POWER CONDITIONING FOR ENERGY SYSTEMS IN GREEN BUILDINGS

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DEDICATION

Specially dedicated to my supervisor, my family, and Jasmine who encouraged me throughout my journey of education.

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ABSTRACT

This research work proposes an improved model of stand-alone renewable energy system for green buildings by using a sinusoidal pulse width modulation (SPWM) multilevel inverter with a smaller number of power switches. The energy sources for this system is photovoltaic (PV) solar panels. The main advantage of using multilevel inverter rather than normal two-level inverter is the reduction in the output voltage harmonics and this leads to a reduction in the filter size. In this case, the number of power switches used as well as the number of the gate driver circuits required is less compared to the cascaded H-bridge multilevel inverter (CHMI), therefore the weight and switching losses due to the inverter is reduced. To test the effectiveness of the proposed model simulations are carried out using MATLAB/Simulink under temperature and irradiance varying conditions. In addition to the use of the multilevel inverter, a perturb and observe (P&O) maximum power point tracking (MPPT) algorithm is used for the PV array and a feedforward control system is used for the output voltage control. This research work is carried out to develop a model of stand-alone renewable energy system which is capable to provide constant 240 volts to the load at 50 Hz irrespective to the disturbances on the PV side. Simulations are carried out for both constant as well as for varying conditions and it is found that the output voltage of the inverter is constant and stable for both the cases at 240 volts, 50 Hz.

ABSTRAK

Kerja penyelidikan ini mencadangkan satu model sistem tenaga diperbaharui untuk bangunan hijau dengan menggunakan penyongsang pelbagai aras "sinusoidal pulse width modulation (SPWM)" yang lebih kecil. Sumber kuasa untuk sistem ini ialah panel solar fotovolta (PV). Kelebihan utama menggunakan penyongsang pelbagai aras berbanding penyongsang dua aras ialah pengurangan harmonik voltan keluaran yang membawa kepada pengurangan saiz penapis. Dalam kes ini, jumlah suis kuasa yang digunakan dan bilangan litar pemacu get yang diperlukan adalah kurang berbanding dengan penyongsang pelbagai aras lata-jambatan H (CHMI), maka berat dan kehilanggan pensuisan disebabkan oleh penyongsang dapat dikurangkan. Bagi menguji keberkesanan model simulasi yang dicaddangkan menggunakan MATLAB / Simulink telah dijalankan di bawah keadaan suhu dan jradiasi berubah-ubah. Sebagai tambahan kepada penggunaan penyongsang pelbagai aras, algoritma pengesanan dan pemantauan (P&O) pengesanan titik kuasa maksimum (MPPT) digunakan untuk jajaran PV dan sistem kawalan suapan hadapan digunakan untuk kawalan voltan keluaran. Kerja penyelidikan ini dijalankan untuk membangunkan satu model sistem tenaga boleh diperbaharui kendiri yang dapat memberikan 240 Volt yang berterusan kepada beban pada 50 Hz tanpa mengira gangguan pada bahagian PV. Simulasi dijalankan untuk kedua-dua keadaan malar dan berubah-ubah dan didapati bahawa voltan keluaran penyongsang adalah malar dan stabil untuk kedua-dua kes pada 240 Volt, 50 Hz.

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LIST OF ABBREVIATIONS

MG	–	Microgrid
DG	–	Distributed Generation
P	–	Active Power
Q	–	Reactive Power
PWM	–	Pulse Width Modulation
SPWM	–	Sinusoidal Pulse Width Modulation
IGBT	–	Insulated-Gate Bipolar Transistor
PV	–	Photovoltaic
THD	–	Total Harmonic Distortion
DG	–	Distributed Generation
P&O	–	Perturb & Observe
SMES	–	Superconducting Magnetic Energy Storage
FFT	–	Fast Fourier Transform
VSI	–	Voltage Source Inverter
CSI	–	Current Source Inverter
MPPT	–	Maximum Power Point
Fs	–	Sampling Frequency
Fc	–	Cutoff Frequency
ref	–	Reference Value
i	–	Current
v	–	Voltage
	–	
	–	

CHAPTER 1

INTRODUCTION

1.1 Background Study

Power is one of the most critical components for economic growth and welfare of the nations. Currently, the Malaysian power system is based on fossil fuel and fossil fuels have many disadvantages such as environmental pollution and global warming. The price of these fuels also increases day by day this is since we have a limited amount of fossil fuels and the energy requirement is increasing because of the modernization and development.

Nowadays, a large part of the world population lives without access to electricity. According to the report of the IEA (International Energy Agency), 1.3 billion people still have no access to electricity [1]. This lack of access to energy is because a large proportion of the population in developing countries lives in rural areas far from the main grid.

The solution to these problems is to shift from conventional power to renewable power. Renewable energy is clean and freely available, except for the cost of the system used to convert this energy into electrical energy. Nowadays people are turning towards the concept of microgrid. A microgrid is a small energy system which consists of different combinations of energy sources such as wind/solar, wind/solar/hydro, hydro/solar/biomass etc. The combination of the energy sources depends upon the location of the microgrid system that is on the availability of the different types of the resources on the particular location. Since ample amount of solar energy is available almost everywhere in Malaysia throughout the year, therefore, it is beneficial to use solar energy as one of the energy sources for the energy systems in Malaysia.

A microgrid system is basically a small power grid, which can operate independently, as well as with the main power grid. Various sources of energy such as solar, wind, geothermal, hydro, biomass are used to feed the power to the load by using suitable energy converters, inverters, and controllers. It makes it possible to generate local power for local loads. It comprises several small sources of power that makes it extremely flexible and efficient. Enables grid upgrading, improves the integration of renewable and distributed sources of energy to the main grid.

When we deal with renewable energy sources, there are always the issues of harmonics and power fluctuations. Harmonics is because of the power electronic converters and power fluctuations is because of the variation in the renewable power. For example, in the case of solar PV the intensity of the solar radiation striking on the PV panels changes with the position of the sun and this radiation also depends on the weather conditions.

The purpose of this study is to develop a standalone microgrid system for a green building by using solar PV as the energy source and multilevel inverter with smaller number of switches. A PWM multilevel inverter is used to reduce the THD in the load voltage as well as in the load current. This chapter describes the problem statement, the objective of this project and the significance of this study.

1.2 Problem Statement

When we deal with a system in which power source is DC such as photovoltaic (PV) and the load requires AC power, then DC to AC conversion is required. There are harmonics in the output voltage and current at the AC side. These harmonics in the load voltage and load current can be reduced by using various techniques such as a PWM inverter with low pass filter or by using a multilevel inverter with low pass filter. In both the cases we can also use active filters, but the designing of the active filters is more difficult than passive filters. The size of the passive filters is large in the case of PWM inverter, but the size of the filters is smaller in the case of multilevel PWM inverters. As the number of output voltage levels increases the size of the filter decreases. This is due to the fact, that as the number of levels is increased the output voltage of the multilevel inverter looks more sinusoidal. In a standalone microgrid system, the voltage and frequency of the system need to be controlled to a predefined value, which is suitable for the load.

1.3 Objective

The objectives of this research work are:

(a) To develop a small microgrid system for a green building by using PV as the power source using MATLAB/Simulink.

(b) To improve the power quality by using a multilevel inverter with less number of power switches along with a passive low pass filter.

(c) To design a control scheme which produces a constant 240 Volts, 50 Hz inverter output voltage irrespective of any change at the PV side.

1.4 Scope

This project is totally based on simulation, with no actual hardware implementation. This works covers the design of a microgrid system for green buildings with an SPWM multilevel inverter. In addition, of the use of the SPWM multilevel inverter a perturb and observe (P&O) maximum power point tracking (MPPT) algorithm is used for the PV array and a control circuit is used to control the output voltage of the inverter to a constant value of 240 Volts at 50 Hz irrespective of the changes on the PV side. In this project, the effects of partial shading and load variation are not considered.

1.5 Contributions of Research Work

The most important contributions to this research work are as follows:

1. A microgrid system for green building has been developed.
2. The performance evaluation of the proposed system has been carried out under different conditions for the PV such as constant insolation and constant temperature, varying insolation and constant temperature, varying insolation as well as varying temperature.
3. An SPWM multilevel inverter is used to reduce the THD in the load voltage and load current. A battery-charging unit is also included in the system to charge an electric vehicle at a constant current.

The outcome of this research shows the effectiveness of the SPWM inverter in the reduction of the THD in the load voltage as well as in the load current and the effectiveness of the buck converter, which keeps the inverter output voltage constant regardless of the changes on the PV side.

1.6 Report Organization

There are five chapters in this report. Chapter 1 includes the discussion of the microgrid systems, problem statement, objective, scope, and significance of this project. Chapter 2 includes a literature review of the microgrid system, solar PV and how the magnitude and frequency of the voltage of the microgrid systems can be controlled in standalone mode. Chapter 3 will discuss the methodolog of the project. Chapter 4 will discuss the simulation and results. Chapter 5 will provide the conclusion of this project and some recommendations for future work.

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