digits. In any time unit, a message of 'k' digits is fed into the encoder & the encoder generates a code block consisting of 'n' code digits.

The 'n' digit code word depends not only on 'k' digit message block of the same time unit but also on the previous $(m-1)$ message block.

The code generated by the above encoder is called (n, k, m) convolution code of ~~to~~ constrained length "nm" digits & rate efficiency "k/n" where n = no of outputs = no of modulo 2 adders

k = no of i/p bits entering at

m = no of stages of the fli

The block codes are better suited for

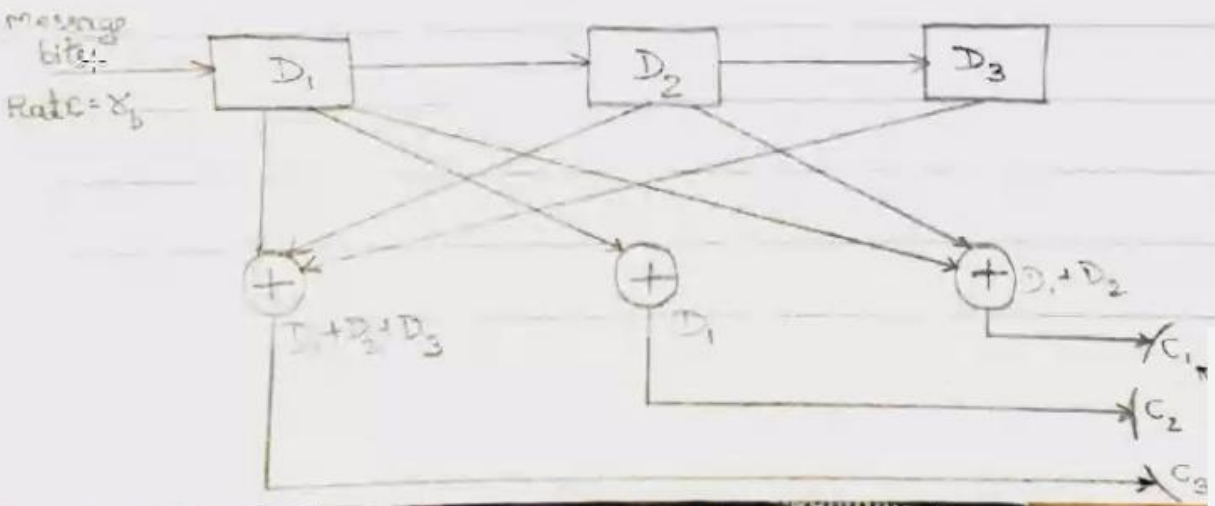
detection &

or error

m = no of stages of the flip-flop.

The block codes are better suited for error detection & convolution codes for error correction.

Ex:- Consider an encoder for $(n, K, m) = (3, 1, 3)$ to generate a convolution code as shown below:



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You

Let $d_K = 10110$
$\quad\quad\quad\; d_1 d_2 d_3 d_4 d_5$

	0 – T_b	T_b – $2T_b$	$2T_b$ – $3T_b$	$3T_b$ – $4T_b$	$4T_b$ – $5T_b$	$5T_b$ – $6T_b$	$6T_b$ – $7T_b$
	d_1	d_2	d_3	d_4	d_5		
Input →	1	0	1	1	0	0	0
Contents of SR →	100	010	101	110	011	001	000
output →	111	101	011	010	001	100	000

In convolution encoder, the message ~~tree~~ stream continu
runs through the encoder whereas in block
coding scheme ... is first
divided ... encoded.

we have, $g^{(1)} = [1011]$; $g^{(2)} = [1111]$

From the definition of discrete convolution,

$$C_l^{j} = \sum_{i=0}^{m} d_{l-i}\, g_{i+1}^{j}$$

$L =$ no. of message sequence bits

where i varies from 0 to m = (0 to 3)

l varies from 1 to $(L+m)$ = (1 to 8)

$d_{l-i} = 0$, for $l \le i$

Let the message sequence be $\underset{d_1\, d_2\, d_3\, d_4\, d_5}{1\,0\,1\,1\,1}$

The o/p sequence is calculated as follows:

For $j = 1$,

$$C_l^{(1)} = \sum_{i=0}^{3} d_{l-i}\, g_{i+1}^{(1)}$$

codeword = $L + m$

$L =$ no. of message bits

$m =$ no. of FFs.

$C_l^{(1)}$ ... $+ \; d_{l-3}\, g_4^{(1)}$

The time domain behaviour of a binary Convolution encoder may be defined in terms of a set of 'n' impulse responses. Let the sequence $[g_1^{(j)} \ g_2^{(j)} \ g_3^{(j)} \ldots\ldots g_{m+1}^{(j)}]$ denote the impulse responses, also called GENERATOR sequences of the input/output path of 'n' no of modulo-2 adders.

In the encoder, there are 2 modulo-2 adders labelled top adder & bottom adder. Hence, there will be 2 generator sequences.

Let $d_1 d_2 d_3 \ldots\ldots d_L$ represent the input message sequence that enters into the encoder one bit at a time starting with d_1.

Then, the encoder generates 2 o/p sequences $C^{(1)}$ & $C^{(2)}$ defined by the discrete convolution sum given by

$$C^{(1)} = [d] * g^{(1)}$$
$$C^{(2)} = [d] * g^{(2)}$$

We have, $g^{(1)} = [1011]$; $g^{(2)} = [1111]$

From ... convolution,

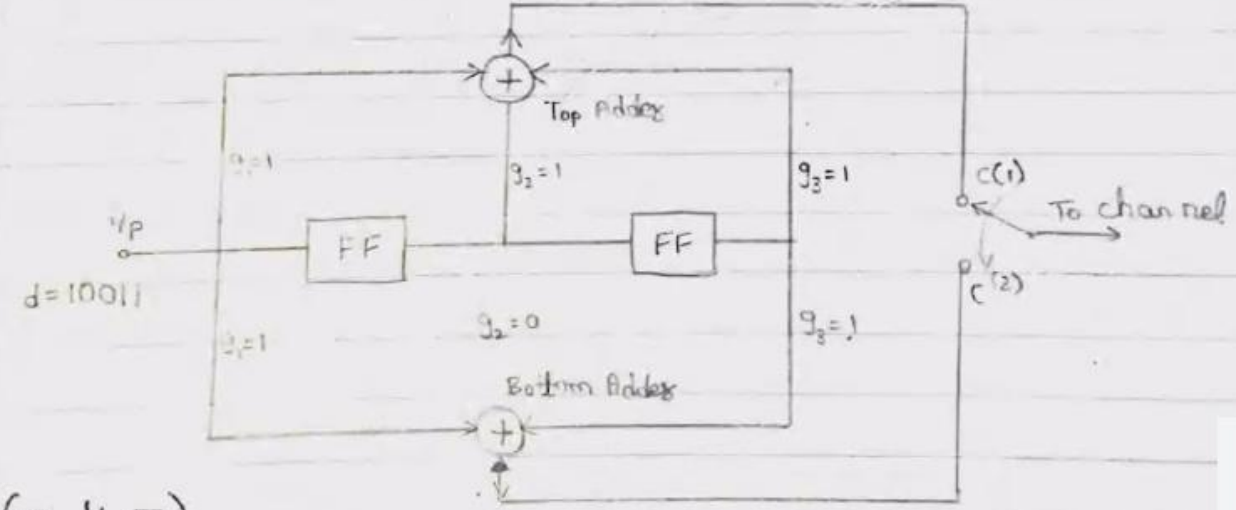
$C^j = \ldots$ message

$$\left[C_1^{(1)}\ C_1^{(2)}\ C_2^{(1)}\ C_2^{(2)}\ C_3^{(1)}\ C_3^{(2)}\ \ldots\ldots\ C_l^{(1)}\ C_l^{(2)}\right]$$

$\therefore$ Code word = 1101 000101 01 0011

P> For the convolution encoder shown, $d = \overset{d_1 d_2 d_3 d_4 d_5}{10011}$. Find the output sequence using the following 2 approaches.

i> Time domain approach. ii) Transfer domain approach.



(n, k, m)

$= (2, 1, 2)$

$g^{(2)} = 1111$

$L = 5 \;;\; C = n(L+m) = 2(5+3) = 16$

$\therefore$ A matrix of (5×16)

$$G = \begin{bmatrix} 11 & 01 & 11 & 11 & 00 & 00 & 00 & 00 \\ 00 & 11 & 01 & 11 & 11 & 00 & 00 & 00 \\ 00 & 00 & 11 & 01 & 11 & 11 & 00 & 00 \\ 00 & 00 & 00 & 11 & 01 & 11 & 11 & 00 \\ 00 & 00 & 00 & 00 & 11 & 01 & 11 & 11 \end{bmatrix}$$

$C = [d][G]$

$= [10111][G]$

$$\boxed{C = 11, 01, 00, 01, 01, 01, 00, 11}$$

$$\begin{bmatrix} \vdots & & & & & & & \\ 0 & 0 & 0 & 0 & \cdots & \cdots & & g^{(1)}_{m+1} \, g^{(2)}_{m+1} \end{bmatrix}$$

P) Previous same problem :

$d = 10111$

$g^{(1)} = 1011$

$g^{(2)} = 1111$

$L = 5$; $C = n(L+m) = 2(5+3) = 16$

$\therefore$ A matrix of (5×16)

$$G = \begin{bmatrix} 11 & 01 & 11 & 11 & 00 & 00 & 00 & 00 \\ 00 & 11 & 01 & 11 & 11 & 00 & 00 & 00 \\ 00 & 00 & 11 & 01 & 11 & 11 & 00 & 00 \\ 00 & 00 & 00 & 11 & 01 & 11 & 11 & 00 \\ 00 & 00 & 00 & 00 & 11 & 01 & 11 & 11 \end{bmatrix}$$

$C = [d][G]$

$= [10111][G]$

$$G = \begin{bmatrix} 0 & 0 & g_1^{(1)} & g_1^{(2)} & g_2^{(1)} & g_2^{(2)} & \cdots & g_m^{(1)} & g_m^{(2)} & g_{m+1}^{(1)} & g_{m+1}^{(2)} & \cdots & 0 & 0 \\ \vdots & \vdots & & & & & & & & & & & & \vdots \\ 0 & 0 & 0 & 0 & \cdots & & & & & & & & g_{m+1}^{(1)} & g_{m+1}^{(2)} \end{bmatrix}$$

P) Previous same problem:

$d = 10111$

$g^{(1)} = 1011$

$g^{(2)} = 1111$

$L = 5 \; ; \; C = n(L+m) = 2(5+3) = 16$

$\therefore$ A matrix of (5×16)

$$G = \begin{bmatrix} 11 & 01 & 11 & 11 & 00 & 00 & 00 & 00 \\ 00 & 11 & 01 & 11 & 11 & 00 & 00 & 00 \\ 00 & 00 & 11 & 01 & 11 & 11 & 00 & 00 \\ 00 & 00 & 00 & 11 & 01 & 11 & 11 & 00 \\ 00 & 00 & 00 & 00 & 11 & 01 & 11 & 11 \end{bmatrix}$$

$C = [d][G]$

$[10111][G]$

convolution encoder. In general, for 2 modulo-2 adders convolution encoder, the generator matrix is given by

$$G = \begin{bmatrix} g_1^{(1)} g_1^{(2)} & g_2^{(1)} g_2^{(2)} & g_3^{(1)} g_3^{(2)} & \cdots & g_m^{(1)} g_m^{(2)} & \cdots & 0 & 0 \\ 0 \quad 0 & g_1^{(1)} g_1^{(2)} & g_2^{(1)} g_2^{(2)} & \cdots & g_m^{(1)} g_m^{(2)} & g_{m+1}^{(1)} g_{m+1}^{(2)} & \cdots & 0 \\ \vdots & \vdots & \vdots & & \vdots & \vdots & & \vdots \\ 0 \quad 0 & 0 \quad 0 & \cdots & & & & & g_{m+1}^{(1)} g_{m+1}^{(2)} \end{bmatrix}$$

P) Previous same problem:

$d = 10111$

$g^{(1)} = 1011$

$g^{(2)} = 1111$

$L = 5$; $C = n(L+m) = 2(5+3) = 16$

$\therefore$ A matrix of (5×16)

convolution encoder. In general, for 2 modulo-2 adders convolution encoder, the generator matrix is given by

$$G = \begin{bmatrix} g_1^{(1)} g_1^{(2)} & g_2^{(1)} g_2^{(2)} & g_3^{(1)} g_3^{(2)} & \cdots\cdots & g_{m+1}^{(1)} g_{m+1}^{(2)} & 0\,0 \cdots & 0\,0 \\ 0 \quad 0 & g_1^{(1)} g_1^{(2)} & g_2^{(1)} g_2^{(2)} & \cdots\cdots & g_m^{(1)} g_m^{(2)} & g_{m+1}^{(1)} g_{m+1}^{(2)} \cdots & 0\,0 \\ \vdots & \vdots & \vdots & & \vdots & \vdots & \vdots \\ 0 \quad 0 & 0 \quad 0 & \cdots & \cdots & \cdots & & g_{m+1}^{(1)} g_{m+1}^{(2)} \end{bmatrix}$$

P) Previous same problem:

$d = 10111$

$g^{(1)} = 1011$

$g^{(2)} = 1111$

$L = 5$;

∴ A ma

$C^{(2)} = 1011111$

$\therefore$ Code word = $[11, 10, 11, 11, 01, 01, 11]$

* MATRIX METHOD :-

The generator sequence

$$g_1^{(1)}\, g_2^{(1)}\, g_3^{(1)} \cdots g_{m+1}^{(1)}$$

for the top adder and

$$g_1^{(2)}\, g_2^{(2)}\, g_3^{(2)} \cdots g_{m+1}^{(2)}$$

for the bottom adder can be interlaced & arranged in a matrix form with the no of rows equal to no of digits in the message sequence i.e. L rows & no of columns equal to $n(L+m)$. Such matrix of the order $\{L \times n(L+m)\}$ is called GENERATOR MATRIX of the

In convolution encoder, the message ~~tree~~ continuously runs through the encoder whereas in block coding schemes, the message stream is first divided into long blocks & then encoded.

In general, there are 2 methods of generating convolution codes.

i) Time domain approach

ii) Transfer domain approach

⇒ Encoding of convolution codes using time domain approach :-

P) Consider a $(n, K, m) = (2, 1, 3)$ convolution encoder as shown in fig. Determine the codes using time domain approach & transfer domain approach.