Circuit Analysis-II

Course Content

Course Content

- ✓ Introduction
- ✓ A.C. & Voltage
- ✓ Sinusoidal Waveforms
- ✓ Capacitors
- ✓ Inductors
- ✓ RC Circuits
- ✓ RLC Circuits
- ✓ Network Theorems
- ✓ Fourier Series

Course Assessment

- ✓ Total Assessment 100%
  - ✓ Mid Term 1 30 %
  - ✓ Final Examination 50 %
  - ✓ Internal Evaluation 20 %

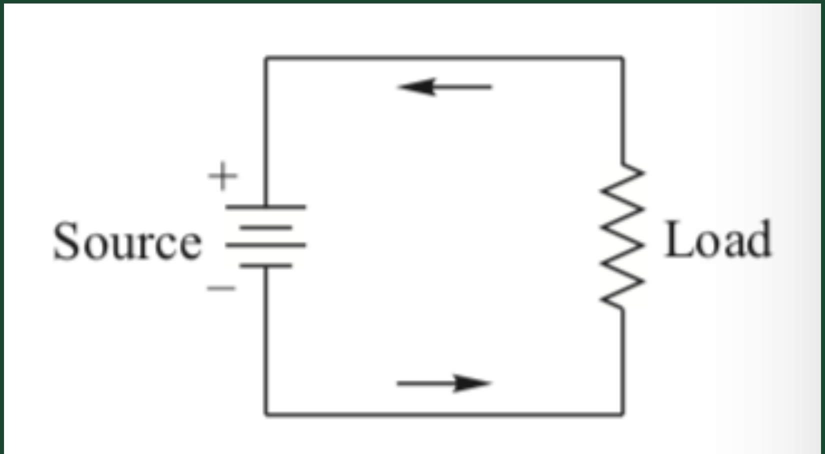
- ✓ Internal Evaluation 20%
  - ✓ Quiz 10 %
  - ✓ Assignments 10%

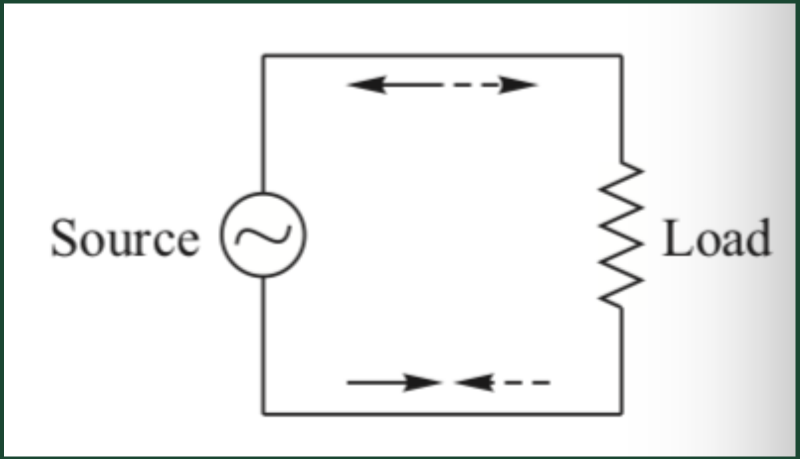
Introduction

Alternating Current (A.C.)

- ✓ A.C. is the current which constantly changes in amplitude, and which reverses direction at regular intervals.
- ✓ An alternating voltage is one that changes polarity at a certain rate.

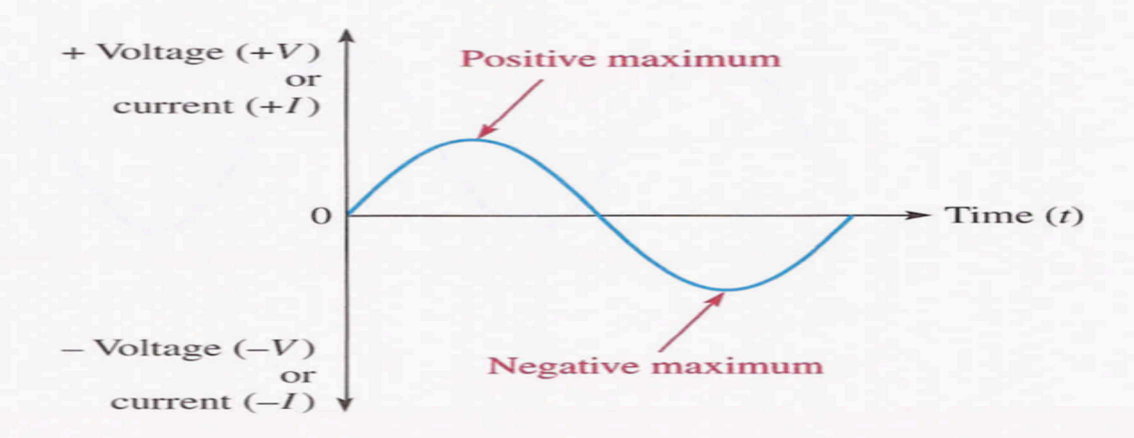
Alternating Current vs Direct Current





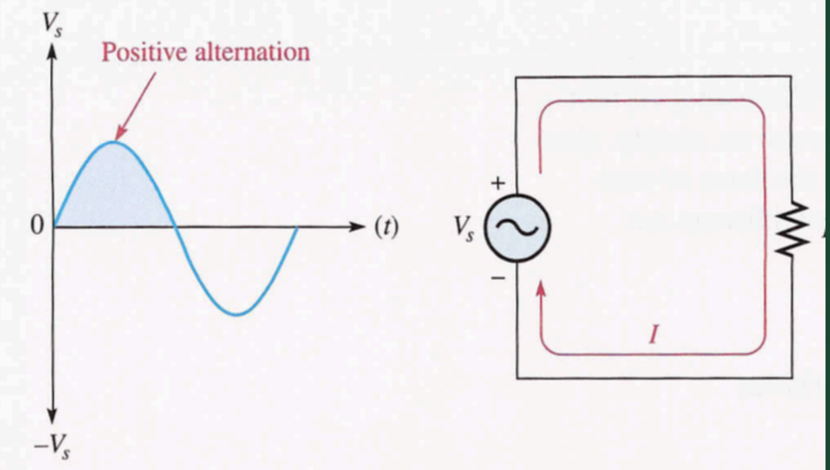
Sinusoidal Waveforms

- ✓ The sinusoidal waveform or sine wave is the fundamental type of alternating current and alternating voltage.
- ✓ Other types of repetitive waveforms are composites of many individual sine waves called harmonics.
- ✓ Sinusoidal voltages are produces by two types of sources:
  - ✓ Rotating electrical machines (A.C. Generators)
  - ✓ Electronic oscillator circuits

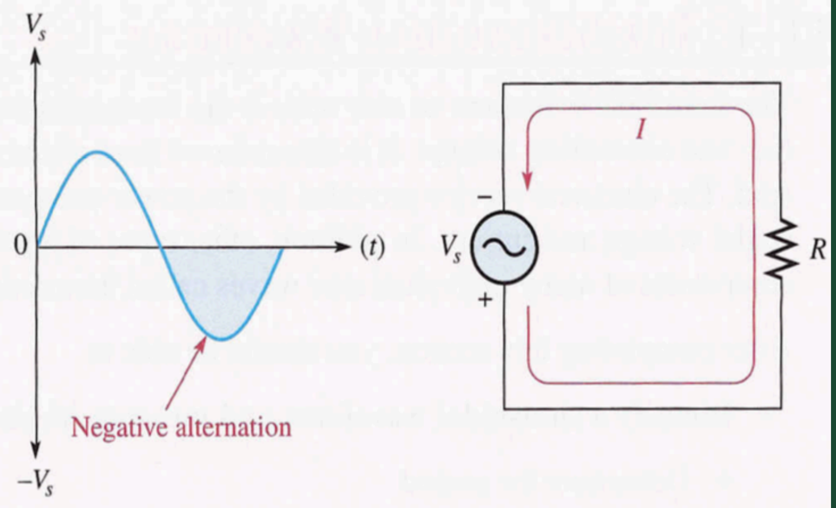


Polarity Of A Sine Wave

✓ Sine wave changes polarity at its zero value i.e., it alternates between positive and negative values.



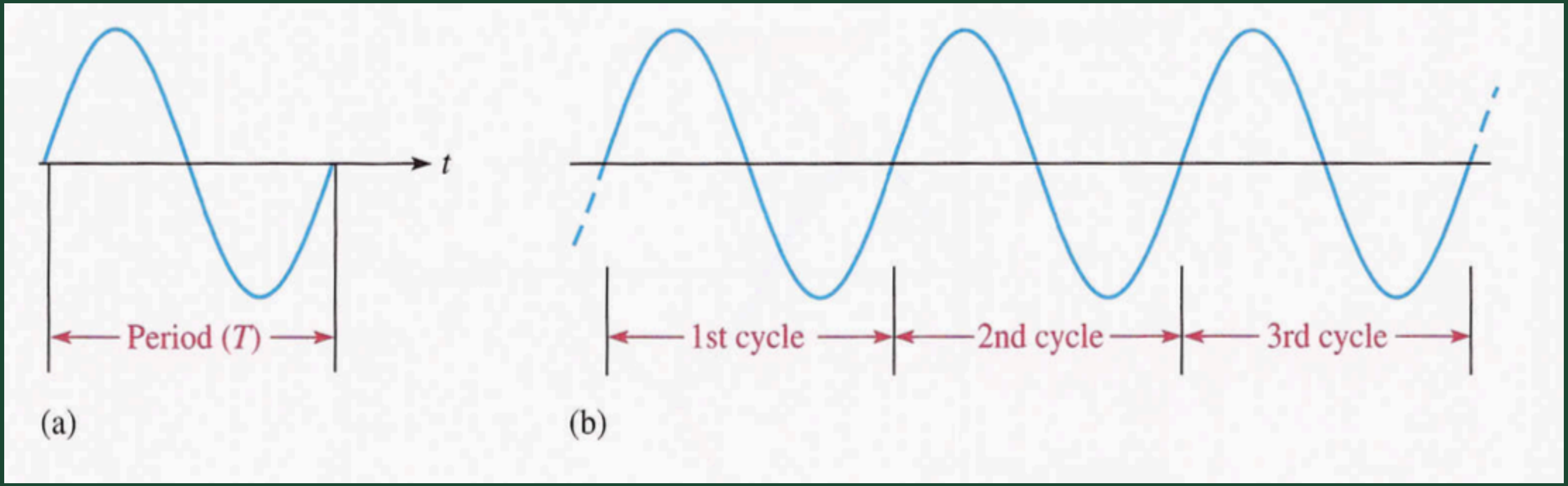
(a) During a positive alternation of voltage, current is in the direction shown.



(b) During a negative alternation of voltage, current reverses direction, as shown.

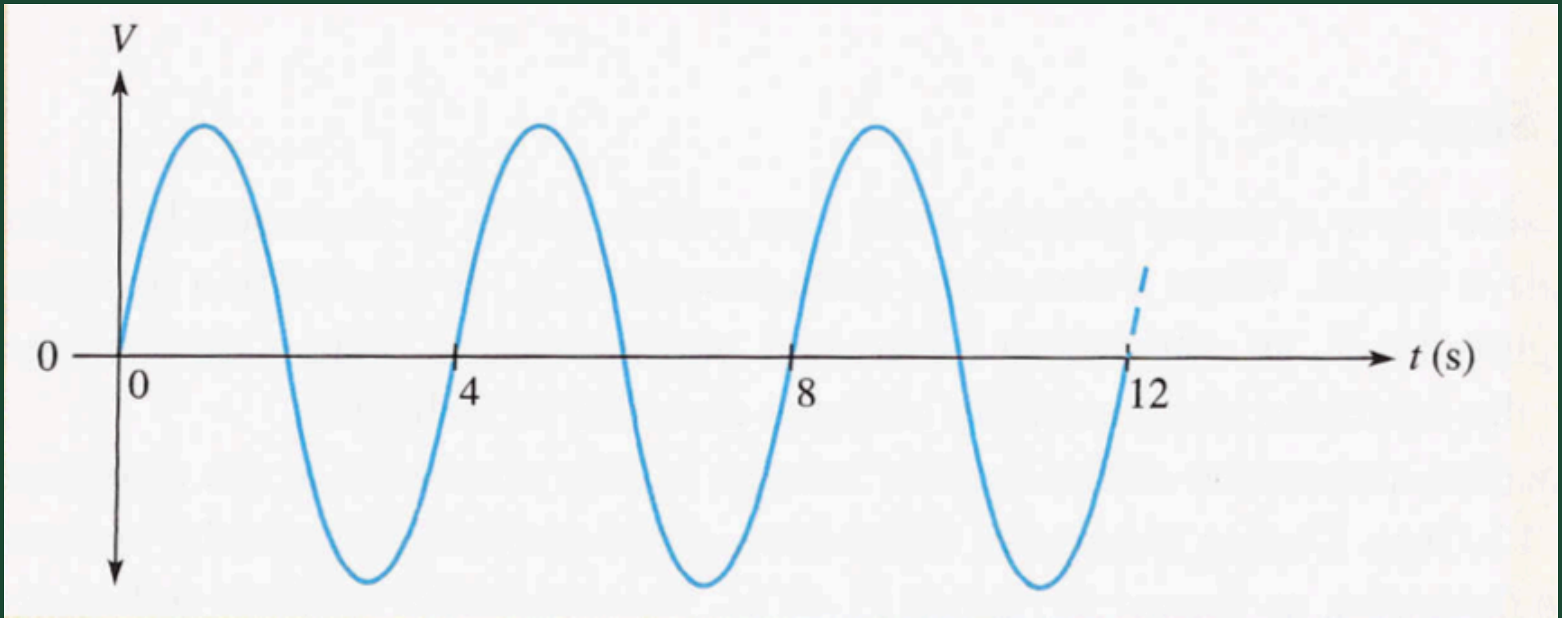
Period of a Sine wave

- ✓ The time required for a sine wave to complete one full cycle is called the period (T).



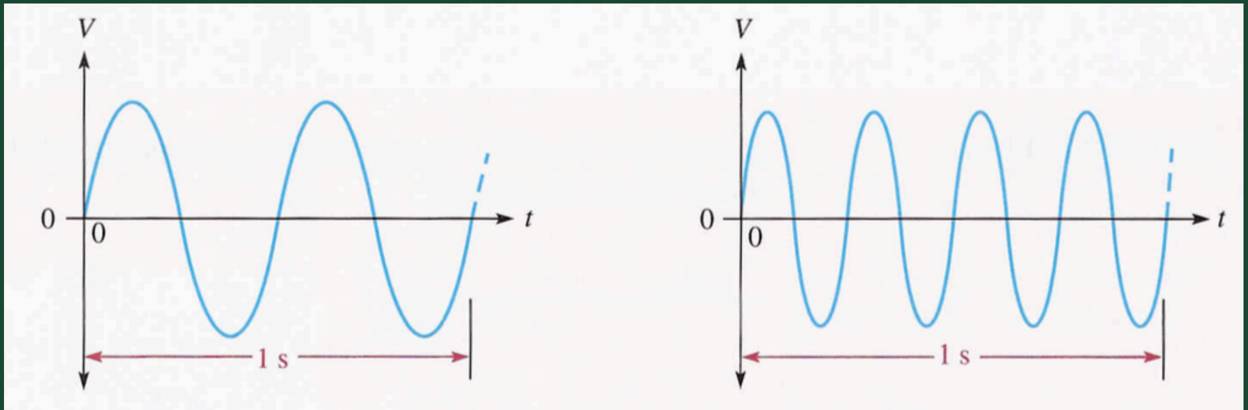
Example 1

✓ What is the period of the sine wave shown below:



Frequency of a sine wave

- ✓ Frequency (f) is the number of cycles that a sine wave complete in one second.
- ✓ The more cycles completed in one second, the higher the frequency.
- ✓ Frequency (f) is measured in units of hertz.
- ✓ One hertz (Hz) is equivalent to one cycle per second.



(a) Lower frequency: fewer cycles per second
(b) Higher frequency: more cycles per second

Relationship of frequency & period

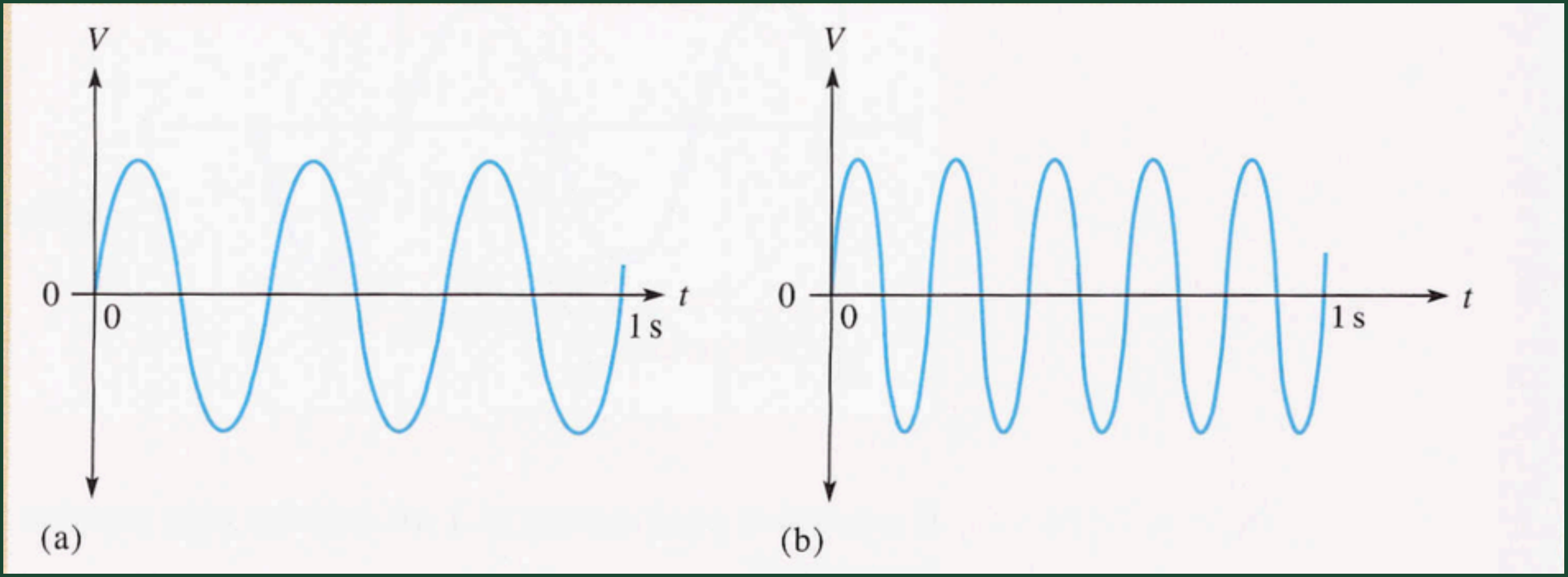
- ✓ The relationship between frequency (f) and period (T) are as follows:

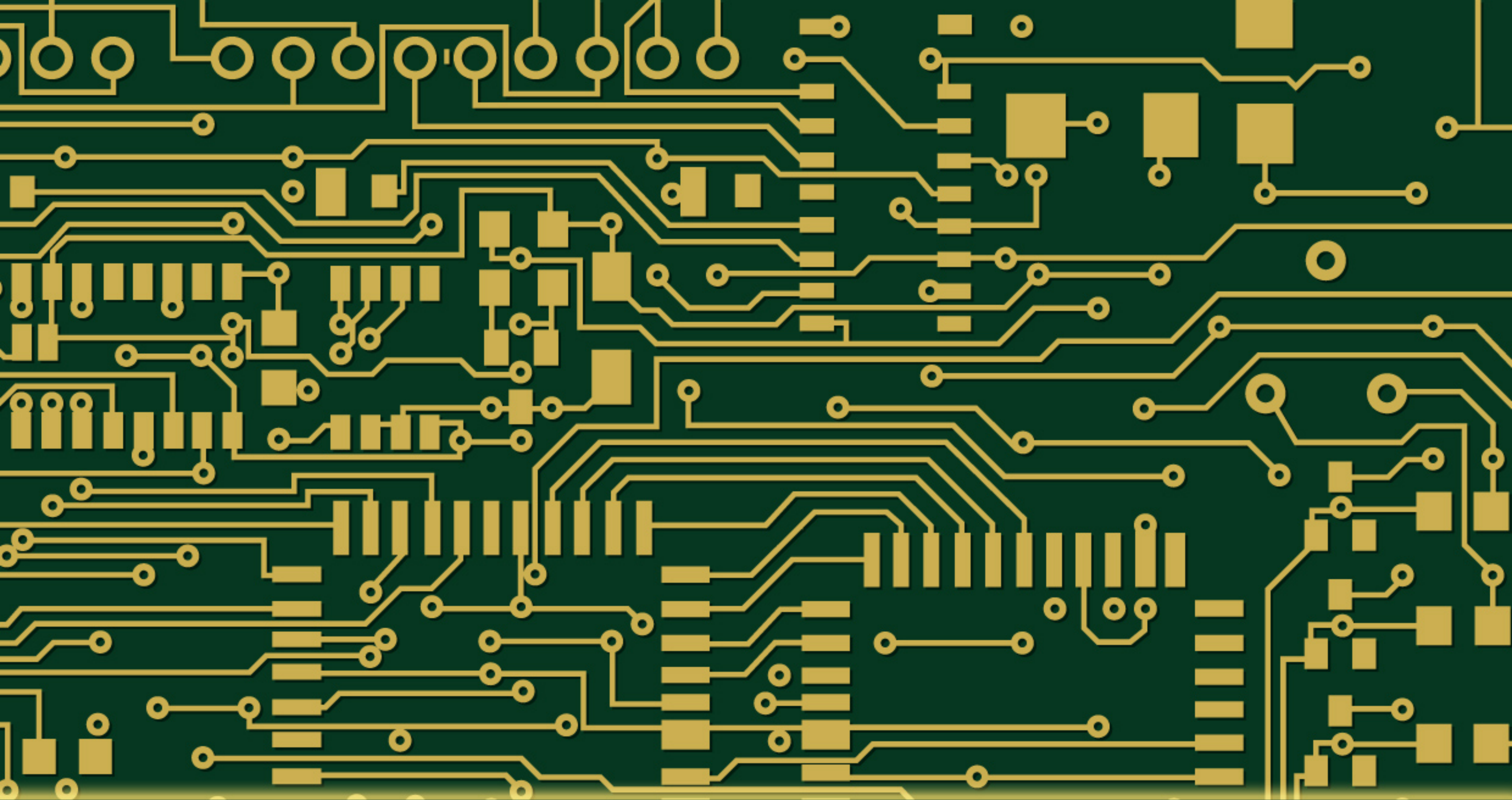
$$f = \frac{1}{T}$$

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

Example 2

- ✓ Which sine wave shown below has a higher frequency? Determine the frequency and the period of both waveforms.





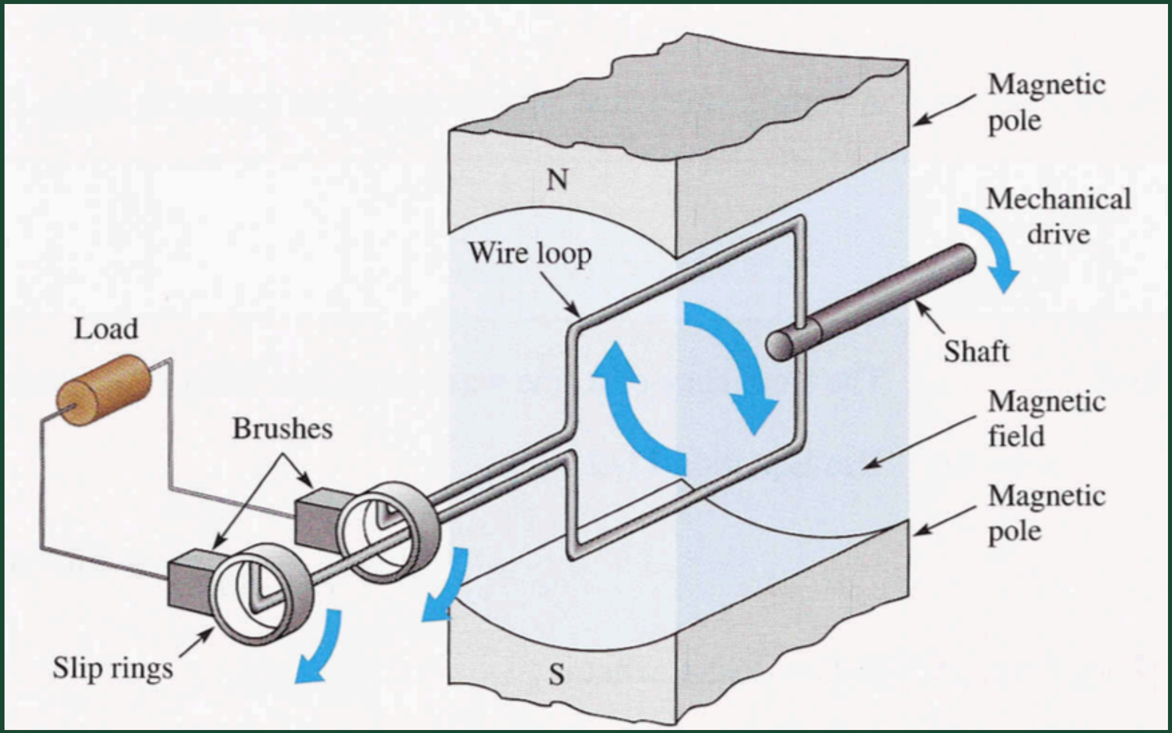
Sinusoidal Voltage Sources

Voltage Source

- ✓ Two basic methods of generating sinusoidal voltages are:
  - ✓ Electromagnetic : Produced by A.C. generators
  - ✓ Electronic : Produced by Oscillator Circuits

A.C. Generator

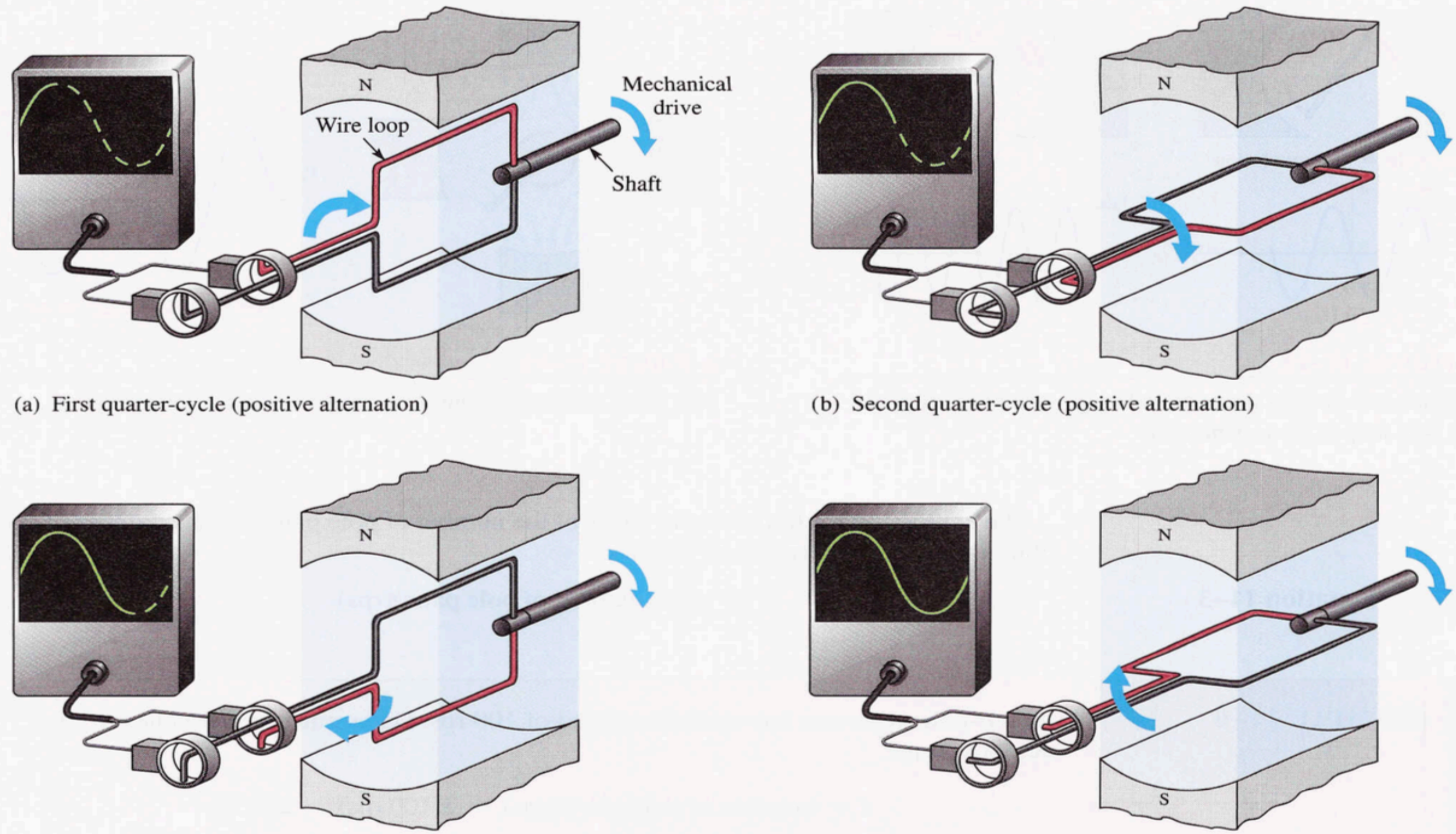
- ✓ An A.C. generator consisting of a single loop of wire in a permanent magnetic field is shown below:



A.C. Generator (cont.)

- ✓ Each end of the wire loop is connected to a separate solid conductive ring called a slip ring.
- ✓ A mechanical drive such as a motor turns the shaft to which the wire loop is connected.
- ✓ As the wire loop rotated in the magnetic field between the north and south poles, the slip rings also rotate and rub against the brushes that connect the loop to an external load.

Working



(a) First quarter-cycle (positive alternation)

(b) Second quarter-cycle (positive alternation)

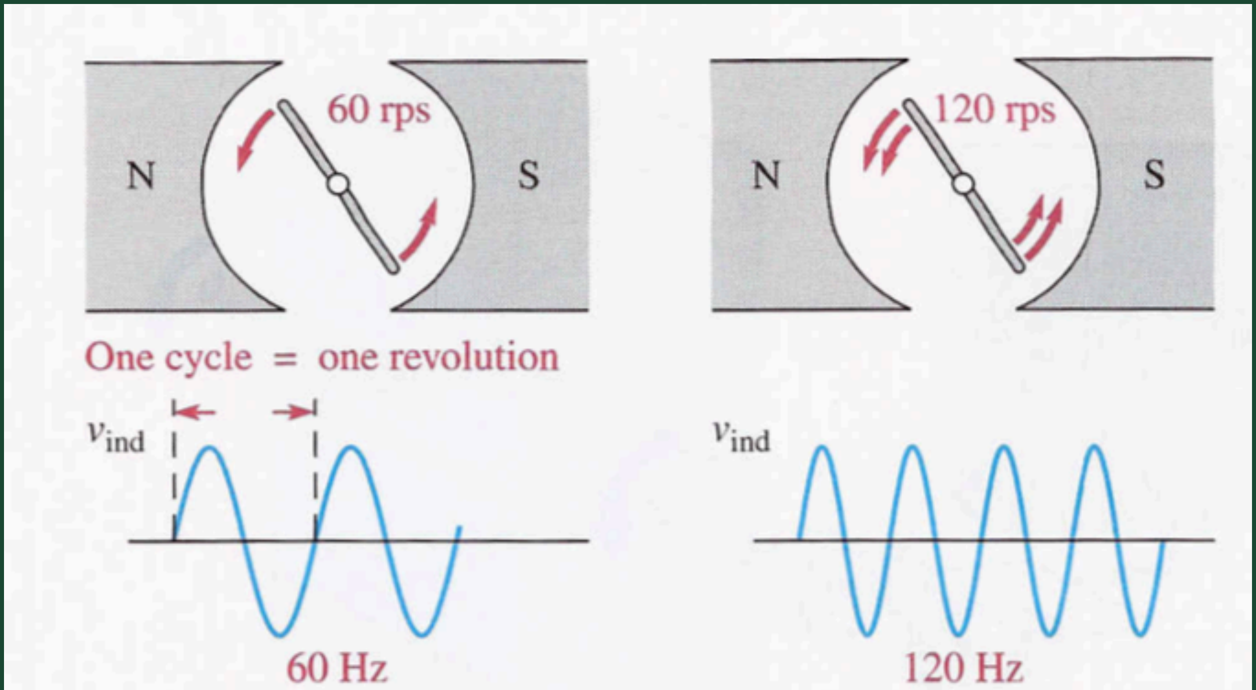
(c) Third quarter-cycle (negative alternation)

(d) Fourth quarter-cycle (negative alternation)

Frequency

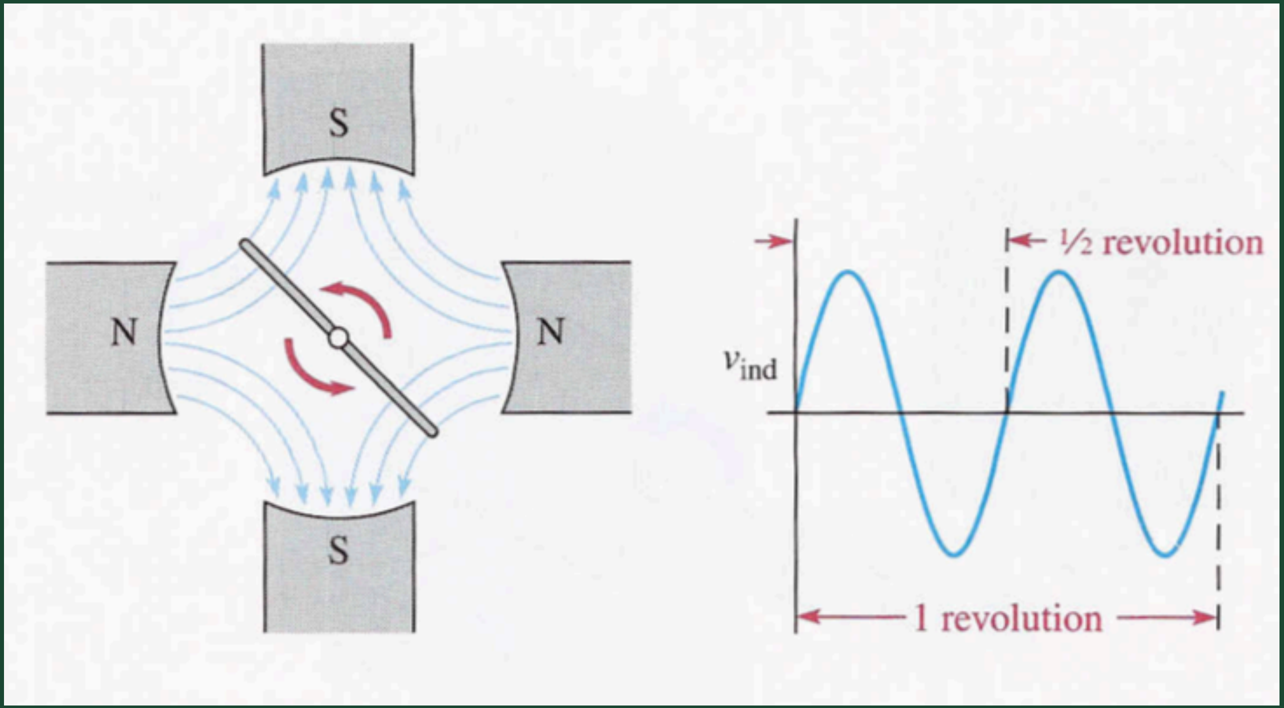
- ✓ One revolution of the conductor through the magnetic field in the basic ac generator (also called an alternator) produces one cycle of induced sinusoidal voltage.
- ✓ It is obvious that the rate at which the conductor is rotated determines the time for completion of one cycle.
- ✓ Another way of achieving a higher frequency is to increase the number of magnetic poles.
- ✓ During one revolution, the conductor passes under a north pole and a south pole, thus producing one cycle of a sine wave.
- ✓ When four magnetic poles are used instead of two, one cycle is generated during one-half a revolution. This doubles the frequency for the same rate of rotation.

Frequency (cont.)



Frequency is directly proportional to the rate of rotation of the wire loop in an ac generator.

Frequency (cont.)



Four poles achieve a higher frequency than two for the same rps.

Example 3

- ✓ A four-pole generator has a rotation speed of 100rps. Determine the frequency of the output voltage.

Voltage Amplitude

- ✓ According to the Faraday's law that the voltage induced in a conductor depends on the number of turns (N), and the rate of change with respect to the magnetic field.
- ✓ When the speed of rotation of the conductor is increased, not only the frequency of the induced voltage increases also does the amplitude which is its maximum value.
- ✓ Since the frequency value normally is fixed, the most practical method of increasing the amount of induced voltage is to increase the number of wire loops.

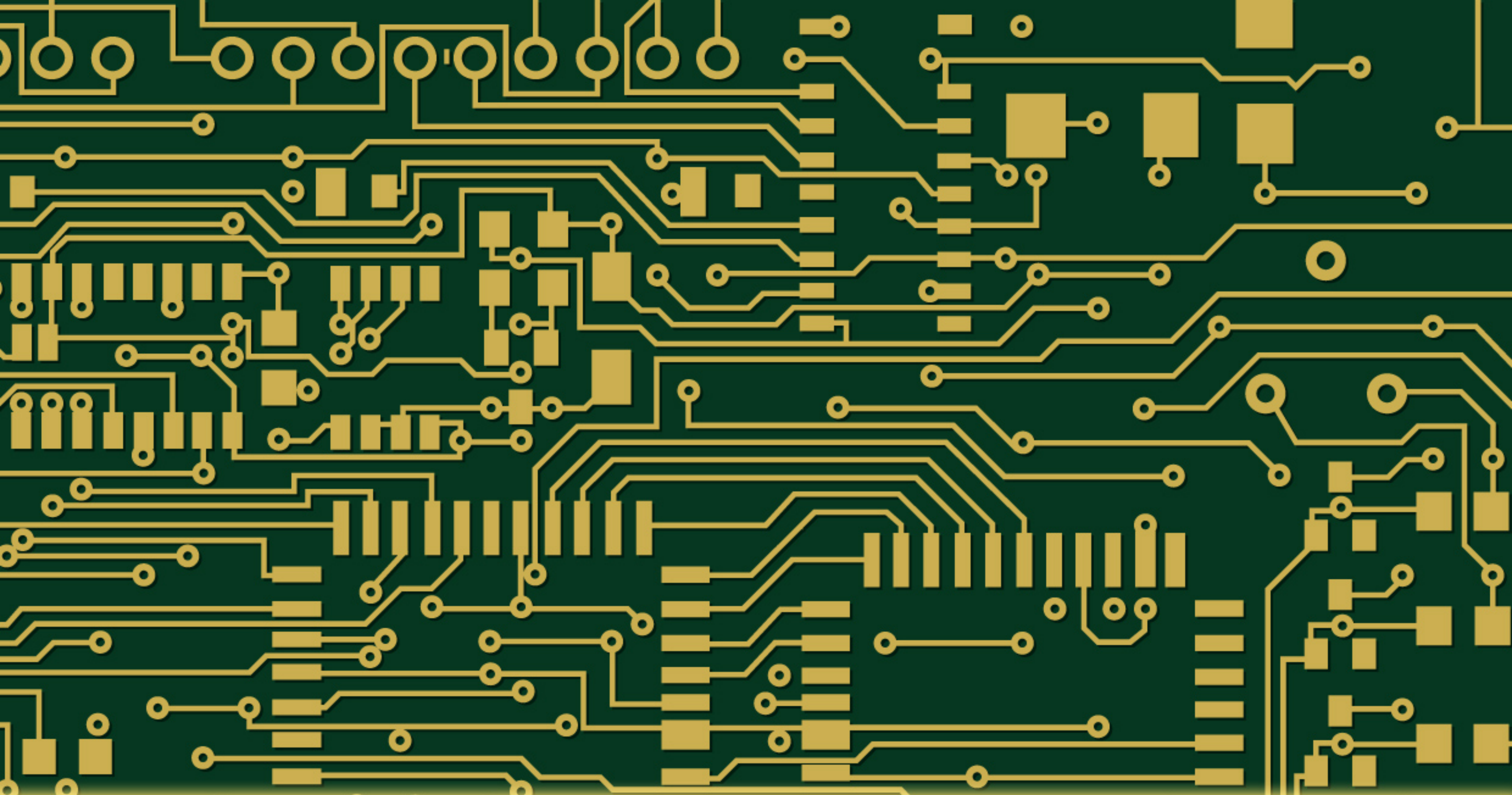
Electronic Signal Generators

- ✓ The signal generator is an instrument that electronically produces sine waves for use in testing or controlling electronic circuits and systems.
- ✓ There are variety of signal generators ranging from special-purpose instruments that produce only one type of waveform in a limited frequency range, to programmable instruments that produce a wide range of frequencies and a variety of waveforms.
- ✓ All signal generators consist basically of an oscillator which is an electronic circuit that produces repetitive waves.
- ✓ All generators have controls for adjusting the amplitude and frequency.

Electronic Signal Generators (cont.)

(a) Examples of function generators

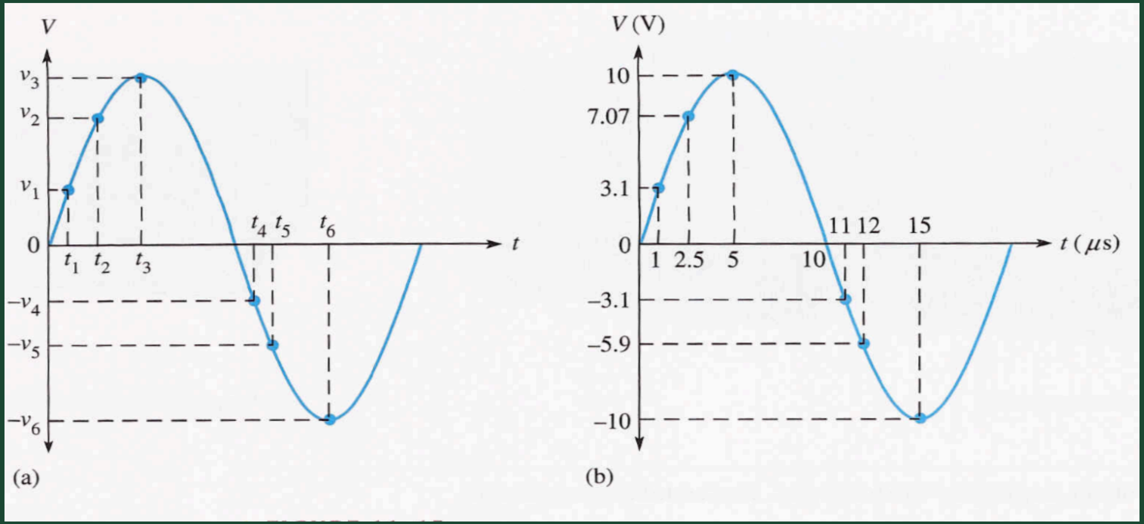
(b) A typical arbitrary waveform generator



Sinusoidal Voltage & Current Values

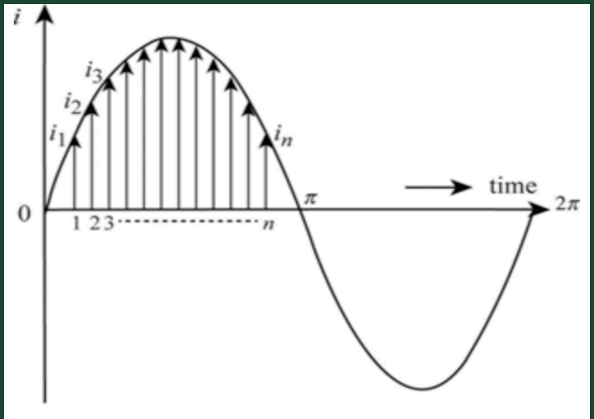
Instantaneous Value

- ✓ The value of an alternating quantity at a particular instant of time in the cycle.
- ✓ There are uncountable number of instantaneous values that exist in a cycle.
- ✓ Instantaneous values of voltage and current are symbolized by lowercase v and I, respectively.



Average Value

- ✓ It is defined as the average of all instantaneous values during one alternation.
- ✓ That is, the ratio of the sum of all considered instantaneous values to the number of instantaneous values in one alternation period.
- ✓ The average value for the entire cycle of alternating quantity is zero. Because the average value obtained for one alternation is a positive value and for another alternation is a negative value. The average values of these two alternations cancel each other and the resultant average value is zero.



Average Value (cont.)

- ✓ The average value of a sine wave taken over one complete cycle is always zero because the positive values offset the negative values.
- ✓ The average value of a sine wave is defined over a half-cycle rather than over a full cycle.
- ✓ The average values is the total area under the half-cycle curve divided by the distance in radians of the curve along the horizontal axis.

$$V_{avg} = \left(\frac{2}{\pi}\right) V_p$$

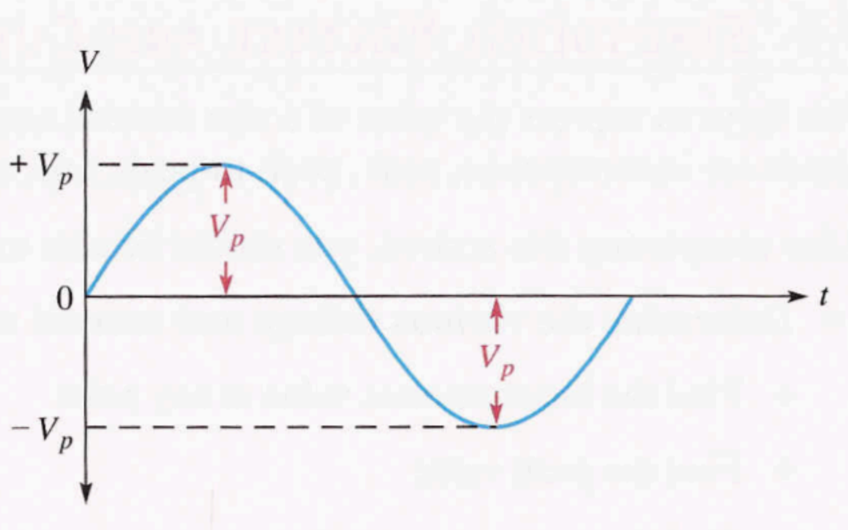
$$V_{avg} = 0.637 V_p$$

$$I_{avg} = \left(\frac{2}{\pi}\right) I_p$$

$$I_{avg} = 0.637 I_p$$

Peak Value

- ✓ It is the maximum value, either positive or negative that a waveforms attains.
- ✓ The peak value of a sine wave is the value of voltage (or current) at the positive or the negative maximum with respect to zero.
- ✓ Since the positive and negative peak values are equal in magnitude, a sine wave is characterized by a single peak value.

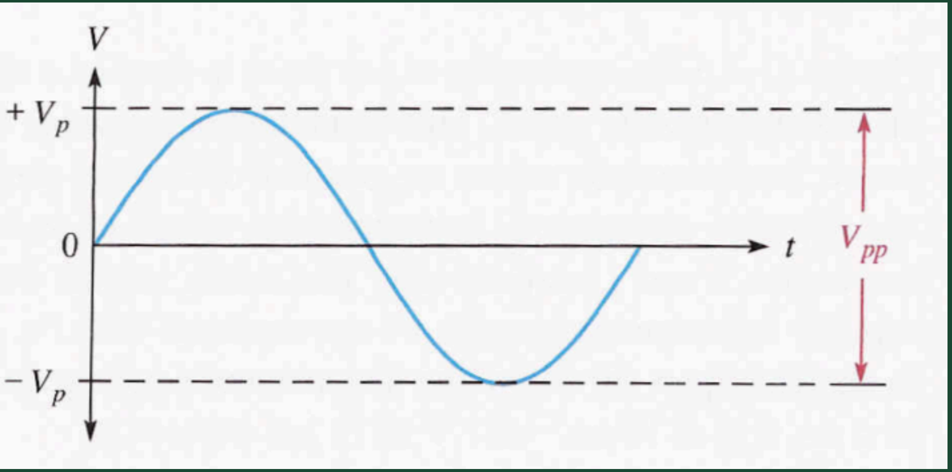


Peak-to-Peak Value

- ✓ The peak-to-peak value of a sine wave is the voltage or current from the positive peak to the negative peak.
- ✓ It is always twice the peak values as expressed in the following equations.
- ✓ Peak-to-peak voltage or current values are represented by V_{pp} or I_{pp}.

$$V_{pp} = 2V_p$$

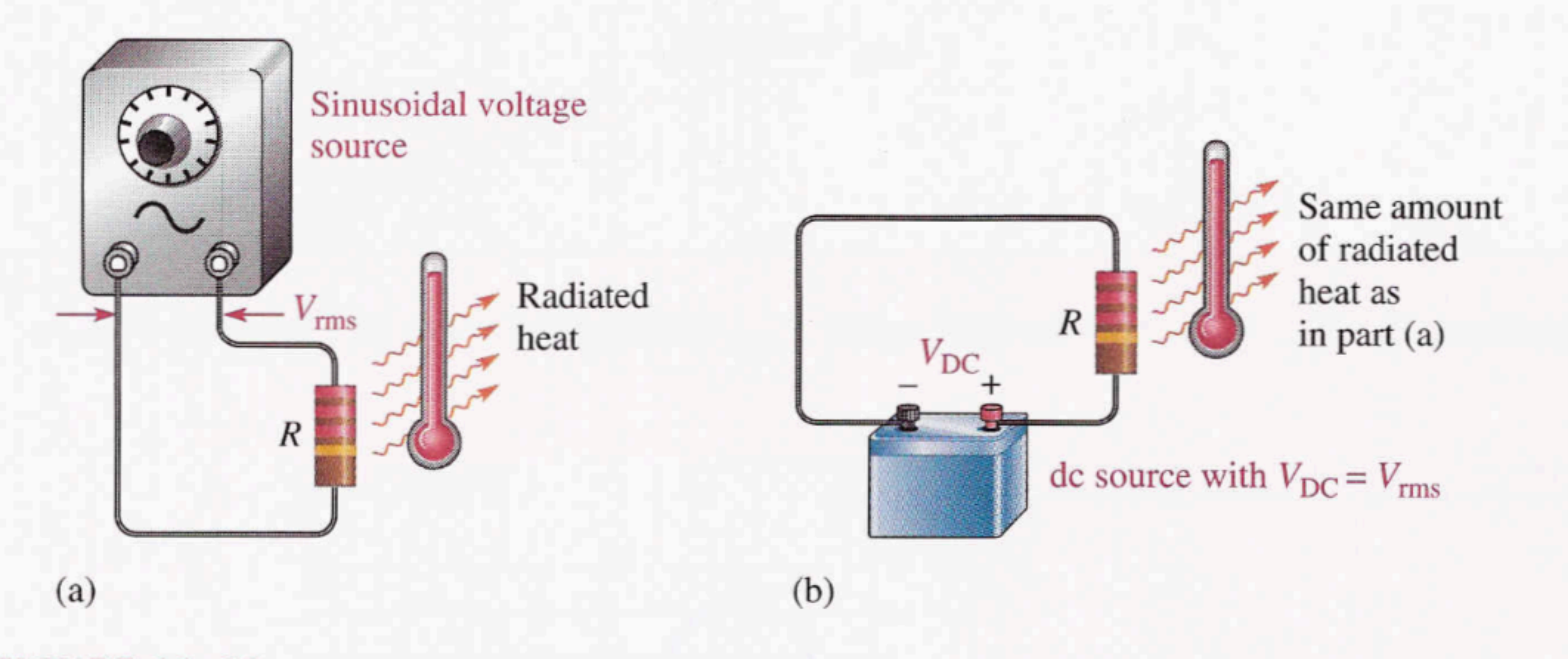
$$I_{pp} = 2I_p$$



RMS Value

- ✓ RMS = Root Mean Square.
- ✓ The RMS value also referred to as the effective value, of a sinusoidal voltage is actually a measure of the heating effect of the sine wave.
- ✓ For example, when a resistor is connected across an ac voltage source a certain amount of heat is generated by the power in the resistor.
- ✓ The value of the dc voltage can be adjusted so that the resistor gives off the same amount of heat as it does when connected to the ac source.
- ✓ The RMS value of a sinusoidal voltage is equal to the dc voltage that produces the same amount of heat in a resistor as does the sinusoidal voltage.

RMS Value (cont.)



RMS Value (cont.)

- The peak value of a sine wave can be converted to the corresponding value using the following relationships, for either voltage or current:

$$V_{rms} = 0.707 V_p$$

$$I_{rms} = 0.707 I_p$$

- Using these formulas, you can also determine the peal value if you know the rms value.

$$V_P = \frac{V_{rms}}{0.707}$$

$$V_P = 1.414 V_{rms}$$

$$I_P = 1.414 I_{rms}$$

RMS Value (cont.)

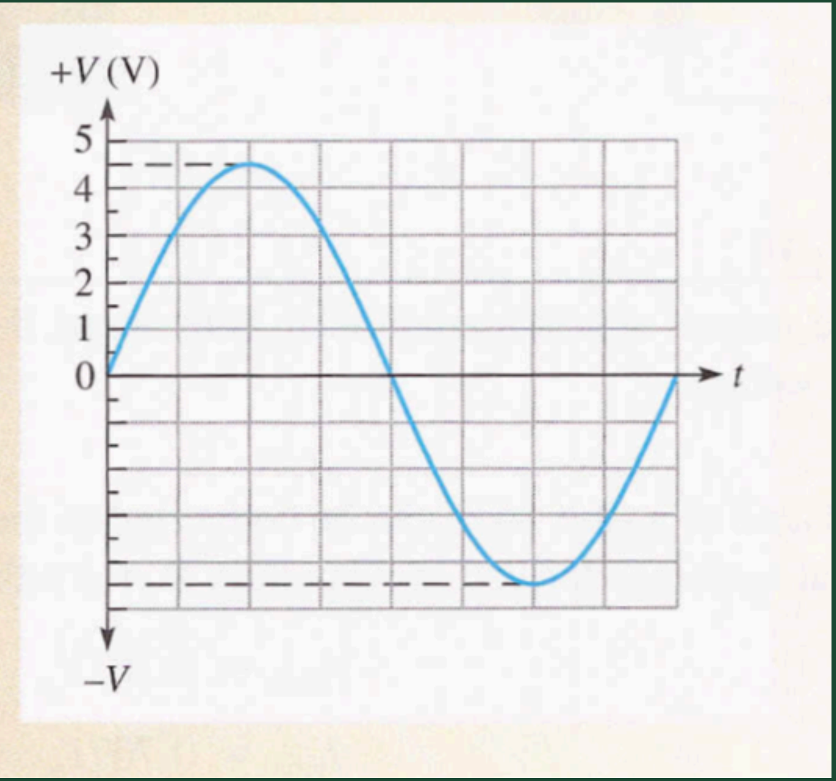
- ✓ To get the peak-to-peak value, simply double the peak value.

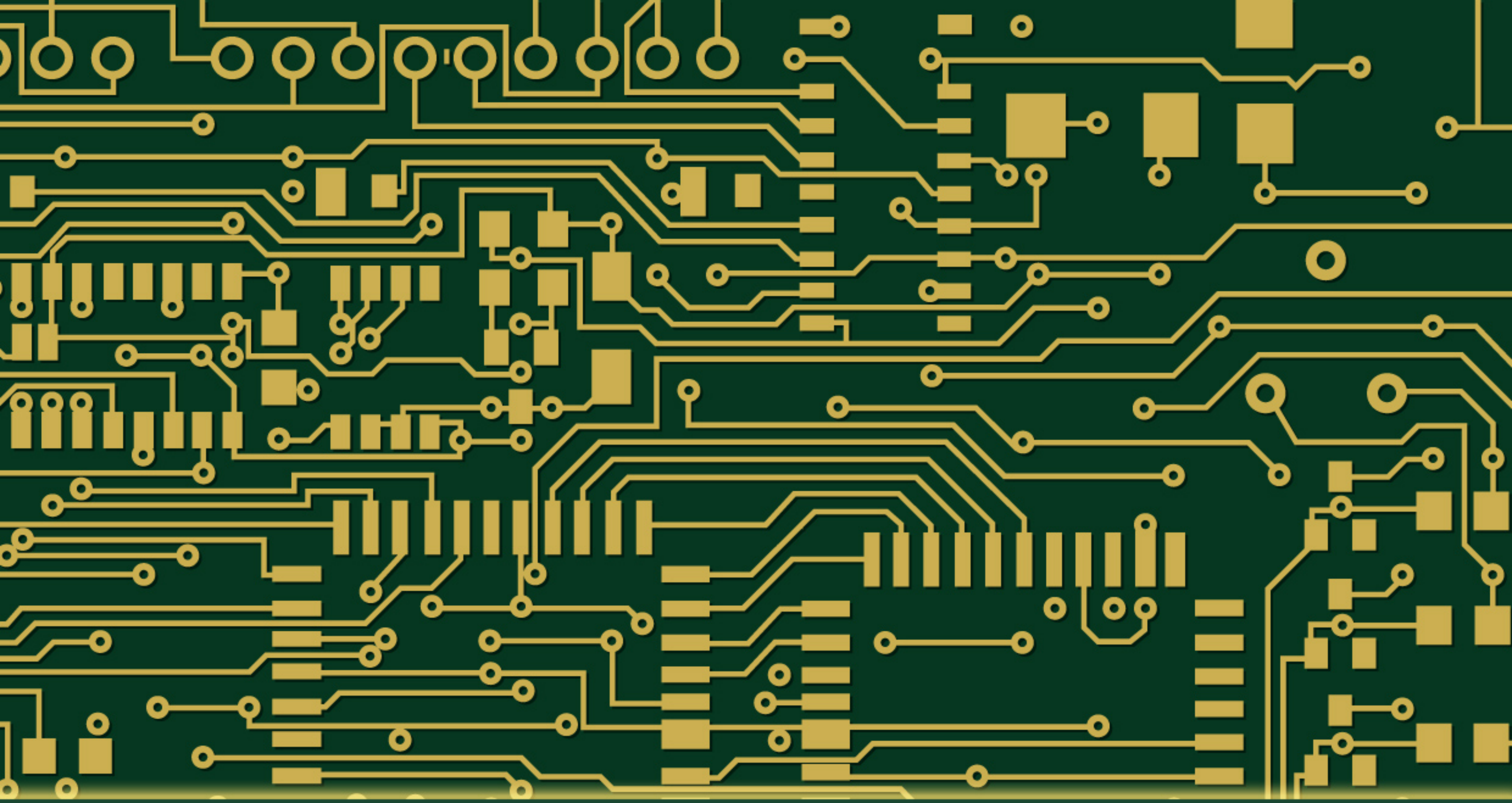
$$V_{PP} = 2.828 V_{rms}$$

$$I_{PP} = 2.828 I_{rms}$$

Example 4

- ✓ Determine V_p ,V_{pp} , v_{rms} and the half cycle V_{avg} for the sine wave shown below:





Thank You