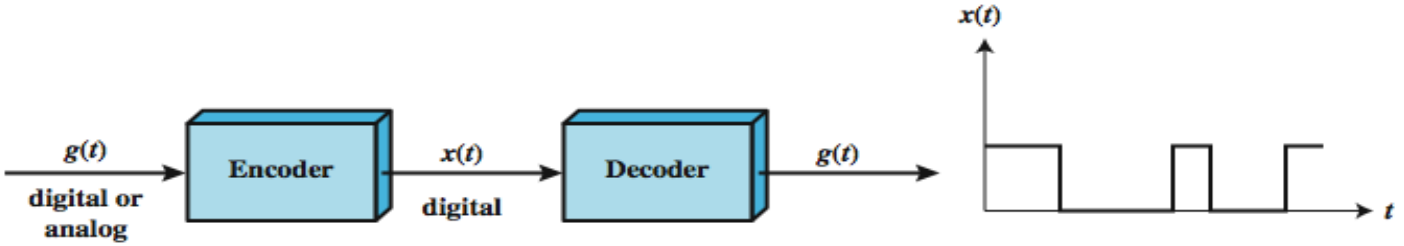
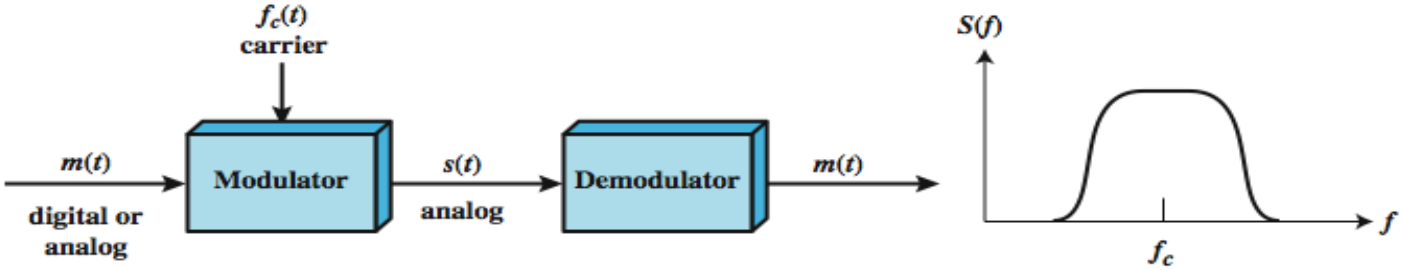
SIGNAL ENCODING TECHNIQUES

DEPARTMENT OF
COMPUTER SCIENCE & ENGINEERING

- **Digital data, digital signals:** simplest form of digital encoding of digital data
- **Digital data, analog signal:** A modem converts digital data to an analog signal so that it can be transmitted over an analog
- **Analog data, digital signals:** Analog data, such as voice and video, are often digitized to be able to use digital transmission facilities
- **Analog data, analog signals:** Analog data are modulated by a carrier frequency to produce an analog signal in a different frequency band, which can be utilized on an analog transmission system



(a) Encoding onto a digital signal

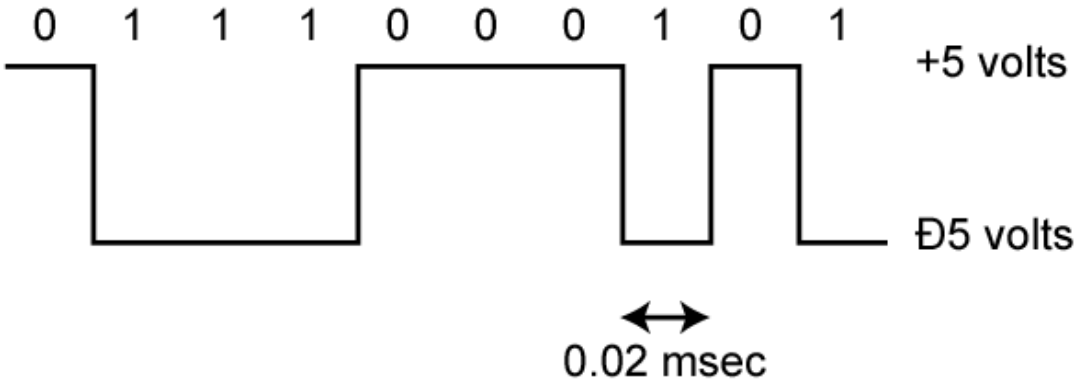


(b) Modulation onto an analog signal

Figure 5.1 Encoding and Modulation Techniques

Digital Data, Digital Signal

- Digital signal
- Discrete, discontinuous voltage pulses
- Each pulse is a signal element
- Binary data encoded into signal elements



Some Terms

- **Unipolar** - signal elements have the same sign
- **Polar** -One logic state represented by positive voltage, other by negative
- **Data rate** - Rate of data (R) transmission in bits per second
- **Duration or length of a bit** - Time taken for transmitter to emit the bit (1/R)
- **Modulation rate** -Rate at which the signal level changes, measured in baud = signal elements per second. Depends on type of digital encoding used
- **Mark and space**-Binary 1 and Binary 0 respectively

Interpreting Signals

Need to know

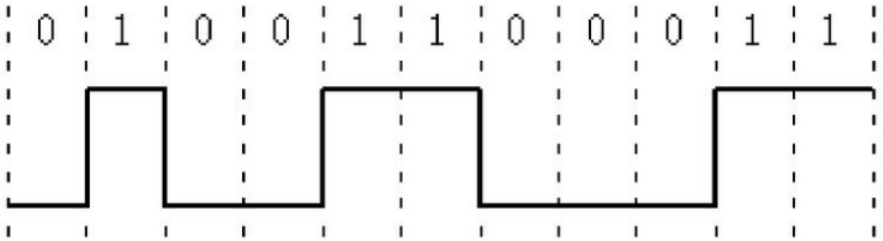
- Timing of bits - when they start and end Signal levels
- Factors affecting signal interpretation
- Signal to noise ratio
- Data rate
- Bandwidth
- Encoding scheme

Comparison of Encoding Schemes

- Signal spectrum
- Clocking
- Error detection
- Signal interference and noise immunity
- Cost and complexity

NonReturn to Zero-Level (NRZ-L)

- In NRZ-L encoding, the polarity of the signal changes only when the **incoming signal changes from a one to zero or from a zero to one**.
- NRZ-L method looks just like the NRZ method, except for the first input one data bit.
- This is because NRZ does not consider the first data bit to be a polarity change, where NRZ-L does.



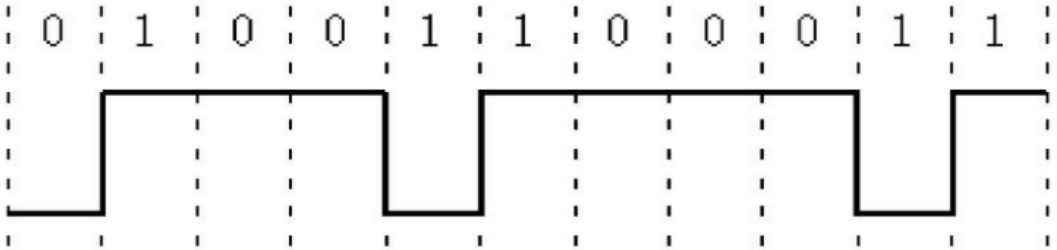
NonReturn to Zero Inverted- NRZI

- ✓ '0' is encoded as no change in the level.
- ✓ **'1'** is encoded depending on the **current state** of the line.

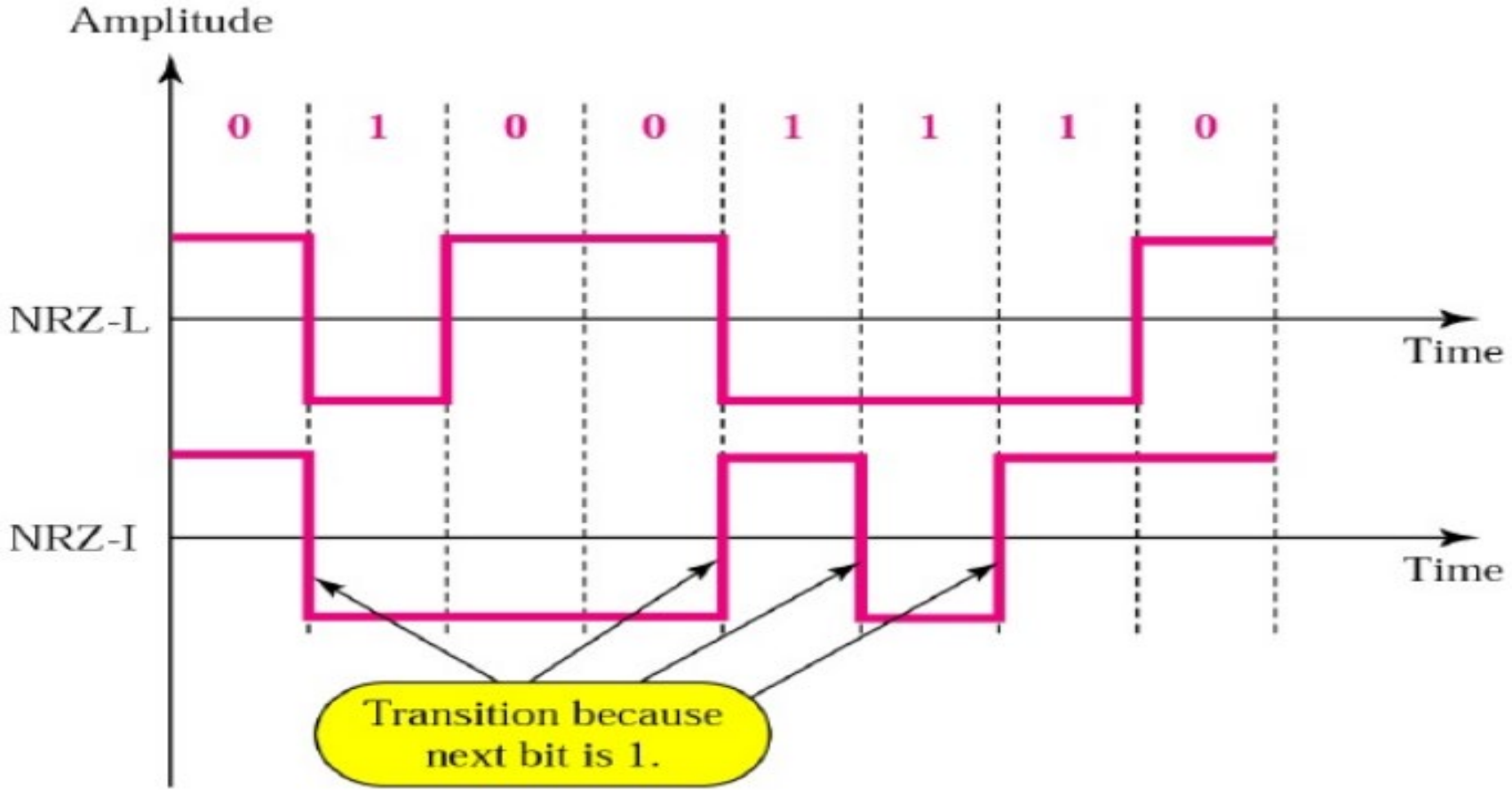
  If the current state is **[low]** the '1' will be encoded as a high,

  if the current state is **[high]** the '1' will be encoded as a low.

  Used with FDDI and USB for example.



Find the Encoding Signals for 01001110 using NRZ-L and NRZI



NRZ Pros & Cons

Pros

- Easy to engineer
- Make good use of bandwidth

Cons

- presence of a DC component
- Lack of synchronization capability
- Consider that with a long string of 1s or 0s for NRZ-L or a long string of 0s for NRZI, the output is a constant voltage over a long period of time. Under these circumstances, any drift between the clocks of transmitter and receiver will result in loss of synchronization between the two.
- Because of their simplicity and relatively low frequency response characteristics, NRZ codes are commonly used for digital magnetic recording.
- However, their limitations make these codes unattractive for signal transmission applications.

Multilevel Binary Bipolar-AMI

Binary 0 is represented by no line signal, and a binary 1 is represented by a positive or negative pulse.

The binary 1 pulses must alternate in polarity.

Advantages

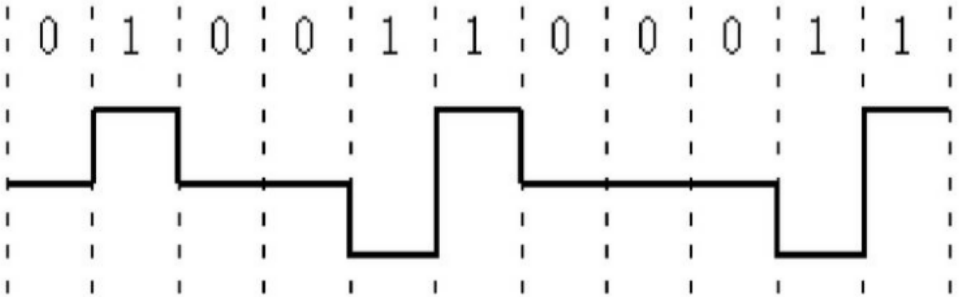
First, there will be no loss of synchronization if a long string of 1s occurs.

Each 1 introduces a transition, and the receiver can resynchronize on that transition.

A long string of 0s would still be a problem.

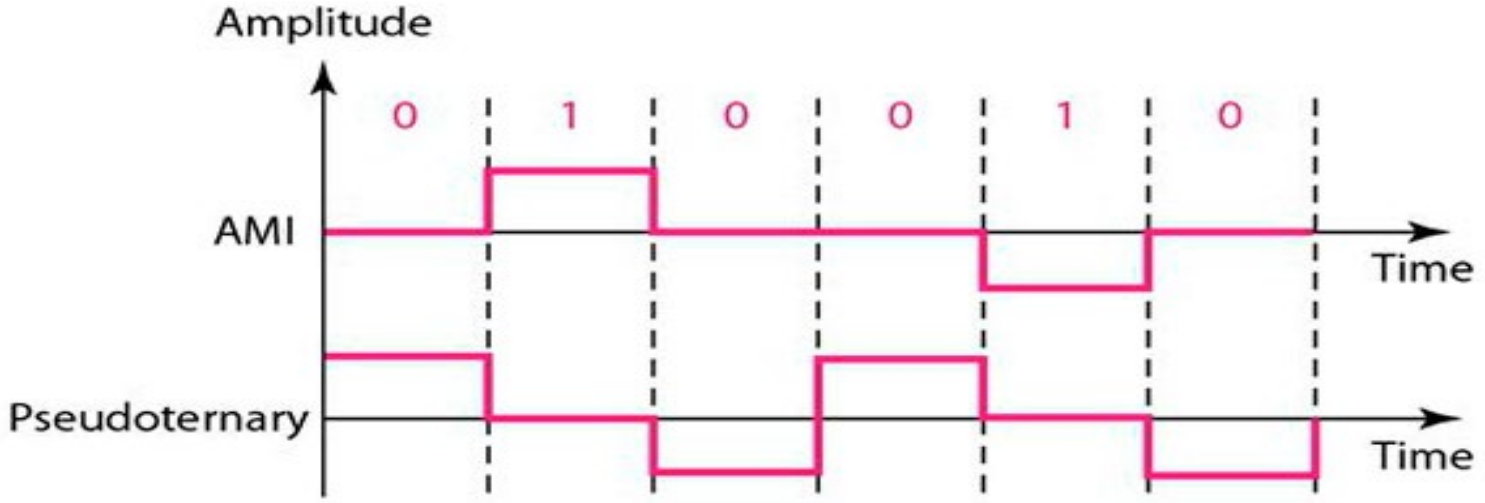
Second, because the 1 signals alternate in voltage from positive to negative, there is **no** net dc component.

- Also, the bandwidth of the resulting signal is considerably less than the bandwidth for NRZ. Finally, the pulse alternation property provides a simple means of error detection.
- Any isolated error, whether it deletes a pulse or adds a pulse, causes a violation of this property.



Multilevel Binary Pseudoternary

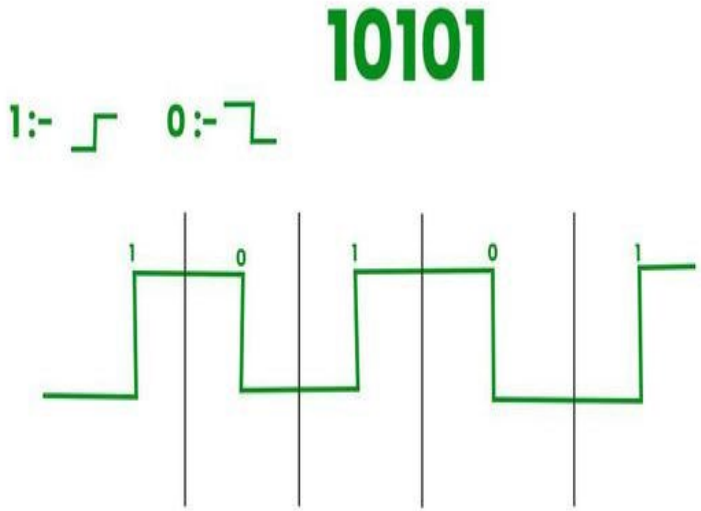
- One represented by absence of line signal
- Zero represented by alternating positive and negative
- No advantage or disadvantage over bipolar-AMI
- Each used in some applications.



Manchester Encoding

- In Manchester duration of a bit is divided into two halves.
- The voltage remains the same at one level during the first half & moves to the other level.
- The transition at the middle of the bit provides synchronization.
- Differential Manchester, combines the idea of RZ and NRZ-I.
- There is always a transition at the middle of the bit, but the bit values are determined at the beginning of the bit.
- if next bit is zero there is transition if next bit is 1 there is none .

- In this Manchester encoding, 0 is represented as high-to-low and 1 is represented as low-to-high.



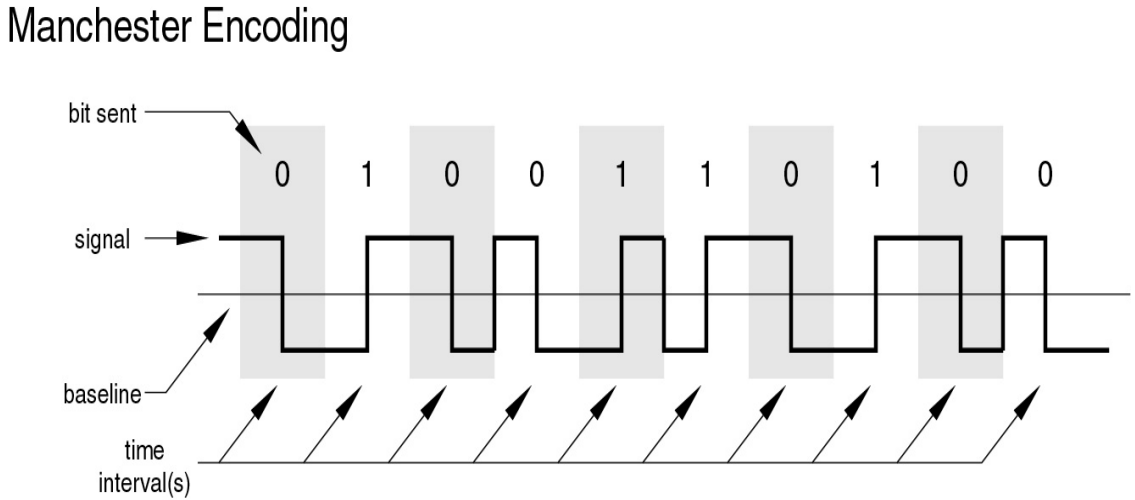
Manchester encoding

Manchester encoding is a biphase encoding in which the transition takes place in the middle of the bit period .The midbit transition serves as a **clocking mechanism** and also as **data**:

a low-to-high transition for **1**,

a high-to-low transition for **0**.

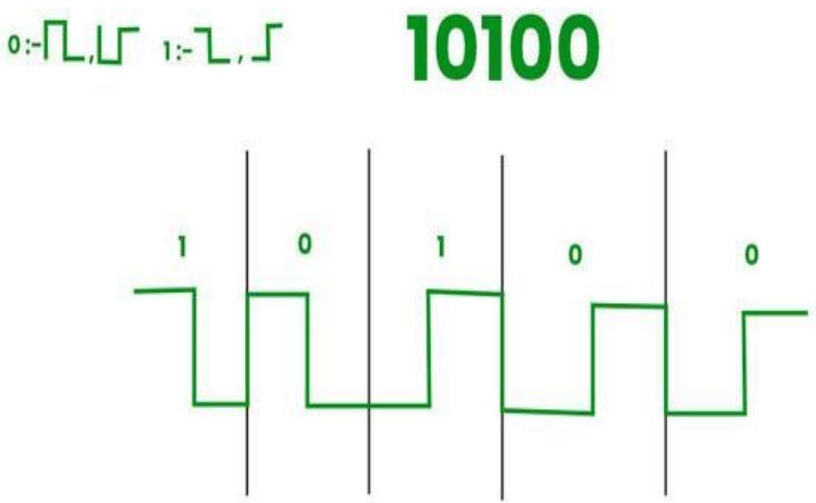
Find the Encoding Signals for 0100110100 ?



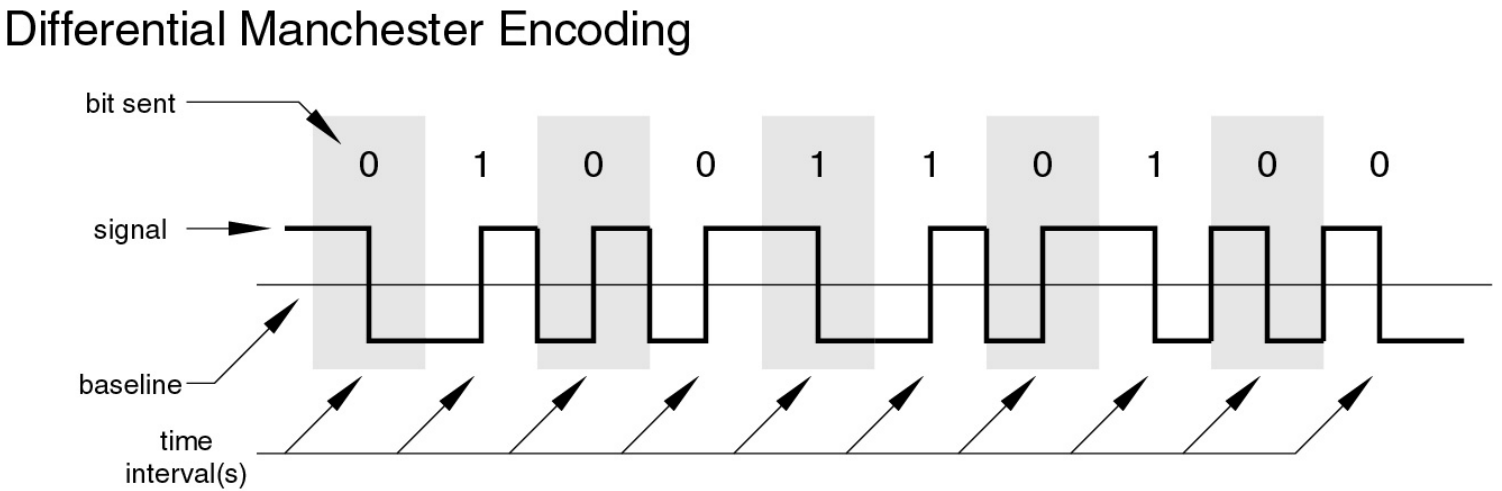
Differential Manchester Encoding

- The mid-bit transition is used only to provide clocking
- The encoding of a 0 is represented by the presence of a transition at the beginning of a bit period, and a 1 is represented by the absence of a transition at the beginning of a bit period.
- Differential Manchester has the added advantage of employing differential encoding.

- The presence and absence of the transition indicate the value.
- In Differential Manchester Encoding 0 should contain an edge but 1 should not contain any edge it should be continuous.



- ✓ Transition at start of bit period representing 0
- ✓ No transition at start of bit period representing 1
  - this is a differential encoding scheme



Biphase Pros and Cons

Con

At least one transition per bit time and possibly two

Maximum modulation rate is twice NRZ

Requires more bandwidth

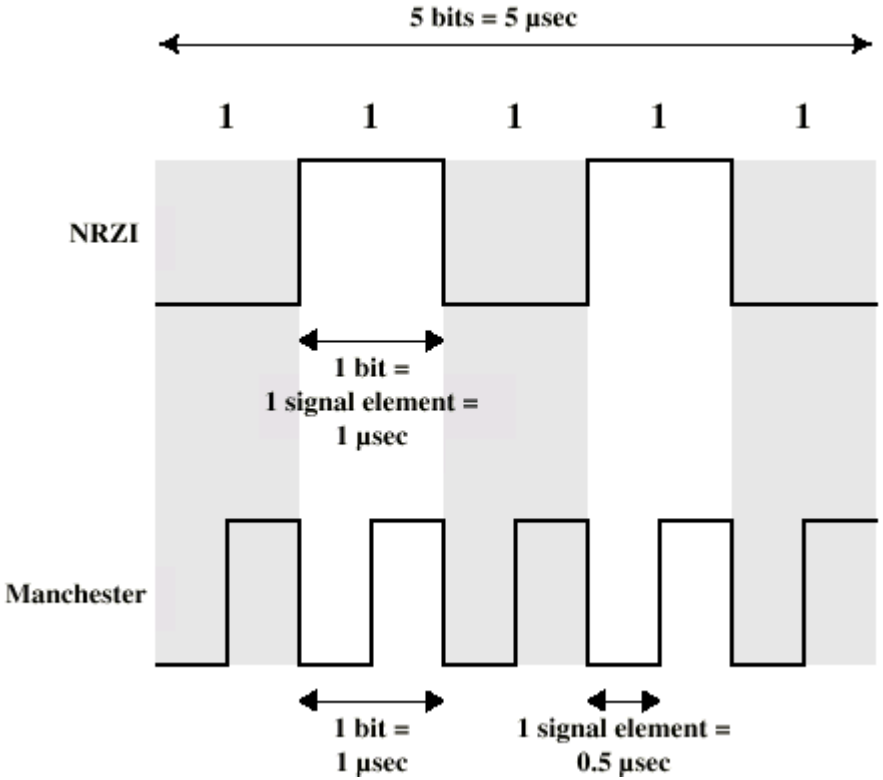
Pros

Synchronization on mid bit transition (self clocking)

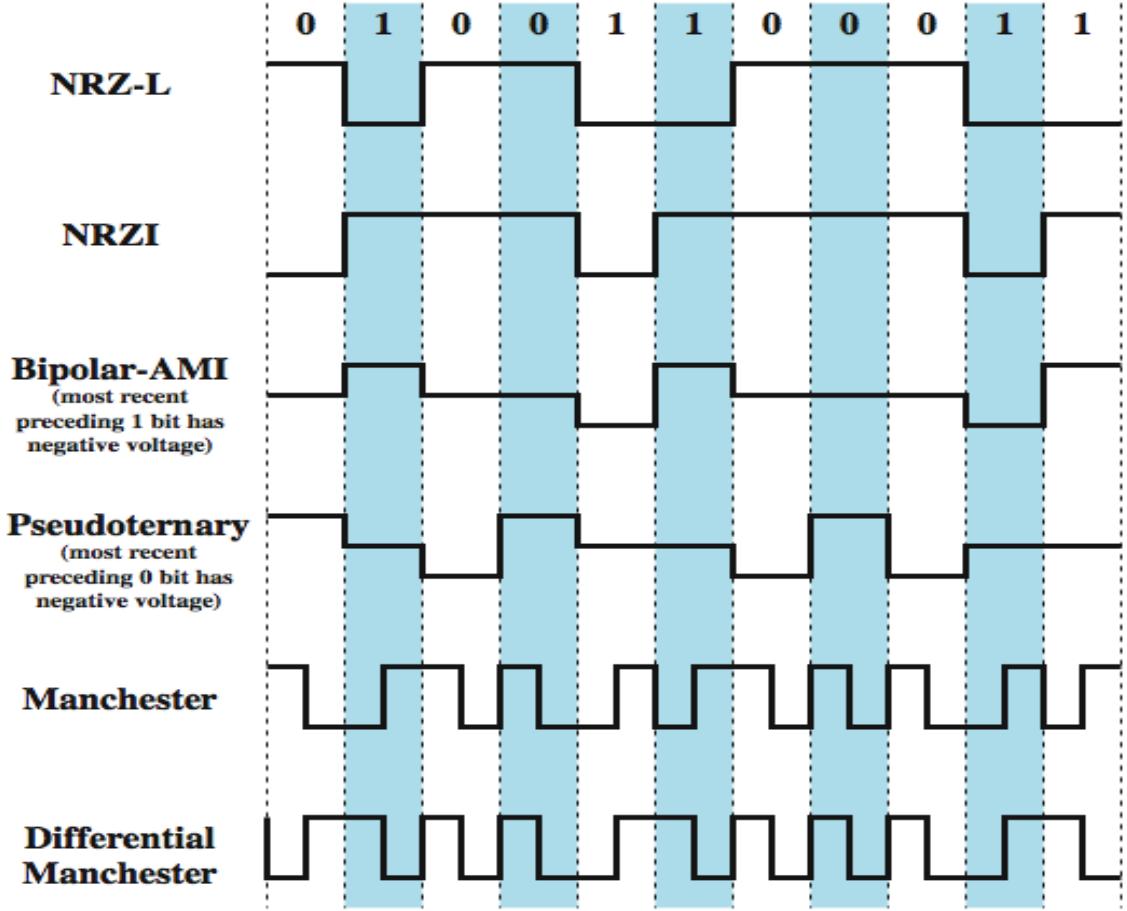
Has no dc component

Has error detection

Modulation Rate



Encoding Schemes



Problems

- Q1. Assume a stream of ten 1's. Encode the stream using the following schemes:

  NRZ-I, AMI, Manchester, Differential Manchester.

  How many transitions (vertical lines) are there for each scheme.

- Q2. For the Manchester encoded binary stream of the following page, extract the clock information and the data sequence.

Fig : Manchester Stream