SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)
COIMBATORE-35
Accredited by NBA-AICTE and Accredited by NAAC – UGC with A+ Grade
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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

19EET202 / ANALOG ELECTRONICS
II YEAR / III SEMESTER

UNIT-I: PN JUNCTION DEVICE

The Insulated Gate Bipolar Transistor (IGBT)

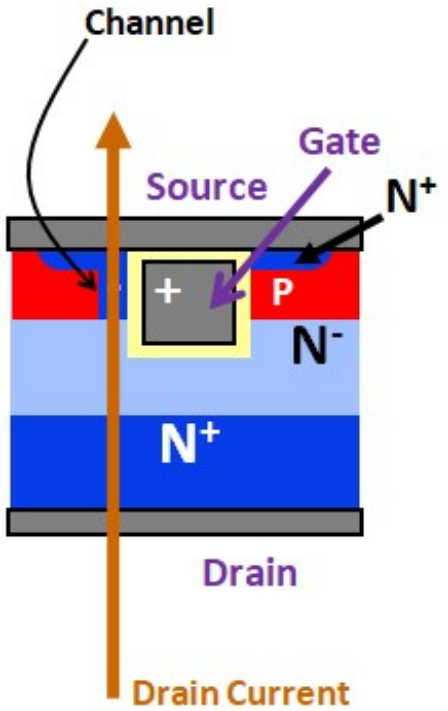
TOPIC OUTLINE

•The main topics to be addressed in this lesson are the following:

- **Introduction.**
- **Review of the basic structure and operation of bipolar junction transistors (BJTs).**
- **Internal structures of IGBTs.**
- **Static characteristics of the IGBTs.**
- **Dynamic characteristics of the IGBTs.**
- **Losses in the IGBTs.**

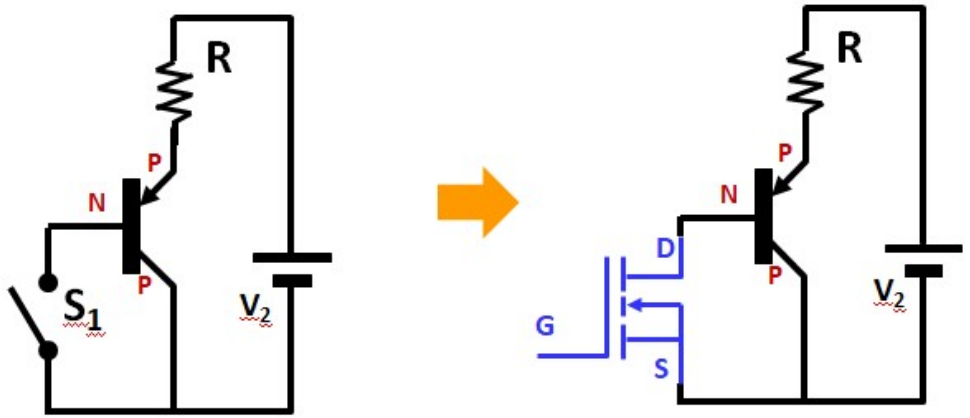
Introduction

- Power MOSFETs are excellent power devices to be used in power converters up to a few kWs.
- They have good switching characteristics because they are unipolar devices.
- This means that the current is due to majority carriers exclusively and that it does not pass through any PN junction.
- Due to this, conductivity modulation does not take place.



Principle of operation and structure of the IGBT

- The IGBT (the Insulated Gate Bipolar Transistor) is based on a structure that allows:
  - ➢ Conductivity modulation (good behaviour for high voltage devices when they are in on-state).
  - ➢ Anti-saturation (not so slow switching process as in the case of complete saturation).
  - ➢ And control from an insulated gate (as in the case of a MOSFET).



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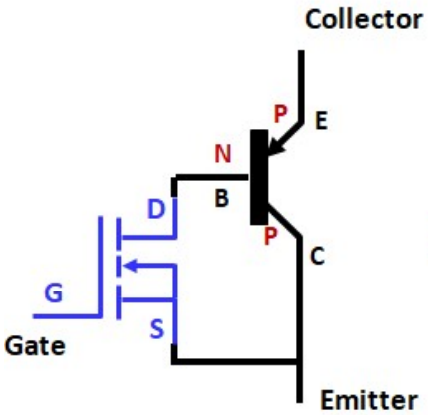
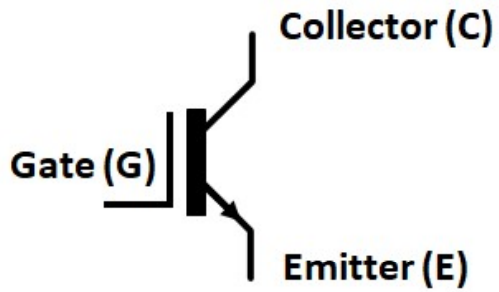
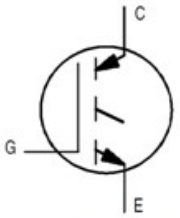


Simplified equivalent circuit for an IGBT.



Schematic symbol for a N-channel IGBT.

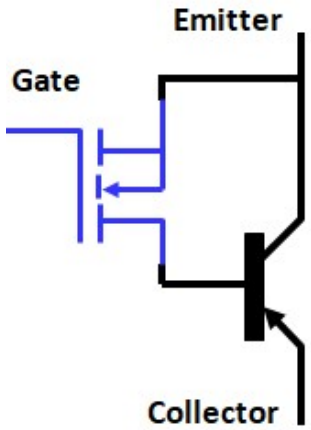


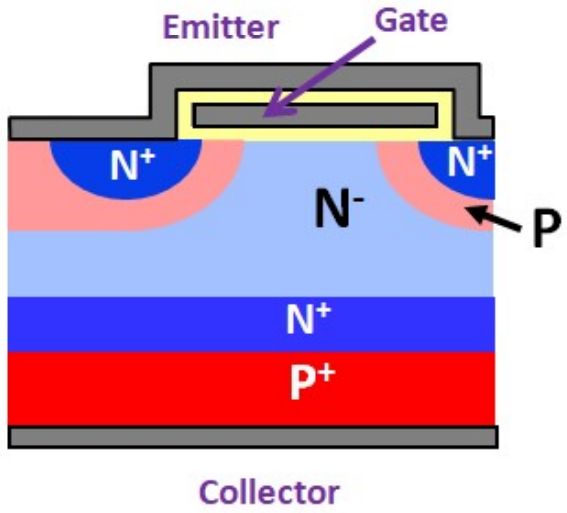
n-channel

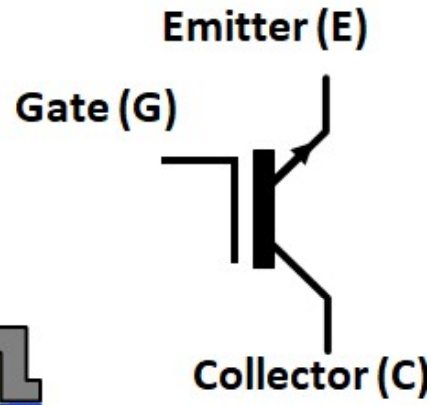
Another schematic symbol also used.

CONTD…

- Internal structure (I).

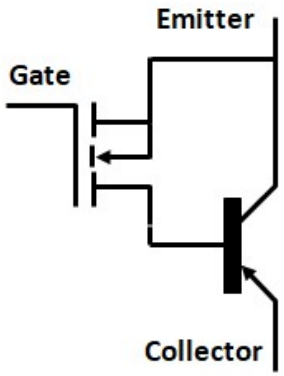




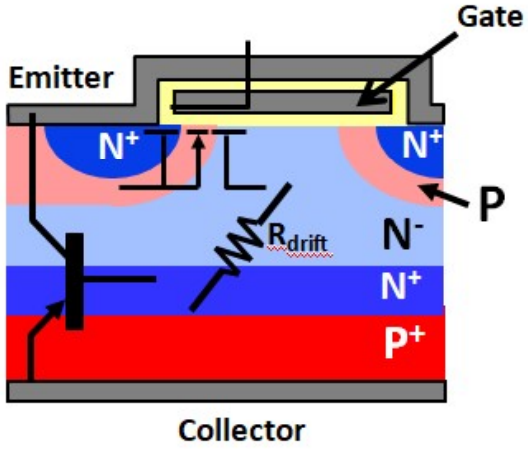


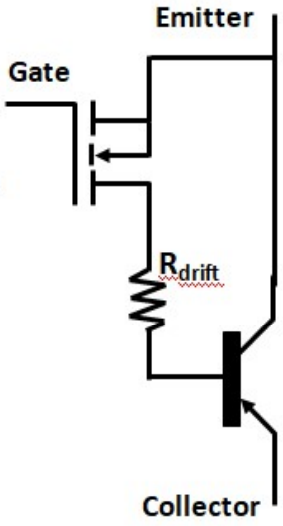
CONTD…

• Internal structure (II).



Simplest model for an IGBT.

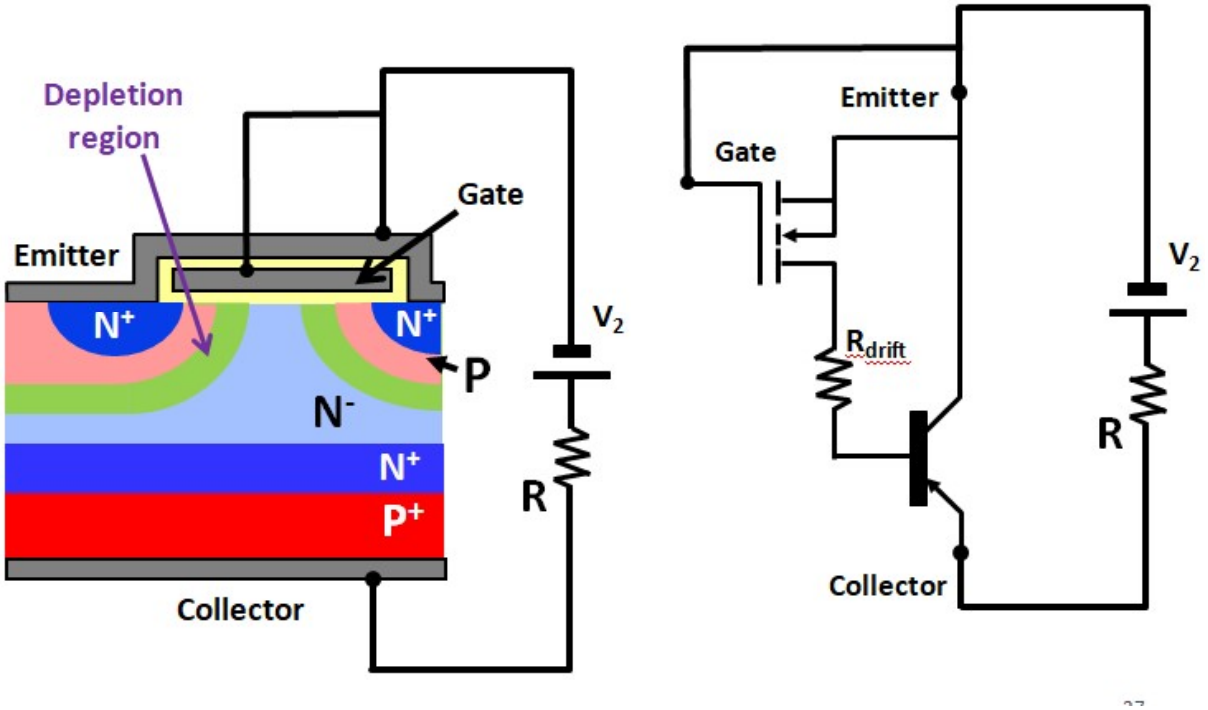




Model taking into account the drift region resistance.

CONTD…

- The IGBT blocking (withstanding) voltage.



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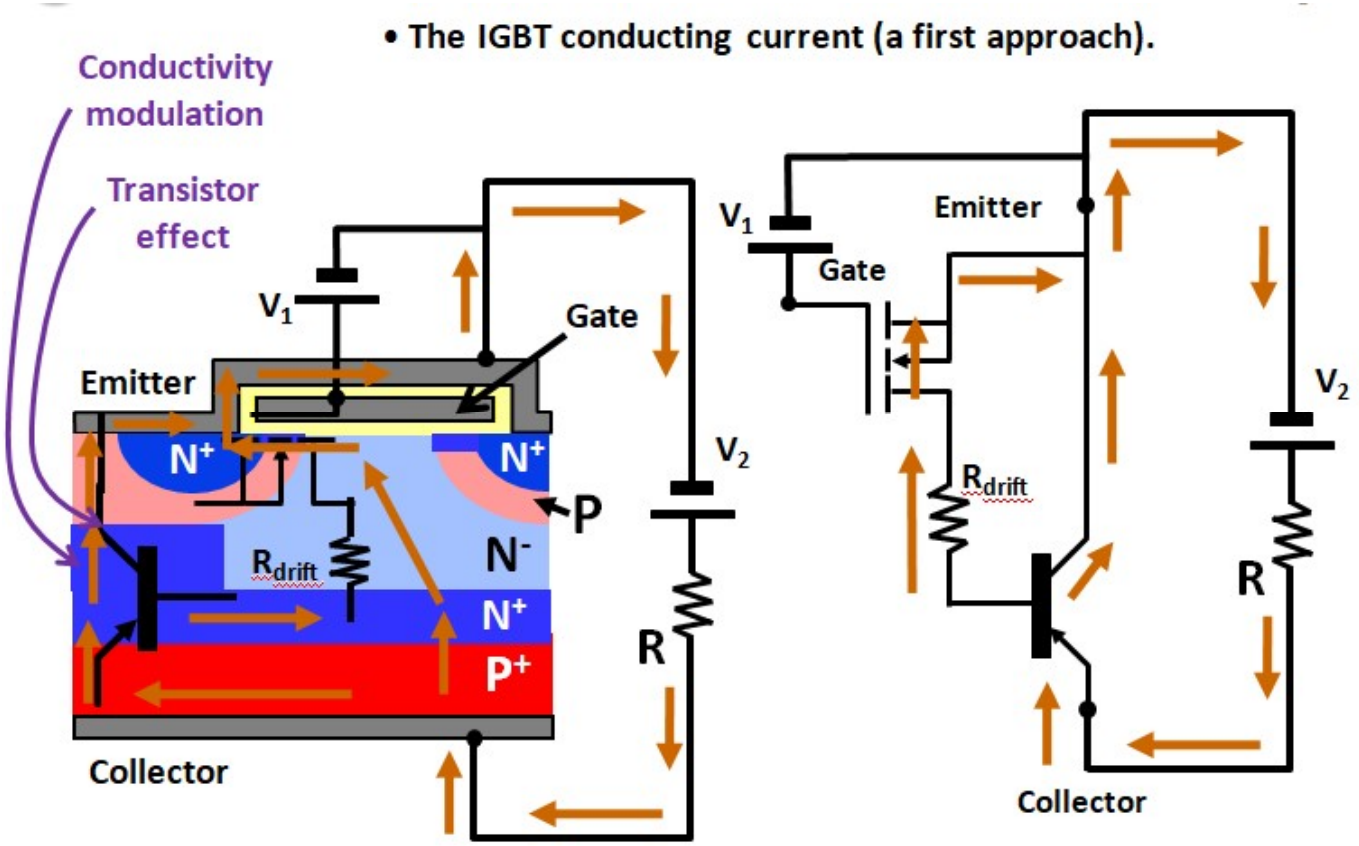
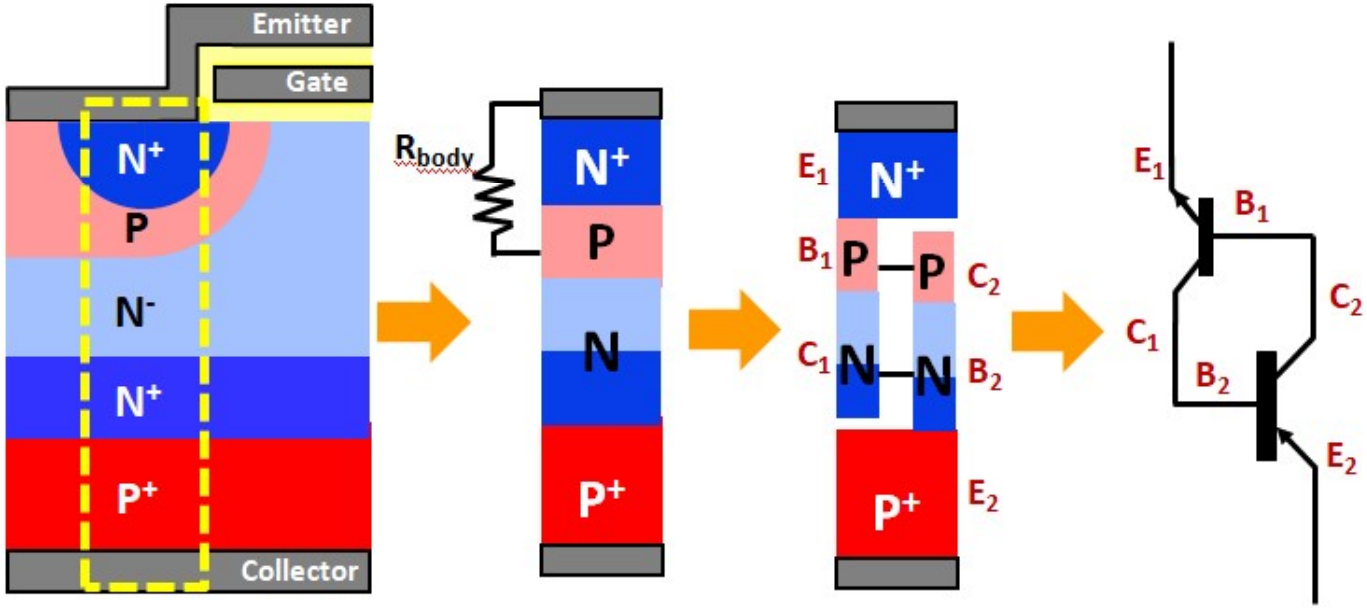
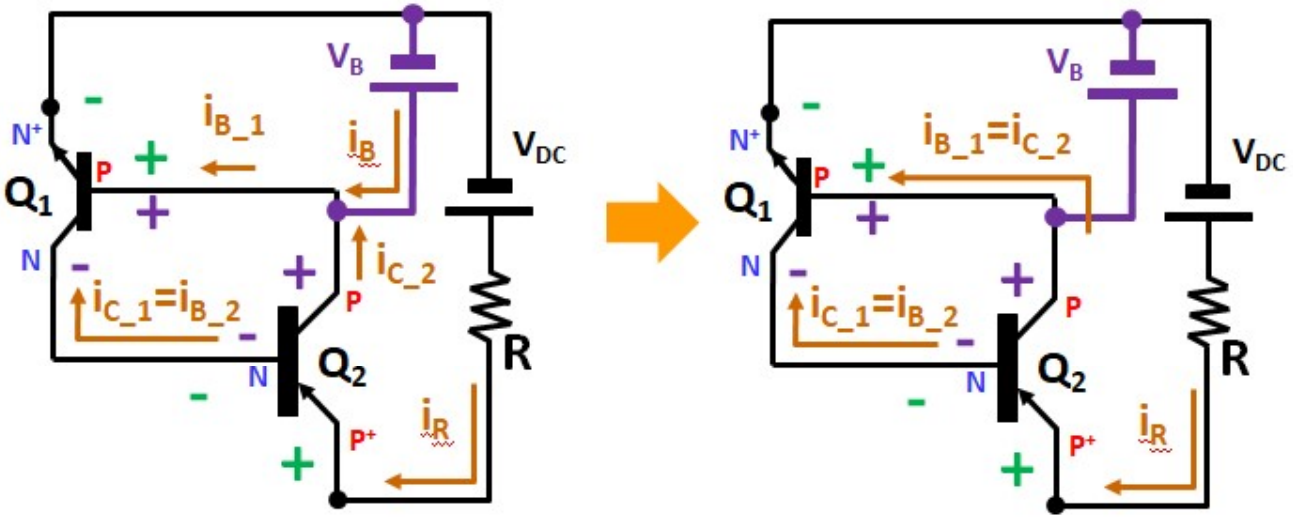

• The IGBT conducting current (a first approach).
Conductivity modulation
Transistor effect
V1
Gate
Emitter
N+
N+
P
N-
N+
P+
Rdrift
R
V2
Collector
V1
Gate
Emitter
V2
Rdrift
R
Collector

CONTD…

• The basics of the thyristor: the PNPN structure (I).



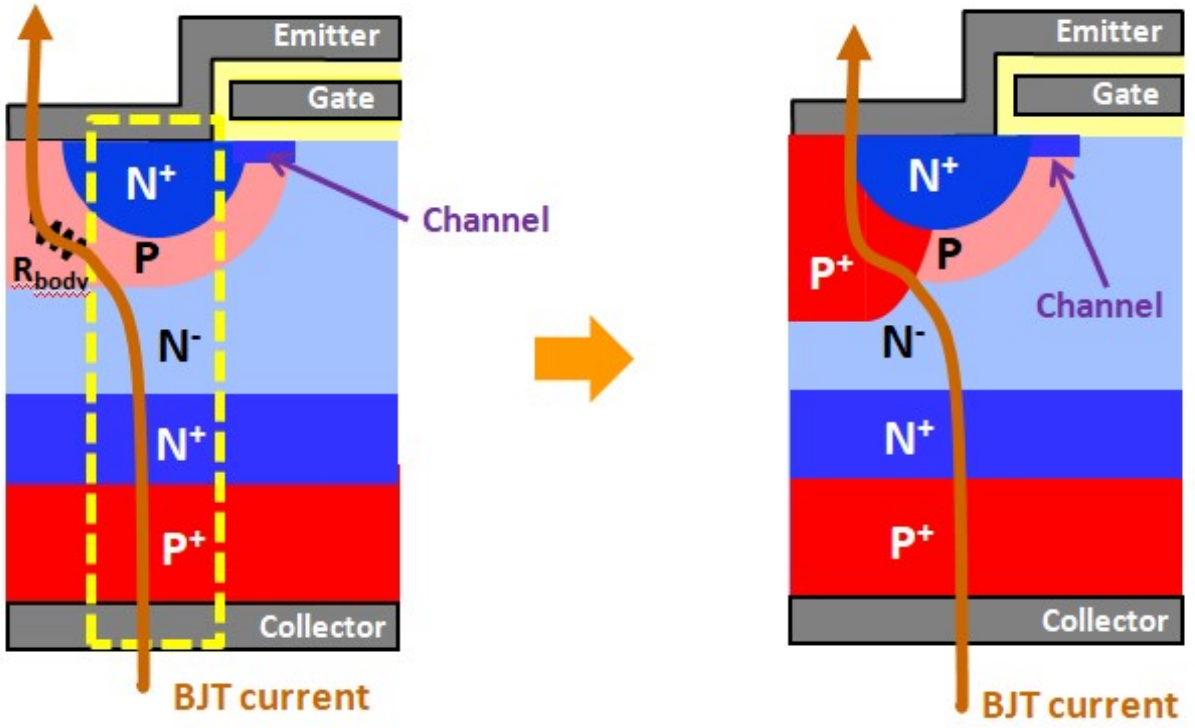
CONTD…



- Initially, the current needed for transistor Q_1 to start conducting (active region) comes from the voltage source V_B.
- When i_{C_1} increases, i_{C_2} strongly increases because $i_{C\_2} = \beta_2 \cdot i_{B\_2} = \beta_2 \cdot i_{C\_1}$. Therefore, current i_{B_1} will be mainly due to i_{C_2}.
- As i_{C_2} is the main current needed to maintain both transistors saturated, the situation does not change if we remove V_B.

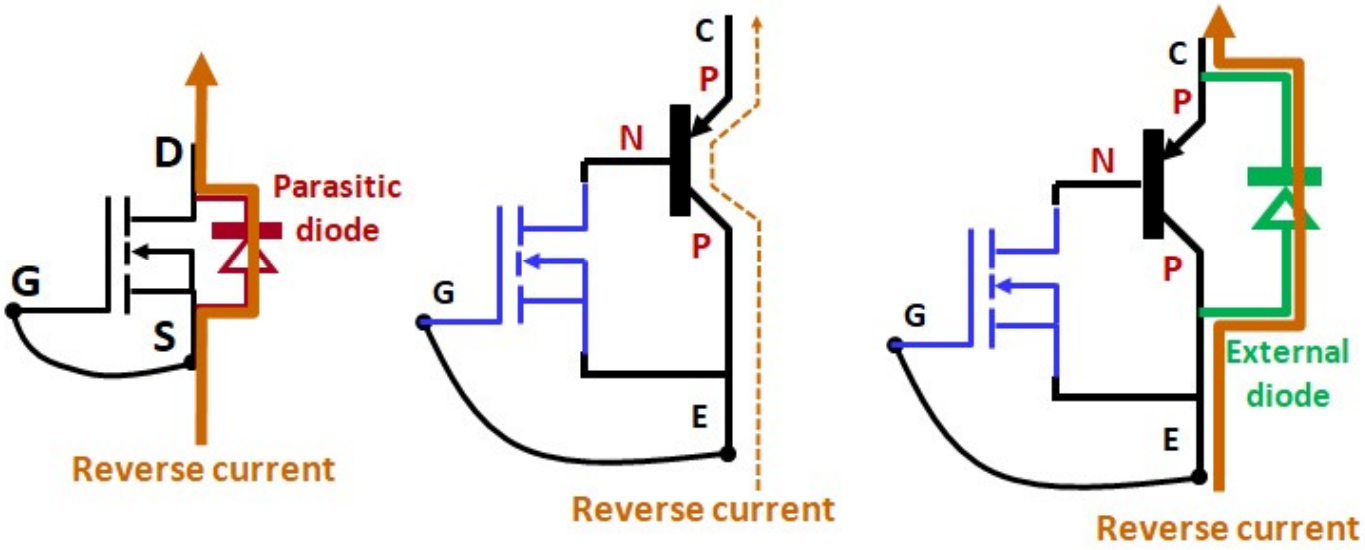
LATCH UP

- To avoid the IGBT latch-up, R_{body} must be as low as possible.

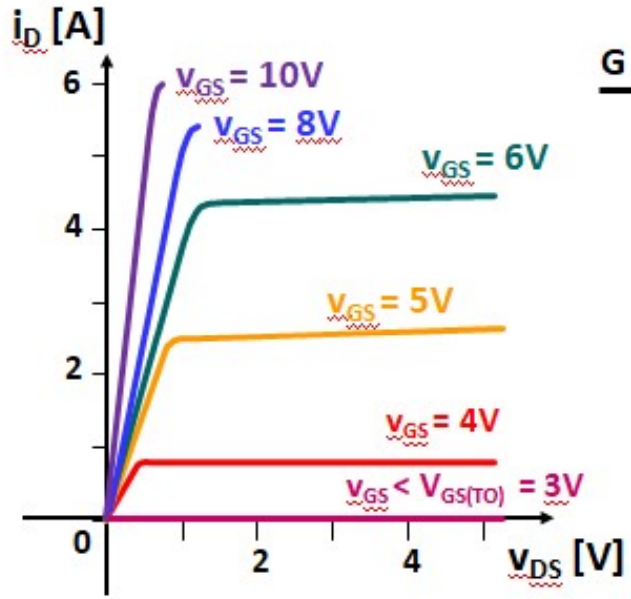


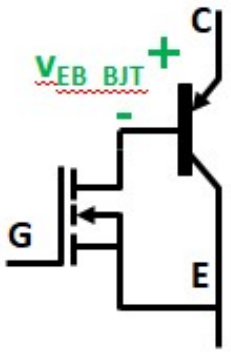
Contd..

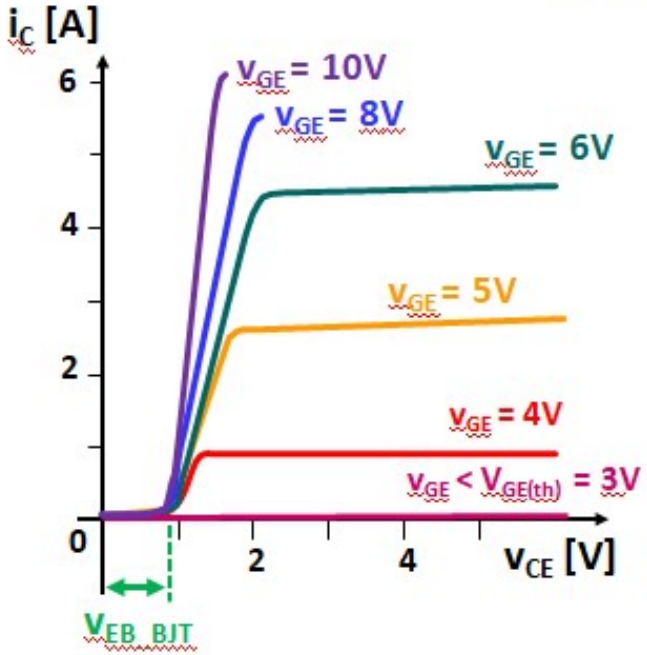
- The IGBT cannot conduct reverse current when v_{GE} = 0 (it is not as the MOSFET).



- This means that it is able to block reverse voltage.







- Static output characteristic curve of a MOSFET.
- It is also the one corresponding to the MOSFET part of a IGBT.

- Static output characteristic curve of a IGBT.
- It can be easily obtained from the MOSFET characteristic curve by adding the voltage drop $V_{EB\ BJT}$ corresponding to the emitter-to-base junction of the BJT part of the IGBT.

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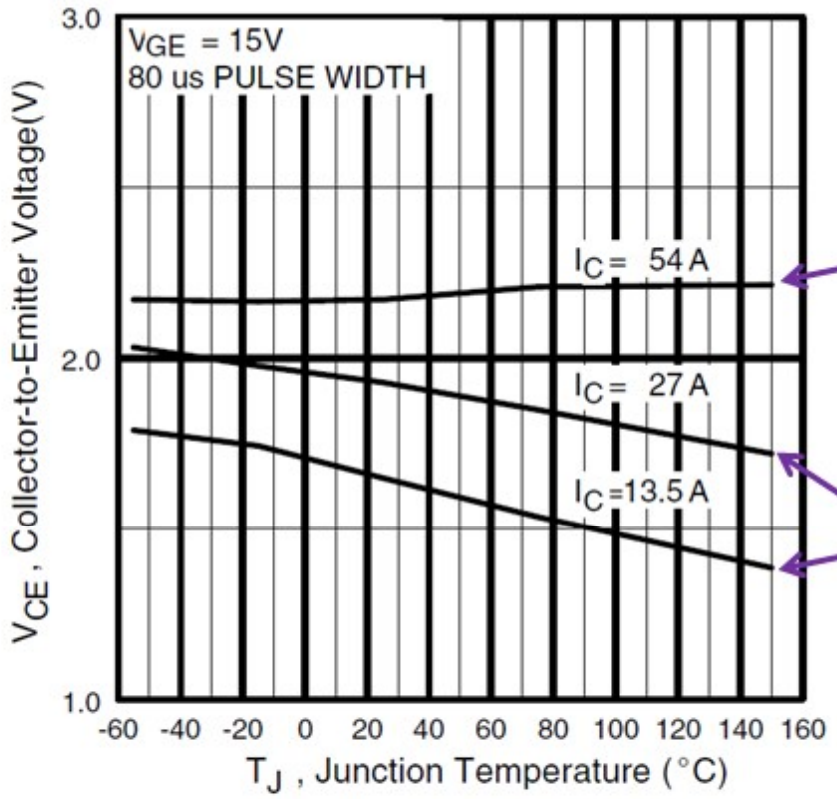

Fig. 5 - Typical Collector-to-Emitter Voltage vs. Junction Temperature

Thermal behaviour like a MOSFET

Thermal behaviour like a BJT

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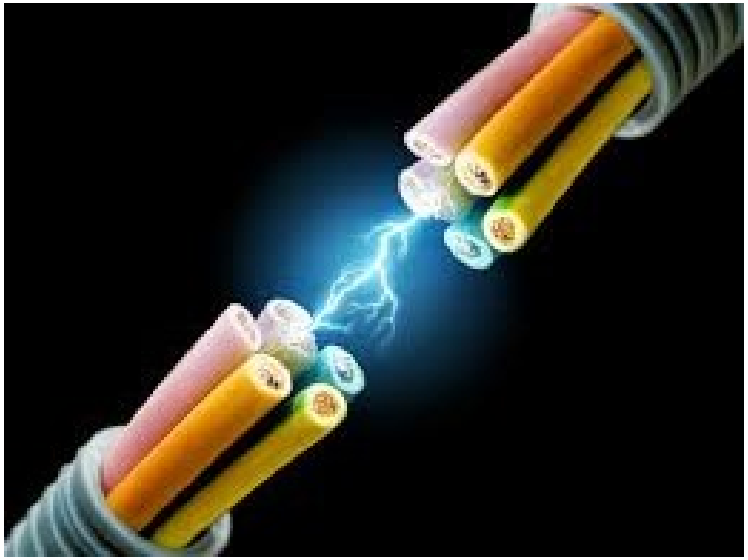
RECAP….



…THANK YOU