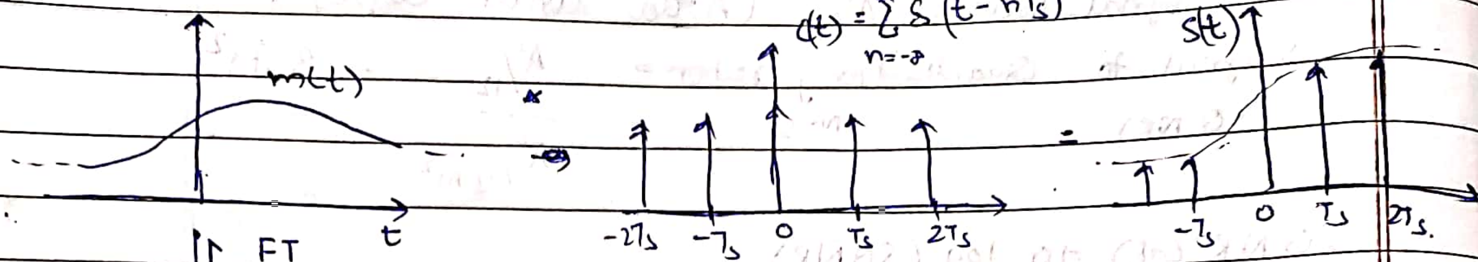
$\boxed{\text{Sampling}}$ → reduction of a band-limited continuous time signal to a discrete time signal.

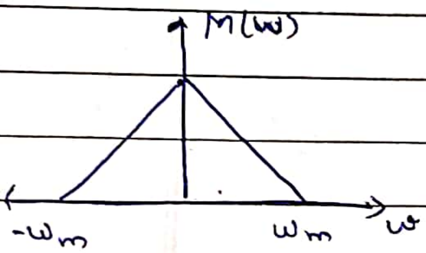
sampling

$$c(t) = \sum_{n=-\infty}^{\infty} \delta(t - nT_s)$$



periodic impulse train

$\Big\downarrow\Big\uparrow$ FT



T_s = Sampling period

$\omega_s = \dfrac{2\pi}{T_s}$ = Sampling Freq.

$s(t) = m(t) \cdot c(t)$

Now we have s(t) we want its FT S(ω)

$S(t) = m(t) \cdot c(t)$

ω_m = max freq compon of m(t)

taking FT

~~S(ω) →~~

FT of c(t)

$$\boxed{C(\omega) = \omega_s \sum_{n=-\infty}^{\infty} \delta(\omega - n\omega_s)}$$

$$S(\omega) = \frac{1}{2\pi}\Big[M(\omega) * \underbrace{C(\omega)}_{\text{convolution}}\Big]$$

$$S(\omega) = \frac{1}{2\pi}\Big[M(\omega) * \omega_s \sum_{n=-\infty}^{\infty} \delta(\omega - n\omega_s)\Big]$$

$$= \frac{1}{T_s} \cancel{\frac{\omega_s}{2\pi}} \Big[M(\omega) * \sum \delta(\omega - n\omega_s)\Big]$$

$$= \frac{1}{T_s}\Big[\sum M(\omega) * \delta(\omega - n\omega_s)\Big]$$

Property of convolution

$$x(t) * \delta(t - t_1) = x(t - t_1)$$

$$S(\omega) = \frac{1}{T_s}\Big[\sum_{n=-\infty}^{\infty} M(\omega - n\omega_s)\Big]$$

Putting value $n = 0, 1, 2, \ldots$

$$S(\omega) = \frac{1}{T_s}\Big[\ldots\ldots M(\omega) + M(\omega - \omega_s) \ldots\ldots\Big]$$

table

1 -> types_of_sampling

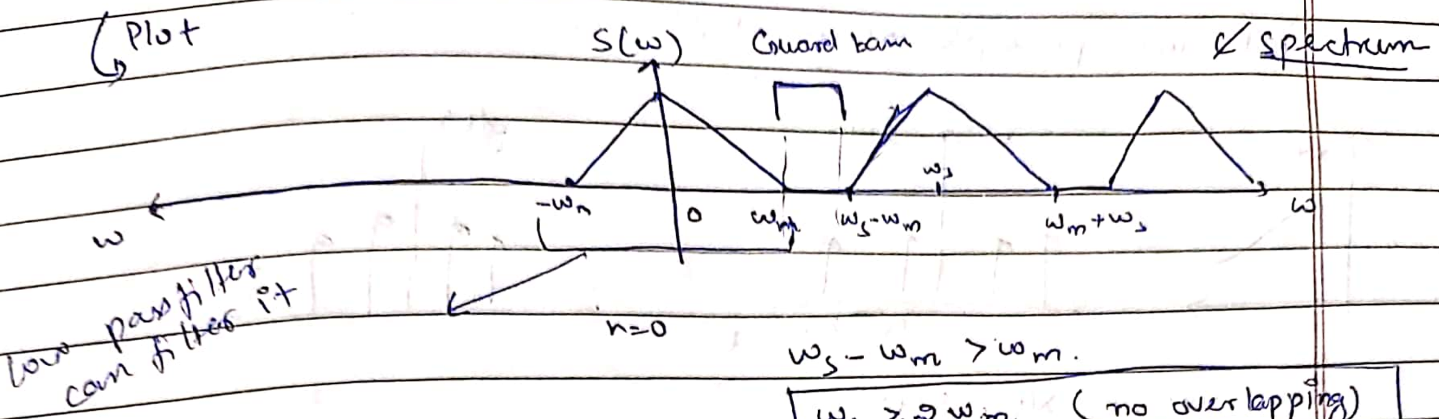
2-> pulse_modulation

3->modulation_bask_psk_ask

4-> DIV_SPACE_TIME

$$S_\omega = \frac{1}{T_s}\left[\ldots M(\omega+\omega_s) + \underset{n=0}{M(\omega)} + M(\omega-\omega_s) \right]$$

Plot



$\omega_s - \omega_m > \omega_m$.

$\boxed{\omega_s \geq 2\omega_m \text{ (no overlapping)}}$

sampling theorm

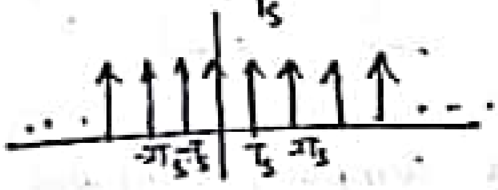
• Sampling Theorem

↳ A band limited signal of finite energy which has no freq component higher than f_m (Hz) is completely by its sample values at uniform interval less than or equal to $\frac{1}{2f_m}$.

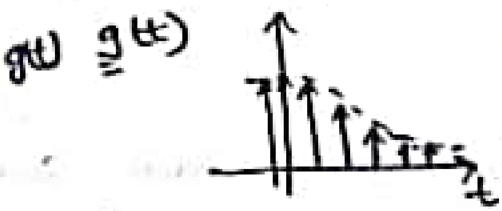
$\boxed{T_s \le \frac{1}{2f_m}}$ or $\boxed{f_s \geq 2f_m}$

Note: if signal is band limited to f_m then,
$X(\omega) = 0$ for $\omega > \omega_m$

$$\delta_{T_s}(t) = \frac{1}{T_s}(1 + 2\cos\omega_s t + 2\cos 2\omega_s t + \dots)$$

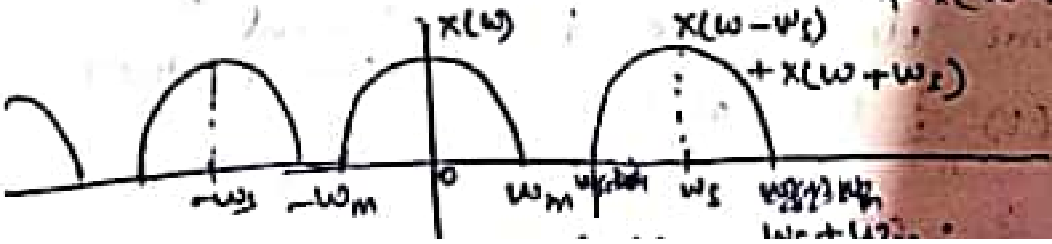


$g(t) = x(t)\,\delta_{T_s}(t)$



$$g(t) = x(t)\left[\frac{1}{T_s}(1 + 2\cos\omega_s t + 2\cos 2\omega_s t \dots)\right]$$

$$G(\omega) = \frac{1}{T_s}\big(X(\omega) + X(\omega - \omega_s) + X(\omega + \omega_s) + X(\omega - 2\omega_s) + X(\omega + 2\omega_s) + \dots\big)$$



- if $f_s > 2f_m$ → no overlapping and periodically repetition.
- At receiver end we place low pass filter of frequency ω_m so we can extract original information.

$f_s > 2f_m$ → no overlapping

$f_s = 2f_m$ → touch (nyquist rate) nyquist rate nyquist rate

$f_s < 2f_m$ → overlapping (distortion)

$T_s = \frac{1}{2f_m}$ → Nyquist time interval.

Effect of under sampling → Aliasing aliasing aliasing

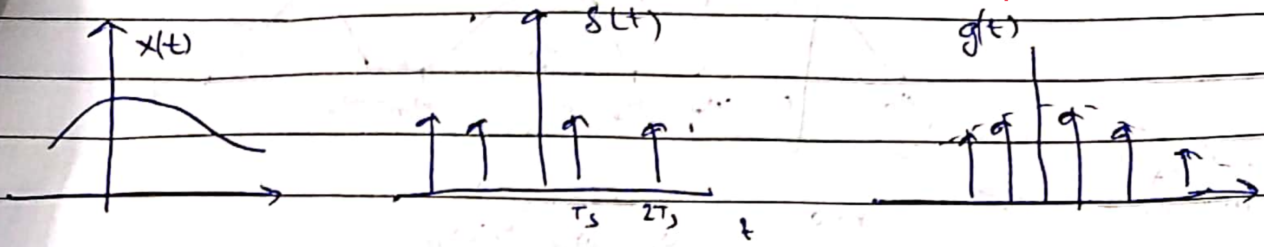
if $f_s < 2f_m$ when we apply LPF we won't be able to extract og sample bcos of aliasing (overlapping).

↳ If we go for sampling, we pass original signal through LPF, this is even referred to as pre alias filter other name is band limit filter. → Avoid aliasing

or $f_s > 2f_m$

→ Ideal sampling / Instantaneous / Impulse. sampling.

It uses principle of multiplication.



$$g(t) = x(t) \cdot \delta(t)$$

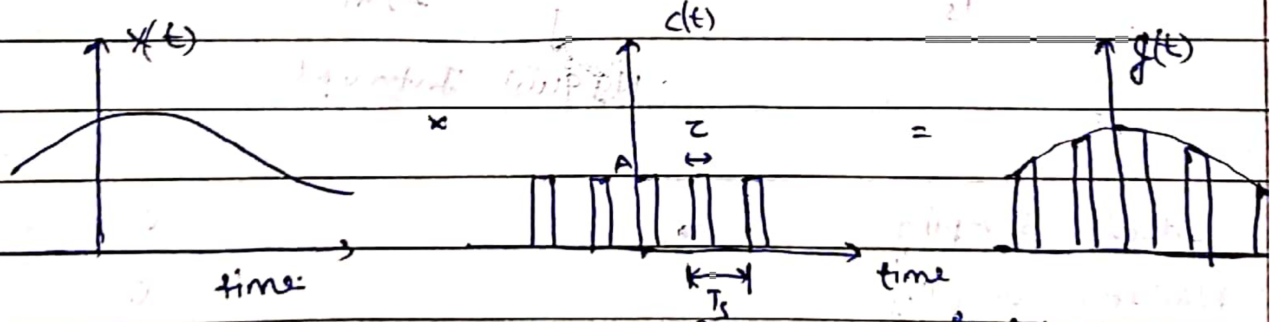
Time domain $\quad g(t) = x(t) \cdot \sum_{-\infty}^{\infty} \delta(t - nT_s)$

Frequency domain $\quad c(\omega) = f_s \sum X(f - nf_s)$ $\quad$ convolution (previous page)

- Practically not possible, (as always their is width ≠
- Noise interference.
- Passing low energy (0 width pulse)

→ Natural Sampling! natural

→ It uses chopping principle.



$$c(t) = \frac{\tau A}{T_s} \sum_{-\infty}^{\infty} \text{sinc}(f_n \tau)\, e^{i2\pi f_s t}$$

So $\quad g(t) = x(t)$ when $c(t) = A$

$\quad\quad\quad\; = 0 \quad ; c(t) = 0$

$$g(t) = x(t)\, c(t)$$

$$g(t) = \frac{\tau A}{T_s} \sum x(t)\, \text{sinc}(n f_s \tau)\, e^{j 2\pi f_s t}$$

$$\hat{g}(\omega) = \frac{\tau A}{T_s} \sum \text{sin}(n\, t_s \tau)\, X(f - n f_s) \rightarrow \text{convolu}$$

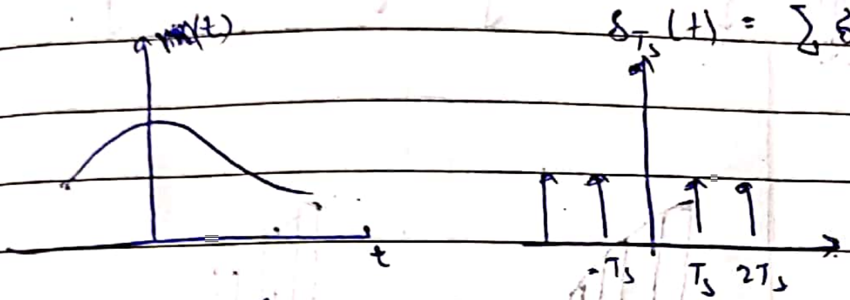
<u>Flat-top sampling:</u> / <u>PAM → Pulse Amplitude Modulation.</u>

<u>Sample and hold ckt.</u>

$\delta_{T_s}(t) = \sum \delta(t - nT_s)$

flattop

PAM

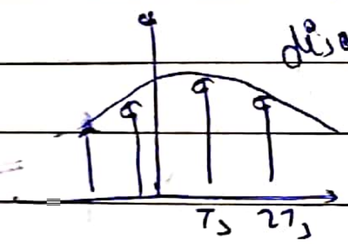


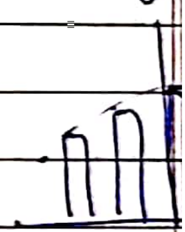
$H(t) = \begin{cases} 1 & 0 < t < \\ 0 & \text{elsewi} \end{cases}$

$s(t) = m(t)\, \delta_{T_s}(t)$ — discrete form of m(t)

$H(T)$ (Hold signal)

g





$$g(t) = s(t) \circledast H(t).$$

Time domain $\quad g(t) = \sum s(t) \circledast h(t - nT_s)$

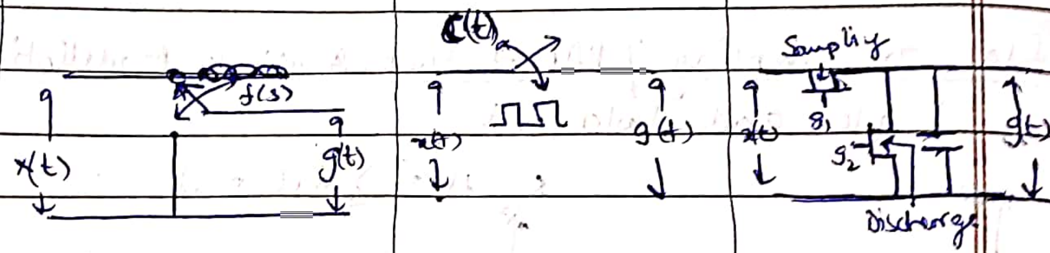
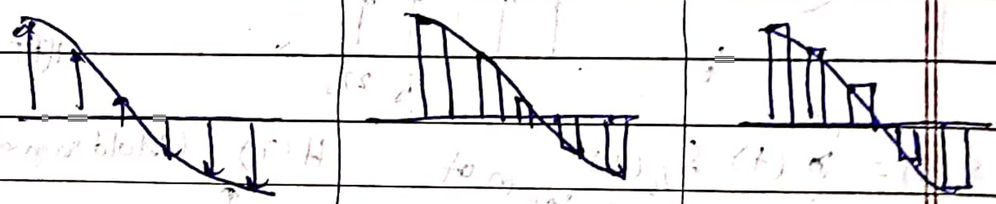
Freq domain $\quad \hat{g}(\omega) = f_s \sum M(f - n f_s)\, H(f)$

~~check sin ma~~

Type text here

Till now

table1

	Ideal sampling	Natural sampling	Flat top [PAM]
Sampling Principle	Multiplication	Chopping	Sample and Hold.
Circuit			
Waveform			
Feasibility	Not possible	✓	✓
Noise	very high	low	high
Time domain	$g(t) = \sum x(t)\,\delta(t-nT_s)$	$g(t) = \frac{\tau A}{T_s} \sum x(t)\, \text{sinc}(n f_s \tau)\, e^{j2\pi n f_s t}$	$g(t) = \sum x(t)\, h(t-nT_s)$
Freq domain	$G(f) = f_s \sum X(f-nf_s)$	$G(f) = \frac{\tau A}{T_s} \sum \text{sinc}(nf_s\tau)\, X(f-nf_s)$	$G(f) = f_s \sum X(f-nf_s)$

quantisation

Basic of Quantisation.

Analog Signal $x(t)$ → Sampling → Discrete Sig $x(n)$ → Quantisation → Coding → Digital data

Time is continuous
Amp is continuous

Time → Discrete
Amp → Cont

Time - Discrete
Amp → Discrete
So discrete values of amplitude.

$x(t) = \sin(2\pi f t)$ Analog signal.

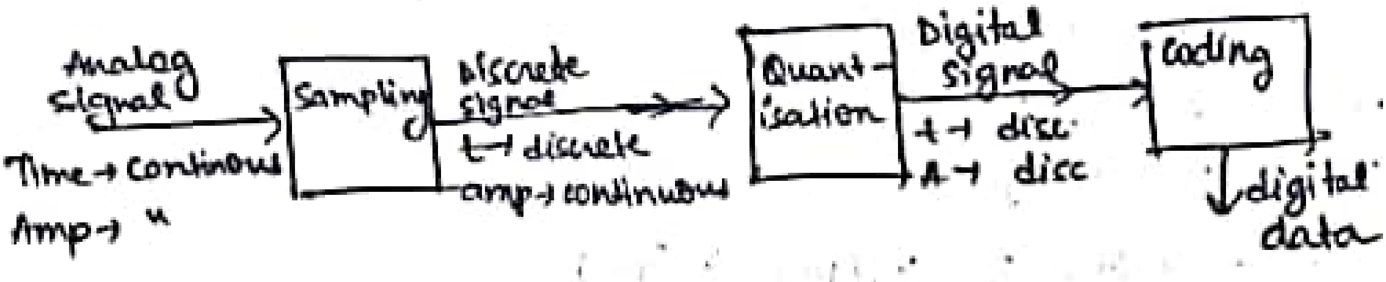
t can be → 0.1, 0.11, 0.112 --- continuous.

$x(n) = \sin(2\pi f n T_s)$ $n = 0, 1, 2 \ldots$ Discrete.

Difference of Pulse Code Modulation

quanta

Quantisation quantisation

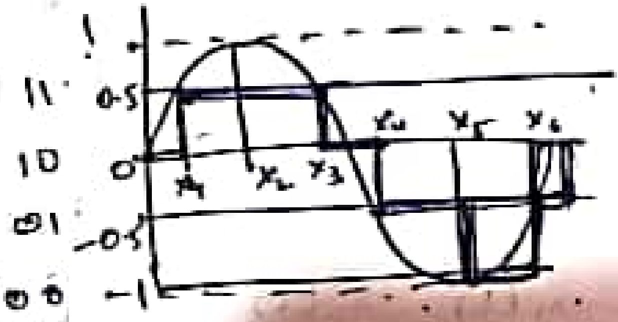


no. of bits = n = 2 (say)

" " levels = 2^n , ⇒ 4

Step size $\Delta = \frac{A_{max} - A_{min}}{L}$

= 0.5



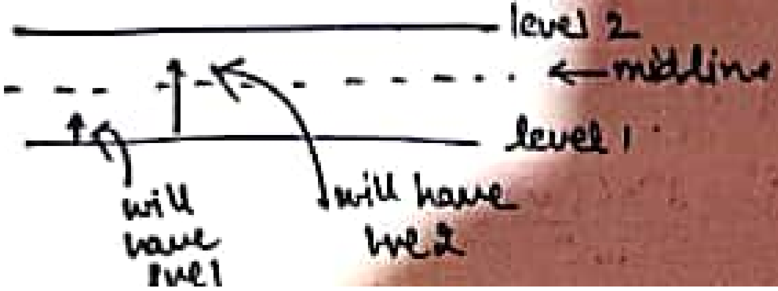
points	x_1	x_2	x_3	x_4	x_5	x_6	x_7
sampling	0.57	0.8	0.6	−0.6	−0.9	−0.5	
quantisation	0.5	0.5	0.5	0.5	1	0.5	
quantisation error	0.07	0.3	0.1	0.1	0.1	0	

features of quantisation :

1) continous ⟶ ~~lim~~ finite set
2) infinite precision ⟶ finite precision
3) Rounding off samples to nearest quantised level.

to choose a level of quantisation divide the 2 levels an. and chose the level acc. to region

ex :



dynamic range of quantisation dynamic range of quantisation

↳ ratio of largest to smallest measurable amplitude.

$$= 20 \log \left[\frac{\text{largest Amp}}{\text{Smallest Amp}}\right]$$

$$= 20 \log \left[\frac{2^{n-1}\Delta}{2^{-1}\Delta}\right] = 20 \log 2^n = 20 n \log 2$$

dynamic range of quanta

$$= \cancel{6.02n} \quad \underline{\underline{6.02n}}$$

SNR of quantisation

snr of quantisation

$$SNR = 20 \log \left[\frac{\text{signal rms voltage}}{\text{noise rms voltage}}\right]$$

$$q_e^2 = \frac{1}{\Delta}\int_{-\Delta/2}^{\Delta/2} q^2\,dq = \frac{1}{\Delta}\left[\frac{q^3}{3}\right]_{-\Delta/2}^{\Delta/2} = \frac{\Delta^2}{12}$$

quantisation error

qe

$$q_e = \frac{\Delta}{2\sqrt{3}} \leftarrow \text{noise rms}$$

qe

quanta error

full scale signal $= V_{max} - V_{min} = V_{fs}$

Peak voltage $= V_f/2$

Rms of Peak voltage $= \dfrac{V_f}{2\sqrt{2}} = \dfrac{2^n\Delta}{2\sqrt{2}}$

$$\Delta = \frac{V_{max} - V_{min}}{2^n} \Rightarrow V_f = 2^n\Delta$$

$$SNR = 20 \log \left[\frac{\frac{2^n \cancel{\Delta}}{2\sqrt{2}}}{\frac{\cancel{\Delta}}{2\sqrt{3}}}\right] = 20 \log\left(\cancel{\frac{}{}}\,\frac{2^n\sqrt{3}}{2}\right)$$

$$= 6.02n + 1.76$$

snr of quanta

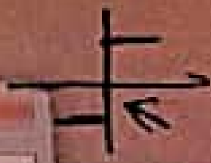
$$\boxed{SNR = 6.02n + 1.76}$$ (same for sqnR)

midrise

uniform (step size = same)   non unifor

midrise

midtread



Quantisation noise / error (for uniform step size)

PDF of quantisation error

$$f_Q(q) \begin{cases} \frac{1}{\Delta} & -\frac{\Delta}{2} < q < \frac{\Delta}{2} \\ 0 & \text{else} \end{cases} \quad \Big\} \text{ uniform distribution}$$

quantisation error

qe

qe

quanta error

mean of quantisation error

$$= \int_{-\Delta/2}^{\Delta/2} q \left(\frac{1}{\Delta}\right) dq = \frac{1}{\Delta}\left[\frac{q^2}{2}\right]_{-\Delta/2}^{\Delta/2} = 0$$

Variance of quantisation

$$E(x^2) = \int_{-\infty}^{\infty} x^2 f(x)\, dx$$

$$\sigma_Q^2 = \int_{-\Delta/2}^{\Delta/2} q^2 \left(\frac{1}{\Delta}\right) dq = \frac{1}{3\Delta}\left[q^3\right]_{-\Delta/2}^{\Delta/2}$$

(Same as SNR) $$= \frac{\Delta^2}{12}$$

- If step size ↑ → Quantisation noise ↑
  If step size ↓ → channel noise ↑

∴ for large variance → large step size
  for small variance → small step size

∴ non uniform step size.

← linear

output

Pulse modulation

pulse modulation

↳ Process where one parameter of carrier signal varies according to modulating signal.

pulse modulation

Modulating signal → low freq which we want to transfer

carrier signal → high freq.

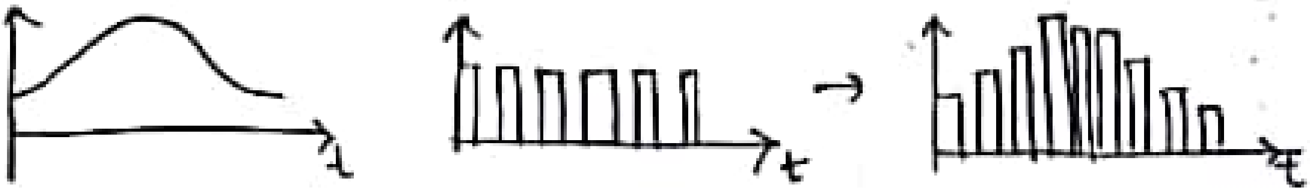
size of antenna → $\frac{\lambda}{4}$.

size of antenna

size of antenna

1) Pulse Amp modulation (flat top)

PAM



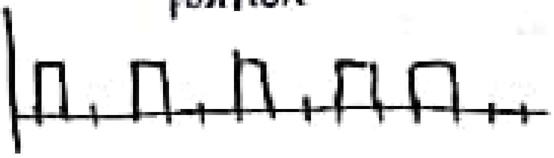
2) Pulse width modulation

PWM

where amp is high
↳ width is high

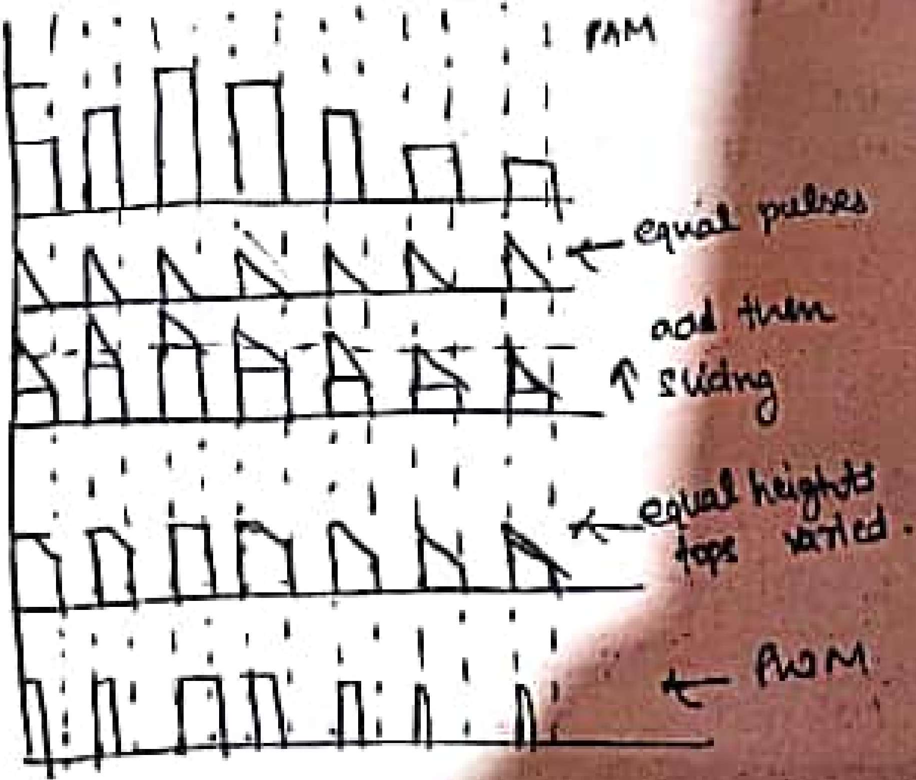
3) Pulse ~~phase~~ position modulation

PPM

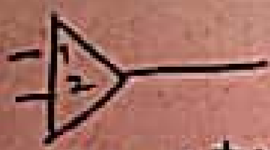


width is same
where the pulse ends in PWM the pulse size in ~~PWM~~ ppm and drop a ie are a with same width

Generation



for slicing we use comparator



1>2 → +ve
1<2 → 0

advantages of PPM

↳ less affected by noise

↳ noise contaminated can be reconstructed

↳ transmitted power is constant.

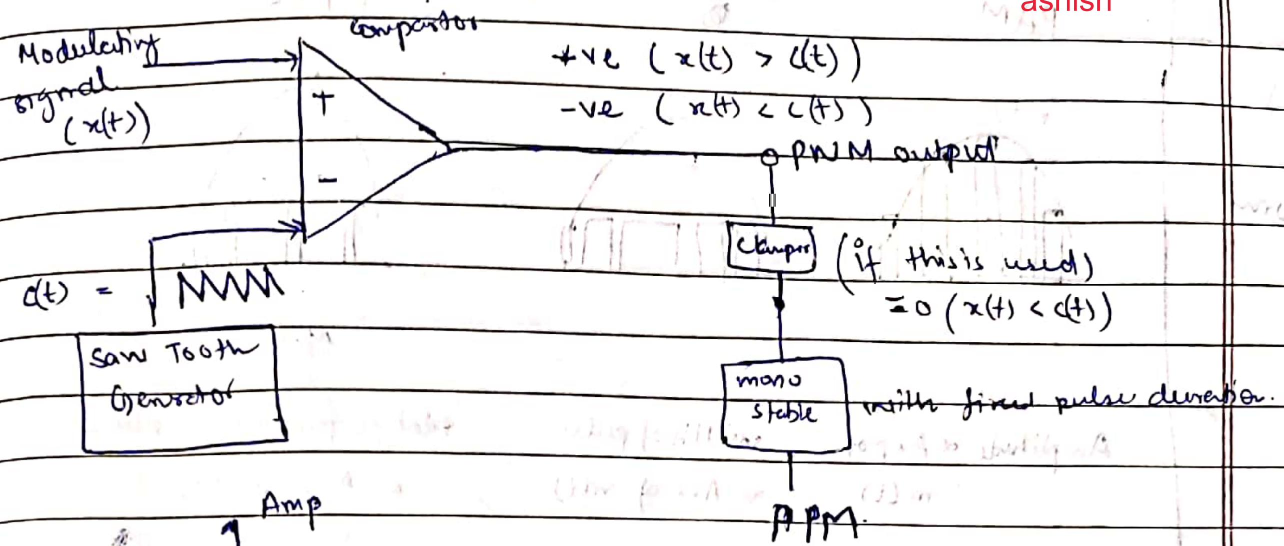
disadvantages of PPM

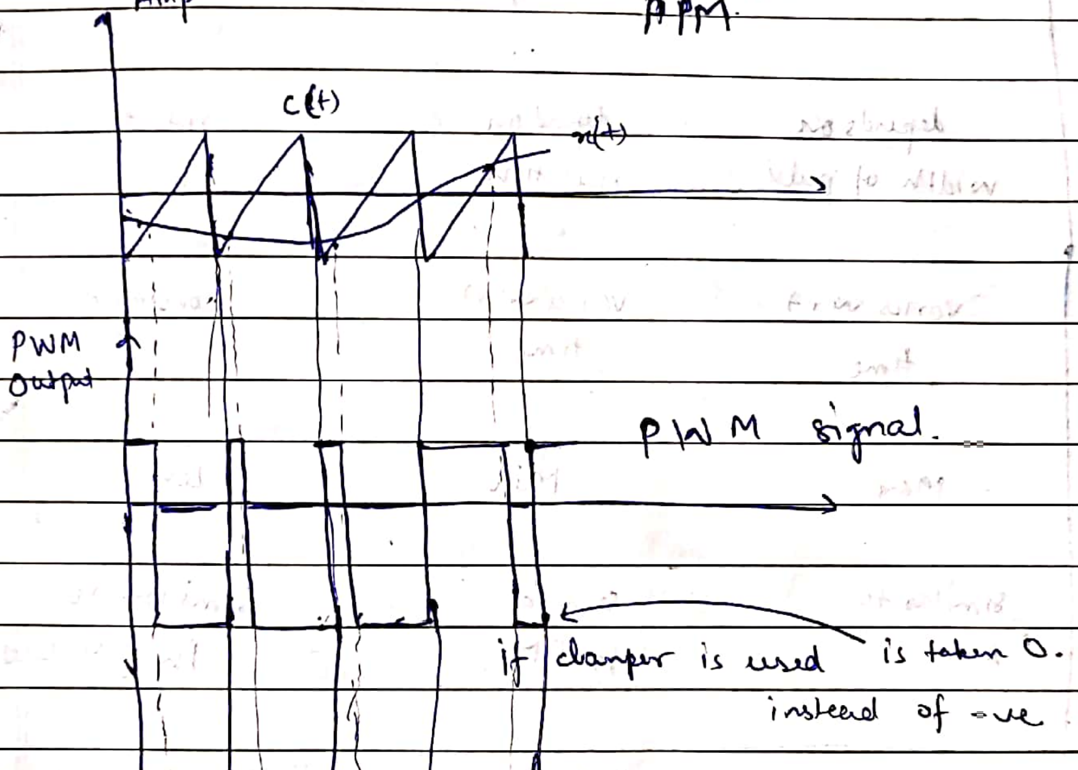
↳ synchronisation is reqd at demodulation

↳ requires high bandwidth.

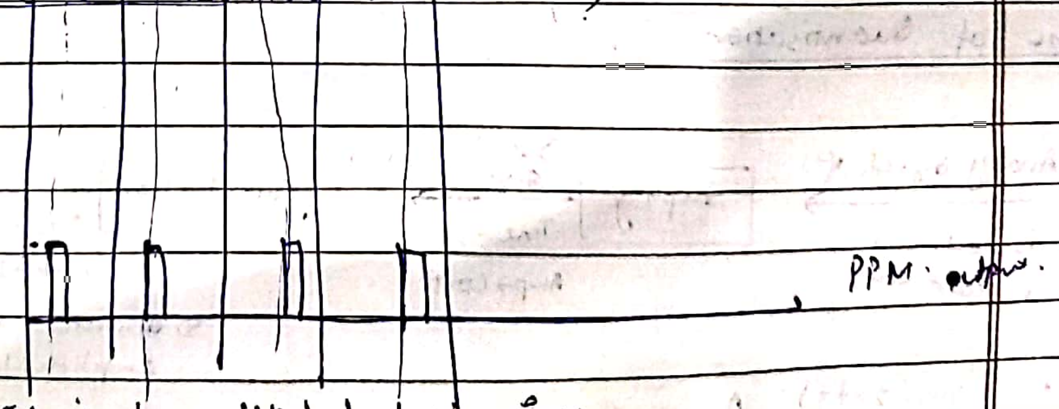
PWM (Pulse width Modulation)

ashish





PPM (Pulse Position Modulation)



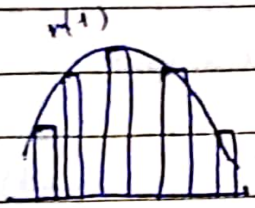
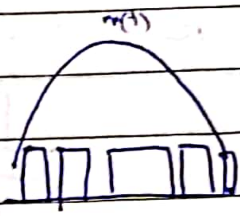
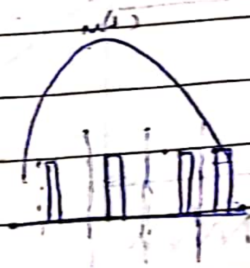
Adv

(1) It is less affected by noise.
(2) Noise contaminated signal can be reconstructed.
(3) ~~Transmitted Power~~ Is constant.

Dis

(1) Sync. is required at demodulation.
(2) High band width

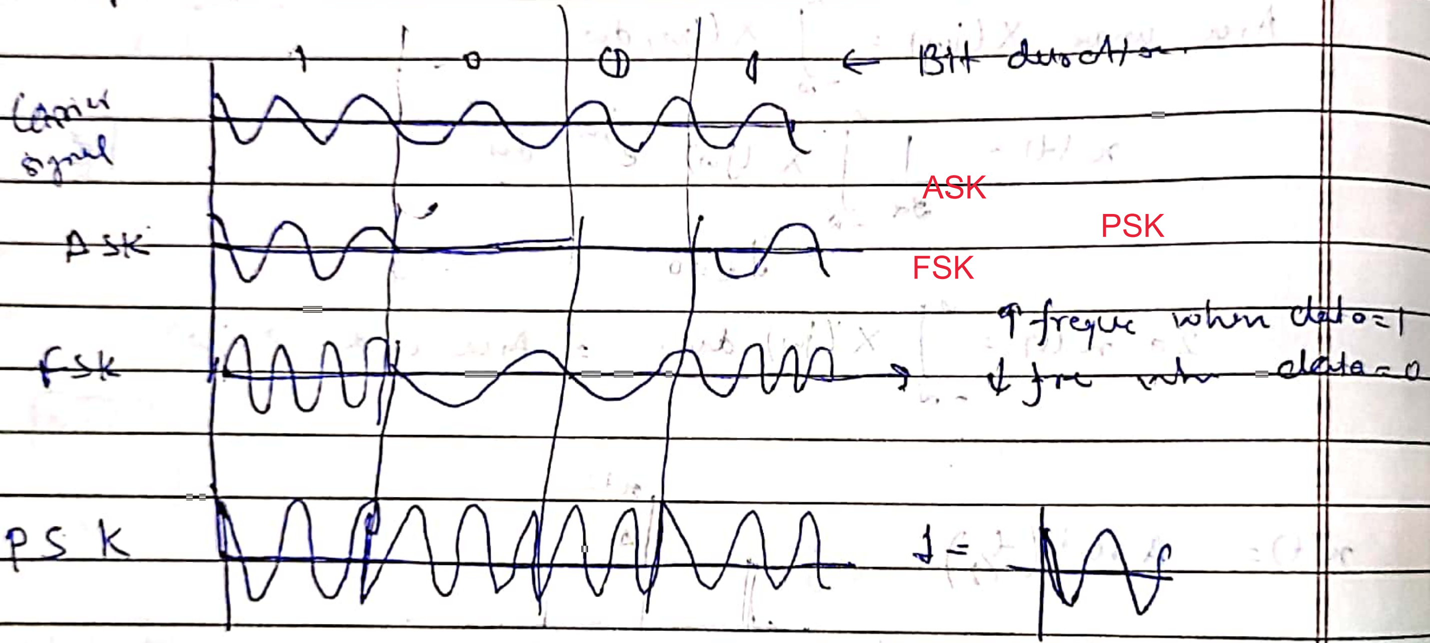
table2

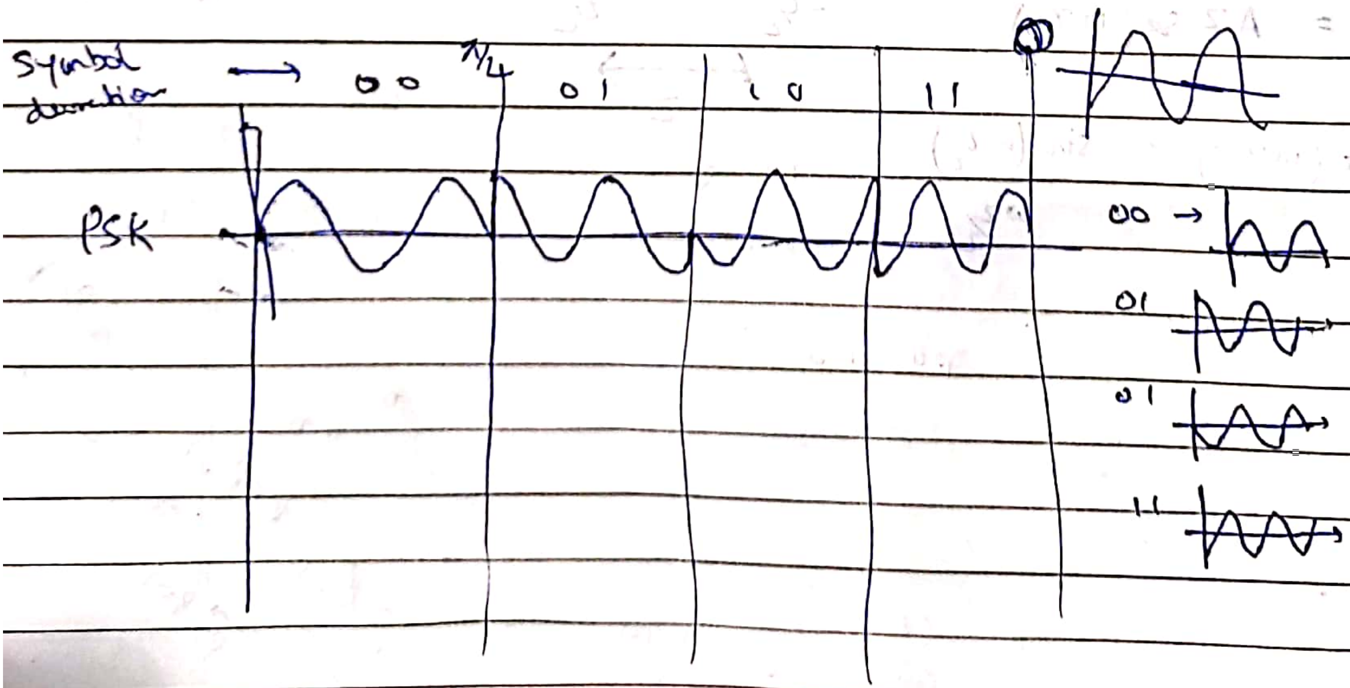
	PAM	PWM	PPM
Waveform			 reference
Working principle	Amplitude $\propto$ Amp of m(t)	width of pulse $\propto$ Amp of m(t)	relative position of pulse $\propto$ Amp of m(t)
Bandwidth	depends on width of pulse	depend on rise time	rise time
Transmitted power	varies w.r.t. time	varies w.r.t time	constant
Noise Interference	Max	Min	less
Analog Modulation	similar to AM	similar to FM	similar to Phase Modulation

Modulation
- Analog — AM, FM, PM
- Pulse — PAM, PPM, PWM
- Digital
  - ASK
  - PSK
  - FSK

Pulse Code Modulation (PCM)
Diff ——— (DPCM)
Delta Modulation (DM)
} Not Modulation Techniques

Adaptive ——— (ADM)





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Date:

Digital modulation

digital modulation

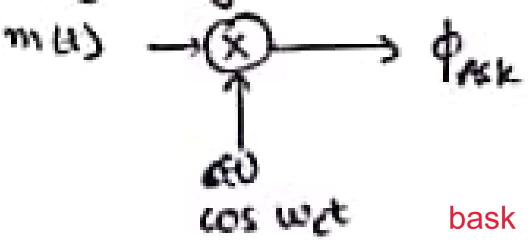
Digital → Analog

digital modulation

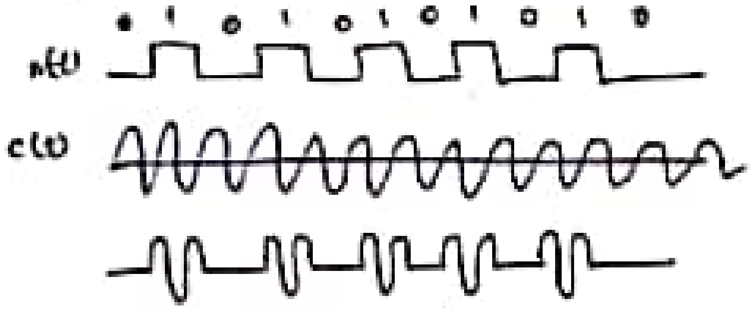
1) Amplitude shift keying

bask

Amplitude of carrier signal varies wrt amplitude of msg signal



bask



For Binary, n=1
↳ BASK, OOK
on-off keying

band width and baud rate

Band width :

band width and baud rate

$BW \propto r$ (baud rate)

$BW = (1+d)r$

$BW = (1+d)\frac{R}{n}$

R → data Rate
n → bits reqd for sc elements
d → factor for modulation and filtering process
$\in (0, 1)$
↑ ideal ↑ worst

- modulation of ASK (generation of ASK)

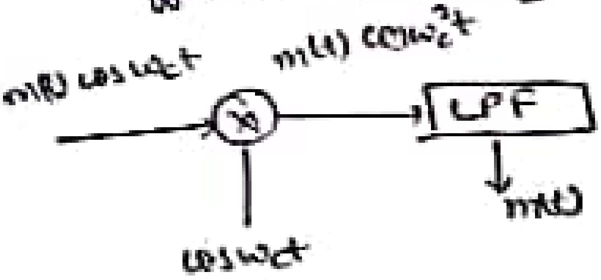
$m(t) \times c(t)$

m(t) { 1 → +ve ; 0 → 0 no voltage }

- demodulation ASK

Synchronous (coherent)

efficient but costly



non synchronous (non coherent)

low cost

poor performance with less SNR received signal.

Transmitted signal.

$x_1(t) = A \cos 2\pi f_c t$ ← bit 1

$x_2(t) = 0$ bit 2

E_B = energy per bit

$$= \int_0^{T_B} x_1^2(t)\,dt = \int_0^{T_B} (A \cos 2\pi f_c t)^2 dt$$

$$= \frac{A^2}{2}[T_B - 0]$$

$$E_B = \frac{A^2 T_B}{2}$$

gram-schmidt orthogonalisation gsop

Gram-Schmidt orthogonalization procedure GSOP

According to GSOP

$$\phi_1(t) = \frac{x_1(t)}{\sqrt{E_B}} \Rightarrow \sqrt{\frac{2}{T_B}} \cos 2\pi f_c t$$

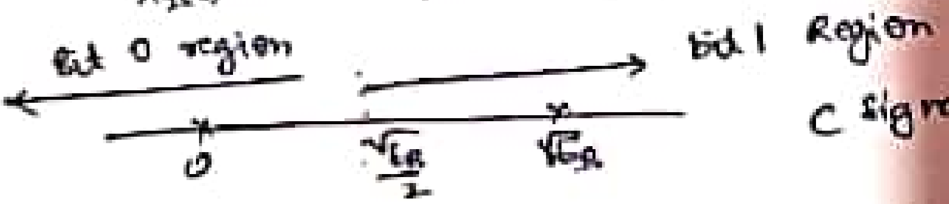
$$\phi_2(t) = 0$$

$M = 2$ ← transmitted waveform

$N = 1$ ← basic fn reqd.

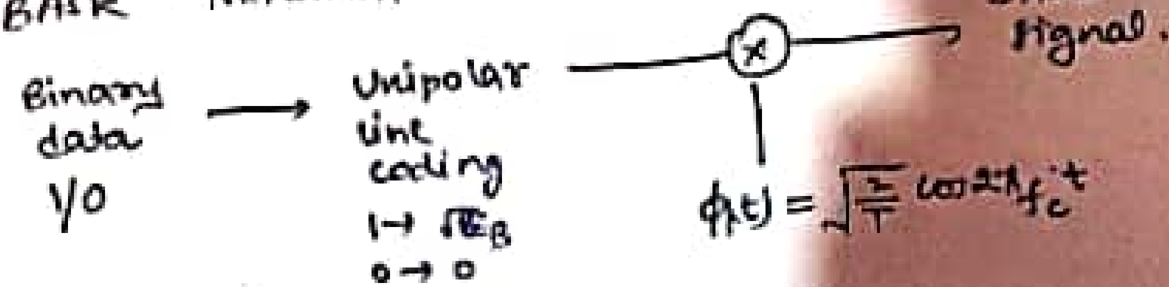
as $x_1(t) = \sqrt{E_B}\,\phi_1(t)$ ← bit 1

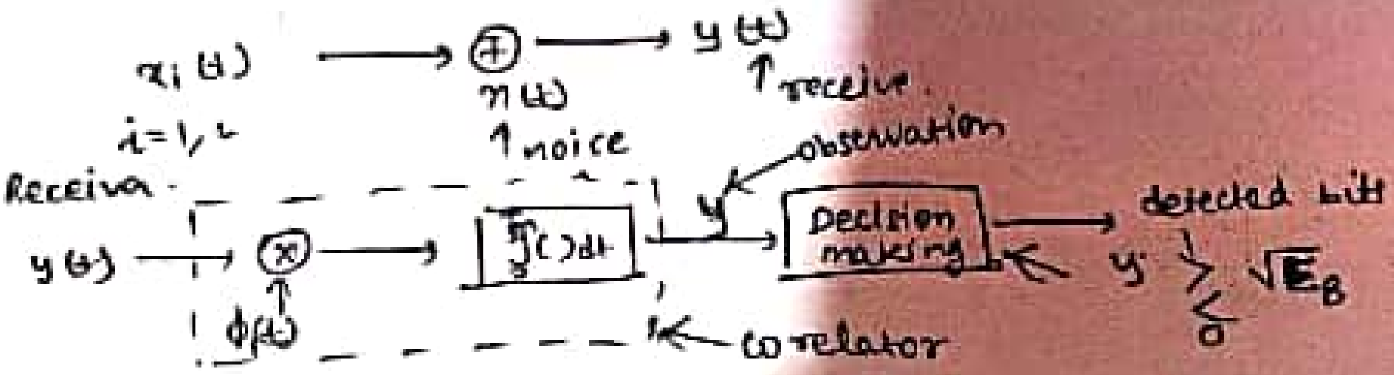
$x_2(t) = 0\,\phi_1(t)$ ← bit 2



(signal space diagram)

BASK Transmitter.





Probability of error

$P_e \to \frac{P_e(1) + P_e(0)}{2}$

$\left.\begin{array}{l} 1 \to 0 \\ 0 \to 1 \end{array}\right\}$ error

$y(t) \begin{cases} x(t) + n(t) & \text{bit 1} \\ 0 + n(t) & \text{bit 2} \end{cases}$

corelation receiver output

$$y = \int_0^{T_B} y(t)\, \phi_1(t)\, dt$$

for bit 1

$$y = \int_0^{T_B} \left(x_1(t) + n(t)\right) \phi_1(t)\, dt$$

$$= \int_0^{T_B} \left(\sqrt{E_B}\,\phi_1(t) + n(t)\right) \phi_1(t)\, dt$$

$$= \sqrt{E_B} \underbrace{\int_0^{T_B} \phi_1^2(t)\, dt}_{\text{orthogonal} \Rightarrow 1} + \underbrace{n}_{\text{Gaussian as } n(t) \text{ is gaussian}}$$

$\Rightarrow y = \sqrt{E_B} + n$ bit 1

$y = n$ bit 0

n is Gaussian with mean 0 and varian $\frac{N_0}{2}$

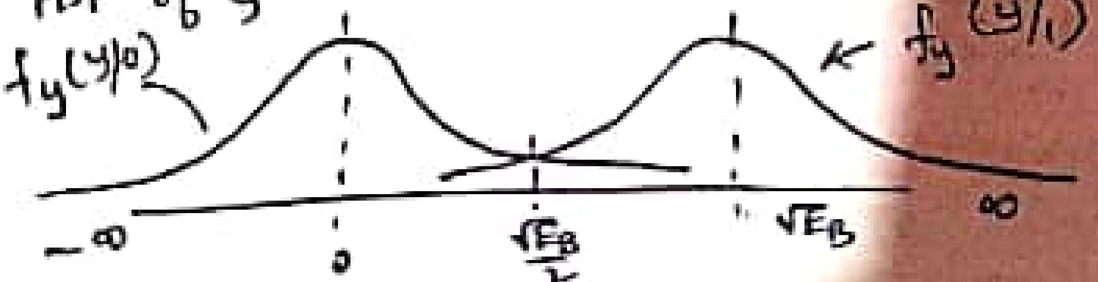
Mean of y = $E(y) \cdot \begin{cases} \sqrt{E_B} & \text{bit 1} \\ 0 & \text{bit 0} \end{cases}$

variance of y

$E(y - \bar{y})^2 = E\left\{\left((\sqrt{E_B} + n) - \sqrt{E_B}\right)^2\right\} =$ $E(n^2) = \frac{N_0}{2}$

$E(y - \bar{y}^2) = E(n-0)^2 = E(n^2) = \frac{N_0}{2}$

PDF of y



$$f_y(y/0) = \frac{1}{\sqrt{\pi N_0}} e^{-y^2/N_0} \qquad f_y(y) = \frac{1}{\sqrt{2\pi\sigma_y^2}} e^{-\frac{(y-\mu_y)^2}{2\sigma_y^2}}$$

$$f_y(y/1) = \frac{1}{\sqrt{\pi N_0}} e^{-\frac{(y-\sqrt{E_B})^2}{N_0}}$$

Likelihood fn.

$$P_e(0) = \int_{\sqrt{E_B}}^{\infty} f_y(y/0)\,dy = \int_{\sqrt{E_B}/2}^{\infty} \frac{1}{\sqrt{\pi N_0}} e^{-y^2/N_0}\,dy$$

$$\boxed{\operatorname{erfc}(x) = \frac{2}{\sqrt{\pi}} \int_x^{\infty} e^{-z^2}\,dz}$$

$$= \quad z = \frac{y}{\sqrt{N_0}}$$

$$\Rightarrow \frac{1}{\sqrt{\pi N_0}} \int_{\frac{1}{2}\sqrt{\frac{E_B}{N_0}}}^{\infty} e^{-z^2}\sqrt{N_0}\,dz$$

$$= \frac{1}{2}\left(\frac{2}{\sqrt{\pi}} \int_{\frac{1}{2}\sqrt{\frac{E_B}{N_0}}}^{\infty} e^{-z^2}\,dz\right)$$

$$\Rightarrow P_e(0) = \frac{1}{2}\operatorname{erfc}\left(\frac{1}{2}\sqrt{\frac{E_B}{N_0}}\right)$$

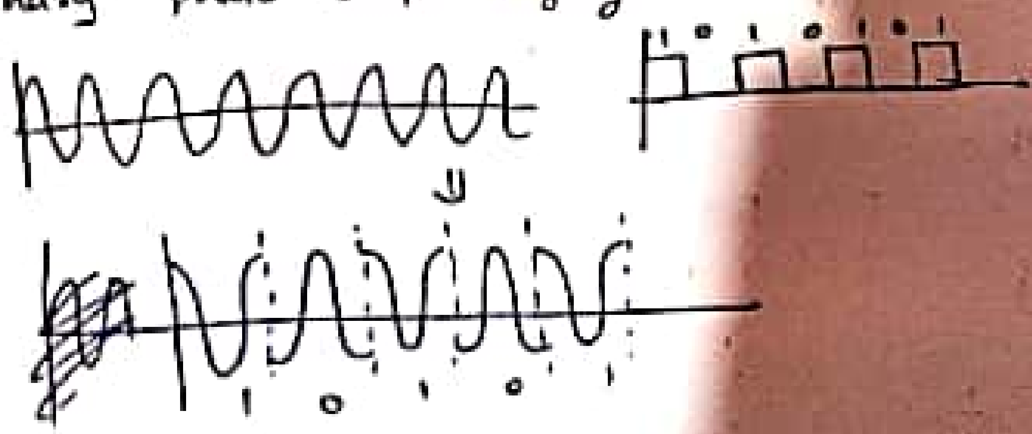
$$P_e(1) = \int_{-\infty}^{\frac{\sqrt{E_B}}{2}} f_y(y/1)\,dy = \frac{1}{2}\operatorname{erfc}\left(\frac{1}{2}\sqrt{\frac{E_B}{N_0}}\right)$$

$$\Rightarrow P_e = \frac{P_e(0) + P_e(1)}{2} = \frac{1}{2}\operatorname{erfc}\left(\frac{1}{2}\sqrt{\frac{E_B}{N_0}}\right)$$

4) Binary phase shift keying

bpsk

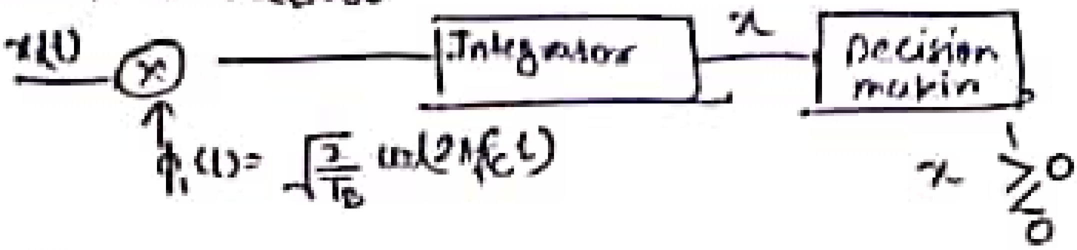
bpsk



1 → phase

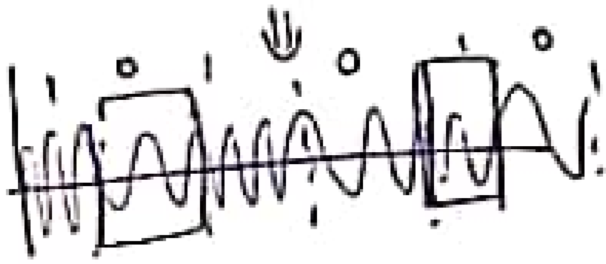
0 → opposite phase.

circuit at receiver



BFSK

bfsk



$$s_1(t) = \sqrt{\frac{2E_B}{T_B}} \cos 2\pi f_1 t \qquad s_2(t) = \sqrt{\frac{2E_B}{T_B}} \cos 2\pi f_2 t$$

Basis fn

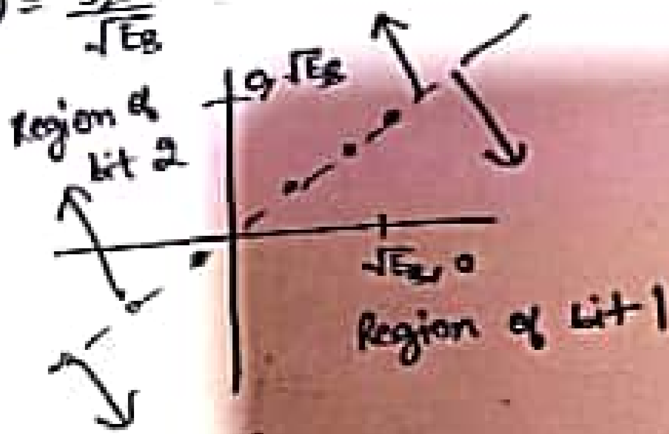
$$\phi_1(t) = \frac{s_1(t)}{\sqrt{E_B}} \qquad \phi_2(t) = \frac{s_2(t)}{\sqrt{E_B}}$$

$$s_{11} = \int s_1 \phi_1 = \sqrt{E_B}$$

$$s_{12} = \int s_1 \phi_2 = 0$$

$$s_{21} = \int s_2 \phi_1 = 0$$

$$s_{22} = \int s_2 \phi_2 = \sqrt{E_B}$$



error is BFSK is less than BPSK b'cos distance b/w $(\sqrt{E_B}, 0)$ and $(-\sqrt{E_B}, 0)$ is less than $2\sqrt{E_B}$
(easily understandable by graph)

if received signal is $x(t)$

$$x_1 = \int_0^{T_B} x(t)\, \phi_1(t)\, dt$$

$$x_2 = \int_0^{T_B} x(t)\, \phi_2(t)\, dt$$

$$x_1 \underset{x_2}{\overset{x_1}{\gtrless}} x_2$$

Type → Binary (single bit is modulated)
Quadrature (2 bit) → 4 combination ($\phi = \pi/2$)
m-array (general)

no. of level ↑ → P_e ↑

$$s_1(t) = \sqrt{\frac{2E_B}{T_B}} \cos(2\pi f_c t)$$

$$s_2(t) = \sqrt{\frac{2E_B}{T_B}} \cos(2\pi f_c t + \pi) = -\sqrt{\frac{2E_B}{T_B}} \cos(2\pi f_c t)$$

orthogonal signals → signals lie in diff direction ∴ min noise interference

$$\int \phi_1 \phi_2 = 0 \quad \text{as} \quad \phi_1 \perp \phi_2$$

↑ orthonormal fn

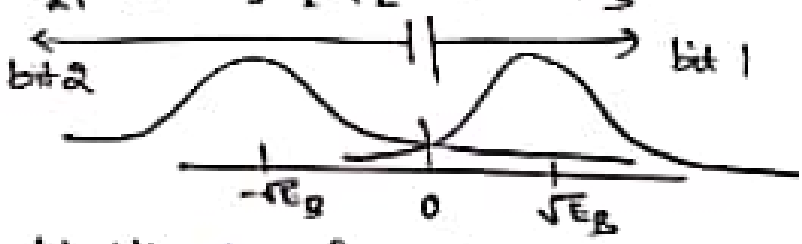
$$\phi_1 = \sqrt{E_B} \cancel{\cos} \sqrt{\frac{2}{T_B}} \cos(2\pi f_c t)$$

$$s_{11} = \int_0^{T_B} s(t)\,\phi_1(t) = \int_0^{T_B} \sqrt{E_B}\, \phi_1^2(t)\, dt$$

$$\int \phi_i \cdot \phi_i = 1$$

$$\int \phi_i\, \phi_j = 0 \quad i \neq j$$

$$\left.\begin{aligned} s_{11} &= \sqrt{E_B} \\ s_{21} &= \int s_2\, \phi_2 = -\sqrt{E_B} \end{aligned}\right\} \leftarrow \text{mean}$$



likelihood fn when 0 is transmitted.

$$f_x(x|0) = \frac{1}{\sqrt{\pi N_0}} \exp\left[-\frac{1}{N_0}(x_1 + \sqrt{E_B})^2\right]$$

$$P_e(0) = \int_0^{+\infty} f_x(x|0)\, dx = \frac{1}{2} \operatorname{erfc}\left(\sqrt{\frac{E_B}{N_0}}\right)$$

$$P_e(1) = \int_{-\infty}^{0} f_x(x|1)\, dx = \frac{1}{2} \operatorname{erfc}\left(\sqrt{\frac{E_B}{N_0}}\right)$$

$$P_e = \frac{P_e(0) + P_e(1)}{2} = \frac{1}{2} \operatorname{erfc}\left(\sqrt{\frac{E_B}{N_0}}\right)$$

bpsk error bpsk error

bpsk pe bpsk pe

bpsk probability error

for error calculation

error $= x_1 - x_2$

let $x_1 - x_2 = L$

$$l \underset{z_2}{\overset{z_1}{\gtrless}} 0$$

expectation is linear fn

expectation value

$$E[L|1] = E[x_1|1] - E[x_2|1]$$

$$= \sqrt{E_B} - 0 = \sqrt{E_B}$$

$$E[L|0] = E[x_1|0] - E[x_2|0]$$

$$= 0 - \sqrt{E_B} = -\sqrt{E_B}$$

$$Var[L] = Var[x_1] + Var[x_2] = \frac{N_0}{2} + \frac{N_0}{2} = N_0$$

$L \rightarrow$ mean $= 0$
var $= N_0$

conditional probability

$$f_L(l|0) = \frac{1}{2\pi N_0} e^{\left(\frac{-l+\sqrt{E_B}}{2N_0}\right)^2}$$

$$P'(l|0) = \int_0^\infty f_L(l|0)\, dl$$

$$= \frac{1}{2} \operatorname{erfc}\left(\sqrt{\frac{E_B}{2N_0}}\right)$$

$||^{ly}$ $P(l|1) = \frac{1}{2} \operatorname{erfc}\left(\sqrt{\frac{E_B}{2N_0}}\right)$

$$P_e = \frac{1}{2} \operatorname{erfc}\left(\sqrt{\frac{E_B}{2N_0}}\right)$$

clearly error is BFSK < BPSK

bfsk error
bfsk pe
bfsk probability error

bfsk error
bfsk pe

Properties | Sampling PAM, PWM, PPM, Quantization FT

(1) Linearity

Fourier Modulation

$x_1(t) \xleftrightarrow{FT} X_1(f)$

$x_2(t) \xrightarrow{FT} X_2(f)$

$$a x_1(t) + b x_2(t) \xrightarrow{FT} a X_1(f) + b X_2(f)$$

(2) Time shifting $x(t) \xrightarrow{FT} X(f)$

$x(t - t_0) \xrightarrow{FT} X(f) e^{-j2\pi f t_0}$

(3) Frequency shifting:

$$x(t) e^{j2\pi f_0 t} \longleftarrow X(f - f_0)$$

(4) Scaling: $x(t) \xleftrightarrow{FT} X(f)$

$x(at) \longrightarrow \frac{1}{|a|} X(f/a)$

(5) Time Reversal:

$x(t) \xrightarrow{FT} X(f)$

$x(-t) \xrightarrow{FT} X(-f)$

(6) Differentiation in Time domain.

$x(t) \longrightarrow X(f)$

$\frac{d\,x(t)}{dt} \longleftrightarrow j2\pi f\, X(f)$

$\frac{d^n}{dt^n} x(t) \longleftarrow (j2\pi f)^n X(f)$

Fourier transform: transform

$$F(g(t)) = \int_{-\infty}^{\infty} g(t)\, e^{-j2\pi f t}\, dt$$

Page No.:
Date:

BPSK

$P = A^2/2 = E/T$

let for 0 $\quad s_1(t) = \sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t)$

$T_b \rightarrow$ bit duration

$E_b \rightarrow$ bit energy

let for 1 $\quad s_2(t) = \sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t + \pi) = -s_1(t)$

Since 1 basis function is need to represent both of the bi

1st basis function $\rightarrow \phi_1(t) = \sqrt{\frac{2}{T_b}} \cos(2\pi f_c t)$

$s_1(t) = \sqrt{E_b}\, \phi_1(t)$

$s_2(t) = -\sqrt{E_b}\, \phi_1(t)$

Orthogonal basis function

$\int_0^T \phi_i(t)\, \phi_j(t) = 0 \quad i \neq j$

~~$S_{ij} = \int$~~

Orthonormal

$\int_0^T \phi_i(t)\, \phi_j(t) = 1 \quad i = j$

$= \int_0^T \phi_i^2(t) = 1.$

$S_{ij} = \int_0^T s_i(t)\, \phi_j(t)\, dt$

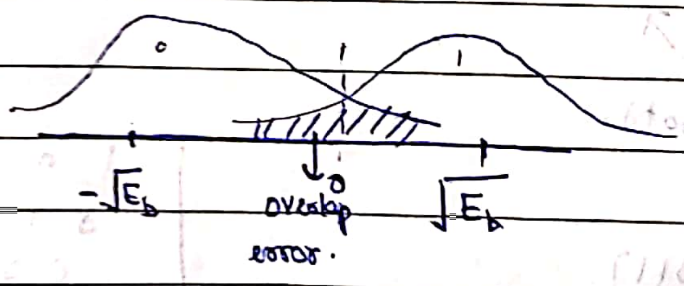
$S_{11} = \int_0^T s_1(t)\, \phi_1(t)\, dt$

$= \int_0^T \sqrt{E_b}\, \phi_1^2(t)\, dt = \sqrt{E_b}$

$S_{21} = -\sqrt{E_b}$

$S_{22} = S_{12} = 0$

Since it has 1 basis func it is 1-D Modulation.



Guassian distribution for bit 0 and 1

$$\boxed{P(e) = P_0(e) = P_1(e) = \frac{1}{2}\, \mathrm{erfc} \sqrt{\frac{E_b}{N_0}}}$$

BFSK $\quad s_1(t) = \sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_1 t)$

$s_2(t) = \sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_2 t)$.

2 basis function. ϕ_1 and ϕ_2

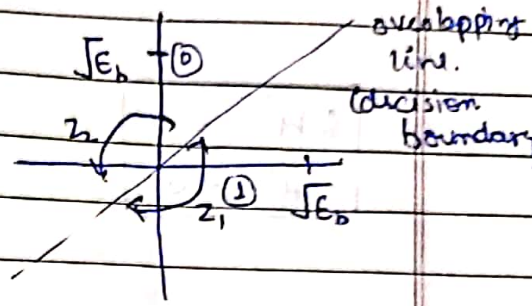
$s_1(t) \to \sqrt{E_b}\ \phi_1(t)$

$s_2(t) \to \sqrt{E_b}\ \phi_2(t)$

$s_{11} = \int s_1(t)\ \phi_1(t) = \sqrt{E_b}$

$s_{12} = s_{21} = 0$

$s_{22} = \sqrt{E_b}$



2 basis funct $\to$ 2 dimension Modulato

$$\boxed{P(e) = \frac{1}{2} \operatorname{erfc} \sqrt{\frac{E_b}{2N_0}}}$$

ashish

BASK $\quad s_1(t) = \sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t)$

OOK $\quad s_2(t) = 0 \qquad$ 1 basis function

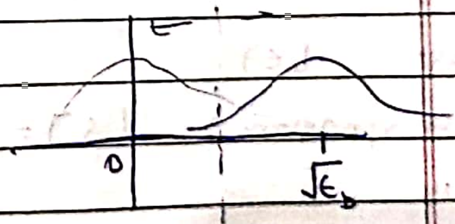
on-off keying

$s_1(t) = \sqrt{E_b}\ \phi_1(t)$

$s_2(t) = 0$

$s_{11} = \sqrt{E_b}$

$s_{21} = s_{22} = s_{12} = 0$

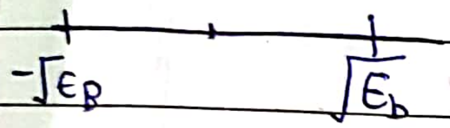
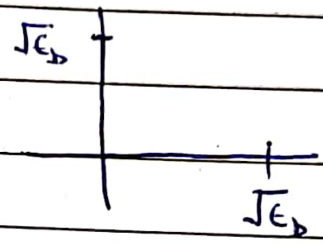
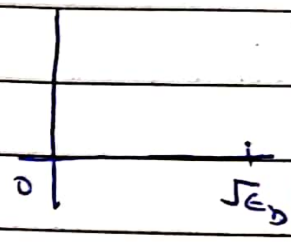


$$\boxed{P(e) = \frac{1}{2} \operatorname{erfc}\left(\frac{1}{2}\sqrt{\frac{E_b}{N_0}}\right)}$$

Page No.:
Date:

$$F(g(t)) = \int_{-\infty} g(t)\, e^{-j2\pi f t}\, dt.$$

table3

BPSK (Phase) $(0, \pi)$	BFSK (Frequency) (f_1, f_2)	BASK / OOK (A…
1 basis func	2 basis func	1 basis fun…
constellation points		
$s_{11} = (\sqrt{E_b}, 0)$	$s_{11} = (\sqrt{E_b}, 0)$	$S_{11} = (\sqrt{E_b}, 0$
$s_{21} = (-\sqrt{E_b}, 0)$	$s_{12} = (0, \sqrt{E_B})$	
		
distance $2\sqrt{E_b}$	$\sqrt{2E_B}$	$\sqrt{E_b}$
$P(e) = \frac{1}{2}\, erfc \sqrt{\frac{E_b}{N_0}}$	$\frac{1}{2}\, erfc \sqrt{\frac{E_b}{2N_0}}$	$\frac{1}{2}\, erfc\left(\frac{1}{2}\sqrt{\frac{E_b}{N_0}}\right.$

P_e Error = BASK < BFSK < BPSK

Error $\propto$ Distance

Page No.:

Date:

DPCM

dpcm

Type text here

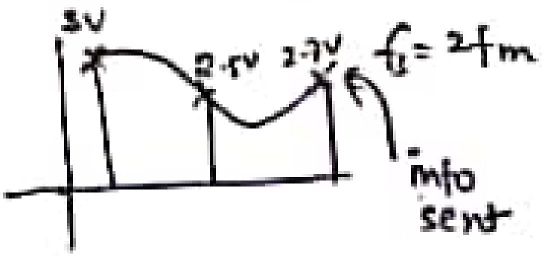
Differential pulse code modulation

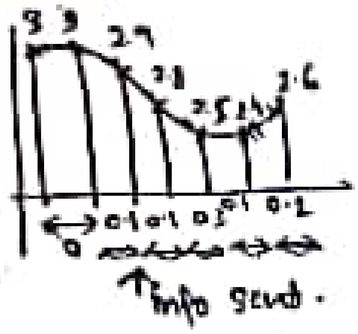
dpcm

↳ when $f_s > 2f_m$ (sampling) then successive samples become more correlated.

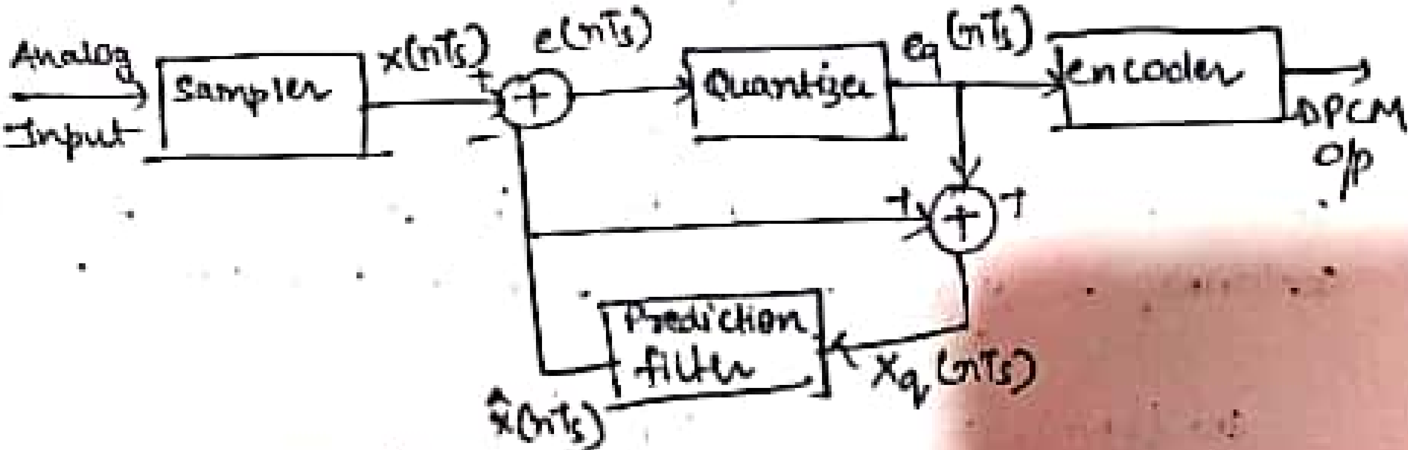
↳ Instead of sending data for individual sample (like in PCM) we send data abt successive difference in pulse voltage.

∴ no. of levels ↓ → bit rate ↓





DPCM encoder



$e(nT_s)$ = Error signal

$= x(nT_s) - \hat{x}(nT_s)$

Quantised error signal.

$e_q(nT_s) = e(nT_s) + q_e(nT_s)$

Input to prediction filter

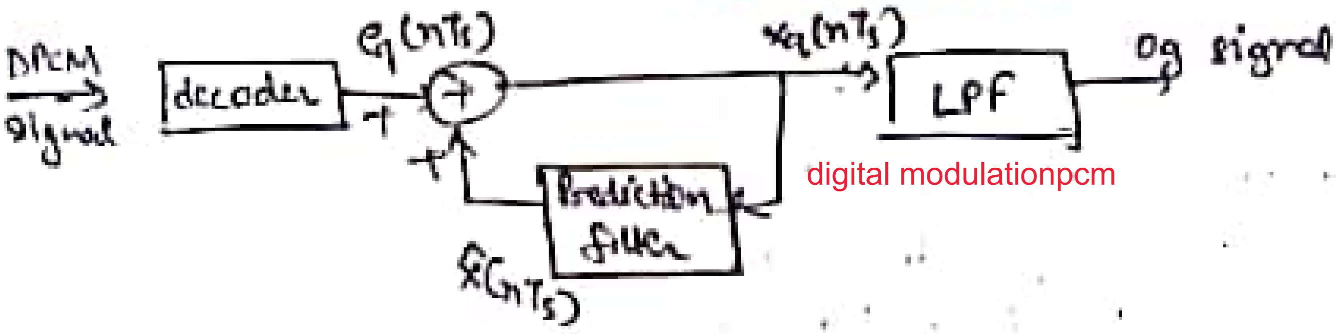
$x_q(nT_s) = e_q(nT_s) + \hat{x}(nT_s)$

$= e(nT_s) + q_e(nT_s) + \hat{x}(nT_s)$

$= x(nT_s) - \hat{x}(nT_s) + q_e(nT_s)$

$x_q(nT_s) = x(nT_s) + q_e(nT_s)$

DPCM decoder.



digital modulationpcm

SQNR of DPCM

 sqnr of dpcm

$(SNR)_o = \frac{\sigma_x^2}{\sigma_Q^2}$ at o/p of quantiser

σ_x^2 = variance of original V, $x(nT_s)$

σ_Q^2 = variance of quantised error $e_q(nT_s)$

σ_E^2 = variance of prediction error $e(nT_s)$

$$(SNR)_o = \underbrace{\left(\frac{\sigma_x^2}{\sigma_E^2}\right)}_{G_P} \underbrace{\left(\frac{\sigma_E^2}{\sigma_Q^2}\right)}_{(SNR)_P}$$

production gain

G_P → Prediction gain produced by differential quantisatio

~~SR~~ $(SNR)_P = \frac{\sigma_E^2}{\sigma_Q^2}$ = Prediction error to quantisation noise ratio.

~~SR~~ $(SNR)_o = G_P \times (SNR)_P$

$G_P > 1 \rightarrow \sigma_x^2 > \sigma_E^2$

we can't change σ_x^2 but can change σ_E^2

our goal is to minimise σ_E^2 (better prediction filter) t

Type text here

Attenuation

attenuation

attenuation

- loss of energy
- due to conduction loss, dielectric loss & propogation loss
- measured in dB
- for this we use amplifier.
- Shape of signal won't change. (only magnitude change)
- it only decays amplitude of info

dB (decibel)

decibel

decible

decibel

- used to measure loss / gain
  - measure relative power / voltage

$D = 10 \log\left(\frac{P_2}{P_1}\right) = 20 \log\left(\frac{V_2}{V_1}\right)$ and $P \propto V^2$
Power ↑ ↑ voltage

$D > 0 \rightarrow$ gain
$< 0 \rightarrow$ loss.

dB is linear (can be added or subtracted)

Bit rate (R)

- no. of bits / sec
- data rate
  - bits per sec
    - bps
    - or Kbps

bit rate

bit rate

baud rate

baud rate

Baud rate (r)(r) (or elements)

- no. of symbols / sec
- data rate

n = no. of bits / symbols

$R = rn$

L = Total no. of symbols $= 2^n$

Unit = baud
elements/sec
symbol /sec

Scanned with CamScanner

analog → Sampling → Sampled output → Quantiser → Quantised output → encoding → digital output

Note: If high frequency component are there at analog input then we should use LPF at input before sampling.

Process of PCM
1) Filters (LPF)
2) sampling — ideal / Natural / flat
3) Quantiser — Linear / non linear
4) encoding

Quantisation error = quantisation distortion.
↳ To decrease this, increase levels.

USA

& PCM standard pcm standard pcm standard india
america
- europian (India) 30 channels
- American — 24 channels.

Bitrate = $n f_s$ ← sampling frequency
n ↑ no. of bits

Bandwidth → depends on encoding.

Advantages
↳ Uniform transmission quality
→ compatibility of different class of traffic In network
→ Integrated digital network
→ Increased utilisation of existing ckt
→ Good performance over poor transmission path (correct error)

disadvantage
↳ large b.w
↳ low noise but large attenuation.

Application
↳ compact disk
↳ digital audio application.

Hamming code :

(n, k) code

n → total bits

k → message bit

(n−k) parity bit

$\boxed{2^p \geq p+k+1}$

hamming code

eg (7,4) code

7	6	5	4	3	2	1
D_7	D_6	D_5	P_4	D_3	P_2	P_1

$P_1 = D_3 \oplus D_5 \oplus D_7$

$P_2 = D_3 \oplus D_6 \oplus D_7$

$P_4 = D_5 \oplus D_6 \oplus D_7$

Error detection and correction

given msg =

D_7	D_6	D_5	P_4	D_3	P_2	P_1
1	1	1	0	1	0	1

~~$P_1 = 1$~~ ~~$P_2 = 0$~~ ~~$P_4 =$~~

$P_1 = 1 \wedge 1 \wedge 1 = 1 \equiv 1$ T

$P_2 = 1 \wedge 1 \wedge 1 = 1 \neq 0$ False

$P_4 = 1 \wedge 1 \wedge 1 = 1 \neq 0$ F

Error on 110 bit

Correct data =

1110101 $\oplus$ 0100000

---

linear block code:

$c_p = c_i + c_k$

Sum of two codeword is a code word.

Property (1) [0 ⋯ 0] is codeword

(2) $c_p = c_i + c_k$ then $d(c_i, c_k) = W(c_p)$

linear block code

$d_{min} = w_{min}$

no of min no should be same.

Page No.:

Date:

Generator matrix to make codewords.

$$[G] = [I : P] \quad \text{(Systematic generator matrix)}$$

$$\underset{\text{codewords}}{[C]} = \underset{\text{message}}{[I]}\,[G]$$

generator matrix

if G is systematic generator matrix.

$[C] = [I : P_c]$ $\quad P_c = [\,I\,][P]$

Systematic Generator matrix

$$[G] = [I_K : P]$$

Parity check Matrix:

$$[G] = [I \mid P]$$

Parity check Matrix $[H] = [P^T : I_{n-k}]$

↳ used at reciever side to decode the data

parity check matrix

$$\boxed{\begin{aligned} GH^T &= 0 \\ CH^T &= 0 \end{aligned}}$$

$$GH^T = [I_k : P]\,[P^T \mid I_{n-k}]^T$$

$$[I_k \mid P]\begin{bmatrix} P \\ \hline I_{n-k} \end{bmatrix}$$

$$= I_k P + P I_{n-k}$$

$$= P + P$$

$$= 0 \quad (\text{we take } \%2)$$

$$CH^T = [i][G][H^T]$$

$$= [i][0]$$

$$= [0]$$

syndrome

error syndrome

Error syndrome:

noise added.

$$\boxed{T_x} \rightarrow [C] \qquad [Y] \xleftarrow{R_x} [\;]$$

$$[Y] = [C] + [E] \quad \leftarrow \text{Error}$$

$$[C] = [Y] + [E] \quad (\text{because } \%2)$$

Error = $[E]$

$$\boxed{\text{error syndrome} = [S] = [Y][H^T]}$$

is $[E] = 0$

$$[Y] = [C]$$

so $[S] = [C][H^T] = 0$

else. $[S] = [E][H^T]$

detect correct

$d_{min} \geq s+1$ $\boxed{s \rightarrow \text{detect}}$ $\boxed{\text{Error correction}}$

↓

minimum hamming distance.

$d_{min} \geq 2t+1$.

PSD

Power spectral Density → A composite signal is composed of several freq components. Each freq corr sp → to a signal. Such signals of different frequencies ~~as~~ put together forms a composite signal. Also different signals have different channel noise conditions.

PSD

Type text here

power spectral density

PSD specifies the power of various freq present in the signal.

How we make composite sig? Fourier transform

PSD of NRZ Unipolar

(1) find fourier Transfor $X(f) = T_b \,\text{sinc}(f T_b)$

(2) Auto correlation of Unipolar (signal$_i$ × signal$_{i-n}$) $R_A = \begin{cases} a^2/2, & n=0 \\ a^2/4, & n \neq 0 \end{cases}$

(3) $P(f) = \dfrac{a^2 T_b}{4} \text{sinc}^2(f T_b) + \underline{\dfrac{a^2}{4} \delta(f)}$

→ DC components leads to distortion in signal.

PSD

PSD of NRZ Polar

(1) $X(f) = T_b \,\text{sinc}(f T_b)$

(2) $R_A = \begin{cases} a^2 & n = 0 \\ 0 & n \neq 0 \end{cases}$

(3) $P(f) = a^2 T_b \sin^2 (f T_b)$.

better than Unipolar as no DC component.

PSD of NRZ Bipolar

(1) $X(f) = T_b \,\text{sinc}(f T_b)$

(2) $R_A = \begin{cases} a^2/2 & n=0 \\ -a^2/4 & n = \pm 1 \\ 0 & |n| \geq 2. \end{cases}$

(3) $P(f) = a^2 T_b \,\text{sinc}^2(f T_b) \sin^2(\pi f T_b)$.

Page No.:

Date:

NRZL

NRZ-L

NRZ- level → level of voltage determine value of bit

~~bit 1 → +ve~~ ~~bit 0 → -ve~~.

bit 1 → +ve bit 0 → -ve.

or

NRZ- Inversion → change ~~of~~ lack of change of voltage determines the value of bit

NRZI

bit 1 → change bit 2 change

NRZ-I

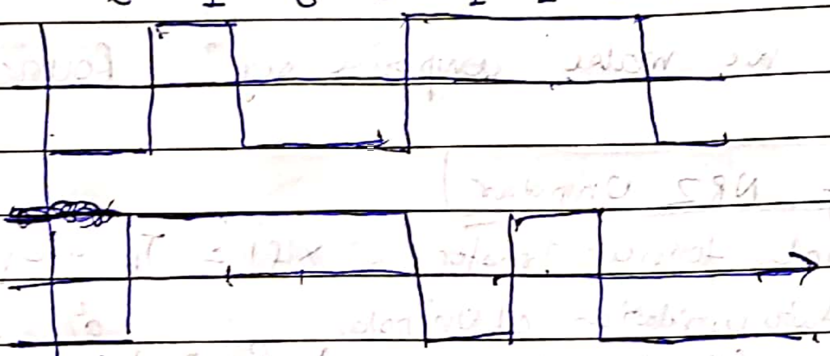
~~Except~~

example

0 1 0 0 1 1 1 0

NRZ-L

NRZ-I



let assume level is -ve initially

↑ no change

	NRZ-L	NRZ-I
Problem		
Base level wandering.	2 twice severe	
Syncronization	more severe	
Change of polarity	affected	
DC components	Both have DC components.	

Page No.:

Date:

DC

Data Communication → Exchange of data 2 node via wire | wireless.

FLEX

SIMPLEX — SIMPLEX
Unidirectional

HALF DUPLEX
Both dirn
not a same time

DUPLEX
Both dirn
same time

Protocols → set of rules for communication.
What ? How ? When ?

Elements → (1) Message encoding, ~~formatting~~ → Signal / waves — wired / wireless

(2) Message Formatting & Encapsulation.
↳ Source and destination info (IP Address)

PROTOCOLS

(3) Message size (break in small parts)

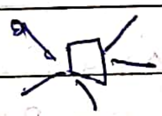
(4) — Timing → Flow control ↔ synchronization.
→ Response Timeout. → Acknowlegment.

(5) Delivery → unicast, multicast, broadcasting.

PEAR PEER

Peer to Pear Network → All pears are equal, Not scalable.

Client Server Network



server may overload
High traffic

~~Layering~~ Layering — IP address + Mac Address + Port Address is added before sending.

OSI (not a protocol)
Open system Interconnection.
→ Its a design

TCP/IP
Transport's Co / Internet —
was developed earlier.
→ heirarcical model.

OSI

OSI layers

open system Interconnection

Array Application → Ashish
Pizza Present → SH hsi A
Sauce Session
Trdemm Transport
Not Network
DO Data link → DL + NL + TL + encoded mess
Relax Physical → convert to binary to send on networ.

Application layer → Enables users to access net resources
Services → File transfer Access Managment (FTAM)
APPLICATION
→ Mail services
→ Director services

Presentation → syntax and semantics
↳ If divided in section what each section express
PRESENTATION
↳ what do data represent
Service → Translation, Encryption, Compression

Session layer → maintaing, establish, sync interaction.
SESSION
Service → Dailog control, Sync.

Transport layer → Port addressing PORT NO
→ segmentation and Reasm
Port No → Connection Control
TRANSPORT
→ End-to End → Flow control OSI
→ Error control

Network layer → logical addressing deals with IPaddress IP
IP adress → Routing → finding best route ROUTING
NETWORK
→ Host to Host

Data link → Moving frames from one node to other node.
MAC Address (48 bit) (12 digit hexadecimal)
• Framing MAC HDLC
• Flow control
DATA LINK
• Error control
• Access control → which computer have current access over that network

Page No
Date:

Physical → Transport bits in signals | waves.
→ So encoding.
→ Sync.
→ Line conf. ? point to point or not
→ Physical topology

PHYSICAL

TCP/IP → Historical model.

Protocols:

Application	:	HTTP, DNS, FTP.
Trasport	:	TCP, UDP
Internet	:	IPv4, IPv6
Network access	:	PPP, frame relay, Ethernet.

layers ↓

TCP/IP

What is info called? ↓

Application layer	→	Data
Trasport	→	segment
Newtwo	→	Packets
Data link	→	frame
Physical layer	→	Bits.

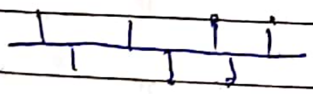
SEGMENT

Topology Arragment of nodes.

TOPOLOGY

Bus

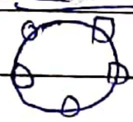
bus



→ Everyone gets data
→ If cable खराब ⊥
→ One way to reach node.

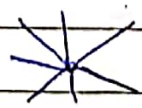
Ring (Token)

ring



. Unidirectional comm

Star node

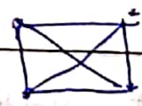


star

• ~~Pt to P~~ scalable
• Over load
• high trafic.

mesh

mesh



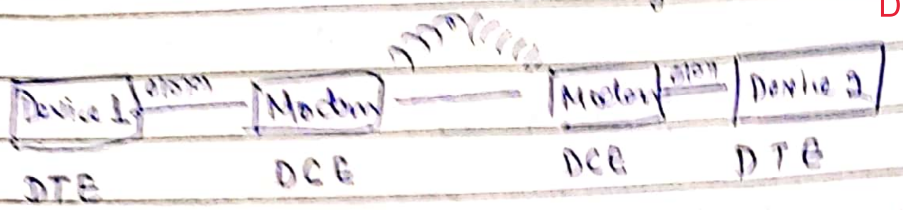
→ Reliable | Backup.
→ Expensive.

Page No.:
Date:

→ DTE → Data Terminal Equipment
DCE → Data circuit Equipment.
terminating

DTE

DCE



DCE → transmits or receive data in analog / digital signals

Standards → EIA standard → EIA-232, 442, 449
ITU-T V series & X series

Pucha liya to RIP.

Data Pins in EIA 52 .... 25 pins
data pins, Control pins, Timing pins.

Switching: switch to get best path route.

→ ~~Circuit switching~~

SWITCHING

Circuit switing → space & time division.
Message switch
Packet switch → virtual, Datagram switing

① Circuit switching:
(1) Dedicate path b/w sender reciever (eg. Telephone)
(2) Before data transfer, connection is established.

CIRCUIT SWITCHING

SPACE

Page No.:
Date:

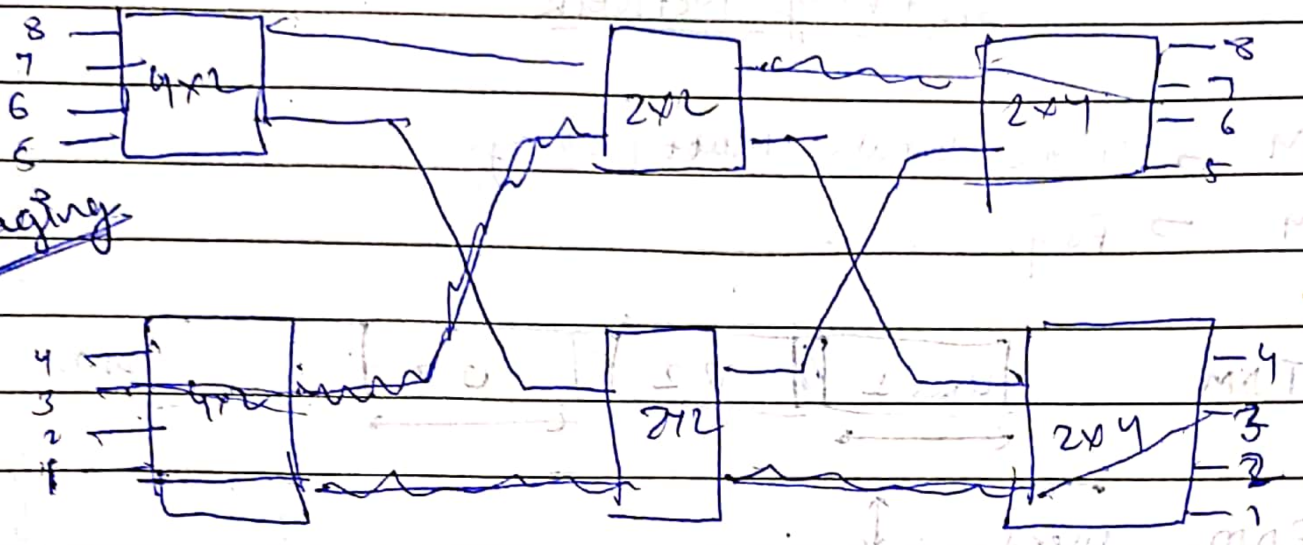
DIVISIONS

table1 Type text here

MULTISTAGING AND CROSSBAR

Space division switching

Call blocking : No route is available



multistaging

At most 2 lines can communicate next will block call eg (4 – 7)

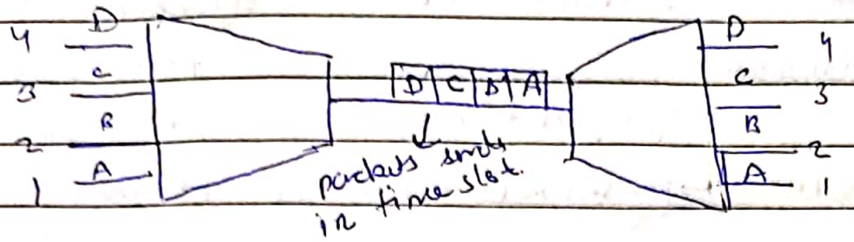
disadvantage

call blocking

Page No.:

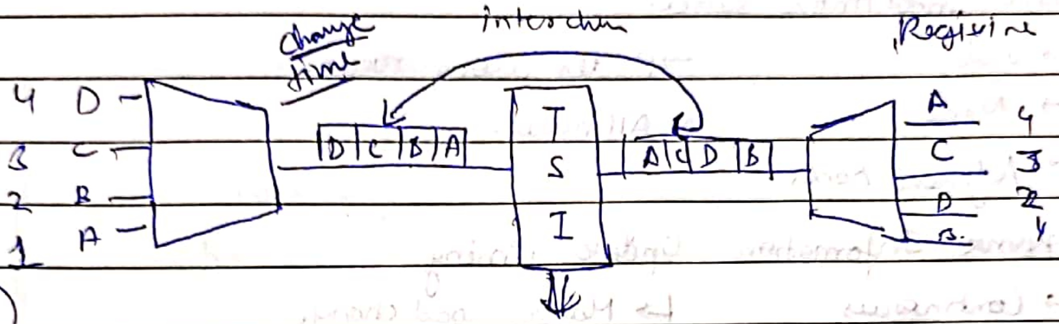
Date:

Time division : (1) Time slot Interchange
(2) TDM bus.



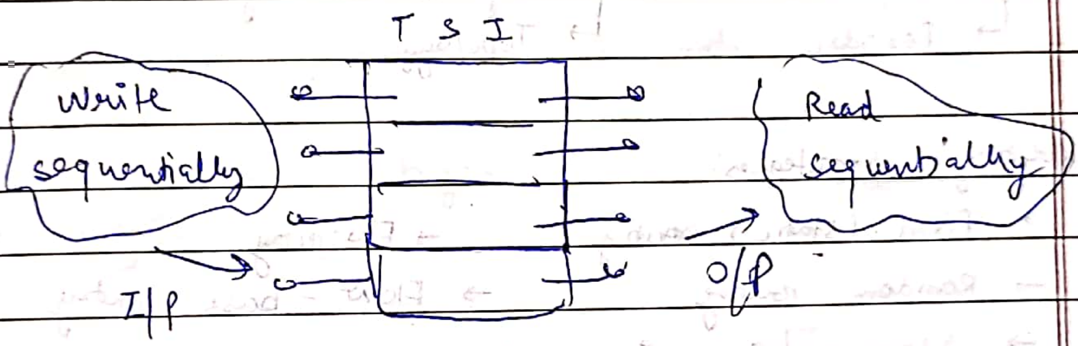
Connection
4 → 4
3 → 3
2 → 2
1 → 1

TIME DIVISION



Send → Receive (Data)
1 → 4 (A)
2 → 1 (B)
3 → 3 (C)
4 → 2 (D)

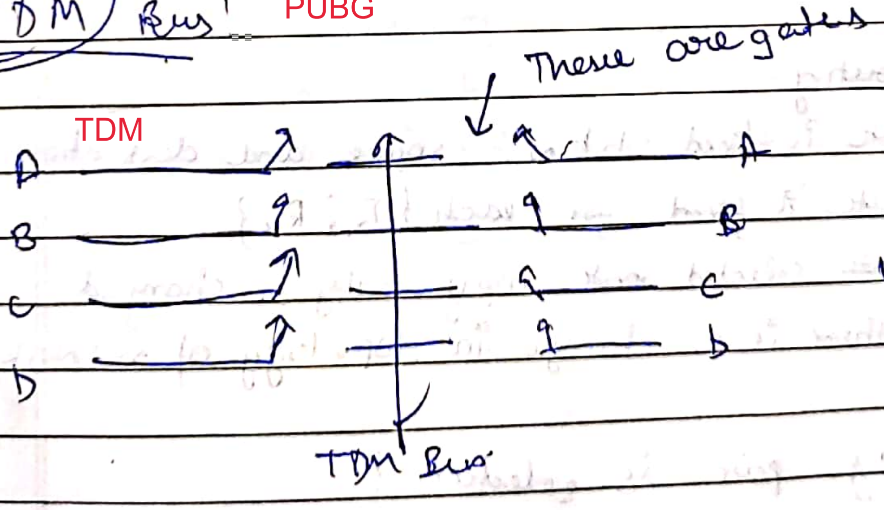
TSI



TSI

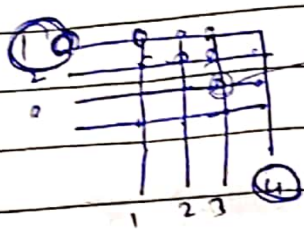
TDM Bus! PUBG

TDM



Jiska data jisko bhejna ho vo gate close kardo

Space division → Paths in circuit are seperated with each other spaitially.



→ cross points — expensive.

cross bar switches
Multistaging switch.

CROSSBAR SPACE

~~Input~~ 1–4 computer some cross points are enables.

fixed

Time division S →

	Space	Time
	fast	• No need of cross-points
Adv →	dedicated points for each pair.	
		• TSI cause delay.
Dis	→ More cross bars	
	→ Blocking in Multistaging.	

TABLE4

Message switching — Store and forword to intermediatry node.
Not used in live, streaming

MESSAGE

Packet switching: packet can be send individual
→ Each pack → source/dest IP address
→ 2 packets can have different route.
→ Sequence is assigned in case of recovery, detect missing packet.
send Ack.

Datagram — Virtual.

PACKET

Page No.:

DATAGRAM

Datagram → Connectionless switching
→ they are independent packets.
→ May or may not have same path.
→ Intermediatory nodes make decision of route of packets

VIRTUAL

Virtual → Connection-oriented switching.
→ preplanned route.
→ fixed path
→ one after another.

FLOW CONTROL

Flow control is a set of procedures that tells how much data it can transmit before it must wait for an acknowledgment from the reciever.

ARQ

Protocols

- Noiseless
  - → Simplest
  - → Stop & wait.
    - ↓ Infinite waiting in case of fault. on both side Ack/Data is delayed/lost.
- Noisy
  - Stop & wait ARQ
  - Go-Back-N-ARQ
  - Selective Repeat

ARQ → Automatic Repeat Request.

Go-Back-N-ARQ and Selective Repeat → Sliding window

Stop & Wait ARQ
→ If ack is not recieved, resend packets
→ frame is lost
→ ack is lost
→ time expires.

STOP AND WAIT

Page No.:	
Date:	

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↓ size of window

→ Go-Back N - ARQ

→ If ack is not recieved all the packets inside sliding window are resend.

GO BACK

Packet.

→ Advantage → Multiple frame can be send.
They have sequence no.

ARQ

→ Selective Repeat ARQ

SELECTIVE REPEAT

- Only lost frames are retransmitted, while correct frames are recieved and buffered.
- → No significance of window afterwards

→ HDLC → Hight Data link Protocol.
→ Bit oriented protocol.

HDLC

Frame Format

FRAME

8	16		16	8
Begining sequence	Header	Body	CRC	Ending sequence

01111110
clocks are sync.

Header:
→ Address field
→ Control field

CRC → Cyclic Redundancy check. (Error dection)

Control field:

1 bit → 0	→ I-Frame	→ Information frame
01	→ S-frame	→ Supervisor frame
11	→ V-Frame	→ Un-numbered frame

I.S.

I-FRAME S-FRAME V-FRAME

IFRAME SFRAME VFRAME

ERROR CONTROL

Error control

- → Check sum
- → Cyclic Redundancy check (CRC)
- → Verticle Re — (VRC)
- → Longitudinal — (LRC)

Puch Liya to RIP !!

CRC

bol dena Frameset me use hota hai
Frame format

CRC → HDLC, ~~Ethernet~~ IEEE 802.3

Checksum → PPP , IEEE 802.11

DDCMP → Digital Data Communication Message Protocol (Nahi karna)

PPP — Point to point Protocol

PPP DDCMP

→ Byte oriented.

→ Used in WLAN, broad band communication having heavy loads and high speeds.

→ connected (p-t-p) devices.

Frame format   1 byte → 8 bits.   FRAME

8	8	8	16		16	8
Flag	Address	Control	Protocol	Body	Checksum	Flag
01111110	11111111	11000000	↓ Type of data in Body		↓ Error Detection	

PPP Stack : 3 protocols

STACK

→ LCP (Link ~~control~~ control Protocol) → Establish, → Maintain, → Configure, → Terminate

→ Authentication Protocol

PPPSTACK

→ Network Control Protocol (NCP)

→ connect to network layer

→ encapsulation of data from network layer to PPP stack.

IEEE

802.3 .3 → CMCA / CD Technology

802.4 .4 → Token Bus   CMCA

802.5 .5 → Token Ring. TOKEN

IEEE

Ethernet works on 802.3 .3   → 10 base 5 — 10 MBPS - 500m

Types → 10 base 5 → Thick coaxial cable

10 base 2 → Thin

ETHERNET

10 base T → Twisted pair

10 base F → Optical Fibre.

Topology → Bus

Page No.:

Date:

Start Frame Delemiter (Flag Byte)

Ethernet 802.3

Frame Format

FRAME

Physical layer — Data Link layer

Preamble	SFD	D A	SA	length	Body	CRC
7	1	6	6	2	46B–1500B	4

Cyclic Redundancy check.

PREAMBLE

7 → 56 bits → 1010 10 . . .

D A → Destination address of next node

SA → source address

length → length of frame

CRC

SFD

SFD → 10101011

IEEE 802.11

.11 WIFI

↳ wifi Wireless Fidelity.

Frame Format :

FRAME

	Frame control	Duration	Add 1	Add 2	Add 3	Seq	Add 4	Data	Check sum
Bytes	2	2	6	6	6				4

↳ Sub parts RIP blah jao.

Token ring

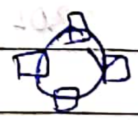
IEEE 802.5

TOKEN

→ 3 ~~bty~~ bytes frame travels inside ring.

→ Token is examined at each successive station

→ Used in Ring Topology



→ sets the bit and message in frame and passes it → Uni direction.

Page No.:

Date:

Token Bus: Same to Token Ring (prev page) just that it is in LAN or Bus topology.

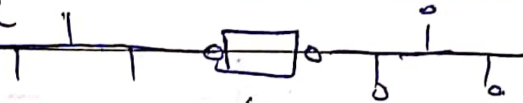
IEEE 802.4 standards

FDDI → Fiber Distributed Data Interference.
→ Use Optical Fiber over LAN.
→ 100 Mbits/sec. at lower cost.
→ Fast Ethernet.

FDDI

DEVICES

Repeaters (Physical layer)

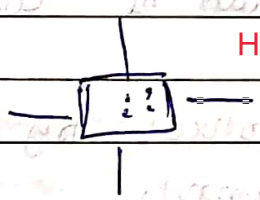


(Hardware)

REPEATERS

→ 2 port device ↳ regenerate signal strength.
→ Forwarding
→ No Filtering → collision Domain.

Hub (Physical layer)



HUB

→ n port device.
→ blinks → checks connection. (Red lights)
→ Forwarding → Half Duplex
→ No filtering → Broadcast to everyone (no memory)
→ Collision Domain. → layer 1 device

Switch → Switch has memory. → works on LAN
→ Store MAC address
→ layer 2 device.
→ doesn't always broadcast unlike hub.
since it knows the exact destination.
→ can do unicasting, multicasting, broadcasting.
→ Full Duplex.

SWITCH

devices which can read MAC add are 2 layer device
~~store routing table~~ — 3 layer

Bridge → Repeat + read MAC address.

BRIDGE

→ 2 layer device.

→ 2 LANs working on ~~same protocol~~ same protocol

→ 2 port device.

Routers → Forward data b/w 2 ~~differ~~ LAN, WAN - LAN, ISP network, MAN

ROUTERS

→ 3 layer device

→ store routing table.

→ decision are based on IP address.

MAP MULTIPLE ACCESS PROTOCOL

Multiple Access Protocol: If ~~do~~ multiple data ~~of~~ of different network is send over same channel data can be corrupted, lost etc.
So there would be collision of data on the channel.
Multi Access protocol try to reduces collisions on shared channels.

RANDOM ACCESS CONTROLLED ACCESS

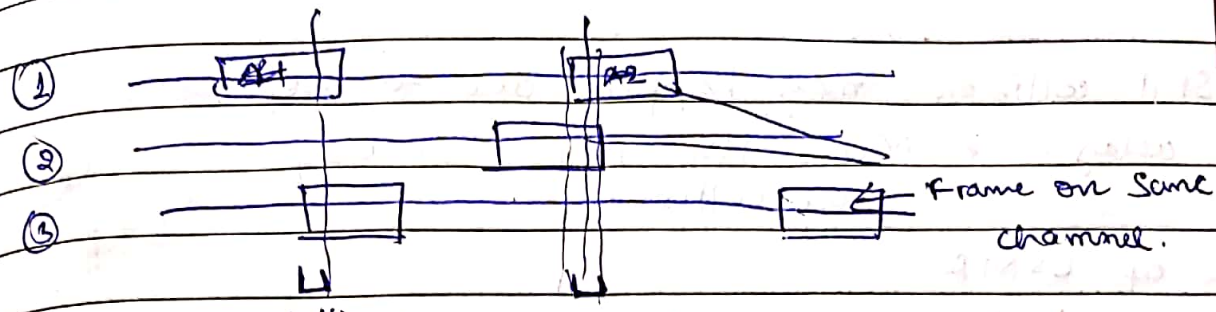
Random Access	Controlled Access (Only send if other allows aisa kuch.)	Channelisation
ALOHA	→ Reservation	→ FDMA
CSMA / CD	→ Polling	→ TDMA
CSMA / CA	→ Token passing	→ CDMA

Not in Syllabus

All station are at same level
None is supierior, can send data whenever.
No station control other station.

ALOHA → random access protocol

Pure Aloha ALOHA Slotted Aloha



PURE ALOHA

Pure Aloha → send data whenever want.

→ If we ~~got~~ doesn't get ack. means packet / data is collided. Data is transfered again on random time. This time would be propably different from other collided packet so now collision is reduced.

→ The throughput is inc is frames are of fixed size.

→ Even if they collide for small interval of time there are resend completely.

Vaherable Time (Possible collision time) = $2 \times T_r$

throughput = $G \times e^{-2G}$ T_r → time of 1 frame.

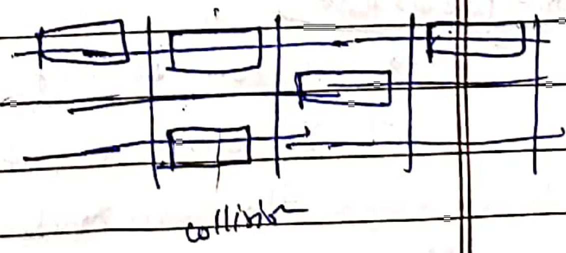
Max efficien = 18.4% $G = \frac{1}{2}$ (mat bacha unsla puche)

Slotted Aloha SLOTTED ALOHA

↳ channel is divided into fixed time slots.

so frames can be send only on ~~fixed~~ fixed intervals unlike Pure Aloha.

Rest is same



Venerable time = T_r

Throughput = $G e^{-G}$

Max effic = 36.8 $G = 1$

Page No.:

CSMA → carrier sense Multiple Access
→ Principle → "sense before transmit"
→ Carrier / medium can be busy or idle.

CSMA

Still collision may happen due to propagation delay. • More the propogation delay more collision.

Types of CSMA
(1) 1- Persistent CSMA
(2) P- Persistent CSMA
(3) Non - Persistent CSMA
(4) O - Persistent CSMA.

PERSISTENT

Modified Protocoloses are →
CSMA / CD (Collision Detection)
/ CA (Avoidance)

1 - Persistant

→ Before sending, it ~~checks~~ listens to channel to see if any one is transmitting or not.
→ If idle → transmits
→ If channel busy → continous keep on checking until its idle
check every second
→ station trasmits frame with probability 1 so is it name (1-persistent).

PERSISTENT

Non- persistant

→ Before sending, senses if channel is free or not.
→ If busy, it does not continuously sense the channel, but waits for random period of time and then repeats Algo.
→ Better utilization but longer delays than 1-persistent

Page No.:

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→ P- Persistent → continuous senses.
→ Applies to slotted channels.
→ If idle, transmits with probability P.
→ Q = 1-P, it waits until next slot.
→ If still busy, repeats Algo

~~note~~

O - Persistent :- Each node is assigned transmission order. by a supervisor node.

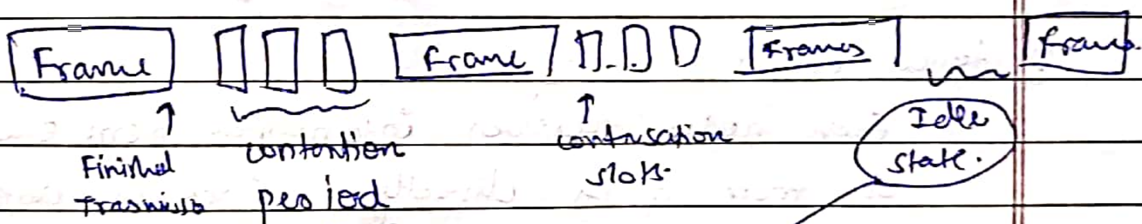
CSMA | CD Ethernet uses CSMA/CD.

Carrier Sense Multiple Access. → No acknowledment.

→ As soon as collision is detected station should stop & transmitting. their frames. $\boxed{\text{Transmission Time} > \text{Progation delay} \times 2}$

→ Occurs when two station senses a idle channel and start transmitting packets. they both will detect collision immediately.

CSMA/CD



minimum time to make sure that no others packet has been transmitted.

pulse width is used to detect collision

waits again, until its idle random till for next time

Datalink

CSMA/CA

CSMA | CA Collision Avoidance

Carrier Sense Multiple Access Used in WiFi (802.11)

→ We have to Avoid collision before sending them as they are used in wireless transmission. And we can't detect once packets is send.

Page No.:
Date:

~~Net~~ Routing

Congestion control → controls trafic mainly done on trasport layer though.

Methods → Token bucket, leaky bucket

IGMP Protocol.

ROUTING

Routing Protocols:

Each router has routing table which have info of other routers and what doing on the network

→ Dynamic protocol (keep on updating)

DISTANCE VECTOR

Routing Protocols

- Intradomain
  - DistanceVector (Routing Info Protocol
  - linkstate
- Inter domain
  - Path Vector

Distance vector Routing:

(1) Each nodes recieves information from one or more of its directly neighbours, perform calculation and then distributes result back to neighbours.

(2) Process keeps on repeating until no more info is available to exchange.

→ It is a dynamic algo.

→ Info is shared with neighbour at regular intervals

→ Only distance array / vector is shared with neighbours

→ least cost are related by Bellmen ford algo.

routing table :

Destination	Distance	Next
D_1		
D_2		
D_3		
D_4		

DICK DSA

Dijkstra

↳ Single source shortest path.

→ computes shorthest path to all nodes from source.

→ doesnt work on -ve cycle.

line coding

line coding → binary data → digital data.

Basic Pulse Shaping Techniques.

unipolar

Unipolar	bits	levels
	1 →	+a
	0 →	0

polar

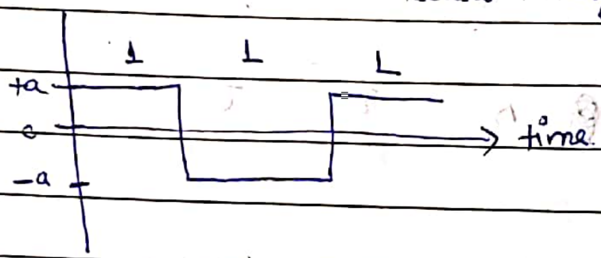
Polar	bits	levels
	1 →	+a
	0 →	−a

bipolar

Bipolar	bits	levels
	1 →	+a, −a
	0 →	0

Bipolar is also refered as Pseudo ternary code.

eg of Bipolar

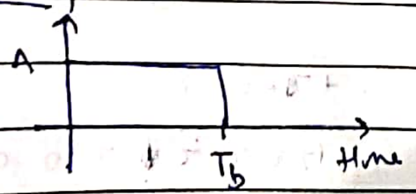


This method of Bipolar is refferd Alternate Marked Inversion (AMI) code.

Basic Pulses NRZ, RZ, Manchester.

nrz

→ NRZ → Not Return To Zero!



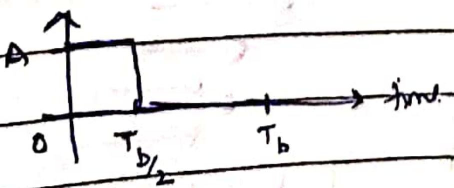
→ within T_b, Pulse not retain to zero

bit duration.

RZ

ZERO

→ RZ → Return to Zero!

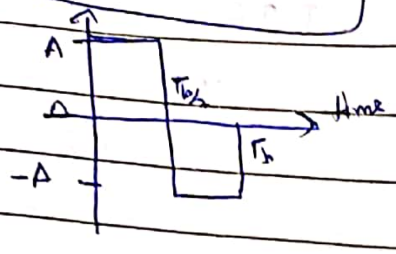


bit duration $T_{b/2}$

Page No.:
Date:

Manchester Pulse

MANCHESTER



→ at half duration there is transition from higth to low or low to high

PLOT