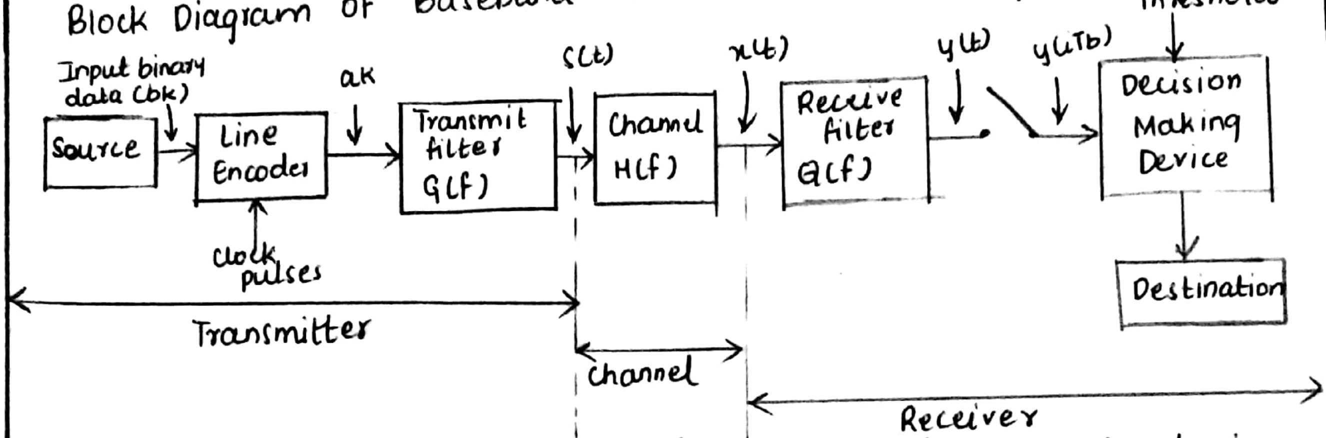
Baseband Transmission of Binary Data :-

In baseband transmission, there is no requirement of carrier signal for transmission, channel is called low pass channel KUMAR P transmission,

In baseband transmission of binary data Discrete PAM is most suitable technique. This technique is most efficient in terms of power & bandwidth used. In this method amplitude of the transmitted pulse is varied in discrete form in accordance with given digital data.

Block Diagram of Baseband Transmission of Binary Data:-



It consists of blocks info source followed by line encoder having clock pulse & Transmitting filter with T.F G(f) & then channel H(f) After transmitting through channel, the binary data is received through receive filter Q(f) (type of optimum mesh filter). The o/p of received filter is sampled at $t = iT_b$, T_b - bit duration. After sampling, sampled o/p $y(iT_b)$ is passed to decision making device. The function of decision making device is to decide whether the o/p is bit 1 / bit 0.

Initially source generates input binary data sequence (b_k) at sampling instant $t = KT_b$ $T_b \to$ bit duration, $K = 0, \pm 1, \pm 2 \dots$

$b_k \to$ bit 1 / bit 0.

Source $\xrightarrow[\text{Generate}]{}$ $\{b_k\}$ $\longrightarrow$ Line Encoder $\rightarrow$ a_k

@ $t = KT_b$. ↑ clockpulse produce level encoded signal.

This input binary data b_k is applied to line encoder which operates with a clock pulse & produce level encoded signal.

i.e based on line encoding (ex:- NRZ). The encoded o/p a_k has +ve & -ve amplitude levels i.e

$$a_k = \begin{cases} +1 & \text{if i/p } b_k \text{ is } 1 \\ -1 & \text{if i/p } b_k \text{ is } 0 \end{cases}$$

This level encoded signal is represented in terms of +ve & -ve pulses of fixed amplitude of short duration. These pulses correspond to unit impulse of opp polarity.

$$a_k \rightarrow \underset{G(f)}{\overset{g(t)}{\text{Transmit Filter}}} \rightarrow \text{sequence of pulse of discrete PAM}$$

The encoded signal a_k act as modulating signal & is applied to the transmit filter having T.F $G(f)$. The transmit filter produce discrete PAM signal (basic form of baseband transmission) i.e (sequence of pulses.)

discrete PAM signal $\Rightarrow$ $s(t) = \sum_{k=-\infty}^{\infty} a_k\, g(t - kT_b)$

$a_k \rightarrow$ coefficient & pulse $g(t)$ is shifted acc to sampling instant (kT_b).

The discrete PAM signal $s(t)$ is transmitted using linear channel having T.F $(H(f))$. The o/p of channel, $x(t) = s(t) * h(t)$ ↳ in time domain

$$s(t) \rightarrow \underset{H(f)}{\overset{h(t).}{\text{Channel}}} \rightarrow x(t) = s(t) * h(t)$$

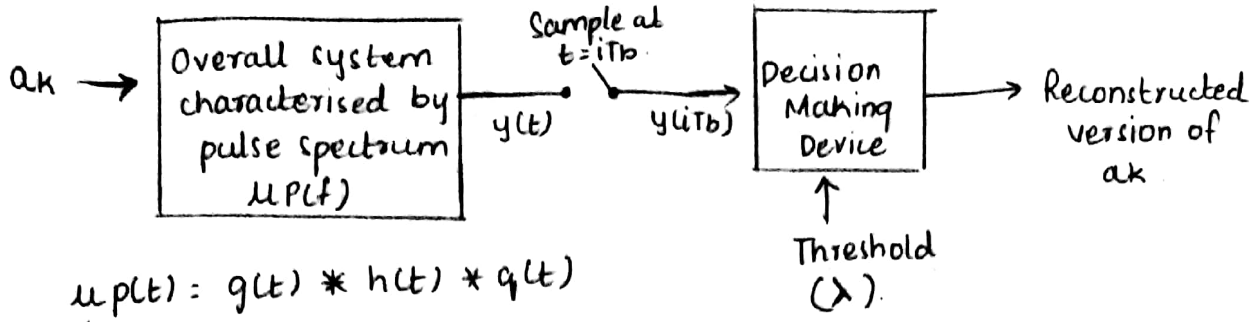
↳ convolution in time domain.

At the receiver, filter called receive filter with T.F $Q(f)$, o/p ($y(t)$)

$$x(t) \rightarrow \underset{Q(f)}{\overset{q(t)}{\text{Receive filter}}} \rightarrow y(t) = x(t) * q(t)$$

During baseband transmission, there is double convolution, one at channel o/p & other at receiver o/p.

Simplified Representation of System :-



$\mu p(t) = g(t) * h(t) * q(t)$

scaled pulse $\mu \rightarrow$ scaling factor.

Here overall system indicating tranimitter, channel, receiver is characterised by pulse spectrum ($\mu P(f)$) → in freq domain. In time domain, it is represented by $\mu p(t)$ called as scaled pulse. The overall pulse spectrum has i/p $\{a_k\}$ (level encoded signal). The o/p $y(t)$ of overall system is sampled at instant $t = iT_b$, & we get sampled o/p $y(iT_b)$. In order to recover original modulating signal (a_k), a decision making device with threshold value λ is used.

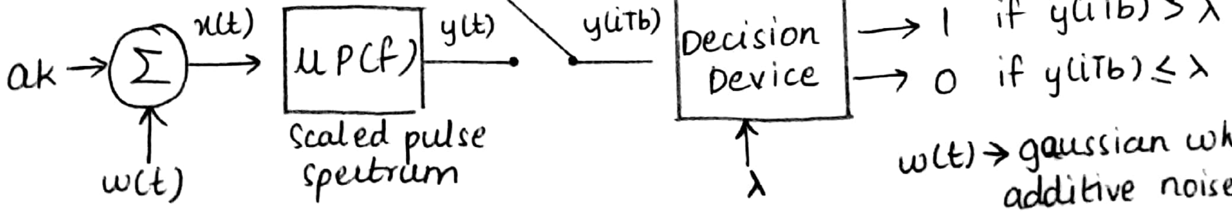
If $y(iT_b) > \lambda$, select bit 1

$y(iT_b) \leq \lambda$, select bit 0. at o/p & according we get reconstructed binary sequence.

Note - We assume pulse $p(t)$ is normalised by setting $p(0) = 1$

Intersymbol Interference (ISI) problem :- ISI is due to the dispersive nature of the low pass channel / baseband channel. Here the freq. response of LP channel is deviated from ideal low pass filter and introduces an interference called ISI. Here we include the effect of additive channel noise.

Block Diagram :-



$w(t) \rightarrow$ gaussian white additive noise.

$\mu p(t) = g(t) * h(t) * q(t)$
↳ Impulse response $p(t)$ is diff from $g(t)$

The characteristic of overall system is represented by scaled pulse spectrum ($\mu P(f)$) in time domain ($\mu p(t)$).

Input signal $x(t)$ is combination of line encoded signal a_k & gaussian white noise $w(t)$. The simplified baseband transmission system produces modified PAM signal $y(t)$

$$y(t) = \mu \sum_{k=-\infty}^{\infty} a_k \, p(t - kT_b) + \underbrace{n(t)}_{\text{filtered noise}} \rightarrow (1).$$

sampled at $t = iT_b$

put $t = iT_b$ in eq(1) we get (2)

$$y(iT_b) = \mu \sum_{k=-\infty}^{\infty} a_k \, p(iT_b - kT_b) + n(iT_b) \longrightarrow (2)$$

$$\Rightarrow \mu \sum_{k=-\infty}^{\infty} a_k \, p\left[(i-k) T_b \right] + n(iT_b)$$

For 1st term we separate summation for $k = i$ & $k \neq i$

for $k=i$ for $k \neq i$

$$y_i \Rightarrow \underbrace{\mu a_i \, p(0)}_{\text{I term}} + \underbrace{\mu \sum_{k=-\infty}^{\infty} a_k \, p[(i-k) T_b]}_{\text{II term}} + \underbrace{n(iT_b)}_{\text{III term}}$$

y_i ↓ sampled o/p

$p(0) = 1$ (Assume that $p(t)$ is normalised $p(0) = 1$).

I term → represents contribution of i^{th} transmitted bit

II term → represents residual effect of all other transmitted bit in decoding of i^{th} bit & this residual effect is called ISI

III term → $n(iT_b)$ ⇒ sampled noise. In baseband transmission of binary data there is problem due to ISI, channel noise represented by II term & III term respectively.

Under ideal condition, in absence of both ISI & noise

$$y(iT_b) = \mu a_i$$

Under this condition, the i^{th} transmitted bit is decoded correctly.

Decision Making Device with threshold λ, with $y(iT_b)$ given as input, make a decision with condition:

$\rightarrow 1$ if $y(iT_b) > \lambda$

$\rightarrow 0$ if $y(iT_b) \leq \lambda$.