Electric Circuits and Networks | **07-08-2018**

Lecture 5: Power and Energy (Cont'd...)

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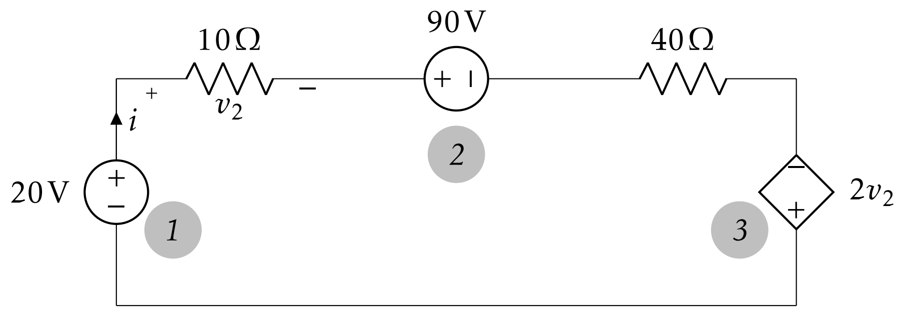
Power and Energy

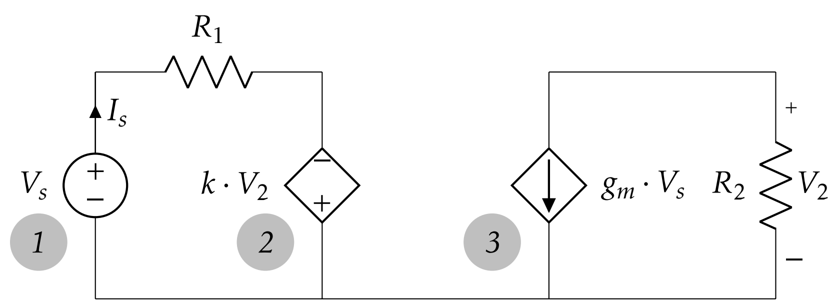
Example 1. *Consider the following circuit and calculate the power of each voltage source*



$$20 - 10i - 90 - 40i - 2(10i) = 0$$
$$i = -1A$$

$p_1 = 20W$ (absorbing power), $p_2 = -90W$ (delivering power), $p_3 = 20W$ (absorbing power)

Example 2. *Consider the following circuit with $k, g_m > 0$*



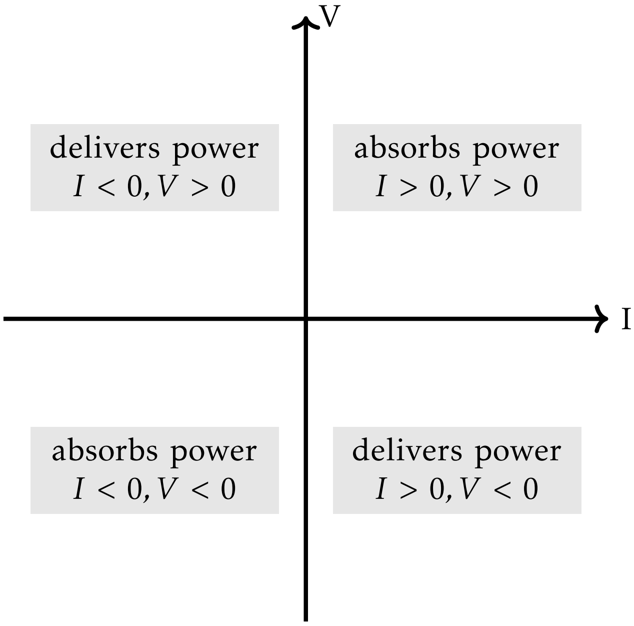
$$V_s - I_s R_1 - kV_2 = 0, \quad g_m V_s R_2 = -V_2$$
$$V_s = I_s R_1 + k(-g_m V_s R_2)$$
$$I_s = \frac{V_s}{R_1}(1 + k g_m R_2)$$

p_1 is $-ve$, p_2 is $-ve$, p_3 is $-ve$. Therefore all the sources (both independent and dependent) in the above circuit deliver power.

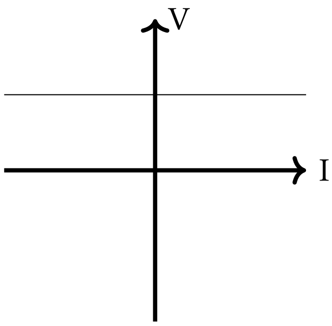
Controlled sources can deliver power or absorb power similar to independent sources.

I-V characteristics

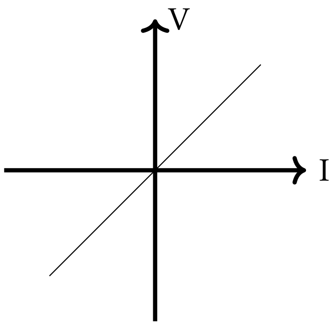
Any generic element absorbs power if it is operating in 1^{st} or 3^{rd} quadrant and delivers power if it is operating in 2^{nd} or 4^{th} quadrant. V is the voltage drop and the reference direction for I is in the direction of the voltage drop.



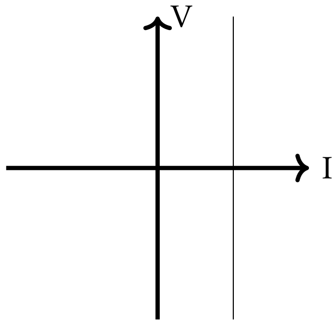
- **Ideal Voltage Source:** Ideal voltage source can deliver power or absorb power depending upon which quadrant it is operating in.



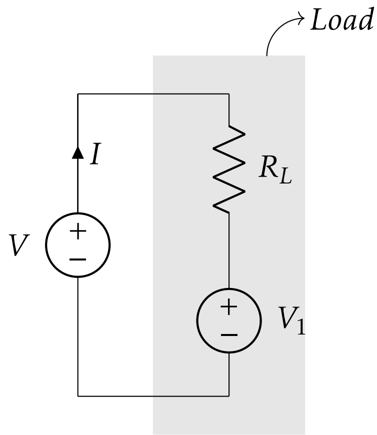
- **Resistor:** Resistor always absorbs power.

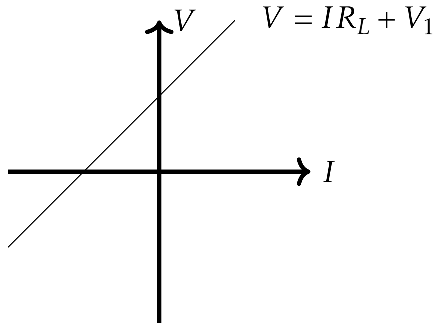


- **Ideal Current Source:** Ideal current source can deliver or absorb power depending on its operating point.



Example 3. *Consider the following circuit*



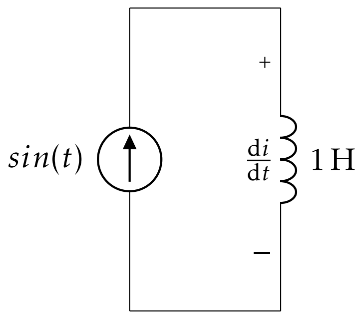


I-V characteristic of 'Load'

In this example 'Load' can operate in three quadrants, capable of both generating and absorbing power.

I-V characteristics can be draw for any part of circuit, considering that part as a generic 'Load' element.

Example 4. *Consider the following circuit*



Power $= i\frac{di}{dt} = sin(t) \cdot cos(t) = \frac{1}{2}sin(2t)$. *In this case, inductor oscillates between absorbing and delivering power at twice the frequency of current source.*

Unilateral Laplace transform

$$\text{Bilateral Laplace transform: } F(s) = \int_{-\infty}^{\infty} f(t)e^{-st}\mathrm{d}t$$

$$\text{Unilateral Laplace transform: } F(s) = \int_{-\infty}^{\infty} f(t)u(t)e^{-st}\mathrm{d}t = \int_{0^-}^{\infty} f(t)e^{-st}\mathrm{d}t$$

Bilateral Laplace transform of $e^{-at}u(t)$ and $-e^{-at}u(-t)$ are same ($\frac{1}{s+a}$) but with different region of convergences. For $e^{-at}u(t)$ it is $s > -a$ and for $-e^{-at}u(-t)$ it is $s < -a$. We want the inverse transform to be causal. It is enough to do unilateral Laplace transform (referred as just Laplace transform) since its inverse gives unique causal signal.