Unit 2: **Silicon Controlled Rectifier (SCR)**

Module 08: PUT firing circuit, Pulse transformer firing circuit and Light activated firing circuit, SCR as a Static switch.

The **Gate Triggering Circuit** means a signal is applied between the gate and the cathode of SCR. These are three types,

DC Signals

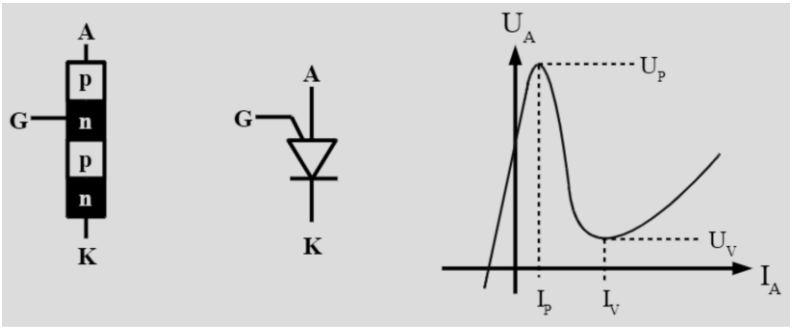
AC Signals

Pulse signals.

Programmable UJT (PUT).

- PUT is similar to UJT, however It is programmable
- It has a four layered construction just like the thyristors and have three terminals named anode(A), cathode(K) and gate(G) again like the thyristors
- It is called programmable because the parameters like intrinsic standoff ratio (η) and peak voltage(Vp) can be programmed with the help of two external resistors.
- The main applications of programmable UJT are relaxation oscillator, thyristor firing, pulse circuits and timing circuits.

The internal block diagram and circuit symbol of PUT are shown below.



From the above figure, you can see that the PUT has a four layered construction. Topmost P-layer is called the anode (A). The N-layer next to the anode is called the gate (G). The P-layer next to the gate is left alone. The bottom most N-layer is called cathode (K). Ohmic contacts are made on the anode, cathode and gate layers for external connection.

PUT characteristics.

PUT characteristics is essentially a plot between the anode voltage Va and anode current Ia of the PUT. The typical biasing diagram and characteristics plot of a PUT is shown below.

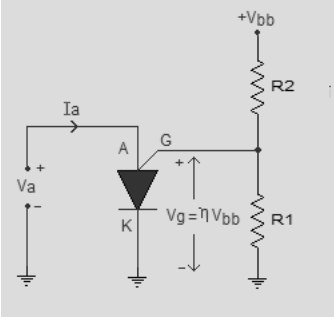


Fig 3: PUT biasing circuit

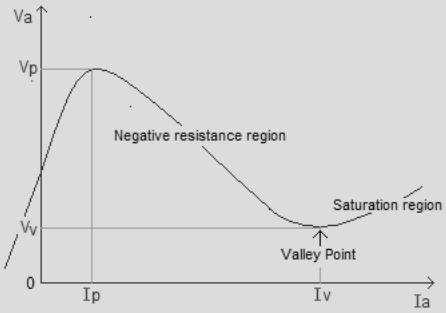


Fig 4: PUT characteristics

Typically, the anode of the PUT is connected to a positive voltage and the cathode is connected to the ground. The gate is connected to the junction of the two-external resistor R1 and R2 which forms a voltage divider network. It is the value of these two resistors that determines the intrinsic standoff ratio(η) and peak voltage (Vp) of the PUT.

When the anode to cathode voltage (Va)is increased the anode current will also get increased and the junction behaves like a typical P-N junction. But the Va cannot be increased beyond a particular point. At this point sufficient number of charges are injected and the junction starts to saturate. Beyond this point the anode current (Ia) increases and the anode voltage (Va) decreases. This is equal to a negative resistance scenario and this negative resistance region in the PUT characteristic is used in relaxation oscillators. When the anode voltage (Va) is reduced to a particular level called “Valley Point”, the device becomes fully saturated and no more decrease in Va is possible. There after the device behaves like a fully saturated P-N junction.

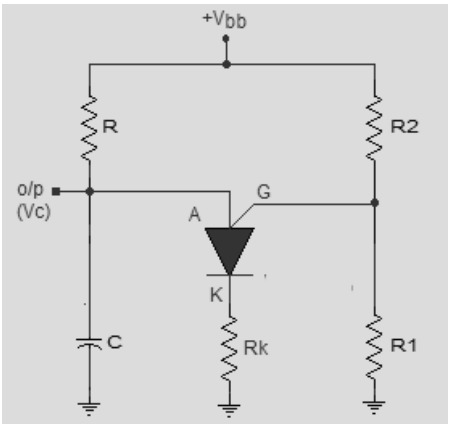
Peak voltage (Vp): It is the anode to cathode voltage after which the PUT jumps into the negative resistance region. The peak voltage Vp will be usually one diode drop (0.7V) plus the gate to cathode voltage (Vg). Peak voltage can be expressed using the equation:
Vp = 0.7V + Vg = 0.7V + VR1 = 0.7V + ηVbb . Where η is the intrinsic standoff ratio and Vbb is the total voltage across the external resistor network.
Intrinsic standoff ratio (η) : Intrinsic standoff ratio of a PUT is the ratio of the external resistor R1 to the sum of R1 and R2. It helps us to predict how much voltage will be dropped across the gate and cathode for a given Vbb. The intrinsic standoff ratio can be expressed using the equation:

η = R1/(R1+R2).

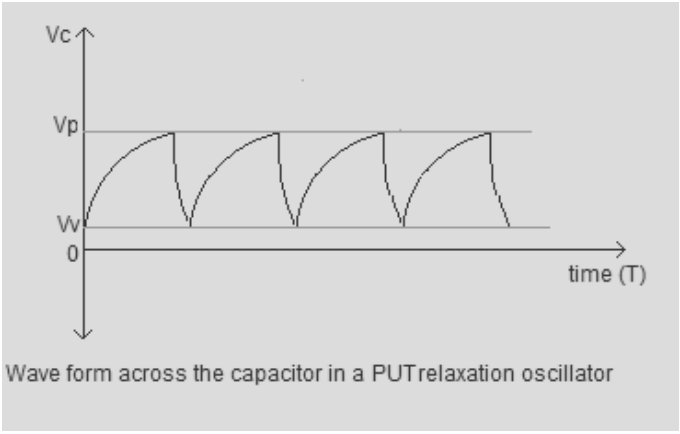
PUT oscillator for generating firing pulses to trigger SCR

Relaxation oscillator is of course the most common application of a programmable UJT. PUT relaxation oscillator can be used for generating a wide range of saw tooth wave forms. It is called a relaxation oscillator because the timing interval is started by the gradual charging of

a capacitor and the timing interval is terminated by the sudden discharge of the same capacitor. The circuit diagram of a PUT relaxation oscillator is shown below.



Resistors R1 and R2 set the peak voltage (Vp) and intrinsic standoff ratio (η) of the PUT. Resistor Rk limits cathode current of the PUT. Resistor R and capacitor C sets the frequency of the oscillator. When the supply voltage Vbb is applied, the capacitor C starts charging through resistor R. When the voltage across the capacitor exceeds the peak voltage (Vp) the PUT goes into negative resistance mode and this creates a low resistance path from anode(A) to cathode(K). The capacitor discharges through this path. When the voltage across the capacitor is below valley point voltage (Vv) the PUT reverts to its initial condition and there will be no more discharge path for the capacitor. The capacitor starts to charge again and the cycle is repeated. This series of charging and discharging results in a sawtooth waveform across the capacitor as shown in the figure below.



Wave form across the capacitor in a PUTrelaxation oscillator

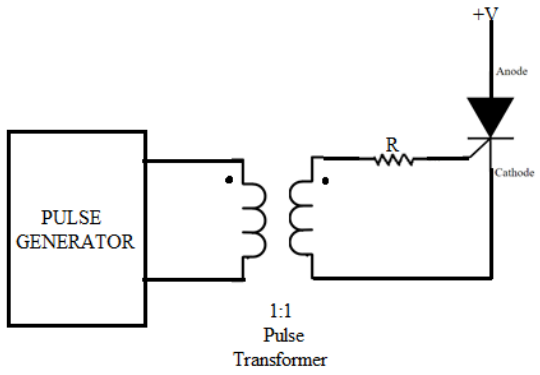
The frequency of oscillation of a PUT relaxation oscillator can be expressed by the following equation:

$$F = 1/ (RC \ln(1/(1-\eta)).$$

Where F is the frequency, η is the intrinsic standoff ratio, R is the resistance and C is the capacitance.

Pulse Transformer Firing Circuit

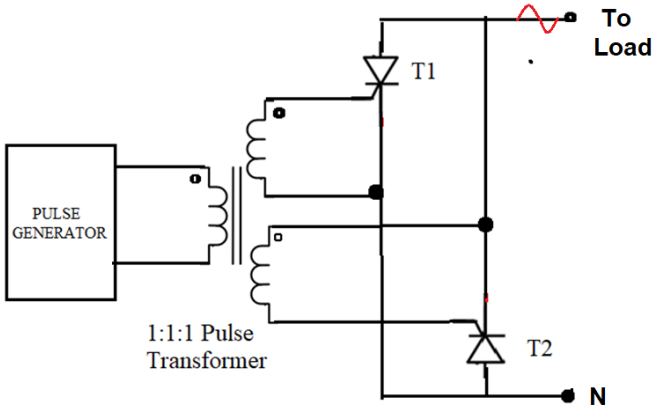
The Pulse Triggering is the most popular method for triggering the SCR. In this type the gate circuit can produce a single pulse appearing periodically or a sequence of high frequency pulses. Pulse transformer is used for isolation.



Pulse transformer consists of one primary winding and one or more secondary windings. It is used in pulsed mode of triggering.

Advantages:

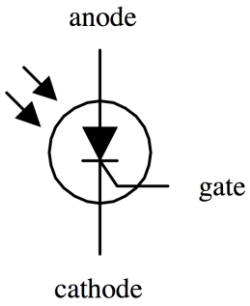
Easy to use
Provides very good isolation between power circuitry and the triggering circuitry.



1. Pulse Transformer output G1 (To SCR gate-1)
2. Pulse Transformer output K1 (To SCR Cathode-1)
3. Pulse Transformer output G2 (To SCR gate-2)
4. Pulse Transformer output K2 (To SCR Cathode-2)

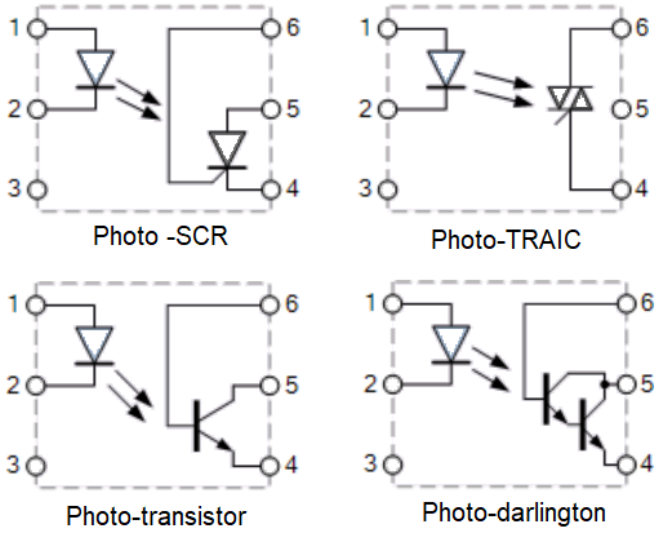
The commonly used pulse transformers are 1:1 or 1:1:1 and are designed to have low winding resistance, low leakage reactance and low inter-winding **capacitance**.

LASCR (Light Activated Silicon Controlled Rectifier)

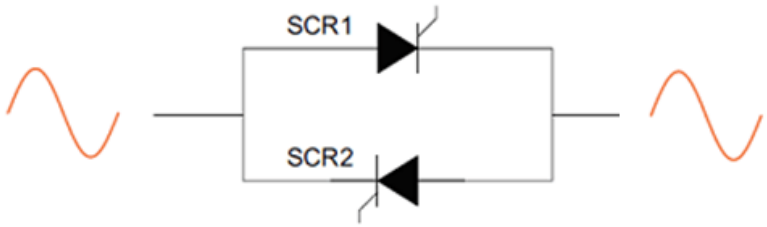


- Provides optical isolation between the firing circuit and the load circuit.
- Commonly used in industrial applications where a three-phase voltage up to 440V ac and currents up to 1000A are controlled.
- These circuits have uncontrolled transient voltage spikes that may be 3-4 times the original supply voltage.
- If these transient voltages make their path into the firing circuits, they may damage the device.
- In traditional circuits these transient spikes travel from the load circuit back into the firing circuit through a common ground, however an opto-coupler such as LASCR blocks the reverse path for such transients to appear on the side of firing circuits, thus protecting device.

TYPES OF OPTOCOUPLERS

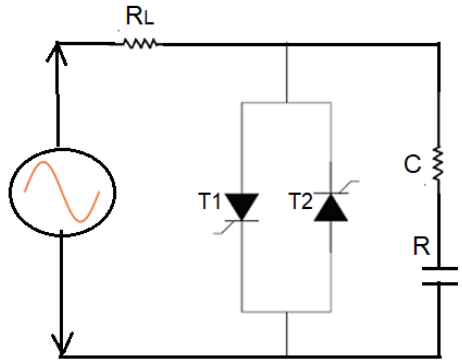


SCR as Static switch.

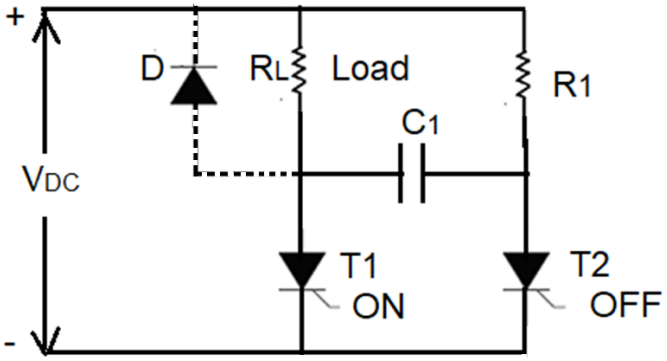


- The static switch is an device that uses power semiconductor devices for the ON-OFF switching action.
- It has both conducting(ON) and non-conducting(OFF) stable states.
- The static switch is so-called as it typically uses semiconductor silicon controlled rectifiers (SCRs) rather than mechanical switching elements.

AC Static Switch



DC Static Switch



Advantages of static switches

- They are totally static, hence no arc is produced during their operation and they are totally silent in operation.

- They are very fast, compact and have a long life.
- They are much more reliable, and their range is much wider than that of electromechanical switches.
- They can be operated in explosive atmospheres like mines.

Applications of Static switches

These switches are extensively used as solid state relays.

- Power control for aircraft.
- Traffic signal controls.
- Computer control applications.
- UPS systems.