COURSE NUMBER: ET1101

COURSE TITLE: Electrotechnology

COURSE DESCRIPTION:

This is a continuation of the Electrotechnology course taken in the first semester. It covers the basics of A.C. theory and the application of this to solve circuits containing resistance, capacitance and inductance. An introduction to transformers and polyphase A.C. circuits is also included.

PREREQUISITES: ET1100 - Electrotechnology

CO-REQUISITES: None

CREDIT VALUE: Four (4)

COURSE HOURS PER WEEK: Three (3)

LAB HOURS PER WEEK: Two (2)

SUGGESTED TEXT:

Boylstad, L. R. (2010). *Introductory circuit analysis* (12th ed.). Prentice-Hall. ISBN-10: 0131746663 or ISBN-13: 97801317146666

Or

Robbins, A.H., & Miller, W.C. (2012). *Circuit analysis theory and practice* (5th ed.). Delmar Publishing Inc. ISBN-10: 1133281001; ISBN-13: 978-1133281009

Or

Jackson, H.W., Temple, D., & Kelly, B.E (2012). *Introduction to electric circuits* (9th ed.). Oxford University Press. ISBN-13: 978-0-19-543813-0

And accompanying lab book:

Jackson, H.W., Temple, D., & Kelly, B. (2012). *Introduction to electric circuits: Lab manual* (9th ed.). Oxford University Press. ISBN-13: 978-0-19-542310-5

LEARNING RESOURCES:

Zbar, P.B., & Rockmaker, G. (2000). *Basic electricity: A text-lab manual* (7th ed.). McGraw-Hill. ISBN 9780078212758

MAJOR TOPICS:

1.0 Basic A.C. Theory
2.0 Inductance in A.C. Circuits
3.0 Capacitance and its Effect in A.C. Circuits
4.0 Resonance
5.0 Introduction to Transformers
6.0 Introduction to Polyphase A.C.

LEARNING OBJECTIVES:

The expected learning outcome is that the student will be able to:

1.0 Basic A.C. Theory

1.1 Introduction to A.C.
1.1.1 Advantage of A.C. in Power Systems
1.1.1.1 Explain why power systems are alternating current systems

1.1.2 Simple A.C. Generator
1.1.2.1 Sketch diagram
1.1.2.2 Describe voltage produced by rotating coil

1.1.3 A.C. Voltage Sine Wave
1.1.3.1 Sketch sine wave voltage

1.1.4 Equation of A.C. Voltage
1.1.4.1 Write equation for A.C. voltage
1.1.4.2 Define maximum value
1.1.4.3 Define period
1.1.4.4 Define frequency

1.2 A.C. Quantities
1.2.1 Instantaneous Value of Voltage
1.2.1.1 Define instantaneous value
1.2.1.2 Calculate instantaneous voltage

1.2.2 Instantaneous Current in a Resistance
1.2.2.1 Apply Ohm's law to A.C. resistive circuit
1.2.2.2 Calculate instantaneous current
1.2.2.3 Draw sine wave diagram of voltage and current

1.2.3 Instantaneous Power in a Resistance
1.2.3.1 Write formula for instantaneous power
1.2.3.2 Sketch power waveform
1.2.3.3 Calculate average power
1.2.3.4 Calculate power frequency

1.2.4 Root Mean Square (RMS) Value of Voltage and Current
1.2.4.1 Compare D.C. and A.C. circuits in terms of power produced
1.2.4.2 Derive equation of R.M.S. current
1.2.4.3 Calculate RMS power

1.3 Phasors
1.3.1 Vector Representation of a Sine Wave
1.3.1.1 Describe how a sine wave may be represented by a rotating vector
1.3.1.2 Define "phasor"

1.3.2 Phase Difference
1.3.2.1 Draw sine wave diagram showing phase difference
1.3.2.2 Describe vector representation of two alternating quantities having a phase difference
1.3.2.3 Describe the use of a reference vector

1.3.3 Sum of Two Alternating Quantities
1.3.3.1 Determine sum by graphical addition
1.3.3.2 Determine sum by phasor addition

2.0 Inductance in A.C. Circuits

2.1 Pure Inductance
2.1.1 A.C. Current in an Inductor
2.1.1.1 Describe action of a pure inductor when connected to an A.C. supply

2.1.2 Inductive Reactance
2.1.2.1 Define inductive reactance
2.1.2.2 Specify symbol and unit of inductive reactance
2.1.2.3 Write Ohm's law using inductive reactance
2.1.2.4 Describe factors influencing inductive reactance
2.1.2.5 Write equation for inductive reactance

2.1.3 Phasor Diagram
2.1.3.1 Draw phasor diagram for pure resistive circuit
2.1.3.2 Draw phasor diagram for pure inductive circuit

2.1.4 A.C. Power in a Pure Inductance
2.1.4.1 Sketch power waveform
2.1.4.2 Define reactive power
2.1.4.3 Specify symbol and units for inductive reactive power
2.1.4.4 Write formula for inductive reactive power

2.2 R-L Series Circuit
2.2.1 Phasor Diagram
2.2.1.1 Sketch waveforms and phasor diagram
2.2.1.2 Define phase angle

2.2.2 Impedance
2.2.2.1 Define impedance
2.2.2.2 Specify symbol and units
2.2.2.3 Derive formula for impedance of series R-L circuit
2.2.2.4 Sketch impedance triangle for series R-L circuit

2.2.3 Practical Inductors
2.2.3.1 Explain why inductors have resistance
2.2.3.2 Define A.C. resistance
2.2.3.3 List factors contributing to A.C. resistance
2.2.3.4 Draw equivalent circuit of practical inductor
2.2.3.5 Define figure of merit (Q-factor)
2.2.3.6 Calculate Q-factor

2.2.4 A.C. Power in an R-L Series Circuit
2.2.4.1 Sketch power waveform
2.2.4.2 Define real, reactive and apparent power
2.2.4.3 Write equations for real, reactive and apparent power
2.2.4.4 Sketch power triangle

2.2.5 Power Factor
2.2.5.1 Define power factor
2.2.5.2 Explain significance of power factor in power systems
2.2.5.3 Calculate power factor of R-L series circuit

3.0 Capacitance and its Effect in A.C. Circuits

3.1 Capacitance
3.1.1 Parallel Plate Capacitor
3.1.1.1 Draw a simple parallel plate capacitor
3.1.1.2 Define dielectric

3.1.2 Capacitor in a D.C. Circuit

3.1.2.1 Explain the charging of a capacitor in a D.C. circuit

3.1.3 Definition of Capacitance
3.1.3.1 Define capacitance
3.1.3.2 Express capacitance in terms of charge

3.1.4 Factors Governing Capacitance
3.1.4.1 List factors controlling capacitance

3.1.5 Formula for Capacitance
3.1.5.1 Specify formula for capacitance of parallel plate capacitor
3.1.5.2 Define dielectric constant

3.1.6 Capacitors in Series
3.1.6.1 Derive formula total capacitance of series capacitors

3.1.7 Capacitors in Parallel
3.1.7.1 Derive formula total capacitance of parallel capacitors

3.1.8 Dielectric Strength
3.1.8.1 Define dielectric strength
3.1.8.2 Calculate working voltage of capacitors

3.1.9 Types of Capacitors
3.1.9.1 Describe various types of capacitors

3.2 Pure Capacitance in A.C. Circuits
3.2.1 Phase Shift Caused by Pure Capacitance
3.2.1.1 Describe effect of pure capacitance in an A.C. circuit
3.2.1.2 Draw waveforms and phasor diagram

3.2.2 Capacitive Reactance
3.2.2.1 Define capacitive reactance
3.2.2.2 Specify symbol and unit
3.2.2.3 Describe factors influencing capacitive reactance
3.2.2.4 Write formula for capacitive reactance
3.2.2.5 Calculate current in a pure capacitance

3.2.3 Power in Pure Capacitance
3.2.3.1 Draw power waveform
3.2.3.2 Calculate capacitive reactive power

3.3 R-C Series Circuit
3.3.1 Phasor Diagram
3.3.1.1 Sketch phasor diagram

3.3.2 Impedance
3.3.2.1 Write equation for impedance of a series R-C circuit
3.3.2.2 Draw impedance triangle
3.3.2.3 Calculate phase angle

3.3.3 Power in R-C Series Circuit
3.3.3.1 Sketch power waveform
3.3.3.2 Calculate real, reactive and apparent power
3.3.3.3 Draw power triangle
3.3.3.4 Calculate power factor

3.4 R-L-C Series Circuit
3.4.1 Phasor Diagram
3.4.1.1 Draw phasor diagram for lagging phase angle
3.4.1.2 Draw phasor diagram for leading phase angle

3.4.2 Impedance
3.4.2.1 Write equation for impedance of a series R-L-C circuit
3.4.2.2 Draw impedance triangles
3.4.2.3 Calculate phase angle

3.4.3 Power in R-L-C Series Circuit
3.4.3.1 Explain cancelling effect of capacitive and inductive powers
3.4.3.2 Write equation for net reactive power
3.4.3.3 Write equations for real and apparent power
3.4.3.4 Draw power triangle
3.4.3.5 Calculate power factor

3.5 Power Factor Correction
3.5.1 Use of Capacitors to Improve Lagging Power Factors
3.5.1.1 Describe how capacitors can raise lagging power factors

3.5.2 Calculation of Capacitor Size
3.5.2.1 Calculate correct size capacitor

4.0 Resonance

4.1 Series Resonance
4.1.1 Definition of Resonance
4.1.1.1 Describe the resonance effect in a series R-L-C circuit

4.1.2 Resonant Frequency
4.1.2.1 Derive the formula for resonant frequency
4.1.2.2 Sketch graphs of Z, I, and phase angle Vs. frequency

4.1.3 Selectivity of a Resonant Circuit
4.1.3.1 Describe selectivity
4.1.3.2 Describe the factors influencing selectivity

4.1.4 Q of a Resonant Circuit
4.1.4.1 Define Q of a resonant circuit
4.1.4.2 Show how selectivity is dependent on Q-factor

4.1.5 Bandwidth
4.1.5.1 Define bandwidth
4.1.5.2 Calculate bandwidth of a resonant circuit

5.0 Introduction to Transformers

5.1 Basic Transformer Principles
5.1.1 Transformer Operation
5.1.1.1 Sketch simple transformer circuit
5.1.1.2 Describe operation of transformer

5.1.2 Unloaded Transformer
5.1.2.1 Define magnetizing current
5.1.2.2 Sketch current and voltage waveforms of unloaded transformer

5.1.3 Transformer Equation
5.1.3.1 Derive transformer equation

5.1.4 Transformation Ratio
5.1.4.1 Define transformation ratio

5.2 Transformer Under Load
5.2.1 Effect of Load on a Transformer
5.2.1.1 Describe the effect on currents when a load is placed on a transformer

5.2.2 Transformer Capacity
5.2.2.1 Define transformer capacity
5.2.2.2 Calculate load currents using transformer capacity

5.2.3 Transformer Losses and Efficiency
5.2.3.1 Describe the losses found in a transformer
5.2.3.2 Relate losses to load current
5.2.3.3 Calculate transformer efficiency

6.0 Introduction to Polyphase A.C.

6.1 Two-Phase A.C. (3 wire Systems)
- 6.1.1 Two Phase A.C. Generator
  - 6.1.1.1 Sketch diagram of simple two phase generator
  - 6.1.1.2 Explain nature of voltages induced

- 6.1.2 Phasor Diagram
  - 6.1.2.1 Draw voltage waves and phasor diagram

- 6.1.3 Two Phase Currents
  - 6.1.3.1 Draw circuit of two phase generator
  - 6.1.3.2 Calculate phase currents
  - 6.1.3.3 Calculate neutral current

- 6.1.4 Comparison to Single Phase System
  - 6.1.4.1 Calculate line currents for equivalent single phase system
  - 6.1.4.2 Sketch power waves of single and two phase system
  - 6.1.4.3 Describe advantages of polyphase system compared to equivalent single phase system

6.2 Three-Phase A.C.
- 6.2.1 Three Phase A.C. Generator
  - 6.2.1.1 Sketch diagram of simple three phase generator

- 6.2.2 Phasor Diagram
  - 6.2.2.1 Sketch voltage waves and phase diagram

- 6.2.3 Wye Connected Source
  - 6.2.3.1 Draw circuit of a wye connected source with loads
  - 6.2.3.2 Calculate line currents
  - 6.2.3.3 Sketch phasor diagram of voltages and currents
  - 6.2.3.4 Define balanced load
  - 6.2.3.5 Show graphically that ‘Phase currents = 0’ for a balanced load

- 6.2.4 Line Voltages
  - 6.2.4.1 Define line voltage
  - 6.2.4.2 Derive relationship between line and phase voltages for a wye connected source

- 6.2.5 Three Phase Power
  - 6.2.5.1 Write equation for three phase power in terms of phase quantities
  - 6.2.5.2 Write equation for three phase power in terms of line quantities

- 6.2.6 Delta Connected Source
  - 6.2.6.1 Draw circuit of a delta connected source

6.2.6.2 Describe relationship between line and phase voltages
6.2.6.3 Describe relationship between line and phase currents
6.2.6.4 Describe possible hazard with delta connection
6.2.6.5 Calculate line and phase currents in a delta connected load

Laboratories:

1.0 Oscilloscope operation - triggered scope (Exp. 20)
Single-generator operation (Exp. 31)
2.0 Oscilloscope voltage measurements (Exp. 32)
3.0 Peak, RMS and average values of A.C. (Exp. 33)
4.0 Characteristics of an inductance (Exp. 34)
5.0 Inductances in series and parallel (Exp. 36)
6.0 Impedance of a series R-L circuit (Exp. 41)
7.0 Reactance of a capacitor (X) (Exp. 38)
Capacitors in series and parallel (Exp. 39)
8.0 Impedance of a series R.C. circuit (Exp. 43)
9.0 Power in A.C. circuits (Exp. 45)
10.0 Frequency response of a reactive circuit (Exp. 46)
11.0 Impedance of a series R-L-C circuit (Exp. 47)

EVALUATION:

Assignments:	5%
Laboratories:	15%
Quizzes:	30%
Final Exam:	50%

If a student misses a laboratory session *without a valid documented reason***, a mark of 0 for that lab will be assigned. In order to be eligible to write the final examination (including a supplementary final examination) and pass the course, students must pass (minimum of 50%) the essential laboratory component of the course. A student who misses more than 3 labs without valid documentation will be required to drop the course. Please note that dropping the course without academic prejudice must be done within established College processes and time frames.
** What would be considered as a “valid documented reason” will be at the discretion of the Campus Administrator in consultation with the faculty responsible for this course.

DATE DEVELOPED: **DATE REVIEWED:**

REVISION NUMBER: 4 **DATE REVISED:** April 2013

Note to instructor: Check PIRS to ensure this outline is the most current version.

ET1101 Addendum

Preamble

This addendum is designed to provide the Recording Arts student with some practical information for dealing with electrical circuits he/she may encounter while working as a sound technician. This is in no way designed to be a miniature electrician's course. If the sound technician has any doubts about any electrical work, or has any safety concerns, consult an electrician.

Basic Electrical

1. State the standard colours of the hot, neutral and ground wires in a 120/240V electrical panel.
2. Identify the hot, neutral, and ground wires in a 240/120V electrical panel.
3. State the voltage obtained across two different phase hot wires, across a hot and a neutral, across a hot and a ground, and across a ground and a neutral in a 240/120V electrical panel.
4. Measure the voltages mentioned in objective 2 above.
5. Identify the hot, neutral, and ground slots in a typical household receptacle.
6. State the common voltages across the following points in an ordinary household receptacle:
   (a) Hot - neutral
   (b) hot - ground
   (c) ground - neutral

7. Measure the voltages mentioned in objective 5 above.
8. Properly connect a standard household receptacle in a 120V circuit.
9. State why it is always wise to check a receptacle, which you have not used previously, for proper voltages on the correct slots.
10. View the Home "Electrical" Video.

Grounding

1. State the colour of a typical ground wire in an a-c household circuit.
2. Describe how a ground wire is connected to an appliance.
3. Describe how grounding an appliance prevents electrical shock.
4. Explain why "lifting grounds" is terribly unsafe and should never be done.
5. Describe how you would set up a proper grounding system if you are experiencing grounding problems at a site.
6. State what minimum size wire is required for the grounding system mentioned in objective 5.
7. Describe why some water lines may not provide an adequate ground.
8. Describe why attention to grounding is even more important in wet areas.
9. Identify Ground Fault Interrupter Receptacles.

10. Describe the purpose of Ground Fault Interrupter Receptacles.
11. Identify an Isolated Ground Receptacle.
12. State how Isolated Ground Receptacles are different from ordinary receptacles.
13. Explain why Isolated Ground Receptacles are often used to supply power for sound productions.
14. Research the internet and paraphrase two articles relating to grounding problems in sound productions.
1.5 Read the article "Lifting the Grounding Enigma" at http://www.equitech.com/articles/enigma.html
16. Read the article "Church Sound System Safety" at http://ww43.soundinstitute.com/article/chruchsound/safety.html

Power Requirements

1. Calculate the electrical power requirements for any appliance from the nameplate.
2. Calculate the total electrical lighting power, and the total electrical sound power requirements for a sound system to be used at a remote site.
3. Apply safety factors to the calculations in objective 2 so that you can call ahead to your next venue to describe what your circuit requirements will be.

Generated Power

1. Calculate the total electrical power requirements for a particular sound set-up and specify the minimum wattage portable electric generator that is required.
2. Explain why one should never use two distinct portable generators for one sound system.
3. Properly ground a portable electric generator.

Troubleshooting

1. List and describe the common safety procedures to follow when working on electrical equipment.
2. Use a multimeter to check to see if there is voltage to a source.
3. Use an ac voltage detector to see if there is voltage to a source.
4. Perform a simple test with a multimeter to check for continuity.
5. Check fuses for continuity to see if they are "blown" or not.

Electrical Circuits

1. State the recommended size 'cab tire' extension cord to be used for electrical supply for sound applications.
2. State how the size of the extension cord is influenced if the length of the cord is more than 30m.
3. Explain why this extension cord must have three conductors.
4. Explain why the ground prong on an electrical extension cord must never be removed.
5. Route electrical wire safely for remote hook-up i.e. avoid wet areas, high heat areas, areas

of high usage, sharp bends in the cord, etc.

Isolating Audio and Lighting Power

1. Explain why the power feeding the lighting and audio circuits should be from different phase hot lines from your electrical panel.
2. Wire the control panel for your sound system to isolate audio and lighting power.