Roomba Lawnmower

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Project Description

Our team consists of two electrical engineers, both with robotics minors, as well as a computer engineer. Together we have developed a robot capable of mowing a yard while autonomously avoiding obstacles and staying within the predetermined boundaries.

We are utilizing an Intel Realsense camera to visually identify obstacles and boundaries as well as a bump sensor as an additional obstacle detection device. Also in use is a remote control that can disable or enable operation of the mower.

The main controller being utilized is a Jetson Nano developed by NVIDIA we are using this to process images from the camera and to send data to the Arduino Mega where the data is parsed and utilized in controling of the drive motors and blade motor.
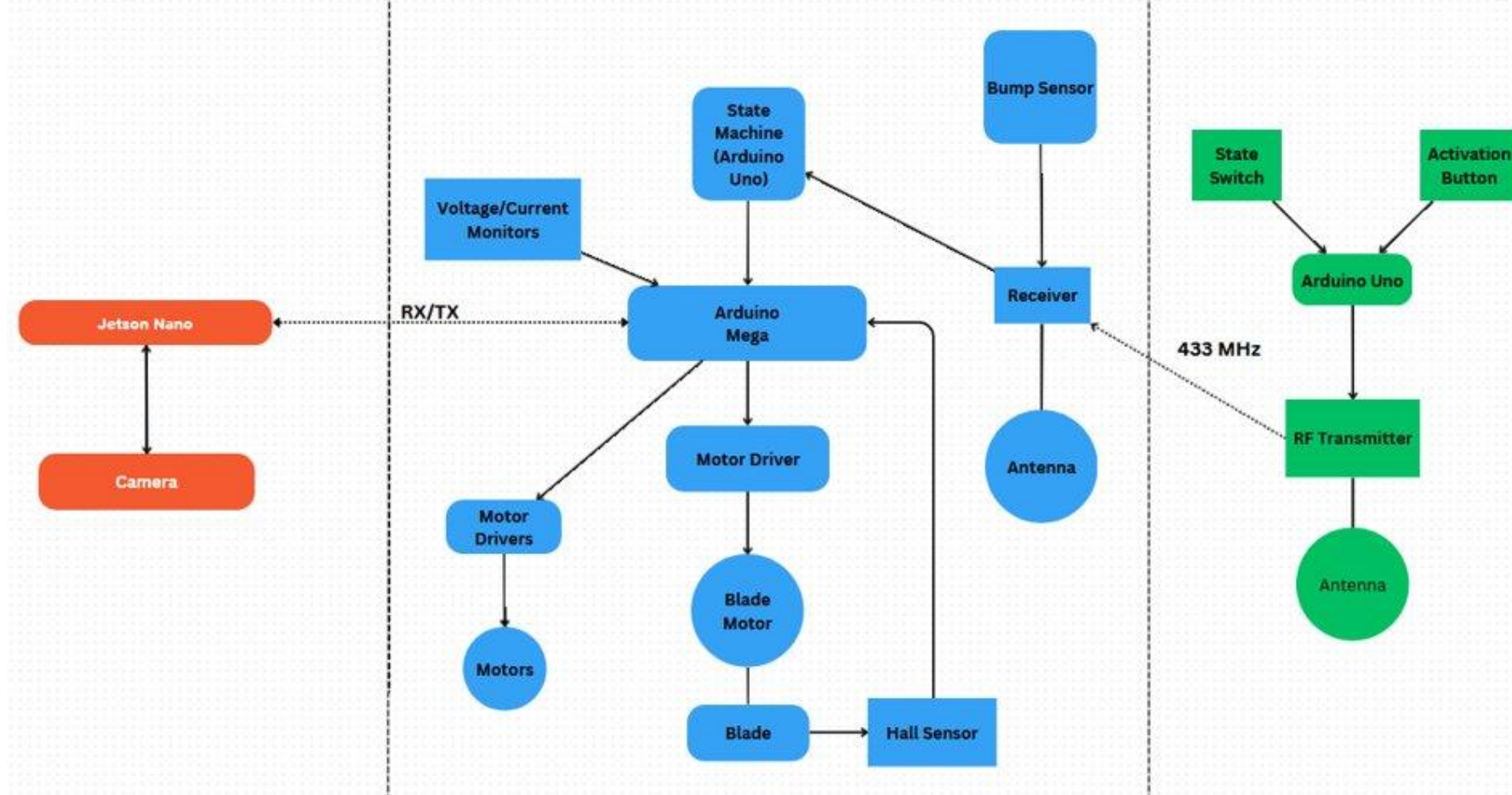
Mower has four drive motors and a single blade motor. The power to the mower is provided by a 48V 14Ah battery making the mower capable of operation for over 1.5 hours of operation.

Throughout this project we have utilized skills developed here at Trine and throughout internships and Co-Ops to complete this project.

Finished Project

Overview

Computer Vision

Computer vision is processed by the Jetson Nano that collects its data from an Intel D435 RGB-D camera running at 30 frames per second. The camera seperates the view into 16 regions of interest. The top row is considered the secondary ROI set where a small course correction is made if an object is detected within the ROI. If an object is detected in the bottom row, primary ROI set, then the mower starts a zero-turn process to avoid the obstacle.
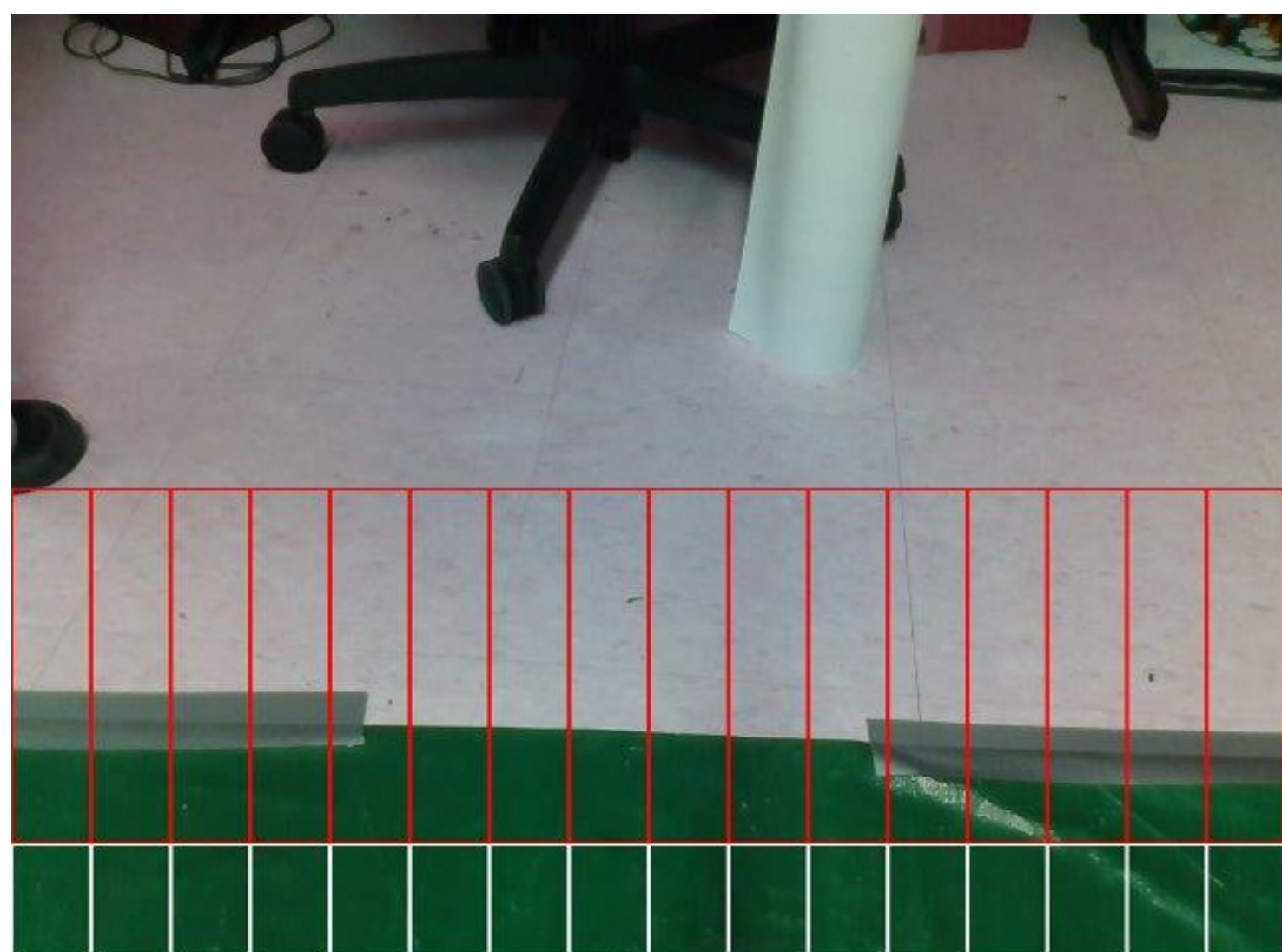

Arduino Mega Connections

Analog Pins

Pin Name	INPUT/OUTPUT	Signal Name	Description
A0	INPUT	V_Mon_48_Pin	Voltage monitor for 48V rail
A1	INPUT	V_Mon_12_Pin	Voltage monitor for 12V rail
A2	INPUT	V_Mon_5_Pin	voltage monitor for 5V rail
A3	INPUT	I_Mon_Blade_Pin	Current monitor for blade motor (Hardware not installed)
A4	INPUT	I_Mon_Drv_Pin	Current monitor for the drive motors
A5	INPUT	I_Mon_5_Pin	current monitor for the 5V rail

Digital Pins

Pin Name	INPUT/OUTPUT	Signal Name	Description
D0	N/A		
D1	N/A		
D2	INPUT	Hall_Sensor_Pin	Interrupt pin connected to output of hall sensor circuit used for PID control of blade
D3	INPUT	State_Machine_Flag	Flag input from arduino uno state machine [1] is flag [0] is no flag
D4	OUTPUT	Blade_Relay_Pin	Pin that controls the relay open close position [1] is closed [0] is open
D5	OUTPUT	L_Mtr_PWM_Pin	PWM pin for drive motors 490Hz frequency 0-100% duty cycle
D6	OUTPUT	R_Mtr_PWM_Pin	PWM pin for drive motors 490Hz frequency 0-100% duty cycle
D7	OUTPUT	L_Mtr_Dir_Pin	Direction for motors to spin [1] forward [0] reverse
D8	OUTPUT	R_Mtr_Dir_Pin	Direction for motors to spin [1] forward [0] reverse
D9	OUTPUT	Blade_Ctrl_Pin	Pin used to pwm the blade motor control circuitry 490Hz 0-100% duty cycle

SCL	Connected to IIC screen	
SDA	Connected to IIC screen	

State Machine

Motion and navigation is managed by a state machine containing a total of 9 states. Switching between each state is controlled by the values of several segmented regions that are checked in the computer vision section of the robot.
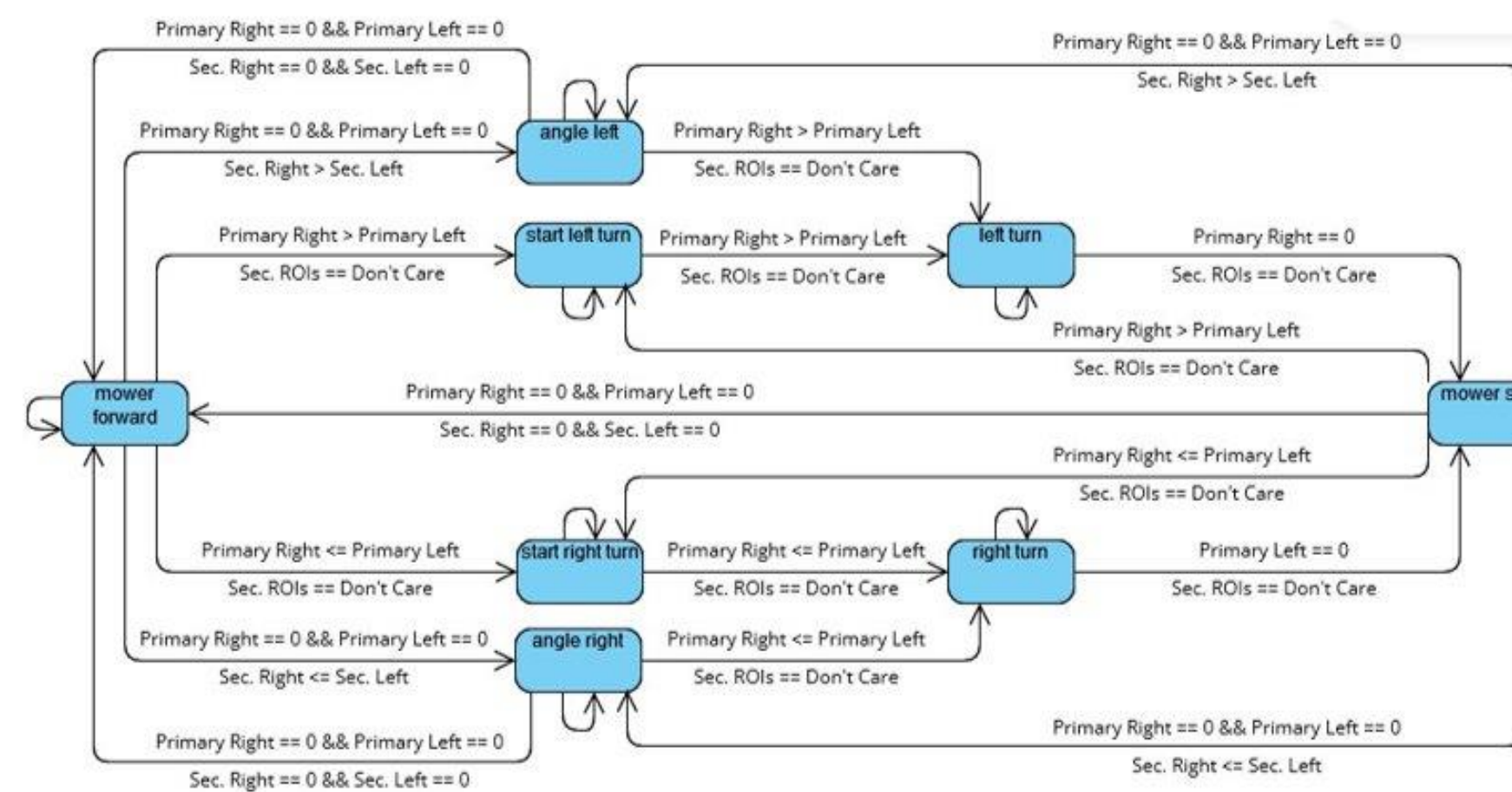
Primary Right & Primary Left: Number of primary ROIs that read as NOT green on respective sides of frame
Sec. Right & Sec. Left: Number of secondary ROIs that read as NOT green on respective sides of frame

Output values of the above states are tabled below:

| State	Left Dir	Left Speed (%)	Right Dir	Right Speed (%)	Blade Enabled
Mower forward	1	75	1	75	1
start left turn	0	0	1	100	1
start right turn	1	100	0	0	1
Mower left turn	0	100	1	100	1
Mower right turn	1	100	0	100	1
Angle left	1	50	1	75	1
Angle right	1	75	1	50	1
Mower stop	1	0	1	0	1
Mower shutdown	0	0	0	0	0

Communication

Data is sent between the Jetson and the Arduino Mega over UART using the USB communication standard.

Left Dir	Left Motors' Speed (%)			Right Dir	Right Motors' Speed (%)			Blade EN	Err Byte
1	0	7	5	1	0	7	5	1	0

Blade Motor

AmpFlow E30-150-48
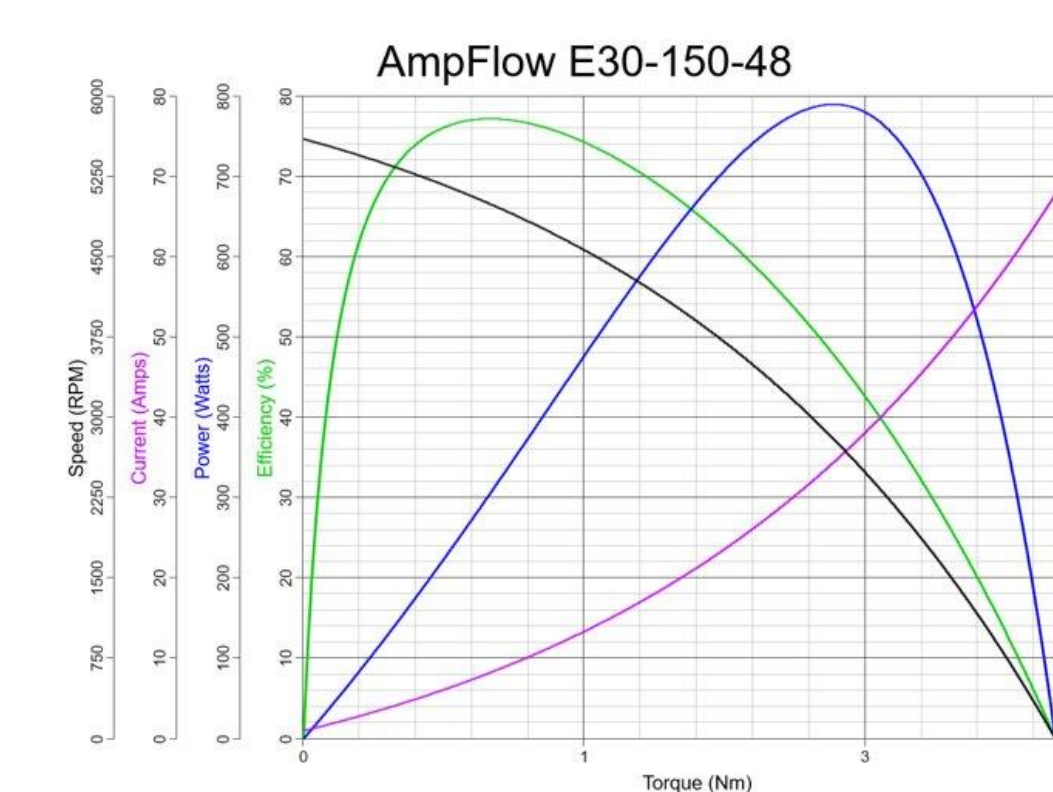
Blade Control Circuitry
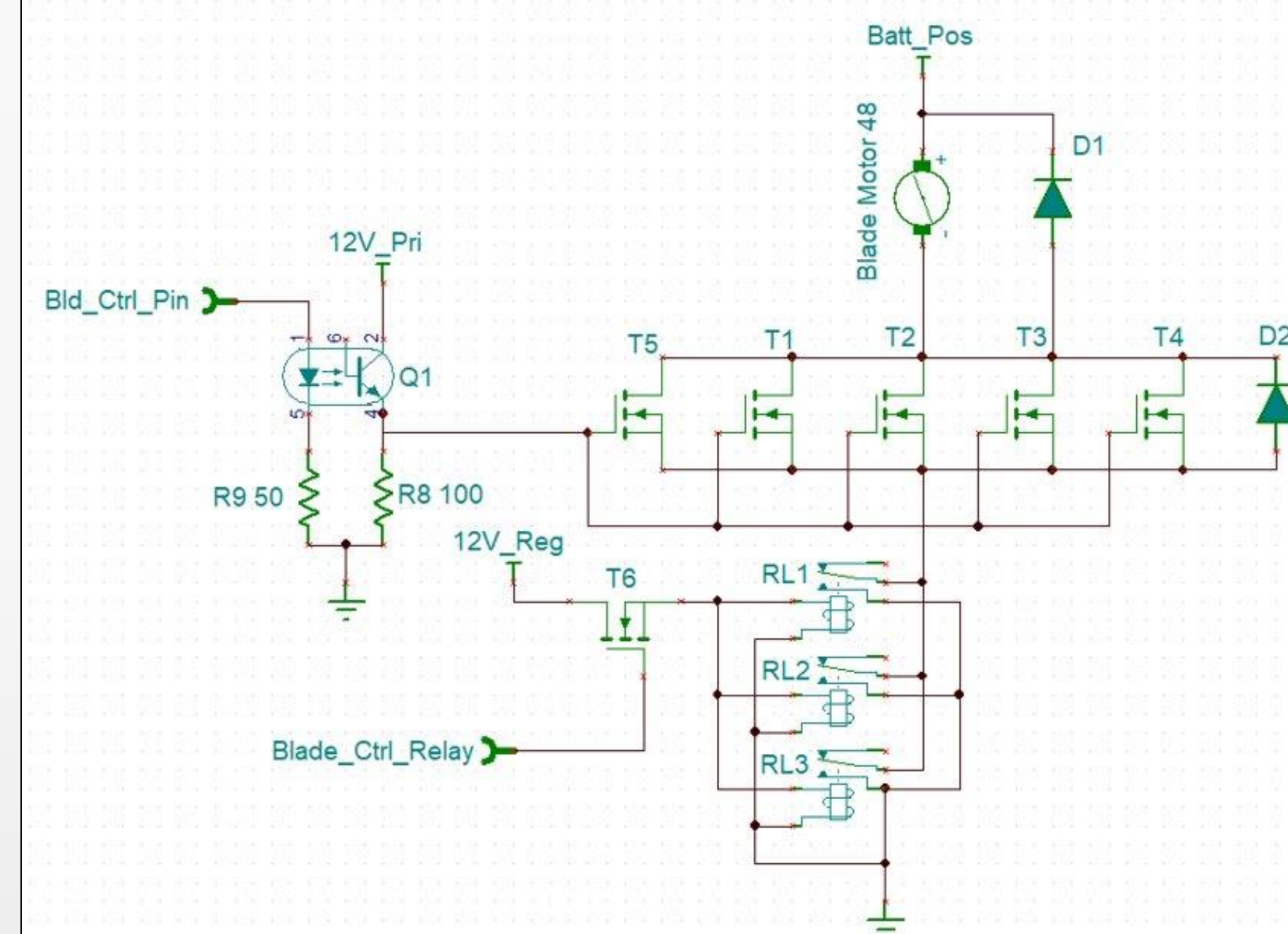
Control of the blade is done utilizing MOSFETs in parallel to handle current needs and is controlled by a PWM signal sent by the Arduino Mega. There are also some emergency relays in place to disconnect the motor from the battery. The state of the relay is controlled by either a high or a low signal sent by the Arduino Mega.

Transmitter / Receiver

Using a single-core wire, the transmitter has a monopole quarter wave antenna with a range of 54 feet.

Transmitter utilizes amplitude shift keying. Receiver consists of op amps that amplify the received wave. The received signal is fed into a phase lock loop for decoding digital bits. The RadioHead library encapsulates data into a digital data packet for transmitting/receiving.

Bump Sensor

The pressure switch is set to activate at 4 PSI. It has a rubber latex tube attached to it. When the tube is hit at 4 PSI, it switches closed (similar to a push button). It has a max rating of 8 A and 12 V. When a collision is detected, it sends a signal to be processed and causes the mower to stop.