THE DESIGNATION OF A DRIVING CIRCUIT USING INSULATED GATE BIPOLAR TRANSISTOR (IGBT) FOR A SINGLE PHASE INVERTER APPLICATION

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MARCH 2005

"I / We admit that I/we have read this literature work through my/our observation which has fulfilled the scope and quality in order to be qualified for the conferment of Bachelor Degree in Electrical Engineering (Industry Power)."

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"I admit that this is done by myself except the conclusion and extracts taken from other sources that I explained each in detail."

Signature : .....Thomas.....

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Date : 9th March 2005

This literature piece is dedicated to my beloved mother and father.

Appreciation

In this section, I would like to take an opportunity to thank my faculty dean, Professor Dr Marizan Sulaiman and my supervisor, En. Azziddin Bin Mohamad Razali, who assist and guide me a lot in executing my project. I would also like to thank all my family members and course mates for giving moral supports.

Abstract

This paper is regarding a project of the designation of a driving circuit using Insulated Gate Bipolar Transistor (IGBT) for a single phase inverter application. Literature reports a lot of papers on resonant switching power converters and their main drawbacks such as the variable driving frequency. In these paper, faster devices like IGBT is used at high frequencies (>20KHz) showing that good performances and efficiency can be easily obtained. As IGBT has high switching frequency (>20kHz), it reduces power consumption and noise levels (sounds above 16kHz in frequency are practically inaudible to the human ear). In this project, microcontroller is used to generate Pulse Width Modulation signal for the inverter. The function of the microcontroller can be assigned by programming it using a programmer via a compiler to enable interface between software and hardware. The use of microcontroller or other application of software can help to save cost by mean that fewer electronic and power components are required. Besides, software based technology allows us to select Line Interactive (VI) technology to provide power from the mains to non-sensitive loads in certain circumstances where voltage tolerance and frequency tolerance can be set as required via programming. As a result, the output expected from the inverter is of alternating current square wave form.

Abstrak

Kertas kerja ini berkenaan dengan projek merekabentuk litar pemacu yang menggunakan *"Insulated Gate Bipolar Transistor"* (IGBT) untuk penukar DC-AC satu fasa. Banyak kertas kerja yang berkaitan dengan penukar kuasa secara pensuisan resonan dan penyuapbalik utama seperti pemacu frekuensi bolehubah. Dalam kertas kerja ini, peranti yang mempunyai kelajuan yang lebih tinggi digunakan pada frekuensi (>20KHz), menunjukkan hasil keluaran yang baik dan kecekapan yang lebih tinggi boleh diperolehi. Disebabkan IGBT mempunyai kadar pensuisan yang tinggi (>20KHz), ini akan mengurangkan penggunaan kuasa dan gangguan (bunyi pada 16KHz ke atas tidak kedengaran oleh manusia biasa). Pengawal mikro digunakan di dalam projek ini untuk menjanakan isyarat *Pulse Width Modulation* bagi kegunaan penukar DC-AC. Fungsi-fungsi atau kerja-kerja boleh diarahkan kepada pengawal mikro dengan memprogramkan chip pengawal mikro dengan menggunakan *programmer* dan kompiler yang membolehkan hubungan antara muka di antara perisian dan perkakasan. Penggunaan pengawal mikro atau aplikasi perisian yang lain dapat membantu menjimatkan kos disebabkan kurang peranti elektronik diperlukan. Selain itu, teknologi berasaskan perisian membolehkan kita memilih teknologi *Line Interactive (VI)* untuk membekalkan kuasa daripada litar utama ke beban kurang peka dalam sesetengah keadaan di mana ralat voltan dan ralat frekuensi boleh dilaraskan mengikut keperluan melalui *programming*. Secara kesimpulan, keluaran daripada penukar DC-AC yang direkabentuk dalam projek ini adalah berbentuk AC square wave.

Keywords

User-Friendly Software-based IGBT Inverter

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INTRODUCTION

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INTRODUCTION

1.1 Objectives

The objective of the Final Semester Project (PSM) project is to understand the characteristics and functions of the Insulated Gate Bipolar Transistor (IGBT) as a driving circuit. At the same time, I can learn how to manage cost, schedule (time) and resources when handling a project. Before a project is started, analysis on the IGBT inverter circuit and its functions has to be done. Besides, I have to learn to match or interface the software or microcontroller with the IGBT inverter. In this project, the use of user-friendly and environmentally friendly devices is emphasized. Furthermore, more research is done on the advantages or disadvantages of IGBT applied to an inverter.

1.2 Problem Statements

Before I started my project, I've found out the problem statements regarding my project. These statements are required to allow me to overcome the problems through my project as listed below: -

1. The designation of an inverter may use IGBT as a switch be complicated for existing inverter available in market.
2. The selection of a suitable software or microprocessor controller may help to save cost as compare to the existing IGBT inverter which required Pulse Width Modulation circuit to serve as switching device and this may lead to high expenses.
3. The existing IGBT inverter may cost more for driving AC motor using Dc sources, as they are more complicated type. So, the designation of user-friendly software based IGBT inverter may allow people of all range of age to use them in future when this inverter is applied to solar panel as they are more economic.
4. The depletion of energy sources and environmental issue is the main problems lead to the designation of the IGBT inverter in this project.
5. The existing IGBT inverters may be heavier, importable and complicated which may lead to difficulties when repairing them. So, the idea of building a simple IGBT inverter may help people to reduce difficulties mentioned above.

1.3 Project Methodology

The project is conducted base on the methodology listed below:-

1. Analyze and do research on Insulated Gate Bipolar Transistor (IGBT) to obtain the characteristics and the performance of this device.
2. Analyze and do research on inverter to understand the basic circuit and its function.
3. Analyze and do research on driving circuit for inverter.
4. Choose the right software or microprocessor control to interface the IGBT inverter and understand the functions and the programming language of the software.
5. Create a new program that allows us to program the input of the inverter via encoder to get the output required from the inverter if possible.
6. If there is an option, used the applicable software kit to control the output of the inverter.
7. Choose the right driver circuit to match the software or microprocessor with the IGBT inverter.
8. Design a complete block diagram of the IGBT inverter.
9. Design a complete circuit diagram of the IGBT inverter via software such as P-Spice, Multisim, Protel. Proteus Lite 6.0, MPLAB C17, MPLAB IDE, MPLAB ASM and etc.
10. Transfer the designation of the IGBT inverter circuit via Protel on to the PCB.
11. Etching process is made to get a complete circuit on the PCB.
12. Fabrication, installation and soldering process is made on to the PCB.
13. The complete circuit of the IGBT inverter is tested manually to get the output required.
14. If there is no problem occurs, proceed to the designation of the software or the microprocessor control to interface with the IGBT inverter.
15. The complete software or microprocessor control is tested on the IGBT inverter and the output of the IGBT inverter is measured or evaluated by using oscilloscope.
16. If there is no problem occurs, the modification of the IGBT inverter can be made to improve the present result.
17. Finally, start to do a complete set of report to be submitted to the supervisor in-charged.

CHAPTER 2 :

BASIC OPERATION

CHAPTER 2

BASIC OPERATION

Basic block diagram consists of the user interface, switching pattern generation unit, driver circuit, power supply and power circuit and the output unit are shown in Figure 2.1. The user can select the mode of operation out of square wave, regular sample and harmonic elimination. In square wave and regular sample modes the user can input the output voltages and the frequency.

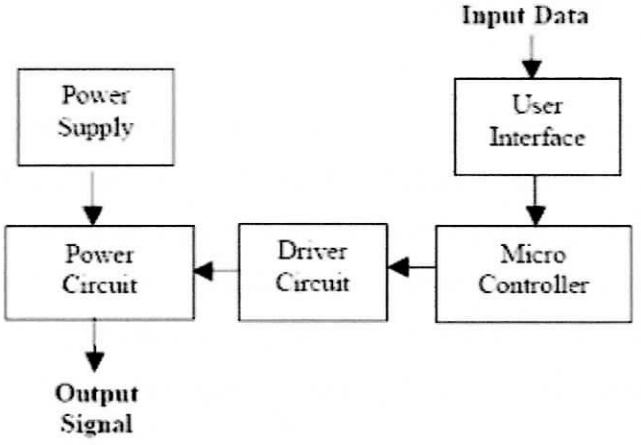

Figure 2.1: Basic Block Diagram of the s/w controlled inverter

In harmonic elimination mode, the users can eliminate the harmonics from the output while setting the magnitude of the fundamental voltage. In order to keep the convenience of the program, selection of harmonics to be eliminated and the voltage magnitudes were restricted to limited number of combinations. According to the combination input by the user, appropriate switching time is calculated within the software program.

2.1 Insulated Gate Bipolar Transistor (IGBT)

From Figure 2.1, user programmed the microcontroller according to the setting desired. The microcontroller serve as the driver circuit to do switching on the power circuit. For DC-AC converter, the power circuit normally consists of a H-bridge circuit serves as a DC-AC converter and some protection devices. Besides, the power circuit also serves as an isolator to protect devices from input power supply. Finally, when the power supply or a DC supply is connected to the power circuit, the power circuit will convert the DC source to AC output. For more understanding, further details will be explained in the next chapter.

The Insulated Bipolar Gate Transistor (IGBT) is widely used nowadays as its performance satisfied almost every critical requirement in power electronic industrial. However, the most accurate answer to its best performance is that IGBT has high voltage rating up to 3.3 kV but required only a low voltage or low power control signals to operate from 2V to 3V. Generally, IGBT is chosen as switching device in many switching circuits as compared to other switching devices as it is controllable and has a high voltage ratings. (Table 2.1)

Table 2.1: Switches Comparison

	Thyristor	BJT	FET	GTO	IGBT
Availability	Early 60s	Late 70s	Early 80s	Mid 80s	Late 80s
State Of Technology	Mature	Mature	Mature/ Improve	Mature	Rapid Improve
Voltage Ratings	5 kV	1kV	500V	5kV	3.3kV
Current Ratings	4kA	400A	200A	5kA	1.2kA
Switch Frequency	N/A	5kHz	1MHz	2kHz	100kHz
On-State Voltage	2V	1-2V	I*Rds (ON)	2-3V	2-3V
Drive Circuit	Simple	Difficult	Very Simple	Very Difficult	Very Simple
Comments	Cannot turn off using gate signals	Phasing out in new product	Good performance in high frequency	King in very high power	Best overall performance

Insulated Gate Bipolar Transistor (IGBT) has a combination of BJT and MOSFET characteristics. Compromises include:

1. Gate behavior similar to MOSFET where it is easy to turn 'ON' and 'OFF'.
2. Low losses like BJT due to low on-state Collector-Emitter voltage (2-3V)