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DESIGN AND DEVELOPMENT OF SOLAR CHARGER CONTROLLER SYSTEM WITH LI-ION BATTERY AT ELECTRICAL VEHICLE

Rafiuddin Syam, Iqbal Nurpauzi, Vina Oktaviani and Efri Sandi
Electronic Engineering Education Study Program, Faculty of Engineering, Universitas Negeri Jakarta, Indonesia
E-Mail: sarfas1805@gmail.com

ABSTRACT

Charging Stations for charging electric vehicles (EV) are limited and it takes time for the charging process which is the main reason for increasing the efficiency of EVs and utilizing additional energy. The Additional energy that is commonly used is the Photovoltaic System. In this study, the researcher using of a photovoltaic system as alternative energy for the charging system for electric cars. The model used in this system is a dc-to-dc step-down asynchronous model with a 72V charging system output. The Solar Charging Controller (SCC) design for the use of photovoltaic systems can be monitored based on IoT. Experiments were carried out on the UNJ Electric Car, for 8 hours of charging data collection. Good results are obtained when electricity generated from solar panels has a power yield of 72V battery voltage and a maximum current of 4A with a charging efficiency of up to 96%.

Keywords: solar cell controller, Li-Ion battery, electric vehicle.

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INTRODUCTION

The Indonesian government is encouraging the use of electric cars. Through the Directorate General of Electricity, the Ministry of Energy and Mineral Data Resources of the Republic of Indonesia has developed an Environment to support the use of Electrical Vehicles. In addition, efforts to use new and renewable energy sources are still being developed in the form of static and/or mobile photovoltaic, attached to electric vehicles.

A solar cell or photovoltaic system is a device that can convert sunlight energy into electrical energy directly. To be able to connect the solar cell with the battery in the electric car electrical system, a tool is needed; the SCC (Solar Charger Controller) is using the SCC electricity generated from the solar cell that can be adjusted to the electricity in the electric car vehicle.

A previous study recharged batteries from a multifunctional solar PV and grid-based onboard converter for electric vehicles (Ankit 2020). The research conducted research for electric cars where there are two sources of energy, the first is charging electricity using a charging station and the second is using a photovoltaic system with a DSPACE-1104 controller. This study has limitations, in that it does not have a monitoring system and data analysis and has not been connected to the IoT network.

Then another study on the mitigation of solar irradiance intermittency in photovoltaic power systems with integrated electric-vehicle charging functionality (Joshua 2012). In his research, Joshua made a battery charging system for electric cars using two sources of electricity, namely the Electrical Company in Indonesia (PLN) and solar cells. The charging system already uses a dc to dc step down with a synchronous type so that charging has an efficiency of up to 98%. This research still has limitations, namely, the system used is not yet connected to the IoT network and does not yet have a monitoring system so for data retrieval additional measuring tools must be added.

Another research (Hafelzan, *et al*. 2020), carried out charging using a 24V solar cell and using a 12V lead acid battery. The charging system uses a step-down dc to dc system that can lower the solar cell voltage so that it can charge lead acid batteries and use the Arduino Uno microcontroller. This study has limitations, namely the electricity is derived using a dc to dc step-down asynchronous model which has poor efficiency, then the working voltage is still limited to a working voltage of 12V. Meanwhile, for electric cars that are used have a fairly high working voltage above 12V such as 72V so that the application is less extensive and the system is not yet based on IoT, then data retrieval can only be done by looking at the available LCD. Data collection must add additional measuring tools.

From the research that has been done previously, the researcher concludes that the system made previously has several shortcomings, namely the voltage on the battery is still low, 12V, then for charging the battery using a dc to dc step down asynchronous model which has poor efficiency so that when monitoring an IoT network and additional devices are needed so that they can monitor in real-time.

The purpose of this study is to design battery charging in electric cars using solar cells which have a higher battery working voltage of 72V, produce battery charging that has a higher efficiency above 80% to close to 100% and create a charging system that can be monitored continuously. Real-time using IoT.

From the existing limitations, the researcher wants to develop and add to the shortcomings of the existing system, namely making the battery voltage capable of being used at a higher voltage, namely 72V with a Li-Ion battery type, then to improve charging

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efficiency, a dc to dc step down synchronous model system is used, so it has a higher efficiency. To monitor and collect data, the system is added to IoT so that monitoring can be done in real-time.

Solar charger controller

According to (Junaldy *et al,* 2019) in their research entitled Design of Current and Voltage Monitoring Devices in Arduino Uno-Based Solar Cell Systems. Solar Charger Controller is a tool that has a function to regulate electricity to the battery, know and monitor battery capacity so that there is no overcharging or overvoltage when the battery is full.

According to (Ahmad Wahid, *et al*, 2014) Electrical energy is one of the community's needs and is an economical and most important resource needed in various activities. In the industrial era 4.0, almost all lines of human life cannot be separated from the role of technology and require the role of electrical energy as an energy source. Tech electrical energy is separated from the main measurement namely electric power or can be called watts which are generally used at home on KWh meters or loads used such as irons and others, to measure electrical power P, Voltage V, and Current I, can be used the following equation:

$$P = V \times I$$

To be able to measure the power that has been used, then use the additional time as the measurement data, If Powerper time unit W_h, Power Electricity P and time t. to calculate it can use the following equation:

$$W_h = P \times t$$

In this vehicle a Li-Ion type battery with a configuration of 20 Series with a 72V configuration because it is used for large loads of 10KWh.

BATTERY CHARGING EFFICIENCY

According to (Dodi, 2018) Electrical efficiency is a comparison between the output power and the incoming power, efficiency is an important performance factor and determines the level of energy consumption in electrical equipment. The higher the value of electrical efficiency, the more power can be utilized and not wasted. If the output of power P_{out} and input of power P_{in}, then the efficiency can be seen as follows:

$$\eta = \frac{P_{out}}{P_{in}}.100\%$$

Blynk is an application that uses an Android base or OS that can be used in general to be able to control Arduino, ESP32, ESP8266 Raspberry Pi, and several other types of microcontrollers using the internet network.

Figure-3 shows The ADS1115 ADC module is a module that is used to read Analog Digital Converter (ADC) with I2C communication with a resolution of up to 16-bit with 4 channels.

It's functionally easy to use for measuring a wide range of signals with a voltage range from 2v to 5v, and it's great for measurements with 16-bit resolution.

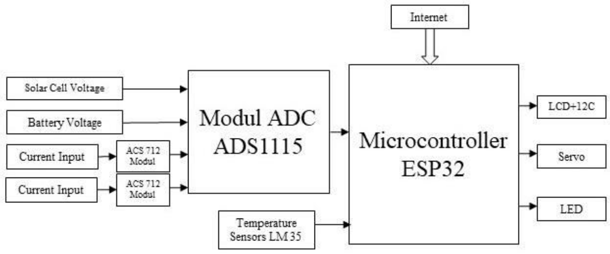

Figure-1. System block diagram.

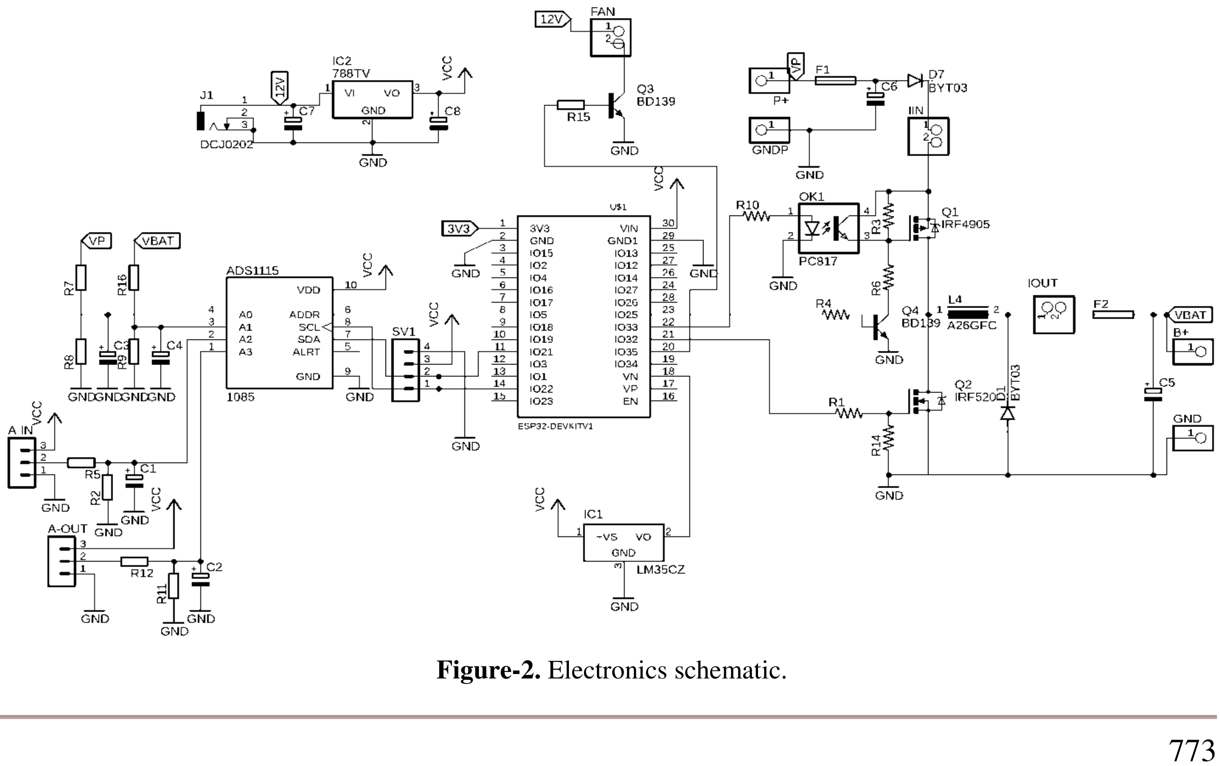

Figure-2. Electronics schematic.

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In Figure-1 is a series of control systems as a whole, to find out the subsystem of each component is described as follows:

No	Components	Function
1	ESP32	Microcontroller
2	ADS1115	Voltage Sensor
3	Elco 10uF/10V	Noise Filter
4	Output block	power output to the battery
5	Input block	electricity input from the solar cell
6	Elco 470uF/250V	Noise Filter
7	ACS712-5b	Current Sensor
8	PC817	Mosfet driver
9	RF9630	Mosfet, electrical control from solar panel to battery
10	LM35	as a temperature sensor
11	Inductor	temporary electricity storage
12	IRF740 MOSFET	electrical control from the solar panel to the battery
13	Fan control	a regulator on or off Fan
14	LM7805 5v	voltage regulator
15	Electrical input	Power for System

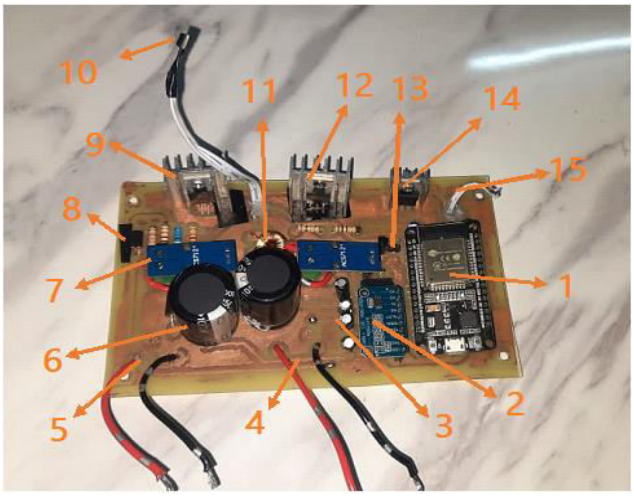

Figure-3. Comprehensive Toolkit.

Figure-3 shows the device Solar Cell Controller and the description of each detail component can be found in Table-1.

RESULT AND DISCUSSIONS

The result of this research is new components of the charging system that is the Solar Cell Controller of electric vehicles.

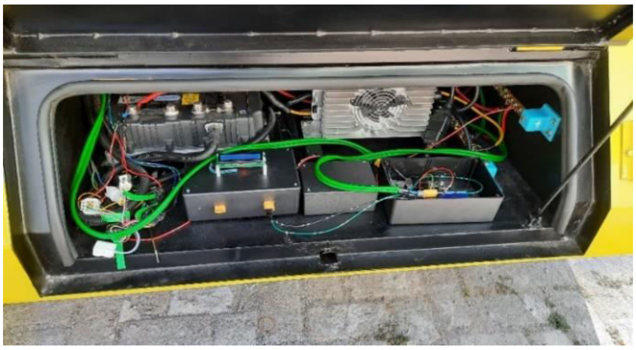

Figure-4. Position of controller in the electric vehicle.

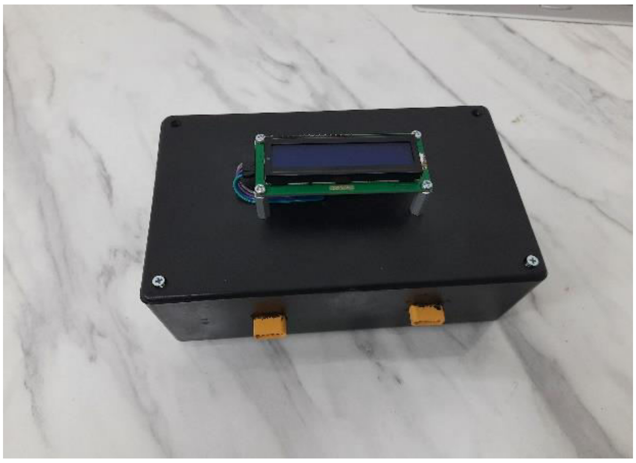

Figure-5. Box of solar cell controller.

Figures 4 and 5, show the box of the controller of the Solar Cell. Figure-6 shows the grid of photovoltaic panels at the top of electric vehicles.

Figure-6. Solar cells used.

The Blynk application is used as an interface and monitoring that is connected online to display measured data and is managed by esp32, calculation and measurement data are sent using the internet via Wi-Fi on esp32. The Blynk application will display the solar cell voltage, incoming power output voltage, output power,

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efficiency, battery capacity, and the total power generated. The measurement data can be seen in Table-1.

Table-1. Blynk application testing results.

Indicator	Display On Blynk
Input voltage	VOLTAGE(PV) 84.118V
Incoming power	WATT(PV) 118W
Battery voltage	VOLTAGE(BATTERY) 81.9V
Power out	WATTOUT 114w
Temperature	TEMP 49°C
Efficiency	EFISENSI 96.124
Total power generated	WHOUT 121 Wh
Battery Capacity	BATTERY 91.570
Overall System View	84.1181 118W 114w 96.124 49°C 91.570 81.9V 121 Wh

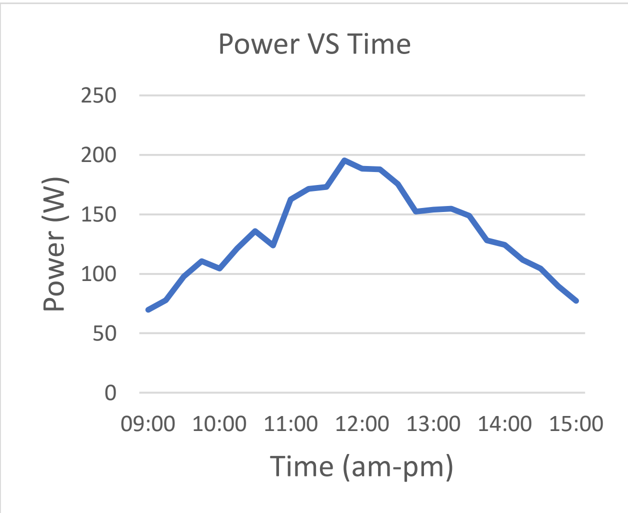

Figure-7. Graph of output power measurement data for 2 days.

After experiments of the Solar Charger Controller System Design Tool With Li-Ion Batteries in Microcontroller and IoT-Based UNJ Electric Cars for a period of 2 days from 09:00 to 15:00 hours, which can be seen in Figure-4.3 power generated from solar panels in harmony with the position of the sun, when the sun is at its peak or during the day, the power generated will be maximized, and at the beginning of the day and the end of the day the power generated will be smaller than during the day, can be seen in the graph 11 the power generated is not linear with the time or position of the sun, there are other factors such as clouds that cause the sunlight that hits the solar cell is not optimal so that the power generated can decrease.

CONCLUSIONS

In this research, a solar cell controller has been successfully made and tested. This device is the controller for the charging process the battery uses a 72V battery configuration with a Li-Ion battery getting a maximum charging current of 4A and using a solar cell with a capacity of 250WP.

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