Chapter 10

Data Encoding & Modulation

Encoding : It is the technique of assigning binary value to a signal. In case of digital data, encoding is directly done while for analog data, sampling & quantization are neccessary before encoding.

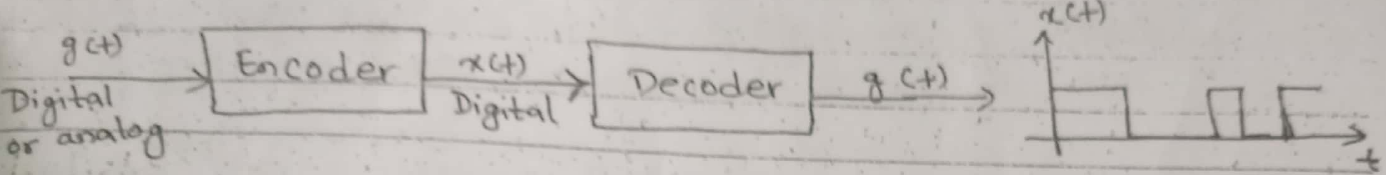


Fig: Encoding onto a digital signal.

Modulation : Modulation is the process of changing signals into a suitable form for analog transmission.

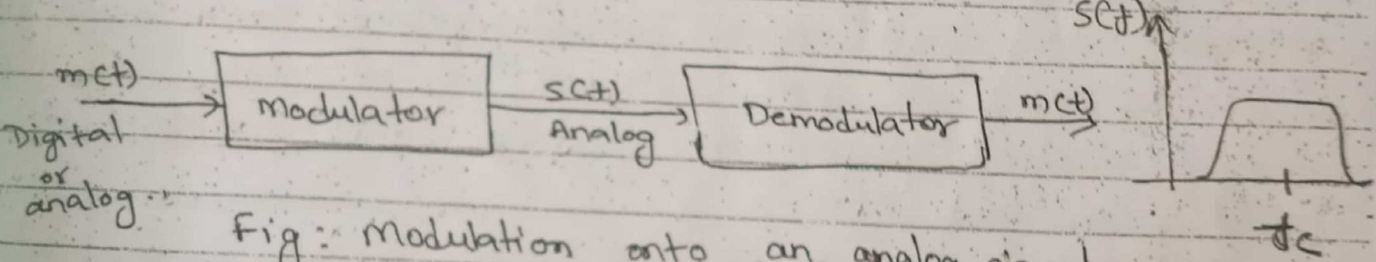


Fig: Modulation onto an analog signal.

- The input signal m(t) may be analog or digital & is called the modulating signal or baseband signal.
- The baseband signal is modulated with a continuous constant-freq^n signal known as the carrier signal.
- s(t) is modulated signal. s(t) is a bandlimited signal centered on fc. (bandpass)

Depending on data & signals used in transmission, different encoding & modulation techniques are adopted as follows

- Digital data, digital signals : Digital encoding of digital data is to assign one voltage level to binary one & another to binary zero. e.g line coding

- Digital data, analog signal : A modem converts digital data to an analog signal so that it can be transmitted over an analog line. e.g Amplitude Shift keying (ASK), freqⁿ shift keying (FSK), Phase shift keying (PSK).

Analog data, digital signals : Analog data, such as voice & video, are often digitized to be able to use digital transmission facilities. e.g pulse code modulation (PCM).

Analog data, analog signals : Analog data are modulated by a carrier freqⁿ to produce an analog signal in a different freqⁿ band, which can be utilized on an analog transmission system. e.g amplitude modulation (AM), freqⁿ modulation (FM) & Phase modulation (PM).

* Line Coding

Line Codes

- Unipolar
  - RZ
  - NRZ
- Polar
  - RZ
  - NRZ
  - Manchester
- Bipolar
  - AMI (Alternative mark inversion)

Line Coding (Encoding of Digital data as Digital Signals)

Binary data can be transmitted using a number of different types of pulses. The choice of a particular pair of pulses to represent the symbols 1 & 0 is called Line Coding. After line coding pulses may be filtered or otherwise shaped to further improve their properties such as spectral efficiency, immunity to ISI (intersymbol interference.)

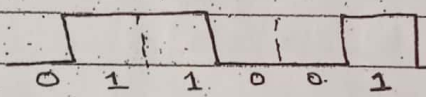
Types:

1) Unipolar signalling

→ also called on-off keying (OOK).

→ In this line coding one binary symbol (e.g 0) is represented by the absence of pulse (i.e a space) & the other binary symbol (e.g 1) is represented by the presence of pulse (i.e a MARK).

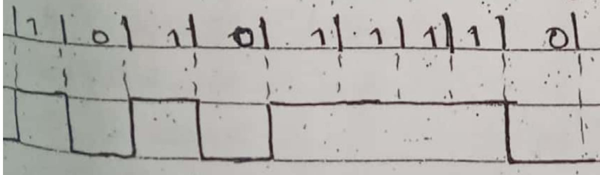
e.g 011001



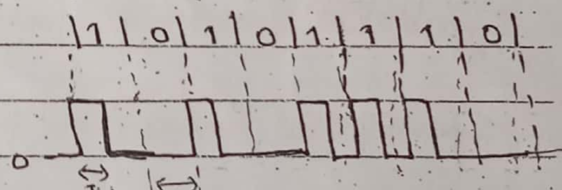
Two common variations of Unipolar signalling

(half 1 other 0)

Unipolar Non-Return to zero (NRZ)



Unipolar Return to zero (RZ)



Symbol '1', $x(t) = A$ for $0 \le t < T_b$

Symbol '0', $x(t) = 0$ for $0 \le t < T_b$

Symbol '1', $x(t) = A$ for $0 < t < T_b/2$, $x(t) = 0$ $T_b/2 < t < T_b$

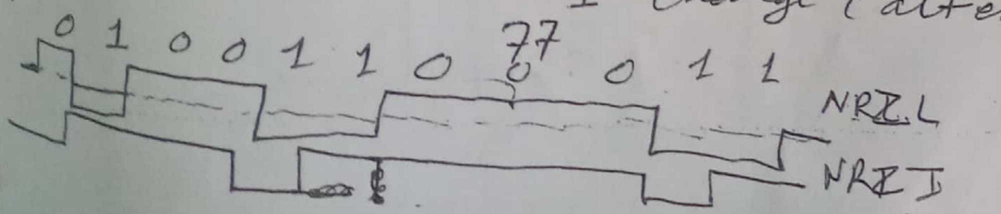
Symbol '0', $x(t) = 0$ for $0 < t < T_b$

NRZ L (NRZ Level) 0 - high level

1 - low level.

NRZ I (NRZ inverted) 0 - no change

1 - change (alternate/invert)

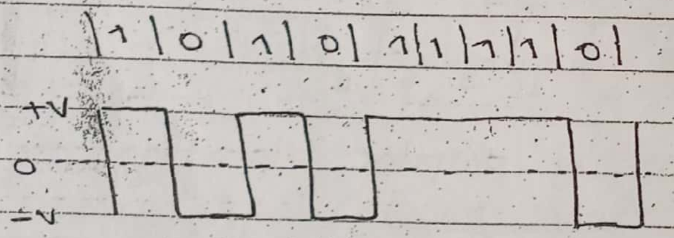


Advantages
→ Simple to implement

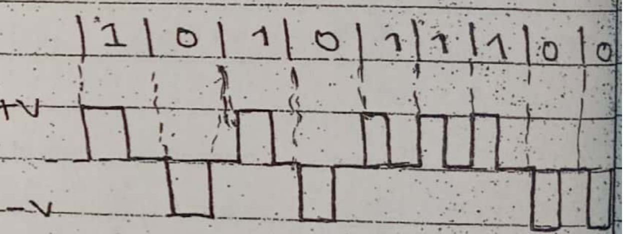
Disadvantages
→ Presence of DC level.
→ Contains low freq^n components causes 'signal Droop'.
→ Does not have any error correction capability.

) Polar Signalling
In polar signalling a binary 1 is represented by a pulse $g_1(t)$ & a binary 0 by the opposite (or antipodal) pulse $g_0(t) = -g_1(t)$. Polar signalling also has NRZ & RZ.

Polar NRZ



Polar RZ

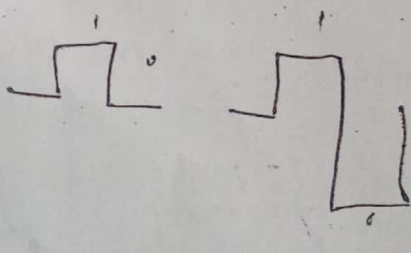


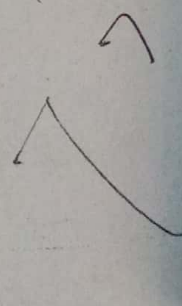
Symbol '1', $x(t) = V$; for $0 \le t < T_b$

Symbol '0', $x(t) = -V$, for $0 \le t < T_b$

Symbol '1', $x(t) = V$, for $0 \le t <$
$= 0$, for $T_b/2 \le t$

Symbol '0',
$x(t) = -V$, for $0 \le t < T_b$
$= 0$, for $T_b/2 \le t$





Advantages
simple to implement
, No DC component.

Disadvantages
contains low freqⁿ component
, Does not have any error correction capability
, " " posses any clocking component for ease of synchronisation

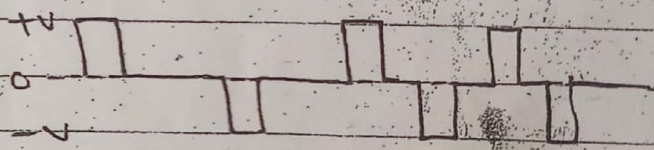
) Bipolar Signalling (AMI)
→ is also called - 'alternate mark inversion' (AMI).

Bipolar NRZ

|1|0|1|0|1|1|1|1|0|

Bipolar RZ

|1|0|1|0|1|1|1|1|0|



Advantages
→ No DC component
→ Does not suffer from Signal droop.
→ Occupies less bandwidth than unipolar & polar NRZ schemes.
→ Possesses single error detection capability.

Disadvantage
→ Does not posses any clocking component for ease of synchronisation.

1) Manchester encoding | Signalling (Biphase)

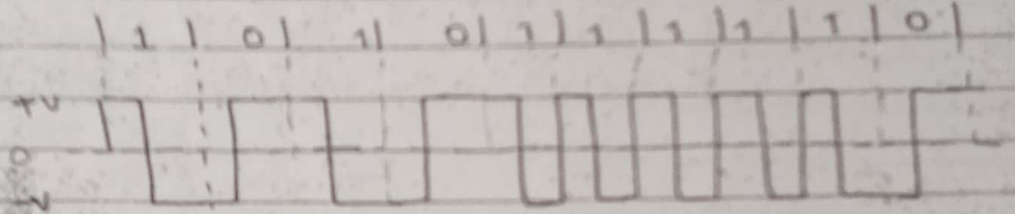
In manchester encoding, the duration of the bit is divided into two halves. The voltage remains at one level during the first half & moves to the other level during the second half.

For symbol '1'

$$x(t) = \begin{cases} A/2, & \text{for } 0 \le t \le T_b/2 \\ -A/2, & \text{for } T_b/2 \le t < T_b \end{cases}$$

For symbol '0'

$$x(t) = \begin{cases} -A/2, & \text{for } 0 \le t < T_b \\ A/2, & \text{for } T_b/2 \le t < \end{cases}$$



→ Manchester encoding is called self-synchronizing.

Advantages
→ No DC component.
→ Does not suffer from signal droop.
→ Easy to synchronise with

Disadvantages
→ Does not have error detection capability.
→ occupies large bandwidth.