A Review on Solar Hotspot Finding with Bypass

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Abstract: Hot spotting is a reliability problem in photovoltaic (PV) panels where a mismatched cell heats up significantly and degrades PV panel output power performance. High PV cell temperature due to hot spotting can damage the cell encapsulate and lead to second breakdown, where both cause permanent damage to the PV panel. Therefore, the design and development of a hot spot mitigation technique is proposed using a simple, low-cost and reliable hot spot activation technique. The hot spots in the examined PV system is detected using bypass method. Several experiments have been studied during various environmental conditions, where the PV module P-V curve was evaluated in each observed test to analyze the output power performance before and after the activation of the proposed hot spot mitigation technique.

Keywords: Solar panel, hotspot, clearance, analysis

Literature Survey:

T.V. Ramachandra et al. (2011) proposed solar hotspots are the regions characterized by an exceptional solar power potential suitable for decen-tralized commercial exploitation of energy. Identification of solar hotspots in a vast geographical expanse with dense habitations helps to meet escalating power demand in a decentralized, effi-cient and sustainable manner. This communication focuses on the assessment of resource potential with variability in India derived from high resolution satellite derived insolation data. Data analysis reveals that nearly 58% of the geographical area potentially represent the solar hotspots in the coun-try with more than 5 kWh/m^2 /day of annual average Global insolation. A techno-economic analysis of the solar power technologies and a prospective minimal utilization of the land available within these solar hotspots demonstrate their immense power generation as well as emission reduction potential. The study evaluates the progress made in solar power generation in the country espe-cially with the inception of an ambitious National Solar Mission (NSM) also termed as ‘Solar India’. The organizational aspects of solar power generation with focus on existing policy elements are also addressed so as to probe the actual potential of the identified solar hotspots in meeting the NSM targets and beyond.

J. Bauer et al. (2012) proposed in order to be creditable, the line of reasoning linking the microscopic image of the hot spot with the macroscopic measure-ment should have been worked out thoroughly. However, the authors perform the following local measurements on several samples with diameters of at least one cm, divided into three different classes: hot spot center, outside hot spot area and non hot spot areas. Their argument for this selection is that the temperature decreases, ‘‘as you move away from the hot-spot center area’’. This indicates a misunderstanding of the physical mechanisms involved in heat generation and heat spread over the wafer and essentially results in a random choice of the samples. We suggest that a systematical selection by thermography or luminescence images with higher resolution well below 1 mm is preferable for such kind of sample selection. It is therefore questionable whether the authors hit the correct origin of the hot spot for the further investigations. Please note that already in 1990, Simo and Martinuzzi [9] located hot spot regions with a high accuracy by mesa diode etching after thermographic locali-zation. The procedure done in [1] implies that the origin of the hot spot is of a statistical, distributed nature, neglecting the highly individual character of each hot spot.

T. Bai (2013) proposed a new analysis method is introduced for investigating whether major flares are clustered in certain fixed regions of the Sun in rigidly-rotating coordinate systems. This method is applied to analysis of major flares of solar cycles 19–23. Northern and southern hemispheres are separately analyzed, and it is found that longitude distributions of flares in the two hemispheres are different. Therefore, the term “hot spot” is used instead of “active longitude.” Seven hot-spot systems are found to be significant, with their rotation periods ranging from 25 to 29 days. Four of them are single-hot-spot systems, and the remaining three are doublehot-spot systems. A double-hot-spot system is made of two hot spots that rotate with the same period but are separated by about 180◦ in longitude. The most significant hot-spot system is the double-hot-spot system with a period of 26.73 days that operated in the northern hemisphere during cycles 20 and 21. It was previously detected by analysis of flare data of cycles 20 and 21. Now it is found that the prominent hot spot of this system was active during cycle 22. Another double-hot-spot system (with a period of 27.41 days) is found to be in operation in the northern hemisphere during solar cycles 19–21. Another interesting hot-spot system is a single hot spot with a rotation period of 27.0 days, which operated in the northern hemisphere during cycle 21. This hot spot may have the same cause as the 27.03 day periodicity observed in solar wind speed and interplanetary magnetic field. During cycle 23, a double-hot-spot system with a rotation period of 28.2 days is detected in the southern hemisphere but none are detected in the northern hemisphere.

J Venkata Subbamma et al. (2015) described that in recent days utility of renewable energy sources is increased for various purposes and at varied locations under various conditions. While using solar panels for generation of power, many challenges are there. One of important challenge is partial shading of the panel and subsequent failure of PV cells due to hotspots. In the shading on the PV cell, the shaded part of the module operates at current levels higher than those of the non shaded PV cells, and affected cells are forced to reverse bias and start to dissipate power, consequently temperature increases due to overheating (hotspot) of the PV cells. Hotspot may also occur due to some manufacturing defects, impurities of the PV cell material etc. Based on these considerations an automatic detection scheme (KIT) is developed to identify the hotspot condition, and to isolate the PV panel which is under hotspot hence avoid the permanent damage of the cell and remove the power losses. If an error is detected (the current is reversed), the micro controller gives the signal to alarm circuit and relay circuit. Then the Alarm circuit gives an alarm sound and the affected panel is isolated by using relay circuit and restarts automatically if the error is removed. The removing of error is done by manual removing or panel tracking or automatic cleaning systems (depending on requirement).

April M. Salazar et al. (2016) described An increased interest on generating power from renewable sources has led to an increase in solar photovoltaic (PV) system installations worldwide. Power generation of such systems is affected by factors that can be identified early on through efficient monitoring techniques. This study developed a non-invasive technique that can detect localized heating and quantify the area of the hotspots, a potential cause of degradation in photovoltaic systems. This is done by the use of infrared thermography, a well-accepted non-destructive evaluation technique that allows contactless, real-time inspection. In this approach, thermal images or thermograms of an operating PV module were taken using an infrared camera. These thermograms were analyzed by a Hotspot Detection algorithm implemented in MATLAB. Prior to image processing, images were converted to CIE L*a*b color space making kmeans clustering implementation computationally efficient. K-means clustering is an iterative technique that segments data into k clusters which was used to isolate hotspots. The devised algorithm detected hotspots in the modules being observed. In addition, average temperature and relative area is provided to quantify the hotspot. Various features and conditions leading to hotspots such as crack, junction box and shading were investigated in this study.

Miguel Garcia et al. (2016) proposed a number of findings have shown that the test procedures currently available to determine the reliability and durability of photovoltaic (PV) modules are insufficient to detect certain problems. To improve these procedures, on going research into the actual performance of the modules in the field is required. However, scientific literature contains but few references to field studies of defective modules. This article studies two different localized heating phenomena affecting the PV modules of two large-scale PV plants in Spain. The first problem relates to weak solder joints whilst the second is due to microcracks on the module cells. For both cases, the cause is identified, and consideration is given with regard to the effect on performance, the potential deterioration over time, and a way to detect the problems identified. The findings contained in this paper will prove to be of considerable interest to maintenance personnel at large-scale PV plants and also to those responsible for setting module quality standards and specifications, and even the PV module manufacturers themselves.

N.D.Mani et al. (2016) proposed that solar energy has been widely tapped around the world replacing conventional non-renewable energy. Currently, one of the most challenging problems is to increase the quantity of energy tagged from solar energy. Before installing solar panels, assessing where solar panels should be placed can significantly benefit panel performance. This study aims to conduct a site selection analysis for solar panel installation using Geographical Information Systems (GIS). The focus of the analysis is on building rooftop PVC panel installation.

M. Bressan et al. (2017) presented an emulation in real-time of the shaded PV systems with a hot-spot prevention. The PV model takes into account the photo-induced current contributions from unshaded and shaded sides thanks to parameters such as the shadow transmittance and the percentage area of the shadows. The use of shadow fault detection in real time is employed avoiding all form of hot-spot formation and PV cells power dissipation. The calculation uses a simple derivative equation able to give the area of detection in function of the PV module voltage. The implementation of the emulator in FPGA takes advantages as a result of their features of adaptability and parallel processing suitable for emulation of complex shading visible on PV systems. The emulation of the proposed PV model and the hot-spot prevention are validated through two experimental tests on PV modules.

Shifeng Deng et al. (2017) proposed Based on the working principles of solar cells, the photovoltaic module mismatch model was constructed to simulate the heat dissipated by one single cell with different shading percentage ranging from 10% to 100%. ANSYS simulation was utilized in this paper to explore the relationship of hot spot temperature and type of solar cell defects (for example point defect and planar defect) with the module output power. The simulation results showed that the module hot spot temperature is inversely correlated with the solar cell defective area, and positively correlated with module output power. Solar cells with different type of defects and solar modules with different output power were picked to conduct the hot spot experiments, in which the leakage currents for the defected solar cells and the high-efficiency module cells (normal cells) were less than 1.5 A and 0.1 A, respectively, for an applied negative bias of 12 V. The results showed that the temperature of the module with point defected solar cell and the high- efficiency module reached up to 200 and 170°C, respectively, which could lead to encapsulation failure. The experimental data was consistent with the simulation, demonstrating the accuracy of the simulation model and providing directives for solving the hot spot problem of the high-efficiency module.

Dalvir Singh et al. (2018) presented the photovoltaic market has quickly increasing over a couple of years. One of the main reasons for this high growth in PV industry is the reduction of PV production costs. The output power obtained from the PV module is mainly depend upon the two parameters named as irradiance and temperature. There are number of factors that affects the performance of the PV array, such as diode and connection loss, mismatch loss, DC/AC wring loss, sun tracking loss, shading loss, soiling loss and material loss. From the above mentioned techniques, in the proposed research work, we have considered three faults named as shading loss, soiling loss and material loss. When these faults occur in the network, the power loss of the module decreases. In this research work, we have presented a simulation model fault detection procedure for PV systems, based on the power losses analysis. This automatic supervision system has been developed in MATLAB (MATrix Laboratory) &in Simulink environment. It includes parameter extraction techniques to calculate main PV system parameters for monitoring data in real conditions of work, taking into account the environmental irradiance and module temperature evolution, allowing simulation of the PV system behaviour in real time. The automatic supervision method has analysed the output power losses in the DC side of the PV generator, capture losses. Also, a classification technique named as ANN (Artificial neural network) is used to classify the type of error and to know the level of power loss. ANN is also used to reduce the power loss occurred in the PV array. The performance parameters named as power loss, Idc and Vdc are measured. The power loss is measured without ANN and with ANN to know the efficiency of the system.

Conclusion: Hot spots are areas of elevated temperature affecting only part of the solar panel. They are a result of a localized decrease in efficiency, which results in lower power output and an acceleration of the materials degradation in the affected area. Bypass diodes help to limit the maximum output power that can be dissipated through a reverse biased PV cell, but the power level depends on the length of the cells in the PV module. More cells in the series PV module will dissipate more heat than strings with fewer cells. Thus, bypass diodes are more effective in mitigating hot spots for short PV module length. Placing bypass diodes over every two cells would ensure that a PV cells never dissipate more than the nominal power of two cells, which is the required power that is unlikely to damage the cells.

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