

ECG 720 - Advanced Analog IC Design

Catalog Data

Advanced analog design considerations including: noise, common-mode feedback, high-speed design, and design for analog signal processing.

Credits 3

Offered every other year

Prerequisites and/or Corequisites

Prerequisite EE 420 or ECG 620

Relevant Textbooks

Baker, "CMOS Circuit Design, Layout, and Simulation, Third Edition," *Wiley-IEEE*

Baker, "CMOS Mixed-Signal Circuit Design, Second Edition," *Wiley-IEEE*

Gray, Hurst, Lewis, and Meyer, "Analysis and Design of Analog Integrated Circuits, Fifth Edition," *Wiley*

Library Resources

Students may consult <https://www.library.unlv.edu/consultation> with a librarian on research needs. For this class, the subject librarian is Sue Wainscott.

(http://www.library.unlv.edu/contact/librarians_by_subject). UNLV Libraries provides resources to support students' access to information. Discovery, access, and use of information are vital skills for academic work and for successful post-college life.

Access library resources and ask questions at <http://www.library.unlv.edu>.

Coordinators

Dr. R. Jacob Baker

Dr. Peter Stubberud

Course Topics

- Electrical noise
 - power spectral density of electrical noise
 - calculating and modeling electrical noise in passive and active circuits
 - thermal, flicker, shot, avalanche and random telegraph signal noise
 - noise figure/factor, signal-to-noise ratio
 - reducing noise in circuits and verifying with simulations
- Advanced op-amp topologies
 - biasing for power and speed
 - basic concepts when designing fully-differential op-amps
 - common-mode feedback, theory and implementation

- design using switched-capacitor (dynamic) common-mode feedback
- applications of op-amps in signal processing circuits
- simulate the operation of advanced op-amp topologies
- Dynamic analog circuits
 - the MOSFET as an analog switch, charge injection, capacitive feedthrough, kT/C noise
 - fully-differential circuits, gain, common-mode feedback, noise
 - sample-and-holds
 - switched-capacitor circuits including the integrator
 - circuits for reducing offset voltages, comparators, current mirrors, amplifiers
- Nonlinear analog circuits
 - basic comparator design, pre-amps, decision circuits, output buffers
 - characterizing the comparator
 - clocked comparators
 - input buffers
 - adaptive biasing
 - analog multipliers using the multiplying quad and squaring circuits
- Data converter fundamentals
 - analog and discrete time signals
 - converting analog signals to digital signals
 - sample-and-hold characteristics
 - digital-to-analog converter (DAC) specifications including: differential nonlinearity (DNL), integral nonlinearity (INL), offset, gain error, latency, signal-to-noise ratio (SNR), dynamic range
 - analog-to-digital converter (ADC) specifications including: quantization error, DNL, missing codes, INL, offset, gain error, aliasing, SNR, aperture error
 - mixed-signal layout issues
- Data converter architectures
 - DAC architectures including: resistor string, current steering, charge-scaling, cyclic, pipeline
 - ADC architectures including: flash, two-step, pipeline, integrating, successive approximation, and oversampling (delta-sigma)
 - mismatch errors in various ADC and DAC topologies
 - accuracy issues related to offsets, finite gain, and finite bandwidth
 - layout of data converters
- Implementing data converters
 - R-2R topologies including: the current-mode DAC, the voltage-mode DAC, the wide-swing DAC, segmentation
 - practical design concerns for improving performance including trimming and calibration
 - DAC architectures without an op-amp
 - limitations of op-amps in data converters, finite bandwidth and gain, offsets
 - design of sample-and-holds, cyclic ADCs, and pipeline ADCs
 - using 1.5 bits/stage in a pipeline ADC along with capacitor error averaging

- layout of pipeline ADCs
- simulation of data converters and a data converter's internal components

Course Outcomes

After completing ECG 720 students will be able to:

1. analyze and calculate noise in a passive and active electronic circuit
2. suggest, and simulate to verify, ways to improve the noise performance of a circuit
3. design very-high speed op-amps for use in analog signal processing and data converter design
4. design clocked and non-clocked comparators with and without offset storage
5. simulate, and discuss the limitations, of advanced analog circuits and systems including: op-amps, comparators, digital-to-analog converters, and analog-to-digital converters
6. discuss the design (speed, accuracy, layout size, power, etc.) trade-offs between different data converter topologies
7. implement and layout analog-to-digital and digital-to-analog converters

Program Outcomes

1. The appropriate technical knowledge and skills
 - 1.1 An ability to apply mathematics through differential and integral calculus,
 - 1.2 An ability to apply advanced mathematics such as differential equations, linear algebra, complex variables, and discrete mathematics,
 - 1.3 An ability to apply knowledge of basic sciences,
 - 1.5 An ability to apply knowledge of probability and statistics,
 - 1.6 An ability to apply knowledge of engineering,
 - 1.7 An ability to design a system, component, or process to meet desired needs within realistic constraints,
 - 1.8 An ability to identify, formulate, and solve engineering problems,
 - 1.9 An ability to analyze and design complex electrical and electronic devices,
 - 1.10 An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice,
 - 1.11 An ability to design and conduct experiments, as well as to analyze and interpret data.

Computer Usage

Students use SPICE to create, simulate, and analyze analog integrated circuits.

Grading

Homework, quizzes, midterm exam, course project, and a final exam are used for grading assessment.

UNLV Policies

Academic Misconduct – Academic integrity is a legitimate concern for every member of the campus community; all share in upholding the fundamental values of honesty, trust, respect, fairness, responsibility and professionalism. By choosing to join the UNLV community, students accept the expectations of the Student Academic Misconduct Policy and are encouraged when faced with choices to always take the ethical path. Students

enrolling in UNLV assume the obligation to conduct themselves in a manner compatible with UNLV's function as an educational institution.

An example of academic misconduct is plagiarism. Plagiarism is using the words or ideas of another, from the Internet or any source, without proper citation of the sources. See the *Student Academic Misconduct Policy* (approved December 9, 2005) located at: http://www.unlv.edu/sites/default/files/page_files/27/UNLVStudentConductCode1212016.pdf.

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Disability Resource Center (DRC) – The UNLV Disability Resource Center (SSC-A 143, <http://drc.unlv.edu/>, 702-895-0866) provides resources for students with disabilities. If you feel that you have a disability, please make an appointment with a Disabilities Specialist at the DRC to discuss what options may be available to you. If you are registered with the UNLV Disability Resource Center, bring your Academic Accommodation Plan from the DRC to the instructor during office hours so that you may work together to develop strategies for implementing the accommodations to meet both your needs and the requirements of the course. Any information you provide is private and will be treated as such. To maintain the confidentiality of your request, please do not approach the instructor in front of others to discuss your accommodation needs.

Religious Holidays Policy – Any student missing class quizzes, examinations, or any other class or lab work because of observance of religious holidays shall be given an opportunity during that semester to make up missed work. The make-up will apply to the religious holiday absence only. It shall be the responsibility of the student to notify the instructor no later than the end of the first two weeks of classes, **January 29, 2016**, of his or her intention to participate in religious holidays which do not fall on state holidays or periods of class recess. For additional information, please visit: <http://catalog.unlv.edu/content.php?catoid=6&navoid=531>.

Incomplete Grades - The grade of I – Incomplete – can be granted when a student has satisfactorily completed three-fourths of course work for that semester/session but for reason(s) beyond the student's control, and acceptable to the instructor, cannot complete the last part of the course, and the instructor believes that the student can finish the course without repeating it. The incomplete work must be made up before the end of the following regular semester for undergraduate courses. Graduate students receiving "I" grades in 500-, 600-, or 700-level courses have up to one calendar year to complete the work, at the discretion of the instructor. If course requirements are not completed within the time indicated, a grade of F will be recorded and the GPA will be adjusted

accordingly. Students who are fulfilling an Incomplete do not register for the course but make individual arrangements with the instructor who assigned the I grade.

Tutoring – The Academic Success Center (ASC) provides tutoring and academic assistance for all UNLV students taking UNLV courses. Students are encouraged to stop by the ASC to learn more about subjects offered, tutoring times and other academic resources. The ASC is located across from the Student Services Complex (SSC). Students may learn more about tutoring services by calling 702-895-3177 or visiting the tutoring web site at: <http://academicsuccess.unlv.edu/tutoring/>.

Rebelmail – By policy, faculty and staff should e-mail students' Rebelmail accounts only. Rebelmail is UNLV's official e-mail system for students. It is one of the primary ways students receive official university communication such as information about deadlines, major campus events, and announcements. All UNLV students receive a Rebelmail account after they have been admitted to the university. Students' e-mail prefixes are listed on class rosters. The suffix is always @unlv.nevada.edu. **Emailing within WebCampus is acceptable.**

Final Examinations – The University requires that final exams given at the end of a course occur at the time and on the day specified in the final exam schedule. See the schedule at: <http://www.unlv.edu/registrar/calendars>.

Course Syllabus Preparer and Date
R. Jacob Baker, Friday, April 8, 2016