Design of phototherapy device for neonatal jaundice using high power blue LED

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Abstract. Neonatal jaundice is the yellowish condition due to high level bilirubin in new born baby. This condition must be treated if the bilirubin level above 12 mg/dL. One of the common treatment is by using blue light phototherapy to convert bilirubin become more soluble in the water then easily excreted from the body. The wavelength of light is 460-490 nm with minimum intensity of 30 μW/cm². In this study, the phototherapy device is designed and tested. The blue light source is high power LED consisted six chips of CREE EZ900. Heat sink and fan are employed for LED package cooling system. Solar power meter and spectrometer are used to analyse the intensity and wave length produced by the LED. The device results 30 μW/cm² and 460 nm of wavelength.

1. Introduction
Neonatal jaundice is the yellowish condition due to high level bilirubin in new born baby [1]. In jaundice new born baby, the liver is relatively immature thus unable to conjugate and excrete the bilirubin properly [2-3]. Statistically, this condition is experienced by some 60% of new born babies in their first week [4]. However the level of bilirubin must be monitored since it can causes chronic bilirubin encephalopathy [5].

The therapy for neonatal jaundice can be classified from the bilirubin level in blood, age and condition of the baby [6]. Illuminate the baby by sun light in the morning is traditional treatment if the bilirubin level in blood is below 12 mg/dL. For higher level, i.e 12 mg/dL to 25 mg/dL, phototherapy using blue light is effective to reduce bilirubin level. The properties of light for this treatment are 460-490 nm wavelength with the minimum intensity of 30 μW/cm² [7]. For higher level than 25 mg/dL, the exchange transfusion is urgently performed [8].

In this study, the design of blue light phototherapy device for neonatal jaundice is conducted and its light properties are measured. The light source is blue light high power LED package which consists of eight LED chips. The device is designed to be portable and easy to use.

2. Experimental Methods
The phototherapy device was designed to meet the light requirement for neonatal jaundice. In this device the light source was made by high power blue LED package which consisted of eight chips of CREE EZ900, shown in figure 1. The dimension of the LED package was 32 x 30 mm.

The cooling system of LED was needed since its performance decreases at high temperature, therefore heat sink and fan were employed, shown in figure 2 [9]. The LED package was attached at the baseplate of plate-fin heat sink. The thermal interface material was used to reduce contact thermal resistance.
between LED package and heat sink. To increase heat transfer coefficient, the air is flown through the channels of the fins using fan.

![Figure 1. High Power Blue LED](image)

**Figure 1.** High Power Blue LED

![Figure 2. Heat sink and fan for cooling system](image)

**Figure 2.** Heat sink and fan for cooling system

The device is designed to illuminate the patient from above with the area 40 x 70 cm. The distance between LED and illuminated area was 80 cm, shown in figure 3. The electronic system consisted DC power supply to convert from 220 VAC to DC electric. The dimmer was used to control the intensity of light.

![Figure 3. Design of phototherapy neonatal jaundice](image)

**Figure 3.** Design of phototherapy neonatal jaundice

### 3. Results and Discussion

Two main variables for neonatal jaundice phototherapy are light intensity and wavelength. These two variables were measured by solar power meter and spectrometer respectively. The measurements were conducted on the patient area at nine different points to investigate the distribution over the area, shown in figure 4. The results showed that the intensity was 0.3 W/m² at all measurement points. The voltage and current on the LED package were 4.3 Volt and 1.2 A respectively.
Figure 4. Measurement points at patient area

Figure 5 shows the wavelength produced by the LED. The horizontal axis is the wavelength of light while the vertical axis is the analogue to digital counts for the intensity. Based on this result, the peak wavelength was at 460 nm which is in the range of requirement of phototherapy. This light properties is reported changes trans-bilirubin into the water-soluble bilirubin isomer [10]. It means that the bilirubin is easier to excrete.

Figure 5. Wavelength measurement result

To analyse the performance of the light source, the efficacy and durability of LED were also calculated. By using lux-meter the luminous flux on the patient area was 18 lux, so the luminous efficacy was calculated by dividing luminous flux and light intensity to be 60 lumen/Watt. For the durability, the device was turned on for eight hours nonstop, shown in figure 6. The light intensity remained constant for test duration. This test is needed since the therapy can be performed for hours [11].
4. Conclusion
The design of phototherapy for neonatal jaundice device has been conducted. Based on the test measurement, the device was able to produce the light intensity of 0.3 W/m² with wavelength of 460 nm. Based on this result it can be concluded that the device met the requirement for neonatal jaundice phototherapy.

5. References

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