$$u(nT_s) = \hat{x}(nT_s) + y(nT_s)$$

$$y(nT_s) = u(nT_s) - \hat{x}(nT_s)$$

For step size estimation → n samples are used

For predicting the ~~no~~ i/p ~~of~~ samples → m samples are used

$$\text{Accuracy} \propto \text{No. of samples} \propto \frac{1}{\text{Delay, Space}}$$

Predictor → uses actual sample not the error sample

Line codes :

Line codes are pulse waveforms which are mapped to binary digits If line code has a zero level and a single non zero voltage level, then the signal is called unipolar On the other hand, if the levels used are both positive and negative, then the code is called a bipolar one

Line codes are classified as

Return to 0 (RZ)

Non-return to 0 (NRZ)

In RZ, signal comes back to zero level after a small part within the bit interval The bit interval T_b is the time

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duration which is used to send information about a single bit usually the transition to zero occurs at half the bit duration

In NRZ, waveform stays at any non zero level, for whole Interval of T_B

Properties of line codes

(1) DC component

Eliminating DC energy from signal power spectrum enables transmitter to be AC coupled. Magnetic recording systems or systems using transformers are less sensitive to very low freq signal components. Thus, low freq. information may get lost in the presence of DC or near DC spectral components. Thus, line codes avoid DC components

(2) Self synchronization

Most digital Communication systems require bit synchronization. Also coherent detectors require carrier ~~detection~~ synchronization. Some line codes have inherent synchronization features. Thus, extra overhead can be avoided.

Manchester code has a transition at the middle of every bit interval & this provides a clocking level at bit level

(3) Error detection

Some codes such as duobinary provide means of detecting data errors inherantly

(4) Bandwidth Compression.

Some multilevel codes increase the efficiency of bandwidth utilization by allowing a reduction in required bandwidth for a given data rate.

(5) Differential encoding

This technique is useful ~~and~~ as it allows the polarity of differentially encoded waveforms to be inverted without affecting the data detection.

(6) Noise immunity

Certain line codes posses lesser bit detection of error property when compared to others in the presence of noise. For example, the non return to zero waveforms have better noise performance than RZ.

(7) Transperancy

A line code should be so designed that the receiver does not go out of Synchronization For any sequence of data symbols if the code is not transparent, clock is lost.

(8) Spectral compatibility with channel

Transmission bandwidth of a particular code should be sufficiently small compared to the channel bandwidth in order that ISI (Inter Symbol Interferance) could me minimized. In cases where the channel characteristic varies over different frequency bands a line code with similar power spectral density would be preffared over others.

RZ unipolar Format PSD

$R_A(n=0)$ =

Symbol	A_K	A_K^2	P_K
0	0	0	1/2
1	a	a^2	1/2

$R_A(0) = a^2/2$

~~$R_A(n \neq 0)$=~~

Symbol		A_K	A_{K-n}	$A_K \cdot A_{K-n}$	P_K
Prev.	Present				
0	0	0	0	0	1/4
0	1	0	a	0	1/4
1	0	a	0	0	1/4
1	1	a	a	a^2	1/4

$R_A(n \neq 0) = a^2/4$

$$V(f) = \frac{T_b}{2} \operatorname{sinc}\left(\frac{fT_b}{2}\right)$$

$$S(f) = \frac{1}{T_b} |V(f)|^2 \sum_{n=-\infty}^{\infty} R_A(n) \exp(-j2\pi f n T_b)$$

$$S(f) = \frac{1}{T_b} \frac{T_b^2}{4} \operatorname{sinc}^2\left(\frac{fT_b}{2}\right) \sum_{n=-\infty}^{\infty} R_A(n) \exp(-j2\pi f n T_b)$$

$$= \frac{T_b}{4} \operatorname{sinc}^2\left(\frac{fT_b}{2}\right) \left[R_A(0) \exp(-j2\pi f n T_b) + \sum_{n\neq 0} R_A(n\neq 0) \exp(-j2\pi f n T_b)\right]$$

$$= \frac{T_b}{4} \operatorname{sinc}^2\left(\frac{fT_b}{2}\right) \left[\frac{a^2}{2} \exp(-j2\pi f(0)T_b) + \sum_{n\neq 0} \frac{a^2}{4} \exp(-j2\pi f n T_b)\right]$$

$$S(f) = \frac{T_b}{4} \operatorname{sinc}^2\left(\frac{fT_b}{2}\right) \left[\frac{a^2}{2} + \sum_{\substack{n=-\infty \\ n\neq 0}}^{\infty} \frac{a^2}{4} \exp(-j2\pi f n T_b)\right]$$

Using Poisson eq. $\sum_{n=-\infty}^{\infty} \exp(-j2\pi f n T_b) = \frac{1}{T_b}\sum_{n=-\infty}^{\infty} \delta\left(f - \frac{n}{T_b}\right)$

$$S(f) = \frac{1}{4}\delta(f)\frac{a^2}{4} + \frac{a^2}{2}\frac{T_b}{4}\operatorname{sinc}^2\left(\frac{fT_b}{2}\right)$$

$$S(f) = \frac{a^2}{16}\delta(f) + \frac{a^2}{8}T_b\operatorname{sinc}^2\left(\frac{fT_b}{2}\right)$$

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RZ polar Format :

$R_A(n=0)$

Symbol	A_k	A_k^2	P_k
0	$-a$	a^2	$1/2$
1	$+a$	a^2	$1/2$

$R_A(0) = a^2$

Symbol		A_k	A_{k-n}	$A_k \cdot A_{k-n}$	P_k
Prev	Present				
0	0	$-a$	$-a$	a^2	$1/4$
0	1	$-a$	a	$-a^2$	$1/4$
1	0	a	$-a$	$-a^2$	$1/4$
1	1	a	a	a^2	$1/4$

$R_A(n \neq 0) = 0$

$$V(f) = \frac{T_b}{2}\,\text{sinc}\left(\frac{fT_b}{2}\right)$$

$$S(f) = \frac{1}{T_b}|V(f)|^2 \sum_{n=-\infty}^{\infty} R_A(n)\exp(-j2\pi f n T_b)$$

$$S(f) = \frac{1}{T_b}\frac{T_b^2}{4}\,\text{sinc}^2\left(\frac{fT_b}{2}\right)\left[R_A(0)\exp(-j2\pi f(0)T_b) + \sum_{\substack{n=-\infty \\ n\neq 0}}^{\infty} R_A(n\neq 0)\exp(-j2\pi f n T_b)\right]$$

$$= \frac{T_b}{4}\,\text{sinc}^2\left(\frac{fT_b}{2}\right)\left[a^2 \cdot\right]$$

$$= \frac{a^2 T_b}{4}\,\text{sinc}^2\left(\frac{fT_b}{2}\right)$$