Monitoring of Photovoltaic Systems: A case study URERMS Adrar

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ABSTRACT

The electrical energy generation via the Photovoltaic system is widely utilized in the world especially in the countries where it is characterized by considerable potential of solar energy. PV systems are affected by several factors that can reduce its efficiency such as PV generator aging, failures. Photovoltaic systems monitoring is a important task for guaranteeing the reliability and stability of PV system operation. This paper addresses the monitoring of PV systems in renewable energy research unit in the Saharan region (URERMS) Adrar, through to give an insigth about the methods of measuring, acquisition, data storage of monitored parameters. In addition, the existing problems for insuring the suitable solution.

I. Introduction

The expansion and development of industrial sector, as well as the population rapid growth, has resulted in a significant increase in demand of energy in the world. The use of traditional sources like (petrol, gas, coal) was lead to environmental pollution since the last century. The integration of renewable energy system in power generation was become indispensable task for reducing the world GHG gas emission that causes the global warming [1]. In the last years the Algerian government was done various actions for promoting the renewable energy sector and decreasing the dependence to fossil (petrol and gas marketing) through instating divers photovoltaic system and wind turbine connected to grid, which reached 354.3 MW till June 2018 [2]. PV systems are influenced by various factors that can reduce its efficiency like PV generator aging [3–7], missing real time system monitoring [8]. In order to better manage and operate the photovoltaic systems, it is great necessity installing hard-software equipments for supervising, monitoring the electrical and mythological parameters of PV systems in real time [9].

The Adrar region is expected to be the area which receives most of the photovoltaic energy investments and projects [10], the creation of digital platforms for the SAHARA region (control system, monitoring, sized plants, estimating and forecasting of output Power generation) and databases (temperature, sunshine, wind turbine, etc…) and the development of expert studies on the scale and feasibility.

The connection of photovoltaic energy (centralized or decentralized) to the Adrar networks causes malfunctions in these systems, making it more important to examine the behaviors and actions of photovoltaic systems and their effects on these networks.

The PV monitoring system [11], the role of which is to optimize the operating efficiency of a PV system at the lowest of the system expense is considered a total solution to all such problems. The aim of the photovoltaic

monitoring systems is to provide / reports on the energy capacity, energy collected, operational temperature analysis of possible faults and associated energy loss. The tracking data can also be used for early detection/alert, climate change assessment, etc. These problems have become more and more relevant. The literature has presented a complete analysis of the latest PV monitoring systems for use of sensors and data acquisition systems.

The paper describes the monitoring of photovoltaic systems in renewable energy research unit in the Saharan region (URERMS) Adrar and organized as follows: Section 2 gives a description of the PV monitoring system and describes the current issues by detailing the definition of PV electronic factors. The various features of the monitoring system are discussed in Section 3. Although the major instruments used in the PV monitoring system have been reviewed, specific data acquisition systems developed based on the software LabView and used to manage sensor output dat.

II. The installed PV systems in URERMS Adrar

The general classification of solar PV systems is given in Figure 1:

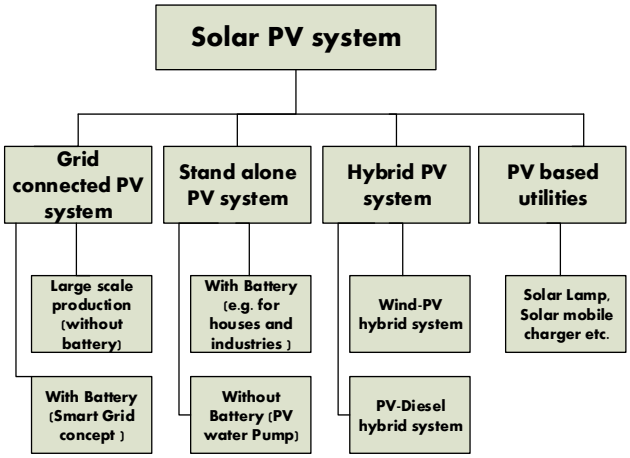

Figure 1. Classification of PV system.

Before starting, it more suitable to give a brief information about the local of study.Renewable energy research unit in the Saharan region (URERMS) is part of EPST Renewable Energy Development Center (CDER), it is created in 2004. URERMS is located in Adrar province, Figure 2 presents a map from google map.

Figure 2. URERMS by google map.

Several renewable energy systems have been installed in the renewable energy research unit in the Saharan region (URERMS) such as [12] :

Three Grid-connected photovoltaic systems are found in URERMS Adrar [8,12,13]:

- 28 kWp system (see Figure 3)
- 2.5 kWp system (see Figure 4)
- 1.75 kWp system (see Figure 5)

The technical specification detail is provided in Table 1.

Table 1. The technical specification detail.

PV system	PV module	Inverter type
28 kWp	112 PV modules mono-c-Si (BJP-250SA 250 W)	three SMA SMC 11000TLRP-10
2.5 kWp	10 PV modules mono-c-Si SM-250 W	Sunny Boy 2500
1.75 kWp	10 PV modules mono-c-Si SHARP (NTR5E3E)	FRONIUS IG 15

Figure 3. The 28 kWp Grid-connected PV system [12].

Figure 4. The 2.5 kWp PV system [14].

Figure 5. The 1.75 kWp PV system [15].

The water pumping system consists of the following elements:

- PV array generator (4.5 kWc) : 3 branch connected in parallel, each branch formed from 7 modules Isofoton I-75 W connected in series
- water tank storage with capacity equal to 80 m3
- Moto-pump system of the type Lorentz CSJ 8-7 of 1.2 KW: brushless submersible motor with centrifugal pump.
- LORENTZ controller PS1800 integrated MPPT (Maximum Power Point Tracking).
- Water well: depth =15.75 m and Ns=9 m

III. Monitoring system and existing problems

The main elements of the monitoring system are:

- Sensors
- acquisition system
- communication system
- supervision system

The monitored parameters in PV systems divided into two main categories:

- Metrological
- Electrical

Table 2 provides the monitoring parameters to be measured of the Grid connected system.

Table 2 The monitoring parameters to be measured.

Parameters of PV system		
Metrological	Electrical	
	Photovoltaic array	Utility grid
1.Irradiance 2.Ambient and module temperature 3.Wind speed and direction 4.Humidity	1.Output voltage 2.Output current 3.Output power 4.Output energy	1. AC voltage 2.AC Current 3.AC Power 4.AC energy

The measurement of meteorological parameters is assured by the meteorological station (NEAL) installed in URERMS (See Figure 6).

Figure 6. Meteorological station (NEAL).

The measurement of monitored parameters in the 28 kWp system which is a recently installed system is done by the SMA monitoring system (Sunny Web Box). The data acquisition used in the 2.5 kW and 1.75 kW systems are based on the FLUK HYDRA 2635A data logger as presented in Figure 7.

Figure 7. FLUK HYDRA 2635A data logger.

The main characteristics for the measurement of this instrument are cited below:

- Voltage (continuous from 90 mV to 300V, alternative from 300mV to 300V with 20Hz to 100 kHz)
- The resistance (from 300Ω to 10 MΩ)
- the temperature (RTD from -200 ° C to 600 ° C, Thermocouple from -100 ° C to 2316 °
- Frequency and period measurements (15 Hz to 1 MHz).

The CM 11 Kipp & Zonen pyranometer and Type-K thermocouple were used. Where the main technical characteristics of both sensors irradiance and temperature are provided in Table 3 and 4 respectively.

Table 3 CM 11 pyranometer specifications

Specifications	CM 11
Maximum irradiance (W/m^2)	4000
Response time at 95 % (s)	12
Sensitivity (µV/W/ m^2)	4-6
Accuracy (%)	± 3
Spectral rang (nm)	305-2800
Operating temperature (°C)	-40 to +80
Calibration coefficient (µV/W/ m^2)	4.46

Table 4 Type-K thermocouple specifications.

Specifications	**Type-T**
Range (°C)	-200 to 1250
Accuracy (°C)	1

The measurement of the current and voltage of the PV field are assured by LEM LA25-NP (current) LEM LV25-P (voltage) as illustrated in Figure 8.

Figure 8. Sensors for measuring PV field DC current and voltage.

The measurement of the AC current and voltage of the inverters are assured by LA25-NP (current) LEM LV25-P (voltage) as illustrated in Figure 9.

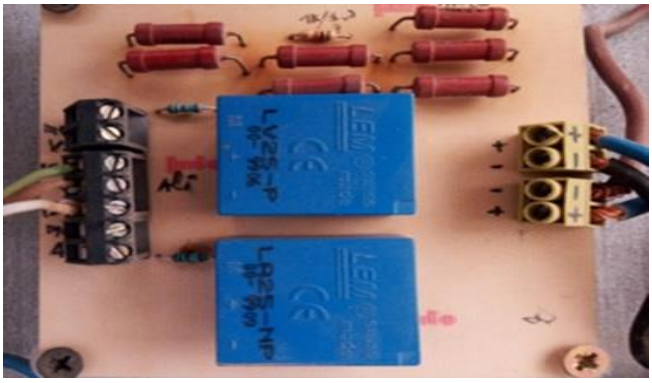

Figure 9. Sensors for measuring AC current and voltage of inverters.

Several issues were existing and occurred in the monitoring system in URERMS Adrar, among:

- Sensor failure
- Insufficient storage memory
- Miss of PC supervision system for the 2.5 kW and 1.75 kW systems
- Offline performance treatment
- Power supply permanent presence

For removing these problems, a project entitled “Development of diagnostic tools for grid-connected solar power plants" and “221CDER/DGRST “reference” has been launched in 2017 in URERMS Adrar, where the main objectives are cited below:

- Development of a new software for supervision and real-time monitoring of a PV system for the southern regions, which can be controlled remotely with the use of a web server that will allow us to visualize and control of our acquisition system.

- Development of software based on new models for the design, estimation of PV production in the Sahara region.
- Real time diagnosis of grid-connected systems fault

This software based on:

- Human-machine interface based on LabVIEW (National Instruments) software for the supervision of different parameters.
- Input/Output NI USB-6353 interface card allowing the data acquisition from sensors.

A software has been devolopped and divided into several sections as shown in Figure 10, which complement each other after finishing the main part of the software, which is to develop a PV system monitoring tool that makes the selection, record, classification, processing and technical analysis. The application is considered as a development tool of monitoring for PV plants which is oriented to the grid connedtd PW systems.

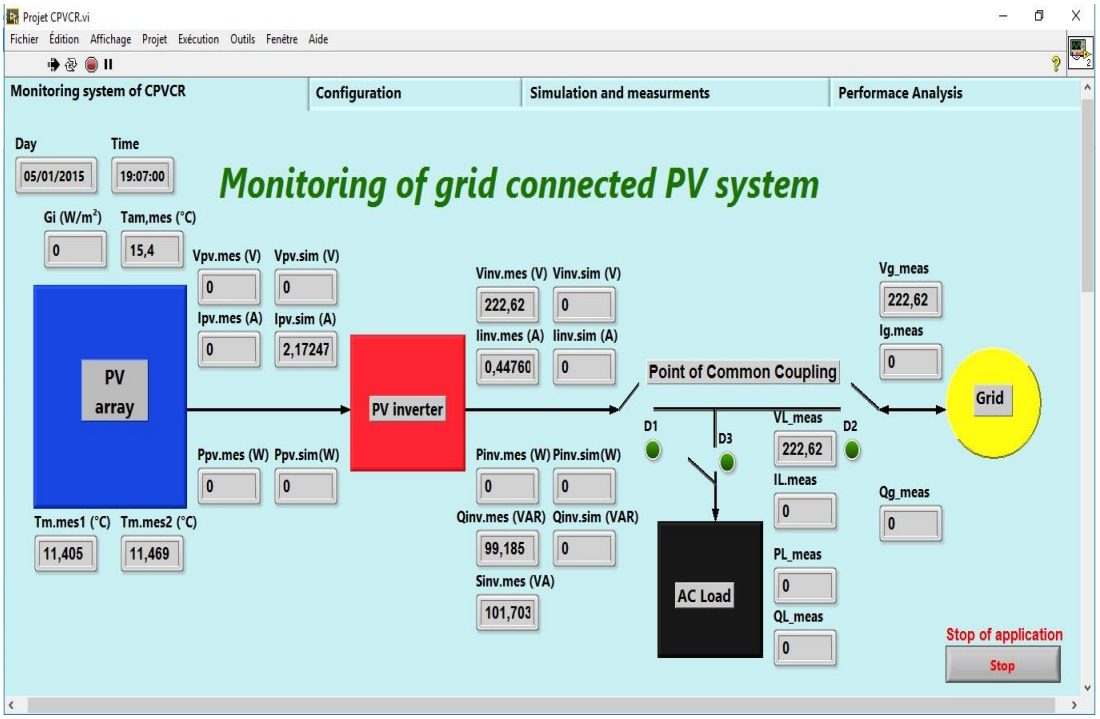

Figure 10. The main part of the software

This interface operates in real-time mode and consists of a variety of micro-interfaces for viewing PV plant results and data. Models of the impact of temperature and shading have been introduced in this release. This helps us to forecast and detect any faults in these systems in order to predict the power and energy provided by the PV system.

The "PV Plant Overview" interface (Figure x) allows you to display the various results and measurement data of solar power plants and "PV station diagram" inverters, the "Weather parameters" part allows us to set some parameters manually. The other parts are devoted to the display of the various results and data ("DC & AC current", "DC & AC voltage", "DC & AC energy", ...).

The software, a data processing application was built, this application allows to retrieve, organize, filtering and process measurement data from PV systems as present below. So, a new database is created with data processed and filtered which will be saved in “file.csv” files. They will then be used by other software applications. Figure 11 shows the basic program and monitoring of data plotting for this application in LabVIEW.

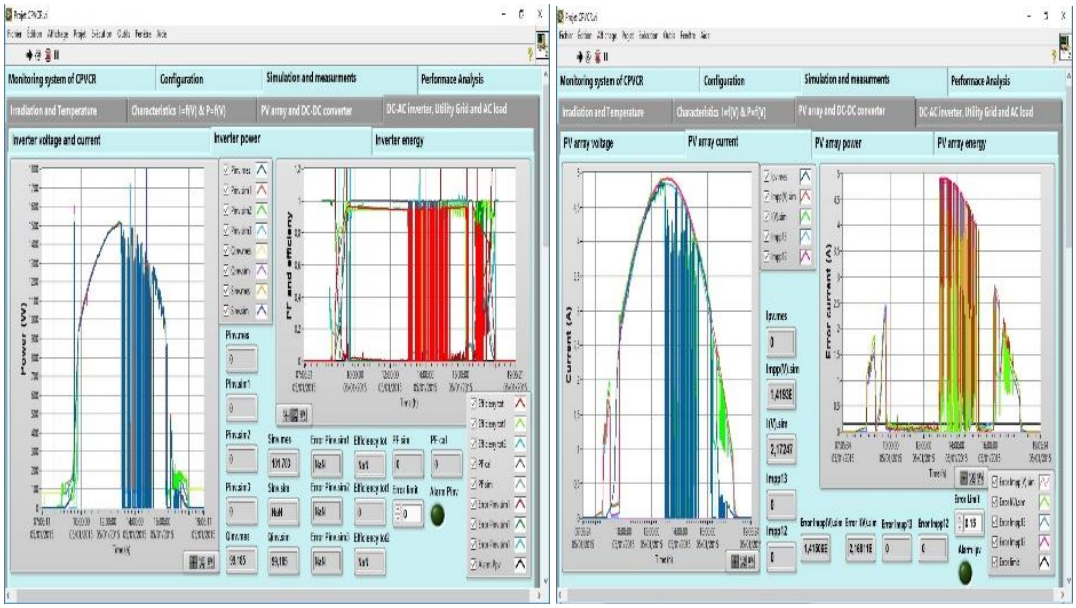

Figure 11. Monitoring of data plotting for this application in LabVIEW

IV. Conclusion

In this paper, a comprehensive review of the PV systems monitoring reported in renewable energy research unit in the Saharan region (URERMS) Adrar and was addressed in this study, to offer insight into the various elements of the monitoring system, such as the acquisition system (FLUK HYDRA 2635A data logger), the sensors section deals with the sensors used in various PV monitoring systems for essential operational and metrological parameters (e.g., voltage, current, solar radiation, temperature) sideways with their basic concepts. Furthermore, the existing problems such as sensor failures, insufficient storage memory, offline performance treatment, and is of PC supervision system for some PV systems. A highlight of the proposed solutions in frame a in the frame of a socio-economic project is also given.

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