2026 STORM Design Report

University of Arkansas

Robotics Interdisciplinary Organization of Teams (RIOT)

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Team Organization and Team Members

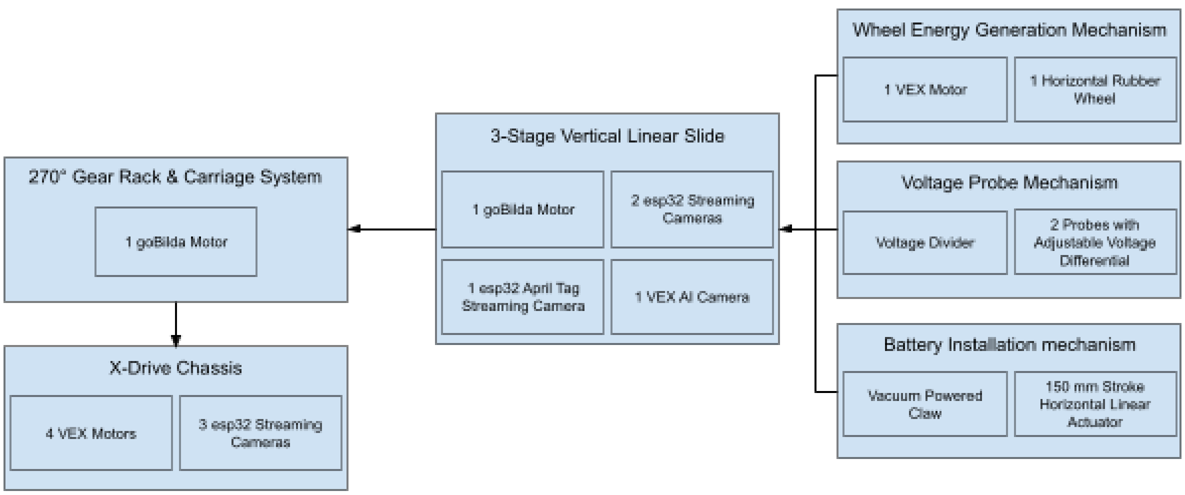
Robotics Interdisciplinary Organization of Teams (RIOT) is a student-led organization from the University of Arkansas. The goal of RIOT is to promote cross-disciplinary robotics competitions, research, and involvement with the hope of bringing more students into the robotics field. The organization hosts multiple robotics projects for students to propose and get involved in, with one option being the STORM competition this year.

Gavin Hill
Team Captain · Mechanical Lead
Robot Operator

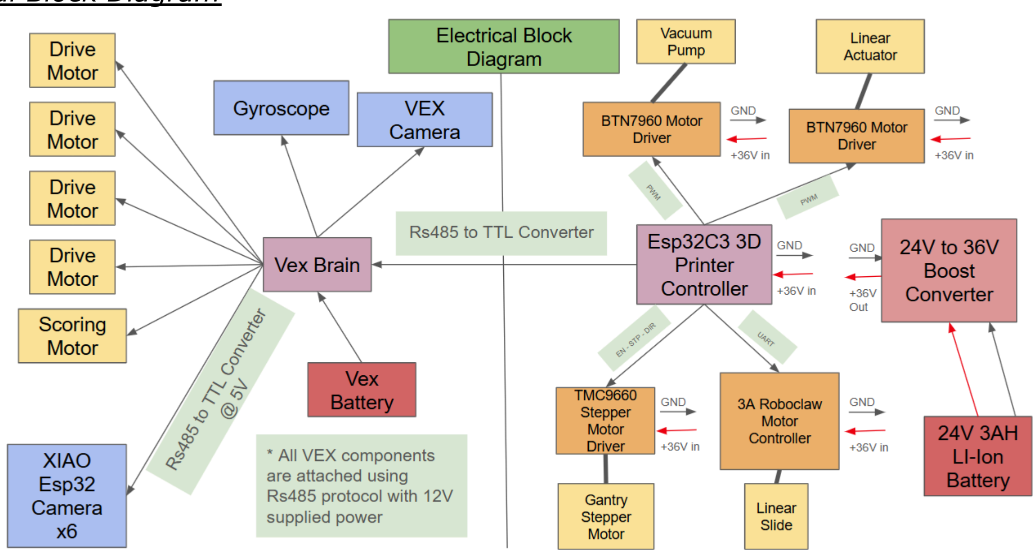
Cedric Serio
Electrical Lead · Programming Lead
Mechanical · Robot Operator

High-level Block Diagrams of the Robot

Mechanical Block Diagram

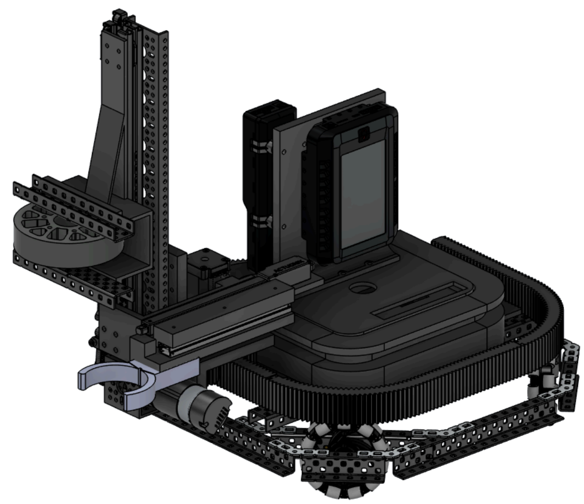


Electrical Block Diagram



Mechanical Design

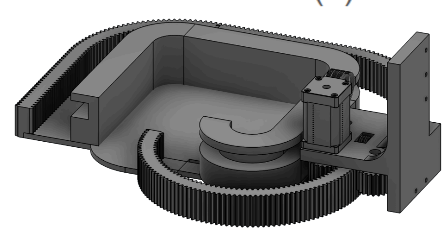
The philosophy driving our mechanical design is efficiency and simplicity. The robot boasts a high-velocity X-drive with task-adaptive end-effectors designed to interact with any given scenario. The 270-degree gear rack and carriage move all of our scoring mechanisms to the side where it's needed. The placement of the wheel energy generation mechanism and voltage differential probes relative to each other allows for the robot to produce simultaneous energy generation. The use of a vacuum claw enables the system to grab onto upright batteries and transfer them into battery banks through dual motion capabilities achieved through a vertical linear slide and horizontal linear actuator. Collectively, we felt the best strategy was to forego the floodwater point opportunities, strictly focusing on decreasing the cycle time of the batteries and increasing driving efficiency.



Drivetrain Configuration

From the start, we wanted a quick, omnidirectional base for ease of maneuverability and low cycle times. An X-drive, mecanum wheels, or swerve drive was considered with this in mind. Ultimately, an X-drive (5) was chosen due to cost and prior experience, knowing this would satisfy our conditions. A VEX motor operates in each corner of a VEX aluminum C-channel base, moving omnidirectional wheels for 3 degrees of freedom. After testing with the other mechanisms, a steel base plate was mounted onto the drive train for a lower center of gravity.

(1)



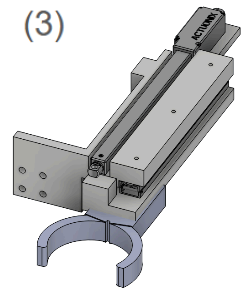
Mechanisms

The 270-degree gear rack and carriage system (1) was implemented as a means to allow all scoring mechanisms to be operational on three sides of the robot. This is not a requirement but allows for decreased cycle times and increased simplicity in driver control due to uniquely not turning the drive base at all throughout a match. The mechanism uses a goBilda powered carriage that drives a gear engaging a curved gear rack, supported by 3 idler gears for smoother motion. The gear rack is curved on one side to fit the scoring mechanisms on the carriage into the size requirements at the beginning of a match. The gear rack stayed the same throughout the robot's creation, but there were many iterations of the carriage to decrease friction and increase stability with the heavy load, implementing bearings later on.

(2)

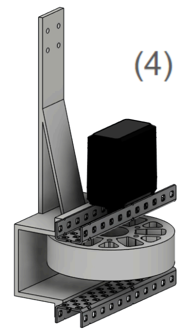
The vertical linear slide mechanism (2) was decided on to enable strictly vertical movement of the robots scoring mechanisms with a small horizontal footprint. The linear slide was iterated upon to include all scoring mechanisms for increased flexibility of scoring during the driver control period. The linear slide mechanism is a 3-stage belt-driven linear slide powered by a goBilda motor.

(3)



The battery installation mechanism (3) needed to be able to interact with the batteries and provide horizontal reach over the battery banks to place batteries into the top level. The vacuum claw design was widely commercially available and gave sufficient results on gripping the batteries with the linear actuator moving the claw horizontally outward until the battery is over the chosen slot. It was discovered that the voltage probe mechanism, simply two probes with a voltage differential, could easily be added to the robot on top of the claw. With the linear actuator extending to ensure contact of the probes onto the grid while at the same time generating energy through the wheel above.

(4)

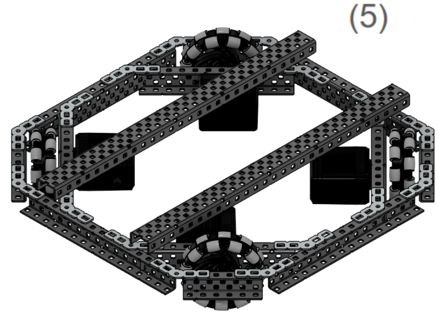


The wheel energy generation mechanism (4) is a horizontal rubber wheel powered by a VEX Motor. This was chosen for simplicity in the interaction of energy generation and different rubber flexibilities were tested with a more forgiving option chosen.

Electrical Design

We developed an electrical design that compartmentalized driving and scoring as separate control schemes, allowing for the minimization of redundant communications. One operator focused on the movement of the robot's drivetrain (5) for field positioning plus the energy generation mechanism (4). A second operator focused on the combined upper gantry system (1)(2)(3) to allow for proper scoring.

(5)



The drivetrain was designed with a VEX base drive system and allows automated communication to be isolated from the communication for the scoring system.

The scoring system consisted of two BTN7960 motor drivers, a vacuum pump, and a linear actuator to operate the claw and a TMC9660 stepper motor driver for the carriage system. The robot runs on a custom pcb with a ESP32S3 microcontroller capable of driving the stepper motor and UART communications. In addition, GPIO attachments are used for three daughter-boards that control three brushed motors.

The overall electrical system, excluding the VEX architecture, is optimized for battery installation, resulting in the use of fewer electrical components. This is all operated with a custom-made remote controller using the ESP-32 architecture.

Software Design

The software consists of three codebases: one for the VEX Brain, one for the ESP32 microcontroller, and one for the various ESP32 cameras which we have on the robot. All three codebases are built on Automat, a robot control library which we have spent the last three months developing. Automat is a powerful command-based robot control library based on the FIRST Robotics Competition library WPILib and is focused on simplicity of design while maintaining complex functionality.

On the robot, our various microcontrollers communicate via UART using a packet interface built into Automat. The connection from the main ESP32 microcontroller to the computer is via a HTTP dashboard that is also built into Automat. The streaming cameras each have their own HTTP servers, built from the HTTP server helpers in the Automat library.

The flexible tools of the Automat library allow us to split robot actions into discrete commands which have a defined start and end, allowing us to string them together into complex movements and sequences. The robot is also split into subsystems, with each subsystem only allowed to interact with one command at a time to prevent conflicting signals. Not only do these features help prevent repeated code and encourage good practice, they also make full scoring motions and autonomous sequences extremely easy to build and maintain.

Operator Interface

Our operator interface, as mentioned before, consists of a robot dashboard on a HTTP server hosted on the main ESP32 microcontroller. The operators use USB controllers connected to the computer and the button events are sent via POST request to the robot. The HTTP server and joysticks are built into the Automat library.

The operator controls are designed to minimize the number of required actions and remove, to the best that we are able, all manual alignment of all wheels and mechanical systems. We use a system of experimentally obtained setpoints to allow us to recreate motions consistently and score from known locations. Each button triggers a sequence of commands, performing some action such as scoring a game piece before returning to the neutral position. Joystick positions are used as selectors for which position to score in, which camera to use to orient, etc.

Our camera system seeks to eliminate all manual alignment of the drivetrain through the detection of Apriltags for the scoring elements and color detection for the game pieces. At the press of a button, the robot uses the drivetrain to center the Apriltag or game pieces in the camera's field of vision, creating a known, consistent location from which to score or intake a piece.

Safety and Reliability

In order to ensure operational safety, the robot has three modes: disabled, autonomous, and tele-operated. When powered on, the robot defaults to the disabled state, and cannot enter any other state until the computer is connected via the dashboard. On loss of the heartbeat signal from the dashboard, the robot will return to the disabled state within one second. The heartbeat is built into the Automat library.

Though most of our robot control is very high-level, incorporating several movements with a number of setpoints, we have fallback controls in case of misalignment or miscalibration. While the operator is holding the left trigger, the control scheme swaps to a fully manual setup with individual control of all subsystems.

To prevent accidental miscalibration or failure to calibrate, we made sure to have none of our mechanical systems require hand calibration before a match. All systems have a means to calibrate via software using absolute encoders, limit switches, or hard stops.

We also made sure that the voltage supplied across the jumpstart probes is limited to a max of 20mA, as per competition guidelines.

Bill of Materials

Item	**Quantity**	**Item Price**
goBilda Linear Slide	1	$129
Xiao Esp32S3 Cameras	6	$11
5kg Filament	1	$55
3AH 24V Lion Battery	1	$24
Esp32S3 Control Board	1	-
2ft x 1ft 1008 Hot Rolled Steel	1	$11
Stepper Motor	1	$25
Roboclaw 2x7A drive	1	$80
Vacuum Pump	1	$25
BTN7960 Motor Driver	2	$17
Buck Boost Converter	1	$29
LN2986 Buck Converter	3	$8
Vacuum Claw	1	$34
Wire Loom Tubing	1	$9.99
VEX V5 System Bundle	1	$779.49
VEX Motion Parts	1	$178.90
VEX Structure Parts	1	$158.96
VEX Camera	1	$95.49
Total		$1758.83