Laboratory 1: Linear Block Codes

1 Objective

Objective of the lab: The objective of this lab is to give the student some practical exposure to the concepts and theory of linear block codes presented in class.

2 Requirements

Note: This lab requires some preparation, in terms of theoretical background as well as the use of the tools (use of the D-Lab, Matlab, the m-files, etc.).

Instructions, source material and preparation required:

- You are required to do all the preparation needed to implement the algorithms beforehand.
- Lab partners must operate in groups of two (and no larger) and may help each other during the lab but each should use his/her unique messages or codewords in all the exercises and write his/her own lab report.

Report: The report will take the form of the following group of files which should all be attached to a single email:

- An answer sheet (in PDF format) with your name and your lab partner's name and student numbers, the date and experiment number, and your results for the various questions.
- All the m-files used in the lab.

3 Assignments

3.1 Assignment 1: Encoding

1. Generate the Hamming (7, 4) code C_1 based on the Equation 2.6 (hand-out 1)
2. Generate the Hamming (7, 4) code C_2 based on the generator polynomial $g(x) = 1 + x + x^3$ (Hint: in Matlab, polynomial multiplication and division can be implemented by the functions 'gfconv()' and 'gfdeconv()')
3. Compare C_1 and C_2
4. Systematic encoding of the Hamming (7, 4) code (Hints: parity bits are generated by $m(x)x^{n-k}/g(x)$)
5. Calculate the minimum Hamming distance of C_1
   (a) Two rather simplistic ways of calculating the minimum distance of a code is:
   - Go through all the possible combinations of combining the basis vectors in $\mathbf{G}$ (which is the same as calculating the weight of every nonzero codeword).

- Go through all the possible combinations of adding the column vectors of the **H** matrix.

6. Calculate the minimum weight of C_1
7. Find out the relationship of the minimum weight and the minimum Hamming distance of a linear block, and state the reason in the report
8. Use your student number and encode it with the generator matrix **G**. The message is constructed as follows: Assume your student number is 0608851N. Take the last three digits and convert them to binary, i.e., 851 $\rightarrow$ (1000 0101 0001). Encode this to form the codewords c. (Write down the message as well as c in your report.).

3.2 Assignment2: Decoding

1. Implement the syndrome decoding method by using a look-up table according to Example 2.2 (hand-out 1). Verify that the decoder is working correctly by modifying a known codeword and decoding it. Enumerate all 7 possible error patterns at 7 different positions in a codeword. At each time, only one bit in the codeword is corrupted by a substitution error. Check if your decoder is working correctly. Use 'dlmread()' and 'dlmwrite()' functions in Matlab to load and save your results.
2. Calculate the syndromes by using the remainder of the received sequences divided by $g(x)$. Show if your decoding is working correctly.