
UNIVERSITI PUTRA MALAYSIA

# PHOTOVOLTAIC BOOST DC/DC CONVERTER WITH ADAPTIVE PERTURB AND OBSERVE-FUZZY MAXIMUM POWER POINT TRACKING ALGORITHM

MUHAMMAD AMMIRRUL ATIQI B MOHD ZAINURI

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By

**MUHAMMAD AMMIRRUL ATIQI B MOHD ZAINURI**

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**August 2013**

**Chair: Mohd Amran Mohd Radzi, PhD**

**Faculty: Engineering**

Photovoltaic energy is one of the popular renewable energy sources. Its major issue is low efficiency of ultra-violet light to electrical energy conversion in about 30 % only. Irradiance and temperature are major factors to determine its ability to achieve maximum power output. Maximum power point tracking is developed in photovoltaic system to maintain maximum power output produced by its source. Boost dc-dc converter is used with maximum power point tracking algorithm to operate at desired voltage level. In the market, perturb and observe maximum power point tracking is the simplest and most popular but its main weaknesses are possibility of failing to track the maximum power point and inability to locate the point at low irradiance. In artificial intelligence approach, fuzzy logic control has quite significant drawback from its inputs. By using error and change of error as inputs which involve complicated mathematical process, it affects overall performance of maximum power point tracking.

Therefore, this research work proposes design and development of photovoltaic boost dc-dc converter with adaptive perturb and observe-fuzzy maximum power point tracking algorithm, which is capable to extract energy at maximum operating level of photovoltaic module. This algorithm considers suitable parameters of various irradiance conditions especially at low irradiance and additional noise that occurs in the photovoltaic system, which contribute to originality of this research work. The simulation work covers modelling of photovoltaic module, boost dc-dc converter and maximum power point tracking algorithm to form a photovoltaic system. This system was evaluated under steady state and dynamic tests. For comparison purpose, conventional perturb and observe, and fuzzy logic control algorithms were modelled too. In hardware development, the prototype was developed and tested to verify simulation work. Multiple loads such as resistor, power light emitting diode and battery were used to test the prototype.

From both simulation and experimental results, the proposed algorithm shows the best performance as compared to the conventional algorithms. It produces less overshoot (1 V), high maximum power ratio (98-100 %), fast time response, clean dc output, is tolerable with noise, and is more stable. Its significant achievement is through good performance at low irradiance. In conclusion, the proposed algorithm is able to extract maximum power of photovoltaic source effectively and dynamically, and is robust to various irradiation conditions.

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

**PENUKAR ARUS TERUS KE ARUS TERUS GALAK FOTOVOLTA DENGAN ALGORITMA PENJEJAKAN TITIK KUASA MAKSIMUM USIK DAN CERAP-KABUR SUAI**

Oleh

**MUHAMMAD AMMIRRUL ATIQI B MOHD ZAINURI**

**Ogos 2013**

**Pengerusi: Mohd Amran Mohd Radzi, PhD**

**Fakulti: Kejuruteraan**

Tenaga fotovolta adalah satu daripada sumber boleh diperbaharui yang popular. Isu utamanya adalah kecekapan yang rendah bagi penukaran cahaya ultraungu.ke tenaga elektrik dalam lingkungan hanya 30 %. Sinaran dan suhu adalah faktor utama bagi menentukan kemampuannya untuk mencapai keluaran kuasa maksimum. Titik penjejakan kuasa maksimum dibangunkan dalam sistem fotovolta untuk mengekalkan keluaran kuasa maksimum yang dihasilkan oleh sumbernya. Penukar arus terus ke arus terus digunakan dengan algoritma titik penjejakan kuasa maksimum untuk beroperasi pada tahap voltan dikehendaki. Di pasaran, titik penjejakan kuasa maksimum usik dan cerap adalah paling mudah dan terkenal tetapi kelemahannye adalah kemungkinan untuk ia gagal menjejak titik kuasa maksimum dan ketidakupayaan untuk mencari titik tersebut pada sinaran rendah. Dalam pendekatan kepintaran buatan, kawalan logik kabur mempunyai kelemahan agak ketara dari bahagian masukannya. Dengan

menggunakan ralat dan perubahan ralat sebagai masukan yang melibatkan proses matematik yang rumit, ia mempengaruhi keseluruhan prestasi penjejakan titik kuasa maksimum.

Oleh yang demikian, kerja penyelidikan ini mencadangkan rekabentuk dan pembangunan penukar arus terus ke arus terus galak fotovolta dengan algotrihma titik pengjejakan kuasa maksimum usik dan cerap-kabur suai, yang mampu untuk mengeluarkan tenaga di tahap operasi maksimum modul fotovolta. Algoritma ini mempertimbang parameter sesuai untuk keadaan sinaran yang pelbagai terutama pada sinaran rendah dan isyarat hingar yang berlaku dalam sistem fotovolta, yang menyumbang kepada keaslian kerja penyelidikan ini. Kerja simulasi meliputi pemodelan modul fotovolta, penukar arus terus ke arus terus galak dan algoritma titik penjejakan kuasa maksimum untuk membentuk satu sistem fotovolta. Sistem ini telah dinilai di bawah ujian keadaan mantap dan dinamik. Bagi tujuan perbandingan, algoritma konvensional usik dan cerap, dan kawalan logik kabur telah dimodelkan juga. Dalam pembangunan perkakasan, prototaip telah dibangunkan dan diuji untuk mengesahkan kerja simulasi. Pelbagai beban seperti perintang, lamput kuasa diod pancaran cahaya dan bateri telah digunakan untuk menguji prototaip.

Daripada kedua-dua keputusan simulasi dan eksperimen, algoritma yang dicadangkan menunjukkan prestasi terbaik berbanding dengan algoritma konvensional. Ia menghasilkan terlajak yang kurang (1 V), nisbah kuasa maksimum yang tinggi (98-100 %), masa sambutan yang pantas, keluaran arus terus yang bersih, boleh diterima dengan

isyarat hingar, dan lebih stabil. Pencapaiannya yang penting adalah melalui prestasi yang baik pada sinaran rendah. Kesimpulannya, algoritma yang dicadangkan mampu untuk mengeluarkan kuasa maksimum sumber fotovolta dengan berkesan dan dinamik serta teguh kepada pelbagai keadaan penyinaran.

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I certify that a Thesis Examination Committee has met on **1 August 2013** to conduct the final examination of Muhammad Ammirrul Atiqi B Mohd Zainuri on his thesis entitled "**Photovoltaic Boost Dc-Dc Converter with Adaptive Perturb and Observe-Fuzzy Maximum Power Point Tracking Algorithm**" 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:

**Norman Mariun, PhD, PEng**
Professor,
Faculty of Engineering,
Universiti Putra Malaysia
(Chairman)

**Mohd Zainal Abidin Ab. Kadir, PhD, PEng**
Professor,
Faculty of Engineering,
Universiti Putra Malaysia
(Internal Examiner)

**Suhaidi Shafie, PhD**
Senior Lecturer,
Faculty of Engineering,
Universiti Putra Malaysia
(Internal Examiner)

**M.A. Hannan, PhD**
Professor,
Department Electrical, Electronic and Systems Engineering,
Faculty of Engineering,
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:

**Mohd Amran Mohd Radzi, PhD**
Senior Lecturer
Faculty of Engineering,
Universiti Putra Malaysia
(Chairman)

**Azura Che Soh, PhD**
Senior Lecturer
Faculty of Engineering,
Universiti Putra Malaysia
(Member)

**Nasrudin Abd Rahim, PhD**
Professor
UM Power Energy Dedicated Advanced Centre (UMPEDAC),
University of Malaya
(Member)

**BUJANG BIN 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 institution.

**MUHAMMAD AMMIRRUL ATIQI B MOHD ZAINURI**

Date: 1 August 2013

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