Condition Monitoring of PV Systems for Reliable and Efficient Operation

Anirudh Sharma C A, Jayanth Bhargav, Shrikesh Sheshaprasad, K Uma Rao [Guide]

Department of Electrical and Electronics Engineering, R V College of Engineering®

1. Abstract

The rise in pollution levels and the rapid depletion of non-renewable fuel resources requires urgent attention to fulfill increasing energy demands. Clean energy solutions that are feasible, cost-effective and innovative are the need of the hour. The most popular clean energy source in countries like India are Solar power systems. The fast growing utility-scale PV industry in India demands well managed operation & maintenance (O&M) services to keep plant performance at par with the needed expectations as well as applicable regulations. As utilities embrace and rely on solar PV grid-connected plants for both commercial and industrial applications, all aspects of O&M of solar systems help to deliver optimal power.

In this project, a robust monitoring system which ensures careful logging of operation data and periodically processing it to determine abnormal or slowly deteriorating conditions is built. Control and supervision of operating conditions is necessary for efficient operation. Wide and rapid variations in voltage and frequency conditions indicate the abnormal system conditions. An automatic alert system is built for notifying the operator about critical operating points of the PV panels.

4. IoT Based Monitoring System for Panels

The sensors deployed on the PV panel are interfaced with Arduino UNO Microcontroller. Sensors are calibrated with actual readings of standard meters and the data is transmitted serially to Node MCU – Wireless module. In the wireless node, internet connection is established and the data is transmitted to ***Ubidots*** – An open source cloud server for sensor data acquisition and analysis. In the cloud, a Dashboard is developed for condition monitoring of various panel parameters. The cloud platform has data plots and statistical analysis tools for data processing and analysis. An automated operator notification system for dust levels on the panel is configured in the cloud.

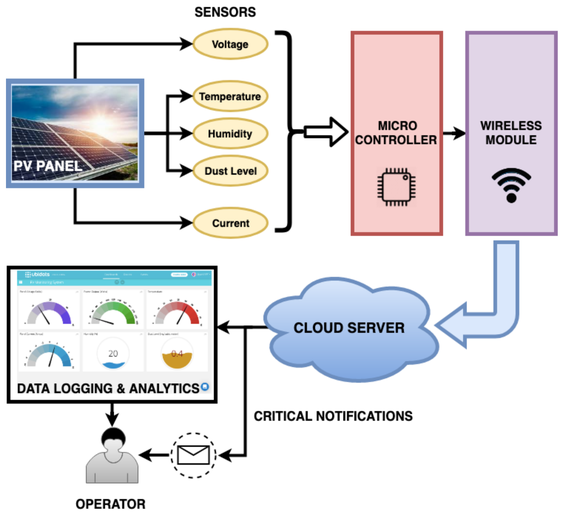

Figure 1: Architecture of the proposed IoT system

2. Operation and Maintenance of Solar PV Systems

The scope of O & M is for trouble free operation of the PV system to ensure that maximum solar energy is fed to the grid or delivered to the loads. PV systems have various components : both electrical and mechanical. In a PV system, there are various equipment and different manufacturers. The table below shows the various subsystems and their maintenance activities along with their frequency of inspection.

Table 1: Operation and Maintenance scheduling for PV systems

Sl. No.	Inspection	Actions Required	Inspection Frequency
1	**Solar Modules**		
	i. Dust levels on the panel	Cleaning of the PV modules	15 days (average)
	ii. Junction Box Connections (visual inspection)	Replace Junction Box/Module in case of failure	1 Month
2	**Mounting Structure** Inspect the mounting structure and hardware	Check for fasteners – replace if required Check lugs and conductors for corrosion	3 months
3	**Inverter Input Parameters: DC Voltage and Current**	Manual Measurement	3 months
4	**Inverter**		
	i. Loose Cable Termination	Tighten the connection	6 months
	ii. Dust accumulation	Cleaning the equipment	Monthly
	iii. Air Filter inspection	Cleaning the equipment	Monthly
	iv. Performance monitoring	Visual monitoring	Daily
	v. Data logging	Manual Checking	Daily
	vi. Report Preperation		Monthly
5.	**Inverter Output Parameters :Voltage, Current & Frequency**	Manual Checking	3 Months
6.	**LT Panel**		
	i. Loose Cable Termination	Tighten the connection	6 Months
	ii. Scheduled Maintenance as indicated by supplier	Follow panel supplier instructions	As stated by supplier
	iii. Dust accumulation	Cleaning the panel	Monthly
	iv. Performance Monitoring		Daily
7.	**LT Panel Parameters: Voltage, Current & Frequency**	Manual Checking	Monthly
8.	**Transformer**		
	i. Scheduled Maintenance as indicated by supplier	Follow transformer supplier instructions	As stated by supplier
	ii. Dust accumulation	Cleaning the equipment	Monthly
	iii. Performance Monitoring		Daily
9.	**Transformer Parameters: Voltage, Current & Frequency**	Manual Checking	Monthly
10.	**MV Panel**		
	i. Dust accumulation	Cleaning the equipment	Monthly
	ii. Scheduled Maintenance as indicated by supplier	Follow panel supplier instructions	As stated by supplier
11.	**MV Panel Parameters: Voltage, Current & Frequency**	Manual Checking	2 months
12.	**Spare Parts and Accesories**	Ensure availablity of spare parts in the foundry	Monthly
13.	**Irradiance Meter (Pyranometer) cleaning**	Cleaning with soft cloth	Daily/Weekly
14.	**Cables (AC and DC)**	Visual inspection	15 days
15.	**SCADA**	Data Monitoring	Daily

3. Implementation of Sensor Network for Panel Monitoring

A sensor network is implemented on the 250 W peak panel installed at RV College of Engineering. The sensors installed measure electrical parameters: Panel Voltage, Panel Current and environmental conditions: Humidity, Temperature and Dust levels on the panel. The sensors are interfaced to cloud server of ***'Ubidots for Education'*** through Arduino UNO microcontroller and Node MCU wireless communication module. Figure 2 shows the schematic of the hardware which describes the circuit connections.

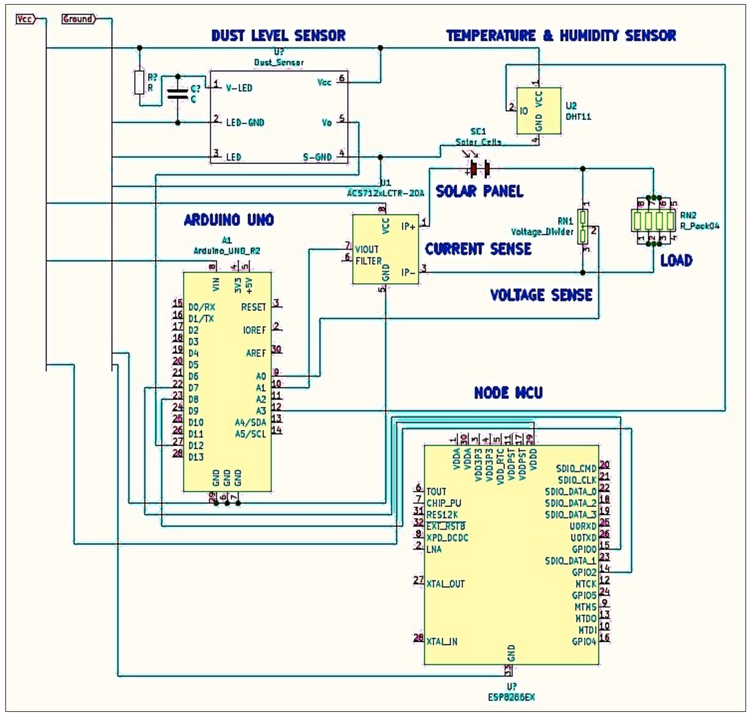

Figure 2: Schematic of Sensor Network implemented on PV panel at RVCE

5. User Interface and Data Analytics in Cloud

The data acquired from sensors are logged into the Ubidots Cloud in internet. A secure login is created in the Ubidots online webpage where the operator can access the sensor data. A display dashboard as shown in Figure 3 is developed in the webpage for monitoring. In case of high dust levels on the panel, an automatic notification system is configured in the webpage which will send an email notifying the operator to clean the panels. In the cloud server, data visualization and analytics can be performed. The data logging system provides time-stamped data, averages and other statistical measures of the sensor data which aid in monitoring and fault diagnosis of the PV system. Figures below show the Cloud Dashboard for monitoring and various data analytic operations in the cloud.

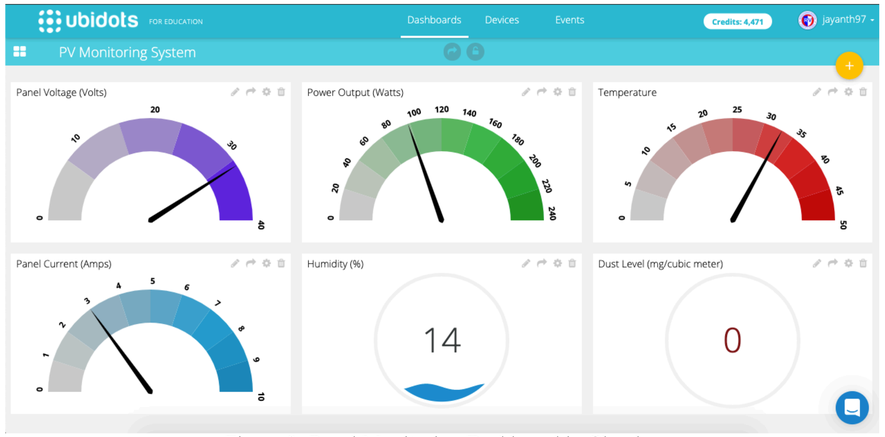

Figure 3: Panel Monitoring Dashboard in Cloud

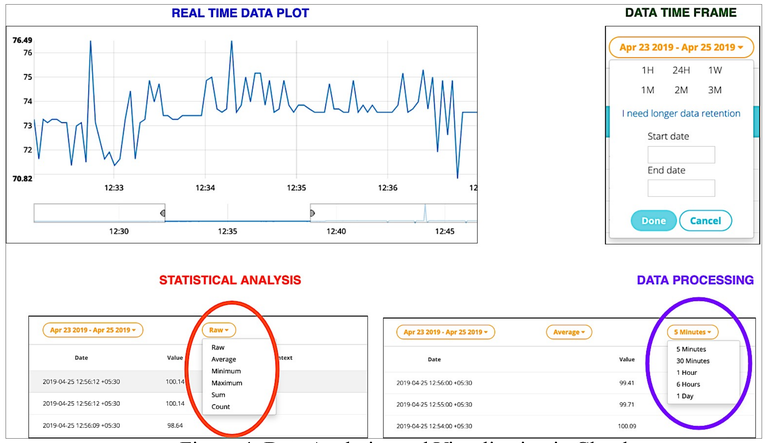

Figure 4: Data Analytics and Visualization in Cloud