**ECE 544 Design of Electronic Packaging and Interconnects**

**Course Website:**  [https://moodle-courses1819.wolfware.ncsu.edu/course/view.php?id=7036](https://moodle-courses1819.wolfware.ncsu.edu/course/view.php?id=7036)

**Description:** A study of the design of digital and mixed signal interconnect and packaging. Topics covered include: single chip (surface mount and through-hole) and multichip module packaging technology, packaging technology selection, electrical performance of packaging, thermal design, electrical design of printed circuit boards, backplane and multichip module interconnect, receiver and driver selection, EMI control, CAD tools, and measurement issues. 3 credit hours.

**Instructor:** Dr. Robert Evans  
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**Section 001:** Tuesday/Thursday 11:45-1:00 PM  
Room 2232-EB3

**Office Hours:** Tuesdays 2:00-3:00 PM, Thursdays 10:00-11:00 AM, or by Appointment

**Teaching Assistant:** Pedro Vergara  
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ece544-spring-2019-sup-yzmcscln@wolfware.ncsu.edu

**Prerequisite:** An undergraduate-level course on the sophomore or junior level in RLC and in TTL and MOS transistor circuit analysis. You must be familiar with NCSU’s online resources, including email, Unity accounts, etc. If you need help, see the Campus Resources chapter of the E 115 online textbook ([http://www.eos.ncsu.edu/e115/text.php](http://www.eos.ncsu.edu/e115/text.php)) or the main Eos web site ([http://www.eos.ncsu.edu](http://www.eos.ncsu.edu)).

**Course Objectives:** This class has been designed to equip students with the required knowledge and techniques so that they will be able to select amongst packaging and functional multi-chip partitioning alternatives so as to best meet the aim of the system and design systems to meet electrical delay, noise and other requirements, which includes determining technology details, selecting the appropriate active devices, placement and routing of the system.

**A student will:**
- Learn about packaging and interconnect options available, including printed circuit boards, single chip packaging, both surface mount and through-hole, and multichip modules
Learn how to select amongst competing packaging options in order to meet system performance and cost requirements and goals.

Learn how the partitioning of a system amongst different chips and packages affects systems requirements and goals.

Learn about the fundamentals of digital circuit interconnect design, including characteristics of drivers for different logic families, impedance control, reflection noise, crosstalk noise, switching noise (ground bounce), and electromagnetic interference.

Learn how to design printed circuit board, backplane, and multichip module interconnect to achieve electrical delay and noise (signal integrity) aims.

Learn how to select (or design) drivers and receivers for different applications.

Learn about timing driven design.

Learn about the thermal design of packages.

Be exposed to industry Computer Aided Design tools that assist in this process.

Discuss modeling and other issues associated with these tools.

Learn the principles of EMI control and discuss the associated rules.

Be exposed to the considerations associates with design for testability and design for manufacturability, with emphasis on surface mount and multichip module technologies.

Be exposed to electronic interconnect performance measurement techniques and standards.

Course Topics:

- Review of Electronic Interconnect Measurement Standards and Techniques
- Overview of Packaging Technology Options
- Relevant characteristics of digital drivers-receivers
- Timing Modeling and Noise Budgeting
- Transmission Line Theory and Fundamentals
- Differential Signaling
- Frequency-dependent properties of dielectric materials and interconnect
- Non-ideal return paths
- Delay, attenuation, and ringing
- Crosstalk noise
- Simultaneous Switching Noise
- Power Delivery System Design
- S-parameters for digital engineers
- Serial Channel Design
- Equalization
- EMI and EMC guidelines
- Thermal Design

Course Requirements:

- Homework: Two-week cycle (20%). Six problem sets total.
- Participation: Class participation (5%)
- In-class Quizzes: (10%). Short 10-15-minute in-class open-book quizzes will be offered once or twice a week. The lowest two grades are dropped in calculating the grade average.
- Examinations: Two midterm exams (20% each) and a final exam (25%).
- All exams are closed-book and closed-notes. Essential formulae and constants may be used individually by each student. Two pages for mid-terms, four pages for the final exam.
- Projects: None

Software Requirements: Access to the NCSU eos Linux system is required. You should ensure that you have access to the NCSU eos system. Simple remote usage instructions will be given near the start of the course. And the TA can help you with specifics.

Audit Requirements: To receive audit credit for this class the student will be required to score a minimum of 70% credit on the homework, in-class quizzes, and participation grades. Audit students do NOT need to take the midterm or final exams.

Computer and Internet Requirements: NCSU and Engineering Online have recommended minimum specifications for computers. For details, click here.

Homework: Online homework assignments will be submitted through the Moodle site. Some of these assignments will be problem solving on paper, and some will involve software tools. I highly encourage you to work together in groups to complete the homework assignments. However I expect each of you to submit your own unique answers, no blatant copying will be allowed.

Participation: Each on-campus student is expected to participate in class. This will include but is not limited to discussions, problem solving, tool issues, etc. To achieve this class attendance is mandatory. The class recordings, both audio and video, will NOT be available for on-campus students.

In-Class Assignments: We will be using an online tool called Top Hat to take attendance and for interactive in-class exercises. There is a site-wide license for TopHat so there is no additional charge for this software. Please set up your TopHat account at: https://tophat.com/ by the end of the first week of class. We will use it on the second week of class! Please link your account to the proper join code based on your location. PLEASE use your NCSU Unity ID and Email for your account at TopHat! It allows to synchronize it with our Moodle system.

NCSU: Join code: 742157
To use Top Hat, you must have a laptop, tablet, or smartphone in class. TopHat assignments **MUST** be completed while **in the classroom**! Logging into TopHat to complete an assignment while away from the classroom will be considered cheating and the appropriate policies will apply! Assisting other students with the TopHat information will be similarly handled. Please be **On Time** for class!

**Class Policies and Resources**

*Preferred Means of Communication:*
The best way to reach me is through email. The preferred email is ece544-sprg-2019-sup-yzmcschn@wolfware.ncsu.edu (ece544-sup). Emails to this address will be seen by me and by all of the TAs, so you have a better chance of getting a quick answer. If you get an answer from me, or from a TA, please continue to include ece544-sup in your replies, so that everyone can see the discussion.

If you want to communicate with me personally, send email to rjevans@ncsu.edu. Unless the email needs to be confidential, I will most likely include ece544-sup when I reply.

I also highly encourage the use of the Moodle Discussion Forum. This allows other students to see your question, and the answer, so that we don't have to answer the same question 20 times. I also encourage students to answer each other's questions, as long as you don't provide solutions to homework problems.

I am also available by phone during normal office hours: 919-513-0987.

*Computer Resources*

**Course web site:** Login to wolfware.ncsu.edu and click on ECE 544. This will take you to the Moodle site. Direct link is: [https://moodle-courses1819.wolfware.ncsu.edu/course/view.php?id=7036](https://moodle-courses1819.wolfware.ncsu.edu/course/view.php?id=7036)

**Email aliases:** ece544-sprg-2019-sup-yzmcschn@wolfware.ncsu.edu (instructor and TAs)

All class announcements will be posted to the Moodle site’s **Announcements** forum. All announcements will also be emailed to all students, because everyone is forced to subscribe to the Announcements forum. The Moodle site will also contain links to homework assignments and solutions, lecture notes, past exams, and other relevant information. You are expected to check the Moodle site frequently for homework assignments and other timely information.

**Discussion Forums** are provided for on-line class discussions. Students may add a new topic to a forum or reply to a previous posting. Please make sure that posted material is appropriate and course-related. Do not post off-color jokes, offensive material, job listings, for-sale ads, virus alerts, etc. Do not post explicit homework solutions, but ideas for solving may be discussed. If the message board is abused, it will be deleted, and the abusers will be referred to the Office of Student Conduct.

**Late Assignments**

Assignments will not be accepted after the due date, except for University-excused absences. In the case of an excused absence, the assignment is due within 24 hours of your return to school. (For extended absences with multiple missed assignments, talk to the instructor.)
Incomplete Grades
Incomplete grades will be assigned when a student cannot complete the course due to unforeseeable conflicts or obstacles. Incomplete grades will normally be made up by completing the work during the following semester, on a schedule agreed upon by student and instructor.

Missed Quizzes and Exams
Attendance at all exams is mandatory. Only University-approved excuses will be accepted, provided that they are accompanied by the appropriate official documentation. Makeup exams may be given for excused absences at the discretion of the instructor. If you miss an exam without an acceptable excuse, you will receive a zero for that exam.
For more information about University-approved absences, see:
http://policies.ncsu.edu/regulation/reg-02-20-03

Regrading Requests
If you have discussed your grading on an assignment with your TA and are still not satisfied, you may submit a request to me within one (1) week of the graded assignment being returned to you. You must write a cover sheet explaining why you feel you deserve additional points on a given problem, attach it to the front of your graded paper, and give it to me either in class or my office. Regrading requests will NOT be considered more than one week after the assignments are returned.

Academic Integrity
Consultation on assignments is encouraged, but copying of solutions is not. Evidence of copying or any other use of unauthorized aid on exams, homework, programming assignments, or problem sessions will be investigated and potentially referred to the Office of Student Conduct as a violation of the Code of Student Conduct.
For more information on the Code of Student Conduct, see:
http://studentconduct.ncsu.edu
http://policies.ncsu.edu/policy/pol-11-35-01
Any work submitted for this class (homework, problem session, exam, is subject to the Honor Pledge: “I have neither given nor received unauthorized aid on this test or assignment.” An Honor Pledge statement must be signed for every exam. For other assignments, it is the understanding and expectation of the instructor that the submission of work with your name on it means that you neither gave nor received unauthorized aid.

Students with Disabilities
Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, 515-7653. http://dso.dasa.ncsu.edu/
For more information on NC State’s policy on working with students with disabilities, please see:
http://policies.ncsu.edu/regulation/reg-02-20-01

Inclement Weather
The class will follow the University's closure policy. If classes are not cancelled, I will make every effort to be in class on time, and so should you. Please do not send me email asking whether class is going to meet. Instead, check the University website or the weather hotline (513-8888). If possible, I will provide video material to make up for a cancelled class.

Remote sites: If your local site cancels class due to inclement weather, I do not expect you to come to class. I do, however, expect you to view the recorded lecture and submit online assignments. Extended and widespread power outages can result in deadline extensions.

Laboratory Safety, Physical Activity, and Field Trips
There is no laboratory, physical activity, or field trip associated with this course.

Extra Expenses
This course has no extra expenses beyond the costs of the required textbook.

Transportation
As there are no field trips or internships associated with this course, there are no expected transportation requirements.

NCSU Transgender Inclusive Act

“In an effort to affirm and respect the identities of transgender students in the classroom and beyond, please contact me if you wish to be referred to using a name and/or pronouns other than what is listed in the student directory.”

Course Evaluation
Online class evaluations will be available for students to complete during the last two weeks of class:
   April 15 (8am) – April 26 (8am)
Students will receive an email message directing them to a website where they can login using their Unity ID and complete evaluations. All evaluations are confidential; instructors will never know how any one student responded to any question, and students will never know the ratings for any instructors.
Evaluation website:  http://go.ncsu.edu/cesurvey
Student help desk: classeval@ncsu.edu
More information about ClassEval: https://oirp.ncsu.edu/surveys/classeval

ABET Accreditation
Our ECE department is participating in ongoing accreditation with ABET. Your complete, graded work (exams, problem sessions, homework, etc.) will be randomly copied and held for this accreditation before it is returned to you.

Important Dates
<table>
<thead>
<tr>
<th>January 7</th>
<th>First day of classes.</th>
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<tbody>
<tr>
<td>January 21</td>
<td>University Holiday (MLK Day)</td>
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<tr>
<td>January 18</td>
<td>Census Date / Official Enrollment Date – Last day to drop without a “W”</td>
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<tr>
<td>February 26</td>
<td>Exam 1 (tentative date)</td>
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<td>March 11-15</td>
<td>Spring Break</td>
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<td>March 4</td>
<td>Drop/Revision Deadline</td>
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<td>April 19</td>
<td>Spring Holiday - University Holiday</td>
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<tr>
<td>April 18</td>
<td>Exam 2 (tentative date)</td>
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<td>April 22-26</td>
<td>Dead Week - no tests or quizzes or new assignments. There may be in-class assignments.</td>
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<tr>
<td>April 26</td>
<td>Last day of classes.</td>
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<td><strong>May 7</strong></td>
<td>Final exam (8:00 - 11:00 am)</td>
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Updated 1/3/2019