

**VILLANOVA UNIVERSITY**  
**DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING**

ECE 5690 MICROWAVE NETWORKS FALL, 2020

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Web Page – will use BlackBoard exclusively

TEXT/SOFTWARE *Microwave Engineering, 4<sup>th</sup> ed.*, by D. Pozar, 2005 (available on Bb).  
Class Notes, Microwave Software Packages, nanoVNA

REFERENCES: Other technical sources as appropriate.

PREREQUISITES: ECE 3690, Engineering Electromagnetics, or equivalent

OFFICE HOURS: By appointment via teleconference (COVID-19 protocol in place)

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**COURSE OBJECTIVES**

Modern communication systems, regardless of whether the system is primarily digital or analog, all require high frequency systems to extract or inject the appropriate signal into the transmission medium. The course objectives of ECE 5690 are to provide you with an introduction to the tools the modern microwave engineer uses in the analysis and design of microwave systems. These tools include a theoretical background in transmission lines and network theory as well as some solid-state devices, a knowledge of modern microwave simulation tools, and the ability to use, perform and understand microwave measurement equipment. Various in-class and out of class assignments will be used to help you in understanding and using these tools.

**TENTATIVE COURSE CONTENT**

1. Network Theory

**Objective:** The topics listed below constitute an introduction to into the use of structured network parameter theory to describe generalized networks. This generalized network theory will be shown to provide the basis for the use of S parameters in microwave circuit and system representation and measurement.

- Z and Y one and two port parameters
- S and T two port parameters
- S parameters examples and uses

2. Transmission Line Theory

**Objective:** The topics listed below build upon the transmission line theory you were introduced to in earlier electromagnetics courses. The effects of lossy lines as well as techniques for extending the bandwidth of matching structures are covered. The Smith Chart is used not only as a means to compute transmission line parameters but also as a means to present frequency-dependent microwave data.

- Transmission Line Equivalent Circuit
- Lossless Lines, the Smith Chart and Impedance Transformation
- Impedance Matching
- Lossy Lines

3. Practical Transmission Lines

**Objective:** Different physical structures can be used as a means to transmit microwave power. This section of the course will cover the specific transmission line parameters of a number of widely used transmission lines in terms of the generalized transmission line parameters introduced in part 1. A short introduction into transmission line filters is also presented

- Waveguides
- Coaxial lines
- Strip-style transmission lines
- Transmission line filters

#### 4. Directing Microwave Energy

**Objective:** In many microwave applications, power from two different sources needs to be combined into a single signal. Alternately, power from a single source must be split, possibly unevenly split, between two loads. The topics listed below cover the generalized theory of power coupling for several transmission line types.

- Power Dividers
- Directional Couplers

#### 5. Microwave Filters

**Objective:** In many microwave applications, filtering is required to either prevent out of band microwave energy from entering a circuit, or to suppress unwanted microwave energy when a signal is transmitted. The topics listed below cover the generalized Insertion Loss Method of filter design.

- Lumped element filters, LC prototype filters

#### 6. Microwave and RF System Fundamentals

**Objective:** This section covers some of the fundamental concepts of Microwave and RF system fundamentals. The topics listed below cover the following areas:

- Noise and Noise Figure and Temperature
- System Nonlinearities, including harmonic and intermodulation
- System Gain and Dynamic Range

WEEK	DATE	TENTATIVE LABORATORY SCHEDULE
1	18-Aug-20	No lab
2	25-Aug-20	Introduction to Microwave Office - Guest lecture
3	1-Sep-20	CAD Laboratory #1
4	8-Sep-20	Measurement Laboratory #1
5	15-Sep-20	CAD Laboratory #2
6	22-Sep-20	Test #1
7	29-Sep-20	Measurement Laboratory #2
8	6-Oct-20	CAD Laboratory #3
9	13-Oct-20	Measurement Laboratory #3
10	20-Oct-20	CAD Laboratory #4
11	27-Oct-20	Test #2
12	3-Nov-20	Measurement Laboratory #4
13	10-Nov-20	Filter Design #1
14	17-Nov-20	Filter Measurements #2

### ADDITIONAL INFORMATION

You will also be responsible for use of a microwave circuit simulator for completing a number of projects as part of the course requirements. Laboratory time will be spent with tutorials on the use of these circuit simulators and well as traditional and contemporary equipment (as available). If available, the Microwave Electromagnetics Laboratory in CEER 214 will be used for the hardware tests, and each laboratory exercise will be based on equipment available in that laboratory or in the laboratory parts kit provided to you. Laboratory handouts will be provided on the day of the exercise.

### GRADING

There will be **two** tests given during the semester that comprise 60% of your final grade. 25% of your grade will be based on your performance on homework quizzes, laboratory reports and other assignments, and a final project (which will be worth 15%). Besides being a portion of your grade, I strongly urge you to do the homework and review the solutions when they are made available since these exercises are helpful in understanding microwave concepts. Missing a homework quiz without a valid excuse approval will result in a zero for that quiz. Missing a quiz with excuse approval will not suffer a penalty. Any missed test with a valid excuse (see attendance policy) will make the other 40% of the course grade increase accordingly.

### SOME COURSE OUTCOMES

1. Students will use design principles and the Smith Chart, and verify with CAD software, a variety of impedance matching structures using practical and realizable transmission lines and lumped elements.
2. Students will use design principles and CAD software to design and simulate a variety of microwave power dividers and couplers using both waveguide and strip-style transmission lines.
3. Students will use microwave laboratory equipment to measure fundamental microwave parameters such as SWR, insertion loss, isolation, coupling, transfer functions and power.
4. Students will use modern microwave design and measurement techniques, software and instrumentation to design, simulate, fabricate and verify the operation of a passive microstrip microwave circuit.

### Attendance Policy:

Attendance is strongly encouraged for the lecture class, whether it be seated and ready to start class in a classroom setting, or being at your laptop with camera on if virtual. Attendance for the laboratory portion of the course is **mandatory** (unless with an excused absence), whether it be seated and ready to start the laboratory, or being at your laptop with camera on if virtual. Problems in class will be reviewed and sometimes laptops will be used to reinforce concepts. Where possible, students should inform their instructors if they plan to be late or absent from class. Missing a test or a quiz will require an excused absence approval from the Dean's office. Students should be prepared to provide documentation to petition for *excused* absences to the Associate Dean for Student and Strategic Programs, Dr. Stephen Jones, and not the course instructor. Students should use the [form for requesting an excused absence](#) and submit to Dr. Jones' office. Absence from class does not release the student from work assigned.

The University's list of excused absences for all students includes the following:

- participation in NCAA athletic competitions
- participation in special academic events (e.g., conferences, field trips, project competitions)
- participation in official university business (e.g., student representatives attending meetings related to university governance)
- attendance at significant events involving the immediate family (e.g., funerals, weddings)
- religious holidays - see the University's policy on Religious Holidays

- college-approved participation in placement activities (e.g., job interviews, graduate school interviews, attending job fairs)
- legally required absence (jury duty, court appearance, short-term military service)
- documented serious illness, such as COVID, or disability

It is solely your responsibility to make up work of any excused absence session. Most importantly, you are not permitted to use another student's results should you miss a session for any reason.

### **Inclusive Classroom**

I consider our classroom to be a place where everyone is treated with respect. All members of this class are expected to contribute to a respectful, welcoming, and inclusive environment for every other member of the class.

### **Academic Integrity**

The College of Engineering is committed to creating an environment of academic integrity and ethical decision-making that we hope is reflected in the actions of our students and graduates. As Villanova students, integrity is central to the University mission. As engineers, our code of conduct requires us to place honor and integrity at the forefront of everything we do. As engineering students, it is expected that you will begin to adopt these values and instill them into your work habits. Students violating the academic integrity policy will receive a zero on that assignment or exam and the violation will be reported to the Associate Dean for Academic Affairs. Students are encouraged to read the [University's academic integrity policy](#).

The College of Engineering has adopted the following exam guidelines:

- Students must arrive before the start of the exam. Under exceptional circumstances a student may need to arrive late, but he/she can enter the exam no later than 5 minutes after the start of the exam.
- All cell phones must be turned off and stored away until the student exits the exam room.
- The official Villanova class attendance policy must be followed when requesting excuses for absences or lateness to an exam.
- Each student must write and sign the following statement, *"I have neither given nor received any unauthorized assistance in the completion of this exam."* If taking an exam remotely, students still need to copy and sign this statement (even if signed electronically).
- In the case of virtual exams, the instructor may implement video proctoring or other measures to ensure academic integrity. For consent purposes, the instructor will announce ahead of time to students if they plan to use any form of video proctoring during an assessment and whether a recording will take place.

### **Adherence to the Student Code of Conduct and the CARITAS Commitment**

Students are expected to act in a professional and respectful manner to their fellow students, faculty, and staff. Students should become acquainted with and understand the responsibilities set forth in the Student Handbook, especially those in the sections on Policy and Regulations. Adherence to University regulations is expected and required for successful completion of the program of studies. Enforcement within the classroom of policies regarding classroom behavior is the responsibility of the faculty member. All other discipline problems are to be referred to the Dean of Students.

Students, faculty, and staff are expected to comply with the [CARITAS Commitment](#). Students **must** wear masks (unless they have a medical exemption), practice social distancing and good hygiene, wipe down their work area upon arrival and departure, and request an excused absence if they are not feeling well.

## **Online Expectations**

To foster a professional environment, please wear appropriate clothes, mute if you are not talking to cut down on background noise, refrain from eating, and select an appropriate setting whenever we meet online.

## **Students with Disabilities**

It is the policy of Villanova to make reasonable academic accommodations for qualified individuals with disabilities. If you are a person with a disability please contact me after class or during office hours to make arrangements.

If you have a non-physical disability you need to register with the Learning Support Office by contacting 610-519-5176 or at [learning.support.services@villanova.edu](mailto:learning.support.services@villanova.edu) as soon as possible. Registration is needed to receive accommodations.

- The Office of Disability Services collaborates with students, faculty, staff, and community members to create diverse learning environments that are usable, equitable, inclusive and sustainable. The ODS provides Villanova University students with physical disabilities the necessary support to successfully complete their education and participate in activities available to all students. If you have a diagnosed disability and plan to utilize academic accommodations, please contact and register with Gregory Hannah, advisor to students with disabilities @ 610-519-3209 or visit the office on the second floor of the Connelly Center.

## **Electronics Policy**

Online portions of this class may be recorded so that students that are absent may view the content later. The use of electronic devices, such as phones, laptops, tablets, etc., during class is prohibited unless specifically part of the instruction; this will be announced when needed. Students are prohibited from making any audio or visual recordings (including taking photographs) of lectures, discussions, or other classroom activities, unless a student (1) has written permission in advance from the instructor, or (2) is permitted to record under terms and conditions as approved by the University's Office of Disability Services or Learning Support Services. Students who have received approval to record classes as an academic accommodation must provide supporting documentation from the Office of Disability Services or Learning Support Services in advance of any recording. Students may use authorized recordings only for the purposes of individual study in the course and may not disseminate or share them with a wider audience without explicit permission.

## **Copyright Policy**

The materials used in Villanova University courses ("Course Materials") generally represent the intellectual property of course instructors, third parties and/or the University which may not be disseminated or reproduced in any form for public distribution (e.g., sale, exchange, etc.) without the written permission of the course instructor. Course Materials include all written or electronic documents and materials, including syllabi, current and past examination questions/answers, and presentations such as lectures, videos, PowerPoints, etc., provided by a course instructor. Course Materials may only be used by students enrolled in the course for academic (course-related) purposes.

Published course readings (book chapters, articles, reports, etc.) available in Blackboard are copyrighted material. These works are made available to students through licensed databases or fair use. They are protected by copyright law, and may not be further disseminated or reproduced in any form for distribution (e.g., uploading to websites, sale, exchange, etc.) without permission of the copyright owner.

Follow these links for more information about [intellectual property](#), [copyright](#), and [computer acceptable use](#).

## OTHER EDUCATIONAL RESOURCES

### **The Learner's Studio**

Villanova's Learners' Studio provides free content tutoring for over 100 courses (excludes writing, math, and entry level VSB courses). From quick homework clarification questions to prep for final exams, we can help! Our peer tutors are each endorsed by two faculty members and are trained according to CRLA national standards. All tutoring services at the university can be found [here](#). Don't see the class you want listed? Click [here](#). For more information, contact [juliana.studer@villanova.edu](mailto:juliana.studer@villanova.edu) or call 610-519-5862.

### **The Center for Speaking and Presentation**

Villanova's Center for Speaking and Presentation provides expert guidance on topics including organizing presentation material, performing as a cohesive group, voice modulation, vocal interruptions, speaking anxiety and more! All tutoring services at the university can be found [here](#). For more information, contact [juliana.studer@villanova.edu](mailto:juliana.studer@villanova.edu) or call 610-519-5862.

## DEPARTMENT OUTCOMES SATISFIED IN ECE5690

- 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.
- 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.