# EE 465.3
# Design of a DSP System

College of Engineering
Winter 2022


**Instructors:**

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**Laboratory Instructor:**

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**Office Hours:** No formal office hours, but students are welcome to contact the instructor via email or phone to schedule a mutually convenient time for a meeting to get help with the course.

**Lectures:** Mondays, Wednesdays, and Fridays, 12:30-1:20PM, Room 2B52, Engineering

**Laboratory:** Officially scheduled for Tuesdays, 4:00-6:50PM, Room 2C70/74, Engineering

However, students are given the freedom to access the lab equipment and perform the laboratory work at their convenience, as was the case in other classes in the DSP stream. The schedule and process for connecting to the remote equipment will be posted on the class website and discussed in the lectures.

**Website:** Assignments, solutions, lab schedules, general course information, and announcements will be posted on the course website on Canvas. Students are responsible for keeping up-to-date with the information on the course website.

https://canvas.usask.ca/

**Description:** This course falls into the category of "guided design". The students will be guided through the design and implementation of a complex DSP-based system. The course covers the application specific theory as well as the application specific implementation issues for a specific DSP-based system. The specific DSP system that is designed in this course will change from time to time as necessary to maintain relevancy. The current design problem is a digital communication system based on quadrature amplitude modulation. The students will be guided through the design of the system, design of the modulator, the modelling of the channel and the design of the demodulator.

**Prerequisites:** EE 456

**Course Reference Numbers (CRNs):** 25065 (lectures), 25066 (laboratory)

| | |
|---|---|
| **Textbook:** | No required textbook |
| **Reading List:** | Interesting/relevant/helpful materials may be posted on the class website periodically. |
| **Important Notes Regarding Course Delivery:** | Please note that the following plans are subject to change, pending College or University policy updates in response to the evolving COVID-19 situation. Students are responsible for monitoring course announcements to keep up to date with any changes to the course delivery methods.<br><br>For 2021-2022, the current expectation is that the course will be mostly offered through in-person learning. Due to the current rapid spread of COVID-19, the first approximately two weeks of lectures will be conducted synchronously online through Zoom. The current plan is for lectures to return to in-person lectures after January 24. Laboratory/design work will be conducted in person as scheduled above.<br><br>This course is occurring during a time of transition in which we are moving back to in-person learning at the university after a long absence. The past 18-24 months have been extremely difficult, with trauma and loss experienced by many in our university community and beyond. Transitioning out of this pandemic period will involve significant changes, which will likely be challenging for many of us. All participants in this course should keep this in mind and interact with empathy and care for one another throughout the term. The following information is included to help guide everyone through the term safely.<br><br>During this transition term it is important that we undertake in-person elements of this class safely. In order to do this the university has developed a set of expectations and safety protocols that all students must adhere to if they are to engage in in-person activity.<br><br>Throughout the term:<br><br>• Protect the pack: Right now, the impact of student choices and activities when not on campus cannot be separated from time spent on campus. In order to "protect the pack", the university is asking all students who are doing in-person work to be mindful and do whatever possible to lower the risk that you will contract COVID-19 and bring it onto campus.<br><br>• Know what is required and expected of you: One of the critical lessons learned in dealing with COVID-19 is knowing that situations can change and we must be flexible and ready to adjust our safety protocols. Instead of listing all of the relevant information in your course outline, the university has created a webpage where all up-to-date information around returning to campus is listed. You are responsible for regularly checking the health and safety guidelines and knowing what is expected of you throughout the fall term.<br>https://covid19.usask.ca/about/safety.php#Expectations<br><br>• Follow all guidance: Students are expected to follow all guidance provided by the University's Pandemic Recovery/Response Team (PRT), College/Department, professors, lab instructors, TAs, and any other staff member involved in the in-person academic program activities (e.g., Protective Services, Safety Resources).<br><br>• Key channels of communication: If there is a need for the class to pause meeting |

in-person for a period of time you will be notified. If this occurs, you will be provided with detailed information on what you will need to do in place of the in-person class sessions (e.g., read content posted in Canvas, etc.).

**Assessment:**

Context:

EE465 is not a regular engineering science type of course. EE465 is perhaps best described as a project-based design course where the instruction could be described as guidance on the block-by-block design of a complicated system. For this reason the grading schemes used in conventional engineering science courses do not fit.

There are four components to the class: Lectures, assignments, building circuits in the lab, and presentations.

1. The lectures will usually have a lecture component and a question-and-answer component. The lectures introduce a limited amount of new theory and engineering science. The majority of the lecture component will review relevant material from other DSP classes and explore the proper use of equipment and software tools.
2. The students will design, analyze and model (in Matlab) the circuits and system in the assignment portion.
3. The students will build, debug and test the system first in Modelsim and then in an FPGA-based hardware platform in the laboratories.
4. The students will communicate what they have learned, the depth of their understanding and the strengths and weaknesses of their designs in the presentation exam.

The class has six milestones, each having predefined deliverables in the form of a working circuit. The students will have to demonstrate that the circuit associated with each milestone works properly and achieves the design goals.

The planned methods of assessment and their respective weightings are given below:

| | |
|---|---|
| Kickstart Lab Exam: | 5% |
| Deliverable 1 Lab Exam: | 10% |
| Deliverable 2 Lab Exam: | 10% |
| Deliverable 3 Lab Exam: | 10% |
| Deliverable 4 Lab Exam: | 10% |
| Deliverable 5 Lab Exam: | 10% |
| Participation: | 10% |
| Final Presentation: | 30% |
| Peer Design Assessment: | 5% |

**Participation:**

As this class focuses on applying concepts learned in prior courses rather than teaching new theory, a significant portion of the learning comes from discussing ideas with the instructor and the student peers.

Due to the "discussion-based" nature of the class periods, it is important that students consistently attend the sessions and participate in the discussions by

asking and answering questions. This will be monitored by the instructor and a participation grade will be assigned at the end of the term.

**Expected Workload:**

From an engineering project point of view, the objective is to design, build and test a 16-QAM modulator and 16-QAM demodulator for a CATV system in piece-by-piece fashion over 12 weeks.

The course has a 3L-3P classification, which has the following student workload implications:

1. 3L classes have 3 hours of lectures per week and students are expected to attend all lectures
2. 3L classes have assignments that are expected to consume 3 hours per week of student effort.
3. Normally classes with a 3P designation have a 3 hour per week practicum component that involves students making measurements in the labs for 3 hours per week and writing the report outside the lab, which is expected to take another 1.5 hours per week.
4. Therefore, the student workload for a normal 3L-3P class consists of 3 hrs lectures/week, 3 hrs assignments/week, 3 hrs labs/week and 1.5 hrs report writing/week. The total workload is 3 hrs lectures/week plus 7.5 hrs/week outside the lectures.

EE465 is not a regular 3L-3P class so does not have the standard 4 components, but the 3L-3P designation still carries the implication of 7.5 hours/week of work outside of the lectures. Over a 12-week period this amounts to 90 hours of work outside the lectures.

This class, being a guided design, does not fit the standard class template where typically 12 assignments and 12 labs are issued at weekly intervals. Furthermore, the assignments and labs are combined with the outcome being a few large and well-specified deliverables. The students are expected to spend 7.5 hours per week designing, building and testing circuits. The proportion of that time spent in the lab to time spent outside the lab will vary from week to week.

**Final Grades:**

The final grades will be consistent with the "literal descriptors" specified in the university's grading system
(at the link below, click on "for undergraduate students").

https://students.usask.ca/academics/grading/grading-system.php

For information regarding appeals of final grades or other academic matters, please visit the Student Conduct and Appeals section of the University Secretary's website:

http://www.usask.ca/secretariat/student-conduct-appeals/

**Academic Courses Policy:**

More information on the Academic Courses Policy on course delivery, examinations and assessment of student learning can be found at:

http://policies.usask.ca/policies/academic-affairs/academic-courses.php

**Learning Charter:** The University of Saskatchewan Learning Charter is intended to define aspirations about the learning experience that the University aims to provide, and the roles to be played in realizing these aspirations by students, instructors and the institution. A copy of the Learning Charter can be found at: https://teaching.usask.ca/about/policies/learning-charter.php

**Examinations:**

**Lab Exams:**

Lab exams will be conducted in a show-and-tell fashion, in which the student will configure the relevant hardware and demonstrate to the instructor that the designed circuits achieve the design goals. The instructor will ask questions to assess the student's knowledge regarding the design and the testing process, and may request to see certain measurements made in real time.

**Presentation Exam:**

Near the end of the term, each student will be asked to give a presentation to a small group (3-5) of peers summarizing the key design decisions, debugging techniques, challenges faced, and lessons learned throughout the project. There will be an opportunity after the presentation for the both the student peers and the course instructor to ask questions in order to help assess the speaker's overall depth of understanding of the course material.

**Important Dates: (tentative)**

| | |
|---|---|
| Mon, Jan. 10 | First day of classes |
| Tues, Jan. 11 | 3 hour "kickstart lecture" during lab timeslot |
| Tues, Jan. 18 | Kickstart lab exam during lab timeslot (tentative) |
| Tues, Feb. 1 | Deliverable 1 lab exam during lab timeslot (tentative) |
| Tues, Feb. 15 | Deliverable 2 lab exam during lab timeslot (tentative) |
| Feb. 21 – 25 | Winter Break |
| Tues, Mar. 8 | Deliverable 3 lab exam during lab timeslot (tentative) |
| Week of Apr. 4 – 8 | Deliverables 4+5 lab exam and Presentation exam (tentative) |
| Fri, Apr. 8 | Last day of classes. |

Note that the deliverables build upon each other such that they must be completed in a sequential fashion. Earlier deliverables must be completed before later ones can be attempted. If students fall behind on their deliverables, they may demonstrate earlier deliverables at later lab exams in order to "catch up". However, any deliverables that are demonstrated after the initial due date (the corresponding lab exam listed above) will be marked out of 75% instead of 100%.

**Policies on Academic Dishonesty, Academic Appeals and Course Delivery:**

Students are expected to undertake all aspects of their academic work in an ethical manner. Students are expected to submit their own individual work for academic credit, properly cite the work of others, and to follow all rules for examinations. Academic misconduct, plagiarism, and cheating will not be tolerated. Students are responsible for understanding the university's policies on academic integrity and academic misconduct. If you ever have questions about what may or may not be permitted, ask your instructor. If any form of academic misconduct is discovered, appropriate disciplinary action will be taken.

***In previous offerings of EE 465, academic misconduct in the form of copying of assignment solutions through Verilog and/or Matlab code has been a problem. To discourage such violations, students will be required to submit their code for all deliverables. Plagiarism detection software may be used to analyze the submitted code for evidence of code sharing. Any students caught cheating will be given a mark of 0 for the deliverables in question.***

For more information on what constitutes academic misconduct, please consult the University Council *Regulations on Student Academic Misconduct* (https://secretariat.usask.ca/student-conduct-appeals/academic-misconduct.php) as well as the Standard of Student Conduct in Non-Academic Matters and Procedures for Resolution of Complaints & Appeals (https://secretariat.usask.ca/student-conduct-appeals/non-academic-misconduct.php).

For information regarding appeals of a final grade or other academic matters, please consult the University Council document on *Student Appeals of Evaluation, Grading and Academic Standing* (http://policies.usask.ca/policies/student-affairs-and-activities/student-appeals.php).

Additional policies and procedures related to student conduct and appeals are provided on the University Secretariat website (www.usask.ca/secretariat/student-conduct-appeals) and on the University website http://www.usask.ca/integrity/.

A summary of University of Saskatchewan polices relating to academic courses is provided in the document: *Academic Courses Policy on Class Delivery, Examinations, and Assessment of Student Learning* (http://policies.usask.ca/policies/academic-affairs/academic-courses.php).

**Safety:**

Safety is of paramount importance in the College of Engineering. Students are expected to work in a safe and responsible manner, to follow all safety instructions, and use any specified personal protective equipment. Students failing to behave in a safe manner will be asked to leave.

**Recording Lectures:**

Recording of live in-person lectures is prohibited unless explicit permission is granted by the instructor. In the event the course returns to online learning, the instructor may post recorded video lectures. Please remember that any such course recordings belong to your instructor, the University, and/or others (like a guest lecturer) depending on the circumstance of each session, and are protected by copyright. Do not download, copy, or share recordings without the explicit permission of the instructor.

For questions about recording and use of sessions in which you have participated, including any concerns related to your privacy, please contact your instructor. More information on class recordings can be found in the Academic Courses Policy.
https://policies.usask.ca/policies/academic-affairs/academic-courses.php#5ClassRecordings

**Copyright:**

Course materials are provided to students based on their registration in a class. Any materials created by course instructors is the intellectual property of the instructors. This includes exams, tests, PowerPoint/PDF slides and other course notes. Additionally, other copyright-protected materials created by textbook publishers and authors may be provided to students based on license terms and educational exceptions in the Canadian Copyright Act (see http://laws-lois.justice.gc.ca/eng/acts/C-42/index.html).

Before copying or distributing others' copyright-protected materials, students need to ensure that their use of materials is covered under the University's Fair Dealing Copyright Guidelines available at http://www.usask.ca/copyright/basics/copyright-policy/fair-dealing-guidelines/index.php. For example, posting others' copyright-protected materials on the internet is not covered under the University's Fair Dealing Copyright Guidelines; doing so requires permission from the copyright holder. For more information about copyright, please visit http://www.usask.ca/copyright/students/rights/index.php or contact the University's Copyright Coordinator at copyright.coordinator@usask.ca.

Students should be aware that a violation of the university's copyright policies could be an instance of non-academic misconduct. For example, the practice of uploading or posting copyright-protected materials to course-sharing websites, depositories, or "drop boxes", without the permission of the copyright holder, could result in a charge of non-academic misconduct under the university's "Standard of Student Conduct in Non-Academic Matters", found at the following location: https://secretariat.usask.ca/student-conduct-appeals/non-academic-misconduct.php.

**Student Conduct:**
Ethical behaviour is an important part of engineering practice. Each professional engineering association has a Code of Ethics, which its members are expected to follow. Since students are in the process of becoming Professional Engineers, it is expected that students will conduct themselves in an ethical manner.

The APEGS (Association of Professional Engineers and Geoscientists of Saskatchewan) Code of Ethics states that engineers shall "conduct themselves with fairness, courtesy and good faith towards clients, colleagues, employees and others; give credit where it is due and accept, as well as give, honest and fair professional criticism" (Section 20(e), The Engineering and Geoscience Professions Regulatory Bylaws, 1997).

The first part of this statement discusses an engineer's relationships with his or her colleagues. One of the ways in which engineering students can demonstrate courtesy to their colleagues is by helping to maintain an atmosphere that is conducive to learning, and minimizing disruptions in class. This includes arriving on time for meetings and turning cell phones and other electronic devices off during meetings. In an online learning environment, this also includes engaging in respectful communication with your peers and instructors via email and message boards. A guide on netiquette, principles to guide respectful online learning interactions https://teaching.usask.ca/remote-teaching/netiquette.php

**Access and Equity Services (AES) for Students**
Students who have disabilities (learning, medical, physical, or mental health) are strongly encouraged to register with Access and Equity Services (AES) if they have not already done so. Students who suspect they may have disabilities should contact AES for advice and referrals at any time. Those students who are registered with AES with mental health disabilities and who anticipate that they may have responses to certain course materials or topics, should discuss course content with their instructors prior to course add / drop dates. In order to access AES programs and supports, students must follow AES policy and procedures. For more information or advice, visit https://students.usask.ca/health/centres/access-equity-services.php, or contact AES at 306-966-7273 or aes@usask.ca.

Students registered with AES may request alternative arrangements for mid-term and final examinations or module tests. Students must arrange such accommodations through AES by the stated deadlines. Instructors shall provide the examinations for students who are being accommodated by the deadlines established by AES.

**Support Services for Engineering Students:**

- Engineering Student Centre (Rm. 2A05 Engineering Building)
    - Email: esc@usask.ca; Phone: 306-966-5274; https://engineering.usask.ca/contact_info/esc-office.php

**Student Learning Services**

Student Learning Services (SLS) offers assistance to U of S undergrad and graduate students. For information on specific services, please see the SLS web site: https://library.usask.ca/studentlearning/.
Remote learning support information: https://students.usask.ca/remote-learning/index.php
Class and study tips: https://students.usask.ca/remote-learning/class-and-study-tips.php
Remote learning tutorial: https://libguides.usask.ca/remote_learning
Study skills materials for online learning: https://libguides.usask.ca/studyskills
A guide on netiquette, principles to guide respectful online learning interactions: https://teaching.usask.ca/remote-teaching/netiquette.php

**Recommended Technology for Remote Learning**

Students are reminded of the importance of having the appropriate technology for remote learning. The university-specified list of recommendations can be found at https://students.usask.ca/remote-learning/tech-requirements.php.

**Teaching, Learning and Student Experience**

The Teaching, Learning and Student Experience Unit (TLSE) focuses on providing developmental and support services and programs to students and the university community. For more information, see https://students.usask.ca/. Specific resources include:

- Student Wellness Centre (3rd & 4th Floors, Place Riel): https://students.usask.ca/health/
- Financial Services: https://students.usask.ca/money/

**Learning Outcomes:** By the end of this course, students will be able to:

1. Design (i.e., synthesize and analyze), build and test each of the circuits (i.e., the blocks in a block diagram) into a reasonably large, but well-defined, system, where the function and performance goals of each circuit are well defined.
2. Analyze the system, integrate the circuits (i.e., the blocks) into a system and measure the performance. They must also debug and test the system and redesign/refine blocks as necessary for the system to meet specification.
3. Evaluate the quality (strengths and weaknesses) of circuits designed by other students.
4. Contribute to discussions where ideas are translated to concepts and then shaped into circuits or systems (perhaps this could be likened to brain-storming sessions).
5. Communicate the operation of circuits and systems that they have designed, build and tested to a group of their peers.
6. Implement DSP systems in FPGAs.
7. Use software tools and measurement equipment that are commonly used in the design, implementation, and testing of digital signal processing systems.

**Attribute Mapping:**

*Instructional Level*‡

| Learning Outcome | Attribute† | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **A1** | **A2** | **A3** | **A4** | **A5** | **A6** | **A7** | **A8** | **A9** | **A10** | **A11** | **A12** |
| **1** | A | A | | A | A | | | | | | | |
| **2** | | A | | A | A | | | | | | | |
| **3** | | A | | A | | | A | | | | | |
| **4** | | | | | | | A | | | | | |
| **5** | | | | | | | A | | | | | |
| **6** | A | | | | A | | | | | | | |
| **7** | | | | | A | | | | | | | |

†Attributes:

**A1** A knowledge base for engineering
**A2** Problem analysis
**A3** Investigation
**A4** Design
**A5** Use of engineering tools
**A6** Individual and team work
**A7** Communication skills
**A8** Professionalism
**A9** Impact of engineering on society and the environment
**A10** Ethics and equity
**A11** Economics and project management
**A12** Life-long learning

‡Instructional Level:

**Introduced (I)** – Students learn the working vocabulary of the area of content, along with some of the major underlying concepts.

**Developed (D)** – Students use their working vocabulary and major fundamental concepts to probe more deeply, to read the literature, and to deepen their exploration of the concepts. They may begin to practice, extend, or refine knowledge in familiar contexts.

**Applied (A)** – Students approach mastery in the area of content. They explore deeply into the discipline and experience the controversies, debate, and uncertainties that characterize the leading edges of any field. They practice, extend, or refine knowledge in unfamiliar contexts.

**Accreditation Unit (AU) Mapping**: (% of total class AU)

| Math | Natural Science | Complementary Studies | Engineering Science | Engineering Design |
|---|---|---|---|---|
| 0% | 0% | 0% | 0% | 100% |

**Accreditation Data Collection and Privacy:**

Undergraduate programs in the College of Engineering are accredited by the Canadian Engineering Accreditation Board. Student performance data may be collected in this course to support accreditation and continuous program improvement processes. Anonymous samples of student work may also be collected for accreditation purposes. All data provided to the accreditation body or external entities is anonymized and reported in aggregate form to protect your information and identity. If you have any concerns about how your personal information is used or maintained, please contact the Associate Dean Academic, College of Engineering.