

TDM

Examples

Examples

EXAMPLE 5.9. Two analog signals $x_1(t)$ and $x_2(t)$ are to be transmitted over a common channel by means of time division multiplexing (TDM). The highest frequency of $x_1(t)$ is 4 kHz and that of $x_2(t)$ is 4.5 kHz. What will be the minimum value of permissible sampling rate?

Solution: The highest frequency component of the composite signal consisting of $x_1(t)$ and $x_2(t)$ is 4.5 kHz. Therefore, the minimum value of permissible sampling rate will be,

$$f_{s(\min)} = 2 \times 4.5 \text{ kHz} = 9 \text{ kHz} \quad \text{Ans.}$$

EXAMPLE 5.10. A signal $x_1(t)$ is bandlimited to 3 kHz. There are three more signals $x_2(t)$, $x_3(t)$ and $x_4(t)$ which are bandlimited to 1 kHz each. These signals are to be transmitted by a TDM system.

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1. Design a TDM scheme where each signal is sampled at its Nyquist rate
2. What must be the speed of the commutator
3. Calculate the minimum transmission bandwidth of the channel.

solution:

Solution: (i) Table 5.3 shows different message signals with corresponding Nyquist rates.

Table 5.3

S.No.	Message signal	Bandwidth	Nyquist rate
1.	$x_1(t)$	3 kHz	6 kHz
2.	$x_2(t)$	1 kHz	2 kHz
3.	$x_3(t)$	1 kHz	2 kHz
4.	$x_4(t)$	1 kHz	2 kHz

If the sampling commutator rotates at the rate of 2000 rotations per second then the signals $x_2(t)$, $x_3(t)$ and $x_4(t)$ will be sampled at their Nyquist rate. But, we have to sample $x_1(t)$ also at its Nyquist rate which is three times higher than that of the other three. In order to achieve this, we should sample $x_1(t)$ three times in one rotation of the commutator. Therefore, the commutator must have at least 6 poles connected to the signals as shown in figure 5.44.

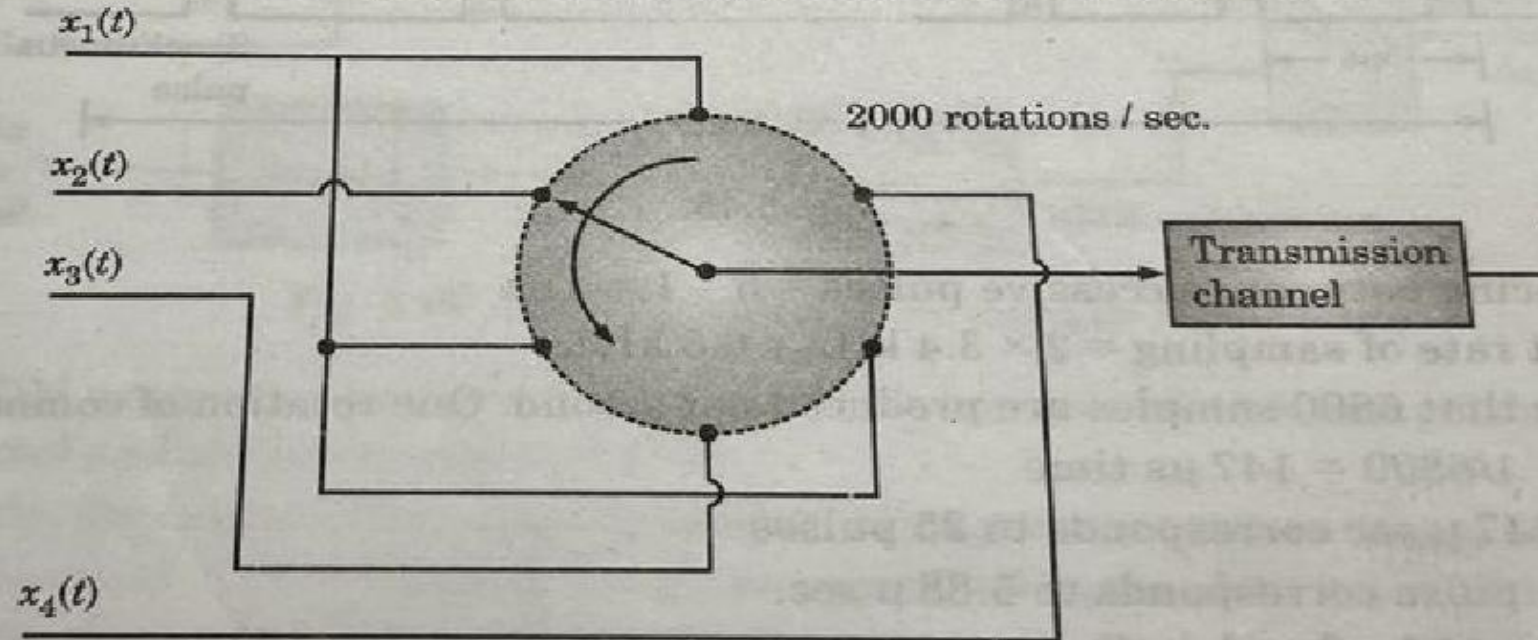


Fig 5.44

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Fig. 5.44.

(ii) The speed of rotation of the commutator is 2000 rotations/sec.

(iii) Number of samples produced per second is calculated as under:

$x_1(t)$ produces $3 \times 2000 = 6000$ samples/sec.

$x_2(t)$, $x_3(t)$ and $x_4(t)$ produce 2000 samples/sec. each.

Therefore, number of samples per second = $6000 + (3 \times 2000) = 12000$ samples/sec.

$\therefore$ Signaling rate = 12000 samples/sec.

(iv) The minimum channel bandwidth will be

$$BW = \frac{1}{2} (\text{signaling rate}) = 12000/2 = 6000 \text{ Hz} \quad \text{Ans.}$$

Example

Twenty- four voice signals are sampled uniformly and then Time Division Multiplexed.

the sampling operation uses flat – top samples with 1 μ s. Duration. the multiplexing operation includes provision for synchronization by adding an extra pulse of appropriate amplitude and 1 μ s. Duration.

The highest frequency component of each voice signal is 3.4 KHz

(i) Assuming a sampling rate of 8 kHz, calculate the spacing between successive pulses of the multiplexed signal.

(ii) Repeat (i) assuming the use of Nyquist rate sampling.* (GATE Examination 1997)

Solution: (i) Given that

Sampling rate = 8 kHz = 8000 samples/sec.

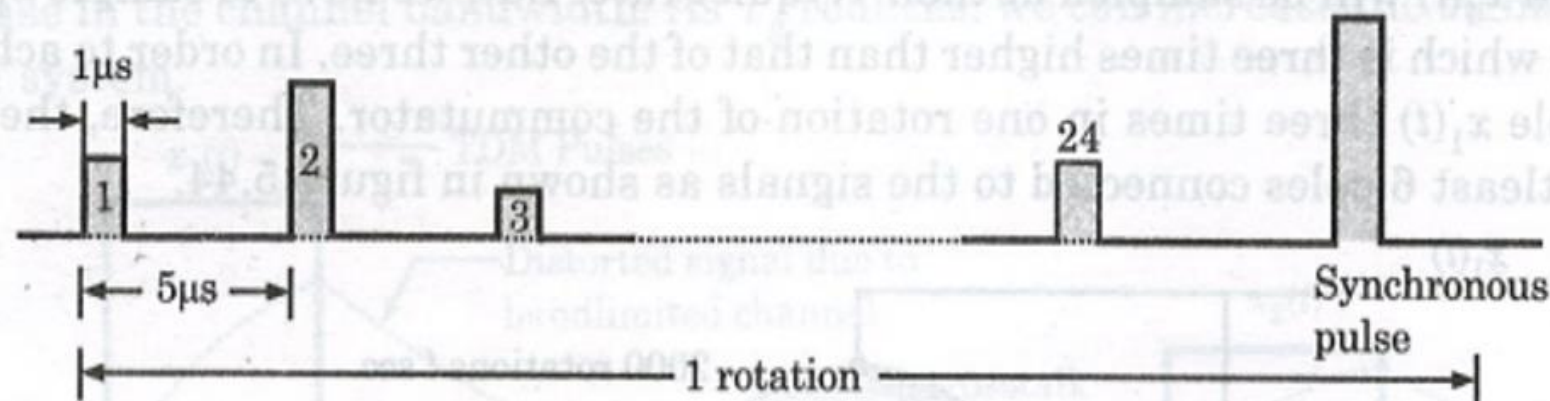
There are 24 voice signals + 1 synchronizing pulse.

Pulse width of each voice channel and synchronizing pulse is $1\ \mu\text{s}$.

Now, time taken by the commutator for 1 rotation = $\frac{1}{8000} = 125\ \mu\text{sec}$.

Number of pulses produced in 1 rotation = $24 + 1 = 25$

Therefore, the leading edges of the pulses are at $\frac{125}{25} = 5\ \mu\text{seconds}$ distance as shown in figure 5.45.



Hence, spacing between successive pulses = $5 - 1 = 4 \mu\text{s}$

(ii) Nyquist rate of sampling = $2 \times 3.4 \text{ kHz} = 6.8 \text{ kHz}$.

This means that 6800 samples are produced per second. One rotation of commutator takes

$$1/6800 = 147 \mu\text{s time}$$

Therefore, $147 \mu\text{ sec}$ corresponds to 25 pulses

Therefore, 1 pulse corresponds to $5.88 \mu\text{ sec}$.

As the pulse width of each pulse is $1 \mu\text{ sec}$, the spacing between adjacent pulses will be $4.88 \mu\text{ sec}$ and if we assume $\tau = 0$ then the spacing between the adjacent pulses will be $5.88 \mu\text{ sec}$.

EXAMPLE 5.12. Six message signals each of bandwidth 5 kHz are time division multiplexed and transmitted. Determine the signaling rate and the minimum channel bandwidth of the PAM/TDM channel.

Solution: The number of channels $N = 6$

Bandwidth of each channel, $f_m = 5$ kHz

Therefore, minimum sampling rate $= 2 \times 5 \text{ kHz} = 10 \text{ kHz}$

Signaling rate = Number of bits per second

$$= 6 \times 10 \text{ kHz} = 60 \text{ K bits/sec.} \quad \text{Ans.}$$

Minimum channel bandwidth to avoid cross talk in PAM/TDM is,

$$BW = Nf_m = 6 \times 5 \text{ kHz} = 30 \text{ kHz} \quad \text{Ans.}$$