DESIGN AND IMPLEMENTATION OF RESONANT CONVERTER FOR PV POWERED BATTERY CHARGERS

By

Ahmed Yahia Farag Abd-elfatah

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
In
Electrical Power and Machines Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis:

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Key Words:
Solar Energy; MPPT; Resonant converter; Battery charger; Renewable Energy

Summary:

Resonant converters design is complicated especially for wide input voltage range and wide output voltage range as in PV powered battery chargers. Hence, a clear design steps is proposed to ensure high efficiency operation.. A control technique for resonant converter is proposed based on Perturb and Observe (P&O) technique. The converter will operate in constant current (CC) charging mode or constant voltage (CV) charging mode in maximum power point tracking MPPT mode The proposed design and control are verified by the results of MATLAB/SIMULINK simulations and experimental setup.

Disclaimer

I hereby declare that the thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the reference section.

Name: Date:

Signature:

Dedication

To my Father.
The reason of what I become today.
Thanks for your great support and continuous care.

To my mother.
I wish you were here with me. You are my first and the most woman I have ever loved.
May Allah gather us in his paradise.

To my family.
Thank you for your endless love

To everyone who wanted to see me successful and I missed.
Here is my thesis.

Acknowledgments

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Abstract

Environmental problems such as global warming and pollution guide us to replace the conventional energy sources with Renewable energy sources. Egypt targets to generate 20 % of the total capacity of generated electricity from renewable sources by 2022.
Renewable energy sources are not limited to bulk power generation but it's also used in distributed power generation especially Stand-alone Photovoltaic (PV) power systems. Besides supplying AC loads, Stand-alone systems can be used for street lighting, electric bikes, golf carts and electric vehicles.
Existing stand-alone PV power systems employ pulse-width-modulated (PWM) DC–DC converters battery charging control. However, PWM converters suffers from high switching loss and high electromagnetic interference. The resonant converters can overcome these problems as they attain soft switching and low EMI.
Resonant converters design is complicated especially for wide input voltage range and wide output voltage range as in PV powered battery chargers. Hence, a clear design steps is proposed to ensure high efficiency operation by achieving zero voltage switching (ZVS) for primary MOSFETs and zero current switching (ZCS) for secondary rectifiers.
A control technique for resonant converter is proposed based on Perturb and Observe (P&O) technique. The converter will operate in constant current (CC) charging mode or constant voltage (CV) charging mode depending on the battery's state of charge (SOC). The converter will operate in maximum power point tracking MPPT mode if the available solar power is not adequate to match the charging profile. The proposed design and control are verified by the results of MATLAB/SIMULINK simulations and experimental setup.

Chapter 1- Introduction

1.1 Background and Challenges

Renewable energy sources and Electrical Energy Storage Systems (EESS) have experienced a great interest and development in the past years. Environmental problems such as global warming and pollution guided us to replace the conventional energy sources with clean and environmentally friendly sources. Renewable energy sources are available almost over all geographical areas, unlike conventional sources, which are focused in a few countries. Moreover, Renewable energy sources have a low running cost because it just need a periodic maintenance. On the contrary, conventional sources have a high running cost due to the fuel cost which will continue to increase until fuels will be depleted.

According to the International Renewable Energy Agency (IRENA) [1], the total installed capacity of renewable energy reached 2,179 GW in 2017 with annual growth around 8.3% as shown in Figure 1-1.A portion of the recent installed capacity aims to keep up with the loads and customers increment and the portion aims to replace the conventional power sources.

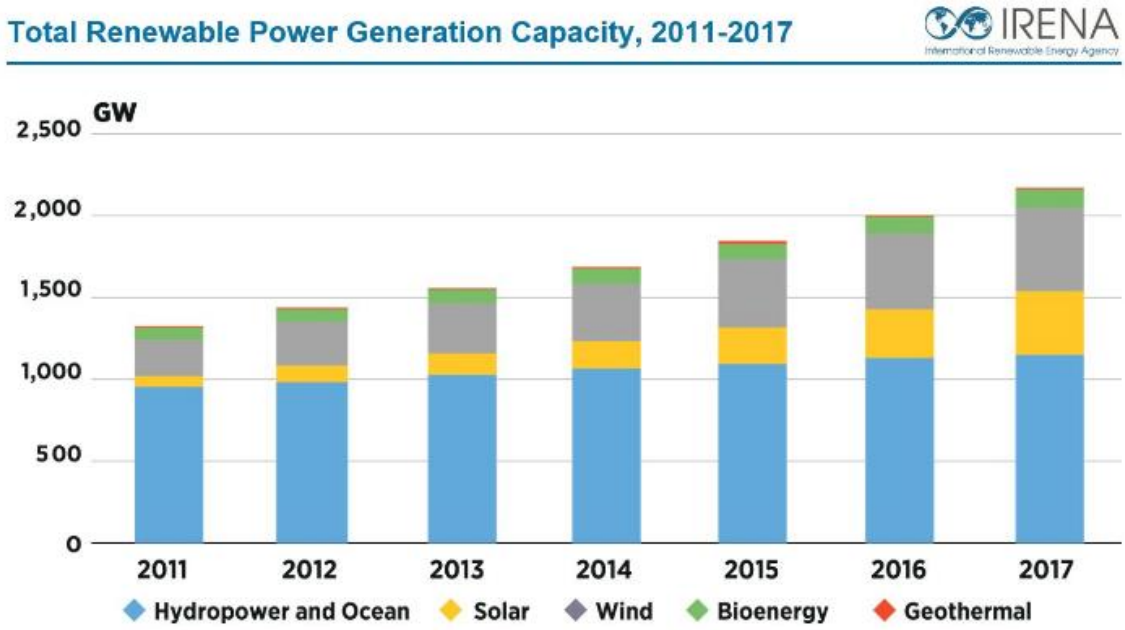

Figure 1-1 Renewable energy generation (2011:2017)

Hydropower is the largest supplier of renewable energy until now but with small growth per year. The most promising sources are solar and wind energies. "Figure 1-2 shows the recently added worldwide capacities in 2017 with around 93 GW of solar energy and 47 GW of wind energy. These data indicate the worldwide heading to a great use of solar and wind energies.