b) Pulse Time Modulation (PTM)

Here the pulses will have the same amplitude. However, one of their timing characteristics is made proportional to the amplitude of the sampled signal. This variable characteristic can be either frequency, position or width. This way pulse time modulation can be classified into two types.

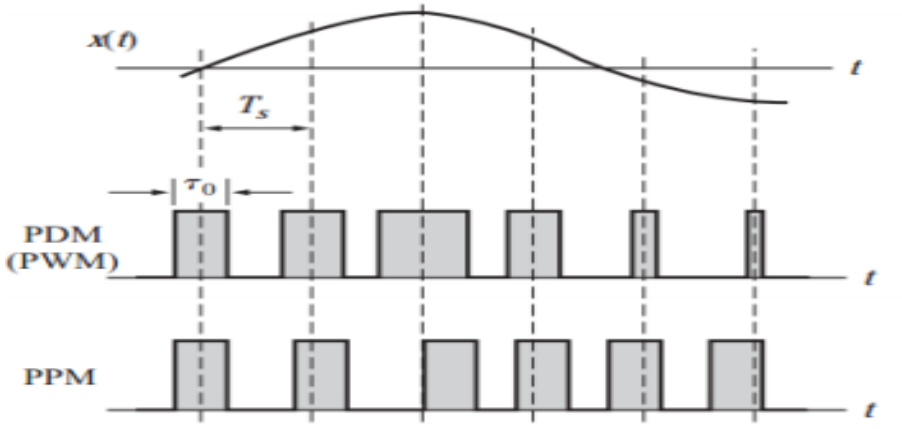
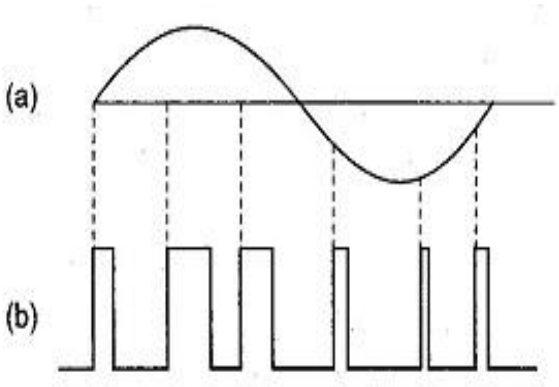


Figure : Types of pulse-time modulation.

i) Pulse Width Modulation (PWM)

Pulse Width Modulation is also known as pulse duration modulation (PDM). Here, as the name suggests, the width of the pulse is varied in proportional to the amplitude of the signal. Since the width is changing, the power loss can be reduced when compared to PAM signals.



Advantages of PWM

a) Low power consumption.
b) It has an efficiency of about 90 percent.
c) Noise interference is less.

Disadvantages of PWM

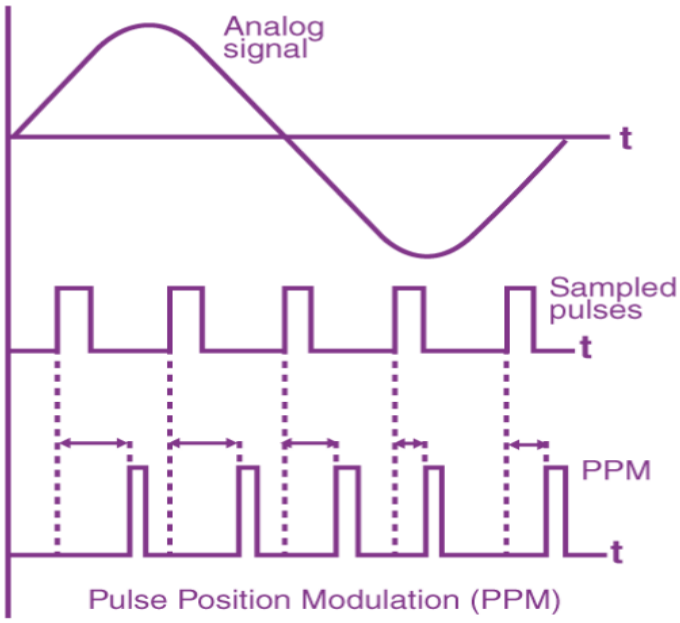
a) The circuit is more complex.
b) The system is expensive as it uses semiconductor devices.
c) Switching losses will be more due to high PWM frequency.

Applications of PWM

a) Used in encoding purposes in the telecommunication system.
b) Used to control brightness in a smart lighting system.
c) Helps to prevent overheating in LED's while maintaining its brightness.
d) Used in audio and video amplifiers.

ii) Pulse Position Modulation(PPM)

In this type of modulation, both the amplitude and width of the pulse are kept constant. We vary the position of each pulse with reference to a particular pulse. Here a single pulse is transmitted with the required number of phase shifts. So we can say that pulse position modulation is an analogue modulation scheme where the amplitude and width of the pulse are kept constant, while the position of the pulse with respect to the position of a reference pulse is varied according to the instantaneous value of message signal.



Advantages of PPM

a) As it has constant amplitude noise interference is less.
b) We can easily separate signal from a noisy signal.
c) Among all three types, it has the most power efficiency.
d) Requires less power when compared to pulse amplitude modulation.

Disadvantages of PPM

a) The system is highly complex.
b) The system requires more bandwidth.

Applications of PPM

a) It is used in the air traffic control system and telecommunication systems.
b) Remote controlled cars, planes, trains.
c) It is used to compress data and hence it is used for storage.

Generation of PWM and PPM

Figure below shows the block diagram and waveforms of a system that combines the sampling and modulation operations for either PDM or PPM. The system employs a comparator and a sawtooth wave generator with period (Ts). The output of the comparator is zero except when the message waveform $x(t)$ exceeds the sawtooth wave, in which case the output is a positive constant A. Hence, as seen in the figure, the comparator produces a PDM signal with trailing edge modulation of the pulse duration. **Position modulation** is obtained by applying the PDM signal to a monostable pulse generator that triggers on trailing edges at its input and produces short output pulses of fixed duration

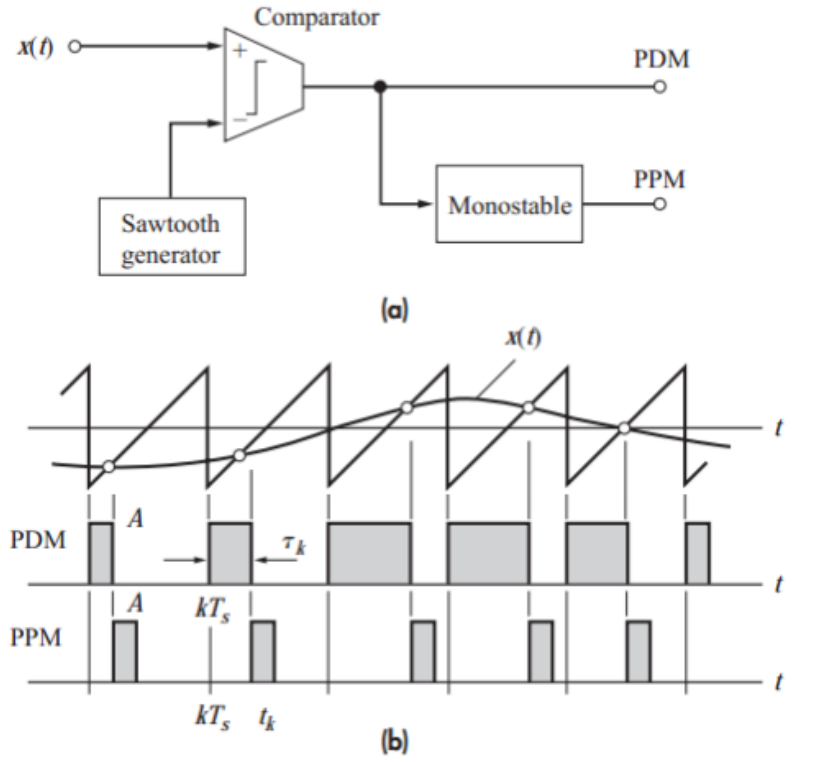


Figure : Generation of PDM or PPM: (a) block diagram; (b) waveforms.

No.	PAM	PWM	PPM
1	Amplitude of the pulse is proportional to the 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
2	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 rise time of the pulse.
3	The instantaneous power of the transmitter varies with amplitude of pulses	The instantaneous power of the transmitter varies with width of pulses	The instantaneous power of the transmitter remains constant with width of pulses
4	Noise interference is high	Noise interference is minimum	Noise interference is minimum
5	Similar to Amplitude modulation	Similar to frequency modulation	Simple to Phase modulation

No.	Examples
1	**An analog signal is expressed by the equation** $x(t) = 3\cos 50\pi t + 10\sin 300\pi t - \cos 100\pi t$ **Calculate the Nyquist rate for this signal**

Solution

If the frequencies are represented as

$w_1 = 2\pi f_1,\ w_2 = 2\pi f_2\ and\ w_3 = 2\pi f_3$

the signal can be written as:

$x(t) = 3cos\, w_1 t + 10sin\, w_2 t - cos\, w_3 t$

substituting we get:

$2\pi f_1 = 50\pi\ or\ f_1 = 25Hz$

$2\pi f_2 = 200\pi\ or\ f_2 = 150Hz$

$2\pi f_3 = 100\pi\ or\ f_3 = 50Hz$

The Nyquist frequency is therefore twice the highest frequency component or

$f_{Nyquist} = f_s = 2B = 2f_m = 300Hz.$

2	**A continuous time signal is given below** $x(t) = 8\,cos\,200\pi t$ **Determine** **a) sampling rate** **b) Bandwidth of PAM, when duration of each pulse is 1** $m\,sec$

Solution

a) $2\pi B = 200\pi$

$B = 100\ Hz$

$f_s \geq 2B \geq 200Hz$

b) $B_{PAM} \geq \frac{1}{2\tau}$

$B_{PAM} \geq \frac{1}{2 * 10^{-3}}$

$B_{PAM} \geq$500 Hz