



SmartRVAC

Group C

Claudio, C.p.E.

Francisco Martinez, E.E.

Sergio Perez-Aponte, C.p.E.

Customer/Sponsor: RV Intelligence



Introduction

- **Recreational Vehicle (RV) market is been growing for eight consecutives years.**
- **AC systems on RV hasn't keep up with technology changes in the market.**
- **Monitoring and control product for RV AC units.**

Motivation

- A/C have become an essential commodity of our society.
- Not having a working unit can be a life and death situation and a huge inconvenience.
- It is found almost every, houses, Hospitals, vehicules, etc.
- We wanted to put our grain of sand for the betterment of society.

Goals and Objectives

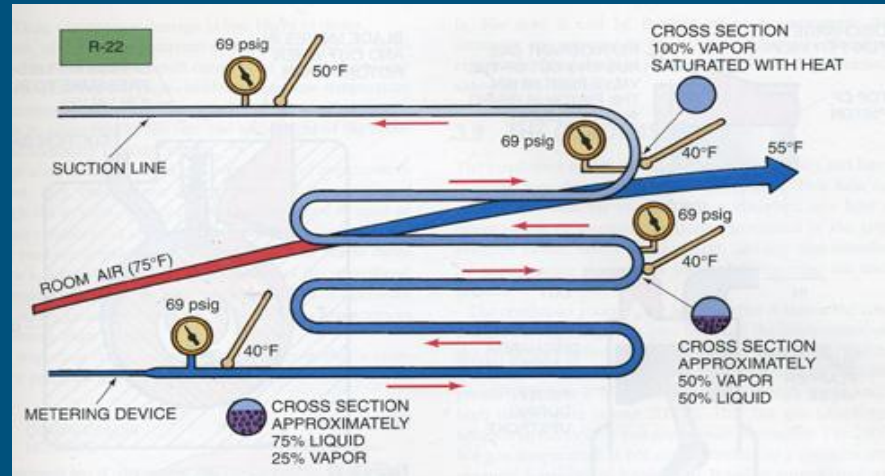
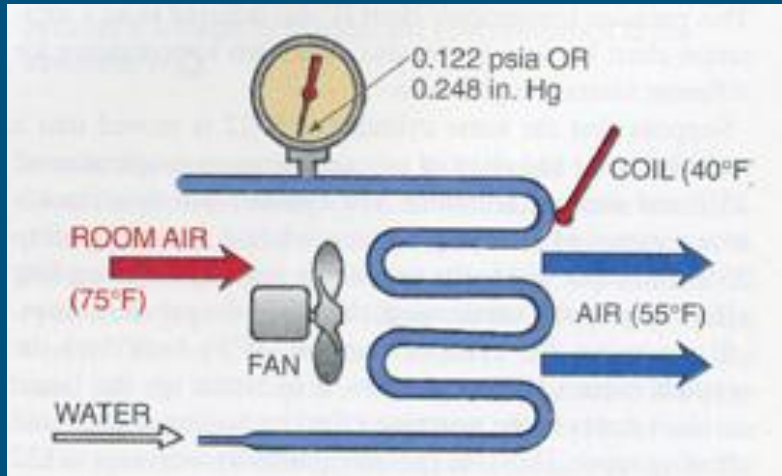
- A product that monitors a RV A/C unit.
- Display the monitoring data on app.
- User can control the A/C thermostat on app.
- A device that is easy to use, install and empower the user.
- An application that is easy to use and shows relevant data.

A/C Basics

- Evaporator and the Condenser
- Metal coils
- Compressor
- Gay-Lussac's Law
- Pressure is proportional to Temperature
- $P \uparrow T \uparrow$. $P \downarrow T \downarrow$

A/C Basics

- Fans for circulation
- Water vs Refrigerant
- Expansion Valve



Implementation

- Critical points of AC unit:

Condenser Expansion Valve Fan Current
Evaporator Compressor Current

- Remote Temperature Sensors
- Power measuring devices
- Relays for controlling current flow

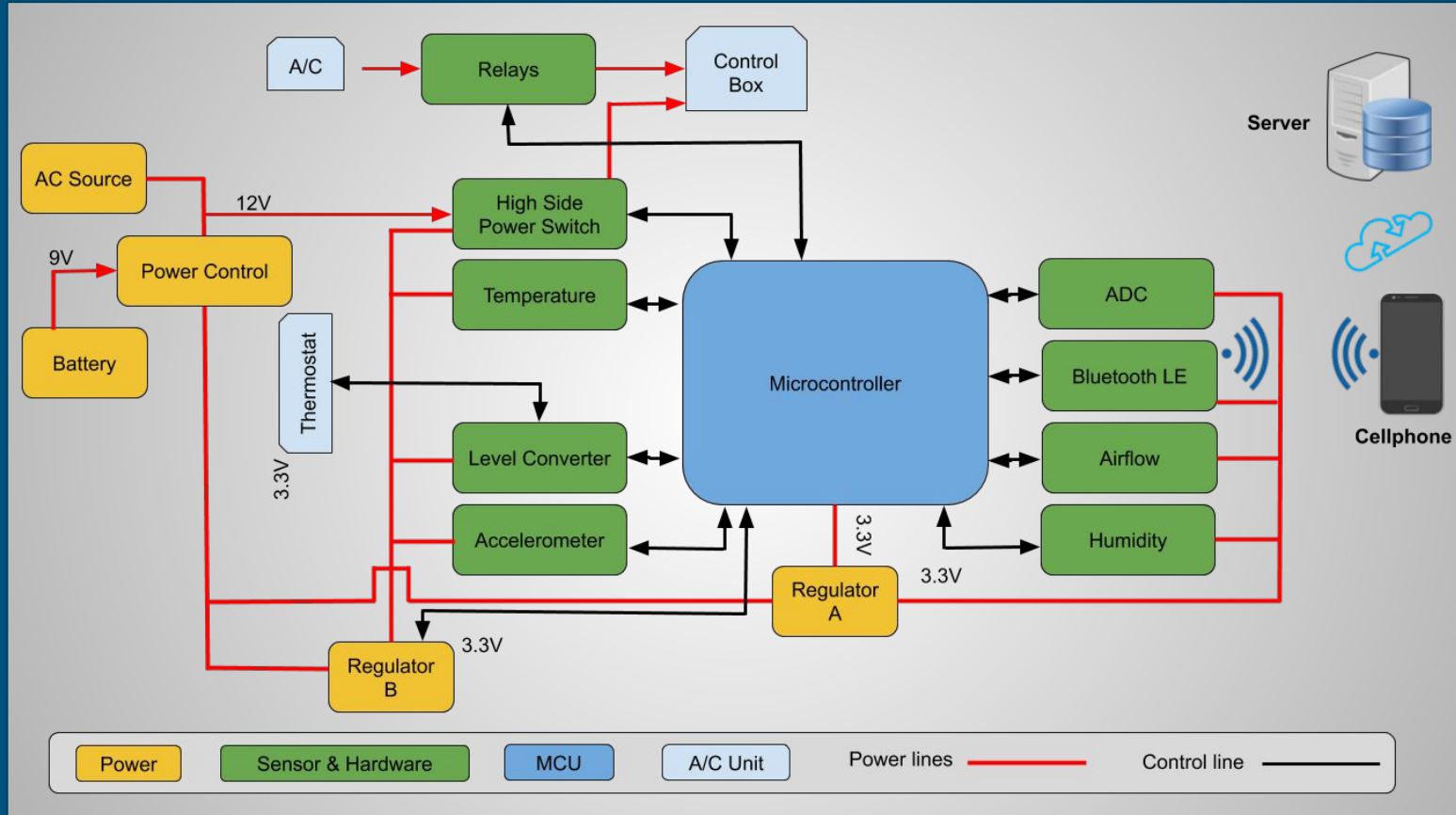
User considerations

- Previous technology
 - Thermostat
 - AC Control Boxes
- User control:
 - Compressor
 - Fan
- Diagnostic Data
- User accessabilities via phone application

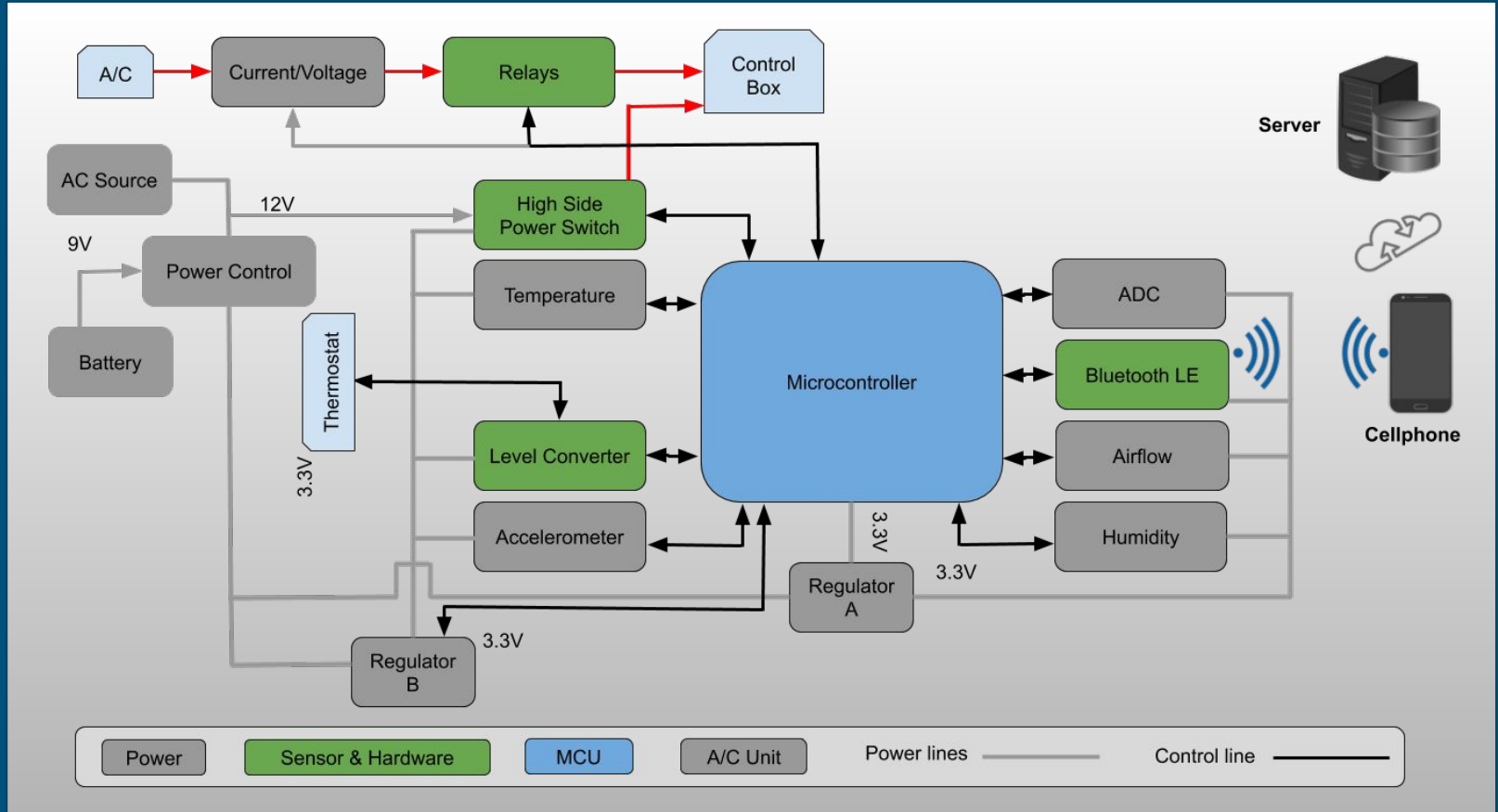
Specification & Requirements

- The device should not weight more than 1lb
- The device should have a battery to operate while the 12v are not supply.
- The device shall have a microcomputer and Bluetooth low energy.
- The microcontroller should have two serial communication blocks and 21 GPIO pins.
- The device shall have BLE to communicate to the application.
- The Device shall record upto a day of data when BLE is not connected.
- The device measure current, voltage, temperature, moisture, and vibrations.
- The mobile app UX shall display the data in an easy to read manner.
- The mobile application shall receive data from the device and send to the server.
- The server should store and compute sensor data to be display on the application.

System Block Diagram



Thermostat User Interface Controls



Thermostat Interface

Standard thermostat signal lines consist of

R: 12V Power

Y: Compressor

GH: High Fan

GL: Low Fan

W: Heat

B: Ground

Necessary Design Criteria

Level conversion from 12V to 3.3V

Signal Replication to Control Box

Relay control

AC Current and Voltage Measurement

- Mate-N-Lock Connection Header
- Continuity for the AC parts in the 3x3 header
- Relays to control continuity for AC current



Project Difficulties

- Sponsor selected bluetooth module
- Limited number of GPIO pins
- Digi-Key out of stock on current sensors
- Allegro SPI VS I2C Part
- Microchip Redesign
- Current and humidity sensor I2C corruption
- Compress Failure

Difficulty Solutions

- GPIO Expander
- I2C Chip selections on parts
- Second choice in current measurement device
- Redesigning the board in the current section with the new microchip part

Design Changes

- Sponsor Design Changes
- Three separate boards

Thermostat

Main

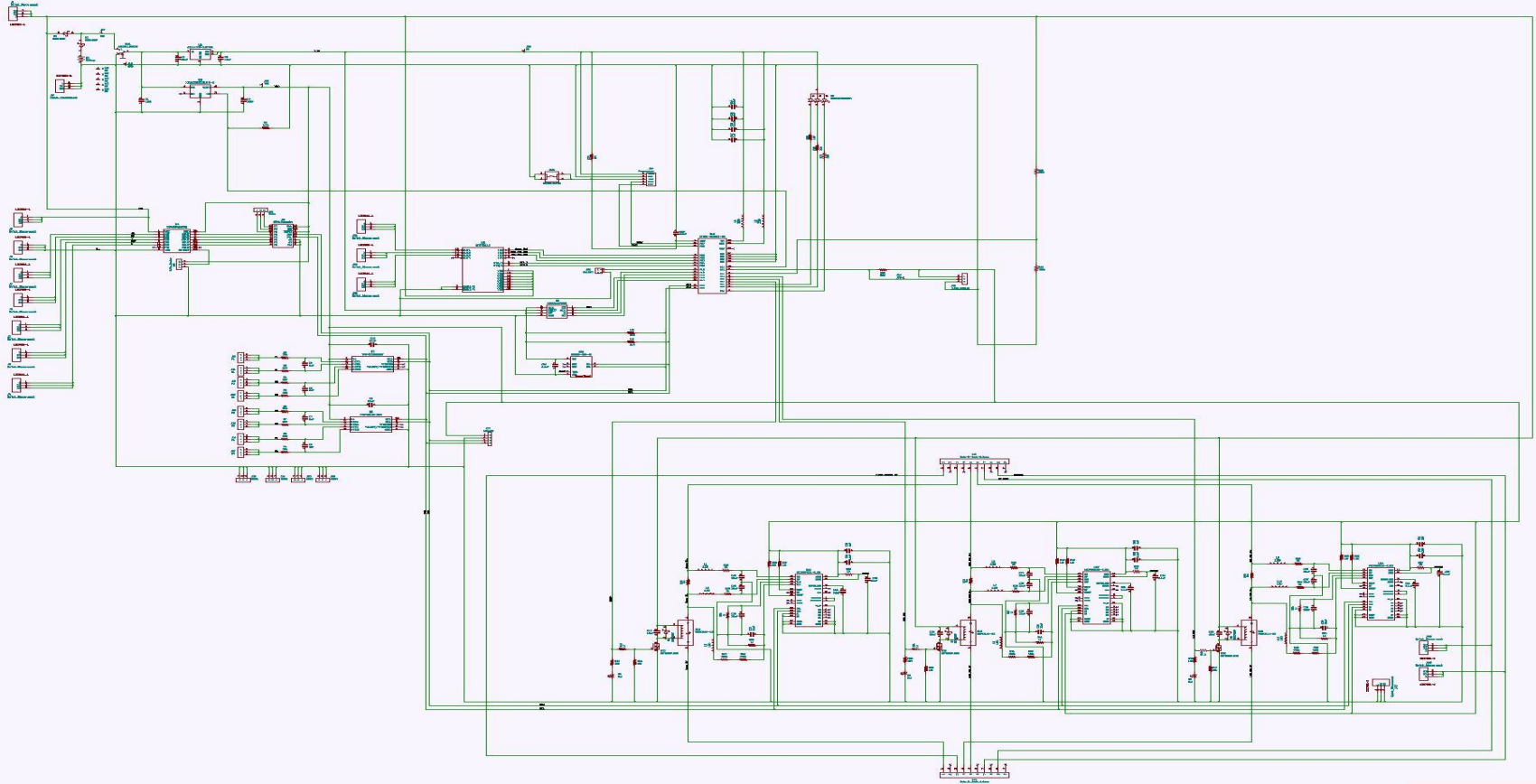
Sensors

- RS-485 Communication
- Rogowski coil to measure current

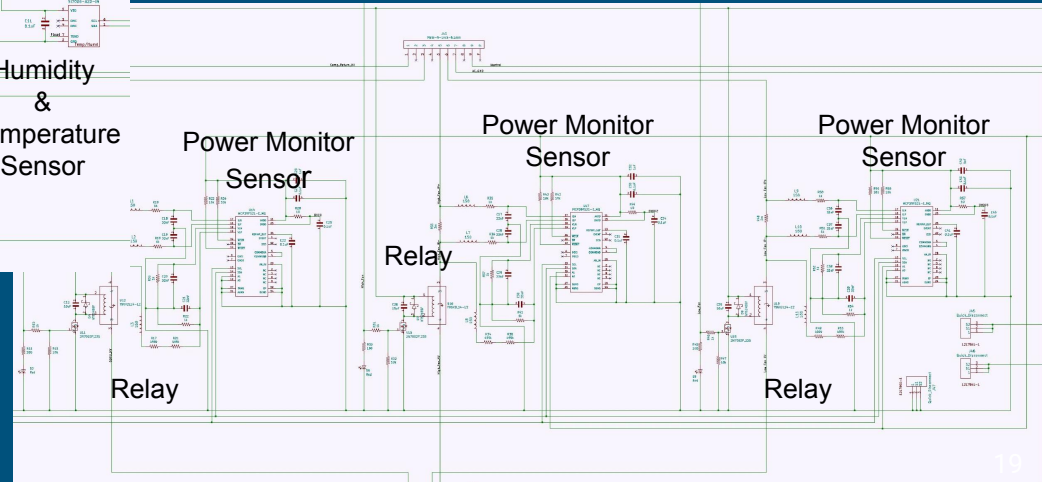
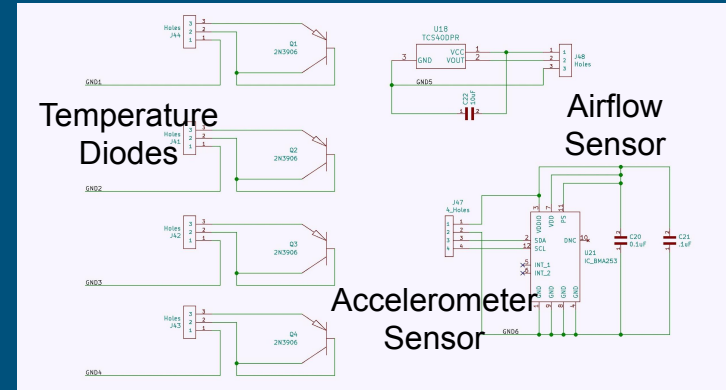
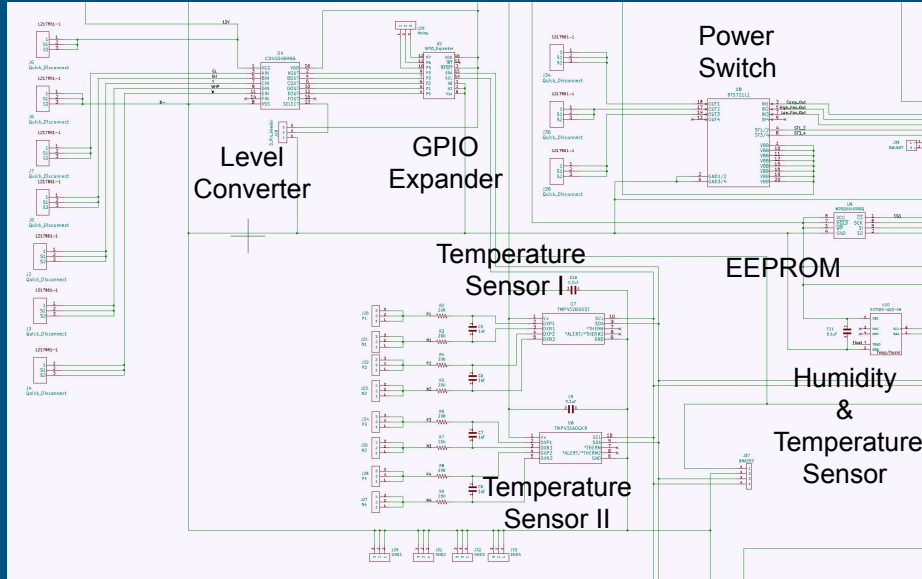
Design Solutions

- Cost of having three boards
- Complexity of software design
- Easy connections for user
- One board to install with direct module communication to the phone
- Remote temperature sensors come out from the board

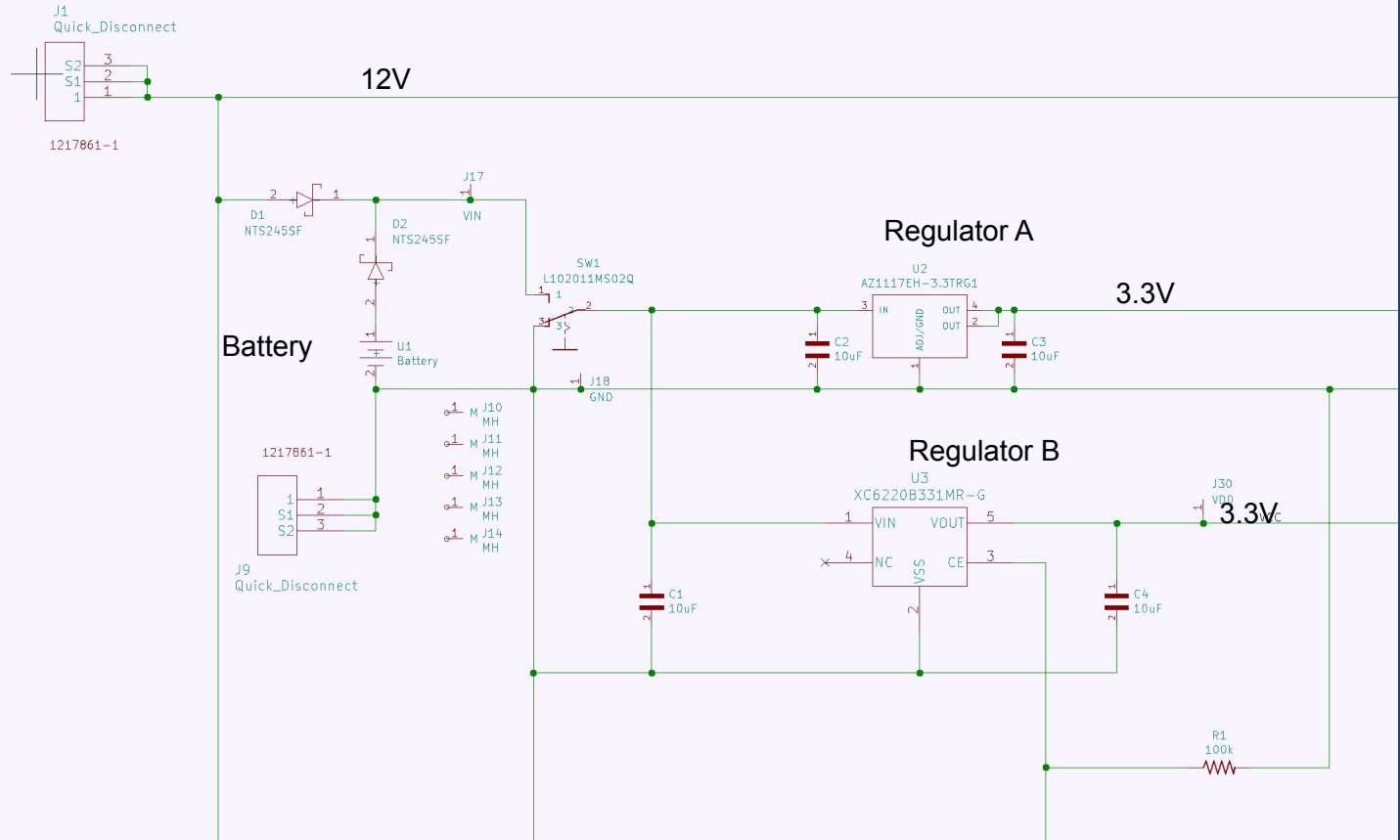
Overall Schematic



Overall Schematic



Power



Power

- Two regulators that step down from 12V to 3.3V
- Battery and 12V source
- Diode steering to switch from battery back up to source
- First Regulator

Module

Local/Remote Temperature

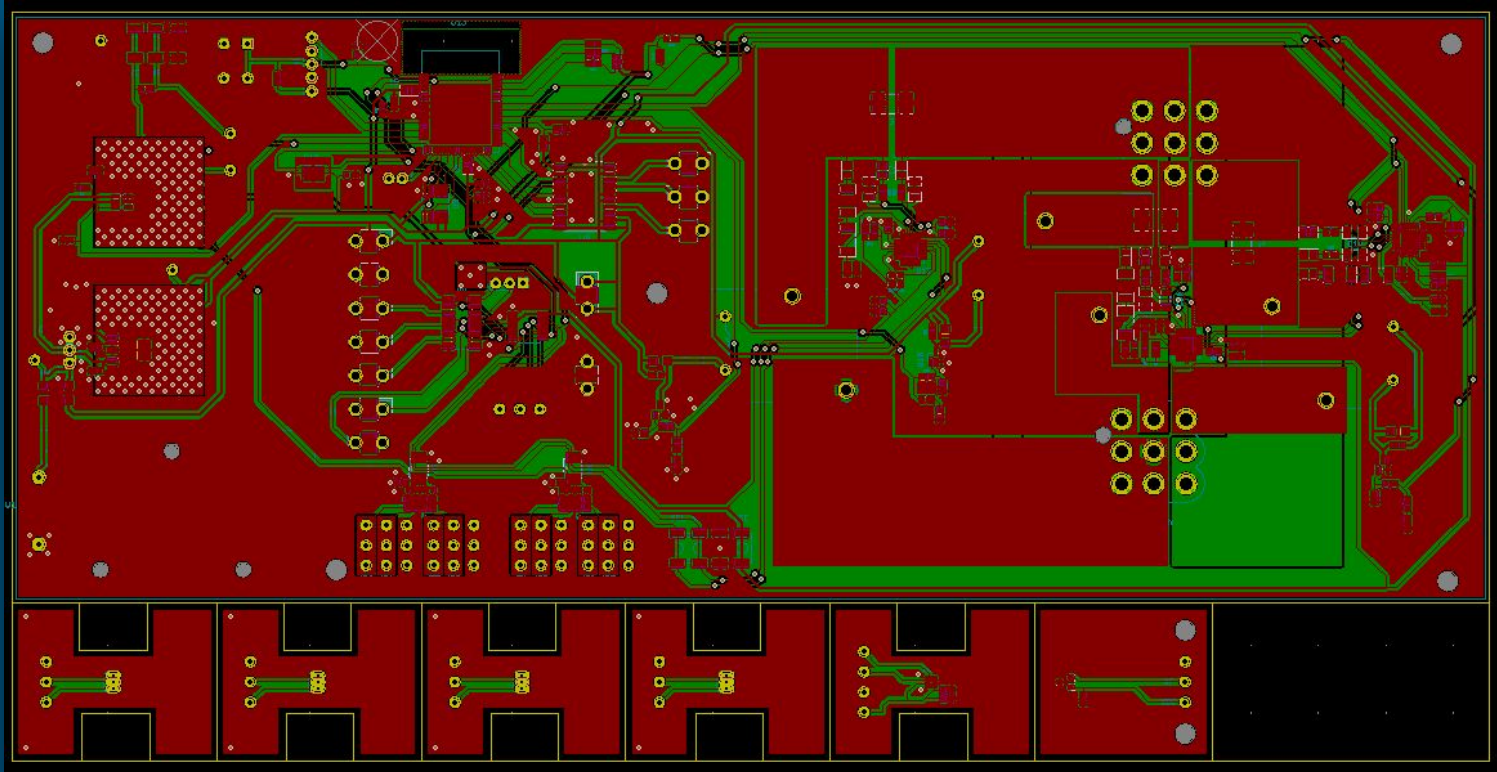
- Second Regulator

Sensors

GPIO Expander

Level Converter

PCB Design



PCB Designing Tool Decision

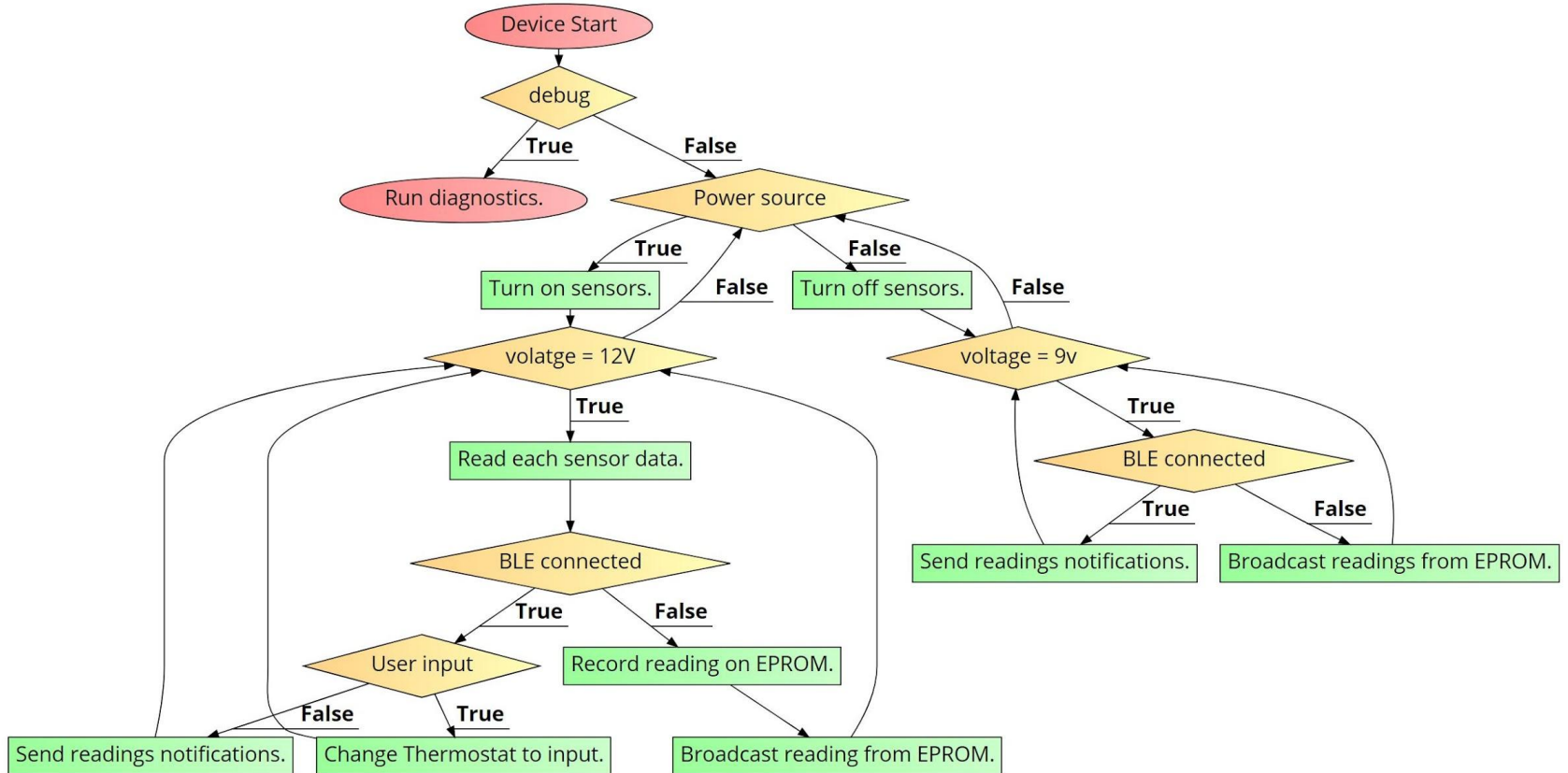
- Kicad
- Free software
- No limits to board size
- No license
- Easy to use

Microcontroller Decision

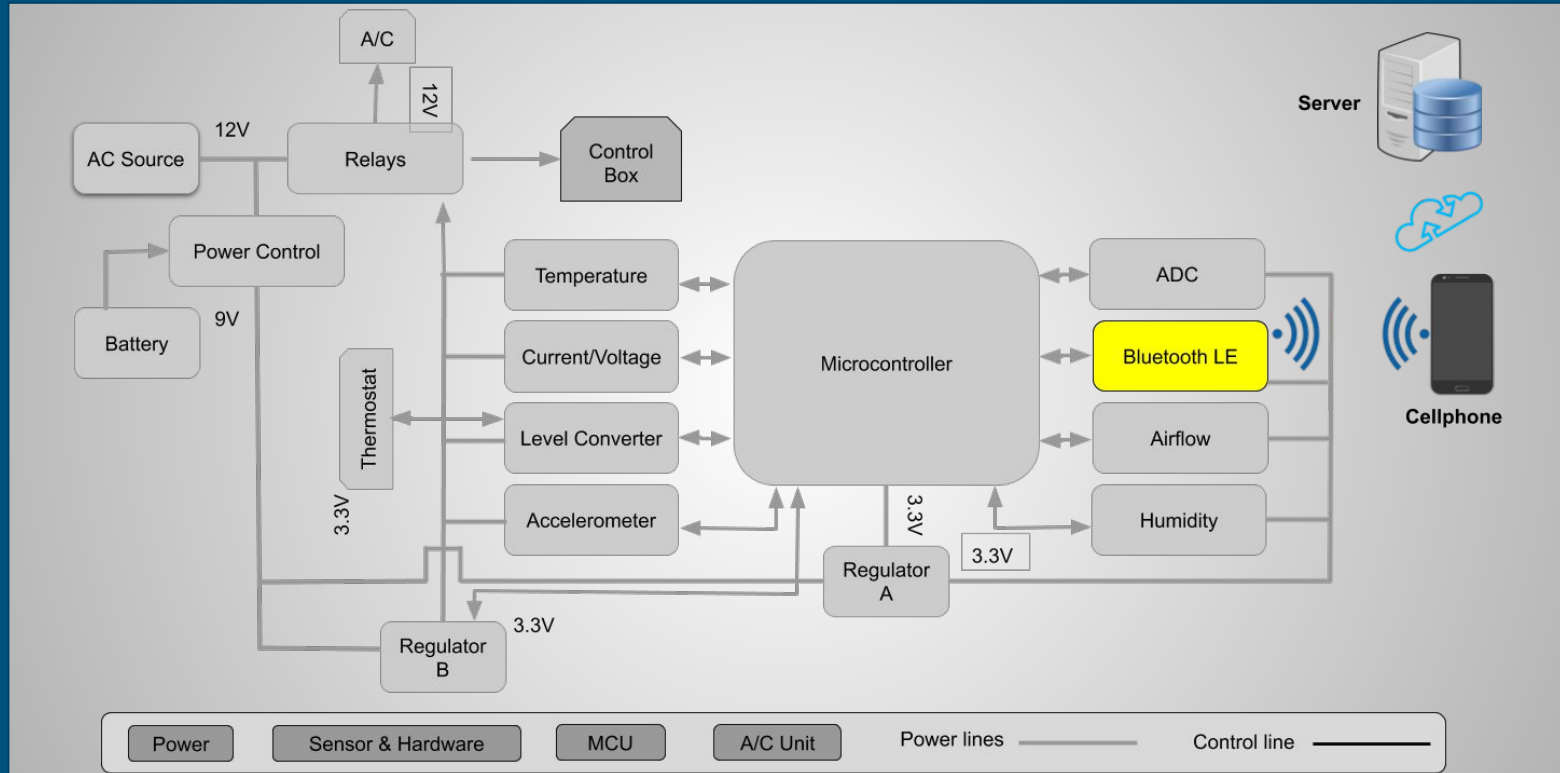
Chip Family	Low Energy	Microcontroller Core	Programmable Logic	Configurable Analog Peripherals	Hardware Blocks
SoC	Yes	Yes	No	No	No
PSoC	Yes	Yes	Yes	Yes	Yes

- Cypress Semiconductor offer PSoC with BLE in module format.
- The modules have received certification by different countries.

Embedded Flowchart



Device-App Communication Block Diagram



System Software

This subsystem is responsible for:

- **Display A/C unit diagnoses:** display temperature readings, humidity readings, vibration readings, power consumption readings, current readings, voltage readings, thermostat control lines wire readings.
- **Remotely Control the A/C Unit:** change ambient temperature, turn on/off each thermostat control wire wire and other AC features, turn off the A/C unit.

Software Features

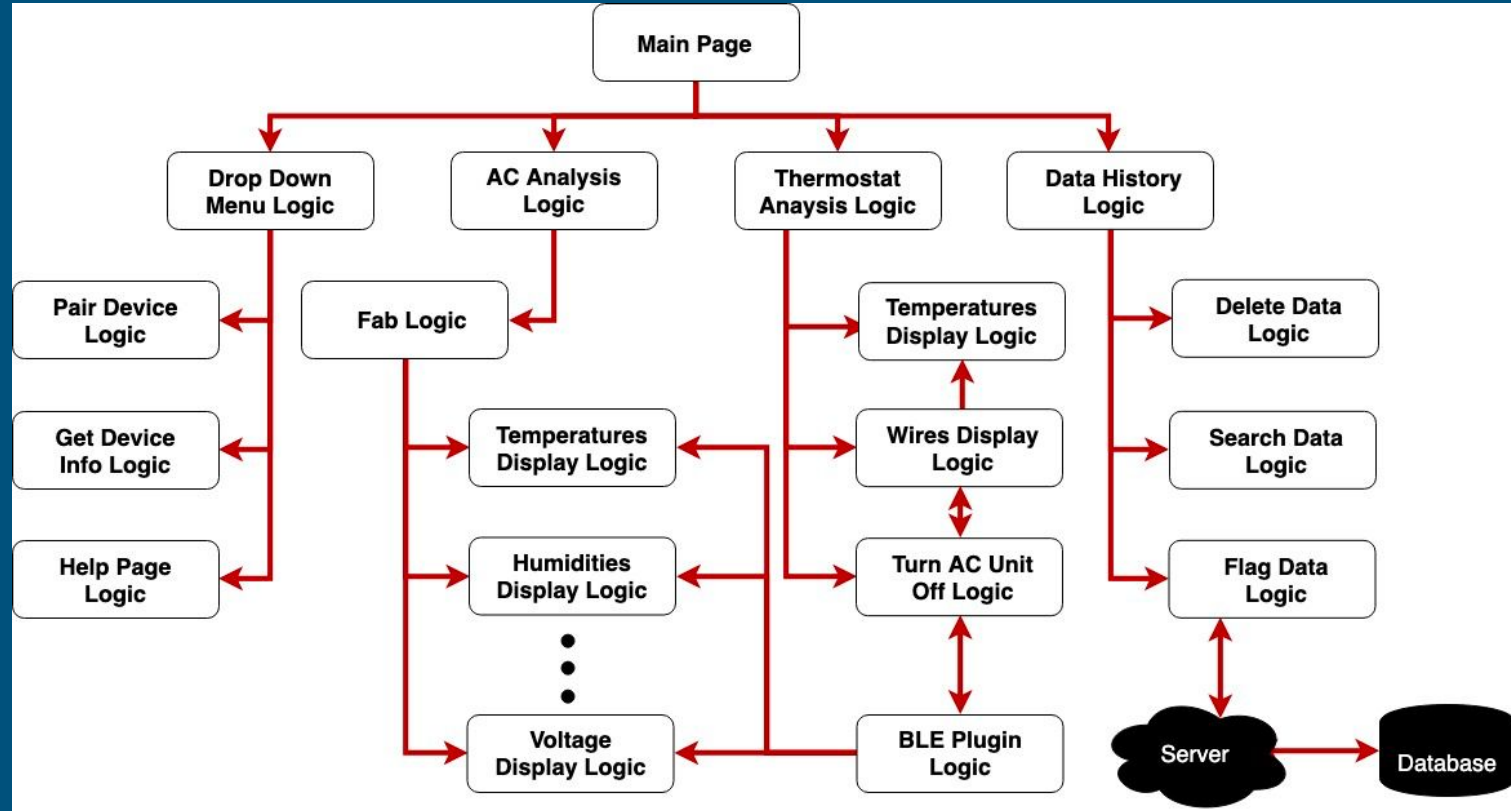
Building Blocks:

- Mobile Platform
- Implementation Approach
- Development Tools / APIs
- Programming Languages
- Server
- Database or Storage
- Graphical User Interface Design

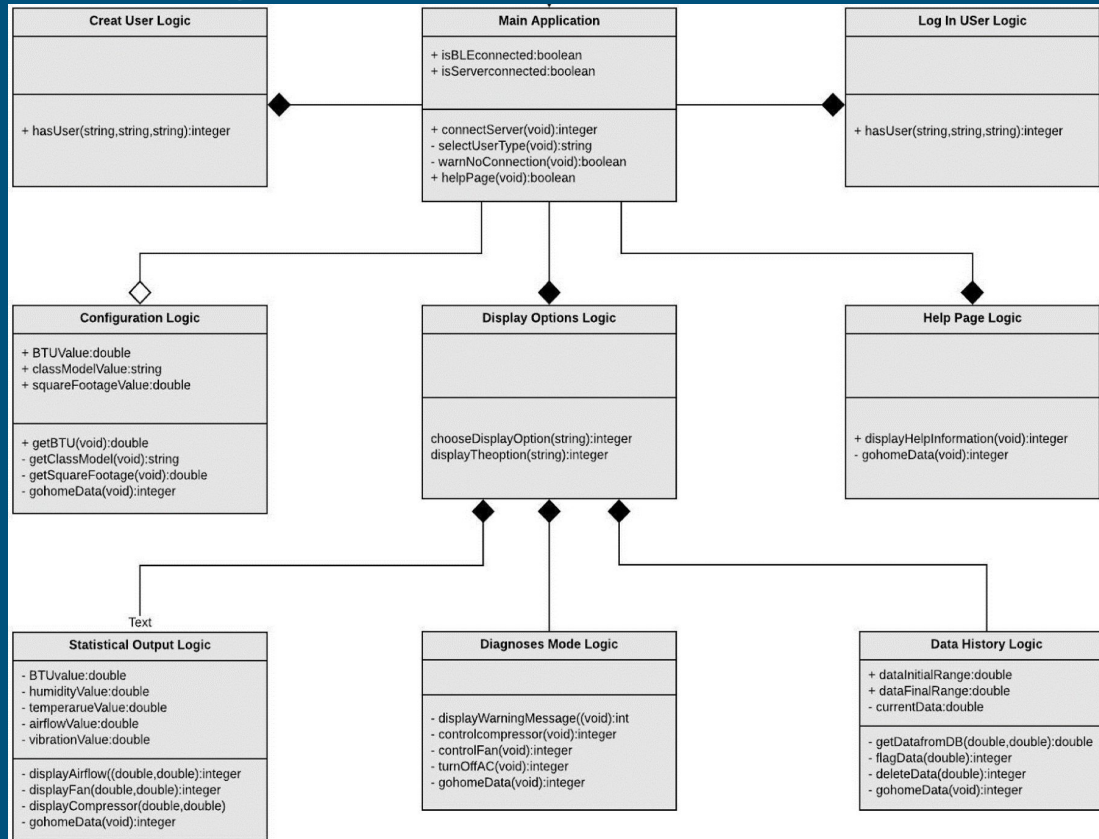
Mobile Platform Decision

Platform	Iphone Compatibility	Android Compatibility	Web Browser Compatibility	Desktop Compatibility	Need Installation
iOS	Yes	No	No	No	Yes
Android	No	Yes	No	No	Yes
Web App	Yes	Yes	Yes	Yes	Yes/No

Software Implementation Approach



UML Class Diagram



Development Tools Decision

API	Support for Other Tools	PWA Development	Native iOS/Android Conversion	Flexible to Use
Ionic 4	Yes	Yes	Yes	Yes
Angular	No	Yes	Yes	No
React	No	Yes	Yes	No

We are using Ionic 4, with Angular 7 as a wrapper.

Programming Language Decision

Language	Supported by Ionic 4	Front End	Back End
Python	No	Yes	Yes
Java	No	Yes	Yes
Javascript	Yes	Limited	Yes
HTML & CSS	Yes	Yes	No

Server Decision

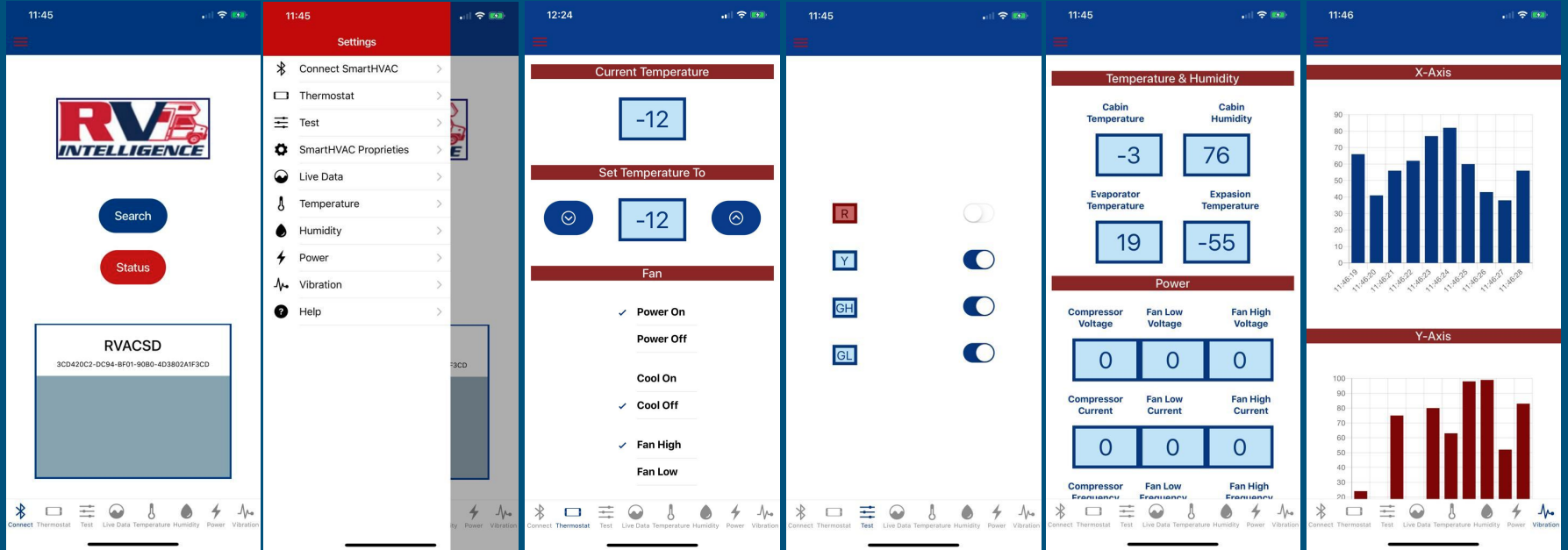
Provider	Charging	Regions	Integrated in Ionic 4	Storage	Longer Subscription
AWS	\$ / Hour	21 Regions, and 60 Availability Zones	No	Simple Storage Services (SS3)	Yes
GCP	\$ / Minute	18 Regions and 55 Availability Zones Availability	No	Google Cloud Storage	No
Firebase	-	18 Regions and 55 Availability Zones Availability	Yes	Google Cloud Storage	-

Firebase uses Google Cloud Platform services.

Database Decision

Provider	Require Internet Connectivity	Storage Capacity
MongoDB	YES	Unlimited
Firebase	YES	Unlimited
Ionic 4 SQL Lite	NO	Phone Storage Capacity
Ionic 4 Local Storage	NO	10 MB

GUI Interface



Software Design Challenges

- Implement BLE plugin due to lack of Ionic 4 tutorial materials available on online platforms.
- Implement iOS/Android native plugins on Ionic 4 cross-platform plugin, Capacitor, due to its small library.
- Run cordova on Linux (Ubuntu 16.04 LTS) operating system due to platform incompatibility.
- Pass objects in between pages due to Ionic 4 Angular Routing.
- Use P5.js FFT library.

Software Design Solution

- Used the Ionic community support and worked in group.
- Changed to Ionic 4 cross-platform plugin, Apache Cordova.
- Migrate the project to macOS.
- Stop the BLE notification when leaving a page, and start when entering a different page.
- Use Ionic Local Storage to pass objects between pages.
- Use import FFT.js support on Ionic 4, and use different graphing APIs to graph the data.

Budget

Part	Cost
PCB	\$14.52
PCB Parts	\$108.00
Demo	\$140.00
A/C unit	Donated
Total	\$262

Work Distribution

Group Member	Primary Work	Secondary Work	Tertiary Work
Francisco Martinez	Sensors and PCB Boards	Embedded Code	Web App and Server
Claudio Leandro de S. Afonso	Web App and Server	Embedded Code	Sensors and PCB Boards
Sergio E. Perez-Aponte	Embedded Code	Web App and Server	Sensors and PCB Boards



Questions?