Universitatea Transilvania din Brașov

HABILITATION THESIS

SUMMARY

Title: METHODS AND ELECTRONIC SYSTEMS FOR PHOTOVOLTAIC CELLS CHARACTERISATION

Domain: ELECTRONIC ENGINEERING, TELECOMMUNICATIONS AND INFORMATION TECHNOLOGIES

Author: Assoc. Prof. Dr. Cotfas Daniel Tudor

Transilvania University of Brasov

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Renewable energy is a crucial topic with major implications in the economic, social and political life. The jobs number created in the renewable energy domain by the end of 2017 was over 10 milions, of which almost 4 milions are in solar energy domain and over 3 milions in solar photovoltaic (PV). China added for solar PV installed capacity in 2017 more than 50GW which means more than the total solar PV installed capacity in 2010.

The author' scientific contributions in solar PV domain after obtaining the doctoral degree in 2008, recognized by the scientific community through publication in international journals with high impact factor, books or awards, laid the basis of the habilitation thesis entitled "Methods and electronic systems for photovoltaic cells characterisation".

The habilitation thesis is structured in two main parts:

- in the first part the theory and experimental results about the methods and the systems used to characterised the photovoltaic cells are presented;
- in the second part the main developed applications of the photovoltaic cells are presented.

The dynamic of the solar PV domain is presented in the first chapter. The latest developments in photovoltaic cells research and market are briefly discussed.

The PV cells can be characterized in static and dynamic regimes. The current voltage characteristic is the most important tool used to determine the important parameters of the photovoltaic cells. Four original methods to determine de parameters of the photovoltaic cells in static regime are presented in the second chapter of the habilitation thesis. Two of them used analytical methods and the other two used metaheuristic methods: a genetic algorithm and a successive discretization algorithm. The first method is used to determine the series resistance and the shunt resistance of the photovoltaic cells. The other three methods allow the determination of all important photovoltaic cells parameters: the photogenerated current, the reverse saturation current, the ideality factor of the diode and the parasite resistances - the series resistance and the shunt resistance. An original method to determine de parallel capacitance of the photovoltaic cells is also presented in the second chapter.

The techniques used to measure the current voltage characteristic are enumerated and explained. The original system developed to measure and analyse the photovoltaic cells using the NI ELVIS platform or NI myDAQ is also presented in this chapter. This system can be used in the didactic process as well as in research. It is used in order to determine the important parameters in function of the temperature,

irradiance and the angle between the incident light and the photovoltaic cell. The methods from the scientific literature are implemented for each important parameter of the photovoltaic cell. This system was awarded three prizes at the international competition which took place in Austin, USA in 2013 and it also won the gold medal at Euroinvent, Iasi, 2015.

Various applications with the photovoltaic cell as major component are briefly described in the third chapter. This chapter is structured in six parts. In the first part the author presents the electronic systems developed to measure the components of the solar radiation: the global horizontal solar radiation, the diffuse solar radiation and the albedo. The last system developed by the author's team was used to measure the albedo for different wheat crops in a collaboration with National Institute for Agricultural Research and Development Fundulea. The method to determine the ageing lifetime of the solar cell is presented in the second part. For this method the author's team has forwarded a patent application in 2015. Due to a good collaboration with the industrial environment the author successfully participated at developing the prototype of an intelligent solar lamp for Steinel company. The Steinel currently produces this intelligent solar lamp. The contribution of the author is presented in the third part of the third chapter. The possibility to increase the power generated by the photovoltaic cells and of course to improve their efficiency is presented in the fourth and fifth parts. The behaviour of the photovoltaic cells parameters as a function of the radiation and temperature is also described in the fourth part. In the fifth part a new hybrid system PV-TEG-STC (photovoltaic cells or panel, thermoelectric generator and solar thermal collector) is presented. The behaviour of the hybrid system under natural sunlight conditions presented by the author' team was among the first from the scientific literature. In this part the hybrid systems are analysed in laboratory under artificial light, under natural sunlight and concentrated light. The measurements in concentrated light were made using the facilities of the Paul Scherrer Institute from Switzerland and the system developed by the author's team in laboratory. In the last part the model developed for estimation of the monthly average daily solar global horizontal and diffuse radiation are presented. These models are developed as local ones.

The author's research activity, presented in the habilitation thesis, also performed by national and international collaborations, comprises a large number of papers published in ISI journals with high impact factor, such as: Renewable and sustainable energy reviews, Energy, Energy Conversion and Management, Energies,

Measurements, International Journal of Photoenergy, etc. Moreover, the author won four international projects, two national ones and also proposed two patent applications.