

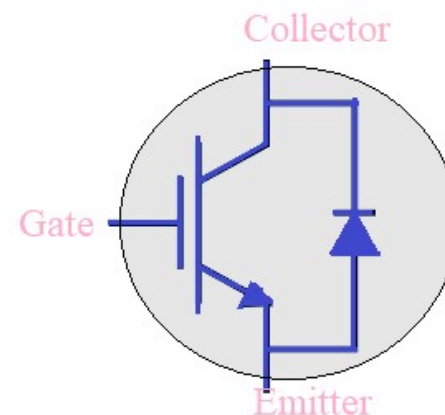
**INSULATED GATE BIPOLAR  
TRANSISTOR (IGBT)**

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## IGBT: Insulated-Gate Bipolar Transistor

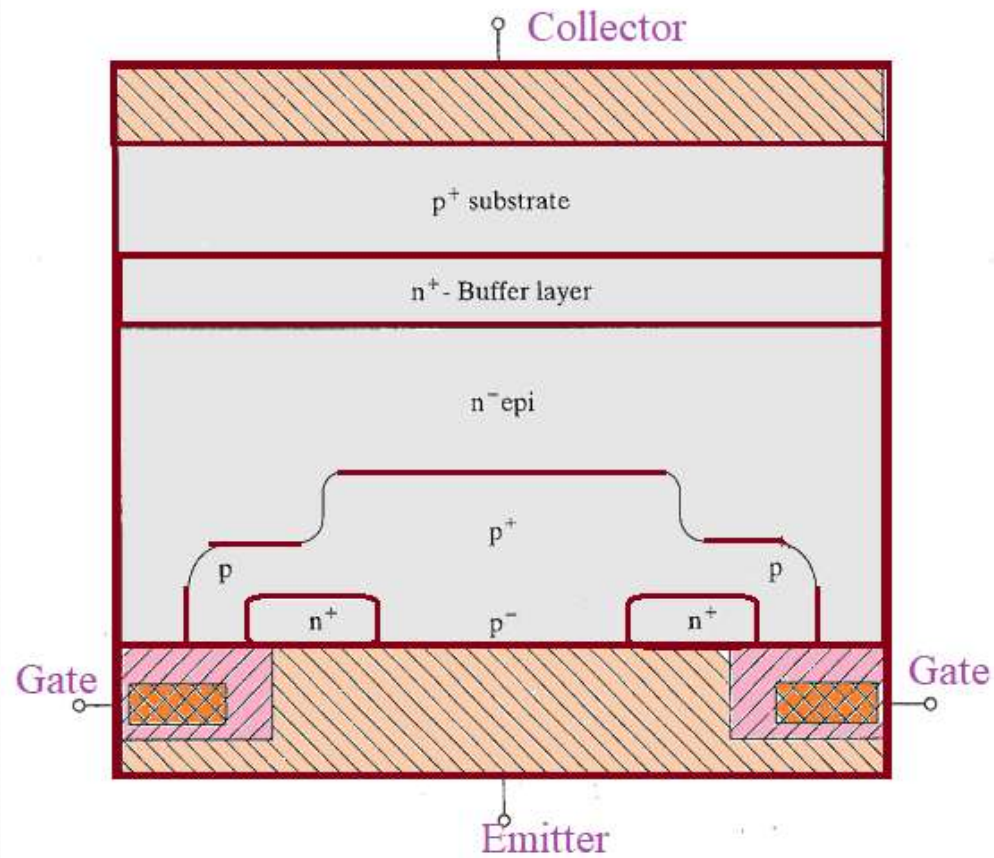
- Combination BJT and MOSFET
  - High Input Impedance (MOSFET)
  - Low On-state Conduction Losses (BJT)
- High Voltage and Current Ratings
- Symbol



# School of Electrical, Electronics and Communication Engineering

Course Code : BTEE3011

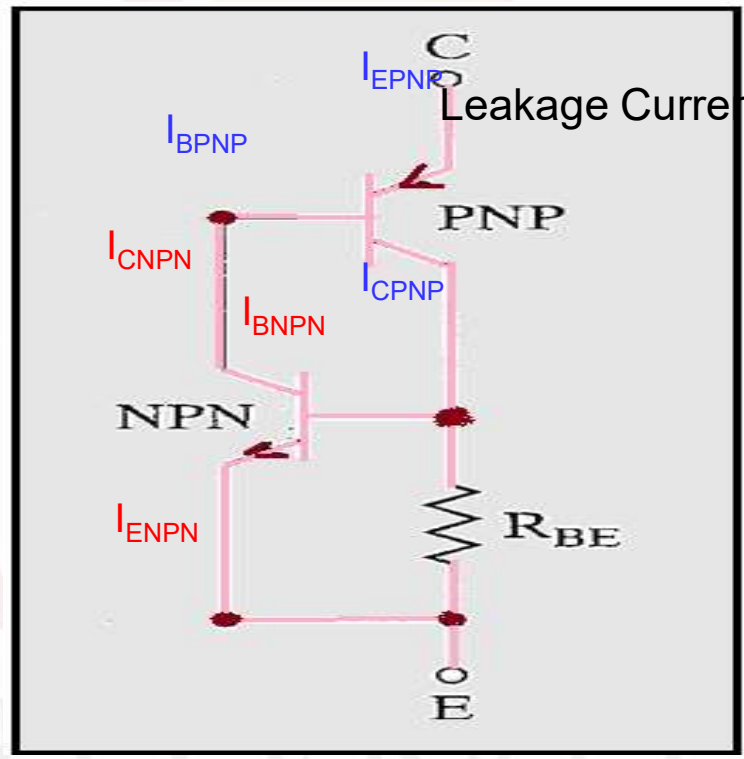
Course Name: Power Electronics



Name of the Faculty: Saravanan D

Program Name: B.Tech-EE/EEE

### IGBT Equivalent Circuit for $V_{GE} < V_T$

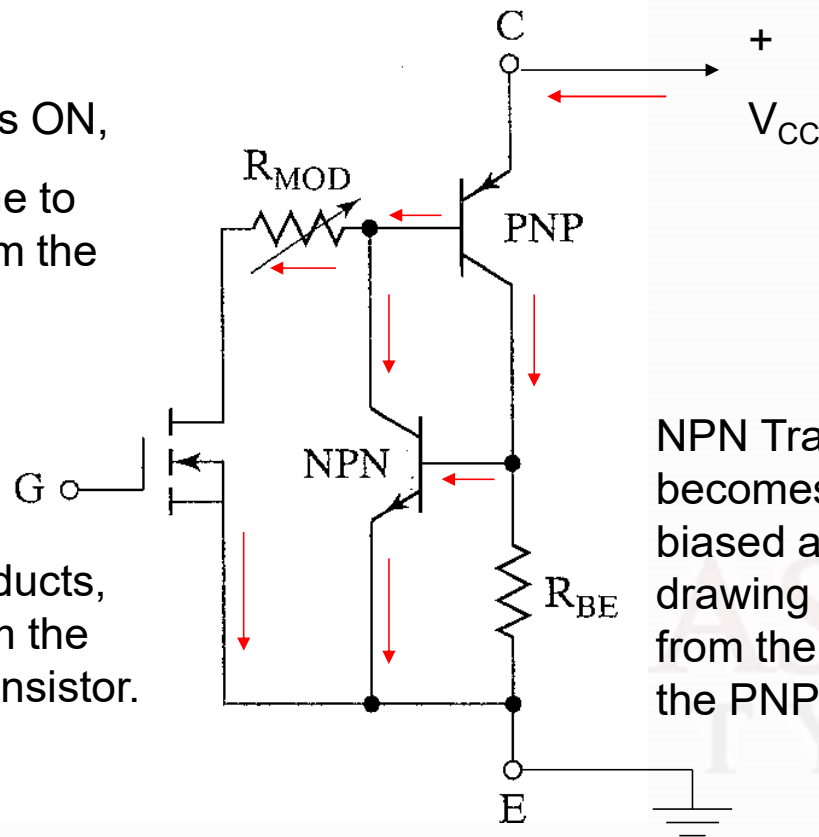


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## IGBT Equivalent Circuit for $V_{GE} > V_T$

PNP transistor turns ON,  
 $R_{MOD}$  decreases due to carrier injection from the PNP Emitter.

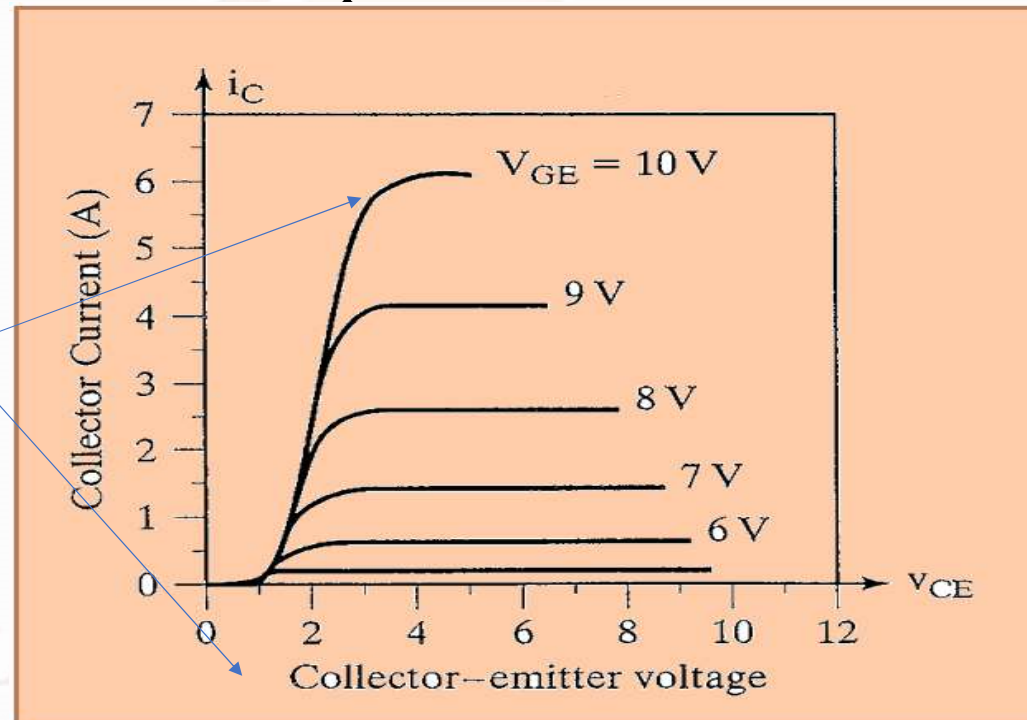
MOS transistor conducts, drawing current from the Base of the PNP transistor.



NPN Transistor becomes forward biased at the BE, drawing current from the Base of the PNP transistor.

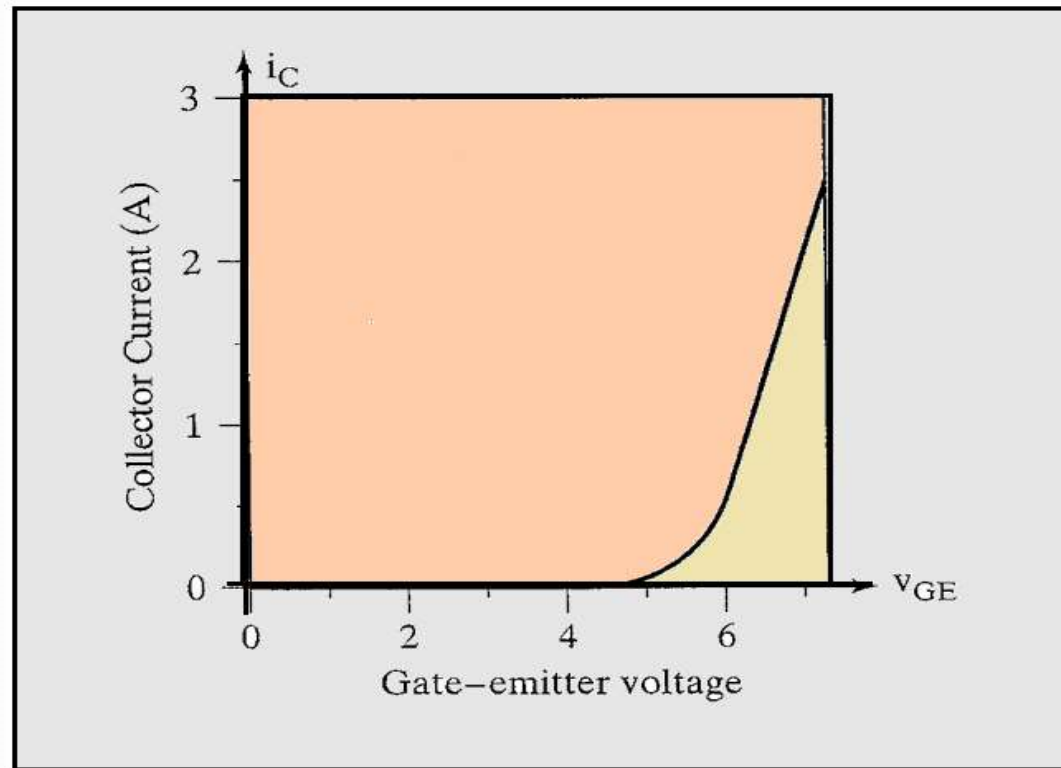
## IGBT Output Characteristics

Follows an SCR characteristic



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## IGBT Transfer Characteristic



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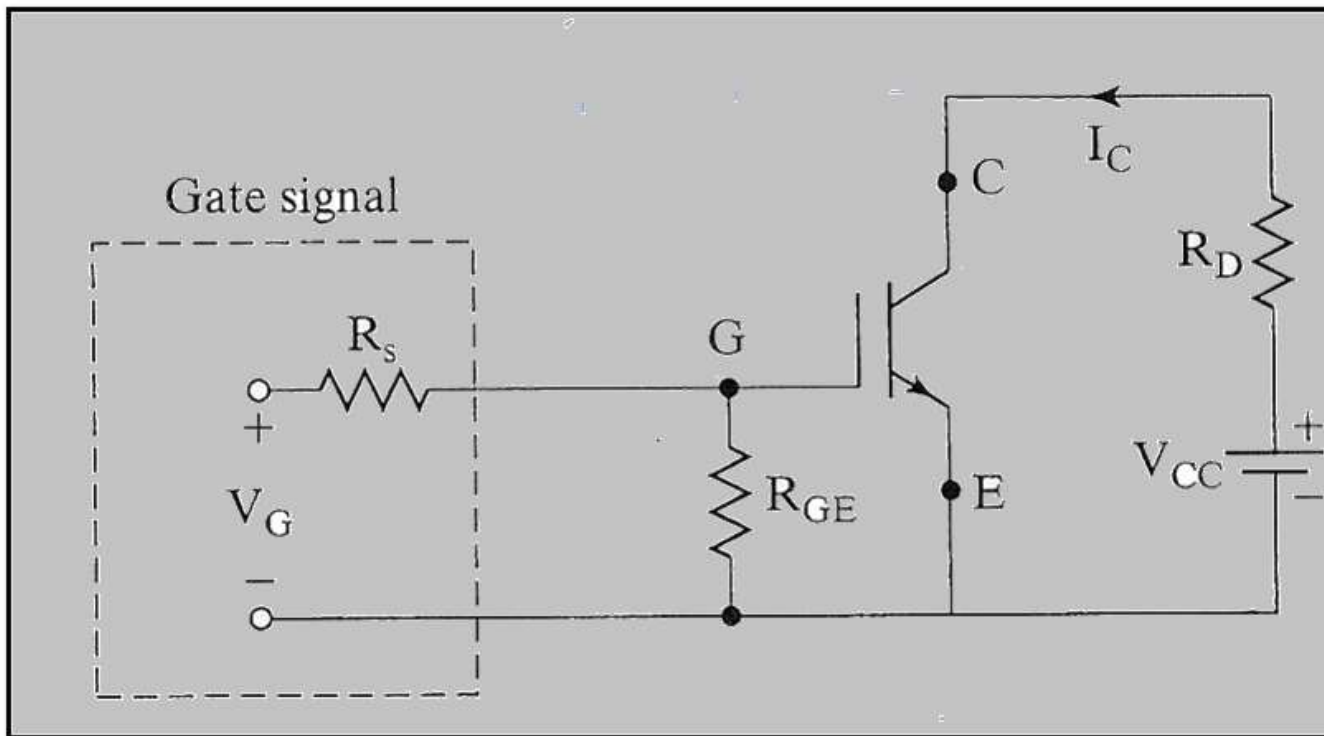
Characteristic	Symbol	Definition (For ratings, see the relevant technical datasheets.)
Gate leakage current	$I_{GES}$	The gate-emitter current that flows when the rated voltage is applied across the gate and the emitter with the collector and emitter electrodes shorted
Collector cut-off current	$I_{CES}$	The collector-emitter current that flows when the rated voltage is applied across the collector and the emitter with the gate and emitter electrodes shorted
Gate-emitter cut-off voltage	$V_{GE(OFF)}$	The gate-emitter voltage at which the rated collector current flows when the rated collector-emitter voltage is applied
Collector-emitter saturation voltage	$V_{CE(sat)}$	The collector-emitter voltage when the rated gate-emitter voltage is applied and the collector current is at the rated value
Diode forward voltage <sup>*8</sup>	$V_F$	The emitter-collector voltage when the rated forward current is applied to the freewheeling diode of an IGBT

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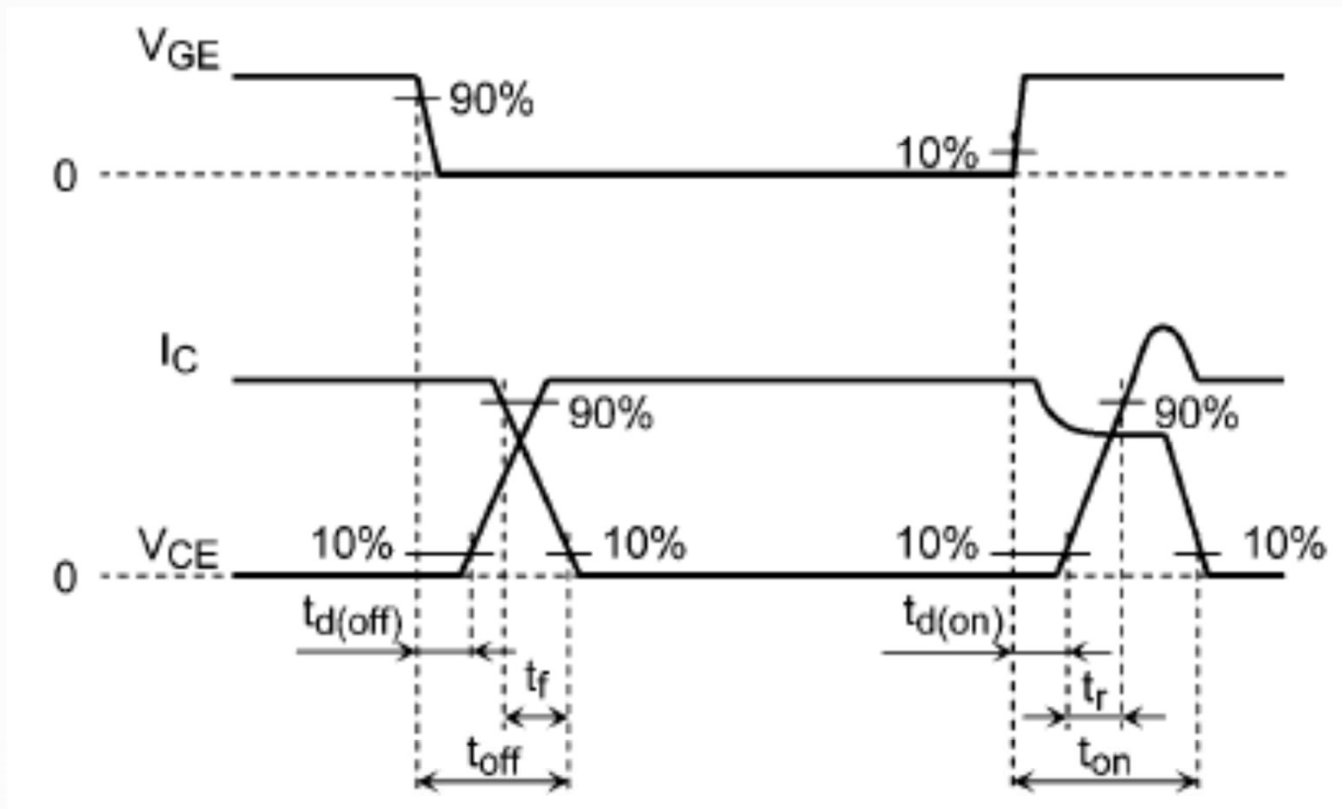
## IGBT Used as a Switch



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Characteristic	Symbol	Definition (For ratings, see the relevant technical datasheets.)
Input capacitance	Cies	The capacitance between the gate and the emitter at the rated gate-emitter voltage, collector-emitter voltage, and frequency
Turn-on delay time	td(on)	The time it takes for the collector current to reach 10% of the rated value at turn-on from the time at which the gate voltage is 10% of the rated value (inductive load)
Rise time	tr	The time it takes for the collector current to rise from 10% to 90% of its rated value at turn-on
Turn-on time	ton	The time it takes for the collector current to reach either 90% of its rated value (in the case of a resistive load) or 10% of the drain-source voltage (in the case of an inductive load) at turn-on from the time at which the gate voltage is 10% of the rated value
Turn-off delay time	td(off)	The time it takes for the drain-source voltage to reach 10% at turn-off from the time at which the gate voltage is 90% of the maximum rated value
Fall time	tf	The time it takes for the collector current to fall from 90% to 10% of its rated value at turn-off
Turn-off time	toff	The time it takes for the collector current to reach 10% of its rated value at turn-off from the time at which the gate voltage is 90% of the maximum rated value
Switching loss (Turn-on loss)	Eon	The amount of energy lost during turn-on until the collector-emitter voltage reaches the rated value
Switching loss (Turn-off loss)	Eoff	The amount of energy lost during turn-off until the collector-emitter voltage reaches the rated value
Reverse recovery time(*10)	trr	The period of time during which reverse recovery current flows through the freewheeling diode under the rated conditions that is connected in anti-parallel between the collector and the emitter

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