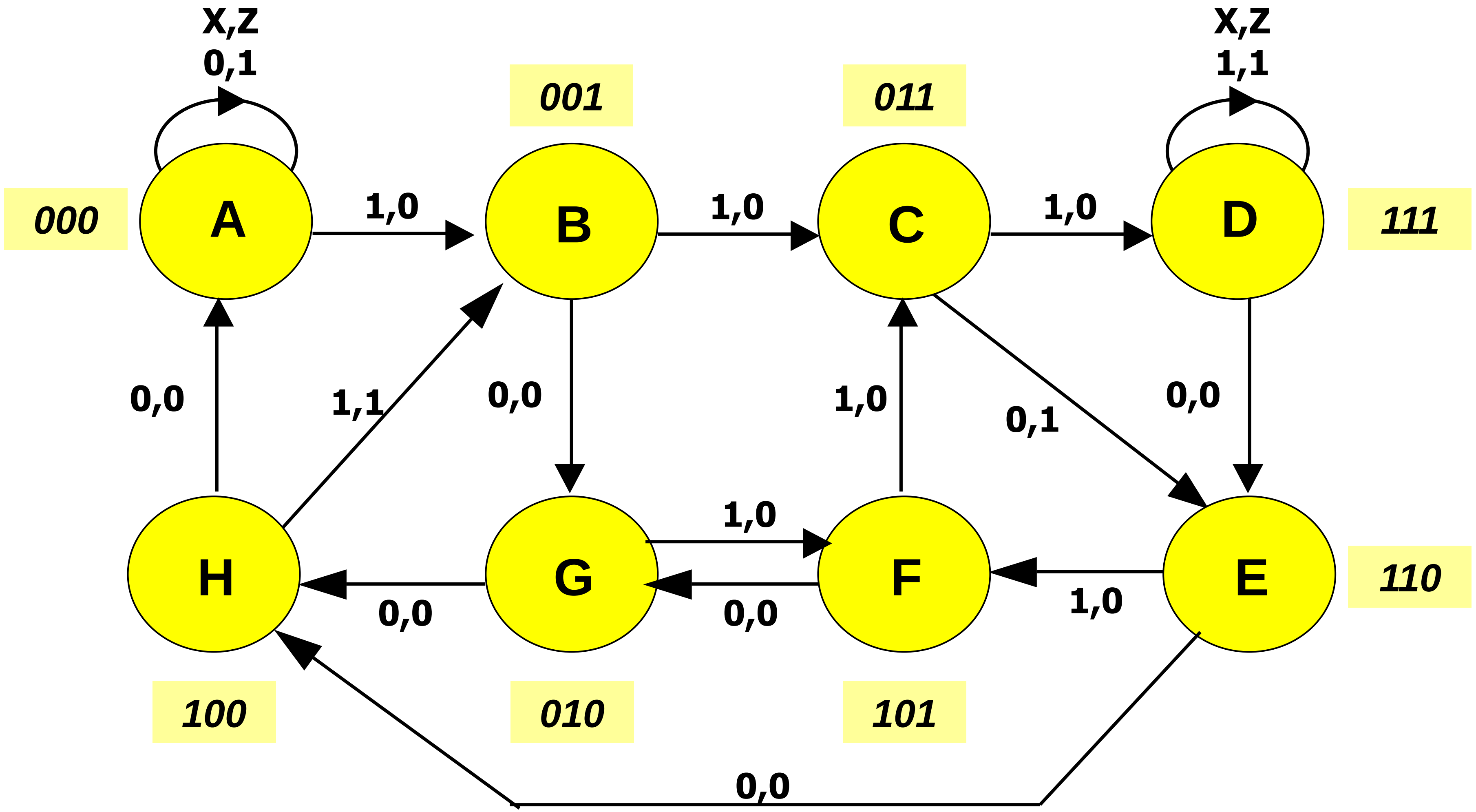
Esercizio 10 – Domanda 1



Esercizio 10 – Domanda 2 e 3

$(X)^n$

s.p.

	0	1
A	A,1	B,0
B	G,0	C,0
C	E,1	D,0
D	E,0	D,1
E	H,0	F,0
F	G,0	C,0
G	H,0	F,0
H	A,0	B,1

s.f., Z^n

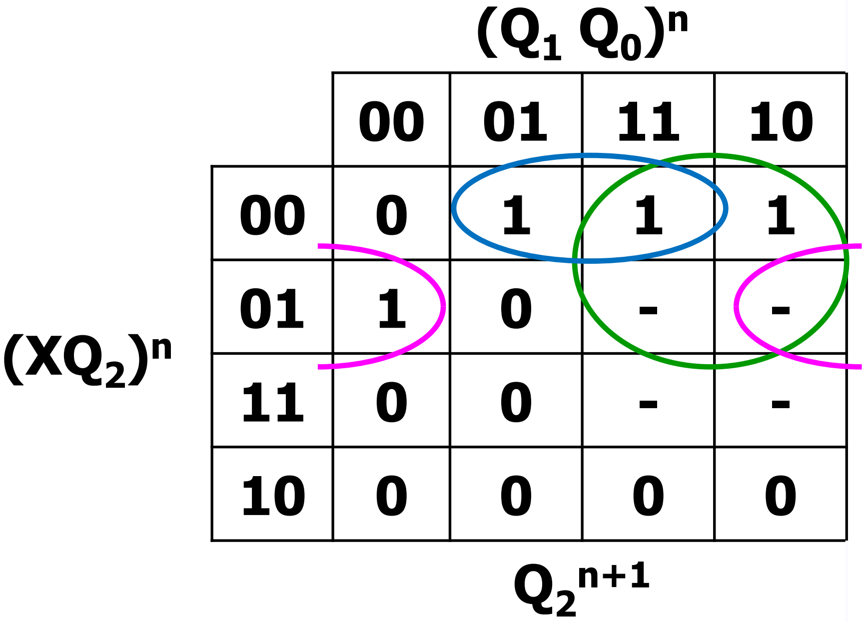
$(X)^n$

$(Q_2 Q_1 Q_0)^n$

	0	1
A=000	000,1	001,0
BF=001	100,0	011,0
C=011	100,1	010,0
D=010	100,0	010,1
EG=100	101,0	001,0
H=101	000,0	001,1
111	---,-	---,-
110	---,-	---,-

$(Q_2 Q_1 Q_0)^{n+1}$, Z^n

Esercizio 10 – Domanda 4

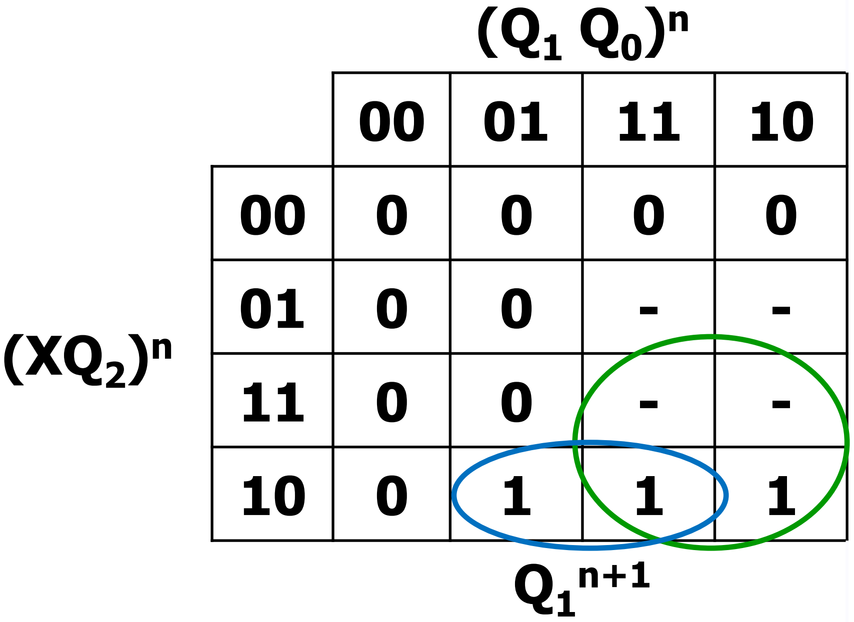


$(Q_1\ Q_0)^n$

$(XQ_2)^n$

	00	01	11	10
00	0	1	1	1
01	1	0	-	-
11	0	0	-	-
10	0	0	0	0

Q_2^{n+1}



$(Q_1\ Q_0)^n$

$(XQ_2)^n$

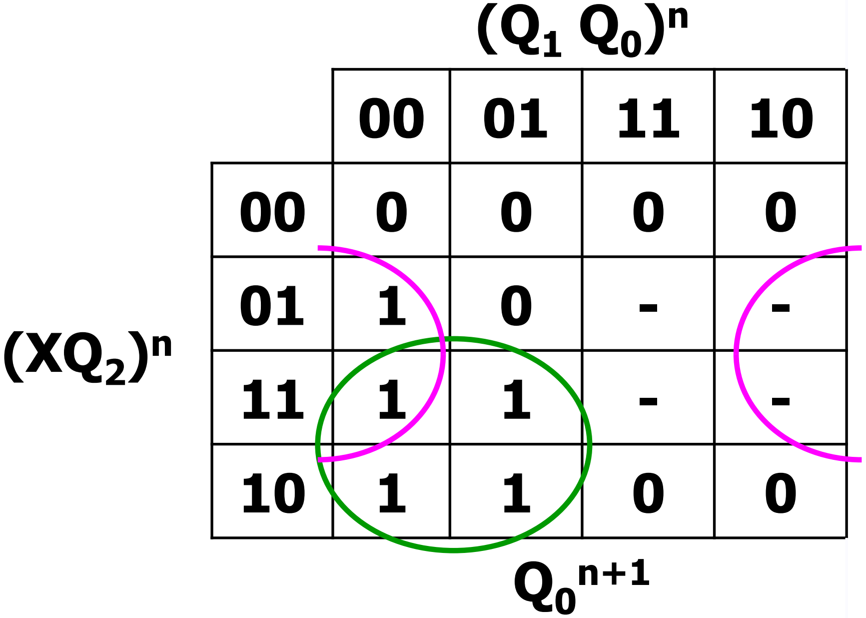
	00	01	11	10
00	0	0	0	0
01	0	0	-	-
11	0	0	-	-
10	0	1	1	1

Q_1^{n+1}

$Q_2\ (SP) = X'\ Q_2\ Q_0' + X'\ Q_1 + X'\ Q_2'\ Q_0$

$Q_1\ (SP) = X\ Q_1 + X\ Q_2'\ Q_0$

$Q_0\ (SP) = Q_2\ Q_0' + X\ Q_1'$



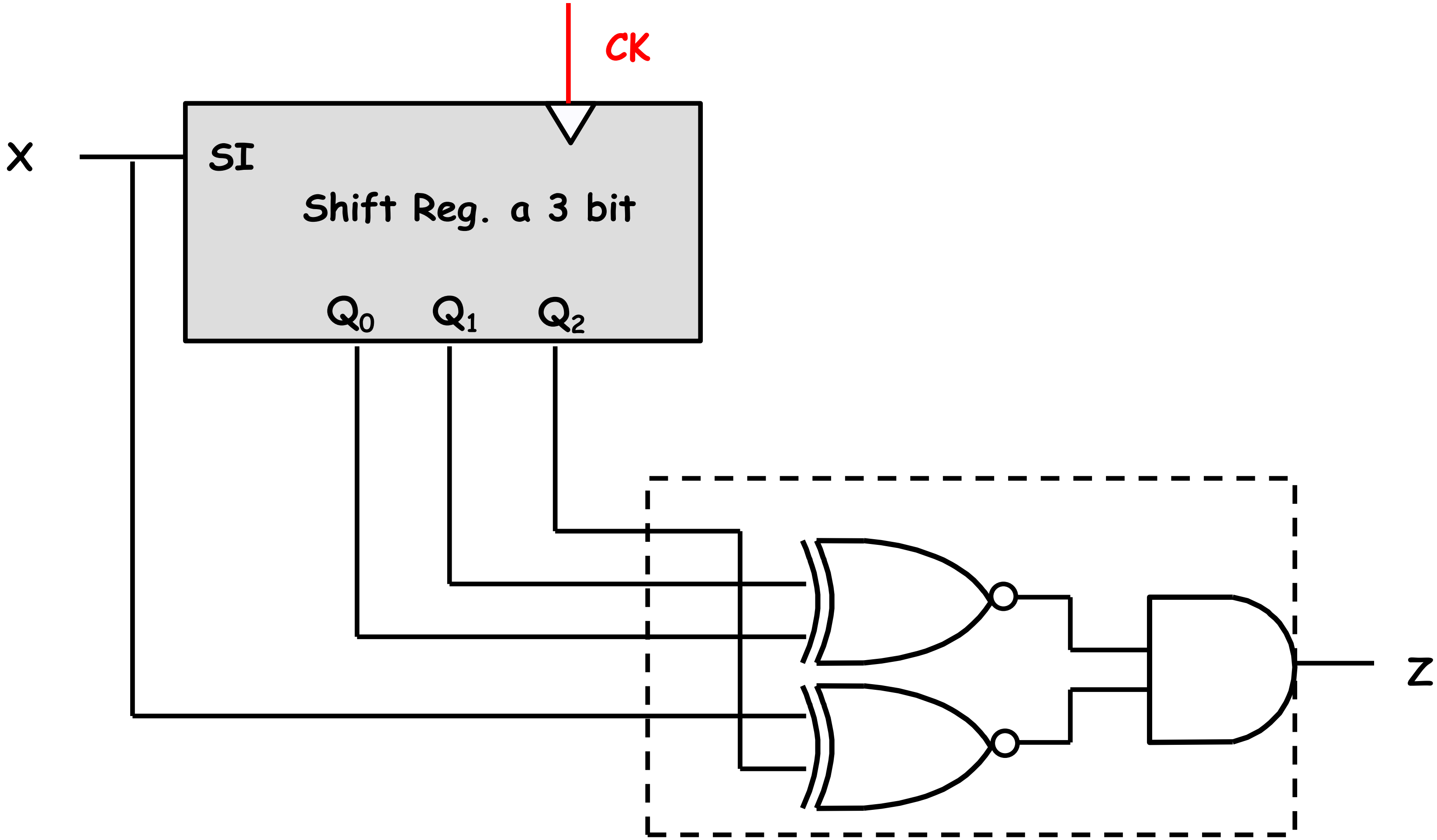
$(Q_1\ Q_0)^n$

$(XQ_2)^n$

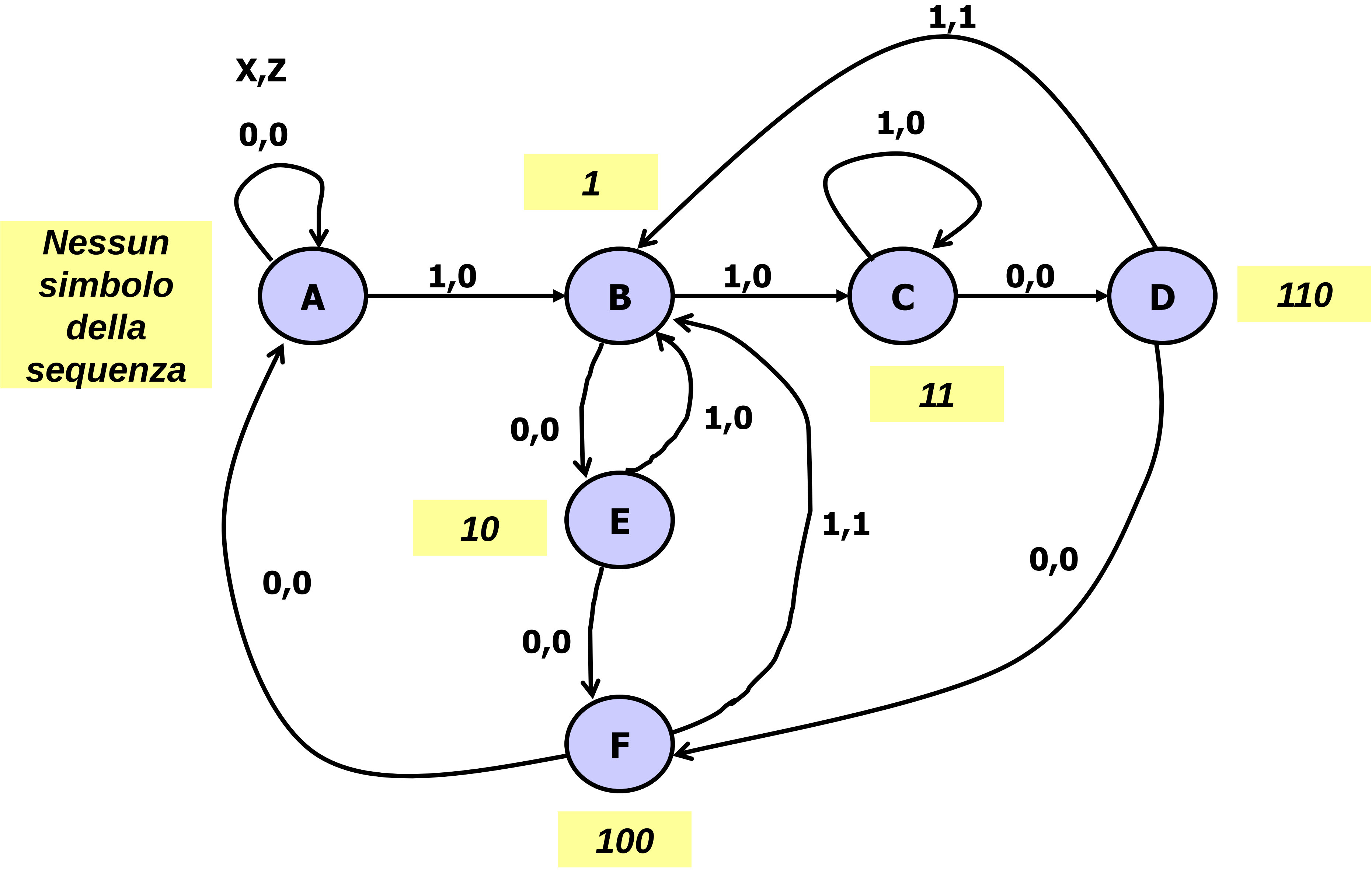
	00	01	11	10
00	0	0	0	0
01	1	0	-	-
11	1	1	-	-
10	1	1	0	0

Q_0^{n+1}

Esercizio 10 – Domanda 5



Esercizio 11 – Domanda 1



Esercizio 11 – Domanda 2 e 3

$(X)^n$

s.p.

	0	1
A	A,0	B,0
B	E,0	C,0
C	D,0	C,0
D	F,0	B,1
E	F,0	B,0
F	A,0	B,1

s.f., Z^n

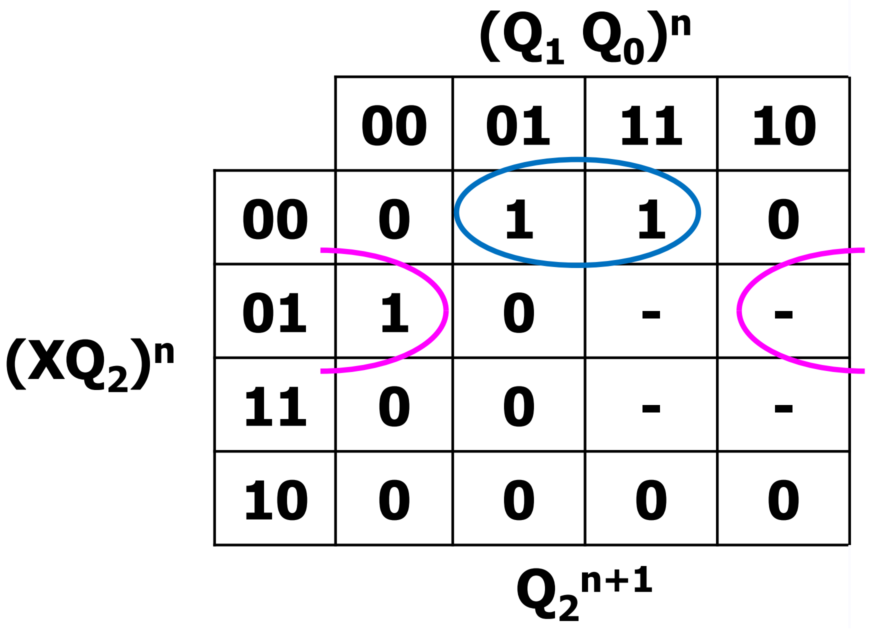
$(X)^n$

$(Q_2 Q_1 Q_0)^n$

	0	1
A=000	000,0	001,0
B=001	100,0	010,0
C=010	011,0	010,0
D=011	101,0	001,1
E=100	101,0	001,0
F=101	000,0	001,1
111	---,-	---,-
110	---,-	---,-

$(Q_2 Q_1 Q_0)^{n+1}$, Z^n

Esercizio 11 – Domanda 4

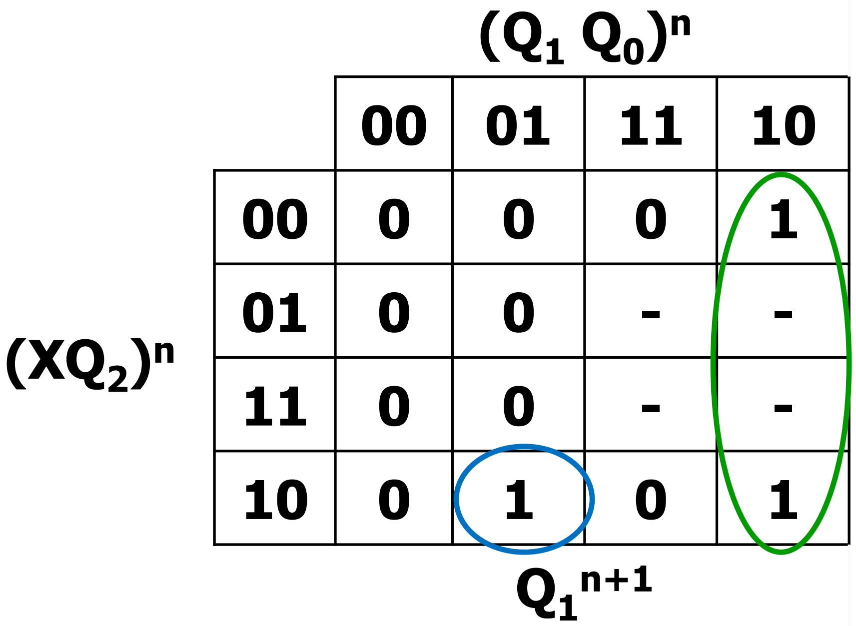


$(Q_1\ Q_0)^n$

$(XQ_2)^n$

	00	01	11	10
00	0	1	1	0
01	1	0	-	-
11	0	0	-	-
10	0	0	0	0

Q_2^{n+1}

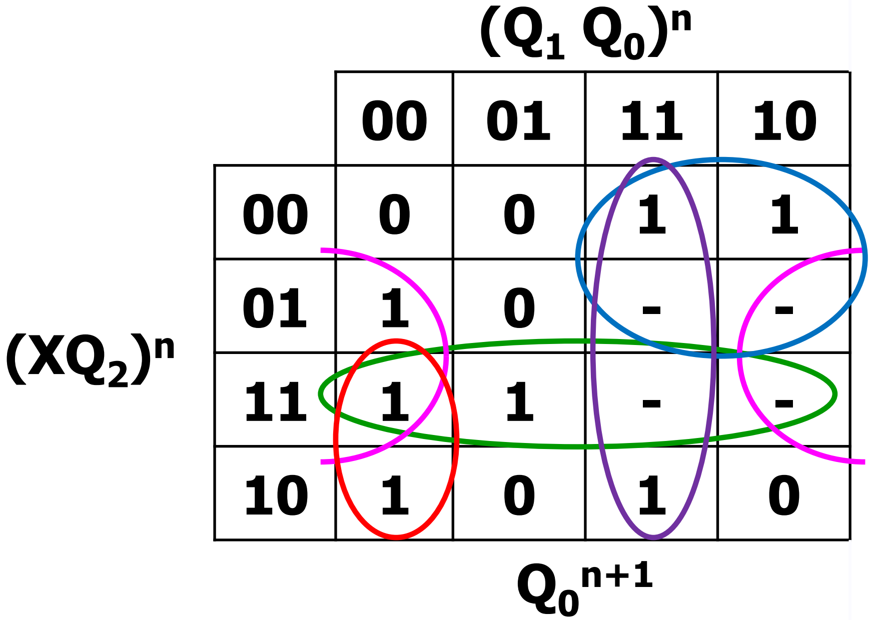


$(Q_1\ Q_0)^n$

$(XQ_2)^n$

	00	01	11	10
00	0	0	0	1
01	0	0	-	-
11	0	0	-	-
10	0	1	0	1

Q_1^{n+1}



$(Q_1\ Q_0)^n$

$(XQ_2)^n$

	00	01	11	10
00	0	0	1	1
01	1	0	-	-
11	1	1	-	-
10	1	0	1	0

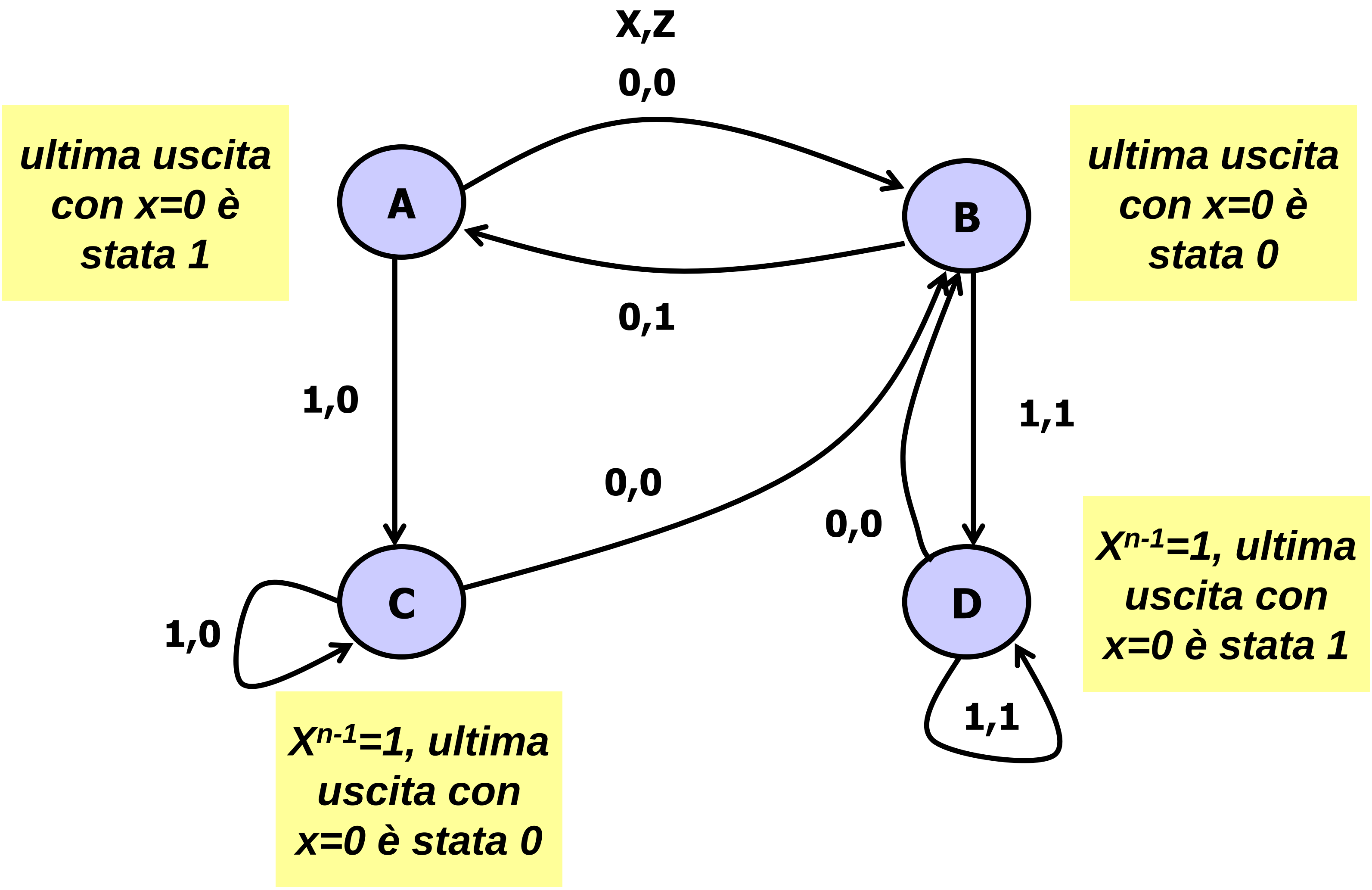
Q_0^{n+1}

$Q_2\ (SP) = X'\ Q_2\ Q_0' + X'\ Q_2'\ Q_0$

$Q_1\ (SP) = Q_1\ Q_0' + X\ Q_2'\ Q_1'\ Q_0$

$Q_0\ (SP) = Q_2\ Q_0' + X\ Q_1'\ Q_0' + X\ Q_2$
$+ X'\ Q_1 + Q_1\ Q_0$

Esercizio 12 – Domanda 1



ultima uscita con x=0 è stata 1

ultima uscita con x=0 è stata 0

$X^{n-1}=1$, ultima uscita con x=0 è stata 1

$X^{n-1}=1$, ultima uscita con x=0 è stata 0

Esercizio 12 – Domanda 2 e 3

$(X)^n$

s.p.	0	1
A	B,0	C,0
B	A,1	D,1
C	B,0	C,0
D	B,0	D,1

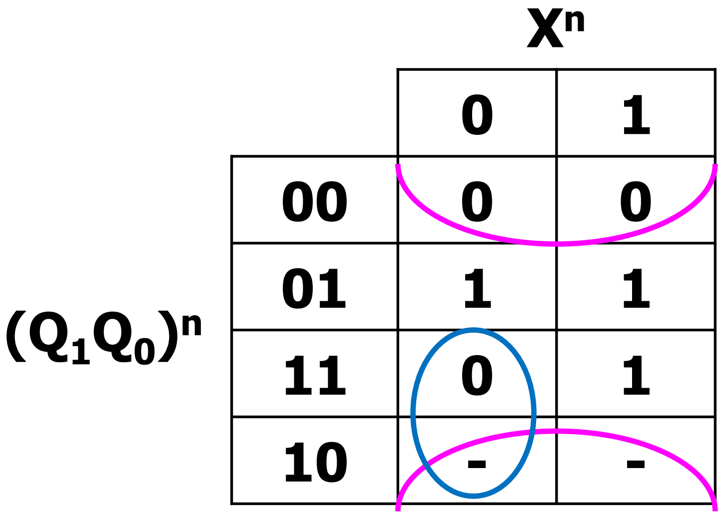
s.f., Z^n

$(X)^n$

$(Q_1Q_0)^n$	0	1
AC=00	01,0	00,0
B=01	00,1	11,1
D=11	01,0	11,1
10	--,-	--,-

$(Q_1Q_0)^{n+1}$, Z^n

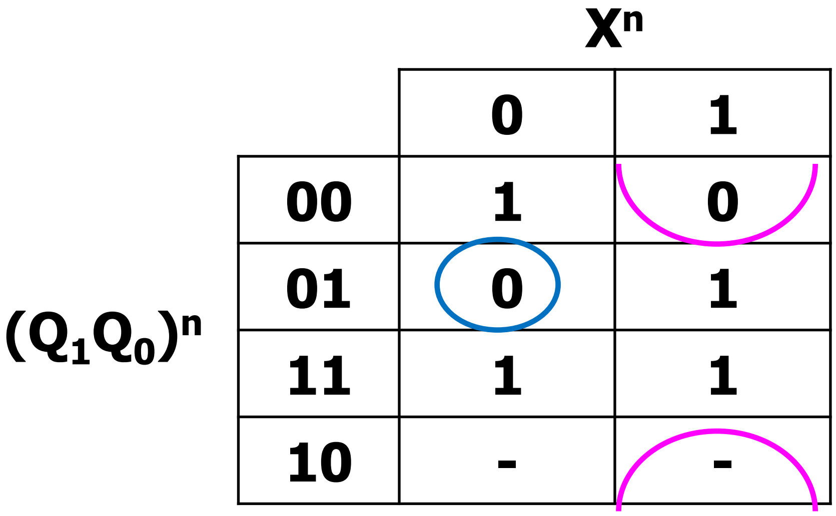
Esercizio 12 – Domanda 4



X^n

$(Q_1Q_0)^n$	0	1
00	0	0
01	1	1
11	0	1
10	-	-

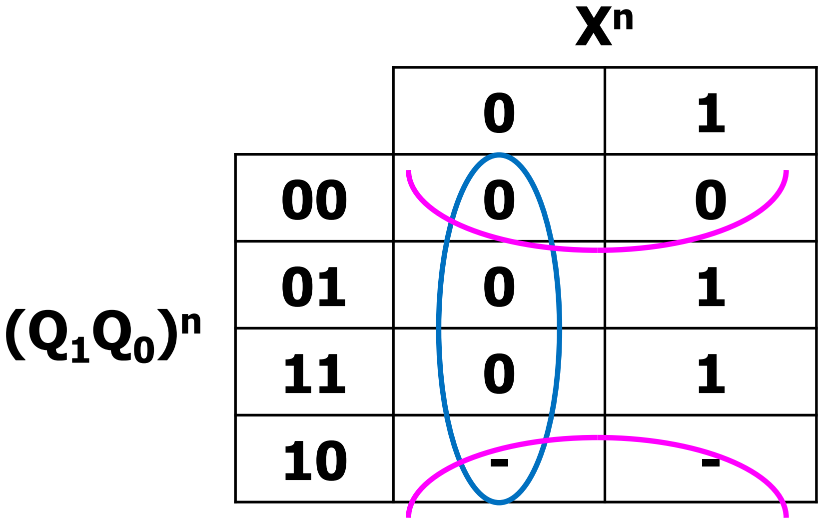
Z^n



X^n

$(Q_1Q_0)^n$	0	1
00	1	0
01	0	1
11	1	1
10	-	-

Q_0^{n+1}



X^n

$(Q_1Q_0)^n$	0	1
00	0	0
01	0	1
11	0	1
10	-	-

Q_1^{n+1}

$Z\ (PS) = Q_0\ (X + Q_1')$

$Q_1\ (PS) = (X' + Q_0)\ (X + Q_1 + Q_0')$

$Q_0\ (PS) = Q_0\ X$

$Z\ (NOR) = Q_0' \downarrow (X \downarrow Q_1')$

$Q_1\ (NOR) = (X' \downarrow Q_0) \downarrow (X \downarrow Q_1 \downarrow Q_0')$

$Q_0\ (NOR) = Q_0' \downarrow X'$

Esercizio 13 – Domanda 1 e 2

	Codifica 1	Codifica 2
A	00	00
B	01	11
C	10	10
D	11	01

y_1y_0

Avendo a disposizione U/D’, gli stati possono essere condificati percorrendo l’anello che essi formano all’aumentare o al diminuire del valore del contatore.

Nel seguito si farà riferimento alla prima codifica.

X^n

$(y_1y_0)^n$

	0	1
00	01,0	00,0
01	00,0	10,0
10	11,1	10,1
11	10,1	00,1

$(y_1y_0)^{n+1}, Z^n$

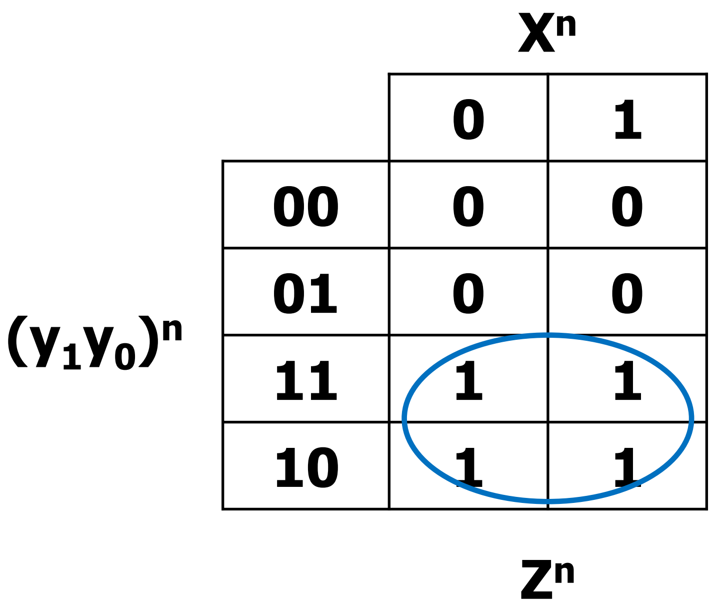
X^n

$(y_1y_0)^n$

	0	1
00	1 1,0	0 -,0
01	1 0,0	1 1,0
10	1 1,1	0 -,1
11	1 0,1	1 1,1

(EN U/D’, Z)^n

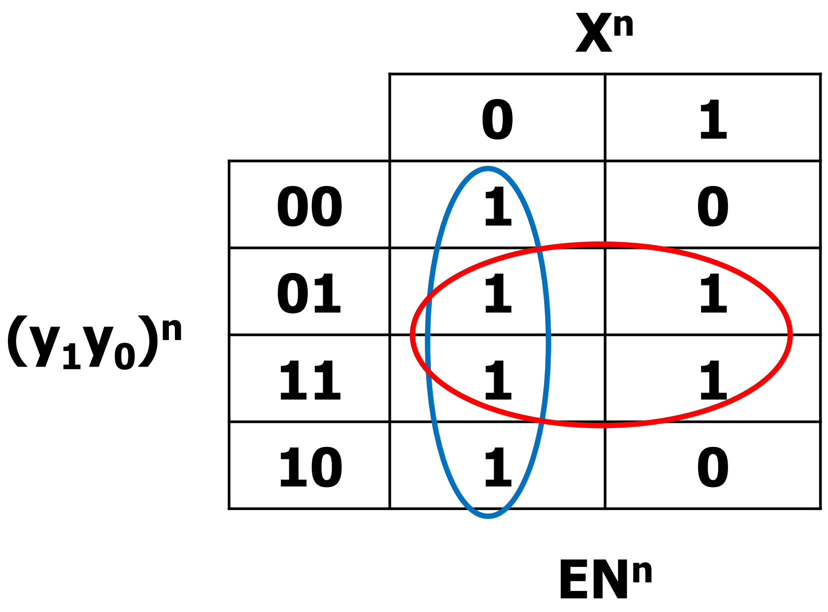
Esercizio 13 – Domanda 4



X^n

$(y_1y_0)^n$	0	1
00	0	0
01	0	0
11	1	1
10	1	1

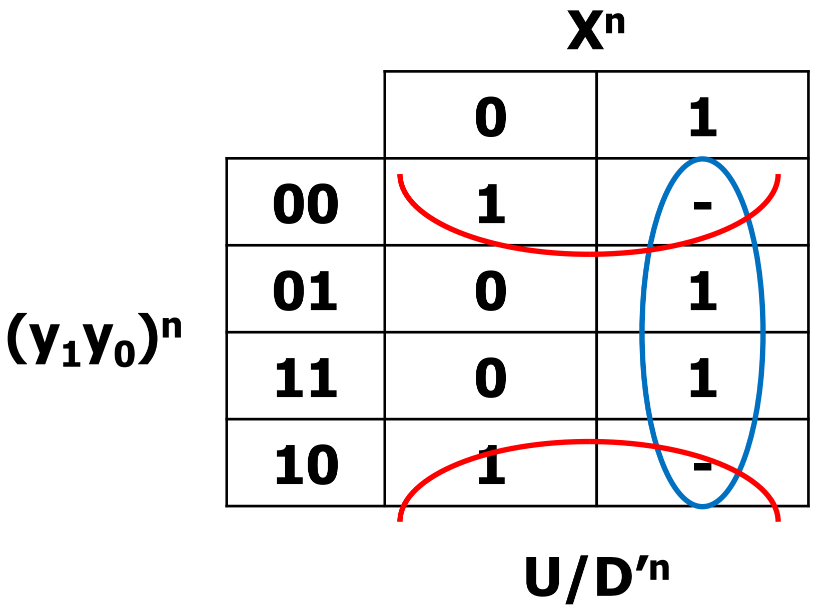
Z^n



X^n

$(y_1y_0)^n$	0	1
00	1	0
01	1	1
11	1	1
10	1	0

EN^n



X^n

$(y_1y_0)^n$	0	1
00	1	-
01	0	1
11	0	1
10	1	-

U/D'^n

Z (SP) = y_1

EN (SP) = $y_0 + X'$

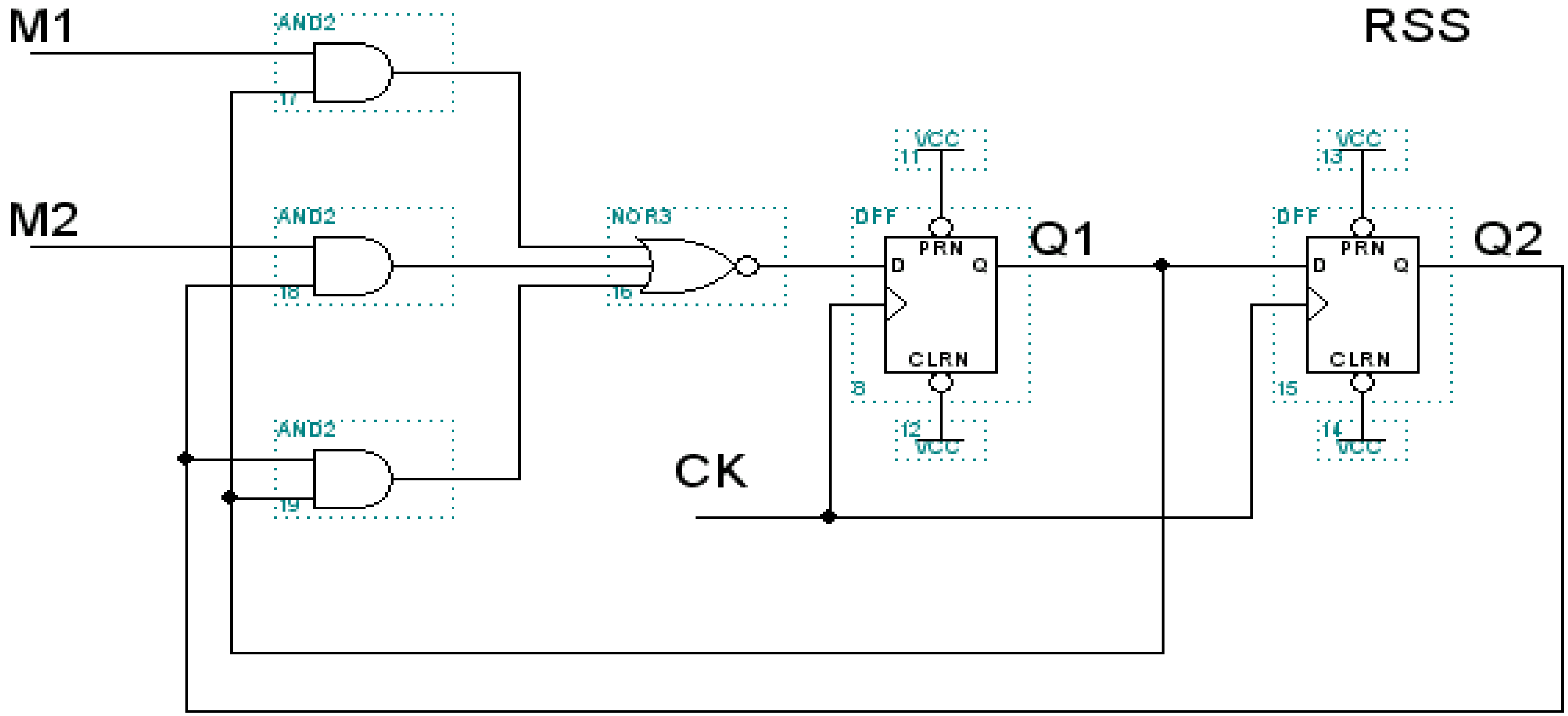
U/D′ (SP) = $y_0' + X$

Z (NAND) = y_1

EN (NAND) = $y_0' \uparrow X$

U/D′ (NAND) = $y_0 \uparrow X'$

Esercizio 14 – Domanda 1



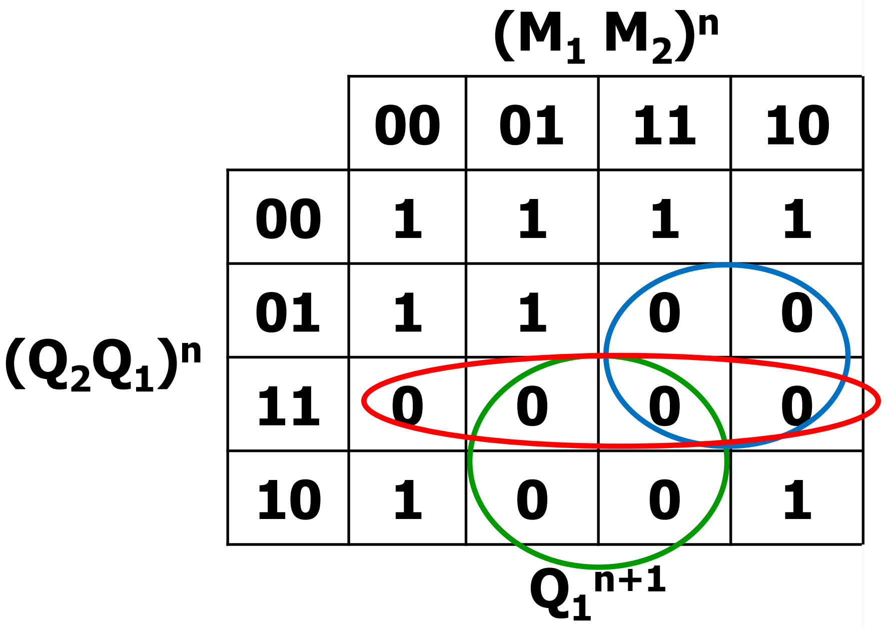
$Q1^{n+1} = D1^{n} = (\ (M1Q1 + M2Q2 + Q1Q2)'\ )^{n}$ **(De Morgan)**

$= (\ (M1Q1)'\ (M2Q2)'\ (Q1Q2)'\ )^{n}$ **(De Morgan)**

$= (\ (M1'+Q1')\ (M2'+Q2')\ (Q1'+Q2')\ )^{n}$

$Q2^{\ n+1} = D2^{n} = Q1^{n}$

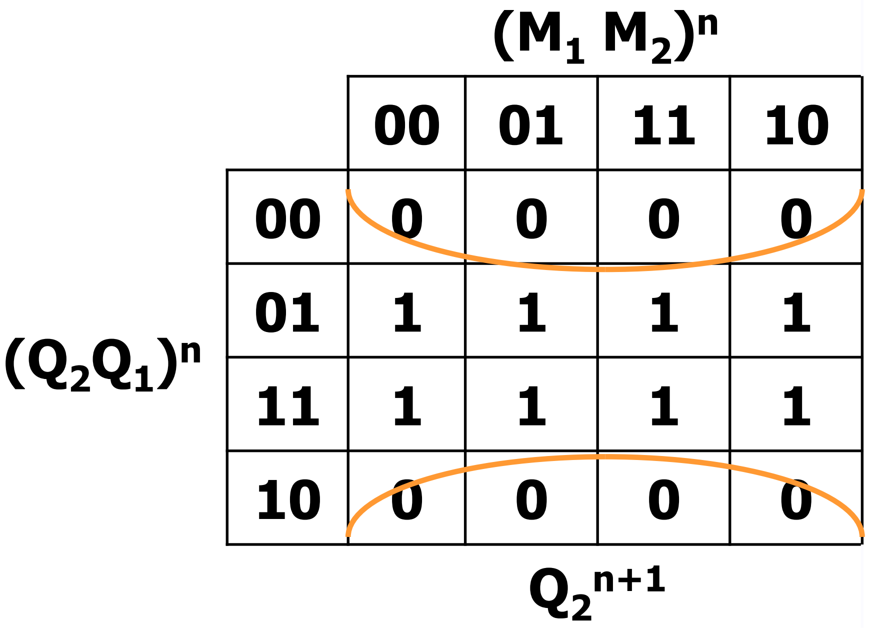
Esercizio 14 – Domanda 2



$(M_1\ M_2)^n$

$(Q_2Q_1)^n$	00	01	11	10
00	1	1	1	1
01	1	1	0	0
11	0	0	0	0
10	1	0	0	1

Q_1^{n+1}



$(M_1\ M_2)^n$

$(Q_2Q_1)^n$	00	01	11	10
00	0	0	0	0
01	1	1	1	1
11	1	1	1	1
10	0	0	0	0

Q_2^{n+1}

Q_1 (PS) = $(M_1' + Q_1') + (M_2' + Q_2') + (Q_2' + Q_1')$

Q_2 (PS) = Q_1

Esercizio 14 – Domanda 3

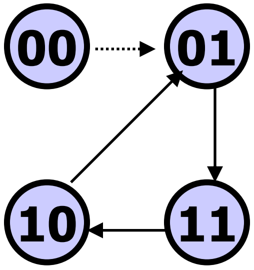
$(M_1\ M_2)^n$

$(Q_2Q_1)^n$

	00	01	11	10
00	01	01	01	01
01	11	11	10	10
11	10	10	10	10
10	01	00	00	01

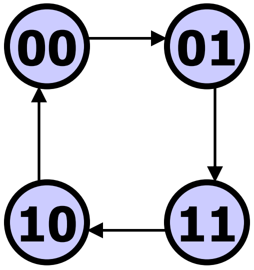
$(Q_2Q_1)^{n+1}$

M1M2 = 00



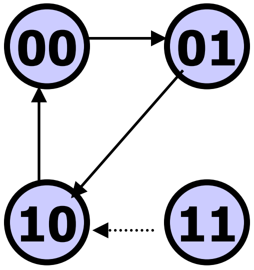
**Stati
a regime: 3**

M1M2 = 01



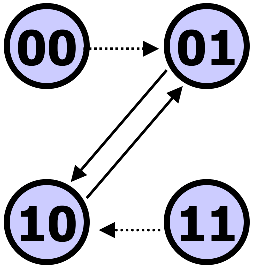
**Stati
a regime: 4**

M1M2 = 11



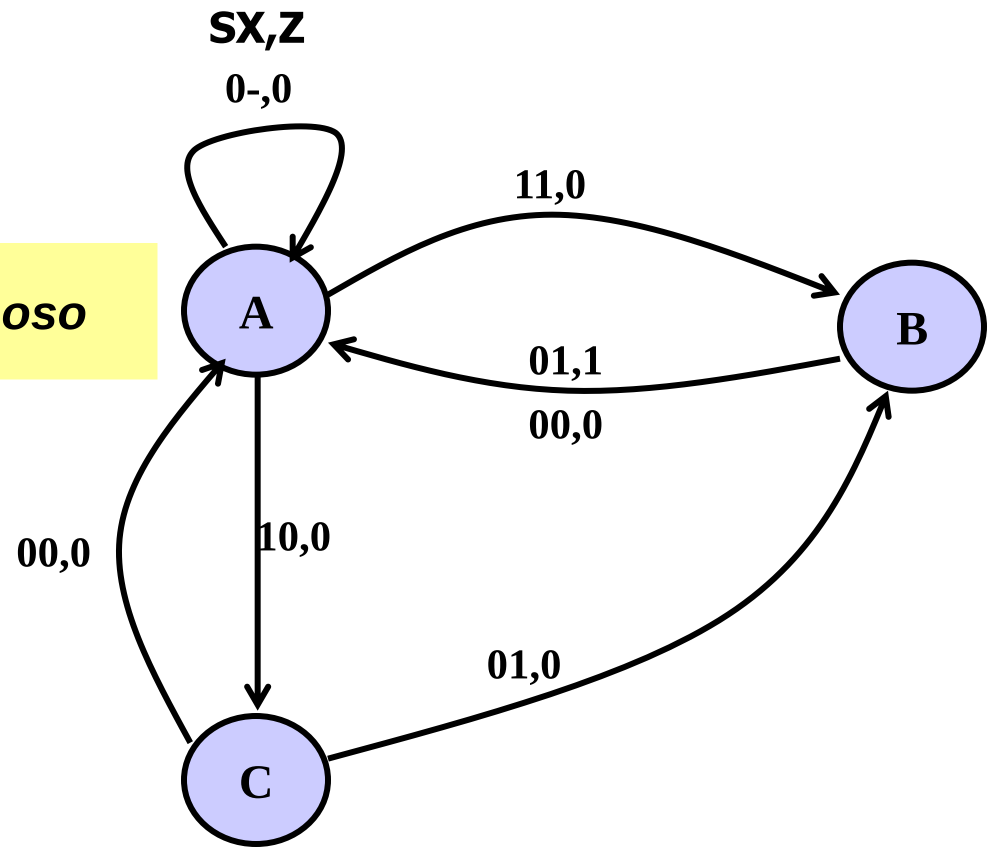
**Stati
a regime: 3**

M1M2 = 10



**Stati
a regime: 2**

Esercizio 15 – Domanda 1



A riposo

Il precedente ingresso (primo o secondo nella sequenza) era 1

Il primo ingresso della sequenza era 0

Esercizio 15 – Domanda 2 e 3

$(S\ X)^n$

s.p.

	00	01	11	10
A	A,0	A,0	B,0	C,0
B	A,0	A,1	-,-	-,-
C	A,0	B,0	-,-	-,-

s.f., Z^n

Il comportamento della rete segue il modello di Mealy poiché l’uscita dipende sia dallo stato sia dall’ingresso: se lo stato è B e l’ingresso è 00 l’uscita vale 0 mentre se lo stato è B e l’ingresso è 01 l’uscita vale 1.

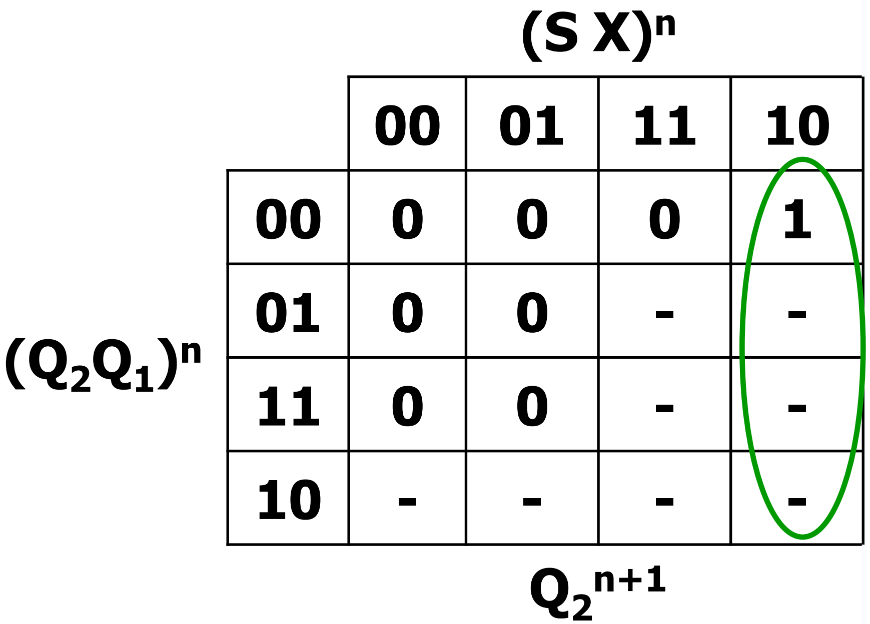
$(S\ X)^n$

$(Q_2\ Q_1)^n$

	00	01	11	10
A= 00	00,0	00,0	01,0	11,0
B= 01	00,0	00,1	--,-	--,-
C= 11	00,0	01,0	--,-	--,-
10	--,-	--,-	--,-	--,-

$(Q_2\ Q_1)^{n+1}$, Z^n

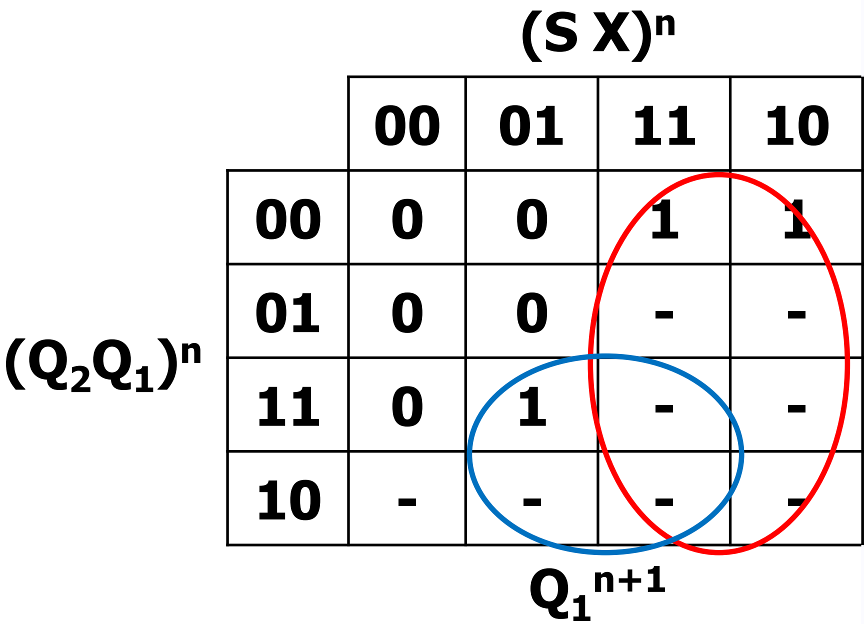
Esercizio 15 – Domanda 4



$(S\ X)^n$

$(Q_2Q_1)^n$	00	01	11	10
00	0	0	0	1
01	0	0	-	-
11	0	0	-	-
10	-	-	-	-

Q_2^{n+1}



$(S\ X)^n$

$(Q_2Q_1)^n$	00	01	11	10
00	0	0	1	1
01	0	0	-	-
11	0	1	-	-
10	-	-	-	-

Q_1^{n+1}

$Q_2\ (SP) = S\ X'$

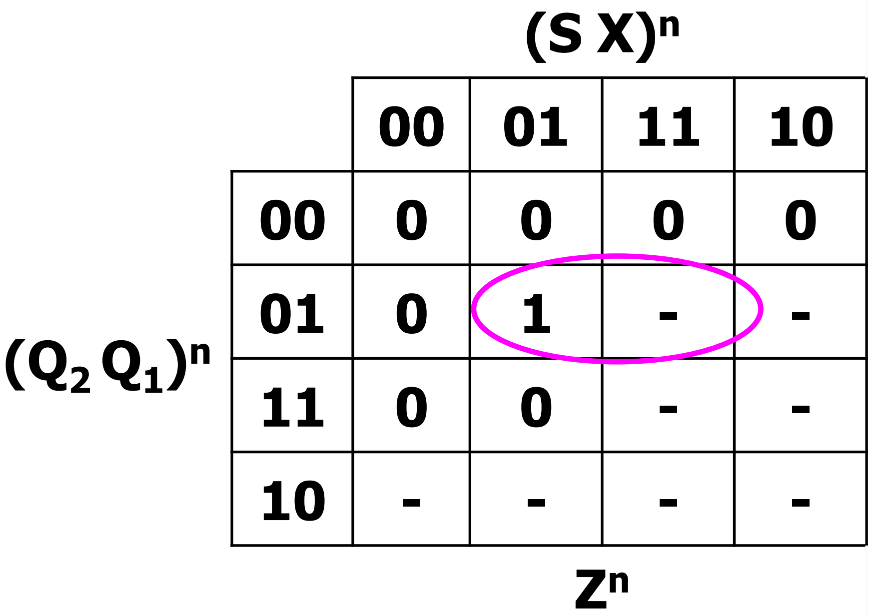
$Q_1\ (SP) = Q_2\ X + S$

$Z\ (SP) = Q_2'\ Q_1\ X$

$Q_2\ (NAND) = (S \uparrow X') \uparrow 1$

$Q_1\ (NAND) = (Q_2 \uparrow X) \uparrow S'$

$Z\ (NAND) = (Q_2' \uparrow Q_1 \uparrow X) \uparrow 1$

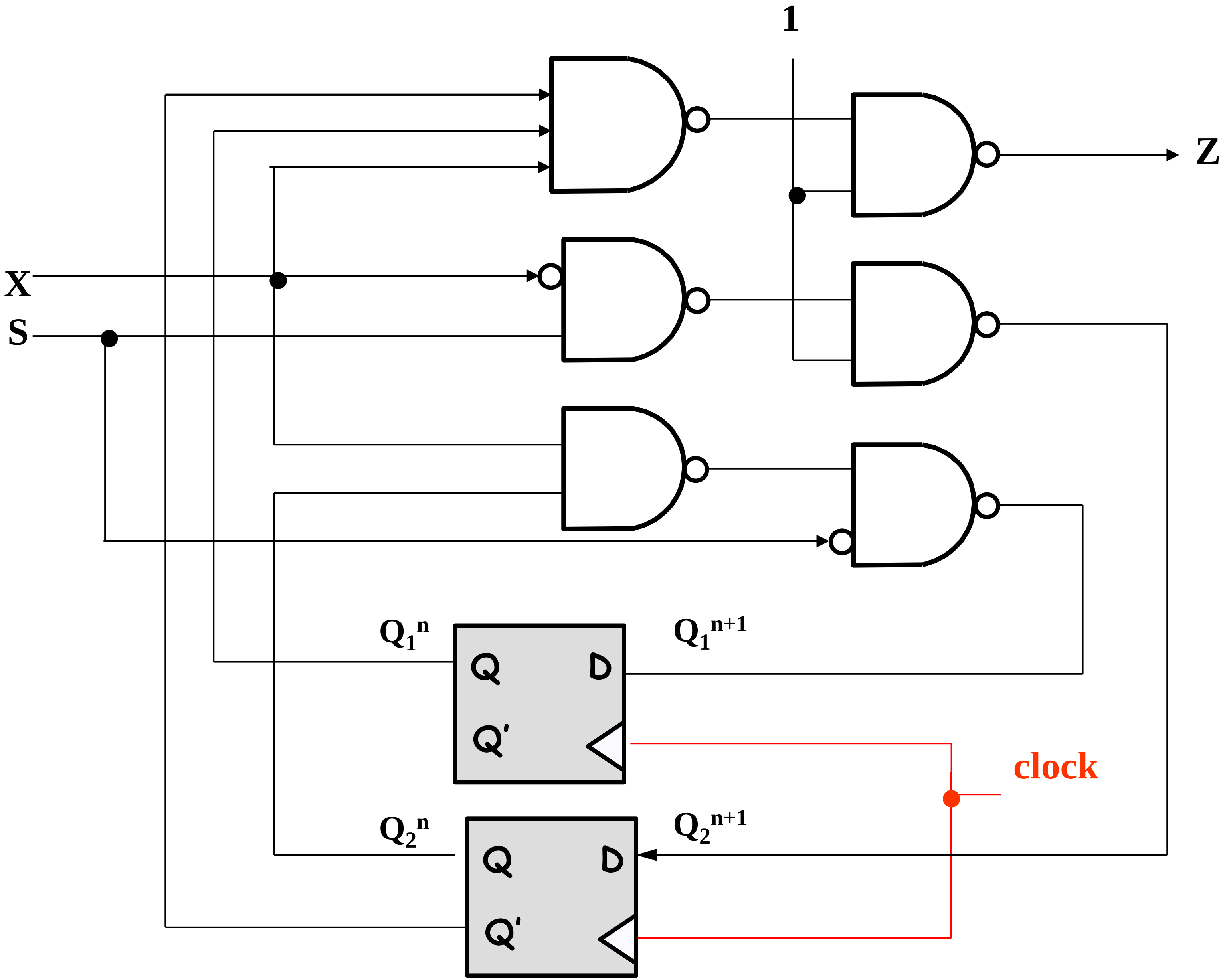


$(S\ X)^n$

$(Q_2\ Q_1)^n$	00	01	11	10
00	0	0	0	0
01	0	1	-	-
11	0	0	-	-
10	-	-	-	-

Z^n

Esercizio 15 – Domanda 5



Esercizio 16 – Domanda 1

Un contatore per 8 in codice Gray è un contatore avente gli stati codificati con le 8 configurazioni del codice Gray a 3 bit:

$Q_2Q_1Q_0$
0 0 0
0 0 1
0 1 1
0 1 0
1 1 0
1 1 1
1 0 1
1 0 0

Un contatore per 4 in codice Gray è un contatore avente gli stati codificati con le 4 configurazioni del codice Gray a 2 bit:

Q_1Q_0
0 0
0 1
1 1
1 0

Q_2^n

$(Q_1Q_0)^n$	0	1
00	0	1
01	0	1
11	0	1
10	1	1

$RESET^n$

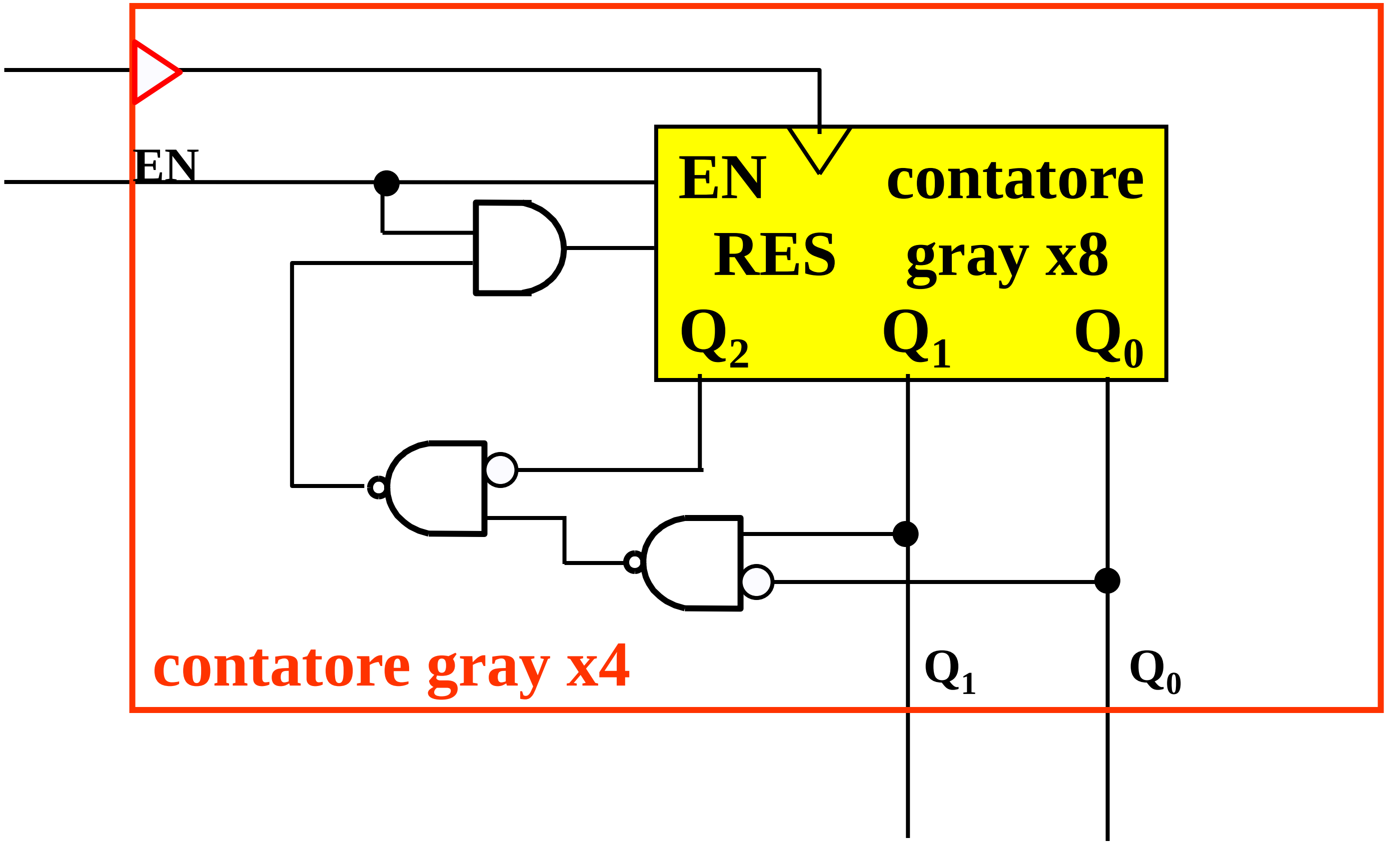
Reset attivo nel quarto stato del ciclo per portare la base di conteggio da 8 a 4…….

….ed anche negli stati 5,6,7,8 in maniera da ottenere l'autoinizializzazione in un clock

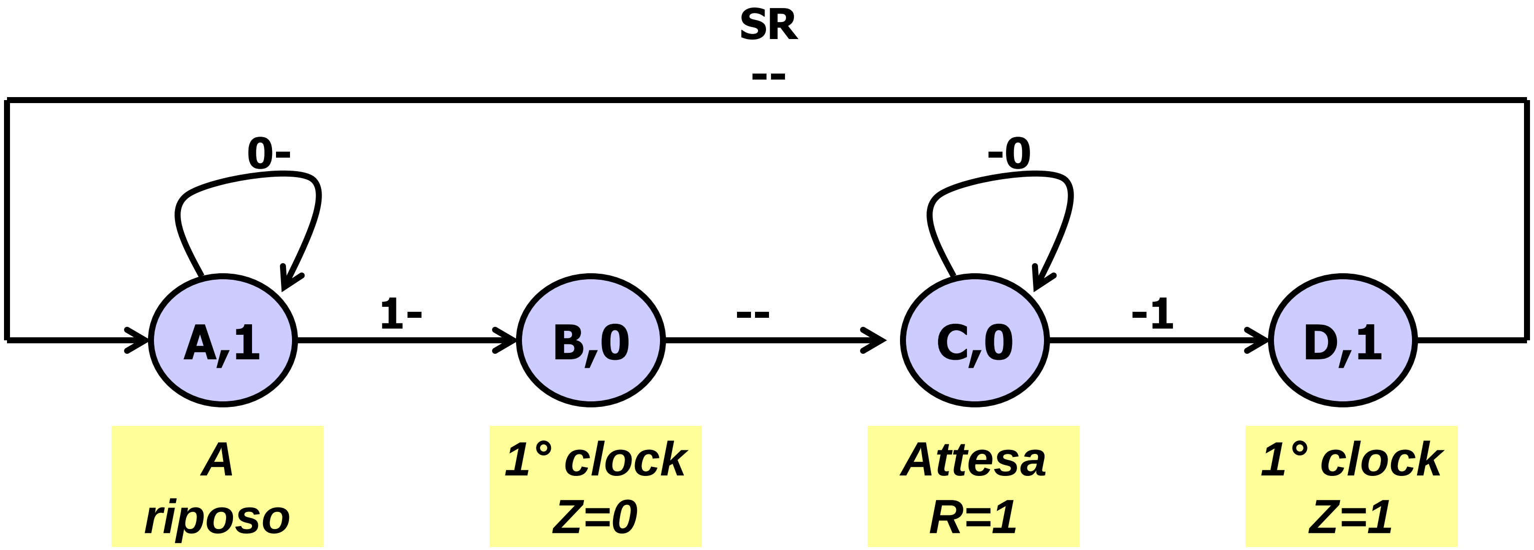
$RESET\ (SP) = Q_1\ Q_0' + Q_2$

$RESET\ (NAND) = (Q_1 \uparrow Q_0') \uparrow Q_2'$

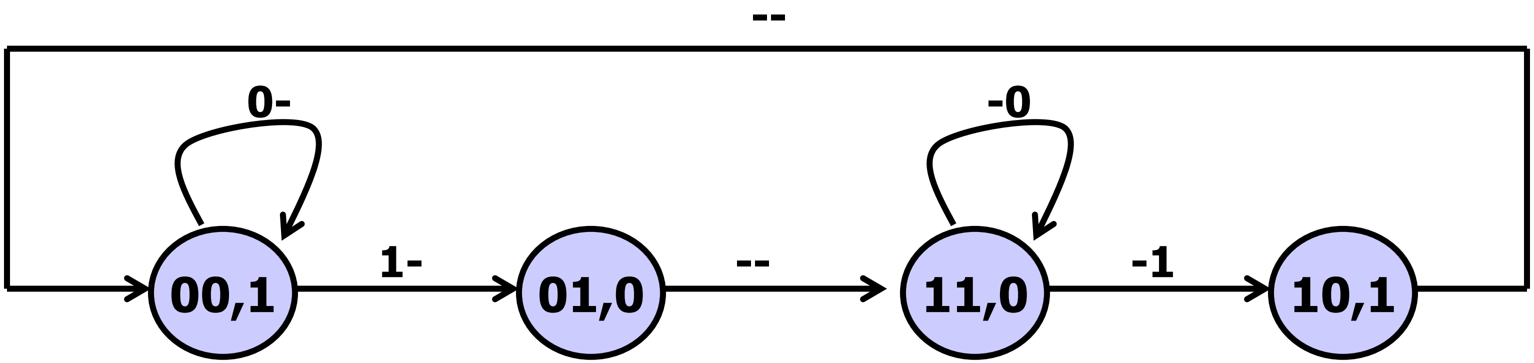
Esercizio 16 – Domanda 1



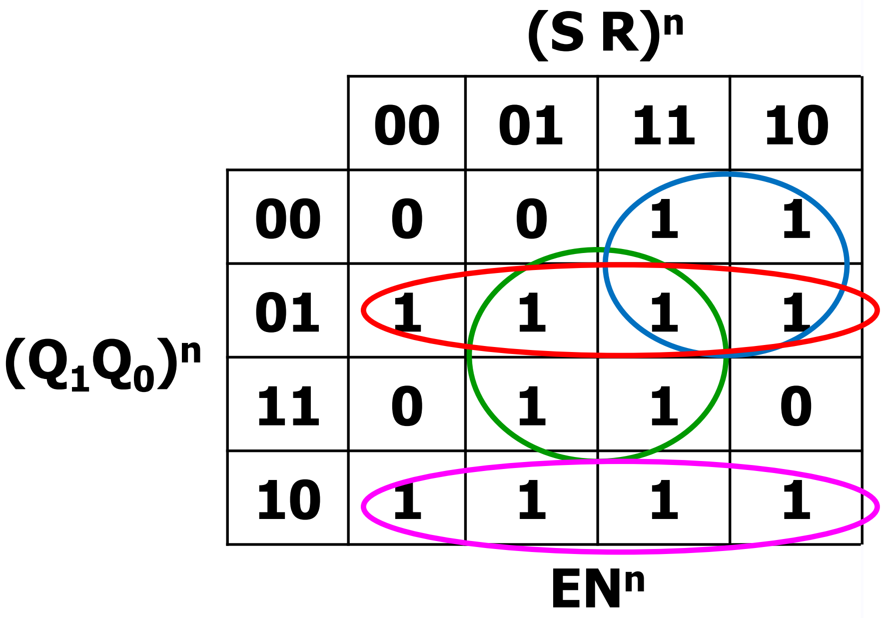
Esercizio 16 – Domanda 2 e 3



Codifica degli stati con contatore Gray x4: A=00, B=01, C=11, D=10



Esercizio 16 – Domanda 3

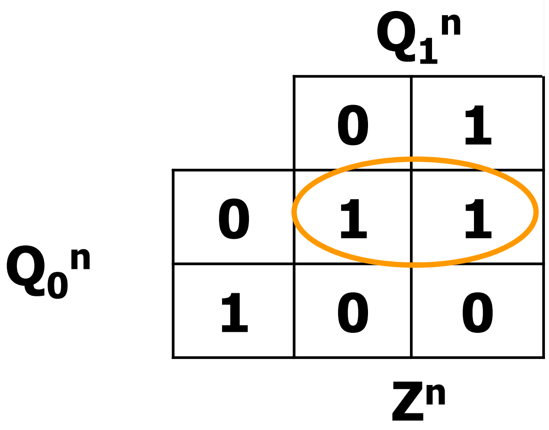


$(S\,R)^n$

$(Q_1Q_0)^n$

	00	01	11	10
00	0	0	1	1
01	1	1	1	1
11	0	1	1	0
10	1	1	1	1

EN^n



Q_1^n

Q_0^n

	0	1
0	1	1
1	0	0

Z^n

$Z\ (SP) = Q_0'$

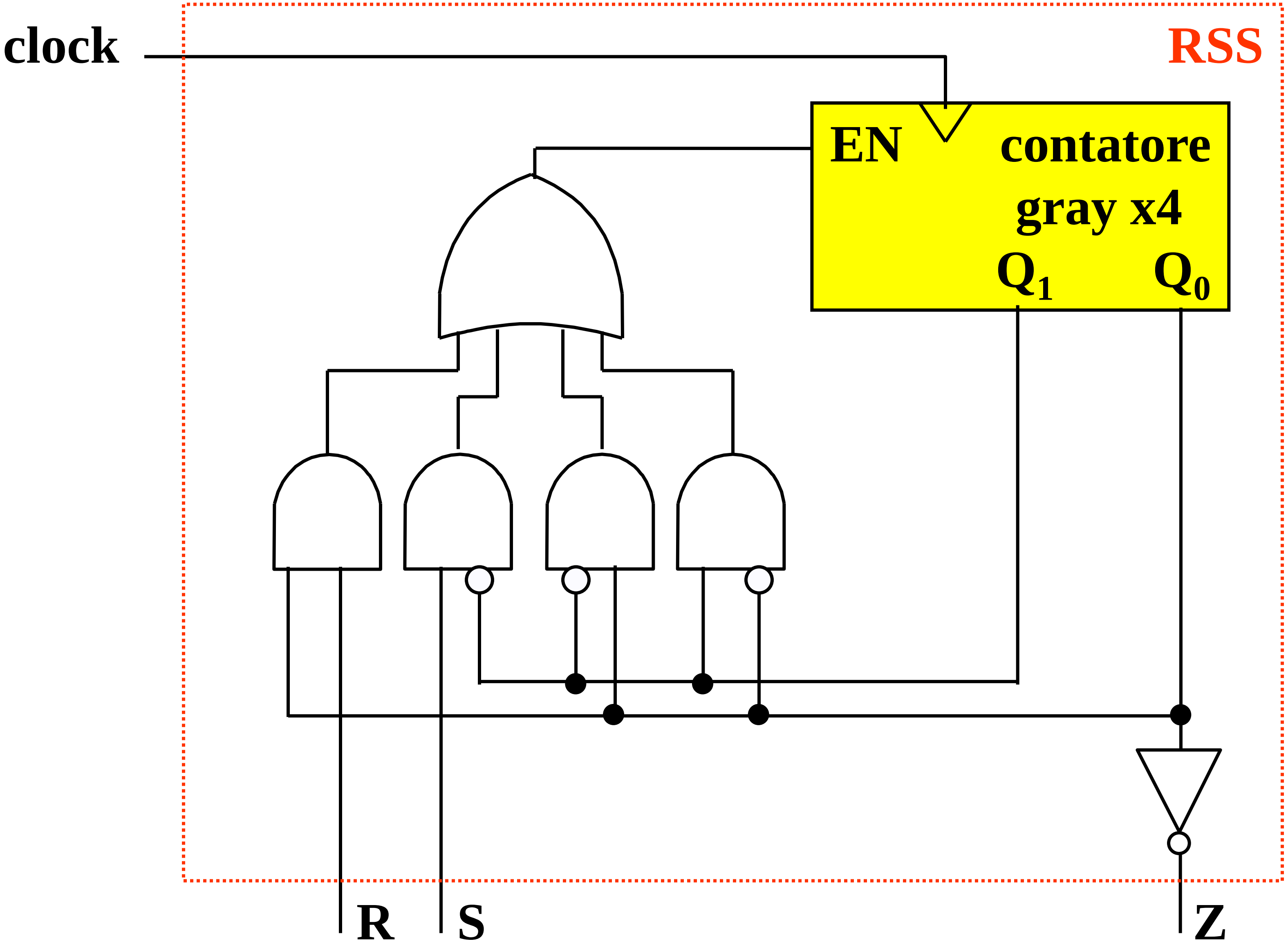
$EN\ (SP) = Q_1'\,S + Q_0\,R + Q_1'\,Q_0 + Q_1\,Q_0'$

oppure $Q_0'\,S + Q_0\,R + Q_1'\,Q_0 + Q_1\,Q_0'$

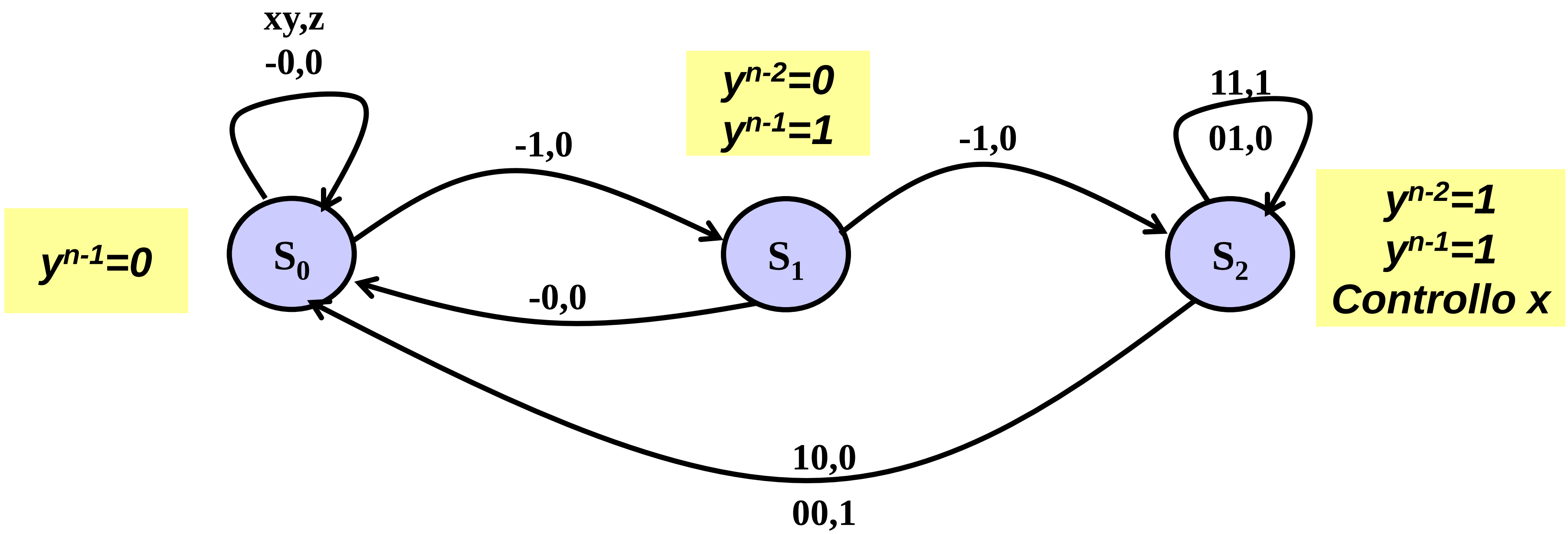
oppure $Q_1'\,S + Q_1\,R + Q_1'\,Q_0 + Q_1\,Q_0'$

oppure $Q_0'\,S + Q_1\,R + Q_1'\,Q_0 + Q_1\,Q_0'$

Esercizio 16 – Domanda 3



Esercizio 17 – Domanda 1



Esercizio 17 – Domanda 2 e 3

(x y)^n

		00	01	11	10
s.p.	S_0	S_0,0	S_1,0	S_1,0	S_0,0
	S_1	S_0,0	S_2,0	S_2,0	S_0,0
	S_2	S_0,1	S_2,0	S_2,1	S_0,0

s.f., z^n

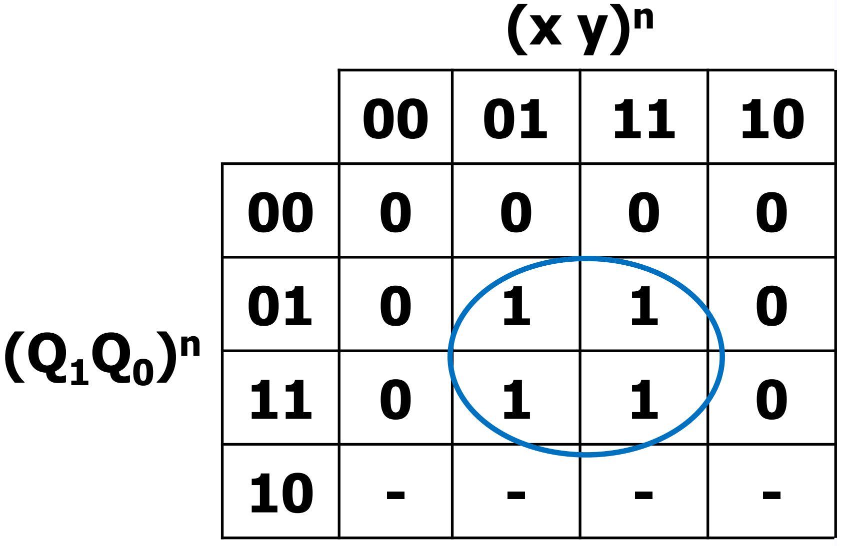
Il comportamento della rete segue il modello di Mealy poiché l'uscita dipende sia dallo stato sia dall'ingresso: se lo stato è S2 e l'ingresso è 00 o 11 l'uscita vale 1 mentre se l'ingresso è 01 o 10 l'uscita vale 0.

(x y)^n

		00	01	11	10
(Q_1 Q_0)^n	S_0= 00	00,0	01,0	01,0	00,0
	S_1= 01	00,0	11,0	11,0	00,0
	S_2= 11	00,1	11,0	11,1	00,0
	10	--,-	--,-	--,-	--,-

(Q_1 Q_0)$^{n+1}$, z^n

Esercizio 17 – Domanda 4

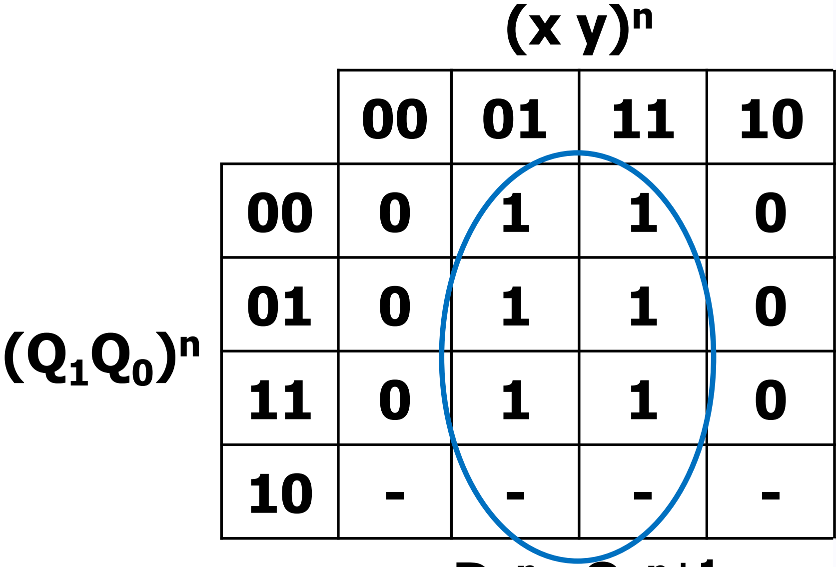


$(x\ y)^n$

$(Q_1Q_0)^n$

	00	01	11	10
00	0	0	0	0
01	0	1	1	0
11	0	1	1	0
10	-	-	-	-

$D_1^n=Q_1^{n+1}$



$(x\ y)^n$

$(Q_1Q_0)^n$

	00	01	11	10
00	0	1	1	0
01	0	1	1	0
11	0	1	1	0
10	-	-	-	-

$D_0^n=Q_0^{n+1}$

D_1 (SP) = $Q_0\ y$

D_0 (SP) = y

Esercizio 17 – Domanda 4 e 5

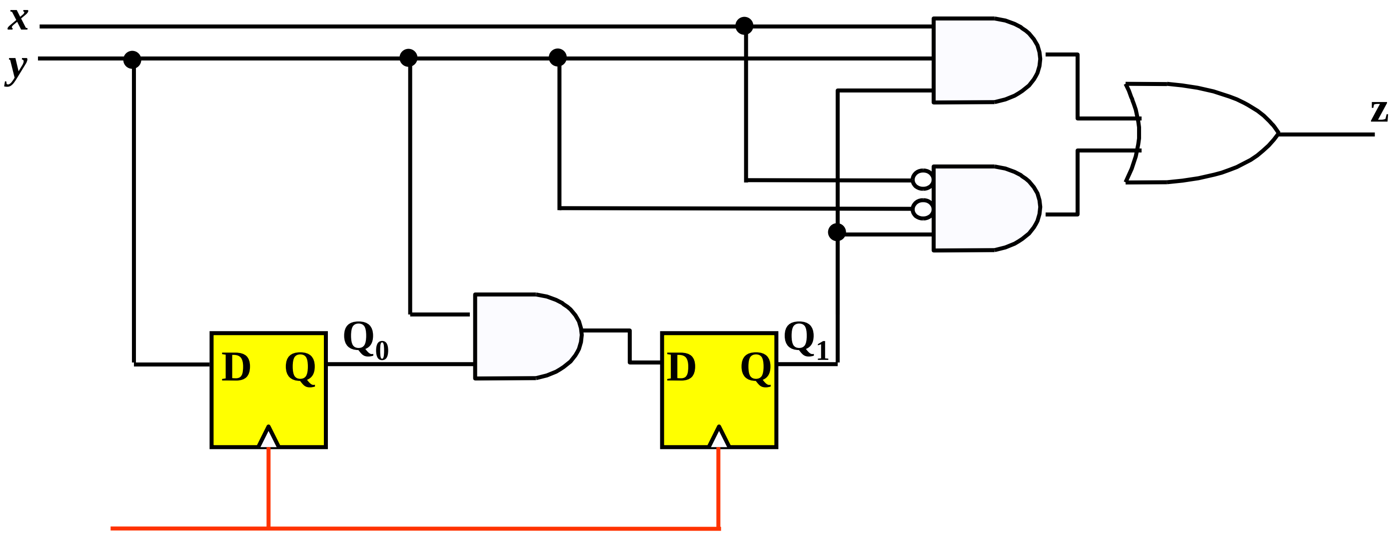
$(x\ y)^n$

$(Q_1Q_0)^n$

	00	01	11	10
00	0	0	0	0
01	0	0	0	0
11	1	0	1	0
10	-	-	-	-

z^n

z (SP) = $Q_1\ x'\ y' + Q_1\ x\ y$



Esercizio 18 – Domanda 1

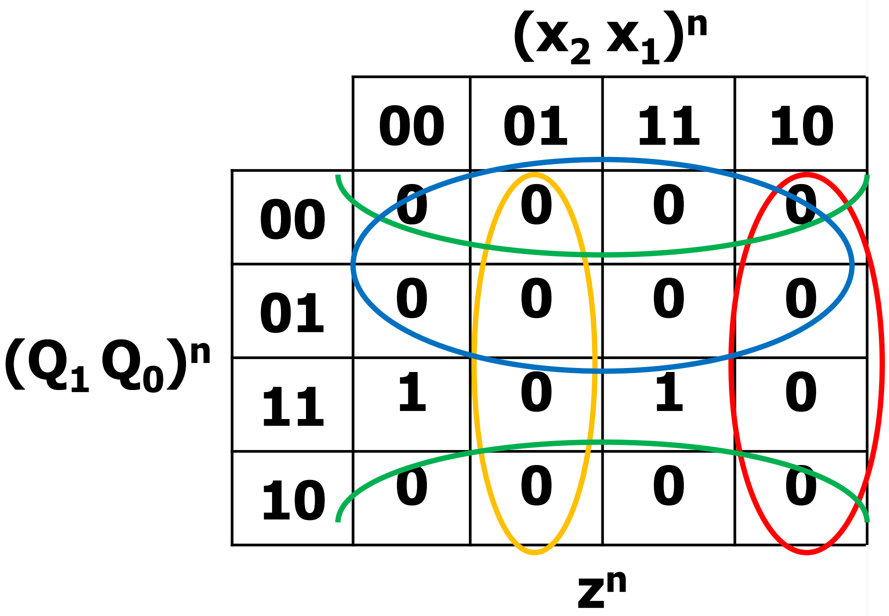
Q_1^{n+1} (NOR) = $(Q_0)^n$

Q_0^{n+1} (NOR) = $(x_2)^n$

z^n (NOR) **=** $((x_1' \downarrow x_2) \downarrow (x_1 \downarrow x_2') \downarrow Q_0' \downarrow Q_1')^n$

$$z^n \text{ (PS)} = ((x_1' + x_2) \downarrow (x_1 + x_2') \downarrow Q_0' \downarrow Q_1')^n$$
$$= ((x_1' + x_2) (x_1 + x_2') Q_0 \, Q_1)^n$$

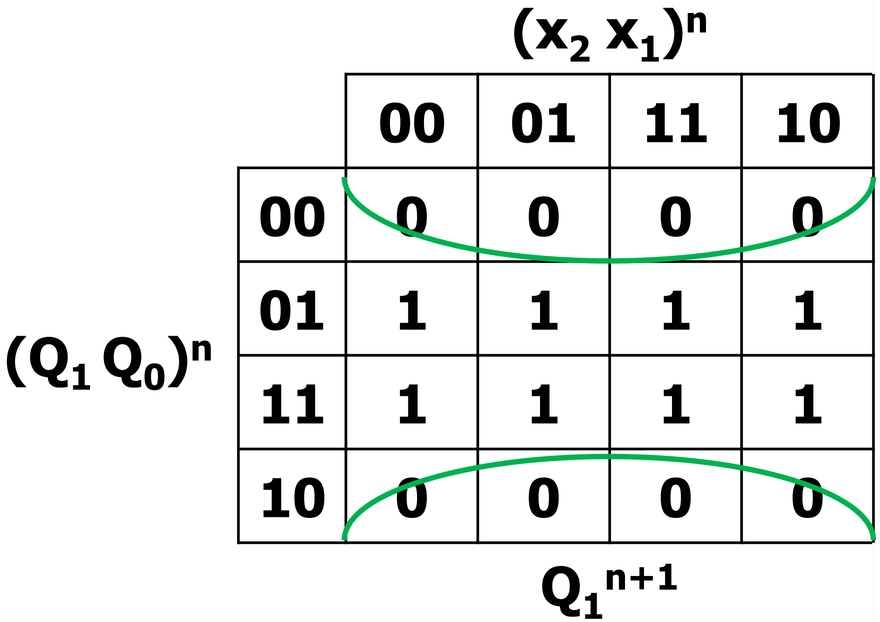
Esercizio 18 – Domanda 2



$(x_2 x_1)^n$

$(Q_1 Q_0)^n$	00	01	11	10
00	0	0	0	0
01	0	0	0	0
11	1	0	1	0
10	0	0	0	0

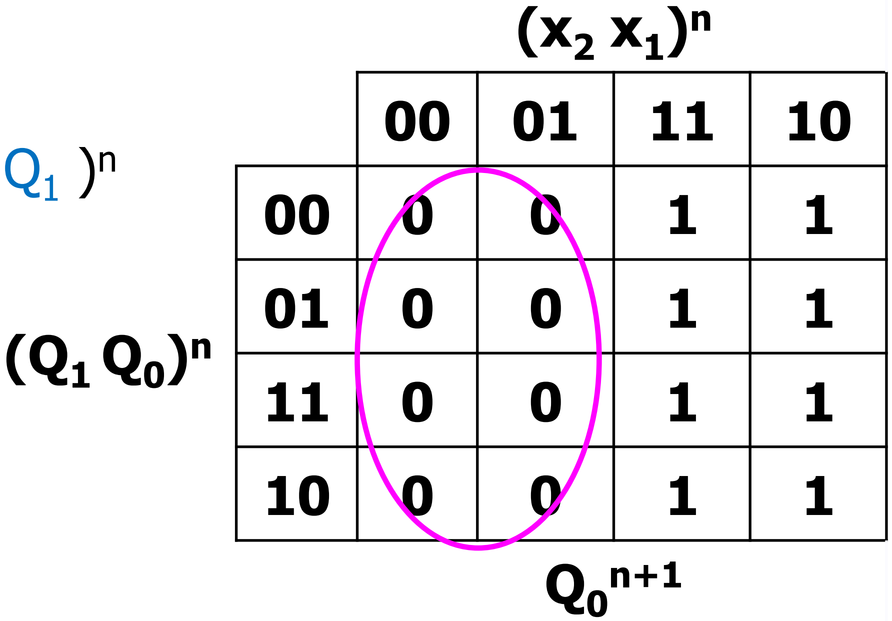
z^n



$(x_2 x_1)^n$

$(Q_1 Q_0)^n$	00	01	11	10
00	0	0	0	0
01	1	1	1	1
11	1	1	1	1
10	0	0	0	0

Q_1^{n+1}



$(x_2 x_1)^n$

$(Q_1 Q_0)^n$	00	01	11	10
00	0	0	1	1
01	0	0	1	1
11	0	0	1	1
10	0	0	1	1

Q_0^{n+1}

$z^n \text{ (PS)} = ((x_1' + x_2) (x_1 + x_2') Q_0 Q_1)^n$

$Q_1^{n+1} \text{ (PS)} = (Q_0)^n$

$Q_0^{n+1} \text{ (PS)} = (x_2)^n$

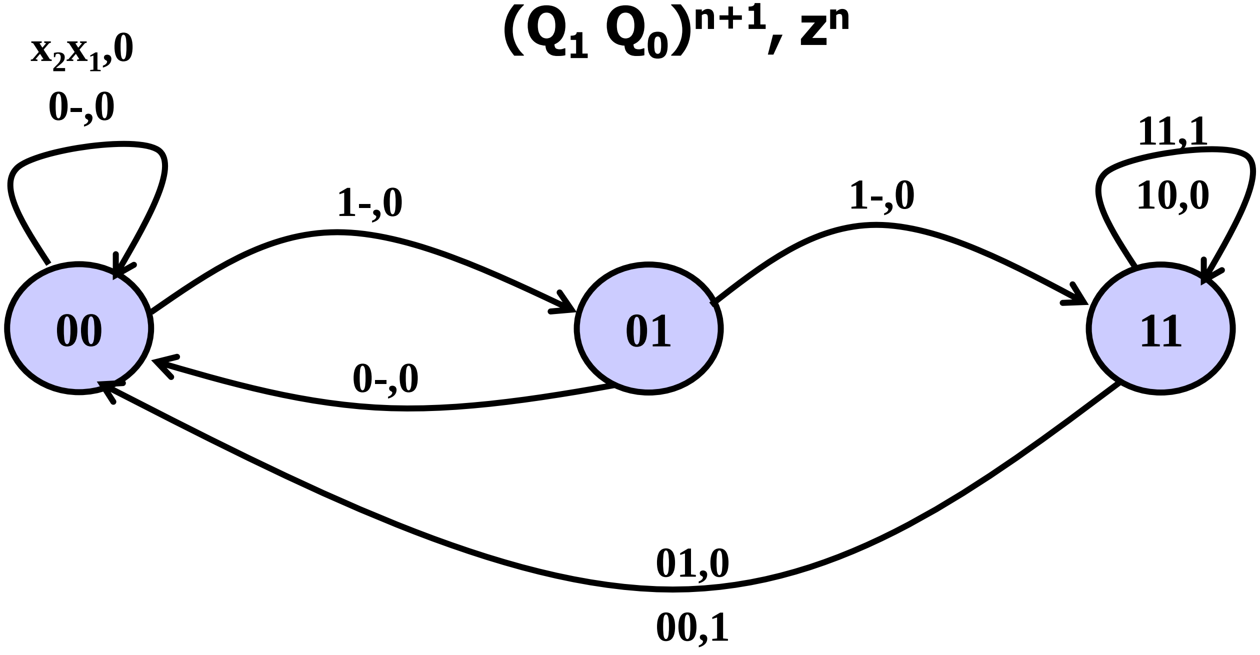
Esercizio 18 – Domande 2, 3, 4, 5

$(x_2\ x_1)^n$

$(Q_1\ Q_0)^n$	00	01	11	10
00	00,0	00,0	01,0	01,0
01	10,0	10,0	11,0	11,0
11	10,1	10,0	11,1	11,0
10	00,0	00,0	01,0	01,0

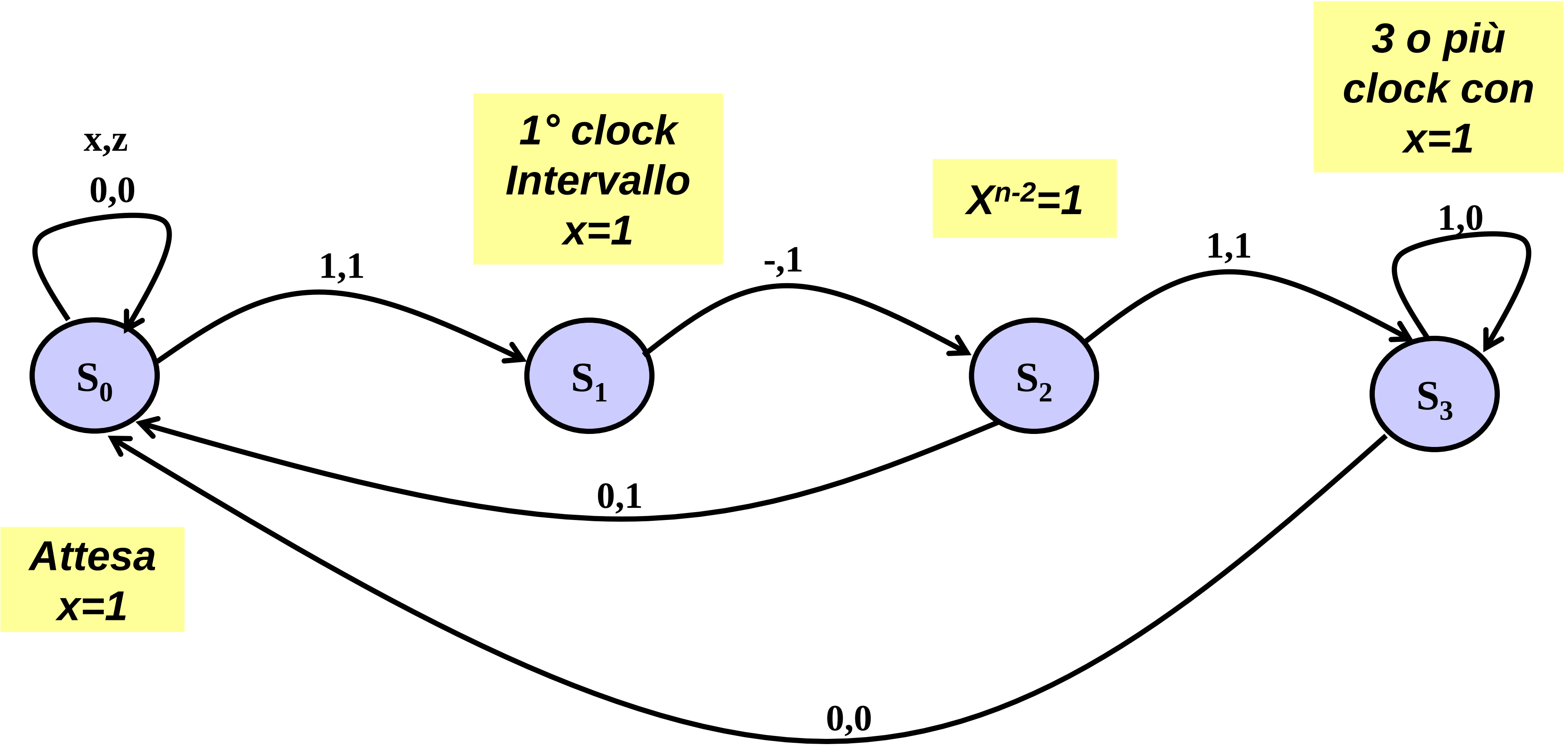
$(Q_1\ Q_0)^{n+1}, z^n$

Stati indistinguibili



Il diagramma è identico a quello ottenuto nell'Esercizio precedente. Conseguentemente, il comportamento della rete da analizzare può essere descritto come segue: dati gli ingressi x_1, x_2 la rete fornisce uscita 1 quando sull'ingresso x_2 si presenta la sequenza "11x_1".

Esercizio 19 – Domanda 1



1° clock Intervallo x=1

X^{n-2}=1

3 o più clock con x=1

Attesa x=1

Esercizio 19 – Domanda 2

x^n

s.p.

	0	1
S_0	S_0,0	S_1,1
S_1	S_2,1	S_2,1
S_2	S_0,1	S_3,1
S_3	S_0,0	S_3,0

s.f., z^n

x^n

$(Q_1\ Q_0)^n$

	0	1
S_0=00	00,0	01,1
S_1=01	10,1	10,1
S_2=10	00,1	11,1
S_3=11	00,0	11,0

$(Q_1\ Q_0)^{n+1}$, z^n

Esercizio 19 – Domanda 3

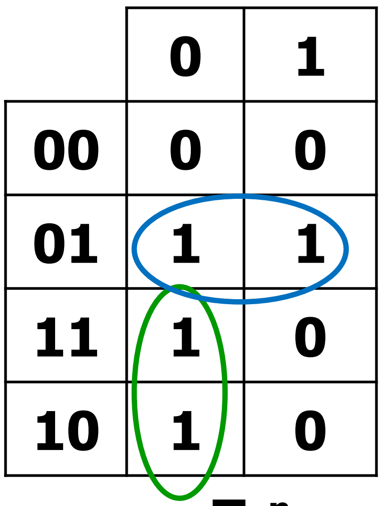
x^n

$(Q_1Q_0)^n$

	0	1
00	0	0
01	1	1
11	0	1
10	0	1

Q_1^{n+1}

x^n

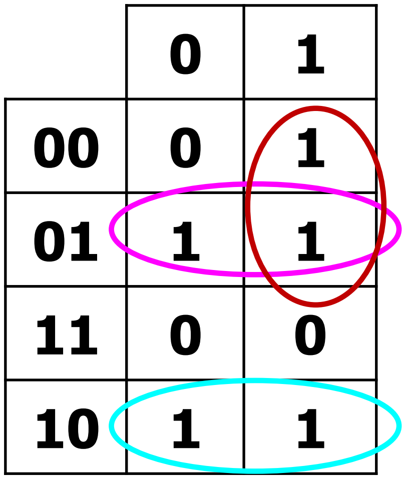


	0	1
00	0	0
01	1	1
11	1	0
10	1	0

T_1^n

$(x\ y)^n$

$(Q_1\ Q_0)^n$



	0	1
00	0	1
01	1	1
11	0	0
10	1	1

z^n

T_1 (SP) = $Q_1' Q_0 + x' Q_1$

T_0 (SP) = $Q_1' Q_0 + Q_0' x + x' Q_0$

z (SP) = $Q_1' Q_0 + x Q_1' + Q_1 Q_0'$

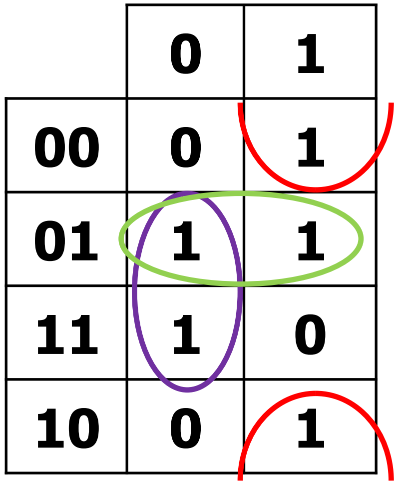
x^n

$(Q_1Q_0)^n$

	0	1
00	0	1
01	0	0
11	0	1
10	0	1

Q_0^{n+1}

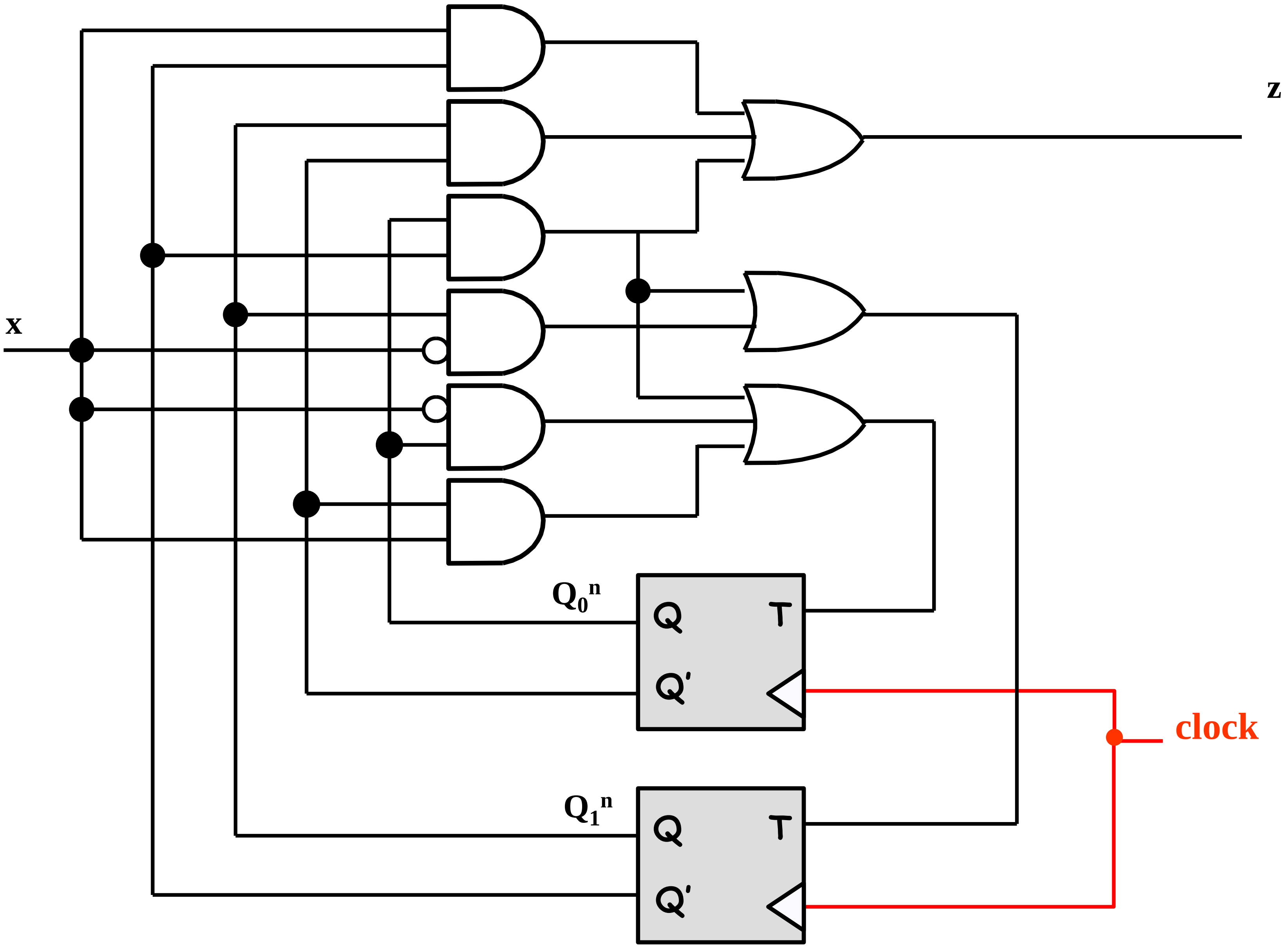
x^n



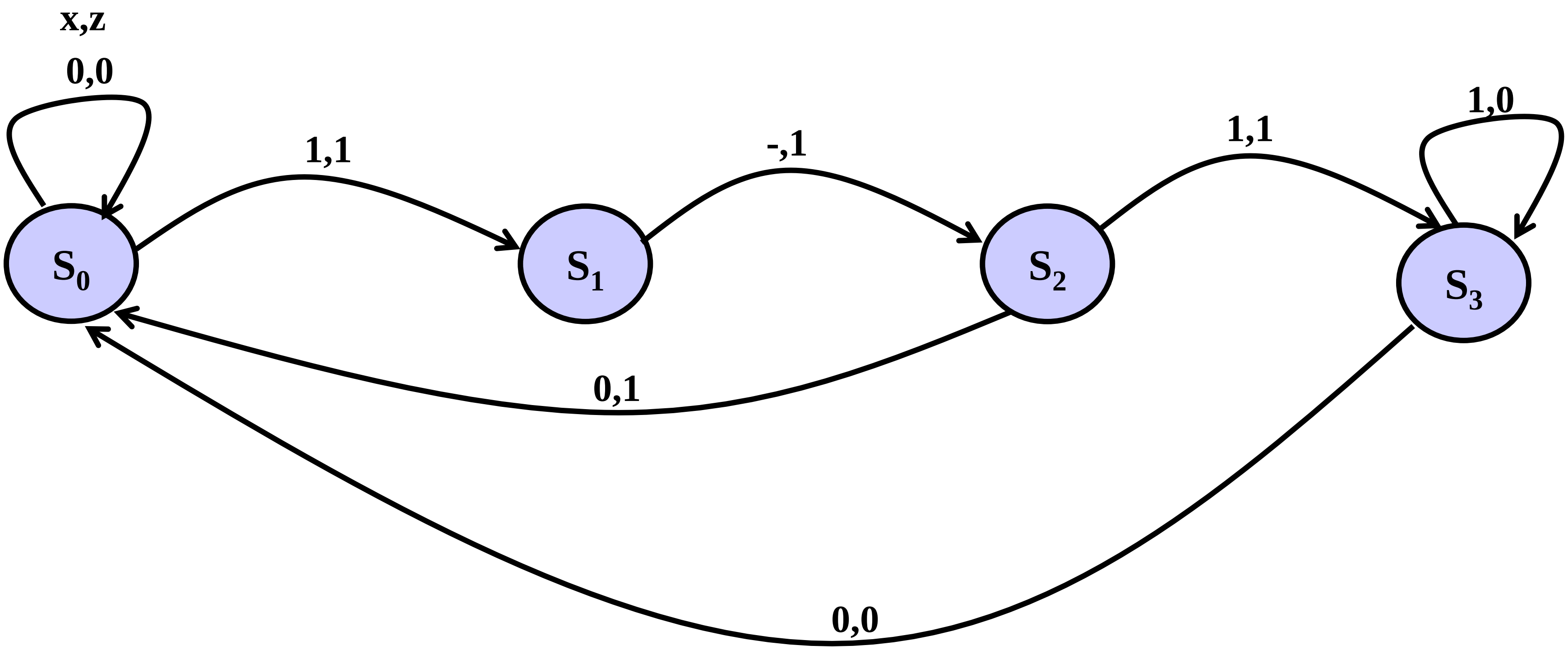
	0	1
00	0	1
01	1	1
11	1	0
10	0	1

T_0^n

Esercizio 19 – Domanda 4



Esercizio 19 – Domanda 5



Poiché la rete ha *4* stati è opportuno utilizzare un contatore binario per 4 (quindi *n*=*4*). Si codificano poi lo stato S_0 con la configurazione binaria 00 perché S_0 deve essere raggiungibile da tutti gli altri stati e deve quindi corrispondere allo stato in cui porta il RESET. Gli altri stati devono essere visitati a partire da S_0 nell'ordine S_1, S_2, S_3 e devono quindi essere rispettivamente codificati con 01,10, 11. La codifica risulta la stessa adottata in precedenza.

Esercizio 19 – Domanda 6

Per effettuare la transizione di stato richiesta, il contatore deve

- **Resettarsi (RES = 1, EN = -)**
- **Contare (RES = 0, EN = 1)**
- **Mantenere lo stato (RES = 0, EN = 0)**

Da 00 posso andare in 00 o mantenendo lo stato del contatore o resettandolo

x^n

$(Q_1Q_0)^n$

	0	1
00	00/00	01
01	10	10
11	00/00	11
10	00	11

$(Q_1Q_0)^{n+1}$

Da 11 posso andare in 00 o contando o resettando il contatore

x^n

$(Q_1Q_0)^n$

	0	1
00	0/-	1
01	1	1
11	1/-	0
10	-	1

EN^n

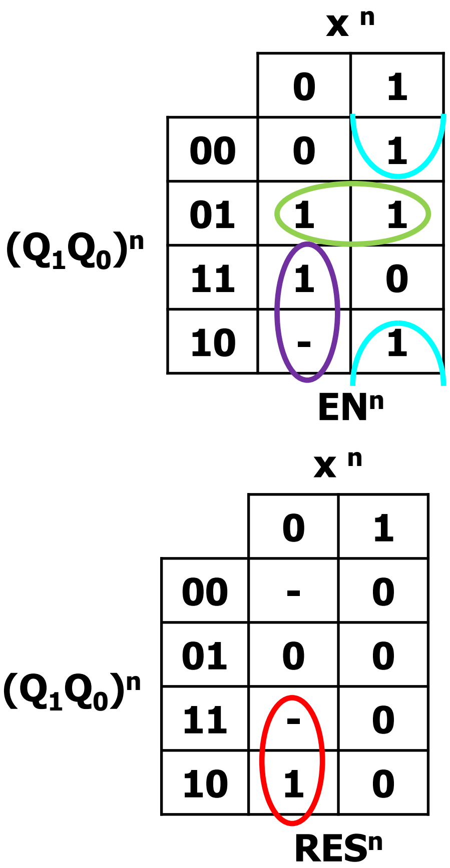
x^n

$(Q_1Q_0)^n$

	0	1
00	-/1	0
01	0	0
11	-/1	0
10	1	0

RES^n

Esercizio 19 – Domanda 7



x^n

$(Q_1Q_0)^n$	0	1
00	0	1
01	1	1
11	1	0
10	-	1

EN^n

x^n

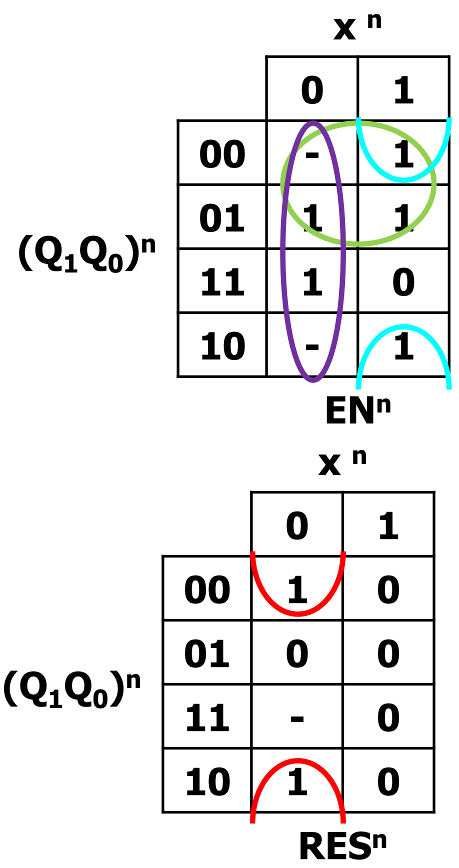
$(Q_1Q_0)^n$	0	1
00	-	0
01	0	0
11	-	0
10	1	0

RES^n

EN (SP) = $Q_1' Q_0 + Q_0' x + Q_1 x'$

RES (SP) = $Q_1 x'$

1 OR 3 ing.
4 AND 2 ing.



x^n

$(Q_1Q_0)^n$	0	1
00	-	1
01	1	1
11	1	0
10	-	1

EN^n

x^n

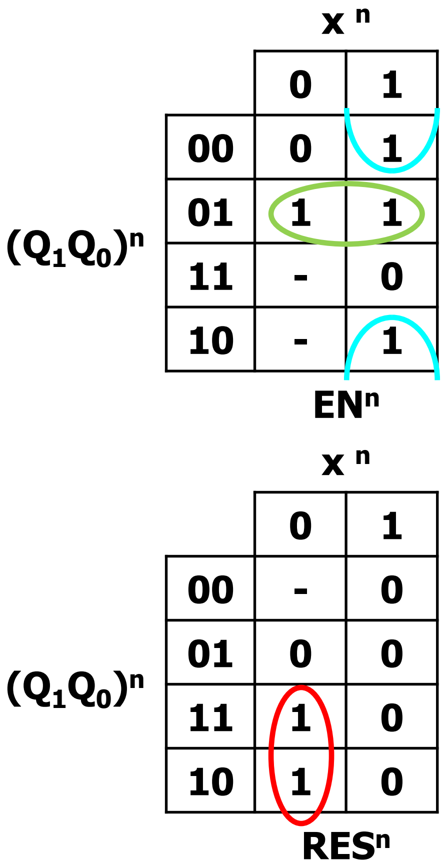
$(Q_1Q_0)^n$	0	1
00	1	0
01	0	0
11	-	0
10	1	0

RES^n

EN (SP) = $Q_1' + Q_0' x + x'$

RES (SP) = $Q_0' x'$

1 OR 3 ing.
2 AND 2 ing.



x^n

$(Q_1Q_0)^n$	0	1
00	0	1
01	1	1
11	-	0
10	-	1

EN^n

x^n

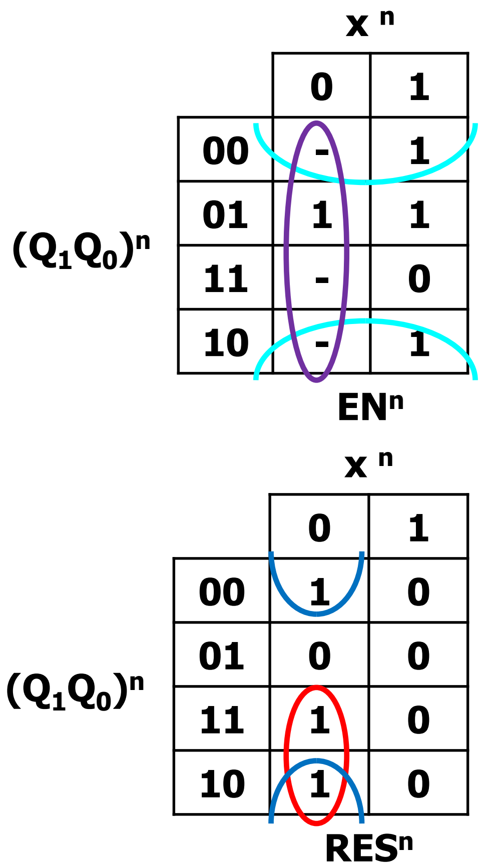
$(Q_1Q_0)^n$	0	1
00	-	0
01	0	0
11	1	0
10	1	0

RES^n

EN (SP) = $Q_1' Q_0 + Q_0' x$

RES (SP) = $Q_1 x'$

1 OR 2 ing.
3 AND 2 ing.



x^n

$(Q_1Q_0)^n$	0	1
00	-	1
01	1	1
11	-	0
10	-	1

EN^n

x^n

$(Q_1Q_0)^n$	0	1
00	1	0
01	0	0
11	1	0
10	1	0

RES^n

EN (SP) = $x' + Q_0'$

RES (SP) = $Q_1 x' + Q_0' x'$

2 OR 2 ing.
2 AND 2 ing.

Esercizio 19 – Domanda 8