NinjaSecurity

"…Because Everyone Deserves to Feel Safe!"

Version: (C4) Date: 04/30/2015

TABLE OF CONTENTS

1. PROJECT DEFINITION

1.1 Functions

Ninja Security is an exciting new security system that caters to all people. Formerly designed to cater to the deaf and hard-of-hearing, Ninja Security can help keep you and your family secure regardless of special needs.

Features include:

- Loud siren to alarm owners, neighbors, and intruders that alarm system has tripped
- Flashing lights to signal alarm and alarm delays for those who cannot hear or would have trouble hearing the siren and beeps.
- Bed shaker to signal alarm during night hours for hard sleepers or deaf/hard-of-hearing.
- Door and windows sensors
- Integrated doorbell with customized tones and flash sequence to the security system for audio and visual alerts when someone arrives at the residence.
- Motion sensor to alert unwanted movement inside the home while away.
- Panic button to immediately trip alarm in case of emergencies.
- LCD interface for visual status and current updates.
- Add and remove features, expandable and customizable to meet your personal needs.

1.2 Customer

This system was originally geared toward the deaf and hard-of-hearing, this security system can be used by anyone. We have surveyed deaf, hard-of-hearing, and hearing people alike to determine which features are most important to them in accordance with their lifestyles. After analyzing the data from these surveys, we believe our product will be preferred over any other.

1.3 Team Identity

Ninja Security

- Jesse Daniels – Project Engineer

- Tahsin Rahman – Design & Development Engineer
- Thomas Manahl – Systems Engineer
- Chanh Tran – Support Engineer

2. WBS

2.1 WBS

Tasks

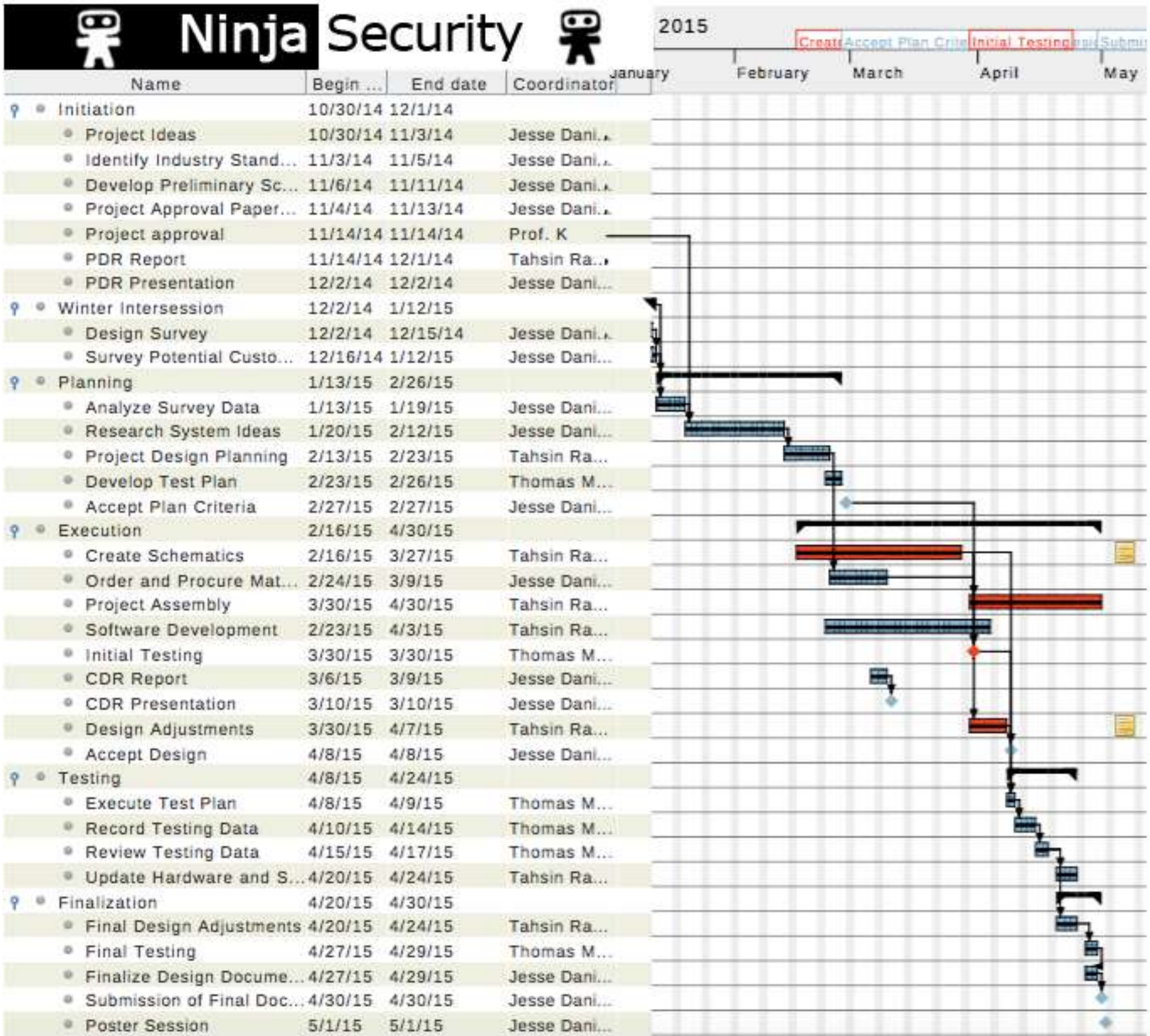
Name	Begin date	End date	Coordinator
Initiation	10/30/14	12/1/14	
Project Ideas	10/30/14	11/3/14	Jesse Daniels
Identify Industry Standards for Project Objectives	11/3/14	11/5/14	Jesse Daniels
Develop Preliminary Schedule and Staffing	11/6/14	11/11/14	Jesse Daniels
Project Approval Paperwork	11/4/14	11/13/14	Jesse Daniels
Project approval	11/14/14	11/14/14	Prof. K
PDR Report	11/14/14	12/1/14	Tahsin Rahman
PDR Presentation	12/2/14	12/2/14	Jesse Daniels
Winter Intersession	12/2/14	1/12/15	
Design Survey	12/2/14	12/15/14	Jesse Daniels
Survey Potential Customers	12/16/14	1/12/15	Jesse Daniels
Planning	1/13/15	2/26/15	
Analyze Survey Data	1/13/15	1/19/15	Jesse Daniels
Research System Ideas	1/20/15	2/12/15	Jesse Daniels
Project Design Planning	2/13/15	2/23/15	Tahsin Rahman
Develop Test Plan	2/23/15	2/26/15	Thomas Manahl
Accept Plan Criteria	2/27/15	2/27/15	Jesse Daniels, Tahsin Rahman, Thomas Manahl, Chanh Tran
Execution	2/16/15	4/30/15	
Create Schematics	2/16/15	3/27/15	Tahsin Rahman
Order and Procure Materials	2/24/15	3/9/15	Jesse Daniels, Tahsin Rahman
Project Assembly	3/30/15	4/30/15	Tahsin Rahman
Software Development	2/23/15	4/3/15	Tahsin Rahman
Initial Testing	3/30/15	3/30/15	Thomas Manahl
CDR Report	3/6/15	3/9/15	Jesse Daniels, Tahsin Rahman
CDR Presentation	3/10/15	3/10/15	Jesse Daniels, Tahsin Rahman, Thomas Manahl, Chanh Tran
Design Adjustments	3/30/15	4/7/15	Tahsin Rahman

Tasks

Name	Begin date	End date	Coordinator
Accept Design	4/8/15	4/8/15	Jesse Daniels, Tahsin Rahman, Thomas Manahl, Chanh Tran
Testing	4/8/15	4/24/15	
Execute Test Plan	4/8/15	4/9/15	Thomas Manahl
Record Testing Data	4/10/15	4/14/15	Thomas Manahl
Review Testing Data	4/15/15	4/17/15	Thomas Manahl
Update Hardware and Software	4/20/15	4/24/15	Tahsin Rahman
Finalization	4/20/15	4/30/15	
Final Design Adjustments	4/20/15	4/24/15	Tahsin Rahman
Final Testing	4/27/15	4/29/15	Thomas Manahl
Finalize Design Documentation	4/27/15	4/29/15	Jesse Daniels, Tahsin Rahman
Submission of Final Documents	4/30/15	4/30/15	Jesse Daniels, Tahsin Rahman, Thomas Manahl, Chanh Tran
Poster Session	5/1/15	5/1/15	Jesse Daniels, Tahsin Rahman, Thomas Manahl, Chanh Tran

2.2 Schedule

- Actual Project Gantt Chart



See GANTT.pdf for larger version

3. SPECIFICATIONS (SUMMARY)

3.1 Microcontroller

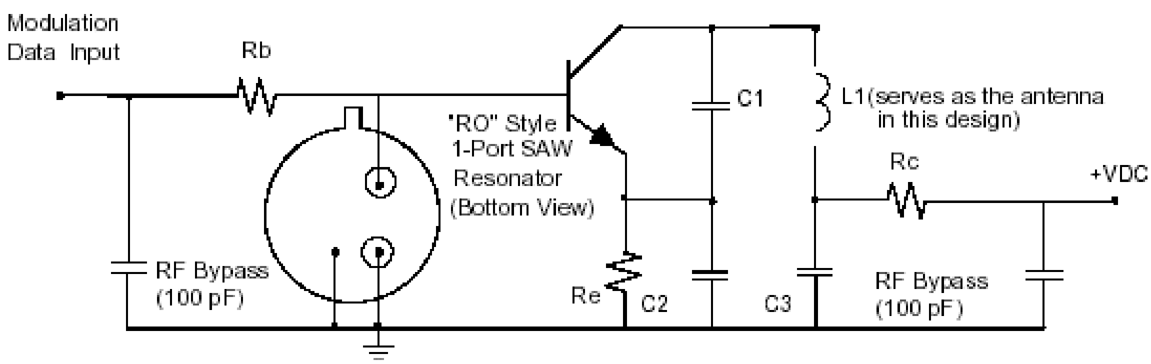
- ATmega328p
  - For Testing
  - 8-bit
  - 28 pin PDIP

- Operating Voltage 1.8 – 5 Volts
- Digital I/O Pins 14
- Analog Input Pins 6 (10 bit)
- I/O Pin Current 40 mA
- Flash Memory 32 KB
- SRAM 2 KB
- EEPROM 1 KB
- Clock Speed 16 MHz
  - External crystal
- Detailed specification at Attachment P1

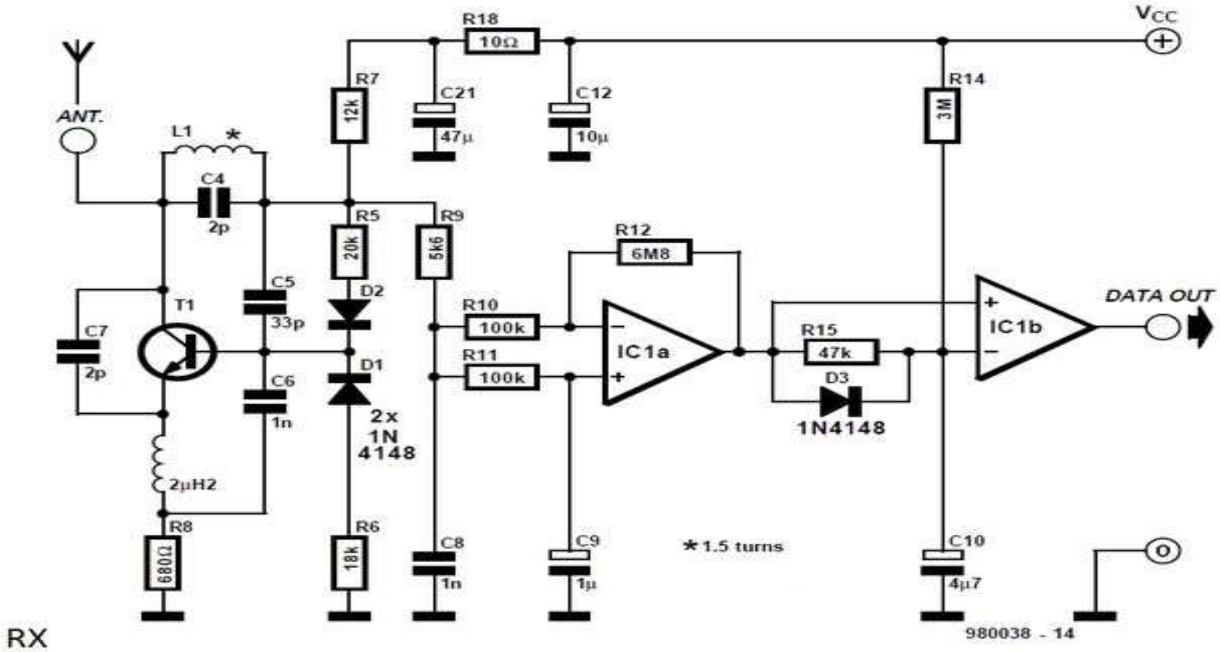
- ATtiny85
  - Production
  - 8-bit
  - 8 pin PDIP
  - Operating Voltage 2.7 – 5 Volts
  - Digital I/O Pins 6
  - Analog Input Pins 4 (10 bit)
  - I/O Pin Current 40 mA
  - Flash Memory 32 KB
  - SRAM 512 B
  - EEPROM 512 B
  - Clock Speed 1 MHz
    - Internal Calibrated RC Oscillator
  - Detailed specification at Attachment P2

3.2 RF Modules

- **Transmitter**
  - Frequency: 433Mhz
  - Modulation: Amplitude-shift keying (ASK)
  - Transmitter Input Voltage: 3-12V
  - High voltage = more transmitting power
  - Transmitting range @5V: 40m indoor, and 100m in open air



- **Receiver**
  - Frequency: 433Mhz
  - Modulation: Amplitude-Shift Keying (ASK)
  - Receiver Data Output: High - 1/2 V_{CC}, Low - 0.7V
  - Receiver Input Voltage: 3.3-6V
    - High Voltage = More Receiving Power



3.3 Sensors

- **Door / Window**
    - Operation Current:30mA
    - Idle Current: 8uA
    - Operation Frequency: 433MHz
    - Modulation: Amplitude-Shift Keying (ASK)
    - Transmission Time: ≈ 1s
    - Operating Voltage: 12V, 3V
        - 12Volt for RF
        - 3Volt for MCU
    - Transmit Range: approx. 100M line-of-sight,
    - Operation Temp: -10C~50C; Humidity: ≤90%
    - Dimension: 71mm*36mm*15mm

- **Motion**
  - Power Supply : 9V
  - Static current : 1 ≤ 30mA
  - Alarm current : 2 ≤ 20µA
  - Frequency: 433Mhz
  - Transmission Time : ≧1s
  - Detected Distance : 5-8m
  - Transmit Distance : approx. 100m Line-of-sight
  - Detect angle : Horizontal: 110, Vertical: 60
  - Working Condition : Temperature : -10°C ~ 40°C (approx. 14°F ~104°)

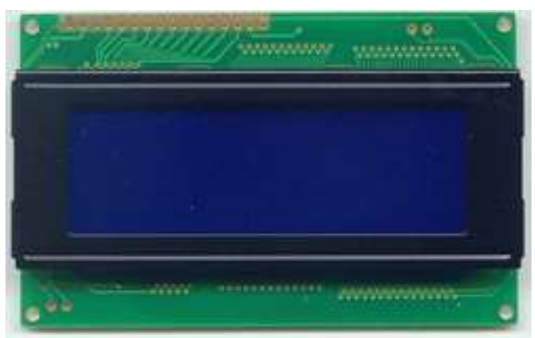
- **Panic Button / Doorbell**
  - Operation Current

- Standby: 1uA
- Operating Current: 10mA
- Operation Frequency: 433MHz
- Modulation: Amplitude-shift keying (ASK)
- Transmission Time : ≧1s
- Operating Voltage: 12V
- Transmit Range: approx. 100M line-of-sight,
- Operation Temp: -10C~50C;Humidity:≤95%
- Dimension:65cm*38mm*15mm

3.4 Audio / Visual

- **Fire alarm**
  - Modified fire alarm
  - High dB Output
  - up to 87.9 dBA @ 10ft
  - Frequency Range 400-4000Hz
  - Speaker voltage 25
  - Field selectable power taps: 1/8W, 1/4W, 1/2W, 1W, 2W, 4W
  - Xenon Strobe
  - Maintains Constant Flash Rate (1Hz) Regardless of Input Voltage
  - 75 candela light output

- **LCD Display**
  - Custom alarm display box
  - Operation Frequency: 433MHz
  - Modulation: Amplitude-shift keying (ASK)
  - Operating Voltage: 5V
  - Operating Current: 100mA
  - ATmega328p MCU
    - 16MHz
  - Capable of both sending and receiving data



3.5 Seismic Feedback

- **Bed Shaker**
  - 12 volt operating voltage
  - Built-in temperature sensor protects the unit against overheating
  - Claims to wake up extremely heavy sleepers
  - Ideal for Deaf and Hard-of-Hearing

4. FUNCTIONAL DECOMPOSITION DIAGRAM

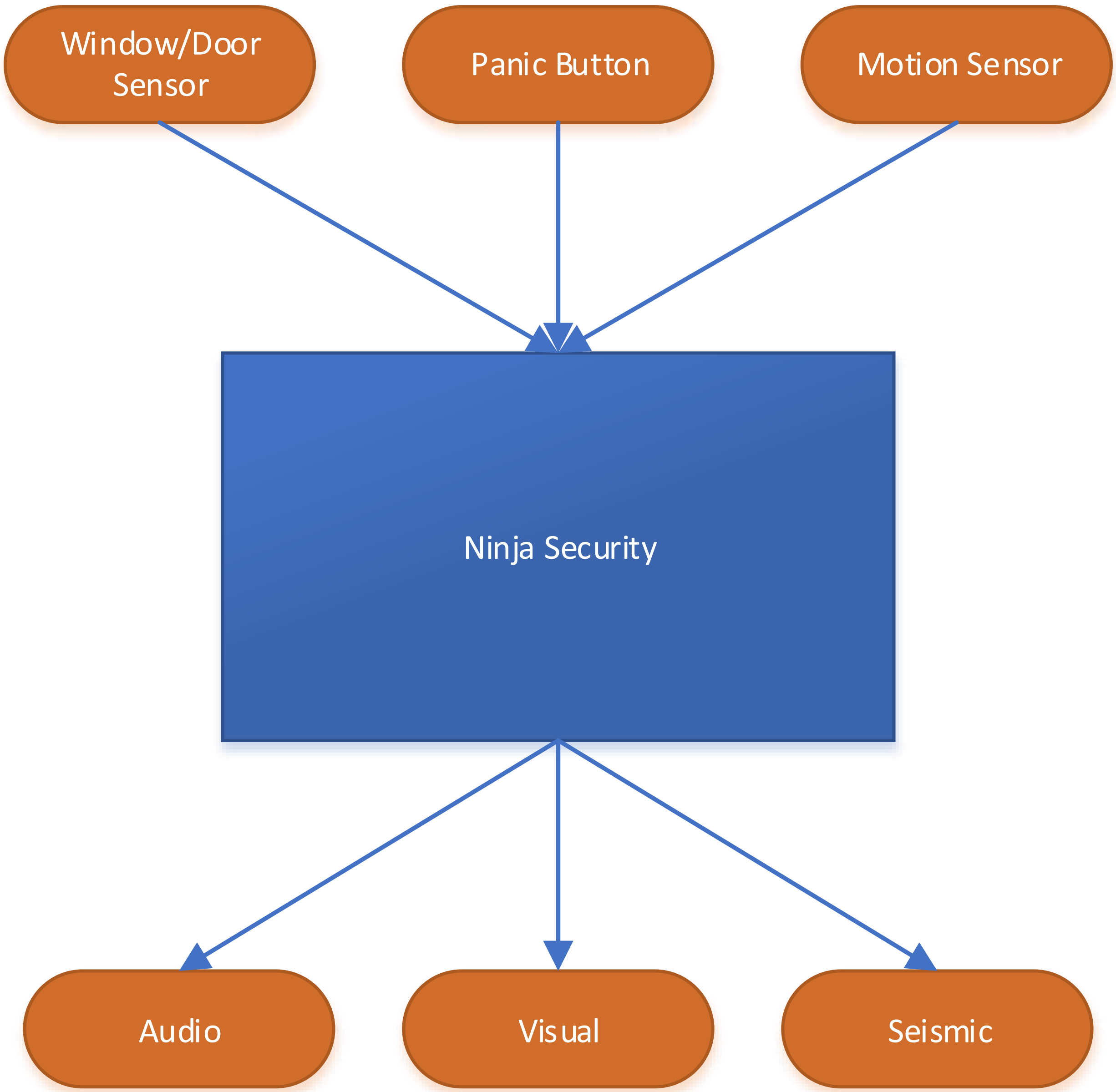
4.1 Level 0

- **Input**
  - Various input for the main system
- **Output**
  - Data output to various systems

4.2 Level 1

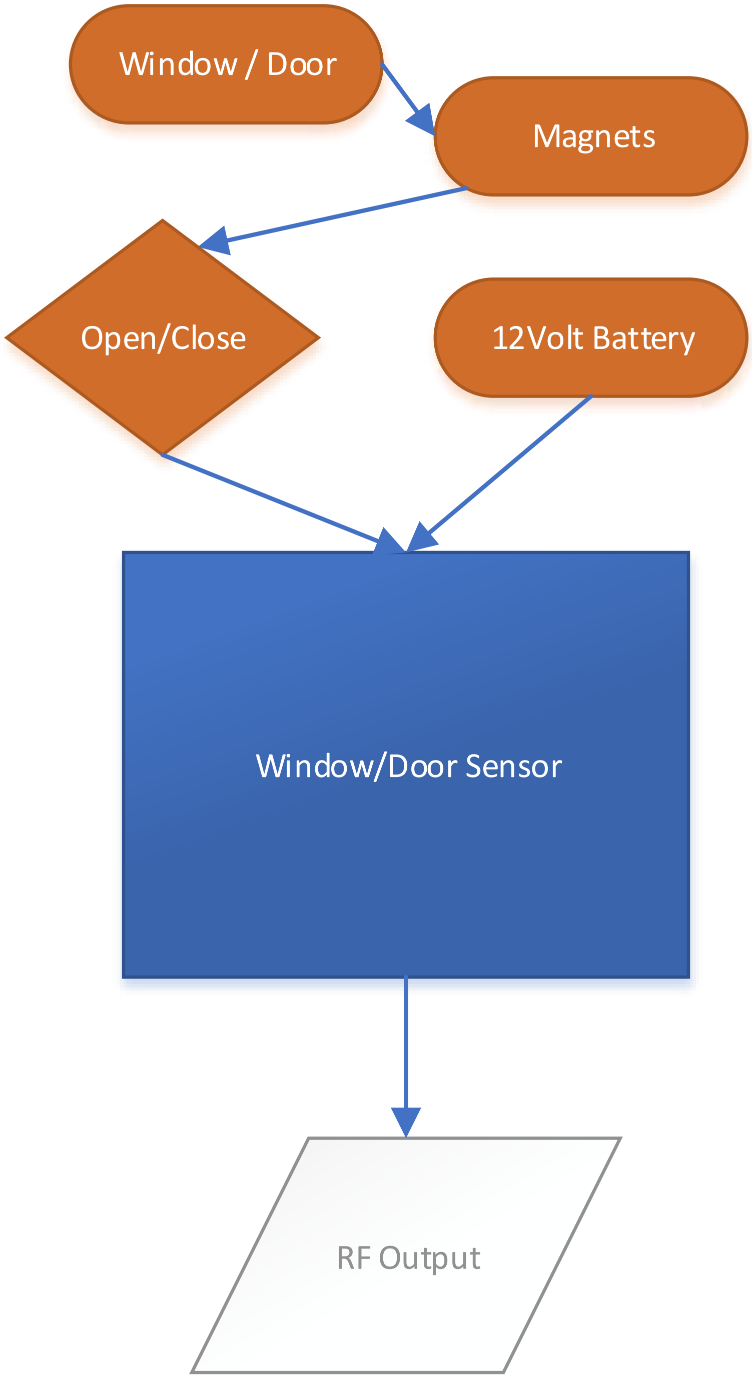
- **Input**
  - Window Sensor
    - Wireless magnetic window sensor
      - Window opens or closes
  - Door Sensor
    - Wireless magnetic door sensor
      - Door opens or closes

    - Motions Sensor
        - PIR based wireless motion sensor
            - Movement within motion range
    - Panic Button
        - In case of emergencies button
            - Push Button
    - Door Bell Button
        - Visitor at door alert
            - Push Button
- **Output**
    - Visual
        - Sends data to local visual systems
    - Audio
        - Sends data to local audio feedback system
    - Seismic
        - Sends data to local vibration feedback system



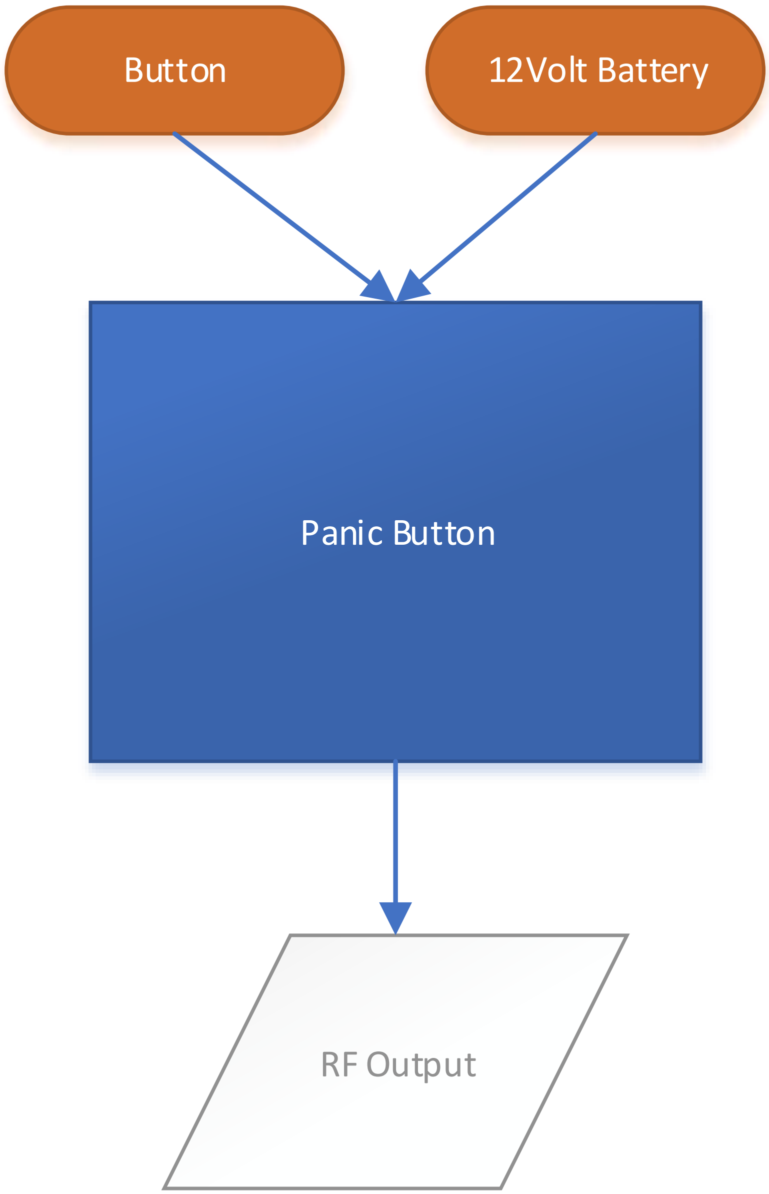
4.3 Level 2

- **Input – Window/Door Sensor**
  - Battery
    - 12Volt A23 Battery
  - Magnets
    - To open and close the magnetic relay
- **Output**
  - RF Output
    - 433MHz ASK
    - Different open and close codes



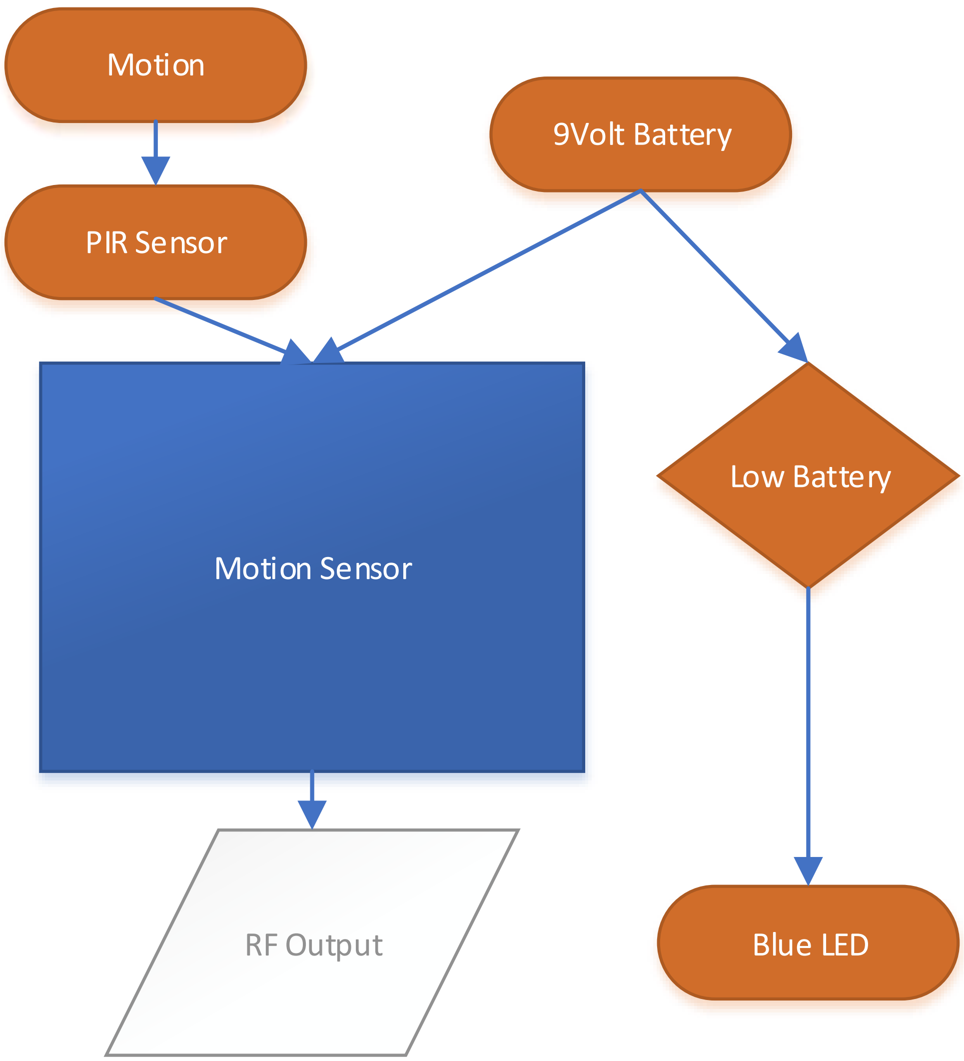
- **Input – Panic Button**
  - Button
    - Tells the unit to send the data
  - Battery

        - 12Volt A23 Battery
- **Output**
    - RF Output
        - 433MHz ASK
        - Single code



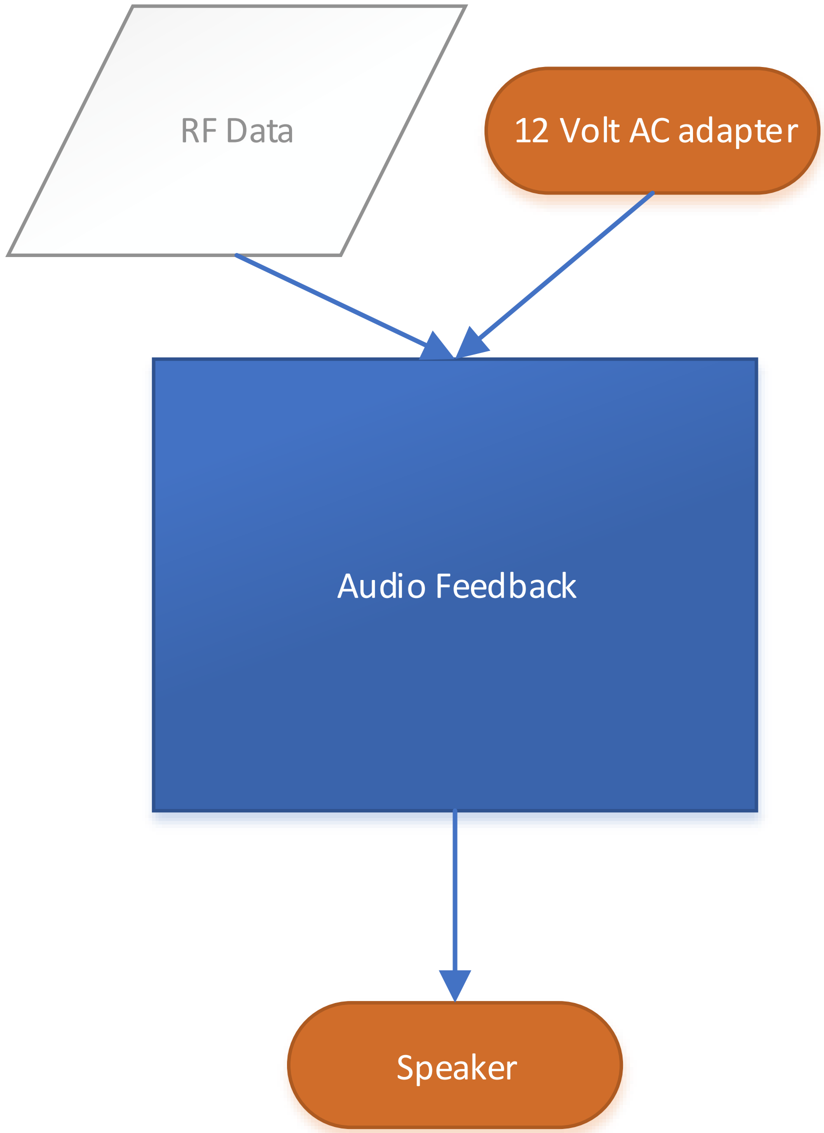
- **Input – Motion Sensor**
    - PIR Module
        - Tells the unit to send that it detected a person
    - Battery
        - 9Volt Battery

- **Output**
  - RF Output
    - 433MHz ASK
    - Single code
  - Low battery
    - Blue LED is turned on for low battery

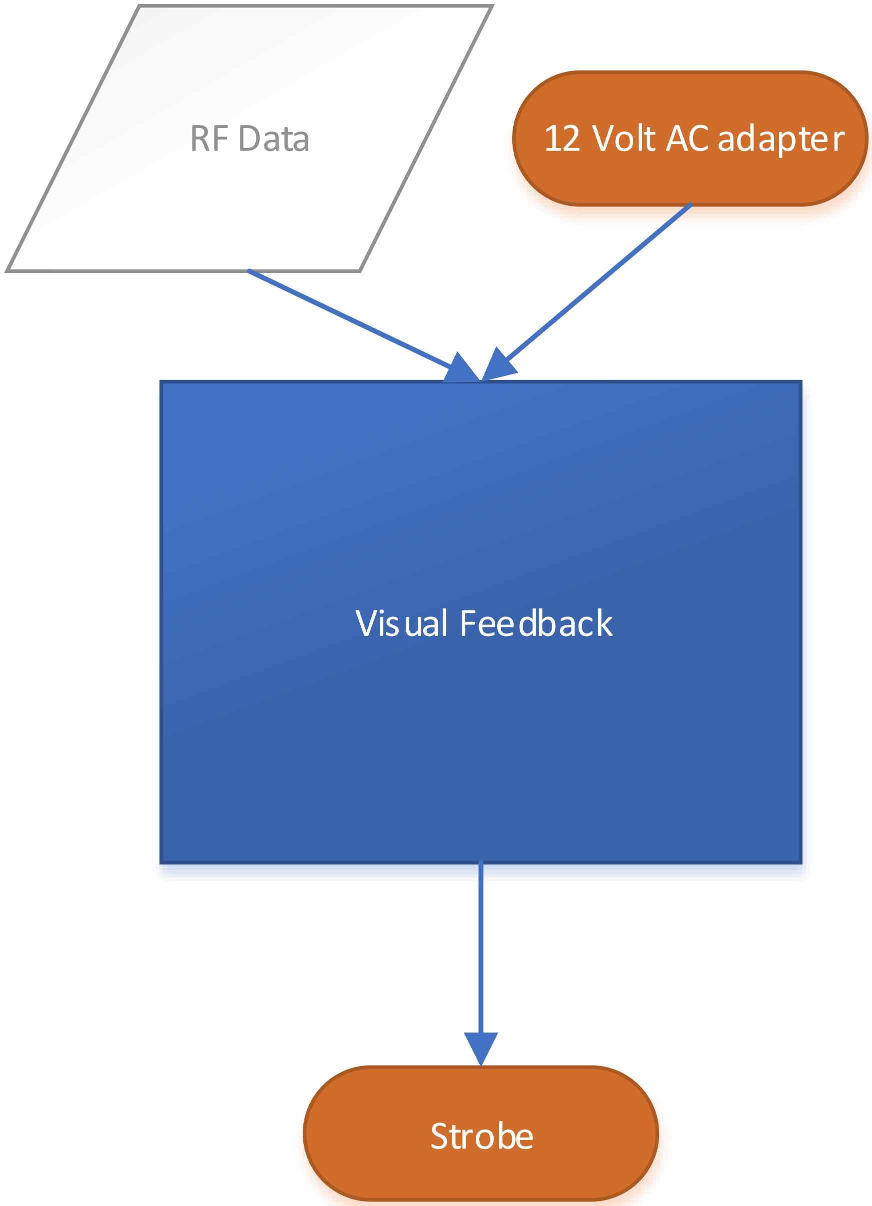


- **Input – Audio Feedback**
  - RF Data
    - RF data it received from the main system
  - Power
    - 12Volt AC adapter
- **Output**
  - Speaker

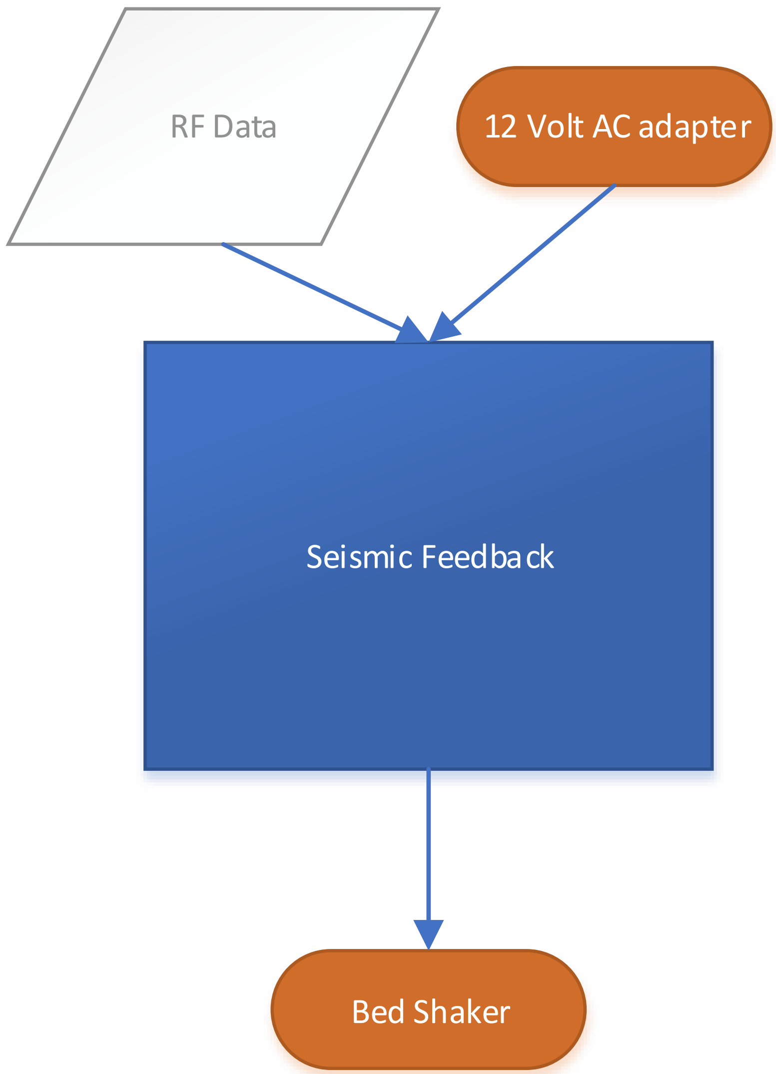
- Play different sounds



- **Input – Visual Feedback**
  - RF Data
    - RF data it received from the main system
  - Power
    - 12Volt AC adapter
- **Output**
  - Strobe
    - 1Hz flashing arc strobe

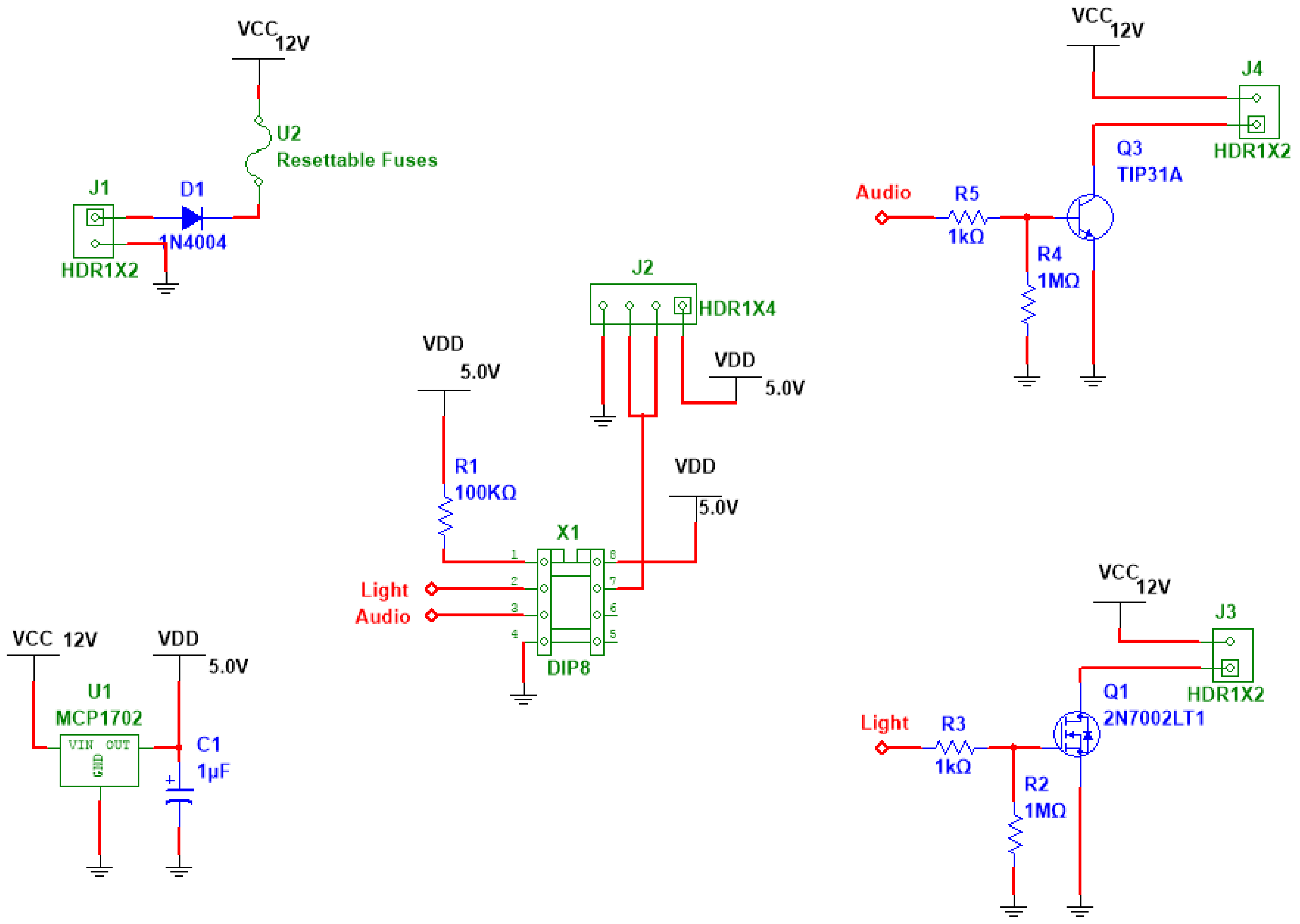


- **Input – Seismic Feedback**
  - RF Data
    - RF data it received from the main system
  - Power
    - 12Volt AC adapter
- **Output**
  - Bed shaker
    - Pulsed and continuous modes

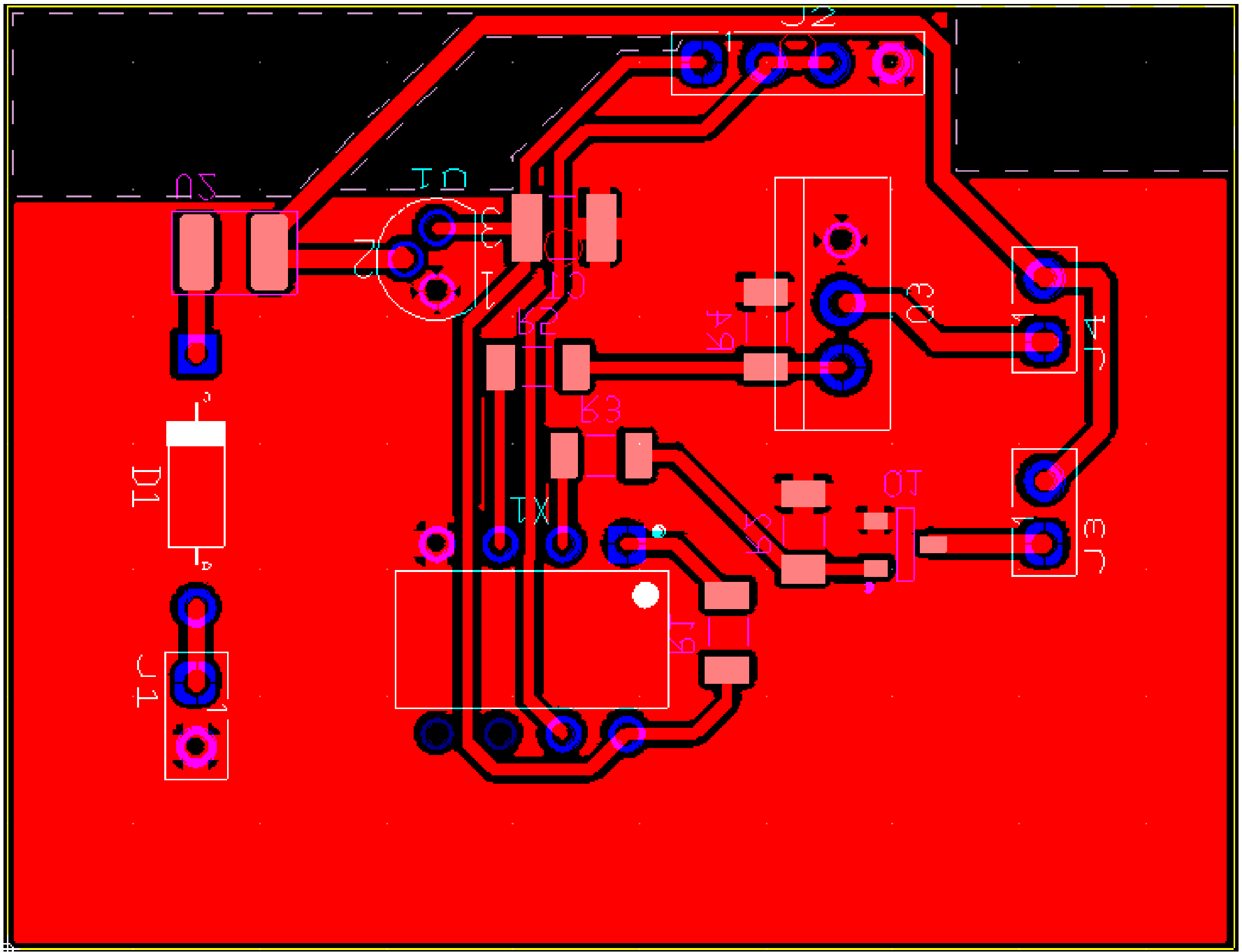

RF Data
12 Volt AC adapter
Seismic Feedback
Bed Shaker

5.0 DESIGN CONCEPTS

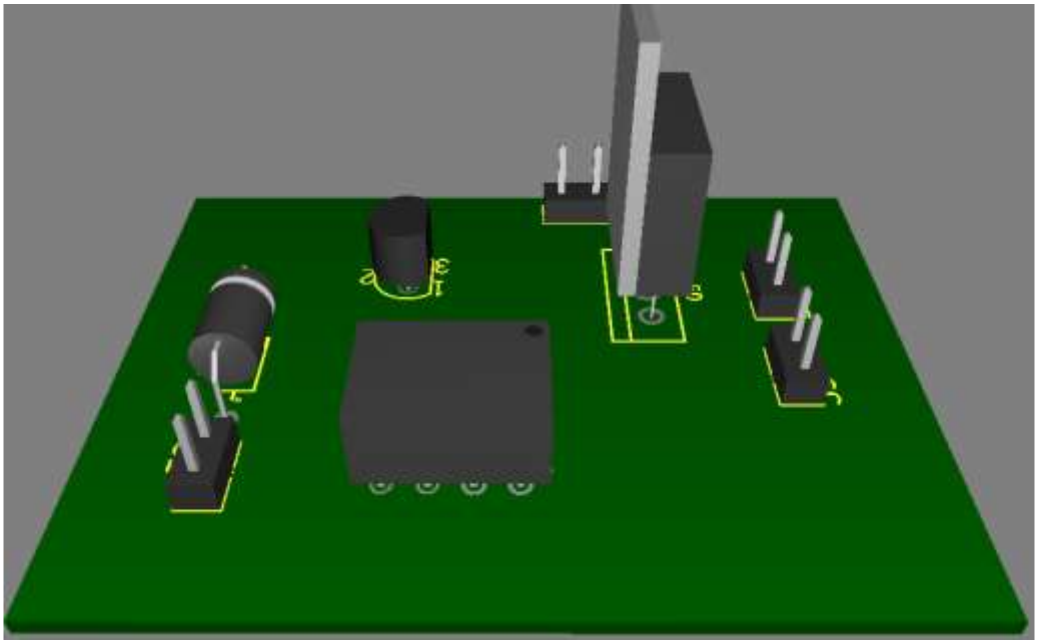
5.1 Audio / Visual



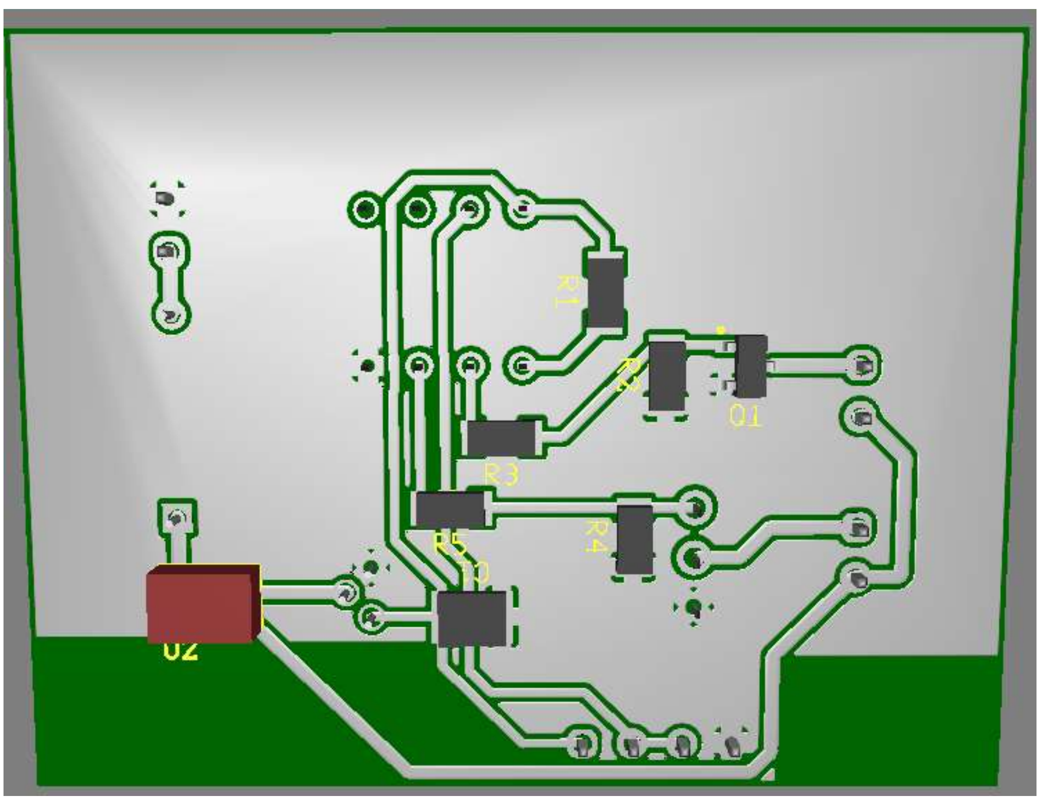
Schematic



Board Layout

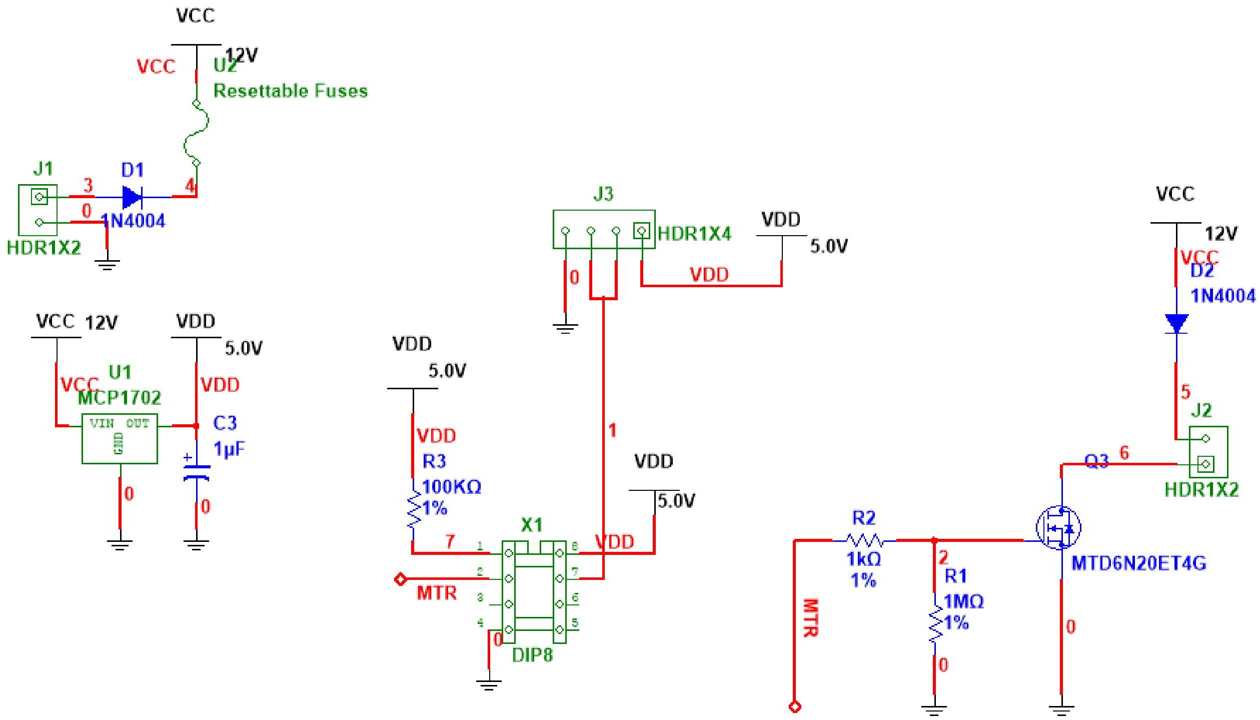


3D Top

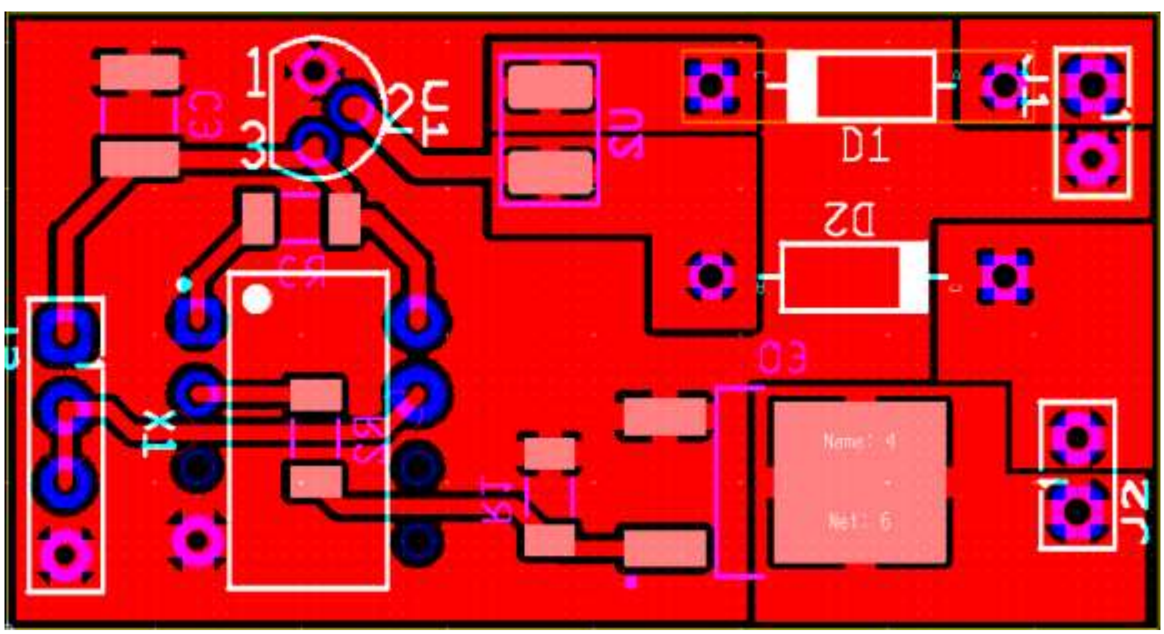


3D Bottom

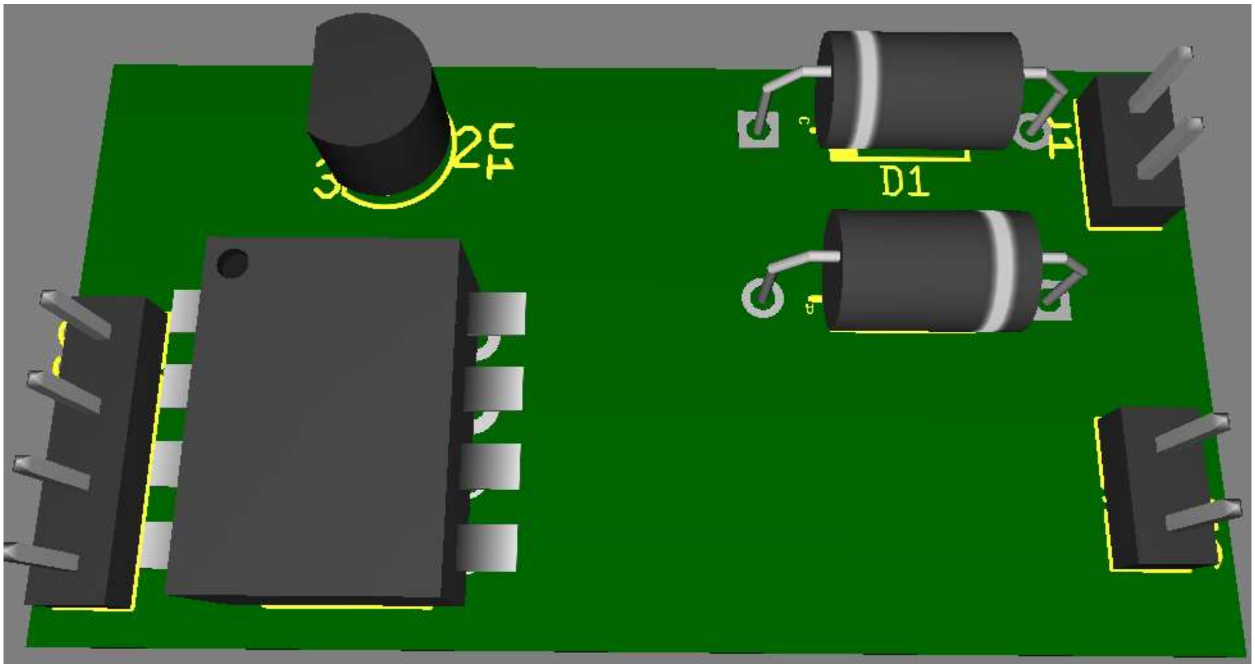
5.2 Seismic Feedback



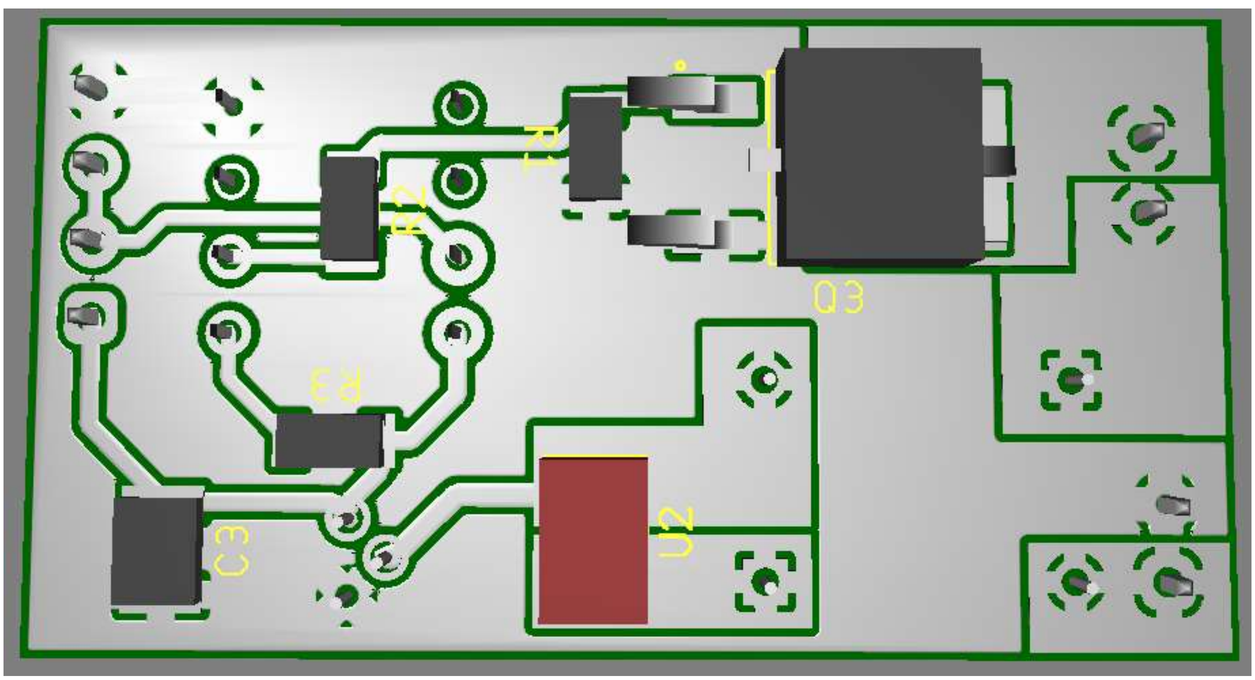
Schematic



Board Layout

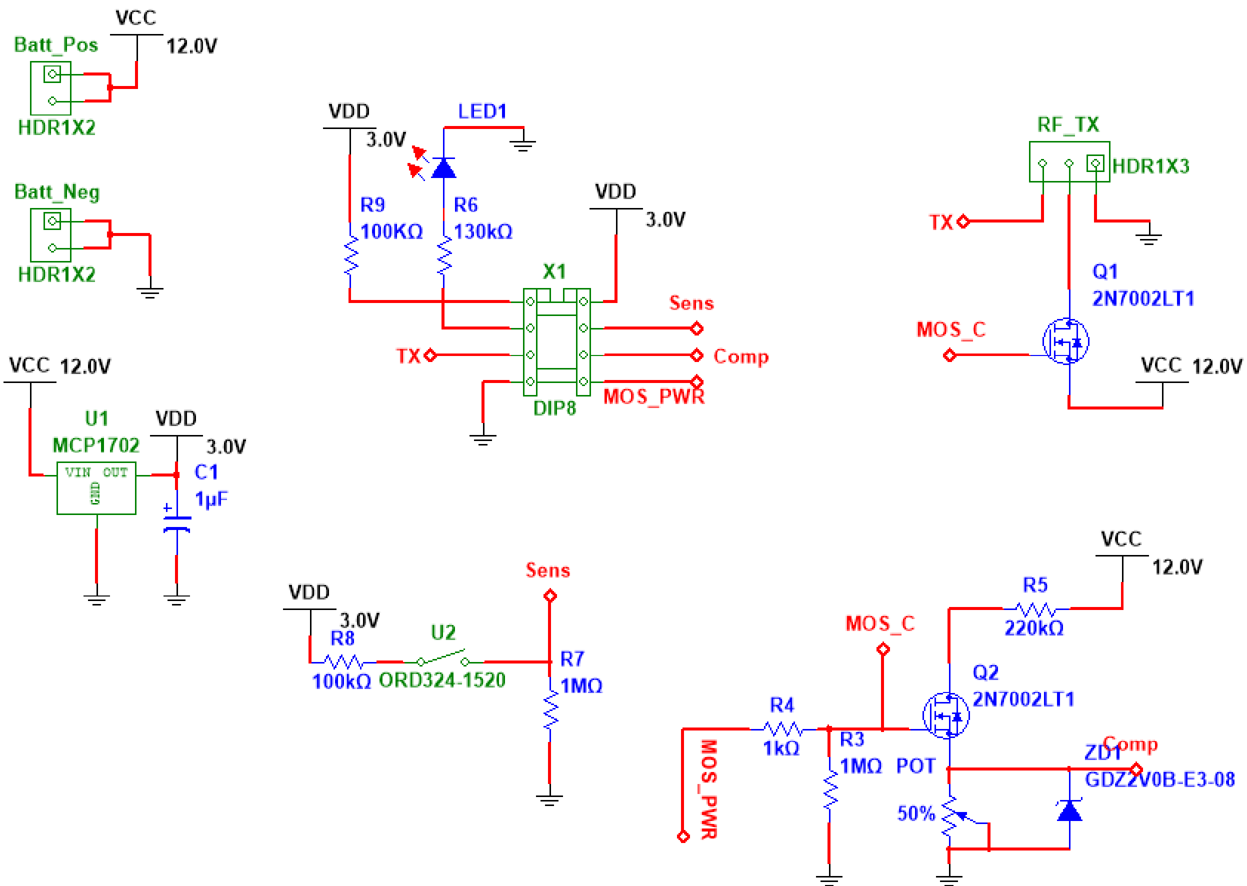


3D Top

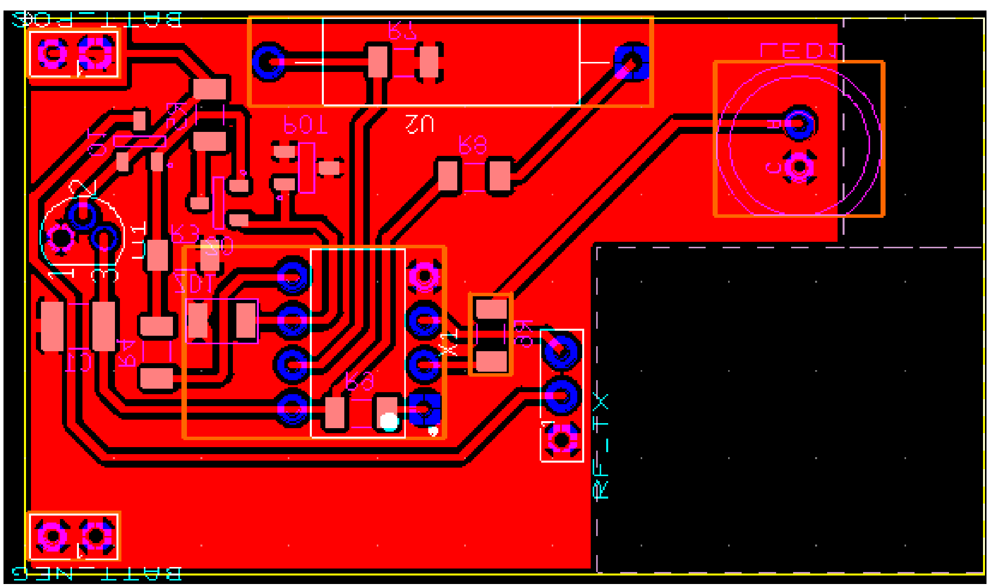


3D Bottom

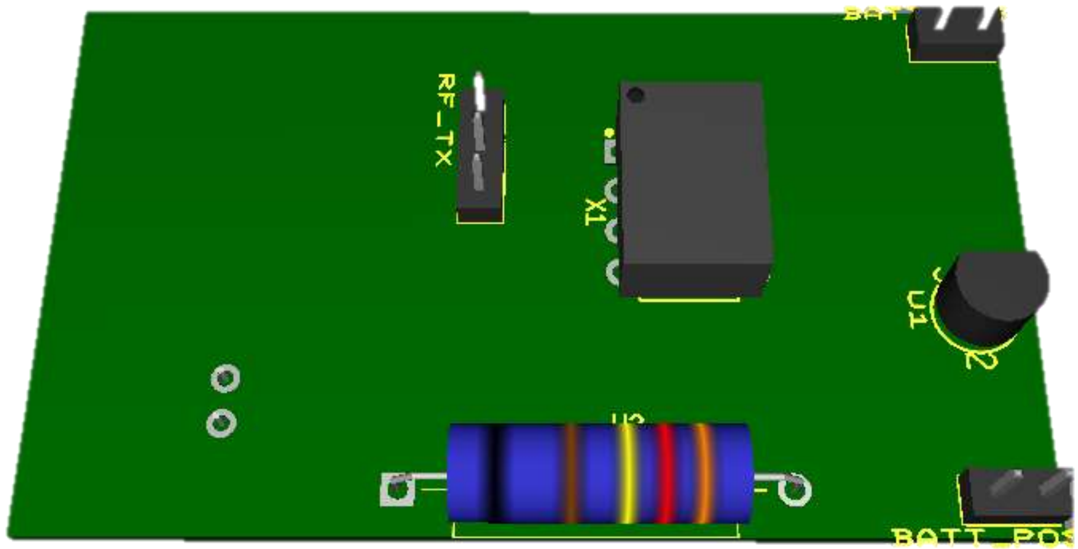
5.3 Window / Door Sensor



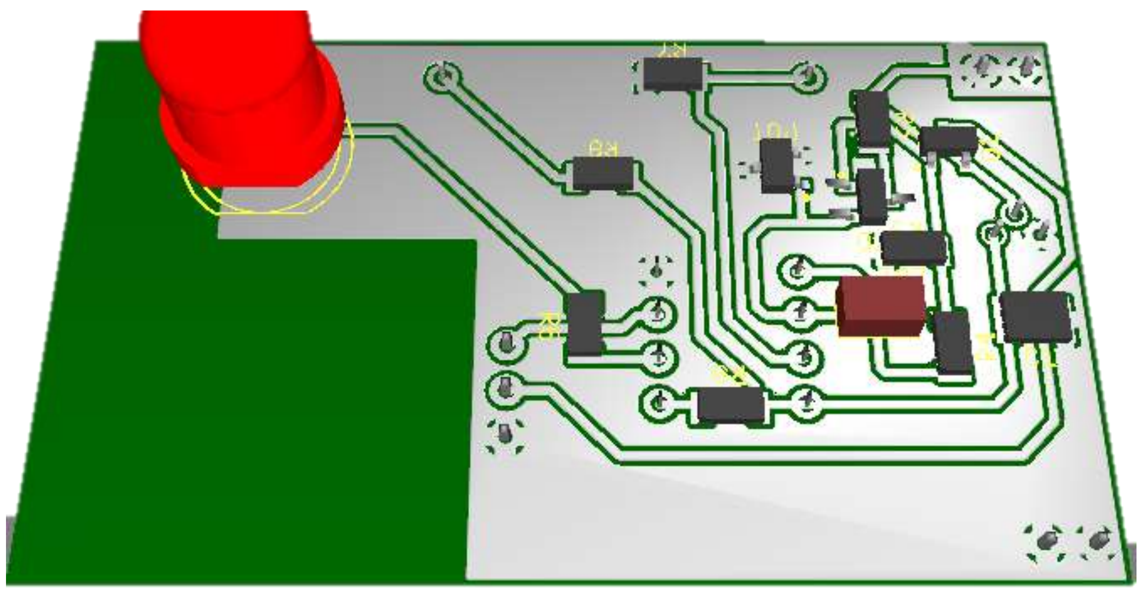
Schematic



Board Layout



3D Top

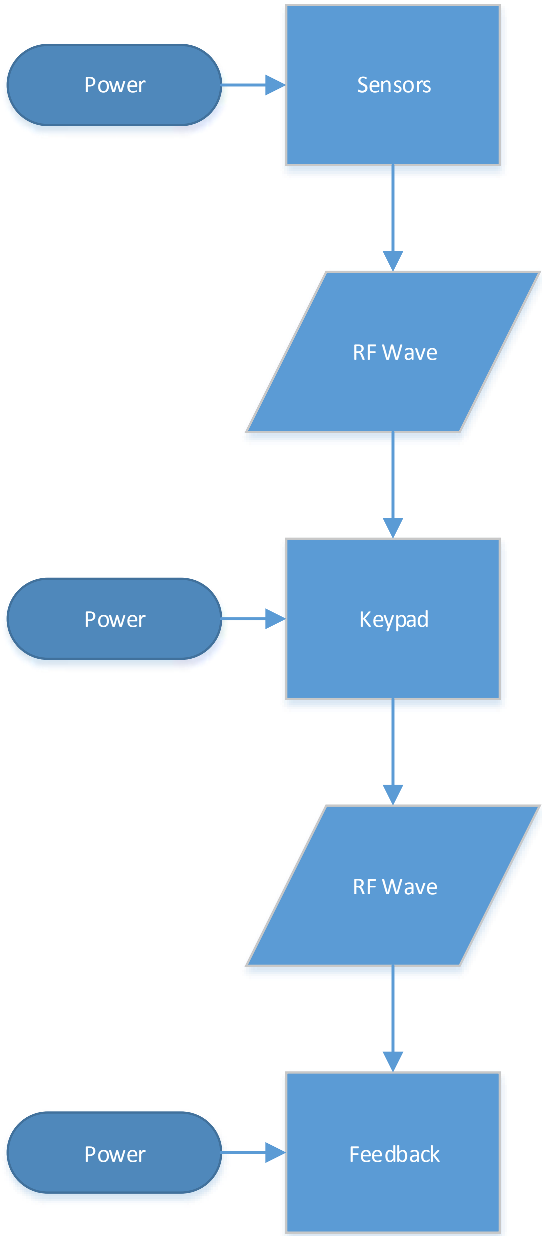


3D Bottom

6.0 INTERFACE CONNECTIONS

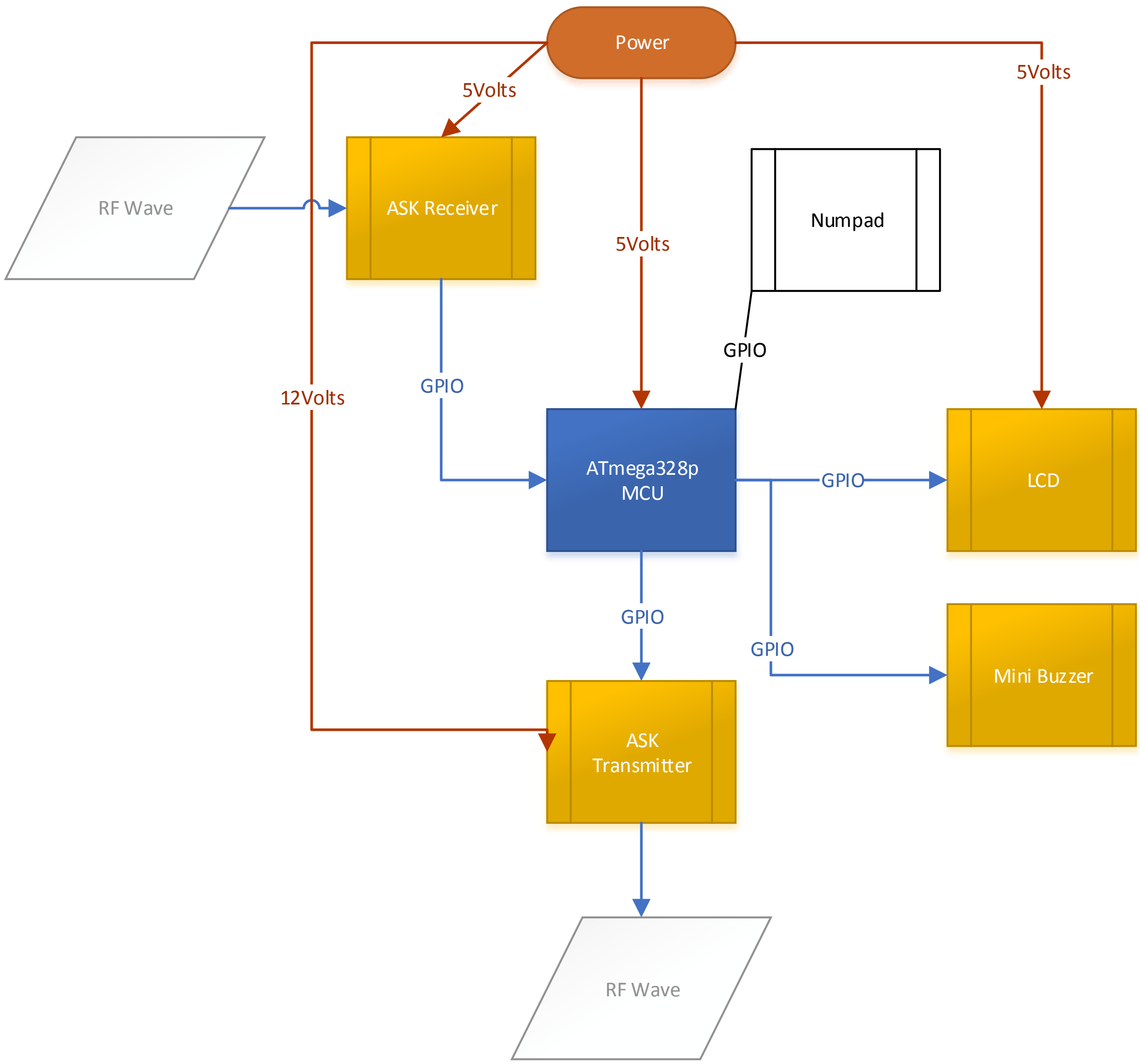
6.1 General Overview

A general overview of the system. The sensors, keypad and feedback system had its own dedicated power units. They are all communicate by 433MHz RF.



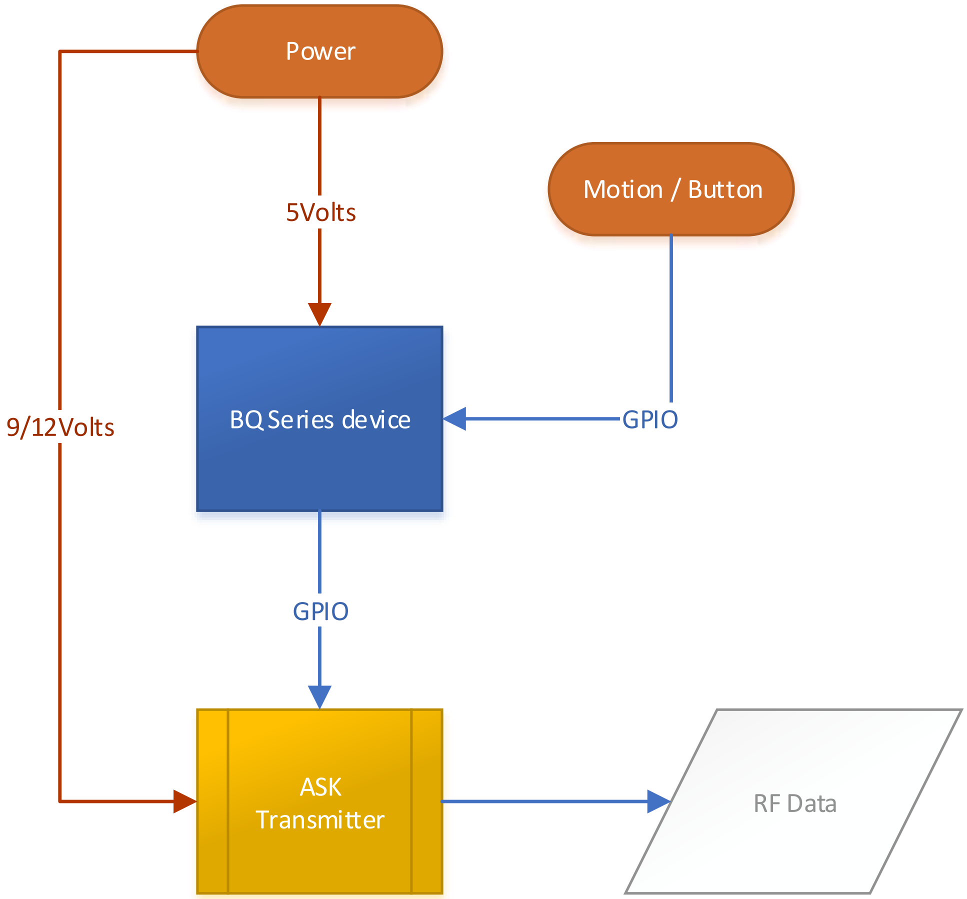
6.2 Display Panel

The display panel is considered as a central hub of the system. It is powered by a 12Volt adapter from the mains. The voltage regulator then converts the power to 5Volts to power the LCD, MCU, RF receiver. The MCU gets its data from the RF receiver through one of its general purpose input-output pins (GPIO). The MCU outputs data to three systems. The LCD, mini buzzer and RF transmitter is connected through GPIO pins.



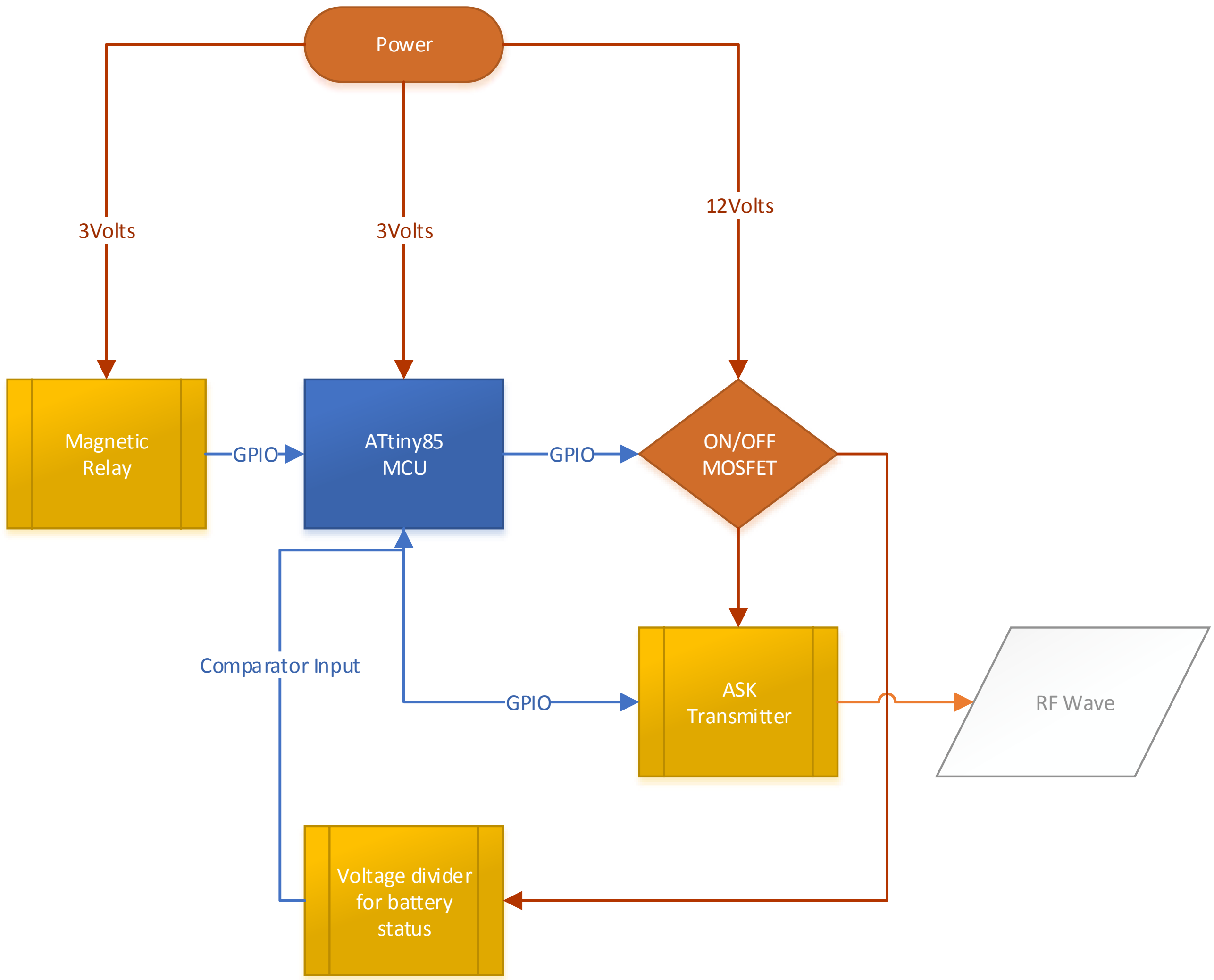
6.3 Sensors

The motion and the panic button is powered by a 9Volt or a 12Volt A23 battery. The regulator then takes the power to 5 volts to power the BQ series device. The raw input power is also connected to the RF transmitter. The BQ series device get its input from a button / motion information through GPIO pin. Then it sends the data out to the RF transmitter using a different set of GPIO pin.



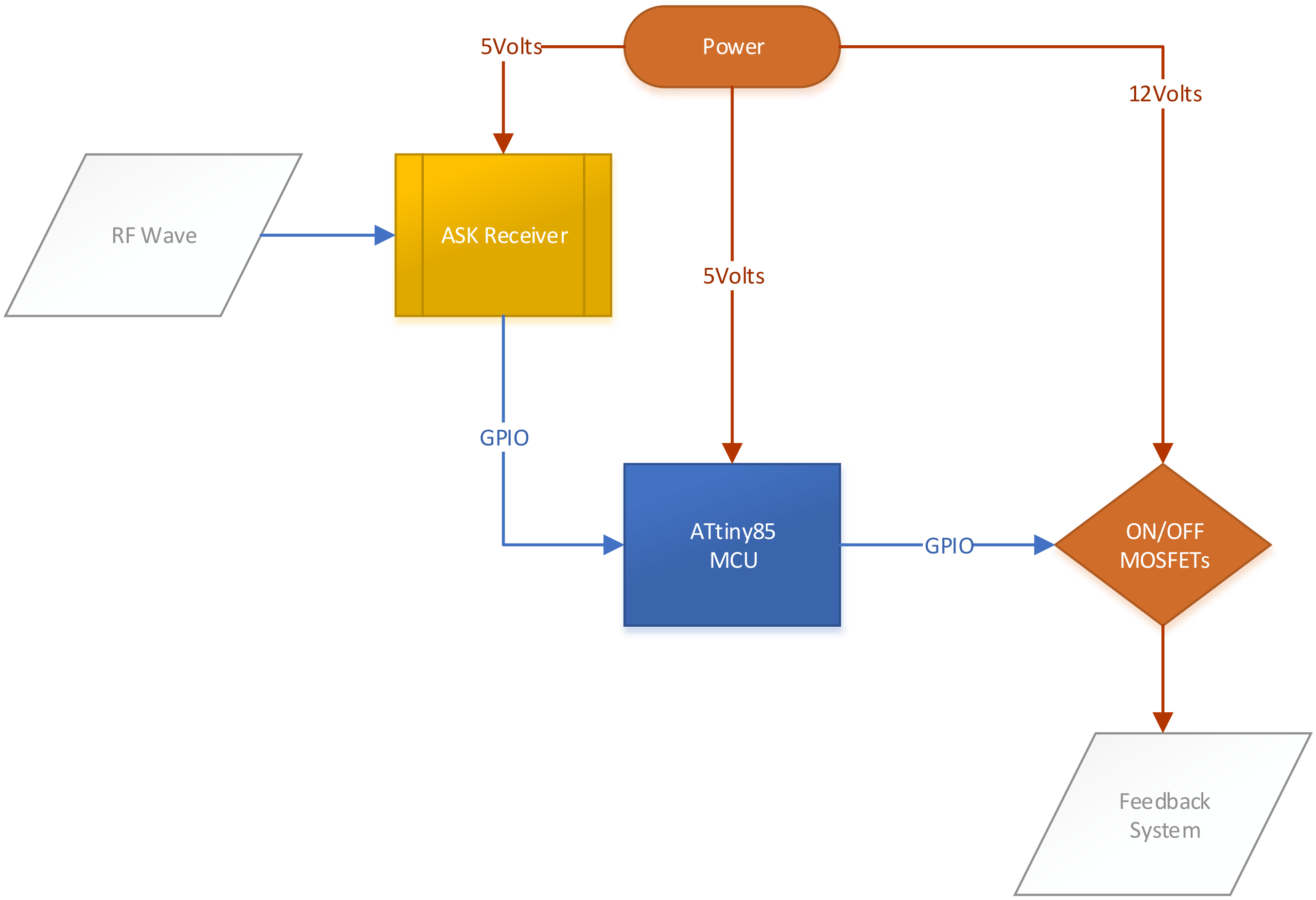
6.4 Window/Door Sensor

The window / door sensor employs variety of ways to conserve power. Its main power source is a A23 12Volt battery. The voltage controller converts the 12Volts to 3Volts to power the MCU and the magnetic relay. The raw battery power also goes to the MOSFET then to the RF transmitter and the voltage divider. The MCU reads the relay information from a GPIO pin. Then turns on or off the MOSFET to power the RF module and the voltage divider. Another GPIO pin is used to send information to the RF transmitter.



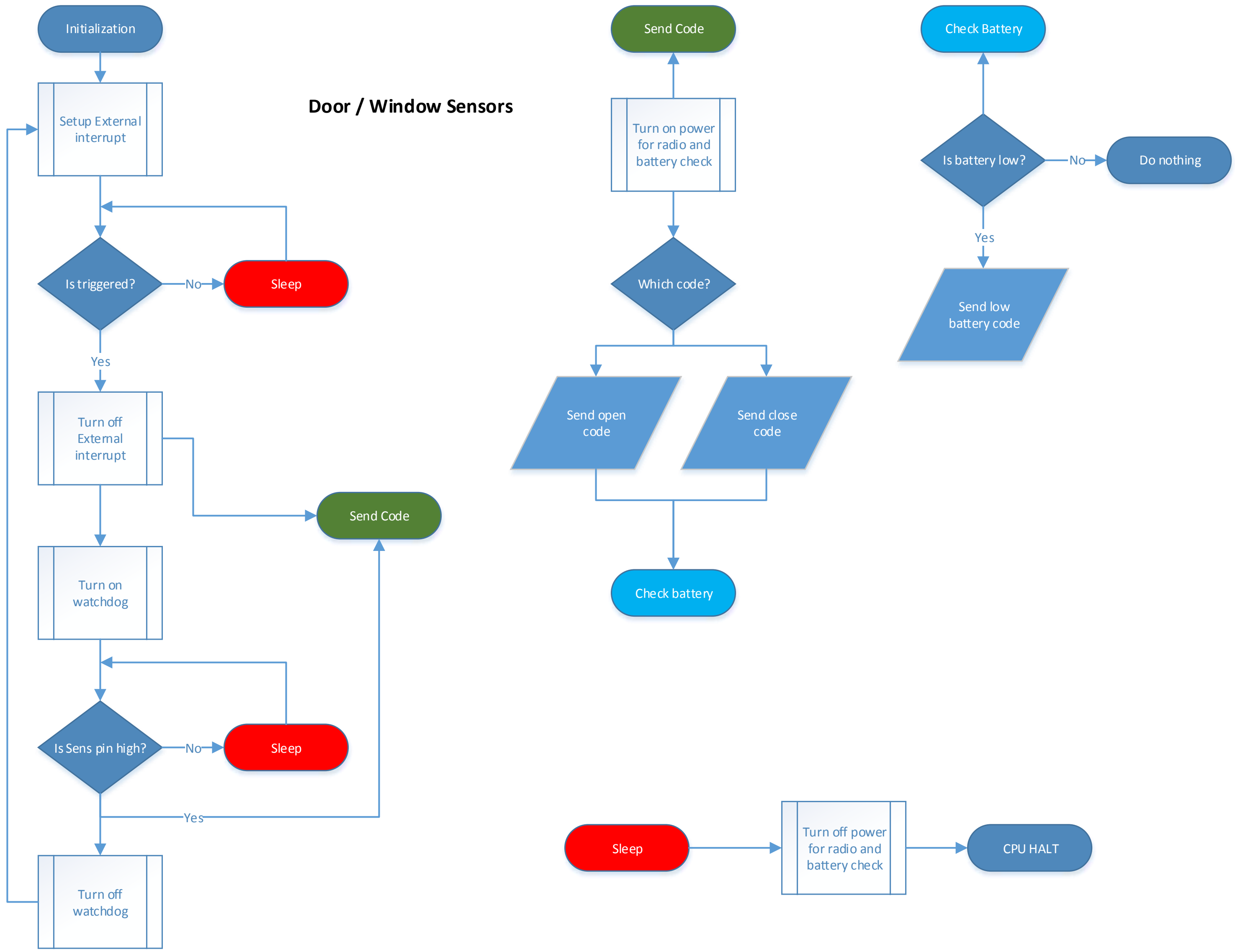
6.5 Feedback

All feedback system has the same underlying hardware concept. There is AC power input from the mains. The mains power is converted down to 12 volts and 5 volts. The 5 volts are sent to the MCU and the RF receiver. The 12 volts are sent to the MOSFETS to control the output devices. The RF ASK receiver outputs the data in binary values. The MCU reads the data from one of its general purpose input-output pins (GPIO). The MCU also uses its GPIO pin to control the power for the output devices: e.g. strobe, bed shaker, audio alarm.

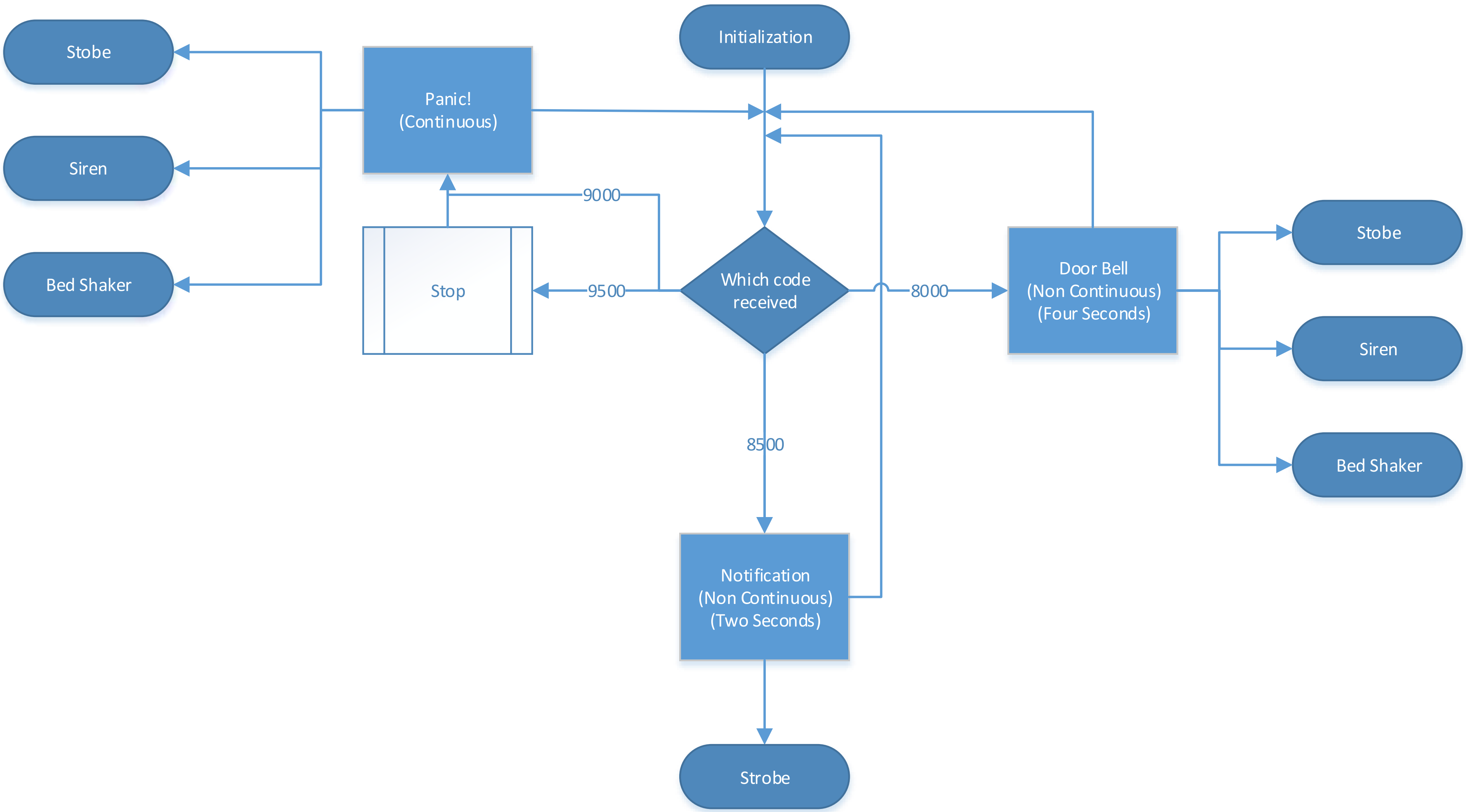


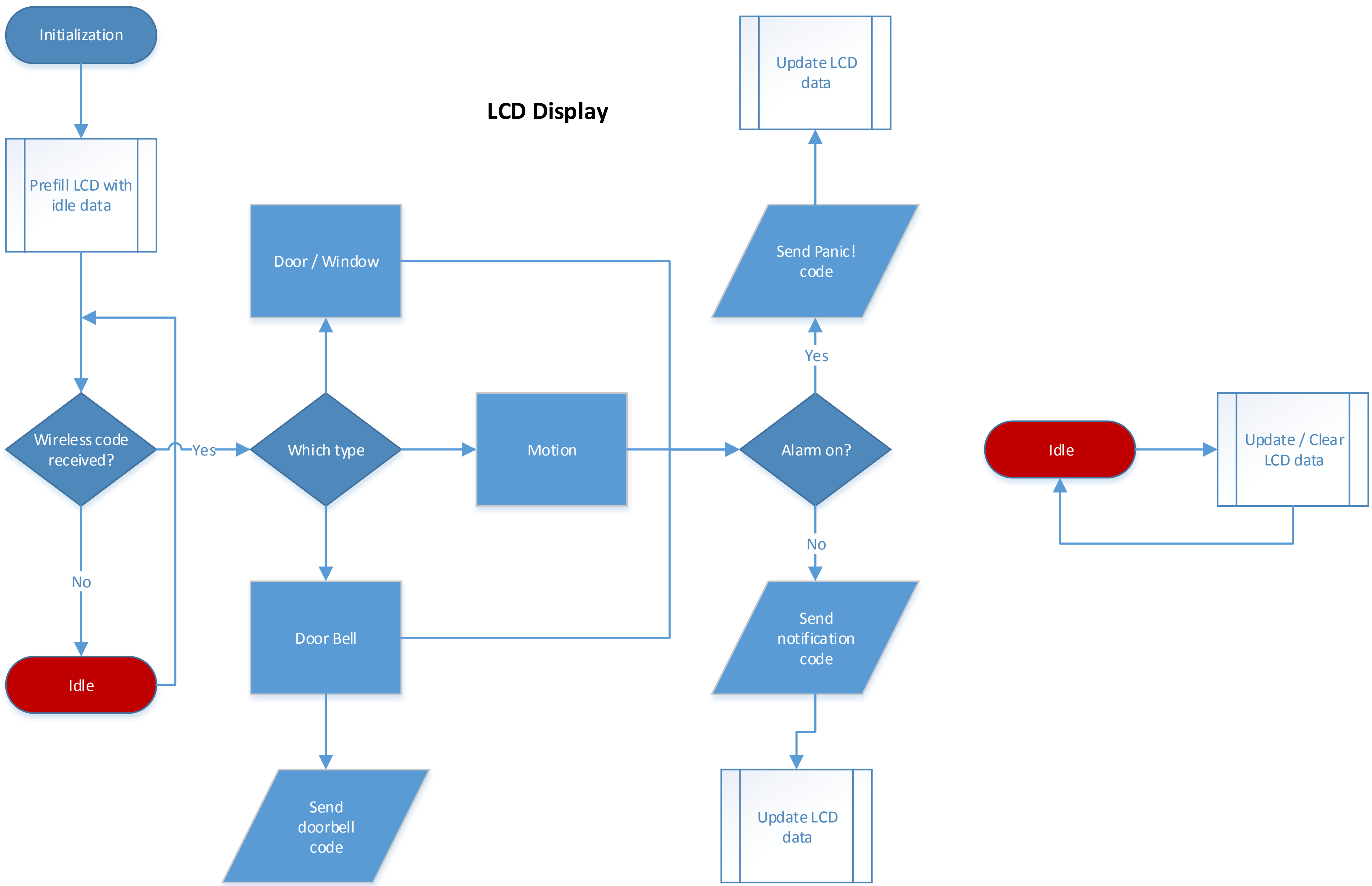
Power
5Volts
12Volts
RF Wave
ASK Receiver
5Volts
GPIO
ATtiny85
MCU
GPIO
ON/OFF
MOSFETs
Feedback
System

7.1 SOFTWARE FLOW CHARTS (See attachment SFC.pdf for larger version)



Alarm Unit


Stobe
Siren
Bed Shaker
Panic!
(Continuous)
Initialization
9000
Stop
9500
Which code
received
8000
Door Bell
(Non Continuous)
(Four Seconds)
Stobe
Siren
Bed Shaker
8500
Notification
(Non Continuous)
(Two Seconds)
Strobe


LCD Display
Initialization
Prefill LCD with idle data
Wireless code received?
Yes
No
Idle
Which type
Door / Window
Motion
Door Bell
Send doorbell code
Alarm on?
Yes
No
Send Panic! code
Update LCD data
Send notification code
Update LCD data
Idle
Update / Clear LCD data

9.0 CRITICAL COMPONENTS

9.1 Measurement Instruments

- Multimeter: Used to measure voltages on the system.
- Oscilloscopes: Used for making sure the data is send correctly.
- Logic probe: Used to supplement the oscilloscope.

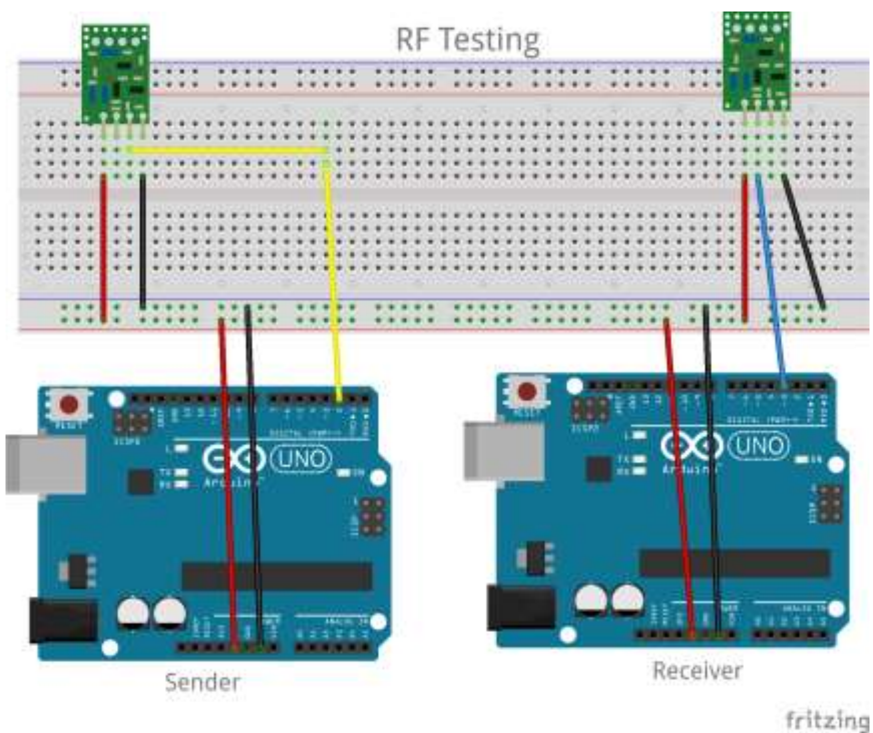
9.2 PCB Development

- Soldering iron: Used to solder things to PCB.
- Wave soldering oven: Greatly helps soldering surface mount devices.
- Milling machine: Used to mill PCB.

10.0 TESTING

10.1 RF-Transmit to RF-Receiver Communication Testing

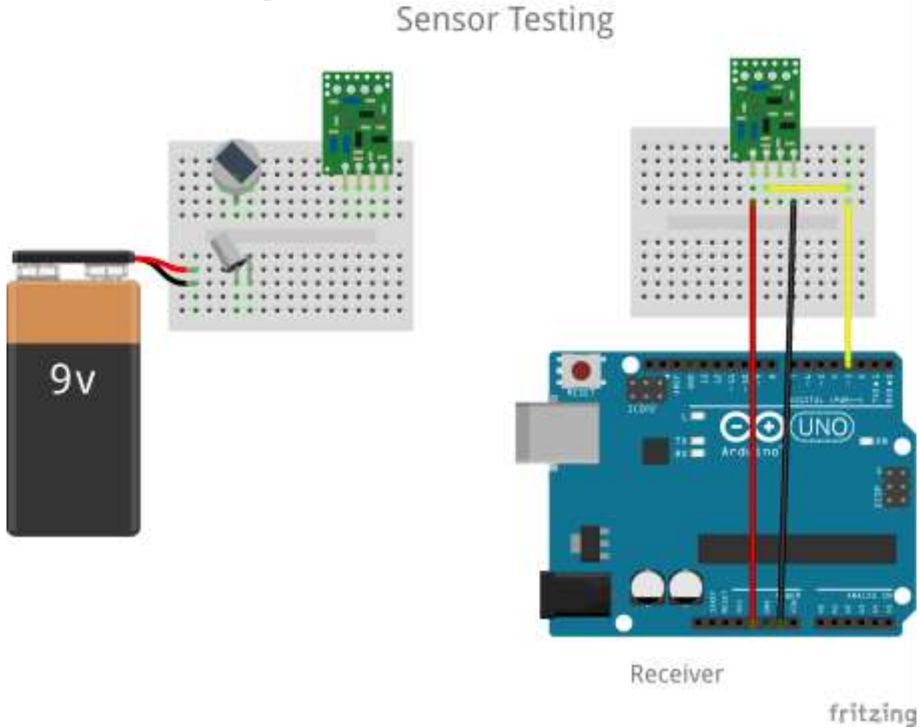
- Arduino platform is the basis to test the RF units.
- Tests will be done at various distances to identify the range of the devices.



10.2 Sensor to Receiver Communication Testing

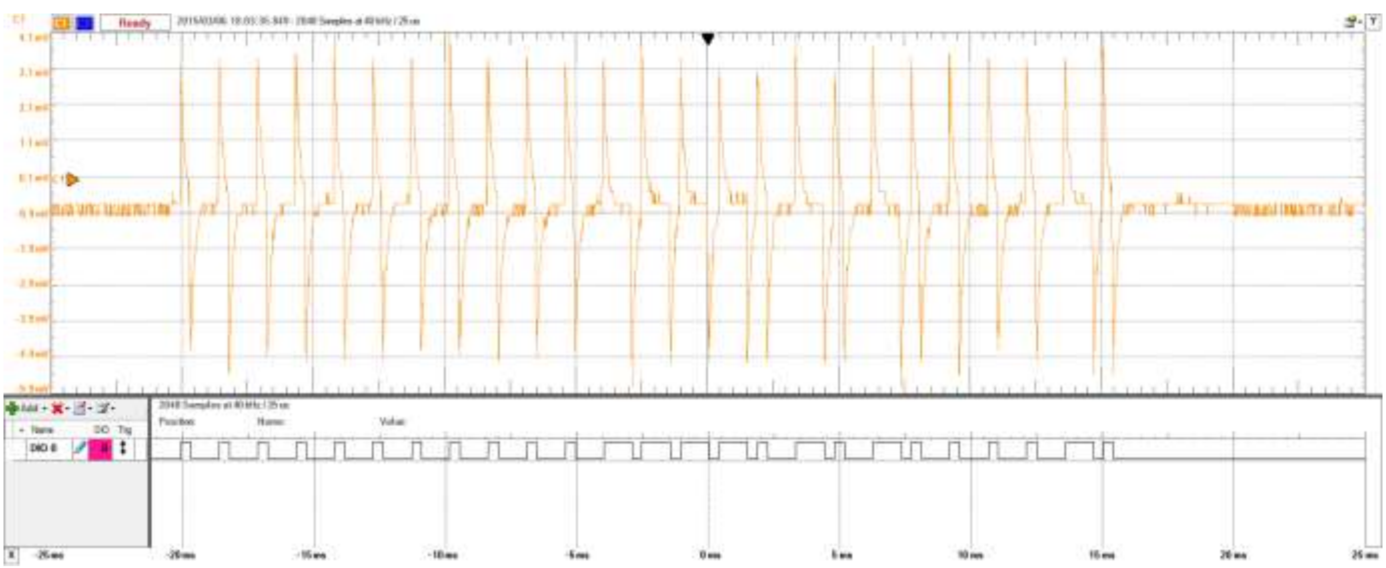
- Arduino platform is the basis to test the RF units.

- Identify the protocol used for the COTS devices.
    - Record the unique IDs
- Tests will be done at various distances to identify the range of the devices.
- Use oscilloscope to check data transmission

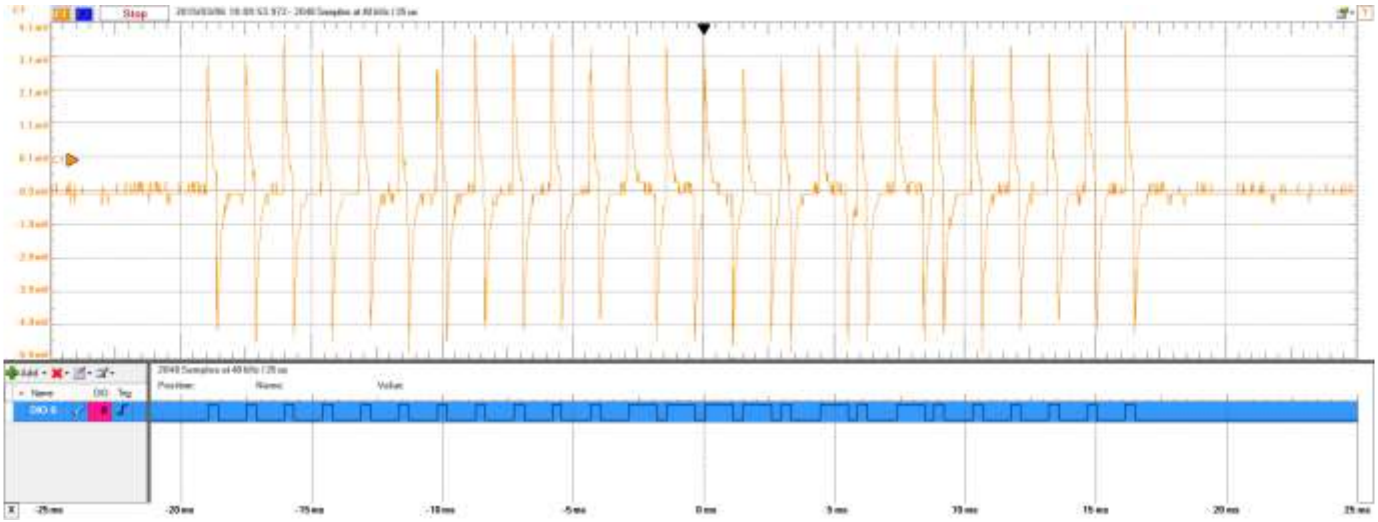


11.1. TESTING RESULTS

11.1 Digital signal to RF



11.2 RF to Digital Signal



11.3 Antenna Testing

- Helical Antenna
  - The key fob range was about 6 feet from the base station in a speed of about 1 second.
  - Through Wall Testing
    - Window/Door Sensor
      - Had a calculated range of 73.93 feet by using Pythagorean theorem.
    - Motion Sensor
      - Had a calculated range of 49.4 feet by using Pythagorean theorem.
    - Notice: The more dense metal in the walls the more difficult it was for the signal to reach the base station.
  - Line of Sight Testing
    - Window/Door Sensor went to 81.6 feet base station.
    - Motion Sensor went up to 70.3 feet from base station.

- Monopole Antenna
  - The FOB range was increased to 10 feet from base station.
  - Through Wall Testing
    - Window/Door Sensor
      - Had a calculated range of 84.96 feet by using Pythagorean theorem.
    - Motion Sensor

            - Had a calculated range of 62.07 feet by using Pythagorean theorem.
        - Notice: Monopole antenna worked better when we raised it higher than it did with the helical antenna.
    - Line of Sight Testing
        - Window/Door Sensor went to 85.5 feet from base station.
        - Motion Sensor went past 150 feet but couldn't get accurate readings past a point because it would have passed through metal doors which would interfere with the signal.

12. RISK / MITIGATION PLAN

12.1 Risks

- Sensors
    - Risks
        - Battery: Only 55mAh of energy.
        - Range: Dependent on battery.
        - Signal Quality
        - Magnets for door / window sensors: Not permanent magnets.
        - Signal transmit: Dependent on voltage level.
        - Sensor elements: Passive Infrared (PIR) can fail.

- Electronics
    - Risks
        - ESD can destroy the delicate MOSFETs.
        - Electrocution from AC mains.
        - Burns from soldering iron

12.2 Mitigation Plan

- Battery (High Risk): It also affects the range of the transmission. In the window and the door sensors, battery life is extremely important. The analog comparator inside the ATtiny85 will be used to measure battery voltage. When the battery reaches 9 volts a low battery signal will be sent. Otherwise use a DMM to measure the voltage left in the battery and change it out. Indicator light will appear if battery needs change.

- Range (High Risk): The range is dependent on the battery. An external antenna is added to further increase the default range. To monitor this, trigger the sensors to send a signal to the base station. If the range is short change the antenna or check the battery life of the sensor or base station to see what is the cause of the range change.

- Signal Strength (High Risk): Use SDRSharp program to see the signal strength given off from each of the sensors.

- Magnets (Low Risk): Check to see if magnets still have magnetism by triggering the sensor to send a signal to the base station. If it doesn't, put a different magnet on there.

- Signal transmission (High Risk): The sensor sends the signal three times for redundancy. Use SDRSharp program to check the signal strength of each component.

- Sensor elements (High Risk): Components can overheat so put in cool dry areas to avoid that risk. Do not place the sensors in areas like the bathroom or other humid areas.

- Radiation (Low Risk): Wireless systems have RF radiation which can affect the human body. To detect how much the system is radiating use an RF meter. If it's too much you can turn off the system when at home then when leaving turn it back on so that one can avoid its radiation.

13. CDR APPROVALS