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

Signature : .....

Supervisor's name : AZZIDDIN B MOHD RAZALI

Date : 17/11/05

DEVELOPMENT OF UNINTERRUPTIBLE POWER SUPPLY (UPS)

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

Signature : .....

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

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Thank you all.

ABSTRACT

Power from a wall socket may suffer abnormalities such as blackout, surge and noise. In worst case, the abnormalities condition of power supply can course loss of data in computer system or damage to electronic equipment. It is the function of Uninterruptible Power Supplies (UPS) to act as a buffer and provide clean, reliable power to valuable electronic equipment. The basic concept of UPS is to storage energy during normal operation (through battery charging) and release energy (through DC to AC conversion) during a power failure. Normally, UPS systems consist a combination of complex circuits such as battery charger, rectifier, power factor correction, battery boost, free running chopper, input power protection and inverter. This project will focus on developing single phase PWM inverter circuits. The inverter circuits consist a gate drive circuits and PWM circuit generator.

ABSTRAK

Kuasa daripada soket alur keluar akan terdedah kepada gangguan seperti terputus bekalan, pusuan dan hingar. Di dalam kes yang kritikal, gangguan bekalan kuasa boleh mengakibatkan kehilangan data dalam sistem komputer atau merosakan peralatan elektronik. Fungsi Bekalan Kuasa Tidak Terganggu (BKT) adalah bertindak sebagai penampan dan menghasilkan bekalan kuasa yang boleh dipercayai dan bersih kepada peralatan elektronik yang bernilai. Konsep BKT ialah menyimpan tenaga semasa operasi normal (melalui pengecas bateri) dan akan membebaskan tenaga (melalui penukaran AT kepada AU) semasa berlaku kegagalan kuasa. Kebiasaannya sistem BKT terdiri daripada kombinasi litar komplek seperti, pengecas bateri, penerus, pembetulan faktor kuasa, pemotong bebas, pelindung kuasa masukan dan penyonsang. Projek ini memfokuskan kepada pembangunan litar penyonsang PWM satu fasa. Litar penyonsang mengandungi litar pengawal pensuisan dan litar penjana PWM.

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LIST OF ABBREVIATIONS

AC	Alternating Current
ADC	Analogue to digital converter
BJT	Bipolar Junction Transistors
CPU	Central Processor Unit
DC	Direct Current
IGBT	Insulated Gate Bipolar Transistor
SCR	Silicon Control Rectifier
MOSFET	Metal Oxide Silicon Field Effect Transistor
PWM	Pulse Width Modulation
THD	Total Harmonic Distortion
APOD	Alternative Phase Opposition Disposition
POD	Phase Opposition Disposition
PD	Phase Disposition
VVI	Variable Voltage Inverter
CSI	Current Source Input
DCMI	Diode-Clamp Multi Level Inverter
FCMI	Flying Capacitor Multilevel Inverter
CISDCS	Cascaded Inverter Separated DC Source

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CHAPTER 1

GENERAL INTRODUCTION

1.1 Background

The need for reliability in power supplies has obviously been in use for many years. With the increased use of electrical power and our dependence on an electrical supply, reliability has become an increasing concern. Initially the market for uninterruptible power supply equipments was of low demand and was led by users who sought clean and secure electricity supplies from their various engineering groups [1].

The first uninterruptible power supplies equipments (then known as no-break power supplies) was of rotary design, and so far this appeared during the 9050s. The market at that time was related to defence equipment such as communications and radar. The earlier sets were probably developed for military purpose during the 1939-45 war and the development continued thereafter to achieve greater reliability, increased in efficiency and reduction of maintenance [1].

1.2 Definition

A UPS system is a circuit which ensures a continuous power supply to the load respective of the outages, spike, brownouts, or other disturbances from the

normal incoming mains supply. It is achieved by using solid-state circuitry which employs a battery or possibly kinetic energy as the alternative energy source [2].

1.3 Basic Design

The UPS is a system that consists of a combination of a complex circuit. A typical basic system consist the rectifier circuit, inverter circuit and static switch. Under normal operation power to the load is fed through the circuit, in other words, rectifier/battery charger, and inverter load. On unavailability of the mains supply for any reason then the load is fed from the battery/inverter [2].

1.4 Inverter

Inverter is a part of the UPS system; it is the technology for converting DC source from battery to AC sine wave for supply to the load. Inverter system has advanced over the years and is the major area contributing to advances in system reliability and efficiency. The basic design is a simple bridge switching circuit. Clearly the switches utilized a variety of solid-state switches and as such devices increased in performance so the inverter developed [2]. The earlier circuit resulted in square wave output clearly requiring a large filter and has a poor dynamic performance. With developments in circuitry and availability of switching devices step wave systems were developed with an increased in system dynamic performance.

The inverter circuit, consist of the output filter and the feedback loop. The function of the filter and feedback loop is to produce a pure and clean sine wave output at 240V 50 Hz.

CHAPTER 2

LITERATURE REVIEW

2.1 UPS function

It is the function of an Uninterruptible Power Supply (UPS) to act as a buffer and provide clean, reliable power to vulnerable electronic equipment. The basic concept of a UPS is to store energy during normal operation (through battery charging) and release energy (through DC to AC conversions) during a power failure. UPS systems are traditionally designed using analogue components. Today these systems can integrate microcontroller with AC sine wave generation, offering many benefits such as [3]:

a) High quality sine wave output.
b) Flexibility where core control features and operation can be changed with software modification only.
c) Transportability of Design.
d) Variable loop response.
e) Digital filtering.
f) Parts and complexity reduction peripheral integration.
g) Ease of interfacing.
h) Testability
i) Time to market

2.2 UPS circuit

UPS system which consists of a combination of complex circuits such as:

a) Battery charger
b) Rectifier
c) Power factor correction
d) Battery boost
e) Free running chopper
f) Input power protection
g) Inverter

2.3 Latest developments of UPS equipment

Systems are developed to achieving higher efficiency, less space utilization, ease of installation, and user-friendly interfaces. Instead of being presented with its multiplicity of switches and analogue meters, the operator sees a few push buttons and indicator lamps. Measurements are displayed digitally, and the run-up procedure is probably automatic. Operation is becoming simpler, and the equipment is therefore becoming more reliable [1].

Now that scaled recommendation lead-acid batteries are the normal choice, the opportunity is frequently taken to install the UPS equipment in the computer room, rather than in a distance plant room. Some computer manufacturers tend to incorporate the UPS equipment into their own enclosures so that it becomes, in effect, a part of the Centre Processing Unit (CPU) [1].

Servicing and maintenance maybe carried out by undertaking a diagnostic check using a small built –in or portable microprocessor. In most cases of failure, the service technician merely has to replace printed circuit boards [1].

2.4 Inverter design

Early design used power transistor and thyristors, and nowadays a device known as an insulated gate bipolar transistor (IGBT) is in common used. This device is the result of the combination of the properties of the bipolar transistor and the MOSFET.

The bipolar transistor has advantages of high current and high voltage characteristic and the MOSFET of speed and single gate drive requirements. The resultant device IGBT now possesses high switching characteristics and good voltage control.

The IGBT module provides a high-speed switching system using PWM waveform. Switching speed vary between manufacturer usually between 3 to 30 KHz. The choice of switching speed is governed to a great extent by two side effects. The higher the switching speed tends to evolve high EMC disturbances. Also high switching speeds tend to increased losses and heat output [2].

There is no doubt that IGBT designs have had a significant effect on the output filter size, thus reducing the overall size of the module. Dynamic performance has improved no load-to-full load and its converse, being in the order of +/-5 percent and returning to 1 percent within 40ms. Additionally the circuit has improved the ability to cope with crest factors, a typical UPS now being able to support a crest factor 3:1 at full load [2].

2.5 Inverter applications

Inverters are circuits specifically design to change DC voltage to AC voltage. As we know, system such as variable-frequency motor drive and uninterruptible power supplies (UPS) convert AC power to DC and the convert the DC back to AC.

This may sound like a strange way to provide an AC output voltage if AC voltage is the original supply, but in the case in variable-frequency motor drive, the frequency of supply voltage will be 50 or 60 Hz and the output AC need the possibility of frequencies between 1 and 120 Hz. In the case of the UPS, the AC supply voltage need to be change to DC so it can be store in a battery for latter used if the power supply is interrupted. Since the voltage is changed to DC and is store in a battery, its must change back to AC to be usable. In the UPS the output frequency will be a constant 60 Hz [4].

2.6 Type of an inverter

Single-phase inverter is the simplest inverter to understand, which takes a DC input voltage and converts it to single-phase AC voltage. The main components of the inverter can either be four silicone controlled rectifier (SCR) or another four switching device such as; transistor, IGBT and MOSFET. Figure 2.1 shows a typical inverter circuit that uses four transistors. Originally called a DC-link converter, now it is simply called an inverter [4].

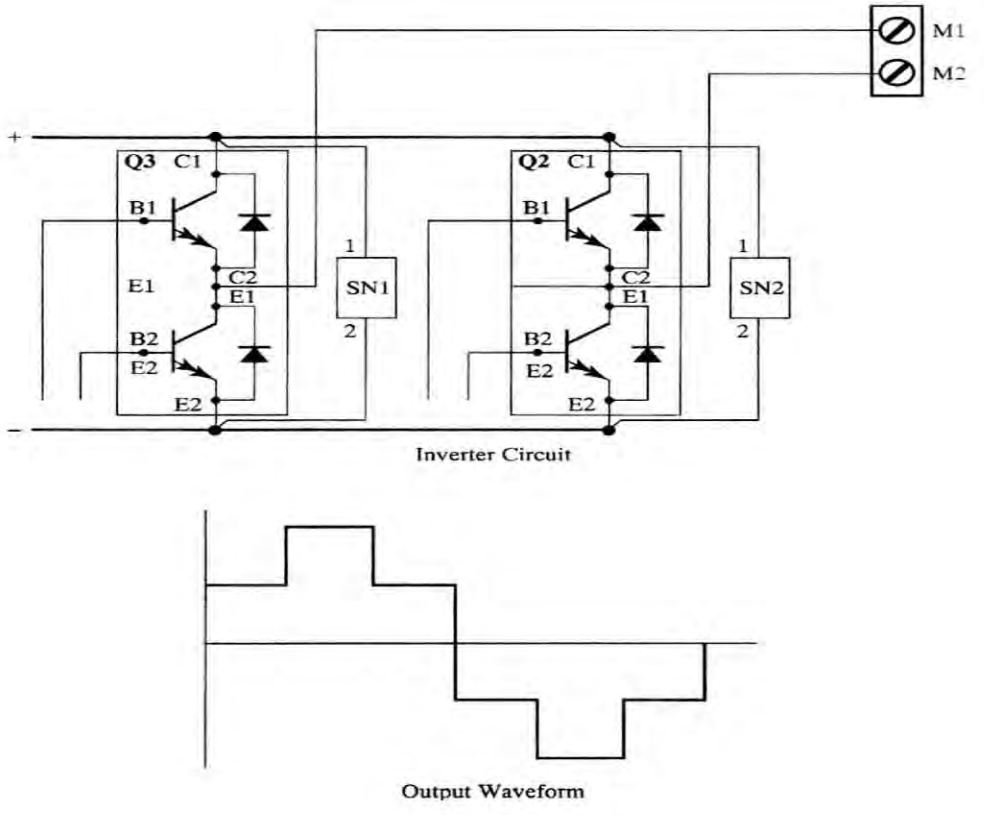

Figure 2.1: Electronic diagram of a transistor inverter with the output waveforms for the AC voltage

The diagram in Figure 2.2 shows four SCRs used in the inverter circuits. In this circuit SCR1 and SCR4 are fired into conduction at the same time to provide the positive part of the AC waveform and SCR2 and SCR3 are fired into conduction at the same time to the negative part of the AC waveform. The waveform for AC output voltage is shown in this figure, and you can see that it is an AC square wave [4].

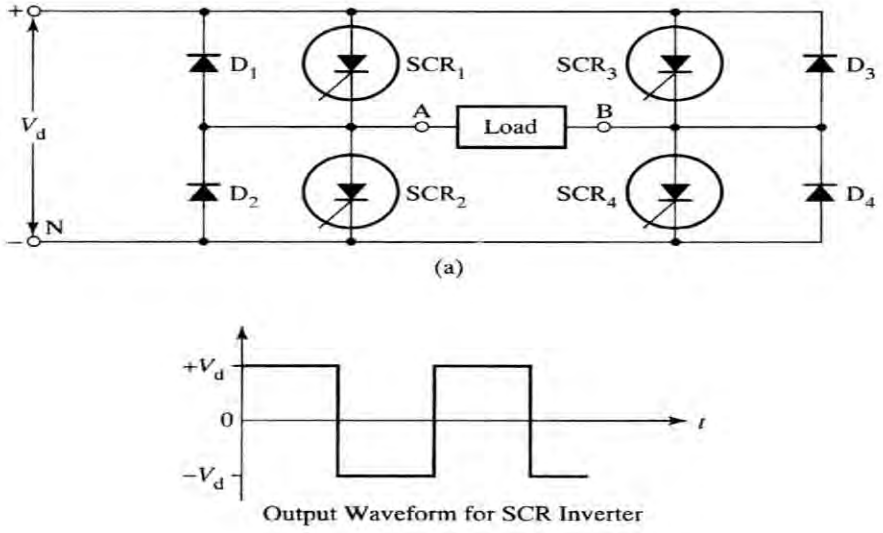

Figure 2.2: Electrical diagram of a typical inverter circuit that uses four silicon-controlled rectifiers (SCRs) and the output waveform for SCR inverter

Three-phase inverters are much more efficient for industrial applications where large amounts of voltage and current are required. The basic circuit and theory of operation are similar to the single-phase inverter. Figure 2.3 shows the diagram a three-phase inverter with three pairs of transistors. Each pairs of transistor operates like the pairs in the single-phase six step inverter. This means the transistor of each pair that is connected to the positive DC bus voltage will conduct to produce the positive half-cycle and the transistor that is connected to the negative DC bus voltage will conduct to produce the negative half-cycle [4].

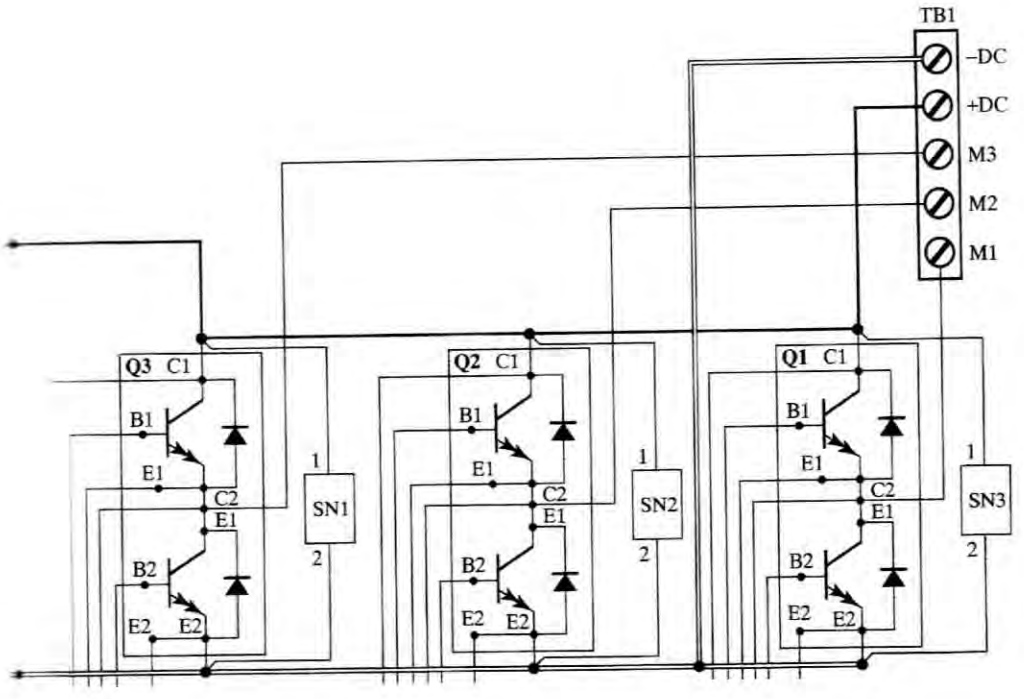

Figure 2.3: Electrical diagram of three-phase inverter that uses six transistors

2.7 Types of inverters operation

A variable-voltage inverter (VVI) is basically a six step, single-phase or three-phase inverter. The need to vary the amount of voltage to the load became necessary when this inverter circuit were used in AC variable-frequency motor drives and welding circuits. Originally this circuit provides a limited voltage and limited variable frequency adjustment because oscillator will used to control the biasing circuits. Also many of the early VVI inverters used thyristor technology, which meant that group of SCR, were used with chopper circuit to create the six-step waveform. After microprocessors became inexpensive and widely used, they were used to control the biasing circuit for transistor-type inverter to give this six-step inverter circuit the ability to adjust the amount of voltage and the frequency through a much wider range [4].