Key Engineering Materials Vols. 594-595 (2014) pp 914-918 *Online: 2013-12-05*

doi:10.4028/www.scientific.net/KEM.594-595.914

Photovoltaic Powered Uninterruptible Power Supply Using Microcontroller PIC16F628-I/P

M. Irwanto[1, a], M. Farreq[2, b], S.P. Hadi[3, c], N. Gomesh[4, d] and Y.M. Irwan[5, e]

[1,2,4,5] Centre Excellence for Renewable Energy (CERE), School of Electrical System Engineering, Universiti Malaysia Perlis (UniMAP), Malaysia

[3] Department of Electrical and Information Technology, Gadjahmada University (UGM), Indonesia

[a]irwanto@unimap.edu.my, [b]mfareq@unimap.edu.my, [c]sasongko@te.ugm.ac.id, [d]gomesh@unimap.edu.my, [e]irwanyusoff@unimap.edu.my

Keywords: Photovoltaic, Uninterruptible Power Supply, Microcontroller.

Abstract. Uninterruptible power supply (UPS) sits between a power supply such as wall outlet and devices to prevent undesired feature that can occur within the power source such as outages, sags, surges and bad harmonics from the supply to avoid a negative impact on the devices. This paper presents a photovoltaic (PV) powered UPS using microcontroller PIC16F628A-I/P. It is a standby UPS whereas if the main power source fails to supply power to loads, a battery powered inverter turns on to continue supplying power. The battery is charged by the PV using solar charger and transfer switch controlled by the microcontroller. The UPS was tested to a load of 240 V, 20 W AC aquarium water pump. The test result shows that the UPS perform well, when the main power source fails, the battery could power inverter and the microcontroller controls the transfer switch of the UPS inverter and the main power source.

Introduction

Uninterruptible power supplies are widely used as standby power for critical loads in case of utility power failure. It is usually derived directly from the power line, until power fails. After power failure, a battery powered inverter turns on to continue supplying power. Batteries are charged, as necessary, when line power is available. This type of supply is sometimes called “offline” UPS [1]. There are four major types of UPS [1, 2, 3]. They are stand by UPS, ferroresonant or hybrid UPS, line interactive UPS and online UPS.

Nowadays, PV power generations are widely used for converting solar energy to direct current (DC) electrical energy, the DC can be converted to alternating current (AC) using inverter. A method of relay controller that efficiently utilizes PV array to UPS is described by [4]. The UPS have three-relay controller using a low cost microprocessor. The relay controller, through its port, may indicate anomalies detected by examining open circuit and maximum voltage.

This paper presents a photovoltaic (PV) powered UPS using microcontroller. It is a standby UPS whereas if the main power source fails to supply power to loads, a battery powered inverter turns on to continue supplying power. The battery is charged by the PV using solar charger and transfer switch controlled by microcontroller.

Proposed PV UPS System

The proposed UPS in this paper is a photovoltaic powered uninterruptible power supply using the microcontroller PIC16F628A-I/P. Based on types of UPS that are discussed above, it is a standby UPS whereas if the main power source fail to supply power to loads, a battery powered inverter turns on to continue supplying power. The battery is charged by the PV using solar charger and transfer switch controlled by the microcontroller PIC16F628A-I/P.

A proposed circuit of photovoltaic powered uninterruptible power supply using the microcontroller PIC16F628A-I/P is shown in Fig. 1. Based on the circuit, its components will be discussed as this below.

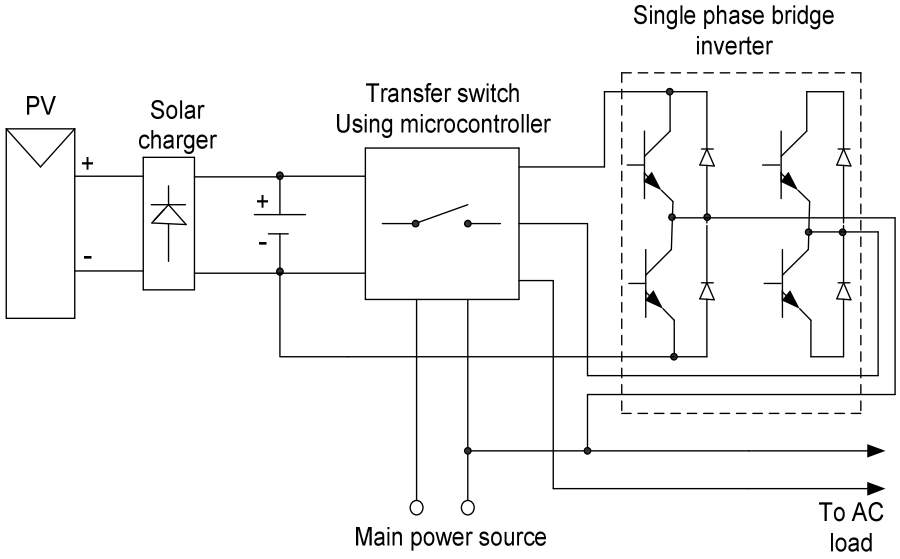

Fig. 1. A proposed block diagram of PV powered UPS using the microcontroller PIC16F628A-I/P

22 V, 50 W, 2.3 A photovoltaic is used in this UPS. The PV can convert solar energy become DC electrical energy. The PV is as main DC source and used to charge the battery using the solar charger. Output voltage and current of the PV depends on solar irradiance and temperature. The needed output voltage to charge battery is usually above 12 V and the flowing current through the solar charger follows the voltage change. Function of the solar charger is to charge the battery. The used solar charger in this UPS is as applied by [4,5].

The transfer switch of the UPS consists of microcontroller PIC16F628A-I/P and three 12 V DC relays. The supply of microcontroller is 5 V DC that produced by LM 7805. Each 12 V DC relay is connected to the pin 11, 12 and 13 of the microcontroller. This inverter is a modified square sine wave inverter where low orders of harmonics content are reduced using the microcontroller PIC16F628A-I/P.

Results and Discussion

The AC load of UPS is 240 V, 20 W AC water pump. The water pump is used to give water circulation of aquarium and have to run continuity. If the main power source fails, the water pump can be run by the UPS inverter. The hardware of proposed PV powered UPS using the microcontroller and experimental set up are shown in Fig. 2 and 3, respectively.

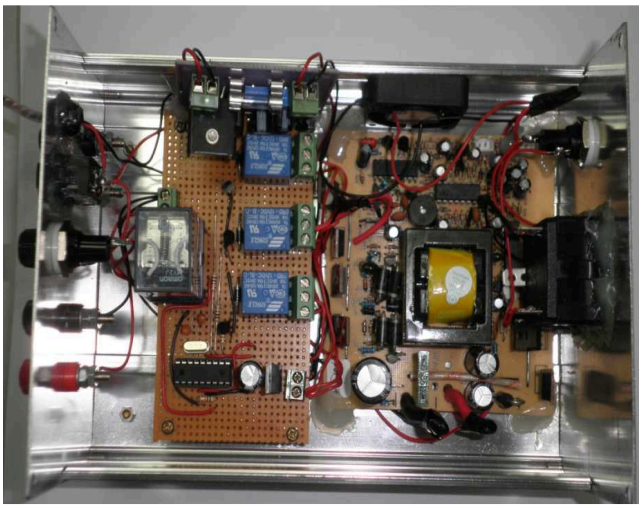

Fig. 2. Hardware of proposed PV powered UPS using microcontroller

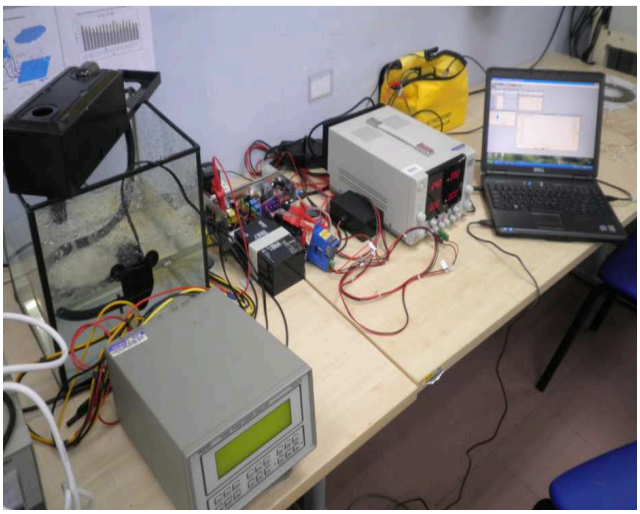

Fig. 3. Experimental set up

The experimental set up is done to know the performance of the PV powered UPS. On the same time, solar irradiance, PV voltage, voltage and current of the battery and performance of the AC load were measured. The solar irradiance was measured by the solar power meter, the PV voltage, voltage and current of the battery were measured by the electrocorder , the performance of AC load was measured by the PM 300 power analyzer.

The testing was done on 13 May 2013 at 11.06 am to 11.53 am. The data of solar irradiance, PV voltage, voltage and current of battery are shown in Fig. 4 and 5, respectively.

The maximum, minimum and average solar irradiance are 1088 W/m^2, 256.4 W/m^2 and 818.21 W/m^2, respectively. The maximum, minimum and average of PV voltages are 15.53 V, 13.81 V and 14.68 V, respectively.

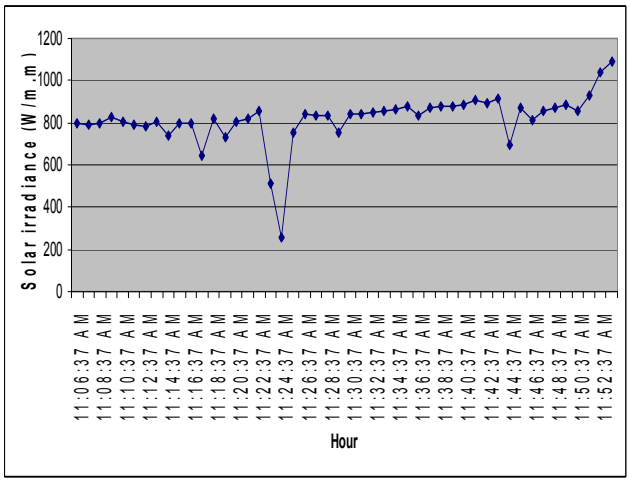

Fig. 4. Solar irradiance

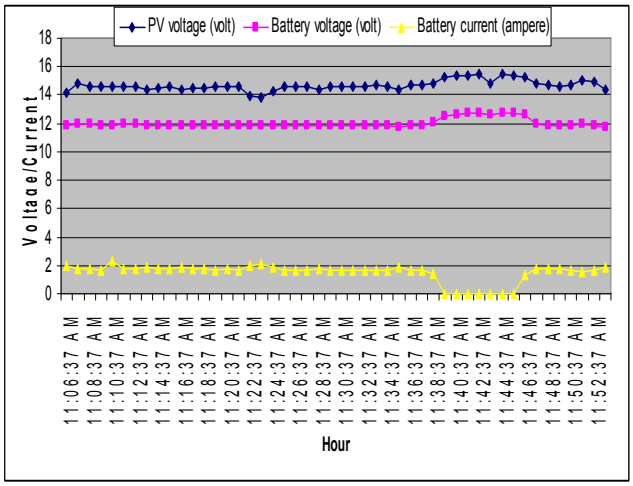

Fig. 5. PV voltage, voltage and current of battery

Fig. 5 shows that on 11.06 am to 11.38 am the UPS inverter run and its average current is 1.77 A (it means there is no main power source) and on 11.39 to 11.45 the UPS inverter didn't run (it means there is main power source). The Fig. 5 shows that when the UPS inverter run the battery voltage is

lower than when the UPS inverter didn't run. The average battery voltage when the UPS inverter didn't run is 12.67 V.

The waveform of main power source and UPS inverter and their harmonic spectrum are shown in Fig. 6 to 9.

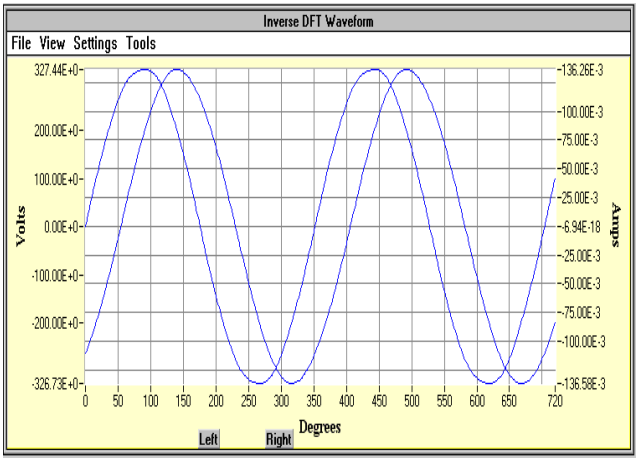

Fig. 6. Waveform of main power source

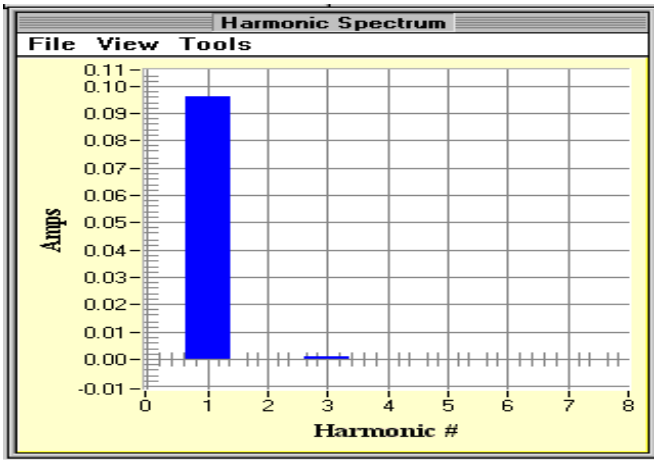

Fig. 7. Harmonic spectrum of the main power source

Fig. 6 shows that the wave form of main power source is pure sine wave. When the AC water pump was loaded, its current total harmonic distortion is 0.878 % as shown its harmonic spectrum in Fig. 7.

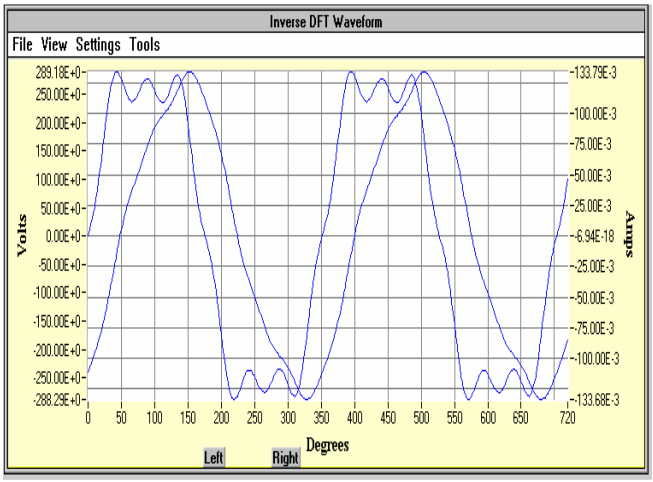

Fig. 8. Waveform of the UPS inverter

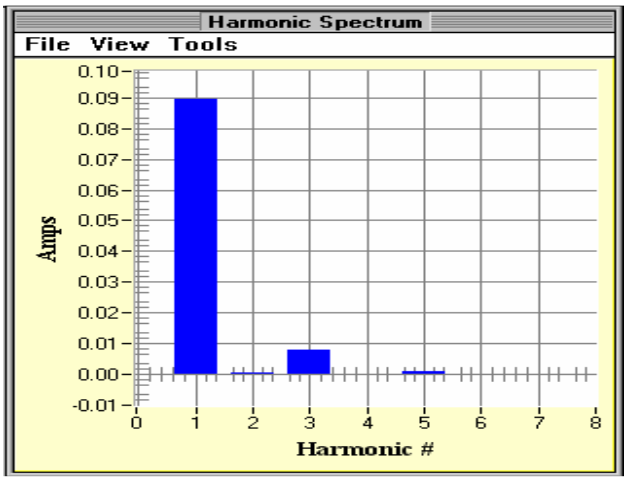

Fig. 9. Harmonic spectrum of the UPS inverter

Fig. 8 shows that the wave form of the UPS inverter is modified sine wave. When the AC water pump was loaded, its current total harmonic distortion is 9.258% as shown its harmonic spectrum in Fig. 9.

Conclusion

This paper presents a photovoltaic (PV) powered UPS using microcontroller. It is a standby UPS whereas if the main power source fails to supply power to loads, a battery powered inverter turns on to continue supplying power. The battery is charged by the PV using solar charger and transfer switch controlled by microcontroller PIC16F628A-I/P. The UPS was tested to a load of 240 V, 20 W AC aquarium water pump. The test result shown that the UPS perform well, when the main power source fails, the battery could power inverter and the microcontroller controls the transfer switch of the UPS inverter and main power source.

Acknowledgements

This work was financially supported by the Exploratory Research Grant Scheme (ERGS), Ministry of Higher Education, Malaysia.

References

[1] M. S. Racine, J. D. Parham and M.H. Rashid, "An overview of uninterruptible power supplies", IEEE Explorer, 2005.

[2] W. bower, " Bimode uninterruptible power supply compatibility in renewable hybrid energy system ", IEEE AES magazine, August 1990.

[3] I. Daut , M. Irwanto and Surya Hardi. *Photovoltaic Powered Uninterruptible Power Supply Using Smart Relay*. The 4rd International Power Engineering and Optimization Conference PEOCO2010), Shah Alam, Selangor, MALAYSIA. 23-24 June 2010. Published in IEEEXplore, p. 453-457.

[4] S. Jayasimha and T. P. Kumar, " Photovoltaic UPS ", TENCON 2003.

[5] G. F. Cook, "Buck Mode Switching Regulator for Solar Applications", http:// www.solorb.com/elect/solarcirc/buckreg1/ index.html, June 23, 2006.

Advanced Materials Engineering and Technology II
10.4028/www.scientific.net/KEM.594-595

Photovoltaic Powered Uninterruptible Power Supply Using Microcontroller PIC16F628-I/P
10.4028/www.scientific.net/KEM.594-595.914