Design and Development of Low-Cost Data Acquisition System for Solar PV Power Plant Monitoring

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***Abstract*— We need to know that the meaning of solar panels is a device consisting of solar cells that can be used to convert light into electricity. These solar cells need to be protected from moisture and damage that can occur. This is done so as not to significantly damage the efficiency of solar panels and reduce their useful life. Usually, these solar panels have a lifespan of around 20 years. Within this time period the use of solar panels will not experience a significant decrease in efficiency. At present, despite the use of technological advances, most commercial solar panels are only able to achieve an efficiency of around 15%. Commercial solar panels are very rare which can exceed 20% efficiency. Solar panels do not emit harmful greenhouse gas as in fossil fuels burning . So the use of solar panels does not contribute to the effects of climate change. By using solar panels, we can get clean energy from the most abundant energy source on the planet, namely the sun.**

***Keywords*—photovoltaic, PV system, monitoring, low cost, power plant**

I. Introduction

Geographically, Indonesia is located in equator where Solar Irradiation is available in almost every day in year. This solar energy can be used to generate electricity during daytime. Solar Photovoltaic (PV) is a technology that can convert solar energy to become electricity directly. It is an opportunity for us to get benefit from this because we can make values from Solar Irradiation to be electric power source which can be used for our life in many aspect, in our house, office, industry, etc.

Secondly, Solar Irradiation is a renewable energy source. It has chance to replace the conventional energy source, which made from fossil and coal. We know that conventional energy source is limited and non-renewable, also emit carbon dioxide and greenhouse gas and is harmful for our earth. The use of Solar PV can reduce the enviromental impact of power generation, displacing diesel fuel and reducing the overall electricity price [1].

II. LITERATURE REVIEW

The potovoltaic effect is a basic physical process in which PV cells convert sunlight into the electricity. Sunlight is composed of photons or particle of solar energy. These photons contain various amounts of energy that correspond to different wavelength of solar variation. When the photons are about PV cells, photons can be reflected or absorbed. Only photons are absorbed that produce electricity. When this happens, photon energy is transfered to electrons in the cell atom (usually a silicon atom). Electrons are able to escape from their normal positions asociated with atoms to be part of a current in an electric circuit [2-6].

The doping process inserts atoms into silicon crystals to change their electrical properties. The element used for doping has three or five valence electrons. This can be used to make type N (Phosphorus has 5 valence electrons) and Boron type P (Boron has 3 valence electrons). In polycrystalline thin film cells, the upper layer is made of semiconductor material that is different from the lower semiconductor layer [2].

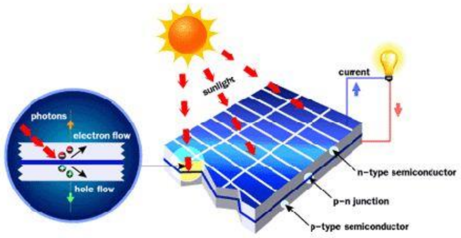

Fig. 1 Illustration of how solar cells work with the p-n junction principle [6]

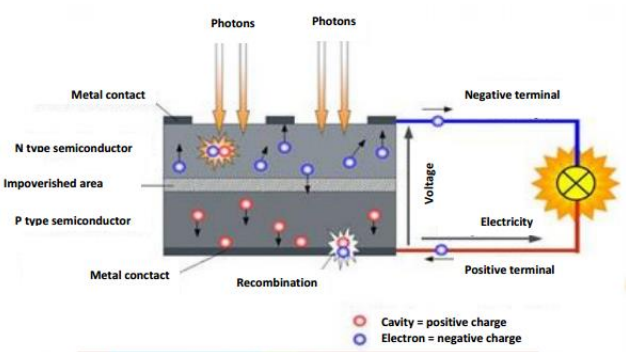

Fig. 2 Functioning of the photovoltaic cell [3]

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous version [4,7-8].

These are technical specification of an Arduino boards as shown in Fig. 3:

Microcontroller	: ATmega328
Operating Voltage	: 5V
Input Voltage (recom)	: 7-12V
Input Voltage (limits)	: 6-20V
Digital I/O Pins	: 14 (of which 6 provide PWM output)
Analog Input Pins	: 6
DC Current per I/O Pin	: 40 mA
DC Currrent for 3.3V Pin	: 50 mA
Flash Memory	: 32 KB of which 0.5 KB used by bootloader
RAM	: 2 Kb
EEPROM	: 1 Kb
Clock Speed	: 16 MHz

Fig. 3 Arduino mega boards

III. Result And Discussion

Materials and Equipment

1. PV Panel Type Polychristalline
2. Microcontroller Arduino Mega 2560
3. Charge Controller
4. Battery 12 Volt
5. Cable
6. Voltage Sensor
7. Current Sensor
8. LM35 Sensor
9. LED Lamp

This study monitors a PV panel that is operating from morning to evening (Fig. 4). Data acquisition is done in a simple way by using the Data Streamer facility in Microsoft Excel.

The first step in this experiment is installing a PV panel installation consisting of a PV Panel, Arduino Microcontroller, Battery, Lights and Charger Controller. Then a current sensor and a voltage sensor are installed on each device to measure the current and voltage when the installation is on. The current and voltage sensors are installed in the PV Panel, Battery and Lamp. Then an LM35 sensor will also be installed on the PV Panel surface to measure the PV Panel surface temperature when the PV Panel system is operating as shown in Fig. 5.

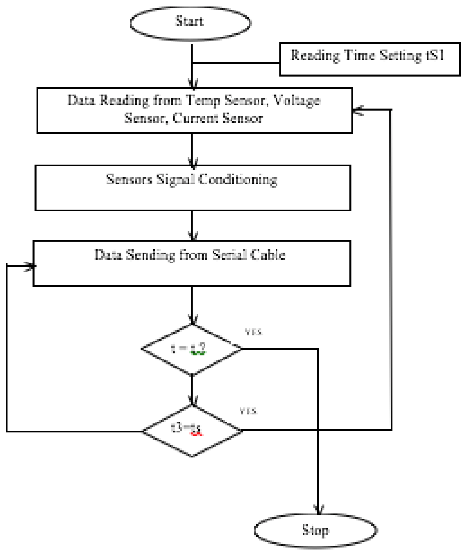

Fig. 4 Monitoring flowchart

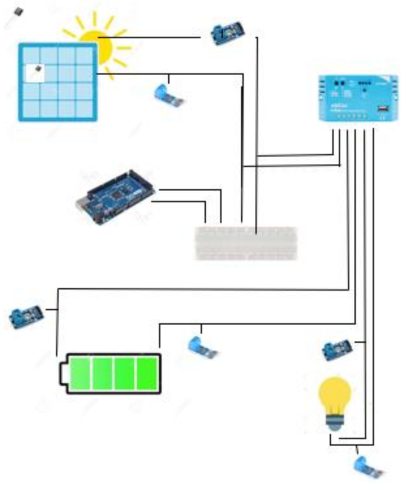

Fig. 5 PV panel

IV. Conclusion

Connecting installation to the Data Streamer on Microsoft Excel as shown in Fig. 6, Table 1 and Table 2:

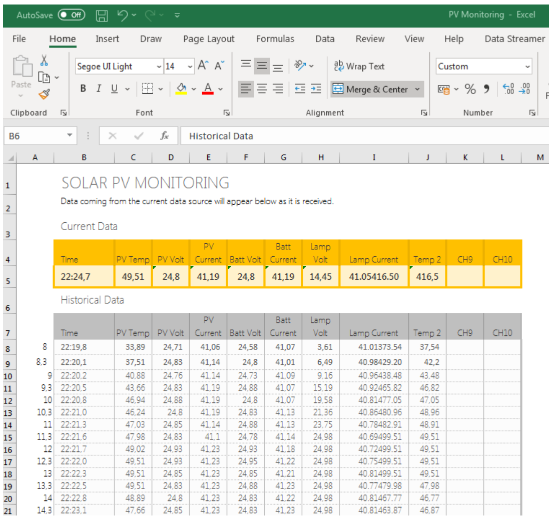

Fig. 6 Data streamer

TABLE I
MEASUREMENT LIST OF SENSOR, FUNCTION AND PRICES

No	Sensor Name	Function	Price (IDR)	Quantity
1	LM35	❖ Measuring PV Panel Temperature ❖ Measuring Ambient Temperature	15000	2
2	Voltage Sensor	❖ Measuring voltage of PV Panels ❖ Measuring voltage of Lamp ❖ Measuring voltage of Battery	25000	3
3	Current Sensor	❖ Measuring current of PV Panels ❖ Measuring current of Lamp ❖ Measuring current of Battery	25000	3
4	Charger Controller	❖ Set the current for charging to the battery, avoid overcharging, and overvoltage.	150000	1
5	Arduino Mega 2560	❖ Microcontroller	160000	1

TABLE II
MEASUREMENT OF SENSOR AND CONNECTION TO ARDUINO

No	Sensor Name	Connection to Arduino
1	LM35	Analog Input A0
2	Voltage Sensor - PV Panel	Analog Input A1
3	Voltage Sensor - Lamp	Analog Input A2
4	Voltage Sensor - Battery	Analog Input A3
5	Current Sensor PV - Panel	Analog Input A4
6	Current Sensor - Lamp	Analog Input A5
7	Current Sensor - Battery	Analog Input A6

Monitoring Performance of the installation as shown in Fig. 7-Fig. 13:

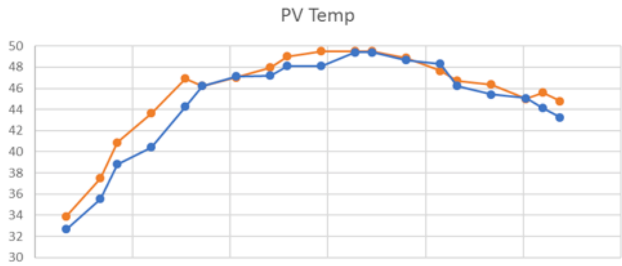

Fig. 7 Measurement of PV panel temperatur versus time

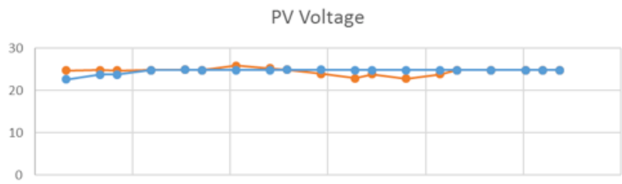

Fig. 8 Measurement of PV panel voltage versus time

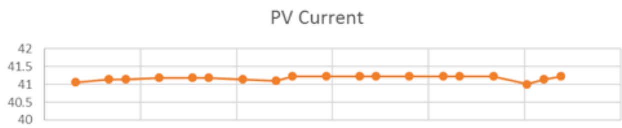

Fig. 9 Measurement of PV panel current versus time

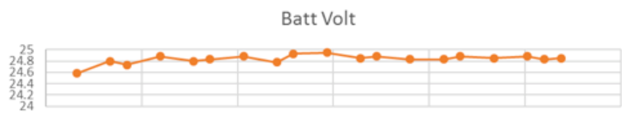

Fig. 10 Measurement of battery voltage versus time

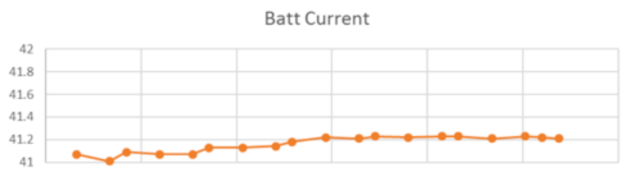

Fig. 11 Measurement of battery current versus time

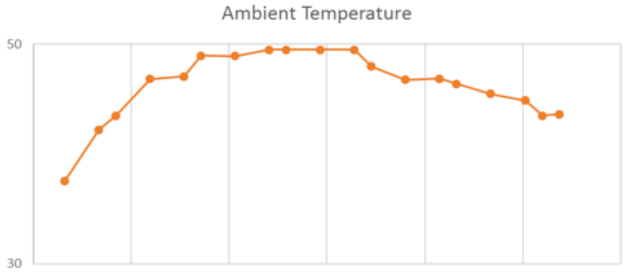

Fig. 12 Measurement of ambient temperature versus time

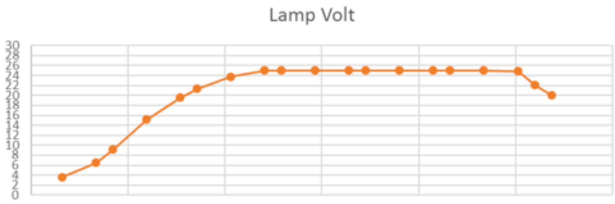

Fig. 13 Measurement of lamp voltage versus time

The graph above shows (Fig. 7-Fig. 13) the performance of a monitoring system conducted with low budget devices on a PV panel work system. Charts are made from data collected from morning to evening. The graph shows the performance of the PV Panel installation work system that is monitored with a simple device and low budget. From the data obtained, it is known that this monitoring system works well.

From this study it can be concluded that a PV panel system can be monitored in a simple and low budget way. PV panel system can be installed sensors on each device to be measured then the measurement value can be displayed directly and realtime using the Data Streamer facility in the Microsoft Excel Program. From monitoring the performance of the PV Panel system, the optimum value can be obtained from the system.

In this study, a simple monitoring method and low budget that can be displayed in realtime is obtained. From this, a PV panel monitoring method can be developed by adding measurement techniques and parameters so that more complex results can be obtained in terms of PV Panel monitoring such as by adding sensors and adjusting the angle of the PV Panel's surface to sunlight. Then to make the research results more interesting, in the future it is necessary to develop the user interface with the aim of improving this research.

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