2019 TECHNICAL BINDER

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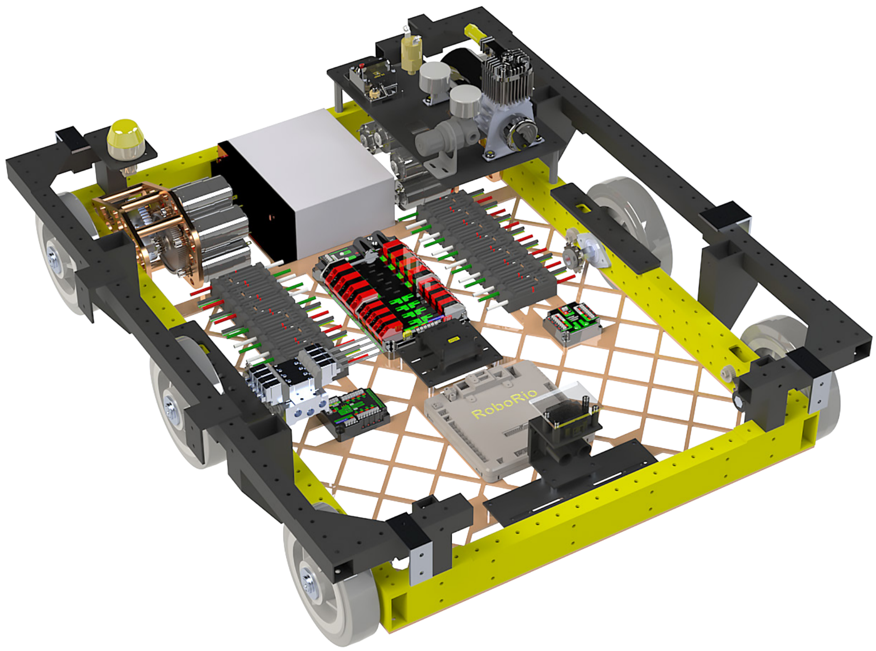
DRIVETRAIN

RENDER

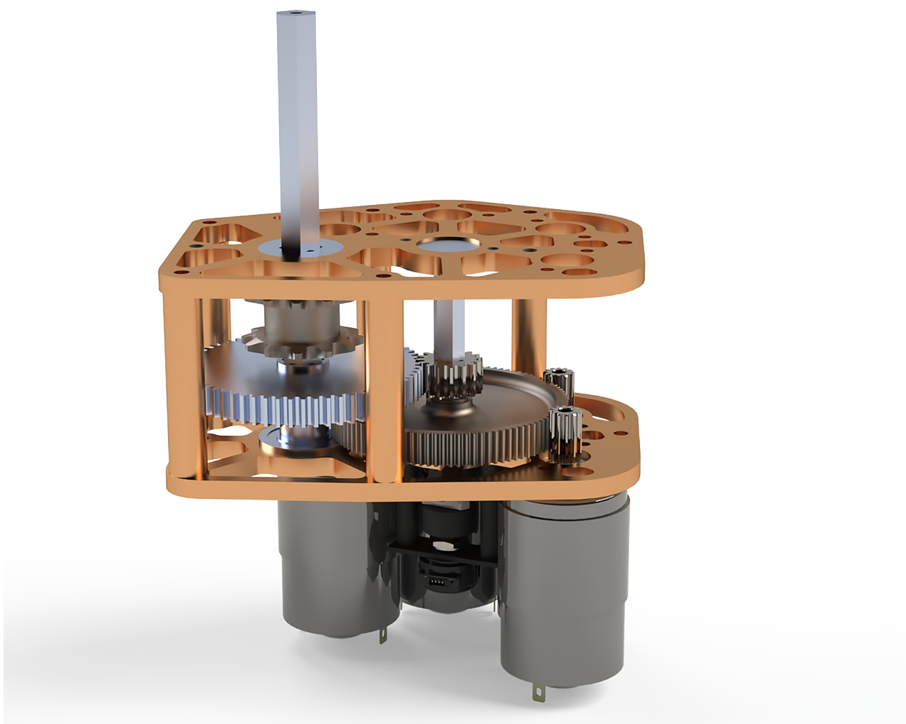


FEATURES

- 6 Wheel West Coast Drive
- 6'' Colsons with .094 Center Wheel Drop
  - Can drive up the hab level 1 platform
  - Ground clearance for the cargo holding area
- Bumper cutouts provide clearance for hatch handling as well as a lower position lidar and vision camera
- 35 chain with adjustable cam tensioner
  - Selected for durability
- Wide wheel base increases stability with elevator up, provides larger intake area for cargo

DRIVE GEARBOX

RENDER



FEATURES

- 4 x 775pro
  - Lightweight drive system
  - Team experience with producing durable 775pro drive systems utilizing current limits
- Gearbox in the back to help move center of gravity rearward to offset the weight at the front of the cargo and hatch handling systems
- Geared at 15.2 ft/s with a 32.29:1 gear ratio
- Low profile design
- Lowers center of gravity
  - Provides maximum clearance for other mechanisms
  - Final robot center of gravity is slightly to rear of robot center wheel when cargo intake is stowed, and is directly under the elevator when the cargo handler is in the intake position.

ELEVATOR

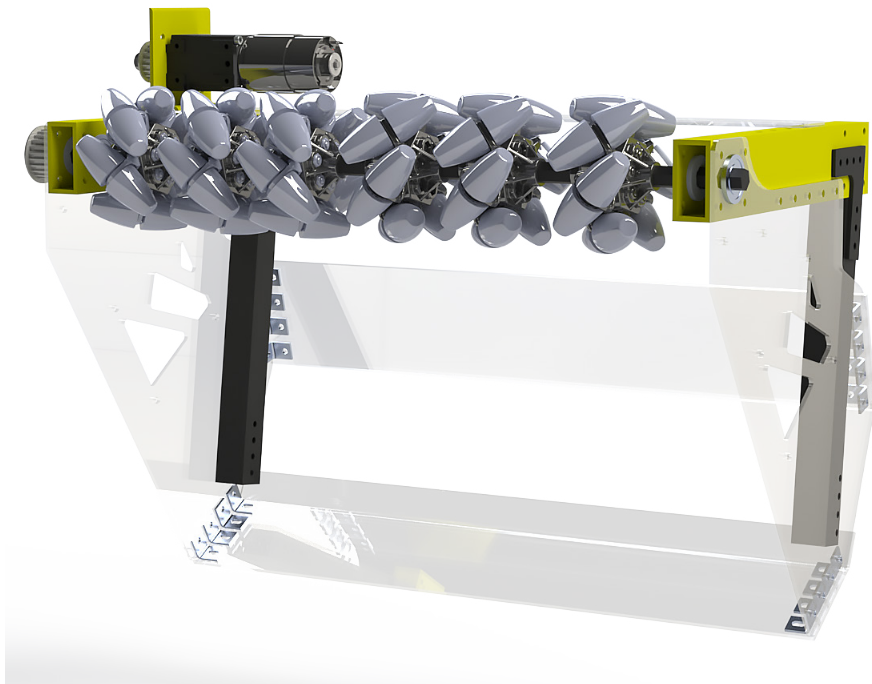
RENDER

FEATURES

- 2 mini CIM with 10.86:1 gear ratio
  - Encoder feedback with bottom limit switch
- Uses an off the shelf gearbox as packaging space was not a major constraint
- 2 stage, cascaded
  - Cascade selected to provide more constant torque in raising the elevator
- 3mm dyneema spooled around 2in diameter knurled drum
  - Up & down pull
  - 55 inch travel
- 2x 16.5lb constant force springs to counterbalance the carriage
- 5/8 OD 1/4 ID bearings on side
- 7/8 OD 3/8 ID bearings inset in side tube allow for a more compact design
- Waterjet cut lightening pockets for weight reduction.

CARGO INTAKE

RENDER

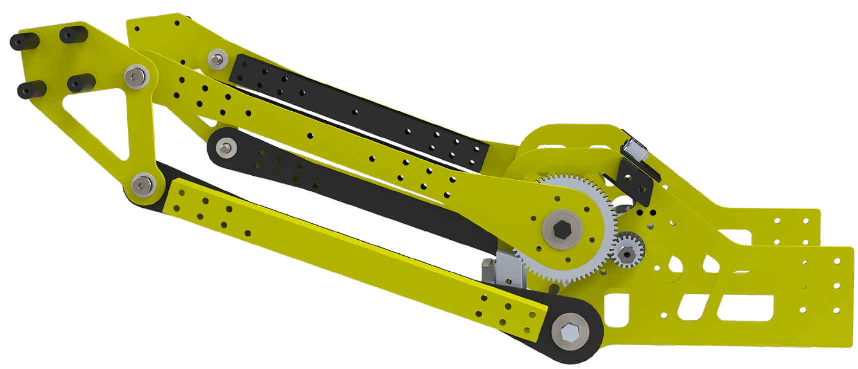


FEATURES

- 4 mecanum wheels
  - Rapidly self centers providing a repeatable
  cargo position that allows for easy placement
  - 1 775pro with 9.33:1 reduction for a 35 ft/s surface speed
- 1/8’ polycarbonate plates and foam bottom backing constrain ball
Stiffened by 2’’ x 1’’ x 1/8’’ and 1’’ x 1’’ x 1/16’’ tube

4-BAR LINKAGE

RENDER

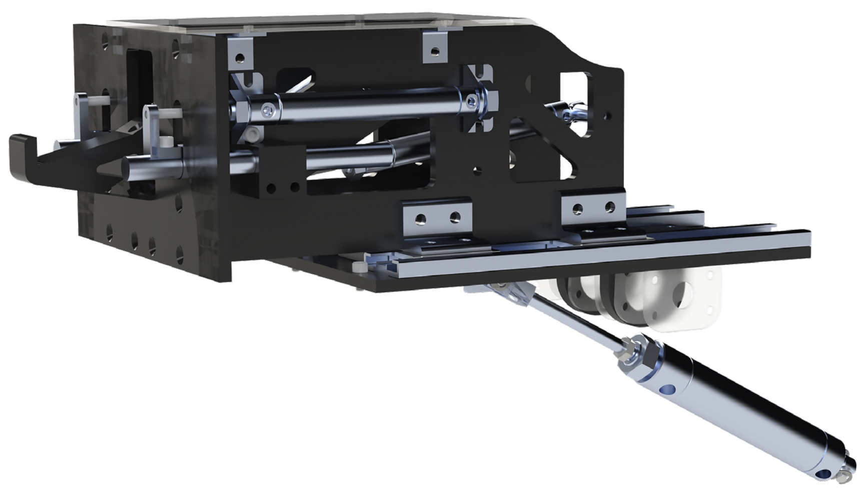


FEATURES

- Provides large angular displacement with minimal end effector rotation
  - A non-parallel linkage obeying the Grashof equation for full rotation was calibrated to allow for optimal ground intake geometry as well as optimal placement geometry while only requiring 1 actuation.
- 63:1 VersaPlanetary and 3.55:1 single ear stage for a total reduction of 223.65:1
  - Embedded SRX Magnetic encoder stage in VersaPlanetary
- Driven by 1 775pro
- Limit switch at top and bottom of travel allow for zeroing
  - Intake position at the bottom hard stop to allow passive operation while intaking.
- 3/16” plate stiffened with 1’’ x 1’’ x 1/16’’ tube

HATCH INTAKE

RENDER



FEATURES

- Fits within cargo 4 bar linkage
- Pneumatics selected for speed of operation
- Piston stows hatch intake down below cargo intake
  - Torsion springs aid in lifting intake
- Piston slides out intake from position inside the frame perimeter for starting configuration holding a hatch plus use of the human load station and cargo ship with the bumper recesses and a second position extended to the bumper perimeter for loading hatches onto the rocket.
- 1'' width delrin hook fits through center of hatch panel and clamps it
  - Narrow hook allows large margin for driver misalignment when intaking from the human load station.
  - Hatch self-centers on the hook to provide placement accuracy by holding the hatch in a consistent location with respect to the robot.
- Piston actuated pushers eject hatch panel to correct for driver misalignment
  - Pistons support hatch from below to prevent it from falling back onto the hook.

SOFTWARE

SENSOR LIST

Optical Encoders (left and right drive train, elevator): measure velocity and position, used for moving the elevator to a fixed setpoint and for driving sandstorm and docking paths

CTRE Magnetic Encoders (cargo intake arm): measure position, used for moving the arm to a fixed setpoint and holding it.

Pigeon IMU: measures heading, used for autonomous driving

Jevois camera: allows vision target detection during sandstorm and teleop

Color sensors: allow detection of white alignment line in front of rockets, cargo ships, and the hatch loading station.

Current Sensors: allows us to control torque on the drive train

Lidar: allows us to see how far away we are from the rocket

Webcam: allows our drivers to see what is in front of the robot when it is in hard to visualize locations or blocked by something.

Drive Train:
Our autonomous routines are controlled by a system of cascaded PID Controllers that drive one of two different curves, a clothoid or a bezier spline. Driving a clothoid allows us to have a continuous rate of change of curvature, meaning we can move smoothly in and out of turns and connect them with segments of driving in a straight line. We wrote an auto plotting program to help us create and visualize these curves and input them into code. This year, we use primarily bezier splines and use this technique during our sandstorm period to maximize efficiency and accuracy. To generate these paths, we created lookup tables, as sines and cosines are computationally expensive processes.

During the teleoperated period, we use our vision system (a GRIP pipeline that uses HSV to isolate targets) to identify the two vision targets and coupled with our lidar, identify their exact coordinates in relation to our robot. We use these coordinates to generate a quadratic bezier. If we are too close to the rocket, the program allows us to backup and try again. If there are no robots blocking the way, our drivers can use this system to dock in front of the rocket or cargo ship quickly and accurately.

Elevator:
Our elevator is tuned using a system of cascaded PID controllers. We ramp our setpoints to help us control the fall of our elevator so that it does not crash to the ground when we move to a lower setpoint. We are able to smoothly transition between manual and autonomous control to allow our drivers to make fine adjustments to setpoints as they see fit during the match.

Cargo Intake:
Our cargo intake arm is tuned using a system of cascaded PID controllers. To prevent our 775 motor from burning out, we apply a holding current as a failsafe when the arm is all the way up or all the way down to prevent running a high current for an extended period of time if the setpoint is unreachable, thus burning the motor. This was created as we did experience some problems with stalling the motor for too long in our early testing periods. We also have several failsafes set in place to avoid running the cargo intake arm when the hatch intake is in its “lifted” position so they do not run into each other. When we are holding cargo, we also apply a small holding current to our cargo rollers to prevent the ball from rolling out of the intake during the match.

CONTROL SYSTEMS

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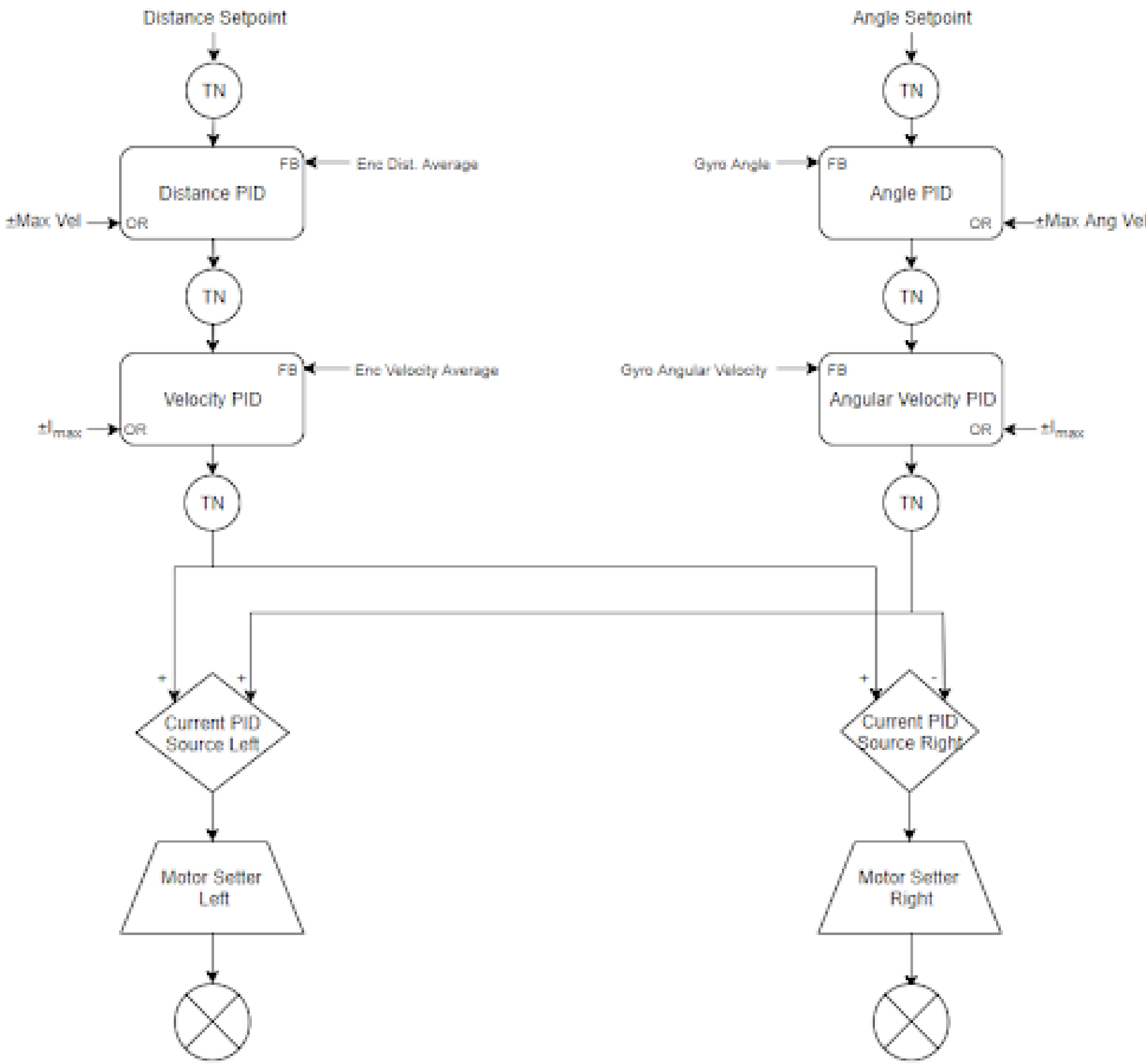
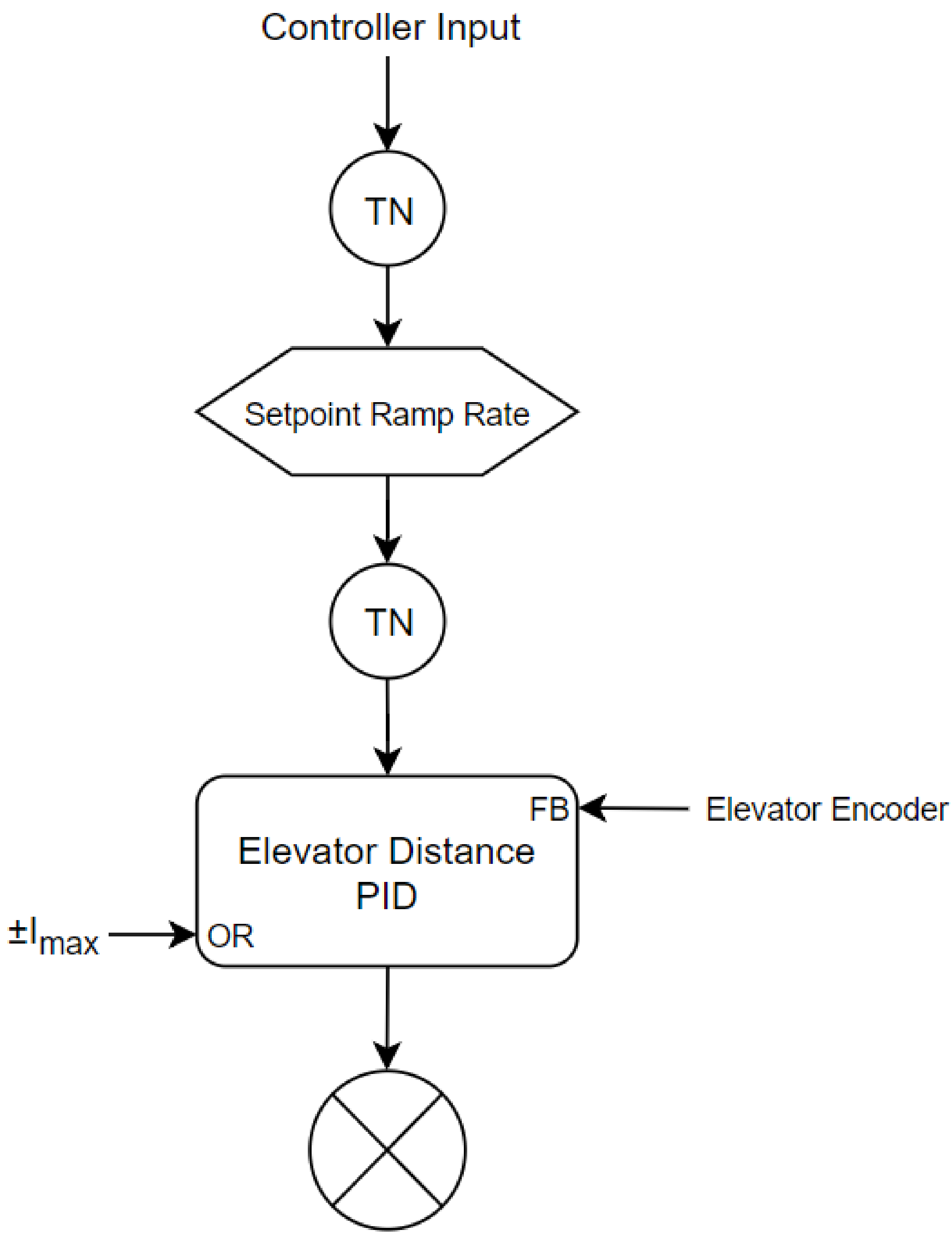
CONTROL DIAGRAMS




Controller Input
TN
Setpoint Ramp Rate
TN
FB
Elevator Encoder
Elevator Distance
PID
±Imax
OR

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