VIETNAM NATIONAL UNIVERSITY HO CHI MINH CITY
HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY
FACULTY OF COMPUTER SCIENCE AND ENGINEERING

# Electronic Device component (CO2104)

## Lab report

# Lab 1 report

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# 1 Report of lab 1

In lab 1, there are 10 problems to be solved. In each problem, we need to solve it first by hand and then verify the result by using simulation tools. In this report, we will use PSpice for TI to verify our results.

## 1.1 Exercise 1

Given the following circuit. Calculate the value of the voltage $v_0$ and the current $i$. Then, simulate the circuit to check it out.

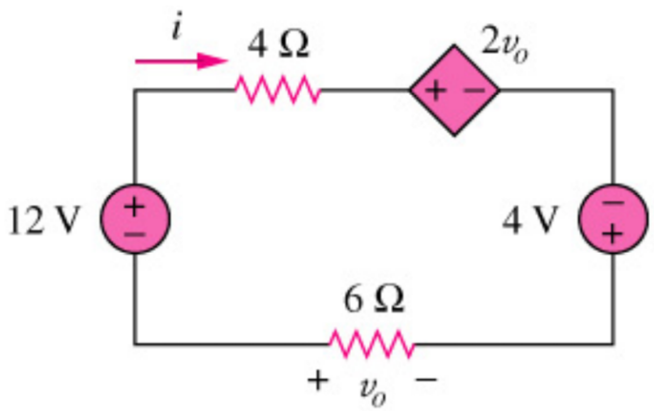



Figure 1.1: Find the voltage and the current in the given circuit using KVL

### 1.1.1 Calculation

***Notes:*** *Explanations, formulas, and equations are expected rather than only results.*

According to the KVL (Kirchhoff's Voltage Law), we have the equations of the loops as follows:

$$12 - 0 = 4i + 2v_0 - 4 + 6i \tag{1.1}$$

According to the Ohm's Law, we have:

$$i = \frac{-v_0}{6} \tag{1.2}$$

From (1) and (2), we have:

$$12 = 4\left(\frac{-v_0}{6}\right) + 2v_0 - 4 + 6\left(\frac{-v_0}{6}\right) \Rightarrow v_0 = 48(V)$$

By substituting $v_0 = 48$ into (2), we have: $i = \dfrac{-48}{6} = -8(A)$

### 1.1.2 simulation

After redrawing the circuit in PSpice for TI, and run then simulation, we have the results as follows:

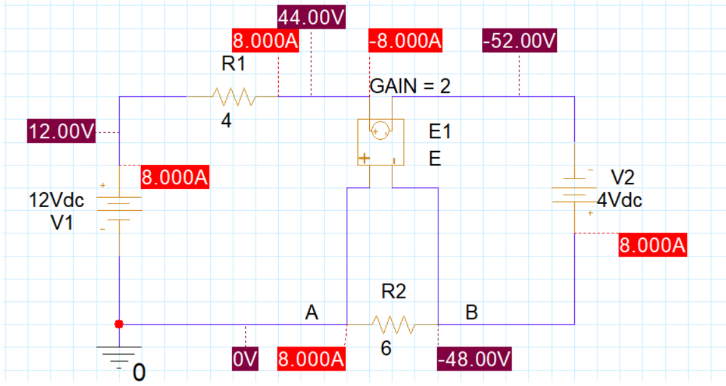



Figure 1.2: Simulation result of the circuit in Figure 1.1

Let $A$ and $B$ be the nodes across the voltage source $v_0$. From the simulation result in Figure 1.2, we have:

$$\begin{cases} v_0 = V_A - V_B = 48(V) \\ i = I = -8(A) \end{cases}$$

Even though the current $i$ has a negative value, it is still correct because the direction of the current in the simulation is opposite to the assumed direction in the calculation.

**Conclusion:** The result of PSpice simulation matches the result of the calculation. Therefore, the calculation is correct.

## 1.2 Exercise 2

Given the following circuit, students rearrange the circuit to clarify its serial and/or parallel topology. Then, apply the knowledge you've learned to find the equivalent resistance value between two circuit terminals A and F. Finally, perform the simulation to check if the current through the whole circuit is correctly calculated.

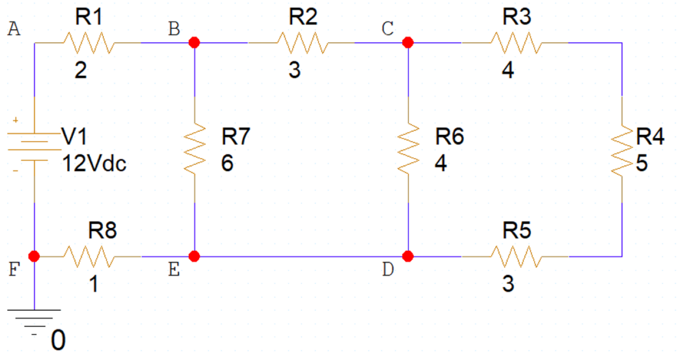



Figure 1.3: Find the equivalent resistance between terminals A and F

### 1.2.1 Rearrange the circuit

By extending wire between nodes B and E, we have the following rearranged circuit:

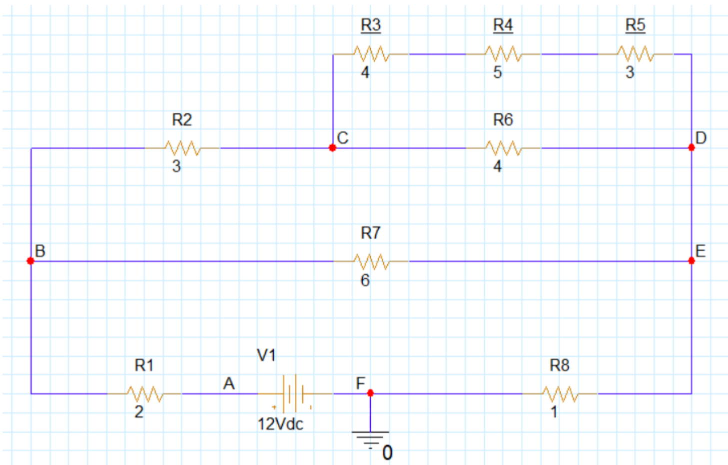



Figure 1.4: Rearranged circuit

### 1.2.2 Calculation

***Convention:*** *The equivalent resistance between the two terminals A and B of a circuit segment containing only R1, R2, R3, and R4 may be named* $R_{AB\_1234}$.

Belong to the rearranged circuit, we have: $R6 \parallel (R3 + R4 + R5)$. Thus, we calculate the equivalent resistance $R_{CD\_3456}$ as follows:

$$R_{CD\_3456} = \frac{1}{\frac{1}{R_6} + \frac{1}{R_3 + R_4 + R_5}} = \frac{1}{\frac{1}{4} + \frac{1}{4+5+3}} = 3(\Omega)$$

Next, looking at the circuit between $B$ and $E$, we have: $R7 \parallel (R2 + R_{CD\_3456})$. Thus, we calculate the equivalent resistance $R_{BE}$ as follows:

$$R_{BE} = \frac{1}{\frac{1}{R_7} + \frac{1}{R_2 + R_{CD\_3456}}} = \frac{1}{\frac{1}{6} + \frac{1}{3+3}} = \frac{1}{\frac{1}{2} + \frac{1}{6}} = 3(\Omega)$$

Now move to $A$ and $F$, we have: $R1 + R_{BE} + R8$. Thus, we calculate the equivalent resistance $R_{AF}$ as follows:

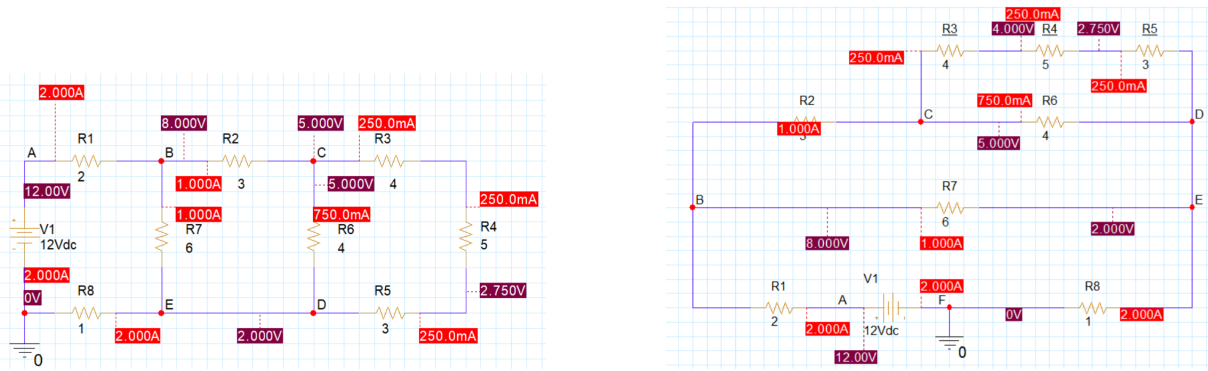
$$R_{AF} = R_1 + R_{BE} + R_8 = 1 + 3 + 2 = 6(\Omega)$$

By applying Ohm's law, we can find the current $I_{AB}$ through the whole circuit:

$$I_{AB} = I = \frac{U}{R_{AF}} = \frac{12}{6} = 2(A)$$

### 1.2.3 Simulation

To verify the calculation above, we did perform the simulation twice: first, for original circuit; second, for rearranged circuit. The results are as follows:




(a) Simulation for original circuit (b) Simulation for rearranged circuit

Figure 1.5: Simulation results

As shown, the value of current $I$ and voltage $V$ between corresponding terminals in both simulations are the same. Thus, our calculation and rearrangement are correct.

## 1.3 Exercise 3

Given the following circuit, students rearrange the circuit to clarify its serial and/or parallel topology. Next, apply the knowledge you've learned to find the equivalent resistance value between two circuit terminals A and F, the voltage values at A, B, C, D, and E. Finally, perform the simulation to check your calculation.

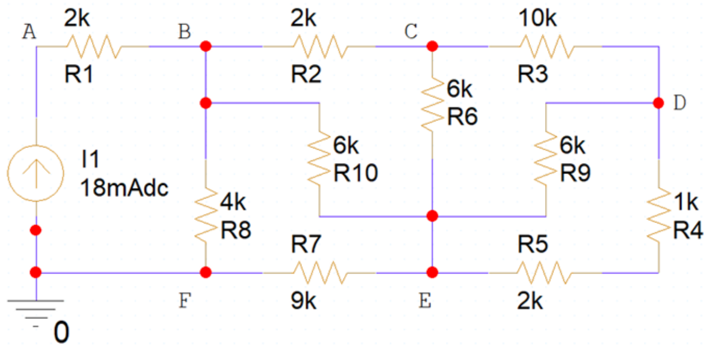



Figure 1.6: Find the whole-circuit equivalent resistance and the voltages at A, B, C, D, and E

### 1.3.1 Rearrange the circuit

By drawing a wire with current source I1, A, B, C, D, and E, we can clarify the circuit topology. As follows:

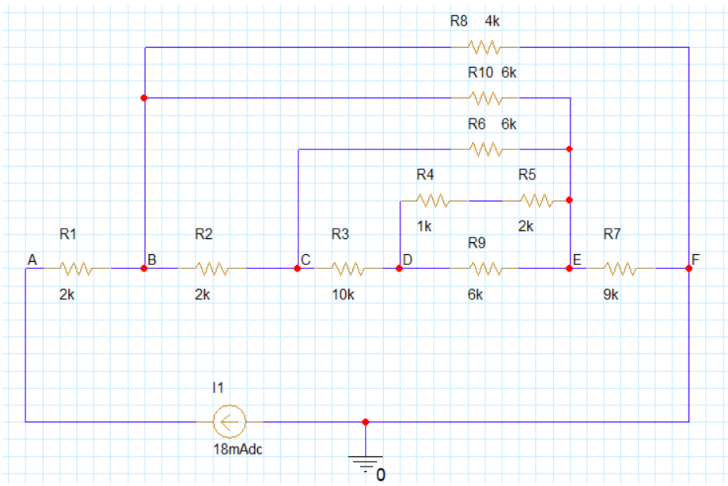



Figure 1.7: Rearranged circuit

### 1.3.2 Calculation

As the rearranged circuit showed in Figure 1.7, we can calculate the equivalent resistance $R_{AF}$ by the following steps: First, we calculate $R_{DE}$. Because $R9 \parallel (R4 + R5)$, we have:

$$R_{DE} = \frac{1}{\frac{1}{R_9} + \frac{1}{R_4 + R_5}} = \frac{1}{\frac{1}{6} + \frac{1}{1+2}} = 2(k\Omega)$$

Next, we calculate $R_{CE}$. Because $R6 \parallel (R3 + R_{DE})$, we have:

$$R_{CE} = \frac{1}{\frac{1}{R_6} + \frac{1}{R_3 + R_{DE}}} = \frac{1}{\frac{1}{6} + \frac{1}{10+2}} = 4(k\Omega)$$

Now, we calculate $R_{BE}$. Because $R10 \parallel (R2 + R_{CE})$, we have:

$$R_{BE} = \frac{1}{\frac{1}{R_{10}} + \frac{1}{R_2 + R_{CE}}} = \frac{1}{\frac{1}{6} + \frac{1}{2+4}} = 3(k\Omega)$$

We then calculate $R_{BF}$. Because $R8 \parallel (R7 + R_{BE})$, we have:

$$R_{BF} = \frac{1}{\frac{1}{R_8} + \frac{1}{R_7 + R_{BE}}} = \frac{1}{\frac{1}{4} + \frac{1}{3+9}} = 3(k\Omega)$$

Finally, we calculate $R_{AF}$. Because $R1 + R_{BF}$, we have:

$$R_{AF} = R_1 + R_{BF} = 2 + 3 = 5(k\Omega)$$

By applying Ohm's law, we can find the voltage value between terminals A and F:

$$V_{AF} = V = I \times R_{AF} = 18 \times 5 = 90(V)$$

We have voltages at nodes A, B, C, D, and E as follows:

$$\begin{cases} V_A - V_F = V_{AF} = 90 \Rightarrow V_A = 90 + V_F = 90 + 0 = 90(V) \\ V_{BF} = I \times R_{BF} = 18 \times 3 = 54(V) \Rightarrow V_B = V_F + V_{BF} = 0 + 54 = 54(V) \end{cases}$$

By applying the voltage divider rule, we have:

$$V_{EF} = V_{BF} \times \frac{R7}{R_{BE} + R7} = 54 \times \frac{9}{3+9} = 40.5(V) \Rightarrow V_E = V_F + V_{EF} = 0 + 40.5 = 40.5(V)$$

$$\begin{aligned} V_{CE} =& V_{BE} \times \frac{R_{CE}}{R_{CE} + R_{DE}} = (V_B - V_E) \times \frac{R_{CE}}{R_{CE} + R_{DE}} = (54 - 40.5) \times \frac{4}{4+2} = 9(V) \\ \Rightarrow& V_C = V_E + V_{CE} = 40.5 + 9 = 49.5(V) \end{aligned}$$

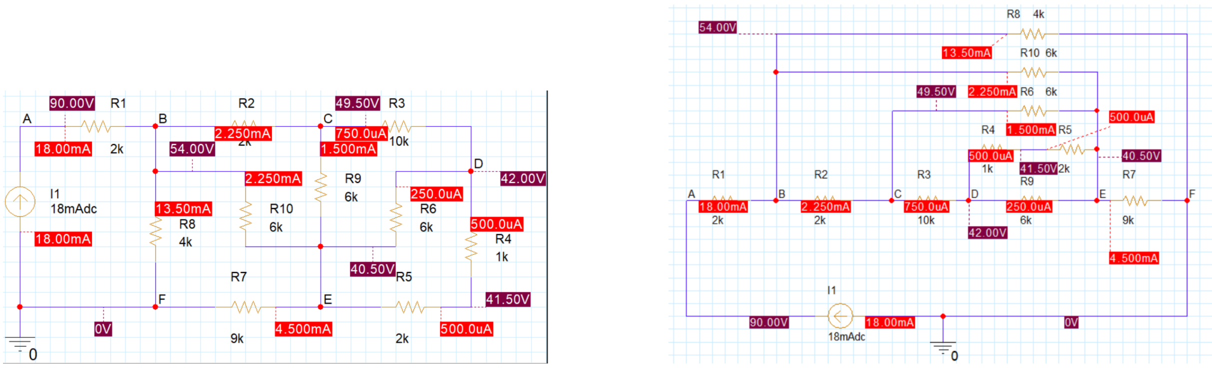
$$\begin{aligned} V_{DE} =& V_{CE} \times \frac{R_{DE}}{R_{DE} + R_3} = (V_C - V_E) \times \frac{R_{DE}}{R_{DE} + R_3} = (49.5 - 40.5) \times \frac{2}{2+10} = 1.5(V) \\ \Rightarrow& V_D = V_E + V_{DE} = 40.5 + 1.5 = 42(V) \end{aligned}$$

**Conclusion:** After rearranging the circuit and calculating step-by-step, we have:

$$\begin{cases} R_{AF} = 5(k\Omega) \\ V_A = 90(V), V_B = 54(V), V_C = 49.5(V), V_D = 42(V), V_E = 40.5(V) \end{cases}$$

### 1.3.3 Simulation

To verify the calculation above, we did perform the simulation twice: first, for original circuit; second, for rearranged circuit. The results are as follows:




(a) Simulation for original circuit

(b) Simulation for rearranged circuit

Figure 1.8: Simulation results

From the simulation results in Figure 1.8, we can see that the equivalent resistance $R_{AF}$ and voltages at nodes A, B, C, D, and E are the same for both original and rearranged circuits. The simulation results confirm our calculations are correct.

## 1.4 Exercise 4

Given the following circuit, find $I_1$, $I_2$, $I_3$, $V_a$, and $V_b$. Present your calculation steps and check them out by performing the simulation.

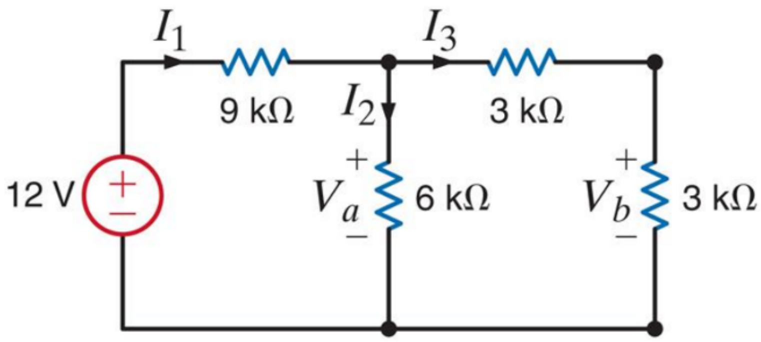



Figure 1.9: Find $I_1$, $I_2$, $I_3$, $V_a$, and $V_b$

### 1.4.1 Calculation

The whole circuit equivalent resistance:

$$R_{eq} = 9 + \frac{1}{\frac{1}{6} + \frac{1}{3+3}} = 9 + \frac{1}{\frac{1}{6} + \frac{1}{6}} = 12(\Omega)$$

By applying Ohm's law, we can find the total current $I_1$:

$$I_1 = \frac{V}{R_{eq}} = \frac{12}{12} = 1(mA)$$

By the current division rule, we can find $I_2$ and $I_3$:

$$I_2 = I_1 \times \frac{6}{6+3+3} = 1 \times \frac{6}{12} = 0.5(mA)$$
$$I_3 = I_1 \times \frac{3+3}{6+3+3} = 1 \times \frac{6}{12} = 0.5(mA)$$

By applying Ohm's law, we can find $V_a$ and $V_b$:

$$V_a = I_2 \times 6 = 0.5 \times 6 = 3(V)$$
$$V_b = I_3 \times 3 = 0.5 \times 3 = 1.5(V)$$

### 1.4.2 Simulation

By performing the simulation in PSpice for TI, we have the following results:

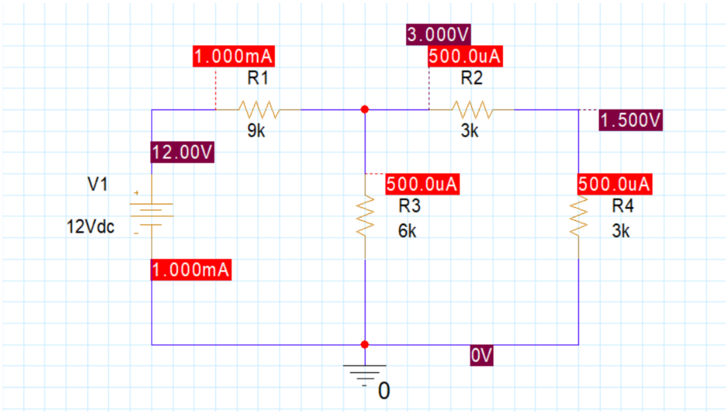



Figure 1.10: Simulation results of Exercise 4

As shown in Figure 1.10, the simulation results match our calculation.

## 1.5 Exercise 5

Given the network as shown below

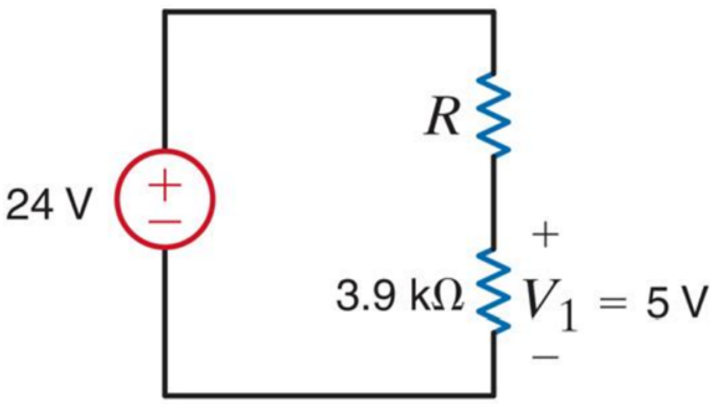



Figure 1.11: Select resistor R from the standard resistors list and do the following requirements

a. Find the required value for the resistor. By applying Ohm's law for $3.9k\Omega$ resistor, we have:

$$I = I_1 = \frac{5}{3.9} = 1.282(mA)$$

Then by applying Ohm's law for resistor $R$, we have:

$$R = \frac{V}{I} = \frac{24-5}{1.282} = 14.821(k\Omega)$$

b. Use Table 2.1 in the lecture slide to select a standard 10% tolerance resistor for $R$. $R$ in the circuit may be a single resistor or a combination of resistors as long as these resistors meet the standard values and are available in the market. From the standard resistor list with 10% tolerance, we can select $15k\Omega$ resistor for $R$.

c. Using the resistor selected in (b), determine the voltage across the 3.9 kΩ resistor. By applying Ohm's law for resistor the whole circuit, we have:

$$I = \frac{V}{R_{eq}} = \frac{24}{3.9+15} = 1.270(mA)$$

Then by applying Ohm's law for $3.9k\Omega$ resistor, we have:

$$V_1 = I \times 3.9 = 1.270 \times 3.9 = 4.95(V)$$

d. Calculate the percent error in the voltage $V_1$ if the standard resistor selected in (b) is used. The percent error in the voltage $V_1$ is calculated as follows:

$$\text{Percent error} = \left|\frac{V_{1,calculated} - V_{1,selected}}{V_{1,calculated}}\right| \times 100\% = \left|\frac{5-4.95}{5}\right| \times 100\% = 1\%$$

e. Determine the power rating for this standard component. The power rating for the $15k\Omega$ resistor is calculated as follows:

$$P = I^2 \times R = (1.270 \times 10^{-3})^2 \times 15 \times 10^3 = 0.024(W)$$

Therefore, a standard resistor with a power rating of at least $0.025W$ should be selected.

## 1.6 Exercise 6

Given the following circuit. Apply the knowledge you've learned to transform it into another form in which you can find total equivalent resistance $R_{ab}$ more easily. Next, find the value of the current $i$ through the circuit and perform a simulation to check it out.

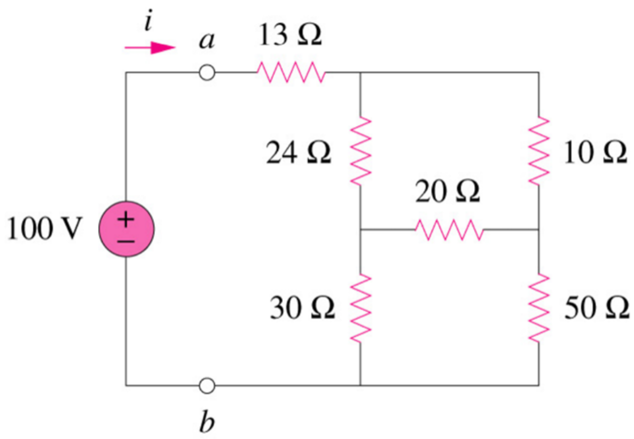



Figure 1.12: Transform the circuit, then find the equivalent resistance $R_{ab}$ and the current $i$ through the circuit.

**Identifying the $\Delta$ network**: In the circuit showing in figure 1.12, three resistors $24\ \Omega,\ 20\ \Omega,\ 10\ \Omega$ form a delta connection (let the vertices be $T$ (top), $L$ (left), $R$ (right)):

$$R_{TL} = 24\ \Omega, \quad R_{LR} = 20\ \Omega, \quad R_{RT} = 10\ \Omega.$$

**Delta-to-Wye ($\Delta \to Y$) conversion formula:**

For a delta network with sides $R_{12}, R_{23}, R_{31}$, the equivalent Y resistances connected to the vertices (denoted $R_1, R_2, R_3$) are:

$$R_1 = \frac{R_{12}R_{31}}{R_{12}+R_{23}+R_{31}}, \quad R_2 = \frac{R_{12}R_{23}}{R_{12}+R_{23}+R_{31}}, \quad R_3 = \frac{R_{23}R_{31}}{R_{12}+R_{23}+R_{31}}.$$

By substituting $R_{12} = 24,\ R_{23} = 20,\ R_{31} = 10$, in the formulas above, we have the resistances of the equivalent $Y$ network:

$$S = 24 + 20 + 10 = 54\ \Omega.$$

$$\begin{aligned} R_T &= R_1 = \frac{24 \cdot 10}{54} = \frac{240}{54} = \frac{40}{9} \approx 4.4444\ \Omega, \\ R_L &= R_2 = \frac{24 \cdot 20}{54} = \frac{480}{54} = \frac{80}{9} \approx 8.8889\ \Omega, \\ R_R &= R_3 = \frac{20 \cdot 10}{54} = \frac{200}{54} = \frac{100}{27} \approx 3.7037\ \Omega. \end{aligned}$$

**Equivalent circuit after $\Delta$-$Y$ conversion:**

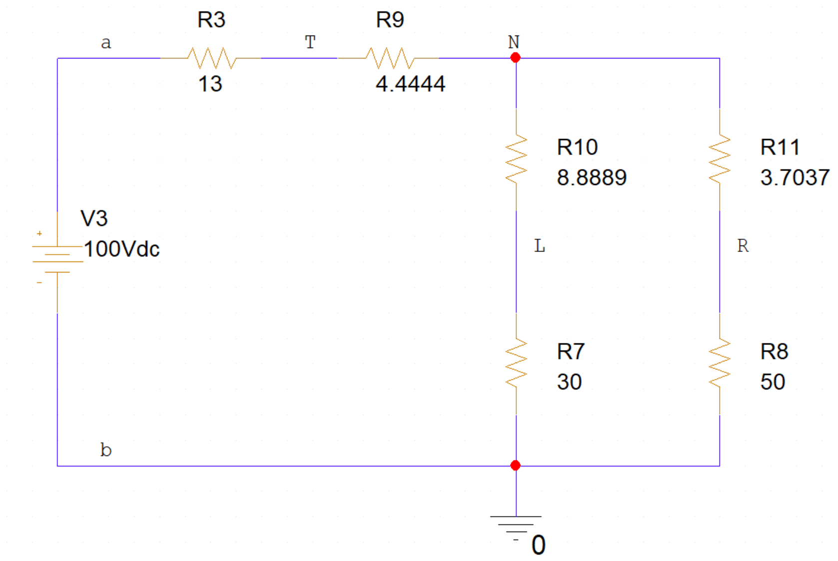



Figure 1.13: Circuit after $\Delta - Y$ transformation

**Calculating the equivalent resistance:** Consider the path from $a$ to the central node $N$:

$$R_{aN} = 13\ \Omega + R_T = 13 + \frac{40}{9} = \frac{157}{9}\ \Omega \approx 17.4444\ \Omega.$$

From node $N$ to $b$, there are two parallel branches:

$$\text{Branch 1: } N \to L \to b: \quad R_1 = R_L + 30 = \frac{80}{9} + 30 = \frac{350}{9}\ \Omega \approx 38.8889\ \Omega$$
$$\text{Branch 2: } N \to R \to b: \quad R_2 = R_R + 50 = \frac{100}{27} + 50 = \frac{1450}{27}\ \Omega \approx 53.7037\ \Omega$$

Their parallel equivalent is:

$$R_{Nb} = \frac{R_1 R_2}{R_1 + R_2}.$$

Substitute:

$$R_1 = \frac{350}{9}, \qquad R_2 = \frac{1450}{27}.$$

Compute:

$$R_{Nb} = \frac{\frac{350}{9} \cdot \frac{1450}{27}}{\frac{350}{9} + \frac{1450}{27}} = \frac{\frac{507500}{243}}{\frac{1050 + 1450}{27}} = \frac{\frac{507500}{243}}{\frac{2500}{27}} = \frac{203}{9} \approx 22.5556\ \Omega.$$

Finally,

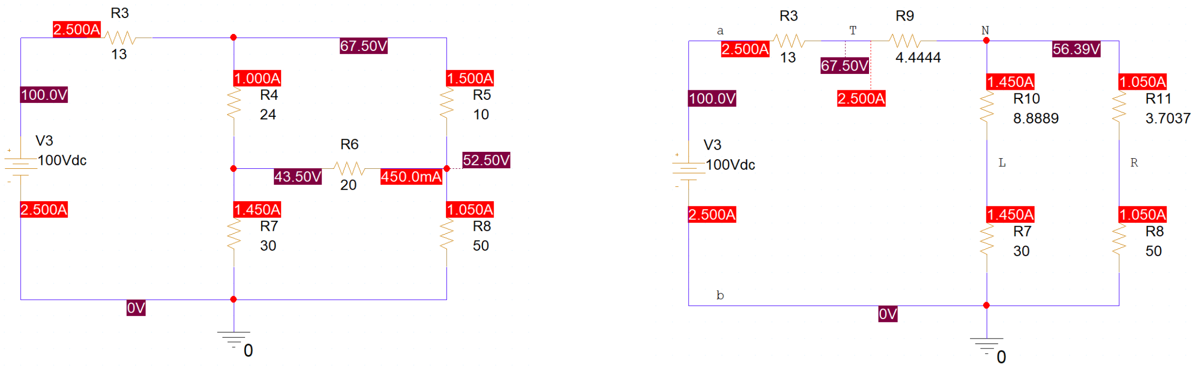
$$R_{ab} = R_{aN} + R_{Nb} = \frac{157}{9} + \frac{203}{9} = 40\ \Omega.$$

By applying Ohm's law, we can find the current value through the circuit when a voltage source of 100 V is connected between terminals $a$ and $b$:

$$i = \frac{100 \text{ V}}{R_{ab}} = \frac{100}{40} = 2.5 \text{ A}.$$

**Summary of results**:

- After $\Delta \to Y$ conversion: $R_T = \dfrac{40}{9}\ \Omega$ ($\approx 4.4444\ \Omega$), $R_L = \dfrac{80}{9}\ \Omega$ ($\approx 8.8889\ \Omega$), $R_R = \dfrac{100}{27}\ \Omega$ ($\approx 3.7037\ \Omega$).
- Equivalent resistance between terminals $a$ and $b$: $\boxed{R_{ab} = 40\ \Omega}$.
- Circuit current with 100 V source: $\boxed{i = 2.5 \text{ A}}$.




(a) Original circuit simulation (b) Transformed circuit simulation

Figure 1.14: PSpice simulation results for Exercise 6

## 1.7 Exercise 7

Given the following circuit. Apply the knowledge you've learned to transform it into another form in which you can find total equivalent resistance more easily. Next, find the value of the current $I_S$ through the circuit and perform a simulation to check it out.

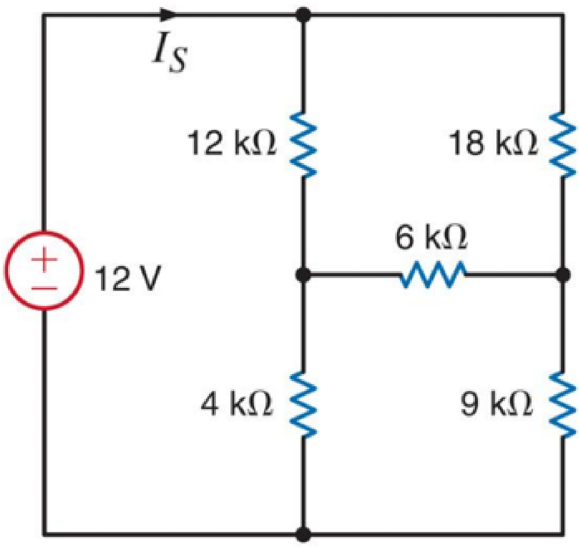



Figure 1.15: Transform the circuit, then find the equivalent resistance and the current $I_S$ through the circuit.

**Identifying the $\Delta$ network:** In the circuit showing in figure 1.15, three resistors $12\ k\Omega$, $18\ k\Omega$, $6\ k\Omega$ form a delta connection (vertices $T$, $L$, $R$):

$$R_{TL} = 12\ k\Omega, \quad R_{LR} = 6\ k\Omega, \quad R_{RT} = 18\ k\Omega.$$

**Delta-to-Wye $\Delta \to Y$ conversion formula:**

$$R_1 = \frac{R_{12}R_{31}}{R_{12}+R_{23}+R_{31}}, \quad R_2 = \frac{R_{12}R_{23}}{R_{12}+R_{23}+R_{31}}, \quad R_3 = \frac{R_{23}R_{31}}{R_{12}+R_{23}+R_{31}}.$$

By substituting $R_{12} = 12$, $R_{23} = 6$, $R_{31} = 18$, in the formulas above, we have the resistances of the equivalent $Y$ network:

$$S = 12 + 6 + 18 = 36\ k\Omega.$$

$$\begin{aligned} R_T = &R_1 = \frac{12 \cdot 18}{36} = 6\ k\Omega, \\ R_L = &R_2 = \frac{12 \cdot 6}{36} = 2\ k\Omega, \\ R_R = &R_3 = \frac{6 \cdot 18}{36} = 3\ k\Omega. \end{aligned}$$

**Equivalent circuit after $\Delta \to Y$ transformation**

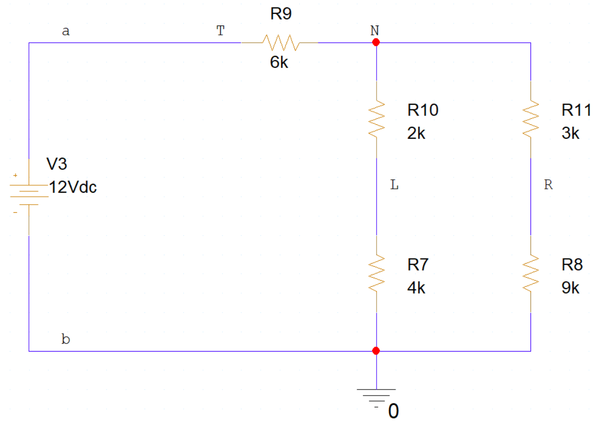



Figure 1.16: Circuit after $\Delta - Y$ transformation

**Calculating the equivalent resistance**

From $a$ to the central node $N$, we have $R_{aN}$:

$$R_{aN} = R_T = 6\ k\Omega.$$

From $N$ to $b$ there are two parallel branches:

$$\text{Branch 1: } N \to L \to b : R_1 = R_L + 4 = 6\ k\Omega,$$
$$\text{Branch 2: } N \to R \to b : R_2 = R_R + 9 = 12\ k\Omega.$$

Parallel combination:

$$R_{Nb} = \frac{R_1 R_2}{R_1 + R_2} = \frac{6 \cdot 12}{6 + 12} = 4\ k\Omega.$$

Therefore,

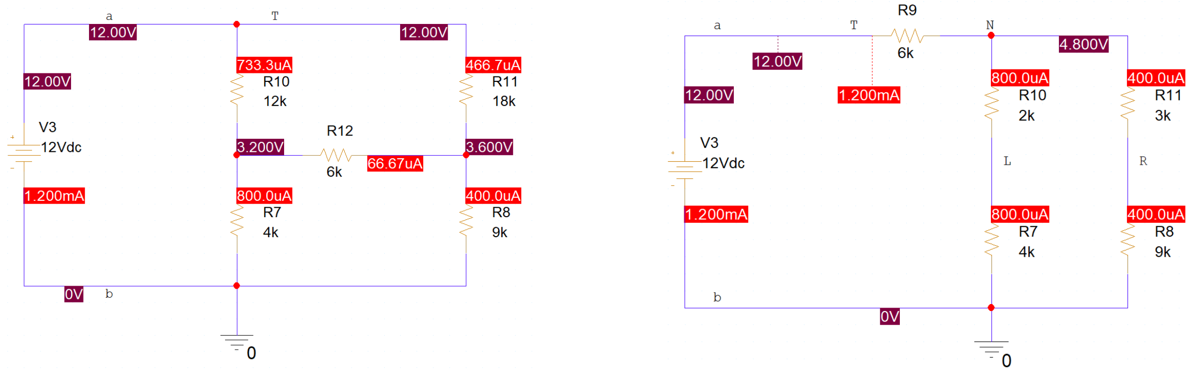
$$R_{ab} = R_{aN} + R_{Nb} = 6 + 4 = 10\ k\Omega.$$

By applying Ohm's law, we can find the source current value when a voltage source of 12 V is connected between terminals $a$ and $b$:

$$I_S = \frac{12\text{ V}}{R_{ab}} = \frac{12}{10} = 1.2\text{ mA}.$$

**Summary of results**

- After $\Delta \to Y$: $R_T = 6\ k\Omega$, $R_L = 2\ k\Omega$, $R_R = 3\ k\Omega$.
- Equivalent resistance seen from $a, b$: $\boxed{R_{ab} = 10\ k\Omega}$.
- Source current for 12 V: $\boxed{I_S = 1.2\text{ mA}}$.




(a) Original circuit simulation (b) Transformed circuit simulation

Figure 1.17: PSpice simulation results for Exercise 7

## 1.8 Exercise 8

Given the following circuit with $p_2$, $p_3$, and $p_4$ are absorbing powers of unknown electrical elements. First, use the knowledge you've learned to identify whether they are active or passive elements (supplying or absorbing power). To an element absorbing power, use a pure resistor with a proper value as a representative. To a power element, use an ideal DC voltage source with the corresponding value as a representative. Next, redraw the circuit and calculate the power that each element absorbs. Note that here we use the passive sign convention. Then, perform a simulation with the elements determined by the previous step

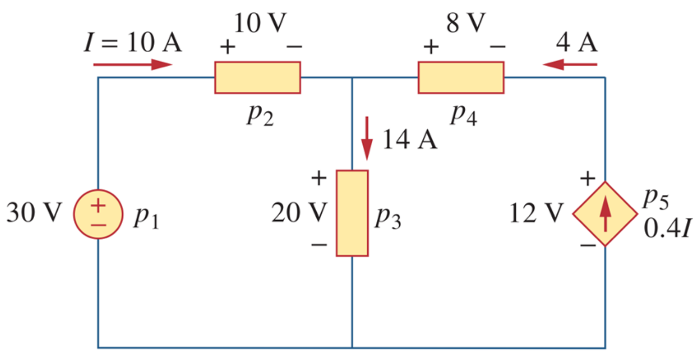



Figure 1.18: Determine the unknown elements and calculate the absorbing power of each.

### 1.8.1 Identify the unknown elements

1. **Element $\mathbf{p_2}$ (10 V element):**
   The current 10 A is shown entering the positive terminal. Using the passive sign convention,

   $$p_2 = (+10 \text{ V})(+10 \text{ A}) = \mathbf{100} \text{ W}.$$

   Since $p_2 > 0$, this element **absorbs** power (passive). Its equivalent resistance is

   $$R_2 = \frac{V}{I} = \frac{10 \text{ V}}{10 \text{ A}} = \mathbf{1\ \Omega}.$$

2. **Element $\mathbf{p_3}$ (20 V element):**
   The current 14 A is shown entering the positive terminal.

   $$p_3 = (+20 \text{ V})(+14 \text{ A}) = \mathbf{280} \text{ W}.$$

   Since $p_3 > 0$, this element **absorbs** power (passive). Its equivalent resistance is

   $$R_3 = \frac{20 \text{ V}}{14 \text{ A}} \approx \mathbf{1.4286\ \Omega}.$$

3. **Element $p_4$ (8 V element):**
The current 4 A is shown leaving the positive terminal (i.e., current exits the positive terminal). Using passive sign convention,

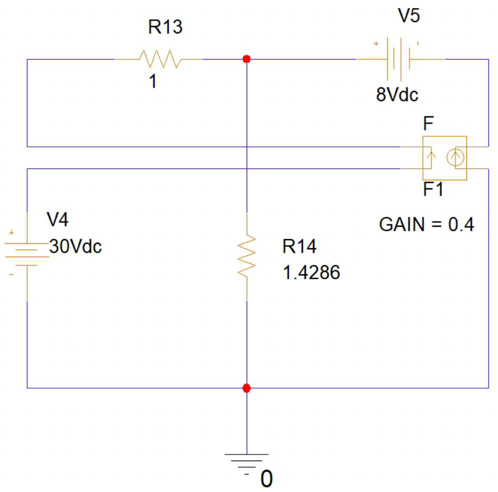
$$p_4 = -(8 \text{ V})(4 \text{ A}) = -\mathbf{32} \text{ W}.$$

Since $p_4 < 0$, this element **supplies** power (active). It can be represented as an ideal voltage source $V = 8$ V.

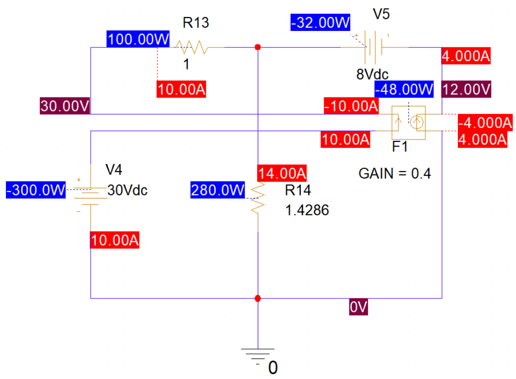
### 1.8.2 Redraw the circuit and simulation result

A redrawn circuit (with passive elements replaced by their resistances where applicable) is shown below: Summary (numerical):

- $p_2 = +100$ W (absorbing), $R_2 = 1\ \Omega$.
- $p_3 = +280$ W (absorbing), $R_3 \approx 1.4286\ \Omega$.
- $p_4 = -32$ W (supplying), represented as 8 V ideal source.




(a) Redrawn circuit with determined elements




(b) PSpice simulation of the redrawn circuit

Figure 1.19: Redrawn circuit and its PSpice simulation for Exercise 8

## 1.9 Exercise 9

Given the following circuit. Find the voltage $v$ and the current $i_x$. According to the result, determine the elements whose absorbing power respectively $p_1$ and $p_2$ are reactive or passive (calculations are required). Note that here we use the passive sign convention. If an element consumes power, use a pure resistor with an appropriate value as a representative. If it is a power supply element, use a corresponding ideal DC voltage source to represent it. Perform a simulation to check how the circuit works.

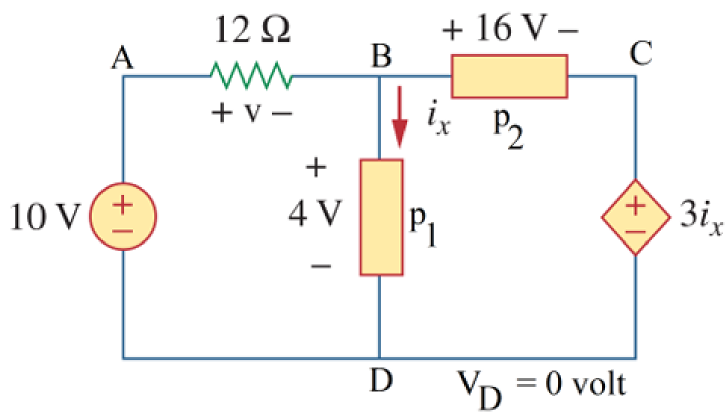



Figure 1.20: Find the unknown elements and variables, then check them out by simulation.

### 1.9.1 Finding node voltages

- Node $D$ is the reference: $V_D = 0$.
- Left source sets $V_A = 10$ V.
- Middle source sets $V_B = 4$ V (positive at the top).

The voltage $v$ across $A$ and $B$ is: $v = V_{AB} = V_A - V_B = 10 - 4 = 6$ V.
By applying Ohm's law for the 12 $\Omega$ resistor between $A$ and $B$, we find the current $I_{AB}$ (from $A$ to $B$):

$$I_{AB} = \frac{V_A - V_B}{12\ \Omega} = \frac{6}{12} = 0.5 \text{ A}.$$

As we have $V_B = 4$ V, and $V_{BC} = 16$, we can find $V_C$:

$$V_C = V_B - 16 = 4 - 16 = -12 \text{ V}.$$

Then, we have $V_{CD}$ as follows:

$$V_{CD} = V_C - V_D = -12 - 0 = -12 \text{ V}.$$

### 1.9.2 Finding the remaining unknown values

The right dependent source relates $V_C - V_D = 3i_x$. Substituting $V_C - V_D = -12$,

$$-12 = 3i_x \quad \Rightarrow \quad i_x = -4 \text{ A}.$$

The negative sign indicates the actual current is opposite to the reference arrow; i.e., 4A flows from $D$ to $B$.

By applying KCL at node $B$ we could find the current from $B$ to $C$. We have:

Currents (signs: positive = from the listed node → other node):

$$\begin{aligned} I_{BA} &= \frac{V_B - V_A}{12} = \frac{4-10}{12} = -0.5 \text{ A}, \\ i_x &= -4 \text{ A} \quad (\text{meaning 4 A flows into } B \text{ from } D), \\ I_{BC} &= ? \text{ (from } B \to C). \end{aligned}$$

KCL at $B$: $I_{BA} + i_x + I_{BC} = 0$. Thus,

$$(-0.5) + (-4) + I_{BC} = 0 \quad \Rightarrow \quad I_{BC} = 4.5 \text{ A}.$$

### 1.9.3 Power calculations (passive sign convention)

- For the 4 V element (top positive): $p_1 = V \cdot i_{enter} = 4 \text{ V} \times i_x = 4 \times (-4) = \mathbf{-16}$ W. The negative sign means this element delivers 16 W to the circuit (acts as a source).
- For the 16 V source between B and C: $p_2 = V_{BC} \cdot I_{BC} = 16 \text{ V} \times 4.5 \text{ A} = \mathbf{72}$ W (absorbing).
- Equivalent resistance $R_2$ seen by the 16 V branch:

$$R_2 = \frac{V_{BC}}{I_{BC}} = \frac{16}{4.5} \approx \mathbf{3.5556\ \Omega}.$$

### 1.9.4 Summary and simulation results

- $v = 6$ V.
- $i_x = -4$ A (actual current 4 A from $D \to B$).
- $I_{AB} = 0.5$ A (from $A \to B$).
- $I_{BC} = 4.5$ A (from $B \to C$).
- $U_{CD} = -12$ V.
- $p_1 = -16$ W (element supplies 16 W).

- $p_2 = 72$ W (element absorbs 72 W).
- $R_2 \approx 3.5556\ \Omega$.

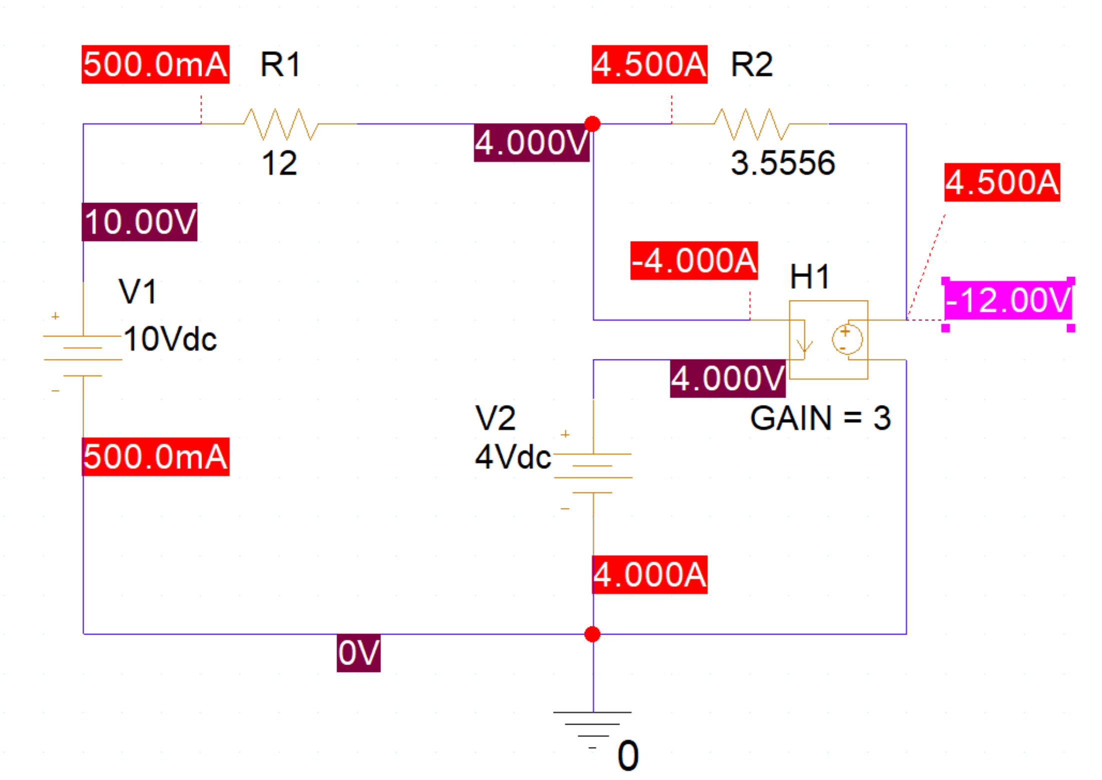



Figure 1.21: PSpice simulation result for Exercise 9

## 1.10 Exercise 10

Given the following circuit. Find the voltage $V$. You can do this in any way but remember to explain it in detail. Then simulate the circuit to check the result.

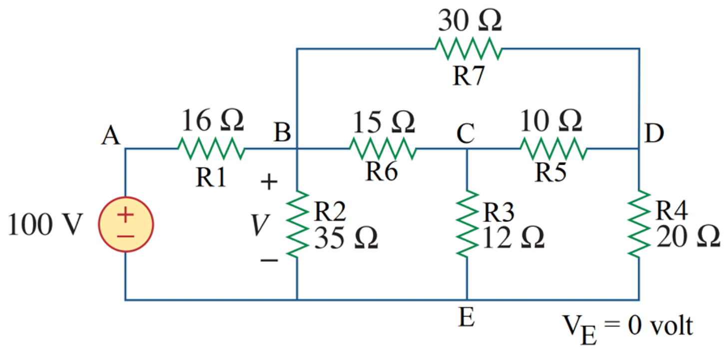



Figure 1.22: Find the voltage $V$

We write KCL (currents leaving each node) for nodes $B$, $C$, and $D$. All resistances and sources are as given; node $E$ is ground ($V_E = 0$), and $V_A = 100$ V.

### 1.10.1 Solution

By applying KCL at node B:

$$\frac{V_B - V_A}{R_1} + \frac{V_B - V_E}{R_2} + \frac{V_B - V_C}{R_6} + \frac{V_B - V_D}{R_7} = 0.$$

Substitute numeric values:

$$\frac{V_B - 100}{16} + \frac{V_B - 0}{35} + \frac{V_B - V_C}{15} + \frac{V_B - V_D}{30} = 0.$$

Multiply by 1680 (LCM of 16,35,15,30) and simplify:

$$321V_B - 112V_C - 56V_D = 10500. \tag{1}$$

By applying KCL at node C:

$$\frac{V_C - V_B}{R_6} + \frac{V_C - V_E}{R_3} + \frac{V_C - V_D}{R_5} = 0.$$

Substitute numbers:

$$\frac{V_C - V_B}{15} + \frac{V_C - 0}{12} + \frac{V_C - V_D}{10} = 0.$$

Multiply by 60 and simplify:

$$-4V_B + 15V_C - 6V_D = 0. \tag{2}$$

By applying KCL at node D:

$$\frac{V_D - V_B}{R_7} + \frac{V_D - V_C}{R_5} + \frac{V_D - V_E}{R_4} = 0.$$

Substitute numbers:

$$\frac{V_D - V_B}{30} + \frac{V_D - V_C}{10} + \frac{V_D - 0}{20} = 0.$$

Multiply by 60 and simplify:

$$-2V_B - 6V_C + 11V_D = 0. \tag{3}$$

We have the system:

$$\begin{cases} 321V_B - 112V_C - 56V_D = 10500, \\ -4V_B + 15V_C - 6V_D = 0, \\ -2V_B - 6V_C + 11V_D = 0. \end{cases}$$

From (3), we have:

$$11V_D = 2V_B + 6V_C \quad \Rightarrow \quad V_D = \frac{2V_B + 6V_C}{11}.$$

Substitute into (2):

$$-4V_B + 15V_C - 6\left(\frac{2V_B + 6V_C}{11}\right) = 0.$$

Multiply by 11 and simplify:

$$-56V_B + 129V_C = 0 \quad \Rightarrow \quad V_C = \frac{56}{129}V_B.$$

Compute $V_D$:

$$V_D = \frac{2V_B + 6\left(\frac{56}{129}V_B\right)}{11} = \frac{54}{129}V_B.$$

Substitute $V_C$ and $V_D$ into (1) and solve for $V_B$:

$$321V_B - 112\left(\frac{56}{129}V_B\right) - 56\left(\frac{54}{129}V_B\right) = 10500.$$

After arithmetic,

$$32113\,V_B = 1354500 \quad \Rightarrow \quad V_B = \frac{1354500}{32113} \approx \mathbf{42.18}\ \text{V}.$$

### 1.10.2 Conclusion

The required node voltage is

$$\boxed{V = V_B \approx 42.18\ \mathrm{V}}.$$

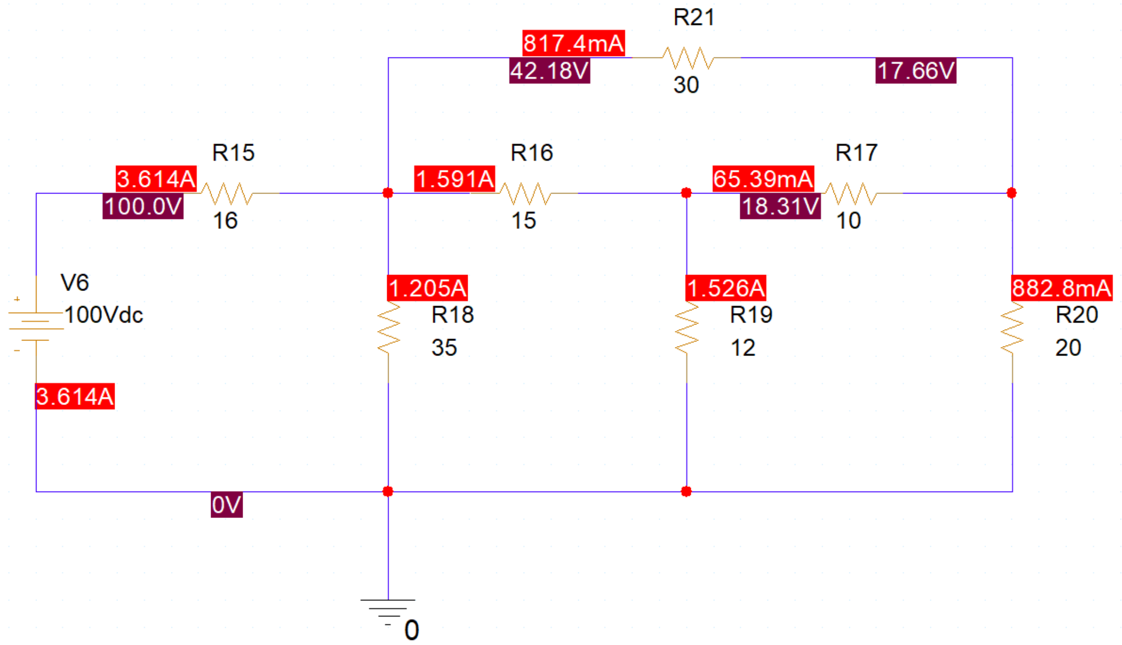



Figure 1.23: PSpice simulation result for Exercise 10

# References

[1] Le Trong Nhan. *CO2104 Fall 2025 Lab 02*. Ho Chi Minh University of Technology - VNUHCM, 2025.