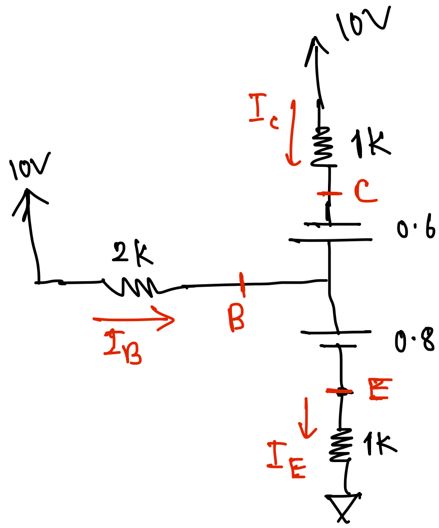
SPRING 2025

Analyze the circuit in Figure-2, and calculate I_B, I_C , I_E, V_C & V_E using the method of assumed states. You must validate your assumption.



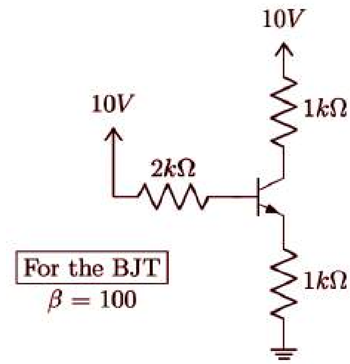


Figure-2

Assume Saturation mode. Based on the equavalent circuit.

Applying KVL across Base to Emitter line,

$$-10 + 2I_B + 0.8 + I_E + 0 = 0$$

or, $\boxed{2I_B + I_E = 9.8}$ — ①

Applying KVL across Collector to Emitter Line,

$$-10 + I_c - 0.6 + 0.8 + I_E + 0 = 0$$

or, $\boxed{I_c + I_E = 9.8}$ — ②

And we know for all condition, $\boxed{I_c + I_B = I_E}$ — ③

Solving eq ① ② ③,

$I_c = 3.92\ mA$

$I_B = 1.96\ mA$

$I_E = 5.88\ mA$

$V_c = 10 - I_c \times 1K$

$= 6.08\ V$

$V_E = I_E \times 1K$

$= 5.88\ V$

Verify:

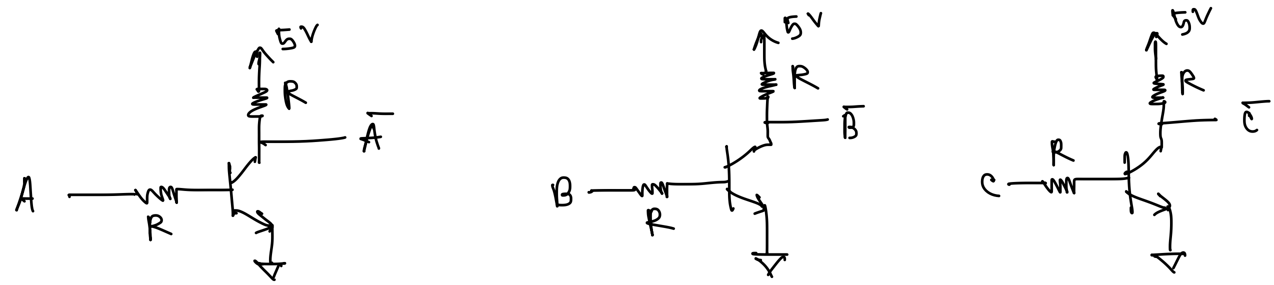
$$\frac{I_c}{I_B} = \frac{3.92}{1.96} = 2 < \beta = 100$$

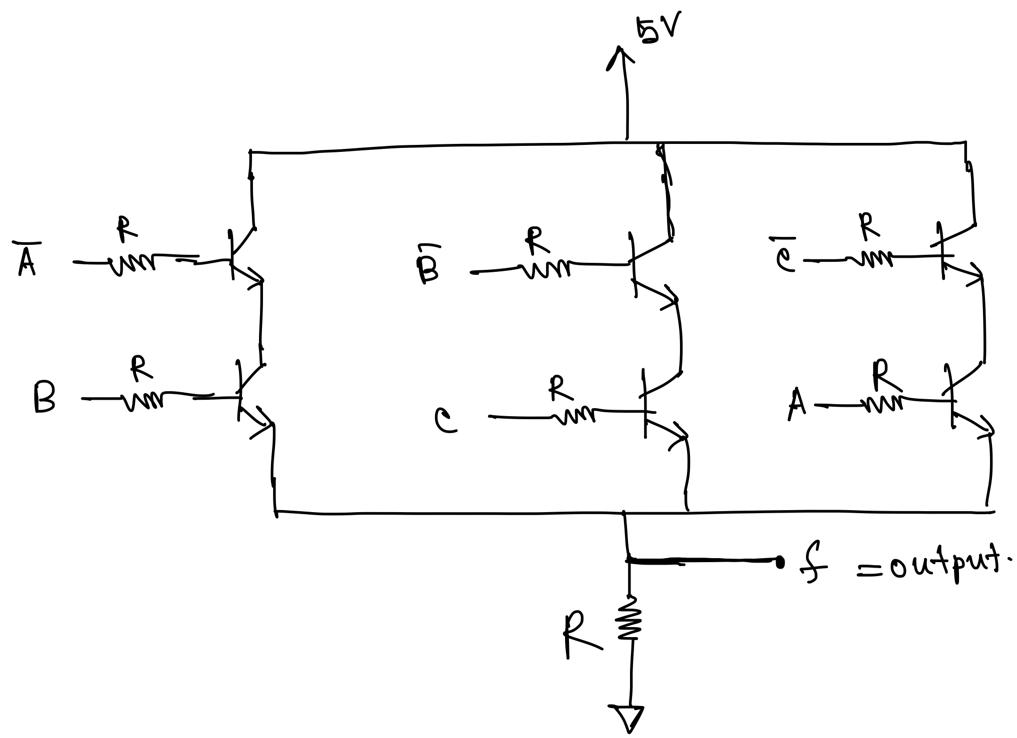
verified.

Design a circuit with boolean inputs A, B, and C using BJTs to implement the boolean logic Function.

$$f = \overline{A}.B + \overline{B}.C + \overline{C}.A$$

BJT means a resistor at every input terminal.





* You need to draw seperate NOT Gates for each boolean input. Here. three seperate for each of A, B, C.

Analyze the circuit in Figure-2, and calculate I_B, I_C , I_E, V_C & V_E using the method of assumed states. You must validate your assumption.

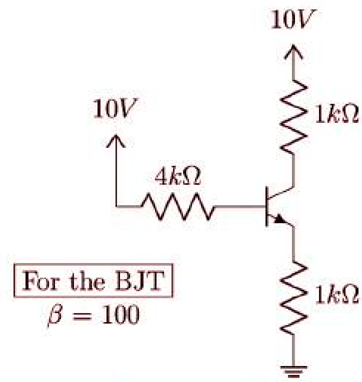


Figure-2

FALL 2024

Analyze the circuit in Figure-1 and calculate the values of I_B, I_C , I_E, and V_O using the method of assuming states. You must validate your assumption. Here, β = 100.

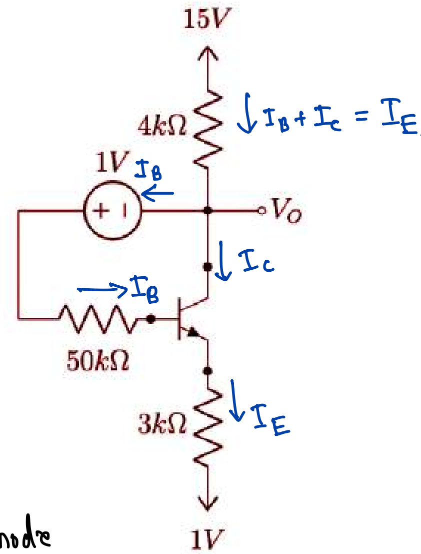
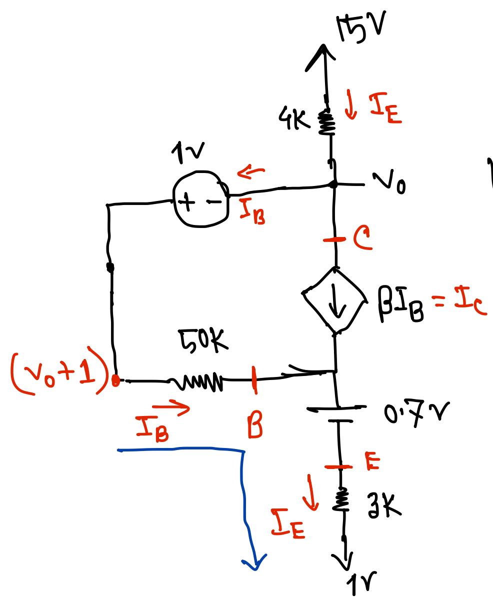


Figure-1

Based on the annotations in the given circuit diagram (blue), it is clear that I_E goes through 4kΩ and 3kΩ. Let's assume Active Mode.



KCL at V_o ensures,

$$I_E = I_B + I_c.$$

$$\text{So, } I_E = \frac{15 - V_o}{4} \quad \text{— (1)}$$

Applying KVL from (V_o+1) node to emitter line.

$$-(V_o+1) + 50 I_B + 0.7 + 3 I_E + 1 = 0 \quad \text{— (2)}$$

In active mode, $I_E = (\beta+1) I_B$ or, $\boxed{I_E = 101\, I_B}$

from equation (1), $101 I_B = \dfrac{15 - V_o}{4}$ or, $\boxed{V_o = 15 - 404 I_B}$

from equation (2), $50 I_B + 3(101 I_B) + 1.7 = V_o + 1 = 15 - 404 I_B + 1$

or, $50 I_B + 303 I_B + 404 I_B = 16 - 1.7 = 14.3$

or, $\boxed{I_B = 0.018 \text{ mA.}}$

So, $I_E = 101\, I_B = 1.907 \text{ mA}$

$I_c = \beta I_B = 1.8 \text{ mA}$

$V_o = 7.728V$

* verify: $V_c = V_o = 7.728V$

$V_E = 3 I_E + 1$

$= 6.721V$

So, $V_{CE} = \boxed{1V > 0.2V}$ verified.

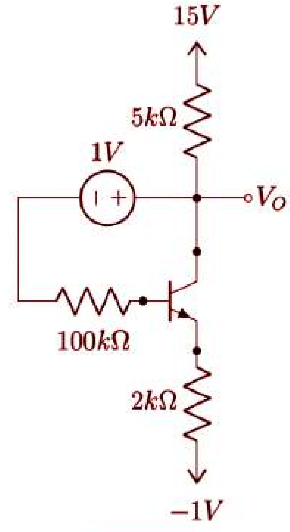


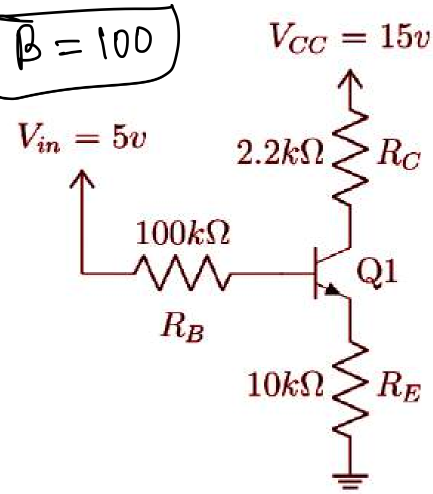
Figure-1

SUMMER 2024

Karim designed a BJT circuit. When his friend Rahim saw it, he claimed that the BJT would operate in Active mode. Then Rahim built a circuit and asked Karim to figure out the operating mode of the BJT.

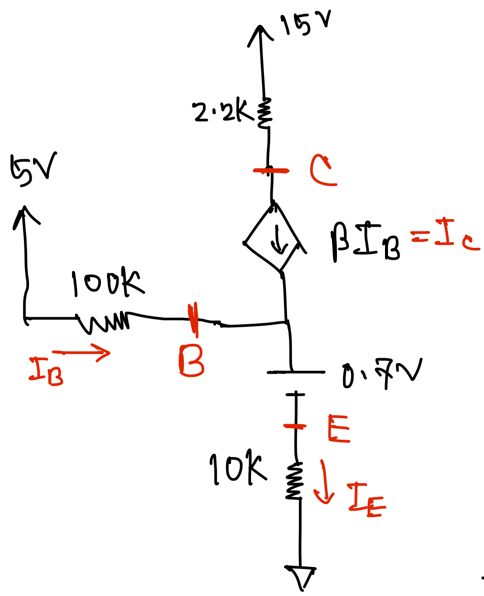
Calculate I_B, I_C , I_E, V_{CE} in Karim's circuit and determine whether Rahim was correct or not.

$\boxed{\beta = 100}$



Karim's Circuit

Let's assume Active mode,



Apply KVL from Base line to Emitter line.

$$-5 + 100 I_B + 0.7 + 10 I_E + 0 = 0$$

But in Active mode, $I_E = (\beta+1) I_B = (100+1) I_B = 101 I_B$

So, $100 I_B + 10(101 I_B) = 5 - 0.7 = 4.3$

or, $I_B = 0.0038$ mA.

So, $I_c = \beta I_B = 100 I_B = 0.387$ mA

and $I_E = 101 I_B = 0.391$ mA

So, $V_c = 15 - 2.2 I_c = 14.148$ V

$V_E = 10 I_E = 3.91$ V

* verify:

$V_{CE} = 10.23V > 0.2V$

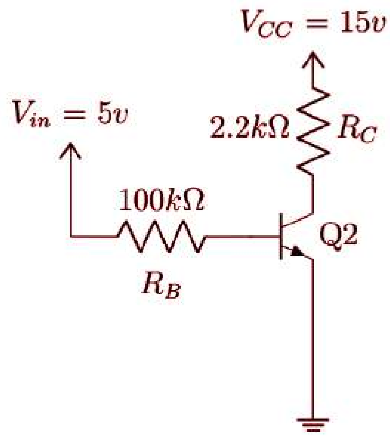
verified

Active mode. Rahim was correct.

So, $V_{CE} = 14.148 - 3.91$

$= 10.238V$

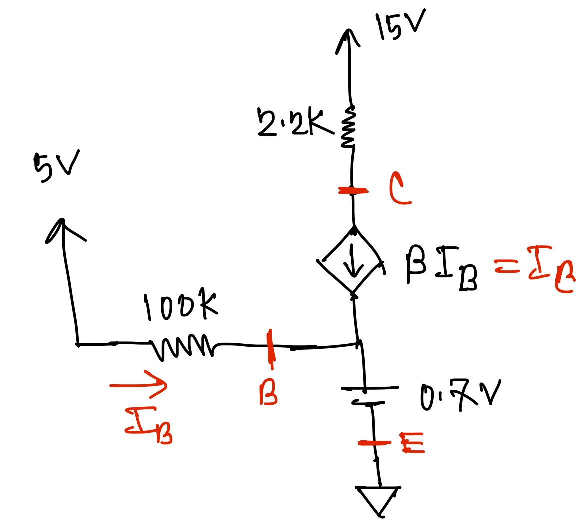
Analyze Rahim's circuit and Calculate I_B, I_C , I_E, V_{CE} to help Karim determine the operating state of the BJT.



Rahim's Circuit

$\boxed{\beta = 100}$

Again assume Active Mode.



Apply KVL from Base to Emitter,

$$-5 + 100 I_B + 0.7 = 0 \quad \text{or,} \quad I_B = 0.043 \text{ mA}$$

So, $I_C = \beta I_B = 100 I_B = 4.3 \text{ mA}$

$I_E = (\beta + 1) I_B = 101 I_B = 4.343 \text{ mA}.$

$V_C = 15 - 2.2 I_C = 5.54V$

$V_E = 0V$

So, $V_{CE} = V_C - V_E = 5.54V$

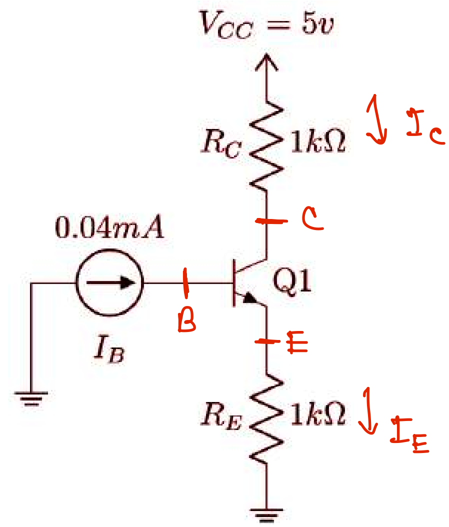
* Verify: $V_{CE} = 5.54 > 0.2V$

verified Active mode.

Analyze 'Circuit-C' and calculate I_B, I_C , I_E, V_{CE} using the method of assumed states. You must validate your assumptions.

BJT Parameters

$$\beta = 90$$
$$V_{BE(Active)} = 0.7v$$
$$V_{BE(Saturation)} = 0.8v$$
$$V_{CE(Saturation)} = 0.2v$$



Circuit-C

Assume Active mode.

Given, $I_B = 0.04\,mA$

in Active mode,

$$I_c = \beta I_B = 90 I_B \approx 3.6\ mA$$

$$I_E = (\beta+1) I_B = 91\, I_B = 3.64\ mA$$

$V_c = 5 - 1 \times I_c = 1.4V$

$V_E = R_E I_E = 3.64V$

So, $V_{CE} = -2.24 < 0.2$ ✗

Not Active Mode

Assume Saturation. Given,

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

or, $0.2 = V_{CB} + 0.8$ or, $\boxed{V_{BC} = 0.6V}$

Applying kvm Collector line to Emitter line.

$$-5 + I_c - 0.6 + 0.8 + I_E + 0 = 0$$

or, $\boxed{I_c + I_E = 4.8}$ —— (1)

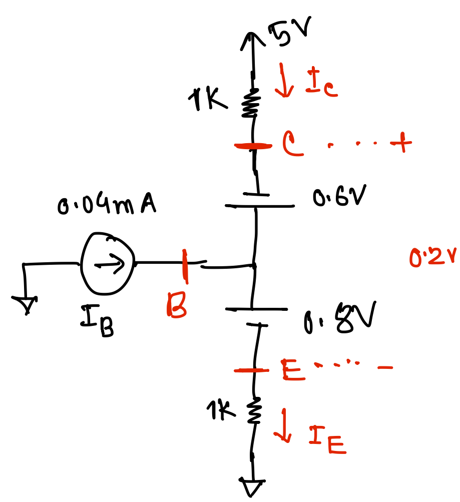
We know, $I_E = I_c + I_B = I_c + 0.04$

So, from eq. (1), $I_c + (I_c + 0.04) = 4.8$

or, $\boxed{I_c = 2.38mA}$

So, $I_E = I_c + I_B = \boxed{2.42\ mA}$

$V_{CE}\,(sat) = 0.2V$



* Verify:

$$\frac{I_c}{I_B} = \frac{2.38}{0.04} = 59.5 < \beta\ (90)$$

So, verified Saturation.

For ‘Circuit-C’, the operating state of the BJT found in part-B can be changed by changing the value of V_{CC} . Determine how you should change the value of V_{CC} to change the operating state of the BJT found previously. Show necessary calculation.

Previously found = Saturation ; where $V_{CE} = 0.2$

Target state = Active ; where $V_{CE} > 0.2$

To change from Saturation to Active, we need to $\boxed{\text{increase } V_{CE}.}$

$V_{CE} = V_C - V_E = (V_{cc} - I_c R_c) - V_E = \boxed{V_{cc} - I_c - I_E}$ (from the circuit)

So, to increase V_{CE}, we need to $\boxed{\text{increase } V_{cc}.}$

How much should we increase?

Ans: Set $V_{CE} = 0.2$; but solve in Active mode to $\boxed{\text{find } V_{cc}.}$

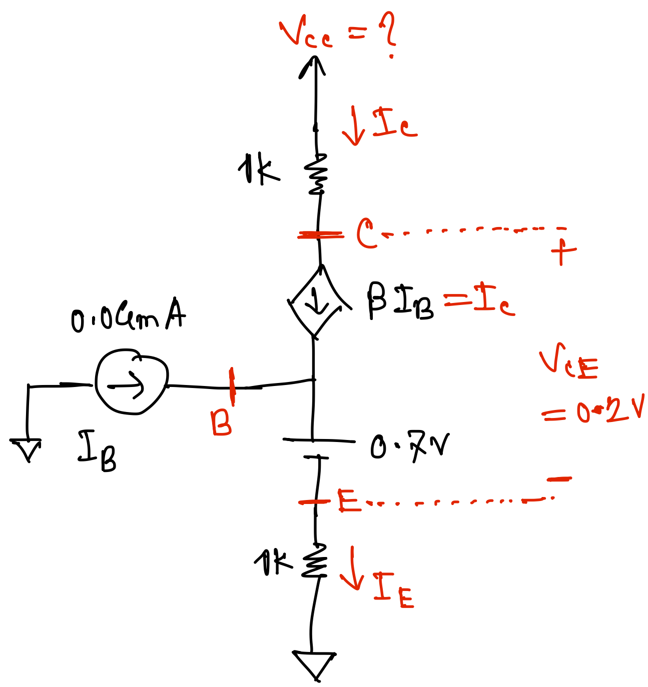
That value would be the minimum required V_{cc}.

In Active,

$I_B = 0.04\,mA$, $\beta = 90$

$I_c = \beta I_B = 3.6\,mA$

$I_E = I_B(\beta+1) = 3.64\,mA$



Applying KVL from V_{cc} to Emitter.

$-V_{cc} + I_c + V_{CE} + I_E + 0 = 0$

or, $V_{cc} = 3.6 + 3.64 + 0.2$

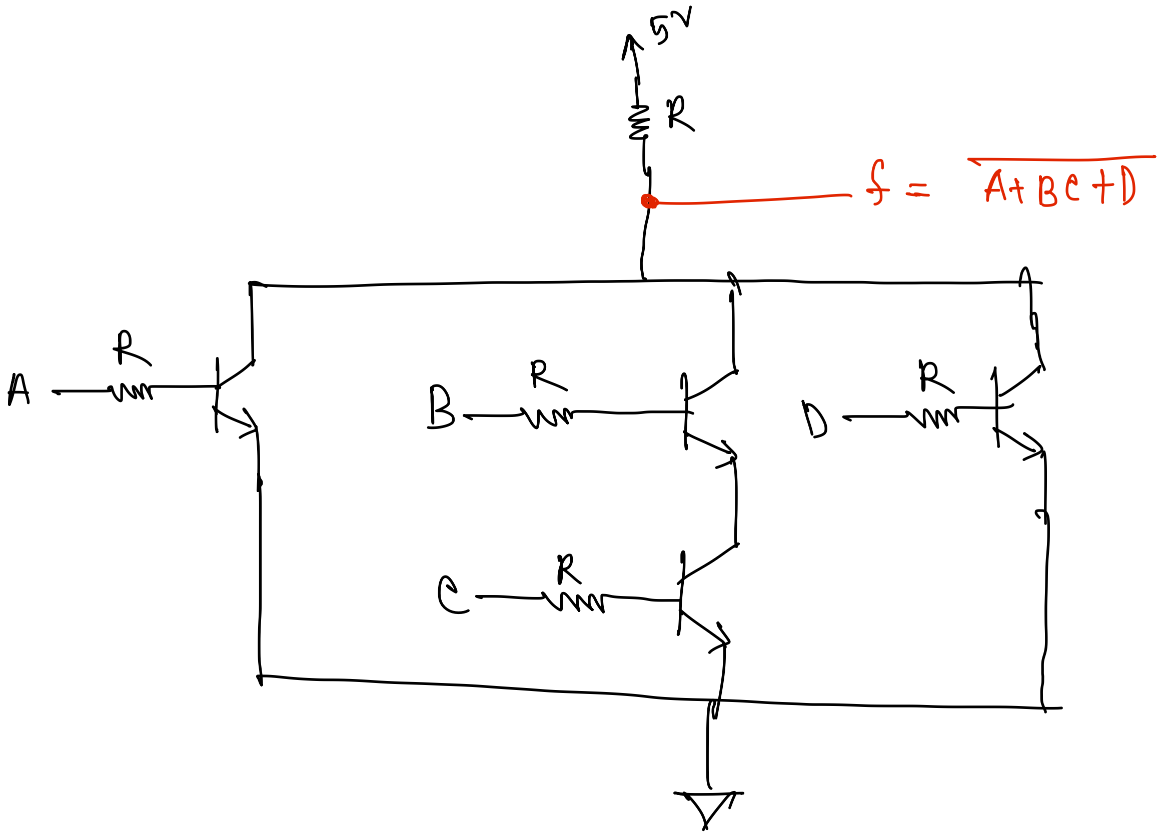
$= \boxed{7.44V}$

So, if $V_{cc} > 7.44V$,

only then, V_{CE} would be $> 0.2V$

We have to set V_{cc} at $7.44V$ or higher.

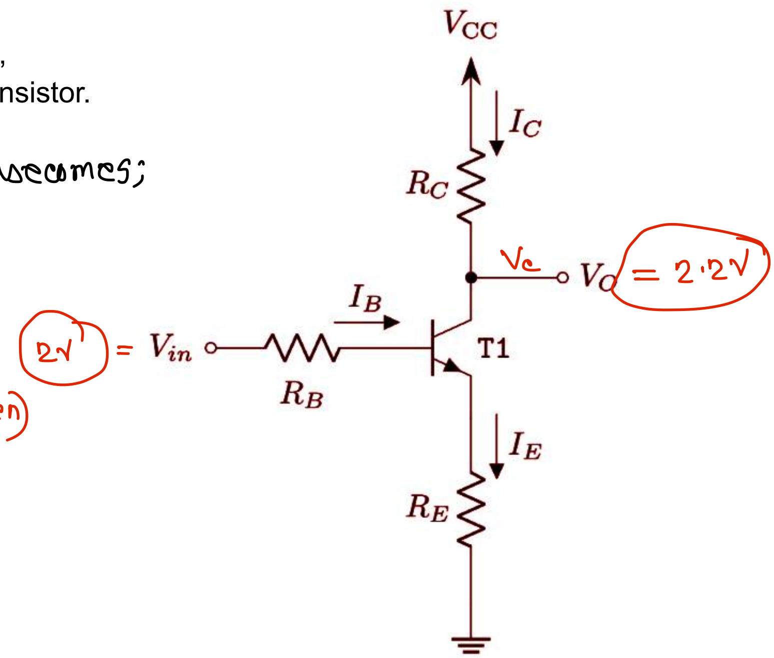
Implement the logic function, $f = \overline{A + BC + D}$ using BJTs where A, B, C, D are boolean inputs.



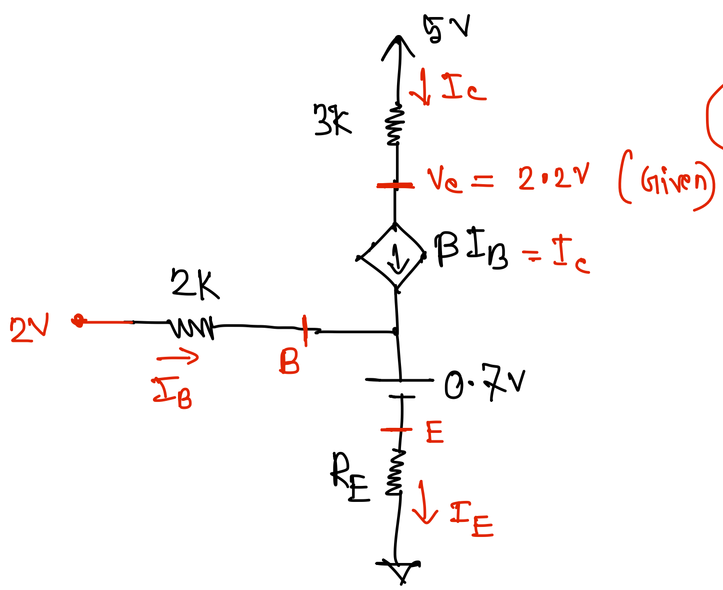
SPRING 2024

Andrew and Nicole found the adjacent circuit built in a trainer board. From the transistor model, they knew it had a gain of β = 80. They also saw VCC = 5 V, RB = 2 kΩ, and RC = 3 kΩ. However, the RE resistor was an unknown one. So, they provided an input of Vin = 2 V and measured the output to be V0 = 2.2 V. Nicole said, "In this condition, the transistor is in active mode". But, Andrew disagreed.

Design the circuit, i.e., determine the value of R_E, using what Nicole said about the mode of the transistor.



For Active mode, the circuit becomes;



Since, $V_o = V_c = 2.2V$ is Given,

$$I_c = \frac{5 - V_c}{3} = \frac{5-2.2}{3} = 0.933 \text{ mA}$$

Then, $\beta = 80$ (Given) and $I_B = \frac{I_c}{\beta} = 0.0117 \text{ mA}$

Applying KVL across Base to Emitter,

$$-2 + 2I_B + 0.7 + I_E R_E + 0 = 0$$

or, $2I_B + (\beta+1) I_B R_E = 1.3$

or, $R_E = \frac{1.3 - 2I_B}{(\beta+1) I_B} = \boxed{1.347 \text{ k}\Omega}$

Use the previous calculations, and determine who is right between Andrew and Nicole.

We got, $R_E = 1.347\,k\Omega$

So, $V_E = I_E R_E = (\beta+1) I_B \times 1.347 = (80+1) \times 0.0117 \times 1.347$

$= 1.276\,V$

$V_C = 2.2V$ (Given) ; So, $V_{CE} = V_C - V_E = 0.924V > 0.2V$

So, verified Active mode. So, Nicole was right.

Using the $\boxed{\text{value of } R_E \text{ obtained previously}}$, determine who will be right if V_{in} = 4V

When, $V_{in} = 4V$ and $V_{CC} = 5V$, it $\boxed{\text{should be in Saturation.}}$

In Saturation,

KVL along Base → Emitter.

$-4 + 2I_B + 0.8 + 1.34 I_E + 0 = 0$

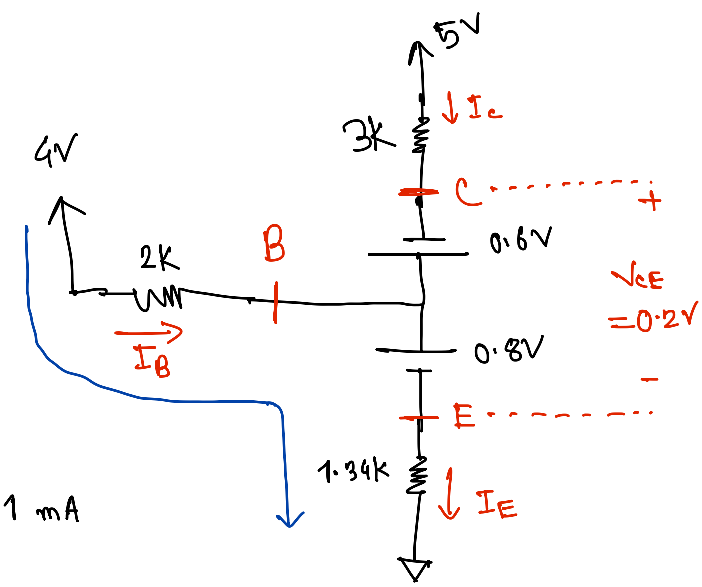
KVL along Collector → Emitter:

$-5 + 3I_C + 0.2 + 1.34 I_E + 0 = 0$

And, we know, $I_C + I_B = I_E$

Solving above eqns, we get,

$I_B = 0.58mA$, $I_C = 0.92mA$, $I_E = 1.511\,mA$



* Verify:

$$\frac{I_C}{I_B} = \frac{0.92}{0.58} = 1.586 < \beta\,(80)$$

So, verified Saturation Mode, this time Andrew would be right.

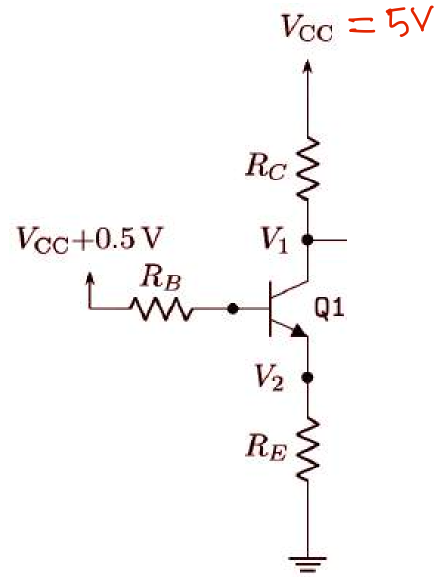
Find out the currents going through the three terminals of the transistor Q1. Also, determine the value of V_1 and V_2.

Q1

$\beta = 100$
$v_{CE(Sat)} = 0.2\,V$
$v_{BE(Act)} = v_{BE(Sat)} = 0.7\,V$

Resistor values in (kΩ)

R_B	R_C	R_E	R_G	R_D
100	1.1	1	3	-



Here, $V_1 = V_C$

$V_2 = V_E$

Assuming Saturation Mode;

Given,

$V_{BE(sat)} = 0.7$

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

or, $0.2 = V_{CB} + 0.7$ or, $\boxed{V_{BC} = 0.5V}$

KVL along Base → Emitter

$-5.5 + 100 I_B + 0.7 + I_E + 0 = 0$

KVL along Collector → Emitter

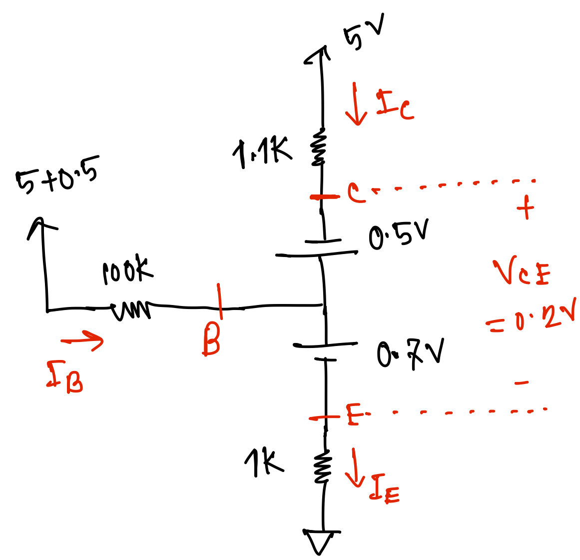
$-5 + 1.1 I_C + 0.2 + I_E + 0 = 0$

We know, $I_B + I_C = I_E$

Solving, $I_B = 0.025\,mA$

$I_C = 2.273\,mA$

$I_E = 2.298\,mA$



$V_C = V_1 = 5 - 1.1 I_C = 2.5V$

$V_2 = V_E = I_E R_E = 2.298V$

Verify: $\frac{I_C}{I_B} = \frac{2.273}{0.025} = 90.92 < \beta\ (100)$

So, verified Saturation Mode.