Basic Electrical Engineering

3rd Mech & Mall Engineering.

How Electricity reaches our homes / offices / Industries ?

As you are aware that electrical energy is generated with the help of Electrical generators installed in various types of power stations, like Hydroelectric, Thermal, Gas, Diesel, wind, Solar, etc. These power stations are usually quite far from population / load centres / homes / offices. Thus we need to transmit this power from these generating stations over long transmission lines (Both overhead / underground). This energy is to distributed also among various localities / load centres / villages and finally it is made available at our doorstep / Consumers. This way the entire power System comprises of four essential parts —

(1) Generation (2) Transmission (3) Distribution
(4) Utilization.

The voltage level of large generators is in the range of 13.8 KV to 24 KV. If power is transmitted at this low voltage, there will be a

tremendous power loss as well as voltage drop along the length of transmission line. In order to reduce this loss we step up the voltage at Generator terminals to a higher level (33 KV / 132 KV / 220 KV / 400 KV) so as to minimise power loss and subsequently reduce Voltage drop along the tr. line / cable.

While moving towards the consumer side, the power can not be utilized at this high voltage and thus voltage is to be brought down at the consumer terminals. This job of stepping up and stepping down of voltage for the purpose explained above is the use of transformers at various stages as explained in the following single line diagram of a simple power System:

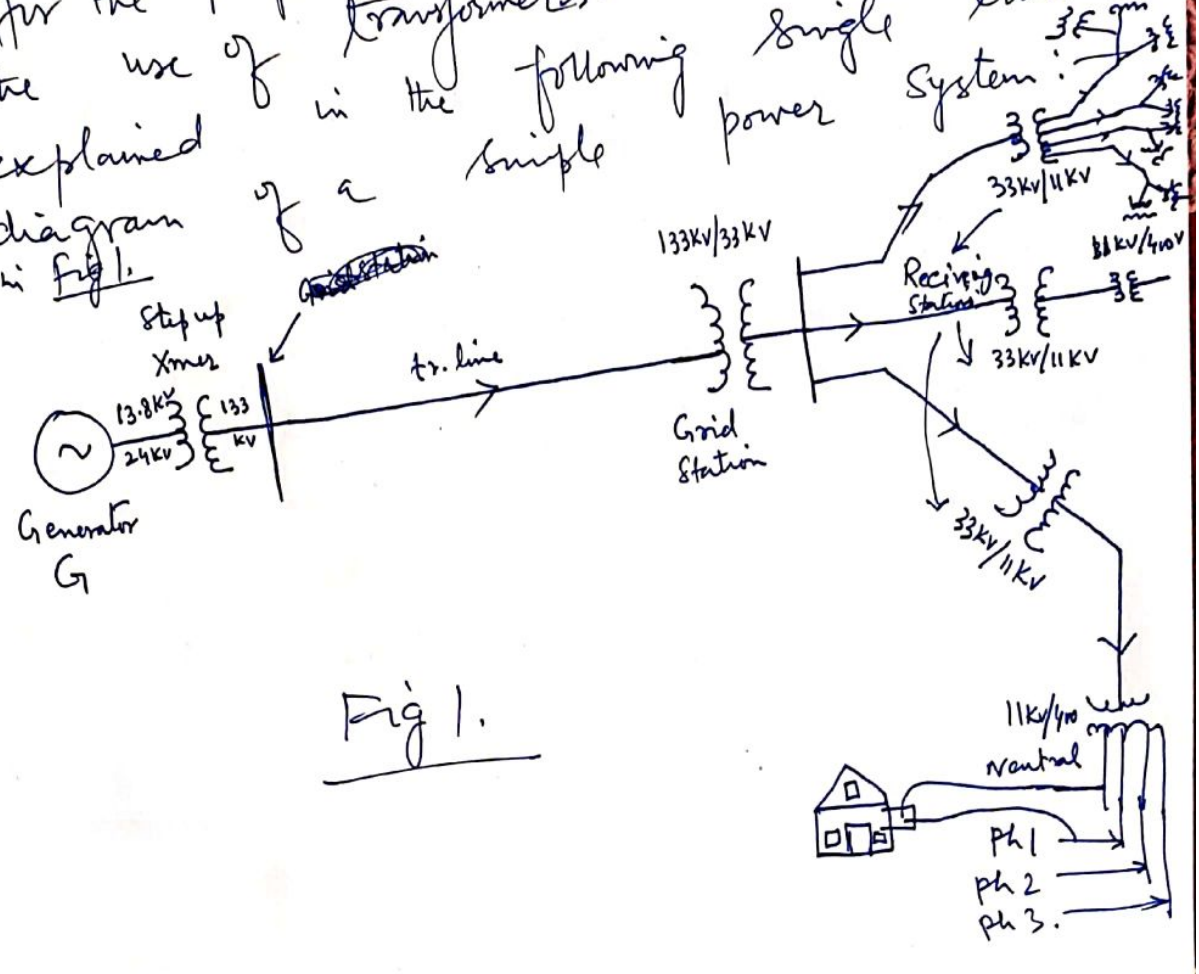


Fig 1.

Fig 1 shows the single line diagram of a typical power System. Power is generated at a voltage of 13.8 or 24 KV and is immediately stepped up to 133 KV with help of a transformer. This power is transmitted over long tr. line and finally reaches to a Station which we Called a grid station. Here voltage is stepped down from 133 KV to 33 KV and then many feeders come out to cater to different areas. This 33 KV line enters a recieving station where the voltage is stepped down further to 11 KV and further distributed among various localities. one such feeder reaches our locality where there is a pole-mounted transformer which further steps down it to 400 volt line to line and 230 V line to neutral. It is this line & neutral which enetens our homes in form of service lines. Some industries which consume power at higher voltages are accordingly fed at appropriate levels as demanded by Item.

Thus power flows from source to Generation in a closed path Continuesly as long as the the path is Completed. This gives rise to an electric circuit.

Electric circuit

An electric circuit is simply an interconnection of various elements which we call circuit elements. The various circuit elements are resistance, inductance, capacitance, voltage and current sources.

There are two types of elements found in electric circuits, called passive elements and active elements. An active element is one which can supply energy to the circuit and passive element is one which consumes the energy or stores it in itself in the form of electrostatic or electromagnetic field.

Examples of active elements: Generators, Batteries,
" " passive elements: Resistor, Capacitors, inductors, etc.

The most important active elements are voltage and current sources that generally deliver power to the elements connected to them.

Current and voltage sources

There are two types

1) Independent sources
2) Dependant sources

(1) Independant Sources

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

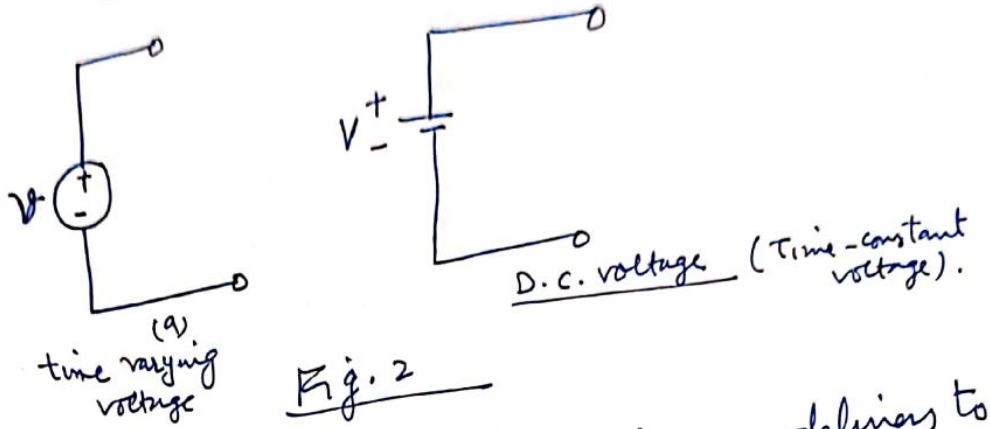


Fig. 2

An ideal independant voltage source delivers to the circuit whatever current is necessary to maintain its terminal voltage. Physical sources such as batteries and generators may be regarded as approximations to ideal voltage sources.

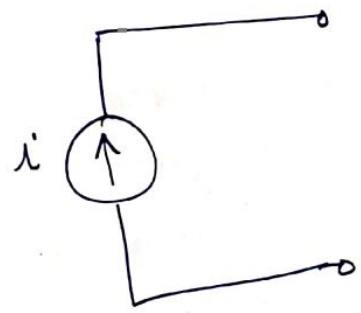


Fig. 3.

Similarly an ideal independent current source is an active element that provides a specified current completely independent of the voltage across the source. That is, the current source delivers to the circuit whatever voltage is necessary to maintain the designated current. The symbol is shown in fig 3. The arrow indicates the direction of current.

(2) Dependant Sources

Dependant sources are usually designated by diamond-shaped symbol (◇) as shown in fig 4. Since the control of the dependant source is achieved by a voltage or current of some other element in the circuit, and the source can be voltage or current, it follows that there are four possible types of dependant sources.

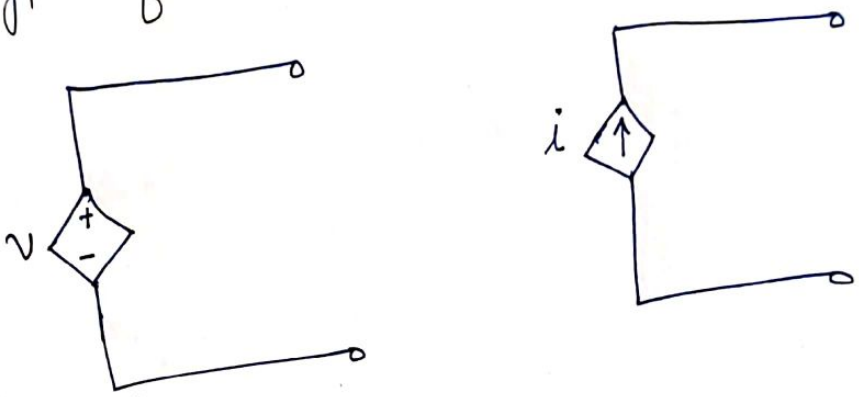


Fig. 4.

1. A voltage-controlled voltage source (VCVS)
2. A current-controlled voltage source (CCVS)
3. A voltage controlled current source (VCCS)
4. A current controlled current source (CCCS).

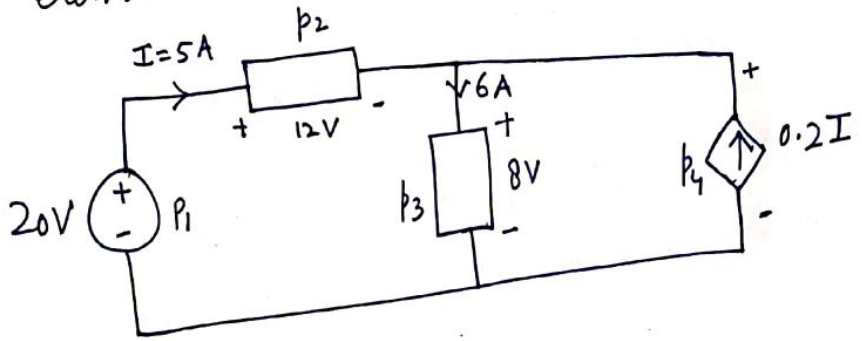
It should be noted that in ideal voltage source (dependant or independent) will produce any current requir to ensure that the terminal voltage is as stated, whereas an ideal current source will produce the necessary voltage to ensure the stated current flow. Thus an ideal source could in theory supply an infinite amount of energy.

It should also be noted that not only do sources supply power to a circuit, they can absorb power from a circuit too.

For a voltage source, we know the voltage but not the current supplied or drawn by it. Similarly, for a current source, we know the current supplied or drawn by it but not the voltage across it.

Example: 1

Calculate power supplied or absorbed by each element in the following figure.



Passive Sign Convention :- when current enters through the positive terminal of an element, $P = +vi$ and when current enters through the -ve terminal, $P = -vi$

$P = +vi \longrightarrow$ absorbing power

$P = -vi \longrightarrow$ Supplying power.

However vice-versa sign convention can be used.

Sol/

$p_1 = 20(-5) = -100\,W$ — power supplied

$p_2 = 12 \times 5 = +60\,W$ — power dissipated

$p_3 = 8 \times 6 = +48\,W$ — power dissipated

$p_4 = ?$; since p_4 & p_3 are in parallel; voltage across p_4 is same as p_3.

$p_4 = (0.2 \times 5)(8) \rightarrow -8\,W$ — power supplied.

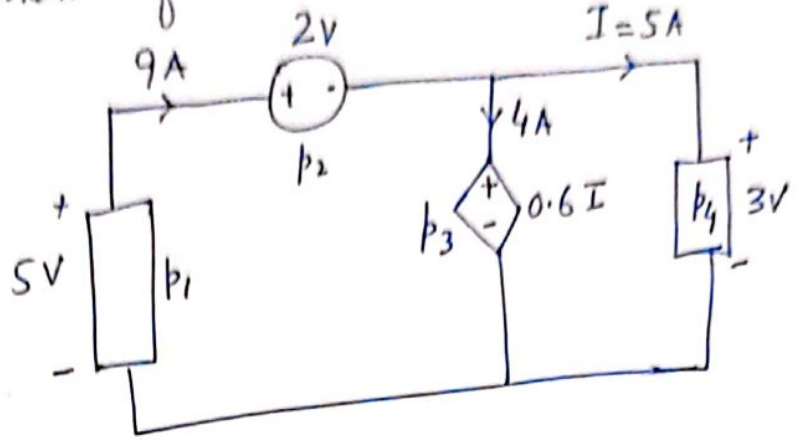
Thus two sources 20V independant voltage source and $0.2I$ dependant current sources deliver power of 100 W and 8 W respectively. whereas p_2 & p_3 consume 60 and 48 W respectively.

Thus total power $= p_1 + p_2 + p_3 + p_4$

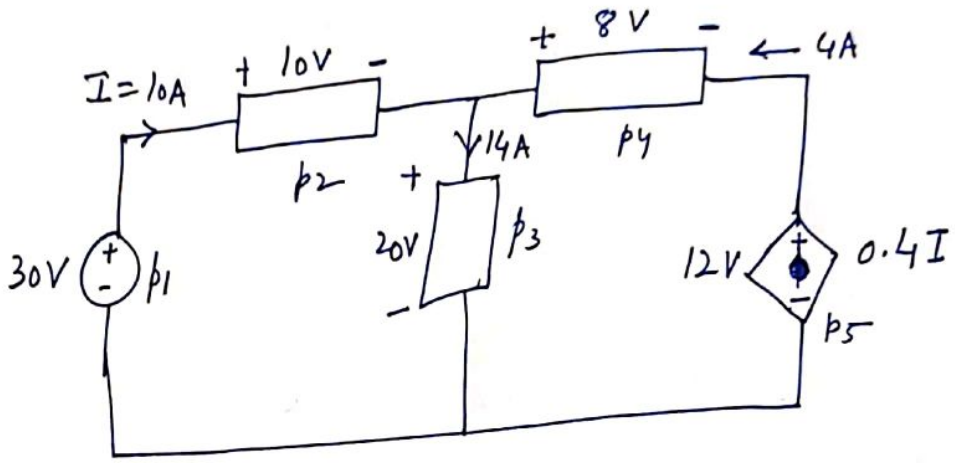
$= -100 + 60 + 48 - 8 = 0.$

Thus total power supplied equals the total power consumed.

Exp 2: Find power absorbed or supplied by each component of the circuits shown below:-



Exp 3.



Exp 4. Find V_o and the power absorbed by each element in the following figure:-