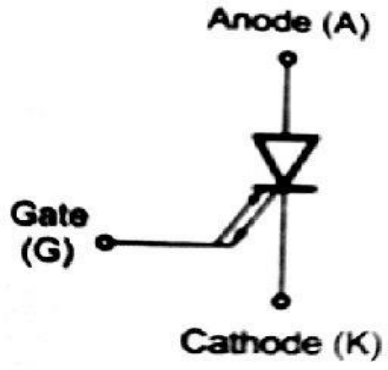
GATE TURN-OFF THYRISTOR (GTO)

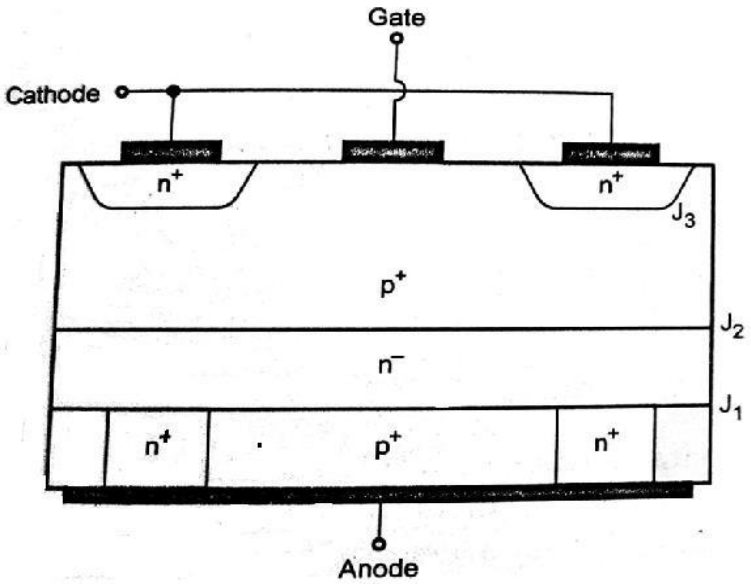
A GTO is a PNPN device like a conventional SCR but it can be turned ON by a small positive gate current and turned OFF by a slightly large pulse of negative gate current.

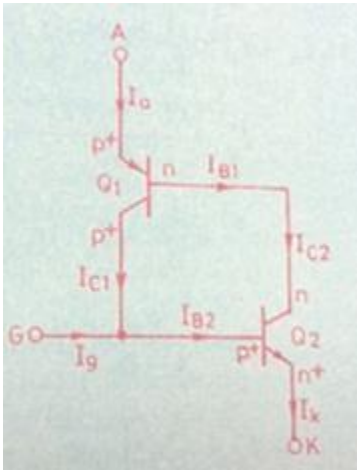
This turn off capability of GTO makes it most suitable device for inverter and chopper circuits without using expensive and bulky commutation circuits. GTO has higher switching speed than regular SCR and can withstand higher voltage and current than BJT and MOSFET. The symbol of GTO is shown below.



Structure of GTO:

- A GTO is a PNPN, three terminal device with Anode (A), cathode (K) and gate (G).
- The four layers are p+ n^- p+ n+ as shown in the fig.
- The anode p+ layer has n+ type fingers diffused into it.
- Like a regular SCR, the GTO can be modeled by a two transistor analogy as shown in fig.
- Transistor Q_1 is p+ n- p+ type and transistor Q_2 is n- p+ n+ type, with p+ emitter of Q_1 as anode and n+ emitter of Q2 as cathode. Fig also shows the symbol of the GTO.





Operation: The turn-on and turn-off mechanism of a GTO can be explained as follows:

Turn-on mechanism:

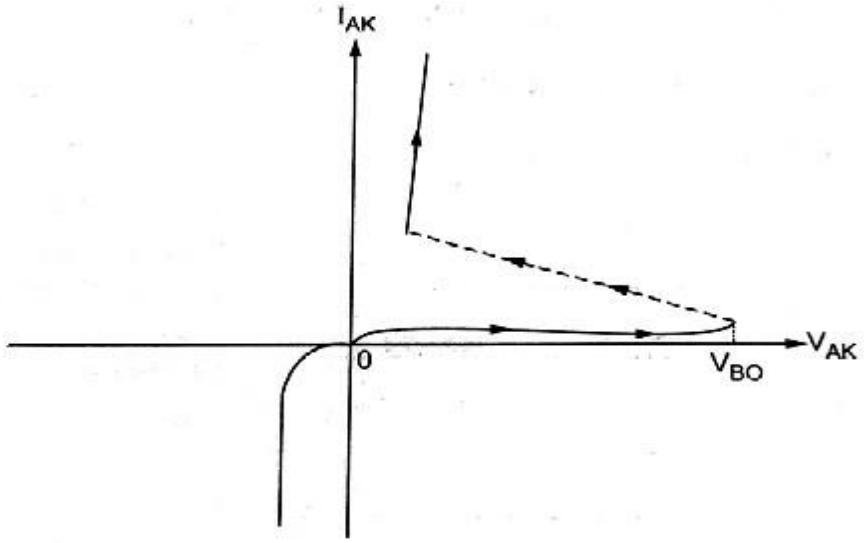
- Turning on of a GTO is similar to that of a conventional transistor.
- With GTO being forward biased, it is turned on by applying a small positive gate current.
- When a positive gate current is applied, the current gains α1 and α2 of pnp and npn transistors begins to rise.
- When α1+α2=1, saturation level is reached and the GTO is turned on just like SCR. The anode current I_A is limited by load impedance.

Turn-off mechanism:

- The turn-off action can be explained as follows.
- Considering two transistor model of GTO, when negative voltage is applied to the gate, the excess carriers are drawn from the base of the npn transistor and collector of pnp transistor and is directed into external gate circuit.
- This removes base drive of npn transistor and in turn base drive of pnp transistor is removed.

- Now both the transistor goes into cutoff region and the anode current goes on decreases and finally the device stops conducting.

GTO CHARACTERSTICS



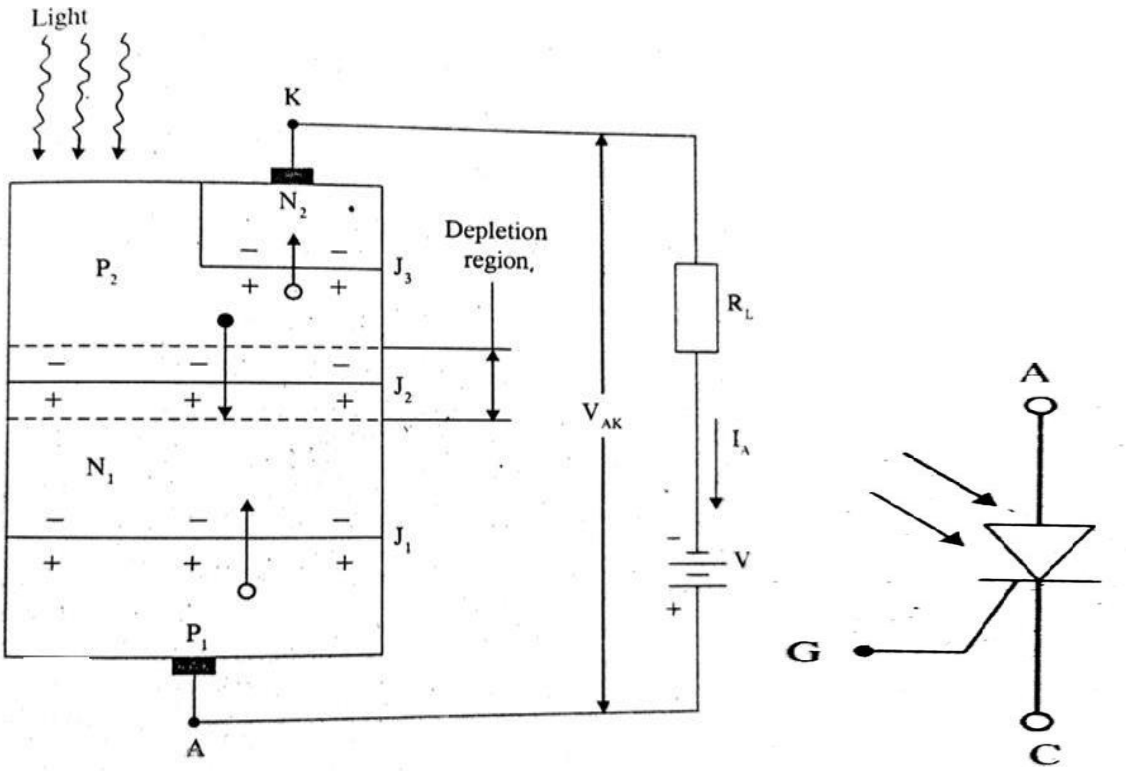
- The V-I characteristics of GTO in forward direction are similar to that of SCR.
- But in reverse direction GTO has virtually no blocking capability.
- Observe that GTO starts conducting in reverse direction after very small reverse (20 to 30 V) voltage. This is because of the anode short structure.

Applications of GTO: GTOs are used in

1. High performance drive systems, such as field oriented controlled scheme used in rolling mills, robotics and machine tools
2. Traction purposes because of their lighter weight
3. Adjustable frequency inverter drives.

LIGHT ACTIVATED SCR (LASCR)

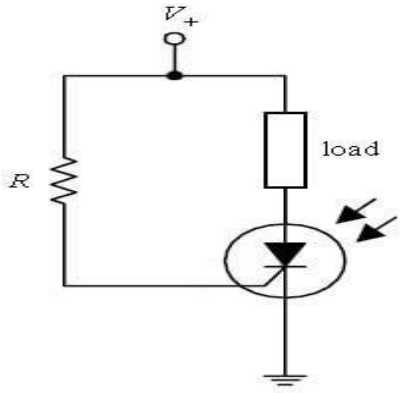
A light activated silicon controlled rectifier (LASCR) is a silicon controlled rectifier (Thyristor) that conducts when the gate is exposed to light. The structure and symbol of an LASCR is shown in figure. LASCR is turned ON with light source or sometimes the combination of light source and gate signal. For this, the gate is biased with voltage or current slightly less than that required to turn ON. Then a beam of light is directed at inner P layer junction to turn ON the SCR. The light intensity required to turn on is depends on voltage applied to gate. Higher the gate voltage, lower is the light intensity required.

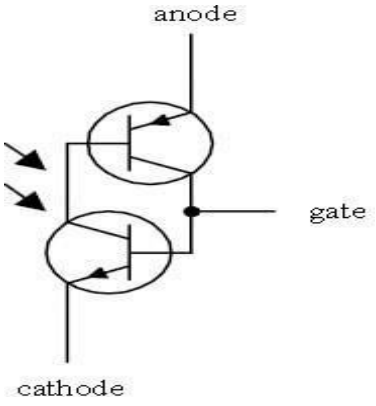


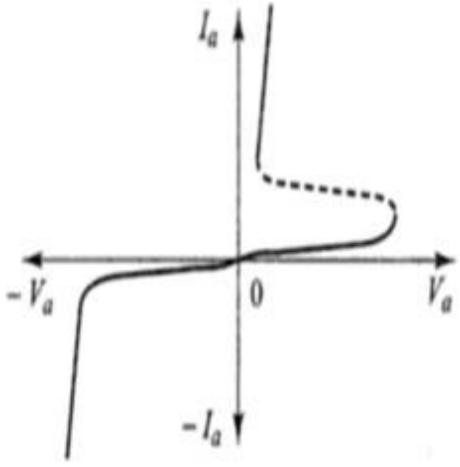
Operation of LASCR:

- With forward bias applied to the LASCR and light is made to fall on P2 gate region, electron-hole pairs are created at junction J3.

- The electrons from junction J1 and holes from junction J3 arrive at junction J2 and reduce the resistance of J2 region.
- This causes voltage across junction J2 to reduce and voltage across junctions J1 and J3 to increase.
- This further increases the carrier injection from junctions J1 and J3. These injected carriers arrive at J2 and further reduces the resistance of J2.
- This continues till the avalanche breakdown of junction J2 occurs and the device turns on.
- Once turned on, the device continues to be in on state even when the light source is removed.
- The device can be turned off only by reducing the current below holding current value.
- If the intensity of light falling on the SCR is increased, the device turns on at a lower applied voltage.







Applications

1. The Light activated SCRs have complete electrical isolation between the light triggering source and the high voltage anode-cathode circuit.
2. In High Voltage Direct Current(HVDC) transmission systems, several SCRs are connected in series-parallel combination and their light-triggering has the advantage of electrical isolation between power and control circuits.
3. The primary use of light triggered thyristors is in high-voltage high- current applications, Static reactive-power compensation etc.
4. They are also used in power control circuit that requires response to the light.

Question Bank on GTO:

1. Define GTO and list its applications
2. Explain the principle of operation of GTO
3. Draw the layer structure of LASCR and explain its operation.