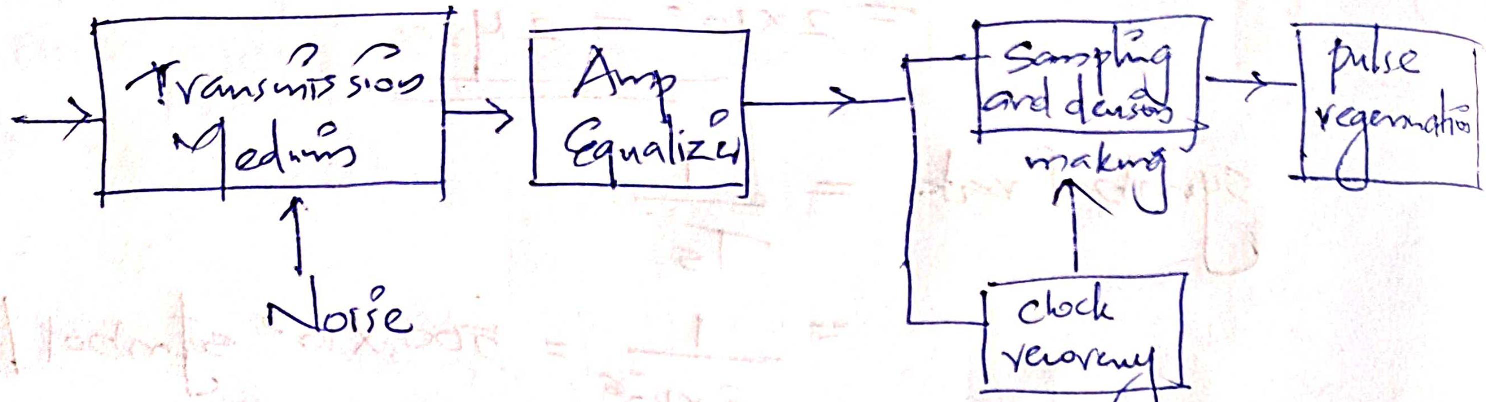
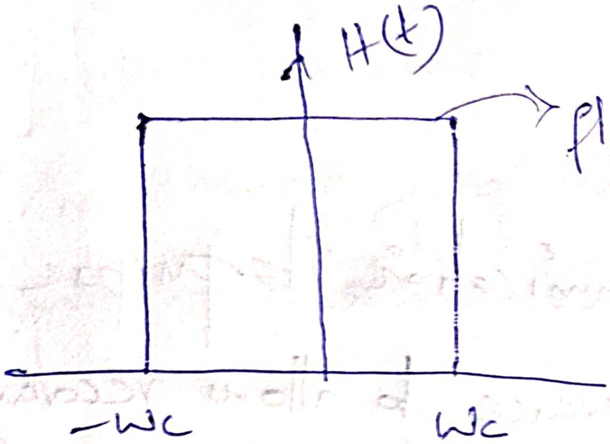
Equalizer:

Structure of Regenerative Repeater:

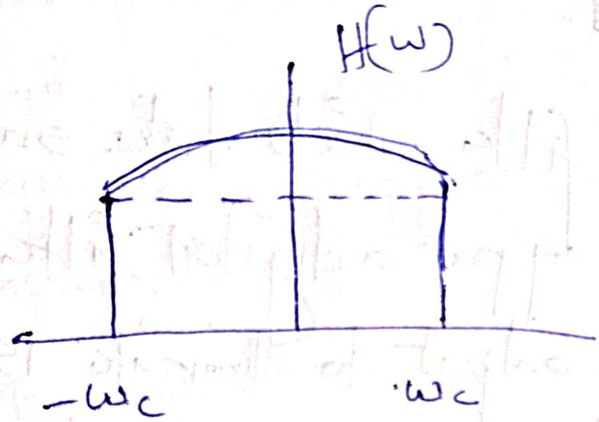


i) to know the start and end of the
ii) actual sampling instant

The signal that is coming along distance experiences attenuation noise and distortion, the attenuation can be compensated using a amplifier while distortion can be compensated using a device called equalizer. This General form of distortion some freq are attenuated highly while rest are attenuated differently this changes the shape of pulse. To compensate this behaviour of channel we use equalizer with freq response which is reciprocal to that of the channel as shown.

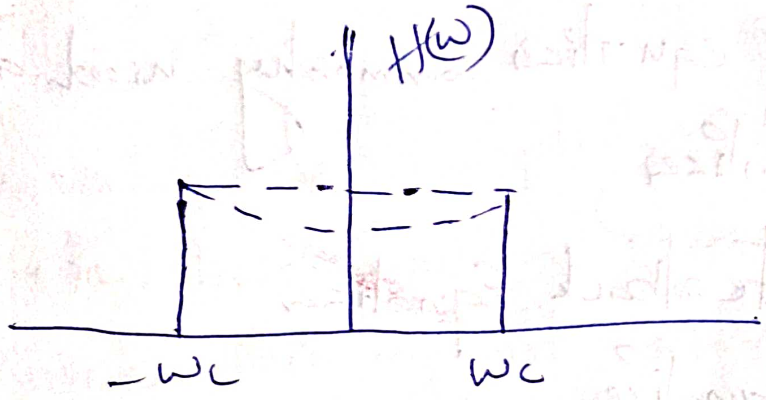


Ideal channel response



Practical channel response.

If the channel response is not a straight line the signal get distorted. ie, at f=0 gain is maximum as we move from 0 to Wc the gain will decrease and it will change the property of the signal. This will cause distortion.



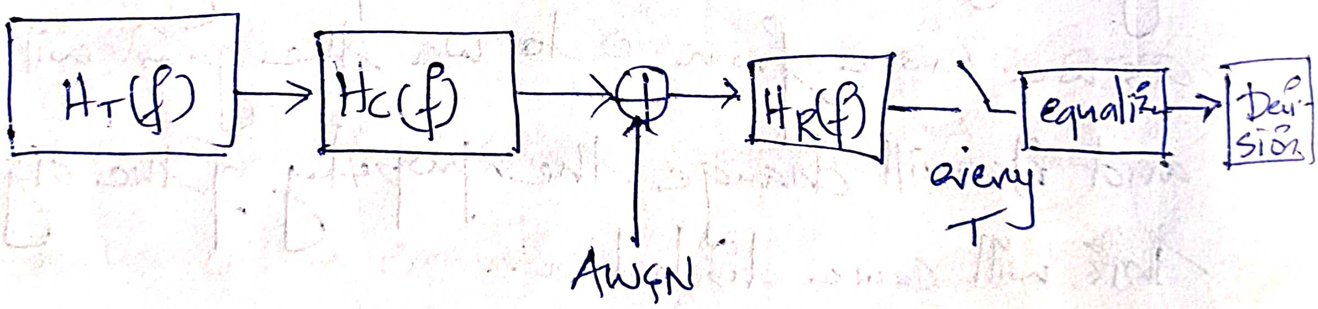
This will be nullified and will get a straight line.

Response of Equalizer.

Equalizers:

In digital communication, its purpose is to reduce Intersymbol interference to allow recovery of the transmit symbols.

We choose a filter which take samples at intervals T and put a digital filter called equalizer at the output to eliminate ISI as shown. This approach to remove ISI is usually known as equalization.



The types of equalizer commonly used are.

i) Linear equalizer
ii) Decision Feedback Equalizer
iii) Blind Equalizer
iv) Adaptive Equalizer
v) Zero forcing equalizer.

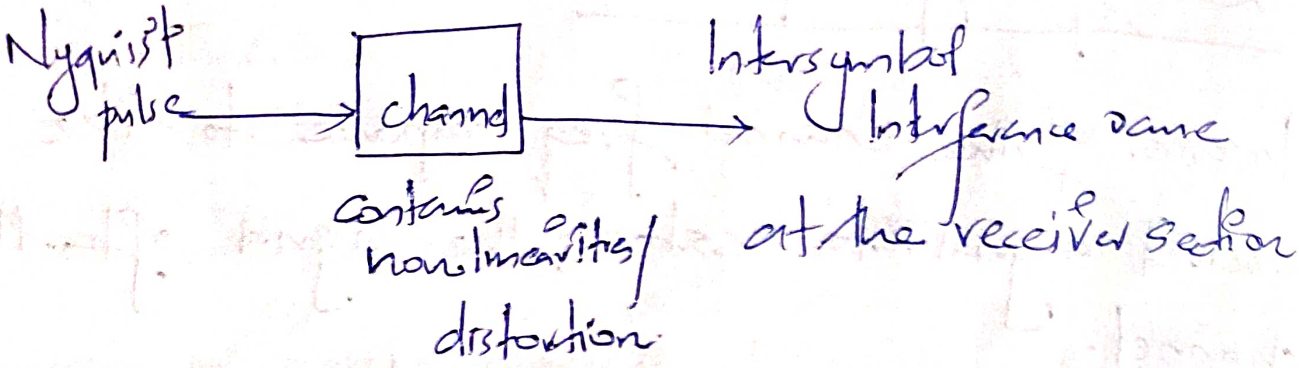
Zero forcing Equalizer:

- Inverse of the channel freq response to the received signal. to restore the signal after the channel.
- Forcing corresponds to bringing down the ISI to zero in a noise free case. This will be helpfull when ISI is significant compared to noise.
- Simple implementation
- The longer equalizer, the more the ideal conditions for distortionless transmission.

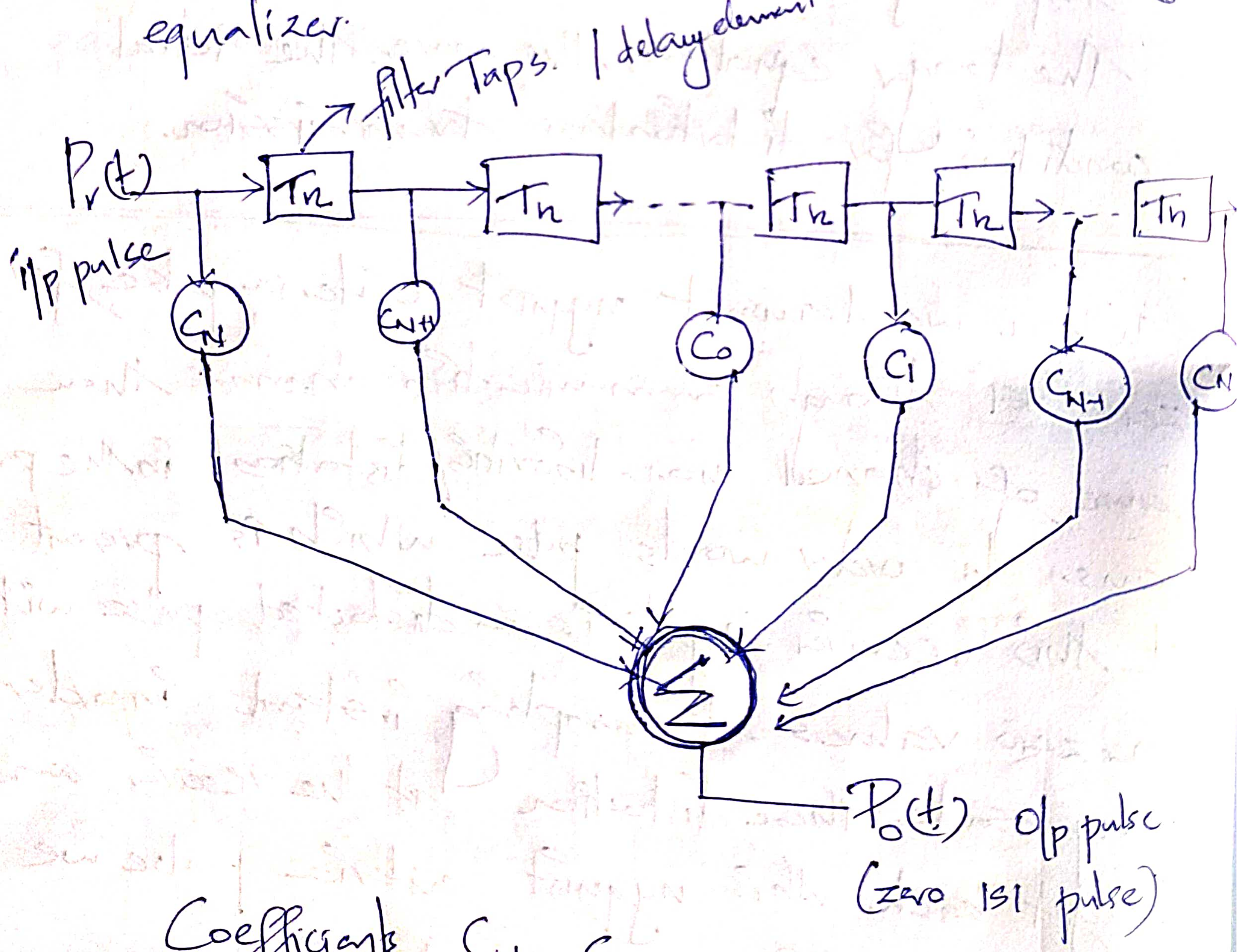
When we transmit nyquist criteria pulse for zero ISI through communication channel then because of channel non-linearities/distortions in the pulse occurs. In order words pulse which is present at this receiver input is a distorted pulse with non-zero values at sampling instants in order to compensate these distortion at the receiver and to get back this nyquist criteria pulse we use equalizer. One such equalizer is a zero forcing equalizer.

Nyquist pulse → channel → Intersymbol Interference came at the receiver section

contains nonlinearities / distortion



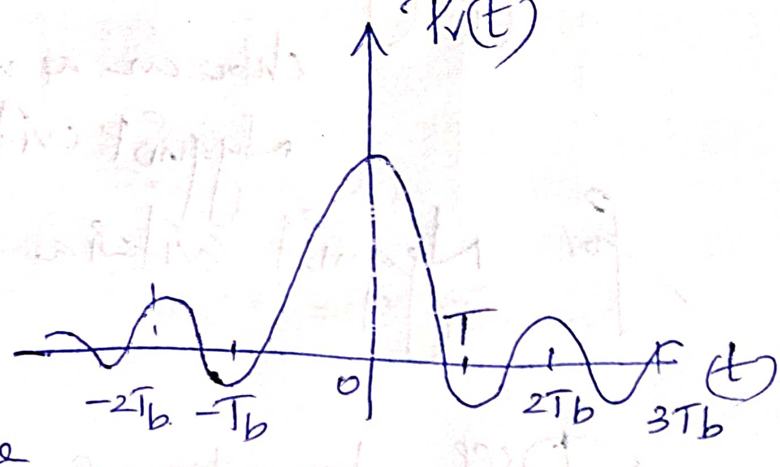
At transmitter have no ISI but at the receiver section will have ISI. In order to remove this ISI at the receiver section we use zero forcing equalizer.



Coefficients C_{-N} C_{-N+1} --- C_0, C_1,

It is a types of filter, The no. of delay element $2N$

And No: of coefficients are 2N+1.



at Tb, 2Tb, 3Tb the values $\neq 0$ it is not a Nyquist criteria pulse

So we have to design a receiver section having zero ISI pulse.

$$P_o(t) = \sum_{n=-N}^{+N} C_n P_r(t - nT_b)$$

at sampling instant $t = kT_b$.

$$P_o(kT_b) = \sum_{n=-N}^{N} C_n P_r[kT_b - nT_b] \quad k = 0, \pm 1, \pm 2 \ldots$$

$$\boxed{P_o(k) = \sum_{n=-N}^{N} C_n P_r[k-n]} \quad \text{--- (1)}$$

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

$k \rightarrow$ is an integer

$$P_o(k) = \begin{cases} 1, & k = 0 \\ 0, & k \neq 0 \end{cases}$$

Designing :- here the coefficients should be choosen as which satisfy the Nyquist criteria.

for Nyquist criteria $P_o(k) = 1 \ , k=0$

$\qquad\qquad\qquad\qquad\quad 0 \quad k \neq 0$

Different values of k i.e., $-N$ to N in equation ①

$k=-N$ } $P_o(-N) = C_{-N} P_r(0) + C_{-N+1} P_r(-1) \text{ - - - } + C_N P_r(-2N)$

$k=-N+1$ } $P_o(-N+1) = C_{-N} P_r(1) + C_{-N+1} P_r(0) + \text{ - - - } C_N P_r(-2N+1)$

design o/p $\quad$ Pr (matrix) $\quad$ coefficients

$$\begin{bmatrix} 0 \\ 0 \\ 0 \\ \vdots \\ \vdots \end{bmatrix}_{(2N+1)\times 1} = \begin{bmatrix} P_r(0) & P_r(-1) & \cdots & P_r(-2N) \\ P_r(1) & P_r(0) & \cdots & P_r(-2N+1) \\ \vdots & & & \\ P_r(2N) & \cdots & \cdots & P_r(0) \end{bmatrix}_{(2N+1)(2N+1)} \begin{bmatrix} C(-N) \\ C_{-N+1} \\ \vdots \\ C_0 \\ \vdots \\ C_N \end{bmatrix}$$

Q) Design a three tap zero equalizer if following parameter given

$P_r(0) = 1$ $\quad$ $P_r(2) = 0.1$

$P_r(-1) = 0.2$ $\quad$ $P_r(-2) = 0.05$

$P_r(1) = -0.3$

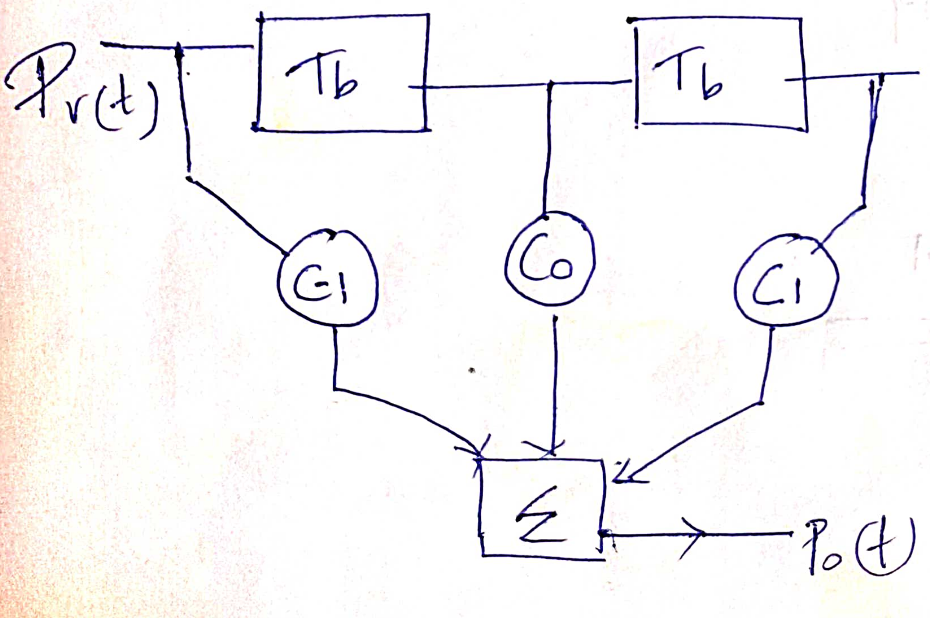
all are non-zero values ie; pulse received donot satisfy nyquist criteria.

Solution:

$2N+1 = \underbrace{3}_{3\text{ tap}}$

So; $N = 1$

1st step: Structure of equilizer



$$\begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} = \begin{bmatrix} P_r(0) & P_r(-1) & P_r(-2) \\ P_r(1) & P_r(0) & P_r(-1) \\ P_r(2) & P_r(1) & P_r(0) \end{bmatrix} \begin{bmatrix} C_{-1} \\ 0 \\ C_1 \end{bmatrix}$$

$$\begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 1 & -0.2 & 0.05 \\ -0.3 & 1 & -0.2 \\ 0.1 & -0.3 & 1 \end{bmatrix} \begin{bmatrix} C_{-1} \\ C_0 \\ C_1 \end{bmatrix}$$

$$0 = C_{-1} - 0.2C_0 + 0.05C_1$$

$$1 = -0.3C_{-1} + C_0 - 0.2C_1$$

$$0 = 0.1C_{-1} - 0.3C_0 + C_1$$

$C_{-1} = 0.209$

$C_0 = 1.12$

$C_1 = 0.31$