UNIVERSITI PUTRA MALAYSIA

DESIGN AND IMPLEMENTATION OF AN OPEN-LOOP DUAL-AXIS ACTIVE SOLAR TRACKING SYSTEM WITH PRECISION ANGLE CONTROLLER

SALSABILA AHMAD

DESIGN AND IMPLEMENTATION OF AN OPEN-LOOP DUAL-AXIS ACTIVE SOLAR TRACKING SYSTEM WITH PRECISION ANGLE CONTROLLER

By

SALSABILA AHMAD

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

July 2012

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

DESIGN AND IMPLEMENTATION OF AN OPEN- LOOP DUAL-AXIS ACTIVE SOLAR TRACKING SYSTEM WITH PRECISION ANGLE CONTROLLER

By

SALSABILA BINTI AHMAD

July 2012

Chairman : Suhaidi Shafie, D. Eng

Faculty : Engineering

Malaysia is moving forward in fully utilizing its Renewable Energy resources, due to its long term benefits. The challenge in electricity generation from solar technology is that it is still economically expensive due to higher equipment cost and low efficiency, while solar tracking devices add more to the cost. The objectives of this research are to come out with a design of an open-loop dual axis solar tracker with one degree angle controller and compare the power produced from the solar tracker with horizontally fixed panel and solar tracker with ten degree angle controller.

Overall, the significant contribution of this research is in terms of the system's structural design, where the structure was designed to accommadate and maneuver two heavy solar panels with minimal power consumption. The main component of

this solar tracker is a Programmable Logic Controller with Real Time Clock that controls the motors and other electromechanical devices. The total daily energy consumed for the driving system is 6.66×10^{-2} Wh. In terms of improving the energy collected, this research focuses on producing a maximum energy possible by minimizing the solar incidence angle on the solar panel based on the programming that controls the panel's angle to face the sun by one degree precision.

The experiment shows a comparison of performance of a two-axis tracking system compared to a fixed horizontal panel. The results data provide evidence that the energy produced from the system on a clear and sunny day is higher by 58.74% and 58.42% compared to a fixed horizontal panel for one and ten degree angle controller, respectively. In comparison of one-degree and the ten-degree angle controllers, one-degree angle controller gives better results between 1% to 48%, than ten-degree angle controller, with a more significantly higher percentage during the late afternoon.

Finally, the results provide a conclusion that two-axes solar tracking system in this climate is relevant due to a high energy gain for a clear and sunny day. On the whole, this research should help to flourish research in Renewable Energy efforts particularly solar, in Malaysia, as the implementation of the system locally can help to maximize the efficiency and minimize the cost of solar power generation.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

REKABENTUK DAN PELAKSANAAN SISTEM PENJEJAK SURIA AKTIF DUA PAKSI KAWALAN GELUNG-BUKA DENGAN PENGAWAL SUDUT PERSIS

Oleh

SALSABILA BINTI AHMAD

Julai 2012

Pengerusi : Suhaidi Shafie , D. Eng

Fakulti : Kejuruteraan

Malaysia sedang menuju ke arah memaksimumkan penggunaan sumber Tenaga Boleh Diperbaharui kerana faedah jangka masa panjangnya. Terdapat pelbagai cabaran dalam penjanaan elektrik daripada teknologi suria kerana ia dikatakan masih tidak praktikal untuk dilaksanakan kerana kos peralatannya yang tinggi dan kecekapannya yang rendah. Tambahan pula, penjejakan suria akan menambahkan lagi kos keseluruhannya. Tesis ini bertujuan untuk menghasilkan rekabentuk sebuah penjejak suria dua paksi dengan kawalan gelung-buka bagi kawalan satu darjah dan memberikan perbezaan antara kuasa yang dihasilkan daripada penjejak suria tersebut dengan panel yang diletakkan secara melintang tetap dan penjejak suria berkawalan sepuluh darjah.

Secara keseluruhan, sumbangan penting kajian ini ialah dari segi struktur reka bentuk yang direka untuk memegang dan menggerakkan dua panel suria yang berat dengan penggunaan kuasa yang minimum. Komponen asas penjejak suria ini adalah Pengawal Pengaturcaraan Logik dengan jam masa nyata yang mengawal motor-motor dan peranti-peranti elektromekanik yang lain. Jumlah tenaga yang digunakan untuk sistem pacuannya ialah 6.66×10^{-2} Wh. Dari segi peningkatan tenaga yang dikumpul, kajian ini memberi fokus kepada penghasilan tenaga maksimum dengan meminimumkan sudut tuju matahari terhadap panel suria berdasarkan pengaturcaraan yang mengawal panel suria mengadap matahari dengan pergerakan satu darjah.

Eksperimen ini menunjukkan perbandingan prestasi penjejak suria dua paksi dengan panel yang diletakkan dalam posisi secara melintang dan tetap. Data keputusan membuktikan bahawa tenaga yang dihasilkan daripada sistem pengawalan satu dan sepuluh darjah berbanding dengan panel yang diletakkan secara posisi melintang tetap, masing-masing adalah 58.74% dan 58.42% lebih tinggi pada hari yang panas dan cerah. Berdasarkan perbandingan antara kawalan satu dan sepuluh darjah pula, kawalan satu darjah memberikan keputusan yang lebih baik antara 1% hingga 48% berbanding dengan kawalan sepuluh darjah, dengan peratusan yang lebih ketara menjelang lewat petang.

Akhir sekali, kesimpulannya, penjejakan suria dua paksi dalam iklim ini adalah relevan kerana perolehan tenaga pada hari yang panas dan cerah adalah tinggi. Secara keseluruhannya, penyelidikan ini dapat membantu perkembangan penyelidikan dalam Tenaga Boleh Diperbaharui khususnya tenaga suria di Malaysia

dan pelaksanaan sistem ini dalam suasana tempatan boleh membantu memaksimumkan kecekapan dan meminimumkan kos penjanaan kuasa suria.

ACKNOWLEDGEMENTS

Praise to Allah, Most Gracious, Most Merciful.

I would like to acknowledge and extend my heartfelt gratitude to the following persons who have made the completion of this thesis possible:

My supervisor, Dr. Suhaidi Shafie, for his guidance, understanding, motivation and support.

My supervisory committee member, Assoc. Prof. Dr. Mohd Zainal Abidin Ab Kadir, for the guidance, assistance and inspiration he extended.

All Electrical and Electronics Engineering faculty members and staff for their help every time needed.

Most especially to my family and friends, for the support, prayer and hope they gave.

Thank you for all the love, patience and encouragement.

Salsabila Ahmad

I certify that a Thesis Examination Committee has met on 26 July 2012 to conduct the final examination of Salsabila binti Ahmad on her thesis entitled "Design and Implementation of an Open-loop Dual-axis Active Solar Tracking System with Precision Angle Controller" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Maryam Mohd Isa, PhD
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Nor Mariah Adam, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Mohd Amran Mohd Radzi, PhD
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Nowshad Amin, PhD
Associate Professor
Faculty of Engineering & Built Environment
Universiti Kebangsaan Malaysia
(External Examiner)

SEOW HENG FONG, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the **Degree of Master of Science**. The members of the Supervisory Committee were as follows:

Suhaidi Shafie, D. Eng
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Mohd Zainal Abidin Ab Kadir, PhD
Associate Professor
Faculty of Engineering
University Putra Malaysia
(Member)

BUJANG KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institutions.

_____

SALSABILA BINTI AHMAD

Date: 26th July 2012

TABLE OF CONTENTS