PARAMETERS AFFECTING THE ACCURACY MEASUREMENT APPLIED TO SOLAR SIMULATORS FOR PANELS CONCENTRATION PHOTOVOLTAIC CHARACTERIZATION

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1. Abstract

The increasing use of concentrating PV systems and the development of photovoltaic cells more and more innovative and efficient is demanding the development of IV characterization systems increasingly precise and stable. The solar simulation device has to provide easy incorporation of the module to the measuring system, in addition to this, the simulator must lean towards a downward trend in the measurement time in the trace of the characteristic curve of the panel, and a comprehensive improvement the accuracy of the measurement made.

2. Introduction

There are two possibilities to make a correct characterization of concentrating technologies. Measurements in the field or "outdoor" have always a distinct possibility of a study unequivocally through duly established standard conditions, but it is precisely the inevitable changes in atmospheric conditions that lead to consider the possibility of realization of measures manufacturing environments or laboratories solar simulation.

The accuracy of the measurement line is especially important for photovoltaic technology, where the device characterization and efficiency provide the most relevant data for continuous improvement. Specifically, the use of solar simulators as a means of qualification of the module are to assess those parameters relating to the characteristics of light, such as the divergence angle, the irradiance and the solar spectrum, as well as the time qualities that remain optimal.

In the scheme shown we can see a study of the conditions required for proper analysis of the characterization by solar simulation

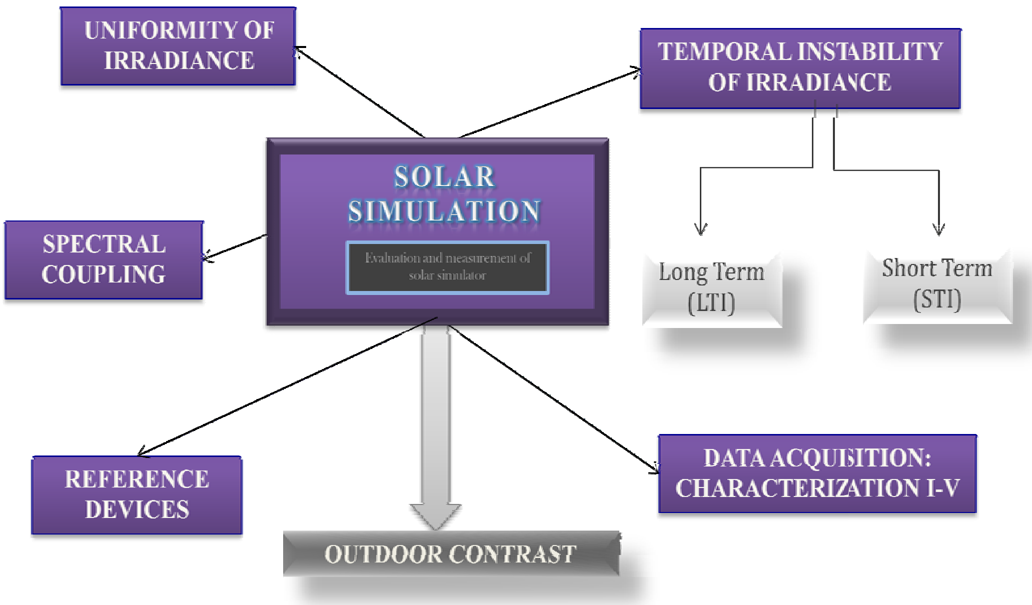

Figure 1: Parameters affecting the accuracy of the measure solar simulators

3. Spectral coupling

The electromagnetic radiation emitted by the sun, are particularly difficult to measure, when light passes through the atmosphere, the spectrum is affected by refraction and dispersion of the rays. The uniformity of the solar spectrum has to stick to a relative distribution for an air mass 1.5 (AM 1.5). The spectral response represents the relationship between the percentage calculated for the spectrum of the simulator and the solar spectrum. Through the standard 60904-9 [IEC 60904-9] defines a spectral coupling limits (Table 1), we provide a categorical classification of the solar simulator used.

Table 1: Limits of spectral solar simulators link

Classification	Spectral Coupling
A	0,75-1,25
B	0,6-1,4
C	0,4-2,0

There are multiple technologies available for the measurement of this parameter, the methodology described (IEC 60904-8) incorporates a measurement error that can be solved by correcting the spectral decoupling occurred between the tester and the reference spectrum (IEC 60904-7).

4. Uniformity of irradiance

The irradiance reached in the measurement plane depends on the peak voltage injected into the solar simulator. This parameter shows a decline over time, and for its use, the measure must adhere to limits of uniform irradiance.

To measure this parameter simulator, must be sampled at least 64 positions (IEC 60904-9) (Dominguez, C, 2008) of the measurement plane. Depending on the type of simulator used (continuous or pulse) the methodology is different.

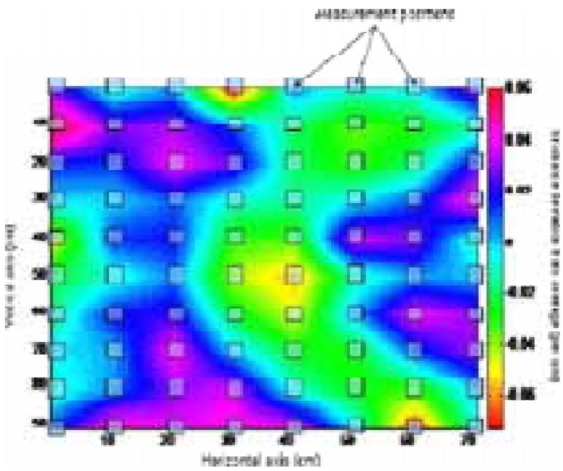

Figure 2: Measure the uniformity of irradiance in the measurement plane. 90 positions (Dominguez, C, 2008)

For continuous solar simulators, you should have at least one measurement of irradiance at each position while in the case of pulsed solar simulators is more comprehensive study. During the flash duration, irradiance may cease to be constant over time shooting, so it must be at least 10 readings during the pulse that makes the characterization measurements or obtaining IV curves.

The diversion occurred in the irradiance uniformity introduced by the solar simulator is a deviation in the quality of the measurement obtained by characterizing the photovoltaic device, which is why quality is defined as the percentage deviation from the uniformity of the irradiance:

Table 2: Limits on non-uniformity of irradiance for solar simulators

Classification	Non-uniformity of irradiance
A	2 %
B	5 %
C	10 %

5. Temporal instability of irradiance

To measure the temporal instability of irradiance influences not only the simulator used, but the data acquisition system used. This parameter is necessary to evaluate the short term (STI) and long term (LTI) and again there will be differences depending on whether it is a solar simulator continuous or pulsed.

In determining the short-term temporary instability (STI), will influence the input channels involved in the sampling, if the acquisition of voltage and current irradiance is at a time, directly considered the simulator class A (table 3). If, however, is done sequentially, temporal instability is defined by the worst measure between two data sets.

The temporal instability of the long-term measure irradiance (LTI) is determined by counting the change in irradiance data sets for the duration of the flash.

For the qualification of the solar simulator, ranges are established for the variation of irradiance in the short (STI) and long term (LTI) (Table 3)

Table 3: Specifications for solar simulators Temporal Instability

Clasificación	Inestabilidad Temporal	
	Inestabilidad de la irradiancia a corto plazo STI	Inestabilidad de la irradiancia a largo plazo LTI
A	0,5 %	2 %
B	2 %	5 %
C	10 %	10 %

The three parameters measured above, we provide the basic data qualification and certification of solar simulator. The plates of the same see a three-letter code that defines the quality and accuracy of the measure provided by the device.

6. Reference devices

All measurements have to be referenced and calibrated by reference devices, fine-tuning of these devices makes an important contribution to the measurement accuracy in the characterization of photovoltaic devices.

In the case of solar concentration, it is important to note that the encapsulation of the device has features similar to one that is under study, the same way must be taken into account the optical device, since it will influence significantly in the quality of light entering the solar cell.

In general, two configurations are used as a reference, individual solar cells and a panel of similar characteristics.

In the case of individual reference cells will be essential to have at least two units of reference, the spectral decoupling them should not exceed ± 1% and photovoltaic devices are stable, if photovoltaic characteristics will not suffer a variation over 5% compared to the initial calibration. (IEC 60904-8)

When using modules as reference devices for calibration of the solar simulator, in addition to the above, we should note that the form factor and short-circuit currents are within a tolerance of 2%. (H. B. Serreze, 2009).

7. Conclusions

Each of the parties is a necessary premise in the accuracy of the measure, and individual assessment is a prerequisite for reliable results in the characterization of photovoltaic devices concentration. It should also be a contrast of measurements made with the solar simulator through outdoor tests that provide a clear basis in the comparative accuracy of the premises obtained by simulation.

The development of techniques to carry out the IV curves obtained in laboratory is very important since the uncertainty of the weather, often an impediment when it comes to qualify the quality of the modules both in the context of research and in supply lines.

8. Acknowledgments

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9. References

1. IEC 60904-9 “Photovoltaic devices. Part 9: Solar simulator performance requirements”

2. IEC 60904-8 “Photovoltaic devices - Part 8: Measurement of spectral response of a photovoltaic (PV) device”

3. IEC 60904-7 “Photovoltaic devices. Part 7: Computation of the spectral mismatch correction for measurements of photovoltaic devices.

4. Dominguez, C.; Anton, I.; Sala, G., “Solar simulator for indoor characterization of large area high-concentration PV modules”; 33rd IEEE Photovoltaic Specialists Conference, PVSC '08, 2008

5. David Faiman , V. Melnichak, R. Rabinovici and A. Razon. Characterization of WPVS reference cells using natural sunlight.

6. H. B. Serreze, H. M. Sobhie and S. J. Hogan Spire Solar, Inc, Solar Simulators Beyond Class A. Bedford, MA 01730 USA, 2009.

8. Pravettoni, M.; Norton, M.; Aitasalo, T.; Galleano, R.; Georghiou, G.; Kenny, R.P.; Barnham, K.W.J., “Electrical characterization of concentrator PV cells: A comparison between outdoor testing under direct solar radiation and indoor measurements on a high intensity solar Simulator”, 35th IEEE Photovoltaic Specialists Conference (PVSC), 2010

9. IEC 60904-2 “Photovoltaic devices. Part 2: Requirements for reference solar devices.”
10. EN 60904-6“Photovoltaic devices. Part 6 Requirements for reference solar modules.”
11. H. B. Serreze, H. M. Sobhie and S. J. Hogan Spire Solar, Inc, Solar Simulators Beyond Class A. Bedford, MA 01730 USA, 2009.