A SINGLE-PHASE INVERTER WITH HYSTERESIS CURRENT CONTROL METHOD

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A report submitted
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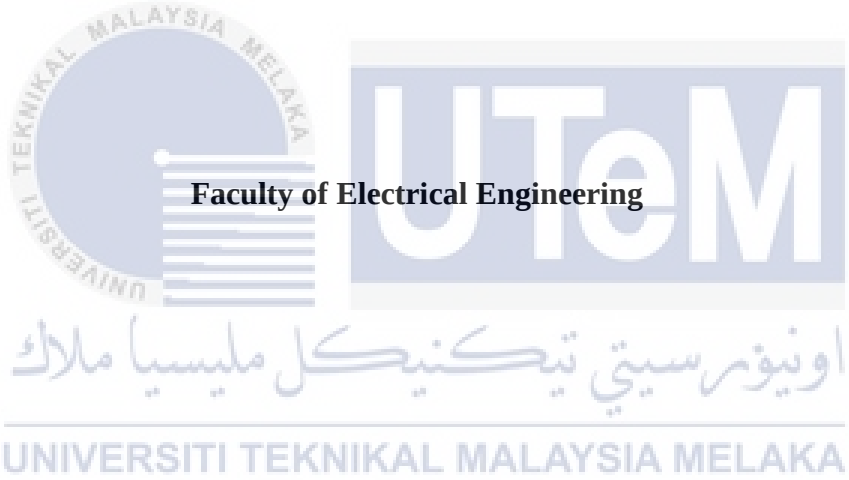

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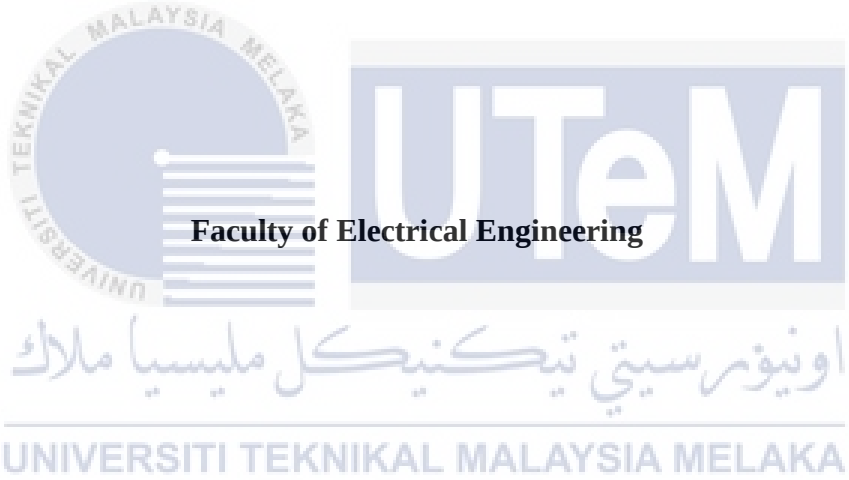

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2021

DECLARATION

I declare that this thesis entitled "A SINGLE-PHASE INVERTER WITH HYSTERESIS CURRENT CONTROL METHOD" is the result of my own research accept as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

SIGNATURE : .....

NAME : FATIN NABILA ARISA BINTI ROSLAN

DATE : 5 JUNE 2021

APPROVAL

I hereby declare that I have checked this report entitled "A SINGLE-PHASE INVERTER WITH HYSTERESIS CURRENT CONTROL METHOD" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours.

Signature : .....

Supervisor Name : Dr. Maaspaliza Azri

Date : 5/7/2021

DEDICATIONS

To my beloved mother and father

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I also would like to express my thanks to all my colleagues who helped me in completing this thesis.

ABSTRACT

Nowadays, the use of grid connected inverter (GCI) has been widely used in various applications. It is because the renewable energy as a source for the inverter has been reduced the usage of fossil fuel. The function of the GCI is to regulate the active and reactive power that the grid generates from a renewable source. However, the main problem is, the active and reactive power received that from renewable source has suffer from the great losses due to the complicated of current controller (CC) structure. In order to overcome the problem, a simple hysteresis current controller (HCC) with reduced losses has been implement for a single-phase inverter connected inverter. The hysteresis current controller is chosen as a current control method because HCC is known for its simple topology and providing a fast performance response. The results of the simulation were explained in term of output current and THD_i of the system.

ABSTRAK

Pada masa ini, penggunaan penyongsang bersambung grid telah banyak digunakan dalam pelbagai aplikasi. Hal ini kerana tenaga yang boleh diperbaharui sumber penyongsang telah mengurangkan penggunaan bahan bakar fosil. GCI bertanggungjawab untuk mengawal daya aktif dan reaktif yang diterima dari sumber tenaga yang diperbaharui ke grid. Namun, masalah utamnya adalah daya aktif dan reaktif yang diterima dari sumber tenaga yang boleh diperbaharui telah mengalami kerugian besar kerana struktur pengawal masa yang rumit. Untuk mengatasi masalah tersebut, pegawal arus histeresis sederhana dengan pengurangan kerugian untuk penyongsang fasa tunggal telah dicadangkan. Pengawal arus histeresis dipilih sebagai kaedah kawalan semasa kerana HCC terkenal dengan topologi sederhana dan memberi tindak balas prestasi yang cepat. Hasil simulasi dijelaskan dari segi arus keluaran dan THD_i pada sistem.

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LIST OF SYMBOL AND ABBREVIATIONS

DC	-	Direct Current
AC	-	Alternating Current
CC	-	Current Control
GCI	-	Grid-Connected Inverter
DCC	-	Direct Current Control
THD	-	Total Harmonic Distortion
RE	-	Renewable Energy
PV	-	Photovoltaic
HCC	-	Hysteresis Current Controller
VSI	-	Voltage Source Inverter
CSI	-	Current Source Inverter
R	-	Resistor
L	-	Inductor
PWM	-	Pulse-Width Modulation
CC-PWM	-	Current Control Pulse-Width Modulation
SMC	-	Sliding Mode Controller
MOSFET	-	Metal Oxide Silicon Field-Effect Transistor
IGBT	-	Insulated Gate Bipolar Transistor

CHAPTER 1

INTRODUCTION

1.1 Overview

Microgrid have been widely used in various application because of their apparent advantages which include increase reliability that they can run with and lower pollution standards over conventional generation. One of the important electronics power devices in microgrid is inverter. An inverter commonly used for electrical power applications where high currents and voltages are presents. An inverter transforms a direct current (DC) to alternating current (AC).

The inverter is normally supplied with an AC fed from a DC source, such as a grid-connected inverter. The grid-connected microgrid system is commonly used because the battery is not needed to store energy and thus greatly reduces overall costs [1]. The grid-connected inverter (GCI) is mounted between the grid and the electrical generator, such as the solar panel, the wind turbine and the hydroelectric generator. The grid-connected inverter manages the active and reactive power supplied to the grid [1]. In order to manage the power supplied to the grid, current controller is needed to improves the performance of the grid connected system.

One of the current controllers (CC) method that has been commonly used for various applications is hysteresis current control (HCC). This controller system is known as a direct current control (DCC) [1]. The hysteresis current controller is the simplest CC for inverter applications. HCC is a method of controlling a voltage source inverter where the measurement of instantaneous current is compared to the reference current [2].

In this project research, the basic performance of pulse width modulation (PWM) for unipolar single phase and bipolar single phase have been compared in order to observe their performance in term of THD value. Hence, the implementation of hysteresis current controller for a single-phase GCI is proposed to in order to reduce the losses in the inverter.

1.2 Motivation

Fossil fuels restrictions have steadily contributed to the formation of alternative energy sources, called renewable energy [2]. The rising concerns about the usable fossil fuel reserve and the effect on the environment has assigned a higher encourage to the usage of the renewable sources in the current of energy generation [12]. Renewable energy is the energy that could be produced from renewable resources such as sunlight, wind, rain, biomass, etc. The renewable energy emerges from the renewable sources and the system continuous replenished.

The Government of Malaysia has set the target to obtain a better integration of renewable energy sources (RE) into the Malaysian energy mix [13]. The existing energy mix for Malaysia's electricity production is primarily required by natural gas and coal [13]. The contribution of solar wind and energy in the top 10 countries that mainly from the European zone, is seen in Figure 1-1, whereas Malaysia currently has only 2% of the RE penetration, which is commonly gained from solar photovoltaic fuel (PV) [13].

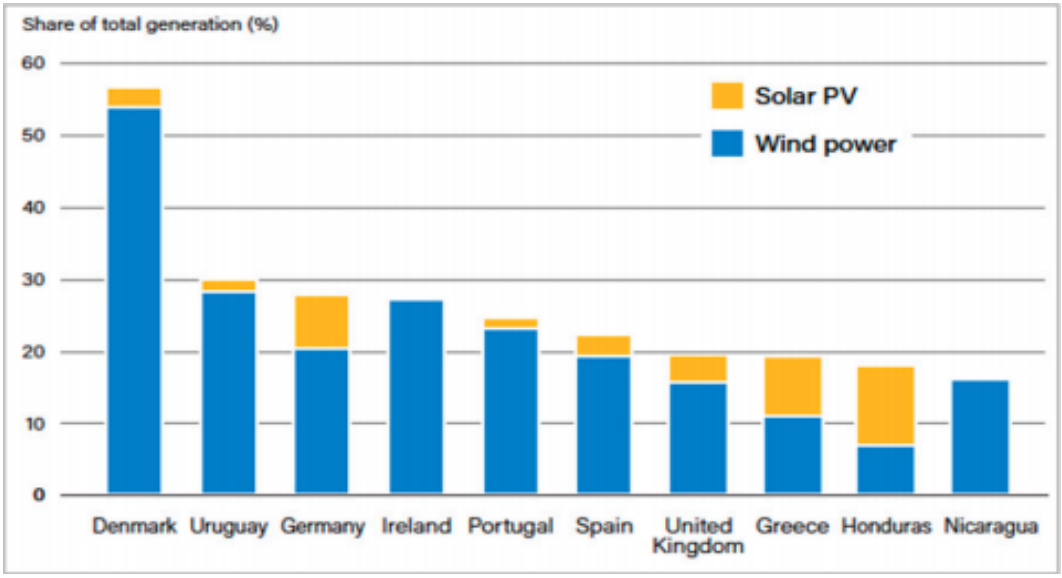

Fig 1-1: Renewable electricity power supply, top 10 countries in 2017

From the Figure 1-1 shows that the wind power is widely used in Europe region. Even though solar photovoltaic (PV) has not been widely used in Europe, but solar (PV) has the most sources in the world. Recently, the Grid-connected PV system has received much interest for its simple structure, control strategy and high performance.

Therefore, in this research, the hysteresis current controller is developed in a single-phase inverter of GCI in order to improve the performances of single-phase inverter in a simplified way without losing the output current ripple. This research also observed the performance of bipolar PWM and unipolar PWM without hysteresis in terms of their THD values.

1.3 Problem Statement

The trend of using PV system to reduce the usage of fossil fuel is definitely increasing among the domestic and industrial applications. PV systems is one of the distributed energies, must be converted to an alternating current (AC) source in order to link to the grid. In a photovoltaic system, the inverter is an integral element. GCI is used in order to regulate the active and reactive power from renewable energy sources. To control the power from renewable resources to the grid, hysteresis current controller needs to be implemented. Even though there were several methods of current controller that can be used in order to control the losses, however, hysteresis current control is the best among others controller because it has a robust current control performance against load and sources parameter change. To overcome this problem, the simple hysteresis current control is implemented in the single-phase inverter in order to reduce the output current ripple and to improve the performance of the system.

1.4 Objective

The objectives of the research are:

1. To design hysteresis current controller for the single-phase GCI system
2. To investigate the performance of proposed system in term of output current ripple, and %THD values.
3. To compare the performance of unipolar inverter and bipolar inverter in term of THD values with different frequency switching.

1.5 Scope

The aim of this project is to design single phase inverter using hysteresis current controller for GCI application. MATLAB Simulink is used to model and analyze the output current and THD value of hysteresis current controller for single-phase inverter. For simulation of hysteresis current control, the voltage that produced from inverter must higher than the V_{grid}. This aim of this project also to model and analyze the current output and switching pattern between unipolar PWM and bipolar PWM. In modeling the inverter system for all simulation were using IGBT and RL as a load. This research only covers the simulation and showed that the losses can be reduced by using hysteresis current control in single phase grid connected inverter.

1.6 Outline

This report consists of five chapters which is started with chapter 1 which is explained the introduction of the project. Chapter 2 is discussed the literature review of the previous research. In chapter 3, methodology of the project is explained. For chapter 4, results and discussions of the project is discussed. In chapter 5, conclusion and recommendation is discussed.

For chapter 1 consist of explanation on project overview, problem statement, motivation, objective project and also scope of the project.

For chapter 2, there are some literature reviews based on the previous research such as inverter and its type and topology, current controller method and also controllable power switch.

For chapter 3 contains a flowchart of the project, project milestone, project Gantt chart, comparison switching technique between bipolar PWM and unipolar PWM, the flowchart of a single-phase inverter with hysteresis current control method and also simulation model.

For chapter 4, simulation result of the unipolar PWM, bipolar PWM and a single-phase hysteresis current control method were analyzed and discussed.

For chapter 5, the conclusion is discussed and the recommendation of the research is suggested for the future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Inverter is a circuit that converts a direct current (DC) source to an alternating current (AC) load. The basic of inverter was described in this chapter. For the type of inverter, there are two types of inverters being presented in this chapter which is single-phase inverter and three phase inverter. For single-phase inverter, it divided into two types which is single-phase full-bridge inverter and half-bridge inverter. Next, in this chapter also explained the controllable power switch such as IGBT and MOSFET. Other than that, PWM switching technique, unipolar PWM and bipolar PWM also being describe in this chapter. Predictive current controller, linear PI current controller and hysteresis current controller are described under current controller method. In this chapter also explained the controllable power switch such as IGBT and MOSFET.

2.2 Inverter

The inverter is a circuit that transforms an AC load from a DC source using transformers, switching and control circuits. Renewable electricity such as DC is used to source the inverter. Inverters are used to power electrical equipment generated by a vehicle or from renewable sources of energy. DC power is acts as the batteries that store the energy, while AC power is what most electrical machines need to operate such that an inverter is required to transform the power into a functional way.