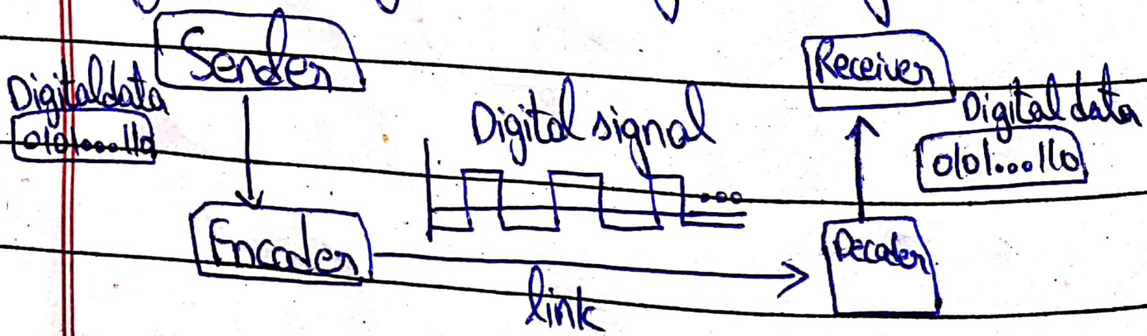
Unit 4

Line Coding:

Process of converting digital signal to digital signal. It converts sequence of bits to digital signal. At sender, digital data are encoded into digital signal. At receiver, digital data are recreated by decoding the digital signal.



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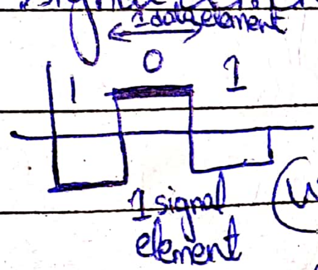
Signal element vs Data element:

A data element is smallest entity that can represent piece of info, this is bit.

A signal element carries data elements.

☆. Data elements are what we need to send and signal elements are what we can send.

Ratio (r) is number of data elements carried by signal element.



(with r = 1)

(Bit Rate) **Data Rate**: It defines no. of data elements (bits) sent in 1s.

(Pulse Rate) (Baud Rate) **Signal Rate**: Number of signal elements sent in 1s. Unit is baud.

As, $S = N/r$ where N = data rate, S = signal rate.

$S_{ave} = c \times N \times (1/r)$ baud.

Ex#4.1: Data Rate/Bit Rate (N) = 100kbps = 100,000 bps

c = 1/2

$S_{ave} = ?$, r = 1

$S_{ave} = (1/2) \times \underline{100,000} \times \left(\frac{1}{1}\right) = 50,000 = \boxed{50k\text{ baud}}$

Bandwidth

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* Actual Bandwidth of digital signal is infinite,
  effective " is finite.

The minimum bandwidth: $B_{min} = c \times N \times (1/r)$

$N_{max} = (1/c) \times B \times r$

Self-synchronization: A self-synchronizing digital signal includes timing info. in data being transmitted. This can be achieved if there are transitions in signal that alert receiver to beginning, middle or end of pulse. If receiver's clock is out of synchronization, these points can reset clock.

Ex#4.3: Receiver clock is 0.1% faster than sender clock. How many extra bits per second does receiver receive if data rate is 1kbps? How many if data rate is 1Mbps?

Sol At 1Kbps, receiver received 1001 bps instead of 1000 bps.

$10^3 \times \frac{0.1}{100} = 1$ bps addition

1000 bits sent → 1001 bits received → 1 extra bps.

At 1Mbps, receiver recived 1,001,000 bps instead of 1,000,000 bps.

$10^6 \times \frac{0.1}{100} = 1000$ bps addition

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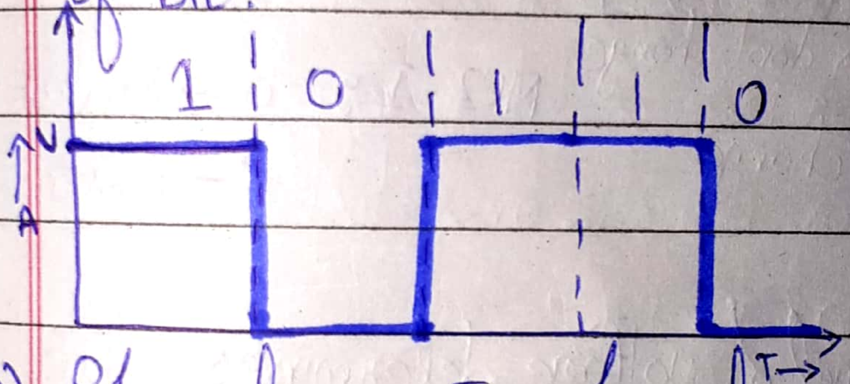
Line Coding Schemes:

1). Unipolar scheme: In unipolar scheme, all signal levels are on one side of time axis, either above or below.

a). NRZ: in which positive voltage defines bit 1 and zero voltage defines bit 0. It is called NRZ because signal does not return to zero at middle of bit.



2). Polar scheme: In polar scheme, voltages are on both sides of time axis. e.g., voltage level for 0 can be +ve and voltage level for 1 can be -ve

a). NRZ: In polar NRZ, we use two levels of voltage amplitude. In NRZ-L (NRZ-Level), level of voltage determines value of bit.

In NRZ-I (NRZ-Invert), change or lack of change in level of voltage determines value of bit. If there is no change, bit is 0, if there is change bit is 1.

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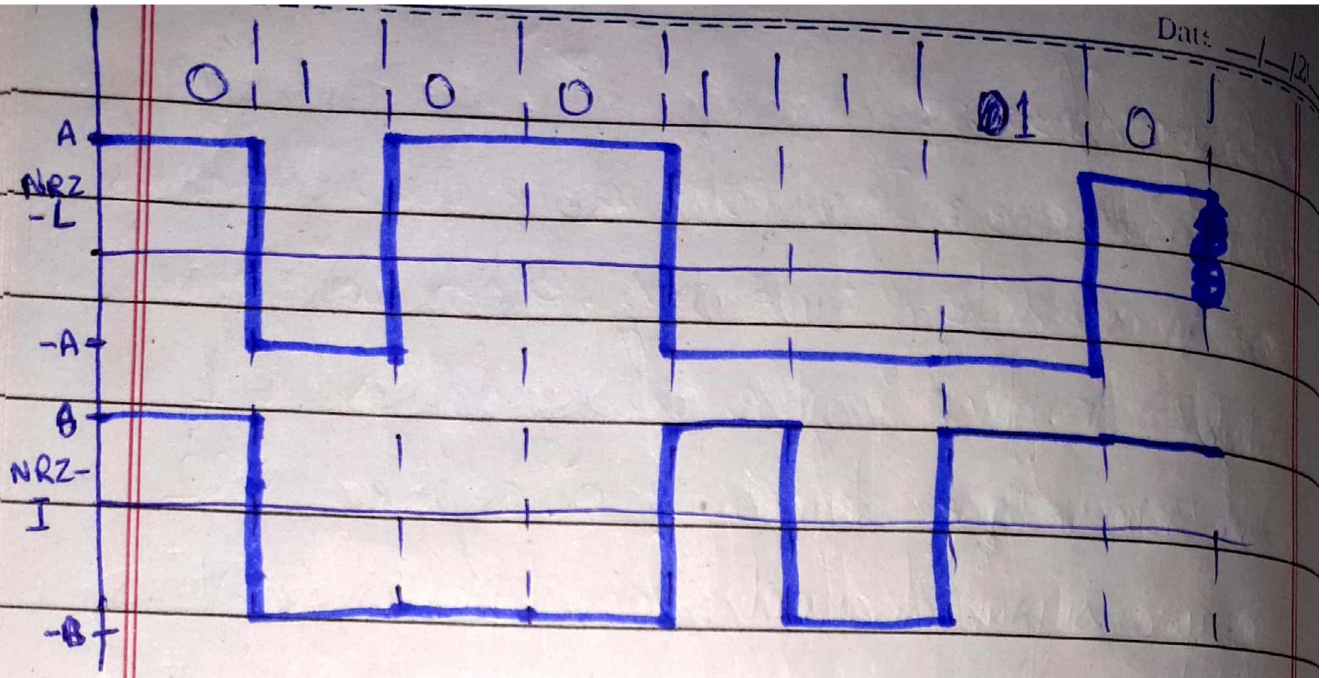


Short cut:
- If 0 comes, then dont change direction
- If 1 comes, then change direction.

NRZ-I: 0 – No Transition
1 – Transition

- In NRZ-L, level of voltage determines value of bit. In NRZ-I, inversion or lack of inversion determines value of bit.
- Both NRZ-L, NRZ-I have avg. signal rate of N/2 Bd.
- Both NRZ-L and NRZ-I have DC-Components.

Ex#4.4 Uses NRZ-I to tranfer 10 Mbps data. What are avg. signal rate and min. B?

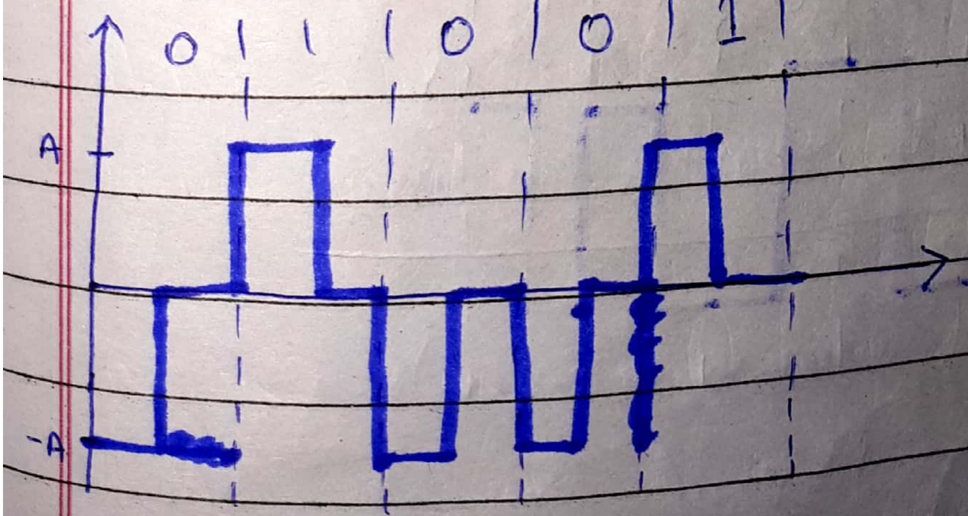
Sol $S = N/2 = \frac{10,000}{2} = 5,000$ kbaud.

$B_{min} = S = 500\,KHz$

6). RZ: The main problem with NRZ encoding occurs when sender and receiver clocks are not synchronized. The receiver does not know which one bit has ended and next bit is starting. One sol is RZ scheme, which uses three values; positive, -ve and zero. In RZ, signal changes not b/w bits but during bit. signal will goes to 0 at middle. It remains there until beginning of next bit.

The main disad. of RZ is that it requires two signal changes to encode a bit and therefore occupies greater bandwidth.

And other is that, it uses three levels of voltage, which is more complex to create and discern.

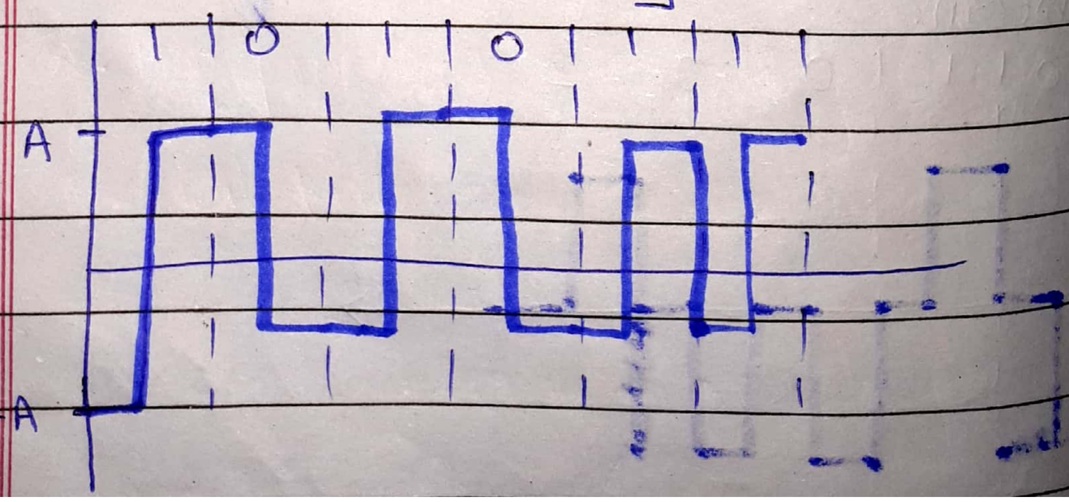


Polar biphase:

c). MANCHESTER: In manchester encoding, duration of bit is divided into two halves. The volt. at one level during first half and moves to the other level in second half. The transition at middle of bit provides synchronization.

* It overcomes problems with NRZ-L ~~and~~ &
* In Manchester and diff. Manchester encoding transition at middle of bit is used for synchroni...
* Signal rate for Manch.. and diff. Manch.. is double that for NRZ.
* Minimum bandwidth of Manc.. and diff. Manch.. is 2 times that of NRZ.

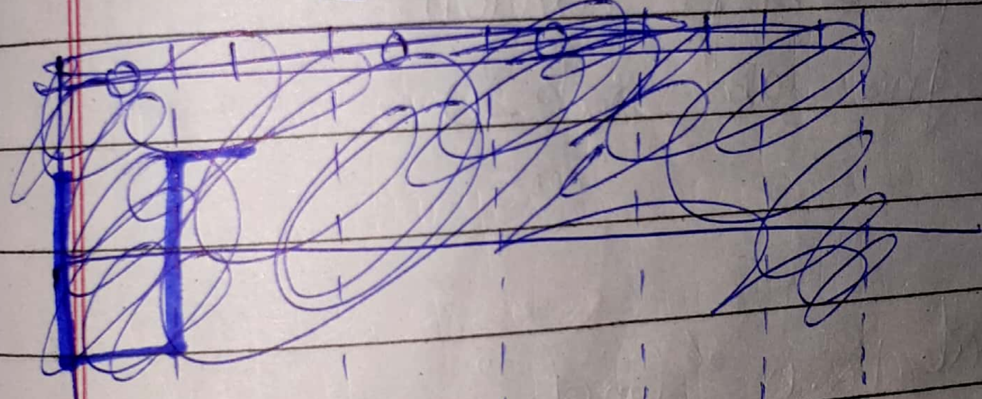
For 0 → ⌉_ , 1 → _⌈

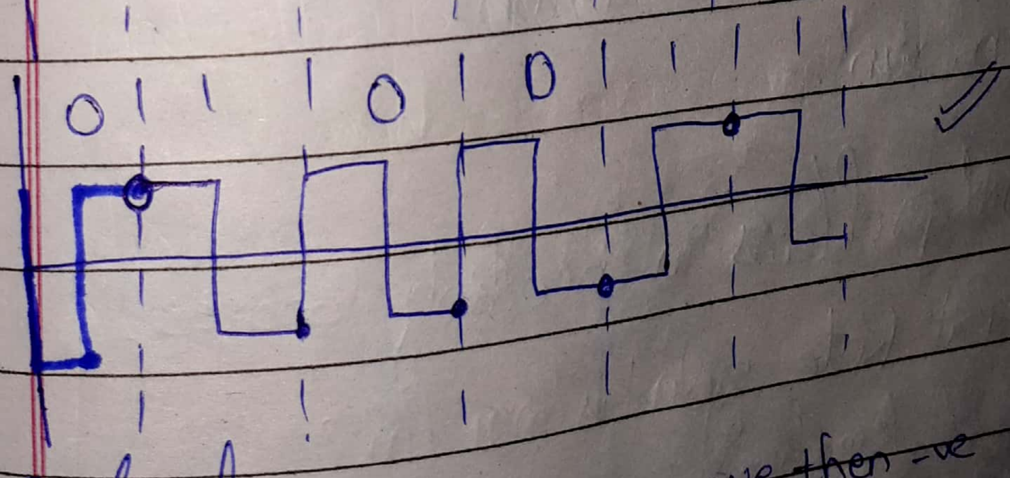


d). Diff. Manchester : It combines idea of RZ and NRZ-I. There is always transition at middle of bit, bit values are determined at beginning of bit. If next bit is 0, there is transition; if next bit is 1, there is none.

* It overcomes problems associated with NRZ-I.

For 0 : , 1 :





3) Bipolar scheme :

AMI : ~~1 is +ve then~~ -ve

Pseudo- : 0 is +ve then -ve.

(0 is +ve at first)

MLT-3:

1). If first bit is 0 then plot on zero.

2). On 1^{st} 1's plot on +ve, then on 2^{nd} 1's plot on zero, then on 3^{rd} 1's plot on -ve and again repeat step 2.

3). No transition of 0.

B8ZS: 8 consecutive zero should be replaced

Case-I (If prev is +ve) then

0 0 0 +ve -ve 0 -ve +ve.

Case-II. (If prev is -ve) then

0 0 0 -ve +ve 0 +ve -ve

Use AMI for other bits till 8 cons zero comes.

HDB3: Use AMI if non cons. zero's are less than 4.

Check total number of prev ~~cons.~~ 1

if

1). even and prev. is -ve

then +ve 0 0 +ve

2). even and prev is +ve.

then -ve 0 0 -ve

3). odd and prev is +ve

0 0 0 +ve

4). odd and prev is -ve : 0 0 0 -ve.

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B8ZS:

If prev. is +ve, 000+-0-+

If prev. is -ve, 000-+0+-

HDB3:

If no. of previous 1's are odd, then 000-

If " " " " even, then +00+

Analog to Digital

PCM: Change analog signal to digital data.

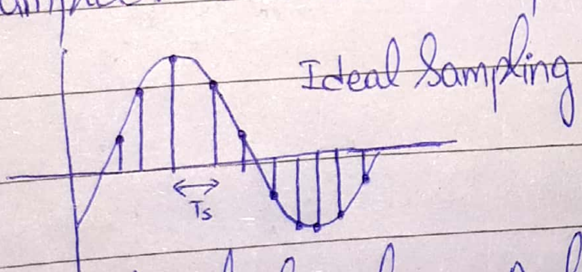
Three processes: 1). Analog signal is sampled.

2). Sampled signal is quantized.

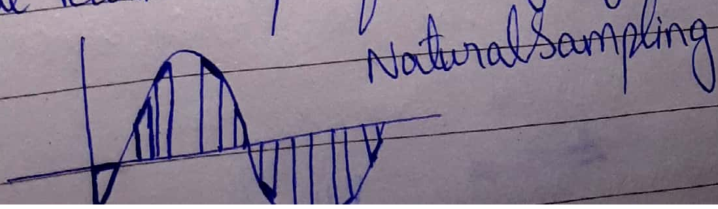
3). Quantized values are encoded as streams of bits.

i- Sampling: Analog signal is sampled every T_s sec, where T_s is period. There are three sampling methods,

a). Ideal Sampling: Pulses from analog signals are sampled. It cannot be implemented easily.



b). Natural Sampling: A high speed switch is turned on for only small period of time when sampling occurs. Result is sequence of samples that retain shape of analog signal.



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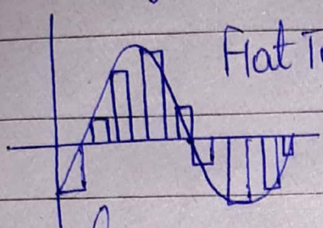
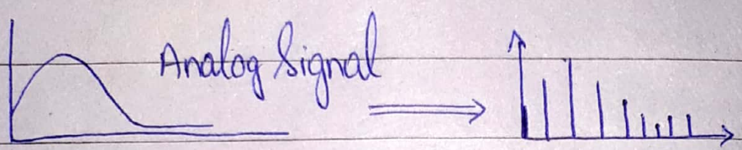
c). Flat Top Sampling: The most sampling method, called sample and hold, however, creates flat top samples.



The sampling process also called PAM. (Pulse Amplitude Modulation).



Sampling Rate:

According to Nyquist theorem, to reproduce the original signal, the sampling rate must be at least 2 times highest frequency contained in signal.

2). Quantization: It is process to convert infinite value signal into finite level.

Quantization Error: Diff. b/w actual value and quantized value.

$E \alpha \frac{1}{L}$ The more zone will result in smaller error but more bits are required to encode data.

A non-uniform quantization is introduced to reduce quantization error. $SNR_{dB} = 6.02 n_b + 1.76 dB$

~~...lbea Signal~~ :

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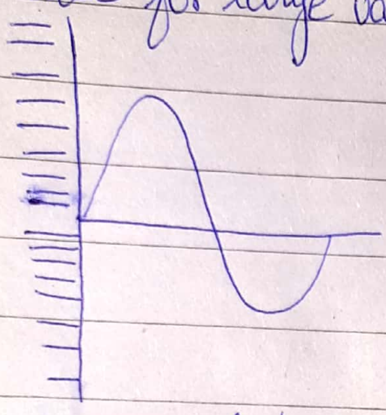
Non-Uniform Quantization:

It can be achieved by process called companding and expanding. The signal is companded at sender before conversion, it is expanded at receiver after conversion.

Companding means reducing instantaneous voltage amplitude for large values and expanding is opposite process



It can be proved that non-uniform quantization effectively reduces SNR_{dB} of quantization.

3). Encoding: The last step in PCM is encoding.

After each sample is quantized and no. of bits per sample is decided, each sample can be changed to an n_b

No. of bits $n_b = \log_2 L$.

Bit Rate $= f_s \times n_b$ = Sampling Rate x no. of bits per sample

PCM decoder: It first uses circuitry to convert code words into pulse that holds amplitude until next pulse. After staircase signal is completed, it is passed through

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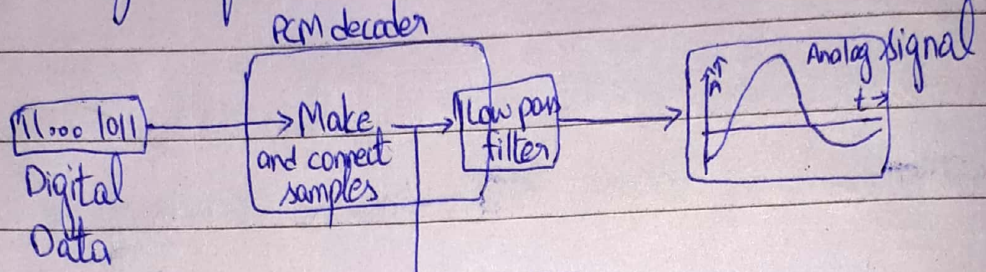
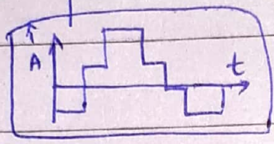
low pass filter to smooth staircase signal into an analog signal. If signal has been sampled at Nyquist sampled rate and if there are enough quantization levels, original signal will be recreated.





PCM Band

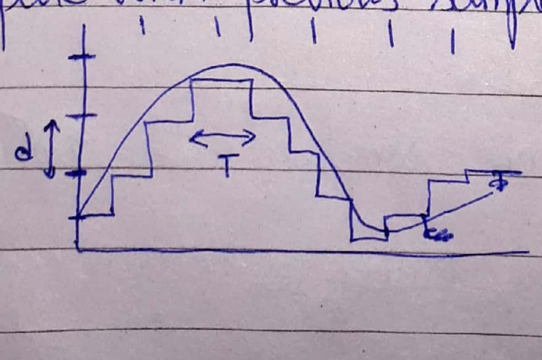
$$\boxed{B_{min} = n_b \times B_{analog}}$$

and $N_{max} = 2 \times B \times \log_2 L$ bps

$$B_{min} = \frac{N}{(2 \times \log_2 L)} \text{ Hz}$$

Delta Modulation:

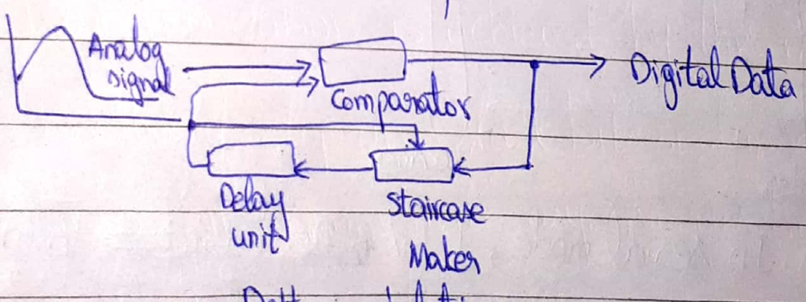
To reduce complexity of PCM. In delta modulation, transmit one bit per sample and present sample value compare with previous sample value.



Modulator: It is used at sender site to create stream of bits from analog signal. The process records small positive or negative changes called delta δ. If δ is +ve, process records 1, if it is -ve, then process records 0.

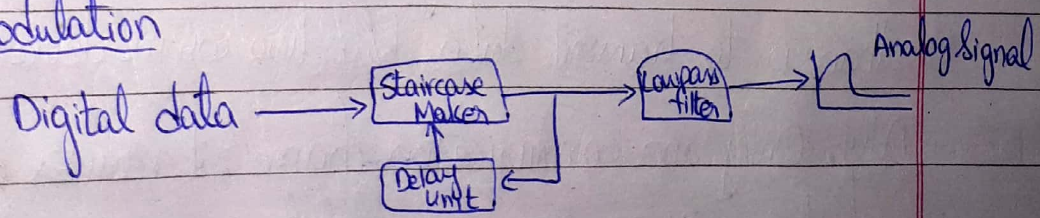
The modulator at each sampling interval, compares value of analog signal with last value of staircase signal. If amplitude of analog signal is larger, next bit is 1 otherwise it is 0.

for demodulation: If next bit is 1, stairmaker moves last point of staircase up. else it makes down. We need a delay unit to hold staircase function for period b/w two comparisions.



Delta modulation

De-modulation



Quantization Error: It is always introduced in process. However, QE of DM is much less than for PCM.

Isochronous Asynchronous Synchronous
Transmission of binary data.

Transmission Modes:

1). Parallel:

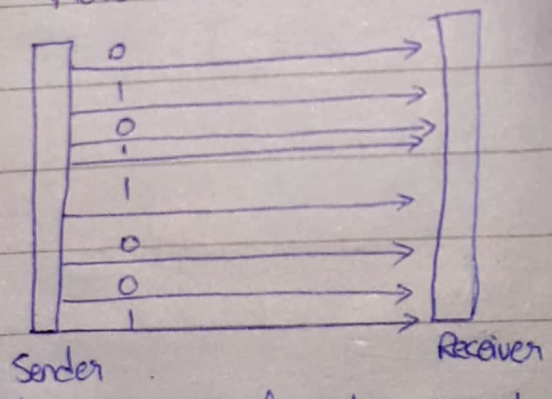
Multiple bits are sent at a time instead of 1 in parallel in the form of 0 and 1. This is called parallel transmission.

Mechanism: Use n wires to send n bits at one time.

Advantage: Is speed. Parallel transmission can increase transfer speed by factor of n over serial transmission.

Disadv.: Is cost. Parallel transmission requires n communication lines just to transmit data stream. Because this is expensive, it is usually limited to short distances.

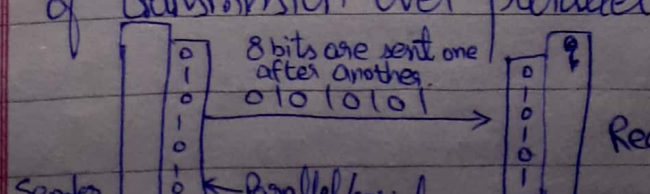
Use: A large amount of data is being sent and data being sent is time sensitive, and data needs to sent quickly.



2). Serial:

In serial mode, 1 bit ~~[illegible]~~ follows another, so we need only communication channel rather than n to transmit data b/w two comm. devices.

Adv.: Only one communication channel, it reduces cost of transmission over parallel transmission.



Disadv: requires conversion devices.

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Use: It is normally used for long distance data transfer. It is also used in cases where amount of data being sent is relatively small.

It occurs in three ways:

a). Asynchronous Transmission:

Transfers of data with start and stop bits and variable time interval b/w data units.

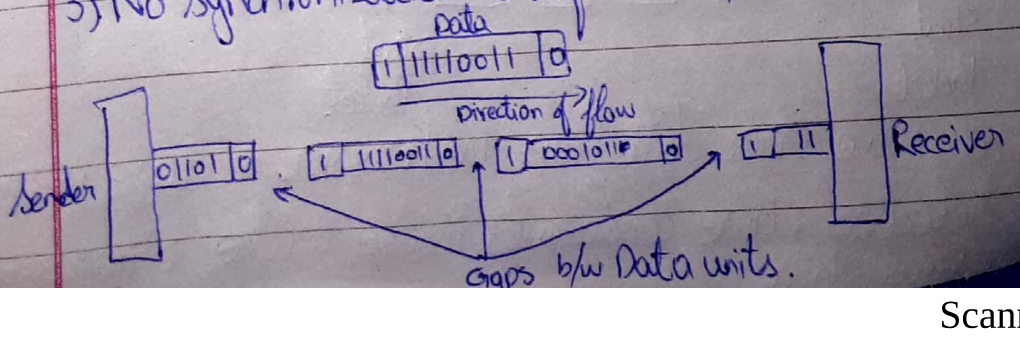
Without synchronization, receiver cannot use timing to predict when next group will arrive. To alert receiver to arrival of new group, an extra bit is added to beginning of each byte. This bit is 0. called start bit. And, to alert receiver that byte is finished, we use bit 1 also called stop bit used at end of each byte. And synchronization is achieved by this method.

Disad: The addition of stop and start bits and insertion of gaps into bit stream make asynchronous transmission slower than other forms of transmission.

Adv: 1) It is cheap and effective.

2). Ideal for low speed comm.

3) No synchronization is required b/w transmitter and receiver devices



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b). Synchronous :

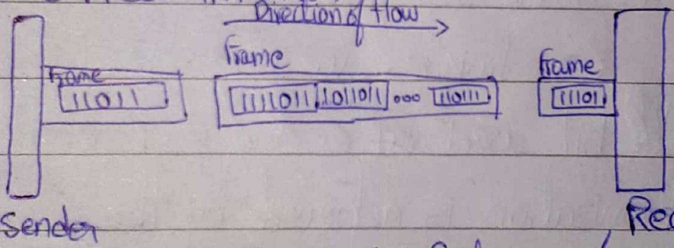
Bit Stream is combined into longer frames, possibly containing multiple bytes.

Def: In synchronous transmission, we send bits one after other without start or stop bits or gaps. It is responsibility of receiver to group the bits.

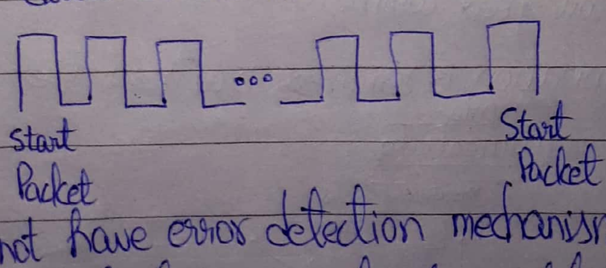
Adv: is speed. As, no extra bits or gaps between the bits, so synchronous transmission is faster than asynchronous

Use: More useful for high speed apps such as transmission of data from one comp. to another.

Disad: For correct operation, receiver must start to sample line at correct instant.



c). Isochronous: It combines the features of sychronous and asynchronous data transfer system. Isochronous data transfer is used where data must be delievered within certain time constraints like streaming video. The isochronous transmission guarantees that data arrive at fixed rate



Disad: It do not have error detection mechanism, because if an error were detected, time constraints would make it impossible to resend data.

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Baseline Wandering: In decoding digital signal, incoming signal power is evaluated against baseline (a running average of received signal power). A long string of 0's and 1's can cause baseline wandering and make it difficult for receiver to decode correctly.

DC Component: When voltage level in digital signal is constant for while, spectrum creates very low frequencies, called DC Components, that present problems for system that cannot pass low frequencies.