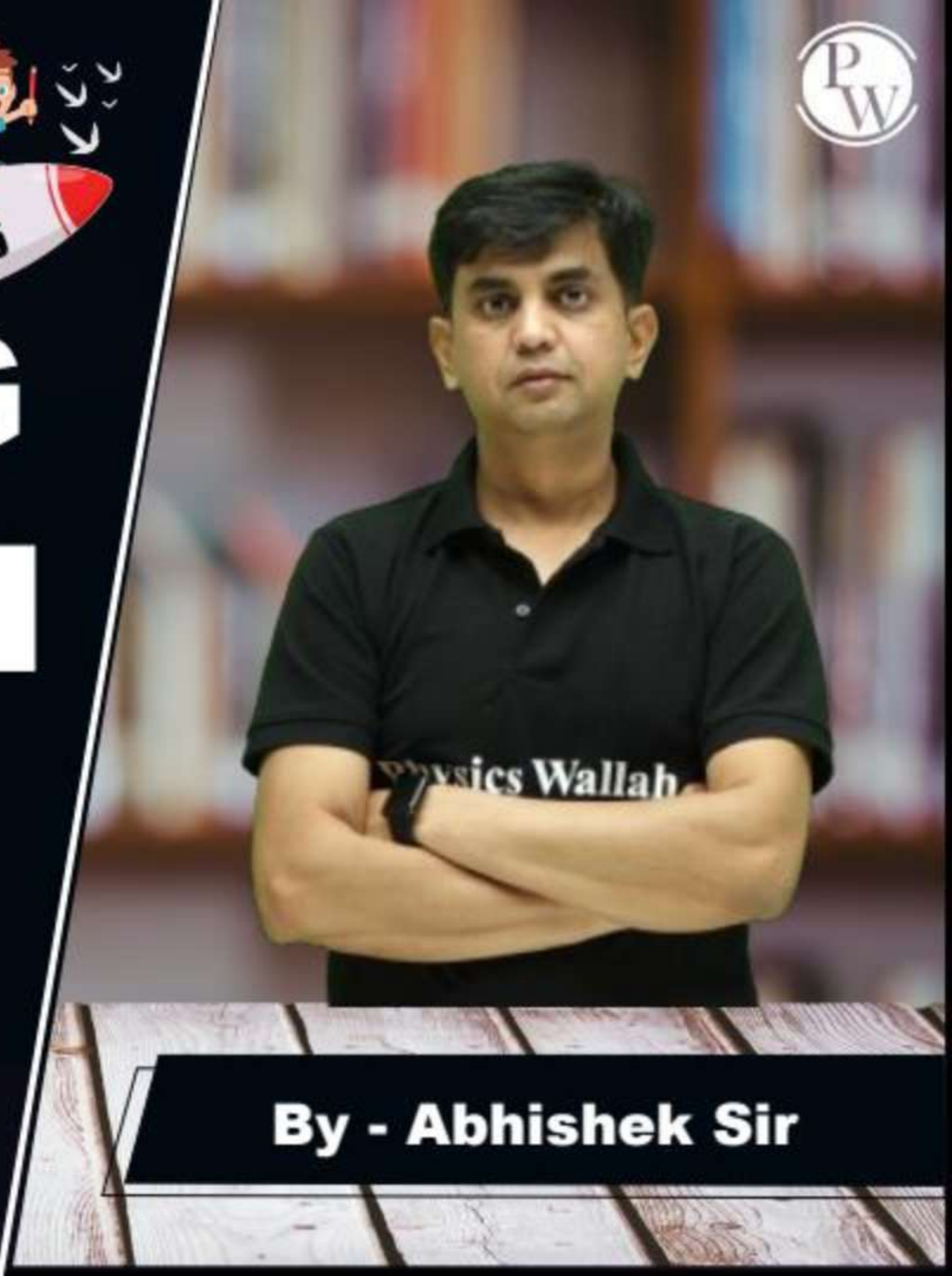
CS & IT ENGINEERING

Computer Network

Error Control

Lecture No. - 04



By - Abhishek Sir

Recap of Previous Lecture

Topic

CRC

Topics to be Covered

Topic	CRC

ABOUT ME

Hello, I'm Abhishek

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

Telegram Link : https://t.me/abhisheksirCS_PW

Topic : CRC

Example 2 :

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

$M(X) = X^7 + X^4 + X^3 + X^2 + 1$

$M(X) * X^3 = X^{10} + X^7 + X^6 + X^5 + X^3$ Divident

[$M(X) * X^3$] [Modulo-2 Division] [$G(X)$]

Topic : CRC

$X^7 + X^5 + 1$

$X^3 + X + 1$ | $X^{10} + X^7 + X^6 + X^5 + X^3$

$X^{10} + X^8 + X^7$

$X^8 + X^6 + X^5 + X^3$

$X^8 + X^6 + X^5$

X^3

$X^3 + X + 1$

$X + 1$

Modulo 2 division
[bit-wise X-OR]

Topic : CRC

Example 2 :

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

$M(X) = X^7 + X^4 + X^3 + X^2 + 1$

$M(X) * X^3 = X^{10} + X^7 + X^6 + X^5 + X^3$

[M(X) * X^3] [Modulo-2 Division] **[G(X)]**

R(X) = $0*X^2 + 1*X^1 + 1*X^0$ $= X + 1$

Topic : CRC

Example 2 :

$M(X) * X^3 = X^{10} + X^7 + X^6 + X^5 + X^3$

$R(X) = X + 1$

Transmitter transmit : $M(x) * x^3 + R(x)$

$X^{10} + X^7 + X^6 + X^5 + X^3 + X + 1$

Topic : CRC

Example 2 :

$G(X) = X^3 + X + 1$ DIVISOR = 1011

$M(X) = X^7 + X^4 + X^3 + X^2 + 1$ DATA = 10011101

$M(X) * X^3 = X^{10} + X^7 + X^6 + X^5 + X^3$

Divident = 1 0 0 1 1 1 0 1 0 0 0

DATA zero

[$M(X) * X^3$] [Modulo-2 Division] [$G(X)$]

Topic : CRC

```
1011 | 1 0 0 1 1 1 0 1 0 0 0
       1 0 1 1
       -------
         1 0 1 1
         1 0 1 1
         -------
             1 0 0 0
             1 0 1 1
             -------
               0 1 1
```

Modulo 2 division
[bit-wise X-OR]

CRC

Topic : CRC

Example 2 :

$G(X) = X^3 + X + 1$ DIVISOR = 1 0 1 1

$M(X) = X^7 + X^4 + X^3 + X^2 + 1$ DATA = 1 0 0 1 1 1 0 1

$M(X) * X^3 = X^{10} + X^7 + X^6 + X^5 + X^3$

1 0 0 1 1 1 0 1 0 0 0

[M(X) * X^3] [Modulo-2 Division] **[G(X)]**

R(X) = $0*X^2 + 1*X^1 + 1*X^0$

CRC = 0 1 1

Topic : CRC

(37/10) → (Remainder : 7)

Example 2 :

$M(X) * X^3 = X^{10} + X^7 + X^6 + X^5 + X^3$

1 0 0 1 1 1 0 1 0 0 0

$R(X) = 0*X^2 + 1*X + 1*X^0$

CRC = 0 1 1

Transmitter transmit : $(M(x) * x^3) + R(x)$

$X^{10} + X^7 + X^6 + X^5 + X^3 + X + 1$

1 0 0 1 1 1 0 1 0 1 1

MSb

LSb

Topic : CRC

Receiver protocol :

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

R'(X) : Remainder at receiver (of above equation)

if **R'(X) == ZERO** :

then Receiver concluded "**No any error detected**"

else

Receiver concluded "**Error detected**"

Topic : CRC

Example 2 :

Transmitter transmited :

$X^{10} + X^7 + X^6 + X^5 + X^3 + X + 1$

1 0 0 1 1 1 0 1 0 1 1

Receiver received :

$X^{10} + X^7 + X^6 + X^5 + X^3 + X + 1$

1 0 0 1 1 1 0 1 0 1 1

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

DIVISOR = 1 0 1 1

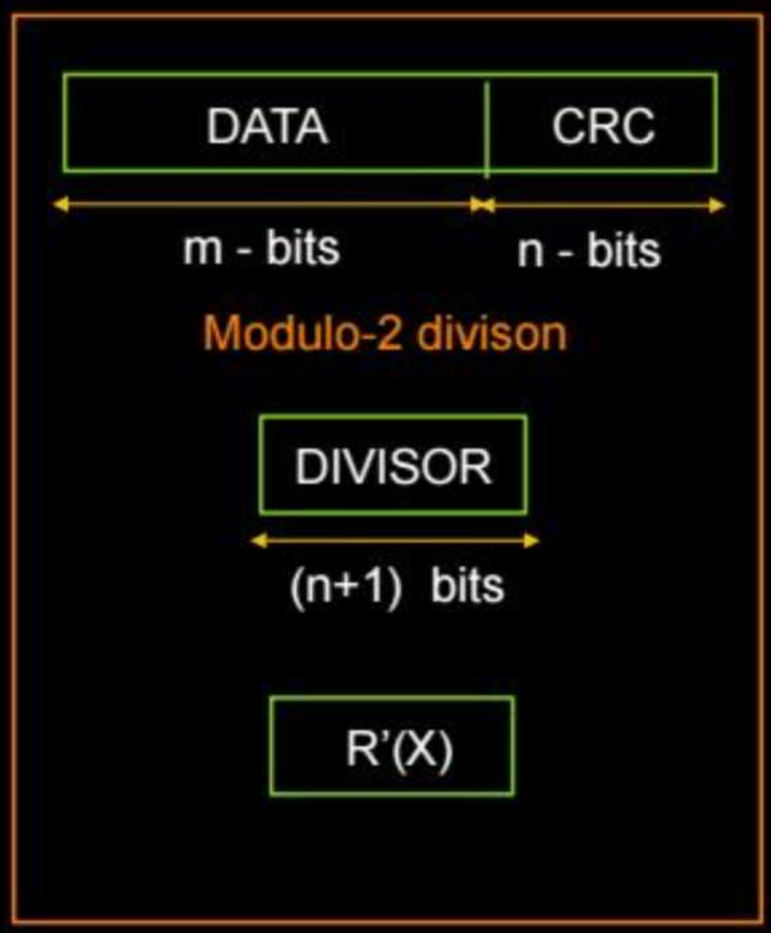
Topic : CRC

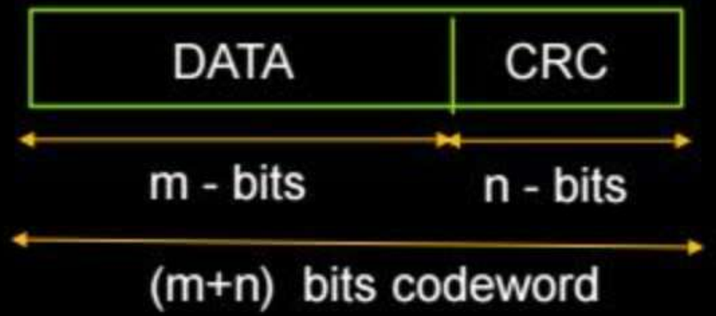
```
1 0 1 1 | 1 0 0 1 1 1 0 1 0 1 1
          1 0 1 1
          -------
            1 0 1 1
            1 0 1 1
            -------
              1 0 1 1
              1 0 1 1
              -------
                0 0 0
```

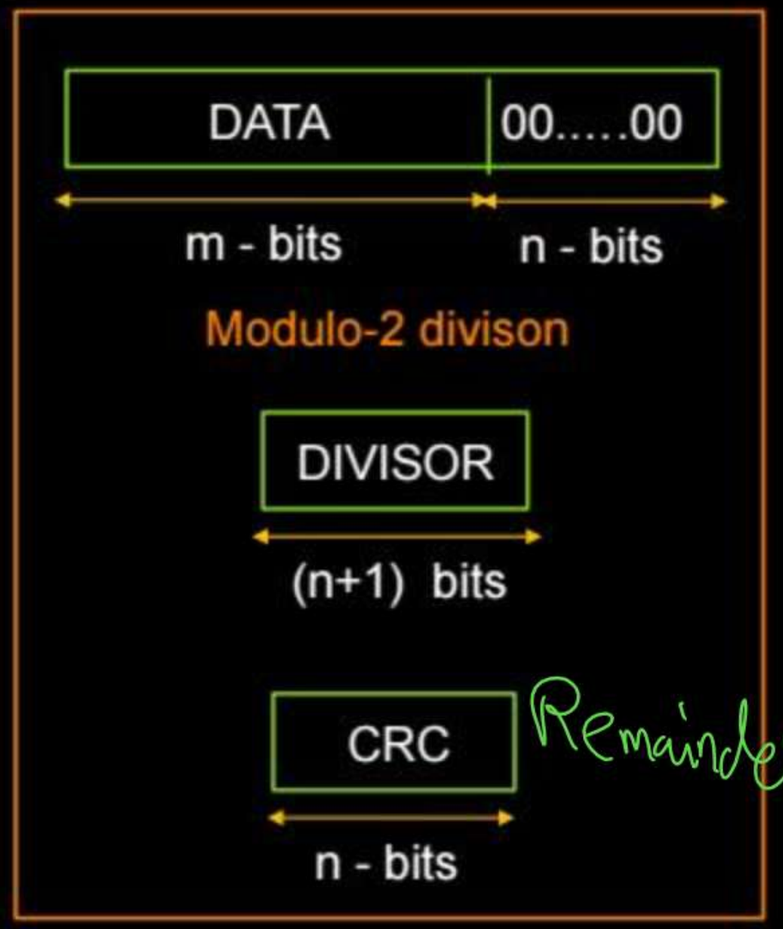
Modulo 2 division
[bit-wise X-OR]

Topic : CRC

$G(X) = X^n + ... + 1$ where $n > 0$







#Q. Consider the message M = 1010001101. The cyclic redundancy check (CRC) for this message using the divisor polynomial $x^5 + x^4 + x^2 + 1$ is

[GATE 2005]

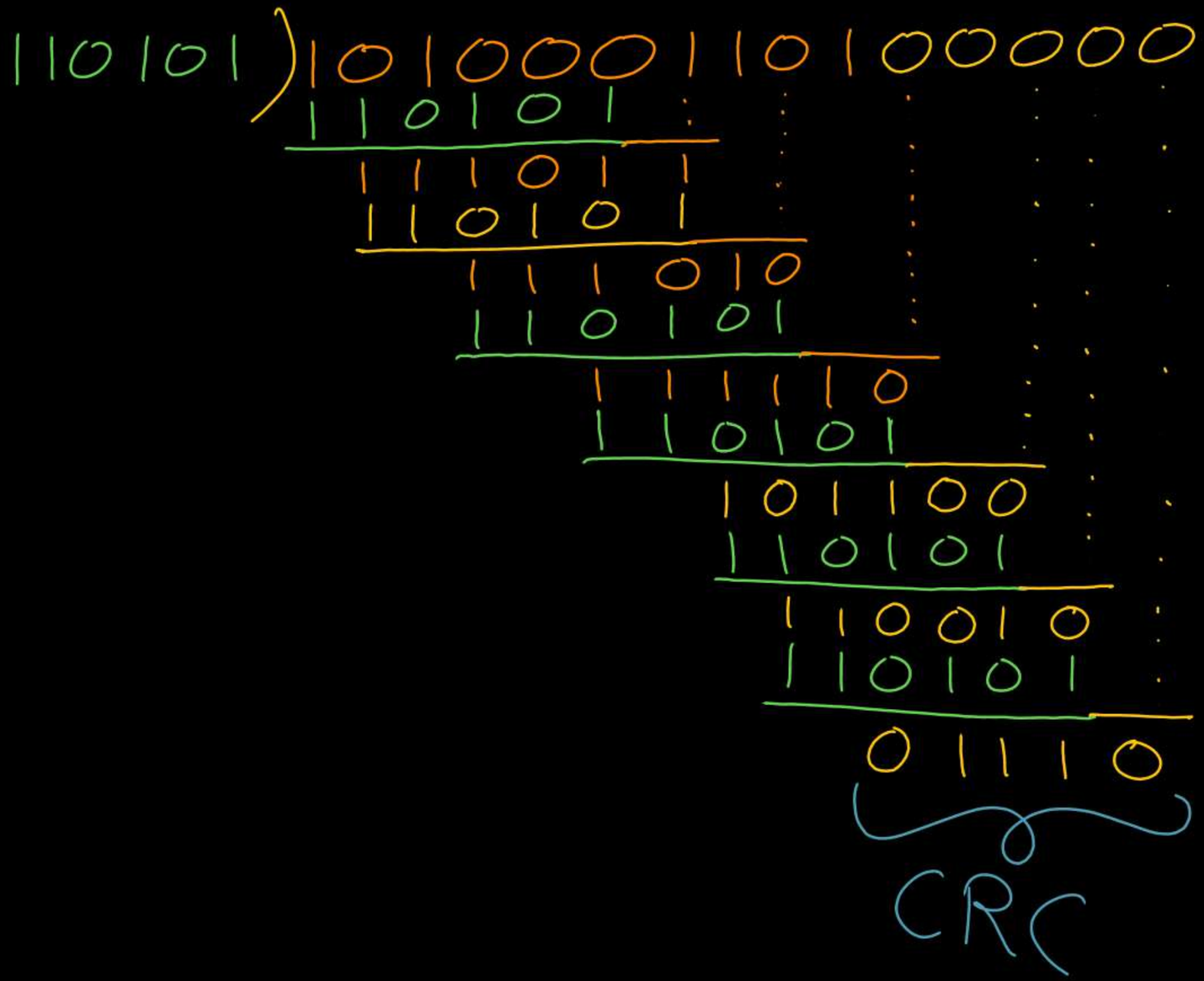
(A) 01110
(B) 01011
(C) 10101
(D) 10110

$G(x) = x^5 + x^4 + x^2 + 1$

Divisor = 110101

6 bit

Ans: A


110101
1010001101000000
110101
111010
110101
111010
110101
111110
110101
101100
110101
110010
110101
01110
CRC

#Q. The message 11001001 is to be transmitted using the CRC polynomial $x^3 + 1$ to protect it from errors. The message that should be transmitted is :

[GATE 2007]

(A) 11001001000

(B) 11001001011

(C) 11001010

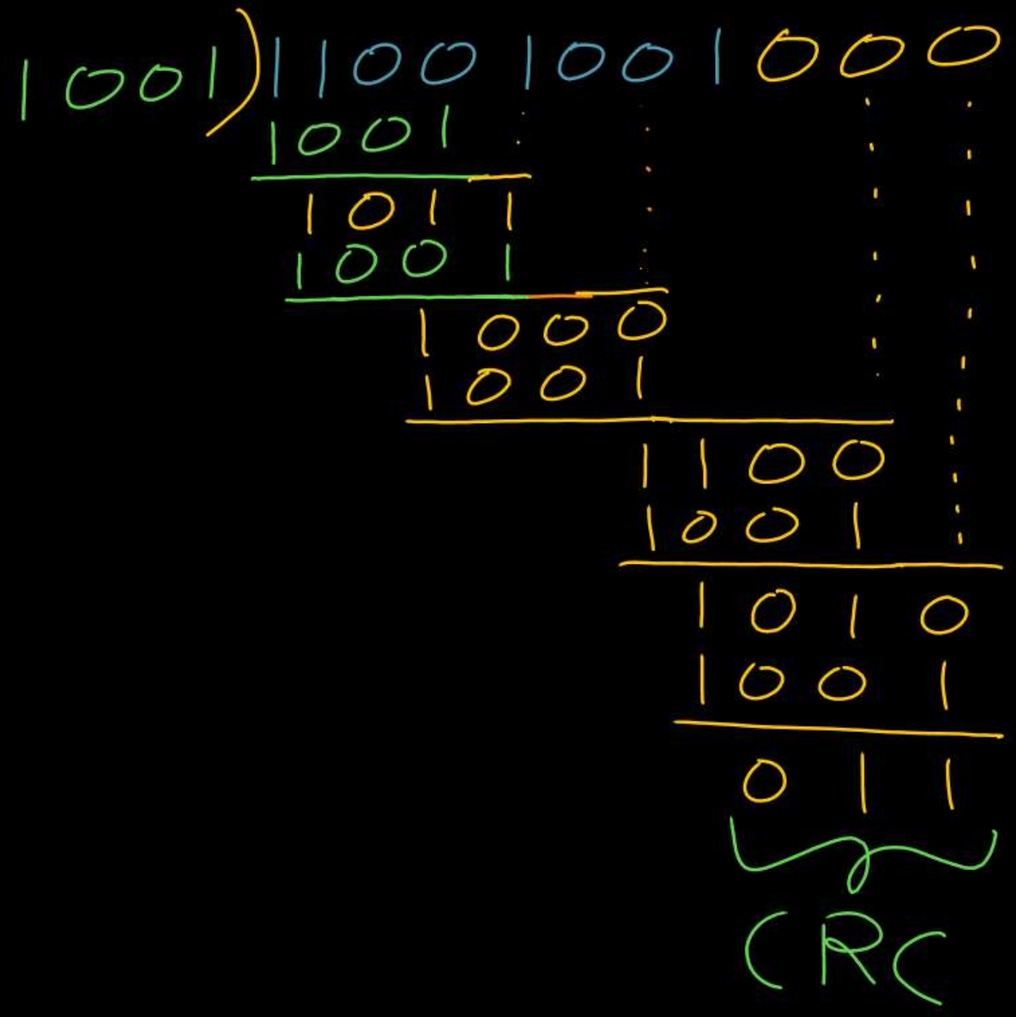
(D) 110010010011

$G(x) = x^3 + 1$

Divisor = 1001

+ 3 bit

Ans: B


1001)11001001000
1001
1011
1001
1000
1001
1100
1001
1010
1001
011
CRC

#Q. A computer network uses polynomials over GF(2) for error checking with 8 bits as information bits and uses $x^3 + x + 1$ as the generator polynomial to generate the check bits. In this network, the message 01011011 is transmitted as :

(A) 01011011010

(B) 01011011011

(C) 01011011101

(D) 01011011100

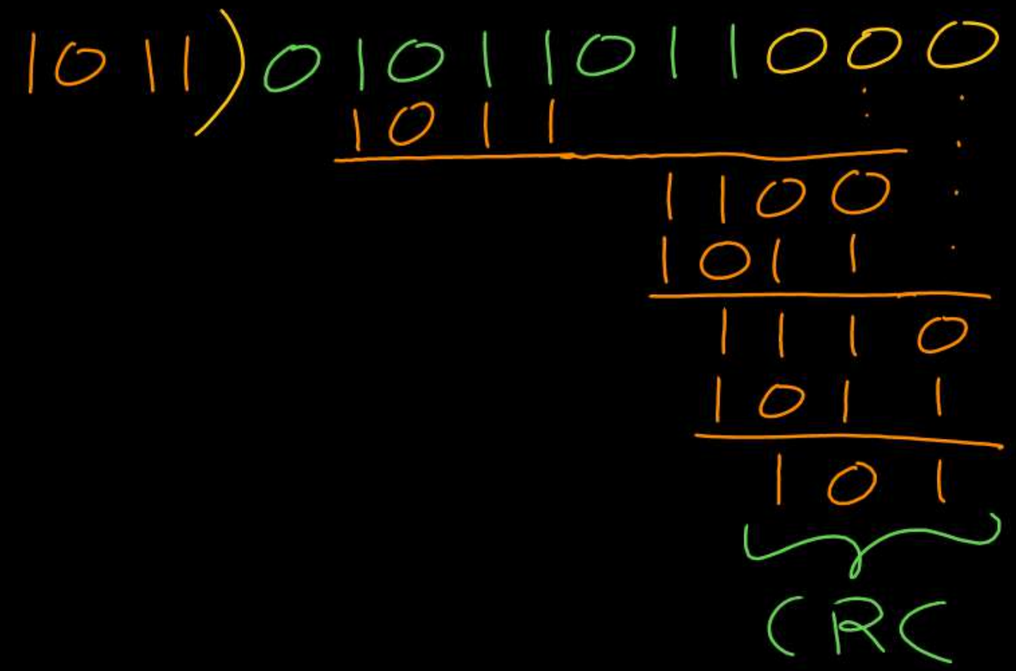
$G(x) = x^3 + x + 1$

Divisor = 1011

[GATE 2017]

IIIT-R

Ans : C


1011)0101101011000
1011
1100
1011
1110
1011
101
CRC

#Q. Consider the cyclic redundancy check (CRC) based error detecting scheme having the generator polynomial X^3+X+1. Suppose the message $m_4m_3m_2m_1m_0 = 11000$ is to be transmitted. Check bits $c_2c_1c_0$ are appended at the end of the message by the transmitter using the above CRC scheme. The transmitted bit string is denoted by $m_4m_3m_2m_1m_0c_2c_1c_0$. The value of the checkbit sequence $c_2c_1c_0$ is :

[GATE 2021, Set-2, 2-Mark]

(A) 101

(B) 110

(C) 100

(D) 111

$G(x) = x^3+x+1$, Divisor = 1011

```
1011 ) 11000000
       1011
       ----
        1110
        1011
        ----
        1010
        1011
        ----
         100
```

(CRC)

Ans: C

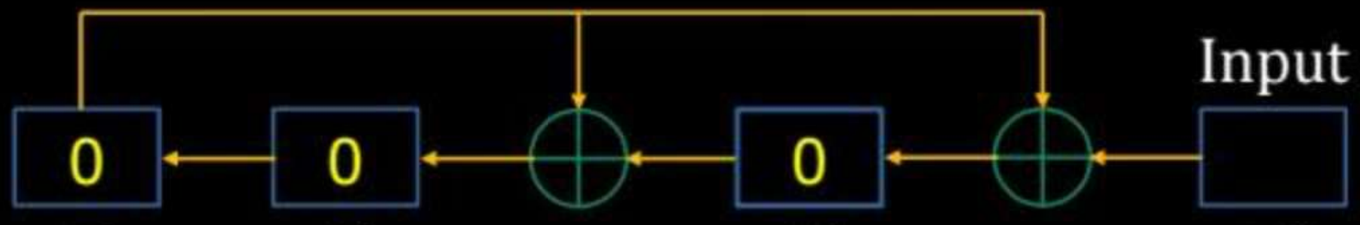
Topic : CRC

Example 2:

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

Message (DATA) = 1 0 0 1 1 1 0 1

CRC = 0 1 1

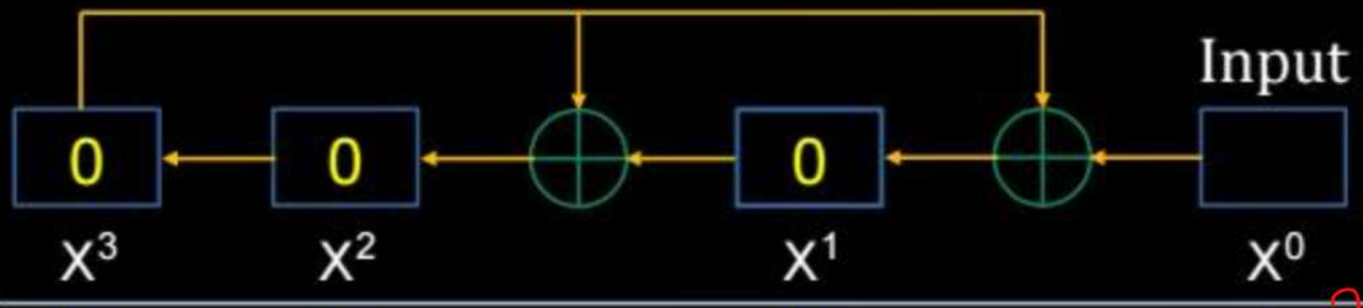


AT Sender (Transmitter)

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

Data Zero

X^3	X^2	X^1	X^0
0	0	0	1
0	0	1	0
0	1	0	0
1	0	0	1
0	1	0	1
1	0	1	1
0	0	0	0
0	0	0	1
0	0	1	0
0	1	0	0
1	0	0	0
0	1	1	



X^3	X^2	X^1	X^0	
0	0	0	1	Data
0	0	1	0	
0	1	0	0	
1	0	0	1	
0	1	0	1	
1	0	1	1	
0	0	0	0	
0	0	0	1	
0	0	1	0	CRC
0	1	0	1	
1	0	1	1	
R'(X)=0	0	0		

AT Receiver

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

Data CRC

if **R'(X) == ZERO** :
then Receiver concluded
"**No any error detected**"
else
Receiver concluded
"**Error detected**"

Topic : CRC

CASE I : No any error

Transmitter transmit : $[M(X) * X^n] + [R(X)]$

Receiver received : $[M(X) * X^n] + [R(X)]$

Receiver protocol :

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

Above equation will definitely lead "zero remainder"

Receiver conclude : "No any error detected"

Topic : CRC

CASE II : Error Included

Transmitter transmit : $[M(X) * X^n] + [R(X)]$

Receiver received : $[M(X) * X^n] + [R(X)] + [E(X)]$

Topic : Error Polynomial

E(X) : Error Polynomial Function

→ Coefficient are either Zero or One

Data : m bits CRC : n bits

Codeword : (m + n) bits

Degree(**E(X)**) < (m + n)

2 mins Summary

Topic CRC

THANK - YOU