
# Development of Low Power Wireless Sensor Network using Zigbee Protocol for Terrace Farm

EE 692 R & D

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# Agenda

# Introduction

- Why do we want WSN on Terrace Farm?
  - Automatic irrigation
  - Crop health monitoring - Leaf wetness sensor, soil temperature
  - Measurement of light intensity and pH levels
  - Terrace farm as prototype/testbed to test solution at small level
- Why and how much low power?
  - Typically a battery operated on 2AA or rechargeable battery should last for months if not years.
  - Optimal hardware choice and software design based on application

# Wireless Protocols

Table : Comparision of Bluetooth, Zigbee and Wifi

| | Bluetooth | Zigbee | Wi-Fi |
|---|---|---|---|
| IEEE Specs | 802.15.1 | 802.15.4 | 802.11 |
| Frequency Band | 2.4GHz | 868/915 MHz or 2.4 GHz | 2.4 GHz; 5GHz |
| Signal Rate | 1Mb/s | 250Kb/s | 54Mb/s |
| Range | 10m | 10-100m | 100m |
| $T_x$ Current (mA) | 57 | 24.7 | 219 |
| $R_x$ Current (mA) | 47 | 27 | 215 |

# Computation of system power

Average power consumption of a system can be expressed by equation 1:

$$P_{avg} = (P_{active} + P_{sleep} + P_{transition})/T_{total} \quad (1)$$

where:

$P_{active}$ = Power being consumed in active mode * Time for which system is active
$P_{sleep}$ = Power being consumed in sleep mode * Time for which system is sleep
$P_{transition}$ = Power consumed while making transition from sleep mode to active mode

# Power consumption of microcontroller

The power consumption by CMOS circuit is given by equation [3]:

$$P = f * C_L * V_{dd}^2 \tag{2}$$

Where:
$P$: Power Consumed
$f$: Operating Frequency of controller
$C_L$: Load capacitance
$V_{dd}$: Supply Voltage used to run the controller

- Load capacitance $C_L$ is determined during IC design
- Operating Frequency($f$) and Supply Voltage $V_{dd}$ can be controlled


# Low power design consideration

- Pull all GPIO pins of microcontroller to low level to prevent leakage current
- Selecting lowest possible operating voltage and frequencies to reduce current consumption
- Selecting proper low power mode
- Turn off peripherals when not used

# Hardware Design - MSP430F5529

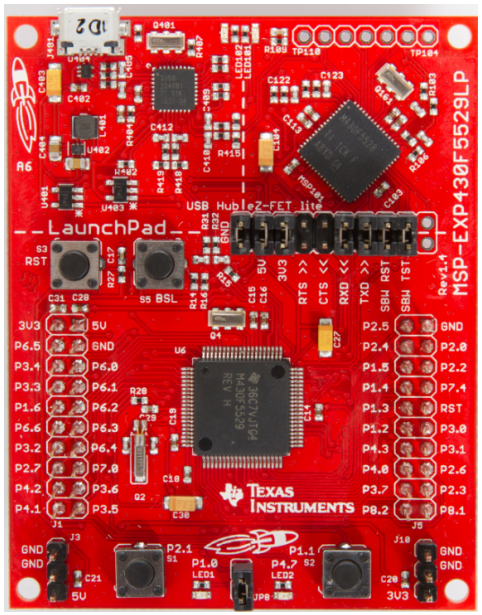



image courtesy: `http://processors.wiki.ti.com`

- Operating Voltage: 3.6V - 1.8V
- 5 different clock source
- Operating frequency: 10KHz - 25MHz
- 3 clock signals
- 12-bit ADC
- 2 UART
- 63 IO pins

# Hardware Design - Xbee S2C


image courtesy: `http://digi.com`

- Operating Voltage: 2.1-3.6V
- Indoor range: 60m
- Outdoor range(LoS): 1200m
- $T_x$ current: 45mA@3.3V
- $R_x$ current: 31mA@3.3V
- Sleep current: $1\mu A$
- Interface: UART/SPI

# Hardware Design - DHT22 Sensor

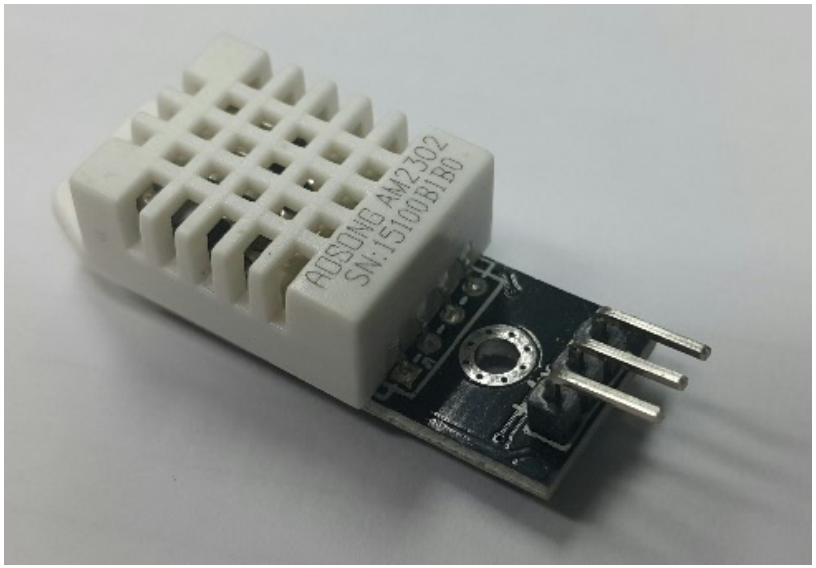
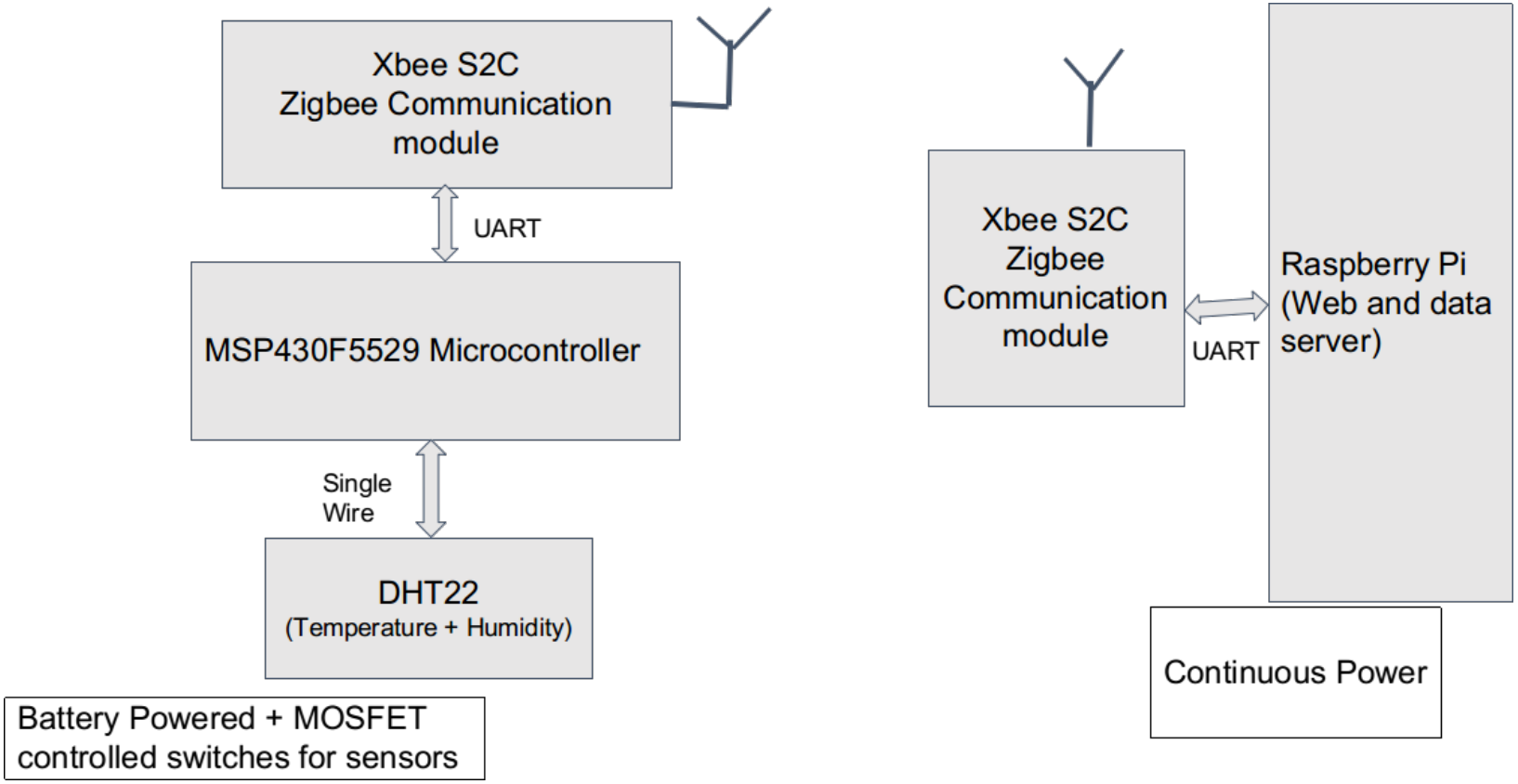



image courtesy: `http://sparkfun.com`

- Operating Voltage: 3.3-6V
- Output signal: digital signal on Single wire
- Temp. Range: -40-80$C$
- Humidity Range: 0-100% RH
- Resolution: 0.1
- Sensing period: 2S
- Active Current: 1mA
- Sleep Current: 50$\mu$A

# System Architecture



# Network Topologies

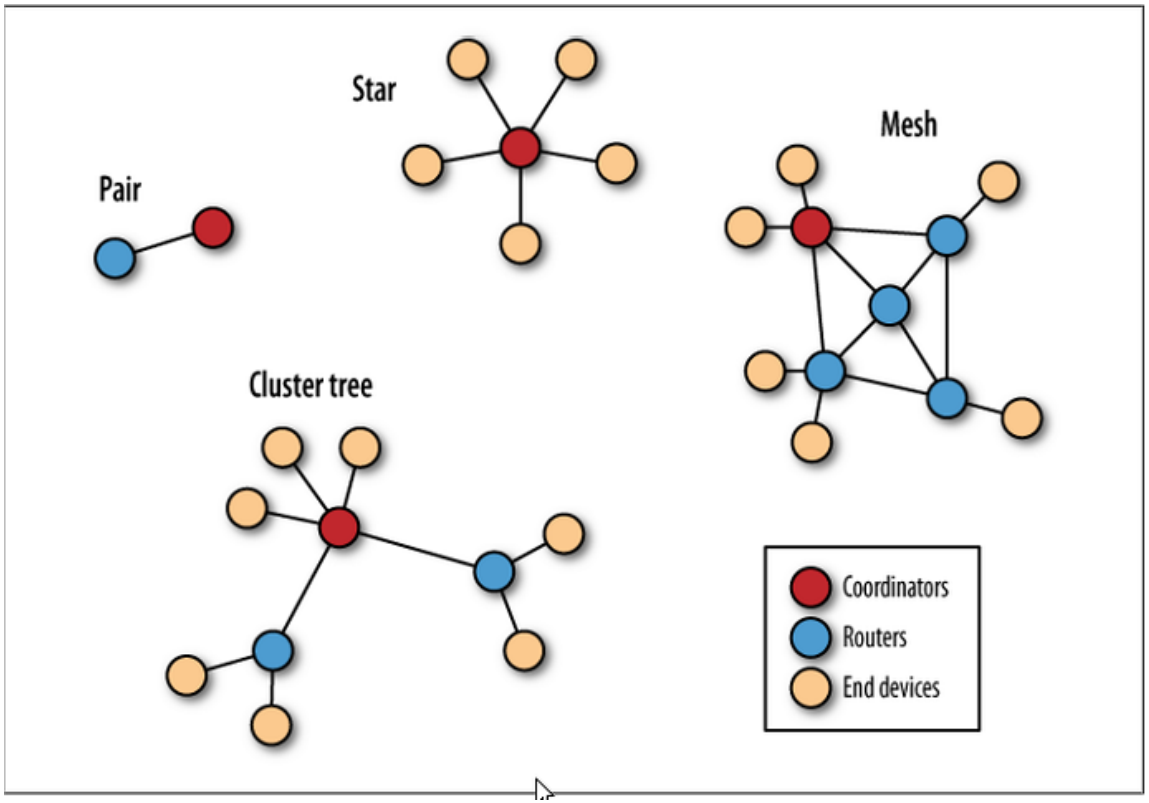
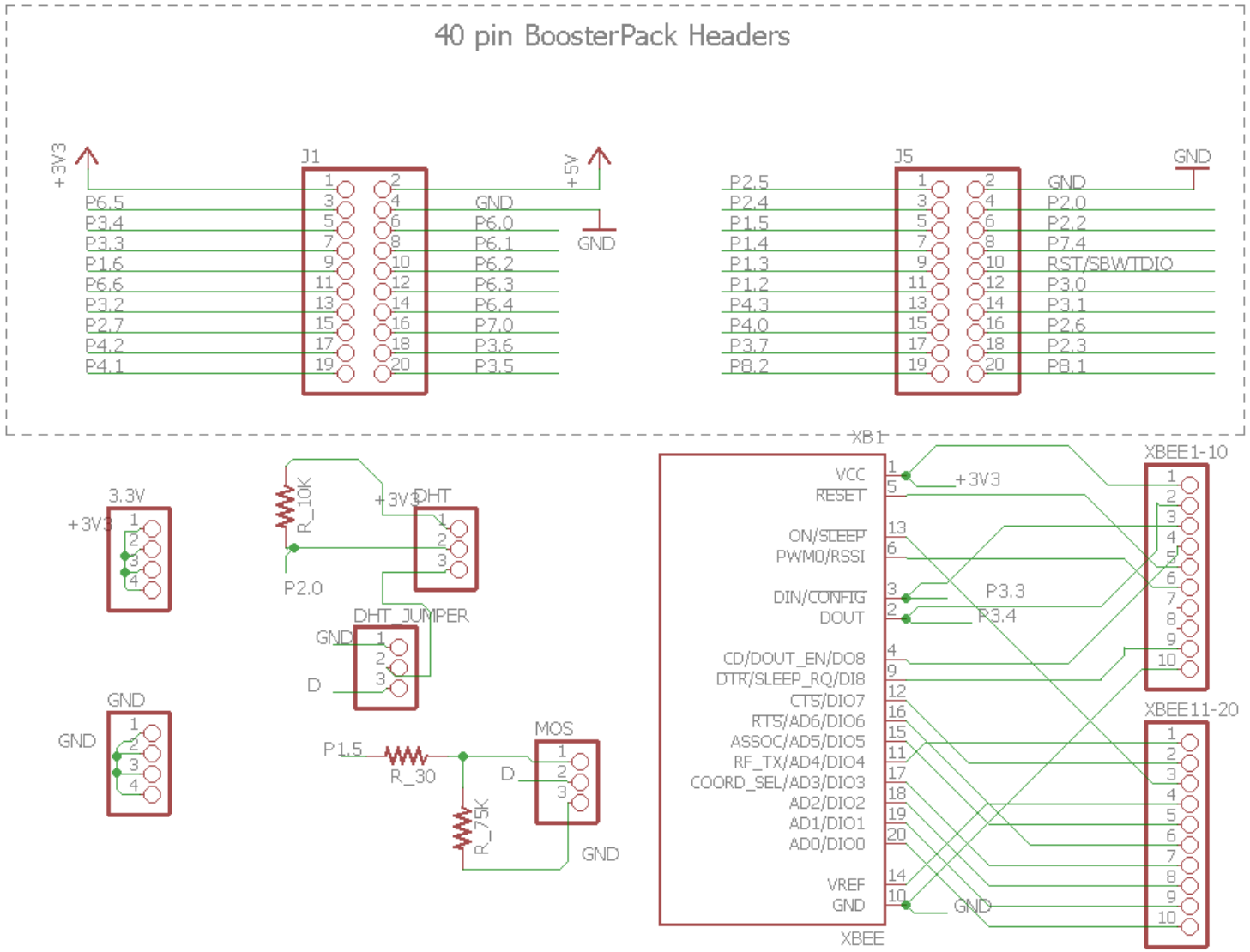


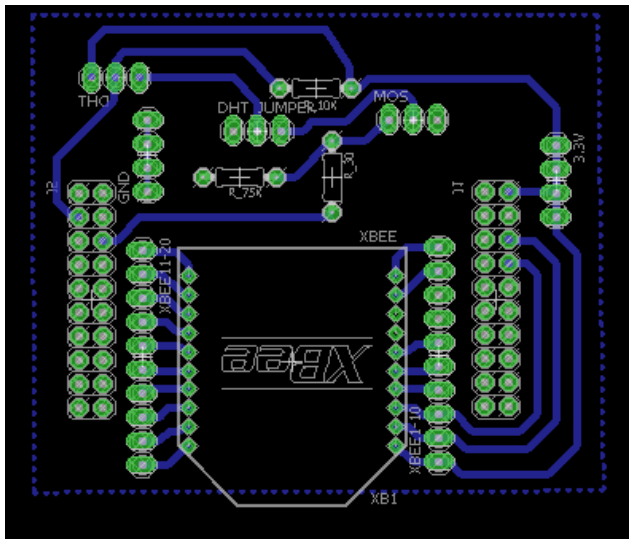

image courtesy: `http://freemindscafe.com`

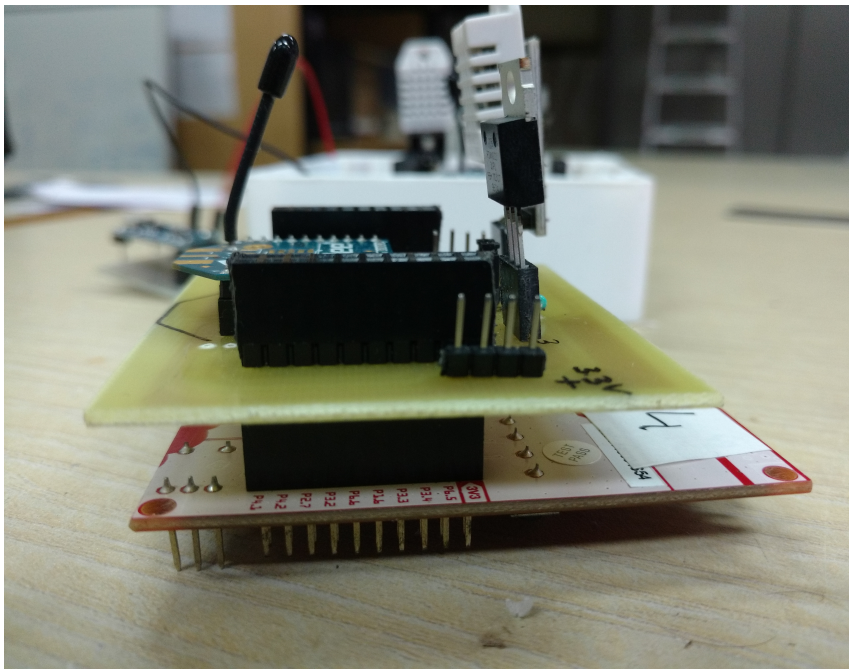
# Circuit Design - Schematic




Schematic for Stack

# Circuit Design - PCB



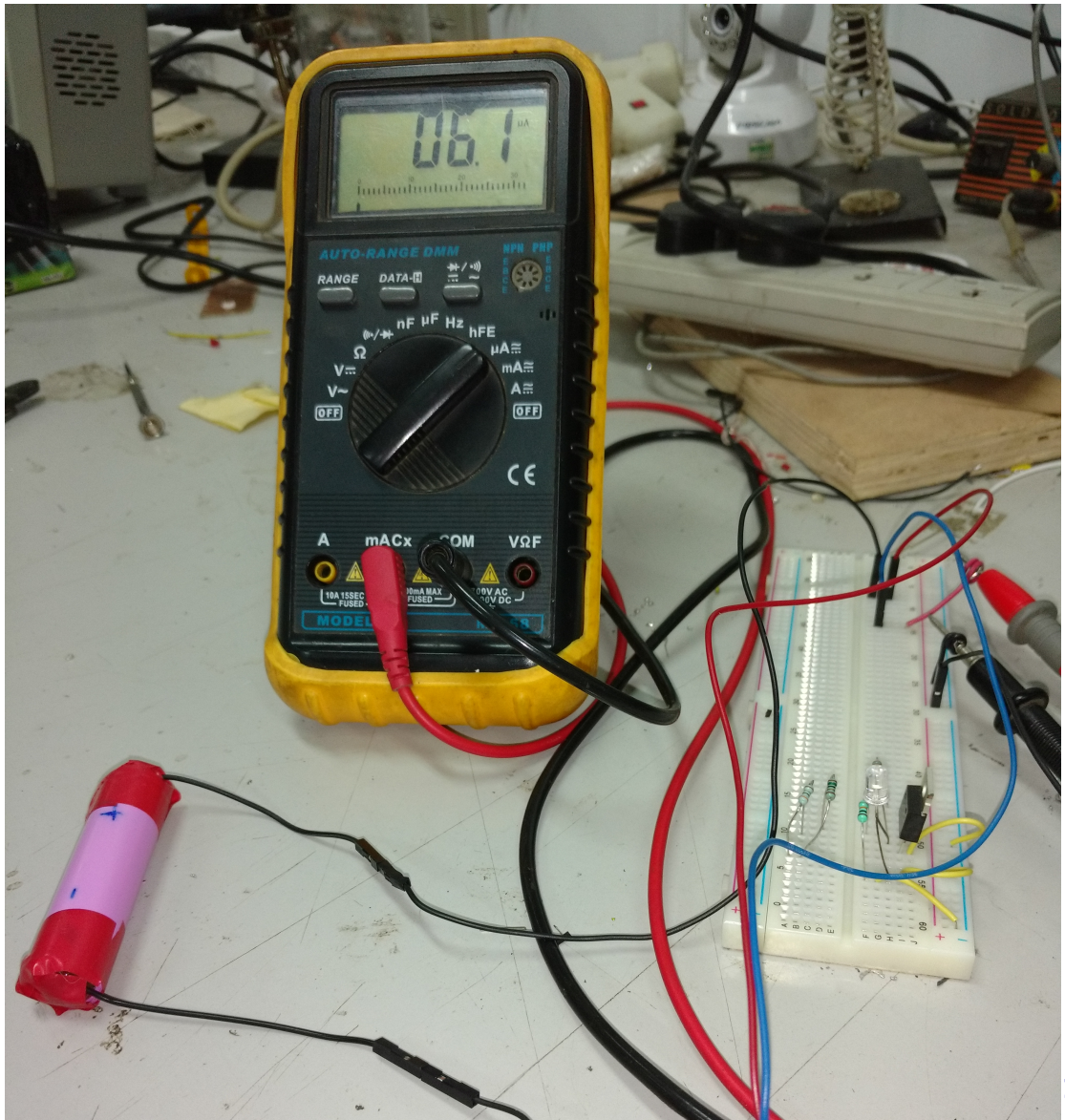



# Current Measurement for peripherals

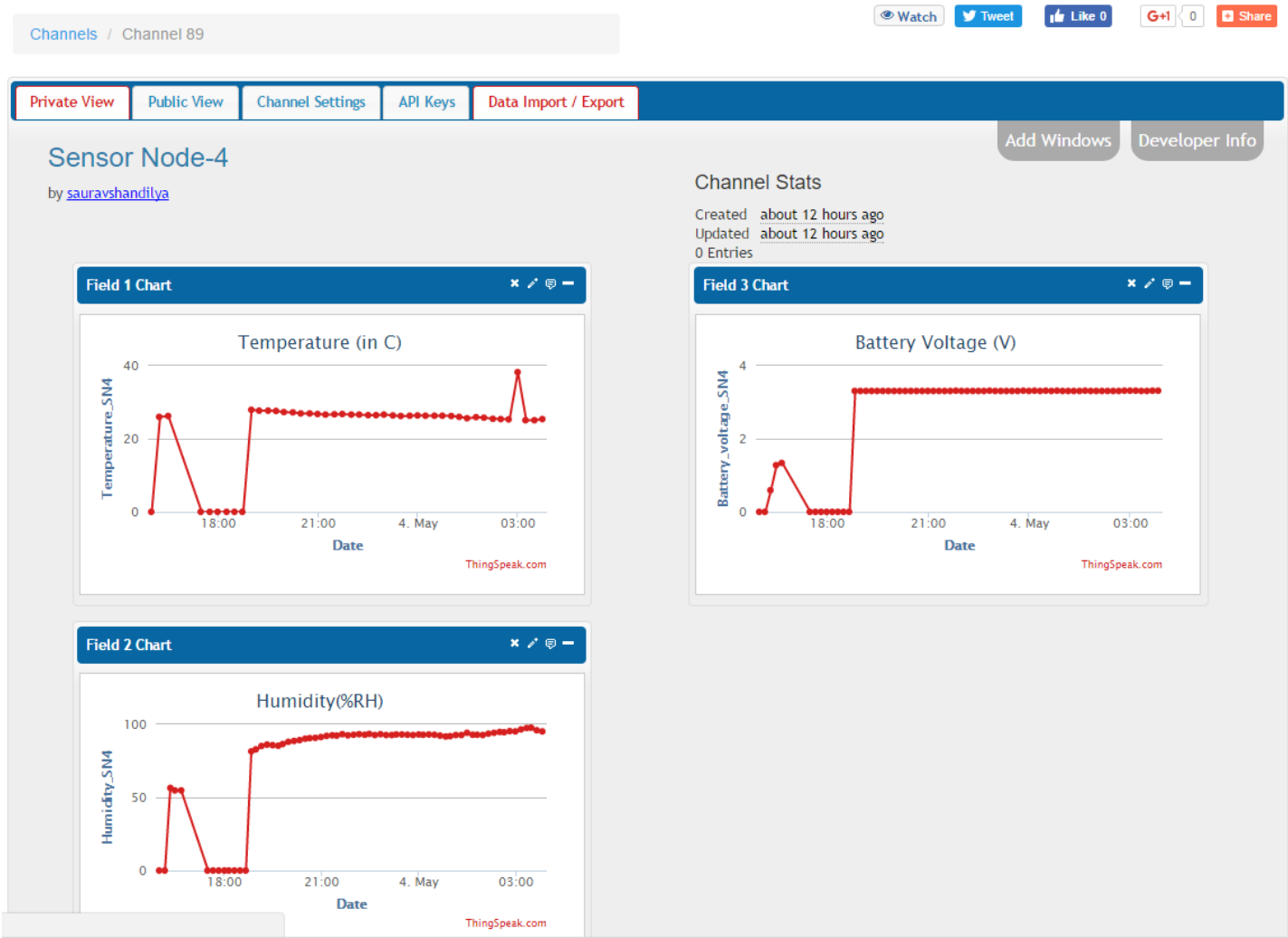
Table : Comparision of Bluetooth, Zigbee and Wifi

| Case | Current | Expected |
|---|---|---|
| No peripherals connected | 6$\mu$A | 2$\mu$A |
| DHT on | 1mA | 1mA |
| DHT off | 18$\mu$A | 7$\mu$A |
| Xbee $R_x$ | 45mA | 31mA |
| xbee $T_x$ | 53mA | 45mA |

# Current Measurement for peripherals



# Field Reading



# Discussion and Challenges

- Selecting right Zigbee module
- Configuring controller to operate in low power mode
- Computing average power of system
- Designing protocol to read value from all sensor node
- Design of casing for sensor node to withstand outdoor environment

# Future Work

- Interface different sensors and use effective stack design
- Trying different topologies, count and location of node for terrace farm
- Design of weather proof casing and small form factor sensor node
- Simulating the network

# References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