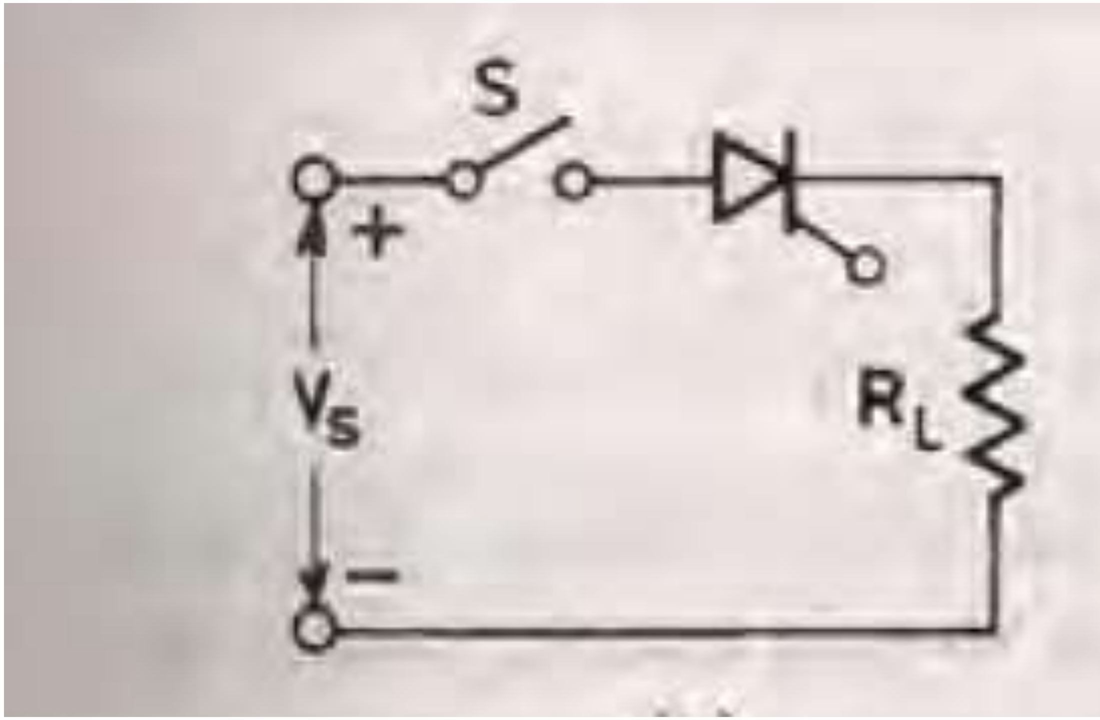
SCR Protection Circuits

SCR di/dt Protection

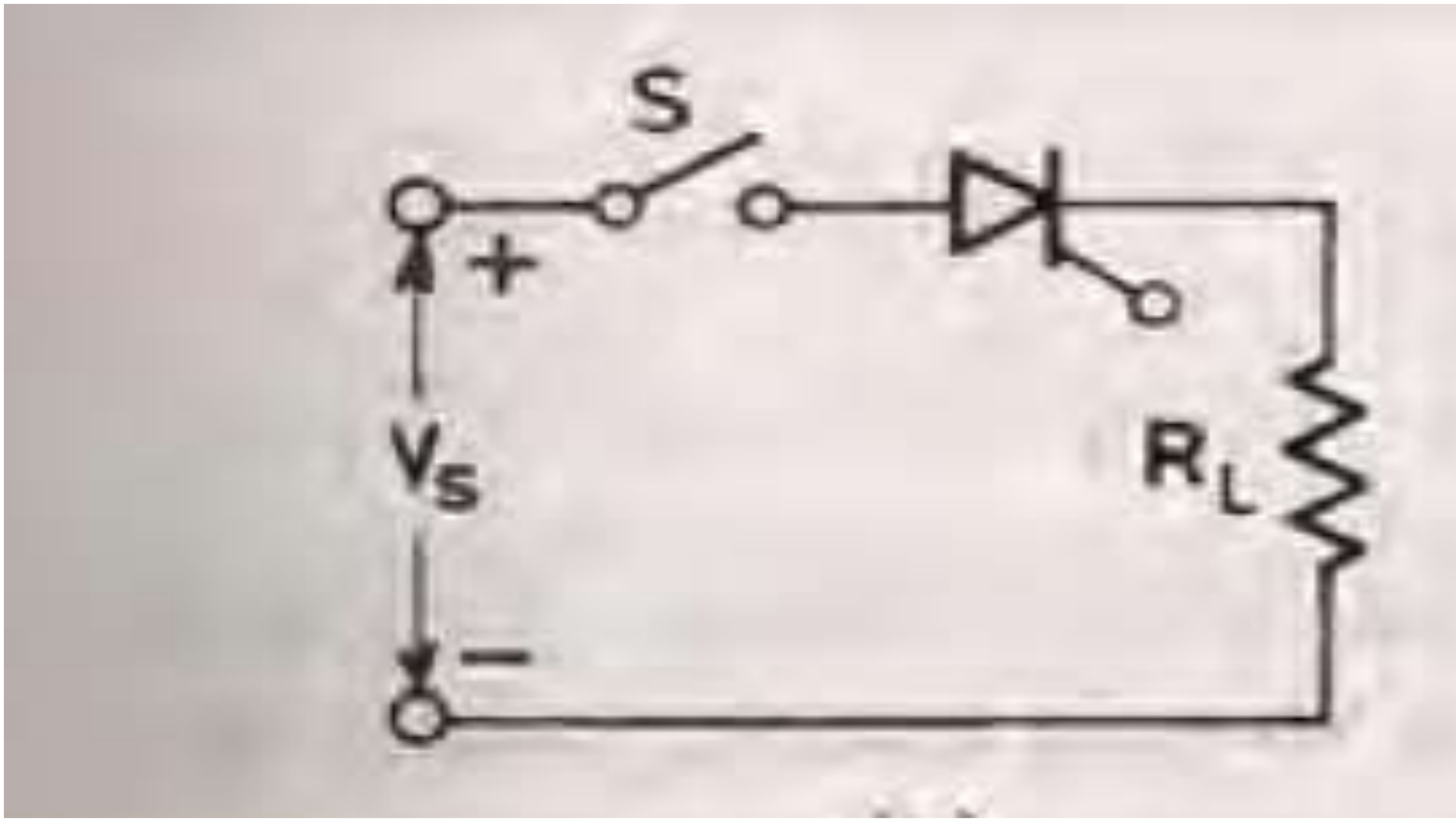


SCR di/dt Protection

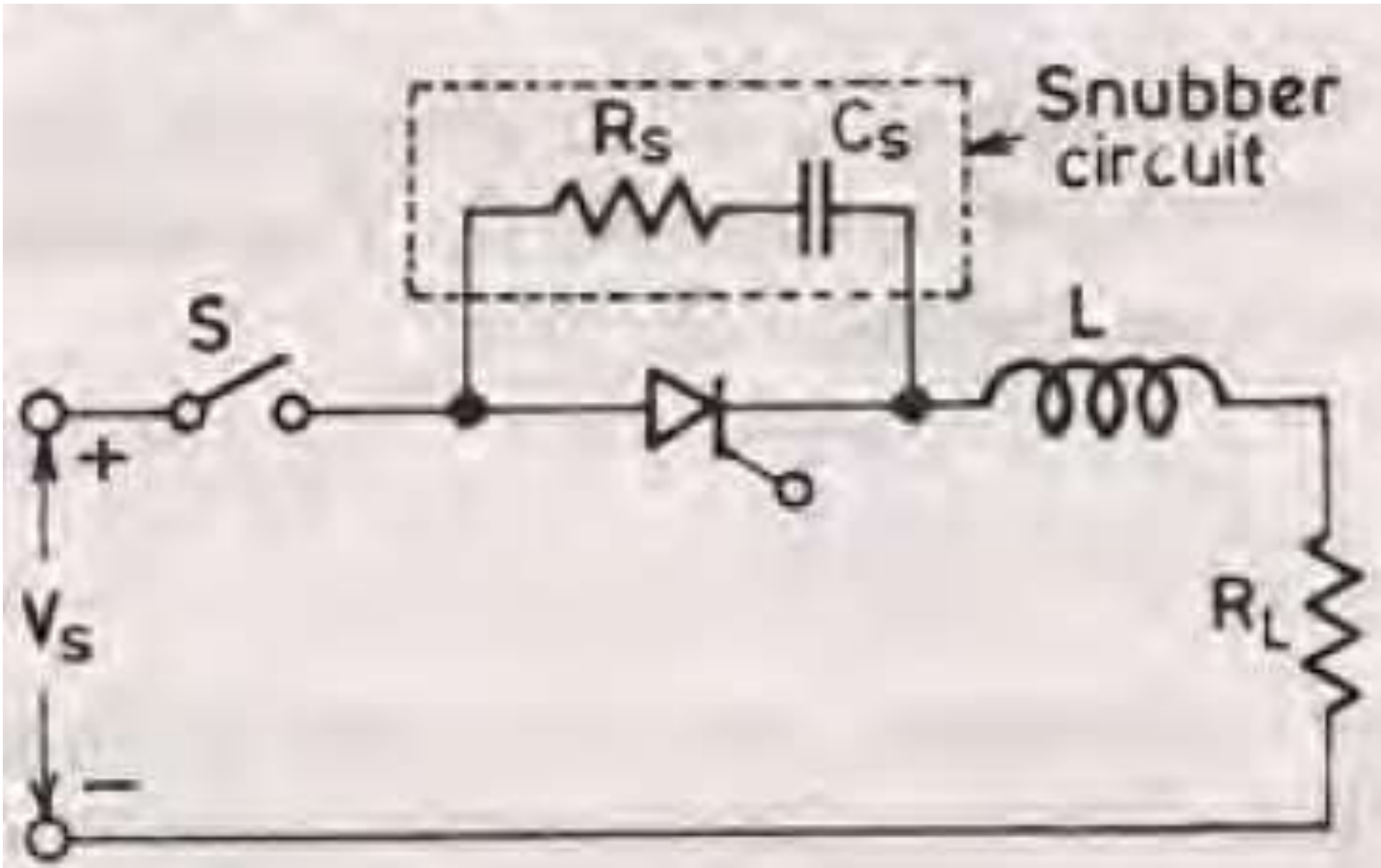
(a) *di/dt protection*. When a thyristor is forward biased and is turned on by a gate pulse, conduction of anode current begins in the immediate neighbourhood of the gate-cathode junction, Thereafter, the current spreads across the whole area of junction. The thyristor design permits the spread of conduction to the whole junction area as rapidly as possible. However, if the rate of rise of anode current, *i.e. di/dt*, is large as compared to the spread velocity of carriers, local hot spots will be formed near the gate connection on account of high current density. This localised heating may destroy the thyristor. Therefore, the rate of rise of anode current at the time of turn-on must be kept below the specified limiting value. The value of *di/dt* can be maintained below acceptable limit by using a small inductor, called *di/dt inductor*, in series with the anode circuit. Typical *di/dt* limit values of SCRs are 20–500 A/μ sec.

Local spot heating can also be avoided by ensuring that the conduction spreads to the whole area as rapidly as possible. This can be achieved by applying a gate current nearer to (but never greater than) the maximum specified gate current.

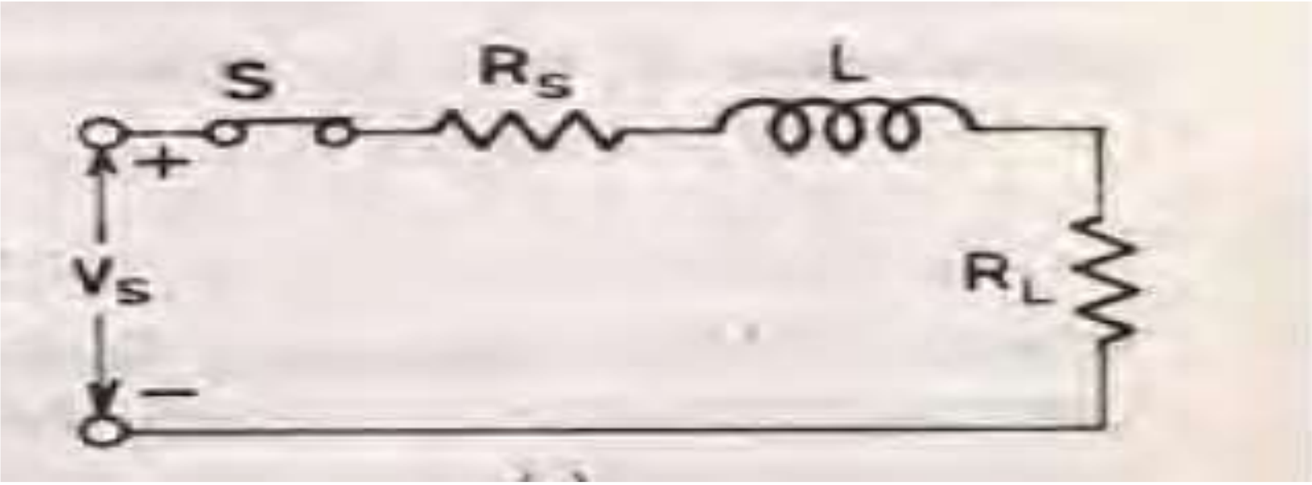
SCR dv/dt Protection



Snubber Circuit



Design guidelines : Snubber Circuit



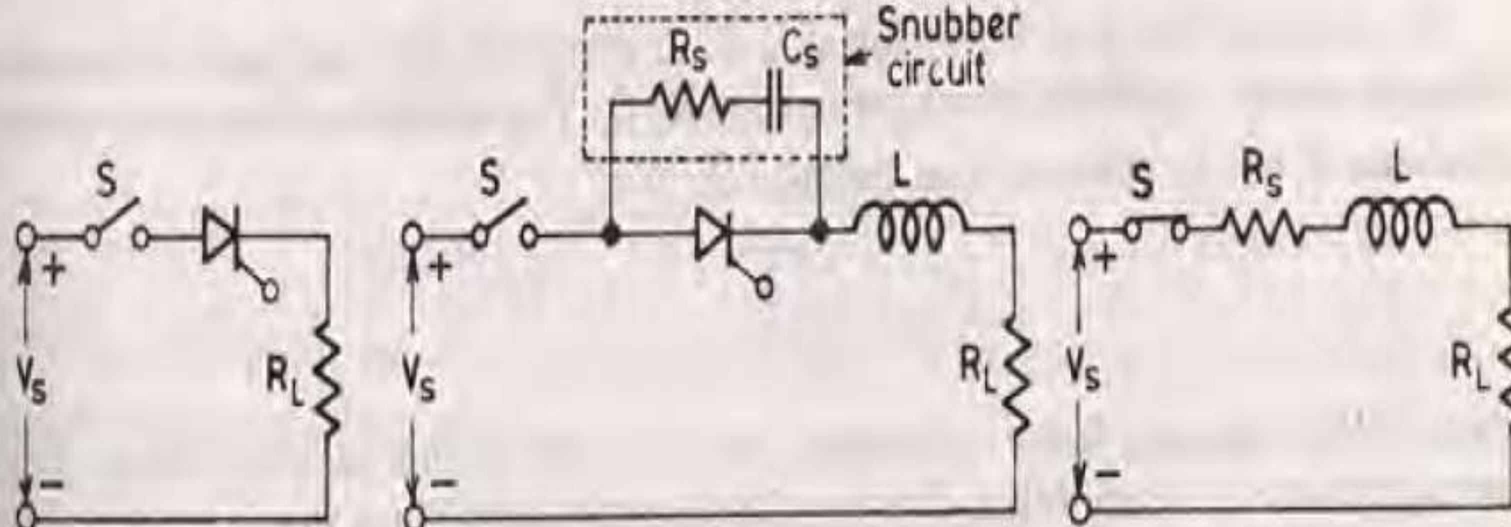
$$V_s = (R_s + R_L)\, i + L \frac{di}{dt}$$

$$i = I\,(1 - e^{-t/\tau})$$

$$I = \frac{V_s}{R_s + R_L} \quad \text{and} \quad \tau = \frac{L}{R_s + R_L}$$

Design of Practical Circuit

shows a thyristor controlling the power in a load resistance R_L. The supply voltage is 240 V dc and the specified limits for di/dt and dv/dt for the SCR are 50 A/μsec and 300 V/μsec respectively. Determine the values of the di/dt inductance and the snubber circuit parameters R_s and C_s.



Design Continues

$$\frac{di}{dt} = I \cdot e^{-t/\tau} \cdot \frac{1}{\tau} = \frac{V_s}{R_s + R_L} \cdot \frac{R_s + R_L}{L} e^{-t/\tau}$$

$$= \frac{V_s}{L} e^{-t/\tau}$$

The value of di/dt is maximum when $t = 0$.

$$\therefore \qquad \left(\frac{di}{dt}\right)_{max} = \frac{V_s}{L}$$

or

$$L = \frac{V_s}{(di/dt)_{max}} = \frac{240 \times 10^{-6}}{50} = 4.8\ \mu\text{H}$$

The voltage across SCR is given by, $v_a = R_s \cdot i$

or

$$\frac{dv_a}{dt} = R_s \cdot \frac{di}{dt}$$

or

$$\left(\frac{dv_a}{dt}\right)_{max} = R_s \cdot \left(\frac{di}{dt}\right)_{max}$$

From Eq. (4.7 *b*) and (4.8),

$$\left(\frac{dv_a}{dt}\right)_{max} = \frac{R_s \cdot V_s}{L}$$

or

$$R_s = \frac{L}{V_s}\left(\frac{dv_a}{dt}\right)_{max} = \frac{4.8}{240} \times 300 = 6\ \Omega$$

Design Continues

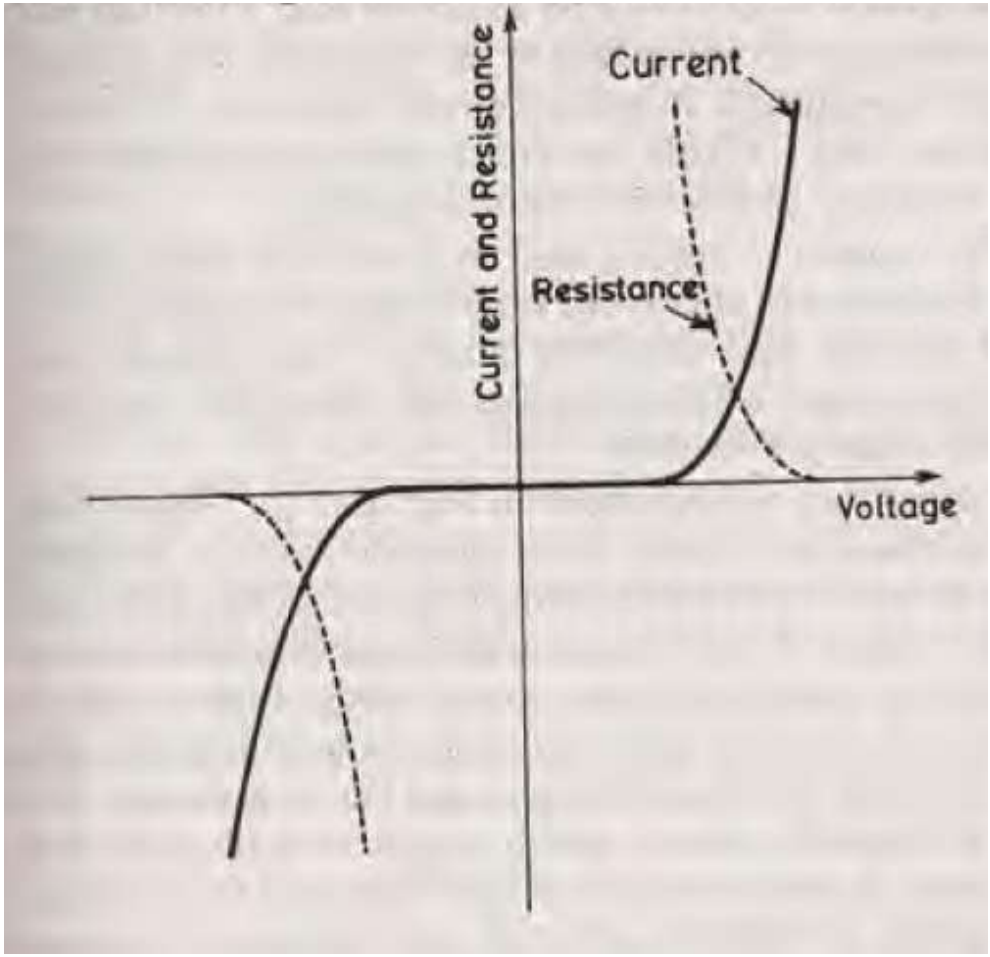
$$R_s = 2\xi\sqrt{\frac{L}{C_s}}$$

$$C_s = \left(\frac{2\xi}{R_s}\right)^2 L = \left(\frac{2 \times 0.65}{6}\right)^2 \times 4.8 \times 10^{-6} = 0.2253\ \mu\text{F}$$

$$L = \frac{R_s \cdot V_s}{(dv_a/dt)_{max}} = \frac{10 \times 240}{300} = 8\ \mu\text{H}$$

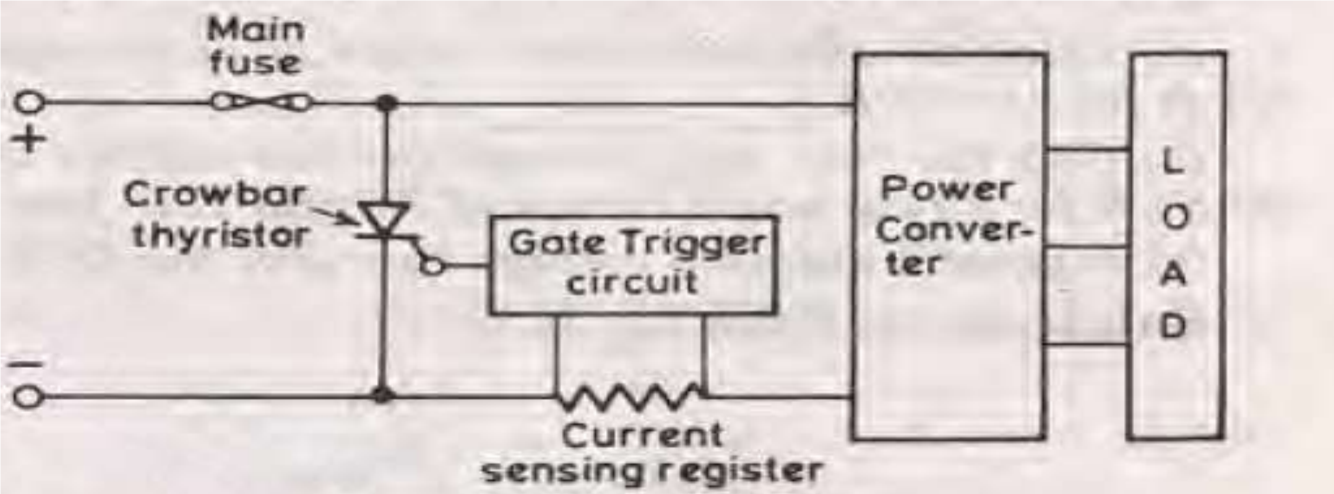
SCR Over Voltage Protection

Using
Varistor /
Voltage
Clamping
Device



SCR Over Current Protection

- FUSE : Fast Acting Current Limiting Fuse
- MCB : Miniature Circuit Breaker
- Crowbar Protection



Current sensing resistor
Elementary electronic crowbar circuit.

Gate Protection