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Optical Localization Sensor

TNTN Robotics | Electronics and embedded software

I designed a compact localization board that combines an optical flow sensor and IMU to estimate robot movement without tracking wheels. My work covered the PCB, firmware, and integration with the robot.

Board design

The six-layer PCB is approximately 25 mm wide and uses an STM32 microcontroller. I laid out the power distribution and sensor interfaces, then checked power and signal behaviour with an oscilloscope and logic analyzer during bring-up.

Sensor processing

I wrote FreeRTOS firmware for sensor acquisition and implemented Kalman-filter sensor fusion to estimate robot movement from the optical flow sensor and IMU.

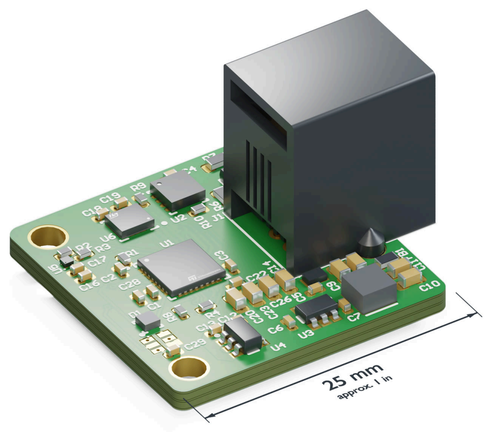
Robot integration

We used an RS-485 UART to communicate with the robot. We prioritized robustness, using COBS to delimit packets and CRC-16 to detect transmission errors. The robot’s main controller could request the sensor’s position estimate at any time, and the sensor would respond with a timestamped position and velocity.

Results

The finished sensor provided millimetre-scale localization for the robot.

The project was part of TNTN Robotics’ 2025 season. The team won the VEX U Tournament Championship, Skills Championship, and Excellence Award.



Localization board render, approximately 25 mm wide.

TNTN Robotics at the 2025 VEX U World Championship.

ENPH 253 Autonomous Robot

UBC Engineering Physics | Summer 2026

ENPH 253, or Robot Summer, is a six-week design course in which teams of four build autonomous robots from scratch. In 2026, sixteen teams competed in two-minute heats to complete Mars-habitat tasks. Our team built a robot that navigated the field, identified targets, and moved objects autonomously.

Our approach

We chose not to pursue radio-tower points to avoid the added mechanical complexity. Our robot was working nearly two weeks before the other teams, leaving time to tune complete runs on the field. I developed the embedded software and controls; my teammates and I built and tested the full robot together.

Drive and localization

I programmed holonomic motion with angular and linear PID control for the mecanum drivetrain. We used OTOS, my optical tracking odometry sensor, to estimate pose and refined routes through repeated field tests.

Arm control

I used inverse kinematics to command the two-DOF arm. Magnetic encoders measured each joint, nested position and velocity PID loops controlled motion, and battery-voltage compensation improved consistency.

Electronics and software

Our team designed and assembled custom boards for the main controller, tape sensors, metal detectors, motor drivers, and power distribution. Vision on a second processor detected the hidden targets; tape sensors recalibrated position and dual metal detectors identified metal in rocks.

I wrote C++/FreeRTOS firmware for the ESP32, using tasks and queues to coordinate driving, sensing, and manipulation.

Our robot on the ENPH 253 competition field.

Results

Our robot won the 16-team competition. We reached the final after the opening and knockout heats, then won a close match decided by habitat assembly. The early working build gave us time to make complete runs more consistent, even without attempting the radio tower.

[Read UBC's competition report.] [Watch the CityNews interview.]

[Read the full project story.]

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Electrostatic Brake Driver

Power electronics and embedded control

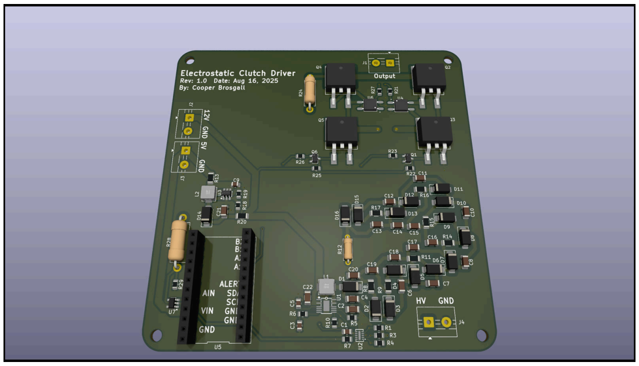
I designed a compact high-voltage driver for electrostatic clutch experiments. The board takes a 12 V input and is designed to generate up to 1,000 V, with an H-bridge that reverses the output polarity.

Voltage generation

An eight-stage charge pump raises the output voltage while keeping the boost converter switch voltage lower. A voltage divider measures the output for software control.

Output control

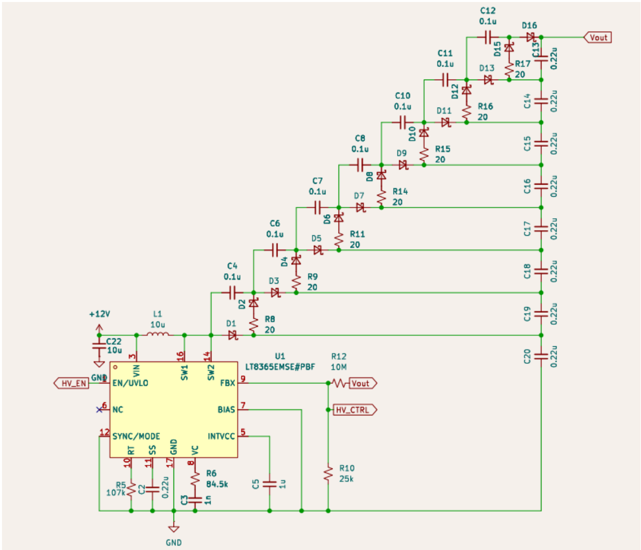
The H-bridge alternates the voltage across the clutch at 10-20 Hz. Photovoltaic gate drivers isolate the high-side switches from the low-voltage controller.



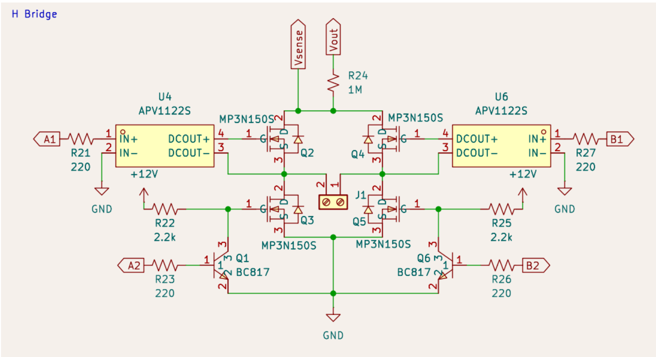
PCB render combining the power supply, H-bridge, voltage measurement, and microcontroller interface.

Firmware

The nRF52840 firmware provides wireless configuration and closed-loop voltage regulation. Voltage and switching frequency can be varied in software during clutch testing.



Boost converter and eight-stage charge pump.



Bipolar H-bridge with isolated high-side gate drivers.