



## 10 - Electrical current - basic principles and nomenclature



**Voltage:** is the difference of electrical potential between two points of an electronic circuit, expressed in volts (V). It is a measure of the capacity (not the technical meaning) of an electric field to cause an electric current in an electrical conductor. Depending on the difference of electrical potential it is called extra low voltage, low voltage, high voltage or extra high voltage.

Voltage is measured with the voltmeter connected in parallel to the electric circuit.

**Current:** is by definition the flow of electric charge in an electrical conductor, expressed in ampere (A). Current is measured with the amperometer connected in series to the electric circuit.

**Power:** measured in Watt (W) is the product between current and voltage .  $W = V \times I$

For example a 15 mm valve power is 2,3W at 24 VDC

Current =  $2,3 / 24 = 0,095 \text{ A} = 95 \text{ mA}$

Power =  $24 \times 0,095 = 2,3 \text{ W}$

**Frequency:** is the measurement of the number of times that a repeated event occurs per unit of time. It is also defined as the rate of change of phase of a sinusoidal waveform. Is measured in Hertz (Hz). In Europe the frequency is 50Hz, In the USA is 60Hz.

In order to use a 50Hz coil on a 60Hz application it is necessary to compensate the voltage by a 60/50 factor and vice-versa

$$V(60\text{Hz}) = V(50\text{Hz}) \cdot (60/50) \quad V(50\text{Hz}) = V(60\text{Hz}) \cdot (50/60)$$

**Alternating current (AC)** is an electrical current whose magnitude and direction vary cyclically, as opposed to direct current, whose direction remains constant. The usual waveform of an AC power circuit is a sine wave. The number of repetitions per second is the frequency

**Direct current (DC)** is an electrical current whose magnitude and direction remain constant in time. In a Direct current system it is important to observe the current direction, or the polarity.

**Resistance (R):** is a measure of the degree to which an object opposes the passage of an electric current, measured in ohm ( $\Omega$ ).

The quantity of resistance in an electric circuit determines the amount of current flowing in the circuit for any given voltage applied to the circuit.

In a long wire with small section the resistance will be greater than in a short wire with a larger section. This is similar to what happens in pneumatic applications where with a long and small bore pipe, the flow is smaller than in a shorter pipe with larger bore.

## Coils

The coil working principle is based on a conductor (usually copper wire) wound around a cylindrically shaped support manufactured in a non-magnetic material. When energised the conductor generates a magnetic field which passes through the centre of the coil itself. If a metallic object is positioned in the centre of the support, the magnetic field strength is increased. The two points where the magnetic field enters the coils represent its magnetic poles as in a magnet.

## Magnetic gap

In an electromagnetic system the magnetic gap is the distance between the moving metal core and the fixed armature. When working with alternating current the impedance is maximum when the magnetic gap is nil and vice versa (impedance is minimum when the magnetic gap is maximum). As a consequence, according to Ohm's law, the current consumption is higher at start up and lower during the holding condition.

## Shading ring

The magnetic field generated by an alternating current coil periodically fluctuates from a maximum value to zero which generates vibration of the moving core. The solution to this phenomenon is the "shading ring" which is a small copper ring positioned at the end of the fixed armature. The shading ring generates an out of phase current which prevents the magnetic field from reaching zero, such that the vibration is not longer perceptible

## Equations

Voltage	$V = R \times I$	Volt (V)	Product of resistance and current
Current	$I = V / R$	Ampere (A)	Voltage / resistance ratio
Power	$= V \times I$	Watt (W)	Product of voltage and current
	$W = R \times I^2$		Product of resistance and current <sup>2</sup>
	$= V^2 / R$		Voltage <sup>2</sup> / resistance ratio
Resistance	$R = V / I$	Ohm ( $\Omega$ )	Voltage / current ratio
	$= V^2 / W$		Voltage <sup>2</sup> / power ratio