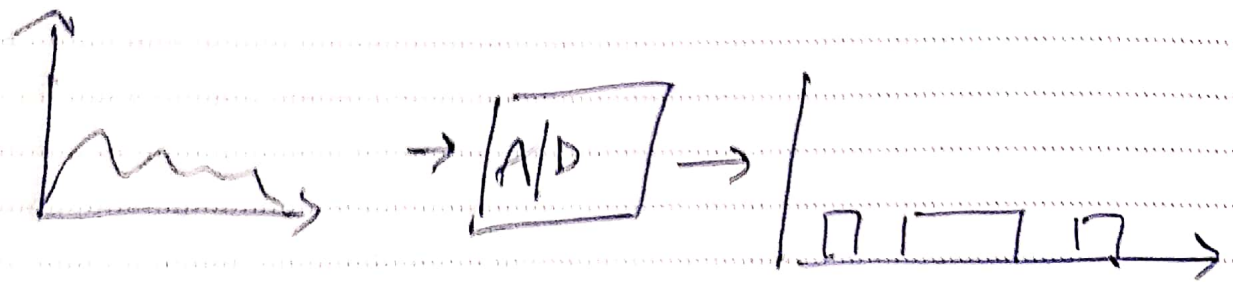


Analog to Digital Conversion

We sometimes need to digitize the analog signal. For eg. to send human voice over a long distance, we need to digitize it since digital signals are less prone to noise.

This is called as analog to digital conversion.



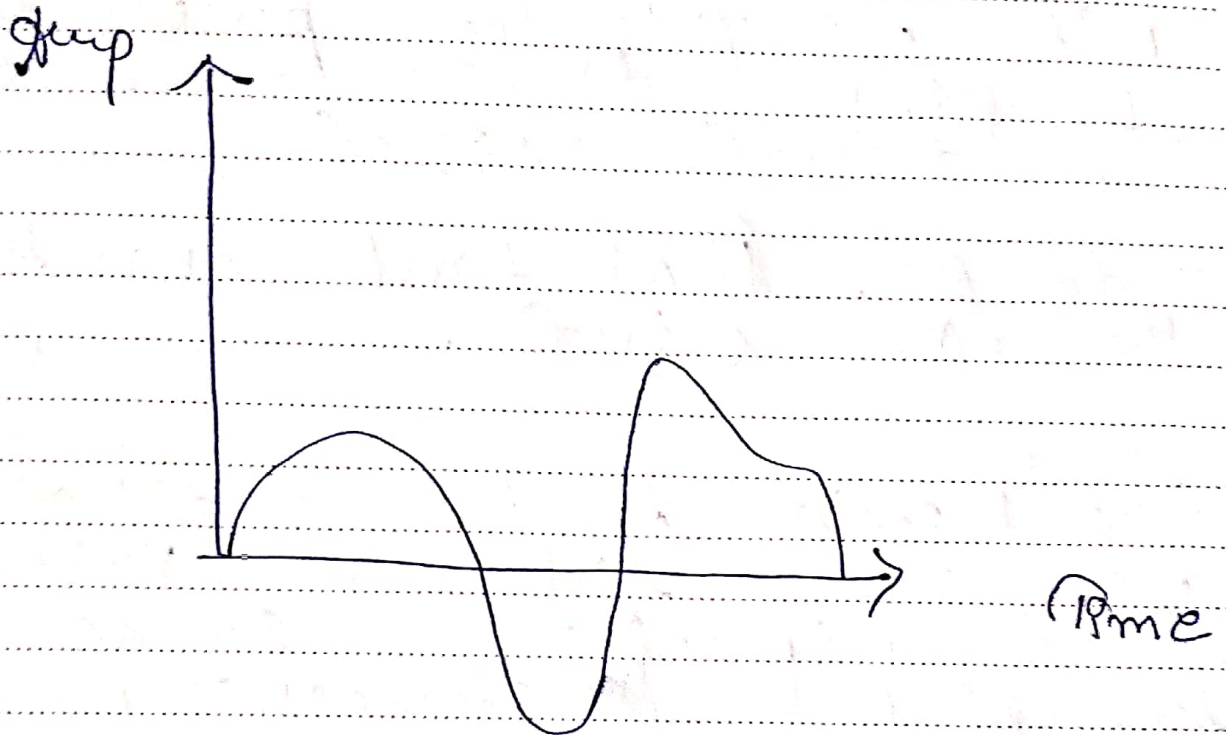
Pulse Amplitude Modulation →

The 1st step in analog to digital conversion is pulse amplitude modulation.

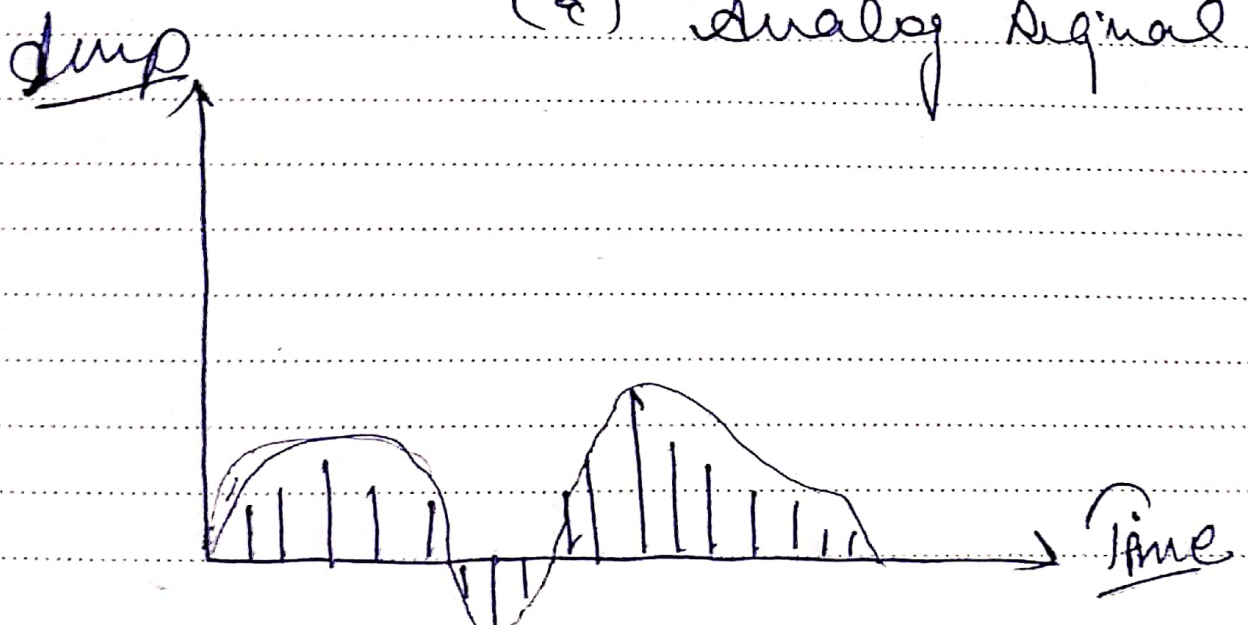
This technique takes an analog signal, samples it and generates a series of

pulses based on results of sampling.


The term "Sampling" means measuring the amplitude of the signal at equal intervals.



(a) analog signal



(b) PAM.



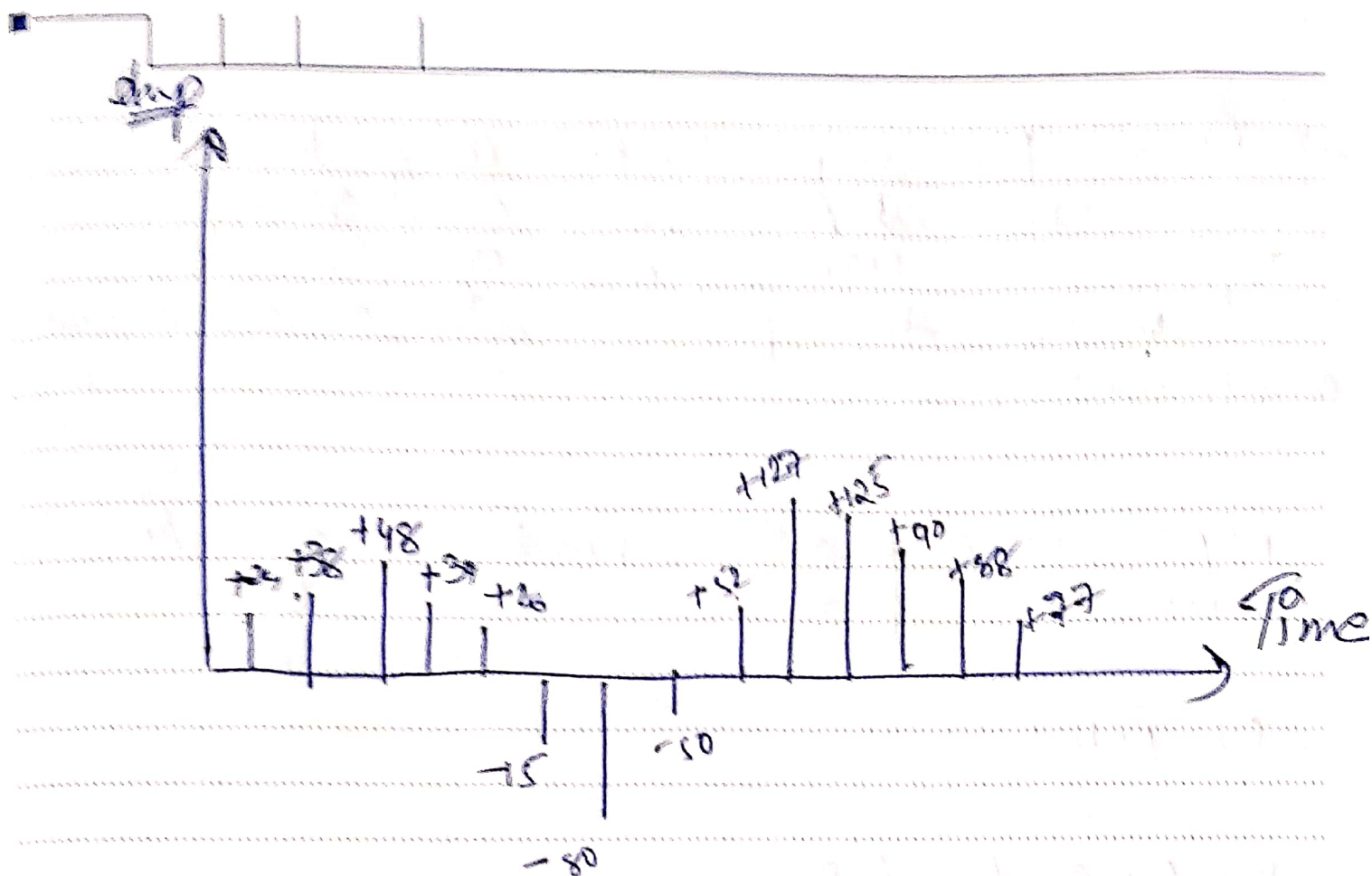
But PAM is not useful for data communication as the pulses are still not completely digital.

Pulse Code Modulation \rightarrow

PCM modifies the pulses created by PAM to create a completely digital signal.

To do so, PCM first quantizes the PAM signal.

"Quantization is the method of assigning integral values in a specific range to sampled instances."



→ Fig shows a simple method of assigning values to quantized samples.

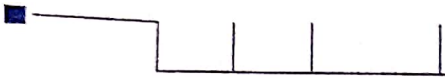
→ Each value is then transformed into its 7-bit binary equivalent

eg $+024 \rightarrow 00011000$

$+038 \rightarrow 00100110$

and so on. . .





→ The binary bits are then transformed into a digital signal using one of the digital to digital encoding methods.

PCM is actually made up of 4 separate processes —

1) PCM

2) Quantization

3) Binary Encoding

4) Digital to Digital Encoding -

Sampling Rate: - The question is -

"How many samples are sufficient?"

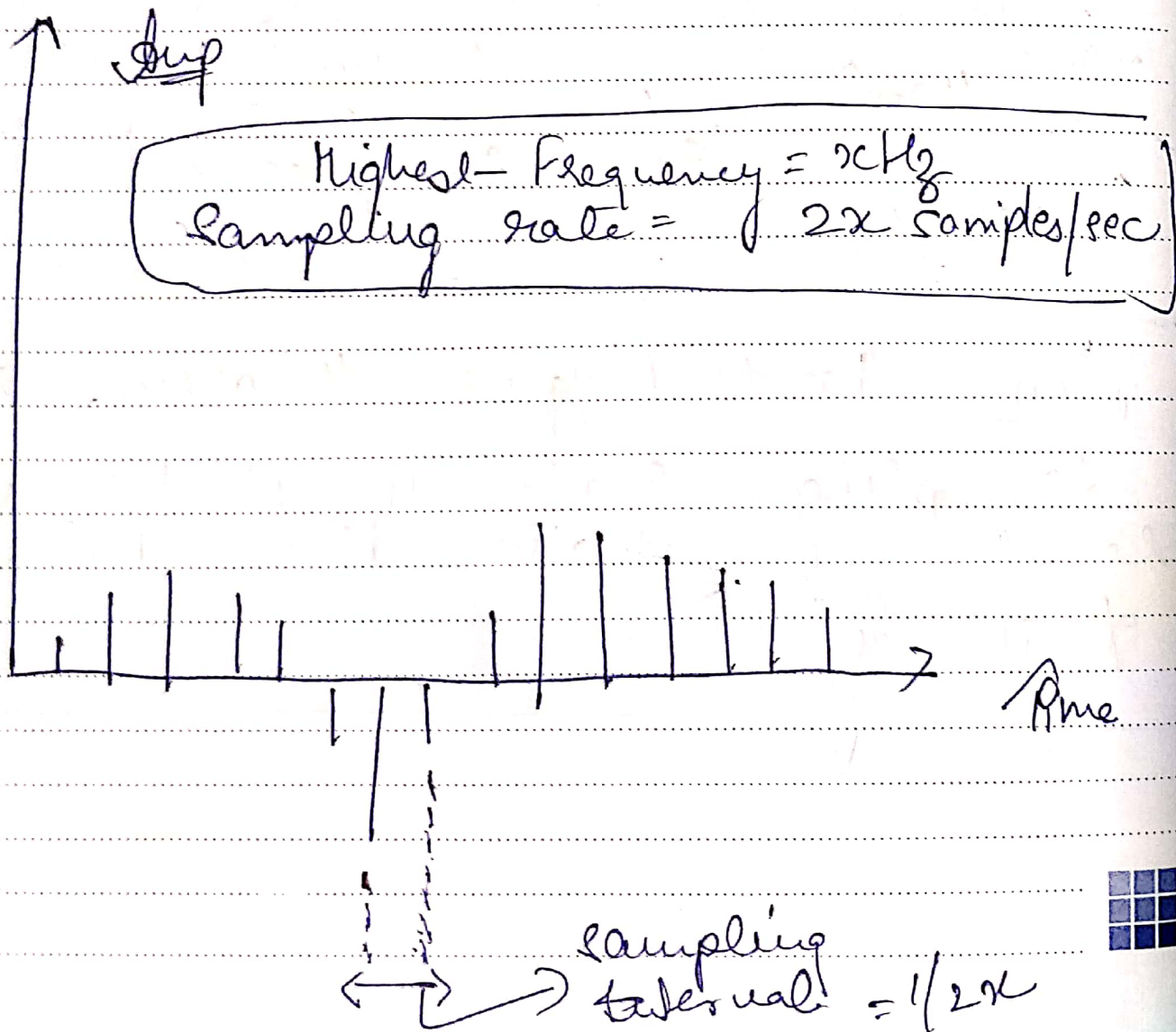
According to the "Nyquist theorem", to ensure the accurate reproduction of an analog signal using PAM, the sampling rate must be at least twice the frequency of original signal.

So if we want to sample telephone voice with maximum frequency of 4000 Hz. We need a sampling rate of 8000 samples per second.

Note: - Acc to Nyquist theorem, the sampling rate must be at least twice the highest frequency.

For eg a sampling rate of twice
the frequency of $x Hz$
means the signal must be
sampled at every $1/2x$ seconds.

So it means that using voice-
phone lines - one sample at
every $1/8000$ second.



Q What sampling rate is needed for a signal with a bandwidth of $10,000 \text{ Hz}$ (1000 to $11,000 \text{ Hz}$)?

Ans The sampling rate must be twice the highest frequency

$$\text{so } S.R = 2(11000) = 22,000 \text{ samples/sec}$$

Bit Rate: - After we found the sampling rate, we ~~found the~~ need to determine the no. of bits to be transmitted for each sample.

After finding the no. of bits/sample, we can calculate the Bit Rate using formula -

$$\text{Bit Rate} = S.R \times \text{No. of bits/sample}$$

Q We want to digitize the human voice. What is the bit rate assuming eight bits / sample?

Ans The human voice contains frequencies from 0 to 4000 Hz.

So

$$S.R = 4000 \times 2 = 8000 / \text{second}$$

$$= 8000 \text{ samples / second}$$

$$\text{The B.R} = S.R \times \text{No of bits / sample}$$

$$= 8000 \times 8 = 64000 \text{ bits/s}$$

$$= \underline{64 \text{ kbps}}$$

