Universidad Carlos III de Madrid

| DENOMINACIÓN ASIGNATURA: Subsistemas de radiofrecuencia y antenas / Radiofrequency Subsystems and Antennas. | | |
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| MÁSTER: Ingeniería de Telecomunicación/Telecommunications Engineering | CURSO: 1º | CUATRIMESTRE: 1º |

*The course consists of 29 sessions spread over 14 weeks. The labs can be held on any of these days. Due to the 29 sessions, an additional session will be required in one week, which will be held at 1:00 p.m. in Puerta de Toledo and at 7:00 p.m. in Leganés. The classroom at Puerta de Toledo is 0:A06 (at 11:00 a.m. on Tuesdays and 9:00 a.m. on Fridays), while the classroom at Leganés is 4:1:E01 on Tuesdays at 5:00 p.m. and 4:0:D03 on Thursdays at 3:00 p.m. (tbc).*

*The 25-26 course will first cover subsystems and then antennas. The course can be passed through continuous assessment provided that the average of the exams (not including the practical) is higher than 6.0 in each part. The sessions that appear in blue are circuit sessions, while the sessions in orange are antenna sessions. The lab-sessions are indicated in green. There are some changes to certain sessions, which are indicated directly in the schedule. This schedule is common to both the Puerta de Toledo and Leganés groups (the corresponding day for each group is indicated in the session box).*

*In addition, there are four review sessions (marked in olive-green color) that will be held in Leganés in classroom 4:2:E03 and broadcast on BBC. These sessions will last 100 minutes and will be recorded. These four sessions will be held at the beginning of each thematic block (subsystems, laboratory, and antennas) so that the content is as "fresh" as possible before starting the block. These sessions are marked in olive green. The contents of these review sessions will be: passive microwave circuits and introduction to antennas (essential for students who have not previously taken this course and recommended for all other students) and use of circuit and antenna design software. The concepts that will be taught in these sessions are: transmission line concept and Smith chart, S parameters, passive microwave circuits, and introduction to antennas. We will begin with two review sessions on antennas.*

| COURSE SCHEDULE | | | | | | | |
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| **WEEK** | **SESSION** | **SESSION CONTENT DESCRIPTION** | Indicate space different than the classroom (e.g., computer lab, lab, etc.). | Indicate if it is a 2 - teacher session **(Note)** | **STUDENT WORK DURING WEEK** | | |
| | | | | | **DESCRIPTION** | **In-person hours** | **Work hours (Max. 7,5 H)** |
| 0 | **Repaso 1**<br>**Sept 5: 19:00**<br>**4:2:E03** | **Chapter 0.1: Waveguides and transmission lines; Smith chart. AWR.** | | | Review of TAF (GITT) contents, required for the course: TX lines and Smith chart. | | |
| | **Repaso 2**<br>**Sept. 8: 11:00**<br>**4:2:E03** | **Chapter 0.2: S-parameters and microwave circuits.** | | | Review of TAF (GITT) contents, required for the course: S-parameters and passive circuits. | | |
| 1 | 1<br>9 sep. Leg: 4:1:E01<br>9 sep. PT: *0:A06* | **Chapter 1: Passive frequency conversion and control devices**<br>1.1. Description of transmitters and receivers in communications.<br>1.2. Diodes in microwaves: modelling<br>1.3. Basic concepts of mixing (part 1) | NO | | Review of diode theory and basic concepts of mixing explained in class. | 1,66 | 7 |
| | 2<br>11 sep. Leg. 4:0:D03<br>12 sep. PT: *0:A06* | **Chapter 1: Passive frequency conversion and control devices**<br>1.4. Basic concepts of mixing (part 2)<br>1.5. Diode-based mixers: fundamentals of mixing.<br>1.6. Single diode mixer circuit. | NO | | Review of mixer theory explained in class. | 1,66 | |
| 2 | 3<br>16 sep. Leg: 4:1:E01<br>16 sep. PT: *0:A06* | **Chapter 1: Passive frequency conversion and control devices**<br>1.7. Single balanced mixers.<br>1.8. Diode-based detectors.<br>1.9. Exercises. | NO | | Review of mixers and detectors theory explained in class. | 1,66 | 7 |
| | 4<br>18 sep. Leg. 4:0:D03<br>19 sep. PT: *0:A06* | **Chapter 2: Microwave amplifiers**<br>2.1. BJT bipolar transistors in microwaves: modelling<br>2.2. MESFET transistors in microwaves: modelling<br>2.3. Introduction to microwave linear amplifiers.<br>2.4. Introduction: Bias in amplifiers. | NO | | Review of transistors and microwave amplifiers theory explained in class. | 1,66 | |
| 3 | 5<br>23 sep. Leg: 4:1:E01<br>23 sep. PT: *0:A06*<br>23 sep. Leg. Se adelanta al 11 de sept. a las 19:00: | **Chapter 2: Microwave amplifiers**<br>2.5. Amplifier gain and stability.<br>2.6. Constant gain circles.<br>2.7. Unilateral amplifiers.<br>2.8. Design of a specific-gain amplifier: Exercises: problem 1, part 1 | NO | | Review of microwave amplifier theory explained in class; exercises. | 1,66 | 7 |
| | 6<br>25 sep. Leg. 4:0:D03<br>26 sep. PT: *0:A06*<br>25 sep. Leg, se adelanta al 18 sep. a las 19:00 | **Chapter 2: Microwave amplifiers**<br>2.8. Design of a specific-gain amplifier: Exercises: problem 1, continuation<br>2.9. Low-noise amplifiers and noise circles.<br>2.10. Conjugate gain circles.<br>2.11. Mismatching circles. Problem 4, part 1. | NO | | Review of microwave amplifier theory explained in class; exercises.<br>Lab session 1 previous work. | 1,66 | |
| | **Repaso 3**<br>**Sept. 26: 13:00**<br>**4:2:E03 (tbc)** | **Chapter 0.3: AWR and passive microwave circuits.** | NO | | Review of TAF (GITT) contents, required for the course: AWR and passive circuits. | | |

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| 4 | 7<br>30 sep. Leg: 4:1:E01<br>30 sep. PT: *0:A06* | **Chapter 2: Linear microwave amplifiers**<br>2.11. Problem 4, continuation.<br>2.12. Design of a multi-stage amplifier.<br>2.13 Low-noise and specific-gain amplifiers exercises. | NO | | Review of microwave amplifiers theory explained in class; exercises.<br>Lab session 1 previous work. | 1,66 | 7 |
| | 8<br>2 Oct. Leg. 4:0:D03<br>3 Oct. PT: *0:A06* | 2.14. Multi-stage amplifiers exercises.<br>2.15. Amplifier measurement: gain (network analyzer) and noise. | NO | | Review of microwave amplifiers theory explained in class; exercises.<br>Lab session 1 previous work. | 1,66 | |
| | 9<br>Sesión 29<br>2 oct. PT y Leg. (a las 13:00 horas y a las 19:00 respectiv.) | Lab session 1: Design of a low-noise active antenna: 1) Non-linear system based on diodes (session 1). It will be designed with AWR software | NO, virtual desktop | | Design of a low-noise active antenna: 1) Non-linear system based on diodes (session 1). | 1,66 | |
| 5 | 10<br>7 Oct. Leg: 4:1:E01<br>7 Oct. PT: *0:A06* | **Chapter 2: Amplifiers: conclusions.**<br>**Chapter 3: Microwave oscillators**<br>3.1. Basic oscillator concepts.<br>3.2. Oscillators based in single-port devices: oscillation condition.<br>3.3. Stability in oscillators. | NO | | Review of microwave oscillators theory explained in class, exercises.<br>Test and exam preparation. | 1,66 | 7 |
| | 11<br>9 Oct. Leg. 4:0:D03<br>10 Oct. PT: *0:A06* | **Chapter 3: Microwave oscillators**<br>3.4. Design of a negative resistance oscillator. Exercise.<br>3.5. Transistor-based oscillators.<br>3.6 Generalization of oscillation condition to N-ports networks.<br>3.7. Design of a transistor-based oscillator. | NO | | Review of microwave oscillators theory explained in class, exercises.<br>Test and exam preparation. | 1,66 | |
| 6 | 12<br>14 Oct. Leg: 4:1:E01<br>14 Oct. PT: *0:A06* | **Chapter 3: Microwave oscillators**<br>3.8. Oscillators based in dielectric resonator (DRO).<br>3.9. Design of a transistor-based oscillator and DRO. Exercises.<br>3.10. Exercises<br>**Test on everything covered (40 minutes, 20 questions), it will be ONLINE but in-person** | NO | | Review of microwave oscillators theory explained in class, exercises.<br>Exam preparation. | 1,66 | 7 |
| | 13<br>16 Oct. Leg. 4:0:D03<br>17 Oct. PT: *0:A06* | Lab session 2: Design of a low-noise active antenna: 1) Low-noise amplifier (session 2). It will be designed with AWR software. | NO, virtual desktop | | Basic design of a low-noise amplifier. Electrical design optimization. Lab report submission: 1 dec. 14:00. | 1,66 | |
| 7 | 14<br>21 Oct. Leg: 4:1:E01<br>21 Oct. PT: *0:A06* | **Chapter 4: Fundamentals and radiation parameters.**<br>4.1. Radiation mechanism.<br>4.2. Antenna types.<br>4.3. Antenna fundamental parameters. Exercises. | NO | | Review of the basic antenna theory and exercises proposed in class.<br>Continuation of the electrical circuit for the lab.<br>Active devices exam preparation. | 1,66 | 7 |
| | 15<br>23 Oct. Leg. 4:0:D03<br>24 Oct. PT: *0:A06* | **Chapter 4: Fundamentals and radiation parameters. Review.**<br>4.4 Equivalence and uniqueness theorems.<br>4.5 Link budget and exercises on radiation parameters. | NO | | Review of the basic antenna theory and exercises proposed in class.<br>Continuation of the electrical circuit for the lab.<br>Active devices exam preparation. | 1,66 | |

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| 8 | 16<br>28 Oct. Leg: 4:1:E01<br>28 Oct. PT: *0:A06*<br><br>28 oct. 13:00<br>Leganés y PT | **Individual exam: chapters 1, 2 and 3.**<br>**Contents can be exempted if the grade is above 6 (without the lab).** | YES | | | 1,66 | 7 |
| | 17<br>30 Oct. Leg. 4:0:D03<br>31 Oct. PT: *0:A06*<br>Grupo de Leganés adelanta al 28 | **Chapter 4: Fundamentals and radiation parameters. Review**<br>4.6. Noise temperature in antennas.<br>4.7 Exercises. | NO | | Review of the basic antenna theory and exercises proposed in class.<br>Circuit layout definition. | 1,66 | |
| | **Repaso 4**<br>**Oct. 30: 15:00**<br>**4:0:D03** | **Chapter 0.4: fundamental antenna parameters and CST.** | | | Review of basic antenna parameters explained in EM Fields (GITT) and introduction to simulation SW. | | |
| 9 | 18<br>4 Nov. Leg: 4:1:E01<br>4 Nov. PT: *0:A06* | **Chapter 5: Radiation integrals and auxiliar potential functions.**<br>5.0. Introduction to radiation integrals.<br>5.1. Retarded potentials.<br>5.2. Radiation vectors.<br>5.3. Fresnel and Fraunhofer regions. | NO | | Review of the basic antenna theory and exercises proposed in class.<br>Circuit layout definition. | 1,66 | 7 |
| | 19<br>6 Nov. Leg. 4:0:D03<br>7 Nov. PT: *0:A06* | Lab: low-noise amplifier integration (session 3) and pre-design of a patch antenna. | NO, virtual desktop | 2 teachers | Practical explication of simulation SW.<br>Lab preparation from this explanation.<br>Some designs may be manufactured.<br>Report submission: 1 Dec- 14:00. | 1,66 | |
| 10 | 20<br>11 Nov. Leg: 4:1:E01<br>11 Nov. PT: *0:A06* | **Chapter 5: Radiation integrals and auxiliar potential functions.**<br>5.4. Range of measurement determination.<br>5.5. Equivalence, uniqueness and reciprocity theorems.<br>**Chapter 6: Elementary antennas.**<br>6.1 Elementary wire antennas.<br>6.2. Elementary loop antennas. | NO | | Review of elementary antennas theory and exercises proposed in class.<br>Preparation of antenna lab. | 1,66 | 7 |
| | 21<br>13 Nov.Leg. 4:0:D03<br>14 Nov. PT: *0:A06* | **Chapter 6: Elementary antennas.**<br>6.3. Dipole antennas and resonant antennas.<br>6.4 Image theory<br>6.5 Monopoles<br>6.6 Exercises | NO | | Review of elementary antennas theory and exercises proposed in class.<br>Preparation of antenna lab. | 1,66 | |
| 11 | 22<br>18 Nov. Leg: 4:1:E01<br>18 Nov. PT: *0:A06* | **Chapters 4, 5 and 6: Antennas exercises.**<br>**Chapter 7: Antenna arrays.**<br>7.1. Radiated fields by arrays. | | | Review of elementary antennas theory and exercises proposed in class.<br>Preparation of antenna lab. | 1,66 | 7 |
| | 23<br>20 Nov.Leg. 4:0:D03<br>21 Nov. PT: *0:A06* | **Chapter 7: Antenna arrays.**<br>7.2. Radiation diagram of arrays.<br>7.3. Typical current distributions. | NO | | Review of elementary antennas and arrays theory explained, and exercises proposed in class.<br>Preparation of antenna lab. | 1,66 | |

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| | 24<br>22 nov. PT: *0:A08*<br>21 nov. Leg: 4:0:E06<br>A las 13:00 y a las 19:00.<br>adelanto 11 y 12 dic en Leganés | Lab session 4: Design of a linear planar antenna: patch. It will be designed with CST software | SI | 2 teachers | **2 teachers**<br>Practical explication of simulation SW.<br>Lab preparation from this explanation.<br>Some designs may be manufactured.<br>Report submission: 1 Dec- 14:00. | 1,66 | |
| 12 | 25<br>25 Nov. Leg: 4:1:E01<br>25 Nov. PT: *0:A06* | **Chapter 7: Antenna arrays.**<br>7.4. Arrays directivity.<br>7.5 Exercises. | NO | | Review of elementary antennas and arrays theory explained, and exercises proposed in class.<br>Preparation of antenna lab. | 1,66 | 7 |
| | 26<br>27 Nov.Leg. 4:0:D03<br>28 Nov. PT: *0:A06* | **Chapter 7: Antenna arrays.**<br>7.6. Planar arrays.<br>7.7. Arrays feeding.<br>7.8. Introduction to arrays synthesis.<br>7.9. Exercises | NO | | Review of elementary antennas and arrays theory explained, and exercises proposed in class.<br>Preparation of antenna lab. | 1,66 | |
| | **Voluntaria** previa coordinación profesor<br>Semana 12 a las 19:00 horas en Leganés | Lab session 5: Location using a portable radar system | SI | 2 teachers | Lab preparation from the theory explained in class.<br>Report submission: 24 nov. | | |
| 13 | 27<br>2 Dic. Leg: 4:1:E01<br>2 Dic. PT: *0:A06* | **Chapter 7: Antenna arrays**<br>7.9 Exercises.<br>**Chapter 8: Aperture antennas**<br>8.1 Introduction to aperture antennas.<br>8.2 Elementary apertures. | NO | | Review of elementary antennas and arrays theory explained, and exercises proposed in class.<br>Preparation of antenna lab. | 1,66 | 7 |
| | 28<br>4 Dic. Leg. 4:0:D03<br>5 Dic. PT: *0:A06* | **Antenna test, including arrays (40 minutes) it will be ONLINE but in-person.**<br>**Chapter 8: Aperture antennas**<br>8.3 Horn antennas.<br>8.4 Horn antennas exercises.<br>8.5 Introduction to reflectors. | NO | | Review of elementary antennas and arrays theory explained, and exercises proposed in class.<br>Preparation of antenna lab. | 1,66 | |
| 14 | 29<br>9 Dic. Leg: 4:1:E01<br>9 Dic. PT: *0:A06* | **Chapter 8: Aperture antennas**<br>8.6. Exercises | | | Review of elementary antennas and arrays theory explained, and exercises proposed in class.<br>Preparation of antenna lab. | 1,66 | 7 |
| | Examen<br>11 diciembre a las 13:00 horas en los dos grupos | **Individual exam on antennas: chapters 4, 5, 6, 7 and 8**<br>**Contents can be exempted if the grade is above 6 (without the lab).** | | | Review of theory explained in class. Exercises. | 1,66 | |
| **SUBTOTAL** | | | | | | **48,14 +105 = 153,14** | |
| 16 | | Preparation of final exam on January, 23rd. | | | | | 23 |
| 17 | | | | | | | |
| **TOTAL** | | | | | | **180** | |

**(*) El número de sesiones con 2 profesores o de laboratorios experimentales en grupos de 20 alumnos estará comprendido entre un mínimo de 2 y un máximo de 6. Además, al menos 2 de estas sesiones se celebrarán fuera del horario regular, para lo cual se debe rellenar la tabla que aparece más abajo CRONOGRAMA LABORATORIOS EXPERIMENTALES.**
(**) 105 horas de trabajo del alumno como máximo en 15 semanas, suponiendo 30 horas por crédito ECTS.

## Course organization and evaluation.

The course will be assessed through continuous assessment. The continuous assessment consists of:

1) Practical exercise distributed in 4 sessions. It has a weighting of 15%
2) Mid-term exam on active circuits. Contents can be exempted if and only if the average grade of the active circuits part is above 6. Both groups will be evaluated on October 28th, and it weighs 15%
3) Contents can be exempted if and only if the average grade of the active circuits part is above 6. Both groups will be evaluated on December 11th, and it weighs 15%.
4) There are two mid-term tests with a weight of 10%.
5) Final exam with a 45% weighting.

## Final grade

The final grade will be obtained as:

A) Students with a grade above 6/10 in the continuous assessment of both parts (active devices and antennas, without the lab): the grade will be weighted 85% and added to the lab grade multiplied by 0.15. These students can improve their grade in the final exam.
B) Students with a grade below 6/10 in one of the parts of the continuous assessment: they are exempted of the other part and they only have to do the final exam on this part, requiring a minimum grade of 4.5 to average with the exempted part. The final grade in this case will be: exempted part*0,425+0,20*cont. assessment no exempted + 0,225 final exam no exempted.
C) Students below 6/10 in the continuous assessment: 55% of the continuous assessment plus 45% of the final exam. A minimum grade of 4.0 is required to average with the continuous assessment.
D) The optional lab and the active participation in the problem forum plus the realization of a podcast for this forum can improve the grade up to 1,5 point, provided that the minimum grade in all the parts has been achieved.