

Electrical and Computer Engineering

Instructor:	David C. Burnett, Ph.D.
Office:	FAB 160-13
Availability:	Office hours will be held TBD.
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Class Meeting Times:	Tuesdays and Thursdays 12 PM to 1:50 PM Final exam: Thursday December 12 10:15 AM to 12:05 PM

Course Description

This course will take students through design and verification of a complete system-on-chip in real silicon. Students will experience team-based design of intellectual property (IP) cores, convert to layout using a real process development kit (PDK), and send the result for manufacturing in an industrial semiconductor process.

Students will use the Berkeley RISC-V processor and Chipyard support IP core system architecture to propose, design, and tape out their own SoC with a variety of functions. These functions must be verified in simulation, preferably also in FPGA, then taped out to final GDSII output file by the end of the term. The result will be submitted to Intel for fabrication in their 16nm FinFET process. Opportunities to test will be available through independent study credits upon return of the silicon. Students will work together in one or few large teams to produce their design.

Course Outcomes/Learning Objectives

Planned instructional topics include:

- Software tools such as Chisel, Synopsys Design Compiler and Integrated Circuit Compiler, Cadence Genus and Innovus, and Siemens Calibre and Synopsys IC Validator for verification
- System-on-Chip architecture
- Berkeley RocketChip generator and RISC-V architecture with RTL generation
- Layout verification including DRC/LVS techniques
- Reliability issues including antenna, latch-up, and ESD mitigation strategies
- Design coordination and documentation

Upon completion of the course students should be able to:

- Design a complex system on chip and send it for manufacturing in a modern FinFET semiconductor process
- Design circuits consistent with unique FinFET design rules

- Understand and use modern design automation frameworks for more rapid system-on-chip integrated circuit design
- Anticipate practical electromechanical considerations and include them into early stages of design
- Work in a multidisciplinary engineering team with interconnected components and achieve success through clear communication and rigorous testing

Course Prerequisites

Enrollment is by instructor permission. Both graduate students and advanced undergraduate students are welcome! Enrollment will be granted to students who (a) have prerequisite experience in the form of ECE 540 or ECE 526 or ECE 530, or equivalent, (b) demonstrate mastery of prerequisite skills through satisfactory completion of course pre-labs, and (c) sign a nondisclosure agreement necessary to protect Intel Confidential Information.

Required Materials

- Access to Canvas: <https://canvas.pdx.edu/>.
- Access to MCECS Linux servers: <https://cat.pdx.edu/platforms/linux/user-environment/list-of-common-mcecs-linux-systems/>
- Established account on MCECS Gitlab to access Pre-Labs: <https://gitlab.cecs.pdx.edu/>
- No required textbook

Reference Books

The books below are useful reference materials:

- Digital Design with Chisel by Martin Schoeberl
 - Available free online: <https://github.com/schoeberl/chisel-book>
- Digital VLSI Chip Design with Cadence and Synopsys CAD Tools by Erik Brunvand
- The Art of Analog Layout by Alan Hastings
- FinFET Devices for VLSI Circuits and Systems by Samar K. Saha
- Fundamentals of Ultra-Thin-Body MOSFETs and FinFETs by Jerry G. Fossum and Vishal P. Trivedi

Grading Criteria

Students will attend twice weekly lecture periods that will provide information about manufacturable FinFET system-on-chip design. Lecture periods will also serve as team coordination and project update periods, and will be used for design reviews. In teams, students will work on a term-long project to produce a system-on-chip design, including a mix of individual and group responsibilities.

Final grades will be composed of:

- Weekly individual design progress updates (40%)

- Midterm design review presentation (20%)
- Final design review presentation (20%)
- Final design documentation (20%)

All presentations and documentation must be typed with any equations typeset. All figures must be computer-generated, include axis labels with units, a descriptive caption, and all text must be legible. Any block diagrams or circuit schematics should be carefully evaluated to remove extraneous detail to enhance clarity without sacrificing correctness.

Any questions or concerns about grading will be accepted in writing via email only. Please email Dr. Burnett with a clear description of the concern within 48 hours of the digital or physical return of the assignment. Include a copy of the assignment. The entire work in question (exam, assignment, etc.) will be re-graded which may result in the final score increasing, decreasing, or staying the same.

If, at the end of the term, a student is close to the cutoff for the next highest grade Dr. Burnett may elect to round the student's grade up if and only if the student has demonstrated mastery of the material in ways above and beyond graded assignments.

Grading Scale

A	B	C	D	F
>90%	80% to 89%	70% to 79%	60% to 69%	60% to 69%

Instructor discretion may be applied to the boundaries between letter grades.

Flexibility Statement

The instructor reserves the right to modify course content and/or substitute assignments and learning activities in response to institutional, weather, or class situations.

Tentative Course Calendar/Schedule

Week 1	Course, security, and chipyard introduction; block design/role assignments
Week 2	Chisel and full Intel PDK design flow; first check-in on block simulation
Week 3	Tilelink bus; team progress check-in
Week 4	Design for Test and die-on-PCB interface considerations
Week 5	Midterm presentations; RTL freeze and mock tape-out
Week 6	Interface issue analysis and whole-chip verification
Week 7	Floorplanning and routing errors
Week 8	Reliability issues including antenna, latch-up, and ESD mitigation strategies
Week 9	Testing and verification check-ins
Week 10	Individual block design final presentations
Finals Week	Final fixes and GDS tapeout

Course Attendance Policies

Regular attendance in lecture is expected but please DO NOT come to class if you are sick, have tested positive for COVID, or show COVID symptoms. If you have been exposed to COVID, please consider testing before attending class even if you are not experiencing symptoms. If you decide to come to class while sick with something that does not appear to be COVID, your classmates and instructors would greatly appreciate if you take measures to prevent the spread of illnesses, such as wearing a mask and sitting farther away from people. This is a graduate course, so schedule accommodations are expected for research obligations such as conference travel. Please make arrangements with Dr. Burnett as early as possible before the dates of such conflicts.

Late Work Policies and Delay Tickets

Students can miss up to two weekly check-ins, no questions asked, without penalty. For any other schedule accommodations for assignments such as exams or in-class presentations, requests must be submitted to Dr. Burnett in writing at least five full business days beforehand. When requesting an accommodation, please contact Dr. Burnett with (1) an explanation of the situation and (2) suggested method of accommodation. If you are arranging for an accommodation through the Disability Resource Center (DRC), please also notify Dr. Burnett at the same time. Accommodations not requested through the DRC are at the discretion of the instructor. Missing an exam or in-class presentation without prior arrangement will result in a zero except in documented emergencies. An excused missed in-class assignment will usually result in that assignment being dropped with the other exam scores scaled to fit. If you are experiencing an extenuating circumstance that requires needing more accommodations, please make an appointment to discuss your situation with Dr. Burnett.

Generative AI and Plagiarism Policy

Generative AI systems such as ChatGPT can be valuable resources to quickly gather and synthesize information. Please note that in this class, students are expected to compose all responses personally without the use of generative AI tools. If it becomes apparent that a student has used generative AI tools in submitted work, that work will be found to have not met the terms of the assignment. AI tools, like any other resource, may be consulted in preparation of student work. And, like all resources, the use of AI tools must be disclosed and cited appropriately. Failure to cite supporting resources always constitutes plagiarism. Monash University has developed suggested techniques to acknowledge the use of AI tools: <https://www.monash.edu/student-academic-success/build-digital-capabilities/create-online/acknowledging-the-use-of-generative-artificial-intelligence>. Resources from <https://aieducation.trubox.ca/> were consulted while preparing this portion of the syllabus.

PSU Policies & Resources

Academics

Academic Integrity

Academic integrity is a vital part of the educational experience at PSU. The [Student Code of Conduct](#) is the university's policy on academic dishonesty. A confirmed violation of that code in this course may result in failure of the course.

Incomplete Grades Policy

Students do not have a right to receive or demand an Incomplete grade. The option of assigning an Incomplete grade is at the discretion of the instructor when these criteria are met:

- Required satisfactory course completion/participation
- Reasonable justification for the request
- Not sought as a substitute for a poor grade
- Presence of a written agreement (such as the [Incomplete Contract](#))
- A plan in place to resolve Incomplete status

The Office of the Registrar's website has [the full Incomplete Grades policy](#).

Student Services

Disability Access Statement

If you have, or think you may have, a disability that may affect your work in this class and feel you need accommodations, contact the [Disability Resource Center](#) to schedule an appointment and initiate a conversation about reasonable accommodations. The DRC is at 116 Smith Memorial Student Union, 1825 SW Broadway; 503-725-4150; drc@pdx.edu.

Safe Campus Statement

Portland State University desires to create a safe campus for our students. As part of that mission, PSU requires all students to take the learning module entitled Creating a Safe Campus: Preventing Gender Discrimination, Sexual Harassment, Sexual Misconduct and Sexual Assault. If you or someone you know has been harassed or assaulted, you can find the appropriate resources on PSU's Enrollment Management & Student Affairs: Sexual Prevention & Response website at <http://www.pdx.edu/sexual-assault>

Basic Needs at Portland State

The Basic Needs Hub provides students with one place to stop for all concerns related to providing for basic needs support. Visit the [Basic Needs Hub](#) to get more information about emergency funds, food assistance, housing services and other basic needs so you can focus on academics, career goals, and interpersonal relationships. Please notify me for additional support if you feel comfortable doing so.

Title IX Reporting

As an instructor, students frequently come to me for assistance in matters that are not related to the course material. Please be aware that PSU's policies require instructors to report any instance of sexual harassment, sexual and relationship violence and/or other forms of prohibited discrimination to University Officials, who keep the information private. If you would rather share information about these experiences with a PSU staff member who does not have

these reporting responsibilities and can keep the information confidential, please contact one of the following campus resources.

- Confidential Advocates: 503.894.7982, or by [scheduling on-line](#) (for matters regarding sexual harassment and sexual and relationship violence)
- Center for Student Health and Counseling ([SHAC](#)): 1880 SW 6th Ave, 503.725.2800
- [Student Legal Services](#): 1825 SW Broadway, (SMSU) M343, 503.725.4556 For more information, please complete the required student module Understanding Sexual Misconduct and Resources in Canvas.

[PSU Sexual Misconduct Response website](#) gives you comprehensive information about how to support and/or report an incident.

Please complete the required student module [Understanding Sexual Misconduct and Resources](#) in Canvas, which provides information about PSU policy and resources.

You may also report sexual and relationship violence to law enforcement on campus with [Campus Public Safety Office \(CPSO\)](#).

Or you may file an [anonymous report with Campus Public Safety Office](#) or a [Bias Incident report](#) with the [Bias Review Team \(BRT\)](#). PSU does not typically investigate the reports that are made through these two avenues. These reports help PSU understand what students and employees are experiencing on and around campus and provide support where needed.

Suicide Prevention Training

Mental health challenges like anxiety, depression, and thoughts of suicide are common -- especially among college students. Life can be stressful! It is critical for our campus community to have the skills and confidence to support each other when we're struggling. That's why [SHAC](#), the School of Social Work, Portland State students, and Aedin Powell Media have created a self-paced, online suicide prevention training. [Self-enroll here](#). Learn how to support someone who is experiencing thoughts of suicide and how to access mental health resources on- and off-campus. Learn about important considerations for supporting communities that experience elevated risk for suicide, including: military-affiliated, autistic, LGBTQIA2S+, and international students. Take the 2-hour training and join PSU's movement for suicide prevention.

If you are in need of immediate mental health support, call or text 9-8-8, the National Suicide and Crisis Lifeline.

Technology

Recording Technology Notice

We will use technology for virtual meetings and recordings in this course. Our use of such technology is governed by FERPA, the [Acceptable Use Policy](#) and PSU's [Student Code of Conduct](#). A record of all meetings and recordings is kept and stored by PSU, in accordance with the Acceptable Use Policy and FERPA. Your instructor will not share recordings of your class activities outside of course participants, which include your fellow students, TAs/GAs/Mentors, and any guest faculty or community-based learning partners that we may engage with. **You may not share recordings outside of this course. Doing so may result in disciplinary action.**

Turnitin

Students agree that by taking this course all required papers may be subject to submission for textual similarity review to Turnitin.com for the detection of plagiarism. All submitted papers will be included as source documents in the Turnitin.com reference database solely for the purpose of detecting plagiarism of such papers. Use of Turnitin.com page service is subject to the Usage Policy and Privacy Pledge posted on the Turnitin.com site.

Discrimination and Bias Incidents

[The Office of Equity and Compliance](#) (OEC) addresses complaints of discrimination, discriminatory Harassment, and sexual harassment against employees (faculty and staff). If you or someone you know believes they have been discriminated against, you may file a complaint. Someone from the OEC will contact you to discuss how to best address your complaint.

[The Bias Review Team](#) (BRT) gathers information on bias incidents that happen on and around campus, and gives resources and support to individuals who experience them. You can report a bias incident you experienced or learned about. A member of the BRT will contact you if you indicate you would like to be contacted.

Religious Accommodations

If you would like to obtain religious accommodations, such as flexibility in attending evening courses or extension on assignments, please contact your instructors. If you need additional assistance, please contact the Office of the Dean of Student Life (DOSL) by emailing askdos@pdx.edu.

Cultural Resource Centers

Cultural Resource Centers (CRCs) create a student-centered inclusive environment that enriches the university experience. They honor diversity, explore social justice issues, celebrate cultural traditions, and foster student identities, success, and leadership. They provide opportunities for student leadership, employment, and volunteering; student resources such as computer labs, event, lounge, and study spaces; and extensive programming. All are welcome!

- Multicultural Student Center
- La Casa Latina Student Center
- Native American Student and Community Center
- Pan African Commons
- Pacific Islander, Asian, and Asian American Student Center
- Middle East, North Africa, South Asia Initiative

Covid-19 Response

Classroom Requirements for All Students and Faculty Due to Covid-19

The University has established rules and policies to make the return to the classroom as safe as possible. It is required for everyone to follow all the Return to Campus rules and policies. To participate in this class, PSU requires all students to comply with the following.

Vaccination

- Be vaccinated against COVID-19 and complete the [COVID-19 vaccination attestation](#) form. Those students with medical or nonmedical exemptions or who will not be on campus at all must complete the process described on the “COVID-19 Vaccine Exemption Request Form” to establish those exemptions.

Health Check, Illness, Exposure, or Positive Test for COVID-19

- If you are feeling sick or have been exposed to COVID-19, do not come to campus. Call [The Center for Student Health and Counseling \(SHAC\)](#) to discuss your symptoms and situation at 503-725-2800. They will advise you on testing, quarantine, and when you can return to campus.
- If you test positive for COVID, [report your result to SHAC](#) and do not come to campus. SHAC will advise you on quarantine, notification of close contacts, and when you can return to campus.
- Please notify me (i.e. your instructor), should you need to miss a class period for any of these reasons so that we can discuss strategies to support your learning during this time.
- If I become ill or need to quarantine during the term, either I or the department chair will notify you via PSU email about my absence and how course instruction will continue.

Failure to Comply with Any of these Rules

As the instructor of this course, the University has given me the authority to require your compliance with these policies. If you do not comply with these requirements, I may ask you to leave the classroom, or I may need to cancel the class session entirely.

In addition, failure to comply with these requirements may result in a referral to the Office of the Dean of Student Life to consider charges under PSU's Code of Conduct. A student found to have violated a university rule (or rules) through the due process of student conduct might face disciplinary and educational sanctions (or consequences). For a complete list of sanctions, see Section 14 of the [Student Code of Conduct & Responsibility](#).

Guidance May Change

Please note that the University rules, policies, and guidance may change at any time at the direction of the CDC, State, or County requirements. Please review the University's main [COVID-19 Response](#) webpage and look for emails from the University on these topics.