Tutorial 2

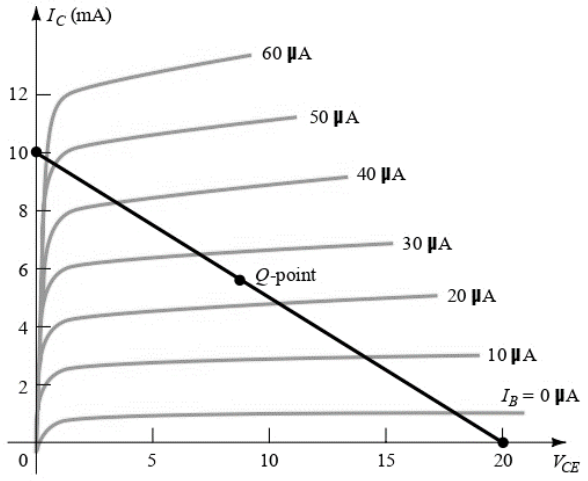
Numerical on transistor

Topics:

a. **Simple transistor circuits analysis to apply KVL or KCL rules to estimate I_C, I_B, I_E, β, and α (using dc biasing – fixed bias, emitter bias and voltage divider)**
b. **Simple transistor values to estimate I_C, I_B, I_E, leakage current, CE and CB voltage and current gain**
c. **Q-point analysis**

Below are the examples for the above topics. Please note that the exam questions will be modified. However, the analysis pattern would remain same. So, please practice more similar questions.

1. **Given the load line of Figure and the defined Q-point, determine the required values of V_{CC}, R_C, and R_B for a CE fixed-bias configuration.**



Answer: V_{CC} = 20 V (DC load line)
$I_{c,sat}$ = 10 mA = V_{CC} / R_C i.e. R_C = 20 V / 10 mA = 2 kΩ
In CE configuration fixed bias,
$V_{CC} – I_BR_B - V_{BE} = 0$ (See the below figure)
i.e $R_B = 20 – 0.7/I_B$
Please note, the V_{BE} should always be taken as 0.7 V, unless mention.
If we see the figure, I_B at the Q point is 25 µA.
Hence R_B = 772 kΩ

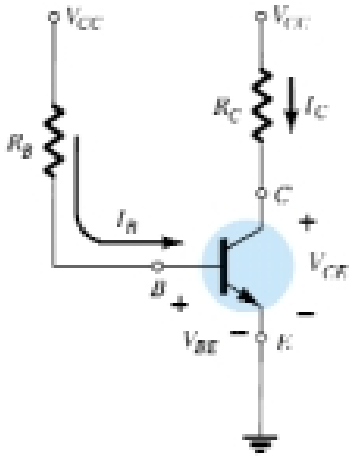
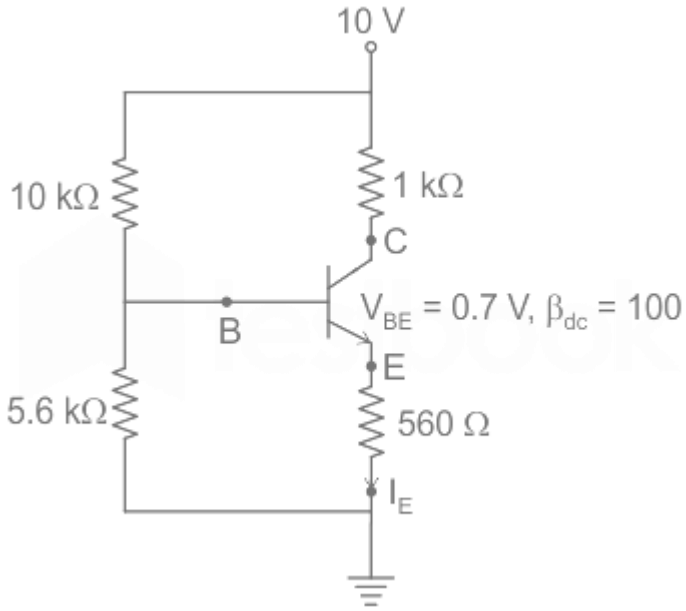


Figure of fixed bias configuration from boylestad.

2. **Find the emitter current.**

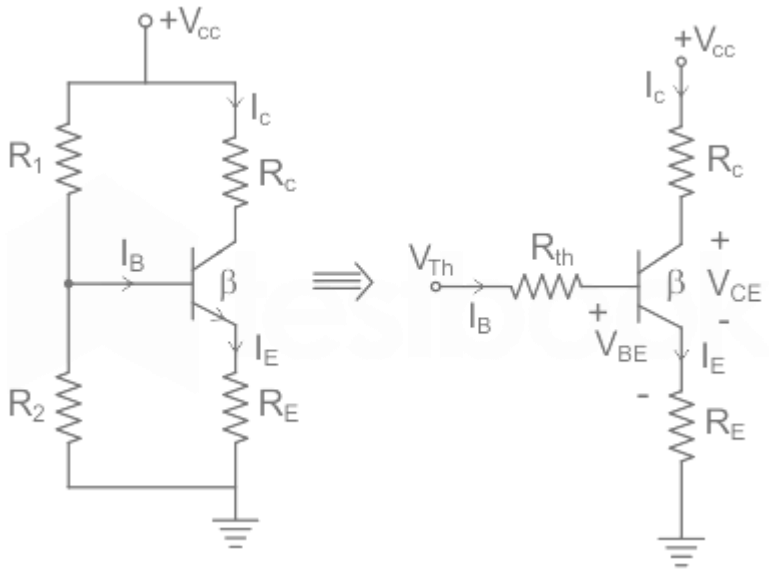


Answer: 5 mA

Hint: Calculate $V_{th} = V_B$ = 10 V * (10/10+5.6) - voltage divider rule at point B

Apply KVL $V_B - V_{BE} - I_E R_E = 0$ this will give I_E = 5 mA

3. **Consider voltage divider circuit: R_1 = 50 kΩ, R_2 = 10 kΩ, R_E = 1 kΩ, β = 100, V_{CC} = 12 V and V_{BE} = 0.7 V. Find out the I_C,**



Answer: 1.2 mA
Calculate V_{th} and R_{th}.

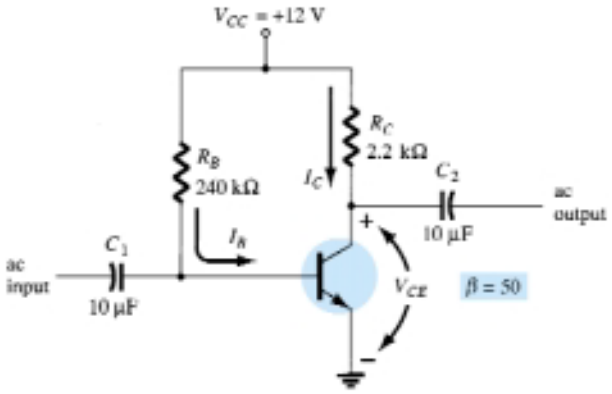
V_{th} = 12* (10/10+50) = 2 V and $R_{th} = R_1||R_2$ = 25/3 kΩ

Now apply KVL,
$V_{th} - I_BR_{th} – V_{BE} – I_ER_E = 0$

Put, $I_E = I_B (\beta+1)$,

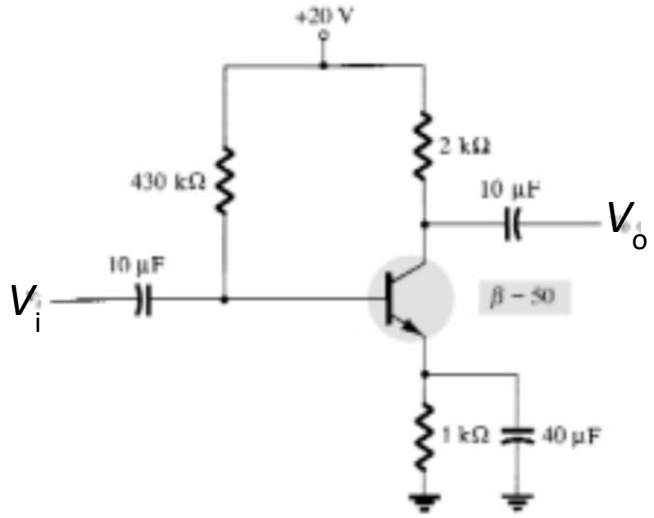
I_B = 11.9 µA (approx. value 12)
We know, Ic = β*I_B
Hence, Ic = 1.19 mA (approx. value 1.2)

4. **For the fixed bias network, find out I_B, I_C, V_{CE}, V_B, V_C, and V_{BC}. What happen if β increases to 100.**



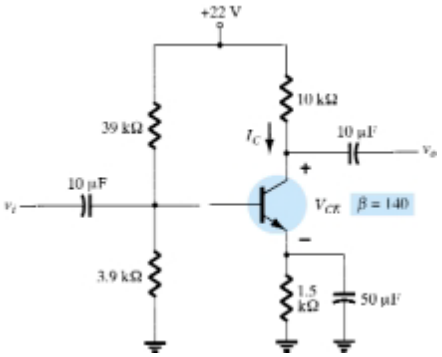
Answer: Please see solved example 4.1 and 4.5 in the Boylestad book. Already discussed in the class.

5. **For the emitter bias network, determine:**
I_B, Ic, V_{CE}, Vc, V_E, V_B, V_{BC}. What happen if β is increased to 100.



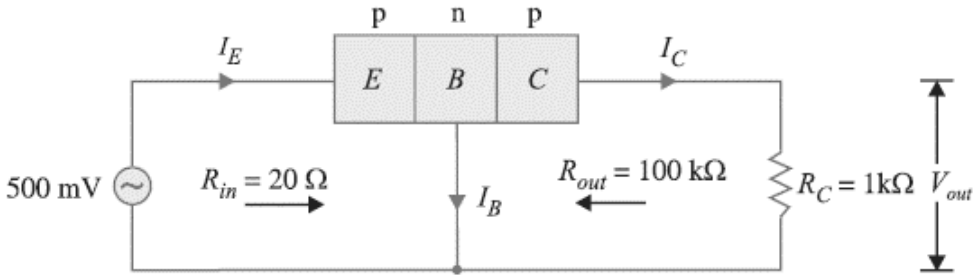
Answer: Please see solved example 4.4 and 4.5 in Boylestad book. Already discussed in the class.

6. **In the voltage divider circuit, find out I_C and V_{CE}. Also, find out what happen if β is decreases to 70.**



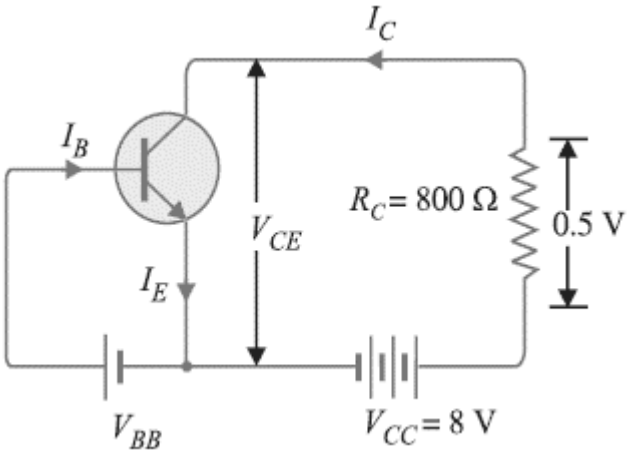
Answer: Please see solved example 4.7 and 4.9. Already discussed in the class using beta value 50 and 100.

7. **Consider the CB configuration, if α is nearly one, find the voltage gain for the following circuit:**



Answer: 50
Here, I_E = 500 mV / 20 Ω = 25 mA
$I_C = I_E$
V_{out} = 25 mA * 1 k Ω = 25 V
Gain = 25 V / 500 mV = 50

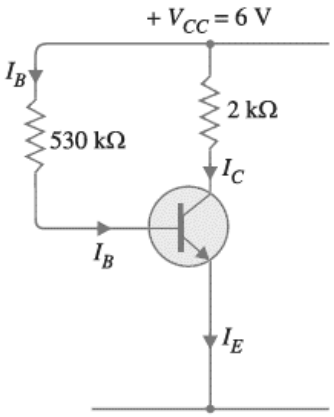
8. **Find base current and V_{CE}, if α = 0.96**



Answer: 26 µA and 7.5 V
$V_{CE} = V_{CC} - I_C R_C = 8 – 0.5 = 7.5$ V
I_C = 0.5 V / R_C = 0.625 mA
β = 0.96/(1-0.96) = 24
I_B = 0.625 / 24 = 0.026 mA

9. **The collector leakage current in a transistor is 300 µA in CE arrangement. If the transistor is connected in CB arrangement, what will be the leakage current? Given that β = 120.**
Answer: 2.4 µA
Here, the leakage current in CE and CB configuration is I_{CEO} and I_{CEO}.
$I_{CEO} = I_{CBO} / (1-\alpha)$
α = 0.992
I_{CBO} = 300 *0.08 = 2.4 µA

10. **Consider the fixed bias configuration:**



Draw the dc load line. If V_{BE} = 0.7 V and β=100, find operating point i.e., I_C and V_{CE}.

Answer: To draw DC load line, we need to determine $I_{c,sat} = V_{CC}/R_C$ = 6 V / 2 kΩ = 3 mA

Operating point: Using KVL

6- 530 kΩ * I_B – 0.7 = 0

I_B = 10 µA

I_C = 1 mA

$V_{CE} = V_{CC} - I_C R_C$ = 4V