International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 3 Issue: 3 1367 - 1370

Microcontroller Based Three Phase Inverter

Mr. R. U. Ghanmare
Electrical Engineering
DBACER, Nagpur
ghanmare.rahul@gmail.com

Ms. P. M. Palpankar
Electrical Engineering,
DBACER, Nagpur
prachi_bd22@yahoo.com

Mr. A. A. Dutta
Electrical Engineering,
DBACER, Nagpur
abhijitak2003@gmail.com

Mr. N. S. Damle
Electrical Engineering,
TGPCET, Nagpur
navaldamle@gmail.com

***Abstract*—**This paper presents the idea and design of a three-phase inverter that produces a symmetric AC output voltage of desired magnitude and frequency. Although the inverter has traditionally been designed as analog circuitry, now the digital inverters are preferred. Microcontroller used for generating the control signal for the three-phase inverter. The importance of the proper design of control signals with powerful switching is to reduce the harmonics and power losses of the inverter output voltage. The potential of the microcontroller to carry out the mathematical and logical functions allows it to imitate logic and electronics circuit. The PIC18FXX2 of Microchip is used for the implementation of inverter. PWM control is the most powerful technique that offers a simple method for controlling of analog systems with the processor's digital output. All PWM generating methods aim at generating a sinusoidal inverter output voltage without low-order harmonics. With the availability of low cost high performance microchips characterized by the execution of most instructions in one instruction cycle, complicated control algorithms can be executed with fast speed, making very high sampling rate possible for digitally-controlled inverters.

***Keywords*—** *Three-phase inverter, SPWM, PIC microchip*

*****

I. INTRODUCTION

The lots of advances in semiconductor technology, power electronics devices with high power handling capabilities are commercially available and inexpensive. Power electronics are playing an important role in today's technology; they have an increasing number of applications in the industrial and domestic areas.

The major function of power electronics is to control the flow of power by shaping the supplied power from the source. Power electronics also introduces distortion of the output waveform and injects harmonics into the supplier system; using appropriate filter circuits can reduce these harmonics. PWM control is the most powerful technique that offers a simple method for controlling of analog systems with the processor's digital output. Control methods, which generate the necessary pulse width modulation (PWM) patterns, have been discussed extensively in literature. These could be classified as voltage con- trolled and current controlled PWM. All these methods aim at generating a sinusoidal inverter output voltage without low-order harmonics. With the availability of low cost high performance microchips characterized by the execution of most instructions in one instruction cycle, complicated control algorithms can be executed with fast speed, making very high sampling rate possible for digitally-controlled inverters.

It is possible to supply a three-phase load by using three separate single-phase inverters, if each inverter produces an output displaced by 120° of fundamental frequency with respect to each other. The function of inverter is to change a dc voltage to ac voltage by operating the active device in switch mode. Switch mode of operation of devices, only three values of voltage can be delivered to the output positive, negative and zero. But the desired output is a continuous wave commonly a sinusoidal. Pulse width modulation (PWM) solves the problem of generating a real value range of (+U, -U) for the output from three discrete values of +U, -U, and zero.[7][10]

II. SYSTEM OVERVIEW

A. PIC Microchip

PIC is a family of modified Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "Peripheral Interface Controller".

Microchip introduced the PIC18 architecture in 2000. Unlike the 17 series, it has proven to be very popular, with a large number of device variants presently in manufacture. In contrast to earlier devices, which were more often than not programmed in assembly, C has become the predominant development language.[13]

B. Inveter

The function of an inverter is to change a DC input voltage to an AC output voltage of desired frequency and magnitude. In case of 3-phase inverter, the inverter circuit changes a DC input voltage to a symmetrical AC output voltage of desired magnitude and frequency. Output voltage could be fixed or variable at a fixed or variable frequency. Variable output voltages are obtained by varying the input DC voltage with maintaining the gain of the inverter constant. Meanwhile, if the DC input voltage fixed and not controllable, variable output voltage can be obtained by varying the frequency of the inverter that is usually done by implementing PWM control within the inverter. The output voltage of an inverter has a periodic waveform, which is not purely sinusoidal, but with numbers of techniques it can be designed to closely approximate to this desired waveform. Inverter can be built with any number of output phases. Practically, single-phase and three-phase inverters are most commonly used. It depends on the user requirement whether in the industrial applications, transportations and home appliances. In most circumstances, three-phase inverter offered better performances as compared to single-phase inverter. [10]

Power semiconductors switches are the basic building component of the inverter. Generally there were two types of inverter topology, named as Voltage Source Inverter (VSI) and Current Source Inverter (CSI). Voltage waveform is the

independently controlled AC output in the VSI topologies. Meanwhile, in CSI topologies, the independently controlled AC output is a current waveform. VSI can be further divided into three categories, which is PWM Inverter, Square Wave Inverter and Single-phase Inverters with Voltage Cancellation.

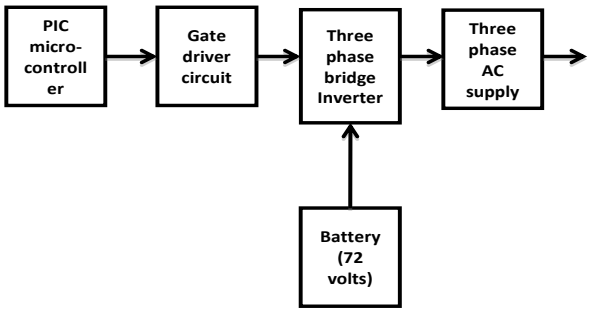

Figure:-1 Block diagram of Hardware implemented system

C. Gate Diver Circuit

The function of gate driver circuit is to turn ON and OFF the switch in the inverter and vice-versa. The power rating of the drivers varies depending on the type of switches being used. There is another function that driver circuit also creates the blanking time for switches in same leg. The voltage and current level of the microchip output signal fails to operate the IGBTs. IGBT driver circuit amplifies the microchip output signal to the required level for triggering the IGBTs and isolates the microchip from the power circuit.

III. HARDWARE FEATURES

The complete hardware divided into three main parts

A. Microchip
B. Gate driver circuit
C. Three-phase inverter

A. Microchip

Although the inverter has traditionally been designed as analog circuitry, now the digital inverters are preferred. These devices use low-cost microcontrollers and digital signal processors and offer sophisticated control algorithms with highly flexible software, the ability to add user interface, reduce components, and introduce testing procedures with increase reliability.

The microchip PIC18FXX2 family is used for digital generation of control signal for driver circuit. The PIC18FXX2 controller includes program memory of 32K words (16-bit) of Program Flash and PIC18FX52 devices can store up to 16K of single word instructions. On chip RAM of 1.5K bytes and data EEPROM of 256 bytes. 18 interrupt sources are present, five input-output port are present namely A, B, C, D and E. the two PWM modules are present. Parallel Slave Port (PSP) is available for parallel communication. Analogy feature are Compatible10-bitAnalog-to-DigitalConverter module (A/D) with Fast sampling rate and Conversion available during SLEEP. The PIC18FXX2 has a 16-bits wide instructions and this allows operations up to 10MIPS (Mega Instructions per Second) @ 40MHz. All the analog circuitry has been replaced by a digital modulation scheme.

B. Gate driver circuit

TLP250 ICs are commonly used for drivers' circuit for IGBTs. This gate driver circuit also has built in over current protection. It senses the current from IGBTs drain and determines the whether the inverter handling too much current or not. An opto-isolator, also called an optocoupler, photo coupler, or optical isolator, is an electronic device designed to transfer electrical signals by utilizing light waves to provide coupling with electrical isolation between its input and output. The main purpose of an opto-isolator is "to prevent high voltages or rapidly changing voltages on one side of the circuit from damaging components or distorting transmissions on the other side. [3][14]

Figure: -2 practically implementation of Gate driver circuit

C. Three phase Inverter

The function of inverter is to change the input DC voltage to a symmetrical voltage with controllable magnitude and frequency. The dc input of the inverter is obtained from the battery. The three-phase inverter has six switches in the circuit with three arms. Each arm of bridge has two switches. Each switch of the inverter is control by the small signal. Switches in the same leg are not turn ON at the same time to prevent short circuit in that leg. Blanking time must be added to make sure that there are no two switches in the same leg turning on at the same time. The three-phase inverter has an input of 72 volt dc and consists of six Insulated gate bipolar transistors (IGBTs). Higher switching frequency capability than competitive IGBTs. Highest efficiency available and minimized recovery characteristics require less/no-snubbing equations.

The figure 3 shows IGBT based three-phase inverter. The gating signal of inverter should be advanced or delayed by $120^0$with respect to each other to obtain three phase balanced fundamental voltage. The transformer primary winding must be isolated from each other, where as the secondary winding may be connected in "wye" or delta [2][5]

D. Capacitors and Diode

In the three-phase bridge inverter capacitor is used at the input terminal, which helps to maintain the constant dc supply voltage to inverter. This capacitor also helps to suppress harmonic resulting for inverter operations and prevent them from reaching to DC source. Filter capacitors are capacitors used for filtering of undesirable frequencies. [8]

Figure: -3 practically implementation of Three phase inverter circuit

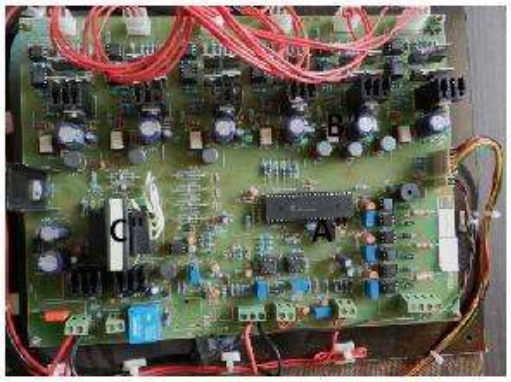

Figure: -4 Photographic view of three phase Inverter circuitry

The figure 4 shows the control circuit where (A) shows the microchip, which gives the digital signal for the gate driver circuit. The output waveform of microchip shown in the figure (4). The power supply for microchip fed for the output for the transformer connected at the output side of bridge. The gate driver circuit indicates by (B). The SMPS indicated by (C), the 5 V and 12V power supply from the SMPS.

The figure 3 represents the power circuit where six IGBTs switches are connected. The output from the driver's circuit with current amplification gives to IGBTs. The bridge output is of 35 volts the voltage fed to step up-transformer. The transformer secondary side voltage is 230 Volts. There are three such single phase transformer connected that gives the line to line three phase 440 Volt power. The transformer taps 0-230 Volts and 0-10 Volts. The 0-10 Volts power fed back to microchip circuit through the switch we can vary the output voltage.

IV. EXPERIMENTAL RESULT

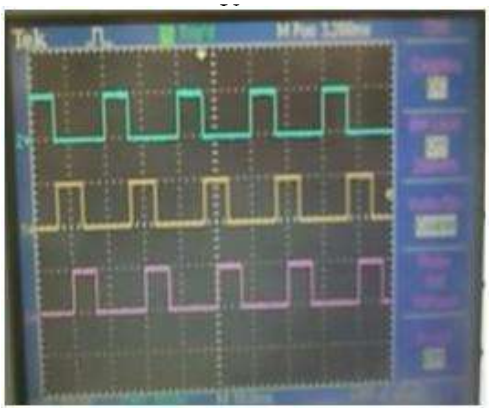

Figure: -5 Output waveform of microchip

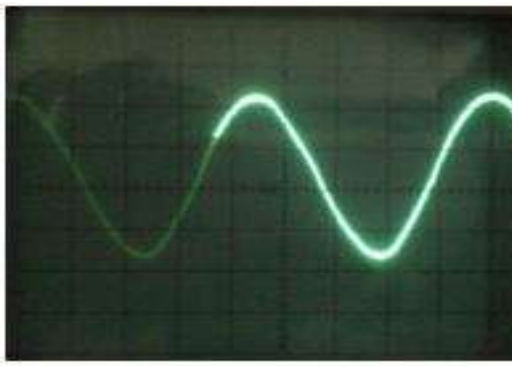

Figure: -6 Output Waveform of Inverter

Figure 4 gives the idea about of hardware implementation for the three-phase inverter. When we considering the main functional diagram of inverter one circuit are used for generation of gate pulse. When we use TLP250 for the gate drive circuit, advantage of this IC it provide the blanking time between the switch in the same leg. The three-phase inverter has an input of 72 volt dc and consists of six Insulated gate bipolar transistors (IGBTs). The control signal is generated with the help of PIC18F452. The gate signal is transferred toward gate drive circuit; from this circuit signal is give to the transistor pair that makes the Darlington pair, which is used for current amplification. The current comes from the gate drive circuit not able to trigger the IGBT switch. IC 4n35 is an electronic device designed to transfer electrical signals by utilizing light waves to provide coupling with electrical isolation between its input and output. Figure 6 shows the output waveform of three-phase inverter.

VI. CONCLUSION

The control scheme for three-phase inverter is described. PWM inverter develops more theoretical and practical knowledge on digital controlled inverter and their applications. The inverter unit consists of six discrete IGBTs connected as a bridge and control circuit forms a cost efficient scheme.

VII. REFERENCE

[1] M. A. Jabbar, Ashwin M. Khambadkone and Zhang Yanfeng, " Space- Vector Modulation in a Two-Phase

Inuction Motro Drive for Constant-Power Operation", IEEE Trans. on Industrial Electronics, Vol. 51 No. 5 , pp 1081-1088, October 2004.

[2] Khaled A. Madi and Mohammad E. Salem Abozaed, " Microcontroller Based Varible Frequency Power Inverter", IMECS, Vol. III, pp1250-1261, March 2010

[3] Nalin Kant Mohanty and Ranganath Muthu, " Microcontroller Based PWM Controlled Four Switch Three Phase Inverter Fed Induction Motor Drive", Serbian Journal of Electrical Engineering, Vol. 7, No. 2, pp 195-204, Nov 2010

[4] N. Senthil Kumar and K Saravanan, " Speed control of PMSM Drive using VSI", IEEE Industrial Electronics Socity, Vol. 1, pp 888-895, Nov 2004.

[5] Pop O, Chindris G and Dulf A, " Using DSP technology for true sine PWM generators for Power Inverters" Electronics Tech: Meeting the Challenges of Electronics Tech. Progress, Vol. 1, pp 141-146, May 2004.

[6] Anawach Sangswang, George Rost and C.O. Nwankpa, "A Modular Simulink-Based Controlled Three-Phase Switch Mode Inverter", IEEE Power Engineering Society Summer Meeting, Vol. 4, pp 2101-2106, 2000.

[7] B. K. Bose " Modern Power Electronics and AC Drives" 1st edition, this edition is published by arrangement with Pearson Education, Inc. And Dorling Kindersley publishing Inc, in South Asia, India 2006.

[8] M.H. Rashid "Power Electronics circuit, Devices and Applications" 3rd edition, Published by Dorling Kindersley licensees of Pearson Education publication south Asia 2007.

[9] Ned Mohan, Undeland and Robins, " Power Electronics Converters, Applications and Design", 3rd Edition, Published John Wiley & Sons, Inc, New Delhi, 2010.

[10] Deodatta Shingare, " Industrial and Power Electronics", 3rd edition, Electrotech Publication, Satara, 2005

[11] Joachim Holtz, "Pulsewidth Modulation for Electronic Power Conversion", Proceeding of IEEE, Vol. 82, No8, pp1194-1214, August 1994.

[12] Zhichao LIU, Pengju KONG, Xuezhi WU and Lipei Huang, " Implementation of DSP- based Three-level Inverter With Dead time Compensations," 4th International Power Electronics and Motion Control Conference, Vol. 2, pp 782-787, Aug 2004.

[13] http://www.microchip.com

[14] http://www.alldatasheet.com