Rotobeam

Fighting Mongooses

Ball Aerospace & Technologies Corp.

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Objective

Rotobeam is a complex and intelligent drone wireless charging system. The goal of the project is wirelessly charging a drone in 10 hours with very few human interactions.

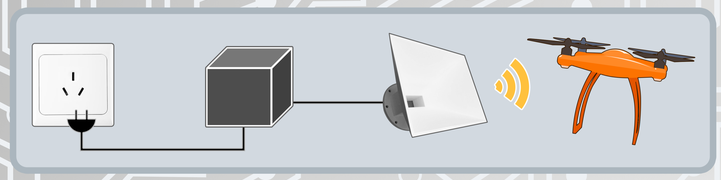

Figure 1: Representation of Base Station System w/ Horn Antenna and Drone

- Provide a solution to achieve fully-autonomous unmanned vehicle(UV) charging operation.
- The need to physically connect wires for battery charging necessitates some level of human/UV interaction.
- The goal for the project is to wireless charge a 5000mA-hr battery in 10 hours.

Embedded Systems

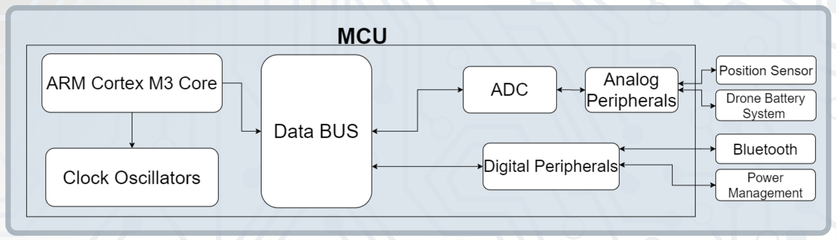

Figure 2: MCU Functional Block Diagram

The embedded systems component controls and directs the functionality of the other sub-modules. The main components include:

- Microcontrollers (MCUs)
  - STM32F411CEU6
- Displacement sensors
- Bluetooth modules

Once the drone has landed, the base station MCU will turn on the Power chain which powers the RF chain.

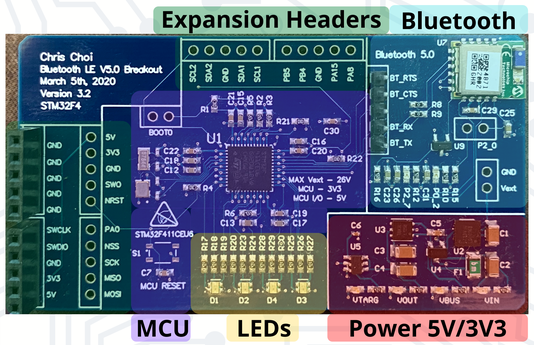

Figure 3: Drone MCU and Labeled Sub-sections

RF Chain

- Rotobeam utilizes far-field to accommodate the imprecision of UV positioning.
- The rectenna array consists of a microstrip bowtie antenna array, with RF diodes connected between antenna elements to achieve signal rectification.
- For this project, we used power amplifiers that were graciously donated to our team by both Qorvo and Wolfspeed, A Cree Company.

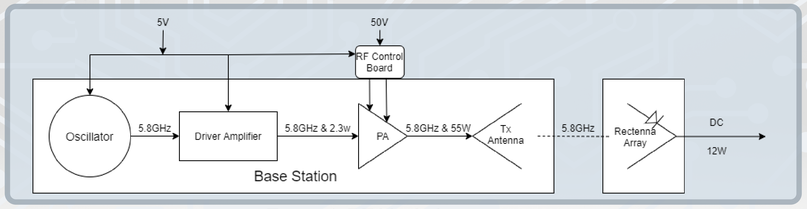

Figure 4: RF block diagram

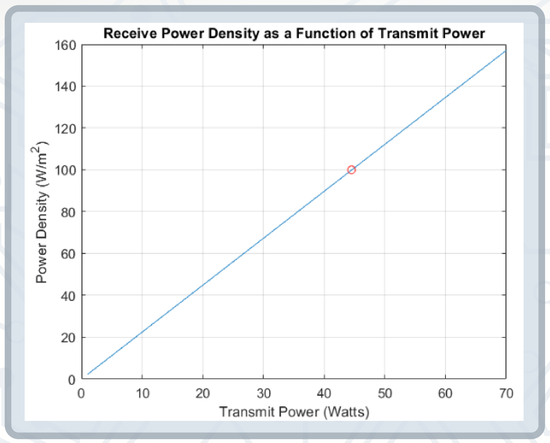

Figure 4: Receive Power Density vs. Transmit Power Function

- To meet charge time requirement, need 500mA average current
- Determined 100W/m^2 receive power density requirement
- Fig. 4 shows that our minimum transmit power to meet requirement is 44W

Power

In order for operational RF transmission, power rails of the base station must supply RF components with proper DC voltage and current. A PCB was fabricated integrating the MCU with power converters and protective relays following the diagram. The system will turn on and off each component in a specific order using these relays.

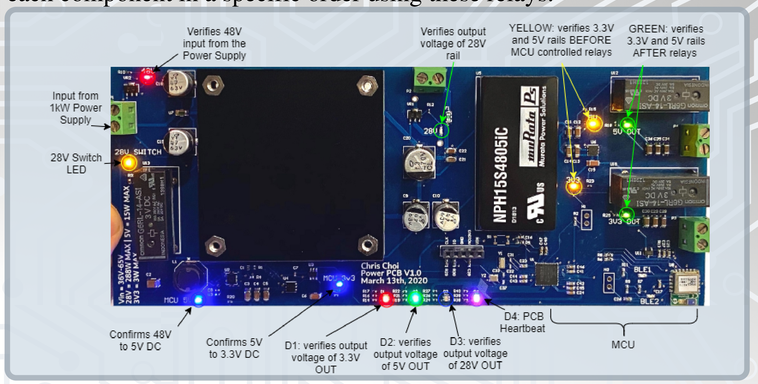

Figure 6: Base Station Power System Including MCU Integration

The drone battery will provide energy for the drone and MCU. The estimated charging time will be about 10 hours and it will fly 5-10 mins in full battery state.

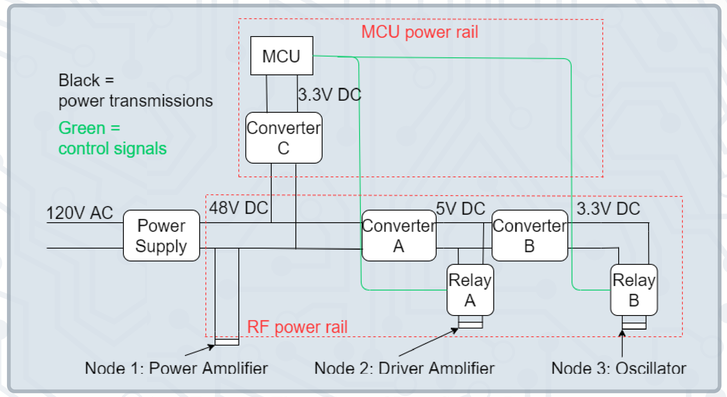

Figure 7: Flow Chart of Base Station Power

Conclusion

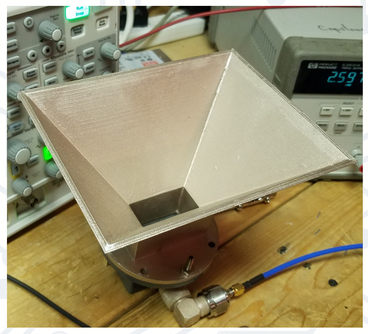

Figure 5: 3D Printed Horn Antenna

Overall - We were able to successfully receive 40 mW of power with our limited resources. Due to COVID-19, the system development is 90% complete and just needs manufacturing finishes.

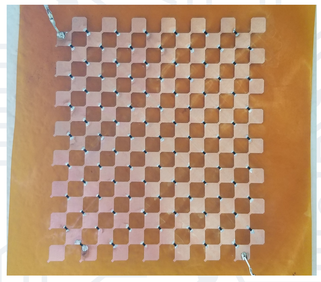

Figure 8: Hand-Etched Rectenna Array

- The rectenna array will transfer the RF power to DC and will charge battery cells.
- The drone battery will provide energy for the drone and MCU.

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