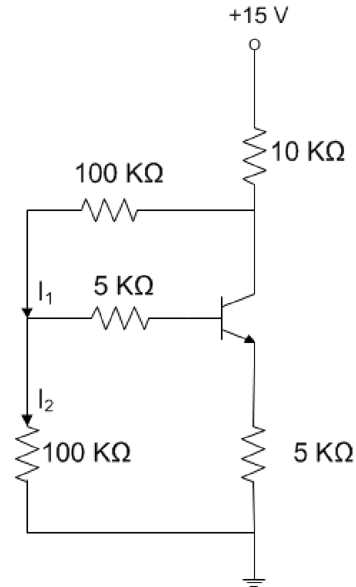
Department of Electronics and Electrical Engineering
Indian Institute of Technology Guwahati
EE101 Quiz1 Problem and Solution



1. Consider the biasing circuit shown in the Fig. 1 where the transistor used has β=20 when working in the active region and $V_{CE,sat}$=0.1 V when it is in saturation.

(a) Give a logical argument (*No calculations!)* why the transistor cannot be in saturation. **[1]**

(b) Assuming that the transistor is working in the active region, calculate its bias point (i.e. V_{CE}, I_C, and I_B). **[3]**

(c) Confirm that the transistor is indeed in active region as assumed in part (b). **[1]**

Solution

(a) I_B must be +ive (i.e. going into the base) for a transistor in saturation. Therefore I_2 must also be +ive. This implies that I_1 must also be +ive. However, if that is the case then the B-C junction must be reverse-biased so the transistor cannot be in saturation. **(1 Mark)**

(b) Assuming transistor is in the active region, $I_c=20I_B$ and $I_E=21I_B$

$V_E=105I_B$ $\quad V_B=0.7+105I_B$ $\quad I_2=0.01(0.7+105I_B+5I_B)= 0.007+1.1I_B$ $\quad I_1=0.007+2.1I_B$

This gives $\quad V_C=V_B+5I_B+100I_1= 1.4+320I_B$

But, we also have $\quad V_C=15 - 10(I_1+I_C) = 15 - 10(0.007+22.1I_B) = 14.93 - 221I_B$

Therefore, $\quad I_B$=0.025 mA, I_C=0.5 mA and I_E=0.525 mA $\quad$ also I_1=0.0595 mA

V_E=2.625 V $\quad V_B$=3.325 V $\quad V_C=V_B+100I_1+5I_B$ = 9.4 V

Bias Point: V_{CE}=6.775 V I_C=0.5 mA I_B=0.025 mA **(3 Marks)**

(c) Since V_B = 3.325 V and V_C=9.4 V, the B-C junction is reverse biased as it should be **(1 Mark)**

2.

(a) The readings on the voltmeter and the ammeter (assumed ideal) were 14.4 V and 3.2 A respectively, when they were connected separately across terminals *a* and *b* of the linear network shown in Fig. 2 (a). Draw the Thevenin's equivalent circuit and the Norton's equivalent circuit for the network showing the values of all necessary parameters. **[1]**

(b) Write and solve the mesh equations for the circuit shown in Fig. 2(b) and calculate the total current through the 3 Ω resistor. **[2]**

(c) Verify the result of 2(b) using nodal anslysis. Take node 4 as the reference. **[2]**

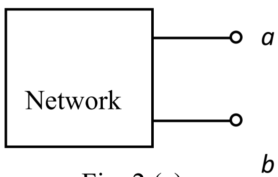


Fig. 2 (a)

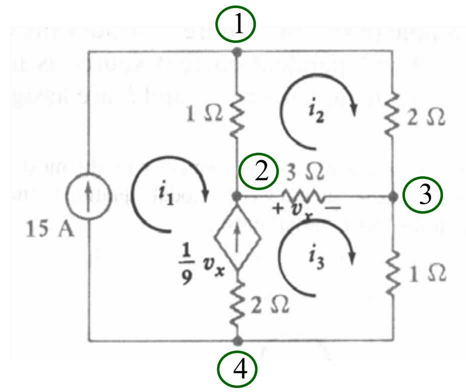
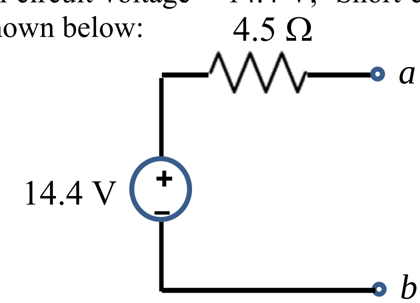


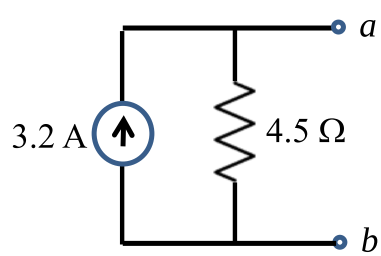
Fig. 2 (b)

Solution:

(a) Open circuit voltage = 14.4 V, Short circuit resistance = 14.4/3.2 = 4.5 Ω. Therefore the equivalents are as shown below:



Thevenin's equivalent



Norton's Equivalent (0.5+0.5)

(b) The mesh equations are:

$$i_1 = 15,$$
$$v_x = 3\times(i_3 - i_2)$$
$$i_3 - i_1 = v_x/9 = (i_3 - i_2)/3 \quad \Rightarrow \quad 2i_3 + i_2 = 45$$
$$(i_2 - i_1)\times 1 + 2i_2 = (i_3 - i_2)\times 3 \quad \Rightarrow \quad 2i_2 - i_3 = 5$$

(0.5+0.5+0.5)

Solving, $i_1 = 15$ A, $i_2 =$ 11 A, $i_3 = 17$ A

Current through 3Ω resistor $= i_3 - i_2 = 6$ A (0.5)

(c) The node equations are:

1. $$\frac{v_1 - v_2}{1} + \frac{v_1 - v_3}{2} = 15 \quad \Rightarrow \quad 3v_1 - 2v_2 - v_3 = 30$$
2. $$\frac{v_2 - v_3}{9} = \frac{v_2 - v_1}{1} + \frac{v_2 - v_3}{3} \quad \Rightarrow \quad 9v_1 - 11v_2 + 2v_3 = 0$$ (0.5+0.5+0.5)
3. $$\frac{v_3 - v_1}{2} + \frac{v_3 - v_2}{3} + \frac{v_3}{1} = 0 \quad \Rightarrow \quad 3v_1 + 2v_2 - 11v_3 = 0$$

Solving, $v_1 = 39$ V, $v_2 =$ 35 V, $v_3 = 17$ V

Current through 3Ω resistor $= \dfrac{v_2 - v_3}{3} = 6$ A (0.5)