BlepH - A reliable, power efficient and low cost bluetooth pH sensor

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HI11312 - HALO™ pH Probe with Bluetooth® Smart Technology $195.00

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The World's First pH Electrode with Bluetooth® Smart Technology

HALO™ is the world's first professional pH probe with Bluetooth® Smart technology (Bluetooth® 4.0). It is a high quality, double junction, refillable glass pH probe with a built-in temperature sensor that can be used virtually anywhere: in the field, laboratory or classroom. Its flexibility and ease of use will revolutionize the way pH is measured. HALO™ transmits measurement data directly to an iPad® (not included) running the Hanna Lab App.

One press Connect

Easily connect to the Hanna Lab App (required for use) at the press of a button via Bluetooth® wireless technology (10 m range (33')).

Status Indicator

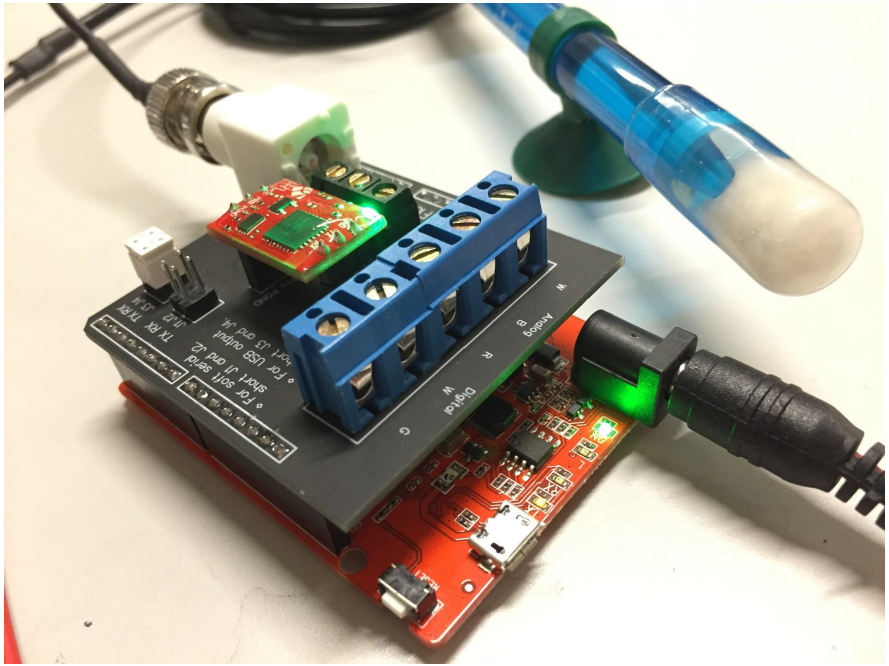
Motivation

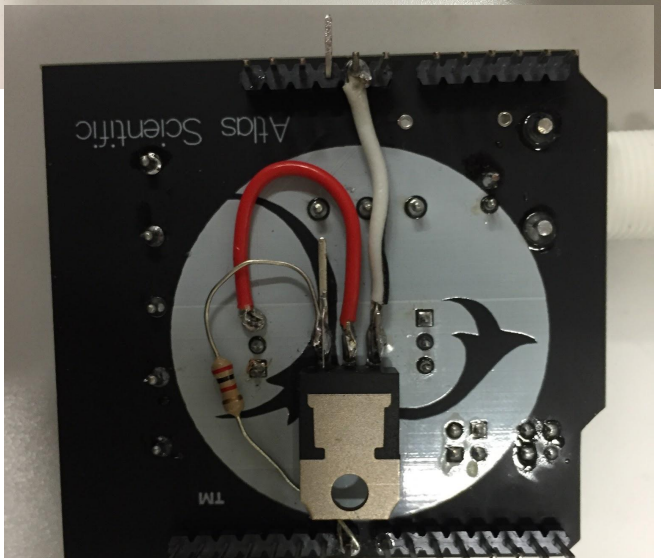
- Most pH sensing devices on the market are very expensive.
- There is an increasing demand for such devices in agriculture, food and health care.
- Most usage requires the device to run in a remote location for a long time

Goal

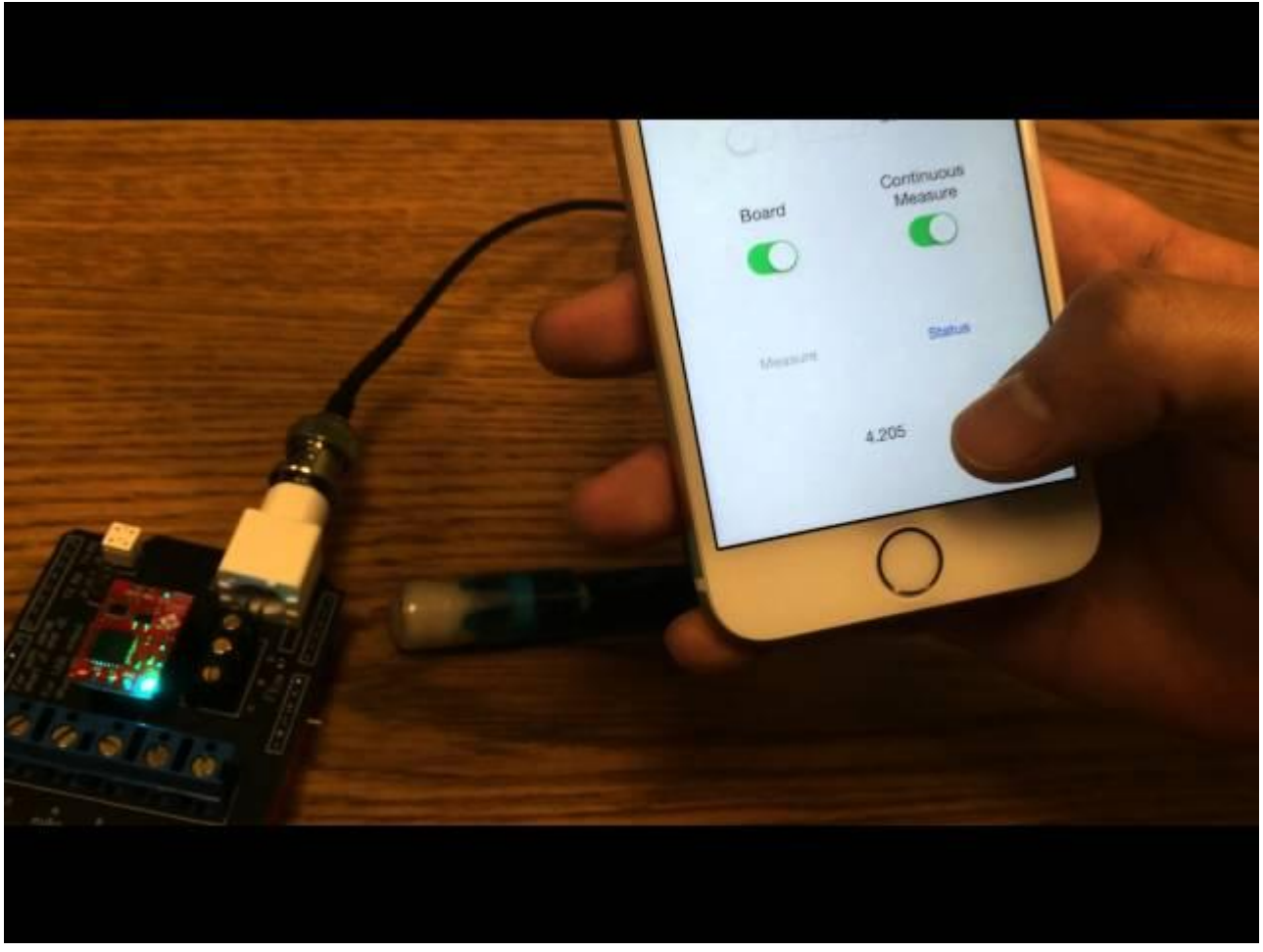
- Measure pH value of a solution remotely.
- Run a long lasting measurement probe with tight energy budget
- Access the characteristics of the system’s power consumption.

Finished Product

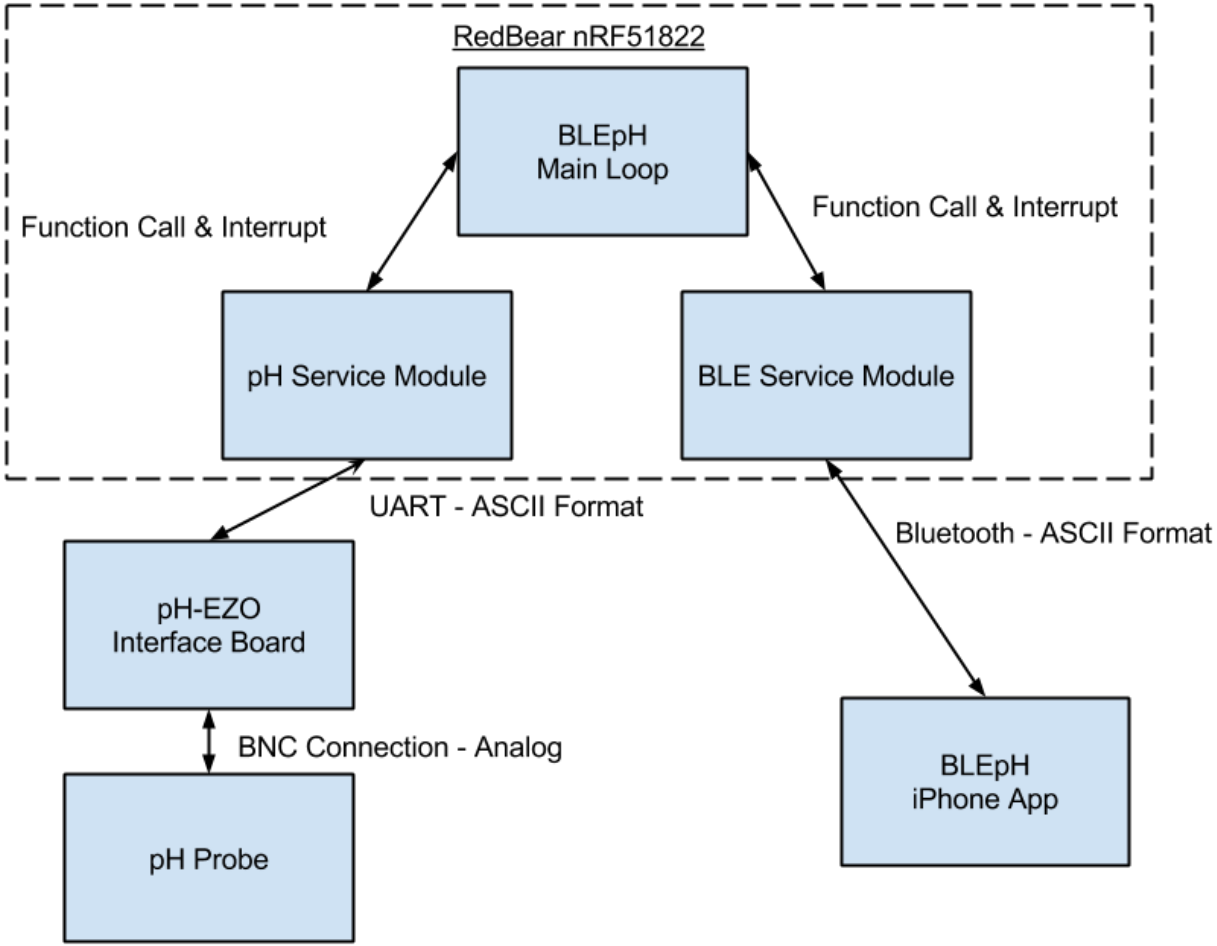




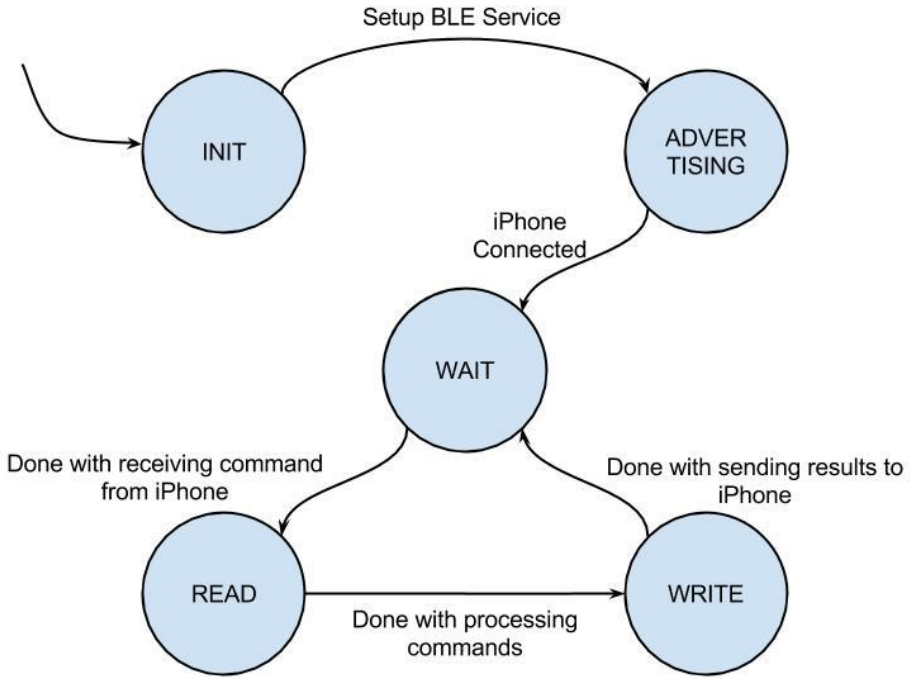
Video Demo

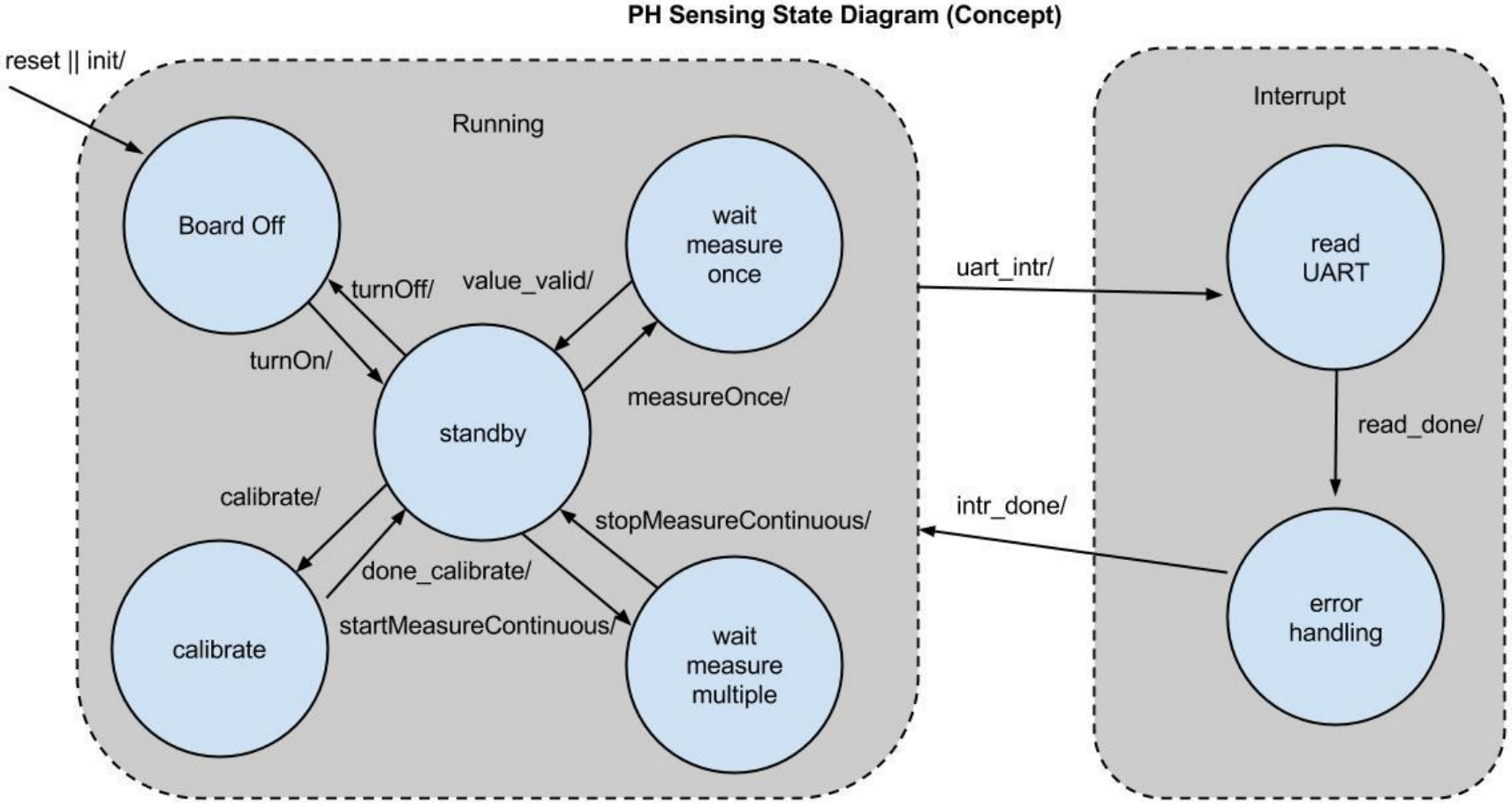


BLEpH System Functional Diagram

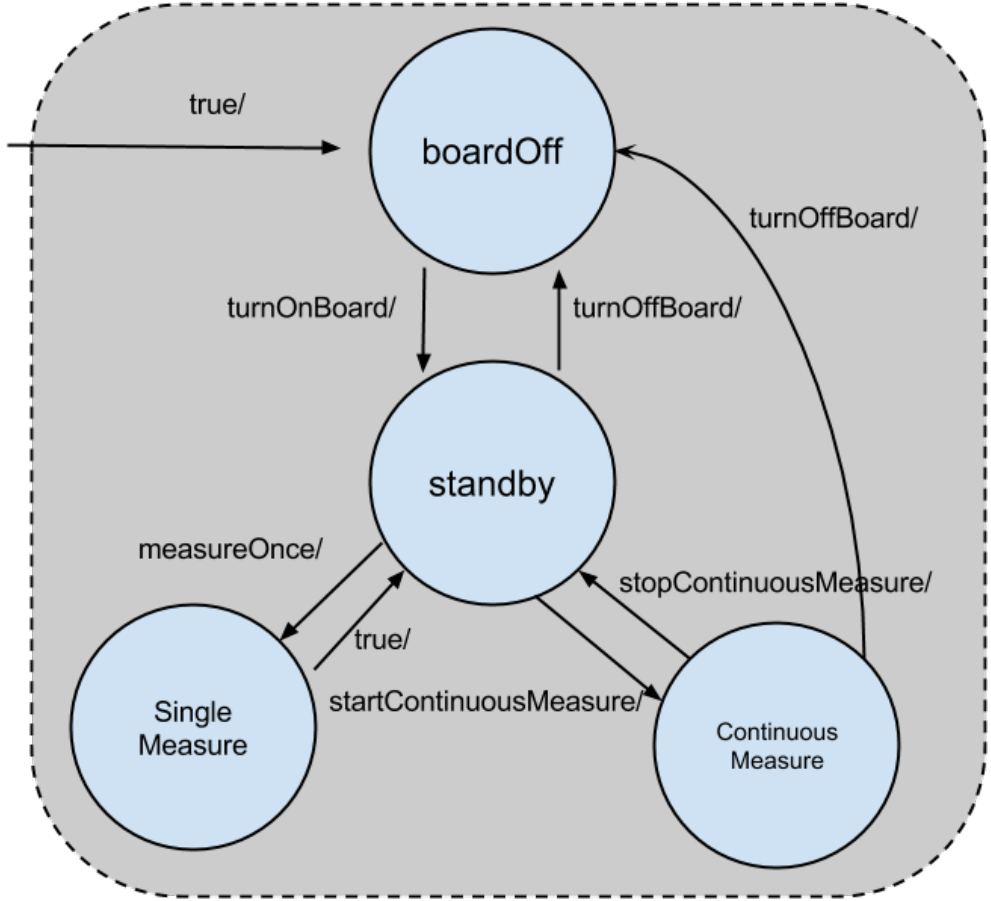


State Machine - BLE Service




PH Sensing State Diagram (Concept)
reset || init/
Running
Board Off
turnOff/
value_valid/
wait measure once
turnOn/
standby
measureOnce/
calibrate/
stopMeasureContinuous/
done_calibrate/
startMeasureContinuous/
calibrate
wait measure multiple
uart_intr/
Interrupt
read UART
read_done/
intr_done/
error handling

Main Function State Diagram (Concept)



Available Features

- Control ON/OFF of the pH interface board
- Single Measurement
- Continuous Measurement
- Periodical Measurement

Additional Details

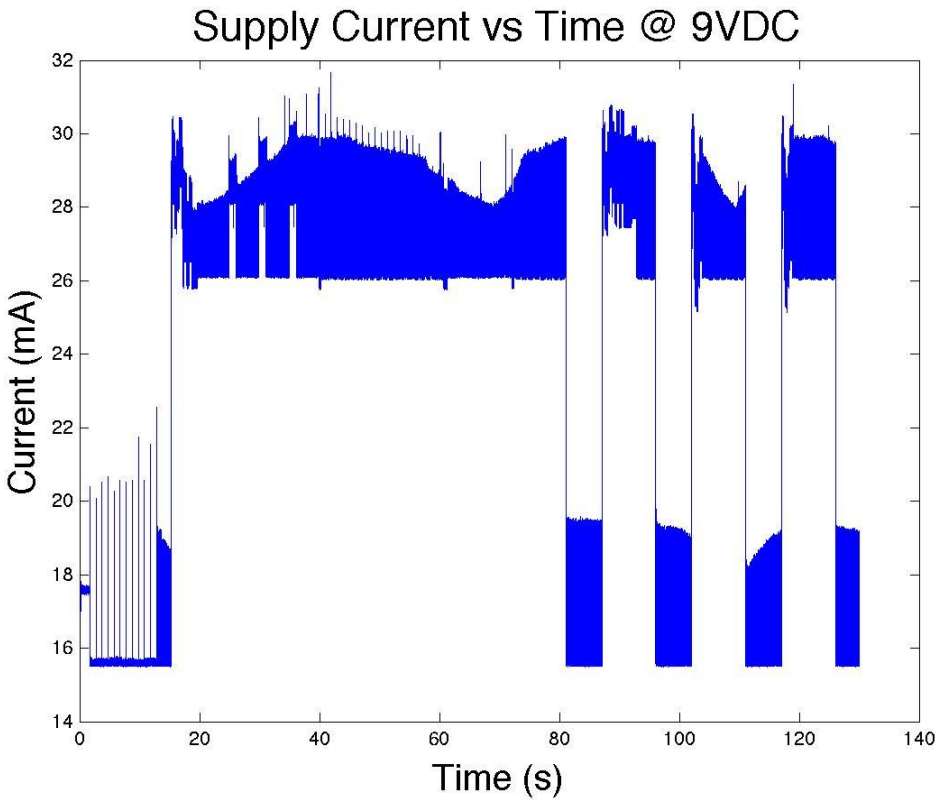
- A control system built up with sleep and interrupts
  - UART interrupt used to control communication with pH measurement circuit
  - BLE interrupt used to control communication with phone
  - Timer interrupt used to control periodical measurements.
  - NO busy wait.
- Additional hardware to enable and disable pH measurement circuit

Power Efficiency Analysis

- Assume 600mAh power budget from an 9V battery
- 1 year of intended battery lifetime
- Consists of THREE parts, pH sensing board, nRF51822(BLE), MK20 companion chip
- Data acquired using LabView @ 1k sample/s, 9V rail, 10 uA current resolution

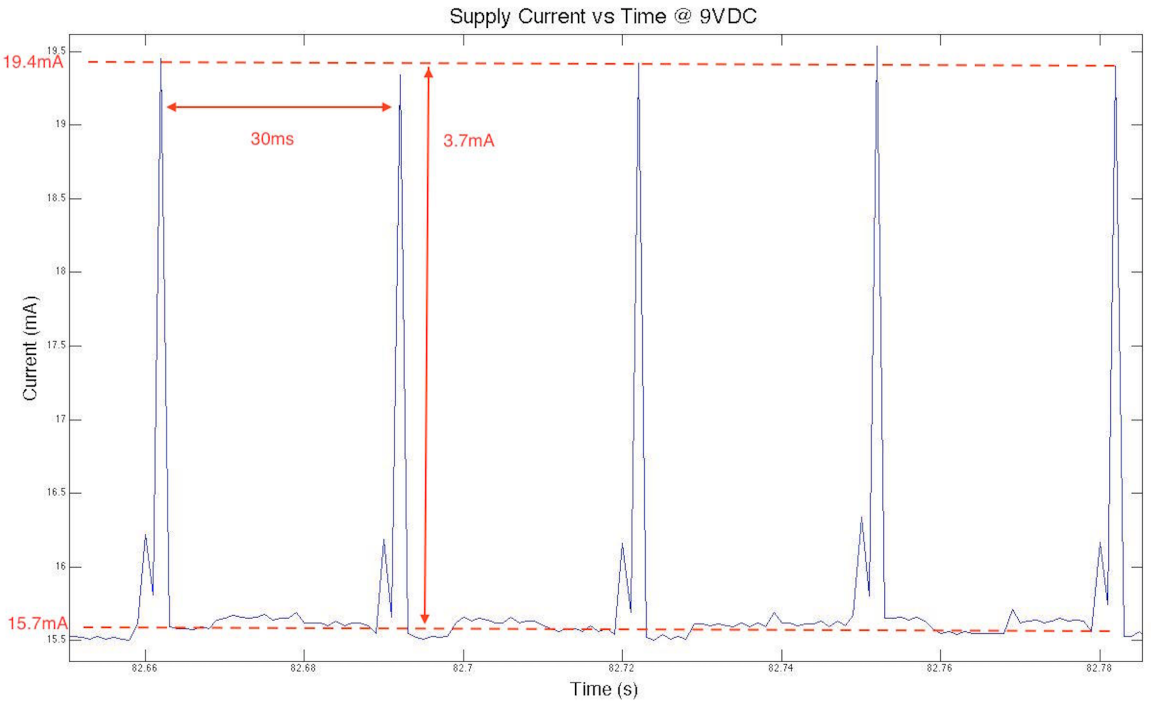
Power Efficiency Analysis

- Overall power profile
- Includes consumption from all 3 components



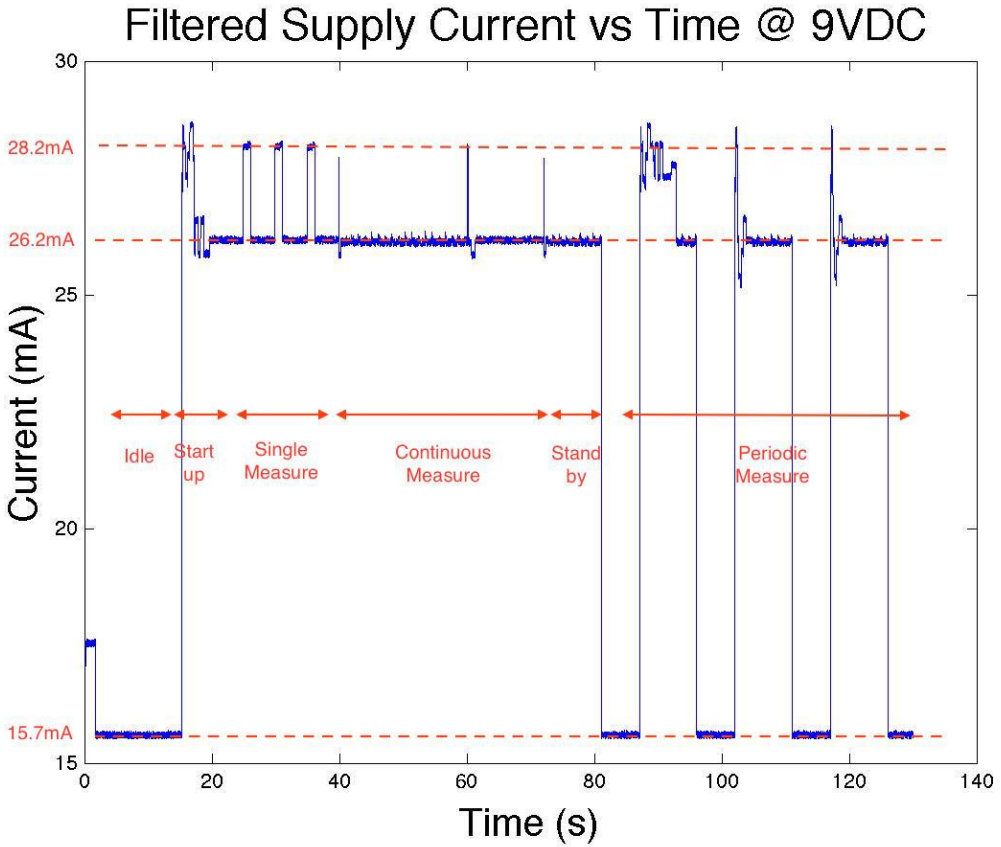
Power Efficiency Analysis

- BLE power profile when connected
- 6% duty cycle
- 0.247mAh
- Superimposed on others
- Can be made much smaller



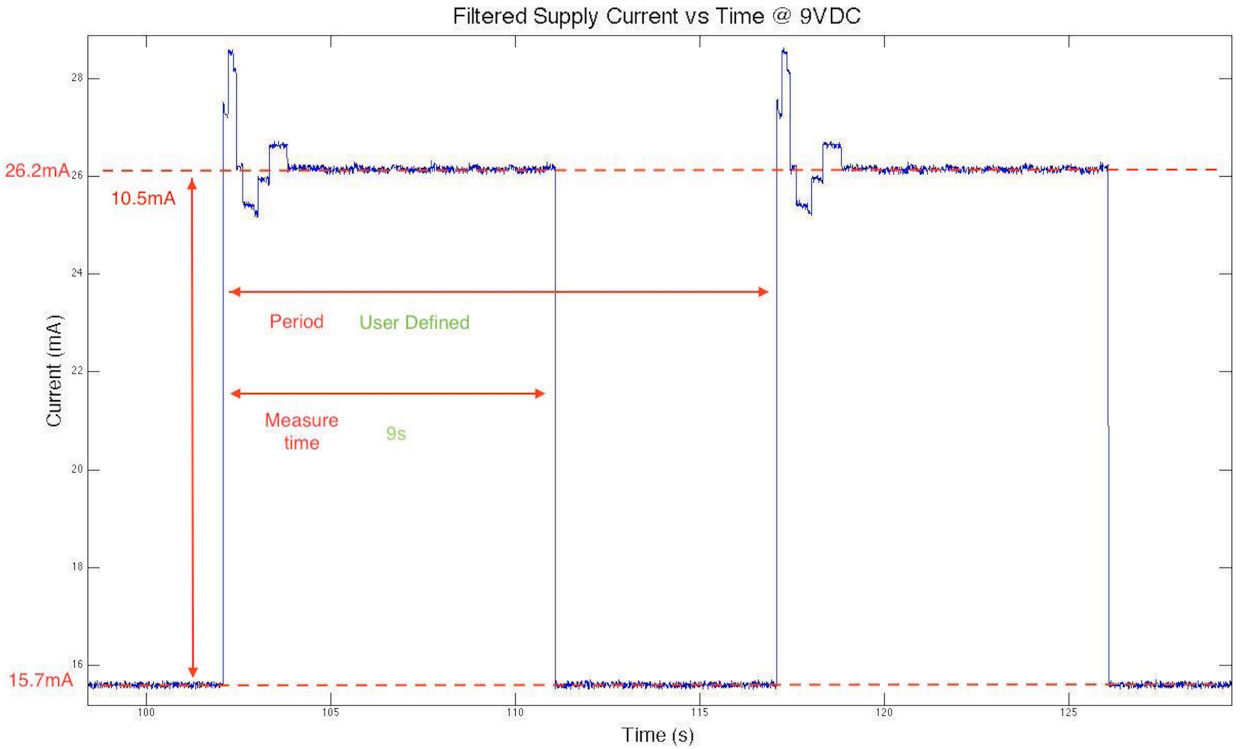
Power Efficiency Analysis

- Power profile after applying 15-point median filter
- Power consumption of pH sensing board & MK20



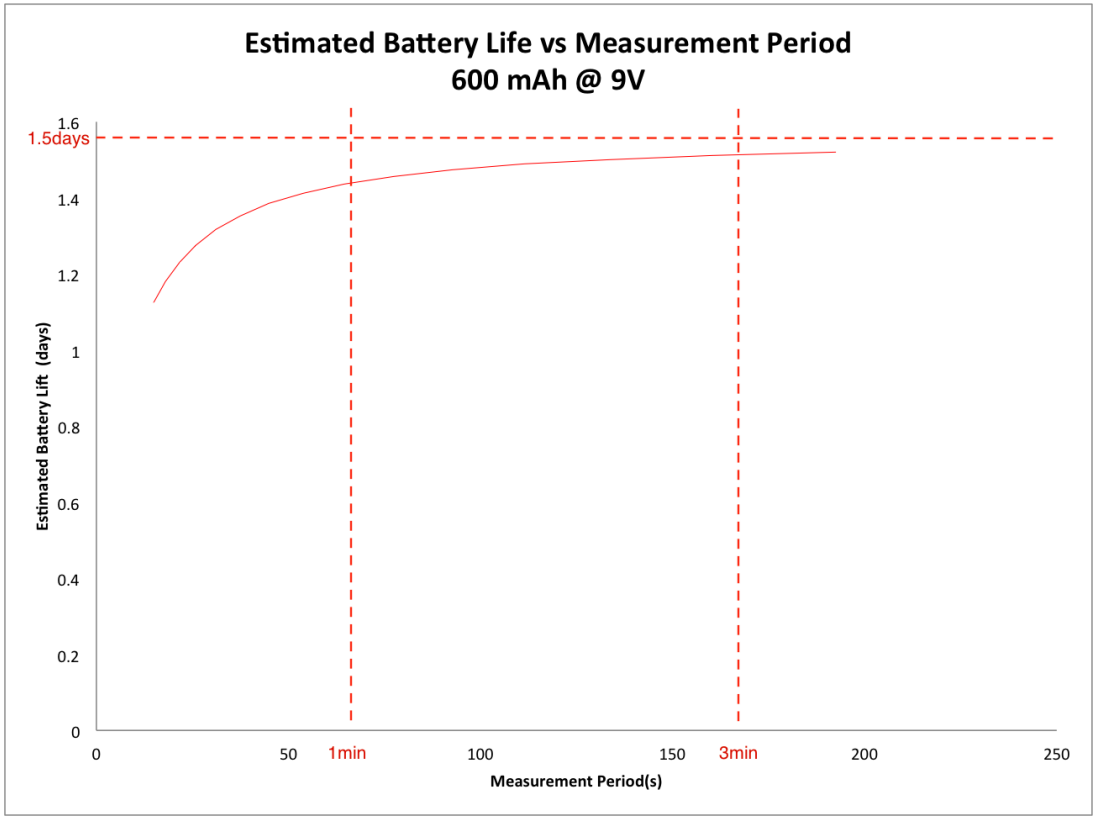
Power Efficiency Analysis

- Periodical measurement power profile
- Depends on Period and Measure Time



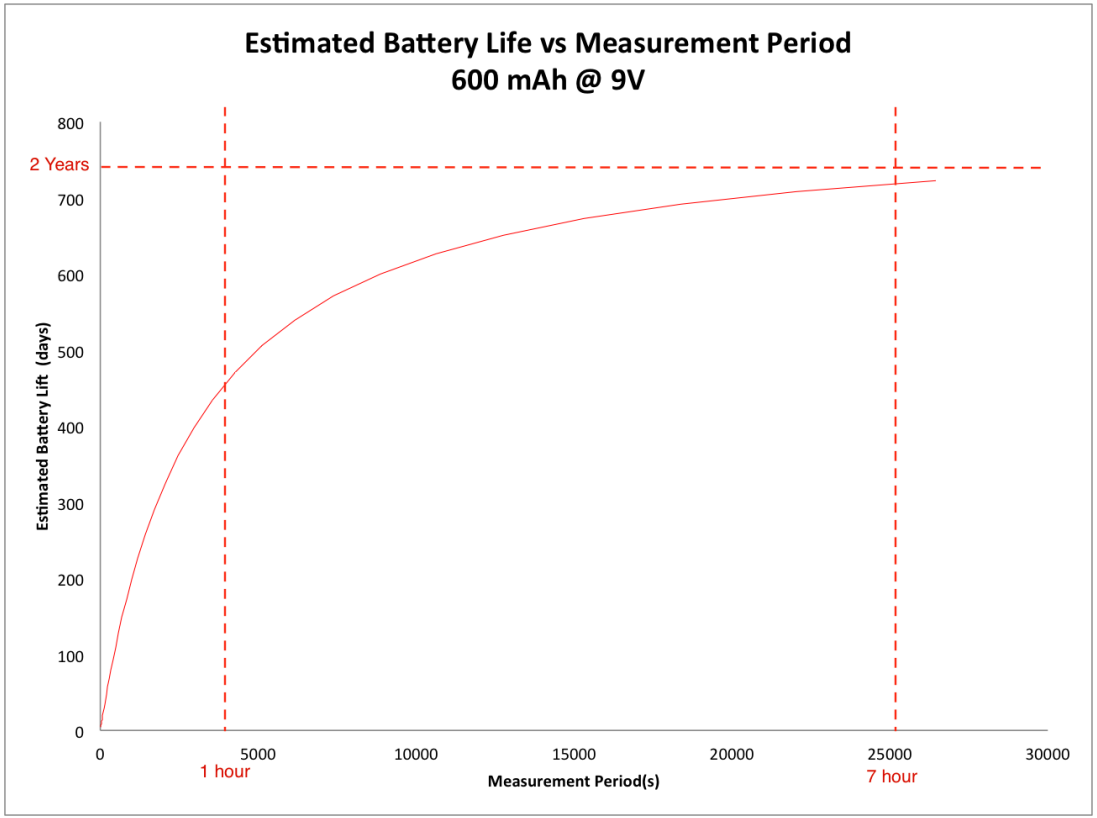
Estimated Battery Life

- Only 1.5 days
- Total standby current for nRF51822(BLE) and MK20 is > 16mA
- Bottleneck is on nRF51822 and MK20



Estimated Battery Life

- Assume no MK20 companion chip
- A better procedure for BLE standby, i.e, disconnect while waiting -> 30uA standby current for nRF51822(BLE)
- Can easily achieve 2 years battery life



Cost

Item	**Cost**
RedBear Lab nRF51822 Board	$39.90
American Marine pH Probe	$39.99
pH Probe Interface Circuit	$34.00
Arduino Rapid Development Shield	$24.00
Battery & Connectors	$4.00
Total	**$141.89**

Future Plan

- Design and validate customized an integrated circuit such that any unnecessary components are excluded
- Improve software features such as a better iPhone app and BLE standby procedure
- Build a distributed system for large scale data acquisition
- Enables the design of other BLE systems.

Thank You

Questions