

Parallel Circuits

Parallel Circuits

Parallel components and parallel circuits establish another fundamental way to connect electrical and electronic devices. Components are connected in parallel when they are connected across one another.

Most of the electrical lights and appliances in your home are connected in parallel. A parallel circuit is characterized by having the same voltage across each component in the circuit.

Two components are in parallel with each other if both ends of both components connect directly together. Since the components are connected directly across each other, they will inherently have the same voltage across them.

Figure 6 -1 shows that one terminal of each light bulb is connected to the positive terminal of the battery and the other terminal of light bulb is connected to the negative terminal of the battery. These points of connections are often termed as nodes.

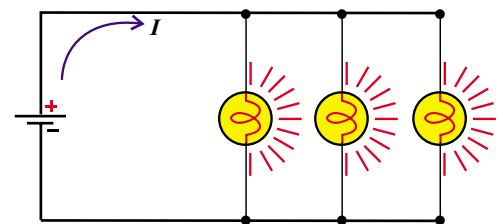


Fig 6-1 Simple Parallel Circuit

Elements or branches are said to be in a parallel connection when they have exactly two nodes in common.

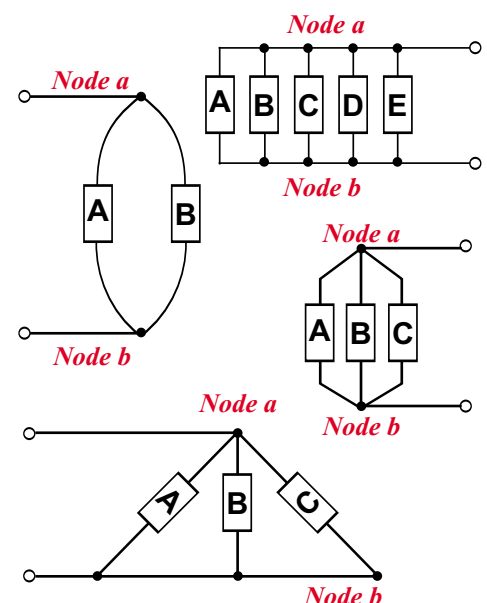
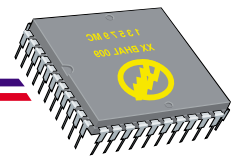


Fig 6-2 Parallel Elements

Figure 6-2 shows several different ways of sketching parallel elements. The elements between the nodes may be any two-terminal device such as voltage sources, resistors etc.

**Nodes**

In the illustrations of Figure 6 - 2, notice that every element has two terminals and that each of the terminals is connected to one of the two nodes.

Series Parallel

Very often, circuits contain a combination of series and parallel components. When analyzing a particular circuit, it is usually easiest to first designate the nodes (we will use lowercase letters) and then to identify the types of connections.

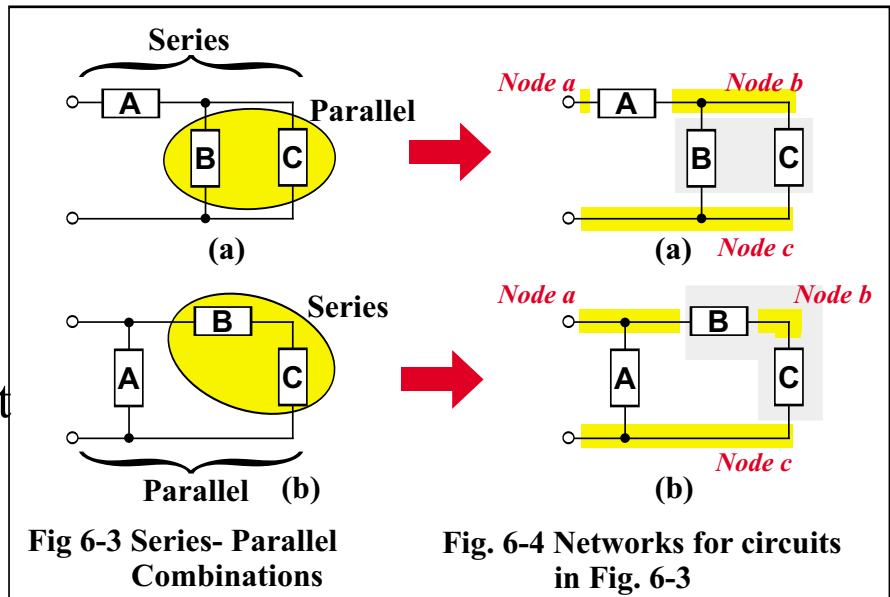
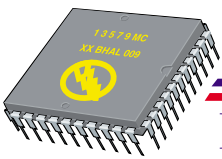


Figure 6-3 shows two series parallel combinations. Figure 6- 4 shows the nodes for each network.

In Fig. 6-4 (a), *element B is in parallel with element C* since they each have *nodes b and c* in common.

In Fig. 6-4 (b), *element B is in series with element C* since these elements have a single common node: *node b*.

The branch consisting of the series combination of elements B and C is then determined to be in parallel with element A.



Kirchhoff's Current Law

Kirchhoff's current law states the following: *the summation of currents entering a node is equal to the summation of currents leaving the node.*

$$\sum I_{\text{entering node}} = \sum \sum I_{\text{leaving node}}$$

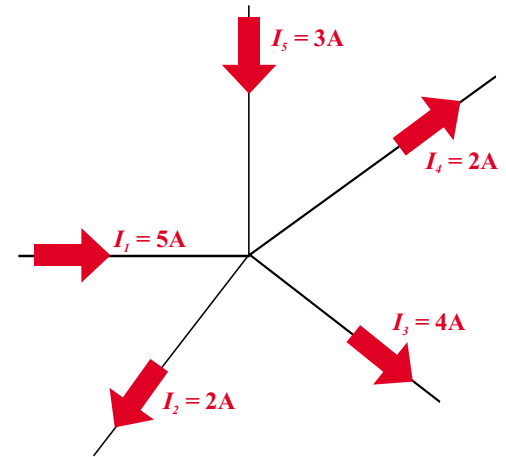


Fig. 6-5 Kirchhoff's Current Law

Resistors in Parallel

Figure 6-6 shows a simple parallel circuit.

The voltage source will result in current from of a positive terminal of the source towards *node a* as shown.

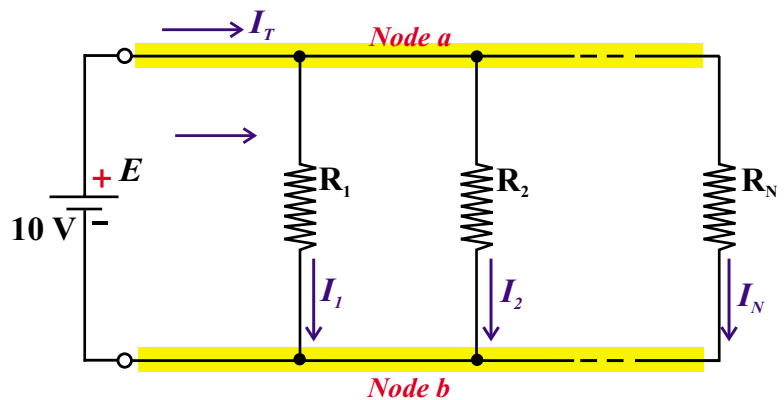


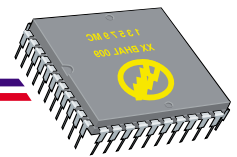
Fig 6-6 Parallel Resistors

At this point the current will split between the various resistors and then recombined at *node b* before continuing to the negative terminal of the voltage source.

Node a is connected to the positive terminal of the voltage source and *node b* is connected to the negative terminal. Each resistor has one end connected to *node a* and the other to *node b*.

It should be obvious that there will be 10 volts across each resistor.

The voltage across all parallel elements in a circuit will be the same

**Finding The Total Resistance**

The equivalent resistance for parallel resistor circuit may be determined in one step as follows:

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_1} + \dots + \frac{1}{R_N}} \quad [\Omega]$$

An important effect of combining parallel resistors is that the resultant resistance will always be smaller than the smallest resistor in the combination.

Examples 6-4 and 6-5 Page 184-185**Equal Resistors In Parallel**

For equal value resistors in parallel the formula is:

$$R_T = \frac{R}{n} \quad [\Omega]$$

Remember that this formula only works for equal value resistors.

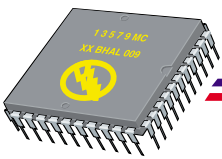
If we had 4 -100 Ω resistors in parallel, R_T would be $100/4 = 25 \Omega$.

Two Resistors In Parallel

Very often circuits have only two resistors in parallel. In such a case, the total resistance of the combination may be determined using this formula:

$$R_T = \frac{R_1 R_2}{R_1 + R_2} \quad [\Omega]$$

Examples 6-6, 6-7 and 6-8 Page 186-188



Voltage Sources in Parallel

Voltage Sources in Parallel

When *two equal potential sources* are connected in parallel, each source will deliver half the required circuit current.

For this reason automobile batteries are sometimes connected in parallel to assist starting a car with a “weak” battery.

Figure 6-7 skills to batteries of equal potential connected in parallel across a load. If the load draws 2 A, each battery will provide 1 A each.

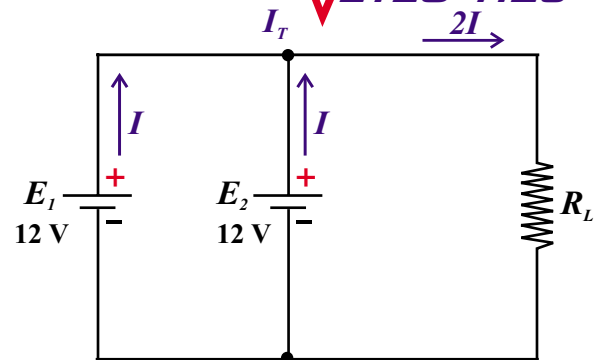


Fig 6-7 Two equal voltage sources in parallel

Voltage sources of different potentials should never be connected in parallel.

If voltage sources of different potentials are placed in parallel, the result can be disastrous. Very high currents can occur between the two batteries even if no load is present.

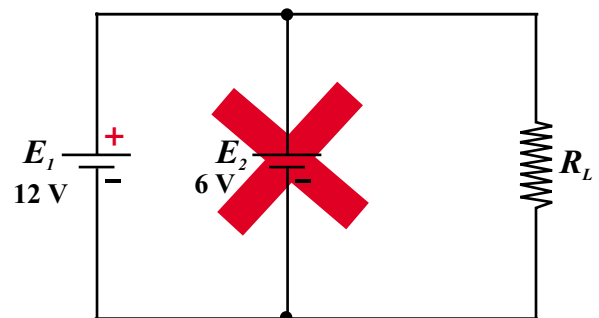
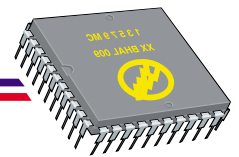


Fig 6-8 **Voltage sources of different potentials must never be placed in parallel.**

In the case of automotive batteries, connecting a 6 V and 12 V battery in parallel can cause a current high enough to permanently damage the batteries. In some cases the batteries may explode due the heat created by their internal resistance.

One More Time

Voltage sources of different potentials should never be connected in parallel.



The Current Divider Rule

In parallel networks, the voltage across all parallel elements is the same. However, the currents through the various elements are typically different.

Recall that a series circuit can be viewed as a voltage divider, because the source voltage is divided among the resistors in the circuit.

In a similar fashion, a parallel circuit can be viewed as a current divider, because the source current is divided among the branches in the circuit.

The current divider rule is used to determine how current entering the circuit is split between the various parallel resistors connected to it.

The current divider rule is as follows:

$$I_x = \frac{R_T}{R_x} I_T$$

using resistance

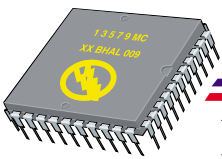
$$I_x = \frac{G_x}{G_T} I_T$$

using conductance

A Review of Conductance

Remember that resistance is a measure of the opposition to current flow. **Conductance**, by contrast *is the inverse of resistance*. It expresses how readily current can flow through material. The unit of measure for conductance (G.) is Siemens (S.). The relationship between resistance and conductance is:

$$G = \frac{1}{R}$$



Parallel Networks

Parallel Networks -- Important Characteristics

1. If current enters a parallel network consisting of any number of ***equal*** resistors, then the current entering the network will ***split equally*** between all of the resistors.
2. If current enters a parallel network consisting of ***several values of resistance***, then the ***smallest value*** of resistor in the network will have the ***largest*** amount of current.
Inversely, the ***largest value*** of resistance will have the ***smallest*** amount of current.

This characteristic may be simplified by saying that ***most of the current will follow the path of least resistance.***

Examples 6 -10, to 6-15 Pages 192 to 197