Journal of Physics: Conference Series

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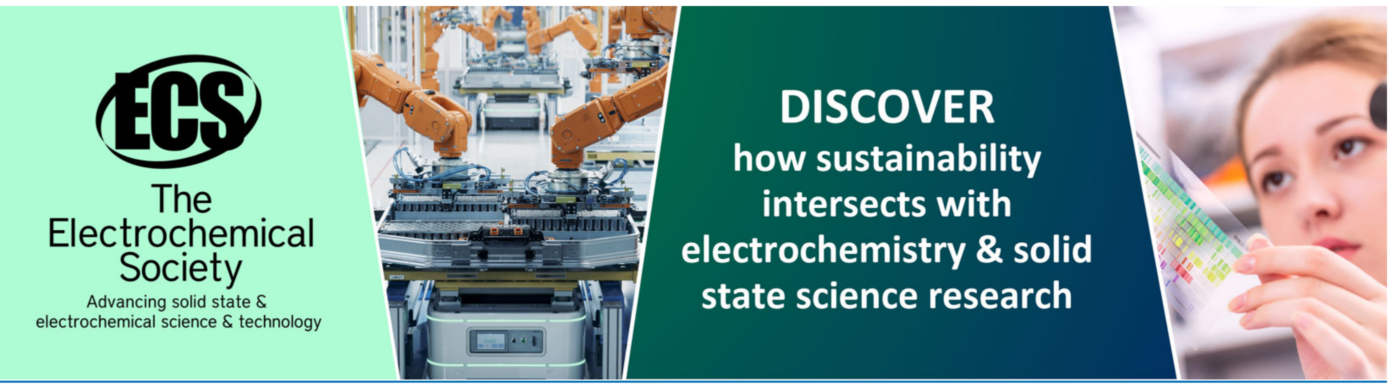
To cite this article: Mokh. Sholihul Hadi *et al* 2018 *J. Phys.: Conf. Ser.* **1028** 012065



Stand-Alone Data Logger for Solar Panel Energy System with RTC and SD Card

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Abstract. In this research stand-alone data logger device that can be used for measuring solar panel power characteristics is introduced. With RTC and SD Card installed on the device, the energy produced by solar panel is measured, then data are stored in CSV format that is compatible with MS Excel. Stand-alone feature makes it suitable for monitoring solar panel systems installed on remote area. Research result exhibits that all device sub systems are working perfectly. Voltage sensor convert the output voltage range of solar panel 0-24V to suitable voltage for microcontroller 0-5V. Real Time Clock (RTC) is able to show real time hours, minute and seconds of every measurements. Current sensor could measure the current with similar result compared to standard lab instruments. Despite data stored to SD Card, a 16x2 LCD display real time measurement results. Overall, the device works very well as if standard data logger instrument, but featuring real time monitoring and computer compatibility data.

1. Introduction

One of the fundamental aspects for the development of the economy both in developed and developing country is energy production. Its insufficiency, or shortage, brings reflections in finding of an alternative reliable energy sources [1][2]. This fact encourages to trends in the development of energy production from clean technologies that can also attend remote area but easy to maintain its reliability and flexibility [3].

Solar farming energy system is growing extensively in the last decades. Both on grid and off grid configuration are developed to meet people need [4][5]. The energy source of this system is solar radiation, that converted into electricity by solar panel, then either saved to battery for farther used or directly converted into AC current using inverter to power the load [6].

The hole system efficiency is usually depends on the solar panel efficiency [7]. Its capability and reliability to convert solar energy into electricity is progressively researched by many researchers around the world. Thus, to evaluate it solar panel power characteristic is measured and evaluated [7]. Most company in the recent days claim that, their solar panel is able to work up to 25 years, by predicting based on short reliability test. However, further investigation of its performance must be conducted.

Data logger is an instrument that can measure solar panel power characteristic automatically [8][9]. The ability to obtain data on instantaneous power consumption for long period is necessary for operation of any higher levels system. Since many solar panel system configurations today can be referred to as smart or intelligent system, both in plug or unplug area. It could be said that they data logger must be capable to be applied in both systems. Fachri, Sara, & Away [10] argumented that Real time monitoring connected to PC is power consuming, thus not suitable for remote area. In this research, a novel stand-alone data logger device for solar panel energy system is introduced.

2. System Architecture and Working Principal

The proposed architecture of data logger development for power characteristics of solar panel using ATmega328p are divided into two parts A. Hardware Part& B. Software Part. The concept of this project is to develop ATmega 328p microcontroller and to develop data logger. The proposed system is able to save the power parameter of the solar system within long term time range. In the circuit, it consists of current sensor, voltage sensor, RTC (Real Time Clock), LCD (Liquid Crystal Display) and SD card module. ATmega328p microcontroller that is compatible with Arduino IDE is used. This feature was selected as Arduino IDE based microcontroller is user friendly and easier to develop than others platform [11]. Block diagram of data logger device is shown in Figure 1.

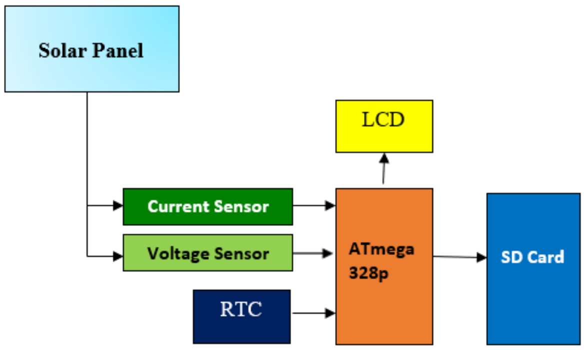
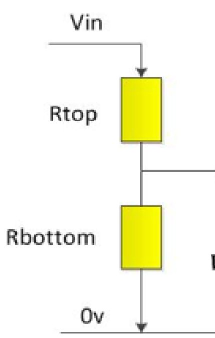


Figure 1. Block diagram of data logger device

2.1. Data Logger Sub Systems

2.1.1. Voltage Sensor . Voltage sensor is used to convert 0 – 48V solar panel output range to 0 – 5V ADC input voltage range. The sensor basically using voltage divider principle. 2 resistor connected in series, R_{top} and R_{bottom}. The voltage of R_{bottom} is used as the input for microcontroller ADC. Fig 2 shows voltage divider principle.



$$V_{out} = \frac{R_{bottom}}{(R_{bottom} + R_{top})} x V_{in}$$

Figure 2. Working principle of Voltage divider

2.1.2. Current sensor. For current measurement ACS712 is used. The sensor converts electric pulse from solar panel, then convert it into 0 to 5 V that meet the microcontroller ADC input range. Fig 3 shows sensor configuration with microcontroller. ACS712 current sensor output pin is connected to ADC input at C.1. ADC input is used, in order to get more accurate value of current than using digital pin.

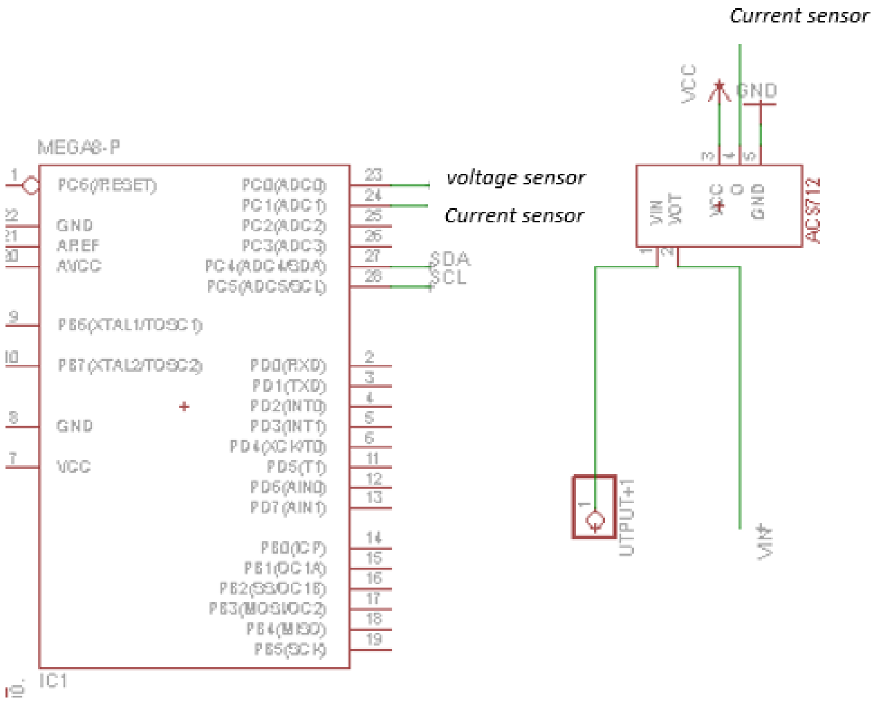


Figure 3. Current Sensor and Voltage Sensor pin configuration

In order to make microcontroller understand the representative value of each measurement, formula 1 to 4 is used.
To calculate voltage of solar panel:

$$Voltage\ variable\ (Kv) = \frac{V_{max}}{1023} \quad (1)$$

$$V_{solar\ panel} = V_{ADC\ in} * Kv \quad (2)$$

To calculate Current of solar panel:

$$Current\ variable\ (Ka) = \frac{Imax\ -(-Imin\ )}{1023} \quad (3)$$

$$I_{solar\ panel} = (\text{Input arus ADC} - 508) * \text{Ka} \quad (4)$$

2.1.3. RTC. RTC is the system clock, that is necessary to make the device performs real time monitoring. RTC has its own supply voltage, so RTC is always on even when the device supply voltage is shutdown. In this system, DS1307 RTC is used. RTC is could save seconds, minutes, hour, date, month, year up to year of 2100. Figure 4 shows DS1307 pin configuration and minimum system.

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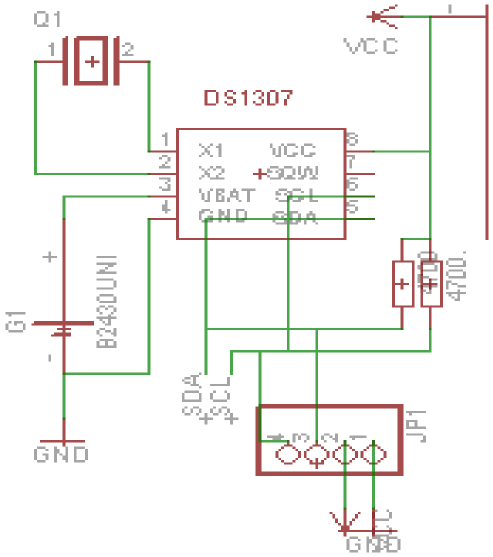

Figure 4. DS1307 RTC pin configuration

Pin no 5 (SDA) dan Pin no 6 (SCL) from RTC module is connected to Pin C.4 (ADC4) and pin C.5 (ADC5) of Atmega328 microcontroller consecutively.

2.1.4. LCD. LCD is the system output unit, to show the measurement result, so that user is able to see real time measurement. Data displayed in LCD is recent current and voltage measurement result. Figure 5 shows 16x2 LCD pin configuration.

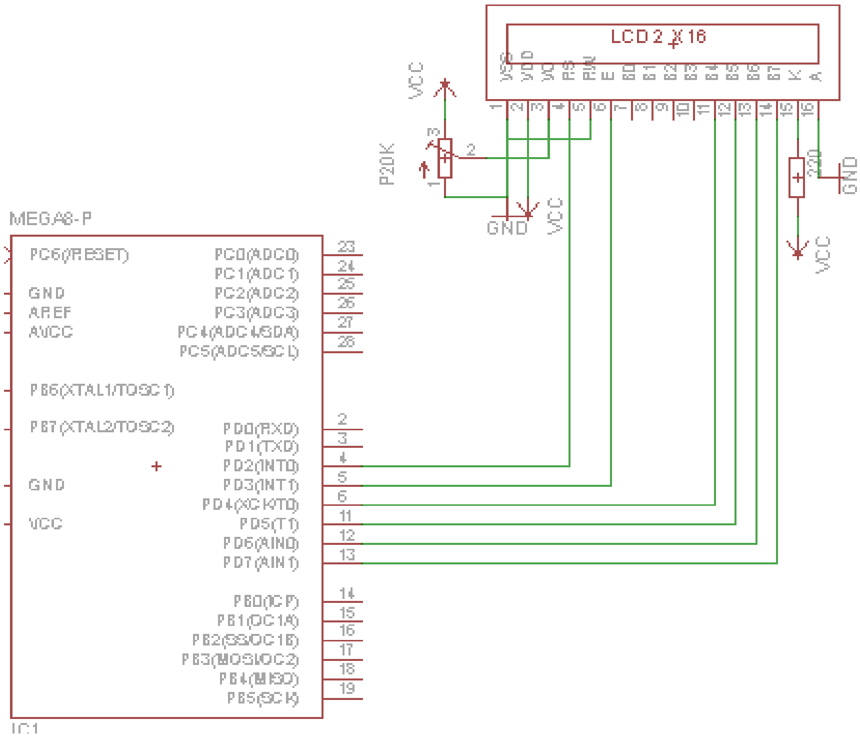

Figure 5. LCD pin configuration

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2.1.5. SD Card Modul. SD Card modul is used as data storage unit of data logger device. SDcard Vgen with 8GB of memory capacity used in the experiment. The memory card is replaceable for convenient of uses. Whenever needed, data from SD card can be copied to PC for further analysis. Figure 6 shows SD card module pin configuration.

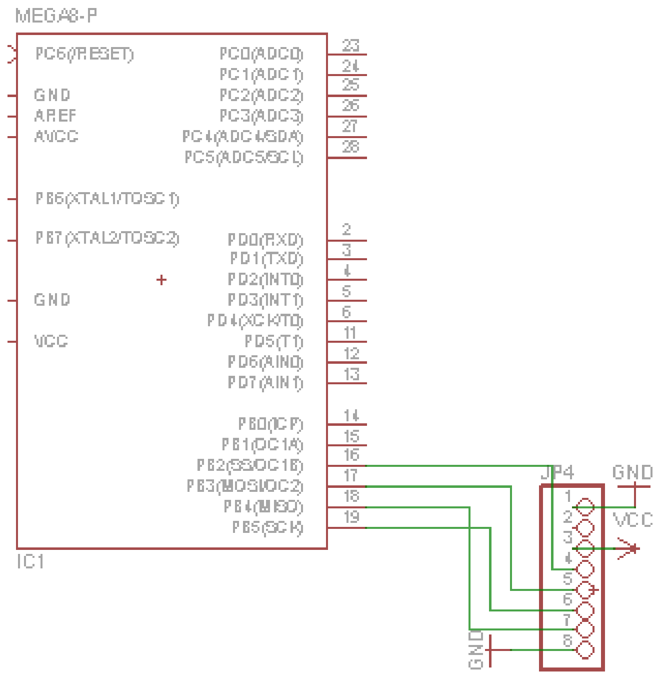

Figure 6. SD card module pin configuration

2.2. Hardware packaging

Total dimension of data logger is 23cm x 12cm x 7cm. Fig 7 shows data logger box, with inlet and outlet wiring for portable use. The box is designed for experimental purpose only, and to show the compact dimension and weight of data logger for further development until mass production.

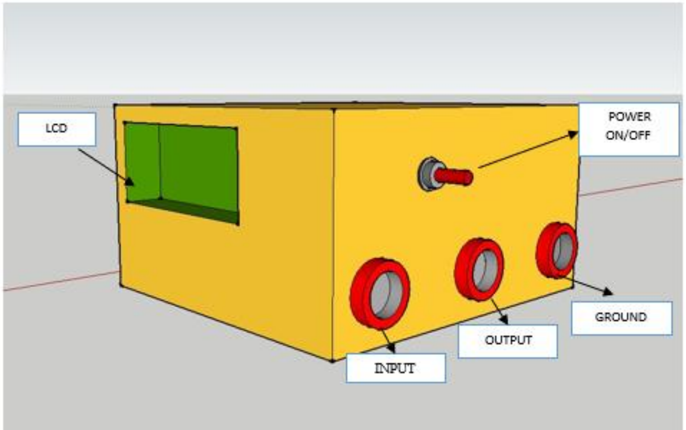

Figure 7. Data logger box

2.3. Software

Software was developed using Arduino IDE, Figure 8 shows main program flowchart. Once power button switch ON, device create new data. After reading sensor, and RTC simultaneously then data saved to SD Card in CSV format. While saving data to SD Card memory, data are displayed on LCD. CSV format make it compatible with MS Excel, so this will make user friendly feature for further data analysis.

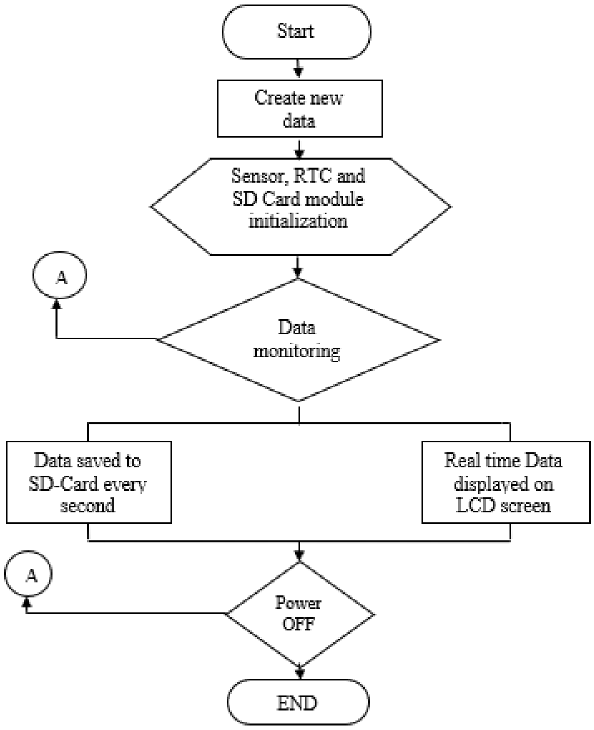

Figure 8. Main Program Flowchart

3. Experimental Results

Device sub systems was measured using standard laboratory instruments. Experimental results are explained as follows:

3.1. Voltage Sensor Measurement

To conduct voltage sensor experiment, the sensor input is connected with variable voltage source 2V to 12V sensor output then also measured with calibrated voltmeter.

Table 1. Voltage Sensor Experimental Results

No.	Input Voltage	Output Voltage
1.	12V	2,79V
2.	10V	2,32V
3.	8V	1,86V
4.	6V	1,39V
5.	4V	0,93V
6.	2V	0,46V

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3.2. Current Sensor Measurement

Table 2 show current sensor experimental results. Using the same input configuration with voltage sensor measurement, sensor output is to DC motor 0.9A as circuit load, the current is measured using calibrated Amperemeter.

Table 2. Current Sensor Experimental Results

No.	Input Voltage	Output Current
1.	12V	1A
2.	10V	1A
3.	8V	0,9A
4.	6V	0,7A
5.	4V	0,5A
6.	2V	1,7mA

3.3. Data Logger Device Testing

To perform device testing, device is connected to Solar Panel SLP100-12 with 100Wp, maximum output 21,3V, maximum current 5,81A. Solar Panel system was connected to LED 5W lamp. The air temperature during measurement is 27,5^{0} C, and at sunny day.

4. Discussion

Experimental result in Fig 9a and 9b show that there is voltage different between voltmeter reading and data logger reading with 0,22v. On the other hand, current measurement result, both amperemeter and data logger device exhibit the same value. Measured data saved in SD card memory is compatible with MS Excel, as shown in Figure 10. Measured data show current, voltage, and power of solar panel system. Other parameter such as time of measurement was also recorded. File size saved after 1 hour measurement is 114KB. This mean that 8 GB SD card memory could save up to 3000 days of data.

(a)

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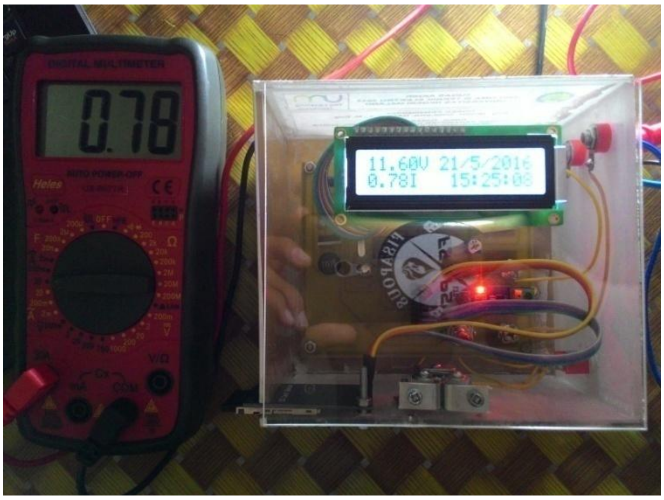

(b)

Figure 9. Voltage and Current sensor measurement, (a) compared to Voltmeter measurement result, (b)compared to Amperemeter measurement result

	A	B	C	D	E
1	Stand alone Data Logger for Solar Panel System				
2	PV :	Panel Surya Jurusan Elektro FT UM			
3	Tgl :	19/5/2017			
4	Hari :	Friday			
5					
6	Time	Voltage	Current	Power	
7	10:30:26	11.7	0.93	10.87	
8	10:30:27	11.75	0.73	8.61	
9	10:30:28	11.64	0.93	10.81	
10	10:30:29	11.73	0.83	9.74	
11	10:30:30	11.81	0.73	9.24	
12	10:30:31	11.7	0.88	10.3	
13	10:30:32	11.62	0.88	10.22	
14	10:30:33	11.5	0.73	8.58	
15	10:30:34	11.64	0.78	9.04	
16	10:30:35	11.8	0.44	5.12	
17	10:30:36	11.75	0.78	8.99	
18	10:30:37	11.66	0.39	4.56	
19	10:30:38	11.6	0.34	3.97	
20	10:30:39	11.53	0.78	9.02	

Figure 10. Copied Data from SD Card Displayed in MS Excel

5. Conclusion

Research result exhibits that all device sub systems are working very well. Voltage sensor convert the output voltage range of solar panel 0-24V to suitable voltage for microcontroller 0-5V. 3% of error measurement indicates that error measurement is in the raCurrent sensor could measure the current with similar result compared to calibrated standard lab instruments. Real Time Clock (RTC) is able to show the date and time of measurement. SD Card save data with format compatible to MS Excel, a 16x2 LCD display real time measurement results.

Acknowledgments
This research was fully supported by Ministry of Research, Technology and Higher Education of Indonesia, under Penelitian Unggulan Perguruan Tinggi research scheme.

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