VOL. 11, NO. 14, JULY 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

ARDUINO BASED MAXIMUM POWER POINT TRACKING FOR PHOTOVOLTAIC SYSTEM

Iqram Idris, Mohamad Solehin Robian, Abd Kadir Mahamad and Sharifah Saon
Embedded Computing System, Research Focus Group, Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia
E-Mail: kadir@uthm.edu.my

ABSTRACT
Photovoltaic (PV) system is one of the solution to the energy and environmental issue. It offer possibility of converting sunlight to electricity. Unfortunately, the conversion efficiency of electric power generation are very low especially under low irradiation condition and the amount of electric power generated by solar array change continuously with weather condition. In order to overcome this problem, Maximum Power Point Tracking (MPPT) is being used. This project proposes to design Perturb and Observe (P&O) controller in order to maintain maximum power delivered by the PV system. The performance of proposed method is evaluated by using Matlab/Simulink and Arduino Mega. The proposed method is capable to maximise the power point for PV system.

Keywords: photovoltaic, maximum power point tracking, perturb and observe, arduino.

INTRODUCTION
Due to the energy and environmental issue such as pollution and global warming effect, PV system becomes one of the solutions. Photovoltaic system offer possibility of converting sunlight to electricity. It is also more secure power and friendly source since it is pollution free (Enslin J.H.R, 1991). In addition, photovoltaic solar systems are renewable of electrical energy. An economical energy conversion system should be more basic, reliable, low cost and high efficient. However, the output voltage produce by the conversion of sunlight to electricity are low. The conversion efficiency of electric power generation is not good enough to input into an electricity bank or into the main grid because it is not constant in terms of voltage (Mahamad A.K. *et al*., 2014).

Furthermore, a campaign has been conducted by Malaysian Green Technology Corporation to conserve natural environment and resources in 2009. The development and application of products, equipment and systems are used to conserve the natural environment and resources, which minimizes and reduces the negative impact of human activities. Another campaign launched by government to reduce the environmental issue is “Energy Policy in the 8th Malaysia Plan/Five Fuel Policy”. The goals of the 8th Plan include a safe, cost-effective, secure energy supply which means promoting renewables, cogeneration, diversification, efficiency and using auditing, financial and fiscal incentives, technology development, and labelling. The 8th Plan includes several incentive mechanisms for the promotion of environmental measures and the use of renewables in the private sector (Ismail N. S., 2011).

In order to support the Malaysian Government, initiative been made by using Maximum Power Point Tracking frequently referred as MPPT. It is an electronic system that operates the PV modules in a manner that allow the modules to produce electricity. MPPT is not a mechanical tracking system that “physically moves” the module to make them point more directly at the sun but it is a fully electronic system that varies the electrical operating point of the module so that modules are able to deliver maximum power. In this research, the MPPT of PV system is design using MATLAB Simulink and the design is tested using Arduino MEGA.

PHOTOVOLTAIC (PV) SYSTEM
Photovoltaic energy is the energy produces by the Photovoltaic System (PV) through the conversion of the sunlight (solar energy). It is renewable, inexhaustible and non-polluting energy that readily available. The PV systems are one of the ways of generating electricity from solar energy through solar cells. The solar cell (photovoltaic cell) is an electrical device that can converts the energy of light directly into electricity by the photovoltaic effect. The photovoltaic effects are the generation of the PV system under certain condition. The conditions that effect the energy conversion by the PV system are irradiation of sunlight and the cell temperature. Both of these factors affect the output current and output voltage of the PV system. Several type of PV module such as monocrystalline, polycrystalline and thin film are listed in Table-1.

In this project, a PV module SM140P produces by SM Solar is chosen. The electrical characteristic of SM140P is described in Table-2.

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Table-1. PV module.

Number	Types	Characteristic
1	Monocrytaline	• Produced from a single silicon ingot. • Use widely in the present. • More efficient and less space taking. • Life span of 25 years or more. • Price is higher due to more complicate in production process. • Facing out in the market due to the higher price.
2	Polycrstalline	• Manufactured from a block of multi-crystalline silicon. • More common now due to the material source. • Slightly less efficient than monocrystalline module. • Have the same life span. • Lower price than monocrystalline solar cell.
3	Thin Film	• New technology applying silicon on glass or stainless steel. • Can be used to build the building exterior and roof top. • Less efficient compare in area but work better in dim light condition thus generate 20% more power. • Armosphous is the common material in thin film solar panel. • Not commonly use due to the lower efficient with big area size. • CIGS is the higher efficient solar panel comparable to polycrystalline cell. • Price is highest of all.

Table-2. The electrical characteristic of SM140P.

Typical Electrical Characteristic	SM140P
Maximum power at STC (Pmax)	140W
Optimum operating voltage (Vmp)	17.2V
Optimum operating current (Imp)	8.14A
Open-circuit voltage (Voc)	21.6V
Short-circuit current (Isc)	8.61A
Short-circuit temperature coefficient	(0.065±0.015) %/C
Open-circuit voltage temperature coefficient	-(80±10)mV/C
Peak power temperature coefficient	-(0.5±0.05) %/C
NOCT (Air 20C; Sun 0.8kW/m wind 1ms/s)	47±2 C
Operating temperature	-40C to 85C
Maximum system voltage	1000V DC
Power tolerance	±3%

With STC: Irradiance 1000W/m^2,
Module Temperature: 25 ^oC, and AM = 1.5

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PERTURB AND OBSERVE (P&O)

There have many control techniques proposed by other researcher such as Fuzzy Logic Controller (Mohammed, 2012), (Cheikh and Larbes, 2007), (Alajmi *et al.*, 2011), PI controller (Govind *et al.*, 2013), particle swarm optimization (Selvapriyanka and Vijaykumar, 2014) and many other techniques, but P and O controller (Abdelsalam *et al.*, 2011) become most popular controller due to easy in implementation. Figure-1 shows the flowchart of the P and O method to maintain the power output. The (k) is the current state of value while (k-1) is the previous state value and C is the step size. The P&O method calculates the values and compares it with the current state and previous state. If ΔP >0, then the operation continues in the same direction of perturbation. Otherwise the operation reverses the perturbation direction (Mahamad *et al*., 2014).

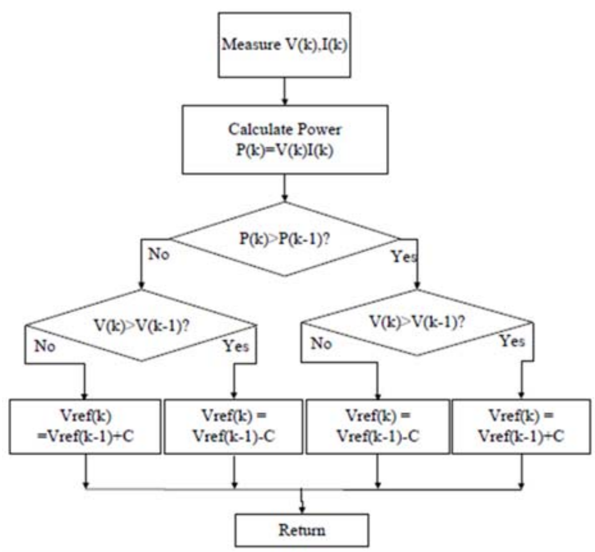

Figure-1. Flowchart of P and O.

PV SYSTEM USING MATLAB SIMULINK

Figure-2 shows the PV module SM140 that contain of six sub-subsystems with irradiance, V_{in} and cell temperature are the input and V_{out} and I_{PV} are the output. While Figure-3 shows the overall MPPT of PV system with the boost converter subsystem simulated using the MATLAB Simulink.

RESULTS AND ANALYSIS

The simulink model of the P&O are downloaded into the Arduino Mega using Arduino support package in Simulink. The input of the model are current and voltage. The data of the current and voltage are taken from the excel spreadsheet as shown in Figure-4. Figure-5 shows the PWM signal generated from Arduino Mega with the voltage of 5.24V and frequency of 98.8Hz. This signal is generated as an input of boost converter circuit as shown in Figure-6. This circuit is used to boost the generated PWM input signal. The component used for this circuit are inductor (11mH), diode (IN4148), mosfet (IRF530) and capacitor (100uF). PWM from Arduino Mega are transmitted through Pin 6 and connected to the Mosfet (Pin G). The PWM duty cycle control the switching waveform of the boost converter. The PWM output signal captured from the boost converter shown the increment of frequency value to 490 Hz, as in Figure-7.

From the result show in Figure-5 and Figure-7 its can be concluded that the implementation of Arduino based MPPT for PV system is operate as expected to generate the PWM signal. The PWM signal then is used to control the MPP of PV system.

CONCLUSIONS

The development of the Maximum Power Point Tracking technique (controller) and modelling of the PV module SM140P had done using Arduino board. The controller for MPPT are analyzed between the software and hardware implementation. The Perturb and Observe controller was designed as the MPPT controller using the MATLAB Simulink software. The designs are downloaded into Arduino Mega and have been tested. The outputs from the Arduino Mega are equivalent to the simulation result in MATLAB Simulink. The boost converter circuit are able to amplify the input frequency from 98.8 Hz to 490 Hz.

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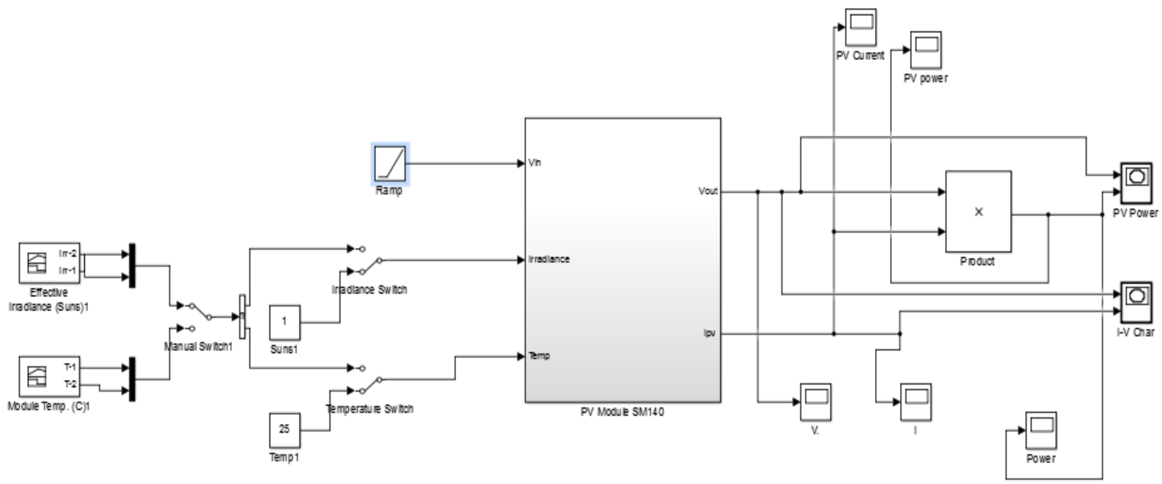

Figure-2. PV module SM140.

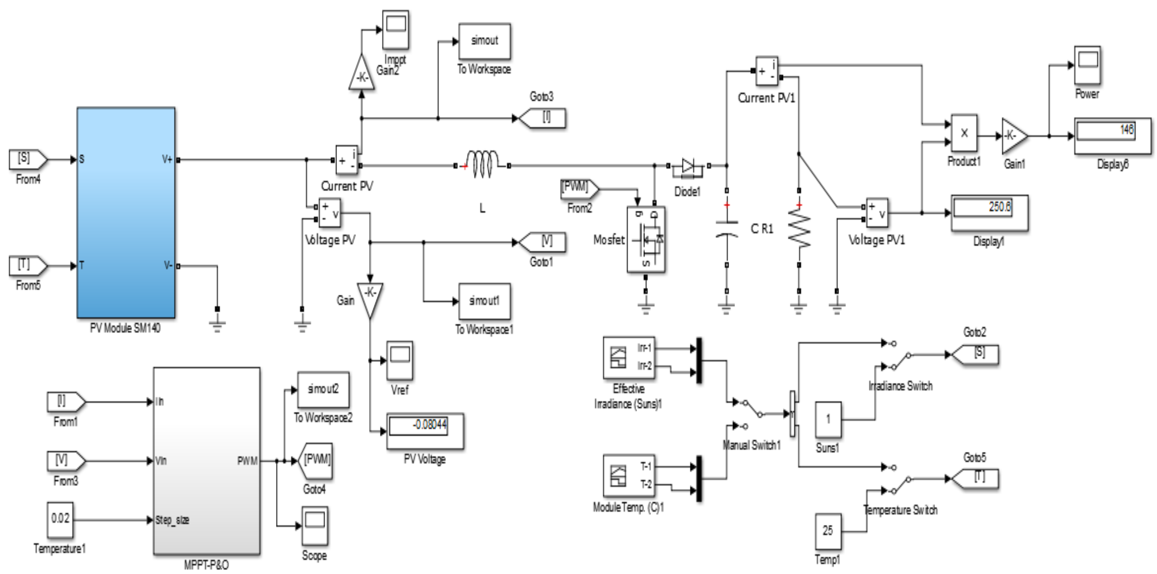

Figure-3. MPPT of PV system.

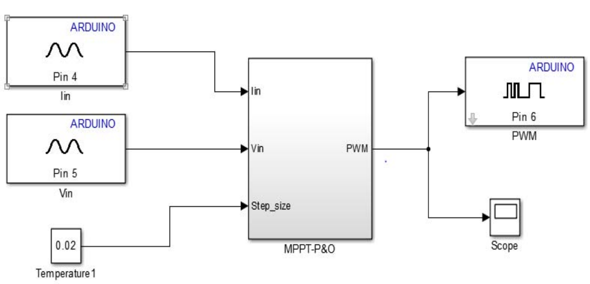

Figure-4. P and O controller using Simulink.

Figure-5. The PWM input signal.

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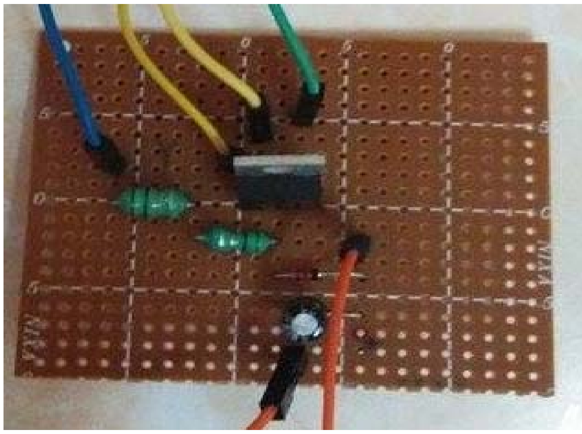

Figure-6. The boost converter circuit.

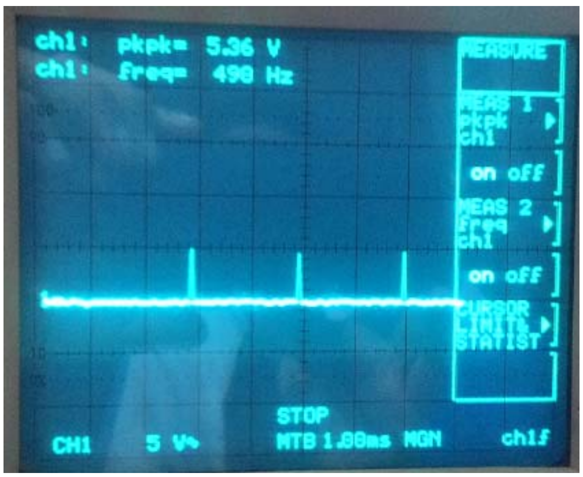

Figure-7. The PWM output signal.

ACKNOWLEDGEMENTS

The financial support received from the Exploratory Research Grant Scheme (ERGS) (Vot No: E036), Office for Research, Innovation, Commercialization and Consultancy Management (ORICC), Universiti Tun Hussein Onn Malaysia is gratefully acknowledged.

REFERENCES

Abdelsalam, A.K., Massoud, A.M., Ahmed, S. and Enjeti, P.N. 2011. High-performance adaptive perturb and observe MPPT technique for photovoltaic-based microgrids, IEEE Transaction on Power Electronics. 26(4), pp. 1010-1021.

Alajmi, B.N., Ahmed, K.H., Finney, S.J. and Williams, B.M. 2011. Fuzzy logic-control approach of a modified hill-climbing method for maximum power point in micro grid standalone photovoltaic system, IEEE Transaction on Power Electronics., 26(4), pp. 1022–1030.

Cheikh, A. M. S. and Larbes, C. 2007. Maximum power point tracking using a fuzzy logic control scheme, Revue des Energies Renouvelables, 10, pp. 387-395.

Enslin J.H.R. 1991. Renewable energy as an economic energy source for remote areas, Proc. Renewable Energy, 1(2), pp. 243-248.

Govind Anil, Nirmal Murugan, Mufeed Ubaid. 2013. PI controller based MPPT for a PV system, IOSR Journal of Electrical and Electronic Engineering (IOSR-JEEE), 6.

Ismail N. S. 2011. Green Technology Policy on Energy in Malaysia. Thesis Master of Environment, Universiti Putra Malaysia.

Mahamad A.K., Saon S., Diaw K. 2014. FPGA Based Maximum Power Point Tracking of Photovoltaic System using Perturb and Observe Method during Shading Condition. International Conference on Internet Services Technology and Information Eng.

Mohammed S. EL-Moghany. 2012. Fuzzy Controller Design Using FPGA for Photovoltaic Maximum Power Point Tracking, International Journal of Advanced Research in Artificial Intelligence, 1(3).

Selvapriyanka. P and Vijaykumar. G. 2014. Particle optimization based MPPT for PV system under partial shading condition, International Conference on Engineering Technology and Science.