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ITC Tutorial 6

Q1) Given the generator polynomial $g(x) = 1+x^2+x^3$ for (7,4) cyclic codes

a) Write the generator matrix G in non-systematic form.

b) What are the code words generated for the messages [1001] and [1011] in systematic form?

Q2) What are the properties of cyclic codes?

Q1) $g(x) = 1 + x^2 + x^3 \longrightarrow (n, k) = (7, 4)$

$x^3 + x^2 + 1 = 1101$

$G = [\, I_K \mid P \,]_{[K \times (n-K)]}$

$[G] = x^{n-k} g(x) \longrightarrow r_1$

$x^{(n-k)-1} g(x) \longrightarrow r_2$

$x^{(n-k)-3} g(x) \longrightarrow r_4$

$$[G] = \begin{array}{l} \left[\begin{array}{cccc|ccc} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 \end{array}\right] \end{array} \begin{array}{l} \rightarrow x^3 \cdot g(x) \\ \rightarrow x^2 \cdot g(x) \\ \rightarrow x \cdot g(x) \\ \rightarrow 1 \cdot g(x) \end{array}$$

$\cancel{x(g(x))}$ $r_3 \longrightarrow r_3 \oplus r_4$

$$G = \left[\begin{array}{cccc|ccc} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 \end{array}\right]$$

$r_2 \longrightarrow r_2 \oplus r_3$

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

$$r_1 \rightarrow r_1 \oplus r_2 \oplus r_4$$

$$\left[\begin{array}{cccc|ccc} 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 \end{array}\right] \longrightarrow \text{Systematic}$$

ii) code Words for $[1\ 0\ 0\ 1]$
$[1\ 0\ 1\ 1]$

$$\frac{x^{n-k}\ m(x)}{g(x)} \qquad [m]K = [1\ 0\ 0\ 1]$$

$$m(x) = x^3 + 1$$

$$\frac{x^{7-4}\ (x^3+1)}{1+x^2+x^3} = \frac{x^6+x^3}{1+x^2+x^3}$$

$$x^3 + x^2 + x + 1$$

$$x^3 + x^2 + 1 \ \big) \ x^6 + x^3$$

$$-\cancel{x^6} + x^5 + x^3$$

$$\cancel{x^5}$$

$$-\cancel{x^5} + x^4 + x^2$$

$$\cancel{x^4} + x^2$$

$$-\cancel{x^4} + x^3 + x \quad = 0 1 1$$

$$x^3 + x^2 + x$$

$$x^3 + x^2 + 1$$

$$x + 1$$

$$C(x) = [1001\ 011]$$

$$c(x) = x^3(x^3+1)$$

$$= x^6 + x^3 + x + 1$$

$\therefore$ codeword for $[1001] = 1001\ 011$

$$[1011] \times \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$$

Codeword for

$$[1011] = [1011100]$$

Q2) Some properties of cyclic codes are:-

1. Linearity Property - $C = \{c_1, c_2, c_3 \cdots c_n\}$

eg: $c_1 \oplus c_2 = c_3$

$c_2 \oplus c_4 = c_5$ then 'C' satisfies the linearity property

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2. Cyclic Property

When code word is rotated to right or left by no. of bits then the shifted code word belongs to set of codewords

eg - { 0000, 0101, 1010, 1111 }

~~Over if above set of codewords~~