Chapter 4

Digital Transmission

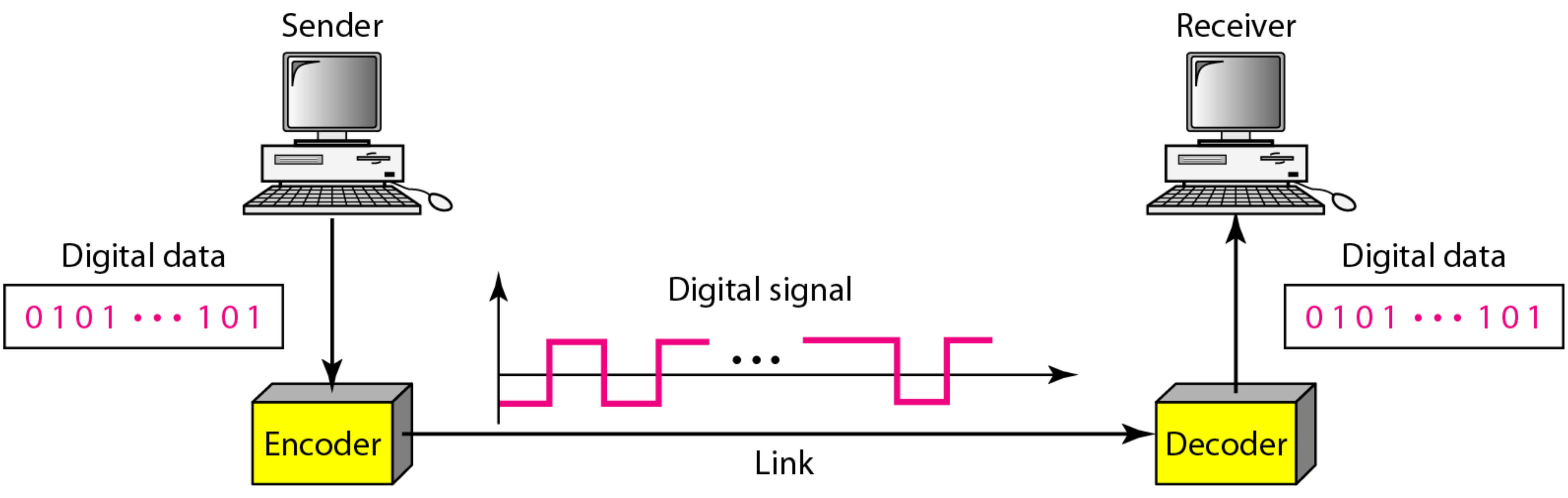
4-1 DIGITAL-TO-DIGITAL CONVERSION

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.

Topics discussed in this section:

Line Coding
Line Coding Schemes
Block Coding
Scrambling

Figure 4.1 *Line coding and decoding*



A few basics …

Date Rate (N): Number of data element sent in one second – bps

Signal Rate (S): Number of signal element sent in one second – baud rate

r: Number of data element carried in one signal

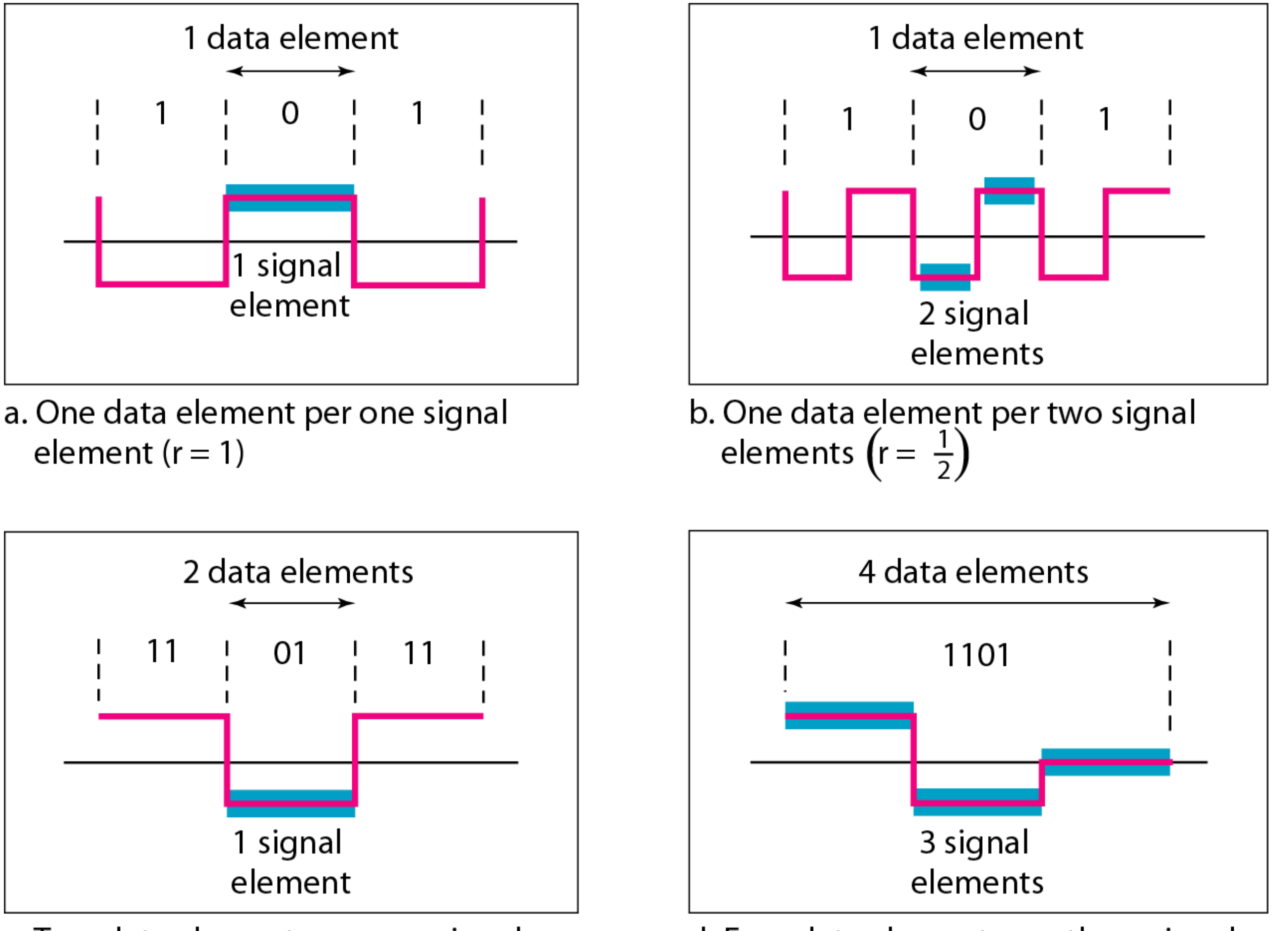
$$S= N/r$$

Objective is to:

Increase the data rate and decrease the signal rate

$S_{avg} = c \times N \times (1/r)$ where c: case factor

Figure 4.2 *Signal element versus data element*



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 $\left(r = \frac{4}{3}\right)$

Note

Although the actual bandwidth of a digital signal is infinite, the effective bandwidth is finite.

Figure 4.3 *Effect of lack of synchronization*

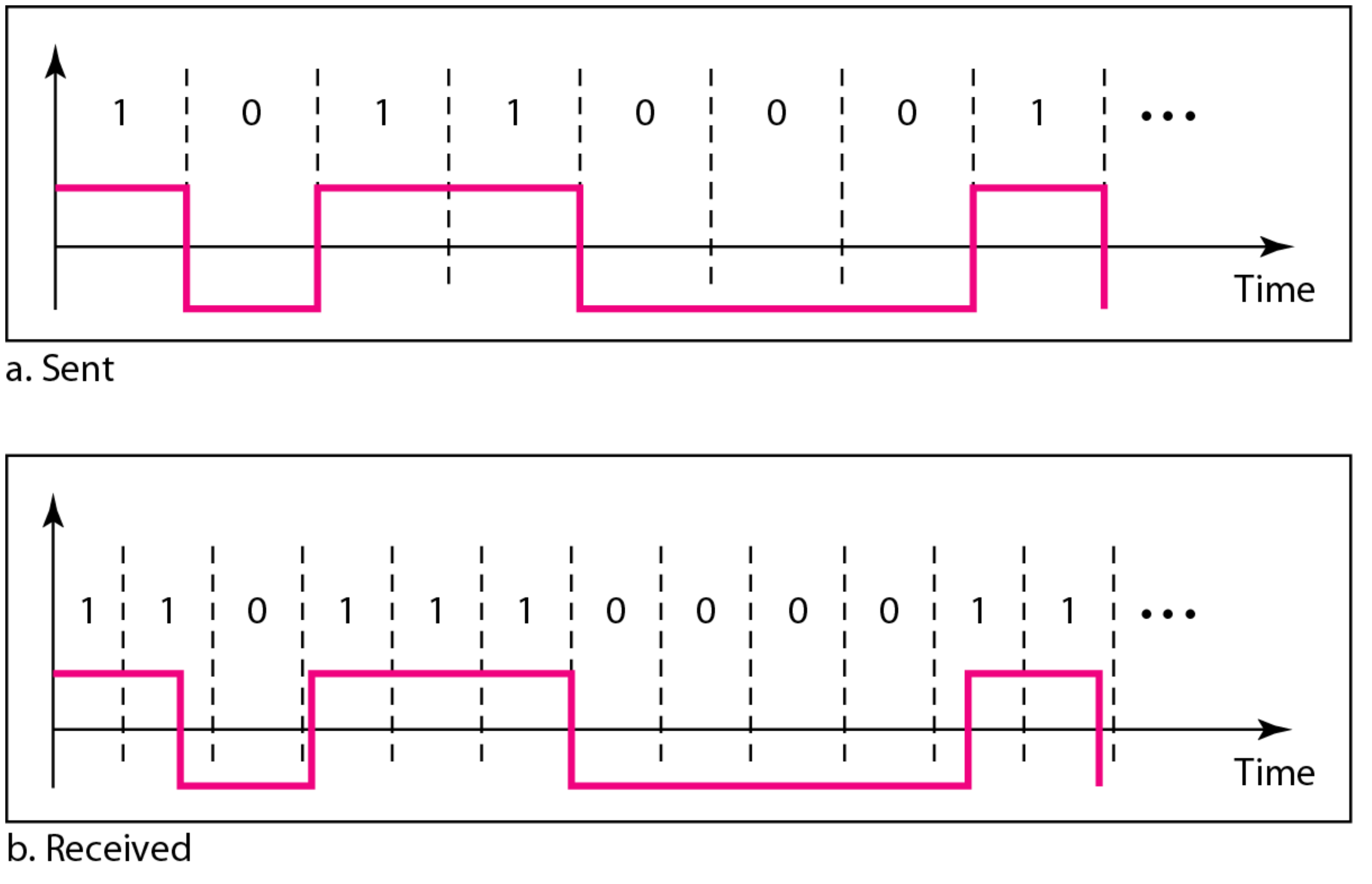


Figure 4.4 *Line coding schemes*

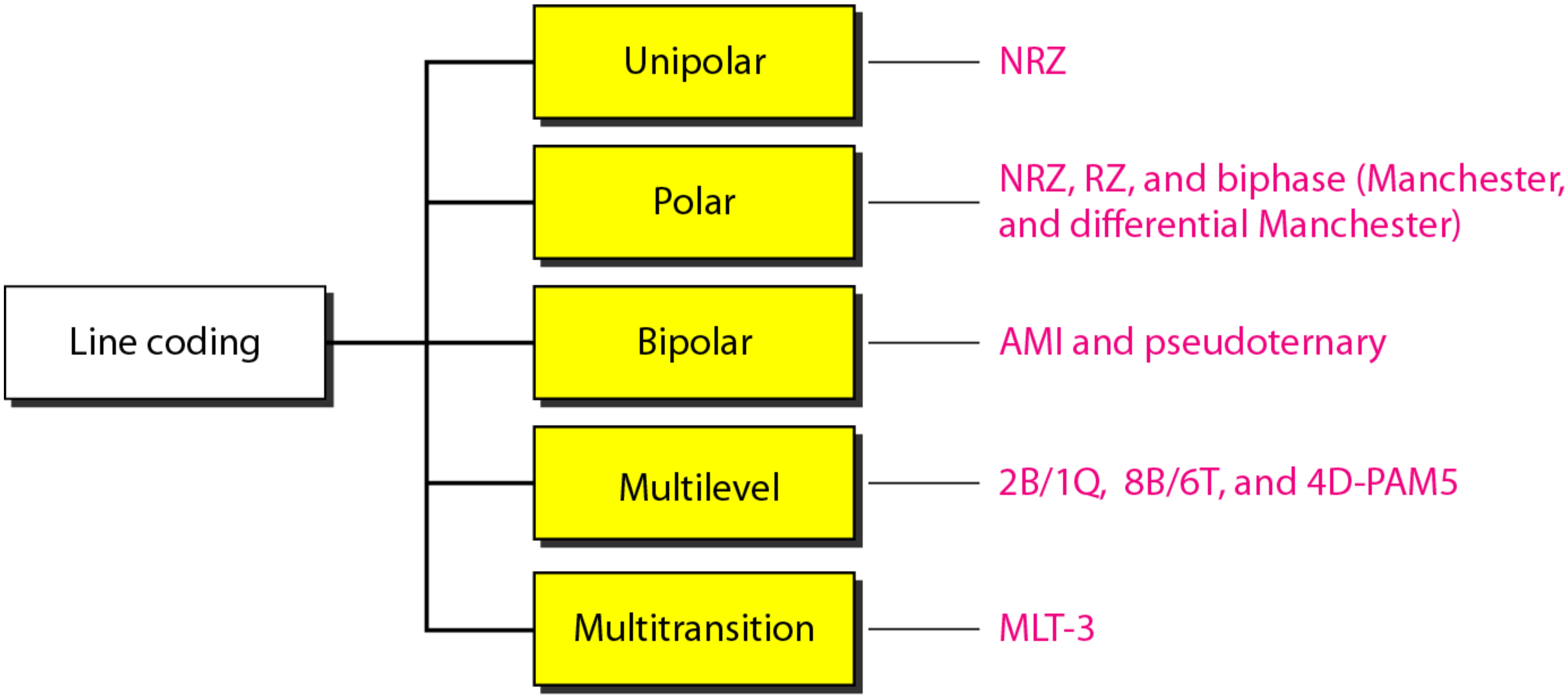


Figure 4.4 *Line coding schemes*

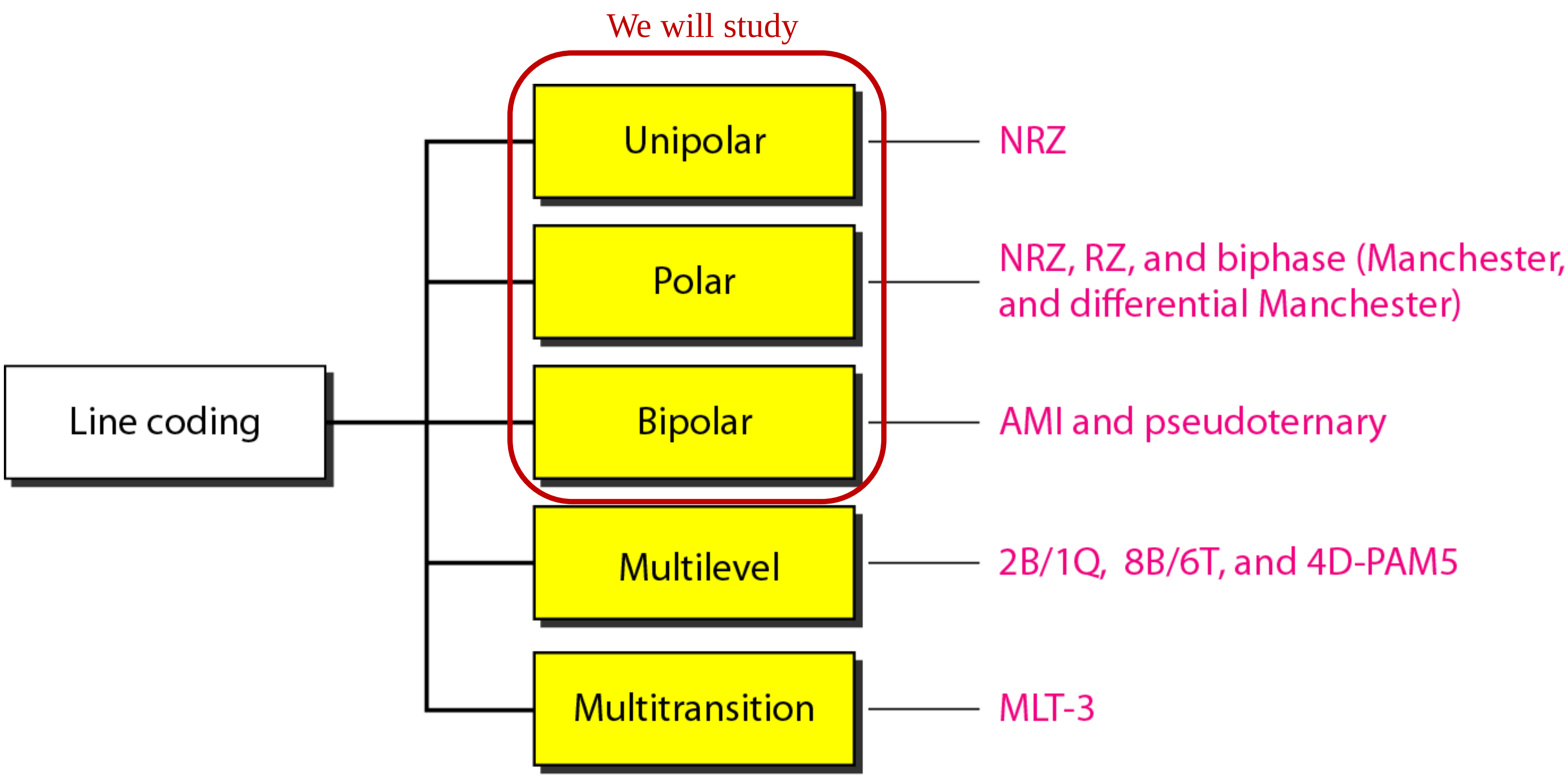
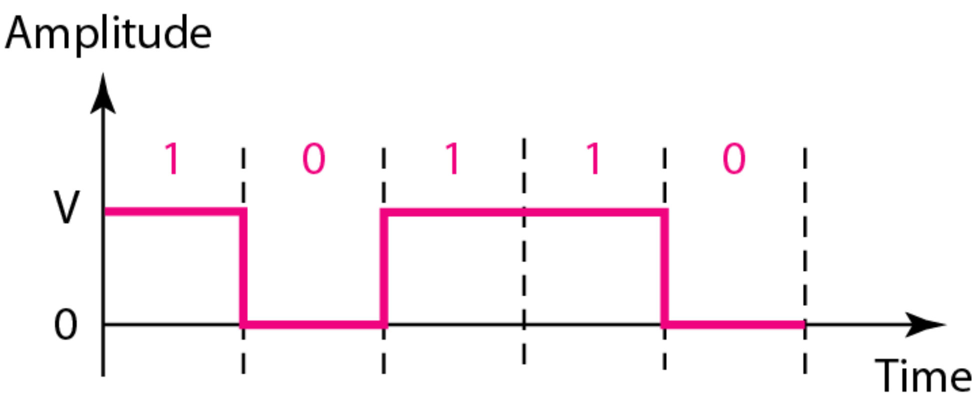


Figure 4.5 *Unipolar NRZ scheme*

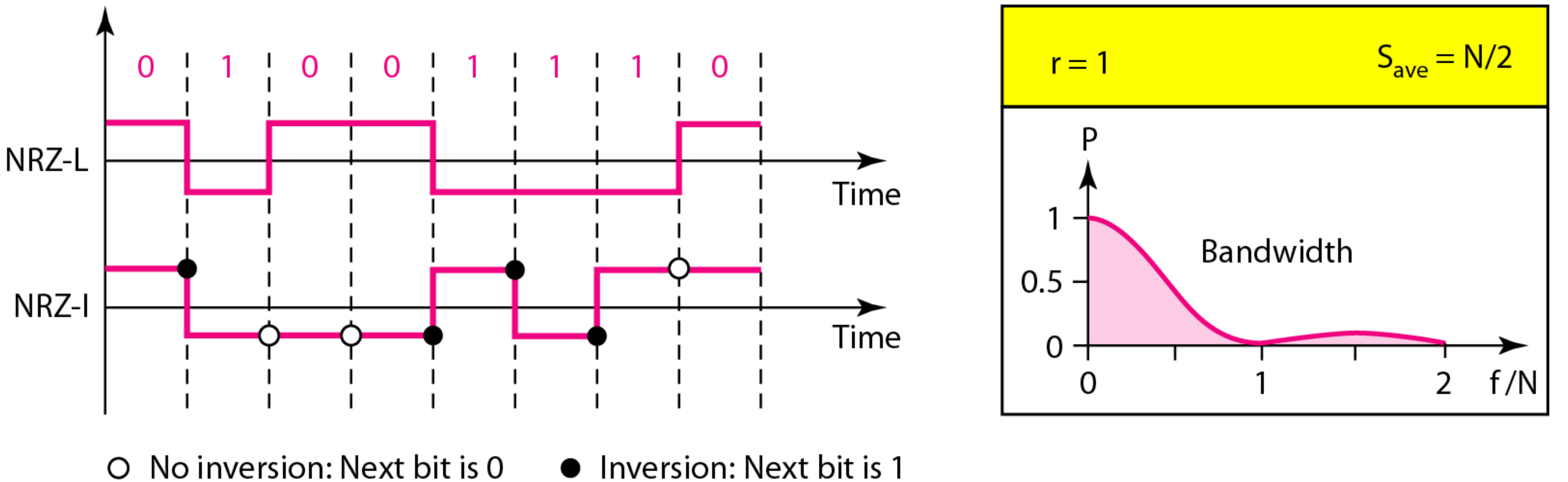


$$\frac{1}{2}V^2 + \frac{1}{2}(0)^2 = \frac{1}{2}V^2$$

Normalized power

NRZ: Not return to zero at the middle of the bit
Normalized power: the power needed to send 1 bit per unit line resistance

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



- NRZ-L: Level of voltage determine the value of bit
- NRZ-I: If there is no change, bit is 0; if there is a change, the bit is 1
- S_{avg} = c × N × 1/r, n is data rate, c is case factor, S is no. of signal element per second, r is no. of data element is carried by one signal

Figure 4.7 *Polar RZ scheme*

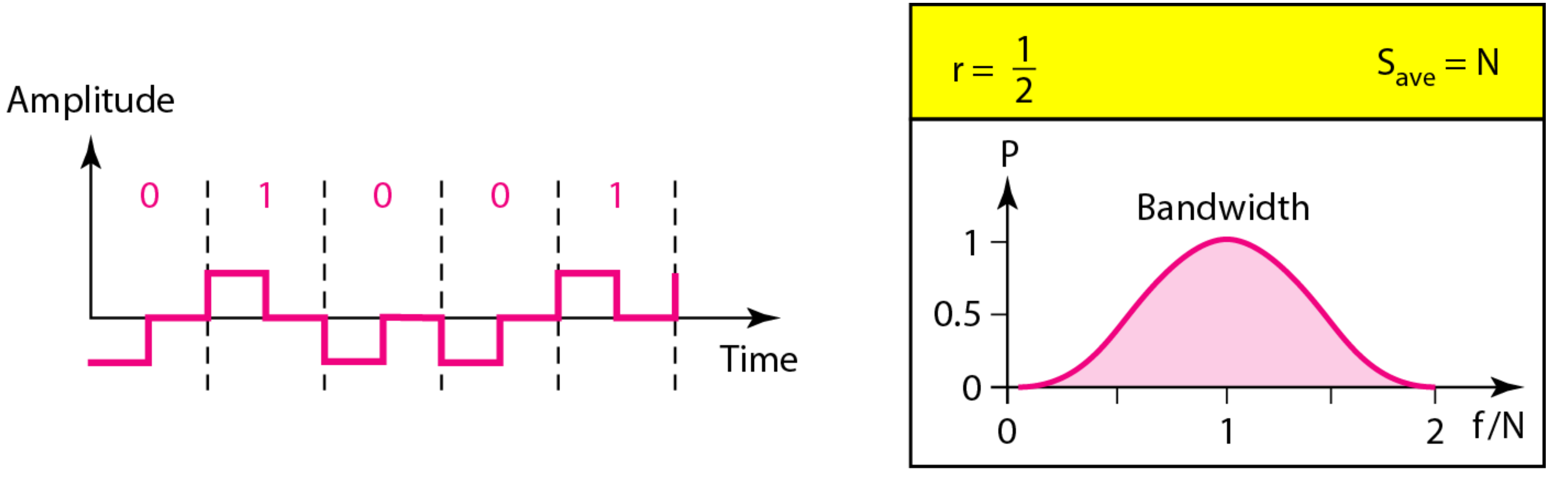
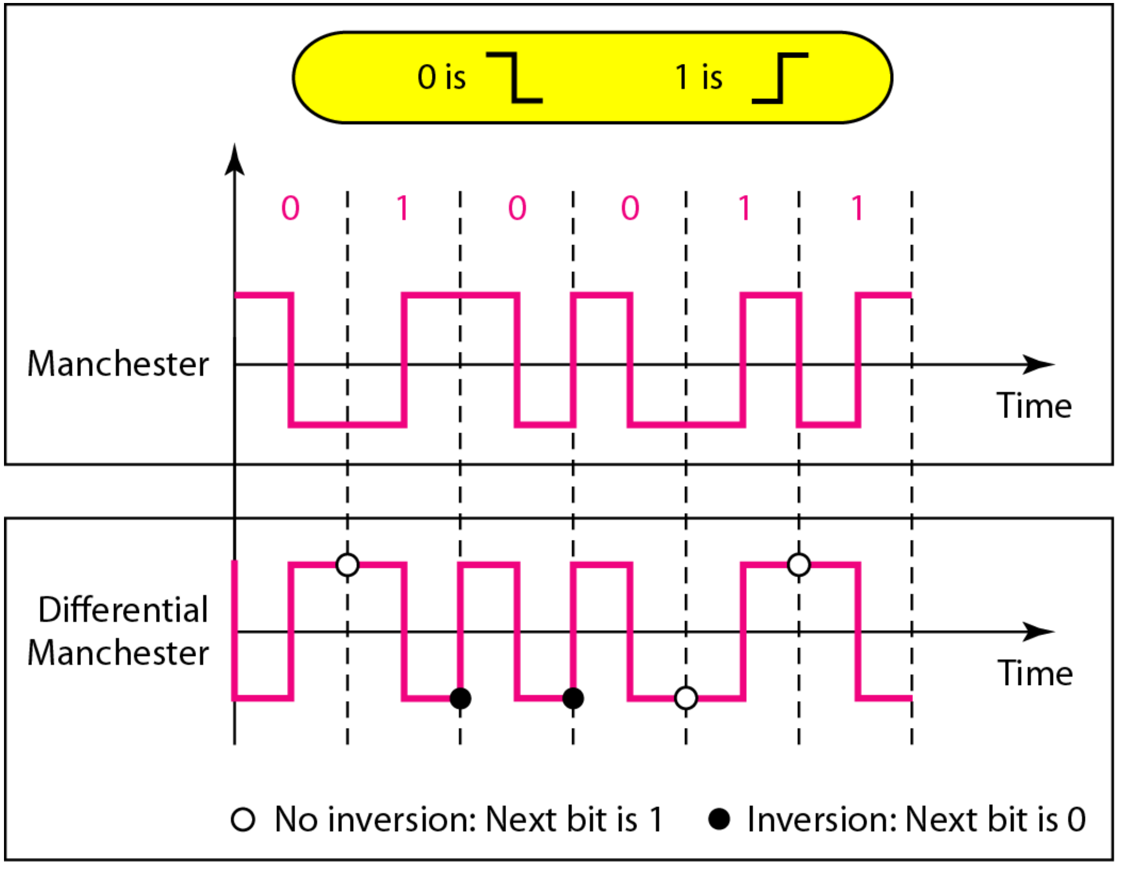
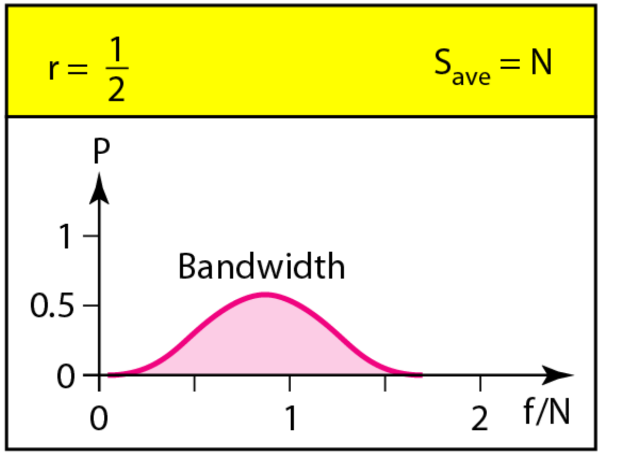


Figure 4.8 *Polar biphase: Manchester and differential Manchester schemes*



Polar RZ+NRZ-L



Polar RZ+NRZ-I

Note

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

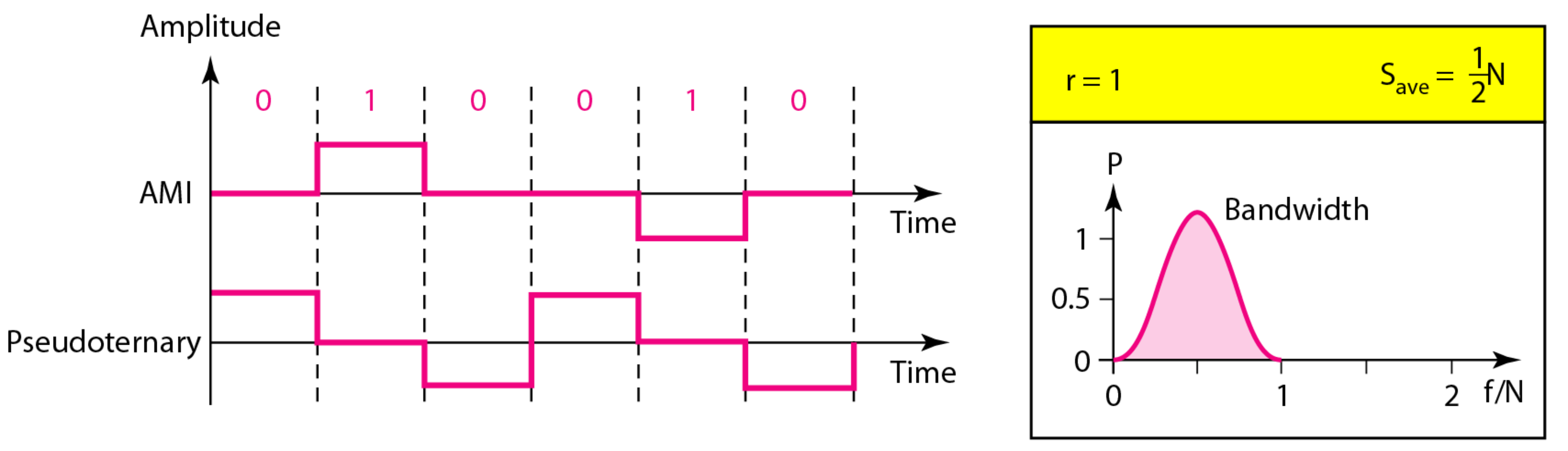
Note

The minimum bandwidth of Manchester and differential Manchester is 2 times that of NRZ.

Note

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

Figure 4.9 *Bipolar schemes: AMI and pseudoternary*



AMI: Alternate Mark Inversion