(2 marks questions) Transistors

1) Define current gain (α)

⇒ It is the ratio of collector current to emitter current. $\alpha_{dc} = \frac{I_C}{I_E}$

2) Define current gain (β)

⇒ It is the ratio of collector current to base current

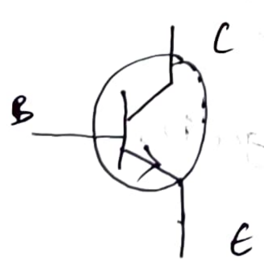
$$\beta_{dc} = \frac{I_C}{I_B}.$$

3) In a common base connection, $I_C = 0.95\ mA$ & $I_B = 0.05 mA$. find the value of α?

4) What is the name given to the semiconductor device; that has 3 or more elements?

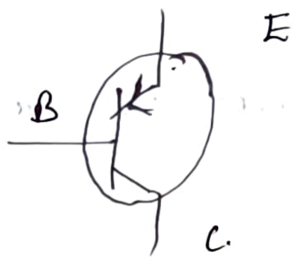
⇒ BJT (Bipolar junction transistor), FET

5) In which direction does the arrow point on an npn transistor?

⇒ 

outward direction, from base - Emitter.

6) In which direction does the arrow point to an pnp transistor?

⇒ 

inward direction

Emitter - base

7) what is the name of the device that provides an increase in current, voltage or power of a signal without appreciably altering the original signal?

⇒ Amplifier.

(5 marks questions)

1) obtain Relationship b/w α_{dc} & β_{dc} in a transistor.

$$I_E = I_C + I_B \rightarrow ①$$

WKT,

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

from the above eqn.

$$I_C = \alpha_{dc} I_E \rightarrow ②$$

α_{dc} is emitter - collector current gain.

Sub eqn ① in ②

$$I_C = \alpha_{dc} (I_C + I_B)$$

$$I_C = \alpha_{dc} I_C + \alpha_{dc} I_B$$

$$I_C - \alpha_{dc} I_C = \alpha_{dc} I_B$$

$$I_C (1 - \alpha_{dc}) = \alpha_{dc} I_B$$

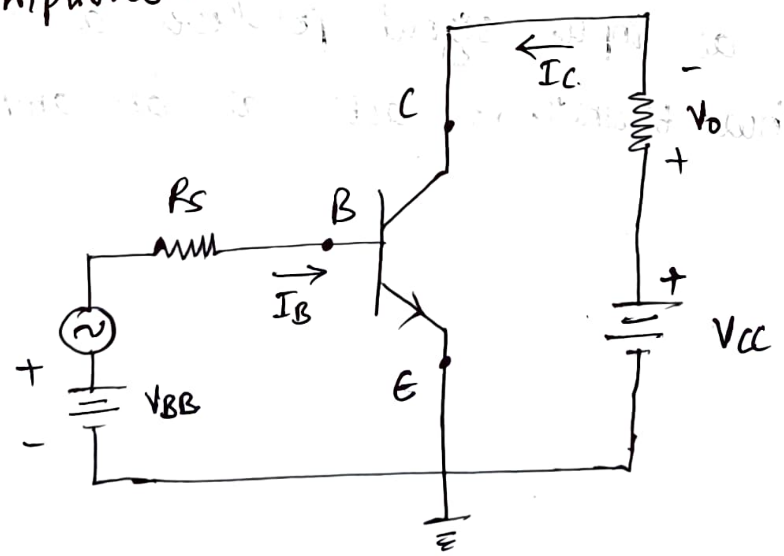
$$I_C = \frac{\alpha_{dc}}{1-\alpha_{dc}} \cdot I_B$$

$$\boxed{I_C = \beta I_B.}$$

where, $\boxed{\beta = \frac{\alpha_{dc}}{1-\alpha_{dc}}}$

2) Show that transistor could be used as an amplifier.

⇒ Transistor increases the strength of weak signal acting as an amplifier.



Basic common emitter amplifier.

⇒ The supply voltage V_{BB} forward biases the emitter to base junction & V_{CC} reverse biases the collector to base junction. Thus transistor operates in active region.

⇒ The magnitude of the ac input signal is such that it always forward bias the emitter to base junction regardless of polarity of ac input signal.

⇒ During +ve half cycle of the input signal, the forward bias across the emitter to base junction is increased which increases the collector current. The increased collector current produces a greater voltage drop across resistance 'R_C'

⇒ During -ve half cycle of the input signal, forward bias across the emitter to base junction is decreased, which decreases the collector current. The decreased collector current produces smaller voltage drop across resistance 'R_C'

⇒ The small ac input signal produces a large ac output signal. Thus transistor acts as an amplifier.

Solutions to Numericals from Question Bank on Transistors

Q). In a common base connection, $I_C = 0.95\,mA$, and $I_B = 0.05\,mA$ find the value of α.

1

A): $I_E = I_C + I_B = 0.95\,mA + 0.05\,mA$

$= 1\,mA$

$\alpha = \frac{I_C}{I_E} = \frac{0.95\,mA}{1\,mA} \Rightarrow \boxed{\alpha = 0.95}$

Q). Find the value of β if $\alpha = 0.9$.

A): $\beta = \frac{\alpha}{1-\alpha} = \frac{0.9}{1-0.9} = \frac{0.9}{0.1} \Rightarrow \boxed{\beta = 9}$

Q): Find the value of β if $\alpha = 0.98$

A): $\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{1-0.98} = \frac{0.98}{0.02}; \boxed{\beta = 49}$

Q): Find the value of β if $\alpha = 0.99$

A): $\beta = \frac{\alpha}{1-\alpha} = \frac{0.99}{1-0.99} = \frac{0.99}{0.01} \Rightarrow \boxed{\beta = 99}$

Q): Calculate I_E in a transistor for which $\beta = 50$ and $I_B = 20\,\mu A$.

A: $I_C = \beta I_B \Rightarrow I_C = 20\,\mu A \times 50 = 1\,mA$

$I_E = I_B + I_C = 1\,mA + 20\,\mu A$

$= \underline{1.02\,mA}$ or $\underline{1020\,\mu A}$

Q): If the base current in a transistor is 20 μA when the emitter current is 6.4 mA, what are the values of α & β? Also calculate the collector current. (2)

A): $I_E = I_B + I_C$,

Collector current $I_C = I_E - I_B$

$= 6.4\,mA - 20\,\mu A$

$= 6.38\,mA$

Current gain, $\beta = \frac{I_C}{I_B} = \frac{6.38\,mA}{20\,\mu A} \Rightarrow \boxed{\beta = 319}$

$\alpha = \frac{I_C}{I_E} = \frac{6.38\,mA}{6.4\,mA} \Rightarrow \boxed{\alpha = 0.9968}$

Q): Calculate α_{dc} & β_{dc} for the transistor if I_C is measured as 1 mA & $I_B = 25\,\mu A$. Also determine the new base current to give $I_C = 5\,mA$.

A): $\beta_{dc} = \frac{I_C}{I_B} = \frac{1\,mA}{25\,\mu A} = 40$

$I_E = I_C + I_B = 1\,mA + 25\,\mu A = 1.025\,mA$ & $1025\,\mu A$

$\alpha_{dc} = \frac{I_C}{I_E} = \frac{1\,mA}{1.025\,mA} \Rightarrow \cancel{\alpha_{dc} = 97.56}$

$\boxed{\alpha_{dc} = 0.9756}$

The new value of base current for collector current of 5 mA is $I_B = \frac{I_C}{\beta} = \frac{5\,mA}{40} = \underline{125\,\mu A}$

Q): Calculate the value of I_C & I_E for a transistor that has $\alpha_{dc} = 0.98$ & $I_B = 100\,\mu A$. Also determine the value of β_{dc} for the transistor. (3)

A):

$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{1-0.98} = \frac{0.98}{0.02} \Rightarrow \underline{\beta = 49}$$

$$I_C = \beta \times I_B = 49 \times 100\,\mu A \Rightarrow \underline{I_C = 4.9\,mA}$$

$$I_E = I_C + I_B = 4.9\,mA + 100\,\mu A \Rightarrow \underline{I_E = 5\,mA}$$