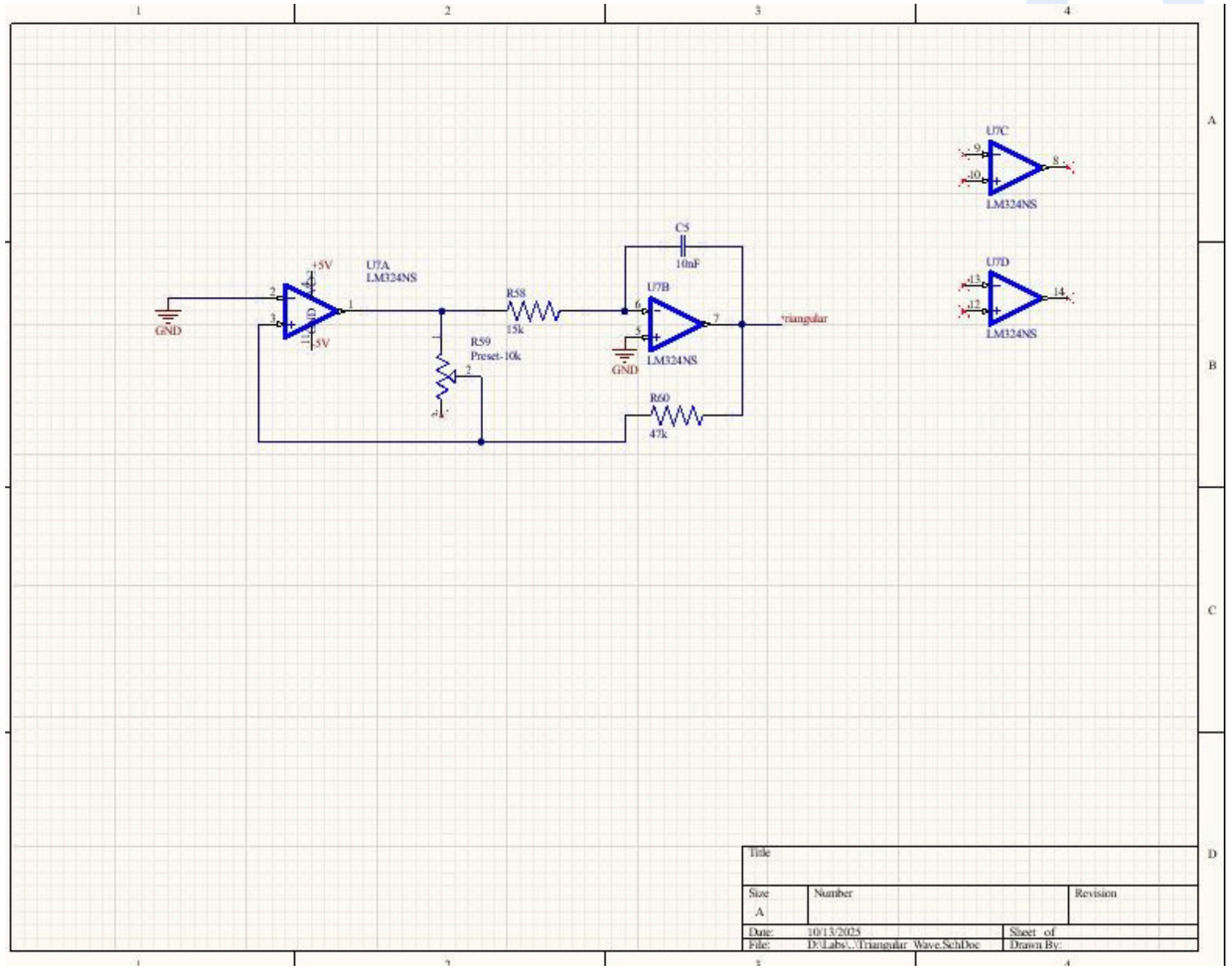
Functionality

Triangle Wave Generator

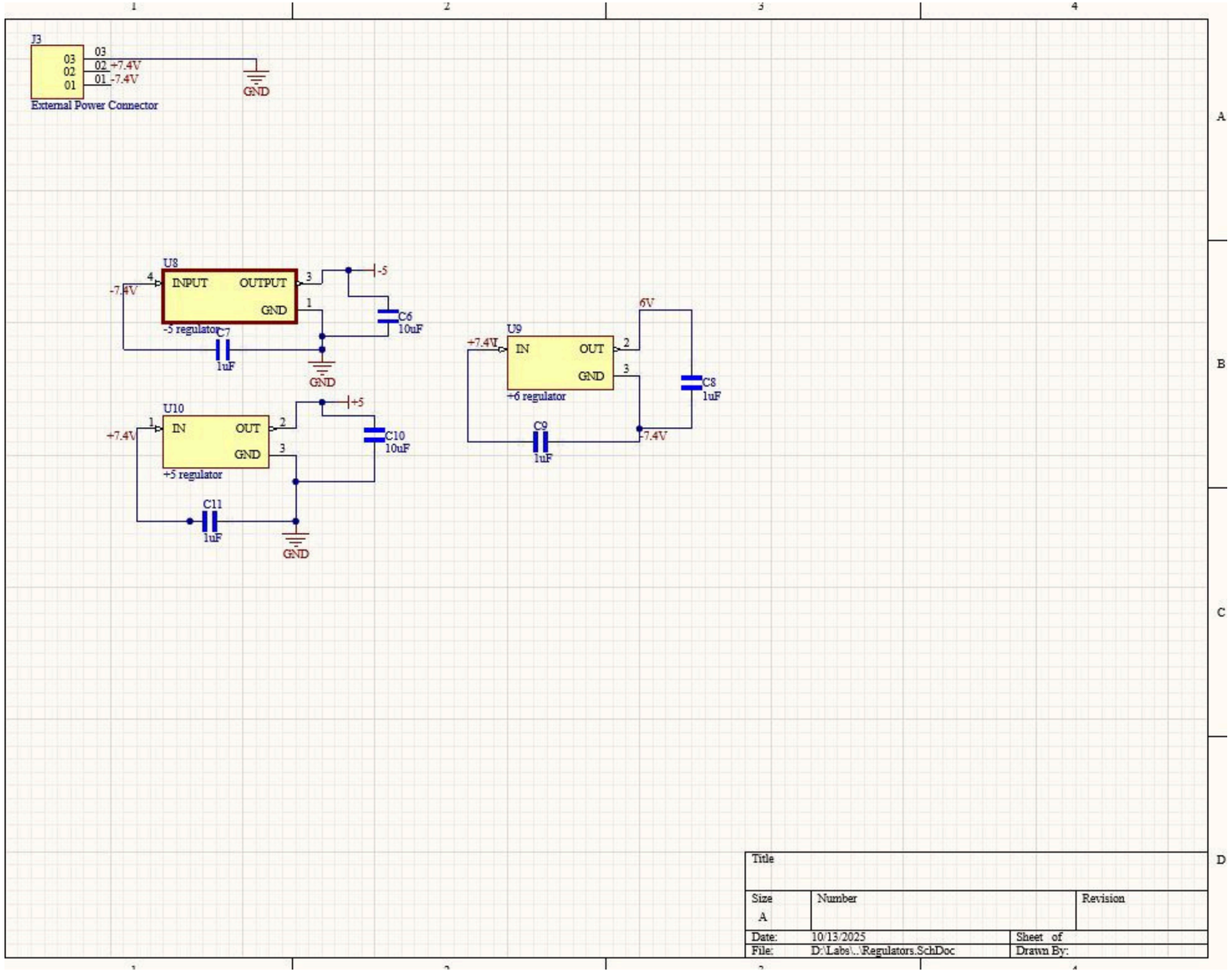
Function: Produces a periodic triangle waveform.
Component: Op-amp-based integrator + comparator.

Comparator

Function: Compares PID output with triangle wave to generate PWM.
Component: Op-amp in comparator mode.

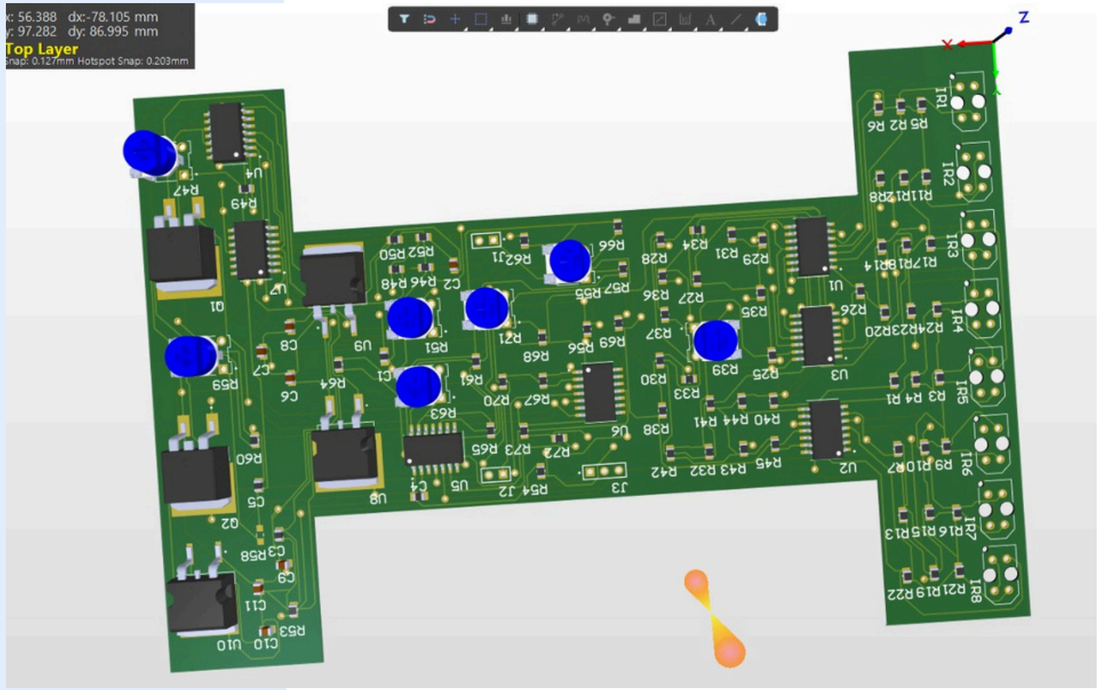


Triangular wave generator



Regulators and power management circuits

PCB Design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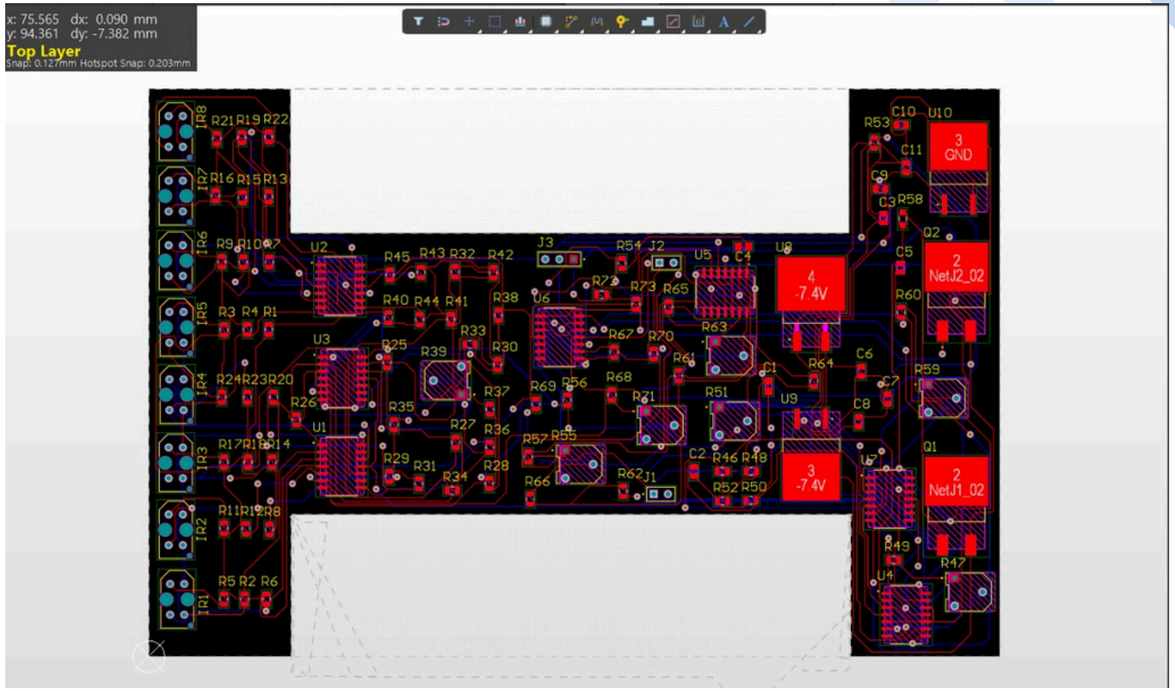
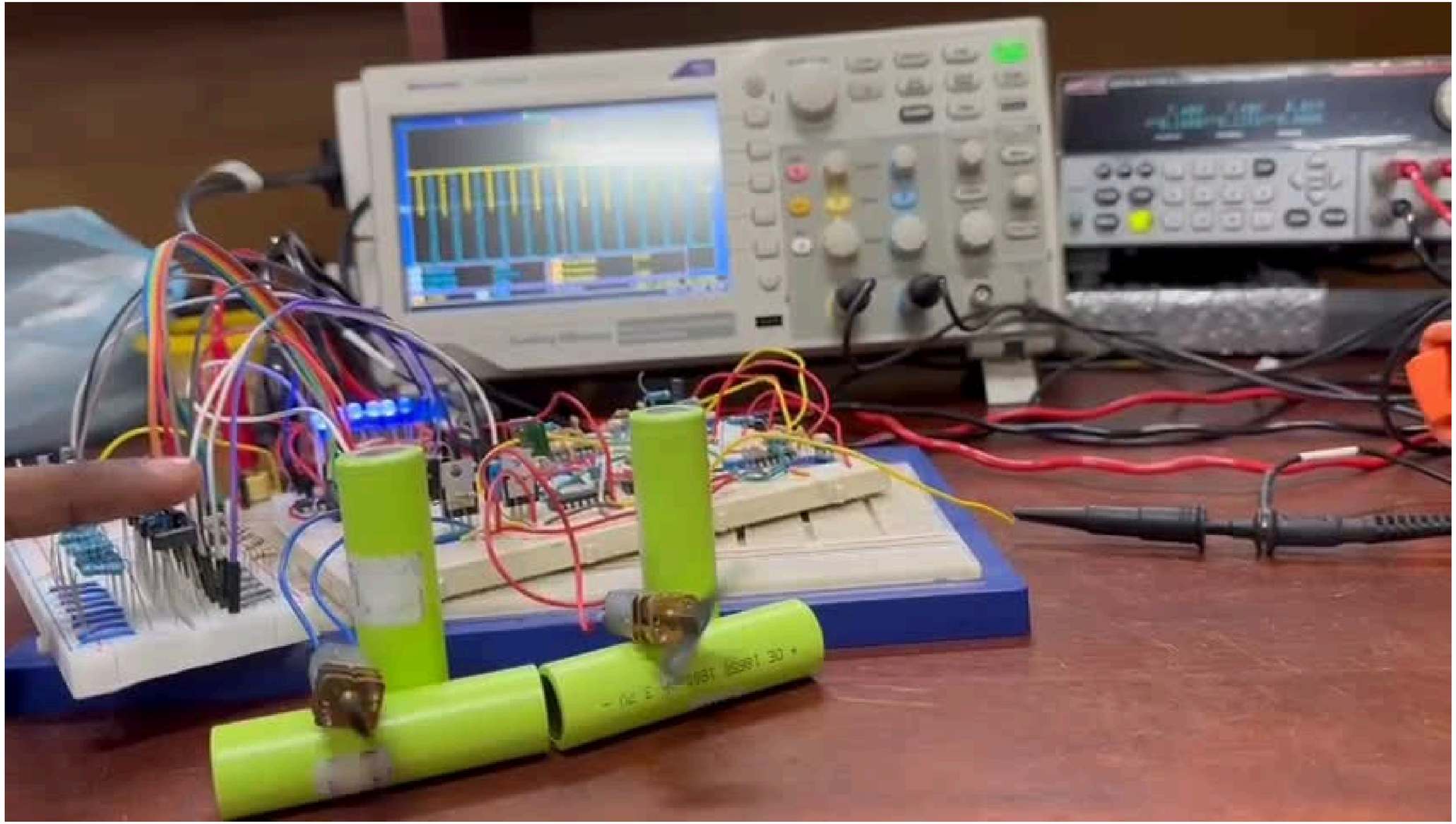
y: 97.282 dy: 86.995 mm
Top Layer
Snap: 0.127mm Hotspot Snap: 0.203mm


x: 75.565 dx: 0.090 mm
y: 94.361 dy: -7.382 mm
Top Layer
Snap: 0.127mm Hotspot Snap: 0.203mm
3
GND
4
-7.4V
2
NetJ2_02
3
-7.4V
2
NetJ1_02



THANK YOU!