

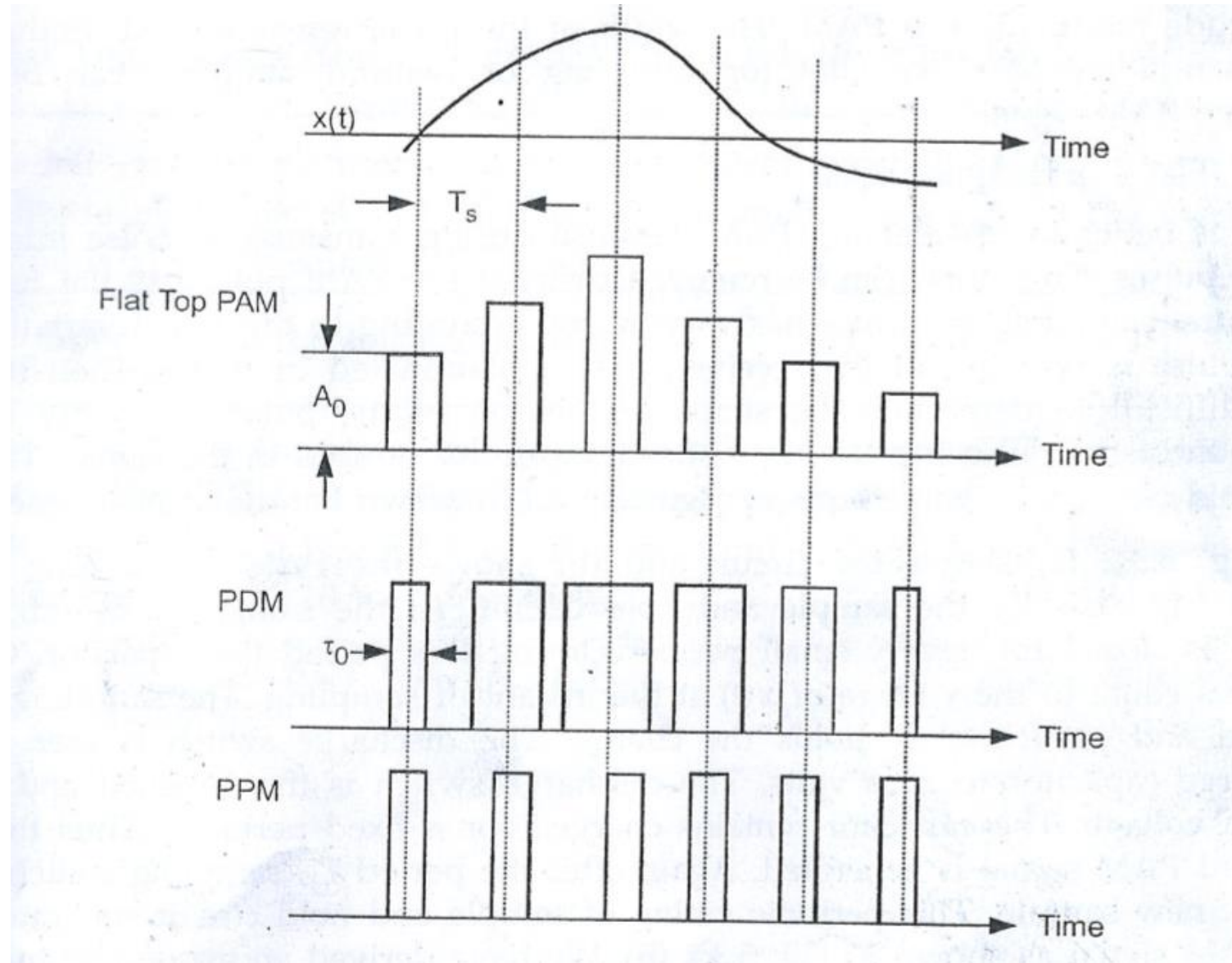
Analog pulse Modulation Methods

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Analog pulse Modulation Methods

- A continuous time signal $x(t)$ to be transmitted, is sampled by a pulse train at frequency F_s sufficiently above the highest frequency present in $X(t)$.
- The amplitude of the modulating signal $x(t)$ (**analog**) modulates one parameter of the **pulse** train. *So it called Analog Pulse Modulation*
- The parameters are : **AMPLITUDE , DURATION (WIDTH) and POSITION.**
- If the modulating signal **MODULATE THE AMPLITUDE** of the pulse train then the modulation type is called **PULSE AMPLITUDE MODULATION PAM**
- If the modulating signal **MODULATE THE DURATION** of the pulse train then the modulation type is called **PULSE DURATION MODULATION PDM**
- If the modulating signal **MODULATE THE POSITION** of the pulse train then the modulation type is called **PULSE POSITION MODULATION PPM**

Different types of analog pulse modulation techniques



1. Pulse Amplitude Modulation PAM

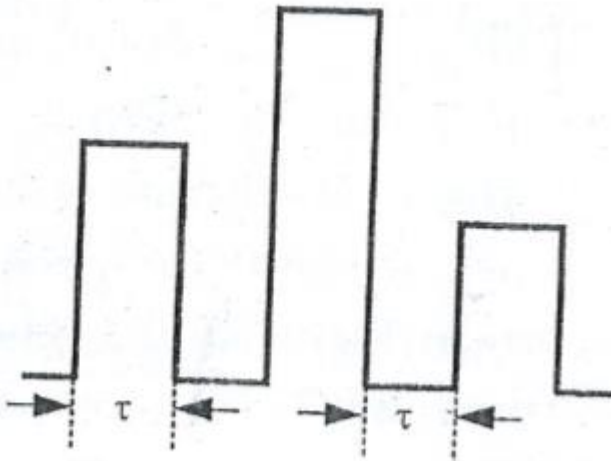
- In this type of modulation , the amplitudes of regularly spaced rectangular pulses vary with the instantaneously sample values of a continuous message signal in a one to one fashion.
- The width of the pulse remains **fixed**.
- Both types of practical sampling, **Flat top** sampling or **Natural sampling** can be used to generate **PAM** signal.

Flat Top Sampled PAM

- **It is better to use Flat Top PAM , because during transmission noise interferes the top of pulses. This noise interference can be removed easily if the PAM pulse has flat top.**
- **Sample and hold circuit is used to generate the flat top PAM**

Transmission Bandwidth of PAM signal

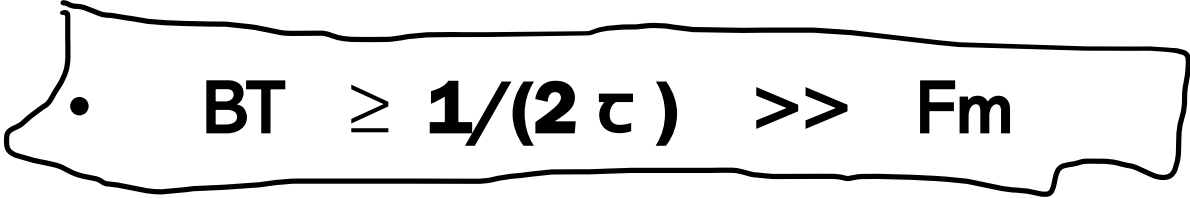
- The pulse duration “ τ ” is supposed to be very small compared to time period T_s between the two samples.
- If the maximum frequency in the signal $x(t)$ is F_m then by sampling theorem , F_s should be $F_s \geq 2F_m$ or $T_s \leq 1/(2F_m)$ since $F_s = 1/T_s$
- And $\tau \ll T_s \ll 1/(2F_m)$
- If ON and Off time of the pulse is same , then frequency of the PAM pulse
- Becomes $F_{max} = 1/(\tau + \tau) = 1/(2\tau)$



Continue...

- $\therefore$ Bandwidth required for transmission of PAM signal will be equal to maximum frequency $F_{\max}$ given by above equation
- $BT \geq F_{\max}$ hence $BT \geq 1/(2\tau)$

- Since $\tau \ll 1/(2F_m)$ because $\tau \ll T_s$



• $BT \geq 1/(2\tau) \gg F_m$

- Transmission bandwidth of PAM signal : $BT \gg F_m$

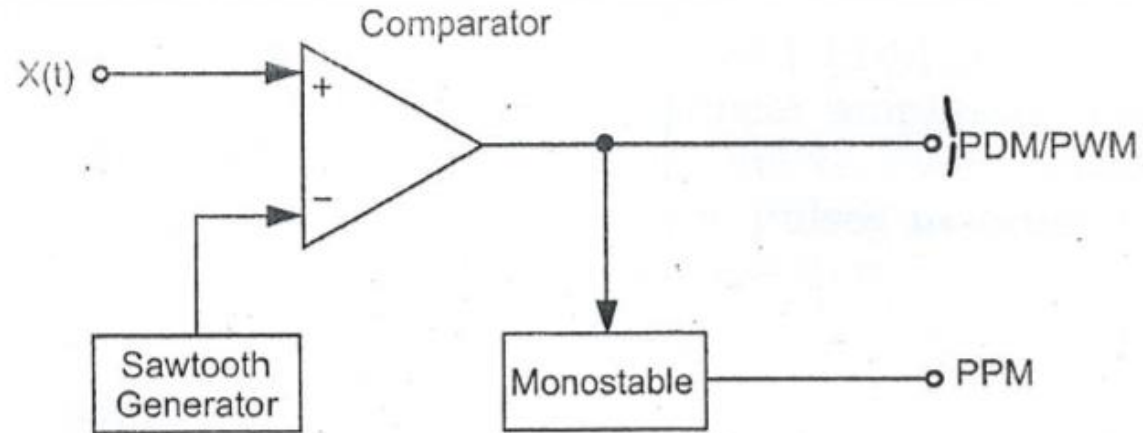
Disadvantages of PAM

- The bandwidth needed for transmission of PAM signal is very -very large compared to its maximum frequency content. (F_m)
- The amplitude of PAM pulses varies according to modulating signal, therefore interference of noise is maximum for the PAM signal and this noise cannot be removed very easily.
- Since amplitude of PAM signal varies, this also varies the peak power required by the transmitter with modulating signal.

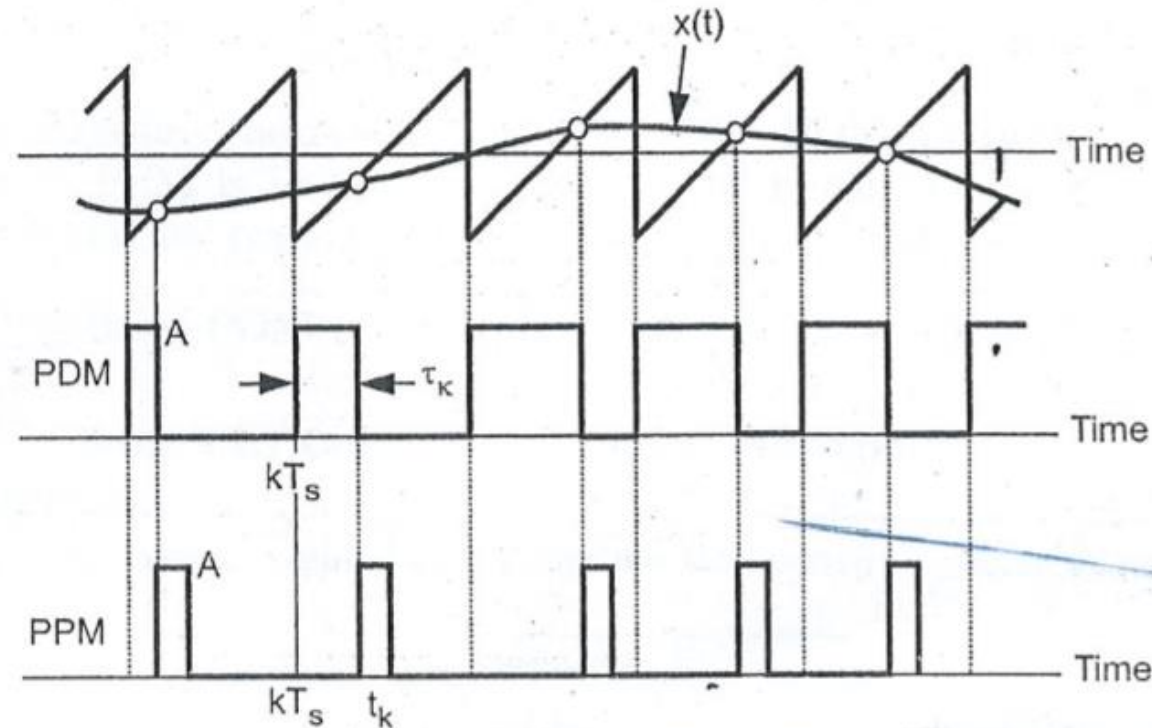
2- Pulse Duration and Pulse Position Modulation

- **Pulse Position Modulation (PPM) and Pulse Duration Modulation(PDM) or (PWM) both modulate the time parameter of the pulses.**
- **PPM has fixed width pulses where as width of PDM pulses varies.**
- **Both the methods are of constant amplitude.**

Generator of PPM and PDM, Block Diagram and Waveform



(a)



(b)

Transmission bandwidth of PDM and PPM

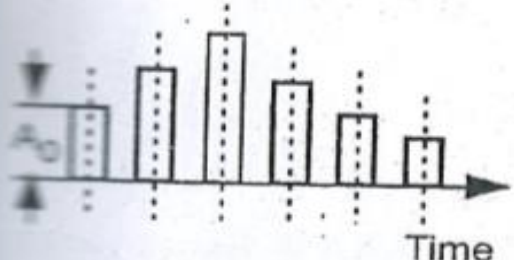
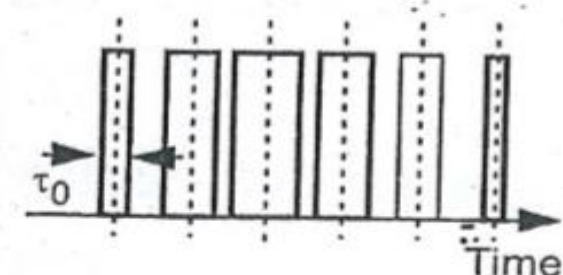
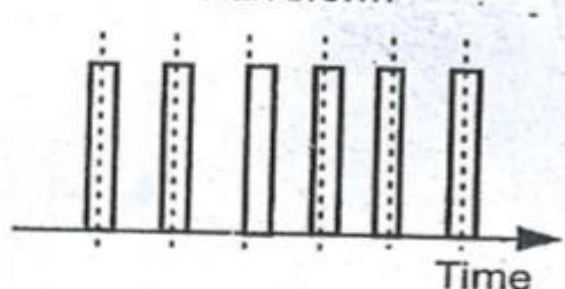
- Both PPM and PWM needs a sharp rise time and fall time for pulses in order to preserve the message information.
- Rise time should be very – very less than T_s $t_r \ll T_s$ and

Transmission Bandwidth, BT should be,

$$BT \geq \frac{1}{2t_r}$$

Thus the transmission band width of PPM and PDM is higher than PAM

Table 5.3.1 Comparison of PAM, PPM and PDM

Pulse Amplitude Modulation	Pulse Width/Duration Modulation	Pulse Position Modulation
Waveform 	Waveform 	Waveform 
Amplitude of the pulse is proportional to amplitude of modulating signal	Width of the pulse is proportional to amplitude of modulating signal	The relative position of the pulse is proportional to the amplitude of modulating signal
The bandwidth of the transmission channel depends on width of the pulse	Bandwidth of transmission channel depends on rise time of the pulse	Bandwidth of transmission channel depends on rising time of the pulse
The instantaneous power of the transmitter varies.	The instantaneous power of the transmitter varies	The instantaneous power of the transmitter remains constant
Noise interference is high.	Noise interference is minimum	Noise interference is minimum
System is complex	Simple to implement	Simple to implement
Similar to amplitude modulation	Similar to frequency modulation	Similar to phase modulation

Example -1

- A voice signal of $F_{\max} = 3\text{KHz}$ is to be transmitted by Pulse amplitude modulation technique.

Calculate the required transmission bandwidth B_T if the sampling frequency, $F_s = 8\text{KHz}$ and pulse duration $\tau = 0.1 T_s$

Solution:

Sampling interval, $T_s = 1/F_s = 1/(8 \times 10^3) \text{ sec}$

$$\text{then } \tau = 0.1 T_s = \frac{0.1}{8000} \text{ sec.}$$

$$B_T \geq \frac{1}{2\tau} \geq \frac{1}{\frac{2 \times 0.1}{8 \times 10^3}} = 40 \text{ KHz}$$

Example

Ex.5.3.2 Sketch the naturally sampled PAM waveform that results from sampling a 1 cycle sine wave at a 4 kHz rate. Also sketch the flat top sampled waveform. Take $\frac{\tau}{T_s} = \frac{1}{5}$.

Sol. : Fig. 5.3.6 shows the required waveforms.

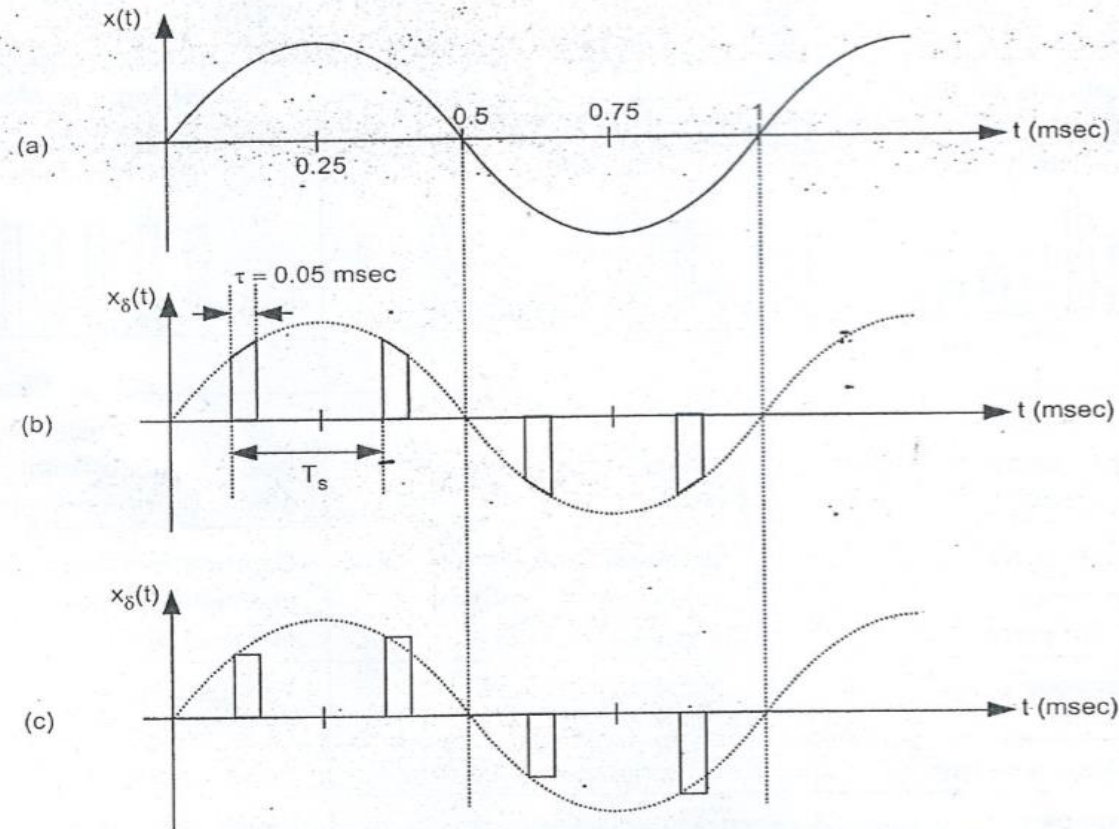


Fig. 5.3.6 (a) Original continuous time signal
(b) Naturally sampled signal
(c) Flat top sampled signal

The duty cycle is, $\frac{\tau}{T_s} = \frac{1}{5}$

We know that $f_s = 4 \text{ kHz}$, $\therefore T_s = \frac{1}{f_s} = 0.25 \text{ msec}$

Example -3

- For the signal given in example – 1, if the rise time is 1% of the width of the pulse(τ)

Find out the minimum transmission bandwidth needed for transmission of signal by using PDM and PPM.

Solution: in example1, we obtain the pulse width $\tau = 0.1 T_s = \frac{0.1}{8000}$

The rise time, t_r is given by 1% of τ

$$t_r = \tau \times 0.01 = \frac{0.1}{8000} \times 0.01 = 1.25 \times 10^{-7} \text{ sec.}$$

$$\text{with } BT \geq \frac{1}{2t_r} \geq \frac{1}{2 \times 1.25 \times 10^{-7}} \geq 4 \text{ MHz}$$

which is very high compare with bandwidth needed for PAM (40KHZ)