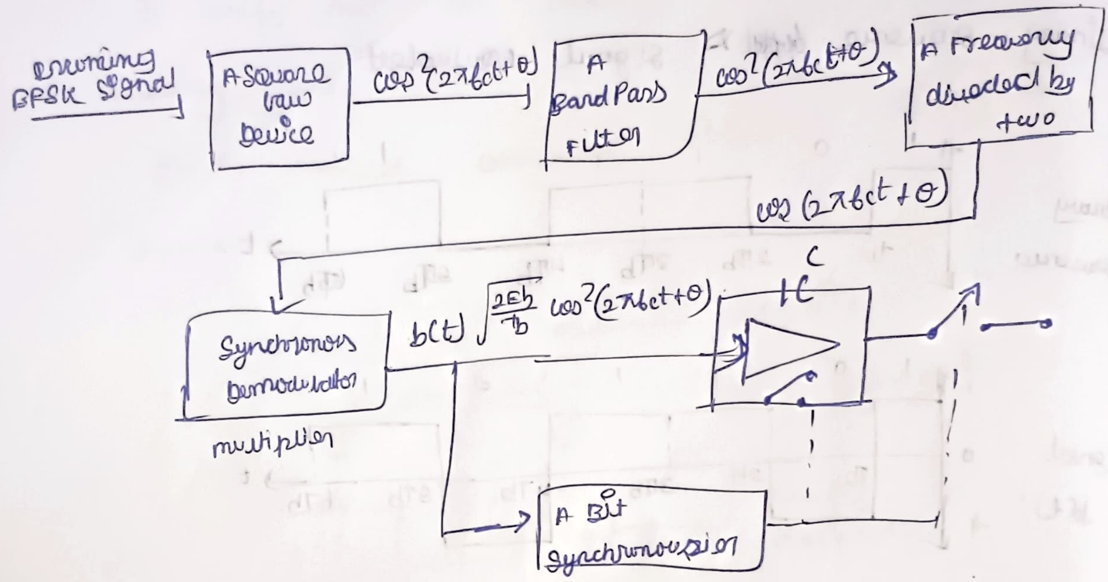
NO	Input Binary	Bipolar NRZ signal	BPSK output signal
1	Binary 0	$b(t) = -1$	$-\sqrt{\frac{2E_b}{T_b}} \cos 2\pi f_c t$
2	Binary 1	$b(t) = +1$	$\sqrt{\frac{2E_b}{T_b}} \cos 2\pi f_c t$

Reception of BPSK signal:



* consider a 'θ' phase shift, the input signal can be written as

$$s(t) = b(t)\sqrt{2P}\cos(2\pi f_c t+\theta)$$

* the carrier signal is separated from the input to the Receiver, now it is send to the square law device.

$$\Rightarrow \cos^2(2\pi f_c t+\theta)$$

$$\cos^2\theta = \frac{1+\cos 2\theta}{2}$$

$$= \frac{1+\cos 2(2\pi f_c t+\theta)}{2}$$

$$= \frac{1}{2} + \frac{1}{2}\cos 2(2\pi f_c t+\theta).$$

⇒ At Band Pass filter it removes [illegible], and the output is

$$\Rightarrow \cos 2(2\pi f_c t + \theta)$$

⇒ At frequency divider, it is divided by '2' and the output is

$$\cos(2\pi f_c t + \theta).$$

⇒ Synchronous demodulator, input signal and recovered carrier

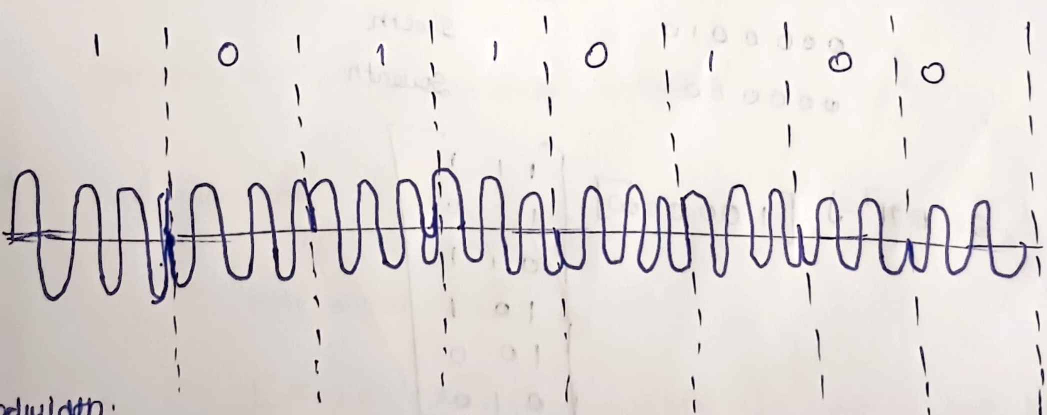
$$b(t)\sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t + \theta) \times \cos(2\pi f_c t + \theta)$$

$$\Rightarrow b(t)\sqrt{\frac{2E_b}{T_b}}\cos^2(2\pi f_c t + \theta)$$

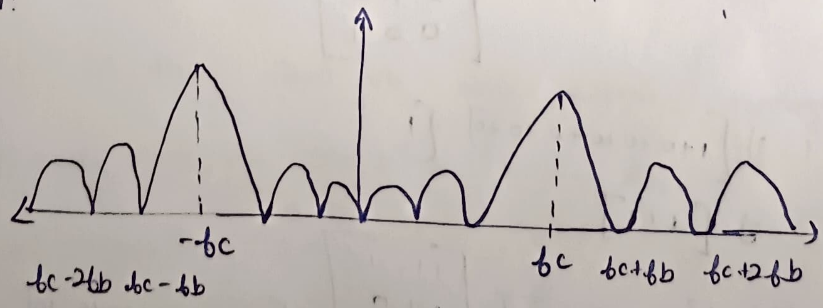
$$= b(t)\sqrt{\frac{\cancel{2}E_b}{T_b}} \times \left[\frac{1+\cos 2(2\pi f_c t + \theta)}{\cancel{2}}\right]$$

$$= b(t)\sqrt{\frac{E_b/T_b}{2}}\left[1+\cos 2(2\pi f_c t + \theta)\right]$$

output [waveform]



Bandwidth:



Bandwidth = H.F − L.F

$= (F_C + F_b) - (F_C - F_b)$

$$\boxed{BW = 2F_b}$$

Frequency / Frequency / Shift / Key

N Of Frequency 10, 11 and 1to 1 transmitted:

16/9

The Parity check matrix (7,4) hamming code.

$$H = \begin{bmatrix} 1 & 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$, Calculate the Syndrome vector

For single bit errors.

$S = EH^T$ — Error vector — Bit 'n' error

$E = [1\,0\,0\,0\,0\,0\,0]$	First
0 1 0 0 0 0 0	second
0 0 1 0 0 0 0	third
0 0 0 1 0 0 0	fourth
0 0 0 0 1 0 0	fifth
0 0 0 0 0 1 0	sixth
0 0 0 0 0 0 1	Seventh:

$$S = EH^T \Rightarrow [1\,0\,0\,0\,0\,0\,0] \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$\Rightarrow [1+0+0+0+0+0+0]$ [1

$\Rightarrow [1\,1\,1]$

$$= [0\,0\,1\,0\,0\,0\,0] \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$\Rightarrow [0+0+0+0+0+0+0]$

$[0+0+1+0+0+0+0]$

$[0+0+1+0+0+0+0]$

$\Rightarrow [0\,1\,1]$

Error vector:	Syndrome vector	Relation with H^T
	1 1 1	1st row
1 0 0 0 0 0 0	1 1 0	2nd row
0 1 0 0 0 0 0	0 1 1	3rd row
0 0 1 0 0 0 0	1 0 1	4th row
0 0 0 1 0 0 0	1 0 0	5th row
0 0 0 0 1 0 0	0 1 0	6th row
0 0 0 0 0 1 0	0 0 1	7th row:
0 0 0 0 0 0 1		

cyclic code:

A binary code said to be a cyclic code if it exhibits the following properties

i) Linearity property ⟹ A code is said to be linear if sum of any two code is also a code word

ii) cyclic property

⇓

A code is said to be cyclic if any cyclic shift of the code word results in the formation of the another codeword.

Code word polynomial

x The code word given by:

$[x_0, x_1, x_2, \ldots\ldots x_{n-1}]$, which can be expressed in the form of code word polynomial as

$x(P) = x_0 + x_1 P + x_2 P^2 + \ldots\ldots x_{n-1} P^{n-1}$

Generated polynomial

* $x(P) = m(P) \cdot G(P)$

where: $G(P) = 1 + g_1 P + g_2 P^2 + \ldots\ldots g_{n-k-1} P^{n-k-1} + P^{n-k}$

$G(P) = 1 + \sum_{i=1}^{n-k-1} g_i P^i + P^{n-k}$ //

Non - Systematic code vectors (or words)

$x_1(P) = m_1(P) \cdot G(P)$

$x_2(P) = m_2(P) \cdot G(P)$

$x_3(P) = m_3(P) \cdot G(P)$

⋮

0P
0P

Generation of Systematic code words

$$\left[P^{n-k} M(P)\right] \oplus C(P) = X(P)$$

$C(P) \Rightarrow$ Remainder Polynomial

$$\frac{P^{n-k} M(P)}{G(P)} = Q(P) \oplus \frac{C(P)}{G(P)}$$

Problem

1) The generated polynomial for a (7,4) cyclic hamming code is given by $G(P) = 1 + P + P^3$, determine all systematic and non systematic code vectors.

Non systematic:

$x_1(P) = M_1(P) \cdot G(P)$

$m(0000) \Rightarrow$

$M(P) = 0 + 0P + 0P^2 + 0P^3$

$G(P) = 1 + P + P^3$

$x(P) = m(P) \cdot G(P)$

$0P + 1P$

$1P$

$= 0 + 0P + 0P^3 + 0P + 0P^2 + 0P^4 + 0P^2 + 0P^3 + 0P^5 + 0P^3 + 0P^4 + 0P^6$

$\Rightarrow 0 + 0P + 0P^3 + 0P^4 + 0P^5 + 0P^6 + 0P^2$

parity message

$0 + 0P + 0P^2 + 0P^3 + 0P^4 + 0P^5 + 0P^6$

message:

$m(1100)$

$m(P) = 1 + P + 0P^2 + 0P^3$

$G(P) = 1 + P + P^3$

$x(P) = m(P) \cdot G(P)$

$= 1 + P + P^3 + P + P^2 + P^4 + 0P^2 + 0P^3 + 0P^5$

$+ 0P^3 + 0P^4 + 0P^6$

$= 1 + 0P + 1P^2 + 0P^3 + 1P^4 + 0P^5 + 0P^6$

$mC \Rightarrow [\underbrace{1\ 0\ 1}_{\text{Parity}}\ \underbrace{1\ 1\ 0\ 0}_{\text{message}}]$

$1 + 0P + 1P^2 + 0P^3$

$m(1010)$

$m(P) = 1 + 0P + P^2 + 0P^3$

$G(P) = 1 + P + P^3$

$x(P) = m(P) \cdot G(P)$

$= 1 + P + P^3 + 0P + 0P^2 + 0P^4 + P^2 + P^3 + P^5$

$+ 0P^3 + 0P^4 + 0P^6$

$\Rightarrow 1 + 1P + 1P^2 + 0P^3 + 0P^4 + 1P^5 + 0P^6$

$= [\underbrace{1\ 1\ 1}_{\text{parity}}\ \underbrace{0\ 0\ 1\ 0}_{\text{message}}]$

$m(0010)$

$m(P) = 0 + 0P + P^2 + 0P^3$

$G(P) = 1 + P + P^3$

$x(P) = m(P) \cdot G(P) = 0P + 0P^2 + 0P^4 + P^2 + P^3 + P^5$

$= 0 + 0P + 0P^3 + 0P + 0P^2 + 0P^4 + P^2 + P^3 + P^5$

$+ 0P^3 + 0P^4 + 0P^6$

$\Rightarrow 0 + 0P + 1P^2 + 1P^3 + 0P^4 + 1P^5 + 0P^6$

$= [\underbrace{0\ 0\ 1}_{\text{Parity}}\ \underbrace{1\ 0\ 1\ 0}_{\text{message}}]$

systematic

$m(1010) \Rightarrow 1 + p^2$

$x(p) = c(p) \oplus p^{n-k} m(p)$
$(7-4)$

$x(p) = c(p) \oplus p^3 (1+p^2)$

$$c(p) = \frac{p^{n-k}(m(p))}{G(p)} \Rightarrow \frac{p^3(1+p^2)}{1+p+p^3} \Rightarrow \frac{p^3+p^5}{1+p+p^3}$$

[non systematic]

Generated and Parity check matrices of cyclic codes.

$$G(P) = P^{n-k-1} + P^{n-k} g_{n-k-1} + \dots + g_2 P^2 + g_1 P + 1$$

$$P^i \times G(P) = P^{n-k+i} + P^{n-k+i-1} + \dots g_2 P^{2+i} + g_1 P^{1+i} + 1$$

$i = (k-1), (k-2), \dots 2, 1, 0.$

Problem

1) For a (7,4) cyclic code determine the generated matrix if $G(P) = 1 + P + P^3$

$n = 7$

$k = 4$

$i = (0, 1, 2, 3)$

$i = 3$ $\quad G(P) \times P^i$

$G(P) * P^3 \Rightarrow P^3 + P^4 + P^6$

$\Rightarrow P^6 + 0P^5 + P^4 + P^3 + 0P^2 + 0P + 0$

$i = 2$ $\quad P^2 \times G(P)$

$P^2 \times [1 + P + P^3]$

$\Rightarrow P^2 + P^3 + P^5$

$0P^6 + P^5 + 0P^4 + P^3 + P^2 + 0P + 0$

$i = 1$ $\quad P^1 \times G(P)$

$P^1 \times [1 + P + P^3]$

$\Rightarrow P + P^2 + P^4$

$i = 0$ $\quad P^0 \times G(P)$

$P^0 \times (1 + P + P^3)$

$\Rightarrow 1 + P + P^3$

$\Rightarrow 0P^6 + 0P^5 + 0P^4 + P^3 + 0P^2 + P + 1$

$G_{(k \times n)}$
$_{4 \times 7}$

$$G_{(4 \times 7)} = \begin{bmatrix} 1 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

Code word :

$x = m \times G$ $\qquad (7,4) \Rightarrow 2^k = 2^4 = 16$

$m(0110)$

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

$\Rightarrow [0]\ [0+1+0+0]\ [0+0+1+0]\ [0+1+0+0]$

$[0+1+1+0]\ [0+0+1+0]\ [0+0+0+0]$

$= [0\ 1\ 1\ 1\ 0\ 1\ 0]$

$m(0010) \Rightarrow$

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

$\Rightarrow [0+0+0+0]\ [0+0+0+0]\ [0+0+1+0]\ [0+0+0+0]$

$[0+0+1+0]\ [0+0+1+0]\ [0+0+0+0]$

$= [0\ 0\ 1\ 0\ 1\ 1\ 0]$

m(0101)

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

$$= [0+0+0+0]\,[0+1+0+0]\,[0+0+0+0]\,[0+1+0+1]\,[0+1+0+0]$$

$$[0+0+0+1]\,[0+0+0+1]$$

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

m(1100)

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

$$= [1+0+0+0]\,[0+1+0+0]\,[1+0+0+0]\,[1+1+0+0]\,[0+1+0+0]$$

$$[0+0+0+0]\,[0+0+0+0]$$

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

m(1010)

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

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

m(1110)

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

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

m(1011)

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

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

Code

Generated matrix for the systematic codes:

$$p^{(n-i)} \oplus R_i(P) = Q_i(P) \cdot G(P)$$

where $i = 1, 2, 3 \ldots k$

$$\frac{p^{(n-i)}}{G(P)} = Q_i(P) \oplus \frac{R_i(P)}{G(P)}$$

~~Generated matrix for the~~

Problems:

1. For a $(7,4)$ systematic cyclic code, determine the generated matrix, parity check matrix.

Given $G(P) = P^3 + P + 1$

$$P^{(n-i)} \oplus R_i(P) = Q_i(P) \cdot G(P)$$

$i = 1, 2, 3, 4$, $n = 7$

$i = 1$

$$P^6 \oplus R_1(P) = Q_1(P) \cdot G(P)$$

$$\Rightarrow \frac{P^{(n-i)}}{G(P)} = Q_i(P) + \frac{R_i(P)}{G(P)}$$

$$\Rightarrow \frac{P^6}{G(P)}$$

$$
\begin{array}{r|l}
 & p^3 + 0p^2 + p + 1 \\
\hline
p^3+p+1 & \cancel{p^6} + 0p^5 + 0p^4 + 0p^3 + 0p^2 + 0p + 0 \\
 & \cancel{p^6} \quad + p^4 + p^3 \\
\hline
 & \cancel{0p^5} + p^4 + p^3 + \cancel{0p^2} \\
 & \cancel{0p^5} \quad + 0p^3 + \cancel{0p^2} \\
\hline
 & \cancel{p^4} + \cancel{p^3} + 0p + 0 \\
 & \cancel{p^4} \quad + 1p^2 + p \\
\hline
 & \cancel{p^3} + p^2 + \cancel{p} + 0 \\
 & \cancel{p^3} \quad + \cancel{p} + 1 \\
\hline
 & p^2 + 1
\end{array}
$$

$i = 1$

$$p^{(n-i)} \oplus R(p) = Q(p) \; G(p)$$

$$p^6 \oplus p^2+1 = (p^3+p+1)\;(p^3+p+1)$$

$$= p^6 + p^4 + p^3 + p^4 + p^2 + p + p^3 + p + 1$$

$$p^6 \oplus p^2+1 = p^6 + p^4 + p^3 + p^4 + p^2 + p + p^3 + p + 1$$

$$= p^6 + p^2 + 1 \Rightarrow [1\,0\,0\,0\,1\,0\,1]$$

$i = 2$

$$p^{(n-i)} \oplus R_i(p) = Q_i(p) \cdot G(p)$$

$$p^5 \oplus R_2(p) = Q_2(p) \cdot G(p)$$

$$\frac{p^5}{G(p)} = Q(p) \oplus \frac{R_2(p)}{G(p)}$$

$$
\begin{array}{r|l}
 & p^2 + 0p + 1 \\
p^3+p+1 & p^5 + 0p^4 + 0p^3 + 0p^2 + 0p^1 + 0 \\
 & \cancel{p^5} + \quad + p^3 + p^2 \\
\hline
 & \cancel{0p^4} + 1p^3 + p^2 + 0p \\
 & \cancel{0p^4} \quad + 0p^2 + 0p \\
\hline
 & \cancel{1p^3} + 1p^2 + 0 \\
 & \cancel{1p^3} + 1p + 1 \\
\hline
 & 1p^2 + p + 1
\end{array}
$$

$p^5 + p^2 + p + 1$

$\Rightarrow [0100111]$

$i = 3:$

$p^4 \oplus \quad R_i(P) = Q_i(P) \cdot G(P)$

$$\frac{p^{(n-i)}}{G(P)} = R_i(P)$$

$$\frac{p^4}{p^2+p+1} = R_i(P)$$

$$
\begin{array}{r|l}
 & p^2 + \\
p^3 + p + 1 & p^4 + 0p^3 + 0p^2 + 0p + 1 \\
 & \cancel{p^4} + p^3 + p^2 \\
\hline
 & 1p^3 + p^2 + 0p
\end{array}
$$

$$
\begin{array}{r|l}
 & p + 0 \\
p^3 + p + 1 & p^4 + 0p^3 + 0p^2 + 0p + 0 \\
 & \cancel{p^4} \quad + p^2 + p \\
\hline
 & \cancel{0p^3} + p^2 + p + 0 \\
 & \cancel{0p^3} \quad + 0p + 0 \\
\hline
 & p^2 + p + 0
\end{array}
$$

$$p^4 \oplus (p^2+p+0) = (1p)\cdot(p^3+p+1)$$

$$= p^4+p^2+p$$

$$\Rightarrow [0\ 0\ 1\ 0\ 1\ 0\ 1]$$

$i=4$:

$$\frac{p^3}{G(p)} = Q(p) + \frac{R_4(p)}{G(p)}$$

$$\begin{array}{r|l} & 1 \\ \hline p^3+p+1 & p^3 + 0p^2 + 0p + 0 \\ & p^3 \qquad\quad + p + 1 \\ \hline & 0p^2 + p^2 + 1 \end{array}$$

$$p^3 \oplus (p^2+1) = 1\cdot p^3+p+1$$

$$= p^3+p+1$$

$$= [0\ 0\ 0\ 1\ 0\ 1\ 1]$$

$$G = \begin{array}{c} \begin{array}{ccccccc} p^6 & p^5 & p^4 & p^3 & p^2 & p^1 & p^0 \end{array} \\ \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix} \end{array} \qquad G = [I_K \mid P]$$

$$P = \begin{bmatrix} 1 & 0 & 1 \\ 1 & 1 & 1 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \end{bmatrix} \qquad H = [P^T \mid I_{n-k}]$$

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

obtain the code vector for a (7,4) code having the $G(P) = 1 + p + p^3$

$2^4 \Rightarrow 16.$

$$x = m G$$

take G from the previous sum:

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

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

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

Encoder for cyclic codes.

Encoder is useful for generating the systematic cyclic codes.

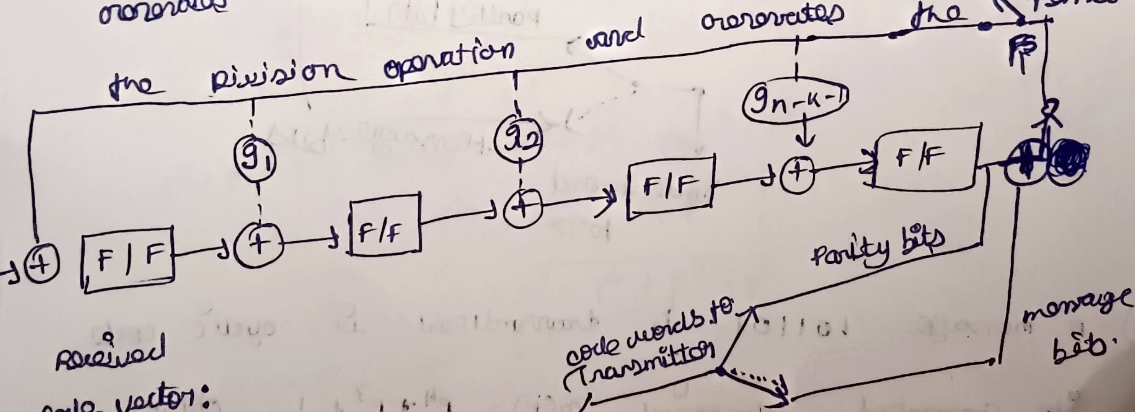
Flipflops are used to construct a shift register, operations of all these flipflops are governed by the external clock.

The flipflop contains will get shifted in the direction of arrow corresponding to each clock pulse.

All the Flipflops are initialized to zero state.

After shifting the 'k' message bits the shift register will contain n-k parity (or) check bits. Therefore after shifting the message bits the feedback switch is open circuited. And the output switch is thrown to parity bit position.

Now every shift the parity bits are transmitted over the channel thus the encoder generates the code word. The encoder performs the division operation and generates the remainder.



Received code vector:

Problems:

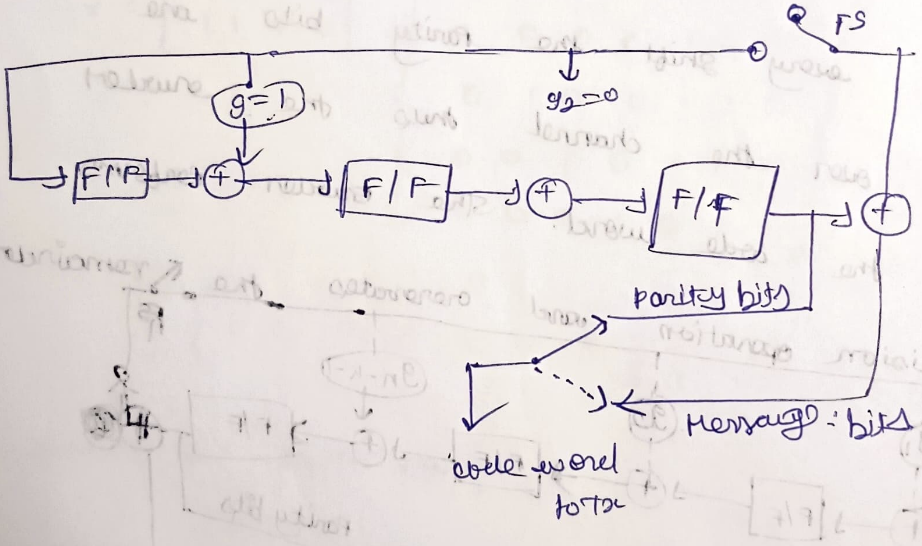
1) Draw the encoder for a (7, 4) cyclic hamming code generated by the generated polynomial $G(P) = 1+P+P^3$

Generated polynomial

$$G(P) = 1 + \sum_{i=1}^{n-k-1} g_i P^i + P^{n-k}$$

$$= 1 + \sum_{i=1}^{2} g_i P^i + P^3$$

$$G(P) = 1 + g_1 P + g_2 P^2 + P^3$$



2) A message 101101 is transmitted in cyclic code with generated polynomial $G(P) = P^4+P^3+1$. obtain the transmitted code word.

i) how many check (or) parity bits does the encoded message contain

ii) Draw the encoding arrangement for the same.

Systematic code:

$M = 101101$

$k = 6$ $n - k$ = parity bits

$n - 6 = 4$ → highest degree of polynomial.

$n = 4 + 6$

$\boxed{n = 10}$

$(n, k) = (10, 6)$

$$x(p) = p^{n-k}\, M(p) \oplus c(p)$$

$$\frac{p^{n-k} M(p)}{G(p)} = Q(p) + \frac{C(p)}{G(p)}$$

$$\frac{p^4 \times (101101)}{p^4 + p^3 + 1} \rightarrow M(p) = 1 + 0p + p^2 + p^3 + 0p^4 + 0p^5$$

$$\Rightarrow \frac{(1 + 0p + p^2 + p^3 + 0p^4 + p^5) \times (p^4)}{p^4 + p^3 + 1}$$

$$= p^4 + 0p^5 + p^6 + p^7 + 0p^8 + p^9.$$

$$\begin{array}{r|l}
 & p^5 + p^4 + p^2 \\
\hline
p^4 + p^3 + 1 & p^9 + 0p^8 + p^7 + p^6 + 0p^5 + p^4 \\
 & \cancel{p^9} + p^8 \qquad\qquad + p^5 \\
\hline
 & p^8 + p^7 + p^6 + p^5 + p^4 \\
 & \cancel{p^8} + \cancel{p^7} \qquad\qquad + \cancel{p^4} \\
\hline
 & p^6 + p^5 \\
 & \cancel{p^6} + \cancel{p^5} + p^2 \\
\hline
 & p^2
\end{array}$$

$$p^5 + p^4 + p^2 + \frac{p^2}{p^4 + p^3 + 1}$$

115 → A
210 − A
100 → ne
200 → J
100 → A
95 r
500

$Q(p) = p^5 + p^4 + p^2$

$C(p) = p^2$

$$x(p) \Rightarrow p^4(1 + 0p + p^2 + p^3 + 0p^4 + 0p^5) \oplus p^2$$

$$= (p^4 + 0p^5 + p^6 + p^7 + 0p^8 + 0p^9) \oplus p^2$$

$$= p^9 + 0p^8 + p^7 + p^6 + 0p^5 + p^4 + p^2$$

$$x = \begin{array}{c} \underbrace{\overset{m_5}{1}\ \overset{m_4}{0}\ \overset{m_3}{1}\ \overset{m_2}{1}\ \overset{m_1}{0}\ \overset{m_0}{1}}_{\text{msg bits}}\ \underbrace{\overset{c_3}{0}\ \overset{c_2}{1}\ \overset{c_1}{0}\ \overset{c_0}{0}}_{\text{parity bits}} \end{array}$$

Problems:

1) why are cyclic codes Effectively detecting error Burst.

The message 100100101010 is to be transmitted In a cyclic code with a generated polynomial $G(x) = x^2 + 1$

i) how many check bits does the encoded message contains

ii) obtain the transmitted code word.

iii) Draw encoding arrangement to obtain remainder bits

iv) after the Recieve word is docked to the decoder encoder what should be content of Register stores.

$m = 1001001010 10$ $\quad k = 10$

$n - k =$ Parity bits

$n - k = 2$

$(n, k) = (12, 10)$ $\quad n - 10 = 2$

$\boxed{n = 12}$

$x(p) = p^{n-k} \; M(p) \oplus C(p)$

$$\frac{p^{n-k} \; M(p)}{G(p)} = Q(p) + \frac{C(p)}{G(p)}$$

$$\frac{p^2 \times (1001001010 10)}{x^2+1} = \frac{p^2 \times (p^9 + op^8 + op^7 + p^6 + op^5 + op^4 + p^3 + op^2 + p + 1)}{x^2+1}$$

$$\Rightarrow \frac{p^{11} + op^{10} + op^9 + p^8 + op^7 + op^6 + p^5 + op^4 + p^3 + 0}{x^2+1}$$

$$p^9 + 0p^8 + p^7 + p^6 + p^5 + p^4 + p^2 + p + 1$$

$p^2 + 1 \;\big)\; p^{11} + 0p^{10} + 0p^9 + p^8 + 0p^7 + 0p^6 + p^5 + 0p^4 + p^3 + 0$

$\cancel{p^{11}} \qquad + 1p^9$

$0\cancel{p^{10}} + p^9 + p^8$

$0\cancel{p^{10}} \qquad + 0p^8$

$\cancel{p^9} + p^8 + 0p^7$

$\cancel{p^9} \qquad + p^7$

$\cancel{p^8} + p^7 + 0p^6$

$\cancel{p^8} + \qquad + p^6$

$\cancel{p^7} + p^6 + p^5$

$\cancel{p^7} \qquad + p^5$

$\cancel{p^6} + 0p^5 + 0p^4$

$\cancel{p^6} + \qquad + p^4$

$\cancel{p^4} + p^3 + 0$

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

$\cancel{p^3} + p^2$

$\cancel{p^3} + p$

$\cancel{p^2} + p$

$\cancel{p^2} + \quad + 1$

$p + 1$

$$a(p) = p^9 + 0p^8 + p^7 + p^6 + p^5 + p^4 + p^2 + p + 1$$

$$x(p) = p^{n-k}\, m(p) \oplus c(p)$$

$$= p^2 \times [p^9 + 0p^8 + 0p^7 + p^6 + 0p^5 + 0p^4 + p^3 + 0p^2 + p + 0] \oplus [p+1]$$

$$= p^{11} + 0p^{10} + 0p^9 + p^8 + 0p^7 + 0p^6 + p^5 + 0p^4 + p^3 + 0 + p + 1$$

$$\Rightarrow p^{11} + 0p^{10} + 0p^9 + p^8 + 0p^7 + 0p^6 + p^5 + 0p^4 + p^3 + p + 1$$

$$\Rightarrow p^{11} + 0p^{10} + 0p^9 + p^8 + 0p^7 + 0p^6 + p^5 + 0p^4 + p^3 + p + 1$$

$$x(p) \Rightarrow \underbrace{1\,0\,0\,1\,0\,0\,1\,0\,1\,0}_{\text{message :}}\ \underbrace{1\,1}_{\text{parity}}$$

2) Determine the encoded message for the following 8 bit data codes using the following CRC generating polynomial, $P(x) = x^4 + x^3 + x^0$

i) message 1100 1100 [higher degree to lower degree]

ii) message 0101 1111

$n-k=4$

$n-8=4$