Smartphone-controlled Toy Boat with Purification System

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1. Introduction

1.1. Objective

The objective of this project is to build a toy boat controlled by a smartphone application using Bluetooth. The primary objective to build a boat that notifies the user if the boat is too far away or running out of battery. In addition, ozone may be used for a water purification system, since ozone purification devices on the market are expensive and lack mobility, it will make this product has its advantages that other do not. Ultimately, this boat combines work and play; keeping a pool clean while playing with a toy boat so that the end user can use the time efficiently.

1.2 Background

The objective of this project is to build a toy boat controlled by a smartphone application. Control and communication between the boat and the smartphone will be done via Bluetooth communication integrated in the Microcontroller chip which also will be communicating with other components such as sensors, motors, batteries, and the ozone system for purification.

The toy boat is a lot of fun for children who are playing in the water. However, when children play, they don't know how many batteries are left and how far the toy boat is. When children are playing with toy boats, toy boats can be easily lost because children lose control of the boat when the signal between the remote control and the toy boat gets weaker as they grow further and further apart and when the battery is done. Therefore, we designed a toy boat that gives signals to the user if the toy boat is too far away from the remote control and if the battery is too low.

Moreover, we came up with the idea of a toy with a water purification system so the time playing with the toy boat can be efficiently used. If a toy boat can purify water while fulfilling the joy of children, it will be great for both children and parents. And as a water purification system without consuming any extra time and chemical substances, it will be also eco-friendly. If I was a buyer for my children, I would not hesitate to buy a toy boat with water purification system. We also decided to develop a smartphone application for the remote control. People usually forget where they put the remote control especially when they don't use it every time, like with the TV remote control. If we developed a smartphone application, users would be able to control the boat conveniently.

1.3. High-level Requirements

- The system shall be controlled using a smartphone, which will communicate with the boat over Bluetooth
- Power System must be able to supply 4000V to the onboard ozone system in a safe and consistent manner
- Power supply need to provide sufficient amount of battery to run all the components for at least 4 hours

2. Design

2.1 Block Diagram

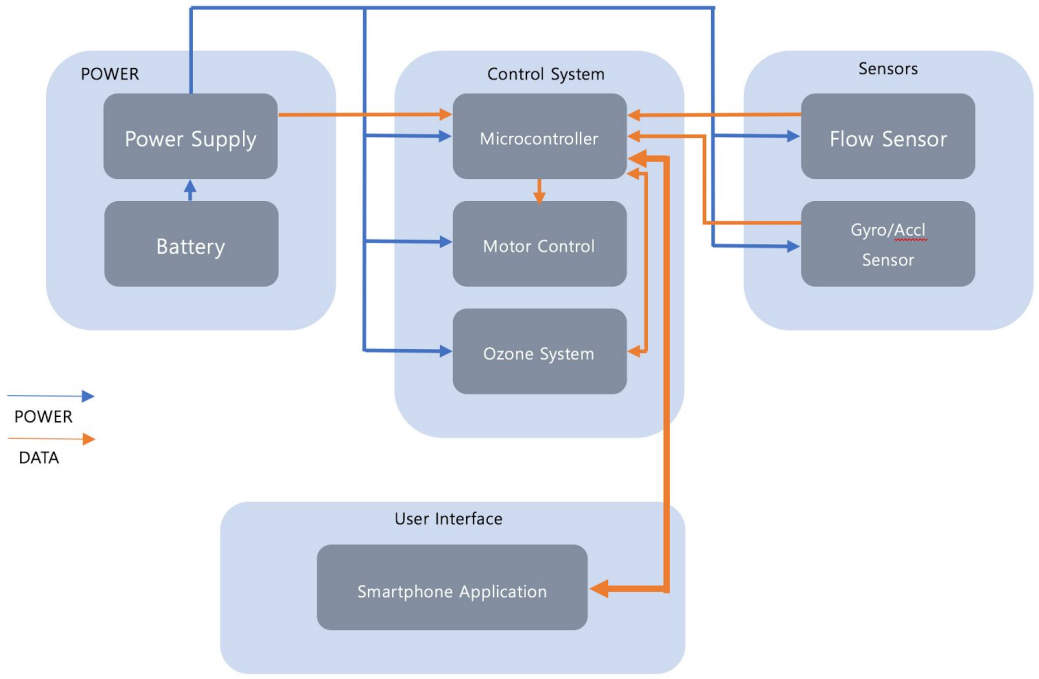

Figure 1. Block Diagram of the Overall System

2.2 Power supply

Battery is one of the essential parts of the boat. It should provide a sufficient amount of battery so that the boat can run as long as possible while the boat simultaneously produces ozone to purify the water and communicates with the smartphone. Therefore, at least two 9V batteries will be used to supply enough amount of voltage that can run every component on the board at least for 4 hours. This amount is subject to change anytime for further running time of the device in the future. The voltage value will be measured on the power supply system and will be transferred to the Microcontroller. If the voltage goes under a certain threshold, the microcontroller will send a warning signal to the user via Bluetooth.

Requirement: Power supply shall adopt batteries that provide 9V or higher DC power with at least 4 hours of running time.
Requirement: Power supply module need to send signal to the microcontroller when voltage falls below 6V.

2.3 Control System

The control system consists of three parts: microcontroller, motor control, and ozone system. The main part of the control system is the microcontroller. It receives all the data from the sensors, power supply, ozone system, and smartphone application.

2.3.1 Microcontroller

We will be using Nordic's nRF52480 microcontroller, which is the advanced multi-protocol SoC supporting BLE (Bluetooth Low-Energy) for energy efficiency[1]. All the data will be received and sent from this microcontroller as seen on the figure above.

Requirement: The microcontroller shall support Bluetooth communication module.
Requirement: The microcontroller shall operate on a supply voltage of 5.5V to 1.7V.

2.3.2 Motor Control

There will be three motors for this boat--two for moving forward and one for moving backward. All the motors will receive signals from the microcontroller board for its direction and the speed.

Requirement: The motor control shall operate on a supply voltage of 5V±0.5V.
Requirement: The motor control shall be able to adjust the speed of operation.

2.3.3 Ozone System

The ozone system consists of two main parts--one for the production of ozone using the ambient air, and the other for detecting the density of the ozone produced. This system also communicates with the microcontroller board and will be adjusting the amount of ozone produced while preventing excessive generation of the ozone. Plus, 3SP-O3-5 sensor from Spec Sensor will be used to calculate the density of ozone to control ozone production[5].

Requirement: The ozone system shall be able to detect the ozone density in the water.
Requirement: The ozone system shall operate on a supply voltage of 5V±0.5V.

2.4 Sensors

2.4.1 Flow sensor

Flow sensor will be used for calculating the flow of the water where the boat is floating. By knowing how the water flows near the boat, the user can decide where to go in order to purify the water as efficiently as possible.

Requirement: The flow sensor shall operate on a supply voltage of 5V±0.5V.
Requirement: The flow sensor shall be able to measure 1~5 LPM with liquid flow sensor type.

2.4.2 Gyro & Accelerometer sensor

Accelerometer and gyro sensors will be attached on the boat to calculate the speed and direction of the boat. By letting the user know in what speed and direction the boat is moving, the user can decide whether to decrease or increase the speed as needed.

Requirement: The accelerometer sensor shall operate on a supply voltage of 5V±0.5V.
Requirement: The gyro & accelerometer sensor shall provide 2-dimensional (X and Y Axis) analogue data value with less than 1000mV/g of sensitivity.

2.5 User Interface

Instead of a conventional remote controller, we will be developing a smartphone application for boat control. Since smartphones are universally used in contemporary society, controlling the boat via a smartphone will be as convenient or entertaining as playing a game on his/her smartphone.

Requirement: The user interface shall operate on Android Operating System.
Requirement: The user interface shall consistently communicate with the microcontroller system.

2.6 Risk Analysis

This ozone chip is very lightweight and compact. This factor helps us to build the inside of the boat so that it doesn't bother its operation on the water (If it's too heavy, we might need a complex design to make the boat float on the water). However, we need to supply 4000 V of voltage into this ozone chip to produce O3 from O2 in the air. We will need a transformer to connect the ozone chip and the power supply. However, if water reaches any of this system, the power supply will die. We have to make a really firm and complete water-proof toy structure so that this never happens.

3. Safety and Ethics

There are some potential safety hazards that may occur while the end user is playing with this boat. Since our project includes an ozone system for water purification, if the end user wishes to swim in the water during purification, it may result in either an irritation in the respiratory system or an electric shock. According to the Green and Healthy, it is said that ozone may result in throat and lung irritation[3], so we should adjust the amount of ozone so that the least amount of ozone is produced. Environmental Protection Agency (EPA) suggests that typical concentrations of ozone found during the purification ranges from 0.1 to 1 mg/L[4]. However, it is also said that the ozone level should be no more than 0.1 mg/L for an eight-hour work day, so the amount of ozone produced should be regulated carefully. In addition, high voltage is required when producing ozone from the oxygen.

Potential hazards mentioned above will be addressed to the end user and other project-related personnels in compliance with the IEEE Code of Ethics #1; our project should be done in safe and healthy, in order not to affect public health in any terms. Also, it is worth noting that there will be no disrespectful actions regarding clause #3 of the code. In order to ensure that this project is safe and will not hurt other people or property regarding #9, we will honestly report any available data concerning the safety, and will cooperate with other colleagues and co-workers without any discrimination regardless of anything to follow clauses #8 and #10[5].

4. Reference

[1] Nordic Semiconductor. (2016). *nRF52840 Objective Product Specification v0.5* [online]. Availabe: http://infocenter.nordicsemi.com/pdf/nRF52840_OPS_v0.5.pdf

[2] Spec Sensors. (2017). *Ozone Sensor, 0-5 ppm* [online]. Availabe: https://www.spec-sensors.com/product/ozone-sensor/

[3] Green and Healthy. (2013). *Danger of ozone generators* [online]. Availabe: http://www.greenandhealthy.info/toxinozone.html

[4] United States Environmental Protection Agency. (1999). Alternative Disinfectants and Oxidants Guidance Manual [online]. Available: https://nepis.epa.gov/Exe/ZyNET.exe/2000229L.txt?ZyActionD=ZyDocument&Client=EPA&Index=1995%20Thru%201999&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C95THRU99%5CTXT%5C00000015%5C2000229L.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1

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