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TESI DI DOTTORATO

Photovoltaic Systems Reconfiguration

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A photovoltaic field is typically composed by series-connected panels, thus composing strings, which are then connected in parallel. By this way, the current and the voltage values of the photovoltaic generator are adapted to operating range of the power electronics systems that transform the generated energy, conveying it to the load and to the electrical grid.
The performance of the photovoltaic systems are reduced when a partial shading of the field occurs. In this case, the modules could work under very different conditions from each other, so that the system components may not be able to maximize the generated energy and/or the operating constraints of power electronics systems are not respected.
The reconfiguration of the electrical connections among the panels leads to maximize the performance of the photovoltaic systems but it requires additional hardware and it causes further energy consumptions that have to be minimized by executing the reconfiguration procedure only when the shading phenomena occur.
The choice of the electrical configuration of the panels is determined by an appropriate algorithm and then it is actuated by a matrix of relays.
The reconfiguration algorithm proposed in this research work is based on an evolutionary approach.
In order to minimize the execution time, the number of samples of the voltage - current characteristics of the panels is reduced by a proper under-sampling technique.
The under-sampling algorithm can be used also for diagnostic purposes. For example, it can be used to determine how the modules in each panel are differently illuminated.
In this Thesis, the results obtained by the genetic algorithm by using both the original and the under-sampled curves of panels are compared.
Since each execution of the reconfiguration procedure leads to a reduction of the energy produced because it requires the disconnection of the panels, although for a very limited period of time, the effects of the reconfiguration frequency on the daily generated energy are evaluated.
A fixed reconfiguration frequency could be misaligned respect to the transit speed of a shadow passing over the photovoltaic field.
So, the reconfiguration of PV systems is able to maximize the generated energy only when it is also able to detect and react promptly to the shading phenomena over the field.
For this reason, in this Thesis a rules-based algorithm for detection of the partial shading phenomena of the PV field is proposed. Basing on this method, the reconfiguration of the PV field is triggered only when at least one specific rule is verified. These rules are based on the analysis of changes of the voltage and current values of the photovoltaic strings respect to the values achieved after each reconfiguration.
However, since this procedure is able to reduce the reconfiguration frequency when no shadowing occurs, but it may not be able to limit the number of reconfigurations during the transit of the shadow, a technique for estimating the motion path followed by a shadow on the PV array and the relative transit speed is also proposed.
This estimation is performed by analyzing the current values returned by the under-sampling algorithm. By this way, it is also possible to predict the amount of time required by the shadow to move of a specified number of photovoltaic modules or strings and then to predict the next reconfiguration time.