USN

INTERNAL ASSESSMENT TEST – II

Sub:	DIGITAL COMMUNICATION							Code:	18EC61
Date:	23 / 05 / 2023	Duration:	90 mins	Max Marks:	50	Sem:	VI	Branch:	ECE

Answer any 5 full questions

		Marks	CO	RBT
1	With a neat block diagram explain the digital PAM transmission through bandlimited baseband channels. Derive Nyquist criterion for zero ISI.	[10]	CO4	L3
2a	Starting from Nyquist criterion for zero ISI, obtain the ideal solution to ISI. What are the practical difficulties in implementing ideal solution?	[05]	CO4	L3
2b	Explain raised cosine spectrum as a practical solution to ISI. Plot the spectrum for $\alpha = 0.5$.	[05]	CO4	L3
3	With a neat block diagram and necessary equations, explain duobinary coder. Derive the impulse response of duobinary coder and plot the same.	[10]	CO4	L3

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4a	Binary sequence "**101010101010**"is applied to a duobinary coder. Obtain the output of duobinary coder. Obtain the receiver output assuming that amplitude due to first bit reduces to **0**.	[05]	CO4	L2
4b	Binary sequence "**101010101010**" is applied to a duobinary coder with precoder. Obtain the precoded output, transmitted amplitudes and receiver output.	[05]	CO4	L2
5a	Binary sequence "**101010101010**" is applied to a modified duobinary coder. Obtain the output of modified duobinary coder. Obtain the decoded bits assuming that amplitude due to second bit becomes **0**.	[05]	CO4	L2
5b	Binary sequence "**101010101010**"is applied to a modified duobinary coder with precoder. Obtain the output of precoder and transmitted amplitudes and decoded bits.	[05]	CO4	L2
6a	Write a short note on Eye Pattern and its applications.	[04]	CO4	L2
6b	What is equalization? What is the need for equalization? Explain zero forcing equalizer with a neat block diagram.	[06]	CO4	L2

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Scheme Of Evaluation
Internal Assessment Test II – May 2023

Sub:	DIGITAL COMMUNICATION					Code:	18EC61
Date:	23 / 05 / 2023	Duration:	90 mins	Max Marks:	50	Sem: VI	Branch: ECE

Note: Answer 5Questions

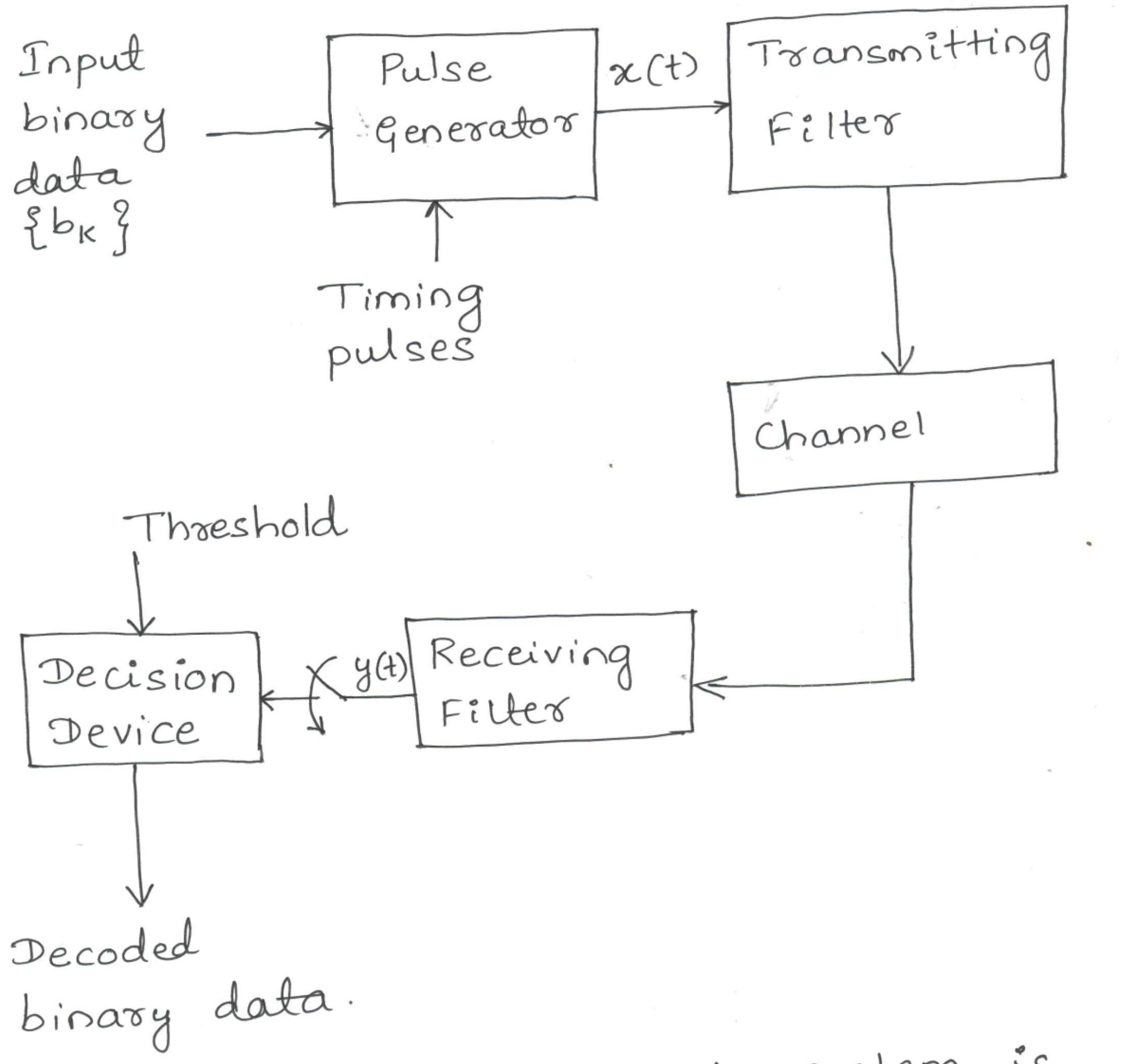
Question #		Description	Marks Distribution		Max Marks
1		Explain binary pulse amplitude modulation (PAM) system with a neat block diagram. Derive Nyquist criterion for distortionless baseband transmission.		10	10
		• Block diagram • Explanation • Derivation	2 2 6		
2	a	Starting from Nyquist criterion for zero ISI, obtain the ideal solution to ISI. What are the practical difficulties in implementing ideal solution?		5	10
		• Derivation • Practical Limitation	3 2		
	b	Explain raised cosine spectrum as a practical solution to ISI. Plot the spectrum for α=0.75.		5	10
		• Equation • Plot	3 2		
3		Explain the design of bandlimited signals with controlled ISI. Obtain duobinary signal pulse and plot the same. What is the need for precoder in a duobinary coder.		10	10
		• Block diagram • Explanation • Derivation	2 2 6		
4	a	Binary sequence "111100001010"is applied to a duobinary coder. Obtain the output of duobinary coder. Obtain the receiver output assuming that amplitude due to second bit reduces to 0.		5	10
		• Transmitter Output • Receiver Output	3 2		
	b	Binary sequence "111100001010"is applied to a duobinary coder with precoder. Obtain the precoded output, transmitted amplitudes and receiver output.		5	

		• Transmitter Output • Receiver Output	3 2		
5	a	Binary sequence "111100001010" is applied to a modified duobinary coder. Obtain the output of modified duobinary coder. Obtain the decoded bits.		5	10
		• Transmitter Output • Receiver Output	3 2		
	b	Binary sequence "111100001010" is applied to a modified duobinary coder with precoder. Obtain the output of precoder and transmitted amplitudes and decoded bits.		5	
		• Transmitter Output • Receiver Output	3 2		
6	a	Write a short note on Eye Pattern and its applications.		4	10
		• Explanation			
	b	What is equalization? What is the need for equalization? Explain zero forcing equalizer with a neat block diagram.			
		• Definition • Explanation • Block diagram		2 2 2	

Solutions

1.

Block diagram of binary PAM system.



The input to the binary PAM system is a binary data sequence $\{b_K\}$ with bit duration of T_b seconds.

This sequence is applied to a pulse

generator producing the discrete PAM signal,

$$x(t) = \sum_{K=-\infty}^{\infty} a_K v(t - kT_b) \quad \ldots (1)$$

where $v(t)$ denotes the basic pulse.

The coefficient a_K depends on the input data and type of signaling used.

The PAM signal $x(t)$ passes through a transmitting filter of transfer function $H_T(f)$.

The resulting filter output defines the transmitted signal which is modified as a result of transmission through the channel of transfer function $H_C(f)$.

The channel may be a coaxial cable or an optical fiber, where the major source of signal degradation is dispersion in the channel.

We assume that the channel is noiseless, but dispersive.

The channel output is passed through a receiving filter of transfer function $H_R(f)$.

The receiving filter output is sampled at time $t = iT_b$, $i = 0, \pm 1, \pm 2, \ldots$

Each sample is compared with a threshold value.

If the sample value exceeds the threshold, a decision is made in favor of bit '1' otherwise in favor of bit 0.

The receiving filter output may be written as

$$y(t) = \mu \sum_{K=-\infty}^{\infty} a_K \, p(t - KT_b) \quad \ldots (2)$$

The scaling factor μ accounts for the attenuation in the channel.

$p(t)$ is the basic pulse at the receiver.

The sampled version of $y(t)$ is given by

$$y(iT_b) = \mu \sum_{K=-\infty}^{\infty} a_K \, p(iT_b - KT_b)$$

$$= \underset{(\text{when } k=i)}{\mu \, p(0) \, a_i} + \mu \sum_{\substack{K=-\infty \\ K \neq i}}^{\infty} a_K \, p(iT_b - KT_b) \quad \ldots (3)$$

The term $\mu \, p(0) a_i$ is due to the i^{th} transmitted bit.

$$a_K = \text{PAM}(b_K)$$

$$= \begin{cases} +1V & \text{if } b_K = 1 \\ -1V & \text{if } b_K = 0 \end{cases} \quad \ldots (1)$$

The output of duobinary coder,

$$c_K = a_K + a_{K-1} \quad \ldots (2)$$

We assume an ideal channel with frequency response,

$$H_c(f) = T_b \,, \quad -\frac{R_b}{2} \leq f \leq \frac{R_b}{2} \quad \ldots (3)$$

The overall frequency response of duobinary system is given by,

$$H(f) = \left[1 + e^{-j2\pi f T_b}\right] H_c(f)$$

$$= \left[1 + e^{-j2\pi f T_b}\right] T_b \,, \quad -\frac{R_b}{2} \leq f \leq \frac{R_b}{2} \quad \ldots (4)$$

$$\therefore \; H(f) = e^{-j\pi f T_b} \left[e^{j\pi f T_b} + e^{-j\pi f T_b}\right] T_b$$

$$= e^{-j\pi f T_b} \, 2\cos(\pi f T_b) \, T_b$$

$$-\frac{R_b}{2} \leq f \leq \frac{R_b}{2}$$

$$\ldots (5)$$

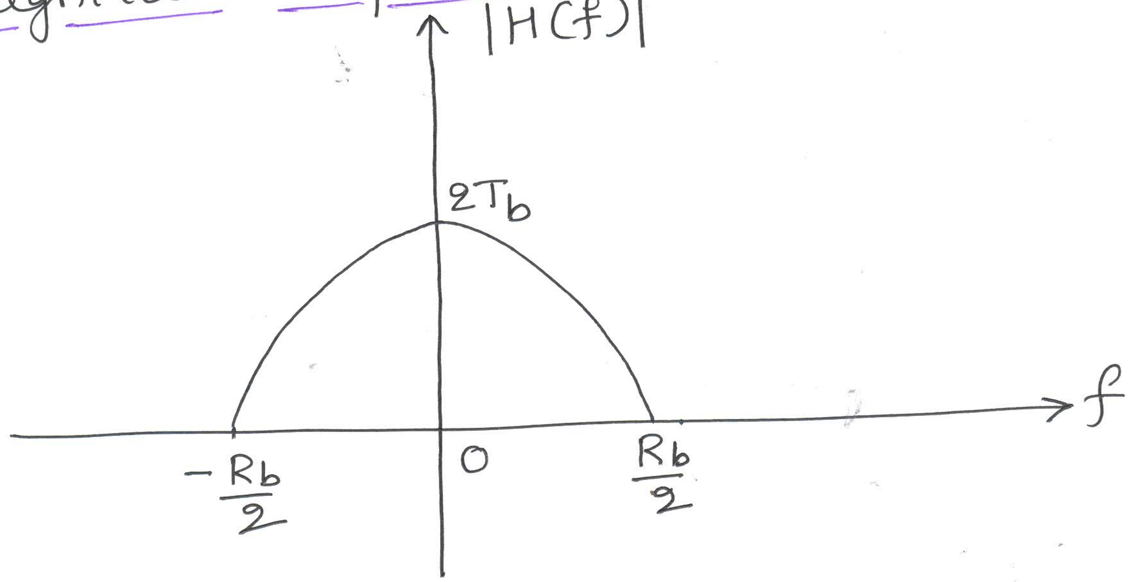
∴ Magnitude response,

$$|H(f)| = 2T_b \cos(\pi f T_b), \quad -\frac{R_b}{2} \le f \le \frac{R_b}{2}$$

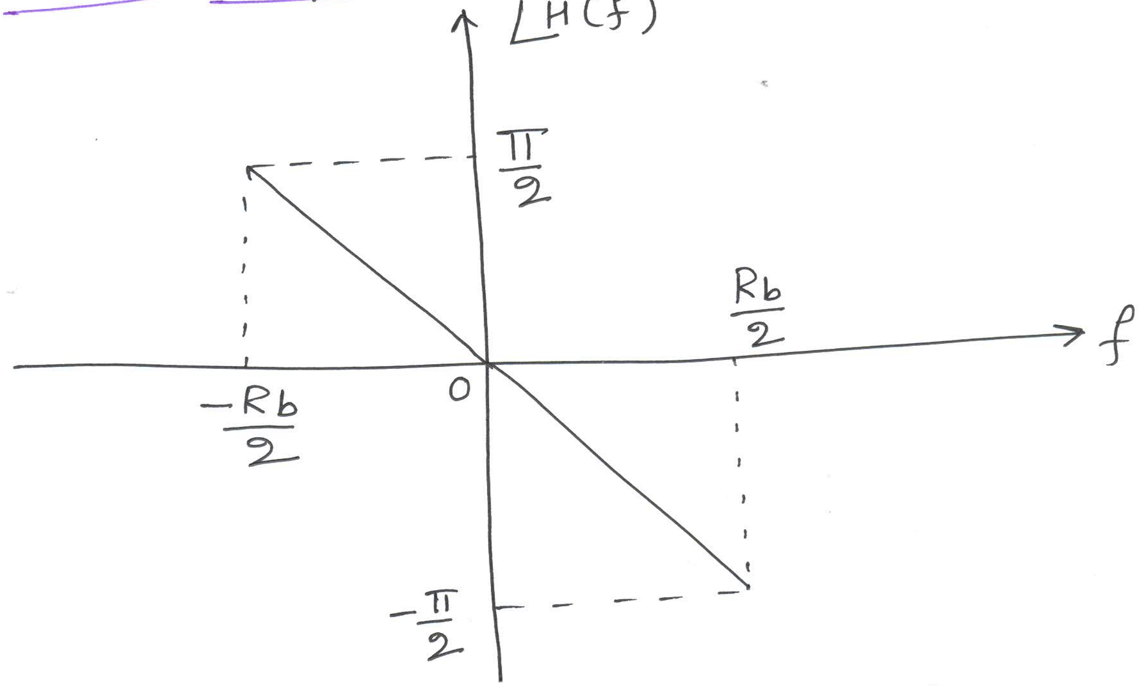
Phase response,

$$\angle H(f) = -\pi f T_b, \quad -\frac{R_b}{2} \le f \le \frac{R_b}{2}$$

Magnitude Response



Phase response



Note that $|H(f)| \neq 0$ @ $f = 0$.

⇒ The system produces DC component.

The impulse response of the duobinary system can be found by computing IFT of frequency response given by (4).

$$\therefore h(t) = \int_{-\infty}^{\infty} H(f)\, e^{j2\pi f t}\, df$$

$$= \int_{-\frac{R_b}{2}}^{\frac{R_b}{2}} \left[1 + e^{-j2\pi f T_b}\right] T_b\, e^{j2\pi f t}\, df$$

$$= T_b \int_{-\frac{R_b}{2}}^{\frac{R_b}{2}} e^{j2\pi f t}\, df + T_b \int_{-\frac{R_b}{2}}^{\frac{R_b}{2}} e^{j2\pi f (t-T_b)}\, df$$

$$= T_b \left.\frac{e^{j2\pi f t}}{j2\pi t}\right|_{-\frac{R_b}{2}}^{\frac{R_b}{2}} + T_b \left.\frac{e^{j2\pi f (t-T_b)}}{j2\pi (t-T_b)}\right|_{-\frac{R_b}{2}}^{\frac{R_b}{2}}.$$

$$= \frac{T_b}{j2\pi t}\left[e^{j\pi R_b t} - e^{-j\pi R_b t}\right] + \frac{T_b}{j2\pi (t-T_b)}\left[e^{j\pi R_b (t-T_b)} - e^{-j\pi R_b (t-T_b)}\right]$$

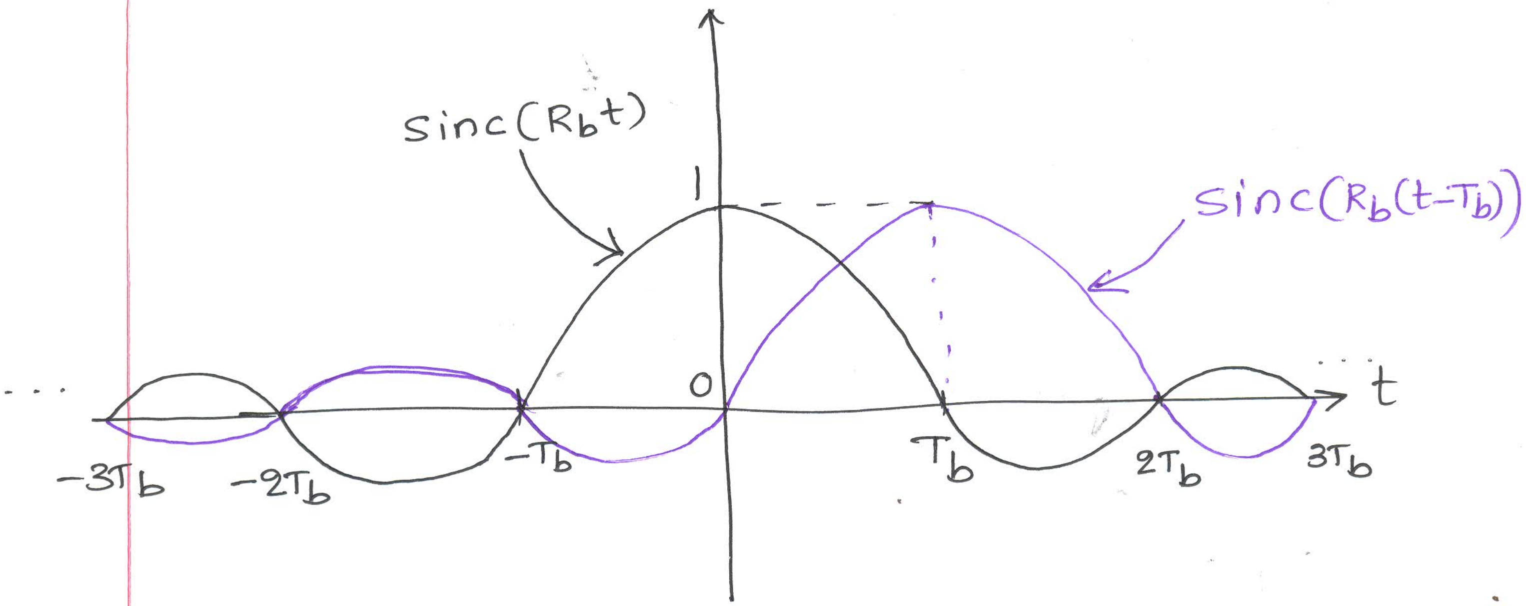
$$= \frac{T_b}{j2\pi t}\, 2j \sin(\pi R_b t) + \frac{T_b}{j2\pi (t-T_b)}\, 2j \sin(\pi R_b (t-T_b))$$

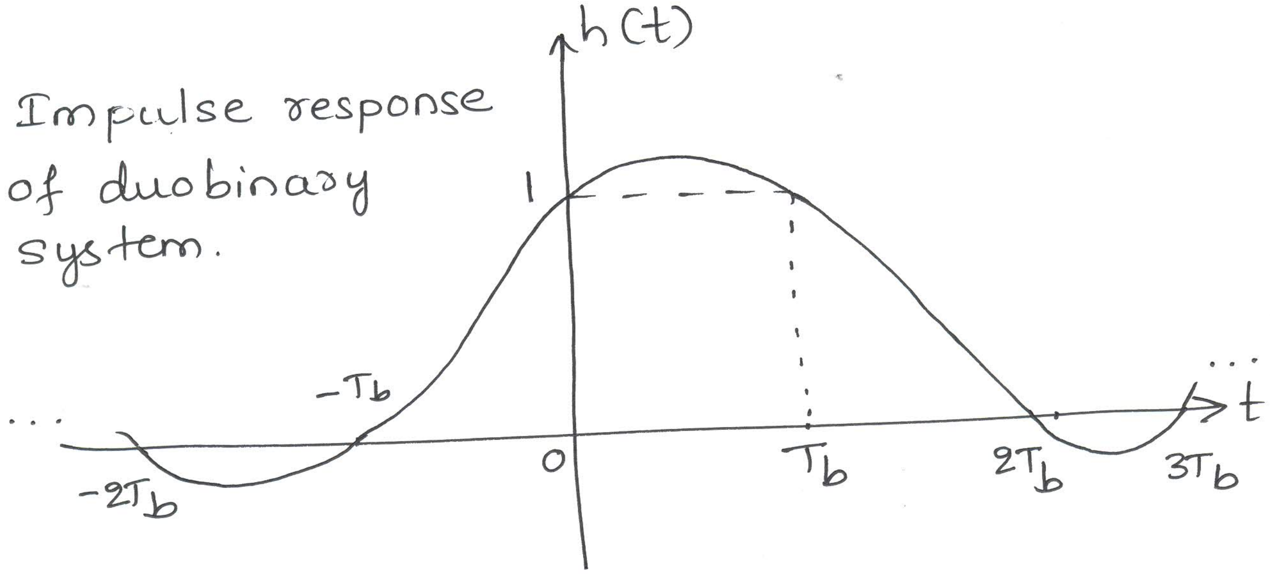
$$= \frac{\sin(\pi R_b t)}{\pi R_b t} + \frac{\sin(\pi R_b (t-T_b))}{\pi R_b (t-T_b)}$$

$$= \text{sinc}(R_b t) + \text{sinc}(R_b(t-T_b)) \quad \dots (6)$$

This is the impulse response of the duobinary system.

To plot $h(t)$ v/s t.





Impulse response of duobinary system.

From (2),

$$c_k = a_k + a_{k-1}$$

@ Receiver,

we evaluate,

$$\hat{a}_K = \hat{c}_K - \hat{a}_{K-1} \quad \ldots (7)$$

Decision rule:

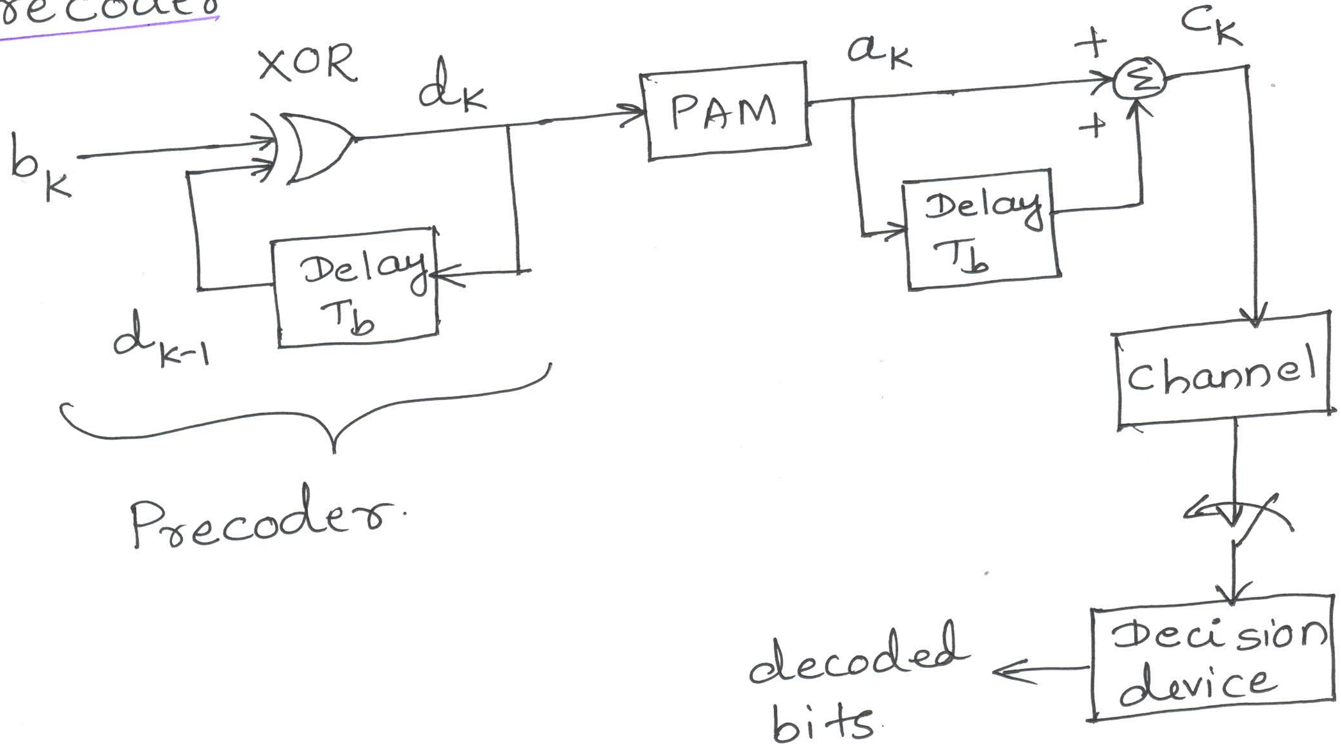
$$\hat{b}_K = \begin{cases} 1 & \text{if } \hat{a}_K = 1 \\ 0 & \text{if } \hat{a}_K = -1 \end{cases} \quad \ldots (8)$$

Note that the decision on the current bit depends on previous decision.

∴ In the detection process, once an error is made, the error tends to propagate.

This can be avoided using a precoder before duobinary coder.

Block diagram of duobinary coder with precoder



Precoder output , $d_K = b_K + d_{K-1}$ ...(9)

$$a_K = \text{PAM}(d_K)$$

$$= \begin{cases} +1V & \text{if } d_K = 1 \\ -1V & \text{if } d_K = 0 \end{cases} \quad \ldots (10)$$

$$c_K = a_K + a_{K-1} \quad \ldots (11)$$

$$c_K = \begin{cases} \pm 2V & \text{if } b_K = 0 \\ 0V & \text{if } b_K = 1 \end{cases} \quad \ldots (12)$$

(see problem #8).

Decision rule @ receiver.

$$\hat{b}_K = \begin{cases} 0 & \text{if } |c_K| > 1V \\ 1 & \text{if } |c_K| \leq 1V. \end{cases} \quad \ldots (13)$$

Note that present decision depends only on present amplitude but not on previous decision.

∴ If an error is made, it will not affet the future decisions.

Hence, error propagation can be prevented.

Note: Duobinary coding is also called Partial Response Signalling

4a

b_k 1 1 1 1 0 0 0 0 1 0 1 0

a_k 1 1 1 1 1 -1 -1 -1 -1 1 -1 1 -1

c_k 2 2 2 2 0 -2 -2 -2 0 0 0 0

$\hat{c}_k$ 2 0 2 2 0 -2 -2 -2 0 0 0 0

$\hat{a}_k$ 1 1 -1 3 -1 1 -3 +1 -1 1 -1 1 -1

$\hat{b}_k$ 1 0 1 0 1 0 0 0 1 0 1 0

4b

b_k 1 1 1 1 0 0 0 0 1 0 1 0

d_k 1 0 1 0 1 1 1 1 1 0 0 1 1

a_k 1 -1 1 -1 1 1 1 1 1 -1 -1 1 1

c_k 0 0 0 0 2 2 2 2 0 -2 0 2

5a

b_k 1 1 1 1 0 0 0 0 1 0 1 0

a_k 1 1 1 1 1 1 -1 -1 -1 -1 1 -1 1 -1

c_k 0 0 0 0 -2 -2 0 0 2 0 0 0

5b

b_k 1 1 1 1 0 0 0 0 1 0 1 0

d_k 1 1 0 0 1 1 1 1 1 1 0 a 1 1

a_k 1 1 -1 -1 1 1 1 1 1 1 -1 1 1 1

c_k -2 -2 2 2 0 0 0 0 -2 0 2 0