El Camino College
COURSE OUTLINE OF RECORD – Official

Course Acronym:	ECHT
Course Number:	124
Descriptive Title:	Operational Amplifiers and Linear Integrated Circuits
Division:	Industry and Technology
Department:	Electronics and Computer Hardware Technology
Course Disciplines:	Electronic Technology, Electronics
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.
Prerequisite:	
Co-requisite:	
Recommended Preparation:	Electronics and Computer Hardware Technology 11 or equivalent
Enrollment Limitation:	
Hours Lecture (per week):	2
Hours Laboratory (per week):	4
Outside Study Hours:	4
Total Course Hours:	108
Course Units:	3
Grading Method:	Letter Grade only
Credit Status:	Credit, degree applicable
Transfer CSU:	Yes
Effective Date:	Prior to July 1992
Transfer UC:	No
Effective Date:	
General Education: ECC	
Term:	
Other:	
CSU GE:	

Term:	
Other:	
IGETC:	
Term:	
Other:	
Student Learning Outcomes:	**SLO #1 Operational Amplifier** Given a schematic diagram of a basic Operational Amplifier (Op-Amp) with negative feedback, the students will be able to assemble, test and measure the circuit for its operational parameters. **SLO #2 Advanced In-Circuit Measurements** The student will make advanced "in-circuit" measurements using Bench and Portable Digital Multimeter (DMM), Oscilloscope, and Volt Ohm Milliammeter (VOM), on Advanced Solid-State-Systems. **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.
Course Objectives:	1. Predict the electrical performance of operational amplifier circuits employing negative feedback, using the first approximation of operational amplifier behavior. 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. 3. Explain the need for hysteresis in comparator circuits and calculate the amount of hysteresis required for typical applications. 4. Evaluate common comparator circuits and explain the difference between laboratory results and theoretical predictions. 5. Analyze representative practical operational amplifier circuits and describe their performance limitations. 6. Calculate the magnitude of common-mode signal rejection necessary for an instrumentation amplifier to comply with specified error signal limits. 7. Research and compile a list of commercially available operational amplifiers, ranked according to 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.
Major Topics:	**I. OVERVIEW OF LINEAR DEVICES (1 hour, lecture)** A. Safety lecture and examination B. The importance of linear circuits C. Review of basic electronics **II. INVERTING AND NON-INVERTING AMPLIFIERS (3 hours, lecture)** A. Inverting amplifiers

B. Summing amplifier
C. Nnon-inverting amplifier
D. Voltage follower

III. INVERTING AND NON-INVERTING AMPLIFIERS (8 hours, lab)

A. Inverting amplifiers
B. Summing amplifier
C. Non-inverting amplifier
D. Voltage follower

IV. OSCILLATORS (2 hours, lecture)

A. Multivibrators
B. Generating sine, triangle and sawtooth waveforms

V. OSCILLATORS (4 hours, lab)

A. Multivibrators
B. Generating sine, triangle and sawtooth waveforms

VI. ACTIVE FILTERS (7 hours, lecture)

A. Review of passive filters
B. The low-pass Butterworth filter
C. The high-pass Butterworth filter
D. Band-pass filters
E. Notch filters

VII. ACTIVE FILTERS (14 hours, lab)

A. Review of passive filters
B. The low-pass Butterworth filter
C. The high-pass Butterworth filter
D. Band-pass filters
E. Notch filters

VIII. INTEGRATED CIRCUIT TIMERS (2 hours, lecture)

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

IX. INTEGRATED CIRCUIT TIMERS (4 hours, lab)

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

X. POWER SUPPLIES AND REGULATORS (4 hours, lecture)

A. 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

XI. POWER SUPPLIES AND REGULATORS (8 hours, lab)

A. 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

XII. COMPARATORS (3 hours, lecture)

A. Voltage level detectors
B. Zero-crossing detectors
C. Window comparators and applications
D. Stair-step comparators
E. Hysteresis, positive feedback, and noise

XIII. COMPARATORS (6 hours, lab)

A. Voltage level detectors
B. Zero-crossing detectors
C. Window comparators and applications
D. Stair-step comparators
E. Hysteresis, positive feedback and noise

XIV. WAVE SHAPING WITH SIGNAL DIODES (3 hours, lecture)

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

XV. WAVE SHAPING WITH SIGNAL DIODES (6 hours, lab)

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 **XVI. DC PERFORMANCE: BIAS, OFFSETS AND DRIFT (2 hours, lecture)** 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 **XVII. DC PERFORMANCE: BIAS, OFFSETS AND DRIFT (4 hours, lab)** A. Nulling the effects of offset voltage B. Nulling the effects of bias current C. Measurement of bias current and offset voltage **XVIII. AC PERFORMANCE: BANDWIDTH, SLEW RATE AND NOISE (6 hours, lecture)** A. Amplifier gain and frequency response B. Slew rate and output voltage C. Amplifier noise D. External frequency compensation **XIX. AC PERFORMANCE: BANDWIDTH, SLEW RATE AND NOISE (12 hours, lab)** A. Amplifier gain and frequency response B. Slew rate and output voltage C. Amplifier noise D. External frequency compensation **XX. INSTRUMENTATION AND BRIDGE AMPLIFIERS (3 hours, lecture)** A. Basic differential amplifier B. Improving the differential amplifier C. Instrumentation amplifier D. Sensing and measurement with the instrumentation and bridge amplifier circuits **XXI. INSTRUMENTATION AND BRIDGE AMPLIFIERS (6 hours, lab)** A. Basic differential amplifier B. Improving the differential amplifier C. Instrumentation amplifier D. Sensing and measurement with the instrumentation and bridge amplifier circuits
Total Lecture Hours:	36
Total Laboratory Hours:	72

Total Hours:	108
Primary Method of Evaluation:	3) Skills demonstration
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 recorded test results in graphic form, plotted on semi-log paper and submit to the instructor.
Critical Thinking Assignment 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.
Critical Thinking Assignment 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.
Other 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
Instructional Methods:	Demonstration Discussion Laboratory Lecture Multimedia presentations
If other:	Internet Presentation/Resources
Work Outside of Class:	Study Answer questions Required reading Problem solving activities
If Other:	
Up-To-Date Representative Texts:	Albert Malvino, David Bates, Patrick Hoppe, Electronic Principles, 9th Edition, McGraw-Hill Education, 2021.
Alternative Texts:	
Required Supplementary Readings:	
Other Required Materials:	Scientific calculator Spiral bound notebook

Requisite:	
Category:	
Requisite course(s): List both prerequisites and corequisites in this box.	
Requisite and Matching skill(s):Bold the requisite skill. List the corresponding course objective under each skill(s).	
Requisite Skill:	
Requisite Skill and Matching Skill(s): Bold the requisite skill(s). If applicable	
Requisite course:	Electronics and Computer Hardware Technology-11
Requisite and Matching skill(s):Bold the requisite skill. List the corresponding course objective under each skill(s).	**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.
Requisite Skill:	or equivalent
Requisite Skill and Matching skill(s): Bold the requisite skill. List the corresponding course objective under each skill(s). If applicable	If a student has completed an equivalent course at another college, the student will have the knowledge needed to enroll in this course. If students have basic electronics knowledge, they will be will be prepared to enroll in this course. It is recommended that students have knowledge in electronics to enhance their success in this course.
Enrollment Limitations and Category:	
Enrollment Limitations Impact:	
Course Created by:	Douglas R. Martson
Date:	09/01/1983

Original Board Approval Date:	
Last Reviewed and/or Revised by:	Arnulfo Runas
Date:	11/25/2023
Last Board Approval Date:	06/17/2024
Effective Term:	FALL 2025