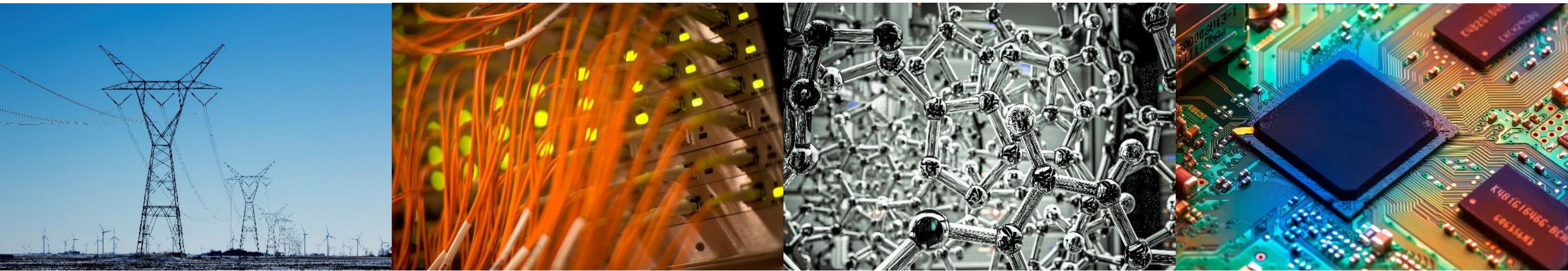


Educational Coordinated Robotics

John Kan, Louis Lu, David Null
Team 6, Dongwei Shi



I ILLINOIS

Electrical & Computer Engineering

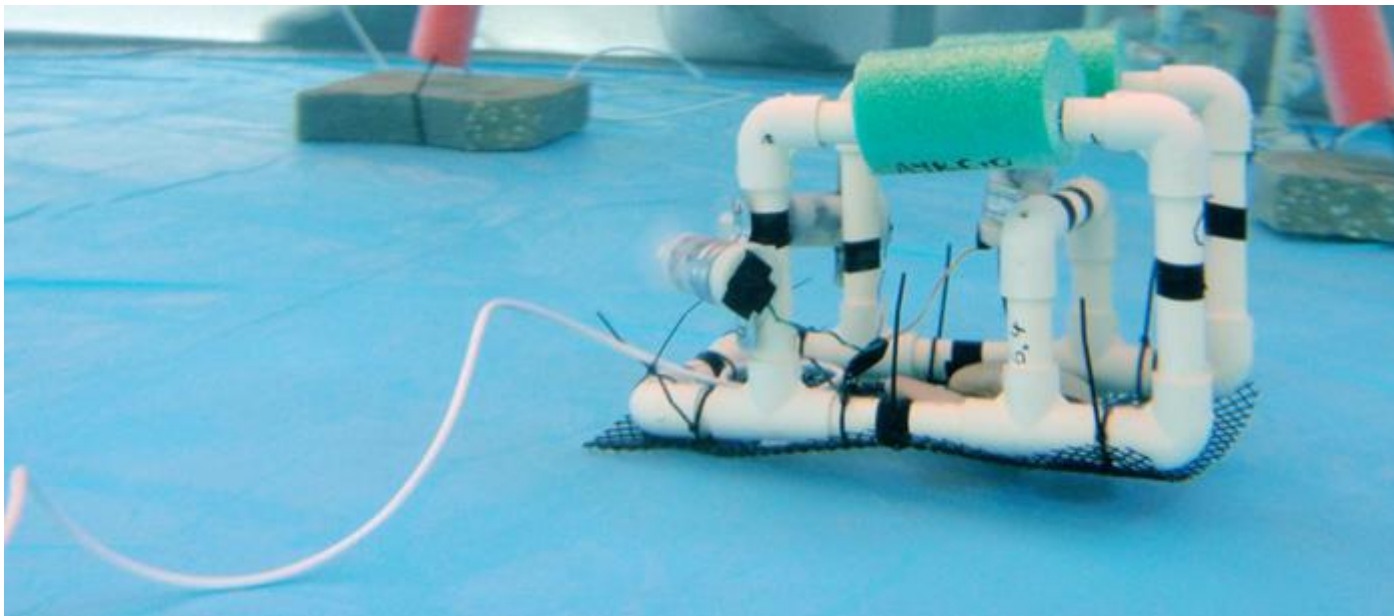
COLLEGE OF ENGINEERING

Introduction

Background and Objective



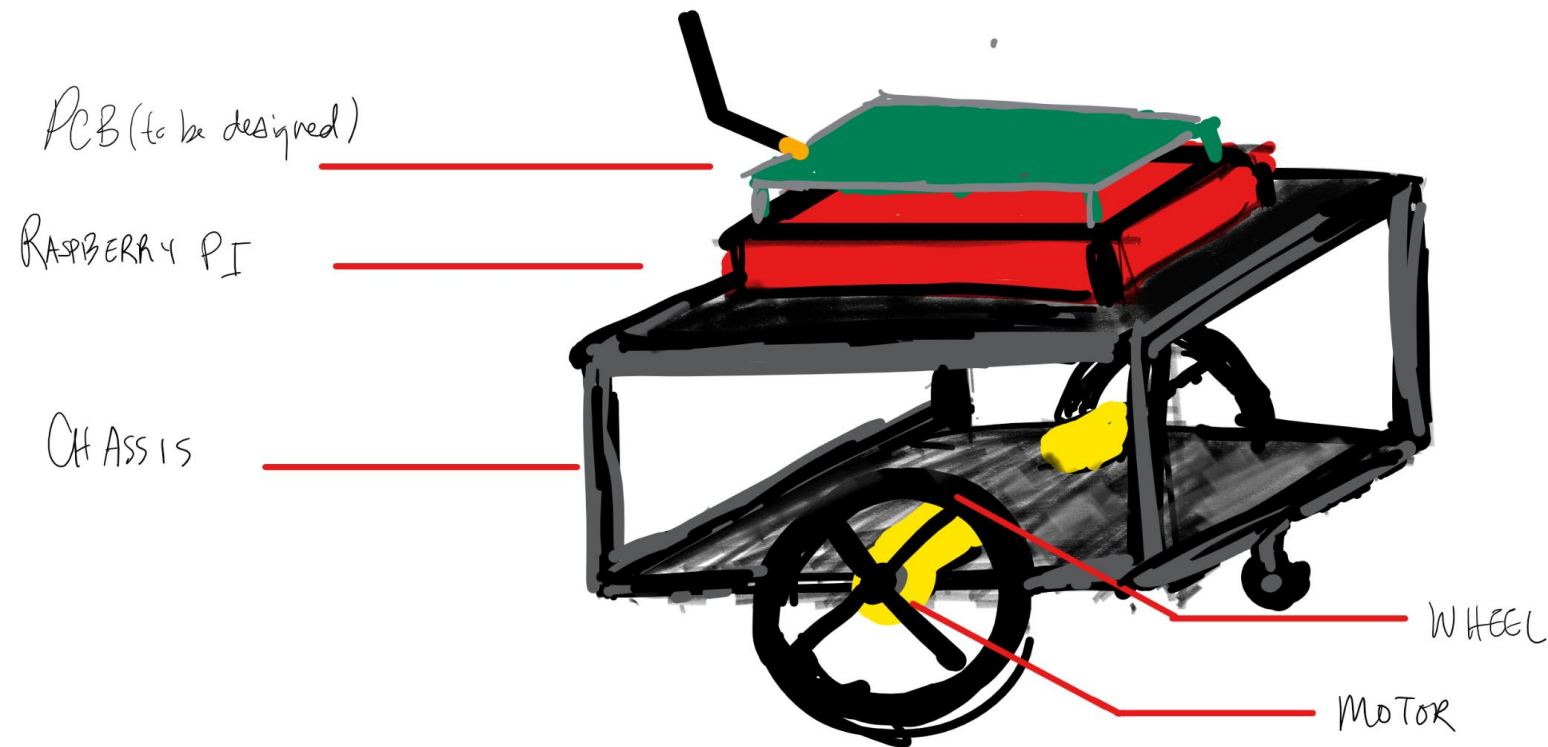
<https://www.seaperch.org/index>



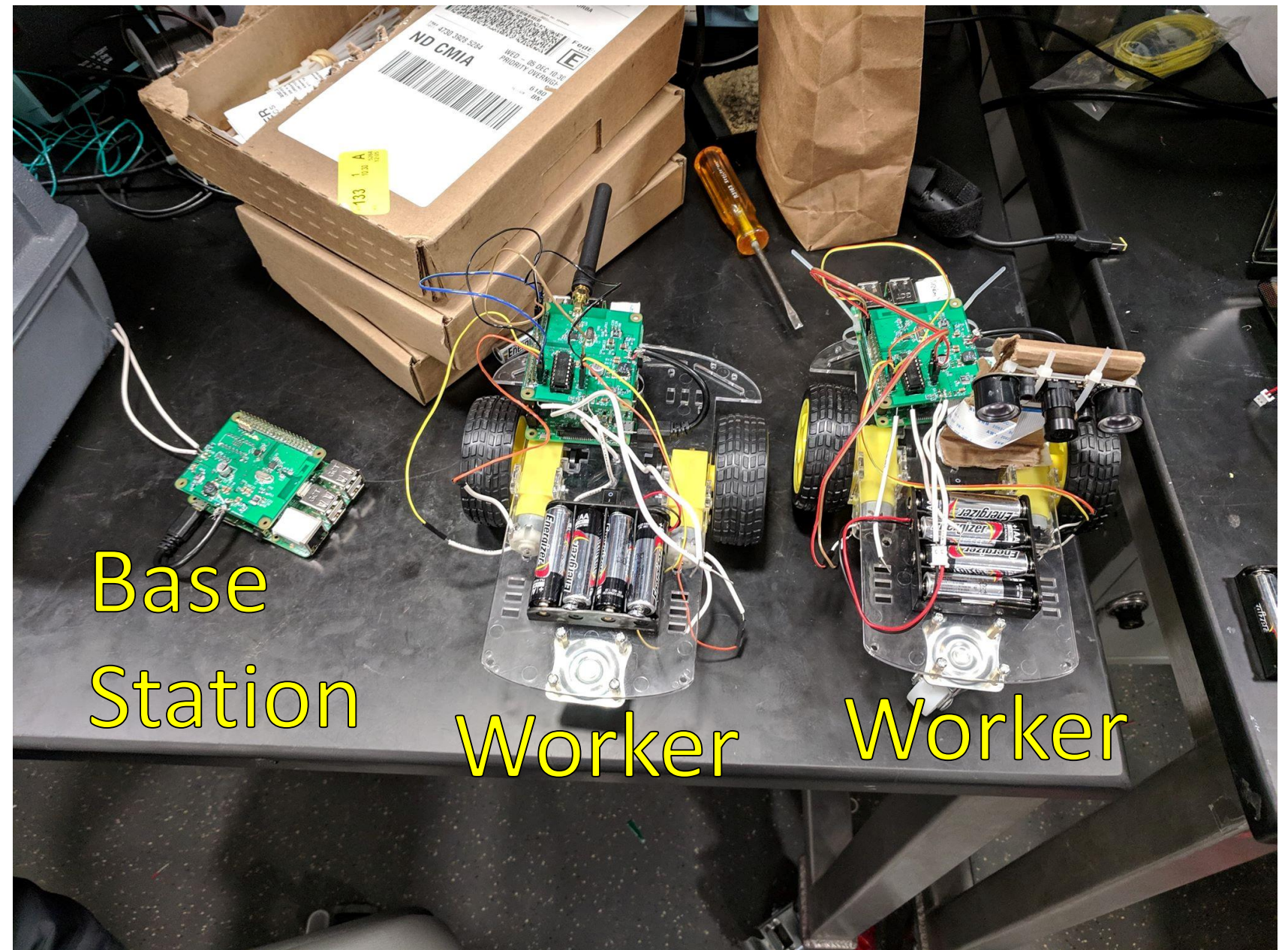
https://robotpig.net/robotics-news/mit-sea-perch---diy-underwater-rov-_1753

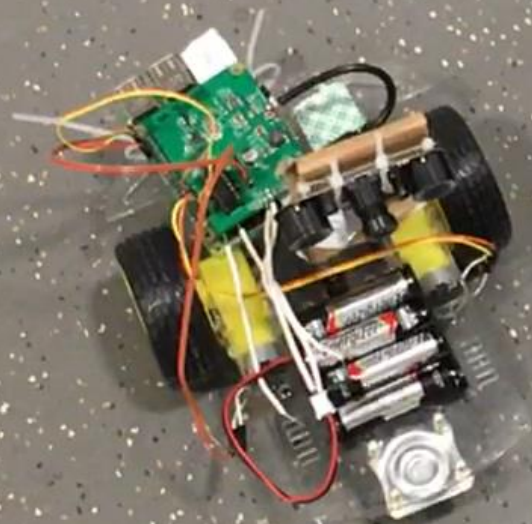
Background and Objective

- Hardware Interface for Coordinated Educational Robotics Development



Working Product

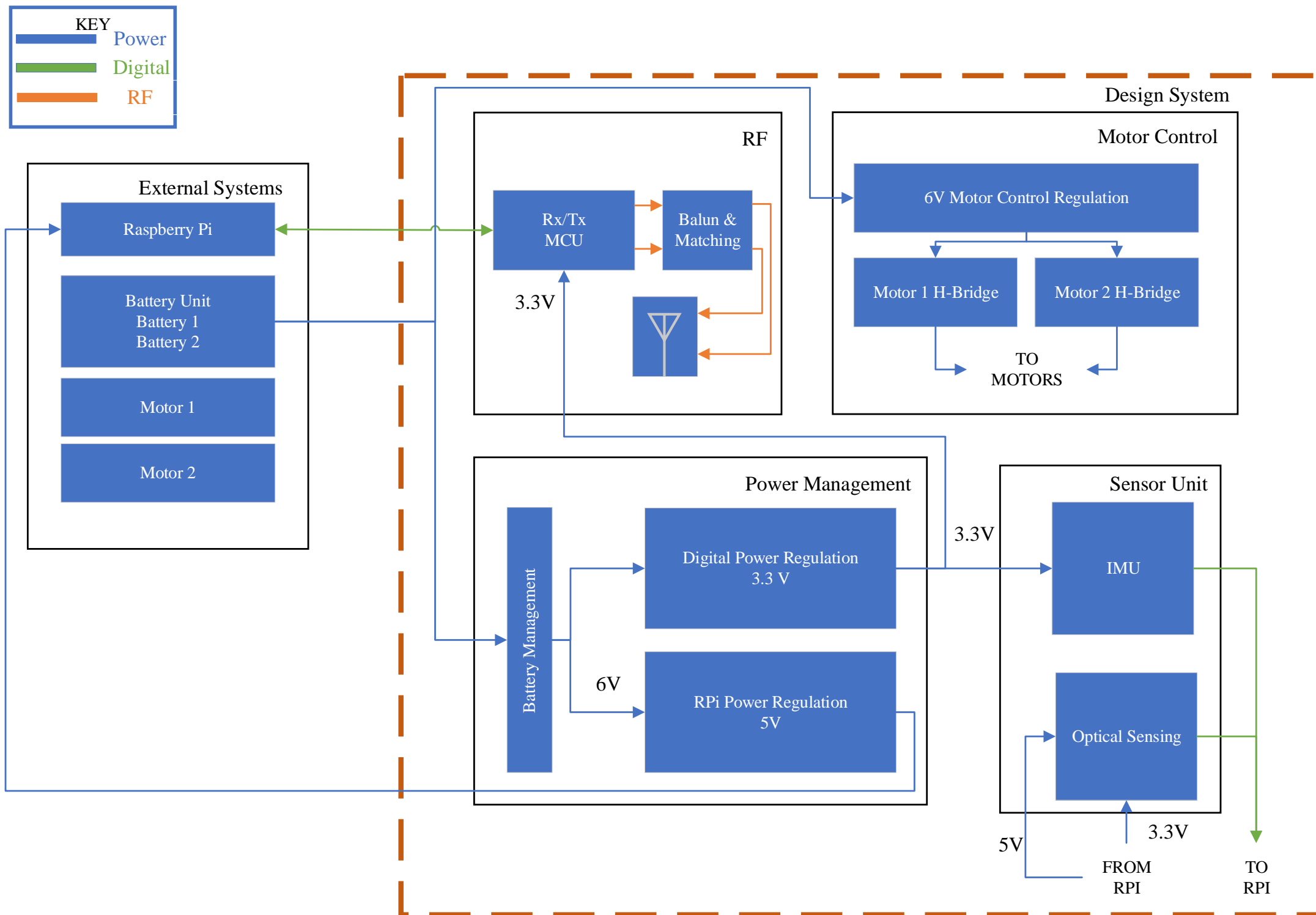




Design

Hardware Modules

- Power
- RF (Radio Frequency)
- IMU (Inertial Momentum Unit)
- Motor H-Bridge

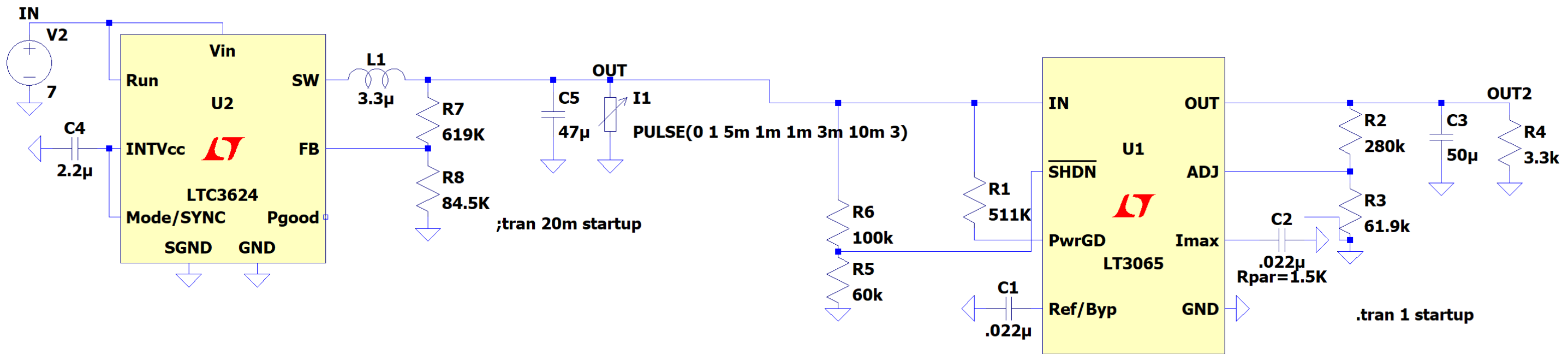


Hardware Design: Power System

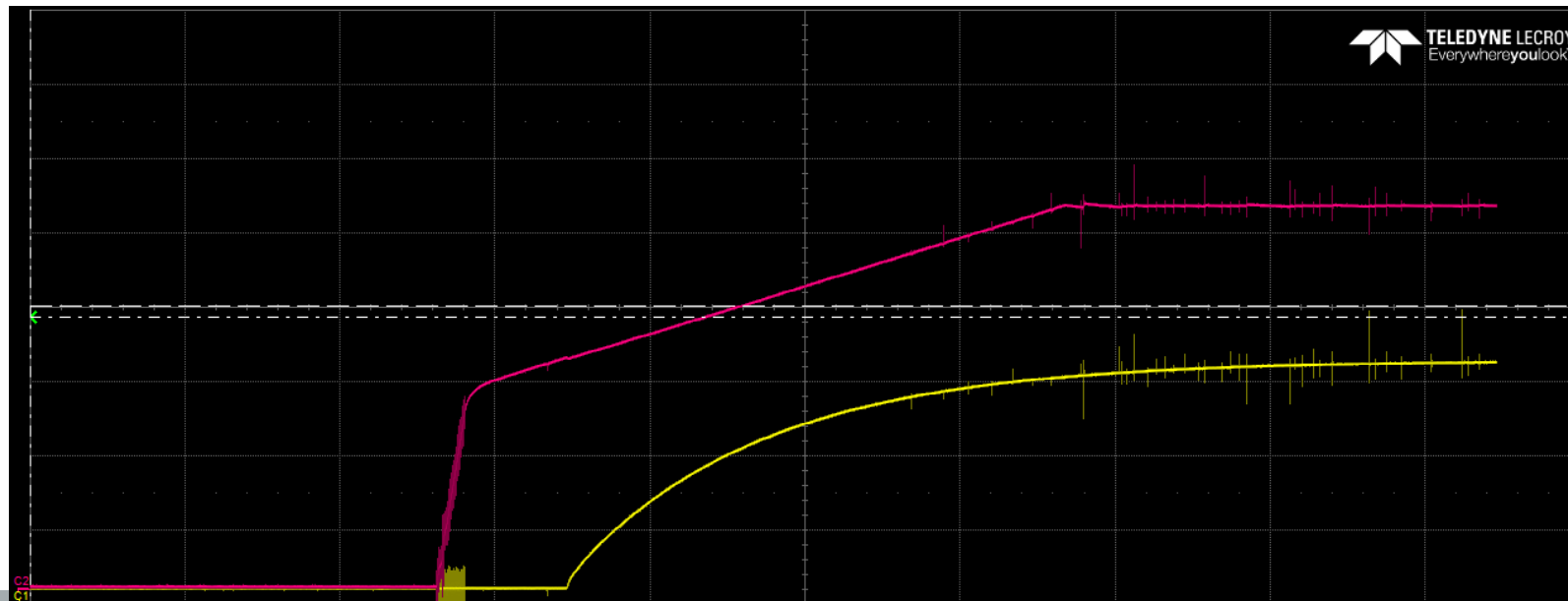
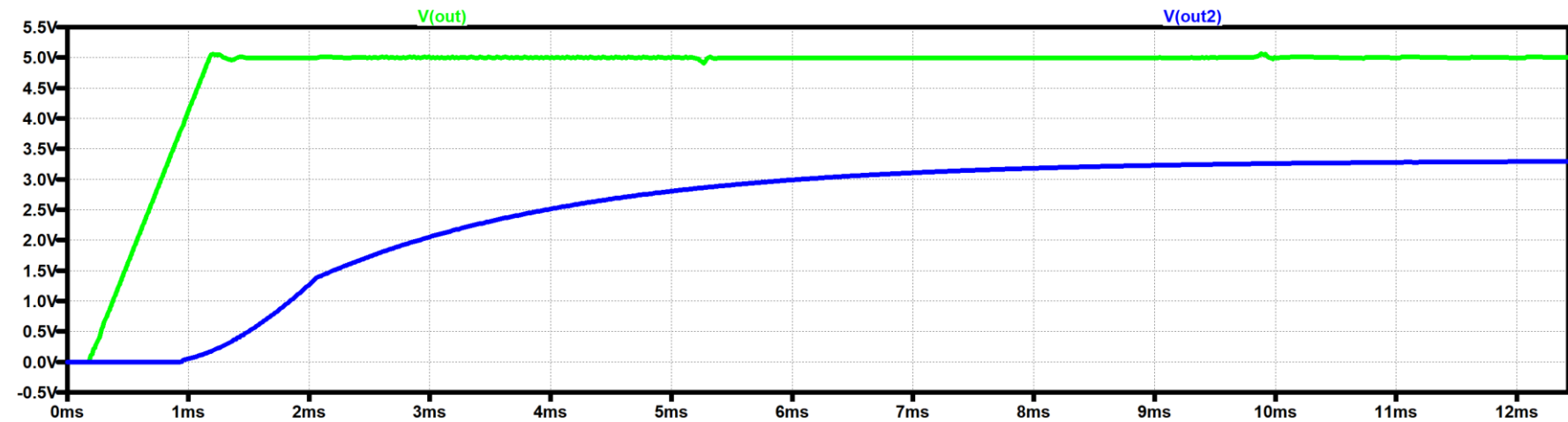
- High-Efficiency 5V system
 - 3.3V System
 - Raspberry Pi
- 3.3V Peripheral



Spice Schematic

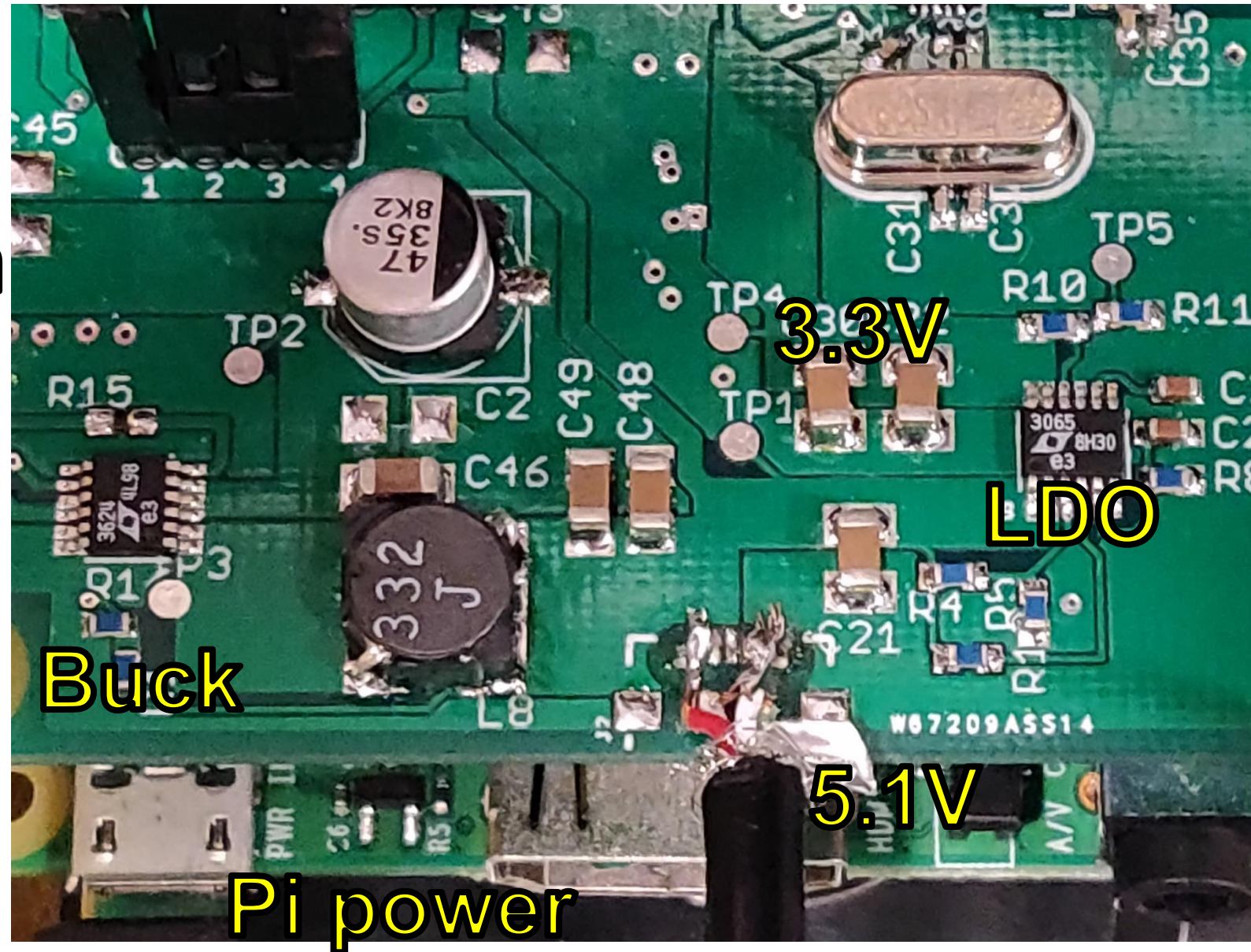


Simulation and Final Data

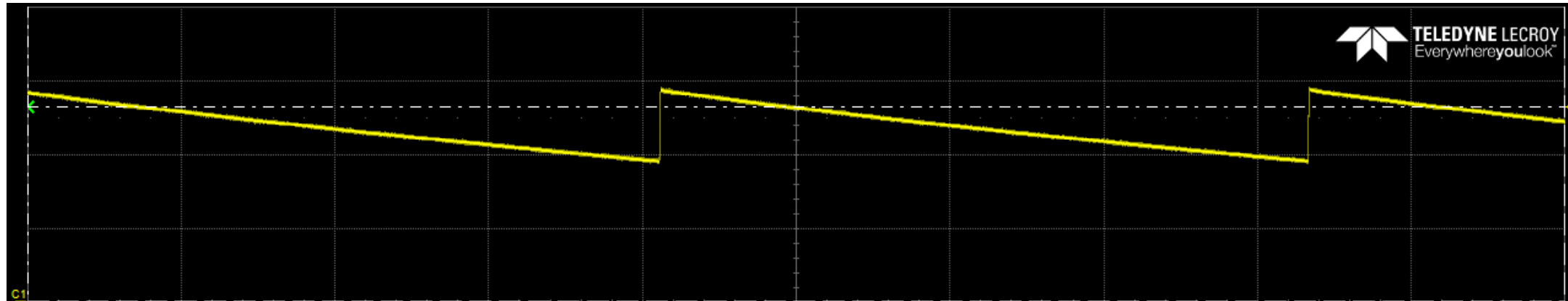


Power

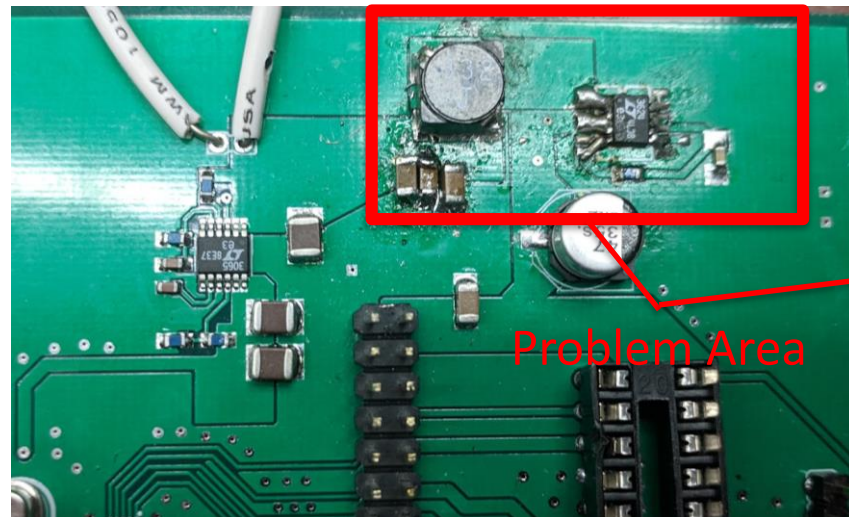
6V in



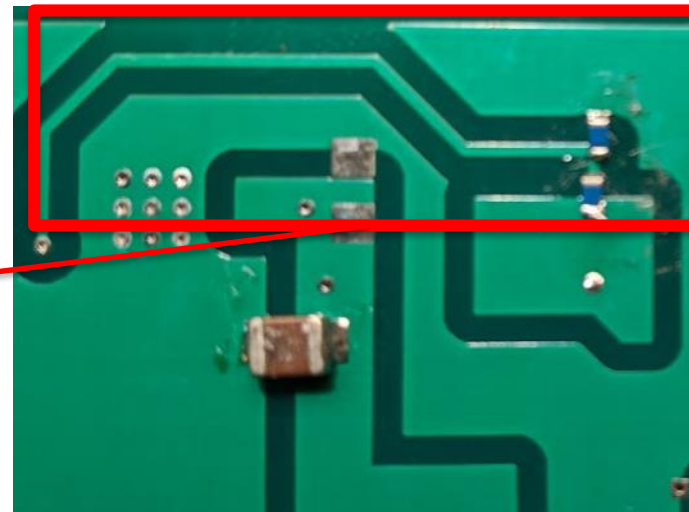
Power: Interference Rerouted



Voltage Ripple = $\sim 2V$
Mean Voltage = 5.8V



Front

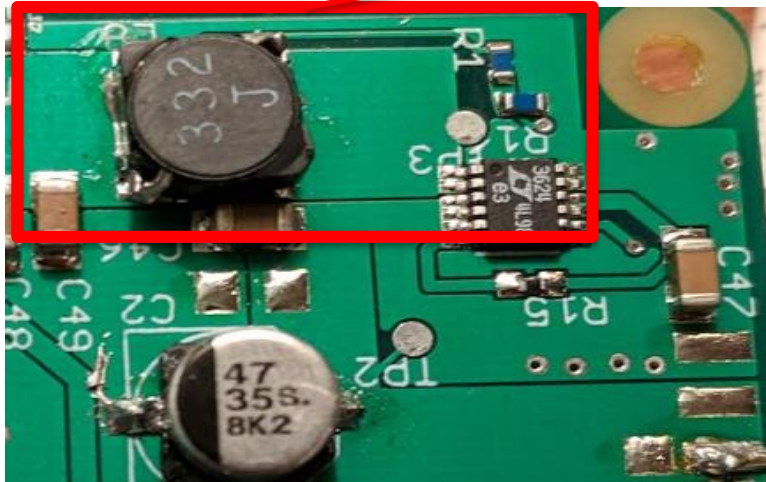


Back

Power: Interference Rerouted

- Corrected Ripple Issues
- Well-Regulated Output

Final Layout



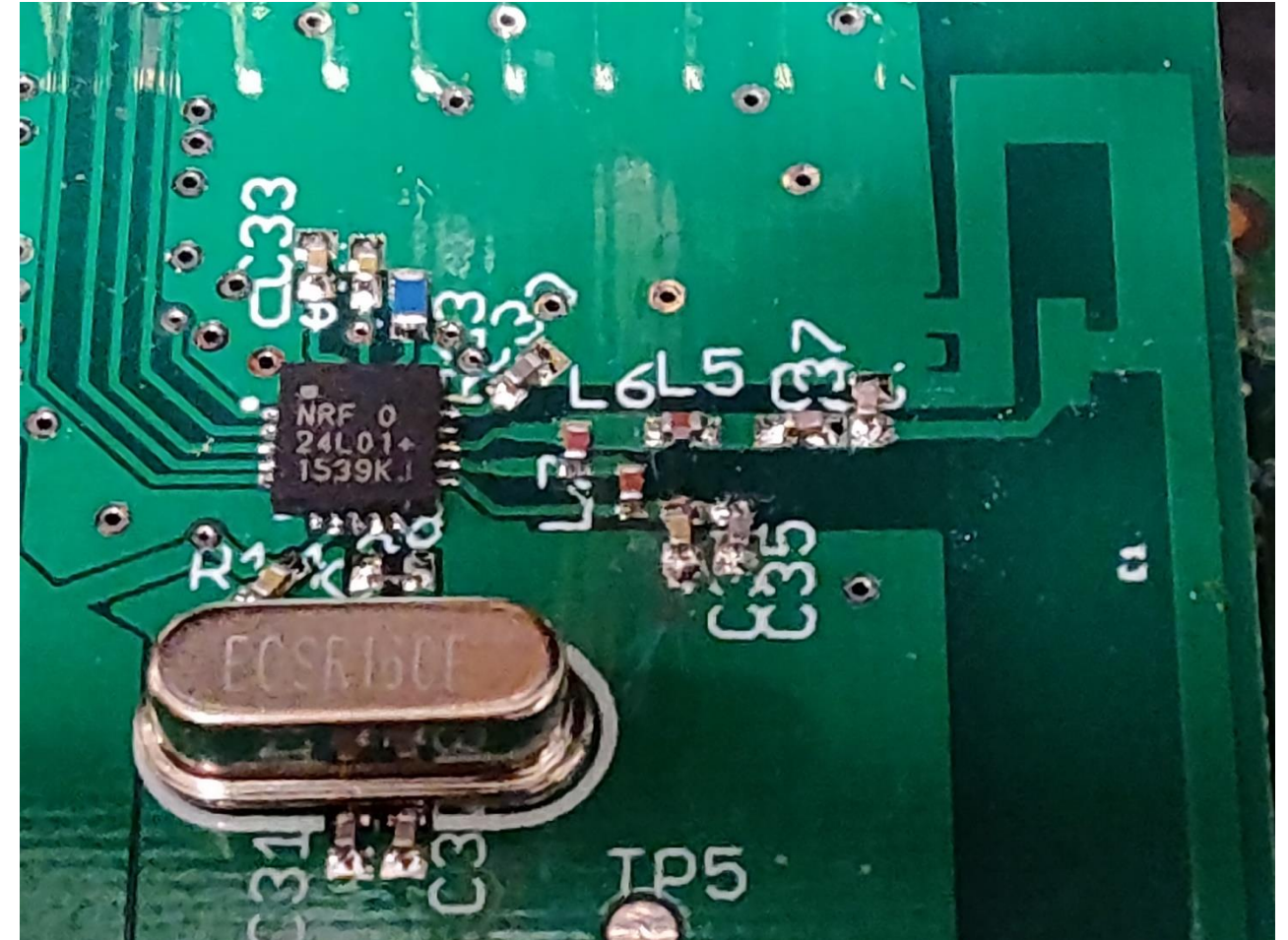
Final



Initial

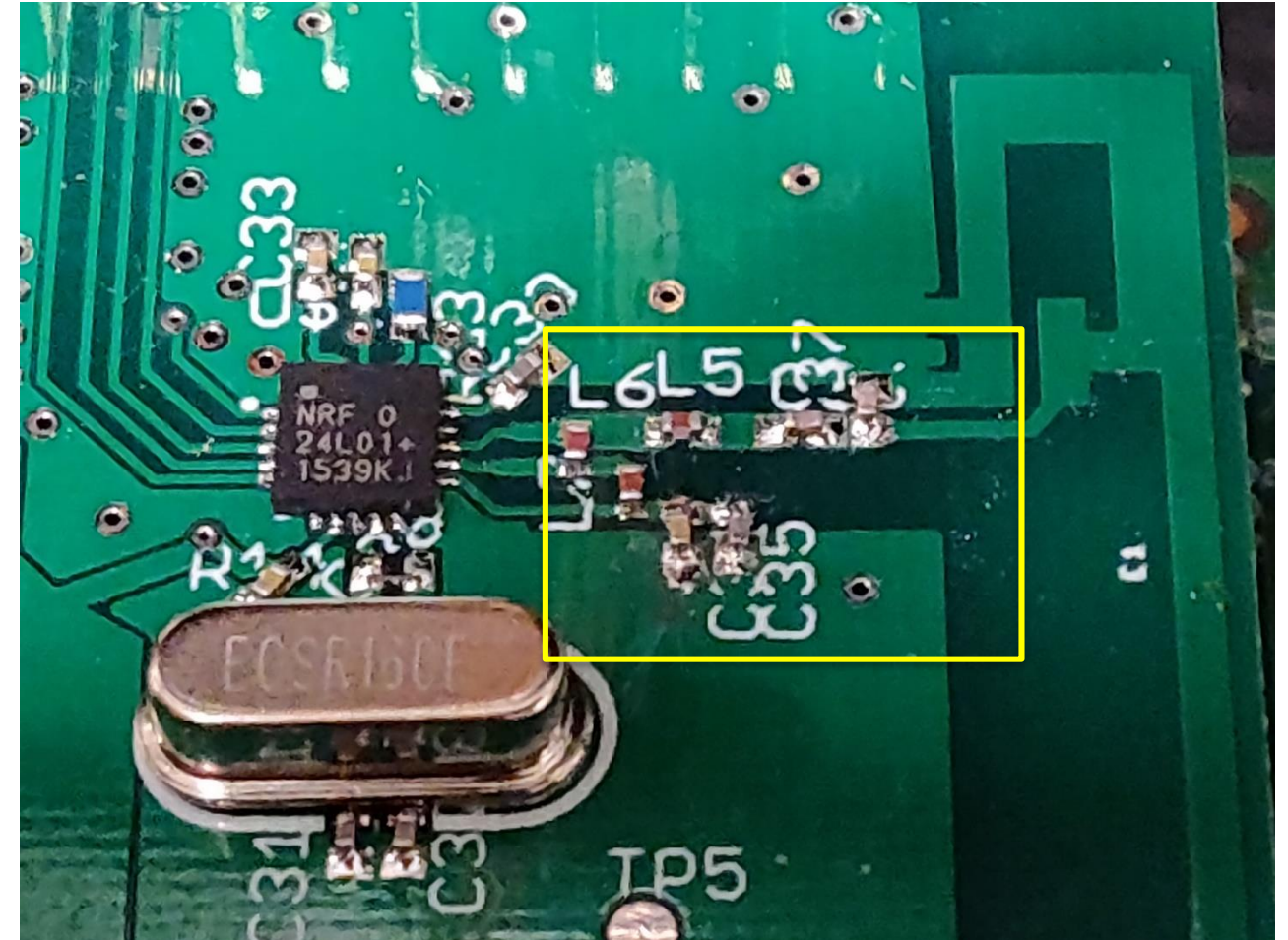
RF Module

- nRF24L01

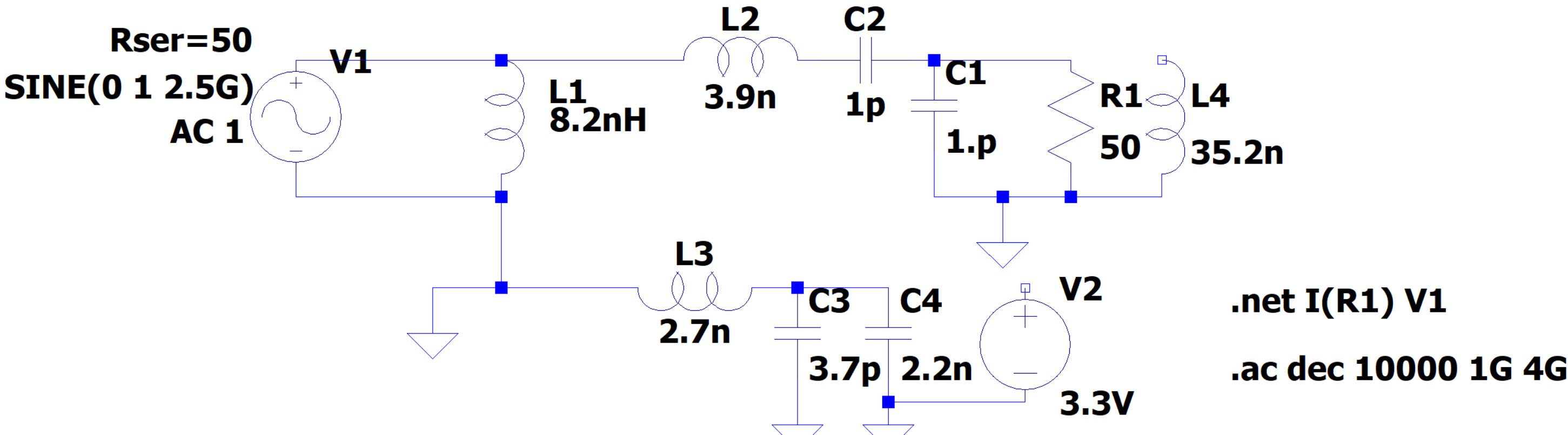


Design of Output Network

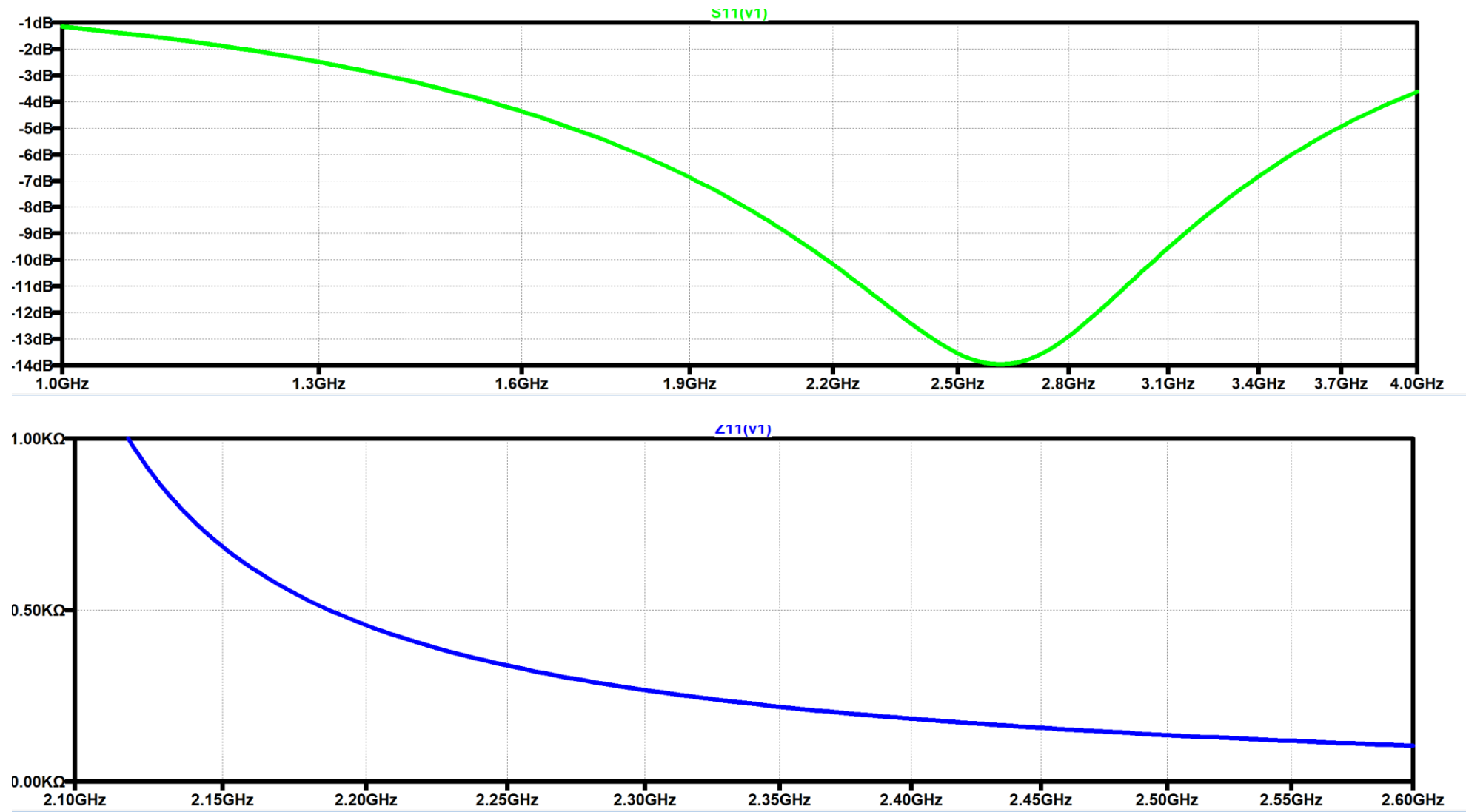
- Recommended setup
- Requirement
- Choice of Components
- Tolerance Analysis



RF Module – Network Analysis

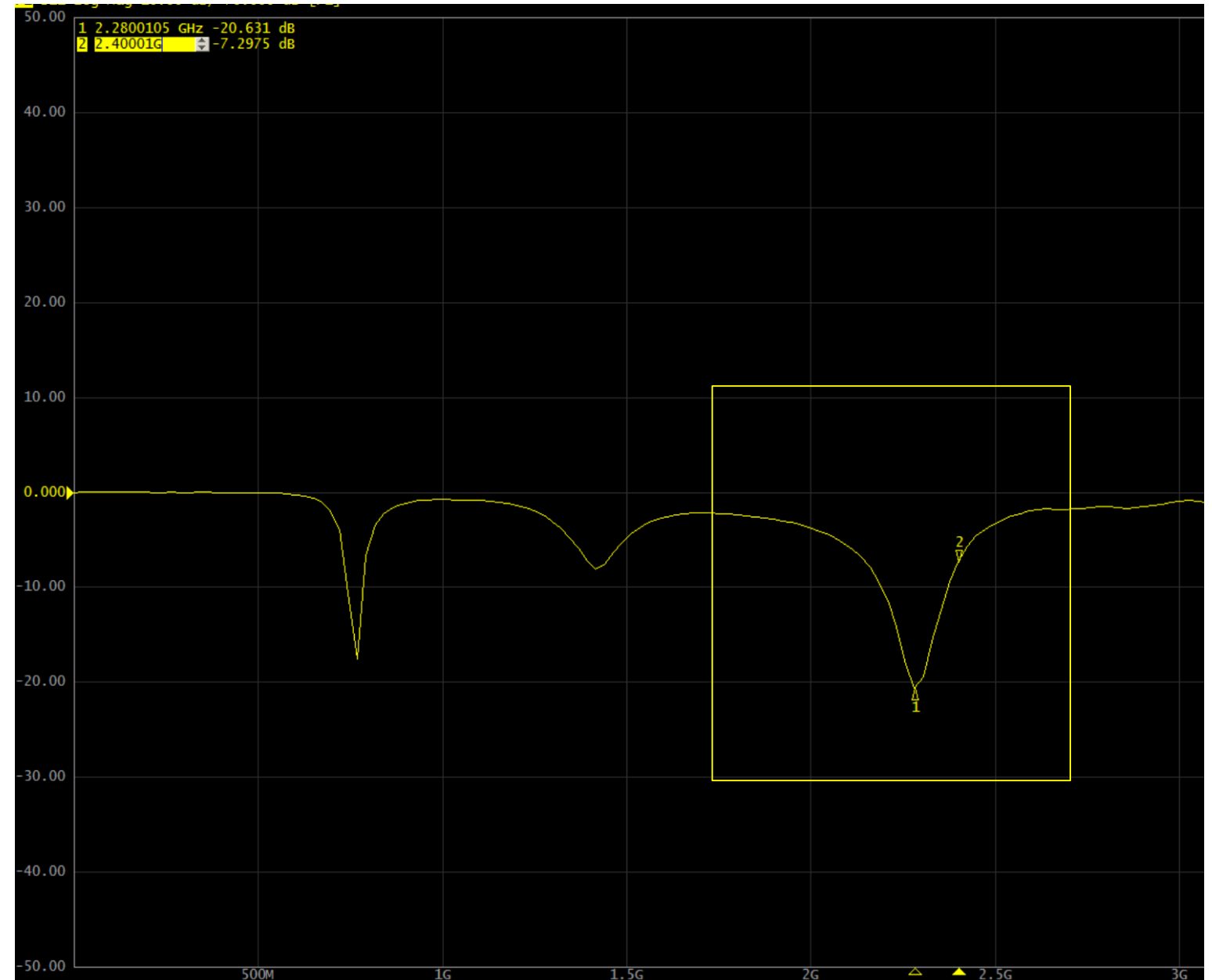


RF Module – Network Analysis Simulation

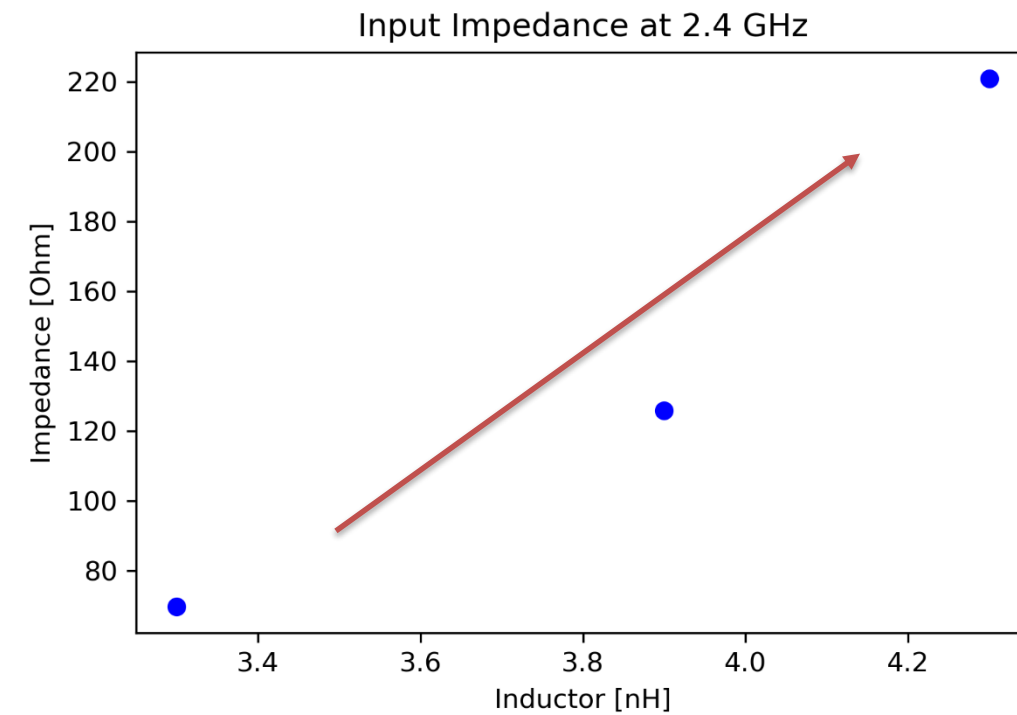
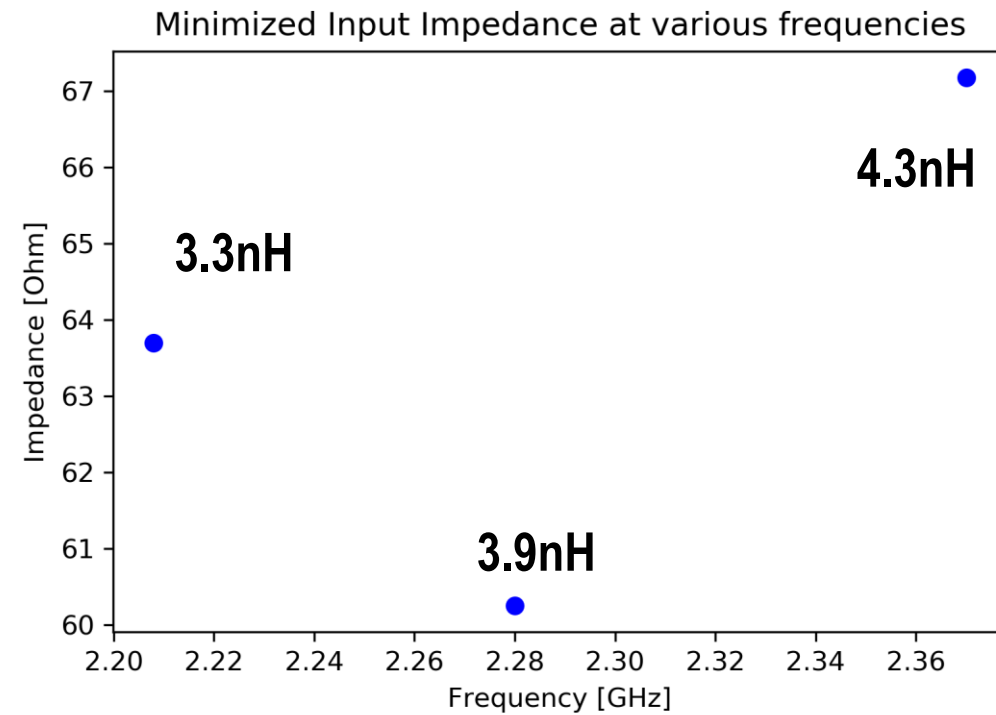


Real Data –

- Calculation and Determination of Input Impedance
- Other Considerations

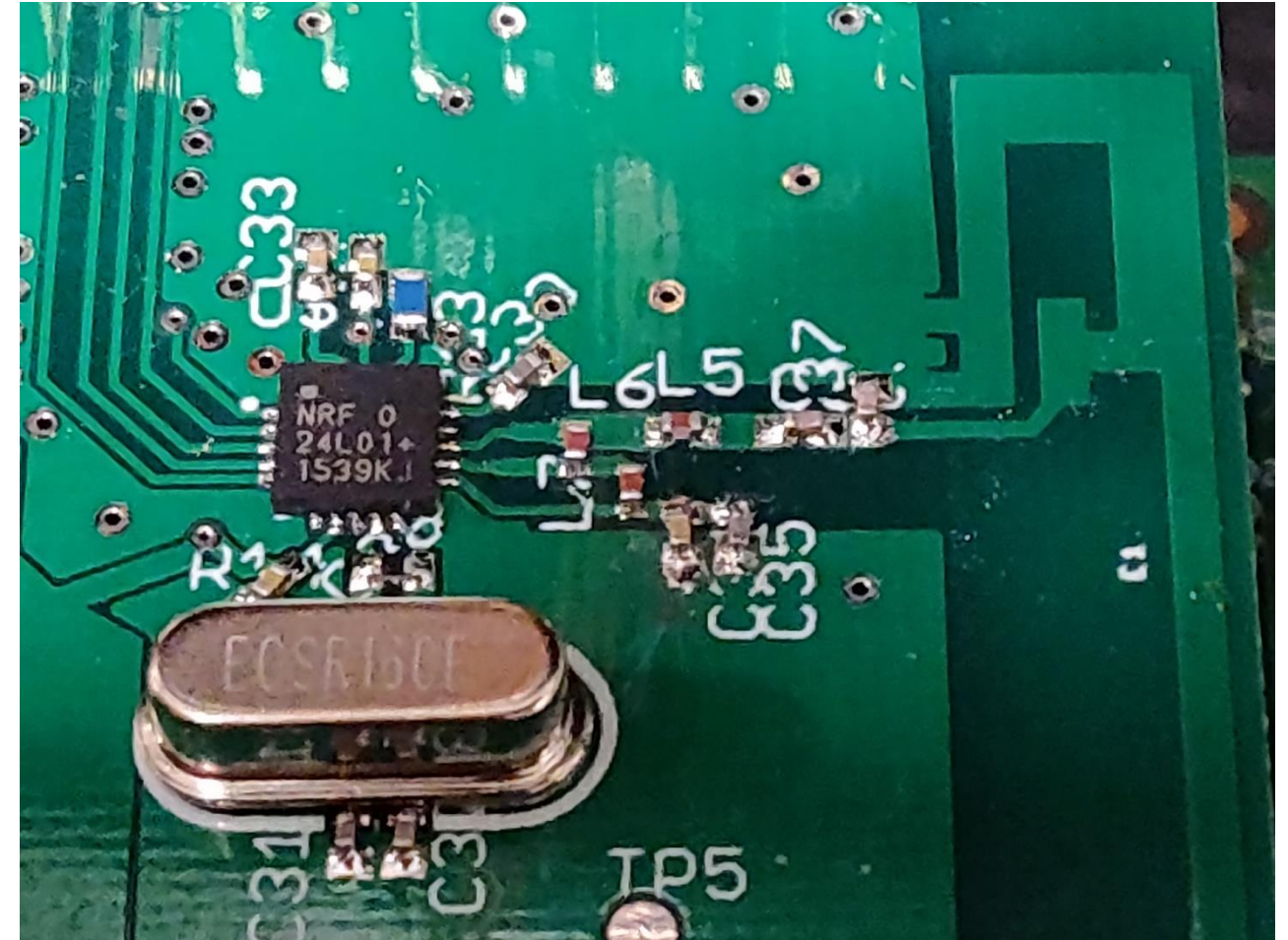


Input Impedance Analysis



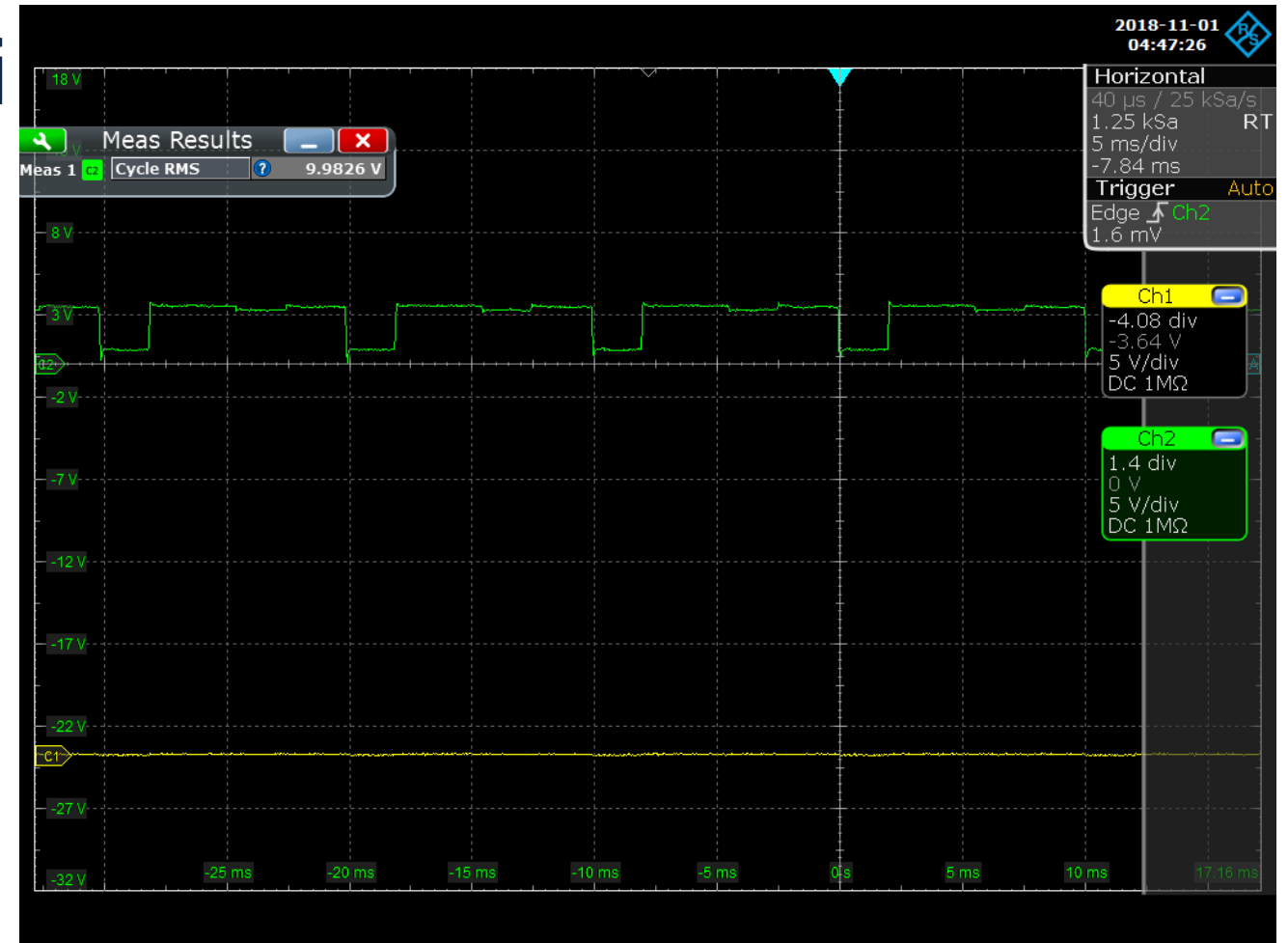
RF: Impedance Overcome

- Capacitance Matters
- Ground Plane
- EMI issues
- Driver Issues



Motor Characterization and Control

- Soft PWM from Raspberry Pi
- Motor choice
- Current Considerations



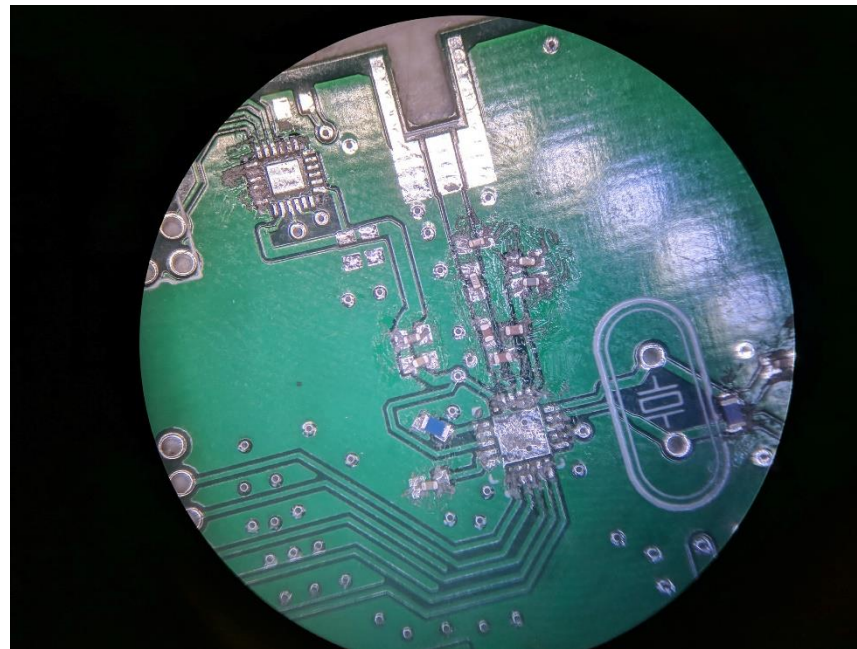
Battery

- Battery Ratings
- Requirements
- Experimental Results



Inertial Measurement Unit (IMU)

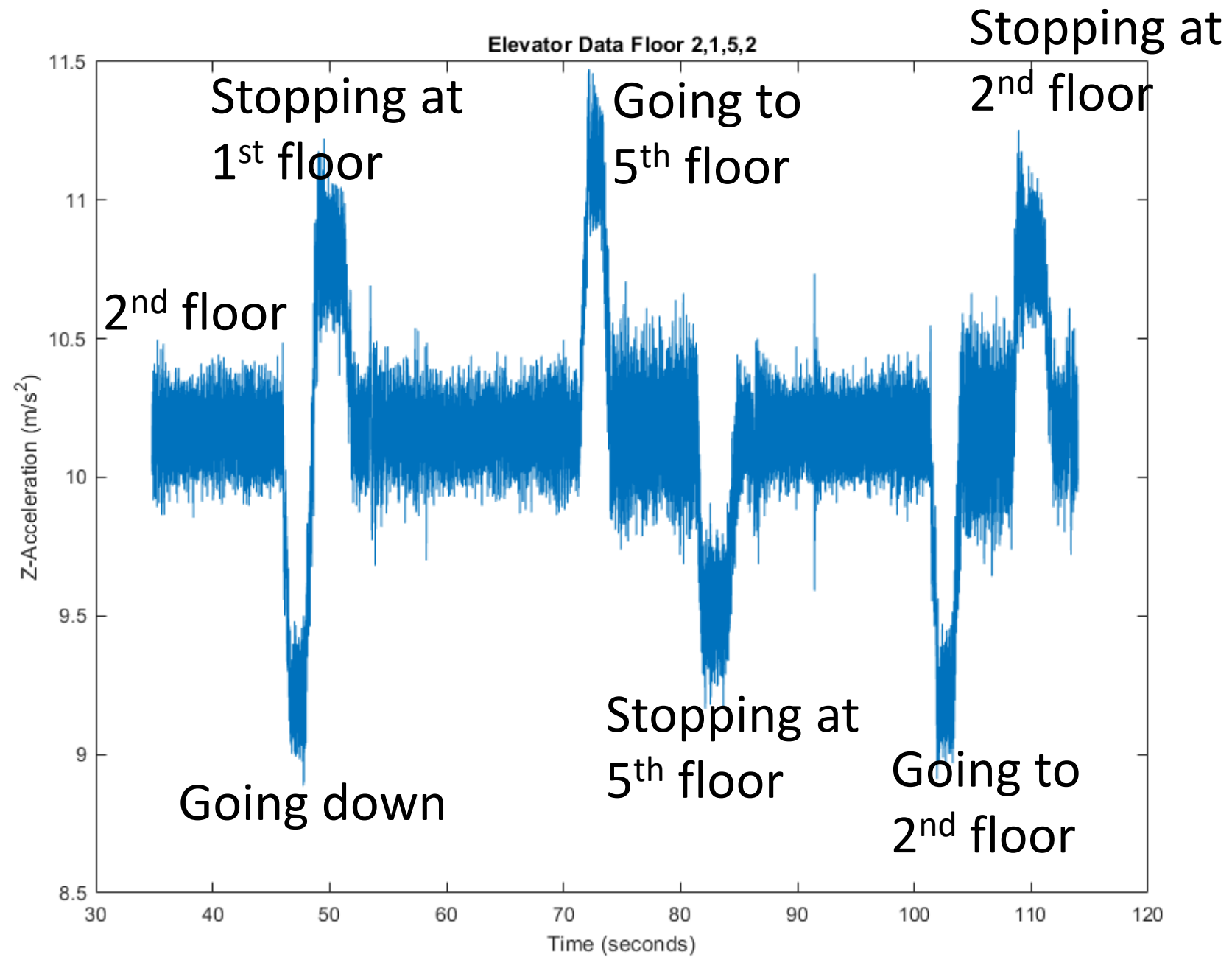
- Simple sensing circuit
- ICM 20648
- Driver

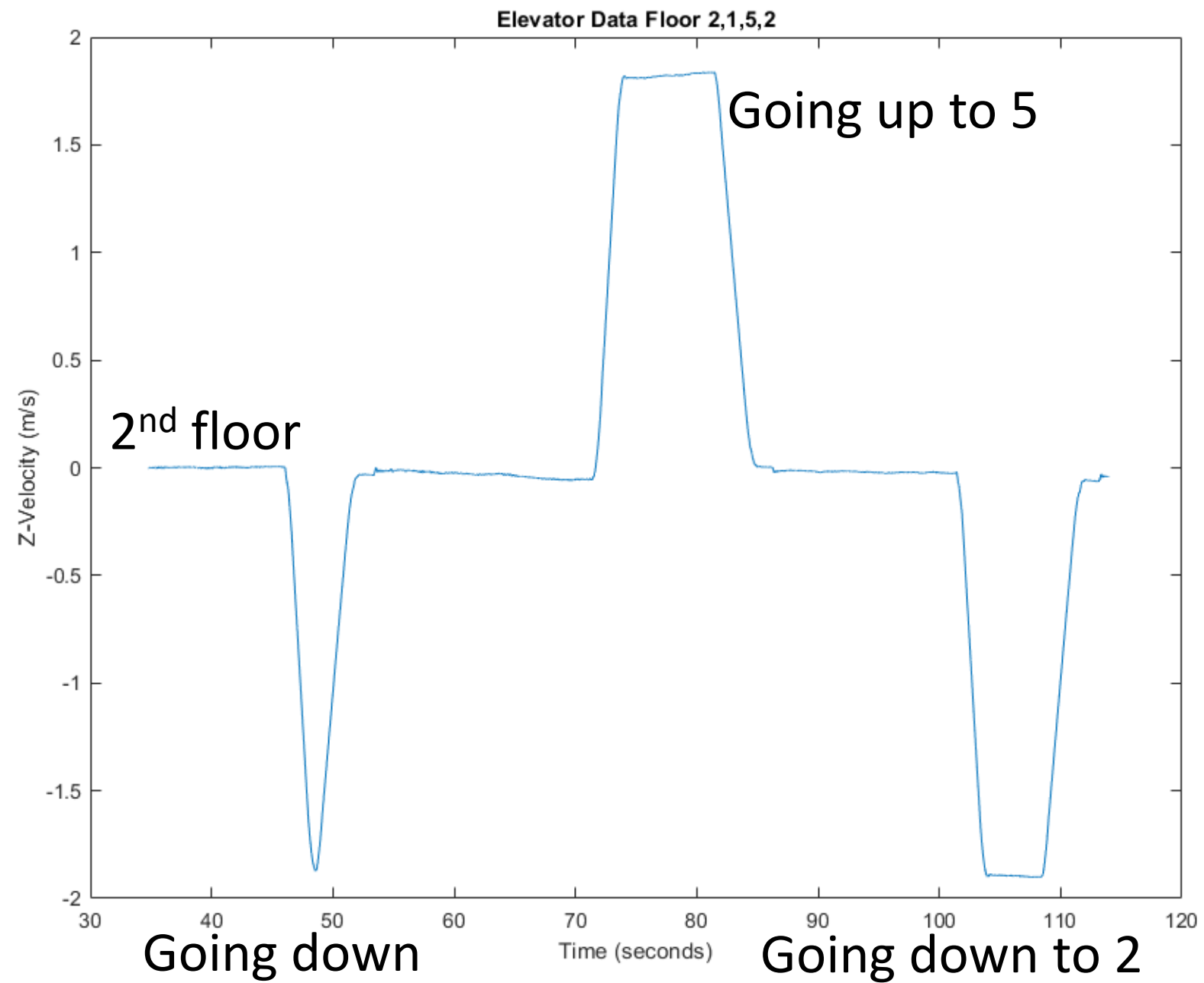


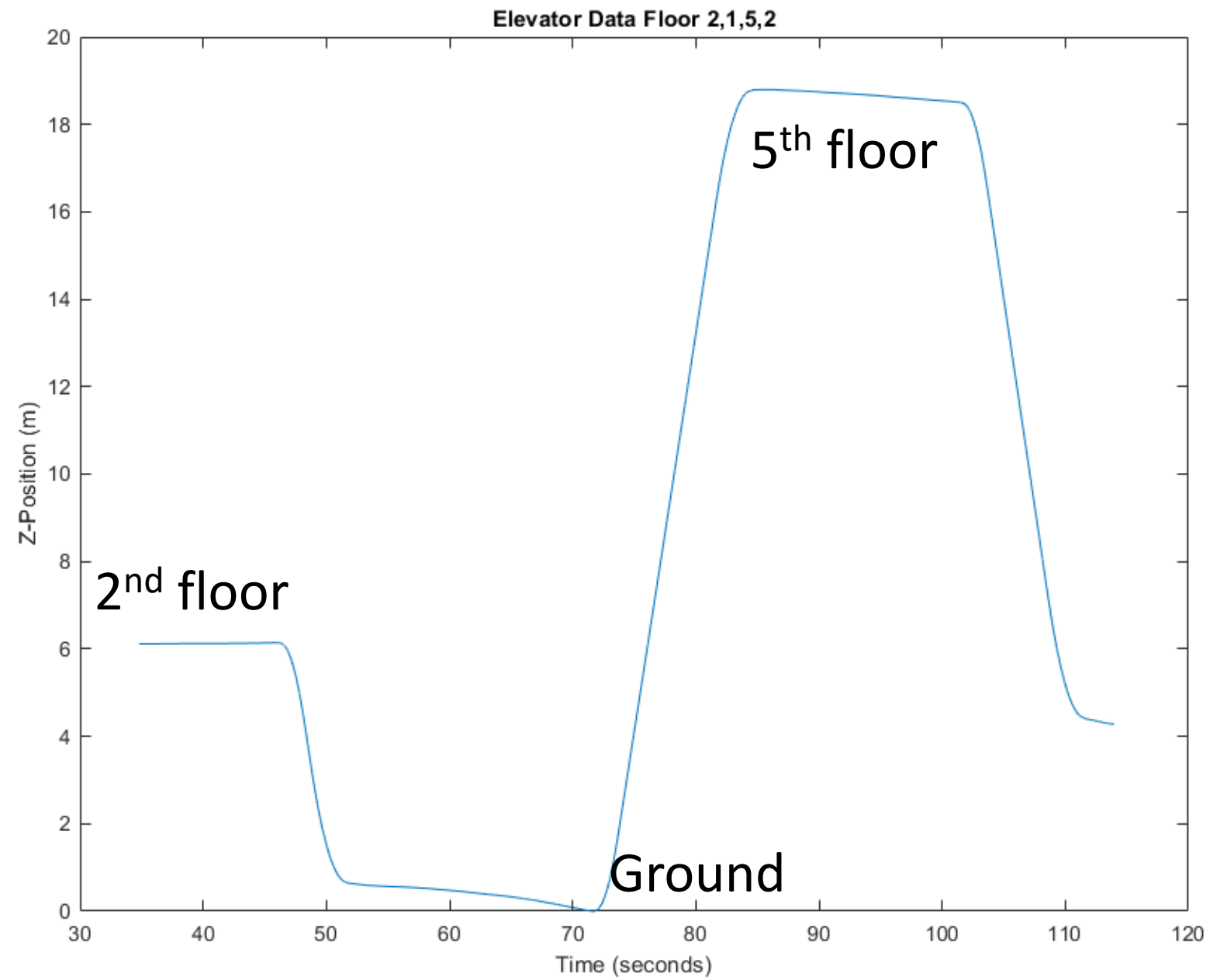
IMU Demo

- Elevator ride



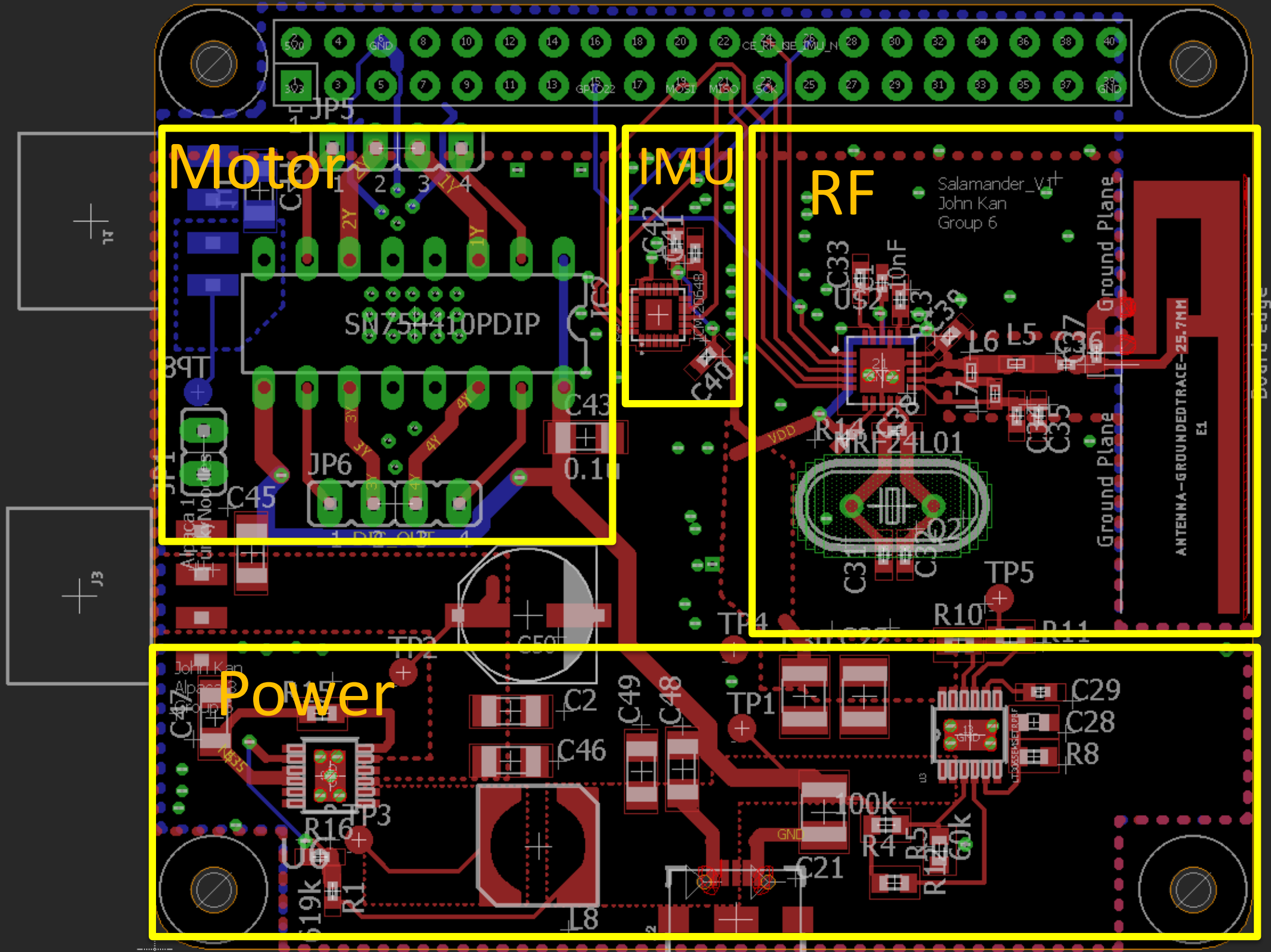


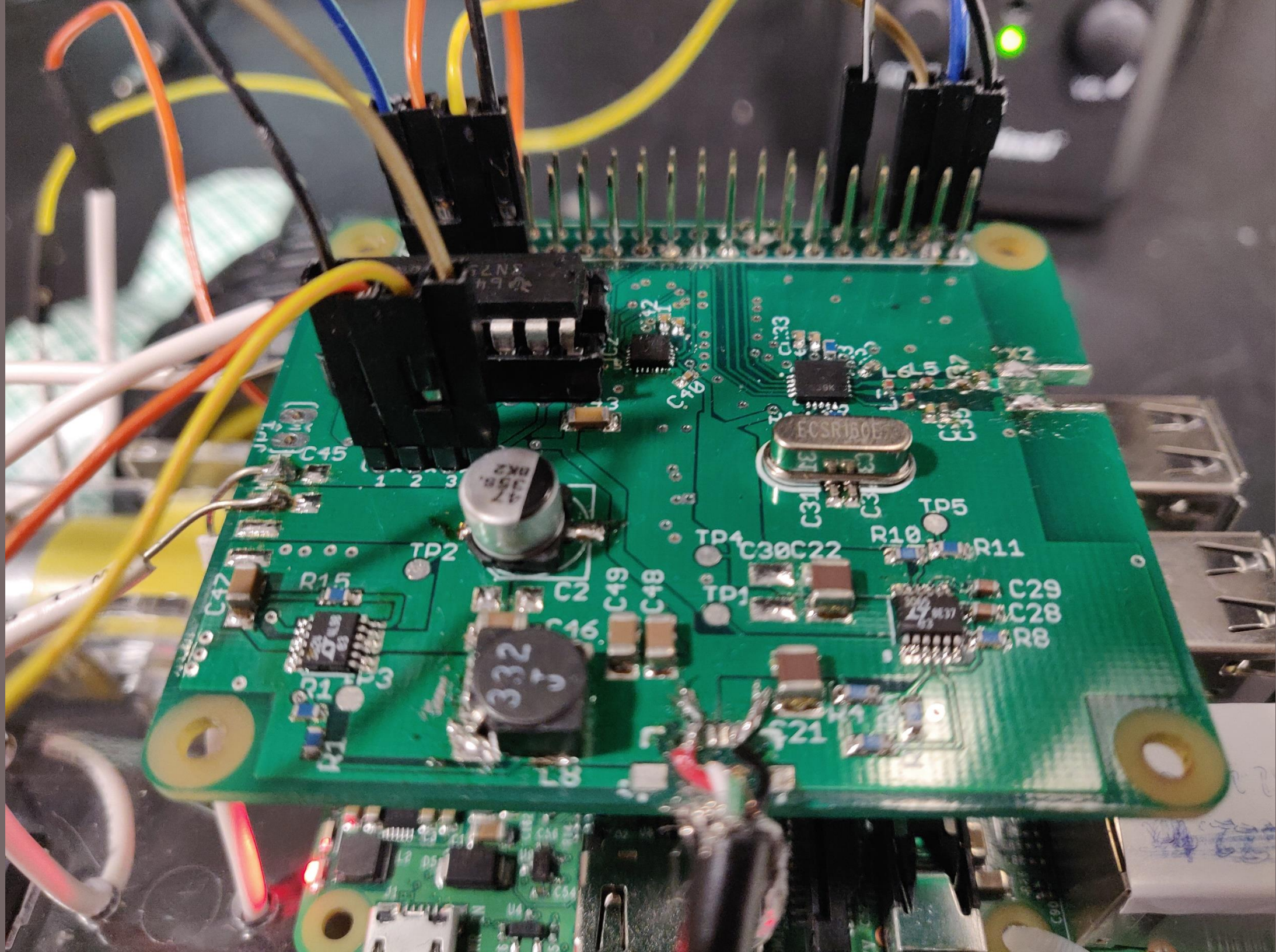




IMU: Inertia Overcome

- Driver issues
- Manufacturer errors
- Soldering Difficulties





Software Support

- Drivers for RF and IMU
- Motor controller integration

Software Modules

- User inputs
- Camera Distance Detection
- ROS (Robot Operating System)

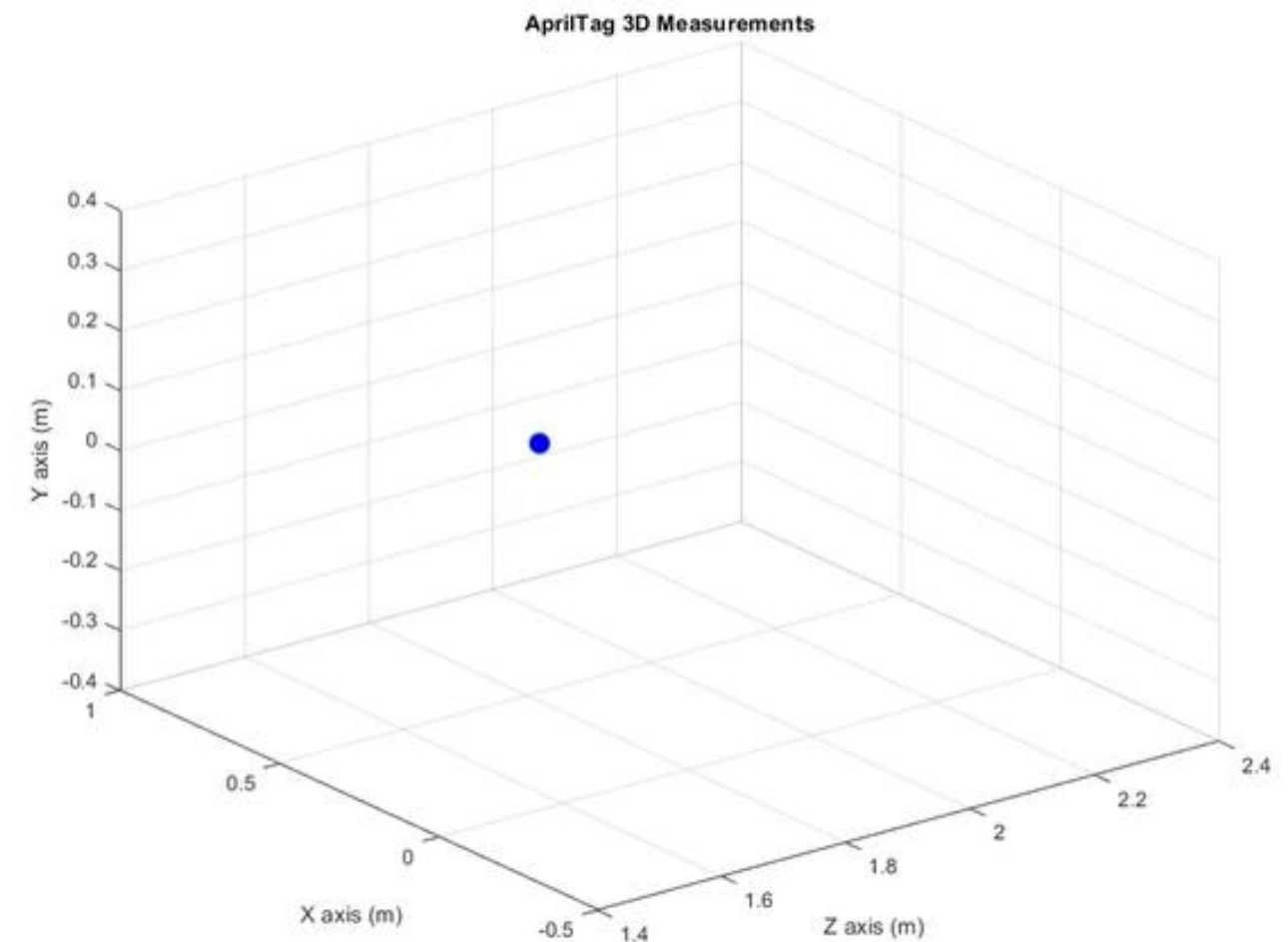
Camera Distance Estimation

- Estimate robot position relative to an April tag

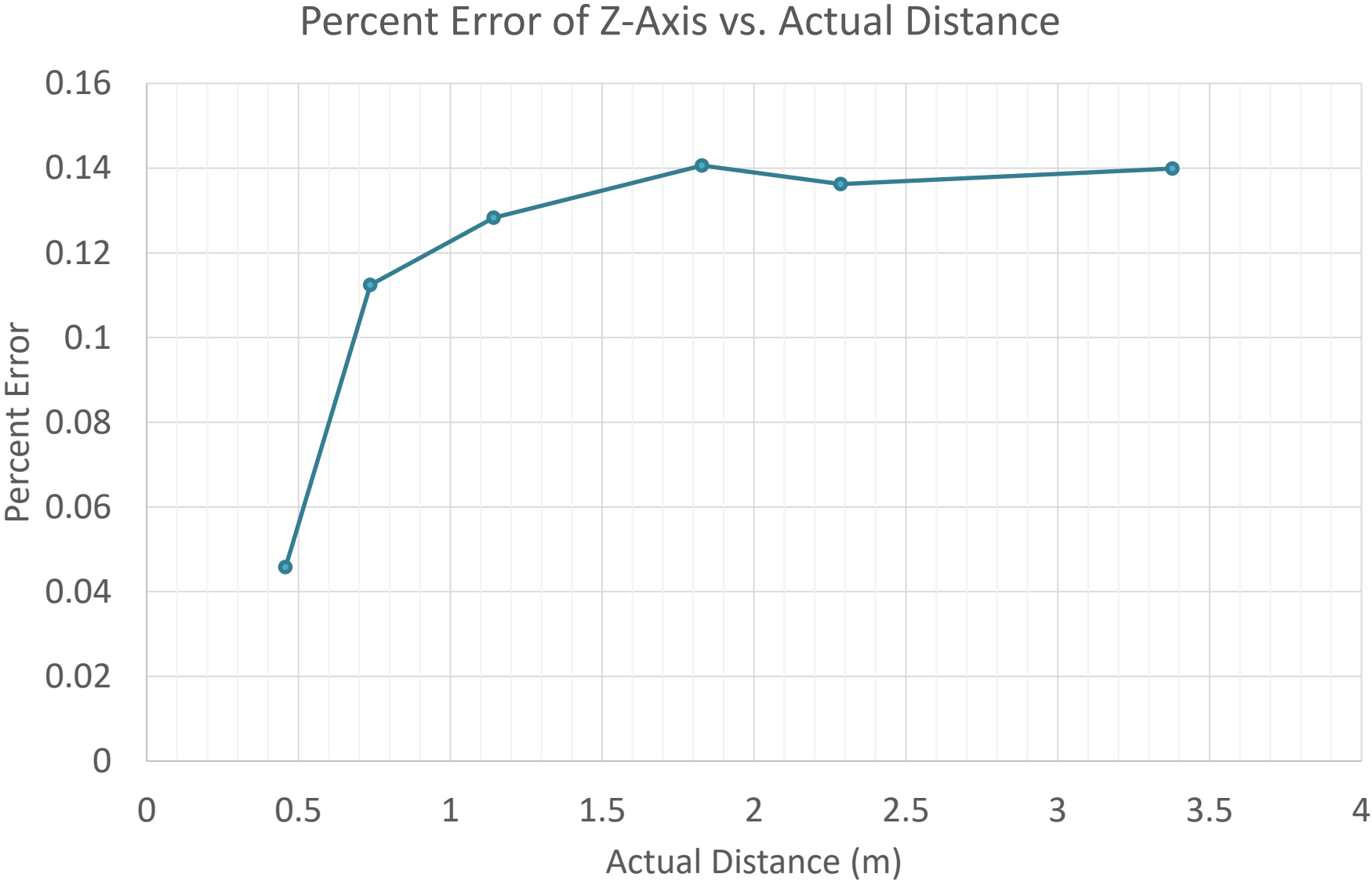


<https://april.eecs.umich.edu/software/apriltag>

Distance Estimation Demo

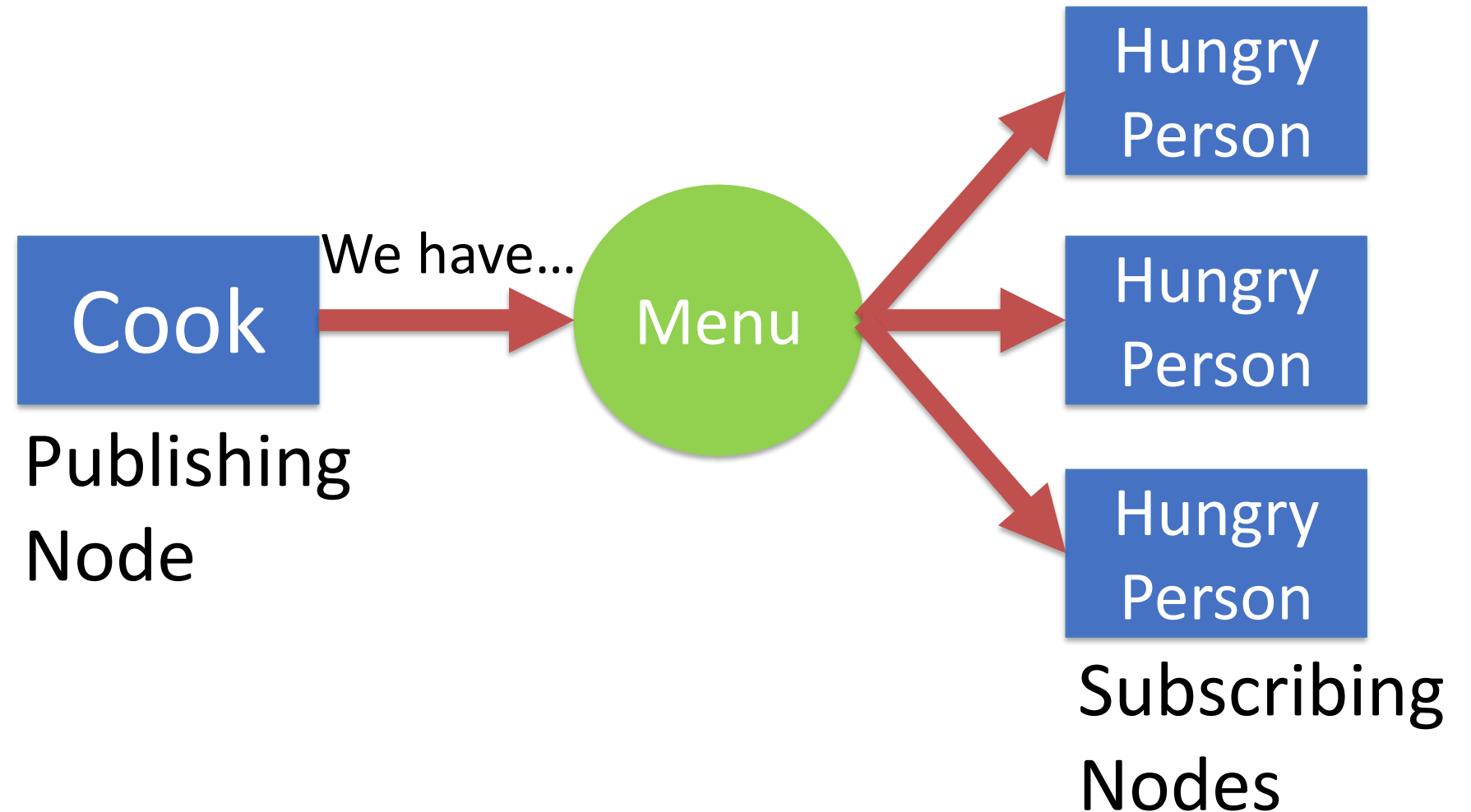


Z-Axis Accuracy

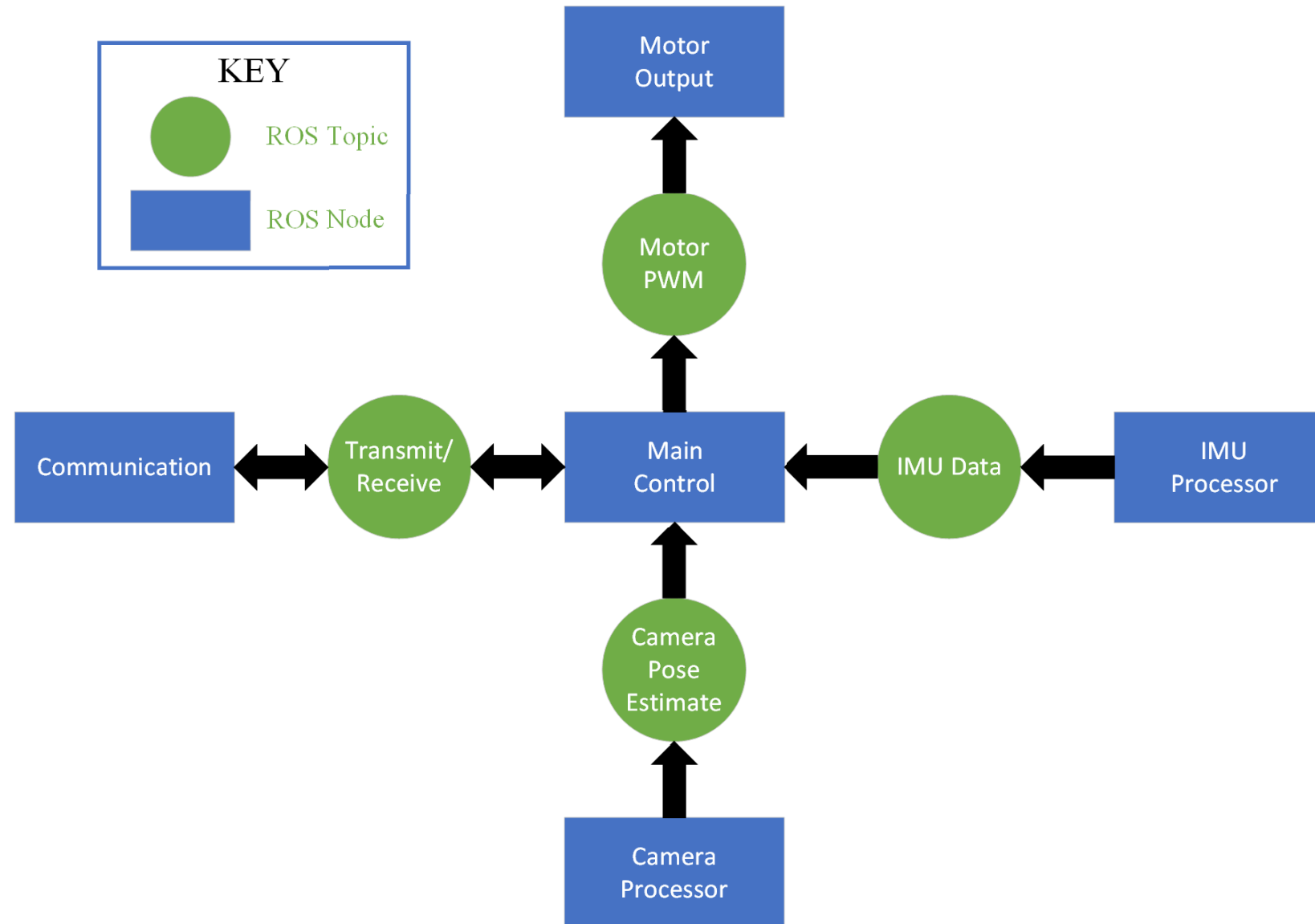


Robot Operating System (ROS)

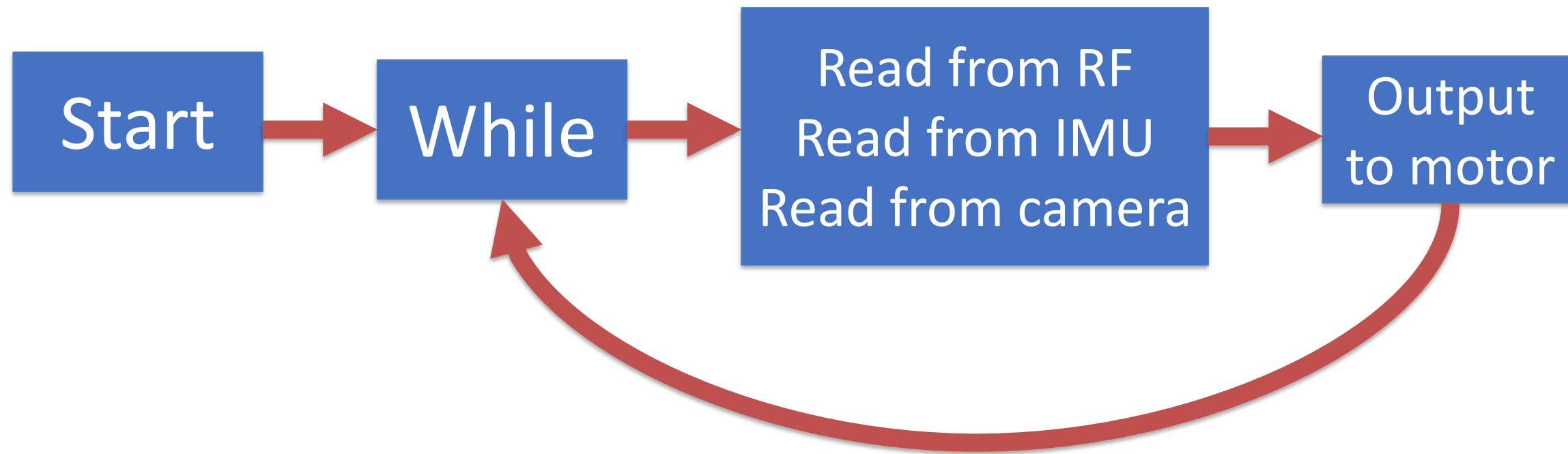
- Nodes
- Topics



How We Use ROS



Main Control Node Example



Costs

Part	Count	Cost for Each
NRF24L01+	1	\$3.53
LT3065	1	\$4.00
LTC3624	1	\$4.00
RCL Components	50	\$0.005
SN75441NE	1	\$1.95
Motors	2	\$1.00
Robot Kit	1	\$15.00
IMU	1	\$9.67
Camera	1	\$30.00
PCB Orders	1	\$1.00
Total	1	\$67.78

Further Work

- More sensors
- Optimize RF transmission range
- Better motor drive support
- Better software framework

Conclusion

- Works as expected
- Real application example