THREE PHASE DC AC INVERTER

MOHD SAFUWAN BIN MASIRON

APRIL 2007

"I hereby declared that I have read through this report and found that it has been complied the partial fulfillment for awarding the degree of Bachelor Engineering (Industrial Power)".

Signature : ....

Name : PROF MADYA DR ZULKIFLIE BIN IBRAHIM

Date : 30 APRIL 2007

THREE PHASE DC AC INVERTER

MOHD SAFUWAN BIN MASIRON

This Report Is Submitted In Partial Fulfillment of Requirements For The Degree of
Bachelor In Electrical Engineering (Industry Power)

Faculty of Electrical Engineering
Universiti Teknikal Malaysia Melaka

30 APRIL 2007

"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references"

Signature :..

Name : MOHD SAFUWAN BIN MASIRON

Date : 30 APRIL 2007

Special dedicated to my beloved family

ABSTRACT.

This project is about three-phase DC-AC inverter. Generally an inverter is used for high-power applications such as induction motor, air-conditioner and ventilation fans. This project is about to control the sequence frequency of an induction motor using the three-phase DC-AC inverter controller. Three-phase inverter can be formed by three single-phases inverters which are connected in parallel. The gating signals of single-phase inverters should be advanced or delayed by 120° with respect to each other to obtain three-phase balanced voltages. If the output voltages of single-phase inverters are not perfectly balanced in magnitudes and phases, the three-phase output voltages are unbalanced. A three-phase output can be obtained from a configuration of six MOSFET and six diodes. The MOSFET are controlled by a controller and a gate drive. The gate drive is a medium that will make sure the MOSFET can be operated smoothly and it will be applied between controller circuit and the MOSFET. Each gate drive will control one MOSFET, so it will need six gate drives in order to make this inverter operate. There are two types of control signals can be applied to the transistors which are 180° conduction and 120° conduction. The preferable method is 180° conduction because it has better utilization of the switches.

ABSTRAK

Projek ini adalah mengenai penyongsang tiga fasa AT ke AU. Secara umumnya, penyongsang tiga fasa digunakan untuk aplikasi yang menggunakan kuasa dan voltan yang tinggi seperti motor aruhan, penghawa dingin dan juga kipas penyejuk. Fokus utama projek ini adalah untuk mengawal turutan frekuensi atau kelajuan motor aruhan dengan menggunakan pengawal penyongsang tiga fasa AT ke AU. Secara teorinya, penyongsang tiga fasa ini boleh dibina dengan menyambungkan tiga penyongsang satu fasa dengan secara selari. Isyarat get perlu diatur supaya mendahului atau membelakangi antara satu sama lain dengan kadar 120^{o} bagi mendapatkan voltan keluaran tiga fasa yang seimbang. Jika voltan keluaran penyongsang satu fasa adalah tidak seimbang atau sempurna dari segi magnitud dan fasa, voltan keluaran tiga fasa yang akan diperolehi adalah tidak seimbang. Voltan keluaran tiga fasa boleh diperolehi melalui konfigurasi enam MOSFET dan enam diod. MOSFET ini semuanya akan dikawal oleh satu pengawal dan pemacu get. Pemacu get ini adalah komponen yang akan memastikan MOSFET akan berfungsi dengan baik dan lancar di mana ia akan dipasang di antara bahagian litar pengawal dan MOSFET. Satu pemacu get akan mengawal satu MOSFET, jadi dalam projek ini sebanyak enam pemacu get yang diperlukan bagi memastikan penyongsang tiga fasa ini dapat berfungsi. Terdapat dua jenis isyarat kawalan yang boleh digunakan untuk mengawal MOSFET tersebut iaitu konduksi 180^{o} dan konduksi 120^{o}. Isyarat kawalan yang lebih sesuai untuk digunakan dalam projek ini adalah konduksi 180^{o} kerana aplikasinya adalah lebih sesuai untuk mengawal suis pada penyongsang.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF APENDICES

CHAPTER I

INTRODUCTION

As of today, most of the market's readily-made inverters, regardless single-phase or three-phase, are all of confidential and covered up. These cover-ups are to ensure that no duplication of same products is being reproduced and also to avoid market competition and rivalry. Inverters are used in many applications in power systems, power electronics and machine drives' fields. Although necessary components needed to build an inverter is relevantly cheap and easily obtained in the electronic devices market, the market sales for a specific package of inverters with a desired load capability and desired outputs such as drives, are too costly

Generally, Inverters are used to transform DC power into three-phase AC power. For inverter operation, power flow can be from the dc side to the ac side or reversible for converter operation. In this project, we will be focusing on the three phase inverter part where dc source (240V) is converted into ac source (240V), which is normally used in motor drives and uninterruptible ac power supplies. The ac output's magnitude and frequency can be controlled.

In inverters, the power semiconductor devices always remain forward-biased due to the dc supply voltage, and therefore, self-controlled forward or asymmetric blocking devices such as IGBTs and power MOSFETs are suitable. A three-phase inverter is a combination of three single-phase inverters along with synchronization so that the three-phase voltages are separated by 120°.

1.1 Objective

The objectives of this project are to design and develop a three phase inverter that able to invert the input voltage of 240V DC to an output voltage 240V AC. In order to design the inverter, a simulation and hardware construction has to be done stage by stage. The simulation is done by using PROTEUS and MULTISM software. The purposes of this project are to design and develop an inverter based on 8-bit microcontroller. Another objective of this project is to analyze, investigate and evaluate inverter performance in terms of efficiency and losses.

1.2 Project Background.

This project is initially proposed by En. Kasrul bin Abdul Karim and then it is continue with the supervision of Prof Madya Dr Zulkiflie. In general, this project is divided into three main blocks. They are controller, gate drive and switches blocks. The controller will produce and control the switching sequence of the inverter bridge. It is mean that this part will control the speed of the motor that we used as load in this project. The second block is gate drive that provides isolation and protection between low voltage side (controller) and the high voltage side (bridge inverter). This part also will control the switch (on/off). For the third block, it is the switching part. This part will allow the current flow through the bridge inverter and then through the load. The main objective of this project is to develop a controller of an inverter that is low in cost and reliable. Besides, the output waveform should be approximately to the 180° conduction.

1.3 Project Scopes

This project is focus on the three phase inverter system. Generally, in industry the inverter system is integrated with a converter in order to provide the dc source. The project utilized the available of DC voltage supply as a DC link voltage to the three-phase voltage source inverter. The aim of this project is to utilize a simple 8-bit controller three-phase voltage source inverter so then the inverter manage to control the load like motor and heater. In addition, the construction must use minimum cost and should be reliable. In this project, the control signal of 180° conduction method will be applied in the control scheme in order to produce AC output voltage. PIC is the controller that will be used in this project. This type of controller can be programmed in order to get the desire output voltage. So, it is more suitable for this project because in this project we need to control the frequency of the inverter by manipulate the switching sequence. The function of this inverter also has to be precise. It should be able to invert an input of 240V DC to an output of 240V AC. Finally, the load that will be used in this project is a motor with a low power rating. (0.2kW).

1.4 Problems Statement

There are many applications required DC-AC conversion especially in industrial. In example, motor control and renewable energy where the DC source will be inverted to AC output to suit the motor rating. The speed of the AC motor can be controlled by controlling the output voltage frequency and amplitude. So, this DC-AC inverter is designed to achieve this task. Today, the cost of the three-phase voltage inverter is still very expensive. So, this project should be able to help because its objective is to develop a low cost inverter that should be reliable.

In the development progress of this project, it is hard to get the suitable component with the desired rating. It is because of out of stock problem occurring in order to get the components. In spite of that, the price of the component also has a major effect to this project. For certain component like PIC16F877, it is expensive to purchase the item at electronic shop. In addition of that, there is a problem to program the PIC because it takes some time to learn about it.

Then, since this project is focusing to the three-phase inverter, there are several of step that should be done before this project can be tested. One of them is to check the connection of each component. That mean, the connection of each component should be correct.

CHAPTER II

LITERATURE REVIEW

To make sure that this project is successful, some research has been done. The purposes of this research are to obtain and gain some information about the project. It is to compare the previous project with this project in order to make some improvement or more exactly is to try the method that has been used for the previous project.

2.1 Three Phase Inverter

In the development process of this project, a lot of research had been made related to this project. Those include the journal from internet and revision book from the library. All those research that has been made, it all helps to get through the project planning and analysis that have been planned earlier. Here, the best method and suitable component with the correct rating of equipment can be selected based on their information.

Three-phase DC AC inverter is commonly used in the industry. There are many application in industry that used this type of conversion (DC to AC) in order to operate. In addition, the types of inverter that is used to make sure all those applications operate also have several of types. Here are several types of three-phase inverter that is used in industry. Figure 2.1 shows a conventional three-phase voltage-source inverter VSI.

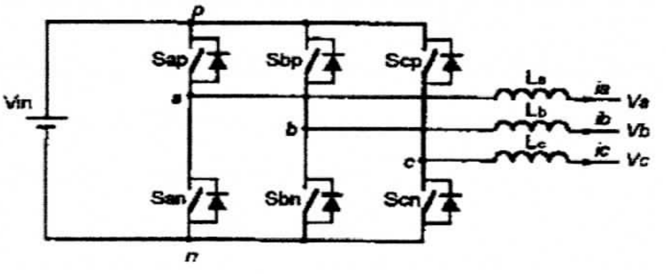

Figure 2.1: Conventional three-phase Voltage-Source Inverter

This type of arrangement may be only suitable for certain conditions. However, at most times, it requires either a three-phase output transformer or separate access to each of the three phases of the load. In real practice, this type of access is generally unavailable since it will then require 12 switches [7].

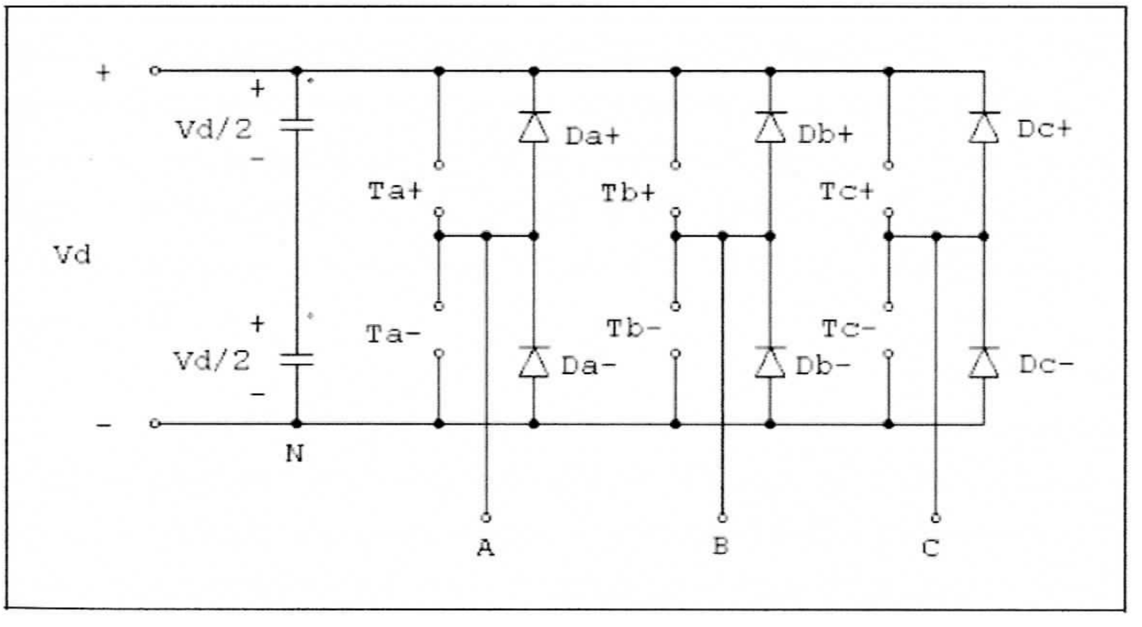

Figure 2.2: Three-phase inverter circuit diagram from PSIM drawing

From Figure 2.2, each inverter leg is similar to the one used for describing the basic *oneleg* inverter. Hence, the output of each leg, lets take the node VAN (with respect to the negative dc bus), depends only on V_d and the switch status; the output voltage is independent of the output load current since one of the two switches in a leg is always on at any instant [7]. The blanking time required in practical circuits by assuming the switches to be ideal is ignored. We can say that the inverter output voltage is independent of the direction of the load current.

2.1.1 Three-Phase Multilevel Inverter.

The multilevel inverter was introduced as a solution to increase the converter operating voltage above the voltage limits of classical semiconductors [1]. The main idea is to increase the quality of the output voltage waveform, without adding any complexity to the power circuit. This approach induces a switching optimization configuration of each power switch [3]. There are several ways to build multilevel inverters. The main topologies are the neutral point clamped inverters, the flying capacitors inverters and the cascades inverters. These topologies are known as asymmetrical or hybrid multilevel inverters, they may be divided in three categories by ascending order of hybridation [1]. In the Three-Phase Multilevel Inverter, smaller distortion in the multilevel inverter AC side waveform can be achieved even at low switching frequencies. This result can be achieved by applying the stepped modulation technique [5].

A multilevel inverter can eliminate the need for the step-up transformer and reduce the harmonics produced by the inverter. Although the multilevel inverter structure was initially introduced as a means of reducing the output waveform harmonic content, it was found that the dc bus voltage could be increased beyond the voltage rating of an individual power device by the use of a voltage clamping network consisting of diodes. A multilevel structure with more than three levels can significantly reduce the harmonic content. By using voltage-clamping techniques, the system KV rating can be extended beyond the limits of an individual device. The intriguing feature of the multilevel inverter structures is their ability to scale up the kilovolt-ampere (kVA)-rating and also to improve the harmonic performance greatly without having to resort to PWM techniques [5] [6] [7].

2.1.2 Three-Phase Voltage Source Inverter.

Three phase DC/AC Voltage Source Inverters (VSI's) schematically shown in Figure 2.3 are now used extensively in motor drives, active filters and unified power flow controllers in power systems and uninterrupted power supplies to generate controllable frequency and AC voltage magnitudes using various pulse-width modulation (PWM) strategies [4].

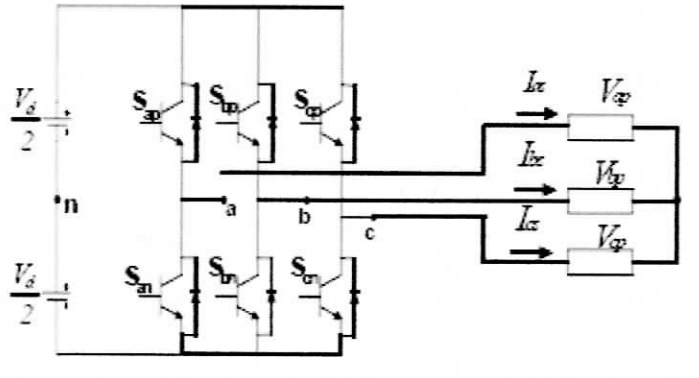

Figure 2.3: Three-phase Voltage Source Inverter

Of the possible PWM methods, the carrier-based PWM is very popular due to its simplicity of implementation, defined harmonic waveform characteristics and low harmonic distortion. Two main implementation techniques exist for PWM are the direct digital method and the sine-triangle intersection scheme. In the traditional sine-triangle intersection PWM (SPWM) technique, three reference modulation signals are compared with a triangular carrier signal and the intersections define the switching instants of the controllable devices. It has been shown that the properties of the three-phase voltage source inverters feeding three-phase star-connected loads can be improved by augmenting the modulation signals with an appropriate zero sequence or non-sinusoidal waveform [4].

The absence of a neutral wire in star-connected three-phase loads provides this degree of freedom in modulation methodology since the voltage between the neutral of the load and the reference of the DC source, can take any value. This zero sequence waveform is used to alter the duty cycle of the inverter switches. Adding the same zero sequence waveform to each of the three reference phase voltages does not change the inverter output line-line voltage per carrier cycle average value; however, if the waveform is properly selected, one can achieve any of the followings like switching losses can be drastically reduced, the waveform quality may be improved, the linear modulation range can be extended, and common mode voltage of motor drives can also be drastically diminished. These potentials have been explored leading to investigations into and determination of various zero sequence waveforms, resulting in a large number of published carrier-based PWM methods [4].

2.1.3 PWM Inverters.

Three-phase PWM inverters are normally used for high power applications. Three single-phase half (or full)-bridge inverters can be connected in parallel as shown in Figure 2.4 to form the configuration of a three-phase inverter. The gating signals of single-phase inverters should be advanced or delayed by 120° with respect to each other to obtain three-phase balanced (fundamental) voltages. The transformer primary windings must be isolated from each other, whereas the secondary windings maybe connected in star or delta.

The transformer secondary is normally connected in delta to eliminate triplen harmonics ($n = 3, 6, 9, \ldots$) appearing on the output voltages and the circuit arrangement is shown in Figure 2.5. This arrangement requires three single-phase transformers, 12 transistors and 12 diodes. If the output voltages of single-phase inverters are not perfectly balanced in magnitudes and phases, the three-phase output voltages are unbalanced [6].

A three-phase output can be obtained from configuration of six transistors and six diodes as shown in Figure 2.6. Two types of control signals can be applied to the transistors, which are 180° conduction or 120° conduction. The 180° conduction has better utilization of the switches and is the preferable method. [6].

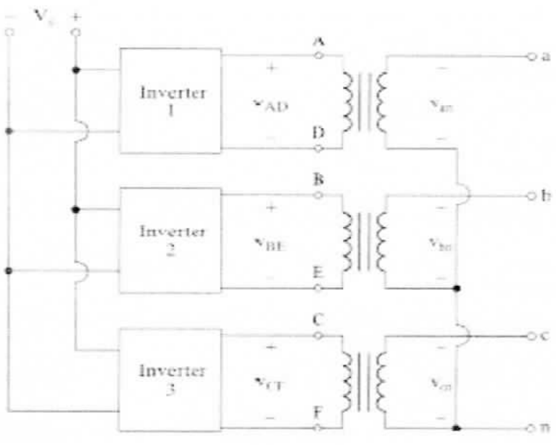

Figure 2.4: Three single-phase half (or full)-bridge inverters

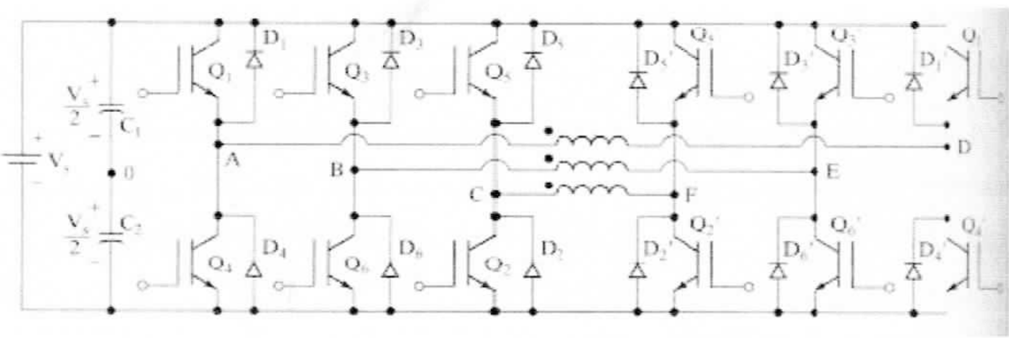

Figure 2.5: Arrangement of three single-phase inverters