Sir Syed University of Engineering & Technology (SSUET)

Computer Engineering Department

Course Name: Basic Electronics

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Batch: 2010(Sections: A,B)

Solution of Assignments # 5

Course Responsible

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SIR SYED UNIVERSITY OF ENGINEERING AND TECHNOLOGY
COMPUTER ENGINEERING DEPARTMENT
BASIC ELECTRONICS
2010 BATCH (Sections: A, B)

Solution of Assignment # 5

Q1. Using the characteristics of Fig. 3.7, determine V_{BE} at $I_E = 5$ mA for $V_{CB} = 1$, 10, and 20 V. Is it reasonable to assume on an approximate basis that V_{CB} has only a slight effect on the relationship between V_{BE} and I_E?

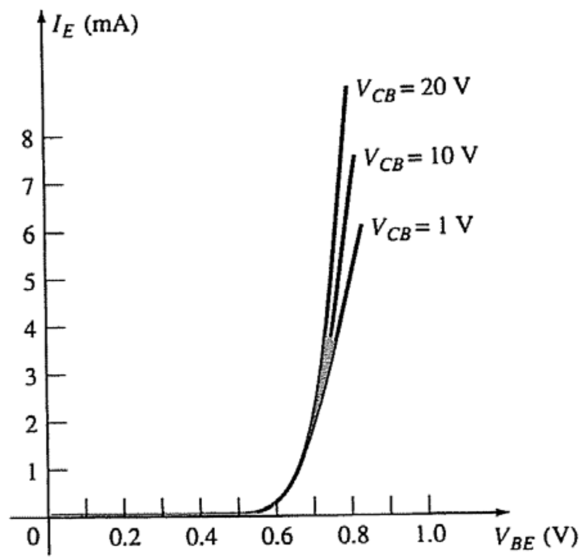


FIG. 3.7
Input or driving point characteristics for a common-base silicon transistor amplifier.

Ans.

$I_E = 5mA$, $V_{CB} = 1V$: $V_{BE} = \underline{800mV}$

$V_{CB} = 10V$: $V_{BE} = \underline{770mV}$

$V_{CB} = 20V$: $V_{BE} = \underline{750mV}$

the change in V_{CB} is $20V : 1V = \underline{20:1}$

the resulting change in V_{BE} is $800mV : 750mV = \underline{1.07:1}$ (very slight)

Q2. (a) Using the characteristics of Fig. 3.8, determine the resulting collector current if $I_E = 4.5$ mA and $V_{CB} = 4$ V.

(b) Repeat part (a) for $I_E = 4.5$ mA and $V_{CB} = 16$ V.

(c) How have the changes in V_{CB} affected the resulting level of I_C?

(d) On an approximate basis, how are I_E and I_C related based on the results above?

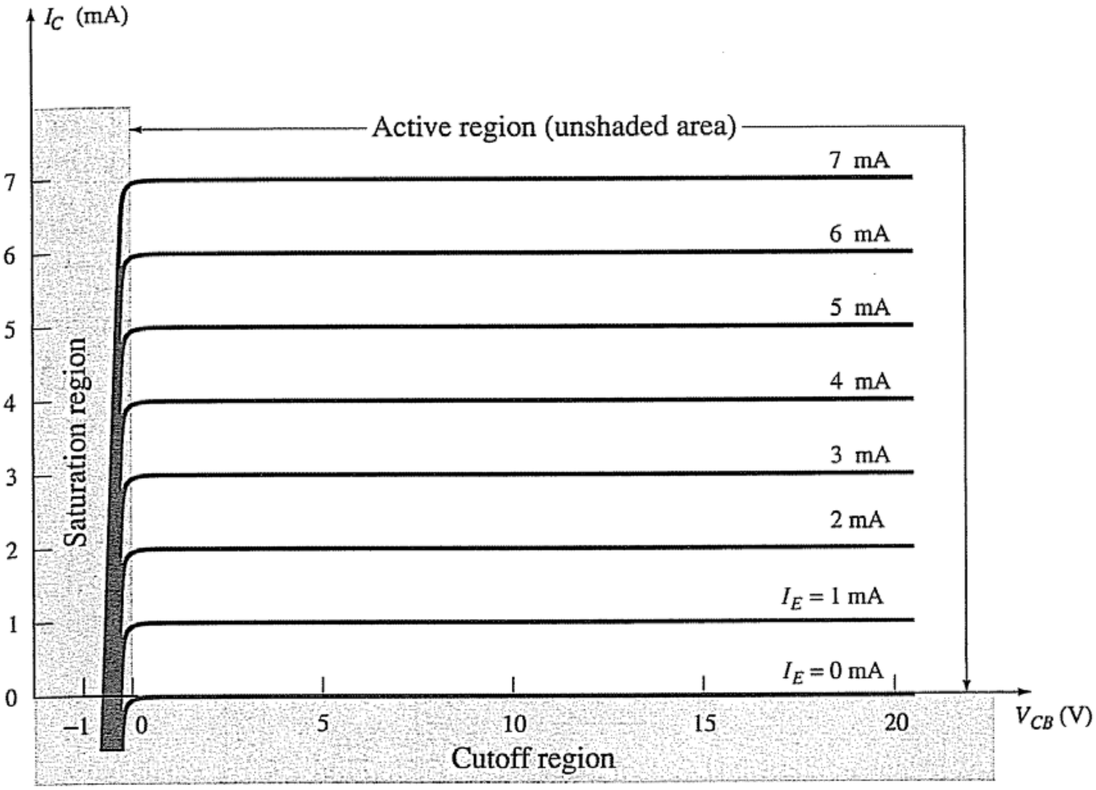


FIG. 3.8

Output or collector characteristics for a common-base transistor amplifier.

Ans.

(a) $I_C \cong I_E = 4.5mA$

(b) $I_C \cong I_E = 4.5mA$

(c) negligible: change cannot be detected on this set of characteristics.

(d) $I_C \cong I_E$

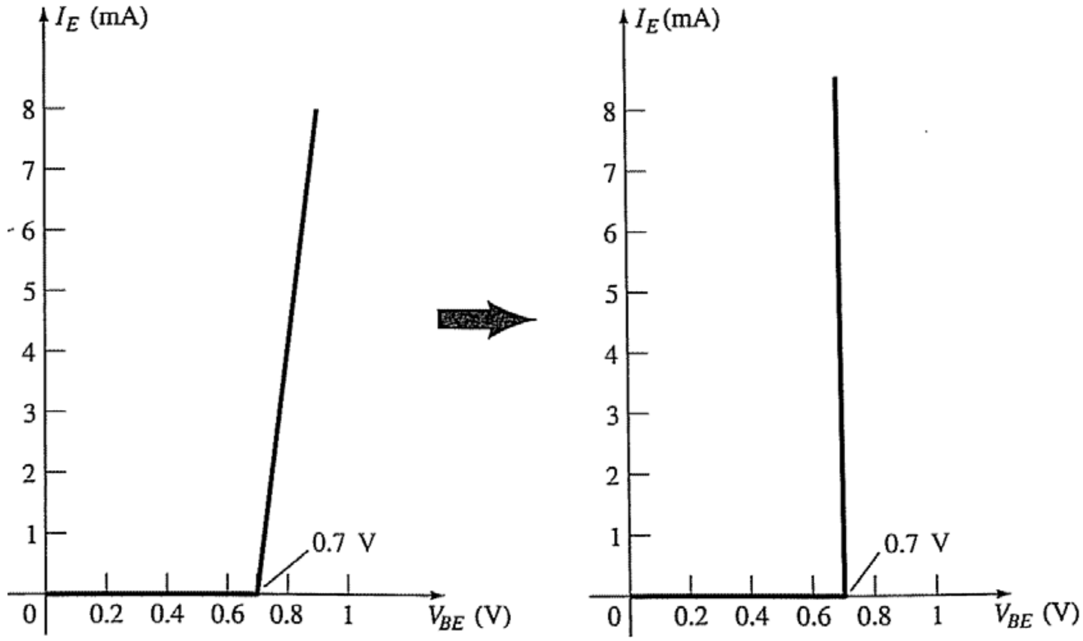
Q3. (a) Using the characteristics of Figs. 3.7 and 3.8, determine I_C if V_{CB} = 10 V and V_{BE} = 800 mV.

(b) Determine V_{BE} if I_C = 5 mA and V_{CB} = 10 V.

(c) Repeat part (b) using the characteristics of Fig. 3.10b.

(d) Repeat part (b) using the characteristics of Fig. 3.10c.

(e) Compare the solutions for V_{BE} for parts (b), (c), and (d). Can the difference be ignored if voltage levels greater than a few volts are typically encountered?



(b) (c)

FIG. 3.10

Ans.

(a) Using Fig. 3.7 first, $I_E \cong 7$ mA
Then Fig. 3.8 results in $I_C \cong$ 7mA

(b) Using Fig. 3.8 first, $I_E \cong 5$ mA
then Fig. 3.7 results in $V_{BE} \cong$ 0.78V

(c) Using Fig. 3.10(b) $I_E = 5$ mA results in $V_{BE} \cong$ 0.81V

(d) Using Fig. 3.10(c) $I_E = 5$ mA results in $V_{BE} =$ 0.7V

(e) Yes, the difference in levels of V_{BE} can be ignored for most applications if voltages of several volts are present in the network.

Q4. (a) Given an α_{dc} of 0.998, determine I_C if $I_E = 4$ mA.
(b) Determine α_{dc} if $I_E = 2.8$ mA and $I_B = 20\mu A$.
(c) Find I_E if $I_B = 40\mu A$ and α_{dc} is 0.98.
Ans.

(a) $I_C = \alpha I_E = (0.998)(4mA) = \underline{3.992\ mA}$

(b) $I_E = I_C + I_B \Rightarrow I_C = I_E - I_B = 2.8mA - 0.02\ mA = 2.78mA$

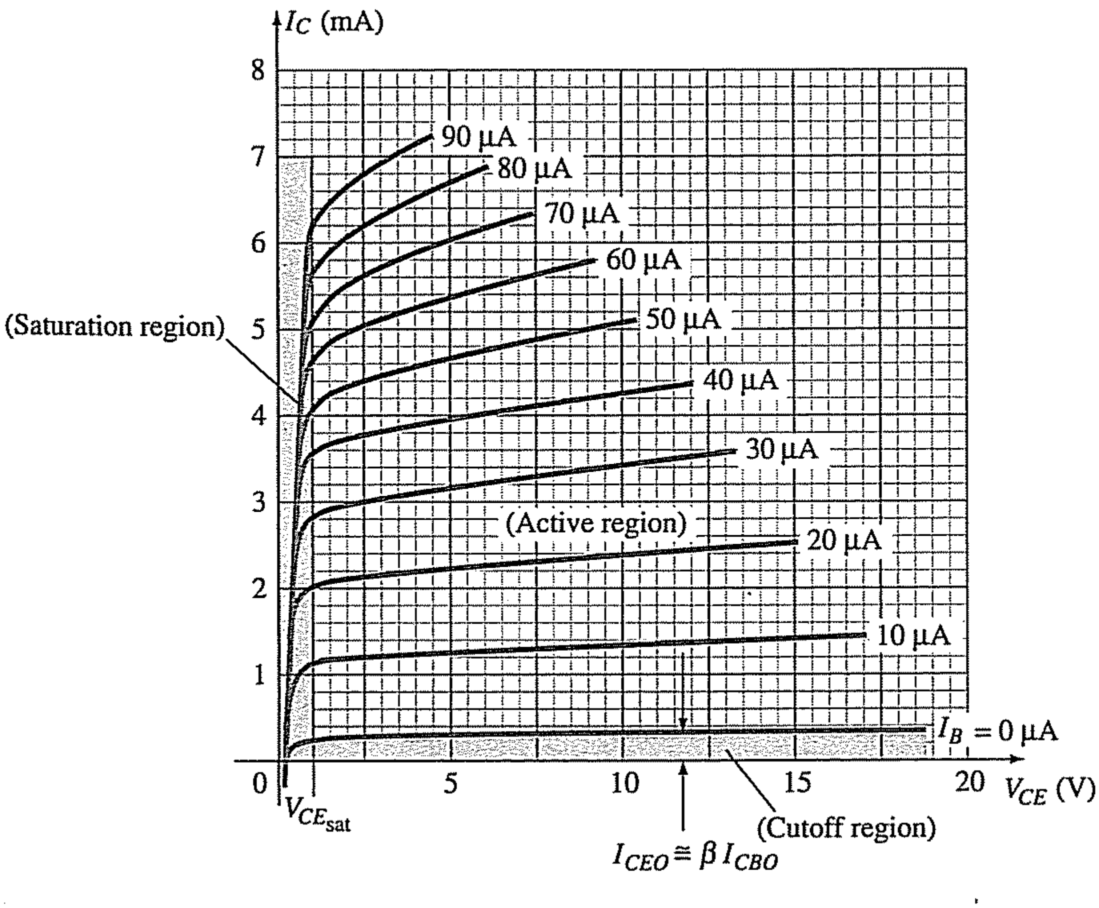
$$\alpha_{dc} = \frac{I_C}{I_E} = \frac{2.78mA}{2.8mA} = \underline{0.993}$$

(c) $I_C = \beta I_B = \left(\frac{\alpha}{1-\alpha}\right) I_B = \left(\frac{0.98}{1-0.98}\right)(40\mu A) = 1.96mA$

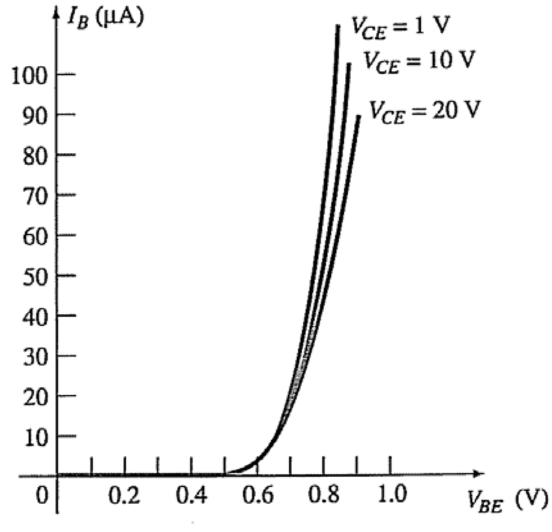
$$I_E = \frac{I_C}{\alpha} = \frac{1.96mA}{0.993} = \underline{2\ mA}$$

Q5. Define I_{CBO} and I_{CEO}. How are they different? How are they related? Are they typically close in magnitude?

Q6. Using the characteristics of Fig. 3.14:
(a) Find the value of I_C corresponding to V_{BE} =750 mV and V_{CE} = 5 V.
(b) Find the value of V_{CE} and V_{BE} corresponding to I_C = 3 mA and I_B = 30 µA.



(a)



(b)

Figure 3.14. Characteristics of a silicon transistor in the common-emitter configuration: (a) collector characteristics; (b) base characteristics.

Ans.

(a) Fig. 3.14 (b): $I_B \cong 35\mu A$

Fig. 3.14 (a): $I_C \cong \underline{3.6 mA}$

(b) Fig. 3.14 (a): $V_{CE} \cong \underline{2.5 V}$

Fig. 3.14 (b): $V_{BE} \cong \underline{0.72 V}$

Q7. (a) For the common-emitter characteristics of Fig. 3.14, find the dc beta at an operating point of V_{CE} =8 V and I_C = 2 mA.

(b) Find the value of _ corresponding to this operating point.

(c) At V_{CE} = 8 V, find the corresponding value of I_{CEO}.

(d) Calculate the approximate value of I_{CBO} using the dc beta value obtained in part (a).

Ans.

(a) $\beta = \frac{I_C}{I_B} = \frac{2mA}{17\mu A} = \underline{117.65}$

(b) $\alpha = \frac{\beta}{\beta+1} = \frac{117.65}{117.65+1} = \underline{0.992}$

(c) $I_{CEO} = 0.3mA$

(d) $I_{CBO} = (1-\alpha) I_{CEO}$

$= (1-0.992)(0.3mA) = \underline{2.4\mu A}$

Q8. (a) Using the characteristics of Fig. 3.14a, determine I_{CEO} at $V_{CE} = 10$ V.
(b) Determine β_{dc} at $I_B = 10\ \mu A$ and $V_{CE} = 10$ V.
(c) Using the β_{dc} determined in part (b), calculate I_{CBO}.
Ans.

(a) Fig. 3.14(a): $I_{CEO} \cong \underline{0.3\text{mA}}$

(b) Fig. 3.14(a): $I_C \cong 1.35\text{mA}$

$$\beta_{dc} = \frac{I_C}{I_B} = \frac{1.35\text{mA}}{10\mu\text{A}} = \underline{135}$$

(c) $$\alpha = \frac{\beta}{\beta+1} = \frac{135}{136} = 0.9926$$

$$I_{CBO} \cong (1-\alpha) I_{CEO}$$
$$= (1-0.9926)(0.3\text{mA})$$
$$= \underline{2.2\mu\text{A}}$$

Q9. (a) Using the characteristics of Fig. 3.14a, determine β_{dc} at $I_B = 80\ \mu A$ and $V_{CE} = 5$ V.
(b) Repeat part (a) at $I_B = 5\ \mu A$ and $V_{CE} = 15$ V.
(c) Repeat part (a) at $I_B = 30\ \mu A$ and $V_{CE} = 10$ V.
(d) Reviewing the results of parts (a) through (c), does the value of dc change from point to point on the characteristics? Where were the higher values found? Can you develop any general conclusions about the value of β_{dc} on a set of characteristics such as those provided in Fig. 3.14a?
Ans.

(a) $$\beta_{dc} = \frac{I_C}{I_B} = \frac{6.7\text{mA}}{80\mu\text{A}} = \underline{83.75}$$

(b) $$\beta_{dc} = \frac{I_C}{I_B} = \frac{0.85\text{mA}}{5\mu\text{A}} = \underline{170}$$

(c) $$\beta_{dc} = \frac{I_C}{I_B} = \frac{3.4\text{mA}}{30\mu\text{A}} = \underline{113.33}$$

(d) β_{dc} does change from pt. to pt. on the characteristics.
Low I_B, high V_{CE} → higher betas
High I_B, low V_{CE} → lower betas

Q10. (a) Using the characteristics of Fig. 3.14a, determine β_{ac} at $I_B = 80\ \mu A$ and $V_{CE} = 5$ V.
(b) Repeat part (a) at $I_B = 5\ \mu A$ and $V_{CE} = 15$ V.
(c) Repeat part (a) at $I_B = 30\ \mu A$ and $V_{CE} = 10$ V.
(d) Reviewing the results of parts (a) through (c), does the value of β_{ac} change from point to point on the characteristics? Where are the high values located? Can you develop any general conclusions about the value of β_{ac} on a set of collector characteristics?
Ans.

(a) $\beta_{ac} = \left.\frac{\Delta I_C}{\Delta I_B}\right|_{V_{CE}=5V} = \frac{7.3mA - 6mA}{90\mu A - 70\mu A} = \frac{1.3mA}{20\mu A} = \underline{65}$

(b) $\beta_{ac} = \left.\frac{\Delta I_C}{\Delta I_B}\right|_{V_{CE}=15V} = \frac{1.4mA - 0.3mA}{10\mu A - 0\mu A} = \frac{1.1mA}{10\mu A} = \underline{110}$

(c) $\beta_{ac} = \left.\frac{\Delta I_C}{\Delta I_B}\right|_{V_{CE}=10V} = \frac{4.25mA - 2.35mA}{40\mu A - 20\mu A} = \frac{1.9mA}{20\mu A} = \underline{95}$

(d) β_{ac} does change from point to point on the characteristics. the highest value was obtained at a higher level of V_{CE} and lower level of I_C. The separation between I_B curves is the greatest in this region

(e)

V_{CE}	I_B	β_{dc}	β_{ac}	I_C	β_{dc}/β_{ac}
5V	80μA	83.75	65	6.7mA	1.29
10V	30μA	113.33	95	3.4mA	1.19
15V	5μA	170	110	0.85mA	1.55

As I_C decreased the level of β_{dc} and β_{ac} increased. Note that the level of β_{dc} and β_{ac} in the center of the active region is close to the average value of the levels obtained. In each case β_{dc} is larger than β_{ac} with the least difference occurring in the center of the active region.

Q11. Using the characteristics of Fig. 3.14a, determine dc at $I_B = 25\ \mu A$ and $V_{CE} = 10$ V. Then calculate α_{dc} and the resulting level of I_E. (Use the level of I_C determined by $I_C = \beta_{dc} I_B$.)
26. (a) Given that $\alpha_{dc} = 0.987$, determine the corresponding value of β_{dc}.
(b) Given $\beta_{dc} = 120$, determine the corresponding value of α_{dc}.
(c) Given that $\beta_{dc} = 180$ and $I_C = 2.0$ mA, find I_E and I_B.
Ans.

$$\beta_{dc} = \frac{I_C}{I_B} = \frac{2.9\ mA}{25\ \mu A} = \underline{116}$$

$$\alpha = \frac{\beta}{\beta+1} = \frac{116}{116+1} = \underline{0.991}$$

$$I_E = I_C/\alpha = 2.9mA/0.991 = \underline{2.93mA}$$

Q12. (a) Given that $\alpha_{dc} = 0.987$, determine the corresponding value of β_{dc}.
(b) Given $\beta_{dc} = 120$, determine the corresponding value of α_{dc}.
(c) Given that $\beta_{dc} = 180$ and $I_C = 2.0$ mA, find I_E and I_B.
Ans.

(a) $$\beta = \frac{\alpha}{1-\alpha} = \frac{0.987}{1-0.987} = \frac{0.987}{0.013} = \underline{75.92}$$

(b) $$\alpha = \frac{\beta}{\beta+1} = \frac{120}{120+1} = \frac{120}{121} = \underline{0.992}$$

(c) $$I_B = \frac{I_C}{\beta} = \frac{2mA}{180} = \underline{11.11 \mu A}$$

$$I_E = I_C + I_B = 2mA + 11.11\mu A$$
$$= \underline{2.011 \, mA}$$

Q13. Determine the region of operation for a transistor having the characteristics of Fig. 3.14 if $I_{Cmax} = 7$ mA, $V_{CEmax} = 17$ V, and $P_{Cmax} = 40$ mW.
Ans.

$$P_{Cmax} = 30mW = V_{CE} I_C$$

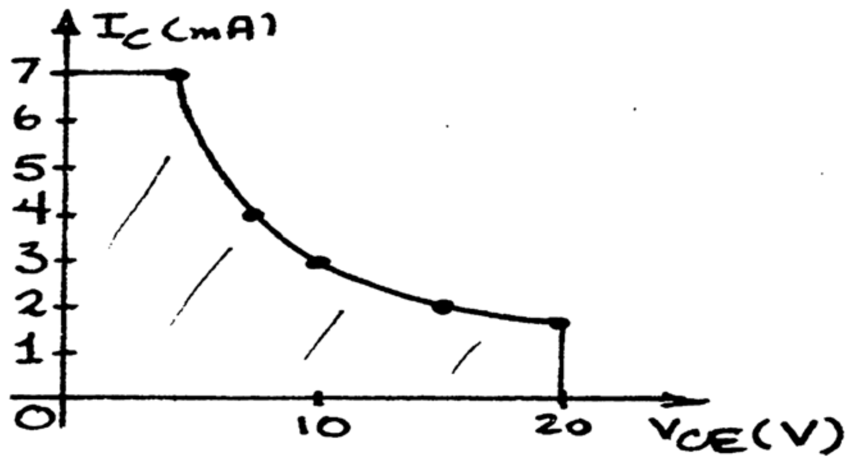
$I_C = I_{Cmax}$, $V_{CE} = \frac{P_{Cmax}}{I_{Cmax}} = \frac{30mW}{7mA} = 4.29V$

$V_{CE} = V_{CEmax}$, $I_C = \frac{P_{Cmax}}{V_{CEmax}} = \frac{30mW}{20V} = 1.5mA$

$V_{CE} = 10V$, $I_C = \frac{P_{Cmax}}{V_{CE}} = \frac{30mW}{10V} = 3mA$

$I_C = 4mA$, $V_{CE} = \frac{P_{Cmax}}{I_C} = \frac{30mW}{4mA} = 7.5V$

$V_{CE} = 15V$, $I_C = \frac{P_{Cmax}}{V_{CE}} = \frac{30mW}{15V} = 2mA$



Q14. Determine the region of operation for a transistor having the characteristics of Fig. 3.8 if $I_{Cmax} = 6$ mA, $V_{CBmax} = 15$ V, and $P_{Cmax} = 30$ mW.
Ans.

$$I_C = I_{C_{max}},\quad V_{CB} = \frac{P_{C_{max}}}{I_{C_{max}}} = \frac{30\,mW}{6\,mA} = \underline{5V}$$

$$V_{CB} = V_{CB_{max}},\quad I_C = \frac{P_{C_{max}}}{V_{CB_{max}}} = \frac{30\,mW}{15V} = \underline{2mA}$$

$$I_C = 4mA,\quad V_{CB} = \frac{P_{C_{max}}}{I_C} = \frac{30\,mW}{4mA} = \underline{7.5V}$$

$$V_{CB} = 10V,\quad I_C = \frac{P_{C_{max}}}{V_{CB}} = \frac{30\,mW}{10V} = \underline{3mA}$$