RF Systems

Master degree in:

Telecommunications Engineering
Electronic Engineering

Teacher:
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Contact

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Office hours: Thursday 15.00 – 18.00

Lessons Organization

All the lessons will be given in presence and transmitted in streaming (Webex platform). Students alternate presence and streaming according this scheme (Team A: even person code, Team B: odd person code):

Tuesday (9:30-11:30, classroom 2.1.1)
Team A: presence, Team B: remote
Wednesday (12:30-14:30, classroom 26.0.4)
Team A: remote, Team B: presence
Thursday (9:30-11:30, classroom 2.1.2)
Team A: presence, Team B: remote
Friday (15:30-17:30, classroom 21.0.3)
Team A: remote, Team B: presence

Practical information (2)

Examination procedure

The exam consists of a written test.

If the score exceeds 27, an oral verification may be requested (at the teacher' discretion)

Midterm Exam

This year, due to the limitations imposed by the risk of COVID-19 epidemic, the midterm exam will not take place.

Aim of the Course

To introduce the methodologies to model, analyze and design the radio front-end of a communication system.

The first part of the course is devoted to the analysis of the various blocks composing the receiving and transmitting units of a front-end from the functional point of view.
In the second part, the basis of the microwave circuits are introduced and the techniques for the analysis and design of various devices used in the RF front-end are illustrated

Program of the Course (Summary)

- First part (systems)
  - Basic blocks of a communication system
  - Frequency conversion and conversion receiver
  - Noise
  - Antennas
  - Link budget
  - Linear and non-linear distortion
  - Behavioral model of systems components (amplifier, mixer, etc.)
  - Figure of merit of a RF System. System simulation with dedicated software

- Second part (microwave circuits)
  - Matrix characterization of *n*-port networks
  - Introduction to microwave circuits
  - Impedance matching
  - CAD of microwave circuits
  - Recalls on planar technologies
  - Design of narrow band microwave amplifiers and microwave oscillators
- Innovative Didactics (flipped classroom)
  - Linearization through pre-distortion and feedforward (1 credit)

Suggested Bibliography

Michel Steer: *Microwave and RF Design*: *A System Approach*. Scitech Publishing, Inc.
David M. Pozar: *Microwave Engineering*, Addison-Wesley
Sophocles J. Orfanidis: *Electromagnetic waves and Antennas* Free download from:
http://www.ece.rutgers.edu/~orfanidi/ewa/

On the teacher's web site (**http://home.deib.polimi.it/macchiar)** you can find the slides used during the lectures (and other teaching aids)

RF Systems

Introduction

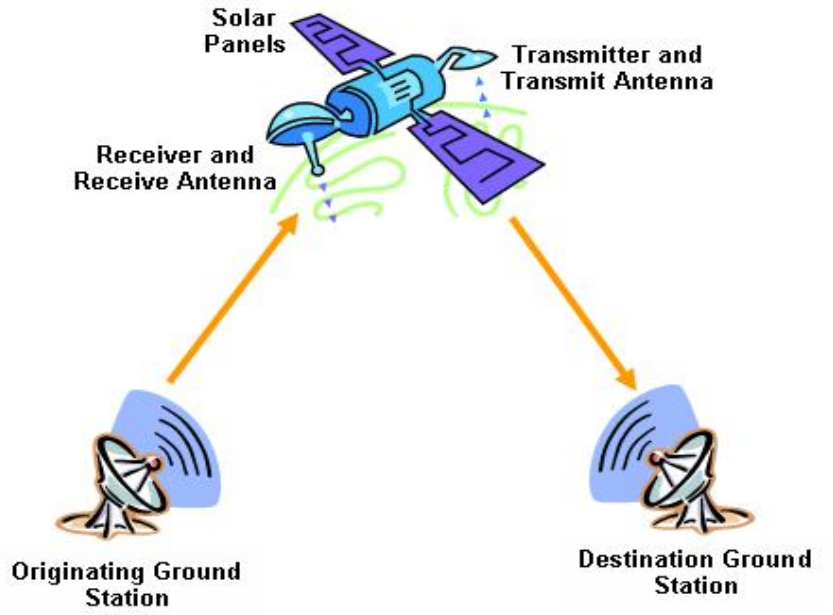
What are RF Systems?

For exchanging information by means of electrical signals we need to associate the information to the signal itself. This process is called modulation and the signals so generated are called modulated signals.
Modulation is also used to move the spectrum of a signal to a frequency sufficiently high to allow the free space propagation (wireless transmission). In this case the bandwidth of the signal is much smaller than its center frequency and the signal is referred to as a **RF Signal.**
All those system dealing with RF Signals are called **RF Systems**

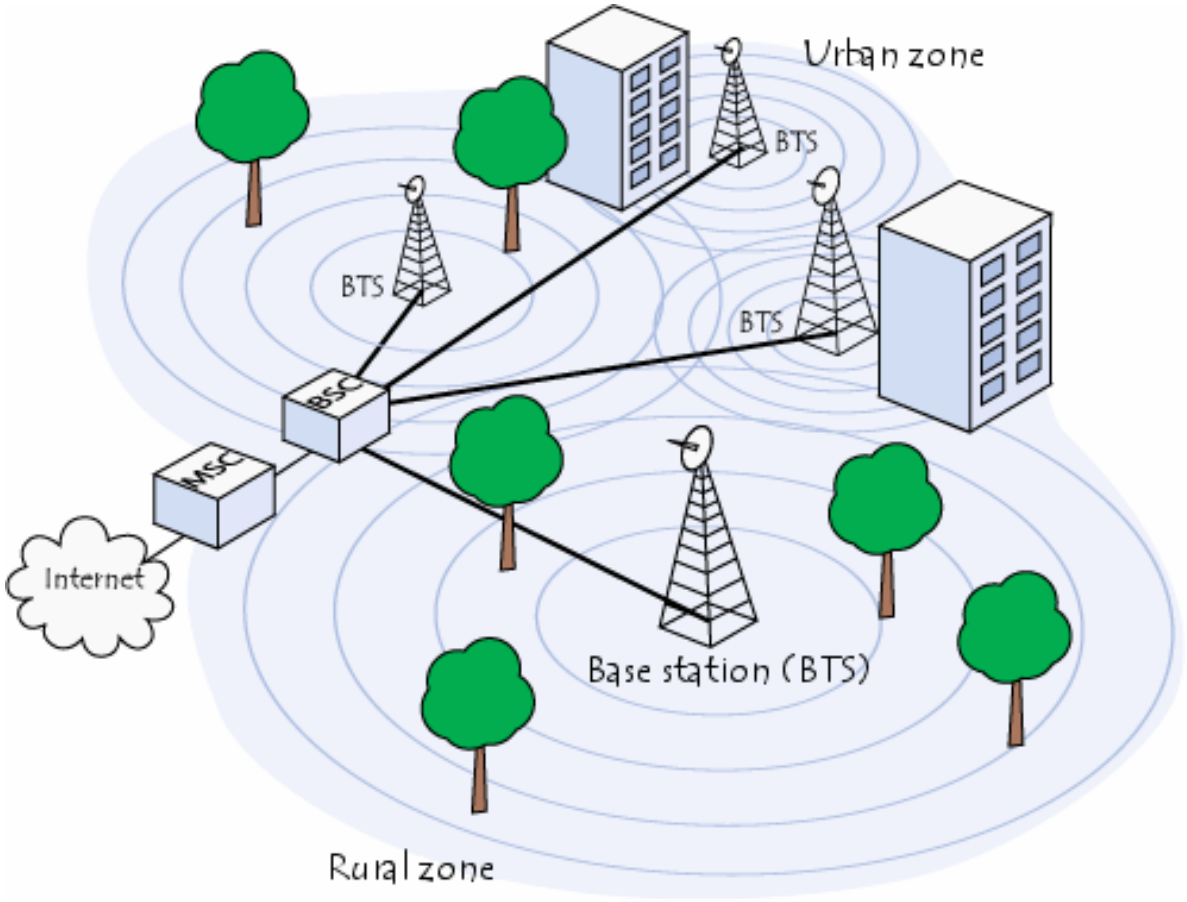
Example of modern RF Systems

Terrestrial Radio Links

Satellite Links

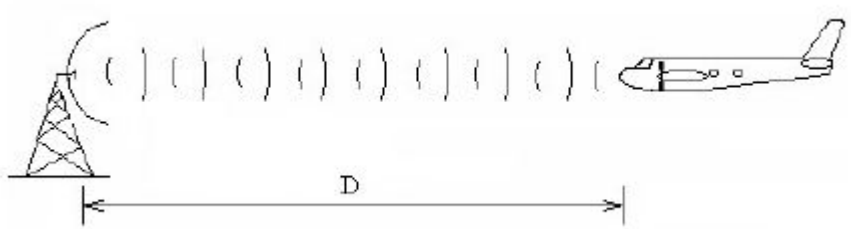


Cellular communications

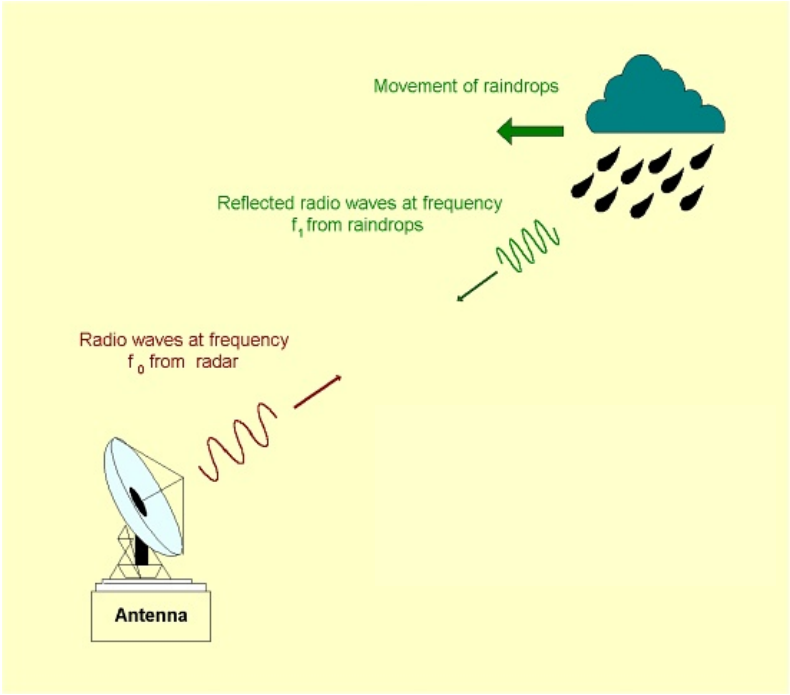


Radar

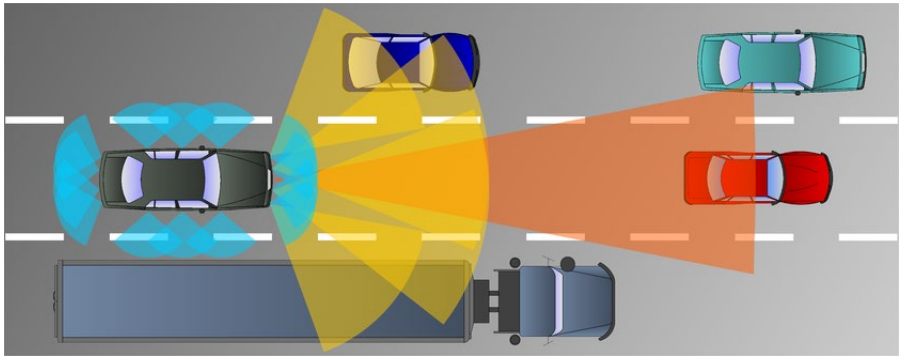
Discovery



Weather

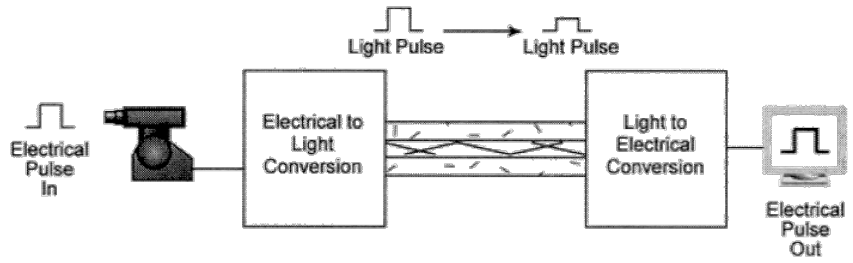


Automotive



Other applications of RF signals

- Intermediate frequency for optic fiber links



- Radio astronomy
- Industrial RF heating
- …..

What is the common feature in all these systems?

- The use of a carrier frequency in the microwaves range!

Microwaves in RF Systems

- The word *microwaves* identifies the range of electromagnetic spectrum spanning from 300 MHz to 300 GHz (approximately). The wavelength of these signals is then between 1m and 1mm
- The small wavelength has a number of beneficial effects, which have been exploited in telecommunications to achieve goals very difficult (or even impossible) to obtain at lower frequencies of the electromagnetic spectrum
- One of the most important advantage is the relatively high gain of the antennas used at microwaves (the gain increases, for a given antenna size, with the frequency of the radiated signal)
- The gain of the antennas is a consequence of the directivity: the radiated energy is concentrated in a preferential direction (less wasted energy, less interferences between services using the same frequency)

- Applications made possible by the microwaves in telecom:
  - ✓ Satellite Communications (global radio coverage of the earth by means of geo-stationary satellites)
  - ✓ Very broadband communication systems ((the higher is the carrier frequency, the larger can be the bandwidth of the modulated signal)
  - ✓ RADAR (detection of objects by means of radio waves) and GPS (definition of the global position through radio waves)
  - ✓ Radio aids to air navigation (accuracy of ILS depends on wavelength)
  - ✓ Mobile communications (today this is the most rapidly growing segment of the global telecommunications market)

Microwave Circuits

- The technology requested for realizing microwave circuits is quite different from the one used in electric circuits operating at lower frequency (where the size of the components is much smaller than the wavelength)
- Microwave circuits typically employ distributed components, which are realized by transmission lines suitably interconnected. They may also include lumped components (specifically in case of circuits with active devices), but the dimensions must satisfy the previous condition
- Using suitable semiconductor materials (GaAs), the realization of integrated circuits at microwave frequencies (MMIC) has become possible in recent times.