Republic of Iraq

Ministry of Higher Education

and Scientific Research

Al-Mustaqbal University College

Computer Engineering Techniques Department

Subject: Fundamentals of Electrical Engineering

First Class

Lecture Seven

By

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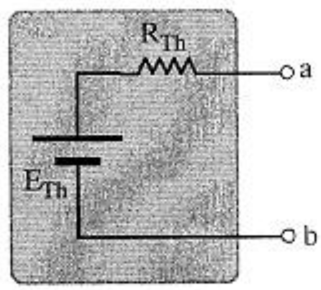
نظرية ثيفنين Thevenin's Theeorem

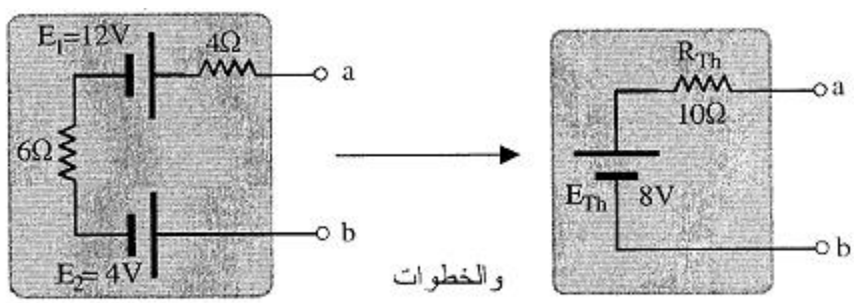
نظرية ثيفنين هي نظرية لتحليل الداوائر الكهربائية.

فائرة ثيفنين هي دائرة تحتوي على مقاومة تسمى مقاومه ثيفنين (R_{Th}) ومصدر جهد ثيفنين (E_{Th}), اي ان اي دائرة كهربائية ذات تيار مستمر يمكن استبدالها بدائرة ثيفنين وهي عباره عن حاوية لها مخرجين (a) و (b) كما بالشكل:

المقاومة (R_{Th}) موصله على التوالي مه المصدر (E_{Th}).



والشكل التالي يوضح كيفية اختزال دائرة كهربائية لتصبح دائرة ثيفنين



والخطوات التالية توضح طريقة تحويل دوائر كهربائية للوصول الى دائرة ثيفنين:

١. اقطع الجزء من الدائة المراد تحديد مكافئ ثيفنين له.
٢. حدد المخرجين a و b للدائرة.
٣. اوجد قيمة (R_{Th}) وذلك باستبدال جميع المصادر في الدائرة, حيث يستبدل مصدر الجهد بدائرة مغلقة (Short circuit) مصدر التيار بدائرة مفتوحه (Open circuit) وبالتالي يمكن حساب المقاومة (R_{Th}) ما بين النقطتين a وb.

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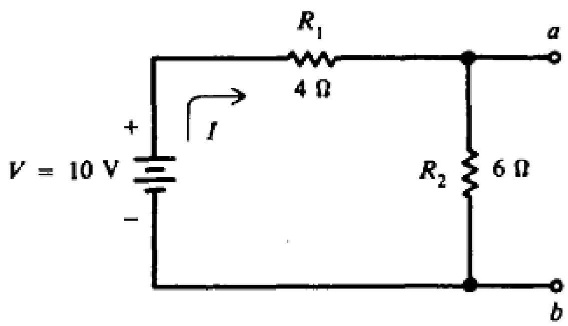
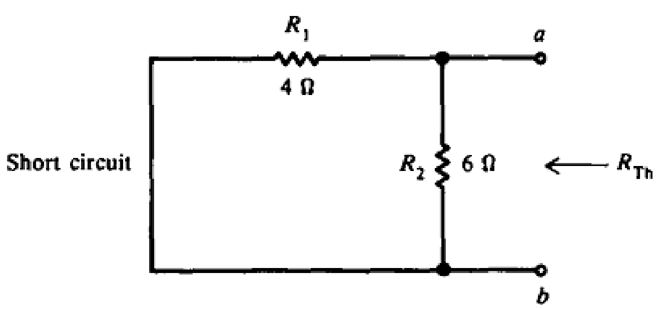
٤. احسب الجهد (E_{Th}) وذلك بارجاع جميع المصادر الى حالتها الاصلية ومن ثم ايجاد فرق الجهد ما بين النقطتين a وb.
وفي حال وجود اكثر من مصدر جهد نستخدم طريقة التراكيب لايجاد (E_{Th}) الكلية.
٥. نرسم دائرة ثيفنين المكافئة مع ارجاع الجزء المحذوف من الدائرة الاصلية.

Example 1: Find the Thevenin equivalent to the circuit at terminals a and b



Sol: Step **1.** Find **RW.** Short-circuit the voltage source **V** = **10V. R**₁ and **R₂** are in parallel.



$$R_{Th} = \frac{R_1 R_2}{R_1 + R_2} = \frac{4(6)}{4+6} = \frac{20}{10} = 2.4\Omega$$

Find V_{Th}. V_{Th} is the voltage across terminals **a** and **b**, which is the same as the voltage drop across resistance R_2.

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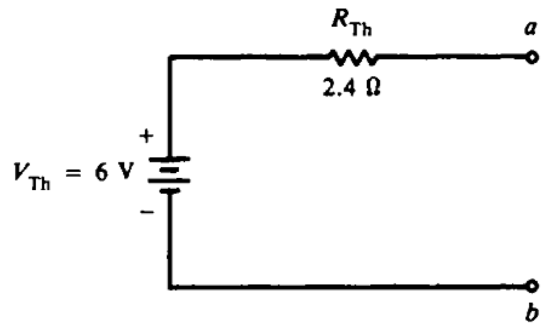
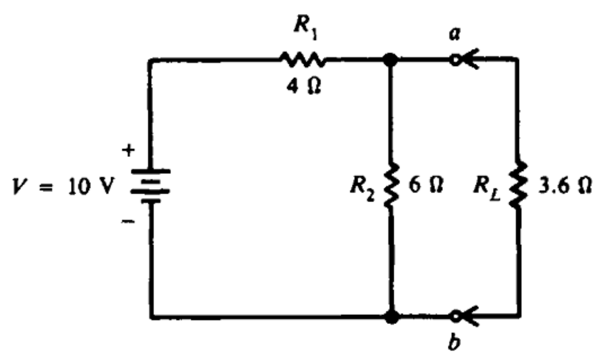
$$I = \frac{V}{R_1 + R_2} = \frac{10}{4+6} = \frac{10}{10} = 1\ \text{A}$$

$$V_{Th} = V_2 = IR_2$$

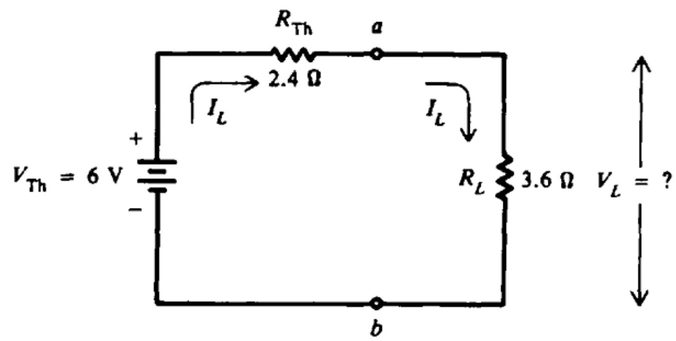
$$V_{Th} = 1(6) = 6\ \text{V} \qquad \textit{Ans.}$$



Example 2: To the circuit of Example 1**,** add a resistor load $\mathbf{R_L}$ of **3.60** and find the current $\mathbf{I_L}$ through the load and voltage $\mathbf{V_L}$ across the load.



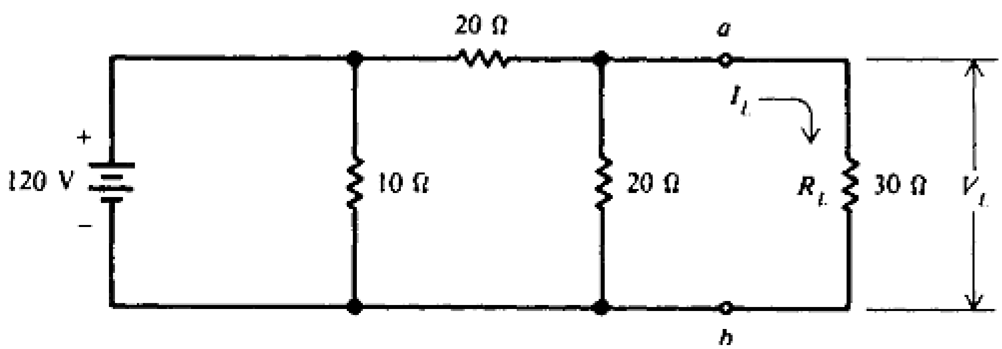
Sol:



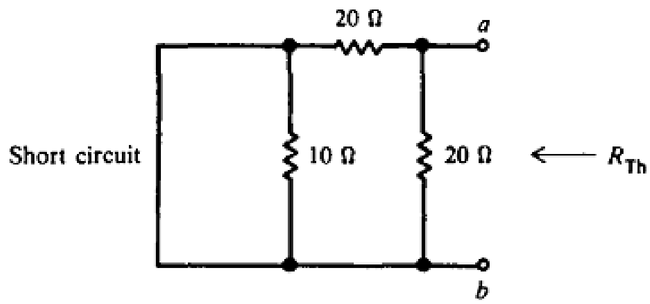
$$I_L = \frac{V_{Th}}{R_{TH} + R_L} = \frac{6}{2.4 + 3.6} = \frac{6}{6} = 1\text{ A}$$

$$V_L = I_L R_L = 1(3.6) = 3.6\text{ V} \qquad \textit{Ans.}$$

Example 3: Find the load current I_L and the load voltage V_L in the circuit of fig below by use of Thevenin's theorem.



Sol: **Step 1**.Find R_{Th}. Remove the load R_L. Short-circuit the voltage source of 120V. Short-circuiting the battery also short-circuits the 10**Ω** resistor, leaving two 20**Ω** resistors in parallel.

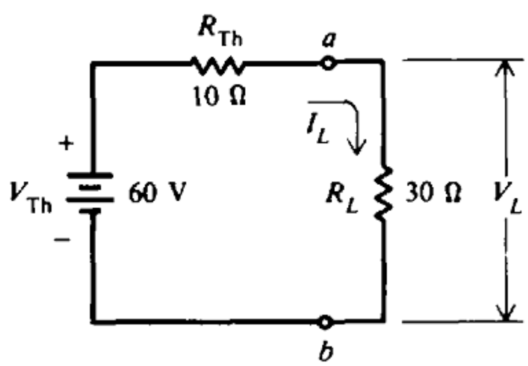


$$R_{Th} = \frac{20}{2} = 10\Omega$$

Step 2: Find $\mathbf{V_{Th}}$**.** The two **20Ω** resistors are in series across the **120-V** line. Since the
voltage is the same across equal resistances and $\mathbf{V_{Th}}$ is the open-circuit voltage at **a** and **b** across the **20Ω**resistor,

$$V_{Th} = \frac{120}{2} = 60V$$

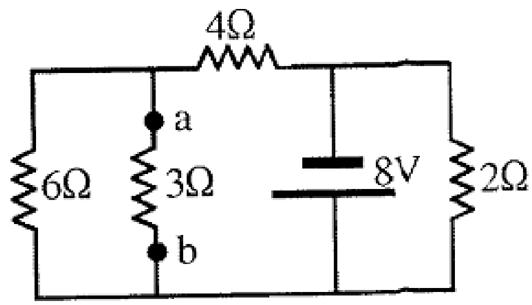
Step 3. Draw the equivalent circuit with R_L and find I_L and V_L.



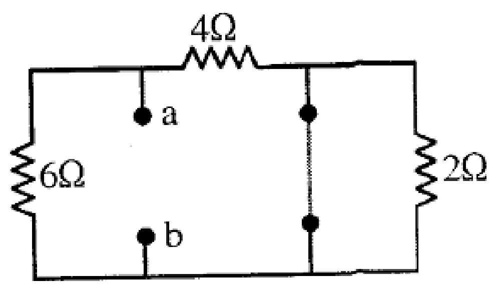
$$I_L = \frac{V_{Th}}{R_L + R_{Th}} = \frac{60}{30 + 10} = \frac{60}{40} = 1.5\text{ A} \qquad \textit{Ans.}$$

$$V_L = I_L R_L = 1.5(30) = 45\text{ V} \qquad \textit{Ans.}$$

Example 4: Find the Thevenin equivalent to the circuit at terminals a and b



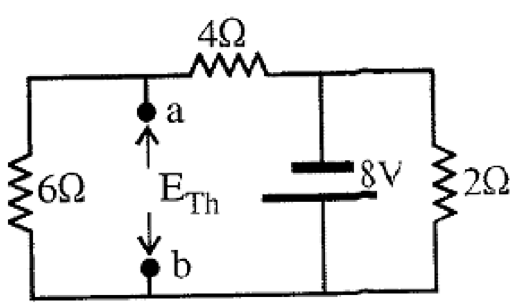
Sol: Step 1. Find R_{Th} by replace the voltage source with short circuit



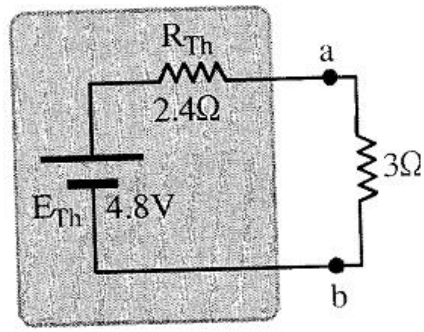
$$R_{Th} = 4//6$$

$$R_{Th} = \frac{4 \times 6}{4 + 6} = \frac{24}{10} = 2.4\Omega$$

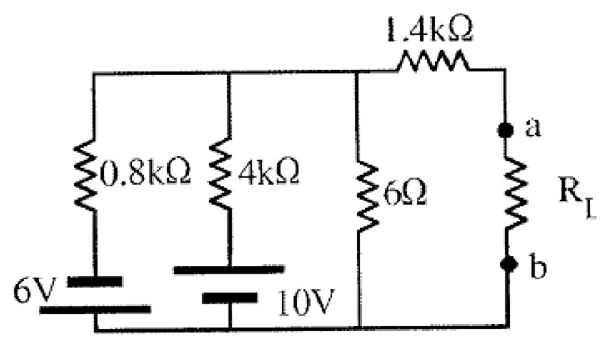
Step 2: find V_{Th} which is the voltage across the 6 Ω resistance



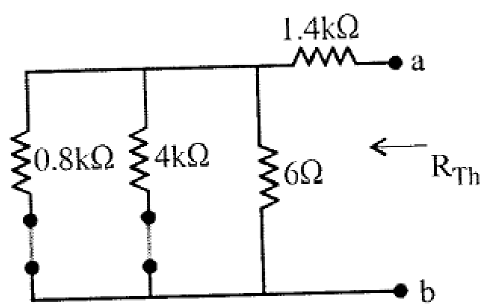
$$E_{Th} = \frac{8V \times 6\Omega}{6\Omega + 4\Omega} = \frac{48}{10} = 4.8V$$



Example 5: Find the Thevenin equivalent to the circuit at terminals a and b



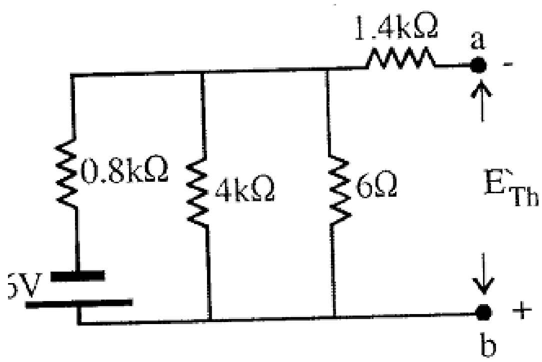
Sol: Step 1. Find R_{Th} by replace the voltage source with short circuit



$$0.8k\Omega \,//\, 4k\Omega \,//6k\Omega = 0.6k\Omega$$

$$R_{Th} = 0.6k\Omega + 1.4k\Omega = 2k\Omega$$

Step 2: find V_{Th} with the effect of (6V) voltage source



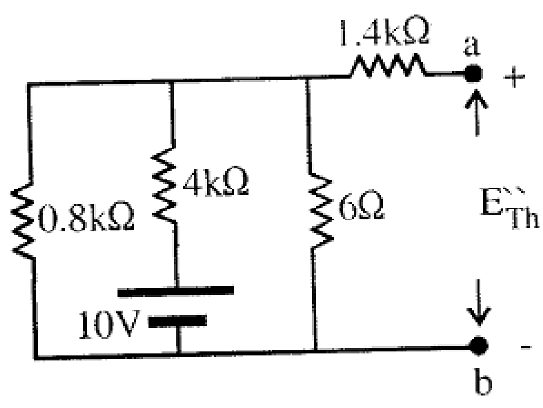
The resistance (1.4k Ω) neglected because the circuit is open. So V_{Th} is the voltage across the 6 *Ω* resistance

$$4k\Omega // 6k\Omega = 2.4k\Omega$$

By using voltage divider rule

$$E'_{Th} = \frac{6V \times 2.4k\Omega}{2.4k\Omega + 0.8k\Omega} = \frac{14.4}{3.2} = 4.5V$$

the effect of (10V) voltage source



$$0.8\text{k}\Omega//6\text{k}\Omega = 0.706\text{k}\Omega$$

$$E''_{Th} = \frac{10\text{V} \times 0.706k\Omega}{0.760k\Omega + 4\text{k}\Omega} = \frac{7.06}{4.706} = 1.5V$$

Since E'_{Th} and E''_{Th} are opposite to each other the

$$E_{Th} = E'_{Th} - E''_{Th}$$

$$E_{Th} = 4.5 - 1.5 = 3V$$