LED Acrylic Gyro-Cube

Homework 3 - PDS

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Github	https://github.com/nnikolov3/ECE411				
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Executive Summary

The project is an acrylic cube containing addressable LEDs at the bottom. The LED change their brightness and color in response to the motion of the Cube on the x y z plane. When left static (no movement), it serves as a source of ambient light (night light, desk light etc). Removing the device from the charging station, it turns ON and tilting the device at an angle of more than 45 degrees while static it turns OFF. Therefore, it can either serve as an entertainment device or an ambient light source. The Cube is suitable for all ages, and it is an excellent choice for the entire family.

Brief Market Analysis

The primary customer group for the project is early adolescents and college students. In general, people from all age groups who are interested in visually entertaining and stimulating light represent the target group for the product.

The competition for this device is LOFTEK. LOFTEK offers an aesthetically pleasing LED light cube for $19.99. The distinction between our product and LOFTEK's product is the interactivity that our LED light Cube provides. We offer an interactive device that will not solely serve as a luminous source but will serve as an entertainment medium. Products that involve human interaction, like the "fidget spinner," have shown to be exceptionally popular on the market. The objective is to develop an interactive device suitable for all ages and offers an exciting and entertaining stimulus.

According to the research, we conducted the average price for similar items are between $16 and $30. However, none of the items in the category had the same features as our product, and most of the competitive products were significantly smaller. Our product has a considerably ampler size than the competition. It will be powered by a Li-Ion battery that provides more than two hours of continuous operation. Moreover, it supports a variety of modes for operation. The price we intend to market our product is in the range of $35.

Requirements

Marketing Requirements	External Requirements	Engineering Requirements
1,2,3,7	4	The device should be contained within a 6x6x6” Acrylic container that allows for LEDs light to shine through, and must have at least 2 mounting points for the PCB, and a place to secure the battery.
5, 7, 1	6, 3, 5	The main boards of the device must be printed on a 2 layer, 5.5x5.5” PCB with locations for voltage regulators, the microprocessor, LEDs, and a processor programming pinout.
7	9, 2	The device LEDs must turn ON after one second when it detects that it is withdrawn from the charging station.
2,6	1, 2	The device’s LEDs must respond to the change in angular direction of the device on the x y z axis. Tilting a 90 degree tilt towards a direction should correspond with a maximum brightness output on the LED that is in the direction of tilt, and a minimum light output on the LED that is opposite of the tilt direction. The device’s LEDs should respond to the speed of change in angular direction, a speed of change greater than a degree of second should produce a wave effect on the LED lights for 1 second.
3,7,6,4	4	The device must be safely rechargeable on a charge station. The device must be able to last 2 hours without the charge station.
5	7	The device should cost less than 25$ in components, and should cost less than 35$ when factoring in assembly.
6	2	The light source should be capable of 5 candle-feet of illumination in a dark setting and may include capacitive touch sensor for switch functionality.
2	3	The device must be response, there must not be a delay of more than .5 seconds between sensor inputs and actuator outputs. There should be a delay of no more than .1s between sensor input and actuator output.

External Requirements:

1. The device must have 1 sensor.
2. The device must have 1 actuator.
3. The device must have a processor that is programmable on the PCB.

4. The device must be safe.
5. The device must have >= 2 layer PCB with solder mask, a top-side silk screen, an area of between 9 - 900 cm^2 and linear dimensions between 2 - 30 cm^2.
6. The device must have >= 25% surface mount components.
7. The device must be assembled.
8. The device must be tested.
9. There must be 4 PCBs returned from the manufacturer, and 1 must work.

Market Requirements:

1. The device must be durable.
2. The device must be visually appealing and entertaining.
3. The device must be safe for use by children.
4. The device must last 2 hours on battery alone.
5. The device must be competitively priced, less than 35$.
6. The device must have more than one use to justify purchase.
7. The device must be portable.

System Architecture

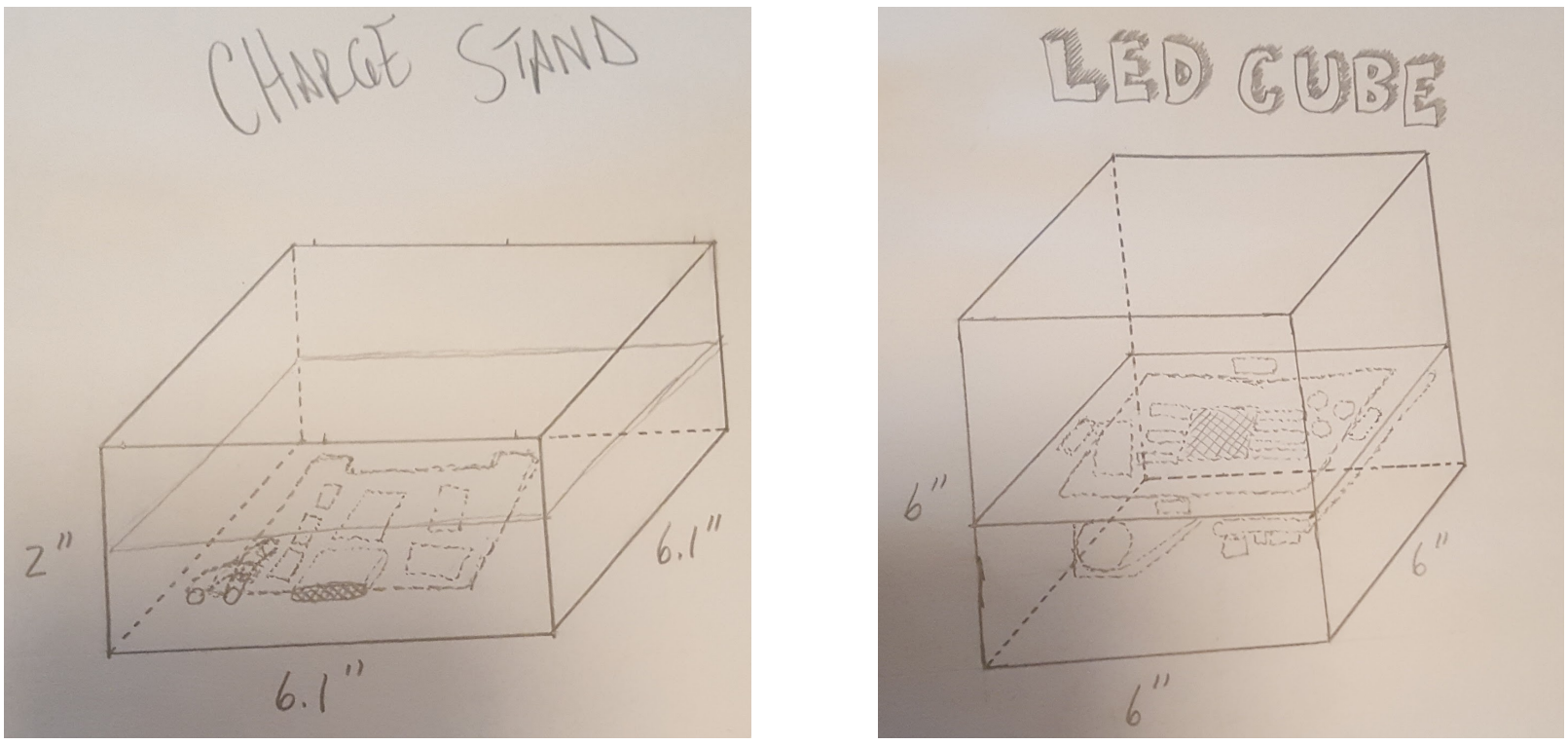

Figure 1: *Draft drawings of the design*

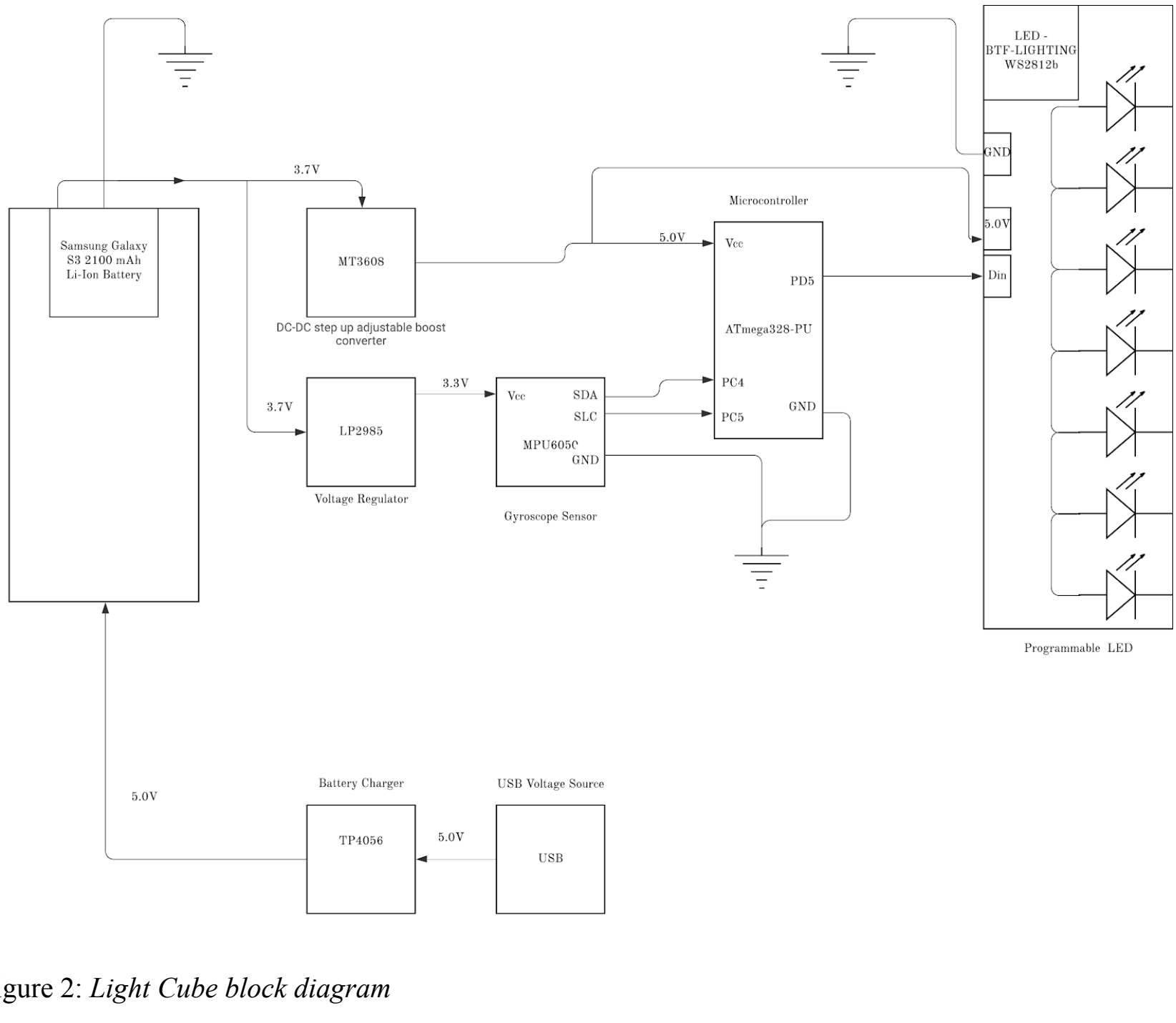

Figure 2: *Light Cube block diagram*

Design specification

Electronics:

- Sensor - MPU6050 Module 3 Axis Analog Gyro Sensors and 3 Axis Accelerometer Module (Daughter Board)
    - http://www.invensense.com/wp-content/uploads/2015/02/MPU-6000-Datasheet1.pdf
    - 3.3v Voltage regulator - IC REG LINEAR 3.3V 150MA SOT23-5

- Processor - ATmega328P-PU
    - http://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-7810-Automotive-Microcontrollers-ATmega328P_Datasheet.pdf

- Actuator - LED - BTF-LIGHTING WS2812b
    - WS2812B-LED-datasheet.pdf

- Power
    - 3.7V 2100 mAh Li-Ion Battery (or voltage equivalent)
    - Micro USB TP4056 Lithium Battery Power Charger Board Module TE420 (Daughter Board)
        - https://dlnmh9ip6v2uc.cloudfront.net/datasheets/Prototyping/TP4056.pdf
    - Step Buck Boost Converter - MT3608 on (Daughter Board)

Mechanical:

- Physical - Acrylic 6”x 6” Sheets

Software:

- Development Environment - Arduino development environment
    - FastLEDs - Addressable LED library
    - I2CDevlib / MPU6050 - gyroscope/accelerometer library

The Cube is using the MPU6050 sensor on a daughterboard. The sensor operates at 3.3V or less. Further, we use a voltage regulator to lower the 3.7V battery output to 3.3V for the sensor. The LED and microcontroller require 5.0V. The project uses a daughterboard step boost converter to increase the voltage to these two outputs.

A Lithium-Ion battery powers the system; however, the battery requires a charge board for safety. A daughterboard with a micro USB charger connects the battery with the voltage source.

The LEDs are SMD soldered down in a ring around the microprocessor and gyroscope. Additionally, the voltage regulators and the other passive components are SMD soldered too.

The programming of the microcontroller is done using the Arduino IDE, open-source libraries for I2C and LED, and in house developed code.