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Roll No. – 1801CS43

CS226 LAB-9

Q1)

Q1. 4 Bit Synchronous counter  
(a) SR flip flop.

Present State				Next State				Flip Flop Input							
$Q_4$	$Q_3$	$Q_2$	$Q_1$	$Q_4^*$	$Q_3^*$	$Q_2^*$	$Q_1^*$	$S_4$	$R_4$	$S_3$	$R_3$	$S_2$	$R_2$	$S_1$	$R_1$
0	0	0	0	0	0	0	1	0	x	0	x	0	x	1	0
0	0	0	1	0	0	1	0	0	x	0	x	1	0	0	1
0	0	1	0	0	0	1	1	0	x	0	x	x	0	1	0
0	0	1	1	0	1	0	0	0	x	1	0	0	1	0	1
0	1	0	0	0	1	0	1	0	x	x	0	0	x	1	0
0	1	0	1	0	1	1	0	0	x	x	0	1	0	0	1
0	1	1	0	0	1	1	1	0	x	x	0	x	0	1	0
0	1	1	1	1	0	0	0	1	0	0	1	0	1	0	1
1	0	0	0	1	0	0	1	x	0	0	x	0	x	1	0
1	0	0	1	1	0	1	0	x	0	0	x	1	0	0	1
1	0	1	0	1	0	1	1	x	0	0	x	x	0	1	0
1	0	1	1	1	1	0	0	x	0	1	0	0	1	0	1
1	1	0	0	1	1	0	1	x	0	x	0	0	x	1	0
1	1	0	1	1	1	1	0	x	0	x	0	1	0	0	1
1	1	1	0	1	1	1	1	x	0	x	0	x	0	1	0
1	1	1	1	0	0	0	0	0	1	0	1	0	1	0	1

K-map

$Q_4 Q_3 \backslash Q_2 Q_1$	00	01	11	10
00	1	0	0	1
01	1	0	0	1
11	1	0	0	1
10	1	0	0	1

$$S_1 = \bar{Q}_1$$

$Q_4 Q_3 \backslash Q_2 Q_1$	00	01	11	10
00	0	1	1	0
01	0	1	1	0
11	0	1	1	0
10	0	1	1	0

$$R_1 = Q_1$$

$Q_4 Q_3 \backslash Q_2 Q_1$	00	01	11	10
00	0	1	0	X
01	0	1	0	X
11	0	1	0	X
10	0	1	0	X

$$S_2 = Q_1 \bar{Q}_2$$

$Q_4 Q_3 \backslash Q_2 Q_1$	00	01	11	10
00	X	0	1	0
01	X	0	1	0
11	X	0	1	0
10	X	0	1	0

$$R_2 = Q_1 Q_2$$

$Q_4 Q_3 \backslash Q_2 Q_1$	00	01	11	10
00	0	0	1	0
01	X	X	0	X
11	X	X	0	X
10	0	0	1	0

$$S_3 = Q_1 Q_2 \bar{Q}_3$$

$Q_4 Q_3 \backslash Q_2 Q_1$	00	01	11	10
00	X	X	0	X
01	0	0	1	0
11	0	0	1	0
10	X	X	0	X

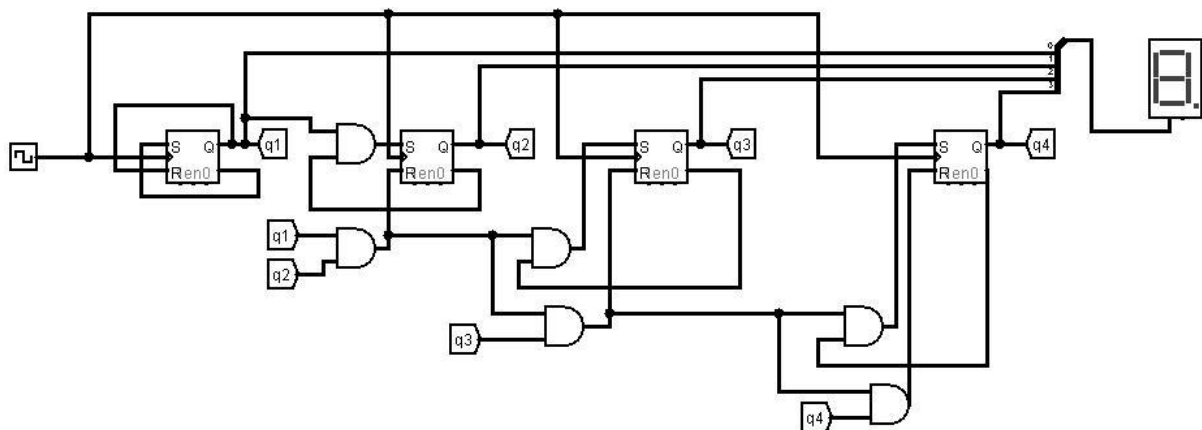
$$R_3 = Q_1 Q_2 Q_3$$

$Q_4 Q_3 \backslash Q_2 Q_1$	00	01	11	10
00	0	0	0	0
01	0	0	1	0
11	X	X	0	X
10	X	X	X	X

$$S_4 = Q_1 Q_2 Q_3 \bar{Q}_4$$

$Q_4 Q_3 \backslash Q_2 Q_1$	00	01	11	10
00	X	X	X	X
01	X	X	0	X
11	0	0	1	0
10	0	0	0	0

$$R_4 = Q_1 Q_2 Q_3 Q_4$$



### (B) J-k flip flop

Excitation table for reference.

Q	Q <sub>next</sub>	J	K
0	0	0	x
0	1	1	x
1	0	x	1
1	1	x	0

Present state				Next state				Flip Flop Inputs							
Q <sub>4</sub>	Q <sub>3</sub>	Q <sub>2</sub>	Q <sub>1</sub>	Q <sub>4</sub> <sup>*</sup>	Q <sub>3</sub> <sup>*</sup>	Q <sub>2</sub> <sup>*</sup>	Q <sub>1</sub> <sup>*</sup>	J <sub>4</sub>	K <sub>4</sub>	J <sub>3</sub>	K <sub>3</sub>	J <sub>2</sub>	K <sub>2</sub>	J <sub>1</sub>	K <sub>1</sub>
0	0	0	0	0	0	0	1	0	x	0	x	0	x	0	x
0	0	0	1	0	0	1	0	0	x	0	x	1	x	x	1
0	0	1	0	0	0	1	1	0	x	0	x	x	0	1	x
0	0	1	1	0	1	0	0	0	x	1	x	x	1	x	1
0	1	0	0	0	1	0	1	0	x	x	0	0	x	1	x
0	1	0	1	0	1	1	0	0	x	x	0	1	x	x	1
0	1	1	0	0	1	1	1	0	x	x	0	x	0	1	x
0	1	1	1	1	0	0	0	1	x	x	1	x	1	x	1
1	0	0	0	1	0	0	1	x	0	0	x	0	x	1	x
1	0	0	1	1	0	1	0	x	0	0	x	1	x	x	1
1	0	1	0	1	0	1	1	x	0	0	x	x	0	1	x
1	0	1	1	1	1	0	0	x	0	1	x	x	1	x	1
1	1	0	0	1	1	0	1	x	0	x	0	0	x	1	x
1	1	0	1	1	1	1	0	x	0	x	0	1	x	x	1
1	1	1	0	1	1	1	1	x	0	x	0	x	0	1	x
1	1	1	1	0	0	0	0	x	1	x	1	x	1	x	1

K map:

$q_2 q_1$	00	01	11	10
$q_4 q_3$				
00	1	x	x	1
01	1	x	x	1
11	1	x	x	1
10	1	x	x	1

$$J_1 = 1$$

$q_2 q_1$	00	01	11	10
$q_4 q_3$				
00	x	1	1	x
01	x	1	1	x
11	x	1	1	x
10	x	1	1	x

$$K_1 = 1$$

$q_2 q_1$	00	01	11	10
$q_4 q_3$				
00	0	1	x	x
01	0	1	x	x
11	0	1	x	x
10	0	1	x	x

$$J_2 = q_1$$

$q_2 q_1$	00	01	11	10
$q_4 q_3$				
00	x	x	1	0
01	x	x	1	0
11	x	x	1	0
10	x	x	1	0

$$K_2 = q_1$$

$q_2 q_1$	00	01	11	10
$q_4 q_3$				
00	0	0	1	0
01	x	x	x	x
11	x	x	x	x
10	0	0	1	0

$$J_3 = q_1 q_2$$

$q_2 q_1$	00	01	11	10
$q_4 q_3$				
00	x	x	x	x
01	0	0	1	0
11	0	0	1	0
10	x	x	x	x

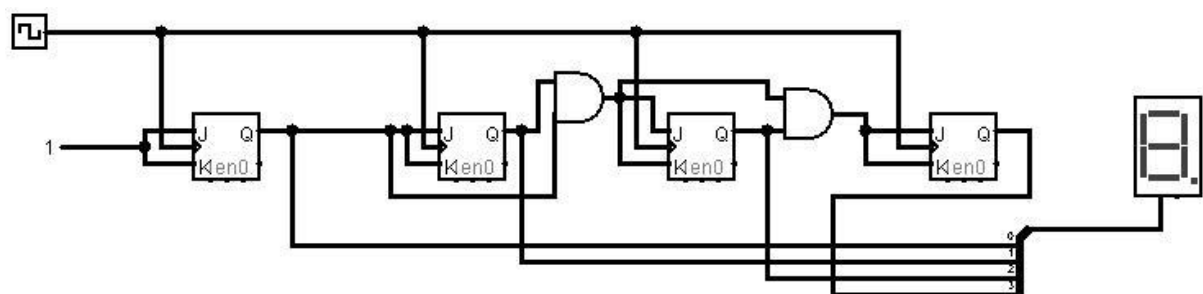
$$K_3 = q_1 q_2$$

$q_2 q_1$	00	01	11	10
$q_4 q_3$				
00	0	0	0	0
01	0	0	1	0
11	x	x	x	x
10	x	x	x	x

$$J_4 = q_1 q_2 q_3$$

$q_2 q_1$	00	01	11	10
$q_4 q_3$				
00	x	x	x	x
01	x	x	x	x
11	0	0	1	0
10	0	0	0	0

$$K_4 = q_1 q_2 q_3$$

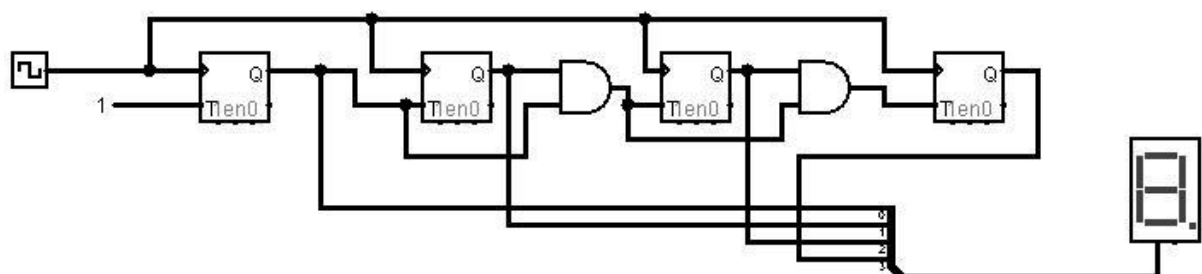
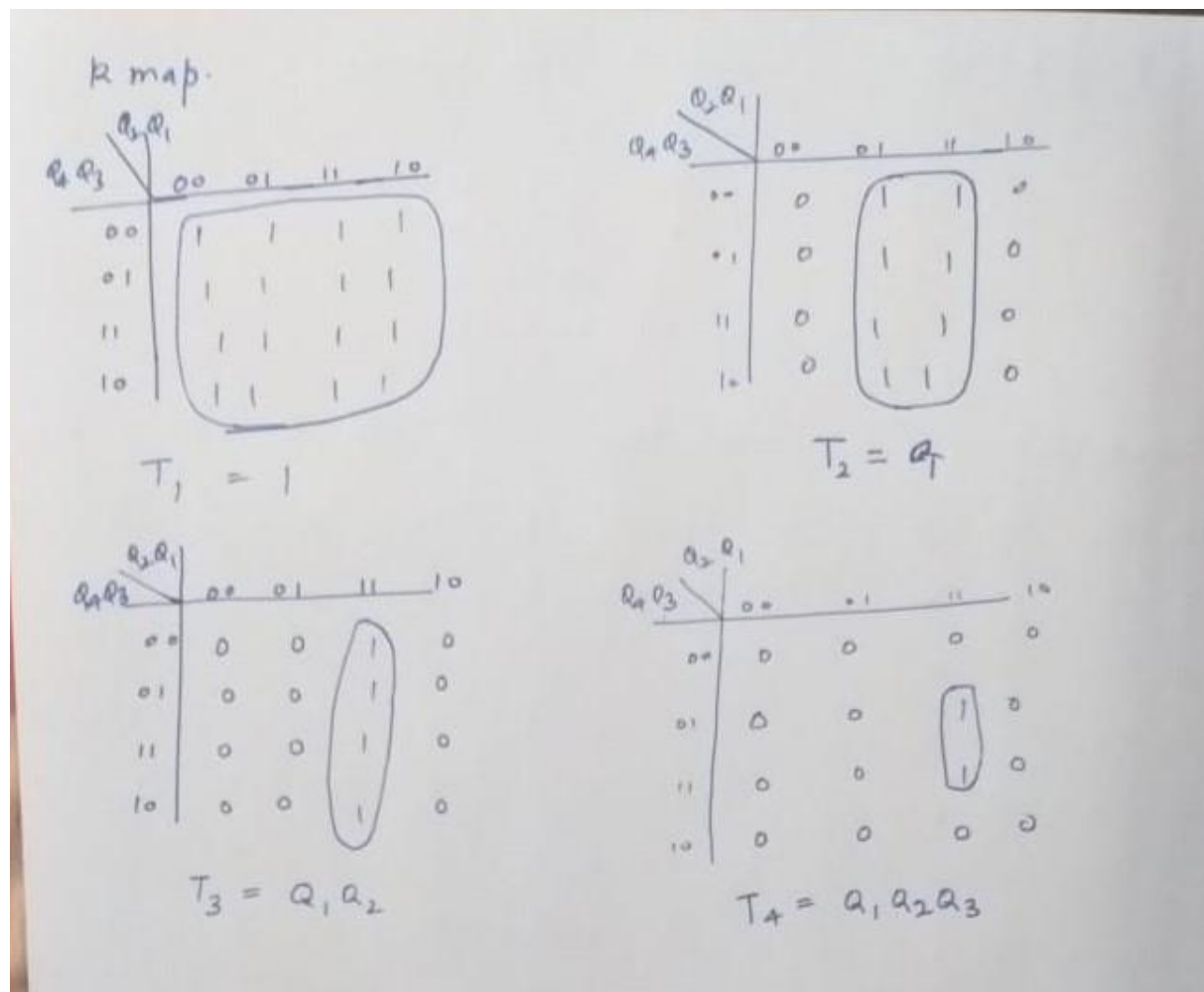


(C) T-flip flop

Excitation table for reference

$Q_n$	$Q_{n+1}$	T
0	0	0
0	1	1
1	0	1
1	1	0

Present State				Next State				Flip flop input			
$Q_4$	$Q_3$	$Q_2$	$Q_1$	$Q_4^*$	$Q_3^*$	$Q_2^*$	$Q_1^*$	$T_4$	$T_3$	$T_2$	$T_1$
0	0	0	0	0	0	0	1	0	0	0	1
0	0	0	1	0	0	1	0	0	0	1	1
0	0	1	0	0	0	1	1	0	0	0	1
0	0	1	1	0	1	0	0	0	1	1	1
0	1	0	0	0	1	0	1	0	0	0	1
0	1	0	1	0	1	1	0	0	0	1	1
0	1	1	0	0	1	1	1	0	0	0	1
0	1	1	1	1	0	0	0	1	1	1	1
1	0	0	0	1	0	0	1	0	0	0	1
1	0	0	1	1	0	1	0	0	0	1	1
1	0	1	0	1	0	1	1	0	0	0	1
1	0	1	1	1	1	0	0	0	1	1	1
1	1	0	0	1	1	0	1	0	0	0	1
1	1	0	1	1	1	1	0	0	0	1	1
1	1	1	0	1	1	1	1	0	0	0	1
1	1	1	1	0	0	0	0	1	1	1	1



Present state				Next state				flip flop inputs			
$Q_4$	$Q_3$	$Q_2$	$Q_1$	$Q_4^*$	$Q_3^*$	$Q_2^*$	$Q_1^*$	$D_4$	$D_3$	$D_2$	$D_1$
0	0	0	0	0	0	0	1	0	0	0	1
0	0	0	1	0	0	1	0	0	0	1	0
0	0	1	0	0	0	1	1	0	0	1	1
0	0	1	1	0	1	0	0	0	1	0	0
0	1	0	0	0	1	0	1	0	1	0	1
0	1	0	1	0	1	1	0	0	1	1	0
0	1	1	0	0	1	1	1	0	1	1	1
0	1	1	1	1	0	0	0	1	0	0	0
1	0	0	0	1	0	0	1	1	0	0	1
1	0	0	1	1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	1	1	0	1	1
1	0	1	1	1	1	0	0	1	1	0	0
1	1	0	0	1	1	0	1	1	1	0	1
1	1	0	1	1	1	1	0	1	1	1	0
1	1	1	0	1	1	1	1	1	1	1	1
1	1	1	1	0	0	0	0	0	0	0	0

Kmap:

$Q_4 Q_3$ \ $Q_2 Q_1$	00	01	10	11
00	1	0	0	1
01	1	0	0	1
11	1	0	0	1
10	1	0	0	1

$D_1 = \bar{Q}_1$

$Q_4 Q_3$ \ $Q_2 Q_1$	00	01	11	10
00	0	1	0	1
01	0	1	0	1
11	0	1	0	1
10	0	1	0	1

$D_2 = Q_1 \bar{Q}_2 + \bar{Q}_1 Q_2 = Q_1 \oplus Q_2$



$Q_3 \backslash Q_2 Q_1$	00	01	11	10
00	0	0	1	0
01	1	1	0	1
11	1	1	0	1
10	0	0	1	0

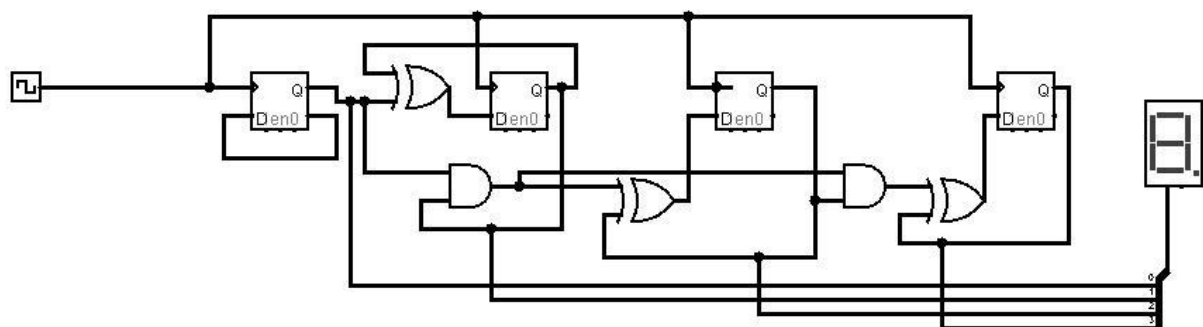
$$D_3 = Q_3 \bar{Q}_2 + Q_3 \bar{Q}_1 + Q_1 Q_2 \bar{Q}_3$$

$$= (Q_1 Q_2) \oplus Q_3$$

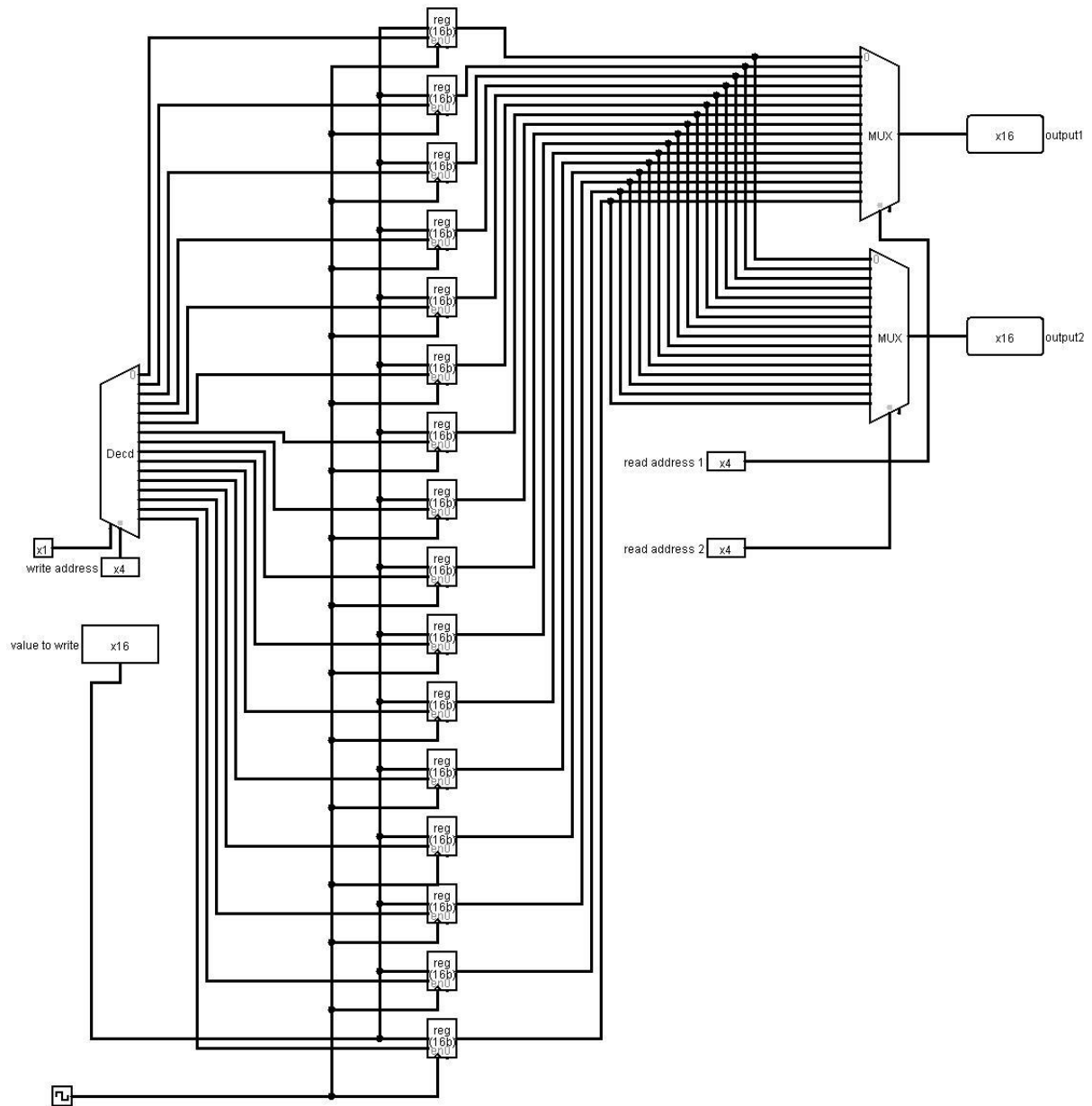
$Q_4 \backslash Q_3 Q_2 Q_1$	000	001	011	100
000	0	0	0	0
001	0	0	1	0
011	1	1	0	1
100	1	1	1	1

$$D_4 = Q_4 \bar{Q}_3 + Q_4 \bar{Q}_2 + Q_4 \bar{Q}_1 + \bar{Q}_4 Q_1 Q_2 Q_3$$

$$= (Q_1 Q_2 Q_3) \oplus Q_4$$



**Q2)** a register file (16x16) with two read ports and one write port.



### Write Operation -

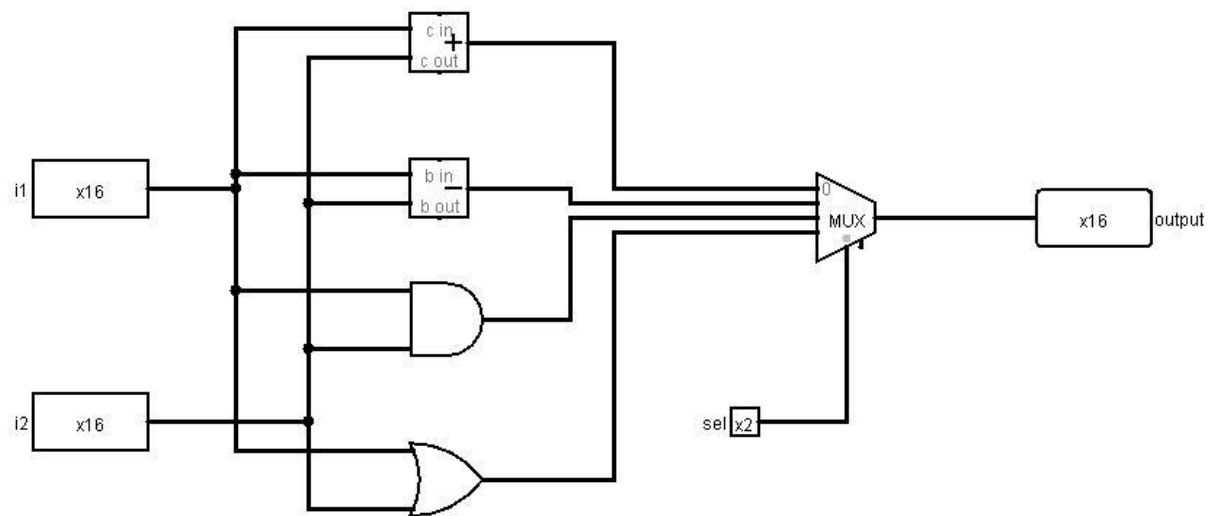
- 1) Put the value to be written in write value.
- 2) Mention write address corresponding to register where you want to store value
- 3) Set enable of Decoder to be 1
- 4) Generate a clock pulse. At rising edge value gets stored

### Read operation -

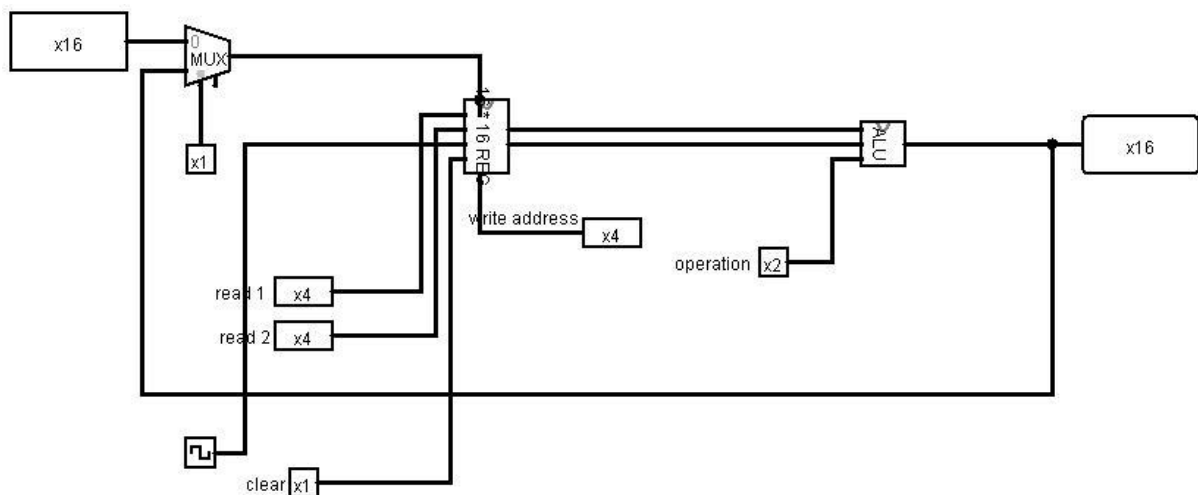
- 1) Mention read Address from where you want to read value.
- 2) Generate clock pulse. At rising edge value is read and displayed.

**Q3)** Combine register file and ALU

## Design of ALU

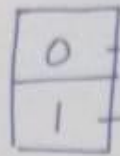


Register file combined with ALU . Here 16 \* 16 register file of previous question is used.



43.

Write  
Selector



Writes Input value

Writes Result to address

16 Bit ALU

0 0 → Addition

0 1 → Subtraction

1 0 → AND

1 1 → OR

Now

- 1) We set write address from 1 to 10 and write the value 1 to 10 in all 10 registers

For computing sum

Read Ad 1	Read Ad 2	Result (decimal)
0 0 0 0	0 0 0 1	1 → write this to 1011
1 0 1 1	0 0 1 0	3 "
1 0 1 1	0 0 1 1	6 "
1 0 1 1	0 1 0 0	10 "
1 0 1 1	0 1 0 1	15 "
1 0 1 1	0 1 1 0	21 "
1 0 1 1	0 1 1 1	28 "
1 0 1 1	1 0 0 0	36 "
1 0 1 1	1 0 0 1	45 "
1 0 1 1	1 0 1 0	55 "