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Thermographic Analysis of Photovoltaic Panels

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Abstract. The paper proposes processing and interpretation of the thermo-graphical images acquired on a grid-connected photovoltaic plant (20 kWp). Infrared analysis allows a reliable evaluation of the state of health of the plant and at the same time the detection of the actions needed of the maintenance. In particular the identification of possible differences between the strings and the rapid location of local hot spots, breakdowns or other problems are presented.

Key words

Photovoltaic plant, Thermography.

1. Introduction

Specific issues about PhotoVoltaivc (PV) plants can affect the PV modules or the inverters. Some of them regarding the PV modules are reported in [1]-[2], while specific models of defects implemented in FEM-based software are reported in [3]. Reliability issues about the several parts of PV plants are listed in [4].

As the temperature coefficient for the power peak of PV modules is negative, it is very important to monitor their temperature in order to verify that the PV plant produces the maximum energy. Moreover, to monitor the temperature allows to detect anomalies before they become failures. Then, the thermo-graphy can give meaningful support just for this aim.

Section 2 reports acquisition issues and instrumentation used for an under study case, Section 3 presents the results and Section 4 the conclusions.

2. Acquisition and instrumentation

The infrared acquisitions on the PV plant has been performed with one survey in date 11 February 2009. The good weather conditions has enabled the correct acquisition of the images. Thermo-camera used has been the FLIR ThermaCAM B4. The not cooled detector with resolution 320 x 240 has provided high quality InfraRed (IR) images, measuring and analyzing rigorously the 76.800 points that make every IR image. It works between -20 °C and +55 °C with thermal sensibility of 0,08 °C (80 mK) and this has allowed to detect small variations of temperature and to have clear and deprived images of troubles. Then the captured images have been analyzed through the software Quick-Report v. 1.1 supplied with the same thermo-camera. Based on MS Windows, it integrates functions of analysis of the images and creation of technical report. During the thermo-camera setup it has been necessary to provide specific parameters of reference, because some of them can influence strongly the results.

In particular following parameters have been set:

Emissivity = 0.85 (typical value for the glass). It is the measure of the radiation sent forth by the object compared to that one would send forth if it were a perfect black body. Normal range of emissivity for objects goes from 0.1 to 0.95. The emissivity of a very shiny (mirror) surface goes down under 0.1, while an oxidized surface or painted has a very great value of emissivity. In our case the value of the glass emissivity has been set, because it represent the frontal surface of the PV panel and the thermocamera operates in the near IR range.
Environment Temperature = 10°C. This parameter is used for compensating the radiation reflected on the object and the radiation sent forth by the atmosphere between the thermo-camera and the object.
Relative damp = 54% . Correct value of the relative damp compensates the influence of itself on the transmittivity.
Distance = 2 m. It corresponds to the distance between the surface of the object and the frontal lens of the camera. This parameter is used for correcting the absorption of the radiation among the object and the camera and the reduction of transmittivity due to the distance.

3. Results

Not-defected PV cell (with irrelevant temperature variations with respect to the average of the surface) has been taken as reference cell. The measures of temperature of the Area1 have an average of 28,6°C with no hot spots.

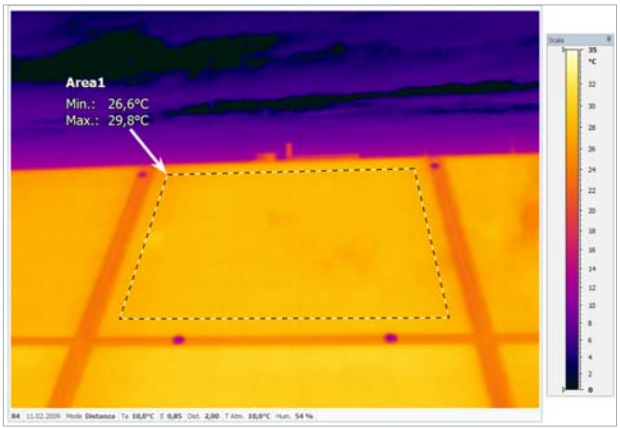

Figure 1. Module with absence of some type of defects.

As visible in figure 2, almost all the analyzed modules have an area characterized by a superior temperature of few degrees (max 6°C) to the average whose cause is due to the presence of the connection box on the back of the module (Fig. 3). It limits the cooling for convention and therefore the surfaces result warmer.

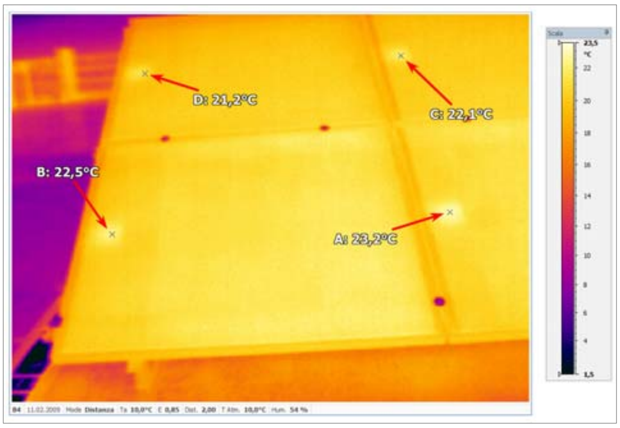

Figure 2. Hot spots due to the connection box.

Figure 3. The connection box.

The module in figure 4 show anomalies on 18 cells (besides another one in the left corner) having superior temperature (about 3,5 °C) with respect to the average one. Such area has been underlined by the Line 2 and compared with a generic Line 1 (figure 5). Such module have also a strong hot spot in the zone of the connection box with overheating about of 10°C. Figure 6 reports a 3D temperature diagram, which highlights the overheating cells.

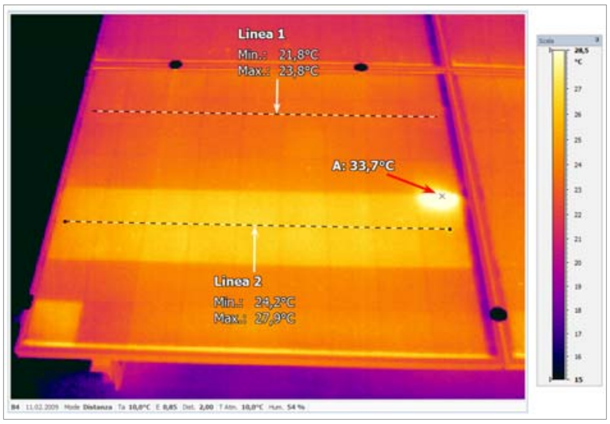

Figure 4. Module with interrupted cells.

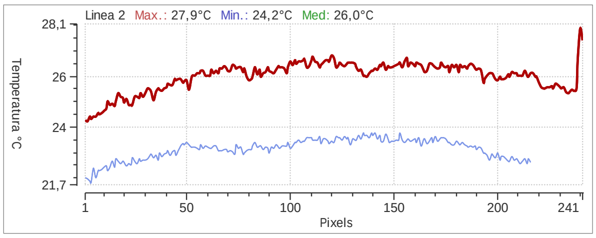

Figure 5. Temperature along the Line 2 (red) and Line 1 (blu).

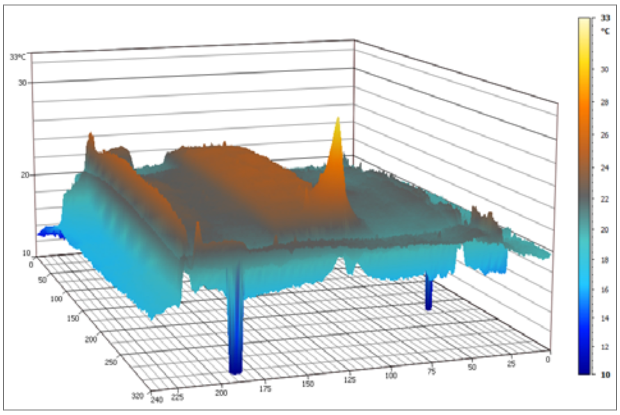

Figure 6. Tridimensional temperature diagram of module with interrupted cells.

Some modules have introduced a not uniform distribution of the temperature values on the whole surface whose more meaningful differences are attested around 6 °C (Figure 7). This could be compatible with the presence on the glass of accumulated great dirt in comparison to other areas. Figure 8 reports its 3D temperature diagram.

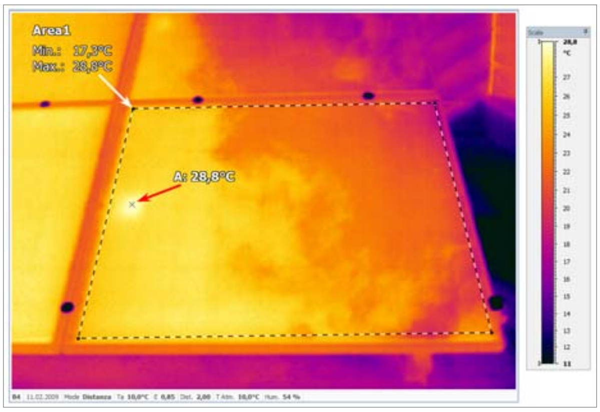

Figure 7. Module with dirt on the protection glass.

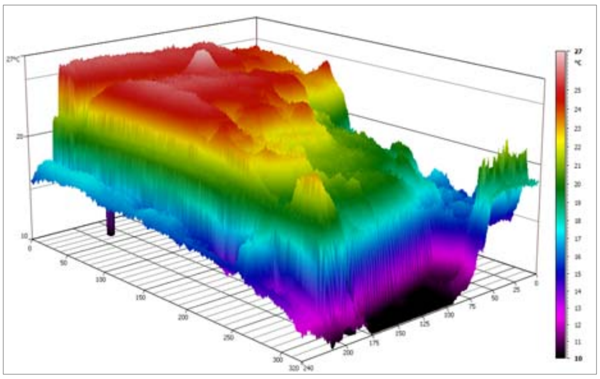

Figure 8. Tridimensional temperature diagram of module with dirt on the protection glass.

The figure 9 is the histogram of the temperature density on Area 1. It results that the measured points belong to a very wide range.

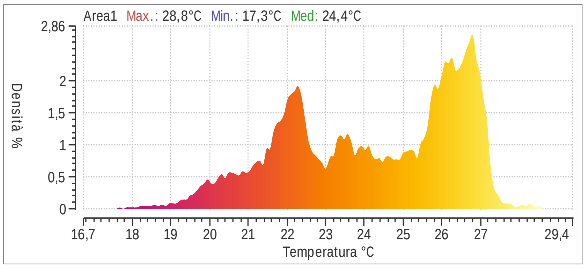

Figure 9. Histogram density of temperature on Area 1.

In Figure 10 several specific cells show an abnormal overheating (about 3°C) with respect to the average temperature. Probably it is not an electric problem of the PV module, but a local.

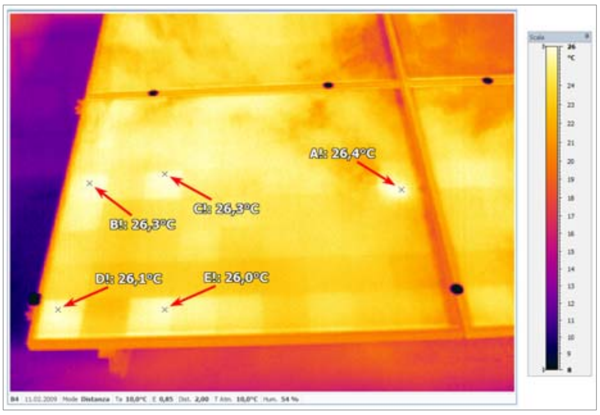

Figure 10. Module with hottest single cells

4. Conclusions

The work has shown that the infrared analysis can be usefully utilized for the efficiency analysis of PV plants. In fact, efficiency depends strongly on the temperature of the PV modules and an overheating causes a decrease of the produced energy. The paper has shown some specific issues related to operating PV plants and it has allowed to quantify the temperature increase for specific hot spots as well as for wider areas.

References

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