COURSE NUMBER: AE2231

COURSE TITLE: Analog Electronics II

COURSE DESCRIPTION:

This course provides further study of transistor amplifiers, with emphasis on frequency response characteristics. Also included is a study of oscillators and power control using thyristors.

PREREQUISITES: AE2330 – Analog Electronics I

CO-REQUISITES: None

CREDIT VALUE: Four (4)

COURSE HOURS PER WEEK: Three (3)

LAB HOURS PER WEEK: Two (2)

SUGGESTED TEXT:

Boylestad, R. and Nashelsky, L. (2012). *Electronic devices and circuit theory* (11th ed.). Prentice Hall. ISBN-13: 978-01332622264

LEARNING RESOURCES: None

MAJOR TOPICS:

1.0 Differential and Multistage Amplifiers
2.0 Frequency Response
3.0 Power Amplifiers - Class C and D
4.0 Oscillators
5.0 Power Control Using Thyristors

LEARNING OBJECTIVES:

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

1.0 Differential and Multistage Amplifiers

1.1 Explain the operation of a Transistor Differential Amplifier
  1.1.1 Analyze the DC biasing of differential amplifiers
  1.1.2 Determine the AC gain and impedance characteristics

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

- 1.2.1 Explain the purpose of using capacitors to couple AC energy from one stage to another
- 1.2.2 Sketch the frequency response of the passive high-pass RC filter
- 1.2.3 Calculate voltage gain and phase at DC, high frequency and the cutoff frequency using circuit equations

1.3 Assess the operation of a capacitively coupled multistage Bipolar Junction Transistor (BJT) amplifier

- 1.1.1 Draw the AC equivalent circuit of cascaded BJT stages
- 1.1.2 Determine the input impedance, output impedance, and voltage gain of the amplifier system using circuit equations
- 1.1.3 Calculate the lower cutoff frequency for each stage of a multistage BJT amplifier due to coupling capacitors
- 1.1.4 Determine the voltage gain and overall lower cutoff frequency of the amplifier system using circuit simulation software

1.4 Assess the operation of a capacitively coupled multistage Field Effect Transistor (FET) amplifier

- 1.2.1 Draw the AC equivalent circuit of cascaded FET stages
- 1.2.2 Determine the input impedance, output impedance, and voltage gain of the amplifier system using circuit equations
- 1.2.3 Calculate the lower cutoff frequency for each stage of a multistage BJT amplifier due to coupling capacitors
- 1.2.4 Determine the voltage gain and overall lower cutoff frequency of the amplifier system using circuit simulation software

1.5 Assess the operation of a Cascode amplifier

- 1.5.1 Explain the advantages of using direct coupling between stages
- 1.5.2 Explain how the combination of a Common Emitter and Common Base configuration provides high input impedance, gain, and bandwidth
- 1.5.3 Determine the DC currents and voltages within a cascode amplifier
- 1.5.4 Draw the AC equivalent circuit of a cascode amplifier
- 1.5.5 Determine the input impedance, output impedance, and voltage gain of the amplifier system
- 1.5.6 Determine the DC currents and voltages and voltage gain using circuit simulation software
- 1.5.7 Explain why a cascode amplifier has a superior high frequency response

1.6 Describe the operation of a Darlington Pair

- 1.6.1 Explain how a Darlington Pair provides a high current gain transistor configuration
- 1.6.2 Determine the DC currents and voltages within a Darlington amplifier
- 1.6.3 Draw the AC equivalent circuit of a Darlington amplifier

1.6.4 Determine the input impedance, output impedance, current gain and voltage gain of the amplifier system

1.6.5 Determine the DC currents and voltages and voltage gain using circuit simulation software

1.7 Describe the operation of a Feedback Pair

1.7.1 Determine the DC currents and voltages within a feedback pair

1.7.2 Draw the AC equivalent circuit of a feedback pair

1.7.3 Determine the input impedance, output impedance, current gain and voltage gain of the amplifier system

1.7.4 Determine the DC currents and voltages, current gain and voltage gain using circuit simulation software

2.0 Frequency Response

2.1 Calculate the effect of the Emitter/Source Bypass Capacitor

2.1.1 Explain how a bypass capacitor across the emitter or source resistor provides AC feedback and exhibits high-pass filter operation

2.1.2 Calculate the cutoff frequency due to the bypass capacitor

2.1.3 Calculate the cutoff frequency using circuit simulation software

2.2 Calculate the high frequency effects of parasitic capacitances on an amplifier

2.2.1 Identify causes of parasitic capacitances in a transistor amplifier circuit (i.e. junction, component leads, Printed Circuit Board (PCB) construction, etc.)

2.2.2 Explain how parasitic capacitance in an inverting amplifier can be modeled as a capacitor connected between the output and the input

2.2.3 Explain how modeled parasitic capacitances can be replaced with equivalent input and output capacitors

2.2.4 Calculate the Miller Capacitors for a BJT or FET amplifier

2.2.5 Sketch the frequency response of a passive low-pass RC filter

2.2.6 Calculate voltage gain and phase at DC, high frequency and the cutoff frequency of a passive low-pass RC filter

2.2.7 Calculate the upper cutoff frequency at the input of a transistor amplifier

2.2.8 Calculate the upper cutoff frequency at the output of a transistor amplifier

2.2.9 Determine the overall upper cutoff frequency of a transistor amplifier using simulation software

2.2.10 Explain the dependence of transistor current gain on operating frequency

2.3 Draw the Bode Plot for an amplifier

2.3.1 Convert between linear and logarithmic units in order to position a point on a logarithmic frequency axis

2.3.2 Convert linear voltage or power gain to a decibel representation

2.3.3 Draw the frequency response (voltage or power gain in db) of an amplifier system on semi-log graph paper

2.3.4 Draw the phase response of an amplifier along with the frequency response
2.3.5 Calculate the upper or lower cutoff frequencies of a multistage amplifier consisting of identical stages
2.3.6 Determine the 3dB bandwidth of an amplifier system from its BODE plot
2.3.7 Determine whether unwanted feedback is likely to happen in an amplifier using a Bode Plot
2.3.8 Determine the 3dB bandwidth of an amplifier system using circuit simulation software

3.0 Power Amplifiers - Class C and D

3.1 Assess the operation of a Class C amplifier
3.1.1 Draw and label the block diagram of a Class C tuned-load amplifier
3.1.2 Explain how a low conduction angle combined with a tank circuit can be used to provide the efficient amplification of a sinusoidal input
3.1.3 Draw a simplified schematic diagram of a series tuned or parallel tuned Class C amplifier that is biased for a conduction angle of approximately 120 degrees
3.1.4 Identify the fault in a malfunctioning Class C amplifier

3.2 Assess the operation of a Class D amplifier
3.2.1 Describe the generation and characteristics of a Pulse-Width Modulated signal based on a Nyquist sampled analog signal (i.e. triangle wave and comparator or digital processor methods)
3.2.2 Draw and label the block diagram of a Class D filtered amplifier including the Pulse Width Modulator
3.1.3 Explain how cutoff to saturation operation of a transistor combined with a filter circuit can be used to provide the efficient amplification of a pulse width modulated analog input
3.1.4 Draw a simplified schematic diagram of the driver section of a Class D amplifier using a MOSFET, including a pi inductor/capacitor LPF
3.1.5 Identify the fault in a malfunctioning Class D amplifier

4.0 Oscillators

4.1 Describe oscillation in a positive feedback circuit
4.1.1 Explain the role of positive feedback in producing oscillations
4.1.2 State the Barkhausen Criteria
4.1.3 Explain the events that allow oscillation to build up when power is first applied
4.1.4 Define Adaptive Feedback and explain why it is needed to produce low distortion sine wave outputs

4.2 Evaluate the operation of Phase-shift Oscillators

4.2.1 Determine the gain needed in the active portion of a FET phase shift oscillator
4.2.2 Draw the schematic diagram of a FET phase shift oscillator
4.2.3 Calculate the frequency of oscillation of a FET phase shift oscillator
4.2.4 Determine the output voltage waveform of a FET phase shift oscillator using circuit simulation software
4.2.5 Compare the calculated oscillation frequency to the measured frequency of a practical FET Phase-Shift oscillator
4.2.6 Draw the schematic diagram of a BJT Phase-Shift oscillator
4.2.7 Calculate the frequency of oscillation of a BJT phase shift oscillator
4.2.8 Determine the output voltage waveform using circuit simulation software
4.2.9 Compare the calculated oscillation frequency to the measured frequency of a practical BJT Phase-Shift oscillator

4.3 LC Oscillators
4.3.1 Explain the advantage of the LC tank circuit for a sinusoidal oscillator
4.3.2 Evaluate the operation of a Colpitts Oscillator
4.3.2.1 Sketch and label a Colpitts Oscillator
4.3.2.2 Derive an expression for the frequency of oscillation for a Colpitts Oscillator
4.3.2.3 Explain how the bias clamp circuit regulates output signal amplitude in a JFET Colpitts Oscillator
4.3.2.4 Explain how the bias clamp circuit regulates output signal amplitude in a BJT Colpitts Oscillator
4.3.2.5 Determine the output voltage waveform using circuit simulation software

4.3.3 Evaluate the operation of a Hartley Oscillator
4.3.3.1 Sketch and label a Hartley Oscillator
4.3.3.2 Derive an expression for the frequency of oscillation for a Hartley Oscillator
4.3.3.3 Explain how the bias clamp circuit regulates output signal amplitude in a JFET Hartley Oscillator
4.3.3.4 Explain how the bias clamp circuit regulates output signal amplitude in a BJT Hartley Oscillator
4.3.3.5 Determine the output voltage waveform using circuit simulation software

4.3.4 Evaluate the operation of a Crystal Oscillator
4.3.4.1 Sketch a diagram indicating the equivalent circuit of a piezoelectric crystal
4.3.4.2 Calculate the series-resonant and parallel-resonant frequencies of a crystal
4.3.4.3 Determine whether a crystal oscillator is operating the crystal in series-resonant or parallel-resonant mode and hence determine the exact frequency of oscillation

5.0 Power Control Using Thyristors

5.1 pnpn Devices

5.1.1 Silicon-Controlled Rectifier (SCR)

- 5.1.1.1 Draw and label the basic construction of the SCR
- 5.1.1.2 Draw and label the equivalent circuit of the SCR
- 5.1.1.3 Explain the basic operation of the SCR
- 5.1.1.4 Draw and label the characteristic curves of the SCR
- 5.1.1.5 Define the characteristics and ratings of the SCR
- 5.1.1.6 Explain the operation of a phase-control circuit using the SCR

5.1.2 Shockley Diode

- 5.1.2.1 Draw and label the basic construction of the Shockley diode
- 5.1.2.2 Draw and label the characteristic curve of the Shockley diode
- 5.1.2.3 Explain the operation of a trigger circuit for the SCR using a Shockley diode

5.1.3 DIAC

- 5.1.3.1 Draw and label the basic construction of the DIAC
- 5.1.3.2 Draw and label the characteristic curve of the DIAC
- 5.1.3.3 Explain the basic operation of the DIAC

5.1.4 TRIAC

- 5.1.4.1 Draw and label the basic construction of the TRIAC
- 5.1.4.2 Draw and label the characteristic curve of the TRIAC
- 5.1.4.3 Explain the basic operation of the TRIAC
- 5.1.4.4 Explain the operation of phase-control circuits using the TRIAC with various gate control circuits

EVALUATION:

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

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

REVISION NUMBER: **DATE REVISED:**

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