DESIGN OF SYNCHRONIZED PHOTOVOLTAIC AND WIND HYBRID POWER GENERATION SYSTEM FOR STREET LIGHTING APPLICATION

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UNIVERSITI MALAYSIA PERLIS

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DESIGN OF SYNCHRONIZED PHOTOVOLTAIC AND WIND HYBRID POWER GENERATION SYSTEM FOR STREET LIGHTING APPLICATION

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By

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DECLARATION OF THESIS

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LIST OF SYMBOLS

ω	Sunset hour angle for the tilted surface for the mean day of the month
ϕ	Latitude
β	Tilted surface.
δ	Declination angle
n	Day number, with January 1 as day 1 and December 31 being day number 365.
ω_s	Mean sunrise hour angle
%	Percent
A	Area sweep of wind turbines
a	Empirical coefficient
A_i	Area of orientation surface
b	Constants obtained by fitting data.
$E_{solar,i}$	Available solar radiation on different orientation surfaces
f	Utilization factor
L	Latitude of the site
$^{\circ}$	Degree
η	Efficiency
η_{pv}	Efficiency of PV modules
μ	Location parameter
v	Wind before past the wind turbine
φ	Ground albedo
ρ	Density of air
σ	Deviation

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Σ Total tilt angle of PV modules

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LIST OF ABBREVIATION

A	Ampere
AC	Alternated current
ACF	Autocorrelation function
ADC	Analog to Digital converters
AhB	Capacity of the battery
AhC	Ampere hour charger
BASCOM	Basic Compilier
C	Capacitor
CDF	Cumulative distribution function
CERE	Centre of Excellent for Renewable Energy
CF	Cumulative probability
CP	Conditional probability
DACs	Digital to Analog converter
DC	Direct current
DF	Eccentricity correction factor of the earth's orbit
DSC	Duration of the speed curve
F	Frequency
FF	Fill Factor
I	Current
I_0	Current at t=0
IC	Integrated Circuit
I_L	Load current
I_{mp}	Maximum Power Current
I_{ph}	Photogenerated current
I_s	Reverse saturation current

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I_{sc}	Short Circuit Current
JS	Saturation current density.
k	Boltzmann’s constant
L	Inductor
L_{min}	Minimum inductor value
MCB	Mini Circuit Breaker
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
P	Power
PCB	Printed Circuit Board
PDF	Probability distribution function
P_{in}	Power input
P_{max}	Maximum Power
P_m	Mechanical power
P_{out}	Power output
Pr	Theoretical power
PV	Photovoltaic modules
q	Elementary charge
R	Load resintance
RAM	Read Access Memory
RISC	Reduce Instuction Set Computer
ROM	Read Only Memory
Rs	Serie resistance
R_{Sest}	Solar radiation estimation
R_{sh}	Shunt resistance
R_{Smea}	Measured value measurement
SC	Solar constant
T	absolute temperature

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Te	Battery Discharge time (hours).
T_h	Total time (hours)
V	Voltage source
V_f	Provision MOSFET types of silicon (0.7)
$V_{i(min)}$	Input voltage
V_{mp}	Maximum Power Voltage
V_O	Output voltage
V_{OC}	Open Circuit Voltage
WE	Wind energy
Z	Rainfall transform
ΔI_L	Ripple current of the inductor
V_{dc}	Direct current voltage
V_{rms}	RMS voltage
X_C	Capacitance impedance
X_L	Inductance impedance

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Reka Bentuk Disegerakkan Hibrid fotovoltaik dan Angin
Sistem Penjanaan bagi Kegunaan Lampu Jalan

Turun naik dalam tenaga angin dan sinaran suria yang tidak selaras menjadi cabaran utama bagi membina loji kuasa alternatif. Ketidak-pastian ke dua sumber tenaga ini menjadi permasalahan dalam membuat penyegerakan. Untuk membina satu loji, terlebih dahulu dilakukan ujian potensi tenaga yang boleh digunakan. Ujian potensi tenaga angin menggunakan kaedah Weibull dan anggaran tenaga sinaran suria menggunakan model Annandale, Hargreaves dan model yang dicadangkan serta ke tiga model ini diuji statistik menggunakan simulasi MATLAB. Tenaga angin dan sinaran suria yang berubah-ubah dan ketidakselarasan berakibat pada voltan yang dibangkitkan tidak malar. Untuk voltan yang tidak malar boleh diatasi menggunakan buck-boost penukar. Buck-boost penukar merupakan penukar dc-dc yang dapat menaikkan dan menurunkan voltan. Reka bentuk dan membangun buck-boost penukar dengan menggabungkan komponen elektronik seperti Peraruh, Kapasitor, Diod, XL6009, TIP2955 dan LM7815. Suatu kesusahan untuk menggabungkan kedua-dua loji secara langsung dengan voltan tidak malar. Penggabungan tenaga angin dan sinaran suria menggunakan mikropengawal, yang berkhidmat untuk menyambung atau memutuskan kepada dua sumber tenaga kepada sistem tenaga elektrik, jika salah satu atau ke dua sumber tenaga mempunyai voltan lebih kecil atau lebih besar daripada voltan yang ditentukan, maka mikropengawal bekerja untuk memutuskan sumber tenaga ke bateri. Apabila salah satu atau ke dua sumber tenaga mempunyai voltan sama dengan voltan yang ditentukan, maka mikropengawal bekerja menghubungkan sumber tenaga kepada bateri. Berdasarkan simulasi MATLAB bahawa potensi tenaga angin dan sinaran suria di Perlis menunjukkan bahawa, tenaga angin rendah iaitu kelajuan angin maksimum 1.10 m/s pada PDF 0.44 (Tahun 2011) dan kelajuan angin maksimum 1.11 m/s pada PDF 0.51 (Tahun 2014), sedangkan hasil anggaran dan uji statistik (CRM, RMSE dan e%) untuk sinaran suria menggunakan MATLAB diperolehi bahawa model yang dicadangkan (gabungan Hargreaves dan Annandale model) lebih baik daripada dengan model Hargreaves dan Annandale dan tenaga sinaran suria sangat baik dengan sinaran suria rata rata 1,316 wh/m^2 (diatas nilai standard iaitu 1,000 wh/m^2). Reka bentuk dan pembangunan buck-boost penukar dengan penambahan komponen Peraruh 35.5 µH dan Kapasitor 220 µF dapat menaikkan dan menurunkan voltan dari sumber tenaga angin dan sinaran suria. Pelaksanaan buck-boost penukar pada sistem penyelarasan tenaga boleh angin dan Suria sinaran digunakan untuk pengisian batere. Masa pengecasan bateri 5-6 jam dan masa menyahcas batere 28 jam.

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Design of Synchronized Photovoltaic and Wind Hybrid Power Generation System for Street Lighting Application

Fluctuation of wind energy and solar radiation that is inconsistent become a major challenge to build alternative power generation. The uncertainties to two energy sources is a problem in synchronizing. To build a plant, first performed testing the potential energy that can be harnessed. Testing the potential of wind energy using Weibull distribution methods and estimation of solar energy radiation using a model Annandale, Hargreaves and the proposed model as well as to these three models were tested statistically using MATLAB simulation. Wind energy and solar radiation are fluctuating and inconsistent results in the voltage generated are not constant. For the voltage is not constant can be fixed using a buck-boost converter. Buck-boost converter is a dc-dc converter that can increasing and decreasing the voltage. Design buck-boost converter uses a combination of electronic components such as inductors, capacitors, diodes, XL6009, TIP2955 and LM7815. Of a difficulty to combine the two plants directly with a voltage are not constant. Merger of wind energy and solar radiation using a microcontroller, which serves to connect or disconnect the two energy sources to the electrical power system, if one or two sources of energy have a voltage less than or greater than the voltage is specified, then the microcontroller works to break source energy to the battery. If one or both energy sources have the same voltage with the voltage specified, then the microcontroller to work connecting the energy source to the battery. Based on MATLAB simulation that the potential for wind energy and solar radiation in Perlis show that wind energy is low at maximum wind speed of 1.10 m/s in PDF 0.44 (in 2011) and a maximum wind speed of 1.11 m/s in PDF 0.51 (2014), while the results of estimation and statistical tests (CRM, RMSE and e%) for solar radiation using MATLAB shows that the proposed model (combination Hargreaves and Annandale model) is better than model Hargreaves and Annandale and energy of solar radiation is very good with solar radiation average 1,316 wh/m^2 (above the standard value of 1,000 wh/m^2). Design and development of buck-boost converter with the addition of components Inductors 35.5 µH and capacitors 220 µF can increasing and decreasing the voltage of the source of wind energy and solar radiation. Implementation buck-boost converter in the synchronization system wind energy (WP) and photovoltaic (PV) is used for charging batteries. The battery charging of 5-6 hours and discharging the battery of 28 hours.

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CHAPTER 1

INTRODUCTION

1.1 Background

In this era, the rapid economic growth and industrial development in all parts of the world resulted in growing energy demands. The primary energy sources in the world is still dominated by fossil energy, whilst alternative energy is only contributing a small portion of the world energy market (Alam & Manfred, 2010). High dependency in non-renewable energy like fossil fuels causes the energy crisis due to dwindling fossil energy availability besides causing damage to the environment. One of the solutions is to develop the technologies to harvest the alternative energy such as energy from sunlight and wind efficiently and economically.

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Wind is the movement of air caused by the rotation of the earth and because of the pressure difference in the surrounding air. Wind moves from high pressure areas to low air pressure. Changes depending on the pressure of the surrounding air, so it will affect the speed of the wind. Wind speed near the equator faster than those far from the equator, while the higher places, the wind is blowing too fast (Barbie Bischof et al, 2003).

Modeling and prediction of the wind speed characteristics and the potential of wind energy can be done by using Weibull distribution function (Odo et.al, 2012). Wind speed estimation based on sensorless maximum wind power with tracking control is able to extract the maximum energy from the wind power for variable speed wind turbine generator (Qiao et, al, 2008). Evaluation of wind energy potential in Lagos, Nigeria, showed that an annual average wind speed of more than 5 m/s (with a theoretical capacity factor of 0.09) can generate electrical energy of 512.11MWh (Sanusi and Abisoye, 2011).

Wind speed characteristics consist of daily, monthly and yearly average is analyzed using the Weibull distribution function is used to calculate the potential for wind power generation. The potential of wind power plants is observed and analyzed for 24 hours (March 9, 2011). The results of the analysis of monthly average wind power and energy density indicates that the early (January-March) and end (December) years have high power wind and energy potential, but in mid-they are very low, it is necessary to develop a wind power plant specifically capable of utilizing resources little wind power available in Perlis (I. Daut et al, 2011).

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To determine the feasibility of solar and wind energy generation in Perlis, it is necessary to study the potential of both solar and wind estimation in advance before building the alternative power generation plant. Many models, such as Annandale and Hargreaves models, can be used to estimate the solar radiation. (Almorox, J, 2009; Al Riza et al, 2011; Oliveira et al, 2014), whilst the wind speed can be predicted by using the Weibull distribution (Sarkar, 2011; Ahmeda & Mahammeda, 2012).

Perlis is the northern states of Peninsular Malaysia and is known as the hottest country in Malaysia with an average of 12 hours of sunlight received per day. Solar radiation average year, in Ulu Pauh, Perlis. From the overall observation and discussion, it was concluded that the Ulu Pauh area known as the potential for harvesting solar energy. It is the support by the methods used in the equations and data collected from weather stations. Some of the parameters and the necessary modifications to take into greater detail before developing as a center for solar energy harvesting in Perlis (Syafawati A.N et al, 2011).

Solar and wind energy both suffer fluctuations, resulting in inconsistent output voltage produced. Due to this drawback, it can not be used directly as a source of power generation (Leavey and Hild, 2012). To counter this problem, voltage stabilizer is needed. One of the circuit topologies that can be used for this purpose is the buck-boost converter.

In 2013, Surendra et al. designed a full-bridge DC-DC converter using zero voltage switchings (ZVS) of the active switches in the entire range of conversion. In which the ZVS operation over a range of conversions can be achieved without significant increase in conduction loss, making the full-load converter suitable in applications where high efficiency output is needed.

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The buck-boost converter proposed in this thesis consists of XL6009, TIP2955, LM7815, inductor (L), capacitor (C) and ATmega16 microcontroller. XL6009 is a type of DC-DC converter which can increasing and decreasing the voltage. Increasing and decreasing the voltage depending on the magnitude of the duty cycle (D) of the PWM wave. If D is less than 0.5, then XL6009 work as a step-down the voltage, if D is greater than 0.5, it works as a step-up voltage. TIP2955 is a type of PNP transistor that function