Surname, Name, Matr. (ID): ..... Signature: .....

Answer to the questions carefully, and according to the order assigned in the text. An answer consisting of ONLY FEW LINES of text will be considered NOT sufficient.

If the hand written text and the general organisation of the answers on the paper will not be CLEANLY and CLEARLY written, and therefore difficult to be properly read and interpreted, the answer would NOT BE TAKEN into account in the final evaluation.

Any NOT GIVEN or COMPLETELY WRONG answer will be taken into account negatively (i.e., producing a penalty (negative marks)) in the overall evaluation.

Part1 (Exercises on Error Control Codes)

1.
   - A block code is characterized by the Generator matrix given in Figure 1. Determine the possible codewords.
     Determine the parity check matrix, and indicate the values assumed by one of the sindromes associated to a possible single bit error, a possible two bits error, and a possible 3 bits error. How many different distinct (not the same) sindromes are possible, in case of one error ?

$$G = \begin{bmatrix} 0 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 0 \end{bmatrix}$$

   - Consider a block code with $N = 48$, $K = 24$, $d = 12$. Determine the number of possible codewords, the probability of error (hard decision, using the more precise approximation), and the minimum bandwidth required to transmit 10 Mbit/sec.

2. Consider the BCH code of length $N = 31$ and generator polynomial (in octal description) 107657. In this code there is 1 word composed by all zeros, 155 words with 7 ones, 465 with 8 ones, 5208 with 11 ones, ...
   - What is the generator polynomial of this code (g(D)= ...) ? Determine the number of possible codewords, and the probability of error (in case of hard and soft decision).

3. Consider a convolutional code with $R = 1/2$, and octal generators $(5, 7)$.
   - Draw the tree diagram of the code.
   - Determine the code word associated to the information sequence 010101100, and the minimum bandwidth required in case of an information bit-rate equal to 10 Mbit/sec.
   - Determine and draw the trellis diagram of the code.

Part2 (Modulation systems)

1. Basic Theory
   - Define and describe the equations related to the concept of "complex envelope".
   - Indicate the use of this concept in case of OFDM modulation.
2. OFDM
   - Describe the block diagram of an OFDM encoder and decoder.
   - Describe in some detail the channel equalization procedure used in the OFDM modulation systems, indicating the role of the cyclic prefix and of the pilot carriers.
3. DSSS
   - Define and describe the basic properties of the m-sequences. Why are this seq. used in the DSSS modulation ?
   - Describe the basic ideas used in the CDMA systems, giving an idea about its performance.
4. CPM
   - Draw the phase-tree in the case of MSK modulation.
   - Describe the analytical expression of the likelihood function that should be maxi-mized by the optimal receiver in the case of MSK modulation.
5. Turbo-LDPC Codes
   - Describe the basic idea of the Tanner graphs, using a simple example.
   - Describe the basic idea of the bit-flipping algorithm for the decoding of an LDCP code.