The aim of the research proposal linked to to the invitation of Prof. Spagnuolo to the Univ. of Cergy-Pontoise concerns the system parameters identification devoted to diagnostic functionality in power processing systems for renewable energy sources, in particular for Photovoltaic (PV) applications. The main result will be the design and implementation of numerical techniques in embedded systems for real-time diagnosis. The methodologies will be suitable for performing the diagnosis of different components of the PV plant: the PV cells/modules/arrays as well as the electronic components of the power processing system and the energy storage elements.
The two groups started the cooperation some years ago in the frame of an Erasmus agreement. Currently one PhD student (Mattia Ricco), in co-tutorship with the two universities, and another student (Patrizio Marganiello) with a research contract with joint supervision, are working on this topic.
Preliminary results on the system identification have been obtained by implementing on a FPGA a Cross-Correlation-Method based on a Pseudo-Random Binary Sequence. The subject of the study is the real-time identification of a system including a PV array and the dc/dc converter managing the power produced thereof. The encouraging results have allowed promoting this method as one of the possible candidates to perform the diagnostic functionality.

Project description:
A summary of the work that will be developed in the frame of the joint research activity is listed below:

- Analysis of the state of health of the whole PV plant by means of model-based and/or model-free approaches suitable to be integrated in a digital platform for the real-time implementation. It is expected that the information coming from this analysis will be useful to adjust the optimal operating point by keeping into account the effects of components drift and aging.

- Identification of abnormal operating conditions of the PV plant due to mismatch. PV source operating in mismatched conditions (especially when the mismatch is localized on few PV cells) can be subjected to the hot-spot phenomena leading to a permanent damage of PV panel, or even more to trigger a fire. If this condition is preventively recognized, the risk of fire is avoided and the PV panel is saved. This aspect is particularly important in residential PV applications, which are the largest part of worldwide PV plants, where the mismatched conditions are frequently induced by the presence of partial shading (e.g chimney, antennas,….) or not predictable shadow (snow, dirty, … ). In some cases these conditions are difficult to be identified. It is expected that, when the by-pass diodes are active for the presence of mismatch, the dynamical behavior of the PV source should change then, by injecting in the PV field particular signals, it should be possible to detect the abnormal operating condition.

- Estimation of residual lifetime of the most critical electronic components. For example, it is well established that electrolytic capacitors have a short lifetime but they are still extensively used in many PV inverter because a large capacitance might be required for ensuring small voltage ripples. Another component that might be subjected to a high probability of failure is the by-pass diode (DB). Indeed, by-pass diodes of the PV cells subject to the mismatch work in a heavy condition can be stressed very much so that the degradation phenomena are accelerated. This task will be performed by extracting information on real operating conditions of the critical components by using direct and indirect electrical measurements, thermal measurements inside the power processing system in conjunction with estimation methods (e.g Kalman filter).