ECE ILLINOIS

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Boeing NFC Project

Team #43

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ECE 445-Senior Design
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Team Members

- Neil Misak
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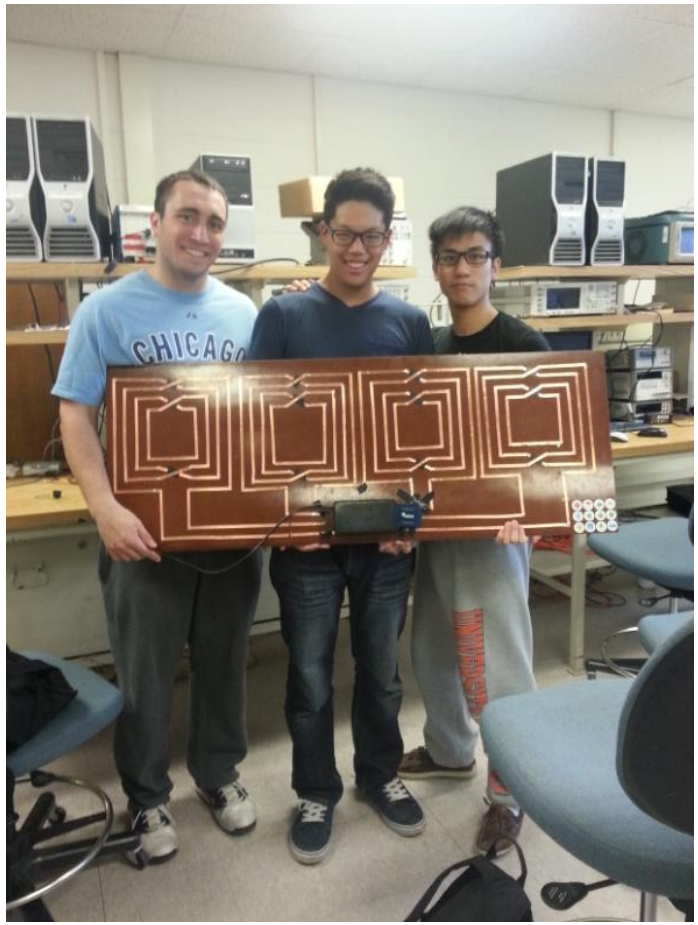


Collaboration with BOEING

Our 6 team members visited Boeing's manufacturing site in St. Louis on February 22nd

- Saw firsthand all technology currently being used in their factory
- Analyzed opportunities for improvement

Weekly conference calls

- Spoke with two Boeing employees every Friday
- Closely monitored our progress and frequently offered suggestions

Final Presentation

- At least four Boeing employees will come to Champaign on May 10th to view our final demonstration

In addition to the technical aspect of our project, the opportunity to work with Boeing has given us real-world experience in client relations and addressing actual business needs.

Objective

- Boeing wants to investigate NFC capabilities
- Areas of potential interest:
  - Inventory/part tracking
  - FOD mitigation
  - Quality assurance checks
  - Manual drilling aid ("jig")

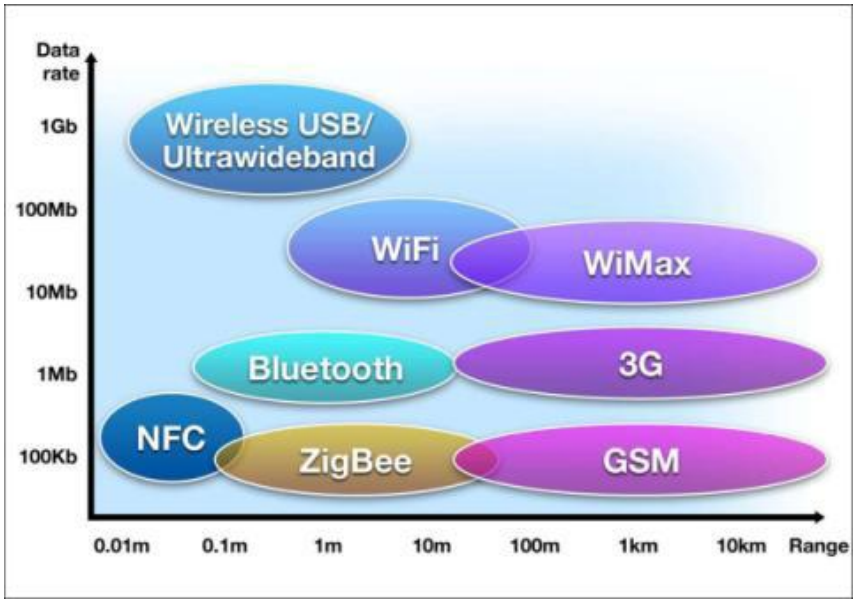
We will explore each of these areas in a series of case studies that show how NFC can improve upon Boeing's current system in place.

What is NFC?

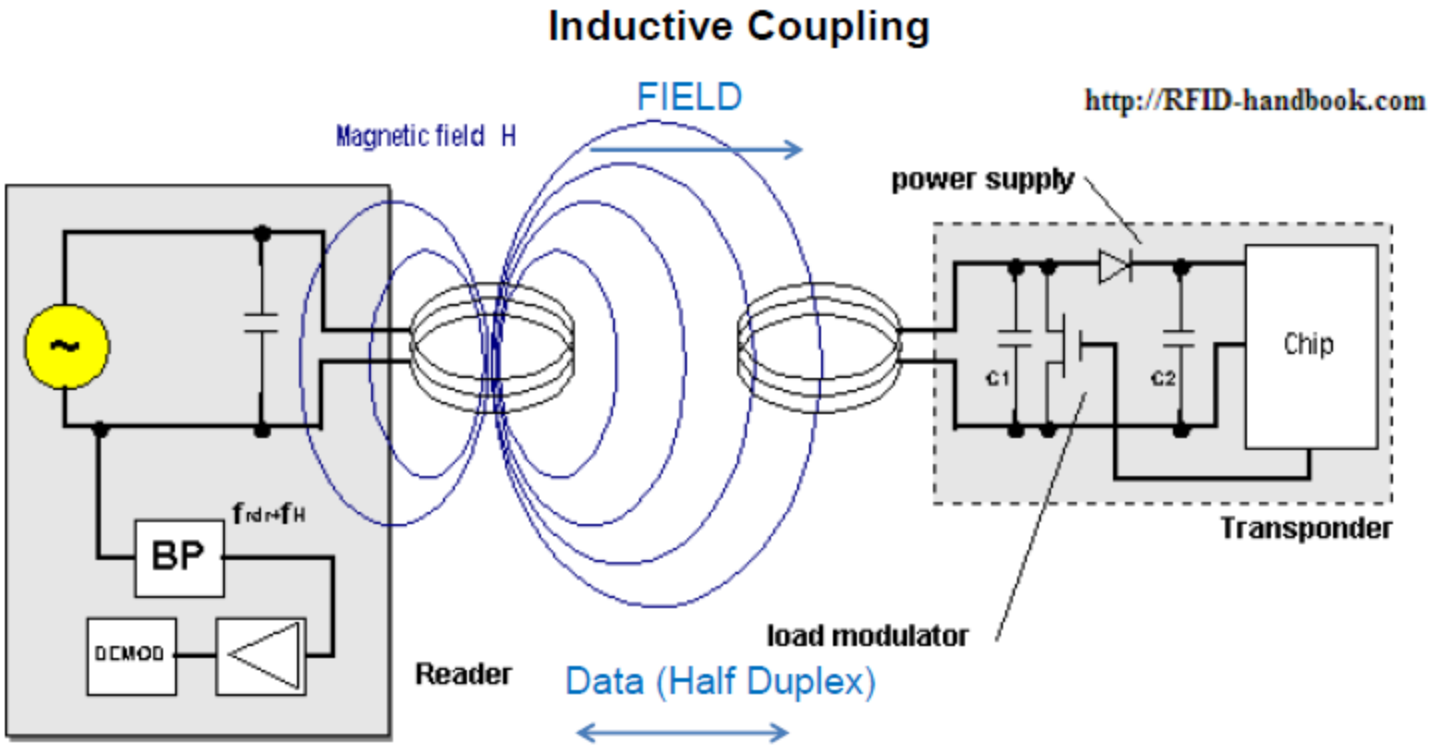
Near **F**ield **C**ommunication

- Short-range wireless technology
- Typically requires a distance of 4cm or less
  - TAP
- Operates at 13.56 MHz and at rates ranging from 106 to 848 kbit/s

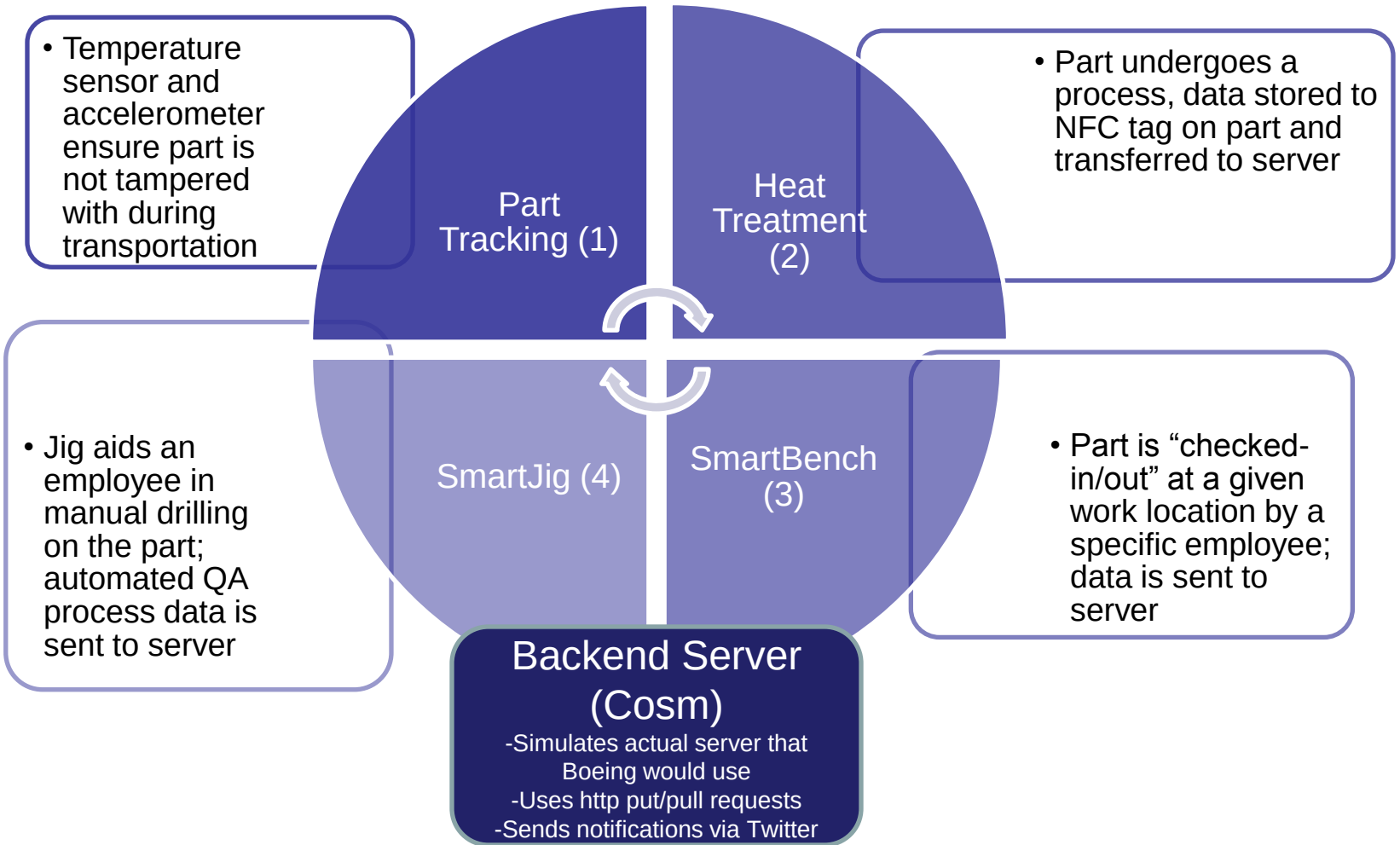
Comparison to other Wireless Technologies



How does NFC work?

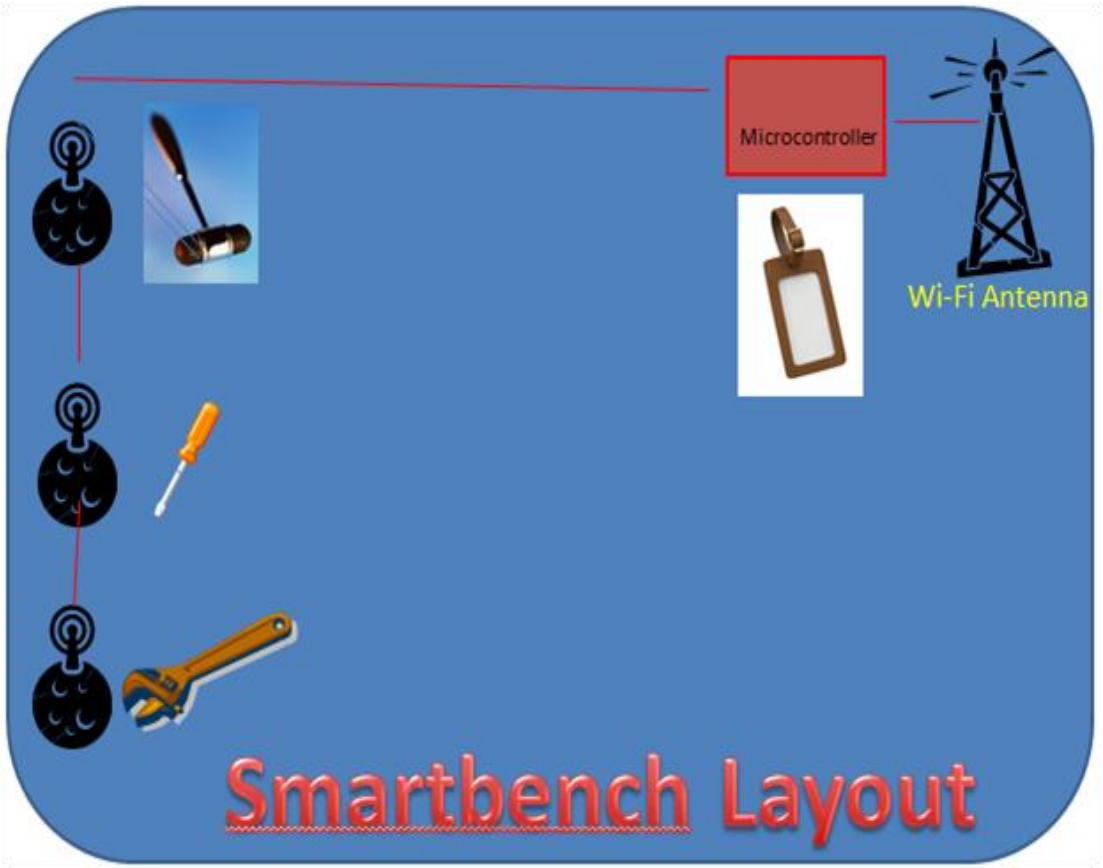


Flow Chart for Four Vignettes



Use Case 3-SmartBench

- NFC tags are placed on all tools and parts
- 13.56 MHz antennas read/write to these tags
- Able to determine presence/ absence of tools and parts
- Able to track which employee is in possession of tool/part

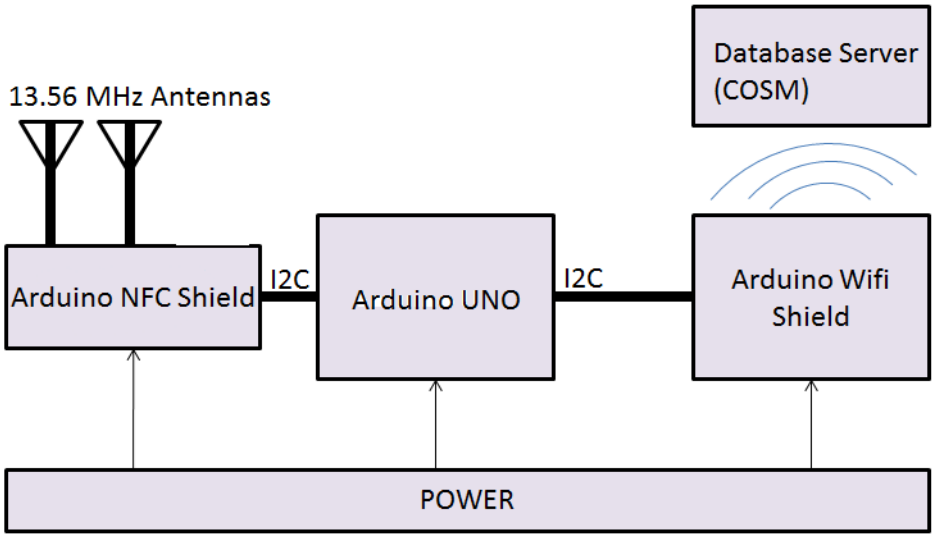


SmartBench (Case 3) Overview

Components

- Arduino Uno
- Arduino WIFI Shield
- Arduino NFC Shield
- TRF 7970A NFC Module
- MUX ADG904
- NFC Tags
- 13.56 Customized Antennas

Block Diagram



Antenna Design Process-1

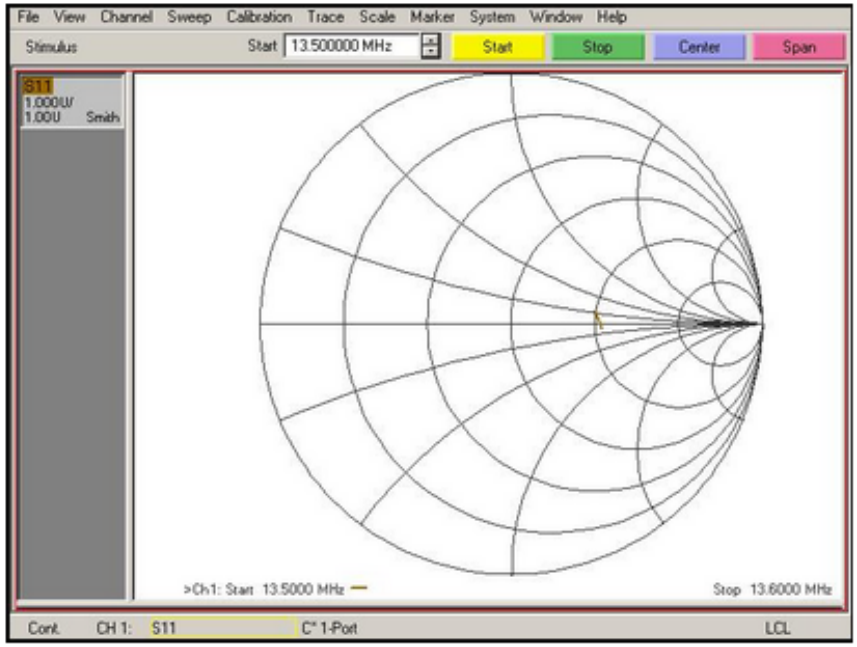
DLP (DLP-RFID-ANT) Features:

- Tuned to 13.56MHz with embedded matching network
- 15 foot coax cable
- Attached reverse polarity SMA connector
- 2-4 inch read range

Accomplishments:

- Connected external antenna to TRF7970a (worked)
- Successfully measured impedance
- Verified our calibration methods for the Vector Network Analyzer were correct
- Provided a basis as to how our external antennas should be designed!

DLP Antenna Measurements



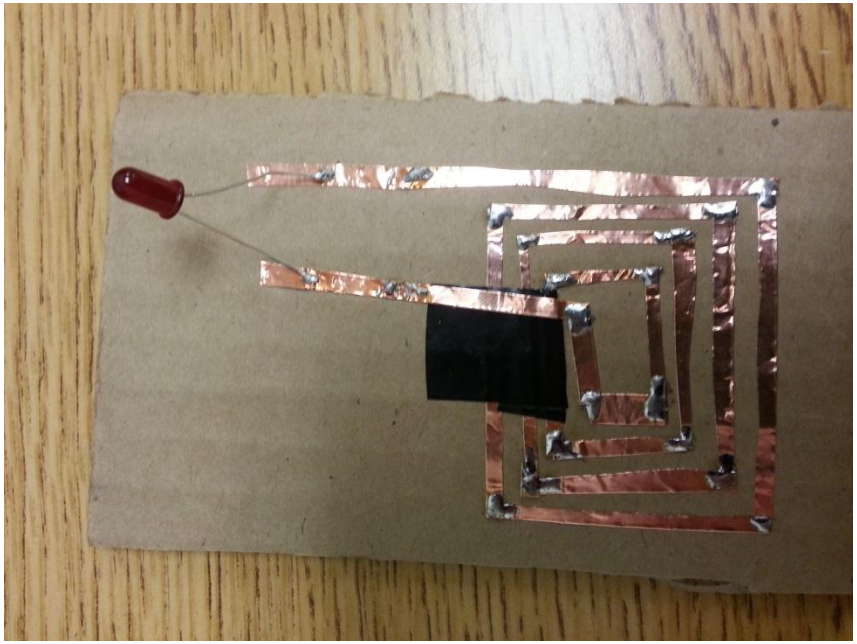
There is a resonant frequency very close to 13.56 MHz; the Smith Chart shows that the antenna and matching network are tuned almost exactly to 50 ohms.

Antenna Design Process-2

Experiments

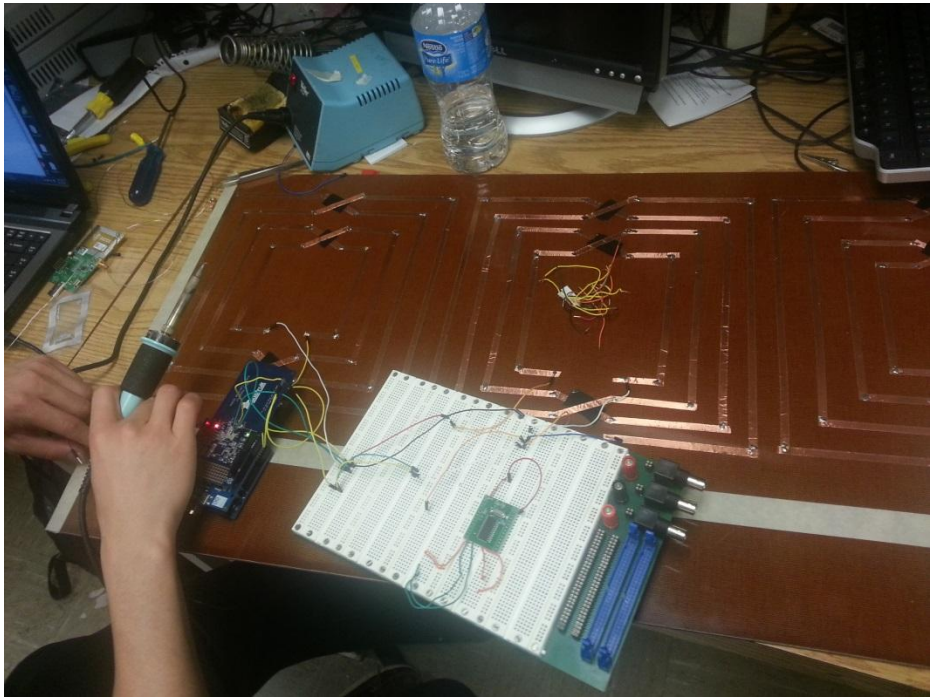
- Used ¼ inch copper tape as our antenna trace
- Tried different designs and sizes of antennas
- Tested antennas both with TRF7970a Module and Network Analyzer
- Optimal design was 4 loop antenna!

Prototype 1

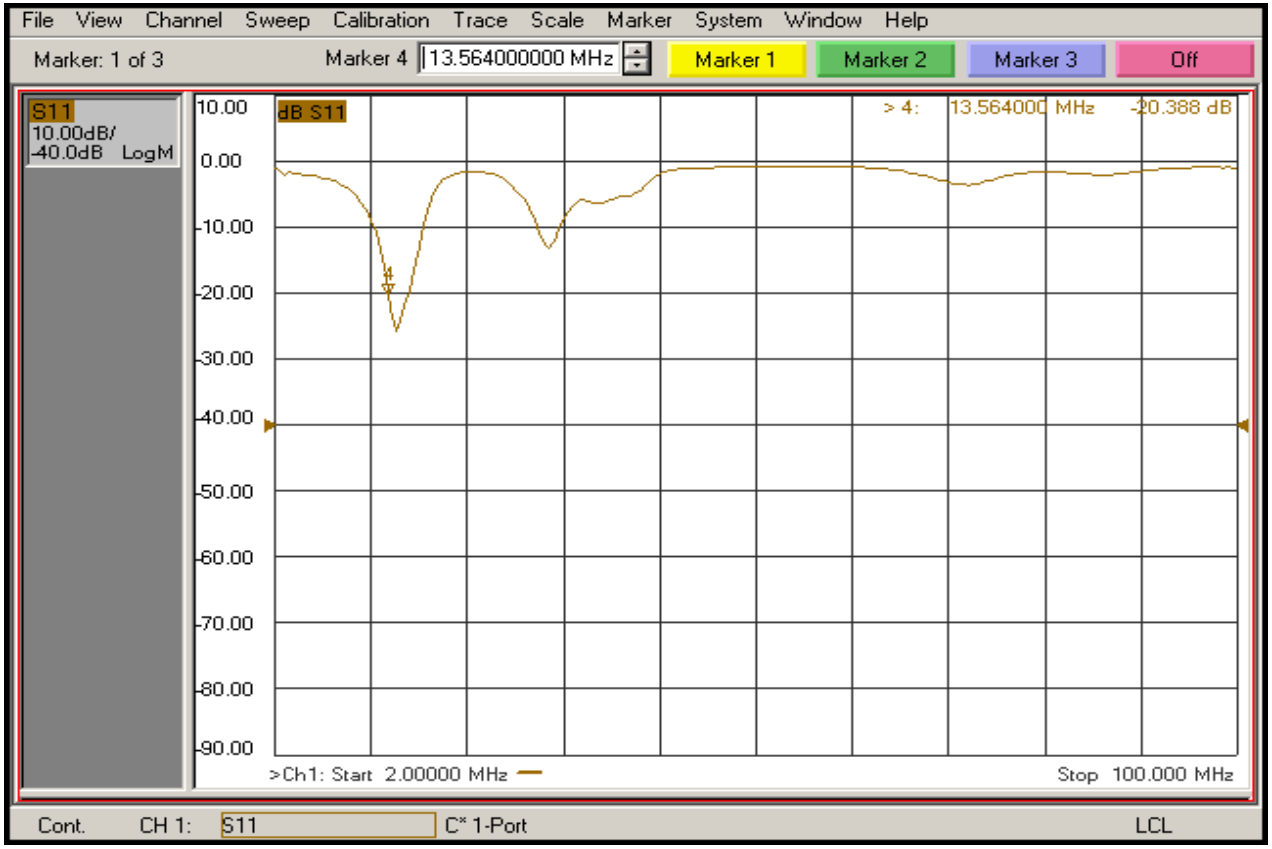


Antenna Design Process-3

- Connected two 24cm by 24cm antennas in parallel
- Antennas connected to TX1 and GND on the Arduino NFC Shield
- Return loss (S11) is well beyond what was expected! (-20dB or more)

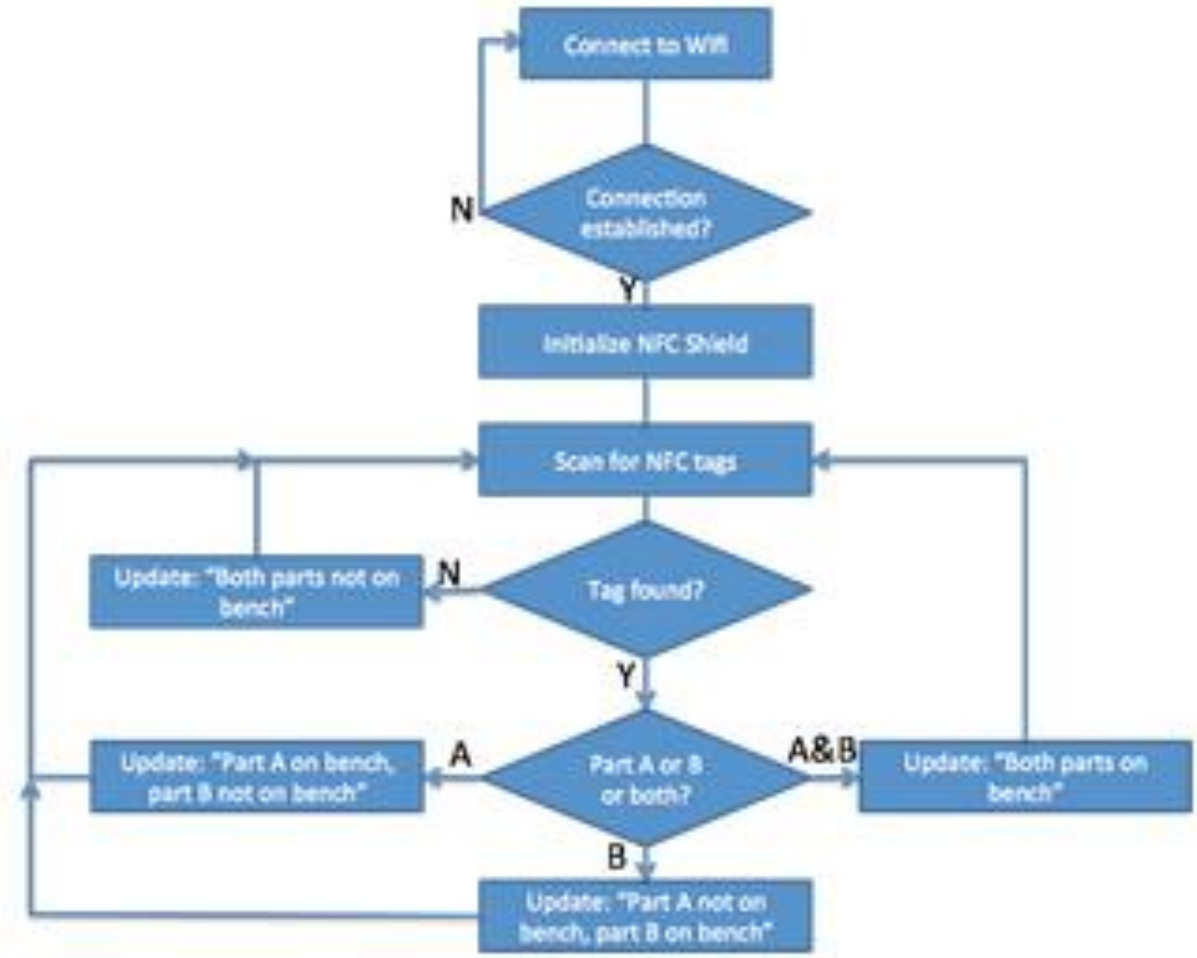


Final Antenna Design

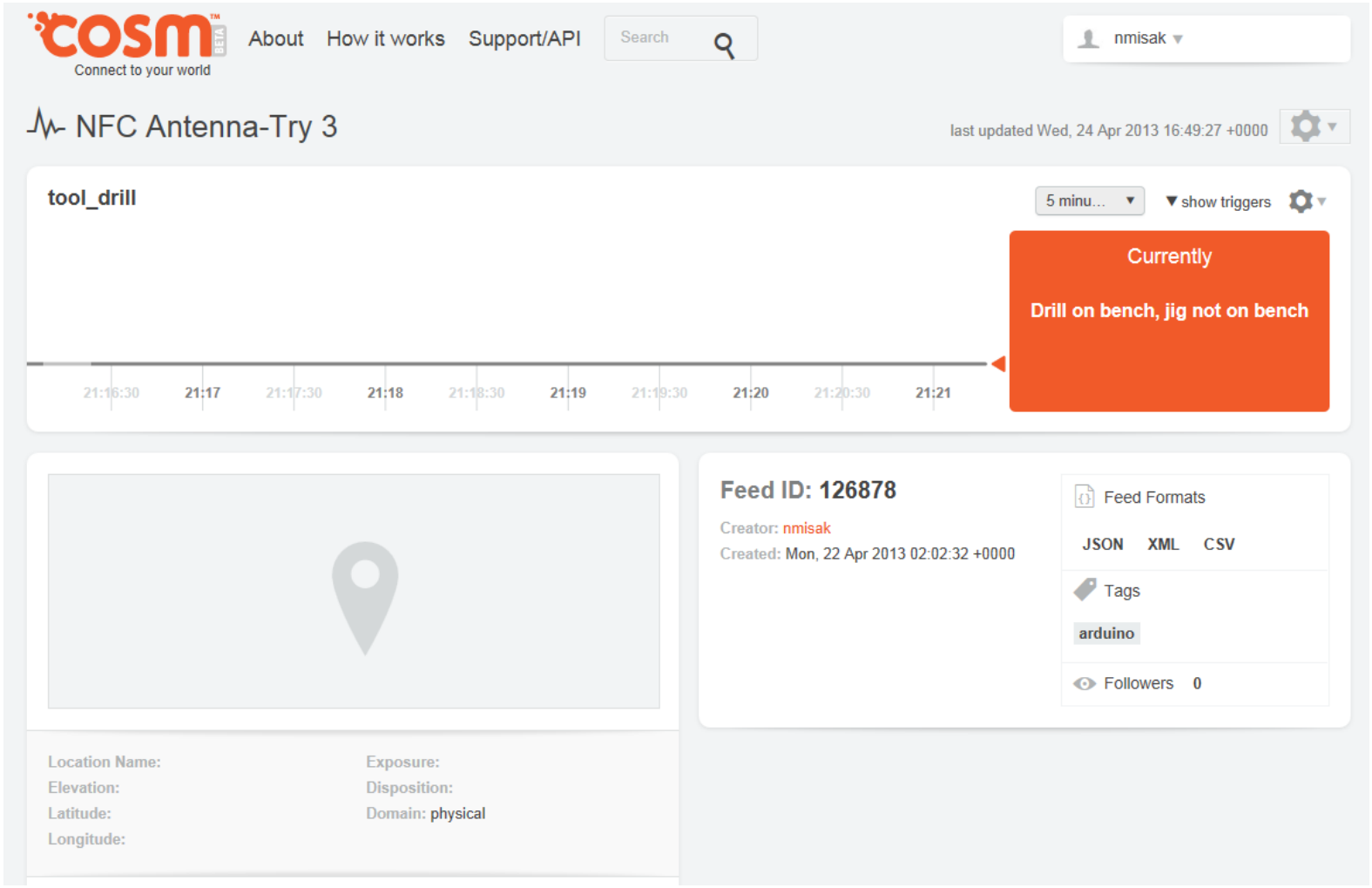


Frequency sweep analysis between 2-100 MHz; return loss of approximately -20dB at 13.56MHz!

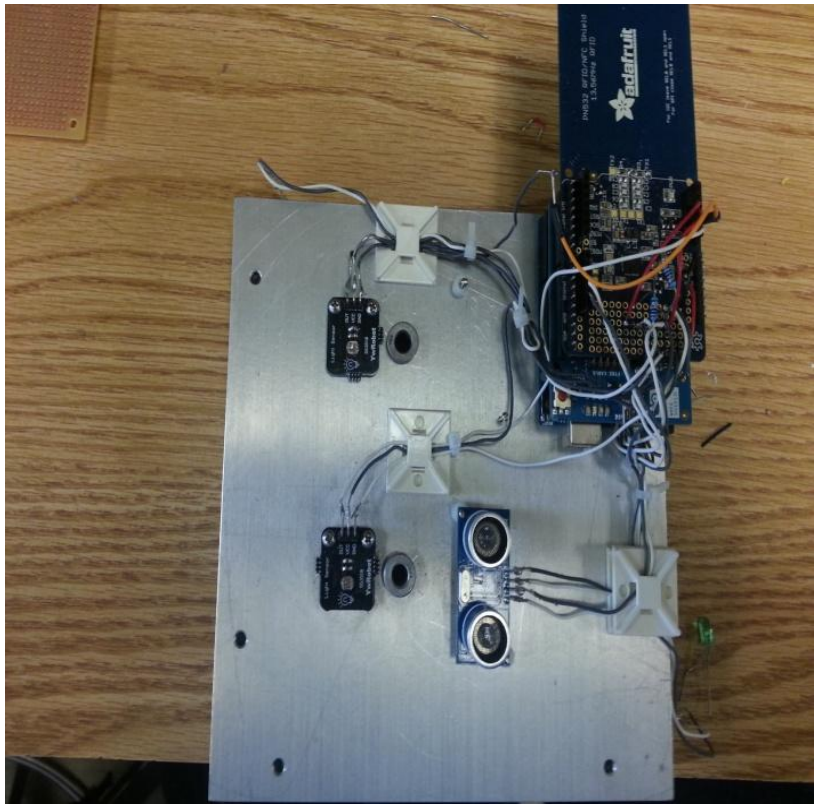
SmartBench Software



Backend Server - COSM



Use Case 4-SmartJig



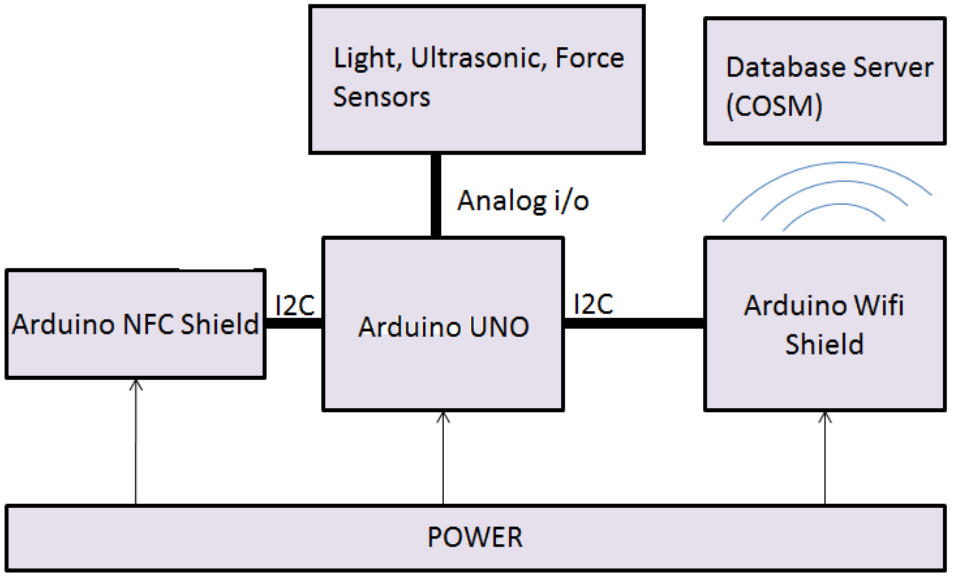
- NFC reader allows employee check-in
- Aid employee in manual drilling and automate QA
- Force sensors ensure jig is in correct location on the part
- Light sensors on jig determine what hole is being drilled
- Ultrasonic sensors on jig determine the depth of the drilled hole

SmartJig (Case 4) Overview

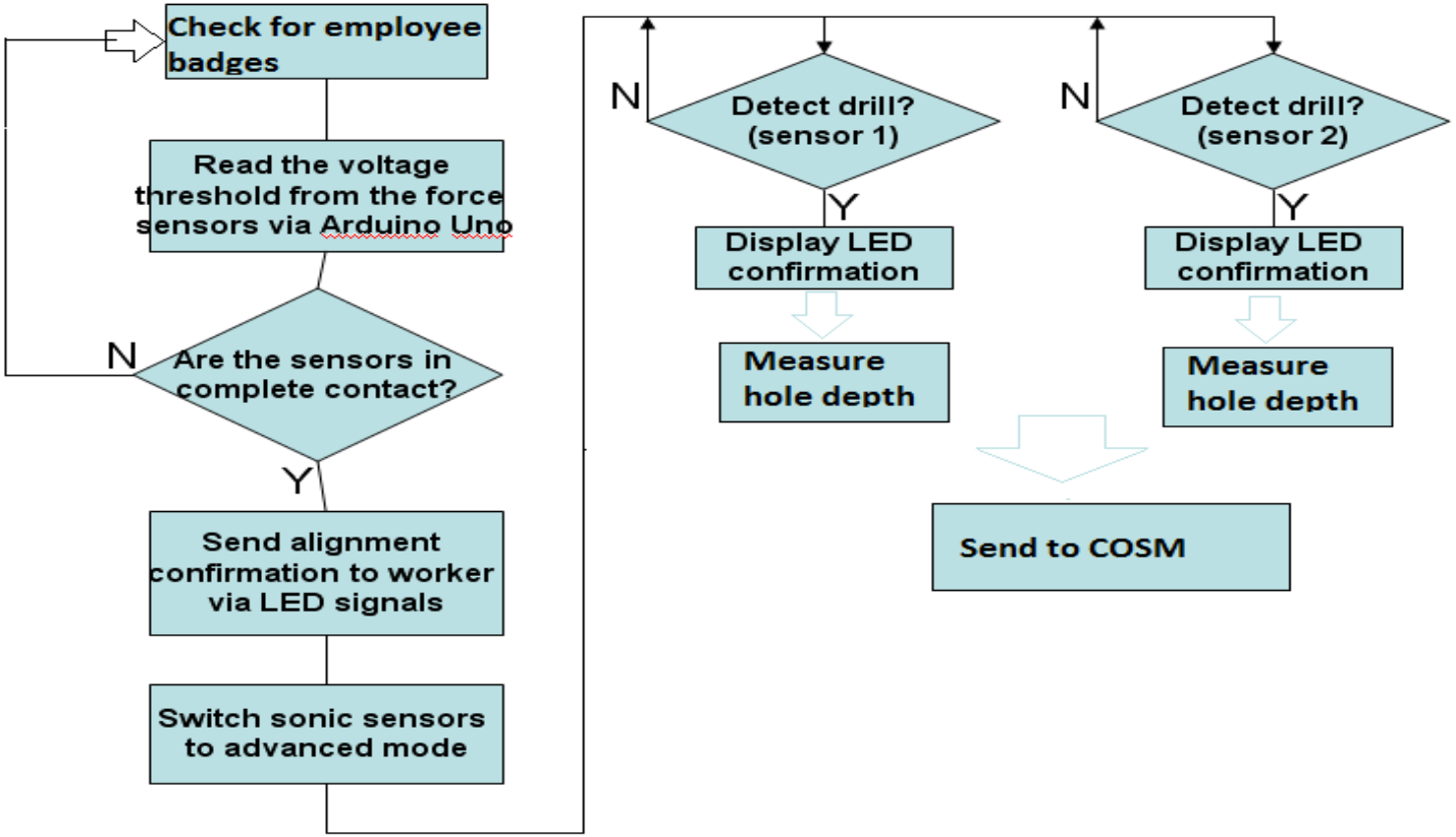
Components

- Arduino Uno
- Arduino WIFI Shield
- Arduino NFC Shield
- Ultrasonic HC-SR04 Sensor
- FSR408 Force Sensor
- Light Sensor
- Sharp IR Range Finder

Block Diagram



SmartJig Software



Components NOT in Final Design

- External Antenna: SMA port to network analyzer
- Sharp IR Range finder: not stable and does not detect less than 10 cm
- TRF 7970A: Cannot successfully transfer data to the Arduino (cannot put in serial SPI mode)
- SM130: Firmware update failure, cannot successfully detect tags
- MUX: tested 3 MUX's-ADG904, 16 pin MUX, 74LS153

SmartBench: Going Forward

- Better success rate in uploading data and better structured Back-End server for multiple data entry
- NFC library that supports UART anti-collision interface
- Boost power to support more external antennas and tags
- Further optimized antennas for different scenarios
- Battery powered
- LCD display

SmartJig: Going Forward

- More accurate distance sensor to increase performance
- Replace the light sensor with a mechanical switch sensor
- Battery powered
- LCD display
- Connect to back-end server connection without using the Arduino Wi-fi Shield

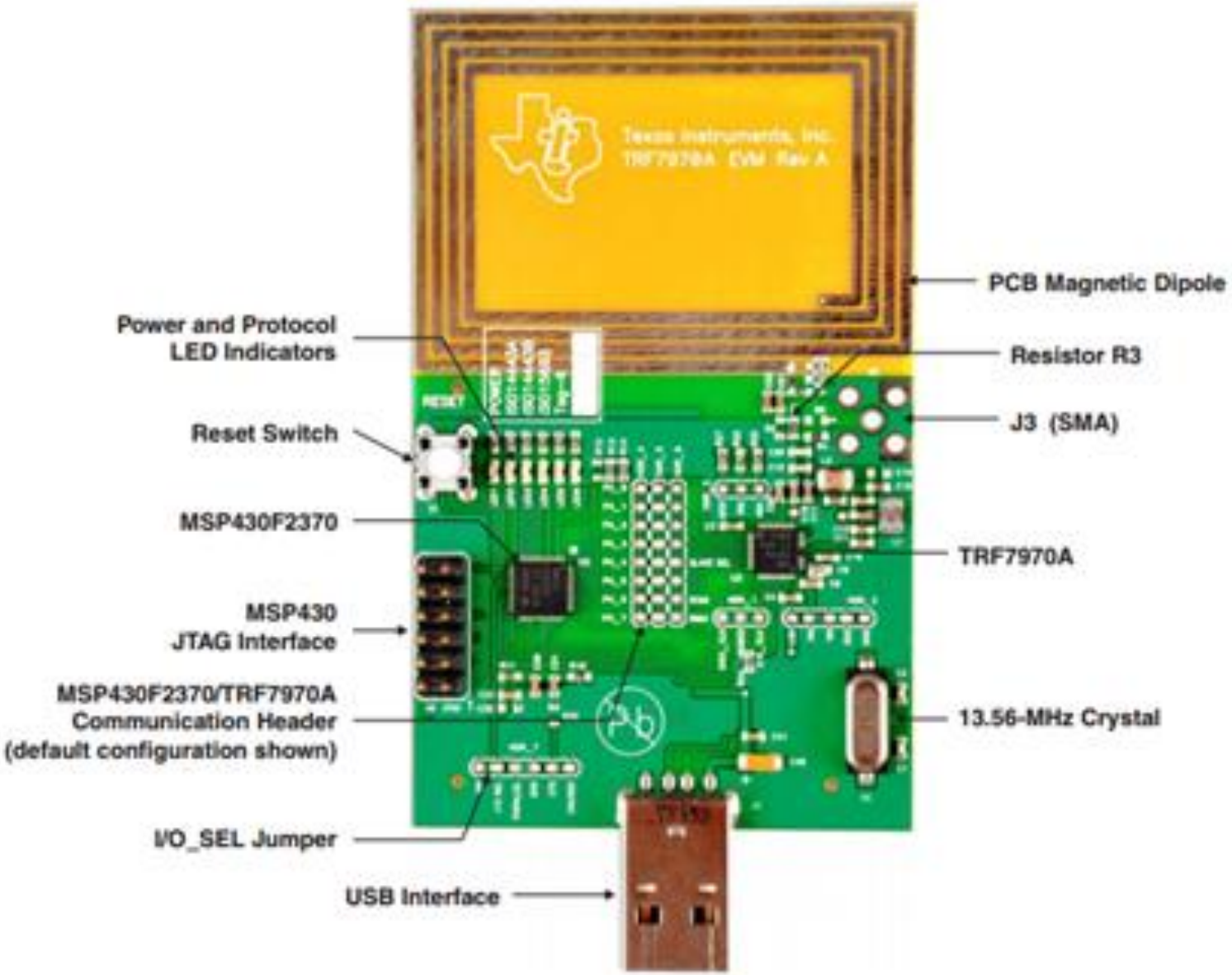
Ethical Issues

- Concerns with RFID over privacy and security
  - IEEE Code of Ethics #1
  - Tags are small and almost unnoticeable
  - Little/no security encryption on these tags
  - Employees (not only parts) are constantly monitored
- NFC badge check-in allows for increased safety in a factory setting
  - IEEE Code of Ethics #6
  - Employee must check-in before using smart-jig
  - NFC badge stores whether or not employee is qualified to use the jig (or any other equipment)

Acknowlegements

- Special thanks to:
  - Prof. Carney
  - Eric Nicks
  - Dallas Scholes
  - Bryan Wilcox
  - Kevin Bassett
  - Mentors from parts and machine shops

Appendix 1


PCB Magnetic Dipole
Power and Protocol LED Indicators
Resistor R3
Reset Switch
J3 (SMA)
MSP430F2370
TRF7970A
MSP430 JTAG Interface
MSP430F2370/TRF7970A Communication Header (default configuration shown)
13.56-MHz Crystal
I/O_SEL Jumper
USB Interface