# The scheme of making electrical circuits with parallel-series-parallel to reduce the heat generated - On going development of prototype LED-blanket bluelight phototherapy for newborn jaundice's treatment

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# The Scheme of Making Electrical Circuits with Parallel-Series-Parallel to Reduce the Heat Generated - On Going Development of Prototype LED-Blanket Bluelight Phototherapy for Newborn Jaundice's Treatment.

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**Abstract.** Bluelight phototherapy is an essential non-invasive interventional therapy method commonly used in jaundice infants or physiological hyperbilirubinemia in the neonatal period. The use of phototherapy helps mobilize unconjugated bilirubin through the process of isomerization into a more water-soluble form of lumirubin that excrete through feces and urine. The source of phototherapy has evolved from conventional fluorescent, LED lights, halogens, and halogen fiberoptic blankets. Research related to the development of phototherapy technology, engineering, and its implementation is continuing because phototherapy is still very varied in health care facilities. The American Academy of Pediatrics (AAP) recommends that conventional phototherapy devices provide a blue-green light spectrum of 8 to 10 μW/cm$^2$/nm at 430-490 nm wavelengths. In comparison, intensive phototherapy (double phototherapy) is given as much of the baby's surface area as possible through blue-green light spectrum rays of at least 30 mW/cm$^2$/nm at the same wavelength. We are currently developing a prototype phototherapy blanket using LED lights with wavelengths of 460 - 470nm and an area of 50cm x 45cm x 2cm consisting of 18 LED strips each 50cm long. We use parallel-series-parallel circuit schemes to distribute energy evenly throughout the blanket area. LED-Blanket blue light phototherapy is expected to be more practical because it does not require additional tools, is effective, helping to introduce and strengthen the bond of mother and baby, provides breast milk exclusively optimally, and reduces the cost of treatment.

*Keywords*: LED blanket, phototherapy, jaundice, neonatal hyperbilirubinemia

## INTRODUCTION

Phototherapy, otherwise known as ray therapy, is a noninvasive interventional therapy commonly used for jaundice infants [1,2]. The use of phototherapy helps mobilize non-conjugated bilirubin through the process of isomerization into a water-soluble form of lumirubin that excrete through feces and urine [1,2]. The use of phototherapy has developed from conventional use using fluorescent tube lamps. Halogen, fiberoptic halogen, to Light Emitting Diode (LED) [3,4].

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The American Academy of Pediatrics (AAP) recommends that conventional phototherapy devices provide a spectrum of blue-green light with radiation of 8 to 10 μW/cm$^2$/nm at wavelengths of 430-490 nm. In contrast, intensive phototherapy (double phototherapy) is administered to as much of the baby's surface area as possible through blue-green light spectrum rays of at least 30 mW/cm$^2$/nm at the same wavelength [5,6]. Maximum radiation can be achieved by bringing the light source close to the baby; however, it cannot be done with halogen lamps because the resulting heat can cause burns [2]. Recommendations for placing the lamp are at a distance of 15-20 cm (6-8 inches) from the baby [1]. LED phototherapy is more practical because it does not require additional tools, is effective, and has minimal supervision [1,6]. In research using LED phototherapy in hospitals or at home to conclude there are several advantages, including avoiding continued treatment in the hospital, helping to introduce and strengthen maternal and infant bonding, opportunities for exclusive breastfeeding optimally, and reducing hospital treatment costs [7–10]. Currently, phototherapy blankets in health facilities in Indonesia use fiber-optic blanket phototherapy at a reasonably high price. Therefore, researchers tried to make phototherapy blankets with LED materials that are cheaper in health care facilities throughout the nation.

## MATERIALS AND METHODS

We are currently developing a prototype phototherapy blanket using LED lights with wavelengths of 460 - 470nm and an area of 50cm x 45cm x 2cm consisting of 18 LED strips each 50cm long. We use Parallel-series-parallel circuit schemes to distribute energy evenly throughout the blanket area.

Blanket made of Berber Fleece warm, soft, and light, size 100 x 75 cm. Made from fleece polyester yarn, knitted into fabric, and brushed to compact the material and smooth the surface. The blanket is a strong, elastic, non-faded fabric, accessible to sewn and glued LED lights [11].

LED lights materials using brand Ilker 5050 SMD 60 LED/m Blue Indoor Strip LED code 5102, with DC12V low-voltage power supply, security, and energy efficiency with high brightness and low power consumption 14,4 W/m, lighting angle 120°, quantity: 60LEDs/m, operation temperature: -20 – 50°C, lifetime: 50,000 hours, waterproof rating IP20. LEDs are glued to the fabric using a 3M double tape [12].

## RESULTS AND DISCUSSIONS

We are developing LED phototherapy blankets to become a prototype. By using the materials above, we develop a less expensive blanket and efficient to be used as therapy in newborns with jaundice with clinical trials first. We use Ilker 5050 SMD 60 LED/m with pure color and full-reflected monochromatic blue light, suitable for a 12V, solid-state light source. The LED was a patented design with high flexibility, scalability, and robustness; frequency close to the frequency of the human eye, no visible flicker, low power, natural light color; focus light, the brightness is higher than the conventional light source [12].

The characteristics of electrical and flux as shown from the table below:

**TABLE 1.** Electrical and Flux Characteristics [12]

**Flux Characteristics**

| Code | Number of LEDs (M) | Case | Colour | Wavelength | Lm (M) | Angle |
|---|---|---|---|---|---|---|
| 5102 | 60 | SMD 5050 | Blue | 460-470 nm | 170lm/m | 120° |

**Electrical Characteristics**

| Code | Colour | Forward Current (mA/M) | Input Voltage (CV) | Power (W/m) | Lm (M) |
|---|---|---|---|---|---|
| 5102 | Blue | 1200mA | 12 VCD | 14,4 W | 170 lm/m |

This prototype phototherapy blanket uses blue-colored LED lights with wavelengths of 460-470nm. The wavelength is in line with those recommended by the American Academy of Pediatrics (AAP).

Figure 1 shows the electric current source connected with the LED light panel.

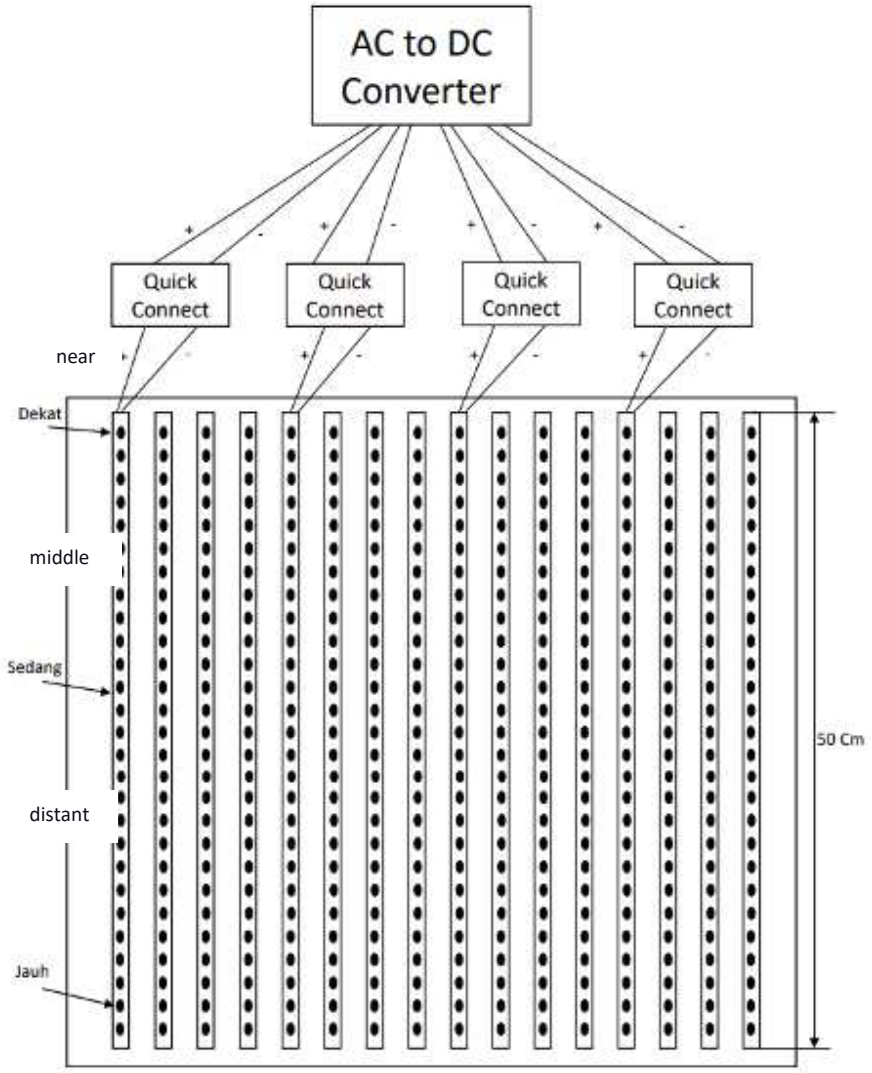
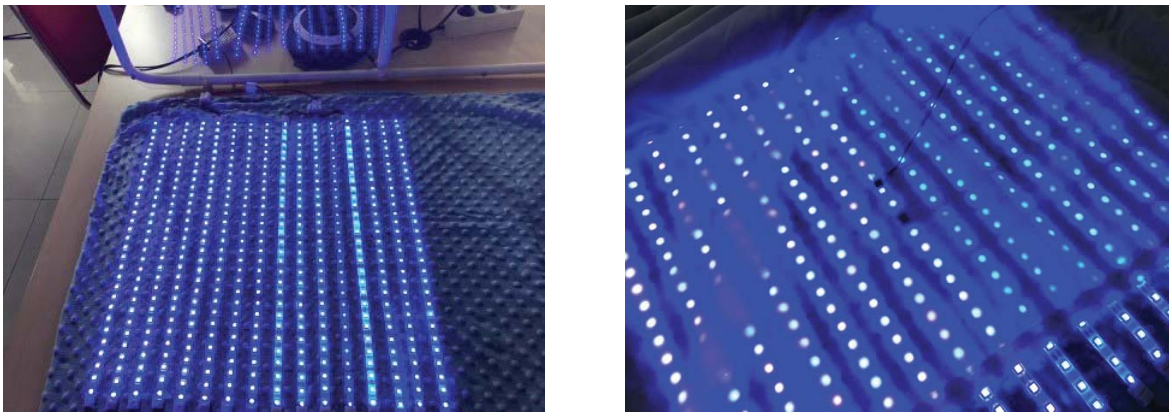



**FIGURE 1.** Connection diagram for LED blanket consist of 16 LED strips.

There are 16 LED strips with a length of 50 cm each with a total power of 115.2 watts. Temperature measurement using Temperature Data Acquisition (DAQ) with Thermocouple Type K and Arduino UNO for microprocessor thermometer after the blanket is turned on for 30 minutes, divided into three parts closest to the current source or near (0 cm), middle (25 cm), and distant (50 cm) (Fig. 1). DC electric current input is made into 4 to divide the energy so that the heat is produced by the LED evenly. With the method above, the highest temperature produced by LEDs is 39.5 °C (Fig. 2 and 3).



(a) (b)

**FIGURE 2.** (a) LED blanket prototype, (b) Temperature test using DAQ.

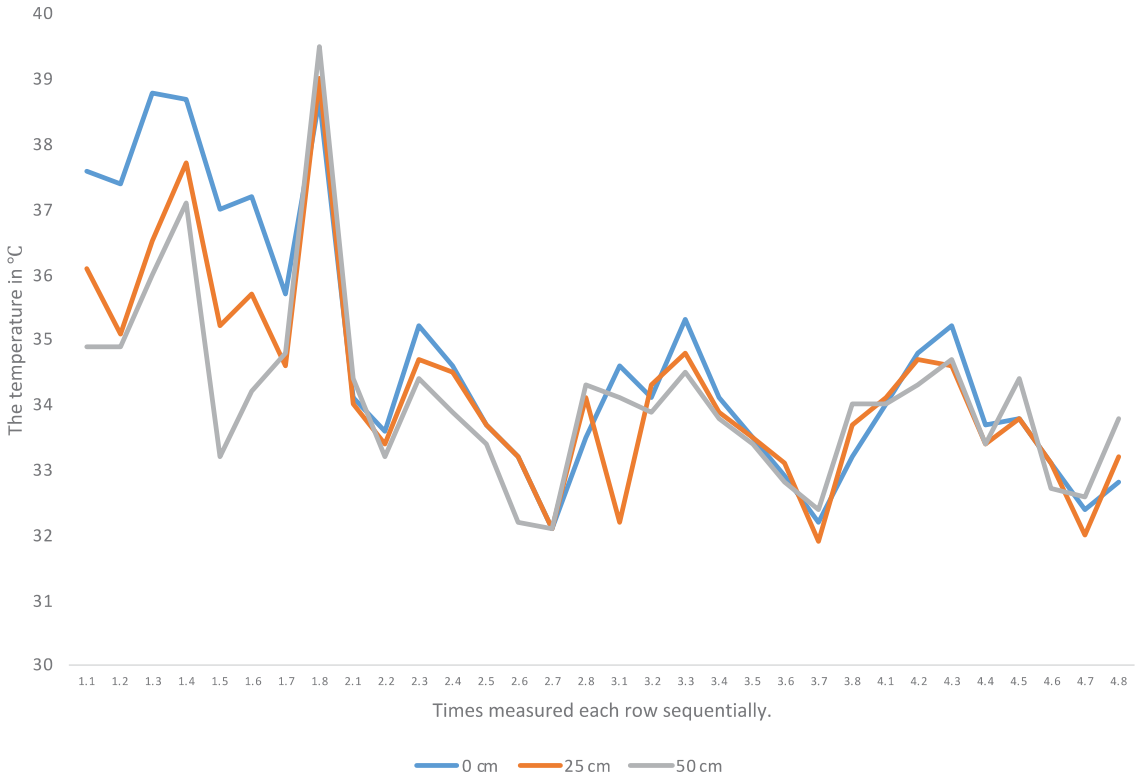



**FIGURE 3.** Temperature test results divided by four line input current with eight measurement sequences

Figure 3 Temperature results on four rows of LEDs. Each series is measured eight times, sequentially at a distance of 0 cm, 25 cm, and 50 cm.

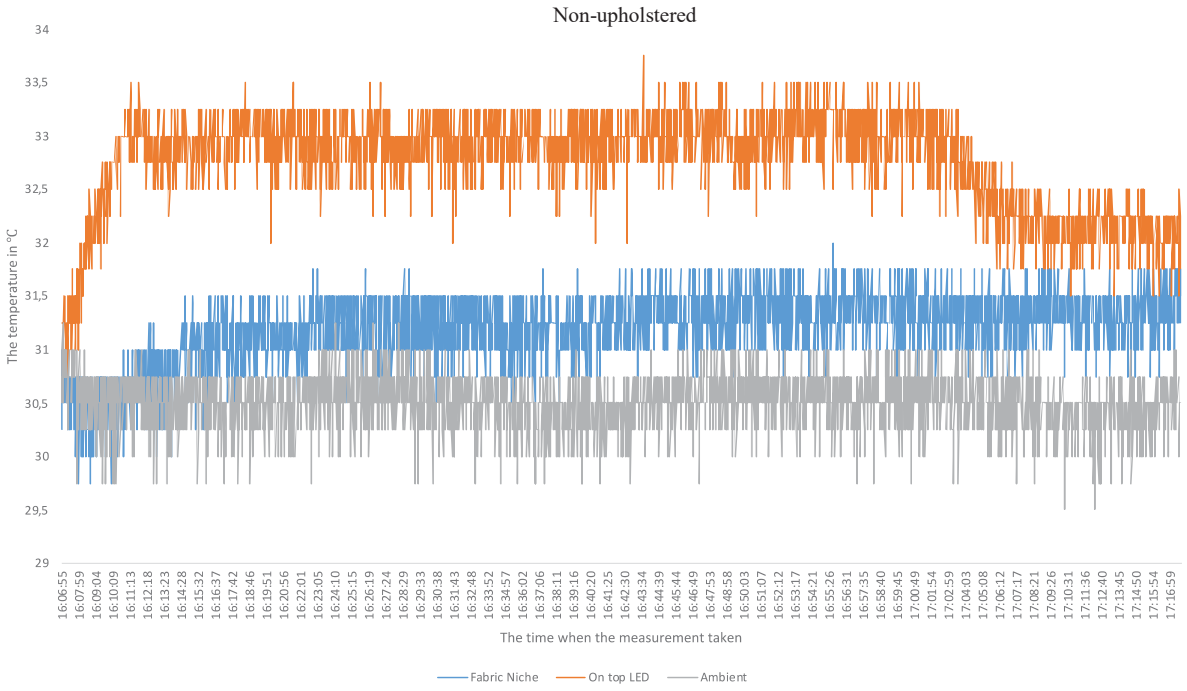
The overview of temperature measurement results performed against the blanket prototype with the upholstered and the non-upholstered showed in Table 2 below. Temperature measurement is also performed based on the distance between the source of the inflow and the measurement location.

**TABLE 2.** Temperature Measurement Results of LED Blanket Phototherapy Prototype (ºC)

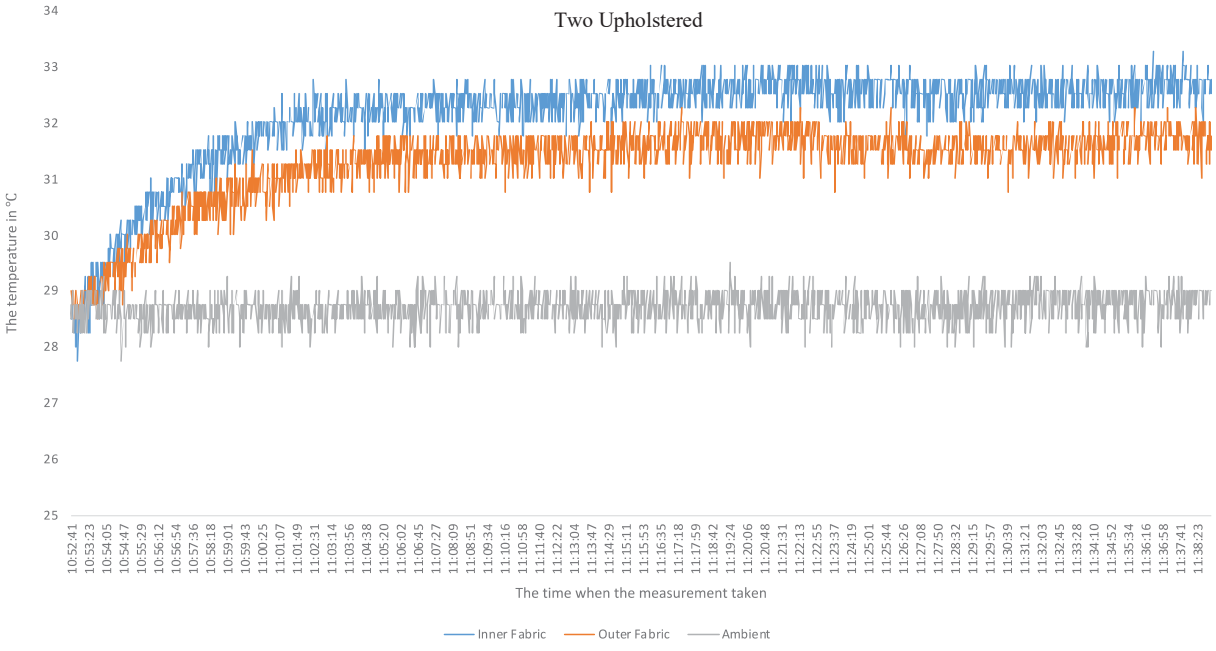
| **Non-upholstered (measurement time 3021 seconds)** | | **Fabric niche** | **Top LED** | **Ambient** |
|---|---|---|---|---|
| | Mean | 31,20177 | 32,77796 | 30,50538 |
| | SD | 0,333515 | 0,449175 | 0,254698 |
| | Min | 29,75 | 30,75 | 29,5 |
| | Max | 32 | 33,75 | 31,25 |
| **Two Upholstered (measurement time 1975 seconds)** | | **Inner Fabric** | **Outer Fabric** | **Ambient** |
| | Mean | 32,1222166 | 31,2705 | 28,71508 |
| | SD | 0,88216784 | 0,706317 | 0,254295 |
| | Min | 27,75 | 28,5 | 27,75 |
| | Max | 33,25 | 32,25 | 29,5 |
| **Current Source Distance (measurement time 1355 seconds)** | | **Central** | **Near** | **Distant** |
| | Mean | 31,65192 | 44,01217 | 31,09864 |
| | SD | 0,386898 | 1,562162 | 0,309886 |
| | Min | 30,5 | 40,5 | 29,75 |
| | Max | 33 | 47 | 32,5 |

The mean temperature on blankets non-upholstered ranging from fabric niche, top led lights, and ambient, respectively of 31.2 ± 0.33, 32.7 ± 0.45, and 30.5 ± 0.25. Temperature measured on the top of LED becomes higher because it is closest to the expenditure of heat energy produced by the LED. While the mean temperature for blankets that are upholstered sequentially from the inner layer, outer layer, and ambient is 32.1 ± 0.88, 31.2 ± 0.7, and 28.7 ± 0.25. After being given the upholstery, the measured temperature outside is lower than the temperature inside the layer upholstered. The mean temperatures sequentially measured using current source distances from the middle, near, and distant are 31.6 ± 0.38, 44.01 ± 1.5, and 31.09 ± 0.3. The temperature measured closest to the current source produces the highest temperature reaches to 47°C maximum (Fig. 3).

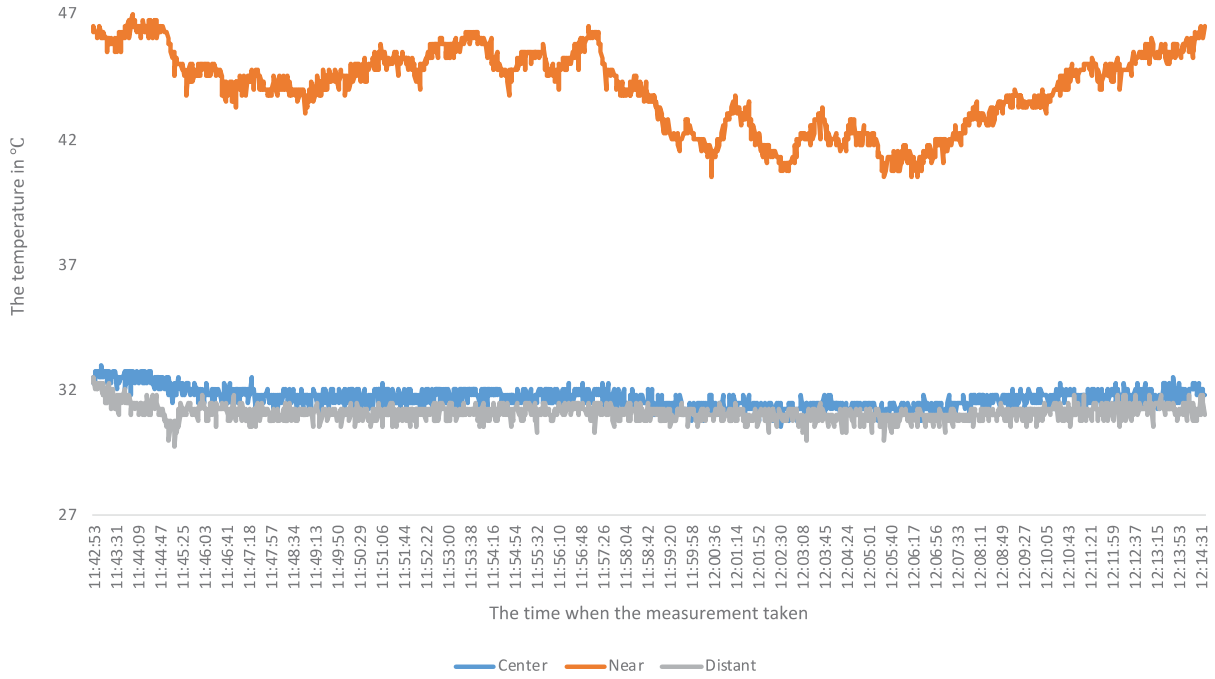
Figure 4 below is a graph of the temperature measurement results.


Non-upholstered
The temperature in °C
The time when the measurement taken
Fabric Niche
On top LED
Ambient

**(a)**


Two Upholstered
The temperature in °C
The time when the measurement taken
Inner Fabric
Outer Fabric
Ambient

**(b)**




**(c)**

**FIGURE 3.** (a) Graphic temperature result for no upholstery fabric, (b) Graphic temperature result for two upholstery fabrics, (c) Graphic temperature results for current source distance before being divided into four electric currents.

## CONCLUSION

We are currently developing a phototherapy blanket using LEDs as its light source. It is necessary to conduct a series of experiments related to the temperature produced when the lights are on for the patient's safety. From what we have developed currently, the scheme of making electrical circuits with parallel-series-parallel is sufficient to reduce the heat generated. LED-Blanket blue light phototherapy is expected to be more practical because it does not require additional tools, is effective, helping to introduce and strengthen the bond of mother and baby, provides breast milk exclusively optimally, and reduces the cost of treatment. For ongoing research, the consistency of wavelengths while using the blanket should determine by calibration measurements. This calibration is required to ensure the values indicated by this prototype instrument comply with the values obtained in the recommended standards and conduct at the Jakarta Health Facility Security Center (Balai Pengamanan Fasilitas Kesehatan, BPFK Jakarta).

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