| Country | Institution | Module | ECTS |
|---|---|---|---|
| BULGARIA | Vasil Levski National Military University | **Error Correcting Codes** | **5.0** |

| Service | Minimum Qualification for Lecturers |
|---|---|
| **All** | • English: Common European Framework of Reference for Languages (CEFR) Level B2 or NATO STANAG 6001 Level 2.<br>• Information theory basics.<br>• Digital data transfer.<br>• Boolean Algebra. |
| Languages<br>**English, Bulgarian** | |

| Prerequisites for international participants: | Goal of the Module: |
|---|---|
| • English: Common European Framework of Reference for Languages (CEFR) Level B1 or NATO STANAG Level 2.<br>• Begining of the 3rd year of national (military) higher education.<br>• Communication theory basics. | • Presentation of techniques for correcting digital data, rules and procedures of mathematical equations generation.<br>• Development of technological skills for digital data conversion and coding.<br>• Bit error rate analysis in digital communication channels.<br>• Underlying the importance of digital signal processing.<br>• Acquiring knowledge of contemporary communication networks and systems. |

| Learning outcomes | | |
|---|---|---|
| | Knowledge | • Analog to digital data conversion.<br>• Principles, rules and procedures of digital data error correction coding in transmitters.<br>• Principles, rules and procedures of digital data error correction decoding in receivers.<br>• Mathematical equations for digital data representation.<br>• Procedures and algorithms for error correction coding.<br>• Algorithms for error correction decoding. |
| | Skills | • Digital data codeword conversion.<br>• Single Bit error correction.<br>• Multiple bit error correction.<br>• Decoding with Viterbi algorithm.<br>• Describing the process of error correction in transceivers.<br>• Communicate within the team during problems solving. |

| | | |
|---|---|---|
| | Competences | • Appropriate choice of error correcting scheme according the BER and Signal-to-Noise ratio.<br>• Performing Bit Error Rate (BER) analysis.<br>• Mathematical operation with Galois Field (GF) elements.<br>• Implementation of GF prime elements in error correction.<br>• Application of digital signal processing (DSP). |

**Verification of learning outcomes**

- **Observation**: Throughout the Module students are to accomplish bit error correction tasks individually or in teams. The Module has two Chapters which include block and convolution coding – the most used methods in digital communications.
- **Test**: At the end of each Chapter the students have to accomplish specific calculation tasks given by the tutor:
  - error correction coding and decoding if 1 bit was lost;
  - error correction coding and decoding if 2 bits were lost;
  - error correction coding and decoding if burst errors occur.

| **Module Details** | | |
|---|---|---|
| **Main Topic** | **Recommended WH** | **Details** |
| **Chapter I "Block coding"** | | |
| Hamming codes | 6 | • General considerations regarding Hamming distance.<br>• Knowledge of essential principles, rules and procedures of creating syndrome matrix.<br>• Bit position encoding. |
| Cyclic codes | 16 | • Generator polynomials<br>• One bit error correction<br>• Multiple bits error correction<br>• Bose-Chaudhury-Hocquengem codes<br>• Reed-Solomon codes |
| **Chapter II "Convolutional coding"** | | |
| Basic Principles of convolutional codes | 12 | • Methods for convolutional code description.<br>• Generator polynomials.<br>• Maximum likelihood algorithm.<br>• Viterbi Algorithm |
| Practical Aspects of Turbo codes | 10 | • Matrix interleaving.<br>• Convolutional coders concatenation<br>• The Viterbi deciding algorithm for turbo codes. |
| **Additional hours to increase the learning outcomes** | | |
| Self-Study | 3 | • Enhancing knowledge by studying specific documents.<br>• Reflection of the topics issued. |
| Total | 75 | |