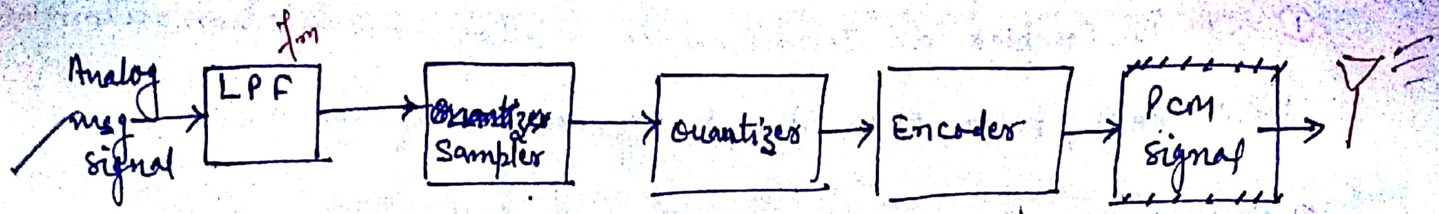
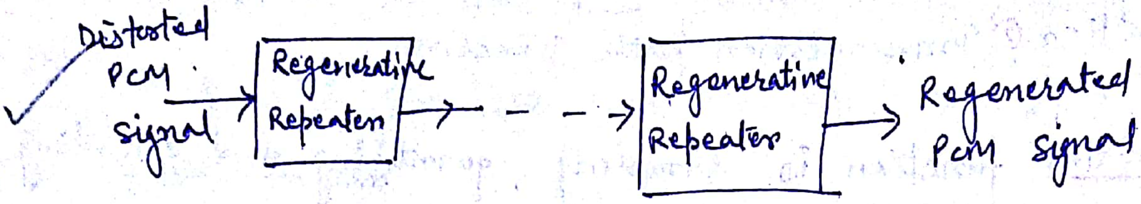
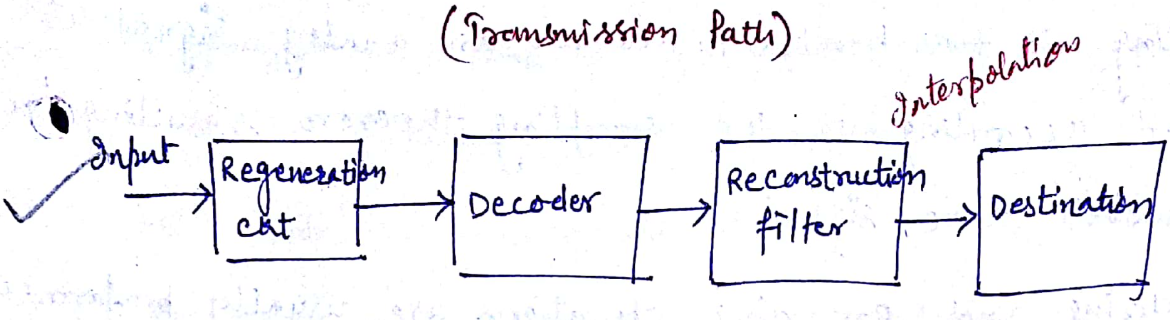
Basic Block Diagram of PCM



(Transmitter)



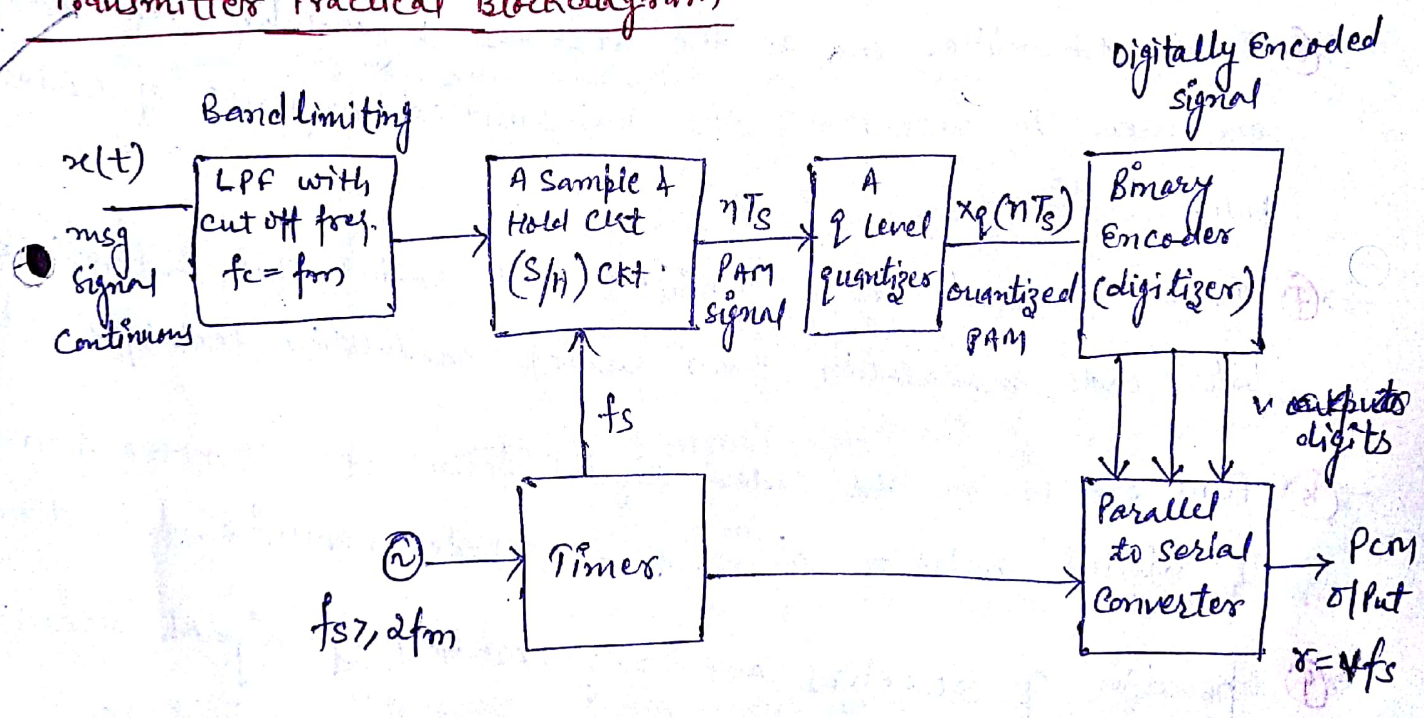
(Transmission Path)



(Receiver)

PCM

① Transmitter Practical Blockdiagram



① signal $x(t)$ first passed through the low pass filter of cut off freq. f_m Hz. This LPF blocks all frequency above f_m Hz.

② Now the $x(t)$ is band limited to f_m Hz.

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PCM (Pulse code modulation)

→ ① PCM is complex as compared to analog modulation technique like PAM, PWM, PPM. due to great no. of operation. ①

→ ② PCM system consist of three main parts i.e. ① Transmitter, ② Transmission path, ③ Receiver.

→ ③ Transmitter function is sampling, quantizing and encoding.

→ ④ Sampling is the process in which an analog signal is sampled according to the sampling theorem resulting in a discrete time signal.

→ ⑤ Quantizing and encoding operations are usually performed in the same ckt known as ADC.

→ ⑥ From transmitter ~~and~~ to the receiver regenerative repeaters are used to reconstruct the transmitted sequence of coded pulse.

→ ⑦ It is combined use of quantizing and coding that distinguishes pulse code modulation from analog modulation technique.

→ ⑧ PCM o/p is in the coded digital form. It is in the form of digital pulse of constant amplitude, width and position.

→ ⑨ Operation of receiver are regeneration of signal, decoding and demodulation of the train of quantized sample.

→ ⑩ These operation is performed in the same ckt which is known as DAC.

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③ Sample and hold ckt then sample this signal at the rate of fs.

④ fs is selected sufficiently above nyquist rate to avoid aliasing.

$\boxed{f_s \geq 2 f_m}$ ②

⑤ O/P of Sample and hold ckt is denoted by $x(nT_s)$. This signal is discrete in time and Continuous in amplitude.

⑥ A q level quantizer compares input $x(nT_s)$ with its fixed digital levels.

⑦ It assigns any one of the digital level to $x(nT_s)$ which results in minimum distortion or error.

⑧ This error is <u>quantization error</u>.

⑨ Thus O/P of quantizer is a digital level called $x_q(nT_s)$.

⑩ Now the quantized signal level $x_q(nT_s)$ is given to binary encoder. This encoder converts input signal v digits binary word.

⑪ Thus $x_q(nT_s)$ is converted to 'v' binary bits.

⑫ This encoder is known as digitizer.

<u>Note</u>: ① It is not possible to transmit each bit of the binary word separately on transmission line.

② Therefore v binary bits (digits) are converted to serial bit stream to generate single base band signal.

③ Parallel to serial conversion <u>shift register</u> does this job.

④ O/P of PCM Generator is thus a single base band signal of binary bits.

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⑤ An oscillator Timer generates the clocks for sample and hold ckt and parallel to serial converter.

⑥ In the PCM sample and hold, quantizer and encoder combinely form an analog to digital converter (ADC).

② PCM Transmission Path

① Path over which PCM signal travel b/w PCM Transmitter and PCM receiver is called PCM Tr. path.

② PCM systems lies in its ability to control the effects of distortion and noise when the PCM wave travels on the channels.

③ PCM accomplishes this capacity by means of using a chain of regenerative repeaters.

④ Repeaters are spaced close enough to each other on the Transmission path.

⑤ Regenerative performs basic three operations Equalization, timing and decision making.

⑥ Hence each repeater actually reproduces the clean noise free PCM signal from the PCM signal distorted by the channel noise.

⑦ This improves the performance of PCM in presence of Noise.

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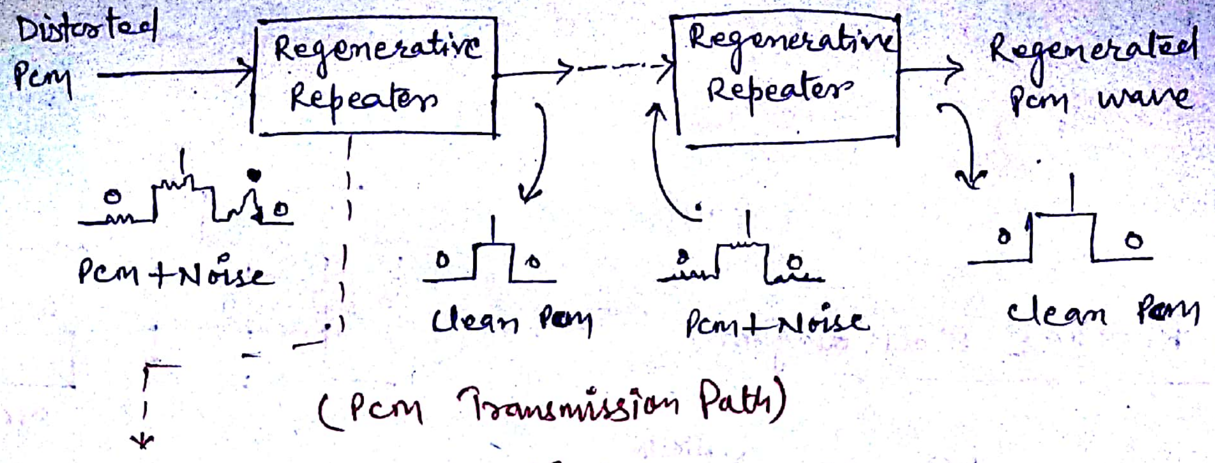
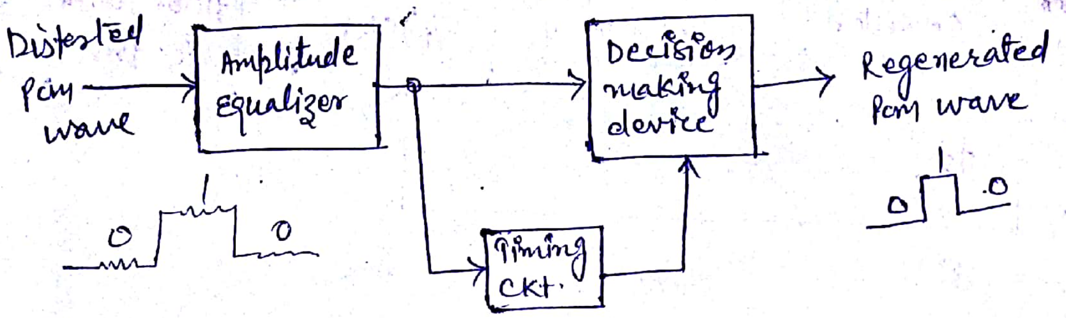


(Pcm Transmission Path)

Regenerative Repeater Block diagram



1. Amplitude equalizer shapes the distorted Pcm wave so as to compensate for the effects of amplitude and phase distortions
2. Timing ckt. produces a periodic pulse train which is derived from the input Pcm Pulses.
3. Pulse train is then applied to the decision making device
4. The decision making devices uses this pulse train for sampling the equalized Pcm Pulses.
5. The sampling is carried out at the instants where the signal to noise ratio is maximum.
6. The decision device makes a decision about whether the equalized Pcm wave at its input has a 0 value or 1 value at the instant of sampling.

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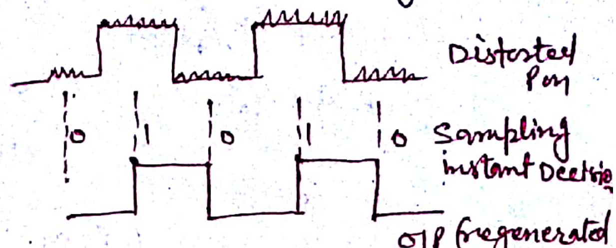
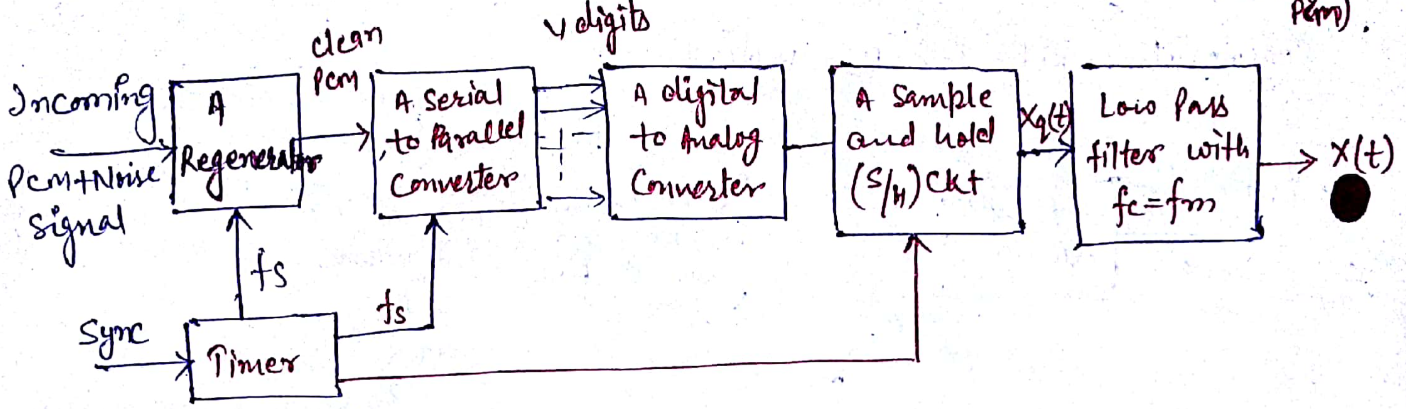
(7) Such a decision is made by comparing equalized Pcm with a reference level called decision threshold.

(8) At the o/p of decision device we get a clean Pcm signal with out any trace of noise.

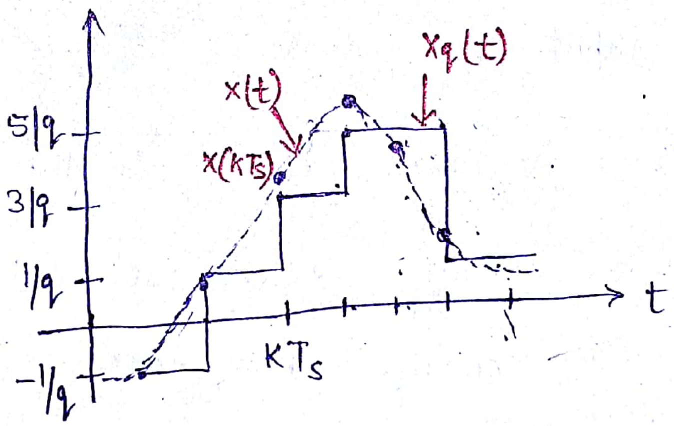


Pcm Receiver Block diagram



(1) Regenerator at the start of Pcm receiver reshapes the pulse and removes the noise.

(2) This signal is then converted to parallel digital words for each sample.



(3) Now, the digital word is converted to its analog value denoted as xq(t) with the help of a sample and hold ckt.

(4) This signal, at the o/p of sample and hold ckt, is allowed to pass through a Low pass reconstruction filter to get the appropriate original msg signal denoted as x(t).

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(5) It is impossible to reconstruct exact original signal $x(t)$ bcz of permanent quantization error introduced during quantization at the transmitter.

(6) This quantization error can be reduced by ↑ing the binary levels.

(7) This is equivalent to ↑ing binary digits per sample.

(8) But ↑ing bits 'v' ↑ing the signalling rate as well as transmission bandwidth as we have already done.

(9) Therefore noise due to quantization error is in tolerable limits.

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Applications of PCM

1. with advent of O.F.C. cable PCM is used in telephony
2. In space comm. transmit power is very low (10 to 15 W) and distance is very large, due to high noise immunity only PCM systems can be used in such application.

Advantages of PCM

1. High noise immunity
2. Due to digital nature we can place repeaters b/w tr. and ~~repeaters~~ receiver to reduce the effect of noise.
3. storage possibility is more.
4. Using different coding technique only desired person can decode ~~the~~ the received signal.

Draw back of PCM

1. The encoding, decoding and quantizing circuitry of PCM is complex
2. PCM requires a large Bandwidth as compared to the other system

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⇒ Digital level are chosen as $\pm \frac{D}{2}$, $\pm \frac{3D}{2}$ etc to reduce the quantization noise or error.

Transmission Bandwidth in a PCM System ⇒

⇒ Let us assume that quantizer use 'v' no. of binary digits to represent each level.

⇒ Then no. of levels that may be represented by v digits will be.

$$q = 2^{v}$$

↓

Total no. of digital level of a q level ~~equ~~ quantizer.

For - Example. if v=4 bits then total No. of level will be.

$$q = 2^{4} = \underline{\underline{16 \text{ levels}}}$$

Each sample is Converted to v binary bits ie

No. of bits per sample = V.

- We know that

No. of sample per second = fs

⇒ Therefore No. of bits per second is (r) = [No. of bits per samples × No. of sample per second]

⇒ No. of bits per second is known signaling rate of Pcm.

$$[r = v f_s]$$

where $f_s \geq 2f_m$

Therefore

$$BW \geq \frac{1}{2} r$$

$$r = v f_s \quad \text{or} \quad r = v \cdot 2f_m.$$

Note: Since BW needed for PCM transmission is half of the signaling rate.

$$B.W = \frac{1}{2} r$$

$$= \frac{1}{\cancel{2}} \times v \cdot \cancel{2} f_m$$

$$\boxed{BW = v f_m}$$

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Note : ① In input o/p char. of a uniform quantizer of the midtread type, which is so called because the origin lies in the middle of a tread of the staircase like graph.

② In midrise type origin lies in the middle of a rising part of the staircase like graph.

③ Both types of uniform quantizer midtread and midrise are symmetric about the origin.

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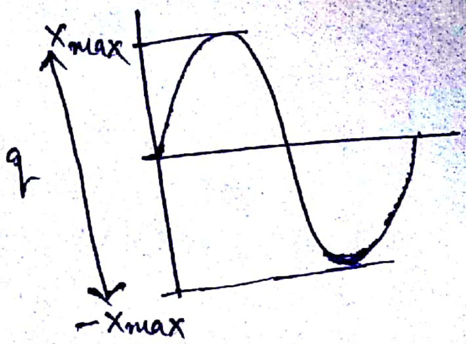
$\left(\frac{S}{N}\right)$ signal to quantization noise ratio for PCM system

$$\frac{S}{N} = \frac{\text{Signal Power}}{\text{Noise Power}} = \frac{P}{\frac{\Delta^2}{12}}$$



$$\frac{S}{N} = \frac{P}{\left(\frac{2x_{max}}{2^v}\right)^2 \times \frac{1}{12}}$$

Total Amplitude $= X_{max} - (-X_{max})$

$= 2X_{max}$

$$\boxed{\Delta = \frac{2X_{max}}{q}}$$

or $\boxed{q = 2^v}$

$$\frac{S}{N} = \frac{P}{\frac{\cancel{4}X^2_{max}}{2^{2v}} \times \frac{1}{\cancel{12}\,3}}$$

$$\frac{S}{N} = \frac{P \times 3 \times 2^{2v}}{X^2_{max}}$$

$$\frac{S}{N} = 3 \times 2^{2v}$$

$X_{max} = 1$ Nomalized input $x(t)$

$P \leq 1$ Normalized Power P

In dB

$$10\log_{10}\left(\frac{S}{N}\right)dB = 10\log_{10}\left(3 \times 2^{2v}\right)$$

$$\left[\left(\frac{S}{N}\right)dB \leq (4.8 + 6v)\,dB\right]$$