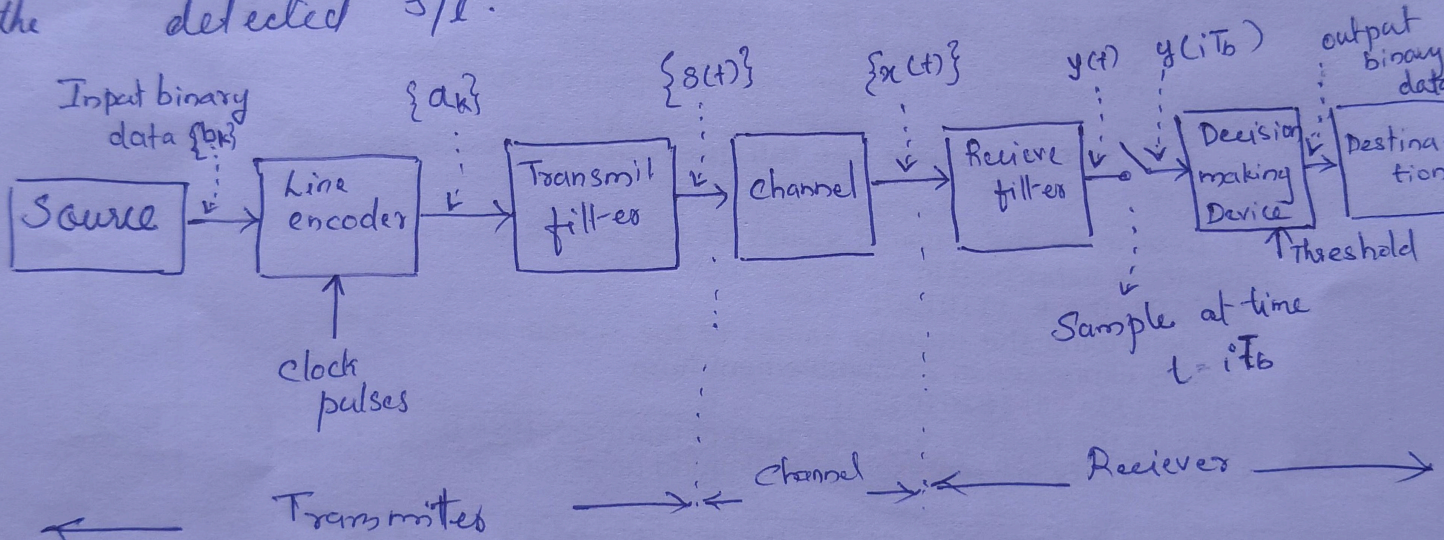
Inter Symbol Interference in Base band Transmission of Binary data

In a communication system when the data is being transmitted in the form of pulses (bits) the output produced at the reciever due to other bits or symbols (ie; unwanted bits or noises) interferes with the output produced by the desired bit. This is known as intersymbol interference (ISI). It (ISI) will produce errors in the detected s/l.



In Base band transmission there is no requirement of carrier s/l for transmission purpose. Here the channel is called as lowpass channel. For Base band transmission of binary data discrete pulse amplitude modulation is used because it is most efficient in terms of power and bandwidth. In this method amplitude of the pulse is varied in discrete manner in accordance with the digital data.

This system consist of blocks such as information source followed by line encoder having a clock pulse the transmit filter having transfer function $G(f)$ and the channel $H(f)$. After transmitting through the channel binary data is recieved by the reciever filter $Q(f)$. It is a type of optimum matched filter. O/p of reciever filter get sampled at $t = iT_b$ where T_b is its bit duration; after sampling it is passed through the decision making device. The decision making device has a threshold value, It's function is to decide whether the o/p symbol is 1 or 0. this is called binary output data.

Now we can see the working in detail.

Initially the source generates binary data sequence $\{b_k\}$ at sampling instant $t = kT_b$

where T_b is the bit duration

$$k = 0, \pm 1, \pm 2 \ldots$$

b_k represents binary s/e 1 or 0.

b_k applied to the line encoder that operate with clock pulse (which is a pulse generator)

The encoded o/p a_k have +ve and −ve amplitude levels

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

This level encoded s/l is represented in terms of +ve and −ve pulses of fixed amplitude and short duration. So it can be viewed as a unit impulses of opposite polarity

Now a_k acts as modulating s/l. In effect a_k is multiplied by $\delta(t - kT_b)$

ie, $$a(t) = \sum_{k=-\infty}^{\infty} a_k \, \delta(t - kT_b)$$

this is applied to the transmit filter of transfer function of $g(t)$ or $G(f)$ in frequency domain this transmit filter produce discrete pulse amplitude modulated s/l which is basic form of base band transmission in the form of sequence of pulses

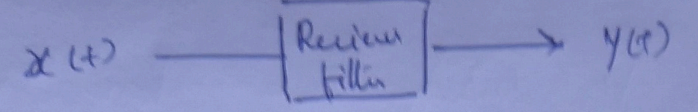
$$s(t) = a(t) * g(t)$$

$$= \sum_{k} a_k \, \delta(t - kT_b) * g(t)$$

$$s(t) = \sum a_k \, g(t - kT_b)$$ – By property of convolution.

Now $s(t)$ is the transmitted s/l.

$s(t) \longrightarrow$ | channel $h(t)$ | $\longrightarrow x(t) = s(t) * h(t)$

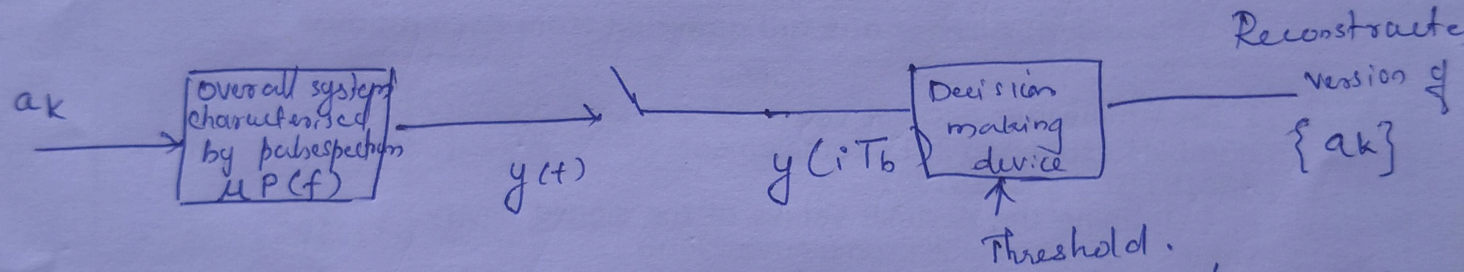


Transfer function of Reciever filter $Q(f)$

o/p of Reciever filter $y(t) = x(t) * q(t)$

So during base band transmission there is double convolution. One at the channel o/p and other at the reciever filter o/p.

Simplified Representation



Overall system indicates transmitter, channel and reciever in time domain it is characterised by $\mu p(t)$

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

$\mu p(t)$ is known as the scaled pulse

μ = scaling factor.

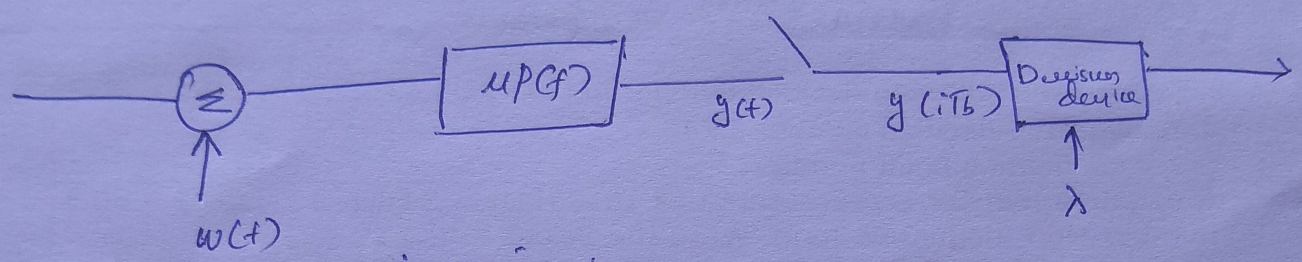
o/p overall system = $y(t)$ which is sampled at $t = iT_b$ so we get sampled o/p $y(iT_b)$ Inorder to recover original modulating s/g $\{a_k\}$ a decision making device is used. it has a threshold value λ.

if the input $y(iT_b) > \lambda$ then symbol 1 is selected at o/p.

$< \lambda$ then select symbol 0.

Consider

A random noise is added to the transmitted s/l when it travels over the transmission channel. Thus the s/l recieved at the recieving end is contaminated with noise.



white guassian noise.

when the noise is added y(t) will be a modified PAM signal.

$$\therefore \quad y(t) = \mu \sum_{k=-\infty}^{\infty} a_k\, p(t - kT_b) + n(t)$$

μ - scaling factor

$p(t - kT_b)$ combined impulse response of the recieving filter.

$n(t)$ is the filtered noise; the noise which added during the transmission.

This $y(t)$ is sampled at $t = iT_b$.

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

we can seperate the summation from the Ist term

term as $k = i$ and $k \neq i$

$$y_i = \underbrace{\mu\, a_i\, p(0)}_{k=i} + \mu \sum_{\substack{k=-\infty \\ k \neq i}}^{\infty} a_k\, p\,[(i-k)T_b + n(iT_b)]$$

Assume that pulse $p(t)$ is noromalised so $p(0) = 1$

$$y(i) = \underbrace{\mu a_i}_{\text{desired bit}} + \underbrace{\mu \sum_{\substack{k=-\infty \\ k \neq i}}^{\infty} a_k p[(i-k)T_b] + n(iT_b)}_{ISI}$$

$\mu a_i \rightarrow$ represents the contribution of i^{th} transmitted bit

Second term represents the residual effect of all the transmitted bit obtained at the time of sampling the i^{th} bit. this residual effect is known as inter symbol interference (ISI)