

Insulated Gate Bipolar Transistor (IGBT)

The Insulated Gate Bipolar Transistor (IGBT) is a Transistor which combination of Bipolar Junction Transistor (BJT) and Metal oxide Field effect transistor MOSFET, and It is a semiconductor device used for switching related applications, and it's a voltage control device. The IGBT combines features of both BJT and MOSFETs, as it has high current amplification like the BJTs and Switching characteristics as the MOSFETs.

Structure

An IGBT consists of four semiconductor layers arranged in a PNPN structure.

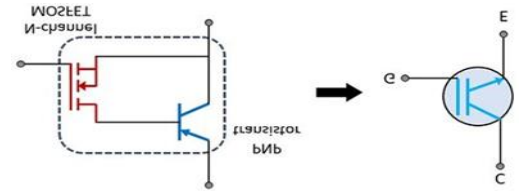
These layers are:

Emitter: Located between the P and N layers.

N-type layer: Forms PN junction J1 with the P+ substrate.

P-type layer: Attached to the collector electrode.

Collector: Connected to the P layer.



Key Parameters

- Transconductance g_m
characterizes the IGBT ability to amplify gate voltage changes into current variations, it affects switching speed and efficiency.
- Threshold Voltage $V_{gs(th)}$
This is the minimum gate-emitter voltage required to turn on the IGBT.
- **Maximum Collector Current I_c :**

This parameter defines the maximum current the IGBT can manage without damage which is essential to ensure safe operation.

Operation Regions:

- **Cutoff Region:** In this region, the gate-emitter voltage V_{GE} is below the threshold voltage V_{th} and the IGBT is in an off state. There is no significant current flowing from the collector to the emitter, and the device is effectively an open switch.
- **Active or Linear Region:** When the gate-emitter voltage is above the threshold but not high enough to fully turn on the IGBT, the device operates in the active region in this region, the IGBT behaves like a voltage-controlled bipolar transistor. It allows current flow from collector to emitter.
- **Saturation Region:** When the gate-emitter voltage is sufficiently high, the IGBT enters the saturation region, where it is fully on. In this state, the IGBT conducts a large current with a low voltage drop across the collector-emitter terminals, the IGBT is fully turned on, and the voltage drop across it is minimal. It acts as a low-resistance switch.