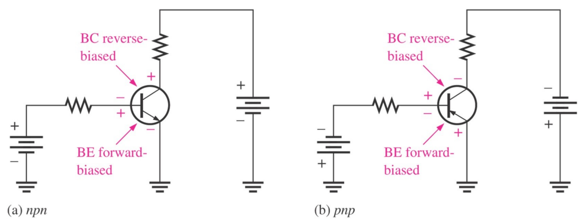
BJT OPERATION

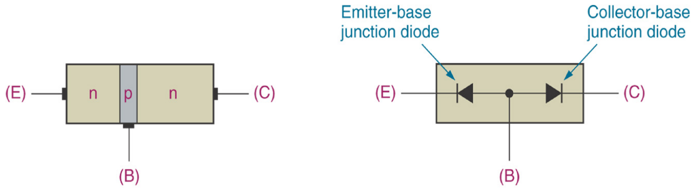
2. BJT OPERATION

- To operate the transistor properly, the two pn junction must be correctly biased with external dc voltages.
- The figure shows the proper bias arrangement for both *npn* and *pnp* transistor for its operation as an amplifier.

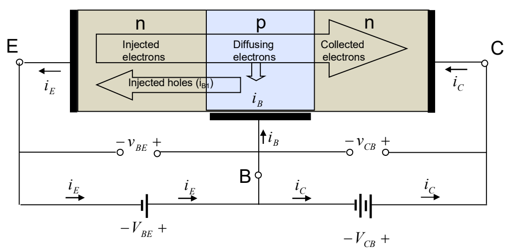


2. BJT OPERATION

- Transistor is made of 3 separate semiconductor materials that joined together to form two pn junction.
- Point at which emitter and base are joined forms a single pn junction → base-emitter junction
- Collector-base junction → point where base and collector meet.

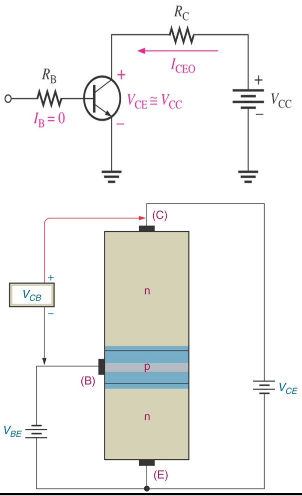


2. Operation of the npn Transistor in the Active Mode



2. BJT OPERATION

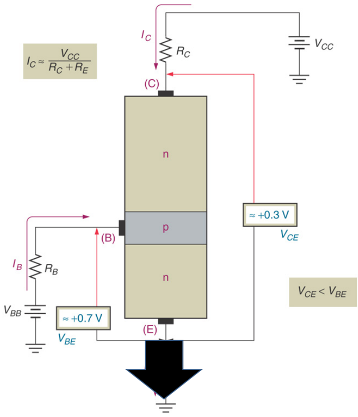
- Cutoff region
- Both transistor junctions are reverse biased.
- With large depletion regi on between C-B and E-B, very small amount of rev erse current, I_{CEO} passes from emitter to collector and can be neglected.
- So, $\mathbf{V_{CE} = V_{CC}}$



2. BJT OPERATION

- Saturation region

$$I_c = \frac{V_{CC}}{R_C}$$



2. BJT OPERATION

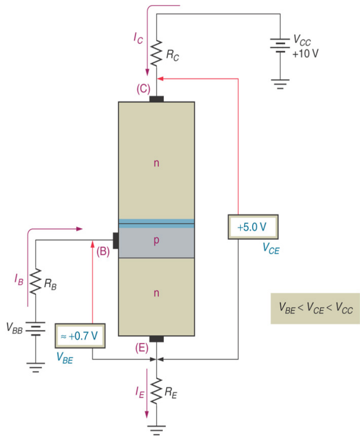
•Active region

•*BE* junction is forward biased an d the *BC* junction is reverse biase d.

•All terminal currents have some measurable value.

•The magnitude of I_C depends on the values of β and I_B.

•V_{CE} is approximately near to 0.7 V and V_{CE} falls in ranges V_{BE}<V_{CE} <V_{CC}.



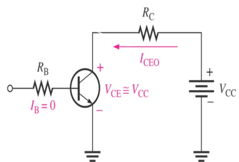
2. BJT OPERATION

Transistor Operating Regions:

1.Cutoff region:

• Both transistor junctions are reverse biased

•All terminal current are approximately equal to zero. Since I_{CEO} neglected, $\mathbf{V_{CE} = V_{CC}}$



2.Active region:

•The *BE* junction is forward biased and the *BC* junction is reverse biased

•All terminal currents have some measurable value

•The magnitude of I_C depends on the values of β and I_B

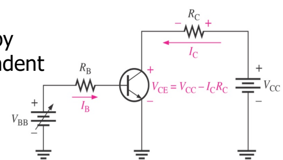
•V_{CE} is approximately near to 0.7V and V_{CE} falls in ranges V_{BE}<V_{CE}<V_{CC}

3.Saturation:

•Both transistor junctions are forward biased

•I_C reaches its maximum values- determine by the component in the CE circuit, and independent of the values of β and I_B

•V_{BE} is approximately 0.7V and V_{CE} < V_{BE}



3. BJT CHARACTERISTICS & PARAMETERS

3. BJT CHARACTERISTICS & PARAMETERS

DC Beta (β_{DC}) and DC Alpha (α_{DC}):

- The ratio of the dc collector current (I_C) to the dc base current (I_B) is the dc beta

(β_{DC}) = dc current gain of transistor

- Range value : 20< β_{DC} <200
- Usually designed as an equivalent hybrid (*h*) parameter, h_{FE} on transistor data sheet – $h_{FE} = \beta_{DC}$

$$\beta_{DC} = \frac{I_C}{I_B}$$

- The ratio of the dc collector current (I_C) to the dc emitter current (I_E) is the dc alpha (α_{DC}) – less used parameter in transistor circuits
- Range value-> 0.95< α_{DC} <0.99 or greater , but << 1 (I_C< I_E)

$$\alpha_{DC} = \frac{I_C}{I_E}$$

3. BJT CHARACTERISTICS & PARAMETERS

Current and Voltage Analysis:

- The current and voltage can be identified as follow:
- Current:

dc base current, I_B

dc emitter current, I_E

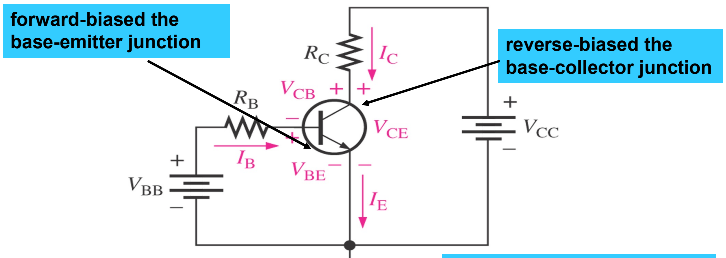
dc collector current, I_C

Voltage:

dc voltage at base with respect to emitter, V_{BE}

dc voltage at collector with respect to base, V_{CB}

dc voltage at collector with respect to emitter, V_{CE}



Transistor current & voltage

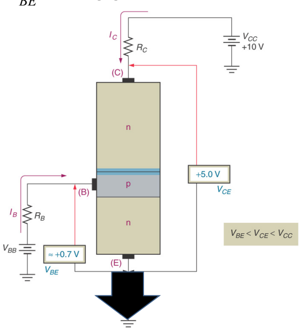
3. BJT CHARACTERISTICS & PARAMETERS

Current and Voltage Analysis:

- When the *BE* junction is forward-biased, like a forward biased diode and the voltage drop is $V_{BE} \cong 0.7V$
- Since the emitter is at ground (0V), by Kirchhoff's voltage law, the voltage across R_B is: $V_{R_B} = V_{BB} - V_{BE}$ ....(1)
- Also, by Ohm's law:
- $V_{R_B} = I_B R_B$ ....(2)
- From (1) ->(2) : $V_{BB} - V_{BE} = I_B R_B$

Therefore, the dc base current is:

$$I_B = \frac{V_{BB} - V_{BE}}{R_B}$$



3. BJT CHARACTERISTICS & PARAMETERS

Current and Voltage Analysis:

➢The voltage at the collector with respect to the grounded emitter is: $V_{CE} = V_{CC} - V_{R_C}$

➢Since the drop across R_C is: $V_{RC} = I_C R_C$

➢The dc voltage at the collector with respect to the emitter is:

$$V_{CE} = V_{CC} - I_C R_C$$

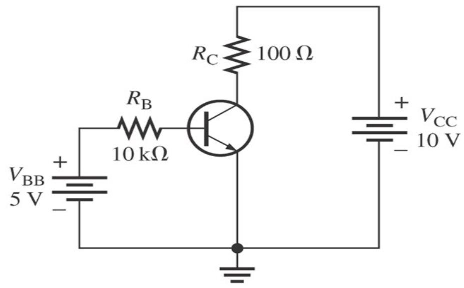
where $I_C = \beta_{DC} I_B$

➢The dc voltage at the collector with respect to the base is:

$$V_{CB} = V_{CE} - V_{BE}$$

Example 1

- Determine I_B, I_C, I_E, V_{CE} and V_{CB} in the circuit below. The transistor has a β_{DC}=150.



Solution Example 1

When BE junction is FB, act as normal diode. So, V_{BE}=0.7V.
The base current,

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{5 - 0.7}{10k\Omega} = 430\,\mu A$$

Collector current, $I_C = \beta_{DC} I_B = 150\ (430\ \mu A) = 64.5\,mA$

Emitter current, $I_E = I_C + I_B = 64.5mA + 430\,\mu A = 64.9\,mA$

Solve for V_{CE} and V_{CB}.

$$V_{CE} = V_{CC} - I_C R_C = 10V - (64.5mA)(100\Omega) = 3.55V$$

$$V_{CB} = V_{CE} - V_{BE} = 3.55 - 0.7 = 2.85V$$