Department of Electrical Engineering

Final Project Report

Subject : Power Electronics

Submitted to : Sir Engr Shayan Tariq Jan

Title of Project

Thyristor Power Control by IR Remote

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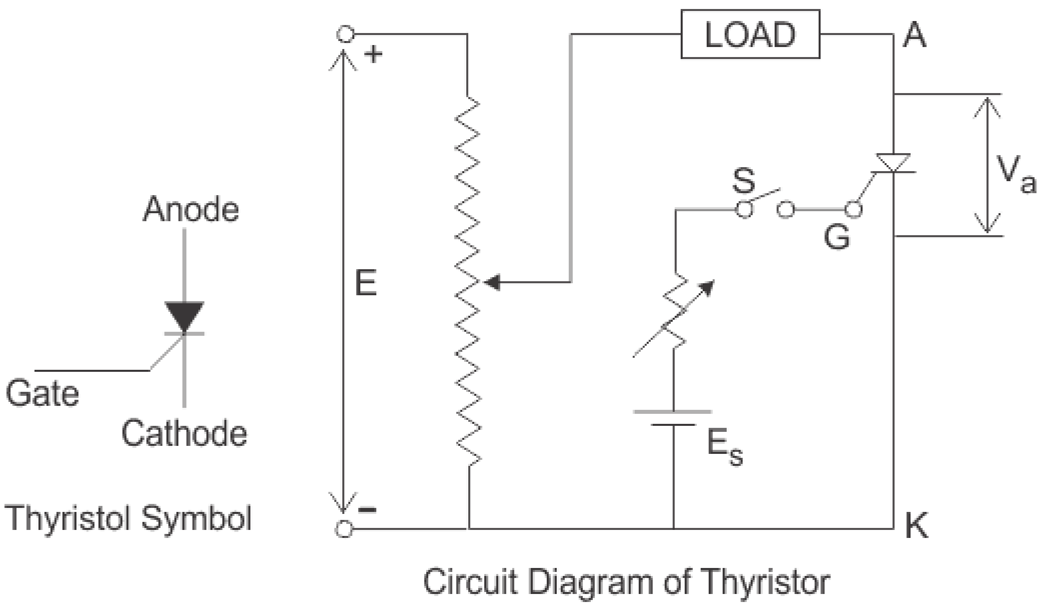
Characteristics of Thyristor (SCR)

A thyristor is a four layer 3 junction p-n-p-n semiconductor device consisting of at least three p-n junctions, functioning as an electrical switch for high power operations. It has three basic terminals, namely the anode, cathode and the gate mounted on the semiconductor layers of the device. The symbolic diagram and the basic circuit diagram for determining the characteristics of thyristor is shown in the figure below,

Thyristor symbol and circuit



From the circuit diagram above we can see the anode and cathode are connected to the supply voltage through the load. Another secondary supply Es is applied between the gate and the cathode terminal which supplies for the positive gate current when the switch S is closed.

On giving the supply we get the required V-I characteristics of a thyristor show in the figure below for anode to cathode voltage Va and anode current Ia as we can see from the circuit diagram. A detailed study of the characteristics reveal that the thyristor has three basic modes of operation, namely the reverse blocking mode, forward blocking (off-state) mode and forward conduction (on-state) mode.

Merits of Thyristor

The advantages of Thyristor includes:

- Low cost.
- Can be protected with the help of fuse.

- Can handle large voltage/ current.
- Able to control AC power.
- Very easy to control.
- Easy to turn on.
- GTO or Gate Turnoff Thyristor has high efficiency.
- Takes less time to operate.
- Thyristor switches can operate with large frequency.
- Requires less space when compared to mechanical switches.
- Can be used for robust operations.
- Maintenance cost of Thyristor is very less.
- Very easy to use for sophisticated controlling.
- Power handling capacity is very good.
- Can be used as an oscillator in digital circuits.
- Can be connected in parallel and in series to provide electronic control at high power levels.
- Thyristors conduct current only in one direction.
- It can be used as a protection device, like a fuse in a power line.

Demerits of Thyristor

- The disadvantages of Thyristor includes:
- Cannot be used for higher frequencies.
- In AC circuit, Thyristor needs to be turned on each cycle.
- SCR takes time to turn on and off. This causes delay or damage in the load.
- It can stop the motor when connected, but cannot hold it stationary.
- The response rate of Thyristor is very low.
- Not much use in DC circuits, as the Thyristor cannot be cutoff just by removing the gate drive.
- Low Efficiency.
- Latching and Holding current is more in GTO Thyristor.
- Reverse blocking capability of voltage is less than forward blocking capability.
- Reliability of TRIAC thyristor is less than SCR.

Half Wave Rectifier

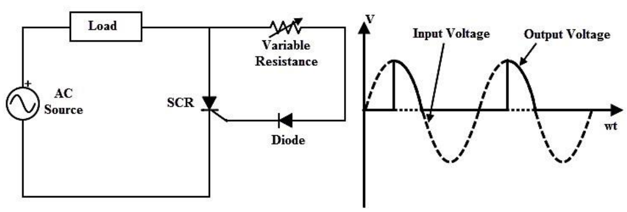
The circuit below shows the single phase half wave rectifier circuit using SCR. A diode in series with the variable resistor is connected to the gate which is responsible to trigger the SCR.

During the negative half cycle of the AC input signal, the SCR is reverse biased. Hence, no current flows through the load.

During the negative half cycle of the input, SCR is forward biased. If the resistor is varied such that the minimum triggering current is applied to the gate, then the SCR is turned ON. Hence the current starts flowing to the load.

If the gate current is higher, the supply voltage at which the SCR is turned ON will be lesser. The angle at which the SCR starts conducting is referred as firing angle. For this rectifier circuit, firing angle can be varied during the positive half cycle only.

Therefore, by varying the firing angle or gate current (by changing the resistance in this circuit), it is possible to make the SCR conduct part or full positive half cycle so that the average power fed to the load get varied.



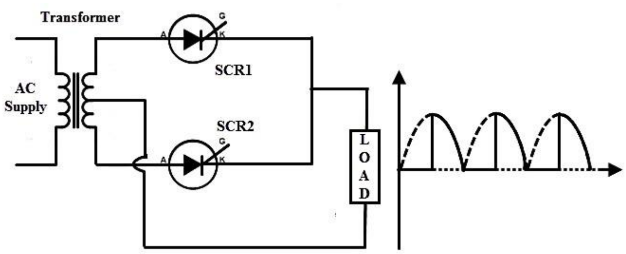
Full Wave Rectifier

In a full wave rectifier, both positive and negative wave of the input supply are rectified. Hence, compared to the half wave rectifier, the average value of the DC voltage is high and also ripple content is less. The below figure shows the full wave rectifier circuit consisting of two SCRs connected with centre tapped transformer.

• During the positive half cycle of the input, SCR1 is forward biased and SCR2 is reverse biased. By applying the proper gate signal, SCR1 is turned ON and hence load current starts flowing through it.

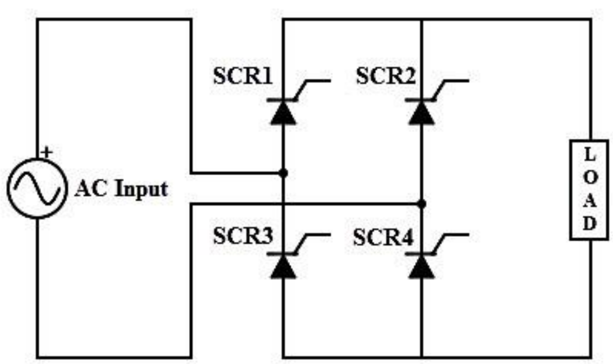
• During the negative half cycle of the input, SCR2 is forward biased and SCR1 is reverse biased. With a gate triggering, SCR2 is turned ON and hence the load current flows through the SCR2.

• Therefore, by varying the triggering current to the SCRs, the average power delivered to the load is varied.



<u>**Full Wave Bridge Rectifier**</u>

Instead of using a centre tapped transformer, it is also possible to use four SCRs in a bridge configuration to get the full wave rectification. During the positive half cycle of the input, SCR1 and SCR2 are in conduction. During the negative half cycle, SCR3 and SCR4 are in conduction. The conduction angle of each thyristor is adjusted by varying the respective gate currents. And hence, the output voltage across the load is varied**.**



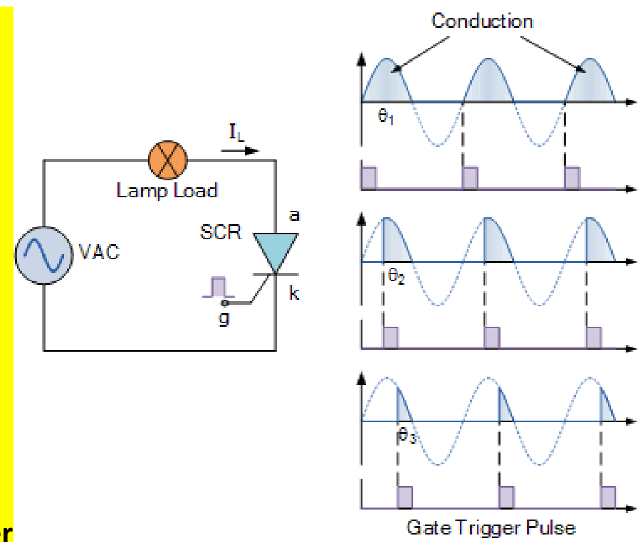
The project is designed to control the speed of an induction motor such as fans, by using a standard TV remote. In home automation application, convenience of remotely controlling the speed of the fan is achieved.

A standard TV remote sends coded infrared data to the control board, which is then received by an IR sensor (at the receiver end) interfaced to a micro controller of 8051 family. Each time a button is pressed it sends a specific coded data in infrared range. This coded data is executed by the micro controller to deliver delayed firing pulses to the thyristor through optical isolation. The power to the load connected in series with the thyristor is controlled based on the received signal. Also the firing angle is displayed on a 7-segment display. A lamp load shall be provided in place of a motor whose varying intensity demonstrates the varying power to the motor for speed control. A lamp is provided in place of an induction motor for demonstration purpose.

Further the project can be enhanced by adding more outputs from the micro controller feeding relay drivers to switch ON/OFF the domestic loads together with the speed control of fan.

In this project, we use a standard TV remote for speed control of an induction motor such as fans. An IR receiver is interfaced to a micro controller to read the coded data from the remote to activate the corresponding output with a digital display.

SILICON CONTROLLED RECTIFIER



Silicon Controlled Rectifier

Function of Silicon Controlled Rectifier:

A silicon controlled rectifier or semiconductor controlled rectifier is a four-layer solid-state current-controlling device. The principle of four-layer p–n–p–n switching was developed by Moll, Tanenbaum, Goldey and Holonyak of Bell Laboratories in 1956.The practical demonstration of silicon controlled switching and detailed theoretical behavior of a device in agreement with the experimental results was presented by Dr Ian M. Mackintosh of Bell Laboratories in January 1958. The name "silicon controlled rectifier" is General Electric's trade name for a type of thyristor. The SCR was developed by a team of power engineers led by Gordon Hall and commercialized by Frank W. "Bill" Gutzwiller in 1957**.**

Function of this Circuit:

Function of Operation of SCR.Depending on the biasing given to the SCR, the operation of SCR is divided into three modes. They are..

Forward Blocking Mode:

In this mode of operation, the Silicon Controlled Rectifier is connected such that the anode terminal is made positive with respect to cathode while the gate terminal kept open. In this state junctions J1 and J3 are forward biased and the junction J2 reverse biased.

Due to this, a small leakage current flows through the SCR. Until the voltage applied across the SCR is more than the break over voltage of it, SCR offers a very high resistance to the current flow. Therefore, the SCR acts as a open switch in this mode by blocking forward current flowing through the SCR as shown in the VI characteristics curve of the SCR.

Forward Conduction Mode:

In this mode, SCR or thyristor comes into the conduction mode from blocking mode. It can be done in two ways as either by applying positive pulse to gate terminal or by increasing the forward voltage (or voltage across the anode and cathode) beyond the break over voltage of the SCR.

Once any one of these methods is applied, the avalanche breakdown occurs at junction J2. Therefore the SCR turns into conduction mode and acts as a closed switch thereby current starts flowing through it.

Uses of thyristor in this circuit:

The primary function of a thyristor is to control electric power and current by acting as a switch. For such a small and lightweight component, it offers adequate protection to circuits with large voltages and currents (up to 6000 V, 4500 A).

Uses of Gate Trigger Impulse:

To reduce gate power dissipation, SCR firing circuits generate a single pulse or a train of pulses instead of a continuous DC gate signal. This allows precise control of the point at which the SCR is fired. In addition, it is easy to provide electrical isolation between the SCR and the gate trigger circuit.

SCR Applications:

Due to the wide variety of advantages, like ability to turn ON from OFF state in response to a low gate current and also able to switch high voltages, makes the SCR or thyristor to be used in a variety of applications.

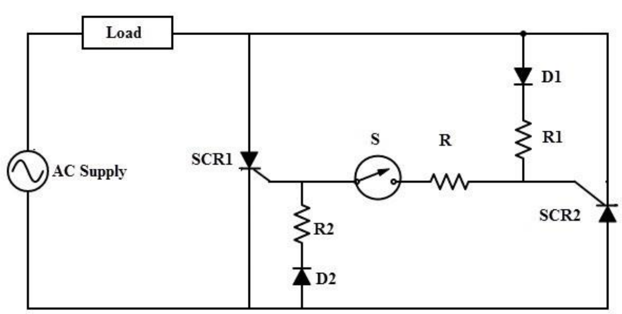
These applications include switching, rectification, regulation, protection, etc. The SCRs are used for home appliance control include lighting, temperature control, fan speed regulation, heating, and alarm activation.

For industrial applications, SCRs are used to control the motor speed, battery charging and power conversions.

SCR as a Switch:

The switching operation is one of the most important applications of the SCR. The SCR is often used as solid state relay and has more advantages than electromagnetic relays or switches as there are no moving parts in SCR.

The below figure shows the application of an SCR as a switch to ON and OFF the power supplied to the load. The AC power supplied to the load is controlled by applying alternate triggering pulses to the SCR. The resistors R1 and R2 protect the diodes D1 and D2 respectively. The resistor R limits the gate current flow.



During the positive half cycle of the input, SCR1 is forward biased and SCR2 is reverse biased. If the switch S is closed, gate current is applied to the SCR1 through diode D1 and hence SCR1 is turned ON. Therefore, the current flows to the load through SCR1.

Similarly, during the negative half cycle of the signal, SCR2 is forward biased and SCR1 is reverse biased. If the switch S is closed, gate current flows to the SCR2 through diode D2. Hence the SCR2 is turned ON and the load current flows through it.

Therefore, by controlling the switch S the load current can be controlled at any desired position. It is observed that, this switch handles a few mill ampere current to control the several hundred ampere current in the load. So this method of switching is more advantageous than mechanical or electromechanical switching.

Power Control Using SCRs

The SCRs are capable to control the power transmitted to the load. It is often required to vary the power delivered to the load depends on the load requirements such as motor speed control and light dimmers.

Under such conditions power varying with conventional adjustable potentiometers is not a reliable method due to the large power dissipation. For reducing this power dissipation in high power circuits, SCRs are the best choice as power control devices.

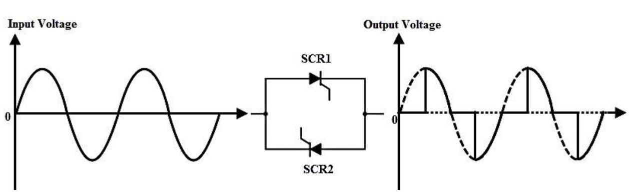
AC Power Control using SCR

In AC circuits, the phase control is the most common form of SCR power control. In phase control, by varying the triggering angle alpha at the gate terminal, power control is obtained.

Below figure shows a full AC wave control circuit that illustrates the phase control method. Consider that the AC supply is given to the two anti-parallel SCRs. During the positive half cycle of the signal SCR1 conducts while in negative half cycle SCR2 conducts when proper gate pulses are applied to them.

By varying the firing angle to the respective SCRs, the turn ON times are varied. This leads to vary the power consumed by the load. In the below figure SCRs are triggered at delayed pulses (that means an increase of firing angle) results to decrease of the power delivered to the load.

The main advantage of the phase control is that the SCRs are turned OFF automatically at every current zero position of AC current. Hence, no commutation circuit is required to turn OFF the SCR.

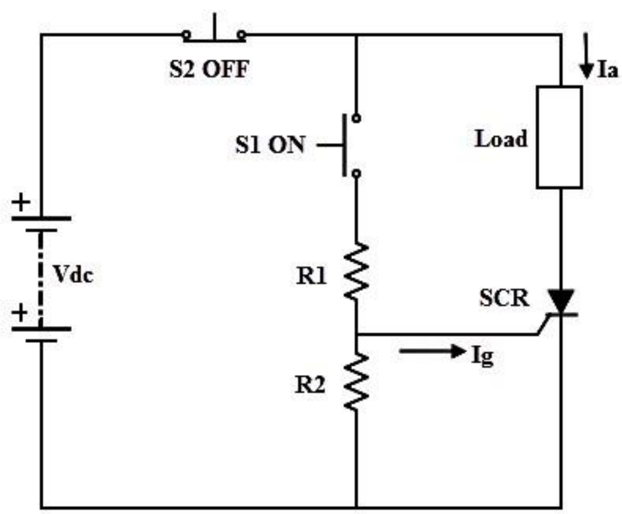


DC Power Control using SCR

In case of a DC circuit, power delivered to the load is varied by varying the ON and OFF durations of the SCRs. This method is called as a chopper or ON-OFF control. Below figure shows the simple ON-OFF control of load using SCR.

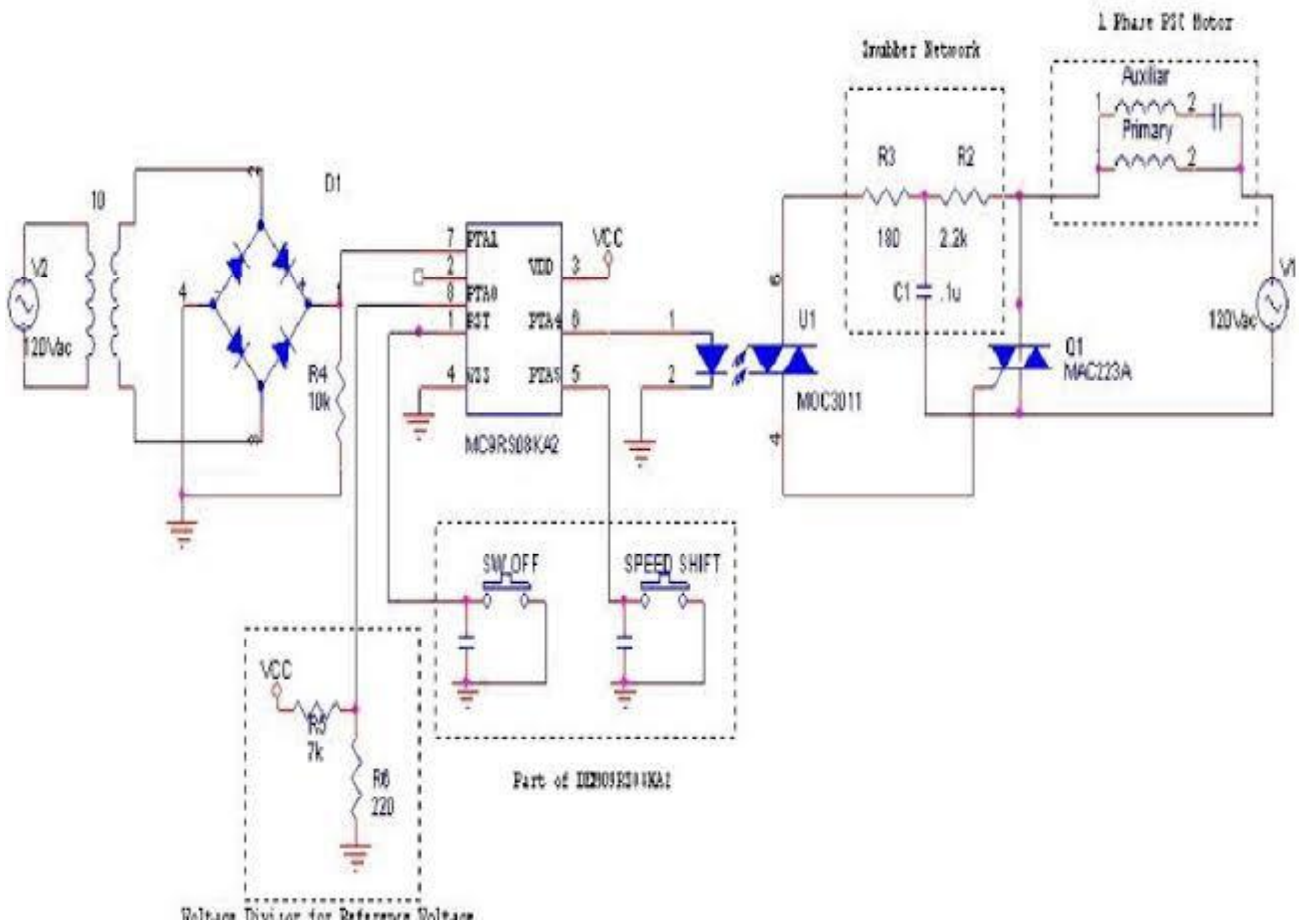
It is also possible to switch the SCR at certain triggering frequency so that the current flowing to the load is varied. The example of such circuit is the PWM based SCR circuit to produce the variable output to the load.

It is possible to produce the variable DC power to the load by using phase control rectifier circuits. The average DC power delivered to the load is controlled by controlling the instant of turning ON of the SCR. Some of these rectifier circuits are given below.



IR Remot Control Of Induction Motor

(Fan) Circuit Diagram:



Parameters of circuit

Trigger Angle In Radian s	Output Voltage V_o (Volts)	Output Current I_o (Amps)	Output Power W (Watts)	Lighting Efficiency η %
Pi/6	228.34	2.2834	521.39	98.75
Pi/3	218.47	2.1847	477.29	98.5
Pi/2	199.19	1.9919	396.73	95.68
2pi/3	177.83	1.7783	316.19	88.56
5Pi/6	164.97	1.6497	272.118	84.23
pi	162.63	1.6263	264.49	84.16

DESIGN CALCULATION:

The Input supply voltage of the thyristor based system is given below
VS= Vmsin ω
t= √ 2VS sin ω t;
The Output voltage across the load and Output load current is obtained using
For ωt=α to π and ωt= (π +α) to 2π
Vo= V L = V m sinωt;
Io=V O/R= I msin ωt /R;
The rms output voltage can be found using the equations of the anti parallel thyristor

$$Vo(rms)^2 = V\,L^2 = \int_0^{2\pi} V\,L^2\, d(\boldsymbol{\omega t})$$

Lighting System Efficiency = System Lumen Output ÷ Input Wattage

When α=30°

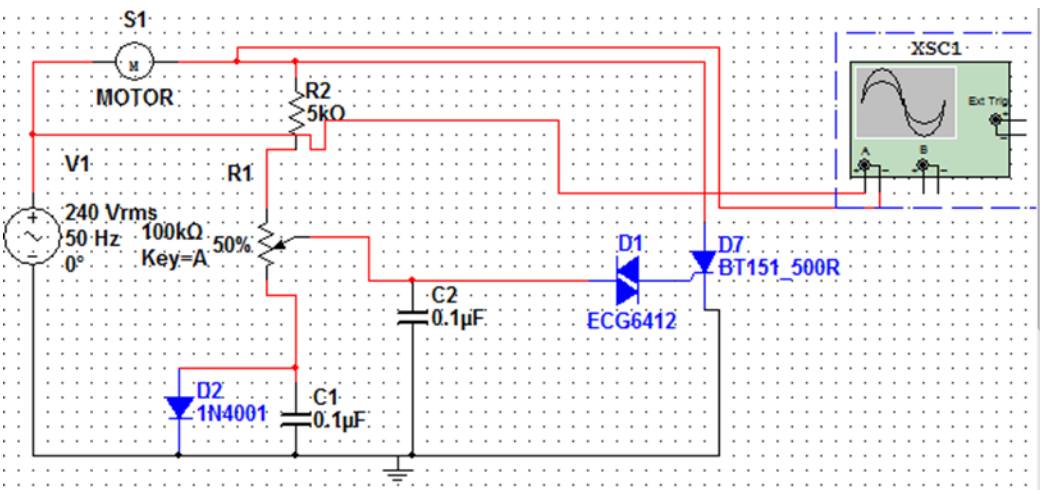
$$Vo(rms) = VS\sqrt{\frac{1}{\pi}(\pi - 30) + \left(\sin\frac{2 * 30}{2}\right)}$$

Vo(rms) = 228.34V;

Io (AMPS)=228.34 = 2.28A ;
100

P = VI = 521.39

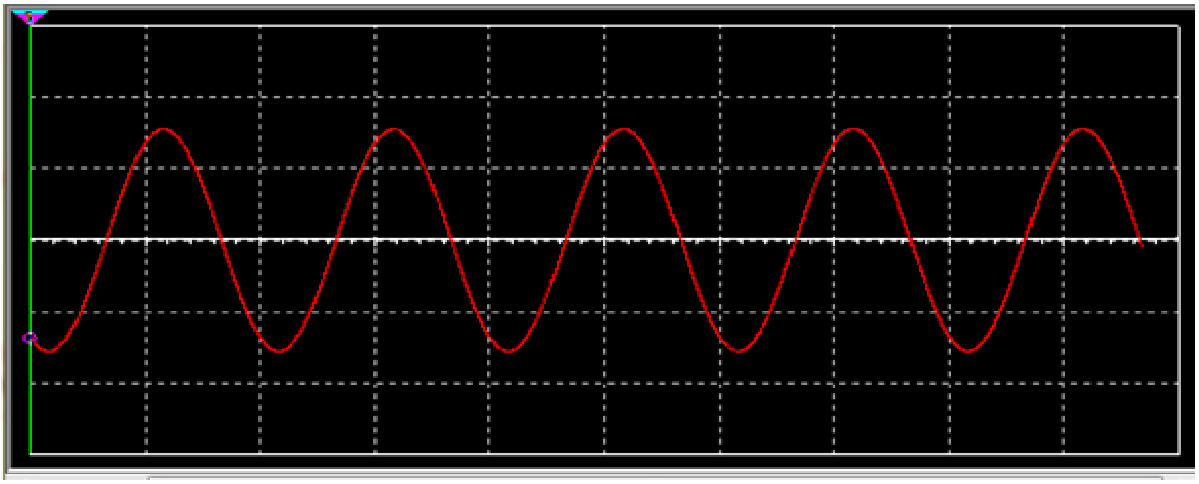
Control Circuit on Multisim Software:



Simulation Results

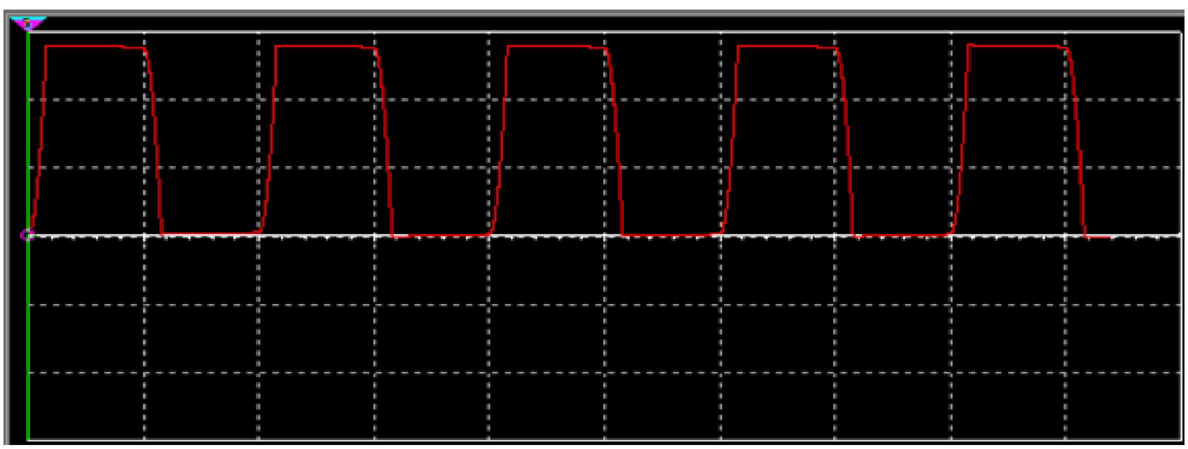
The modelled circuit was simulated and the results were obtained. The input waveform obtained from the alternating current (AC) signal 220V single phase power line

Input AC signal waveform



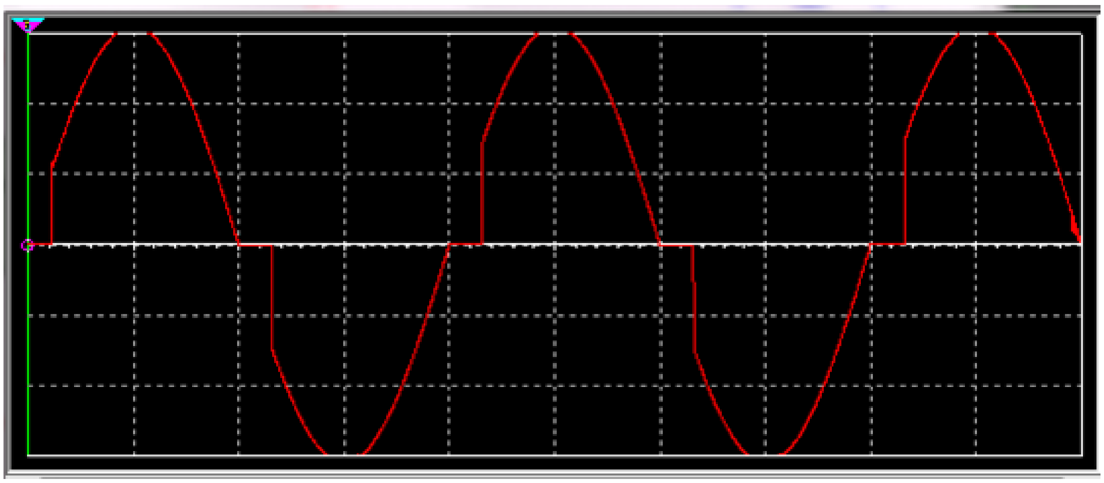
The above signal is fed into the relaxation oscillation circuit to generate an 'on' and 'off' signal which turns the thyristor 'on' and 'off' at a preset value of potentiometer. The square wave signal

Output waveform from the RC Network Circuit.



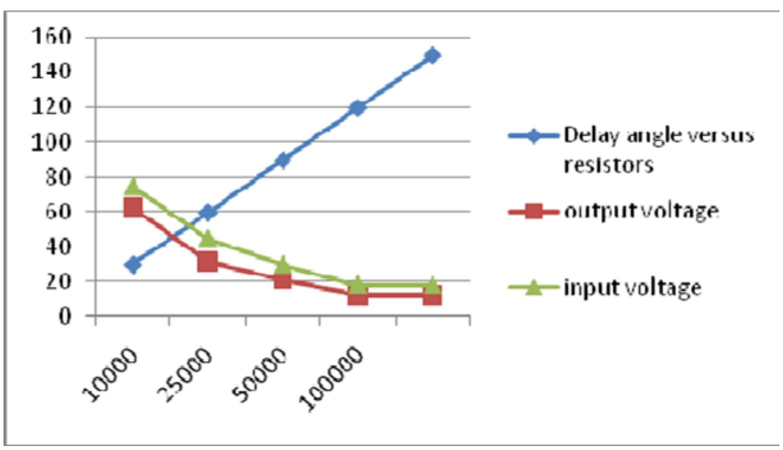
The action of the thyristor or triac is controlled by a diac which is switched on by a charge on the capacitor under the control of potentiometer R. The resistance of the diac is virtually infinite as long as the voltage across it remains within the breakover voltage limits, -VBO to +VBO. During each half cycle of the mains sinewave, the capacitor charges until the voltage across it exceeds the diac breakover voltage. The diac then switches on and capacitor discharges itself into the gate of the triac and switches it on. The above simulation results shows that the input supplies to the RC network circuit is sinusoidal waveform, the signal then transform into square wave to operate the silicon controlled rectifier. Therefore, the RC integrator circuit acts as delay circuit. The firing angle α is varied by the adjusting the potentiometer at the input terminal of the diac. Figure shows the waveform at the firing angle of 30^0 (the conduction angle of 150^0).

Output Waveform at 30^0 Firing Angle



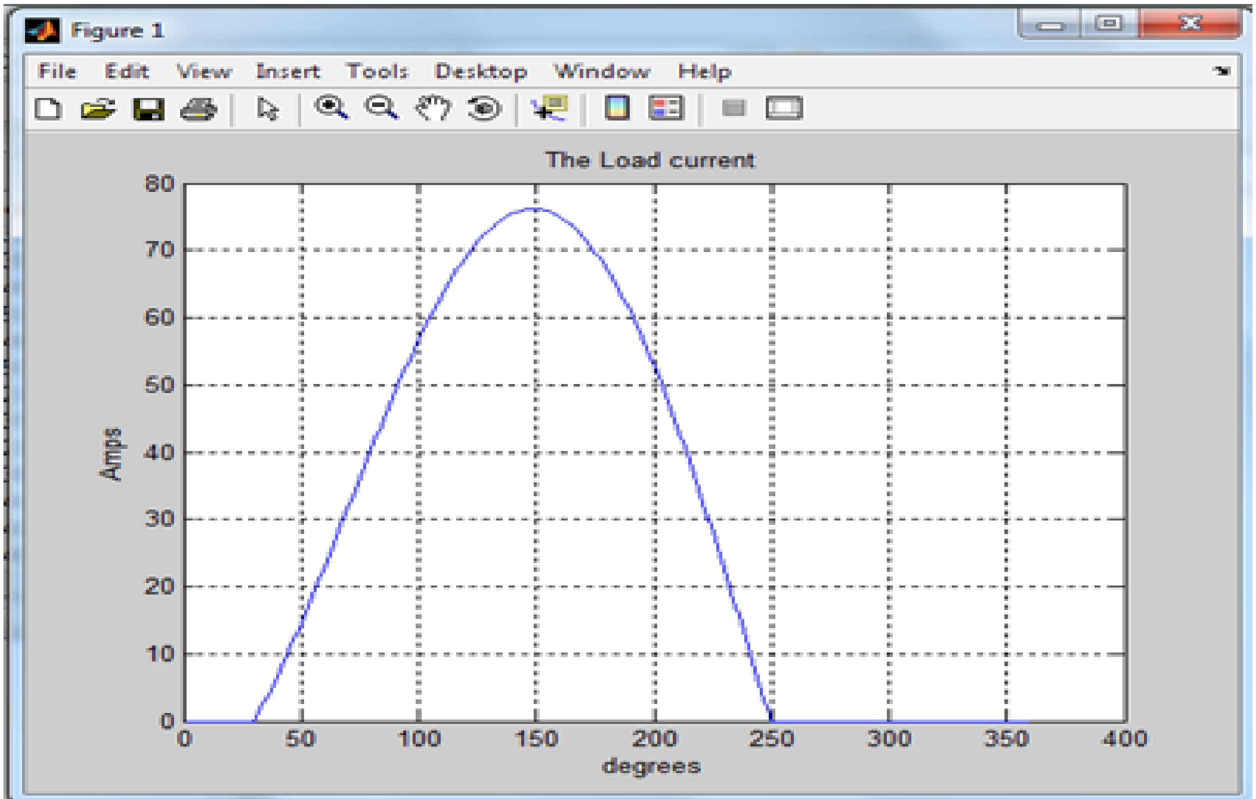
The above waveform shows that as the firing angle is been varied by adjusting the value of the potentiometer, the conduction angle is also varied and thereby the output voltage supplied to the load is been controlled. The values of potentiometer when α is varied were obtained and illustrated as

Phase Voltage Variation for Different Firing Angle

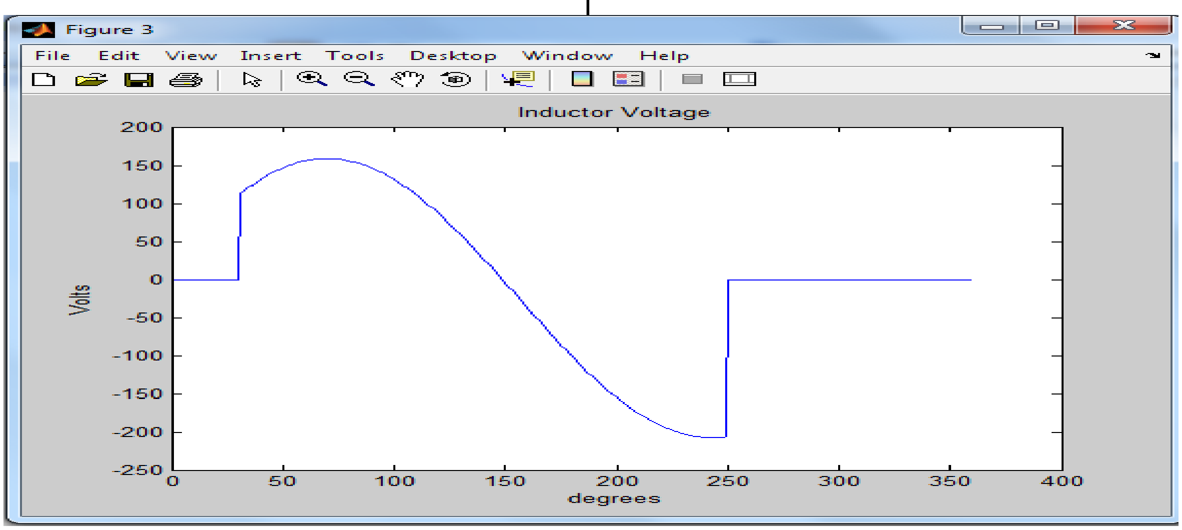


From the above table, when the potentiometer value is increased, the delay angle will increase and the width of the positive and negative half cycle will become smaller. Therefore, the motor speed is reduced.
The matlab simulation and the output waveform at 30^0 delay angle obtained were shown below having a good correlation with output from the Multisim software.

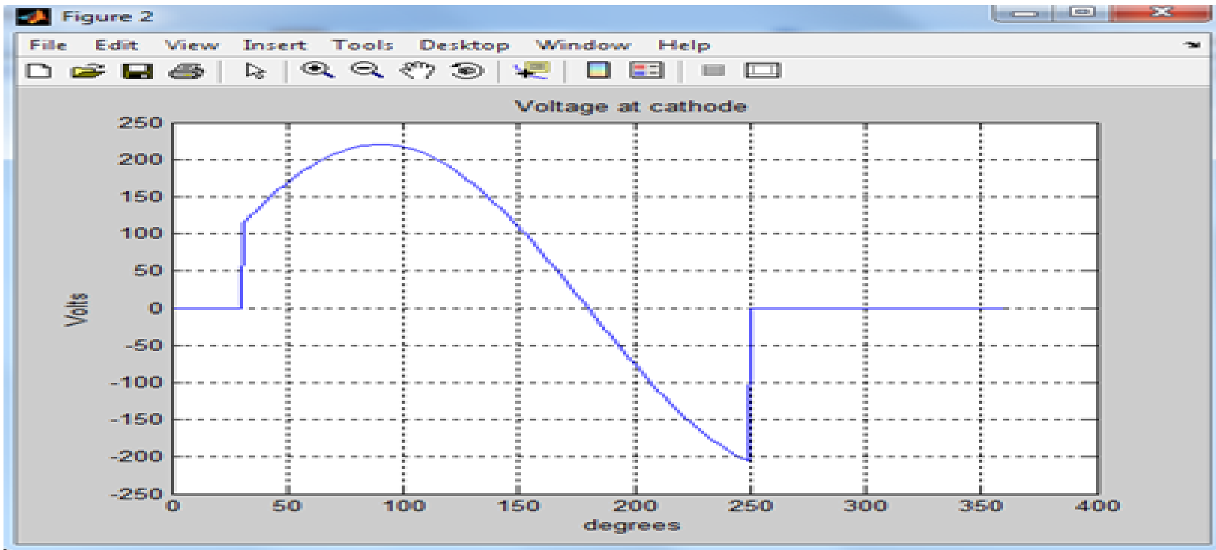
Waveform of the load current



Waveform of the load current



Waveform of Inductor Voltage



Conclusion:

This paper is to develop an automatic control system for home appliances.IR remote control signal using thyristor is implemented using micro controller and its application is successfully demonstrated for home applications.The system is quite cheap, reliable and easy to operate. And reduces human efforts and makes life a bit easy.

THANK YOU