

Simulation of Push-Pull Inverter for Photovoltaic Applications via Multisim

S.S. Shema, I. Daut, Syafawati A.N., M. Irwanto, Shatri C.

Abstract-- This paper presents the circuit design of a push-pull topology inverter for photovoltaic (PV) applications. The inverter is a critical component responsible for the control of electricity flow between the modules, battery and loads in any PV based system. A brief technical information is given on the inverter design and the operation of the circuit used. This circuit design is simulate using the NI Multisim software. The circuit design and simulation result are presented in this paper. Based on the simulation result obtained it has been possible to build this inverter for feeding small house appliances.

Index Terms-- Push-pull inverter, Photovoltaic, NI Multisim software, Simulation.

I. INTRODUCTION

Recently, the need of renewable energy has become important contribution in energy consumed such as solar, wind, biomass and geothermal. Among them, solar energy is one of the important renewable energy sources because it is inexhaustible. Besides, its conversion free from the emission of air or water pollutions or the generation of solid waste [3]. Malaysia is one of the countries that receive abundant of sun light in average mostly in northern side of Peninsular Malaysia where Perlis, Kedah and Penang have high potential in applying solar energy [5]. The output of photovoltaic (PV) is in DC form. Therefore, it requires sophisticated conversion techniques to make them usable because the power utilisation is mostly in AC form. This conversion can be done by using

inverter that converts DC input into AC output. The inverter is a critical component responsible for the control of electricity flow between the modules, battery and loads in any PV based system.

II. SYSTEM DESIGN

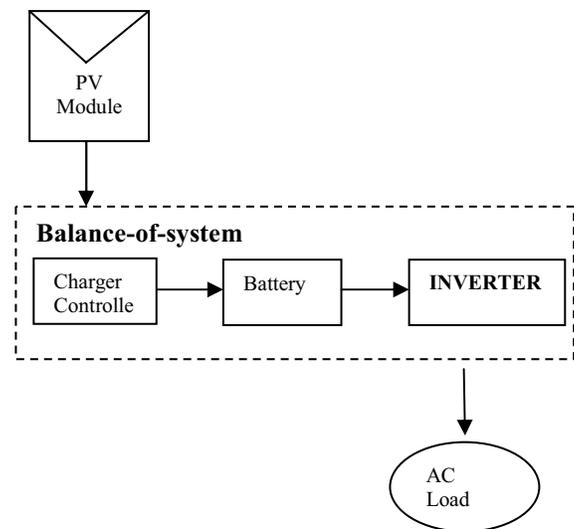


Fig. 1. Block diagram representation of photovoltaic system.

This photovoltaic system consists of three main subsystem which are PV devices (modules, panel or arrays), balance of system (BOS) and AC load. PV devices collect solar radiation from the sun and actively convert that energy to electric dc power. The BOS typically contains structures for mounting the PV arrays or modules and the power conditioning equipment that converts the electricity to the proper form and magnitude required by load. The BOS in this system consists of charger, battery and inverter [5].

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S.S.Shema is with School of Electrical Systems Engineering, University Malaysia Perlis (saidatul_shema@yahoo.com).

I.Daut is with Research Kluster, University Malaysia Perlis (ismail.daut@unimap.edu.my).

Syafawati A.N. is with School of Electrical Systems Engineering, University Malaysia Perlis (nsyafawati85@gmail.com).

M. Irwanto is with School of Electrical Systems Engineering, University Malaysia Perlis (irwanto@unimap.edu.my).

S. Champakeow is with School of Electrical Systems Engineering, University Malaysia Perlis (shatri.c@gmail.com).

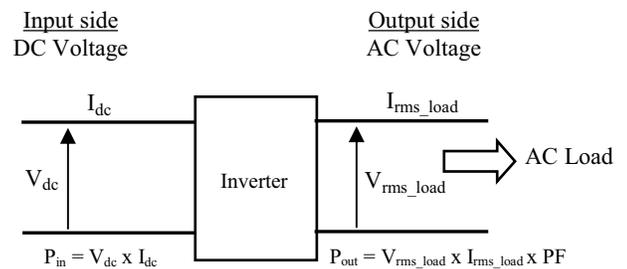


Fig. 2. Power flow in an inverter.

The inverter is a DC to AC converter that converts DC input into AC output. The power flow in an inverter is shown in Figure 2. The inverter finds very useful applications and widely used in industrial applications such as variable speed drives for single-phase and three-phase AC motors, standby or emergency power supplies, induction heater and AC appliances run from an automobile battery. Inverter is inevitably an integral part of the photovoltaic system. An inverter design consist of the DC input, control circuit, power circuit and step-up transformer.

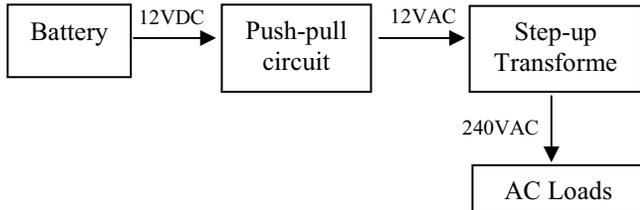


Fig. 3. General flow of push-pull inverter topology.

The DC input voltage into an inverter can be obtained in various ways. For this system, the inverter draws its DC input from batteries charged by photovoltaic. The charger will regulate the voltage and current coming from the photovoltaic going to the battery. The battery is the key components in PV systems as it act as energy back-up for the renewable energy systems. It also functions as storage devices for storing PV generated electricity during cloudy days and at night.

The control circuit and power circuit is an important part in an inverter. The selection of the main devices are depends on factors such as the DC voltage, the load current, the maximum operating frequency and others. The devices need to be force-commutated devices with high switching frequencies like insulated gate bipolar junction transistors (IGBTs), power MOSFET or gate-turn-off thyristors (GTOs) that can provide natural turn-off facilities [1].

To produce the required output waveform, the devices are switched in a particular sequence determined by the control circuit. The control circuit of the inverter determines the waveform of the output voltage and its frequency. In inverter that having high power ratings, the control circuit may incorporate protection circuits such as current limiting. The power circuit consists of the main switching devices that carry the load current. The power circuit also includes protection circuits such as reverse conduction diodes [1].

III. NI MULTISIM SOFTWARE

NI Multisim was formerly known as MultiSIM is an electronic schematic capture and simulation program which is part of a suite of circuit design programs. Multisim is widely used in academia and industry for circuit education, electronic schematic design and SPICE simulation. This software equips user such as educators, students and professionals with the tools to analyze circuit behavior.

The intuitive and easy-to-use software platform combines schematic capture and industry-standard SPICE simulation into a single integrated environment. Multisim abstracts the complexities and difficulties of traditional syntax-based simulation. Therefore, user no longer needs to be an expert in

SPICE to simulate and analyze circuits. Multisim is available in two distinct versions to meet the teaching needs of educators or the design needs of professionals [4].

Multisim Education is for circuit teaching. Multisim makes it easier to engage students and reinforce theory. Educators worldwide are using the academic features of the Multisim education edition to foster learning and guide student exploration of circuit concepts. Using “what-if” experiments and simulation-driven instruments to visualize circuit behaviour, students gain intuition and a deeper understanding of circuit concepts [4].

Multisim Professional is for circuit design and prototyping. Engineers, researchers, and domain experts use the Multisim environment for schematic capture, SPICE simulation, and circuit design. Without needing any expertise in SPICE, engineers can use simulation to reduce prototype iterations earlier in the design flow. Multisim can be used to identify errors, validate design behaviour, and prototype faster. Schematics can then be transferred to NI Ultiboard layout to prototype completed printed circuit boards (PCBs) [4].

This project use NI Multisim 10 Power Pro Edition for the circuit design and simulation. This software is the premier circuit capture and simulation environment. It optimizes design behaviour with 20 advanced analyses and 22 virtual instruments and has comprehensive database of more than 17,500 devices and simulation models. This software also advanced integration with real measurement data for custom design verification, advanced project management; includes project packing, version control and advanced spreadsheet view. It was integrated with NI Ultiboard layout for complete and streamlined prototyping [4].

IV. SIMULATION RESULT

The design of the inverter circuit was implemented using push-pull topology as shown in Figure 3. The push-pull topology is suitable for producing square and modified square wave inverter. This design will convert the 12 VDC to 12VAC and use step-up transformer to step-up the voltage to 240VAC.

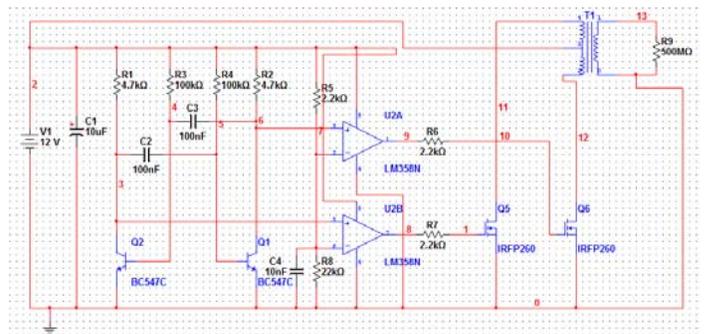


Fig. 3. Simulation Layout using Multisim.

This circuit used a simple multi-vibrator oscillator, Q1 and Q2 which is BC547. The frequency is determined by the 100nF capacitor and 100kΩ resistors, R3 and R4 which is 60Hz operating frequency. It is common to choose either MOSFET or IGBT as a switching device. They offer several advantages over the BJTs which are very high input impedance, very high switching frequency and low switching

loss. The power transistor use in this circuit design is a MOSFET IRFP260.

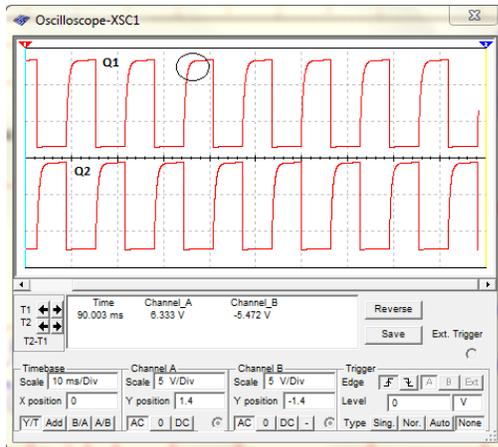


Fig. 4. The output waveform of Q1 and Q2 transistors.

The multi-vibrator output of Q1 and Q2 could be fed directly to the gates of MOSFET but it needs to be turned 100% ON or 100% OFF for best efficiency. From the Figure 4, it shows that the Q1 and Q2 not generate a nice and clean square wave. It has a problem on the positive slope. There will be dissipation of power if the MOSFETs are only 1/2 ON. The time interval between OFF and ON may be small but it is enough to cause the output of MOSFET to dissipate power. However, this slope can be use to cause a delay. So, there is a moment of pause between the two MOSFETs ON time and this will avoid overlap.

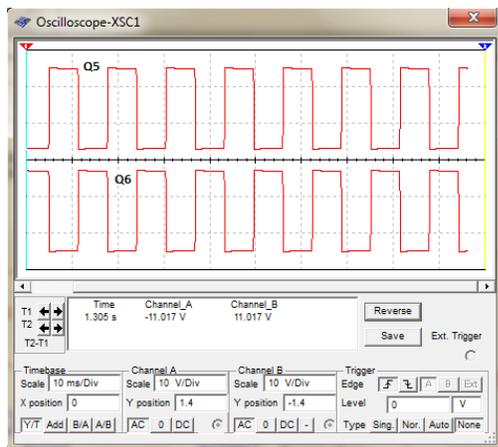


Fig. 5. The output waveform of Q5 and Q6 MOSFETs.

The operation amplifier LM358 is use to switch ON and OFF cleanly and also act as a level detector. When the transistors Q1 and Q2 have reached about 11 Volt, the LM358 will change the state with clean 0-12 Volt square waves to Q5 and Q6 MOSFETs.

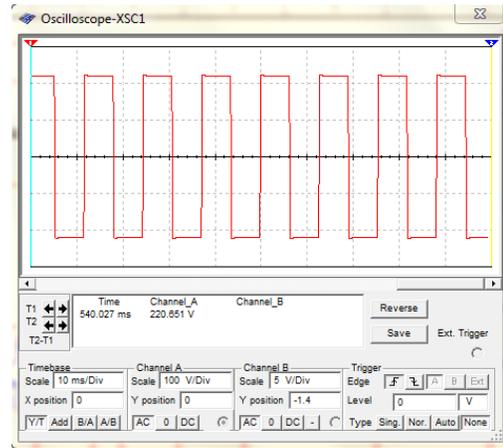


Fig. 6. The output waveform of push-pull inverter circuit.

Based on Figure 6, it shows that this inverter circuit produced a square waveform. This circuit design also successful converts the 12VDC to 220 VAC using step up transformer.

V. CONCLUSION

In this paper, a model of a push-pull topology inverter was designed and simulated. The simulation was performed using the NI Multisim software. The inverter design consist of the DC input, control circuit, power circuit and step-up transformer. From the simulation result obtained, the output waveform of this inverter circuit is square waveform. This inverter successfully converts the 12 VDC into 220 VAC.

VI. ACKNOWLEDGMENT

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VIII. BIOGRAPHIES



Saidatul Shema Binti Saad was born in Perlis, Malaysia on February 1, 1984. She is postgraduate student in Electrical System Engineering at University of Malaysia Perlis (UniMAP). She received her Bachelor of Electrical and Electronic Engineering at University of Malaysia Pahang (UMP) in 2007.

Her master research is about inverter design and her research interest is in renewable energy.



Noor Syafawati Binti Ahmad was born in Perlis, Malaysia on October 2, 1985. She received her Bachelor of Electrical Engineering at University of Tun Hussien Onn (UTHM) in 2008 and Master of Science in Electrical Systems Engineering from University of Malaysia Perlis (UniMAP) in 2010. She is currently a lecturer in the School of Electrical System Engineering at University Malaysia Perlis (UniMAP).

Her research interest includes renewable energy.



Ismail Daut received his B. App Sc. (Hons) from University of Science Malaysia in 1980 and M.Sc. in Electrical and Electromagnetic Engineering from University of Wales, College of Cardiff, United Kingdom in 1984 and Ph.D. in Energy Conservation and Power Engineering from University of Wales, College of Cardiff, United Kingdom in 1991.

His research interest includes energy conversion, electrical machine design and high voltage. He has authored and co-authored more than 185 technical papers in the national, international journal and conferences.



Muhammad Irwanto was born in Tebing Tinggi, Indonesia on October 27, 1974. He received his B.Eng from Medan Institute of Technology in 1998 and Master Degree in Electrical Power System from University of Gadjahmada, Jogjakarta, Indonesia in 2002. He is currently a lecturer in the School of Electrical System Engineering at University Malaysia Perlis (UniMAP). He is member of Electrical Energy and Industrial Electronic System Cluster, University Malaysia Perlis (UniMAP)

Perlis, Malaysia. His research interest includes electrical power system stability and solar power.



Shatri Champakeow A/L Eh Bon was born in Kedah, Malaysia on July 6, 1985. He received his Bachelor of Electrical System Engineering at Unimap in 2009. He is currently postgraduate student in Electrical System Engineering at University of Malaysia Perlis (UniMAP).

His master research is about solar, wind and hybrid system and his research interest is in renewable energy.