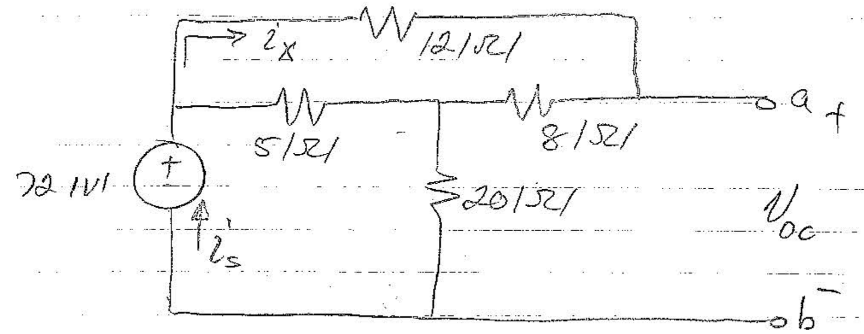
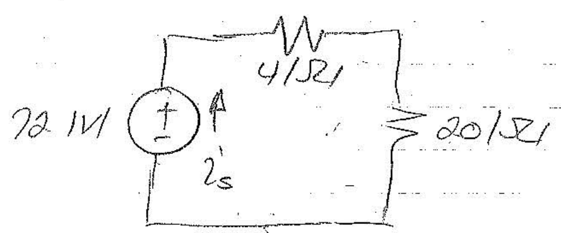
PROBLEM 4.1 (Nilsson & Reidel 8 ed.)

Find the Thevenin Equivalent at a, b.



Note that a, b is open circuit ⇒ 12 |Ω| is in series with 8 |Ω|.

So ... $(12+8) \parallel 5 = \frac{20 \cdot 5}{25} = 4 \,|\Omega|$



Of course now we have lost terminals a, b so we need to "unfold" this circuit:

$i_s' = 72/24 = 3 \,|A|$

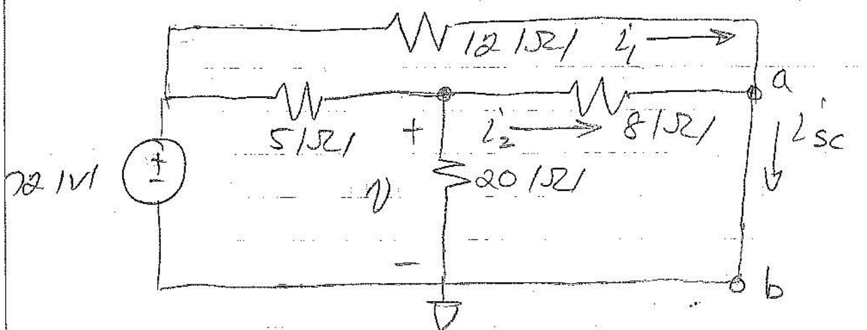
In original circuit we can use current divider to find i_x:

$$i_x = i_s' \cdot \frac{5}{(12+8)+5} = i_s' \cdot \frac{5}{25} = 0.6 \,|A|$$

Now. $v_{oc} - i_s' \cdot 20 - i_x' \cdot 8 = 0$

$$\underline{\underline{v_{oc}}} = 20 i_s' + 8 i_x' = \underline{\underline{64.8 \ |V|}}$$
$$= v_{Th}$$

Short-circuit current:



Note that we must take i_{sc}' in the direction a→b if we take v_{oc} with positive polarity at a.

$$\frac{v}{20} + \frac{v}{8} + \frac{v-72}{5} = 0$$

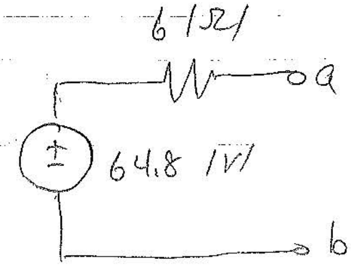
$$\Rightarrow \quad v = 38.4 \ |V|$$

$$\therefore \quad i_2' = v/8 = 4.8 \ |A|$$

$$i_1' = 72/12 = 6 \ |A|$$

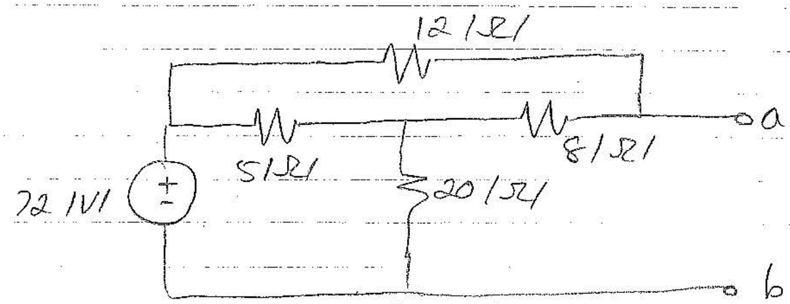
$$\Rightarrow \quad i_{sc}' = i_1' + i_2' = 10.8 \ |A|$$

$$\therefore \quad \underline{\underline{R_{Th}}} = v_{oc}/i_{sc} = \underline{\underline{6 \ |\Omega|}}$$

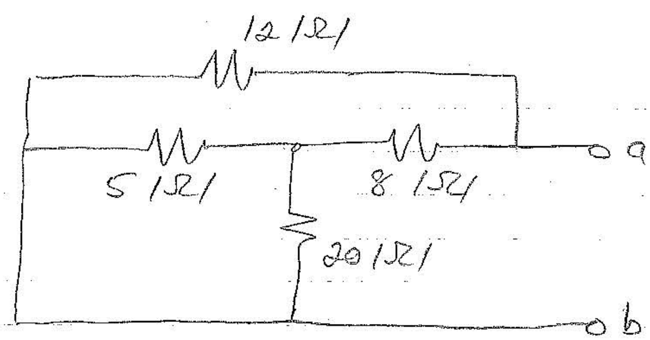


PROBLEM 4.1 REVISITED : R_{TH} calculation

Use test-source idea — but here is a case where we don't need to apply the test source!



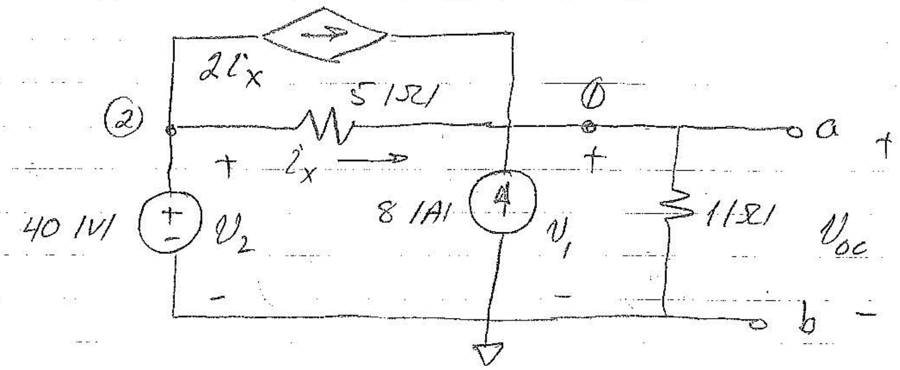
De-activate independent sources:



Now $R_{Th} = (20 \parallel 5 + 8) \parallel 12 = 6 |\Omega|$

PROBLEM 4.2 (Nilsson & Reidel 8ed)

Find the Thevenin Equivalent at a, b.



open-circuit voltage

$$\frac{v_1}{1} - 8 + \frac{v_1 - v_2}{5} - 2i_x = 0$$

$$i_x = \frac{v_2 - v_1}{5}$$

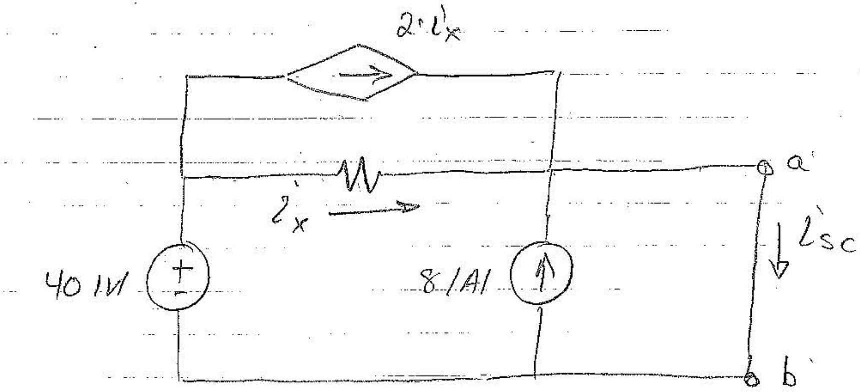
$$v_2 = 40 \ |V|$$

Solution: $v_1 = 20 \ |V|$

$i_x = 4 \ |A|$

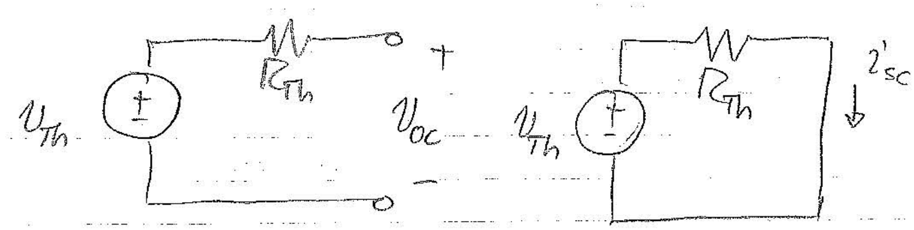
Then $V_{oc} = \underline{\underline{V_{Th}}} = v_1 = \underline{\underline{20 \ |V|}}$

short-circuit current



Note that i_{sc} must be taken in the direction $a \rightarrow b$ if v_{oc} has positive polarity at a.

Why is that? Go back to the Thevenin equivalent:



For $v_{Th} > 0$ and $R_{Th} > 0$, v_{oc} and i_{sc} are positive as indicated.

Note also that we were able to remove the 1 Ω resistor because the short circuit $\Rightarrow$ no current through it.

(PROBLEM 4.2 con't)

KVL: $-40 + 5i'_x = 0$

KCL: $i'_{sc} - 8 - i'_x - 2i'_x = 0$

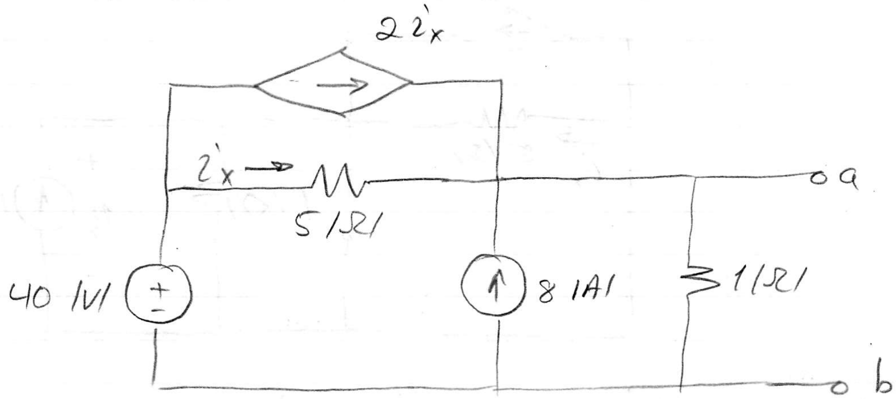
Solution: $i'_x = 8$ /A/

$i'_{sc} = 32$ /A/

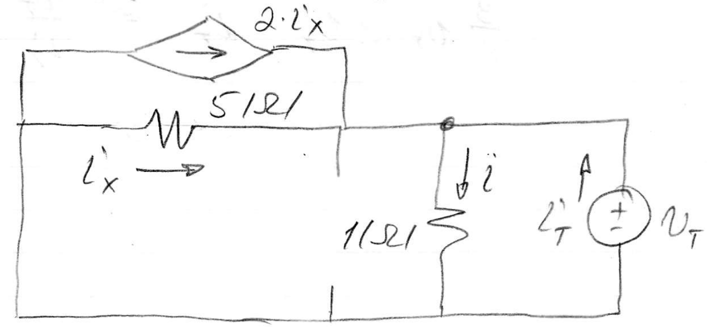
$\therefore \quad R_{Th} = v_{oc}/i_{sc} = 20/32 = 5/8$ /Ω/.

PROBLEM 4.2 REVISITED: R_{TH} calculation

TEST VOLTAGE



Apply test voltage and de-activate independent sources:



KCL: $-i_T - i_x - 2 i_x + i = 0$

$i = v_T/1.$

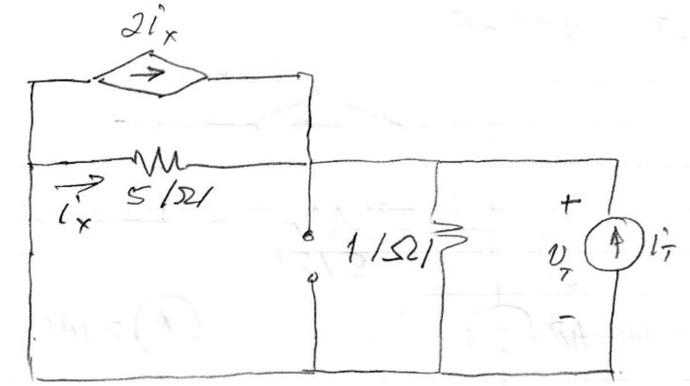
KVL: $v_T + 5 i_x = 0 \Rightarrow i_x = -v_T/5$

$\therefore \quad i_T = -3 i_x + \frac{v_T}{1}$

$= 3/5\, v_T + v_T/1 = v_T(3/5 + 1)$

$\Rightarrow \quad v_T/i_T = 1/(8/5) = \underline{\underline{5/8\ |\Omega| = R_{Th}}}$

TEST CURRENT



KCL: $-2i_x - i_x + \frac{v_T}{1} - i_T = 0$

$$i_x = -\frac{v_T}{5}$$

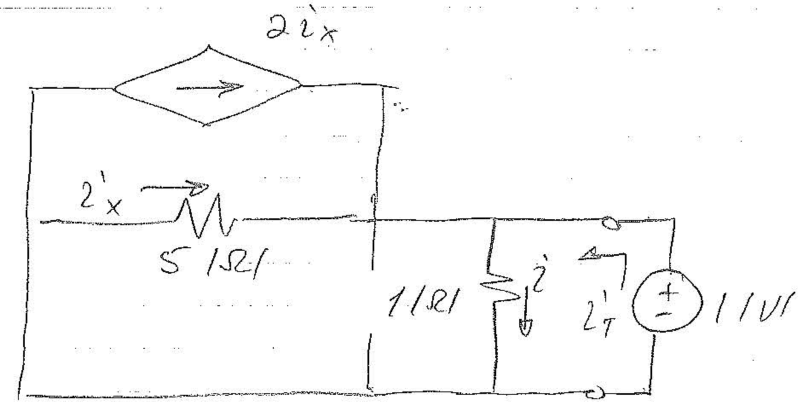
$$\frac{3}{5}v_T + v_T = i_T \Rightarrow \frac{v_T}{i_T} = R_{TH} = 5/8\ \Omega$$

(PROBLEM 4.2 REVISITED con't)

Note that we need to find v_T/i_T so we manipulated our equations to arrive at this.

BUT: Since any test source will work, it is often useful to choose a specific value, say 1 [V] (or 1 [A]).

Looking again at Problem 4.2, we apply a 1 [V] test source:



Now

$$i = 1 \, [A]$$

$$1 + 5i_x = 0 \Rightarrow i_x = -0.2 \, [A]$$

$$\therefore \quad i_T = -3i_x + i$$

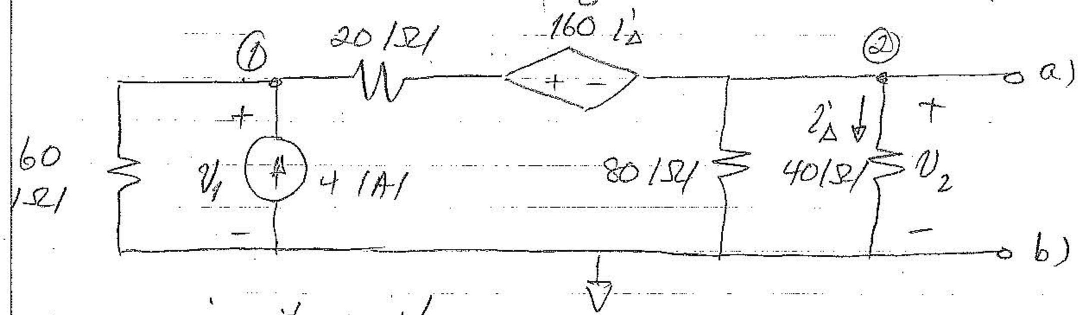
$$= +0.6 + 1 = 1.6 \, [A]$$

$$\Rightarrow \quad R_{Th} = v_T/i_T = 1/1.6 = 0.625 \, [\Omega]$$

$$(= 5/8 \, [\Omega])$$

PROBLEM 4.3 (Nilsson & Reidel, 8 ed)

Find the Thevenin Equivalent at a), b).



open-circuit voltage:

$$\frac{v_2}{40} + \frac{v_2}{80} + \frac{v_2 - v_1 + 160\, i_\Delta'}{20} = 0$$

$$\frac{v_1}{60} - 4 + \frac{v_1 - v_2 - 160\, i_\Delta'}{20} = 0$$

$$i_\Delta' = v_2/40$$

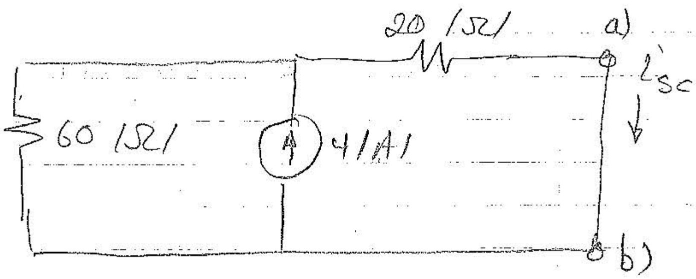
Solution: $v_2 = v_{oc} = \underline{v_{Th} = 30\ |V|}$

$i_\Delta' = 0.75\ |A|$

$v_1 = 172.5\ |V|$

short-circuit current

With a), b) short-circuited, there is no current in the 80 |Ω| or 40 |Ω| resistors. Also, $i_\Delta' = 0$, so the circuit simplifies considerably:

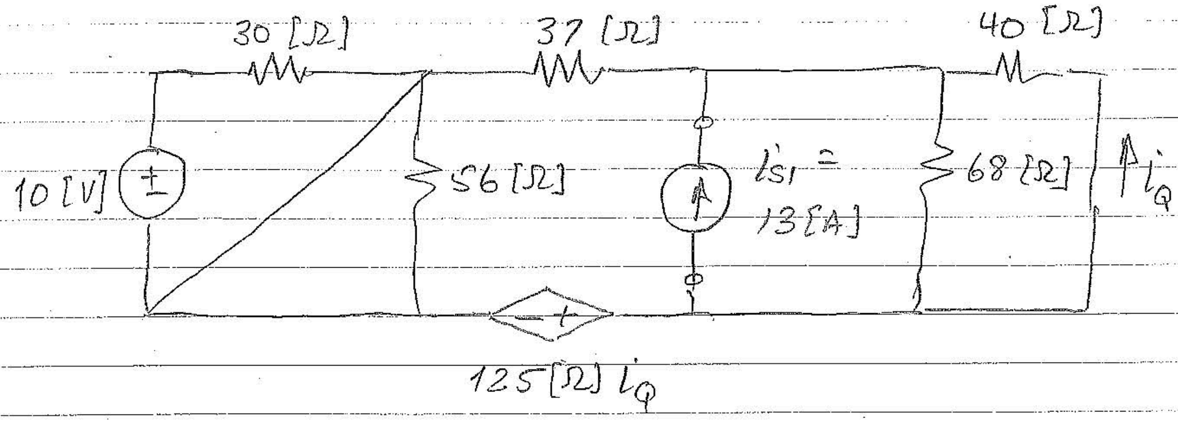


Then $i'_{sc} = 4 \cdot \frac{60}{60+20} = 3/A/$

So $R_{Th} = v_{oc}/i_{sc} = 10 /\Omega/.$

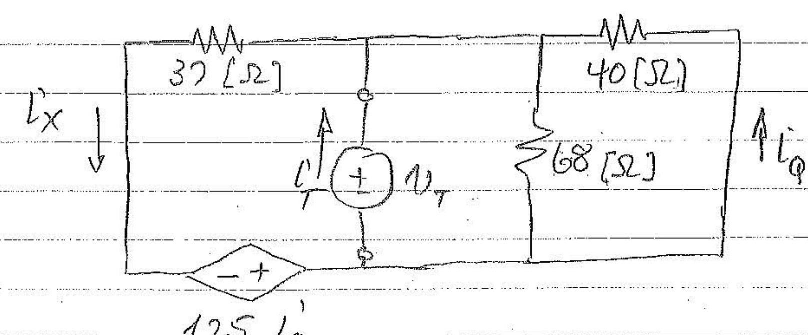
PROBLEM 4.5

- Find the Thevenin Equivalent seen by the current source.



Note: "seen by the current source" means exactly that: what equivalent circuit does the current source see? For that, we need to disconnect the current source because the current source is not part of the equivalent circuit.

Because we have no independent sources, we must find R_{TH} with a test source.



We have removed several components that were in parallel with a short.

KVL: $-v_T - 40 i_\phi' = 0$

Set $v_T = 1$ [V] (arbitrary) $\Rightarrow i_\phi' = -25$ [mA]

KVL: $-v_T + 37 i_x' - 125 i_\phi' = 0$

$$\Rightarrow i_x' = \frac{1 + 125(-0.025)}{37} = -57.43 \text{ [mA]}$$

KCL: $i_T' = i_x' - i_\phi' + \frac{1}{68} = -17.72$ [mA]

$\therefore \boxed{R_{TH} = -56.42 \ [\Omega]}$

Note that the terminals of the Thevenin Equivalent do not "see" any independent sources, which means...

$$v_{TH} = 0$$

So the Thevenin Equivalent is just a resistance: