**ADVANCED MODULATION TECHNIQUES AND CHANNEL CODING**

**(DC2: 2022-2023)**

**Introduction**

Review of the traditional analog modulation systems (AM and FM).

[Haykin] Ch. 2: Secs. 2.1 to 2.7 (i.e., 2.1, 2.2, 2.3, …, 2.7), also 2.15.

Review of the traditional digital modulation systems: Base-Band (PAM). Matched Filter. ISI. Nyquist Pulses.

[Haykin]. Ch. 3: Secs. 3.1, 3.2, 3.3; Ch. 4: Secs. 4.1, 4.2, 4.3, 4.4, 4.5, 4.7, 4.9, 4.12.

Review of the traditional digital modulation systems: Pass-Band (QAM, PSK, FSK).

[Haykin]. Ch.6: Secs. 6.1 to 6.4.

*Or [Carlson]. Ch. 4, Ch. 5. Ch.11: Secs.11.1, 11.2, 11.3; Ch. 14: Secs. 14.1, 14.2, 14.4.*

*Or [Lee-Mess]. Ch.5: Secs. 5.1, 5.2, 5.3.*

**Modulation and demodulation for the AWGN channel**

Characterization of signals and noise waveforms. Vector spaces.

[Haykin] Ch.5: 5.1, 5.2; or [Bellini1] Ch.1.

or, [Proakis] Ch.4: 4.1, 4.2;

or, [Carlson] Sec.16.4;

or, [Lee-Mess] Sec. 2.6.

Modulation and demodulation for the Additive White Gaussian Noise channel (AWGN). The optimal receiver for the AWGN channel. Performance estimation. The Union bound.

[Haykin] Ch.5: 5.3 to 5.8; or [Bellini1] Ch. 2.

or, [Proakis] Ch.5: 5.1.1 – 5.1.3, 5.2.1, 5.2.2;

or, [Carlson] Sec.16.5;

or, [Lee-Mess] Sec. 7.1, 7.2, 7.3.

**Continuous Phase Modulation techniques (CPM)**

Introduction. Full and partial response CPM. Optimal and simplified receivers. Power spectrum estimation. Practical examples (GMSK, TFM, ...).  
Papers (in web); [Bellini1] Ch.7.

or [BenBigl] Ch.6: 6.1 to 6.5;

or [Haykin] Ch.6: 6.5;

**Spread Spectrum Modulation and Code Division Multiple Access techniques**

Direct Sequence Spread Spectrum modulation (DSSS). Spreading and de-spreading. M-sequences. Introduction to the Rake-receiver. Introduction to Code Division Multiple Access systems (CDMA).

Paper (in web); [Haykin] Ch.7: 7.1 to 7.6;

or, [Proakis] Ch.13: 13.1 to 13.2;

or, [Stuber] Ch.9;

or [Carlson] Ch.15.

**Orthogonal Frequency Division Multiplexing (OFDM)**

Transmitter and receiver. Channel equalization in the frequency domain. Effects of non-linearities. Examples of applications of OFDM.  
Papers in web.

Or [Stuber] Ch.10.

Or [Haykin] Ch.6: 6.12, 6.13.

Or [Proakis] Ch.12: Sec. 12.2.2

Or [Bellini1] Ch.6: 6.13.

**Linear block codes**

The generation matrix and the parity check matrix. Cyclic codes. Hard and soft decision decoding. Performance evaluation. Burst error correction. Examples.

[BenBigl] Ch.10; [Bellini2] Ch.2.

or [Lee-Mess] Ch. 12;

or [Haykin] Ch. 10: Sec.10.1 to 10.4;

or [Proakis] Ch.8: Sec.8.1;

or [Stuber] Ch.8: Sec.8.1

or [Carlson] Sec.13.2  
  
**Convolutional codes**

Definition. Optimum decoding. The Viterbi algorithm. Performance evaluation. Classic concatenated codes. Examples.

[Bellini2] Ch.3; [Haykin] Ch. 10: Sec.10.5, 10.6;

or [Lee-Mess] Ch. 12;

or [BenBigl] Ch.11: Sec.11.1

or [Proakis] Ch.8: Sec.8.2;

or [Stuber] Ch.8: Sec.8.2

or [Carlson] Sec.13.3

**Recent trends in channel coding**

Turbo codes.

Papers; [Bellini2] Ch.7; [Haykin] Sec.10.8, 10.9

or [Lee-Mess] Ch. 12;

or [BenBigl] Ch.11: Sec.11.2;

or [Stuber] Sec.8.8

Low Density Parity Check codes.

Papers; [Bellini2] Ch.7; [Haykin] Sec.10.10, 10.11, 10.12;

or [Lee-Mess] Ch. 12;

[Haykin] Simon Haykin, Communication Systems, 4th ed., Wiley, 2001

[Carlson] Bruce Carlson, Communication Systems, 4th ed., Mc Graw Hill, 2002.

[Proakis] J. G. Proakis, Digital Communications, McGraw-Hill.

[BenBigl] S. Benedetto, E. Biglieri, Principles of Digital Transmission, Kluwer Academic-Plenum Publishers.

[Stuber] Gordon Studer, Principles of Mobile Communication Systems, 3rd ed., Springer, 2011  
[Bellini1] Fondamenti di trasmissione numerica, CUSL (fbell.pdf)

[Bellini2] Teoria dell’informazione e codici (tinfcod3.pdf)

[Lee-Mess] Digital Communication, John. R. Barry, Edward A. Lee, David G. Messerschmitt, 3rd ed.