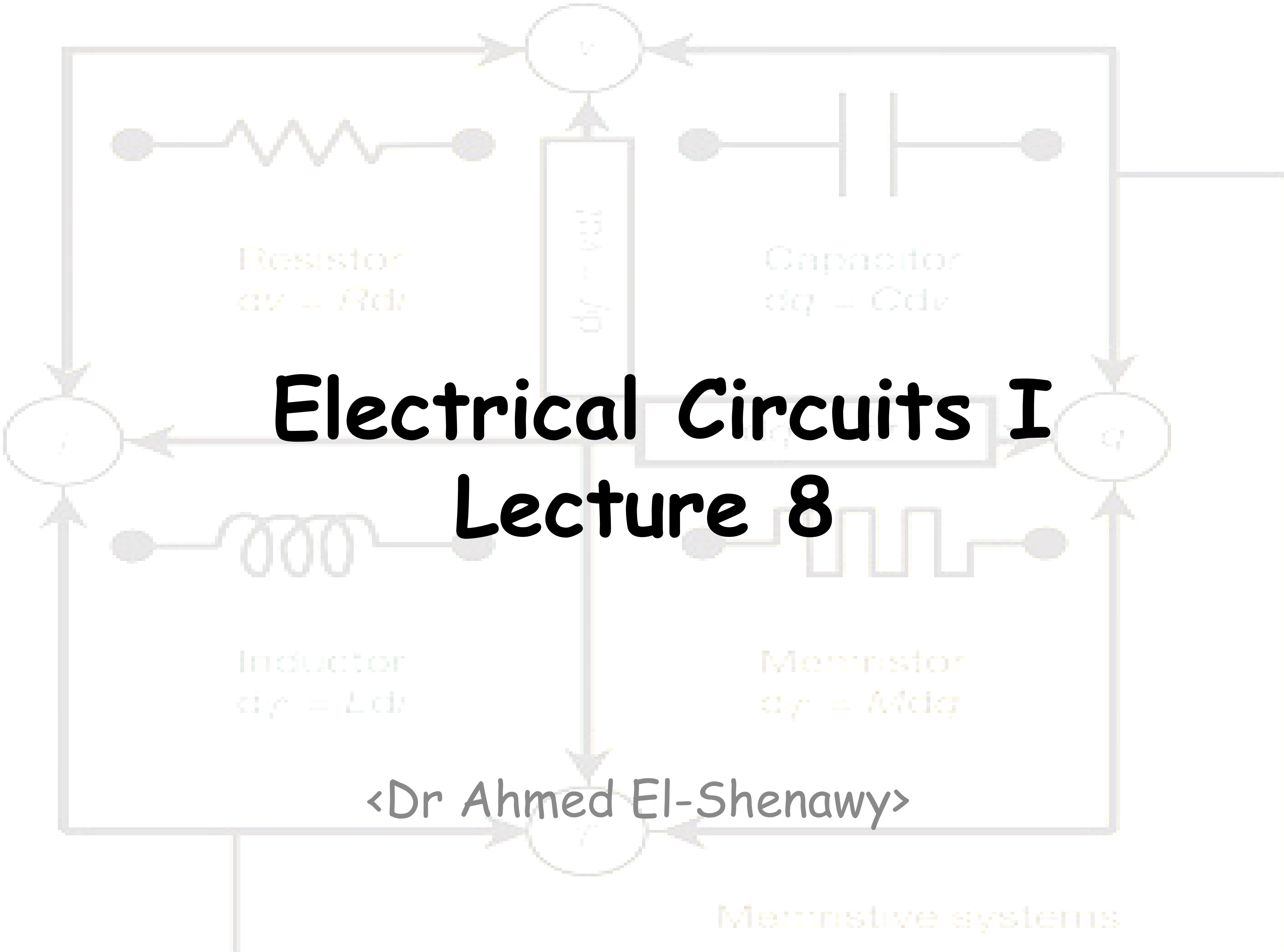
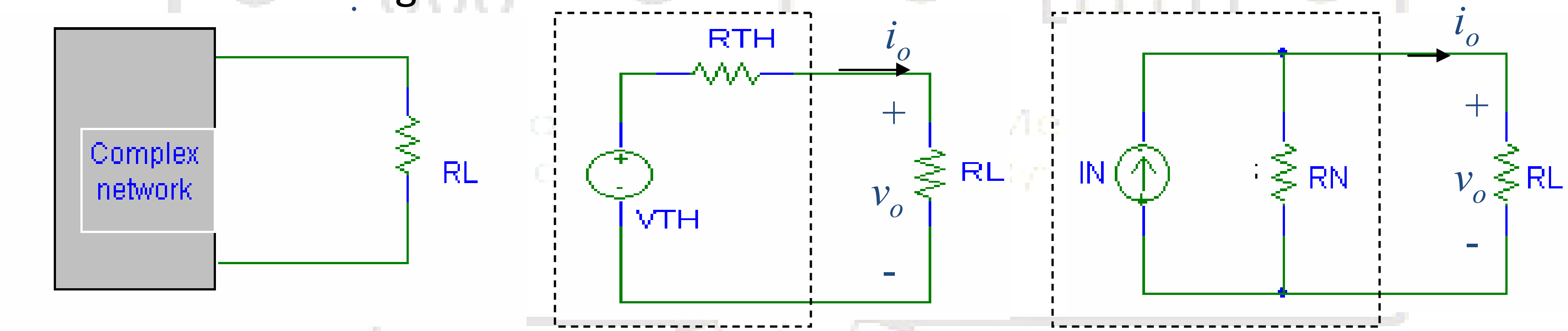


Electrical Circuits I
Lecture 8

<Dr Ahmed El-Shenawy>

Thevenin and Norton theorems

- Thevenin theorem tells us that we can replace the entire network, exclusive of the load resistor, by an equivalent circuit that contains only an independent voltage source in series with a resistor in such a way that the current-voltage (*i-v*) relationship at the load resistor is unchanged.
- Norton theorem tells us that we can replace the entire network, exclusive of the load resistor, by an equivalent circuit that contains only an independent current source in parallel with a resistor in such a way that the current-voltage (*i-v*) relationship at the load resistor is unchanged.

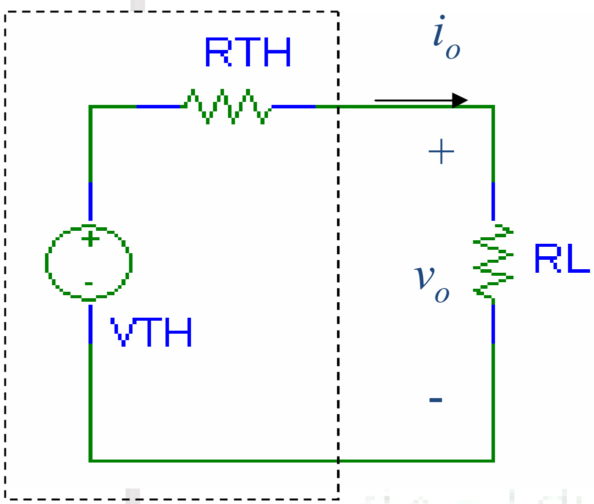


(a) A complex network including a load resistor R_L.

(b) A Thevenin equivalent network

(c) A Norton equivalent network

Thevenin Theorem



•How to determine $v_{TH}(t)$ and R_{TH} for a particular circuit.

•It is helpful to note that if we connect no load and therefore $i_o(t) = 0$, then we can determine $v_{TH}(t)$ from

$$v_{TH}(t) = v_{opencircuit}(t) \equiv v_{oc}(t)$$

where $v_{oc}(t)$ is called the open circuit voltage

•If we short circuit the two terminals to force $v_o(t) = 0$, then we get

$$\frac{v_{TH}(t)}{R_{TH}} = i_{shortcircuit}(t) \equiv i_{sc}(t)$$

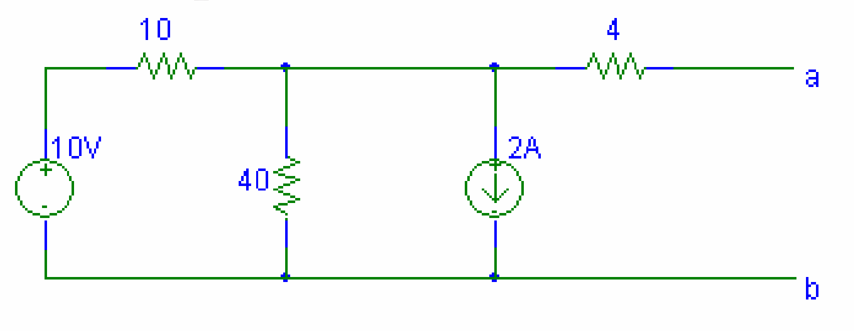
•If $v_{TH}(t) \neq 0$, then $i_{shortcircuit}(t) \neq 0$ and we find

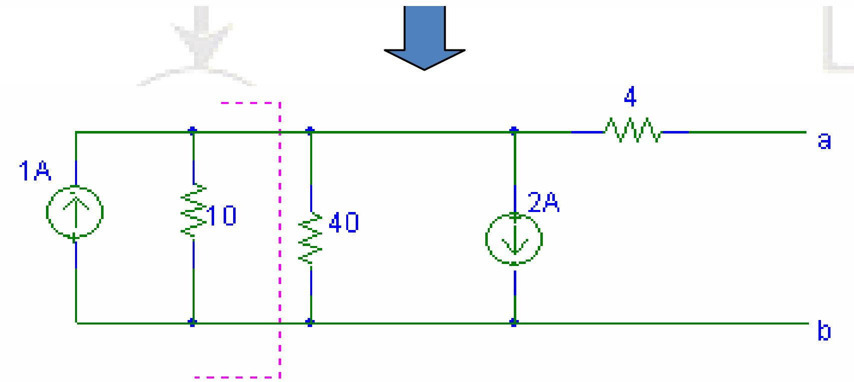
$$R_{TH} = \frac{v_{oc}(t)}{i_{sc}(t)}$$

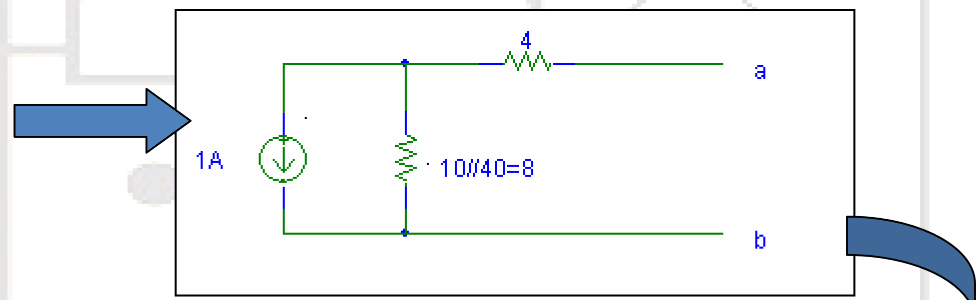
Case 1 example 1

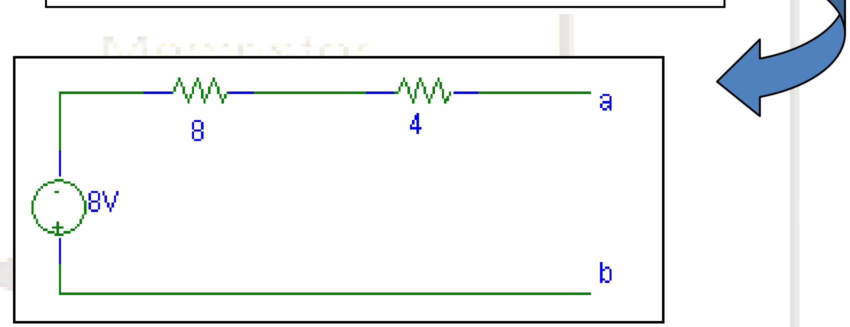
Find the Thevenin equivalent circuit at terminal pair a and b for the circuit shown.

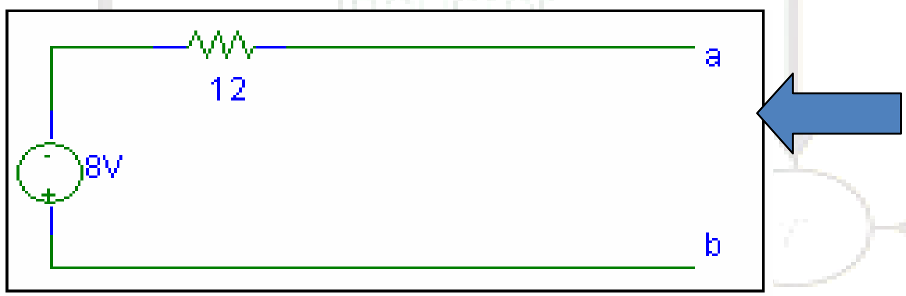
This specific problem can be solved by using different approaches. We solve the problem by using source transformation technique.





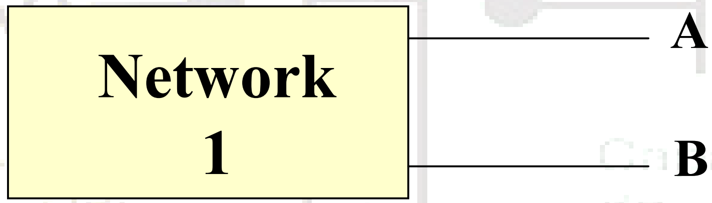






Thus we have $R_{TH} = 12\Omega$ and $v_{TH} = -8V$

Thevenin Theorem



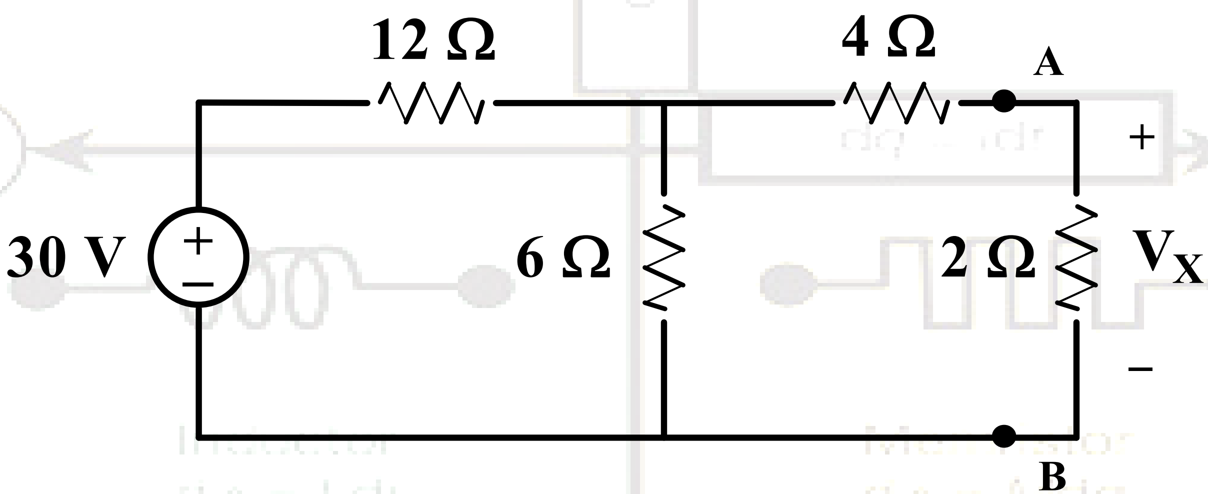
- **We now <u>deactivate all sources</u> of Network 1.**

- **To deactivate a voltage source, we remove the source and replace it with a short circuit.**

- **To deactivate a current source, we remove the source.**

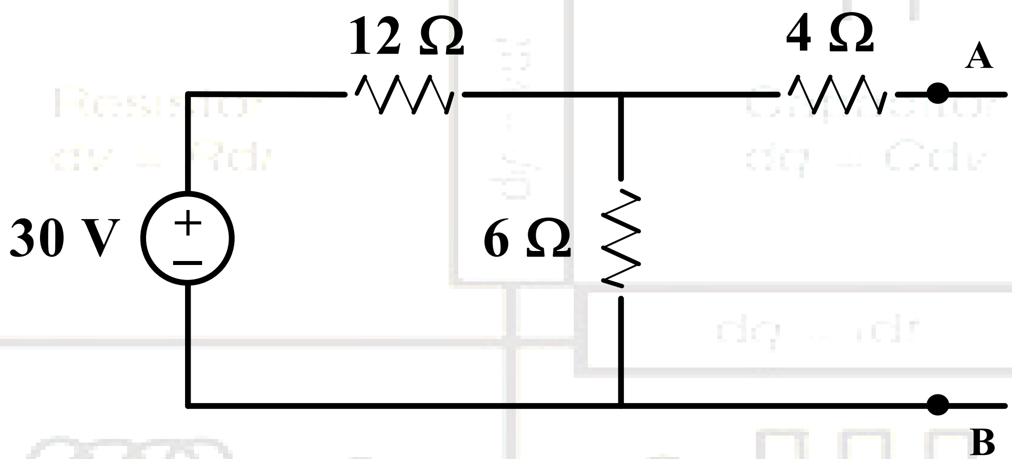
Thevenin Theorem

Find V_X by first finding V_{TH} and R_{TH} to the left of A-B.



First remove everything to the right of A-B.

Thevenin Theorem

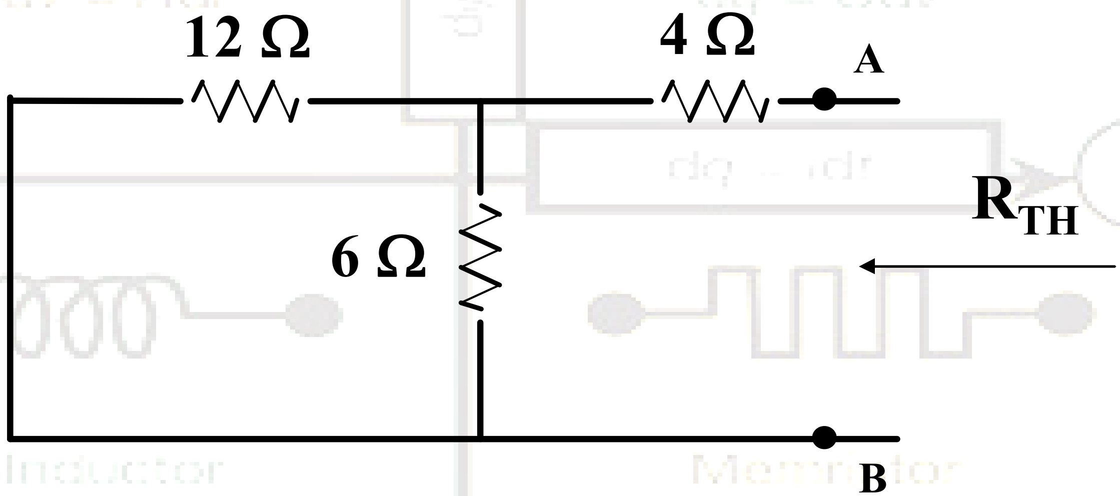


$$V_{AB} = \frac{(30)(6)}{6+12} = 10V$$

Notice that there is no current flowing in the 4 Ω resistor (A-B) is open. Thus there can be no voltage across the resistor.

Thevenin Theorem

We now deactivate the sources to the left of A-B and find the resistance seen looking in these terminals.

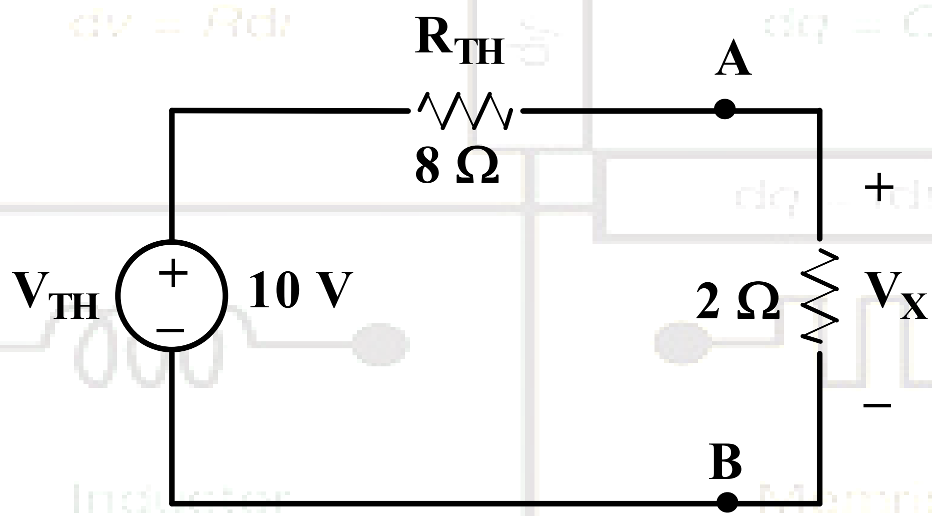


We see,

$$R_{TH} = 12||6 + 4 = 8\ \Omega$$

Thevenin Theorem

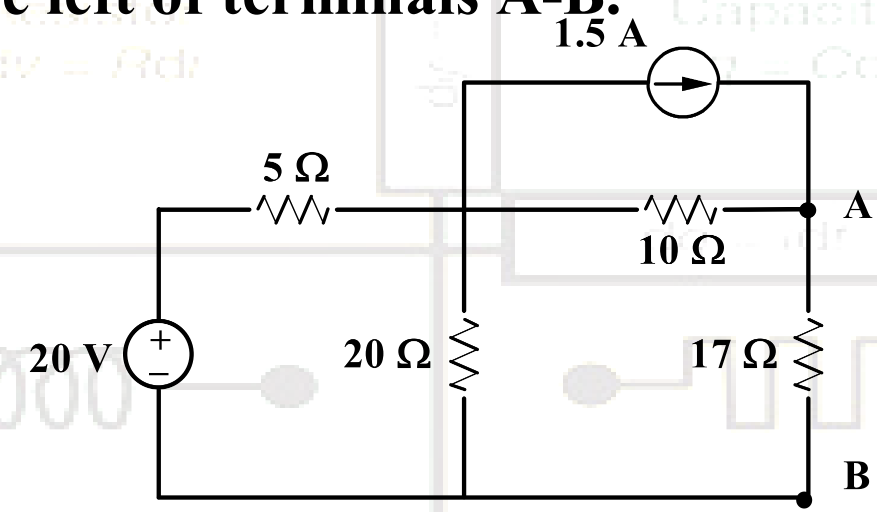
After having found the Thevenin circuit, we connect this to the load in order to find V_X.



$$V_X = \frac{(10)(2)}{2+8} = 2V$$

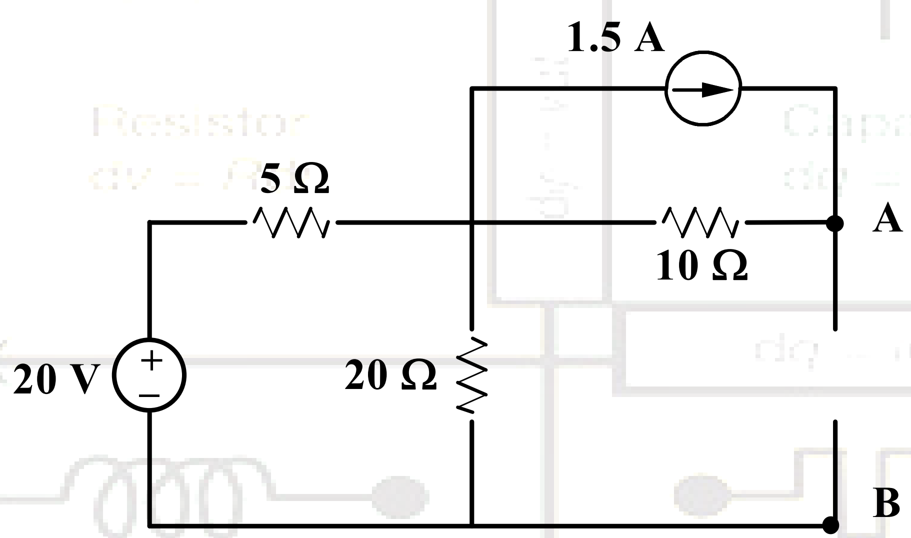
Thevenin Theorem

For the circuit below, find V_{AB} by first finding the Thevenin circuit to the left of terminals A-B.



We first find V_{TH} with the 17 Ω resistor removed. Next we find R_{TH} by looking into terminals A-B with the sources deactivated.

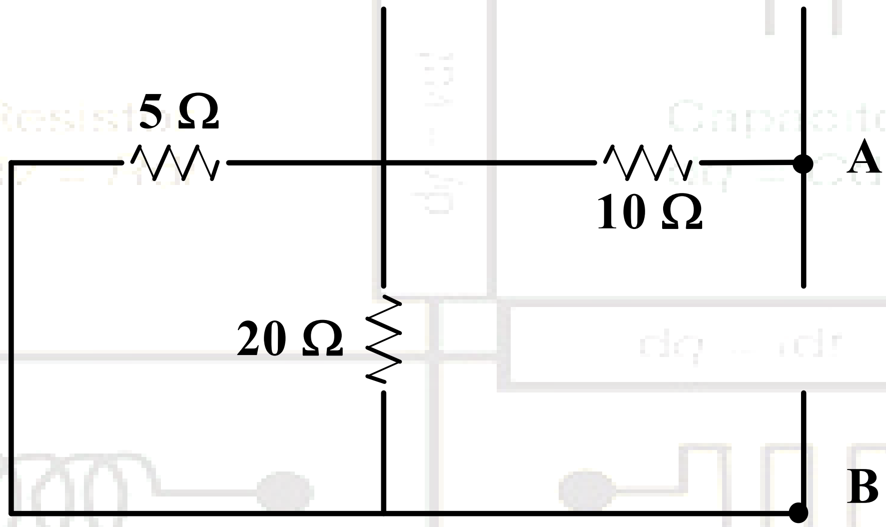
Thevenin Theorem



$$V_{OS} = V_{AB} = V_{TH} = (1.5)(10) + \frac{20(20)}{(20+5)}$$

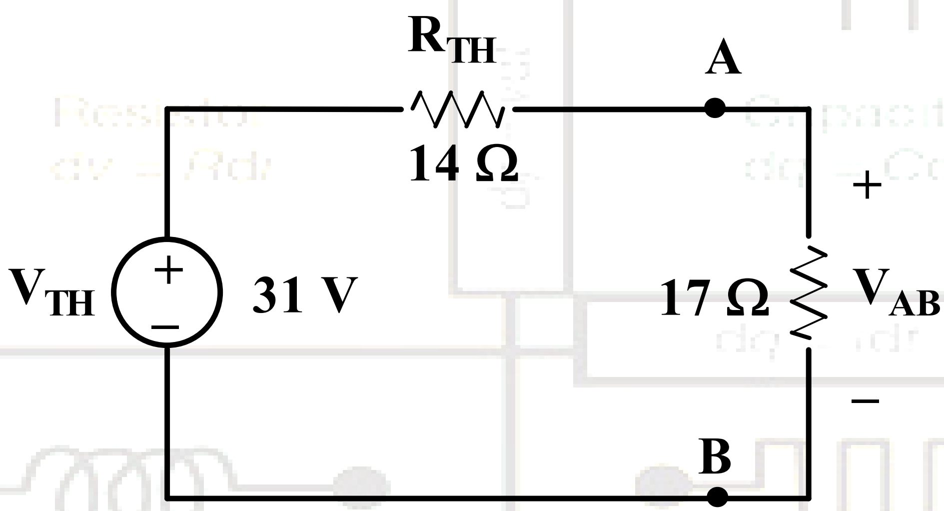
$$\therefore \quad V_{TH} = 31V$$

Thevenin Theorem



$$R_{TH} = 10 + \frac{5(20)}{(5+20)} = 14\Omega$$

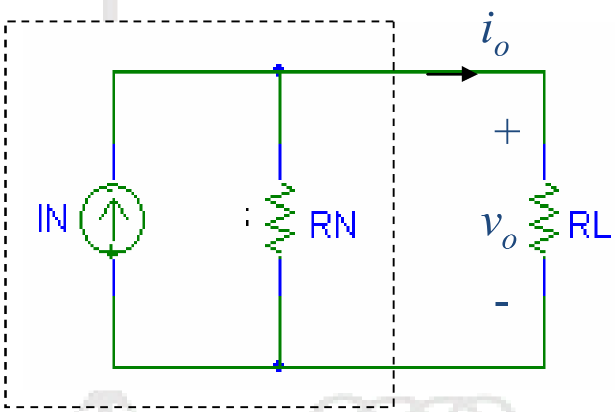
Thevenin Theorem



We can easily find that,

$$V_{AB} = 17V$$

Norton theorem



(c)

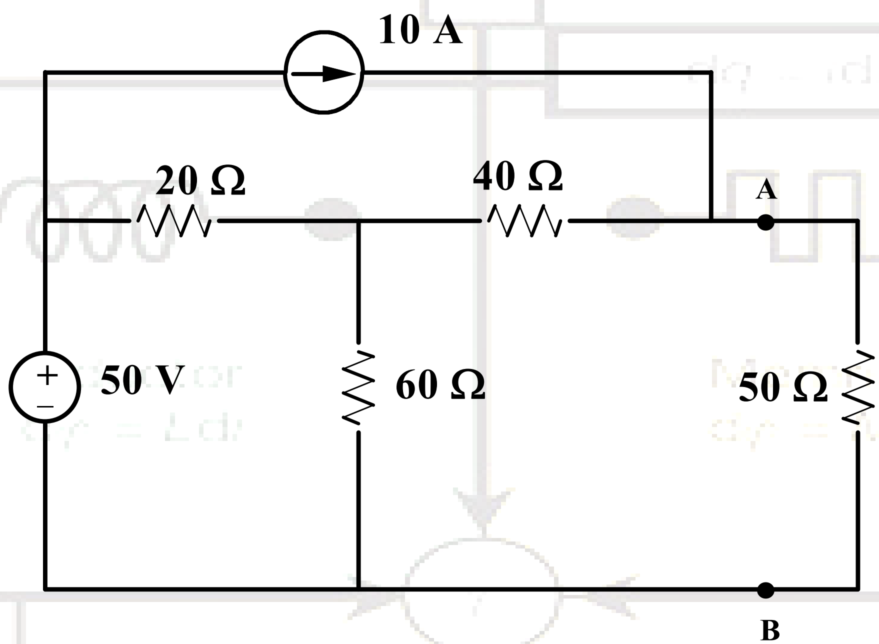
- Based on source transformation we have learned, we can determine $i_N(t)$ and R_N

$$R_N = R_{TH} = \frac{v_{oc}(t)}{i_{sc}(t)}$$

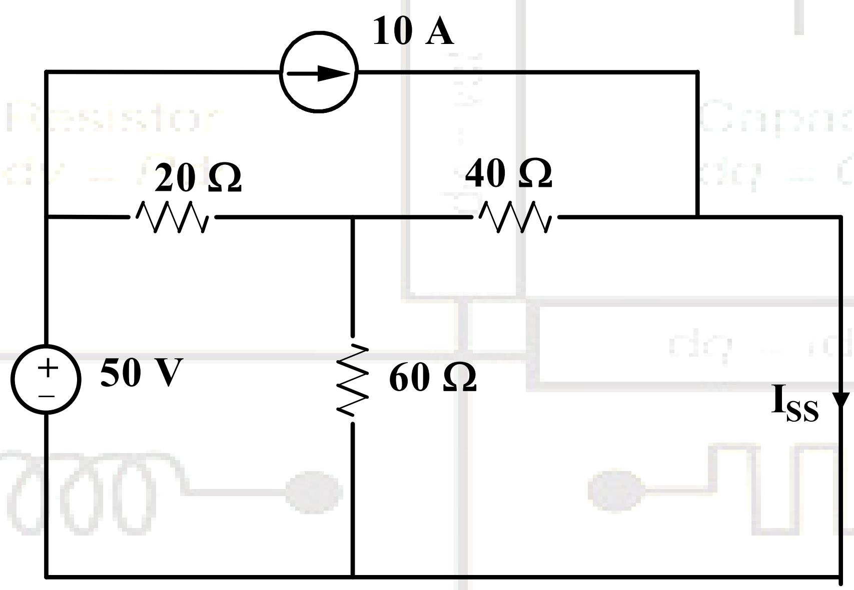
$$i_N(t) = \frac{v_{TH}}{R_{TH}} = i_{shortcircuit}(t) \equiv i_{sc}(t)$$

Norton theorem

Find the Norton equivalent circuit to the left of terminals A-B for the network shown below. Connect the Norton equivalent circuit to the load and find the current in the 50 Ω resistor.



Norton theorem



It can be shown by standard circuit analysis that

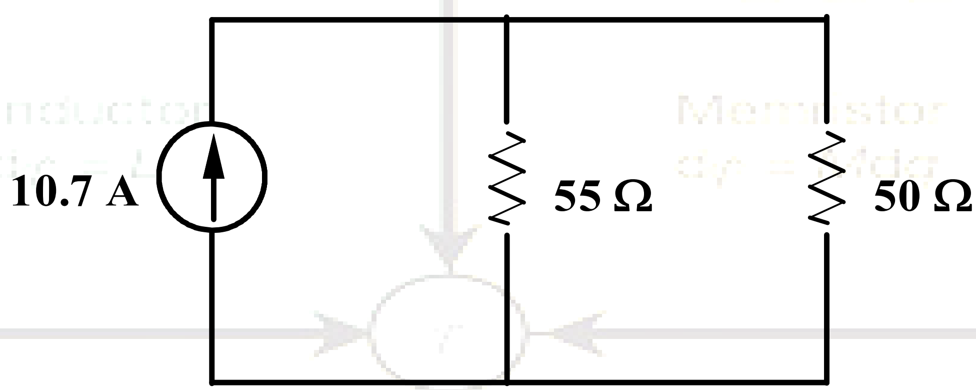
$$I_{SS}=10.7\ A$$

Norton theorem

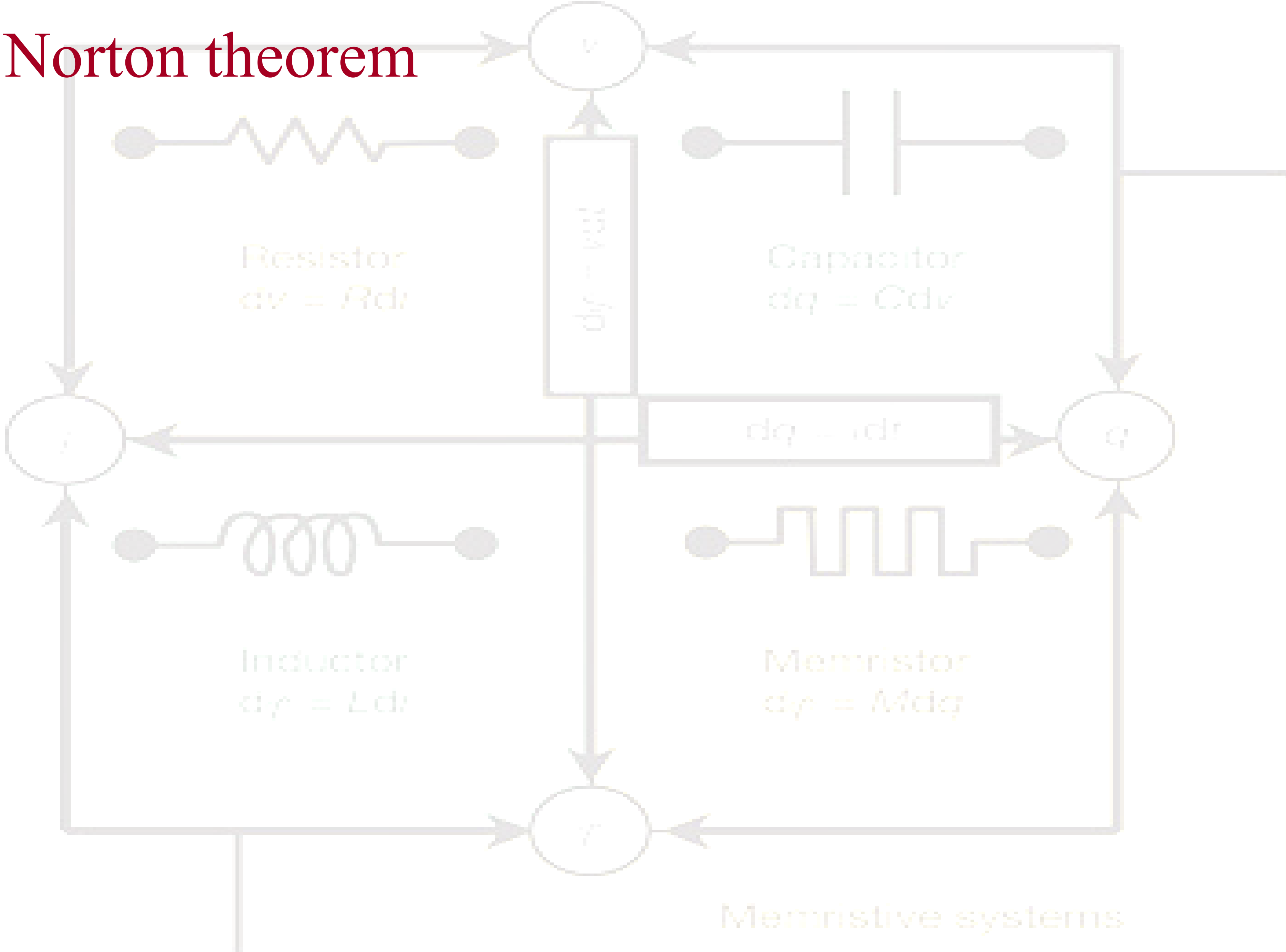
It can also be shown that by deactivating the sources, We find the resistance looking into terminals A-B is

$$R_N = 55\ \Omega$$

R_N and R_{TH} will always be the same value for a given circuit. The Norton equivalent circuit tied to the load is shown below.



Norton theorem



Norton theorem