Electrical Energy Sources

Energy source is defined as the device that generates electrical energy. They are classified according to the current-voltage characteristics. The classification is given below.

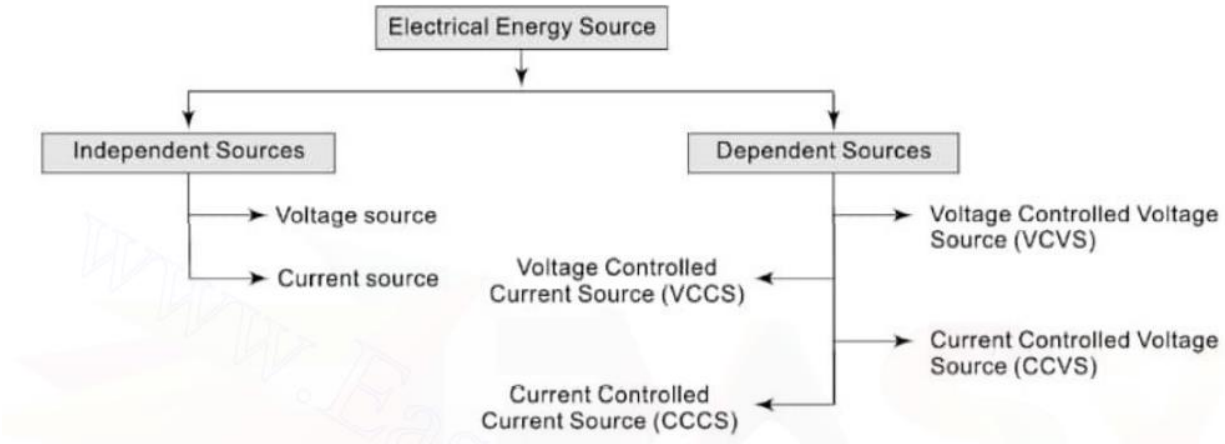

Figure 1: Classification of Electrical Energy Sources.

The most important active elements are voltage or current sources that generally deliver power to the circuit connected to them. There are two kinds of sources: independent and dependent sources.

Independent Source

An ideal independent source is an active element that provides a specified voltage or current that is completely independent of other circuit elements.

Independent Voltage Source

An ideal voltage source has the following features.

(i) It is a voltage generator whose output voltage remains absolutely constant whatever be the value of the output current.

(ii) It has zero internal resistance so that voltage drop in the source is zero.

(iii) The power drawn by the source is zero.

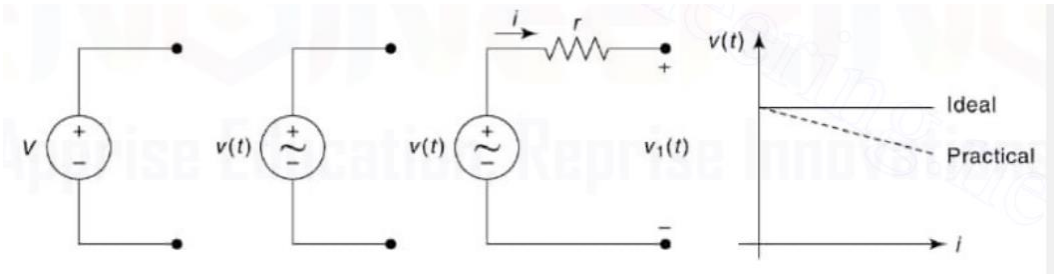

Figure 2: Independent voltage sources and their applications.

In practical, the voltage does not remain constant, but falls slightly. This is taken care of by connecting a small resistance (r) in series with the ideal source. In this case, the terminal voltage will by

$$v_1(t) = v(t) - ir$$

i.e. it will decrease with increase in current i. The V-I characteristics of an ideal and practical voltage source are shown in Fig. 2. A dc or ac generator or batteries are some examples of independent voltage sources.

Independent Current Source

AN ideal current source has the following features.

(i) It produces a constant current irrespective of the value of the voltage across it.

(ii) It has infinity resistance.

(iii) It is capable of supplying infinity power.

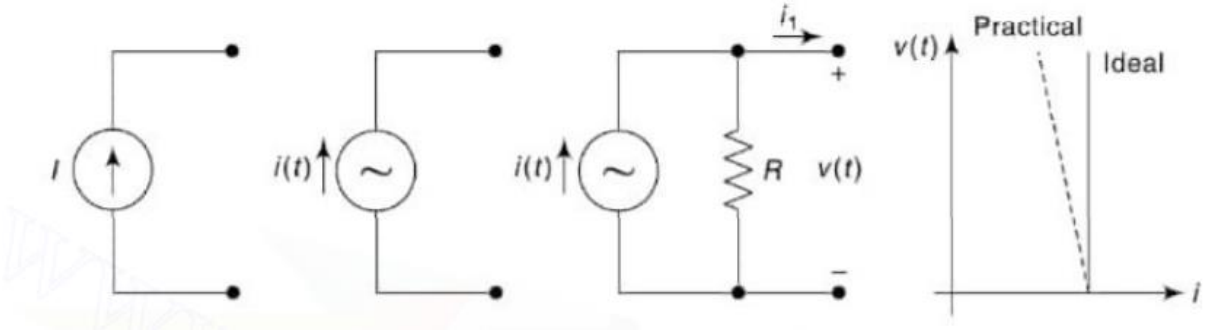

Figure 3: Independent current sources and their applications.

In practice, the output current does not remain constant but decreases with increase in voltage. So, a practical current source is represented by an ideal current source in parallel with a high resistance (R) and the output current becomes,

$$i_1(t) = i(t) - \frac{v\,(t)}{R}$$

Similar to voltage sources, an ideal current source is not practically possible. The output current of a practical current source decreases as the output voltage increases. The V-I characteristics of an ideal and practical current source are shown in Fig. 3. A solar cell, which can produce constant current within a specified range of output voltage, is an example of independent current source. A natural lightning can be considered to be an ideal current source. When a natural lightning strikes the top of a conductor, the resistance to the ground path is ideally zero. But, when the lightning

strikes a non-conducting element (like the top of a tree) a large voltage is developed across the element which is flashed out immediately.

Dependent Sources

In dependent sources (also referred as controlled sources), the source voltage or current is not fixed, but is dependent on a voltage or current at some other location in the circuit. Thus, the dependent source is defined as,

An ideal dependent (or controlled) source is an active element in which the source quantity is controlled by another voltage or current.

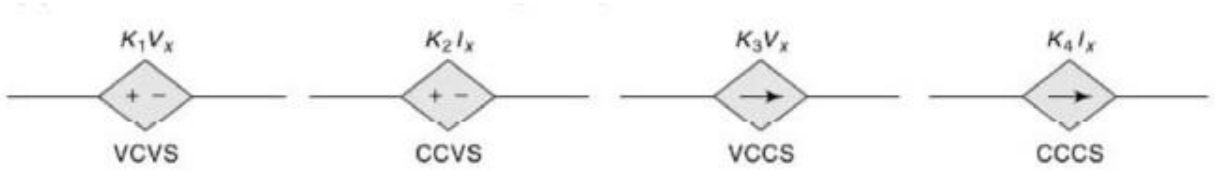

Figure 4: Symbols of Dependent Sources.

Dependent sources are usually designated by diamond-shaped symbols. There are four types of dependent sources.

(a) Voltage Controlled Voltage Source (VCVS)
(b) Current Controlled Voltage Source (CCVS)
(c) Voltage Controlled Current Source (VCCS)
(d) Current Controlled Current Source (CCCS)

Dependent sources are unilateral, because for a voltage controlled voltage source, say, $v_2 = kv_1$,the output voltage v_2 is controlled by the input voltage v_1, but the output current i_2 has no influence on the input v_1.

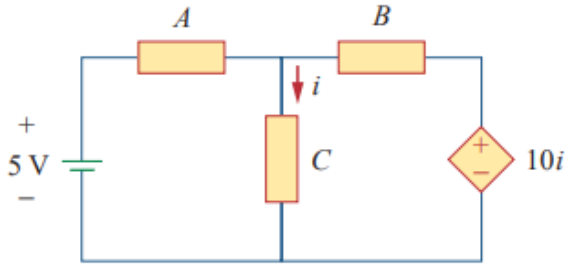

Figure 5: Example of CCVS in a circuit.

Dependent sources are useful in modeling element Such as transistors, operational amplifiers, and integrated circuits. An example of current-controlled voltage source is shown in Fig. 5, where the voltage 10i of the voltage source depends on the current I through element C.

Problem 1: Determine v_0 and i in the circuit shown in Fig. 6 (a).

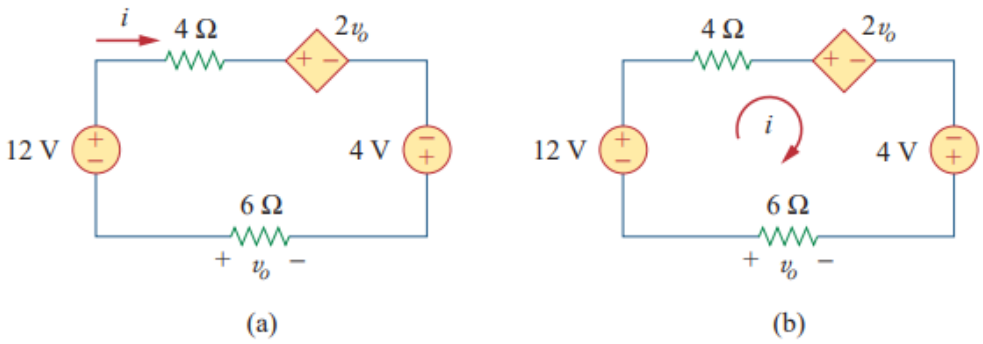

Figure 6.

Solution:

We apply KVL around the loop as shown in Fig. 6(b). The result is

$$-12 + 4i + 2v_0 - 4 + 6i = 0 \qquad (1)$$

Applying Ohm's law to the 6 Ω resistor gives

$$v_0 = -6i \qquad (2)$$

Substituting equ.(2) into equ. (1) yields

$$-16 + 10i - 12i = 0$$

$$i = -8\ A$$

and

$$v_0 = 48\ V$$

Problem 2: Find current i_0 and voltage v_0 in the circuit shown I Fig. 7.

Solution: Try it yourself.

Answer: 6A, 24V.

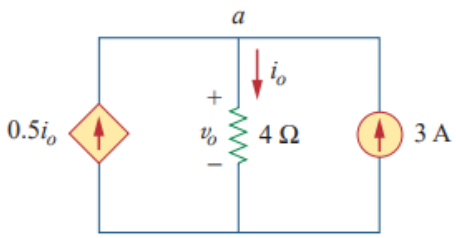

Figure 7.

Problem 3: Find voltage v_0 and current i_0 in the circuit shown I Fig. 8.

Solution: Try it yourself.

Answer: 8V, 4 A.

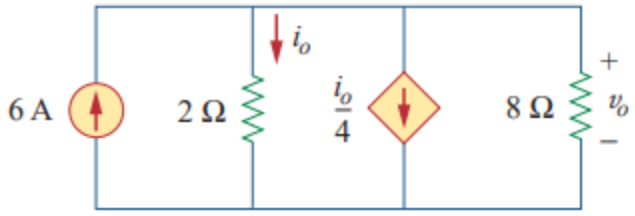

Figure 8.

Problem 4: Determine the value of V and the power supplied by the independent current source in Fig. 9.

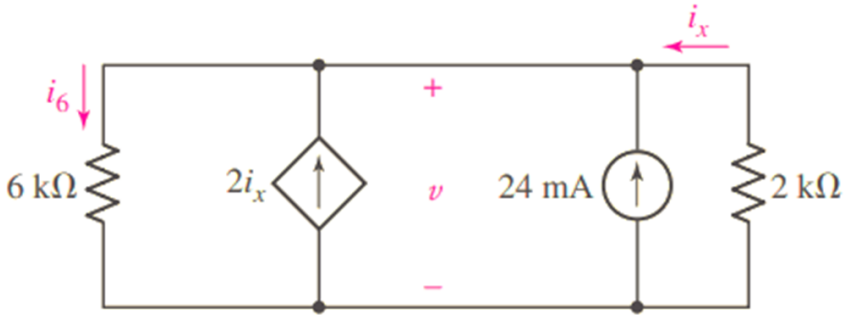

Figure 9.

Solution:

Apply KCL at the upper node

$$i_6 - 2i_x - 0.024 - i_x = 0$$

Apply Ohm's law to each resistor:

$i_6 = \frac{v}{6000}$ and $i_x = \frac{-v}{2000}$

Therefore,

$$\frac{v}{6000} - 2\left(\frac{-v}{2000}\right) - 0.024 - \left(\frac{-v}{2000}\right) = 0$$

So, $v = (600)(0.024) = 14.4\,V$.

The power supplied by the independent source is $p_{24} = 14.4(0.024)W = 0.3456\,W = 345.6\,mW$.