IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-7, Issue-4, April 2019 E-ISSN: 2347-2693

Design and Development of PV Solar Panel Data Logger

Tarun Singh[1*], Ritula Thakur[2]

[1]Electrical Engineering, Government Polytechnic College, Jhalawar, India
[2] Electrical Engineering, National Institute of Technical Teachers Training and Research, Chandigarh, India

[*]*Corresponding Author: taruranjana@gmail.com, Tel.: +91-94603-18756*

DOI: https://doi.org/10.26438/ijcse/v7i4.364369 | Available online at: www.ijcseonline.org

Accepted: 14/Apr/2019, Published: 30/Apr/2019

***Abstract*—** Data logging are an important aspect in a modern day measurement and instrumentation system. Almost all the industrial process requires data logging. Nowadays, cheap and feasible solution of data logging in industrial and scientific process is a difficult task with proprietary data logger. In this research paper, we proposed the design and development of two channel data logger which provide the cheap and feasible solution for monitoring and recording the voltage, current, power and energy of two PV solar panels. The designed prototype data logger is based on Arduino UNO and facilitated the data logging on SD card or on the memory of Bluetooth enabled android mobile phone. Remote monitoring and recording of data is possible with this data logger. The design of this data logger is completely based on the open source software and hardware devices instead of proprietary hardware devices and commercial software. Measurement and monitoring of voltage, current, power and energy of two PV solar panels and its logging on suitable electronic medium are smart features of this data logger.

***Keywords*—**Data Logger, Arduino UNO, SD card, Bluetooth Module HC-05, DS-3231 Real Time Clock

I. INTRODUCTION

The importance of data logger is very wide in industrial and scientific work. It records the data of measurements over certain specified time. Data logger provides the monitoring and logging of data by using transducers, computer and sensors. The designed data logger records the value of real time, voltage, current, power and energy related to two PV solar panels simultaneously. The suggested design of Arduino UNO based data logger facilitates the recording of performance analysis parameter of two PV solar panels on SD card as well as on the memory of mobile phone with wireless transfer facility through Bluetooth module. Arduino is widely used in the embedded design of various applications and both open source hardware and software facility is available on Arduino platform. Inbuilt facility of analog to digital converter in Arduino board provides the easy interfacing of sensors and real time clock to Arduino board and this feature makes Arduino most suitable for data logger application.

USB based data loggers are reusable, compact and portable, and offer easy installation and low cost solution of data logging. Internal and external transducers can be used with USB data logger. Internal sensor model of USB data logger monitors the process near the data logger location while USB data loggers based on external sensors are used to monitor the process far distance from the data logger location. Recorded data on USB data logger can be transferred to Pen drive or connecting the data logger to a computer via USB port. USB port provides the direct interfacing of data logger with computer.

Bluetooth low energy based data loggers can transmit and measure the data wirelessly to Bluetooth enabled mobile devices such as mobile phone over 10 meters distance range. Bluetooth based data logger transmit the data in ISM band from 2.400 to 2.485 GHz range and uses UHF radio waves.
The design of Arduino UNO based data logger in suggested work is based on USB and Bluetooth based data logger and facilitated the transfer of data to computer via SD card, USB port or Bluetooth. The design of suggested data logger is simple and cheap and complete assembly uses Arduino UNO module, DS3231 real time clock, Nokia 5110 LCD, resistance potential divider, ACS712 Hall effect current sensor, HC-05 Bluetooth module and SD card module. The real time electrical parameters of PV solar panel can be wirelessly transferred to Bluetooth enabled android phone. Display and storage of data on android phone are easy with open source Blue terminal android application. This application provides the Bluetooth connection terminal, data display terminal and data storage facility on mobile phone. Data file is saved in text format on SD card and this text file can be easily changed in excel format for analysis work.

This paper is arranged into four sections. Related work on data logger is explained in section II and many literatures including research papers, textbooks, journals, proceeding,

reports and websites have been reviewed by the author in this section. Section III explains the methodology related with suggested work. Section IV demonstrates and explains the results and discussion. The conclusions that have been drawn out from suggested work are explained in section V. Some references used by the author in this research work are given in last section.

II. RELATED WORK

N. N. Mahzan et al. in [1] designed and developed the Arduino Mega 2560 based data logger that was used to monitor the related parameters of 240-W PV system. The design of data logger was reliable, and its performance and accuracy were comparable with commercial data logger.

Shubhankar Mandal et al. in [2] discussed about the sun tracking of PV solar panel and its data acquisition system. The use of proprietary software LabVIEW and open source hardware Arduino help in the design of sun tracking PV solar panel and simulation of real time data acquisition. Real time values of voltage can be imported from LabVIEW to excel sheet. Introduction of two Arduino modules simultaneously serve the sun tracking and data acquisition system.

Aboubakr El Hammoumi et al. in [3] developed the real time virtual instrumentation system for PV solar panel characteristic. Low cost virtual instrumentation system for PV solar panel characteristic can be developed with the use of Arduino and Excel.

S. Fanourakis et al. in [4] proposed the method of data acquisition system for PV solar panel. Interfacing of the external sensors with Arduino not only measures and records the electrical parameters of PV solar panel but also measures and records the physical parameters like temperature, humidity, velocity etc.

Nyoman Sugiartha et al. in [5] had discussed that sensors based data acquisition system removes the need of conventional instrument such as thermocouples and multimeters for data collection of PV solar panel. Embedded data acquisition system based on external sensors and Arduino serve to record the voltage, current, temperature and humidity related with PV solar panel. Each parameter is recorded after 10 minute on SD card.

S. S. Pawar et al. in [6] had discussed that study of the relationship between the voltage generated by PV solar panel and its surrounding temperature can be performed with Arduino based data logger.

M. Fuentes et al. in [7] design and develop the cheap Arduino based data logger for PV panel and discussed that Arduino based data loggers are cheap and solve the problem of monitoring the PV solar panels system in remote and detach area. This type of cheap data logger can serve the solar energy research and applications in developing countries.

Pallavi Soni et al. in [8] had discussed the data logger interfacing with computer and remote data hub. A combination of analog to digital converter and microcontroller provides the cheap solution of data acquisition system and data can be analyzed on the computer through RS232 port.

Wai Mar Myint Aung et al. in [9] designed and developed the solar PV data monitoring system. Interfacing of display devices such as LCD is easy with Arduino and implementation of PV solar data monitoring system is simple and easy. Graphical display represents the real time data in graphics and pictures form that further helps in analysis and triggering.

Patricia A. Beddows et al. in [10] presented the design and execution of low cost data logging platform for environment monitoring system. Power optimization techniques help to improve the operating life of data logger in alkaline environment. PVC casing help to improve the operating life of data logger.

Muhammad Abu Bakar Sidik et al. in [11] had designed and developed the data logger for atmospheric electric field activity measurement. Atmospheric electric field sensors can easily interfaced with Arduino based data logger that helps to observe the collected data from atmospheric electric field sensors. GPS equipped data logger provides the accurate position of collected data with time and position stamping.

The investigator envisages to design and develop the Arduino UNO based data logger that facilitate the data logging of performance analysis parameters i.e. voltage, current, power and energy produced by the two PV solar panels. All the performance parameters will be logged on the SD card or on the memory of mobile phone and analyzed on computer. Provision for data logging of performance analysis parameter of PV solar panel will be made by adding the SD card module and Bluetooth module in Arduino UNO board so data can be stored on SD card or on the memory of mobile phone.

III. METHODOLOGY

The methodology adopted to develop the proposed data logger will include the following activities:

- Two Hall Effect current sensors ACS712 and Two potential divider circuits are used in the design of data logger. Hall Effect current sensor ACS712 provides the output voltage that is accurately proportional to output current of PV solar panel. Output voltages of Hall Effect current sensors ACS712 are applied to the respective analog input pins of Arduino UNO module for conversion, storing, analyzing, measuring and calculating the

value of currents produced by PV solar panels. Potential divider circuit consists of two resistances connected in series. Potential divider provides an output voltage that is accurately proportional to the voltage applied across it. Voltage generated by PV solar panel can be applied across the potential divider which gives proportional output voltage below 5 volt. These proportional output voltages of potential dividers are applied to the respective analog input pins of Arduino UNO module for conversion, storing, analyzing, measuring and calculating the value of voltages produced by PV solar panels. The figure 1 and 2 shows the potential divider and ACS712 Hall effect current sensor, respectively.

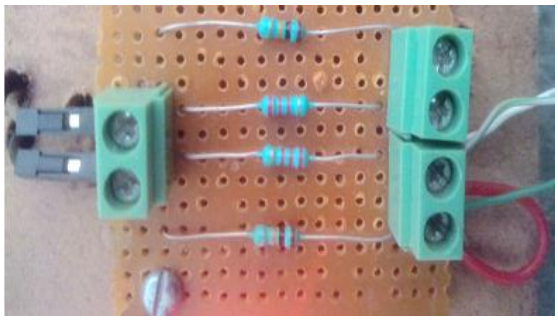

Figure 1. Potential Divider

Figure 2. ACS712 Hall Effect Current Sensor

- Coding and burning of the machine code in Arduino UNO module is done for displaying, storing, calculating and wirelessly transmitting the values of current, voltage, real time, power, energy and special character "NITTTR CHD". Program code for data logger is written in 'C++' programming language on Ardiuno integrated development environment platform and same platform is used to programme the Arduino UNO.
- DS3231 real time clock is interfaced with Arduino UNO module for updating the real time. The update of real time helps in the energy measurement calculations. The SDA and SCL pins of DS3231 real time clock are connected to A4 and A5 pins of Arduino UNO board, respectively. DS3231 provides real time to Arduino UNO through program commands that helps in real time calculation of energy. Figure 3 shows the DS3231 real time clock.

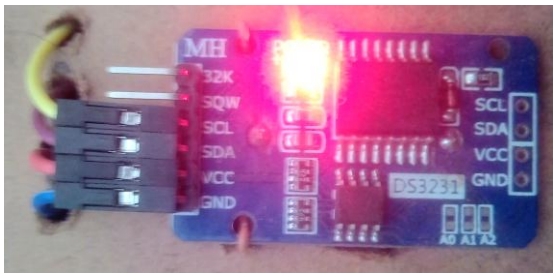

Figure 3. DS3231 Real Time Clock

- Nokia 5110 LCD is interfaced with Arduino UNO module for displaying various performance parameters like real time, voltage, current, power and energy generated by the two PV solar panels. Figure 4 shows the Nokia 5110 LCD which display the real time, special character "NITTTR CHD" and the values of voltage, power, current and energy produced by two PV solar panels.

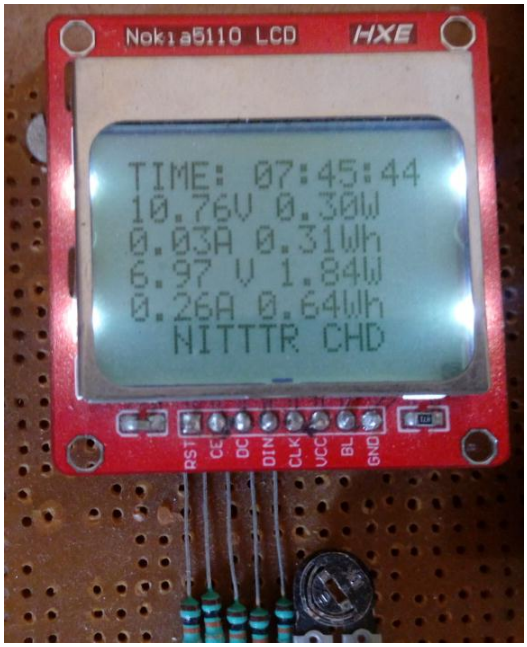

Figure 4. Nokia 5110 LCD

- Micro SD card module is interfaced with Arduino UNO module for storing various performance parameters like real time, voltage, current, power and energy produced by the PV solar panel. This micro SD card module support 16 GB capacity micro SD card. Figure 5 shows the Micro SD card module.

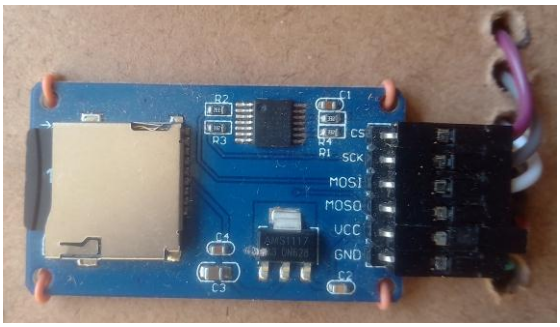

Figure 5. Micro SD card module

- HC-05 Bluetooth module is interfaced with Arduino UNO module for wirelessly transmitting the various electrical performance parameter like real time, voltage, current, power and energy produced by two PV solar panels. Blue term android application is used for establishing the wireless communication between android mobile phone and HC-05 Bluetooth module. HC-05 provides the two way communication. Figure 6 shows the HC-05 Bluetooth module.

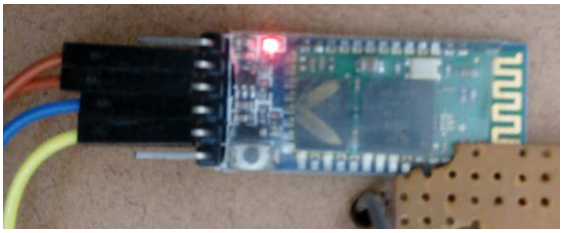

Figure 6. HC-05 Bluetooth Module.

- The readings of various performance parameter like real time, voltage, current, power and energy produced by the PV solar panels are recorded on SD card at everyone second interval and wirelessly transferred to external Bluetooth enabled mobile phone for display and storage. Figure 7 shows the mobile phone screen on which various real time data of two PV solar panels can be seen.

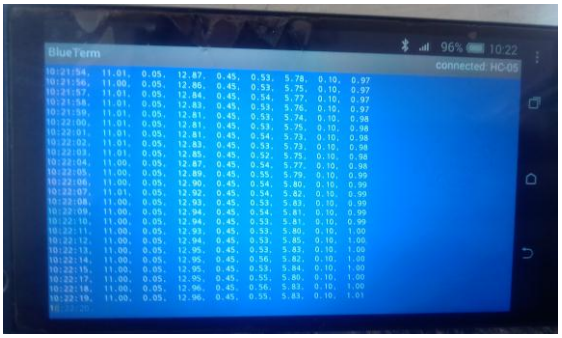

Figure 7. Mobile Phone Screen

The functional block diagram of proposed Arduino UNO based data logger is shown in figure 8.

Hall Effect current sensors and potential divider circuits provide the suitable value of the voltages and currents to Arduino UNO board from the PV solar panel. Load current of the PV solar panel is passed through the ACS712 Hall effect current sensor. This current sensor can measure the current in the range of 0A to 20A and gives the corresponding linearly variable output voltage in the range of 2.5V to 5V. Voltage produce by PV solar panel is applied across resistance potential divider. Resistance potential divider consists of two series connected resistance of the value of 2.2 KΩ and 10 KΩ and output is taken from series junction point. This resistance potential divider gives the output voltage in the range of 0 to 5 volt for input voltage range of 0 to 27.72 volt. Voltages and currents under test are measured by Arduino UNO and provide the real time value of voltage, current, time, power and energy of the both PV solar panel.

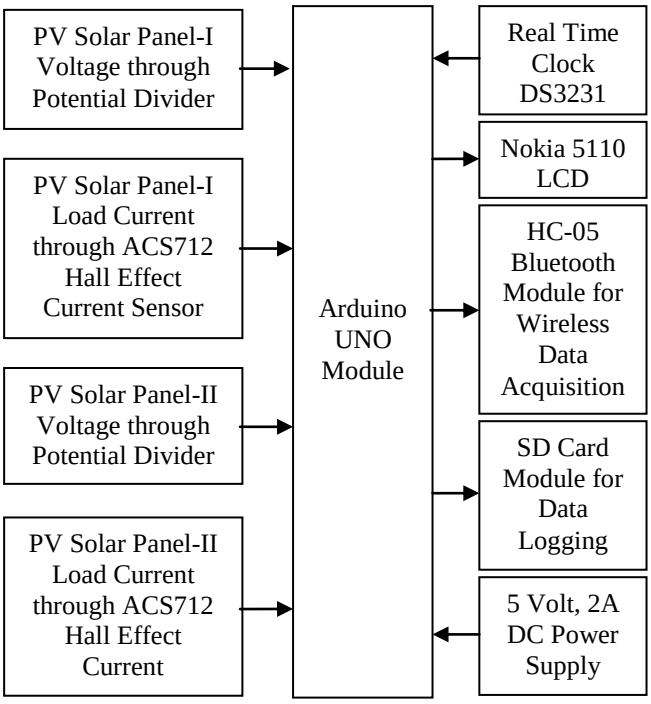

Figure 8. Block Diagram of Data Logger

Real time clock has been providing the current time to Arduino UNO module. Liquid crystal display has used to display the various measuring parameters of PV solar panel. Bluetooth module wirelessly transfers the various electrical measured parameters to an android phone where these parameters are available for displaying on mobile phone screen and storing on mobile phone memory.

Figure 9 shows the complete circuit assembly of designed data logger.

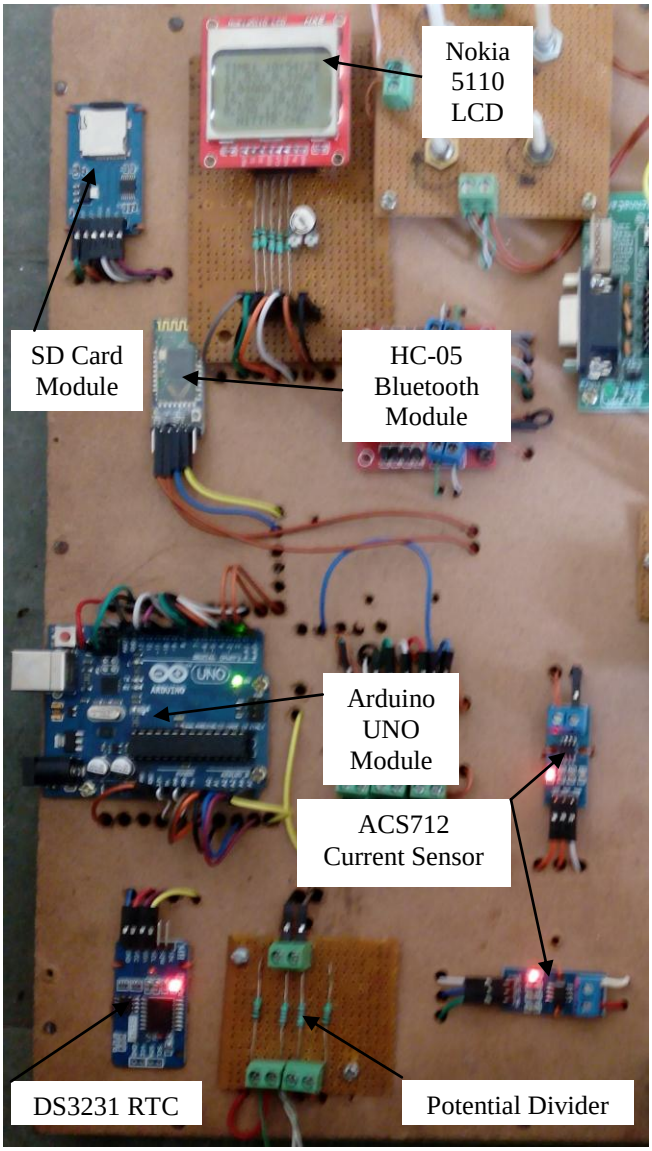

Figure 9. Complete Circuit Assembly of Data Logger

IV. Results and Discussion

After designing and modeling the Arduino based data logger, the data logging of electrical parameters of PV solar panel are implemented successfully. Nokia 5110 LCD in designed data logger was displaying the current time on the first row, current and energy of PV solar panel-I in second row, voltage and power of PV solar panel-I in third row, voltage and power of PV solar panel-II in fourth row, current and energy of PV solar panel-II in fifth row and special character "NITTTR CHD" in sixth row. The same displayed data was transferring successfully to Bluetooth enabled android phone via HC-05 Bluetooth module and was storing on the memory of mobile phone. Similarly, the same data was recorded on SD card. At the time of 07:45:44, the designed data logger was displaying and logging the values of 10.76 Volt, 0.30 Watt, 0.03 Ampere, 0.31 Watt Hour, 6.97 Volt, 1.84 Watt, 0.26 Ampere and 0.64 Watt Hour. Analysis of recorded data can be done on computer. The designed data logger is cheap, robust and does all required functions of data logging. The calibration of data logger is easy and can be done by modifying the formulae of calculations used in the programming of data logger. Direct interfacing of sensors with data logger makes this data logger most efficient and useful in the data acquisition of electrical parameter of PV solar panel.

V. Conclusion and Future Scope

Arduino platform provides the open source software and hardware facility to all applications. Arduino based data logger is fully analyzed for conversion, storage, measurement and calculation of various electrical parameters of two PV solar panels. Inbuilt Analog to Digital converter in Arduino UNO module makes it most useful for data logger application. The designed data logger is found to be compatible to proprietary data logger and serve all the desired functions. The operation and working of designed data logger are found to be satisfactory and the designed prototype data logger has successfully been made to work as proprietary data logger.

This suggested work holds many future possibilities regarding the cheap data logging and monitoring of electrical and physical parameters. In future, we expect to provide an interfacing of internet of things, wireless sensors and wireless relays in the designed data logger which can perform the remote functions of monitoring, data logging and measurement of electrical and physical parameters of PV solar panel. Protection circuit operations with wireless relays could be examined in future work and different physical parameters like temperature; wind speed etc. could be analyzed in further research work. Automatic process control through wireless control could be examined in future research work. The effect of weather conditions was not considered in the design and development of data logger and its working in different weather condition could be examined. The programming of designed data logger is related to data logging of direct current quantity of PV solar panel only and in future, it could be easily modifying to measure the other physical quantity.

References

[1] N. N. Mahzan, A. M. Omar, L. Rimon, S. Z. Mohammad Noor, M. Z. Rosselan, "*Design and Development of an Arduino Based Data Logger for Photovoltaic Monitoring System*", International Journal of Simulation Systems, Science, and Technology, Vol. **17,** Issue. **41**, pp. **15.1-15.5**, **2017**.

[2] Shubhankar Mandal, Dilbag Singh "Real Time Data Acquisition of Solar Panel using Arduino and Further Recording Voltage of the Solar Panel", International Journal of Instrumentation and Control Systems, Vol. **7,** Issue. **3**, pp. **15-25**, **2017**.

[3] Aboubakr El Hammoumi, Saad Motahhir, Abdelilah Chalh, Abdelaziz El Ghzizal, Aziz Derouich, "*Low-Cost Virtual Instrumentation of PV Panel Characteristic using Excel and Arduino in Comparison with Traditional Instrumentation*", Renewables: Wind, Water and Solar, Vol. **5,** Issue. **3**, pp. **2-16**, **2018**.

[4] S. Fanourakis, K. Wang, P. McCarthy, L. Jiao, *"Low-Cost Data Acquisition Systems for Photovoltaic System Monitoring and Usage Statistics*", IOP Conference Series: Earth and Environment Science, Vol**. 93,** pp**. 1-10**, **2017**.

[5] Nyoman Sugiartha, I Made Sugina, I Dewa Gede Agus Tri Putra, Made Alwin Indraswara, Luh Ika Dhivtyasari Suryani, *"Developement of an Arduino-based Data Acquisition Devices for Monitoring Solar PV System Parameters*", Proceedings of the International Conference on Science and Technology, Vol**. 1,** pp**. 995-999**, **2018**.

[6] S. S. Pawar, Akash Yadav, Darshana A. Marathe, Neha D. Vyavhare, "*Data Logger for Solar Photovoltaic Power Stations*", International Journal of Electronics, Electrical and Computational System, Vol. **7**, Issue. **3**, pp. **428-435**, **2018**.

[7] M. Fuentes, M. Vivar, J. M. Burgos, J. Aguilera, J. A. Vacas, "*Design of an Accurate, Low-Cost Autonomous Data Logger for PV System Monitoring using Arduino™ that Complies with IEC Standards*", Solar Energy Materials & Solar Cells, Vol. **130,** pp. **529-543, 2014**.

[8] Pallavi Soni, Gautam Gupta, Vishal Sarode, Shravil Kapoor, Sushma Parihar, "*Data Logger Module for Data Acquisition System*", International Journal of Application or Innovation in Engineering and Management, Vol. **4,** Issue. **4,** pp. **254-259**, **2015.**

[9] Wai Mar Myint Aung, Yadanar Win, Nay Win Zaw, "*Implementation of Solar Photovoltaic Data Monitoring System*", International Journal of Science, Engineering and Technology Research, Vol. **7,** Issue. **8,** pp. **591-596**, **2018**.

[10] Patricia A. Beddows, Edward K. Mallon, "*Cave Pearl Data Logger: A Flexible Arduino-Based Logging Platform for Long-Term Monitoring in Harsh Enviornments*", Sensors, Vol. **18,** Issue. **2,** pp. **2-26**, **2018.**

[11] Muhammad Abu Bakar Sidik, Mohd Qamarul Arifin Rusli, Zuraimy Adzis, Zolkafle Buntat, Yanuar Zulardiansyah Arief, Hamizah Shahroom, Zainuddin Nawawi, Muhammad Irfan Jambak, "Arduino-Uno Based Mobile Data Logger with GPS Feature", Telkomnika, Vol. **13,** Issue. **1,** pp. **250-259**, **2015.**

