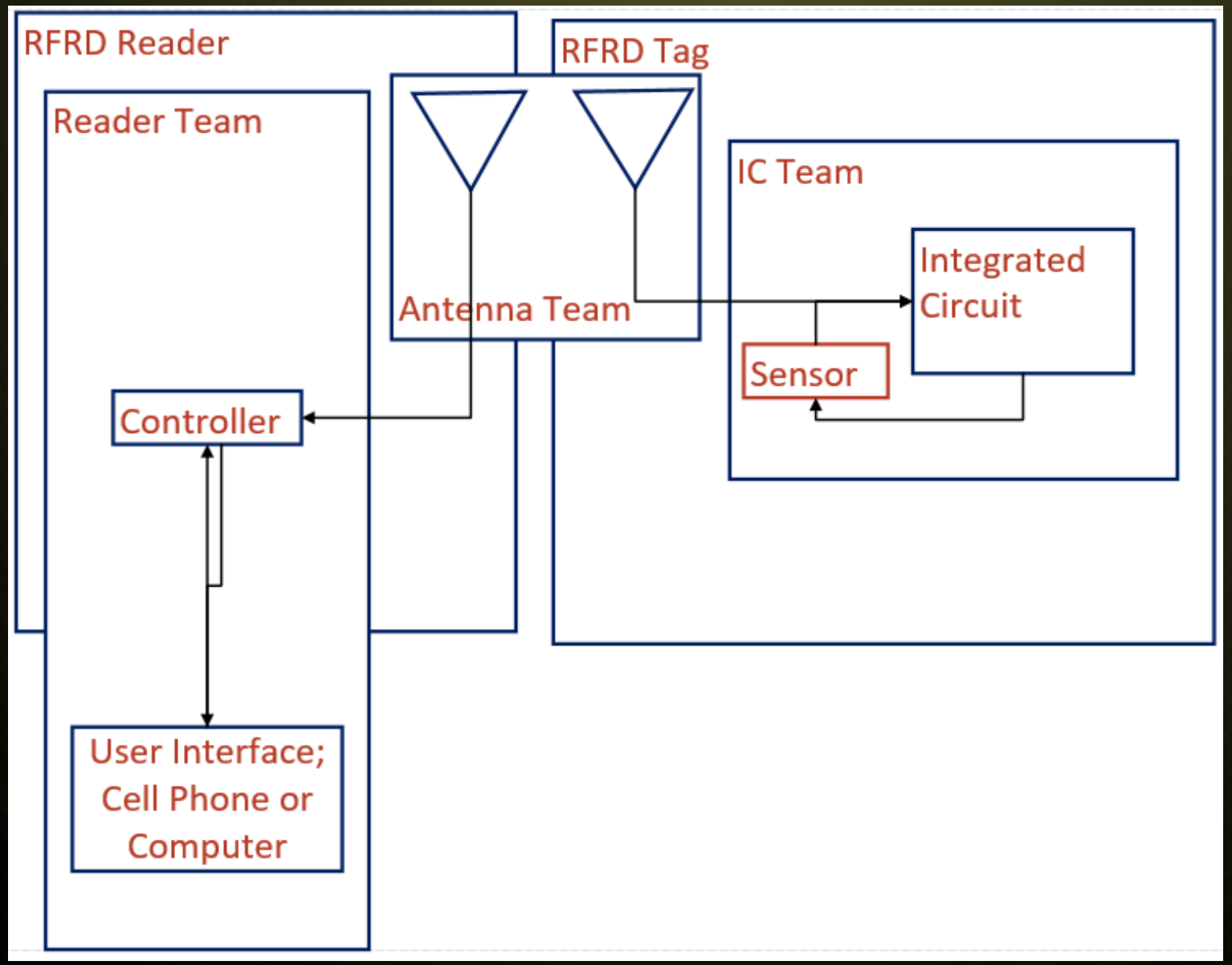
Radio Frequency Readout Device (RFRD)

May 1718
RFRD

Project Overview

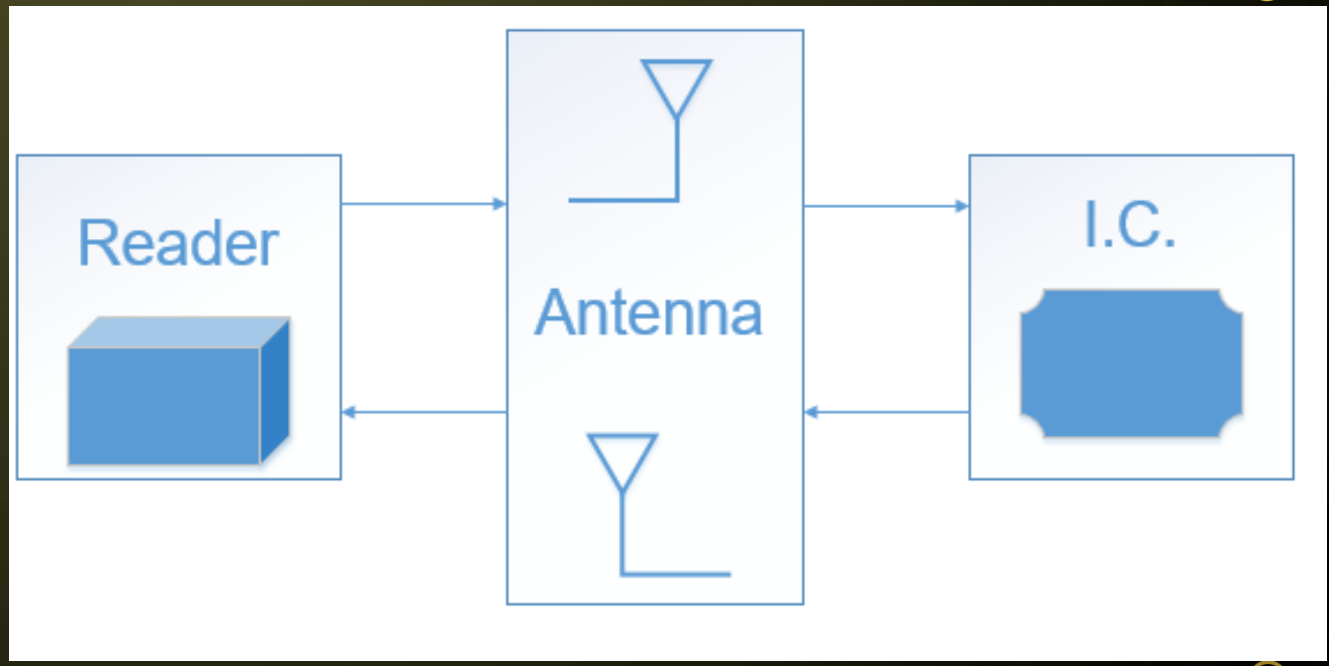
- **Develop Multi-purpose Remote Readout Device**
- **Specific Test Scenario: Street lamps across the United States**
  - 4 – 8 bolts per lamp
  - Thousands of lamps per state
- **Problem**
  - Need to test for tightness of bolts
  - Need for method of checking tightness
- **Client**
  - Dr. Qiao
  - Dr. Song

Team Division



Project Overview

- **IC Team (4 Members)**
  - Design IC
  - Capacitor Sensor
  - Prepare Data for Transmission
- **Antenna Team (2 Members)**
  - Design Antenna System
  - Rectifier
  - Optimization of Power Transfer
- **Reader Team (3 Members)**
  - Build Reader
  - Power to Antenna & Tag
  - User Interface



RFID vs. RFRD

- **RFID**
  - Uses Static State Machine
  - Continuously Sends Repeating Information
- **RFRD**
  - Reads Sensor Data As Additional Input
  - Changing Data In Addition To Tag ID
  - Our Solution: State Machine With Changing Output

Specifications

- **Requirements**
  - RF technology & Energy Siphoning → Create RF tag
  - Value changing readout RF device
  - RF tag Specs
    - Measure Washer Separation via Capacitance
    - Report Capacitance to Reader
  - Important Constraints
    - Power (Passive Tag)
    - Range (5 meter distance)
    - Cost (< $0.50 per Tag)

Research

- **Bands Allowed: 125 kHz, 13.56 MHz, and 900 MHz**
  - 125 kHz, Practical Range of 5-10 cm
  - 13.56 MHz, Practical Range of 2-3 meters
  - 900 MHz, Practical Range 5-10 meters

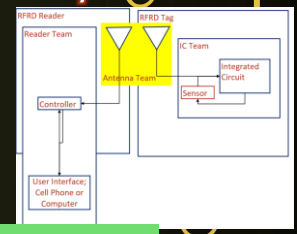
- **Static State Machine**
  - Require Dynamic Output From Sensor
  - Require Static Output For Encapsulating Packet

Design Approach

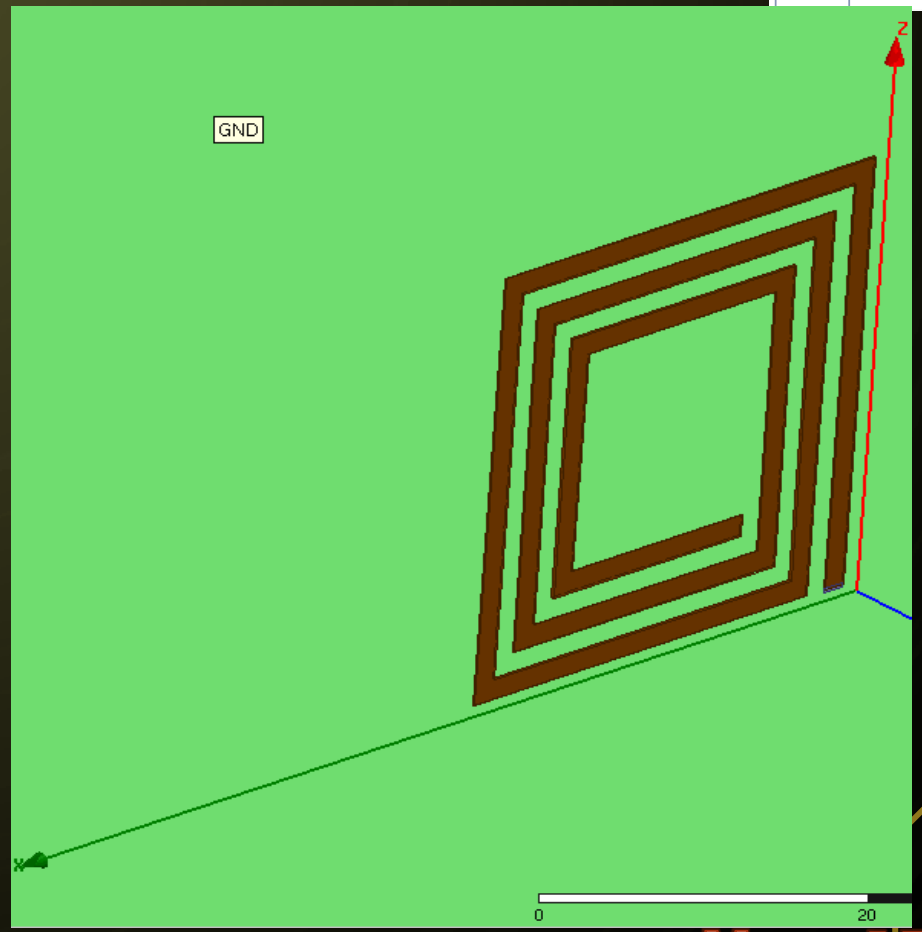
- **State Machine**
  - Parallel In, Serial Out Data

- **Frequency Used**
  - 900 MHz Initial
    - Expensive, Poorly Documented
    - Incapable Of Testing
  - 13.56 MHz Chosen
    - Testable With Our Equipment
    - Testing Costs Reasonable
    - Expecting Problem With Range

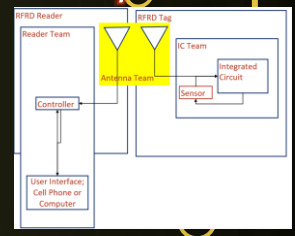
Current State: Antenna Team

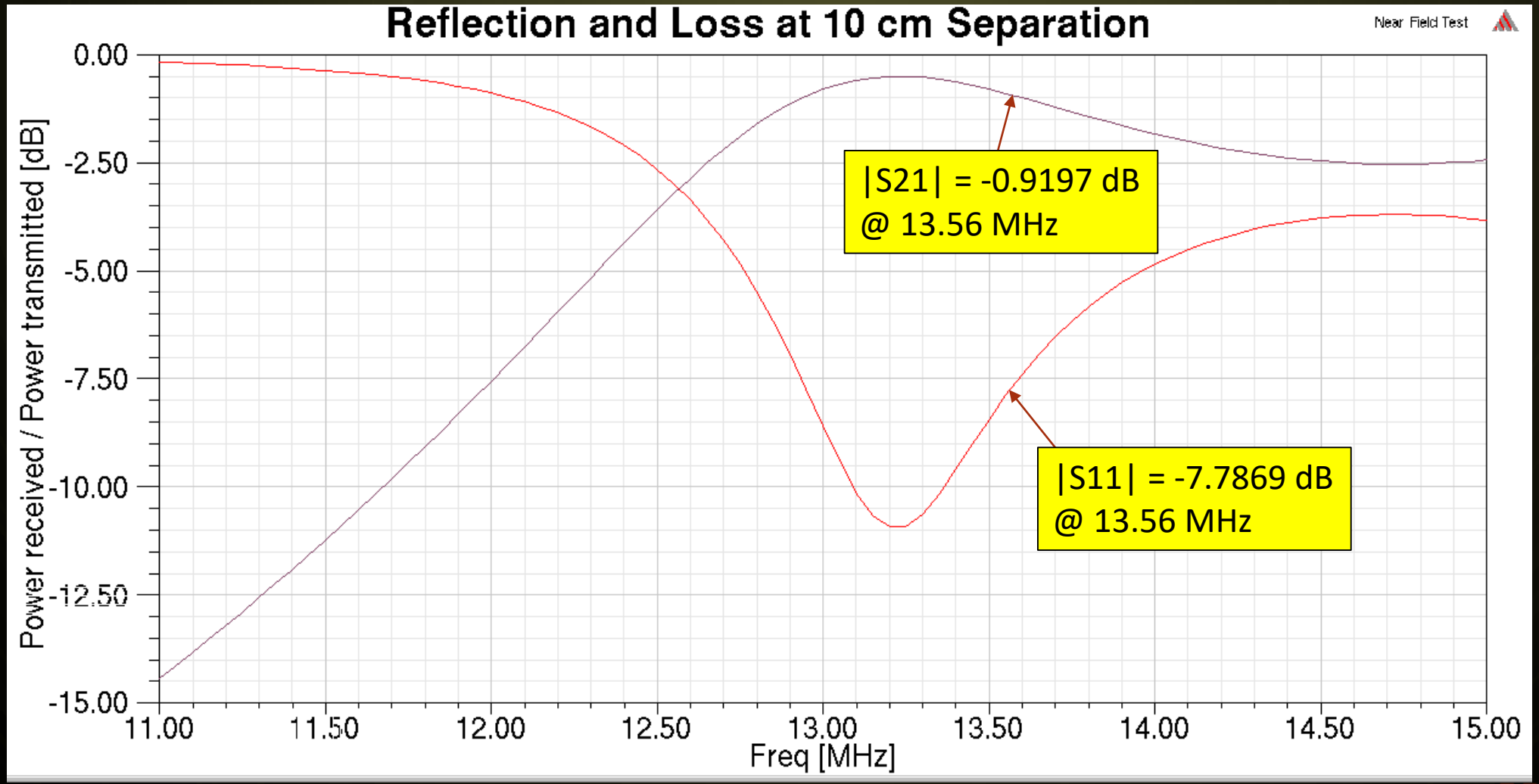


- **Square Coil Antenna at 13.56 MHz**
  - Optimal performance in breadboard tests
  - Logistics → Easier to implement
  - Design Variables
    - Trace Width & Thickness
    - Number of Segments
    - Footprint Size
    - Orientation
    - Presence of Dielectric

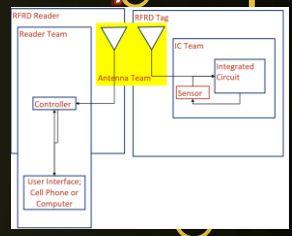


Current State: Antenna Team

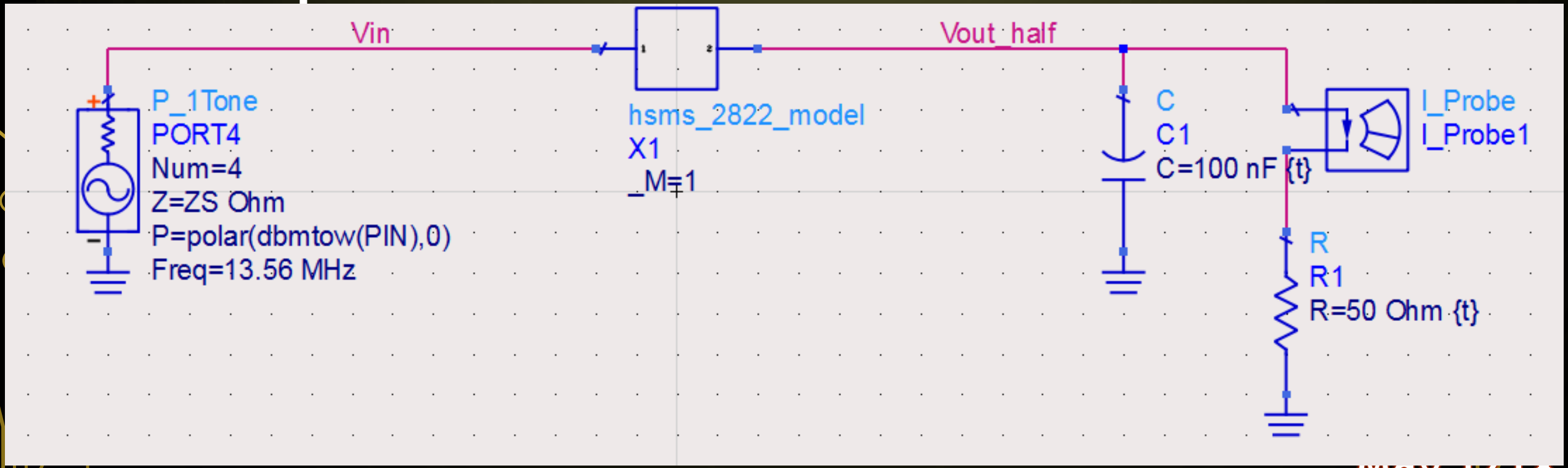




Current State: Rectifier

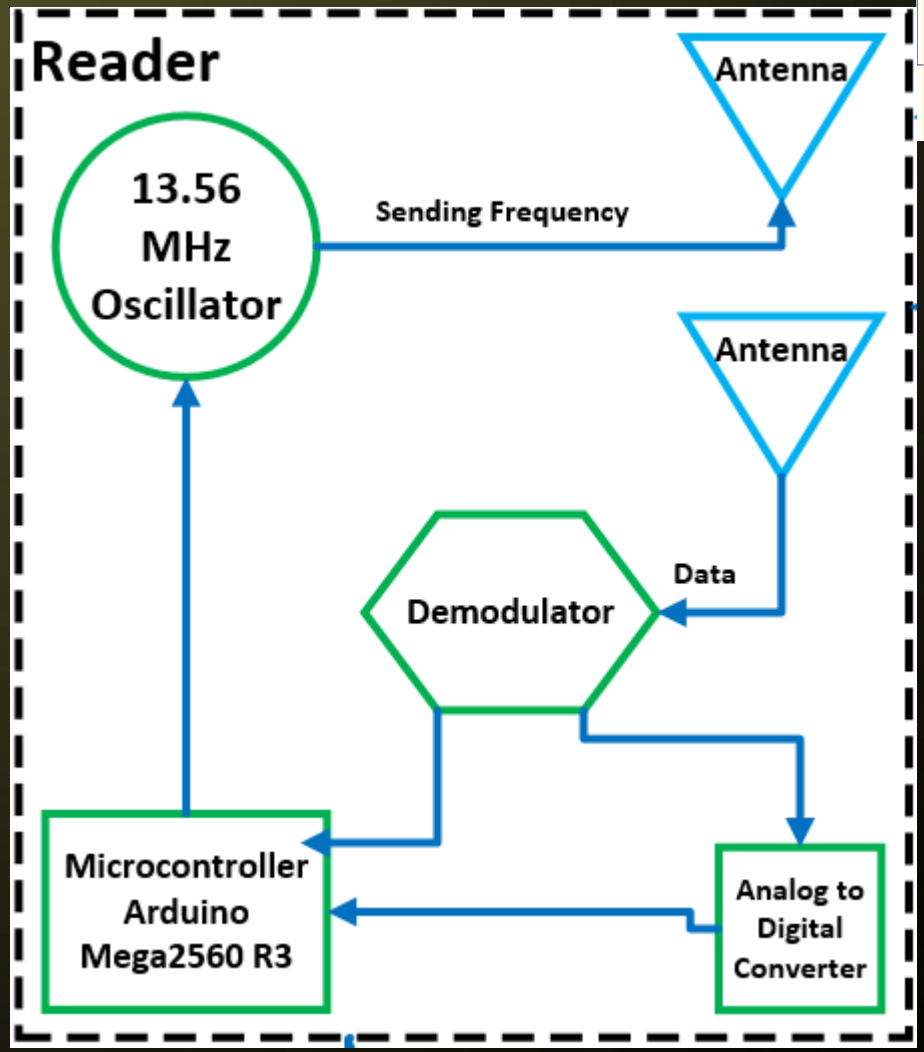


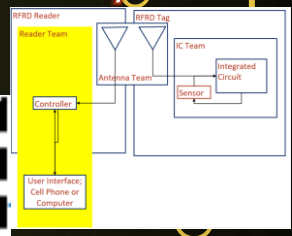
- Preliminary modeling in ADS
- Have not yet done proper simulations for impedance



Current State: Reader Team

- **Parts have arrived → Reader design has begun**
- **Using an Arduino**
  - Good for Signal Processing
  - Easily Programmed
- **Issues with initial design have been found**
  - Oscillator Implementation
  - Power Output to Antenna is too low

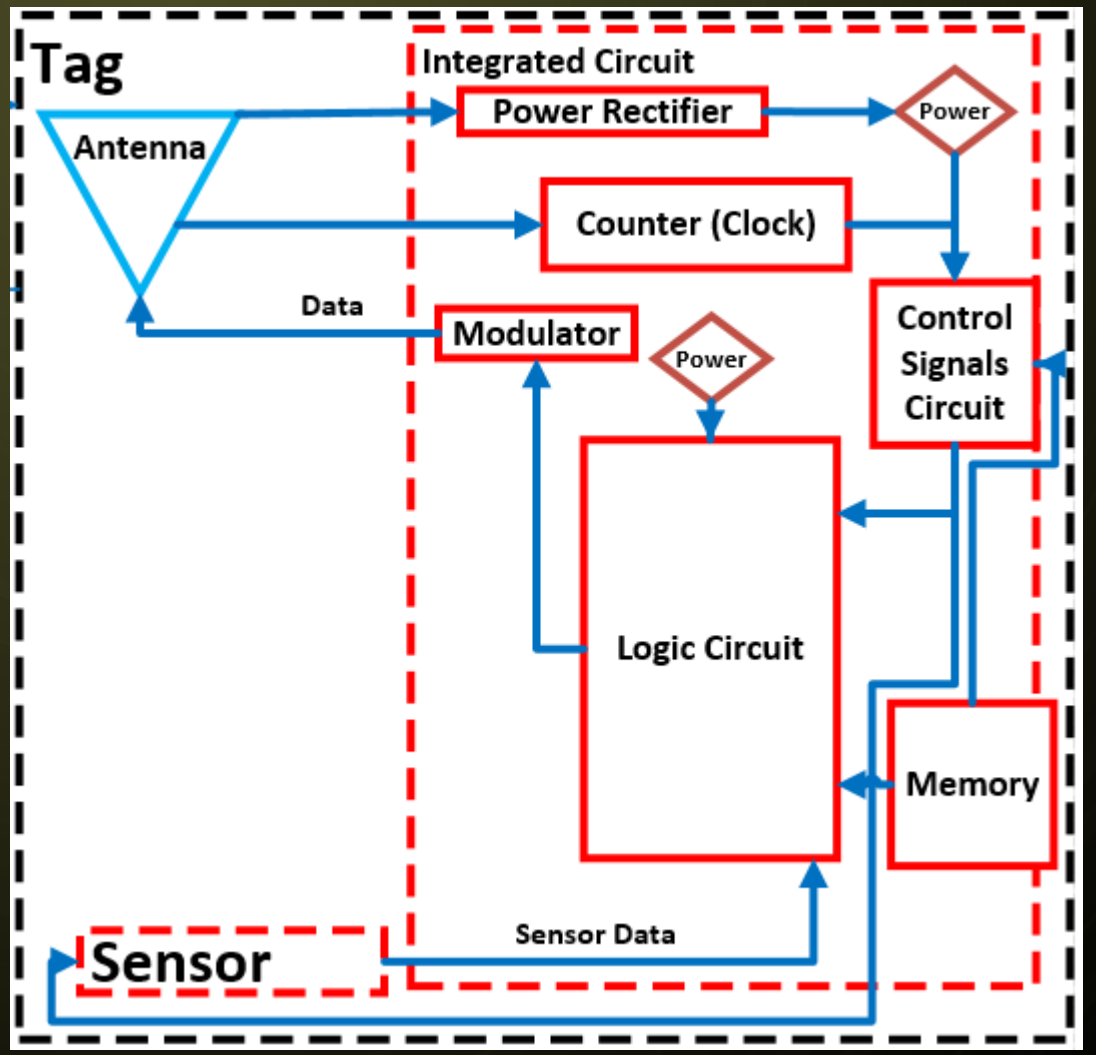




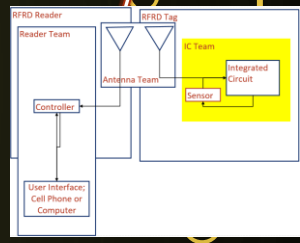
Current State: IC Team

- Component Experimentation

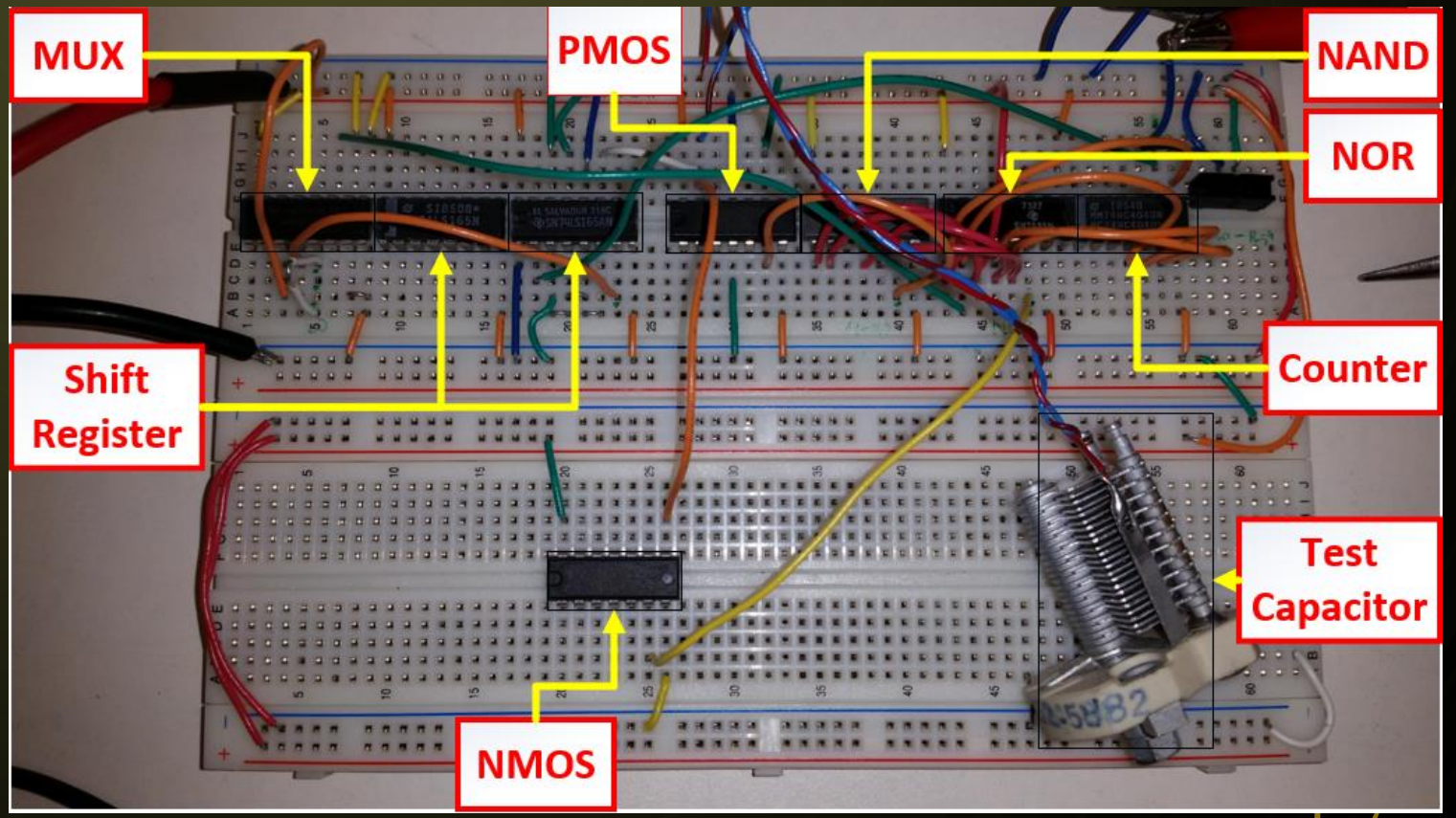
- High Level IC Plan →



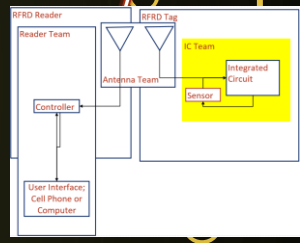
Current State: IC Team Prototype



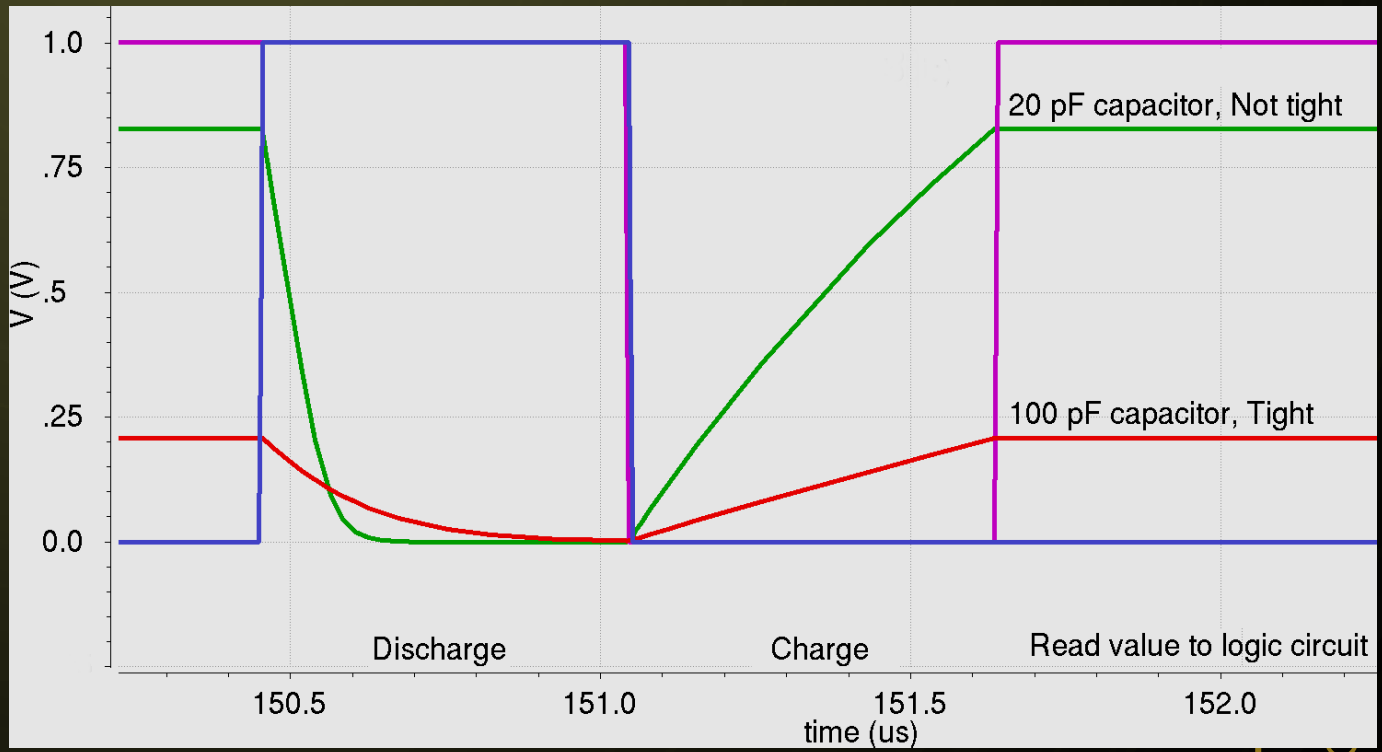
- Discrete Component Prototyping
- Problems with high frequency noise



Current State: Capacitance Sensor



- **Capacitance sensor is working in simulations**
- **Transition Graph**
  - Discharge to reset
  - Charge to sensor value

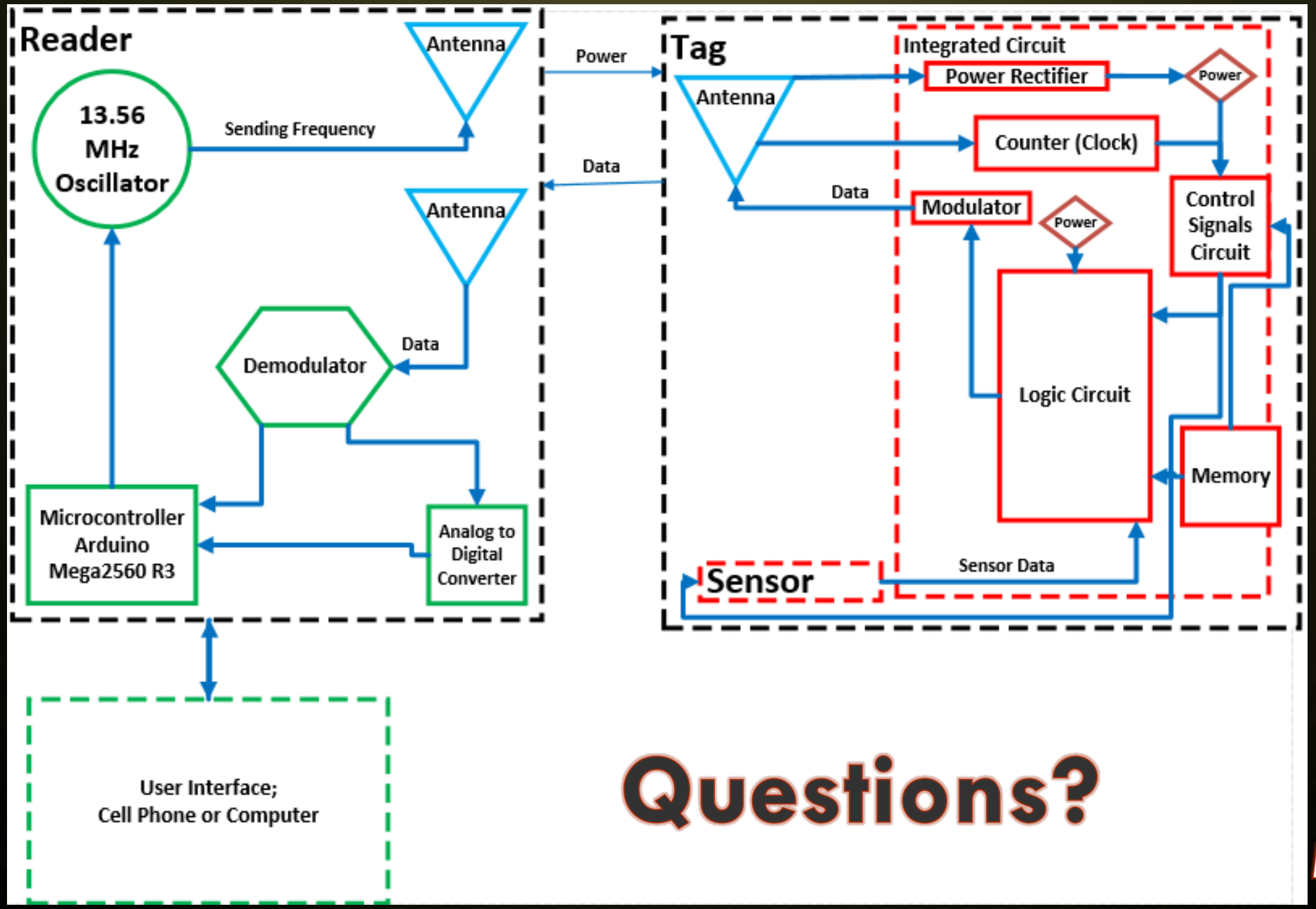


Cost Estimates

- **Reader Team**
  - Reader Materials $200
  - User Interface Materials $75
- **Antenna Team**
  - Antenna Materials $20
  - Rectifier Materials $20
- **IC Team**
  - Discrete Test Components $30
- **Total : $345**

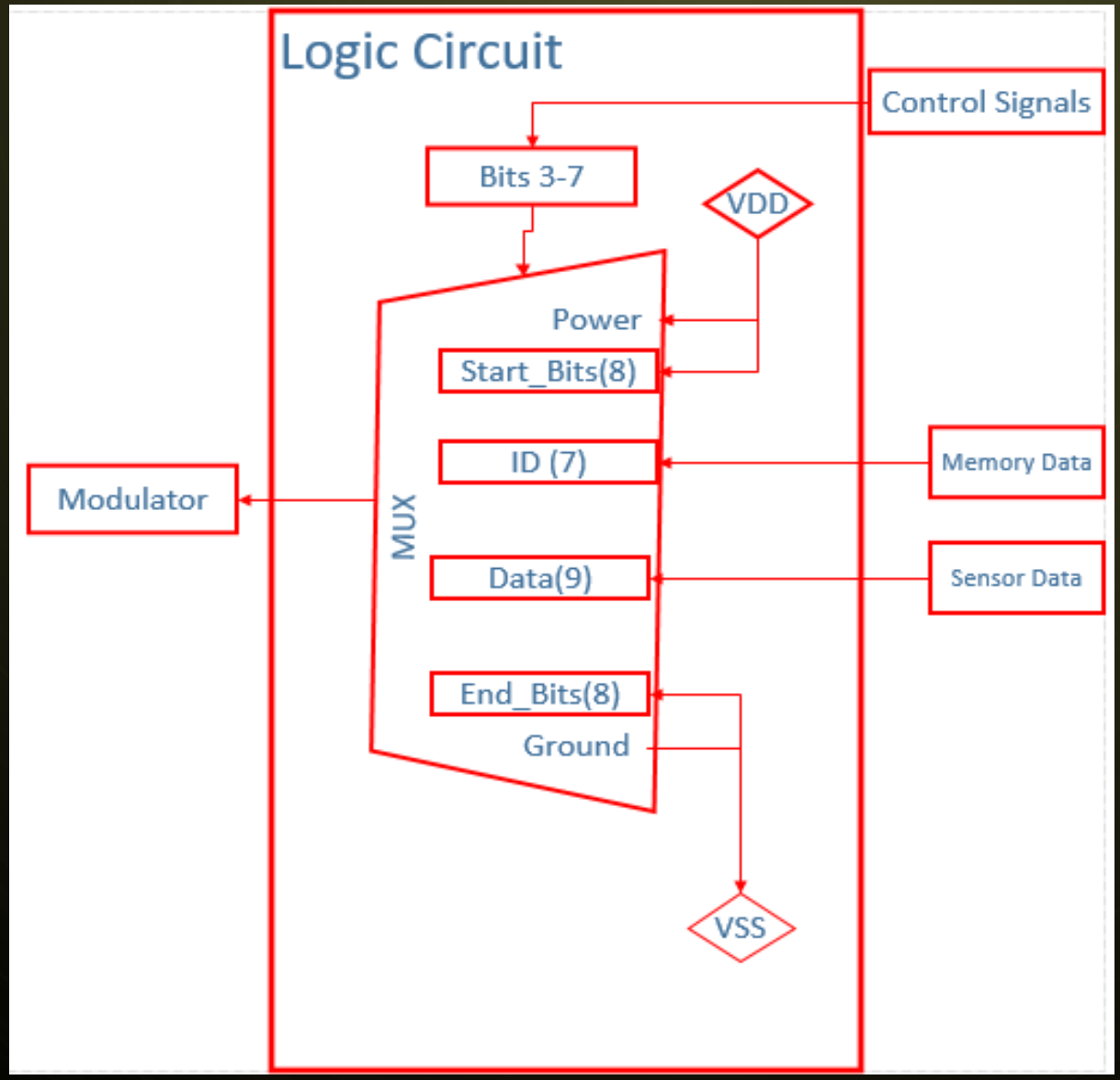
Looking Forward

- **Reader Team**
  - Redesign And Prototype Reader
  - Design User Interface
- **Antenna Team**
  - Optimize Antenna
  - Implement Rectifier in Simulation
  - Explore Manufacturing Cost
- **IC Team**
  - Design IC
  - Cost Considerations

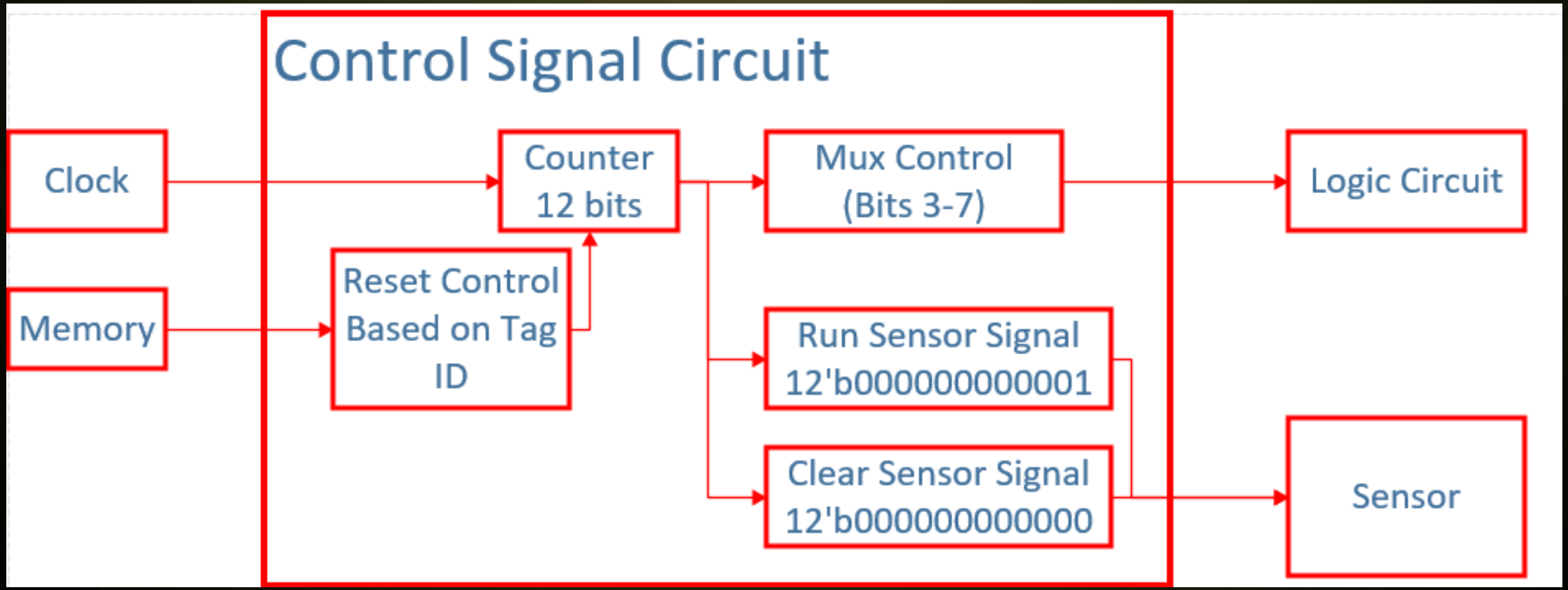

Reader
Antenna
13.56 MHz Oscillator
Sending Frequency
Antenna
Demodulator
Data
Microcontroller Arduino Mega2560 R3
Analog to Digital Converter
Power
Data
Tag
Integrated Circuit
Antenna
Power Rectifier
Power
Counter (Clock)
Data
Modulator
Power
Control Signals Circuit
Logic Circuit
Memory
Sensor
Sensor Data
User Interface;
Cell Phone or Computer

Questions?

Logic Circuit Design



Control Signals Design



Sensor Testing

- Simulating capacitor charging/discharging