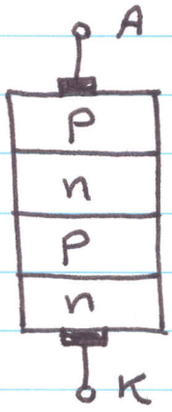
Thyristors and other Devices

Thyristors

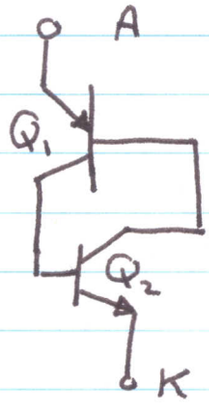
- Devices constructed of four semiconductor layers
- They act as open circuits capable of withstanding a certain rated voltage until they are triggered
- When triggered, they turn on and become low-resistance current path, and remains on, even after the trigger is removed, until the current is reduced 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



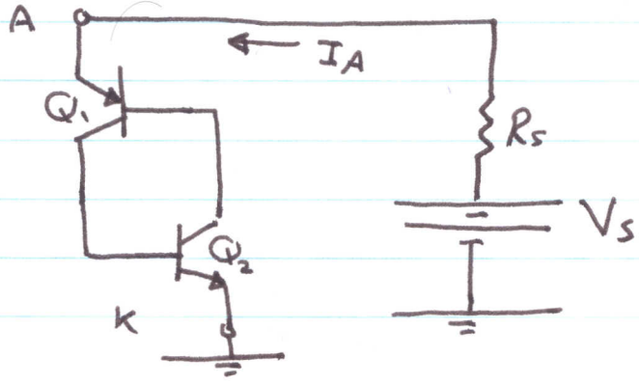
Basic Construction

Circuit Symbol

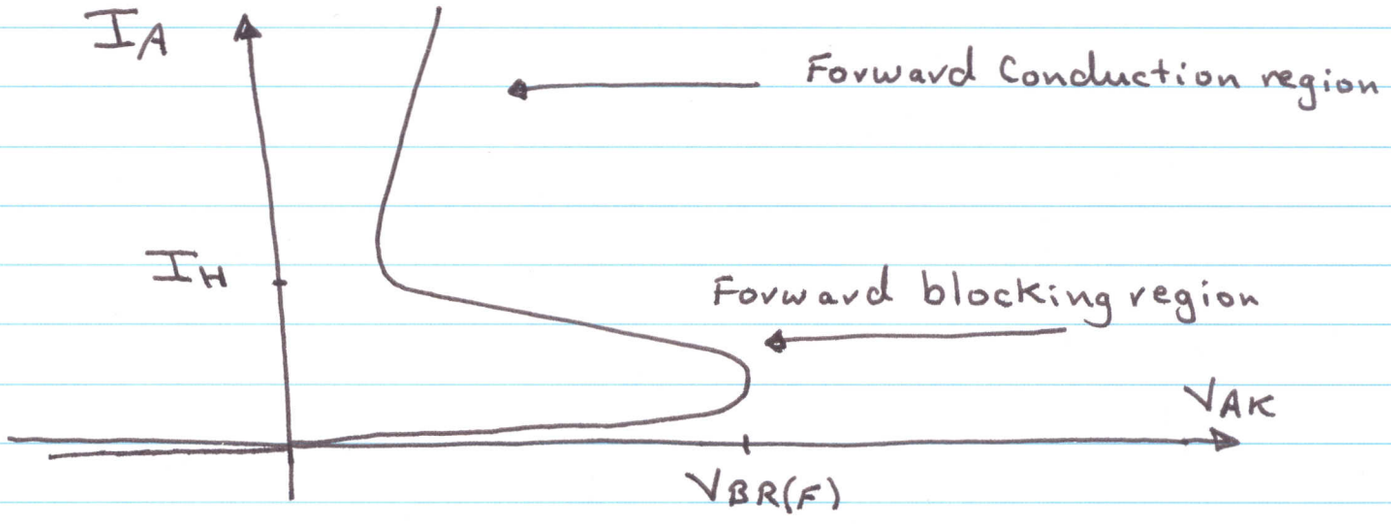


Equivalent Circuit

- The basic 4-lyer device
- It is a two terminal device
- It acts as a switch
- It remain off until the forward voltage reacher a certain value ; then it turns on and Conducts Current.
- Conduction Continue until the Current is reduced below aspecified value



Characteristic Curve

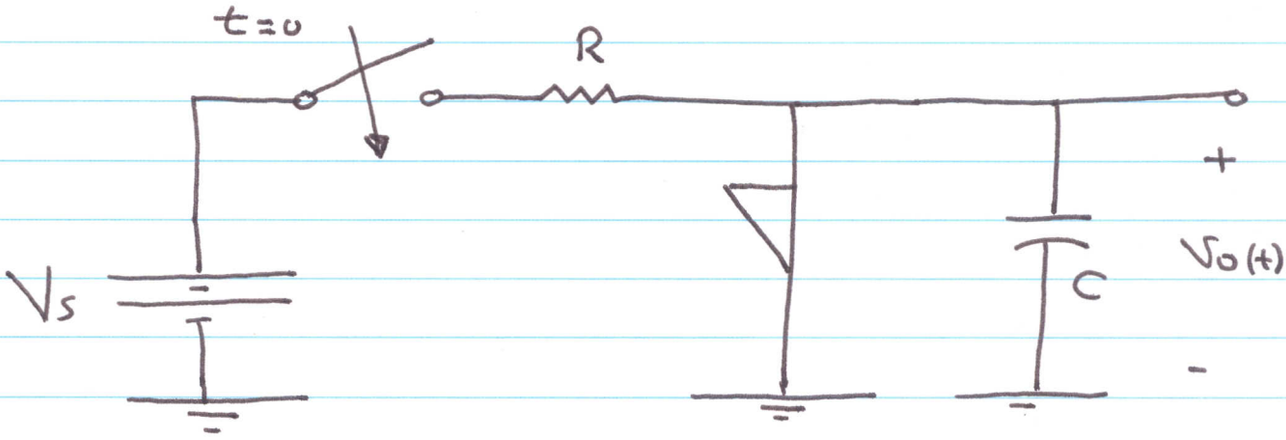


$V_{BR(F)}$ ≡ Forward breakover voltage

I_H ≡ Holding Current

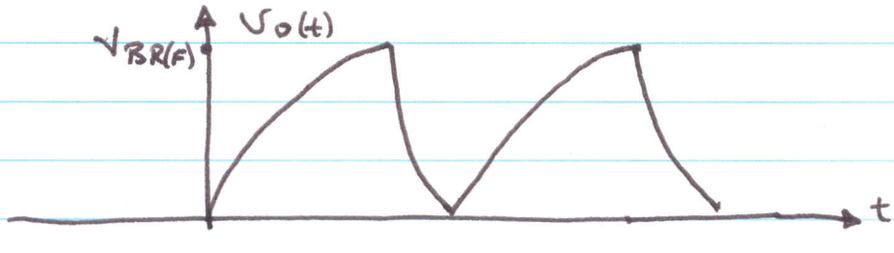
* when $V_s > V_{BR(F)}$; the device is in the on state and acts as a closed switch
* when the anode current I_A drops back below the holding value I_H, the device turns OFF (open circuit)

Application : Relaxation Oscillator

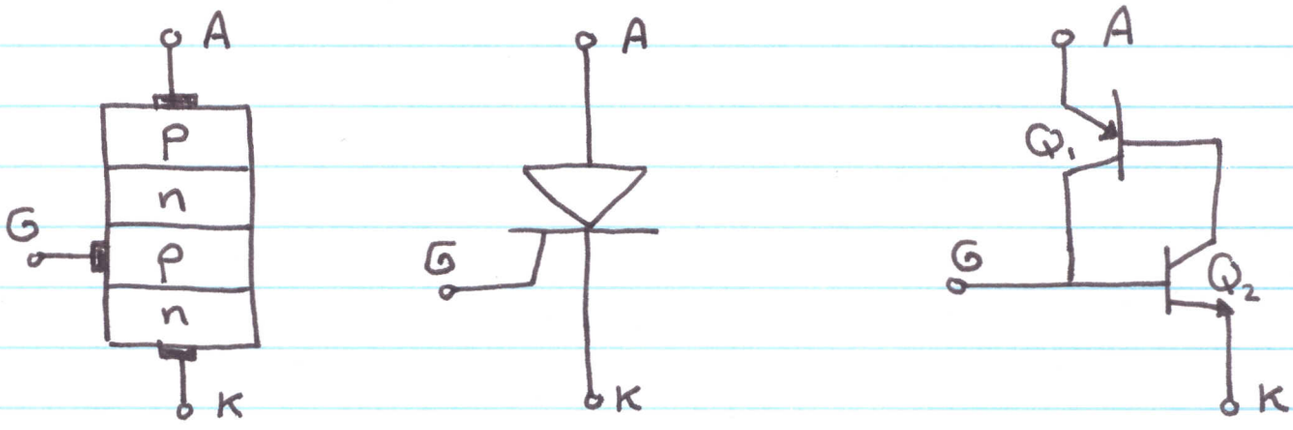


$V_{C(0^-)} = 0$

- At $t = 0^+$, $V_{C(0^+)} = V_{AK(0^+)} = 0$; the device is OFF (open circuit)
- The capacitor charger through R until its voltage reacher $V_{BR(F)}$
- The device switch into conduction (short circuit)
- The capacitor rapidly discharge through the device until $I_A < I_H$
- The device switch back to the OFF state

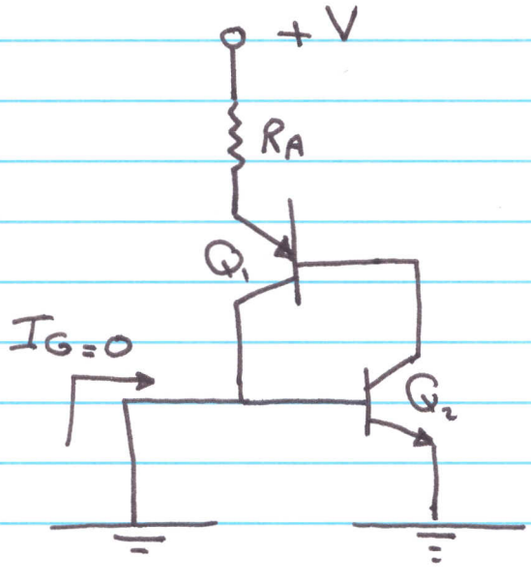


The Silicon Controlled Rectifier : SCR

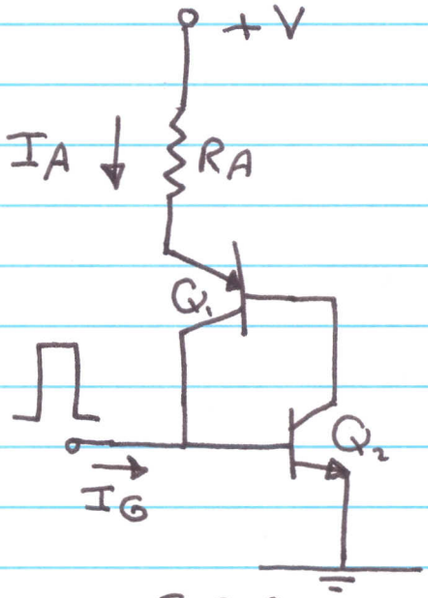


- It is a three terminal device
- It is four Layer pnpn device
- It acts as a switch
- In the off state ; it acts as an open circuit between Anode and Cathod
- In the on state , it acts as short circuit from A to K

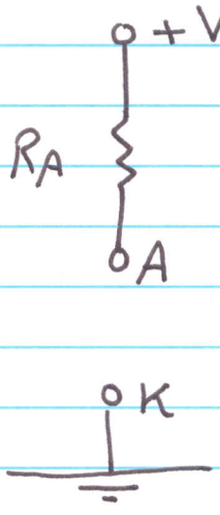
Turning the SCR On

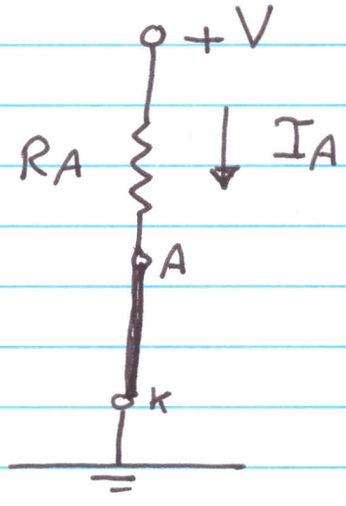


SCR OFF



SCR On





- When $I_G=0$; it act as the Schockley diode in the off state (open Circuit)
- When a positive pulse of Current (trigger) is applied to the gate, both transistors

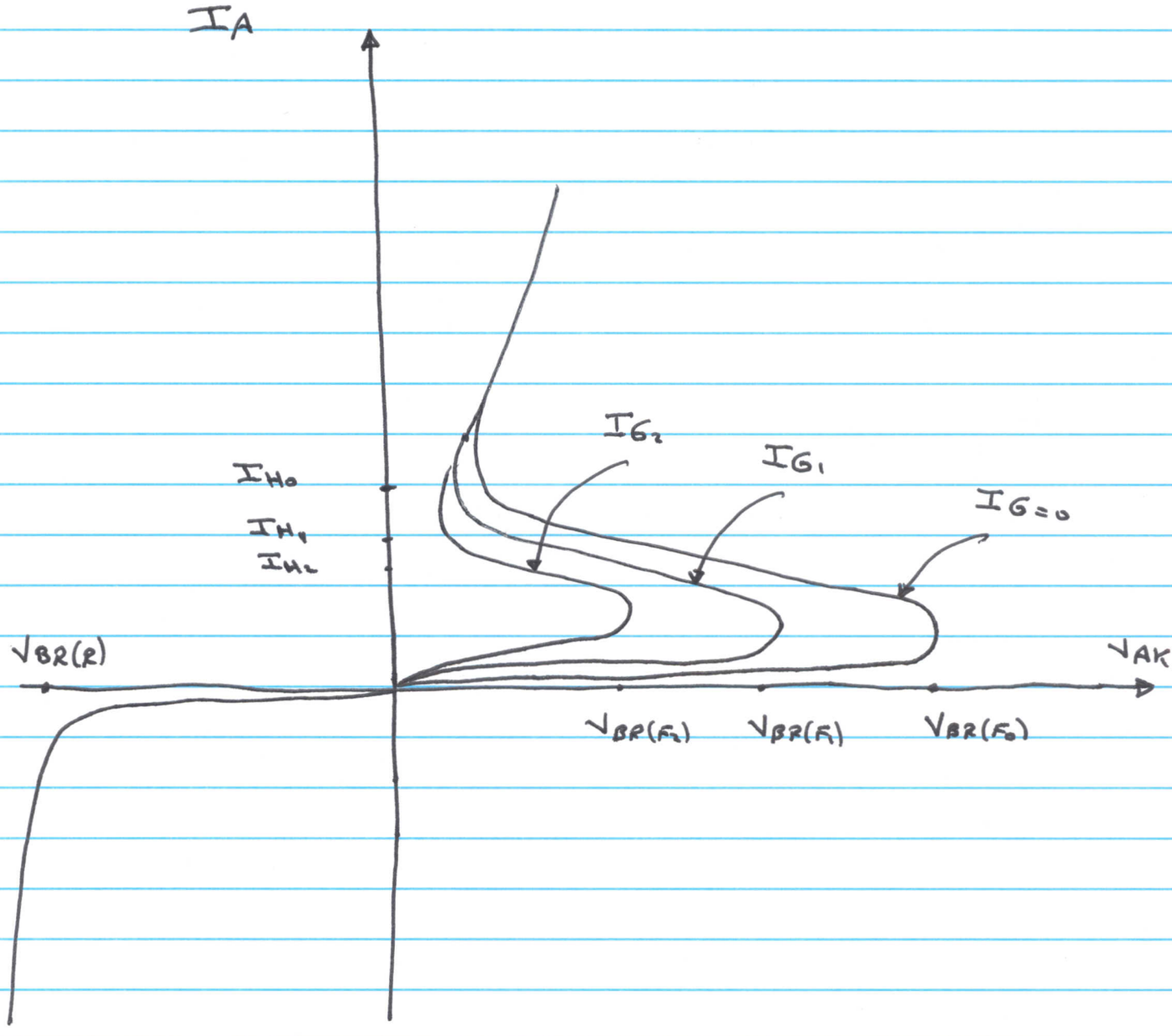
turn on

- The SCR stays on (Latcher) once it is triggered on
- In this state, SCR can be approximated by close switch.
- Like the schockley 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 can not turn off
- It stays in the on state until the anode current I_A drop below I_H

SCR Characteristics 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

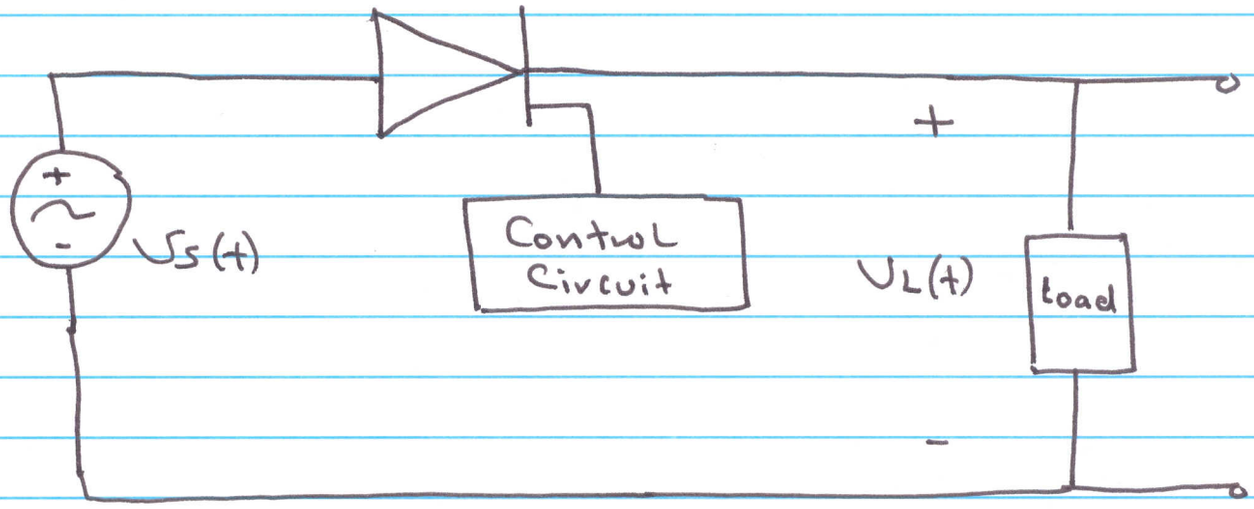
4) Forward Conduction region :

This region Corrverpond to the on Condition of the SCR where there is forward Current from Anode to Cathod.

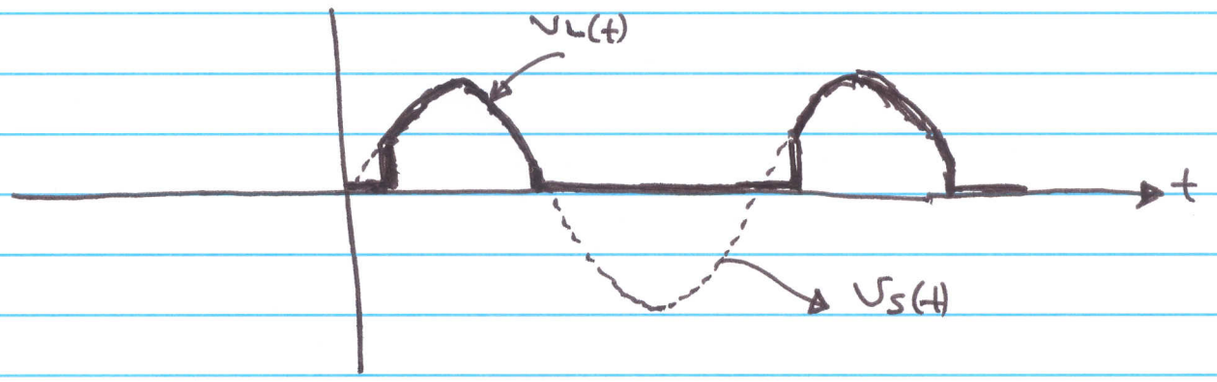
5) Forward blocking region :

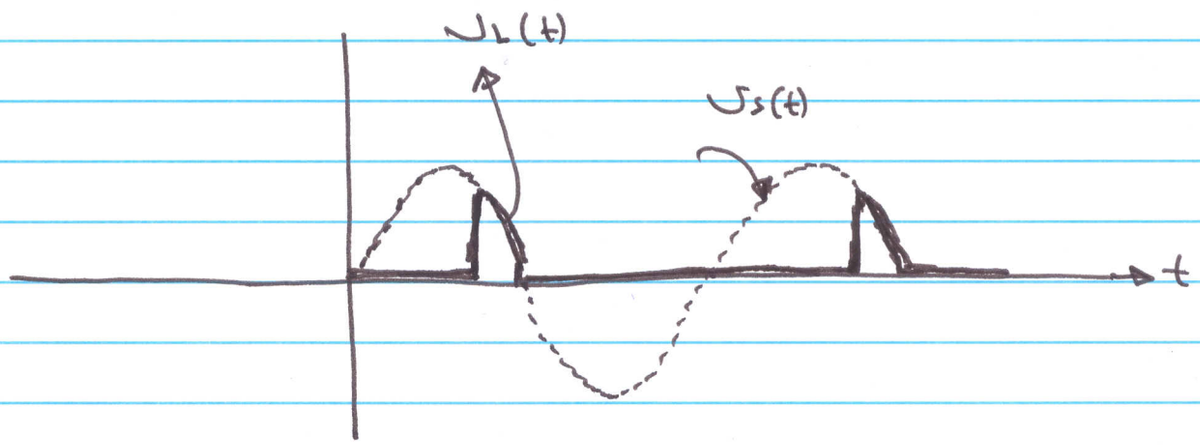
This region Corrverpond to the OFF Condition of the SCR where the forward Current from anode to Cathod is blocked by the open Circuit of the SCR.

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

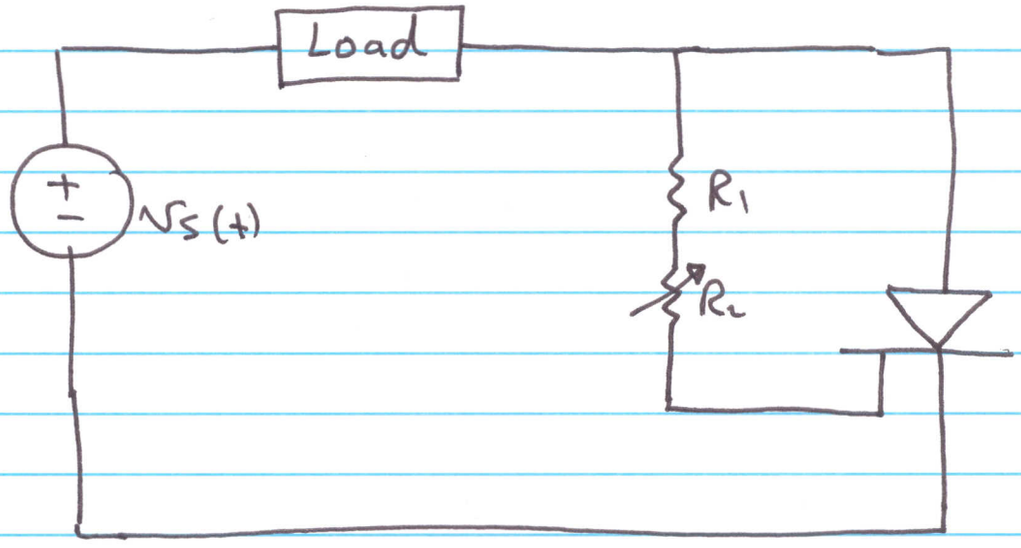
Firing delay angle : is the number of Degrees of an ac Cycle elapes before the SCR is turned on.

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.

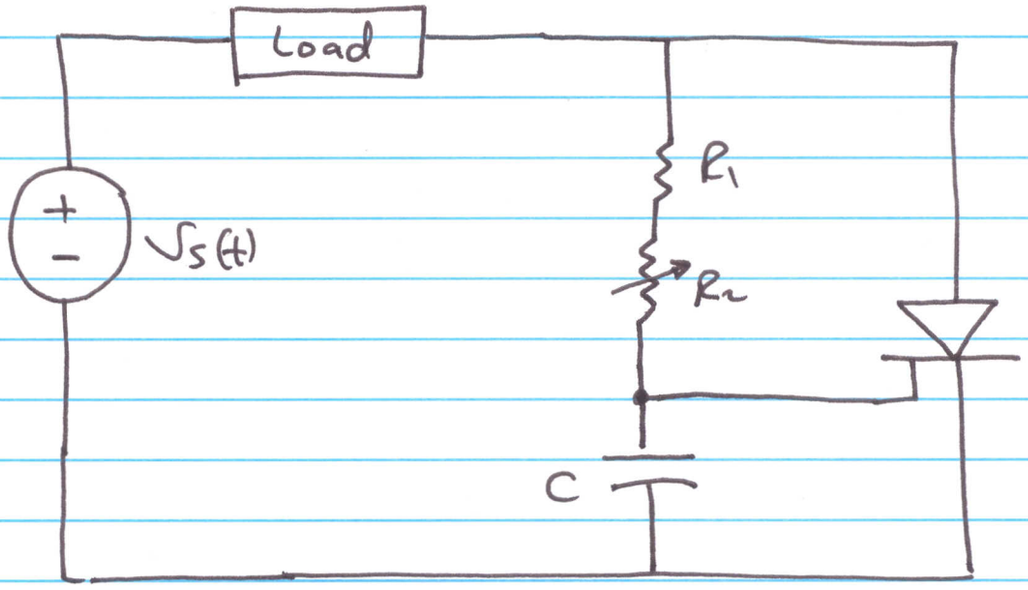
The SCR Can not be turned on more than half the time.

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
- $90 > \theta > 0$

Other Gate Control Circuit



Firing delay angle could be greater than 90°

$R_2 \uparrow$, $T \uparrow$, $\theta \uparrow$