# Soldier Status Monitoring Project

SPRING 2013 ECE445

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# Introduction

- Soldier Status Monitoring
- portable device capable of monitoring body vitals
- The sponsors were interested in using this device to monitor soldiers out in the field

# Goals

- Gather heart rate, body temperature and movement data reliably
- Wireless communication of the sensor data over 100m
- Continuous monitoring of the soldiers vitals for at least 12 hours.

# Features

- Portable and lightweight device
- LED lighting to display when user vitals reach critical threshold
- Non-invasive monitoring of soldier vitals
- Onsite storage of data on external SD/MMC card

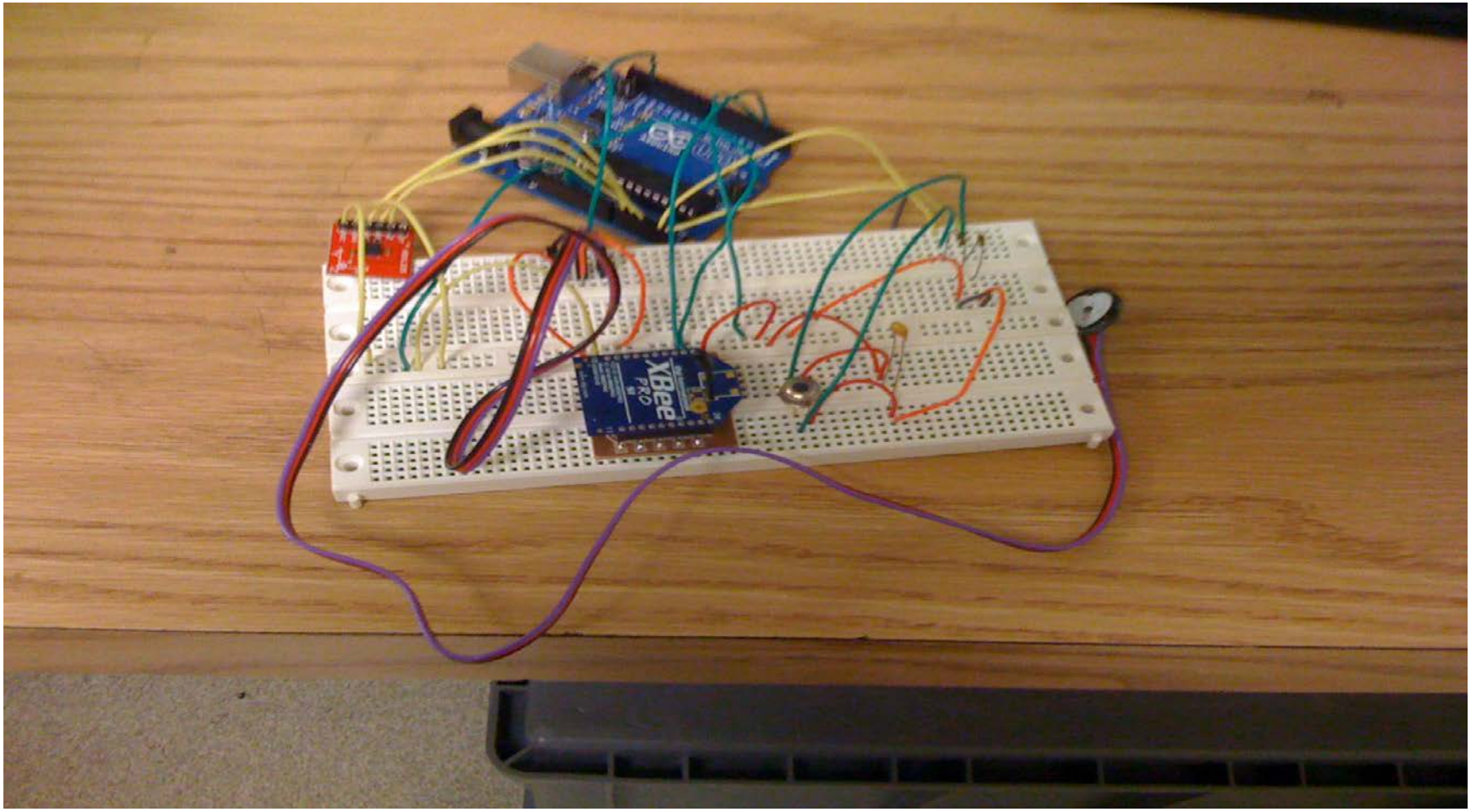
# Main focus area

- Identifying required sensors and its connections with the Arduino microcontroller chip
- Designing custom PCB to incorporate microcontroller and sensors
- Data Packaging and Wireless Communication over 100 to 500m
- Software Coding for analyzing and displaying received sensor data.

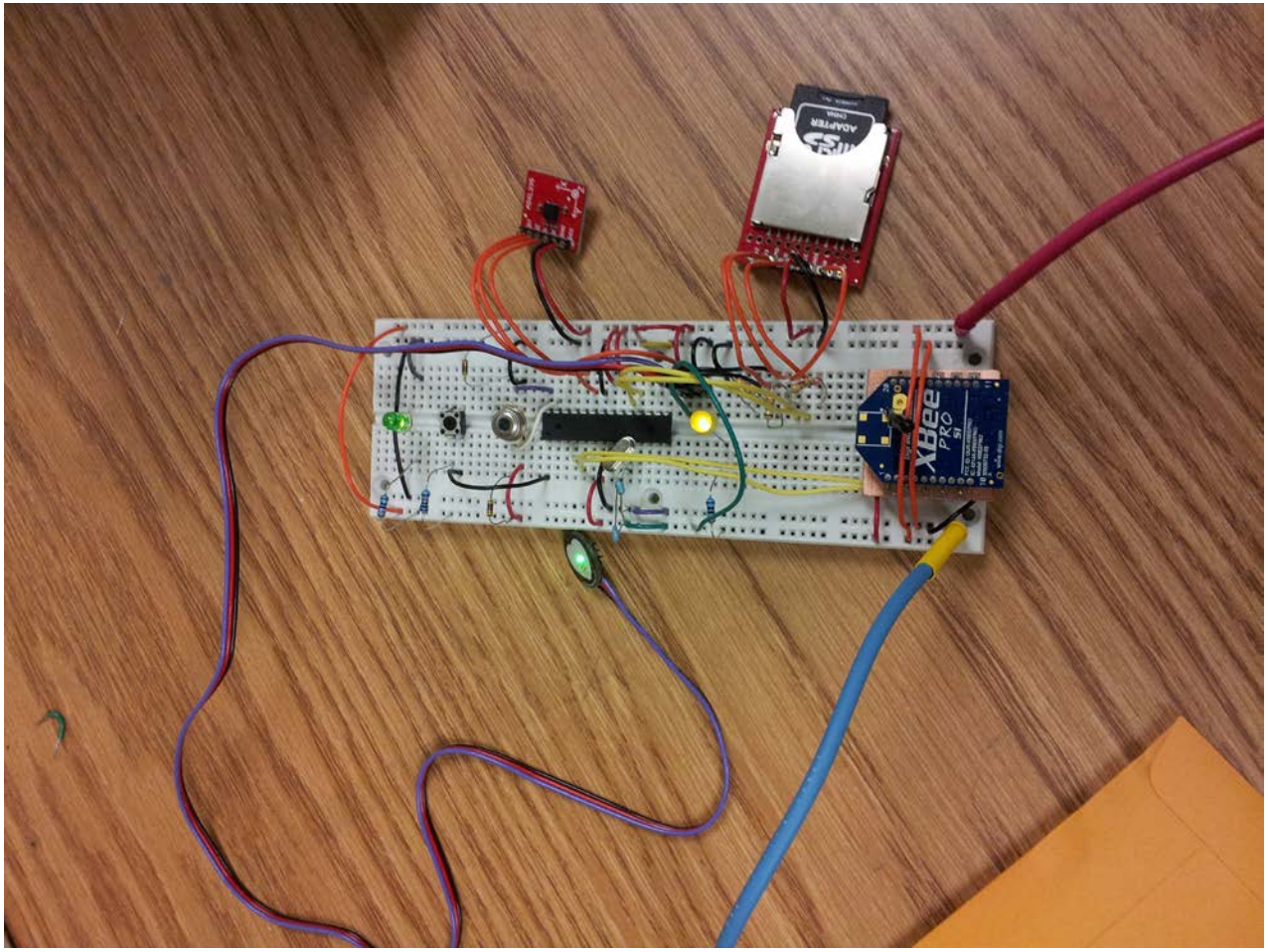
# Intermediate project goals

- Create a prototype device using identified individual components connecting to the Arduino Uno board using a breadboard.
- Create a completely customized board for the device thereby making it even more compact and portable.

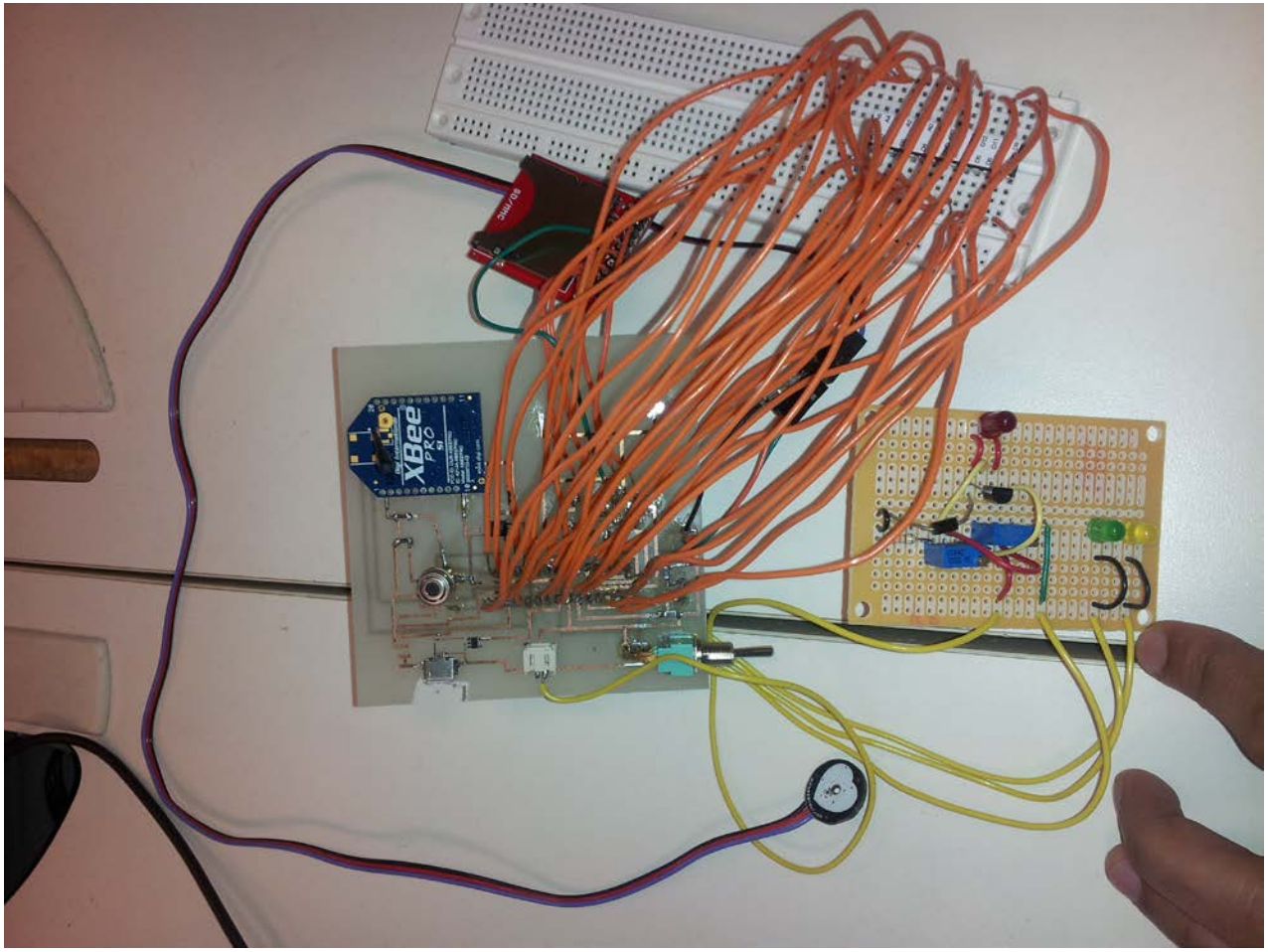
# Protype A



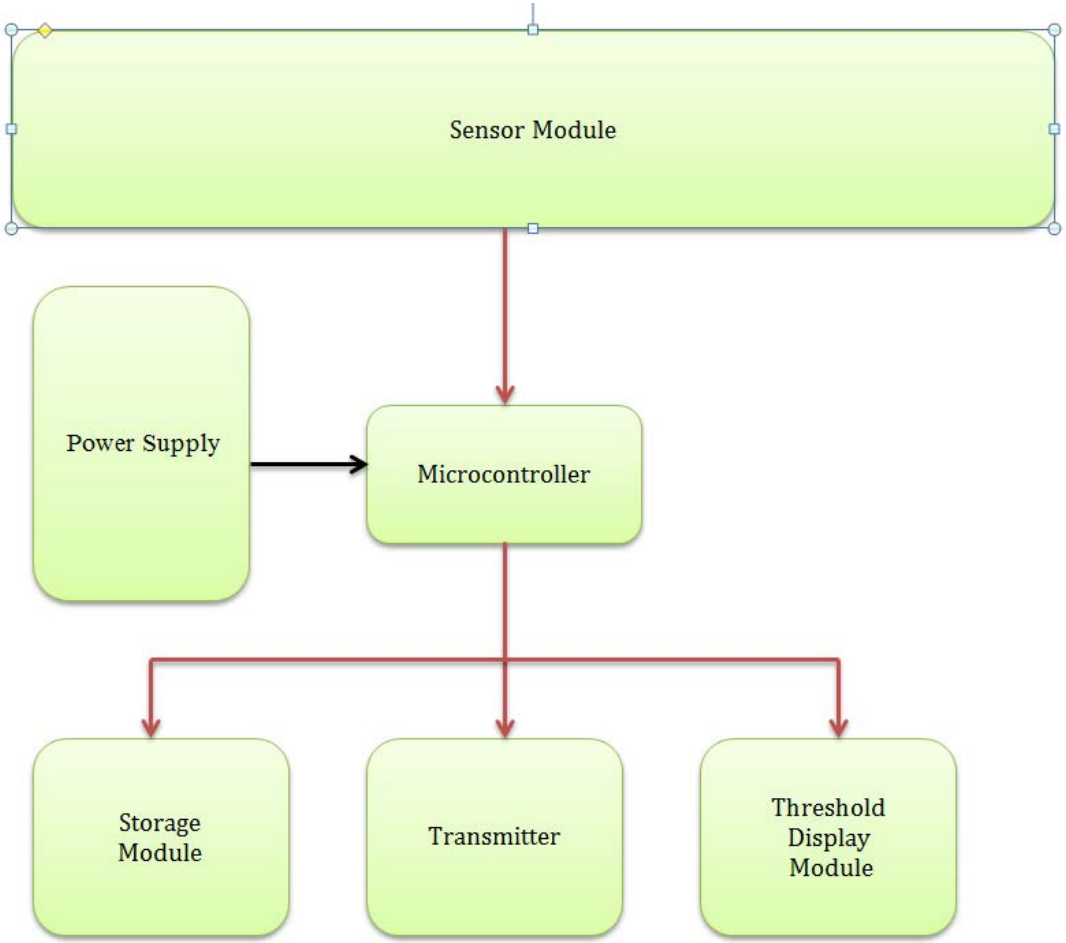
# Prototype B



# Final Product

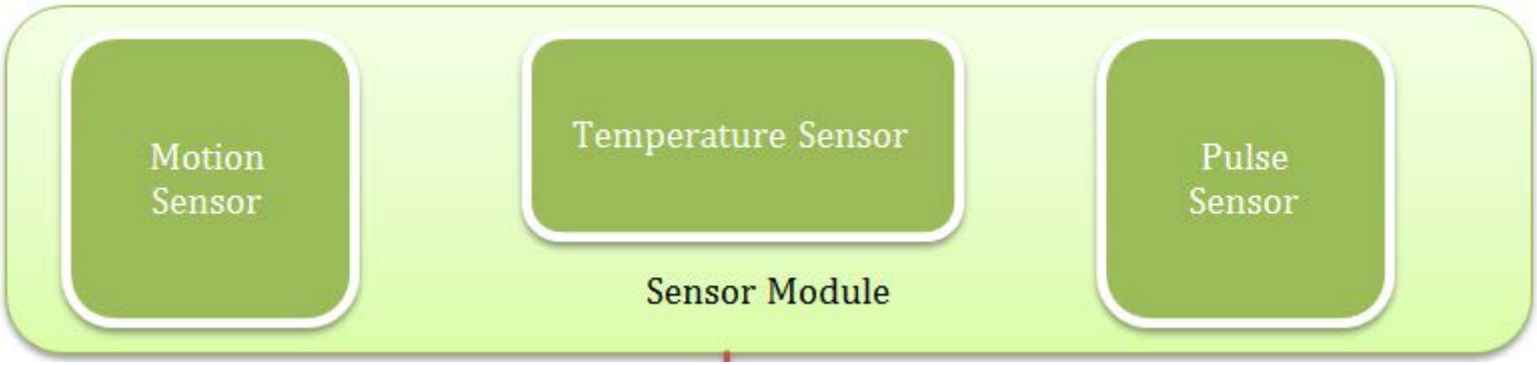


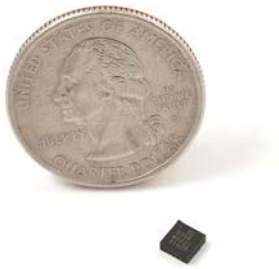
# Overall Block Diagram

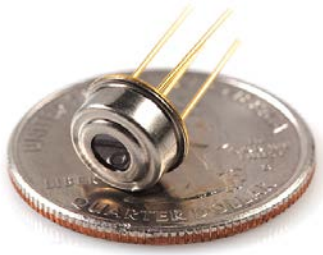


# Threshold Display Module

# Sensor Display Module





# Skin Temperature Sensor (MLX90614)

- Average temperature of all objects in its Field of View.
- $I^2C$ device, outputs literal information of temperature
- 17bit resolution instead of voltage reading

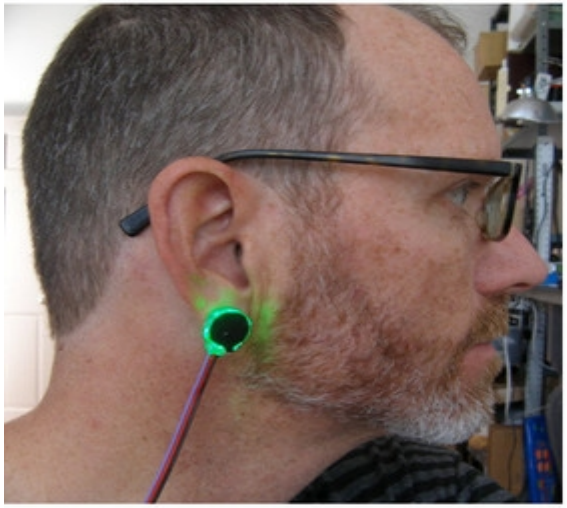
- **INPUT**: 3.3V through Li-Poly battery. Clock input (SCL) from digital 21
- **OUTPUT**: Single ended digital communication. Output Data(SDA) on digital 20

# Comparison of IR sensor

- Infrared Thermometer from Home Depot to test accuracy.
- Holding it same distance, it was 100% accurate.

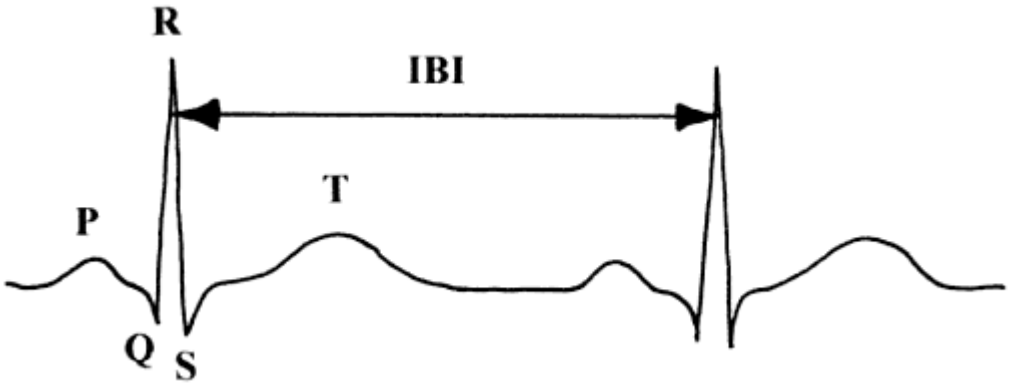

# Pulse Sensor Amped

- Monitor heart rate data in “beats per minute”
- Optical Heart Rate Sensor
- The device will be connected to the ear lobe



- **INPUT:** 3-5V (requires Aref)
- **OUTPUT:** Single wire output is an analog fluctuation in voltage.

# Pulse Sensor Simulation

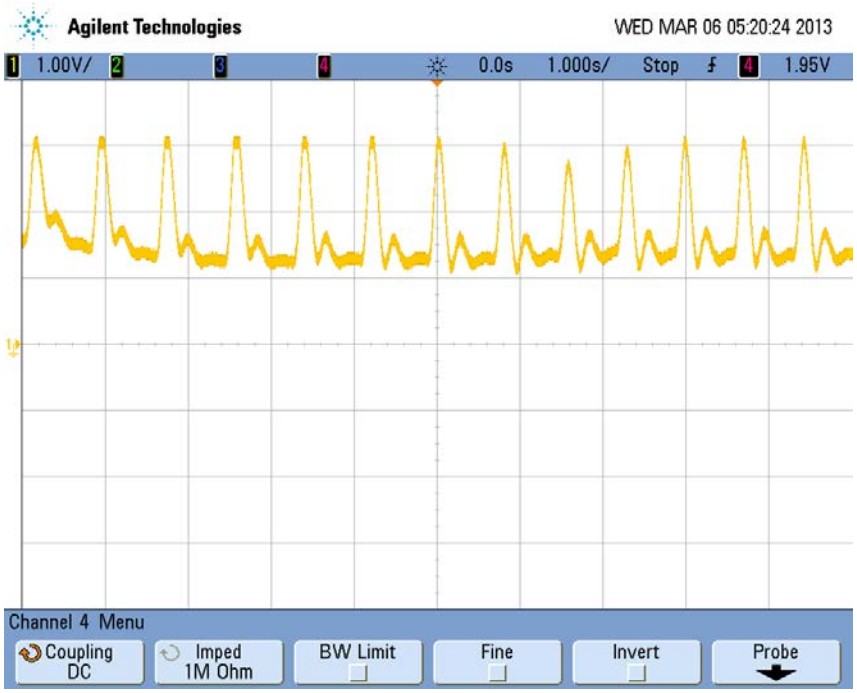



**HR = 60000 / IBI** ;

when IBI is calculated in milliseconds

# Pulse Sensor Simulation with oscilloscope

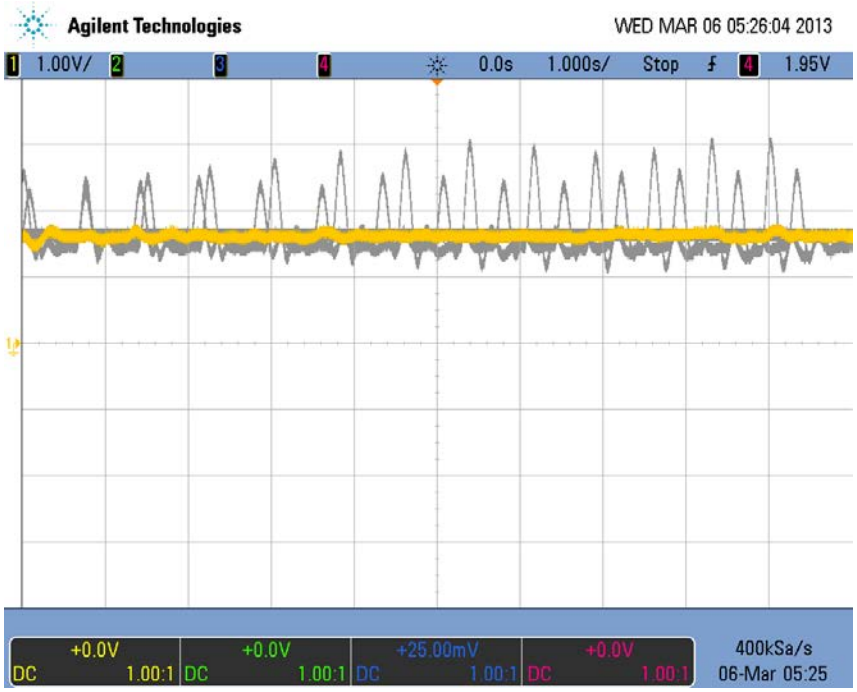
Regular Pulse Reading



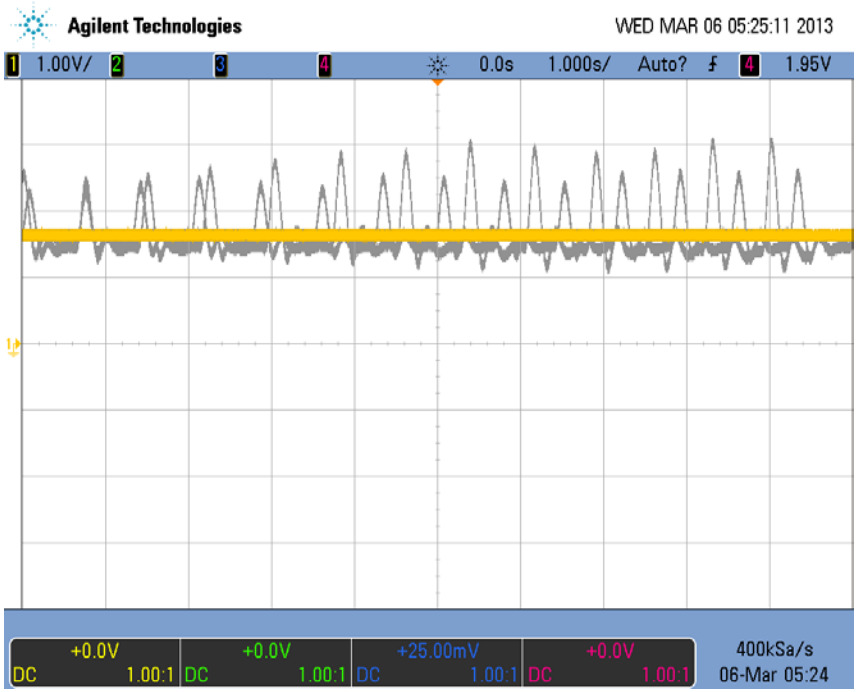

Superimposed Regular Pulse

# Pulse Sensor Simulation with oscilloscope

Pulse reading under constant ambient light

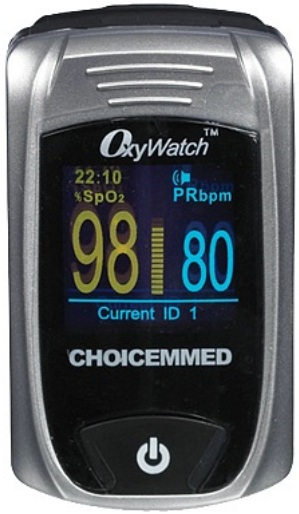



Pulse reading in dark room with no ambient light



# Comparison of Pulse Sensor

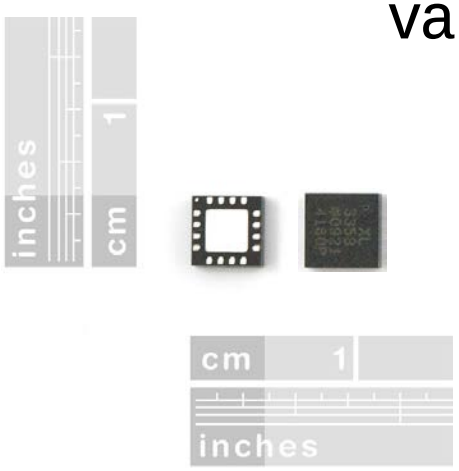
- OxyWatch premium Fingertip Pulse Oximeter from Home Depot
- Pulse Sensor Amped was off by approx 2beats




# Motion Sensor (ADXL 335)

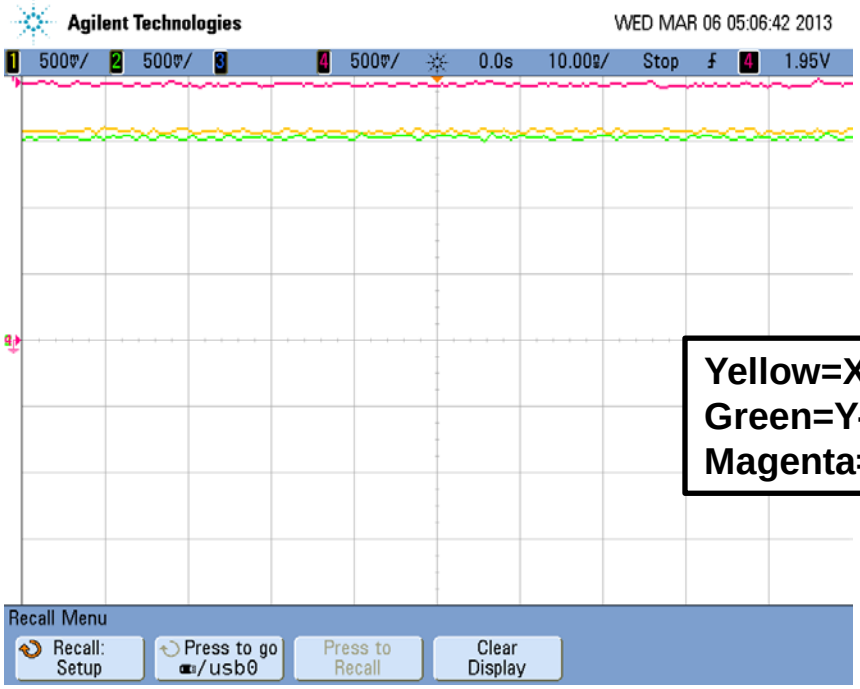
- triple axis accelerometer
- Full scale range of ±3g
- Measures static acceleration due to gravity.
- ADC gives 10bit resolution

- **INPUT:** Input voltage can be between 1.8V to 3.7VDC.
- **OUTPUT:** Accelerometer outputs analog voltage depending on sensed value in each axis.

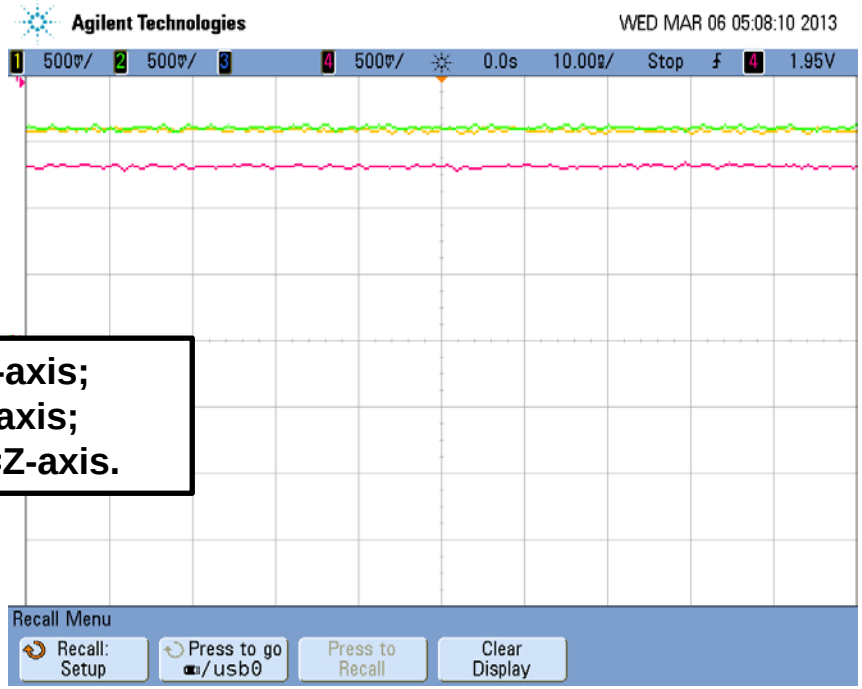


# ADXL335 Simulations with oscilloscope

+Z axis in direction of gravity



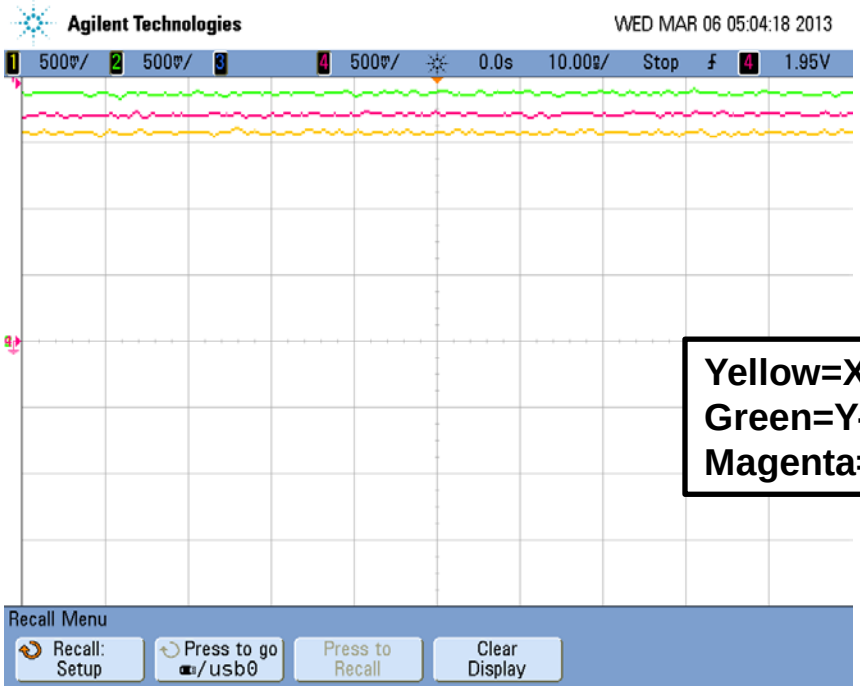

-Z axis in direction of gravity



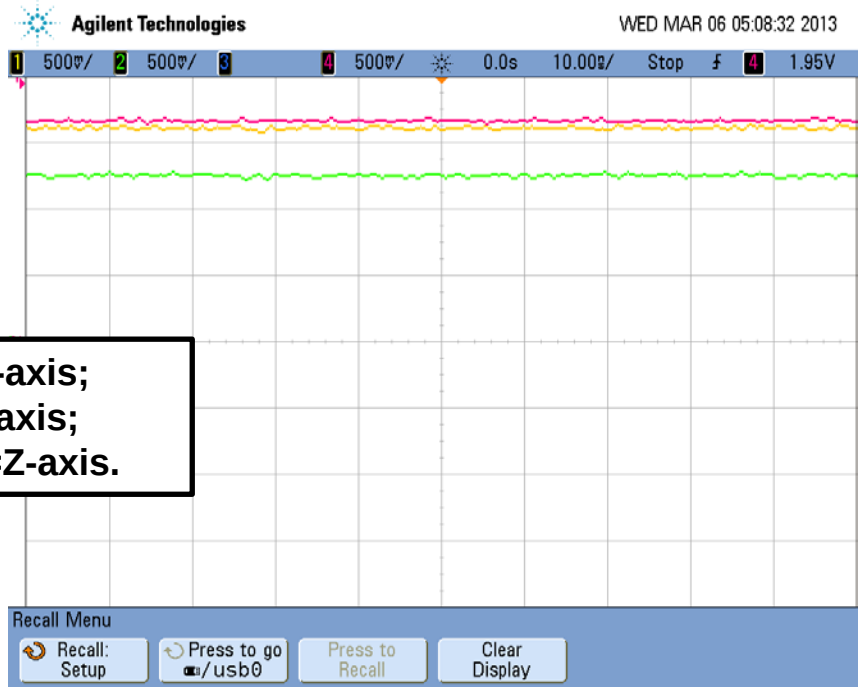

**Yellow=X-axis;**
**Green=Y-axis;**
**Magenta=Z-axis.**

# ADXL335 Simulations with oscilloscope

+Y axis in direction of gravity




-Y axis in direction of gravity

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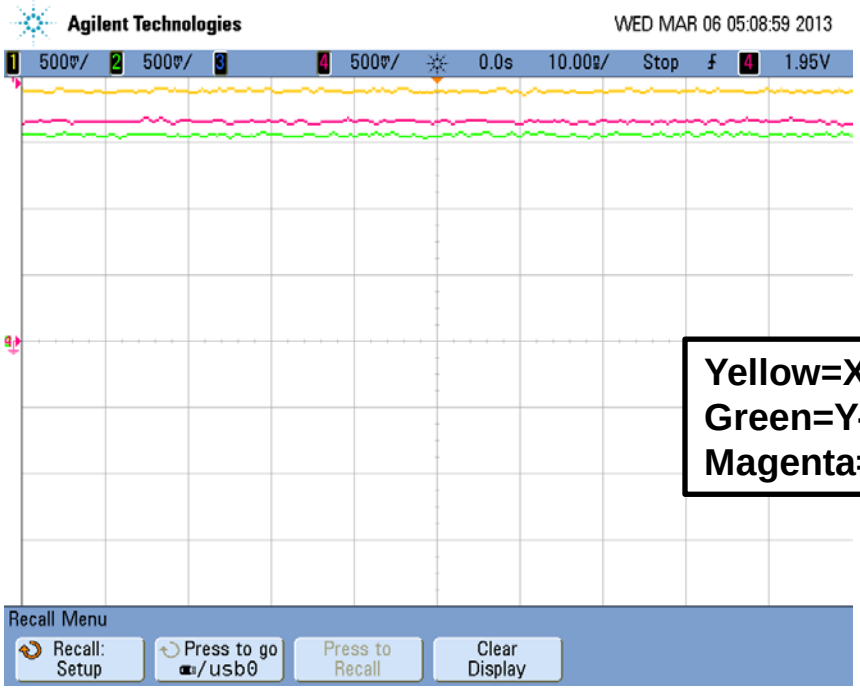
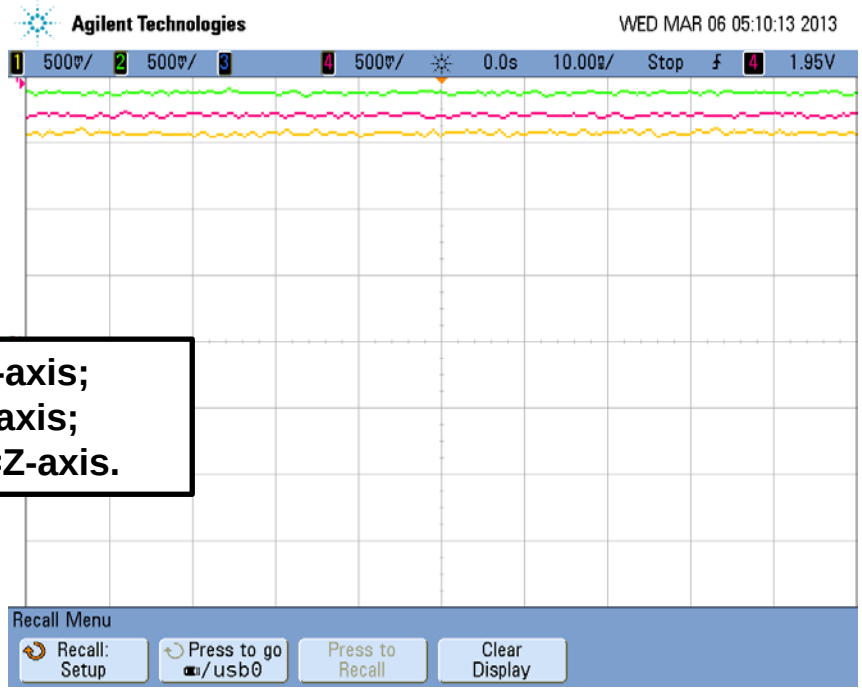
# ADXL335 Simulations with oscilloscope

+X axis in direction of gravity




-X axis in direction of gravity




**Yellow=X-axis;**
**Green=Y-axis;**
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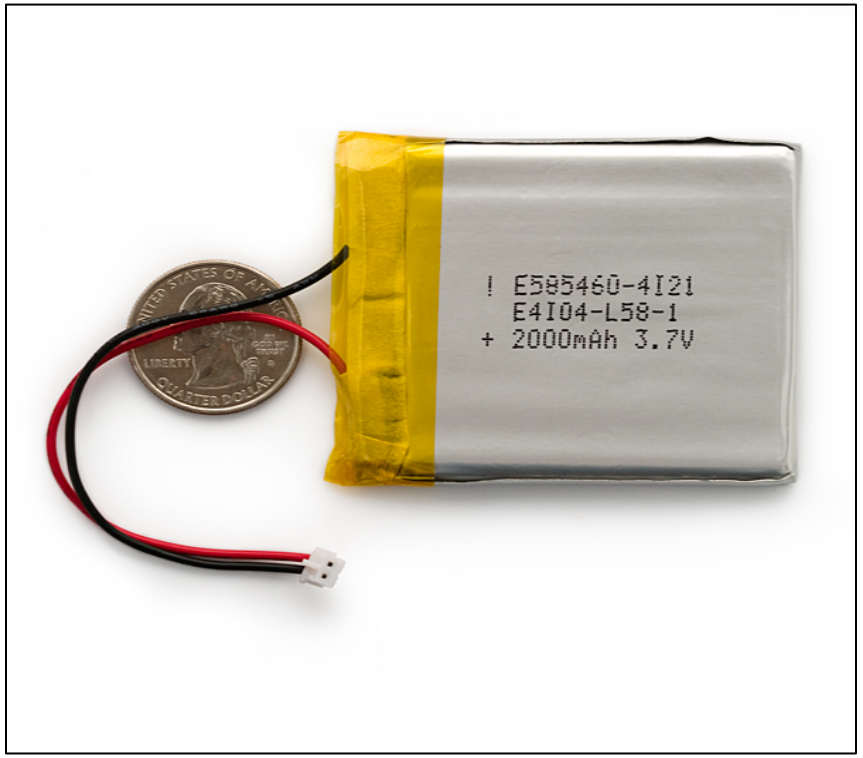
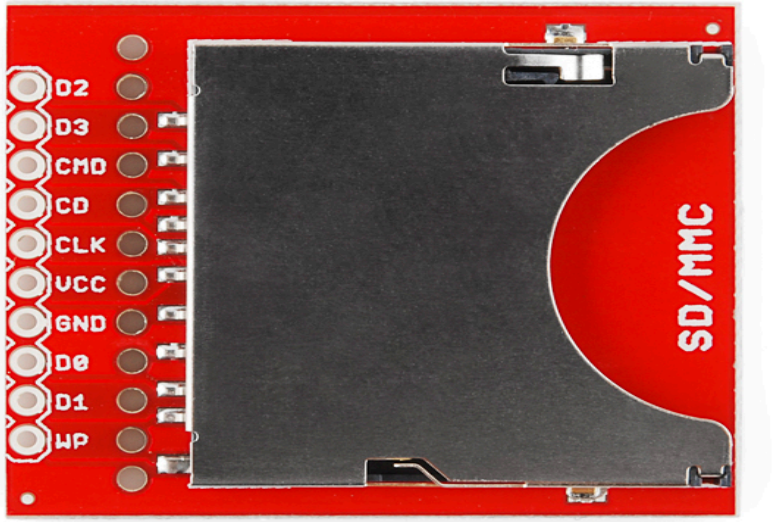
# Power Supply Module

- This module powers the entire device.
- 2000mAh Lithium Polymer battery
- battery includes built-in protection against over voltage, over current, and minimum voltage
- Weight: 36g



# SD/MMC Storage Module

- This module stores all the data acquired from the sensors.
- Packaged sensor data from microcontroller is stored in microSD card before transmitting
- Required voltage of 1.8 to 3.6V

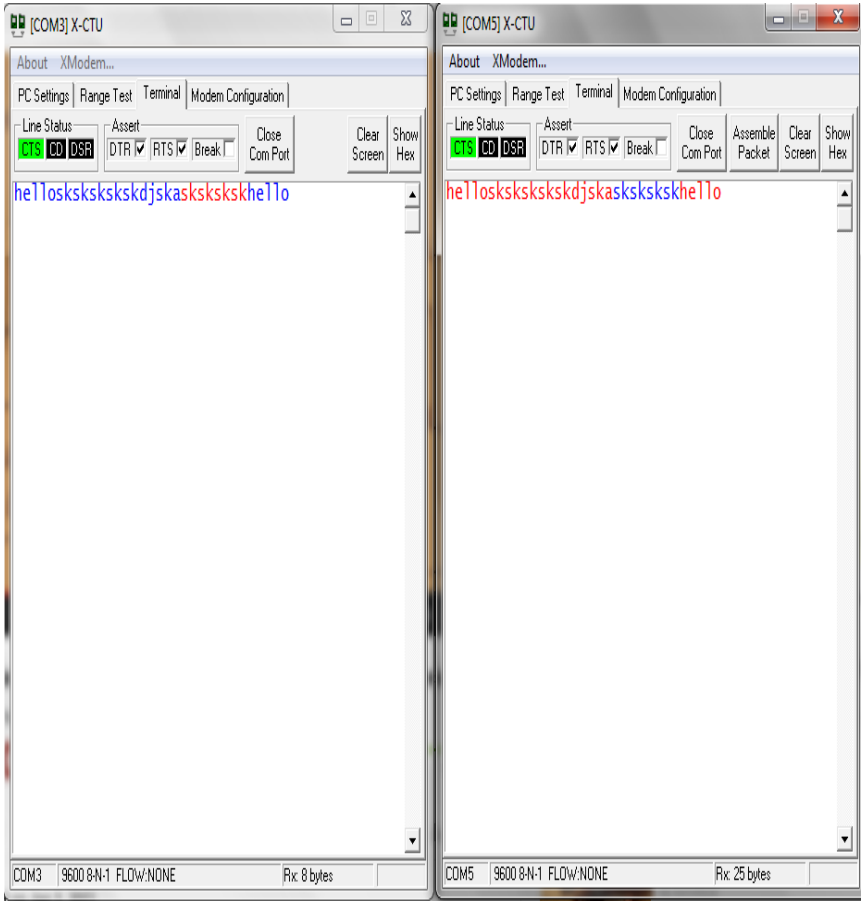


# Wireless Transmission via Xbee module

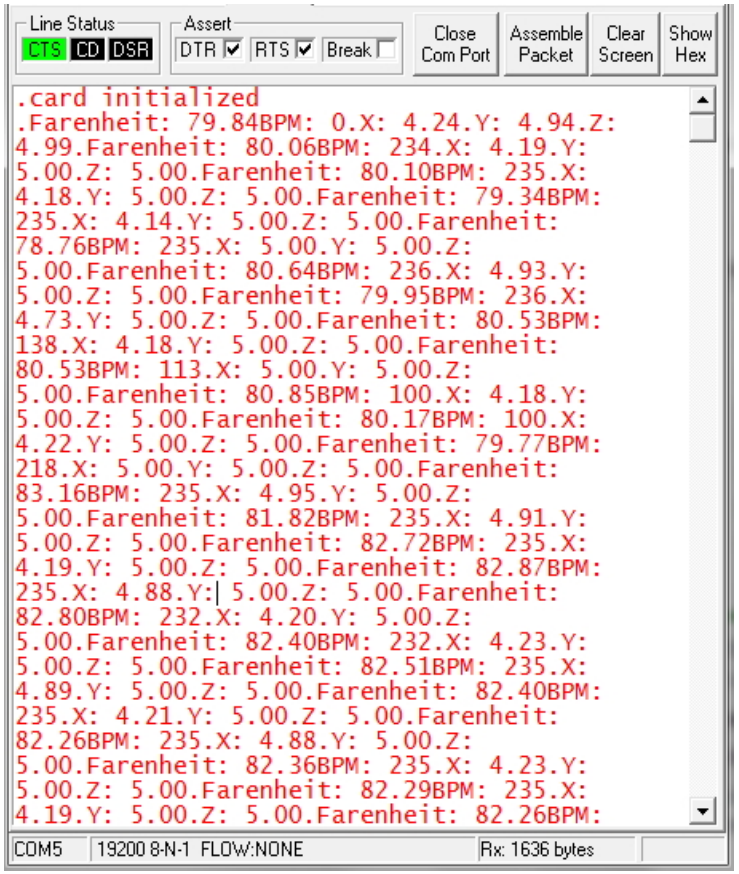

- Allows a very reliable simple wireless communication.
- The two modules act as a transmitter and a receiver accordingly.
- Able to send data from Wright & Green to Wright & Springfield.
- Configured via X-CTU

# Data Transmission via X-CTU

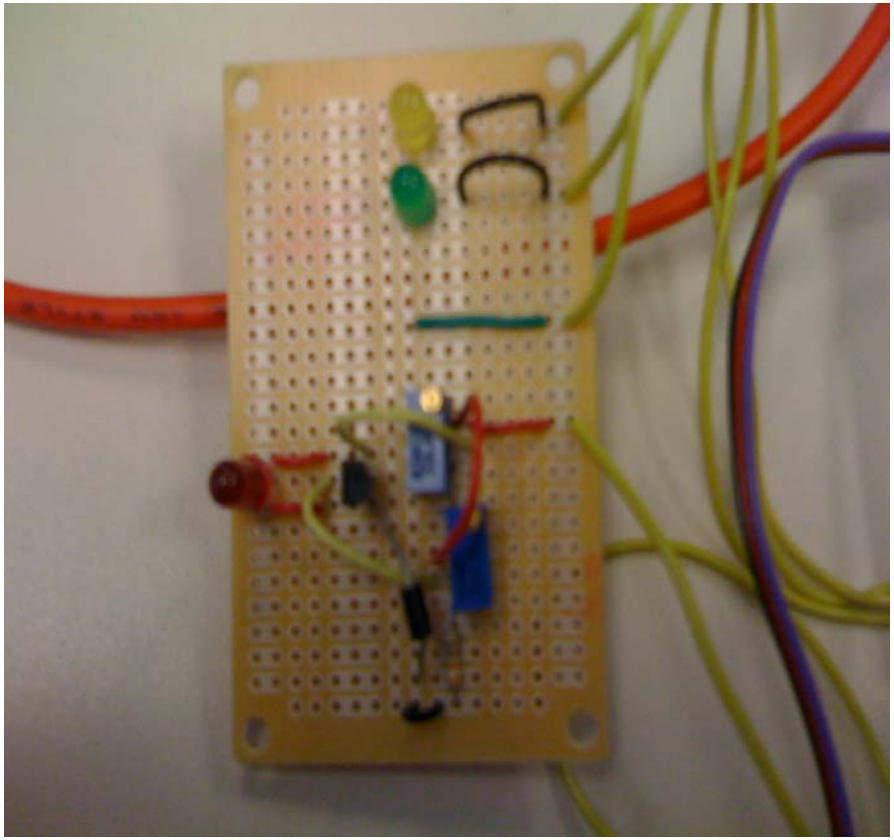
- Characters




- Heart rate, body temperature, motion Speed (Main Goal)

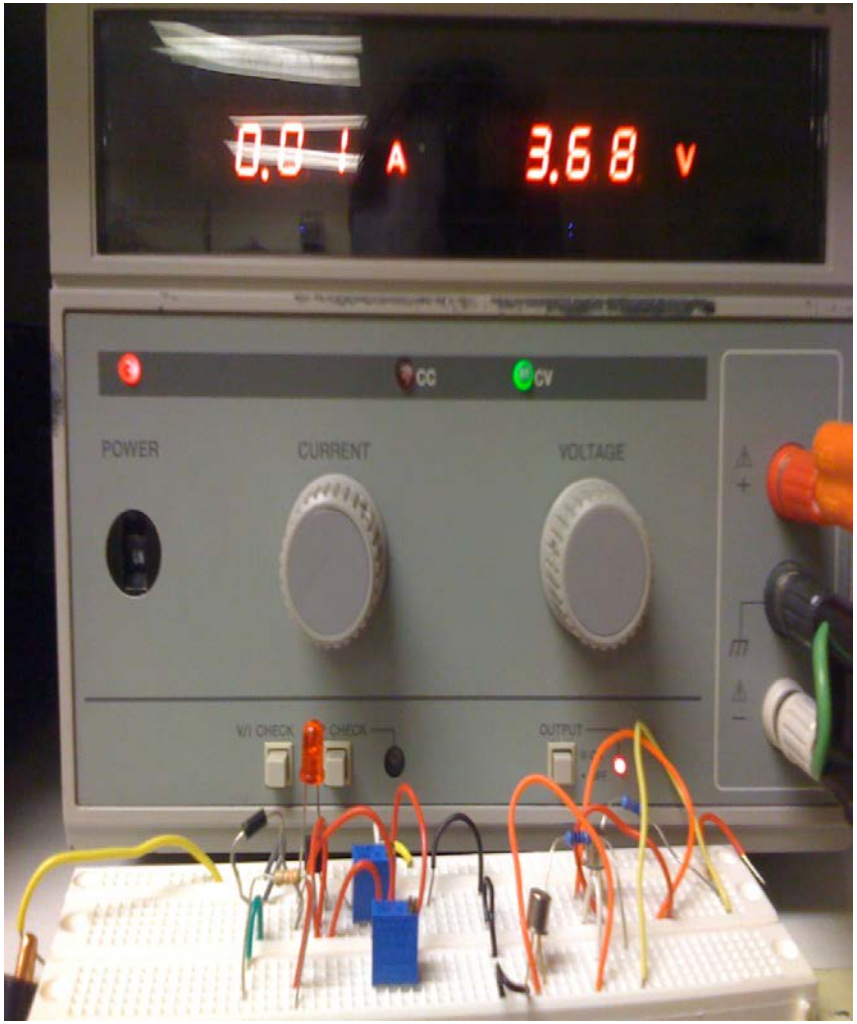


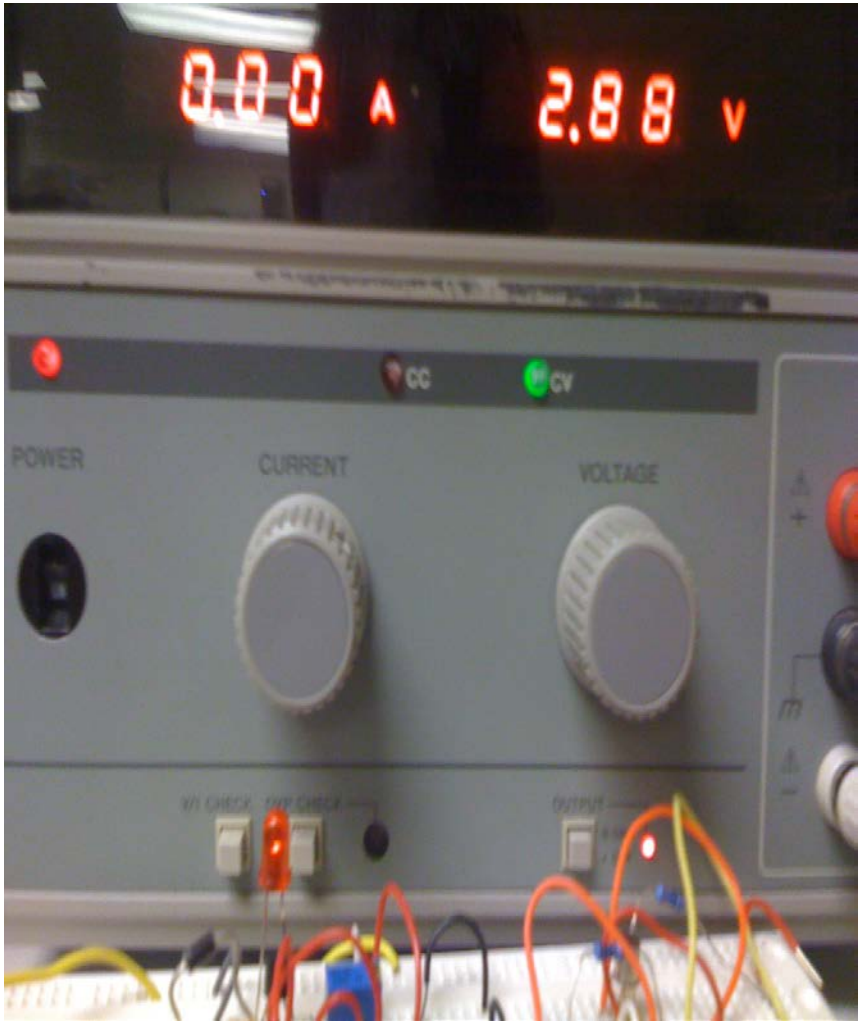
# LED Battery Status Indicator



- **This circuit is responsible for indicating a low status of battery. A full battery is around 3.7v. When the battery goes below 3.0v, the red LED lights as an indication of the low status of the battery.**

# LED Battery Status Indicator Simulation



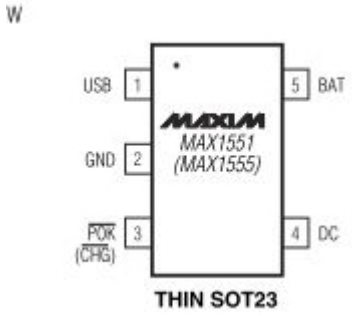



# Phase 2 connections:

- For the purpose of phase 2 we remove the arduinoUno board and the breadboard, and replace it with a custom PCB incorporating the following features:
- **ATmega 328 microcontroller chip connection**
- **ADXL335 accelerometer chip**
- **Footprint for MLX90614 Infrared Temperature Sensor**
- **Lithium polymer battery socket port.**
- **MAX1555 with microUSB port for Lithium polymer battery charging.**
- **SD/MMC card holder**
- **External 16MHz crystal clocking device**
- **Headers for pulse sensor and expansion ports**

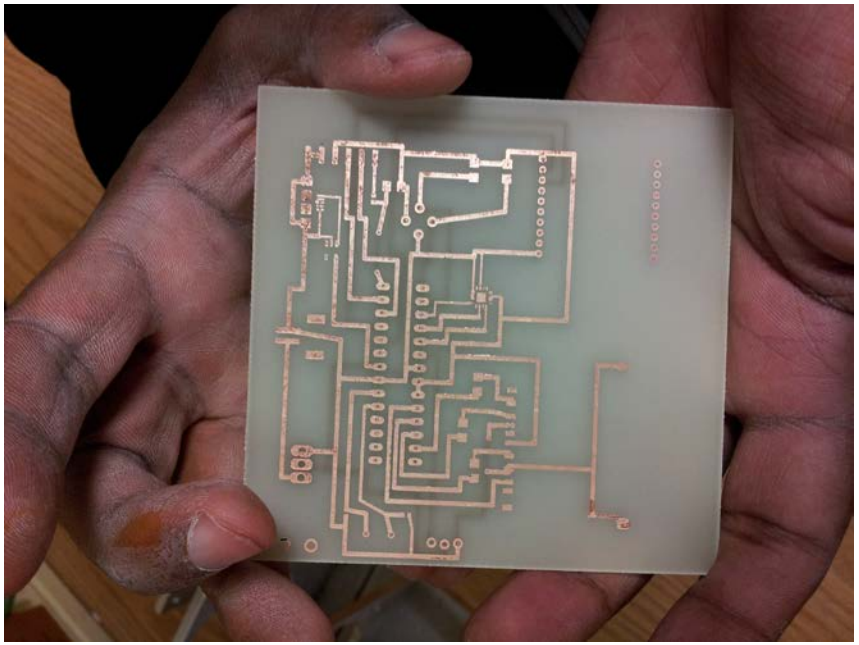
# Battery Charging (MAX1555)

- IC for USB charging of Lithium Polymer battery
- Quick charging
- Current automatically reduced to trickle when charging is complete.




# Making of PCB at EVRT 50N

- Step1: Print PCB layout on glossy paper using laser printer
- Step2: Using clothes iron heat transfer design onto copper board.
- Step3: Use PCB etching solution to etch out all copper except transferred ink traces.
- Wash board completely to remove ink and have copper traces left.



# Future Work

- We could add a gyroscope, magnetometer, and GPS to improve motion detection
- We could add multiple temperature sensors to improve skin temperature data collected
- We could add electrode ECG measurement in addition to pulse oximetry
- Atmega328 has limited ports with no room for expansion. Could upgrade to Atmega2560

# Conclusion

- Tested with arduino with sensors and are able to communicate reliable data
- Tested the xbees with arduino. Able to transmit at least 100m
- Prototyped a working device
- Made a pcb version of the prototyped board
- Need to design a case that is wearable