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Sophisticated Use of Multi-Modal Led Module for Ophthalmologists to Enhanced Vision during Vitrectomy

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Abstract:- During the last few decades Electronics engineering is used more and more in the medical field, especially to aid surgeons in performing surgeries. Different light sources are needed for surgical applications depending on the range of color temperature that is required. Traditional light sources are xenon or halogen lamps emitting white light at varying color temperatures. Ophthalmologists performing vitrectomy procedures require illumination that provides high contrast and clarity. Use of fibers that are in the order of 700 micrometer or less is typical, as this allows the least invasive solution for the patient. A fully functional module of a multi-modal LED meeting specifications and programmable to vary the percentages of RGB components of light for clearer and enhanced vision, and an LED driver to control the LED using a microcontroller have been successfully identified and procured. This prototype is used to design and engineer a biomedical optical device for enhanced vision for ophthalmologists during vitrectomy.

Keywords:- *Vitrectomy, Ophthalmologists, Color Temperature, LED, Microcontroller*

I. INTRODUCTION

The use of electronics in the field of medicine was primitive a century ago. Doctors and surgeons were limited to the use of stethoscope and X-Rays and there were few other electronic devices that they could use in their profession. The situation changed significantly over the last few decades during which a multitude of electronic devices have been invented to help medical professionals in many different ways.

Ophthalmologists have begun to use electronics to aid their inspection, treatment and surgery of eyes. This project has identified an opportunity to enhance the vision of ophthalmologists during vitrectomy by the use of multi modal LEDs (Light Emitting Diodes). Traditional sources of light are xenon lamps or halogen lamps emitting white light at varying colour temperatures.

II. THE MEDICAL CONTEXT TO THE PROJECT

A. Why Vitrectomy?

Vitrectomy addresses vision problems caused when foreign matter invades the usually pristine area of the eye's interior. One example of foreign matter is blood, from conditions such as diabetic vitreous hemorrhage. Light rays passing through the eye can cause the foreign matter to cast shadows on the retina, resulting in distorted or greatly reduced vision. A vitrectomy can restore vision in diabetic retinopathy by removing the natural vitreous that has become clouded by leaking blood vessels and replacing it with clear fluid.

The most common conditions requiring a vitrectomy include

- V - Vitreous haemorrhage due to diabetes
- I - Infection - Endophthalmitis
- T - Traction due to
- R - Retinal detachment
- E - Epiretinal membrane
- C - Cataract related complication
- T - Trauma
- O - Opacity of vitreous cavity
- M - Macular disease

However, a vitrectomy is considered inappropriate and extreme for addressing most ordinary spots and floaters that occur with vitreous detachments affecting almost everyone to some degree as they grow older.

III. THE ELECTRONICS ENGINEERING CONTEXT TO THE PROJECT

A. Vitrectomy Made Possible by Engineers

Surgeries, especially those related to the eye, require precision. Medical instruments aided by technology are needed by surgeons to perform these operations flawlessly. Electronics engineering has made it remarkably feasible for surgeons to conduct surgeries reliably and successfully. Vitrectomy is one such surgical procedure that has greatly benefited from electronics engineering.

B. Challenges in using Traditional Light Sources in Vitrectomy

The challenges faced in using the light sources in the existing systems of vitrectomy are:

- ➢ Difficulty in coupling the light into the fibres.
- ➢ There is a threshold on the clarity of vision perceived by the surgeon as the RGB components in light cannot be varied in a traditional light sources.
- ➢ Different light sources are needed for different surgical applications depending on the range of colour temperature that is required.

For surgical applications in ophthalmology, the use of fibres that are on the order of 700 micrometre or less is typical. This allows the least invasive solution for the

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patient and is therefore highly desirable. The use of these small diameters with any illumination source is challenging due to the difficulty of coupling the light into the fibres.

C. Innovation offered by this project for lighting during Vitrectomy

A multi-modal LED light source in which the percentages of the red, green and blue components of lights can be varied would allow an ophthalmologist flexibility to adjust the contrast and have a clear vision of the inner parts of the eye, differentiating the various parts such as tissues, floaters, blood clots and so on. The vitrectomy lighting devices available in the market today do not have multi-modal LEDs. As part of this project, working together with the team headed by Mr. Sendil Vel in our sponsoring organization Malar Electronics, a multi-modal LED and software driver that can be programmed to control the RGB components have been identified.

This project aims at using the characteristics of multi-modal LED in enhancing the endo-illumination technique in the surgical procedure of vitrectomy. Malar Electronics, the organization sponsoring this project with their project expertise and infrastructure intends to use this combination of multi-modal LED, software driver and microcontroller to design and engineer a biomedical optical device for use by ophthalmologists for enhanced vision during vitrectomy. As technology continues to improve it is important for surgeons to understand the implications that each of these innovations will have on their surgical performance and also how these variables will interact with each other.

IV. PROJECT METHODOLOGY

A. Objective

The project's objective is to identify an RGB multi-modal LED light source module, and to facilitate the sponsoring organization to innovatively design and engineer a sophisticated optical light source to enhance the clarity and contrast in the vision of the ophthalmologist.

B. Methodology

The following methodology was followed to identify the most suitable LED from the market for purpose of engineering the RGB multi-modal LED light source module for vitrectomy.

A seven-stage methodology was used in order to have a structured and sequential process. Each of the stages was completed within a specified timeframe. The individual timeframe for each stage has been tracked in a project tracker. The project tracker has been included as an annexure to this project report.

C. Requirements Analysis

The three factors that influence the choice of LED for this project are:

- *Colour Temperature range*
- *Intensity of light*
- *Safety Temperature range*

D. Parameter Analysis

The parameter analysis is made for the following criteria

- *Colour Rendering Index (CRI)*
- *Luminous Intensity*
- *Colour Temperature*
- *Current*
- *Voltage*
- *Power*

E. Hardware Design

The hardware designing of the project involves the drawing of the schematic diagram which shows the pin configuration and pin connection between the ST microcontroller, LED driver and the RGB LED.

The feedback resistance values and the channel resistance values are calculated and marked in the schematic diagram.

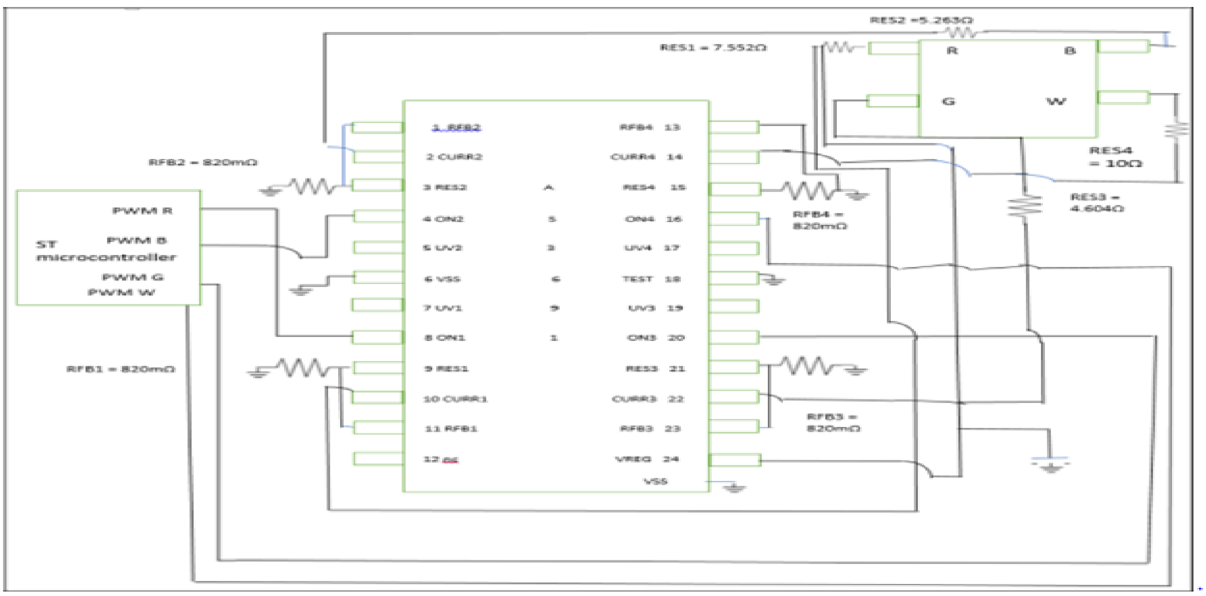

Fig 1

The schematic diagram represents the connections between the LED, LED driver and the microcontroller. The resistances have been calculated based on the information given in the datasheets of the electronic components that have been procured for the project.

The lighting of the LEDs is based on the pulse width modulation input given by the microcontroller. The lighting of each individual LED channel is based on the following three cases:

- When the pulse width modulation input is low, the output of the comparator is also low. This is because the comparator compares the two input voltages given to it. It compares the magnitude of the reference voltage and the pulse width modulation input. Since, the pulse width modulation input is less than the reference voltage, the output of the comparator is low, thereby supplying a lower voltage than the threshold voltage, to the MOSFET. This results in an open circuit and the LED does not glow.
- When the pulse width modulation input is high, the output of the comparator is high. This is because the comparator compares the two input voltages given to it. It compares the magnitude of the reference voltage and the pulse width modulation input. Since, the pulse width modulation input is more than the reference voltage, the output of the comparator is high, thereby supplying a higher voltage than the threshold voltage, to the MOSFET. This results in a closed circuit and the LED glows.
- If the pulse width modulation input is much higher than the reference voltage, then the excess voltage is nullified with the help of the feed back resistor which is grounded. The desired voltage is given as the output of the comparator which results in a closed circuit causing the LED to glow.

Based on the above working principle, each of the LED channels are made to function.

F. Software Design

The software for the project has been done on the Embedded C platform. The variations in white light produced by the module as the output as marked as individual light modes in the software program.

Pulse width modulation (PWM) is a powerful technique for controlling analog circuits with a microprocessor's digital outputs. Pulse width modulation speed control works by driving the motor with a series of “ON-OFF” pulses and varying the duty cycle, the fraction of time that the output voltage is “ON” compared to when it is “OFF”, of the pulses while keeping the frequency constant.

G. Integration

The software module is uploaded on the ST microcontroller and thereby a fully functional RGB LED module prototype is developed.

The various shades of white are obtained by pressing the switches numbered 1 and 2 on the hardware module. The switch 2 has been assigned the increment operation while the switch numbered 1 has been used for the decrement operation.

The number of colour modes that can be viewed depends on the number of colour modes coded for in the software program. The software code together with the hardware design helps produce the various shades of white which would provide an increased resolution for ophthalmologists while carrying out the procedure of vitrectomy.

- *Photographs of Multi-Modal Led Designed and Developed by Project Team*

Fig 2:- Top view of RGB multi-modal LED module

V. NEXT STEPS FOR SPONSORING ORGANIZATION

The concept of using a multi-modal LED to increase the resolution of images featuring the internal parts of the eye aims at bringing about advancement in the surgical procedure used to carry out vitrectomy. The next steps of the sponsoring organization would involve the device that has been developed for vitrectomy being tested by various doctors in reputed hospitals.

The colour modes programmed in the module would be tested by various doctors. The tests are carried out on patients whose eye condition permits them for undergoing the test. The doctors then give feedback regarding the effectiveness of each colour mode. To imitate the surgical procedure of vitrectomy, thin tomato skin is used, instead of the human eye.

After improving on the feedback given by doctors, the product developed would be available in the market to benefit those patients diagnosed with vitrectomy.

VI. CONCLUSION

We are satisfied that we could develop a fully functional module of the RGB LED. We intend to use this combination of multi-modal LED, LED driver and microcontroller to design and engineer a biomedical optical device for use by ophthalmologists for enhanced vision during vitrectomy.

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