South Dakota School of Mines & Technology
Microwave Engineering
Fall 2024
EE 481/581-M01 (3-1) 4 credits

Instructor Information

Instructor's Name- Thomas Montoya

Instructor's Contact Information- (605) 394-1219, Thomas.Montoya@sdsmt.edu, EEP 314

Office Hours- 8:30-9:15 am & 3-4 pm MWF, or when available (open door policy). No appointments.

As I do not always notice voicemails in a timely fashion, e-mails or in person are the preferred contact methods. Unless I am traveling or it arrives after 5 pm, I typically respond to e-mails the same day.

Course Information

Course Start/End Dates- 8/26/2024 to 12/18/2024

Course Meeting Times and Location- MWF from 10-10:50 am in EEP 338

Course Delivery Method- The course will be delivered in-person for lectures, quizzes, and exams. The syllabus and link to my webpage http://montoya.sdsmt.edu will be posted on D2L. This webpage will be used for posting assignments, examples, solutions, etcetera. E-mail will be used to notify students of course-related information/events (**check daily**) using your first.last@Mines.sdsmt.edu address.

Course Description

Presentation of basic principles, characteristics, and applications of microwave devices and systems. Development of techniques for analysis and design of microwave circuits.

Course Prerequisites- EE 382.

Course Corequisites- EE 481L or EE 581L.

Student Learning Outcomes

Student Outcomes (SOs)

Student Outcomes are defined in ABET's accreditation standards for engineering programs:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Course Learning Outcomes (CLOs)

Upon completion of this course, students should demonstrate the ability to:

A. Analyze basic transmission line circuits, e.g., compute quantities as reflection coefficients, standing wave ratio, impedance, power, etcetera (SO 1)

B. Use the Smith chart for basic transmission line calculations. (SO 1)

C. Design and analyze transmission line matching devices including lumped elements, L-networks, stub tuners, and quarter-wave transformers. (SOs 1, 2)

D. Understand, analyze, and/or design simple transmission lines and rectangular waveguides. (SOs 1, 2)

E. Understand and use two-port parameter models (e.g., Z, Y, $ABCD$ and S) of simple circuit elements to analyze microwave circuits. (SO 1)

F. Use signal flow graphs to represent simple microwave circuits and solve for quantities of interest, such as reflection coefficients. (SO 1)

G. Design and analyze microwave power dividers (T-junction and Wilkinson) and hybrids (90° and 180°) constructed from printed microstrip. (SOs 1, 2)

H. Design and analyze coupled line and Lange microwave couplers constructed from printed microstrip. (SOs 1, 2)

I. Design and analyze microwave filters constructed from printed microstrip. (SOs 1, 2)

Course Goals

The objective of this course is to introduce students to the basic concepts of microwave engineering as well as some design.

Course Topics

Transmission lines, impedance matching, waveguides, microwave network analysis, power dividers, directional couplers, and microwave filters are introduced.

Course Materials

Required Textbook(s) and Materials

Microwave Engineering (Fourth Edition), Pozar, Wiley, 2012, ISBN 978-0-470-63155-3.

Technology Equipment Needed for the Course

The course requires use of a computer and a scientific calculator (capable complex number operations).

Technology Skills Needed for the Course

Ability to navigate D2L and internet, upload/download files, use MS-Office programs, communicating via email, connecting computer audio/video, and Zoom (maybe). MATLAB and/or MathCad will be useful for some assignments. Some specialized electromagnetics software may be introduced.

Course Grading

Coursework

➢ Course instruction will be delivered in lectures.

➢ Students in the graduate-level section will be given extra/different homework problems.

- ➤ Bring notes, text, and calculator to every class. Most quizzes will be unannounced and require a calculator (no smartphones/computers/tablets). Some quizzes may be open book/notes (no borrowing/sharing).
- ➤ To facilitate grading, homework shall meet the following specifications (see example on course web page):
  - (a) Use the <u>front</u> side (i.e., single-sided) of 8.5" × 11" engineering graph paper or plain white paper (NO pages torn from spiral notebooks) for assignments. Hardcopy only!
  - (b) At the top of **each** page should be the date, course number, problem number(s), your name, and the page numbering (i.e., page *x* of *y* or *x/y* formats in the right-hand corner). Ensure problems & pages are in order.
  - (c) All work exceeding one page should be stapled - no paper clips, folded corners, or folders.
  - (d) Write-out problem descriptions, copy/draw figures, and **show all** work so it can be understood without the text. No work (i.e., "magic" answer) → no credit.
  - (e) Reference equations derived in the text (e.g., equation number and/or page number). Fundamental equations (e.g., Maxwell's equations, Ohm's Law ...) are excluded from this requirement.
  - (f) Use notation and conventional engineering units & prefixes (i.e., MKS) as given in class and text. Answers with incorrect notation and/or incorrect/missing units are incomplete/incorrect.
  - (g) Writing/figures/graphs must be legible/large enough to read → illegible = no credit.
  - (h) Answers should be boxed/<u>double underlined</u>, in **decimal format** (if numeric), and the variables, values & units (if any) included. For example, $d = 3.4896$ m and ***NOT*** $d = {}^{7\sqrt{42}}\!/_{13}$ m. Use lead zeros for fractional answers, e.g., 0.4 not ".4". Typically, 4-5 significant digits are used.
  - (i) Work problems sequentially in a **single** vertical column with subparts clearly labeled, e.g., a), b) ... Leave a space (e.g., 1/2") between consecutive parts of a problem, and <u>draw a line</u> across the page at the end of each problem if there is more than one. No 'checker boarding'.
  - (j) **No** more than **two** problems on any single page.

Attendance Policy
Attendance is required. Notify instructor in advance (when possible) if you will be absent from class.

Late/Make-up Assignment Policy
- ➤ Homework (HW) is due at the beginning of class on the specified days (up to 20% penalty for being late w/out doctor's note, etcetera). If you know that you will be missing a class, it may be turned in early. HW will **not** be accepted or graded after solutions are posted on the course web page.
- ➤ Missed quizzes will **not** be made up. If you know that you will be missing a class for a school-related activity (athletic travel, conference, etcetera), you may stop by the day before and ask to take a quiz early (if available). Make-ups for exams only allowed for school-sponsored events, documented illness, …
- ➤ If 2/3 of quizzes <u>and</u> 2/3 of HW are completed at a **passing** level, the lowest HW grade and lowest two quiz grades will be dropped (no questions asked). If not, **all** quizzes and HW will count (no drops). The drops are meant to cover any absences, including those due to illness, interviews, trips…

Academic Integrity
South Dakota Mines is committed to academic honesty and scholarly integrity. The [South Dakota Board of Regents Policy 2:33](#) provides a comprehensive definition of "Academic Dishonesty", which include cheating and plagiarism. All Instructors at South Dakota Mines are required to report allegations of

academic misconduct to the Student Conduct Officer. The [South Dakota Board of Regents Policy 3:4](#) provides detailed information regarding key definitions, policy information, prohibited conduct, and the Student Conduct process adhered to at South Dakota Mines. Any student suspected of violating academic integrity standards will be reported in accordance with the process outlined on the [South Dakota Mines website](#).

➢ Students are encouraged to discuss homework with classmates in general terms. However, direct copying/plagiarism … is not acceptable and will be penalized (e.g., grade of zero).

Grading and Assessment

Student learning is assessed by a combination of in-person exams and quizzes as well as homework and laboratories.

Description	Percent
Three (3) Hourly exams	45%
Quizzes	20%
Homework	15%
Final exam	20%
TOTAL	**100%**

Special Note Regarding Final Exams: Per South Dakota Mines Policy ([II-6-2](#)), if you are scheduled to take three or more final/last exams on the same day during finals week, you may request that the middle exam(s) of the day be rescheduled. ***You are required to make this request of your Instructor(s) at least 30 days prior to the last day of regular classes***.

Grading Scale- 100 > A > 90, 89 > B > 80, 79 > C > 70, 69 > D > 60, F < 60.

Academic Freedom Statement

Academic Freedom is the cornerstone upon which higher education is built. Academic freedom, as defined by [BOR policy 1:11](#), is fundamental to the advancement of truth, development of critical thinking, promotion of civil discourse, and contribution to the public good. Each course includes the freedom to discuss relevant matters and present various scholarly views in the classroom, as determined by the subject-matter expertise of the instructor. Students are encouraged to develop the capacity for critical thinking and to pursue the truth, debate ideas, express and evaluate their opinions, and draw conclusions. Students are free to take reasoned exception to the views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled.[1]

[1] Language adapted from the American Association of University Professors "Joint Statement on Rights and Freedoms of Students".

Complaint Process

While we hope that every student has a meaningful and positive experience at South Dakota Mines, should a concern arise, students are encouraged to first attempt to resolve their concern directly with the person or office directly involved. Following that attempt, should the concern remain unresolved, students are encouraged to reach out to the Dean of Students office at DeanOfStudents@sdsmt.edu or 605.394.2416. Additionally, students may access the [online form](#) to submit their complaint, appeal, or grievance.

Grade Appeal Policy

In alignment with BOR Policy 2:9, students who wish to appeal their final course grade shall first discuss the matter with the course instructor. If the concerns are unresolved following that discussion, students may utilize the online form to submit "Appeal – Academic" for a "Grade Dispute".

Opportunity for All - Student Success Services and Support

Students are provided a one-stop source for information regarding all the services and supports to ensure success. Visit the Opportunity for All page to access service and department information including ADA accommodations, Career Services, Counseling, Office for Inclusion, Slide Rule (math support), Student Success, Title IX, Tutoring, and Veterans Services, to name a few.

South Dakota Board of Regents Required Syllabus Statements

The following statements may be found online in South Dakota Board of Regents Academic Affairs Council Guideline 5.3.A:

- Freedom in Learning
- Americans with Disabilities Act
- Academic Dishonesty and Misconduct
- Acceptable Use of Technology
- Emergency Alert Communications

Electronic Devices Policy

Please silence/turn off your cell phone before class starts. No text messaging or headphones in class. You may use a laptop/tablet in class for purposes of note taking (NOT allowed for exams or quizzes). No other use of any other electronic/computer media, other than calculators, is allowed during class time.

Topics/Course Schedule: All/portions of Chapters 1 - 5 & 7 - 8, see attached tentative schedule (subject to revision).

Tentative Course Schedule

Class | Date	Topics/Activities	Reading/Text
1 | 8/26/24 2 | 8/28/24	**Electromagnetic Theory-** Intro, Maxwell's Equations, Fields in Media, Boundary Conditions, wave equation & plane waves	• 1.1 - 1.2 • 1.3 - 1.4
3 | 8/30/24 **9/2/24** 4 | 9/4/24 5 | 9/6/24 6 | 9/9/24 7 | 9/11/24 8 | 9/13/24 9 | 9/16/24	**Transmission Line Theory-** lumped-element circuit model, Telegrapher equations, transmission-line parameters, terminated transmission lines, generator & load mismatches, power flow, Smith Charts, lossy transmission lines	• 2.1 - 2.2 **Holiday** • 2.2 - 2.3 • 2.3, 2.6 • 2.4 • 2.4 • 2.4, 2.7 • 2.7
10 | 9/18/24 11 | 9/20/24 12 | 9/23/24 13 | 9/25/24 14 | 9/27/24	**Impedance Matching and Tuning-** series & parallel lumped elements, *L*-networks, single-stub tuning, double-stub tuning (time allowing), quarter-wave transformers	• Notes, 5.1 • 5.1 • 5.2 • 5.3 (?) • 2.5, 2.4
15 | 9/30/24 16 | 10/2/24	**Transmission Lines and Waveguides-** TEM, TE, & TM waves, rectangular waveguides	• 3.1 • 3.3
17 | 10/4/24	**Exam #1-** Covers material from Chapters 1, 2, 5, and notes	
18 | 10/7/24 19 | 10/9/24	**Transmission Lines and Waveguides cont.-** stripline, microstrip	• 3.7 • 3.8
20 | 10/11/24 **10/14/24** 21 | 10/16/24 22 | 10/18/24 23 | 10/21/24 24 | 10/23/24	**Microwave Network Analysis-** Impedance & equivalent voltages & currents, impedance & admittance matrices, S parameters & scattering matrices, properties, shifting reference planes, power, generalized S-parameters, Transmission (ABCD) matrix, signal flow graphs	• 4.1 - 4.2 **Holiday** • 4.3 • 4.3 • 4.3 - 4.4 • 4.4 - 4.5
25 | 10/25/24 26 | 10/28/24	**Power Dividers and Directional Couplers-** basic properties of dividers and couplers, T-junction and resistive power dividers	• 7.1 • 7.2
27 | 10/30/24	**Exam #2-** Covers material from Chapters 3 and 4	
28 | 11/1/24 29 | 11/4/24 30 | 11/6/24 31 | 11/8/24 **11/11/24** 32 | 11/13/24 33 | 11/15/24	**Power Dividers and Directional Couplers cont.-** Wilkinson power divider, Quadrature (90º) Hybrid, 180º Hybrid, coupled line directional couplers, Lange directional couplers	• 7.3 • 7.5 • 7.5, 7.8 • 7.6 - 7.7 **Holiday** • 7.7 • 7.7
34 | 11/18/24 35 | 11/20/24 36 | 11/22/24 37 | 11/25/24 **11/27 - 11/29** 38 | 12/2/24 39 | 12/4/24	**Microwave Filters-** insertion loss method, impedance & frequency scaling, filter transformations, Stepped-impedance low-pass filters, filter implementation, stub synthesis, Kuroda's Identities, stub filters	• 8.3 • 8.3-8.4 • 8.4 • 8.6 **Holiday** • 8.4, 8.5 • 8.5
40 | 12/6/24	**Exam #3-** Covers material from Chapters 7 and 8	
41 | 12/9/24	**Make-up/review day**	
	Final Exam- Monday, December 16, 2024 from 12-1:50 pm, EEP 338	