LOST
Lost Object Search Technology

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Group #22

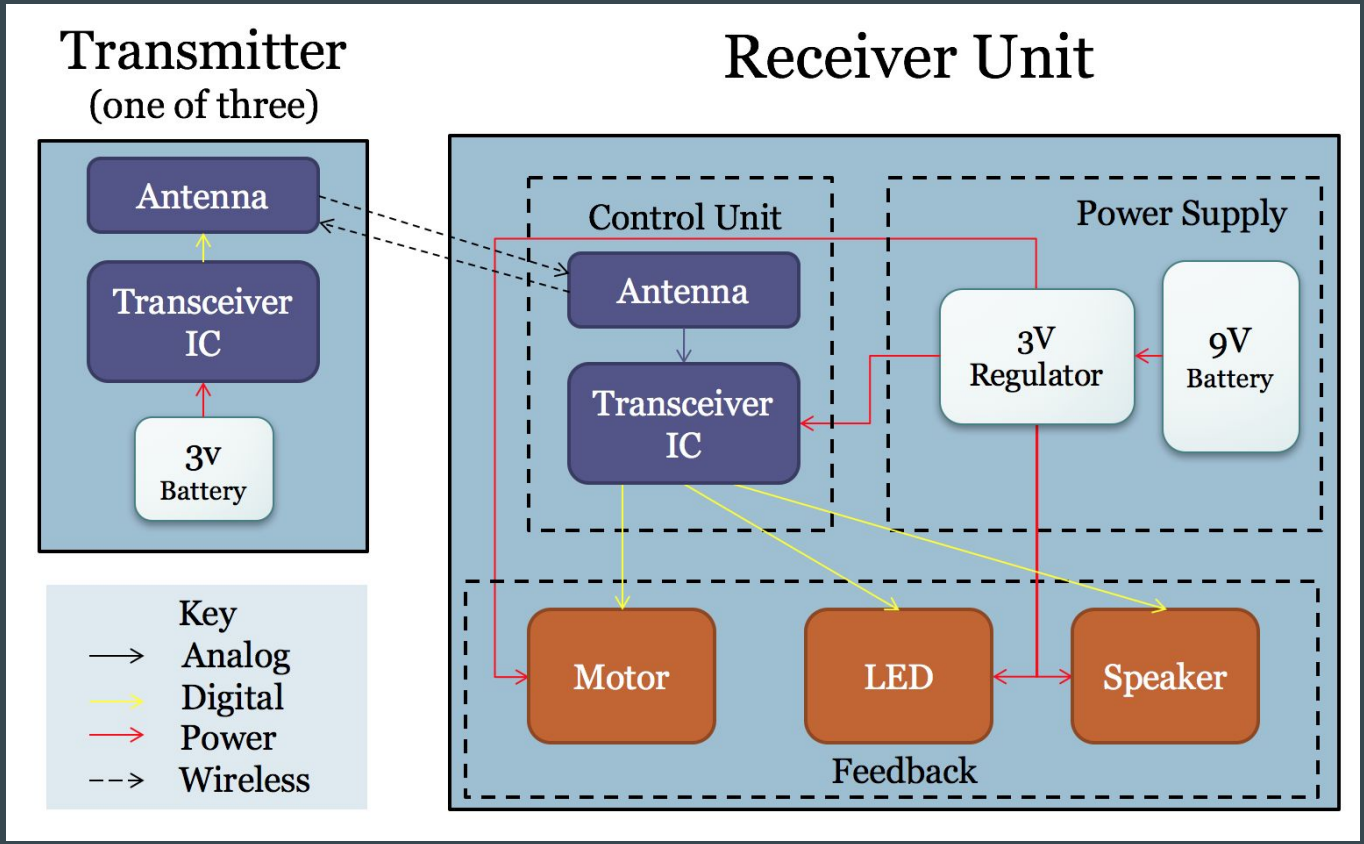
Introduction

- LOST can be used by everyone to find their objects
  - Target market
- Tile's Phone app does not work for blind people
- Deaf people are unable to hear Tile's ringing
- >3.4 million (3%) of Americans ages 40 years and older are either visually or audibly impaired

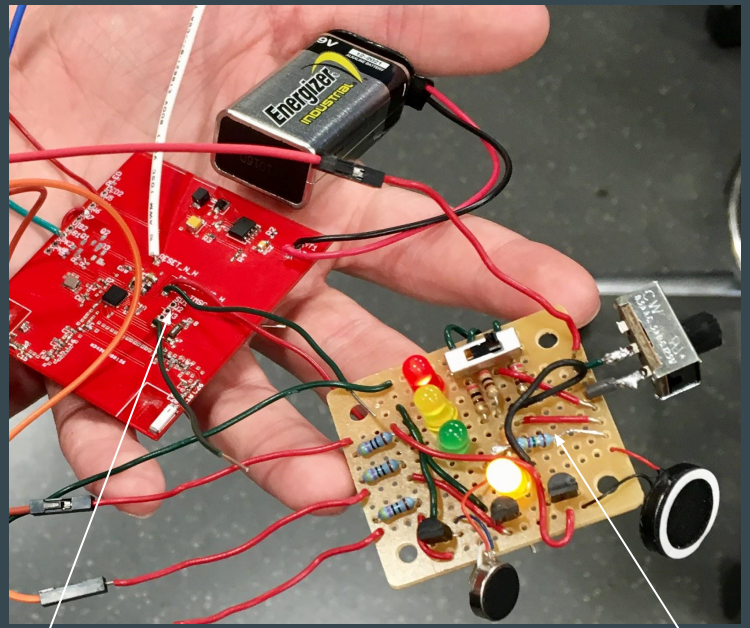
Objective

- Users can easily track down lost objects
- Handheld receiver that connects to one of three transmitters
- Selected transmitter broadcasts to the receiver in the 915 MHz industrial, scientific, and medical (ISM) radio band
- Receiver evaluates signal strength
    - Gives tactile, audio, and visual feedback guide user to transmitter

Block Diagram



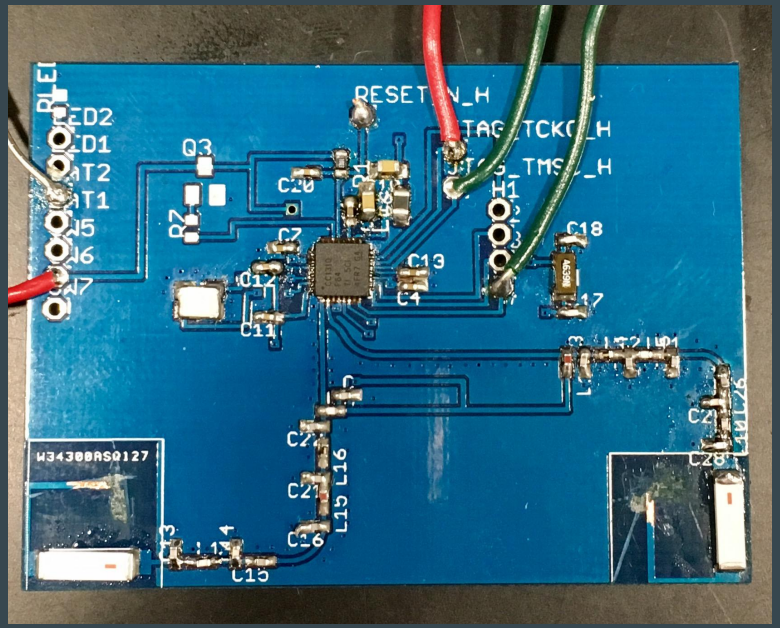
Final System



Receiver Unit

Receiver PCB

Feedback Module



Transmitter

Hardware

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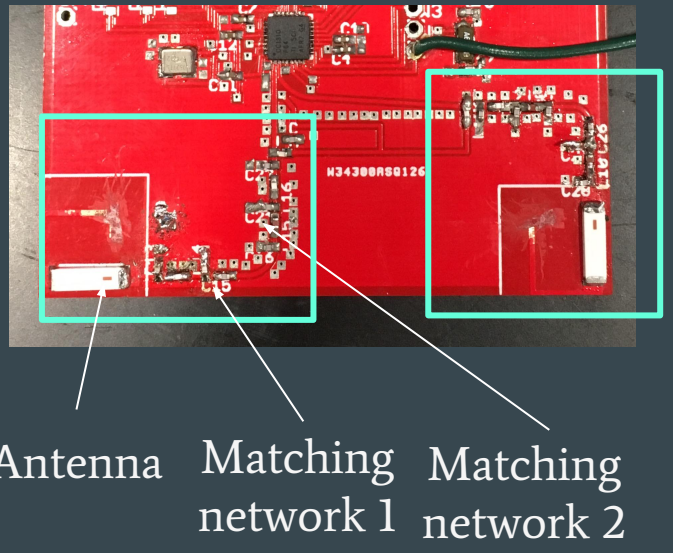
Antenna (Transmitters and Receiver)

Requirements:

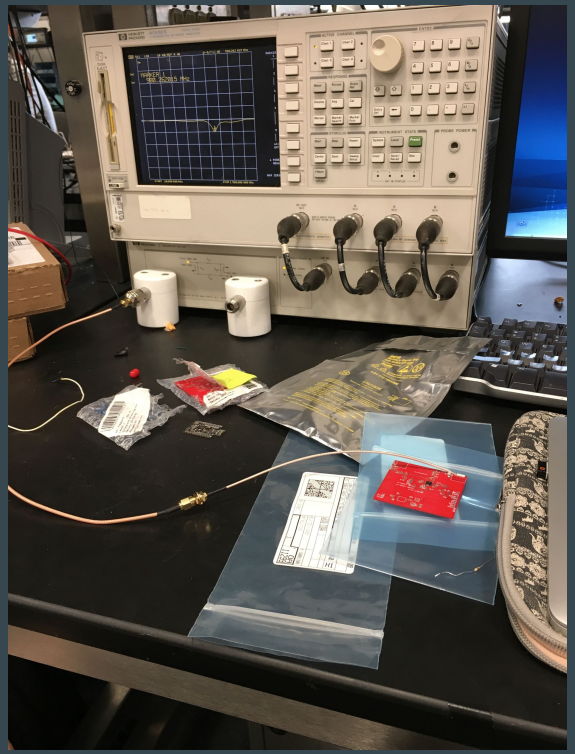
- Antenna must be able to receive and transmit at 902, 915, 927 MHz

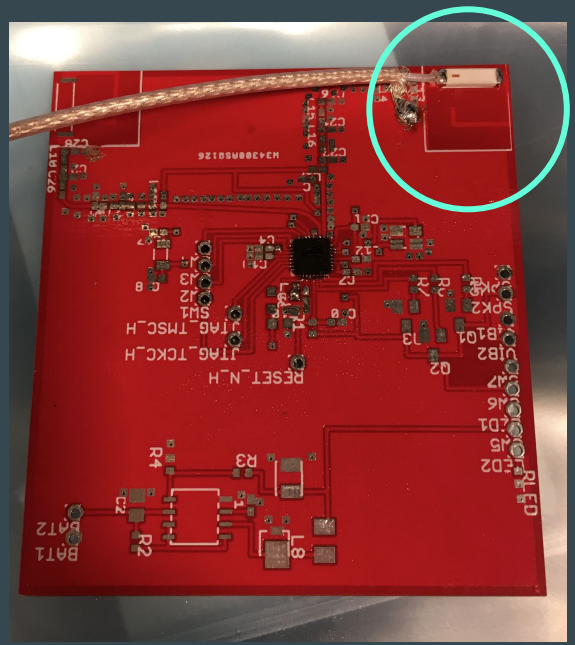
Design:

- Selected chip antenna (size)
- Antenna diversity - two antennas
- Tune resonance of antenna
- Impedance match antenna - two networks



Antenna Tuning - Resonance (Setup)

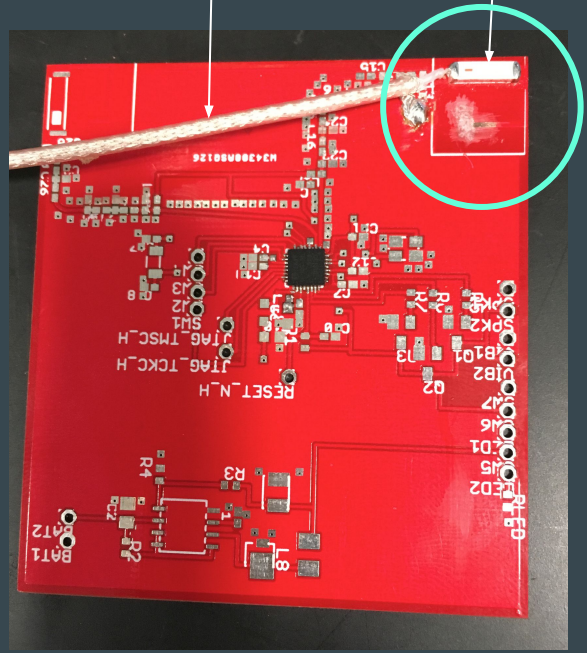




Before

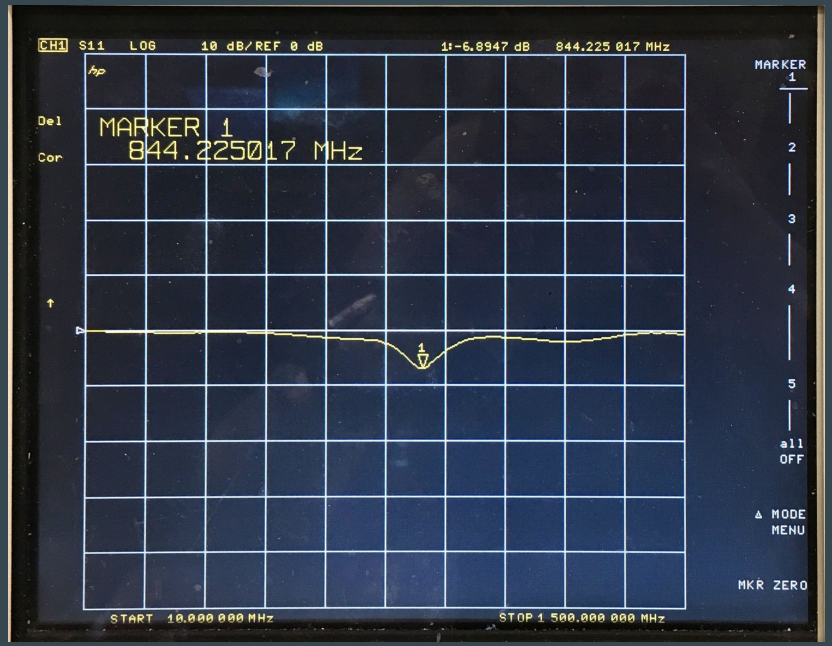
Cable to SMA input

Chip antenna

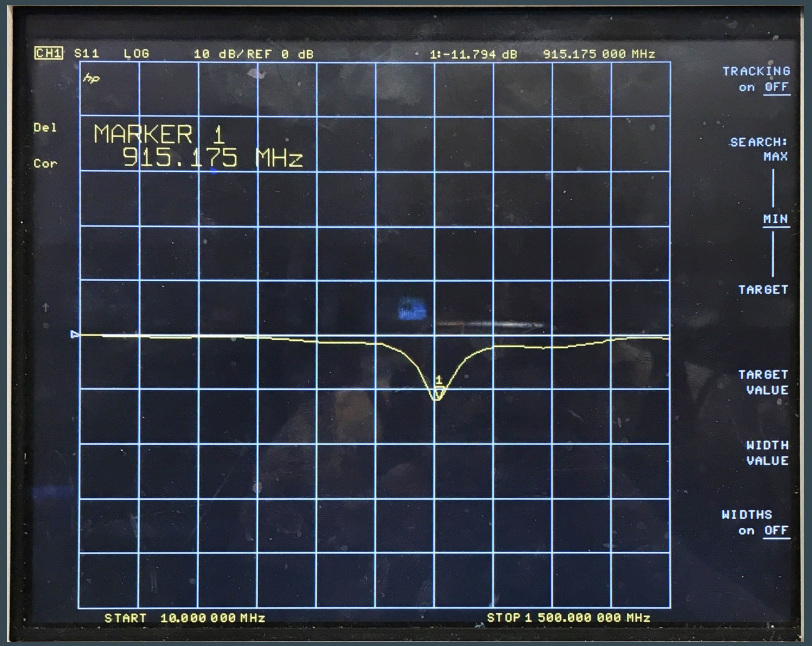


After

Antenna Tuning - Resonance (Data)



Before (844 MHz) (-6.9 dB)



After (915 MHz) (-11.8 dB)

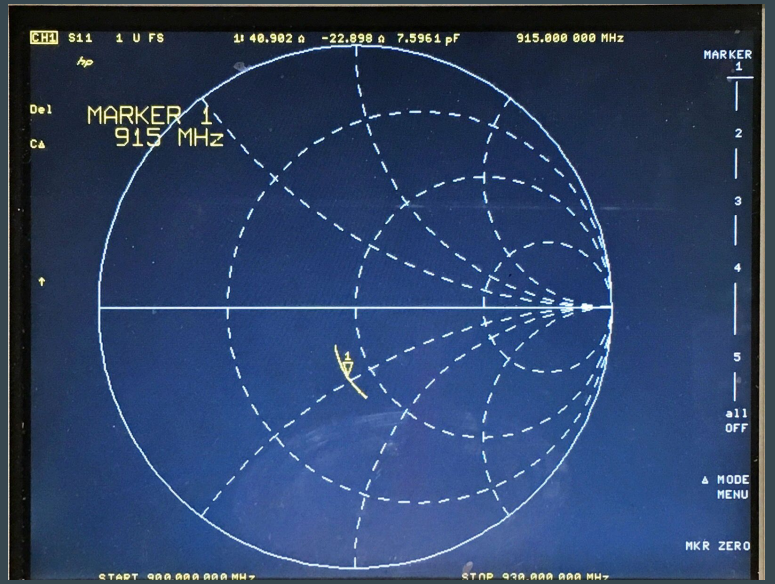
Antenna Tuning- Impedance Matching

S11 Before

No matching network (1) implemented

Z = 28.6 - j17.7 ohms

Mismatch Factor: .881



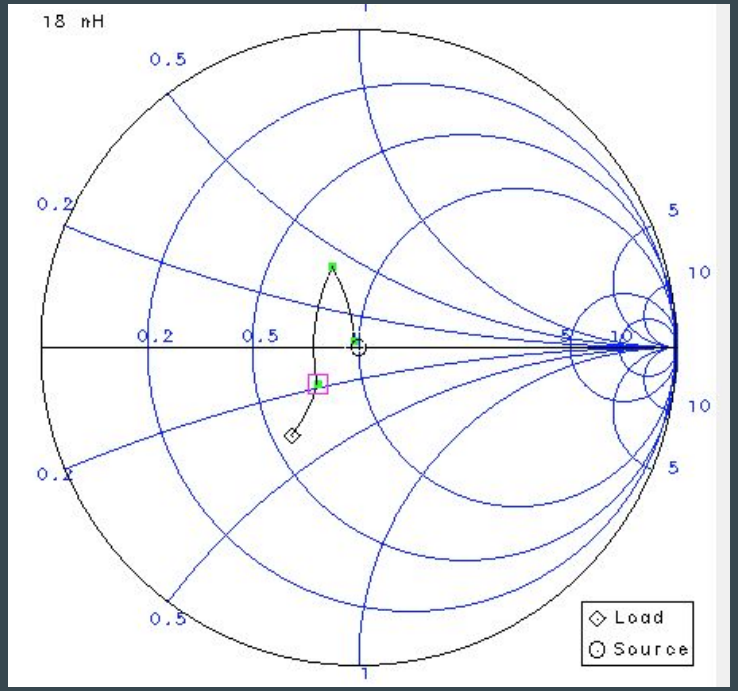
S11 After

Matching network (1) implemented

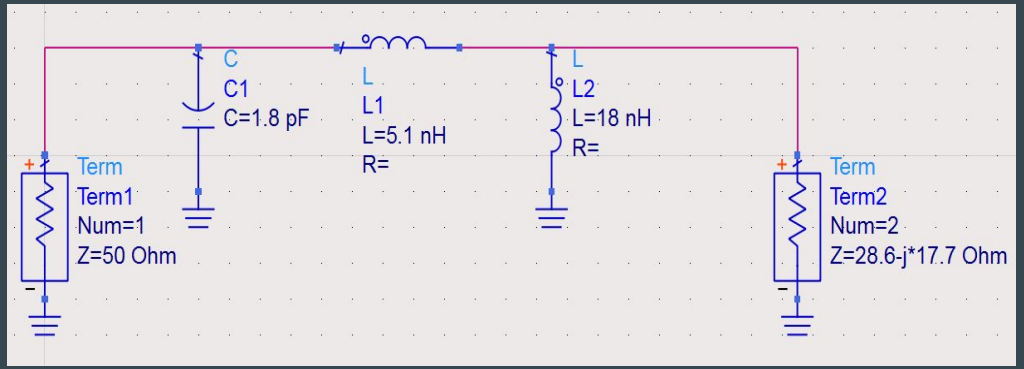
Z = 40.9 - j22.9 ohms

Mismatch Factor: .930

Antenna Tuning - Impedance Matching



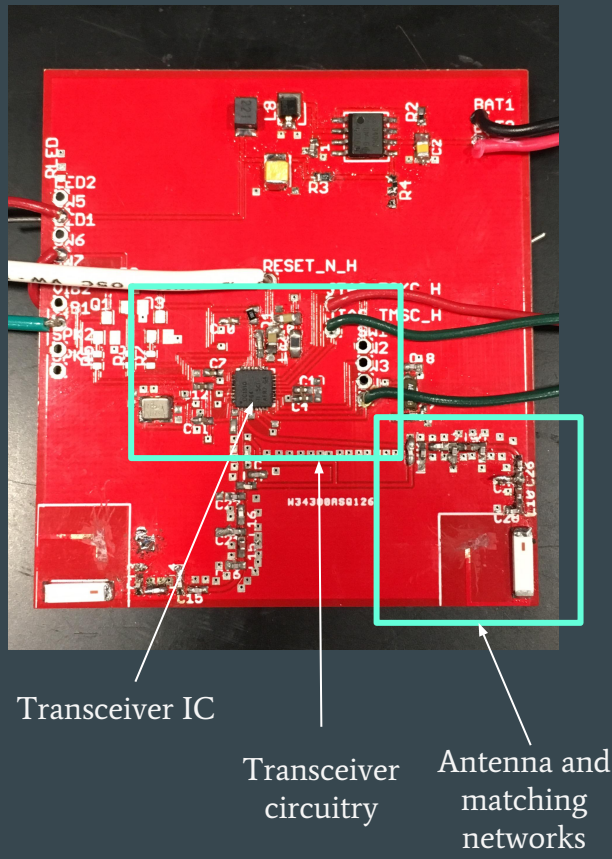
ADS Smith Chart Tool



Matching Network (1)

Requirements for Transceiver IC

1. Receive signals over the 915 MHz ISM band.
2. Transmit signals over the 915 MHz ISM band at selected frequencies (below) within the band (max bandwidth 2 MHz).
   a. 903 MHz
   b. 915 MHz
   c. 927 MHz
3. In listen mode, the transceiver module consumes <= 0.5mA on average
4. During transmission, it will consume < 15 mA.



Transceiver IC (Transmitters and Receiver)

- TI CC1310 SimpleLINK Ultra-Low-Power Sub-1 GHz Wireless MCU
- Low-power RF Transceiver and ARM Cortex-M3 processor with 16kB of RAM
- 10 GPIO (General Purpose Input/Output) pins
  - Both digital and analog inputs available
  - Necessary to work with RSSI Signal and Feedback module

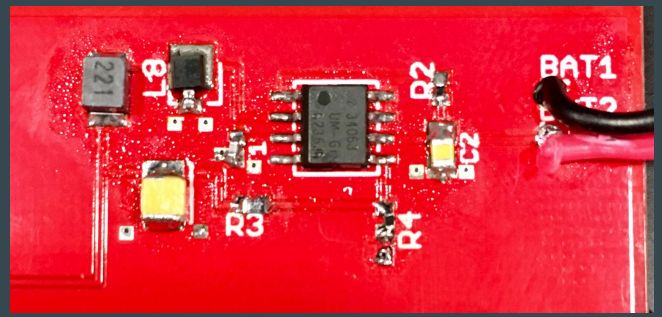
Power Supply - Buck Converter

Requirements:

- Step down 9V to ~3V
  - Provide enough power to turn on receiver (dev board)
  - Power the feedback module

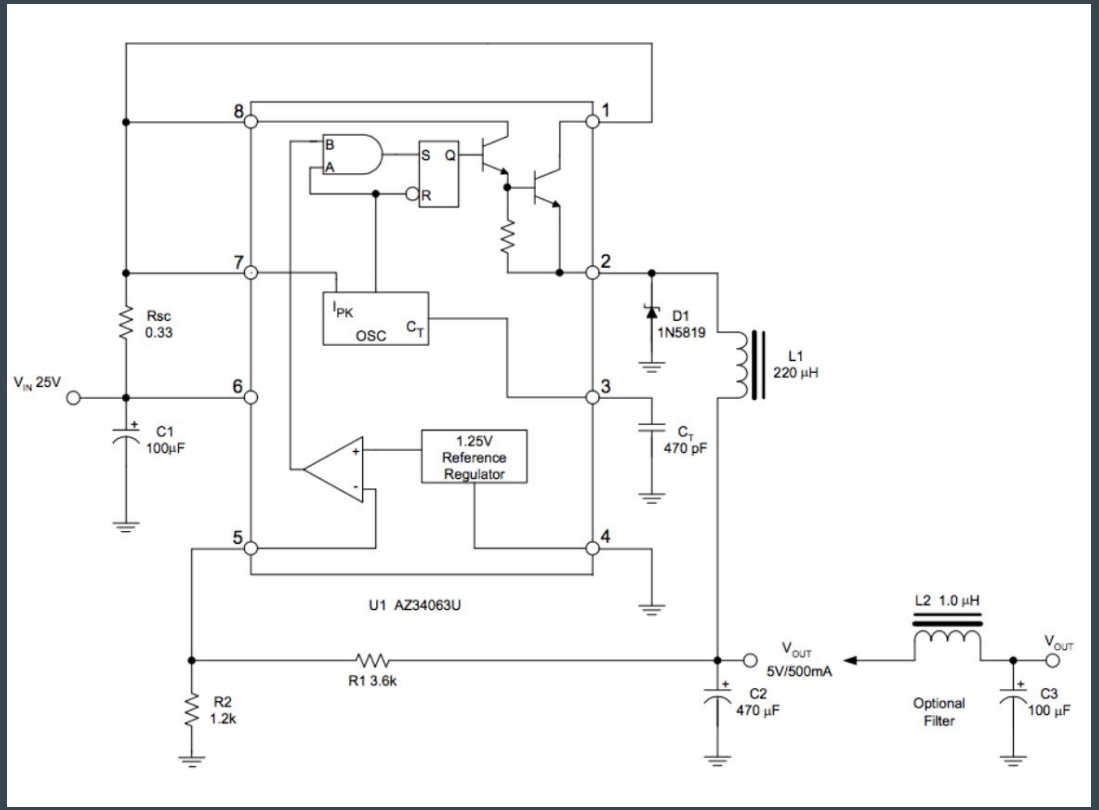
Design:

- Buck converter vs linear regulator - efficiency
- Output voltage - two resistors



Buck Converter circuit mounted on Receiver PCB

Buck Converter Schematic



Design Equations:

$$V_{PIN5} = V_{OUT}\left(\frac{R2}{R1 + R2}\right) = 1.25\ (V)$$

$$V_{OUT} = 1.25\left(\frac{R1 + R2}{R2}\right)\ (V)$$

Values Chosen:

R1 = 2.32k
R2 = 1.2k
Vout (calc) = 3.7 V
Vout (meas) = 3.5 V

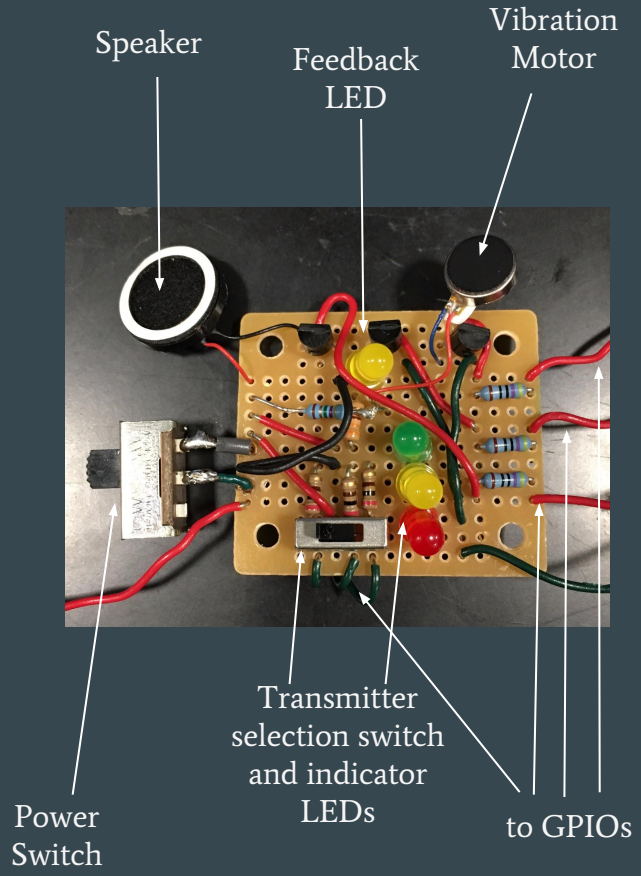
Feedback Module

Requirements:

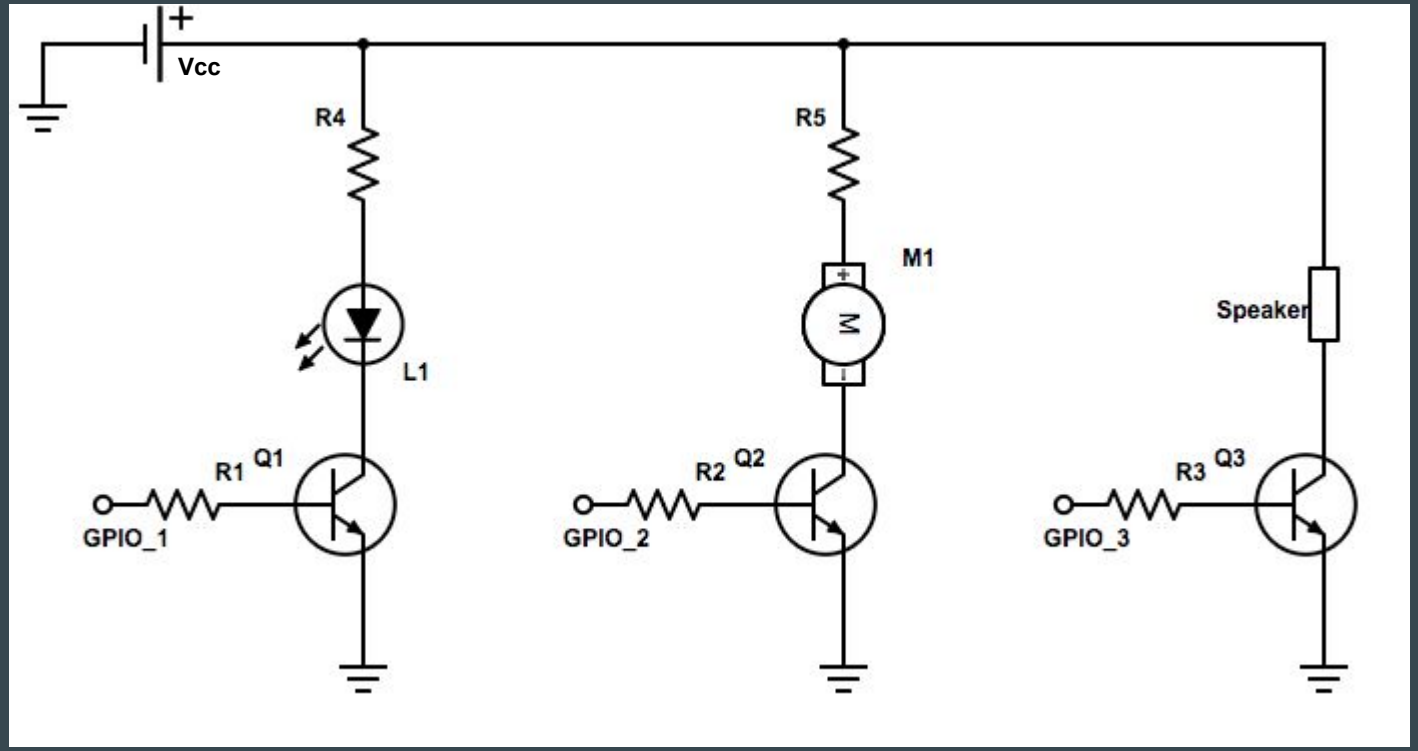
- Motor, LED, speaker controlled by GPIO pins and driver circuit with 3.5V supply (output from buck converter)
- Components should draw less than 22 mA

Design:

- Open-collector configuration - driver
- Circuit incorrect on PCB
  - Final module on perf board
- Components - cost, size, power consumption



Feedback Module Schematic



Vcc = 3.5V
R1 = 470 ohms
R2 = 470 ohms
R3 = 470 ohms
R4 = 47 ohms
R5 = 47 ohms

Software

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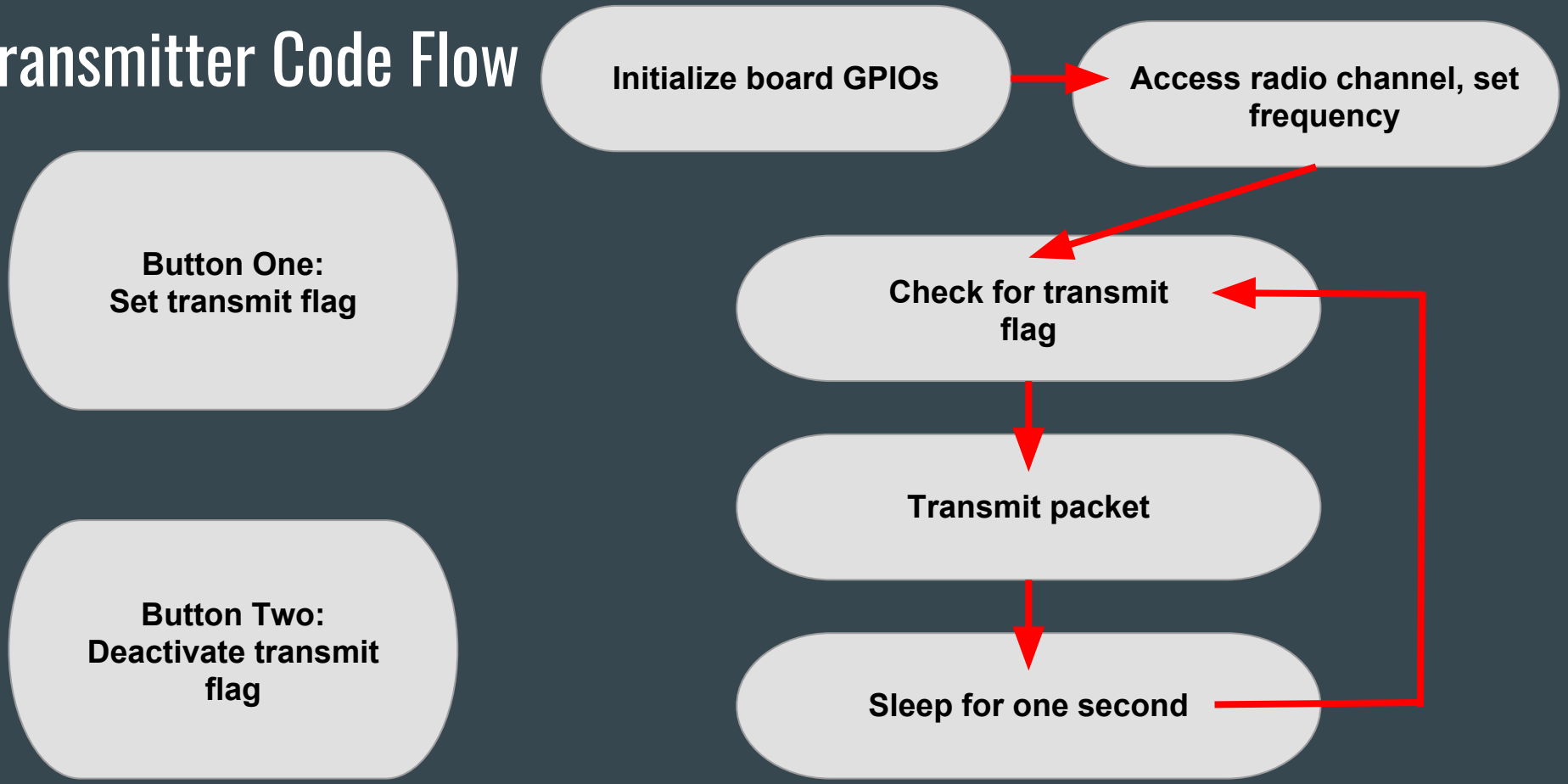
RSSI

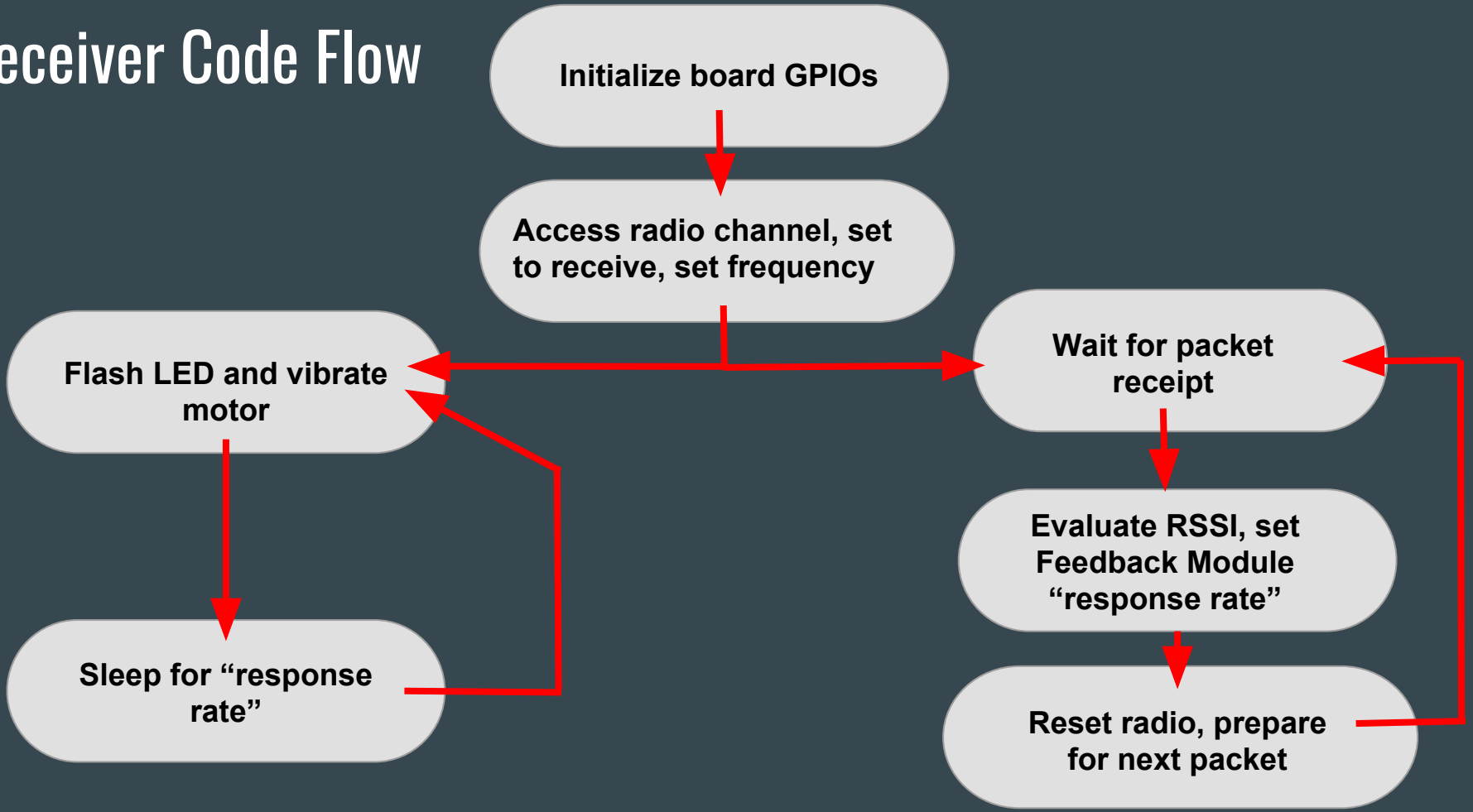
- Foundation of signal strength calculations that goes into feedback module
- Transmit and receive RF signal between two transceivers and access RSSI in dBM
    - Translate RSSI value into a frequency that varies proportionally with distance

Distance vs Received Signal Strength Indicator (RSSI)

Transmitter Code Flow



Receiver Code Flow



CC1310 Troubleshooting

- Configuration files
  - Pin mapping
- JTAG connections
  - Visible communication
- Memory map
- CC1310 clock frequency

Future Development and Conclusion

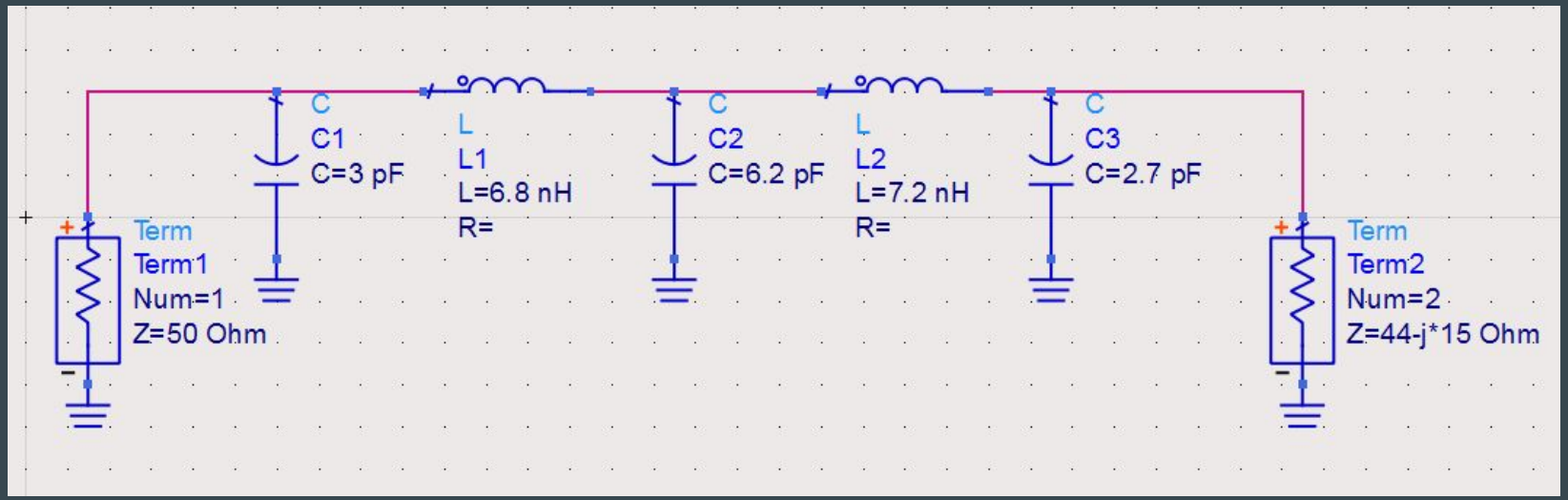
- Successfully implemented all modules required using dev board
  - Microcontroller on PCB failed
- Microcontroller with better documentation
  - Arduino Micro
- Move feedback module onto PCB
- House entire project in small, portable case

Credits

- Michael Goldstein
- Professor Michael Oelze
- Daniel Gardner

Thank You

Appendix - Matching Network 2 Schematic



Optimal impedance seen from the RF pins into the balun and filter and antenna is 44 + j15 ohms - conjugate match