WIND TURBINE CONSTANT VOLTAGE CONTROLLER USING MODIFIED SHEPWM TECHNIQUE

by

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LIST OF ABBREVIATION

DC	Direct Current
AC	Alternating Current
PV	Photovoltaic
HAWT	Horizontal Axis Wind Turbine
VAWT	Vertical Axis Wind Turbine
MAGLEV	Magnetic Levitation
PI	Proportional Integral
PWM	Pulse Width Modulation
SPWM	Sinusoidal Pulse Width Modulation
SHEPWM	Selective Harmonic Elimination Pulse Width Modulation
PCB	Printed Circuit Board
LC	Low pass filter
WTGS	Wind Turbine Generator System Effect
SMPS	Switched Mode Power Supply

MOSFET	Metal Oxide Semiconductor Field Effect Transistor
IGBT	Insulated Gate Bipolar Transistor
CCM	Continuous conduction mode
DCM	Discontinuous Conduction Mode
VSI	Voltage Source Inverter
CSI	Current Source Inverter
THD	Total Harmonic Distortion
Hz	Hertz
kHz	kilo Hertz
IEEE	Institute of Electrical and Electronic Engineer

LIST OF SYMBOL

V_{dc}	Direct Current Voltage
V_{ac}	Alternating Current Voltage
V	Voltage
I	Current
P	Power
V	Volts
A	Ampere
W	Watt
V_A	Voltage Phase A
V_B	Voltage Phase B
V_C	Voltage Phase C
D	Diode
R	Resistor
C	Capacitor
L	Inductor
V_s	Supply voltage
v_L	Voltage across inductor
i_L	Current across inductor

i_C	Current across capacitor
v_O	Output voltage
S_1	Switch 1
S_2	Switch 2
S_3	Switch 3
S_4	Switch 4
D	Duty cycle
T_{on}	Time on
T_{off}	Time off
T_s	Sampling time
V_{SENSE1}	Sensor voltage 1
V_{SENSE1}	Sensor voltage 2
m_f	Frequency modulation
m_a	Amplitude modulation
$f_{carrier}$	Carrier frequency
$f_{reference}$	Reference frequency
f_{tri}	Triangular frequency
$f_{\sin}$	Sinusoidal frequency
$V_{m,reference}$	Reference voltage

$V_{m,\text{carrier}}$	Carrier voltage
A_r	Reference amplitude
A_c	Carrier amplitude
π	Pi
ω	Omega
t	Time
θ	Theta
α	Alpha
η	Efficiency
Ω	Ohm
f_{sw}	Switching frequency

PENGAWAL TURBIN ANGIN DENGAN VOLTAN MALAR MENGGUNAKAN TEKNIK PENGUBAHSUAIAN SHEPWM

ABSTRAK

Cabaran utama dalam merekabentuk pengawal ini adalah kelajuan turbin angin yang tidak sekata dan kandungan harmonik dalam keluaran voltan. Kelajuan turbin yang tidak sekata ini akan menyebabkan ketidakselarasan voltan yang bakal dibekalkan kepada penyongsang dan seterusnya memberi kesan kepada dengan munculnya harmonik pada keluaran voltan. Oleh itu, kajian ini adalah khusus untuk mereka bentuk pengawal terdiri daripada DC/DC penukar rangsangan dan penyongsang DC/AC bersepadu dengan sistem turbin angin. Pengawal ini memainkan dua peranan penting. Pertama, pengawal perlu mengawal keselerasan voltan keluaran DC/DC penukar rangsangan tanpa mengira ketidakselarasan voltan input yang dibekalkan menggunakan pengawal PI. Kedua, pengawal perlu menjana sudut yang tidak menjana harmonik untuk fasa tunggal DC/AC penyongsang menggunakan strategi Pulse Selective Harmonic Penghapusan lebar modulasi (SHEPWM). Sistem keseluruhan telah berjaya dibentuk dengan menggunakan perisian MATLAB Simulink dan dilaksanakan menggunakan perkakasan sebenar. Keputusan daripada kedua-dua simulasi dan perkakasan dikumpul, dianalisis dan dibandingkan. Perkakasan yang diuji dengan beban rintangan dan beban induktif untuk mengkaji prestasi pengawal apabila berurusan dengan pelbagai jenis beban. Daripada keputusan yang diperolehi daripada simulasi dan perkakasan, dapat disimpulkan bahawa litar pengawal direka berfungsi dengan baik walaupun voltan input yang dibekalkan kepada rangsangan penukar berbeza dan voltan keluaran penyongsang adalah sangat rendah dalam jumlah herotan harmonik (THD) hampir 3.6 % untuk voltan THD dan 2.1% untuk THD arus.

WIND TURBINE CONSTANT VOLTAGE CONTROLLER USING MODIFIED SHEPWM TECHNIQUE

ABSTRACT

The major challenges in designing the controller for wind turbine are fluctuations of the wind speed and the harmonic contents of the output voltage. The fluctuations of the wind turbine speed results in inconsistency of voltage supplied to the inverter which will affect the harmonic of the output voltage. Therefore, this research is dedicated to design a controller consists of a DC/DC boost converter and a DC/AC inverter integrated with the wind turbine system. The controller plays two important roles. Firstly, the controller has to control the consistency of the output voltage of the DC/DC boost converter irrespective of the inconsistency of the input voltage supplied using PI controller. Second, the controller has to generate the firing angles that giving out lesser harmonic to the single phase DC/AC inverter using the Selective Harmonic Elimination Pulse Width Modulation (SHEPWM) switching strategy. The overall system has been designed successfully using MATLAB Simulink software and implemented using real hardware. The results from both simulation and hardware are collected, analysed and compared. For boost converter, the output voltage is in constant 50V even though the input voltage supplied to the boost converter is varies and it is suitable to charge the battery system. For inverter, the hardware is tested with a resistive load and an inductive load to study the performance of the controller when dealing with different types of load. From the results obtained from simulation and hardware, it can be concluded that the designed controller circuit is working well even though the input voltage supplied to the boost converter varies and the output voltage of inverter is very low in total harmonic distortion (THD) nearly 3.6% for THD voltage and 2.1% for THD current.

CHAPTER 1

INTRODUCTION

1.1 Research Background

According to the law of energy conservation, energy cannot be created or demolished but can be converted from one form to another. There are various naturally available energies such as solar energy, wind energy, thermal energy, and tidal wave energy. These energies can be harnessed and converted into usable form using specific tools and equipment.

In electrical energy, the electricity can flow as either direct current (DC) or alternating current (AC). In DC, the electricity flows in a one direction and normally used in lower power or battery powered devices such as mobile phone, remote control and most of kid's toys. Whilst for AC, it has two magnitudes of voltage positive and negative oscillating between 0 intersections at X-axis with a specific frequency. AC is usually used for powering the standard household appliances.

In Malaysia, harvesting the solar energy via photovoltaic (PV) is preferable as this country is located close to the Equator, blessed with adequate sunlight radiation throughout the year. Wind energy however is somehow neglected as Malaysia is located in between Thailand, Indonesia and Philippines, thus blocking the potential of harvesting energy from high wind speed. The annual average wind speed in Malaysia is not more than 2m/s which is not enough to move the blades of the normal scale wind