Data Communication

Digital Transmission

DIGITAL-TO-DIGITAL CONVERSION

- In this section, we see how we can represent digital data by using digital signals.
- The conversion involves three techniques: line coding, block coding, and scrambling.
- Line coding is always needed; block coding and scrambling may or may not be needed.

DIGITAL-TO-DIGITAL CONVERSION

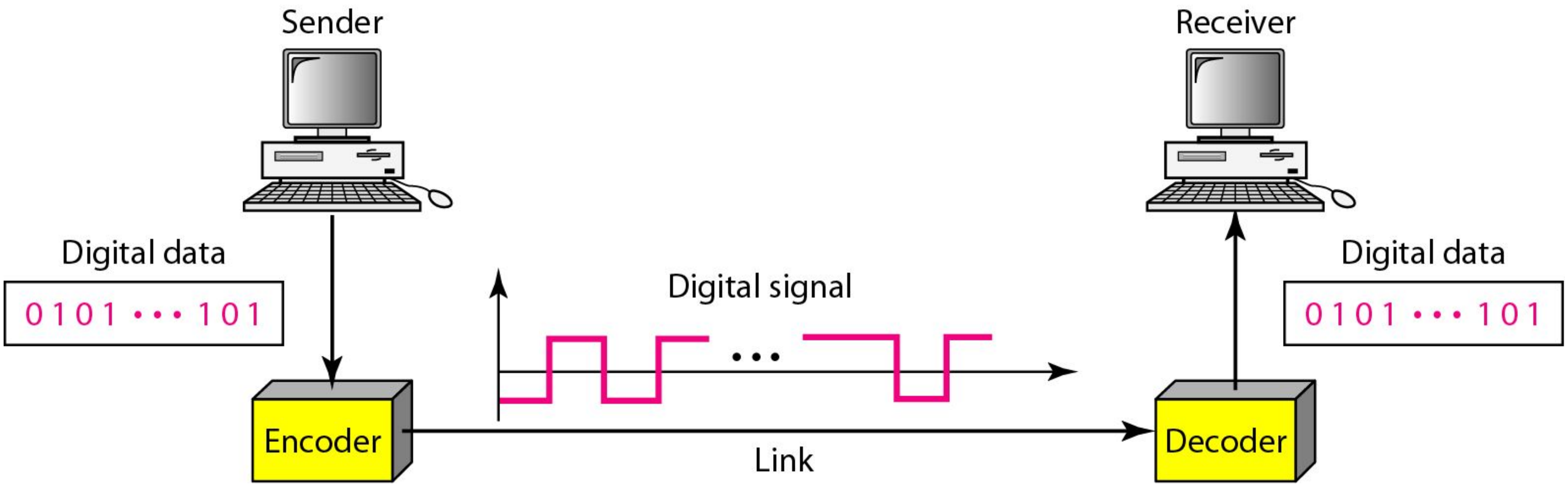
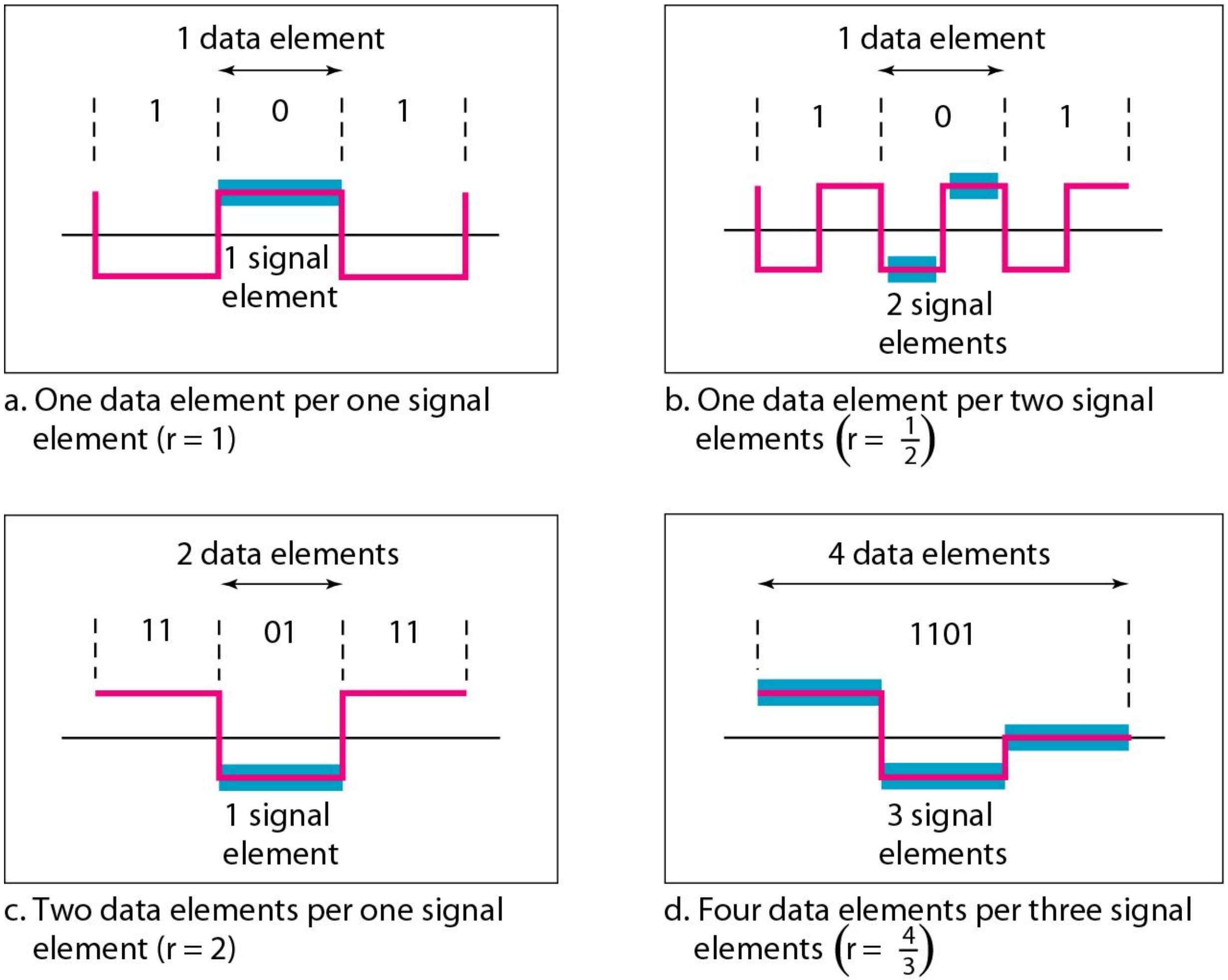


Figure 4.1 ***Line coding and decoding***

DIGITAL-TO-DIGITAL CONVERSION



a. One data element per one signal element (r = 1)

b. One data element per two signal elements $\left(r = \frac{1}{2}\right)$

c. Two data elements per one signal element (r = 2)

d. Four data elements per three signal elements $\left(r = \frac{4}{3}\right)$

Figure 4.2 ***Signal element versus data element***

Data Rate Versus Signal Rate

- The data rate defines the number of data elements (bits) sent in 1s. The unit is bits per second (bps).

- The signal rate is the number of signal elements sent in 1s. The unit is the baud.

- The data rate is sometimes called the bit rate; the signal rate is sometimes called the pulse rate, the modulation rate, or the baud rate.

Line coding

8 Line coding (waveform)

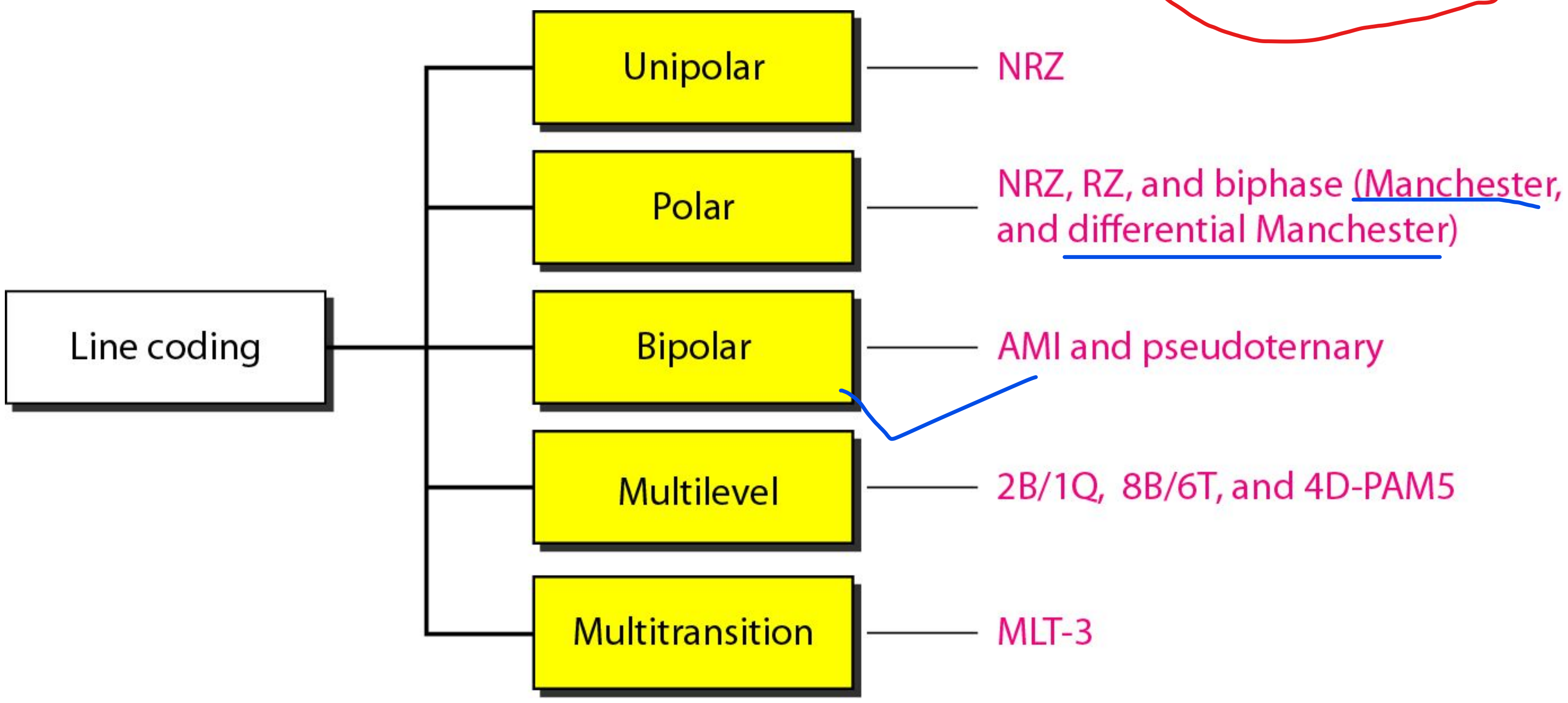


Figure 4.4 ***Line coding schemes***

* Power Fluctuation = voltage up/down/on/off
* Power Consumption = current loss
* Charge Accommodation = charge store (bit dependent)
* Error collection = NRZ-I and Differential Manchester.

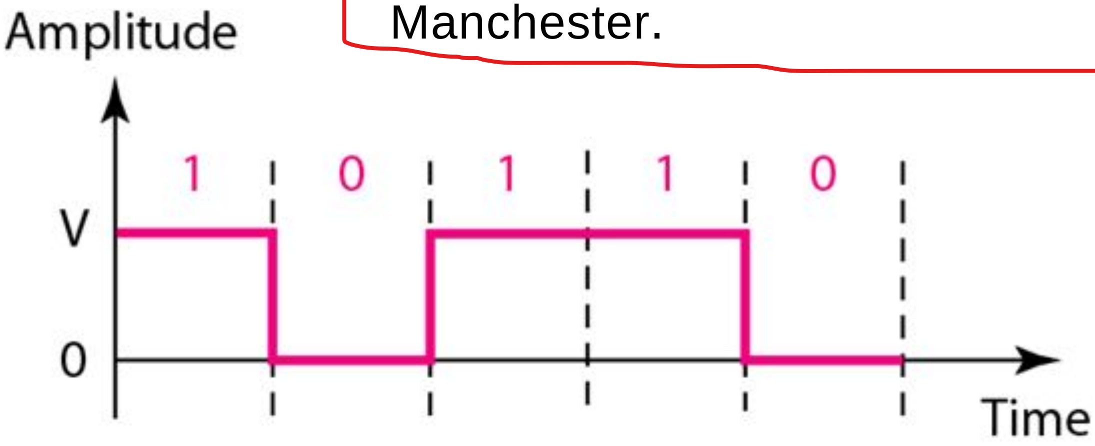
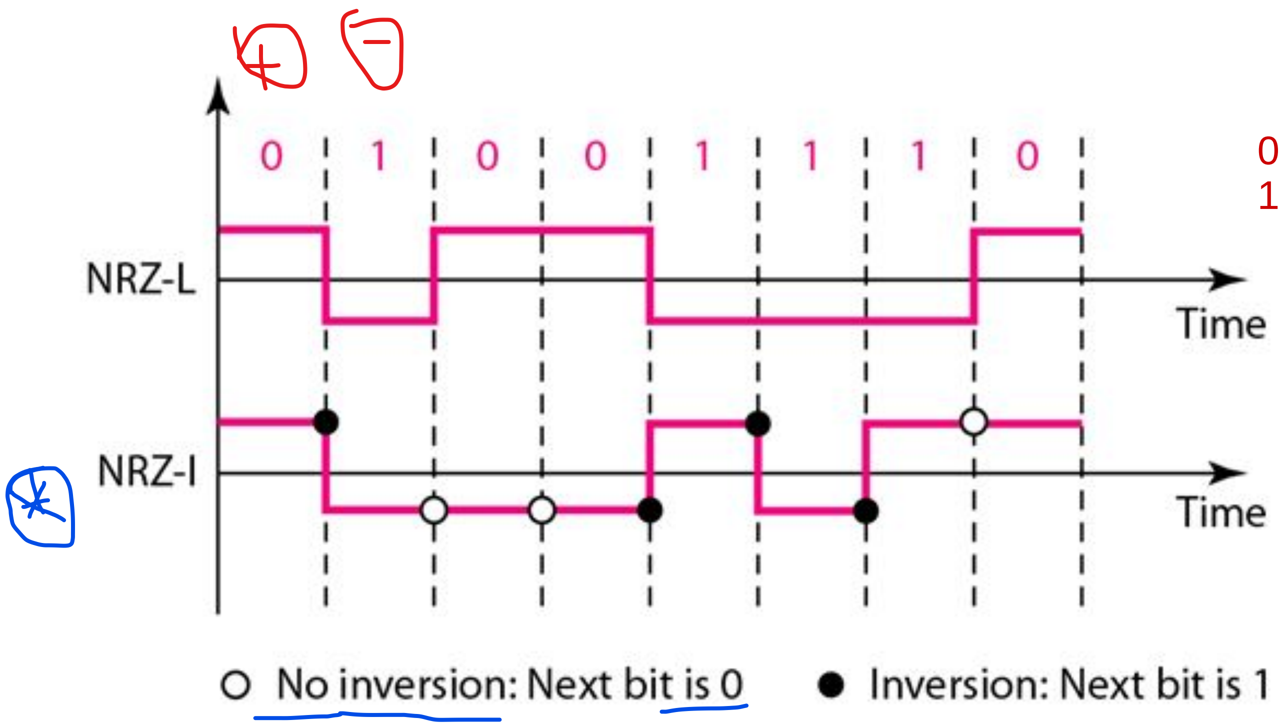


Figure 4.5 ***Unipolar NRZ scheme***



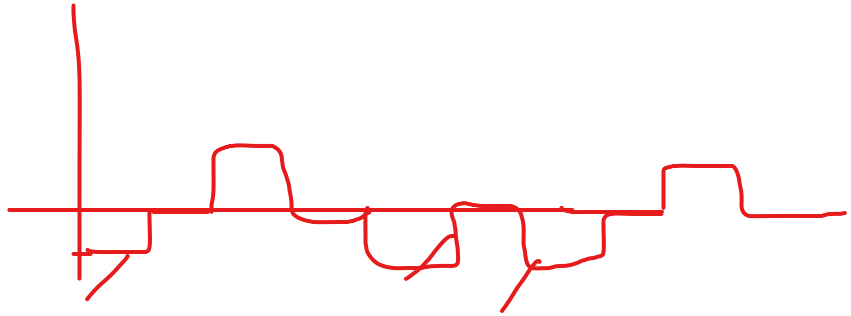
0 = Positive
1 = negative

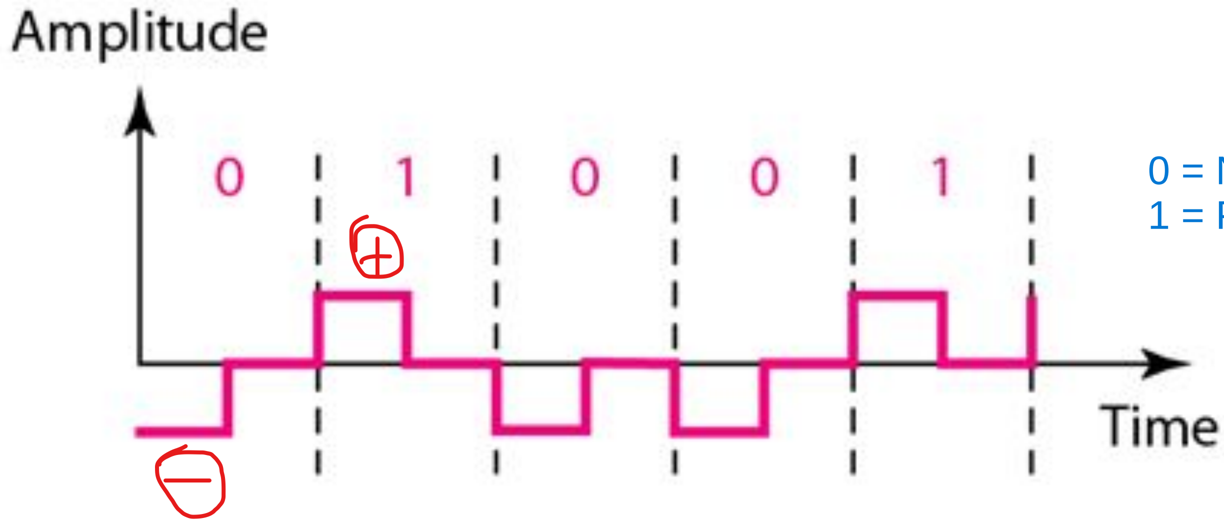
0 = First is Positive,
Always No Change.

1 = Change in Pos &
Neg each side.

Figure 4.6 *Polar NRZ-L and NRZ-I schemes*

In NRZ-L the level of the voltage determines the value of the bit. In NRZ-I the inversion or the lack of inversion determines the value of the bit.





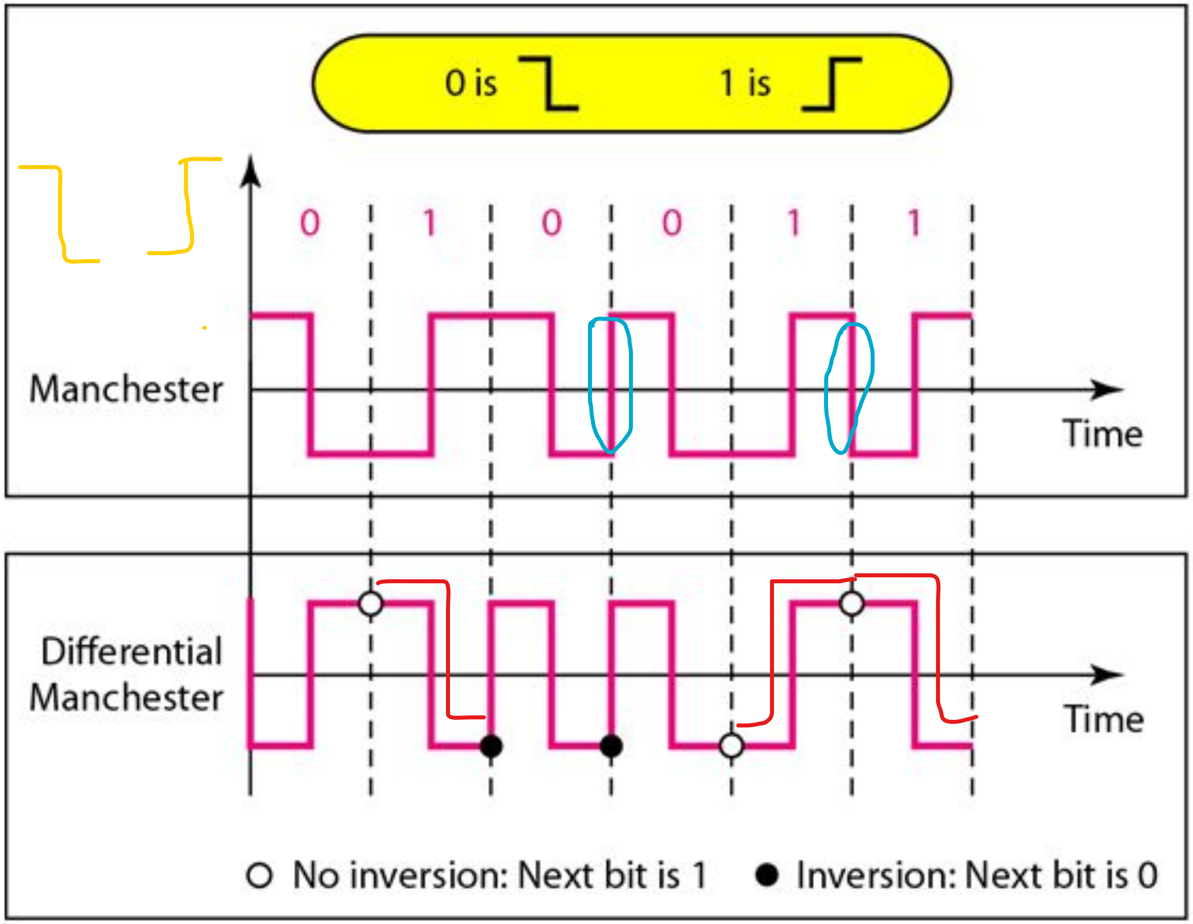
0 = Negative to off
1 = Positive to off

Figure 4.7 ***Polar RZ scheme***

Return Zero

Manchester is half cycle

Not sure



0 and 1 fixed

1 = change (cycle change)
0 = no change

Figure 4.8 ***Polar biphase: Manchester and differential Manchester schemes***

Bit-synchronous operation, clock timing is usually delivered at twice the modulation rate.

In Manchester and differential Manchester encoding, the transition at the middle of the bit is used for synchronization.

In bipolar encoding, we use three levels: positive, zero, and negative.

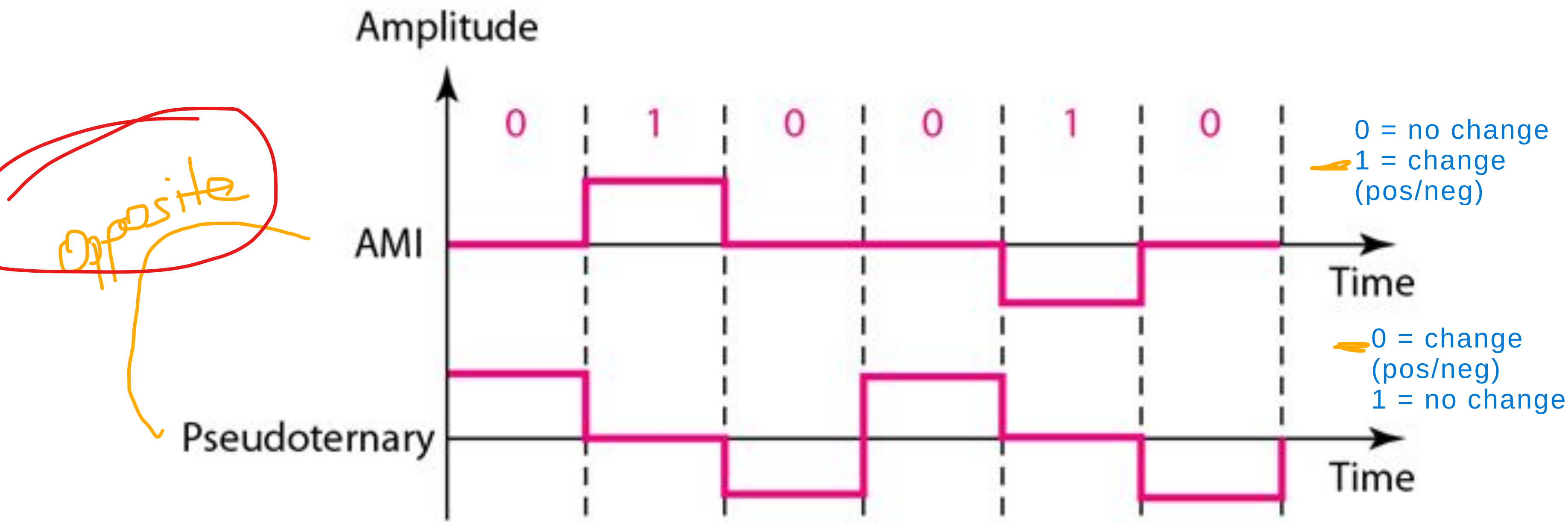


Figure 4.9 ***Bipolar schemes: AMI and pseudoternary***

AMI means Alternate Mark Inversion

Multilevel Schemes

The goal is to increase the number of bits per baud by encoding a pattern of *m* data elements into a pattern of *n* signal elements.

We only have two types of data elements (0s and 1s), which means that a group of *m* data elements can produce a combination of *2m* data patterns.

We can have different types of signal elements by allowing different signal levels.

Multilevel Schemes

- The code designers have classified the encoding process as *mBnL,* where *m* is the length of the binary pattern, *B* means binary data, *n* is the length of the signal pattern, and *L* is the number of levels in the signalling.

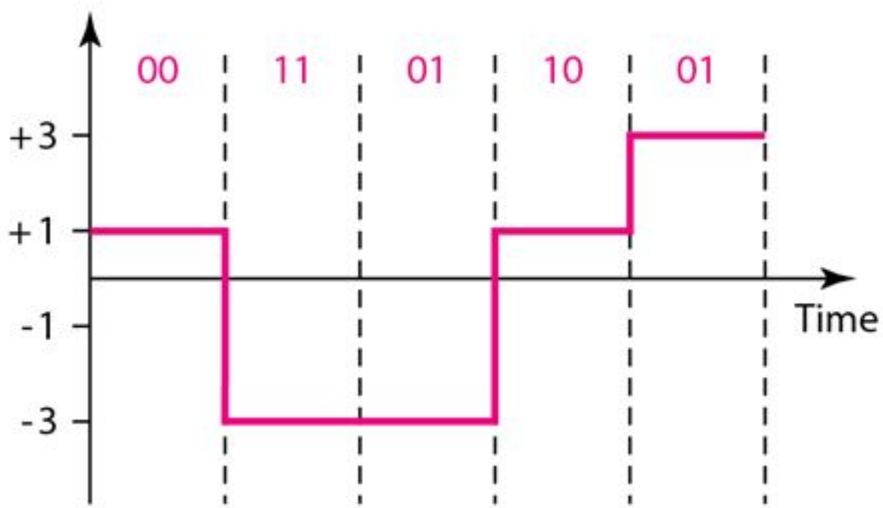
- A letter is often used in place of L:

B(binary) for *L* =2, *T* (ternary) for *L* =3, and Q (quaternary) for *L* =4.

Note that the first two letters define the data pattern, and the second two define the signal pattern.

	Positive	Negative
Next bits	Next level	Next level
00	+1	-1
01	+3	-3
10	-1	+1
11	-3	+3

Transition table



Assuming positive original level

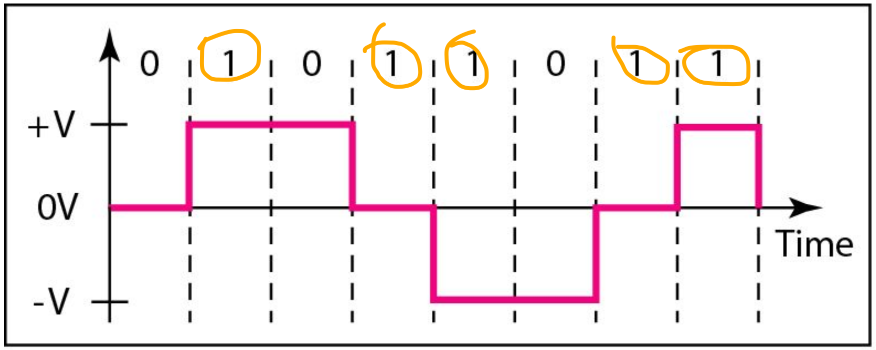
* positive level > positive column
* negative level > negative column

Figure 4.10

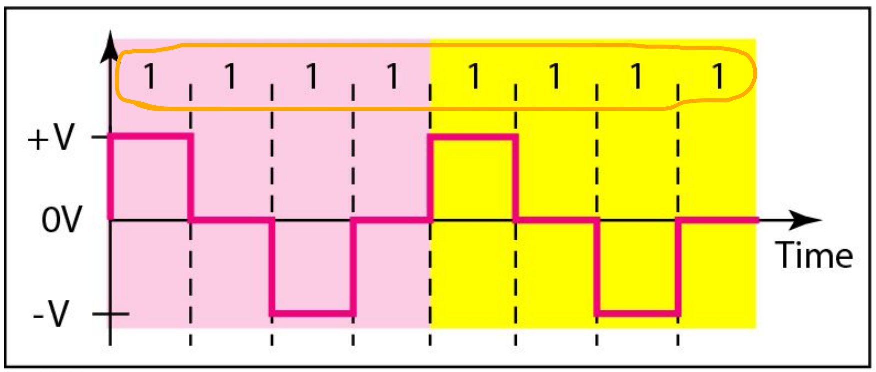
Multilevel: 2B1Q scheme

Multi-line-transition(MLT) Schemes

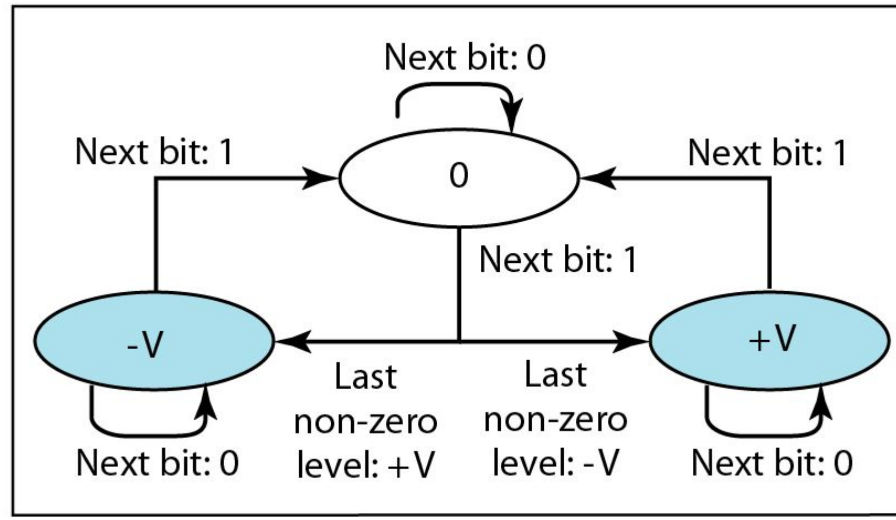
1 = Change, (Changing thing is Pos, zero, neg)
0 = No Change



a. Typical case



b. Worse case



c. Transition states

Figure 4.13 ***Multitransition: MLT-3 scheme***