ECE 445

Design Document

Surgical LED Lamp

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Introduction

1. Problem

Surgeons and medical professionals employ various methods to detect cancerous cells, mostly using their sense of vision and analysis of tissues to determine which cells are malignant and work towards appropriately removing those. However, there is a limit to the human vision especially when dealing with an entity like the human body which is so complex; it is very difficult to detect cancer cells in areas where there is not as much growth and visibility. While biopsies are taken to spot and remove cancerous cells, identifying the exact location of the masses is difficult to locate without a device aiding the surgeon in the location of the masses.

Biopsies and surgeries allow medical professionals to detect cancerous cells; however, it would be far more beneficial if surgeons were able to use a surgical camera nad light to detect cancer in undetected areas. Considering how life threatening cancerous growths are and the fact that cancer is the second most leading cause of death in humans, detection and removal of cancerous cells is of utmost importance. Therefore, there is a critical and growing need to develop tools and methods to aid surgeons in their job of identifying and eliminating cancer cells.

2. Solution

Our solution to this is two-pronged: a microscopic camera and a surgical light. Our team will be working on the surgical light. This lamp will work in tandem with the microscopic camera to better aid cancer specialists to identify cancerous growths during both surgery and early examination. The surgical light solution is a programmable light source that will mainly be used in surgical settings. The light will allow medical professionals to use the infrared light to conduct a thorough examination of different areas that could be affected by cancerous cells. Using different LEDs, such as infrared and visible LEDs, the user can modify the brightness of the light as they deem appropriate and effectively be able to identify cancerous cells that may be harder to see otherwise. Not only will it aid in identifying the location, but it will allow for a more precise identification of where the cancerous cells might be growing. The microcontroller will allow for the adjusting of the brightness and this will be through a connection with a wire. Additionally, an additional LED PCB will be used in order to allow for heat dissipation and terminal release.

The light sources will contain different sets of LEDs. The first set of LEDs would be visible spectrum white LEDs (~400-700 nm) which will be a minimum of 5 kilolux. The second set of LEDs would emit around 700-800 nm infrared light which will be a minimum of 1 milliwatt per cm squared. As a part of the solution, there will be a two layer heat dissipating PCB for LEDs that will defer from a regular PCB that will be designed as the PCB specifically for LEDs will allow the PCB to not melt.

3. Visual Aid

Our surgical LED lamp would consist of two PCB boards. The first board would house the supporting ICs and other electrical components like resistors, inductors, capacitors etc. The second board which would be 6" diameter Metal Core board which would specifically be for hosting the LEDs and dissipating the heat emitted from them faster.

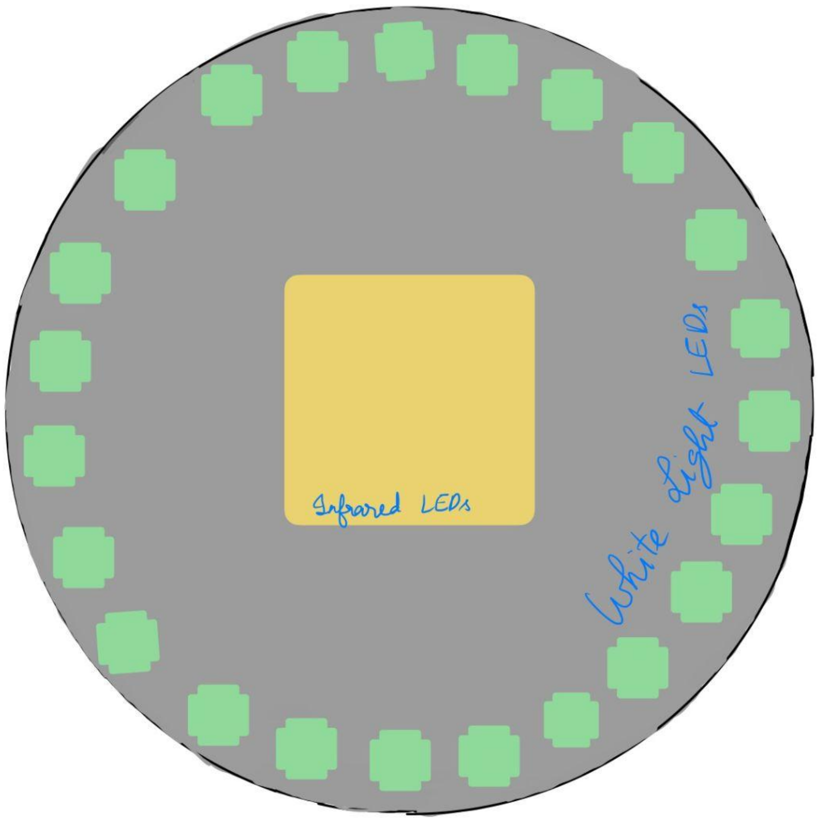


Figure 1. Simpler rendering of our LED PCB board

4. High-Level Requirements

One of the goals of this project includes employing different types of LEDs, such as the infrared light as well as the white light to allow the user or the surgeon to identify cancerous cells. Another requirement for this project is to develop a way for the user to increase or decrease the brightness of the LED as well as the color temperature, so that the surgeon is able to adjust as they see fit. There needs to be a knob for the users to increase or decrease the brightness of the specific lights.

Design

1. Block Diagram and Physical Design

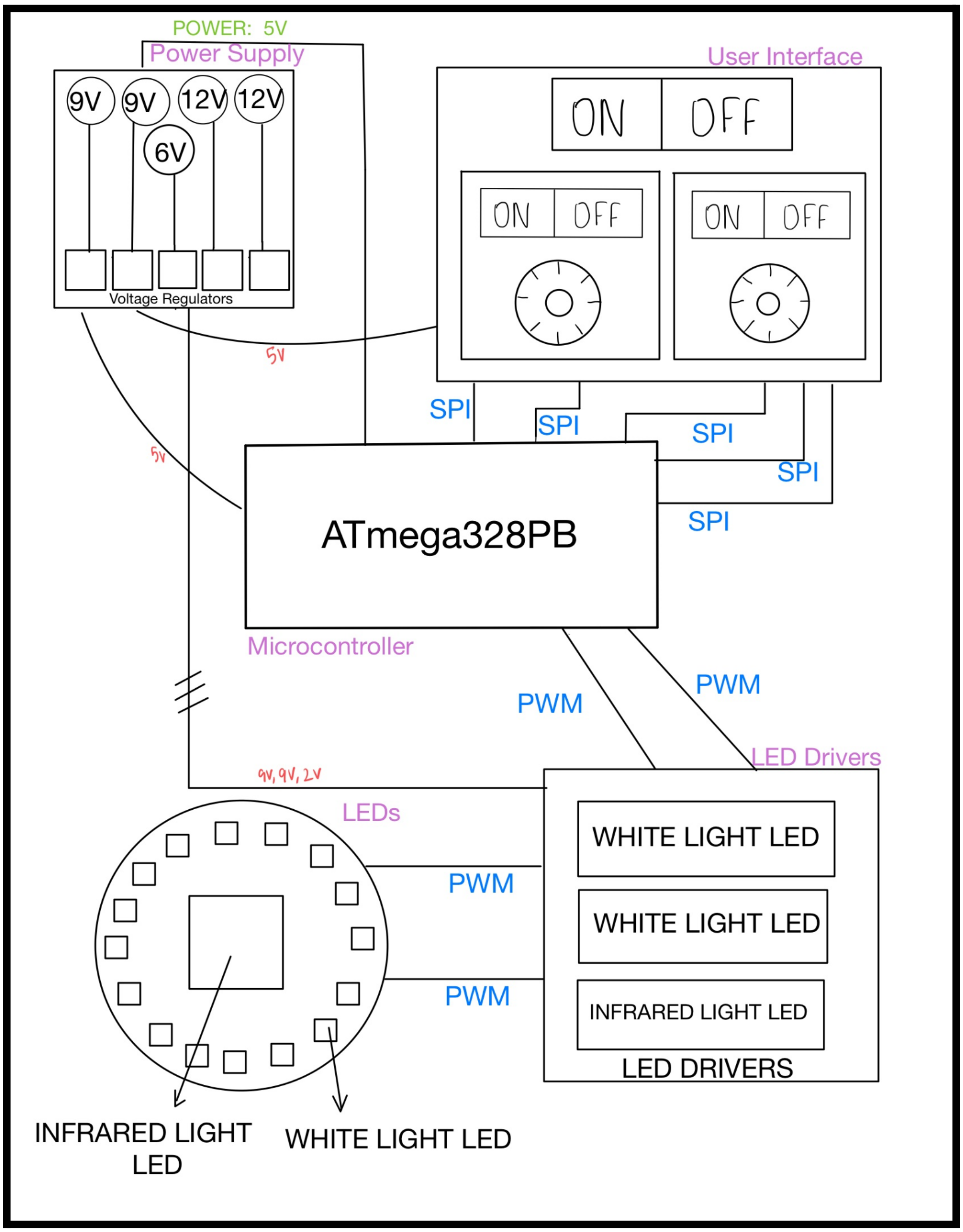


Figure 2. Block Diagram

Our surgical LED lamp would consist of two PCB boards(Table 1). The first board would house the supporting ICs and other electrical components like resistors, inductors, capacitors etc. The second board which would be a 6’’ diameter Metal Core board which would specifically be for hosting the LEDs and dissipating the heat emitted from them faster. Since we will be placing all the LEDs on the same board, we need to ensure that there is (i) enough space for the LEDs as well as the power connections to the LEDs and ensure that the LEDs are placed as far apart as possible while still maximizing the number of LEDs to ensure that the heat dissipated do not negatively affect the neighboring LEDs or connections (ii) have a heat dissipation sink in place to keep the temperature of the board as low as possible.

2. Subsystem Descriptions

Power Supply

To provide power to all of the other subsystems on the project, we will use different batteries for each subsystem, as each requires a different amount of voltage. For the microcontroller, we will use a 9V battery from Duracell that will go through a voltage regulator to reduce the voltage to 5V [6]. Since the voltage regulator will have a 2V dropout voltage, we must provide at least 7V for the microcontroller. The component that will need power is the User Interface. The User Interface can take up to 5V, which will be used to turn on the LEDs. We will put one battery in series to meet the required voltage to run the user interface. Therefore, we will use another 9V battery from Duracell, providing a voltage load of 9V. This will then run through another voltage regulator to reduce the voltage to 5V, sufficient to power the user interface [6]. The next part that will be powered is the LEDs. Two kinds of LEDs, twenty-four white LEDs, and an infrared LED, need to be powered. For the twenty-four white LEDs, they will be grouped into two groups, so each group has twelve LEDs. Within each group, the white LEDs will be placed in parallel with four LEDs in one group. Then, the three parallel groups will be in series. Each LED needs 3V and 60 mA, so the four LEDs in parallel will need 240 mA. Since the three groups of parallel LEDs will be in series, the current will be the same across. However, the voltage of each parallel group is 3V, so the three groups in series will need 9V. Therefore, we will need 9V and 240mAh to power each group of 12 white LEDs. We will put three 3V batteries that provide 1550 mAh, sufficient for each group of 12 LEDs. Additionally, we will use a voltage regulator to manage the voltage of the LEDs. We will use a fourth battery to account for the voltage dropout from the voltage regulator. The LED drivers will regulate the current, so there shouldn’t be an issue with too much current. For the infrared LED, it will need 2V and 350mA. We will use another two 3V batteries to power the LED. The LED only needs 2V, but to compensate for the 2V dropout voltage, we will use two batteries. Just like the white LEDs, an LED driver will regulate the current to the infrared LED[7].

Voltage Regulators

The voltage regulator will be used to provide stability and control the voltage that will be supplied to the other subsystems. The first voltage regulator will be an LM7805, which will be used between the power supply and the microcontroller. This will reduce the 9V battery to 5V, which is the maximum on how much the microcontroller can take. In addition to the voltage regulator, we will have a 0.33uF capacitor connected from the input of the voltage regulator to GND and another 0.1 uF capacitor connected from the output to GND. The following voltage regulators for the user interaction will also use an LM7805, as we will provide the user interface with 5V. Therefore, the capacitor layout around the LM7805 for the microcontroller will also be used here for the other LM7805. The following two voltage regulators will be used for the two groups of white LEDs. The voltage regulator will be LM7809, as we need 9V to supply enough voltage for all 12 white LEDs. It will also use the same capacitors connected in the same places as the LM7805. Therefore, we use another two 0.33uF and 0.1uF capacitors. The last voltage regulator will be an LM1117-2.0 for the infrared LED, as the max voltage for the infrared LED is 2V [5]. At the input of LM1117-2.0, there will be a 10uF capacitor connected from the input to GND. The output will connect a 100uF capacitor from the output to GND. Additionally, in parallel with the capacitor, two resistors will be in series with each other before connecting to GND. The second resistor divided by the first must have a value of 0.6.

User Interface

The interface that will allow the user to work with this design consists of five major components. The user interface block will send information to the microcontroller regarding which LEDs to turn on. Specifically, the interface will contain three toggle switches - one to turn on the entire LED subsystem, one to turn on the infrared LED and one to turn on the visible light LED. The specific toggle switch that we will be using is the A11JP from NKK Manufacturers. This toggle switch was chosen because it SPST(single pole single throw) and the switch has a minimum voltage requirement of 20mV and a maximum of 28V; the applicable range for the current is 0.1mA ~ 0.1A. This will allow us to have a good range of voltages to supply to our three switches. These three switches will be a toggle switch that is actuated by moving a lever back and forth to turn the LED system on and off. The on position for the toggle will be up and the down position will be off. Along with these signals, two potentiometers will be used for control over the brightness of the infrared and visible lights. The potentiometers will be 100 ohms and will have a rated voltage of 120V. The potentiometer will be connected to a resistor to determine the voltage across. The three switches and the two potentiometers will be sent as signals to the microcontroller in order to allow the microcontroller to determine which LEDs should be turned on. The switches will signal a 0 or 1 to pass in the information about which switches are turned on. These signals will be sent to the microcontroller using SPI communication because compared to I2C, it is a faster communication protocol which will be more beneficial to the user as it is important to be able to turn the switches on and off, as well as change the brightness of the lights.

Microcontroller

To communicate the changes in the user interface to the LEDs, we will be using the ATmega328PB microcontroller. This microcontroller is low-power at around 5V which would be good for our group that wants our project to be as small as possible. The microcontroller will take in input from the user interface using the I/O pins where the values passed will determine the state that the LEDs should be in. Then, using the SPI, it will signal to the correct set of LEDs in order to turn on the system of LEDs. Once the switches are turned on, the potentiometers for each LED system will be able to send information to the microcontroller which will take in the voltage of the potentiometer and the LED drivers will make sure that the brightness of the LED system is consistent with the potentiometer. The ATmega328PB microcontroller has two Master/Slave SPI Serial Interfaces which will be used in communication between the UI and the microcontroller. Using the signals for the switches, there will be logic to determine which set of LEDs should be turned on.

LED Drivers

To regulate the current to the LEDs, we have decided to use LED drivers which would output the appropriate level of current for various levels of brightness. Our primary criteria for choosing a LED driver was to ensure that the circuit was as efficient as possible as LED circuits can be highly lossy if not carefully designed and therefore the LED drivers need to be high efficiency switching LED drivers. We chose the TPS92205x 65-V 2-A / 4-A Buck LED Driver with Inductive Fast Dimming since it meets our requirements of handling relatively higher current and voltage levels while ensuring that the power consumed is as low as possible[1]. The user interface knobs and switches would communicate with the microcontroller which in turn would interface with the LED drivers and appropriately send PWM signals of varying duty ratios to the LED driver. The duty ratio can vary from 1% to 100% and a higher duty ratio would produce a brighter LED setting[1]. We would have a fault signal that is sent from the drivers to the microcontroller that would pull high in the event of a fault like overvoltage etc. Since we have two types of LEDs (infrared and white light LEDs), we need to have at least two LED drivers to drive them separately as we want to individually want to control the brightness of the two types of LEDs[2]. Since we are using 24 white light LEDs, we want to divide them in two batches to have an LED driver each for two reasons: (i)increase reliability and robustness as even if one batch of LEDs fail, the other would still be able to work, (ii)decrease the power supplied to each LED driver which inturn would reduce the size of some of the components like the inductors and capacitors. The voltage to the LED driver and in turn the LEDs would be from the power supply and voltage regulators as additional protection method[2].

LEDs

We will be using two kinds of LEDs for this project. Common to both these LEDs is that they should be able to withstand high temperatures as there will also be heat emitted

1. Infrared LEDs: We will have one infrared LED in the middle of our LED PCB. This will be invisible to the human eye as it operates in the 780nm wavelength range[7]. We will be using an 1-Watt infrared LED and our consideration behind choosing this is that it can provide reasonable luminance while at the same time having the power requirements low enough to be powered from a smaller power supply and not produce excessive heat that would negatively affect the other white light LEDs on the same board. We chose the Lumixtar SMD3030 1W IR 780nm High Power LED since it fit these criteria. It takes a nominal current of 350mA and a forward voltage drop of 2.8V. This LED interacts with its LED driver which controls its brightness based on different average current voltages.
2. White Light LEDs: Surrounding the infrared LED are the white light LEDs. We decided to get 24 white LEDs on our board. We had a lot more choice when it came to choosing a manufacturer for this. We chose a standard Luminus MP-2016-1100-27-90 warm-white light LED for this. It has a forward voltage drop of 3V and a nominal current of 60mA, therefore it is rated for 0.18W power. Since there are a lot more of these LEDs, we decided to choose individual LED power to be less than the infrared 1W power rating.

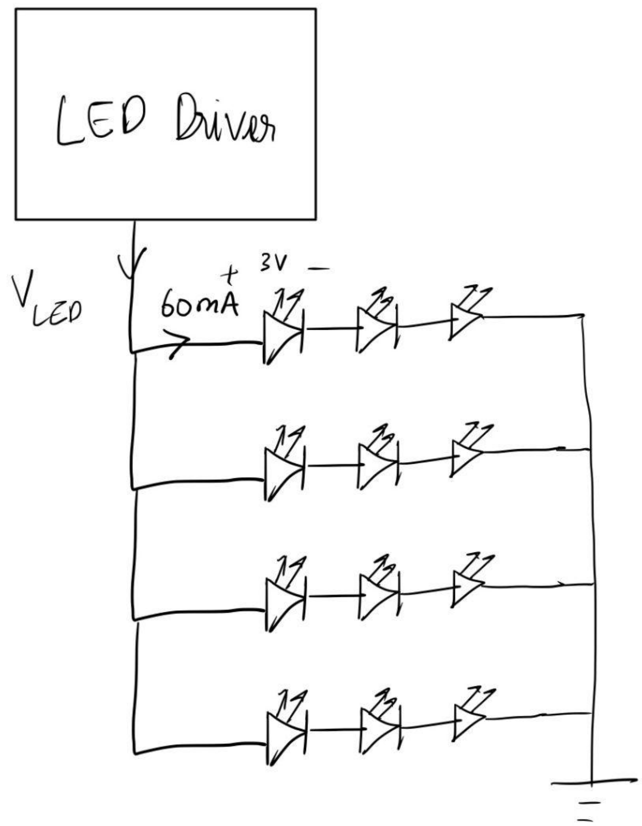


Figure 3. Schematic for one batch of white light LED

3. Subsystem Requirements

Power Supply

1. The power supply will continuously supply the microcontroller 9V. The power supply will provide more than 5V, but the power supply will have a voltage regulator to ensure stability and ensure 5V will be supplied.
2. The power supply will continuously supply the user interface 9V. Like the microcontroller, the user interface's power supply can provide more than 5V, but the voltage regulator will reduce the voltage to 5V.
3. The power supply will provide the white LEDs groups with 12V and 1550 mAh which will be sufficient for the LEDs to work. There will be a voltage regulator to ensure 9V and the LED driver will control the amount of current that will reach the LEDs which is 240 mA.
4. The power supply will provide the infrared LEDS with 6V and 1550 mAh. The voltage regulator will reduce the voltage to 2V and the LED drivers control the current to allow 500 mA.

Voltage Regulators

1. The LM7805 that will be used to regulate the voltage from the power supply to the microcontroller to 5V. The voltage regulator will have a 2V dropout voltage in order to function which means that the power supply needs at least 7V.
2. The LM7805 that will be used to regulate the voltage from the power supply to the user interface to 5V. The voltage regulator will have a 2V dropout voltage to work properly which means that the power supply needs at least 7V.
3. The LM7809 that will be used to regulate the voltage from the power supply to the two groups of white LEDS to 9V. The voltage regulator will have a 2V dropout voltage for the regulator to work which means that the power supply needs at least 11V.
4. The LM1117-2.0 that will be used to regulate the voltage from the power supply to the infrared LED to 2V. The voltage regulator will have a 2V dropout voltage for the regulator to work which means that the power supply needs at least 4V.

User Interface

The user interface has a couple different requirements for that will work with the microcontroller to turn on and off the LEDs.

1. The interface should allow user to turn on entire LED system with the main switch
2. Each of the LED systems, infrared and visible, will need a switch to turn on that specific LED system
3. The three toggle switches that will turn on the LED system need to use a maximum voltage of 28V and a minimum voltage of 20mV, which will be made sure by the power supply to the user interface block, the current range should be around 0.1mA ~ 0.1A
4. Once the switches are turned on, the potentiometer can be used to change the brightness of the specific LED - the potentiometer has a rated voltage of 120V and will be 100 ohms.
5. Each of the five components have information that will be sent to the microcontroller through signals that will allow the microcontroller to determine which set of LEDs to turn on/off. This will need to be communicated to the microcontroller using a protocol - SPI, which will allow for a quicker communication than other protocols such as I2C.

Microcontroller

1. The microcontroller should firstly be able to read the potentiometer voltages accurately and if the switches are on or off.
2. It should be able to produce accurate duty ratio PWM signals to the LED drivers for the two types of LED drivers. The duty ratio is proportional to the voltage across the potentiometer or completely pulled to low if the respective switch or the master switch is turned off. The 5V is around the nominal voltage expected across the potentiometer at its highest resistance setting.

$$\mathbf{DutyRatio_{PWM} = V_{potentiometer}/5V}$$

3. It should have enough storage to contain our logic for controlling the LED drivers.
4. In the event of a fault, it should be able to turn off the LED driver PWM signals to low.

LED Drivers

The LED drivers have several requirements and some are common to both kinds of LED types.

1. The LED driver most importantly should be able to achieve the desired switching frequency. We chose the 400kHz since it is high enough that the human eye cannot detect the flickering on and off the LEDs. This is achievable since the LED driver can support 100 kHz to 2.2 MHz. We can tolerate a relatively large tolerance on this since the human eye cannot reasonably notice a flicker when the frequency is over 200 Hertz.
2. Another important aspect of the LED driver is that it should be able to produce the duty ratio of the current waveform as requested by the microcontroller. When the LEDs are to be turned ON, the duty ratio can range from 1% to 100% of the period of the current waveform. The lowest that the PWM on time can go to is 150ns which is much lower than the 1% dimming at our switching frequency 400kHz so this will not be a constraint when designing our project.
3. Finally the voltage and current supplied through the LED drivers should not exceed the maximum voltage and current ratings of the LEDs.
    a. For the infrared LED, the voltage supplied cannot be greater than 2V but lesser than 1.8V and the current supplied cannot be greater than 500mA. The LED driver has to ensure that these limits are not exceeded.
    b. For the white light LED, since each batch of 12 LEDs are arranged in series of 3 LEDs paralleled as four columns. Each white light LED can handle a maximum of 3V and a minimum of 2.9V and maximum of 120mA and a nominal current of

60mA. So the minimum voltage the LED driver can supply is 9V and a maximum of 9.6V. The current maximum it should supply is 480mA.

LEDs

1. Infrared LEDs: The infrared LED has a current maximum of 500mA and a nominal tested current of 350mA. It has a voltage maximum of 2V but requires at least 1.8V to operate. Since infrared LEDs can usually operate in temperature conditions from -30° to 85° C. For our function, we need the LED to operate in the range of 780nm with a tolerance of 1%.
2. White Light LEDs: The visible white light LEDs have a minimum voltage of 2.9V and a maximum voltage of 3V with a maximum current of 120mA. This LED can operate in temperature range of -30° to 85° C with a ideal testing temperature of 25° C.

4. Subsystem Verifications

Power Supply

1. The voltage that we measure using the voltmeter on the power supply for the microcontroller should be 9V like the product suggested.
2. The voltage that we measure using the voltmeter on the power supply for the user interface should be the 9V that the product was said to have.
3. The voltage that we measure using the voltmeter on both of the power supply for the two groups of white LEDS should be 12V. Since we have batteries in series, we want to ensure the batteries are safely connected before we test the voltage.
4. When we measure the voltage using the voltmeter on the series of batteries, we will get the correct voltage reading of 6V. Additionally, we have to make sure the batteries are correctly connected to avoid accidents.

Voltage Regulators

1. We will connect the power supply that will be used for the microcontroller to the LM7805 with the capacitors correctly layout and test using the voltmeter that the voltage regulator does reduce the voltage to 5V.
2. We will connect the power supply that will be used for the user interface to the LM7805 with the capacitors correctly layout and test using the voltmeter that the voltage regulator does reduce the voltage to 5V.
3. We will connect the power supplies for the voltage regulator with the correct capacitor layouts for the white LEDs separately and test that the LM7809 does reduce the voltage to 9V.

4. Connecting the power supply to the LM1117-2.0 with the correct capacitor and resistor layout as well as the correct resistor values to ensure that this voltage regulator does reduce the voltage to 2V.

User Interface

1. The voltage that is being supplied to the switches can be tested to see if the on/off functionality of the switch is correctly changing the voltage. We will be supplying the switches with 5V so the switches will be checked to make sure the voltage being supplied becomes 0. (Applicable Range for the current will need to be 0.1mA ~ 0.1A at a minimum of 20mV ~ a max of 28V)
2. The voltage should not fluctuate for too long after the switches are turned on and off.
3. The potentiometer can be tested by having someone adjust the potentiometer while checking the ends of the potentiometer to see if the resistance is being adjusted. The potentiometer is 100 ohms so we will make sure that the range of the resistance will be able to reach that.
4. Test the voltage that is being sent to the microcontroller to make sure that the communication protocol is correctly passing information from the switches and the potentiometers.

Microcontroller

1. We will be checking firstly to see if the signals from the user interface are being sent and correctly interpreted by the microcontroller. We can do this using turning the switches on and off.
2. The voltages from the potentiometer are going to be checked to see if the resistance is correct
3. Use shift registers externally to get the output of the SPI communication. The shift registers can be placed with an LED and a 1k ohm resistor to display the output of the communication
4. Have edge cases - test with overvoltage conditions to make sure that the LED drivers are being turned off in the event of a fault signal from the LED drivers.
5. Check the duty ratio produced by the microcontroller going to the LED driver interface. The 5V is around the nominal voltage expected across the potentiometer at its highest resistance setting.

$$\mathbf{DutyRatio_{PWM} = V_{potentiometer}/5V}$$

LED Drivers

1. Voltage supplied: Ensure that the voltage supplied to the LEDs are within the voltages the LEDs can handle.
    a. Infrared LED Driver: 1.8V to 2V
    b. White Light LED Driver: 2.9V to 3V
2. Current Supplied:
    a. Infrared LED Driver: 350mA to 500mA
    b. White Light LED Driver: 60mA to 120mA
3. When there is an overvoltage(any voltage higher than the voltages specified above), the fault signal to the microcontroller is high.
4. The duty cycle of the output current is the same duty ratio with a tolerance of +/- 1% as the input PWM signal from the microcontroller.
5. The frequency of the current output is at 400kHz with a higher tolerance of +/-10%.
6. Once the safety temperature limit is reached, the LED driver should go into thermal protection mode. The thermal limit we set is at 100° C but it can changed later depending on testing circumstances.

LEDs

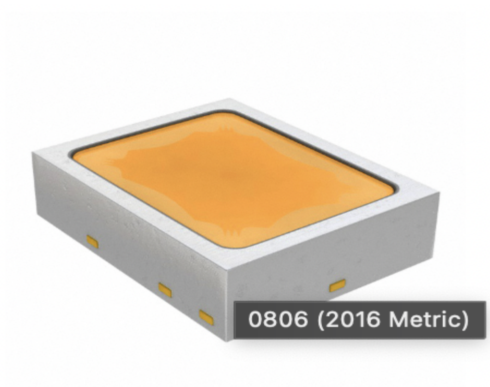
1. The LED should be bright enough on the highest setting on the brightness knob to luminate the cancer cells.
    a. For the infrared LED: The radiant power should be between 100-200mW and this can be measured using a photometer.
    b. For the white light LED: The expected flux is 16-18 Lumens each. We can use a light meter to measure the Lumens.
2. The wavelength of the LEDs should be within the desired limits and we can measure this using a spectrophotometer although this might be hard to obtain.
    a. For the infrared LED: The wavelength should be between 780nm and 785nm.
    b. For the white light LED: The wavelength should be between 400nm and 700nm.

3. Supporting Material

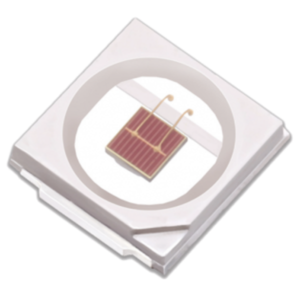
- Toggle Switch:

		Toggle Position NONE = No Position ( ) = Momentary		
Pole	Model	Up (Slot)	Center	Down
SP	A11	OFF	NONE	ON

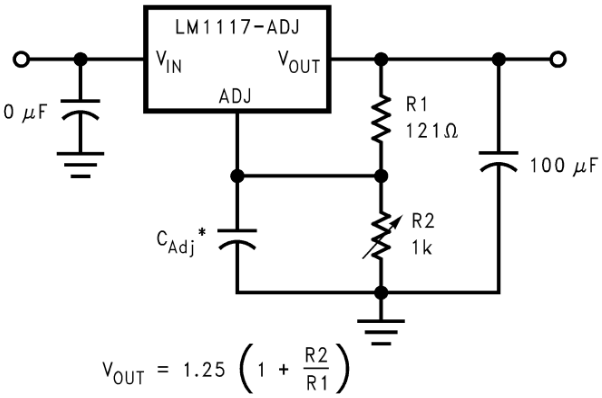
- White LED:



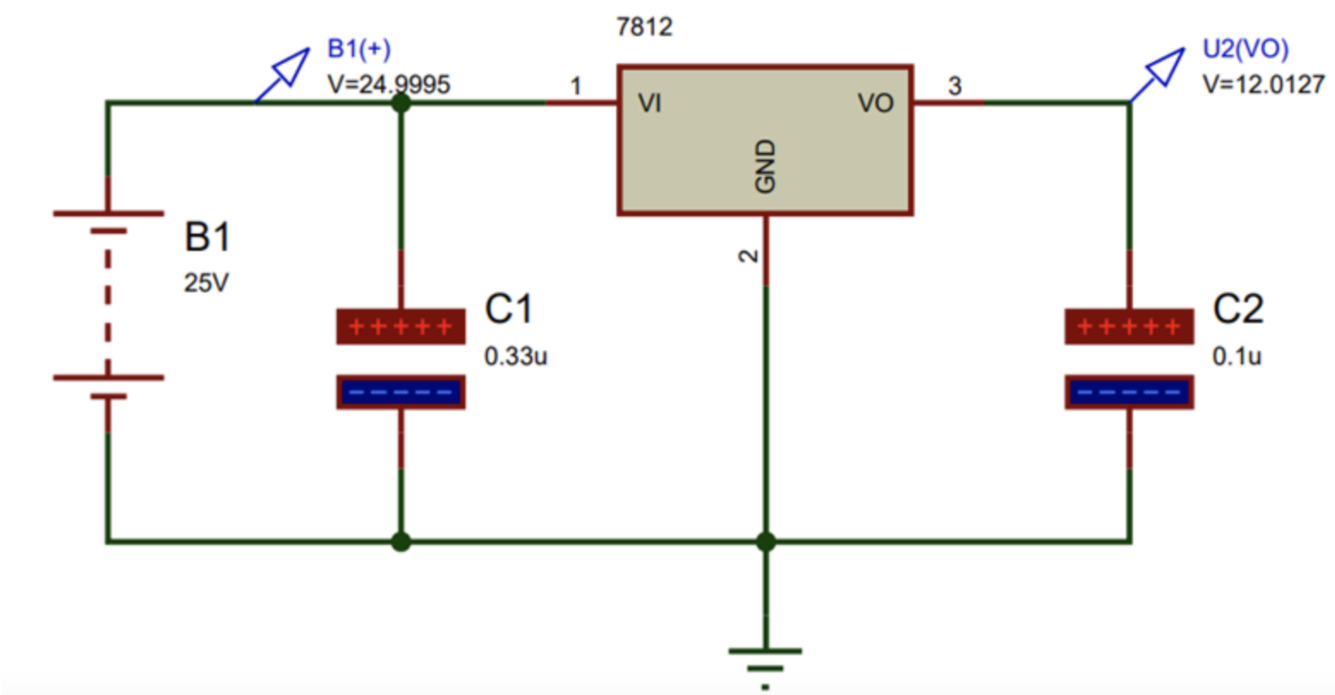
- Infrared LED:



- LM1117-2.0 - Voltage regulator [5]



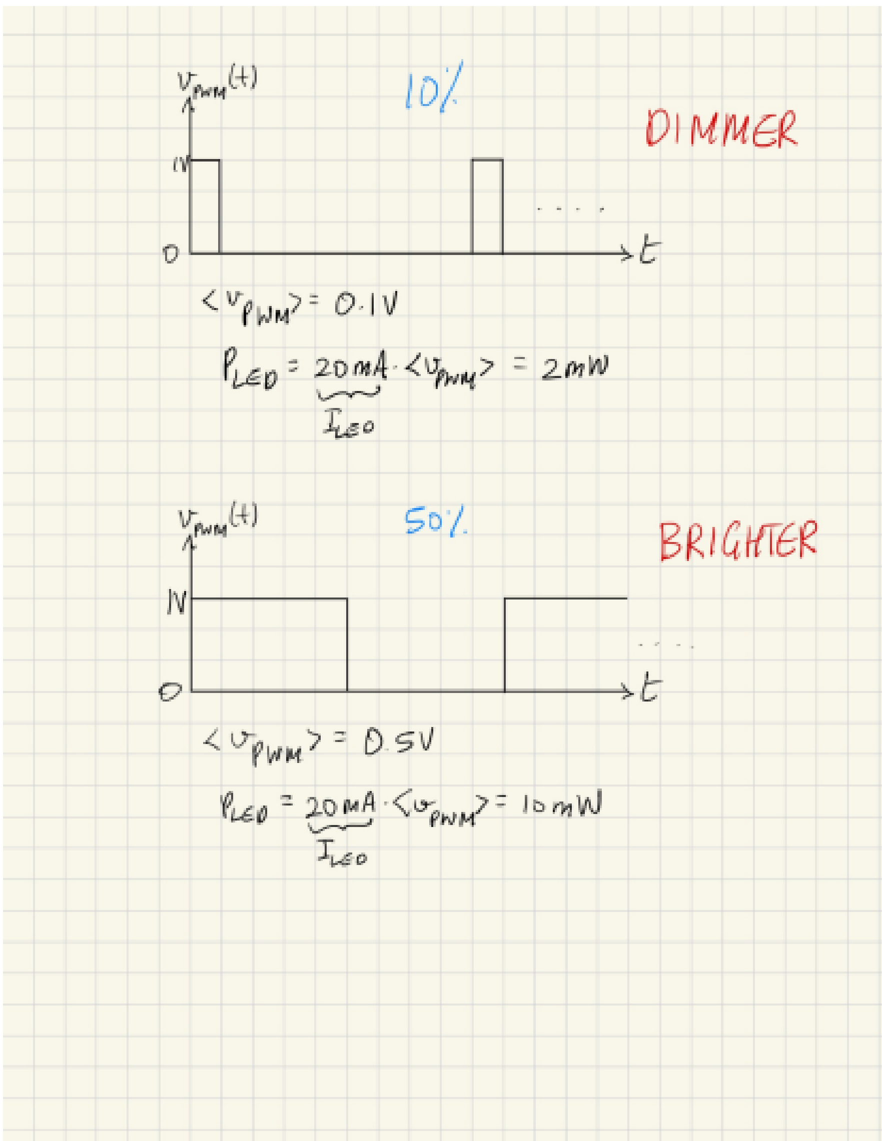
- LM78XX



4. Tolerance Analysis

Something that is highly critical to the success of our project is the ability to adjust the brightness of the LEDs. Since the output of the LEDs are interpreted by the human eyes, there is less emphasis and importance on the speed of the data being transmitted. So the transmission speed can be moderately fast. So this is not a design constraint. Ensuring accurate generation and transmission of the PWM signal from the microcontroller and from the LED derivers is more important to the working of the project.

An illustrative analysis of setting the different brightness of the signal can look like:
Assuming the LEDs take around 20mA current.



As seen above, this way the power to the LED can be adjusted and as along as the microcontroller can produce the PWM, the design will be successful. The microcontroller that we chose has two 8-bit timers with maximum count 65535 and one 16-bit timer with maximum count 65535 that can produce the PWM waveform. We can use the 16-bit timer to produce our PWM signal with the appropriate duty ratios to send to the LED drivers. It is essential that the LED drivers then use this duty ratio to send the appropriate current signals to the LEDs.

5. Cost

To put together the subsystems for this device, the following parts will need to be ordered using our budget:

- User Interface:
  - Three toggle switches - each one at $4.92: $14.76
  - Three potentiometer pack - $20
- LEDs:
  - Infrared Light:
    - Each at an estimated $10
  - White Light: LED XNOVA WARM WHITE 2700K 0806
    - Each one at $0.18: $4.32
- LED Drivers:
  - TPS92205x 65-V 2-A / 4-A Buck LED Driver
    - Each at $1: $3
- Batteries:
  - 3V pack of 12: $30
  - 9V pack of 2: $9
- Voltage Regulators:
  - $11
- PCB: $50
- Total: $152.08

Cost Labor:

The average salary for a computer engineer is around $93,782 per year so according to that estimate, an hourly salary for an individual working in the industry would be around $45.08. For our project, we will be putting in around 10 hours a week, so this will be $450 in a week for each of us. We will be working on this for 8 weeks, so each of our team member's cost of labor will be around $3600. While we mentioned 10 hours, we might be putting in more hours for the preparation of our demo and the research behind the project we are working on.

6. Schedule

Date	Manogna	Jeremy	Yoga
10/2	Look into the logic of the microcontroller on how to send the SPI signal to the LED to get them to work as we want	Create a rough draft of the PCB design that will get shipped out next to to give an idea on what should be on the PCB	Look in the PCB Design where the white and infrared LEDs will be connected to determine what will be needed on the PCB
10/9	Connect the user interface to the microcontroller on a dev board to test the SPI and start looking at edits for the round 2 of PCB design.	Debug and Test the PCB design in time before the first round of orders. Finish at least one day before.	Design and Test the PCB design for the LEDs. Finish this in time for the first round of orders.
10/16	Debug and Test the new PCB design in time before the second round of orders.	Test the PCB designs that were sent from the first round and look for the errors.	Design and Test the PCB design for the LEDs. Finish this in time for the second round of orders.
10/23	Test the second round of PCB design from order and test the connection from the microcontroller to the LEDs on dev board.	Debug and Test the last PCB design in time before the third round of orders.	Design and Test the PCB design for the LEDs before the last round of orders.
10/30	Test the finalized	Test the	Test the finalized

	PCB Design to ensure everything we want is working as intended	connections between the user interface to the LEDs on the dev board.	PCB LED Design to ensure the functionally and shape is what we wanted
11/6	Reserved for unexpected circumstances that arise from testing the final PCB design.	Put all of the parts together using the finalized PCB designs to ensure they work as intended.	Reserved for unexpected circumstances that arise from testing the final PCB design.
11/13	Reserved for last second changes that are arise during mock demo	Reserved for last second changes that are arise during mock demo	Reserved for last second changes that are arise during mock demo
11/20	Fall break	Fall break	Fall break
11/27	Prepare for the demo and presentation. Start working on the report.	Prepare for the demo and presentation. Start working on the report.	Prepare for the demo and presentation. Start working on the report.
12/4	Present presentation and finish the report.	Present presentation and finish the report.	Present presentation and finish the report.

7. Ethics and Safety

Our project aims to create a controllable NIR and bright white LEDs that will help detect cancer cells. One thing that could be an issue is the safety of the LEDs. The first code in the IEEE Code of Ethics states “the safety, health, and welfare of the public.” Since we are trying to get the white LEDs as bright as possible, looking directly at the LED could damage our eyes during development and the users later. As a result, during development, we will be extra careful when handling the LED and unique eyewear when testing the brightness of the white LED. Not only that, the NIR LEDs can also damage the eyes since they emit longer wavelengths than visible light. If one were to look at the NIR LEDs for short periods directly, nothing would happen, but it would still require attention when handling them. This would also apply to the user when using the product. The caution when handling the LED direction would ensure no damage to the eyes would happen to the user. Since the IR light can harm the human eye, there are ethical issues that arise when this device is used maliciously with a intent to harm others. In the event that we test our project on a cancer patient, we will follow Section II of the IEEE Code of Ethics[9].

We will need to make sure that all individuals are prepped with sufficient information about the effects of infrared light and bright light. They will also be made aware that bright light can often trigger traumatic experiences that the individual may have faced. The testee will also be made aware that the detection using this device does not guarantee the detection of all cancer cells. Furthermore, using this device will help in the detection of cancer cells, but it will not necessarily stop any misdiagnosis of cancer and the specific locations that cancer growth might be apparent. We will "treat all persons fairly and with respect, and to not engage in discrimination", "to not engage in harassment of any kind" and "to avoid injuring others, their property, reputation, or employment by false or malicious actions." As said before, we will abide by codes 7, 8, and 9 of the IEEE code of Ethics with everyone involved in the testing[9]. Also, we are using infrared LEDs, which are being bought by manufacturers. This will entail being close to hazardous environments and materials that could be dangerous while designing and creating. According to OSHA(Occupational Safety and Hazard Administration), workers need to wear protective, electrical personal equipment to ensure that they are safe and not being harmed[8].

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