2025
Tech Binder

Boba Bots 253

Mana-TEA

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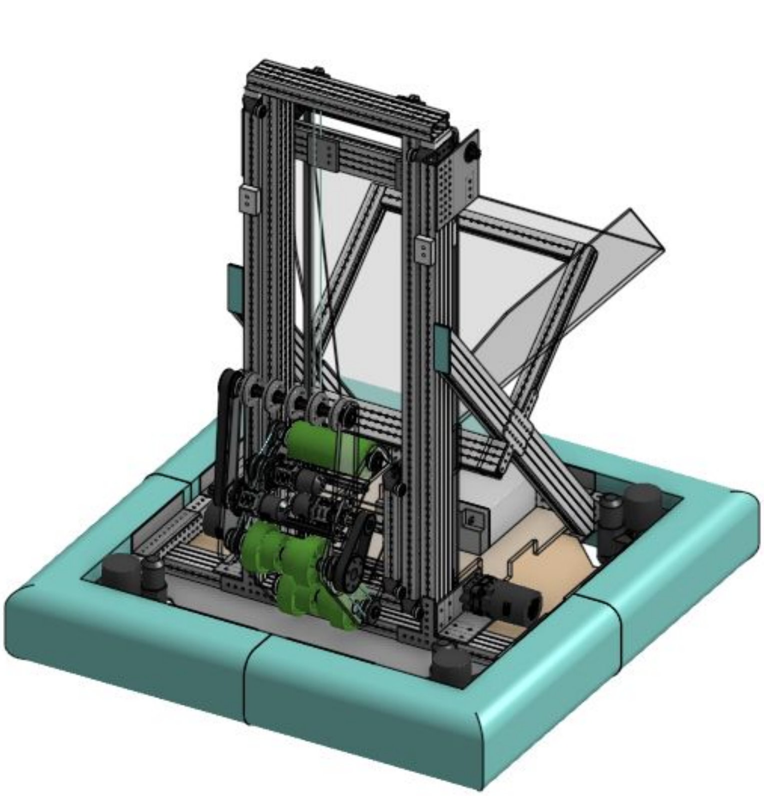
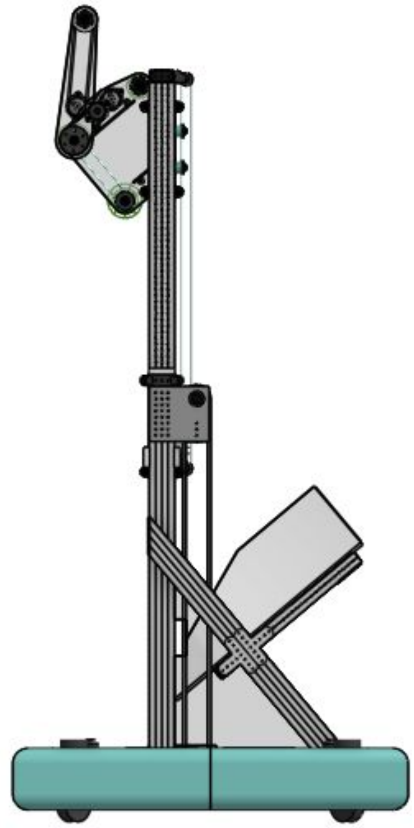
Our Robot: Mana-TEA





Overview:

This robot was built for Reefscape, the 2025 FRC season. It is capable of scoring PVC pipes (called Coral) on a structure called the Reef, using a system of rollers on an elevator to lift the Coral upwards. The robot is also capable of knocking off kickballs, called Algae, from the Reef. Our robot utilizes a swerve drivetrain, which allows the robot to move and strafe in multiple directions simultaneously.

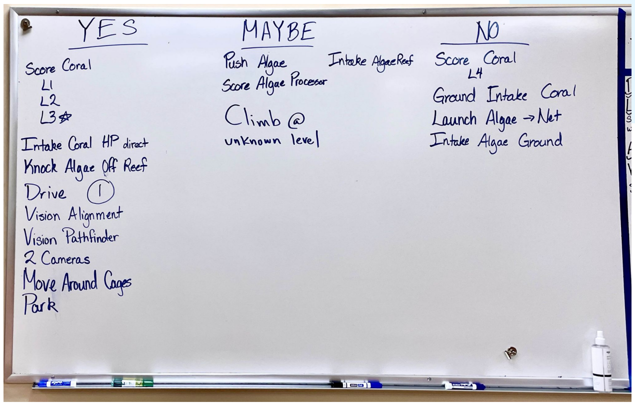
Quick Facts:

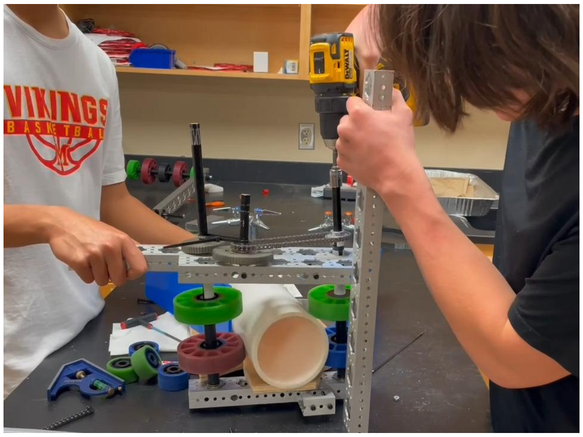
- Starting height: ~38”
- Fully extended height: ~62”
- Weight: ~100 lb with bumpers and battery
- Drivetrain size: 26”x26”
- Capabilities: Station intake Coral, L1, L2, L3, remove Algae from Reef

Design Process

Setting Goals:

During the first couple days of build season, we listed out all possible game actions and identified which ones we wanted to prioritize, taking into consideration our capabilities as a team. We decided to focus on scoring L1-L3 coral and removing algae from the reef, with a shallow or deep climb as a possible add-on after our first competition.





Prototyping/CAD:

After defining our goals, we got right into prototyping, making sure to document everything! We used scrap materials to build low-fidelity prototypes in order to experiment with ideas, then CADed better designs in Onshape with the data we gathered. We also discussed the findings from Open Alliance teams, which allowed us to evaluate ideas that we didn't have the resources to test.

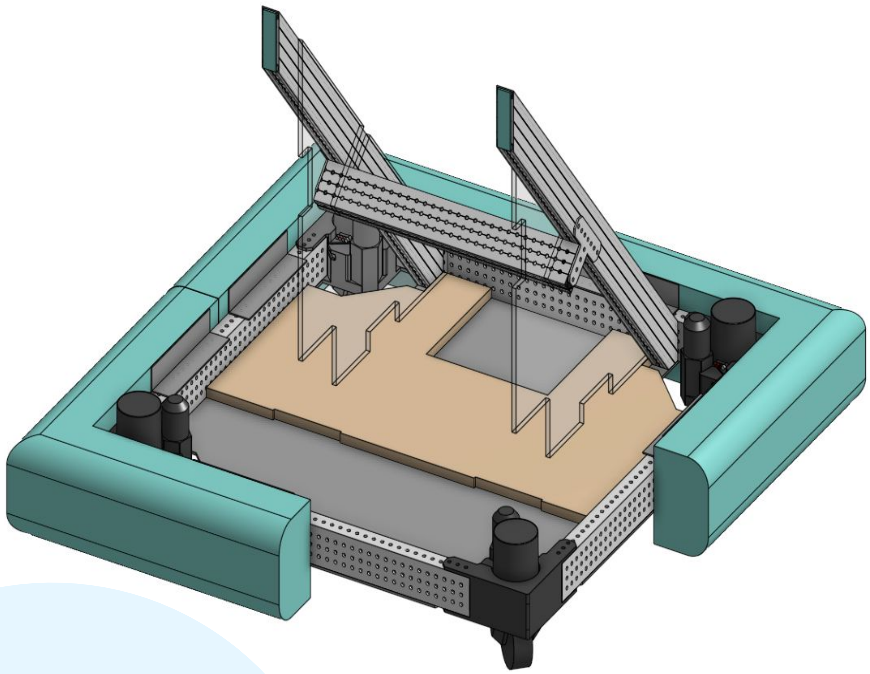
Drivetrain - Mechanical

Swerve:

Our robot utilizes REV MAXSwerve modules with a HIGH (4.71:1) speed configuration. A NEO drives the wheel and a NEO 550 turns the wheel. The drivetrain is 26” x 26”, made of ⅛” wall aluminum box tube and a ⅛” steel bellypan. Our electronics are mounted to a sheet of plywood on top of the steel bellypan to insulate them. The entire drivetrain (without bumpers and battery) weighs around 55 lbs.

Bumpers:

Our 4-piece corner bumpers are made of ¾” plywood backer that is 5” tall and hollow pool noodles, covered with satin fabric. Our team numbers are iron-on vinyl, cut with a Cricut. We used 4-piece bumpers last year and they worked well, so we decided keep using them. This year, we attached the bumpers with permanently mounted ¼-20 bolts and thumb nuts. The bolts are threaded through rivnuts and loctited, forming a stud that the bumper is placed over.



Drivetrain - Electrical

Summary:

We are using a swerve drivetrain which allows omnidirectional movement. This year, we have a 26”x 26” swerve drivetrain that contains 4 REV MAX Swerve modules at each corner. We chose to use this kind of swerve because it’s cheaper and easier to integrate due to the fact that we already have most of the parts.

Choosing a Layout:

Our main goal this year for wiring was to make it as neat and traceable as possible. We made use of zipties, wire covers, and an energy chain–a new component we worked with this year–to ensure that our goal is met. To make wiring easier, we cut out slits in the polycarb panel supports. Some challenges we’ve faced while planning out our wiring layout was the lack of space as well as convenient locations for our core components. One constraint was the placement of the RoboRIO, which had to be in the middle. This is because of the NavX connected on to the RIO. Another constraint was the battery placement; we had to place it horizontally for a better center of gravity. These constraints forced us to come up with new places that we usually wouldn’t have thought of for our core components such as the PDH, SparkMAXes, and Radio.

Drivetrain - Software

Summary:

Field-oriented MAXSwerve drivetrain allows the robot to achieve nimble omnidirectional movement. Strongly implemented sensor-fusion to enhance peripherals, reinforce accurate measurements, and correct erroneous telemetry when updating robot odometry. Primary sensor is the AHRS gyroscope NavX2-mXP connected to the roboRIO. Secondary sensors include our vision solution using dual Limelight 3G's. Provides driveteam with a competitive design reinforced with programming refinement and ease of implementation with PathPlanner for autonomous routines and pathfinding.

Odometry:

The default odometry scheme is a gyro-fused wheel odometry loop running with NavX2-mXP. This loop provides driveteam with sufficient accuracy that is updated on the periodic block (20ms). To combat the occasional drift in the calculation of the current robot's heading, the driver is offered a binded controller button to soft-reset the field-centric zero position. However, the accuracy of this method doesn't handle external factors and influences well (ie:collisions) which negatively affects the accuracy of the inertial-based measurements over the duration of a match. Utilizing our vision solution, we can achieve a greater magnitude of precision and accuracy that accurately maps our position on the field.

Vision Solution

Summary:

Implementation of our vision solution is one of our main upgrades this year. Using Vision-based odometry fused with gyroscope data allows the robot to "know" where it is on the field with high accuracy in real time with low latency.

Defining Limelight:

“Plug-and-Play” Smart Camera with Independent Coprocessinng & Telemetry via Network Tables 4 for tracking April Tags (Fiducial Targets).

Models: “LL-3G’s” - 2 in use | “LL-4’s” - 2 stocked

Philosophy:

Trust the gyroscope reading for rotational data due to the gyroscope having more accuracy (sensor-fusion). Sync limelight data readings within custom vision data class. Use trust factors to determine which localization data to use. Example of trust factors include average tag distance from robot and LL, latency, target closest to crosshair, etc. We also actively seeks nearby tags, downscales our detection plane, and applies a crop factor when within minimum trustworthy distance.

Wiring Vision:

The Limelight telemetry is broadcast across ethernet through a medium: a unmanaged Ethernet switch called a Brainbox. With the newer radio, it has the potential to overheat faster compared to the older mesh radio, which is why it is important we connect the limelights to the brainbox instead of directly to the radio.

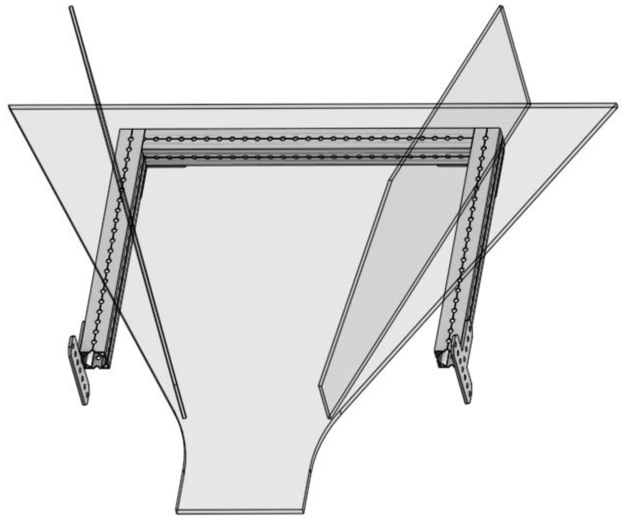
Funnel

Summary:

The funnel on our robot is able to passively center coral loaded from the Coral Station. We decided to go with a passive funnel due to its simplicity and reliability.

Design Details:

The opening of the funnel is ~17” wide. The base is ¼” polycarb, while the funnel walls are 6” tall made from ⅛” polycarb. The relative thinness of the walls gives the funnel some compliance, which helps to soften the bounce of coral. The walls of the funnel are at a 30° angle, while the entire funnel is mounted at 40° relative to the floor. We landed on these values after prototyping different angles and orientations. The base is mounted to the supports with 1x1 tubing, with rivets going through the polycarb into the tubing. The walls are mounted using right angle brackets. The funnel was designed to be able to intake even with a coral between the robot and the Coral Station so that dropped coral doesn’t hinder our cycle time.



Elevator - Mechanical

Summary:

Our elevator is designed to reach L1, L2, and L3, with a max height of around 62”. It is a 2-stage cascading elevator, and is powered by 2 NEOs on a 5:1 reduction. The design is similar to the Thriftybot kit, but using components from multiple suppliers and some custom parts.

Components:

- Chain stage: #25 chain, inline chain turnbuckles for tensioning, 24T sprockets
- Dyneema stage: 3/16” Dyneema rope, 3D printed PLA tensioners
- Bearing blocks: REV End-Mount
- Tubing: Stationary stage is thick-wall REV tubing, moving stages are thin-wall REV tubing
- 2 NEOs on a 5:1 MAXPlanetary
- 3D printed TPU hardstops

Cascade Rigging:

In a cascade elevator, all stages of the elevator can extend at once, as opposed to continuous where one stage of the elevator moves at a time. We chose a cascade elevator in order to maximize our speed. Our first stage is driven by chain, while our carriage is Dyneema.

Elevator - Electrical

Summary:

The main purpose of our elevator system is to provide vertical movement, enabling access to higher levels of the reef (L2 and L3), where we can score more points. For wiring the end effector, we implemented an energy chain, which serves to guide and protect the wires during operation, ensuring smooth movement and durability.

Rigging Energy Chain:

We chose to implement an energy chain in order to organize the wires from the stowed elevator position to the extended elevator position. To install it, we bolted a custom 3D printed part that extends outwards, allowing the energy chain to be attached with a zip tie. We first used a failed 3D print as a prototype and it worked well; we later added a finished prototype. In the end, we accomplished our goal of containing the three sets of power wires, and a set of CAN wires in a neat fashion, ensuring they are protected from damage as they move up the elevator into the end effector.

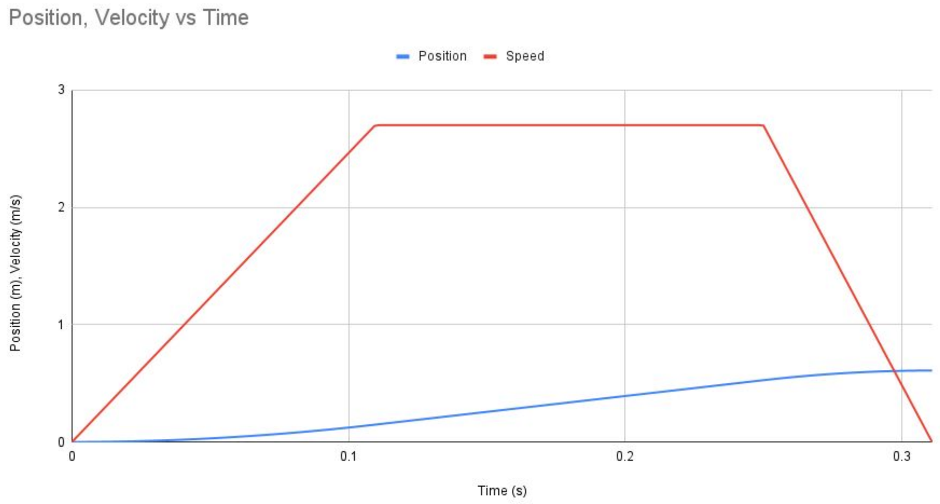
Elevator - Software

Summary:

Programming an elevator was a new experience for many members on the team this year. Our original idea for translating the elevator was to use WPILib default PID Controller. After some issues, we swapped to the MAXMotion Position Control (Profiled PID Controller).The profiled PID controller would enable a more consistent and smoother movement.

Summary:

First confirmed an arbitrary feedforward voltage value that balanced out the gravity of the system. Tuned PID values like normal after setting up trapezoidal motion profile. Extensions are pretty smooth but can be improved with upgrades to speed and overshoot compensation.

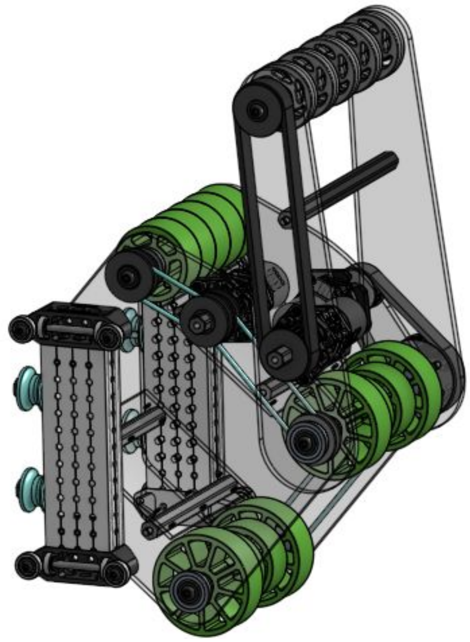


End Effector - Mechanical

Summary:

The end effector is used to score coral and knock algae off the reef. It weighs approximately 11 pounds without coral. The side panels are made out of polycarb, which was machined by our sponsor SendCutSend. The bearing blocks are mounted directly to the polycarb, making it our carriage as well.

Coral Rollers:



The coral rollers are live axle rollers with 2.25” and 3” green compliant wheels. The distance between the rollers is 6.5” and the compression on the coral is minimal. The rollers are driven by a NEO 550 on a 12:1 UltraPlanetary gearbox, connected together by polycord, belt, and pulleys.

Algae Remover:

The algae arm is driven by a NEO 550 with a 25:1 UltraPlanetary gearbox, connected to pulleys and a timing belt. The pulley ratio is 2:1, so the total ratio is 50:1. The roller in the algae arm is driven by another NEO 550 with a 5:1 UltraPlanetary gearbox. The roller is live axle with 2 inch compliant wheels. The side plates of the arm are made out of polycarb for impact resistance. The algae arm starts the match stowed vertically to fit within robot perimeter.

End Effector - Electrical

Summary:

The End Effector is used to score coral. It features three sets of wheels, being powered by three NEO 550s. The NEOs are controlled by separate sparkmaxes, which are connected together through a linear can pathway and also separately connected to the PDH via power wires.

Wiring Coral Intake:

Wiring the Coral Intake was a challenging task because it required complex wiring despite of its small size and because of the parts with polycords and rollers that move extremely fast. To prevent the situation where the electronic parts get caught in a spinning wheel or poly cord and being ripped off, we came up with a way to go around it as safe as possible as well as printing out the covers for those moving parts for extra protection. In the end, those wires were connected back to the drivetrain through our energy chain, where the power wires got connected to the PDH and CAN wires joined their circle at the bottom.

Wiring Algae Remover:

Wiring the algae remover was challenging because of the rotational movement, and that meant we had to be vigilant with protecting the wires in that area. To accomplish this, we used mesh wire covers to protect the wires. Similar to the coral intake, we wired the algae remover to the PDH via the energy chain.

End Effector - Software

Summary:

The programming for the rollers is pretty straight forward. There are 2 NEO 550s that we control for the rollers. In code we apply a voltage to get a certain velocity after reduction. This allows us to use multiple values for voltage to achieve slower and faster speeds. For example when intake we utilize a slower speed as there is no need for high speed, but when scoring we have a higher value to achieve efficiency.

Summary:

The Algae pivot is a cool mechanism that is like a mini arm. For the movement of the pivot we utilize the absolute encoder on it to use PID. With the addition of measured setpoints, we used a PID Control loop to set its position.

Climb - Software (*Not final*)

Summary:

Our climb mechanism uses 2 NEO motors, which are controlled by a PID controller, with the setpoint based on measured values and position-tracked by an absolute encoder. (NOT DONE, MORE WILL BE ADDED/CHANGED)

Reefscape Glossary

Algae: One of the game pieces, scored in the Net or Processor. A large green kickball.

Alliance: A collective of 3 FRC teams that play a match against another Alliance.

Auto: The first 15 seconds of the game, where robots must run without human control.

Auto RP: A Ranking Point gained after all Alliance robots leave the starting zone and one scores a coral during Auto.

Barge: A 8.5 feet tall structure spanning across the center of the field that contains the Nets and Cages

Barge RP: Ranking Point after scoring at least 14 Barge Points, from a Deep Climb, Shallow Climb, or Park.

Cage: Rectangular metal frames that robots can climb at the end of the match.

Coopertition Bonus: Bonus awarded when at least 2 Algae are scored in each Alliance's Processor, reducing the criteria for the Coral RP.

Coral: The other game piece, an 11 ⅞" long, 4.5" diameter PVC pipe that can be scored on the Reef.

Coral RP: A Ranking Point gained after 5 Coral are scored on all 4 levels of the Reef, or 3 if the Coopertition Bonus is achieved.

Coral Station: The station where coral is delivered to the robots by human players.

Deep Climb: When a robot climbs a deep cage and lifts itself fully off the floor, scoring 12 Barge Points.

Net: A goal on top of the Barge in which an Alliance can score Algae.

Park: When a robot's bumpers are completely or partially inside the Barge Zone at the end of a match, earning 2 Barge Points.

Processor: Low goal with a rectangular opening that Algae can be scored in.

Reef: Hexagonal structure where Coral is scored, with 4 levels of different height

Ranking Point: Points achieved for meeting certain criteria in a match; determine rank of a team

Shallow Climb: When a robot climbs a shallow cage and lifts itself fully off the floor, scoring 6 Barge Points

Teleop: Main phase of the match where the robot can be driven around by human drivers.

Technical Glossary

Absolute Encoder: A rotating sensor that can determine its true angular position by sending digital signals while maintaining measurement through cycles.

Beam Break Sensor: A sensor that emits a laser that can detect when something passes it.

CAD: Computer Aided Design, a computer program used to design our robot before building it.

CAN Bus (Wire): Controller Area Network. Packet-based communication protocol that connects a microcontroller (ie: roboRIO) with other electronic devices.

Cascade Elevator: An elevator where all stages move at the same time, making it faster than a continuous elevator.

Dyneema: Stretch-resistant rope used to rig the elevator.

Energy Chain: Protective cable carrier that keeps the wire to the end effector contained, even when the elevator extends.

Limelight: A smart camera that can detect and track fiducial targets (ie: AprilTags), used for precise field localization.

Live Axle: A system where the axle itself spins, with a wheel mounted to the axle.

NEO: A brushless motor made by REV Robotics, lower speed, more torque.

NEO 550: A smaller version of the NEO, higher speeds, less torque.

PDH: Aka Power Distribution Hub. Where all the power wires eventually lead to. Distributes roboRIO requested power to motors from battery.

PID: A control algorithm used to automatically adjust systems.

Rivnut: Insert that can be riveted to to add threads to a non-threaded hole. Used in our bumper mounting system.

RSL: A signal light used to communicate the status of the robot.

SparkMAX: A physical electronic controller that moderates the speed of a motor.

Swerve: Drivetrain that combines translation and rotation synchronously.

Tubing: Aluminum 2”x1” box tube, used to form the structure of the robot.

VRM: Aka Voltage Regulator Module. Regulates the amount of energy being delivered to power-sensitive devices to prevent overcurrenting.

WAGO: Lever-lock clips used to connect CAN wires together.

Reflections

[insert text]