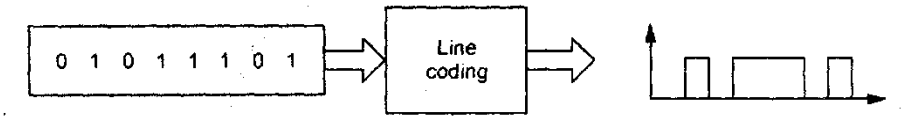
Digital Data Digital Signal

Digital signals are transmitted using LINE CODING technique

Q: What is Line Coding?

In telecommunication, a line code (also called digital baseband modulation, also called digital baseband transmission method) is a code chosen for use within a communications system for baseband transmission purposes. Line coding is often used for digital data transport.



Q: What are the requirements of a Good Line Encoding Schemes

A Desirable Properties for Line Codes are

1. **Transmission Bandwidth**: as small as possible
2. **Power Efficiency**: As small as possible for given BW and
3. **probability of error**
4. **Error Detection and Correction capability**: Ex: Bipolar
5. **Favorable power spectral density**: dc=0
6. **Adequate timing content**: Extract timing from pulses
7. **Avoid Long strings of same pulse**

We can divide line coding schemes into three broad categories

1. Unipolar
2. Polar
3. Bipolar

1. **Unipolar**

Unipolar encoding has 2 voltage states, with one of the states being 0 volts. Since Unipolar line encoding has one of its states at 0 Volts, it is also called Return to Zero (RTZ).

A common example of unipolar line encoding is the TTL logic levels used in computers and digital logic.

2. **Polar**

Polar encoding uses two voltage levels, one positive and one negative. Example NRZI

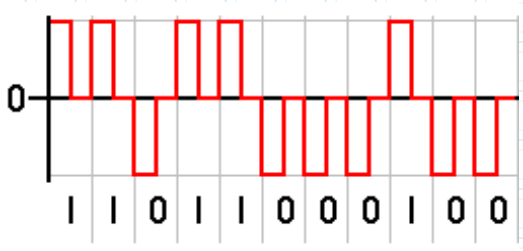
3. **Bi-Polar**

Bipolar encoding, like Rz uses three voltage levels ; positive, negative and zero

Schemes

- **Polar Return to Zero**

Return-to-zero describes a line code used in telecommunications signals in which the signal drops (returns) to zero between each pulse. This takes place even if a number of consecutive 0's or 1's occur in the signal. The signal is **self-clocking.** This means that a separate clock does not need to be sent alongside the signal, but **suffers from using twice the bandwidth** to achieve the same data-rate as compared to non-return-to-zero format.



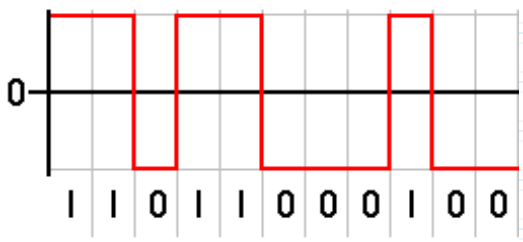
- **Non-Return-to-Zero (NRZ)**

In telecommunication, a non-return-to-zero (NRZ) line code is a binary code in which 1s are represented by one significant condition (usually a positive voltage) and 0s are represented by some other significant condition (usually a negative voltage), with no other neutral or rest condition.

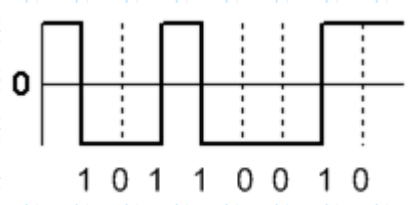
The pulses have more energy than a RZ code.

Unlike RZ, NRZ does not **have a rest state**.

NRZ is **not inherently a self-synchronizing code**,



- **Non-Return-to-Zero Inverted (NRZI)**



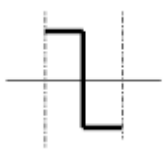
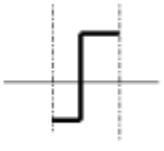
Non return to zero, inverted (NRZI) is a method of mapping a binary signal to a physical signal for transmission over some transmission media.

The two level NRZI signal has a **transition at a clock boundary if the bit being transmitted is a logical 1, and does not have a transition if the bit being transmitted is a logical 0.**

- "One" is represented by a transition of the physical level.
- "Zero" has no transition.

NRZI can have **long series** of **zeros** (or ones if transitioning on "zero"), and thus **clock recovery can be difficult** unless some form of run length limited (RLL) coding is used in addition to NRZI.

- Manchester

Line Coding Scheme	Representation of 0	Representation of 1
Manchester		

In telecommunication and data storage, Manchester coding (also known as **Phase Encoding**, or PE) is a line code in which the encoding of each data bit has at least one **transition and occupies the same time.** It therefore has **no DC component**, and is **self-clocking**,

The name comes from its development at **the University of Manchester**, where the coding was used to store data on the magnetic drum of the Manchester Mark 1 computer.

Manchester coding is widely used (e.g., in 10BASE-T Ethernet)

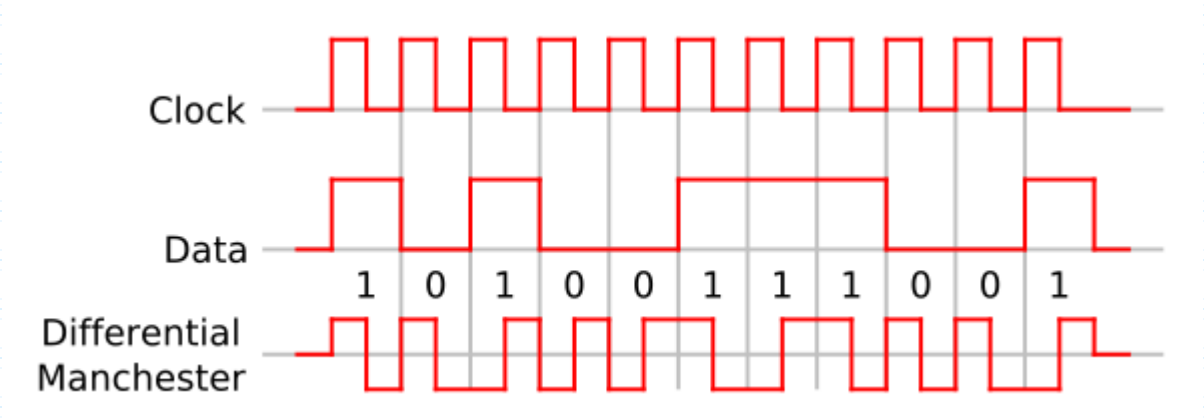
Differentail manchester

Differential Manchester encoding, also called biphase mark code (BMC) or FM1, is a line code in which data and clock signals are combined to form a single 2-level self-synchronizing data stream. It is a differential encoding, using the presence or absence of transitions to indicate logical value. It is not necessary to know the polarity of the sent signal since the information is not kept in the actual values of the voltage but in their change: in other words it does not matter whether a

logical 1 or 0 is received, but only whether the polarity is the same or different from the previous value; this makes synchronization easier.

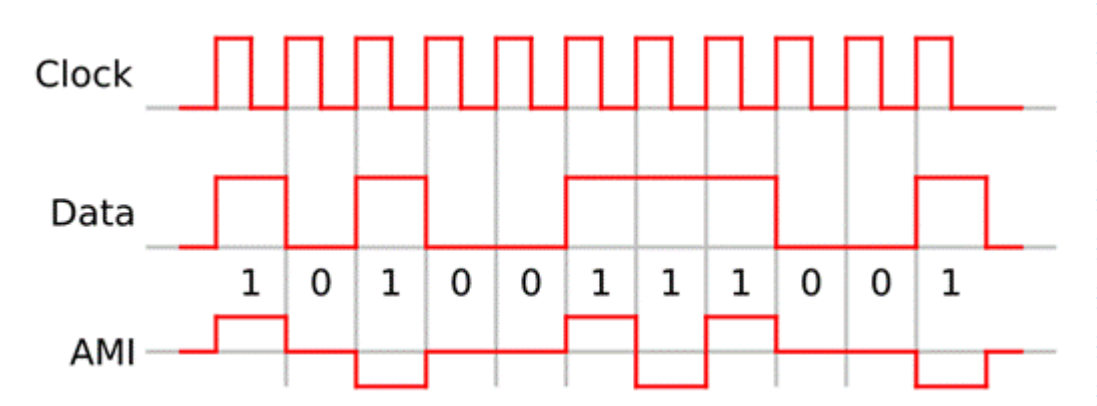
Differential Manchester encoding has the following advantages over some other line codes:

- A transition is guaranteed at least once every bit, allowing the receiving device to perform clock recovery.
- Detecting transitions is often less error-prone than comparing against a threshold in a noisy environment.
- Unlike with Manchester encoding, only the presence of a transition is important, not the polarity. Differential coding schemes will work exactly the same if the signal is inverted (wires swapped). (Other line codes with this property include NRZI, bipolar encoding, coded mark inversion, and MLT-3 encoding).
- If the high and low signal levels have the same voltage with opposite polarity, coded signals have zero average DC voltage, thus reducing the necessary transmitting power and minimizing the amount of electromagnetic noise produced by the transmission line.



Alternate mark inversion

AMI is a bipolar encoding system where neutral (zero) voltage represents binary 0 and alternating positive and negative voltages represents binary 1.



With this line encoding it is the alternating voltages that determine the binary 1s.