3. Electrical Units of Measure

The standard SI units used for the measurement of voltage, current and resistance are the Volt [V], Ampere [A] and Ohms [Ω] respectively. Sometimes in electrical or electronic circuits and systems it is necessary to use multiples or sub-multiples (fractions) of these standard units when the quantities being measured are very large or very small. The following table gives a list of some of the standard units used in electrical formulas and component values.

Standard Electrical Units

Parameter	Symbol	Measuring Unit	Description
Voltage	Volt	V or E	Unit of Electrical Potential **V = I × R**
Current	Ampere	I or i	Unit of Electrical Current **I = V ÷ R**
Resistance	Ohm	R or Ω	Unit of DC Resistance **R = V ÷ I**
Conductance	Siemen	G or ℧	Reciprocal of Resistance **G = 1 ÷ R**
Capacitance	Farad	C	Unit of Capacitance **C = Q ÷ V**
Charge	Coulomb	Q	Unit of Electrical Charge **Q = C × V**
Inductance	Henry	L or H	Unit of Inductance $V_L = -L(di/dt)$
Power	Watts	W	Unit of Power **P = V × I**
Impedance	Ohm	Z	Unit of AC Resistance $Z^2 = R^2 + X^2$
Frequency	Hertz	Hz	Unit of Frequency $f = 1 \div T$

Multiples and Sub-multiples

There is a huge range of values encountered in electrical and electronic engineering between a maximum value and a minimum value of a standard electrical unit. For example, resistance can be lower than 0.01Ω's or higher than 1,000,000Ω's.

By using multiples and submultiple's of the standard unit we can avoid having to write too many zero's to define the position of the decimal point. The table below gives their names and abbreviations.

Prefix	Symbol	Multiplier	Power of Ten
Terra	T	1,000,000,000,000	10^{12}
Giga	G	1,000,000,000	10^{9}
Mega	M	1,000,000	10^{6}
kilo	k	1,000	10^{3}
none	none	1	10^{0}
centi	c	1/100	10^{-2}
milli	m	1/1,000	10^{-3}
micro	µ	1/1,000,000	10^{-6}
nano	n	1/1,000,000,000	10^{-9}
pico	p	1/1,000,000,000,000	10^{-12}

So to display the units or multiples of units for either Resistance, Current or Voltage we would use as an example:

- 1kV = 1 kilo-volt - which is equal to 1,000 Volts.
- 1mA = 1 milli-amp - which is equal to one thousandths (1/1000) of an Ampere.
- 47kΩ = 47 kilo-ohms - which is equal to 47 thousand Ohms.
- 100uF = 100 micro-farads - which is equal to 100 millionths (1/1,000,000) of a Farad.
- 1kW = 1 kilo-watt - which is equal to 1,000 Watts.
- 1MHz = 1 mega-hertz - which is equal to one million Hertz.

To convert from one prefix to another it is necessary to either multiply or divide by the difference between the two values. For example, convert 1MHz into kHz.

Well we know from above that 1MHz is equal to one million (1,000,000) hertz and that 1kHz is equal to one thousand (1,000) hertz, so one 1MHz is one thousand times bigger than 1kHz. Then to convert Mega-hertz into Kilo-hertz we need to multiply mega-hertz by one thousand, as 1MHz is equal to 1000 kHz. Likewise, if we needed to convert kilo-hertz into mega-hertz we would need to divide by one thousand. A much simpler and quicker method would be to move the decimal point either left or right depending upon whether you need to multiply or divide.

As well as the "Standard" electrical units of measure shown above, other units are also used in electrical engineering to denote other values and quantities such as:

- Wh – **The Watt-Hour**, The amount of electrical energy consumed in the circuit by a load of one watt drawing power for one hour, eg a Light Bulb. It is commonly used in the form of **kWh**(Kilowatt-hour) which is 1,000 watt-hours or **MWh** (Megawatt-hour) which is 1,000,000 watt-hours.
- dB – **The Decibel**, The decibel is a one tenth unit of the Bel (symbol B) and is used to represent gain either in voltage, current or power. It is a logarithmic unit expressed in **dB** and is commonly used to represent the ratio of input to output in amplifier, audio circuits or loudspeaker systems.
  For example, the dB ratio of an input voltage (Vin) to an output voltage (Vout) is expressed as $20\log_{10}(Vout/Vin)$. The value in dB can be either positive (20dB) representing gain or negative (-20dB) representing loss with unity, ie input = output expressed as 0dB.
- θ – **Phase Angle**, The Phase Angle is the difference in degrees between the voltage waveform and the current waveform having the same periodic time. It is a time difference or time shift and depending upon the circuit element can have a "leading" or "lagging" value. The phase angle of a waveform is measured in degrees or radians.
- ω – **Angular Frequency**, Another unit which is mainly used in a.c. circuits to represent the Phasor Relationship between two or more waveforms is called Angular Frequency, symbol **ω**. This is a rotational unit of angular frequency $\mathbf{2\pi}\boldsymbol{f}$ with units in *radians per second*, **rads/s**. The complete revolution of one cycle is 360 degrees or 2π, therefore, half a revolution is given as 180 degrees or π rad.
- τ – **Time Constant**, The Time Constant of an impedance circuit or linear first-order system is the time it takes for the output to reach 63.7% of its maximum or minimum output value when subjected to a Step Response input. It is a measure of reaction time.

In the next tutorial about DC Theory we will look at **Kirchoff's Circuit Law** which along with Ohms Law allows us to calculate the different voltages and currents circulating around a complex circuit.

Ref: http://www.electronics-tutorials.ws/dccircuits/dcp_3.html 23 March 2014/Benny Haastrup