CHAPTER 33
ALTERNATING CURRENT CIRCUITS

33.1 AC SOURCES
33.2 RESISTORS IN AN AC CIRCUIT

33.1 AC SOURCES

- An AC circuit consists of a combination of circuit elements and a power source
- The power source provides an alternative voltage, Δv

The output of an AC power source is sinusoidal and varies with time according to the following equation:

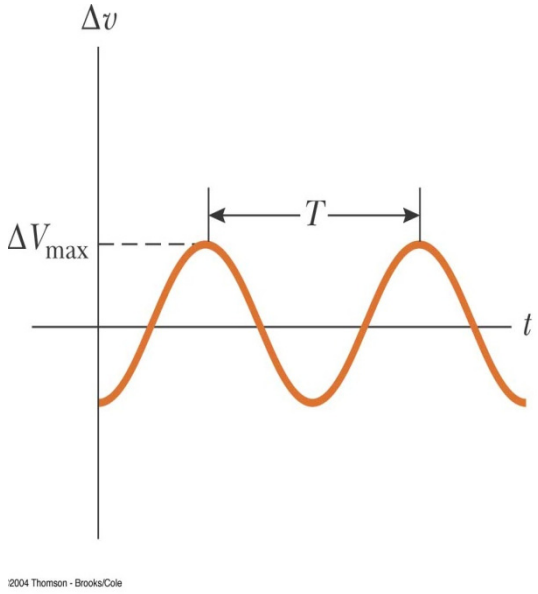
$\Delta v = \Delta V_{max} \sin \omega t$

Δv is the instantaneous voltage

ΔV_{max} is the maximum output voltage of the source

Also called the **voltage amplitude**

ω is the angular frequency of the AC voltage



The angular frequency is

$$\omega = 2\pi f = \frac{2\pi}{T}$$

f is the frequency of the source

T is the period of the source

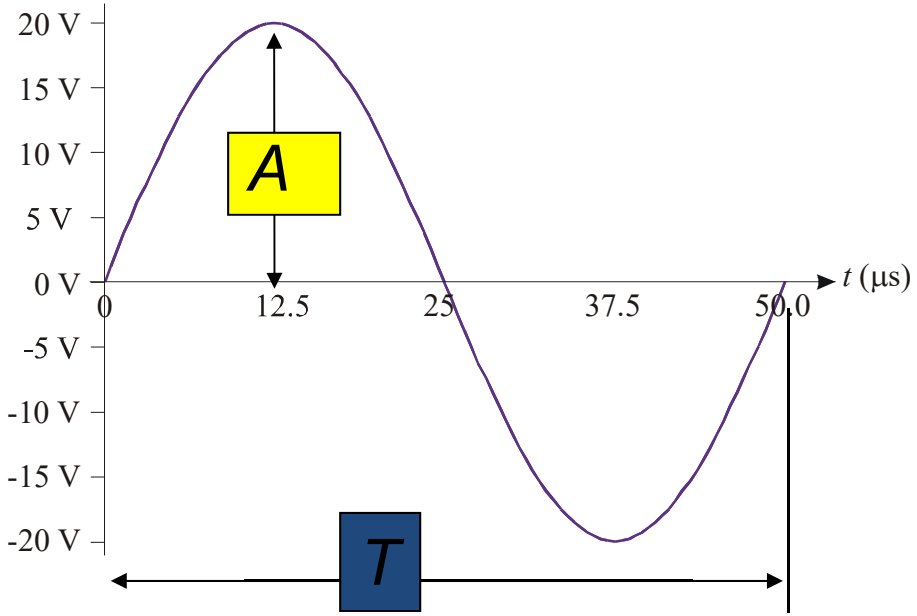
The voltage is positive during one half of the cycle and negative during the other half

- The current in any circuit driven by an AC source is an alternating current that varies sinusoidally with time

Sine waves are characterized by the amplitude and period. The **amplitude** is the maximum value of a voltage or current; the **period** is the time interval for one complete cycle.

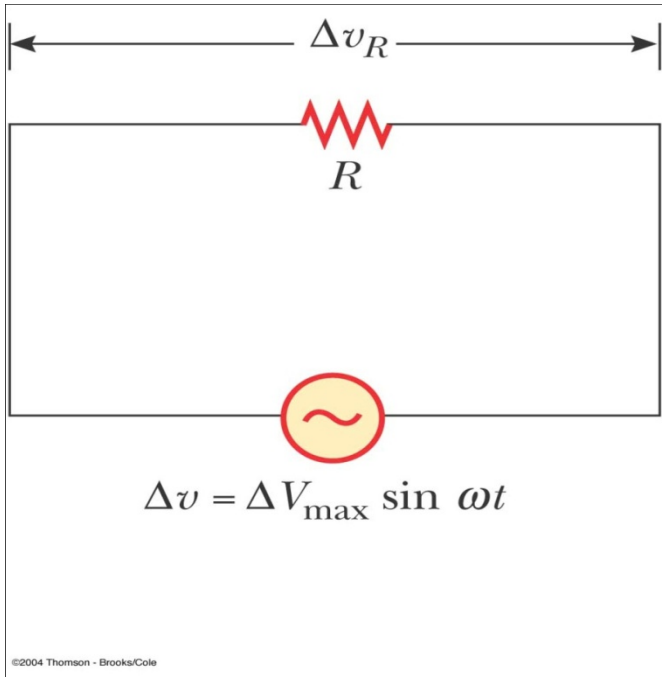
The amplitude (A) of this sine wave is 20 V

The period is 50.0 μs



If the period is 50 μs, the frequency is 0.02 MHz = 20 kHz.

33.2 RESISTORS IN AN AC CIRCUIT



- Consider a circuit consisting of an AC source and a resistor
- The AC source is symbolized by 
- $\Delta v_R = \Delta v = V_{max} \sin \omega t$
- Δv_R is the instantaneous voltage across the resistor

- The instantaneous current in the resistor is

$$i_R = \frac{\Delta v_R}{R} = \frac{\Delta V_{max}}{R} \sin \omega t = I_{max} \sin \omega t$$

- The instantaneous voltage across the resistor is also given as

$\Delta v_R = I_{max} R \sin \omega t$

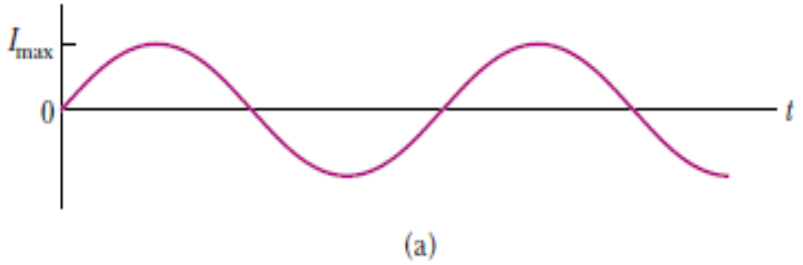
rms Current and Voltage

- The average current in one cycle is zero
- The rms current is the average of importance in an AC circuit
  - rms stands for root mean square

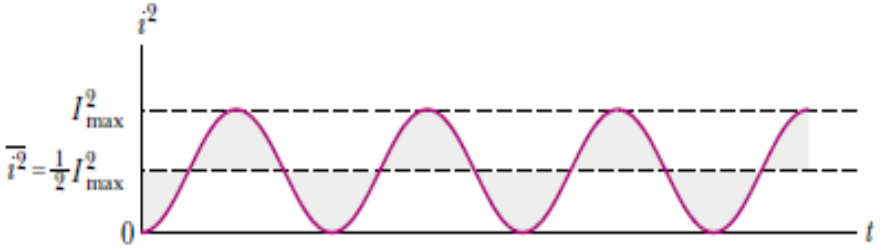
$$I_{rms} = \frac{I_{max}}{\sqrt{2}} = 0.707\, I_{max}$$

- Alternating voltages can also be
- discussed in terms of rms values

$$\Delta V_{rms} = \frac{\Delta V_{max}}{\sqrt{2}} = 0.707\, \Delta V_{max}$$



(a)



(b)

rms Current and Voltage

- The average current in one cycle is zero
- The rms current is the average of importance in an AC circuit
  - rms stands for root mean square

$$I_{rms} = \frac{I_{max}}{\sqrt{2}} = 0.707\, I_{max}$$

- Alternating voltages can also be discussed in terms of rms values

$$\Delta V_{rms} = \frac{\Delta V_{max}}{\sqrt{2}} = 0.707\, \Delta V_{max}$$

rms values are used when discussing alternating currents and voltages because

AC ammeters and voltmeters are designed to read rms values

Example : For a particular device, the house ac voltage is 120-V and the ac current is 10 A. What are their maximum values?

$I_{rms} = 0.707\ I_{max}$

$$I_{\max} = \frac{I_{rms}}{0.707} = \frac{10}{0.707} = 14.14A$$

$V_{rms} = 0.707\ V_{max}$

$$V_{\max} = \frac{V_{rms}}{0.707} = \frac{120}{0.707} = 170\ V$$

Example

- A 60 W light bulb operates on a peak voltage of 156 V. Find the V_{rms}, I_{rms}, and resistance of the light bulb.

- V_{rms} = 110 V
- I_{rms} = 0.55 A
- R = 202 Ω

V_{rms} = 156 V / √2 = 110 V

I_{rms}: P = IV → 60 W = I (110V) → .55 A

$P=V^2/R$ → 60 W = $(110\ V)^2/R$ → R = $(110V)^2/60W$ → 202 Ω

Power

- The rate at which electrical energy is dissipated in the circuit is given by
  - $P = i^2R$
    - i is the *instantaneous current*
    - The heating effect produced by an AC current with a maximum value of I_{max} is not the same as that of a DC current of the same value
    - The maximum current occurs for a small amount of time
- The average power delivered to a resistor that carries an alternating current is $P_{av} = I_{rms}^2 R$

Example:

Assume a sine wave with a peak value of 40 V is applied to a 100 Ω resistive load. What power is dissipated?

$$V_{rms} = 0.707 \times V_p = 0.707 \times 40\ V = 28.3\ V$$

$$P = \frac{V_{rms}^2}{R} = \frac{28.3\ V^2}{100\ \Omega} = 8\ W$$

Example 33.1 **What Is the rms Current?**

The voltage output of an AC source is given by the expression $\Delta v = (200\ \text{V}) \sin \omega t$. Find the rms current in the circuit when this source is connected to a 100-Ω resistor.

$$\Delta V_{\text{rms}} = \frac{\Delta V_{\text{max}}}{\sqrt{2}} = \frac{200\ \text{V}}{\sqrt{2}} = 141\ \text{V}$$

$$I_{\text{rms}} = \frac{\Delta V_{\text{rms}}}{R} = \frac{141\ \text{V}}{100\ \Omega} = 1.41\ \text{A}$$

1- A heater takes 10 A rms from the 230 V rms mains. What is its power?

A) 1,630 W
B) 2,300 W
C) 3,250 W
D) 4,600 W

2- The voltage output of an AC source is given by the expression : v = (200 V) sin wt. Find the rms current in the circuit when this source is connected to a 100-Ωresistor.

$$I_{rms} = \frac{V_{rms}}{R} = \frac{V_{\max}/\sqrt{2}}{R} = \frac{200/\sqrt{2}}{100}$$

$$I_{rms} = 2 \times 0.707 = 1.414 A$$