Chapter 3
New Tools in Hardware and Software Design Applied for Remote Photovoltaic Laboratory

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ABSTRACT

This chapter aims to present a system for remote laboratories dedicated to solar cells in the context of contemporary research development in the field of renewable energy. The system is based on the NI ELVIS rapid prototyping platform, the LabVIEW graphical programming language, remote control techniques, and an original add-on for studying solar cells developed for the platform. The completed NI ELVIS add-on, called SolarLab, is a modular board, which allows users to perform eighteen different lab experiments. Using the developed driver, users can create their own applications according to their needs. Thus, SolarLab can be used for both education and research purposes.

INTRODUCTION

In the context of the contemporary process of continuous and accelerated development, society has become a great energy consumer. The fear that fossil fuels used for energy generation are becoming increasingly rare and that climatic change will create hardship for humankind makes the need to discover alternative sources of energy imperative. As could have been expected, the academic community was the first to take action and use all of its resources to respond to the new challenges.

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Identifying new resources, but especially making them reliable does not only mean doing research work, but also training domain specialists at the same time. The research is well defined and is generally based on consistent budgets, which are not always available in the educational domain. This forces educators to become more inventive, developing new ultramodern methods designed to attract students. Such modern education processes cannot ignore that the global increase in energy consumption is the primary cause of global warming and pollution.

Identifying and developing new renewable sources of energy such as photovoltaic, wind, thermal, geothermal, wave energy, biomass, etc. could fight the global climate changes (Sørensen, 2004). Some of renewable energy sources have advantages that cannot be overlooked.

Why did we choose photovoltaic energy? A first answer is the diversity of its applications: its use for street lighting, street signals, achieving standalone systems of various power sources for buildings, high power systems connected to the electrical network, special applications, etc. Another answer lies in installation flexibility and cost. The installation of photovoltaic systems can be materially supported by individuals for small power systems, and by companies for high power systems. Another strong argument is the placement possibilities of photovoltaic systems. For low power systems, one can use already existing spaces, such as building roofs. If they are well integrated into the building's architecture, they are not even visually polluting. Another argument is the relatively high lifetime of the systems and low lifetime maintenance costs. Due to high volume production, the system cost becomes more competitive. There are, however, some disadvantages. The most important limitation is the amount of solar radiation available in the region where the system is mounted.

Why solar cells? The solar cell is the very heart of the photovoltaic system.

The solar cell directly transforms solar radiation into electric energy, which is commonly called the photovoltaic effect.

The simplest structure of a solar cell has the following parts:

- The main part - the p-n junction;
- The inferior contact - that covers the whole inferior surface of the cell;
- The superior contact - in the shape of fingers to optimize the active area and to lower the series resistance of the cell;
- The antireflection layer needed to maximize use of the radiation that falls on the cell.

Though many types of materials may be used for manufacturing solar cells, the most common is silicon. Nowadays, there are various types of silicon solar cells, due to the abundance of silicon and the following developments of the electronics industry since the 1950s:

- Mono-crystalline;
- Polycrystalline;
- Amorphous silicon;
- Thin film.

Other materials used to manufacture solar cells include: CdTe, GaAs, InP, CuInSe2, GaInP/GaAs/Ge, GaInP/GaAs, GaAs/CIS, a-Si/CIGS.

Triple junction cells were created to raise solar cell efficiency. This type is used to absorb as much energy as possible from the solar radiation spectrum. The efficiency of these cells reached 42% in the lab. In comparison, the highest efficiency of silicon solar cells is 24% (Kramer, 2004).

Solar cell characteristics are critical to the construction of solar panels (Markvart and Castañer, 2003). The parameters of the solar cells have to be identical, meaning the cells should be twins. The main parameters of the solar cells are: I_{sc} - the short circuit current, V_{oc} - the open circuit voltage, V_m - the maximum voltage, I_m - the maximum

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