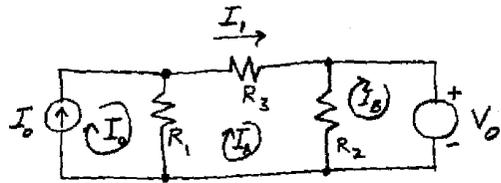


2.18



$$(I_A - I_0)R_1 + I_A R_3 + V_0 = 0$$

$$I_1 = I_A = \frac{I_0 R_1 - V_0}{R_1 + R_3} = 0$$

THIS RATHER SURPRISING RESULT OCCURS BECAUSE THE CONTRIBUTIONS OF THE TWO SOURCES TO  $I_1$ , JUST HAPPEN TO CANCEL EXACTLY.

2.19 CALL THE VOLTAGE AT THE TOP OF  $R_1 = V_1$ , LET BOTTOM OF CIRCUIT BE GROUND. THEN

$$I_0 - \frac{V_1}{R_1} - \frac{V_1 - V_0}{R_3} = 0$$

$$\therefore V_1 = \frac{R_1(I_0 R_3 + V_0)}{R_1 + R_3}$$

$$I_1 = \frac{V_1 - V_0}{R_3} = \frac{I_0 R_1 - V_0}{R_1 + R_3} = 0$$

2.20 (1) THERE ARE FIVE NODES INCLUDING THE GROUND NODE.

(2) THERE ARE EIGHT BRANCHES.

$$\begin{aligned} (3) \text{ NUMBER OF MESH CURRENTS} \\ &= \# \text{ OF BRANCHES} - \# \text{ OF NODES} + 1 \\ &= 8 - 5 + 1 \\ &= \underline{4} \end{aligned}$$

2.21

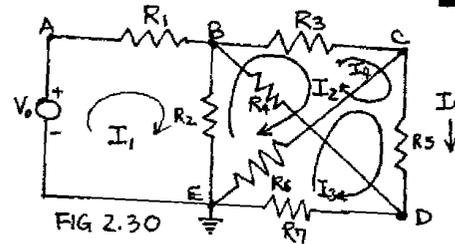


FIG 2.30

WE CHOOSE THE FOUR MESH CURRENTS AS SHOWN. THE TRICK IS TO INCLUDE AS FEW ELEMENTS IN EACH LOOP AS POSSIBLE. KVL AROUND LOOP 1 TO 4 RESPECTIVELY GIVES

$$-V_0 + I_1 R_1 + (I_1 - I_4)R_2 = 0$$

$$(I_4 - I_1)R_2 + (I_2 + I_4)R_3 + (I_2 - I_3)R_6 = 0$$

$$(I_3 - I_2)R_6 + (I_4 + I_3)R_5 + I_3 R_7 = 0$$

$$(I_2 + I_4)R_3 + (I_4 + I_3)R_5 + I_4 R_4 = 0$$

$$\therefore I_5 = I_3 + I_4$$

$$2.28 \text{ (a)} V_1 = \frac{330+470}{(330+470)+270} \cdot 9V = \underline{6.73V}$$

$$\text{(b)} V_1 = V_0 \frac{R_2 \parallel R_3}{(R_2 \parallel R_3) + R_1} = \frac{\frac{R_2 R_3}{R_2 + R_3}}{\frac{R_2 R_3}{R_2 + R_3} + R_1} \cdot V_0$$

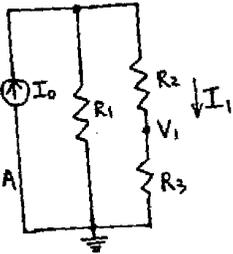
$$= V_0 \frac{R_2 R_3}{R_1 R_2 + R_1 R_3 + R_2 R_3}$$

2.29 BY CURRENT DIVIDER RULE

$$I_1 = \frac{R_1}{R_1 + (R_2 + R_3)} \cdot I_0$$

$$= \frac{4.7K}{4.7K + 2.7K + 3.3K} \cdot 1.4mA$$

$$= 0.615 mA$$



$$\therefore V_1 = I_1 R_3$$

$$= (0.615 mA)(3.3k\Omega) = \underline{2.03 V}$$

2.30 PROCEEDING IN ACCORDANCE WITH THE SUGGESTION, WE NOTE THAT ADDING TWO RESISTORS TO THE INFINITE CHAIN LEAVES THE INPUT RESISTANCE THE SAME AS IT WAS:

$$R + R \parallel R_{AB} = R + \frac{R R_{AB}}{R + R_{AB}} = R_{AB}$$

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2.30 (CONT'D) THIS GIVES THE EQN

$$R_{AB}^2 - R R_{AB} - R^2 = 0$$

$$\Rightarrow R_{AB} = \frac{R}{2} (1 + \sqrt{5}) = 1.62 R$$

2.31 (a) 1 VOLT (b) 1000  $\Omega$

2.32 (a)  $V_{FS} = (10^{-3})(1015) = 1.015 V$

(b) 1015  $\Omega$

(c)  $10 = 10^{-3}(R+15) \Rightarrow R = 9985 \Omega$

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2.33 THE TOTAL RESISTANCE IS THE COMPOSITE OF TEST RESISTANCE AND THE RESISTANCE OF THE VOLTMETER IN PARALLEL.

$$\begin{aligned} \therefore \text{BY OHM'S LAW } I_0 &= \frac{V_{AB}}{27K // 10K} \\ &= \frac{2.16}{7.297K} \\ &= \underline{\underline{0.296 \text{ mA}}} \end{aligned}$$

2.34 IF INTERNAL RESISTANCE = 1 MΩ

$$I_0 = \frac{2.16}{27K // 1M} = \underline{\underline{0.0822 \text{ mA}}}$$

THE OTHER EXTREME IS WHEN THE INTERNAL

RESISTANCE APPROACHES INFINITY

$$I_0 = \frac{2.16}{27K // \infty} = \frac{2.16}{27K} = 0.08 \text{ mA}$$

$$\begin{aligned} \text{NOMINAL RESULTS IS } &\frac{0.0822 + 0.08}{2} \text{ mA} \\ &= 0.0811 \text{ mA} \end{aligned}$$

$$\begin{aligned} \text{POSSIBLE ERROR} &= \frac{0.0822 - 0.08}{2} \text{ mA} \\ &= 0.0011 \text{ mA} \end{aligned}$$

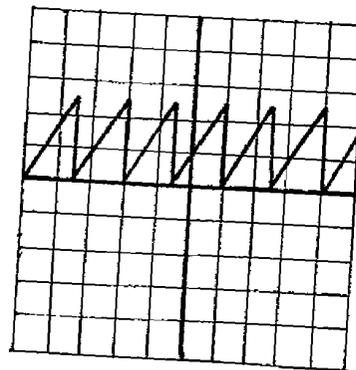
\(\therefore\) THE RANGE OF VALUES IS

$$\underline{\underline{81.1 \mu\text{A} \pm 1.1 \mu\text{A}}}$$

2.35 (a) MAXIMUM VOLTAGE  
= NO. OF DIVISION X VOLTS PER DIVISION  
= 5 mV x 2.5 = 12.5 mV

(b) FREQUENCY =  $\frac{1}{\text{PERIOD}} = \frac{1}{3 \times 5 \text{ msec}}$   
= 6.67 Hz

2.36 NOW THE CHANGE IS THAT THE HORIZONTAL SCALE IS COMPRESSED BY 100%.



END. ■

## CHAPTER 3 - PROBLEMS

- 3.1 THE SUBCIRCUIT IN (a) IS JUST A TWO PORT ELEMENT WITH A COMBINED RESISTANCE OF  $47\text{k}\Omega + 68\text{k}\Omega // 82\text{k}\Omega = 84.2\text{k}\Omega$ , WHICH IS APPROXIMATELY EQUAL TO  $84\text{k}\Omega$  IN (b).

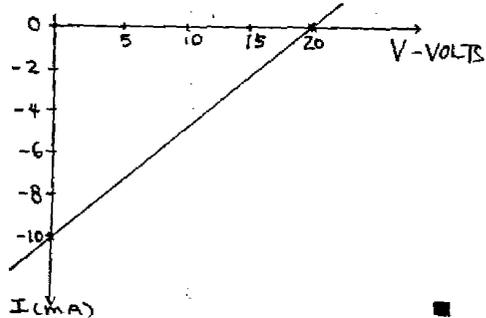
- 3.2 WRITE A NODE EQUATION FOR NODE X:

$$20\text{mA} + \frac{V_B - V_A}{1000\Omega} + I = 0$$

BUT  $V_A - V_B = V - 1000I$

$$\therefore 20\text{mA} - \frac{V - 1000I}{1000\Omega} + I = 0$$

$$\Rightarrow I = 0.5 \times 10^{-3} V - 10 \times 10^{-3}$$



- 3.3 WRITING KCL AT THE POSITIVE TERMINAL

$$I - \frac{V}{4\text{k}} - \frac{V-40}{4\text{k}} = 0$$

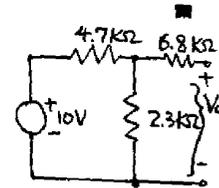
$$\Rightarrow I = \frac{V}{2000} - \frac{10}{1000}$$

THIS IS THE SAME RELATIONSHIP AS IN 3.2. SO THESE TWO SUBCIRCUITS ARE EQUIVALENT.

- 3.4 BY THE VOLTAGE DIVIDER

RULE,  $V_{oc} = \frac{2.3}{4.7 + 2.3} \cdot 10\text{V}$

$$= \underline{\underline{3.29\text{V}}}$$



- 3.5  $I = \frac{10}{4.7\text{k} + 6.8\text{k} // 2.3\text{k}}$

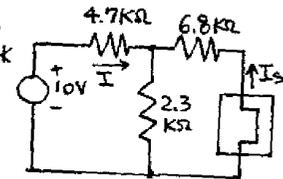
$$= 1.558\text{ mA}$$

BY CURRENT DIVIDER

RULE,

$$I_{sc} = - \frac{2.3\text{k}}{6.8\text{k} + 2.3\text{k}} \cdot 1.558\text{ mA}$$

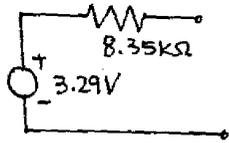
$$= \underline{\underline{-0.394\text{ mA}}}$$



2 (3.6) (a) THÉVENIN CIRCUIT

$$V_T = V_{oc} = \underline{3.29V}$$

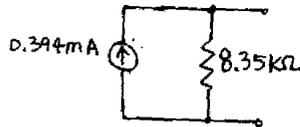
$$R_T = \frac{-V_{oc}}{I_{sc}} = \frac{-3.29V}{-0.394mA} = \underline{8.35k\Omega}$$



(b) NORTON CIRCUIT

$$I = -I_{sc} = \underline{0.394mA}$$

$$R_N = R_T = \underline{8.35k\Omega}$$



(3.7) FROM PROBLEM 3.2

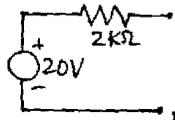
$$I = \frac{V}{2000} - \frac{10}{1000}$$

WHEN  $V=0$ ,  $I_{sc} = -10mA$

WHEN  $I=0$ ,  $V_{oc} = 20V$

$$\therefore R_T = \frac{-V_{oc}}{I_{sc}} = \frac{20}{10m} = \underline{2k\Omega}$$

$$V_T = V_{os} = \underline{20V}$$

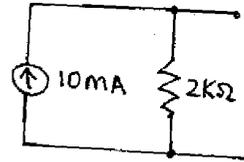


(3.8) FROM PROBLEM 3.3 WE FOUND THAT THE TWO CIRCUITS IN FIG 3.3f ARE EQUIVALENT. HENCE THE THÉVENIN EQUIVALENT IS THE SAME AS IN (3.7)

2 (3.9)  $I_N = -I_{sc} = 10mA$  FROM (3.7)

$$R_N = R_T = 2k\Omega \quad \text{FROM (3.7)}$$

THEREFORE THE NORTON EQUIVALENTS ARE AS FOLLOWS:



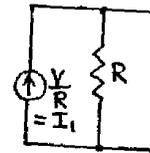
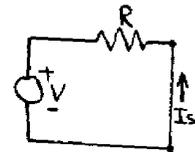
(3.10)  $I_{oc} = -\frac{V}{R}$

$$V_{oc} = V$$

$$R_T = \frac{-V_{oc}}{I_{sc}} = R$$

$$I_N = -I_{sc} = \frac{V}{R}$$

$$R_N = R_T = R$$



NORTON EQUIVALENT

3.27 FROM PROB. 3.19, CURRENT FLOWING INTO THE ELEMENT  $N_1$  IS 2 mA. FROM THE SAME GRAPH, THE VOLTAGE ACROSS  $N_1$  IS 2.4 V THEREFORE POWER ENTERING  $N_1 = 2.4 \times 2 \text{ mA}$   
 $= \underline{4.8 \text{ mW}}$

3.28 BY OHM'S LAW

$$I = \frac{10}{4.7\text{k} + 6.8\text{k} // 2.3\text{k}}$$

$$= 1.558 \text{ mA}$$

$$I_1 = \frac{2.3\text{k}}{2.3\text{k} + 6.8\text{k}} \times 1.558 \text{ mA} = 0.394 \text{ mA}$$

$$I_2 = I - I_1 = (1.558 - 0.394) \text{ mA} = 1.164 \text{ mA}$$

$$a) P_{4.7\text{k}} = I^2(4.7\text{k}) = (1.558 \text{ m})^2(4.7\text{k}) = \underline{11.41 \text{ mW}}$$

$$b) P_{6.8\text{k}} = (0.394 \text{ m})^2(6.8\text{k}) = \underline{1.056 \text{ mW}}$$

$$c) P_{2.3\text{k}} = (1.164 \text{ m})^2(2.3\text{k}) = \underline{3.116 \text{ mW}}$$

$$d) P_{\text{VOLTAGE SOURCE}} = -VI = -10 \times (1.558 \text{ m}) = \underline{-15.58 \text{ mW}}$$

$$\text{SUM OF POWER} = P_{4.7\text{k}} + P_{6.8\text{k}} + P_{2.3\text{k}} + P_{\text{VOLTAGE SOURCE}}$$

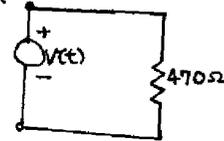
$$= (11.41 + 1.056 + 3.116 - 15.58) \text{ mW}$$

$$\approx \underline{0}$$

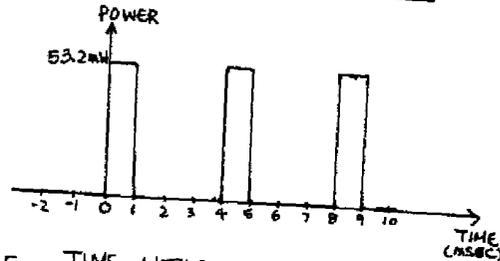
THIS IS THE PRINCIPLE OF CONSERVATION OF POWER.

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3.29 (1) INSTANTANEOUS POWER  
 $= \frac{V^2(t)}{470\Omega}$



THEREFORE IT IS AS SHOWN IN THE GRAPH



$$(2) \text{ DUTY CYCLE} = \frac{\text{TIME WITH POWER}}{\text{PERIOD}} = \frac{1}{4} = \underline{25\%}$$

$$(3) \text{ TIME AVERAGED POWER} = \frac{1}{T} \int_0^T \frac{V^2(t)}{R} dt$$

$$= \frac{\text{INSTANTANEOUS POWER}}{\text{DUTY CYCLE}}$$

$$= \frac{53.2 \text{ mW}}{1/25} = \underline{13.3 \text{ mW}}$$

3.30  $P_{\text{AV}} = \frac{1}{T} \int_0^T v(t) i(t) dt$

$$= \frac{1}{0.004} \left[ \int_0^{0.001} \frac{V^2(t)}{R} dt + \int_{0.001}^{0.004} (0) dt \right]$$

$$= \frac{1}{0.004} \left( \frac{5^2}{470} \right) \times 0.001 = \underline{13.3 \text{ mW}}$$

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