**Unit 4**: **Protection of Power Semiconductor devices**

**Module 12**: Gate protection using shielding and RF filters, Snubber circuit

**Introduction**

Like a thyristor, Gate circuit should also be protected from overvoltages and overcurrents and spikes. Overvoltages in the gate circuit can cause false triggering and overcurrent can cause high junction temperature.

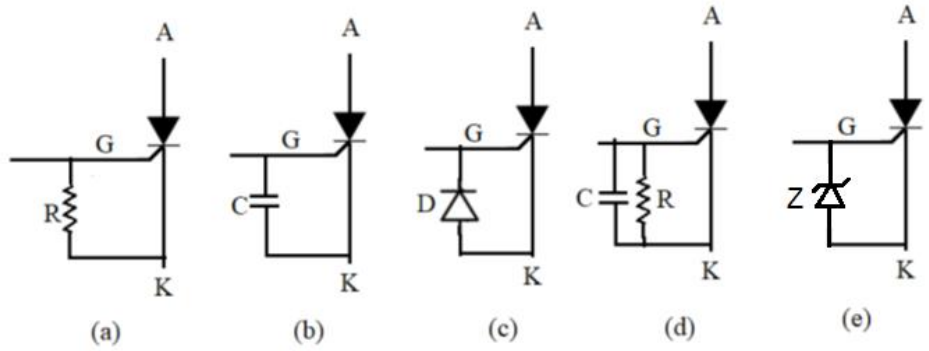
Rapid changes in the thyristor voltage and current can produce unwanted induced voltages across the gate that can cause false triggering of the device.

Over current can cause high junction temperature which may eventually destroy the device.

Therefore, careful screening, grounding and filtering is essential.

Gate protection Circuits

Overvoltages thyristor protection is achieved by using a zener diode and a resistor can be used to protect the gate circuit from overcurrent. Noise in gate circuit can also cause false triggering which can be avoided by using a resistor and a capacitor in parallel. A diode (D) may be connected in series or in parallel with the gate to protect it from high reverse voltage.




(a) Resistor R decreases the gate sensitivity and reduces the turn-off time.

(b) Capacitor C reduces the high frequency noise component by acting as a filter.

(c) Diode D protects the gate from excessive reverse transients and limits the negative bias to 1V (approx).

(d) Capacitor C is used mainly in low power thyristor circuits where dc triggering is used(reduces noise). R limits the dv/dt.

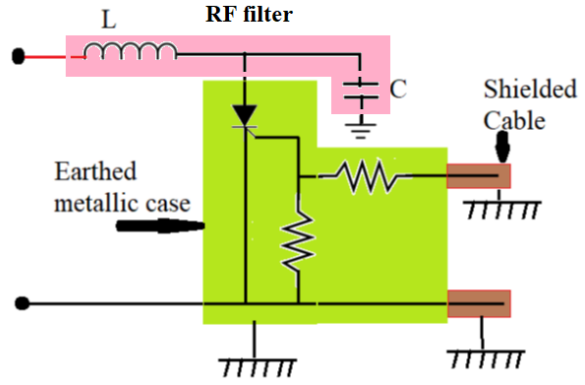
(e) Zener diode is used for gate protection. It protects the gate from negative voltage and also limits the gate voltage to a safe voltage value

**Gate protection from RFI**

Radio Interference Phenomenon

In many power control applications there is frequent switching ON and OFF of a number of SCRs which are mounted close together.
Thus resulting in the collapse of voltage and establishing of current and vice versa.
These changes in the current and voltages results in the generation of electric and magnetic fields.
These changes in electric and magnetic fields give rise to induced voltages in the gate circuits of the nearby thyristors.
These induced voltages may turn on the thyristors at wrong instances, causing mal-operation of the entire control scheme.
This phenomenon is known as radio interference phenomenon.
Hence, the gate cathode circuit of the thyristor must be protected against this phenomenon.

**Gate Protection using shielding and RF filters**




The use of shielded cable protects the gate from spurious signals caused by interference of external electric and magnetic fields.
The RFI is minimized by using R-F filter consisting of a inductance L and capacitance C.

**RF filter**

The effect of radio interference is reduced by using RF filter.

The RF filter is made by using series inductor and parallel capacitor across the circuit.

The inductor decreases the effect of di/dt effect of anode current and capacitor reduces the

effect of forward dv/dt voltage.

The calculation of inductor L and capacitor C is done as below.

$X_L = R_L$ ( Load resisance )

$L = R_L / 2\pi f$

$X_C = R_L$ ( Load resisance )

$1 / 2\pi fC = R_L$

$C = 1 / 2\pi f R_L$

Where f is corner frequency and $R_L$ is load resistance

**Zero voltage switching**

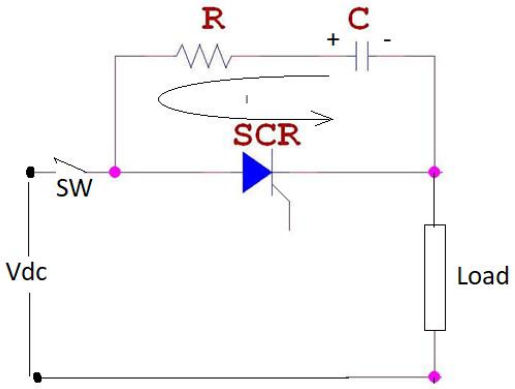
The RF noise contribution of thyristor is primarily due to sudden steps in current as the thyristor switches.

In zero voltage switching the thyristor is switched on at line voltage zeros, giving complete half cycles to the load.

By eliminating the sudden steps of current, the RF noise contribution is brought to an absolute minimum.

This eliminates the use of RF filter components, which for longer heating load, can become quite large and costly.

**Snubber circuit**




Snubber Circuit is a series combination of resistor 'R' and capacitor 'C'.

It is connected across the thyristor to be protected.

The capacitor 'C' is used to limit the dv/dt across the SCR.

The resistor 'R' is used to limit high discharging current through the SCR.

Working Principle of a Snubber Circuit

- When switch S is closed, the capacitor 'C' behaves as a short-circuit. Therefore voltage across SCR is zero.

- As time increases, voltage across 'C' increases at a slow rate.
- Therefore dv/dt across 'C' and SCR is less than maximum dv/dt rating of the device.
- The capacitor charges to full voltage Vs; after which the gate is triggered, and SCR is turned ON and high current flows through SCR.
- As di/dt is high, it may damage the SCR. To avoid this, the resistor R in series with 'C' will limit the magnitude of di/dt.