A MULTIFUNCTIONAL LOW-COST SCALABLE FIELD MONITORING SYSTEM

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ABSTRACT: In this work, a new outdoor characterization system for photovoltaic solar modules is presented. The new low cost system has been designed to acquire the electrical parameters inside of each module through Modbus. Each module is connected to a supervisory system that collects and store the data. The supervisory system allows real-time control of the whole system. This characterization system has been fully designed, built and installed by the Instituto Tecnológico y de Energías Renovables S.A., in collaboration with the University of La Laguna.

Keywords: Characterisation, Energy Performance, Evaluation, Monitoring, Performance, Qualification and Testing

1 INTRODUCTION

The performance analysis and reliability of solar photovoltaic devices in outdoor conditions is an issue of vital importance in order to characterize the solar module parameters and to detect fabrication problems.

The analysis of the solar module electrical behavior is mainly carried out in solar simulators. The degradation analysis is usually evaluated in ageing chambers, where several cycles of UV light and moisture are applied.

According to the international standard IEC 60891, the electrical performance of the modules is translated to to the Standard Test Conditions (STC)

However, these techniques, even when procedures applied according to the normative, allow the characterization of the electrical performance, simulating outdoor conditions, are the best way to analyze the effect of several other possible exposure agents, such as wind impact or dust accumulation. The Instituto Tecnológico y the Energías Renovables, S.A. (ITER), together with the University of La Laguna (ULL), have developed a low cost new outdoor evaluation setup. The final system has been installed in ITER facilities, close to the Sahara Desert in South Tenerife (28º04'16.48"N 16º30'48.15"W), which provide environmental conditions that are unique in terms of very high sun irradiation, salinity, extreme thermal cycles, constant strong winds and atmospheric Saharan dust accumulations [1].

2 SENSOR PREPARATION

First, a preliminary batch of eight one-cell mini-modules was laminated at ITER's module fabrication facilities. Standard 156 mm x 156 mm multicrystalline silicon solar cells have been laminated in a conventional glass/EVA/TPT sandwich structure. Photovoltaic standard anodized aluminum profiles were used to frame each module. In order to preserve the integrity of the cell's circuit terminals and to provide accommodation for housing the electronic measurement components, large four-terminal class junction boxes were attached at their backside.

These mini-modules operate as the main sensors for the outdoor evaluation setup. As it can be observed in Fig. 1, the system is extremely versatile and can be modified on demand by simply laminating solar cells with different configuration, treatments or technology. The system has been designed to further extend its capabilities, in order to include studies of photon conversion or light concentration nature [2,3], adding films containing these materials on the glass of the mini-modules and/or on the encapsulants.

Figure 1: View of the one-cell modules after lamination (up-left), trimming operation (with exposed circuit terminals, up-right), frame (down-left) and junction box attachment (down-right).

3 SUPPORT STRUCTURE

To mount the mini-modules, a new support structure was developed, consisting of a 0.5 m stainless steel profile welded to a base plate, which can be fixed to the ground by using screws. Through inside of that pillar, a secondary pillar of 0.8m is introduced. This second pillar is made of anodized aluminum, which holds a tilting head with 10º steps, on which a flexible number of mini-modules can be installed.

Aluminum clamps fixed to aluminum beams of the required length allow different configuration in the solar modules mounting area (see Figure 2).

Finally, the height of the mounting structure can be changed from 0.8 up to 1.8 m by simply replacing the secondary pillar.

Figure 2: View of the support structure, showing the tilting head (up-left), exchangeable pillar (up-right) and mini-modules attached with clamps (down).

4 MEASURING DEVICES

A new kind of measuring device, consisting of an acquisition card, which can be assembled inside of the mini-module's junction box, in order to obtain better precision and to isolate the electronic device to other sources of external interferences, has been developed.

The sensors included in the electronic device acquire the electrical values. Also, every minute, an IV curve is acquired. The electronic device is implemented with a voltage regulator, controlled by a microcontroller, which also monitors the temperature radiated by the cell with infrared (IR) sensors. The data is acquired through 16-bit analog / digital converters and stored internally. Since the stored data is accessible via an RS485 interface by using Modbus RTU protocol, multiple cards of this kind can be connected in a linear, multidrop bus configuration (see Figure 3). Therefore, although the original configuration consisted of 8 mini-modules, the system is completely flexible in terms of the number of sensing units that can be connected.

Figure 3: View of a mini-module with the junction box opened showing the acquisition card assembled

5 ACQUISITION, STORAGE AND PRESENTATION OF THE DATA

A set of interface software which acquire, store and show on demand the data generated by the system has been developed. The setup for doing so can be summarized in the flowchart diagram shown at Figure 4.

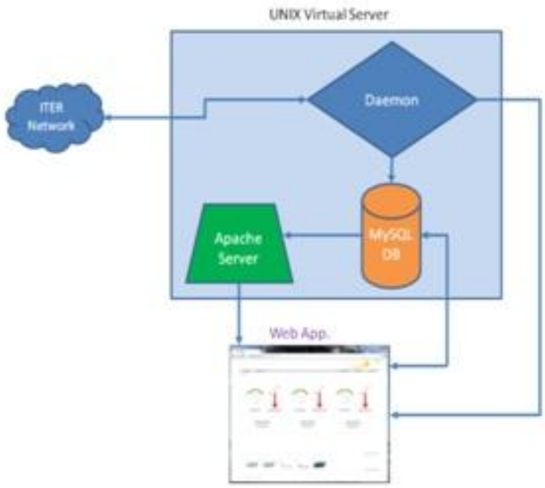

Figure 4: Flowchart diagram describing the acquisition, storage and presentation of the data.

As it can be observed, under a UNIX (Ubuntu) environment of a virtual dedicated server, an application developed in Java as a daemon operates by periodically interrogating the measurement system in real time via the MODBUS protocol. It also performs the necessary calculations and transfers them for their storage in a designed MySQL Data Base, as well as providing them to a web application (written in PHP and jquery) that is capable of displaying such data in different ways via a web server (Apache).

Although the system has been conceived for operating within ITER's supervisory control and data acquisition (SCADA) mainframe, it has been optimized for operating autonomously in lightweight computing hardware, such as single-board computers.

6 FIRST RESULTS AND DISCUSSION

After passing a test period, the system has been in operation since September 2016 at the ITER premises, to evaluate different cell technologies, as well as the effect on the power production of these cells resulting from trying different efficiency improvement strategies, such as applying down-converting films, as it can be observed in Figure 5.

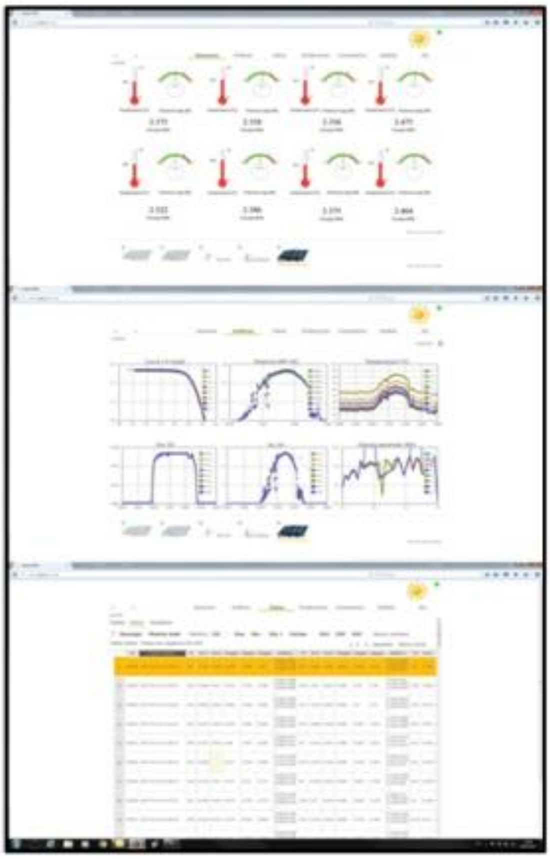

Figure 5: Screenshot captures of the web app. showing real time data acquired (up), processed graphically (middle) and raw data retrieval utilities (down) during the ongoing use of the system.

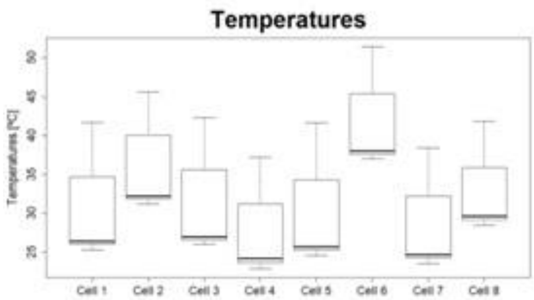

Figure 6: Evaluation of the Nominal Output Temperature (NOCT) from the eight panels under study.

The research results of the first test of minimodules with Down-Shifter layers have been recenty reported [4].

7 ACKNOWLEDGEMENTS

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