

# First Results of the Anomalies Identification Method for PV systems

A. López Agüera<sup>a</sup>, I. Rodríguez Cabo<sup>a</sup>, Eduardo Fernández<sup>a</sup> and C.M. Torres Costa<sup>b</sup>

<sup>a</sup> Department of Particle Physics & Galician Institute of High Energy Physics  
Astroparticle Group. Santiago de Compostela University  
South Campus 15702 Santiago de Compostela (Spain)

phone:+34 981 563100, fax:+34 981521091, e-mail: [ircabo@fpaxpl.usc.es](mailto:ircabo@fpaxpl.usc.es), [lopez@fpaxpl.usc.es](mailto:lopez@fpaxpl.usc.es).

<sup>b</sup> Dpt. Chemical Engineering. Aula Enerxias Renovables. Santiago de Compostela University  
e-mail: [carmenmari.torres@rai.usc.es](mailto:carmenmari.torres@rai.usc.es)

## 1. Introduction

The stand-alone photovoltaic (PV) systems applications are currently characterized by a continuously energy requirement. Under these conditions, a quality check procedure for early detection of PV systems' anomalies is needed [1].

It is well known [2,3] that batteries play an important role in isolated PV systems' performance, and anomalies in their behavior are eventual causes of systems troubles. In this context, we had developed and proposed a quality test for early battery anomalies detection [1], in which we use the battery voltage distribution as a sensitive tool to find the problem before the final lack of energy supply. In this paper we show the first results we obtained by using this protocol.

The experimental set-up is the photovoltaic power supply of the ground detectors at the Pierre Auger Observatory (PAO) [4,5], which consists of a macro-grid of isolated PV systems forming an hexagonal network composed of 1600 particle detector stations. Each 100 Wp station includes two 53 W panels, two series 105 Ah batteries and a MPW regulator which ensure a stable charge-discharge process.

This experiment has an expected lifetime of 20 years, during this period main PV system values are continually monitored each 10 minutes. The data analysis of this experimental set-up constitutes a database of about  $10^5$  data in the first 2 years of normal operation.

**Keywords:** solar energy, PV system's online diagnosis, batteries, system failures, stability.

## 2. Brief Reminder of the Method

The analysis of the battery voltage distribution,  $f(V)$ , was proposed as an indicator of the state of health for the PV system in general. In the  $f(V)$  distribution, we can define four operational regions (see Fig. 1 as an example):

- *Deep discharge region* where the voltage is lower than 11.8 V in the battery;

- *Discharge region* (voltage between 12 V and 13 V);
- *Regulation region* where the battery voltage is in the interval [14,15] V;
- *Over charge region* where the voltage is below 15.5 V in the battery.

The frequency in which each battery is working in each region is used as an indicator of anomalies related to different periods in the battery performance. Deep discharge and over voltage probabilities should constitute a few percent in normal working conditions. Dependence of  $f(V)$  with both irradiation and temperature is taken into account.

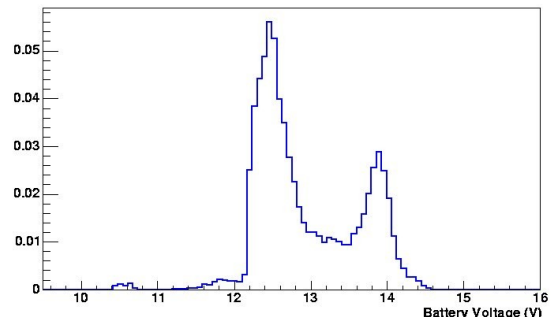


Fig. 1. Generic Voltage Distribution of a battery

## 3. First New Results

It is clear that, once one has a method for the anomalies detection which produces different kinds of alarm, like that we had proposed, it is obligatory to match the method predictions with the actual results. Depending on the time period in which the method is used, we can compare its predictions with the real failures that happened in this period. At the same time, we can feedback the method by using the different cases we find, and achieve an iterative-improving procedure to the best develop of our method.

Taking into account the different kind of anomaly and the two batteries of the stations, we can also study the

relationships between these different anomalies, because of the serial connection/regulation, and the way to solve the asymmetries that do exist there.

### A. Deep discharge

The voltage probabilities in deep discharge should constitute a few percent in normal working conditions, so the batteries with a high integral of the frequencies has an anormal performance which can be an indicator of an anomaly. The most common causes are either connection or installation failures or a broken regulator.

We noticed (see Fig. 3.) that one of the stations' batteries (called battery 1) is twice as probable to be in deep discharge as the other one. At the same time, when we look into the station failures' log, in the corresponding months, we find out that the 80% of the serious deep discharge alarms that our method creates, corresponds to a station which broke down because of a battery failure.

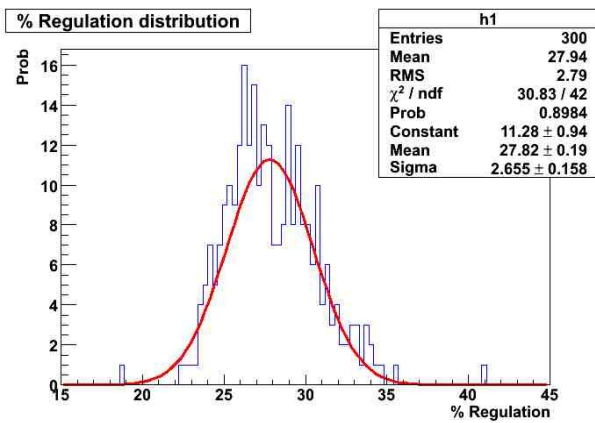


Fig. 2. Distribution of the regulation percentage from 300 stations in March 2005, fitting to Gauss function.

### B. Regulation

As in the case before, the percentage of time in which the battery is in the regulation region is analyzed to find an abnormal performance.

As a general reminder, the distribution of the percentages (%) corresponding to an enough number of stations can give us parameters, by fitting to a Gauss function, with which obtain limit values (see Fig. 2. for example). Moreover, a battery can present this anomaly in two ways, because it has a % below the low normal limit (worse case, except in overcharge case) or because is higher than the high normal limit value (suspicious case, as the other battery could be having an insufficient supply).

In Fig. 3, we can see that the batteries of the set-up which are less probable to have deep discharge are more likely to show a regulation time higher than the others. This is an example of how the differents kinds of anomalies can be related each other, mainly because of the serial connection set-up.

### C. Overcharge

As it is well known [2,3,5], a battery supporting voltages over 15.5 V for long periods of time, gasifies, losing liquid. The effect is a fast decrease on the battery capacity and then on the lifetime.

In this case, when one run the anomalies identification method, the batteries 1 of the stations turn out to be, in a similar sense we have just seen in the previous case, much less probable to be in overcharge than the other ones. Moreover, if we look into the register of the experiment, we find out that the substitutions are notably less frequent in these last cases than in the deep discharge's ones, so we can conclude that the most dangerous anomaly is clearly this last one. Furthermore, we find that in the 20% percent of batteries 1's deep discharge alarms, the other battery is in overcharge, so we can infer that a non-early detection of such an anomaly causes a stress in the other battery that can also be definitive.

The most recomendable thing is that every battery has its own charge regulator, but an anomalies identification method like ours could be enough to prevent these eventualities.

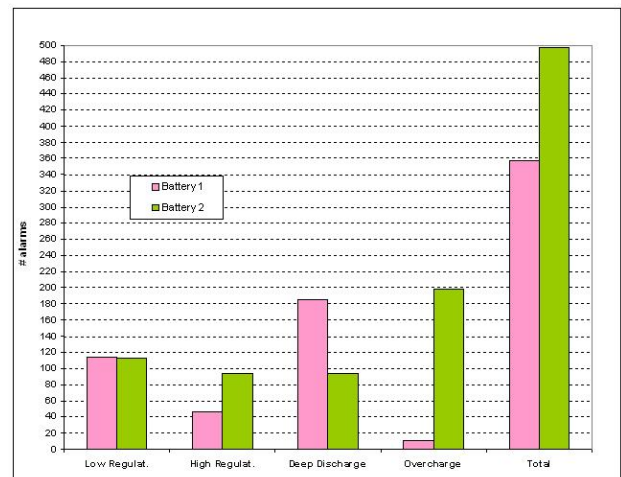


Fig. 3. Summary of several results obtained by applying the proposed method in the year 2005 to all batteries.

## References

- [1] "Anomalies Identification in PV isolated systems". ICREPQ '07
- [2] D. Linden, Handbook of Batteries, McGraw-Hill, New York (1995).
- [3] A. Jossen, J. Garche and D.U. Sauer, Operation conditions of batteries in PV applications, Solar Energy, 76, 759-769, (2004).
- [4] "The Pierre Auger Project". Nucl. Instrum. Meth. A523 50-95, 2004. General information about the project is available at [www.auger.org.ar](http://www.auger.org.ar)
- [5] I. Rodriguez Cabo. Graduation Thesis. USC.

