Bangladesh Army University of Engineering & Technology

CSE-3215
Data Communication

Lecture-19

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Multilevel Line Coding

mBnL Scheme

- A Multi level coding scheme is known as *m*B*n*L, 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 signaling.*
- 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.

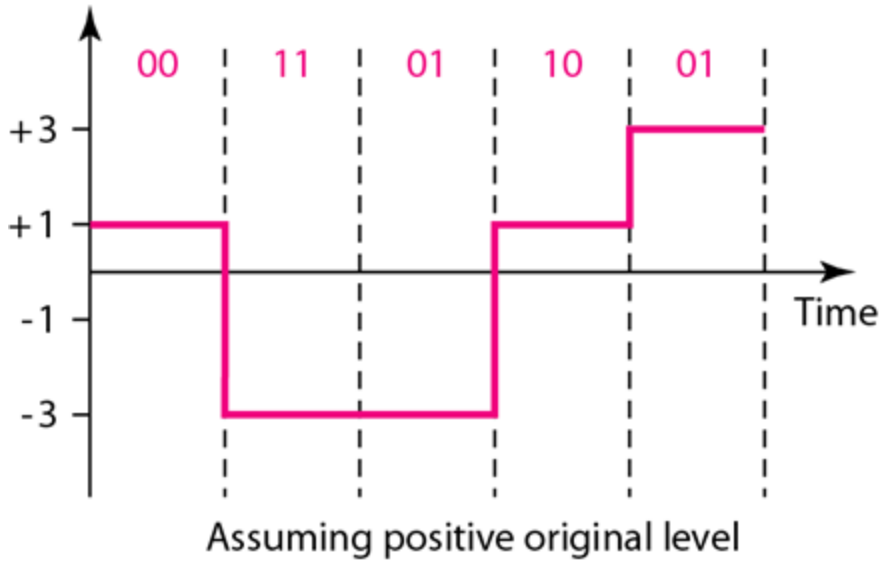
m data is represented by sequence of n pulses

2B1Q

- The **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 (quaternary). Figure shows an example of a 2B1Q signal.
- The 2B1Q scheme is used in DSL (Digital Subscriber Line) technology to provide a high-speed connection to the Internet by using subscriber telephone lines.

Next bits	Previous level: positive Next level	Previous level: negative Next level
00	+1	-1
01	+3	-3
10	-1	+1
11	-3	+3

Transition table



Assuming positive original level

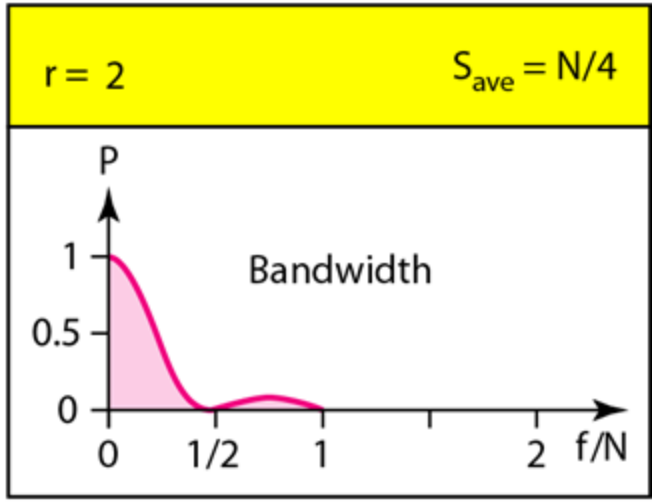


Figure 1 ***Multilevel: 2B1Q scheme***

8B6T

- A very interesting scheme is **eight binary, six ternary (8B6T).**
- *The idea is to encode a pattern of 8 bits as a pattern of six signal elements, where the signal has three levels (ternary).*
- Data element = 8 ; data patterns = $2^8 = 256$ and
- Signal element = 6 ; signal patterns = $3^6 = 729$.
- There are 729 – 256 = 473 redundant signal elements that provide synchronization and error detection.

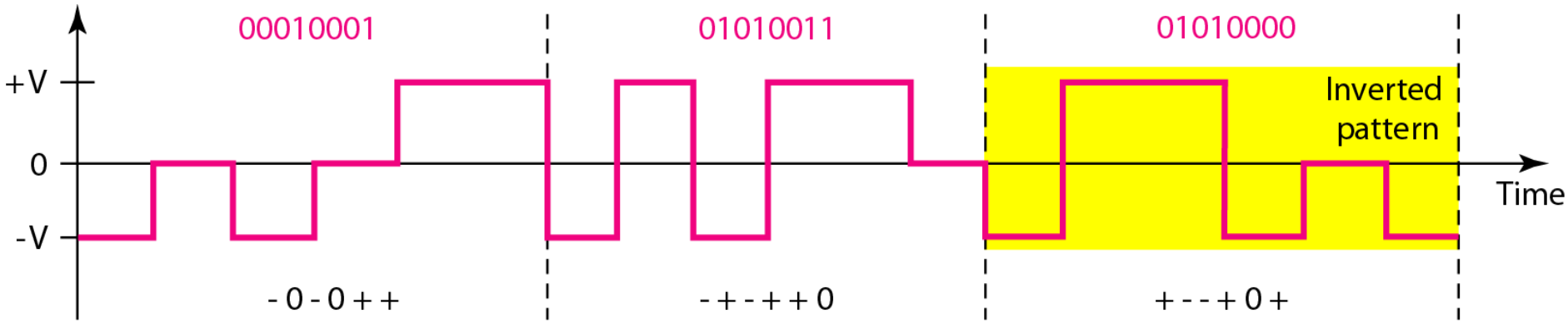


Figure 2 ***Multilevel: 8B6T scheme***

4D-PAM5

- The last signaling scheme in this category is called **four-dimensional five-level pulse amplitude modulation (4D-PAM5)**.
- The 4D means that data is sent over four wires at the same time.
- It uses five voltage levels, such as -2, -1, 0, 1 and 2. However, one level, level 0, is used only for forward error detection.
- In other words, an 8-bit word is translated to a signal element of four different levels.
- Gigabit LANs use this technology to send 1gbps over copper wires

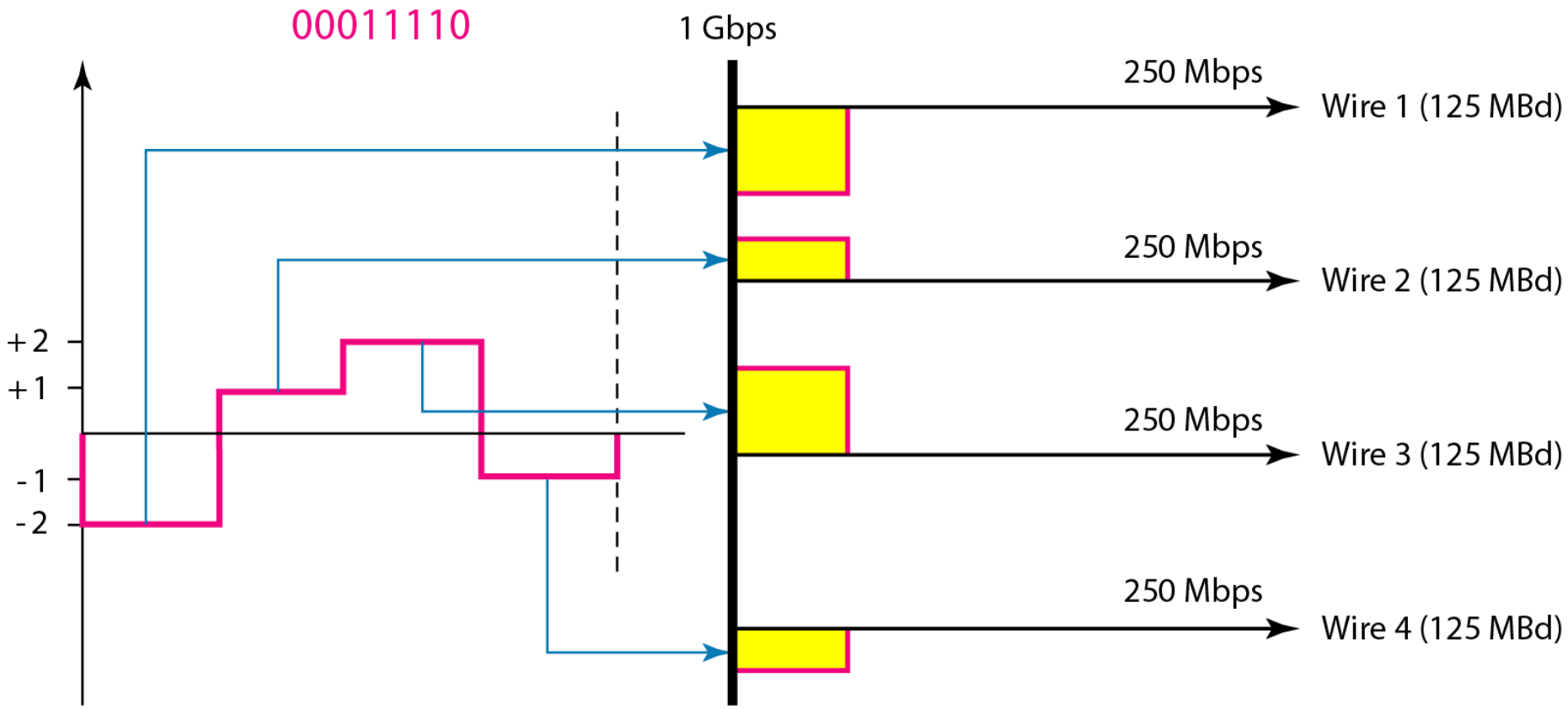


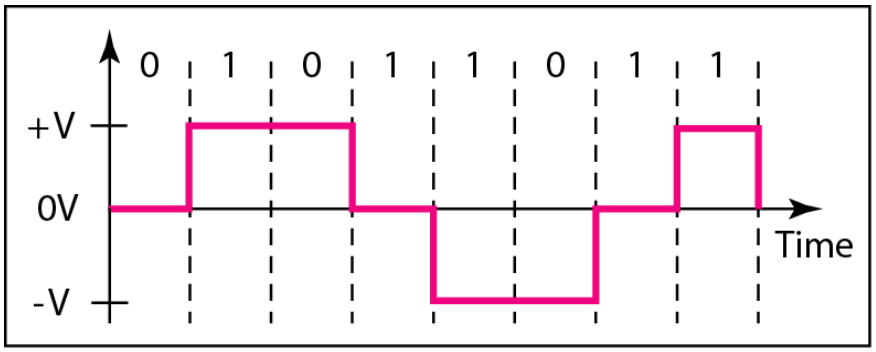
Figure 3 ***Multilevel: 4D-PAM5 scheme***

Multi-Transition Line Coding

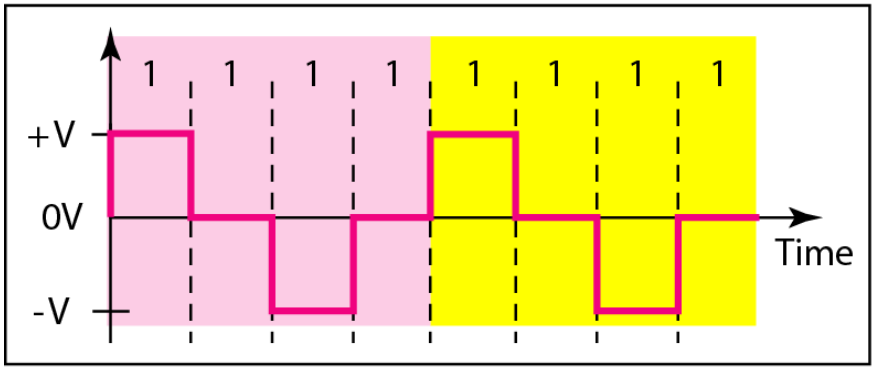
MLT-3 Scheme

- NRZ-I and differential Manchester are classified as differential encoding but use two transition rules to encode binary data (no inversion, inversion).
- *If we have a signal with more than two levels*, we can design a differential encoding scheme with more than two transition rules.
- MLT-3 technique uses more than two transition rules.
- The **multiline transmission, three-level (MLT-3) scheme uses** three levels (+V, 0, and –V) and three transition rules to move between the levels.

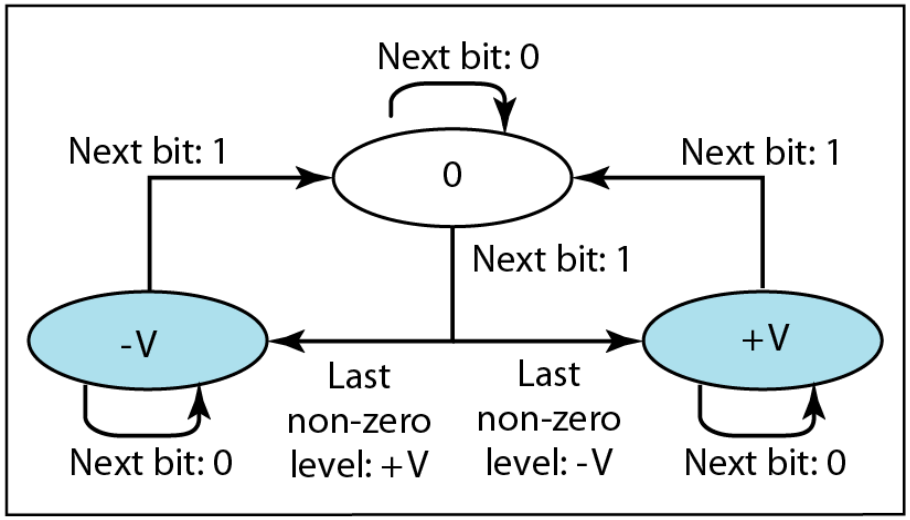
– *If the next bit is 0, there is no transition.*
– *If the next bit is 1 and the current level is 0, the next level is the opposite of the last nonzero level.*
– *If the next bit is 1 and the current level is not 0, the next level is 0.*



a. Typical case



b. Worse case



c. Transition states

Figure 4 ***Multitransition: MLT-3 scheme***

Table 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

That's all for today

Thank You