Water Quality Monitoring

ECE 445- SENIOR DESIGN LABORATORY

DESIGN DOCUMENT GROUP 56

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1. Introduction

1.1.Title

Data collection, GPS monitoring and power management of pollution measurement system on boat.

1.2. Background

The USGS (U.S Geological Survey) has estimated that each person uses up to 130,000 liters of water every year. A big part of this consumption is for drinking and hygiene. Water companies, consumers and environmental scientists need to know the condition of water resources in order to take action if the pollution levels of water raise unexpectedly, given the importance of drinkable water.

Water pollution is a bigger issue than we think. Actually, it causes more deaths than any war. More and more people die due to water pollution every year. The UN (United Nations) has estimated that 1.8 millions of kids younger than 5 years old die every year due to the consumption of polluted water. This is equal to one death every 20 seconds.

1.3. Objective

The company CERSE (Center for Environment Restoration and Sustainable Energy) has realised that water pollution is a big issue, and want to make sure that the water that is being consumed is safe. That is why they came up with this project: a boat that analyses water in lakes and rivers and sends real time alerts if water is not drinkable.

Our duty in this project is to create some of the modules that this boat needs in order to complete its commitment. We want to provide this boat a GPS system, so that we get information on where the boat is located at every instant of time. This is needed in order to know if the boat is in the position where we want to analyse the water. Also, we want to create the module for data transmission system, which is needed to send the data collected by the multiple sensors that the boat is equipped with, and send it to a server so that they can be checked in real time from a laptop or phone. An app will be created to receive this data and get the alerts that the boat sends depending on the water pollution. In addition to this, we are creating the

electric system to power the boat, which includes a solar panel so that the boat can stay offshore for a few days, so that it does not have to pause its job to get charged.

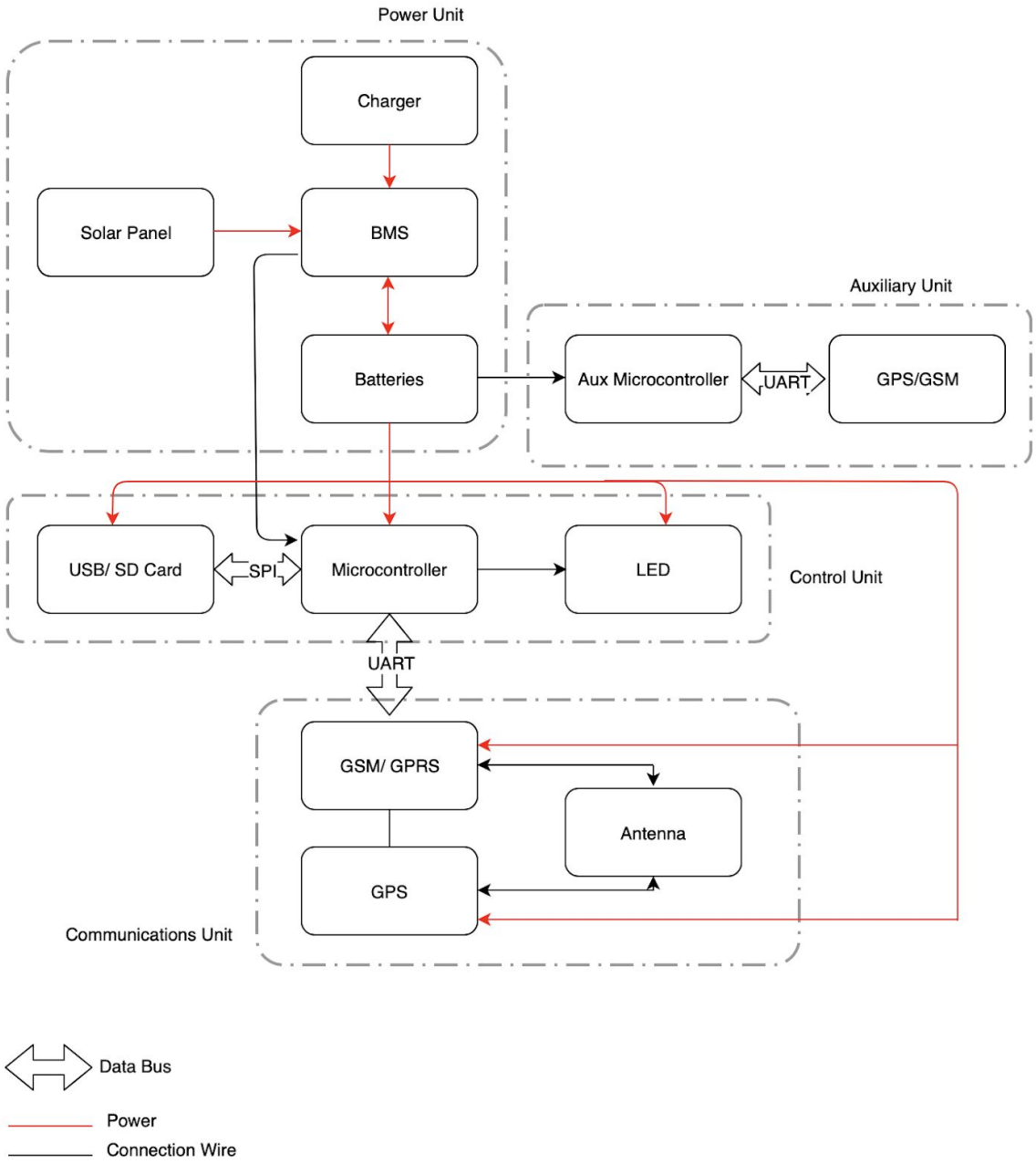
1.4. High-Level Requirement List

CERSE's main requirement for this project are the following:

- Data analysis in real time with desktop and android applications to access the data.
- Autonomy of the boat of up to 15 days, provided by solar panels.
- Monitoring via GPS of the boat and software autopilot for future implementation.

2. Design

2.1. Modular Block Diagram



2.2. Components Descriptions

2.2.1. Power Management Unit

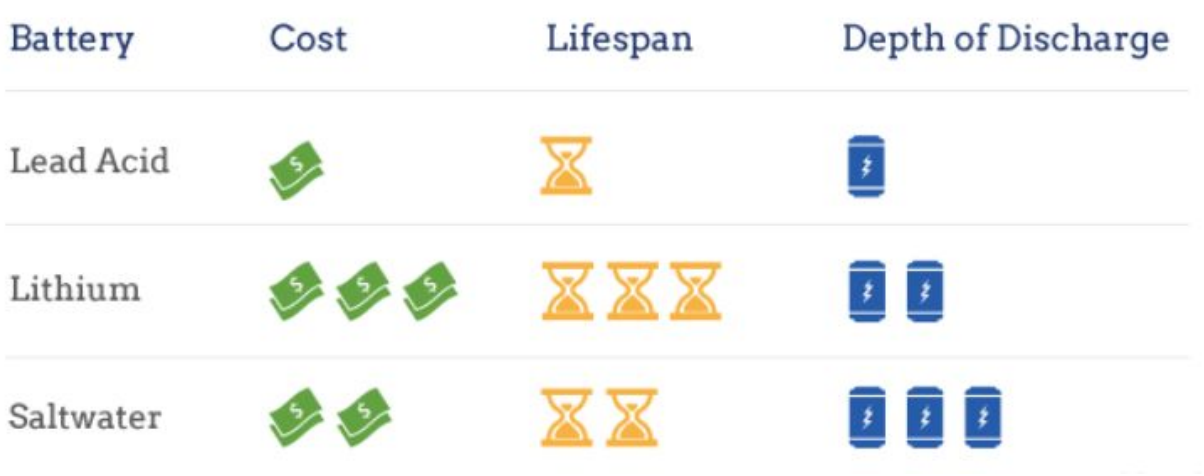
- **Solar panel:** a solar panel is required in order to give the boat the sufficient power to stay in a desired position in a lake or river during various days. The power requirement is yet to be specified by the company.

  The calculation of the solar panel depends on the boat size (still to be specified) and the power needed to power the motor and all the electronics in the boat.

- **Batteries:** a set of batteries is needed in order to store the energy received by the sunlight, and be able to power the boat. Total power needed is still to be specified by the company.

  The calculation of the batteries needed depends on the total energy needed to power the boat, and the amount of days the boat needs to be offshore. Despite that, we have done some research about the batteries that best suit the project. The most common batteries used with solar panels are:

  - Lead acid: these batteries are cheap and have a small depth of discharge. Despite that, they are heavy, have a short lifespan and its chemical components can be hazardous.
  - Lithium Ion: they are the most expensive out of the three types, but are lighter and have the largest lifespan. They are not as dangerous as the Lead Acid.
  - Saltwater: these type of batteries are very eco-friendly, which is good for this project in case something happens to the boat, so that it implies no danger to the environment. Despite that, their depth of discharge is the largest of these three types of batteries. Also, their lifespan is not great and we are not sure if they can be used with a BMS, which is needed for this project.



- **Charger:** a charger wants to be implemented in the boat, so that it can be charged faster than with the solar panels when the boat is just about to be deployed.

  The charger calculations depend on the batteries used, so it is still to be specified.

- **BMS:** Battery Management System to control the state of charge of the batteries and check that all of them are working properly. Also to start/stop getting energy from the solar panels depending on the battery charge.

2.2.2. Control Unit

The control unit manages every other module of the system. Receives the data from the sensors installed on the boat and prepares the information to be sent over the GSM module, as well as stored in an SD. It also provides feedback or alarms over the LED module.

- **Microcontroller:** The microcontroller handles all the data. First, it collects the data from the sensors via its connection pins. Then it stores the data in the SD/ USB module via SPI connection and sends the data to the GSM module via UART. We will work with PIC32, a model that must be able to process the great quantity of data that would be generated by the sensors.

  - Requirements:

        - Simultaneous UART and SPI.
        - Pins with 3.3V output.
        - High data processing.

- **LED:** We will install LEDs in the protoboard in order to see if the module is transmitting and receiving data correctly or something is wrong with the system.
- **USB/ SD Module:** The SD Card module will be connected to the microcontroller via SPI. This is necessary because given the case were data connection is lost, the GSM module won't be able to send the data, and we need it to be stored in a SD module to avoid losing the data.

2.2.3. Communications Unit

- **GSM/ GPRS:** The GSM/ GPRS module will be in charge of sending data to the cloud in order for it to be accessible to the users from a computer or android device.
    - Requirements
        - 2G/ 3G data connection.
        - Send alarms via SMS to a designed number.
- **GPS:** The GPS module has two main functions. First of all, data must be classified according to the geographical coordinates and the date in order to keep a clean record. Second, in case data connection is lost, an SMS alarm must be sent with the current GPS coordinates of the device.
- **Antenna:** An antenna module is necessary in order to increase precision of the GSM and GPS modules, and increase connectivity as well.

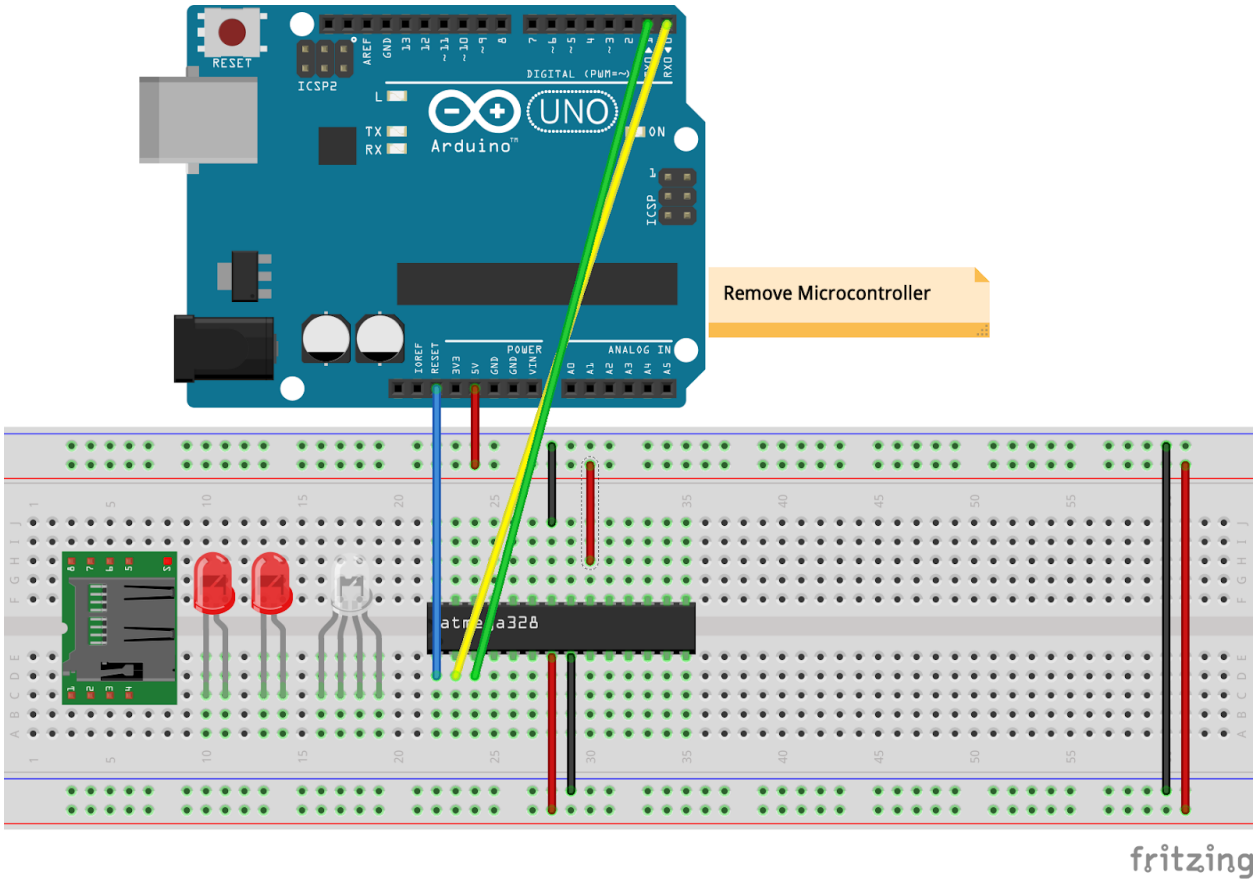
2.3. Risk Analysis

We need to take into account many factors that can influence the performance of our system.

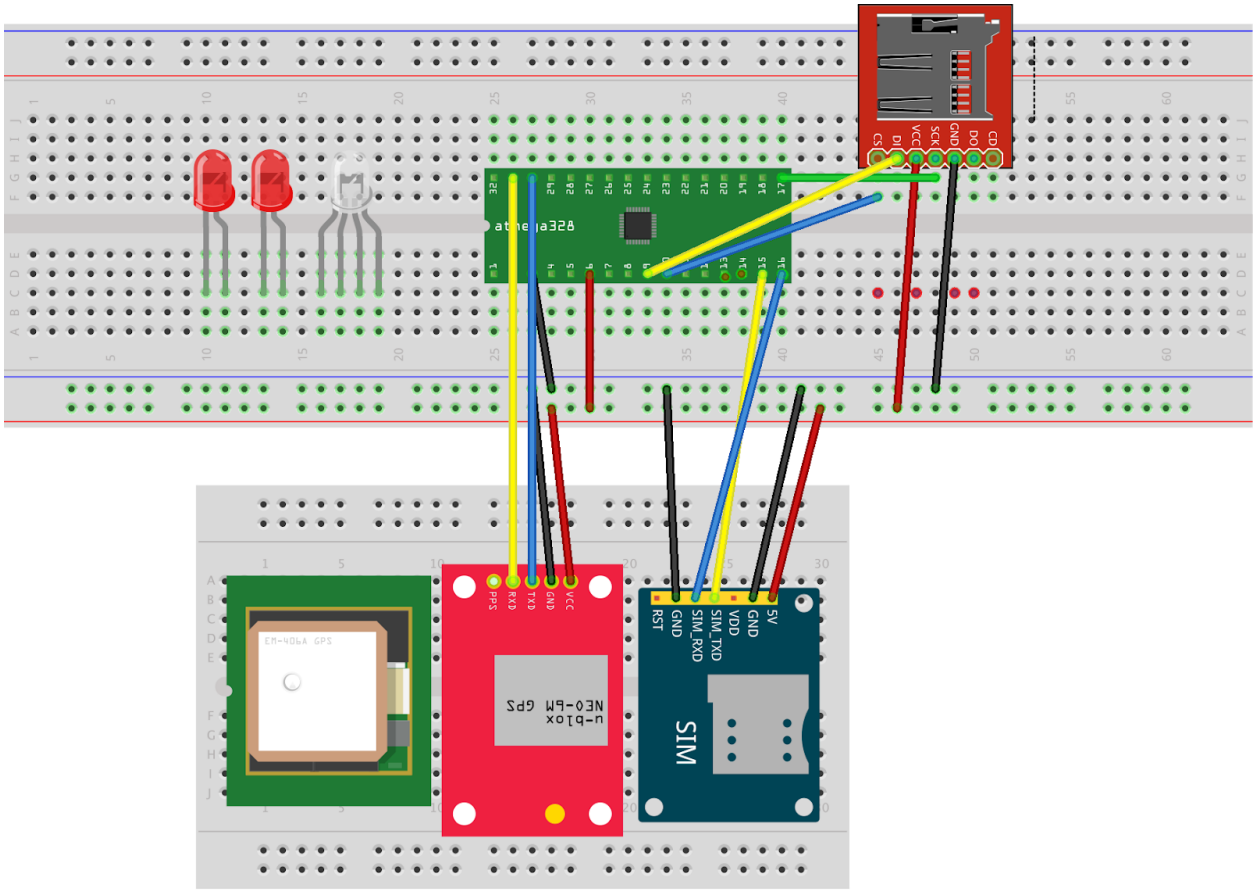
- Climatological conditions can be a factor to take into account given that various components (such as the GPS sensor or the solar panels) can be affected by this. We must guarantee that our system keeps working even on non favorable conditions.
- Remote location can also affect performance. GPS monitoring and data transfer can be affected if the boat final destination is an isolated point. We must guarantee that the GSM/GPRS system provides either 3G or 2G connectivity in order to transfer the data in real time or with the minimum latency possible.

2.4. Schematics

Microcontroller



Option 1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DI
VCC
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GND
DO
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atmega328
PPS
RXD
TXD
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NEO-6M GPS
RST
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SIM_RXD
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5V
SIM
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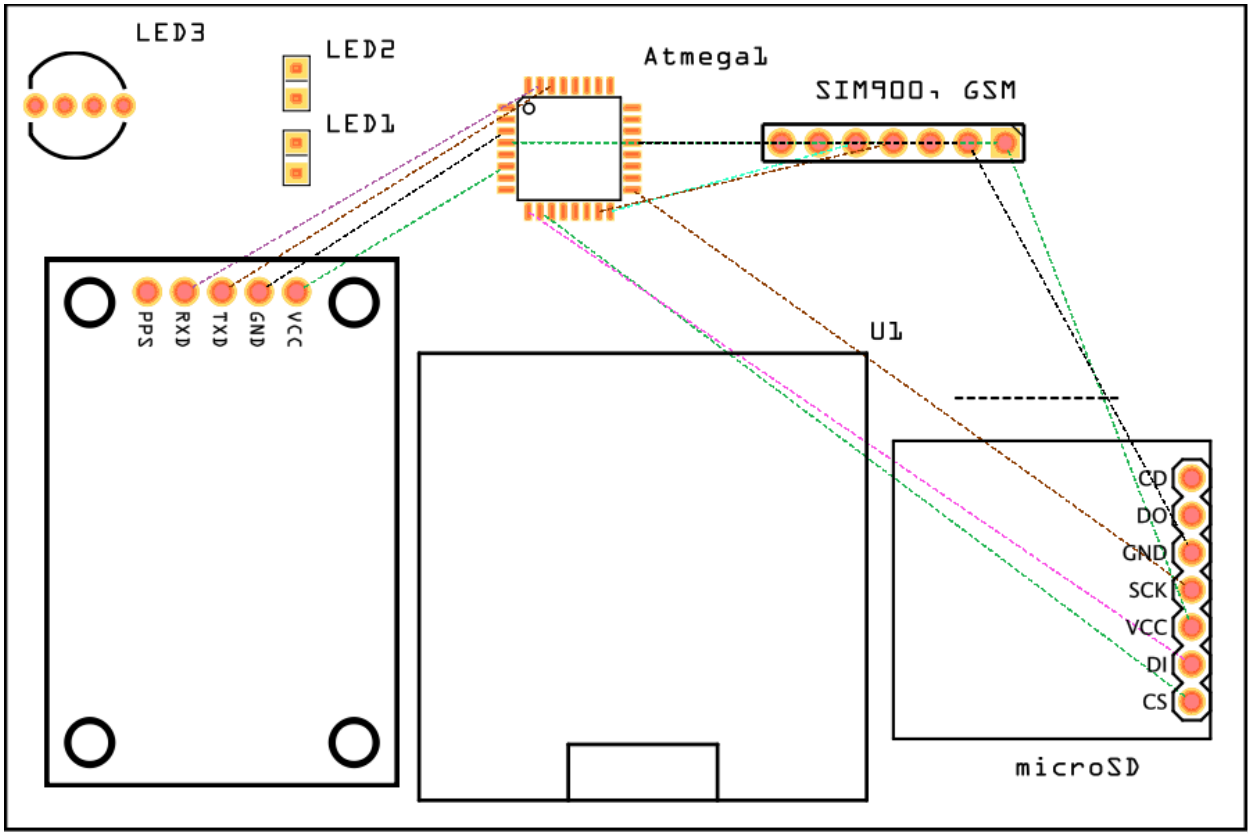
LED3
LED2
LED1
Atmega1
SIM900, GSM
PPS
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TXD
GND
VCC
U1
CD
DO
GND
SCK
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CS
microSD

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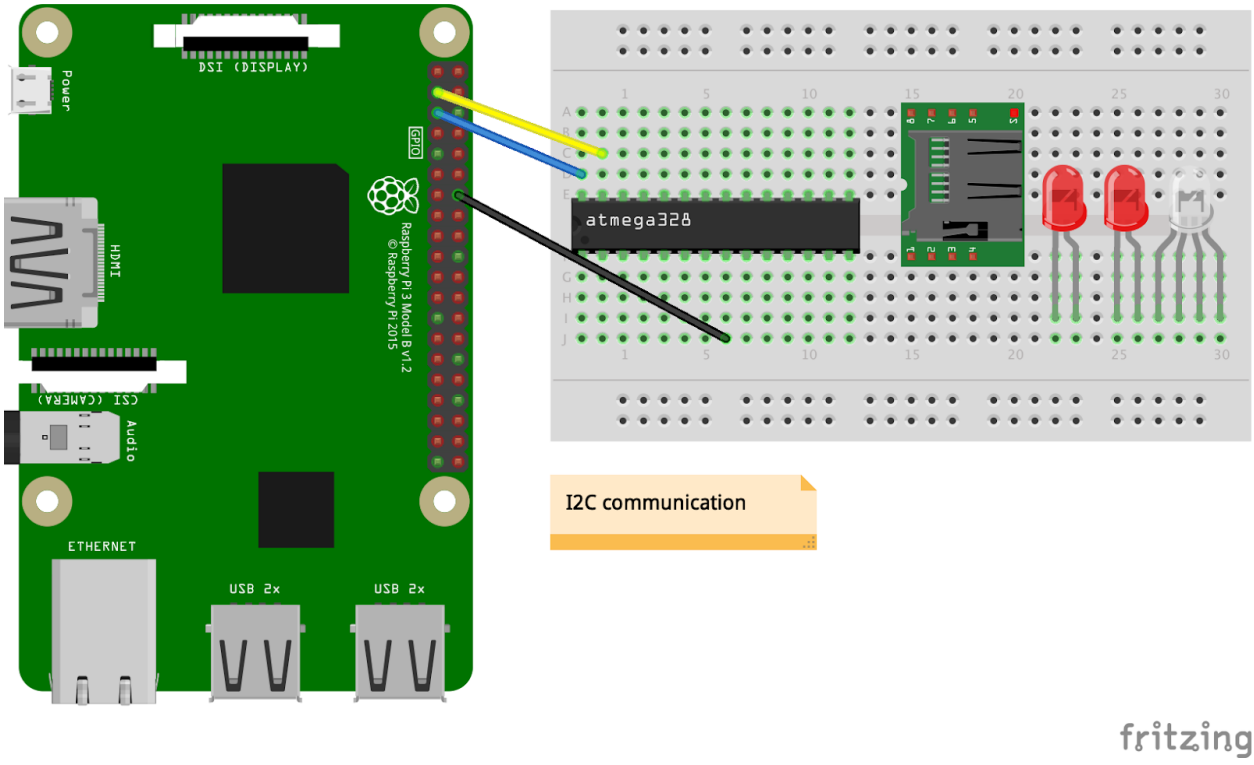
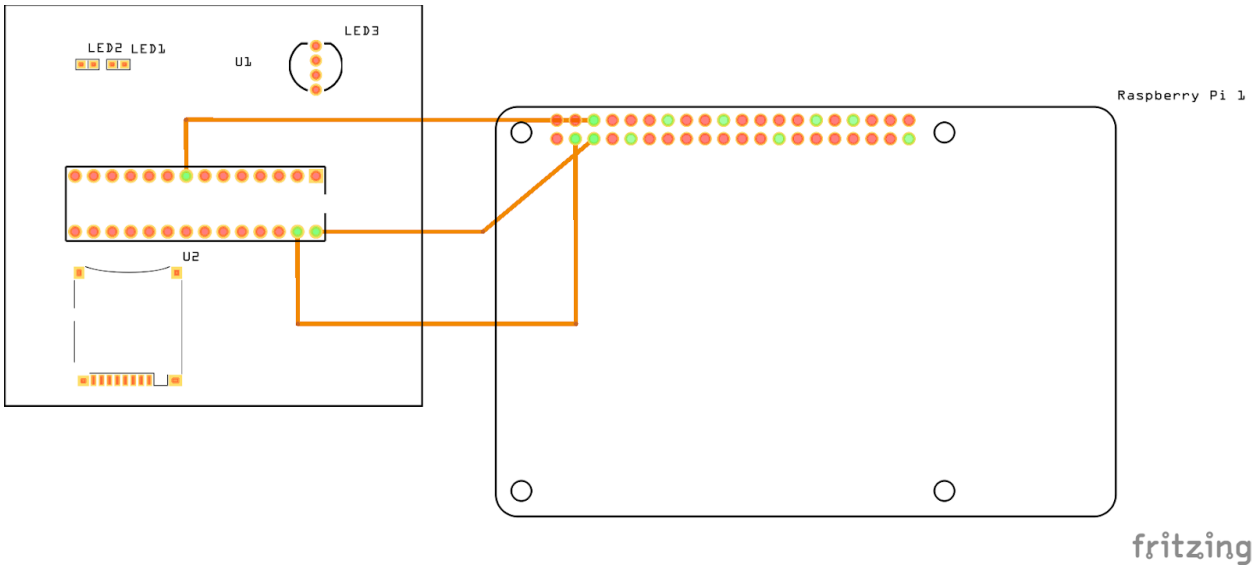
Option 2


DSI (DISPLAY)
Power
GPIO
HDMI
CSI (CAMERA)
Audio
ETHERNET
USB 2x
USB 2x
Raspberry Pi 3 Model B v1.2
© Raspberry Pi 2015
atmega328
I2C communication
fritzing


LED2 LED1
U1
LED3
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Raspberry Pi 1
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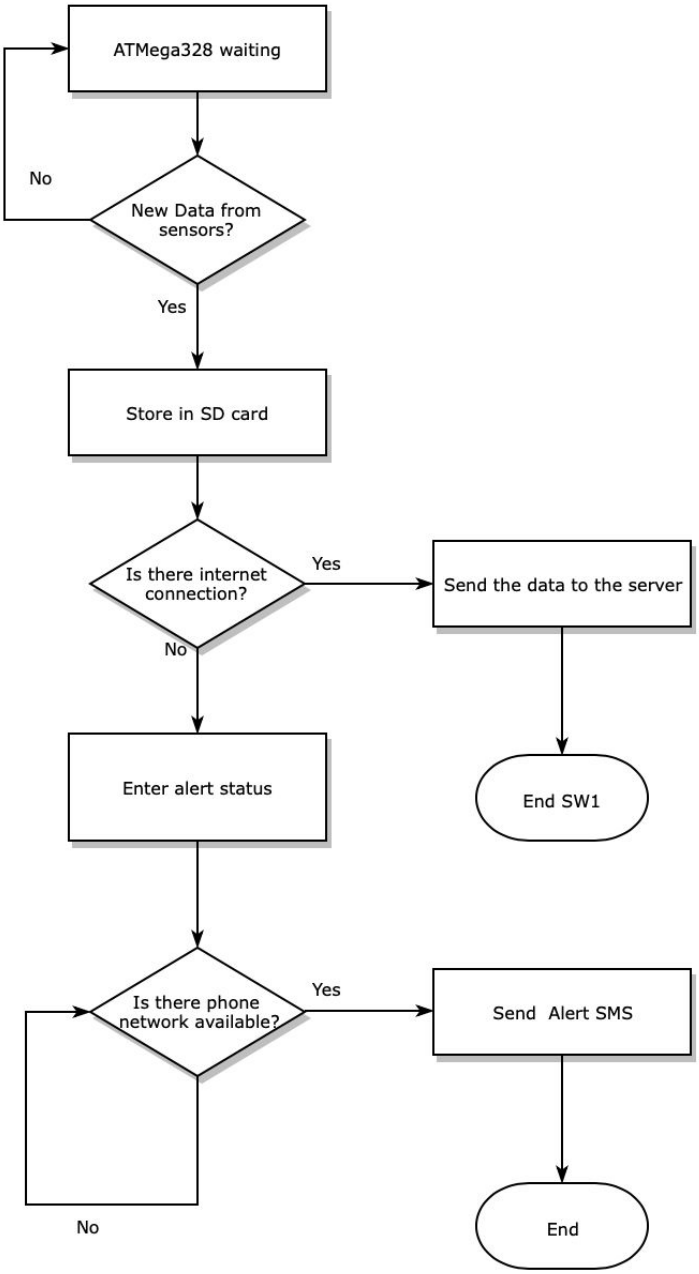
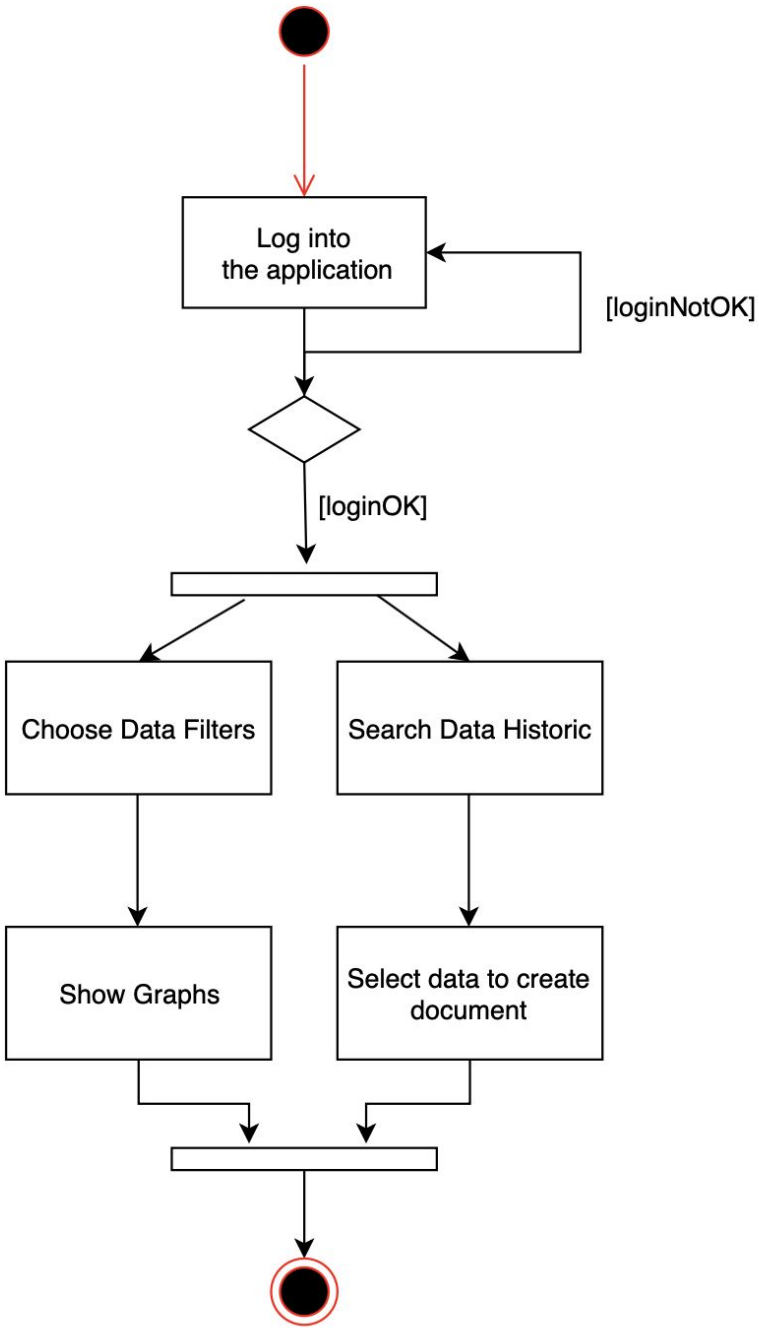
2.5. Software Flowchart

Flowchart Microcontroller Software



Activity Diagram of Desktop Application



2.6. Calculation and Simulation

3. **Requirements and Verifications**

MODULE	**REQUIREMENTS**	**VERIFICATION**
Communications:		
GPS		
GSM/GPRS		
Antenna		
Control unit:		
USB/SD Card		
Microcontroller		

4. **Tolerance Analysis**

5. **Cost Analysis**

- Physical components
- Labour
- Database system
- Data plan

6. **Schedule**

7. Ethics and Safety

This system should entail no risk to the environment, or to the animals living in or around the lakes or rivers that are being analysed. Also, if the water being analysed is polluted, the consumers of this water should be alerted instantly.

In addition, when designing this project we need to keep in mind the environmental impacts that it could have and also guarantee a sustainable system given CERSE's commitment to sustainable practices and its commitment to the environment.

According to the IEEE Code of Ethics, the project we need to agree "to be honest and realistic in stating claims or estimates based on available data". This point has great importance to our project given that the data collected must be analyzed by not biased algorithms and keep people's interests and not companies first, given that drinkable water is a priority in our society.