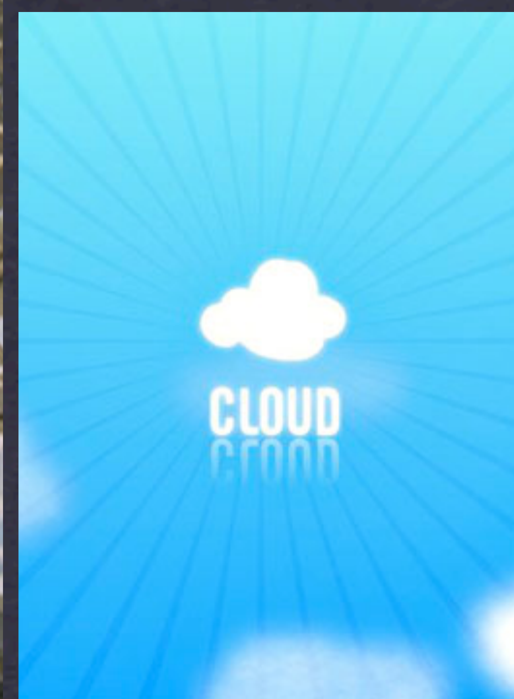

PROJECT

KOMUNIKASI DATA (WEEK 7)

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DATE **GENAP 2012/2013**

CLIENT **JURUSAN SISTEM KOMPUTER (S1)**

Digital Transmission

CHAPTER 4

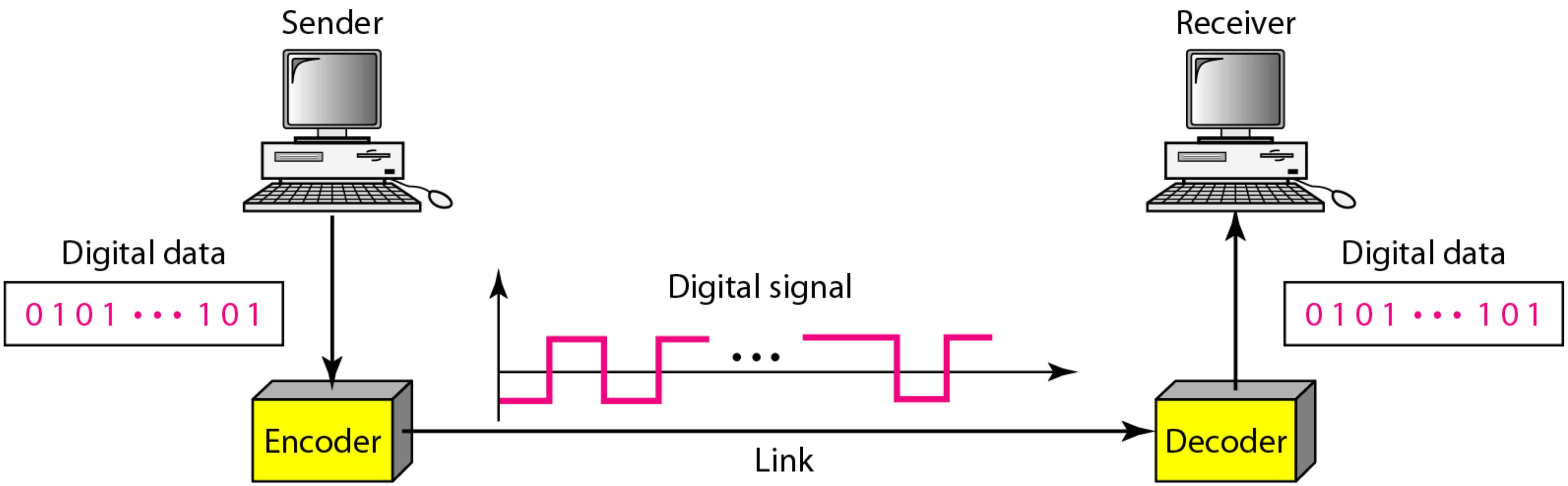
- Computer network is designed to send information from one point to another
- This information needs to be converted to either a digital signal or an analog signal from transmission

Digital to digital Conversion

- The conversion involves three techniques:
  - Line coding
  - Block coding
  - Scrambling

Line Coding

- Line coding is the process of converting digital data into digital signal

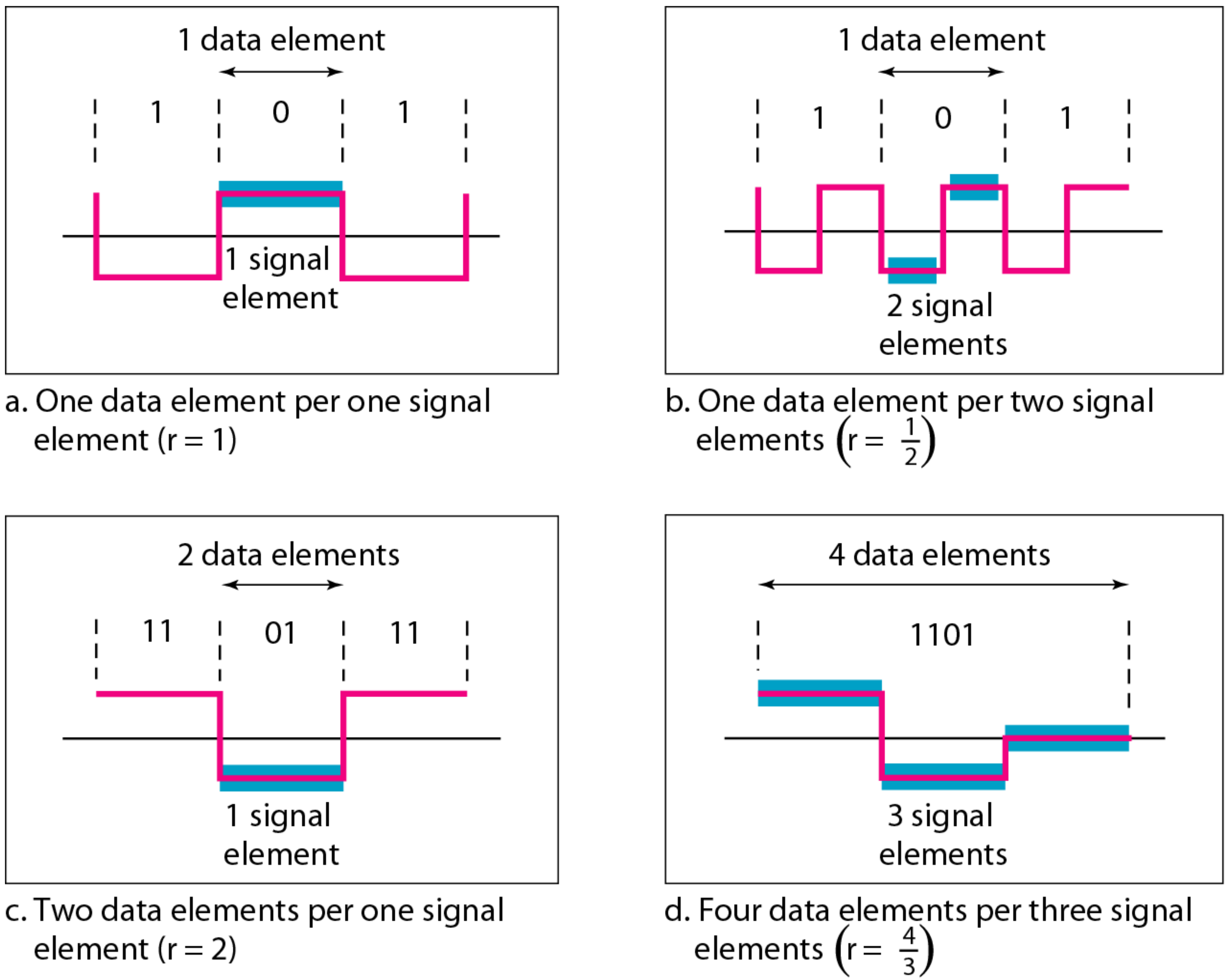


Data Element vs Signal

- In Data Communication, our goal is to send Data Element
- Data Element is the smallest entity that can represent a piece of information. This is the bit.
- In digital data communications, a signal element carries data elements
- A signal elements is the shortest unit of a digital signal

In other words, data elements are what we need to send; signal elements are what we can send.
Data elements are being carried; signal elements is the carriers

Data Element vs Signal 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 $\left(r = \frac{4}{3}\right)$

A ratio (r) is the number of data element carried by each signal element

Data Rate vs Signal Rate

- Data Rate = the number of data elements (bits) sent in 1s, the unit is **bits per second (bps)**
- Signal Rate = the number of signal element sent in 1 s, the unit is **baud**

- Data Rate = Bit Rate
- Signal Rate = Pulse Rate/ Modulation Rate/Baud Rate

What we want?

- Increase Data Rate while decreasing Signal Rate
- Increasing Data Rate increases the speed of transmission
- Decreasing Signal Rate decreases the bandwidth requirement.

Relationship Between Data Rate and Signal Rate

$$S = c \times N \times \frac{1}{r}$$

where N is the data rate (bps),
c is the case factor (varies for each case),
S is the number of signal element,
r is the previously defined factor

Contoh Soal

A signal is carrying data in which one data element is encoded as one signal element (r = 1). If the bit rate is 100 kbps, what is the average value of the baud rate if c is between 0 and 1?

Solution

We assume that the average value of c is 1/2 . The baud rate is then

$$S = c \times N \times \frac{1}{r} = \frac{1}{2} \times 100{,}000 \times \frac{1}{1} = 50{,}000 = 50 \text{ kbaud}$$

- # Bandwidth

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

- The baud rate, not the bit rate, determines the required bandwidth for a digital signal.
- More changes in the signal mean injecting more frequencies into the signal.
- The bandwidth reflects the range of frequencies we need
- There is a relationship between the baud rate and the bandwidth
- The minimum bandwidth can be given is

$$B_{min} = c \times N \times \frac{1}{r}$$

and the data rate if the bandwidth of the channel is given:

$$N_{max} = \frac{1}{c} \times B \times r$$

Contoh Soal

The maximum data rate of a channel (see Chapter 3) is $N_{max} = 2 \times B \times \log_2 L$ (defined by the Nyquist formula). Does this agree with the previous formula for N_{max}?

Solution

A signal with L levels actually can carry $\log_2 L$ bits per level. If each level corresponds to one signal element and we assume the average case ($c = 1/2$), then we have

$$N_{max} = \frac{1}{c} \times B \times r = 2 \times B \times \log_2 L$$

- **Baseline Wandering**

  In decoding a digital signal, the receiver calculates a running average of the received signal power.

  The incoming signal power is evaluated against this baseline to determine the value of the data element

  A good line coding scheme needs to prevent baseline wandering

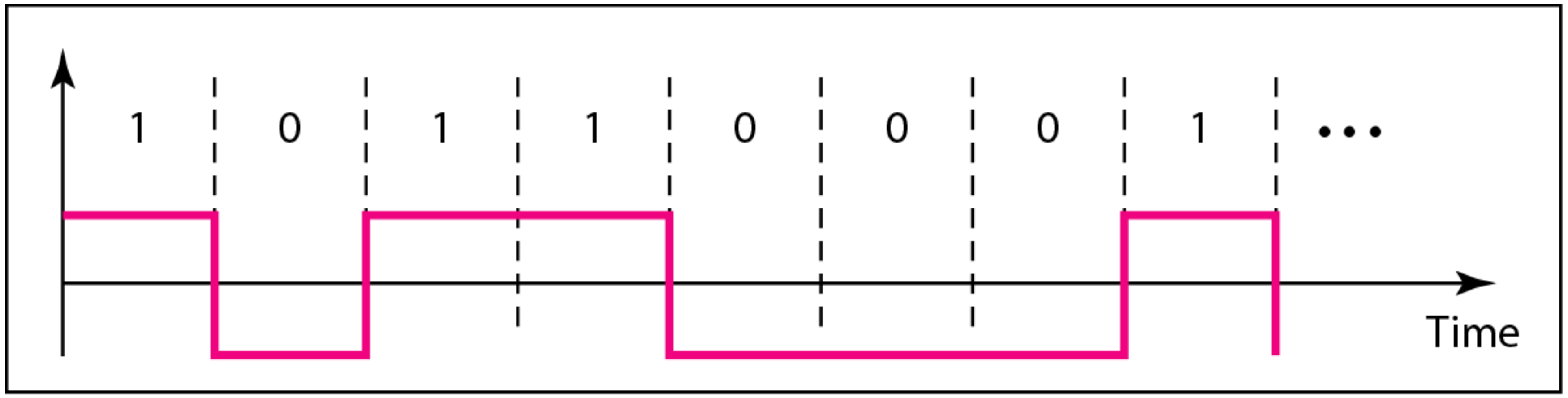
- **DC Components**

  When the voltage level in a digital signal is constant for a while, the spectrum creates very low frequencies (result of Fourier analysis). These frequencies around zero, called DC components, present problems for a system that cannot pass low frequencies or a system that uses electrical coupling (via transformer)

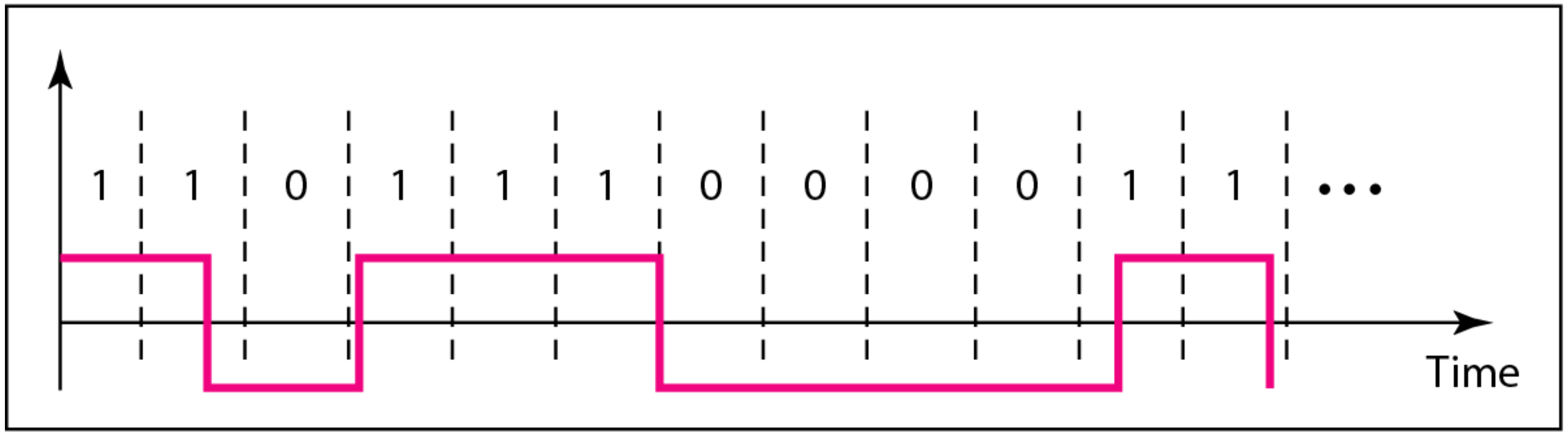
- **Self- synchronization**

To correctly interpret the signal received from the sender, the receiver's bit intervals must correspond exactly to the sender's bit intervals.

If the receiver clock is faster or slower, the bit intervals are not matched and the receiver might misinterpret the signals.



a. Sent



b. Received

Contoh Soal

In a digital transmission, the receiver clock is 0.1 percent faster than the sender clock. How many extra bits per second does the receiver receive if the data rate is 1 kbps? How many if the data rate is 1 Mbps?

Solution

At 1 kbps, the receiver receives 1001 bps instead of 1000 bps.

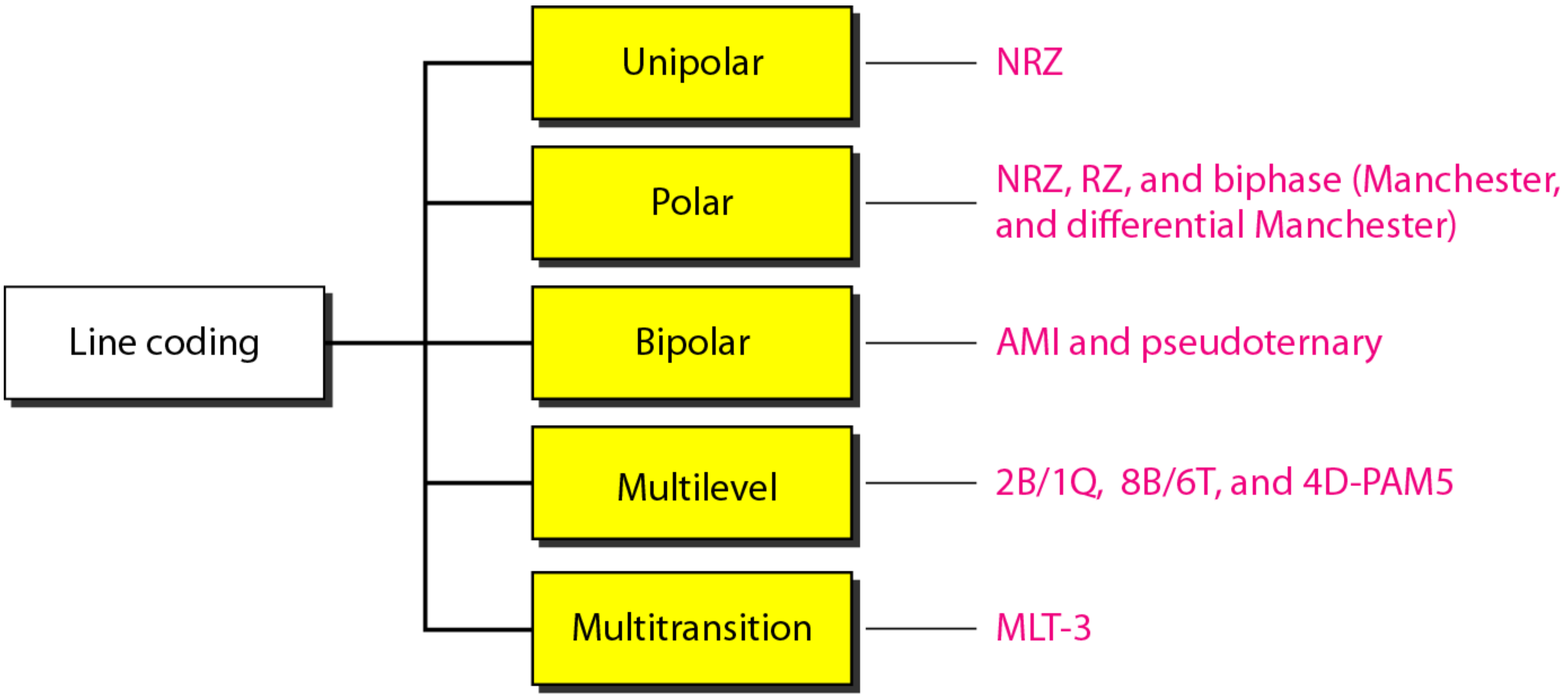
1000 bits sent	1001 bits received	1 extra bps

At 1 Mbps, the receiver receives 1,001,000 bps instead of 1,000,000 bps.

1,000,000 bits sent	1,001,000 bits received	1000 extra bps

- **Built in Error Detection**
  It is desirable to have a built in error detecting capability in the generated code to detect some of or all errors that occurred during transmission. Some encoding schemes that we will discuss have the capability to some extent
- **Immunity to Noise and Interference**
  Another desirable code characteristics is a code that is immune to noise and other interferences. Some encoding schemes that we will discuss have this capability
- **Complexity**
  A complex scheme is more costly ti implement than a simple one.
  For example, a scheme that uses four signal levels is more difficult to interpret than one that uses only two levels

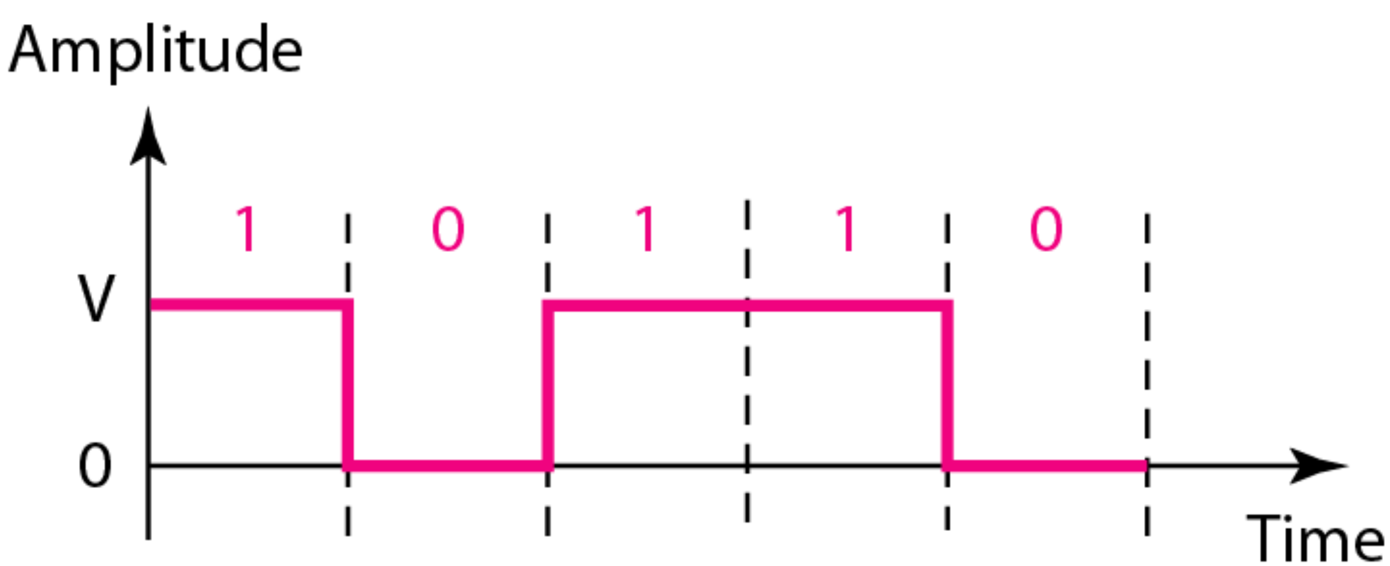
Line Coding Schemes



Unipolar Scheme

In a unipolar scheme, all the signal levels are on one side of the time axis, either above or below

NRZ (Non Return To Zero)



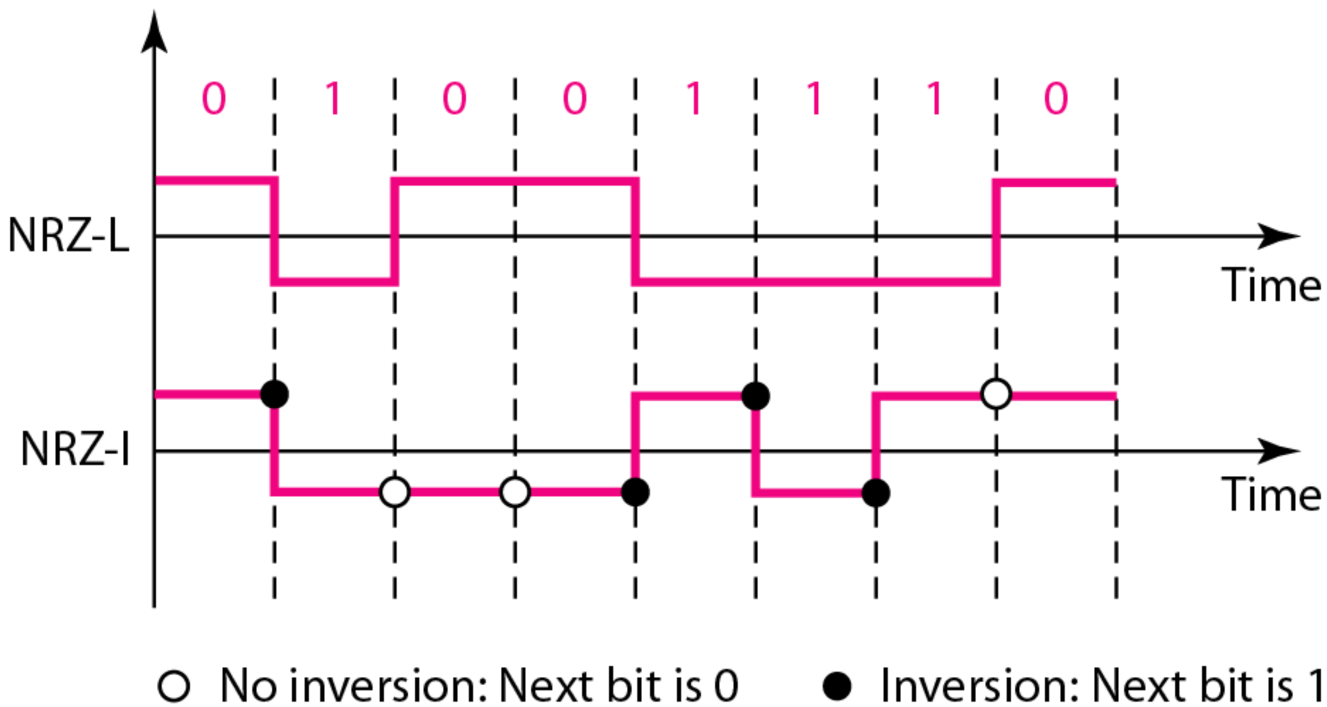
$$\frac{1}{2}V^2 + \frac{1}{2}(0)^2 = \frac{1}{2}V^2$$

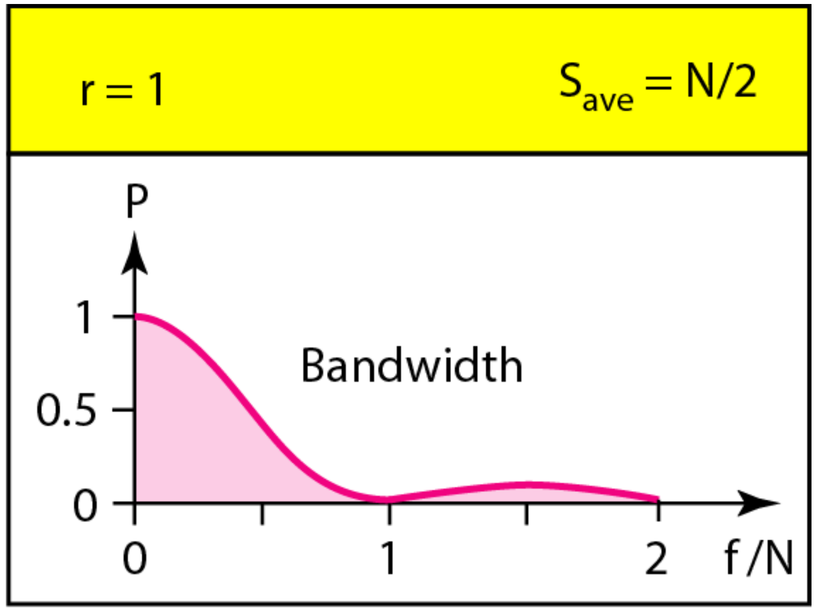
Normalized power

Compared with its polar counterpart, this scheme is very costly.
The power needed to send 1 bit per unit line is double that for polar NRZ. For this reason, this scheme is normally not used in data communication today

Polar Scheme

In polar scheme, the voltages are on the both sides of the time axis





NRZ-L and NRZ-I both have a DC component problem.

Contoh Soal

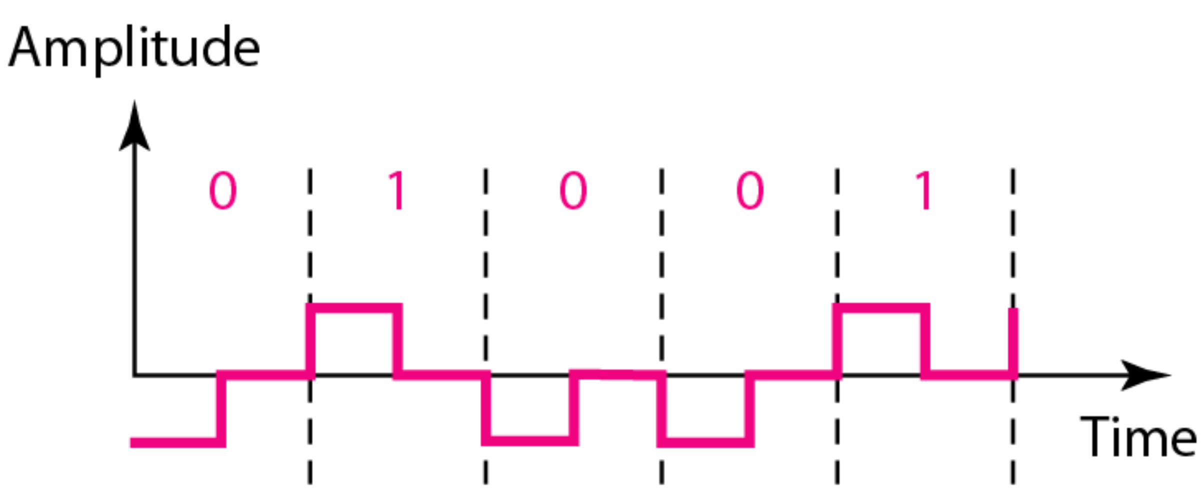
A system is using NRZ-I to transfer 10-Mbps data. What are the average signal rate and minimum bandwidth?

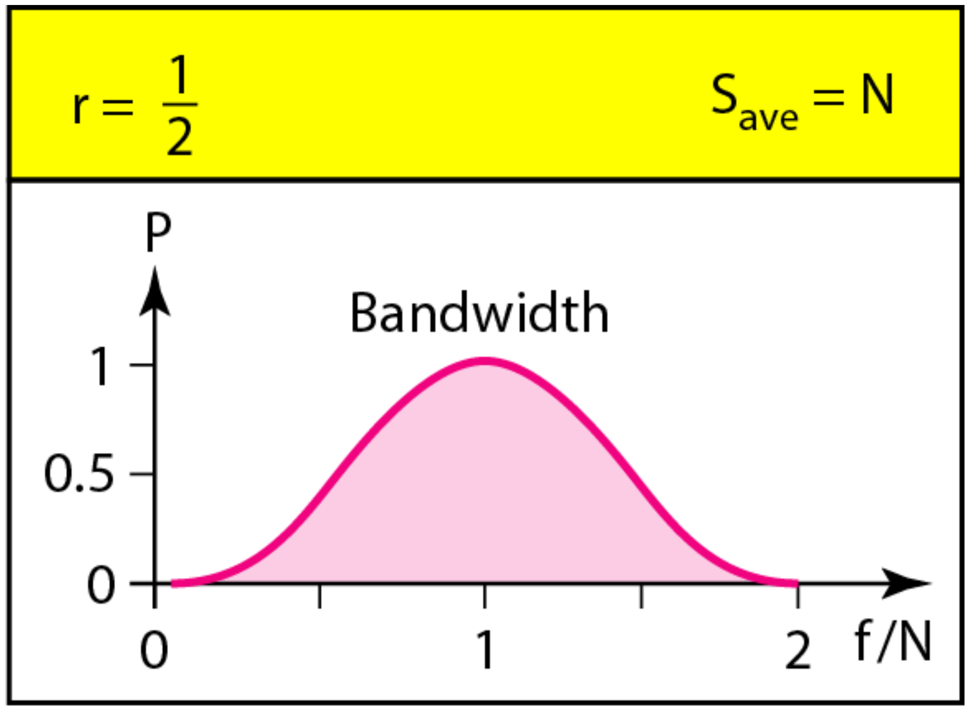
Solution

The average signal rate is S = N/2 = 500 kbaud.
The minimum bandwidth for this average baud rate is B_{min} = S = 500 kHz.

Polar RZ Scheme

- The main problem with the NRZ encoding occurs when the sender and receiver clocks are not synchronized.
- The receiver doesn't know when one bit has ended and the next bit is starting.
- One solution is the return-to-zero (RZ) scheme, which uses three values, positive, negative and zero

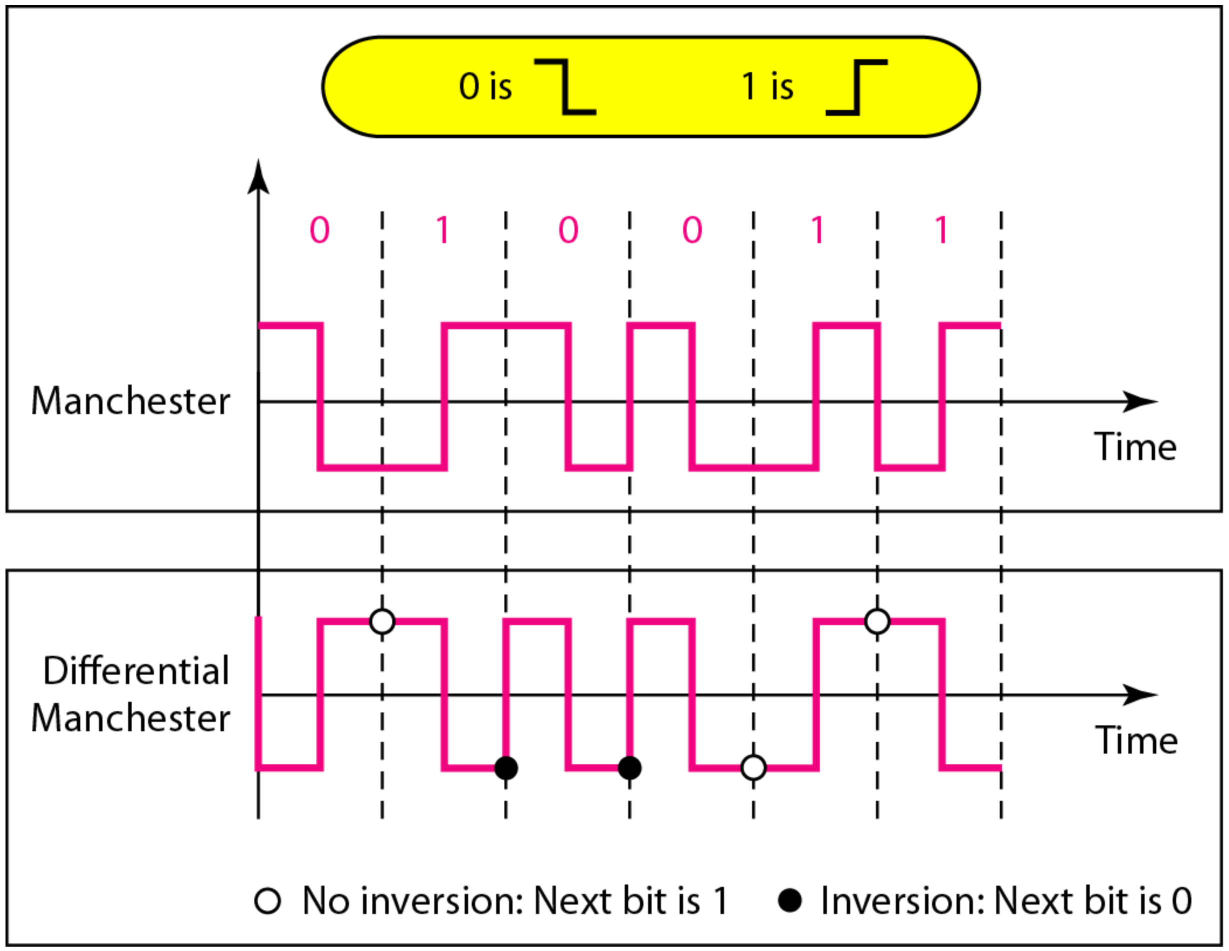


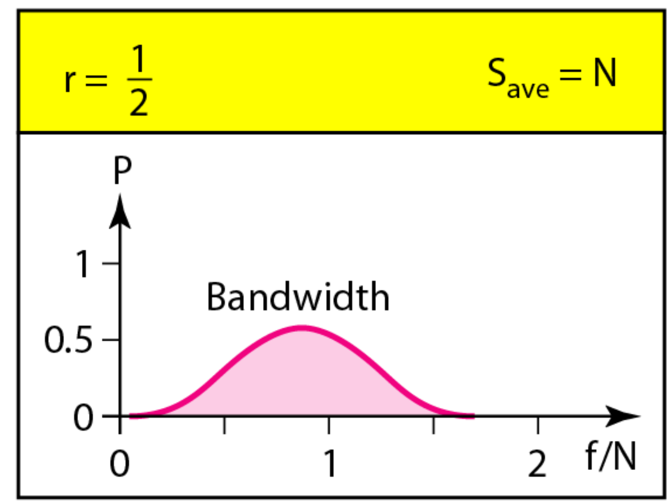


Disadvantage of RZ Encoding

- Require two signal changes to encode a bit, therefore occupies greater bandwidth
- Complexity, because using three levels of voltage
- Not using today, and has been replaced by the better performing Manchester and Differential Manchester Schemes

Polar biphase: Manchester and Differential Manchester schemes





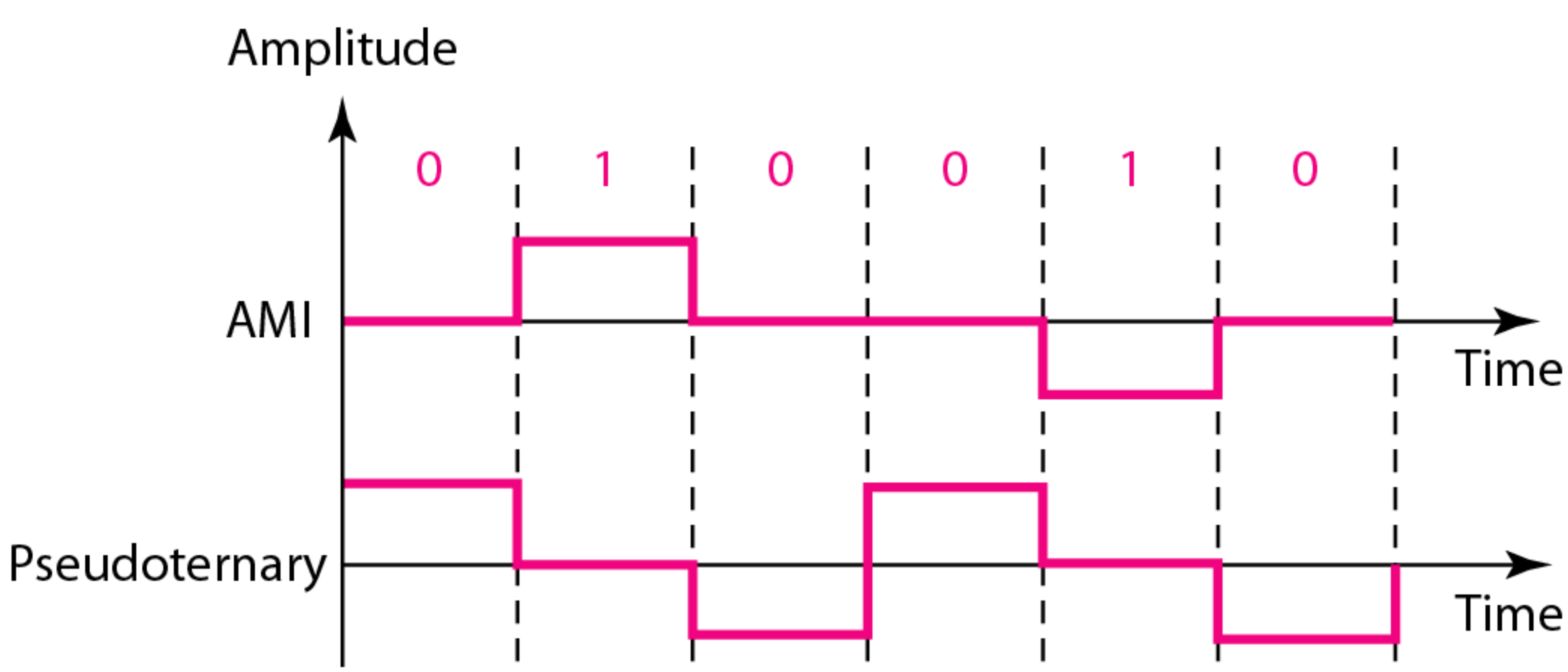
In Manchester and differential Manchester encoding, the transition at the middle of the bit is used for synchronization.

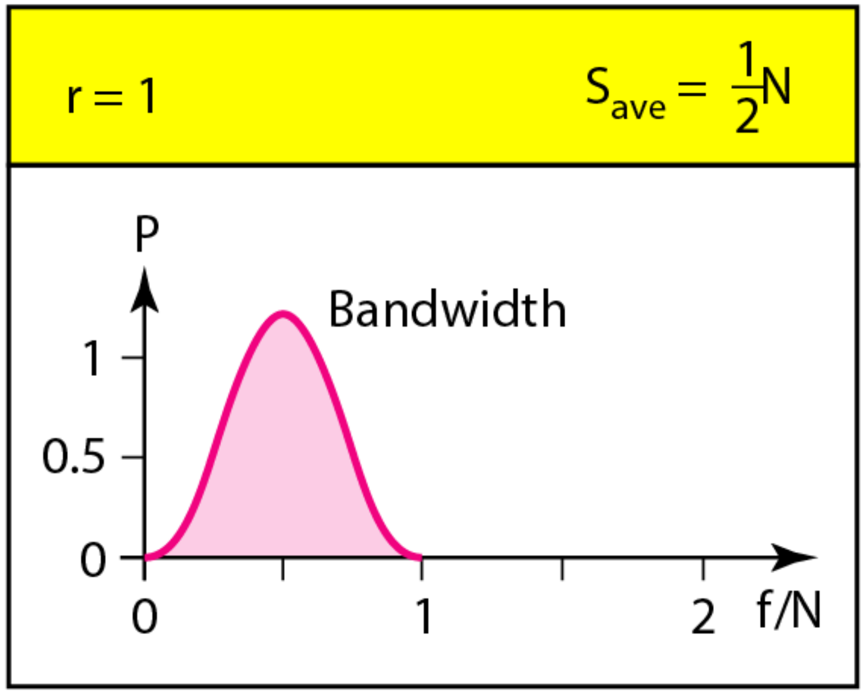
The minimum bandwidth of Manchester and differential Manchester is 2 times that of NRZ.

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

Bipolar Schemes: AMI and Pseudoternary

- The bipolar scheme was develop as an alternative to NRZ.
- The bipolar scheme has the same signal rate as NRZ, but there is no DC component.
- The NRZ scheme has most of its energy concentrated near zero frequency, which makes it unsuitable for transmission over channel with poor performance around this frequency.





- One may ask why we do not have DC component in bipolar encoding. We can answer this question by using the Fourier Transform.

- If we have a long sequence of 1s, the voltage level alternates between positive and negative; it is not constant. There fore there are no DC component.

- For a long sequence of 0s, the voltage remains constant, but the amplitude is zero, which is the same as having no DC component. In other words, a sequence that creates a constant zero voltage does not have a DC component.

- AMI is commonly used for long distance communication, but it has a synchronization problem when a long sequence of 0s is present in the data. Later in the chapter, we will see how a scrambling technique can solve this problem

Multilevel Schemes

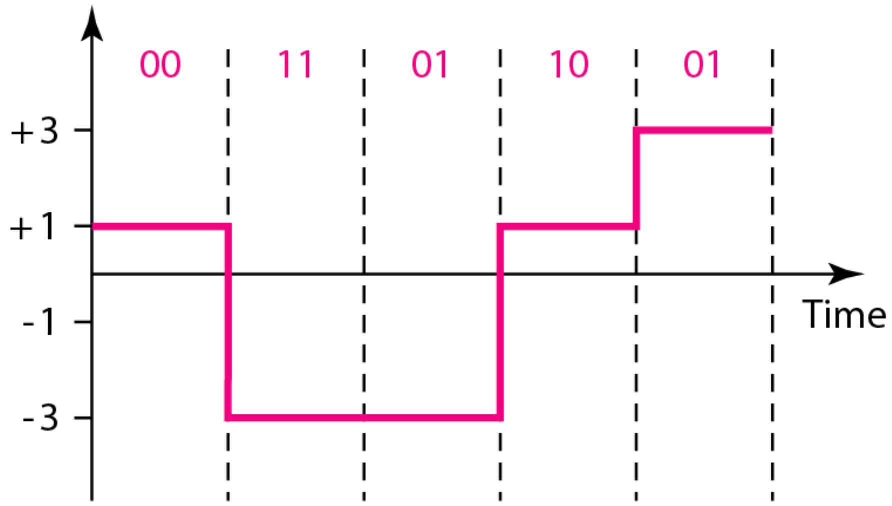
- The desire to increase the data speed or decrease the required bandwidth has resulted in the creation on many schemes.
- The goal is to increase the number of bits per baud by encoding a pattern of m data elements into a pattern of n signal elements.

In *m*B*n*L schemes, a pattern of *m* data elements is encoded as a pattern of *n* signal elements in which $2^m \leq L^n$.

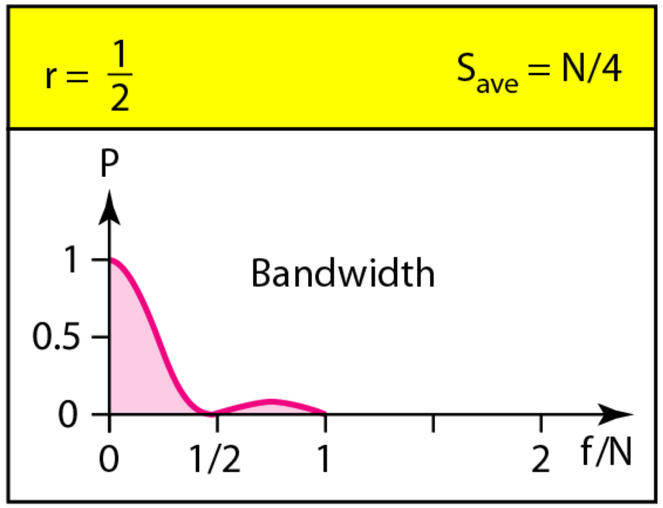
Multilevel: 2B1Q scheme

	Previous level: positive	Previous level: 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

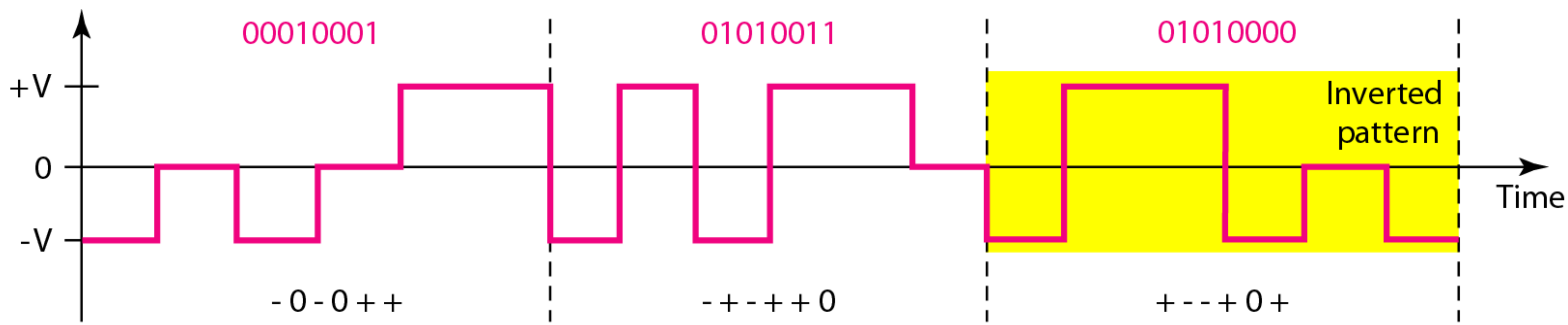


Two binary, one quaternary (2B1Q), uses data patterns of size 2 and encodes the 2-bit patterns as one signal element belonging to a four-level signal. In this type of encoding m =2, n =1, and L =4 (quatemary)

- The average signal rate of 2BIQ is S =N/4. This means that using 2BIQ, we can send data 2 times faster than by using NRZ-L. However, 2B IQ uses four different signal levels, which means the receiver has to discern four different thresholds. The reduced bandwidth comes with a price. There are no redundant signal patterns in this scheme because 2^2 =4^1.

- As we will see in Chapter 9, 2BIQ is used in DSL (Digital Subscriber Line) technology to provide a high-speed connection to the Internet by using subscriber telephone lines.

Multilevel: 8B6T scheme



8B6T A very interesting scheme is eight binary, six ternary (8B6T). This code is used with 100BASE-4T cable

Table 4.1 ***Summary of line coding schemes***

Category	*Scheme*	*Bandwidth (average)*	*Characteristics*
Unipolar	NRZ	$B = N/2$	Costly, no self-synchronization if long 0s or 1s, DC
Unipolar	NRZ-L	$B = N/2$	No self-synchronization if long 0s or 1s, DC
	NRZ-I	$B = N/2$	No self-synchronization for long 0s, DC
	Biphase	$B = N$	Self-synchronization, no DC, high bandwidth
Bipolar	AMI	$B = N/2$	No self-synchronization for long 0s, DC
Multilevel	2B1Q	$B = N/4$	No self-synchronization for long same double bits
	8B6T	$B = 3N/4$	Self-synchronization, no DC
	4D-PAM5	$B = N/8$	Self-synchronization, no DC
Multiline	MLT-3	$B = N/3$	No self-synchronization for long 0s