Implementation of ATMega8 Microcontroller for Data Logger of Solar Irradiation

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Submission date: 31-Mar-2021 07:10PM (UTC+0900)
Submission ID: 1547158161
File name: Adelhard_IJA2M.pdf (467.21K)
Word count: 2891
Character count: 13892

International Journal of Applied Mathematics and Modeling
@KINDI PUBLICATIONS
www.kindipublication.com

Vol. 3, No. 1, 1-8
January, 2015
ISSN: 2336-0054

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Abstract

A data logger based on ATMega8 microcontroller has been implemented in this project to measure the solar irradiance. The sensor is Sumoncle RSC 5514 that is a small solar cell utilized as the sensor to measure the amount of irradiance incident to the location measured. Data is acquired through five channel analog to digital converter of the microcontroller and the data given by the sensor will be sent to a computer via USB port. A PC software also has been implemented to take the data from USB port. The software is developed in Borland Delphi 6.0 and it can be used to save data with either an automatic mode every 30 steps data or a manual mode, and the data can also be shown in a graph. The other function of the PC software is to monitor voltage and current from the solar colector and also to monitor condition of the weather. The system has been tested to measure solar irradiation from a coordinate location of S0^{0}50.124' and E134^{0}05.056'.

Keywords: Microcontroller; ATMega8; USB Port; Data Logger; Solar Irradiance

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I. INTRODUCTION

Solar energy has been used by human over ancient times to present in many variants of technologies. Solar radiation which is radiant energy from the Sun and comes in forms of visible light, radio waves, infrared, ultraviolet and x-rays. Solar irradiance shows the solar power received in a location that is measured in W/m^2. The irradiance can be varying throughout the year depending on the position of the sun, the seasons and the weather.

Data logger can be an electronic device that logs data from measured object over the time. A data logger can work in whole day(s), month(s) or even year(s) to collect data. Many advantages can be reached by using data logger *i.e.* real time measurement, perfect accuracy, no human error, etc. Along with the digital era, people prefer to build data loggers in digital circuit due to simplicity of circuit and flexibility to transfer and process data.

The digital device that can be used to design a data logger is microcontrollers . Microcontro llers are micro computer devices that normally have processor, I/O port and memory. The Atmel ATmega8 is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture [l0]. The ATmega8 has some features that make it a powerful device in mini dimension. Many researches [l]-[7] had been done in the field of data logger but the researches are never used ATMega8 as the main device of the data logger. In this project, ATMega8 is chosen to be used as the main device for measuring solar irradiance.

II. SYSTEM OVERVIEW

The data logger is designed using an ATMega8 microcontroller and the system consists of sensor, hardware, firmware and software. Signal flow of the system is given in Fig.1.

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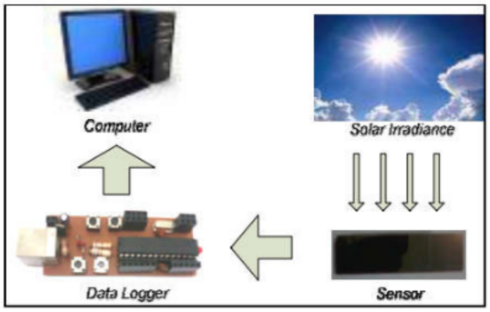

Fig. 1. Signal Flow

When solar irradiation will reach the sensor and the sensor will convert the irradiation to be a magnitude of voltage. The voltage is read by the data logger and the amout of voltage will be sent to a computer via USB pot. In the computer the data will be captured by the software and it will be showed on graph and a table and/or it will be saved in a spreadsheet file.

A. ***Sensor***

Sensor is used to convert the solar irradiation to become electrical energy; therefore the energy can be measured by the micro-controller . The sensor is a small solar cell with type Sumoncle RSC-5514 and it has dimensions about 5.55 cm in length and 1.35 cm in width. In this case, the energy cannot be captured directly because the micro-controller can only read voltage. To be able to measure the energy, the energy from the sensor is used to feed a constant load then the voltage terminal of the load will be measured. This method is well known as voltage divider.

Voltage divider is a method to get an output voltage as a fraction of input voltage. This method can be figured as follows [7].

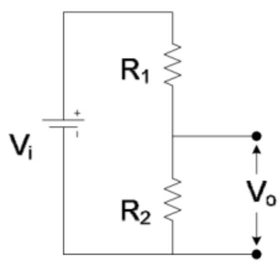

Fig. 2. Simple voltage divider

Using Ohm's Law, electric current (I) of the circuit is equal to input voltage (V_i) divide by total resistance while output voltage is the current (I) multiply by output resistance (R_2). Those can be formulated as follows.

$$I = \frac{V_i}{R_1 + R_2} \quad (1)$$

$$V_o = IR_2 \quad (2)$$

Substituting Eq.1 and Eq.2:

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$$V_o = \frac{R_2}{R_1 + R_2} V_i \tag{3}$$

In case a load is given to the output, R2 will be paralleled with load resistance (Ri,) and eq.3 will be changed to eq. 4.

$$V_o = \frac{R_2 // R_L}{R_1 + (R_2 // R_L)} V_i \tag{4}$$

Output voltage will be high if R2 is high and in the other side it will be lower if Rl is high. On the other hand, if Rl equal to R2 then Vo will be a half of Vi and total power (P) consumed by the circuit is then given as [8]:

$$P = V_i I \tag{5}$$

B. ***Hardware***

Hardware of the data logger is improved from USnooBie [11] that is a microcontroller device that does not require any kit programmer to write and run any firmware code. The hardware of the data logger is commonly used in an ATmega8 microcontroller. It should include the microcontroller itself and an oscillator either internal or external oscillator. Normally the microcontroller can work without the external oscillator because it has internal oscillator. The internal oscillator can provide maximum 1 MHz of its clock. The hardware used by the logger is provided in Fig.3.

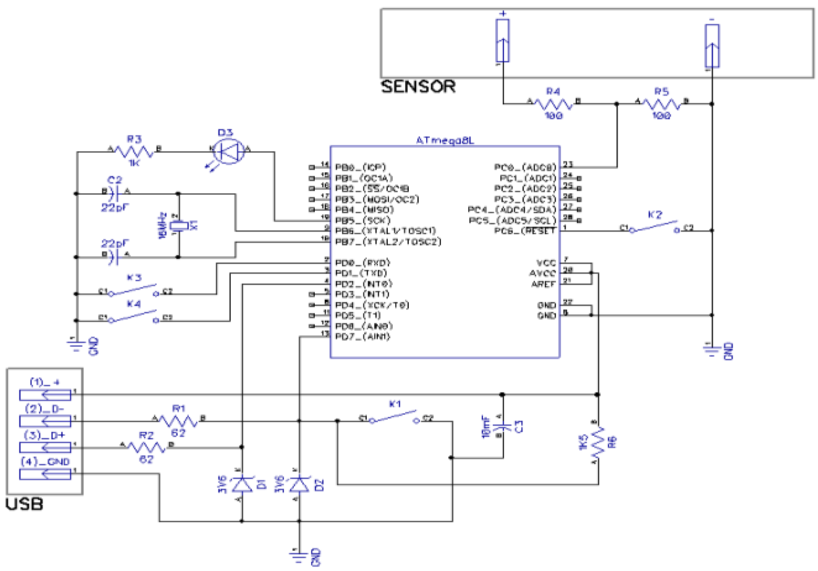

Fig. 3. Hardware

ATMega8 as the microcontroller used in the logger is produced by ATMEL coorporation. The microcontroller has 14 ports of digital I/O and 6 ADC ports. The feature is more than sufficient to be used in this data logger.

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TABLE I. ATMEGA8 FEATURES

Features	Quantity
ISP flash	8 kilobytes
EEPROM	512 bytes
SRAM	1 kilobyte
I/O port	23 lines
ADC channel	6 channel
SPI port	1 port
Watchdog timer	1 timer
Registers	32 registers
Features	Quantity
ISP flash	8 kilobytes
EEPROM	512 bytes
SRAM	1 kilobyte

The hardware has internal boot loader that will be activated when reset button is pressed. When the boot loader is activated, the device is ready to be flashed. This condition will give flexibility to use the microcontroller to the other purposes by pressing reset button and upload the other firmware. The disadvantage of this device is that memory of the ISP flash has been occupied by the boot loader; then the new firmware should be less than 8 kilobytes.

To ensure that the microcontroller can work in faster manner, the data logger is provided with 16 MHz of external oscillator. It is also a good choice because an internal oscillator sometimes cannot work properly while it is used in a long time of a measurement.

There are two standard voltage used of USB bus which are 3.6 V and 5 V. The 5 V standard voltges can work properly to read 3.6 V but it can not be done in the other side. Therefore it saves to keep 3.6 V as the standard of USB bus communication. Then two zener diodas are placed in line D- and D+ of the USB line to provide only 3.6 V in the line and also to protect the line from over voltage.

*C. **Firmware***

Firmware of the logger is written in WinAVR software and the code is done to occupy the hardware as a Human Interface Device (HID) joystick. The firmware is programmed to send an interupt to a connected computer in every cycle process of the microcontroller. It includes V-USB library, a free license library for programming AVR microcontroller, inside the code.

The magnitude of analog to digital converter (ADC) ports will be convert into 8 bit ADC while the hardware can support up to 10 bit ADC. This should be done in 8 bit data because the HID-joystick communication can only support 8 bit data. Data of the ADC ports will be captured in same time and it will be sent to a computer via USB port.

*D. **Software***

Universal serial bus (USB) is a serial bus to communicate with a computer. To be able to use the bus, every device is required to have a specific vendor ID and a product ID. In this case, the firmware has to provide both ID.

The designed software is used in a computer to capture measured data of the logger that is transferred via USB port. The software is written in Borland Delphi 6.0 and the software is work with a dynamic library file named mcHID.dll to make connection with the data logger. The amount of the compiled file of the software is about 926 kB and its appearance and features are shown in Fig. 4.

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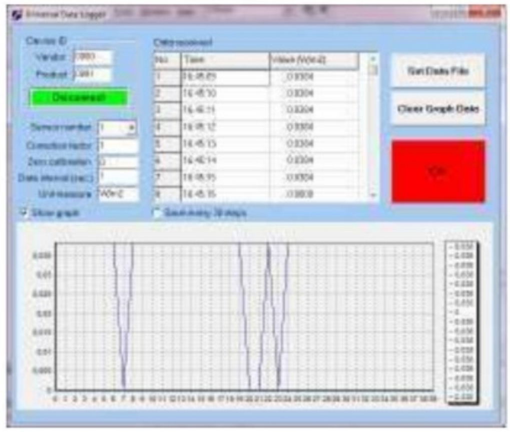

Fig. 4. Running software

The features of the software are device ID, sensor number, correction factor, zero calibration and unit used. The data can be shown in a table and/or in a graph and it can also be saved in a text file.

The data logger has Vendor ID 0000 and Product ID 0001. There are six ports that can be used to measure data and as appear in Fig. 4. Correction factor is used to be multiplied by current value in order to reach equality with the real data. Zero calibration is used if the line is not zero while no data is captured. Unit is only used to notice the magnitude of the output unit. The data can be shovm in a table and/or in a graph and the data can also be saved.

III. RESULTS

A. Calibration

The measured data is voltage from the mini solar panel as used to be the sensor. The sensor is $7.4925.10^4$ m^2 wide and it can send 0.2745 V or about 1.0057 W/m^2 in maximum position of the Sun at 12:00 pm.

It is 1370 Joules of energy arriving every second per m^2. A location, closed to the equator, can receive 75% of the radiation at a cloud free day. About 13% of that solar radiation may be absorbed by the atmosphere and 13% scattered. Therefore the maximum amount of solar energy on the Earth's surface is therefore about 1030 Joules per m2 per second [7].

By assuming at the given position, it should give 1030 W/m2; then the solar irradiance should be 1024.1124 higher than recent value. This multiplied value can be used to be calculated with the measured solar irradiance.

B. Logging Data

The data logger has been used to measured solar irradiance in a location at position of $S0^0 50.124'$ and $E134^0 05.056'$ and the location is about 103 m above sea level. Two days measured data that is in December 2014 from 6:00 am to 18:00 pm is shown in Table II.

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TABLE II. MEASURED DATA

Local time	1st day		2nd day	
	Voltage (V)	Weather condition	Voltage (V)	Weather condition
6:00	0.0000	Cloudy	0.0000	Daylight
6:30	0.0588	Cloudy	0.0392	Daylight
7:00	0.1176	Cloudy	0.1373	Daylight
7:30	0.1176	Daylight	0.1373	Daylight
8:00	0.1569	Daylight	0.1569	Daylight
8:30	0.1569	Daylight	0.1569	Daylight
9:00	0.1765	Daylight	0.1569	Daylight
9:30	0.1765	Daylight	0.1569	Daylight
10:00	0.1765	Daylight	0.1765	Daylight
10:30	0.1765	Daylight	0.1569	Daylight
11:00	0.1765	Daylight	0.1765	Daylight
11:30	0.1961	Daylight	0.1765	Daylight
12:00	0.1765	Daylight	0.1765	Daylight
12:30	0.0784	Daylight	0.1765	Daylight
13:00	0.1373	Overcast	0.1765	Daylight
13:30	0.0588	Overcast	0.1765	Daylight
14:00	0.0980	Rainy	0.1569	Daylight
14:30	0.1176	Rainy	0.1569	Cloudy
15:00	0.1765	Overcast	0.1373	Cloudy
16:00	0.1176	Overcast	0.0196	Cloudy
16:30	0.0980	Overcast	0.0588	Cloudy
17:00	0.0392	Overcast	0.0392	Cloudy
17:30	0.0196	Overcast	0.0196	Cloudy
18:00	0.0000	Overcast	0.0000	Cloudy

The data on the Table II shows that the solar irradiation is begin from 6:30 am to 17:30 pm but it may effective in between 7:00 am to 16:30 pm. Due to big data for measuring per minute, the data will be figured in a graph as shown in fig.5.

Fig. 6 shows that energy in 2nd day is more stable from the other one but it maybe too cloudy; therefore at the day only a little energy will reach its maximum value. On the other hand energy in 1st day is often reach maximum value before it drops due to rainy and overcast. In general both data will have any magnitude after 6:00 am and before 6:21 am then it is lost in around 17:43 pm.

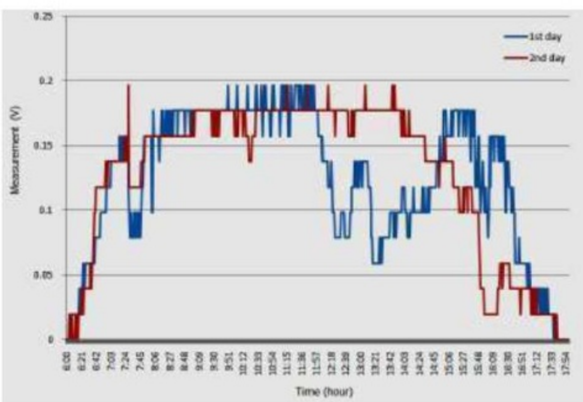

Fig. 5. Measured Data per Minute

C. ***Data Process***

The data logger is operated as a voltmeter that has high internal resistance; therefore it can be assumed that no load is given to the voltage divider and the data will be processed using eq.3. Because R_1=R_2=100 ohm, input voltage will be twice of the output voltage as follows.

$$V_i = \frac{R_1 + R_2}{R_2} V_o = \frac{100\,\Omega + 100\,\Omega}{100\,\Omega} V_o = 2V_o \tag{6}$$

By measuring output voltage, input voltage and electric CUITent can be calculated. Weather condition at the 1st day measurement is complete of cloudy, daylight, overcast and rainy. At 06.30 am, it is measured about 0.0588 V and 0.0923 W/m^2 as output voltage and power sense. Input voltage and current flow in the circuit can be calculated as follows.

$$V_i = 2V_o = 2x0.0588V = 0.1176\text{V} \tag{7}$$

$$I = \frac{V_i}{R_1 + R_2} = \frac{0.1176\text{V}}{200\Omega} = 0.588x10^{-3} A \tag{8}$$

Therefore sense power can be the received power of the logger divide by the area of the sensor and its magnitude is given as follows.

$$\text{P}_{\text{sense}} = \frac{P}{A_{sensor}} = \frac{0.1176\text{V}\text{x}0.588x10^{-3} A}{7.4925\text{x}10^{-4} m^2} = 0.0923 {}^{W}\!/_{m^2} \tag{9}$$

Solar irradiance should be the sense power multiply by correction factor and step time that in this case are about 1003.41 higher than the power.

$$P_{solar} = 1003.41 P_{sense} = 1003.41x0.0923 {}^{W}\!/_{m^2} = 92.6055 {}^{W}\!/_{m^2} \tag{10}$$

In the same manner, the result for the other data calculation is provided in Table III.

TABLE III. DATA CALCULATION

Local time	1st day			2nd day		
	Current (10^{-3}A)	Sense power (W/m^2)	Solar irradiation (W/m^2)	Current (10^{-3}A)	Sense power (W/m^2)	Solar irradiation (W/m^2)
6:00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6:30	0.5880	0.0923	92.6055	0.3920	0.0410	41.1580
7:00	1.1760	0.3692	370.4219	1.3730	0.5032	504.9206
7:30	1.1760	0.3692	370.4219	1.3730	0.5032	504.9206
8:00	1.5690	0.6571	659.3681	1.5690	0.6571	659.3681
8:30	1.5690	0.6571	659.3681	1.5690	0.6571	659.3681
9:00	1.7650	0.8316	834.3945	1.5690	0.6571	659.3681
9:30	1.7650	0.8316	834.3945	1.5690	0.6571	659.3681
10:00	1.7650	0.8316	834.3945	1.7650	0.8316	834.3945
10:30	1.7650	0.8316	834.3945	1.5690	0.6571	659.3681
11:00	1.7650	0.8316	834.3945	1.7650	0.8316	834.3945
11:30	1.9610	1.0265	1030.0000	1.7650	0.8316	834.3945
12:00	1.7650	0.8316	834.3945	1.7650	0.8316	834.3945
12:30	0.7840	0.1641	164.6320	1.7650	0.8316	834.3945
13:00	1.3730	0.5032	504.9206	1.7650	0.8316	834.3945
13:30	0.5880	0.0923	92.6055	1.7650	0.8316	834.3945
14:00	0.9800	0.2564	257.2374	1.5690	0.6571	659.3681
14:30	1.1760	0.3692	370.4219	1.5690	0.6571	659.3681
15:00	1.7650	0.8316	834.3945	1.3730	0.5032	504.9206
16:00	1.1760	0.3692	370.4219	0.1960	0.0103	10.2895
16:30	0.9800	0.2564	257.2374	0.5880	0.0923	92.6055
17:00	0.3920	0.0410	41.1580	0.3920	0.0410	41.1580
17:30	0.1960	0.0103	10.2895	0.1960	0.0103	10.2895
18:00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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Software built in this project has used the formulation to process the raw data from the data logger. The result then will be displayed on the computer. The data on the Table III shows that in two days, maximum power about 1030 W/m2 has been reached at 11:30 am on 1st day measurement.

IV. Conclussion

A data logger based on Atmega8 microcontroller has been build and it had been used to measure solar irradiance in a location close to the Equator. Some conversion has been made to eliminate the limitation of the hardware that can not be used directly to measure solar i1rndiation. The output of the sensor should be multiplied by 1003.41 to give real values. Result of the measurement shows that the designed data logger can work faster and reliable to capture solar irradiation data.

Some improvement should be done to get better performance of the data logger. The logger can also be used as a DAQ and a control device with only replace firmware and upgrading software without hardware changing. The logger also needs a device to calibrate its data, thus it will work perfectly.

Acknowledgment

This project is a part of a project with the contract ID 247/H42/KU/2010. The authors would like to thank to Indonesian Government via DP2M DIKTI that provide fund to conduct this research.

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