UNIVERSITI TEKNOLOGI MARA

INTEGRATED PWM SOLAR CHARGE CONTROLLER AND DC-DC CONVERTER USING FIXED-FREQUENCY CURRENT CONTROL MODE FOR REDUCING SELF-POWER CONSUMPTION OF OFF-GRID SOLAR HOME SYSTEM

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Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science
(Electrical Engineering)

College of Engineering

February 2024

ABSTRACT

The Solar Home System (SHS) stands as a dependable and sustainable solution for powering remote areas without grid access. However, the development of SHS packages faces technical hurdles encompassing self-power consumption, advancements in PWM solar charge controllers, DC-DC converters, and integrating solar charging with voltage conversion in off-grid setups. Despite the efficiency of solar charge controllers, their affordability for smaller systems remains a concern. In addressing these challenges, this study introduces a comprehensive integration method. This method combines a single-stage boost DC-DC converter with an analog PWM solar charge controller using a fixed frequency current control mode algorithm. Through simulation studies, this approach showcases practicality and cost-effectiveness, significantly reducing the number of devices required for off-grid SHS while preserving functionalities similar to AC power systems. Key findings highlight enhanced controller features with essential safety measures, the development of an integrated controller, and a notable decrease in self-power consumption through innovative push-button switch mechanisms. The study systematically resolves technical design challenges, offering a holistic solution that enhances efficiency and cost-effectiveness in off-grid SHS. The resulting integrated system, operating in a fixed frequency current control mode, undergoes rigorous testing. It demonstrates remarkable performance with a maximum load capacity of 350 watts and exceptionally low self-power consumption of 16.89 mW. Furthermore, this integration minimizes required solar panel size without compromising essential system features, attributed to the notable decrease in self-power consumption achieved by the combined device. These achievements affirm the viability, effectiveness, and affordability of the developed controller, presenting a promising path to encourage sustainable energy consumption in underserved communities and drive progress towards a greener future.

ACKNOWLEDGEMENT

Firstly, I wish to thank God for giving me the opportunity to embark on my M Sc. Engineering Degree and for completing this long and challenging journey successfully. My gratitude and thanks go to my supervisor Profesor Madya Ir Dr Hasmaini Binti Mohamad and co- supervisor Dr Siti Zaliha Binti Mohammad Noor, Sr. Lecturer.

My appreciation goes to my wife “Saniya Akter” who provided the assistance during testing and simulation. Special thanks to my colleagues and friends for helping me with this project.

Finally, this thesis is dedicated to the loving memory of my very dear father and mother for the vision and determination to educate me. This piece of victory is dedicated to both of you. Alhamdulilah.

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CHAPTER ONE
INTRODUCTION

1.1 Introduction

Solar energy is becoming increasingly popular as a renewable energy source due to its potential to reduce carbon footprints and increase access to electricity. In particular, solar home systems (SHS) offer a feasible alternative to grid extension for the over 1.1 billion people without reliable electricity. Many rural areas without access to the national grid can benefit from solar energy sources, especially photovoltaic (PV) systems that are widely used for off-grid applications in isolated regions, depending on the climate and latitude [1][2]. The PV solar system is the most installed renewable energy system for residential structures, reducing power expenditures and carbon emissions. Micro-grids, which are tiny PV solar systems for private residences, generate electricity on sunny days, with output power varying from one to tens of kW per property [3] [4].

The stand-alone solar PV system is an excellent approach to powering homes and businesses in remote locations or those far from the electric grid in urban areas. The system generates emission-free electricity powered by the sun, which is dependable, secure, noise-free, user-friendly, and requires no refilling. As renewable energy technologies continue to advance, solar energy sources will likely become increasingly popular in the renewable energy sector [5].

The use of SHS has emerged as a potentially viable solution to address the rural power issue and enhance the dependability and quality of power in remote regions[6]. These systems are particularly useful in areas that are a quarter mile away from the closest power lines, where installing an off-grid PV system is often less expensive than expanding electricity lines. There are three types of solar systems currently installed for domestic and commercial purposes: Grid-tied solar systems, off-grid solar home systems, and net metering solar systems[7]. Off-grid solar home systems are standalone systems that generate and store energy independently of the grid system [8],.

At present, the solar power plant is installed as a power source for domestic and commercial purposes. There are three main applications for SHS:

i) Power generation for application in an isolated area.