Experiment 03:
Study the switching characteristics of IGBT

AIM: Study of IGBT Characteristics.

Objective: To find the characteristics of a given IGBT.

Apparatus Required:

1 Resistors
2 IGBT
3 Transformer
4 Diodes
5 Zener Diodes
6 TLP 250
7 Capacitors
8 DSO
9 Function Generator

THEORY

IGBT combines the advantages of BJT and MOSFET. It has high impedance gate like MOSFET and low on-state conduction losses like BJT. Also, there is no second breakdown problem like BJT. It is a voltage-controlled device, similar to the power MOSFET and has lower switching and conduction losses. IGBT is inherently faster than BJT. However, the switching speed of IGBT is inferior to that of MOSFET. IGBTs are used in medium power applications such as DC and AC motor drives, power supplies, solid- state relays and contactors. The I-V characteristics, transfer characteristics and symbol of an n-channel IGBT are shown in Figs.1(a), (b) and (c) respectively.

In the forward direction, they appear qualitatively similar to those of a logic-level BJT except that the controlling parameter is an input voltage, the gate source voltage, rather than an input base current. The transfer characteristics I_D-V_{GS} is shown in Fig.1(b) is identical to that of E-MOSFET. The curve is reasonably linear over most of the drain current range and becomes nonlinear only at low drain currents, where the gate-source voltage is approaching the threshold. If $V_{GS}<V_{GS\,(th)}$, then the IGBT is in OFF state. The maximum voltage that should be applied to the gate-source (V_{GS}) terminal is usually limited by the maximum drain current (I_D) that is permitted to flow in the IGBT. It is basically a BJT with a MOSFET gate input and thus

the modified BJT for the n-channel IGBT as shown in Fig.1(a). The schematic diagram of an IGBT is shown in Fig.2.

In this experiment, a gate pulse V_{Gate} is applied to the IGBT, the collector current I_C is noted down for the given V_{GE}. The parameters like t_{dn}, t_r, t_{df}, t_{f1} and t_{f2} are noted down as represented in Fig.3.

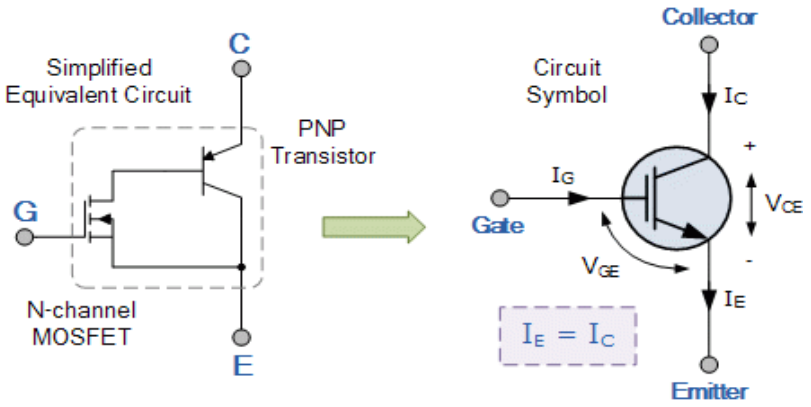

Fig.1 (a). Symbolic representation of IGBT and its equivalent circuit

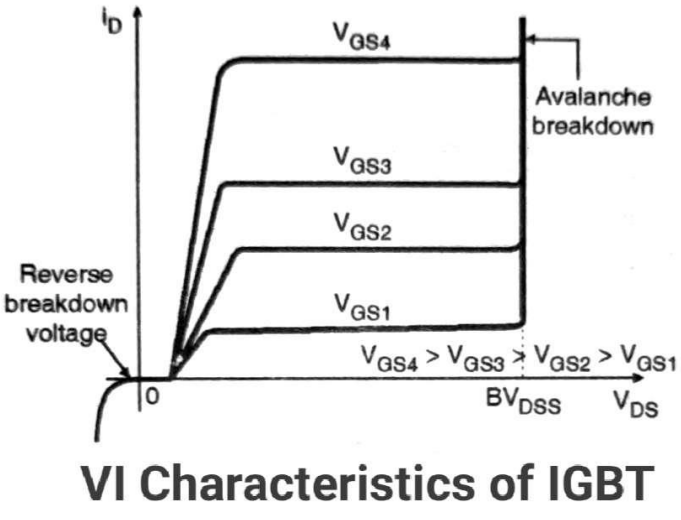

Fig. 1 (b). the IGBT I_D-V_{DS} characteristics

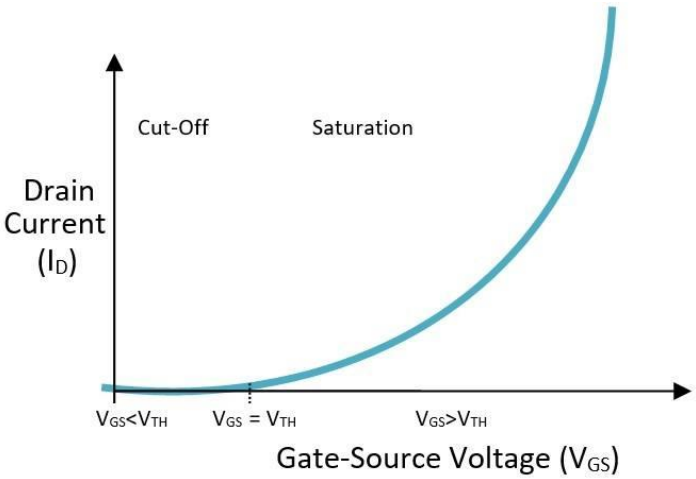

Fig. 1 (c) transfer characteristics of IGBT

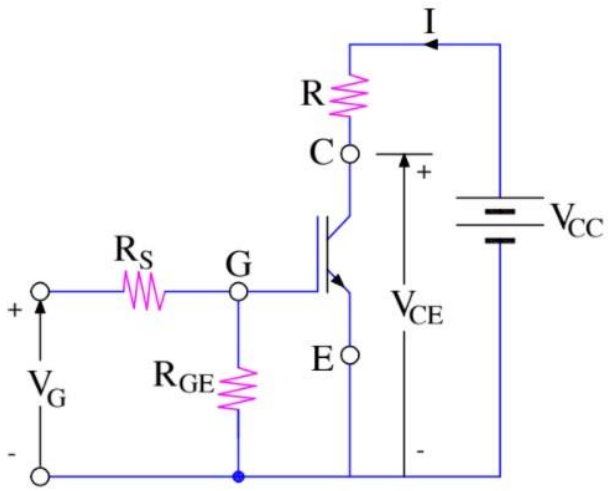

Fig. 2. Schematic diagram of IGBT.

DEFINITIONS

Form the graphical representation shown in Fig.1, the switching parameters are defined as follows:

Delay time (t_{dn})

It is the time in which, the collector current rises from collector-emitter leakage current (I_{CEO}) to 10% of collector current.

Rise time (t_r)

It is the time in which, the collector current rises from 10% of IC to steady state collector current (IC).

Turn–on time (t_{on})

It is the summation of the delay time and rise time.

$$t_{on}=t_{dn}+t_r$$

Delay time (t_{df})

It is the time in which, the collector current falls from 100% to 90%.

Initial fall time (t_{f1})

It is the time in which the collector current falls from 90% to 20%.

Final fall time (t_{f2})

It is the time in which the collector current falls from 20% to10%.

Turn off time (t_{off})

It is the summation of delay time, initial fall time and final fall time.

$$t_{off}=t_{df}+t_{f1}+t_{f2}$$

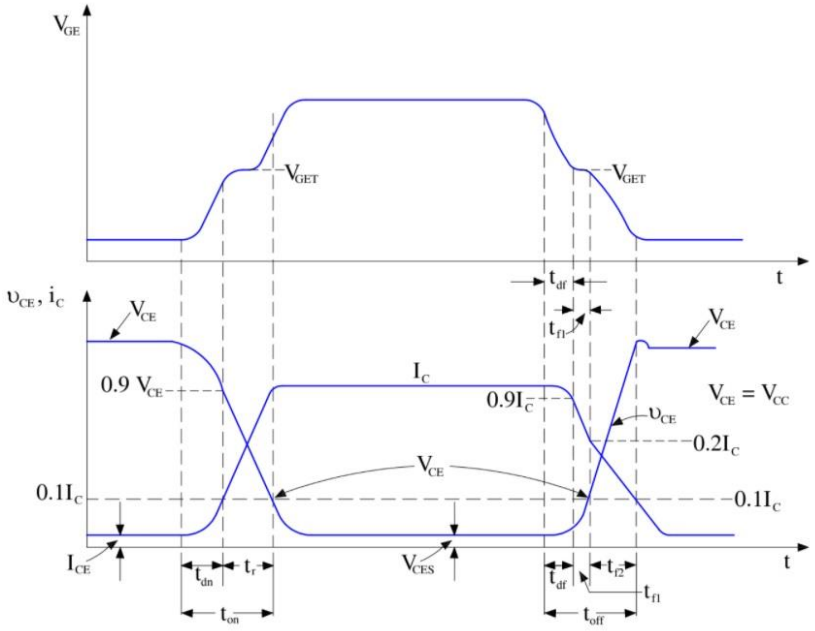

Fig.3. Switching characteristics of IGBT

Firing Circuit Diagram:

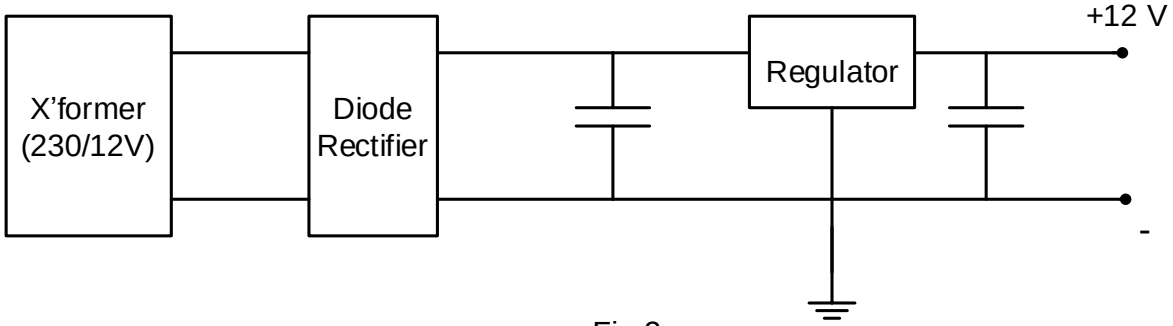

Fig.2

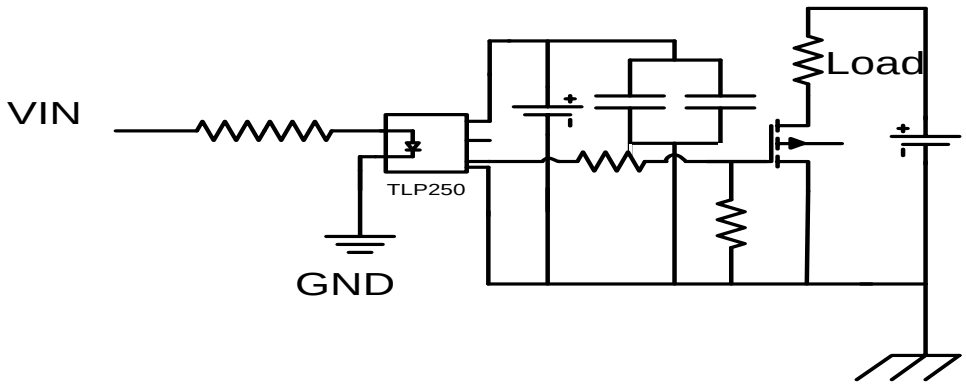

Fig.3 TLP 250 circuit for firing circuit isolation

Procedures:

1. Make the connections as per the circuit diagram.
2. Check the 20V from regulated power supply.
3. Generate the pulse (0-5V), 10 KHz, 50% duty cycle from function generator.
4. Connect the regulated power supply and function generator to TL250.
5. Connect given IGBT to the gate driver circuit.
6. Connect the gate driver circuit to power circuit of IGBT shown in figure.
7. Tabulate the readings and plot the graph.

OBSERVATIONS:

Frequency (kHz)	V_s (V) Source Voltage	T_{rs} (µs) Rise time	T_f (µs) fall time	V_r (V) Rise time voltage	I_r (A) Rise time current	V_f (V) fall time voltage	I_f (A) fall time current

Precautions:

1. Show your circuit diagram to one of the instructors before acquiring the components.
2. Once the circuit connection is completed then show that to one of the instructors and then perform the experiment