1 DT.

Digital Transmission.

Line coding.

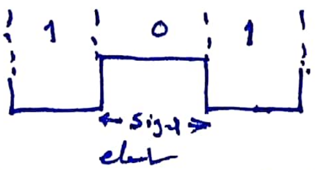
Digital data can be represented by using Digital Signal. The conversion involves Line coding. There are other two techniques also: Block coding and Scrambling; these may or may not be used.

Line coding: Conversion of Digital data to Digital Signal.

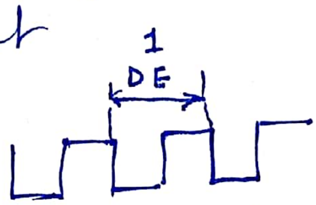
Common characteristic: Signal element vs Data element

In data comm. goal is to send data element. A signal element carries data element. In other words: data element is what we need to send & ~~data element~~ signal element is what we can send. Data element is the being carried & signal element is the carrier.

We define a ratio $r \triangleq$ no. of data elements carried by each signal element

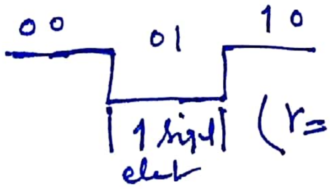


(one data elmt per signal elmt: $r=1$)



(2 signal elmts per one data elmt)

$r = \frac{1}{2}$



($r=2$)

Make scheme for $r = \frac{2}{3}$.

Data rate vs Signal rate: Data rate defines no. of data elmts sent in 1 sec. Unit is bps.

Signal rate: No of signal elmts in 1 sec. The unit is baud

Goal in data communication is to increase data rate and reduce signal rate.

Increasing data rate increases speed of Transmission

Decreasing signal rate decreases band width requirement.

Relationship between Data rate & Signal rate

$$S = c \times N \times \frac{1}{r} \text{ baud}$$

N is data rate (some times called bit rate) in bps.

c is case factor which varies for each case

S is no. of signal elements (r has been defined previously).

Example:

A signal is carrying data in which 1 data element is encoded as one signal element (r=1). If the bit rate is 100 kbps. What is the average value of baud rate. If c is between 0 & 1.

Assume $c = \frac{0+1}{2} = 0.5$

$S = c \times N \times \frac{1}{r} = 0.5 \times 100{,}000 \times \frac{1}{1} = 50{,}000$

50 K baud.

~~Reat the~~ Repeat example for r= 1/2, 2/1, 3/4 etc.

& ~~make~~ ~~diff~~ interpret the results.

Band width.

We know that actual band width of a signal is infinite, the effective band width is finite.
(Students may brush up the concept from Fourier xformation concepts of signal decomposition & from prev. ~~class~~ lecture on Digital Signals)

We can say that baud rate & not the bit rate determines required band width of a digital signal.

Further, bandwidth limitations force us to limit the range of frequencies that should be passed through a channel.

$$B_{min} = c \times N \times \frac{1}{r}$$

Min b.w.

$$N_{max} = \frac{1}{c} \times B \times r$$

Max. Data rate.

(Band width is an impt concept, students should take examples and try to understand the concept fully).

Requirement of a good coding scheme.

* DC component: When the voltage level in a digital signal is constt. for a while, the spectrum creates v. low frequencies (results of Fourier analysis). These frequencies around '0', called DC component, present problems for a system that can not pass low frequencies or for a system that uses electrical coupling (via xformer). Therefore it is desirable for coding scheme to have low d.c. component.
* Base line wandering:
  In decoding a digital signal, the receiver calculates a running average of received signal power. This average is called ~~base~~ ~~line~~ baseline. The incoming signal power is evaluated against this base-line to determine the value of data element. A long string of '0's or '1's can cause drift of baseline (Drift of base line is base line wandering) and make it difficult for receiver to decode correctly. A good coding scheme needs to prevent base line wandering.
* Self-Synchronization: To correctly interpret the signal received from sender, the receiver's bit intervals must correspond to sender's bit intervals; otherwise received bits can be misinterpreted.

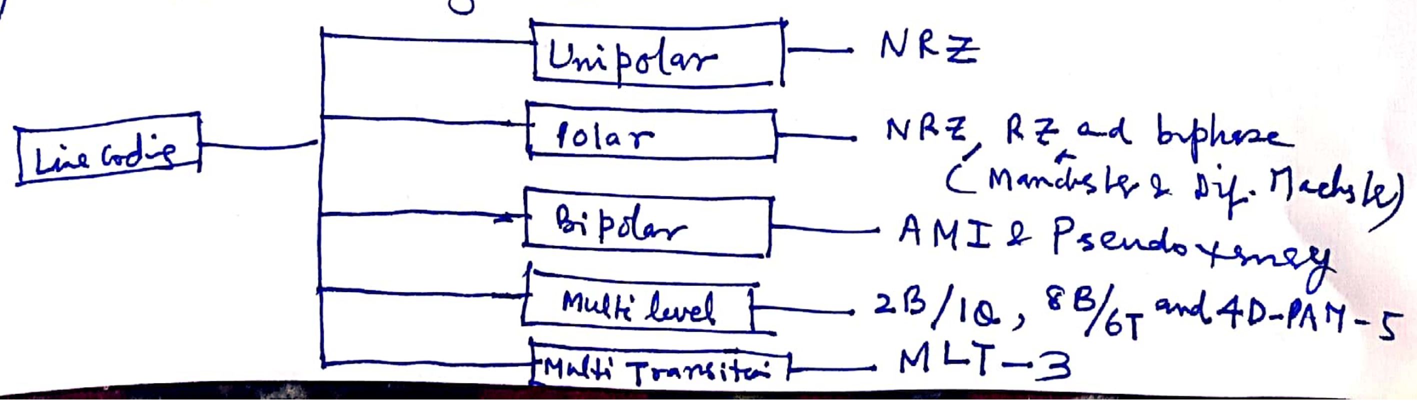
SDT.

A self synchronization digital signal includes timing information in the data being xmitted. This can be achieved if there are transitions in the signal that alert the receiver to the beginning, middle or end of the pulse. If the receiver clk is out of synchronization, these points can reset clk.

* Built in error detection: It is desirable to have built in error-detecting capability in the generated code to detect some or all errors that occurred during transmission.
* Immunity to noise & interference: Another desirable ~~code~~ characteristic is a code that is immune to noise and other interferences.
* Complexity: A complex scheme is more costly to implement than a simple one eg. a scheme that uses four signal levels to interpret than a scheme that uses only two levels.

~~Generally~~ Line coding schemes:

Generally line coding schemes are divided into five broad categories



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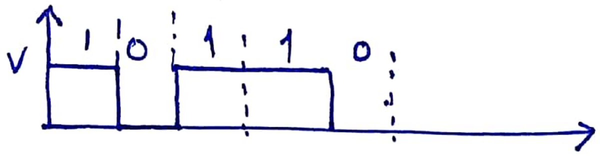
Unipolar scheme:

In unipolar scheme, all signal levels are on one side of the axis; either above or below

NRZ (Non Return to Zero): Here positive voltage defines bit 1 and zero voltage defines bit 0. It is called NRZ because signal does not return to zero at the middle of bit

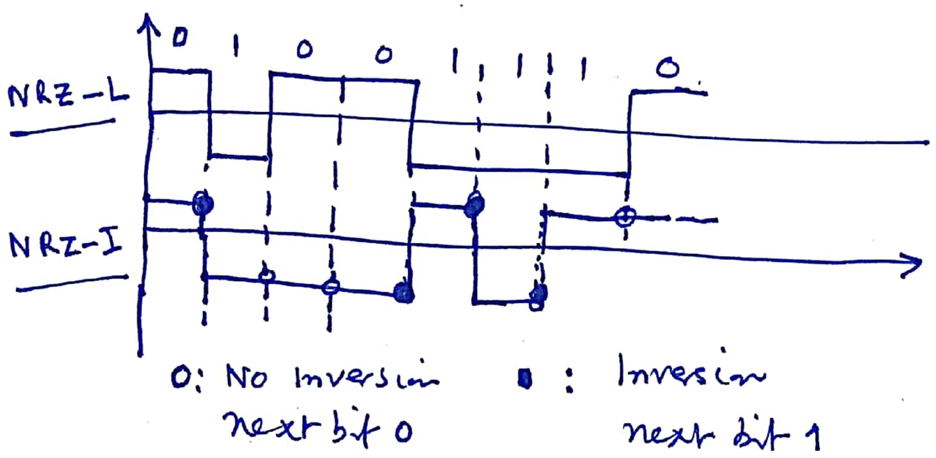


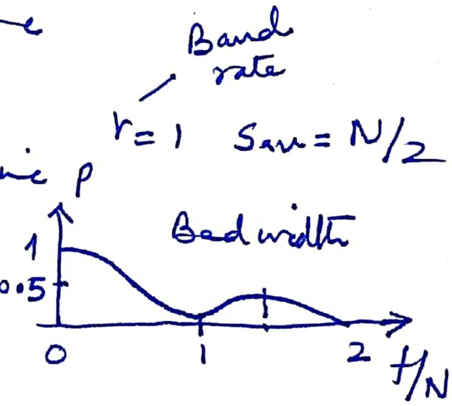
$$\frac{1}{2}V^2 + \frac{1}{2}0^2 = \frac{1}{2}V^2$$

Normalized power

Polar scheme:

NRZ Polar : In NRZ polar, we use two levels of voltage amplitude. We can have two versions of Polar NRZ : NRZ-L and NRZ-I





In NRZ-L : The level of voltage determines the value of the bit

In NRZ-I (↑ invert) : The change or lack of change in the level of voltage determines the value of bit. If there is no change the bit is '0' if there is change, the bit is 1

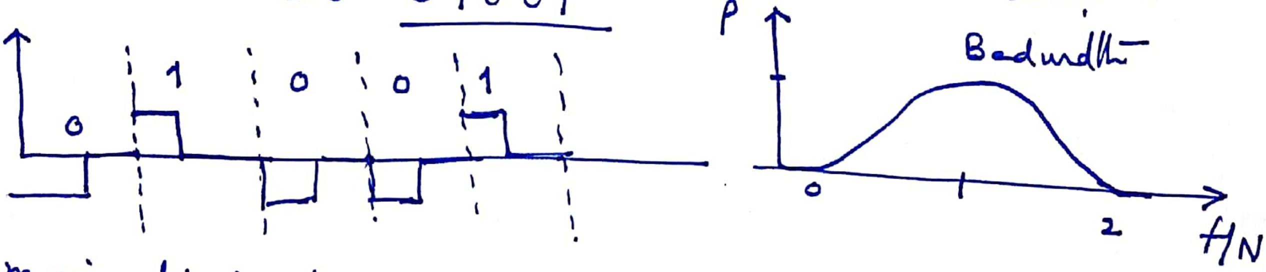
Advise: "Compare the schemes based on previous criteria"

IDT.

Return to Zero (RZ)

Main problem with NRZ coding occurs when sender & receiver clocks are not synchronized. The receiver ~~when~~ does not know when one bit has ended and another started. One soln. is RZ scheme. RZ scheme uses three values: Positive, Negative and zero.
Signal does not change ~~at bits~~ between bits but during the bit.

e.g. ~~0~~ 01001 $r = 1/2$ $S_{av} = N$



The main disadvantage of RZ coding is that it requires two signal changes to encode a bit and therefore occupies greater bandwidth. Here we have no d.c. component problem. However, if there is sudden change in polarity all 0's can be interpreted as 1's and vice versa.
Another problem is complexity; RZ uses three levels of voltage, which is more complex to create & discern.
As a result of all these deficiencies, the scheme is not used today. Therefore, it is replaced by Manchester scheme.

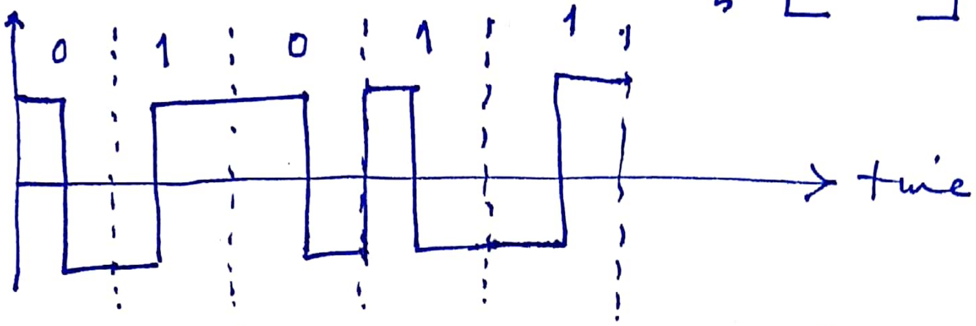
Biphase Scheme:

Manchester & Differential Manchester

In Manchester code, duration of bit is divided into two halves. Voltage remains at one level during first half and moves to other level in the second half

B.DT.

0 is: ⌐L 1 is: ⌐‾



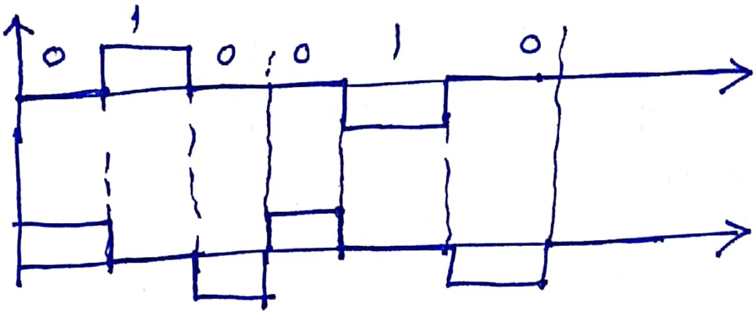
Here transition at the middle of bit is used for Synchronization

$r = 1/2$ $S_{av} = N$

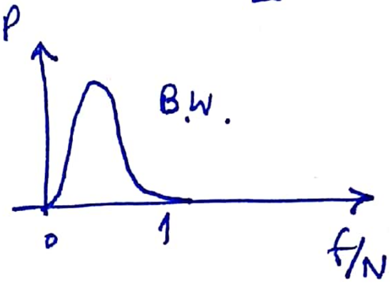
The Manchester coding overcomes several problems with NRZ-L. There is no base line wandering. There is no d.c. component because each bit has +ive & -ive contribution. The only drawback is signal rate which is double to that of NRZ. Manchester & Diff. Manchester are called Biphase schemes. (Do Diff. Manchester yourself).

Bipolar schemes:

AMI



$r = 1$ $S_{av} = \frac{1}{2}N$



AMI means Alternate (Mark=1) Inversion. Neutral zero voltage represents 0. Binary 1s are represented by alternating positive and negative voltages. A variation of AMI encoding is called Pseudoternary in which the 1 bit is encoded as '0' voltage & 0 is encoded as alternating positive and negative voltages (Do adv & disadv yourself).