Guiding Light the Bright Way

Illumination Optimization of a Digital Exoscope

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Background

True Digital Surgery creates digital exoscopes for surgical applications. To create detailed imaging, high intensity LEDs are used at the camera objective. The large power dissipated is overheating the camera and its surroundings. Our team was asked to solve this problem by moving the light sources to the base of the robot and transport the light back to the camera objective.

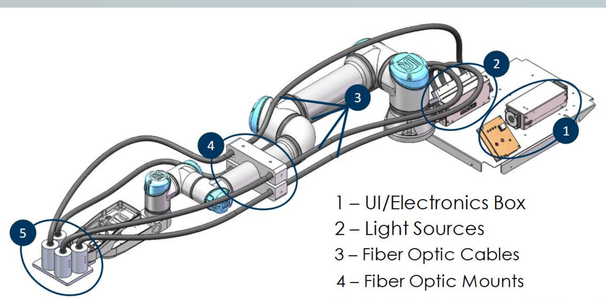
1 – 4k Surgical Display
2 – Camera/Controls
3 – Robotic Arm
4 – Control Monitor
5 – Base

Design Specs

Our product needed to meet the following key specs:

- Four light types: White, UV, IR, Fluorescent
- All light types needed to produce
- User controlled dimming
- 200 mm diameter spot size
- Thermally regulated

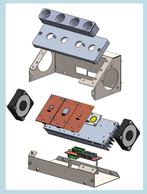
Final Design



1 – UI/Electronics Box
2 – Light Sources
3 – Fiber Optic Cables
4 – Fiber Optic Mounts
5 – Collimator/Collimator Mount

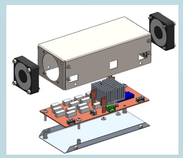
- Custom made user interface to control four different light types.
- Four multi-mode fiber optic bundles the light from source to the objective.
- Plano-convex lens collimates light out of the fiber optics

Key Components



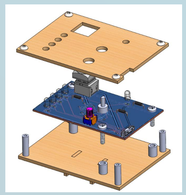
Light Source Box

Contains four LEDs (White, UV, IR, Fluorescent) attached via thermal paste to a heat sink. Fans convectively coo the heat sink. The fiber optic collar holds the fiber optic core at the center of the LEDs.



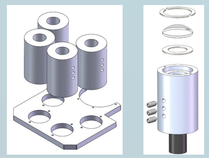
Electronics Box

The Main PCB is housed here. It contains all electrical components for system control. The voltage regulator is connected to a heat sink. Fans convectively cool the whole PCB.



UI Panel

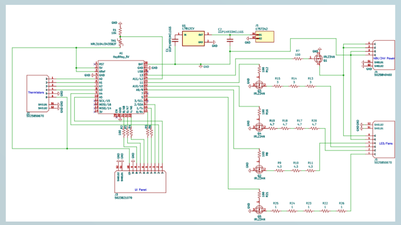
Five throw switch determines LED types the user is controlling. Potentiometer is used for PWM control. Button turns the LED on or off.

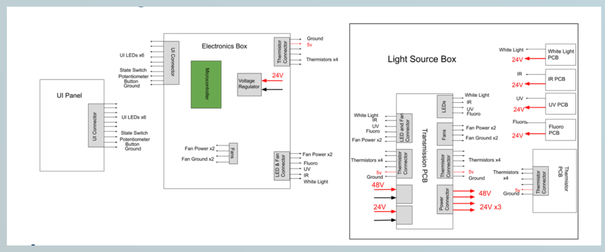


Collimator and Mount

A Plano-convex lens collimates light from the fiber optic to fit a 200 mm diameter spot size. Set screws allow for fiber optic placement adjustability.

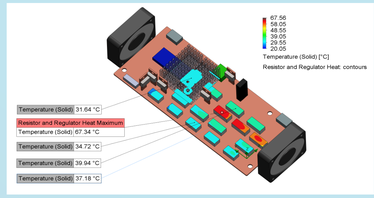
Electronics

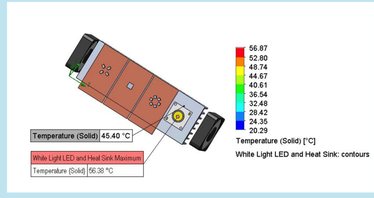


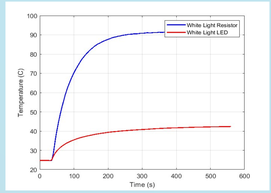


- Thermistors emergency shutdown system in event of over-heating
- Voltage regulator used to accept customer 24V DC supply
- LED intensity controlled with PWM signals

Thermal Simulation and Testing







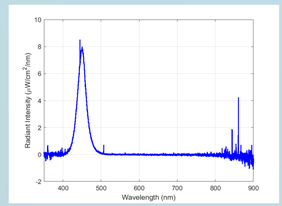
The White Light LEDs thermal model matches within 5 C of physical testing results. Due to observed discrepancies in other parts with complex internals or no matching material in database, physical thermal tests were used to verify the temperature and longevity of the components

Time to thermal failure:

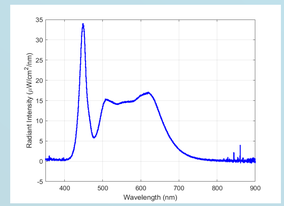
- White Light: Infinite
- UV: 30s
- IR: 2 min
- Fluorescent: 2 min

Light Intensity Testing

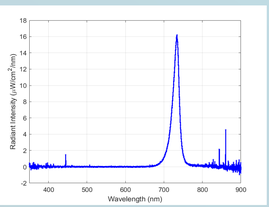
A)



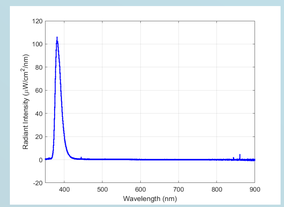
B)



C)



D)



A and B are results from fluorescent and white light, respectively, measured at a distance of 600 mm from the spectrometer. C and D correspond to IR and UV light, measured at 100 mm from the spectrometer. The total loss of the system is ~90%.

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