DEVELOPMENT OF TRAINER KIT USING A CONTROLLED RECTIFIER

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This Project Report Is Submitted In Partial Fulfillment of Requirements for the Degree of Bachelor in Electrical Engineering (Industry Power)

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May 2006

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the Degree of Bachelor in Electrical Engineering (Industry Power)."

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Date : ......4/5/06......................

"I declare that thesis is the result of my own research except as cited in the references."

Signature : ……………………..
Name : ……………………..
Date : ……………………..

This dedicated to my beloved father and mother, my twin, my youngest sister, my eldest and younger brother.

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Alhamdulillahi Rabbil 'Alamin'

ABSTRACT

The development of trainer kit as a teaching aid for Power Electronic Lab is necessary to help the student understand the Power Electronics subject easily and deeply. This project use Silicon Controlled Rectifier (SCR) as a controlled rectifier. The SCR is one of a family of special solid – state switching devices which it is, conducts only one-half of the input waves. Although it can be used as a simple electronically controlled switch, it has other more exciting uses. It can be turned on at any time during the positive portion of the sine wave source. Because of this characteristic it is an excellent device to use for power control. UJT in this circuit acts as gate drive to "on" the SCR. The trainer kit will connect to an oscilloscope to show the output from the circuit. Simulation using ORCAD PSPICE will help to have the right wave or appropriate output.

ABSTRAK

Penghasilan alat bantuan mengajar adalah perlu bagi membantu memudahkan pelajar memahami subjek elektronik kuasa dengan mudah dan mendalam. Projek ini menggunakan Penerus Kawalan Silikon atau SCR sebagai kawalan penerus. SCR adalah salah satu daripada kumpulan alat suis padu istimewa di mana ia hanya akan beroperasi dalam satu kitaran gelombang masukan. Walaupun SCR boleh digunakan sebagai suis kawalan secara elektronik yang ringkas, ia juga mempunyai kegunaan – kegunaan menarik yang lain. Salah satu daripadanya ialah SCR boleh berada dalam keadaan operasi pada bila – bila masa keadaan positif dalam masukan bekalan gelombang sinus. Oleh yang demikian ia mempunyai ciri – ciri yang sempurna untuk kegunaan kawalan kuasa. UJT dalam litar projek pula digunakan sebagai penggerak kepada SCR iaitu penggerak untuk menghidupkan operasi SCR. Alat bantuan mengajar ini akan disambungkan ke osiloskop untuk mendapatkan keluaran gelombang yang diukur dari litar. Simulasi menggunakan ORCAD PSPICE akan membantu untuk mendapatkanke;uaran dalam bentuk gelombang yang betul.

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LIST OF SYMBOLS AND ABBREVIATIONS

DC	-	Direct current
AC	-	Alternated current
UJT	-	Unipolar Junction Transistor
SCR	-	Silicon Control Rectifier
α	-	Delay Angle
MOSFET	-	Metal Oxide Silicon Field Effect Transistor

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CHAPTER 1

INTRODUCTION

1.1 Project Background

The main objective of the development of trainer kit for KUTKM's power electronic lab is intended to produce a teaching aid for the students. The trainer kit consists controlled and uncontrolled rectifier with the source input from AC main. Silicon Control Rectifier (SCR) has an input control terminal (gate), an output terminal (anode) and a terminal common to both the input and output (cathode). SCRs are mainly used where high currents and voltages are involved and are able to control alternating currents, where the change of the sign of current causes the device to switch off automatically. One method to control the output of half and full wave rectifier is to use an SCR as a rectifier and UJT as its drive. This type of thyristor generally operates at the lines frequency and is turned off by natural commutation.

In this project, the UJT is used as a relaxation oscillator to turn on SCR and other high power current – handling devices. Before this, the gate current was required to cause an SCR to turn on. If proper gate current is not applied, the SCR cannot quickly turn on and so may 'stutter' as it attempts to go from the off state to the on state. A UJT can be made to oscillate at a given rate and to supply short, high powered pulses whose peak average power does not exceed the gate power-handling capabilities of the SCR. It is an ideal source of frequency-controlled turn on power for the SCR.

Therefore, this trainer kit helps the students to understand the power electronic subject easily and encourage them to learn this subject. In this case, the students will be compared the simulation result between the experimental result.

1.2 Objectives

In the beginning of this project, the first objective is to study and understand the concept of SCR as a controlled rectifier. The second objective is to simulate the complete circuit that containing SCR as a rectifier and obtain result from the simulation using PSPICE.

Based on the title of the project, the main objective is to facilitate the students to understand the subject of power electronic by using teaching aids. The next objective is expressly to show the different output of single phase – half and full bridge wave by using controlled and uncontrolled rectifier. Besides, the output to the load such as R, L and C will show the different wave and output voltage.

1.3 Scope of Project

The simulations are performed using PSPICE. Each simulation should have an appropriate result in a certain condition. The circuit design should consists single phase uncontrolled rectifier using diode and single phase controlled rectifier using SCR thyristor.

The output should perform in a single phase of half bridge wave and full bridge wave. In this case, comparison from the results, simulation and experimental result can be shown. This trainer kit will determine output voltage (V_o), voltage source (V_s), load voltage (V_L), diode voltage (V_D) and output current (I_o).

1.4 Rectifier

Rectifier is the part of the development of trainer kit; a rectifier is a circuit that converts an ac signal into a unidirectional signal. A rectifier is a type of dc – ac converter. Depending on the type of input supply, the rectifiers are classified into two types: (1) single phase and (2) three phase. In this project, it is focus on single phase full wave rectifier.

1.5 Single Phase Full – Wave Rectifiers

There are two types of single phase full – wave rectifiers which are center tapped transformer and bridge rectifier. The development of trainer kit will stress on a single phase full bridge rectifier. The full bridge rectifier is used in applications ranging from 100 W to 100kW. The objective of a full – wave rectifier is to produce a voltage or current which is purely dc or has some specified dc component.

1.6 Unipolar Junction Transistor (UJT)

As basic information, the UJT is called transistor even though it was originally known as a double based diode, a name that is really more descriptive. It consists of two ceramics bases, a bar of N – type silicon and a wire made of P – type material. The only PN junction in the device is the point where the bar and wire meet.

CHAPTER 2

LITERATURE REVIEW

2.1 Single phase full wave rectifier.

The bridge rectifier is more suitable for high voltage applications (100W – 100kW) because it has a lower peak diode voltage compared to center tapped transformer rectifier. The main advantages compared to half wave rectifier:

1. The average current in the ac source is zero in the full wave rectifier. Thus avoiding problem associated with none zero average source currents, particularly in transformers.
2. The output of the full wave rectifier has inherently less ripple than the half wave rectifier.

Instead of using a center – tapped transformer, we could use four diodes, as shown in figure 2.1. During the positive half cycle of the input voltage, the power is supplied to the load through diodes D_1 and D_2. During the negative cycle, diodes D_3 and D_4 conduct.

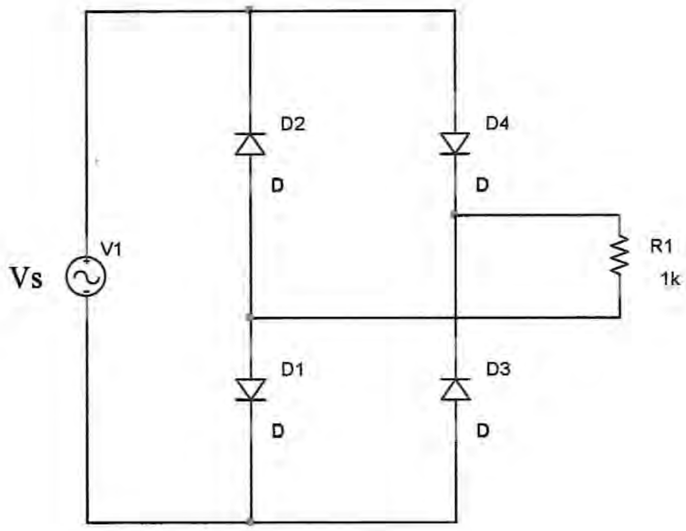

Figure 2.1: Full wave bridge rectifier circuit diagrams

The operation of the single phase full wave rectifier refers to the diode D_1, D_2, D_3, and D_4. In this circuit, D_1 and D_2 conduct together and the same goes to D_3 and D_4. D_1 and D_3 cannot conduct on the same time. Similarly, D_2 and D_4 cannot conduct simultaneously. The load current can be positive or zero but never negative. The voltage across the load is positive V_s when D_1 and D_2 are on and the load voltage is negative V_s when D_3 and D_4 are on. The waveform for the output voltage is shown in figures below.

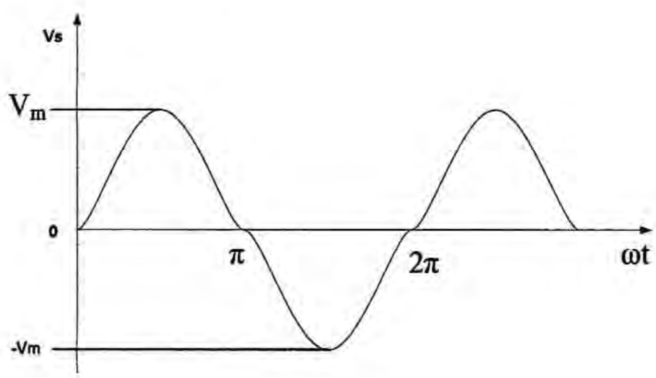

Figure 2.2: Waveform of voltage source

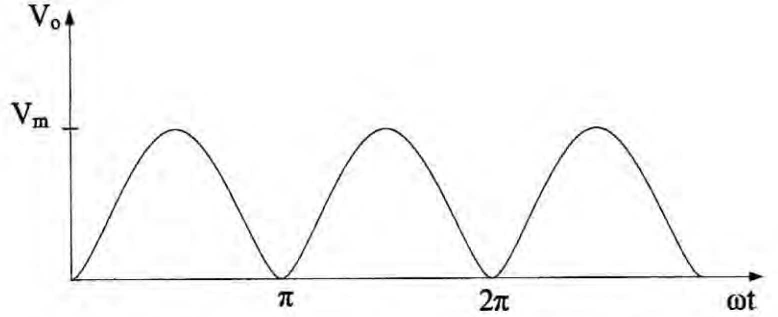

Figure 2.3: Output voltage for bridge rectifier with R load

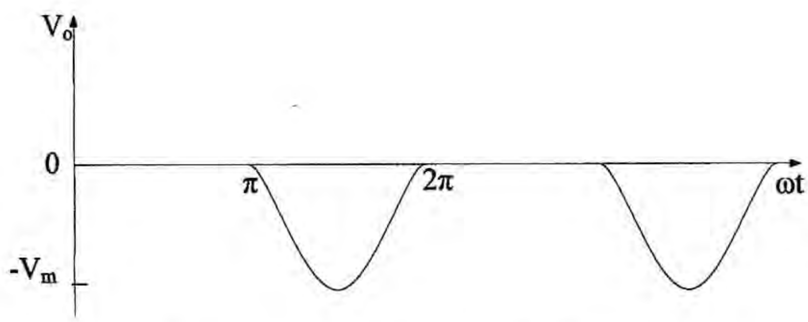

Figure 2.4: Output voltage for D_1 and D_2

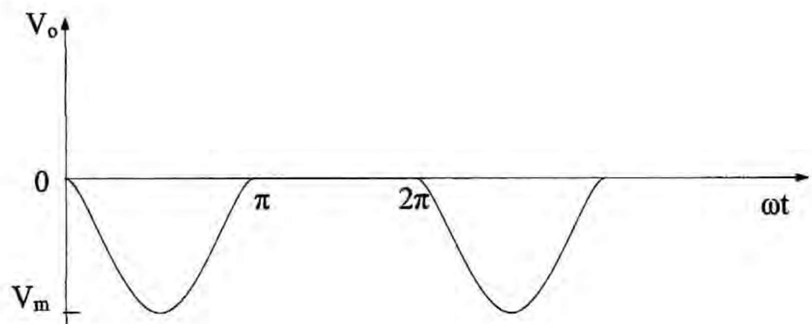

Figure 2.5: Output voltage for D_3 and D_4

The maximum voltage across a reverse biased diode is the peak value of the source. This can be shown by Kirchhoff's voltage law around the loop containing the source, D_1 and D_3. With D_1 on, the voltage across D_3 is negative voltage source.

The current entering the bridge from the source is $i_{D1} - i_{D4}$, which is symmetric about zero. Therefore, the average source current is zero. The rms source current is the same as the rms load current. The source current is the same as the load current for half of the source period and is the negative of the load current for the other half. The squares of the load and source currents are the same, so the rms currents are equal.

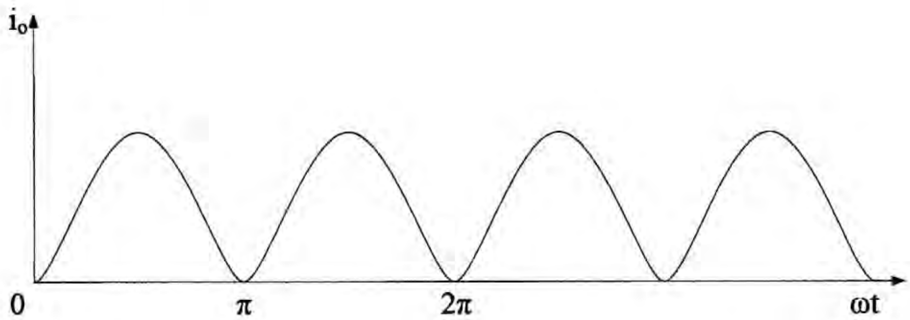

Figure 2.6: Output current for bridge rectifier with R load

The fundamental frequency of the output voltage is2ω, where ω is the frequency of the ac input, since two periods of the output occur for every period of the input. The Fourier series of the output consists of a dc term and the even harmonics of the source frequency.

2.2 Single phase controlled rectifier using SCR thyristor (full wave)

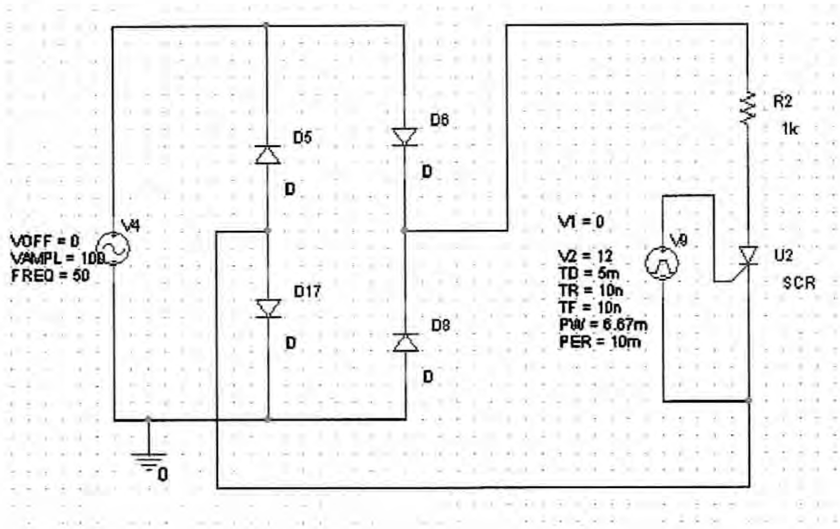

Figure 2.7: Single phase controlled rectifier using SCR (full wave)

A versatile method of controlling the output of a full wave rectifier is used the SCR. Thus the SCR can be made to fire at different points on the input pulse. Note that at full wave rectified source is used for the SCR. Recall that the SCR has two advantages. It conducts for only one half of a sine wave, so when the SCR is operated with a sine wave source, its output is a maximum of 50 percent of full power. Also, if pure dc power is used, the SCR cannot be turned off without special circuitry. With the full wave source, neither of these disadvantages applies. Full power is achieved since both half waves are used, yet the SCR turn off between each pulse.