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# Development of Solar Radiation Intensity Measurement Tool Using BH1750 Sensor Based on The Internet Of Things with Smartphone Display

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**ABSTRACT**

*This research aims to determine the performance and design specifications of the system measuring the intensity of solar radiation using BH1750 sensor based on internet of things with smartphone display. In agriculture, Soil fertility is closely related to maximum yield. Soil fertility and plant growth are determined by many factors, one of the most important is the intensity of solar light. The tools used in the field are still quite simple, where to measure the intensity of solar light still using a lux meter and even though the data read from a digital lux meter cannot be seen anywhere. This measuring instrument is built using the BH1750 sensor, namely as a sensor of solar radiation intensity, NodeMCU ESP8266 as a microcontroller programmed using the Arduino IDE programming language to access the internet network so that it can be sent to the Thingspeak server, and data from Thingspeak is displayed on an Android smartphone using the APP Inventor application, and the data can be displayed. displayed on the Thingspeak server, and also can be stored in memory Micro SD. Based on the results of the development of a measuring instrument for the intensity of solar radiation, it is obtained Data where the highest solar intensity occurs on average between 02.55 – 03.38 UTC ± 0 and between 04.00 – 06.20 UTC ± 0, Each plants has a different need for solar intesity for photosynthesis because the more solar that is sufficient on the plant, so the plants it will become optimal growth.*

**Keywords :** Instruments, Solar radiation intesity, BH1750, Internet of Things, ThingSpeak.



## I. INTRODUCTION

Indonesia is located in a tropical climate which is rich in biodiversity, rainfall balance makes Indonesia's soil fertile so that various plants can grow well. There are internal and external factors that can affect plant growth, and the most important factor in the growth process is determined by solar. Plants grown in areas that have less solar tend to have stems that are not sturdy and easy to fall and grow slower than plants grown in the dark. The process of plant growth is strongly influenced by the environment. The environment is an external factor that greatly interferes with plant growth if environmental conditions are not in accordance with the nature of plant growth. These environmental conditions include the intensity of solar, temperature, and air pressure as well as the presence of microorganisms that interfere with plants.

Excessive exposure of the sun can increase the temperature and lower the humidity, causing damage to plants. Therefore, the solar intensity, temperature, and humidity in the greenhouse must be controlled. Control should use a control system that is integrated with a computer system in order to control and maintan the temperature and humidity in real-time [1]. Solar is used by plants for the process of photosynthesis. The better the photosynthesis process, the better the plant growth.

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Previously, several studies carry out regarding internet of things-based measuring instruments, Rianti (2017)[2], has made a Solar intensity measuring instrument using an Arduino-based BH1750 sensor. This measuring tool uses an LCD as its display. The display has a limited range of data readings that must be on the device and only relies on sources from PLN. If when the PLN source goes out, there is a risk that the tool does not work and the data is not recorded in real-time when there is no power source. Example a colorimeter built with a light detector using the OPT101 sensor [3], designed a colorimeter used to detect food coloring using a photodiode sensor [4], a tool for measuring air pressure with a smartphone display using the DT-Sense Barometric Pressure [5], designed a tool the internet of things for measuring the air temperature and humidity using the SHT75 sensor with a smartphone display. [6]. Based on previous research, Therefore, the author tries to do research with the title "Development of Solar Intensity Measurement Tool Using a BH1750 Sensor Based on the Internet Of Things With a Smartphone Display" so that data can be accessed at any time, can be stored on a SIM card with power in the form of PLN and a battery with a more minimalist design. This research has the following objectives. First, determine the design specifications of the Solar intensity measurement system using the BH1750 sensor based on the internet of things with an android smartphone display. Second, Determine the performance specifications of the solar intensity measurement system using the BH1750 sensor based on the internet of things with an android smartphone

Light is an electromagnetic wave emitted in various wavelengths and frequencies. Light consists of very small light particles emitted by a source in all directions at very high speeds (Newton). Meanwhile, light is a wave as well as sound (Huygens).

The amount of light energy emitted in a given direction is called Light intensity. The figure is expressed in candela which comes from the word candle (candle) which historically was the first artificial light source. So it is used as a unit name for light intensity. The light intensity is defined in equation 1 as follows.

$$I = \frac{F}{\omega} \quad (1)$$

Whereas: I means Light Intensity (cd), F was Luminous flux (lumen) and Ω was Angle of space (steradian)

## II. METHOD

Based on the problems raised in this study, the research model carried out is classified as development research. Research and development is a process or method used to validate and develop a product. Developing products in a broad sense can be in the form of updating existing products so that they become more practical, effective, and efficient or creating new products. In the implementation of research, there are several stages that will be carried out research and development suggests that the research and development steps consist of reviewing existing tools, conducting literature studies and field research, planning tool designs, testing internal designs, revising tool designs, making measuring instruments, limited trials of experimental tools, and product revisions. , main field trial, product revision 2, operational field trial, product revision 3, dissemination, and implementation. First, reviewing the existing tools, the tool to be studied is ASRS (Automatic Sun Radiation Station). ASRS is a digital and automatic tool from BMKG so that measurements are no longer manual in data collection and also update data in real-time. Second, literature studies and board research, literature studies are carried out by browsing several books, journals, articles, and other sources that are relevant and support the research of making solar radiation intensity measuring instruments.

Third, product design planning, to make product designs, starting from reviewing existing experimental set products, compiling Product Design Specifications (PDS), evaluating the design concepts offered, describing the design form, and compiling product design drawings and working drawings. The design is divided into three, namely system design, hardware design, and software design. In system design, the device runs from start to finish. The tool designed and built is a tool to measure the intensity of solar. For a better understanding can be seen in Figure 1.

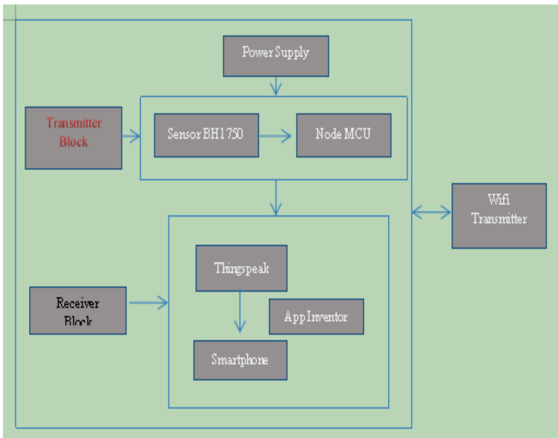


**Fig. 1.** Block diagram of system

The use of digital measuring instruments is more practical and saves time when measuring[7]. Wireless or cordless telemetry has advantages, among others, that it does not require a lot of money compared to using a cable. So that it can be more practical and efficient to use a wireless system in measurement because the user does not need to be close to the device in order to obtain the data needed, so that it can be observed from a distance.[8]. According to the block diagram shown in Figure 1, the BH1750 sensor is a sensor for solar intensity. This sensor is connected to the Node MCU microcontroller. The sensor is programmed using the Arduino programming language and embedded in the Node MCU microcontroller. This program also exists to connect to existing wifi. Once connected, the data will be sent to the server used, namely Thingspeak. After that, using App Inventor programming, the data is retrieved and displayed on an android smartphone. The solar intensity measurement is designed with a small box to house the circuit, microcontroller, and sensor of the measuring instrument. This measuring tool is designed to appear on Android smartphones. The design of this research hardware can be seen in Figure 2.

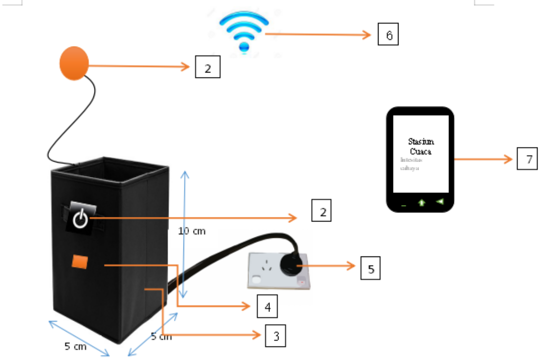


**Fig. 2**. Hardware design

Information: 1. On / Off button
2. Sensor BH1750
3. Measuring tool builder circuit box
4. Reset Button
5. Wire for connecting to a power source
6. Smartphone to display measurement data
7. Wi-fi for transmit a signal so that the microcontroller and android smartphone are

Software is closely related to hardware performance. This software serves to provide instructions and run programming tools. The form of software design of the tool can be seen in Figure 3.

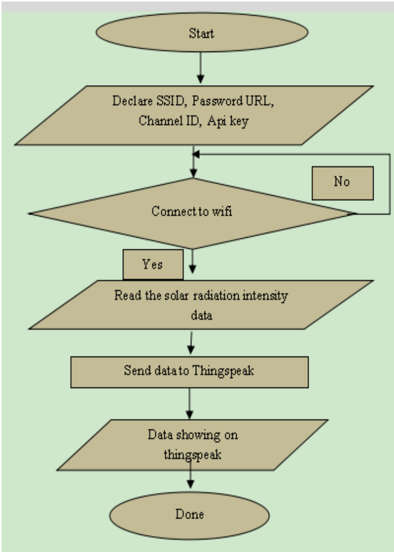


**Fig. 3**. Software design

Figure 3 can be explained the flow of the software. Before designing software on the Arduino IDE, the first step is to install the Node MCU ESP8266 board on the Arduino IDE. The first step is to connect the Node MCU board to the existing wifi transmitter. For the first time, the wifi transmitter that will be used first declares the SSID and password and then continue with connecting. if the board is not connected then the process will start again from the beginning until it is connected and if connected to the wifi transmitter this board can access the internet then the sensor data can be read on the board and the data is sent to the internet, namely Thingspeak. In Thingspeak data appears in graphical form in real-time.

## III. RESULTS AND DISCUSSION

Research data from measuring the intensity of solar radiation using a BH1750 sensor with a smartphone display based on the Internet of Things was carried out to obtain some data. The results obtained from this research are data processing using Arduino software programming in IoT with Thinkspeak. Based on the data obtained, it can be seen in applications that have been created with the help of the App Inventor that has been connected to Thingspeak, or can be viewed directly on the LCD contained in the solar radiation intensity measuring instrument. The unit of data issued on the artificial device is lux. To convert from lux units to W/m$^2$ units. The following calibration steps are ,Firstly provide a lux meter, in this study the lux meter used is the Sanfix LX-1010BS digital lux meter, and then Provide a solar power meter, in this research the solar power meter used is amprobe solar power meter solar-100, So characterization was carried out 3 times starting at 07.00-18.00 WIB with data collection every 30 minutes. Conversion is done by determining the constant in the following equation becomes [2]:

$$\beta = \gamma / \alpha \qquad (2)$$

Whereas $\alpha$ means lux meter measurement results (lux), $\beta$ Constant(0.0187) and $y$ was Measurement Result of Solar Power Meter (W/m).

Performance specifications on a measuring instrument are the components that build a measuring instrument and the function of each of these components in building a measuring instrument. This measuring instrument is designed to observe the intensity of solar radiation. Data obtained from measurements can be stored, so that at any time if needed the data can be viewed again. The results of the measuring instrument design can be seen in Figure 4.

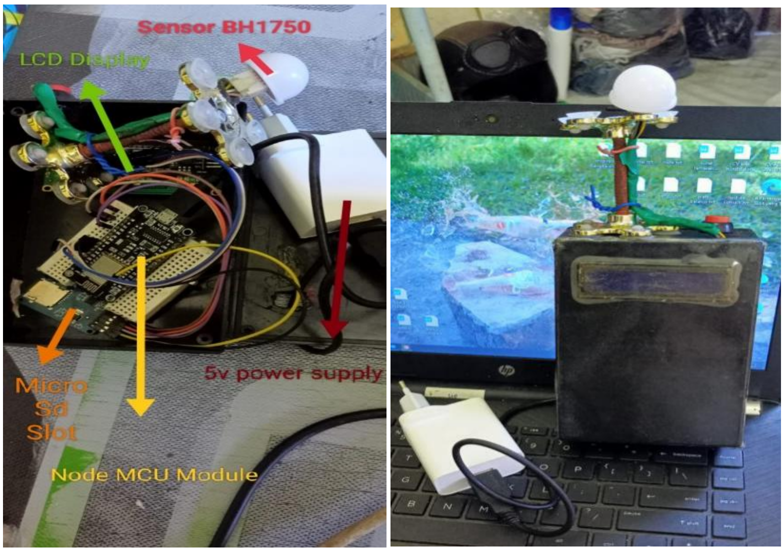


**Fig. 4.** Measuring the intensity of solar radiation

Figure 4 shows the results of designing a solar radiation intensity measuring device. In general, this measuring instrument consists of a circuit box that functions as a circuit holder with a sensor located close to the circuit box. The installation of measuring instruments coupled with the AWOS Pyranometer on the BMKG BIM Padang tool park can be seen in Figure 5.


**Fig. 5.** Installation of measuring instruments in the BMKG BIM Tool Park.

In Figure 5 it can be seen that the measuring instrument is installed adjacent to the AWOS pyranometer standard at the BMK BIM Padang tool park. Data retrieval is carried out for 7 days, the data is directly processed by the program on the MCU Node microcontroller which is connected to Wifi and sent directly to Thingspeak in real-time. The display can be seen in Figure 6.

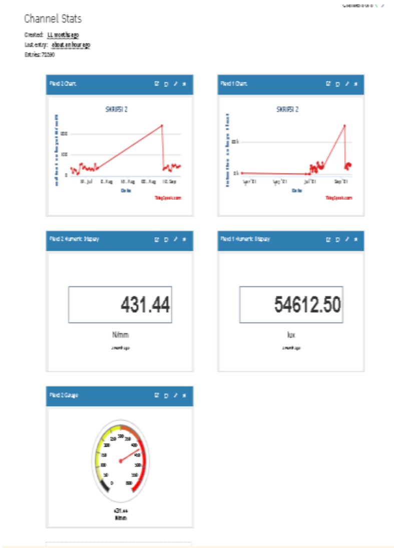


**Fig. 6.** Data display in smartphone.

In Figure 6, we can know that display of the thingspeak data sent by the IoT by the measuring instrument running in real-time is shown. The value of the solar radiation intensity, the save button, the button to share the data that has been saved, and the button continue to the cx page containing the graph. Design specifications or also known as product specifications describe product characteristics, system building materials, system sizes, system dimensions, and tolerances. Design specifications are more focused on system accuracy and precision. To find out the data stored on the measuring instrument, measurements are carried out and save the measurement data. Measurements were taken for seven days from 02 to 09 July 2021 in UTC+0 time. From July 02 at 22.00 to July 09 at 22.00 (UTC±0). Data is saved every minute. The stored data can be seen in Appendix 2. The graph measuring the intensity of solar radiation over time can be seen in Figure 7.

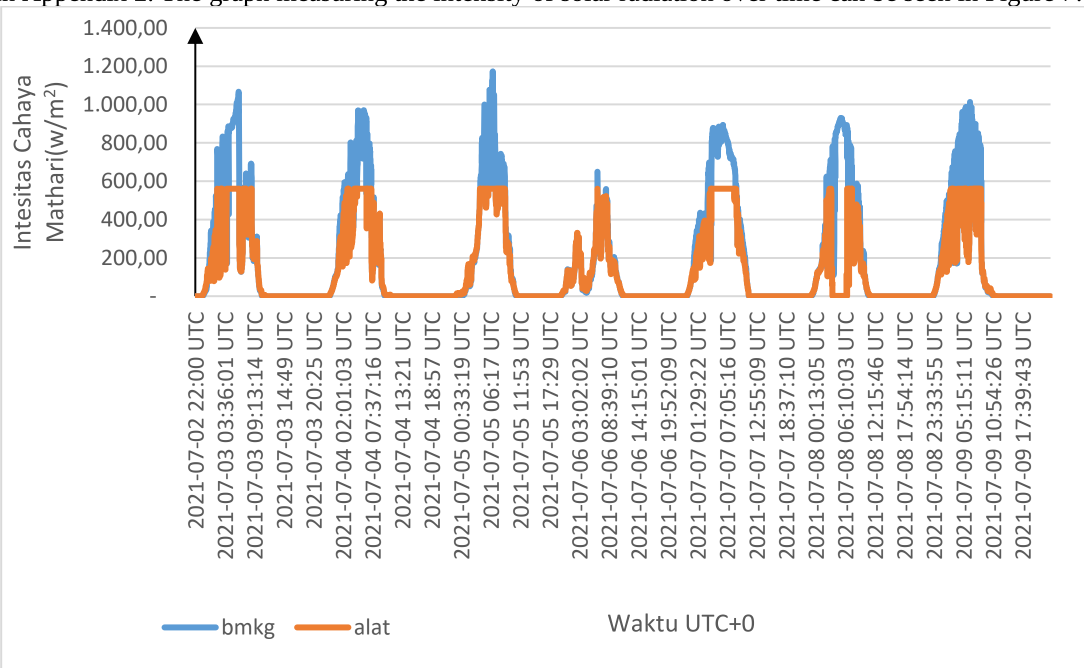


**Fig. 7.** The result of solar radiation intensity measurement

Based on the graph in Figure 7, the data for measuring the intensity of solar radiation for 7 days can be seen that the data on the intensity of solar radiation and the standard pyranometer show an increase and decrease in the value of the intensity of solar radiation. . and has an average data collection accuracy of 95%. As long as the measuring instrument sensor and pyranometer are exposed to solar, the two tools will read the data, if the two tools are not exposed to solar then the data read is 0 to 0.017 w/m2. The highest solar radiation is in the range of 02.09 – 07.52 UTC ± 0 with radiation of 560.87 w/m2. And if the weather conditions are cloudy or rainy, there is no lighting intensity, the data is also read with the lowest value. At night at 11.13 – 23.26 UTC ± 0, the data is also read with the lowest value with solar intensity 0 – 0.017 w/m2.

The accuracy of measuring instruments is to compare the results of measuring instruments designed with standard measuring instruments. Through the calculation can be calculated the percentage of error, relative accuracy, and percentage of accuracy. The measuring instrument data collection is carried out together with the standard measuring instrument of the Meteorology, Climatology, and Geophysics Agency which is being digitized, namely the Automatic Weather Observing System (AWOS). The table of accuracy for measuring the intensity of solar radiation on measuring instruments compared to AWOS can be seen in Appendix 3. Based on the analysis of measurement data on 2 July 2021 from 23:00 to 03 July at 02.30 UTC, the results of instrument measurements compared with AWOS obtained a comparison chart of measuring instruments with AWOS like the picture below. image below. in Figure 8.

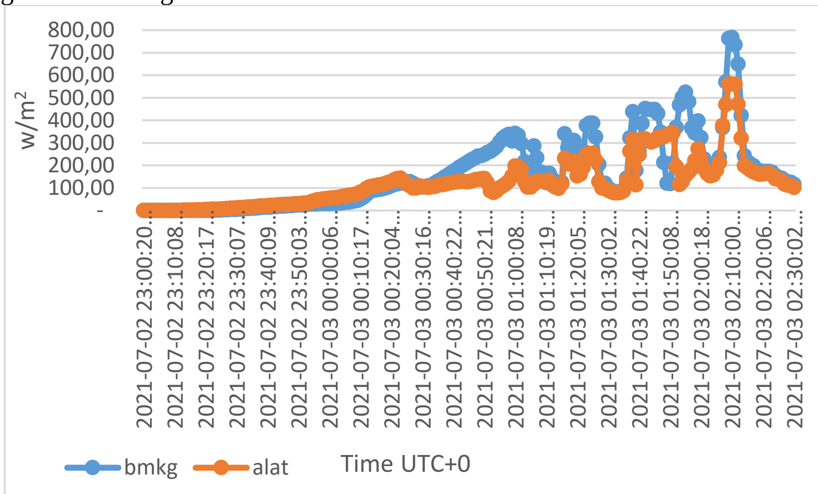


**Fig. 8.** Comparison of measurement of solar radiation intensity with measuring instruments with standard tools on 02 July 2021 at 23.00 to 03 July at 02.30 UTC±0

Based on the graph in Figure 8 at certain minutes there are deviations in the results of the measuring instrument compared to the AWOS tool in the BMKG tool park. This is due to the occurrence of shading, shading is a sensor that is covered by the shadow of the object, and the average duration of shading is 4 to 21 minutes. As seen at 01.52 s / d 01.58 shading occurs on the measuring instrument sensor. However, the intensity of solar radiation with measuring instruments with standard tools is not too far away. At the time of measurement, the weather conditions looked clear without clouds. There is a decrease in data on the intensity of solar radiation caused by the thickness and amount of movement of the sun. The measurement results on July 3, 2021, from 02.31 to 08.30 UTC±0 obtained a comparison chart of the measuring instrument with AWOS as shown in Figure 9.

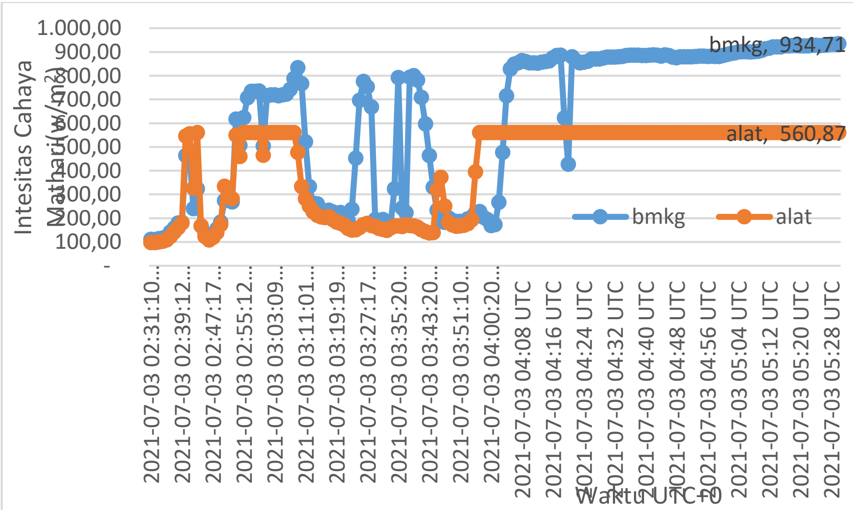


**Fig. 9.** Comparison of measurement of solar radiation intensity with measuring instruments with standard tools on July 3, 2021, from 02.31 to 05.30 UTC±0

Based on the graph in Figure 9, there are deviations in the results of the measuring instrument due to shading on the measuring instrument of 03.23 to 03.44 UTC±0 and shading on the AWOS BMKG tool of 03.46 to 04.10 UTC±0. At the maximum data, deviations from the results of the measuring instrument can also occur, which only has the highest reading limit, namely 54612.20 lux or 560.87 w/m2. However, the intensity of solar radiation with measuring instruments with standard tools is not too far away. At the time of measurement, the weather conditions remained sunny so that there was no decrease in the intensity of solar radiation during the day. The results of measurements by previous researchers 01 to 02 August 2017 at 00.31 to 00.00 UTC±7 measuring instruments obtained a graph as shown in Figure 10.

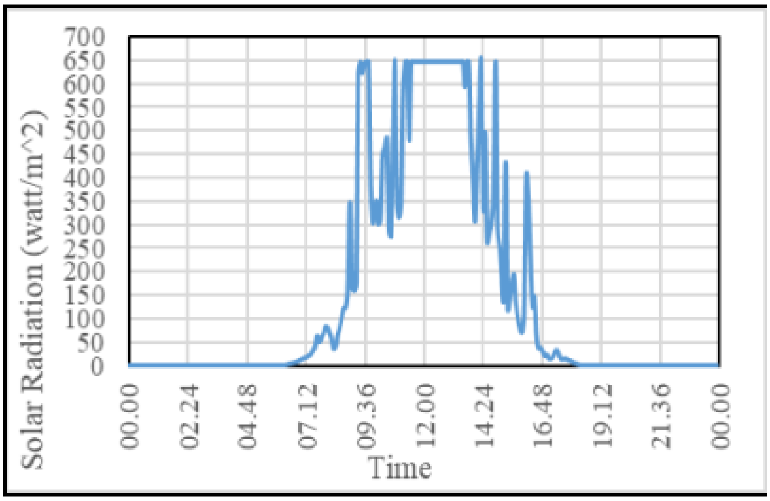


**Fig. 10.** The results of measuring solar radiation using the BH1750 sensor according other research [10].

Figure 10 shows a graph of solar radiation measured on August 1, 2017, the graph is displayed by sampling measurements every 5 minutes. When there is a large amount of solar radiation, the sensor cannot measure this condition given its limited measurement capability (650 Watt/m2) [10]. To determine the accuracy of the measurements, repeated measurements were made under the same conditions. Based on the measurements can be determined the average value and percentage of accuracy. Repeated solar radiation intensity measurement data for instrument accuracy can be seen in Appendix 5. The accuracy of the solar radiation intensity measurement on the measuring instrument is obtained by measuring the solar radiation intensity at the same temperature. condition. Measurements were carried out 10 times with a measuring instrument that reads constantly on a standard tool.

## IV. CONCLUSION

Based on the results of measurements, testing, and analysis of solar intensity using the BH1750 sensor based an Internet of Things with smartphone display, several conclusions can be drawn. First, the results of the specification and performance of the solar intensity measuring instrument consisting of a measuring toolbox containing the electronic circuit that builds the measuring instrument. The electronic circuit of this measuring instrument consists of a BH1750, NodeMCU ESP8266 microcontroller, an on/off switch, and a reset button. The results of the measurement of the intensity of solar appear on a smartphone. The BH1750 sensor senses the intensity of solar and is processed by the NodeMCU ESP8266. Then the data is sent to the ThingSpeak server which will then appear on the smartphone. Second, the exactness of measuring the intensity of solar radiation with a measuring instrument is 96.92%, and the average accuracy of measuring the intensity of solar radiation is 95.78%.

## ACKNOWLEDGMENT

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