

QR Code Based Solar Panel Data Monitoring System

Akash Singh Chaudhary

Department of Electrical Engineering, DEI, Deemed University, Agra, 282005, India
Email: akashsinghchaudhary@gmail.com

D. K. Chaturvedi

Department of Electrical Engineering, DEI, Deemed University, Agra, 282005, India
Email: dkc.foe@gmail.com

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Abstract—Solar panels are safe and one of the commonly used renewable sources of energy generation now-a-days and are subjected to different atmospheric conditions. Data loggers are used to monitor the condition of solar panels with the help of data acquisition system. Zigbee is used as a transferring solar data from solar panels to the recording system (laptop). QR code is basically used to store and share any content, here in this paper an advanced technique is used to store the solar panel data in QR code in video form followed by developing a web application. This solar panel data can easily be accessed by scanning the generated QR code through QR code scanner installed in android mobile phone. One of the advantages of technique used in this research paper is to visualize the variations of graphs and values of data logger which were displayed on the screen of laptop during online in video format. This video format file is stored in QR code which reduces the size of pre-stored solar panel data file. Second advantage of technique used here that QR code allows reducing the size of pre-stored video format file of solar panel data monitoring system into image format without any loss of data.

Index Terms—Data logger, Data monitoring, Solar Panel, QR code, Renewable.

I. INTRODUCTION

The photovoltaic applications are increasing day by day due to rapid rise in the demand of electricity for various applications. The photovoltaic system converts solar radiations into useful electrical energy through photoelectric effect [1,2]. A solar panel has many solar cells connected in series-parallel combination according to requirement [3]. The solar battery, solar inverter and charge controller are the other components connected in a well-designed manner to produce the final output from photovoltaic generation system [4]. The components of photovoltaic generation system are subjected to many

disturbances during their operations which may result into fault. The visual faults in solar panels, batteries or in other components are detected in time but the problem arises when there are chances of fault due to change in electrical and thermal parameters [5]. The performance of solar photovoltaic system is affected by operating temperature [6] shading on solar panels [7,8] and other natural conditions such as degradations, ageing and depositions on solar panels, Sulphur deposition on terminals of solar batteries. Therefore, the need of monitoring the solar photovoltaic components arises [9,10,11]. The monitoring system shows online variations of different parameters of solar photovoltaic generation system due to environmental conditions. The analytical behavior of PV array current, PV voltage solar irradiance, ambient temperature, solar battery voltage and current, solar inverter voltage and current, effect of dust and dirt can be monitored easily using online condition monitoring system [12]. The recording of solar photovoltaic data along with monitoring is beneficial for future analysis [13]. Data loggers interfaced with personal computer are used to monitor and record only the numeric data or graphs of different parameters of solar photovoltaic generated system for the scheduled time with a facility to view the offline report of recorded data either in excel sheet (.csv format) [14,15,16,17,18]. There are different advantages and limitations of different wireless transmission system such as transmission distance, cost, size, power consumption and capability to operate with large applications [19]. Zigbee is a web based wireless system normally used to online monitor and transmits the stored data within the specified range of transmission for solar photovoltaic generation system [20]. The recorded video transmission using Zigbee wireless transmission is difficult, involves time delay and data loss [21]. The QR codes are used to store the different types of information. The recorded video data is stored in QR code to generate a shareable link for further sharing [22].

II. METHODOLOGY FOR SOLAR PANEL DATA TRANSMISSION

A solar photovoltaic system provides electrical energy from generation till availability to the user. The basic components of an off-grid solar photovoltaic system are solar panels, solar batteries, charge controller and solar inverter [23]. The grid connected solar photovoltaic system has solar panels, solar inverter and grid as there is no need of storage so solar batteries are not present [24]. The performance of solar photovoltaic system is affected when they work in different operating conditions. Therefore, the current state of parameter values or data generated by these photovoltaic systems is remotely monitored by different data monitoring and logging (DAQ) methods to represent [25]. The variations in current, voltage, power, temperature, fault in components can be easily detected by these condition monitoring techniques [26]. There are various wireless data transmission techniques such as blue tooth, radio frequency, Zigbee [27] and GSM used now a days according to the need, availability and containing features [28]. The following fig.1. shows the block diagram for condition monitoring and transmitting generated solar data from solar photovoltaic system using data loggers.

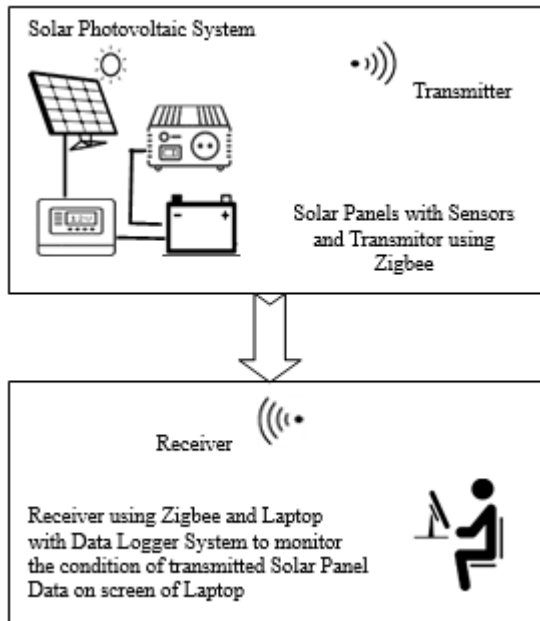


Fig. 1. Showing how to monitor and transmit the condition of solar data using data logger

The generated solar data is stored in excel sheet (.csv format) containing parameter values which can be retrieved later as per convenience to plot the required data graphs in pictorial form offline [29].

III. TRANSFERRING OF DATA USING QR CODES

QR (Quick response) codes are basically 2D barcodes containing a large amount of data coded in two dimensions (horizontal and vertical direction). They have

numerous advantages such as high capacity, reduced size, 360° access, high speed-reading capability and support to many languages (numeric, alpha-numeric, kanji etc) [30]. Maximum of 7089 characters, 4296 alphanumeric characters, 2953 binary bytes and 1817 Kanji characters can be stored in a QR code. The stored information can be shareable link, email, animations, text or digits which can be decoded through a QR code scanner in smart phones. QR code is widely used in many applications like medical, educational, marking etc [31]. The QR code module consists of function pattern region and encoding region. The function pattern region has finder, separator, timing patterns, alignment patterns whereas encoding region has information code words, error correction, and modules to determine the version and type of encoded data. The information is stored in a QR code by coding and retrieved using the process of decoding [32,33]. Since there are several methods to transfer data through wireless means and applications of QR code via mobile phones are increased rapidly due to safe, fast and easy mode of operation [34].

IV. ALGORITHM AND WORK DONE

The transmission of solar data generated by solar photovoltaic system using a new QR code-based technique has several advantages as listed below:

- ❖ Transfer of images, video, audio, text, URL, contact etc
- ❖ Transfer the data anywhere, any time
- ❖ Easy and simple accessing
- ❖ Occupies less space
- ❖ Offline view of real time recorded data

The following fig.2. shows the block diagram of the strategy used for transmission of solar data using QR code in this experiment.

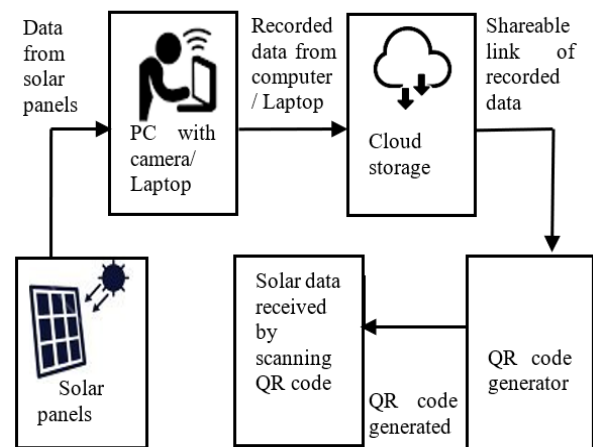


Fig. 2. Shows block diagram of the strategy used for transmission of solar data using QR code

The above fig. 2 explains the complete procedure adopted in transmission of solar data from solar photovoltaic panels to the user through QR code. The

data from solar panels is obtained using Zigbee based data acquisition system and is stored in a laptop having internet connectivity. The recorded solar data is stored on cloud storage automatically by google chrome extension and a shareable link is generated corresponding to recorded data file. Now QR code is generated corresponding to the shareable link of stored solar data. By scanning QR code the solar data is successfully retrieved to any other computer, laptop or android mobile phone easily. Some safety features are also included during the accessing process of solar data such as the storing the analytics of the user scanning QR code. The work is performed on standalone solar photovoltaic generation system installed on the roof of Faculty of Engineering, Dayalbagh Educational Institute, and Agra. The standalone solar photovoltaic generation system is connected with a laptop for online monitoring and control of the generated solar data. The standalone solar photovoltaic generation system consists of four solar panels, six long tubular batteries and one solar inverter. In this experiment only the solar data generated by solar panels (output current, output voltage and output power with ambient temperature) is included. The variations in generated graphs and changes in values of output current, output voltage and output power, ambient temperature are recorded as video file. Then further processing for the generation of QR code is adopted using QR code generator. The work done for transmission of solar data is divided into three sections. The first section includes recording of solar data displayed on screen of computer. Second section deals with generation of QR code and its web development. Third section explains with accessing solar data practically.

The name plate rating details of solar panels used in solar photovoltaic system is given below in table 1 and Fig. 3. shows sticker pasted on back of solar panels used in experimental work.

Table 1. Name plate rating details of solar panels used in solar photovoltaic system installed on the roof of Faculty of Engineering, Dayalbagh Educational Institute, Agra

S. No.	Name	Value		
1.	Company	BHEL		
2.	Module No.	L20220		
3.	P _{maximum}	220 WP		
	Warranted P _{maximum}	160 WP		
	V _{maximum power}	29 V		
	I _{maximum power}	7.60 A		
4.	V _{open circuit}	36 V		
5.	I _{short circuit}	8.3 A		
6.	Maximum system voltage	1000 V		
7.	Min. bypass diode rating	15 A		
8.	Maximum series fuse current protection	15 A		
9.	Fire rating class	C		
10.	A.	STC (Standard test conditions):	Insolation	1000 W/m ²
	B.		AM	1.5 spectrum
	C.		Cell Temp.	25 °C

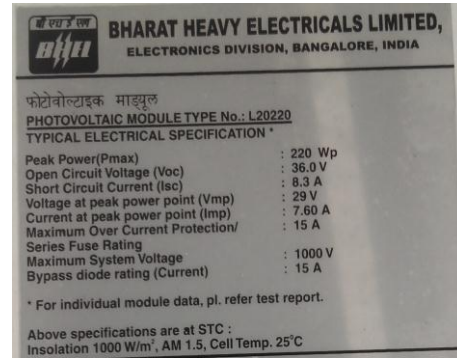


Fig. 3. Sticker pasted at back of solar panel used in experimental work

The details of laptop used for monitoring and recording solar data are given in table 2.

Table 2. Laptop Details used in Experiment

Name	Details
Windows Edition	Windows 7 Ultimate Copyright © 2009 Microsoft Corporation Service Pack 1
Processor	Intel(R) Core (TM)2 Duo CPU T6600 @ 2.20 GHz
System Type	32 Bit Operating System

A. Recording of solar data displayed on screen of computer

Zigbee based data acquisition system sends the solar data into laptop which is monitored on its screen using data logger and is stored in video format (.webm) on google drive through google chrome extension. After completion of the recording of solar data, google drive consists of a shareable link which is used in QR code to access the content. The fig. 4., fig. 5. and fig. 6. shows snapshots of solar panels with Zigbee based data acquisition system, laptop with data logger and data logger windows as displayed on the screen of laptop respectively.



Fig. 4. Solar panels with Zigbee



Fig. 5. Laptop used for monitoring and storage of solar panel data



Fig. 6. Snapshot of data logger

B. Generation of QR code and Developing Web Application

The shareable link from google drive corresponding to the stored solar data is linked with QR code during generation of QR code. An image of solar panel is attached as a logo at the centre of generated QR code for uniqueness. After generation of QR code a content-based web application is developed and generated QR code is attached with it. The following fig. 7. shows the generated QR code having solar data in video format.



Fig. 7. Generated QR code for solar panel data

C. Accessing Solar Panel Data through QR code

Once generation of QR code and development of web application has been completed the solar data is access by scanning the QR code through an android mobile phone with QR code scanner. On scanning the QR code the web application asks for filling up a registration form followed by the downloading the solar panel data. The fig. 8. to fig. 12. shows snapshots of android mobile phone after scanning QR code.

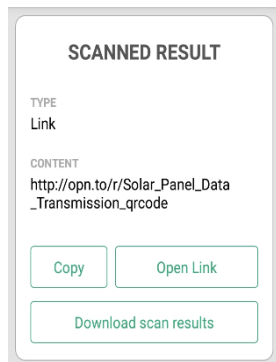


Fig. 8. Snapshot after scanning QR code by android mobile phone



Fig. 9. Welcome window of web application

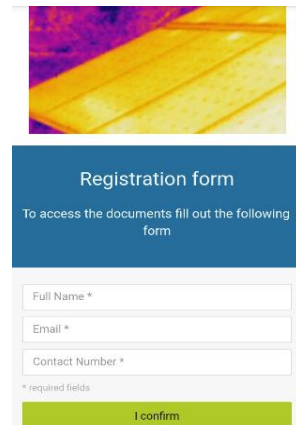


Fig. 10. Window with registration form details

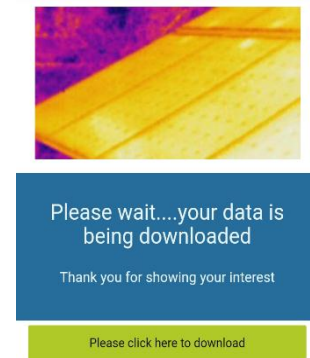


Fig. 11. Window showing about processing of solar panel data

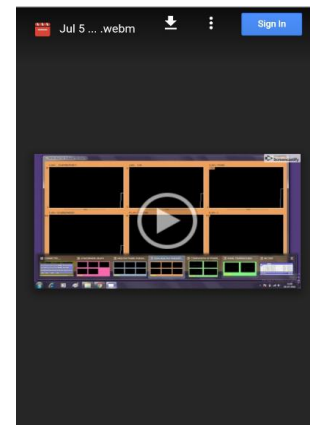


Fig. 12. Window showing solar panel data is downloaded to android mobile phone

V. RESULTS AND DISCUSSION

The paper discusses an advance technique which is a blend of solar panel monitoring system with QR code. The research work is performed using free version of google chrome extension which has some limitations on recording duration but the work can be extended for unlimited recording if paid for the service. Similarly, generation of QR code and development of web application is also obtained without using any payment for service. One of the advantages of the technique used in the research work is to view the live variations of solar panel data parameters in video form. By simply scanning a QR code these stored variations can be accessed any time any place. Second advantage of this technique is considerable reduction in size of the storage type i.e., from video format to QR code. At last storage and sharing of solar panel data in QR form is simple and easy to use. The solar panel data can easily be stored and accessed by scanning QR code through the web application. The following table 3. shows detail of recorded video file before and after conversion into QR code.

Table 3. Details of Recorded Video File for Solar Panel Data and Generated QR Code

S. No.	Size	Format	Resolution
Stored video file	8.37 MB	(.webm)	1280x720 pixels with 30 fps
Generated QR code	43.1 KB	(.png)	300x300 pixels

VI. CONCLUSION

The paper describes an advanced technique for live visualization of pre-stored solar panel data. The variation in graphs for solar panel voltage, current, temperature etc are recorded in video form and visualized in the same manner as they were displayed by data logger on the screen of laptop. Recording of solar panel data is obtained using google chrome extension and stored on google drive therefore there is no need to use additional camera to personal computer or laptop. When solar panel data is stored in QR code i.e., in image form, the size of video file gets reduced from megabytes to kilo bytes which saves the storage area on disk.

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Authors' Profiles



Akash Singh Chaudhary obtained his BSc Engineering in branch of Electrical Engineering in 2005 and M. Tech in Engineering Systems in 2007 from Faculty of Engineering, D.E.I. Deemed University, Dayalbagh Agra, Uttar Pradesh, India.

He has total seven years of teaching experience as Guest Lecturer, Lecturer, Sr. Lecturer and Assistant Professor in Electrical Engineering Department of various institutions. He is actively involved in teaching and published various research papers in different fields. He is pursuing PhD in Electrical Engineering Department from Dayalbagh Educational Institute, Deemed University, Dayalbagh, Agra, Uttar Pradesh, India in the area of electrical power system with research objectives in health monitoring of solar photovoltaic.

Mr. Chaudhary is a life member of ISTE and his interest areas includes networks analysis, electrical machines, solar photovoltaic, digital image processing and thermal imaging.



D.K. Chaturvedi did his B.E. from Govt. Engineering College Ujjain, M.P. then he did his M.Tech (gold medalist) and Ph.D. from D.E.I. Dayalbagh. He has received Young Scientists Fellowship from DST, Government of India. He is the Fellow IE (I), ASI and IETE. ADRDE lab of DRDO conferred him life time achievement award for his valuable contributions in field of aeronautics. He is the consultant of DRDO. He had edited a book on ethics and values and authored three books on soft computing, modeling and simulation and electrical machines lab manual.

Prof. Chaturvedi is working in Elect. Engineering and having additional load of HOD, Department of Footwear Technology, Training and Placement officer, D.E.I. and Advisor, IEI Students' Chapter (Elect. Engineering)

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