Electronic Circuits : Sheet No 1

Exercises:

1. Given an α_{dc} of 0.998, determine I_C if $I_E = 4$ mA.
2. Determine α_{dc} if $I_E = 2.8$ mA and $I_B = 20$ µA.
3. Find I_E if $I_B = 40$ µA and α_{dc} is 0.98.
4. Given that $\alpha_{dc} = 0.987$, determine the corresponding value of β.
5. Given $\beta_{dc} = 120$, determine the corresponding value of α.
6. Given that $\beta_{dc} = 180$ and $I_C = 2.0$ mA, find I_E and I_B.
7. A transistor has $I_{CBO} = 48$ nA and $\alpha = 0.992$.
   i. Find β and I_{CEO}.
   ii. Find its (exact) collector current (I_C) when $I_B = 30$ µA.
   iii. Find the approximate collector current, neglecting leakage current.

Q1: Given a α_{dc} of 0.998, determine IC if IE = 4 mA.

Sol:

To determine the collector current I_C from the emitter current I_E and the current gain α, we can use the following relationship:

$$I_C = \alpha I_E$$

Given:

- $\alpha = 0.998$
- $I_E = 4\,\text{mA}$

Now, substitute the given values:

$$I_C = 0.998 \times 4\,\text{mA}$$

$$I_C = 3.992\,\text{mA}$$

So, the collector current I_C is approximately $3.992\,\text{mA}$.

Q2: Determine αdc if IE = 2.8 mA and IB = 20 μA

Sol:

To determine α_{DC} (the DC current gain), we use the following relationship between the emitter current I_E, base current I_B, and collector current I_C:

$$I_E = I_C + I_B$$

and

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

Step 1: Calculate I_C

From the equation $I_E = I_C + I_B$, we can find the collector current I_C:

$$I_C = I_E - I_B$$

Given:

- $I_E = 2.8\,\text{mA} = 2.8 \times 10^{-3}\,\text{A}$
- $I_B = 20\,\mu\text{A} = 20 \times 10^{-6}\,\text{A}$

Now, substitute these values:

$$I_C = 2.8\,\text{mA} - 20\,\mu\text{A}$$

$$I_C = 2.8\,\text{mA} - 0.02\,\text{mA}$$

$$I_C = 2.78\,\text{mA}$$

Step 2: Calculate α_{DC}

Now that we have I_C, we can calculate α_{DC}:

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

Substitute the values:

$$\alpha_{DC} = \frac{2.78\,\text{mA}}{2.8\,\text{mA}}$$

$$\alpha_{DC} \approx 0.9921$$

Final Answer:

So, α_{DC} is approximately **0.9921**.

Q7: A transistor has ICBO = 48 nA and α = 0.992.

i. Find and ICEO.

ii. Find its (exact) collector current (IC) when IB = 30 A.

iii. Find the approximate collector current, neglecting leakage current.

Sol:

Given:

- $I_{CBO} = 48\,\text{nA}$ (leakage current),
- $\alpha = 0.992$ (current gain in the common base configuration),
- $I_B = 30\,\mu A$ (base current).

i. Find β and I_{CEO}

1. Find β:

The current gain β in the common-emitter configuration is related to α by the following relationship:

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

Substitute the given value of $\alpha = 0.992$:

$$\beta = \frac{0.992}{1-0.992} = \frac{0.992}{0.008} = 124$$

So, the current gain β is:

$$\beta = 124$$

2. Find I_{CEO}:

The collector current I_{CEO} is the collector current when the base current is zero, considering only the leakage current. The formula for I_{CEO} is:

$$I_{CEO} = \frac{I_{CBO}}{1-\alpha}$$

Substitute the given values:

$$I_{CEO} = \frac{48\,\text{nA}}{1-0.992} = \frac{48\,\text{nA}}{0.008} = 6000\,\text{nA} = 6\,\mu A$$

So, the value of I_{CEO} is:

$$I_{CEO} = 6\,\mu A$$

ii. Find the exact collector current I_C when $I_B = 30\,\mu A$

The exact collector current I_C is the sum of two components:

1. The component due to the base current I_B, which is $\beta \cdot I_B$.
2. The leakage current I_{CEO}.

The formula for the exact collector current is:

$$I_C = \beta \cdot I_B + I_{CEO}$$

Substitute the known values:

$$I_C = 124 \cdot 30\,\mu A + 6\,\mu A$$

$$I_C = 3720\,\mu A + 6\,\mu A = 3726\,\mu A$$

Thus, the exact collector current is:

$$I_C = 3726\,\mu A = 3.726\,\text{mA}$$

2. Find I_{CEO}:

The collector current I_{CEO} is the collector current when the base current is zero, considering only the leakage current. The formula for I_{CEO} is:

$$I_{CEO} = \frac{I_{CBO}}{1-\alpha}$$

Substitute the given values:

$$I_{CEO} = \frac{48\,\text{nA}}{1-0.992} = \frac{48\,\text{nA}}{0.008} = 6000\,\text{nA} = 6\,\mu A$$

So, the value of I_{CEO} is:

$$I_{CEO} = 6\,\mu A$$

iii. Find the approximate collector current, neglecting leakage current

If we neglect the leakage current I_{CBO}, the collector current is approximately:

$$I_C \approx \beta \cdot I_B$$

Substitute the known values:

$$I_C \approx 124 \cdot 30\,\mu A = 3720\,\mu A = 3.72\,\text{mA}$$

Thus, the approximate collector current (neglecting leakage current) is:

$$I_C \approx 3.72\,\text{mA}$$

Final Answers:

- $\beta = 124$,
- $I_{CEO} = 6\,\mu A$,
- Exact collector current $I_C = 3.726\,\text{mA}$,
- Approximate collector current $I_C \approx 3.72\,\text{mA}$ (neglecting leakage current).

Q6:

Given:

- $\beta_{DC} = 180$ (current gain)
- $I_C = 2.0\,\mathrm{mA}$ (collector current)

Step 1: Find the emitter current I_E

The relationship between the collector current I_C, emitter current I_E, and base current I_B is:

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

Also, the emitter current is the sum of the collector and base currents:

$$I_E = I_C + I_B$$

We can express I_B in terms of I_C and β_{DC} as:

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

Substitute the given values:

$$I_B = \frac{2.0\,\mathrm{mA}}{180}$$

$$I_B = 0.0111\,\mathrm{mA} = 11.1\,\mu\mathrm{A}$$

Step 2: Find the emitter current I_E

Now, we can calculate I_E:

$$I_E = I_C + I_B = 2.0\,\mathrm{mA} + 0.0111\,\mathrm{mA}$$

$$I_E = 2.0111\,\mathrm{mA}$$