PDHonline Course E171 (4 PDH)

Basic Electrical Theory - Overview of AC Power, AC Generators, AC Reactive Components, and Voltage Regulators

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Course Summary

Remember these facts

1) Efficiency is equal to output divided by input
2) The following terms relate to the AC cycle: radians/second, the velocity the loop turns; hertz, the number of cycles in one second; period, the time to complete one cycle.
3) The period of a waveform is the time required for completing one full cycle. It is measured in seconds
4) The frequency of a waveform is the number of cycles that is completed each second. It is measured in Hertz(Hz)
5) The phase angle of a waveform is angular difference between two waveforms of the same frequency. It is measured in degrees or radians
6) Effective value of AC equals effective value of DC.
7) Root mean square (RMS) values equate AC to DC equivalents:

- Effective Current: $I = 0.707\ I_{max}$
- Effective Voltage: $E = 0.707\ E_{max}$
- Average Current: $Iav = 0.636\ I_{max} = 0.9\ I$
- Average Voltage: $Eav = 0.636\ E_{max} = 0.9\ E$

8) Power factor is a measure of how far current leads or lags voltage

- In pure resistive circuits power factor is unity
- In inductive circuits current lags voltage
- In capacitive circuits current leads voltage

9) As in the case with DC power, the instantaneous electric power in an AC circuit is given by P = E x I, but these quantities are continuously varying.

- In a purely resistive circuit all of the power is consumed and none is returned to the source.
- When an alternating voltage is impressed across a capacitor, power is taken from the source and stored in the capacitor as the voltage increases from zero to its maximum value. Then, as the impressed voltage decreases from its maximum value to zero, the capacitor discharges and returns the power to the source.
- Likewise, as the current through an inductor increases from its zero value to its maximum value the field around the inductor builds up to a maximum, and when the current decreases from maximum to zero the field collapses and returns the power to the source.

Thus, in case of inductive and capacitive circuits, no power is used up in either case, since the power alternately flows to and from the source. This power that is returned to the source by the reactive components in the circuit is called reactive power.

10) Power in AC circuits where power factor is not 100 percent or unity:

- Power = E x I x power factor (for single phase)
- Power = E x I x 1.732 X power factor (for three phase)

This power is also called true power or real power as opposed to apparent power found by calculating volt-amperes.

11) A simple generator consists of a conductor loop turning in a magnetic field, cutting across the magnetic lines of force. The sine wave output is the result of one side of the generator loop cutting lines of force. In the first half turn of rotation this produces a positive current and in the second half of rotation produces a negative current. This completes one cycle of AC generation.
12) Inductance: The property of a circuit, which impedes a change in current. Inductors are the usual source of inductance. Inductance is measured in henrys. In electronic circuits, the usual measure of inductance is henrys (H), milihenrys (mH) or micro henrys (µH) i.e. 1, 1 * e^{-3} or 1 * e^{-6} henrys respectively.
13) Capacitance: The property of a circuit which impedes a change in voltage. Capacitors are the usual source of capacitance. Capacitance is measured in farads in honor of Michael Faraday. In electronic circuits, the usual measure of capacitance is microfarads (µF) or Pico farads (pF), $1e^{-6}$ or $1e^{-12}$ farads respectively.
14) Opposition to the flow of alternating current caused by inductance is called Inductive Reactance (XL). The formula for calculating XL is: XL = 2ЛfL
15) Current (I) lags applied voltage (E) in a purely inductive circuit by 90° phase angle.
16) Opposition to the flow of alternating current caused by capacitance is called capacitive reactance (XC). The formula for calculating XC is: XC = 1/ 2ЛfC
17) Current (I) leads applied voltage by 90º in a purely capacitive circuit.
18) Resonance is a state in which the inductive reactance equals the capacitive reactance (XL = XC) at a specified frequency.
19) Resonant frequency is:

$$f_{Res} = \frac{1}{2\pi\sqrt{LC}}$$

20) R-C-L series circuit at resonance is when net reactance is zero and circuit current output is determined by the series resistance of the circuit.
21) R-C-L parallel circuit at resonance is when net reactance is maximum and circuit current output is at minimum.
22) Observe the equations for apparent, true, and reactive power, and power factor:
23) Unbalanced three-phase circuits are indicated by abnormally high currents in one or more of the phases.
24) The field in an AC generator consists of coils of conductors within the generator that receive a voltage from a source (called excitation) and produce a magnetic flux.
    - The armature is the part of an AC generator in which output voltage is produced.
    - The prime mover is the component that is used to drive the AC generator.
    - The rotor of an AC generator is the part that is driven by the prime mover and that rotates.
    - The stator of an AC generator is the part that is stationary.
    - Slip rings are electrical connections that are used to transfer power to and from the rotor of an AC generator.
25) Power (kW) ratings of an AC generator are based on the ability of the prime mover to overcome generation losses and the ability of the machine to dissipate the heat generated internally. The current rating of an AC generator is based on the insulation rating of the machine.

26) There are three requirements that must be met to parallel AC generators:
    - Their terminal voltages must be equal. A mismatch may cause high currents and generator or distribution system damage.
    - Their frequencies must be equal. A mismatch in frequencies can cause one generator to "motor," causing an overload in the generators and the distribution system.
    - Their output voltages must be in phase. A mismatch in the phases will cause large opposing voltages to be developed, resulting in damage to the generators and distribution system due to high currents.
27) The disadvantage of a stationary field, rotating armature is that the slip-ring and brush assembly is in series with the load circuits and, because of worn or dirty components, may interrupt the flow of current.
28) A stationary armature, rotating field generator has several advantages: (1) a load can be connected to the armature without moving contacts in the circuit; (2) it is much easier to insulate stator fields than rotating fields; and (3) much higher voltages and currents can be generated.
29) The advantage of the delta-connected AC generator is that if one phase becomes damaged or open, the remaining two phases can still deliver three-phase power at a reduced capacity of 57.7%.
30) The advantage of a wye-connected AC generator is that each phase only has to carry 57.7% of line voltage and, therefore, can be used for high voltage generation.