Soil Smart

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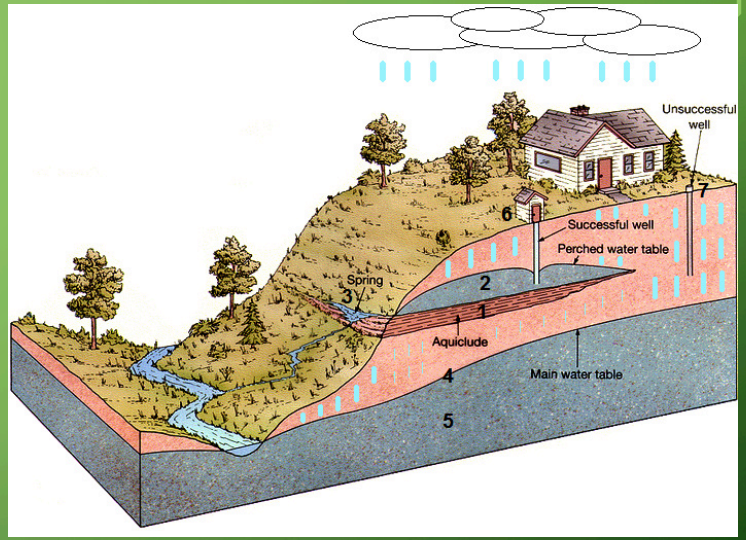
Market Attractiveness

Traditional irrigation techniques take use of a cyclical watering cycle routine with little to no soil moisture content feedback which wastes water, damages the soil and hurts farmer's yields.

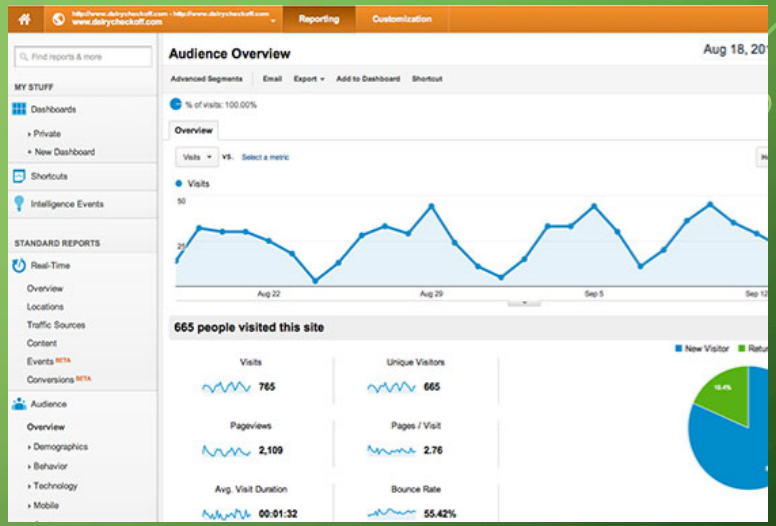
Farmers with variations in soil densities and compositions or geographical variances often suffer from over/under watering their crops in affected areas.



Soil Smart Goals

Provide a user friendly environment that allows farmers to observe data drawn from crops and control irrigation flow based on given conditions.

Display reliable data analytics in a clean environment that informs farmers on past and present soil conditions.



Product Definition

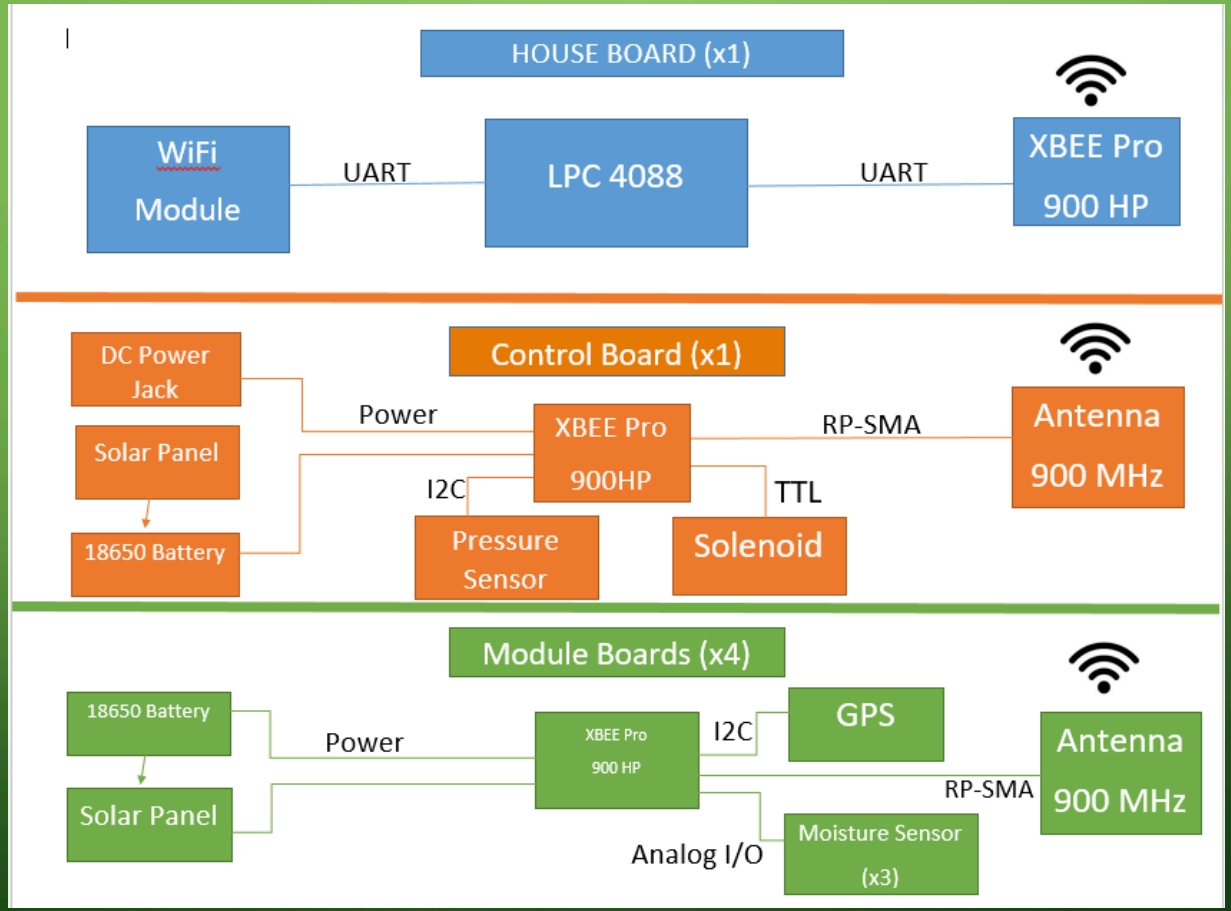
Soil Smart is a wireless sensor network that monitors and records soil conditions, and detects leakage in pipes. This information is used to control irrigation systems and is made available to the user via a mobile app and web interface.

Product User Interface (UI)

Farmer will be able to access soil data from Website or Mobile App

- observe current soil moisture levels at different locations throughout farmland
- control irrigation flow
- view past to present moisture trends displayed with graphs all specific to locations on farmland
- leakage detection

HIGH LEVEL BLOCK DIAGRAM



HIGH LEVEL METHODOLOGY

-Our sensor modules, spread throughout the test area, will use GPS to map their coordinates and form a grid that will periodically relay the drawn data to a control board.

-Each sensor module will have three soil moisture sensors placed at different depth levels which will relay its data to the control board.

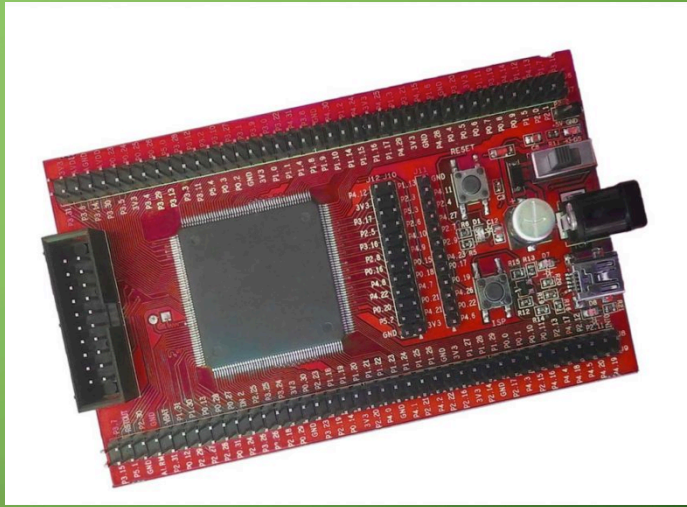
-The control board will send the data to the house board where the data will then be grouped accordingly.

-The house board will send the data to the server through the internet and will be displayed on the mobile app/ website, where solenoids can be controlled from.

MAIN COMPONENTS

- Cortex M4 LPC 4088
- XBEE Pro 900 HP / XBEE Antenna
- Solar Panels
- 18650 Battery
- GPS Module
- WiFi Module
- Soil Moisture Sensor
- Pressure Sensor
- Solenoids

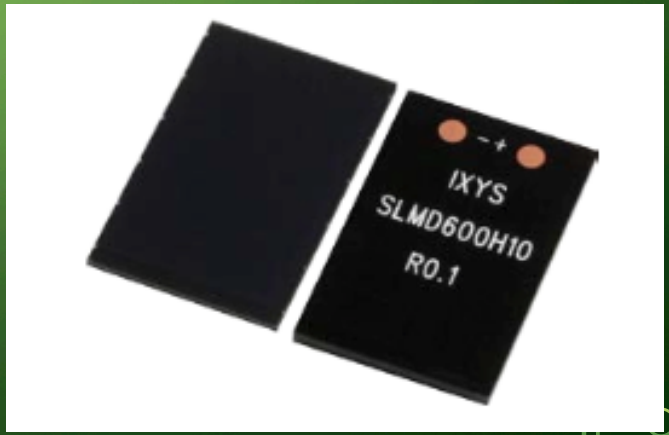
Cortex M4 LPC4088



- Power: 3.3V
- Buses:
  - UART (x5)
  - SSP (x3)
  - I2c (x3)
  - CAN
- Memory: 512KB on-chip flash mem
- Clock Source: main oscillator variable speed

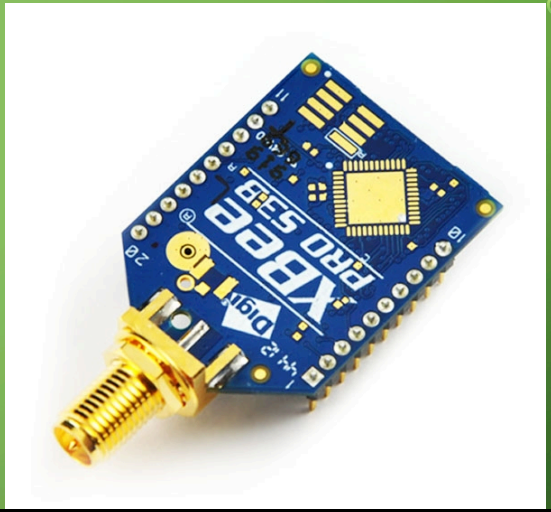
Solar Panel - IXOLAR Solar MD

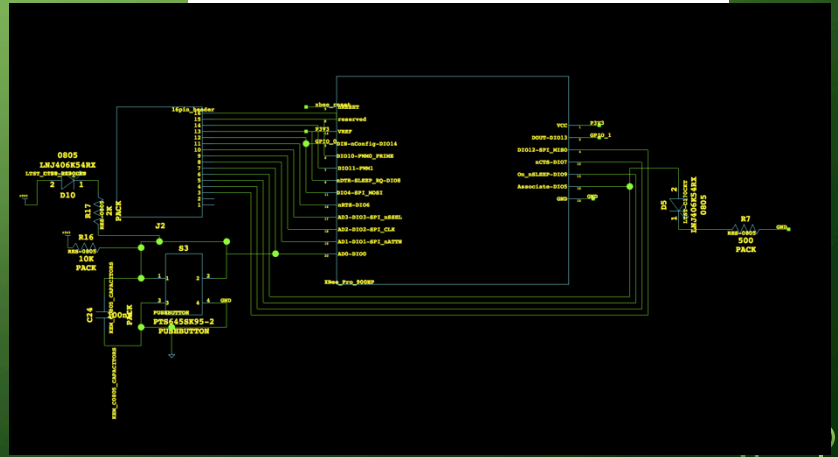
- Voc: 6.3V
- Isc: 25 mA
- Solar Cell Efficiency: 22%
- Dimensions (LxWxH): 22 x 35 x 2 [mm]



XBEE PRO 900HP

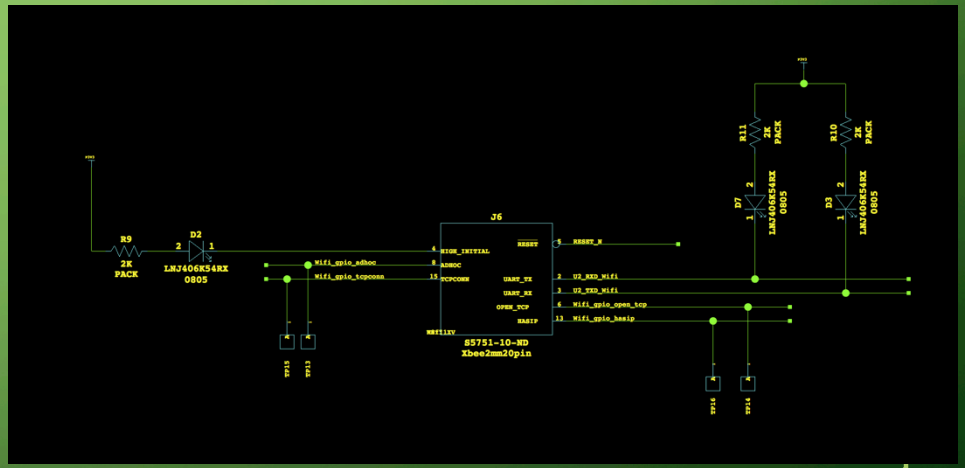
- Processor: Cortex-M3 EFM32G230
- Data Interface: UART (3V), SPI
- GPIO: 15 Digital I/O, 4 10-bit ADC inputs, 2 PWM outputs
- Memory: 32KB Flash / 2KB RAM
- CPU/Clock Speed: HCS08 / 50.33 MHz
- Supply Voltage: 2.4 - 3.6 VDC





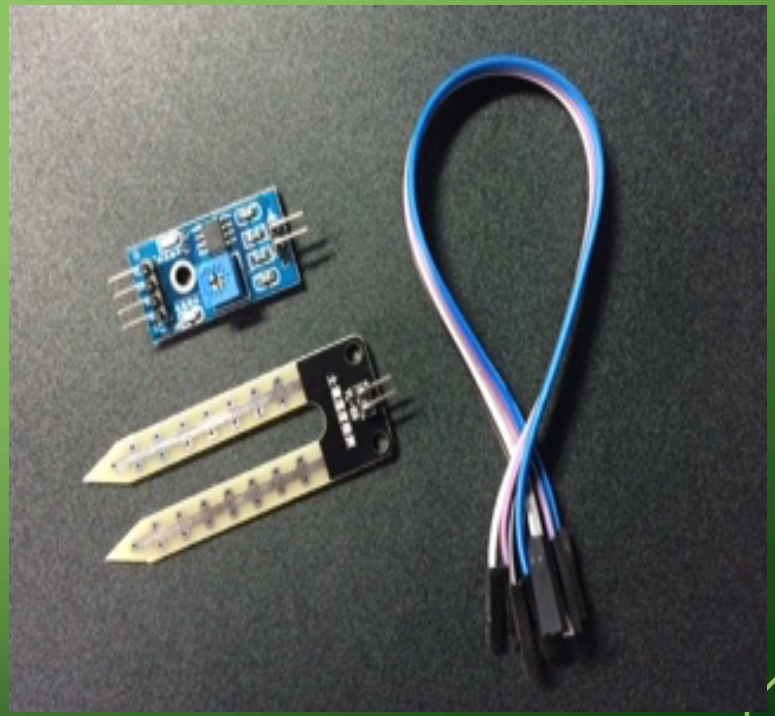
WiFi Module

- Operating Voltage: 3.3V
- Interface: UART TTL
- Data Rate: Up to 464 Kbps
- Standard: 802.11 b/g
- Application Layer Protocols
  - DHCP, DNS, UDP, FTP, HTML



Moisture Sensors

- Operating Voltage: 3.3 – 5 V
- Digital Output: 4.5V (1) or 0.15V (0)
- Analog Output
- Adjustable sensitivity through potentiometer



Pressure Sensors

- Operating Pressure: 150 PSI
- Supply Voltage: 4.75 - 5.25 V
- Supply Current: 4 - 10mA
- Output Voltage: 500mV - 4.5V
- Accuracy: 0.25%

FPT Valve and Solenoid

- Operating Pressure: 10 - 150 PSI
- Solenoid: 7 - 12 VDC, 2-way magnetic latching, normally closed
  - Voltage rate: 6.5 - 12 VDC
  - Coil Resistance: 4.7Ω +/- 0.3
  - Pulse Width: minimum 10mSec

GPS Module

- Update Rate: Up to 10Hz:
- Ultra High Sensitivity: -165dBm (w/o patch antenna)
- Position Accuracy: 3.0m
- Frequency Received: 1.57542GHz +/- 1.023MHz
- Interface: UART TTL
- Supply Voltage: 3.0 - 4.3 VDC

Constraints

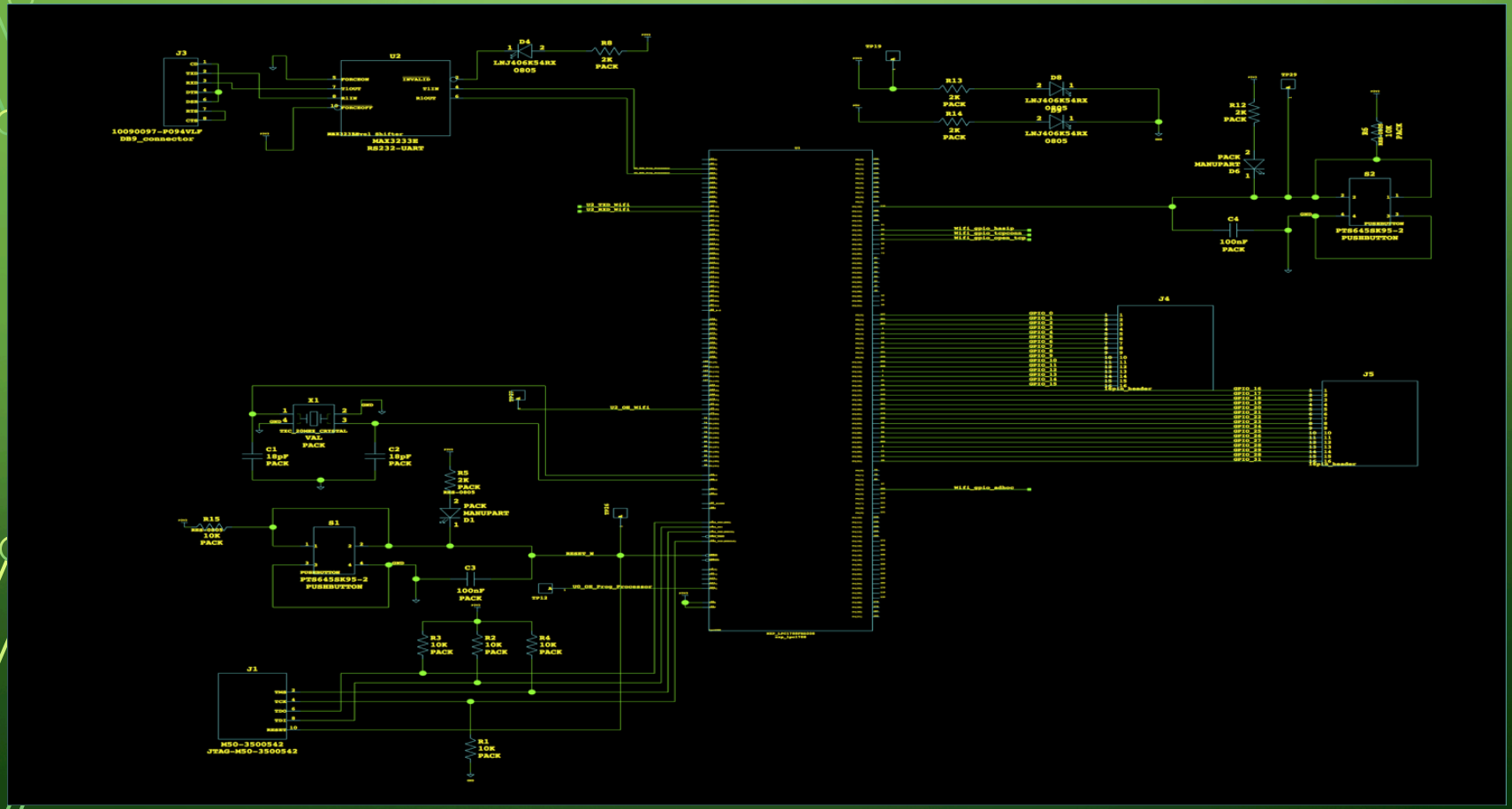
Power

- sensor modules must have ultra low-power consumption to elongate lifespan to avoid constant charging and replacing
- Solution:
  - Install solar panel to charge 18650 battery
  - utilize low-power processors
  - employ interval wake-up periods to draw data then return back to deep-sleep mode

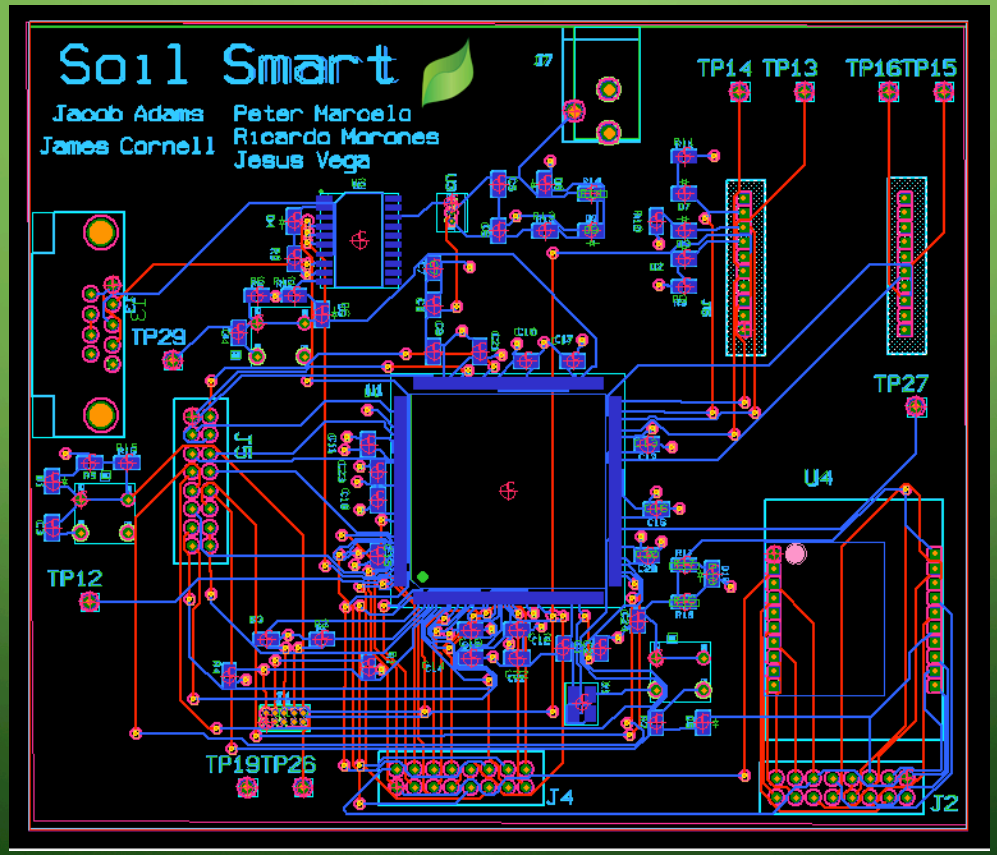
Memory

- XBee programmable MCU flash memory 32Kb
- Solution: efficient coding and do major processing at Home Board

House & Control (No Wifi) Board Schematic



House/Control Board PCB Layout



Module Board Software

- On startup, send GPS location to Control Board along with Node ID.
- Encapsulate and send raw node sensor data collected from moisture sensors to Control Board periodically based on user input.
- Sleep when not sending data.

Control Board Software

- On startup, send GPS location and Node IDs of all sensor nodes to House Board.
- Sleep coordinator: will wake up nodes periodically and ask for sensor samples.
- Detect leakages through pressure sensor data
- Turn solenoids on or off if leakage is detected, or if instructed to by House Board.
- Relay data samples to House Board.

House Board Software

- Uploads raw sensor data to web server hosted on capstone lab computer.
- Send irrigation control commands to Control Board. These commands come via the UI.
- Maintains mapping of Node IDs to GPS coordinates.

Server Software

- Receives raw sensor node data to present node information in an easy-to-use interface.
- Use GPS coordinates to map with Google Maps API to present location of sensor nodes
- Maintain data for a couple of months to give user a history of their water usage.
- Send irrigation control commands to House Board.

Accomplishments so far

-BOM, Layout, etc for all boards
-Designed custom moisture sensors
-Established testing location (Avocado Grove)
-Configured synchronized sleep XBee network

What’s Left

-Make web server and app that controls irrigation relays and displays soil data and leakage status

-Implementation of software

-Field testing

Full Schematic and Bill of Materials can be found in links

Questions?