South Bristol Amateur Radio Club
Lesson 4 – Technical Basics 02: Prefixes and Ohms Law
Syllabus sections 3a.1, 3b.1 – 3b.3

The Foundation Licence requires that you have a basic, but sound, understanding of the concepts of electricity and current flow. However before we launch into this we need to formally introduce a basic principle of the SI units.

In the SI of units, all measurable quantities have a fundamental unit. So items you will be aware of from every day use are:

length – fundamental unit the *metre*
mass – fundamental unit the *gramme*
time – fundamental unit the *second*

And from this course you will already have come across:

frequency – fundamental unit the *Hertz*

However, there are many instances when the fundamental unit is not a practical way to describe what is being measured. For example the distance from Bristol to London is approximately 188,000m (metres). Clearly this is a rather unwieldy amount for every day use.

To overcome this the SI mechanism introduces a range of prefixes which effectively scale up (increase) or scale down (decrease) the fundamental units. Whilst there are a whole range of these prefixes most are too specialised for use in the foundation course and we will restrict ourselves to the more common ones.

Taking the example above; instead of saying Bristol to London was 188,000m (metres) it would be more useful to say that Bristol to London was 188km (kilometres). The use of the prefix “kilo” means multiply by 1,000.

Similarly a bolt or screw that is 0.004m (metres) in diameter is more usually referred to as being 4mm (millimetres) in diameter. The use of the prefix “milli” means divide by 1,000.

The table below lists the more common prefixes that will be employed throughout the Foundation Course.

Prefix	Symbol	Scale	Multiplier	$x10^n$
mega-	M	Million	1,000,000	$x10^6$
kilo-	k	Thousand	1,000	$x10^3$
(none)	(none)	One	1	$x10^0$
milli-	m	Thousandth	0.001	$x10^{-3}$

We can see that, for example:

- 1mA (milliamp) is one thousandth of an Amp (0.001A)
- 500mA is five hundred thousandths of an Amp, or half an Amp (0.5A)
- 1000mA is one Amp (1A)
- 1500mA is one and a half Amps (1.5A)
- 1kW (kilowatt) is one thousand watts (1,000W)
- 11.5kV is eleven thousand five hundred volts (11,500V)
- 435MHz (Mega-Hertz) = 435,000kHz (kilo-Hertz) = 435,000,000Hz (Hertz)

The fundamental units that we will encounter in electricity at the level of the foundation course are:

Current (symbol I) – fundamental unit the *Ampere* (A)
Potential Difference or Voltage (symbol V) – fundamental unit the *Volt* (V)
Resistance (symbol R) – fundamental unit the *Ohm* (Ω)
Power (symbol P) – fundamental unit the *Watt* (W)

Electricity flows through wires and circuits in much the same way as water flows through pipes. Current measures the amount of electricity flowing in the circuit. In fact electricity is the movement of electrons (atomic particles) within the materials making up the wires and components within a circuit.

Materials fall into two basic categories:

- **Conductors**
- **Insulators**

In CONDUTORS the electrons flow easily and in INSULATORS they do not flow at all.

All metals are conductors. Copper and Brass are often used in circuits and components because they are a good conductor and relatively cost effective. Gold and silver are excellent conductors, but their high value prohibits their use in all but the most high end equipment.

Most non-metals are insulators, these materials still have highly desirable properties in electrical circuits. Typical insulators are:

- Ceramic & Glass – high voltage insulators, e.g. at the end of wire aerials because high RF voltages are present when transmitting
- Rubber & Plastic – to cover wires and cables
- Polythene and PTFE – to insulate the centre conductor of coaxial cable, coaxial plugs and sockets
- Plastics – to encase integrated circuits
- Fibreglass – the base material of many printed circuits

Water is a conductor, and this can be a problem. Moisture on the outside of an insulator can allow current to flow through the moisture, wet air and wood also increase their conductivity when the moisture content increases.

The current is the amount of electricity flowing through a circuit and is measured in Amps (A). A higher current will require thicker wires to flow than a lower current, like thicker pipes to carry more water.

The pressure of the electricity flowing (also called potential difference) is measured in volts (V). This is like the difference in level between a water header tank and a tap. The larger the difference in height, the higher the pressure at the tap.

To control the flow of water in a system, pressure-regulating valves may be used. This can be likened to using resistors in an electrical circuit. Resistors make it harder for electricity to flow through the circuit. This is called resistance and is measured in Ohms. The Greek symbol Ω (omega) is used to represent Ohms.

Power is the amount of electricity an appliance consumes when running. Power is measured in Watts (W).

There is a direct relationship between current, voltage, resistance and power. This is called Ohm's Law.

To assist in remembering and using Ohm's Law, we have two mnemonic triangles.

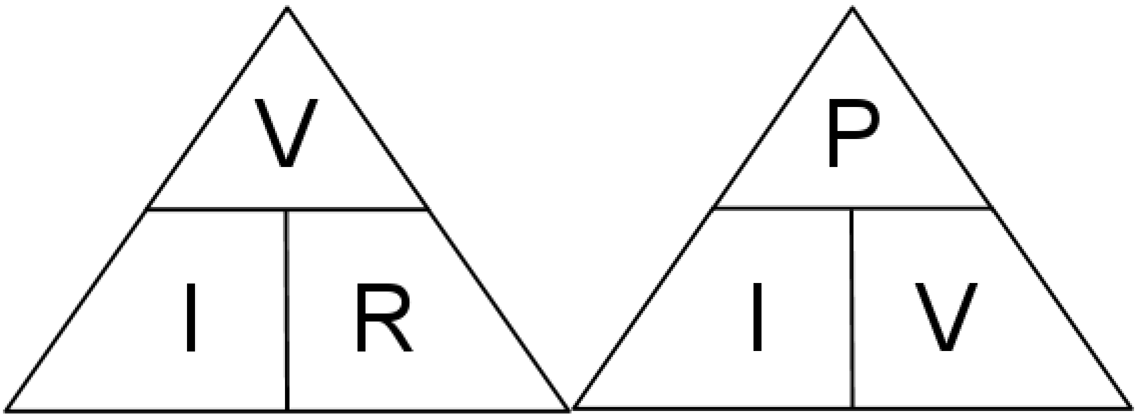

Figure 1 - Ohms Law Mnemonic Triangles

Using the left hand triangle, it is easy to calculate one of the three values in an electrical circuit if you know the other two. Cover up the value you want to find to determine the correct formula. The horizontal line is the divide line and the vertical line is the multiply line.

From the triangle in figure 1 we can create three formulae.

- V = I x R or V=IR (Voltage = Current x Resistance)
- I = V / R (Current = Voltage divided by Resistance)
- R = V / I (Resistance = Voltage divided by Current)

We can apply the same rules to the right hand triangle and create three more formulae.

- P = I x V or P=IV (Power = Current x Voltage)
- I = P / V (Current = Power divided by Voltage)
- V = P / I (Voltage = Power divided by Current)

When working with these formulae, always remember to convert all units back to their fundamental units to avoid any confusion about the order of magnitude of the result. If the result should then be a large or small amount the application of prefixes can simplify the value.

Thus Volts and Amps will always produce Ohms. Similarly Volts and Ohms will always produce Amps and Amps and Ohms will always produce Volts.

Volts and Amps will always produce Watts, Watts and Volts will always produce Amps and Watts and Amps will always produce Volts.

Some example questions are on the Ohms Law worksheet (attached).

Next Lesson
Feeders and Antennas

Lesson 4 – Summary

At the end of this lesson you should be able to:

- Identify the units of, and abbreviations for Potential Difference (Voltage), Current, Power and Resistance. *Note: Prefixes milli, kilo and Mega may be used.*
- Understand that in a metallic conductor, an electric current is the flow of electrons. Recall that a conductor allows the electrons to flow easily and an insulator does not.
- Understand that metals such as copper and brass are good conductors. Plastics, wood, rubber, glass and ceramics are regarded as insulators.
- Understand that water is a conductor, and that wet insulators can conduct electricity through the surface water.
- Recall the relationship between Potential Difference (Voltage), Current and Power (P=VxI, I=P/V, V=P/I).
- Calculate the unknown quantity given the numerical value of the other two.
- Recall that Resistance is the opposition to Current flow.
- Recall the relationship between Potential Difference (Voltage), Current and Resistance (V=IxR, I=V/R, R=V/I).
- Calculate the unknown quantity given the numerical value of the other two.