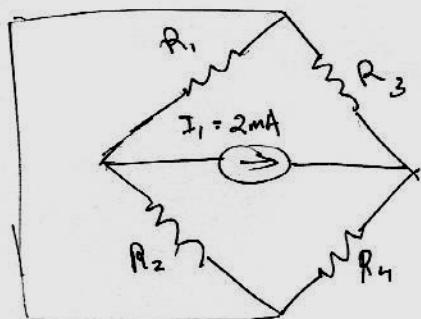
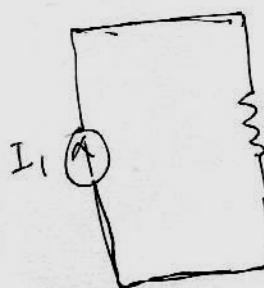
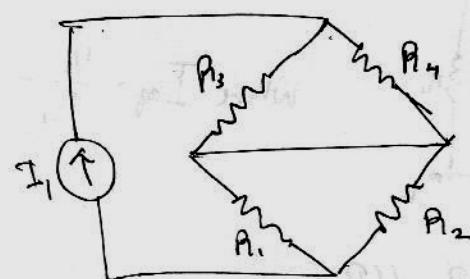


EE 40 M+1 solutions

①



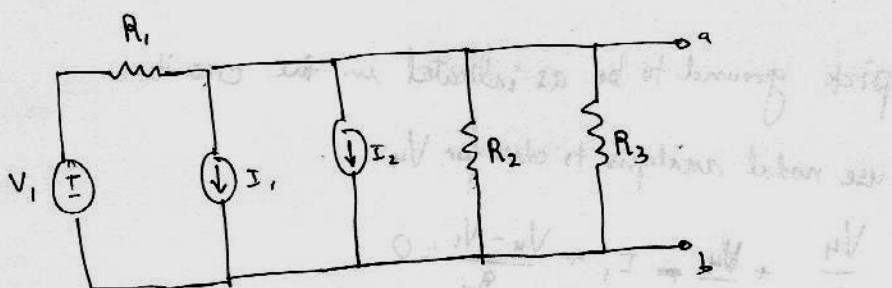
(redraw)



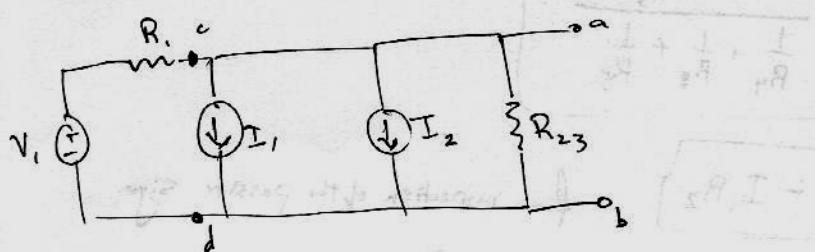
$$R_{\text{eq}} \text{ where } R_{\text{eq}} = \frac{R_1 R_2}{R_1 + R_2} + \frac{R_3 R_4}{R_3 + R_4} = 24 \text{ k}\Omega$$

$$P = I_1 V = I_1^2 R_{\text{eq}} = (24 \text{ k}\Omega)(2 \text{ mA})^2 = \cancel{48} \text{ mW}$$

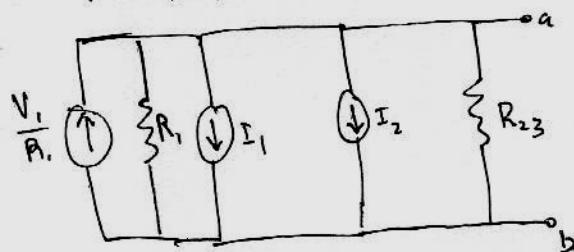
②



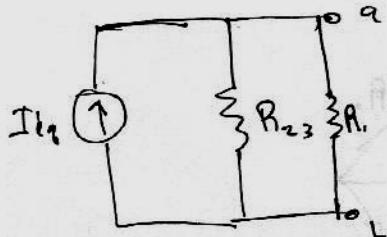
$$\text{combine } R_2 \text{ and } R_3 \text{ into } R_{23} = \frac{R_2 R_3}{R_2 + R_3}$$



use a Norton transformation for the left side of ports c and d:



combine the current source into I_{eq} :

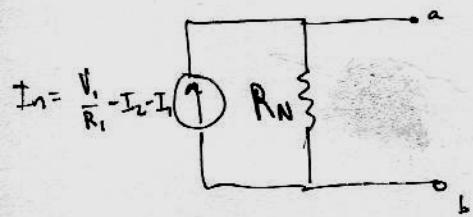


$$\text{where } I_{eq} = \frac{V_i}{R_1} - I_2 - I_1$$

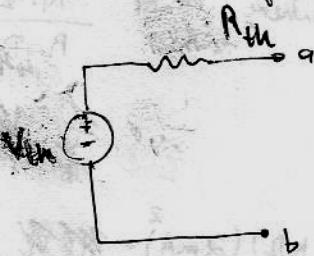
$$I_N = I_{eq}, R_N = R_{23} // R_1 = \frac{R_1 R_2 R_3}{R_1 R_2 + R_1 R_3 + R_2 R_3}$$

$$V_{th} = I_N R_N = \left(\frac{V_i}{R_1} - I_2 - I_1 \right) \frac{R_1 R_2 R_3}{R_1 R_2 + R_1 R_3 + R_2 R_3}, R_{th} = R_{23} // R_1$$

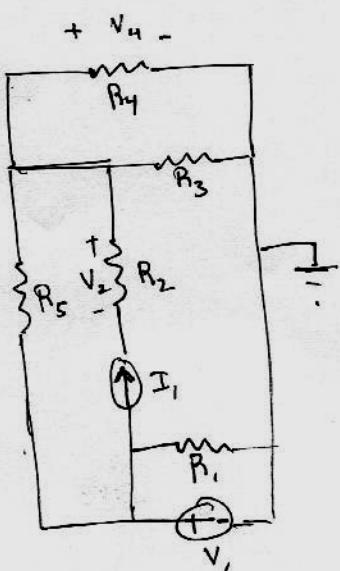
Norton equivalent:



Thevenin equivalent



(3)



pick ground to be as indicated in the circuit.

use nodal analysis to solve for V_4 :

$$\frac{V_4}{R_4} + \frac{V_4}{R_3} - I_1 + \frac{V_4 - V_1}{R_5} = 0$$

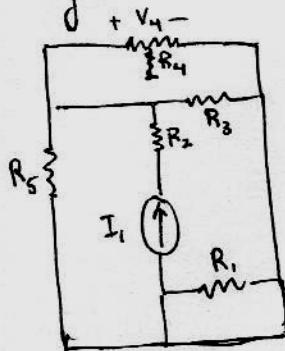
$$V_4 = \frac{I_1 + \frac{V_1}{R_5}}{\frac{1}{R_4} + \frac{1}{R_3} + \frac{1}{R_5}}$$

$$V_2 = -I_1 R_2$$

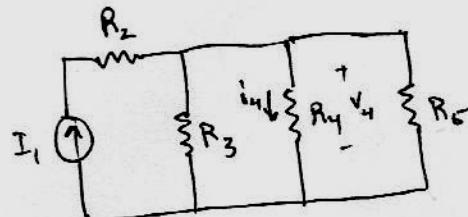
from inspection of the passive sign convention

A solution is also possible using the method of superposition:

only current source:



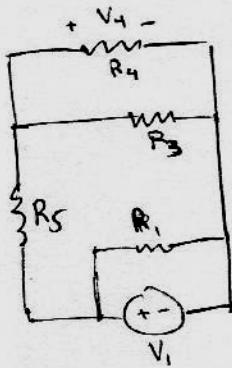
redraw



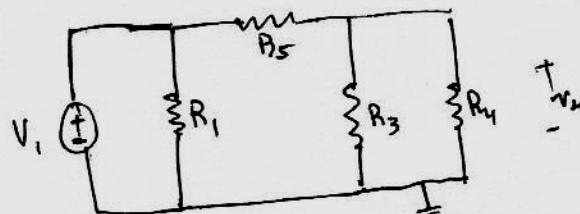
$$V_4 = i_4 R_4 = \frac{R_3 // R_5}{R_4 + R_3 // R_5} I_1$$

$$= R_4 \cdot \frac{R_3 // R_5}{R_4 + R_3 // R_5} I_1$$

only voltage source:



redraw



$$V_4 = \frac{R_3 // R_4}{R_5 + R_3 // R_4} V_1$$

$$\therefore V_4 = R_4 \cdot \frac{R_3 // R_5}{R_4 + R_3 // R_5} I_1 + \frac{R_3 // R_4}{R_5 + R_3 // R_4} V_1$$

$$= \frac{R_4 \cdot \frac{R_3 R_5}{R_3 + R_5}}{R_4 + \frac{R_3 R_5}{R_3 + R_5}} I_1 + \frac{\frac{R_3 R_4}{R_3 + R_4}}{R_5 + \frac{R_3 R_4}{R_3 + R_4}} V_1$$

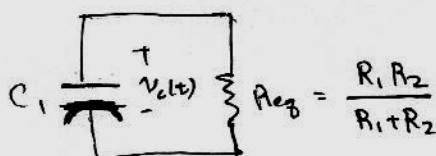
$$= \frac{R_3 R_4 R_5 I_1}{R_3 R_4 + R_4 R_5 + R_3 R_5} + \frac{R_3 R_4 V_1}{R_5 R_4 + R_5 R_3 + R_3 R_4}$$

$$= \frac{I_1 + \frac{V_1}{R_5}}{\frac{1}{R_4} + \frac{1}{R_3} + \frac{1}{R_5}}$$

(4)

Redraw the circuit as

a)



$$R_{\text{eq}} = \frac{R_1 R_2}{R_1 + R_2}$$

From a prederived result, we know that $v_c(t) = V_s e^{-t/R_{\text{eq}} C_1}$

$$q_0(t) = C_1 v_c(t) = V_s C_1 e^{-t/R_{\text{eq}} C_1} = q_0 e^{-t/R_{\text{eq}} C_1}$$

$$i_1(t) = -\frac{d}{dt} q_0(t) \quad \text{since charge is being lost by the capacitor.}$$

$$= \frac{V_s C_1}{R_{\text{eq}} C_1} e^{-t/R_{\text{eq}} C_1} = i_0 e^{-t/R_{\text{eq}} C_1}$$

Let i_0 be the initial current. Then

$$\frac{i_0}{2} = i_0 e^{-t/R_{\text{eq}} C_1}$$

$$\frac{1}{2} = e^{-t/R_{\text{eq}} C_1}$$

$$\Rightarrow t_1 = -RC_1 \ln\left(\frac{1}{2}\right) \quad (\text{time at which current is half of its initial value})$$

$$-RC_1 \ln\left(\frac{1}{2}\right) \left(-\frac{1}{Rc}\right)$$

$$q_1 = q_0(t_1) = q_0 e$$

$$= \frac{q_0}{2}$$

When the current is half the initial value, the charge is half of its initial value.

Thus $\boxed{v_q = \frac{1}{2}}$

$$b) i_1(t) = \frac{V_s}{R_{\text{eq}}} e^{-t/R_{\text{eq}} C_1} = \frac{V_s (R_1 + R_2)}{R_1 (R_2)} \exp\left\{-\frac{t(R_1 + R_2)}{R_1 R_2 C_1}\right\}$$

see above for derivation

c) R_1 and R_2 in parallel form a current divider.

$$i_{R_1}(t) = \frac{R_2}{R_1 + R_2} i_1(t) = \frac{R_2}{R_1 + R_2} V_s \cdot \frac{R_1 + R_2}{R_1 R_2} \exp\left\{-\frac{t(R_1 + R_2)}{R_1 R_2 C_1}\right\} = \frac{V_s}{R_1} \exp\left\{-\frac{t(R_1 + R_2)}{R_1 R_2 C_1}\right\}$$

$$d) P_{R1} = v_c(t) i_{R_1}(t)$$

$$= \frac{V_s}{R_1} \exp \left\{ -t(R_1 + R_2) \right\} \cdot V_s \exp \left\{ -t(R_1 + R_2) \right\}$$

$$\boxed{\rightarrow \frac{V_s^2}{R_1} \exp \left\{ -2t(R_1 + R_2) \right\}}$$



(similar factor like for short circuit voltage voltage)

$$(1) \text{ and } (2)$$

note: Let's write that in words at a lower level at first in terms of what

$$\boxed{\frac{1}{2} \times p_1} \text{ with}$$

$$\left\{ \frac{(-s+R)t - }{s+R} \right\} q_{12} \left(\frac{-s+R}{s+R} \right)^t$$

$$\cdot \frac{1}{2} \times \frac{V}{p_1} = (1), 5$$

representing ref. value as

multiple terms would follow in a similar fashion

$$\left\{ \frac{(-s+R)t - }{s+R} \right\} q_{12} \frac{V}{p_1} = \left\{ \frac{(s+R)t - }{s+R} \right\} q_{12} \frac{V}{s+R} \frac{1}{s+R} = \left(\frac{V}{s+R} \right)^2$$