Al-Mustaqbal University

College of Engineering and Technology

Department of Biomedical Engineering

Stage: Second

Electric Circuits II

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Lecture (1): A. C component

Chapter eight

Sinusoidal Alternating Waveforms

8.1 Introduction

The analysis thus far has been limited to dc networks, networks in which the currents or voltages are fixed in magnitude except for transient effects. We will now turn our attention to the analysis of networks in which the magnitude of the source varies in a set manner. Of particular interest is the time-varying voltage that is commercially available in large quantities and is commonly called the ac voltage, (The letters ac are an abbreviation for alternating current.)

Each waveform of Fig. 8.1 is an **alternating waveform** available from commercial supplies. The term alternating indicates only that the waveform alternates between two prescribed levels in a set time sequence (Fig. 8.1).

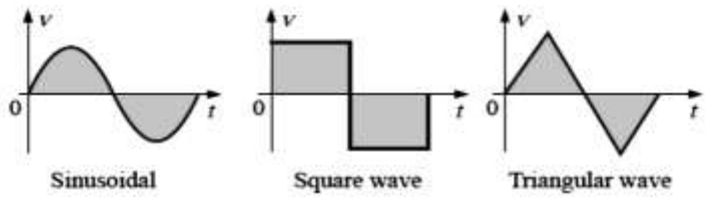

Fig. 8.1 Alternating waveforms.

To be absolutely correct, the term sinusoidal, square wave, or triangular must also be applied. The pattern of particular interest is the **sinusoidal ac waveform** for voltage of Fig. 8.1. Since this type of signal is encountered in the vast majority of instances, the abbreviated phrases ac voltage and ac current are commonly applied without confusion.

8.2 Sinusoidal ac Voltage characteristics and definitions

Generation Sinusoidal ac voltages are available from a variety of sources. The most common source is the typical home outlet, which provides an ac voltage that originates at a power plant; such a power plant is most commonly fueled by water power, oil, gas, or nuclear fusion. In each case an ac generator (also called an alternator).

The power to the shaft developed by one of the energy sources listed will turn a rotor (constructed of alternating magnetic poles) inside a set of windings housed in the stator (the stationary part of the dynamo) and will induce a voltage across the windings of the stator, as defined by Faraday's law,

$$e = N\frac{d\Phi}{dt}$$

Definitions

The sinusoidal waveform of Fig.8.2 with its additional notation will now be used as a model in defining a few basic terms. These terms, however, can be applied to any alternating waveform. It is important to remember as you proceed through the various definitions that the vertical scaling is in volts or amperes and the horizontal scaling is always in units of time.

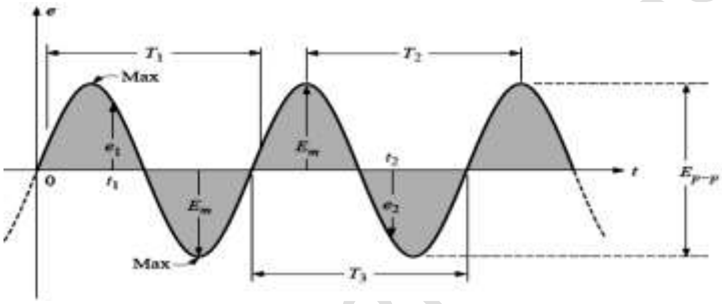

FIG. 8.2 Important parameters for a sinusoidal voltage.

Waveform: The path traced by a quantity, such as the voltage in Fig. 8.2, plotted as a function of some variable such as time (as above), position, degrees, radians, temperature, and so on.

Instantaneous value: The magnitude of a waveform at any instant of time; denoted by lowercase letters (e_1, e_2).

Peak amplitude: The maximum value of a waveform as measured from its average, or mean, value, denoted by uppercase letters (such as E_m for sources of voltage and V_m for the voltage drop across a load).

Peak value: The maximum instantaneous value of a function as measured from the zero-volt level. For the waveform of Fig. 8.2, the peak amplitude and peak value are the same, since the average value of the function is zero volts.

Peak-to-peak value: Denoted by $E_{p\text{-}p}$ or $V_{p\text{-}p}$, the full voltage between positive and negative peaks of the waveform, that is, the sum of the magnitude of the positive and negative peaks.

Periodic waveform: A waveform that continually repeats itself after the same time interval. The waveform of Fig. 8.2 is a periodic waveform.

Period (T): The time interval between successive repetitions of a periodic waveform (the period T1 = T2 = T3 in Fig. 8.2).

Cycle: The portion of a waveform contained in one period of time. The cycles within T 1 , T 2 , and T 3 of Fig. 8.2 may appear different in Fig. 8.3.

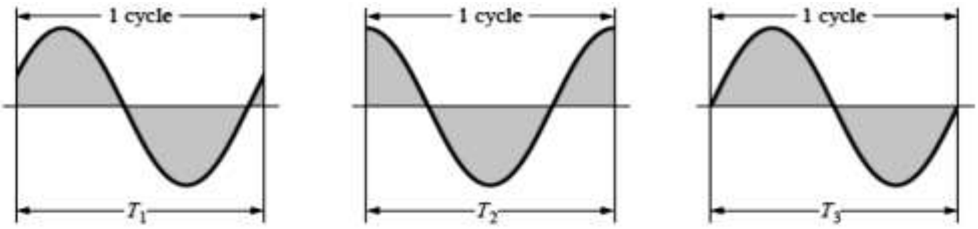

FIG. 8.3 Defining the cycle and period of a sinusoidal waveform.

Frequency (f): The number of cycles that occur in 1 s. The frequency of the waveform of Fig. 8.4(a) is 1 cycle per second, and for Fig. 8.4(b), 2.5 cycles per second, and while for Fig. 8.4(c) the frequency will be 2 cycles per second.

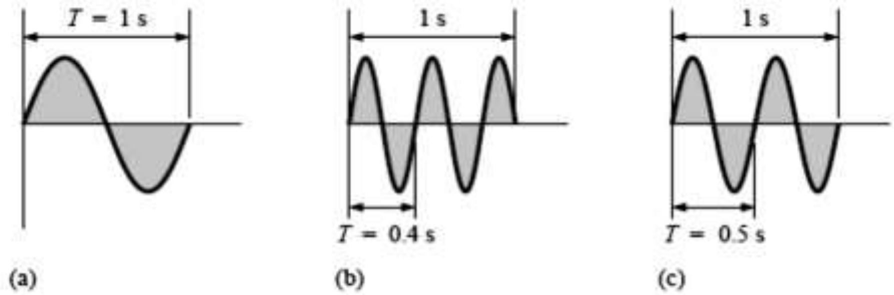

FIG. 8.4 Demonstrating the effect of a changing frequency on the period of a sinusoidal waveform.

The unit of measure for frequency is the hertz (Hz), where

1 hertz (Hz) = 1 cycle per second (c/s) (8.1)

The unit hertz is derived from the surname of Heinrich Rudolph Hertz, who did original research in the area of alternating currents and voltages and their effect on the basic R, L, and C elements. Frequency spectrum from 1 Hz to 1000 GHz can be scaled off on the same axis, as shown in Fig. 8.5.

Since the frequency is inversely related to the period—that is, as one increases, the other decreases by an equal amount—the two can be related by the following equation:

$$\mathbf{f = \frac{1}{T}} \quad (8.2)$$

where f = Hz ,T = seconds (s)

or

$$\mathbf{T = \frac{1}{f}} \quad (8.3)$$