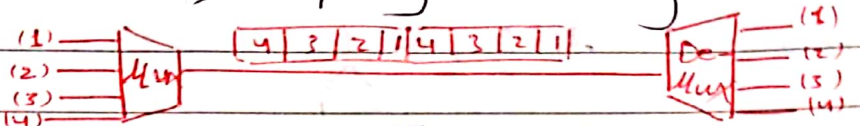
TDM :

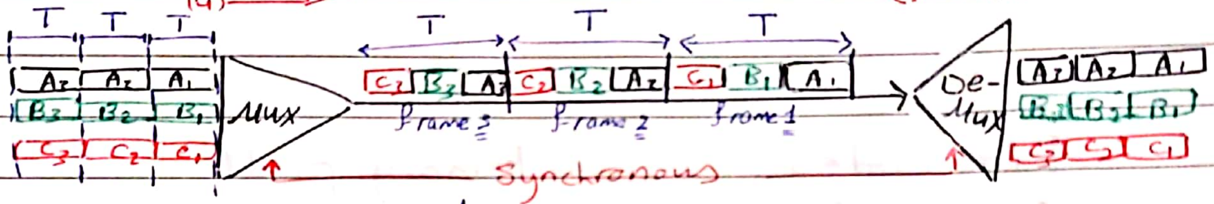
* Applications of sampling :

1) TDM 2) ADC

- → is The Time Interleaving of samples from several Sources
- → known as multiplexing Tech. for Compining several Low rate channels into one high rate one, multiplexing can be (bit-by-bit) or (word-by-word) Interleaving

1) Synch.



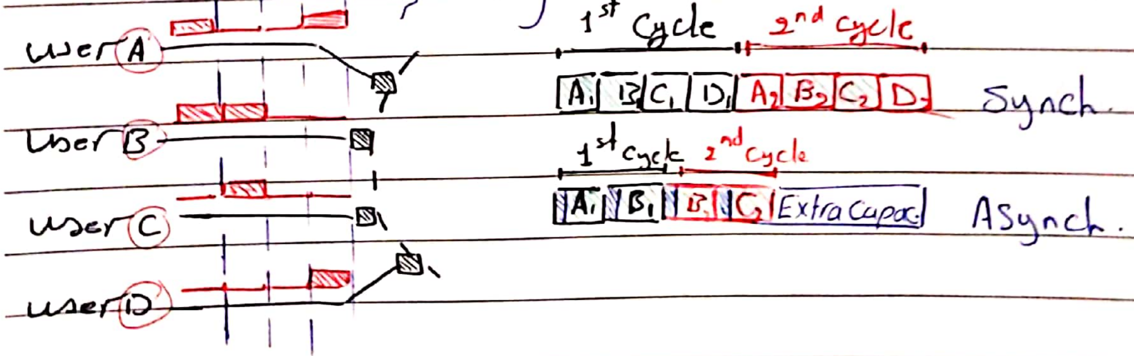


- * Data are Taken from each Line every T sec
- * each frame is 3 Time slots & each Time slot duration = $\frac{T}{3}$
- * The Data rate of The Link is n Times faster & The unit duration is n Times shorter

Called ⇒ cycle operation "each user is allocated a slot whether it is empty or not"

2) Asynch.

Called ⇒ statical TDM "provide more efficient use of B.W. & many More devices can be connected"

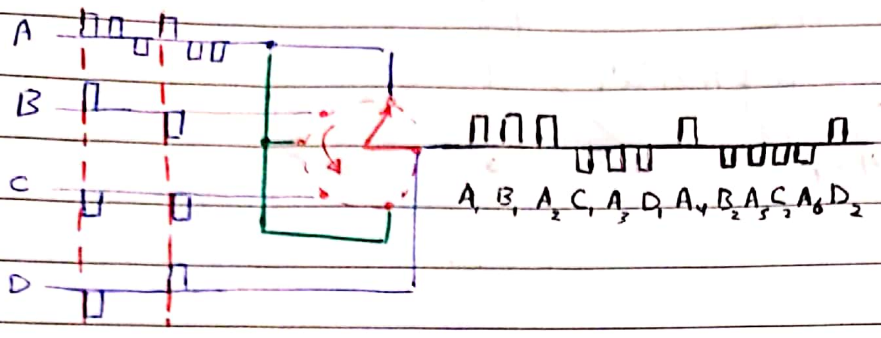


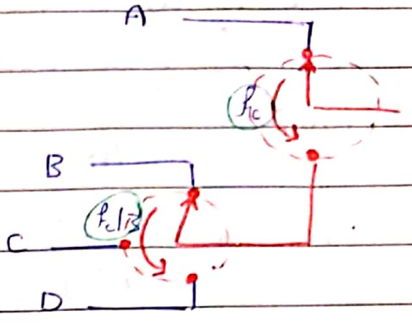
* Analog TDM : using PAM signals
* Digital TDM : using PCM signal

SUB

DATE

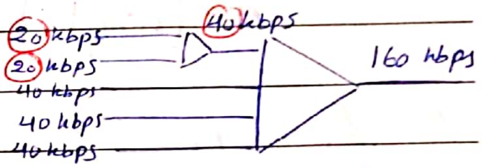
— When The bit rates of incoming chs are not Identical, The high-bit-rate channel is allocated more slots :



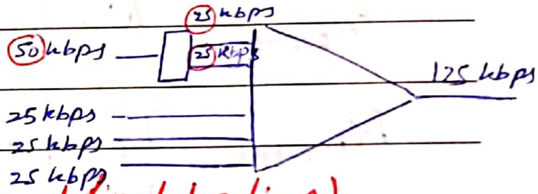


— Handling Different Data rates :

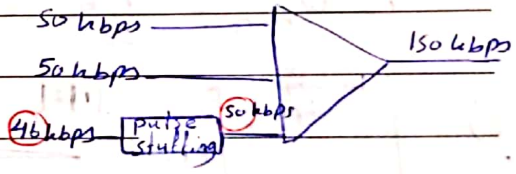
3 Types : ① multilevel multiplexing



② multiple slot Multiplexing



③ pulse stuffing (extra dummy bits at fixed locations)

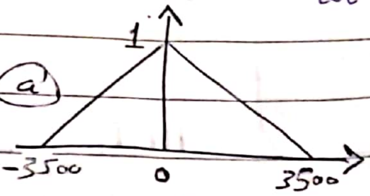


1) 14 users, $M(f) = Tri\left(\frac{f}{3500}\right)$, $P_1 = 2$ watt, $m_p = 3$ volt, SQNR = 40dB

ⓐ f_N ?, ⓑ n ?, $f_s = 1{,}2 f_N$ & $R_b' = (1{,}04)\, n\, f_s$, ⓒ $R_{b_{tot}}$?, ⓓ $B.W_{min}$?

Sol → * B.W = 3500 HZ

$f_N = 2 \cdot 3500 = 7$ kHZ ⓐ



* $SQNR = \frac{P_m}{\Delta^2/12} = \frac{P_m \cdot \cancel{12}^{3}}{\frac{\cancel{4} m_p^2}{L^2}}$

$$10^4 \overset{2}{=} \frac{P_m \cdot L^2 \cdot 3}{\cancel{m_p^2}_{9}}$$

L = 122,5 levels

$n = (\log_2 L) \simeq 7 \frac{\text{bit}}{\text{Sample}}$ ⓑ

* $f_s = 1{,}2 f_N = 8400$ sps

$f_{s\ total} = N \cdot f_s = 14 \cdot 8400 = 117{,}6$ ksps

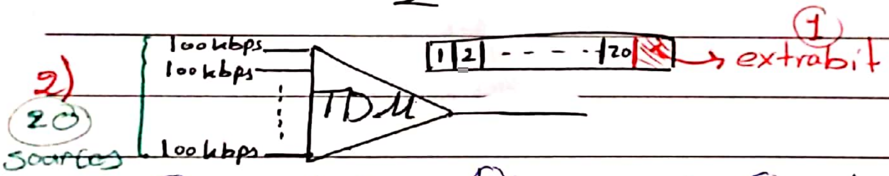
→(# of users)

$R_{b\ total} = 1{,}04 \cdot n \cdot f_{s\ total}$

$= 1{,}04 \cdot 7 \cdot 117{,}6 = 856{,}128$ kbps ⓒ

* $B.W_{min} = \frac{R_b}{2} = 428{,}064$ kHZ ⓓ

2)



ⓐ Size of frame?, ⓑ frame rate?, ⓒ duration of frame?, ⓓ data rate ?, ⓔ efficiency?

Sol → * frame size = 20 + 1 = 21 bit/frame ⓐ

* each frame carries ① bit from each digital source

∴ I/p slot (bit) Time = o/p frame Time = $\frac{1}{100k}$ = ,01 msec ⓒ

* $\text{frame rate} = \frac{1}{\text{duration of frame}} = \frac{1}{,01\ \text{msec}} = 100$ kFps ⓑ

* $\text{Data rate} = \text{frame rate}\left(\frac{\text{frame}}{\text{sec}}\right) \cdot \text{frame size}\left(\frac{\text{bit}}{\text{frame}}\right)$

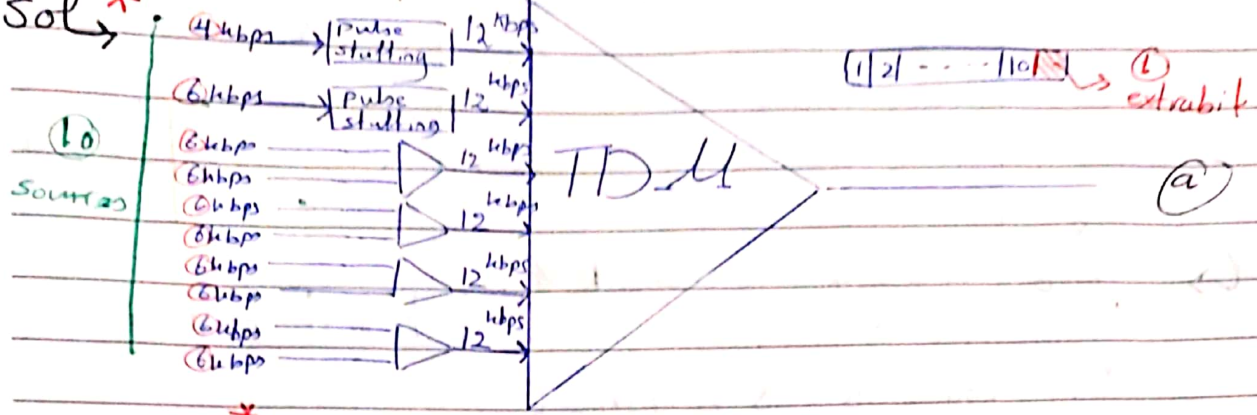
$= 100k \cdot 21 = 2.1$ Mbps ⓓ

* $\text{efficiency} = \frac{\text{useful bits/frame}}{\text{total bits/frame}} = \frac{20}{21} \cdot 100\% = 95{,}23\%$ ⓔ

Nile
STATIONERIES

3) ⓐ Draw The TDM block (12 kbps), ⓑ size of frame?, ⓒ frame rate?, ⓓ frame duration?, ⓔ data rate?

Sol → *



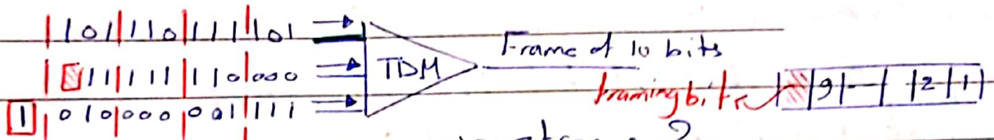
* frame size = 6 + 1 = 7 bit/frame ⓑ

* frame rate = 12 kFps ⓒ

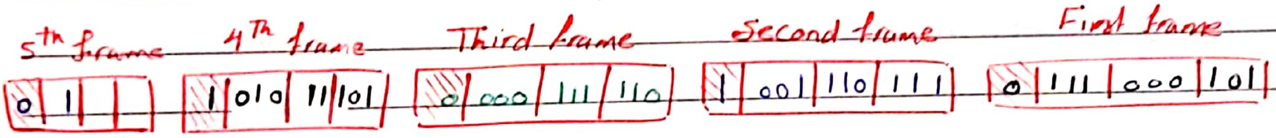
* frame duration = $\frac{1}{12k}$ = 83,3 μsec ⓓ

* datarate = 7 . 12000 = 84 kbpsec ⓔ

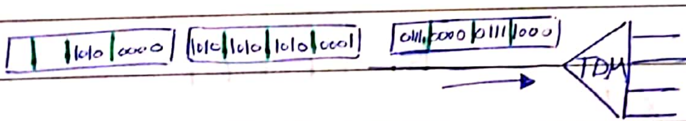
4)



o/p stream ?



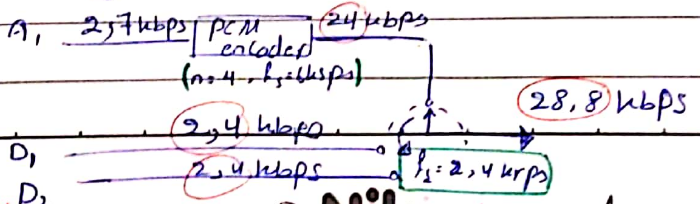
5)



bit stream in each o/p ?

① 0000 0001 1000
② 1010 10100111
③ 10100000
④ 1010 0111

6) D = 2 (2400 bit/sec), A = (BW = 2700 HZ) → [f_s = 1,1111 f_N], 4-bit pcm
ⓐ block diagram, ⓑ data rate at each point, ⓒ BW_{min}



ⓐ } ⓑ

* $BW_{min} = \frac{R_b}{2}$ = 14,4 KHZ ⓒ

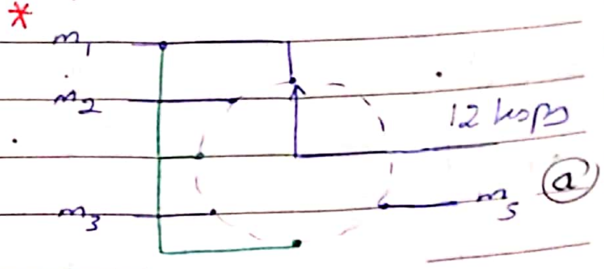
$R_A = n . f_s$ = 4 . 1,111 . (2 . 2,7 k) = 24 kbps

R_{tot} = 2 . 2,4 + 24 = 28,8 kbps

7)

Signals	B.W	$f_s = f_N$
$m_1(t)$	3 kHZ	6 ksps
$m_2(t)$	1 kHZ	2 ksps
$m_3(t)$	1 kHZ	2 ksps
$m_4(t)$	1 kHZ	2 ksps

Sol,



* $f_s = 6 + 2.3 = 12$ ksps ⓑ

*

m_1	m_2	m_1	m_3	m_1	m_4

ⓓ

* Speed = 2 krps ⓒ

* $n = \log_2 256 = 8$ bit/sample

$R_b = 12$ ksps $\cdot\, 8 = 96$ kbps ⓔ

* $B.W_{min} = \frac{R_b}{2} = 48$ kHZ ⓕ

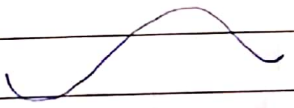
DPCM:

in PCM → to decrease error ⇒ L ↑ ⇒ n ↑ ⇒ R_b ↑ ⇒ BW ↑

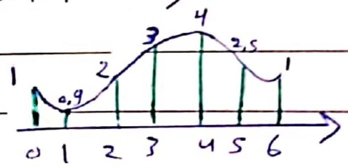
So we use DPCM to Decrease The B.W, HOW?

We'll quantize The diff bet. The successive Samples Instead of quantize The original signal

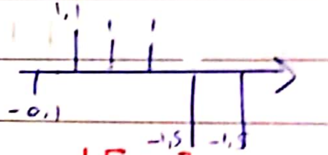
↳ results in: ① Less # of bit → same SNR
② SNR ↑ → Same # of bits



X(t)



X(k)

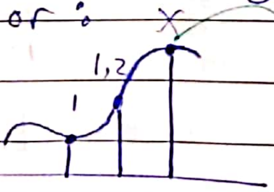


d[k]

⇒ $d[k] = X[k] - X[k-1]$

* Range of d[K] ≪ Range of X[k]

DPCM using predictor:

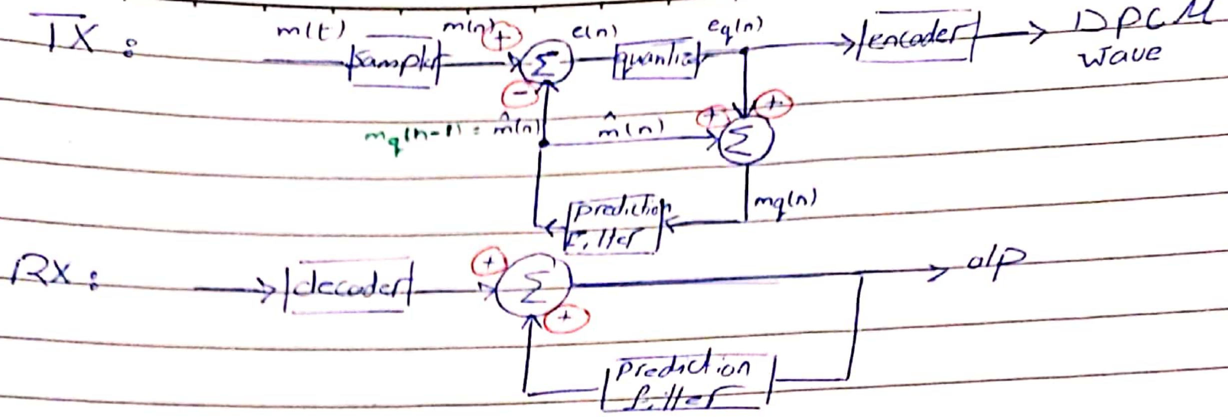


1,3 المتوقع

True value = 1,4

DPCM (Sends 0,2)

Predictor (Sends 0.1)



- (DM) is special case of (DPCM)

14) for DPCM → $SNR_o|_{dB} = \alpha + 6n$, $-3 < \alpha < 15$ (dB)

for PCM → $SNR_o|_{dB} = 4,77 + 6n - 20\log_{10}[\ln(1+\mu)]$

(a) for same (n)

↳ Speech signal have 8 bit/sample ⇒ $n = 8$

⇒ for DPCM → $45 < SNR_o|_{dB} < 63$ dB

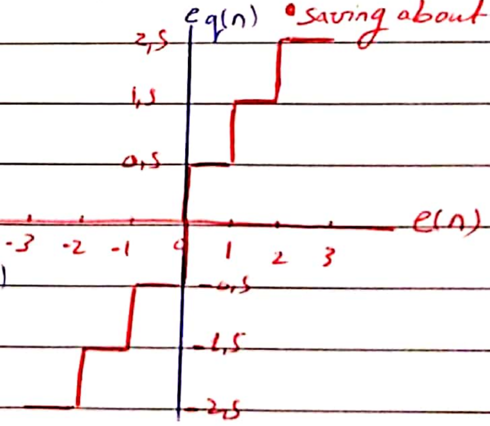
⇒ for PCM → $SNR_o|_{dB} = 38$ dB

- SNR Improvement for DPCM in range of 7 to 25 dB

(b) for same (SNR)

$\boxed{\alpha = 15}$ ⇒ $15 + 6n_1 = 6n_2 - 10$ → $n_2 - n_1 = 4,14$
- Saving about (4 $\frac{\text{bit}}{\text{sample}}$)

$\boxed{\alpha = -3}$ ⇒ $-3 + 6n_1 = 6n_2 - 10$ → $n_2 - n_1 = 1,17$
- Saving about (1 $\frac{\text{bit}}{\text{sample}}$)



15) $m_q(n) \rightarrow$ Prediction Filter $\rightarrow \hat{m}(n)$

$\star\ (\hat{m}(n) = m_q(n-1))$ ⇒ First order

- [assume Initial prediction of filter = 0]

m(n)	$\hat{m}(n)$	e(n)	$e_q(n)$	$m_q(n) = e_q(n) + \hat{m}(n)$
0	$\boxed{0}$	0	0,5	$\boxed{0,5}$
0,3	$\boxed{0,5}$	−0,2	−0,5	$\boxed{0}$
1,5	$\boxed{0}$	1,5	1,5	$\boxed{1,5}$
0,7	$\boxed{1,5}$	−0,8	−0,5	$\boxed{1}$
1	$\boxed{1}$	0	0,5	$\boxed{1,5}$
2,3	$\boxed{1,5}$	0,8	0,5	2

↳ Transmitted sequence = {0,5, −0,5, 1,5, −0,5, 0,5, 0,5}

#