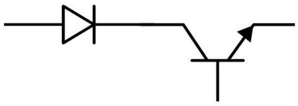
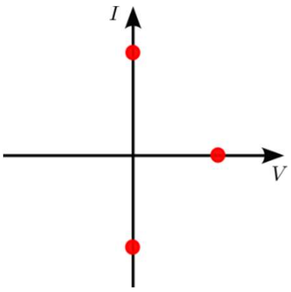
Question 1:

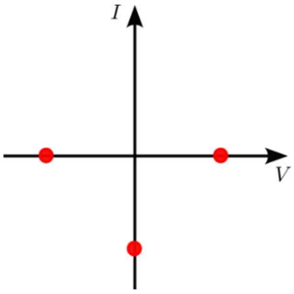
Figure shows a power switching device. Identify the static operating points on V-I plane.



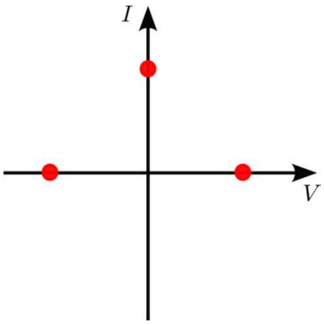
(a)



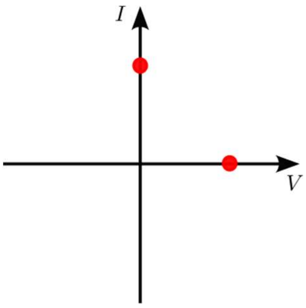
(b)



(c)



(d)

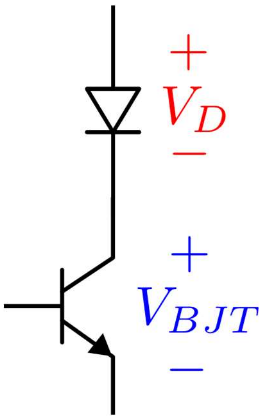


Solution:

The correct option is (c).

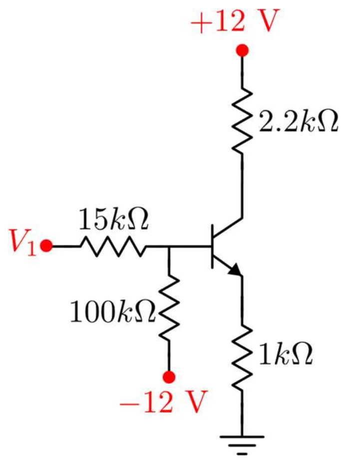
The series diode allows unidirectional flow of current.

BJT can block positive voltage (i.e. $V_{BJT} > 0$ in blocking state) while the diode can block negative voltage (i.e. $V_D < 0$ in blocking state or in other words when it is reverse biased) and hence the switching block acts as a bipolar device.

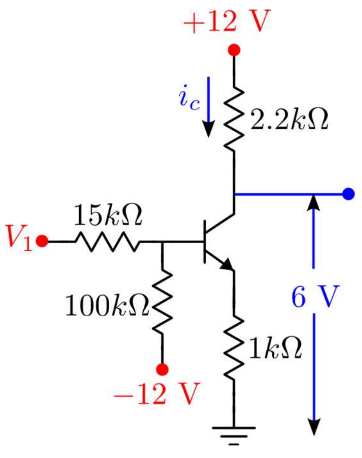


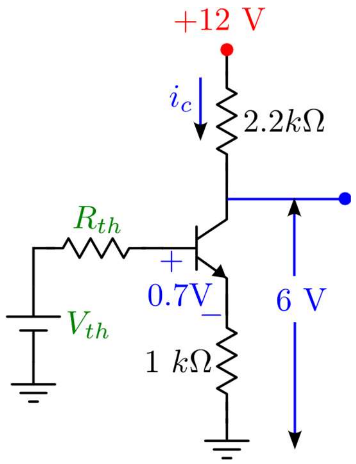
Question 2: Numerical type

*For the given transistor, $\beta = 30$ and the collector to emitter voltage $V_{CE} = 6\,V$. The value of V_1 (in V) is*______________________.



Solution: Range (7-8)





The collector current, i_c, can be calculated as

$$i_c = \frac{12-6}{2.2}\,mA = 2.72\,mA$$

As $V_{CE} > 0.3\,V$, the transistor is in active region and hence the base current, i_b can be calculated as

$$i_b = \frac{i_c}{\beta} = 0.09\,mA$$

By applying Thevenin's theorem we can calculate the Thevenin's Voltage as seen from the base terminal is

$$V_{th} = \frac{100\,V_1 - 180}{115}$$

Similarly, Thevenin's resistance as seen from the base terminals can be calculated as below

$$R_{th} = \frac{15 \times 100}{15 + 100}\ k\Omega = 13.043\ k\Omega$$

By applying KVL we can write

$$V_{th} = i_b R_{th} + 0.7 + (1 + \beta) i_b$$

Thus, we now have

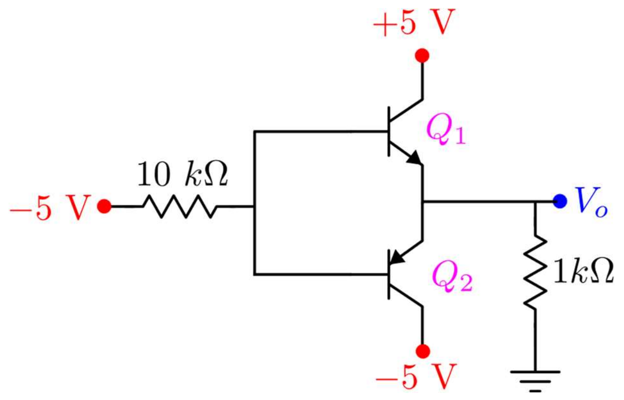
$$\frac{100\ V_1 - 180}{115} = 4.66$$

Solving the equation we get:

$$V_1 = 7.16\ V$$

Question 3:

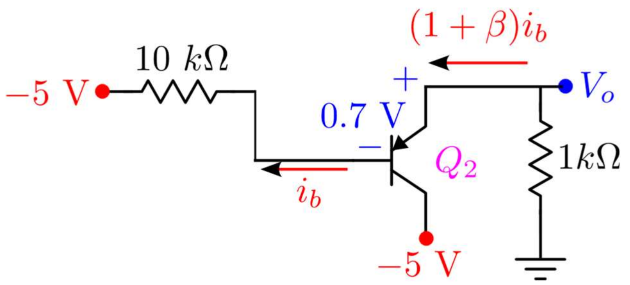
For the circuit shown below $\beta = 100$*, and the base to emitter or emitter to base voltage* $(|V_{BE}|)$ *is 0.7 V. What is the value of the output voltage* V_o*.*



(a) -3.91 V
(b) -4.8 V
(c) 3.91 V
(d) 4.8 V

Solution: Correct option is (a)

The base to emitter junction of Q_1 is reverse biased and hence Q_1 will remain off. Thus, the circuit can be redrawn as shown in the figure below.



Applying KVL we can write

$$(1k \times (1+\beta)i_b) + 0.7 + (10k \times\ i_b) - 5 = 0$$

Thus, the value of the base current is given by

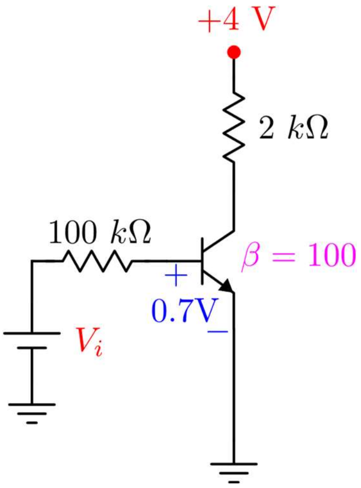
$$i_b = \frac{5 - 0.7}{10k + (1+\beta) \times 1k} = 0.038\, mA$$

The value of the output voltage can then be calculated as

$$V_o = -(1+\beta)i_b \times 1k = -3.91\, V$$

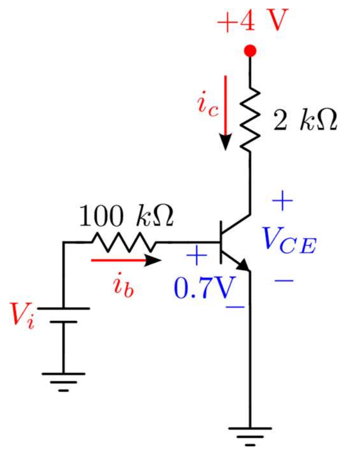
Question 4:

For the transistor circuit shown, the minimum value of V_i *for the transistor to be in saturation region is ________________ (Assume the collector to emitter voltage under saturation* $(V_{CE})_{sat} = 0.2\,V$*)*



(a) 1.65 V
(b) 2.65 V
(c) 3.65 V
(d) 3.85 V

Solution: Correct option is (b)



As the transistor is in saturation, the collector current, i_c, can be calculated as

$$i_c = \frac{4 - (V_{CE})_{sat}}{2}\,mA = 1.9\,mA$$

The expression for the base current, i_b, can be obtained as

$$i_b = \frac{V_i - 0.7}{100}\,mA$$

For the transistor to be in saturation it needs to satisfy the following condition

$$i_b > \frac{i_c}{\beta}$$

Therefore, we have the following relation.

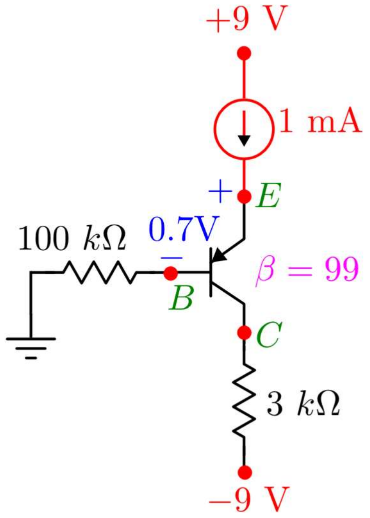
$$\frac{V_i - 0.7}{100} > \frac{1.9}{100}$$

Thus, for the BJT to be in saturation the following condition must hold.

$$V_i > 2.6\ V$$

Question 5: Numerical Type

Find the conduction losses in the transistor circuit shown in the figure in mW.



Solution: Range (7-8)

The emitter current, $i_e = 1\ mA$ as given in the circuit schematic. Thus, the base current, i_b, can be calculated as

$$i_b = \frac{i_e}{1+\beta} = 10^{-2}\ mA$$

Thus, the potential at point B w.r.t ground can be written as

$$V_B = 100 \times i_b = 1\ V$$

Thus, the emitter voltage can now be calculated as

$$V_E = V_B + 0.7 = 1.7\ V$$

Now, we can calculate the collector current, i_c, as

$$i_c = \beta i_b = 99 \times 10^{-2}\ mA$$

Now, the potential at point C w.r.t ground can then be calculated as

$$V_C = -9 + 3k \times i_c = -6.03\ V$$

Thus, the emitter to collector voltage can be calculated as

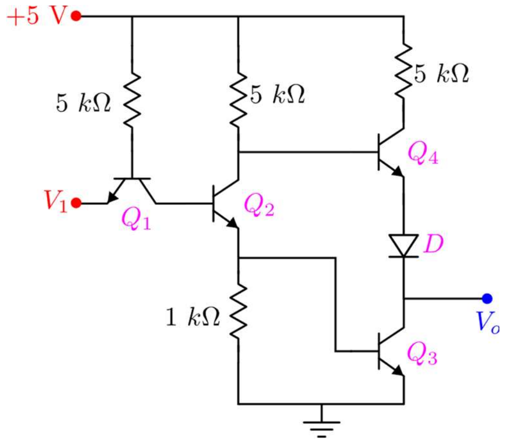
$$V_{EC} = 1.7 + 6.03 = 7.73\ V$$

The power dissipated can be calculated as

$$P_{loss} = V_{EC} \times i_c = 7.65\ mW$$

Question 6:

V_1 is a single input and V_o is the output. Consider a situation when $V_1 = 3.3\,V$ (high), then which of the statements will be correct. Assume all the BJTs are acting as switches. (Assume the collector to emitter voltage under saturation $(V_{CE})_{sat} = 0.2\,V, (V_{BE})_{sat} = 0.8\,V$, and $\beta \to \infty$ and Forward diode drop $V_F = 0.7\,V$)



Statement 1: Q_1 and Q_3 will saturate.

Statement 2: Q_4 cut off and diode D does not conduct.

Statement 3: V_o is low

Statement 4: V_o is high

- *(a) 1, 2*
- *(b) 2,3*
- *(c) 1,3*
- *(d) 2,4*

Solution: Correct option is (b)

Whatever be the value of V_1, V_1 will not be able to drive the base of Q2 as bi-directional current flow is not possible in BJT. Therefore, Q1 is OFF and the Base-Collector junction of Q1 will become forward biased and drive the base of Q2. Since $\beta \to \infty$, Base current tends to zero. So Base of Q1 has a voltage of 5V. The voltage at the Base of Q2 will be somewhere between $4 < V_{B2} < 5$ due to the drop at the base collector junction of Q1.

Assume Q2 to be ON. Since $\beta \to \infty$, $I_{C2} = I_{E2}$, find the current by applying KVL.

$$I_{C2} = \frac{5 - 0.2}{5K + 1K} = 0.8\,mA$$

Find the voltage at the collector and emitter of Q2.

$$V_{C2} = 5 - (5K \times 0.8mA) = 1V$$

$$V_{E2} = V_{C2} - 0.2 = 0.8\,V$$

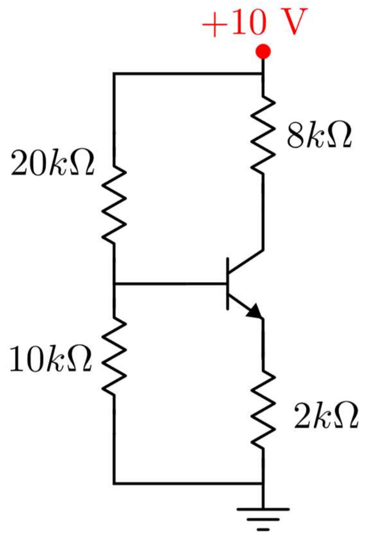
If we compare the voltage, $V_{B2}, V_{E2,} V_{C2}$ we can see that both Base-Emitter and Base-Collector junctions are forward biased and thus Q2 is in saturation and our assumption is correct.

Now $V_{C2} = 1V,$ but to drive Q4 and the diode D, we need a voltage greater than their respective forward drops i.e. 0.8+0.7=1.5V. Therefore, Q4 is cut off and the diode does not conduct.

Now $V_{E2} = 0.8V,$ will drive the base of Q3 and Q3 will go into saturation. Since Q3 is in saturation, Vo is tied to the ground through Q3 and therefore Vo is low.

Question 7:

For the circuit shown in the figure, the transistor is in ___________ (take $\beta = 100$).



(a) *Cut off region*
(b) *Saturation region*
(c) *Active region*
(d) *None*

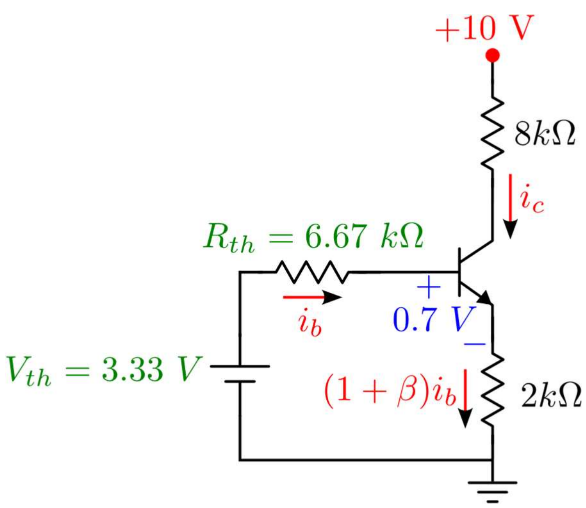
Solution: Correct option is (b)

By applying Thevenin's theorem, the Thevenin voltage and Thevenin resistance as seen from the base terminal of the BJT can be calculated as

$$V_{th} = 10 \times \frac{10}{30} = 3.33\ V$$

$$R_{th} = \frac{20 \times 10}{20 + 10}\ k\Omega = 6.67\ k\Omega$$

Thus, the given circuit can be redrawn as



The base to emitter junction of the transistor is forward biased and hence it cannot be in cut off region.

Let us assume that the transistor is in active region and hence the following relation holds

$$i_c = \beta i_b$$

Applying KVL we can write

$$3.33 = 6.67 i_b + 0.7 + 2(1+\beta) i_b$$

Therefore, the base current, i_b, can be calculated as

$$i_b = \frac{3.33 - 0.7}{6.67 + 2(1+\beta)} = 0.0126\, mA$$

Thus, the collector current, i_c, can now be calculated as

$$i_c = \beta i_b = 1.26\, mA$$

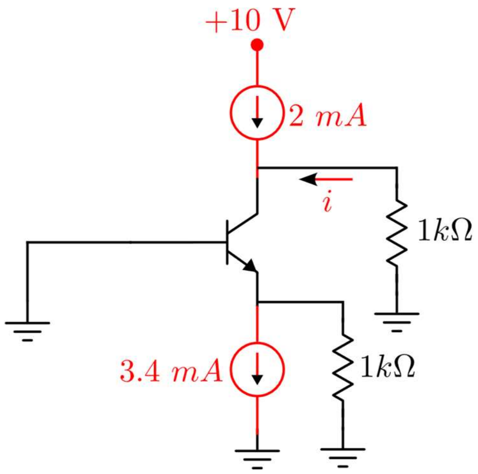
Thus, the collector to emitter voltage can be calculated as

$$V_{CE} = 10 - 8 \times 1.26 - 2 \times 101 \times 0.0126 = -2.62\, V$$

However, V_{CE} can not be negative and hence our assumption was incorrect. Thus, the transistor is in saturation mode.

Question 8:

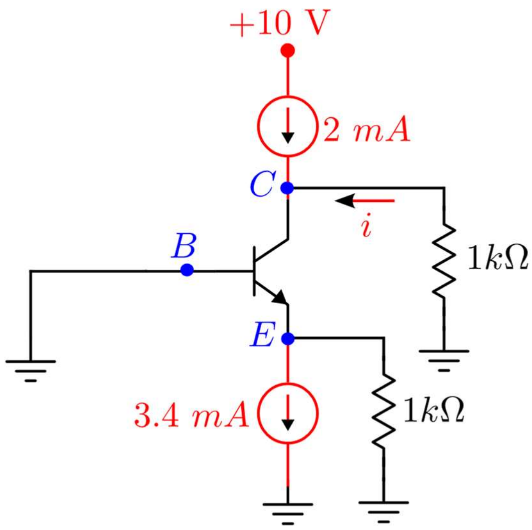
Assume that the transistor shown in the circuit below to be in saturation. Take $[V_{BE}]_{sat} = 0.8\,V$*,* $[V_{CE}]_{sat} = 0.2\,V$*, and* $\beta = 100$*. What will be the value of the current, i, in the circuit schematic.*



(a) -0.6 mA
(b) 0.6 mA
(c) -0.26 mA
(d) 0.26 mA

Solution: Correct option is (b)

The base terminal of the BJT shown in the schematic is grounded.



Therefore, the potential at the base terminal, $V_B = 0\,V$

As has been mentioned in the question the base to emitter voltage under saturation condition $[V_{BE}]_{sat} = 0.8\ V$. We can now calculate the potential at the emitter terminal, V_E, as

$$V_E = V_B - 0.8 = -0.8\ V$$

Again, the collector to emitter voltage under saturation condition is mentioned in the question as $[V_{CE}]_{sat} = 0.2\ V$. Therefore, the potential at the collector terminal can be calculated as

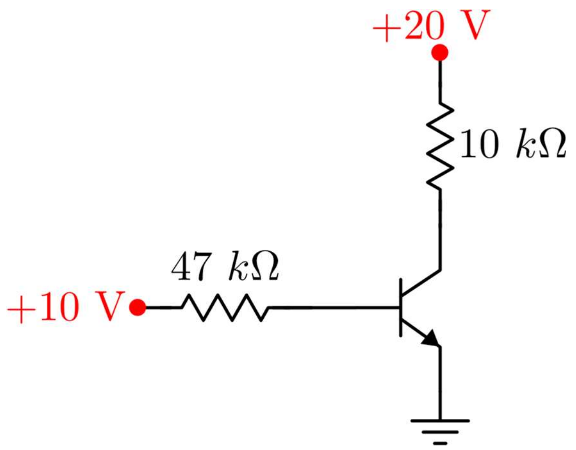
$$V_C = V_E + 0.2 = -0.6\ V$$

Thus, the value of the current i can be obtained as

$$i = \frac{-V_C}{1k} = 0.6\ mA.$$

Question 9:

In the transistor circuit shown below the collector to ground voltage is $+20\,V$. Which of the following is the probable cause of error?

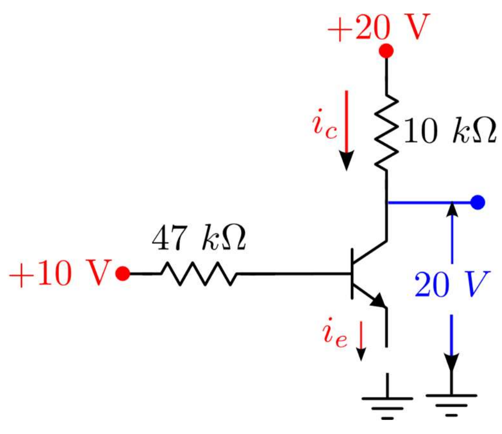


(a) Collector-Emitter terminals are shorted
(b) Emitter-ground connection is open
(c) $10\ k\Omega$ resistor is open.
(d) Collector- base terminals are shorted

Solution: Correct option is (b)

The collector – ground voltage is observed to be $+20\ V$. That means there is no voltage drop across the $10\ k\Omega$ resistor. That will essentially mean that

$$i_c \approx i_e = 0\ A$$



This can only happen if the emitter terminal is open.

Question 10:

A bipolar junction transistor (BJT) is used as a power control switch by biasing it in the cut off region (OFF state) or in saturation region (ON state). In the ON state for the BJT which of the following statements is correct.

(a) Both Base-Emitter and Base-Collector junctions are reverse biased
(b) Base-Emitter junction is reverse biased and Base-Collector junction is forward biased
(c) Base-Emitter junction is forward biased and Base-Collector junction is reverse biased
(d) Both Base-Emitter and Base-Collector junctions are forward biased

Solution: Correct option is (d)

When BJT is in saturation, both the base-emitter and base-collector junctions will be in forward biased condition.