Subject: Antennas and ElectroMagnetic Compatibility
Code: 18475
Institution: Escuela Politécnica Superior
Degree: Telecommunication Technologies and Services Engineering
Level: Bachelor Degree
Type: Core course
ECTS: 6

# COURSE TITLE

## Antennas and Electromagnetic Compatibility (ACEM)

## 1.1. Course area

Transmission Systems

## 1.2. Year

4º

## 1.3. Semester

2º

## 1.4. Faculty data

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## 1.5. Course contents

I. **Introduction to Electromagnetic Compatibility**

1. Definition of electromagnetic interference (EMI), susceptibility (EMS) and compatibility (EMC).
2. EMC basic scheme.
3. Types of coupling according to the propagation mechanism.
    i. Radiated coupling
    ii. Conducted coupling
4. Types of interference sources
    i. Radiated sources
    ii. Conducted sources
    iii. Deficient electrical characterization of discrete components.

5. Methods of EMS decrease due to interference effects.

II. **Basic concepts of antennas - Radiated interference sources**

1. Antenna concept and types.
2. Radiation basics
    i. Resolution of Maxwell equations for radiation applications
    ii. Regions in the antenna radiated field: reactive near field, radiated near field, far-field.
3. Antenna basic parameters
    i. Input impedance and matching coefficient
    ii. Antenna and transceiver impedance matching
    iii. S parameters characterization
    iv. Bandwidth
    v. Radiation Pattern
    vi. Directivity, Gain and Efficiency
    vii. Polarization
4. Reciprocity Theorem in antennas
5. Antenna equivalent area
6. Antenna equivalent noise temperature. Friis equation.

III. **Linear wire and printed antennas**

1. Concept of linear wire antenna
2. Small dipole.
3. Electrical finite lenght dipole (Main interference source of capacitive near field coupling).
4. Image theorem in antennas: vertical monopolo, horizontal dipole in front of metallic ground plane. Concept of balun.
5. Loop antenna (Main interference source of inductive near field coupling).
6. Yagi antennas
7. Microstrip patch antenna (Main interference source in cellular systems)
    i. Transmission line model
    ii. Cavity model
    iii. Feeding types
    iv. Dual and circular polarization in patch antennas.

IV. **Arrays.**

1. Array concept and types
2. Pattern multiplication principle
3. Linear arrays: broadside, endfire and scanning
4. Bidimensional arrays
5. Feeding networks in arrays: serial, corporative and active networks
6. EMC in arrays. Mutual coupling in arrays – Z and S parameter model
7. Introduction to adaptive antennas

V. **Aperture antennas: horn and reflector antennas**

1. Aperture antenna concept.

2. Rectangular aperture antennas: uniform, cosine and separable illumination
3. Equivalence principle and aperture field solution.
4. Rectangular horn antennas: E and H plane, pyramidal and corrugated horn antennas.
5. Conical horn antennas.
6. Reflector antenna concept.
7. Simple and offset parabolic reflector antennas
8. Double reflector antenna: Cassegrain and Gregorian systems.

VI. **Shielding – Radiated coupling immunity**

1. Electromagnetic principle of shielding
2. Near field radiated coupling
    i. Capacitive coupling – Shielding effect
    ii. Inductive coupling – Shielding effect

VII. **Conducted coupling. Sources and cancelation methods**

1. Conducted coupling by common impedance
    i. Difference between circuit ground and earth connection
    ii. Ground connection: Centralized, distributed and hybrid ground
2. Differential (DM) and common (CM) mode interferences
3. Transformers: CM-CM,DM-DM,CM-DM and isolation
4. EMC in cables –BS IEC 61000-5-2 norm.
5. EMC in commutation circuits due to transitory effects
6. Interference cancelation with filters

VIII. **Antenna and EMC measurement systems**

1. Open space antenna systems in far-field region
2. Anechoic chamber
    i. EMC, EMS and EMI measurements
    ii. Antenna radiation pattern measurements: Near and Far-Field measurements.

    EMC measurement example: Radio-electrical emission measurement due to base station cellular antennas.

## 1.6. Course bibliography

Basic:

- Ángel Cardama, Lluis Jofre, Juan Manuel Rius, Jordi Romeu, Sebastián Blanch, Miguel Ferrando "Antenas". 2002 Edicions UPC.
  Disponible en Biblioteca EPS – Referencia INF/B5260/ANT

- Constatine Balanis. "Antenna Theory. Analysis and Design. 2005 John Wiley & Sons.
  Disponible en Biblioteca EPS – Referencia INF/621.396/BAL
  Henry W. Ott, "Electromagnetic Compatibility Engineering". 2009. John Wiley & Sons, Inc.
  Disponible en Biblioteca EPS – Referencia INF/537/OTT
- José Luis Sebastián Franco, "Fundamentos de Compatibilidad Electromagnética",Addison&Wisley, 1999.
  Disponible en Biblioteca EPS – Referencia INF/A4110/SEB

Intermediate and complementary for some specific concepts:

- David M. Pozar, "Microwave Engineering", John Wiley, 2012
  Disponible en Biblioteca EPS – Referencia INF/621.396/POZ
- R. S. Elliot, "Antenna theory and Design", IEEE press, 2003.
  Disponible en Biblioteca EPS – Referencia INF/B5260/ELL
- W.L. Stutzman. "Antenna Theory and Design" 2000. 2nd edition Wiley
  Disponible en Biblioteca EPS – Referencia INF/B5260/STU
- C. A. Balanis, "Modern Antenna Handbook". Wiley, 2008.
  Disponible en Biblioteca EPS – Referencia INF/B5260/MOD
- Joan Pere López Veraguas, "Compatibilidad Electromagnética", MARCOMBO, 2006
- Joan Pere López Veraguas, "Compatibilidad electromagnética y seguridad funcional en sistemas electrónicos",MARCOMBO, 2010
  Disponible en Biblioteca EPS – Referencia INF/537/LOP
- Tim Williams, "EMC for product designers",Elsevier, 2001
  Disponible en Biblioteca EPS – Referencia INF/A4110/WIL
- Robert E. Collin, "Foundations for microwave engineering", McGraw-Hill,2001
  Disponible en Biblioteca EPS – Referencia INF/B1300/COL

Advanced (related to subsequent courses):

- D. L. Sengupta, V.V. Liepa, "Applied Electromagnetics and Electromagnetic Compability", Wiley, 2006
  Disponible en Biblioteca EPS – Referencia INF/A4110/SEN.
- D.G.Fang, "Antenna Theory and Microstrip Antennas", Taylor & Francis, 2010.
  Disponible en Biblioteca EPS – Referencia INF/B5260/FAN
- S. Celozzi, R. Araneo, G. Lovat, "Electromagnetic Shielding", Wiley, 2008.
  Disponible en Biblioteca EPS – Referencia INF/A4110/CEL
- James R. James, "Handbook of Microstrip Antennas, vol.1", P. Peregrinus, 1989.
  Disponible en Biblioteca EPS – Referencia INF/B5260/HAN VOL. 1

- Chandran, Sathish, "Adaptive antenna arrays trends and applications", Springer, 2004.
  Disponible en Biblioteca EPS – Referencia INF/B5260/ADA