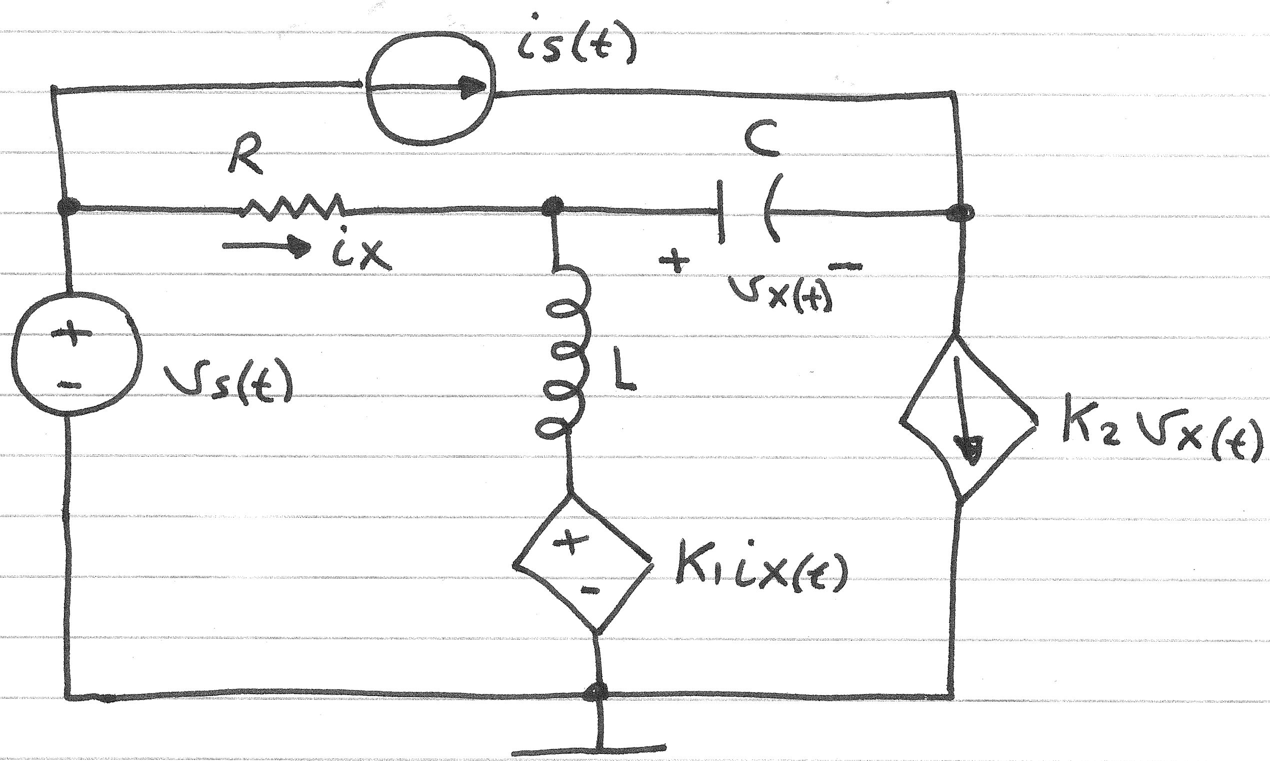
Network Analysis 1 ENEE 231

Ch2: Circuit Elements



Electric Circuit

Network : The interconnection of two or more simple circuit element is called electrical network

Circuit : If the network contains at least one closed path, it is called electric circuit

Circuit analysis : given a circuit in which all the components are specified, analysis involves finding such things as the voltage across some elements or the current through another.

The solution is unique.

Circuit design involves determining the circuit configuration that will meet certain specifications.

The solution is not unique.

Circuit Elements

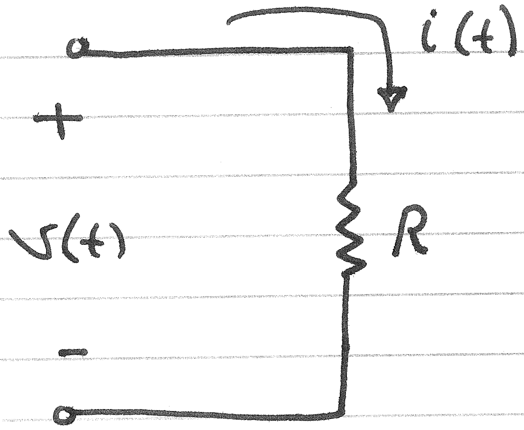
1) Active element : Capable of delivering power to some external elements.
(Sources)

2) Passive element : Capable only of recieving power.
(R, L, C, ...)

Circuit elements can be classified according to the realationship of the current through the element to the voltage a cross the element

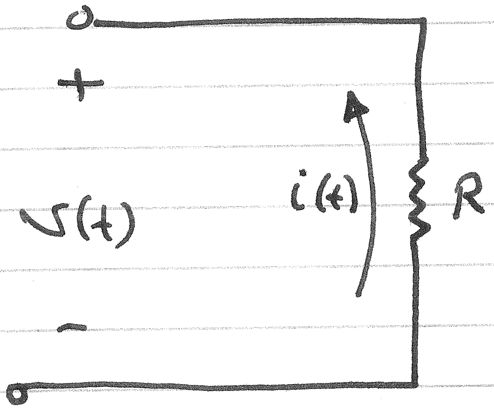
Circuit Elements

1) Resistor



$$v(t) = R\,i(t)$$

$$i(t) = \frac{1}{R}v(t) = G\,v(t)$$

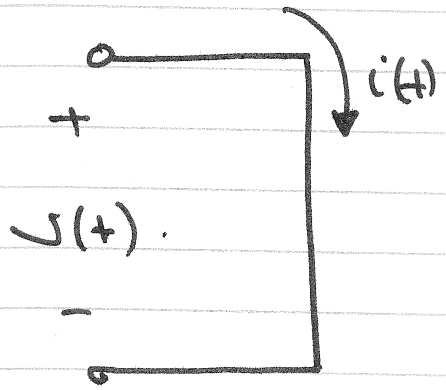


$$v(t) = -R\,i(t)$$

R is called the resistance of the Component and is measured in units of ohm (Ω)

G is called the Conductance of the Component and is measured in units of Siemens ($\mho$)

* Two special resistor values

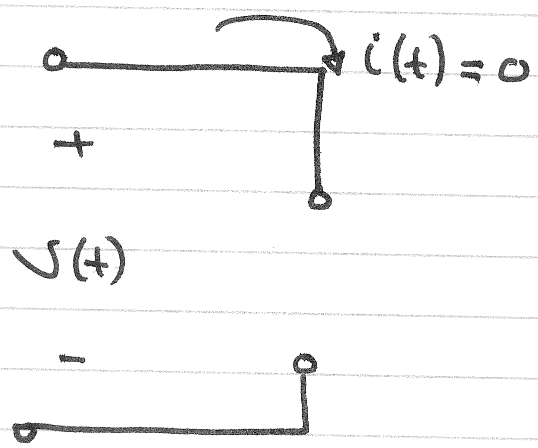


$v(t) = 0$

Short Circuit

$R = 0\ \Omega$

$G = \infty\ \mho$



$i(t) = 0$

open Circuit

$R = \infty\ \Omega$

$G = 0\ \mho$

Resistors and electric power

Resistors are passive elements that can only absorb energy.

$$P(t) = v(t)\, i(t)$$

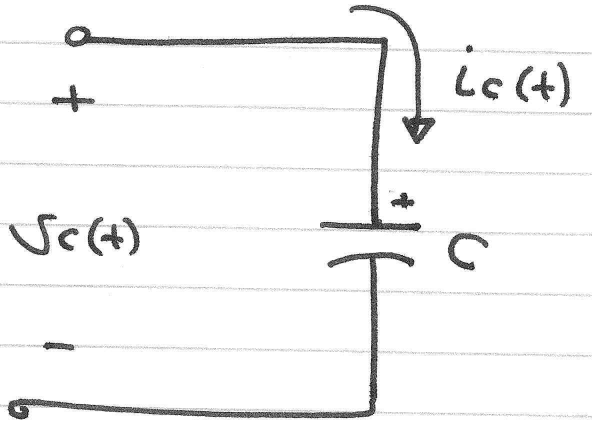
$$v(t) = R\, i(t)$$

$$\therefore \quad P(t) = \frac{v^2(t)}{R}$$

$$P(t) = R\, i^2(t)$$

Circuit Elements

2) Capacitors



$$v_c(t) = \frac{1}{C}\int_{-\infty}^{t} i_c(t)\,dt$$

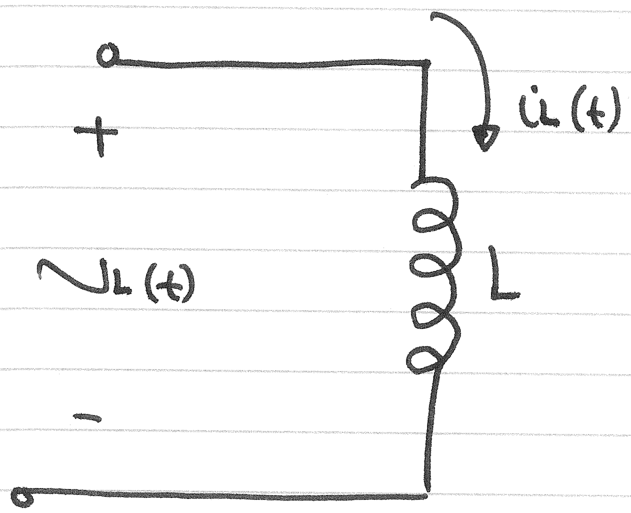
$$v_c(t) = v_c(0^-) + \frac{1}{C}\int_{0^-}^{t} i_c(t)\,dt \quad \text{for } t \geq 0$$

$$i_c(t) = C\,\frac{dv_c(t)}{dt}$$

C is called the Capacitance of the Capacitor and is measured in units of Farad (F)

Circuit Elements

3) Inductors



$$v_L(t) = L \frac{di_L(t)}{dt}$$

$$i_L(t) = i_L(0) + \frac{1}{L}\int_{0^-}^{t} v_L(t)\,dt \quad \text{for } t \geq 0$$

L is called the inductance of the coil and is measured in units of Henry (H)

Circuit Elements

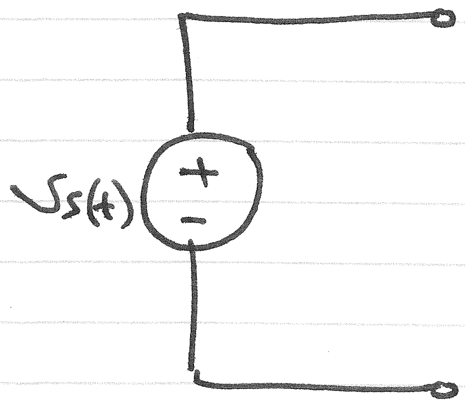
Active elements

- Independent Sources
- Dependent Sources

Independent Sources

1. Independent Voltage Source :

a Circuit element in which the voltage a cross its terminal is Completely independent of the Current through it.

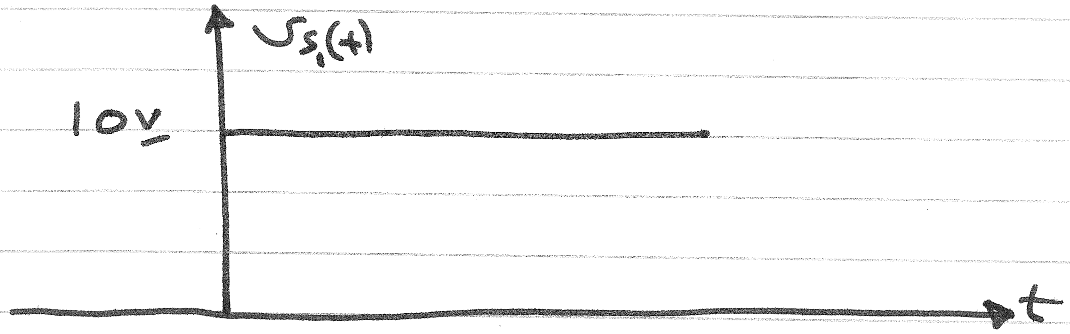


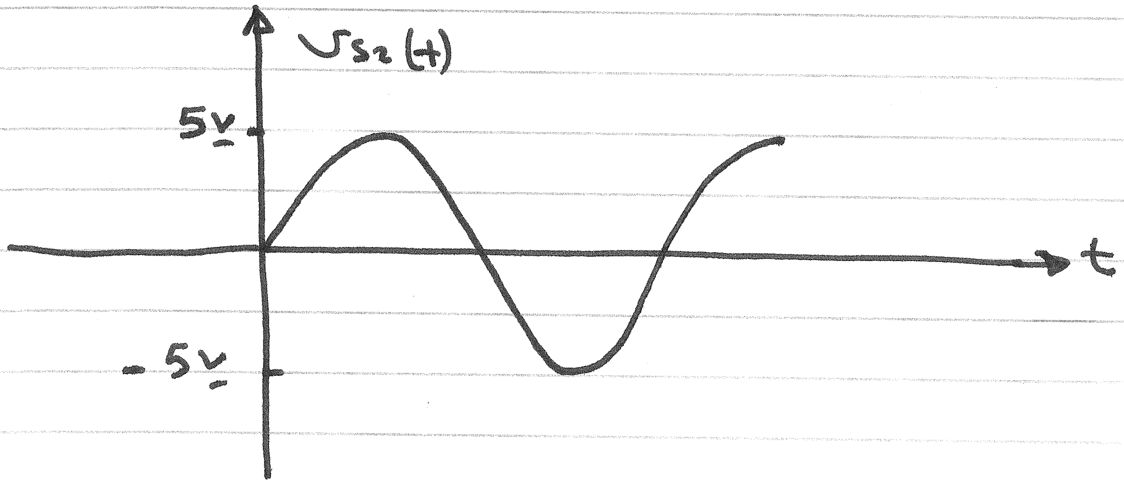
$V_s(t) = 10\,\underline{v}$ (DC)

$V_s(t) = 5 \sin \omega t\ \underline{v}$ (ac)

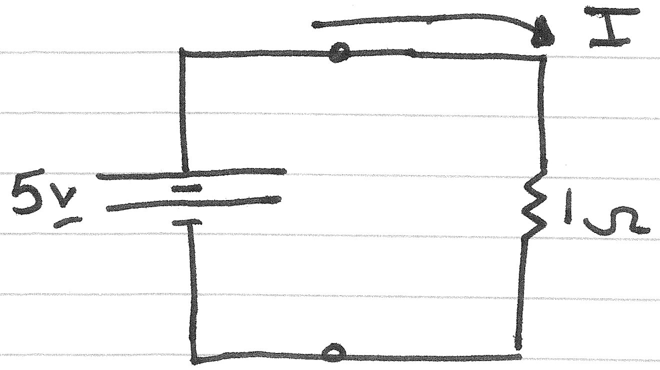
$V_s(t) = 10 e^{-t}\ \underline{v}$

$v_{s_1}(t) = 10\,v$ (Dc)

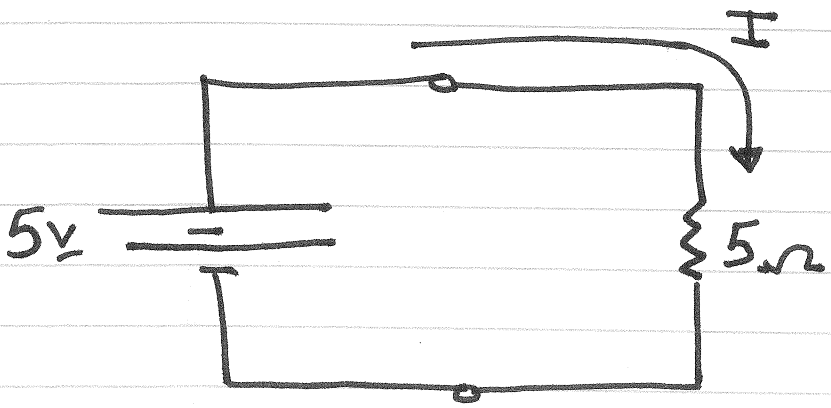




$v_{s_2}(t) = 5 \sin \omega t \; v$ (ac)



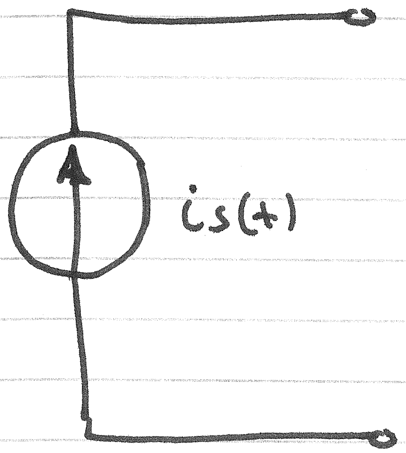
$$I = \frac{5v}{1\Omega} = 5A$$



$$I = \frac{5v}{5\Omega} = 1A$$

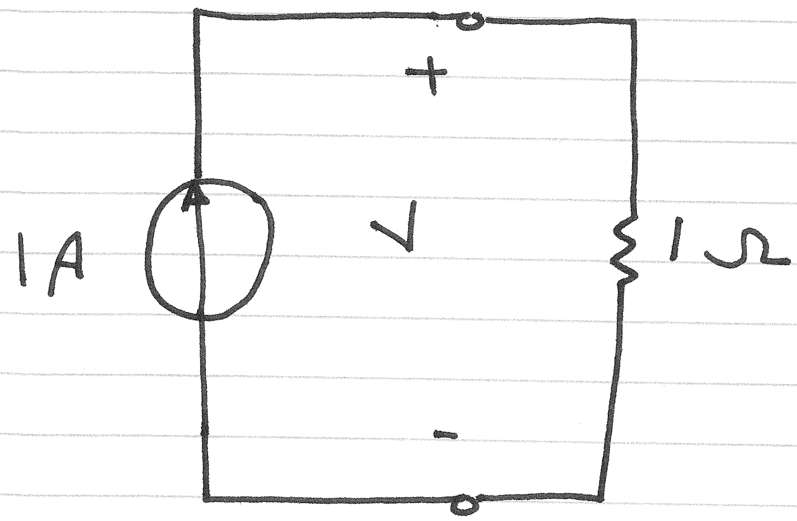
2. Independent Current Source :

a Circuit element in which the Current through it is Completely independent of the voltage across its terminals.

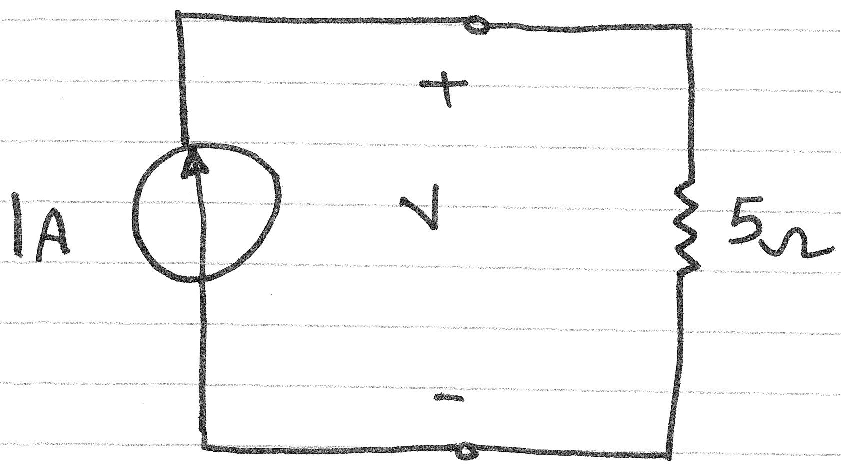


$i_s(t) = 10 \sin\omega t$ A

$i_s(t) = 20$ A



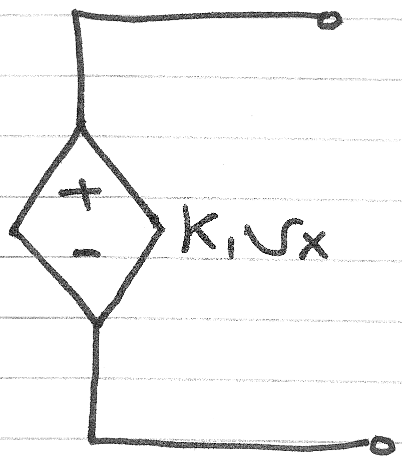
$$v = (1A)(1\Omega) = 1V$$

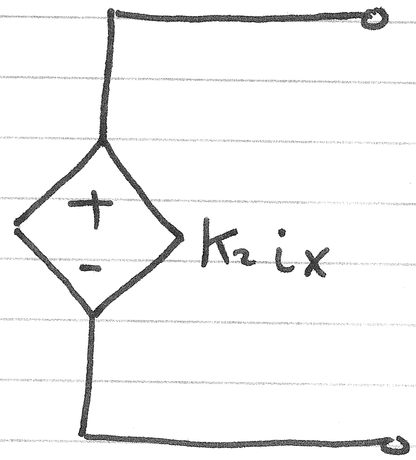


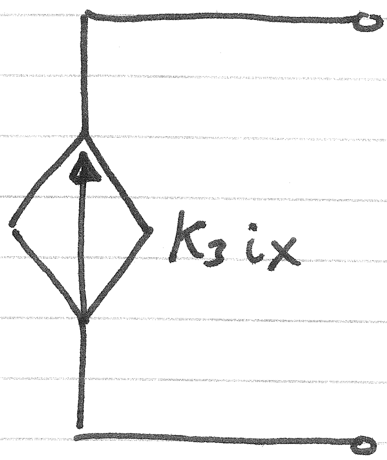
$$v = (1A)(5\Omega) = 5V$$

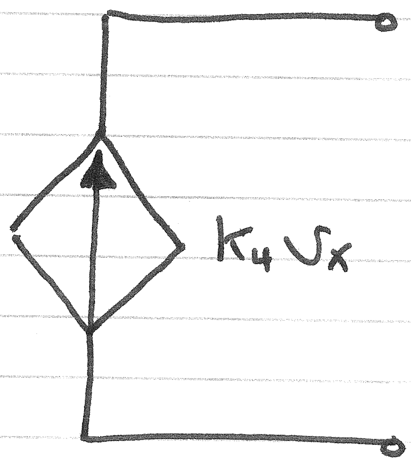
Dependent Sources :

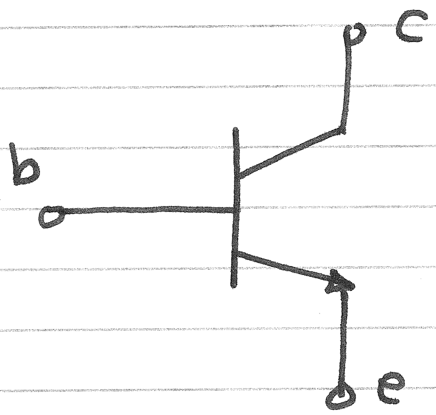
are Sources in which the Source voltage (or Current) depend upon a Current or voltage elsewhere in the Circuit.

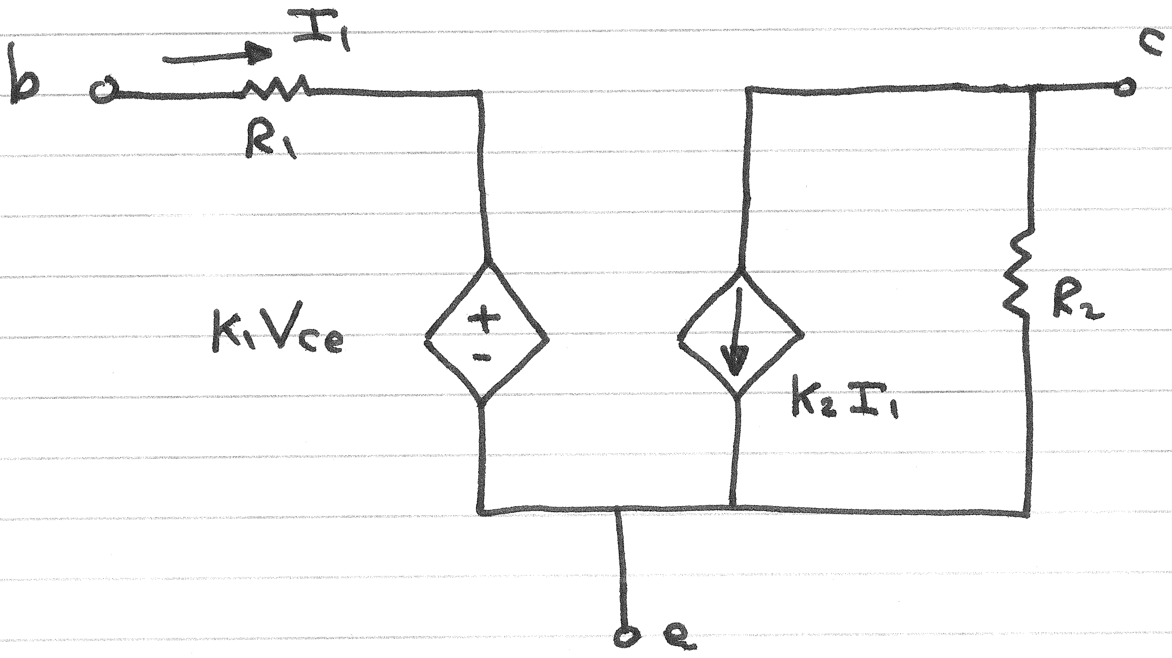






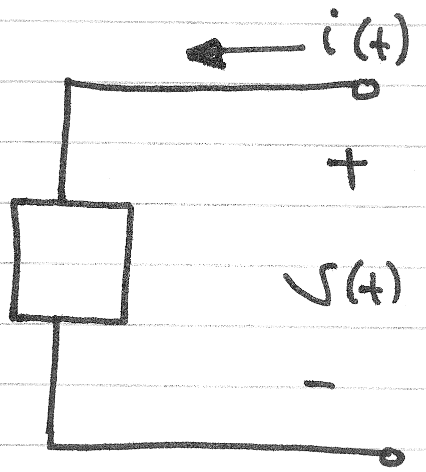



c
b
e

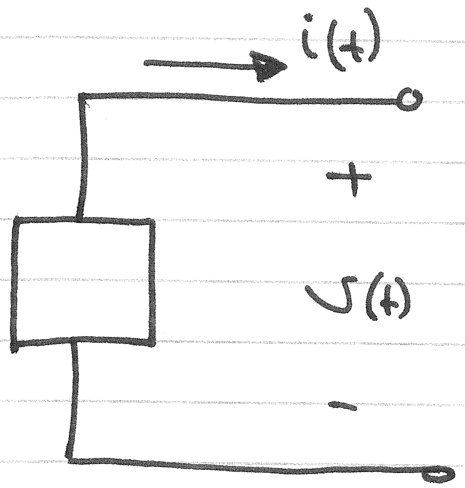

I1
b
c
R1
K1Vce
+
-
R2
K2I1
e

Power and Energy

$$p(t) = \frac{d\,w(t)}{dt}$$



$p(t) = +\,v(t)\,i(t)$ absorbing



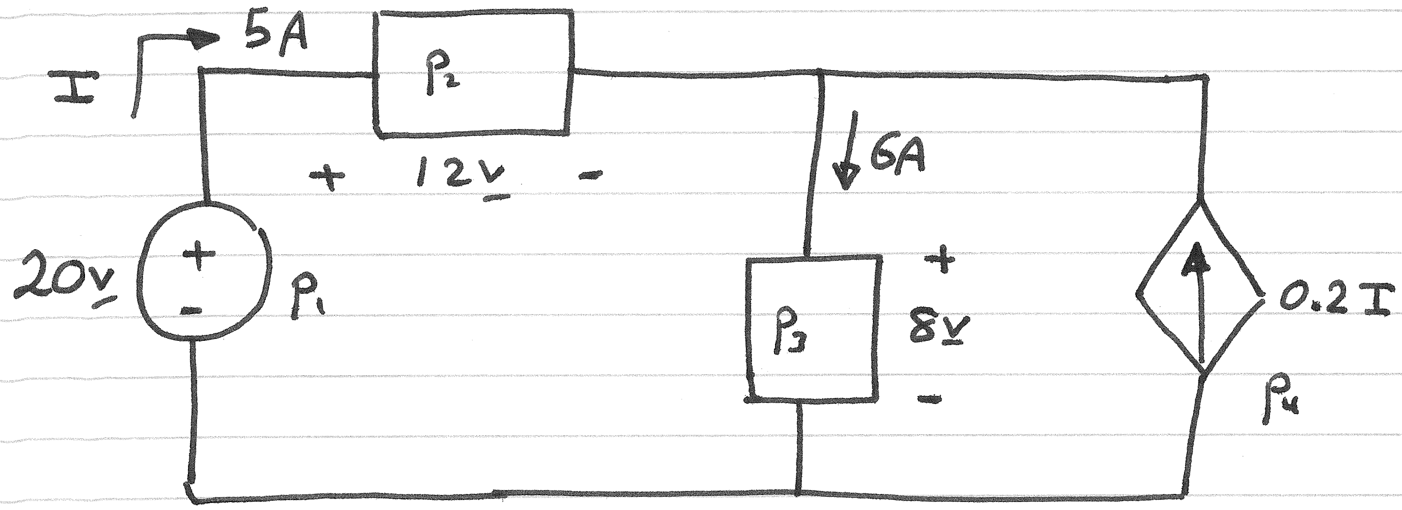
$p(t) = -\,v(t)\,i(t)$ Supplying

The Law of Conservation of energy must be obeyed in any electric Circuit.

The algebraic sum of power in a circuit at any instant of time, must be zero.

$$\sum p(t) = 0$$

Calculate the power supplied or absorbed by each element



$P_1 = (20)(-5) = -100$ W supplied power

$P_2 = (12)(5) = 60$W absorbed power

$P_3 = (8)(+6) = 48$ W absorbed power

$P_4 = (8)(-0.2 \times 5) = -8$W supplied

$P_{absorbed} = P_{supplied}$

$60 + 48 = 100 + 8$