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Physical Layer

Block Coding & Scrambling

DIGITAL-TO-DIGITAL CONVERSION

How we can represent digital data by using digital signals?

The conversion involves three techniques:

- ***Line coding***
- ***Block coding***
- ***Scrambling***

Line coding is always needed; block coding and scrambling may or may not be needed.

Block coding

- We need redundancy to ensure synchronization and to provide some kind of inherent error detecting.
- Block coding is used to provide redundancy and improve the performance of line coding.
- In general, block coding changes a block of *m* bits into a block of *n* bits, where *n* is larger than *m*.

Block coding is normally referred to as *m*B/*n*B coding; it replaces each m-bit group with an n-bit group.

Block coding Types:-

- **4B/5B**
- **8B/10B**

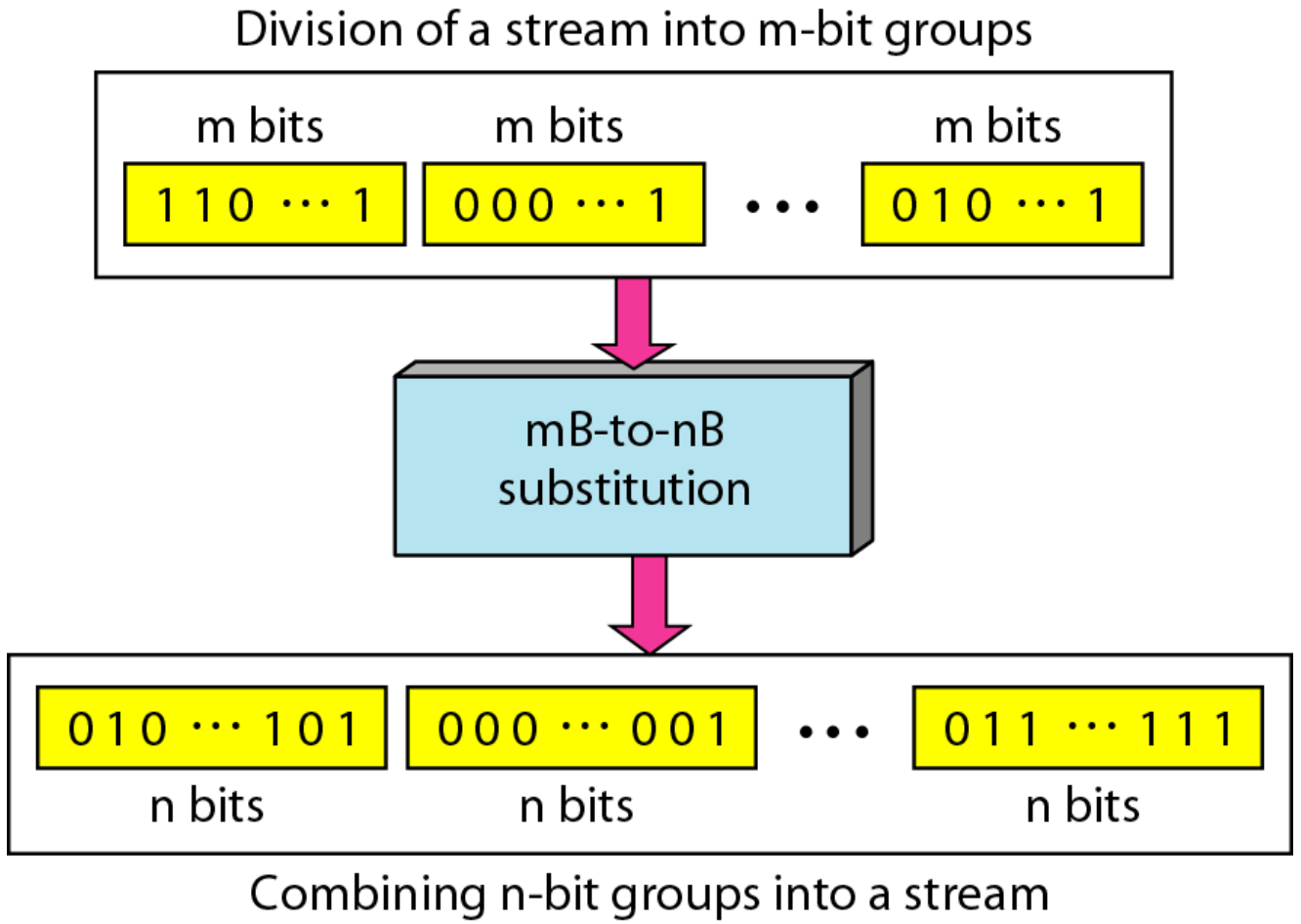
Block coding concept

Block coding normally involves three steps: division, substitution, and combination.

In the division step, a sequence of bits is divided into groups of *m* bits. For example, in 4B/5B encoding, the original bit sequence is divided into 4-bit groups.

In substitution step, we substitute an m-bit group for an n-bit group. For example, in 4B/5B encoding we substitute a 4-bit code for a 5-bit group.

In combination step, the n-bit groups are combined together to form a stream. The new stream has more bits than the original bits.



4B/5B coding Scheme

- The 4B/5B coding scheme was designed to be used in combination with NRZ-I.
- NRZ-I has a good signal rate, one-half that of the bi-phase, but it has a synchronization problem.
- A long sequence of 0s can make the receiver clock lose synchronization. One solution is to change the bit stream, prior to encoding with NRZ-I, so that it does not have a long stream of 0s.

Using block coding 4B/5B with NRZ-I line coding scheme

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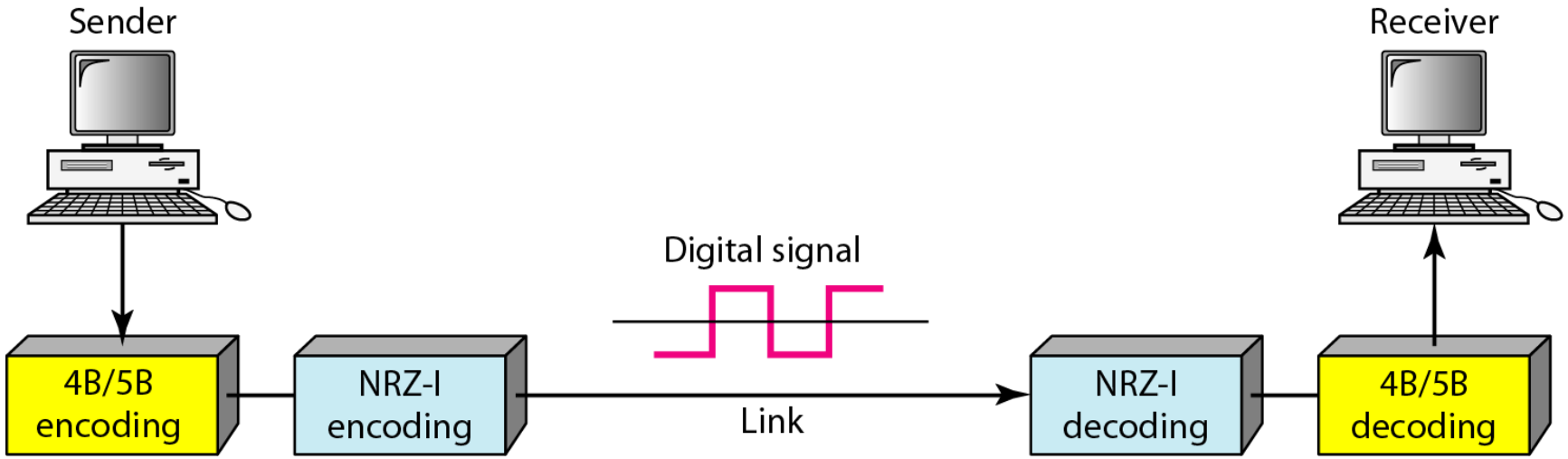
- The block-coded stream does not have more that three consecutive 0s.
- At the receiver, the NRZ-I encoded digital signal is first decoded into a stream of bits and then decoded to remove the redundancy



4B/5B mapping codes

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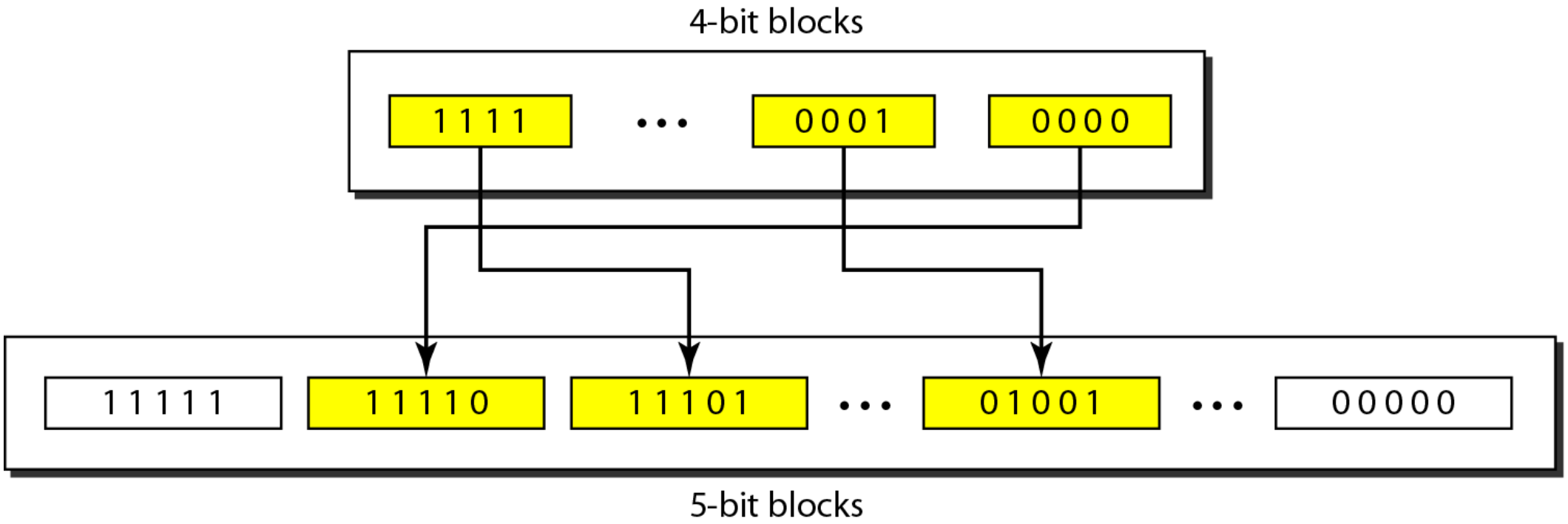
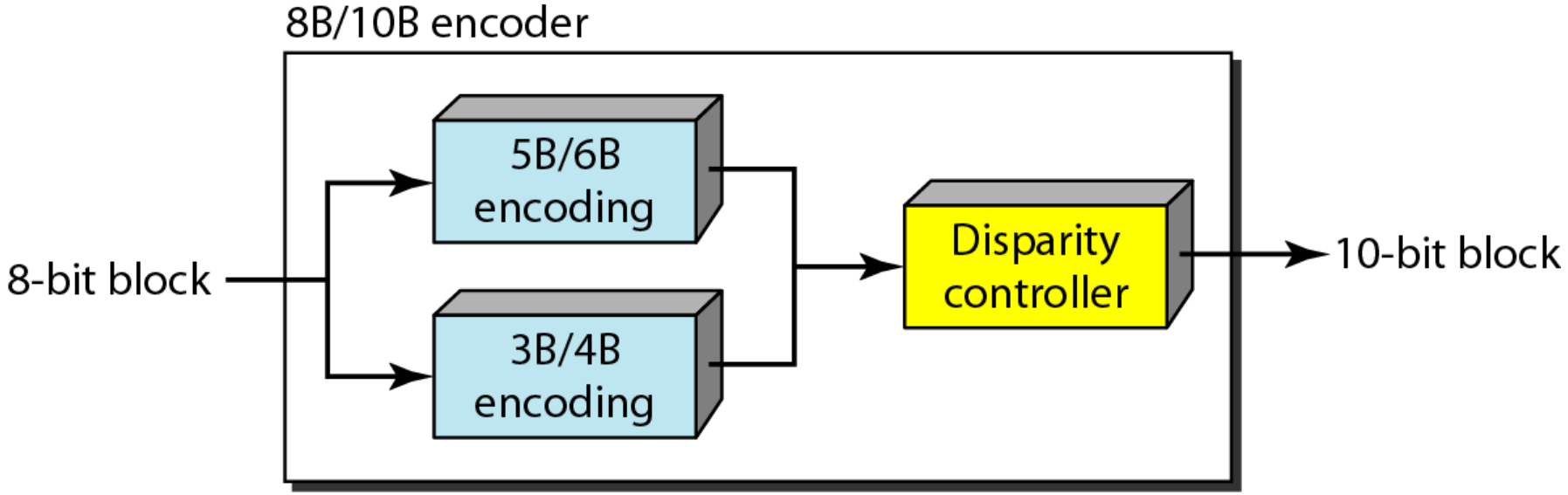
Data Sequence	*Encoded Sequence*	*Control Sequence*	*Encoded Sequence*
0000	11110	Q (Quiet)	00000
0001	01001	I (Idle)	11111
0010	10100	H (Halt)	00100
0011	10101	J (Start delimiter)	11000
0100	01010	K (Start delimiter)	10001
0101	01011	T (End delimiter)	01101
0110	01110	S (Set)	11001
0111	01111	R (Reset)	00111
1000	10010		
1001	10011		
1010	10110		
1011	10111		
1100	11010		
1101	11011		
1110	11100		
1111	11101		

Substitution in 4B/5B block coding



8B/10B block encoding

- The most five significant bits of a 10-bit block is fed into the 5B/6B encoder; the least 3 significant bits is fed into a 3B/4B encoder.
- The split is done to simplify the mapping table.
- Disparity controller:-To prevent a long run of consecutive 0s or 1s, the code uses a disparity controller which keeps track of excess 0s over 1s (or 1s over 0s).
- The coding has $2_{10} - 2_8 = 768$ redundant groups that can be used for **disparity checking** and **error detection**.
- It has better built-in error-checking capability and better synchronization as compared to 4B/5B scheme.



AMI used with scrambling

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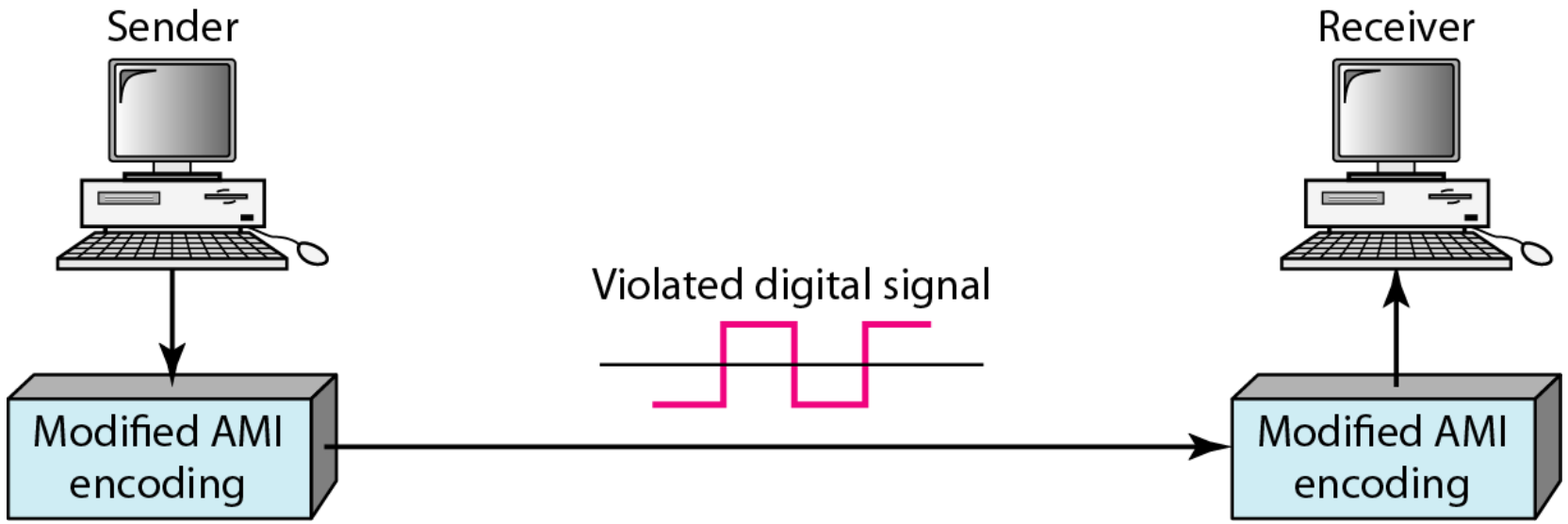
- A technique that does not increase the number of bits and does provide synchronization is desired.
- Scrambling technique substitutes long zero-level pulses with a combination of other levels to provide synchronization.
- Scrambling, as opposed to block coding, is done at the same time as encoding. The system needs to insert the required pulses based on the defined scrambling rules.

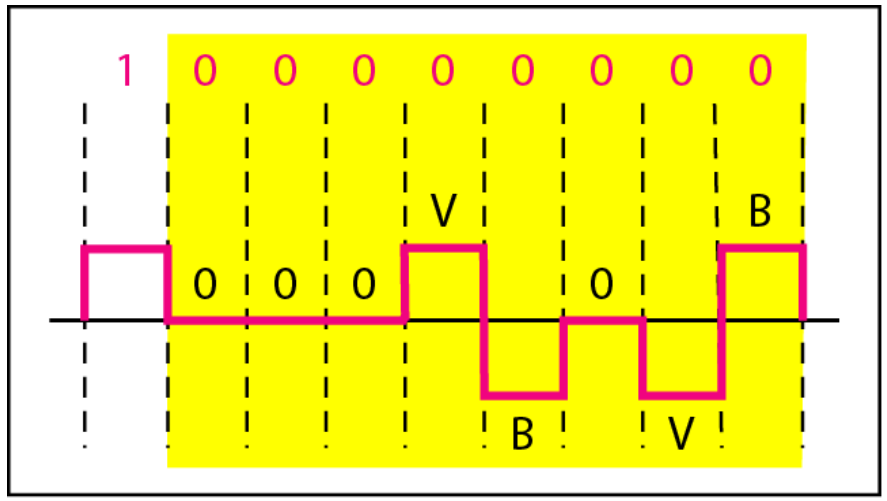
❑ Two common scrambling techniques are

1) B8ZS 2) HDB3

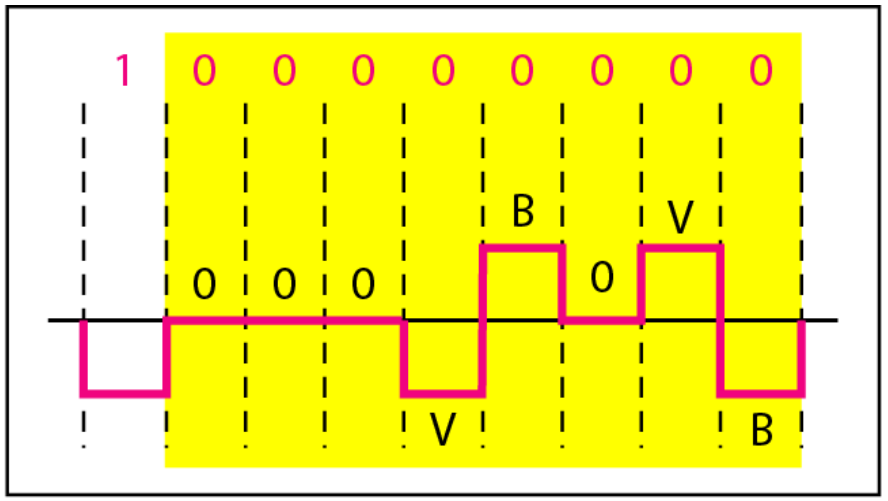


Two cases of B8ZS scrambling technique

- **B8ZS substitutes eight consecutive zeros with 000VB0VB**



a. Previous level is positive.



b. Previous level is negative.

Different situations in HDB3 scrambling technique

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HDB3 substitutes four consecutive zeros with 000V or B00V depending on the number of nonzero pulses after the last substitution