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Smart Lighting For Homes In Densely Populated Areas

Santi Febri Arianti[1], Dedi Bob Lumban Tobing[2], Yosafat Putra Purba[3], and Johan Clinton Manurung[4]

[1] Program Studi Teknik Elektro Fakultas Informatika dan Teknik Elektro Institut Teknologi Del, Jln. Sisingamangaraja Sitoluama, Laguboti, Tobasa 22381 Indonesia

E-mail: santi.febri62@gmail.com

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ABSTRACT

Densely populated homes with minimal lighting due to poor ventilation require a bottle of sodium hypochlorite for daytime lighting, that sunlight can enter the house. Solar cells convert sunlight into electricity and then store it in the battery as a source of energy at night. The light sensor will activate the switch when it gets dark and lights up the LED on the bottle, while the sound sensor will sense a clap to turn the LED off or on. The microcontroller is Arduino and uses a Solar Charge Controller to regulate the power from the solar panels to the battery. The interface is an LCD to display the amount of energy. The results show that the light intensity of the Bottle Lamp during the day is greater than the 8 W lamp. The optimization results show that the optimal battery charging process is at 3.5-4.2 V between 08:00-17:00 WIB. The battery can be used to power the system for 12 hours.

1. Introduction

In densely populated places, one house is so close to another that proper ventilation is impossible. During the day, sunlight cannot enter the house to its full potential. Lack of lighting restricts activity, particularly for children whose parents have gone to work [1]. For lighting at night, the residents of this settlement share a single power grid and only use one small lamp equivalent to 5 W to illuminate the entire house to save electricity costs. Consequently, residents, particularly school-aged children who must study, may not perform their routine activities.

For the house, a device that can capture and emit sunlight is required [2]. The recyclable plastic bottle containing mixed sodium hypochlorite and water was put through a hole in the roof [3]. While light streaming through just the hole would come in through a single, straight, narrow light beam, the water in the bottle refracts the rays so that it can illuminate a larger space, 360 degrees around [4]. The sodium hypochlorite keeps the water clean by preventing algae from forming [5-6]. This device is called the bottle of light. Previous research has focused more on the bottles of light implementation in densely populated areas and has not implemented the internet of things system for lighting and electricity supply.

The significance of this research is to provide smart lighting solutions that are economical and environmentally friendly. Residents no longer need to purchasing power to switch on the lights because they have a solar cell that transforms solar energy into electricity. The light sensor will also provide electricity savings because the lights will turn on when it gets dark and turn off automatically when the sun has risen [7-8]. However, there are instances when people want to turn off the lamp although it is still dark, such as when they want to sleep [9]. An additional switch requires a sound sensor [10-12]. Each of these systems requires a controller that is an Arduino [13-15].

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2. Methods

Testing equipment and proper location for bottles, solar panels, light sensors, and panels including batteries, switching circuits, sound sensors, and Solar Charge Controllers are all part of the study approach (Fig. 1). The system divide into a charging process (Fig. 2 and Fig. 3), a discharging process (Fig. 4), and a switching process (Fig. 5)

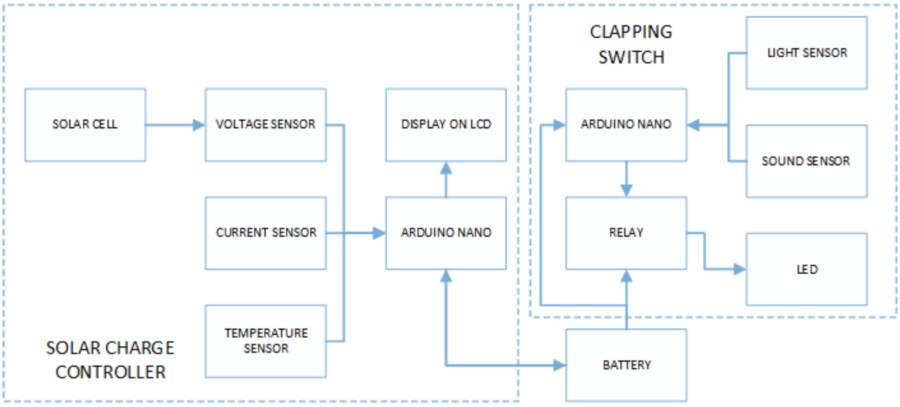

Figure. 1. System Flow chart

2.1 Charging Test

The battery voltage measure during the charging test (3.0 V and 3.5 V). The battery must have a voltage of 7.1 V, so each battery must have a voltage of 3.5 V to be utilized for 12 hours. Charging tests are also performed at a voltage of 3.0 V for each battery to ensure used for more than 12 hours. The charging test process carried out can be seen in Figure 2.

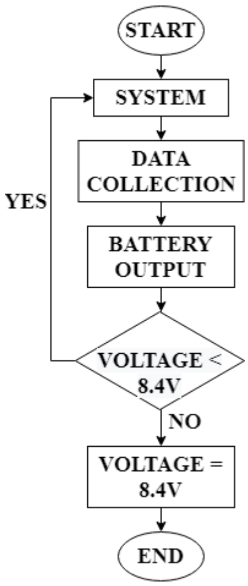

Figure. 2. Charging system

During the charging process, the voltage sensor on the system will measure the voltage on the power bank and display it on the LCD. The charging process will continue as long as the voltage on the power bank has not reached 8.4 V. After the voltage reaches 8.4 V, the Solar Charge Controller will cut off electricity from the solar panel to the power bank so that there will be no overcharge.

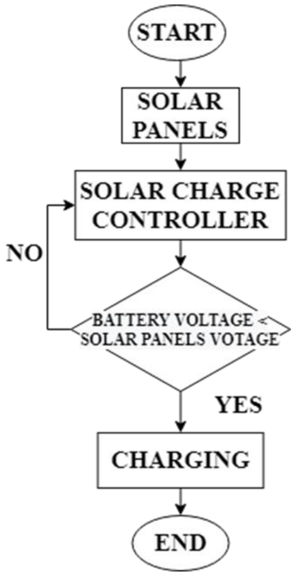

Figure. 3. Charging process procedure

2.2 Discharging Test

Tests are carried out to determine whether the power bank is able to meet the system's needs when it is run thoroughly for 8 hours of use. Tests were also carried out by running all systems for 12 hours in anticipation of longer usage. The test system carried out will be described in Figure 4.

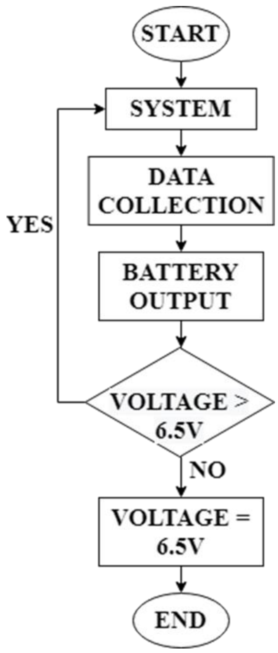

Figure. 4. Discharging process

The discharging process runs by draining electricity from the battery to turn on the led, measuring the voltage, and displaying the voltage data on the LCD. If the voltage on the battery has reached 6.5 V, the SCC will cut off electricity to the load (led). Electricity continues to flow from the battery to the led if the battery voltage remains over 6.5 V.

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2.3 Proses Switching

Tests were done to establish the best time, conditions, and distance for switching. The test arrangement shown in Figure 5 was employed. The initial condition of the switching process on the LED is off. The light sensor will read whether it is bright or dark. When the conditions are bright, the sound sensor turns off. In the dark, the sound sensor will switch on to accept input in the form of clapping sounds. If the claps given are accurate (two claps), the LED will light up; if the claps delivered are erroneous, the LED will remain dark (less or more). Even if the LED is turned on, the sound sensor will remain on in the dark. As long as no more claps are given, the LED remains on and only turns off when two claps are given.

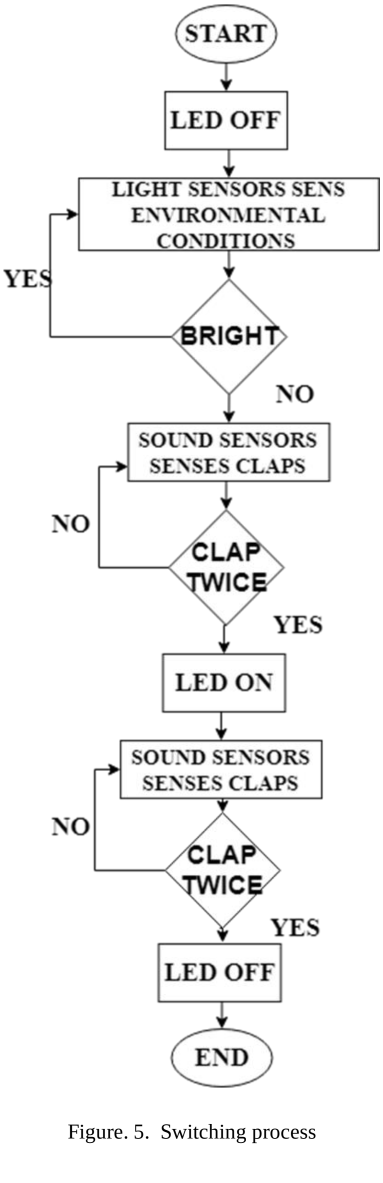

Figure. 5. Switching process

3. Results

3.1 Light Sensor Test

The light sensor (LDR) testing to see if it correctly recognizes the light intensity level based on the current situation. Whether or not the LED lights up in various environmental conditions (bright, dim, and dark) is selected as an indicator.

TABLE 1
RESULTS OF LIGHT SENSOR TESTS BASED ON TESTING DURATION AND LIGHTING CONDITIONS

No.	Time	Environmental lighting conditions	Led response
1	08:00 WIB	bright	off
2	08:30 WIB	bright	off
3	09:00 WIB	bright	off
4	10:00 WIB	bright	off
5	11:00 WIB	bright	off
6	15.00 WIB	bright	off
7	15.30 WIB	bright	off
8	16.00 WIB	bright	off
9	16.30 WIB	dim	on
10	17.00 WIB	dim	on
11	17.30 WIB	dim	on
12	18.00 WIB	dim	on
13	17.00 WIB	dim	on
14	18.00 WIB	dark	on
15	18.30 WIB	dark	on
16	19.00 WIB	dark	on
17	19.30 WIB	dark	on
18	20.00 WIB	dark	on

3.2 Sound Sensor Test

The sound sensor testing aims to identify the maximum distance between the sound source and the sensor. It becomes a test of the sound sensor by emitting sound (two claps) from various distances. The sound sensor's test results have reported in Table 2.

TABLE 2
SOUND SENSOR TEST RESULTS ACCORDING TO DISTANCE

No.	sound source to the soun sensor distance (meters)	Sound sensor sensing
1	2,5	✓
2	3	✓
3	3,5	✓
4	4	✓
5	4,5	✓
6	5	✓
7	6	✓
8	7,5	✓
9	8	x
10	10	x

3.3 A Bottle of Light Test at Day

The test was carried out indoors in 4 x 6 m2 rooms by installing a bottle of light on the roof. The Bottle of Light's brightness is compared to an 8 W fluorescent lamp that is regularly used in the area. The testing took place both during the day and at night. Daylight testing is done without an LED and only with sunlight that enters the room through the light bottle. The results were acquired using a lux meter to quantify light intensity, as shown in Figure 6 and Table 3.

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Figure 6. The process of measuring light intensity during the day

TABLE 3
THE RESULTS OF MEASURING THE LIGHT INTENSITY OF LAMPS AND THE BOTTLE OF LIGHT DURING THE DAY BASED ON DISTANCE

No.	Lux meter to lamp distance (meters)	Lamp luminous intensity (Lux)	The Bottle of Light's light intensity (Lux)
1	0.1	277 lux	422 lux
2	1 m	25 lux	130 lux
3	1.5 m	10 lux	57 lux
4	2.33 m	4 lux	29 ux

3.4 A Bottle of Light Test at Night

At night, the led (5watt) in a light bottle is turned on to conduct the test. Figure 7 depicts the test findings, while Table 5 shows the light intensity comparison between the lamp (8 W) and the Bottle of Light.

Figure 7. The process of measuring light intensity during the night

TABEL 4
THE RESULTS OF COMPARISON THE LIGHT INTENSITY OF LAMPS AND THE BOTTLE OF LIGHT
DURING THE NIGHT BASED ON DISTANCE

No.	Lux meter to lamp distance (meters)	Lamp luminous intensity (Lux)	The Bottle of Light's light intensity (Lux)
1	0.10	277	225
2	1	25	41
3	1.5	10	16
4	2.33	4	5

3.5 Charging Test

The charging test determines the optimal voltage for a fully charged battery. The minimum and maximum voltage limits for the charging test are 3.0 - 4.2 V as the minimum limit and 3.5 - 4.2 V as the maximum limit. Charging takes place between the hours of 08.00 and 17.00 WIB (nine hours). The results of

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testing the minimum and maximum limits are shown in Figure 8.

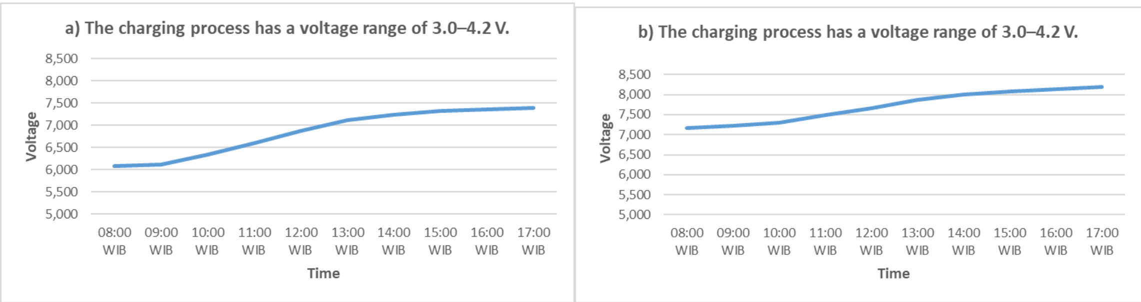

Figure 8. The results of measuring the battery voltage during the charging process with a voltage range of: a) 3.0–4.2 V, b) 3.5–4.2 V.

3.6 Discharging Test

The purpose of the battery discharge test was to determine the optimal battery voltage for a 12-hour runtime. The minimum and maximum voltage limits on each battery tested were 3.8 V as the minimum limit and 4.2 V as the maximum limit. Figure 9 depicts the findings of the lowest limit test, whereas Figure 8 depicts the results of the highest limit test.

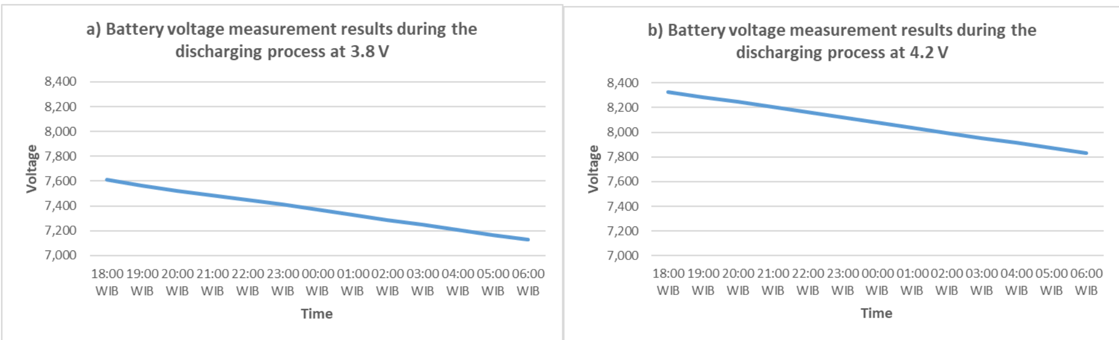

Figure 9. Battery voltage measurement results during the discharging process: a) at 3.8V, b) at 4.2V

3.7 Switching Test

Table 6 performs switching tests at various distances.

TABLE 5
TEST RESULTS FOR SWITCHING BASED ON DISTANCE

No	sound source to the sound sensor distance (meters)	percentage of the switching cycle
1	1	100%
2	2	100%
3	3	90%
4	4	90%
5	5	80%
6	6	60%
7	7	20%

3.8 Discussion

The light sensor can work well based on the test results in Table 1. When outside is cloudy or dark, the LED turns on, but when it is bright, it turns off. The performance of the sound sensor differs depending on the distance between the sound source (input) and the sensor. The sound sensor works well, and the maximum distance between the sound source and the sensor is 7.5 meters. The sound sensor can still sense

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input at distances beyond that, but not as well as priority distances. As a result, 7.5 meters is the maximum distance between the sound source and the sound sensor. The bottle of light testing is carried out during the day and at night. Two data sets, one from the Bottle of Light and the other from an 8 W fluorescent bulb, were compared to perform the measurements. During the day, the system turns off. The bottle of light relies solely on sunlight. The test shows that the light provided by the bottle of light was comparable to that of an 8 W lamp.

For nights when the system is on, the LED in the bottle of light assists with lighting. Based on the night test results, the intensity of the bottle of light is equivalent to an 8 W lamp. Bottle of Light has a better range when compared to fluorescent lamps. The fall in light intensity in the Bottle of Light is smaller than fluorescent bulbs at the same distance. This result proves the function of the water in the bottle to refract light.Charging the battery at the minimum voltage is not sufficient to achieve full conditions. As a result, the ideal charge is between 3.5 and 4.2 V. The intensity of solar radiation also influences the growth in battery voltage during the charging process, as seen in the graph in Figure 8. With the voltage of each battery at the minimum and maximum limits of the discharging process, it has been able to meet system needs for 12 hours. The power does not even run out. This condition has the advantage of preventing battery damage. The process is stable, with a slight increase during discharging.

Based on the sound sensor test, the maximum distance for the sound sensor sensing is 7.5 meters, so the switching test is carried out at a distance of 1m to 7m. The maximum distance between the sound sensor and the sound source that the switching process can still work well is 5 m, based on the results of switching tests.

4 Conclusion

The lighting system's design was applied in illuminating low-income dwellings in *Lumban Pandua* village, *Toba Samosir* Regency, and received positive feedback from locals. According to the results of the questionnaires, customers' problems with low illumination in their houses can be solved.

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