

ECE 544 Design of Electronic Packaging and Interconnects

Updated 1/5/2024

Course Website: <https://moodle-courses2324.wolfware.ncsu.edu/course/view.php?id=6906>

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.

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Section 001: Video Replay

Office Hours: By Zoom by appointment.

Teaching Assistant: None

Support Alias: ece-544-601-sprg-2024-support@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, Windows computing operations, Linux computing operations, etc. If you need help, see the Campus Resources chapter of the E 115 online textbook (<http://www.eos.ncsu.edu/e115/text.php>) or the main Eos web site (<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 associated 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

Textbook: Hall, S.H., H.L. Heck, *Advanced Signal Integrity for High-Speed Digital Designs*, First Edition. Wiley-IEEE Press, 2009. ISBN: 978-0-470-19235-1. I strongly suggest that you purchase the e-book version of this text from the All-In selection from the bookstore.

N.C. State Bookstore Purchase Link:

<https://shop.ncsu.edu/adoption-search-results?ccid=44804&itemid=102436>

Course Requirements:

- Homework: Two-week cycle (20%). Six problem sets total.
- Take Home Quizzes: (15%). Short 10-15-minute open-book quizzes will be offered once or twice a week. The lowest grade is 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.

Software Requirements: Access and familiarity with the NCSU eos Linux system is required. You should ensure that you have access to the NCSU eos system and can use it to manage files and run applications. 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.

Class Recordings

Each class recording is available at the EOL website

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.

Homework	% Weight	Topic	Assign	Due
1	2	Waves, T-lines		
2	2	Reflections, Terms,		
3	3	Timing Calcs		
4	5	SiSoft Pre-Route		
5	4	Power, PaperCalcs, Spreadsheet		
6	4	Sigrity PowerDC		
Total	20%			

Take Home Quizzes: We will do 10-12 take home short exercises to practice the material learned in a given lecture. These may be completed in groups of 2-3 people and will be submitted at the due date/time. The lowest grade will be dropped.

Class Policies and Resources

Preferred Means of Communication:

The best way to reach me is through email. The preferred email is ece-544-601-sprg-2024-support@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.

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-courses2324.wolfware.ncsu.edu/course/view.php?id=6906>

Email aliases: ece-544-601-sprg-2024-support@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.

Lectures

The class lectures have been recorded live in the regular classroom.

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.

Submission of All Assignments

[1] Students will download the assignments and work them at their location. This may be done on soft-copy with a pen computer, or it may be printed and written as in-class. Students without a printer may complete the assignments on plain paper and upload to Moodle in the same fashion.

[2] When finished the students who printed their assignments will scan their assignments on a PC-based scanner, or use a phone app such as **Genius Scan** to scan and create a **single** .pdf file. This file will be uploaded onto Moodle. Photo files (.jpg, etc.) will be prohibited due to their size and varying quality.

Late Assignments

Late Homework and In-class Quiz assignments will be penalized 10% per day after the due date up to a maximum of 5 days late. In the case of an excused absence, the assignment is due within 24 hours of your return to school. For extended absences greater than 5 days with multiple missed assignments, talk to the instructor. In this case the assignments will not be made up but will receive the score of your next midterm exam.

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 Exams

Attendance at all exams is mandatory. Only University-approved excuses will be accepted, provided that they are accompanied by the appropriate official documentation. Medical excuses must be provided

from NCSU Student Health or a local pharmacy mini-clinic (CVS, Walgreens, etc.). Tele-health appointments will **NOT** be accepted as valid excuses.

If you miss an exam without an acceptable excuse, you will receive a **zero** for that exam. Missed exams with university-approved excuses will **NOT** be made up. If you miss **one** midterm exam, the score from your final exam will be used as your missing exam grade. If you miss **two** mid-term exams we need to discuss presenting university-approved excusal. Should you miss the Final Exam for an excused absence you will receive an Incomplete IN grade and retake the final during the first week of the following semester.

Do not ask for permission to take the final exam early or late because of individual family travel plans. These requests will not be granted.

For more information about University-approved absences, see:

<http://policies.ncsu.edu/regulation/reg-02-20-03>

THREE FINAL EXAMINATIONS IN 24 HOURS

No student shall be required to take three consecutively scheduled final examinations within any 24-hour period. For example, a student with exams scheduled at 1:00pm, 6:00pm and 1:00pm the following day would not constitute three consecutively scheduled final exams in a 24-hour period. If students find that they have three consecutively scheduled exams or concurrent exams, they should report to the Department of Registration and Records (1000 Harris Hall) before the exams are to be given, have their schedules verified, and to obtain a form approving their request to change the date of a specific examination designated by the student. The student must take the form to the specified instructor or departmental office and arrange for a new examination date.

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 note explaining why you feel you deserve additional points on a given problem, and email it directly to me. 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:

TBD

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

January 8	First day of classes.
January 15	MLK Jr. Birthday, University Holiday, No classes
January 19	President's Day, NOT a University Holiday, Normal Class Schedule
January 22	Census Date / Official Enrollment Date – Last day to drop without a “W”
February 13	Wellness Day, No Classes
February 28	Exam 1 (tentative date)
March 4	Drop/Revision Deadline
March 11-15	Spring Break
April 8	Exam 2 (tentative date)
April 22	Last day of classes.
April 26	Final Exam

N C State CARES

<https://prevention.dasa.ncsu.edu/nc-state-cares/about/>

The case managers at NC State work collaboratively with campus resources to provide support for students who are in distress or who have been identified as exhibiting concerning or worrisome behaviors. Effective case management ensures that the community at large remains safe while the student involved gains the necessary resources to remain successful academically and personally at NC State. The case managers do this by:

- Providing comprehensive outreach and consultation services to the NC State community in order to proactively identify students who are struggling
- Providing early intervention and behaviorally based assessments to determine appropriate resources and referrals to campus and community resources.
- Working constructively with students to foster resilience and self-advocacy
- Monitoring student progress

N C State Counseling Center


<https://counseling.dasa.ncsu.edu/>

The Counseling Center provides mental health services and resources to students - together we can create a thriving community for all students.



Genius Scan:

GeniusScan allows you to scan documents into a multi-page pdf using your phone or tablet.

Download GeniusScan ahead of time

1. Download to [Android](#) or [iOS](#) device
2. Open **GeniusScan** . Click **Settings** icon, then **General**
3. Change the image processing default filter to Black and White for a smaller file. Reducing file size may be important during upload.

Scan Multiple Pages Using GeniusScan

1. Open **GeniusScan** .
2. Tap the **+** icon then **Scan from Camera**. Make sure it's in **BATCH** mode so your photos will be combined into one PDF.
3. Aim camera at the first page of your document; if it doesn't automatically take a picture, tap the round button. Repeat until you have scanned all pages, then tap **Done**.
4. If your scan looks good, tap **Share**  on bottom right. Tap **Email**. Email it to yourself for upload to Moodle.