Final Presentation

Team 36: LED Surgical Light

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Team Introduction

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Problem

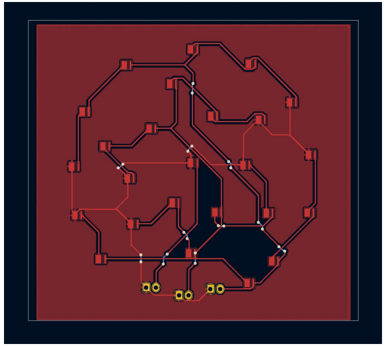
Surgeons and medical professionals use sense of vision and analysis of tissues to find cells that are malignant and work towards appropriately removing those

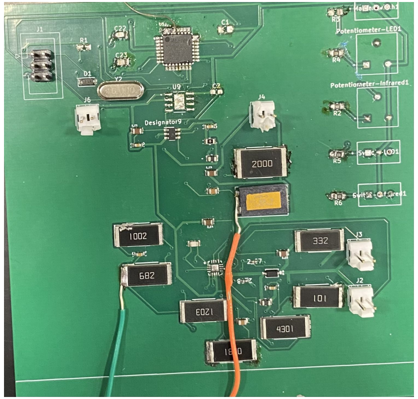
- Limit to the human vision
- It is very difficult to detect cancer cells in areas where there is not as much growth and visibility
- Hard to identify the exact location

Description of Project

Programmable light source that can be used in surgical settings

- Infrared and white LEDs
- User interface that will allow user to change the brightness of each LED system
- 3 PCBs
    - Microcontroller - ATMEGA328PB
    - LED PCB - Infrared LED, 24 White LEDs
    - Rechargeable battery

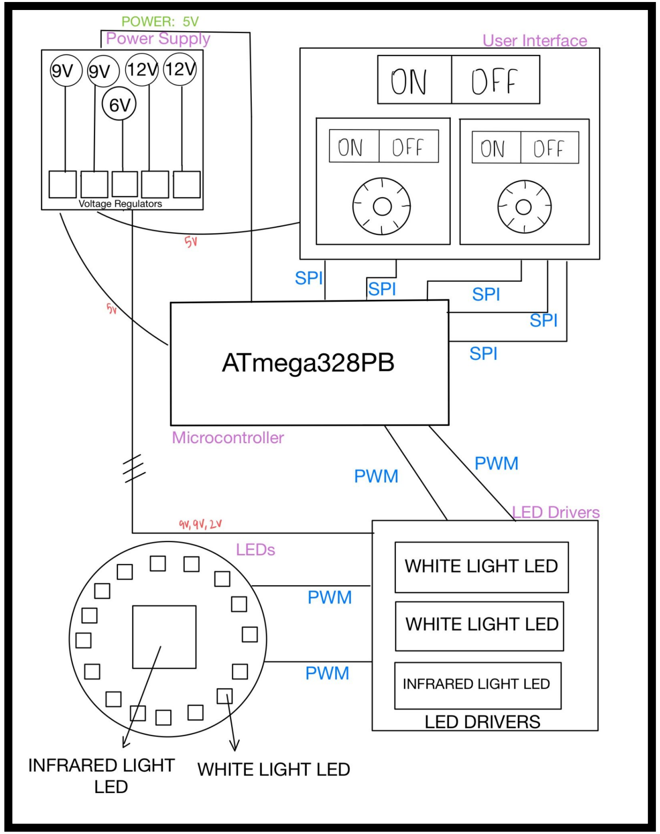




High-Level Requirements

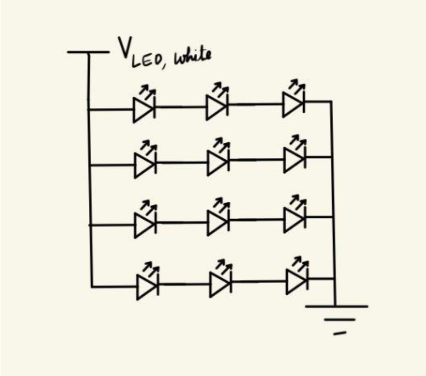
1. Turn on a set of white LEDs- aid surgeons’ to view cells
2. Employ one infrared LED- aid camera to view cells
3. Develop a mechanism to allow user to increase or decrease the brightness of each of the LEDs

Original Design

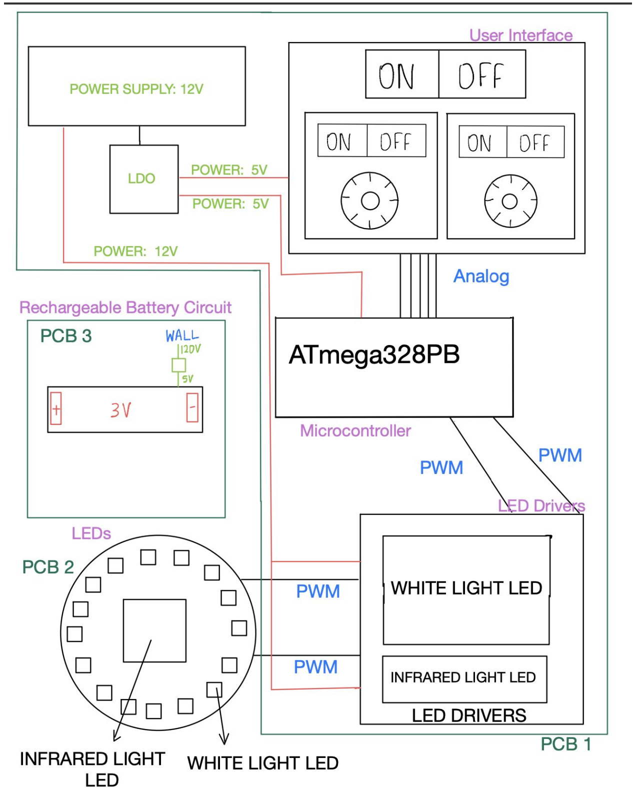


Our original design:

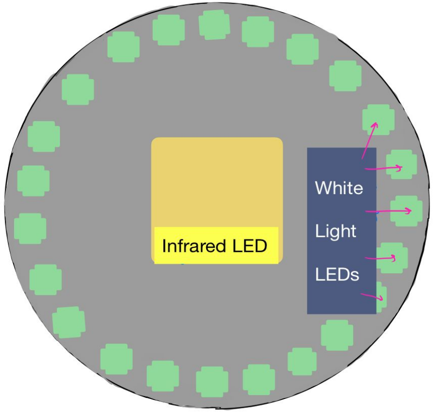
- Multiple Power Supplies: Two 9V, two 12V and a 6V battery
- Linear Dropout Regulators- dropped down 4V
- Two regular LED Drivers
- White light LEDs were placed in a parallel fashion



Changes to the Original Design



- ❑ Replaced the multiple power sources with one battery - 18650 Rechargeable Batteries
- ❑ Combined the LED drivers and buck and boost voltage regulators
- ❑ Used a linear dropout as the voltage regulator for the user-interface and the microcontroller
- ❑ Produced a rechargeable battery circuit to recharge the battery



Subsystems

Power Supply

Batteries

- ❑ 18650 Rechargeable batteries
- ❑ 3 batteries in series to provide 12.6 V

Recharging Batteries

- ❑ Mosfet to control the current flow towards the battery
- ❑ Shunt regulator controls determines the state of Mosfet

Linear Dropout Regulator

- ❑ 5V fixed output LDO regulator

Power Supply Requirements, Verification and Results

Requirements	Verifications	Results
LDO is able to step down the voltage to 5V +/- 0.2V	Using a voltmeter check the output of the voltage	Initially only doing a 3V drop, later there was no voltage drop
Rechargeable battery circuit can charge each battery to 3V +/- 0.2v	Check battery voltage after connecting to the circuit	Batteries weren't used, we weren't able to test a battery charging

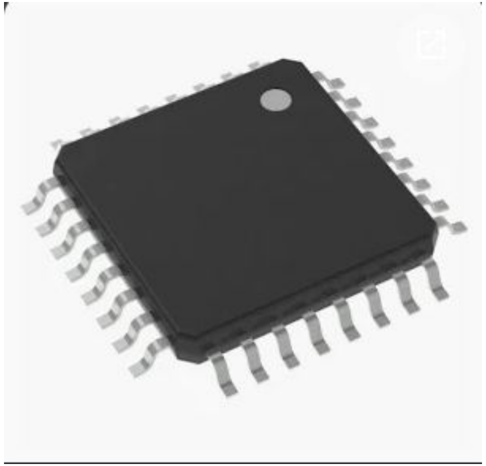
ATMEGA328PB-AU

- Primary requirement:
  - Able to produce multiple PWM signals
  - Have multiple analog and digital input pins

- ATMEGA328PB-AU characteristics:
  - 23 general purpose I/O pins
  - Has two 8-bit PWM and two 16-bit PWM

Coding

- Read the switch values from digital pins and analog pins
  - Use values to determine strength and on/off state
  - Adding delay to mitigate inconsistencies reading



Microcontroller: Requirements, Verifications and Results

Requirements	Verifications	Results
Can read potentiometer voltages and switches voltage	Connect voltages from 0V-5V to the input pins and print out readings	Development Board could read correct digital and analog values
Using the analog and digital inputs, produce accurate duty ratio PWM signals	Output register values should change with analog signals	Output register values changed according the input values separately

```
14:21:17.202 ->  Master:1 WhiteSwitch:1 InfraSwitch0 WhiteAnalog:623 InfraAnalog:0
14:21:17.267 ->  Master:1 WhiteSwitch:1 InfraSwitch0 WhiteAnalog:623 InfraAnalog:0
14:21:17.332 ->  Master:1 WhiteSwitch:1 InfraSwitch0 WhiteAnalog:623 InfraAnalog:0
14:21:17.396 ->  Master:1 WhiteSwitch:1 InfraSwitch1 WhiteAnalog:623 InfraAnalog:80
14:21:17.461 ->  Master:1 WhiteSwitch:1 InfraSwitch1 WhiteAnalog:623 InfraAnalog:80
14:21:17.556 ->  Master:1 WhiteSwitch:1 InfraSwitch1 WhiteAnalog:623 InfraAnalog:80
```

User Interface

Switches - SPST Toggle Switches

- ❑ Main switch
- ❑ White LED switch
- ❑ Infrared LED switch

Potentiometers - 100k Ohm

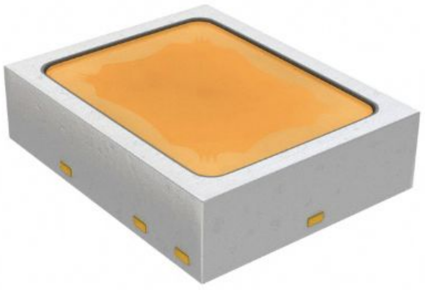
- ❑ White LED, Infrared LED
- ❑ Output is a voltage sent to the microcontroller
- ❑ Necessary for PWM output from microcontroller so LED systems can be set to the correct brightness

User Interface: Requirements, Verifications and Results

Requirements	Verifications	Result
-Switches should control LEDs	The voltage that is being supplied to the switches was tested to see if the on/off functionality of the switch was correctly changing the voltage	-Main switch turns on entire LED system. -The infrared and white LED turn on when the switches are turned on
The potentiometers should change the voltage read by the microcontroller	The change in potentiometer should appropriately change the voltage sent to the microcontroller	The potentiometers change the brightness as expected

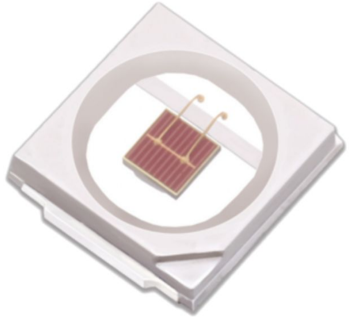
White Light LEDs

- 24 white light LEDs
- Nominal Rating: 3V and 60mA
- 400-700nm wavelength
- Used to aid the surgeon in viewing the affected area better



Infrared Light LEDs

- 780nm wavelength
- Nominal Rating: 2.8V and 350mA
- Able to illuminate skin cancer cells specifically



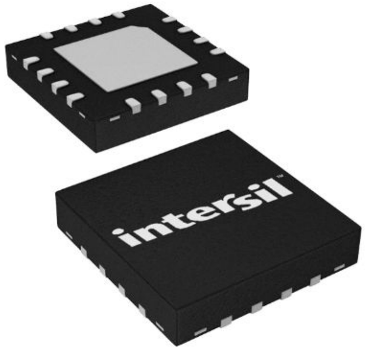
LED Drivers

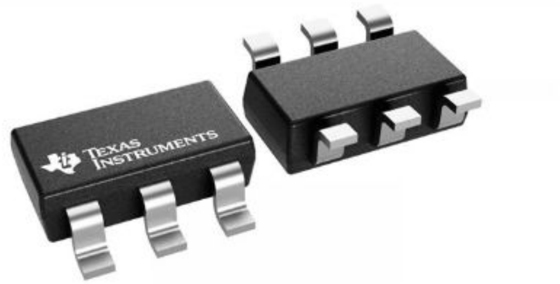
White Light LED Drivers

- ❑ Dual Output LED Driver: ISL97682IRTZ-TK
- ❑ Output at 30kHz
- ❑ Controls through 8-bit PWM signal
- ❑ Boost LED Driver- steps-up from 12.6V to 36V

Infrared Light LED Drivers

- ❑ Synchronous Buck LED Driver: TPS54200
- ❑ Steps-down from 12.6V to 2.8V
- ❑ Fixed 600 kHz PWM frequency
- ❑ Controls through 8-bit PWM signal





LED Driver: Requirements, Verifications and Results

Requirements	Verifications	Results
The voltage and current supplied produced should not exceed: White LED Maximum: 3V and 120mA Infrared LED Maximum: 3V and 500mA	Connect voltage and current probes to the output signals to the LEDs at different PWM duty	-Infrared LED driver meets requirement -White LED driver able to produce total of 2V
Produce the duty ratio and frequency of the current waveform as requested by the microcontroller.	Connect current probe to LED driver outputs and vary brightness	-Infrared LED driver able to vary PWM duty ratio without flickering -White LED driver unable to vary PWM duty ratio

Functional Test Results

Successes and Setbacks

Successes

- ❑ Able to control the user-interface and successfully read the inputs from the user
- ❑ Infrared light LED can be turned on and controlled
- ❑ Bucking action of infrared LED driver works
- ❑ All 24 white LEDs can be turned on

Setbacks

- ❑ Voltage regulator (LDO) short-circuited
- ❑ Failure of LDO lead to failure of microcontroller
- ❑ White light LED driver was not able to produce PWM
- ❑ Were not able to source/contact the infrared LED

Engineering Explanations

Linear Dropout Regulator

- Short circuited due to the overheating during the soldering or heat oven process
- Overvoltage spikes
- Dropping 7 volts may have caused overheating

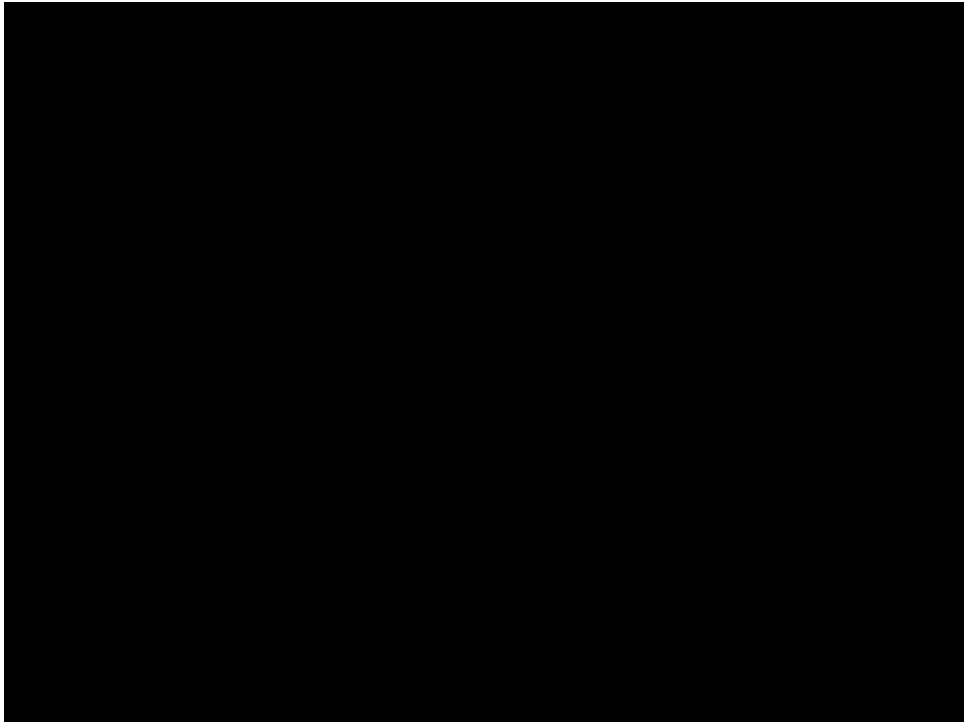
Microcontroller

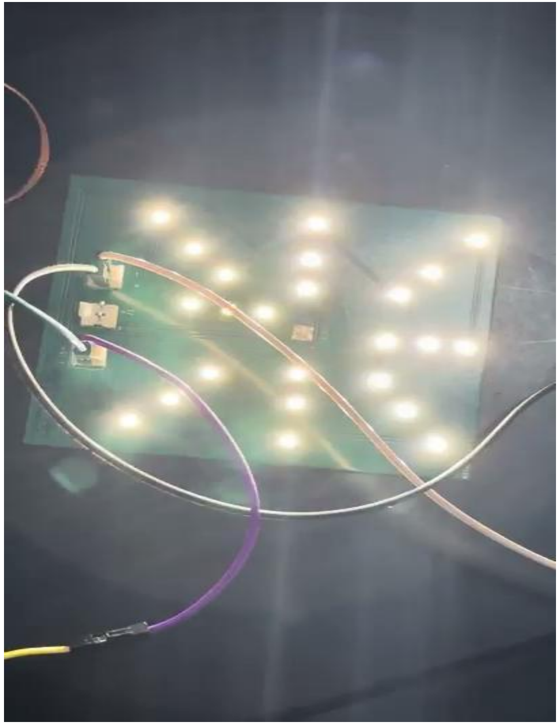
- LDO short-circuit also short-circuited the microcontroller
- Bootloader compatibility
- Difference in clock speed and bootloader clock speed

White LED Driver

- Unable to boost, this could be because there could have been overvoltage and current spikes due to the short-circuit on the board
- Component failure due to overheating when we soldering with a heat gun

Video Evidence





Conclusion

What We Would Have Done Differently

- ❏ Look into using a different microcontroller
- ❏ Replace the LDO regulator with a buck converter
- ❏ Choose an LED driver with more support and resources

Future Work

- ❏ Make the user-interface digital
  - ESP microcontroller can connect through bluetooth
- ❏ Sensor Integration
  - Based on the user's hand movements, the brightness of the LEDs can be modified
- ❏ Integration with the microscopic camera