Notre Dame Rocketry Team Payload Design Review 1

EE 41440 Senior Design 2

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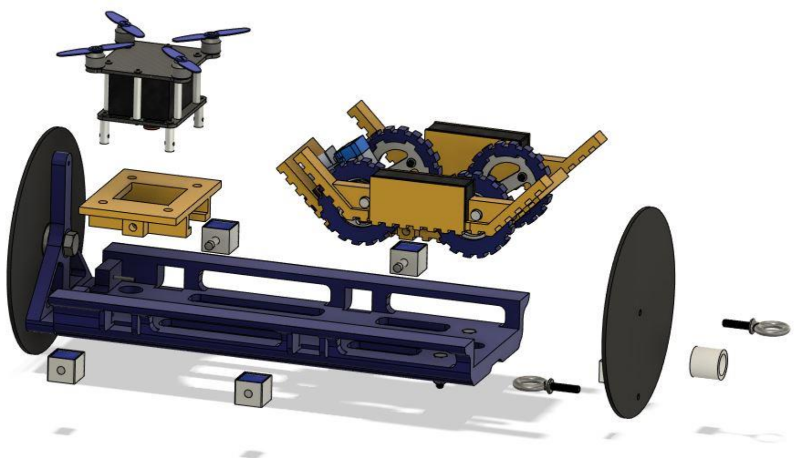
Overview

The project is focused on providing electrical design for a rover as part of the Notre Dame Rocket Team payload in the NASA student launch competition. This year the team's payload design consists of a Rover to drive to and collect a sample from the ground. Additionally, a UAV will be used to fly to the sample and provide GPS coordinates to the rover to attempt autonomous driving. Full documentation for the Rocket Team project can be found on our website. An exploded view of the payload system is shown below.



Major Component Description

<u>Microcontroller</u>

The Microchip PIC32MX795F512H was selected as the MCU that will control the rover system. The PIC32 provides 6 UART modules, 4 SPI modules, 5 I2C modules, 5 pulse width modulation (PWM) pins, and a maximum of 53 GPIO pins. This provides ample pins for the rover system, which will utilize one I2C module, two UART modules, one SPI module, and four PWM signals. The PIC32MX will be configured using PICKIT3 programming modules available to the team through the Notre Dame Electrical Engineering design labs and programmed using Microchip's MPLAB X software. A block diagram of the interface protocols used with the PIC32 are shown in figure 1.

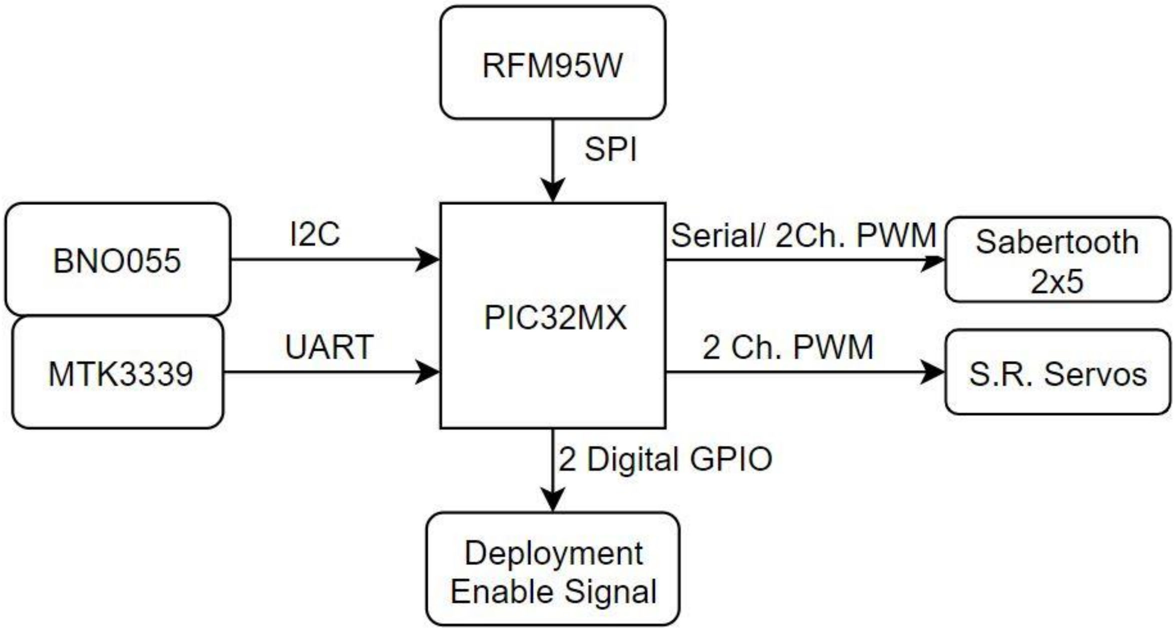


Figure 1: Component Communication

<u>RF Transceiver</u>

The rover will receive commands through a Hope RF RFM95W radio module, shown below in figure 2. This module was chosen based on its long range (LoRa) module with a range of 1.25 miles, license-free ISM 915 MHz band operation, 100mW power rating in order to fulfill requirement 2.22.9, and SPI interfacing to the MCU. One module will be integrated into the design of the rover electronics board, and another transmitting module will be used to send signals from the ground station for manual control and delivering the GPS coordinates of the UAV to the Rover.

<u>Rover GPS</u>

The MTK3339 GPS module from GlobalTop Technology was selected to provide location information for the rover. This module provides a built-in ceramic antenna for tracking from GPS satellites with automatic switching capability and a -165 dBm sensitivity to maintain connection. The 10 Hz refresh rate will be sufficient for the speed of the rover and the 70 mW power rating will allow for longer operation. The GPS module is shown below in figure 2.

<u>Rover IMU</u>

The Bosch BNO055 inertial measurement unit (IMU) was selected to collect acceleration and magnetometer measurements. This package allows for multiple sensor measurements to be collected into a single component package over a single I2C interface to the PIC32. The acceleration data will be used to measure if the rover is moving as well as detect orientation prior to deployment. The magnetometer data will be used to determine the compass orientation of the rover in order to correct the orientation and head in the direction of the UAV transmitted GPS coordinate. A strong benefit of this package is that it is designed to perform data fusion of the acceleration and magnetometer data, allowing it to provide tilt-compensated compass data. An external 32kHz oscillator will be used to provide more accurate performance from the BNO055. The BNO055 integrated circuit packaging is shown below in figure 2.

Figure 2: From the left, RFM95W Radio Module, MTK3339 GPS Module, BNO055 IMU

<u>Rover Drive Motors and Motor Controller</u>

The Actobotics 98RPM Econ Gear Motor from Servo City was selected to provide actuation for the drivetrain of the rover. These motors were selected due to their small size and high torque of 524 oz-in at stall. The motor draws a mere 0.10 A at no load and 3.8 A at stall, which is lower than many competing options and provides flexibility in choosing from numerous available motor controllers meeting these specifications. Two motors will be used in total, one on each side, and each motor weighs 0.20 pounds. The Econ Gear Motor is shown below in figure 3. The Sabertooth 2x5 Motor Controller was selected to control the Econ Gear Motors. The Sabertooth 2x5 motor controller was selected to control the drive motors for the rover. This controller can provide 5 amps of continuous current and 10 amps of peak current to two motor channels, which is enough to safely supply up to the 3.8A stall current of the drive motors without burning out the motor controller. The motor controller has a voltage rating of 6-18V, which exactly matches the accepted input range for the selected motor. This motor controller also provides flexibility in control methods, as the board can receive commands via either pulse width modulation (PWM) signals or a serial interface sending a set of bits identifying the speed at which to run each motor. The Sabertooth also incorporates circuit protections to avoid operation while overheating or drawing too much current. The Sabertooth can be seen below in figure 3.

Figure 3: From the left, Econ Gear Motor and Sabertooth 2x5 Motor Controller

Essential Component Connections

We have components that use input voltages of 3.3V, 5V, and 12V. They are listed below in table 1.

3.3 V Components	**5 V Components**	**12 V Components**
PIC32MX795F512H Pic MicroProcessor	PWM to FS09R (x2) Sample Retrieval Servo Motors	Actobotics 98RPM Econ Gear Motor (x2) Drive Motors
BNO055 IMU	SaberTooth 2x5 MotorController control signals	
RFM95W-915S2 RF Transceiver		
MTK3339 PA6H GPS		

Table 1

We have also created all of our schematics and sent our board CAD files in to have it made. Our schematics are below in figures 4 through 8.

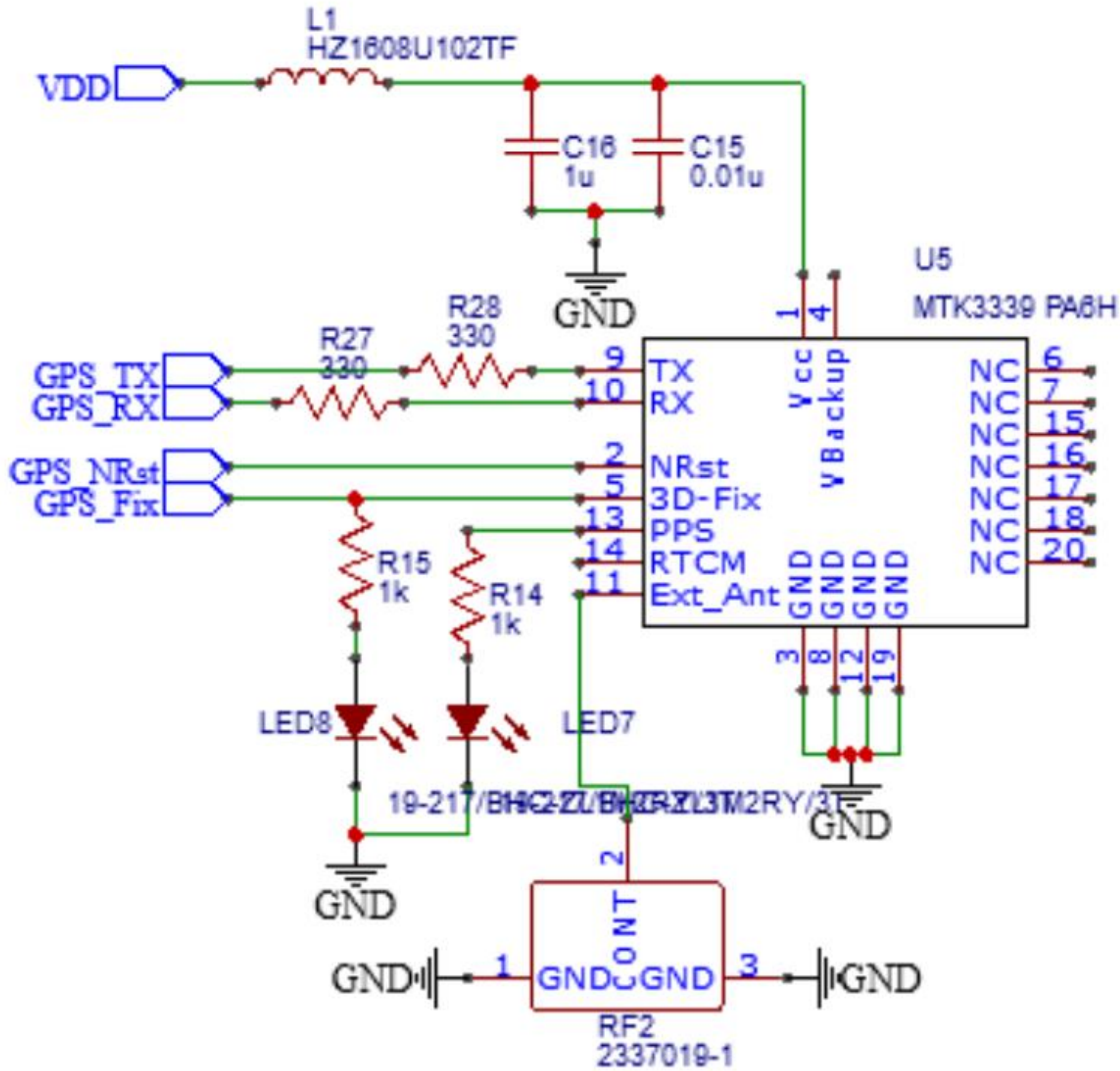


Figure 4:GPS Module

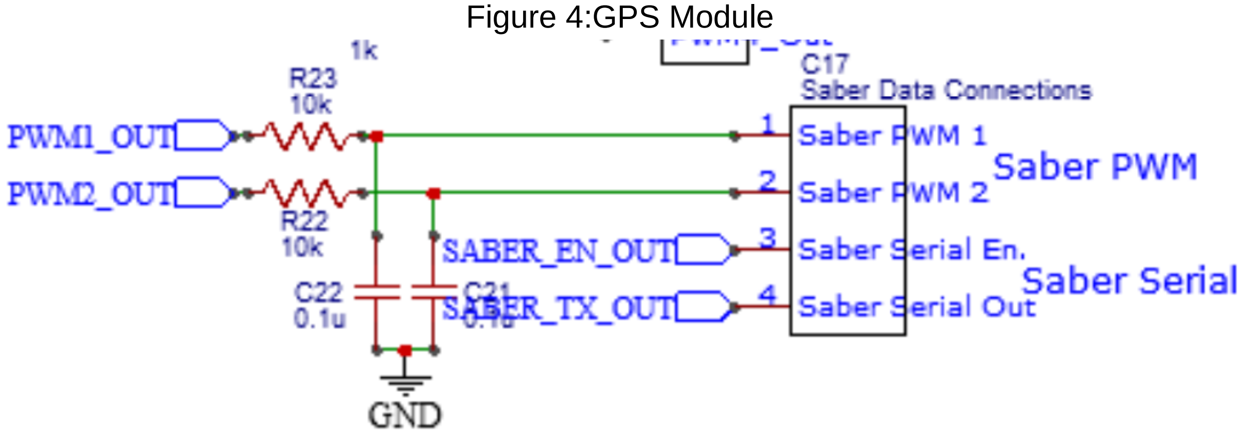


Figure 5:Saber 2x5 MC PWM Connections

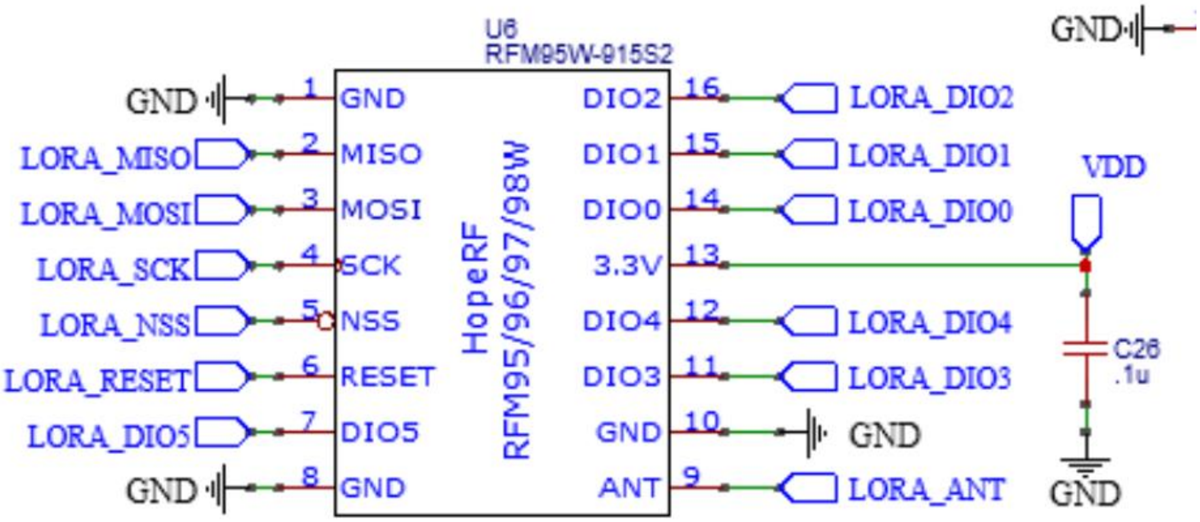


Figure 6:LoRa Radio Module

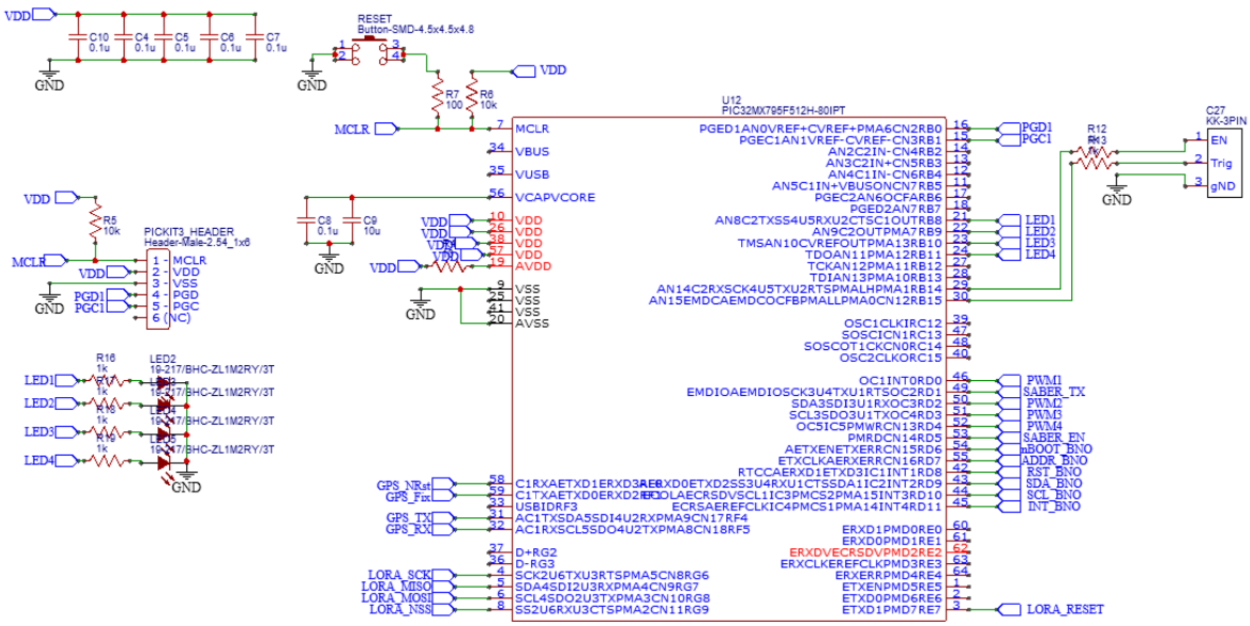


Figure 7:Pic32 Module

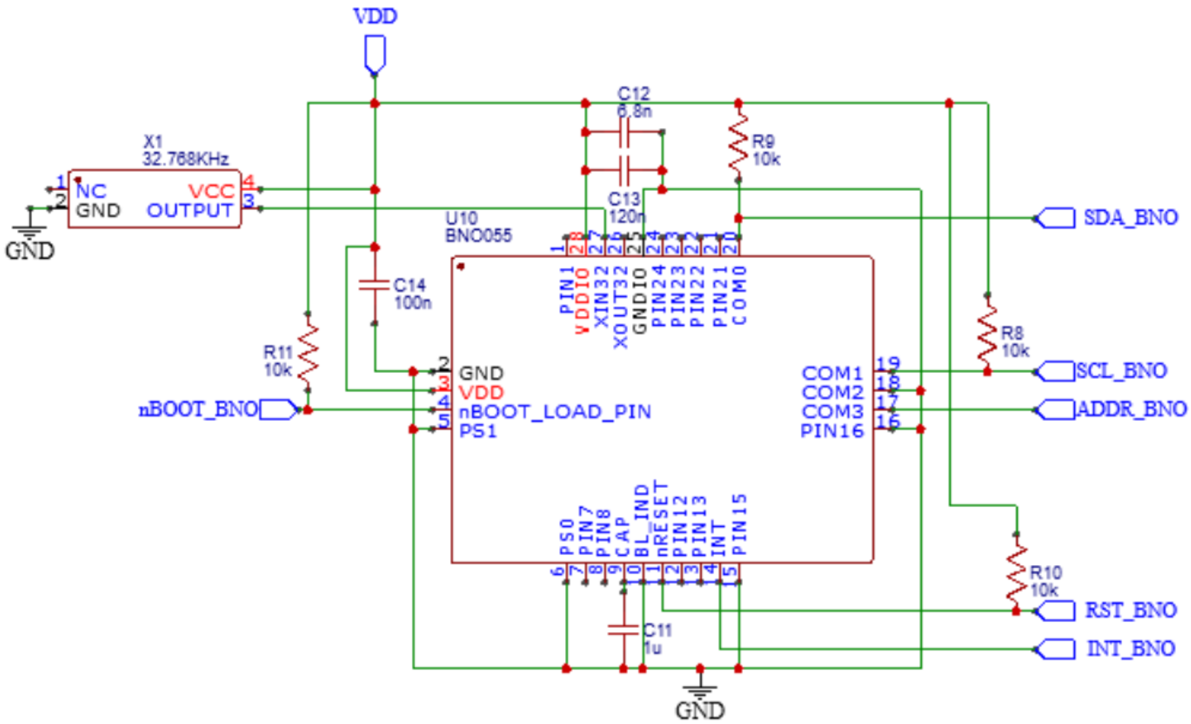


Figure 8:IMU Module

Device/State	Current Draw (mA)
PIC32MX	120
LM2596-3V	10
LM2596-5V	10
BNO055	12.3
MTK3339	20
RFM95W	12.1
2x Motors: half-stall	4000
Total Current:	**4184.4**

Figure 9: Device current draw table

Problems

- We have identified the radio as the critical component that we need to get working but we are experiencing issues. The major problem is that the SPI between the pic and the LoRa module is encountering novel issues.

    - When SS is pulled low, crosstalk appears on all channels. This does not appear when the SS pin is not altered.
    - Troubleshooting needs to be done to determine the root cause
- The control algorithms for GPS data have not been written, only communication has been established.
    - Work can be done with the existing arduino code, and translated to the PIC32 once the communication protocols have been written.

Rocketry Team Webpage

The Rocketry Team senior design webpage has been updated with links to our project proposal, proposal presentation, and high level design that we previously completed. See the link below.

http://seniordesign.ee.nd.edu/2020/Design%20Teams/rocket/index.html