

**Course Outline (F2021)**

**ELE734: Low Power Digital Integrated Circuits**

<b>Instructor(s)</b>	Dr. Andy Ye [Coordinator] Office: ENG319 Phone: (416) 979-5000 x 554901 Email: agye@ryerson.ca Office Hours: TBA
<b>Calendar Description</b>	This course deals with the design of Digital CMOS integrated circuits. The course consists of three essential components: Theory, Laboratory, and project. Variety of design techniques, such as Static CMOS, Dynamic CMOS, and Transmission Gate are discussed in theory. These designs are studied on basic logic gates as well as combinational and sequential circuits. The lessons learned are applied to arithmetic building blocks such as adders and decoders. A MOS transistor is studied using I-V equations, and the different areas of operations are modeled. The static (DC) are dynamic (transient) behaviors for an important building block, a CMOS inverter, are studied in depth.
<b>Prerequisites</b>	ELE 504
<b>Antirequisites</b>	None
<b>Corerequisites</b>	None
<b>Compulsory Text(s):</b>	<ol style="list-style-type: none"> <li>1. CMOS VLSI Design: A Circuit and Systems Perspective, Neil H. E. Weste and David Harris, 4<sup>th</sup> edition, Addison Wesley, 2010.</li> <li>2. ELE734 Low Power Digital Integrated Circuits Laboratory Manual, by Adnan Kabbani and Tarek Khan</li> </ol>
<b>Reference Text(s):</b>	
<b>Learning Objectives (Indicators)</b>	<p>At the end of this course, the successful student will be able to:</p> <ol style="list-style-type: none"> <li>1. Develop good understanding of the appropriate level of modeling used in VLSI design for area, performance and power optimization. <b>(1c)</b></li> <li>2. Use technical knowledge including CMOS layout, delay, and power estimation techniques to design reliable, high performance, and low power CMOS digital circuits and systems. <b>(4a)</b></li> <li>3. Apply the CMOS digital circuit design principles to define an accurate CMOS design problem statement. Recognize that good problem definition assists the CMOS design process. Describe differences between the various approaches that can be used to solve a CMOS digital circuit design problem. Select one specific approach to solve the problem. When the selected approach fails to solve the problem satisfactorily, analyze the cause of failure using the principles of CMOS digital circuit design. Based on the analysis, come up with new suggestions to improve the existing approach. Integrate the new suggestions into the existing design plan. Judge the completeness and quality of the generated solutions based on the principles of CMOS digital circuit design. <b>(4b)</b></li> <li>4. Use Cadence Tools to Implement CMOS digital circuit design and obtained experimental results. <b>(5a)</b></li> </ol>

**NOTE:**Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).

**Course Organization**

3.0 hours of lecture per week for 13 weeks  
2.0 hours of lab per week for 12 weeks  
0.0 hours of tutorial per week for 12 weeks

**Teaching Assistants**

Anas Razzaq, Rupinder Kaur

**Course Evaluation**

Theory	
Midterm Exam	25 %
Final Exam	40 %
Laboratory	
Lab 1	10 %
Lab 2	7 %
Lab 3	10 %
Lab 4	8 %
TOTAL:	100 %

**Note:** In order for a student to pass a course, a minimum overall course mark of 50% must be obtained. In addition, for courses that have both "**Theory and Laboratory**" components, the student must pass the Laboratory and Theory portions separately by achieving a minimum of 50% in the combined Laboratory components and 50% in the combined Theory components. Please refer to the "**Course Evaluation**" section above for details on the Theory and Laboratory components (if applicable).

**Examinations**

Midterm exam in Week 8, 1.5 hours, closed book (covers Weeks 1-6 of lecture and laboratory material).  
Final exam, during exam period, 3 hours, closed book (covers all the course material).

**Other Evaluation Information**

\* The mid-term test and final examination will be closed book.  
\* In order to achieve a passing grade in this course, the student must achieve an average of at least 50% in both theoretical and laboratory components.  
\* The written reports will be assessed not only on their technical or academic merit, but also on the communication skills of the author as exhibited through the reports.

**Other Information**

This year classes will be delivered virtually through Zoom. Please follow the following regulations with regards to the virtually delivered classes:

1. Zoom link for each class would be shared on D2L prior to the class;
2. Zoom link should not be shared with others;
3. Video accessed via Zoom should not be recorded, for voice or video; without prior permission;

Please note the following for the Midterm and the Final Exam:

1. Online exam(s) within this course may use a virtual proctoring system. Please note that your completion of the exam may be recorded via the virtual platform and subsequently reviewed by your instructor. The virtual proctoring system provides recording of flags where possible indications of suspicious behaviour are identified only. Recordings will be held for a limited period of time in order to

ensure academic integrity is maintained.

2. Access to a computer that can support remote recording is your responsibility as a student. The computer should have the latest operating system, at a minimum Windows (10, 8, 7) or Mac (OS X 10.10 or higher) and web browser Google Chrome or Mozilla Firefox. You will need to ensure that you can complete the exam using a reliable computer with a webcam and microphone available, as well as a high-speed internet connection. Please note that you will be required to show your Ryerson OneCard prior to beginning to write the exam. In cases where you do not have a Ryerson OneCard, government issued ID is permitted.

3. Information will be provided prior to the exam date by your instructor who may provide an opportunity to test your set-up or provide additional information about online proctoring. Since videos of you and your environment will be recorded while writing the exam, please consider preparing the background (room / walls) so that personal details are not visible, or move to a room that you are comfortable showing on camera.

## Course Content

Week	Hours	Chapters / Section	Topic, description
1	3	1	Chapter 1- Introduction (Sections 1.1, 1.3, 1.4, 1.5)
2-3	6	2	Chapter 2- MOS Transistor Theory (Sections 2.1, 2.2, 2.3, 2.4, 2.5)
4-5	6	4	Chapter 4- Delay (4.1, 4.2, 4.3, 4.4, 4.5)
6-7	6	5	Chapter 5- Power (5.1, 5.2, 5.3)
8	3	6	Chapter 6- Interconnect (6.1, 6.2, 6.3, 6.4)
9	3	8	Chapter 8- Circuit Simulation (8.1, 8.2, 8.3, 8.4)
10	3	9	Chapter 9- Combinational Circuit Design (9.2)
11	3	11	Chapter 11- Datapath Subsystems (11.1, 11.2))

12	3	10	Chapter 10- Sequential Circuit Design (10.1, 10.3, 10.2, 10.6)
13	3	Review	Review and Catchup

### Laboratory(L)/Tutorials(T)/Activity(A) Schedule

Week	L/T/A	Description
2-4	ENG412 (Online)	Characteristics of MOSFET Devices
5-6	ENG412 (Online)	CMOS Inverter Design
7-10	ENG412 (Online)	CMOS Logic Families
11-13	ENG412 (Online)	1-bit CMOS Full Adder

### Policies & Important Information:

Students must be reminded that they are required to adhere to all relevant university policies found in their online course shell in D2L and/or on the following URL: <http://ryerson.ca/senate/course-outline-policies>

1. Students are required to obtain and maintain a Ryerson e-mail account for timely communications between the instructor and the students;
2. Any changes in the course outline, test dates, marking or evaluation will be discussed in class prior to being implemented;
3. Assignments, projects, reports and other deadline-bound course assessment components handed in past the due date will receive a mark of ZERO, unless otherwise stated. Marking information will be made available at the time when such course assessment components are announced.
4. Ryerson senate policy 157 requires that any electronic communication by students to Ryerson faculty or staff be sent from their official Ryerson email account.
5. Familiarize yourself with the tools you will need to use for remote learning. The [Continuity of Learning Guide](#) for students includes guides to completing quizzes or exams in D2L or Respondus, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.
6. The University has issued a minimum technology requirement for remote learning. Details can be found at: <https://www.ryerson.ca/covid-19/students/minimum-technology-requirements-remote-learning>. Please ensure you meet the minimum technology requirements as specified in the above link.
7. Ryerson COVID-19 Information and Updates (available <https://www.ryerson.ca/covid-19/students>) for Students summarizes the variety of resources available to students during the pandemic.

8. Refer to our **Departmental FAQ** page for information on common questions and issues at the following link:  
<https://www.ee.ryerson.ca/guides/Student.Academic.FAQ.html>.

## Missed Classes and/or Evaluations

When possible, students are required to inform their instructors of any situation which arises during the semester which may have an adverse effect upon their academic performance, and must request any consideration and accommodation according to the relevant policies as far in advance as possible. Failure to do so may jeopardize any academic appeals.

1. **Academic Consideration Requests for missed work** (e.g. missing tests, labs, etc) - According to [Ryerson Senate Policy 134](#), sections 1.2.3, if you miss any exams, quizzes, tests, labs, and/or assignments for health or compassionate reasons you need to inform your instructor(s) (via email whenever possible) in advance when you will be missing an exam, test or assignment deadline. When circumstances do not permit this, you must inform the instructor(s) as soon as reasonably possible "*In the case of illness, a [Ryerson Student Health Certificate](#), or a letter on letterhead from an appropriate regulated health professional with the student declaration portion of the Student Health Certificate attached. For reasons other than illness, proper documentation is also required (e.g. death certificate, police report, TTC report).* **ALL supporting documentation for illness or compassionate grounds MUST be submitted within three (3) working days of the missed work.** **NOTE: You are required to submit all of your pertinent documentation through Ryerson's online Academic Consideration Request system at the following link: [prod.apps.ccs.ryerson.ca/senateapps/acadconsform](http://prod.apps.ccs.ryerson.ca/senateapps/acadconsform).**
2. **Religious, Aboriginal and Spiritual observance** - If a student needs accommodation because of religious, Aboriginal or spiritual observance, they must submit a Request for Accommodation of Student Religious, Aboriginal and Spiritual Observance AND an Academic Consideration Request form within the first 2 weeks of the class or, for a final examination, within 2 weeks of the posting of the examination schedule. If the requested absence occurs within the first 2 weeks of classes, or the dates are not known well in advance as they are linked to other conditions, these forms should be submitted with as much lead time as possible in advance of the absence. Both documents are available at [www.ryerson.ca/senate/forms/reobservforminstr.pdf](http://www.ryerson.ca/senate/forms/reobservforminstr.pdf). **If you are a full-time or part-time degree student, then you submit the forms to your own program department or school;**
3. **Academic Accommodation Support** - Before the first graded work is due, students registered with the [Academic Accommodation Support office](#) (AAS - [www.ryerson.ca/studentlearningsupport/academic-accommodation-support](http://www.ryerson.ca/studentlearningsupport/academic-accommodation-support)) should provide their instructors with an Academic Accommodation letter that describes their academic accommodation plan.

## Virtual Proctoring Information (if used in this course)

Online exam(s) within this course may use a virtual proctoring system. Please note that your completion of any such virtually proctored exam may be recorded via the virtual platform and subsequently reviewed by your instructor. The virtual proctoring system provides recording of flags where possible indications of suspicious behaviour are identified only. Recordings will be held for a limited period of time in order to ensure academic integrity is maintained and then will be deleted.

**Access to a computer that can support remote recording is your responsibility as a student.** The computer should have the latest operating system, at a minimum Windows (10, 8, 7) or Mac (OS X 10.10 or higher) and web browser Google Chrome or Mozilla Firefox. You will need to ensure that you can complete the exam using a reliable computer with a webcam and microphone available, as well as a typical high-speed internet connection. Please note that you will be required to show your Ryerson OneCard prior to beginning to write the exam. In cases where you do not have a Ryerson OneCard, government issued ID is permitted.

Information will be provided prior to the exam date by your instructor who may provide an opportunity to test your set-up or provide additional information about online proctoring. Since videos of you and your environment will be recorded while writing the exam, please consider preparing the background (room / walls) so that personal details are not visible, or move to a room that you are comfortable showing on camera.

## Turnitin (if used in this course)

Turnitin.com is a plagiarism prevention and detection service to which Ryerson subscribes. It is a tool to assist instructors in determining the similarity between students' work and the work of other students who have submitted papers to the site (at any

university), internet sources, and a wide range of books, journals and other publications. While it does not contain all possible sources, it gives instructors some assurance that students' work is their own. No decisions are made by the service; it generates an "originality report," which instructors must evaluate to judge if something is plagiarized.

Students agree by taking this course that their written work will be subject to submission for textual similarity review to Turnitin.com. Instructors can opt to have student's papers included in the Turnitin.com database or not. Use of the Turnitin.com service is subject to the terms-of-use agreement posted on the Turnitin.com website. Students who do not want their work submitted to this plagiarism detection service must, by the end of the second week of class, consult with their instructor to make alternate arrangements.

Even when an instructor has not indicated that a plagiarism detection service will be used, or when a student has opted out of the plagiarism detection service, if the instructor has reason to suspect that an individual piece of work has been plagiarized, the instructor is permitted to submit that work in a non-identifying way to any plagiarism detection service.

## Academic Integrity

Ryerson's [Policy 60 \(the Academic Integrity policy\)](#) applies to all students at the University. Forms of academic misconduct include plagiarism, cheating, supplying false information to the University, and other acts. The most common form of academic misconduct is plagiarism - a serious academic offence, with potentially severe penalties and other consequences. It is expected, therefore, that all examinations and work submitted for evaluation and course credit will be the product of each student's individual effort (or an authorized group of students). Submitting the same work for credit to more than one course, without instructor approval, can also be considered a form of plagiarism.

Suspicious of academic misconduct may be referred to the Academic Integrity Office (AIO). Students who are found to have committed academic misconduct will have a Disciplinary Notation (DN) placed on their academic record (not on their transcript) and will normally be assigned one or more of the following penalties:

1. A grade reduction for the work, ranging up to and including a zero on the work (minimum penalty for graduate work is a zero on the work);
2. A grade reduction in the course greater than a zero on the work. (Note that this penalty can only be applied to course components worth 10% or less, and any additional penalty cannot exceed 10% of the final course grade. Students must be given prior notice that such a penalty will be assigned (e.g. in the course outline or on the assignment handout);
3. An F in the course;
4. More serious penalties up to and including expulsion from the University.

The unauthorized use of intellectual property of others, including your professor, for distribution, sale, or profit is expressly prohibited, in accordance with Policy 60 (Sections 2.8 and 2.10). Intellectual property includes, but is not limited to:

1. Slides
2. Lecture notes
3. Presentation materials used in and outside of class
4. Lab manuals
5. Course packs
6. Exams

For more detailed information on these issues, please refer to the [Academic Integrity policy](#) (<https://www.ryerson.ca/senate/policies/pol60.pdf>) and to the Academic Integrity Office website (<https://www.ryerson.ca/academicintegrity/>).

## Academic Accommodation Support

Ryerson University acknowledges that students have diverse learning styles and a variety of academic needs. If you have a diagnosed disability that impacts your academic experience, connect with Academic Accommodation Support (AAS). Visit the [AAS website](#) or contact [aasadmin@ryerson.ca](mailto:aasadmin@ryerson.ca) for more information.

Note: All communication with AAS is voluntary and confidential, and will not appear on your transcript.

## Important Resources Available at Ryerson

1. The Library (<https://library.ryerson.ca/>) provides research workshops and individual assistance. If the University is open, there is a Research Help desk on the second floor of the library, or go to <https://library.ryerson.ca/workshops>
2. Student Learning Support (<https://www.ryerson.ca/student-life-and-learning/learning-support/>) offers group-based and individual help with writing, math, study skills and transition support, as well as resources and checklists to support students as online learners (<https://www.ryerson.ca/student-life-and-learning/learning-support/>).
3. You can submit an Academic Consideration Request (<https://prod.apps.ccs.ryerson.ca/senateapps/acadconform>) when an extenuating circumstance has occurred that has significantly impacted your ability to fulfill an academic requirement. You may always visit the Senate website (<https://www.ryerson.ca/senate/>) and select the blue radial button on the top right hand side entitled: Academic Consideration Request (ACR) to submit the request.

*Policy 167: Academic Consideration due to COVID-19: Students that miss an assessment due to cold or flu-like symptoms, or due to self isolation, are currently not required to provide a health certificate. Other absences must follow [Policy 167: Academic Consideration](#).*

Also NOTE: Outside of COVID-19 symptoms, the new Policy 167: Academic Consideration does allow for a once per term academic consideration request without supporting documentation if the absence is less than 3 days in duration and is not for a final exam/final assessment. In the absence is more than 3 days in duration and/or is for a final exam/final assessment, documentation is required. For more information please see Senate [Policy 167: Academic Consideration](#).

4. Ryerson COVID-19 Information and Updates for Students (<https://www.ryerson.ca/covid-19/students/>) summarizes the variety of resources available to students during the pandemic.
5. Familiarize yourself with the tools you will need to use for remote learning. The Continuity of Learning Guide (<https://www.ryerson.ca/centre-for-excellence-in-learning-and-teaching/learning-guide/>) for students includes guides to completing quizzes or exams in D2L Brightspace, with or without [Respondus LockDown Browser and Monitor](#), using [D2L Brightspace](#), joining online meetings or lectures, and collaborating with the Google Suite.
6. Information on Copyright for Faculty (<https://library.ryerson.ca/copyright/faculty/copyright-faqs/my-teaching-materials-have-been-posted-online/>) and students (<https://library.ryerson.ca/copyright/home/copyright-for-students-2/students-course-sharing-websites-and-file-sharing/>).
7. At Ryerson, we recognize that things can come up throughout the term that may interfere with a student's ability to succeed in their coursework. These circumstances are outside of one's control and can have a serious impact on physical and mental well-being. Seeking help can be a challenge, especially in those times of crisis. Below are resources we encourage all Ryerson community members to access to ensure support is reachable. <https://www.ryerson.ca/mental-health-wellbeing>.

**If support is needed immediately, you can access these outside resources at anytime:**

- **Distress Line** - 24/7 line for if you are in crisis, feeling suicidal or in need of emotional support (phone: 416-408-4357)
- **Good2Talk** - 24/7 hour line for postsecondary students (phone: 1-866-925-5454)