

## 19.8: Alternating-Current Circuits (Summary)

### Key Terms

<b>ac current</b>	current that fluctuates sinusoidally with time at a fixed frequency
<b>ac voltage</b>	voltage that fluctuates sinusoidally with time at a fixed frequency
<b>alternating current (ac)</b>	flow of electric charge that periodically reverses direction
<b>average power</b>	time average of the instantaneous power over one cycle
<b>bandwidth</b>	range of angular frequencies over which the average power is greater than one-half the maximum value of the average power
<b>capacitive reactance</b>	opposition of a capacitor to a change in current
<b>direct current (dc)</b>	flow of electric charge in only one direction
<b>impedance</b>	ac analog to resistance in a dc circuit, which measures the combined effect of resistance, capacitive reactance, and inductive reactance
<b>inductive reactance</b>	opposition of an inductor to a change in current
<b>phase angle</b>	amount by which the voltage and current are out of phase with each other in a circuit
<b>power factor</b>	amount by which the power delivered in the circuit is less than the theoretical maximum of the circuit due to voltage and current being out of phase
<b>quality factor</b>	dimensionless quantity that describes the sharpness of the peak of the bandwidth; a high quality factor is a sharp or narrow resonance peak
<b>resonant frequency</b>	frequency at which the amplitude of the current is a maximum and the circuit would oscillate if not driven by a voltage source
<b>rms current</b>	root mean square of the current
<b>rms voltage</b>	root mean square of the voltage
<b>step-down transformer</b>	transformer that decreases voltage and increases current
<b>step-up transformer</b>	transformer that increases voltage and decreases current
<b>transformer</b>	device that transforms voltages from one value to another using induction
<b>transformer equation</b>	equation showing that the ratio of the secondary to primary voltages in a transformer equals the ratio of the number of turns in their windings

### Key Equations

AC voltage	<i>[Math Processing Error]</i>
AC current	<i>[Math Processing Error]</i>
capacitive reactance	<i>[Math Processing Error]</i>
rms voltage	<i>[Math Processing Error]</i>
rms current	<i>[Math Processing Error]</i>

inductive reactance	<i>[Math Processing Error]</i>
Phase angle of an RLC series circuit	<i>[Math Processing Error]</i>
AC version of Ohm's law	<i>[Math Processing Error]</i>
Impedance of an RLC series circuit	<i>[Math Processing Error]</i>
Average power associated with a circuit element	<i>[Math Processing Error]</i>
Average power dissipated by a resistor	<i>[Math Processing Error]</i>
Resonant angular frequency of a circuit	<i>[Math Processing Error]</i>
Quality factor of a circuit	<i>[Math Processing Error]</i>
Quality factor of a circuit in terms of the circuit parameters	<i>[Math Processing Error]</i>
Transformer equation with voltage	<i>[Math Processing Error]</i>
Transformer equation with current	<i>[Math Processing Error]</i>

## Summary

### 15.2 AC Sources

- Direct current (dc) refers to systems in which the source voltage is constant.
- Alternating current (ac) refers to systems in which the source voltage varies periodically, particularly sinusoidally.
- The voltage source of an ac system puts out a voltage that is calculated from the time, the peak voltage, and the angular frequency.
- In a simple circuit, the current is found by dividing the voltage by the resistance. An ac current is calculated using the peak current (determined by dividing the peak voltage by the resistance), the angular frequency, and the time.

### 15.3 Simple AC Circuits

- For resistors, the current through and the voltage across are in phase.
- For capacitors, we find that when a sinusoidal voltage is applied to a capacitor, the voltage follows the current by one-fourth of a cycle. Since a capacitor can stop current when fully charged, it limits current and offers another form of ac resistance, called capacitive reactance, which has units of ohms.
- For inductors in ac circuits, we find that when a sinusoidal voltage is applied to an inductor, the voltage leads the current by one-fourth of a cycle.
- The opposition of an inductor to a change in current is expressed as a type of ac reactance. This inductive reactance, which has units of ohms, varies with the frequency of the ac source.

### 15.4 RLC Series Circuits with AC

- An **RLC** series circuit is a resistor, capacitor, and inductor series combination across an ac source.
- The same current flows through each element of an **RLC** series circuit at all points in time.
- The counterpart of resistance in a dc circuit is impedance, which measures the combined effect of resistors, capacitors, and inductors. The maximum current is defined by the ac version of Ohm's law.
- Impedance has units of ohms and is found using the resistance, the capacitive reactance, and the inductive reactance.

### 15.5 Power in an AC Circuit

- The average ac power is found by multiplying the rms values of current and voltage.
- Ohm's law for the rms ac is found by dividing the rms voltage by the impedance.
- In an ac circuit, there is a phase angle between the source voltage and the current, which can be found by dividing the resistance by the impedance.
- The average power delivered to an **RLC** circuit is affected by the phase angle.
- The power factor ranges from  $-1$  to  $1$ .

### 15.6 Resonance in an AC Circuit

- At the resonant frequency, inductive reactance equals capacitive reactance.
- The average power versus angular frequency plot for a **RLC** circuit has a peak located at the resonant frequency; the sharpness or width of the peak is known as the bandwidth.
- The bandwidth is related to a dimensionless quantity called the quality factor. A high quality factor value is a sharp or narrow peak.

### 15.7 Transformers

- Power plants transmit high voltages at low currents to achieve lower ohmic losses in their many kilometers of transmission lines.
- Transformers use induction to transform voltages from one value to another.
- For a transformer, the voltages across the primary and secondary coils, or windings, are related by the transformer equation.
- The currents in the primary and secondary windings are related by the number of primary and secondary loops, or turns, in the windings of the transformer.
- A step-up transformer increases voltage and decreases current, whereas a step-down transformer decreases voltage and increases current.

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