ELECTRICAL AND ELECTRONIC TECHNOLOGY

Syllabus Section 1: **Electrical Principles and Measurements**

Module Lesson: **Type of Currents**

LEARNING OUTCOMES:

At the end of this lesson, you are expected to do the following

- Define DC & AC Current
- Identify DC & AC currents graphically
- Identify A.C. terms graphically
- Convert peak AC values to RMS and Average values
- Show phase relationship between AC current waveforms

There are basically two (2) types of current flow through an electrical circuit, which depends mainly on the type of power source that supplies electrical energy to the circuit. The two (2) types of current flow are, Direct current (d.c.) and Alternating current (a.c.).

DIRECT CURRENT:

Direct current is current that flows in one direction only. This is because the polarities of the d.c. source are fixed and do not change direction. D.C. current may be of two (2) types:

(i) **Steady D.C. current:** Magnitude or value of current value does not change over time (fig1a)

(ii) **Variable D.C. current**: Magnitude of current value changes over time (fig 1b)

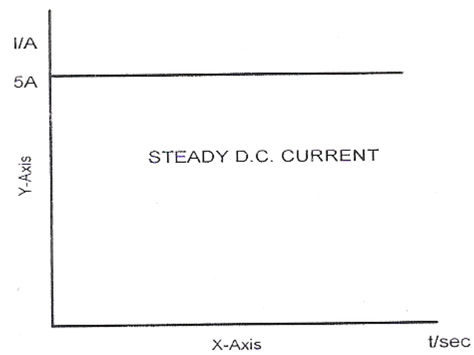


Fig 1(a) Steady d.c. current

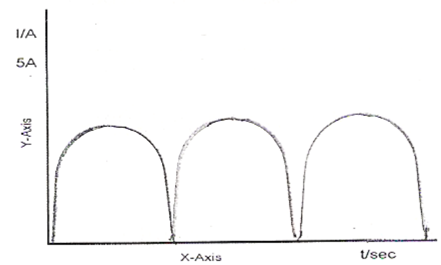


Fig1(b) Variable d.c. current

Some sources of d.c. current are: dry cells, solar cells, thermocouples, d.c. generators. The symbol for a dry cell is shown in Fig 1c and the general symbol of a d.c. source in Fig 1d.

Fig 1(c)

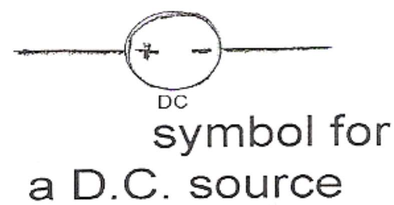


Fig 1(d)

ALTERNATING CURRENT(A.C.)

Alternating current is current flow that changes in both magnitude and direction. This is because the polarities of an a.c. source changes it's charge (positive [+ve] or negative [–ve] charge) continuously. A simple a.c. current takes the shape of a sinusoidal waveform (sine-wave). The diagram of a simple a.c. sinusoidal wave-form is shown in Fig 2.

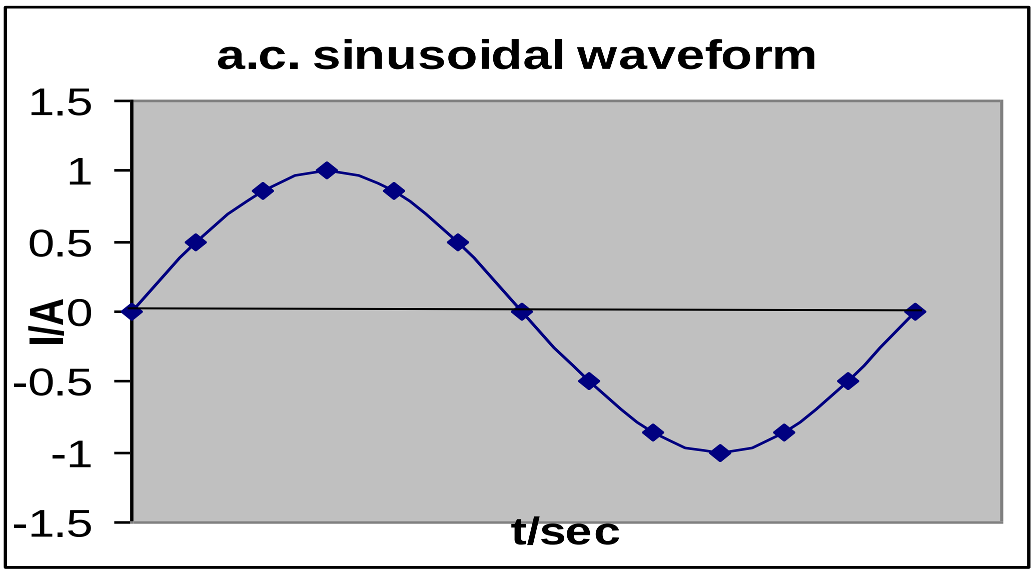


Fig 2: Diagram of a.c waveform

The main source of an a.c. current is an a.c. generator. The symbol for an a.c. source is shown in Fig 2b.

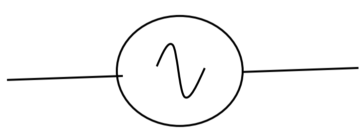


Fig 2 b: symbol for a.c.

ALTERNATING CURRENT TERMS

CYCLE: The movement of an a.c. waveform from zero value to maximum value, to zero value in one direction; then from zero value to maximum value, to zero value in the other direction, is termed one complete **cycle** of an a.c. current.

The diagram in fig 3 shows one complete a.c waveform. **A cycle can also be defined as one complete oscillation of an a.c. waveform.**

ALTERNATION: An alternation is defined as half a complete cycle of an a.c waveform. The a.c. waveform in Fig 3 has two (2) alternations.

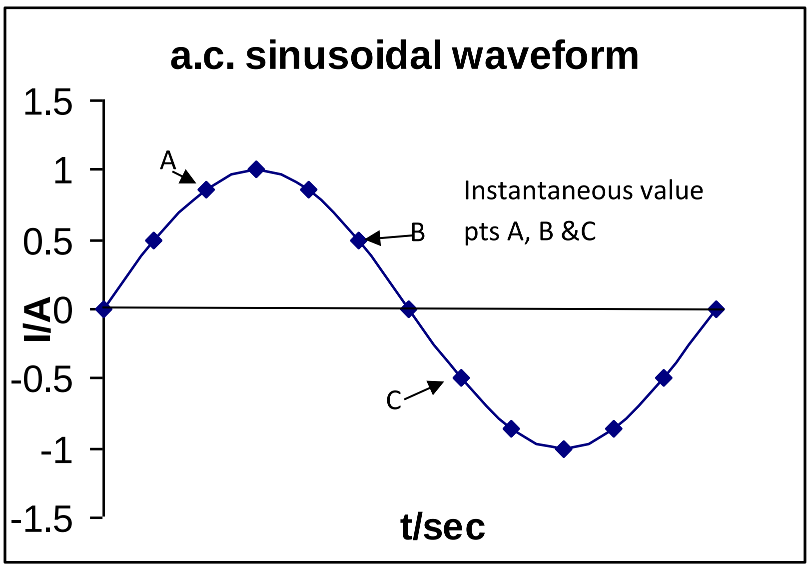


Fig 3: Complete cycle of an a.c. current waveform. Each half cycle is termed an alternation.

INSTANTANEOUS VALUE:

This is the value of a.c. current or voltage at one particular instant of time on the a.c. current sine-wave. Points A, B and C in Fig 3 are the instantaneous values at the particular moments in time shown in the sine-wave graph.

AMPLITUDE AND PEAK VALUE :

The maximum value of an a.c waveform is termed the amplitude or peak value of the a.c. waveform. Normally when the amplitude is expressed, the sign of the value is not indicated (+ve or –ve sign). With the peak value, the sign of the a.c. waveform as well as the value are also expressed. The peak values in fig 4 are 1A and -1A. The amplitude is 1A.

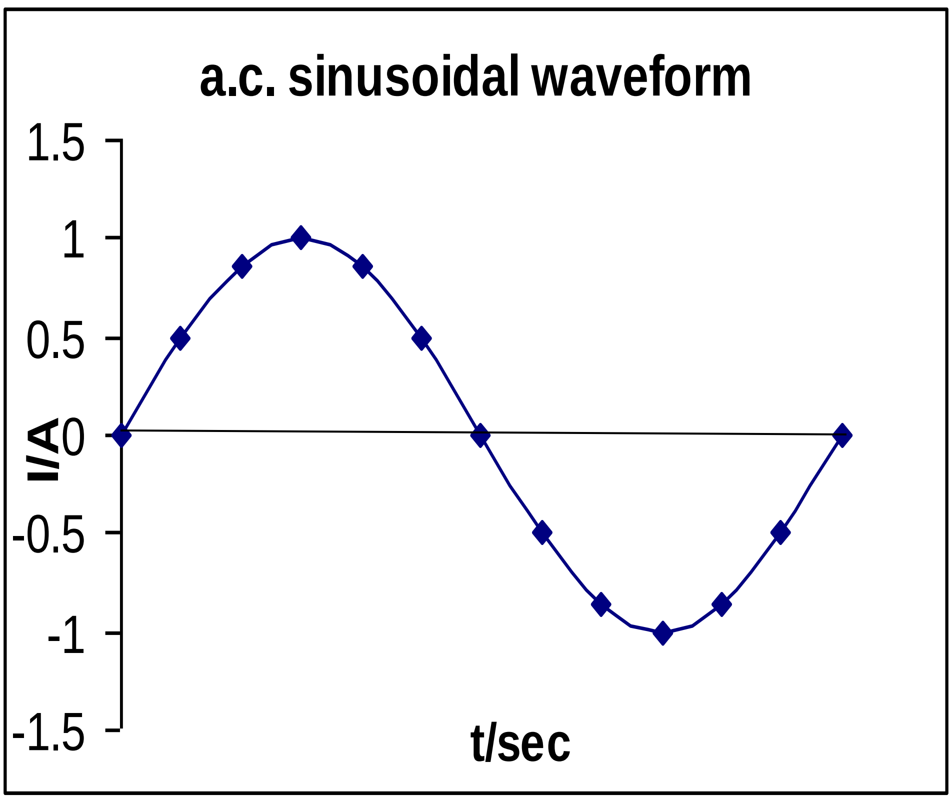


FIG 4: Diagram indicating peak and peak to peak values of a.c. current waveform

PEAK TO PEAK VALUE:

This is the value from one peak of the a.c. waveform to the other peak. For example, the peak to peak value of the a.c. waveform in fig 4, is 2A.

PERIOD: This is the time it takes for the a.c. current waveform to make one complete cycle. The period of an a.c waveform is represented by the symbol, T, and is measured in the units, seconds. The period of the a.c. waveform in fig 5 is 0.4 seconds.

FREQUENCY: The number of cycles of an a.c. current/voltage waveform completed in one second is termed the frequency of the a.c. current/voltage. The symbol for frequency is the letter 'f 'and it's unit, the Hertz(Hz). One (1) Hertz is equal to a frequency of one cycle per second.

The electric power generating company of Trinidad and Tobago, generates current for distribution at a frequency of 60 cycles/second or 60Hertzs(60Hz). There is a relationship between the frequency of an a.c waveform and its period. The frequency = 1/period (f = 1/T) and T=1/f . The frequency of the a.c. waveform in fig 5 is 21/2 Hz and the period is T = 1/f = 1/ 2.5 = 0.4secs.

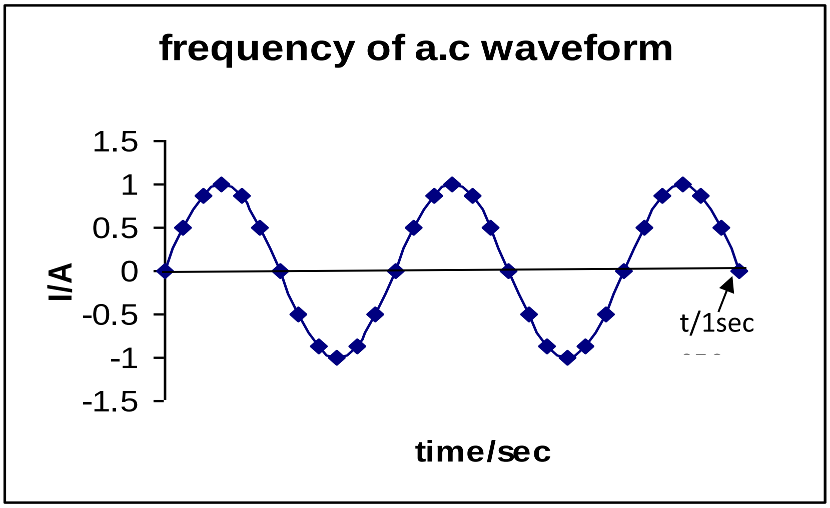


fig 5 : Diagram showing frequency of a.c waveform is 21/2 Hz.

ROOT MEAN SQUARE VALUE (R.M.S VALUE) :

If we were to measure an a.c. current or voltage, what result would the meter indicate as the value of the a.c. current is constantly changing? The answer is easy; the meter reads an equivalent steady d.c. source value. This equivalent d.c. value measured, would consume the same amount of heat and light energy in the circuit load as that powered by the a.c. source being measured in the circuit. This equivalent d.c. value indicated on the measuring instrument, is normally lower than the a.c peak value. Therefore, a 6volts d.c. source will not utilize the same amount of heat and light energy in circuit than an a.c. source with a peak value of 6volts.

If we were to connect a 6 volts steady d.c. source to a circuit for 10seconds, a constant 6volts would supply power and burn energy at a constant rate for those 10seconds. This would not be possible with an a.c. source having a peak value of 6Va.c.. At one moment in time, the a.c. value at the load may be 2Va.c., causing a certain amount of energy to be consumed at that value, while for another brief moment in time the a.c value is 4Va.c., then again, at 6Va.c.. If we were to sum up the total energy used after 10seconds from the a.c. source, it would certainly be less than that of the d.c. source which constantly powered the circuit with $6V_{d.c.}$ for those 10 seconds. In fact, if we were to measure the a.c. value with a meter it would actually result in a value of **4.2volts**. This value that the meter indicates is an equivalent d.c. value.

The **4.2volts steady d.c. value**, would utilize the same amount of heat and light energy as an a.c. source with a peak value of **6volts**. The 4.2volts indicated by the meter is called the **root mean square value (r.m.s. value).**

The r.m.s. value is usually calculated, by multiplying the constant value **0.707** to the a.c. peak value. Therefore, **Vr.m. s = 0.707 x Vp**, where, Vp, is the peak a.c. value.

So for an a.c peak voltage of 6volts, the r.m.s. voltage value is: **Vr.m.s. = 0.707 x 6 = 4.2V**. Also, the same thing applies for a.c. current, where; **$I_{r.m.s.}$ = 0.707 x I_p**. The r.m.s value is represented on the a.c. waveform as shown in fig 6.

It should be noted that whenever an a.c. value is given it should be understood as the r.m.s. value, unless stated otherwise. Other names for the r.m.s. value are also the **'effective value'** and the **'meter value'**.

The R.M.S. value is defined as, that instantaneous value of a.c. current that has the same heating and lighting effect as a d.c. current with the same numerical value. Therefore, the 4.2volts shown on the a.c. waveform in fig 6. is that a.c. voltage value (r.m.s. value) that is equivalent to the d.c. value that gives the same energy (heating & lighting) effect.

The AC receptacle outlet measured voltage of 120 Volts residential Installation is the RMS voltage.

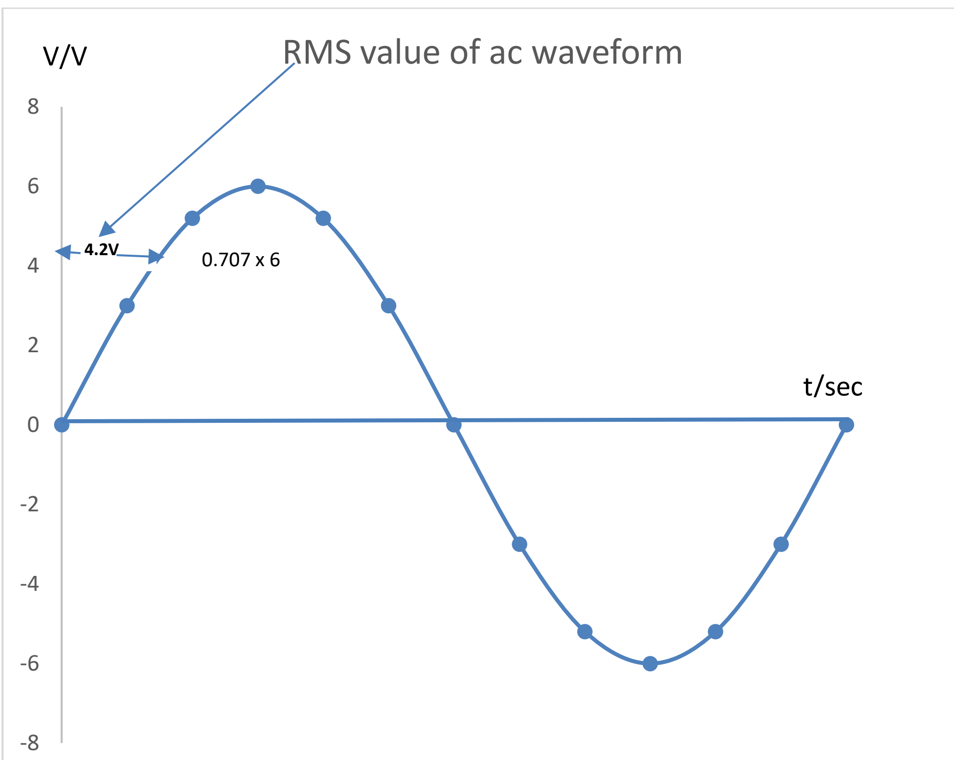


Fig 6 : Diagram indicating root mean square value

AVERAGE VALUE

The average value of an a.c. voltage or current is the average of all the instantaneous values during one half cycle, or alternation. Note that the average is not taken during the whole cycle of a sinusoidal a.c. waveform, since the values on both halves of the horizontal axis of the a.c. waveform, although identical, are however opposite in sign (+ve & -ve values). The average value of an a.c. sine-wave therefore, over one complete cycle, would give a result of zero. This is the reason the average is taken over half a cycle only.

The average of an a.c current or voltage is calculated as follows:

Vavg = 0.637 x Vp …………… Vavg (average voltage): Vp (peak voltage)

and

I avg = 0.637 x Ip …………… Iavg (average current): Ip (peak current)

The average value of an a.c. waveform however, does not really hold any real practical value or consideration in electricity and electronics. Fig 7. shows an a.c. waveform illustrating the average value.

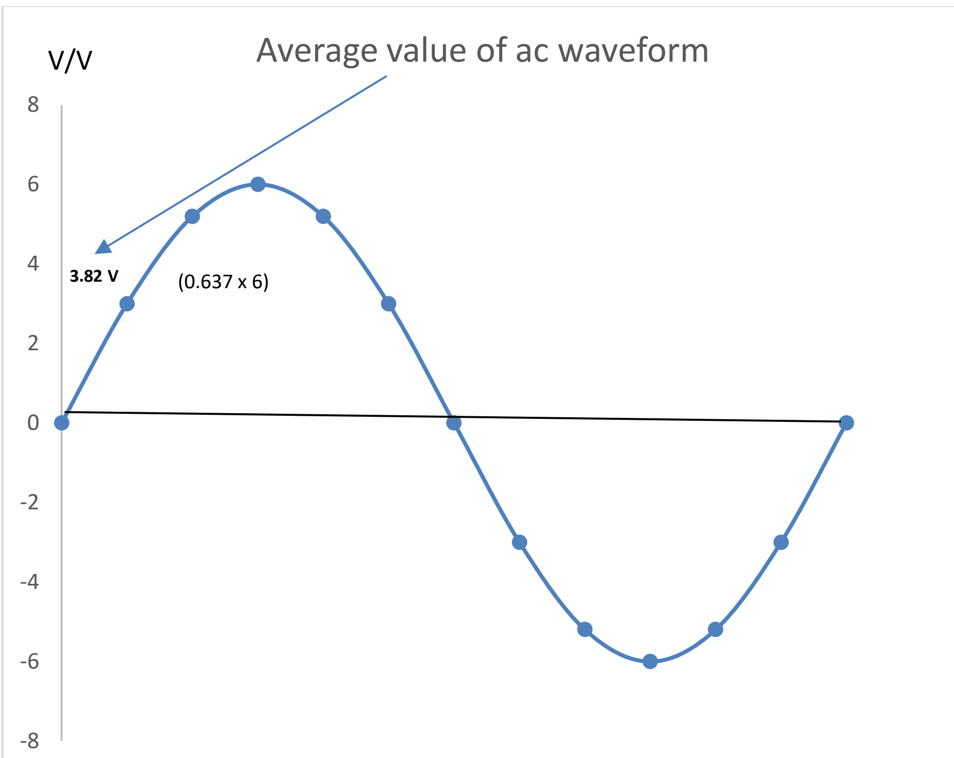


Fig 7 : Average value of a.c. waveform

<u>TIME AXIS IN DEGREES (A.C. CURRENT)</u>

The time axis of an a.c. sine-wave is normally expressed in degrees. This is more convenient when comparing multiple wave-forms on the same graph axis. A simple complete a.c. waveform with the time axis expressed in degrees is shown below in fig 8.

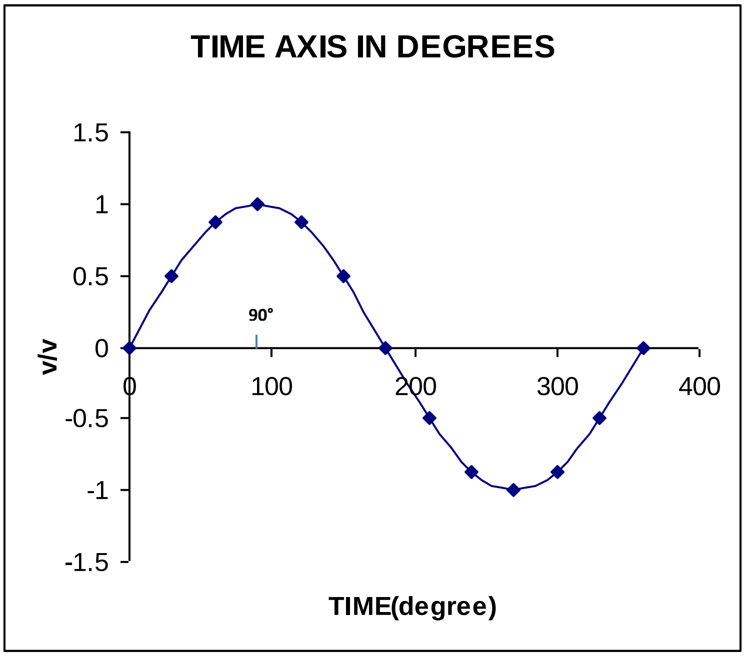


Fig 8: Time axis in degrees

Note: For a normal sine-wave, zero and maximum values have a 90º difference.

PHASE DIFFERENCE

When two a.c. wave-forms alternate in such a way that they go through zero and maximum values at the same time, we say that the two (2) wave-forms are in phase with each-other, fig 9.

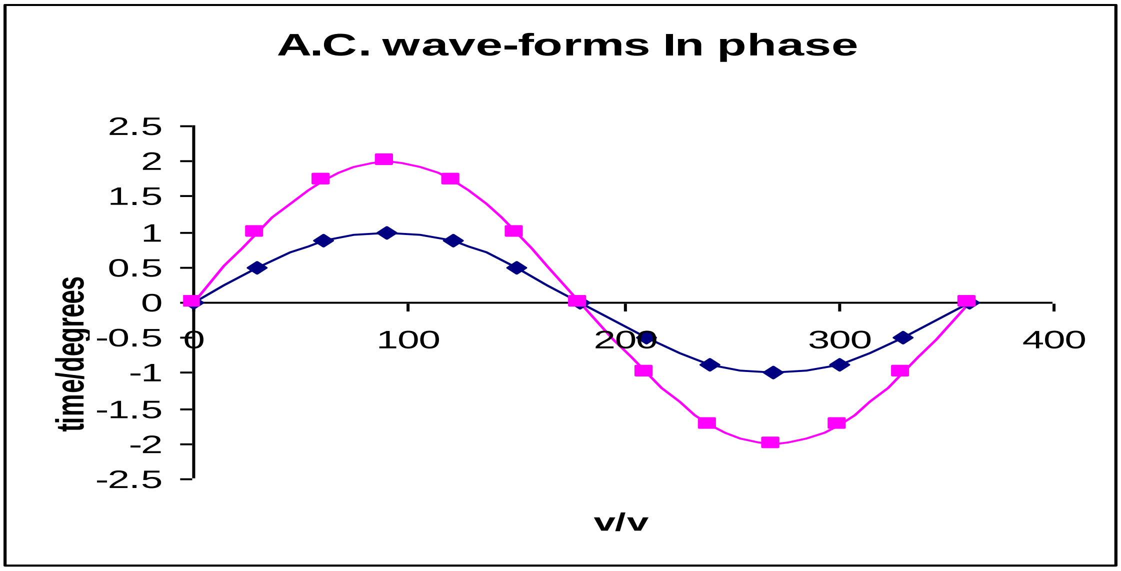


Fig 9: two (2) a.c wave-form in phase (zero phase difference)

If the two (2) wave-forms reach their zero and maximum values at different times, we say that they are **out- of- phase** with each-other. The extent by which they are out of phase with each-other, is expressed in degrees. The two (2) wave-forms shown in fig 10., are 90º out of phase with each-other. This is measured from two successive zero points **(waveforms sloping in the same direction)** of the two wave-forms.

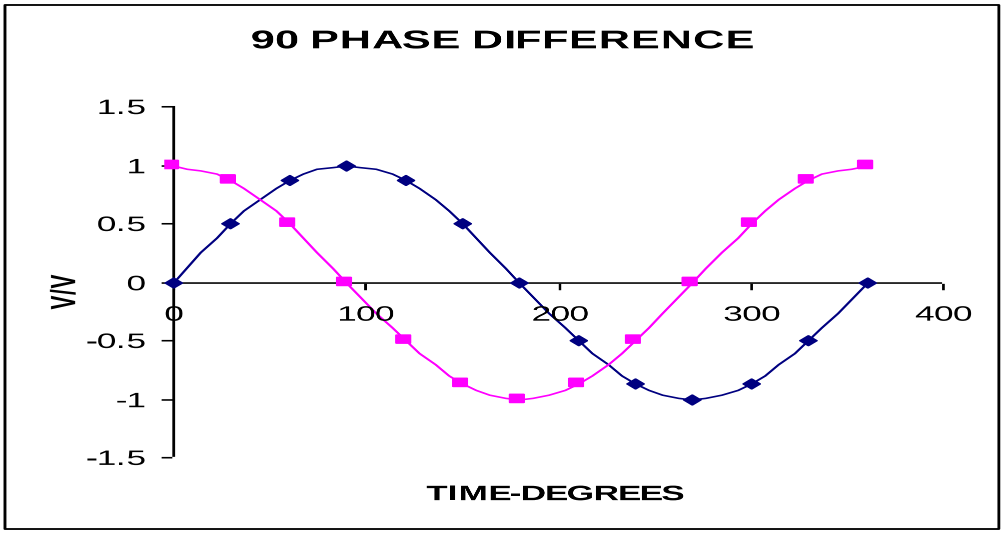


Fig 10: 90º phase difference

It should be noted that the Power Generation Company of Trinidad and Tobago, delivers electrical power to many Industries and Commercial sites using a system of three (3) voltage conductors, each of which are **120º out-of-phase** with one-another. This example is illustrated in fig11.

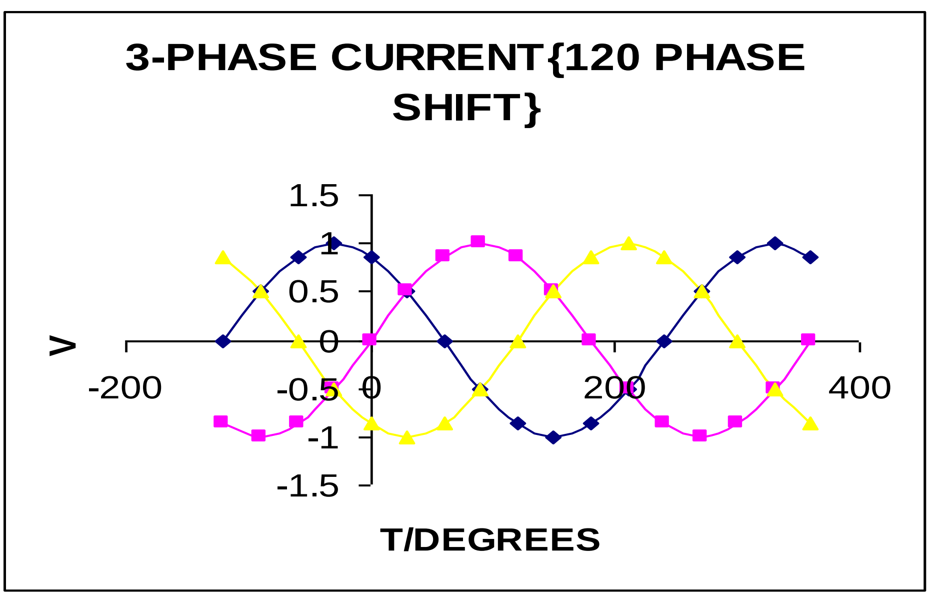


Fig 11: 3-phase system, illustrating 120º phase difference

TEST YOUR KNOWLEDGE

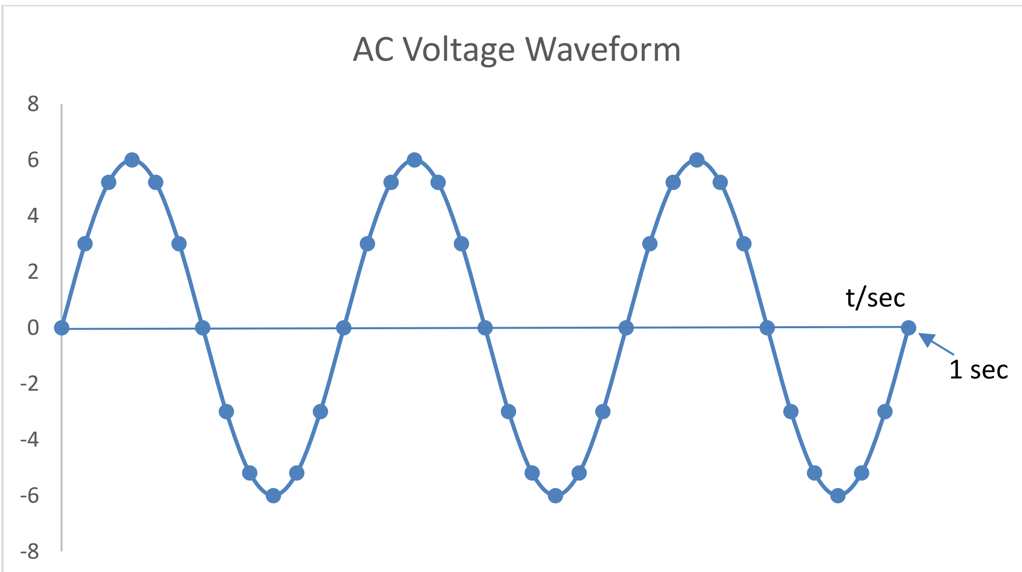
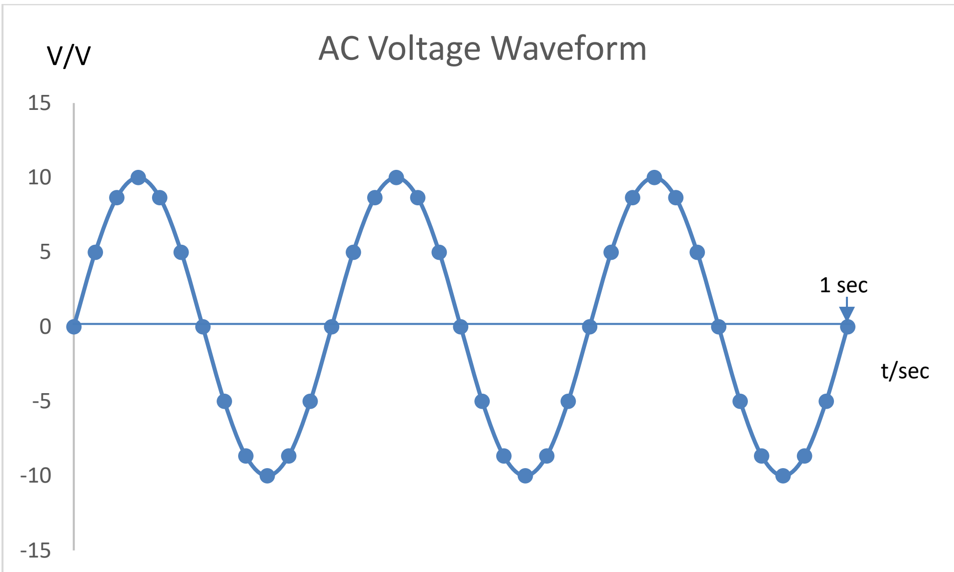


Fig 12

For the AC waveform above in Fig 12, determine the follow

(a) Peak value
(b) Peak to peak value
(c) Frequency of the waveform
(d) Period, T
(e) Average value
(f) RMS Value.

ANSWERS



(a) Peak value; 10 Volts
(b) Peak to Peak value 20 volts
(c) Frequency 3 hz
(d) Period; 0.33sec
(e) 6.37 Volts
(f) 7.07 Volts