Applications of SCR

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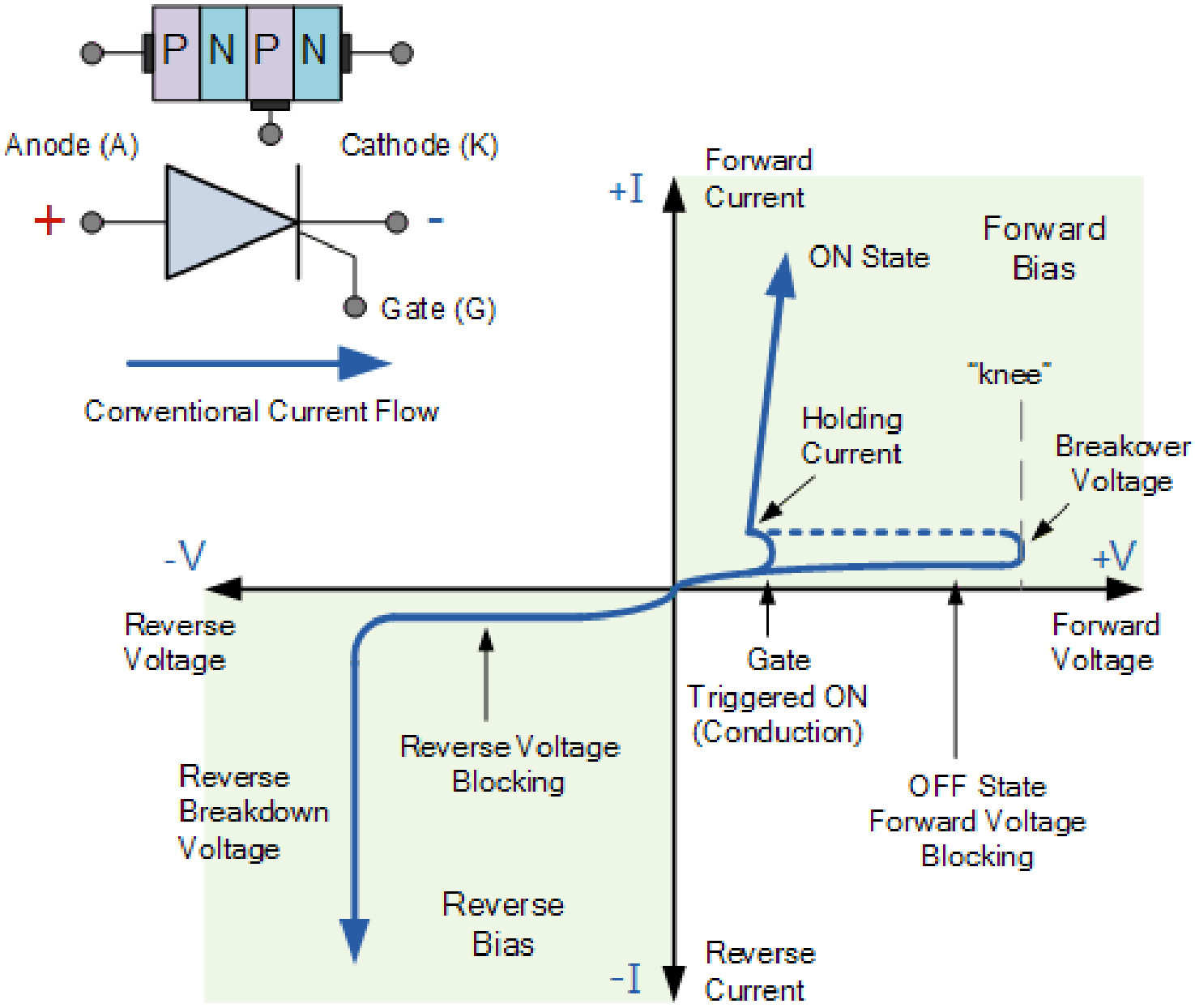
Phase Controlled Rectification

- Unlike diode rectifiers, PCRs or phase controlled rectifiers has an advantage of regulating the output voltage.
- The diode rectifiers are termed as uncontrolled rectifiers.
- When these diodes are switched with SCRs, then it becomes phase control rectifier.
- The o/p voltage can be regulated by changing the firing angle of the SCRs.
- The main application of these rectifiers is involved in speed control of DC motor.

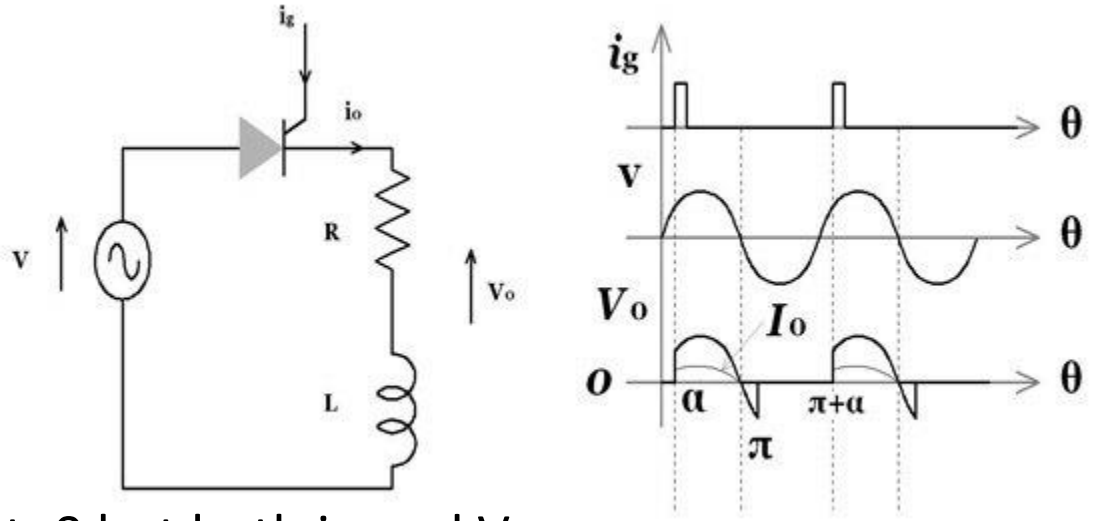
Phase Controlled Rectification

- The term PCR or Phase controlled rectifier is a one type of rectifier circuit in which the diodes are switched by SCRs or SCRs (Silicon Controlled Rectifiers).
- Whereas the diodes offer no control over the o/p voltage, the SCRs can be used to differ the output voltage by adjusting the firing angle or delay.
- A phase control SCR is activated by applying a short pulse to its gate terminal and it is deactivated due to line communication or natural.
- In case of heavy inductive load, it is deactivated by firing another SCR of the rectifier during the negative half cycle of i/p voltage.

SCR I-V Characteristics Curves



Firing Angle of SCR



- Anode voltage is positive at t>0 but both io and Vo are zero as thyristor is not conducting in absense of gate signal.
- Firing Angle of SCR is defined as the angle between the instant SCR would conduct if it were a diode and the instant it is triggered.
- Now after some time **t** (or angle=**2*pi*t/T** , where T is time period of input sine wave) , gate is fired with current pulse.
- As soon as gate is fired, both conditions for turning on of thyristor are fulfilled and it gets turned on and current starts flowing in circuit.
- Now angle at which thyristor gate is fired is called **firing angle=2*pi*t/T** .

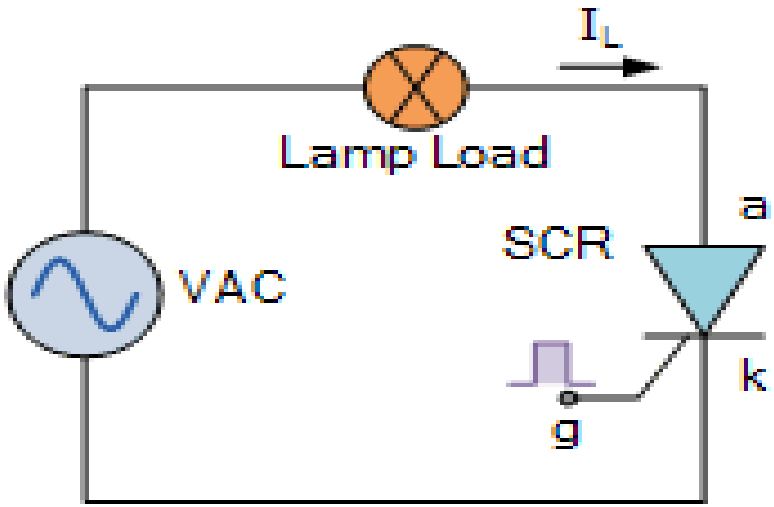
Operating Principle

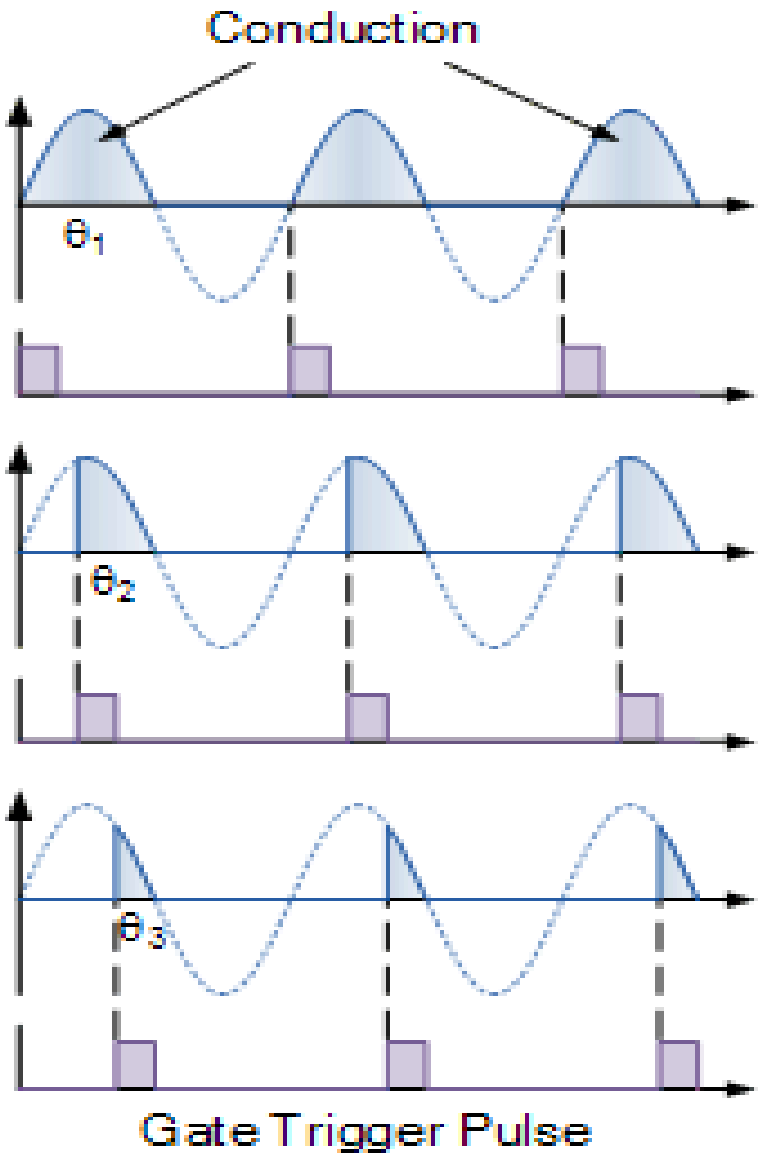
- The SCR has the ability to turn “OFF” whenever the Anode current is reduced below this minimum holding value, it follows then that when used on a sinusoidal AC supply the SCR will automatically turn itself “OFF” at some value near to the cross over point of each half cycle, and as we now know, will remain “OFF” until the application of the next Gate trigger pulse.
- Since an AC sinusoidal voltage continually reverses in polarity from positive to negative on every half-cycle, this allows the SCR to turn “OFF” at the 180^{o} zero point of the positive waveform. This effect is known as “natural commutation” and is a very important characteristic of the silicon controlled rectifier.
- SCRs used in circuits fed from DC supplies, this natural commutation condition cannot occur as the DC supply voltage is continuous so some other way to turn “OFF” the SCR must be provided at the appropriate time because once triggered it will remain conducting.

Operating Principle

- However in AC sinusoidal circuits natural commutation occurs every half cycle. Then during the positive half cycle of an AC sinusoidal waveform, the SCR is forward biased (anode positive) and a can be triggered “ON” using a Gate signal or pulse. During the negative half cycle, the Anode becomes negative while the Cathode is positive. The SCR is reverse biased by this voltage and cannot conduct even if a Gate signal is present.
- So by applying a Gate signal at the appropriate time during the positive half of an AC waveform, the SCR can be triggered into conduction until the end of the positive half cycle. Thus phase control (as it is called) can be used to trigger the SCR at any point along the positive half of the AC waveform and one of the many uses of a **Silicon Controlled Rectifier** is in the power control of AC systems as shown.

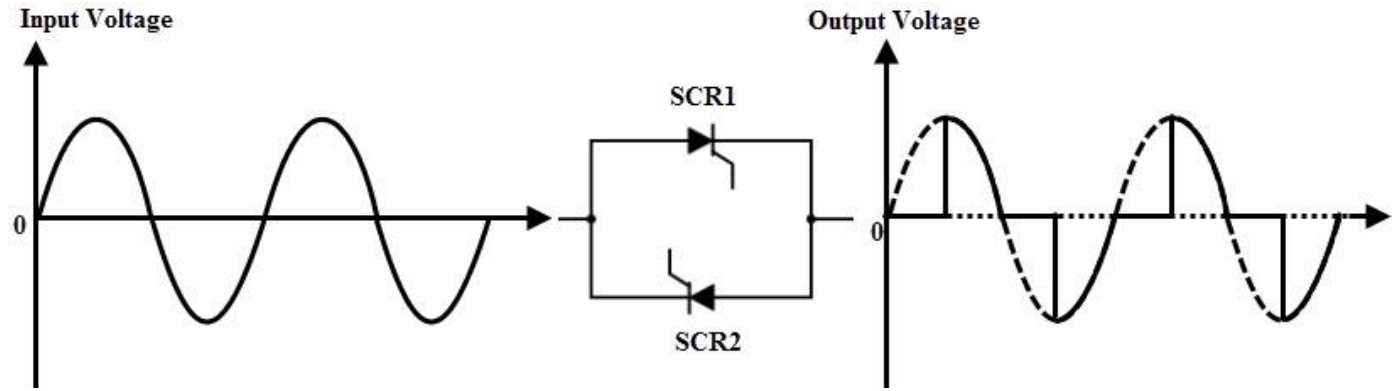
SCR Phase Control





- At the start of each positive half-cycle the SCR is “OFF”. On the application of the gate pulse triggers the SCR into conduction and remains fully latched “ON” for the duration of the positive cycle. If the SCR is triggered at the beginning of the half-cycle ($\theta = 0^o$), the load (a lamp) will be “ON” for the full positive cycle of the AC waveform (half-wave rectified AC) at a high average voltage of **0.318 x Vp**.
- As the application of the gate trigger pulse increases along the half cycle ($\theta = 0^o$ to 90^o), the lamp is illuminated for less time and the average voltage delivered to the lamp will also be proportionally less reducing its brightness.
- Then we can use a silicon controlled rectifier as an AC light dimmer as well as in a variety of other AC power applications such as: AC motor-speed control, temperature control systems and power regulator circuits, etc.

Full wave Phase controlled Recitifier



- Above 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.
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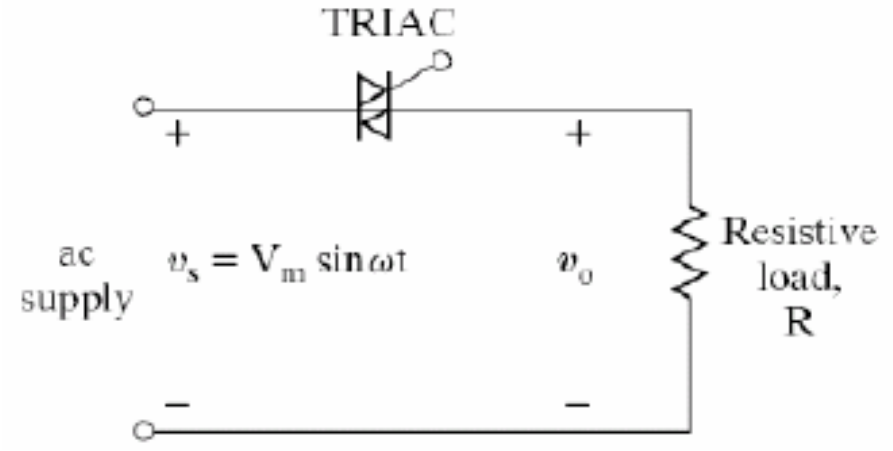
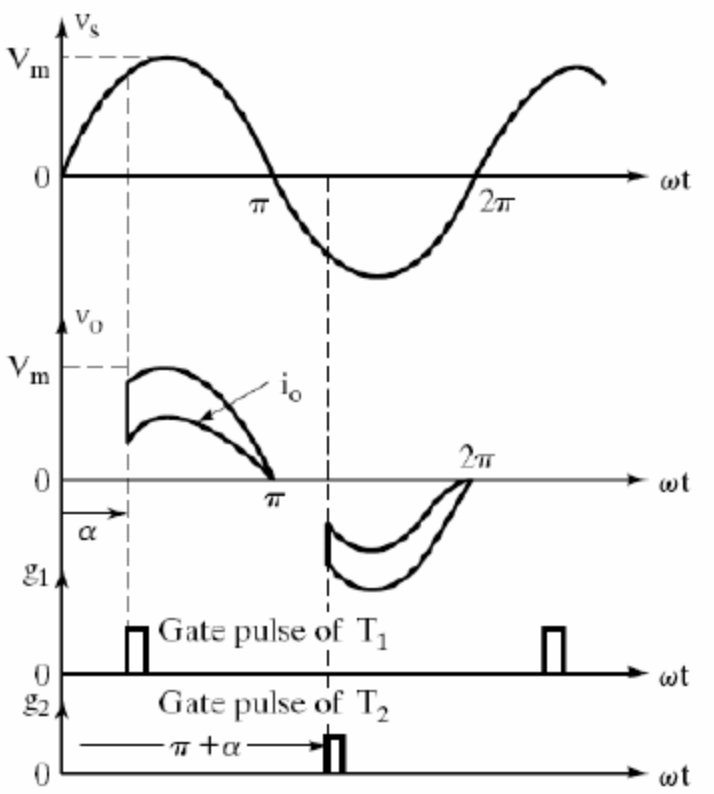
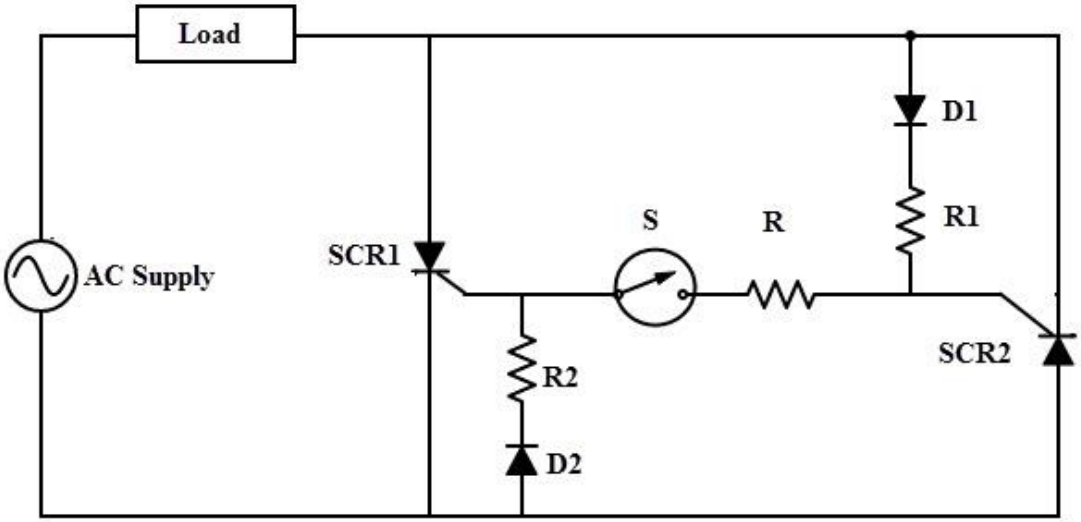
Instead of using two SCR's in parallel, a Triac can be used for full wave acvoltage control.





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.



SCR as a Switch

- 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.