El Camino College

COURSE OUTLINE OF RECORD - Official

I. GENERAL COURSE INFORMATION

Subject and Number: Electronics and Computer Hardware Technology 124
Descriptive Title: Operational Amplifiers and Linear Integrated Circuits

Course Disciplines: Electronics
AND Electronic Technology

Division: Industry and Technology

Catalog Description: This course focuses on linear integrated circuit techniques, including operational amplifiers, comparators, phase locked loops, multiplexers and audio amplifiers. Laboratory activities include telecommunications, instrumentation, industrial electronics and practical measurement methods. In both lecture and laboratory exercises, students study circuits common to electronic systems, in addition to new, novel and useful circuit concepts.

Conditions of Enrollment: **Recommended Preparation**
Electronics and Computer Hardware Technology 11 or equivalent

Course Length: [X] Full Term [ ] Other (Specify number of weeks):
Hours Lecture: 2.00 hours per week [ ] TBA
Hours Laboratory: 4.00 hours per week [ ] TBA
Course Units: 3.00

Grading Method: Letter
Credit Status Associate Degree Credit

Transfer CSU: [X] Effective Date: Prior to July 1992
Transfer UC: [ ] No

General Education:

El Camino College:

CSU GE:

IGETC:

II. OUTCOMES AND OBJECTIVES

A. COURSE STUDENT LEARNING OUTCOMES (The course student learning outcomes are listed below, along with a representative assessment method for each. Student learning outcomes are not subject to review, revision or approval by the College Curriculum Committee)

1. SLO #1 Operational Amplifier

   Given a schematic diagram of a basic Operational Amplifier (Op) with negative feedback, the students will be able to assemble, test and measure the circuit for its operational parameters

2. SLO #2 Advanced In-Circuit Measurements
   The student will make advanced "in-circuit" measurements using Bench and Portable Digital Multimeter (DMM), Oscilloscope, and Voltage Ohm (VOM), Milliamp Meter, on Advanced Solid-State-Systems.

3. SLO #3 Experimental Data and Analysis Reporting

   The students will be able to incorporate experimental data and analysis reporting protocols, using either "paper" or "paperless" environments, similar to data reporting and analysis used by many Electronics Manufacturers and Service Organizations.

The above SLOs were the most recent available SLOs at the time of course review. For the most current SLO statements, visit the El Camino College SLO webpage at http://www.elcamino.edu/academics/slo/.

B. Course Student Learning Objectives (The major learning objective for students enrolled in this course are listed below, along with a representative assessment method for each)

1. Predict the electrical performance of operational amplifier circuits employing negative feedback, using the "first approximation" of operational amplifier behavior.

   Objective Exams

2. Construct and evaluate non-inverting and inverting operational amplifier circuits, calculate percent deviation from theoretical results and explain why laboratory observations do not agree with theoretical values.

   Laboratory reports

3. Explain the need for hysteresis in comparator circuits and calculate the amount of hysteresis required for typical applications.

   Objective Exams

4. Evaluate common comparator circuits and explain the difference between laboratory results and theoretical predictions.

   Laboratory reports

5. Analyze representative practical operational amplifier circuits and describe their performance limitations.

   Objective Exams

6. Calculate the magnitude of common-mode signal rejection necessary for an instrumentation amplifier to comply with specified error signal limits.

   Objective Exams

7. Research and compile a list of commercially available operational amplifiers, ranked according to performance.

   Class Performance

8. Discuss the Alternating Current (AC) and Direct Current (DC) errors that occur in monolithic operational amplifiers due to minor imperfections and physical limitations,

and discuss how these errors can be minimized.

Class Performance

III. OUTLINE OF SUBJECT MATTER (Topics are detailed enough to enable a qualified instructor to determine the major areas that should be covered as well as ensure consistency from instructor to instructor and semester to semester.)

Lecture or Lab	Approximate Hours	Topic Number	Major Topic
Lecture	1	I	OVERVIEW OF LINEAR DEVICES A. Safety lecture and examination B. The importance of linear circuits
Lecture	3	II	INVERTING AND NON-INVERTING AMPLIFIERS A. The inverting amplifiers B. The summing amplifier C. The non-inverting amplifier D. The voltage follower
Lab	8	III	INVERTING AND NON-INVERTING AMPLIFIERS A. The inverting amplifiers B. The summing amplifier C. The non-inverting amplifier D. The voltage follower
Lecture	2	IV	OSCILLATORS A. Multivibrators B. Generating sine, triangle and sawtooth waveforms
Lab	4	V	OSCILLATORS A. Multivibrators B. Generating sine, triangle and sawtooth waveforms
Lecture	7	VI	ACTIVE FILTERS A. Review of passive filters B. The low-pass Butterworth filter C. The high-pass Butterworth filter D. Band-pass filters E. Notch filters
Lab	14	VII	ACTIVE FILTERS A. Review of passive filters B. The low-pass Butterworth filter C. The high-pass Butterworth filter D. Band-pass filters E. Notch filters
Lecture	2	VIII	INTEGRATED CIRCUIT TIMERS A. Operating modes of the 555 timer B. The 555 as an astable multivibrator

			C. The 555 as a monostable multivibrator D. Power-on delay circuits E. Other useful 555 circuits
Lab	4	IX	INTEGRATED CIRCUIT TIMERS A. Operating modes of the 555 timer B. The 555 as an astable multivibrator C. The 555 as a monostable multivibrator D. Power-on delay circuits E. Other useful 555 circuits
Lecture	4	X	POWER SUPPLIES AND REGULATORS A. The unregulated power supply B. DC Voltage regulation C. AC ripple suppression D. Linear integrated circuit voltage regulators E. Adjustable three-terminal regulators F. Logic circuit power supplies G. Switching power supplies
Lab	8	XI	POWER SUPPLIES AND REGULATORS A. The unregulated power supply B. DC Voltage regulation C. AC ripple suppression D. Linear integrated circuit voltage regulators E. Adjustable three-terminal regulators F. Logic circuit power supplies G. Switching power supplies
Lecture	3	XII	COMPARATORS A. Voltage level detectors B. Zero-crossing detectors C. Window comparators and applications D. Stair-step comparators E. Hysteresis, positive feedback, and noise
Lab	6	XIII	COMPARATORS A. Voltage level detectors B. Zero-crossing detectors C. Window comparators and applications D. Stair-step comparators E. Hysteresis, positive feedback and noise
Lecture	3	XIV	WAVE SHAPING WITH SIGNAL DIODES A. Half wave precision rectifiers B. Absolute value circuits C. Peak voltage detectors D. Precision clipper circuits E. Dead-zone detector circuits F. Triangle-to-sine wave converters

Lab	6	XV	WAVE SHAPING WITH SIGNAL DIODES A. Half wave precision rectifiers B. Absolute value circuits C. Peak voltage detectors D. Precision clipper circuits E. Dead-zone detector circuits F. Triangle-to-sine wave converters
Lecture	2	XVI	DC PERFORMANCE: BIAS, OFFSETS AND DRIFT A. Effect of bias currents on output voltage B. Effect of offset current on output volt C. Input offset voltage D. Nulling the effects of offset voltage E. Nulling the effects of bias current F. Measurement of bias current and offset voltage
Lab	4	XVII	DC PERFORMANCE: BIAS, OFFSETS AND DRIFT A. Nulling the effects of offset voltage B. Nulling the effects of bias current C. Measurement of bias current and offset voltage
Lecture	6	XVIII	AC PERFORMANCE: BANDWIDTH, SLEW RATE AND NOISE A. Amplifier gain and frequency response B. Slew rate and output voltage C. Amplifier noise D. External frequency compensation
Lab	12	XIX	AC PERFORMANCE: BANDWIDTH, SLEW RATE AND NOISE A. Amplifier gain and frequency response B. Slew rate and output voltage C. Amplifier noise D. External frequency compensation
Lecture	3	XX	INSTRUMENTATION AND BRIDGE AMPLIFIERS A. The basic differential amplifier B. Improving the differential amplifier C. The instrumentation amplifier D. Sensing and measurement with the instrumentation and bridge amplifier circuits
Lab	6	XXI	INSTRUMENTATION AND BRIDGE AMPLIFIERS A. The basic differential amplifier B. Improving the differential amplifier C. The instrumentation amplifier D. Sensing and measurement with the instrumentation and bridge amplifier circuits
Total Lecture Hours		36	

Total Laboratory Hours	72
Total Hours	108

IV. PRIMARY METHOD OF EVALUATION AND SAMPLE ASSIGNMENTS

A. **PRIMARY METHOD OF EVALUATION:**

Skills demonstrations

B. **TYPICAL ASSIGNMENT USING PRIMARY METHOD OF EVALUATION:**

Construct a band pass filter with a lower cutoff frequency of 300 Hertz and an upper cutoff frequency of 3000 Hertz, with 6 decibels per decade roll off beyond the pass band. Verify the performance of your circuit by Record test results in graphic form, plotted on semi log paper and submit to the instructor.

C. **COLLEGE-LEVEL CRITICAL THINKING ASSIGNMENTS:**

1. Construct an adjustable regulated power supply with output voltage adjustable from 2 to 20 volts; include current limiting circuitry to limit output current to 600 milliamperes. Consult the instructor for evaluation.
2. Given an Instrumentation Amplifier (IA), construct an electronic temperature gauge. Verify the performance of the gauge by providing the room temperature to your instructor.

D. **OTHER TYPICAL ASSESSMENT AND EVALUATION METHODS:**

Essay exams
Performance exams
Other exams
Quizzes
Written homework
Laboratory reports
Class Performance
Homework Problems
Multiple Choice
True/False
Other (specify):
Laboratory Final Exam

V. INSTRUCTIONAL METHODS

Demonstration
Discussion
Internet Presentation/Resources
Laboratory
Lecture
Multimedia presentations

Note: In compliance with Board Policies 1600 and 3410, Title 5 California Code of Regulations, the Rehabilitation Act of 1973, and Sections 504 and 508 of the Americans with Disabilities Act, instruction delivery shall provide access, full inclusion, and effective communication for students with disabilities.

VI. WORK OUTSIDE OF CLASS

Study
Answer questions
Required reading
Problem solving activities

Estimated Independent Study Hours per Week: 4

VII. TEXTS AND MATERIALS

A. **UP-TO-DATE REPRESENTATIVE TEXTBOOKS**
Bob Diaz. The Transistor Connection. El Camino College Bookstore, 2017.
Qualifier Text: El Camino College textbook,

B. **ALTERNATIVE TEXTBOOKS**

C. **REQUIRED SUPPLEMENTARY READINGS**

D. **OTHER REQUIRED MATERIALS**
Scientific calculator
Spiral bound notebook

VIII. CONDITIONS OF ENROLLMENT

A. Requisites (Course and Non-Course Prerequisites and Corequisites)

Requisites	Category and Justification

B. Requisite Skills

Requisite Skills

C. Recommended Preparations (Course and Non-Course)

Recommended Preparation	Category and Justification
Course Recommended Preparation or Electronics and Computer	

Hardware Technology-11	
Non-Course Recommended Preparation equivalent	If the student has not taken ECHT 11 but has taken a similar course at another college, has basic electronic theory through military experience or has work experience in basic electronic theory, the student will be prepared to take this course. If students do not have some form of basic electronic knowledge, students may not succeed in this class.

D. Recommended Skills

Recommended Skills
Build and test a transistor oscillator, working from a schematic drawing and using common test equipment. ECHT 11 - Differentiate color codes and component symbols to build a circuit. ECHT 11 - Connect meters to circuits, select proper meter ranges and obtain accurate measurements. ECHT 11 - Demonstrate the use of various types of test equipment, including Digital Multimeter (DMM), signal generators, power supplies and oscilloscope to make various circuit measurements.
Identify common electronic components. ECHT 11 - Differentiate color codes and component symbols to build a circuit.

E. Enrollment Limitations

Enrollment Limitations and Category	Enrollment Limitations Impact

Course created by Douglas R. Martson on 09/01/1983.

BOARD APPROVAL DATE:

LAST BOARD APPROVAL DATE:

Last Reviewed and/or Revised by Robert Diaz on 09/23/2015

20025