COURSE NUMBER: AE2330

COURSE TITLE: Analog Electronics I

COURSE DESCRIPTION:

This course will include the description, operation, and application of simple electronic components and their use in linear power supplies, small signal amplifiers, and power amplifiers. An introduction to frequency response is also covered. Design and troubleshooting skills are emphasized.

PREREQUISITES: None

CO-REQUISITES: MP2140 – Circuit Analysis I

CREDIT VALUE: Six (6)

COURSE HOURS PER WEEK: Five (5)

LAB HOURS PER WEEK: Three (3)

SUGGESTED TEXT:

Boylestad, R.L., & Nashelsky, L. (2012). *Electronic devices and circuit theory* (11th ed.). Prentice Hall. ISBN-13: 978-0-13-32622264

Boylestad, R.L., Nashelsky, L., & Monssen, F. (2013). *Lab manual electronic devices and circuit theory* (11th ed.). Prentice Hall. ISBN-10: 0-13-262245-9; ISBN-13: 978262245-5

LEARNING RESOURCES: None

MAJOR TOPICS:

1.0 Semiconductor Diodes
2.0 Linear Power Supplies
3.0 Transistor Amplification
4.0 Bipolar Junction Transistor Circuits
5.0 Field-effect Transistor Circuits
6.0 Amplifier Frequency Response
7.0 Power Amplifiers

LEARNING OBJECTIVES:

The expected learning outcomes are that the learner will be able to:

1.0 Semiconductor Diodes

1.1 Explain how current flows through semiconductors

- 1.1.1 Draw the lattice structure of a pure semiconductor
- 1.1.2 Describe the role of heat in the creation of intrinsic carriers
- 1.1.3 Show, with diagrams, how electrons move in a pure semiconductor
- 1.1.4 Explain how temperature affects the resistivity of a semiconductor
- 1.1.5 Describe electron flow and hole flow through a doped semiconductor
- 1.1.6 Explain the relationship between doping levels and conductivity
- 1.1.7 Differentiate between P-Type and N-Type Semiconductors

1.2 Measure the current through a PN Junction Diode

- 1.2.1 Illustrate, using a diagram of a PN junction under zero biasing, the distribution of majority and minority carriers in different parts of the diode
- 1.2.2 Illustrate, using a diagram of a PN junction under forward biasing and reverse biasing, the distribution of majority and minority carriers
- 1.2.3 Describe the effect of the barrier potential in a diode circuit
- 1.2.4 Describe zener and avalanche effects
- 1.2.5 Determine the dynamic resistance of a diode using a graph
- 1.2.6 Calculate the dynamic resistance of a diode
- 1.2.7 Explain the characteristics of a diode using the piece-wise linear approximation
- 1.2.8 Explain the effect of temperature on the characteristics of a diode
- 1.2.9 Calculate the current through a simple forward biased diode circuit when given supply voltage, diode characteristics and resistor value
- 1.2.10 Measure the current through a forward biased diode circuit
- 1.2.11 Identify the cathode and anode of a diode using an ohmmeter
- 1.2.12 Identify a faulty diode using an ohmmeter

1.3 Evaluate Diode Circuits

- 1.3.1 Describe the operation of a half-wave rectifier circuit
- 1.3.2 Describe the operation of a full-wave rectifier circuit
- 1.3.3 Draw and annotate the output waveforms for half-wave and full-wave rectifier circuits
- 1.3.4 Design half-wave and full-wave rectifier circuits, including the PIV and If (max) ratings of the diodes
- 1.3.5 Determine the output waveforms of rectifier circuits using simulation software
- 1.3.6 Measure the output voltage of rectifier circuits using an oscilloscope
- 1.3.7 Identify the fault in a malfunctioning rectifier circuit
- 1.3.8 Draw the output waveform of a series clipper circuit with an AC input
- 1.3.9 Draw the output waveform of a parallel clipper circuit with an AC input
- 1.3.10 Determine the output voltage waveform for clipper circuits using simulation software
- 1.3.11 Differentiate amongst rectifier, switching, zener, varactor, and light

emitting diodes
1.3.12 Design a voltage reference circuit using a zener diode
1.3.13 Design a Light Emitting Diode circuit

2.0 Linear Power Supplies

2.1 Sketch, including labeling, the block diagram of a basic power supply
2.2 Calculate the percent regulation of a filtered, unregulated power supply connected to a load
2.3 Calculate the ripple factor of a filtered, unregulated power supply connected to a load
2.4 Measure the ripple in the voltage of a loaded power supply circuit
2.5 Design a fixed, positive, regulated power supply using a 78XX IC voltage regulator
2.6 Design a fixed, negative, regulated power supply using a 79XX IC voltage regulator
2.7 Design a variable, positive, regulated power supply using an LM317 adjustable voltage regulator
2.8 Troubleshoot a malfunctioning regulated power supply

3.0 Transistor Amplification

3.1 Describe how a Bipolar Junction Transistor is used to amplify voltage
3.1.1 Draw the physical layout of an NPN or PNP BJT transistor, identifying the base, emitter or collector terminals
3.1.2 Explain why current through a BJT transistor is independent of applied supply voltage using a diagram of depletion regions and characteristic curves
3.1.3 Explain simple BJT transistor voltage amplification through the variation of input current

3.2 Describe how a Field Effect Transistor is used to amplify voltage
3.2.1 Draw the physical layout of an N-Channel or P-Channel JFET transistor, identifying the depletion zone, gate, source, and drain terminals
3.2.2 Explain how gate voltage affects the conductivity of a JFET
3.2.3 Explain why current through a JFET transistor is independent of applied supply voltage using a diagram of JFET depletion regions and characteristic curves
3.2.4 Explain simple JFET transistor voltage amplification through the variation of input voltage

3.3 Explain the two-port generalized amplifier model
3.3.1 Draw the diagram of the generalized two port model amplifier identifying the input impedance, output impedance, and voltage gain
3.3.2 Calculate the input voltage of an amplifier using voltage division
3.3.3 Calculate the no-load output voltage of an amplifier

3.3.4 Calculate the output voltage of an amplifier when connected to a load

3.4 Determine BJT Specifications from datasheets

3.4.1 Define the terms: Pc (max), Ic (max), V_{CEO}

3.4.2 Determine the maximum ratings and current gain parameters from a typical datasheet

3.4.3 Identify the base, emitter and collector terminals using a datasheet

3.5 Determine JFET Specifications from datasheets

3.5.1 Define the terms: $P_{D(max)}$, $I_{DSS(max)}$, $r_{DS(on)}$

3.5.2 Determine the maximum ratings and transconductance parameters from a typical datasheet

3.5.3 Identify the gate, source and drain terminals using a datasheet

4.0 Bipolar Junction Transistor Circuits

4.1 Evaluate a Fixed Bias Voltage BJT circuit as a Voltage Amplifier

4.1.1 Draw a diagram of the Common Emitter configuration including input and output currents

4.1.2 Draw and label the input and output characteristic curves

4.1.3 Identify the active, cutoff, and saturation regions on the output characteristic curves

4.1.4 Explain the need for DC Biasing in a transistor amplifier

4.1.5 Calculate the base and collector currents and collector voltage given all component values and the DC current gain (β) of the transistor

4.1.6 Design the biasing network for a Fixed Bias BJT transistor circuit

4.1.7 Describe the effect of an AC signal at the input of a Fixed Bias amplifier circuit on its operating point and output voltage

4.1.8 Calculate the input impedance, output impedance, voltage gain, and current gain of the Fixed Bias amplifier circuit

4.1.9 Calculate the no-load and loaded output voltage of a Fixed Bias amplifier

4.1.10 Determine the output waveform of a Fixed Bias amplifier using circuit simulation software

4.1.11 Troubleshoot a malfunctioning Fixed Bias amplifier

4.2 Evaluate a Voltage Divider Bias Voltage Amplifier

4.2.1 Explain how the Common Emitter amplifier is improved by the addition of the Emitter Resistor and Voltage Divider

4.2.2 Design the biasing network for a Voltage Divider BJT circuit

4.2.3 Describe the effect of an AC signal at the input of a Voltage Divider amplifier circuit on its operating point and output voltage

4.2.4 Calculate the input impedance, output impedance, voltage gain, and current gain of the Voltage Divider amplifier circuit with emitter bypass capacitor

4.2.5 Calculate the no-load and loaded output voltage of a Voltage Divider amplifier

4.2.6 Determine the output waveform of a Voltage Divider amplifier using circuit simulation software
4.2.7 Troubleshoot a malfunctioning Voltage Divider amplifier

4.3 Evaluate a BJT Emitter Follower circuit as a Voltage Buffer
4.3.1 Draw a diagram of the Common Collector configuration including input and output currents
4.3.2 Explain how the Common Collector is useful as a Voltage Buffer
4.3.3 Design the biasing network for an Emitter Follower circuit
4.3.4 Describe the effect of an AC signal at the input of an Emitter Follower amplifier circuit on its operating point and output voltage
4.3.5 Calculate the input impedance, output impedance, voltage gain, and current gain of the Emitter Follower amplifier circuit
4.3.6 Calculate the no-load and loaded output voltage of an Emitter Follower amplifier
4.3.7 Determine the output waveforms of an Emitter Follower amplifier using circuit simulation software
4.3.8 Troubleshoot a malfunctioning Emitter Follower amplifier

5.0 Field-effect Transistor Circuits

5.1 Evaluate a Self-Bias JFET Amplifier
5.1.1 Draw a diagram of the Self-Bias JFET Amplifier
5.1.2 Draw the characteristic curve labeling the pinch-off region
5.1.3 Draw the Transfer curve for a JFET transistor
5.1.4 Calculate the drain current, drain and source voltages, given I_{DSS} and V_P of the JFET, the supply voltage, and the resistor values
5.1.5 Design the biasing network for a Self-Bias JFET transistor circuit
5.1.6 Describe the effect of an AC signal at the input of a Self-Bias amplifier circuit on its operating point and output voltage
5.1.7 Calculate the input impedance, output impedance, voltage gain, and current gain of the Self-Bias amplifier circuit
5.1.8 Calculate the no-load and loaded output voltage of a Self-Bias amplifier
5.1.9 Determine the output waveform of a Self-Bias amplifier using circuit simulation software
5.1.10 Troubleshoot a malfunctioning Self Bias amplifier

5.2 Evaluate a JFET Source Follower Amplifier
5.2.1 Draw a diagram of the Source Follower JFET Amplifier
5.2.2 Explain how a Source Follower circuit can be used as a Buffer
5.2.3 Design the biasing network for a Source Follower JFET transistor circuit
5.2.4 Describe the effect of an AC signal at the input of a Source Follower amplifier circuit on its operating point and output voltage
5.2.5 Calculate the input impedance, output impedance, voltage gain, and current gain of the Source Follower amplifier circuit
5.2.6 Calculate the no-load and loaded output voltage of a Source Follower

amplifier

5.2.7 Determine the output waveform of a Source Follower amplifier using circuit simulation software

5.2.8 Troubleshoot a malfunctioning Source Follower amplifier

5.3 Evaluate a D-MOSFET Amplifier with Voltage Divider biasing

5.3.1 Draw and label the physical construction of a Depletion MOSFET

5.3.2 Describe how positive and negative voltages on the gate affect conductivity

5.3.3 Compare the characteristic curves of the D-MOSFET to the curves of a JFET

5.3.4 Draw a diagram of the Voltage Divider D-MOSFET Amplifier

5.3.5 Design the biasing network for a Voltage Divider D-MOSFET transistor circuit

5.3.6 Describe the effect of an AC signal at the input of a Voltage Divider D-MOSFET amplifier circuit on its operating point and output voltage

5.3.7 Calculate the input impedance, output impedance, voltage gain, and current gain of the Voltage Divider D-MOSFET amplifier circuit

5.3.8 Calculate the no-load and loaded output voltage of a Voltage Divider D-MOSFET amplifier

5.3.9 Determine the output waveform of a Voltage Divider D-MOSFET amplifier using circuit simulation software

5.3.10 Troubleshoot a malfunctioning D-MOSFET amplifier

5.4 Evaluate an E-MOSFET Amplifier with Voltage Divider biasing

5.4.1 Draw and label the physical construction of an Enhancement MOSFET

5.4.2 Describe how positive voltages on the gate affect conductivity

5.4.3 Compare the characteristic curves of the E-MOSFET to the curves of a JFET

5.4.4 Draw a diagram of the Voltage Divider E-MOSFET Amplifier

5.4.5 Design the biasing network for a Voltage Divider E-MOSFET transistor circuit

5.4.6 Describe the effect of an AC signal at the input of a Voltage Divider E-MOSFET amplifier circuit on its operating point and output voltage

5.4.7 Calculate the input impedance, output impedance, voltage gain, and current gain of the Voltage Divider E-MOSFET amplifier circuit

5.4.8 Calculate the no-load and loaded output voltage of a Voltage Divider E-MOSFET amplifier

5.4.9 Determine the output waveform of a Voltage Divider E-MOSFET amplifier using circuit simulation software

5.4.10 Troubleshoot a malfunctioning E-MOSFET amplifier

6.0 Amplifier Frequency Response

6.1 Explain how coupling capacitors and amplifier impedance act as an RC High Pass Filter

6.2 Calculate the cutoff frequency for the input of an amplifier
6.3 Calculate the cutoff frequency for the output of an amplifier

7.0 Power Amplifiers

7.1 Differentiate between small signal and power amplifiers
7.2 Compare the characteristics of Class A, Class B, Class AB, Class C, and Class D power amplifiers
7.3 Explain Class B Amplifier Operation
  7.3.1 Draw the schematic diagram for a Class B amplifier
  7.3.2 Calculate the DC input power
  7.3.3 Calculate the AC output power
  7.3.4 Calculate the maximum theoretical efficiency of the amplifier

7.4 Assess the operation of a Class AB amplifier
  7.4.1 Explain how Class AB amplifiers limit crossover distortion
  7.4.2 Draw the schematic diagram for a push-pull Class AB amplifier
  7.4.3 Draw the schematic diagram for a complementary-symmetry Class AB amplifier
  7.4.4 Calculate the output power of Class AB amplifiers
  7.4.5 Determine the DC input power drawn under optimal maximum output conditions of Class AB amplifiers
  7.4.6 Calculate the efficiency of Class AB amplifiers
  7.4.7 Troubleshoot a malfunctioning Class AB amplifier

EVALUATION:

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

DATE DEVELOPED: March 2012 **DATE REVIEWED:**

REVISION NUMBER: 1 **DATE REVISED:** August 2013

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