Msc Engineering Physics (6th academic year)
Royal Institute of Technology, Stockholm
August 2002 - December 2003

1 2E1511 - Radio Communication (6 ECTS)

The course provides basic knowledge about models and methods of analysis for modern radio communication systems. Special emphasis is given to propagation models for mobile and portable wireless communication and to the fundamental design of radio communication systems and their performance measures.

1.1 Aim

The student should be able to apply propagation models and design basic radio communication links with respect to Signal-to-Noise ratio and outage probabilites.

1.2 Syllabus

- Introduction, historical background. The EM-spectrum. International cooperation and spectrum management.
- Brief review of EM-field theory. Basic propagation mechanisms: free-space propagation, plane-earth models, ground wave. Diffraction. Tropospheric propagation (refraction). Ionospheric propagation. Fieldstrength prediction at VHF/UHF: Okomura-Hata:s model, Multiple Knife-edge diffraction-models. Computer based prediction models.
- System models: Linear time-invariant models, Time variable models, Stochastic models. WSSUS models, correlation properties, delay spread and doppler spectrum. Flat fading and frequency selective channels. Models for mobile radio channels: Rayleigh- and Nakagami-Rice fading, doppler spreading. Log-normal fading.
- Antennas: Basic principles. Transmission lines. Radiation patterns diagram, antenna gain and efficient antenna area. Reciprocity. Common antenna types and their applications.
- Transmitters & Receivers: Historical background, simple receivers, superheterodynes. Spurious. Performance: Selectivity, Intercept point. Noise: Noise sources, noise temperature, sensitivity, noise factor. Cascade rule.

- Radio link design: System performance: Link budget, Availability & outage, Fade margins.
- Diversity. Diversity principles, Combining techniques: Selection diversity, Maximum-ratio/equal gain combining, switching diversity. Performance analysis.

2 2F1521 - Speech Signal Processing (6 ECTS)

Signal processing methods for speech analysis, speech compression and speech synthesis, including speech enhancement and speaker recognition.

2.1 Aim

To provide a good understanding of commonly used speech-processing techniques, and to provide practical experience with signal processing methods.

2.2 Syllabus

- Production and classification speech sounds.
- Acoustics of speech production: tube model, discrete-time modeling.
- Modeling of speech: all-pole and pole-zero modeling.
- Short-term Fourier transform.
- Filter-bank analysis and synthesis.
- Auditory modeling.
- Sinusoidal analysis/synthesis.
- Pitch estimation.
- Nonlinear measurement and modeling techniques.
- Speech Coding: quantization, analysis-by-synthesis techniques.
- Speech enhancement: spectral subtraction, Wiener filtering.
- Speaker recognition: Gaussian mixture modeling.

3 2E1340 - Digital Signal Processing (7.5 ECTS)

Fourier transforms, spectral analysis, non-parametric estimation, quantisation errors, model based signal processing, the least squares method, multirate signal processing.

3.1 Aim

The course will present different methods for digital processing of signals. Of main importance is the ability to understand and analyse situations where only a small number of samples are available for signal analysis or parameter estimation, and how to handle noise and other types of errors.

3.2 Syllabus

- The Two-sided Z-transform. The Discrete Fourier Transform (DFT). Computation of the DFT using Fast Fourier Transform (FFT-algorithms). Use of FFT in Filtering of Long Data Sequences. Nonparametric Methods for estimation of power spectra and correlation functions. Windowing.
- Decimation and interpolation. Multirate Signal Processing.
- Conversion of Analog Signals into Digital form. Quantisation Errors. Round-off effects. Quality Measures. Model based Signal Processing. AR, MA and ARMA models of Stochastic Processes. Linear Prediction, Lattice Filters. Minimum Mean Square Estimation.
- Parametric Methods for Power Spectrum Estimation. Non-linear Least Squares estimation. Subspace methods. Maximum Likelihood. Signal Processors. Applications.

4 2E1431 - Communication Theory (9 ECTS)

Digital communication, information theory, coding, signal detection, modulation.

4.1 Aim

The course gives a broad orientation of the principles for digital communication, with a concentration on signal detection and digital communication systems. Formulation and analysis of simplified communication models are important elements in the course

4.2 Syllabus

- Fundamental limits of performance: Introduction to information theory, entropy and mutual information, source coding, channel capacity.
- Signal detection: Vector representation of signals and noise. The additive white gaussian noise channel (AWGN). Receiver structures and error probability.
- Waveform coding techniques: Quantization noise, signal-to-noise-ratio. Pulse code modulation (PCM), differential PCM (DPCM), adaptive DPCM (ADPCM), delta modulation (DM), adaptive DM (ADM).

- Baseband systems: Antipodal, unipolar, bipolar and orthogonal systems. Intersymbol interference (ISI), the Nyquist condition, channel equalization.
- Digital modulation techniques: Amplitude-, frequency- and phase-shift keying (ASK, FSK, PSK). Coherent and non-coherent systems. Quadrature amplitude modulation (QAM) and minimum shift keying (MSK). Error probability and power spectra. Bandwidth efficiency.
- Error control coding: Block codes and convolutional codes. Combined coding and modulation.

5 2H1260 - Antenna Theory (7.5 ECTS)

The course provides knowledge in general properties of antennas, the electromagnetic theory behind their operation, and an overview of different antenna systems. Equal weight is placed on the electromagnetic aspects important for antenna design and on system aspects. Among the systems discussed are radar, cellular, and adaptive antenna systems.

The course is suited both for antenna designers and those who encounter the antenna as a sub-component in a system.

The course includes three computer exercises which are solved using MatLab and commercially available antenna software.

5.1 Aim

After the course, the student should:

- have knowledge of the different parameters and properties used to characterize antennas.
- be able to make theoretical calculations of fundamental antenna elements such as dipoles and aperture antennas.
- be able to use commercially available program for antenna simulation.
- have knowledge of some antenna systems and the demands of such on the antenna components.

5.2 Syllabus

- Introduction - Examples of antenna systems, radiation patterns, directivity, polarization, antenna impedance, effective area, Friis' equation, the radar equation, antenna temperature and noise.
- Antenna radiation - the antenna as a source of radiation, duality and reciprocity, near- and far-field form a dipole, image theory, mutual coupling. Aperture antennas and Babinet's principle, microstrip antennas. Linear and planar antenna arrays, synthesis of radiation patterns.

- Physical limits - Super directivity, bandwidth vs. size, mutual resistance and correlation.
- Practical design - High gain, conformal, low frequency, and terminal antennas.
- System aspects - Radar, radar cross-section of antennas, radio propagation, link budget, fading space and polarization diversity. Cellular and sector systems, adaptive and multi-beam antennas.

6 2E1512 - Wireless Networks Project Course (12 ECTS)

The course provides in-depth knowledge within the area wireless communication networks. Special emphasis is put on spectrum resource management issues and the capacity analysis in personal communication systems.

6.1 Aim

The students should upon passing the course be able to apply the most important techniques for analysing the capacity of wireless multiuser communication systems. Another objective is to prepare the students for the master thesis, providing elementary skills in research methodology.

6.2 Syllabus

- Fundamentals of wireless area communication systems: Structure and functional blocks. Performance measures: coverage, quality, capacity, Traffic models. Quality of Service (QoS) classes and negociation. Introduction to the Radio Resource Management (RRM)-problem.
- Link performance in interference limited systems: Muliple Access Communication Systems. Orthogonal, non-orthogonal signalling (F/T/CDMA).
- Cellular system concept: Cochannel interference, spectrum reuse, simple capacity analysis, blocking.. Fading models, combined outage/blocking analysis. Advanced cell structures: Sectorization, Hierarchical systems (macro/micro/picocells), adaptive antennas, SDMA.
- Simulation tools for cellular network analysis(RUNE). # Handover & Mobility Management
- Dynamic Resource Allocation
- Transmitter Power Control: Optimal power control. C/I balancing,Removal/Admission strategies, Multirate power control.
- Frequency Hopping Systems: Random Resource allocation
- DS-CDMA systems: Capacity calculations, Power control, Soft-Handoff, Dynamic Cell Management

- Packet-oriented wireless access systems: Delay/Throughput. Multiple Access protocols. ALOHA, CSMA, CRA,PRMA. Wireless LAN:s IEEE 802.11, Hiperlan/2
- System examples: GSM, DECT, IS95(CDMA). DAB/DTV, UMTS/WCDMA, Bluetooth