- Principles of Telecommunication
- Module 5
- Analog Pulse Modulation techniques
- PAM, PWM PPM
- Lecture Plan- PART 3

2. Pulse Width Modulation (PWM)

In PWM, the width of the modulated pulses varies in proportion with the amplitude of modulating signal. The waveforms of PWM is shown in fig.1 below.

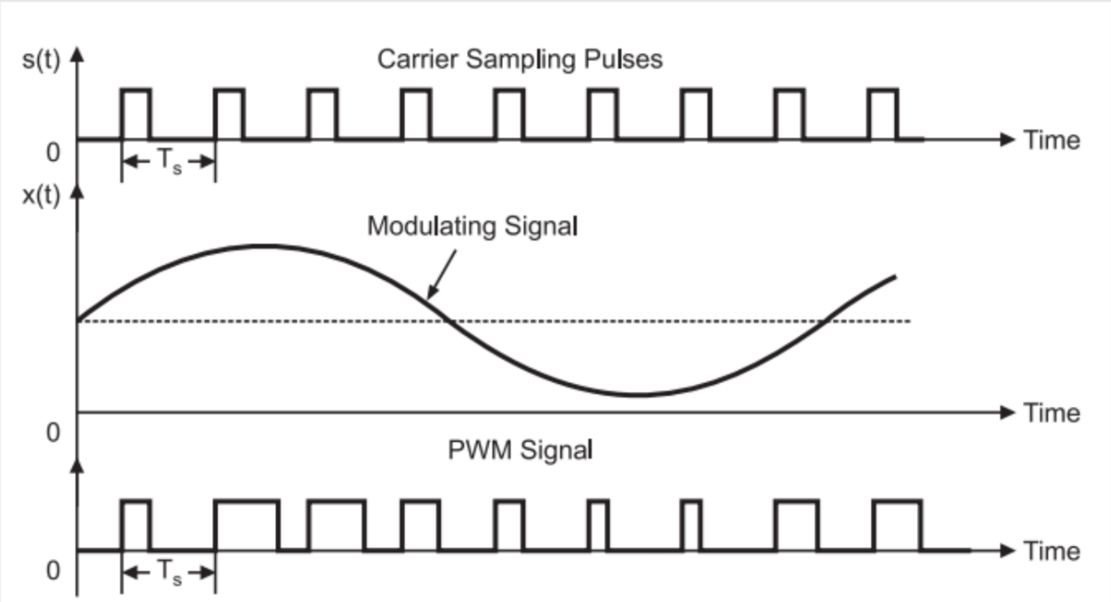

Fig.1 : PWM signal

- As we can observe, the amplitude and the frequency of the PWM wave remain constant. Only the width changes.
- That is why the information is contained in the width variation. This is similar to FM.

- ▢ As the noise is normally additive noise, it changes the amplitude of the PWM signal.
- ▢ At the receiver, it is possible to remove these unwanted amplitude variations very easily by means of a limiter circuits.

As the information is contained in the width variation, it is unaffected by the amplitude variations introduced by the noise. Thus, the PWM system is more immune to noise than the PAM signal.

Generation of PWM Signal

The block diagram of a PWM signal generator is shown in fig.2 below. This circuit can also be used for the generation of PPM signal.

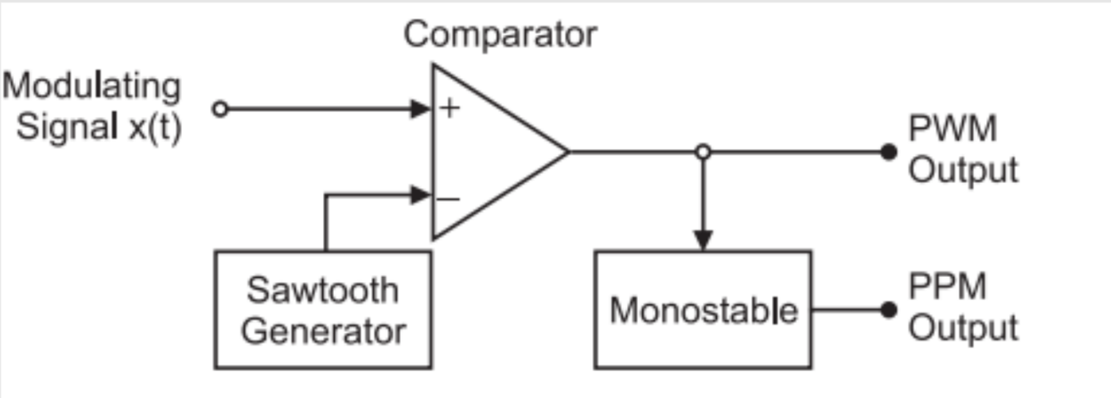

Fig.1 : PWM and PPM Generator

- A sawtooth generator generates a sawtooth signal of frequency fs, and this sawtooth signal in this case is used as a sampling signal.

- It is applied to the inverting terminal of a comparator.

- The modulating signal x (t) is applied to the non-inverting terminal of the same comparator.
- The comparator output will remain high as long as the instantaneous amplitude of x (t) is higher than that of the ramp signal.
- This gives rise to a PWM signal at the comparator output as shown in fig.2.

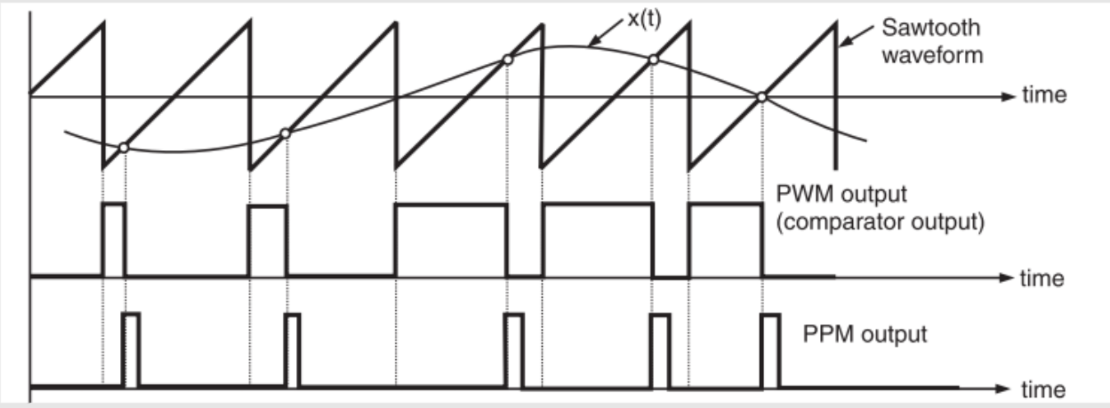

Fig.2 : Waveforms

Here, it may be noted that the leading edges of the PWM waveform coincide with the falling edges of the ramp signal. Thus, the leading edges of PWM signal are always generated at fixed time instants.

However, the occurance of its trailing edges will be dependent on the instantaneous amplitude of x(t). Therefore, this PWM signal is said to be trail edge modulated PWM.

Detection of PWM Signal

The circuit for the detection of PWM signal is shown in fig.3 below

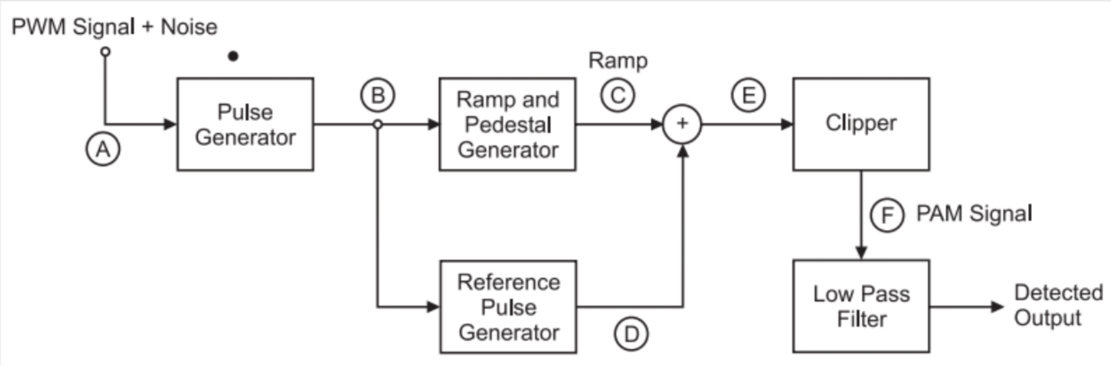

Fig.3 : PWM Detection Circuit

The working operation of the circuit may be explained as under:

- The PWM signal received at the input of the detection circuit is contaminated with noise. This signal is applied to pulse generator circuit which regenerates the PWM signal.
- Thus, some of the noise is removed and the pulses are squared up.
- The regenerated pulses are applied to a reference pulse generator. It produces a train of constant amplitude, constant width pulses.

- These pulses are synchronized to the leading edges of the regenerated PWM pulses but delayed by a fixed interval.

- The regenerated PWM pulses are also applied to a ramp generator. At the output of it, we get a constant slope ramp for the duration of the pulse. The height of the ramp is thus proportional to the width of the PWM pulses.

- At the end of the pulse, a sample and hold amplifier retains the final ramp voltage until it is reset at the end of the pulse.

- The constant amplitude pulses at the output of reference pulse gtenerator are then added to the ramp signal.

- The output of the adder is then clipped off at a thereshold level to generate a PAM signal at the output of the clipper.

- A low pass filter is used to recover the original modulating signal back from the PAM signal. The waveforms for this circuit have been shown in fig.4.

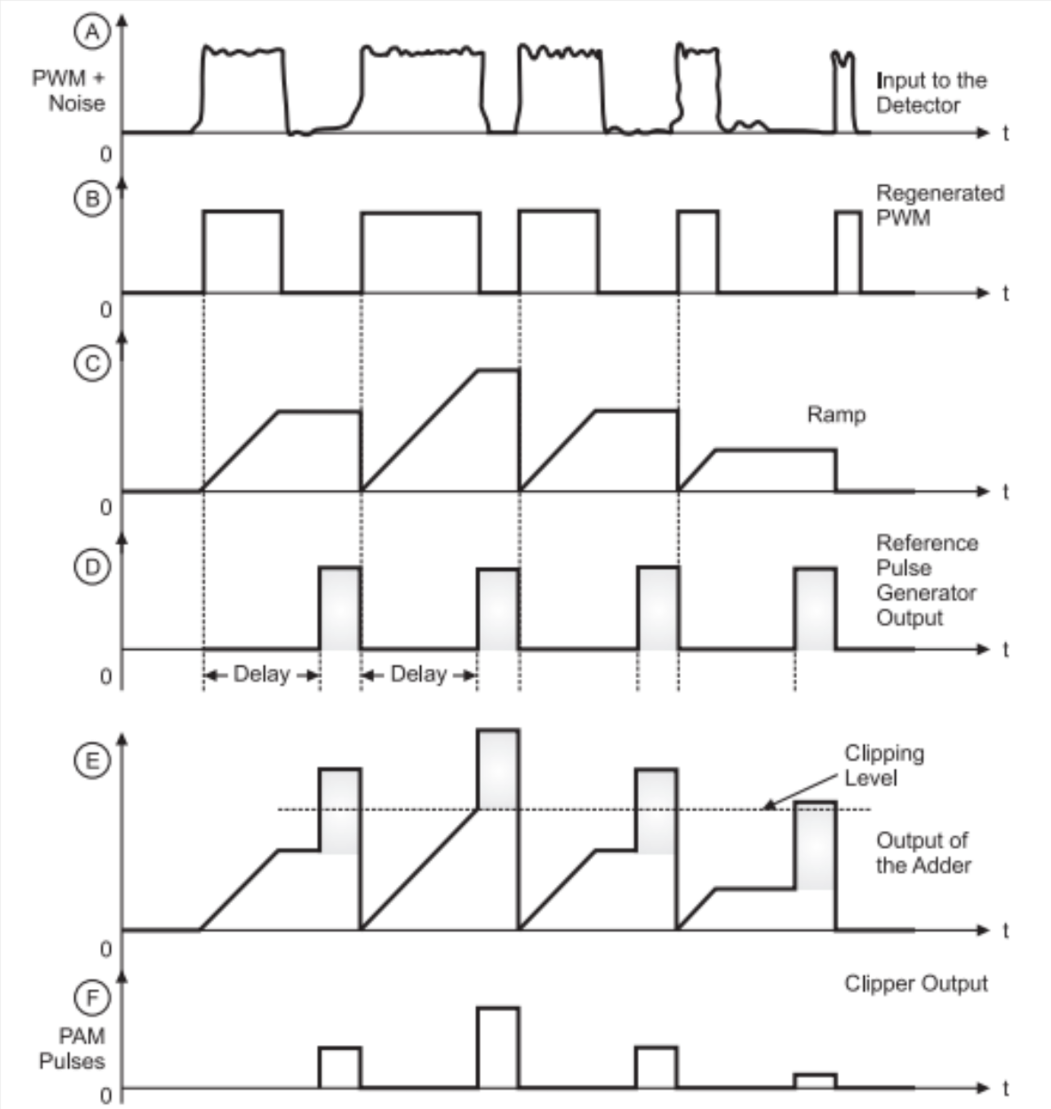

Fig.4 : Waveforms for PWM detection circuit

Advantages of PWM

- Less effect of noise i.e., very good noise immunity.
- Synchronization between the transmitter and receiver is not essential (Which is essential in PPM).
-

It is possible to reconstruct the PWM signal from a noise, contaminated PWM, as discussed in the detection circuit. Thus, it is possible to separate out signal from noise (which is not possible in PAM).

Disadvantages of PWM

- Due to the variable pulse width, the pulses have variable power contents. Hence, the transmission must be powerful enough to handle the maximum width, pulse, though the average power transmitted can be as low as 50% of this maximum power.

- In order to avoid any waveform distortion, the bandwidth required for the PWM communication is large as compared to bandwidth of PAM.

3. Pulse Position Modulation (PPM)

- In PPM, the amplitude and width of the pulses is kept constant but the position of each pulse is varied in accordance with the amplitudes of the sampled values of the modulating signal.
- The position of the pulses is changed with respect to the position of reference pulses.
- The PPM pulses can be derived from the PWM pulses as shown in fig.1.
- Here, it may be noted that with increase in the modulating voltage the PPM pulses shift further with respect to reference.

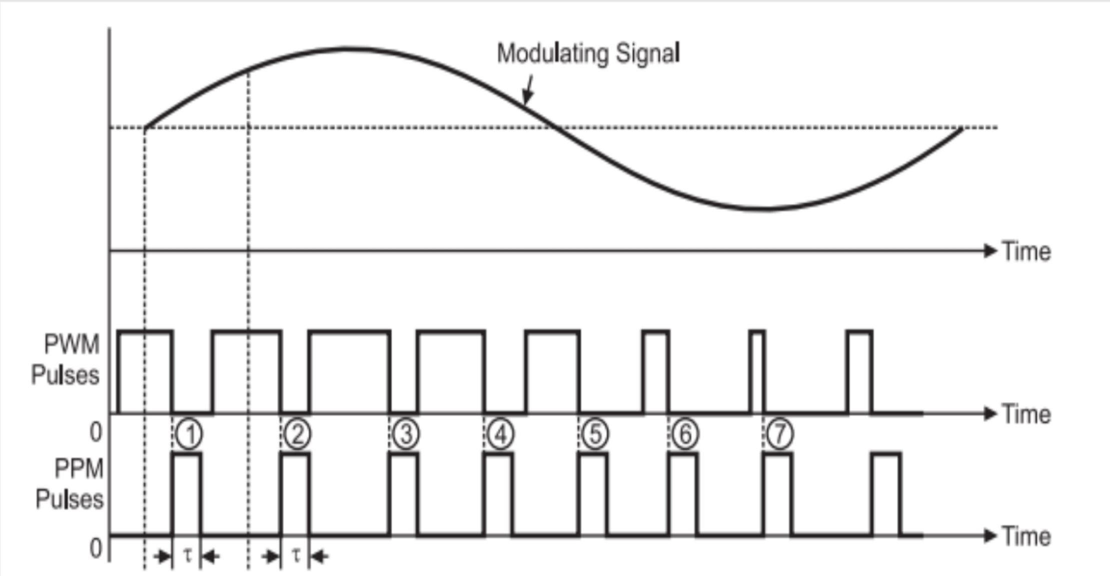

Fig.1 : PPM pulses generated from PWM signal

- The vertical dotted lines drawn in fig.1 are treated as reference lines to measure the shift in position of PPM pulses.
- The PPM pulses marked 1, 2 and 3 in fig.1 go away from their respective reference lines. This is corresponding to increase in the modulating signal amplitude.
- Then, as the modulating voltage decreases, the PPM pulses 4, 5, 6, 7 come progressively closer to their respective reference lines.

Generation of PPM Signal

The PPM signal can be generated from PWM signal as shown in fig.2 (a).

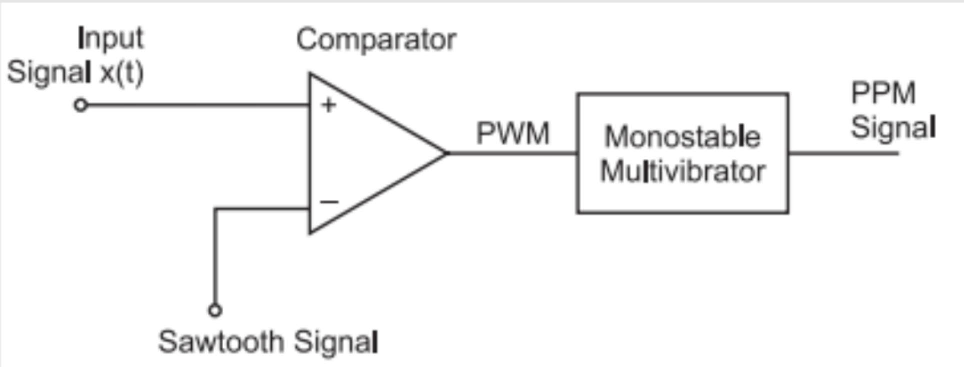

Fig.2 : Generation of PPM signal

The PWM pulses obtained at the comparator output are applied to a monostable multivibrator. The monostable is negative edge triggered.

Hence, corresponding to each trailing edge of PWM signal, the monostable output goes high.
It remains high for a fixed time decided by its own RC components.
Thus, as the trailing edges of the PWM signal keep shifting in proportion with the modulating signal x(t), the PPM pulses also keep shifting, as shown in fig.3.

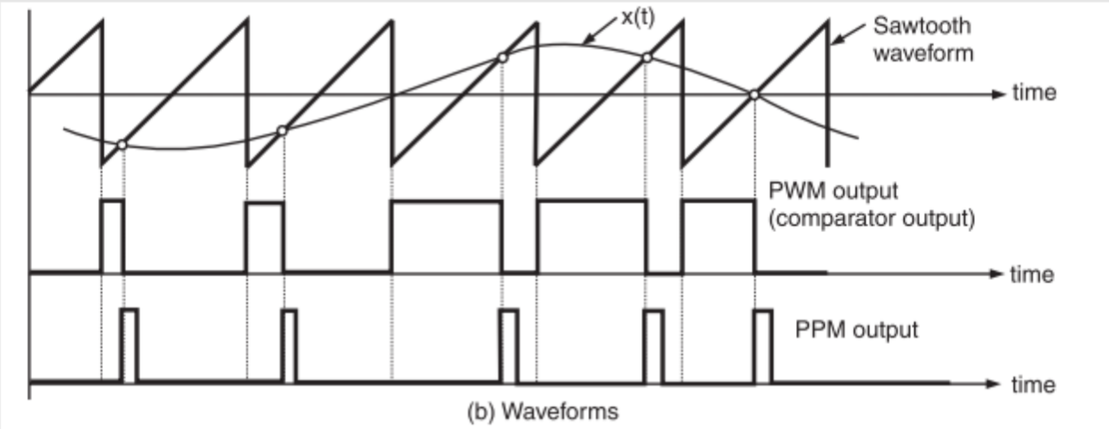

Fig.3 PPM waveform

Demodulation of PPM Signal

The PPM demodulator block diagram has been shown in fig.4 .

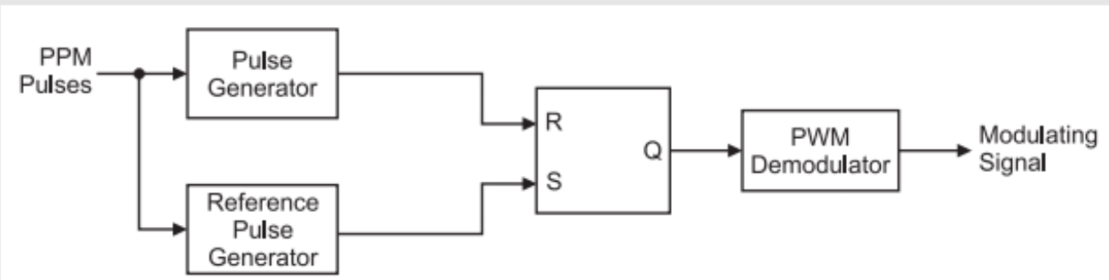

Fig.4 PPM demodulator block diagram

The operation of the demodulator circuit may be explained as under:

- The noise corrupted PPM waveform is received by the PPM demodulator circuit.
- The pulse generator develops a pulsed waveform at its output of fixed duration and applies these pulses to the reset pin (R) of a SR flip-flop.
- A fixed period reference pulse is generated from the incoming PPM waveform and the SR flip-flop is set by the reference pulses.
- Due to the set and reset signals applied to the flip-flop, we get a PWM signal at its output.
- The PWM signal can be demodulated using the PWM demodulator.