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Introduction

This is a learning as well as an exam preparation video.

At the end of the video are practice assignments for you to attempt.

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MEGAForte

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Chapter 7: Alternating Current

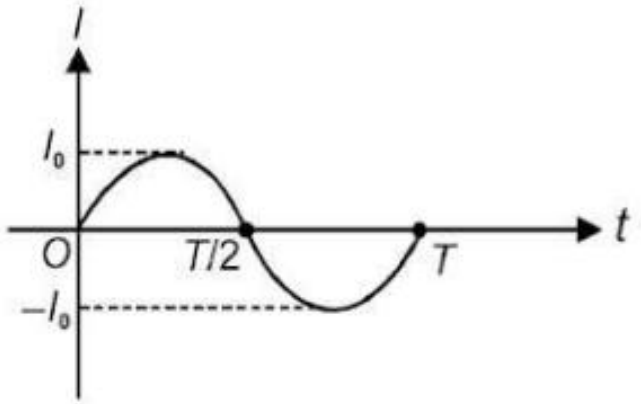
Chapter 7: Alternating Current

Introduction

The magnitude of alternating current changes continuously with time and its direction is reversed periodically. It is represented by

$$I = I_0 \sin \omega t \text{ or } I = I_0 \cos \omega t$$

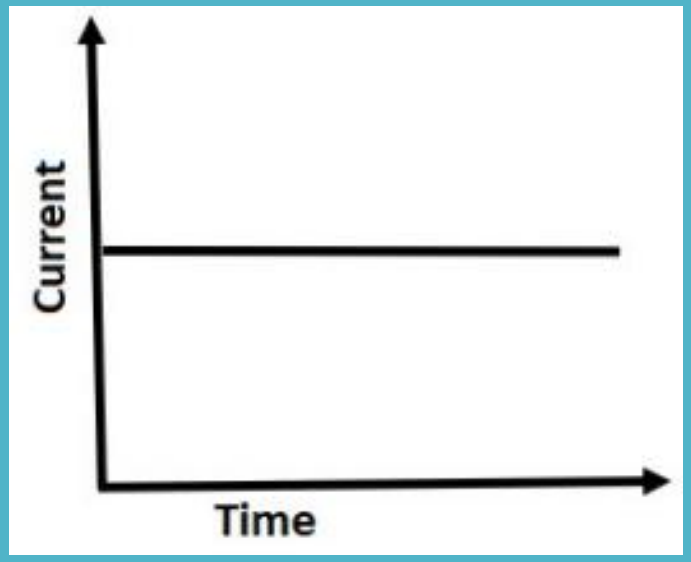
$$\omega = \frac{2\pi}{T} = 2\pi v$$



Chapter 7: Alternating Current

Direct current (DC):

Direct current (DC) is electrical current which flows consistently in one direction. The current that flows in a flashlight or another appliance running on batteries is direct current.



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Mean value for half cycle of AC:

Mean value of AC is the total charge that flows through a circuit element in a given time interval divided by the time interval. emf.

Chapter 7: Alternating Current

Mean value for half cycle of AC:

For half cycle

$$I_{mean} = \frac{\int_0^T I dt}{T}$$

$$I_{mean} = \frac{\int_0^{\frac{T}{2}} I dt}{\frac{T}{2}}$$

$$I_{mean} = \frac{2}{T}\int_0^{\frac{T}{2}} I_0 \sin \omega dt$$

$$I_{mean} = \frac{2I_0}{T}\left[\frac{-\cos \omega t}{\omega}\right]_0^{\frac{T}{2}}$$

$$I_{mean} = \frac{2I_0}{2\pi}\left[-\cos \pi - \cos 0\right] \ldots \left(\because \omega = \frac{2\pi}{T}\right)$$

$$I_{mean} = \frac{2I_0}{\pi}$$

Note: For complete cycle, mean value = 0

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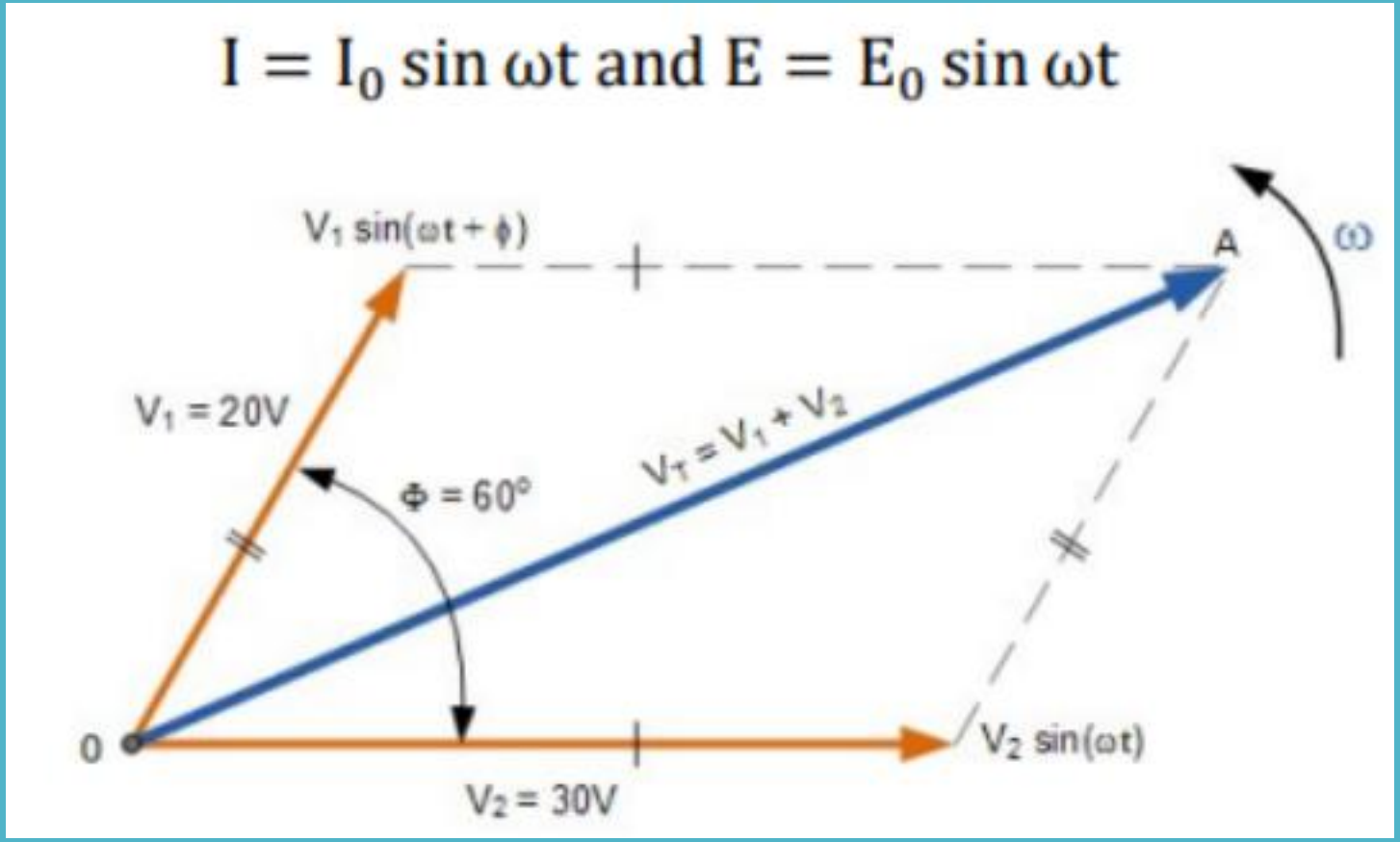
Phasor Diagram:

In the a.c. circuit containing R only, current and voltage are in the same phase. Therefore, in figure, both phasors $\overrightarrow{I_0}$ and $\overrightarrow{E_0}$ are in the same direction making an angle (ωt) with OX. This is so for all times. It means that the phase angle between alternating voltage and current through R is Zero.

Chapter 7: Alternating Current

Phasor Diagram:



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Capacitive Reactance (XC):

The opposing nature of capacitor to the flow of alternating current is called capacitive reactance.

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi fc}$$

Where, C = capacitance

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Capacitive Reactance (XC):

Choke Coil:

A choke coil is an inductor having a small resistance. It is a device used in ac circuits to control current without wasting too much power. As it has low resistance, its power factor cos ϕis low.

Wattless Current:

The current in an AC circuit when average power consumption in AC circuit is zero, is referred as wattless current or idle current.

Chapter 7: Alternating Current

Capacitive Reactance (XC):

A.C. Generator or A.C. Dynamo:

An a.c. generator/ dynamo is a machine that produces alternating current energy from mechanical energy. It is one of the most important applications of the phenomenon of electromagnetic induction. The generator was designed originally by a Yugoslav scientist, Nikola Tesla. The word generator is a misnomer because nothing is generated by the machine. In fact, it is an alternator converting one form of energy into another.

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Capacitive Reactance (XC):

Transformer:

A transformer which increases the a.c. voltage is called a step-up transformer. A transformer

which decreases the a.c. voltages are called a step-down transformer.

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Electromagnetic Spectrum:

After the experimental discovery of electromagnetic waves by Hertz, many other electromagnetic waves were discovered by different ways of excitation.

The orderly distribution of electromagnetic radiations according to their wavelength or frequency is called the electromagnetic spectrum.

Chapter 7: Alternating Current

Electromagnetic Spectrum:

The electromagnetic spectrum has much wider range with wavelength variation 10−14m to 6 × 102m.

The whole electromagnetic spectrum has been classified into different parts and subparts in order of increasing wavelength, according to their type of excitation. There is overlapping in certain parts of the spectrum, showing that the corresponding radiations can be produced by two methods. It may be noted that the physical properties of electromagnetic waves are decided by their wavelengths and not by the method of their excitation.

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Electromagnetic Spectrum:

Main Parts of Electromagnetic Spectrum:

The electromagnetic spectrum has been broadly classified into following main parts; mentioned

below in the order of increasing frequency.

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Electromagnetic Spectrum:

- **Radio waves:**

These are the electromagnetic wave of frequency range from 5 × 105Hz to 109Hz. These waves are produced by oscillating electric circuits having an inductor and capacitor.

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Electromagnetic Spectrum:

Uses:

1. The electromagnetic waves of frequency range from 530 kHz to 1710kH form amplitude modulated (AM) band. It is used in ground wave propagation.

2. The electromagnetic waves of frequency range 1710kHz to 54Mhz are used for short wave bands. It is used in sky wave propagation.

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Electromagnetic Spectrum:

- **Microwaves:**

Microwaves are the electromagnetic waves of frequency range 1GHz to 300GHz. They are produced by special vacuum tubes. namely, klystrons, magnetrons and Gunn diodes etc.

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Electromagnetic Spectrum:

Uses:

1. Microwaves are used in Radar systems for aircraft navigation.

2. A radar using microwave can help in detecting the speed of tennis ball, cricket ball, automobile while in motion.

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Electromagnetic Spectrum:

- **Infrared waves:**

Infrared waves were discovered by Herschel. These are the electromagnetic waves of frequency range 3 × 1011Hz to 4 × 1014Hz. Infrared waves sometimes are called as heat waves. Infrared waves are produced by hot bodies and molecules. These wave are not detected by human eye but snake can detect them.

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Electromagnetic Spectrum:

Uses:

1. In physical therapy, i.e., to treat muscular strain.
2. To provide electrical energy to satellite by using solar cells.
3. For producing dehydrated fruits.

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Electromagnetic Spectrum:

- **Visible Light:**

It is the narrow region of electromagnetic spectrum, which is detected by the human eye. Its frequency is ranging from 4 × 1014Hz to 8 × 1014Hz. It is produced due to atomic excitation.

The visible light emitted or reflected from objects around us provides the information about the world surrounding us.

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Electromagnetic Spectrum:

- **Ultraviolet Rays:**

The ultraviolet rays were discovered by Ritter in 1801. The frequency range of ultraviolet rays is 8 × 1014Hz to 5 × 1016 Hz. The ultraviolet rays are produced by sun, special lamps, and very hot bodies.

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Electromagnetic Spectrum:

Uses: Ultraviolet rays are used:

1. For checking the mineral samples through the property of ultraviolet rays causing fluorescence. electrons in the external shell through ultraviolet absorption spectra.
2. To destroy the bacteria and for sterilizing the surgical instruments.
3. In burglar alarm.

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Electromagnetic Spectrum:

- **X-rays:**

The X-rays were discovered by German Physicist W. Roentgen. Their frequency range is 1016Hz to 3 × 1021Hz. These are produced when high energy electrons are stopped suddenly on a metal of high atomic number. X-rays have high penetrating power.

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Electromagnetic Spectrum:

Uses: X-rays are used:

1. In surgery for the detection of fractures, foreign bodies like bullets, diseased organs and stones in the human body.
2. In Engineering (i) for detecting faults, cracks, flaws and holes in final metal products (ii) for the testing of welding, casting and moulds.
3. In Radio therapy, to cure untraceable skin diseases and malignant growth.

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Electromagnetic Spectrum:

- γ -Rays:

γ -rays are the electromagnetic waves of frequency range 3 × 1018Hz to 5 × 1022Hz. γ-rays have nuclear origin. These rays are highly energetic and are produced by

the nucleus of the radioactive substances.

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Electromagnetic Spectrum:

Uses: γ -rays are used:

1. In the treatment of cancer and tumours.
2. To preserve the food stuffs for a long time as the soft. γ-rays can kill microorganisms easily.
3. To produce nuclear reactions.

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Charging and Discharging of a Capacitor:

The instantaneous charge on a capacitor on charging at any instant of time t is given by

$$q = q_0\left(1 - e - \frac{t}{Rc}\right)$$

where RC = τ, is called time constant of a R – C circuit.

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Charging and Discharging of a Capacitor:

The instantaneous charge on a capacitor in discharging at any instant of time t is given by

$$q = q_0 e - \frac{t}{Rc}$$

Time constant of a R – C circuit is the time in which charge in the capacitor grows to 63.8% or

decay to 36.8% of the maximum charge on capacitor.

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Charging and Discharging of a Capacitor:

Transient Current:

An electric current which very for a small finite time, while growing from zero to maximum or decaying from maximum to zero, is called a transient current.

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Differences between Alternating Current and Direct Current:

Alternating Current	Direct Current
AC is safe to transfer longer distance even between two cities and maintain the electric power.	DC cannot travel for a very long distance. It loses electric power.

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Differences between Alternating Current and Direct Current:

Alternating Current	Direct Current
The rotating magnets cause the change in direction of electric flow.	The steady magnetism makes DC flow in a single direction.
The frequency of AC is dependent upon the country. But generally, the frequency is 50 Hz or 60 Hz.	DC has no frequency of zero frequency.

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Differences between Alternating Current and Direct Current:

Alternating Current	Direct Current
In AC the flow of current changes its direction backwards periodically.	It flows in a single direction steadily.
Electrons in AC keep changing its directions – backward and forward	Electrons only move in one direction – that is forward.

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Use of Transformers in Transmission:

- In electric power transmission, transformers allow transmission of electric power at high voltages, which reduces the loss due to heating of the wires.
- In many electronic devices, a transformer is used to convert voltage from the distribution wiring to convenient values for the circuit requirements.
- Signal and audio transformers are used to couple stages of amplifiers and to match devices such as microphones and record players to the input of amplifiers.

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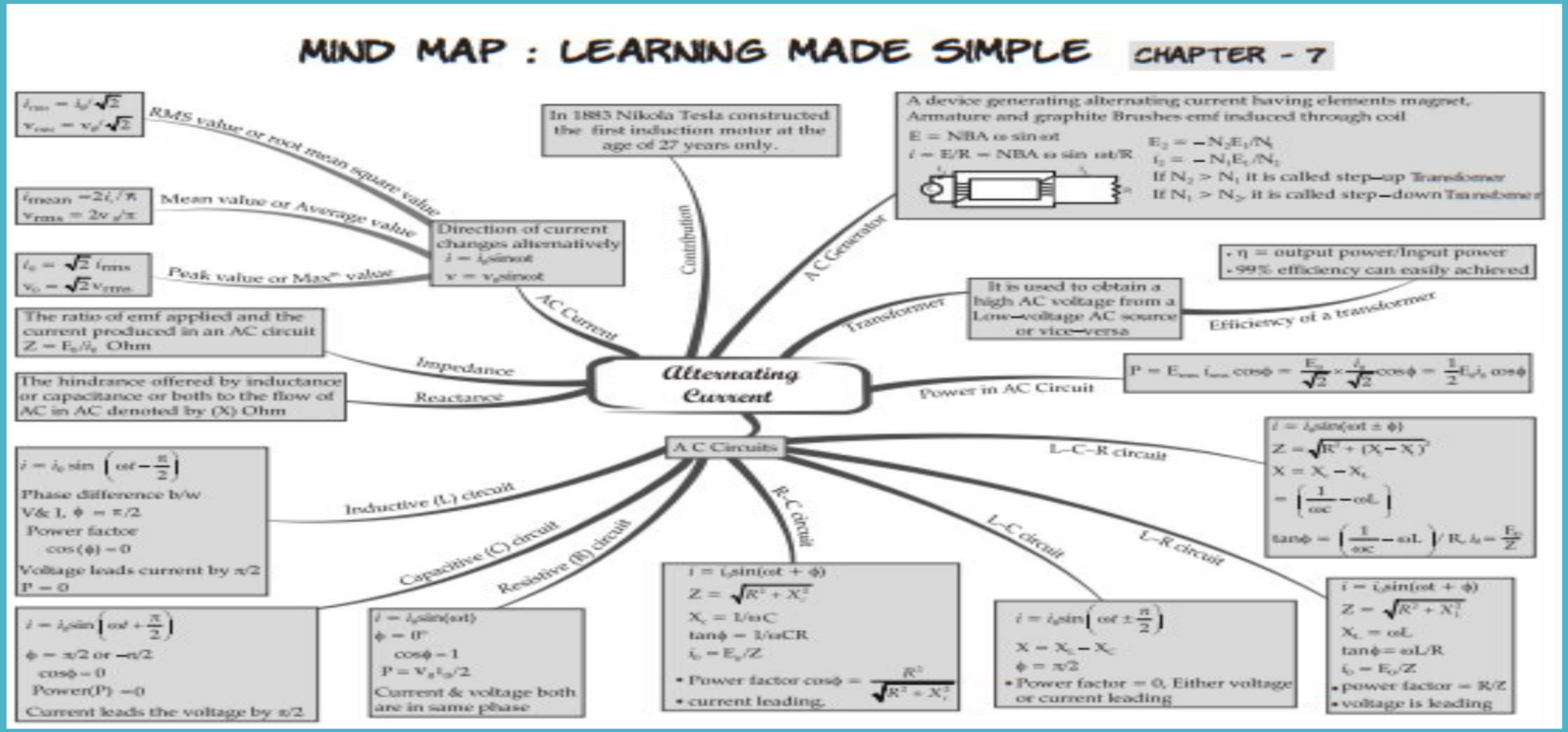
Use of Transformers in Transmission:

- Audio transformers allowed telephone circuits to carry on a two-way conversation over a single pair of wires.
- Resonant transformers are used for coupling between stages of radio receivers, or in highvoltage Tesla coils.

Chapter 7: Alternating Current



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