Electrical Circuit-II

1st Lecture

Alternating Quantities

By:

Dr. Ali Albu-Rghaif

Ref: Robert L. Boylestad, *INTRODUCTORY CIRCUIT ANALYSIS*, Pearson Prentice Hall, Eleventh Edition, 2007

AC

The letters ac are an abbreviation for alternating current.

The terminology ac voltage or ac current is not sufficient to describe the type of signal we will be analyzing. Each waveform in Fig. 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. To be absolutely correct, the term sinusoidal, square-wave, or triangular must also be applied.

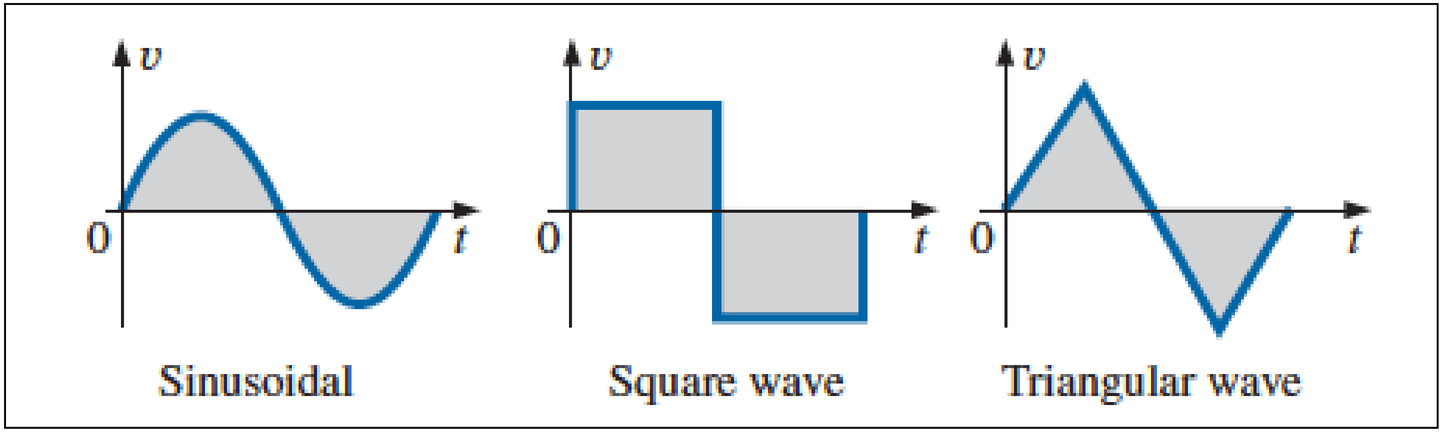


FIG. 1

- ***The pattern of particular interest is the sinusoidal ac voltage in Fig. 1***
- ***One of the important reasons for concentrating on the sinusoidal ac voltage is that it is the voltage generated by utilities throughout the world. Other reasons include its application throughout electrical, electronic, communication, and industrial systems.***

SINUSOIDAL ac VOLTAGE 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. Most power plants are fueled by water power, oil, gas, or nuclear fusion.

In each case, an ac generator (also called an alternator), as shown in Fig. 2, is the primary component in the energy-conversion process. The power to the shaft developed by one of the energy sources listed turns a rotor (constructed of alternating magnetic poles) inside a set of windings housed in the stator (the stationary part of the dynamo) and induces a voltage across the windings of the stator, as defined by Faraday's law.

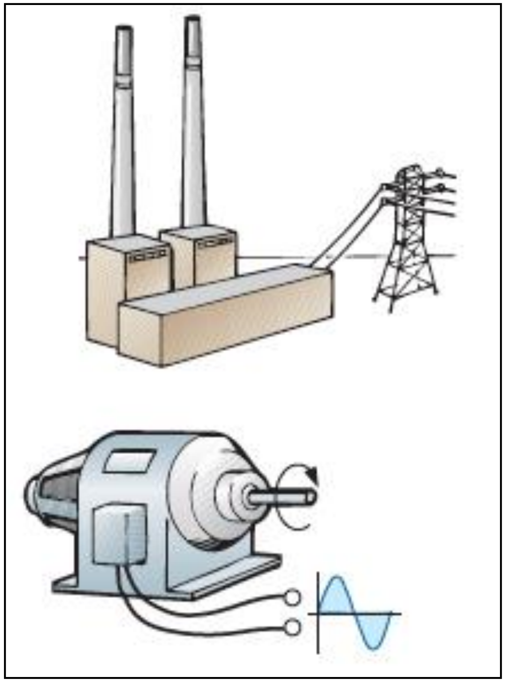


FIG. 2

Definitions

The sinusoidal waveform in Fig. 3 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 in units

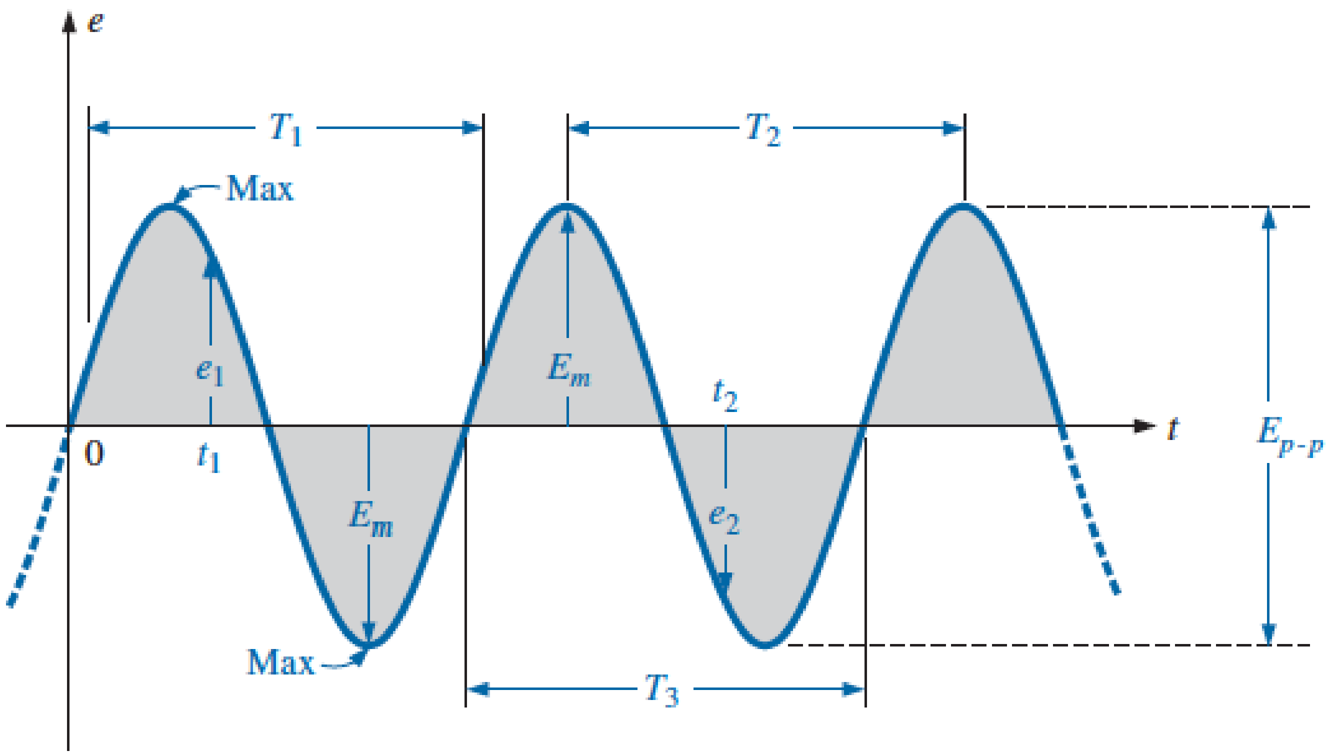


FIG. 3

Definitions

Waveform	***The path traced by a quantity, such as the voltage in Fig. 3, plotted as a function of some variable such as time, position, degrees, radians, temperature.***
Instantaneous value	***The magnitude of a waveform at any instant of time; denoted by lowercase letters (e1, e2 in Fig. 3).***
Peak value	***The maximum instantaneous value of a function as measured from the zero volt level. For the waveform in Fig. 3, the peak amplitude and peak value are the same, since the average value of the function is zero volts.***

Definitions

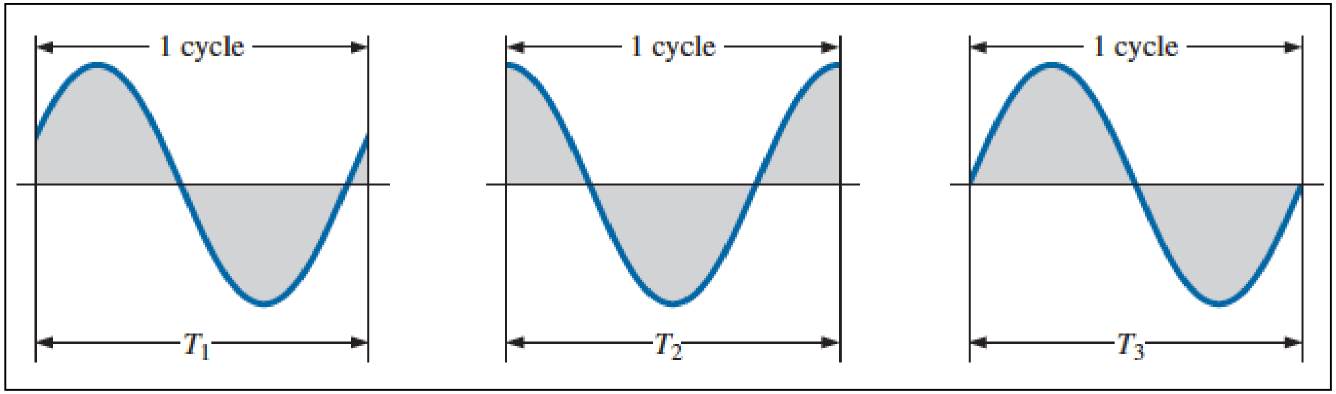
Peak-to-peak value	***Denoted by Ep-p or Vp-p (as shown in Fig. 3), the full voltage between positive and negative peaks of the waveform, that is, the sum of the magnitude of the positive and negative peaks.***
Periodic waveform	***A waveform that continually repeats itself after the same time interval. The waveform in Fig. 3 is a periodic waveform.***
Period (T)	***The time of a periodic waveform.***

Definitions

Cycle

The portion of a waveform contained in one period of time. The cycles within T1, T2, and T3 in Fig. 3 may appear different in Fig. 4, but they are all bounded by one period of time and therefore satisfy the definition of a cycle.

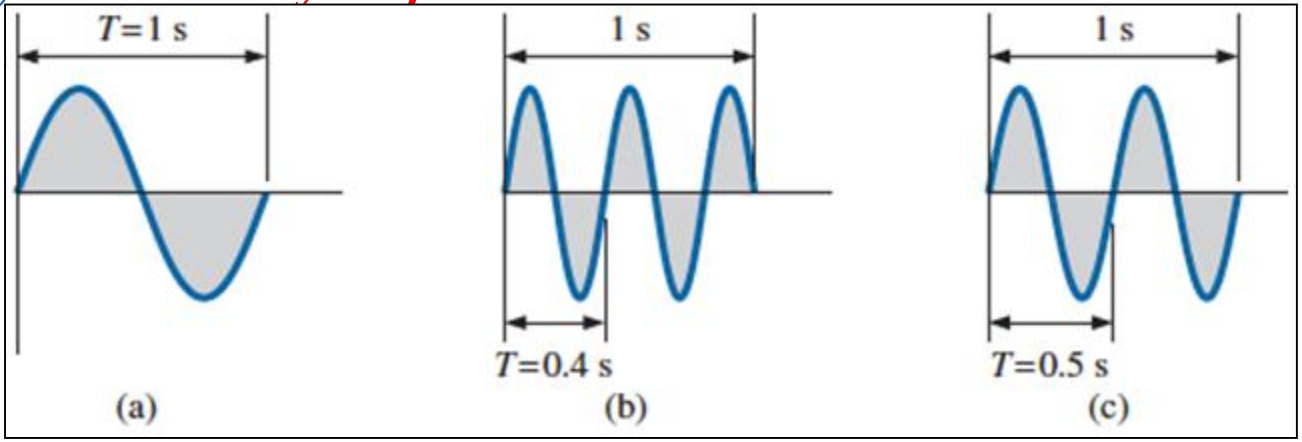
FIG. 4



Frequency (f)

The number of cycles that occur in 1 s. The frequency of the waveform in Fig. 5(a) is 1 cycle per second, and for Fig. 5(b), 2 ½ cycles per second. If a waveform of similar shape had a period of 0.5 s [Fig. 5(c)], the frequency would be 2 cycles per second.

FIG. 5



1 hertz (Hz) = 1 cycle per second (cps)

Example (1)

For the sinusoidal waveform in Fig. 6.
a. What is the peak value?
b. What is the instantaneous value at 0.3 s and 0.6 s?
c. What is the peak-to-peak value of the waveform?
d. What is the period of the waveform?
e. How many cycles are show
f. What is the frequency of t

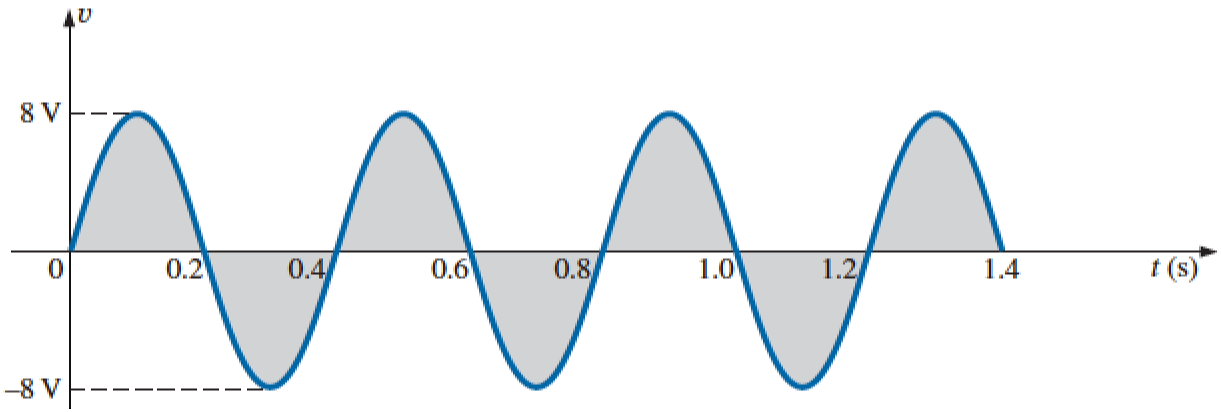


FIG. 6

Solution

a. **8 V.**
b. At 0.3 s, **−8 V**; at 0.6 s, **0 V.**
c. **16 V.**
d. **0.4 s.**
e. **3.5 cycles.**
f. **2.5 cps,** or **2.5 Hz.**

$$f = \frac{1}{T}$$

f = Hz
T = seconds (s)

$$T = \frac{1}{f}$$

Example (2)

Find the period of periodic waveform with a frequency of:

a. 60 Hz.

b. 1000 Hz.

Solution

a. $T = \frac{1}{f} = \frac{1}{60\ \text{Hz}} \cong 0.01667\ \text{s or } \mathbf{16.67\ ms}$

(a recurring value since 60 Hz is so prevalent)

b. $T = \frac{1}{f} = \frac{1}{1000\ \text{Hz}} = 10^{-3}\ \text{s} = \mathbf{1\ ms}$

Example (3)

Determine the frequency of the waveform in Fig. 7

Solution

From the figure:

T = (25 ms 5 ms) or (35 ms 15 ms)

= 20 ms,

$$f = \frac{1}{T} = \frac{1}{20 \times 10^{-3}\ \text{s}} = \mathbf{50\ Hz}$$

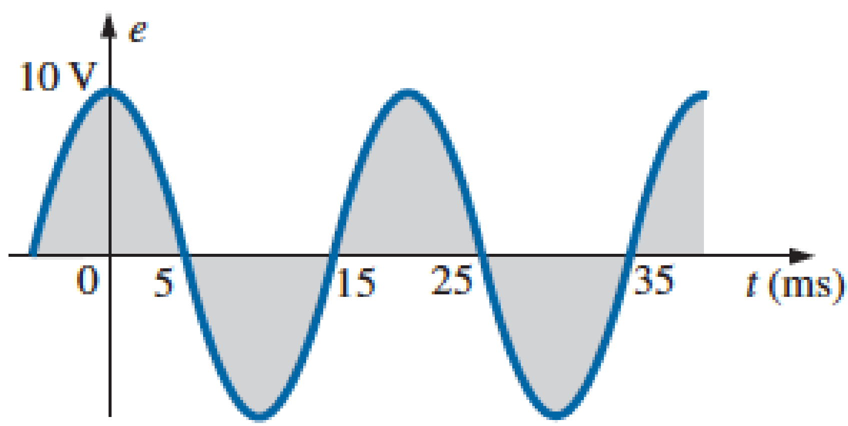
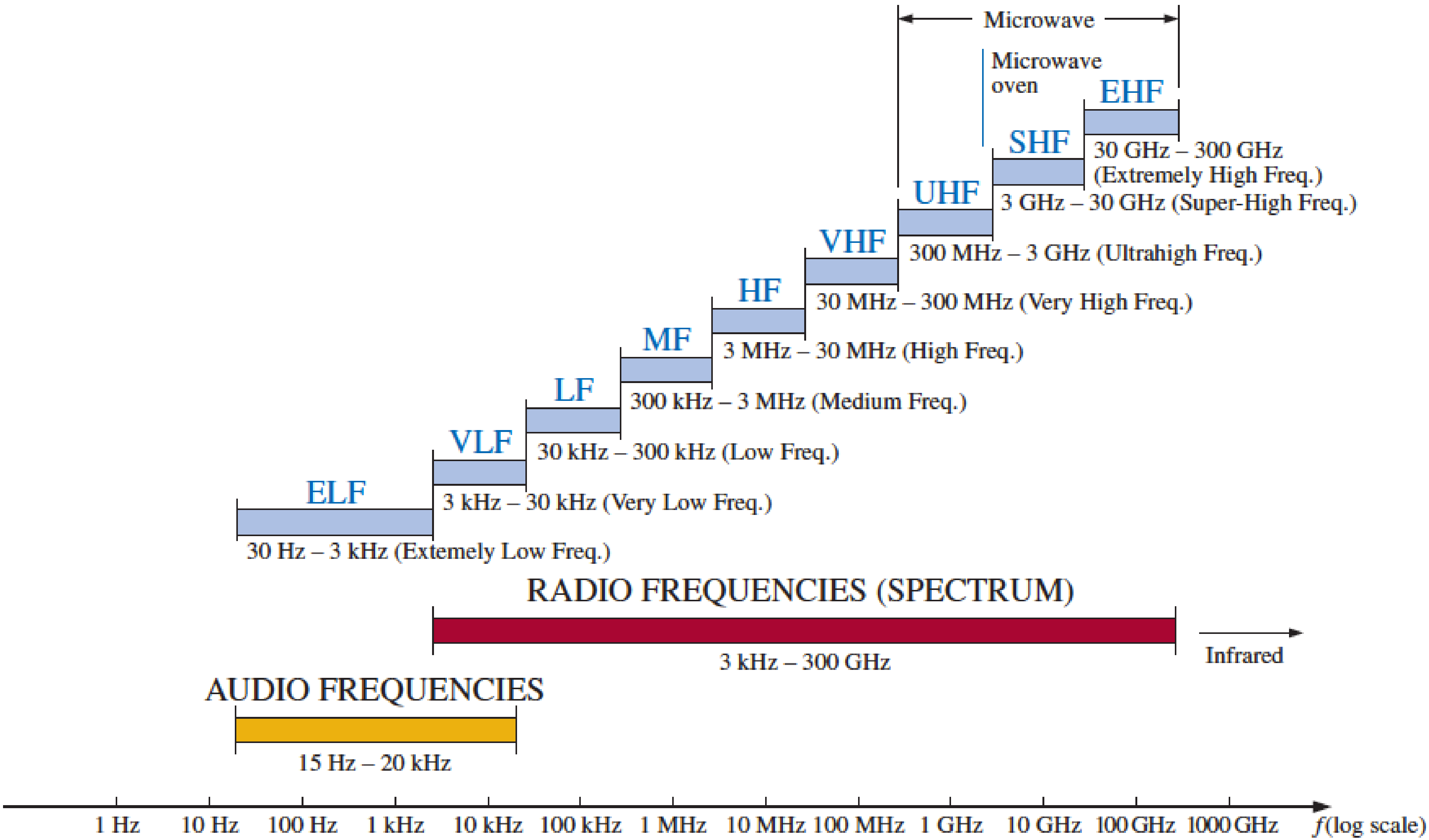


FIG. 7

FREQUENCY SPECTRUM



FREQUENCY SPECTRUM