Design and Implementation of Real-Time Data Acquisition, Monitoring and Smart Tracking System for Solar Modules

K. Ashok Kumar, V.Ravi

***Abstract*: This research work presents the data acquisition, monitoring and hence estimating the efficiency of the solar module using LabVIEW. The working of the solar power system can be determined by continuously monitoring the solar panel parameters namely voltage, current and temperature. LabVIEW tool is used to acquire solar cell data through Data Acquisition (DAQ) Card and display voltage, current, the variation of power with voltage and variation current with voltage graphically in real time. The real-time data are collected under different circumstances such as bright day and cloudy day to monitor the proper working of a photovoltaic solar module. The smart solar tracking system is used to moves the solar module and track the sun throughout the day. Results show that the tracking system helps to obtain the maximum efficiency at all times.**

***Index Terms*: LabVIEW, Data acquisition, solar module, tracking system**

I. INTRODUCTION

Solar energy is the energy from sunlight, which was used by people across the world. It is a major form of renewable energy. Solar energy can be utilized by the people by the solar photovoltaic cell which can be used for many applications. Monitoring of the solar PV cell is more important as to determine the solar cell is working efficiently or the solar cell is not working properly due to some defects. Data acquisition from the solar module and the parameter estimation such as voltage, current, temperature, P-V and I-V characters were done by DAQ card and sensors connected to it. The acquired data can be fed into a standalone PC system using LabVIEW software which is a design and development platform for graphical programming. LabVIEW is used to visualize the solar module characteristics curve and the parameters in the front panel. The solar radiation from the sun determines the efficiency of the solar cell[1]. The monitoring[2] of solar cell and calculation of efficiency is determined under certain conditions and the results are analyzed to determine the proper working of the solar PV module. The data collected in real time and to analyze the performance of the PV system under different climatic and meteorological condition using LabVIEW. The work present on a simple and easy way to monitor the solar module and to measure the performance of the solar cell. The solar tracking system is used to maintain the maximum efficiency at all time, the tracking system can be of hardware as well as software phase. Increasing the intensity of the light falling on the solar panel is other to increase the efficiency but it was not successful as of the tracking system when using dual axis tracking system the overall efficiency is 30% increased. This research work proposes to monitor the solar panel parameters and the performance in real-time and the tracking system is used to increase the efficiency and attain Maximum PowerPoint (MPPT) at all time.

II. LITERATURE REVIEW

From the literature, various methods have been proposed and each method has its own advantage and disadvantage in terms of efficiency, accuracy, complexity and high cost. Rehman S [3] proposed a low cost solar power generation using DAQ and monitor the solar panel.Wu al[4] suggested a new technique where the silicon solar cell combined with the crystalline silicon cell designing PV system with higher performance with the reduction of cost. A Maximum Power Point Tracking (MPPT) in dual mode along with the constant voltage control with incremental conductance is used in order to increase the efficiency at various insolation conditions and thus giving excellent performance with minimal hardware requirement is proposed by Yu et al[5]. Boutana[6] presented an explicit I-V characteristics model for PV cell by simple mathematical expressions the performance is measured in terms of accuracy, the system is very simple and can easily predict the I-V characteristics of the different PV module in great accuracy. Stember [7] proposed a systematic approach for the reliability of the solar PV system. Hasan et al[8] proposed a system which gives the performance near to the PV system with MPPT, he proposed a PV system with near-Maximum Power Point Operation (nMPPO) the major advantage of this system is that the need of hardware is less compared to other system and the performance is increased drastically. Franklin E, Everett[9] proposed a low cost and high efficiency monitoring system for the solar module. Parida B[10] suggested a review of silicon solar cell for better performance. Zervas PL[11] proposed that solar panel used in the power generation will maintain more efficiency. The cost of solar tracking and monitoring using NI-DAQ is more compare to the Arduino system. Matlab to monitor the performance of the solar module which is more difficult to monitor the parameters of the solar panel when compare to LabVIEW which uses G-programming which is very easy to monitor the performance compare to Matlab. Ruther R[12] proposed using solar panel in power generation grid and monitoring the parameters. This paper proposes a method of monitoring solar panel and also measures its efficiency to evaluate the performance

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of the solar module along with the tracking system to attain maximum power point at all time.

III. EXPERIMENTAL SETUP

The experimental setup shown in fig 1 has a temperature sensor, a current sensor, DAQ card, PV solar module, PC with LabVIEW. This setup with that of the DAQ card and sensor can be placed in an open environment condition in order to measure the parameters of the solar PV cell under different aspects and climatic conditions.

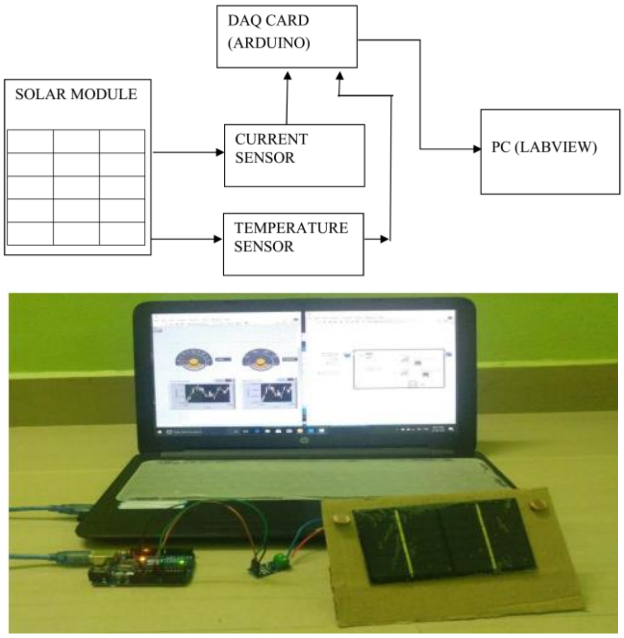

Fig 1. Solar module monitoring system experimental setup

A. Data Acquisition (DAQ)

Data acquisition is performed by DAQ hardware which is known as DAQ card, it can get signals from the external sensor to covert the physical parameter into the electrical signals.it also has signal conditioning circuit to convert sensor analog data to a form digital values by the analog to digital converter and it is controlled by software programs in standalone PC system.

Arduino can also be used as DAQ as it is cost effective and it has ADC for converting the analog values to digital but has low sampling rate of the signals and the resolution also low when compared to other data acquisition system but it can be used where the cost play a major role or cost is the most priority and it is best suited for small data gathering system. Arduino also has great interfacing support with LabVIEW and it can be used for DAQ in PV system.

B. DAQ monitoring system

Laboratory virtual Instrumentation for Engineering Workbench (LabVIEW) is a software tool that uses graphical blocks to program instead of a scripted program; it consists of two main panel 1.front panel 2.block diagrams. The output is seen in the front panel whereas the functional blocks are created in block diagram panel. DAQ assistant block in LabVIEW software allows displaying the external data from the DAQ. It is used to simulate the characteristics of solar cell uniquely. The parameters of PV cell and the I-V as well as P-V characteristics curve can be displayed in the front panel, whereas the functional blocks are present in the block diagram panel.

C. Current sensor

The current sensor is used to detect electric current whether AC or DC in a wire then generates the proportional signal to that of the current. The signal which is generated is used to monitor measured current in ammeter it can be stored for analysis in DAQ.ACS712 is half effect linear current sensor is used in the research as it can handle up to 20 A.

D. Temperature sensor

The temperature sensor is a device used to measure the hotness or the coldness of a system. LM35 has widely used temperature sensor which produces an output proportional to the temperature (degree Celsius), it can measure temperature more accurately than a thermistor. The output signal from the sensor doesn't need any amplification. Humidity sensor can be used for measuring the and sensing the moisture as well as the air temperature, it is used in the experimental setup for measuring the moisture or the humidity in air and the parameter is used to change the characteristics curve and the performance of the solar cell system, the efficiency of the solar cell and the amount of humid in the air can be measured by this sensor.

E. Solar tracking system

The solar tracking system has 2 parts namely: Hardware and software. The hardware part consists of Four Light Dependent Resistor (LDR), Two Servo motor to rotate the panel. Software part consists of a LabVIEW front panel and block diagram where VI is created for the tracking system.

The LDR's are connected to Arduino through the analog pins which act as input to the system. LDR1 and LDR2 make one pair and LDR3 and LDR4 make another pair, when a pair of LDR gets lighter intensity voltage node experience a difference and it is sent to Arduino, then the respective servo motor is rotated to keep the solar panel tracks the sun.

The LabVIEW block diagram to perform a tracking operation is shown in fig 2.The working of the solar tracking system using LDR and servo motor as well as VI is shown in Fig 3.

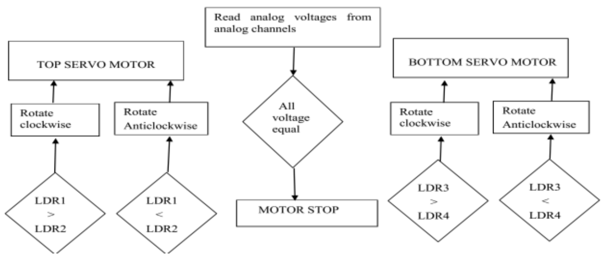

Fig2.VI for solar tracking system

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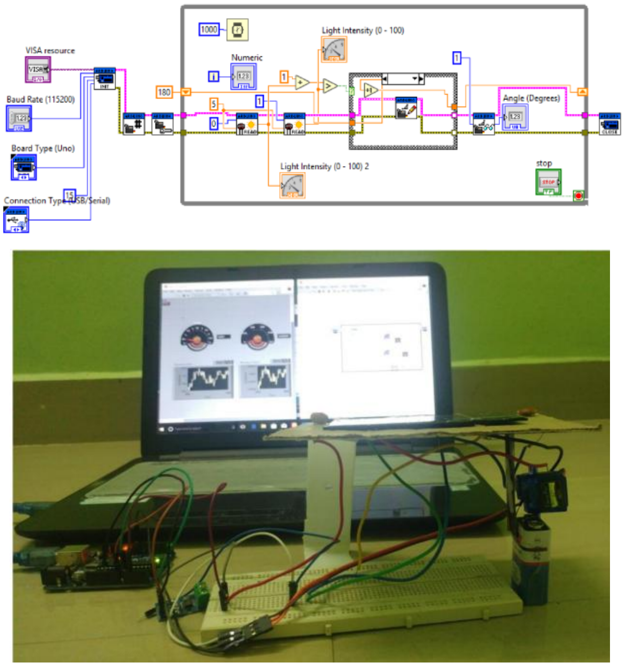

Fig 3. Working of solar tracking system

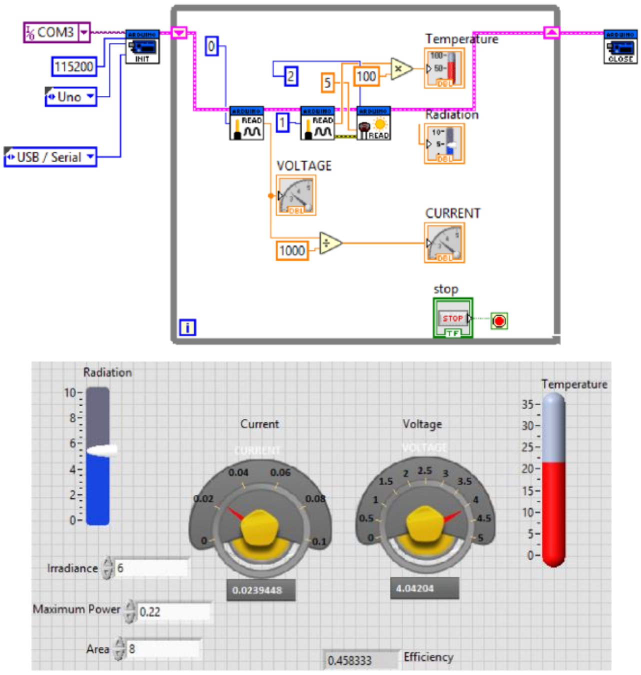

Fig4. VI for voltage and current measurement

IV. METHODOLOGY

The PV solar cell is taken for testing and experimentation with different ratings. DAQ card can interface sensor data with the PC. LabVIEW in PC has a graphical programmable virtual panel which is used to program the GUI and to display the data and parameters in the front panel. The solar cell along with temperature sensor is kept in the open environment.

The data from the outside environment is acquired, processed and stored using Arduino and LabVIEW software. There is a signal conditioning circuit in the DAQ in order to maintain the voltage and the current in the safe range. LabVIEW can do the computation based on the data acquired from the DAQ. LabVIEW has the functional tools which can be used for the real-time simulation from where we can calculate the performance and efficiency of the solar PV module. LabVIEW used for monitoring[13] of the parameters can give real time updates and it can also give the high performance with connecting and communicating various device simultaneously and it can capable of displaying more data and graphs in the front panel it also has the feature of storing the data and it can also be used for further comparison readings and research. This setup can be used in large solar field for the monitoring of more number of the solar PV cells so that it is easy for identifying the performance of every solar cell in the field from the monitoring it will be easy to identify the faulty solar cell and it can be replaced so that the efficiency and output from the solar cell can be increased.

The solar tracking system makes the solar panel to rotate according to the variation of voltage from the LDR's through analog pins of Arduino which has in build ADC so that it processes the data and rotate the top and bottom servo motor to attain MPPT and also to increase the efficiency at all time. The front panel, as well as the block diagram of monitoring system of solar module is shown in fig 4.

Efficiency (η%) = output power (P_{Out}) / input power (P_{in})

The efficiency of the solar PV cell is given by output power by input power where the output power P_{Out} gives the electrical output from the solar cell and the input power Pin is given by product of irradiance of the incident light from the sun in (W/m2) with that of the area of the solar cell given in (m2).

V. RESULT AND DISCUSSION

Data collected from the PV cell is used to monitor the parameters such as voltage, current, and temperature of the solar module using LabVIEW. The solar panel is treated under the different climatic condition and the I-V, P-V characteristic curve is plotted from the data collected from the solar panel and displayed in the front panel of LabVIEW.

The performance of the solar panel is viewed in real-time so that the faulty solar panel can be replaced. The tracking system can be used to maintain the maximum efficiency of the solar panel at every time by tracking the direction according to sun position.

The fig5. and fig6. Shown below is P-V and I-V characteristics curve of the solar cell which is plotted from the voltage, current and power parameters fetched from the solar panel which conveys the V-I and P-V behavior characteristics of the solar panel.

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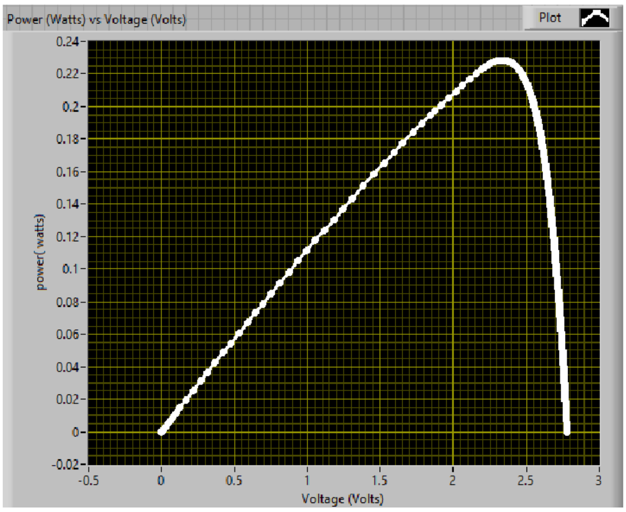

Fig 5. P-V characteristics curve

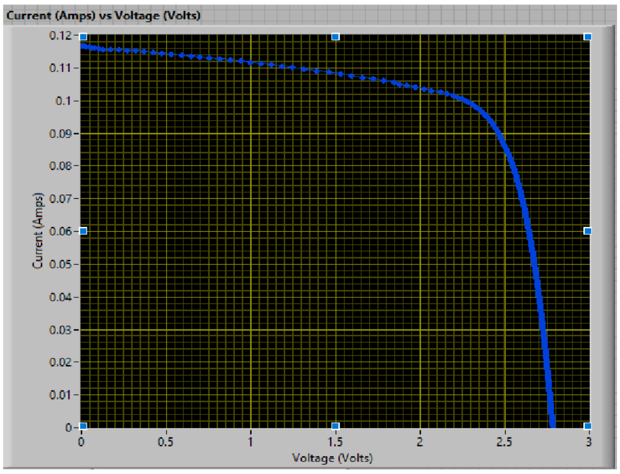

Fig 6. I-V characteristics curve

VI. CONCLUSION

The major objective of our research is to monitor the solar panel and to evaluate the performance of the solar panel in the large solar field along with the tracking system to achieve maximum efficiency at all time is implemented successfully and the utilization of solar energy is increased by this research and so the malfunctioned solar panel can be easily detected and can be replaced in the large solar field. The tracking system is to gain more efficiency than the static system which was one of the ultimate goals of the research.

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