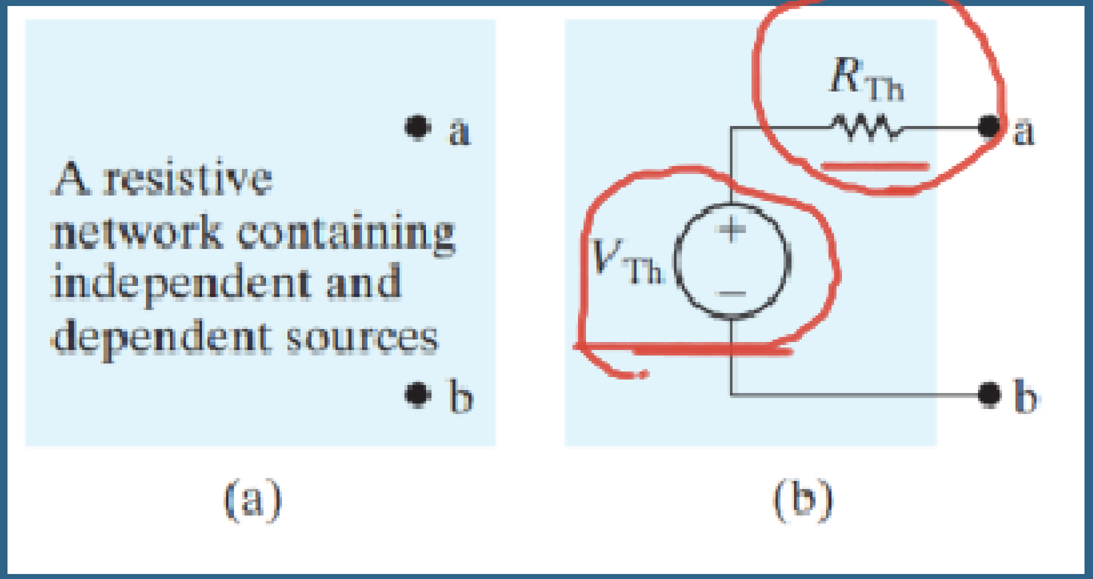
Thevenin Equivalent Circuit

- Thevenin and Norton equivalents are circuit simplification techniques.
- These equivalent circuits retain no information about the internal behavior of the original circuit and focus only on terminal behavior.

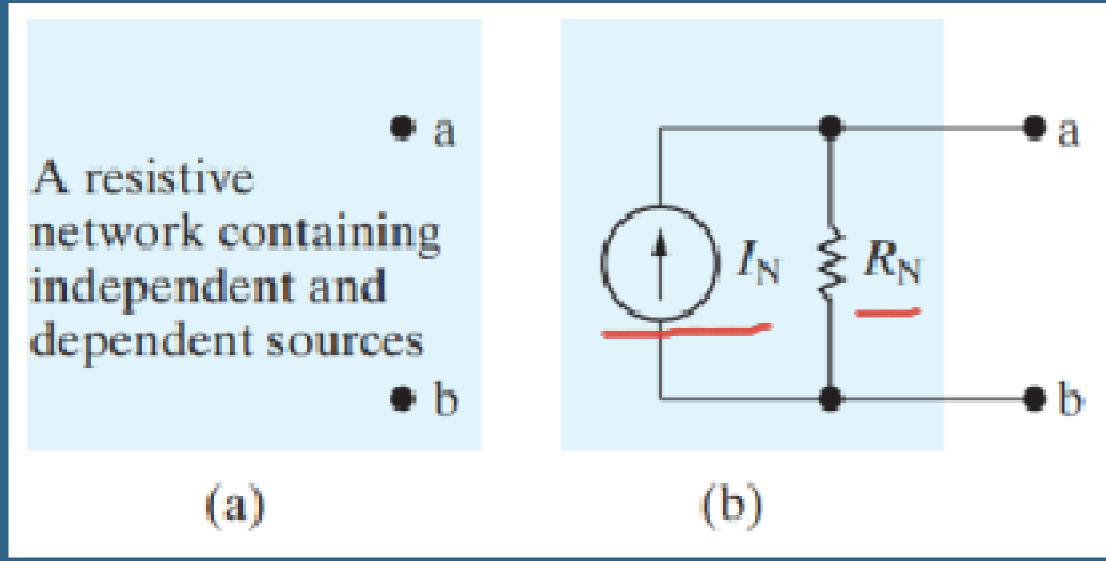


- Thevenin equivalent circuit is an independent voltage source in series with a resistor, which replaces an interconnection of sources and resistors.

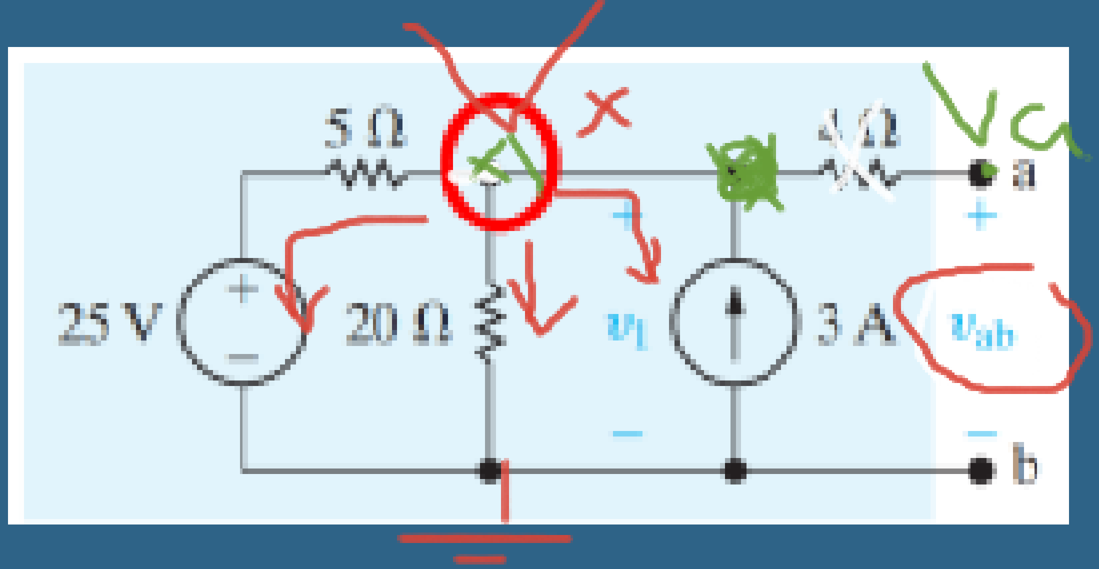
This series combination of VTh and RTh is equivalent to the original circuit in the sense that, if we connect the same load across the terminals a,b of each circuit, we get the same voltage and current at the terminals of the load.

==> In order to get the Thevenin voltage VTh, we assume an open circuit condition at the terminals and deduce the voltage at the terminals. Then we assume a short circtui at the terminals and compute the current Isc from which we find the Rth.

$$R_{th} = \frac{V_{th \to oc}}{I_{sc}}$$



- Example: Finding a Thevenin Equivalent:



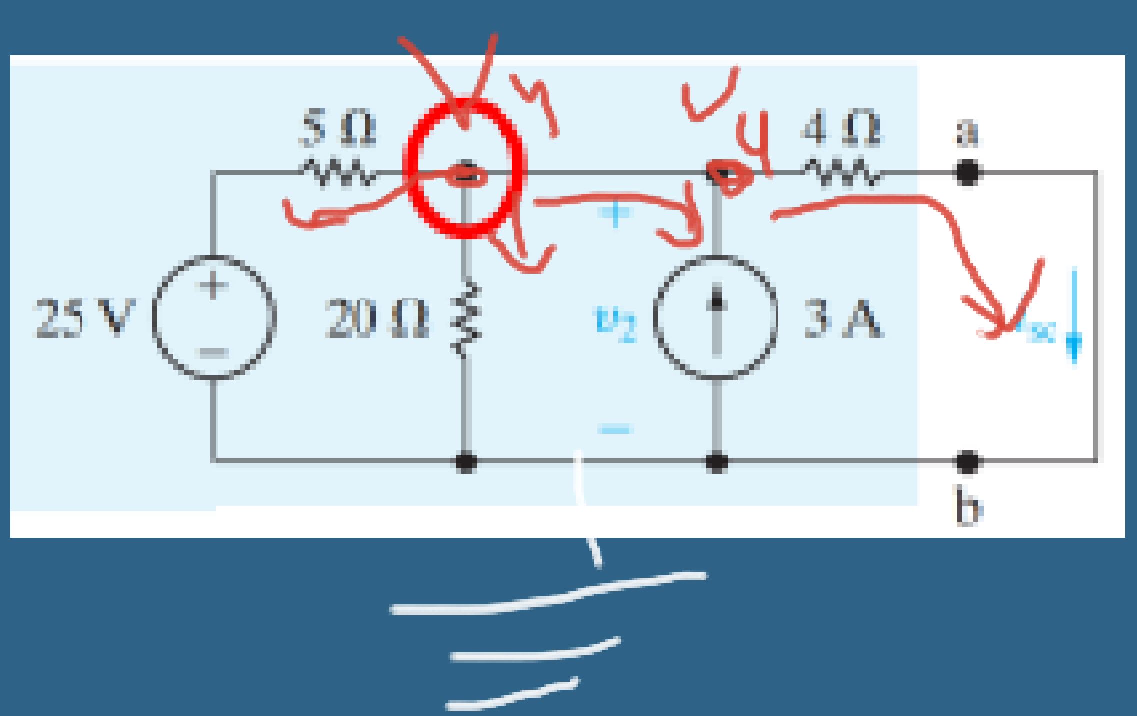
① O.C to get V_{th}

$$\frac{V_x - 25}{5} + \frac{V_x - 0}{20} - 3 = 0 \qquad \boxed{V_x = 32V}$$

Note: $V_a = V_x$ $\quad V_{ab} = V_a - \cancel{V_b}^{\,0} = V_a = 32V \rightarrow V_{th}$

② $i_{s.c}$:

$$\frac{V_y-25}{5}+\frac{V_y-0}{20}-3+\frac{V_y-0}{4}=0$$



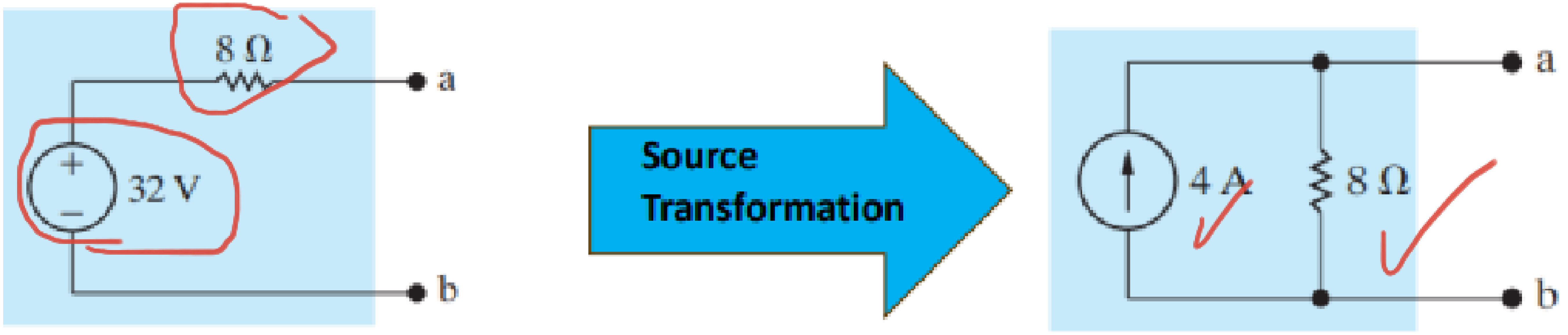
$$\boxed{V_2=16V}$$

$$i_{sc}=\frac{V_2-0}{4}=\frac{16}{4}=\boxed{4A}$$

$R_{th}=8\Omega$

$$R_{th}=\frac{V_{th}}{i_{s.c}}=\frac{32}{4}=\boxed{8\Omega}$$

$$I = \frac{V}{R} = \frac{32}{8} = 4\,A$$

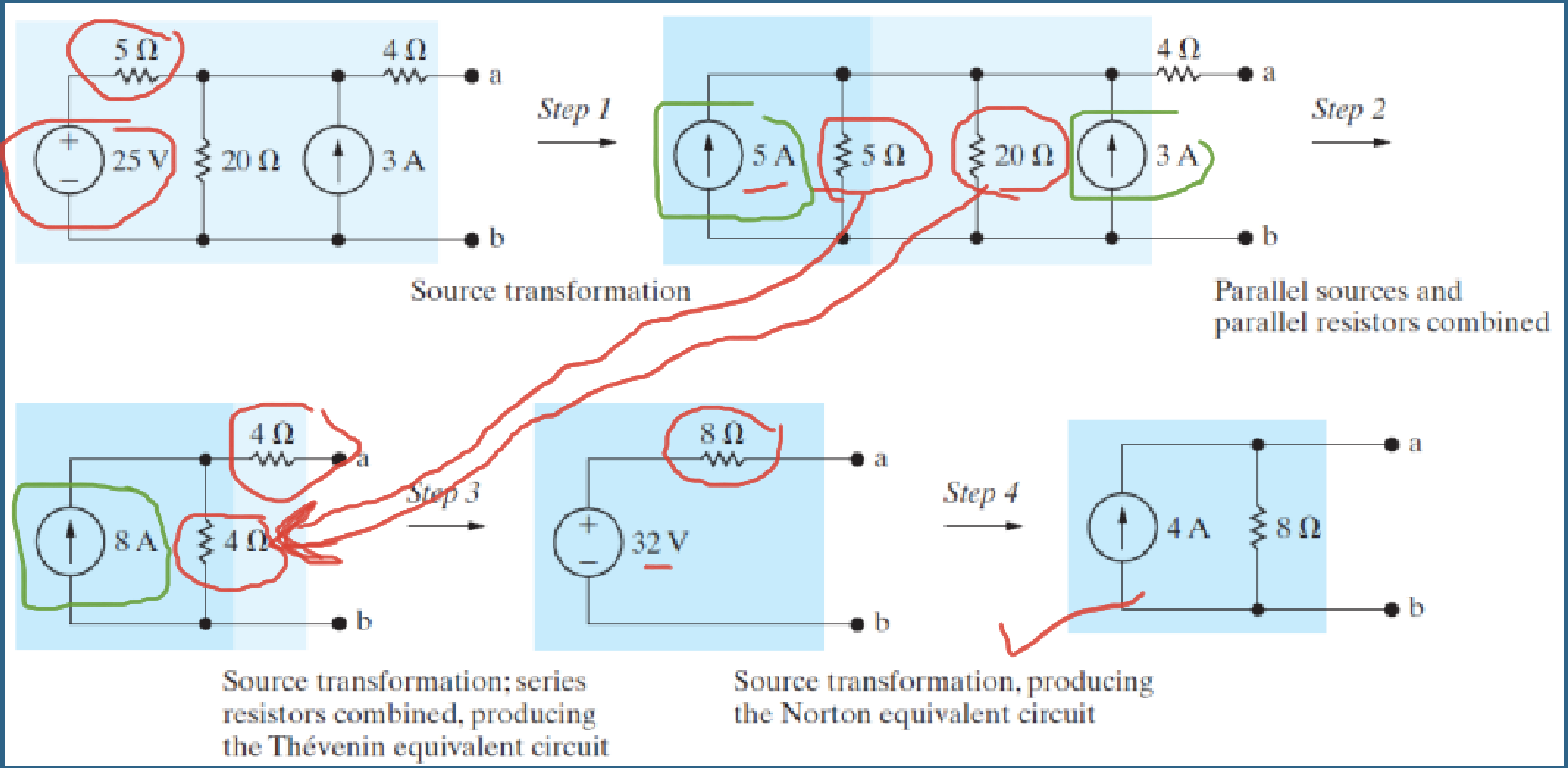


Thevenin equivalent circuit

Norton equivalent circuit

Norton

$$\frac{5*20}{5+20}$$



Thévenin Equivalent of a Circuit with a ~~Dependent~~ Source

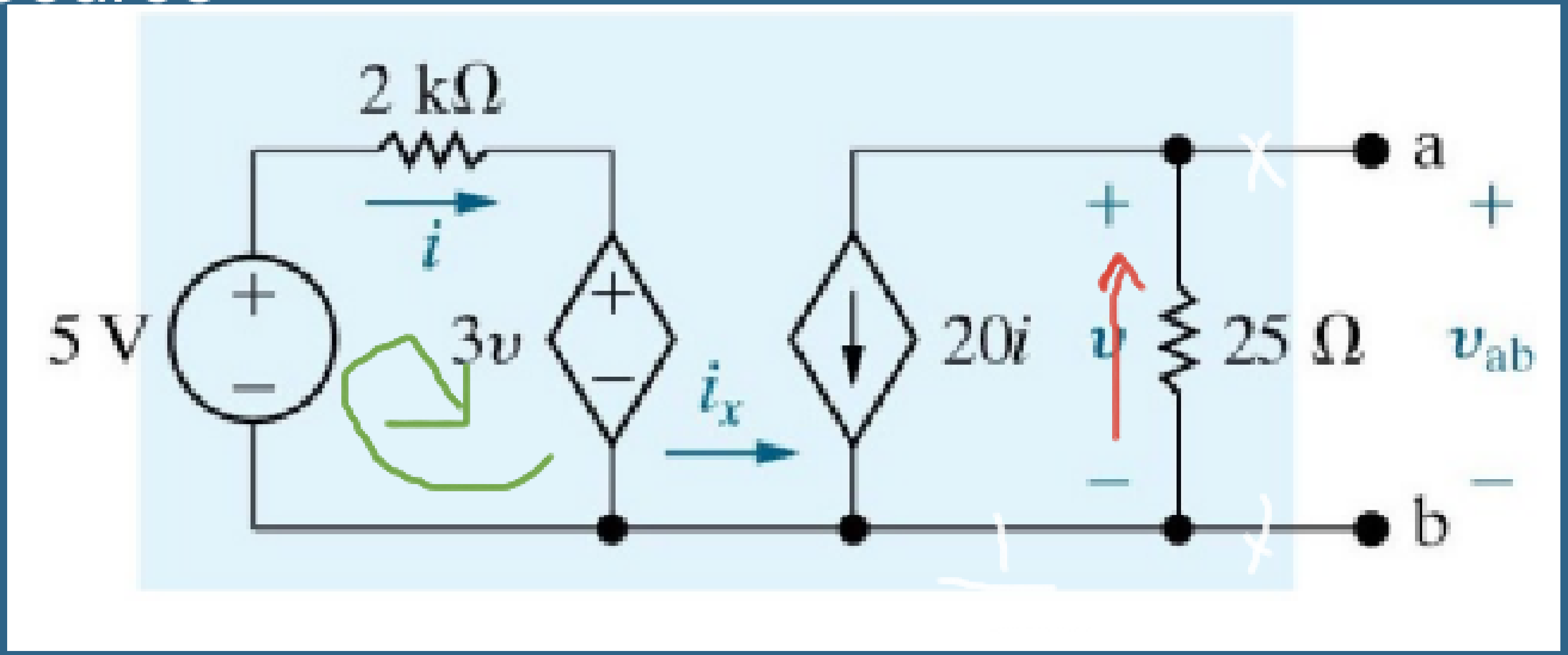
① V_{th} : O.C

$v_{th} = v_{ab} = V_a = (-20i)(25)$

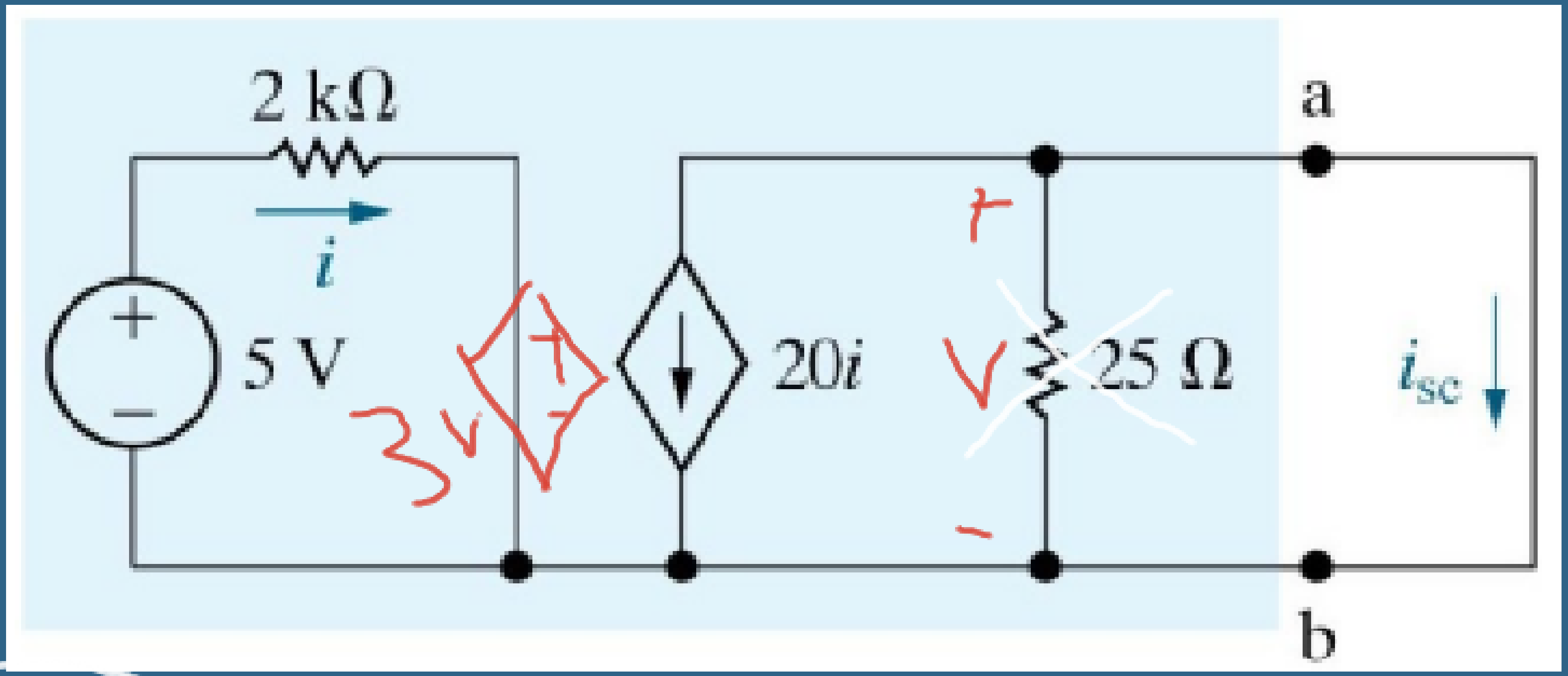
$= \boxed{-500i}$

$-5 + 2000i + 3v \overset{(-500i)}{=} 0 \rightarrow \boxed{i = 0.01A}$

$V_{th} = \boxed{-5V}$



② $i_{s.c}$



$$i_{s.c} = -20\,i$$

$$i = \frac{5 - 3\cancel{V}^{\,0}}{2000} = \frac{5}{2000} = \boxed{\frac{1}{400}\,A}$$

$$i = \frac{-1}{20}\,A$$

$$R_{th} = \frac{V_{th}}{i_{s.c}} = \frac{-5}{\left(\frac{-1}{20}\right)} = 100\,\Omega$$

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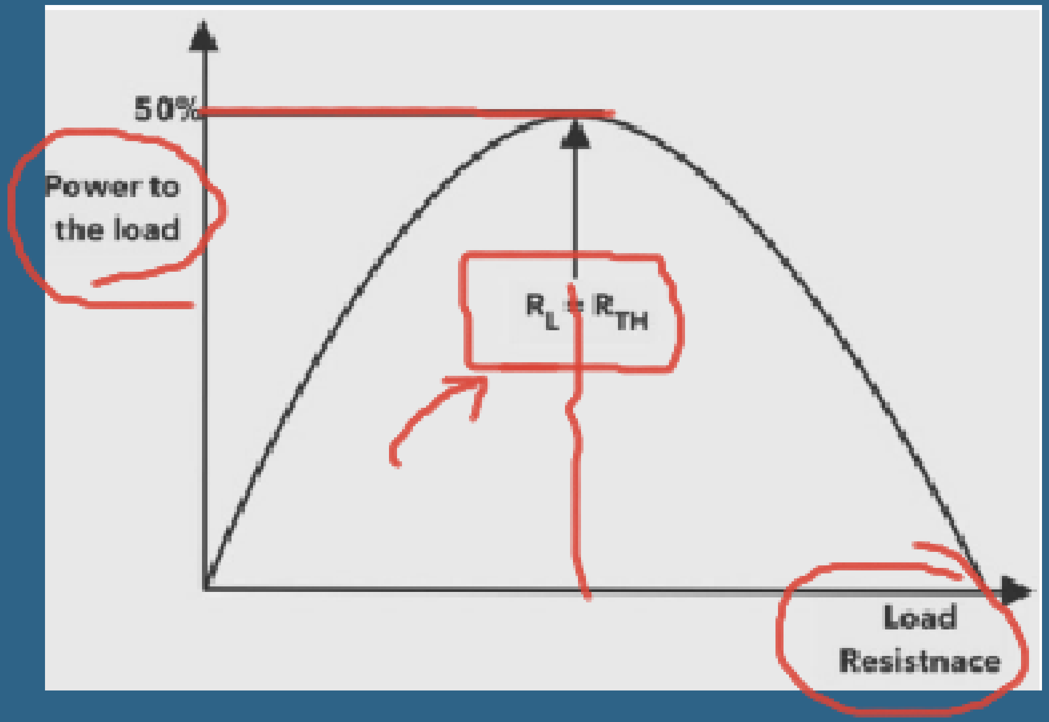
Maximum Power Transfer

- In Communication systems information (data) is transmitted via electric signals, the power available at the transmitter or detector is limited.

Thus, transmitting as much of this power as possible to the receiver (load) is desirable.

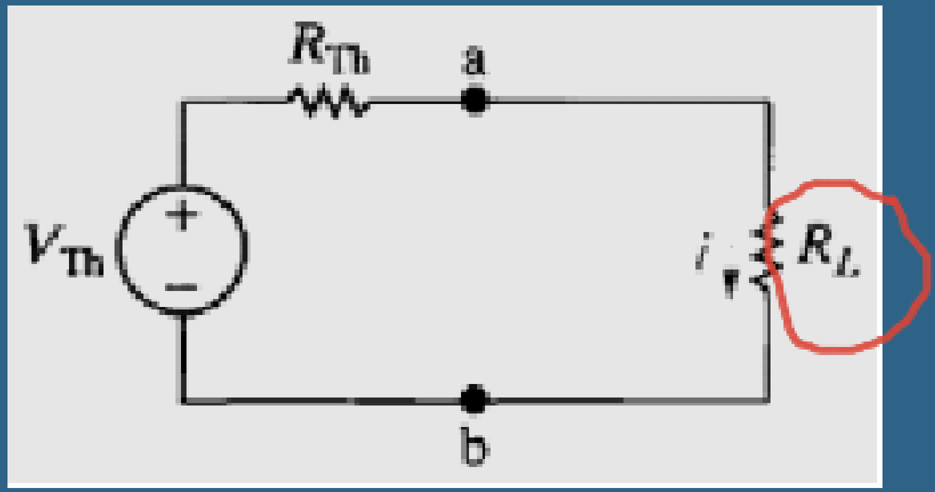


Derivation

$$P_L = Vi = i^2 R_L = \left(\frac{V_{th}}{R_L + R_{th}}\right)^2 R_L$$

$$i = \frac{V_{th}}{R_{th} + R_L}$$

$$\frac{dP_L}{dR_L} = 0$$



$$\underline{p} = \underline{i^2 R_L} = \left(\frac{V_{Th}}{\cancel{R_{Th}} + R_L}\right)^2 R_L.$$

R_L

$R_L = R_{th}$

$$\frac{dp}{dR_L} = V_{Th}^2\left[\frac{(R_{Th} + R_L)^2 - R_L \cdot 2(R_{Th} + R_L)}{\cancel{(R_{Th} + R_L)^4}}\right] = 0$$

$$p_{max} = \frac{V_{th}^2}{4R^2} \cdot R_L$$

$$= \frac{V_{th}^2}{4R_L}$$

$$p_{max} = \frac{V_{Th}^2 R_L}{(2R_L)^2} = \frac{V_{Th}^2}{4R_L}.$$

Maximum Power Transfer

$$V_{Th} = \frac{150}{180}(360) = \boxed{300\text{ V}}$$

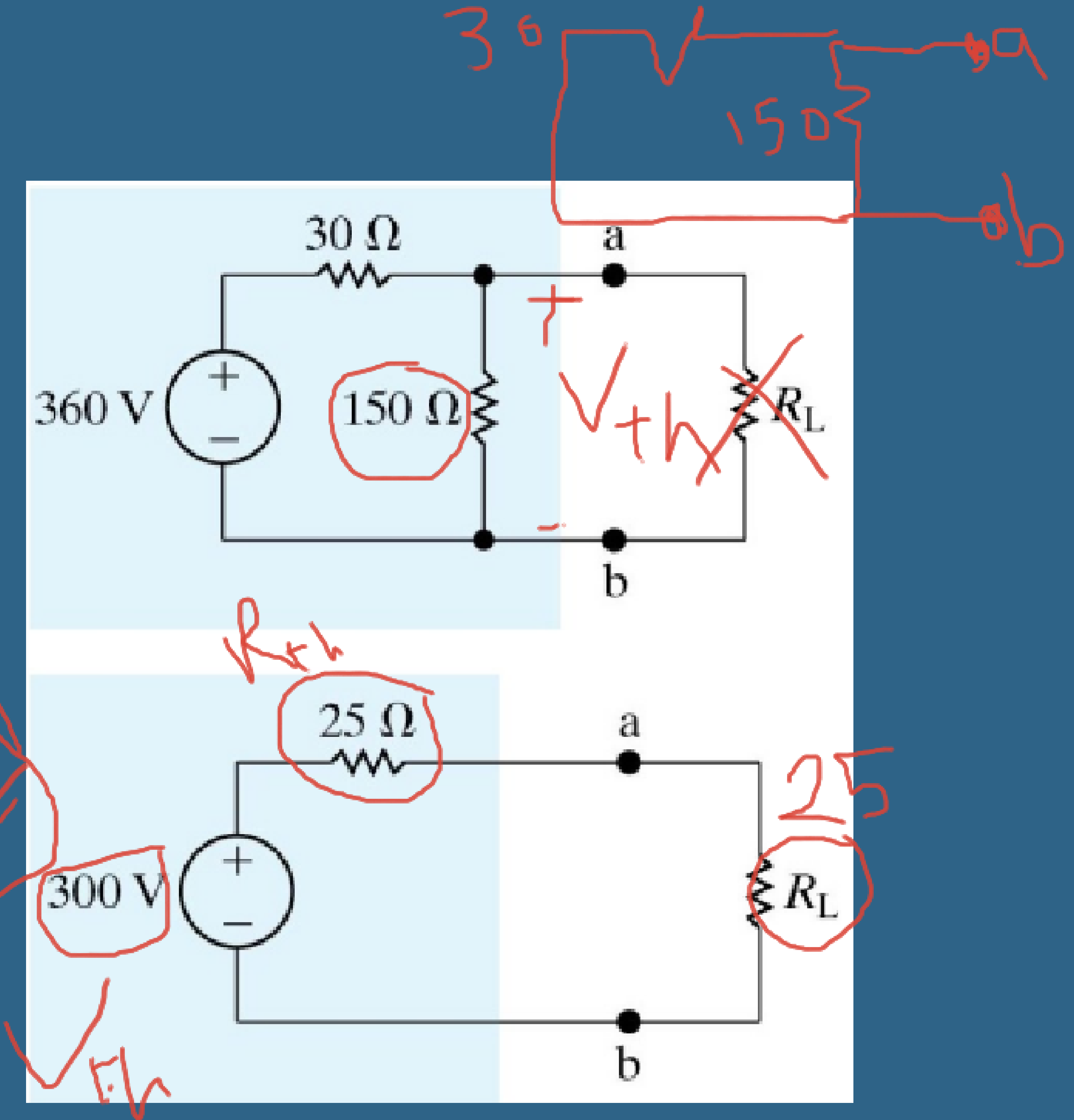
$$R_{Th} = \frac{(150)(30)}{180} = 25\ \Omega$$

$R_L = R_{Th}$

$$p_{max} = \cancel{\left(\frac{300}{50}\right)^2(25)} = 900\text{ W}$$

$\frac{V_{Th}^2}{4R_{Th}}$

$$v_{ab} = \left(\frac{300}{50}\right)(25) = \boxed{150\text{ V}}$$



$$v_{ab} = \left(\frac{300}{50}\right)(25) = 150\text{ V}$$

$$i_s = \frac{360 - 150}{30} = \frac{210}{30} = 7\text{ A}$$

$$p_s = -i_s(360) = -2520\text{ W}$$

$$\frac{900}{2520} \times 100 = 35.71\,\%$$