EET-1210: AC ELECTRIC CIRCUITS

Cuyahoga Community College

Viewing: EET-1210 : AC Electric Circuits

Board of Trustees:

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Academic Term:

Fall 2023

Subject Code

EET - Electrical/Electronic Engineer

Course Number:

1210

Title:

AC Electric Circuits

Catalog Description:

Fundamentals of alternating current (AC) circuits involving resistance, capacitance, and inductance. Sinusoidal voltage, current power, phase, resonance, and frequency response of basic circuit elements in series, parallel, and series-parallel circuits, pulsed circuit analysis. Circuit analysis using network theorems may include Kirchhoff's laws, Mesh, Nodal, and Bridge Network analysis, Superposition, Thevenin's, Norton's and Maximum Power Transfer theorems. Decibels, filters, Bode plots, Fourier series, and system analysis are studied. Computer simulation and practical laboratory experiments using AC instrumentation for measuring series-parallel networks to observe and verify theory and concepts presented in lecture.

Credit Hour(s):

3

Lecture Hour(s):

2

Lab Hour(s):

2

Other Hour(s):

0

Requisites

Prerequisite and Corequisite

EET-1161 Direct Current Circuits; and EET-1180 Surface Mount Soldering, or concurrent enrollment; and MATH-0965 Intermediate Algebra or concurrent enrollment, or qualified Math placement; or departmental approval.

Outcomes

Course Outcome(s):

Demonstrate the properties of sine waves.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Determine the relationship between peak, peak-to-peak and Root Mean Square (RMS) of a sine wave.
b. Determine the period of a sine wave through calculation and measurement.
c. Determine the instantaneous voltage given a time value.
d. Define a radian and convert degrees to radians.
e. Convert radians to degrees.
f. Determine theoretically and through measurement the phase angle of two sine waves and determine which wave is leading and which wave is lagging.

g. Determine theoretically and through measurement the time difference of two sine waves and determine which wave is leading and which wave is lagging.

Course Outcome(s):

Use the rectangular coordinate system to explain the location of imaginary and real values.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Explain the four quadrants in terms of x and y and show the signs of each in each quadrant.
b. Explain the real and imaginary axis.
c. Explain the imaginary operator, "j".
d. Show how "j", in the geometric definition, represents a phase shift of 90 degrees.
e. Show how to add and subtract real and complex numbers in rectangular form.
f. Show how to multiply and divide complex numbers in polar form.
g. Convert values from rectangular to polar form and from polar form to rectangular form.

Course Outcome(s):

Use trigonometry as a tool in AC circuit calculations.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Demonstrate the relationship to side opposite (SO), side adjacent (SA) and the hypotenuse (H).
b. Show the sine function as represented by SO/H.
c. Given SO and H, calculate the sine.
d. Use the inverse sine to find the angle.
e. Show the cosine function as represented by SA/H.
f. Given SA and H, calculate the cosine.
g. Use the inverse cosine to find the angle.
h. Show the tangent function as represented by SO/SA.
i. Explain why the tangent function is not defined at 90 degrees.
j. Given SA and SO, calculate the tangent.
k. Use the inverse Tangent to find the angle.

Course Outcome(s):

Master the basic elements used in AC circuits.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Describe basic terms, prefixes, symbols, and components of AC electrical and electronic networks.
b. Describe how resistors affect the voltage and current phase angle.
c. Calculate capacitive reactance and show its dependency on frequency.
d. Represent capacitive reactance in rectangular and polar form.
e. Through theoretical and lab experimentation, show the current leads the voltage in a (perfect) capacitor by 90 degrees.
f. Calculate inductive reactance and show its dependency on frequency.
g. Represent inductive reactance in rectangular and polar form.
h. Through theoretical and lab experimentation, show that the current lags the voltage in an inductor by 90 degrees.

i. Through theoretical and lab experimentation, show that the current lags the voltage in a (real) inductor with winding resistance by less than 90 degrees.

Course Outcome(s):

Show circuit parameters of a series circuit and its impedance.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Explain impedance and admittance.
b. Represent resistance, capacitive reactance and inductive reactance as an impedance in rectangular and polar form.
c. Plot the impedance of resistors, capacitive reactance and inductive reactance on a rectangular coordinate system.
d. Calculate the total impedance of a RC circuit in polar form (magnitude and angle).
e. Find the voltage drop across R and C.
f. Explain why the voltage drop appears to violate Kirchhoff's voltage law (KVL).
g. Calculate the total impedance of an RL circuit in polar form (magnitude and angle).
h. Find the voltage drop across R and L.
i. Explain why the voltage drop appears to violate (KVL).
j. Calculate the total impedance of an RLC circuit in polar form (magnitude and angle).
k. Using the total impedance, calculate the current and express in rectangular and polar forms.

Course Outcome(s):

Show circuit parameters of a parallel circuit and its impedance.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Calculate the impedance of circuit elements that are in parallel.
b. Find the total impedance of a two branch leg using product/sum (P/S).
c. Convert the impedance of parallel components into their conductance and susceptance.
d. Calculate the admittance based on conductance and susceptance.
e. Convert the total conductance into the total impedance.
f. Find the branch currents, add them to calculate the verify the total impedance.

Course Outcome(s):

Determine the characteristics of series-parallel AC circuits.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Show how to group series parallel circuits into smaller series or parallel subcircuits.
b. Simplify and collapse subcircuits to find the total impedance.
c. Expand the subcircuits find critical node voltages in the process.
d. Determine node voltage while expanding the subcircuits.

Course Outcome(s):

Determine and measure the characteristics of series resonant circuits.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Use the series resonant formula to solve for frequency and component values given the necessary information about the circuit parameters.
b. Calculate a series resonant circuit's response, including impedance, voltage across components and current at resonance.
c. Measure a series resonant circuit's response, including impedance, voltage across components and current at resonance.
d. Using circuit simulation software, determine a series resonant circuit's response, including impedance, voltage across components and current at resonance.
e. Calculate the Q (quality factor) and bandwidth as a function of the resistance and reactance of the circuit.
f. Demonstrate theoretically, experimentally the Q rise in voltage across reactive elements.
g. Explain and demonstrate in circuit simulation software Q's dependence on the L/C ratio (L = inductance, C = capacitance).

Course Outcome(s):

Demonstrate the characteristics of parallel resonant circuits.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Use the parallel resonant formula (Q greater than or equal to 10) to solve for frequency and component values given the necessary information about the circuit parameters.
b. Calculate a parallel resonant circuit's response, including impedance, voltage across components and current at resonance.
c. Measure a parallel resonant circuit's response, including impedance, voltage across components and current at resonance.
d. Using circuit simulation software, determine a parallel resonant circuit's response, including impedance, voltage across components and current at resonance.
e. Calculate the Q (quality factor) and bandwidth as a function of the resistance and reactance of the circuit.
f. Explain the reason why the impedance of a perfect parallel circuit is infinite.
g. Explain and demonstrate in circuit simulation software Q's dependence on the L/C ratio (L = inductance, C = capacitance).

Course Outcome(s):

Use network theorems to analyze AC circuits.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Analyze a circuit using conventional methods and/or circuit software.
b. Use a circuit theorem(s) to verify the response that includes one or more of the following: mesh, nodal, superposition, bridge analysis.

Course Outcome(s):

Calculate and measure resistor-capacitor (RC) response to a pulsed source.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Calculate an RC circuit theoretical response to pulsed wave forms, including time constant calculation, and capacitor, resistor voltage / circuit current at any given time.
b. Measure in lab resistor and capacitor voltages and, based upon these values, calculate the circuit current at any given time.

c. Using circuit simulation software, measure in lab resistor and capacitor voltages and, based upon these values, calculate the circuit current at any given time.

Course Outcome(s):

Calculate, measure and/or simulate circuit parameters in a poly (three) phase system.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Determine the line voltage given the phase voltage in a wye configuration.
b. Determine the phase voltage given the line voltage in a wye configuration.
c. Compare phase voltages and currents of wye and delta source configurations.
d. Determine wye connected load voltage, current and power (assuming a resistive load).
e. Determine delta connected load voltage, current and power (assuming a resistive load.
f. Calculate or simulate voltage, current and power for and unbalanced wye-connected resistive load with and without a neutral connection.
g. Explain triplens and why they are harmful to delta connected sources.

Course Outcome(s):

Construct an electronic project.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Construct an electronic project that requires soldering.
b. Test the project to ascertain that it is functioning properly.
c. Write a formal lab report that includes measured parameters regarding the tests that determine functionality.

Methods of Evaluation:

a. Tests
b. Laboratory performance
c. Homework
d. Computer projects
e. Quizzes

Course Content Outline:

a. Sinusoidal waveforms
    i. Definitions, AC voltage characteristics
    ii. Voltage and current forms of the sine wave
    iii. Phase relationships
    iv. Average and effective values
    v. AC measuring instrumentation
b. Circuit elements and phasors
    i. Definition of the derivative
    ii. Resistance (R), inductance (L), and capacitance (C) response characteristics to sinusoidal voltage or current
    iii. Average power and power factors
    iv. Complex numbers and mathematical operations
    v. Polar, rectangular, and polar/rectangular conversions
    vi. Phasors
c. Series and parallel AC circuits

    i. Impedance and the phasor diagram
    ii. Series circuits
    iii. Voltage divider rule
    iv. Frequency response of RC circuits
    v. Admittance and susceptance
    vi. Resistive-inductive (RL), resistive-capacitance (RC), and resistive-inductive-capacitive (RLC) parallel circuits
    vii. Frequency response of RL circuits
    viii. Equivalent circuits

d. Series-parallel networks
    i. Circuit configurations
    ii. Ladder networks
    iii. Computer analysis
e. Network analysis techniques
    i. Independent and dependent sources
    ii. Mesh analysis
    iii. Nodal analysis
    iv. Bridge networks
    v. Delta-wye and wye-delta conversions
    vi. Computer analysis
f. Network theorems
    i. Superposition theorem
    ii. Thevenin's theorem
    iii. Norton's theorem
    iv. Maximum power transfer theorem
g. Power and power factor correction
    i. Real and apparent power
    ii. Inductance, capacitance, and reactive power
    iii. The power triangle and power calculations
    iv. Power factor correction
    v. Effective resistance
h. Resonance
    i. Series resonant circuit
    ii. Quality factor
    iii. Impedance vs. frequency
    iv. Selectivity (series)
    v. Voltage, current, and frequency
    vi. Parallel resonant circuit
    vii. Selectivity (parallel)
    viii. Quality factor in parallel circuits
    ix. Computer analysis
i. Decibels, filters, and bode plots
    i. Review of logarithms
    ii. Decibels
    iii. Low-pass filter
    iv. High-pass filter
    v. Band-pass filters
    vi. Band-stop filters
    vii. Bode plots
    viii. Filter attenuation
    ix. Computer analysis
j. Three-phase generation
    i. Wye-configured system
    ii. Wye-delta system
    iii. Delta configured combinations
    iv. Delta-wye combinations
    v. Power calculations
    vi. Unbalanced systems
k. Non-Sinusoidal waveforms

   i. Periodic waveforms
   ii. Fourier series
   iii. Circuit response characteristics
   iv. Computer analysis
l. Transformers
   i. Mutual inductance
   ii. Iron-core transformers
   iii. Air-core transformers
   iv. Magnetically coupled coils
m. System analysis
   i. Impedance parameters
   ii. Voltage, current, and power gain
   iii. Cascaded systems
   iv. Hybrid models
   v. Computer analysis
n. Laboratory topics
   i. Use of the oscilloscope for troubleshooting and measurement of circuit parameters
   ii. R, L, and C characteristics that relate to solving voltage, current, phase, etc. circuit characteristics
   iii. Measuring and calculating the frequency response of RL and RC networks
   iv. Series sinusoidal circuits, comparing theoretical with measured results
   v. Parallel sinusoidal circuits, comparing theoretical with measured results
   vi. Measuring and testing series-parallel sinusoidal circuits versus theoretical parameters
   vii. Network theorems
   viii. Power factor correction as related to calculating a resistive solution
   ix. Series resonant circuits, theory of operation and compared to measured results
   x. Parallel resonant circuits, theoretically comparing the three definitions and comparing to measured results
   xi. Passive filters, calculating and measuring frequency response
   xii. Periodic waveforms, measuring exponential decay in pulse waveforms and relating results to theoretical data
   xiii. Use of circuit simulation software to support measured and calculated results

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Resources

Boylestad, Robert L. *Introductory Circuit Analysis*. 14th ed. Upper Saddler River, NJ: Prentice Hall, 2023.

Alexander, Charles and Matthew Sadiku. *Fundamentals of Electric Circuits*. 7th ed. McGraw-Hill, 2020.

Floyd, Thomas L. and David M. Buchla. *Principles of Electric Circuits*. 10th ed. Prentice Hall, 2019.

Instructional Services

OAN Number:

Transfer Assurance Guide OET003

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