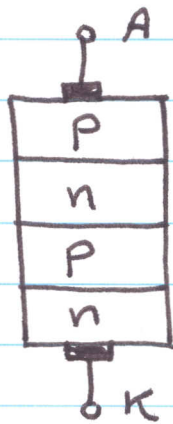


# Thyristors and other Devices

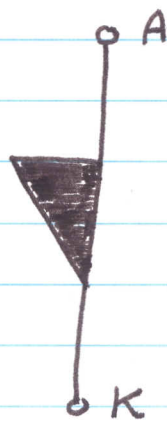
## Thyristors

- Devices constructed of four semiconductor layers
- They act as open circuits capable of withstanding a certain rated voltage until they are triggered
- When triggered, they turn on and become low-resistance current paths, and remain on, even after the trigger is removed, until the current is reduced to a certain level or they are triggered off, depending on the type of the device
- Thyristors can be used to control the amount of ac power to a load
- They are used in lamp dimmers, motor speed controls and charging circuits.

# The Shockley Diode



Basic Construction

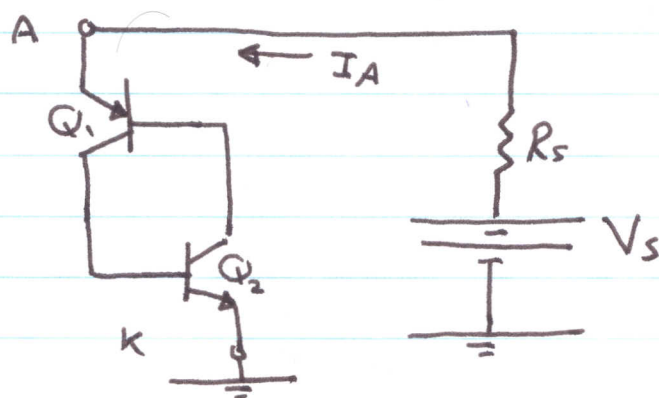


Circuit Symbol

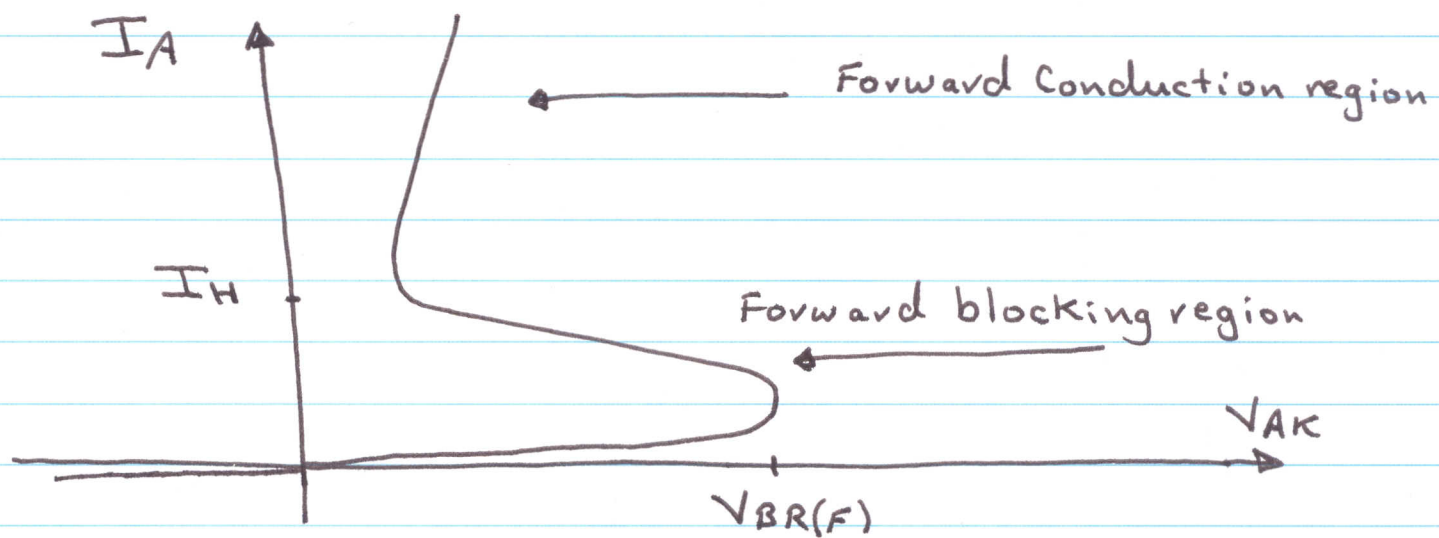


Equivalent Circuit

- The basic 4-layer device
- It is a two terminal device
- It acts as a Switch
- It remain off until the forward voltage reaches a certain value ; then it turns on and conducts current.
- Conduction continue until the current is reduced below a specified value



# Characteristic Curve



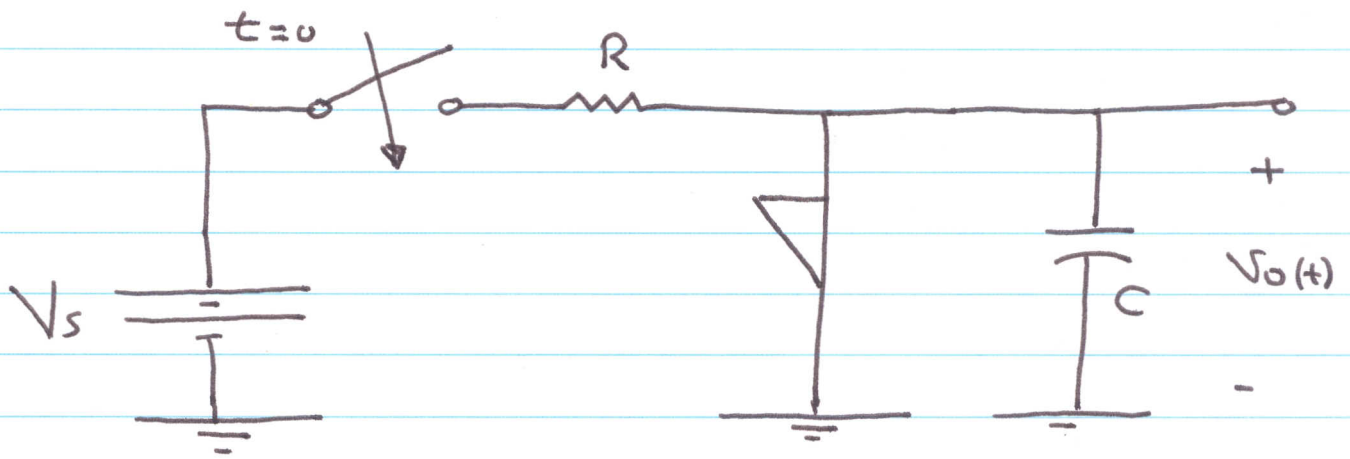
$V_{BR(F)} \equiv$  Forward breakover voltage

$I_H \equiv$  Holding Current

\* When  $V_s > V_{BR(F)}$ ; the device is in the on state and acts as a closed switch

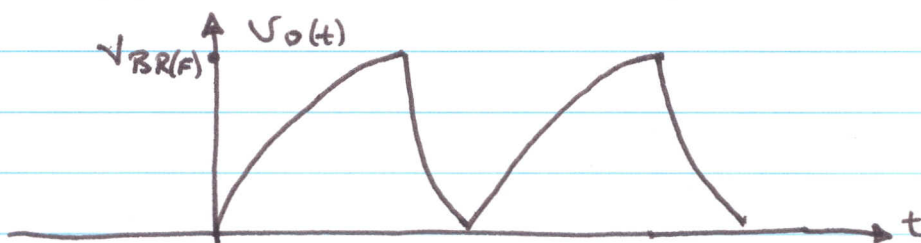
\* When the anode current  $I_A$  drops back below the holding value  $I_H$ , the device turns OFF (open circuit)

# Application : Relaxation Oscillator



$$V_c(0) = 0$$

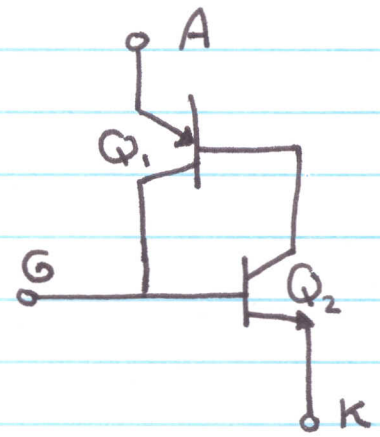
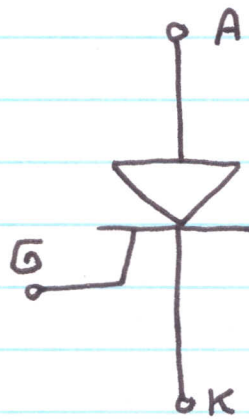
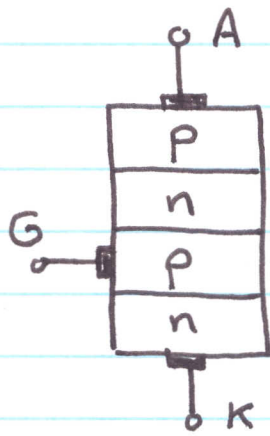
- At  $t = 0^+$ ,  $V_c(0^+) = V_{AK}(0^+) = 0$ ; the device is OFF (open circuit)
- The Capacitor charges through  $R$  until its voltage reaches  $V_{BR(F)}$
- The device switches into conduction (short circuit)
- The Capacitor rapidly discharges through the device until  $I_A < I_H$
- The device switches back to the OFF state





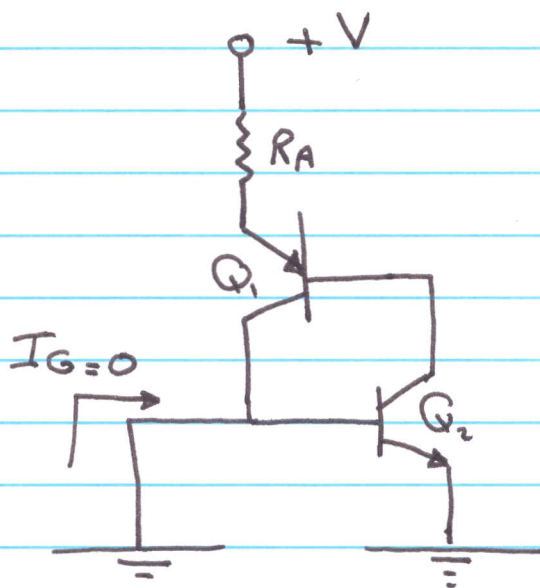
# The Silicon Controlled Rectifier : SCR

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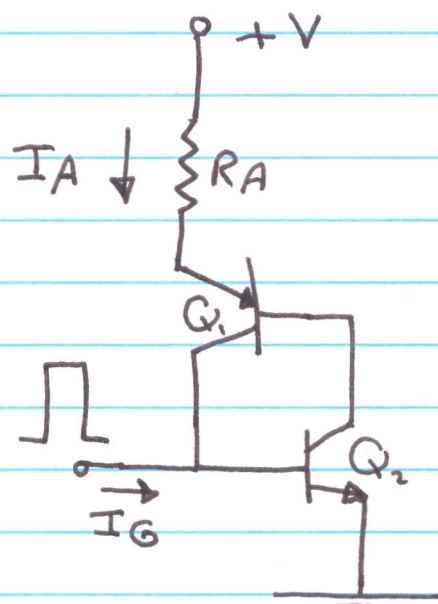


- It is a three terminal device
- It is four Layer pnpn device
- It acts as a switch
- In the off state ; it acts as an open circuit between Anode and Cathode
- In the on state , it acts as short circuit from A to K

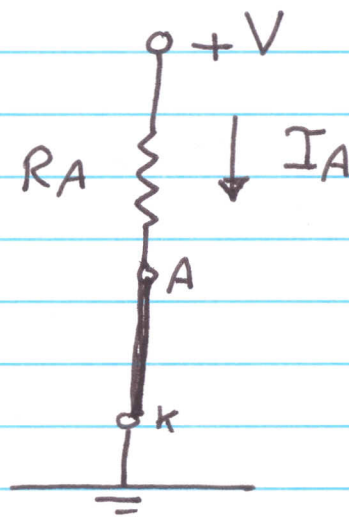
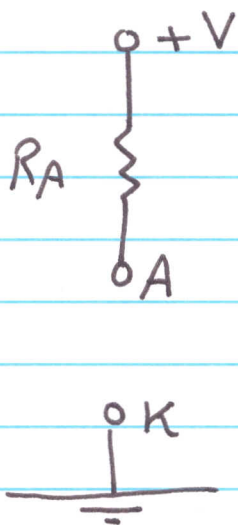
# Turning the SCR On



SCR OFF



SCR On



- When  $I_G = 0$ ; it acts as the Schottky diode in the off state (open circuit)
- When a positive pulse of current (trigger) is applied to the gate, both transistors

turn on

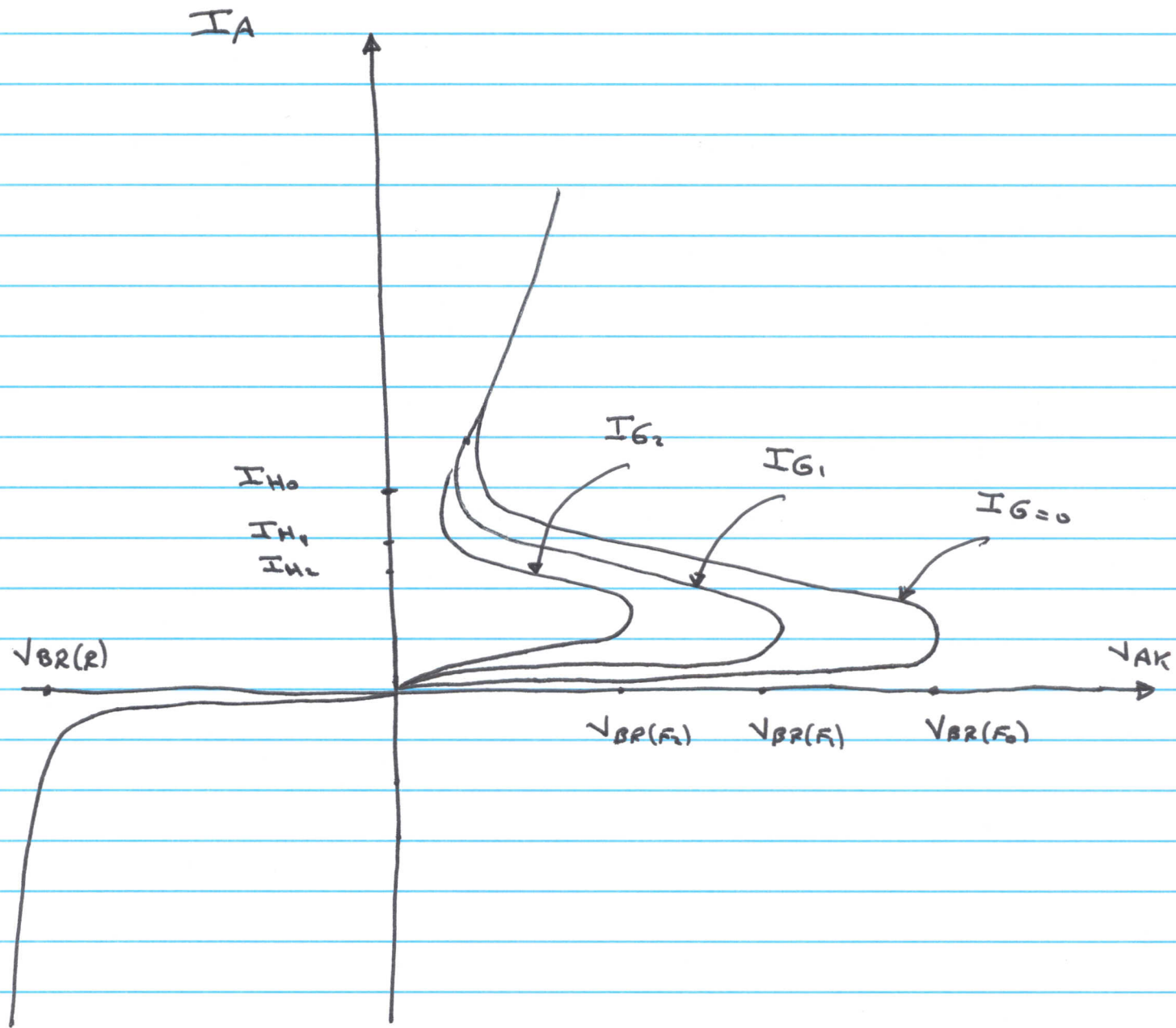
- The SCR stays on (Latches) once it is triggered on
- In this state, SCR can be approximated by close switch.
- Like the Schottky diode, an SCR can also be turned on without gate triggering by increasing  $V_{AK}$  to a value exceeding  $V_{BR}(F_0)$

## Turning the SCR OFF

- When the gate returns to  $0V$ , after the trigger pulse is removed, the SCR cannot turn off
- It stays in the on state until the anode current  $I_A$  drop below  $I_H$



# SCR Characteristic Curves



# SCR Characteristics and ratings

1) Forward breakover voltage :  $V_{BR(F)}$

This is the voltage at which the SCR enters the forward conduction region.

$V_{BR(F)}$  is maximum when  $I_G = 0$ .

When  $I_G$  increases,  $V_{BR(F)}$  decreases.

2) Holding Current :  $I_H$

This is the value of anode current below which the SCR switches from the forward conduction region to the forward blocking region

$I_H \downarrow$  as  $I_G \uparrow$

3) Gate triggering Current :  $I_{GT}$

This is the value of gate current necessary to switch the SCR from the forward blocking region to the forward conduction region

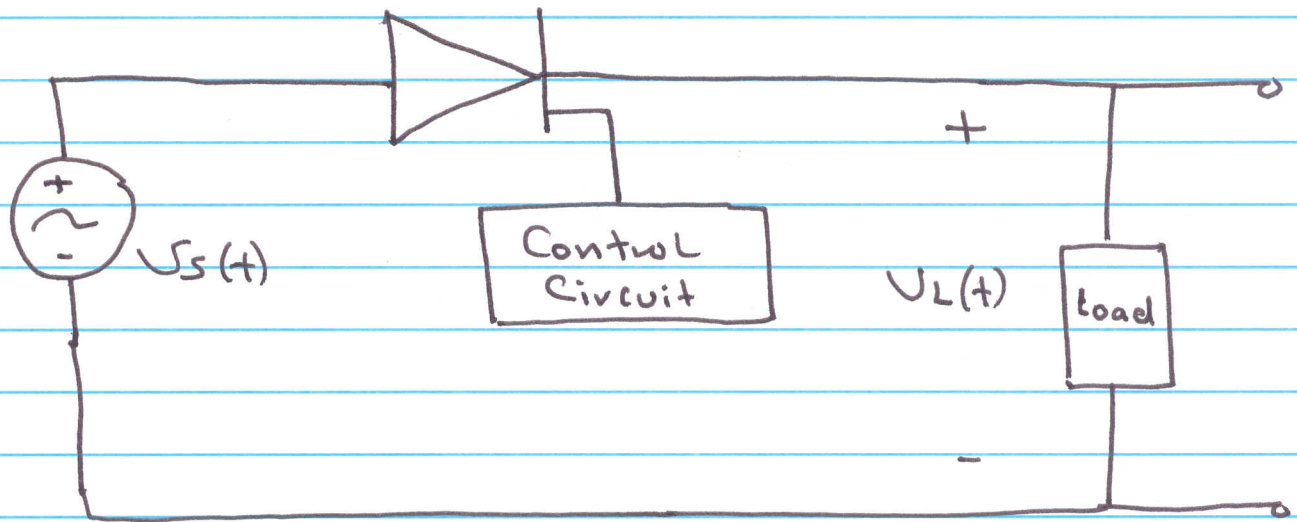
4) Forward Conduction region :

This region correspond to the on condition of the SCR where there is forward current from Anode to Cathod.

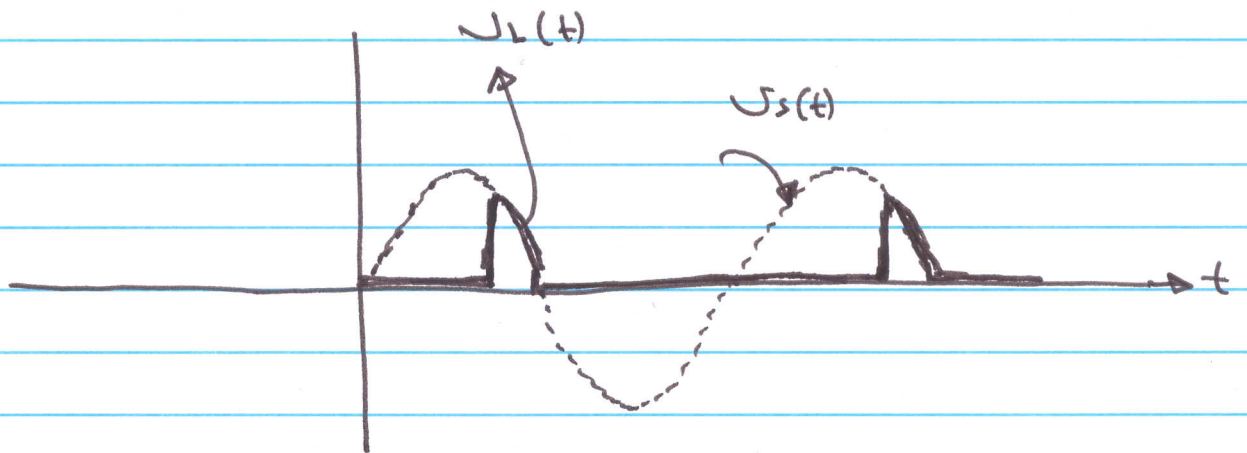
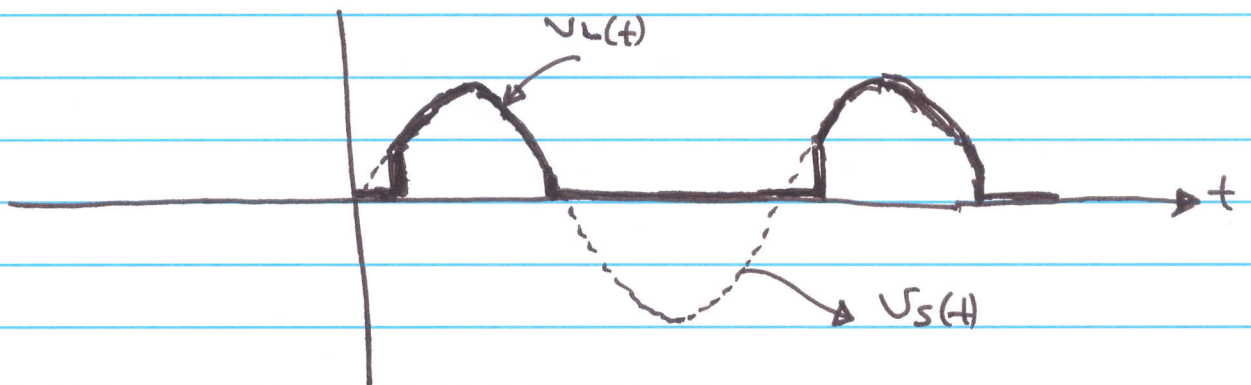
5) Forward blocking region :

This region correspond to the OFF condition of the SCR where the forward current from anode to cathod is blocked by the open circuit of the SCR.

# SCR Application



The average current flow to a load can be controlled by placing an SCR in series with the load.





Conduction angle : is the number of Degrees of an ac cycle during which the SCR is turned on

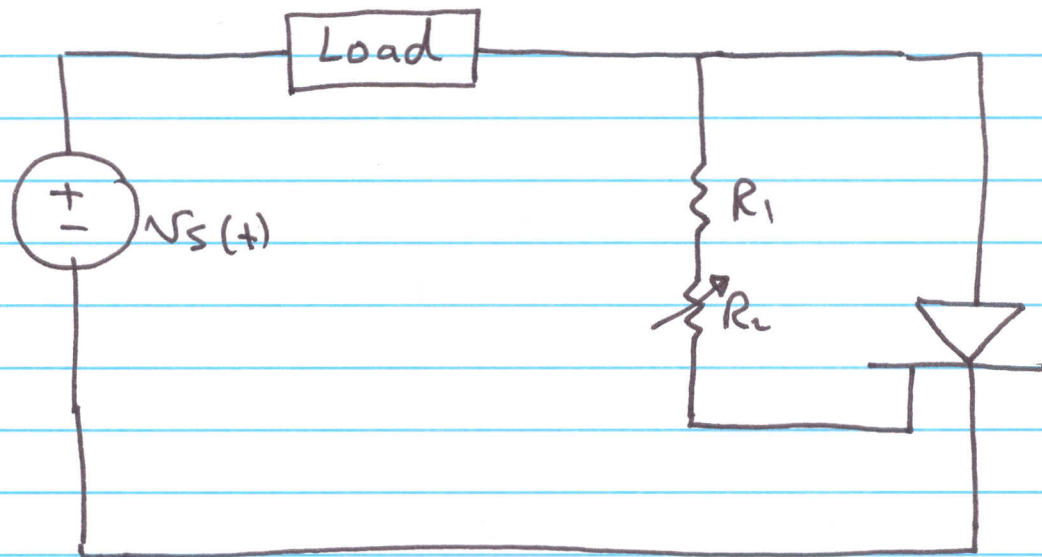
Firing delay angle : is the number of Degrees of an ac cycle elapses before the SCR is turned on.

The SCR spends a certain portion of the ac cycle time in the on state, and the remainder of the time is in the off state.

The amount of time spent in each state is controlled by the gate.

The SCR can not be turned on more than half the time.

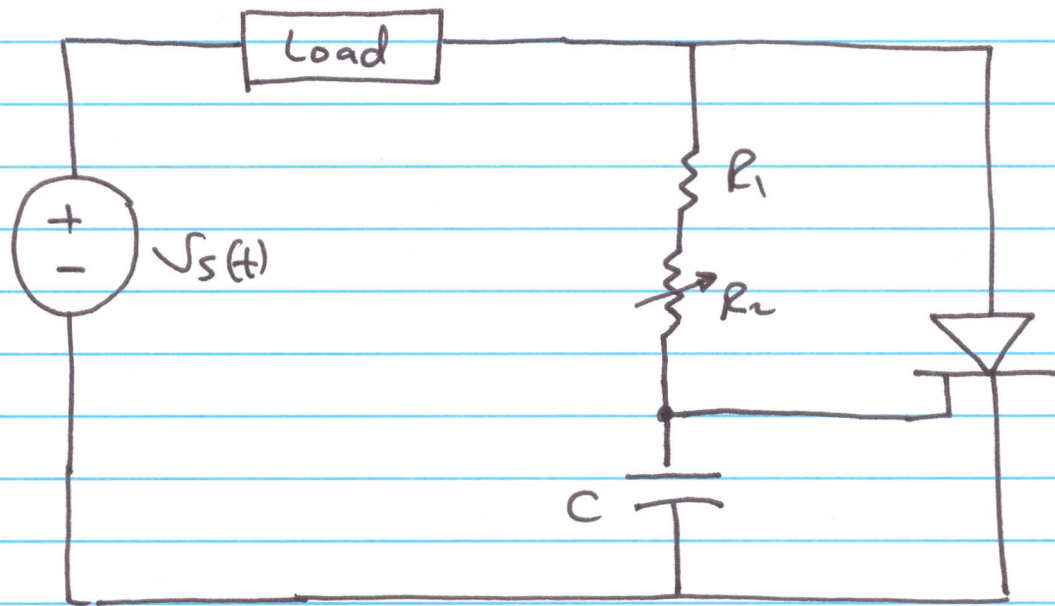
# Typical Gate Control Circuits



- The same voltage supply  $V_s(t)$  is used to power both the gate control and the load
- When the supply voltage  $V_s(t)$  is positive and large enough so that  $I_G > I_{GT}$ ; the SCR turns on
- The firing angle is determined by the setting of  $R_2$
- $90 > \alpha > 0$

## Other Gate Control Circuit

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Firing delay angle could be greater than  $90^\circ$

$R_2 \uparrow$ ,  $\tau \uparrow$ ,  $\theta \uparrow$