AC Fundamentals

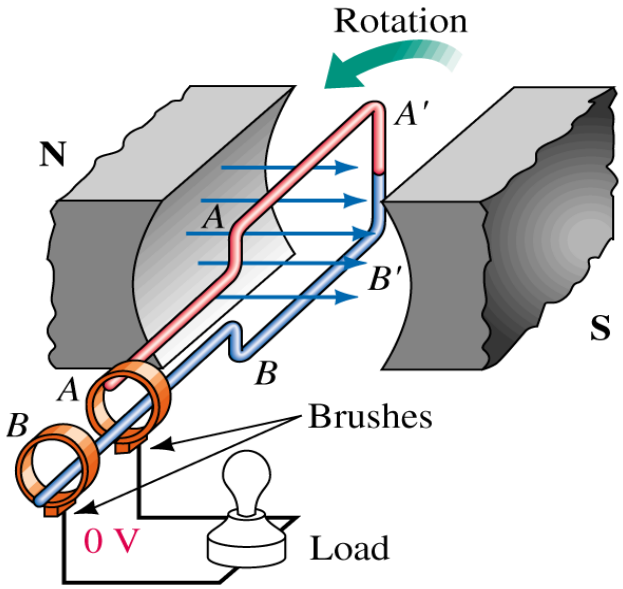
Alternating Current

- Voltages of ac sources alternate in polarity and vary in magnitude
- Voltages produce currents that vary in magnitude and alternate in direction

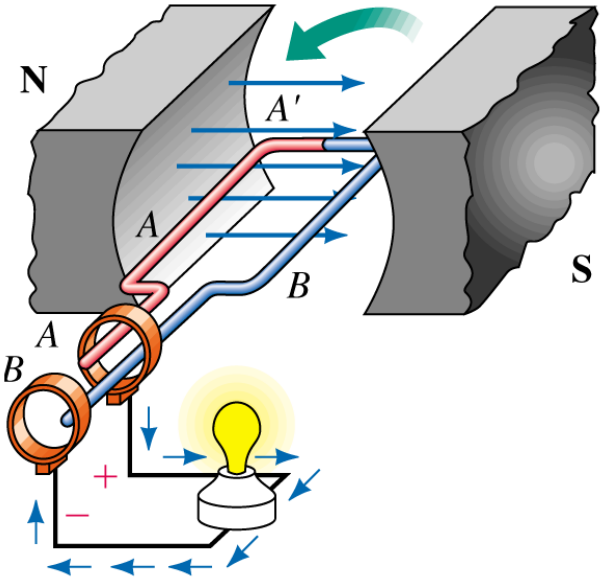
Alternating Current

- A sinusoidal ac waveform starts at zero
  - Increases to a positive maximum
  - Decreases to zero
  - Changes polarity
  - Increases to a negative maximum
  - Returns to zero
- Variation is called a cycle

Generating AC Voltages

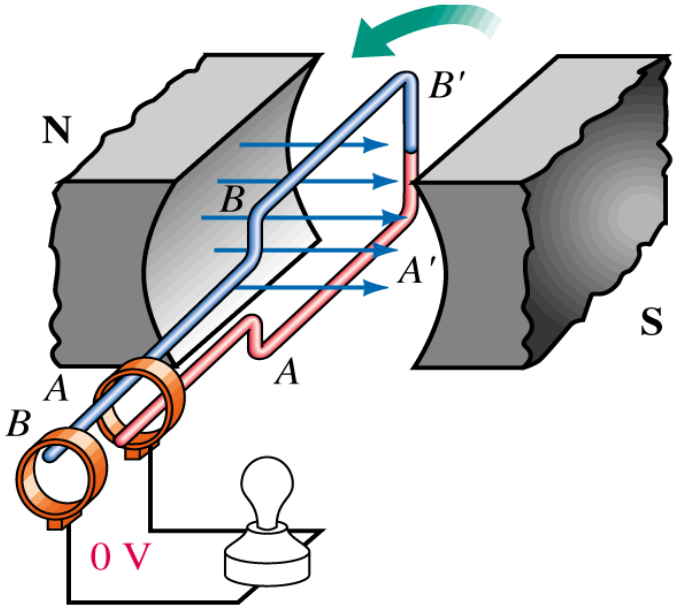


(a) 0° Position: Coil sides move parallel to flux lines. Since no flux is being cut, induced voltage is zero.

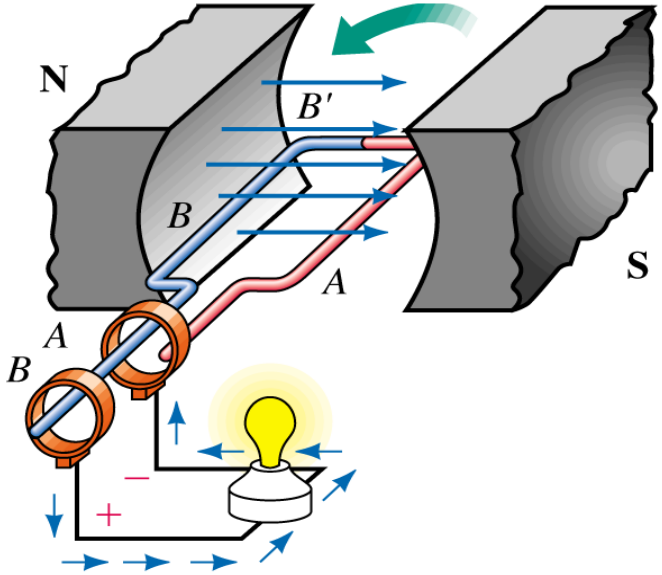


(b) 90° Position: Coil end *A* is positive with respect to *B*. Current direction is out of slip ring *A*.

Generating AC Voltages



(c) 180° Position: Coil again cutting no flux. Induced voltage is zero.



(d) 270° Position: Voltage polarity has reversed, therefore, current direction reverses.

AC Voltage-Current Conventions

- Assign a reference polarity for source
- When voltage has a positive value
  - Its polarity is same as reference polarity
- When voltage is negative
  - Its polarity is opposite that of the reference polarity

AC Voltage-Current Conventions

- Assign a reference direction for current that leaves source at positive reference polarity
- When current has a positive value
  - Its actual direction is same as current reference arrow

AC Voltage-Current Conventions

- When current is negative
  - Its actual direction is opposite that of current reference arrow

Frequency

- Number of cycles per second of a waveform
  - Frequency
  - Denoted by f
- Unit of frequency is hertz (Hz)
- 1 Hz = 1 cycle per second

Period

- Period of a waveform
  - Time it takes to complete one cycle
- Time is measured in seconds
- The period is the reciprocal of frequency
  - $T = 1/f$

Amplitude and Peak-to-Peak Value

- Amplitude of a sine wave
  - Distance from its average to its peak
- We use E_m for amplitude
- Peak-to-peak voltage
  - Measured between minimum and maximum peaks
- We use E_{pp} or V_{pp}

Peak Value

- Peak value of an ac voltage or current
  - Maximum value with respect to zero
- If a sine wave is superimposed on a dc value
  - Peak value of combined wave is sum of dc voltage and peak value of ac waveform amplitude

The Basic Sine Wave Equation

- Voltage produced by a generator is
  - $e = E_m \sin \alpha$
- E_m is maximum (peak) voltage
- α is instantaneous angular position of rotating coil of the generator

The Basic Sine Wave Equation

- Voltage at angular position of sine wave generator
  - May be found by multiplying E_m times the sine of angle at that position

Angular Velocity

- Rate at which the generator coil rotates with respect to time, ω (Greek letter omega)

Angular Velocity

- Units for ω are revolutions/second, degrees/sec, or radians/sec.

$$\omega = \frac{\alpha}{t}$$

$$\alpha = \omega t$$

Radian Measure

- ω is usually expressed in radians/second
- 2π radians $= 360°$
- To convert from degrees to radians, multiply by $\pi/180$

Radian Measure

- To convert from radians to degrees, multiply by $180/\pi$
- When using a calculator
  - Be sure it is set to radian mode when working with angles measured in radians

Relationship between ω, T, and f

- One cycle of a sine wave may be represented by $\alpha = 2\pi$ rads or $t = T$ sec

$$\alpha = \omega t$$

$$\omega T = 2\pi$$

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

$$\omega = 2\pi f$$

Voltages and Currents as Functions of Time

- Since $\alpha = \omega t$, the equation $e = E_m \sin \alpha$ becomes $e(t) = E_m \sin \omega t$
- Also, $v(t) = V_m \sin \omega t$ and $i(t) = I_m \sin \omega t$

Voltages and Currents as Functions of Time

- Equations used to compute voltages and currents at any instant of time
- Referred to as instantaneous voltage or current

Voltages and Currents with Phase Shifts

- If a sine wave does not pass through zero at $t = 0$, it has a phase shift
- For a waveform shifted left
  - $v = V_m \sin(\omega t + \theta)$
- For a waveform shifted right
  - $v = V_m \sin(\omega t - \theta)$