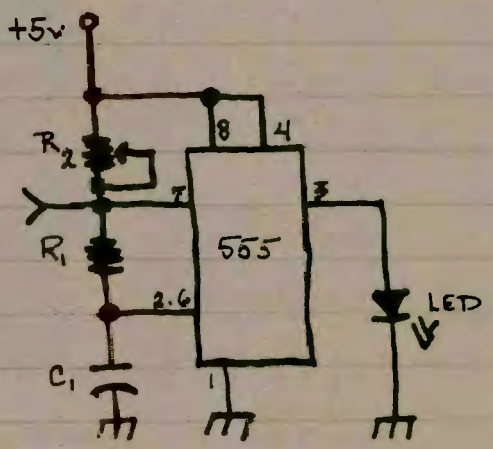
## A Resistor Is An Electricity Sponge

The more water pressure in a pipe, the more water that flows. Similarly, the more volts in a circuit, the more electricity that flows. Volts are the pressure making electrons, or current, flow. The more volts of pressure, the more electrons that flow.

Electron flow, then, is current. Sometimes it's good to have a part of the circuit resist current flow. Thus, we have **resistors**. Resistors are like sponges pushed into water pipes. A sponge would soak up some water before passing it on. To get more water through, you would have to increase the pressure. Similarly, raise the voltage to pressure more current through a resistor in an electrical circuit.




Schematic symbols

We have labels used to name the measures of electricity:

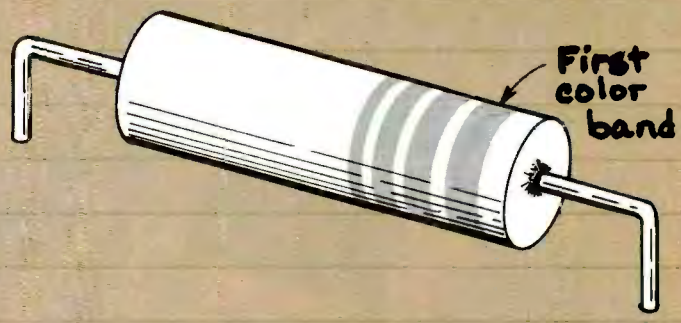
**a.** The electromotive force or pressure in a circuit is measured in **volts**.

**b.** Current flow is measured in amperes or **amps**, for short.

**c.** Resistance provided in a circuit by a resistor is measured in **ohms**. We use the symbol Ω to indicate ohms.

A zig-zag line, in a circuit diagram, indicates a resistor. This schematic represents a timer which will light the LED periodically. Resistor $R_1$ has a fixed value. $R_2$ is variable, like a radio volume control. $C_1$ is a capacitor and 555 is an integrated circuit "chip."

A resistor is a tube with stripes and a wire coming out of each end.




Here are the numbers matching the first two color bands on a resistor. The third band shows the number of zeros following. For example, a 4700 ohm resistor is yellow, violet and red in that order.

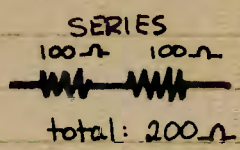
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| BROWN | 1 | ORANGE | 3 | GREEN | 5 | VIOLET | 7 | WHITE | 9 |
| RED | 2 | YELLOW | 4 | BLUE | 6 | GRAY | 8 | BLACK | 0 |

## What if none of your resistors is the right value?

Resistors are manufactured in standard values. Experimenters often stock several values. But, what if you need a 200 ohm resistor and have only two at 100 ohms?

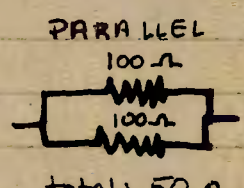
Easy! Put the two end to end in "**series**" in the circuit and add their values.

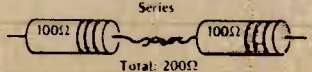
$$R_1 + R_2 + R_3 + R_N = R_{total}$$

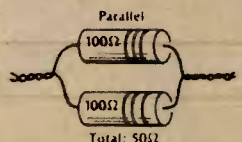



If you had placed the two 100 Ω resistors side by side in "**parallel**" in the circuit, the formula would be:

$$R_{total} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_N}}$$




## Measuring devices

I. **Ammeter** measures current.
II. **Voltmeter** measures emf or voltage.
III. **Ohmmeter** measures resistance.

This instrument is a **volt-ohmmeter** (VOM) to measure volts, amps and ohms. It is model 3300 by Triplett. Meters and test gear make it possible to build or repair electronic equipment.

There is a nice thing about volts, amps and ohms. They relate in a very predictable fashion. Rule of thumb for this relationship is **Ohm's law.**

## Ohm's law

Here's the formula: $E = IR$

E = volts
I = amps
R = ohms

To find volts in a circuit multiply amps times ohms. For example, 100 volts equals 2 amps times 50 ohms.

Turn the formula around to calculate amps. For instance, divide 100 volts by 50 ohms to compute 2 amps.

$$I = \frac{E}{R}$$

Or divide 100 volts by 2 amps to get 50 ohms.

$$R = \frac{E}{I}$$

## Power: how many watts in that circuit?

The strength of an electrical circuit is its power, measured in **watts**. Power can be calculated with the formula: $P = EI$

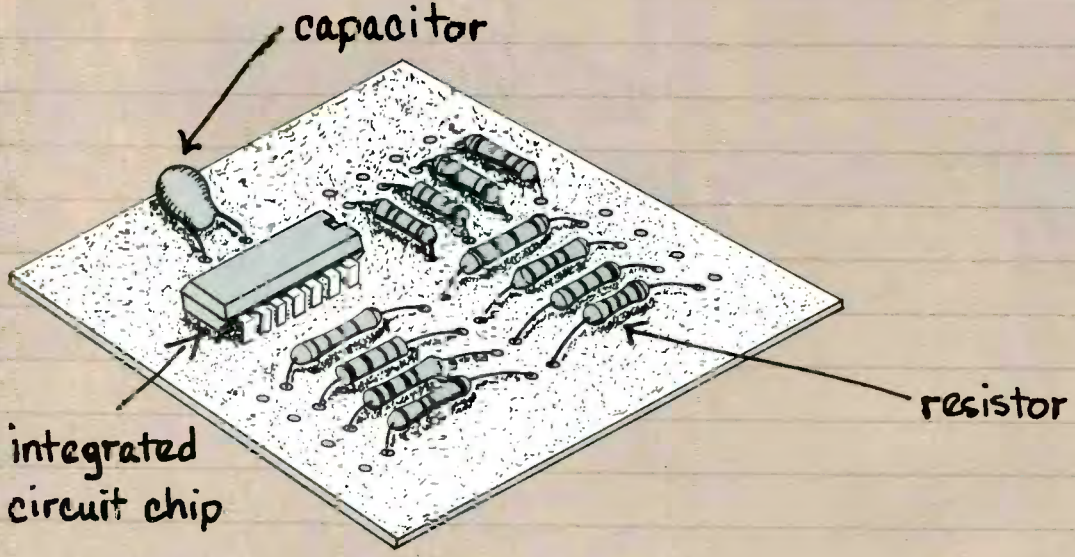
P = watts
E = volts
I = amps

For example, 12 volts pushing 5 amps equals 60 watts.

$12 \times 5 = 60$

Resistors have to be physically big enough to withstand the power of the circuit they are in. For instance, a 10 watt resistor is needed in a circuit where 5 volts and 2 amps are present.

$P = EI. \quad 10 = 5 \times 2$




1978-style hardware usually is built of individual parts soldered to a **printed circuit board**. Above, a PC board holds resistors, a capacitor and an IC.