# Tutorial 6

# Exercise

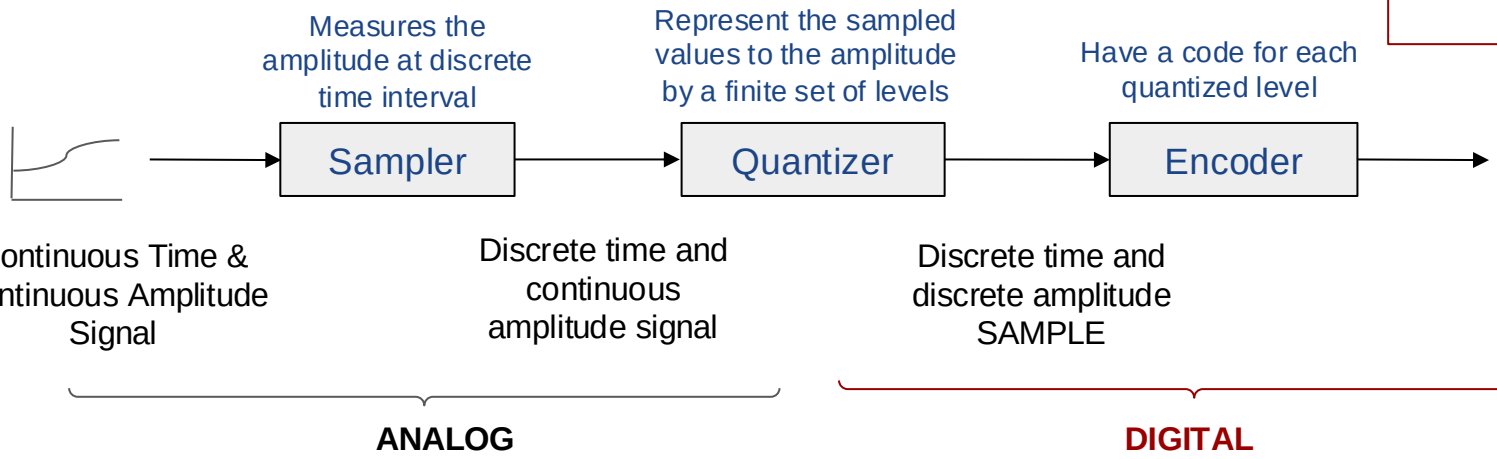
**Question:** Suppose you have 25 magnetic tapes, each containing 40 GB. Assume that you have enough tape readers to keep any network busy. How long will it take to transmit the data over a distance of one kilometer? Assume the choices are Category 5 twisted pair wires at 100 Mbits/second, multi-mode fiber at 1000 Mbits/second, and single mode fibre at 2500 Mbits/second. How do they compare to delivering the tapes by car?

(**Note** Speed of car is 32 kmph; time to load/unload is 300 sec )

# Analog/Digital Conversion

- Also called as **digital pulse modulation**: example PCM(Pulse Code Modulation).
- How to transmit digital data **=>** Pulse Waveforms **?**

Now we will look into the last block: Encoder



# Non Return to Zero (NRZ)

- NRZ signaling/encoding

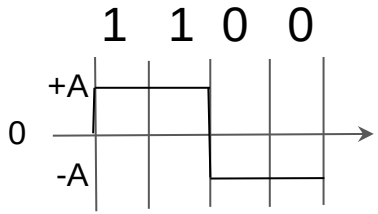
  Symbol 1 : Represented by pulse of positive (poz) amplitude.

  Symbol 0 : Represent by pulse of negative (neg) amplitude.

  | poz amplitude | = | neg amplitude |

- The assigned pulse amplitude is maintained for entire bit interval (bit duration).

  **Example :** 1100



# Bipolar Return to Zero (RZ)

- Bipolar/Polar RZ encoding

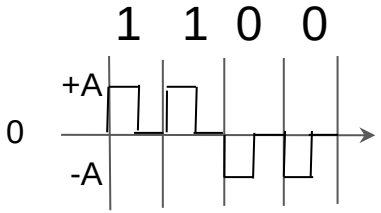
  Symbol 1 : Represented by pulse of positive (poz) amplitude but return to zero before the end of the bit interval.

  Symbol 0 : Represent by pulse of negative (neg) amplitude but return to zero before the end of the bit interval.

  | poz amplitude | = | neg amplitude |

- The assigned pulse amplitude is **not** maintained for entire bit interval (bit duration).

  **Example :** 1100



# Manchester (Spilt-Phase)

- Split-Phase encoding

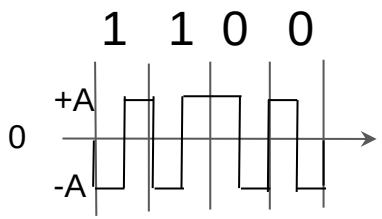
  Symbol 1 : Represented by pulse of negative (neg) amplitude followed by pulse of positive (poz) amplitude.

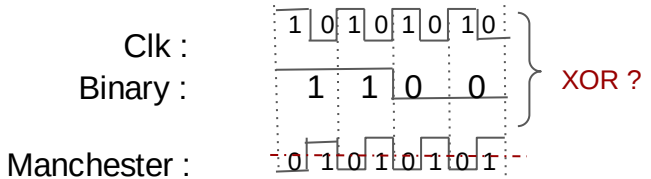
  Symbol 0 : Represented by pulse of positive (poz) amplitude followed by pulse of negative (neg) amplitude.

| poz amplitude | = | neg amplitude |

- Equal pulse amplitude & half bit duration.

**Example :** 1100



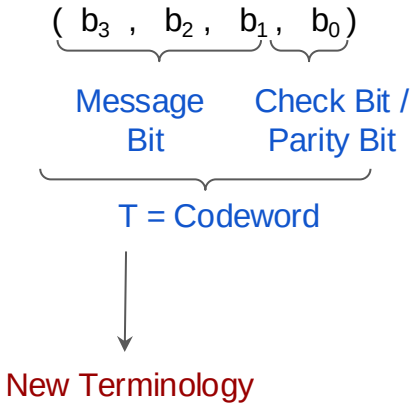




**Question:** For following 8 bit words draw Non return to Zero(NRZ), Bipolar Return to Zero(NZ) and Manchester encoding signals:

10111010 ; 00110101 .

# Error Correction/Detection Code

- Recall LAB 1 & 2 : Parity check bits ( odd/even parity ).




Assume:

Tx = Transmitter

Rx = Receiver


Tx sends message (code word) T over a “noisy channel” to Rx

Channel is NOT perfect (causes transmission error)

# Error Correction/Detection Code

**Exercise:**

# of message bits = 3 = m ——--> # of legal code words = $2^m = 8$

# of check bits = 1 = k

| $b_3$ | $b_2$ | $b_1$ | $b_0$ | |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | —> $T_0 = (0000)$ |
| 0 | 0 | 1 | 1 | —> $T_1 = (0011)$ |
| 0 | 1 | 0 | 1 | |
| 0 | 1 | 1 | 0 | |
| 1 | 0 | 0 | 1 | |
| 1 | 0 | 1 | 0 | |
| 1 | 1 | 0 | 0 | |
| 1 | 1 | 1 | 1 | —> $T_7 = (1111)$ |

Legal Code words

**How many 4 bit word exist ?**

$2^4 = 16 \Rightarrow$ but only 8 of them are legal

**Question 1:** For the following examples answer if $R_i$ is legal ?

$R_0 = (0000)$ ; $R_1 = (0010)$ ; $R_2 = (0100)$ ; $R_3 = (1100)$

**This is Error Detection.**
**(We can do error detection)**

# Error Correction/Detection Code

**Question 2:** For the same example, answer what possible correct code words could be ?

For R1 and R2 as both are not legal

$R_1$ = 0 0 1 0 **(We can’t do error correction)**

$R_2$ = 0 1 0 0 (For Homework)