American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-8, Issue-8, pp-111-117
www.ajer.org
Research Paper Open Access

PC Based wireless remote monitoring system for photovoltaic (PV) panel efficiency analysis

Md. Atiar Rahman[1*],Satarupa Sarker[2],Md. Ahasan Habib[2], Md. Abdullah Al Mamun[1], Sabiha Sattar[1], Mohaimina Begum[1],Md. Serajus Salekin Chowdhury[3]
[1]Electronics Division, Atomic Energy Centre Dhaka,Shahbagh, Dhaka-1000, Bangladesh
[2]Physics Discipline,Khulna University, Khulna-9208,Bangladesh
[3]Plasma Physics Division, Atomic Energy Centre Dhaka, Shahbagh, Dhaka-1000, Bangladesh
Corresponding Author: Md. Atiar Rahman

ABSTRACT : *This paper presents a wireless remote monitoring system for photovoltaic (PV) panel efficiency analysis in terms of its output power i.e. output voltage and current of the panel and irradiance power of light. Electric power output of the PV panel is calculated by measuring its output voltage and current using a simple voltage divider as voltage sensor and a hall current sensor module. Irradiance power is calculated from light intensity measurement using a light sensor module. A low cost microcontroller ATmega8 is used for acquiring and processing of necessary data from the sensors. A liquid crystal display (LCD) is used for displaying the processed data. A radio-frequency (RF) data transmitter and receiver module is used for transmitting the necessary data to remote monitoring unit. For further analysis and archiving purposes, remotely received data has been transferred to PC with graphical user interface program LabVIEW (Laboratory Virtual Instrument Engineering Workbench) through USB to serial converter. The device has advantages in terms of its memory capacities, on-device display, low cost locally available components and portability. The designed system can be effectively used for selection of proper solar panel and also for the maintenance and improvement of the solar power system through analysis of the parameters (both locally and remotely) and usage statistics.*

KEYWORDS:*Photovoltaic panel efficiency, current sensor, voltage sensor, light sensor, LabVIEW.*

Date of Submission: ~~05-08-2019~~22-07-2019 Date of Acceptance: 20-08-2019

I. INTRODUCTION

Solar energy is the most useful resource of renewable energy. Using data processing and applying computer algorithms it can be possible to make this energy system more efficient [1,2]. PV is a method that is unique and distinctive in harnessing the sun's energy. One of the results that should be taken into account in the use of solar panel is the efficiency of the solar panel itself, because efficiency refers to the amount of light of the whole module that turns it into electricity [3]. Knowing the efficiency of solar panel is important in order to get maximum benefit from the solar system. Although, the manufacturer provides the efficiency rating of solar panel, we should have a way to verify it. Moreover, we should have a way to know proper time for repair and maintenance of the solar system. This demands the design of PC based wireless photovoltaic panel efficiency analysis system. The developed system can be used as standalone to measure solar efficiency or can be used as pc based wireless remote system for further analysis of various parameters. It helps us to acquire output electric power, solar irradiance power and efficiency of the panel.

If we search for previous history, we can find out works on solar efficiency measurement, monitoring and analysis. Tansu Filik and Ümmühan Baaran Filik concluded their solar efficiency analysis study as, “the tracking system’s power generations are always higher than fixed one” [4]. Pabbaraju Padmaja and Mandarapu Udaya Shamili designed a system for monitoring and control the variable of the PV system [5]. Martín E. Andreoni López et. al. implemented a system for wireless remote monitoring and control of a solar photovoltaic distributed generator (PV-DG) for microgrids applications [6]. Nur Adilah A. R. et. al. developed a system that will notify the user when efficiency of solar panel falls below a certain level via GSM (Global System for Mobile communication) network [3]. In this work, the authors utilized the output of a light dependent resistor (LDR) and a humidity sensor to represent panel efficiency, which is not a proper way to calculate photovoltaic panel efficiency. P. Pal Pandian et. al. designed a IoT(Internet of Things) based remote monitoring system for photovoltaic panels [7], which is more expensive and s complicated in design. Ersan Kabalci et. al. designed a remote monitoring system that will monitor current, voltage and power magnitudes of the PV panel [8]. In our work, we have employed voltage sensor and current sensor module (ACS712ELCTR-20A-T) to measure output voltage and current, in other word the electric power of solar panel. We also have implemented light sensor module (BH1750) to measure light intensity in order to calculate irradiance power in an effective way. Thus, it is possible to measure output electric power, solar irradiance power and efficiency of the panel in an efficient manner. Also, cost effective RF transmitter and receiver modules (KST-TX01and KST-RX806) are used for transmitting the necessary data to remote monitoring unit.

II. METHODOLOGY

Hardware Design:

Data acquisition and transmission unit (DATU) is designed for measuring necessary data to calculate efficiency of solar system. Functional block diagram of data acquisition and transmission unit is shown in Figure 1. It is shown in Figure 1 that data acquisition and transmission unit is directly connected with solar panel which consists of a AVR series microcontroller ATmega8, a hall current sensor module ACS712ELCTR-20A-T, digital light sensor BH1750, a simple voltage divider as voltage sensor, a LCD display and a RF transmitter module KST-TX01.

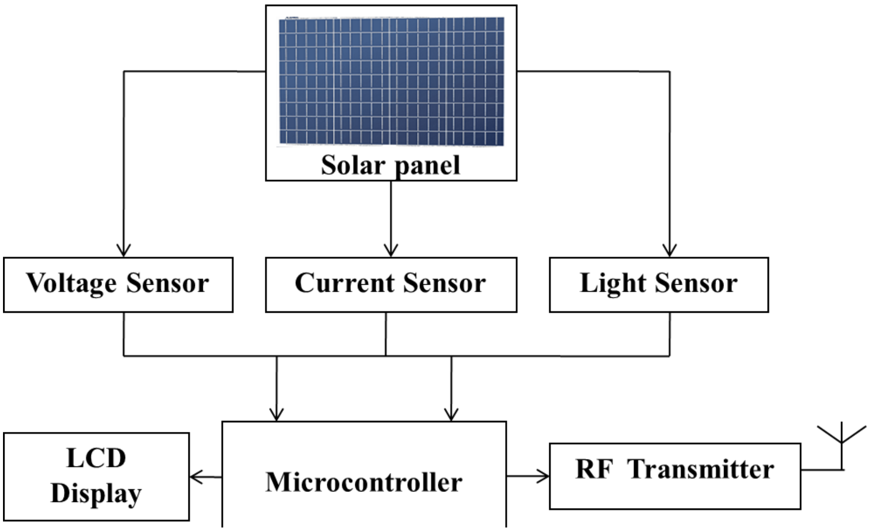


Figure 1: Data acquisition and transmission unit (DATU)

Figure 2 shows the schematic diagram of data acquisition and transmission unit. ACS712ELCTR-20A-T hall current sensor module is used to measure the current from the solar panel. Output of hall current sensor module provides an analog voltage proportional to measured current. It is capable of measuring ± 20A current corresponding to the analog output 100mV / A [9]. A voltage divider with 10 kΩ and 2.2 kΩ resistors are used as voltage sensor in order to measure output voltage of solar panel. Then, the electric power (EP) output from the solar panel is calculated using the simple formula, EP = (I × V) watt. Where EP is the electric power in watt, I is the current in ampere and V is the voltage in volt. BH1750 digital light sensor module is used to measure irradiance power. BH1750 uses Inter-Integrated Circuit (I^2C) protocol to measure ambient light illuminance with wide range and high resolution (1-65535 lx). The amount of illuminance for a given amount of irradiance is 683.002 lux per 1 w/m^2 [10]. Then the irradiance power (IP) is calculated using the formula, IP = (Measured Illuminance (MI)/683.002) W/m^2.Then the efficiency of solar panel is calculated using the formula, Solar panel efficiency = (EP/ IP × Area of Panel)) × 100%.

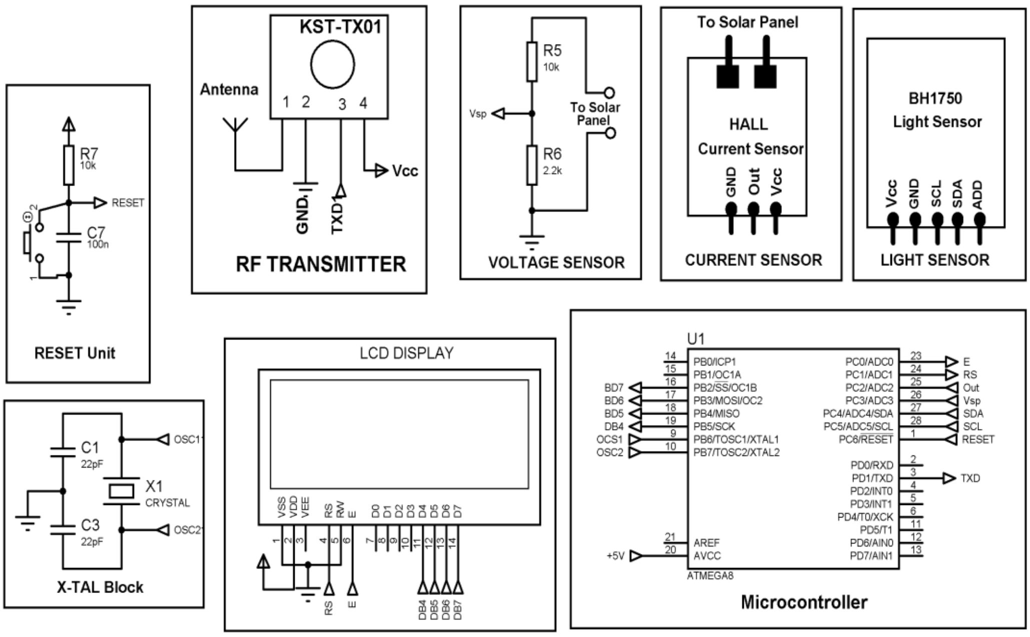


Figure 2: Schematic diagram of data acquisition and transmission unit

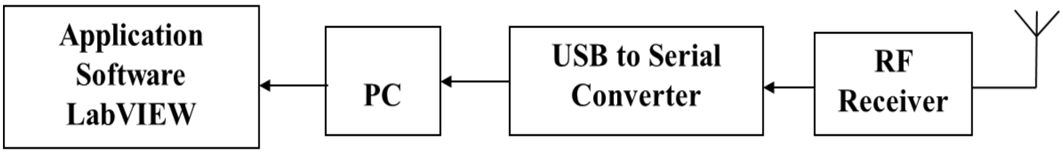


Figure 3: Data reception and presentation unit

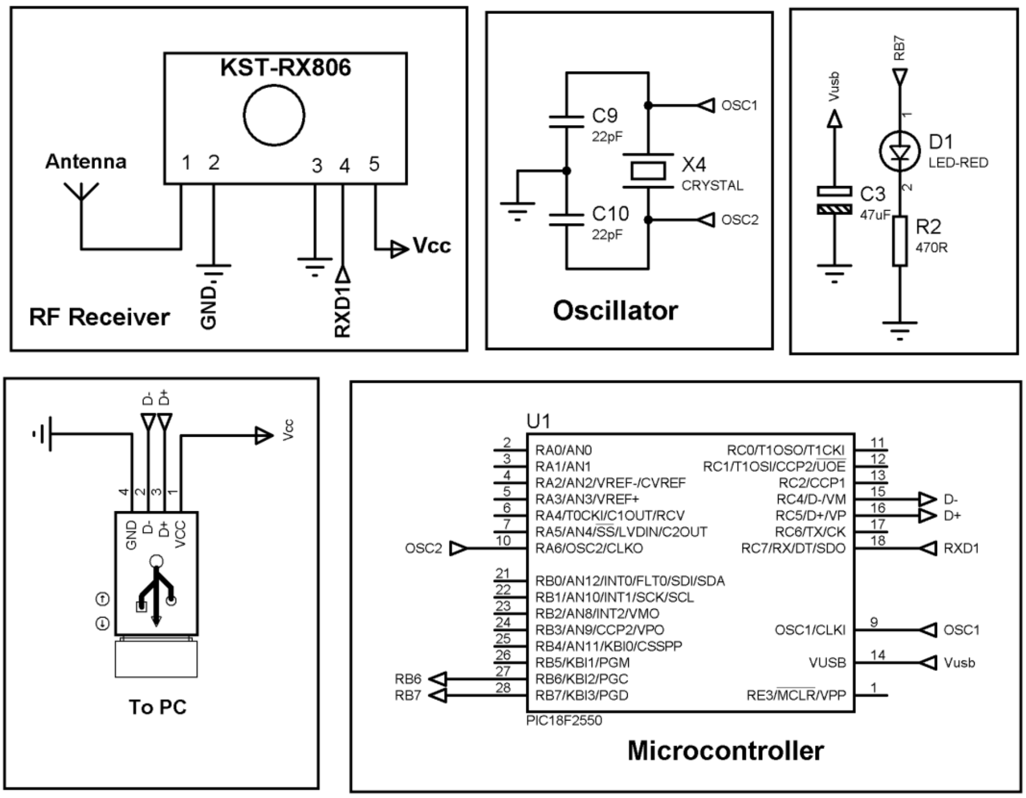


Figure 4: Schematic diagram of data reception and presentation unit

A LCD display is used to present the measured data locally. KST-TX01 transmitter module is used to transmit the data at remote data reception and presentation unit (DRPU) for further analysis and storing of data. Thus the function of DATU is to acquire necessary sensors data to measure output electric power, solar irradiance power and efficiency of the panel and display them to a LCD. Thus, DATU is providing the designed system a stand-alone functionality. At the same time this unit is transmitting the data to remote DRPU using RF transmitter for further analysis and archiving of data.

Figure 3 shows the functional block diagram of remote DRPU. This unit consists of a KST-RX806 RF receiver module for receiving data sent from DATU, a USB to Serial converter for transferring the received data to a personal computer (PC) and a PC with application software LabVIEW. Schematic diagram of DRPU is shown in Figure 4.

Software Design:

The Solar panel efficiency analysis system is made up of hardware and software to give a productive and flexible solution. Schematic circuit diagram and printed circuit board (PCB) for both DATU and DRPU are designed using Proteus-8 Professional software. Firmware for microcontroller is designed using BASCOM-|AVR IDE. Flowchart for data acquisition from current sensor, voltage sensor and light sensor is shown in Figure 5.

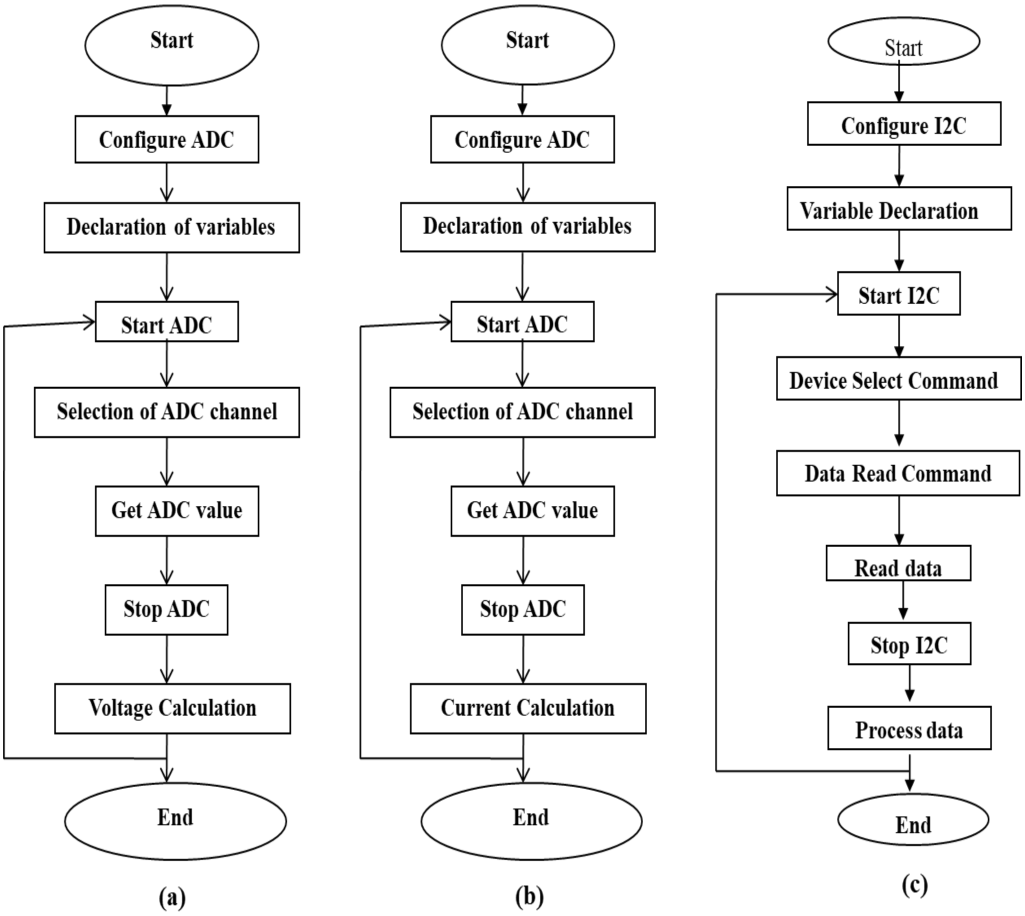
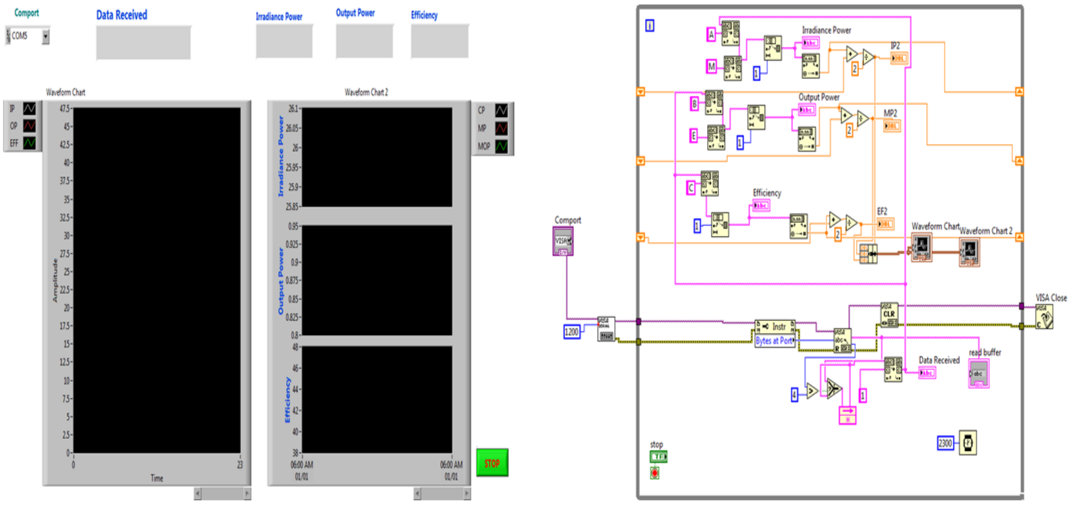


Figure 5: Flowchart for (a) Voltage sensor, (b) Current sensor and (c) Light sensor

The user interface i.e. the application software for pc is designed using LabVIEW (Laboratory Virtual Instrument Engineering Workbench). LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine the order of program execution, LabVIEW uses dataflow programming, where the flow of data through the nodes on the block diagram determines the execution order. The user interface is known as the front panel. The graphical source code for user interface is known as block diagram. Front panel (without data) and block diagram of the designed system is shown in Figure 6.



(a) (b)

Figure 6: LabVIEW application program: (a) Front panel and (b) Block diagram

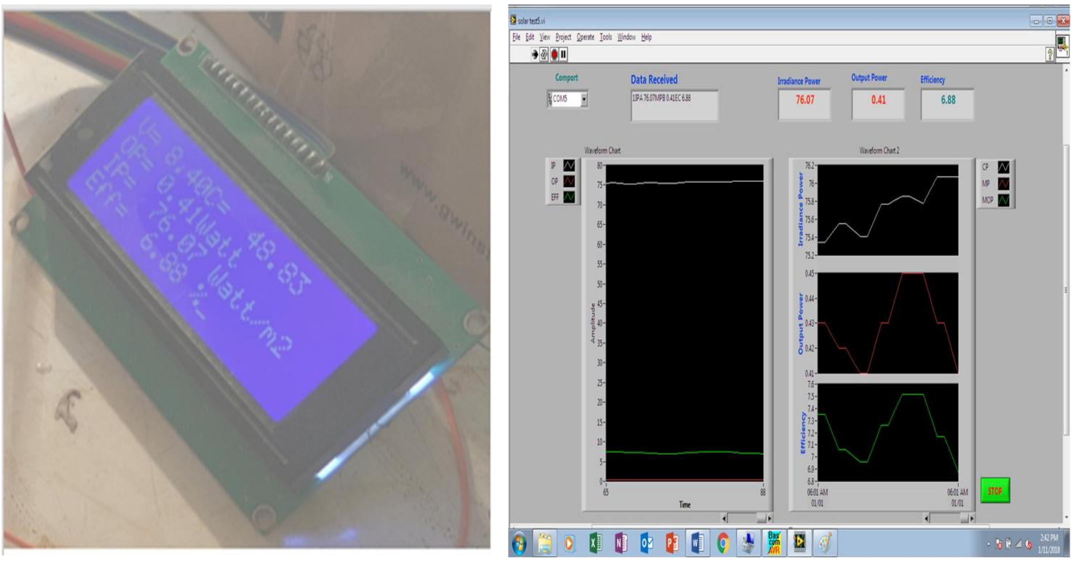
III. RESULTS AND DISCUSSION

A prototype PC based wireless photovoltaic panel efficiency analysis system is designed for measuring solar irradiance power, output power and efficiency of attached solar panel. The data acquisition and transmission unit (DATU) can be used as individual device for direct measurement of solar panel efficiency or can be used together with data reception and presentation unit (DRPU) for remote monitoring and analysis of measured data. The designed system is tested by connecting the DATU with a solar panel. A solar panel with 10W maximum output power and 12V operating voltage is used for this experimental setup. Four 20W filament bulbs are used as light source. Table 1 shows the solar irradiance power, output power and efficiency measured by the designed system with the above experimental setup with two minutes interval.

Table 1: Measured Solar irradiance power, Output power and Efficiency

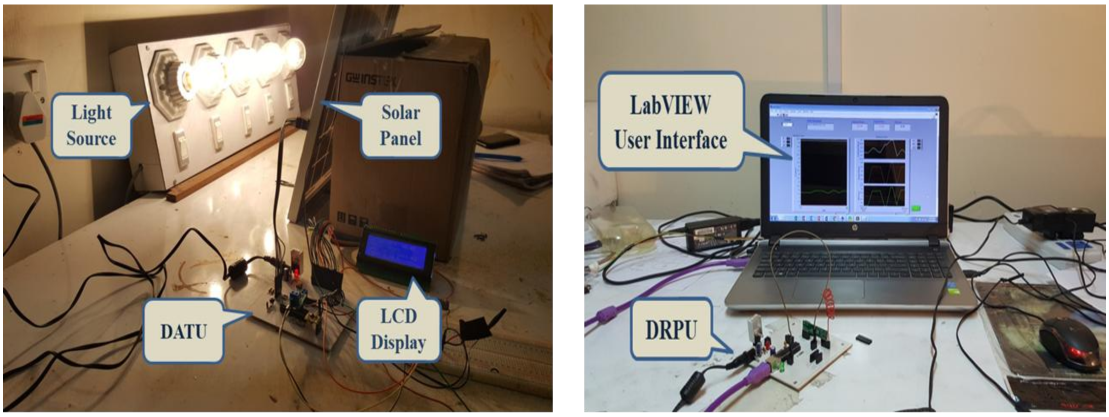
No.of obs.	Time AM	Solar irradiance power W/m^2	Output Power W	Efficiency %
1.	10.00	25.75	0.28	13.86
2.	10.02	25.86	0.29	14.27
3.	10.04	26.05	0.29	14.42
4.	10.06	26.07	0.3	14.70
5.	10.08	26.09	0.31	15.16
6.	10.10	26.11	0.32	15.60
7.	10.12	26.12	0.32	15.62

Figure 7 shows the measured value of solar irradiance power, output power and efficiency of the designed system. From Figure 7, it is observed that the irradiance power, output power and efficiency of both DATU and DRPU are same. This proves a successful real time data communication between DATU and DRPU. It is also observed that the LabVIEW front panel of DRPU is not only displaying the numeric values of present data for solar irradiance power, output power and efficiency but also presenting a graphical waveform with previous data. Hence, the application of LabVIEW is more suitable than manual data analysis and graphical presentation. It is also possible to store real time data in a text file using LabVIEW for future archiving and analysis. Experimental setup for data acquisition and transmission unit (DATU) and data reception and presentation unit (DRPU) at laboratory is shown in Figure 8.



(a) (b)

Figure 7: Measured solar irradiance power, output power and efficiency of (a) DATU and (b) DRPU for 12V



(a) (b)

Figure 8: (a) Data acquisition and transmission unit and (b) Data reception and presentation unit

IV. CONCLUSION

In this paper, a prototype PC based wireless photovoltaic panel efficiency analysis system has been designed and tested in laboratory. The main purpose of the designed system is to calculate photovoltaic panel efficiency by measuring the output voltage and current to calculate electric power and measuring the solar irradiance power. Data acquisition and transmission unit (DATU) is designed to perform the measurement. From the measured solar irradiance power and electric power, solar efficiency is calculated and displayed at DATU and transmitted to Data reception and presentation unit (DRPU) for farther analysis and archiving purpose. At DATU a microcontroller (ATmega8) is interfaced with a low cost voltage sensor (simple voltage divider), a current sensor(ACS712ELCTR-20A-T**)**, a light sensor (BH1750) and radio frequency (RF) transmitter (KST-TX01) to obtain the outcomes of the designed system. On the other hand, DRPU comprises of a RF receiver (KST-RX806), serial to USB converter and a Personal Computer with application software LabVIEW (Laboratory Virtual Instrument Engineering Workbench). The tested results from the system offer real-time measurement accuracy and good performance. The designed system provides more flexibility to user as DATU can be used independently for field level measurement. Also DRPU is capable to receive data from multiple DATU with individual device address for each DATU. The designed system could be helpful for field level measurement and also in numerous research and educational endeavors, where measurement of electric power, irradiance power and efficiency of solar panel with additional remote monitoring and archiving features are important.

REFERENCES

[1]. Belmili, Hocine & Ait Cheikh, Salah & Haddadi, Mourad & Larbes, Cherif. (2010). Design and development of a data acquisition system for photovoltaic modules characterization. Renewable Energy. 35. 1484-1492. DOI: 10.1016/j.renene.2010.01.007.
[2]. Claus Kuhnel, BASCOM programming of Microcontroller with Ease: An Introduction by program examples, Universal Publisher, 2001, ISBN: 1-58112-671-9, URL: WWW.8052.com/tutser.phtml
[3]. A. R. N. Adilah, T. I. T. Nadzlin and A. J. M. Mahadi. (2015). Development of solar efficiency monitoring system by using GSM technology. International Conference on Space Science and Communication (IconSpace), Langkawi, 2015, 362-365. DOI: 10.1109/IconSpace.2015.7283800
[4]. Filik, Tansu & Başaran Filik, Ümmühan. (2017). Efficiency Analysis of the Solar Tracking PV Systems in Eskisehir Region. Anadolu University Journal of Science and Technology A - Applied Sciences and Engineering. 18. 209-209. DOI:10.18038/aubtda.267116.
[5]. Abbaraju, Admaja, ANDARAPU, Daya and HAMILI. (2015). Design and Implementation of Photovoltaic System Control Based on GSM Remote Monitoring. International Journal of Scientific Engineering and Technology Research. 4 – 24. 4663-4667. URL: https://pdfs.semanticscholar.org/3ef1/922ebcab2954a22578df2d85cee7106bf8ca.pdf
[6]. Andreoni, Martin & Mantinan, Francisco & Molina, Marcelo. (2012). Implementation of wireless remote monitoring and control of solar photovoltaic (PV) system. 1 -6. DOI: 10.1109/TDC-LA.2012.6319050.
[7]. P. Pal Pandian, K.Ilamparthi, R.Karuppusamy, B.Sivaram, and M.Surya. (2018). Remote Monitoring System Design for Photovoltaic Panels. International Journal of Pure and Applied Mathematics. 118 – 20. 1475-1477. URL: https://acadpubl.eu/jsi/2018-118-20/articles/20c/22.pdf
[8]. E. Kabalci and Y. Kabalci. (2017). Remote monitoring system design for photovoltaic panels. 10th International Symposium on Advanced Topics in Electrical Engineering (ATEE), Bucharest. 888-891. DOI: 10.1109/ATEE.2017.7905159
[9]. User manual of ACS712 hall current sensor module. URL: http://www.produktinfo.conrad.com/datenblaetter/1600000-1699999/001616236-an-01-en-STROMSENS__MOD__20A_ACS712_ME067.pdf
[10]. User manual of BH1750 digital light sensor module. URL: https://www.elechouse.com/elechouse/images/product/Digital%20light%20Sensor/bh1750fvi-e.pdf
[11]. Datasheet of ATmega8 microcontroller. URL: https://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-2486-8-bit-AVR-microcontroller-ATmega8_L_datasheet.pdf
[12]. User manual of Proteus7 professional. URL: https://www.ele.uva.es/~jesman/BigSeti/ftp/Cajon_Desastre/Software-Manuales/EBook%20-%20Proteus%20Manual.pdf
[13]. User manual of BASCOM-AVR IDE. URL: https://www.bipom.com/documents/bascomavr/bascavr.pdf
[14]. User manual of LabVIEW. URL: https://www.ni.com/pdf/manuals/320999e.pdf

Md. Atiar Rahman" PC Based wireless remote monitoring system for photovoltaic (PV) panel efficiency analysis" American Journal of Engineering Research (AJER), vol. 8, no. 8, 2019, pp. 111-117