The unified snubber circuit:

Figure (1.10) shows a transistor switch which incorporates both a turn-on and turn-off snubber circuits. The power rating of the dissipating resistor R is:

$$P_{Rs} = \frac{1}{2}(L_s I_m^2 + C_s V_s^2) f_m \quad \text{(W)} \quad \text{.....(1.4)}$$

Where f_m is the maximum switching frequency. The snubber capacitor discharges at turn-on via an L-C-R circuit rather than the usual R-C circuit.

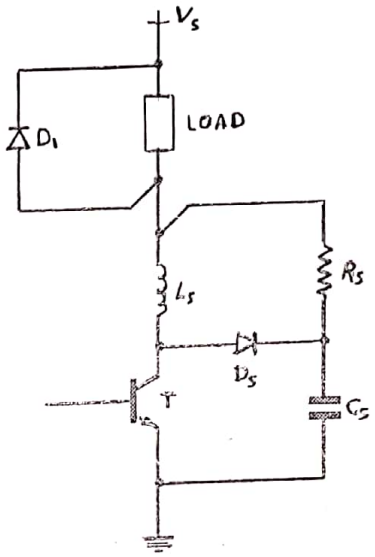

Figure (1.10) Unified snubber circuit incorporating both a turn-on and turn-off circuit which share one dissipation resistor.

1.3 Power MOSFET

The MOSFET (metal oxide semiconductor field effect transistor) is a very fast switching transistor that has showed great promise for applications involving high frequency (up to 1MHz) and low power (up to a few kilowatts). There are other trade names for this device such as HEXFET (International Rectifier), SIMMOS (Siemens), and TIMOS (Motorola).

The circuit symbol of the n-channel MOSFET is shown in figure (1.11a). Unlike the bipolar transistor (which is a current-driven device) a MOSFET is a voltage-controlled device. The basic drain current versus drain-source voltage is shown in figure (1.11b). For comparison figure (1.11c)

shows the corresponding collector emitter characteristics for conventional power bipolar transistor.

The MOSFET has a positive temperature coefficient of resistance and the possibility of secondary breakdown is almost non existent. The safe operating area of a MOSFET is shown in figure (1.11d). It is bounded by three limits:

- The current limit (ab).
- The power dissipation limit (bc).
- The voltage limit (cd).

The SOA can be increased for pulse operation of the device as shown dashed.

The switching characteristics of the MOSFET are similar to those of the BJT. However MOSFET switch on and off very fast, in less than 50 nanosecond and their switching losses are almost negligible.

MOSFET conduction (i.e. on-state) voltage drop is high and therefore conduction loss is high, for example the conduction voltage drop of a 400V device is 2.5V at 10A. MOSFETs power ratings (approximately 600V, 50A) are less than BJTs (approximately 1000V, 500A).

1.4 Insulated Gate Bipolar Transistor (IGBT)

The insulated gate bipolar transistor (IGBT) is a hybrid power semiconductor device which combines the attributes of the BJT and the MOSFET. It has a MOSFET-type gate and therefore has high input impedance. The gate is voltage driven, as in the MOSFET. The symbol used is shown in figure (1.12). Like the power MOSFET, the IGBT does not exhibit the secondary breakdown phenomenon common to the BJT. As well, the IGBT has low on-state voltage drop, similar to the BJT. The switching speed of the IGBT is significantly lower than the MOSFET and similar to the BJT. Power ratings of IGBTs are more than (1500V, 1000A).

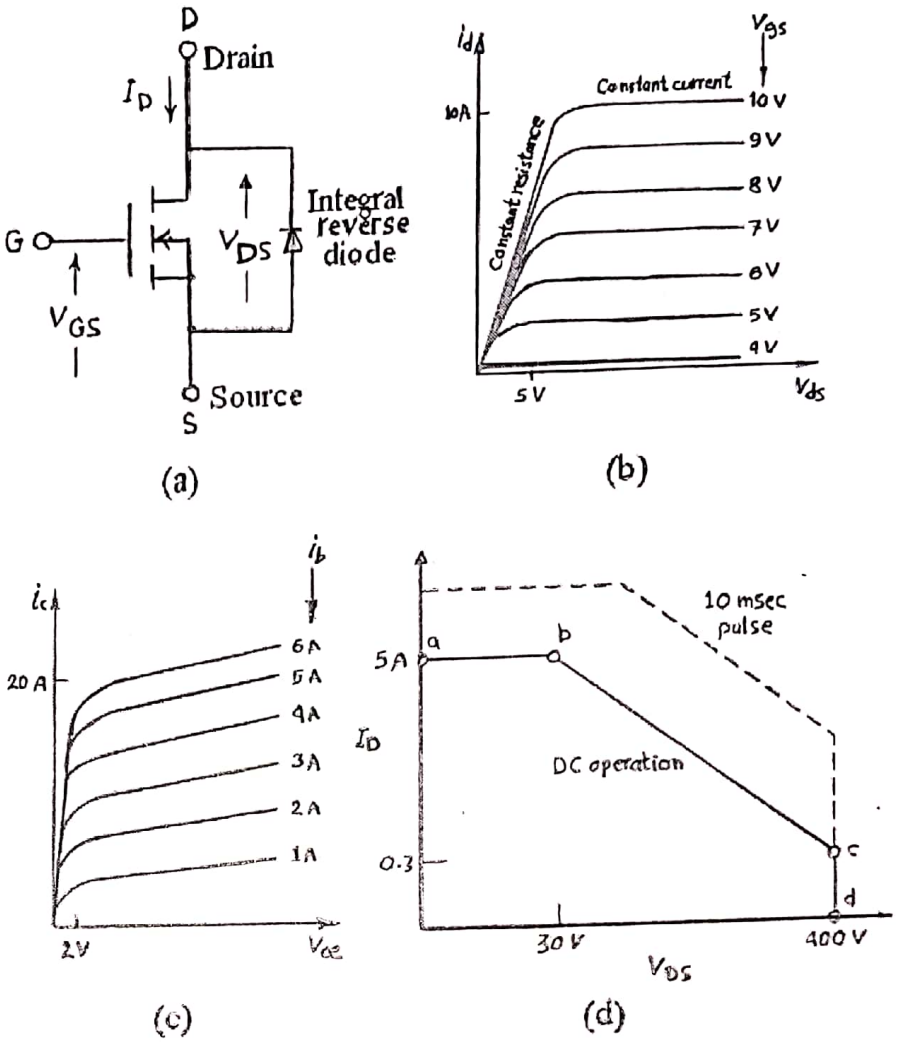

Figure (1.11)

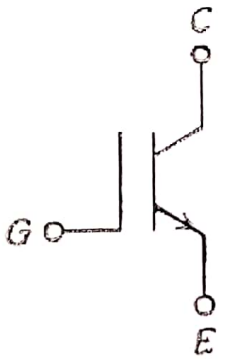

Figure (1.12)