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Build Smart Flying Hot Spot Detection for Large Solar Photovoltaic System using Internet of Things (IoT)

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ABSTRACT: *The potential use of solar power plants (PLTS) as a renewable energy source in Indonesia has not been maximally utilizing. Data from the Ministry of Energy and Mineral Resources (ESDM) in 2016 shows the potential for solar energy in Indonesia is estimated at 207,898 Megawatts (MW), the largest when compared to the renewable energy associated with this country in the air 75,091 MW, 60,647 MW wind and 29,544 MW geothermal. Therefore, the growth of technology in the field of renewable energy conversion is carried out, such as solar photovoltaics. Solar cells (Hot Spot). With a fixed load, solar photovoltaic characteristics will take on the load characteristics and will discard the energy needed can be utilized. Therefore, periodic checking or maintenance is imperative. The impact of the emergence of Hot Spot on solar cells is very detrimental since it can damage the panel. Furthermore, the production of electrical energy will decrease. The system consisting of solar photovoltaic, Drone, and Global Positioning System (GPS) as known as a flying Hot Spot detection for solar photovoltaic systems. This research is designed to monitor solar photovoltaic systems for Hot Spots to be applied to Smart Flying Hot Spot Detection Technology for Large Solar Photovoltaic Systems using the Internet of Things (IoT), which can move large areas and can be employed for solar panel locations that require Hot Spots. This monitoring device is expected to be effectively used to protect solar photovoltaic from Hot Spot harms for 24 hours over a wider area.*

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I. INTRODUCTION

In this age, the need for electrical energy in various regions of Indonesia are necessary. The necessity for electronic goods has increased from over the years. Potential usage of solar power plants (PLTS) as a foundation of renewable energy in Indonesia has not been maximally utilizing. Data from the Ministry of Energy and Mineral Resources (ESDM) in 2016 displays the potential for solar energy in Indonesia is estimated at 207,898 Megawatts (MW), the largest when compared to the renewable energy associated with this country in the air 75,091 MW, 60,647 MW wind and 29,544 MW geothermal. Nowadays, the Solar Power Plants (PLTS) are predicted as one of the power plants that can reduce electricity usage from PLN. In several areas, electricity has been used from solar panels for traffic lights (TL), public street lighting, pump houses, terminals, and public service offices, one of which is in Surabaya. In producing PLTS, several difficulties are related to the usage of solar panels. One of the difficulties can trigger the Hot Spot on solar cells that is very harmful since it can damage the panel. Besides, the production of electrical energy will be decreased. To solve these problems, a solar electricity generation system is needed in the form of a Solar Photovoltaic System, which is equipped with a Smart Monitoring and Hot Spot Tracker device to maximize the absorption of the generated electrical energy.

HOT SPOT

The way of solar panels working is that when sunlight hits a solar cell, the electrons in the solar cell will move from N to P, and then the output terminal of the solar panel will produce electrical energy. The amount of electrical energy produced by solar panels varies depending on the number of combinations of solar cells in the solar panel and the amount of sunlight associated with solar panels. (Bansai 1990)

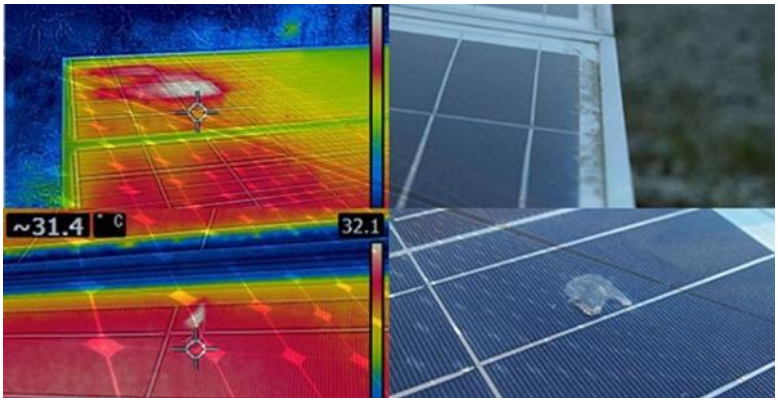


Fig. 1 Solar panels that emit effects from Hot Spots

Fig. 2 Microcrack on a solar panel when receiving a Hot Spot

Some problems arise in solar panels, and the one that can be harmful is Hot Spot. Hot Spot is warming that occurs on one side of a solar cell in a series of it. This happens because the solar cells are affected by the shadow or covered by an object continuously for a certain period. While the solar cell emits a Hot Spot it will produce a smaller electric current than other solar cells, hence this solar panel generates less electric current than the datasheet needed on the solar panel.

A superiority of electric current from solar cells that are not issued by Hot Spot will be forwarded (forward bias) to solar cells that receive Hot Spot, then solar cells needed by Hot Spot will require a reverse bias. When the solar cell released, the Hot Spot effect will be considered to have a certain resistance or power dissipation (waste of electrical power by obstacles). This problem will cause heat in the solar cells that triggered the Hot Spots. The effect of the Hot Spot that occurs for such a long time will cause a microcrack on the solar cells, the interconnection of the solar cell will look like that it is burning, and the solar glass will break.

Fig. 3 The solar glass will break when you remove the Hot Spot

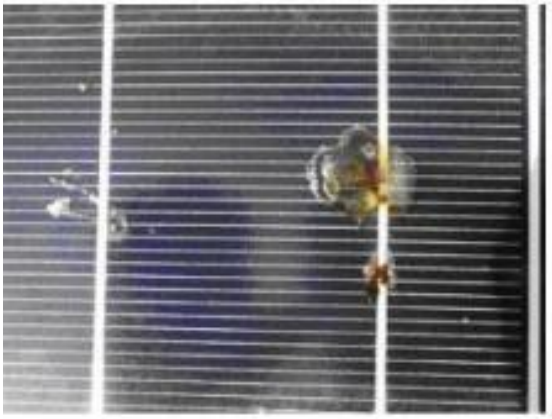


Fig. 4 Interconnection of solar panels when receiving a Hot Spot

GLOBAL POSITION SYSTEM (GPS)

GPS stands for Global Position System, which is a navigation system using satellite technology that can receive signals from satellites. How it works from the GPS itself:

1. Using the "triangulation" calculation from the satellite.
2. For "triangulation" calculations, GPS measures distance using radio signal's travel time.
3. To measure travel time, GPS requires a high amount of time.
4. Calculation of distance, we must understand with certainty the position of the satellite and the altitude in its orbit.
5. Correcting the delay in sending the travel signal in the atmosphere until it is received by the receiver.

This system utilizes 22 satellites that send microwave signals to the earth. This signal is received by a receiver tool (receiver) at the surface of the earth, while the GPS receiver will collect the data information from satellites. The GPS receiver must set the signal for at least three satellites to calculate 2D positions (latitude and longitude) and track the movements. If the GPS receiver can receive 4 satellites or more, it can calculate 3D positions (latitude, longitude and altitude). If the GPS has been able to determine the position of the user, then the GPS data processes other information, such as speed, direction, path, destination, distance, sunrise and sunset. Signals sent by satellite to GPS will be utilized to calculate travel times.

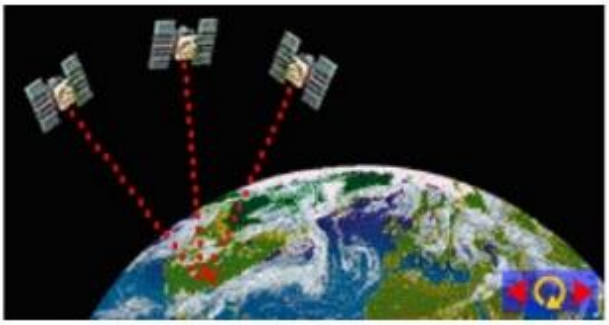


Fig. 5 How the GPS module (receiver) reads coordinates with the help of satellites

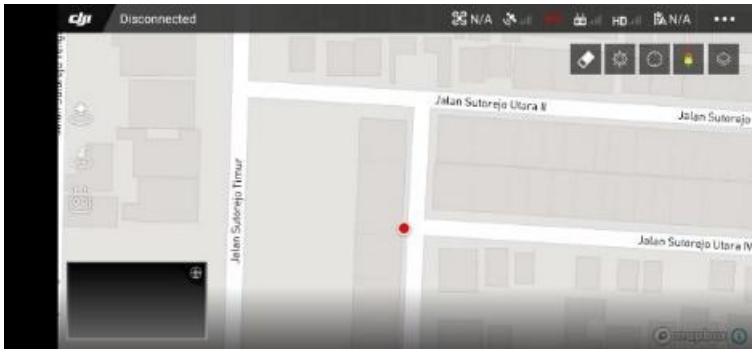


Fig. 6 Display of GPS features in the DJI Go application

II. EXPERIMENTAL SETUP

The method used in overcoming the Hot Spot problem on solar panels is accomplished in several stages, including : (a.) Knowing the causes and symptoms of Hot Spots on solar panels. (b.) Determination of the use of an appropriate GPS module for sending solar panel coordinates.

The initial step in this research is to deportment a literature review and related system forecasting on how to distinguish solar panels that have Hot Spots, as presented in the picture below.

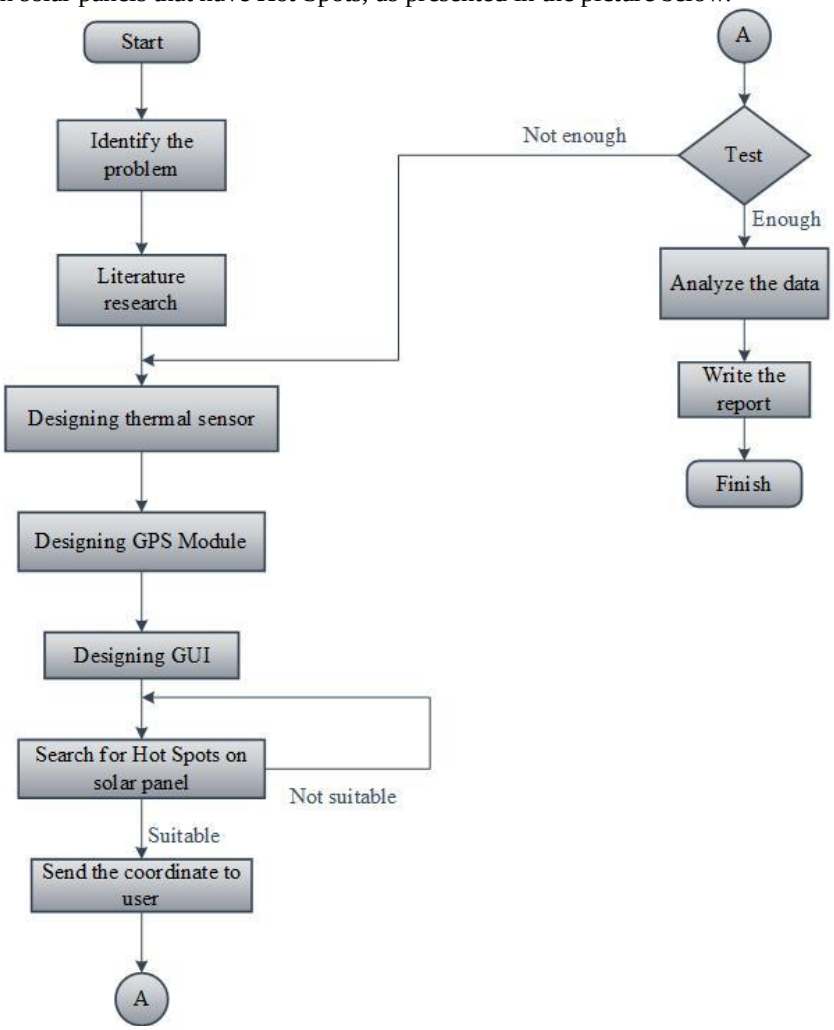


Fig. 7 Research flowchart

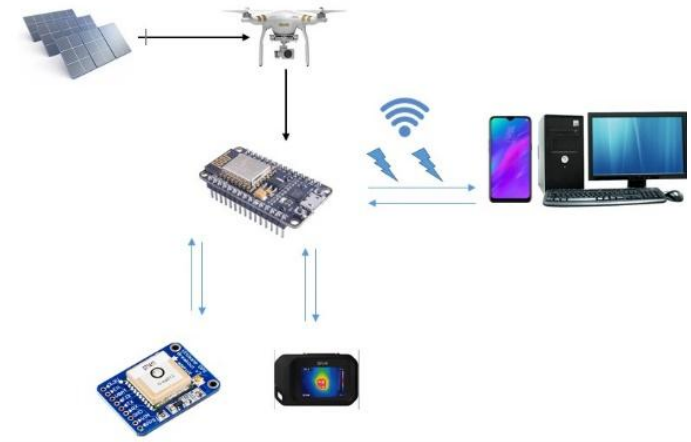


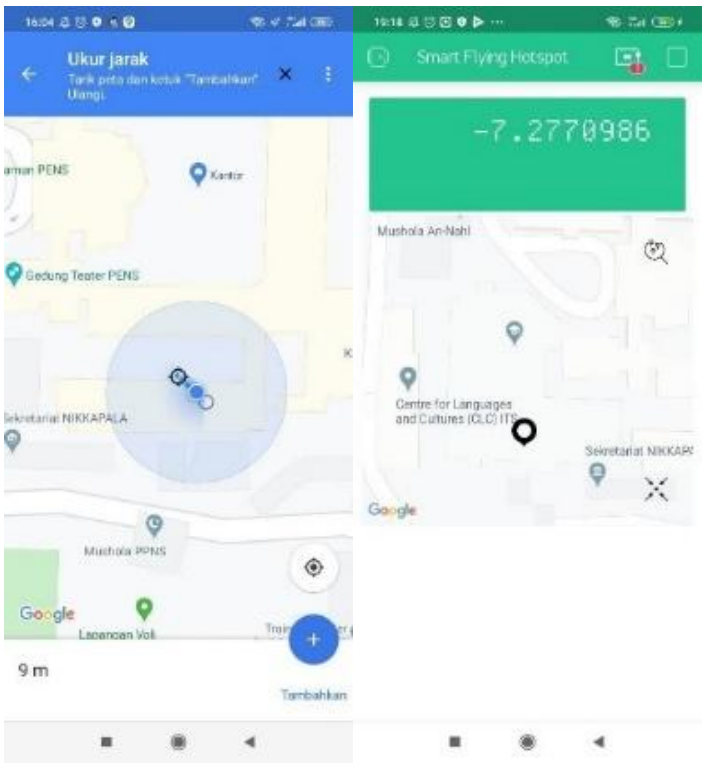
Fig. 8 System block diagram

Grounded on Figure 8 the system block diagram designed. How the system working as follows: when the solar panel is exposed to the light from the sun the drone will be flown to monitor the state of the solar panel and send the drone coordinates by IoT to the user. When a user encounters a Hot Spot problem on a solar panel using a thermal camera. Then the user who is in the control room will know the coordinates of the solar panel that is in trouble and check the damage that occurs in the solar panel.

II. RESULTS AND DISCUSSION

RESEARCH RESULTS

In this research, testing of GPS modules, thermal cameras and drones was carried out. For testing GPS module data which is made to display the coordinate information that is processed by the module. The module will follow the direction of the drone. From the data, we compare the data processed by the GPS module with google maps.

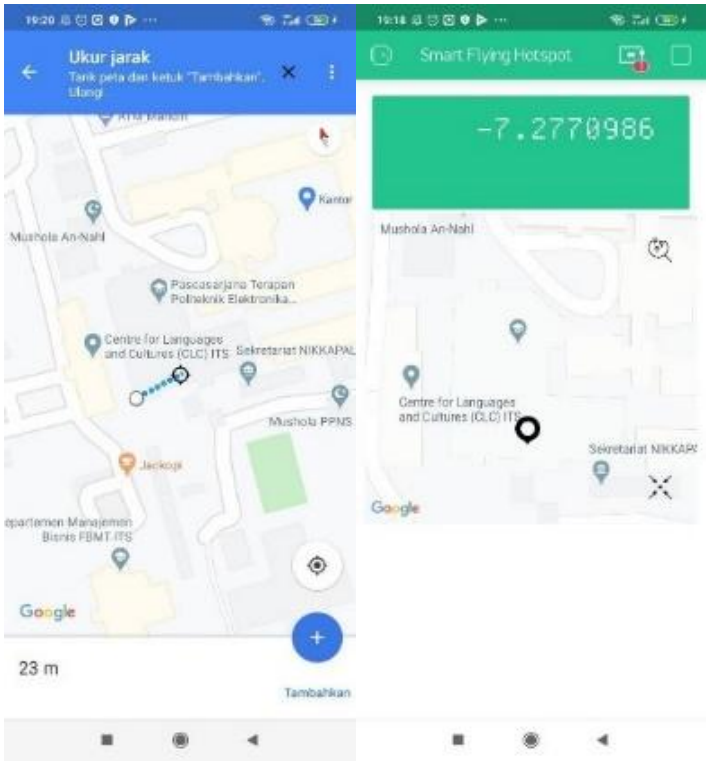


(a) **(b)**

Fig. 9 (a) Image from google maps. (b) Image from the GPS module

Table(1). Result of GPS Module Data Captured Every 3 Minutes

GPS Data Module		GPS Data Google Maps		Error
Latitude	**Longitude**	**Latitude**	**Longitude**	
-7,2755851	112,7941081	-7,2771012	112,7938769	116 Meters
-7,2773987	112,7935384	-7,2771012	112,7938769	49 Meters
-7,2771088	112,7938151	-7,2771012	112,7938769	11 Meters
-7,2770721	112,7938314	-7,2771012	112,7938769	9 Meters
-7,2770762	112,7938151	-7,2771012	112,7938769	5 Meters



(a) **(b)**

Fig. 10 (a) Image from google maps. (b) Image from the GPS module

Table(2). Reseult of GPS Data Captured Every 3 Minutes

GPS Data Module		GPS Data Google Maps		Error
Latitude	**Longitude**	**Latitude**	**Longitude**	
-7,2771230	112,7930664	-7,2770928	112,7929519	14 Meters
-7,2771271	112,7931478	-7,2770928	112,7929519	20 Meters
-7,2771098	112,7931315	-7,2770928	112,7929519	18 Meters
-7,2770945	112,7931803	-7,2770928	112,7929519	22 Meters
-7,2770986	112,7931803	-7,2770928	112,7929519	24 Meters

ANALYSIS

Alluding from those elaborations above, we can conclude that the GPS module requires satellites around the earth to send signals to get position of the coordinates. Based on the research data, it is known that the GPS module has an average error value of 39.4 meters. This is due to interference that prevents the GPS module (receiver) from receiving signals from satellites, including environmental factors. This GPS receiver module is a module that can work optimally if placed in the outdoor which is not obstructed by buildings, trees, cars and others. This is due to the signals from GPS satellites can be distorted. In addition, the longer the GPS module (receiver) receives signals from satellites, the fewer errors will occur. This is proven by the experiment table, the more time needed by the GPS module to operate, the smaller the error that occurs (± 5 meters).

IV. CONCLUSION

From the results of research and analysis, the conclusions obtained from this research are:

1. GPS module (receiver) can only work well when it is operated in outdoor and there are no objects that prevent the GPS module from receiving signals from satellites.
2. The longer the GPS module (receiver) receives signals from satellites, the smaller the difference between the module data and google maps.

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