Carleton University Department of Electronics

Summer2026

ELEC2507: Electronic - I

Introduction

This course covers semiconductor-based devices, their operation, and their applications in simple analog electronic circuits. Chapters 1-7 of the textbook will be addressed, starting with qualitative semiconductor physics, leading to the diode equation and diode circuit analysis. Bipolar junction transistors (BJTs) and Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs) will be introduced, along with the design of biasing circuits and small-signal AC models. The course also includes the design and analysis of operational amplifier circuits, focusing on their use in simple active filters.

As an introductory course in electronics, it centers on four main topics: Operational Amplifiers (Op-Amps), Diodes, BJTs, and MOSFETs. The Op-Amp unit covers inverting/non-inverting amplification, mathematical operations (addition/subtraction), integration and differentiation, and frequency response. Semiconductor components are studied for their foundational role in understanding electronic behaviour, emphasizing their required physical characteristics in Elec2507. This includes the diode equations, circuit analysis, and practical applications. Additionally, the course introduces DC analysis of BJT and MOSFET circuits, and explores smallsignal analysis of diodes and transistors, leading to amplifier gain equations.

Course Description and Requirements

Course Description: The operational amplifier (op-amp) is an integrated circuit (IC) composed of dozens of transistors, crucial for its versatile applications in electronics. Due to its significance, op-amps are extensively covered in separate units within electronics courses. The foundation of semiconductor (SC) physics underpins essential electronic components like diodes, Bipolar Junction Transistors (BJTs), and Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs). Throughout this course, students acquire fundamental skills and knowledge necessary for analyzing and designing electronic circuits.

Includes: Experiential learning activity.

Laboratory and problem analysis: Will be posted on the course website, weekly.

Instructor

Professor: Dr. Mohamed Abouseif
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Course Webpage: https://brightspace.carleton.ca/d2l/home

Course Materials and Textbook:

1. Microelectronics Circuits, 7th Edition, A. Sedra and K. Smith, Oxford University Press (2015).
2. Microelectronics Circuits, 8th Edition, A. Sedra and K. Smith, Oxford University Press (2020).
3. Lectures' notes and handouts

Lecture Outline

Lecture Outlines and Schedule: The following is the broad outline for the course and the intended schedule for this term. Minor variations in it may be made by the instructor at the time of teaching and depending on the circumstances and class schedules.

Lecture (Week wise)	Section(s) in Textbook	Content
Week – 1	1.3, 2.1	Introduction to Analog Electronics: Devices, Circuits, Applications, Digital v/s Analog. Op-Amp Basics
	2.1, 2.2, 2.3	Op-Amps: Basics, Inverting, Non-inverting Configurations, Buffer Circuit, Summing Circuit
	2.4 , 2.5	Amplifier Basics, Gain, Input/output Impedances, Buffer Circuits
		Difference Amplifier, Op-Amp Examples
		Integrator and Differentiator Circuits, Frequency Responses
Week – 2 (Lab1 – Basic circuit theorems)	3.1 3.2, 3.3 3.4	Semiconductors – Intrinsic/Extrinsic Silicon Doping – p, n, Diffusion/Drift Currents Diodes – Concepts of Physical Operation: p-n Junction Formulation
	3.4-3.6	Barrier Potential, Forward Bias, Diode Current Equation, Reverse Bias, Examples
	4.1 4.2	Ideal Diode: Application in Logic Gates, Examples Characteristic Curves
	4.4	Modelling: Exponential Model, Graphical Analysis, Concepts of Load Line, Diode Simplified Models: Battery + Resistance Model, Constant Voltage Drop Model, Diode Small Signal Model, Examples
Week – 3 (Lab2: Op-Amps)	4.3, 4.5	Breakdown Characteristics – Zener Diode, Voltage Regulators

	4.6	Rectify circuits – HWR, FWR Analysis *Reading Assignment – Bridge Rectifier* Signal Processing Applications: Filter Circuits, Clippers and Clampers *Reading Assignment –- Special Types of Diodes: Varactor, LEDs*
	6.1, 6.2	Bipolar Junction Transistors – Basics, Symbols and Conventions, Modes of Operation, NPN - Active Mode, Current Relations, Examples, BJT Characteristics, Early Effect *Reading Assignment – PNP transistor*
		D. C. Circuit Analysis, Fixed Bias, Voltage Divider Bias, Collector Feedback Bias, Examples
Week – 4 (Lab3 – Diodes)	7.1	BJT as an Amplifier, Graphical Analysis, Transistor as an Amplifier, Examples *Reading Assignment – BJT as a switch*
	7.2	BJT Small-Signal Models, Examples
	7.3	Single Stage BJT Amplifiers, Common Emitter Amplifier, Examples, BJT-CB, CC Amplifier Analysis
Week 5 (Lab4 – BJT's)	5.1	FET - Basics, Comparison: BJT v/s FET, Types, n/p Channel, Construction, *Reading Assignment – P-MOS, CMOS*
	5.2	n-channel MOSFET – Operation as V_{DS} increased, Characteristics, MOSFET Regions of Operation, Current-Voltage Relationships, Early Effect,
Week 6 & 7 **(Lab. 5 – MOSFETs)**	5.3	FET: D. C. Analysis; Examples,
	7.1	MOSFET as an Amplifier, Transfer Characteristics, Examples *Reading Assignment – MOSFET as a Switch*
	7.2, 7.3	FET – Small-Signal Operation, MOSFET Amplifier Configurations: CS, CG, CD
	7.4	FET – Current Source Biasing
	7.5	FET – CS Amplifier Analysis
	5.4	FET – Body Effect, CG, CD Amplifier Analysis
	Review	Op-Amps, Diodes, BJT, MOSFET

Laboratory and Problem Analysis Sessions

Upon successful completion of this course, students will have reliably demonstrated the ability to:

- Understand semiconductor physics, including the differences between p-type and n-type materials, p-n junctions, biasing techniques, and related modelling.
- Comprehend the operation of fundamental electronic devices: diodes, BJTs, MOSFETs, and operational amplifiers (op-amps).
- Understand the functioning and design principles of key electronic modules: rectifier circuits, op-amp-based filter circuits, and amplifier circuits.

- Model the behaviour of fundamental electronic devices (diodes, BJTs, MOSFETs) under both DC and AC signals.
- Analyze circuits incorporating diodes, BJTs, and MOSFETs under both DC and AC conditions.
- Design rectifier circuits, op-amp-based filter circuits, and BJT/MOSFET-based amplifier circuits.
- Differentiate and select between various amplifier configurations (CE/FCC/CB, CS/CD/CG).
- Differentiate and choose between different filter configurations (low-pass, high-pass, band-pass, bandstop).
- Construct, experimentally measure, and verify the characteristics of diodes, BJTs, MOSFETs, rectifier circuits, filter circuits, and amplifier circuits.
- Prepare detailed laboratory reports on related experiments, documenting findings and analysis.

These outcomes ensure that students are well-prepared to apply their knowledge in practical electronics applications and to pursue further advanced studies in the field.

Laboratory and Problem Analysis Sessions

3 hours weekly labs and PA sessions as per the schedule and location posted on Brightspace.

Notes for Labs

There are 5 labs as follows:

Lab #	Topic	Due date	grade
Lab1	linear systems	7 July - 9 July	4 %
Lab2	OP Amp-based Circuitry	14 July - 16 July	4 %
Lab3	Rectifier design	21 July - 23 July	4 %
Lab4	BJT amplifier	28 July - 30 July	4 %
Lab5	MOSFET Amplifier	4 Aug. - 6 Aug.	4 %

Lab due dates and grades

Labs are 3 hours in duration and will be held in Room ME4315. You must attend your lab during the session you are registered for. Changing sessions is not allowed without the instructor's permission. A TA will take attendance at each lab session. If, for some reason, a Lab needs to be rescheduled OR a Lab falls on a University holiday, students in those sections must try to rearrange their schedule to make up the lab in another regularly scheduled lab session, as arranged by the instructor. Attend each lab punctually. Be prepared for the lab experiment by reading the lab instruction sheets before entering the lab. Some labs have a pre-lab exercise that must be completed before the start of your lab period. You are not permitted to do the lab unless the prelab is completed. The TA will check that the pre-lab has been completed. A lab report will be submitted online for each lab and by each student. Lab reports are due by 9 PM one week after the day of the lab. Late lab reports must still be submitted. One day late, it will only be worth 50%. Two days late, it is worth 0.

Students will do the labs individually. All data, calculations, graphs, etc., must be recorded in the notebook, and conclusions and discussions must be added at the end of each significant part of the experiments.

1. Lab attendance is mandatory; however, students can complete their work outside the lab timeframe. Being up to 30 minutes late to join the lab session is acceptable. After 30 minutes without an acceptable excuse, the TA has the right to deduct up to 25% of the lab grade (i.e., 1% of the total course grade).
2. LAB Exemptions: No longer accommodated.
3. Lab reports are due before the subsequent lab (see the table below for lab due dates). Late submissions are not accepted, as the lab submission link will not accept them. Make sure to submit your lab reports on time.

Notes for PA Sessions

Several problems will be assigned each week as homework to help understand the lecture material, prepare for the midterm exams and final exam. To learn the course material, it is essential that you attempt solutions for these problems before the PA SESSION. Solutions to these problems will be reviewed in the PA sessions.

Missed PA/Test: If you missed a PA/test, please contact the TA/PA ASAP, along with a filled self-medical form or document-based excuse for making possible alternative arrangements.

Self-Declaration form and Deferred Term work

Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for submitting a self-declaration form no later than three (3) days after the date/deadline of term work including test/midterm, labs, assignments. Any alternate arrangements made with the instructor for submission of term work should be made as soon as possible but within 3 days of the missed due date. If this is not possible after discussion with the instructor, alternate arrangements must be made before the last day of classes in the term as published in the academic schedule.

Instructors can require (or not) the student to submit the self-declaration form. Include the following statement if you require the student to submit a completed self-declaration form:

> **Consult with the instructor no later then 3 days after any missed course work or midterm examination.**
>
> or
>
> **Contact the instructor with the completed self-declaration form no later than 3 days after the date/deadline of term work including test/midterm, labs, assignments.**

Evaluation and Grading Scheme

The cumulative course grade will be determined as follows:

Labs (5)	20% equally distributed.
Tests/Quizzes (4)	20%
Course activities	10% (PA Session and class performance, term paper, Or Project (TBD))
Final Exam	50%

To pass the course, you need: 50% overall, 45% in the final, and complete 3 out of 4 labs

Course Outcomes:

Upon successful completion of this course, students will have reliably demonstrated the ability to:

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- Prepare detailed laboratory reports on related experiments, documenting findings and analysis.

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Tests schedule:

The last 30 to 60 minutes of the lecture are usually reserved for conducting a unit test. However, depending on the circumstances, tests may occasionally be held during the PA. Tests will be graded and returned during the next PA session (within one week). Attendance will be taken at the beginning of each lecture session, and a sign-up sheet will be circulated to record unit test attendance.

Unit Test	Period	Date	Topics included	grade
Test 1	30-60 minutes	14 July - 16 July	Op-Amp	5 %
Test 2	30-60 minutes	21 July - 23 July	SC, Diode, and Zener	5 %
Test 3	30-60 minutes	28 July - 30 July	BJT & FET	5 %
Test 4	30-60 minutes	4 Aug. - 6 Aug.	MOSFET & FET analysis	5 %

Tests information

Graduate Attributes

The Canadian Engineering Accreditation Board requires graduates of undergraduate engineering programs to possess 12 attributes: Graduate-Attributes.pdf (engineerscanada.ca) or GA's. Courses in all four years of our programs evaluate students' progress towards acquiring these attributes. Aggregate data (typically, the data collected in all sections of a course during an academic year) is used for accreditation purposes and to guide improvements to programs. Some of the assessments used to measure GAs may also contribute to final grades; however, the GA measurements for individual students are not used to determine the student's yearto-year progression through the program or eligibility to graduate. Accreditation metrics are based on courses common to all students in a program.

This following list provides the GAs that will be measured in this course, along with the indicators that are intended to develop and assess these attributes.

Graduate Attribute and Level	Indicators or Area for Specialization	Methods used for Evaluation
GA 3.1.1 A knowledge base for engineering	engineering fundamentals, and specialized engineering knowledge	Dedicated Exam Question
GA 3.1.2 Problem analysis	identify, formulate, analyze, and solve complex engineering problems	Dedicated Exam Question
GA 3.1.3 Investigation	appropriate experiments, analysis and interpretation of data, and synthesis	Dedicated Exam Question
GA 3.1.4 Design	design solutions for complex, openended engineering problems	Lab report and Dedicated Exam Question

Academic Integrity and Plagiarism

a) Please consult the Faculty of Engineering and Design information page about the Academic Integrity policy and our procedures: https://carleton.ca/engineering-design/current-students/fed-academic-integrity. Violations of the Academic Integrity Policy will result in the assignment of a penalty such as reduced grades, the assignment of an F in a course, a suspension or, expulsion.

b) One of the main objectives of the Academic Integrity Policy is to ensure that the work you submit is your own. As a result, it is important to write your own solutions when studying and preparing with other students and to avoid plagiarism in your submissions. The University Academic Integrity Policy defines plagiarism as "presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one's own." This includes reproducing or paraphrasing portions of someone else's published or unpublished material, regardless of the source, and presenting these as one's own without proper citation or reference to the original source.

Examples of violations of the policy include, but are not limited to:

- Any submission prepared in whole or in part, by someone else;
- Using another's data or research findings without appropriate acknowledgment;
- Submitting a computer program developed in whole or in part by someone else, with or without modifications, as one's own;
- Failing to acknowledge sources of information through the use of proper citations when using another's work and/or failing to use quotations marks; and
- Unless explicitly permitted by the instructor in a specific course, the use of generative AI and similar tools to produce assessed content (such as text, code, equations, images, summaries, videos, etc.).

Academic Accommodations

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

Pregnancy obligation: Contact us with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For accommodation regarding a formally-scheduled final exam, you must complete the Pregnancy Accommodation Form (click here).

Religious obligation: Contact us with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details click here.

Academic Accommodations for Students with Disabilities: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send us your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, contact us, if needed, to ensure that accommodation arrangements are made.

You should request your academic accommodations in the Ventus Student Portal, for each course at the beginning of every term. For in-term tests or midterms, please request accommodations at least two (2) weeks before the first test or midterm.

Please consult the PMC website for the deadline to request accommodations for formally-scheduled exams (if applicable).

Survivors of Sexual Violence: As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: https://carleton.ca/equity/sexual-assault-support-services

Accommodation for Student Activities: Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation will be provided to students who compete or perform at the national or international level. Contact us with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist: https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf