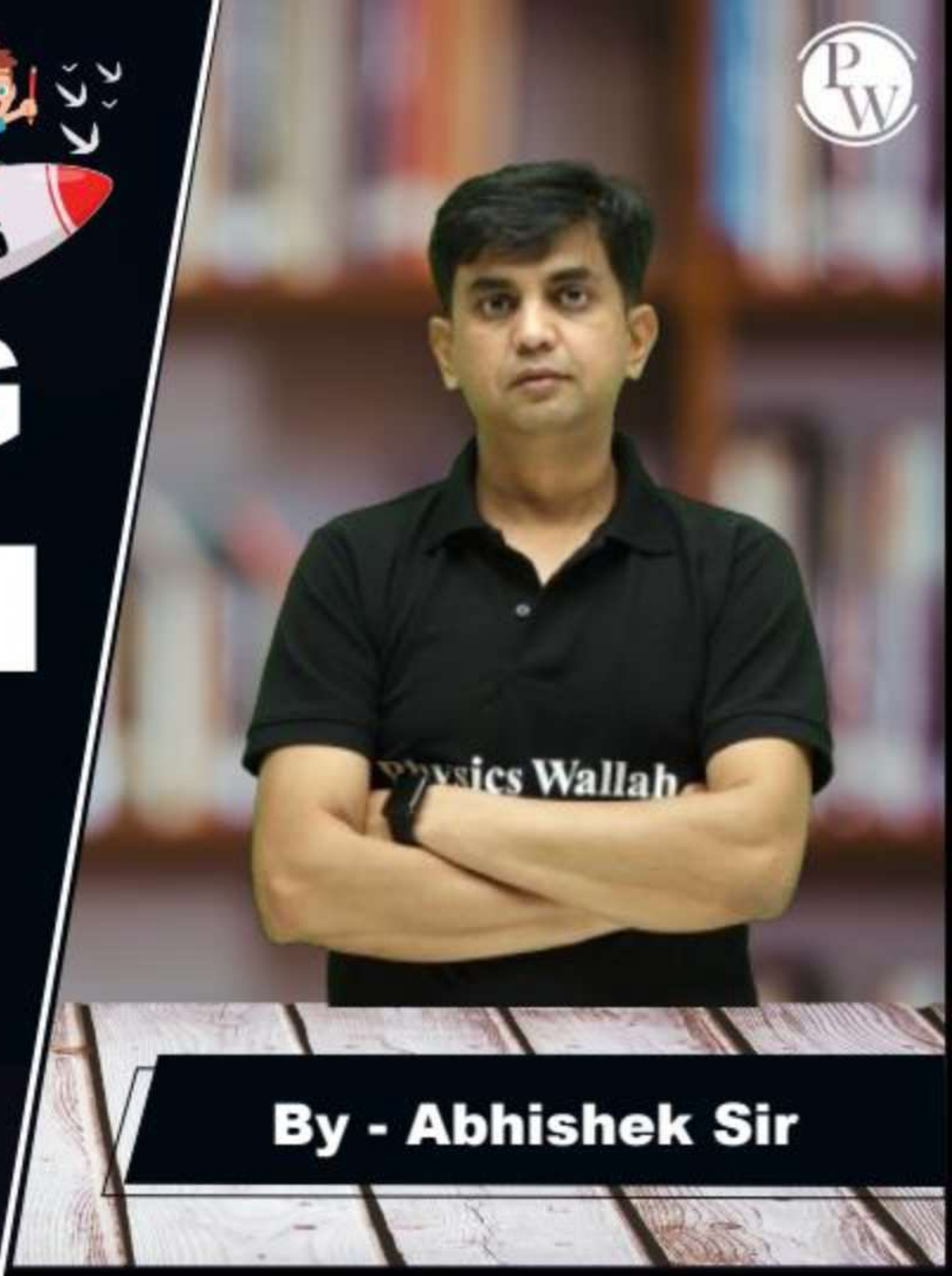
CS & IT ENGINEERING

Computer Network

Error Control

Lecture No. - 02



By - Abhishek Sir

Recap of Previous Lecture

Topic Error Control

Topic One-bit Parity

Topics to be Covered

Topic Block Code

Topic CRC

ABOUT ME

Hello, I'm Abhishek

- GATE CS AIR - 96
- M.Tech (CS) - IIT Kharagpur
- 12 years of GATE CS teaching experience

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Topic : One-bit parity

Suppose "**Even parity**"

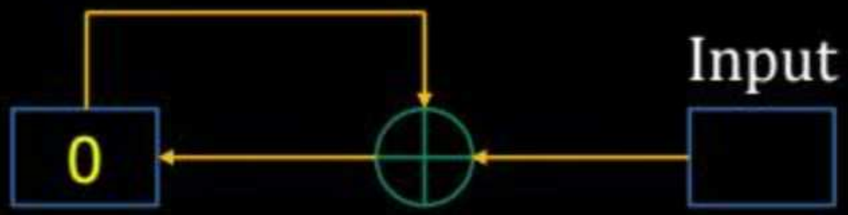
DATA = " 1 0 1 1 1 0 1"
d_1 d_2 d_3 d_4 d_5 d_6 d_7

Transmitted Data = 1 0 1 1 1 0 1 **1**
P

X-OR :-

$a \oplus 1 = \bar{a}$

$a \oplus 0 = a$

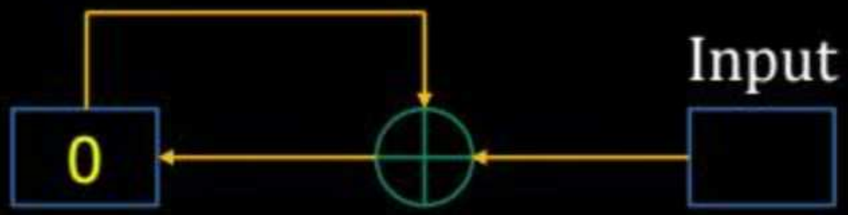


0	$d_1 = 1$
1	$d_2 = 0$
1	$d_3 = 1$
0	$d_4 = 1$
1	$d_5 = 1$
0	$d_6 = 0$
0	$d_7 = 1$
1	$P = 0$
P = 1	

AT Sender (Transmitter)

Input = " 1 0 1 1 1 0 1 **0**"

d_1 d_2 d_3 d_4 d_5 d_6 d_7 **P**



0	$d_1 = 1$
1	$d_2 = 0$
1	$d_3 = 1$
0	$d_4 = 1$
1	$d_5 = 1$
0	$d_6 = 0$
0	$d_7 = 1$
1	**P** = **1**

Result = 0

AT Receiver

Input = " 1 0 1 1 1 0 1 **1** "
d_1 d_2 d_3 d_4 d_5 d_6 d_7 **P**

if **Result** == **ZERO** :
then Receiver concluded
"**No any error detected**"
else
Receiver concluded
"**Error detected**"

Topic : Block Code

k-bits input → n-bits output

k = input data bits

n = code length

→ 2^k codewords of length n.

No. of parity bit in each codeword = (n − k)

Codeword = [data with parity]

Topic : Block Code

One-bit parity (with even parity) and 3 data bits

Data	-->	Codeword
$d_1d_2d_3$	-->	$d_1d_2d_3P$
000	-->	0000
001	-->	0011
010	-->	0101
011	-->	0110
100	-->	1001
101	-->	1010
110	-->	1100
111	-->	1111

Set of ($2^k = 8$) Codewords

Block Code
+
Linear Code
+
Cyclic Code

Topic : Linear Code

→ Linear combination of codewords

if C_i and C_j are codewords in set

then C_k is also be a codeword in that set

where $C_k = C_i \oplus C_j$

```
 0110
 1010
------
 1100
```

Binary arithmatic

Modulo 2 Arithmatic :-

$0 + 0 = 0$

$0 + 1 = 1$

$1 + 0 = 1$

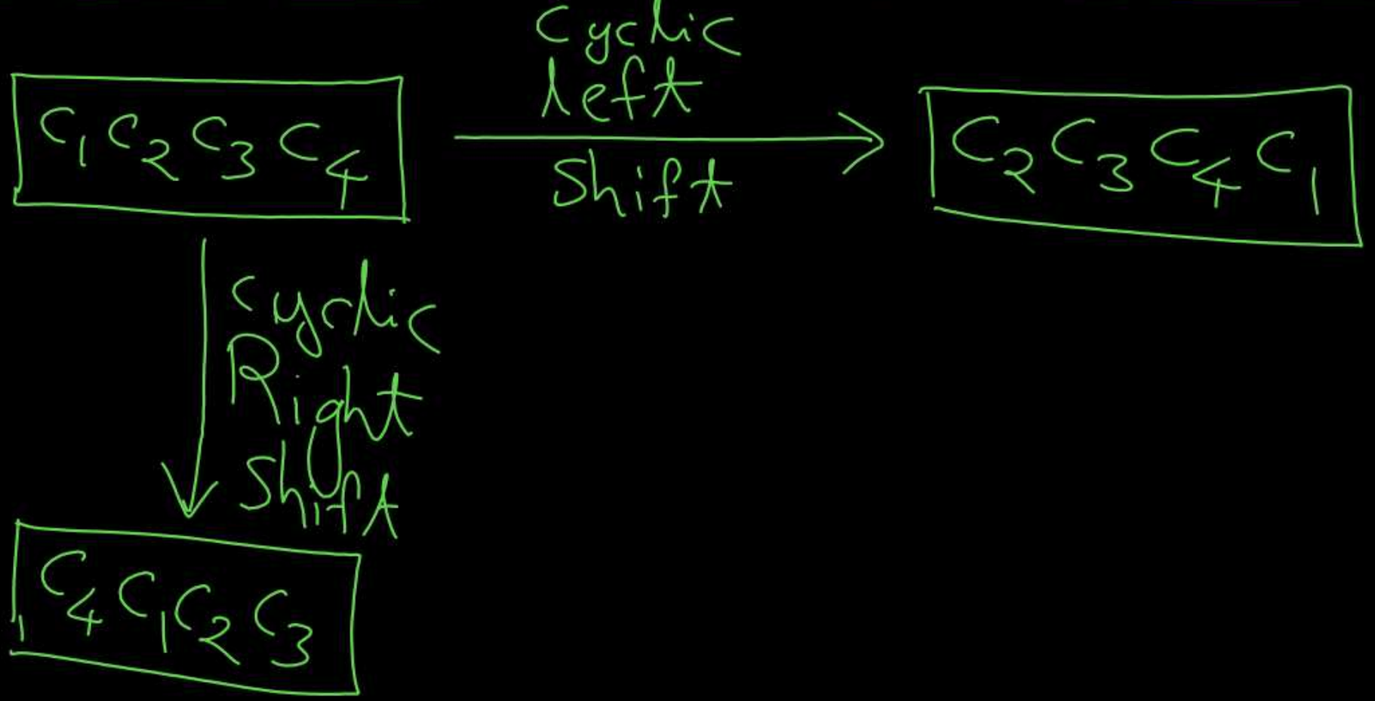
$1 + 1 = 0$

Topic : Cyclic Code

→ Cyclic combination of linear codewords

if C is codeword $[c_1 c_2 c_3 c_4]$

then bit-wise cyclic left or right shift on C is also be a codeword



Topic : Valid Codewords vs Invalid Codewords

→ Valid codewords :

0000,	0011,	0101,	0110,	1001,	1010,	1100,	1111

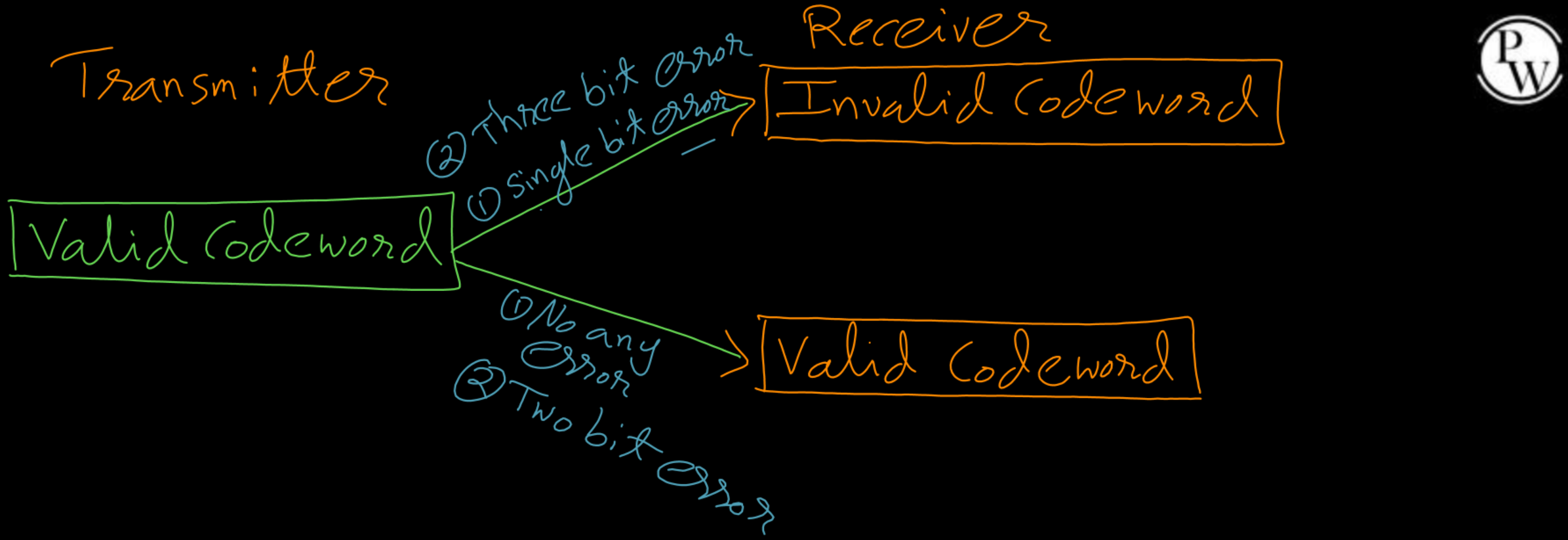
→ Invalid codewords :

0001,	0010,	0100,	0111,	1000,	1011,	1101,	1110

→ Transmitter always transmit valid codeword in the channel.

→ If receiver receives a codeword from channel, which is belongs to valid code set, then receiver conclude "no error detected".

→ If receiver receives a codeword from channel, which belongs to Invalid codeword set then receiver conclude "Error Detected".


Transmitter
Receiver
Valid codeword
② Three bit error
① Single bit error
Invalid codeword
① No any error
② Two bit error
Valid codeword

Topic : CRC

→ Cyclic Redundancy Check (CRC)

→ Frame Check Sequence (FCS)

Topic : Polynomial Function

→ Polynomial function, where coefficients are either zero or one.

Example :

Function = $X^5 + X^2 + 1$

$= 1*X^5 + 0*X^4 + 0*X^3 + 1*X^2 + 0*X^1 + 1*X^0$

Topic : Generator Polynomial

G(X) : Generator Polynomial function

→ **(n+1)** terms [X^n to X^0]

→ Degree[G(X)] = **n** ⇒ Coefficient of the term x^n should be one.

→ Coefficient of term X^0 should be "**one**"
[G(X) shuold not be divisible by X]
completely

→ Both transmitter and receiver must agree on same G(X) .

G(X) = $X^n + ... + 1$

Topic : Divisor

$G(X) = X^n + \ldots + 1$

Divisor : binary string, (n+1) bits [1 . . . . 1]

Example :

$G(X) = X^3 + X^2 + 1$

$= 1*X^3 + 1*X^2 + 0*X^1 + 1*X^0$

Divisor = 1 1 0 1

Topic : Message Polynomial

M(X) : Message Polynomial function

→ **m** terms, [$X^{(m-1)}$ to X^0]

→ coefficients are either zero or one

DATA (Message) : binary string (**m - bits**)

Topic : Message Polynomial

DATA (Message) : binary string (**m - bits**)

Example :-

$$M(X) = X^7 + X^4 + X^3 + X$$

$$= 1*X^7 + 0*X^6 + 0*X^5 + 1*X^4 + 1*X^3 + 0*X^2 + 1*X^1 + 0*X^0$$

DATA = 1 0 0 1 1 0 1 0

Topic : CRC

Transmitter protocol :

[M(X) * X^n] [Modulo-2 Division] [G(X)]

$[f_1(x) * f_2(x)]$ division $[f_3(x)]$

2 mins Summary

Topic Block Code

Topic CRC

THANK - YOU