

## Introduction to RF Circuits

EEL 5934 Section 0004

**Class Periods:** M, W, F, 9 period (4:05 am – 4:55 pm)

**Location:** LAR 0239

**Academic Term:** Fall 2022

### **Instructor:**

Name: Yong-Kyu “YK” Yoon

Email Address: [ykyoon@ece.ufl.edu](mailto:ykyoon@ece.ufl.edu) or [yongkyu.yoon@ufl.edu](mailto:yongkyu.yoon@ufl.edu)

Office Phone Number: (352) 392-5985

Office Hours: Tue and Fri 1 – 2 pm, Larsen Hall 225 (or Zoom: [ufl.zoom.us/j/3523925985](https://ufl.zoom.us/j/3523925985))

### **Teaching Assistant/Peer Mentor/Supervised Teaching Student:**

Please contact through the Canvas website

- Saeyeong Jeon, [s.jeon@ufl.edu](mailto:s.jeon@ufl.edu), BEN 200, TBD
- Alexander Wilcher, [wilcheralexander@ufl.edu](mailto:wilcheralexander@ufl.edu), BEN 200, TBD

### **Course Description**

Introductory course on the radio frequency (RF) fundamentals and related circuits with topics of impedance matching, Smith Chart, s-parameters, waveguides, resonators, filters, active devices and amplifiers (3 credit hours)

### **Course Pre-Requisites / Co-Requisites**

EEL 3472 Electromagnetic Fields and Applications and EEL 3308C Electronic Circuits or their equivalent

### **Course Objectives**

To let students understand the basic concepts of RF/microwave parameters, components and circuits, and enable them to design and analyze RF/microwave components and circuits using analytical and numerical means.

### **Materials and Supply Fees**

N/A

### **Required Textbooks and Software**

- Title: Microwave Engineering
- Author: David M. Pozar
- Publication date and edition: 2013, Wiley, 4<sup>th</sup> Edition
- ISBN number: **0470631554**

### **Recommended Materials**

- Title: Microwave and RF Design
- Author: Michael Steer
- Publication date and edition: 2010, Scitech
- ISBN number

Software:

- High Frequency Structure Simulator (HFSS, ANSYS Inc.)
- Designer (ANSYS Inc.)
- ADS (Agilent Inc.)

### **Course Schedule**

Tentative Schedule

	<b>Impedance Matching</b>	Read	Skim
8/24	0. Course Introduction	1.1,	1.2-1.9

**Course Title, Prefix, and Number**

**Course Instructor and Academic Term**

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8/26	1. Review of Transmission Lines	2.1-2.3	
8/29	2. Smith Chart	2.4-2.7	
8/31	3. Impedance Matching with Lumped Elements	5.1-5.2	
9/2	4. Impedance Matching with Stubs	5.1-5.2	5.3
9/7	5. Single-section and Multi-section $\lambda/4$ Matching	5-4-5.5	
9/9	6. Binomial Broadband Matching (Butterworth)	5.6	
9/12	7. Chebyshev Broadband Matching	5.7	
9/14	8. Tapered Lines	5.8	5.9
	<b>Transmission Lines and Waveguides</b>		
9/16	9. Rectangular Waveguide	3.3	3.1-3.2
9/19	10. Modes and Propagation Behavior	3.10	
9/21	11. Wall Loss in Rectangular Waveguide		
9/23	12. Circular and Ridged Waveguide	3.4	
9/26	13. Coaxial Cables and Microwave Connectors	3.5	
9/28	14. Planar Waveguides (Microstrip, CPW) T-line calculator	3.7-3.8, 3.11	3.6
9/30	<b>Exam #1</b>	Closed book	Formula
	<b>S-parameters and S-matrix</b>		
10/3	15. Scattering Parameters	4.1-4.3	
10/5	16. Scattering Matrices and Properties of S-Matrices		
10/7	Homecoming (No Class)		
10/10	17. Transmission (ABCD) Matrices	4.4	
10/12	17-1. Example of S-Matrices	7.1	
10/14	HFSS Tutorial		
	<b>Couplers</b>		
10/17	18. Example of S-Matrices, Branch Line Coupler	7.2, 7.5	7.4
10/19	19. Coupled Line Couplers	7.6	7.7
10/21	20. The 180° Hybrid, Other Couplers	7.8	7.9
	<b>Resonators</b>		
10/24	21. Series and Parallel Prototype Resonators,	6.1-6.2	
10/26	22. T-line Resonator, Coupling to Resonators	6.7	
10/28	23. Waveguide Cavity Resonators	6.3-6.4	
10/31	24. Nonmetallic Resonators	6.5-6.6	
	<b>Filters</b>		
11/2	25. Filter Design Using Insertion Loss Method	8.3	8.1-8.2
11/4	26. Maximally Flat and Equal Ripple Design	8.4	
11/7	<b>Exam #2</b>	Open book	
11/9	27. Filter Transformation (Richard's, Kuroda)	8.5	
11/14	28. Stepped-Impedance Low Pass Filter	8.6	
	<b>Active Devices</b>		
11/16	29. RF Circuit Background/Concepts	Handout	
11/18	30. Non-linearity in Circuits	Handout	
11/21	31. Noise, Sensitivity, Dynamic Range	11.1	
11/28	32. Solid State Transistor based Microwave Amplifier	11.2	
11/30	33. S-parameter based IMN/OMN Design	11.3	
12/2	34. Power Gain Definition and Stability	11.3	
	<b>Amplifiers</b>		
12/5	35. Single-Stage Amp Design	12.1	
12/7	36. Amplifier Design	12.2 – 12.3	
Final	<b>Final (Follow school schedule)</b>	Closed book	Follow final schedule

## Attendance Policy, Class Expectations, and Make-Up Policy

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies:

<https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/>

## Evaluation of Grades

**\*\*Assessment Guidance from the ECE Graduate Committee:** Course evaluation components should include:

1. At least one component that individually evaluates each student's understanding of course material and ability to apply concepts.
2. At least one evaluation activity that takes place in class.
3. When a project is involved, evaluation rubrics should be explicitly stated.
4. When team work is expected, individual student contribution verification method should be explicitly stated.

*If an in-class exam is administered then 1 and 2 are fulfilled. In the case of a project, a project report that is graded per the stated evaluation rubrics and states which work was done by each student in the project team will address both 3 and 4.*

Students are expected to attend class lectures and arrive on time. Please turn off cell-phones, pagers, and other electronic devices during the class unless you are asked to use them.

Assignment	Total Points	Percentage of Final Grade
Homework Sets	100 each	10%
Design Project	100 each	30%
Exam1	100	20%
Exam2	100	20%
Final Exam	100	20%
		100%

This course is co-listed with the graduate class. The homework portion of the graduate section will involve additional work with respect to the undergraduate section. The exams will also involve additional questions or takehome questions for the graduate section with respect to the undergraduate section. Grading for the homework and projects are different from the undergraduate course. The graduate and undergraduate sections will be graded separately, for which the graduate section has additional problems and different weights for all problems. EEL 5934 has computer software based simulation and design and is required to submit term projects and final reports. Each test has takehome questions, which can be completed using computer simulation using provided design tools.

## Grading Policy

The following is given as an example only.

Percent	Grade	Grade Points
90.0 - 100.0	A	4.00
87.0 - 89.9	A-	3.67
84.0 - 86.9	B+	3.33
81.0 - 83.9	B	3.00
78.0 - 80.9	B-	2.67
75.0 - 79.9	C+	2.33
72.0 - 74.9	C	2.00
69.0 - 71.9	C-	1.67
66.0 - 68.9	D+	1.33
63.0 - 65.9	D	1.00

60.0 - 62.9	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:

<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades>

### ***Students Requiring Accommodations***

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

### ***Course Evaluation***

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

### ***In-Class Recording***

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

### ***University Honesty Policy***

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://sccr.dso.ufl.edu/process/student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

### ***Commitment to a Safe and Inclusive Learning Environment***

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, [jpennacc@ufl.edu](mailto:jpennacc@ufl.edu)
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, [taylor@eng.ufl.edu](mailto:taylor@eng.ufl.edu)
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, [nishida@eng.ufl.edu](mailto:nishida@eng.ufl.edu)

### ***Software Use***

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

### ***Student Privacy***

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

### ***Campus Resources:***

#### ***Health and Wellness***

#### **U Matter, We Care:**

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

**Counseling and Wellness Center:** <https://counseling.ufl.edu>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

#### **Sexual Discrimination, Harassment, Assault, or Violence**

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, [title-ix@ufl.edu](mailto:title-ix@ufl.edu)

#### **Sexual Assault Recovery Services (SARS)**

Student Health Care Center, 392-1161.

**University Police Department** at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

### ***Academic Resources***

**E-learning technical support**, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.  
<https://lss.at.ufl.edu/help.shtml>.

**Career Connections Center**, Reitz Union, 392-1601. Career assistance and counseling; <https://career.ufl.edu>.

**Library Support**, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

**Teaching Center**, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.  
<https://teachingcenter.ufl.edu/>.

**Writing Studio, 302 Tigert Hall**, 846-1138. Help brainstorming, formatting, and writing papers.  
<https://writing.ufl.edu/writing-studio/>.

**Student Complaints Campus**: <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>; <https://care.dso.ufl.edu>.

**On-Line Students Complaints**: <https://distance.ufl.edu/state-authorization-status/#student-complaint>.