Evolution in Electrical and Electronic Engineering Vol. 4 No. 1 (2023) 597-605
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Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

Internet of Things (IoT) Enabled Green Surveillance System for Solar Site

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DOI : https://doi.org/10.30880/eeee.2023.04.01.072
Received 06 February 2023; Accepted 08 March 2023; Available online 30 April 2023

Abstract: A surveillance system powered by solar energy and lithium ion battery pack is one of the systems that is very important nowadays. This system basically will be implemented in dark and dangerous area with no source of electricity. Therefore, the prototype is designed to develop a surveillance system that consists of a camera and lamp that is powered from the PV panel and lithium ion battery pack. Basically, the system will operate by using a full energy source from the sunlight through the PV panel. At the same time, the battery pack will be connected to the PV solar panel to store the electrical energy to provide power supply when the PV solar panel does not generate enough electricity especially during nights and cloudy days. The IP camera and DC lamp will act as loads where the IP camera has its own built-in Internet of Things (IoT) systems where it can be connected with the smart phone. For the DC lamp, it can be controlled by using a smart phone through the Blynk application. The ESP8266 will act as a microcontroller to control the relay module that acts as a switch to open and close the power supply pass through to the lamp. The system operated in 3 different types of weather which are during normal days, cloudy days and rainy days. From the results, it shows that during the normal day, the amount of electricity produced from the PV solar panel is the highest compared to the cloudy and rainy day. Besides, the lithium-ion battery pack also can store the extra energy where it can be used to supply the electricity efficiently especially during the autonomous day. With the sufficient energy sources, the IP camera can function very well where it can record and store data 24/7 while the LED lamp can be turned on at night and turned off during the daylight.

Keywords: Surveillance System, Lithium-Ion Battery Pack, Solar Energy

1. Introduction

Among the power resources, electricity, with no doubt, is the most important component in human's daily life [1]. It provides us humans with the energy needed to perform a wide range of activities from lightning and other electrical appliances at homes. It has revolutionized the way that makes many tasks easier, faster and more convenient. However, the electricity from the grid sometimes had a problem

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where it cannot supply electricity at certain times like a rural area. Therefore, the use of renewable energy like solar energy is very suitable to overcome this problem. This type of renewable energy is very useful in supplying electricity especially for the house that implements the surveillance system which operates 24/7 days. The presence of this surveillance system will help to reduce the criminal cases around the rural areas [2].

This surveillance system is powered by the solar and battery pack energy located at the solar site in Universiti Tun Hussein Onn Malaysia (UTHM). This system helps to prevent any theft cases occurring at solar sites.

This paper promotes the expansion of the conventional device for the surveillance system. Instead of only one parameter which is the camera, the system also has another addition which is LED light. Also, the LED light can be controlled by using smart phone through the IoT.

The objectives of this paper are to design an Internet of Things (IoT) surveillance system with camera and LED light using PV powered lithium-ion battery pack. Next, it also tests the working condition of the prototype based on the function by analyzing I-V characteristics and battery condition of the surveillance system.

2. Materials and Methods

This section will describe the materials and methods that are proposed for the development of the surveillance system using solar energy powered lithium-ion battery pack.

2.1 Materials

Each component is tasked with a specific feature, but the combination of the components is tasked with one job which is to control the surveillance system at the solar site. Table 1 shows further clarification concerning the functionally of each component.

Table 1: Component functionality

	Component	Function
Input	Solar Photovoltaic Panel	Convert sunlight to electrical energy
	Lithium-ion Battery Pack	Stored and supply electricity for the system [3]
Process	MPPT Controller	Control the voltage and current from PV panel
	ESP8266	As a controller for the LED light
	Relay Module	As a switch to ON or OFF the LED light
	DC-DC Buck Converter	Lower down the voltage from the source
Output	Blynk Application	Platform that allows to program and control the system using IoT
	IP Camera	Record and sends footage video via an IP network
	LED Light	Convert electrical energy directly into light

2.2 Methods

The important thing in this system is the battery pack where the design of the battery pack will determine the functionality of the system. If the system only depends on the energy from the PV panels, this system will not be able to function at nighttime. The surveillance system which are camera and LED light fully operates by using sources from solar energy. For the camera, it will record the footage at the solar site and it will send the alert message to the users if there is any movement on the project site. Next, for the LED light, it is controlled by the ESP8266. In this case the ESP8266 is programmed to control the relay module to ON or OFF the LED light by only using the smart phone through the Blynk application.

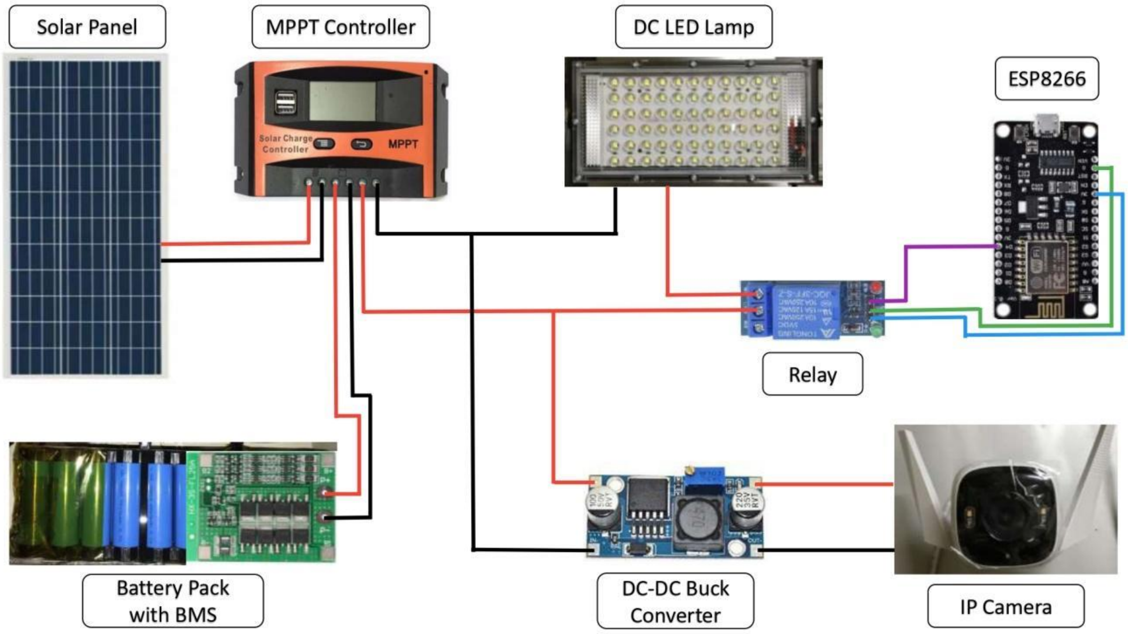

Figure 1: System connection

2.3 Equations

To design the lithium-ion battery pack, the energy consumption of the system must be calculated first [4]. Equation 1 shows the formula for the energy consumption by the system.

$$E = P_{load} \times Quantity \times Hour\ Usage \qquad Eq. 1$$

$$E_{Camera} = 5.4W \times 1 \times 24 = 129.60\ Wh$$

$$E_{LED} = 9.2W \times 1 \times 12 = 110.40\ Wh$$

$$Total_E = 129.60\ Wh + 110.40\ Wh = 240\ Wh$$

The formula is used to calculate the total energy consumption by each component which are camera and LED light. After that, the total lithium ion battery cell needed in this system can be obtained by using the equation below.

$$Total\ Battery = Total\ power\ consumption \div Power\ of\ single\ battery\ cell \qquad Eq. 2\ [5]$$

$$Total\ Battery = 240\ Wh \div 7.64\ Wh$$

$$Total\ Battery = 30\ lithium\ ion\ battery\ cell\ needed$$

The size of the PV panel also needs to be calculated to make sure it can provide enough electricity to the system and the lithium-ion battery pack [6]. The Equation 3 below shows the formula to find out the size of PV panel.

$$P_{PV} = \frac{E}{\eta \times h_p} \qquad Eq. 3$$

3. Results and Discussion

This section will present the data obtained from running the prototype system. First of all, the functionality of the camera and the LED light were tested by using the source from the PV panel and the lithium-ion battery pack. Next, the voltage and current from the PV panel and battery pack were measured in three different days: normal, cloudy and rainy days. After that, the functionality of the lithium-ion battery pack was also tested by running the system during the night time.

3.1 IP camera and LED light test results

Both components were tested during day and nighttime. The result shows that the IP camera and LED light can operate in a good condition. Figure 2 - 6 show the results of the testing.

Figure 2: Live view from the IP camera.

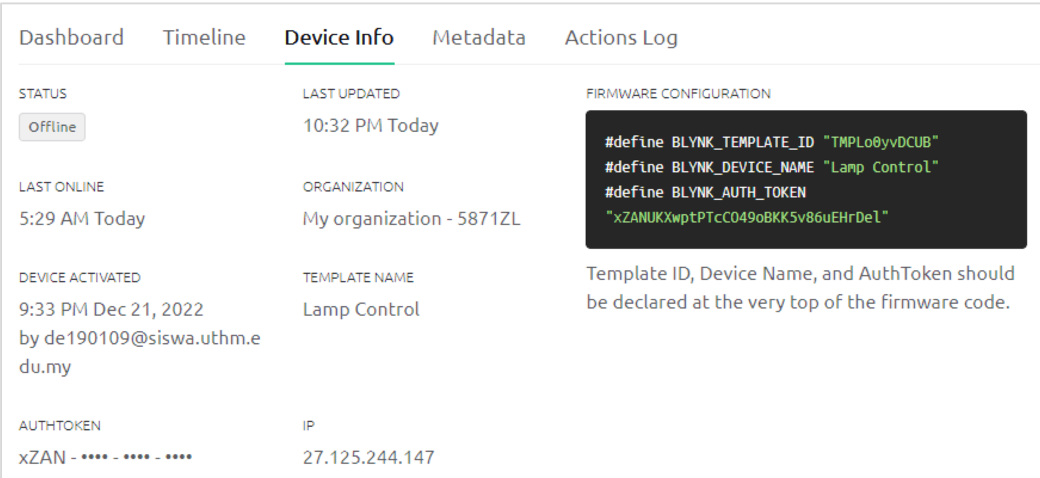

Figure 3: Blynk dashboard setup.

Figure 4: Coding in Arduino IDE.

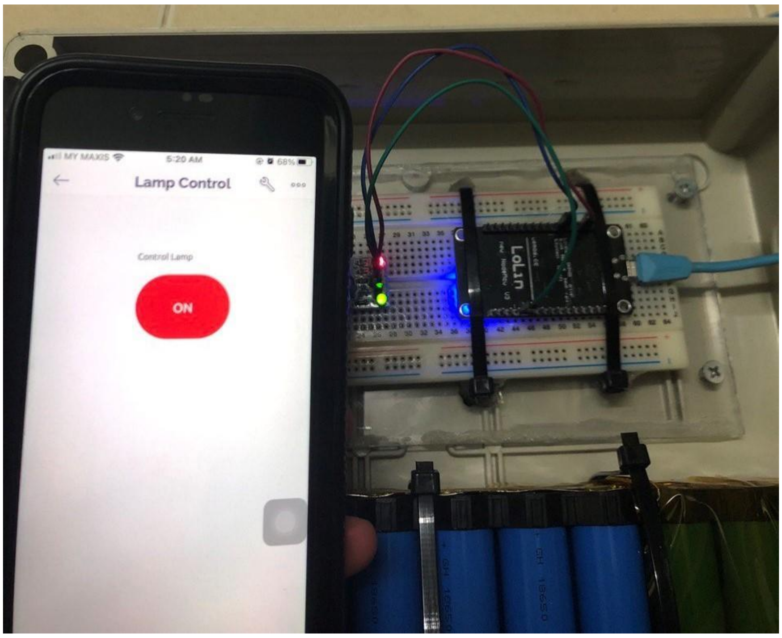

Figure 5: ON state in Blynk application.

Figure 6: LED light in ON condition.

The results above show the IP camera, and the LED light can function well while connecting with the PV panel and lithium-ion battery pack. For the IP camera, it can provide live visual that can be monitored by using the smart phone in the presence of internet connection. Next, for the LED light, it can be controlled by the Blynk application where the lamp will only turn on when the user wants to use it.

3.2 Electrical parameter test results

The data of voltage and current are measured by using a multimeter and clamp meter. There were three different types of weather when the parameter readings were measured: normal (Table 2), cloudy (Table 3) and rainy days (Table 4). The tables below show the measured values for the parameter.

Table 2: Electrical parameter readings in normal day

Time	PV Solar Panel			Battery Pack		
	V(V)	I(A)	P(W)	V(V)	I(A)	P(W)
8:00am	11.50	0.2	2.30	11.53	0.5	5.77
9:00am	11.60	0.3	3.48	11.54	0.4	4.62
10:00am	11.88	0.6	7.13	11.75	0.5	5.87
11:00pm	12.45	1.2	14.94	12.33	0.9	11.10
12:00pm	20.50	1.5	30.75	16.00	1.2	19.20
1:00pm	19.98	2.1	41.96	15.72	1.6	25.12
2:00pm	20.00	1.9	38.00	15.80	2.1	33.18
3:00pm	19.97	1.5	29.96	15.90	1.7	22.03
4:00pm	18.88	1.3	24.54	15.75	1.4	22.05
4:00pm	18.55	1.2	22.26	15.50	1.2	18.60

Table 3: Electrical parameter readings in cloudy day

Time	PV Solar Panel			Battery Pack		
	V(V)	I(A)	P(W)	V(V)	I(A)	P(W)
10:00am	10.88	0.4	4.35	9.98	0.4	4.00
11:00am	11.50	0.6	6.90	10.01	0.5	5.01
12:00pm	18.10	1.0	18.10	17.50	0.9	15.75
1:00pm	19.98	1.6	31.97	18.25	1.3	23.73
2:00pm	17.00	1.6	27.20	14.80	1.4	20.72
3:00pm	15.97	1.2	19.16	14.40	1.1	15.84
4:00pm	14.88	1.0	14.88	13.85	0.9	12.47
5:00pm	14.35	1.0	14.35	12.50	0.8	10.00

Table 4: Electrical parameter readings in rainy day

Time	PV Solar Panel			Battery Pack		
	V(V)	I(A)	P(W)	V(V)	I(A)	P(W)
10:00am	9.85	0.2	1.97	9.75	0.1	0.98
11:00am	10.15	0.4	4.06	9.98	0.3	2.99
12:00pm	13.45	0.8	10.76	11.68	0.8	9.34
1:00pm	14.10	1.0	14.10	13.89	0.8	11.11
2:00pm	12.98	0.9	11.68	11.65	0.7	8.16
3:00pm	12.20	0.7	8.54	10.50	0.5	5.25
4:00pm	11.86	0.5	5.93	10.10	0.2	2.02
5:00pm	11.25	0.3	3.38	9.85	01	0.99

The purpose of this test is to find out capabilities of the PV panel and lithium-ion battery pack to supply the source to the system. Based on the results, during the normal day, the energy produced by the PV panel and the battery pack on normal day is higher than the other day. Overall, the PV panel and battery pack works in maximum capability during the normal day.

3.3 Battery performance during nighttime

This test is done during the nighttime to find out the ability and performance of the lithium-ion battery pack in supplying the power source without the presence of the source from the PV panel. Table 5 shows the data obtained from the testing.

Table 5: Electrical parameter readings for battery pack

Time	Voltage (V)	Current(A)	Power(W)
7:00pm	12.05	1.6	19.28
7:30pm	11.80	1.6	18.88
8:00pm	11.69	1.6	18.70
8:30pm	11.50	1.6	18.40
9:00pm	11.41	1.6	18.26
9:30pm	11.33	1.5	17.00
10:00pm	11.18	1.5	16.77
10:30pm	10.98	1.5	16.47
11:00pm	10.89	1.5	16.34
11:30pm	10.75	1.5	16.12
12:00am	10.58	1.4	14.81
12:30am	10.50	1.4	14.70

Figure 7 shows the battery performance graph. The result shows that the voltage readings decreased in line with the increment of time. This shows that the system is fully using the source from the battery pack. For the current, it is maintained around 1.6A to 1.4A. Overall, the battery was able to supply enough electricity to the system during the night time.

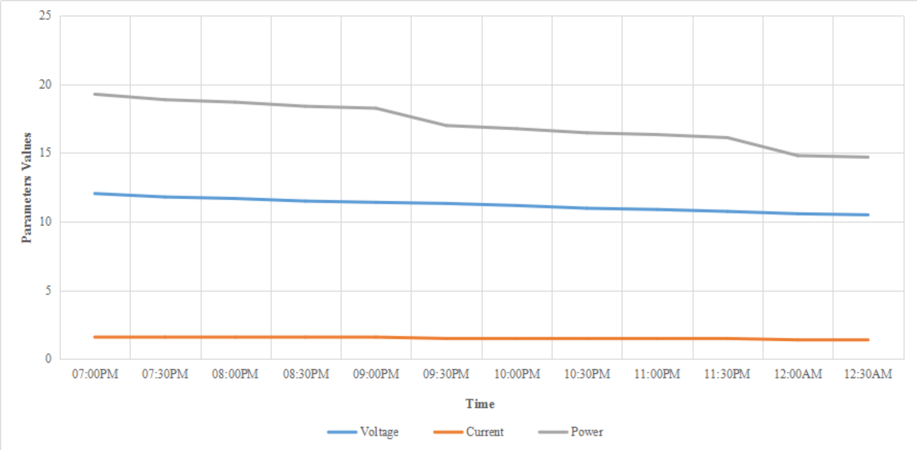

Figure 7: Battery performance graph

4. Conclusion

The system focused on the surveillance system that fully used energy from the PV panel and the lithium-ion battery pack. For the control system of the surveillance system, it can be managed and monitored by using the smartphone. Overall, after running a few testing on the prototype, the IP camera and LED light can function very well. Next, for the PV panel, after the testing on different types of day, it can be concluded that the PV panel operated in maximum capability during the normal day in providing the supply into the system. The lithium-ion battery pack was able to supply the electricity at the night time and during the autonomous day. In the future, a few improvements can be made by adding more IP camera in the system to make sure more areas in the site can be monitored. For now, the system can operate very well and it can be installed in the project site.

Acknowledgement

The authors would like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

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