FE Review

ELECTRONICS # 1 FUNDAMENTALS

Electric Charge

In an electric circuit there is a conservation of charge. The net electric charge is constant. There are positive and negative charges. Like charges repel while unlike charges attract. The SI unit for electric charge (q) is the Coulomb (C)

Electric Energy

Energy is the ability to perform work and has the same units as work: Work = force x dist. The SI unit for energy (w) is the Joule (J).

Basic Variables

Quantity	Symbol	Unit
Mass	m,M	kg
Length	l,L	meter,m
Time	t	sec, s
Energy	w,W	joule, J
charge	q,Q	coulomb, C

Lower case usually indicates a time variant unit.

Electric Current

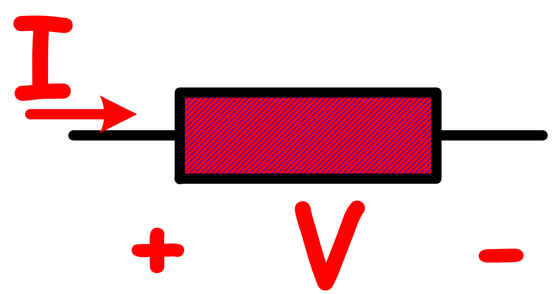
Charge is moved through a circuit as current, which is simply a measure of the charge transferred/sec. The SI unit is the Ampere with the symbol (A).

$$i = \frac{dq}{dt} = I = \frac{Q}{t} \qquad \left(\frac{\text{Coulombs}}{s}\right)$$

Voltage

The work performed/unit charge while moving a charge from one point to another in a circuit is voltage. Voltage is analogous to pressure. The SI unit for voltage is the volt (v)

$$V = \frac{dw}{dq} \qquad \left(\frac{\text{joules}}{\text{coulomb}}\right) = \text{volts}$$



Power

Power (P), **watt, w**

$$P = \frac{dw}{dt} \qquad \left(\frac{\text{joules}}{\text{sec}}\right) \text{ or } (\text{watt})$$

$$P = VI$$

Power is defined as the rate of energy transfer

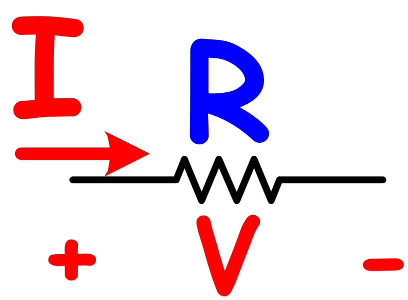
Resistance

Resistance (R) unit is the Ohm (Ω)

A resistance is an element which dissapates energy and can not store energy

$$i = \frac{V}{R} \Leftarrow \text{Ohm's Law} \Rightarrow V = IR$$

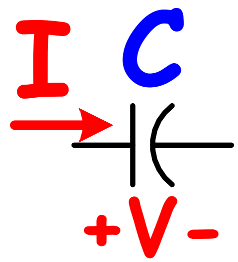
$$R = \frac{V}{I}$$



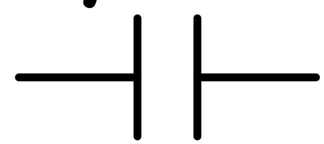
Capacitance

A capacitor is an element which stores energy in an electric field. This energy is returned to the circuit later. The SI unit for capacitance (C) is the farad, F.

$$C = \frac{i}{dv/dt}$$



Alternate Symbol

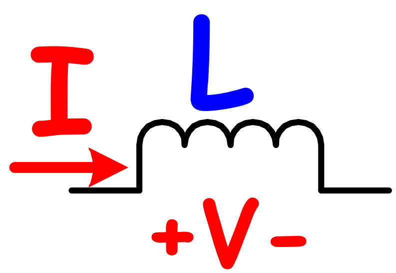


$$i = C\,dv/dt \quad \text{and} \quad V = \frac{1}{C}\int_0^t i(t)\,dt + V(0)$$

Inductance

An inductor (Coil) is an element which stores energy in a magnetic field. The energy is the returned to the circuit later. The SI unit for Inductance (L) is the Henry, H.

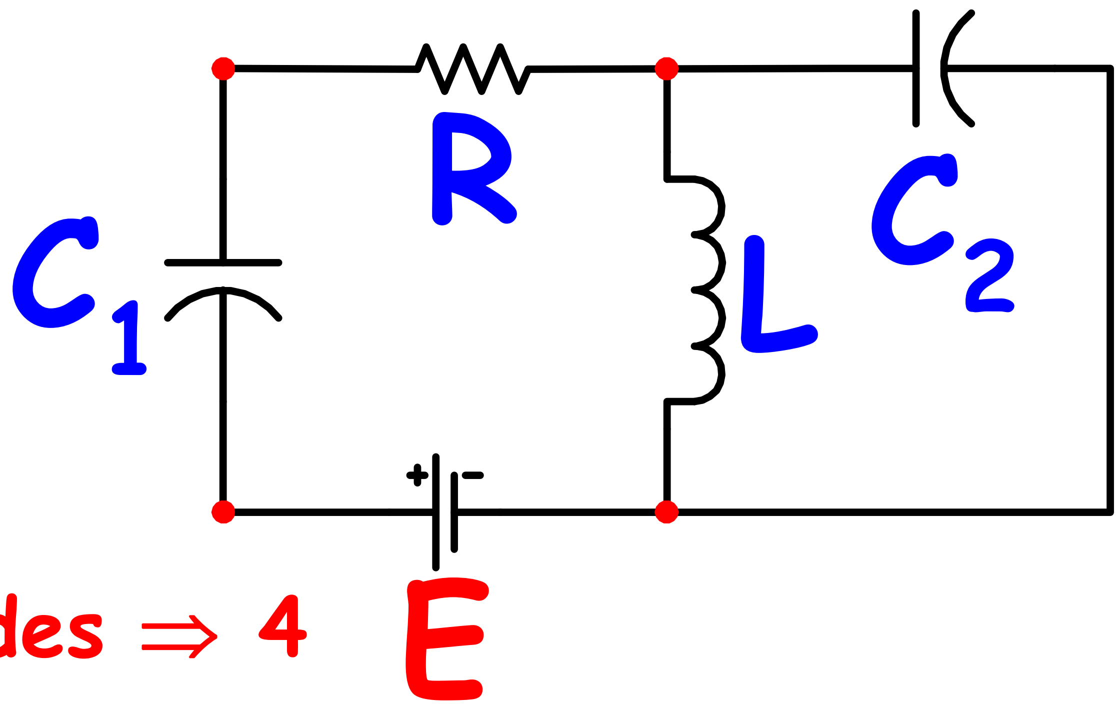
$$L = \frac{v}{di/dt} \quad \text{or} \quad v = L\frac{di}{dt} \quad \text{and} \quad i = \frac{1}{L}\int_0^t v(t)\,dt + i(0)$$



Electrical variables

Quantity	Symbol	Unit
Current	i(I)	Ampere, A
Voltage	v(V)	Volt, V
Power	p(P)	Watt, W
Resistance	R	Ohm, Ω
Capacitance	C	Farad, F
Inductance	L	Henry, H

Some definitions



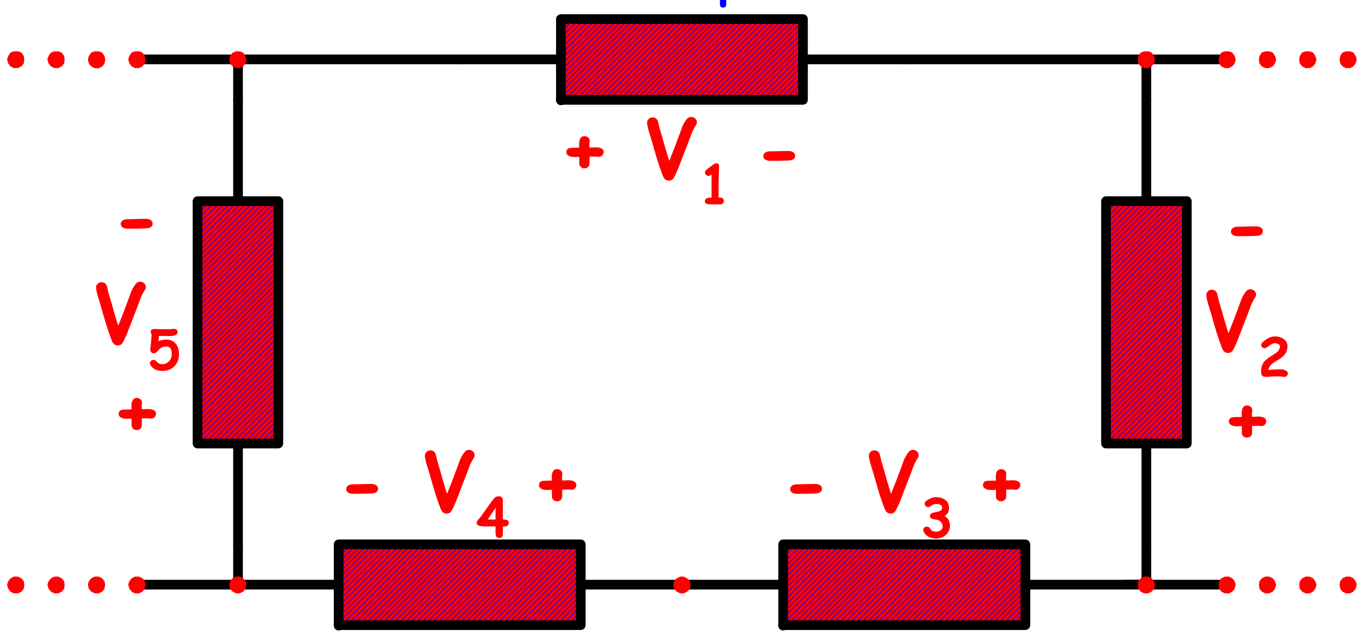
nodes ⇒ 4

loops ⇒ 3

meshs ⇒ 2 (also known as panes)

Kirchhoff's Voltage Law (KVL)

$$KVL \triangleq \sum_{\text{closed loop}} V = 0$$



$$V_1 - V_2 + V_3 + V_4 + V_5 = 0$$

Kirchhoff's Current Law(KCL)

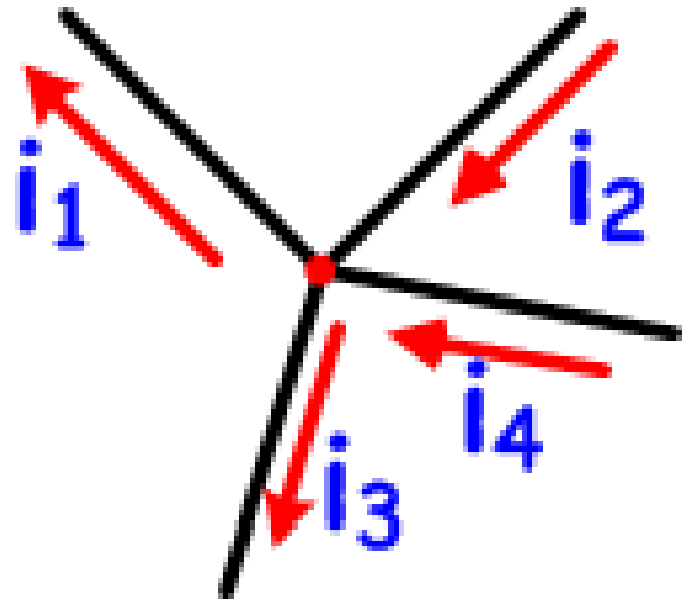
$$KCL \triangleq \sum_{node} i = 0$$

currents entering a node

are defined as -

currents leaving a node

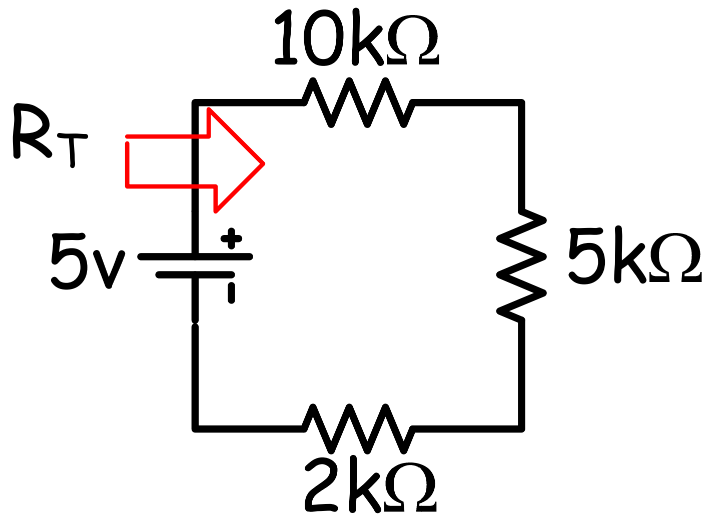
are defined as +



$$i_1 - i_2 + i_3 - i_4 = 0$$

Total Resistance of Series Elements

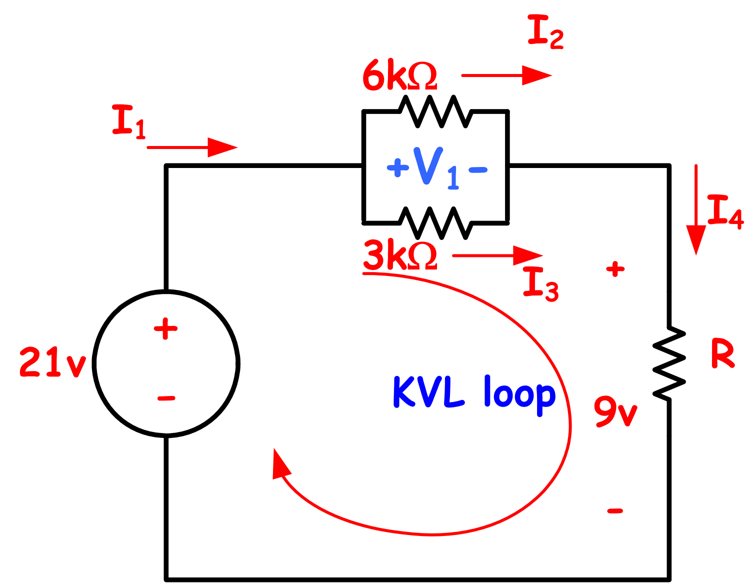
When resistors are in series, the total resistance is simply the sum of the resistors.



$$R_T = 10k\Omega + 5k\Omega + 2k\Omega = 17k\Omega$$

KVL/KCL Example 1

Determine the unknown voltages, currents, and R in the circuit to the right.



Step 1:

Perform a KVL to find the voltage across the 2 parallel resistors, V_1:

$$0 = -21v + V_1 + 9v$$

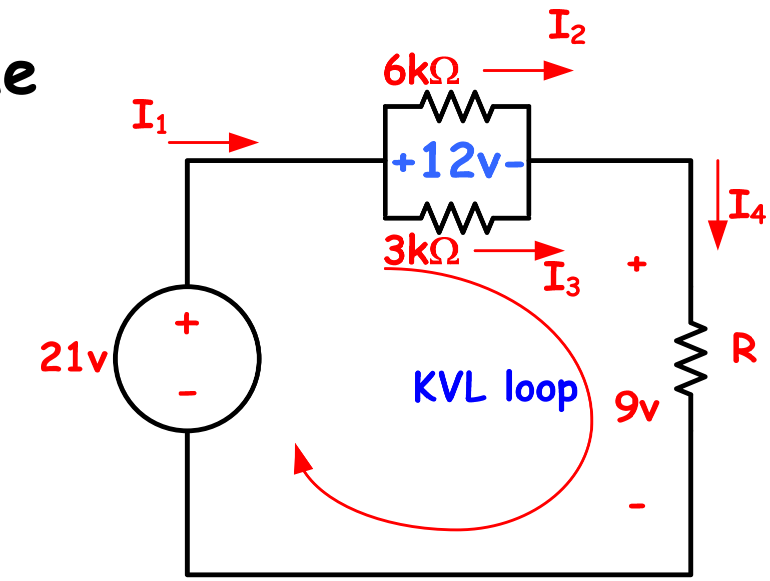
The 2 resistors share the same voltage.

$$V_1 = 21v - 9v = \boxed{12v}$$

Example continued on the next slide.

KVL/KCL Example 1 (cont)

Now that V_1 is known, the currents thru the 2 parallel resistors can be found via Ohm's Law.



$$I_2 = \frac{12v}{6k\Omega} = \boxed{2mA} \qquad I_3 = \frac{12v}{3k\Omega} = \boxed{4mA}$$

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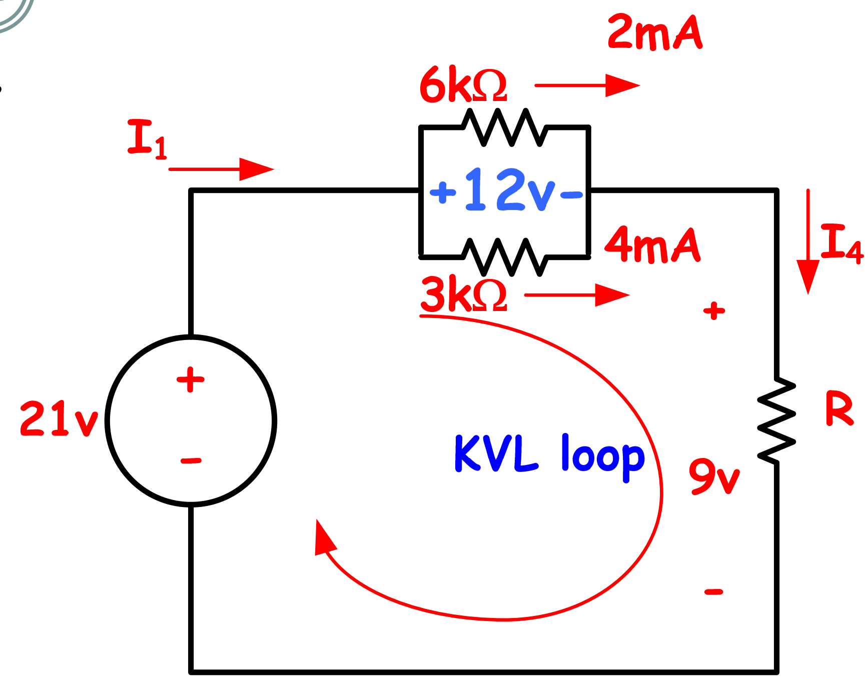
KVL/KCL Example 1 (cont)

Next, use KCL to determine the value of I_1. Perform a KCL at the node to the left of the parallel combination:



$$0 = I_1 - 2mA - 4mA$$

$$I_1 = \boxed{6mA}$$

Finally, with the value of I_1, use Ohm's law to determine the value of R:

$$R = \frac{V_R}{I_1} = \frac{9v}{6mA} = \boxed{1.5k\Omega}$$

Voltage Divider example

$$V_1 = \frac{30\,(5k\Omega)}{5k\Omega + 10k\Omega + 15k\Omega}$$

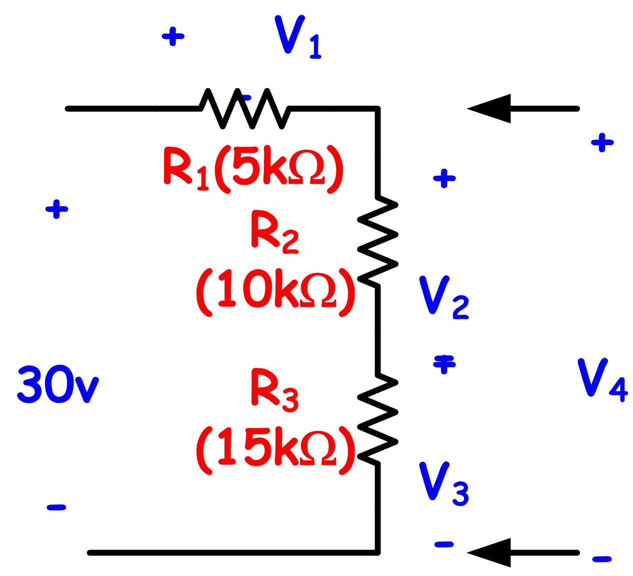
$$= \frac{150}{30} = \boxed{5v}$$

$$V_2 = \frac{30\,(10k\Omega)}{30k\Omega}$$

$$= \frac{300}{30} = \boxed{10v}$$

$$V_3 = \frac{30\,(15k\Omega)}{30k\Omega}$$

$$= \frac{450}{30} = \boxed{15v}$$



$$V_4 = \frac{30\,(10k\Omega + 15k\Omega)}{30k\Omega}$$

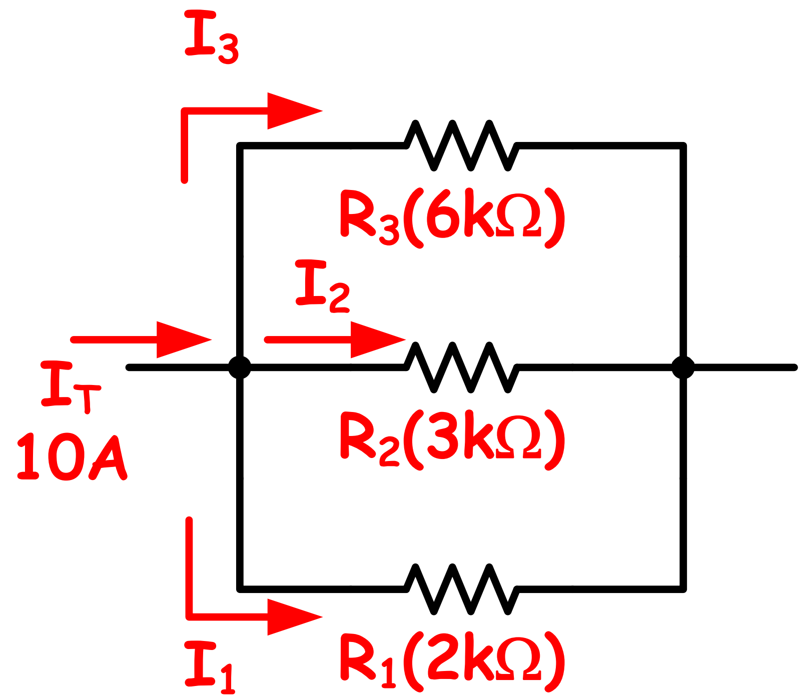
$$= \frac{30\,(25)}{30} = \frac{750}{30} = \boxed{25v}$$

Current Divider example

$$I_1 = \frac{10A\left(6k\Omega \;||\; 3k\Omega\right)}{2k\Omega + \left(6k\Omega \;||\; 3k\Omega\right)}$$

$$= \frac{10A\left(2k\Omega\right)}{2k\Omega + \left(2k\Omega\right)}$$

$$= \frac{20A}{4} = \boxed{5A}$$

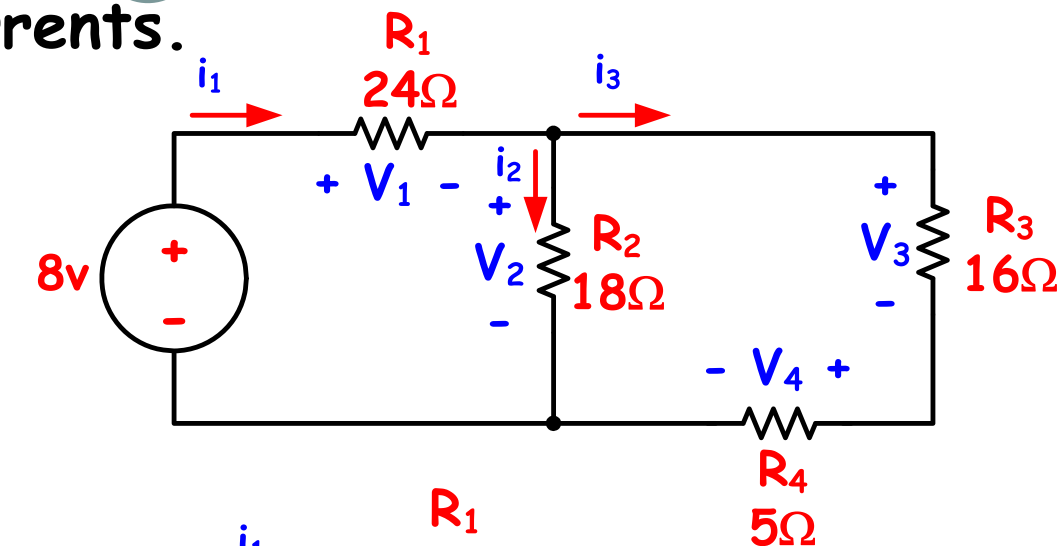


$$R_T = \frac{1}{\frac{1}{6k} + \frac{1}{3k} + \frac{1}{2k}} = 1k\Omega$$

$$R_{1||2} = \frac{R1\left(R2\right)}{R1 + R2} = \frac{2k\left(3k\right)}{2k + 3k} = 1.2k\Omega$$

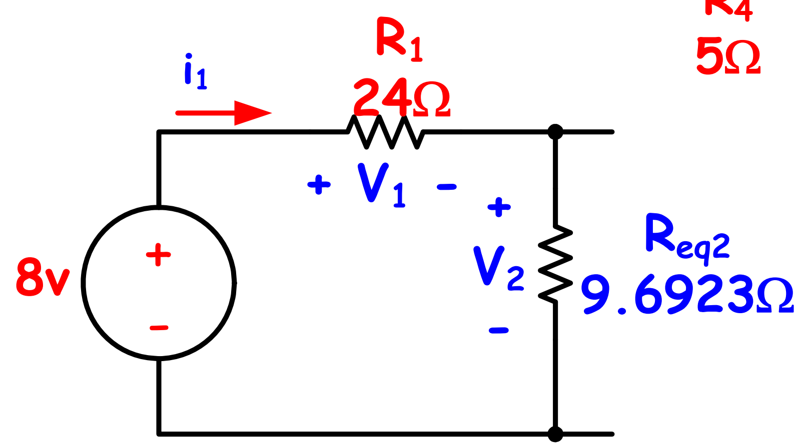
Example

Find all voltages and currents. Verify with KVL.



1st, reduce the circuit.

$$R_{eq1} = R_3 + R_4$$
$$= 16\Omega + 5\Omega = \boxed{21\Omega}$$
$$R_{eq2} = R_2 \,||\, R_{eq1}$$
$$= \frac{18\Omega(21\Omega)}{18\Omega + 21\Omega} = \boxed{9.6923\Omega}$$



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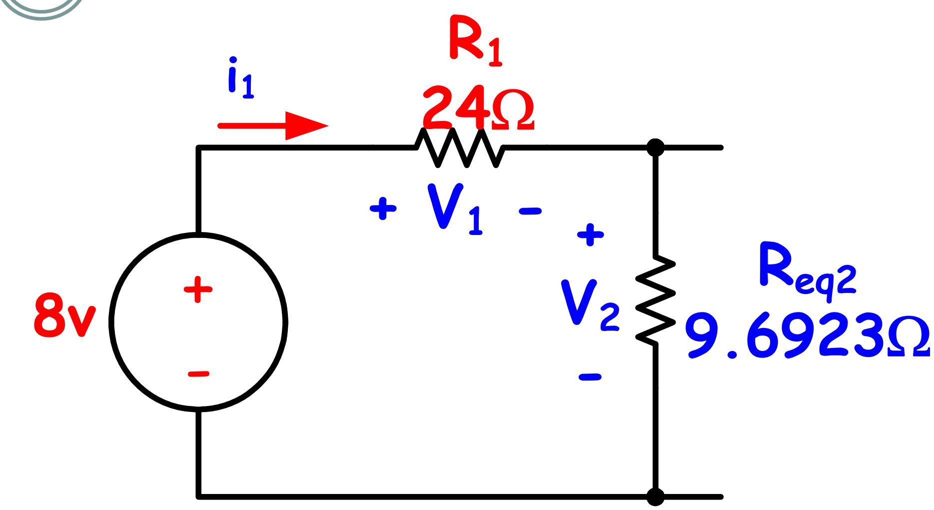
Example (continued)



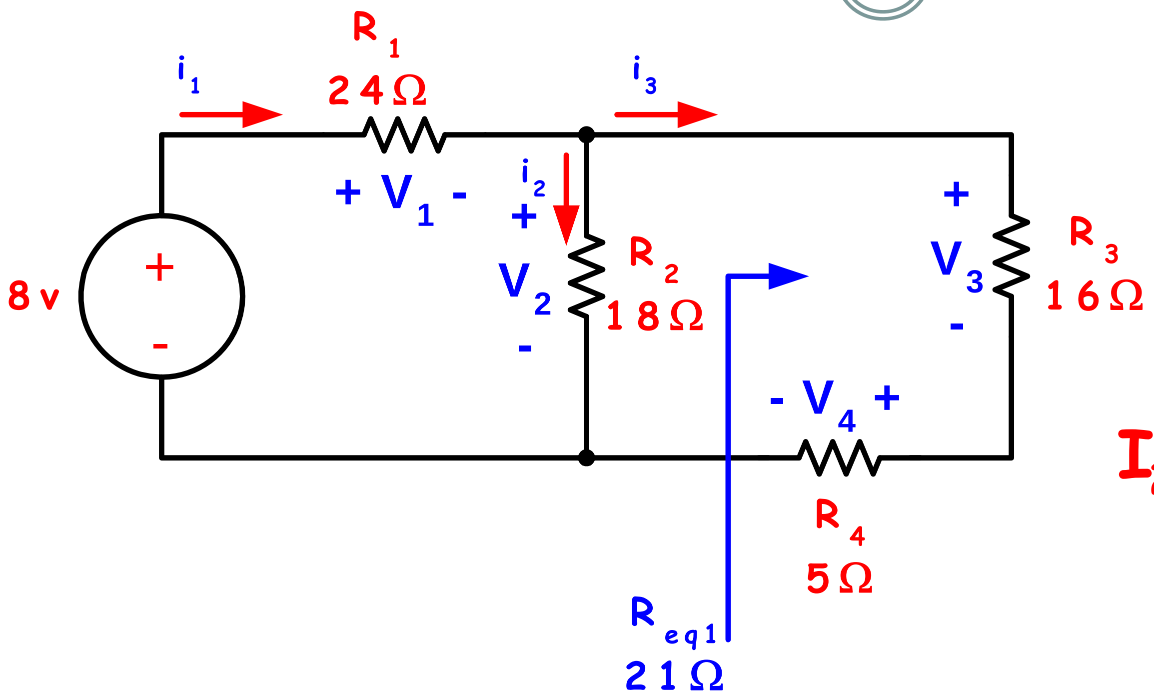
$$I_1 = \frac{8v}{24\Omega + 9.6923\Omega}$$
$$= 237.443mA$$

$$V_1 = I_1 R_1$$
$$= (237.443mA)\,24\Omega$$
$$= 5.6986v$$

$$V_2 = I_1 R_{eq2}$$
$$= (237.443mA)\,9.6923\Omega$$
$$= 2.3014v$$

Example continued on the next slide.

Example (continued)



$$I_2 = \frac{V_2}{R_2}$$

$$= \frac{2.3014v}{18\Omega}$$

$$= 127.8556mA$$

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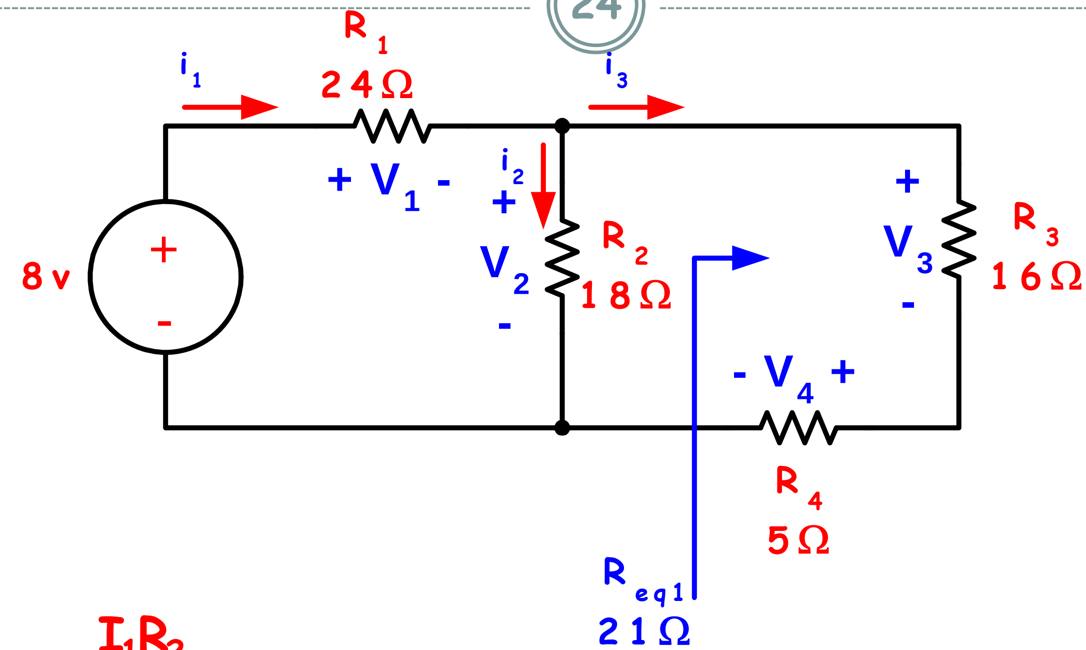
Example (continued)



$$I_3 = \frac{I_1 R_2}{R_2 + R_{eq1}}$$

$$= \frac{237.443\text{mA}\,(18\Omega)}{18\Omega + 21\Omega}$$

$$= \boxed{109.5891\text{mA}}$$

or

$$0 = -I_1 + I_2 + I_3$$

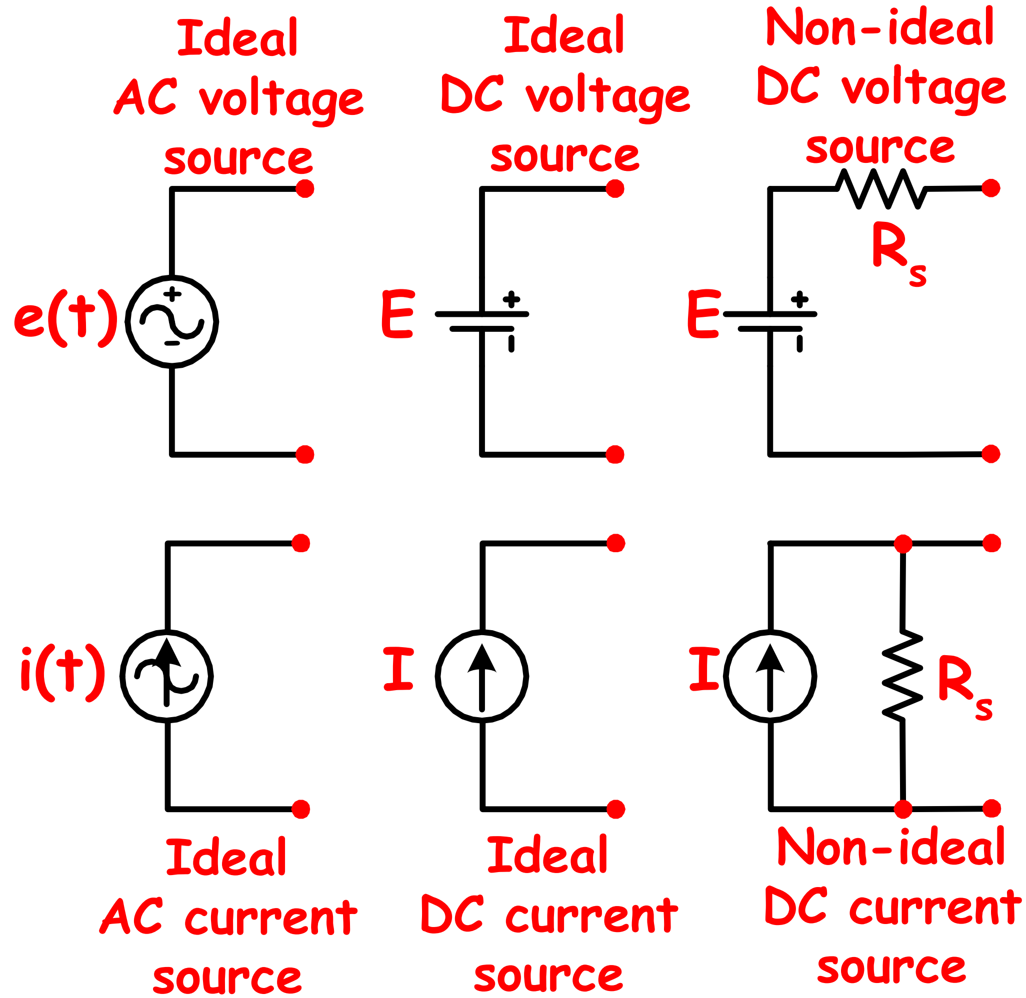
$$I_3 = I_1 - I_2$$

$$= 237.443\text{mA} - 127.8556\text{mA}$$

$$= \boxed{109.5874\text{mA}}$$

Difference is due to round off.

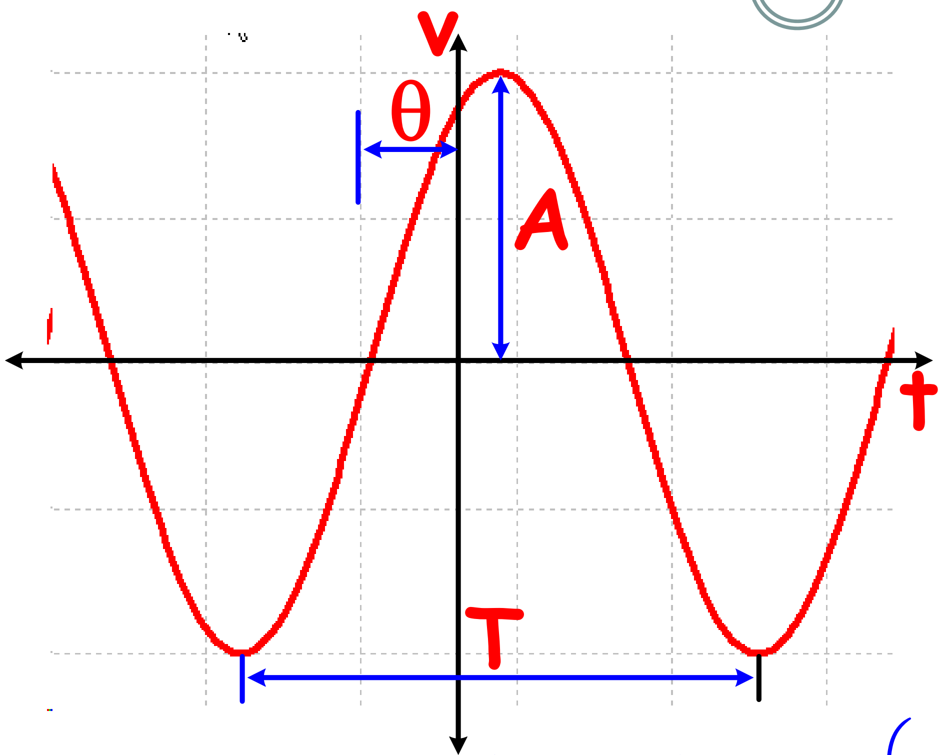
Sources


Ideal
AC voltage
source
Ideal
DC voltage
source
Non-ideal
DC voltage
source
e(t)
E
E
Rs
i(t)
I
I
Rs
Ideal
AC current
source
Ideal
DC current
source
Non-ideal
DC current
source

Waveform shape

1.	$i(t) = I = -4$	dc current
2.	$v(t) = 2e^{-3t}$	AC voltage aperiodic associated with transients
3.	$v(t) = 25\cos(\omega t + \theta)$	AC voltage periodic associated with steady state analysis

The Sine Wave



$$f = \omega/2\pi = \frac{1}{T} = \frac{\text{cycles}}{\text{sec}} = \text{hz}$$

$$f(t) = A\sin\left(\frac{2\pi}{T}t \pm \theta\right)$$

phase + if shifts left

phase - if shifts right

$$\sin(\omega t + \theta) = \cos\left(\omega t + \theta - \frac{\pi}{2}\right)$$

$$\cos(\omega t + \theta) = \sin\left(\omega t + \theta + \frac{\pi}{2}\right)$$

Average Value

$$V_{avg} = \frac{1}{T}\int_0^T v(t)dt$$

Effective value

$$P_{eff} = \sqrt{\frac{1}{T}\int_0^T P^2(t)dt}$$

Essentially, effective heating value

How much power will it use.

Instantaneous Power

$$P = VI$$