Riprogettiamo il contatore per 2,3 o 4 (macchina M_1)
Con la sintesi vincolata (JK etc.):

$x_1x_0Q_1Q_0$	$Q'_1Q'_0$	$Q_1\to Q'_1$	$Q_0\to Q'_0$	J_1	K_1	J_0	K_0	T_1	T_0	D_1	D_0	S_1	R_1	S_0	R_0
0000	01	HvR	TvS	0	X	1	X	0	1	0	1	0	X	1	0
0001	00	HvR	TvR	0	X	X	1	0	1	0	0	0	X	0	1
0010	01	TvR	TvS	X	1	1	X	1	1	0	1	0	1	1	0
0011	00	TvR	TvR	X	1	X	1	1	1	0	0	0	1	0	1
0100	01	HvR	TvS	0	X	1	X	0	1	0	1	0	X	1	0
0101	00	HvR	TvR	0	X	X	1	0	1	0	0	0	X	0	1
0110	01	TvR	TvS	X	1	1	X	1	1	0	1	0	1	1	0
0111	00	TvR	TvR	X	1	X	1	1	1	0	0	0	1	0	1
1000	01	HvR	TvS	0	X	1	X	0	1	0	1	0	X	1	0
1001	10	TvS	TvR	1	X	X	1	1	1	1	0	1	0	0	1
1010	00	TvR	HvR	X	1	0	X	1	0	0	0	0	1	0	X
1011	00	TvR	TvR	X	1	X	1	1	1	0	0	0	1	0	1
1100	01	HvR	TvS	0	X	1	X	0	1	0	1	0	X	1	0
1101	10	TvS	TvR	1	X	X	1	1	1	1	0	1	0	0	1
1110	11	HvS	TvS	X	0	1	X	0	1	1	1	X	0	1	0
1111	00	TvR	TvR	X	1	X	1	1	1	0	0	0	1	0	1

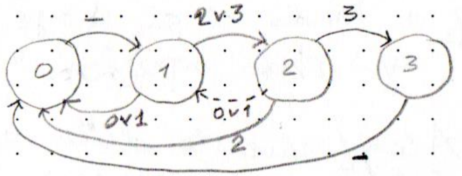
FF T: T or H only
FF D: S or R only

JK	Q'	op.
00	Q	H
01	0	R
10	1	S
11	$\overline{Q}$	T

Q→Q'	JK
HvR	0 X
HvS	X 0
TvR	X 1
TvS	1 X

SR	Q'	op.
00	Q	H
01	0	R
10	1	S
11	–	–

Q→Q'	SR
H vR	0X
HvS	X0
R	01
S	10



$x_1x_0 \backslash Q_1Q_0$	00	01	11	10
00	0	0	X	X
01	0	0	X	X
11	0	1	X	X
10	0	1	X	X

$J_1 = x_1 Q_0$

$x_1x_0 \backslash Q_1Q_0$	00	01	11	10
00	1	X	X	1
01	1	X	X	1
11	1	X	X	1
10	1	X	X	0

$J_0 = \overline{Q}_1 + \overline{x}_1 + x_0$

$x_1x_0 \backslash Q_1Q_0$	00	01	11	10
00	0	0	1	1
01	0	0	1	1
11	0	1	1	0
10	0	1	1	1

$T_1 = \overline{x}_1 Q_1 + x_1 Q_0 + \overline{x}_0 Q_1$

$x_1x_0 \backslash Q_1Q_0$	00	01	11	10
00	X	X	1	1
01	X	X	1	1
11	X	X	1	0
10	X	X	1	1

$K_1 = \overline{x}_1 + Q_0 + x_1\overline{x}_0 = \overline{x}_1 + \overline{x}_0 + Q_0$

$x_1x_0 \backslash Q_1Q_0$	00	01	11	10
00	X	1	1	X
01	X	1	1	X
11	X	1	1	X
10	X	1	1	X

$K_0 = 1$

$x_1x_0 \backslash Q_1Q_0$	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	1	1	1	1
10	1	1	1	0

$T_0 = \overline{x}_1 + \overline{Q}_1 + Q_0$

$x_1x_0 \backslash Q_1Q_0$	00	01	11	10
00	0	0	0	0
01	0	0	0	0
11	0	1	0	1
10	0	1	0	0

$D_1 = x_1\overline{Q}_1Q_0 + x_1x_0Q_1\overline{Q}_0$

$x_1x_0 \backslash Q_1Q_0$	00	01	11	10
00	0	0	0	0
01	0	0	0	0
11	0	1	0	X
10	0	1	0	0

$S_1 = x_1\overline{Q}_1Q_0$

$x_1x_0 \backslash Q_1Q_0$	00	01	11	10
00	1	0	0	1
01	1	0	0	1
11	1	0	0	1
10	1	0	0	0

$S_0 = D_0$ (vedi sotto)

$x_1x_0 \backslash Q_1Q_0$	00	01	11	10
00	1	0	0	1
01	1	0	0	1
11	1	0	0	1
10	1	0	0	0

$D_0 = \overline{Q}_1\overline{Q}_0 + \overline{x}_1\overline{Q}_0 + x_0\overline{Q}_0$

$x_1x_0 \backslash Q_1Q_0$	00	01	11	10
00	X	X	1	1
01	X	X	1	1
11	X	0	1	0
10	X	0	1	1

$R_1 = \overline{x}_1 + Q_1Q_0 + x_1\overline{x}_0Q_1$

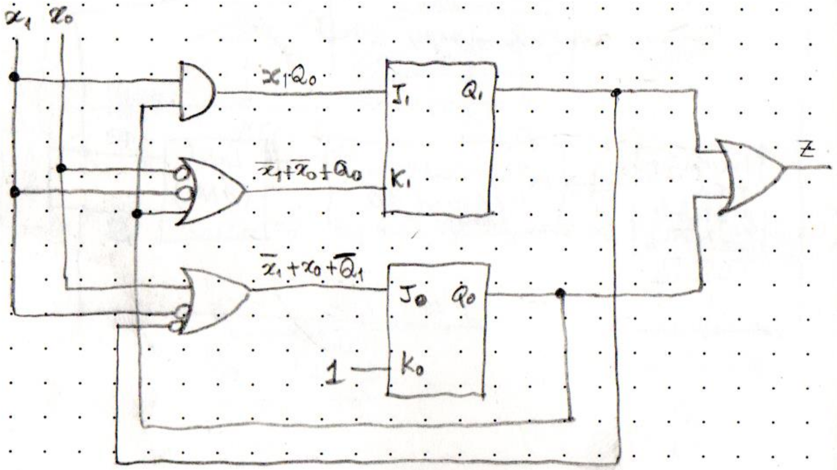
$x_1x_0 \backslash Q_1Q_0$	00	01	11	10
00	0	1	1	0
01	0	1	1	0
11	0	1	1	0
10	0	1	1	X

$R_0 = Q_0$

per lez. 21/10/22

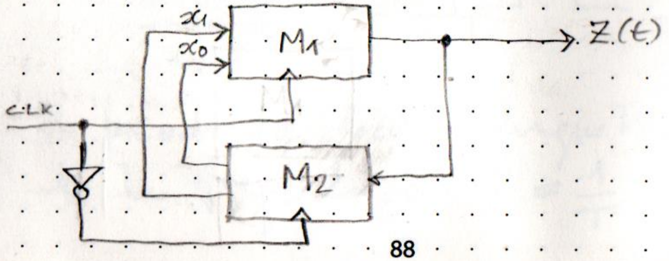
Nuova soluzione del problema del compito 11/2/22

Data la macchina M_1 (progetto a p. 98)



costruire una macchina A QUATTRO STATI M_2 che consenta al complesso delle due macchine, accoppiate attraverso i loro ingressi e uscite, a generare l'uscita periodica (di periodo 9)

$$Z(t) = \ldots 110111010\ldots$$

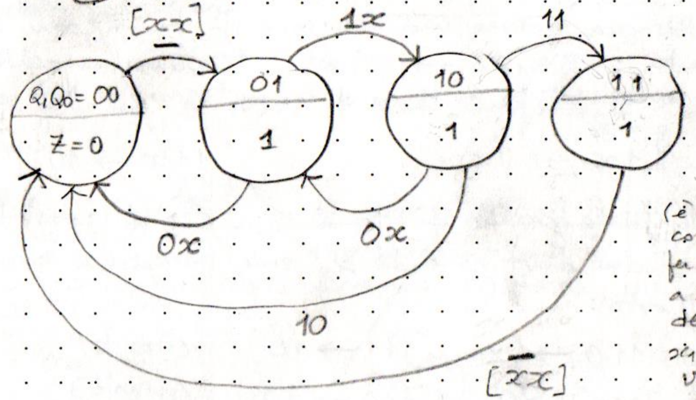


Dall'analisi di M_1 si ricava (cfr. p. 97 e p. 98)

$$\begin{cases} Q_1' = x_1\bar{Q}_1Q_0 + x_1x_0Q_1\bar{Q}_0 \\ Q_0' = \bar{x}_1\bar{Q}_0 + x_0\bar{Q}_0 + \bar{Q}_1\bar{Q}_0 \\ Z = Q_1 + Q_0 \end{cases}$$

se $Q_1Q_0=10 \Rightarrow Q_1'=x_1x_0$, $Q_0'=x_0$

Diagramma degli stati =



(è un contatore per 2, 3 o 4, a seconda dell'ingresso x_1x_0, che va tenuto fisso)

Sequenza da progettare =

	t	0	1	2	3	4	5	6	7	8	9
	Z	0	1	0	1	1	1	0	1	1	0
	Q_1	0	0	0	0	1	{01}	0	0	1	0
	Q_0	0	1	0	1	0	{11}	0	1	0	0
	x_1	x	0	x	1	{01}	{0x}	x	1	1	
	x_0	x	x	x	x	{x1}	{xx}	x	x	0	
caso "3" Sol A	x_1			//		0	0		//		
	x_0					x	x				
Sol B	x_1			//		1	x		//		
caso "4"	x_0					1	x				

N.B. L'uscita Z=0 si può avere solo con $Q_1Q_0=00$, cui deve obbligatoriamente seguire $Q_1Q_0=01$.
Partendo da quest'ultimo stato, l'unico modo per ottenere Z=1 è saltare in $Q_1Q_0=10$. Invece, partendo da 10 si ottiene 1 sia saltando in 01 che in 11 (t=5).

Vediamo ora una delle possibili soluz. B (caso "3")

t	$z\ x_1\ x_0$	$x_1'\ x_0'$
t_0	0 1 0	$\varepsilon_1\ \varepsilon_2$
t_1	1 $\varepsilon_1\ \varepsilon_2$	0 ε_3
t_2	0 0 ε_3	$\varepsilon_4\ \varepsilon_5$
t_3	1 $\varepsilon_4\ \varepsilon_5$	1 ε_6
t_4	1 1 ε_6	1 1
t_5	1 1 1	$\varepsilon_7\ \varepsilon_8$
t_6	0 $\varepsilon_7\ \varepsilon_8$	$\varepsilon_9\ \varepsilon_{10}$
t_7	1 $\varepsilon_9\ \varepsilon_{10}$	1 ε_{11}
t_8	1 1 ε_{11}	1 0

"metodo del Sudoku"

— $t_4 \& t_8$: $\varepsilon_6 \neq \varepsilon_{11}$

(a) $\varepsilon_6 = 0$, $\varepsilon_{11} = 1$ $\overset{t_5}{\Longrightarrow}$ $\varepsilon_7 = 1$, $\varepsilon_8 = 0$ $\overset{t_6 \& t_0}{\Longrightarrow}$ $\varepsilon_1 = \varepsilon_9$, $\varepsilon_2 = \varepsilon_{10}$ $\Downarrow$ incompatibile con $t_1 \& t_7$ (vedi tabella)

(b) $\varepsilon_6 = 1$; $\varepsilon_{11} = 0$ $\overset{t_5}{\Longrightarrow}$ $\varepsilon_7 = 1$, $\varepsilon_8 = 1$

$t_1 \& t_3 \& t_7$

— $(\varepsilon_1, \varepsilon_2) \neq (\varepsilon_4, \varepsilon_5) \neq (\varepsilon_9, \varepsilon_{10})$

$\neq$

Vediamo il caso (a):

t	$z\ x_1\ x_0$	$x_1'\ x_0'$	
t_0	0 1 0	$\varepsilon_1\ \varepsilon_2$	
t_1	1 $\varepsilon_1\ \varepsilon_2$	0 ε_3	
t_2	0 0 ε_3	$\varepsilon_4\ \varepsilon_5$	$(\varepsilon_4, \varepsilon_5) \neq (\varepsilon_1, \varepsilon_2)$
t_3	1 $\varepsilon_4\ \varepsilon_5$	1 0	
t_4	1 1 0	1 1	
t_5	1 1 1	1 0	
t_6	0 1 0	$\varepsilon_1\ \varepsilon_2$	
t_7	1 $\varepsilon_1\ \varepsilon_2$	1 1	
t_8	1 1 1	1 0	

Caso (b):

t	$z\ x_1\ x_0$	$x_1'\ x_0'$
t_0	0 1 0	$\varepsilon_1\ \varepsilon_2$
t_1	1 $\varepsilon_1\ \varepsilon_2$	0 ε_3
t_2	0 0 ε_3	$\varepsilon_4\ \varepsilon_5$
t_3	1 $\varepsilon_4\ \varepsilon_5$	1 1
t_4	1 1 1	1 1
t_5	1 1 1	1 1
t_6	0 1 1	$\varepsilon_9\ \varepsilon_{10}$
t_7	1 $\varepsilon_9\ \varepsilon_{10}$	1 0
t_8	1 1 0	1 0

$\overset{t_1 \&}{t_3}$ $(\neq \varepsilon_1\ \varepsilon_2)$ e $\overset{t_7}{(\neq \varepsilon_9\ \varepsilon_{10})}$

$\overset{t_4}{\Longrightarrow}$ $(\varepsilon_4\ \varepsilon_5)$ può essere $(1, 1)$

$\overset{t_4}{\Longrightarrow}$ $(\varepsilon_9, \varepsilon_{10}) \neq (1, 1)$ e $\neq (\varepsilon_1, \varepsilon_2)$

Si può scegliere $\varepsilon_4 = \varepsilon_5 = 1$
$\varepsilon_9 = 1$, $\varepsilon_{10} = 0$
$\varepsilon_1 = 0$, $\varepsilon_2 = 1$ (opp. $\varepsilon_2 = 0$)

$\varepsilon_2 = 0$

$z\ x_1\ x_0$	$x_1'\ x_0'$
0 0 0 (ε_3)	1 1
0 0 1	X X
0 1 0	0 0
0 1 1	1 0
1 0 0	0 $\varepsilon_3 = 0$
1 0 1	X X
1 1 0	1 0
1 1 1	1 1

$\varepsilon_2 = 1$

$z\ x_1\ x_0$	$x_1'\ x_0'$
0 0 0 (ε_3)	1 1
0 0 1	X X
0 1 0	0 1
0 1 1	1 0
1 0 0	X X
1 0 1	0 $\varepsilon_3 = 0$
1 1 0	1 0
1 1 1	1 1

$z\ x_1\ x_0$	$x_1'\ x_0'$
0 0 0	X X
0 0 1 (ε_3)	1 1
0 1 0	0 0
0 1 1	1 0
1 0 0	0 $\varepsilon_3 = 1$
1 0 1	X X
1 1 0	1 0
1 1 1	1 1

$z\ x_1\ x_0$	$x_1'\ x_0'$
0 0 0	X X
0 0 1 (ε_3)	1 1
0 1 0	0 1
0 1 1	1 0
1 0 0	X X
1 0 1	0 $\varepsilon_3 = 1$
1 1 0	1 0
1 1 1	1 1

questa è la tabella di pag. 6 della soluz. del compito 11/2/2022

Karnaugh per la 4ª tabella:

$z \backslash x_1x_0$	00	01	11	10
0	X	1	1	0
1	X	0	1	1

$x_1' = \bar{z}x_0 + z\cdot x_1$

$\bar{z} \backslash x_1x_0$	00	01	11	10
0	X → 1	1	0	1
1	X → 0	1	1	0

$x_0' = \bar{x}_1 + \bar{z}\cdot\bar{x}_0 + z\cdot x_0$

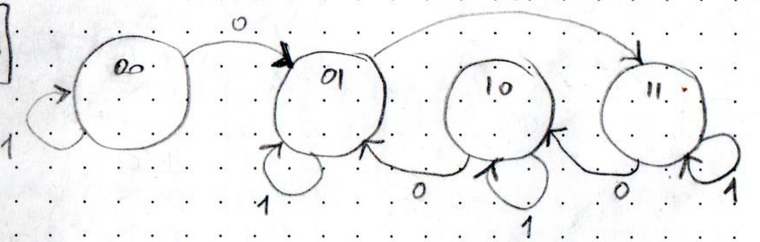
oppure

$\bar{x}_1 x_0 + \underbrace{\bar{z}\bar{x}_0 + z x_0}_{\overline{z \oplus x_0}}$

con i don't care usati nella sol. dell'es. dell' 11/2/22

$z\,x_1\,x_0$	$x_1'\,x_0'$	
0 0 0	X X	0 1
0 0 1	1 1	
0 1 0	0 1	
0 1 1	1 0	
1 0 0	X X	0 0
1 0 1	0 1	
1 1 0	1 0	
1 1 1	1 1	

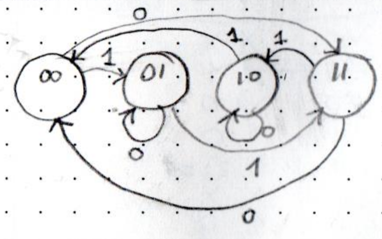
M2 sol. B



Quindi $z=1$ fa hold, e $z=0$ fa ciclare (0) 1 3 2 1 3 2 1 3 2 ,.....

M2 Sol. A

$z\,x_1\,x_0$	$x_1'\,x_0'$
0 0 0	1 1
0 0 1	0 1
0 1 0	1 0
0 1 1	$X^{(0)}\,X^{(0)}$
1 0 0	0 1
1 0 1	1 1
1 1 0	0 0
1 1 1	1 0



Evoluzione

[M1 inizializzato a 00, M2 a 10]

	B: Q_1	Q_0	Z	x_1	x_0	x_1'	x_0'	Q_1'	Q_0'	A: Q_1	Q_0	Z	x_1	x_0	x_1'	x_0'	Q_1'	Q_0'
	1	0	1	1	0					0	1	1	0	0				
t_0	0	0	0			0	1			0	0	0			1	1		
				0	1			0	1				1	1			0	1
t_1	0	1	1			0	1			0	1	1			1	0		
				0	1			0	0				1	0			1	0
t_2	0	0	0			1	1			1	0	1			0	0		
				1	1			0	1				0	0			0	1
t_3	0	1	1			1	1			0	1	1			0	1		
				1	1			1	0				0	1			0	0
t_4	1	0	1			1	1			0	0	0			0	1		
				1	1			1	1				0	1			0	1
t_5	1	1	1			1	1			0	1	1			1	1		
				1	1			0	0				1	1			1	0
t_6	0	0	0			1	0			1	0	1			1	0		
				1	0			0	1				1	0			0	0
t_7	0	1	1			1	0			0	0	0			1	0		
				1	0			1	0				1	0			0	1
t_8	1	0	1			1	0			0	1	1			0	0		
				1	0			0	0				0	0			0	0
(RIP)	0	0	0			0	1			0	0	0			1	1		
				0	1			0	1				1	1				