Power Capacity Enhancement of Transformerless Photovoltaic Inverter

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Abstract—**A conventional inverter uses a transformer. Some transformers connected in parallel are needed to obtain a high power inverter. They cause the inverter has a big in size, expensive cost and low efficiency. To solve the problem, a transformerless photovoltaic inverter (TPVI) is suitable to be applied. This paper proposes a paralleled full bridge circuit (FBI) to enhance the power capacity of three-level transformerless photovoltaic inverter. It has a pulse driver circuit, five full bridge inverter circuits and a power factor correction (PFC) circuit. To obtain the high power capacity of the TPVI, five FBI circuits are connected in parallel. Each FBI circuit uses MOSFET IRFP460 which has rating current of 20 A, therefore the total FBI circuit has applicable maximum current of 100 A. Its main energy source is a photovoltaic (PV) array that consists of three unit PV modules connected in series, each unit has voltage of 81 V and power of 60 W. Some three unit PV modules are connected in parallel to fulfill the demand of high alternating current (AC) power. In this research, the AC three-level waveform of the TPVI is developed using a PIC microcontroller.**

***Index Terms*--Solar irradiance, temperature, transformerless inverter.**

I. INTRODUCTION

Inverter circuit provides an AC electrical energy from a direct current (DC) electrical energy. More precisely, inverter transfers energy from a DC energy to an AC energy. The choice of semiconductor switch (transistor, IGBT, or MOSFET) is important to obtain a power rating of the inverter.

Current source inverter (CSI) is simulated using SIMULINK MATLAB by [1]. A technique of pulse wave modulation to control CSI is applied to the simulation. It maintain constant current at the output of the inverter.

The modulation technique to eliminate the total harmonic distortion (THD) is being widely applied in multilevel inverters wich based on frequency modulation switching [2]. It reduces the voltage THD at point of common coupling. This method can be applied in wind power or photovoltaic generation, where multilevel inverters are needed to convert the DC energy to be AC energy.

An algorithm of pulse wave modulation (PWM) is proposed by [3]. It was n-level three-phase inverters. It can be applied in the hybrid system varying voltage steps with some topologies. It can minimize the voltage.

Normally, the low frequency (50 Hz) inverter uses a transformer that it is bigger in size, heavy and expensive and an AC square wave is a simple technique to transfer the DC energy to AC energy. However, the harmonic and efficiency of the waveform are relatively high and low, respectively. For reducing the size, weight and manufacturing cost, the transformerless PV inverter (TPVI) is suitable [4,5,6,7], it improves efficiency of the system.

This paper proposes a paralleled full bridge circuit to enhance the power capacity of three-level TPVI. It has a pulse driver, a power factor correction (PFC) and five full bridge inverter (FBI) circuits [4]. The advantages of the proposed topology compared to the conventional inverter are that it is easy to create same frequency, phase and waveform of output voltage of each full bridge inverter circuit. It is due to each full bridge inverter circuit is driven by pulse wave which is created by microcontroller PIC16F628A-I/P. Each pulse wave has same frequency and duty cycle. It is easy to create same amplitude of output voltage of each full bridge inverter circuit. It is due to each DC input of the full bridge inverter circuit has same DC voltage which is output voltage of the PFC. Therefore, the current total harmonic distortion (CTHD) of the same loads can be improved and also it can be applied to run high AC loads.

II. METHODOLOGY

A. Weather station and PV array

The Weather Station Pro2 and high power three-level single phase TPVI are installed in front of Centre of Excellent for Renewable Energy (CERE) , Universiti Malaysia Perlis, Northern Malaysia as shown in Fig. 1. The TPVI main energy source has a PV array that consists of three unit PV modules connected in series, each unit has the voltage of 81 V and power of 60 W. Some three unit PV modules are connected in parallel to fulfill the demand of high AC power. The Vantage Weather Station Pro2 and voltage logger are used to measure the data of solar irradiance and the PV voltage, respectively.

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Fig. 1. Weather station and PV array installed in front of CERE, Universiti Malaysia Perlis

B. Proposed topology of high power TPVI

A proposed topology of high power TPVI consists of a pulse driver circuit, five full bridge inverter (FBI) circuit and a power factor correction (PFC) circuit as shown in block diagram in Fig. 2.

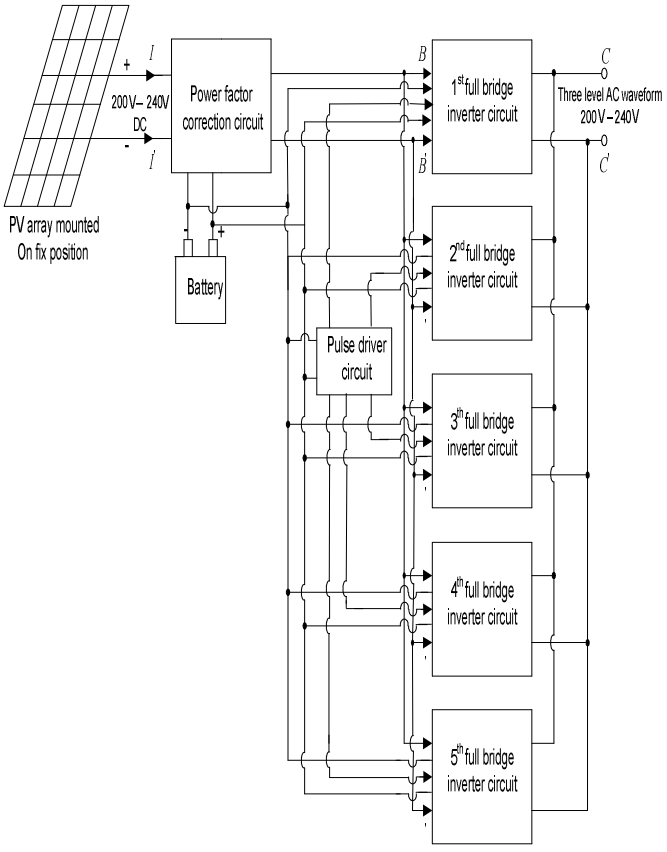

Fig. 3. Block diagram of the proposed high power three-level single phase transformerless PV inverter

The pulse driver and PFC circuits are explained by [4] and the five FBI circuits connected in parallel as shown in Fig. 3. Each FBI is constructed by MOSFET IRFP460 which has rating current of 20 A and for 240 V AC system, therefore each FBI has applicable maximum power of 4.8 kW. For five FBI connected in parallel equals 5 x 4.8 kW.

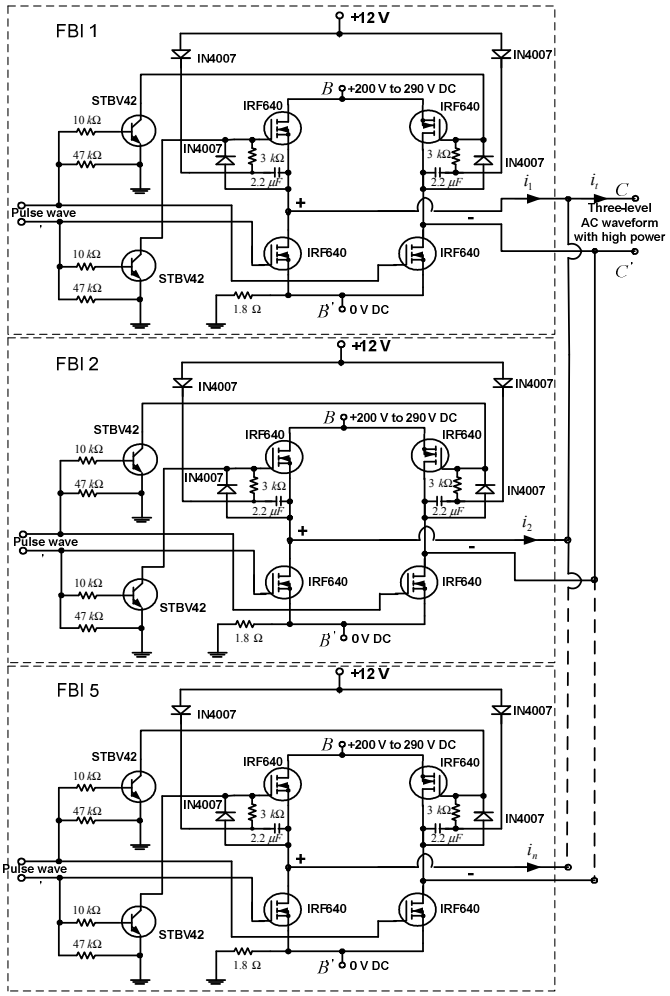

Fig. 3 Five paralleled FBI circuits

Based on connection of paralleled inverters, advantages of the proposed topology are:

1. It is easy to create same frequency, phase and waveform of output voltage of each FBI. It is due to each FBI is driven by pulse wave which is developed by the microcontroller. Each pulse wave has same frequency and duty cycle.
2. It is easy to create same amplitude of output voltage of each FBI. It is due to each FBI at point B and $B^{'}$ has same DC voltage which is output voltage of the PFC.

C. Experimental set up

Main experimental setup equipments of the three-level single phase TPVI consist of PV array, pulse driver circuit, full bridge inverter circuit, power factor correction circuit, battery, and AC load types. The measurement equipments consist of Vantage Weather Station Pro2, electrocorder voltage logger, textronix oscilloscope and PM 300 Analyzer as shown in block diagram in Fig. 4.

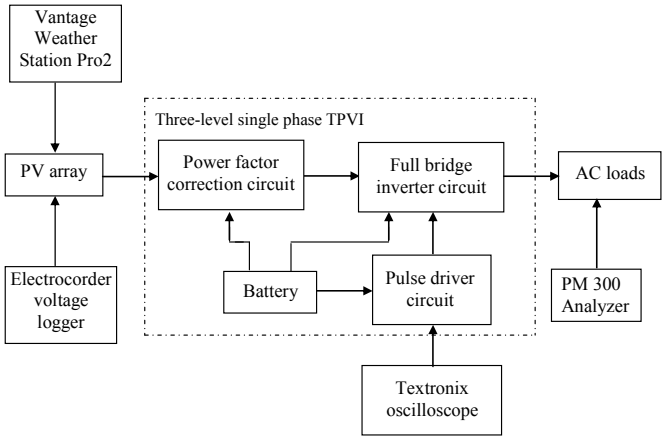

Fig. 4. Block diagram of experimental setup

As shown in Fig. 4, the TPVI input is connected to the PV array and its output is connected to the AC load of 480 W jig saw. The solar irradiance and temperature are measured by the Vantage Weather Station Pro2, their condition is 851 W/m^2 and 31^0, respectively. Performances of the AC load are measured by the PM 300 Analyzer.

III. Result And Discussion

AC load of 480 W jig saw is applied into the TPVI. Performances of the TPVI are shown in Table 1. The TPVI voltage and current waveform for running the 480 W jig saw is shown in Fig. 5. Fig. 6 shows the current harmonic spectrum of TPVI.

TABLE I
PERFORMANCE OF THE TPVI FOR RUNNING 480 W JIG SAW

Solar irradiance (W/m^2)		851
Temperature (^{0}C)		31
AC measured power (W)		234.6
AC Voltage (V)		215.8
Current (A)	A1	0.22
	A2	0.22
	A3	0.22
	A4	0.22
	A5	0.22
	Total	1.102
CTHD		17.56

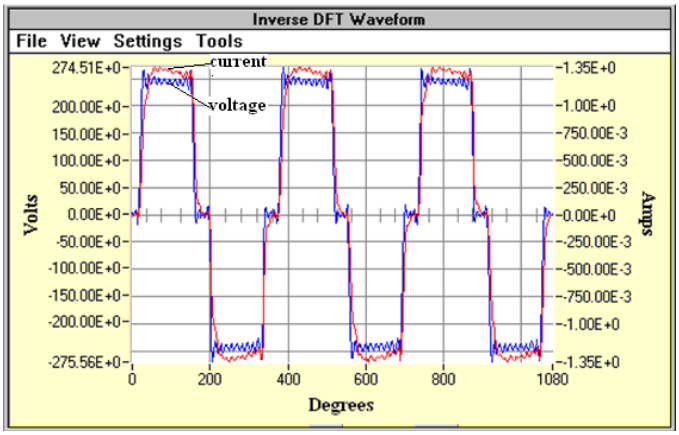

Fig. 5. Voltage and current waveform of the AC load of 480 W jig saw

Fig. 5 shows AC three-level voltage waveform. It has maximum voltage angle, α of 134^0, choose of the maximum voltage angle is explained by [4]. AC current waveform of the AC load affects the current harmonic spectrum and current total harmonic distortion as shown in Fig. 6 and Table 1.

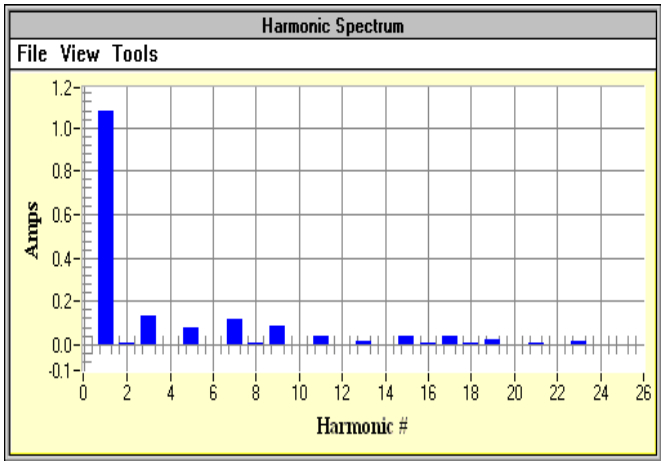

Fig. 6. Current harmonic spectrum of the TPVI loaded by 480 W jig saw

IV. Conclusion

The paralleled full bridge circuit can be used to enhance the power capacity of three-level single phase TPVI, from the result can be summarized as below:

1. The Solar irradiance and temperature affect the PV array voltage. The PV array voltage directly is converted become AC voltage using FBI circuit.
2. Some FBI circuits can be connected in parallel to obtain high AC power. Using MOSFET IRFP460 of the FBI circuit which has rating current of 20 A, therefore the total five FBI circuits have applicable maximum current of 100 A. If it is applied into 240 V AC system, therefore each FBI has

applicable maximum power of 4.8 kW. For fiveFBI connected in parallel equals 5 x 4.8 kW.

3. AC three-level voltage waveform has maximum voltage angle, α of 134^0 with AC current waveform affects current harmonic spectrum and current total harmonic distortion.

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