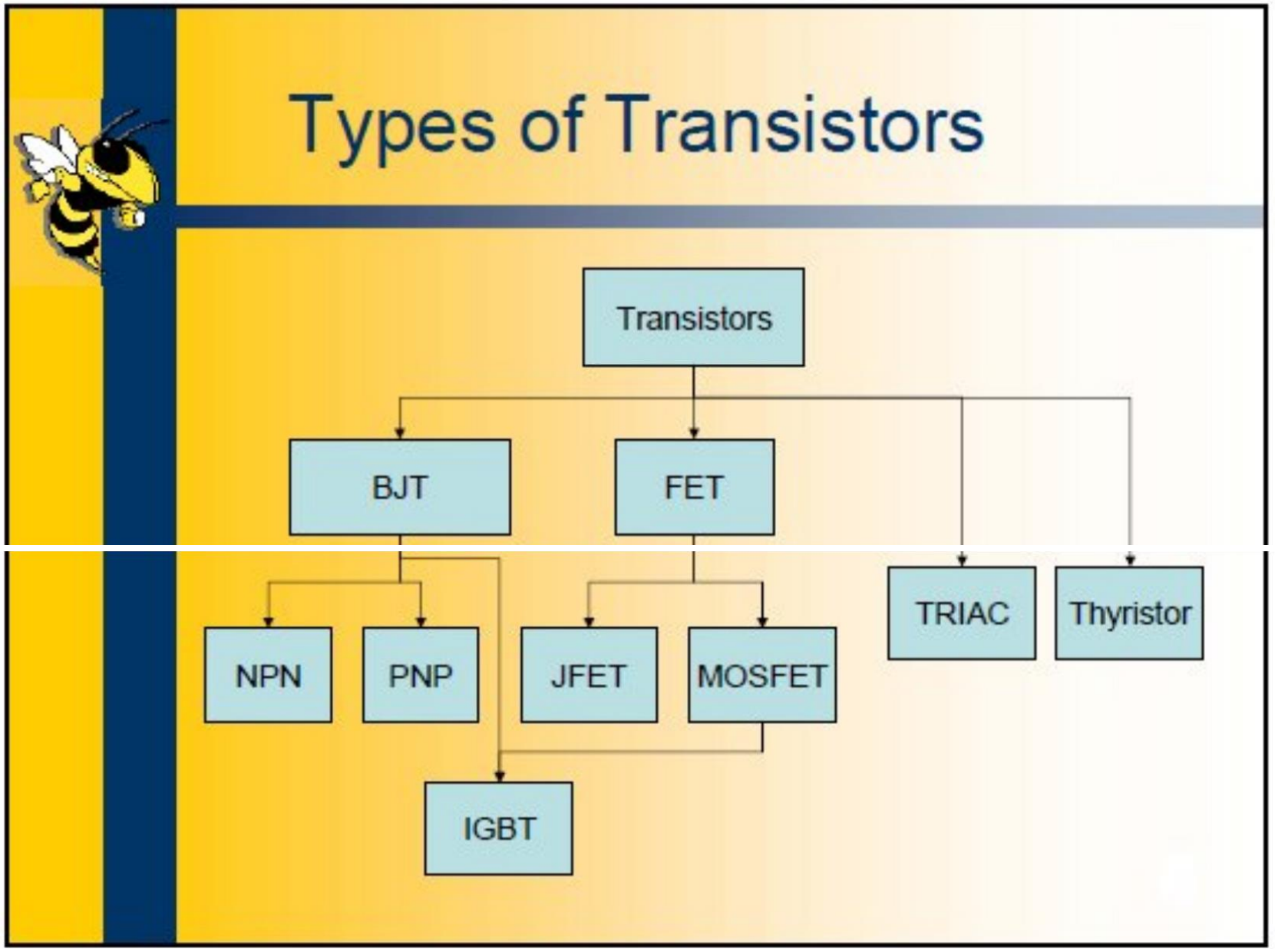
Week No- 3

- Using the transistor as a switch
- Regions of operation
- Switch(cut off and saturation)

Types of Transistors



Transistors

Power Electronic devices that can switch on or off

- Power Transistors (BJT)
- IGBTs
- MOSFETs

The **IGBT** is now the most commonly used for drives

Bipolar Junction Transistor(BJT):

- The BJT is the most common transistor.
- It consists of three sections of semiconductors: an emitter, a base and a collector .
- In an npn-type BJT, the emitter and the collector are made of n-type semiconductors and the base is made of a p-type semiconductor

Transistor Characteristics and Parameters

There are three key dc voltages and three key dc currents to be considered.Note that these measurements are important for troubleshooting.

I_B:dc base current

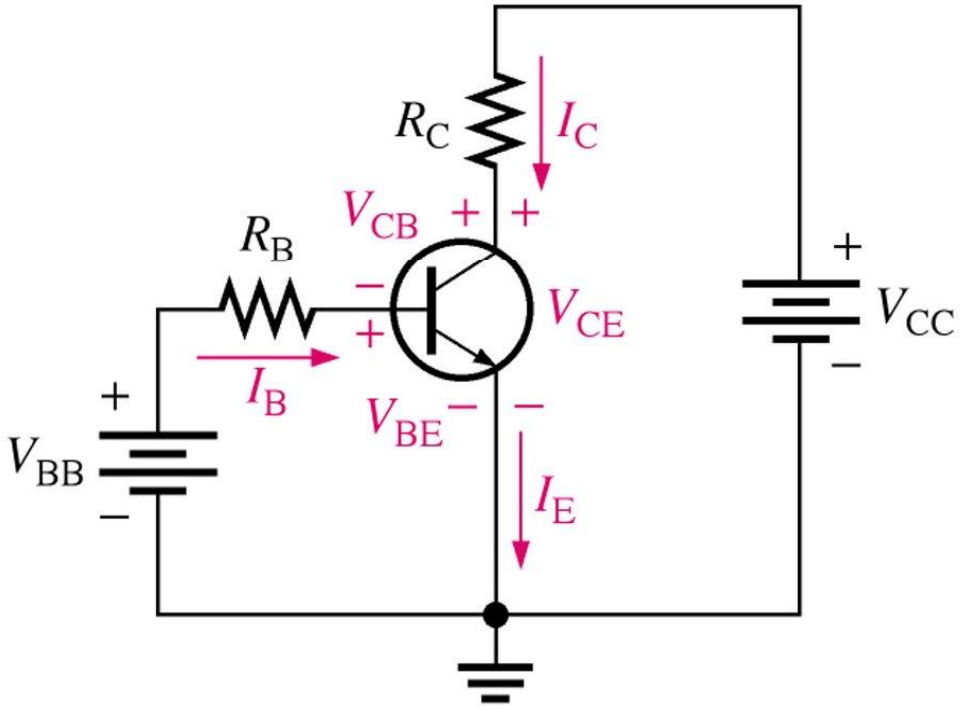
I_E:dc emitter current

I_C:dc collector current

V_{BE}:dc voltage across base-emitter junction

V_{CB}:dc voltage across collector-base junction

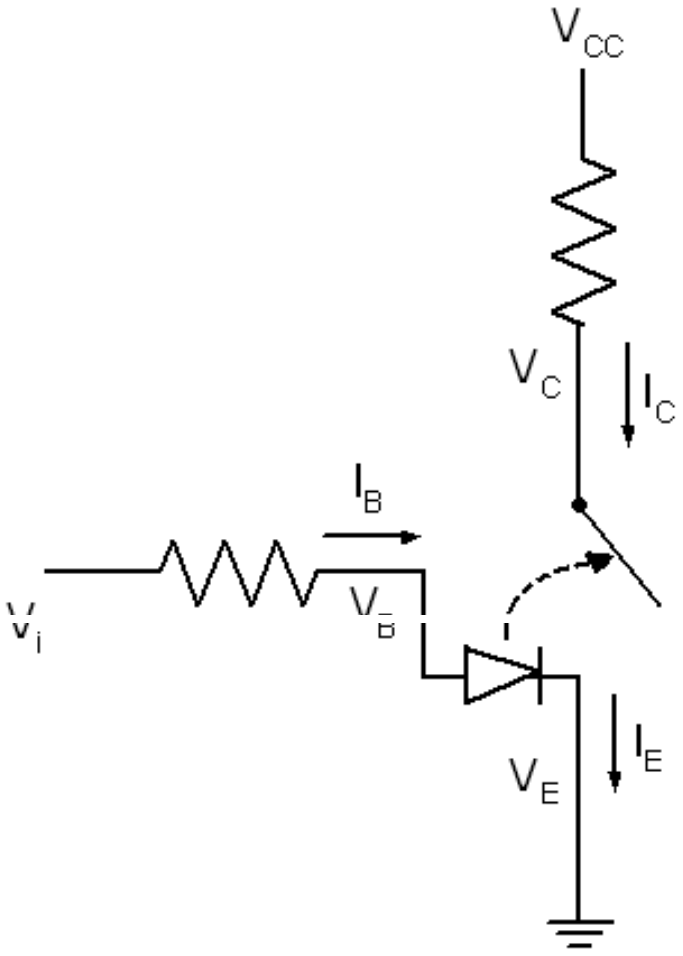
V_{CE}:dc voltage from Collector to emitter



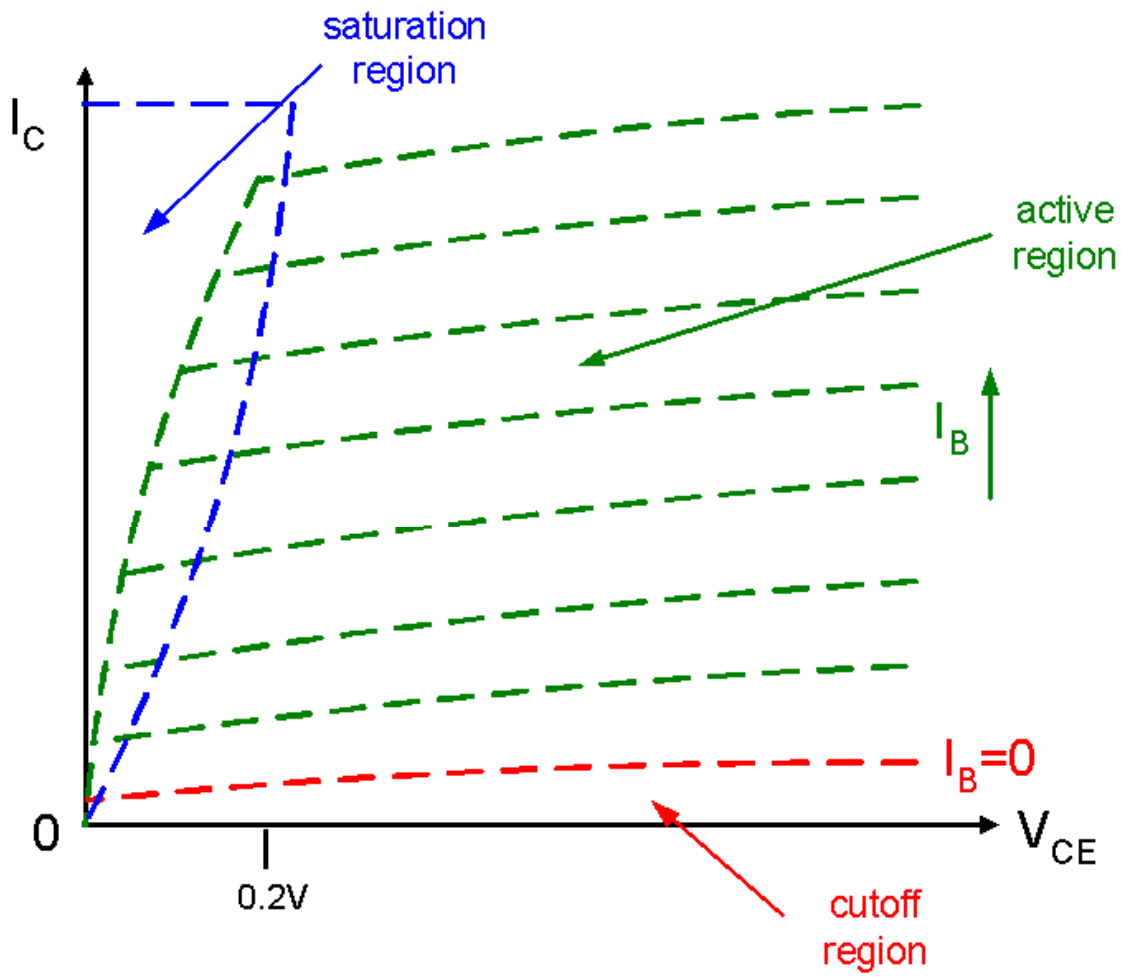
Active region	Saturation region	Cut-off region
• I_E increased, Ic increased • BE junction forward bias and CB junction reverse bias • Refer to the graf, $Ic \approx I_E$ • Ic not depends on V_{CB} • Suitable region for the transistor working as amplifier	• BE and CB junction is forward bias • Small changes in V_{CB} will cause big different to Ic • The allocation for this region is to the left of V_{CB}= 0 V.	• Region below the line of I_E=0 A • BE and CB is reverse bias • no current flow at collector, only leakage current

Diode Model of the npn BJT

- The diode is controlled by the voltage at B.
- When the diode is completely on, the switch is closed. This is the saturation region.
- When the diode is completely off, the switch is open. This is the cutoff region.
- When the diode is in between we are in the active region.



npn Common Emitter Characteristics



$I_C=\beta I_B$

V_{BE} = 0.7V

$$\alpha=\frac{I_C}{I_E}$$

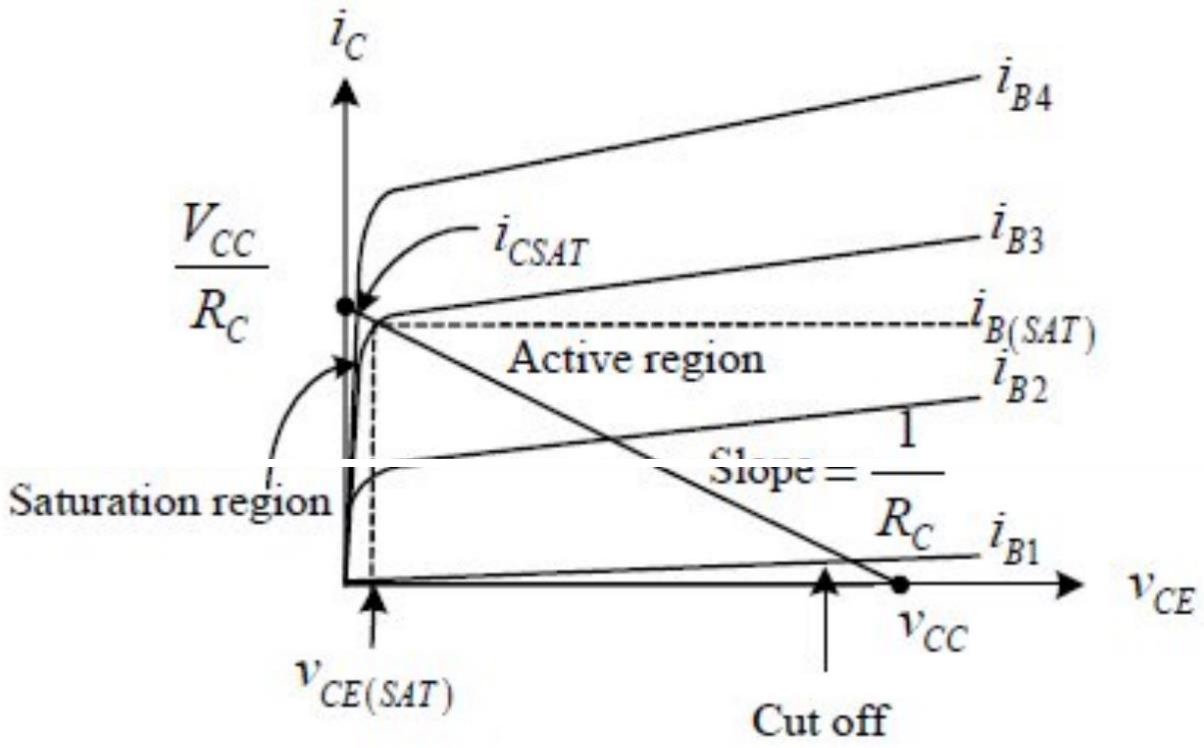
$$\beta=\frac{I_C}{I_B}=\frac{\alpha}{1-\alpha}$$

$0.9<\alpha<0.999$

$10<\beta<1000$

V_{BE}<0.6 V

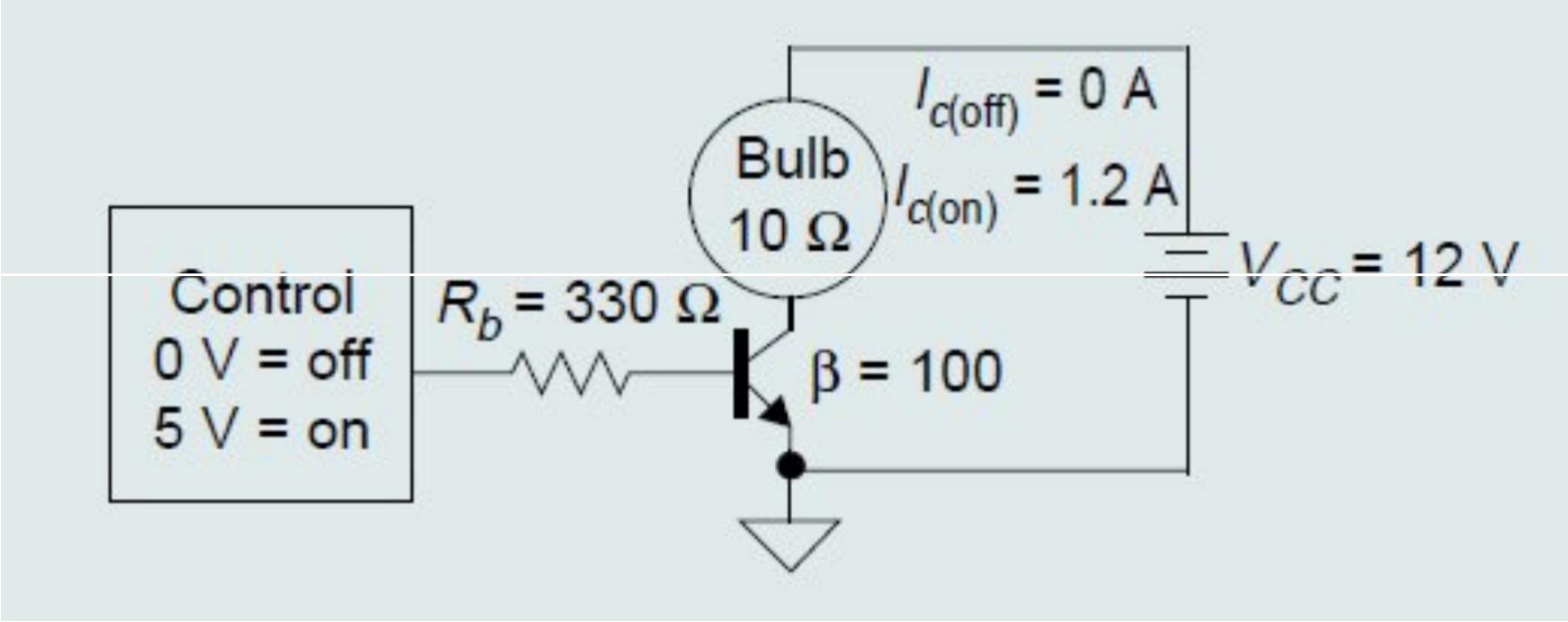
I –V output characteristics of BJT



Common Emitter configuration

EXAMPLE

Design the transistor switching circuit shown in Figure



Step1. Calculate the collector current when the bulb is in the on state. The supply voltage is divided by the resistance of the load (bulb).

$I_C = I_L = V_{CC}/R_L = 12V/10\ \Omega = 1.2A$

Step2. Using beta, calculate the needed base current.

$I_B = I_C/\beta = 1.2A/100 = 12mA$

Step3. Calculate the value of V_{RB}.

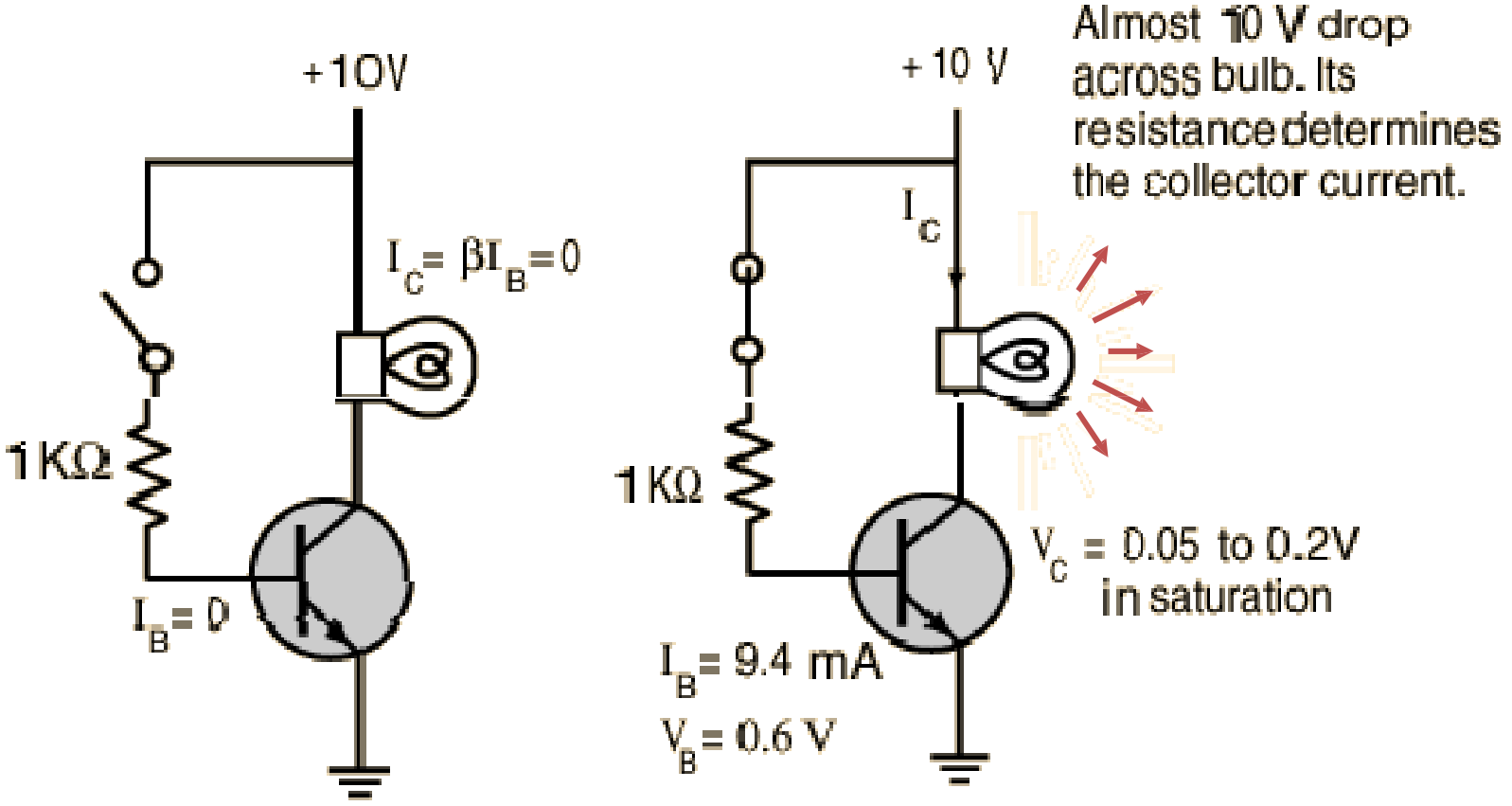
$V_{RB} = V_{control} - V_{BE} = 5V - 0.7V = 4.3V$

Step4. Calculate the value of R_b.

$R_b = V_RB/I_B = 4.3V/12\ mA = 358\Omega$ **(Use the next lower standard value,330Ω.)**

Step5. Draw the switching circuit.(The switching circuit is shown in Figure.)

Using the transistor as a switch

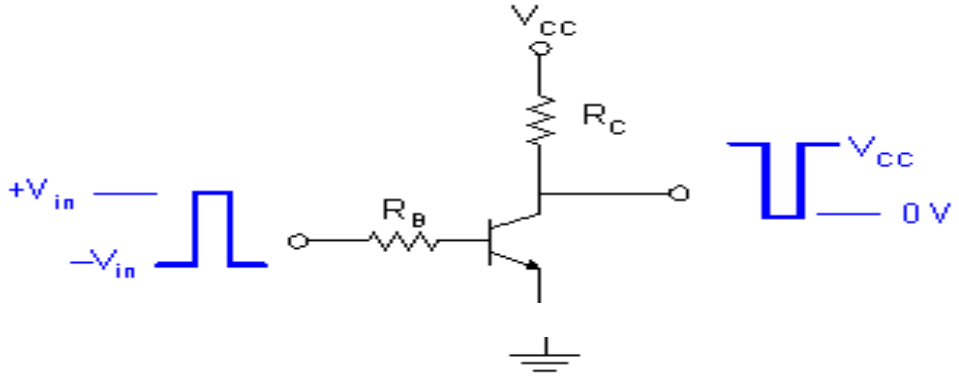


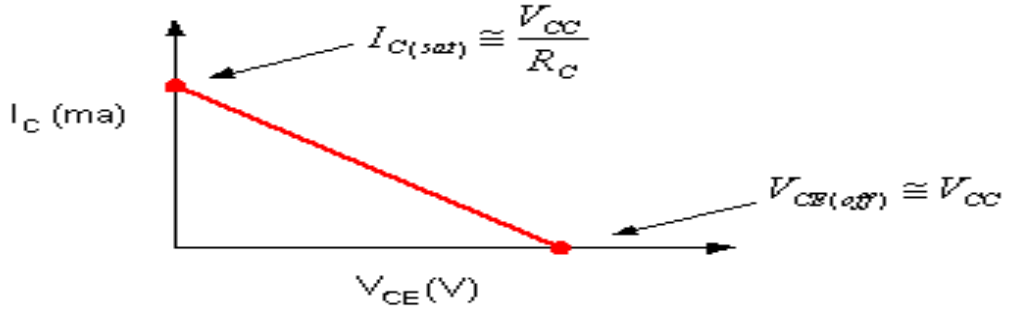
Bulb off

Bulb on

The BJT as a Switch

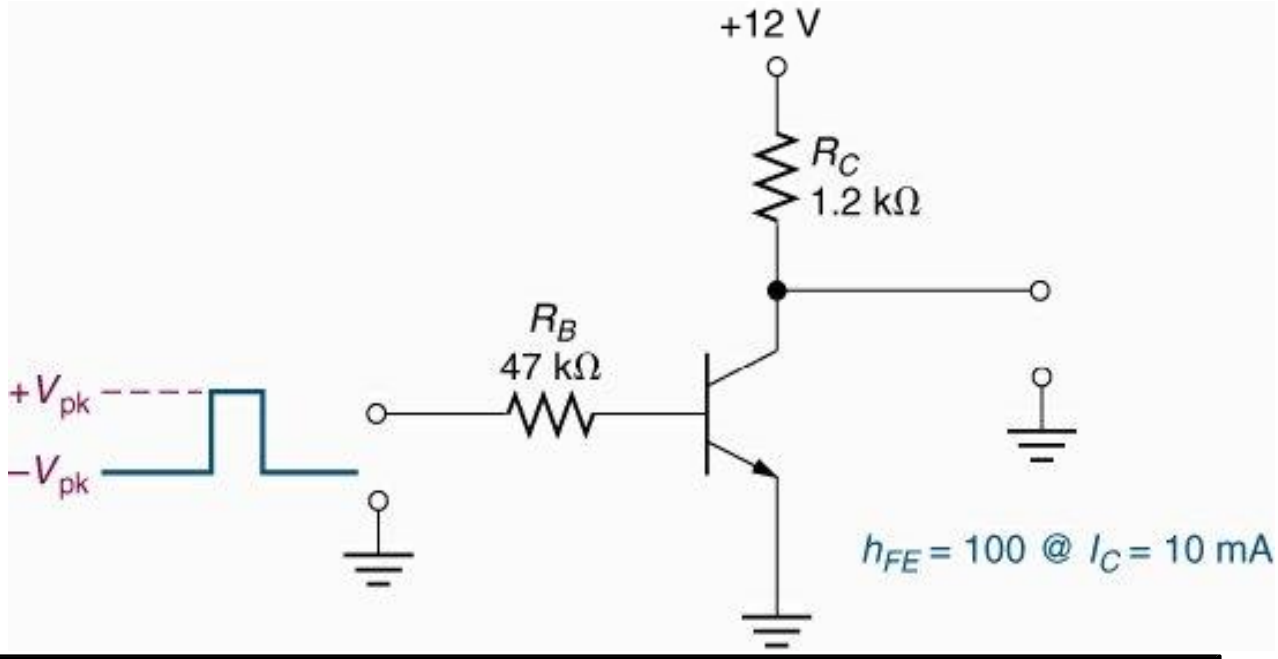
- The BJT can be used as a switch by driving It back and forth between saturation (closed) and cutoff (open).



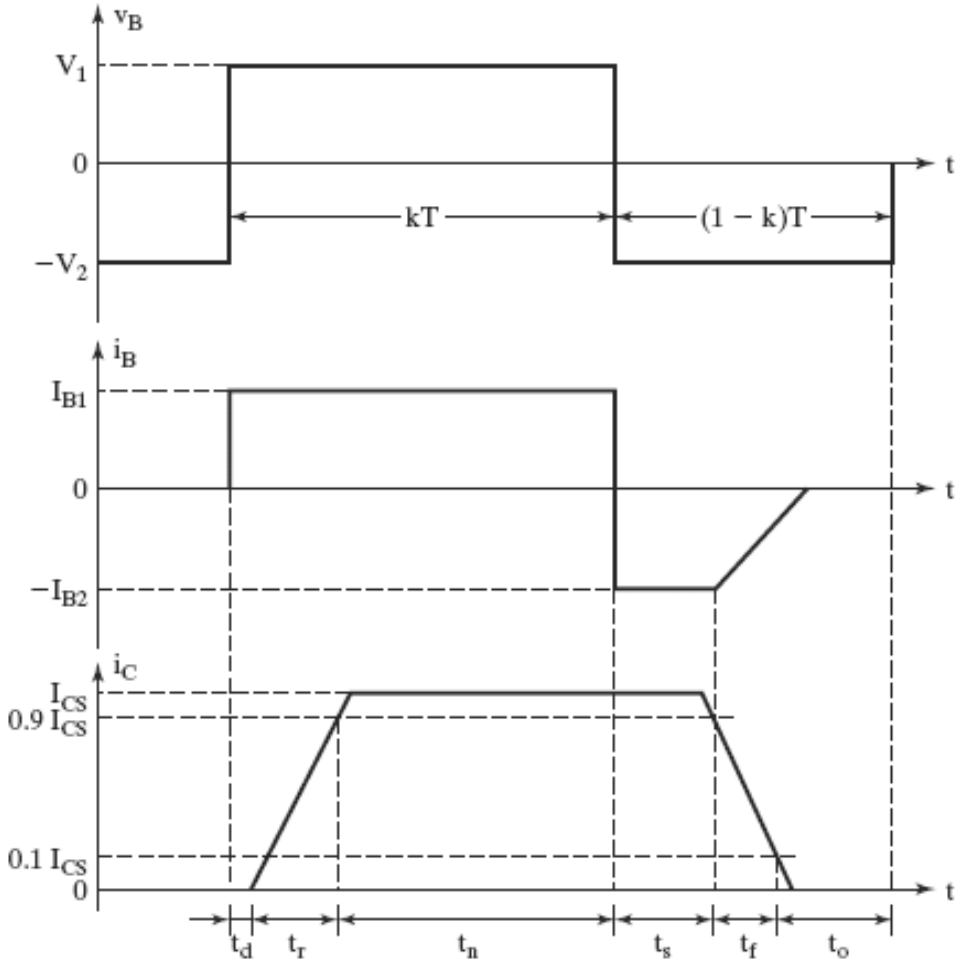


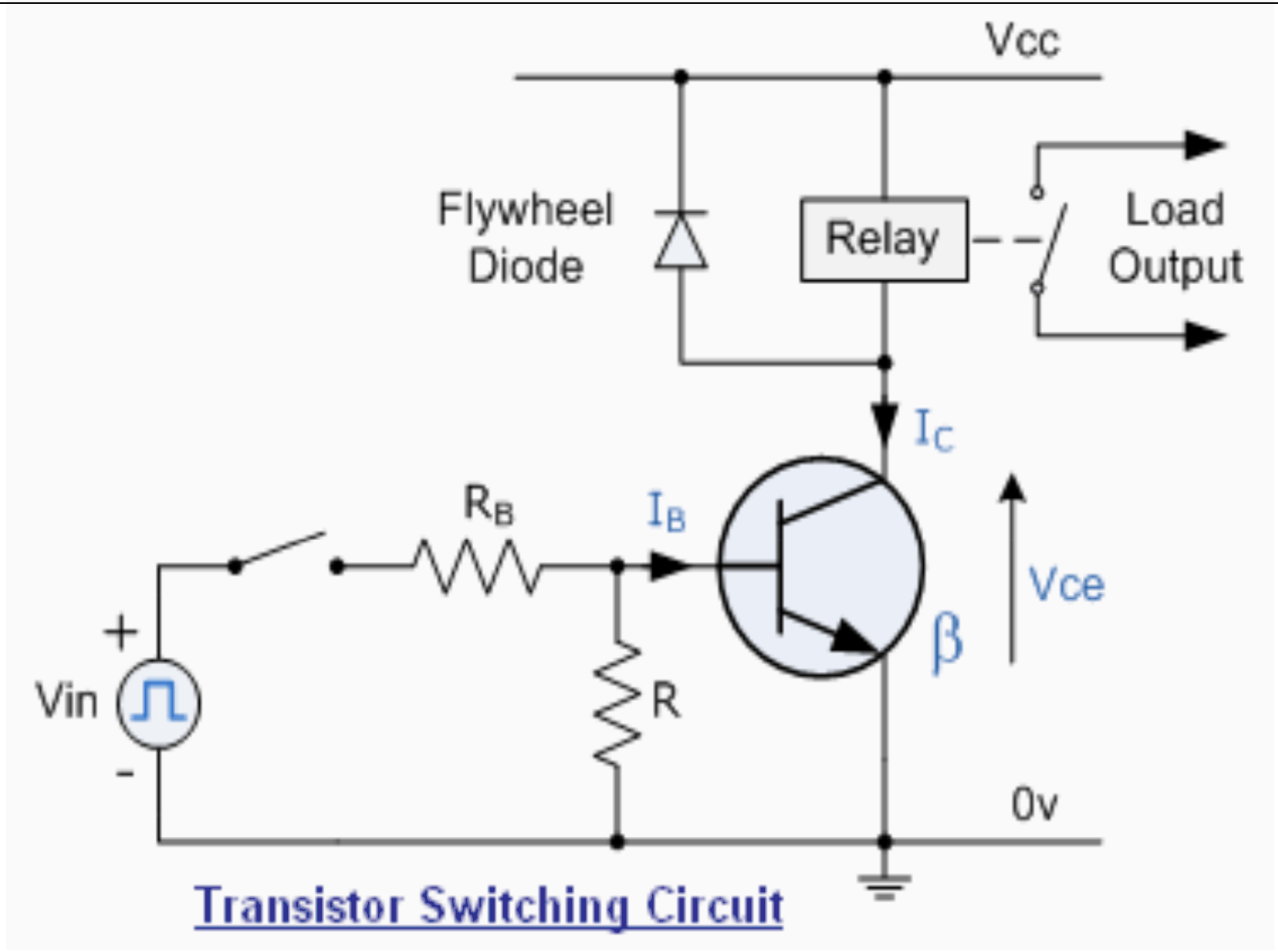
Saturation

- **Transistor saturation can be guaranteed by designing the circuit so that:**
  - **$+V_{pk} = V_{CC}$**
  - **I_B is greater than $I_{C(sat)} / h_{FE}$**



BJT Switching Times





Transistor Switching Circuit

Lesson Summary

- A Bipolar Junction Transistor is a minority carrier, current controlled unidirectional device.
- A BJT can be of n-p-n or p-n-p type with three terminals called the collector, the base and the emitter.
- A BJT can operate in cut-off, active or saturation regions.
- In the cut-off region the base emitter junction is reverse biased and the collector current is almost zero.
- In the active region the ratio of collector current to base current is fairly constant. This ratio is called the dc current gain (β).
- A transistor can be driven into saturation by increasing the base current For a given collector current. In saturation the V_{cE} voltage drop of a transistor is very low.