SCRIM LIGHT

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ECE445 Project Proposal

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1. Introduction

Photography lighting is a complicated and many-faceted issue, often requiring thousands of dollars in equipment to achieve the desired lighting effect. Rick Kessinger, a local photographer in Bloomington, approached the 445 students with a problem; he was attempting to photograph automobiles in a particular fashion, and therefore needed a particular lighting setup in order to achieve that.

1.1 Objective

Our proposed solution would be a light that gives much more control to the user, allowing them to produce different gradients, such as fading from one end to the other, or from the center out and vice versa. The user has the ability to vary the brightness and intensity of the light, adjust the starting position and profile of the gradient, and individually group LEDs together and adjust their brightness to produce a well-defined custom profile. The user is also able to store their current profile for non-volatile retention and later use as a preset mode. Finally, as a last potential feature, we will allow the user to alter the temperature of the light, but this is a secondary feature as temperature of light can be altered through other sources. One of the more important parts of this solution is that the device is cordless and battery powered, which would allow for increased mobility when using the device in the studio. The design is also modular, allowing the user to easily replace any malfunctioning LED and add more if the extra space is properly accommodated.

1.2 Background

When taking pictures of cars, the light would need to be reflected off a surface known as a scrim, and a much more complicated lighting system would be needed to achieve the desired lighting gradient.

Rick proposed a prototype solution: an LED strip which he covered in a particular way to produce the gradient, but his solution only produced a single gradient, was not adjustable, and was unwieldy and difficult to use in the studio due to the power cord.

1.3 High Level Requirements

- The device should, at a minimum, emit a single color temperature of approximately 4500 K at a brightness level of 250 lumens per foot. Additional functionality would include production of multiple color temperatures, ranging from 3000 K or 6000 K.

- The device must be cordless and battery powered, and be able to be run for an entire photography session. This would require it to work over a period of 30-45 minutes, while only being on for increments of 10-20 seconds. According to our power estimates, this would require 4 lithium-ion batteries with a 3.6V nominal voltage, and about 2500 mAh of charge.

- The device should be a 4 foot strip, which would require about 40 LEDs. Depending on the implementation of different color temperature functionality, this may require twice the amount (80) LEDs. These LEDs would require a nominal total current draw of about 3 A without color temperature functionality, and 6 A with, using a supply voltage ranging from 3.2 to 3.6 V.

2 Design

2.1 Block Diagram

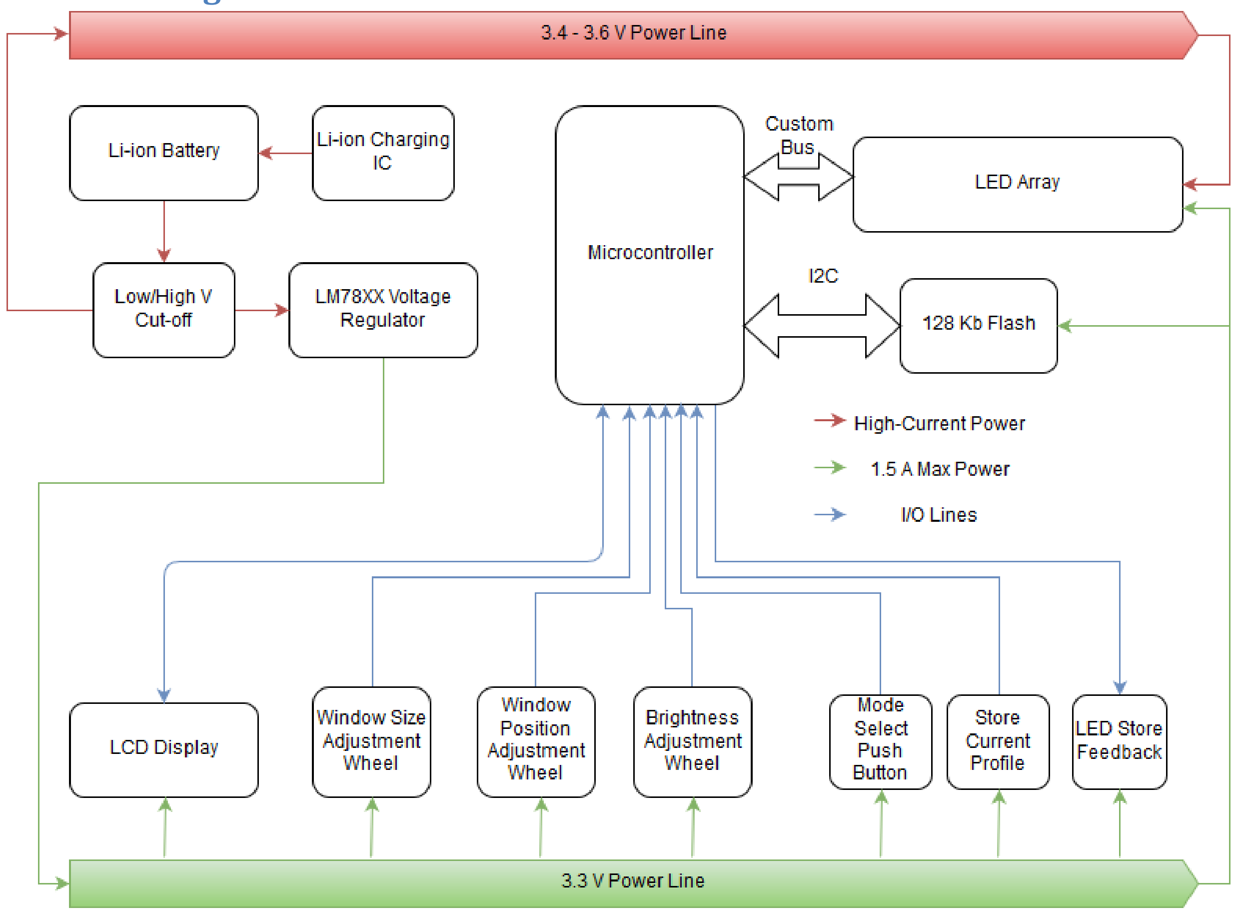

Figure 1 – Block Diagram of General Design

2.2 Physical Design

The device consists of a rectangular housing of dimensions 48x3x1 inches (LxWxH), two handles attached (primary at the top and another below the central point), with the primary handle housing the user interface described in the block diagram. We estimate the handle to have minimum length and width of 3 in and 2 inches, respectively. The main housing will contain the LED array and will sit on two rubber wheels to allow the device to rest and be transported on the ground.

2.3 Functional Overview

2.3.1 Li-ion Battery(ies)

Our current power-time specifications and preliminary component selection require, at a minimum, *approximately 20 Watt-hours (with color temperature functionality included).* Due to the high current nature of our design (40/80 LEDs drawing a constant forward current of 60 mA, with the possibility of expansion to more LEDs) and the mobility requirements, we have decided to power the device with Li-ion, most of which range from 3.6 - 3.7 V. This thus requires that the battery(ies) produce *at least 5,555 mAh (5.5 Ah) at the nominal voltage*.

2.3.2 Li-ion charger

Due to the dangers of using Li-ion batteries, we have opted to purchase an industry-standard charger for the battery(ies) housed in the device. *The charger should be external to the device and be able to charge the battery(ies) to full in about 2 hours.*

2.3.3 High/Low V Cut-off and battery protection

Due to the danger of using Li-ion batteries, again we have opted to purchase an industry-standard protection circuit. We plan to *use a battery pack with a pre-mounted protection circuit, offering temperature safety as well, and a current regulator chip to prevent drawing current above 10 A (which can occur in case of an accidental short).*

2.3.4 Voltage regulator

The microprocessor and all digital circuitry we plan to utilize *require a 3.3 V supply and protection from max-draw current,* and this is achieved by a LM78XX chip with a *1.5 A regulated maximum draw*.

2.3.5 Flash Memory

A flash memory is the most readily available and low-cost non-volatile, rewriteable storage solution. To fit the requirements of the device, the flash memory must have *at least 128 Kb of storage, be rated above 1,000 rewrites, and be I2C compatible.*

2.3.6 User Interface LCD Display

The LCD display will communicate the current settings and mode selected to the user, and must be able to display *at least 20 characters per line with 2 lines with backlighting*. The LCD screen would be facing a different direction from the light, and its brightness is extremely low compared to that of the LED strip. Also, a *timer function must be implemented so that the LCD will turn off after a certain period of inactivity.*

2.3.7 Buttons

The buttons must be normally-open momentary contacts with decent tactile-feedback.

2.3.8 Rotary Encoders/ Thumb-wheel switches

The rotary encoders/thumb-wheel switches must be able to distinguish direction of rotation, and provide tactile-feedback of the change in position. It must also be able to communicate all this in 2 pins or less.

2.3.9 Microcontroller

The microcontroller must operate at 3.3 V and at a minimum clock speed of 200 KHz (anything above that is desired!). It must have a minimum of 20 GPIO and 8 interrupt pins, and be fully compatible with I2C.

2.3.10 Custom Bus LED array

The custom bus LED array must be open-drain, be able to communicate at a minimum of 100 KHz, and support multiple-slave addressing and multiple-slave concurrent data streams (of unfixed size in multiples of 8 bits). The LED setup must be able to produce 250 lumens per foot. The LED array requires both a 3.6V power line and a 3.3 V power line because the regulator line cannot supply more than 1.5 A. The LED array consists of both digital bus control, which requires 3.3 V, and the LEDs, which requires the high current rail.

2.3.11 Risk Analysis

The block that would pose the greatest risk to our completion of the project is the custom bus design. Since this design is untested and new, we would have to design, implement, and debug the bus from scratch which may lead to a lot of unseen problems. Additionally, there is no documentation to assist us in the implementation and debug. If the design ends up not producing the desired results, we would have to restart the array design from scratch, and use an already well established bus communication protocol, like I2C or SPI.

3 Ethics and Safety

Every component and part that we design or use should be RoHS compliant. This falls under the ACM Code of Ethics Section 1.2, which means that our product should avoid harming the end user. By making the product RoHS compliant, we would avoid using dangerous chemicals and substances in our design.

In terms of safety concerns, our greatest involves the usage of Li-ion batteries. These batteries could pose a threat if not charged and used properly. We have turned to industry to provide the necessary guidelines and equipment to safely house, use, and charge the batteries in the device. This includes protection from both thermal and voltage-induced runaway events, preventing potentially harmful explosions and fires.