EXPT No. 08

Title: Linear Block Code for Error Detection and Correction.

Aim: Implementation of Linear Block Code using Scilab.

Software: Scilab open source.

Theory:

Linear Block Code:

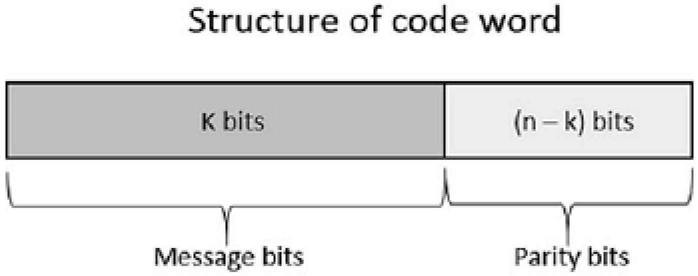
In the linear block codes, the parity bits and message bits have a linear combination, which means that the resultant code word is the linear combination of any two code words.

Let us consider some blocks of data, which contains **k** bits in each block. These bits are mapped with the blocks which has **n** bits in each block. Here **n** is greater than **k**. The transmitter adds redundant bits which are n−kn−k bits. The ratio **k/n** is the **code rate**. It is denoted by **r** and the value of **r** is **r < 1**.

The n−kn−k bits added here, are **parity bits**. Parity bits help in error detection and error correction, and also in locating the data. In the data being transmitted, the left most bits of the code word correspond to the message bits, and the right most bits of the code word correspond to the parity bits.

Any linear block code can be a systematic code, until it is altered. Hence, an unaltered block code is called as a **systematic code**.

Following is the representation of the **structure of code word**, according to their allocation.



Generator matrix:a generator matrix is a matrix whose rows form a basis for a linear code. The codewords are all of the linear combinations of the rows of this matrix, that is, the linear code is the row space of its generator matrix.

$$\boxed{G=[Ik : Pk]}$$

Parity check matrix :, a parity check matrix, H of a linear code C is a generator matrix of the dual code, $C^{\perp}$. This means that a codeword c is in C if and only if the matrix-vector product $Hc^{\top} = 0$ (some authors[1] would write this in an equivalent form, $cH^{\top} = 0$.)

The rows of a parity check matrix are the coefficients of the parity check equations.[2] That is, they show how linear combinations of certain digits (components) of each codeword equal zero. The parity check matrix is

H=[P^T : Ik]

Conclusion:

Implemented Linear Block Code using Scilab and verified Generator matrix, Parity check matrix, Codeword table.

Problems based on linear block code:

Q1). For a systematic linear block code, the three parity equations are given as:

P1=m1+m3

P2=m2+m3

P3=m1+m2

Calculate: 1)Generator matrix

2)Parity check matrix

3)Codeword table

CODE:

```
clc;

n=6; //length of code

k=3; // parity bits

q=n-k; //message bit

I=eye(k,k); //identity matrix

disp(I,"Identity matrix=");

P=[1,0,1; 0,1,1; 1,1,0]; //parity equations

disp(P,"Parity matrix=");

G=[I,P]; //Generator matrix

disp(G,"Generator matrix=");

H=[P',eye(k,k)];

disp(H,"Parity check matrix="); //Parity check matrix
```

```
M=[0,0,0,;0,0,1;0,1,0;0,1,1;1,0,0;1,0,1;1,1,0;1,1,1]; //message matrix
C=M*G; //code word

D=modulo(C,2); //code word table

disp(D,"Codeword table=");
```

OUTPUT:

Identity matrix=

```
1.   0.   0.

0.   1.   0.

0.   0.   1.
```

Parity matrix=

```
1.   0.   1.
0.   1.   1.
1.   1.   0.
```

Generator matrix=

```
1.   0.   0.   1.   0.   1.
0.   1.   0.   0.   1.   1.
0.   0.   1.   1.   1.   0.
```

Parity check matrix=

```
1.   0.   1.   1.   0.   0.
0.   1.   1.   0.   1.   0.
1.   1.   0.   0.   0.   1.
```

Codeword table=

```
0.   0.   0.   0.   0.   0.
0.   0.   1.   1.   1.   0.
0.   1.   0.   0.   1.   1.
0.   1.   1.   1.   0.   1.
1.   0.   0.   1.   0.   1.
1.   0.   1.   0.   1.   1.
1.   1.   0.   1.   1.   0.
1.   1.   1.   0.   0.   0.
```

Q2). For a systematic linear block code, the four parity equations are given as:
P1=m2+m3
P2=m1+m3
P3=m1+m2
P4=m1+m2+m3
Calculate: 1)Generator matrix
2)Parity check matrix
3)Codeword table

<u>CODE</u> :

```
clc;

n=7; //length of code

k=4; // parity bits

q=n-k; //message bit

I=eye(k,k); //identity matrix

disp(I,"Identity matrix=");

P=[0,1,1; 1,0,1; 1,1,0; 1,1,1]; //parity equations

disp(P,"Parity matrix=");

G=[I,P]; //Generator matrix

disp(G,"Generator matrix=");

H=[P',eye(k-1,k-1)];

disp(H,"Parity check matrix="); //Parity check matrix

M=[0,0,0,0;0,0,0,1;0,0,1,0;0,0,1,1;0,1,0,0;0,1,0,1;0,1,1,0;0,1,1,1;1,0,0,0;
1,0,0,1;1,0,1,0;1,0,1,1;1,1,0,0;1,1,0,1;1,1,1,0;1,1,1,1]; //message matrix

C=M*G; //code word

D=modulo(C,2); //code word table

disp(D,"Codeword table=");
```

OUTPUT:

Identity matrix =

```
    1.   0.   0.   0.

    0.   1.   0.   0.

    0.   0.   1.   0.

    0.   0.   0.   1.
```

Parity matrix=

```
    0.   1.   1.
    1.   0.   1.
    1.   1.   0.
    1.   1.   1.
```

Generator matrix=

```
    1.   0.   0.   0.   0.   1.   1.
    0.   1.   0.   0.   1.   0.   1.
    0.   0.   1.   0.   1.   1.   0.
    0.   0.   0.   1.   1.   1.   1.
```

Parity check matrix=

```
    0.   1.   1.   1.   1.   0.   0.
    1.   0.   1.   1.   0.   1.   0.
    1.   1.   0.   1.   0.   0.   1.
```

Codeword table=

```
 0.   0.   0.   0.   0.   0.   0.
 0.   0.   0.   1.   1.   1.   1.
 0.   0.   1.   0.   1.   1.   0.
 0.   0.   1.   1.   0.   0.   1.
 0.   1.   0.   0.   1.   0.   1.
 0.   1.   0.   1.   0.   1.   0.
 0.   1.   1.   0.   0.   1.   1.
 0.   1.   1.   1.   1.   0.   0.
 1.   0.   0.   0.   0.   1.   1.
 1.   0.   0.   1.   1.   0.   0.
 1.   0.   1.   0.   1.   0.   1.
 1.   0.   1.   1.   0.   1.   0.
 1.   1.   0.   0.   1.   1.   0.
 1.   1.   0.   1.   0.   0.   1.
 1.   1.   1.   0.   0.   0.   0.
 1.   1.   1.   1.   1.   1.   1.
```

Q3). For a systematic linear block code, the four parity equations are given as:
P1=m1+m2+m4
P2=m1+m2+m3
P3=m1+m3+m4
P4=m2+m3+m4
Calculate: 1)Generator matrix
2)Parity check matrix
3)Codeword table

CODE :

```
clc;

n=8; //length of code

k=4; // parity bits

q=n-k; //message bit

I=eye(k,k); //identity matrix

disp(I,"Identity matrix=");

P=[1,1,0,1; 1,1,1,0; 1,0,1,1; 0,1,1,1]; //parity equations

disp(P,"Parity matrix=");

G=[I,P]; //Generator matrix

disp(G,"Generator matrix=");

H=[P',eye(k,k)];

disp(H,"Parity check matrix="); //Parity check matrix

M=[0,0,0,0;0,0,0,1;0,0,1,0;0,0,1,1;0,1,0,0;0,1,0,1;0,1,1,0;0,1,1,1;1,0,0,0;
1,0,0,1;1,0,1,0;1,0,1,1;1,1,0,0;1,1,0,1;1,1,1,0;1,1,1,1]; //message matrix

C=M*G; //code word

D=modulo(C,2); //code word table

disp(D,"Codeword table=");
```

OUTPUT:

Identity matrix =

```
1.   0.   0.   0.

0.   1.   0.   0.

0.   0.   1.   0.

0.   0.   0.   1.
```

Parity matrix=

```
1.   1.   0.   1.
1.   1.   1.   0.
1.   0.   1.   1.
0.   1.   1.   1.
```

Generator matrix=

```
1.   0.   0.   0.   1.   1.   0.   1.
0.   1.   0.   0.   1.   1.   1.   0.
0.   0.   1.   0.   1.   0.   1.   1.
0.   0.   0.   1.   0.   1.   1.   1.
```

Parity check matrix=

```
1.   1.   1.   0.   1.   0.   0.   0.
1.   1.   0.   1.   0.   1.   0.   0.
0.   1.   1.   1.   0.   0.   1.   0.
```

```
1.   0.   1.   1.   0.   0.   0.   1.
```

Codeword table=

```
0.   0.   0.   0.   0.   0.   0.   0.
0.   0.   0.   1.   0.   1.   1.   1.
0.   0.   1.   0.   1.   0.   1.   1.
0.   0.   1.   1.   1.   1.   0.   0.
0.   1.   0.   0.   1.   1.   1.   0.
0.   1.   0.   1.   1.   0.   0.   1.
0.   1.   1.   0.   0.   1.   0.   1.
0.   1.   1.   1.   0.   0.   1.   0.
1.   0.   0.   0.   1.   1.   0.   1.
1.   0.   0.   1.   1.   0.   1.   0.
1.   0.   1.   0.   0.   1.   1.   0.
1.   0.   1.   1.   0.   0.   0.   1.
1.   1.   0.   0.   0.   0.   1.   1.
1.   1.   0.   1.   0.   1.   0.   0.
1.   1.   1.   0.   1.   0.   0.   0.
1.   1.   1.   1.   1.   1.   1.   1.
```