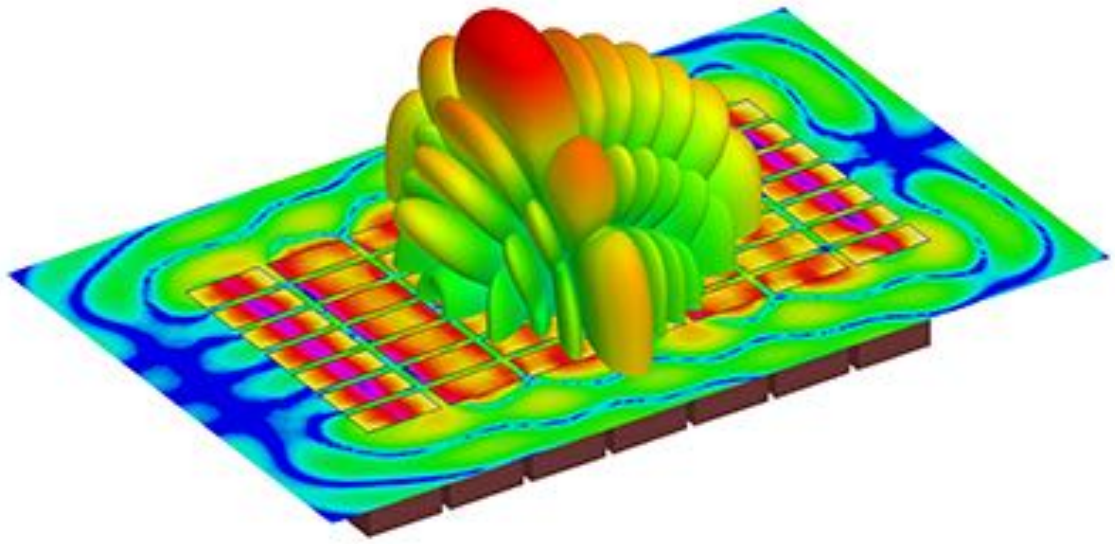

Wireless Electromagnetics

technology

Internet Engineering (9 CFU)
Electronic Engineering (6 CFU)
Medical Eng. (6 CFU)

Prof. **Gaetano Marrocco**
Gaetano.marrocco@uniroma2.it
Tel. 06 72597418

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Wireless Devices in a Networked World






$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t} + \mathbf{J}$$



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Wireless Devices in a Networked World

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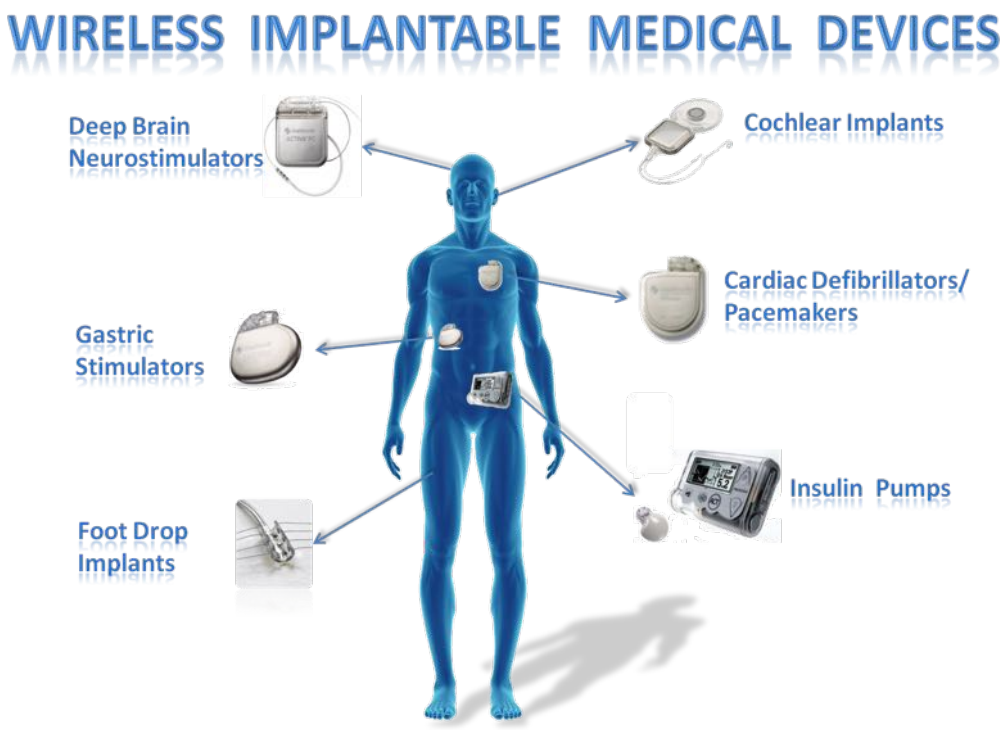
Wireless Devices in a Networked World



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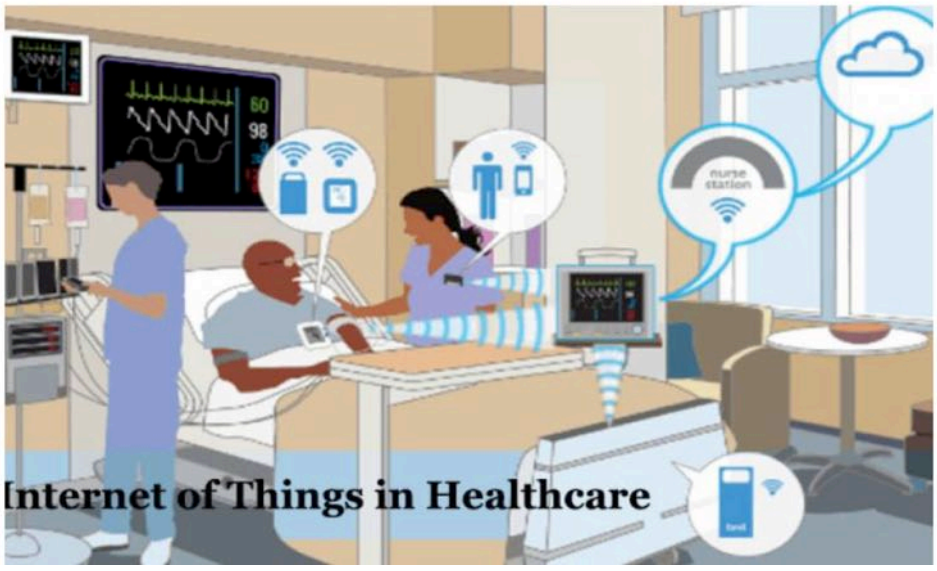
Internet of Things in Healthcare: What are the Possibilities and Challenges?

Ray Parker / 13 Jan 2018 / Health



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Wireless Devices in a Networked World

Getting Connected for Patient Safety. How Medical Device "Plug-and-Play" Interoperability Can Make a Difference

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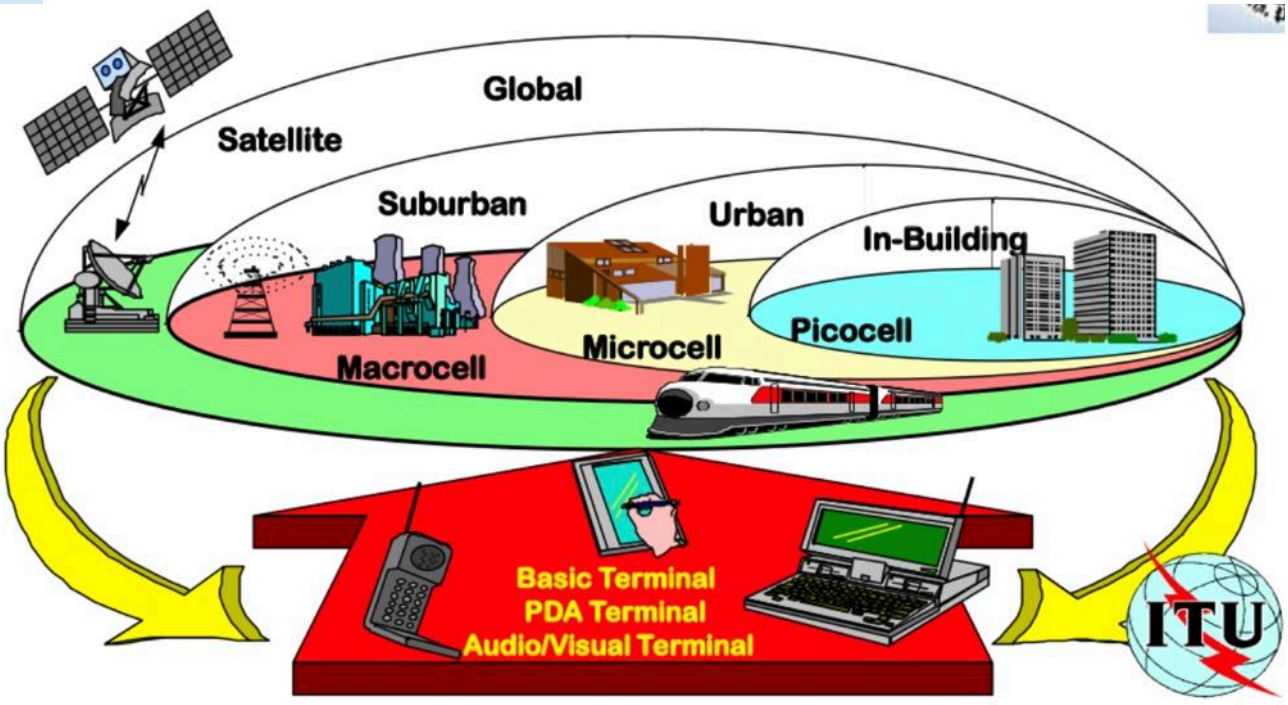
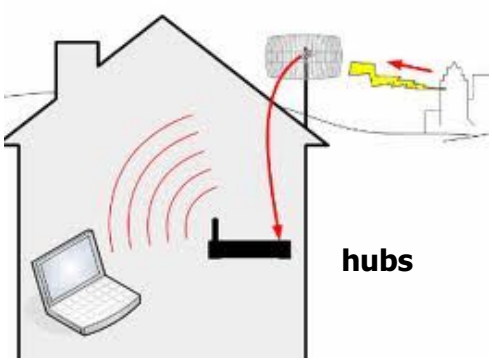
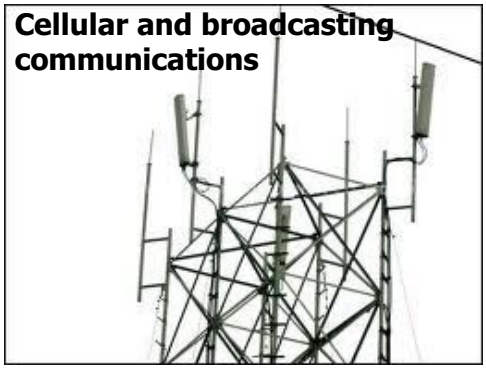
Wireless Devices in a Networked World



Wireless Infrastructures



hubs



Cellular and broadcasting communications

Indoor propagation

Satellite communications

Scales

MACRO-scale

MICRO-scale

Università

Scales

Arecibo Observatory

360° photo

Wireless Electromagnetics Tech.

Shapes

Iphone X

Iphone 4

Number

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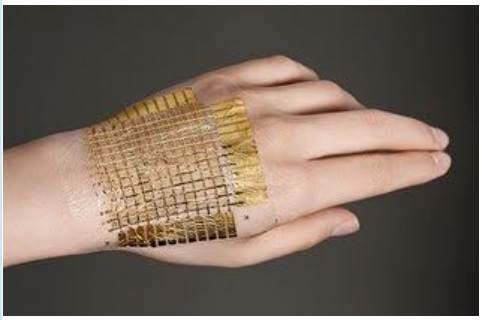
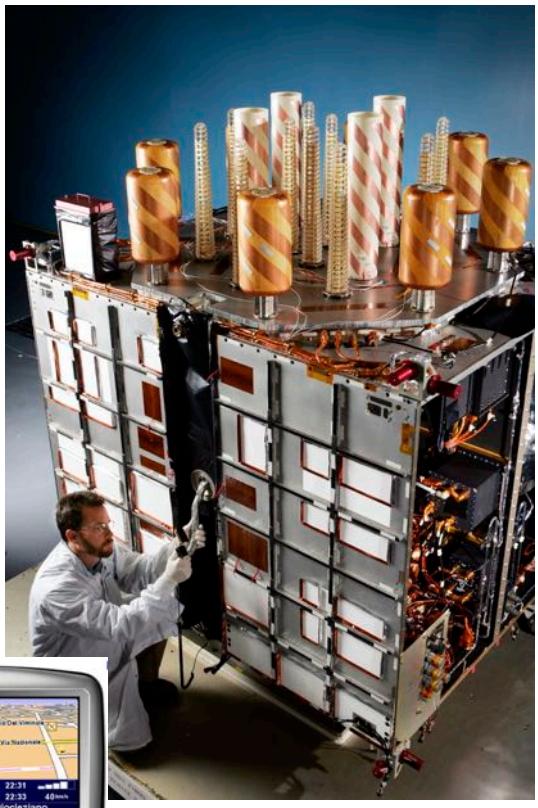
Placement





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Interactions

Wireless Electromagnetics Tech.

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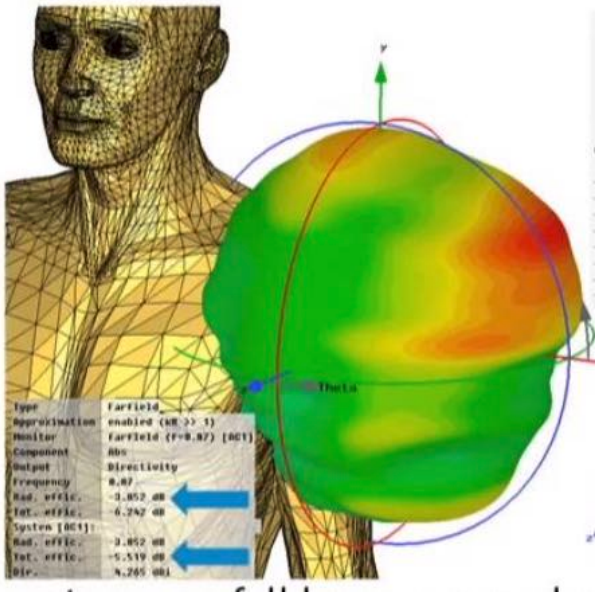
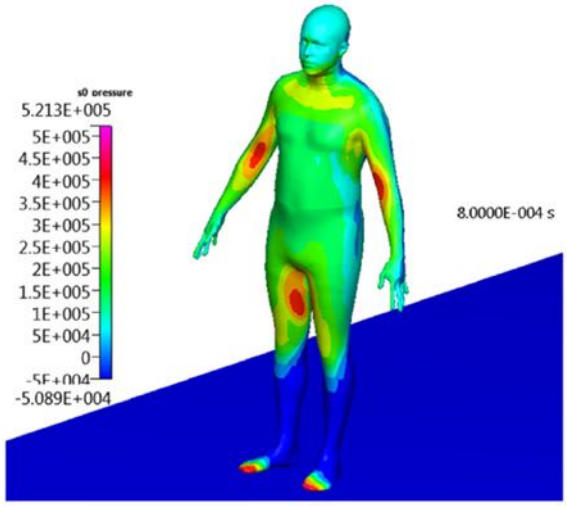
Safety Compliance





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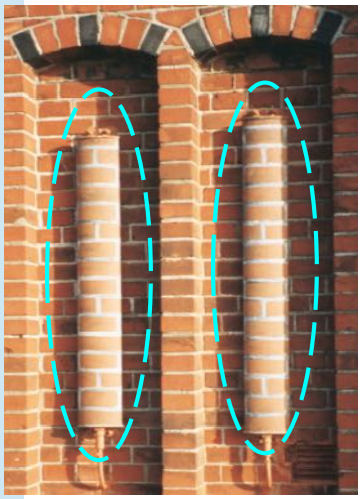
Environment compliance



Painting the antenna with the same texture of the house walls

Hiding the the BSE pylon by means of a ”giant” artificial tree

BSE hidden within a chimneypot-like cover for over-the building applications

Wireless Electromagnetics Tech.

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Compliance with Historical places

San Giovanni in Laterano (Roma)

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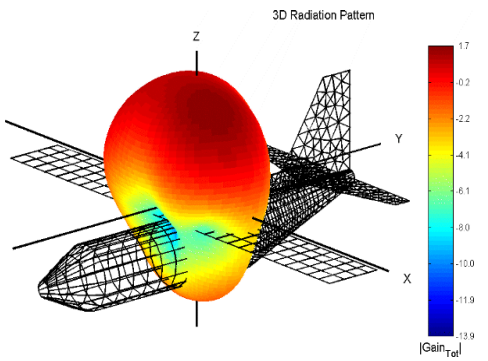
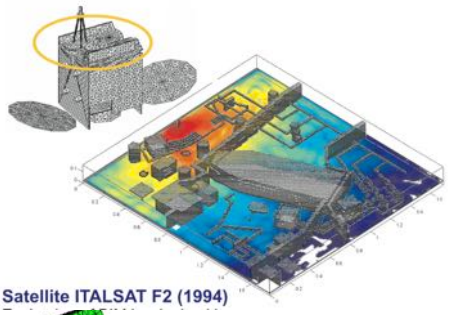
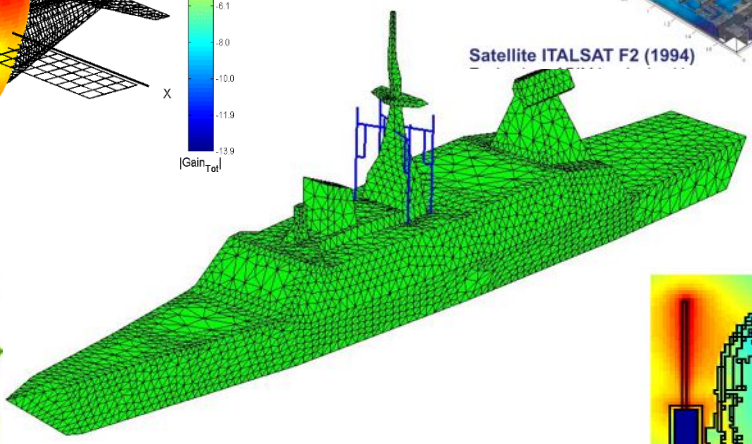
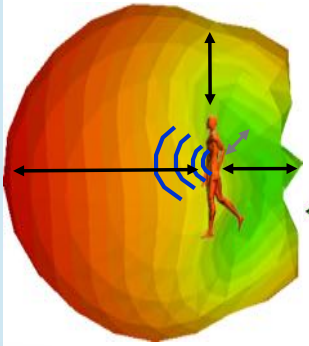
Computer Assisted Modeling

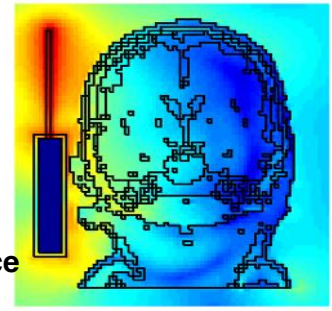








Computer Aided Electromagnetics ⇐ **Physicsl + Mathematics+ Computer Science**



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Program of the course

Modeling
from sources to fields

Design (synthesis)
from field to sources

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Program of the course

1. **Antenna Basics** (from the source to the e.m. field)
2. **Canonical Antennas** (dipoles, loops)
3. **Computer Aided Electromagnetics**
4. **Space-Frequency Processing** (Phased Arrays)
5. **Antennas for Personal and Mobile Communications** (Electronic Antennas)
6. **Wireless Communication Links** (Friis, Rcs, RFID)

6 CFU

+

7. **Broad band communications** (wideband and multi-band antennas)
8. **High-gain communication** (Satellite Antennas)

3 CFU

Exercises:

- Theoretical
- Computer Simulator
- Experimental (lab)

Guests:

Past- alumni from Industry and Research

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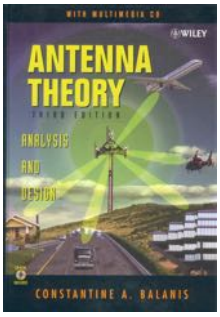
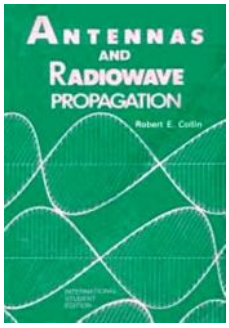
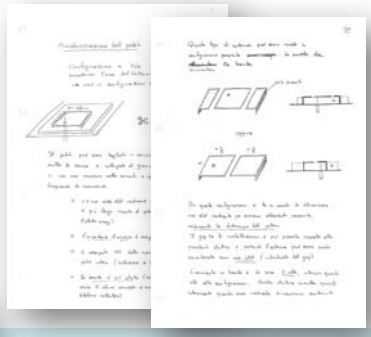
Textbooks



C. Balanis,
Antenna Theory: analysis and design
John Wiley & Sons, 1997
(ISBN 0-471-59268-4)



R.E. Collin,
Antennas and Radiowave Propagation
McGraw-Hill, 1985,
(ISBN-0-07-011808-6)



Lecture notes
(in Italian ..)

www.pervasive.ing.uniroma2.it

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Schedule

Tuesday 14:00 (9)
Thurday 14:00 (B11)
Friday 14:00 (B11)

End lesson (6CFU): Beginning of December

End lesson (9CFU): January 18 2019

Off-lesson explanations:
Thursday 12:00 - 13:00 or after lesson

Anyway Write me..
Gaetano.marrocco@uniroma2.it

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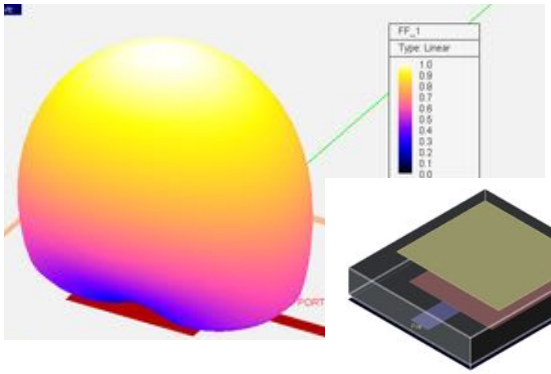
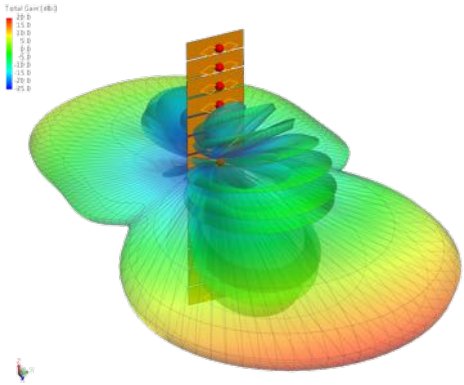
End-course Project

Internet Engineering

Computer model of an antenna for Mobile Communication





➔ **To be completed before the end of the course**

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Exams

1. Project (mandatory)

2. Oral Examinations

I. February 8 2019
II. February 22 2019

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More at www.pervasive.ing.uniroma2.it

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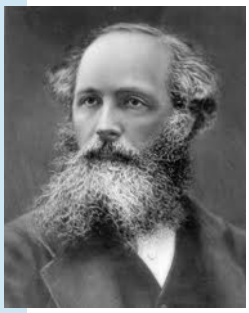
Radio-communication Fathers



James Clerk Maxwell
Mathematician, Physicist
Scotland,
1831-1879 (48y)

Physical-mathematical background

Guglielmo Marconi,
"self" Engineer, Physicist
Italia/England,
1874-1937 (63y)

Wireless transmission

Alan Turing,
Mathematician
England,
1912-1954 (42y)

Automatic Computing

Claude Shannon,
Math&Engineer
England,
1916-2001 (96y)

Information Theory

Chronology

1873	C. Maxwell unified electricity and electromagnetism.
1886	H.R. Hertz developped the first electromagnetic systems comprising a spark generator transmitter (halfwave dipole), a receiver (loop).
1901	G. Marconi sent an electromagnetic signal along trans-oceanic distances by using a 50-wires array powered by a spark generator. A 200m long wire was used as receiving antenna.
1926	High-gain antennas (Yagi-Uda).
1940	New wire antennas in the UHF band (300MHz-3GHz).
1940-45	II World War: microwave antennas up to 1 GHz (apertures, wave guides, reflectors).

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Chronology

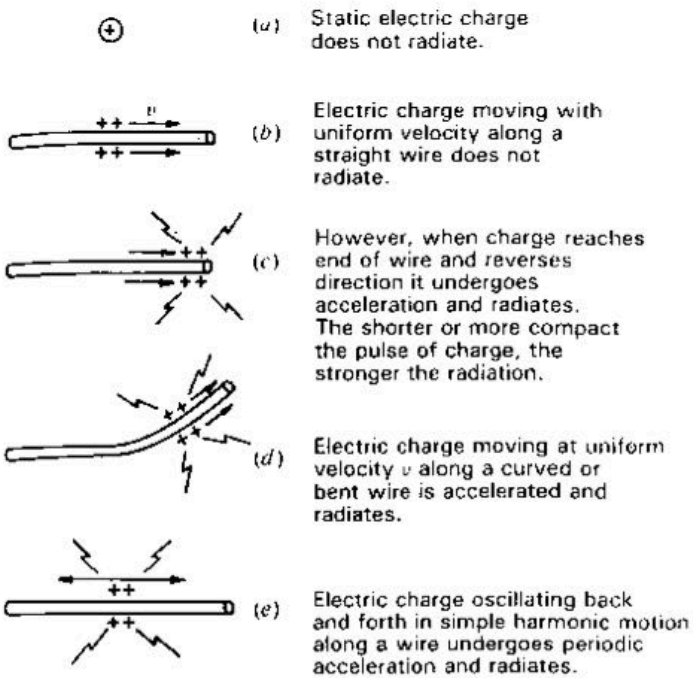
1950	Broadband antennas for TV broadcasting (log-periodic a.)
1960-	Computer-aided modeling and design (numerical methods and tools)
1970-	Microstrip antennas: antennas on PCB (planar circuit boards)
1980-	Active and integrated antennas
1990-	Miniaturized and multi-band antennas for mobile terminals Impulse-radiating antennas (demining, electronic warfare, biomedical imaging)
2000	New materials, smart antennas, RFID
2010-	Sensor networks, bodycentric networks, wearable electronics, skin electronics, UAV, Internet of Things, Interconnected Vehicles, 5G

Radiation basics

Electromagnetic radiation is produced by accelerated charges or by time-varying currents

$$P = \frac{\mu^2 q^2 \dot{v}^2}{6\pi\eta_0}$$

P: radiated power
***q*:** electric charge
***v*:** charge velocity



➔ **NO RADIATION IN DC !!!**

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Radiation basics

radiation by two-accelerated charges along a dipole

Radiation is mostly produced when charges are accelerated/decelerated, e.g. in the middle (acc=0 and at tips (l acc l max).

A wave is radiated when the iso-line of the electric field become closed.

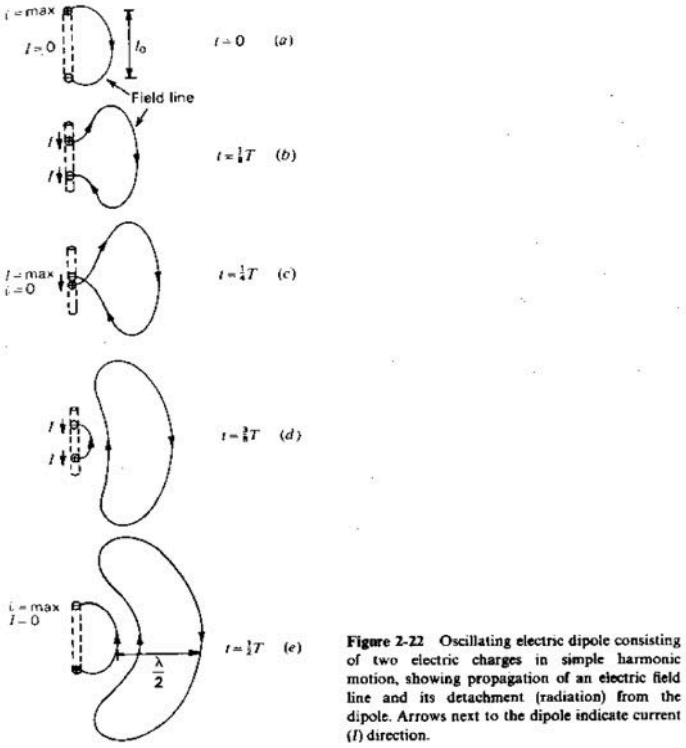


Figure 2-22 Oscillating electric dipole consisting of two electric charges in simple harmonic motion, showing propagation of an electric field line and its detachment (radiation) from the dipole. Arrows next to the dipole indicate current (*I*) direction.

Wireless Electromagnetics Tech.

Radiation basics

The Spark transmitter of Heinrich Hertz

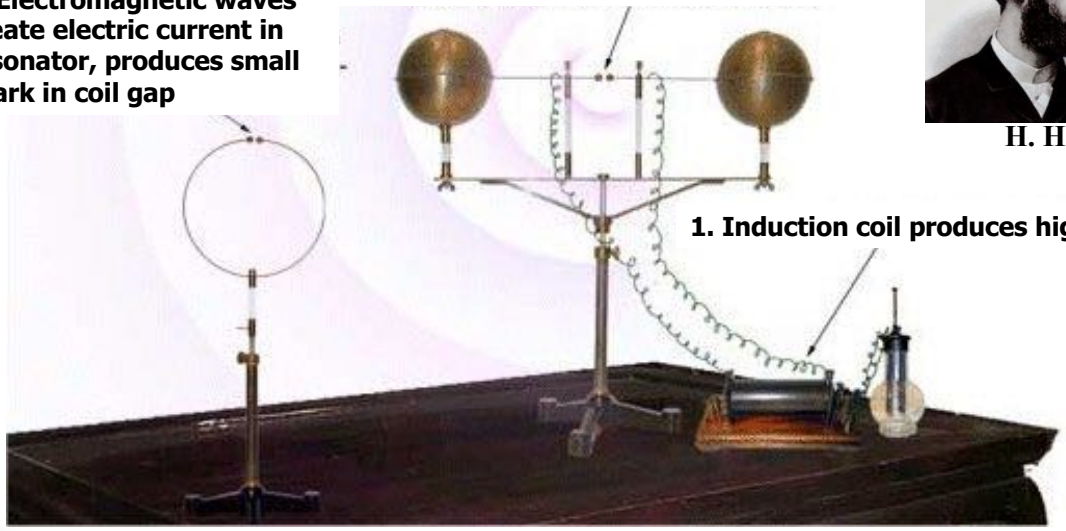
Technical Institute of Karlsruhe (1886)

H. Hertz

2. Sparks produces electromagnetic waves

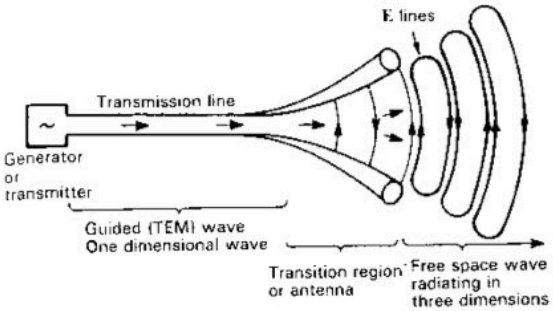
3. Electromagnetic waves create electric current in resonator, produces small spark in coil gap

1. Induction coil produces high voltage



https://www.youtube.com/watch?v=wOtAFgDSVGg
https://www.youtube.com/watch?v=9gDFII6Ge7g

Definition of Antenna



A transducer converting electrons to photons and vice versa

Figure 2-1 The antenna is a region of transition between a wave guided by a transmission line and a free-space wave. The transmission line conductor separation is a small fraction of a wavelength while the separation at the open end of the transition region or antenna may be many wavelengths. More generally, *an antenna interfaces between electrons on conductors and photons in space.* The eye is another such device.

A guided wave traveling along a transmission line which opens out, as in Fig. 2-1, will radiate as a free-space wave. The guided wave is a plane wave while the free-space wave is a spherically expanding wave. Along the uniform part of the line, energy is guided as a plane wave with little loss, provided the spacing between the wires is a small fraction of a wavelength. At the right, as the transmission line separation approaches a wavelength or more, the wave tends to be radiated so that the opened-out line acts like an antenna which launches a free-space wave. The currents on the transmission line flow out on the transmission line and end there, but the fields associated with them keep on going. To be more explicit, the region of transition between the guided wave and the free-space wave may be defined as an *antenna*.

We have described the antenna as a transmitting device. As a receiving device the definition is turned around, and an antenna is the region of transition between a free-space wave and a guided wave. Thus, *an antenna is a transition device, or transducer, between a guided wave and a free-space wave, or vice versa.*[2]

While transmission lines (or waveguides) are usually made so as to minimize radiation, antennas are designed to radiate (or receive) energy as effectively as possible.

The antenna, like the eye, is a transformation device converting electromagnetic photons into circuit currents; but, unlike the eye, the antenna can also convert energy from a circuit into photons radiated into space.[1] In simplest terms *an antenna converts photons to currents or vice versa.*

Definition of Antenna