

For a PCM encoder, an ADC can be replaced for a quantizer & encoder. At the Rxing end, the Rxed s/g is initially requantized & determine whether a pulse is occurring or not over each bit interval. The regenerated pulse train is applied to a decoder which performs the inverse operation of an encoder. In the final stage, LPF with cut-off freq f_m will recover back the actual base band s/g.

→ PCM (Pulse Code Modulation)

In PCM, we represent each quantized level by code

no. & Tx the code no. rather than the sample value itself.
Before Txion, the code no. is converted into its representation
in binary arithmetic. The digits of binary representation
of code are Txed as pulses. Hence the system of Txion
is called (binary) PCM.

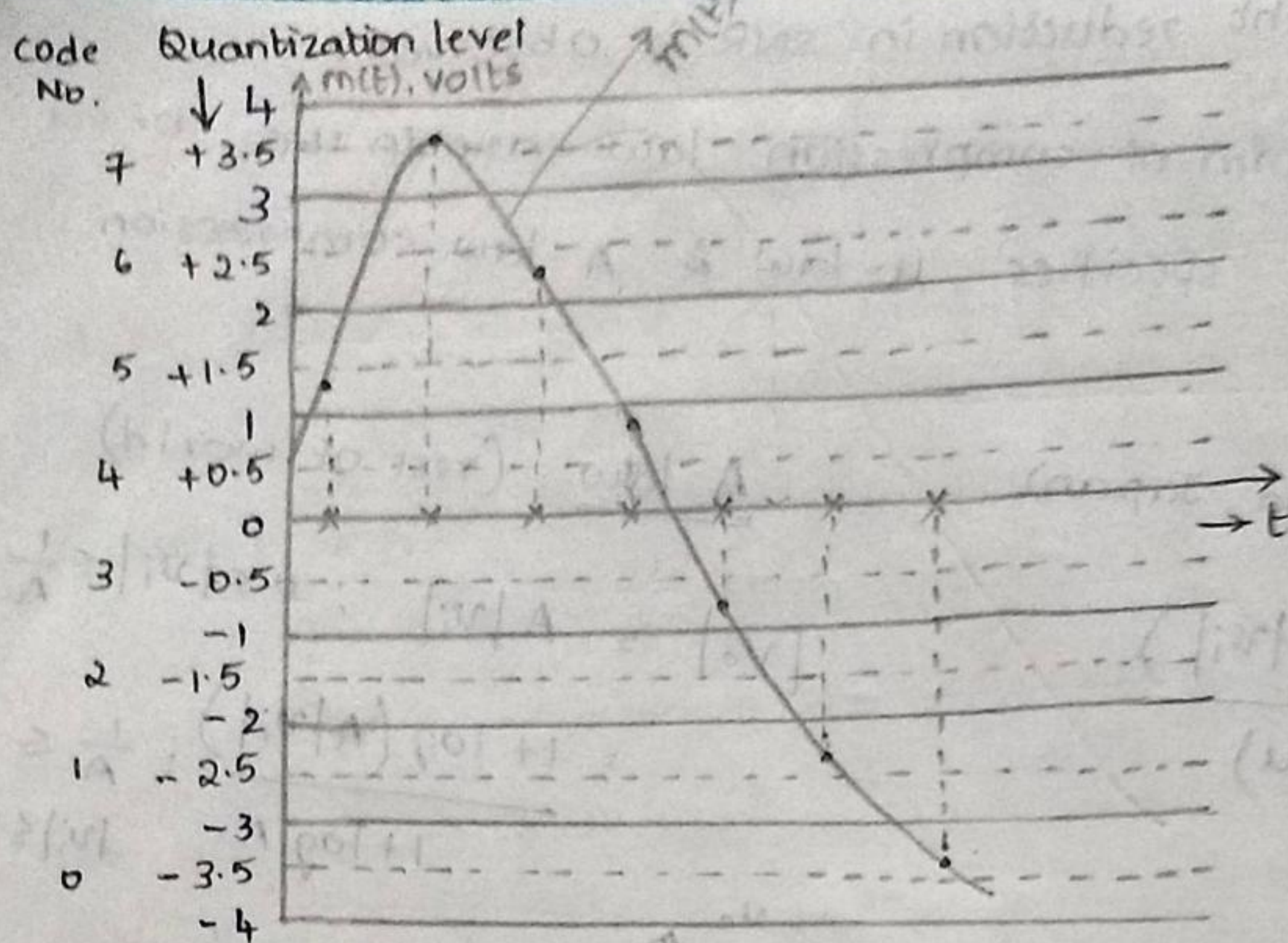
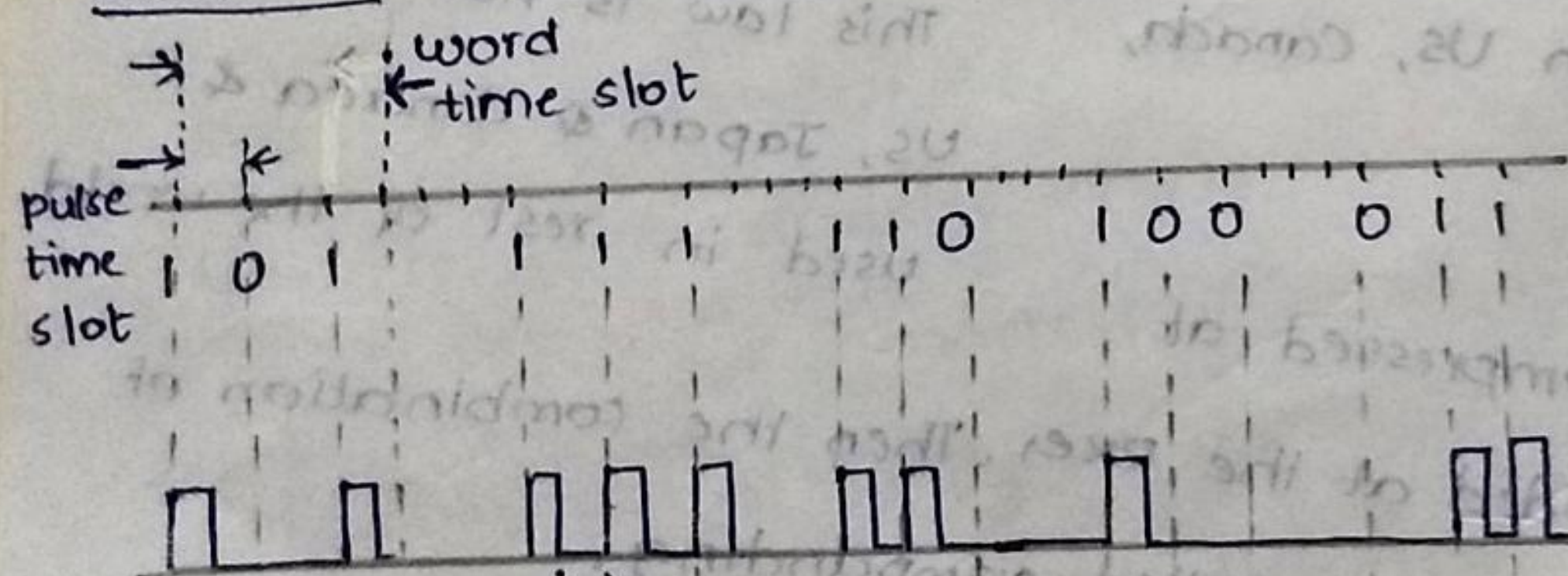


Fig ①

| | | | | | | | |
|------------------------------|-----|-----|-----|-----|------|------|------|
| ① Sample value | 1.3 | 3.6 | 2.3 | 0.7 | -0.7 | -2.4 | -3.4 |
| ② nearest quantization level | 1.5 | 3.5 | 2.5 | 0.5 | -0.5 | -2.5 | -3.5 |
| ③ Code No. | 5 | 7 | 6 | 4 | 3 | 1 | 0 |
| ④ Binary representation | 101 | 111 | 110 | 100 | 011 | 001 | 000 |

Electrical representation of Binary digits :



binary bit

'1' → presence of pulse

'0' → absence of pulse.

Fig a)

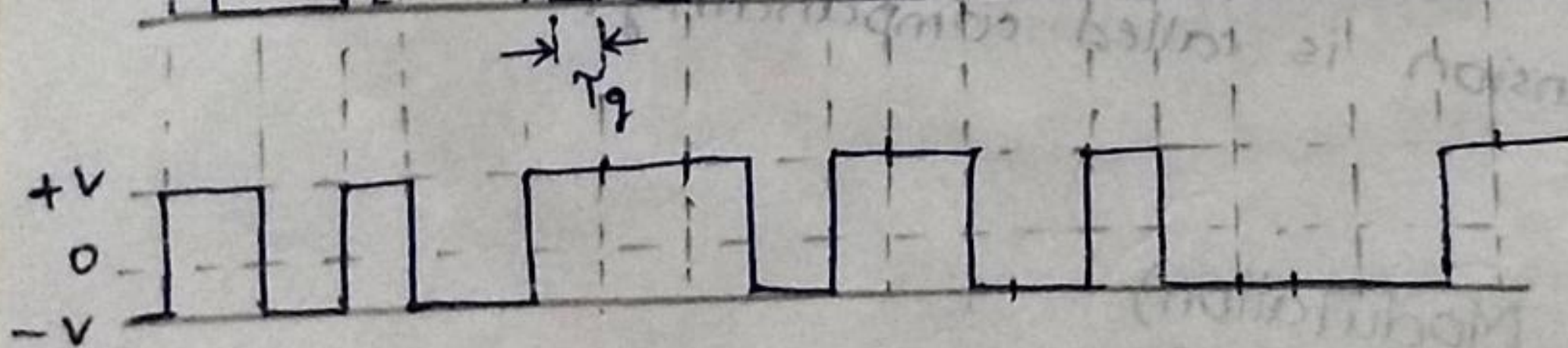


Fig b)

Fig a) Pulse representation of binary no.'s used to code the

samples in Fig ①

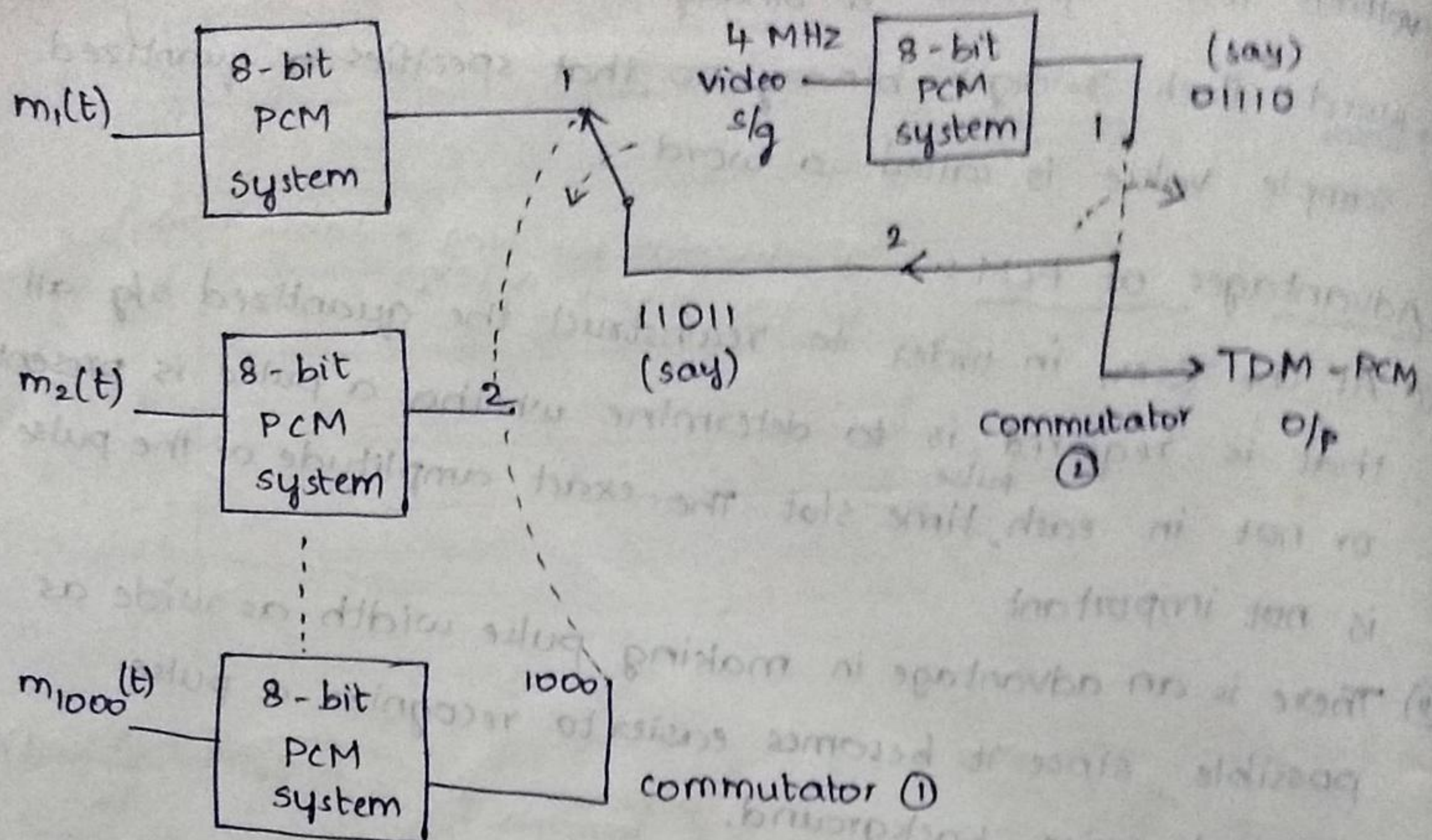
Fig b) Representation by voltage levels rather than pulses.

In Fig b) we eliminate the guard time T_g b/w pulses & when the waveform occupies the lower level in a particular time slot, a binary '0' is represented, while the upper voltage level represents a binary '1'.

→ Synchronous TDM-PCM system ∴ (T1 Digital system)

In synchronous TDM system, there should be relation b/w bandlimiting freqs of the s/gs which are to be multiplexed. To illustrate, a TDM-PCM system, consider an eg in

(25)



which

1000 audio s/gs each of 4 KHz &
1 video s/g at 4 MHz

are to be multiplexed

For good fidelity, use 8-bit PCM system corresponding to Txion of all 1000 s/gs. Multiplex 1000 audio s/gs using a switching mechanism similar to that of TDM-PAM system called commutator-①. To multiplex a video s/g of 4 MHz use another switching mechanism called commutator ②. At the Rxing end, the s/gs can be separated using decommutators.

When there is a pulse at commutator ①, then there is no video s/g & viceversa. Hence at commutator ②, a composite s/g (that is) ^{i.e.,} multiplexed bit pattern of both audio & video s/gs are available as shown in fig.

Using similar type of decommutator switching mechanism the s/gs can be separated at the Rxing end, but synchronization is to be maintained b/w all switching mechanisms.

For audio s/g:

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① sampling time, $T_s = \frac{1}{2f_m} = \frac{1}{2 \times 4 \times 10^3} = \frac{1}{8} \text{ msec}$

$\therefore f_m = 4 \text{ kHz}$

② word duration, $= \frac{T_s}{N} = \frac{\frac{1}{8} \times 10^{-3}}{1000} = \frac{1}{8} \mu\text{sec}$

{ 1000 audio s/gs are to be multiplexed }

③ Bit duration, $T_b = \frac{T_s}{Nb} = \frac{\frac{1}{8} \times 10^{-6}}{8} = \frac{1}{64} \mu\text{sec}$

{ since, we use 8-bit PCM, 1 word here consists of 8 bits $\therefore b = 8$ }

This bit duration is divided into 2 equal halves, one for pulse width (τ) & other for guard time (τ_g)

\therefore Bit duration, $T_b = \tau + \tau_g$
 $\Rightarrow \frac{1}{64} \mu\text{sec} = \left(\frac{1}{128} + \frac{1}{128} \right) \mu\text{sec}$ or $\{ \tau = T_b/2 \}$

For video s/g:

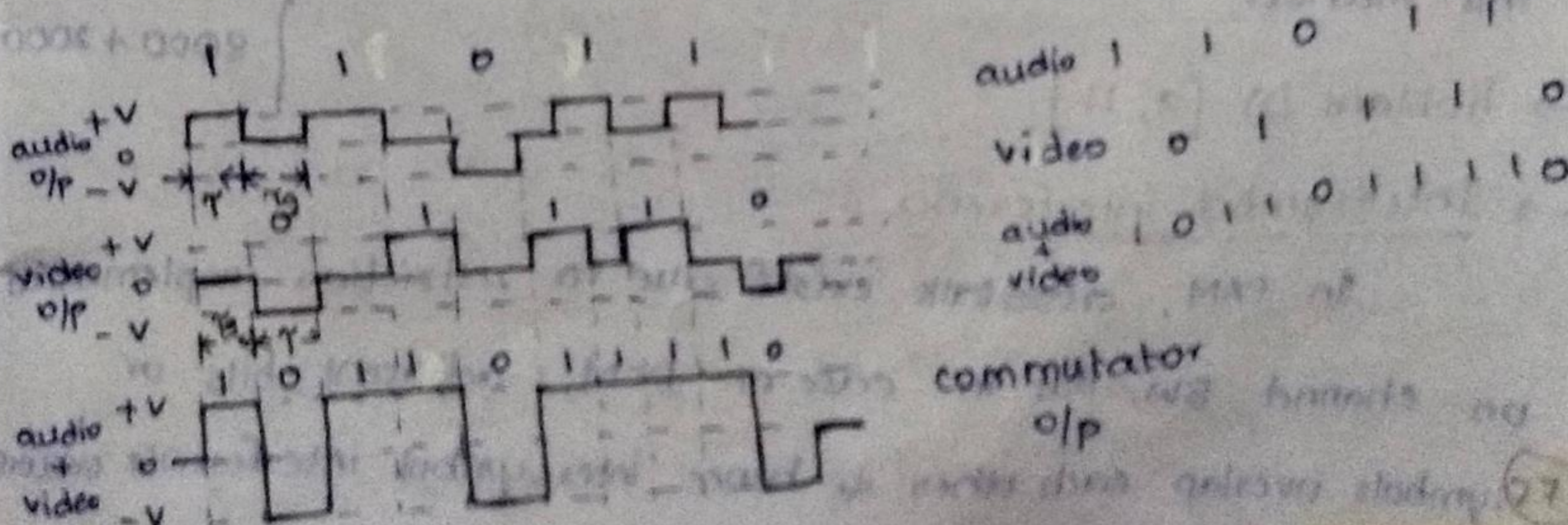
① sampling time, $T_s = \frac{1}{2f_m} = \frac{1}{2 \times 4 \times 10^6} = \frac{1}{8} \mu\text{sec}$

② word duration, $\frac{T_s}{N} = \frac{\frac{1}{8} \mu\text{sec}}{1} = \frac{1}{8} \mu\text{sec}$

③ Bit duration, $T_b = \frac{T_s}{Nb} = \frac{\frac{1}{8} \mu\text{sec}}{8} = \frac{1}{64} \mu\text{sec}$

This bit duration is also divided into 2 equal halves, 1st half is allocated for guard time (τ_g) & 2nd half is allocated for pulse width (τ)

$T_b = \tau_g + \tau$
 $\Rightarrow \frac{1}{64} \mu\text{sec} = \left(\frac{1}{128} + \frac{1}{128} \right) \mu\text{sec}$



Asynchronous TDM-PCM system :-

In asynchronous TDM system, the s/g's which are to be multiplexed will not have definite relationship b/w their bandlimiting frequencies

Consider 2 s/g's $m_1(t)$ & $m_2(t)$ having bandlimiting frequencies as $f_M = 4 \text{ KHz}$ & 5 KHz respectively. The samples of these two s/g's are to be multiplexed for a duration of

1 sec.

① For $m_1(t)$, sampling time, $T_s = \frac{1}{2f_M} = \frac{1}{2 \times 4 \times 10^3} = \frac{1}{8} \text{ msec}$

1 word $\rightarrow \frac{1}{8} \text{ msec}$ $1 \times 1 = \frac{1}{8} \times 10^{-3} N$

$N(?) \leftarrow 1 \text{ sec} \Rightarrow \boxed{N = 8000 \text{ words}}$

\therefore In 1 sec, 8000 words are recorded to $m_1(t)$

② For $m_2(t)$, sampling time, $T_s = \frac{1}{2f_M} = \frac{1}{2 \times 5 \times 10^3} = 0.1 \text{ msec}$

1 word $\rightarrow 0.1 \text{ msec}$ $1 \times 1 = 0.1 \times 10^{-3} \times N$

$N(?) \leftarrow 1 \text{ sec} \Rightarrow \boxed{N = 10,000 \text{ words}}$

\therefore In 1 sec, 10,000 words are recorded to $m_2(t)$

To achieve synchronization, 1st 8000 words of both $m_1(t)$ & $m_2(t)$ can be multiplexed using synchronous TDM system & for remaining 2000 words, Tx continuous pulses of 1's. Hence this method is called pulse stuffing.

\rightarrow Problems (2) [8, 11]

$$\begin{cases} 8000 + 0 \\ 8000 + 2000 \end{cases}$$