ECE 445

Project Proposal Revised

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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 and surgeries allow medical professionals to detect cancerous cells, it would be far more beneficial if surgeons were able to use a surgical camera and 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/Visual Aid:

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.

Below is a visual representation of what the LED PCB board will look like. Our surgical LED lamp would consist of two PCB boards. The infrared LED will be in the middle and the white light LEDs will surround the infrared LED.The PCB for the LEDs would be the appropriate thermal PCB to dissipate heat. It would be circular with a 6'' diameter. The other board would house the supporting ICs and other electrical components like resistors, inductors, capacitors etc.

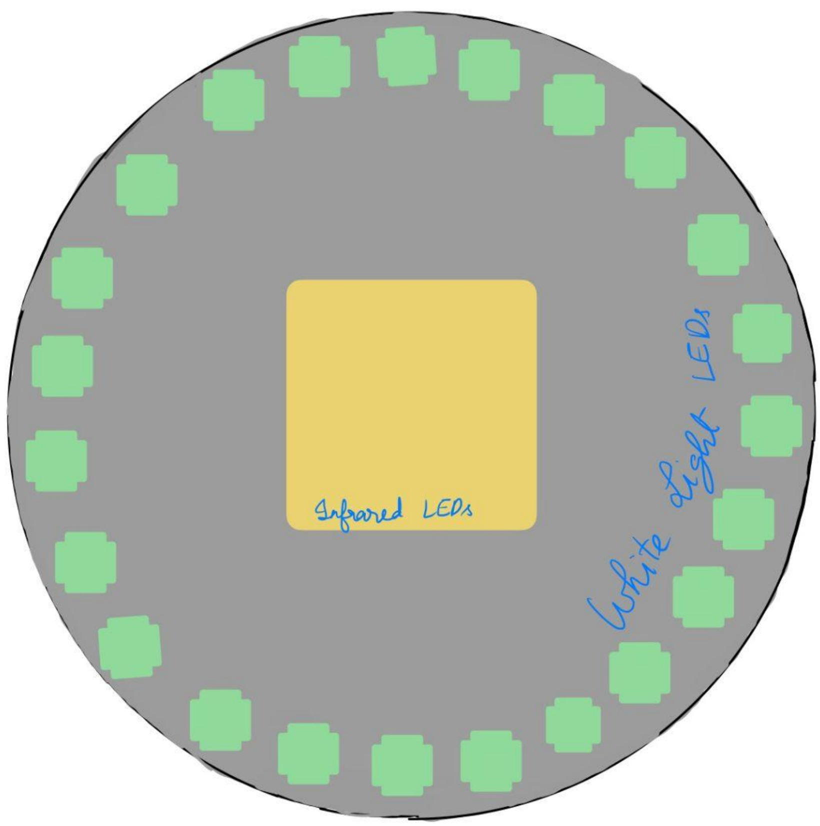


Figure 1. Simpler rendering of our LED PCB board

3. 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 visible light to allow the user or the surgeon to identify cancerous cells.

1.A 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.

2. Secondly, this project would entail an easy-to-use interface for the user to control the brightness and LEDs quickly.

3.Lastly, since the LEDs would be placed near the human skin, it should not heat up beyond reasonable limits.

Design

1. Block Diagram

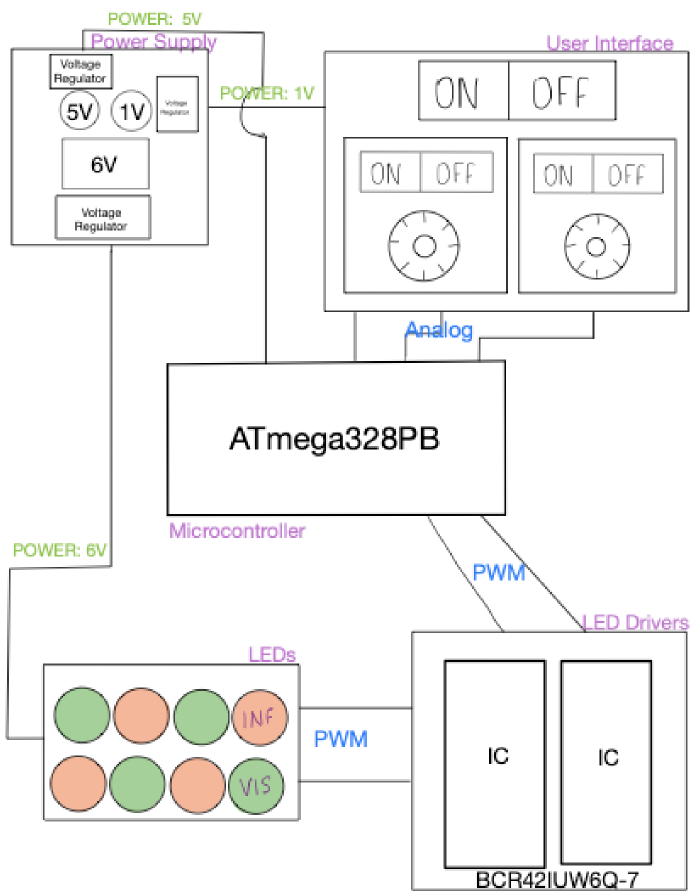


Figure 2. Block Diagram

2. Subsystem Overview

Power Supply

This is the subsystem that supplies power to other subsystems in the project. It contains three main power sources. We are planning on having batteries to provide relatively lower power to the user interface board and the microcontroller. A potential battery that will supply around 1.5V to the user interface is Alkaline battery. We could use a Lithium-Ion button cell to power the microcontroller which can tolerate up to 5V of voltage. Lastly, the biggest power supply would be for the LEDs which usually have an average voltage of 2.2 V. It will also contain voltage regulators to ensure that the voltage supply is consistent and within the limits.

User Interface

The user interface board would be the main control panel from which the user will adjust the LEDs and their brightness. It will contain a master switch which can turn all the LEDs on or off. It will also contain two separate control panels for the visible light LEDs and the infrared LEDs. Each type of LEDs would have a secondary switch to completely turn that LED on or OFF. Each type of LED will also have a knob associated with it which can control the brightness of the LEDs.

Microcontroller

We decided to use the ATmega328PB microcontroller to control the brightness of our LEDs using PWM waves that are generated by the microcontroller. We chose this specific microcontroller for several reasons. It has high performance capabilities but also works low-power (around 5V) which is better for our design as we want to keep the design as small as possible. It has several I/O pins which is essential since we will be connecting these to the LED drivers to power the LED appropriately based on the settings on the user interface board. It also contains 32 kilobytes of flash drive to hold our program.

LED Drivers

LED Drivers are an essential part of our design. Since it is critical to the functioning of the light that we can control the brightness, we require LED drivers to regulate the voltage and current to the LEDs. We would need different drivers for the two kinds of LEDs. We are planning on utilizing an appropriate PWM signal from the microcontroller to drive the LEDs. The PWM duty cycle will depend on the brightness of the LEDs required.We will be using the TPS92205x 65-V 2-A / 4-A Buck LED Driver with Inductive Fast Dimming.

LEDs

Our design contains two types of LEDs, near-infrared LEDs and visible or white light LEDs. Since they emit different wavelengths, they also have different voltage and current requirements. Therefore we will use separate LED drivers to power the LEDs. It will also be connected to the power supply of 5V on the other side to power the LEDs. For the infrared LED, we will be using the Lumixtar SMD3030 1W IR 780nm High Power LED. For the white LEDs, we chose a standard Luminus MP-2016-1100-27-90.

3. Subsystem Requirements

Power Supply

1. The power supply for the microcontroller should be able to continuously supply 5V +/-0.3 V. This is to ensure that the PWM has enough voltage to drive the LEDs. A potential supply for this can be a 5V Li-Ion battery which is rated for 2200mAh. Upon further consideration, we have decided to use a buck converter (TPS560200 4.5-V to 17-V Input, 500-mA Synchronous Step-Down Converter With AdvancedEco-ModeTM) to lower the voltage from the main power supply to 5V.
2. The power supply for the user interface is an alkaline battery for 1.5V rating. This voltage has to be very low since it is only for signals from buttons and knobs similar to potentiometer. Upon further consideration, we have decided to use a buck converter (TPS560200 4.5-V to 17-V Input, 500-mA Synchronous Step-Down Converter With AdvancedEco-ModeTM) to lower the voltage from the main power supply to 5V.
3. The power supply for the LEDs should be around 6V since typically LEDs have a voltage drop of 1.2V for infrared LEDs and around 3.4V for white light so we can place the LEDs in series and then have multiple rows parallel. The alkaline battery used for this should have a current rating of at least 500mA. This can be achieved by using two button cells. Upon further consideration, we have decided to use a Low-Dropout Regulator (TPS7B86-Q1) to ensure that the voltage is only slightly lowered to match the voltage of the LEDs from the main power supply and ensure that the current supplied to the LED drivers is not over 500mA.
4. All the voltage regulators should be able to hold the voltage required for the system i.e. 6V, 5V and 1V.

Voltage Converter

1. We will connect the power supply that will be used for the microcontroller to the TPS560200DBVR, which is a buck converter, with the correct capacitors and resistors layout to reduce the voltage to 5V as well as reduce the current to 0.5 A.
2. We will connect the power supply that will be used for the user interface to the TPS560200DBVR, which is a buck converter, with the correct capacitors and resistors layout to reduce the voltage to 3.3V.
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 TPS7B86-Q1(a low drop-out linear regulator) does reduce the voltage to 9V. [1]
4. Connecting the power supply to the TPS560200DBVR 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. We need a master switch that would turn off the entire LED system. This is especially important in a field so critical like surgery.
2. We need secondary switches to turn on and off the individual types of LEDs depending on the user's needs.
3. Most importantly, knobs are needed to adjust the brightness of the LEDs. The setting of the knob must be proportional to the brightness of the LEDs.

Microcontroller

1. The microcontroller cannot handle more than 5.5 V so care must be taken to ensure that this value is not exceeded.
2. The microcontroller must be able to deliver PWM signals to the firing of the LED driver with the appropriate modulation. The brightness setting should be reflected in the duty of the PWM waveform.
3. The duty ratio cycle will depend on the brightness that is being set for the LEDs. It will not be a static value as the resistance of the potentiometer will be changed using the knob of the potentiometer. Taking an average of the brightness values, assuming that the brightness will be at around 50%, the duty cycle approximation will be around 50%. We will be using the formula below to calculate the PWM duty ratio:

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

4. This duty ratio of the PWM signal will be reflected both in the PWM signal generated by the microcontroller going to the LED drivers and the PWM signal produced by the LED drivers going into the LEDs as LED current.
5. To test the PWM, we will be using an oscilloscope to connect probes to the PWM signal sources and check the PWM to make sure the signal is correct. The duty ratio should be reflected as a ratio of the total “on” time to the total time period of the PWM signal. We can observe the PWM signals to see how long it is high for and then check if it corresponds to the particular potentiometer setting.

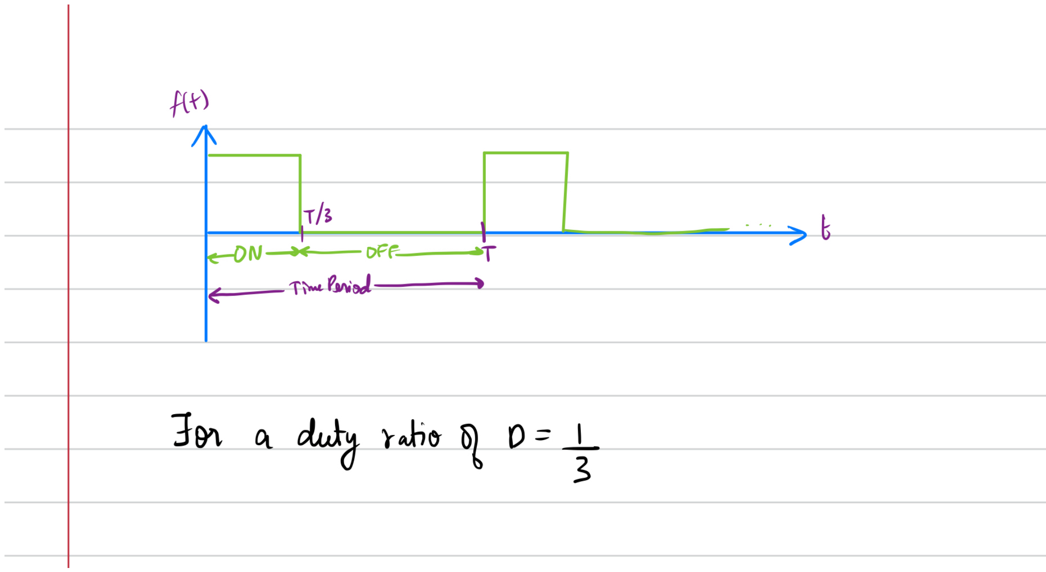


Figure 3. Example Duty Ratio Observation in the PWM signals

LED Drivers

1. The LED driver must be able to correctly interpret the PWM waveforms supplied by the microcontroller and adjust the power to the LED so they can be dimmed appropriately. The power delivered to the LEDs must be proportional to the duty ratio of the PWM.

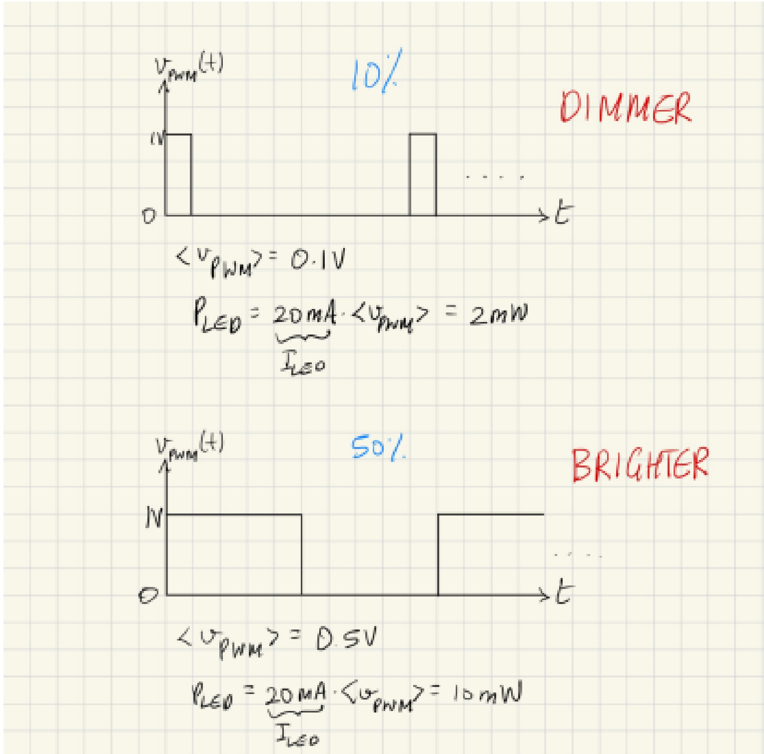
LEDs

1. Infrared LEDs: They usually have a voltage requirement of 1.2V with a +/-10% tolerance and they have a current rating of 20mA but cannot handle more than 40mA of current.
2. Visible LEDs: They can have a current flow of 10mA to 30 mA without damage and have a voltage drop of around 3.4V. The LEDs should be able to handle the power supplied by the LED drivers.

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 is more important to the working of the project.

An illustrative analysis of setting the different brightness of the signal can look like:



Since LEDs typically have a current flow of 10-30mA, we can assume that the LEDs have a current flow of 20mA. 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 and one 16-bit timer that can produce the PWM waveform.

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.

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. 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.

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