

## Course Outline (F2024)

### ELE861: Microwave Engineering

<b>Instructor(s)</b>	Dr. Marco Antoniades [Coordinator] Office: ENG 453 Phone: (416) 979-5000 x 556097 Email: mantoniades@torontomu.ca Office Hours: Tuesdays 1:00 - 2:00 pm by email
<b>Calendar Description</b>	Introduction to microwave technology, transmission line theory and applications, standing waves and voltage standing wave ratio (VSWR), examples of practical transmission lines, the Smith chart, power flow, transmission-line impedance matching networks, L-section lumped-element matching networks, Z, Y, S and ABCD parameters, passive microwave devices: power dividers and directional couplers, introduction to Computer Aided Design (CAD) techniques, theory and design of microwave amplifiers: FETs, BJTs, 2-port power gains, amplifier stability, design for maximum gain, specified gain, and minimum noise figure.
<b>Prerequisites</b>	ELE 531
<b>Antirequisites</b>	None
<b>Corerequisites</b>	None
<b>Compulsory Text(s):</b>	1. David M. Pozar, Microwave Engineering, 4th edition, John Wiley & Sons, 2012.
<b>Reference Text(s):</b>	1. Guillermo Gonzalez, Microwave Transistor Amplifiers: Analysis and Design, 2nd edition, Prentice Hall, 1997. 2. Thomas H. Lee, Planar Microwave Engineering: A Practical Guide to Theory, Measurement, and Circuits, Cambridge University Press, 2004.
<b>Learning Objectives (Indicators)</b>	At the end of this course, the successful student will be able to: <ol style="list-style-type: none"> <li>1. Use microwave network analysis parameters to evaluate the performance of passive and active microwave circuits and devices in wireless communication systems and radar systems. <b>(1c)</b></li> <li>2. Develop, design and analyze passive and active microwave circuit designs for applications in microwave engineering. <b>(4b)</b></li> <li>3. Use analytical methods and Computer Aided Design (CAD) tools to compare the performance of passive and active microwave circuits to meet design specifications. <b>(4c)</b></li> <li>4. Demonstrate proficiency using CAD tools to interactively design and analyze passive and active microwave circuit designs. <b>(5a)</b></li> <li>5. Compare results obtained from multiple analyses of microwave circuits, both theoretical and in simulation, in order to determine the optimal solution based on the design specifications and technology constraints. Draw conclusions based on results. <b>(5b)</b></li> <li>6. Communicate an understanding of principles of operation, analysis, design and critical evaluation of microwave circuit designs through interactive demonstration of laboratory</li> </ol>

results, and written/oral laboratory report presentations evaluated on the basis of completeness, clarity, critical evaluation and presentation. (7a), (7b), (7c)

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

<b>Course Organization</b>	3.0 hours of lecture per week for 13 weeks 1.0 hours of lab per week for 12 weeks 0.0 hours of tutorial per week for 12 weeks												
<b>Teaching Assistants</b>	Nickolas Papoutsis (nickolas.papoutsis@torontomu.ca)												
<b>Course Evaluation</b>	<table border="1"> <tr> <td colspan="2"><b>Theory</b></td> </tr> <tr> <td>Mid-Term Exam</td> <td>30 %</td> </tr> <tr> <td>Final Exam</td> <td>50 %</td> </tr> <tr> <td colspan="2"><b>Laboratory</b></td> </tr> <tr> <td>CAD Simulation Labs</td> <td>20 %</td> </tr> <tr> <td>TOTAL:</td> <td>100 %</td> </tr> </table> <p><b>Note:</b> 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 "<b>Theory and Laboratory</b>" 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 "<b>Course Evaluation</b>" section above for details on the Theory and Laboratory components (if applicable).</p>	<b>Theory</b>		Mid-Term Exam	30 %	Final Exam	50 %	<b>Laboratory</b>		CAD Simulation Labs	20 %	TOTAL:	100 %
<b>Theory</b>													
Mid-Term Exam	30 %												
Final Exam	50 %												
<b>Laboratory</b>													
CAD Simulation Labs	20 %												
TOTAL:	100 %												
<b>Examinations</b>	<p>All exams will be carried out in person.</p> <p>Mid-Term Exam: Conducted in Week 7, covers the material from Weeks 1-6. One and a half (1.5) hrs duration.</p> <p>Final Exam: Conducted during the final exam period, covers all the material from Weeks 1-13. Three (3) hrs duration.</p> <p>Labs: Four (4) labs, each worth 5%, will be conducted starting in Week 6.</p>												
<b>Other Evaluation Information</b>	None												
<b>Teaching Methods</b>	<ol style="list-style-type: none"> <li>Lectures will be delivered synchronously (i.e. for all students at the same time) during the scheduled class hours in person and via Zoom.</li> <li>Notes/slides from the class lectures will be posted on D2L.</li> <li>Lecture recordings will also be posted on D2L.</li> </ol>												
<b>Other Information</b>	Problem sets with homework exercises will be given throughout the term, which will not be assessed. Some of these exercises will be given on the exams.												

## Course Content

Week	Hours	Chapters / Section	Topic, description
1	3	1.1, 2.1, 2.3	Introduction to Microwave Technology Maxwell's Equations Waves on Transmission Lines
2	3	2.4 - 2.5	The Finite Terminated Transmission Line Standing Waves and VSWR
3	1.5	3.7, 3.8, 3.11	Types of Transmission Lines and Waveguides
3-4	3	2.4	The Smith Chart
4	1.5	2.6	Power Flow on Lossless Lines
5	1.5	2.5, 5.2, 5.4	Transmission-Line Impedance Matching Networks
6	1.5	5.1	L-Section Lumped Element Impedance Matching Networks
7	3	4.2, 4.3, 4.4	Microwave Network Analysis: - Z Parameters - Y Parameters - Scattering Parameters - ABCD Parameters
8	3	7.1, 7.3, 7.5, 7.6, 7.8	Power Dividers and Couplers: - Basic Properties of Dividers and Couplers - The Wilkinson Power Divider - The Quadrature Hybrid Coupler - Coupled Line Directional Couplers - Rat Race Directional Couplers

9	3	11.2, 11.3, 11.4, 12.1, 12.2	Microwave Transistor Amplifier Design: - Bipolar Junction Transistors - Field Effect Transistors - Two-Port Power Gains - Stability
10	3	12.3 (a)	Microwave Transistor Amplifier Design: - Design for Maximum Gain
11	3	12.3 (b)	Microwave Transistor Amplifier Design: - Design for Specified Gain
12	3	12.3 (c)	Microwave Transistor Amplifier Design: - Low-Noise Amplifier Design  Advanced Microwave Measurements using Vector Network Analyzers

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

Week	L/T/A	Description
6	Lab 1	Transmission-Line Matching Networks
9	Lab 2	Couplers and Power Dividers
11	Lab 3	Amplifier Design for Maximum Gain
12	Lab 4	Amplifier Design Using the NEC NE68018 Transistor

### University Policies & Important Information

Students are reminded that they are required to adhere to all relevant university policies found in their online course shell in D2L and/or on [the Senate website](#)

Refer to the [Departmental FAQ page](#) for further information on common questions.

## Important Resources Available at Toronto Metropolitan University

- [The Library](#) 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 students can use the [Library's virtual research help service](#) to speak with a librarian.
- [Student Life and 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](#).
- You can submit an [Academic Consideration Request](#) when an extenuating circumstance has occurred that has significantly impacted your ability to fulfill an academic requirement. You may always visit the [Senate website](#) and select the blue radio button on the top right hand side entitled: **Academic Consideration Request (ACR)** to submit this request.

*For Extenuating Circumstances, Policy 167: Academic Consideration allows for a once per semester ACR request without supporting documentation if the absence is less than 3 days in duration and is not for a final exam/final assessment. Absences more than 3 days in duration and those that involve a final exam/final assessment, require documentation. Students must notify their instructor once a request for academic consideration is submitted. See Senate [Policy 167: Academic Consideration](#).*

- If taking a remote course, familiarize yourself with the tools you will need to use for remote learning. The [Remote 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.
- Information on Copyright for [Faculty](#) and [students](#).

## Accessibility

- Similar to an [accessibility statement](#), use this section to describe your commitment to making this course accessible to students with disabilities. Improving the accessibility of your course helps minimize the need for accommodation.
- Outline any technologies used in this course and any known accessibility features or barriers (if applicable).
- Describe how a student should contact you if they discover an accessibility barrier with any course materials or technologies.

## Academic Accommodation Support

Academic Accommodation Support (AAS) is the university's disability services office. AAS works directly with incoming and returning students looking for help with their academic accommodations. AAS works with any student who requires academic accommodation regardless of program or course load.

- Learn more about [Academic Accommodation Support](#).
- Learn [how to register with AAS](#).

Academic Accommodations (for students with disabilities) and Academic Consideration (for students faced with extenuating circumstances that can include short-term health issues) are governed by two different university policies. Learn more about [Academic Accommodations versus Academic Consideration and how to access each](#).

## Wellbeing Support

At Toronto Metropolitan University, 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.

If you are experiencing a mental health crisis, please call 911 and go to the nearest hospital emergency room. You can also 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)

- **Keep.meSAFE:** 24/7 access to confidential support through counsellors via [My SSP app](#) or 1-844-451-9700

If non-crisis support is needed, you can access these campus resources:

- **Centre for Student Development and Counselling:** 416-979-5195 or email [csdc@torontomu.ca](mailto:csdc@torontomu.ca)
- **Consent Comes First - Office of Sexual Violence Support and Education:** 416-919-5000 ext 3596 or email [osvse@torontomu.ca](mailto:osvse@torontomu.ca)
- **Medical Centre:** call (416) 979-5070 to book an appointment

We encourage all Toronto Metropolitan University community members to access available resources to ensure support is reachable. You can find more resources available through the [Toronto Metropolitan University Mental Health and Wellbeing](#) website.