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Photovoltaic Modules Fault Diagnosis Using Low-Cost Integrated Sensors

Authors : Marjila Burhanzoi, Kenta Onohara, Tomoaki Ikegami

Abstract : Faults in photovoltaic (PV) modules should be detected to the greatest extent as early as possible. For that conventional fault detection methods such as electrical characterization, visual inspection, infrared (IR) imaging, ultraviolet fluorescence and electroluminescence (EL) imaging are used, but they either fail to detect the location or category of fault, or they require expensive equipment and are not convenient for onsite application. Hence, these methods are not convenient to use for monitoring small-scale PV systems. Therefore, low cost and efficient inspection techniques with the ability of onsite application are indispensable for PV modules. In this study in order to establish efficient inspection technique, correlation between faults and magnetic flux density on the surface is of crystalline PV modules are investigated. Magnetic flux on the surface of normal and faulted PV modules is measured under the short circuit and illuminated conditions using two different sensor devices. One device is made of small integrated sensors namely 9-axis motion tracking sensor with a 3-axis electronic compass embedded, an IR temperature sensor, an optical laser position sensor and a microcontroller. This device measures the X, Y and Z components of the magnetic flux density (Bx, By and Bz) few mm above the surface of a PV module and outputs the data as line graphs in LabVIEW program. The second device is made of a laser optical sensor and two magnetic line sensor modules consisting 16 pieces of magnetic sensors. This device scans the magnetic field on the surface of PV module and outputs the data as a 3D surface plot of the magnetic flux intensity in a LabVIEW program. A PC equipped with LabVIEW software is used for data acquisition and analysis for both devices. To show the effectiveness of this method, measured results are compared to those of a normal reference module and their EL images. Through the experiments it was confirmed that the magnetic field in the faulted areas have different profiles which can be clearly identified in the measured plots. Measurement results showed a perfect correlation with the EL images and using position sensors it identified the exact location of faults. This method was applied on different modules and various faults were detected using it. The proposed method owns the ability of on-site measurement and real-time diagnosis. Since simple sensors are used to make the device, it is low cost and convenient to be sued by small-scale or residential PV system owners.

Keywords : fault diagnosis, fault location, integrated sensors, PV modules
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