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Portable Nutrient Data Collection System

MAY 1633

Design Document

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0. List of Abbreviations

MEMS: Micro Electronic Mechanical System

RF: Radio Frequency

1. Introduction and background:

Managing nutrients in agriculture continues to be a major challenge in ecosystem science. This project aims to design and implement a portable smartphone-aided nutrient data collection system. There are mainly three parts for this project: Voltage booster and Micro-discharge device, data acquisition using designed microcontroller, and a smart-phone application for nutrient data display based on android system.

2. System requirement:

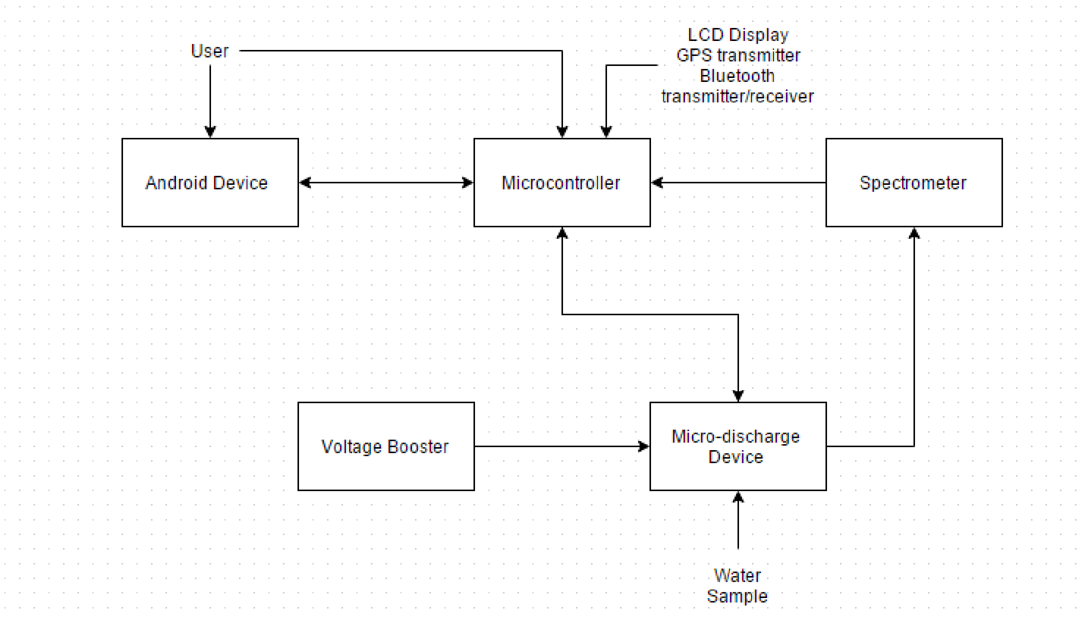
Functional Requirement:

1. Display levels of different elements in water sample with **precision**
2. Application is based on Android
3. The whole process should take less than 30s
4. Have database for the history
5. Have GPS for location information
6. Accurately distinguish between good/bad measurements
7. Transmit data wirelessly to smartphone

Non-functional Requirement:

1. Portable, low power and safe
2. Easy-use-interface. (tutorial, easy to find settings)
3. Be shielded from water and dirt damage
4. 10ml water is acceptable amount to test with
5. Be able to remain powered wirelessly for 1000 trials
6. 95% accurate with reading
7. Smartphone app size should be less than 6MB
8. Total time of analyzing water sample on smartphone application should take less than 30s
9. Communication from device to smartphone should take less than 2s
10. Wireless range should be up to 2m

3. Block diagrams of the concept:



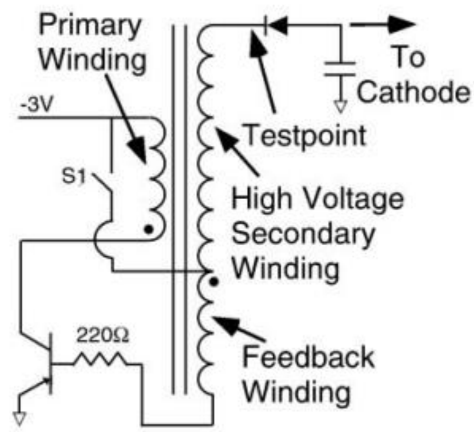
1. User to Device
    a. Android device to microcontroller via Bluetooth
    b. Manual controller via push buttons and LCD screen on microcontroller
2. Start micro discharge device and voltage booster via microcontroller.
3. Send optical information from micro discharge device to spectrometer
4. Send spectrometer data to microcontroller
5. Display results on the Android application or microcontroller's LCD display

4. System analysis:

The whole system is made up by Voltage booster, micro-discharger, microcontroller and Phone App five subsystems.

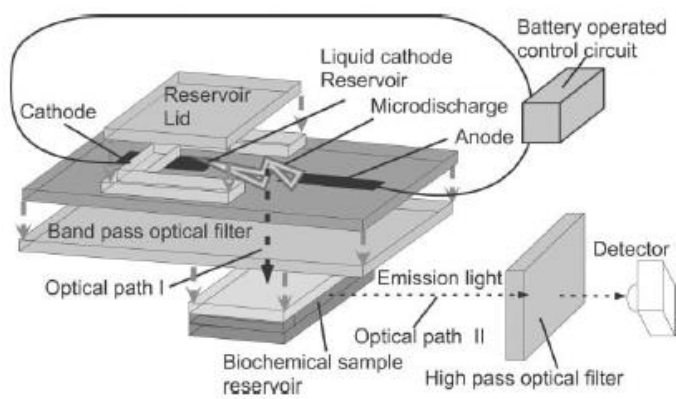
4.1 Voltage booster:

We use the voltage booster in order to boost the voltage in the micro-discharge device to 300V in short period. With this voltage, we can stimulate fluorescence in the solution contained in the micro-discharge device. The circuit of the voltage booster we designed is shown in the figure on the right, we use the xft-5683-3v 3v to 300v transformer, 2sd882 n-p-n 30v 3a transistor and c450-1000u 450v 1000uf capacitor.



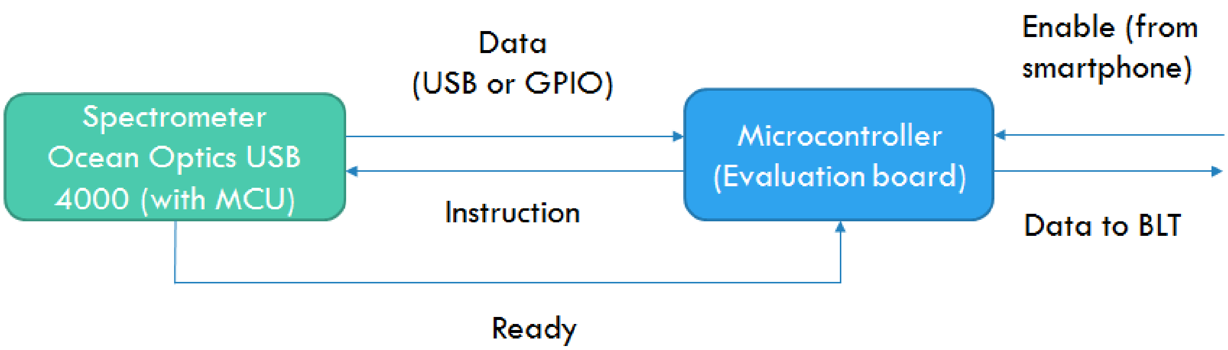
4.2 Microdischarge:

The Micro-discharge device is used to generate electrical break down between two metal electrodes and stimulate the fluorescence in the solution. Exploded schematic of the liquid electrode discharge spectral emission chip (LEdSpEC) is on figure on the right, which is a stacked microchip, and the associated control circuit and detector arrangement. Short arrows indicate the stacking order for the microchip whereas long arrows indicate the two orthogonal optical paths, as noted. The chip is held vertically during operation. We use the spectrumeter as the detector which will be discussed in the section of spectrumeter. The Anode we used is 4mm wide strip of MetGlas foil (Magnetic Alloy 2826 from Metglas Inc). The Cathode we used is saturated salt solution (Need To be Determined). The Glass we used is 506 mm thick, #7740 Pyrex=. The Optical filter we used is commercial dichroic filter made on a 2.5 mm thick quartz substrate.



4.3 Microcontroller:

We are in charge of the micro controller and the Bluetooth transmitter. The purpose of our design is to receive the data we got from the spectrometer and transmit those data to the mobile phone though Bluetooth transmitter. The following is the process:

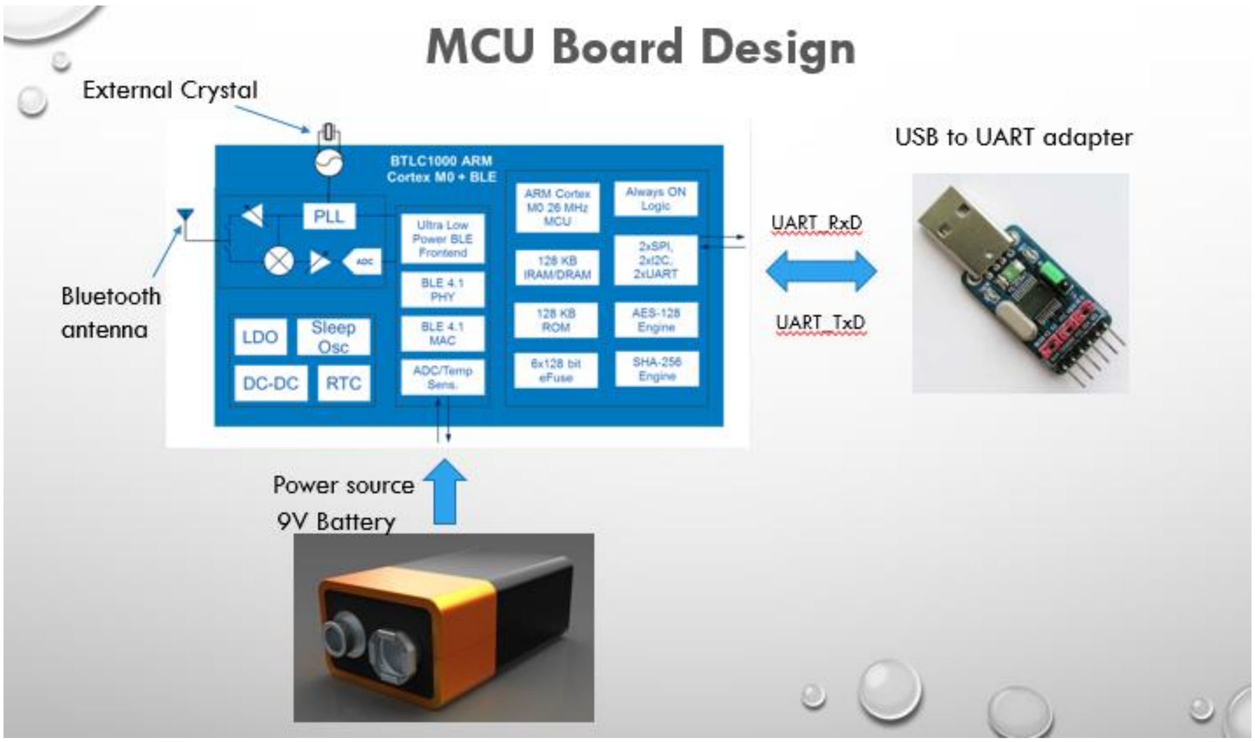


To reduce the size of the whole chip and reduce the total power consumption of the whole system, instead of using a microcontroller connected with another Bluetooth chip, we want to use the microcontroller with the Bluetooth module.

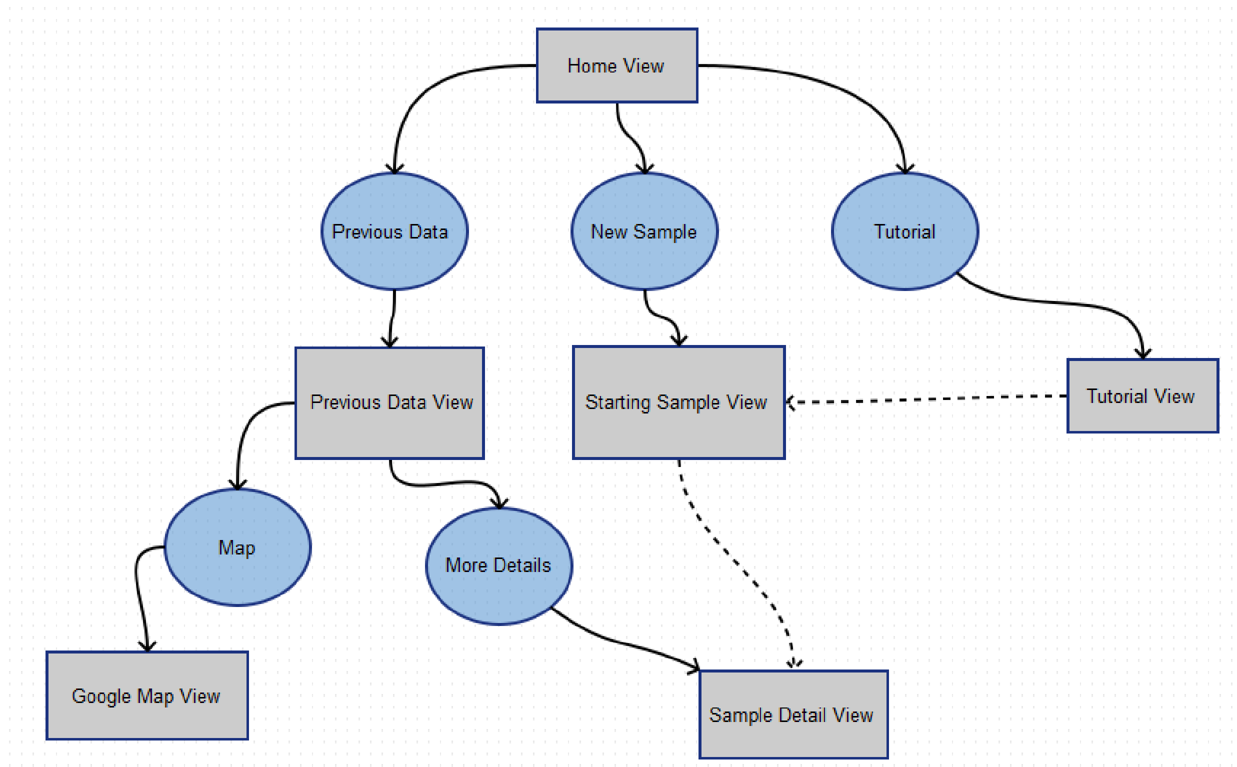
The specific microcontroller we have chosen is Atmel ATBTLC1000. This microcontroller has a Cortex-M0 cup with 26MHz clock frequency. It also has 128Mb ROM and 128Mb RAM. The reason we chose this chip is that,

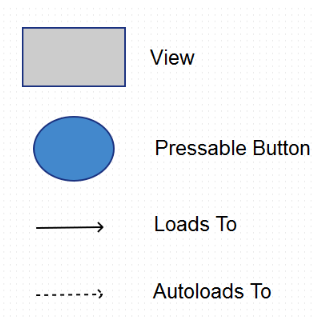
- First, this chip has a pretty big RAM size, which is 128 Mb. Because we need to run programs in this chip in order to receive data from the spectrometer and transmit those data though Bluetooth, the RAM of the microcontroller cannot be too small.
- Second, Atmel is a pretty big company. For the chip Atmel ATBTLC1000, there are lots of example codes online. Those codes will help us a lot during the programing interface process.

After we have chosen the microcontroller, we need to do the PCB design to finish the whole circuit. We decide to use NI Multisim 13.0 to do the PCB design. The following is the hardware parts:



4.4 Smart phone application:





The app will take input (by Bluetooth) from the device between loading from the Starting Sample View and Sample Detail View. Input includes spectrometer data and GPS data. In the Starting Sample View there will be an option to start the data collection process, and therefore start the device. Only on Android devices. Can store up to about 2GB worth of data in the database (Feel free to correct me on this. It is a rough estimate; also this number depends on the operating system and what kind of database we use). About 5 seconds of loading time between views (worst case, another guess).

5. Conclusion:

The system would help farmers to manage the nutrient in the fields easily, decrease the risk of over fertilizing and monitor the plant status. Implementation of this system may also save effort for research involved in elements measurement.