

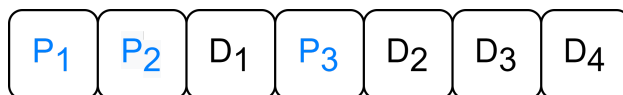
## Error correction codes:

Error correction codes are an integral part of reliability in communication systems. These codes depend on the channel noise model. Their main goals differ from system to system, ranging from trivial error detection to non-trivial error correction.

The main idea is to map the original words to new words in a smart way such that the new words are "far enough" (in terms of Hamming Distance) from each other. When receiving a bad word, the receiver can detect that, and if the code is capable enough, we can correct it. Linear Codes is a notable and famous family of block codes (i.e., all codewords have the same length), and we will implement two examples in this lab.

### Part 1: Hamming code:

Hamming code uses parity bits alongside the data to detect and correct errors during transmission to the receiver. For example, Hamming code (7,4,3):



$$P_1 = D_1 \oplus D_2 \oplus D_4$$

$$P_2 = D_1 \oplus D_3 \oplus D_4$$

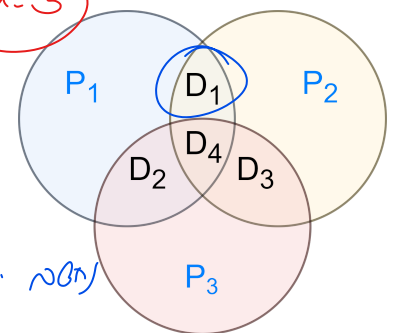
$$P_3 = D_2 \oplus D_3 \oplus D_4$$

$$P_1 = 0 + 0 + 0 = 0$$

$$P_2 = 0 + 1 + 0 = 1$$

$$P_3 = 0 + 1 + 0 = 1$$

$$\Rightarrow 011$$



### Part 2: CRC (Cyclic Redundancy Check):

Unlike the Hamming code, CRC is only used as **error-detecting**, and it is believed to be quite good in terms of error detection and easy to implement in hardware.

CRC uses a generator polynomial known to both the transmitter and receiver.

Example:

CRC-7:  $x^7 + x^3 + 1 \rightarrow 0b10001001 \rightarrow k=7$

Data: 110000001100000000

$$\begin{array}{r} 11000000110000000000000000 / 10001001 \\ \oplus 10001001 \\ \hline 10010001 \\ \oplus 10001001 \\ \hline 10010010 \\ \oplus 10001001 \\ \hline 11011000 \\ \oplus 10001001 \\ \hline 10100010 \\ \oplus 10001001 \\ \hline 10101100 \\ \oplus 10001001 \\ \hline 10010100 \\ \oplus 10001001 \\ \hline \text{CRC} = 1110100 \end{array}$$

המחלקה 0 מתחילה

הקוד נכונה

$$\frac{M(x) + \text{CRC}}{G(x)} = 0$$

$$M(x) \cdot X^k$$

$$G(x)$$

$$\text{CRC} - \text{קוד אזהרה}$$

$$\begin{array}{|c|c|} \hline \text{DATA} & \text{CRC} \\ \hline \end{array}$$

הקוד נכונה