2. Relative dielectric constant for water is 78.5

The transducer consists of two capacitors in parallel

$\begin{cases} \text{one above the surface of the liquid} \\ \text{one below the surface of liquid} \end{cases}$

$$C_{above} = 200 \times \frac{100 - x}{100} = 200 - 2x$$

$$C_{below} = 200 \times \frac{x}{100} \times 78.5 = 157x$$

$$C_{total} = C_{above} + C_{below} = \underline{\underline{200 + 155x}} \text{ pF}$$

Now, suppose there are 100cm of water

$$C_{total} = 200 \times 78.5 = 15700 \text{ PF}$$

However, if the top 1cm is oil rather than wate

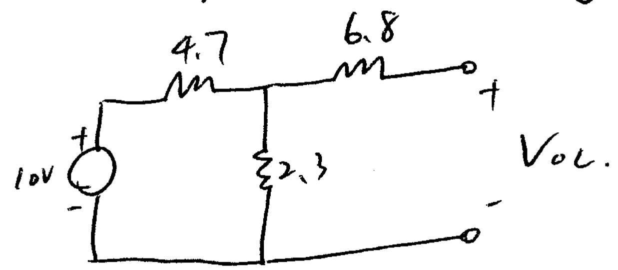
$$C_{water} = 200 \times \frac{99}{100} \times 78.5 = 15543$$

$$C_{oil} = 200 \times \frac{1}{100} \times 10 = 20$$

$$C_{total} = 15543 + 20 = 15563 \text{ PF}$$

$$\Delta C_{total} = 15700 - 15563 = \underline{\underline{137}} \text{ PF}$$

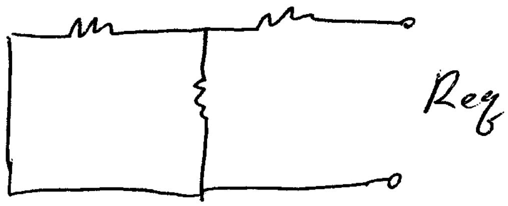
3. Find open-circuit voltage



$$10 \times \frac{2.3}{4.7+2.3} = \frac{23}{7} = \underline{\underline{3.29\ V = V_{oc}}}$$

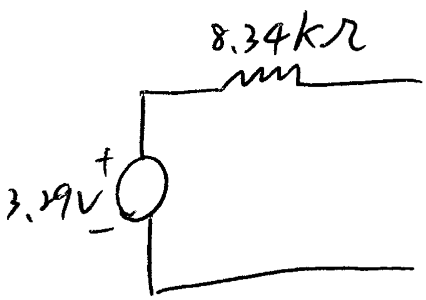
Find Thévenin Resistance

$$6.8 + \frac{1}{\frac{1}{4.7} + \frac{1}{2.3}} = \underline{\underline{8.34\ k\Omega = R_{eq}}}$$

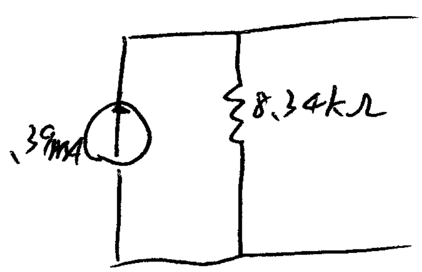


$$I_{sc} = \frac{V_{oc}}{R_{eq}} = \underline{\underline{.39\ mA}}$$

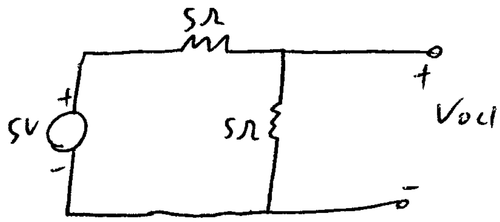
Thévenin equivalent



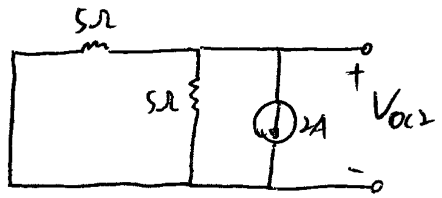
Norton equivalent



4. Find open-circuit voltage through superposition



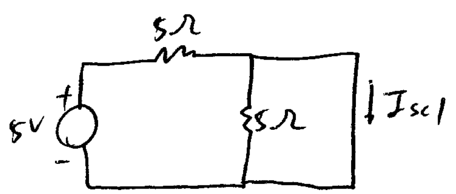
$V_{oc1} = 2.5\ V$



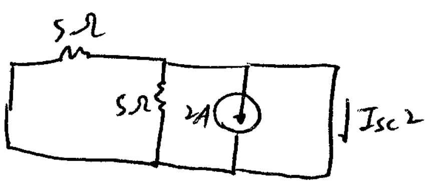
$V_{oc2} = -5\ V$

$V_{oc} = V_{oc1} + V_{oc2} = \underline{\underline{-2.5\ V}}$

Find Thévenin resistance by short-circuit current w/ superposition



$I_{sc1} = 1\ A$

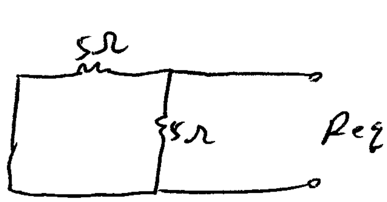


$I_{sc2} = -2A$

$I_{sc} = I_{sc1} + I_{sc2} = \underline{\underline{-1\ A}}$

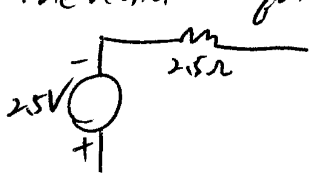
$R_{eq} = \frac{V_{oc}}{I_{sc}} = \underline{\underline{2.5\ \Omega}}$

Find Thévenin resistance in alternative way

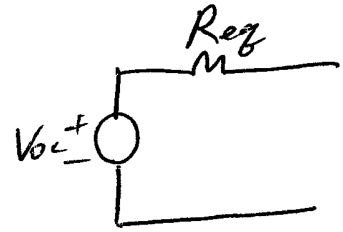


$R_{eq} = \frac{1}{\frac{1}{5} + \frac{1}{5}} = \underline{\underline{2.5\ \Omega}}$

Thévenin equivalent is below

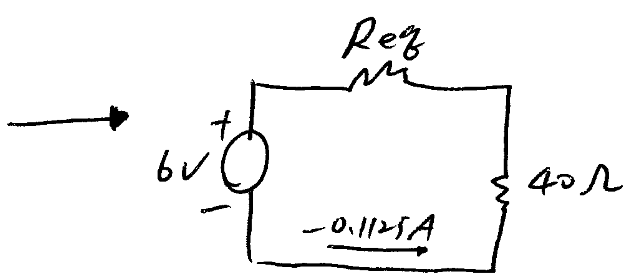


5. The battery can be considered as a circuit w/ Thévenin equivalent



V_{oc} is $\underline{\underline{6V}} = V_T$

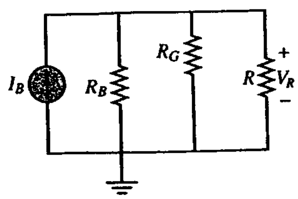
The measured current when connecting a $40\,\Omega$ is -0.11:



$$R_{eq} + 40 = \frac{6}{.1125} = 53.33$$

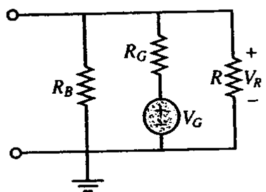
$$R_{eq} = \underline{\underline{13.33\,\Omega}} = R_T$$

6.



(b)

Figure 3.30 (b) Circuit obtained by suppressing the voltage source



(c)

Figure 3.30 (c) Circuit obtained by suppressing the current source

Analysis: Specify a ground node and the polarity of the voltage across R. Suppress the voltage source by replacing it with a short circuit. Redraw the circuit, as shown in Figure 3.30(b), and apply KCL:

$$-I_B + \frac{V_{R-I}}{R_B} + \frac{V_{R-I}}{R_G} + \frac{V_{R-I}}{R} = 0$$

$$V_{R-I} = \frac{I_B}{1/R_B + 1/R_G + 1/R} = \frac{12}{1/1 + 1/0.3 + 1/0.23} = 1.38\text{ V}$$

Suppress the current source by replacing it with an open circuit, draw the resulting circuit, as shown in Figure 3.30(c), and apply KCL:

$$\frac{V_{R-V}}{R_B} + \frac{V_{R-V} - V_G}{R_G} + \frac{V_{R-V}}{R} = 0$$

$$V_{R-V} = \frac{V_G/R_G}{1/R_B + 1/R_G + 1/R} = \frac{12/0.3}{1/1 + 1/0.3 + 1/0.23} = 4.61\text{ V}$$

Finally, we compute the voltage across R as the sum of its two components:

$$V_R = V_{R-I} + V_{R-V} = 5.99\text{ V}$$

Comments: Superposition essentially doubles the work required to solve this problem. The voltage across R can easily be determined by using a single KCL.

7.

$$C_{total} = \frac{1}{\frac{1}{.015} + \frac{1}{.022 + .01}} = \underline{\underline{.01\ \mu F}}$$

$$L_{total} = \frac{1}{\frac{1}{3} + \frac{1}{1 + 2.5}} = \underline{\underline{1.62\ mH}}$$

8、 $I_0 = C \frac{d}{dt} V_c(t)$

$$dV_c = \frac{I_0}{C} dt$$

Integrating : $V_c = \frac{I_0}{C} \int dt$

$$= \frac{I_0 t}{C} + k$$

k represents the value of V_c at time $t=0$

$$k = 0$$

$$V_c = \frac{10\,mA}{10\,\mu F} t = \underline{\underline{1000\,t}} \text{ volt}$$

9、

$$Q = Cv = 5 \times 10^{-6} \times 10^{3} = 5\,\text{mC}$$

$$W = \frac{1}{2} Cv^2 = \frac{1}{2} \times 5 \times 10^{-6} \times (10^3)^2 = 2.5\,\text{J}$$

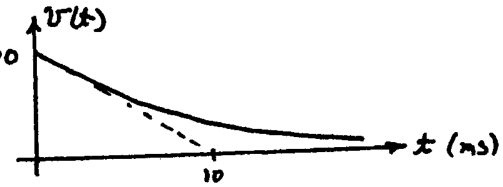
$$P = \frac{\Delta W}{\Delta t} = \frac{2.5}{10^{-6}} = 2.5\,\text{MW}$$

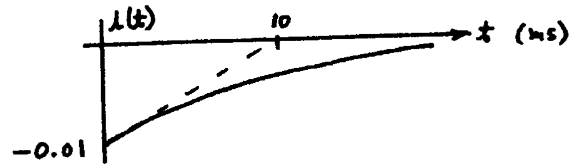
10、

$$i(t) = C\frac{dv}{dt}$$

$$= 10^{-6}\frac{d}{dt}\left(100e^{-100t}\right)$$

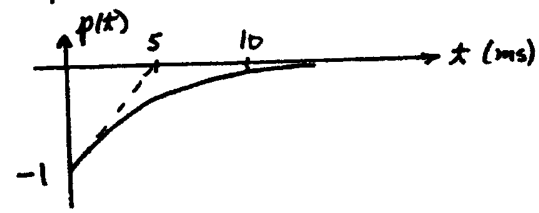
$$= -0.01e^{-100t}\text{ A}$$





$$p(t) = v(t)i(t)$$

$$= -e^{-200t}\text{ W}$$



$$w(t) = \frac{1}{2}C[v(t)]^2$$

$$= 5\times10^{-3}\times e^{-200t}\text{ J}$$