

# Esercizio 1.1 – Espressioni

$$I_A (PS) = x' (Q_A + Q_C') \quad I_B (PS) = x' (Q_B + Q_C')$$

$$I_C (PS) = x' Q_D Q_C Q_B Q_A \quad I_D (PS) = x' Q_D'$$

$$LD (PS) = x + Q_C \quad Z (PS) = Q_D$$

# Esercizio 1.2 – TdT

|           |    | $Q_B Q_A$ |    |    |    |
|-----------|----|-----------|----|----|----|
|           |    | 00        | 01 | 11 | 10 |
| $Q_D Q_C$ | 00 | 0         | 0  | 0  | 0  |
|           | 01 | 1         | 1  | 1  | 1  |
|           | 11 | 1         | 1  | 1  | 1  |
|           | 10 | 0         | 0  | 0  | 0  |

$x = 0$

|  |    | $Q_B Q_A$ |    |    |    |
|--|----|-----------|----|----|----|
|  |    | 00        | 01 | 11 | 10 |
|  | 00 | 1         | 1  | 1  | 1  |
|  | 01 | 1         | 1  | 1  | 1  |
|  | 11 | 1         | 1  | 1  | 1  |
|  | 10 | 1         | 1  | 1  | 1  |

$x = 1$

**LD**

$$\text{LD (PS)} = x + Q_c$$

# Esercizio 1.2 – TdT

|           |    | $Q_B Q_A$ |    |    |    |
|-----------|----|-----------|----|----|----|
|           |    | 00        | 01 | 11 | 10 |
| $Q_D Q_C$ | 00 | 1         | 1  | 1  | 1  |
|           | 01 | 0         | 1  | 1  | 0  |
|           | 11 | 0         | 1  | 1  | 0  |
|           | 10 | 1         | 1  | 1  | 1  |

$x = 0$

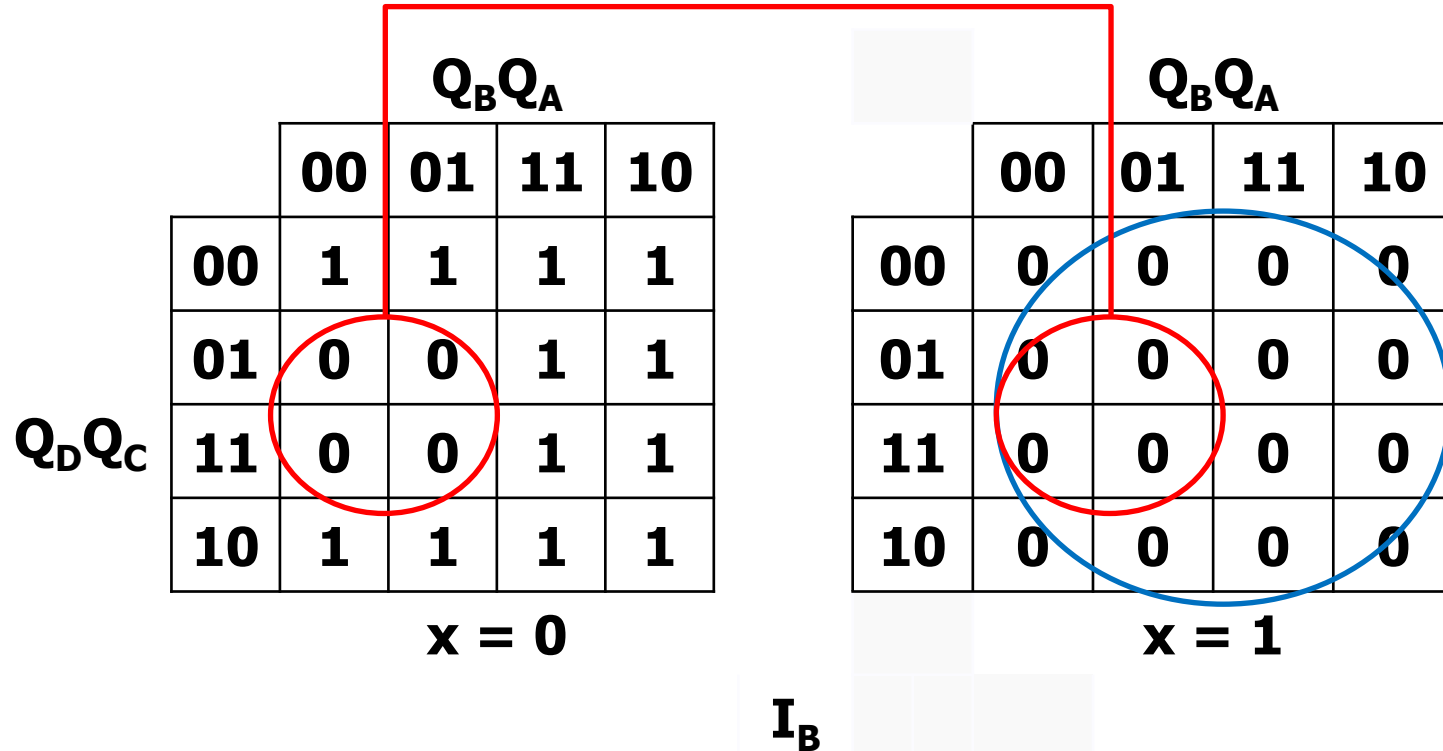
|    |   | $Q_B Q_A$ |    |    |    |
|----|---|-----------|----|----|----|
|    |   | 00        | 01 | 11 | 10 |
| 00 | 0 | 0         | 0  | 0  |    |
| 01 | 0 | 0         | 0  | 0  |    |
| 11 | 0 | 0         | 0  | 0  |    |
| 10 | 0 | 0         | 0  | 0  |    |

$x = 1$

$I_A$

$$I_A \text{ (PS)} = x' (Q_A + Q_C')$$

# Esercizio 1.2 – TdT



$$I_B \text{ (PS)} = x' (Q_B + Q_C')$$

# Esercizio 1.2 – TdT

|           |    |           |    |    |    |
|-----------|----|-----------|----|----|----|
|           |    | $Q_B Q_A$ |    |    |    |
|           |    | 00        | 01 | 11 | 10 |
| $Q_D Q_C$ | 00 | 0         | 0  | 0  | 0  |
|           | 01 | 0         | 0  | 0  | 0  |
|           | 11 | 0         | 0  | 1  | 0  |
|           | 10 | 0         | 0  | 0  | 0  |
|           |    | $x = 0$   |    |    |    |

|           |    |           |    |    |    |
|-----------|----|-----------|----|----|----|
|           |    | $Q_B Q_A$ |    |    |    |
|           |    | 00        | 01 | 11 | 10 |
| $Q_D Q_C$ | 00 | 0         | 0  | 0  | 0  |
|           | 01 | 0         | 0  | 0  | 0  |
|           | 11 | 0         | 0  | 0  | 0  |
|           | 10 | 0         | 0  | 0  | 0  |
|           |    | $x = 1$   |    |    |    |

$I_C$

$$I_C \text{ (PS)} = x' Q_D Q_C Q_B Q_A$$

$$I_C \text{ (SP)} = x' Q_D Q_C Q_B Q_A$$

# Esercizio 1.2 – TdT

|           |    | $Q_B Q_A$ |    |    |    |
|-----------|----|-----------|----|----|----|
|           |    | 00        | 01 | 11 | 10 |
| $Q_D Q_C$ | 00 | 1         | 1  | 1  | 1  |
|           | 01 | 1         | 1  | 1  | 1  |
|           | 11 | 0         | 0  | 0  | 0  |
|           | 10 | 0         | 0  | 0  | 0  |

$x = 0$

|           |    | $Q_B Q_A$ |    |    |    |
|-----------|----|-----------|----|----|----|
|           |    | 00        | 01 | 11 | 10 |
| $Q_D Q_C$ | 00 | 0         | 0  | 0  | 0  |
|           | 01 | 0         | 0  | 0  | 0  |
|           | 11 | 0         | 0  | 0  | 0  |
|           | 10 | 0         | 0  | 0  | 0  |

$x = 1$

$I_D$

$$I_D \text{ (PS)} = x' Q_D'$$

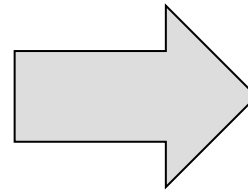
$$I_D \text{ (SP)} = x' Q_D'$$

# Esercizio 1.2 – TdT

$Q_D Q_C Q_B Q_A$

| X    | 0      | 1      |
|------|--------|--------|
| 0000 | 1011 0 | 0000 1 |
| 0001 | 1011 0 | 0000 1 |
| 0011 | 1011 0 | 0000 1 |
| 0010 | 1011 0 | 0000 1 |
| 0100 | 1000 1 | 0000 1 |
| 0101 | 1001 1 | 0000 1 |
| 0111 | 1011 1 | 0000 1 |
| 0110 | 1010 1 | 0000 1 |
| 1100 | 0000 1 | 0000 1 |
| 1101 | 0001 1 | 0000 1 |
| 1111 | 0111 1 | 0000 1 |
| 1110 | 0010 1 | 0000 1 |
| 1000 | 0011 0 | 0000 1 |
| 1001 | 0011 0 | 0000 1 |
| 1011 | 0011 0 | 0000 1 |
| 1010 | 0011 0 | 0000 1 |

$I_D I_C I_B I_A LD$



$(Q_D Q_C Q_B Q_A)^n$

| X    | 0       | 1       |
|------|---------|---------|
| 0000 | 0001, 0 | 0000, 0 |
| 0001 | 0010, 0 | 0000, 0 |
| 0011 | 0100, 0 | 0000, 0 |
| 0010 | 0011, 0 | 0000, 0 |
| 0100 | 1000, 0 | 0000, 0 |
| 0101 | 1001, 0 | 0000, 0 |
| 0111 | 1011, 0 | 0000, 0 |
| 0110 | 1010, 0 | 0000, 0 |
| 1100 | 0000, 1 | 0000, 1 |
| 1101 | 0001, 1 | 0000, 1 |
| 1111 | 0111, 1 | 0000, 1 |
| 1110 | 0010, 1 | 0000, 1 |
| 1000 | 1001, 1 | 0000, 1 |
| 1001 | 1010, 1 | 0000, 1 |
| 1011 | 1100, 1 | 0000, 1 |
| 1010 | 1011, 1 | 0000, 1 |

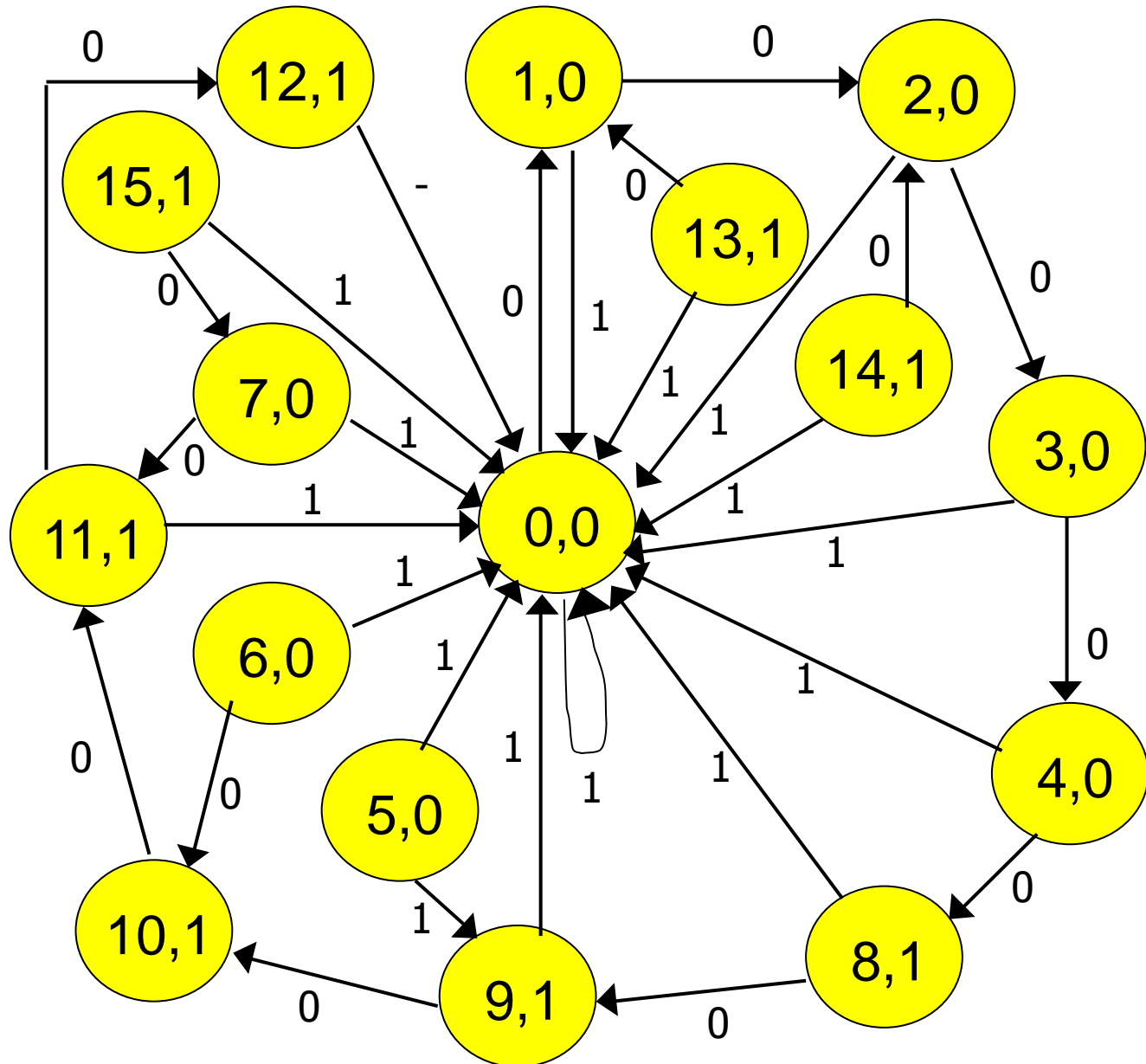
$(Q_D Q_C Q_B Q_A)^{n+1}, Z^n$

# Esercizio 1.3 – Grafo

| X  | 0     | 1    |
|----|-------|------|
| 0  | 1, 0  | 0, 0 |
| 1  | 2, 0  | 0, 0 |
| 3  | 4, 0  | 0, 0 |
| 2  | 3, 0  | 0, 0 |
| 4  | 8, 0  | 0, 0 |
| 5  | 9, 0  | 0, 0 |
| 7  | 11, 0 | 0, 0 |
| 6  | 10, 0 | 0, 0 |
| 12 | 0, 1  | 0, 1 |
| 13 | 1, 1  | 0, 1 |
| 15 | 7, 1  | 0, 1 |
| 14 | 2, 1  | 0, 1 |
| 8  | 9, 1  | 0, 1 |
| 9  | 10, 1 | 0, 1 |
| 11 | 12, 1 | 0, 1 |
| 10 | 11, 1 | 0, 1 |

s.f.,  $Z^n$

s.p.



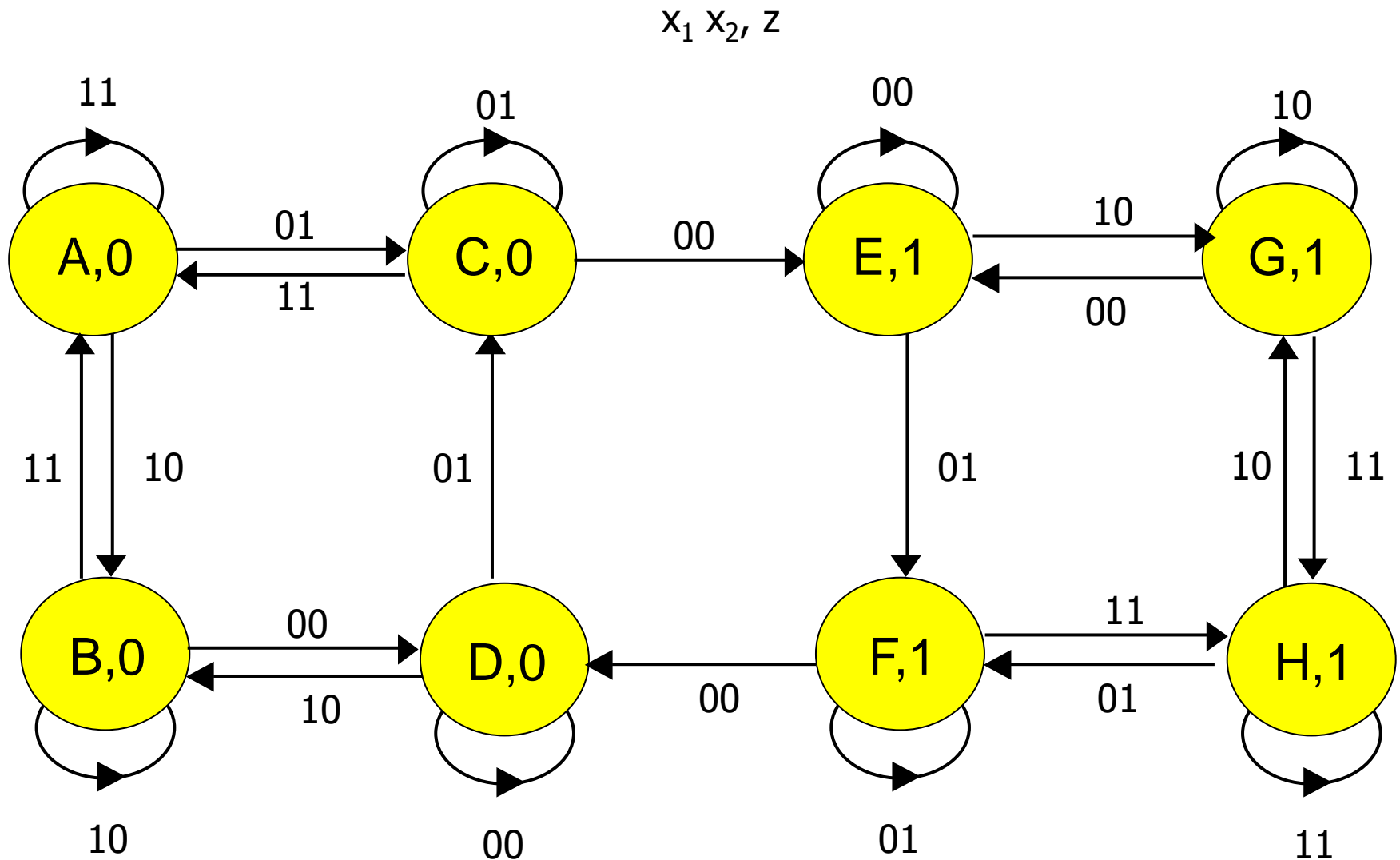


## Esercizio 1.4 – Comportamento

La rete fornisce in output un onda quadra con periodo pari a 10 intervalli di clock quando  $X=0$ .  $X=1$  ha la funzionalità di reset del generatore d'onda.

Gli stati irraggiungibili del contatore sono quelli la cui codifica decimale è rappresentata dai numeri 5,6,7 e 13,14,15. L'autoinizializzazione della rete richiede al più due periodi di clock.

# Esercizio 2.1 – Grafo primitivo



# Esercizio 2.2 – Tabella triangolare

s.p.

|   | $x_1 \ x_2$ |     |     |     |
|---|-------------|-----|-----|-----|
|   | 00          | 01  | 11  | 10  |
| A | -,-         | C,0 | A,0 | B,0 |
| B | D,0         | -,- | A,0 | B,0 |
| C | E,-         | C,0 | A,0 | -,- |
| D | D,0         | C,0 | -,- | B,0 |
| E | E,1         | F,1 | -,- | G,1 |
| F | D,-         | F,1 | H,1 | -,- |
| G | E,1         | -,- | H,1 | G,1 |
| H | -,-         | F,1 | H,1 | G,1 |

s.f., z

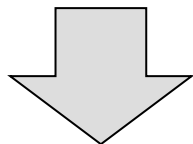
|   |   |    |    |   |    |    |   |
|---|---|----|----|---|----|----|---|
| B |   |    |    |   |    |    |   |
| C |   | ED |    |   |    |    |   |
| D |   |    | ED |   |    |    |   |
| E |   |    |    |   |    |    |   |
| F |   |    |    |   | ED |    |   |
| G |   |    |    |   |    | ED |   |
| H |   |    |    |   |    |    |   |
|   | A | B  | C  | D | E  | F  | G |

# Esercizio 2.2 – TdF automa minimo

$x_1 \ x_2$

|                | 00  | 01  | 11    | 10  |
|----------------|-----|-----|-------|-----|
| <b>a={ABD}</b> | a,0 | b,0 | a/b,0 | a,0 |
| <b>b={AC}</b>  | c,- | b,0 | a/b,0 | a,0 |
| <b>c={EGH}</b> | c,1 | d,1 | c/d,1 | c,1 |
| <b>d={FH}</b>  | a,- | d,1 | c/d,1 | c,1 |

s.f., z



$x_1 \ x_2$

|                | 00  | 01  | 11  | 10  |
|----------------|-----|-----|-----|-----|
| <b>a={ABD}</b> | a,0 | b,0 | a,0 | a,0 |
| <b>b={AC}</b>  | c,- | b,0 | b,0 | a,0 |
| <b>c={EGH}</b> | c,1 | d,1 | c,1 | c,1 |
| <b>d={FH}</b>  | a,- | d,1 | d,1 | c,1 |

s.f., z

# Esercizio 2.3 – Codifica e TdT

|       |          |   |          |
|-------|----------|---|----------|
| y1\y0 | 0        |   | 1        |
| 0     | <b>a</b> | ↔ | <b>b</b> |
|       | ↑        |   | ↓        |
| 1     | <b>d</b> | ↔ | <b>c</b> |

|                                    |             |                                      |             |             |             |
|------------------------------------|-------------|--------------------------------------|-------------|-------------|-------------|
|                                    |             | <b>x<sub>1</sub> x<sub>2</sub></b>   |             |             |             |
|                                    |             | <b>00</b>                            | <b>01</b>   | <b>11</b>   | <b>10</b>   |
| <b>y<sub>1</sub> y<sub>0</sub></b> | <b>a=00</b> | <b>00,0</b>                          | <b>01,0</b> | <b>00,0</b> | <b>00,0</b> |
|                                    | <b>b=01</b> | <b>11,-</b>                          | <b>01,0</b> | <b>01,0</b> | <b>00,0</b> |
|                                    | <b>c=11</b> | <b>11,1</b>                          | <b>10,1</b> | <b>11,1</b> | <b>11,1</b> |
|                                    | <b>d=10</b> | <b>00,-</b>                          | <b>10,1</b> | <b>10,1</b> | <b>11,1</b> |
|                                    |             | <b>y<sub>1</sub>y<sub>0</sub>, z</b> |             |             |             |

# Esercizio 2.4 – Sintesi combinatoria PS

|           |    | $x_1 x_2$ |    |    |    |
|-----------|----|-----------|----|----|----|
|           |    | 00        | 01 | 11 | 10 |
| $y_1 y_0$ | 00 | 0         | 0  | 0  | 0  |
|           | 01 | 1         | 0  | 0  | 0  |
|           | 11 | 1         | 1  | 1  | 1  |
|           | 10 | 0         | 1  | 1  | 1  |

$Y_1$

$$Y_1 \text{ (PS)} = (y_1 + x_1') (y_1 + y_0) (y_1 + x_2') (y_0 + x_2 + x_1)$$

# Esercizio 2.4 – Sintesi combinatoria PS

|           |    | $x_1 x_2$ |    |    |    |
|-----------|----|-----------|----|----|----|
|           |    | 00        | 01 | 11 | 10 |
| $y_1 y_0$ | 00 | 0         | 1  | 0  | 0  |
|           | 01 | 1         | 1  | 1  | 0  |
|           | 11 | 1         | 0  | 1  | 1  |
|           | 10 | 0         | 0  | 0  | 1  |

$y_0$

$$Y_0 \text{ (PS)} = (y_1 + x_1' + x_2) (y_1 + y_0 + x_1') (y_1 + y_0 + x_2) (y_1' + y_0 + x_2') \\ (y_1' + y_0 + x_1) (y_1' + x_1 + x_2') (y_0 + x_1 + x_2) (y_0 + x_1' + x_2')$$

# Esercizio 2.4 – Sintesi combinatoria PS

|           |    | $x_1 x_2$ |    |    |    |
|-----------|----|-----------|----|----|----|
|           |    | 00        | 01 | 11 | 10 |
| $y_1 y_0$ | 00 | 0         | 0  | 0  | 0  |
|           | 01 | -         | 0  | 0  | 0  |
|           | 11 | 1         | 1  | 1  | 1  |
|           | 10 | -         | 1  | 1  | 1  |

$z$

$$z \text{ (PS)} = y_1$$



# Esercizio 2.5 – Sintesi con PLA

|           |    | $x_1 x_2$ |    |    |    |
|-----------|----|-----------|----|----|----|
|           |    | 00        | 01 | 11 | 10 |
| $y_1 y_0$ | 00 | 0         | 0  | 0  | 0  |
|           | 01 | 1         | 0  | 0  | 0  |
|           | 11 | 1         | 1  | 1  | 1  |
|           | 10 | 0         | 1  | 1  | 1  |

$Y_1$

$$Y_1 \text{ (SP)} = y_1 x_1 + y_1 y_0 + y_1 x_2 + y_0 x_1' x_2'$$

# Esercizio 2.5 – Sintesi con PLA

|           |    |           |    |    |    |
|-----------|----|-----------|----|----|----|
|           |    | $x_1 x_2$ |    |    |    |
|           |    | 00        | 01 | 11 | 10 |
| $y_1 y_0$ | 00 | 0         | 1  | 0  | 0  |
|           | 01 | 1         | 1  | 1  | 0  |
|           | 11 | 1         | 0  | 1  | 1  |
|           | 10 | 0         | 0  | 0  | 1  |
|           |    | $y_0$     |    |    |    |

$$\begin{aligned}
 Y_0 \text{ (SP)} = & y_1 x_1 x_2' + y_1' y_0 x_2 + y_1 y_0 x_1 + y_1' y_0 x_1' + y_1' x_1' x_2 \\
 & + y_1 y_0 x_2' + y_0 x_1' x_2' + y_0 x_1 x_2
 \end{aligned}$$

# Esercizio 2.5 – Sintesi con PLA

