Maestría en Ingeniería en Automatización de Procesos Industriales

Design of the voltage passivity-based control for charging a battery using photovoltaic panels

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1. Introduction

Nowadays we live in a society where the most of the products that are used are petroleum derivatives; however, the abuse of this resource has become in the growing scarcity of this. Hubbert is the geophysicist who created the mathematical model that predicts the level of oil extraction over time [1]; according to the 2010 model, the peak of oil was reached and we are currently in what could be called “the decrease of this resource”.

The current energy consumption, due to the increase of the world population and increasing adoption of technological products that require electricity for its operation, it has caused an unprecedented increase in the consumption of electricity. This is generated mainly by energy sources based on the use of so-called fossil sources (oil). According to OPEC (Organization of Petroleum Exporting Countries), around the world 100 million barrels per day will be consumed this year [2]. The abuse of this energy source has contributed to global warming and environmental deterioration, this is why renewable energy sources such as solar are a viable and effective solution to such problems [3]. Although, these sources of energy are efficient, applying various control methods such as passivity-based and power electronics (DC/DC converter), in this way we propose a new vision with the exploitation of renewable energies.

2. Objectives

2.1. General Objectives

To design and to implement a voltage control passivity-based for a buck-boost DC/DC converter used in photovoltaic applications.

2.2. Specific Objectives

- To characterize the solar panel by mathematical modeling to obtain characteristics variable.
- To design the appropriate passivity-based control of the system to maintain the reference voltage.
- To implement the passivity-based voltage control prototype in an embedded system for charging a deep cycle battery.

3. Methodology

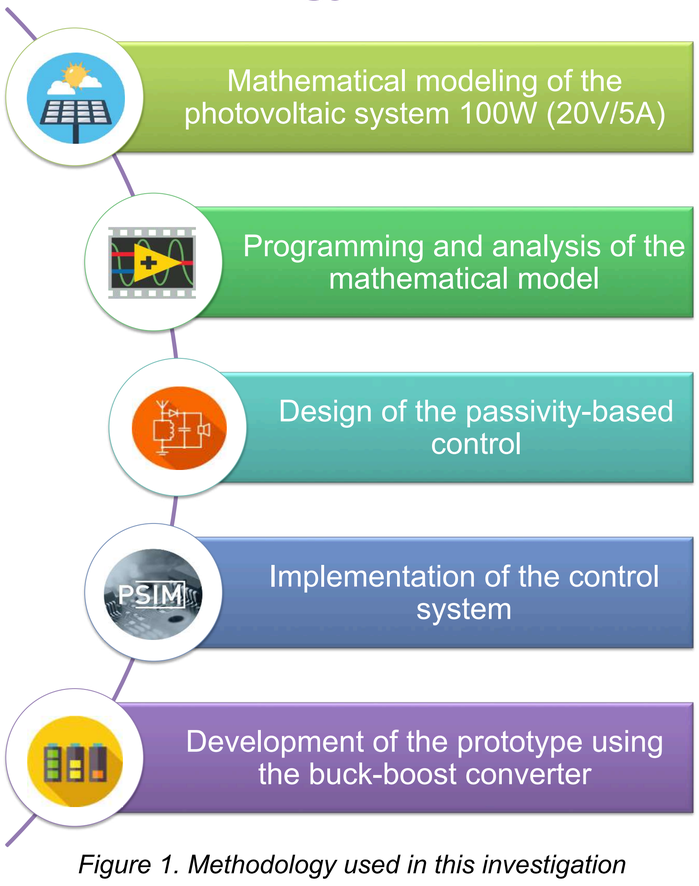
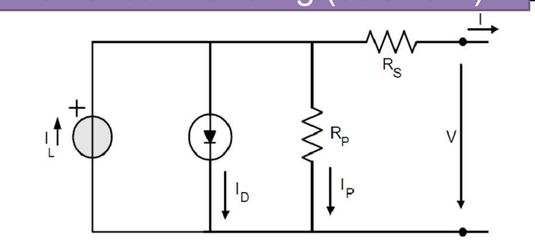


Figure 1. Methodology used in this investigation

Mathematical modeling (solar cell)



$$I=I\downarrow L-I\downarrow O\,[\exp(q(V+IR\downarrow S)/K*T\downarrow C*A)-1] \quad (1)$$

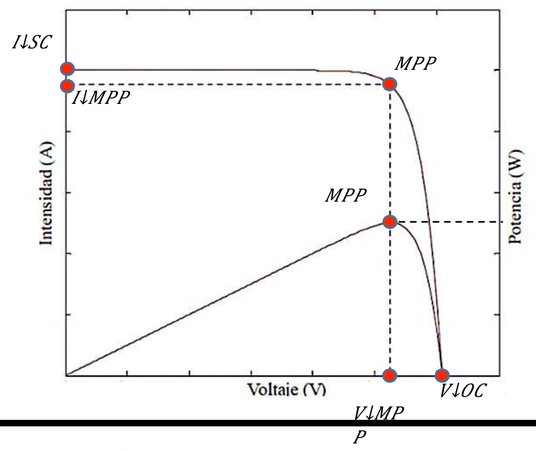


Figure 2. Mathematical model of a solar cell [4]

LabVIEW program

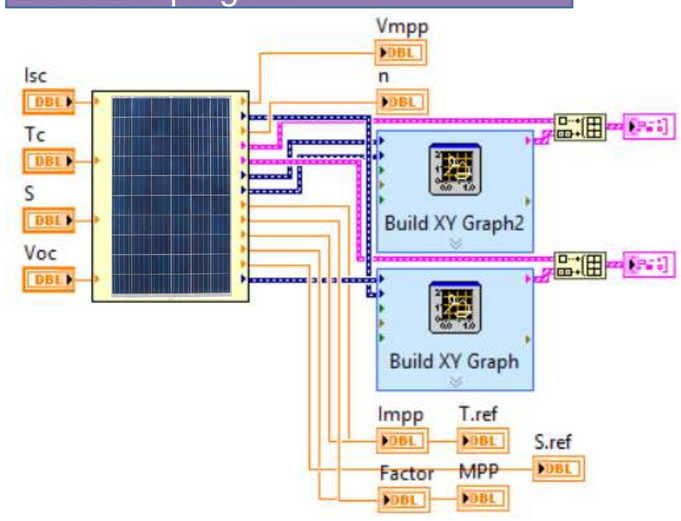
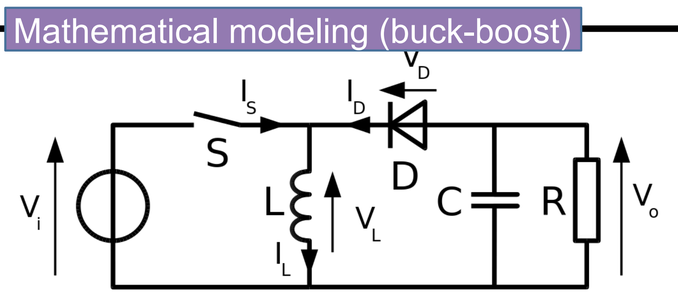


Figure 3. Programming a mathematical model of a solar cell made in LabVIEW

Mathematical modeling (buck-boost)



$$x\downarrow 1=(1-U)x\downarrow 2\,/L+E/L\,U \quad (2)$$

$$x\downarrow 2=-(1-U)x\downarrow 1\,/C+x\downarrow 2\,/RC \quad (3)$$

Figure 4. Mathematical model of a Buck-boost DC/DC converter [5,6]

PSIM program

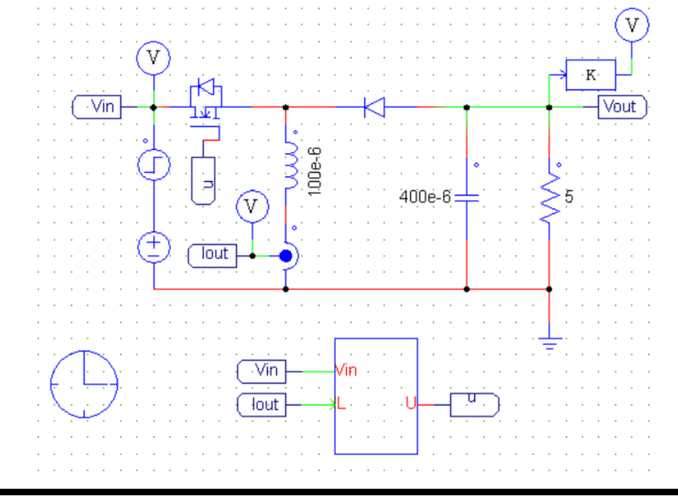


Figure 5. Implemented Control in PSIM [7]

4. Results

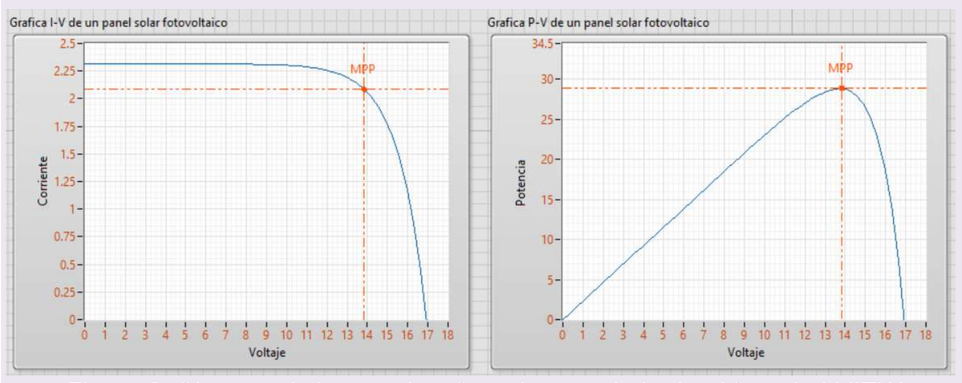


Figure 6. Characteristics graphs of a solar panel obtained from LabVIEW program

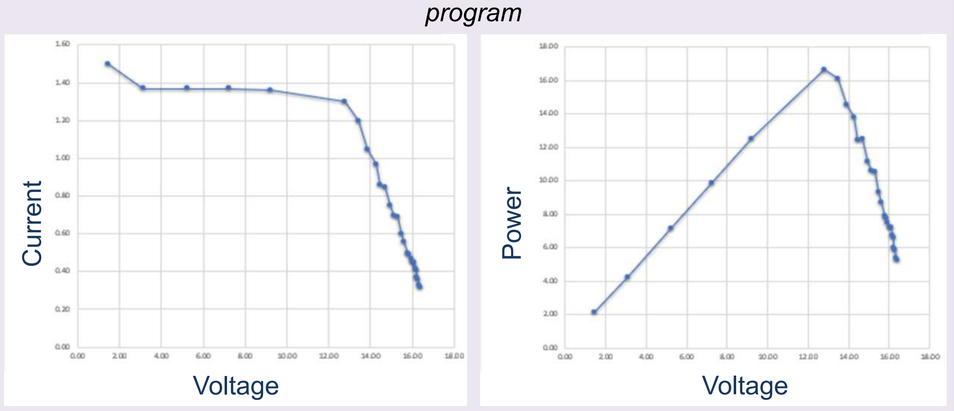


Figure 7. Characteristics graphs of a solar panel obtained from experimentation

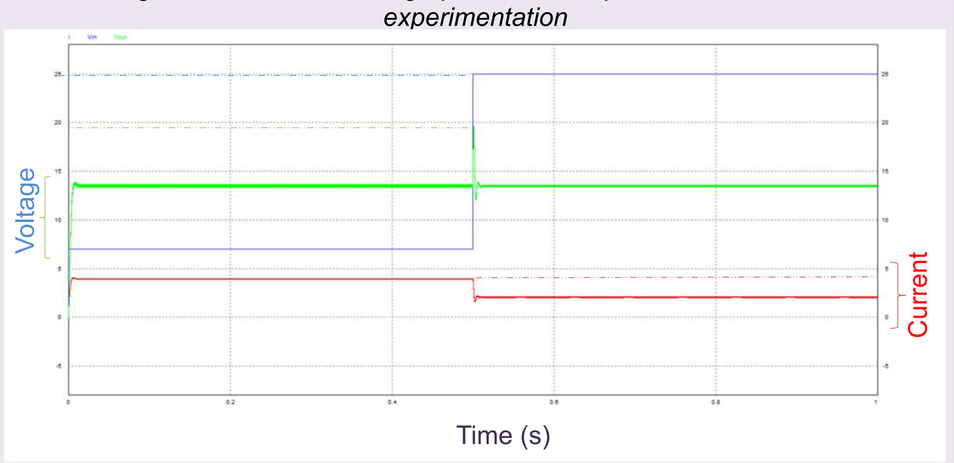


Figure 8. PSIM simulation of the control response

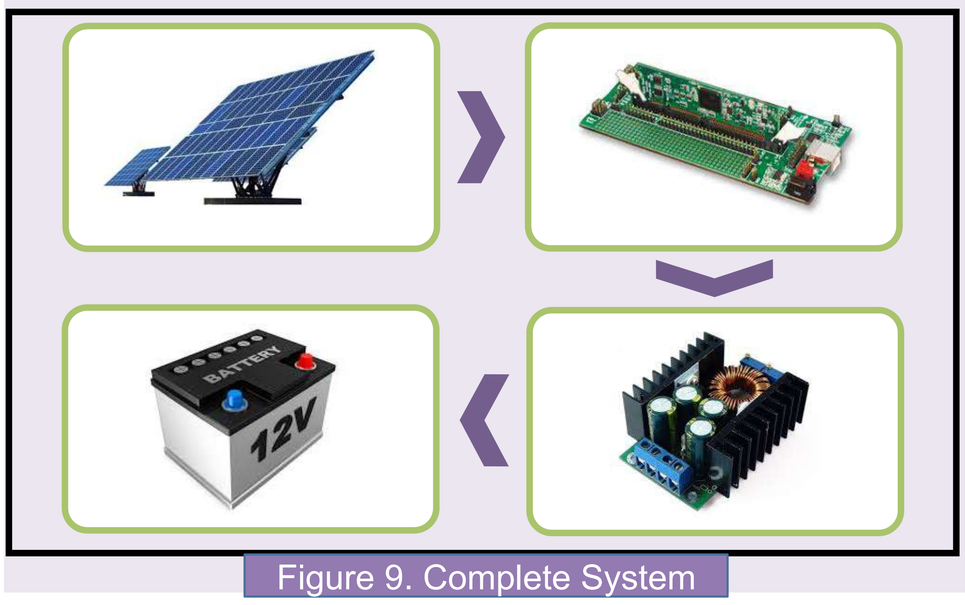


Figure 9. Complete System

5. Conclusions

According the results we can conclude that efficiency of the solar panel has been increased due to implemented control, thus we can obtain the same amount of energy in the battery when the solar panel is at lowest point of production, In addition, the behavior of the response is very fast in the face of climatic changes that may occur.

Acknowledgements

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