Design and Development of an Arduino Based Data Logger for Photovoltaic Monitoring System

N. N. Mahzan, A. M. Omar, L. Rimon, S. Z. Mohammad Noor, M. Z. Rosselan

Faculty of Electrical Engineering
University Teknologi MARA (UiTM) Shah Alam
Selangor, Malaysia

najwa.mahzan@gmail.com

Abstract — This paper describes the design of a general data logger for Photovoltaic (PV) monitoring system that can store bulk data from input channels in large memory storage. It utilizes Arduino Mega 2560 board in conjunction with ATmega2560 chip. For monitoring the related parameters, a 240-W PV system is used where electrical parameters are tapped into the input channels of the data logger. The system will convert the acquired raw data to digital input for data acquisition and will store the data onto SD card. The data logger is also equipped with DS1307 Real Time Clock (RTC) chip for data stamping in the SD card every at the occurrence of the logging process. Results and findings are recorded and compared with the data that was taken by one commercial data logger DataTaker DT80 during the testing stage. This is to test the data reliability as well as to examine the performance of the proposed data logger throughout the testing process.

Keywords - Arduino; data logger; PV monitoring system; microcontroller based monitoring system

I. INTRODUCTION

Data logger has been used widely not only in electronic worlds but in all systems which relates to technology [1]. Due to its capability in storing information for a long time, it is often being used to collect data for a system which relates to electrical parameters and meteorological parameters. Speaking of that, data logger has been used distinctly in monitoring both parameters especially in Photovoltaic (PV) system field. It is very useful for PV system because it has the ability to store a variety of data over an extended long time without fully supervision by a user. As an example, for an Off-Grid PV system, data logger plays important role in logging all the data since the system is located in remote area which is most of the time the place is far from the utility grid. Thus the constant supervision is not worthwhile for a user just to collect the data for observation purposes.

PV system and data logger have been a great companion together as data loggers’ capability to store data over a period of time without regular supervision. These days, PV system has been accepted by the higher authorities in Malaysia and few environmental association as well as industrial organization. Its technology has the possibility in supplying the world’s energy needs in a sustainable and renewable method. Due to that, the PV system needs a reliable method for logging data to store all the electrical and meteorological data for observing and monitoring purpose; a data logger seems to be necessitated in this field.

There are lots of data loggers produced in many electrical and electronics company and researchers to cater the PV system demands. Everything has its own flaws including the data logger itself. In a bright side, the flaws are covered by other advantages presented in the data logger produced. For example, some of them are having large data storage system but lack in input channels [2-8] and some of them are having lots of data input but shortage in memory storage [2, 4, 8-14]. Many high quality data logger are equipped with sophisticated communication unit where sometime it is not really necessary for monitoring PV system [8, 15-19]. And what is more to be bothered is the price which is a little bit expensive [1, 8, 9, 19, 20] suitable with the extra features it has. There are some parameters which are not related to PV systems and happen to be embedded together with the data logger [21].

Few existing data loggers in market are able to cater all the parameters in PV system. One of the problems is they have limited memory size. For instance DataTaker DT80 where the internal memory size is only 128MB [22]. With regards to that, the limitation of data is that can be stored into the data logger will be decreased in number provided that the sampling time and logging time are as low as 1 second. As per stated in the DataTaker DT80 manual, for 1 second scan rate of data, the storage can fill up to 9 hours of reading the whole data [22]. Any other example of existing data loggers in market is Squirrel SQ2020 Data Logger which has 128 MB for internal memory where can store up to 14 million of readings [23] and it has external memory too which is up to 1 GB that merely works for transferring data from internal memory and anything related to storing setups only.
II. DEVELOPMENT OF THE DATA LOGGER

Fig. 1 shows the block diagram for the proposed data logger where it consists of microcontroller, SD card, RTC and sensors.

![Block diagram for the proposed data logger](image)

Figure 1. Block diagram for the proposed data logger.

A. Microcontroller

In this proposed data logger, Atmel ATmega 2560 has been chosen to be the main microcontroller by referring to the past reviews by other researchers. According to [24, 25], a high performance and a low usage of power of microcontroller is needed to build a fast as well as little cost used and it was chosen by many for their researches. The important elements that the microcontroller has are a stable of analog to digital converter (ADC) and universal synchronous and asynchronous serial receiver and transmitter (USART). Besides, the bigger number in input/output (I/O) that ATmega 2560 had made many researchers choose it over other boards. As per written by [26], ATmega 2560 contributes incredibly in electronics control applications such as data logging, data acquisition system and many more as it is well known for its economical and greatly-flexible chip amongst electrical circuit designer. Apart from that, the chip is always referred as a high performance microcontroller and it was totally seconded by many other researchers to have a great performance microcontroller in their researches [2, 10, 17, 27-31]. Furthermore, by performing powerful instruction in a single cycle, the chip manages throughputs approximating 1 MIPS per MHz, thus will balance the power consumption and the processing speed [27, 32].

B. Time stamp

For this prototype data logger, real time clock (RTC) PROTO board has been chosen for time stamping purpose. The product was produced by MikroElektronika© and it includes PCF8583 which is a calendar and clock chip with I2C interface. One of the features that the chip offers is able to manage the current time even when the microcontroller is not operating. The real-time clock is operated by one particular battery which is not linked to the power supply. Thus, the date and time for each data will not be affected whenever power is disconnected from the circuit. Two pieces of 10K pull-up resistors are placed in between the connection of SCL and SDA from PCF8583 to the pins from ATmega 2560. The pull up resistors are needed for a smooth process in the I2C bus [7]. In addition, a crystal of 32.768 kHz is utilized in allowing timing pulses to the RTC chip.

C. Data storage

Two 4GB size of SD cards are used to store all data received from sensors. The reason of choosing only two SD cards are because to test the ability of the memory storage of the data logger can cater throughout logging and storing process. Certainly the SD card can be placed in the data logger as many as possible due to its Serial Peripheral Interface (SPI) pins which can be shared to many slaves; provided that the digital pin for Chip Select (CS/SS) is sufficient in the microcontroller.

D. Proposed data logger

The complete proposed data logger is shown in Fig. 2. While the schematic diagram of the data logger connected to the PV system during testing session is presented in Fig. 3.

![Schematic diagram of the proposed data logger connected to the PV system for testing.](image)

Figure 2. Complete proposed data logger

Figure 3. The schematic diagram of the proposed data logger connected to the PV system for testing.

III. SOFTWARE DEVELOPMENT

Arduino Integrated Development Environment (IDE) is chosen for constructing the codes for the proposed data logger. Fig. 4 shows a brief of software procedure to be referred at before constructing code in the Arduino IDE.
In the beginning of the code, after every variable is initialized, the program will receive a choice from users to pick either logging mode or downloading mode. Logging mode is where the data logging process occurs and the latter one is for downloading existing data in the data storage; i.e. SD card. If users chose for downloading data, the logging process will stop for a while and if the logging mode is selected, then the program will ask users to write input for the next options such as number of channel that is going to use and logging time. An estimated days for data logger can log the data will be calculated and displayed by using the following formula [8]. The program will then check the availability of SD card 1. If the first SD card is available which means not in faulty mode and exists in the SD slot, then the program will check either the size of the SD card is acceptable for storing data. If both conditions are true, then the program will check either the filename based on current date in the SD card existed, if it is not true, the program will quickly make a new filename so that all data can be stored inside the new file. Later, the program will then recheck the availability of the SD card and the free space that it holds before reading sensors stage occurs. After the program reads the sensors, all the data received will directly send to the memory storage for storing purpose. If any of these conditions are not fulfilled, the program will instantly check for another SD card; which is SD card 2 to be activated. The data logging process will take place until the free space in each of the SD cards is full, faulty or brought out.

For getting the formula to calculate estimated days for data logger to logging, one test had been done purposely to check the size of each cell involved during the logging process. For one cell of date and time, the size was constantly showed 19 bytes while other cells each contributes 7 bytes. Thus, the formula is as follows,

\[
\text{Estimated duration} = \frac{\text{Total capacity size of SD card}}{37m + \left(\left[7n + 19\right] \times 24 \times 60 \times 60\right)} \times m
\]

where

- \(m\) = logging time [sec]
- \(n\) = number of channel.

IV. RESULTS AND DISCUSSION

Electrical parameters for one small PV system of 240W power were measured synchronizes with measurement from existing commercial data logger, DataTaker DT80 at the same system. This is to test the reliability of the data logged by the proposed data logger as well to check its performance during logging process. The results were shown in Fig. 5-8.
Based on the graphs, the red lines are showing the data obtained from DT80 while the blue lines are from the proposed data logger. The acquired data from the proposed data logger are seemed almost the same like what DT80 has been recorded. The percentage error for each graph by comparing the average data taken from both data loggers are in the range of 0% to 1.4%.

V. CONCLUSION

The purpose of the study was to design a workable and reliable data logger with its performance is synchronized with other existing data logger in the market. The development of the proposed data logger with Arduino-based microcontroller is justified reliable in monitoring the PV system according to the results obtained. Besides, the proposed data logger was able to get nearly ±0.5% accuracy by comparing the data obtained from the proposed data logger with the data acquired from existing data logger in market, DT80.

ACKNOWLEDGMENT

Authors gratefully acknowledge the support of all members in Green Energy Research Centre (GERC) UiTM Shah Alam that assisted in making the project successful.

REFERENCES


