INVERTER CIRCUIT FOR UNINTERRUPTIBLE POWER SUPPLY (UPS)

NUR KHAIRUL ZHAFRAN B. MUHD NUR AKMAR

7 MEI 2007

"Saya akui bahawa saya telah membaca karya ini dan pada pandangan saya karya ini adalah memadai dari skop dan kualiti untuk tujuan penganugerahan Ijazah Sarjana Muda Kejuruteraan Elektrik (Elektronik Kuasa dan Pemacu)."

Tandatangan : ....

Nama Penyelia : ENCIK ZAIHASRAF BIN ZAKARIA

Tarikh : 7 Mei 2007

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Mei 2007

"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya jelaskan sumbernya."

Tandatangan : ....

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Tarikh : 7 MEI 2007

Untuk ayah dan ibu tersayang

ABSTRACT

This project is to develop an inverter circuit using the electronic components. This project combines the knowledge of electrical and electronic. The objective of this project is to develop an inverter circuit which will convert the direct current voltage from the battery to alternate current voltage. The direct current voltage will be break into pulses through an Integrated Circuit of NE 555 before it flows through the switching components to obtain the alternate current voltage. The output voltage 12V will be increase to 240V using a step-up transformer to supply the electrical equipments. The inverter circuit will be connected to rectifier/battery charger circuit to produce a unit of Uninterruptible Power Supply. The components that will be use are low cost and easy to obtain.

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This project is to develop an inverter circuit using the electronic components. This project combines the knowledge of electrical and electronic. The objective of this project is to develop an inverter circuit which will convert the direct current voltage from the battery to alternate current voltage. The direct current voltage will be break into pulses through an Integrated Circuit of NE 555 before it flows through the switching components to obtain the alternate current voltage. The output voltage 12V will be increase to 240V using a step-up transformer to supply the electrical equipments. The inverter circuit will be connected to rectifier/battery charger circuit to produce a unit of Uninterruptible Power Supply. The components that will be use are low cost and easy to obtain.

ABSTRAK

Projek ini bertujuan untuk membangunkan sebuah litar penyongsang dengan menggunakan komponen elektronik. Projek ini menggabungkan kemahiran dan pengetahuan tentang elektrik dan elektronik. Objektif projek ini adalah untuk membangunkan litar penyongsang yang boleh menukarkan bekalan voltan arus terus dari bekalan bateri kepada voltan arus ulang-alik . Voltan arus terus akan dipecahkan kepada bentuk nadi melalui Litar Bersepadu NE 555 sebelum melalui komponen pensuisan yang akan mendapatkan keluaran voltan arus ulang-alik. Voltan keluaran 12V juga akan ditingkatkan kepada 240V dengan menggunakan sebuah pengubah penaik bagi membekalkan kuasa kepada peralatan elektrik. Litar ini akan digabungkan dengan sebuah litar penerus/pengecas bateri bagi membentuk sebuah unit Pembekal kuasa Tanpa Gangguan. Komponen yang digunakan di dalam pembangunan litar ini adalah berkos rendah dan mudah diperoleh.

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CHAPTER I

INTRODUCTION

1.0 Introduction

Electric has become one of the most important things in our life. As the world is focusing on the development of science and technology, we should not forget that most of our technology today is supplied by electric. However, when the power line is down, the electrical components will not functioning and this will bring us problems. One of the most critical problem is the unsaved data of a computer might lost and this will cost us time, money and energy. Therefore a backup power supply is needed where a battery is the solution. However many electrical equipments use ac voltage instead of the dc voltage supplied by the battery. Therefore, an inverter is designed to convert the dc voltage to ac voltage.

1.1 Problem Analysis

The failure of main power supply or the power line causes interruption in daily routines especially in this modern era where electrical equipments are widely used. This problem is worst when it comes to the use of a computer, where unsaved data will lose when the power line is down. This could affect the performance of the computer, instead of causing losses to the company and the personnel involved. Lost of unsaved data means waste of energy, time and money invested. It will be good if there is equipment which can give a little time for the user to save the data after the power supply is disconnected. Battery is an alternative but many equipments use ac voltages.

Therefore, an inverter is designed to overcome this problem. The inverter circuit will convert dc voltage from the battery to ac voltage which can be used by most of electrical equipments. The combination of the battery and the inverter circuit will become a unit of Uninterruptible Power Supply.

The Uninterruptible Power Supply consists of two main circuits:

1. Battery charger / rectifier circuit
2. Switching / inverter circuit

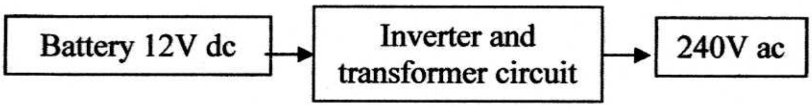

Figure 1.1: Inverter block diagram

The relationships between circuits in an uninterruptible power supply are shown below:

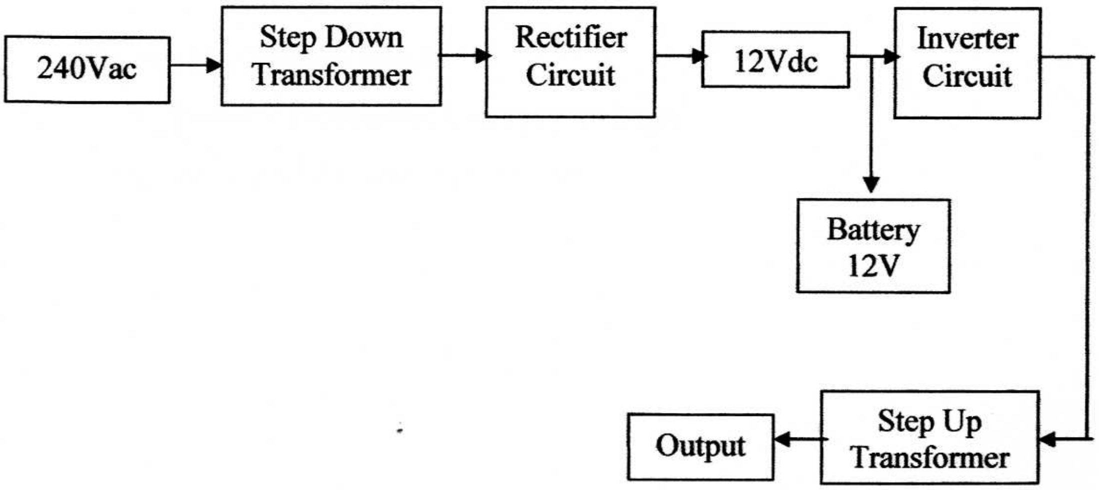

Figure 1.2: Relationship between circuits

The switching circuit will be powered by the 12Vdc battery. This switching circuit will use NE555 to turn on and off the transistors to create an ac voltage. The ac voltage will then be increase to 240Vac by a step up transformer. The output voltage of the inverter will then supply the electrical equipments during power failure.

1.2 Project Objectives

The objectives of this project are:

- To develop an inverter circuit which can convert dc voltage to ac voltage
- To increase the output voltage to 240V ac from 12V by using a transformer
- To combine the inverter and transformer to be use in a unit of Uninterruptible Power Supply

1.3 Project Scope

To realize this project, a few scopes were determined. The projects scopes are very important to make sure that the project is on the right rails. The scopes of the this project are

- Develop the inverter circuit
- Using the right transformer to step up voltages
- Make analysis of the output parameters

CHAPTER II

LITERATURE REVIEW

2.0 Introduction

This chapter will concentrate on the power line disturbances, various types of switching components and the components involved in the implementation of the inverter circuit. The disturbances in the power line represent the problems that need to be solved by the creating of the UPS. Another problem is developing an inverter circuit to produce an ac voltage to the electrical equipments. The switching components are discussed so the selection of the switching component will be much easier and accurate.

2.1 Power Line Disturbances

Ideally, the voltage supplied by the utility system should be a perfect sine wave without any harmonics at its nominal frequency of 60Hz and its nominal magnitude. For a three phase system, the voltages should form a balanced set, with each phase displaced by 120° with respect to the others.

2.1.1 Types of Disturbances

In practice, however, voltages can significantly depart from the ideal condition due to the power line disturbances listed below:

1. **Overvoltage.** The voltage magnitude is substantially higher than its nominal value for a sustained period of a few cycles.

2. **Undervoltage (brownout).** The voltage is substantially lower than its nominal value for a few cycles.

3. **Outage (blackout).** The utility system voltage collapses for a few cycles or more.

4. **Voltage spikes.** These are superimposed on the normal 60Hz waveforms and occur occasionally (not on a repetitive basis). These can be either of a line-mode (differential-mode) or a common-mode type.

5. **Chopped voltage waveform.** This refers to a repetitive chopping of the voltage waveform and the associated ringing, as shown in the Figure 2.1a.

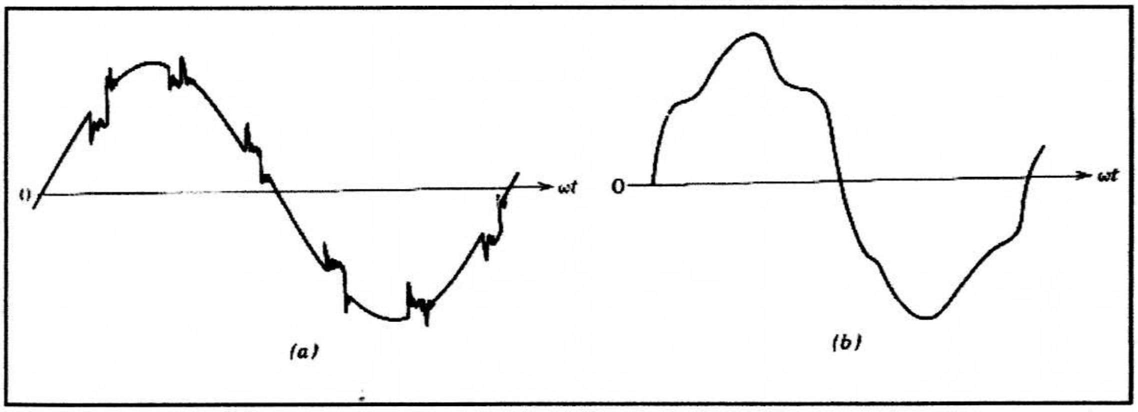

Figure 2.1: Possible distortions in input voltage: a) Chopped voltage waveform; b) Distorted voltage waveform due to harmonics

6. **Harmonics.** A distorted voltage waveform, as shown in Figure 2.1b, contains harmonic voltage components as harmonic frequencies (usually low-order multiples of the line frequency). These harmonics exist on a sustained basis.

7. **Electromagnetic interference.** This refers to high-frequency noise, which may be conducted on the power line or radiated from its source.

2.2 Inverter

An inverter is a circuit for converting direct current (dc) to alternating current (ac). Inverters are used in a wide range of applications, from small switched power supplies for a computer to large industrial applications to transport bulk power. In one simple inverter circuit, dc power is connected to a transformer through the center tap of the primary winding. A switch is rapidly switched back and forth to allow current to flow back to the dc source following two alternate paths through one end of the primary winding and then the other. The alternation of the direction of current in the primary winding of the transformer produces alternating current (ac) in the secondary circuit.

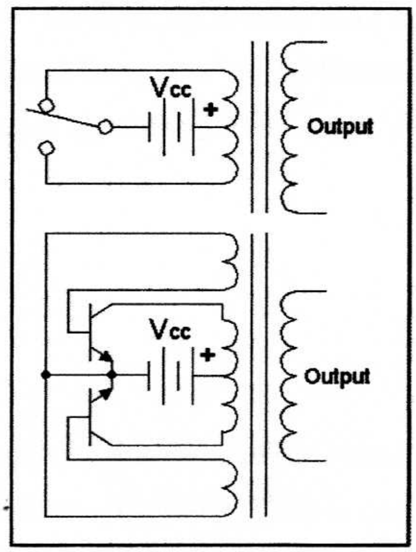

Figure 2.2: Simple inverter circuit

The electromechanical version of the switching device includes two stationary contacts and a spring supported moving contact. The spring holds the movable contact against one of the stationary contacts and an electromagnet pulls the movable contact to the opposite stationary contact. The current in the electromagnet is interrupted by the action of the switch so that the switch continually switches rapidly back and forth. This type of electromechanical inverter switch, called a vibrator or buzzer, was once used in vacuum tubes automobile radios. A similar mechanism has been used in door bells, buzzers and tattoo guns.

These electromechanical inverters explain the source of the term "inverter". Early ac to dc converters combined a synchronous ac motor with a commutator so that the commutator reversed its connections to the ac line exactly twice per cycle. This results in ac-in, dc-out. If we invert the connections, to a converter by putting dc in and get ac out, we will get an inverter. Hence an inverter is an inverted converter. As they became available, transistors and various other types of semiconductor switches have been incorporated into inverter circuit designs.

The filtered output of the inverter is normally specified to contain very little harmonic distortion, even though most loads are highly nonlinear and, inject larger harmonic currents into the UPS. Therefore, the inverter must allow almost instantaneous control over its output ac waveform. The output voltage harmonic content is specified by means of term called total harmonic distortion (THD), which was defined as

$$\%THD = 10 \times \frac{(\sum_{n=2}^{\infty} V_n^2)^{1/2}}{V_1} \tag{2.1}$$

where V_1 is the fundamental-frequency rms value of the output voltage and V_n is the rms magnitude at the harmonic of order n. Typically, THD is specified to be less than 5%; each harmonic voltage as a ratio of V_1 is specified to be less than 3%.

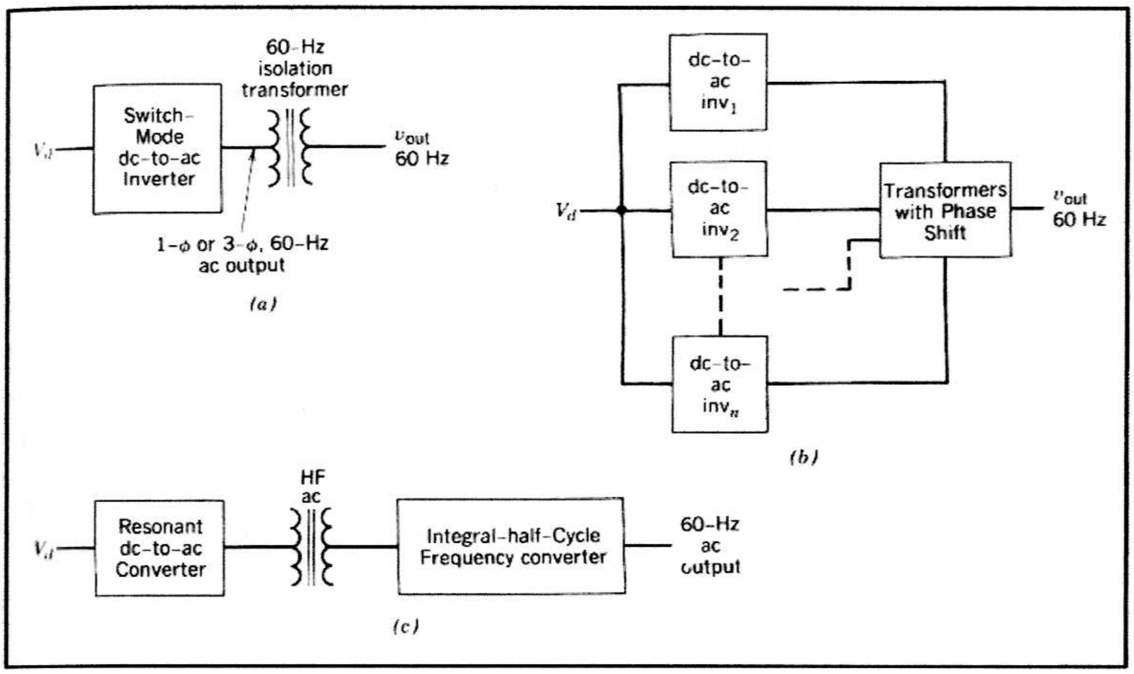

Figure 2.3: Various inverter arrangements

Modern UPSs normally use the PWM dc-to-ac inverters, with either a single-phase or three phase ac output. A schematic is shown in Figure 2.3a, where an isolation transformer is generally used at the output. Large UPSs may employ a scheme where the outputs of two or more such inverters are paralleled through transformers with phase shift, as shown schematically in Figure 2.3b. This allows the inverters to operate at a relatively lower switching frequency, utilizing either a low frequency PWM, selective harmonic cancellation, or a square-wave switching scheme. As shown schematically in Figure 2.3c, it is also possible to use resonant converters concepts.

It is important to minimize the harmonics content of the inverter output. This decreases the filter size, which not only results in cost savings but also results in an improved dynamic response of the UPS as the load changes. A feedback control is shown in Figure 2.4, where the actual output waveform is compared with the sinusoidal reference. The error is used to modify the inverter switching. A control loop with a fast response is needed for a good dynamic performance.