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Encoding in PCM

Encoding in PCM:- We know that encoding is the process that follows the sampling and quantization. Encoding process converts the quantized samples into codewords. In a binary code, each symbol may have either a 0 value or a 1 value. There are various formats (i.e., waveforms) to represent the binary sequence. They are known as line codes. In line coding in which binary symbols are arranged in proper codes for efficient transfer over optical fiber cable. There are three types of line coding for binary symbols in optical fiber communication.

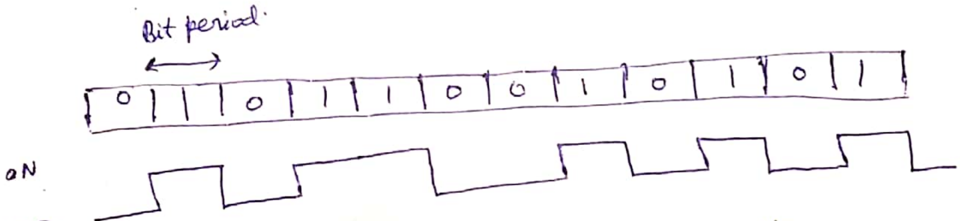
(1) Nonreturn to Zero Coding (NRZ) (2) Return to Zero Coding (RZ) and

(3) biphase or Manchester Coding.

(a) Nonreturn to Zero (NRZ) Coding:- A number of different NRZ codes are widely used and their bandwidths serve as reference for all other code group. The simplest NRZ code is NRZ-level (or NRZ-L), as shown in figure (a). For a serial data stream, an on-off signal represents a '1' by a pulse of current or light filling an entire bit period whereas for a '0' no pulse is transmitted. These codes are simple to generate and decode but they possess no inherent error-monitoring or correcting capabilities and they have no self-clocking (timing) features.

The minimum bandwidth is needed with NRZ coding but the average power input to the receiver is dependent on the data pattern. For example, the high level of received power occurring in a long string of consecutive 1 bits can result in a baseline wander effect. This effect results from the accumulation of pulse tails that arise from the low-frequency characteristics of the ac-coupling filter in the receiver. If the receiver recovery to the original threshold is slow after the long string of 1 bits has ended, an error may occur if the next 1 bit has a low amplitude.

In addition, a long string of NRZ ones or zeros contains no timing information, since there are no level transitions. However, the use of highly stable clocks increases system costs and requires a long system start-up time to achieve synchronization.



(1)

Example of an NRZ-L data pattern

To represent '1' ~~too~~ we have maximum amplitude of the pulse throughout the period. To represent '0' we have zero pulse at that place.

* If the signal consists of both positive and negative voltage pulses, it is said to bipolar.
* If only one polarity of the voltage pulse is present, the signal is said to be unipolar.
* The mapping of binary data bits to signal elements is called encoding.
* A digital signal comprises a series of discrete voltage pulses. An individual pulse in the total signal is called signal element.

(b) Return to Zero (RZ) Coding :- In the ~~unipolar~~ unipolar RZ data, a bit is represented by a half-period optical pulse that can occur in either the first or second half of the bit period. A '0' ... then the

use

By Shannon–Hartley theorem, the channel capacity as under

$$C = B \log_2 \left(1 + \frac{S}{N}\right)$$

where B is bandwidth and S/N is signal to noise ratio.

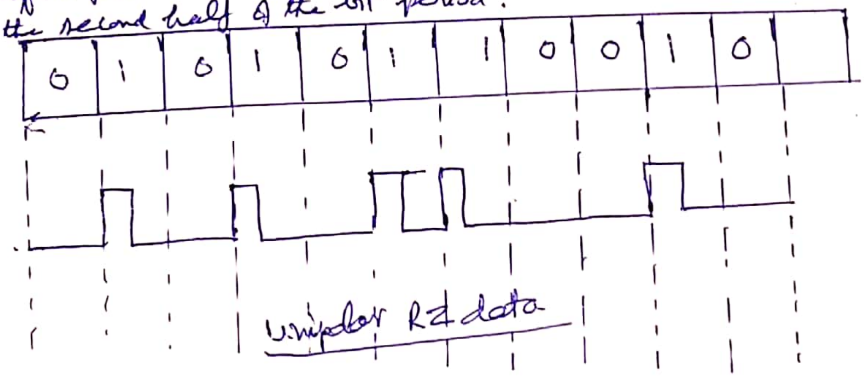
If the communication channel is noiseless, then $N=0$. There $\frac{S}{N} \to \infty$ and, so, C also will tend to ∞. Thus, the noiseless channel will have an infinite capacity.

* There is some white gaussian noise is present, hence $\frac{S}{N}$ is not infinite.

(b) Return to Zero (RZ) Coding :- In the ~~unipolar~~ unipolar RZ data, a bit is represented by a half-period optical pulse that can occur in either the first or second half of the bit period. A '0' is represented by no signal during the bit period. If '1' is present then the pulse in the bit period but return to zero at midway ~~duct~~ of the bit period.

A disadvantage of the unipolar RZ format is that long strings of '0' bits can cause loss of timing synchronization.

The RZ code differs from NRZ code is that only half the bit period is used for data, while the voltage is zero in the second half of the bit period.



Unipolar RZ data

(c) Manchester Coding :- This is a unipolar code, which is in contrast to the (Biphase) or phase encoded) conventional bipolar. Manchester code used in wire lines.

The optical Manchester signal is obtained by direct modulo-2 addition of the baseband (NRZ-L) signal and a clock signal. In this code, there is a transition at the centre of each bit interval. A negative going transition indicates a 1-bit whereas a positive-going transition means a '0' bit was sent. The Manchester code is simple to generate and decode. It requires twice the bandwidth of an NRZ code. In addition, it has no inherent error-detecting or correcting capability

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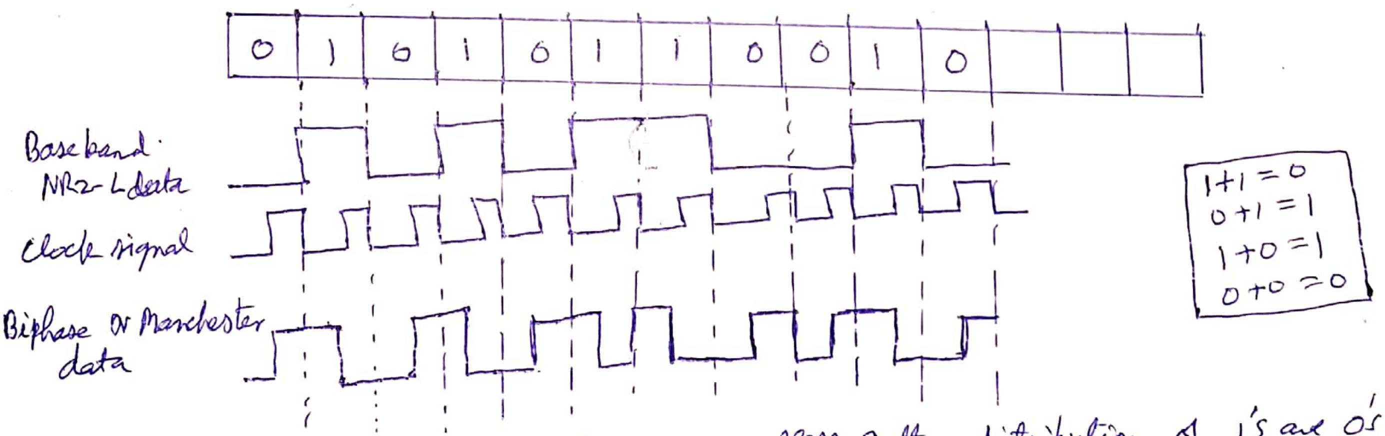
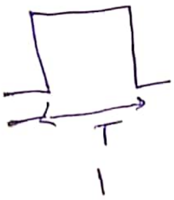
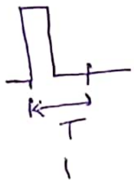
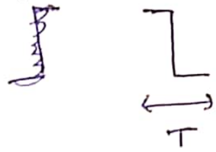


The receiver to recover the clock, regardless of the distribution of 1's and 0's the data. Thus Manchester coding offers the benefits of clock recovery and a.c coupling.

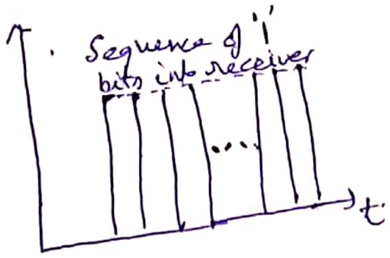
Comparison between NRZ, RZ and Manchester Coding :-

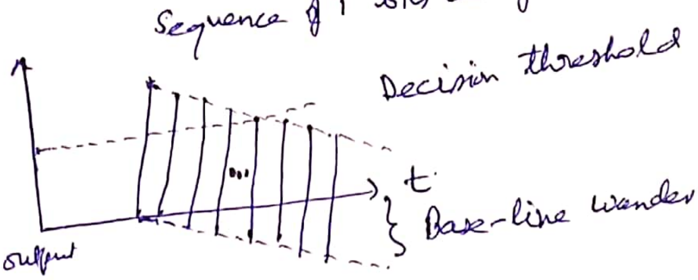
S.No.	NRZ	RZ	Manchester
1.	Bandwidth needs minimum  $BW = c N \times \frac{1}{r}$ $r_{NRZ} = \frac{\text{signal}}{\text{pulse}} = \frac{1}{1}$	Needs almost double BW as compared to NRZ Coding  $r = \frac{1}{2}$ $B.W = 2 \times RZ$	Needs almost double BW as compared to NRZ Coding 
2.	There is more power consumption	There is less power consumption in comparison to NRZ	Better than both RZ and NRZ.
3.	Pulse hight is small so less attenuation margion	Pulse height can be doubled so more attenuation margion	Pulse height can be doubled as compared to NRZ so more attenuation margin.
4.	DC level fluctuation in NRZ coding	DC level fluctuates but less than RZ coding	DC level is constant in Manchester Coding
5.	Repeats 1's can cause error in NRZ coding	Repeats 0's can cause error in RZ coding	There is minimum possibility of error.

Base-line Wander effect :- Consider a square pulse, after passing through a circuit the pulse gets distorted and its tails down to the zero level i.e. the negative side and thus, DC level lowers down. This is called Base line wander effect.

Single receiver input pulse (Square Pulse)

output pulse tails down to zero level i.e. to negative side (Base line wander effect)





Input + Circuit + output

The amount of tailing depends on the pulse rate, time constant of the circuit through which it passes and the number of pulses in the time interval.

It can also causes because of the error in deciding 0's and 1's.

Two common techniques for restricting the longest time interval in which no level transitions occur, are the use of block codes and scrambling. Scrambling produces a random data pattern by the modulo-2 addition of a known bit sequence with the data stream. At the receiver, the same known bit sequence is again modulo-2 added to received data and the original bit sequence is recovered. By using this ~~the complexity~~ of the NRZ encoding and decoding circuitry ~~complexity~~ complexity increases.

Although the randomness of scrambled NRZ data ensures an adequate amount of timing information, the penalty for its use is an increase in the complexity of the NRZ encoding and decoding circuitry.

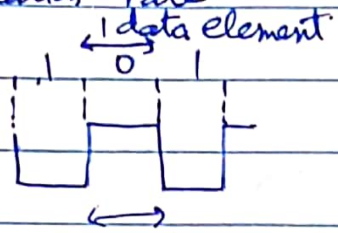
It also arises due to accumulation of pulse tails that arise from low frequency characteristics of a.c. coupling filter in receiver.

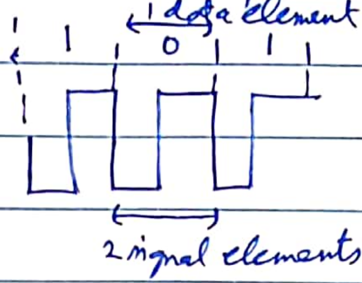
<u>Data Element</u> :- A data element is the smallest piece of information that we want to send. It is bit 0 or 1

<u>Signal Element</u> :- A signal element is the shortest element of the signal (DE is the person and SE is the carrier)

<u>Data rate / Bit rate</u> :- Data element is send in one second. Unit is bit/sec

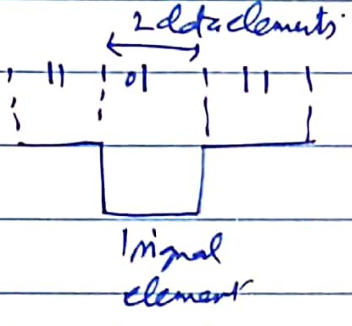
<u>Signal rate / Baud rate</u> :- Signal elements send in one second. Unit is baud. It is also known as pulse rate, baud rate or modulation rate.

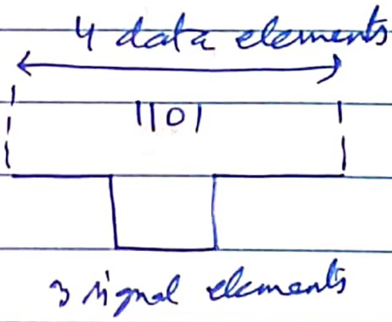




One data element per one signal element ($r=1$)

one data element per two signal element ($r=\frac{1}{2}$)





Two data elements per one signal element ($r=2$)

Four data elements per three signal elements ($r=\frac{4}{3}$)

<u>Aim</u> :- ज्यादा bits को कम signal elements की सहायता से भेजना चाहिए।

level → constant voltage level (series of 0's and 1's create it)

DC component :- It is due to the series of the same bit pattern. It will result in very low freq. component. DC components is difficult to handle in coupling circuits.

In coupling circuit only AC components travel, it blocks DC components.

Line coding —

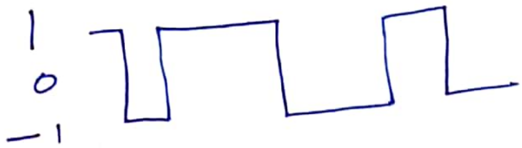
- Unipolar — NRZ
- Polar — NRZ, RZ and biphase (Manchester and differential Manchester
- Bipolar — AMI and pseudoternary
- Multilevel — ~~2B~~ 2B/1Q, 8B/6T, and 4D-PAM5
- multitransition — MLT-3

AMI → Alternative mark inversion.

- less BW
- Syn. Problem

Unipolar

Polar



Bipolar