

| 0           | P | P   | Q | V   | Q   | 11 | 12  |
|-------------|---|-----|---|-----|-----|----|-----|
| 00-0(0,2)   | * | (*) |   |     |     |    |     |
| 0-00(0,4)   | * |     | * |     |     |    |     |
| 010-(1,5)   |   |     | * | *   |     |    |     |
| -100-(1,12) |   |     | * |     |     |    | (*) |
| 01-1(5,11)  |   |     | * | (*) |     |    |     |
| 0-1(9,11)   |   |     |   | (*) | (*) |    |     |

$$F = A'B'D' + BC'D' + A'BD + AB'D$$

$$f_1(A, B, C, D) = \sum m(0, 2, 4, 5, 11, 12) + d(1, 3, 6, 7, 8, 9, 10, 13)$$

|           | column I | column II     | column III        |
|-----------|----------|---------------|-------------------|
| <u>1</u>  | 0001     | 0-01(1,5) *   | -1-1(9,13,7,15) * |
| <u>P</u>  | 0100     | 010-(1,5) *   | -                 |
| <u>Q</u>  | 0101     | 01-1(5,11) *  |                   |
| <u>10</u> | 1010     | -101(5,13) ✓  |                   |
|           |          | 1-10(10,14) * |                   |
| <u>V</u>  | 0111     |               |                   |
| <u>11</u> | 1101     | -111(13,15) ✓ |                   |
| <u>12</u> | 1110     | 11-1(13,15) * |                   |
|           |          | 111-(11,15) * |                   |
| <u>15</u> | 1111     |               |                   |

|                | V1 | V2 | V3 | V4 | V5 |
|----------------|----|----|----|----|----|
| 0-01 (0,2)     | ✓  |    |    |    |    |
| 010- (1,5)     |    | ✓  |    |    |    |
| 01-1 (2,4)     |    |    | ✓  |    |    |
| 1-10 (3,1)     |    |    |    | ✓  |    |
| 11-1 (4,10)    |    |    |    |    | ✓  |
| 111- (5,12)    |    |    |    |    |    |
| -1-1 (6,13,14) |    |    | ✓  |    | ✓  |

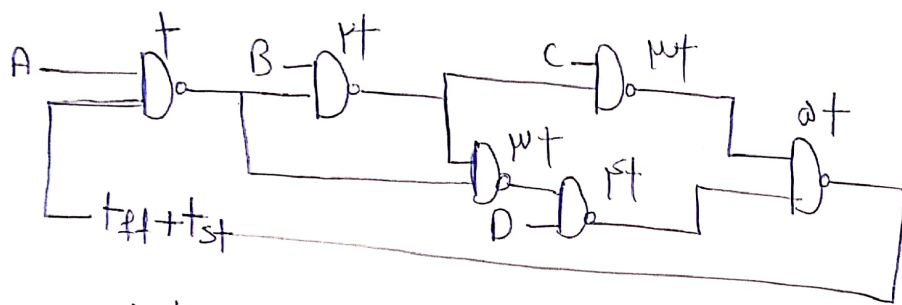
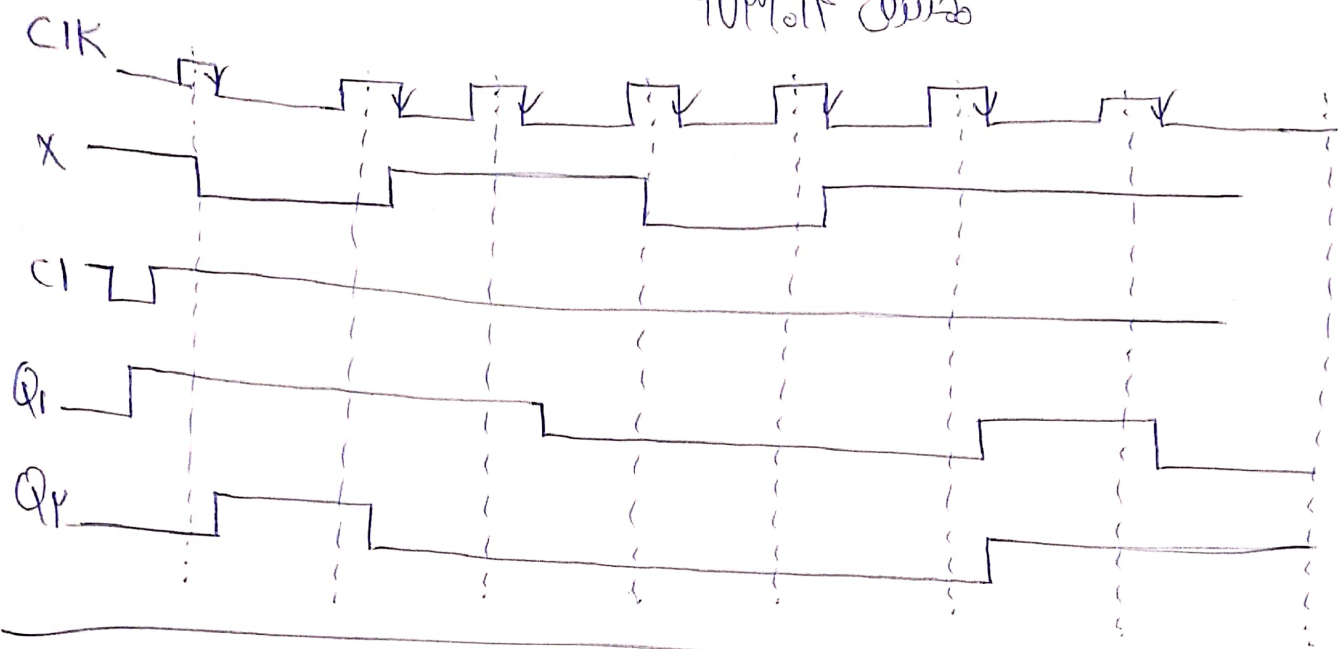
$$F_1 = A'C'D + A'BC' + BD + ACD'$$

| column I | column II         | column III        | column IV                 |
|----------|-------------------|-------------------|---------------------------|
| 0000 ✓   | 0000- (0,1) ✓     | 0110- (1,13) ✓    | -000- (0,1,2,3) ✗ X       |
| 0001 ✓   | 000-0 (0,2) ✓     | 011-0 (1,14) ✓    | 0-0-0 (0,2,4,10) ✗ X      |
| 0010 ✓   | 0-000 (0,4) ✓     | -1100 (1,15) ✓    | 0-0-0 (0,4,13,10) ✗       |
| 0100 ✓   | -0000 (0,14) ✓    | 100-0 (1,16) ✗    | -0000 (0,4,10,16) ✗ X     |
| 1000 ✓   |                   | 10-01 (1,17) ✓    | -000- (0,16,13,10) ✗      |
| 00101 ✓  | 00-01 (1,2) ✓     | 1010- (1,18) ✓    | -0000 (0,16,17,14) ✗      |
| 00110 ✓  | -0001 (1,11) ✓    | 101-0 (1,19,22) ✗ | -0-01 (1,20,17,21) ✗ X    |
| 01010 ✓  | 00-10 (1,3) ✓     | 110-0 (1,23,24) ✗ | -0-01 (1,20,14,23) ✗ X    |
| 01100 ✓  | 0-010 (1,10) ✓    | 11-00 (1,25,26) ✗ | 0--10 (1,24,10,14) ✗ X    |
| 10001 ✓  | 010-0 (1,12) ✓    | 0-111 (1,27,28) ✓ | 0--10 (1,24,16,14) ✗ X    |
| 10010 ✓  | 01-00 (1,13) ✓    | 011-1 (1,29,30) ✓ | 01--0 (1,28,16,17) ✗ X    |
| 10100 ✓  | -1000 (1,24) ✓    | 0111- (1,31,32) ✓ | 01--0 (1,28,17,10,14) ✗   |
| 11000 ✓  | 1000- (1,25,11) ✓ |                   | -1-00 (1,28,17,21) ✗ X    |
| 11001 ✓  | 10-00 (1,26,10) ✓ |                   | 10-0- (1,29,17,20,21) ✗ X |
| 10111 ✓  | 1-000 (1,26,24) ✓ |                   | 10-0- (1,29,16,17,24) ✗   |
| 01101 ✓  | 001-1 (2,5) ✓     |                   | 0-1-1 (2,5,17,12) ✗ X     |
| 01110 ✓  | 0-101 (2,14) ✓    |                   | 0-1-1 (2,5,13,12) ✗       |
| 10011 ✓  | -0101 (2,11) ✓    |                   | 0-11- (2,5,17,12) ✗ X     |
| 10101 ✓  | 0010- (2,1) ✓     |                   | 0-11- (2,14,17,12) ✗      |
| 10110 ✓  | 0-110 (2,14) ✓    |                   | 011-- (1,29,17,13,12) ✗ X |
| 11010 ✓  | -0110 (2,22) ✗    |                   | 011-- (1,29,17,13,12) ✗   |
| 11100 ✓  | 01-10 (1,15,16) ✓ |                   |                           |
| 11111 ✓  | -1010 (1,16,24) ✓ |                   |                           |

$$F_2 = A'CE + B'CE' + A'BD + A'CE + A'CD + A'BC$$

90414 0000

(μz)

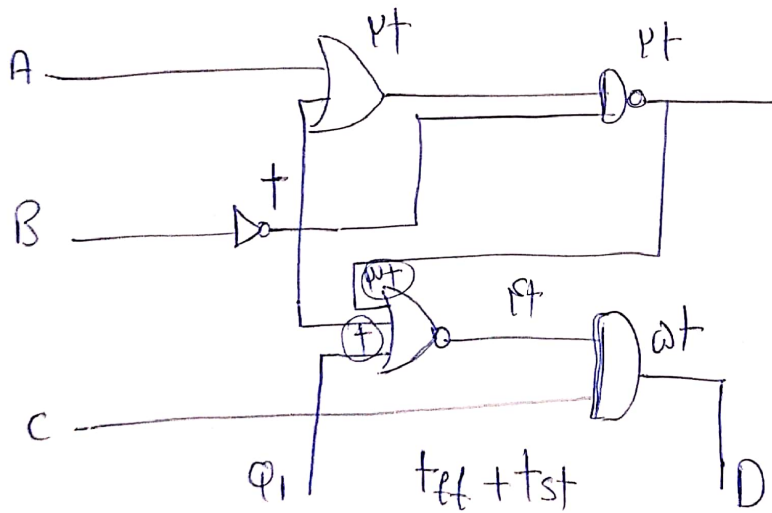


(12)

(6)

$$\text{max-delay} = \Delta t$$

$$\omega t_{\text{gate}} + t_{\text{st}} + t_{\text{eff}} = dK_C \omega_{\text{res}}$$



$$t_{ff} + t_{st} + \Delta t = \text{clk period}$$

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clk  $\rightarrow$  falling edge

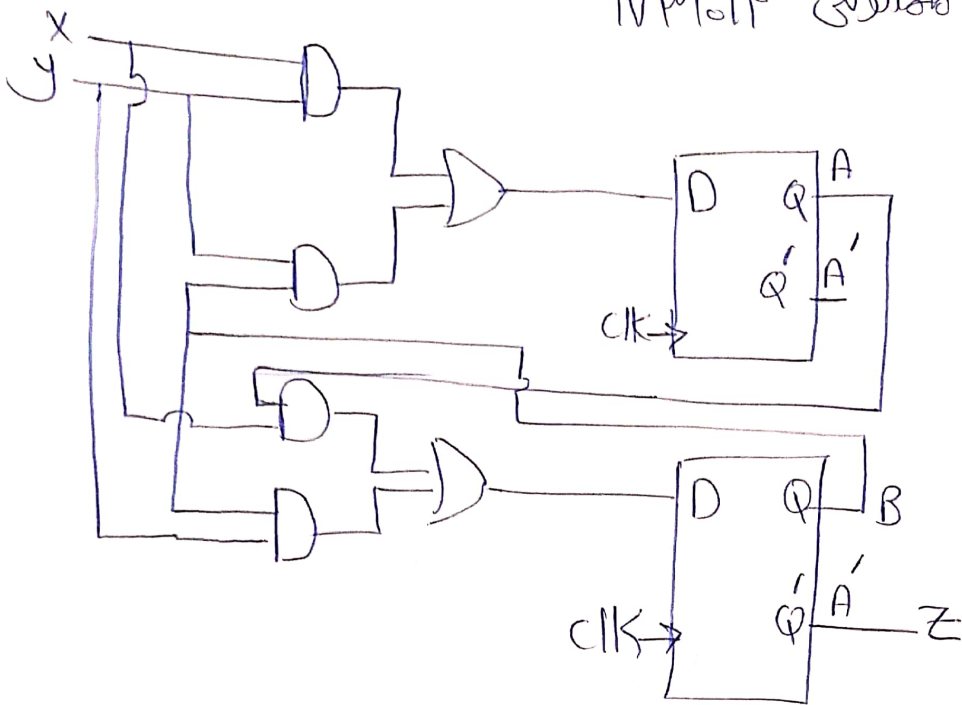
(a2.

$$\begin{array}{cccccccccccc} X & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 1 \\ A & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 1 \end{array}$$

$$A = Q \oplus R \oplus X$$

$$Z_1 = 0 \longrightarrow \varphi_1 = 0 \longrightarrow \varphi = 0$$

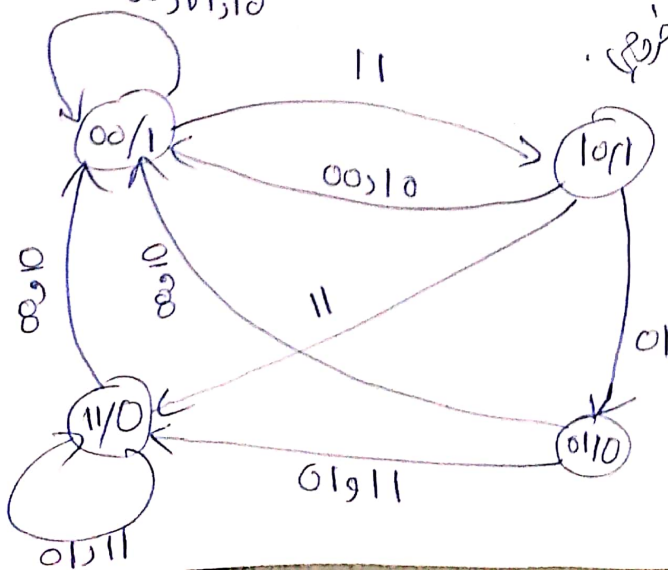
Zy 0 100 000 0000



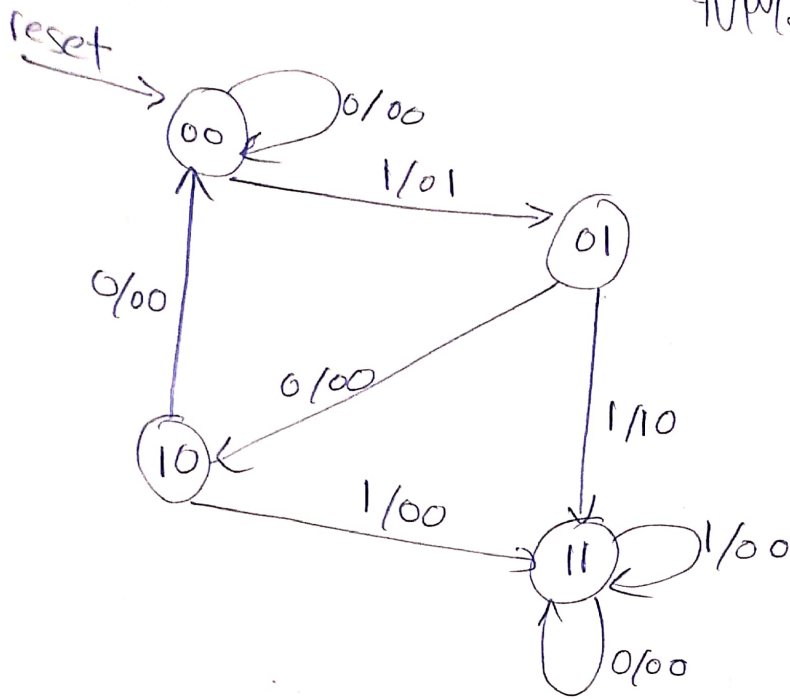
| Present state |      | Input |   | next state |        | output |
|---------------|------|-------|---|------------|--------|--------|
| A(t)          | B(t) | X     | Y | A(t+1)     | B(t+1) | Z      |
| 0             | 0    | 0     | 0 | 0          | 0      | 1      |
| 0             | 0    | 0     | 1 | 0          | 0      | 1      |
| 0             | 0    | 1     | 0 | 0          | 0      | 1      |
| 0             | 0    | 1     | 1 | 1          | 0      | 1      |
| 0             | 1    | 0     | 0 | 0          | 0      | 0      |
| 0             | 1    | 0     | 1 | 1          | 0      | 0      |
| 0             | 1    | 1     | 0 | 0          | 0      | 0      |
| 0             | 1    | 1     | 1 | 1          | 1      | 0      |
| 1             | 0    | 0     | 0 | 0          | 0      | 1      |
| 1             | 0    | 0     | 1 | 0          | 0      | 1      |
| 1             | 0    | 1     | 0 | 1          | 0      | 1      |
| 1             | 0    | 1     | 1 | 1          | 1      | 1      |
| 1             | 1    | 0     | 0 | 0          | 0      | 0      |
| 1             | 1    | 0     | 1 | 0          | 0      | 0      |
| 1             | 1    | 1     | 0 | 1          | 0      | 0      |
| 1             | 1    | 1     | 1 | 1          | 1      | 0      |

00,01,10

Present state, Moore sequence







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| Present state  |                | input |      | next state |        | FF inputs |                |                |                |                |
|----------------|----------------|-------|------|------------|--------|-----------|----------------|----------------|----------------|----------------|
| Z <sub>1</sub> | Z <sub>2</sub> | A(t)  | B(t) | X          | A(t+1) | B(t+1)    | J <sub>A</sub> | K <sub>A</sub> | J <sub>B</sub> | K <sub>B</sub> |
| 0              | 0              | 0     | 0    | 0          | 0      | 0         | 0              | X              | 0              | X              |
| 0              | 1              | 0     | 0    | 1          | 0      | 1         | 0              | X              | 1              | X              |
| 0              | 0              | 0     | 1    | 0          | 1      | 0         | 1              | X              | X              | 1              |
| 1              | 0              | 0     | 1    | 1          | 1      | 1         | 1              | X              | X              | 0              |
| 0              | 0              | 1     | 0    | 0          | 0      | 0         | X              | 1              | 0              | X              |
| 0              | 0              | 1     | 0    | 1          | 1      | 1         | X              | 0              | X              | 0              |
| 0              | 0              | 1     | 1    | 0          | 1      | 1         | X              | 0              | X              | 0              |
| 0              | 0              | 1     | 1    | 1          | 1      | 1         | X              | 0              | X              | 0              |

| X \ AB | 00 | 01 | 11 | 10 |
|--------|----|----|----|----|
| 0      | 0  | 1  | X  | X  |
| 1      | 0  | 1  | X  | X  |

$$J_A = B$$

| X \ AB | 00 | 01 | 11 | 10 |
|--------|----|----|----|----|
| 0      | X  | X  | 0  | 1  |
| 1      | X  | X  | 0  | 0  |

$$K_A = B' A'$$

| X \ AB | 00 | 01 | 11 | 10 |
|--------|----|----|----|----|
| 0      | 0  | X  | X  | 0  |
| 1      | 1  | X  | X  | 1  |

$$J_B = X$$

| X \ AB | 00 | 01 | 11 | 10 |
|--------|----|----|----|----|
| 0      | X  | 1  | 0  | 0  |
| 1      | X  | 0  | 0  | 0  |

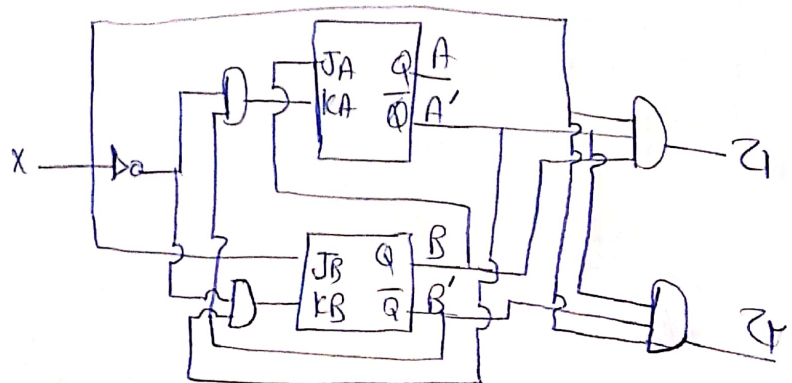
$$K_B = X' A'$$

| X \ AB | 00 | 01 | 11 | 10 |
|--------|----|----|----|----|
| 0      | 0  | 0  | 0  | 0  |
| 1      | 0  | 1  | 0  | 0  |

$$Z_1 = A' B' X$$

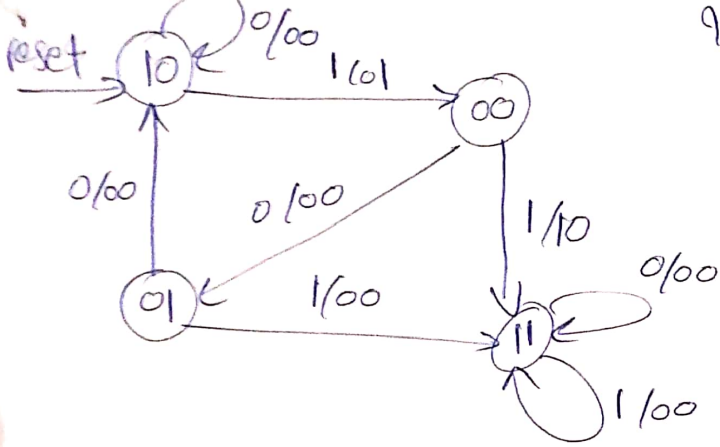
| X \ AB | 00 | 01 | 11 | 10 |
|--------|----|----|----|----|
| 0      | 0  | 0  | 0  | 0  |
| 1      | 1  | 0  | 0  | 0  |

$$Z_2 = A' B' X$$



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| present state |      | input<br>X | next state |        | out put<br>Z1 Z2 |   |
|---------------|------|------------|------------|--------|------------------|---|
| A(t)          | B(t) |            | A(t+1)     | B(t+1) |                  |   |
| 0             | 0    | 0          | 0          | 1      | 0                | 0 |
| 0             | 0    | 1          | 1          | 1      | 1                | 0 |
| 0             | 1    | 0          | 1          | 0      | 0                | 0 |
| 0             | 1    | 1          | 1          | 1      | 0                | 0 |
| 1             | 0    | 0          | 1          | 0      | 0                | 0 |
| 1             | 0    | 1          | 0          | 0      | 0                | 0 |
| 1             | 1    | 0          | 1          | 1      | 0                | 1 |
| 1             | 1    | 1          | 1          | 1      | 0                | 0 |

AB

| q | 00 | 01 | 11 | 10 |
|---|----|----|----|----|
| 0 | 0  | 1  | 0  | 0  |
| 1 | 1  | 1  | 0  | 1  |

AB

| q | 00 | 01 | 11 | 10 |
|---|----|----|----|----|
| 0 | 1  | 1  | 0  | 0  |
| 1 | 1  | 0  | 0  | 0  |

$$T_A = A'B + A'q + Bq = A'B + q(A' + B')$$

$$T_B = A'x' + A'B' + A'(q + B')$$

$$q_0 Z_1 = A'B'q$$

$$q_0 Z_2 = A'B'q$$

