202: Principles of electrical science  
**Handout 13: Sine wave quantities**

**Learning outcome**

The learner will:

1. Understand the fundamental principles which underpin the relationship between magnetism and electricity.

**Assessment criteria**

The learner can:

5.5 identify the **characteristics of sine-waves**

**Range**

**Characteristics of sine-waves**: Root Mean Square (RMS) value, Average value, Peak to peak value, Periodic time, Frequency, Amplitude.

**Sine wave quantities**

**What is alternating current?**

Alternating current (a.c.) is the flow of electrons, which rises to a maximum value in one direction and then falls back to zero before repeating the process in the opposite direction.

The electrons within the conductor do not just flow in one direction. They move backwards and forwards.

The journey taken from start to finish is one cycle and the number of cycles that occur every second is said to be the frequency.

When we look at a sine wave, there are several values that can be measured from the alternating waveform. These are shown on the following diagrams.

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| 01 Sine wave.png |

* **Amplitude** is the maximum voltage reached by the signal. It is measured in **volts** (**V**).
* **Peak voltage** is another name for amplitude.
* **Peak to peak voltage** is twice the peak voltage (amplitude).
* **Frequency** is the number of cycles per second. It is measured in **hertz (Hz)**.

**Periodic time** is the time taken for the signal to complete one cycle. It is measured in **seconds (s)**.

The **Instantaneous** value of an alternating voltage or current is the value of voltage or current at one particular instant. The value may be zero if the particular instant is the time in the cycle at which the polarity of the voltage is changing. It may also be the same as the peak value, if the selected instant is the time in the cycle at which the voltage or current stops increasing and starts decreasing. There are actually an infinite number of Instantaneous values between zero and the peak value.

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| 02 Sine wave.png |

The **Average** value of an alternating current or voltage is the average of **all** the Instantaneous values during **one** alternation. Since the voltage increases from zero to peak value and decreases back to zero during one alternation, the average value must be some value between those two limits. You could determine the average value by adding together a series of instantaneous values of the alternation (between 0° and 180°) and then dividing the sum by the number of instantaneous values used. The computation would show that one alternation of a sine wave has an average value equal to **0.636** times the peak value. The formula for average voltage is:

Where Vavg is the average voltage of one alternation, and Vpeak is the maximum or peak voltage. Similarly, the formula for average current is:

Where Iavg is the average current in one alternation, and Ipeak is the maximum or peak current.

Do not confuse the above definition of an average value with that of the average value of a complete cycle. Since the voltage is positive during one alternation and negative during the other alternation, the average value of the voltage values occurring during the complete cycle is **zero**.

The **effective** value of an alternating current or voltage is the value of alternating current or voltage that produces the same amount of heat in a resistive component that would be produced in the same component by a direct current or voltage of the same value. The effective value of a sine wave is equal to **0.707** times the peak value. The effective value is also called the **root mean square** or **RMS** value. The formula for RMS voltage is:

Where Vrms is the RMS voltage of one alternation, and Vpeak is the maximum or peak voltage. Similarly, the formula for RMS current is:

Where Irms is the average current in one alternation, and Ipeak is the maximum or peak current.

Also:

and

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| **The RMS value is the effective value of a varying voltage or current. It is the equivalent steady d.c. (constant) value which gives the same effect.** |

For example, a lamp connected to a **6V RMS a.c.** supply will light with the same brightness when connected to a **steady 6V d.c.** supply.

However, the lamp will be dimmer if connected to a **6V peak a.c.** supply because the RMS value of this is only 4.2V (it is equivalent to a steady 4.2V d.c.).

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Let’s look at the voltage we use on a daily basis.

**What does ‘230V a.c.’ really mean? Is it the RMS or peak voltage?**

If the peak value is meant then it should be clearly stated, otherwise assume it is the **RMS value**.

In everyday use a.c. voltages (and currents) are always given as **RMS values** because this allows a sensible comparison to be made with steady d.c. voltages (and currents), such as from a battery.

For example, a ‘6V a.c. supply’ means 6V RMS’; the peak voltage is 8.6V.

The UK mains supply is 230V a.c.; this means 230V RMS so the peak voltage of the mains is about 325V!

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