Paper 7, TDC Part-3
Chapter– 3, Number Systems and Codes
Electronics
Lecture - 9

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Number Systems and Codes

Error Detecting and Correcting Code: -

While transmission of information in the form of electrical signal, error may occur because of electrical noise in the transmission channel. Due to this electrical noise, a signal transmitted as a ‘0’ may be received as a ‘1’ or vice-versa.

In most digital systems, millions of bits transferred/ manipulated per second so it is desired to have highly reliable data or at least violation of data must be detectable.

It is desired to detect the error in the received data word, locate bits with error and correct it. Various codes are used to detect and correct error.

The probability of simultaneous occurrence of error in two or more bit positions is negligibly small. Therefore we discuss the detection and correction of error in single bit position.

Error Detecting Codes

Data transmitted may or may not be received correctly at receiver end. At the receiving end it may or may not be possible to detect whether information has been received correctly or not.

Therefore it is convenient to use such a code which becomes invalid code due to the occurrence of the error in single bit.

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One such way is to add 1 extra bit that is the parity bit to the n-bit code. In such the code will have n+1 bits and make the number of ones in the resulting n+1 bits code even or odd. The extra bit is known as parity bit. Parity bit is attached to each code word to make the number of ones in the code even (even parity) or odd (odd parity).

In a even parity code total number of 1's in a code will be even including parity bit while for a odd parity code total number of 1's in a code will be odd including parity bit.

Table in next slide shows BCD code with parity bit, making it even parity or odd parity code.

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Table below shows BCD code with parity bit, making it even parity or odd parity code.

Decimal Code	BCD Code	BCD code with even parity	BCD code with odd parity
	B_3 B_2 B_1 B_0	P B_3 B_2 B_1 B_0	P B_3 B_2 B_1 B_0
0	0 0 0 0	0 0 0 0 0	1 0 0 0 0
1	0 0 0 1	1 0 0 0 1	0 0 0 0 1
2	0 0 1 0	1 0 0 1 0	0 0 0 1 0
3	0 0 1 1	0 0 0 1 1	1 0 0 1 1
4	0 1 0 0	1 0 1 0 0	0 0 1 0 0
5	0 1 0 1	0 0 1 0 1	1 0 1 0 1
6	0 1 1 0	0 0 1 1 0	1 0 1 1 0
7	0 1 1 1	1 0 1 1 1	0 0 1 1 1
8	1 0 0 0	1 1 0 0 0	0 1 0 0 0
9	1 0 0 1	0 1 0 0 1	1 1 0 0 1

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Here ‘P’ in the code position indicate parity bit. Parity bit can be either at MSB or at LSB.

At the transmitting side the parity bit ‘1 or 0’ is attached with the code to be transmitted.

At receiver end the parity bit of the received data is checked. If there is error in only one bit, the erroneous code is detected by parity chanseck at the receiver.

The parity check method can only detect the error in the transmitted word it can not locate the bit which has changed. On detecting the error the receiver ask for retransmission of the word.

Error-correction Techniques:-

Error Correcting Codes:-

In processing of data in digital system, detection of error do not end the task, but it is also necessary to identify the bit position which is erroneous and to correct the error also.

Let us consider a 4-bit binary word "0101" is transmitted along with an even parity bit. Due to transmiss-

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even parity bit. Due to transmission error in one bit position, the erroneous word received may be "00100", "00111", "00001", or "01101" depending on the error in bit position b_0, b_1, b_2 and b_3 respectively, where MSB is the parity bit.

Note :→ Error can also occur ~~be at~~ parity bit.

Let us examine whether these erroneous words are possible with any other message being transmitted. If the word "01100" is transmitted it results in "00100" at receiver due to an error in bit position b_3. Similarly, the other erroneous words are received due to the transmission error in some other words being transmitted. This indicates that a minimum distance of '2' can't locate the bit position in the incorrectly recieved word. Therfore, for a code to be error correcting, its minimum distance must be more than two.

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If the minimum distance is "3", every error in single bit results in an invalid code word which is at a distance of one from the original code word and at a distance of "2" from any other valid code word. Therefore, a single bit error can be detected and located using this code. Once the error bit is located it can be inverted to correct the erroneously recieved message.

In general, a code is said to be error-correcting code if the correct code word can be deduced from the erroneous word. The capability of a code to be error detecting and/or error-correcting can be determined from its minimum distance. If a code's minimum distance is $2c+d+$ it, can correct errors in upto c bits and detect errors in upto d additional bits.

Table below list possible values of c and d for various values of minimum distance of a code.

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Minimum Distace of a code	c	d
1	0	0
2	0	1
3	0	2
	1	0
4	0	3
	1	1

From table, we observe that if the minimum distance of a code is 4, it can correct upto one bit (c=1) and detect errors in upto two (c + d = 1 + 1) bits. The same

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code can also be used for detecting errors in upto 3 bits but correct no errors $(c = 0)$.

Example :- Q.4:- Four messages are encoded in the following code words:

Message	Code
M_1	0 1 1 0 1
M_2	1 0 0 1 1
M_3	0 0 1 1 0
M_4	1 1 0 0 0

Determine the minimum distance of this code.

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Solution:- To determine the minimum distance, we should find out number of bit positions in which any code word differs from any other code word.

Distance between the codes

Same

$M_1(0\ 1\ 1\ 0\ 1)$ and $M_2(1\ 0\ 0\ 1\ 1)$ — 4

Differ at their respective bit

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Similarly

Same

M_1 (0 1 1 0 1) and M_3 (0 0 1 1 0) $\rightarrow$ 3

Differ at 3 bit position

Similarly,

M_1	and	M_4	3
M_2	and	M_3	3
M_2	and	M_4	3
M_3	and	M_4	4

Therefore, the minimum distance of this code is '3'.

Thank You