Brojači i konačni automati

Vežba 4

Zadatak 1.

Koristeći potreban broj JK-flipflopova i dodatnih logičkih kola, realizovati sinhroni brojač unazad modula 5.

Rešenje:

Brojač modula 5 → {0,1,2,3,4} → potrebno minimalno 3 bita za kodovanje navedenih 5 stanja.

Koraci u projektovanju sinhronog (paralelnog) brojača:

- Određivanje potrebnog broja flipflopova
- Kreiranje tabele stanja/prelaza (Q_i, FF, Q'_i):
    1. Popunjavanje stanja Q_i (sve moguće kombinacije)
    2. Popunjavanje narednih stanja Q'_i
    3. Popunjavanje pobude flipflopova na osnovu eksitacione tabele
- Određivanje kombinacione mreže za pobudu flipflopova
- Realizacija mreže

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0									
1	0	0	1									
2	0	1	0									
3	0	1	1									
4	1	0	0									

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0							1	0	0
1	0	0	1							0	0	0
2	0	1	0							0	0	1
3	0	1	1							0	1	0
4	1	0	0							0	1	1

Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0							1	0	0
1	0	0	1							0	0	0
2	0	1	0							0	0	1
3	0	1	1							0	1	0
4	1	0	0							0	1	1

Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X					1	0	0
1	0	0	1							0	0	0
2	0	1	0							0	0	1
3	0	1	1							0	1	0
4	1	0	0							0	1	1

Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X					1	0	0
1	0	0	1							0	0	0
2	0	1	0							0	0	1
3	0	1	1							0	1	0
4	1	0	0							0	1	1

Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X			1	0	0
1	0	0	1							0	0	0
2	0	1	0							0	0	1
3	0	1	1							0	1	0
4	1	0	0							0	1	1

Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X			1	0	0
1	0	0	1							0	0	0
2	0	1	0							0	0	1
3	0	1	1							0	1	0
4	1	0	0							0	1	1

Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X	0	X	1	0	0
1	0	0	1							0	0	0
2	0	1	0							0	0	1
3	0	1	1							0	1	0
4	1	0	0							0	1	1

Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X	0	X	1	0	0
1	0	0	1	0	X	0	X	X	1	0	0	0
2	0	1	0	0	X	X	1	1	X	0	0	1
3	0	1	1	0	X	X	0	X	1	0	1	0
4	1	0	0	X	1	1	X	1	X	0	1	1

Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X	0	X	1	0	0
1	0	0	1	0	X	0	X	X	1	0	0	0
2	0	1	0	0	X	X	1	1	X	0	0	1
3	0	1	1	0	X	X	0	X	1	0	1	0
4	1	0	0	X	1	1	X	1	X	0	1	1

$J_2 = ?$

Q_1Q_0 / Q_2	00	01	11	10
0	1	0	0	0
1	X	X	X	X

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X	0	X	1	0	0
1	0	0	1	0	X	0	X	X	1	0	0	0
2	0	1	0	0	X	X	1	1	X	0	0	1
3	0	1	1	0	X	X	0	X	1	0	1	0
4	1	0	0	X	1	1	X	1	X	0	1	1

$J_2 = \overline{Q_0}\ \overline{Q_1}$

Q_1Q_0 / Q_2	00	01	11	10
0	1	0	0	0
1	X	X	X	X

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X	0	X	1	0	0
1	0	0	1	0	X	0	X	X	1	0	0	0
2	0	1	0	0	X	X	1	1	X	0	0	1
3	0	1	1	0	X	X	0	X	1	0	1	0
4	1	0	0	X	1	1	X	1	X	0	1	1

$J_2=\overline{Q_0}\ \overline{Q_1}$, $K_2=?$

Q_1Q_0 / Q_2	00	01	11	10
0	X	X	X	X
1	1	X	X	X

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X	0	X	1	0	0
1	0	0	1	0	X	0	X	X	1	0	0	0
2	0	1	0	0	X	X	1	1	X	0	0	1
3	0	1	1	0	X	X	0	X	1	0	1	0
4	1	0	0	X	1	1	X	1	X	0	1	1

$J_2=\overline{Q_0}\ \overline{Q_1}$, $K_2=1$

Q_1Q_0 / Q_2	00	01	11	10
0	X	X	X	X
1	1	X	X	X

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X	0	X	1	0	0
1	0	0	1	0	X	0	X	X	1	0	0	0
2	0	1	0	0	X	X	1	1	X	0	0	1
3	0	1	1	0	X	X	0	X	1	0	1	0
4	1	0	0	X	1	1	X	1	X	0	1	1

$J_2=\overline{Q_0}\,\overline{Q_1}$, $K_2=1$

$J_1=?$

Q_1Q_0 / Q_2	00	01	11	10
0	0	0	X	X
1	1	X	X	X

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X	0	X	1	0	0
1	0	0	1	0	X	0	X	X	1	0	0	0
2	0	1	0	0	X	X	1	1	X	0	0	1
3	0	1	1	0	X	X	0	X	1	0	1	0
4	1	0	0	X	1	1	X	1	X	0	1	1

$J_2=\overline{Q_0}\,\overline{Q_1}$, $K_2=1$

$J_1=Q_2$

Q_1Q_0 / Q_2	00	01	11	10
0	0	0	X	X
1	1	X	X	X

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X	0	X	1	0	0
1	0	0	1	0	X	0	X	X	1	0	0	0
2	0	1	0	0	X	X	1	1	X	0	0	1
3	0	1	1	0	X	X	0	X	1	0	1	0
4	1	0	0	X	1	1	X	1	X	0	1	1

$J_2=\overline{Q_0}\ \overline{Q_1},\ K_2=1$

$J_1=Q_2,\ K_1=?$

Q_1Q_0 / Q_2	00	01	11	10
0	X	X	0	1
1	X	X	X	X

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X	0	X	1	0	0
1	0	0	1	0	X	0	X	X	1	0	0	0
2	0	1	0	0	X	X	1	1	X	0	0	1
3	0	1	1	0	X	X	0	X	1	0	1	0
4	1	0	0	X	1	1	X	1	X	0	1	1

$J_2=\overline{Q_0}\ \overline{Q_1},\ K_2=1$

$J_1=Q_2,\ K_1=\overline{Q_0}$

Q_2 \ Q_1Q_0	00	01	11	10
0	X	X	0	1
1	X	X	X	X

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X	0	X	1	0	0
1	0	0	1	0	X	0	X	X	1	0	0	0
2	0	1	0	0	X	X	1	1	X	0	0	1
3	0	1	1	0	X	X	0	X	1	0	1	0
4	1	0	0	X	1	1	X	1	X	0	1	1

$J_2=\overline{Q_0}\,\overline{Q_1}$, $K_2=1$

$J_1=Q_2$, $K_1=\overline{Q_0}$

$J_0=?$

Q_1Q_0 / Q_2	00	01	11	10
0	0	X	X	1
1	1	X	X	X

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X	0	X	1	0	0
1	0	0	1	0	X	0	X	X	1	0	0	0
2	0	1	0	0	X	X	1	1	X	0	0	1
3	0	1	1	0	X	X	0	X	1	0	1	0
4	1	0	0	X	1	1	X	1	X	0	1	1

$J_2=\overline{Q_0}\,\overline{Q_1},\ K_2=1$

$J_1=Q_2,\ K_1=\overline{Q_0}$

$J_0=Q_2+Q_1$

Q_2 \ Q_1Q_0	00	01	11	10
0	0	X	X	1
1	1	X	X	X

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X	0	X	1	0	0
1	0	0	1	0	X	0	X	X	1	0	0	0
2	0	1	0	0	X	X	1	1	X	0	0	1
3	0	1	1	0	X	X	0	X	1	0	1	0
4	1	0	0	X	1	1	X	1	X	0	1	1

$J_2=\overline{Q_0}\,\overline{Q_1},\ K_2=1$

$J_1=Q_2,\ K_1=\overline{Q_0}$

$J_0=Q_2+Q_1,$ $K_0=?$

Q_2 \ Q_1Q_0	00	01	11	10
0	X	1	1	X
1	X	X	X	X

S	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q'_2	Q'_1	Q'_0
0	0	0	0	1	X	0	X	0	X	1	0	0
1	0	0	1	0	X	0	X	X	1	0	0	0
2	0	1	0	0	X	X	1	1	X	0	0	1
3	0	1	1	0	X	X	0	X	1	0	1	0
4	1	0	0	X	1	1	X	1	X	0	1	1

$J_2=\overline{Q_0}\,\overline{Q_1},\ K_2=1$

$J_1=Q_2,\ K_1=\overline{Q_0}$

$J_0=Q_2+Q_1,\ K_0=1$

Q_2 \ Q_1Q_0	00	01	11	10
0	X	1	1	X
1	X	X	X	X

- Realizacija brojača upotrebom *Logisim*-a, na osnovu izračunatih funkcija pobuda flipflopova:

$$J_2=\overline{Q_0}\,\overline{Q_1},\ K_2=1$$
$$J_1=Q_2,\ K_1=\overline{Q_0}$$
$$J_0=Q_2+Q_1,\ K_0=1$$

Zadatak 2.

Koristeći potreban broj D-flipflopova i dodatnih logičkih kola, realizovati sinhroni brojač unapred modula 10.

Rešenje:

Brojač modula 10→ {0,1,2,…,9} → potrebno minimalno 4 bita za kodovanje navedenih 10 stanja.

S	Q_3	Q_2	Q_1	Q_0	D_3	D_2	D_1	D_0	Q'_3	Q'_2	Q'_1	Q'_0
0	0	0	0	0								
1	0	0	0	1								
2	0	0	1	0								
3	0	0	1	1								
4	0	1	0	0								
5	0	1	0	1								
6	0	1	1	0								
7	0	1	1	1								
8	1	0	0	0								
9	1	0	0	1								

S	Q_3	Q_2	Q_1	Q_0	D_3	D_2	D_1	D_0	Q'_3	Q'_2	Q'_1	Q'_0
0	0	0	0	0					0	0	0	1
1	0	0	0	1					0	0	1	0
2	0	0	1	0					0	0	1	1
3	0	0	1	1					0	1	0	0
4	0	1	0	0					0	1	0	1
5	0	1	0	1					0	1	1	0
6	0	1	1	0					0	1	1	1
7	0	1	1	1					1	0	0	0
8	1	0	0	0					1	0	0	1
9	1	0	0	1					0	0	0	0

Q_n	Q_{n+1}	D
0	0	0
0	1	1
1	0	0
1	1	1

S	Q_3	Q_2	Q_1	Q_0	D_3	D_2	D_1	D_0	Q'_3	Q'_2	Q'_1	Q'_0
0	0	0	0	0					0	0	0	1
1	0	0	0	1					0	0	1	0
2	0	0	1	0					0	0	1	1
3	0	0	1	1					0	1	0	0
4	0	1	0	0					0	1	0	1
5	0	1	0	1					0	1	1	0
6	0	1	1	0					0	1	1	1
7	0	1	1	1					1	0	0	0
8	1	0	0	0					1	0	0	1
9	1	0	0	1					0	0	0	0

Q_n	Q_{n+1}	D
0	0	0
0	1	1
1	0	0
1	1	1

S	Q_3	Q_2	Q_1	Q_0	D_3	D_2	D_1	D_0	Q'_3	Q'_2	Q'_1	Q'_0
0	0	0	0	0					0	0	0	1
1	0	0	0	1					0	0	1	0
2	0	0	1	0					0	0	1	1
3	0	0	1	1					0	1	0	0
4	0	1	0	0					0	1	0	1
5	0	1	0	1					0	1	1	0
6	0	1	1	0					0	1	1	1
7	0	1	1	1					1	0	0	0
8	1	0	0	0					1	0	0	1
9	1	0	0	1					0	0	0	0

Q_n	Q_{n+1}	D
0	0	0
0	1	1
1	0	0
1	1	1

S	Q_3	Q_2	Q_1	Q_0	D_3	D_2	D_1	D_0	Q'_3	Q'_2	Q'_1	Q'_0
0	0	0	0	0	0				0	0	0	1
1	0	0	0	1	0				0	0	1	0
2	0	0	1	0	0				0	0	1	1
3	0	0	1	1	0				0	1	0	0
4	0	1	0	0	0				0	1	0	1
5	0	1	0	1	0				0	1	1	0
6	0	1	1	0	0				0	1	1	1
7	0	1	1	1	1				1	0	0	0
8	1	0	0	0	1				1	0	0	1
9	1	0	0	1	0				0	0	0	0

Q_n	Q_{n+1}	D
0	0	0
0	1	1
1	0	0
1	1	1

S	Q_3	Q_2	Q_1	Q_0	D_3	D_2	D_1	D_0	Q'_3	Q'_2	Q'_1	Q'_0
0	0	0	0	0	0	0	0	1	0	0	0	1
1	0	0	0	1	0	0	1	0	0	0	1	0
2	0	0	1	0	0	0	1	1	0	0	1	1
3	0	0	1	1	0	1	0	0	0	1	0	0
4	0	1	0	0	0	1	0	1	0	1	0	1
5	0	1	0	1	0	1	1	0	0	1	1	0
6	0	1	1	0	0	1	1	1	0	1	1	1
7	0	1	1	1	1	0	0	0	1	0	0	0
8	1	0	0	0	1	0	0	1	1	0	0	1
9	1	0	0	1	0	0	0	0	0	0	0	0

Q_n	Q_{n+1}	D
0	0	0
0	1	1
1	0	0
1	1	1

S	Q_3	Q_2	Q_1	Q_0	D_3	D_2	D_1	D_0	Q'_3	Q'_2	Q'_1	Q'_0
0	0	0	0	0	0	0	0	1	0	0	0	1
1	0	0	0	1	0	0	1	0	0	0	1	0
2	0	0	1	0	0	0	1	1	0	0	1	1
3	0	0	1	1	0	1	0	0	0	1	0	0
4	0	1	0	0	0	1	0	1	0	1	0	1
5	0	1	0	1	0	1	1	0	0	1	1	0
6	0	1	1	0	0	1	1	1	0	1	1	1
7	0	1	1	1	1	0	0	0	1	0	0	0
8	1	0	0	0	1	0	0	1	1	0	0	1
9	1	0	0	1	0	0	0	0	0	0	0	0

$$D_3 = Q_3\overline{Q_0} + Q_2Q_1Q_0$$

Q_3Q_2 \ Q_1Q_0	00	01	11	10
00	0	0	0	0
01	0	0	1	0
11	X	X	X	X
10	1	0	X	X

S	Q_3	Q_2	Q_1	Q_0	D_3	D_2	D_1	D_0	Q'_3	Q'_2	Q'_1	Q'_0
0	0	0	0	0	0	0	0	1	0	0	0	1
1	0	0	0	1	0	0	1	0	0	0	1	0
2	0	0	1	0	0	0	1	1	0	0	1	1
3	0	0	1	1	0	1	0	0	0	1	0	0
4	0	1	0	0	0	1	0	1	0	1	0	1
5	0	1	0	1	0	1	1	0	0	1	1	0
6	0	1	1	0	0	1	1	1	0	1	1	1
7	0	1	1	1	1	0	0	0	1	0	0	0
8	1	0	0	0	1	0	0	1	1	0	0	1
9	1	0	0	1	0	0	0	0	0	0	0	0

$$D_3 = Q_3\overline{Q_0} + Q_2Q_1Q_0$$

$$D_2 = Q_2\overline{Q_0} + Q_2\overline{Q_1} + \overline{Q_2}Q_1Q_0$$

Q_3Q_2 \ Q_1Q_0	00	01	11	10
00	0	0	1	0
01	1	1	0	1
11	X	X	X	X
10	0	0	X	X

S	Q_3	Q_2	Q_1	Q_0	D_3	D_2	D_1	D_0	Q'_3	Q'_2	Q'_1	Q'_0
0	0	0	0	0	0	0	0	1	0	0	0	1
1	0	0	0	1	0	0	1	0	0	0	1	0
2	0	0	1	0	0	0	1	1	0	0	1	1
3	0	0	1	1	0	1	0	0	0	1	0	0
4	0	1	0	0	0	1	0	1	0	1	0	1
5	0	1	0	1	0	1	1	0	0	1	1	0
6	0	1	1	0	0	1	1	1	0	1	1	1
7	0	1	1	1	1	0	0	0	1	0	0	0
8	1	0	0	0	1	0	0	1	1	0	0	1
9	1	0	0	1	0	0	0	0	0	0	0	0

$$D_3 = Q_3\overline{Q_0} + Q_2Q_1Q_0$$

$$D_2 = Q_2\overline{Q_0} + Q_2\overline{Q_1} + \overline{Q_2}Q_1Q_0$$

$$D_1 = \overline{Q_3}\,\overline{Q_1}Q_0 + Q_1\overline{Q_0}$$

Q_3Q_2 \ Q_1Q_0	00	01	11	10
00	0	1	0	1
01	0	1	0	1
11	X	X	X	X
10	0	0	X	X

S	Q_3	Q_2	Q_1	Q_0	D_3	D_2	D_1	D_0	Q'_3	Q'_2	Q'_1	Q'_0
0	0	0	0	0	0	0	0	1	0	0	0	1
1	0	0	0	1	0	0	1	0	0	0	1	0
2	0	0	1	0	0	0	1	1	0	0	1	1
3	0	0	1	1	0	1	0	0	0	1	0	0
4	0	1	0	0	0	1	0	1	0	1	0	1
5	0	1	0	1	0	1	1	0	0	1	1	0
6	0	1	1	0	0	1	1	1	0	1	1	1
7	0	1	1	1	1	0	0	0	1	0	0	0
8	1	0	0	0	1	0	0	1	1	0	0	1
9	1	0	0	1	0	0	0	0	0	0	0	0

$$D_3 = Q_3\overline{Q_0} + Q_2Q_1Q_0$$
$$D_2 = Q_2\overline{Q_0} + Q_2\overline{Q_1} + \overline{Q_2}Q_1Q_0$$
$$D_1 = \overline{Q_3}Q_1Q_0 + Q_1\overline{Q_0}$$
$$D_0 = \overline{Q_0}$$

Q_3Q_2 \ Q_1Q_0	00	01	11	10
00	1	0	0	1
01	1	0	0	1
11	X	X	X	X
10	1	0	X	X

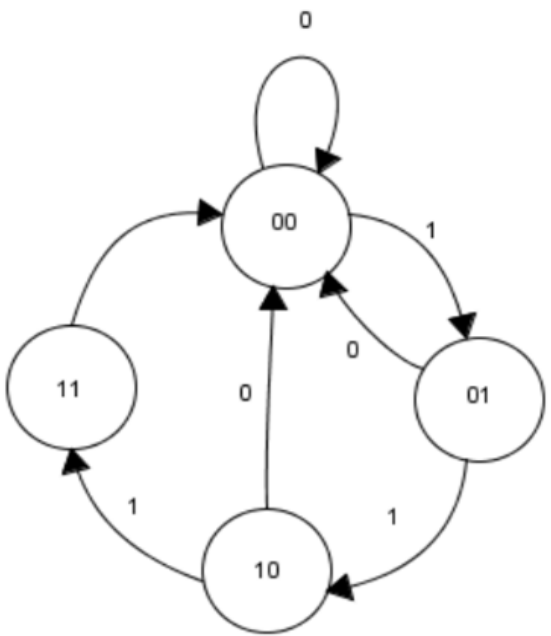
- Realizacija brojača upotrebom *Logisim*-a, na osnovu izračunatih funkcija pobuda flipflopova:

$$D_3 = Q_3\overline{Q_0} + Q_2Q_1Q_0$$
$$D_2 = Q_2\overline{Q_0} + Q_2\overline{Q_1} + \overline{Q_2}Q_1Q_0$$
$$D_1 = \overline{Q_3}\,\overline{Q_1}Q_0 + Q_1\overline{Q_0}$$
$$D_0 = \overline{Q_0}$$

Zadatak 3.

Nacrtati šemu i simulirati rad automata čiji dijagram stanja je prikazan na slici 11.
Pri realizaciji koristiti potrebna logička kola i:

a) JK-flipflopove
b) T-flipflopove
c) D-flipflopove

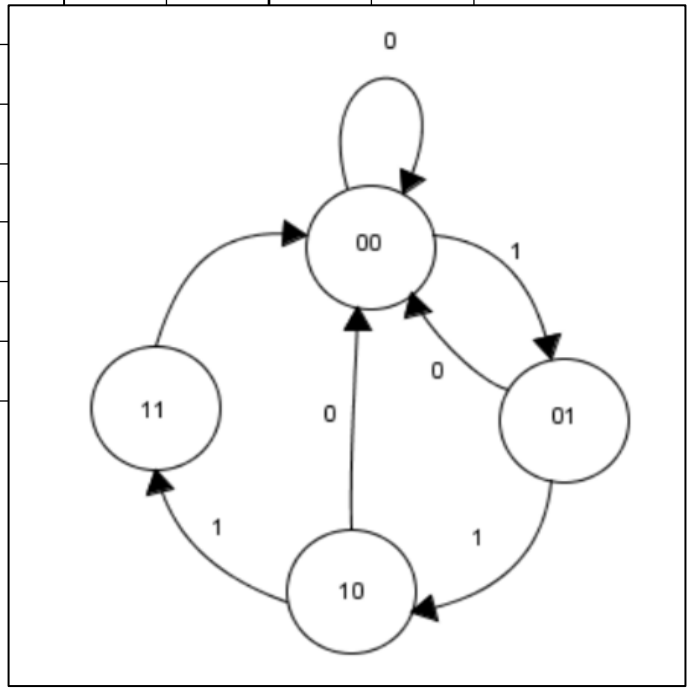


Koraci u projektovanju konačnog automata:

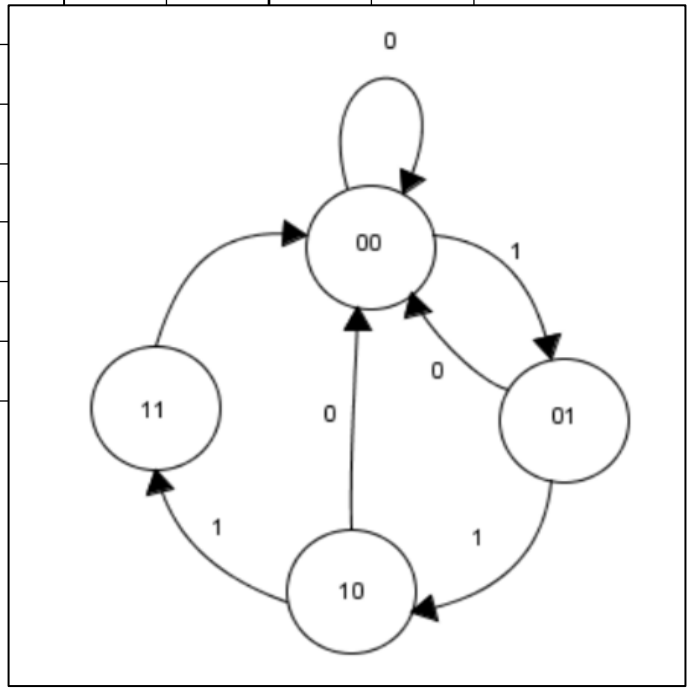
- Određivanje potrebnog broja flipflopova
- Kreiranje tabele prelaza/izlaza na osnovu dijagrama stanja (Q_i, In, FF, Q'_i):
    1. Popunjavanje stanja Q_i i ulaznih signala (sve moguće kombinacije)
    2. Popunjavanje narednih stanja Q'_i
    3. Popunjavanje pobude flipflopova na osnovu eksitacione tabele
- Određivanje kombinacione mreže za pobudu flipflopova
- Realizacija mreže

Trenutno stanje		**Ulazni signal**	**Naredno stanje**		**Pobuda T-FF**		**Pobuda D-FF**		**Pobuda JK-FF**			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0

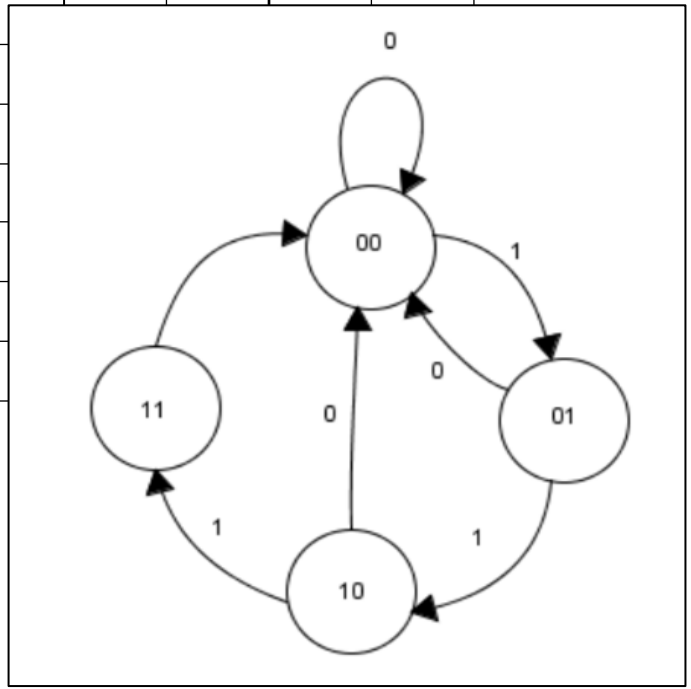
Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0										
0	0	1										
0	1	0										
0	1	1										
1	0	0										
1	0	1										
1	1	0										
1	1	1										



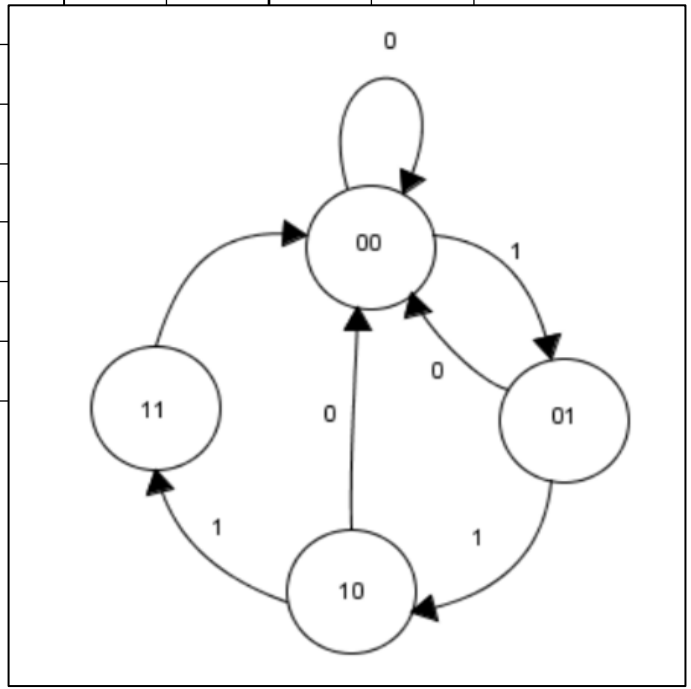
Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0								
0	0	1										
0	1	0										
0	1	1										
1	0	0										
1	0	1										
1	1	0										
1	1	1										



Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0								
0	0	1	0	1								
0	1	0										
0	1	1										
1	0	0										
1	0	1										
1	1	0										
1	1	1										



Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0								
0	0	1	0	1								
0	1	0	0	0								
0	1	1	1	0								
1	0	0	0	0								
1	0	1	1	1								
1	1	0	0	0								
1	1	1	0	0								



Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0								
0	0	1	0	1								
0	1	0	0	0								
0	1	1	1	0								
1	0	0	0	0								
1	0	1	1	1								
1	1	0	0	0								
1	1	1	0	0								

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

Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0						
0	0	1	0	1	0	1						
0	1	0	0	0	0	1						
0	1	1	1	0	1	1						
1	0	0	0	0	1	0						
1	0	1	1	1	0	1						
1	1	0	0	0	1	1						
1	1	1	0	0	1	1						

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

Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0						
0	0	1	0	1	0	1						
0	1	0	0	0	0	1						
0	1	1	1	0	1	1						
1	0	0	0	0	1	0						
1	0	1	1	1	0	1						
1	1	0	0	0	1	1						
1	1	1	0	0	1	1						

Q_n	Q_{n+1}	D
0	0	0
0	1	1
1	0	0
1	1	1

Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0	0	0				
0	0	1	0	1	0	1	0	1				
0	1	0	0	0	0	1	0	0				
0	1	1	1	0	1	1	1	0				
1	0	0	0	0	1	0	0	0				
1	0	1	1	1	0	1	1	1				
1	1	0	0	0	1	1	0	0				
1	1	1	0	0	1	1	0	0				

Q_n	Q_{n+1}	D
0	0	0
0	1	1
1	0	0
1	1	1

Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0	0	0				
0	0	1	0	1	0	1	0	1				
0	1	0	0	0	0	1	0	0				
0	1	1	1	0	1	1	1	0				
1	0	0	0	0	1	0	0	0				
1	0	1	1	1	0	1	1	1				
1	1	0	0	0	1	1	0	0				
1	1	1	0	0	1	1	0	0				

Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0	0	0	0	X	0	X
0	0	1	0	1	0	1	0	1	0	X	1	X
0	1	0	0	0	0	1	0	0	0	X	X	1
0	1	1	1	0	1	1	1	0	1	X	X	1
1	0	0	0	0	1	0	0	0	X	1	0	X
1	0	1	1	1	0	1	1	1	X	0	1	X
1	1	0	0	0	1	1	0	0	X	1	X	1
1	1	1	0	0	1	1	0	0	X	1	X	1

Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0	0	0	0	X	0	X
0	0	1	0	1	0	1	0	1	0	X	1	X
0	1	0	0	0	0	1	0	0	0	X	X	1
0	1	1	1	0	1	1	1	0	1	X	X	1
1	0	0	0	0	1	0	0	0	X	1	0	X
1	0	1	1	1	0	1	1	1	X	0	1	X
1	1	0	0	0	1	1	0	0	X	1	X	1
1	1	1	0	0	1	1	0	0	X	1	X	1

$$T_1 = Q_0R + Q_1\overline{R}$$

Q_0R / Q_1	00	01	11	10
0	0	0	1	0
1	1	0	1	1

Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0	0	0	0	X	0	X
0	0	1	0	1	0	1	0	1	0	X	1	X
0	1	0	0	0	0	1	0	0	0	X	X	1
0	1	1	1	0	1	1	1	0	1	X	X	1
1	0	0	0	0	1	0	0	0	X	1	0	X
1	0	1	1	1	0	1	1	1	X	0	1	X
1	1	0	0	0	1	1	0	0	X	1	X	1
1	1	1	0	0	1	1	0	0	X	1	X	1

$$T_1 = Q_0R + Q_1\overline{R}$$

$$T_0 = R + Q_0$$

Q_0R / Q_1	00	01	11	10
0	0	1	1	1
1	0	1	1	1

Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0	0	0	0	X	0	X
0	0	1	0	1	0	1	0	1	0	X	1	X
0	1	0	0	0	0	1	0	0	0	X	X	1
0	1	1	1	0	1	1	1	0	1	X	X	1
1	0	0	0	0	1	0	0	0	X	1	0	X
1	0	1	1	1	0	1	1	1	X	0	1	X
1	1	0	0	0	1	1	0	0	X	1	X	1
1	1	1	0	0	1	1	0	0	X	1	X	1

$T_1 = Q_0R + Q_1\overline{R}$

$T_0 = R + Q_0$

$D_1 = \overline{Q_1}Q_0R + Q_1\overline{Q_0}R$

Q_1 \ Q_0R	00	01	11	10
0	0	0	[1]	0
1	0	[1]	0	0

Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0	0	0	0	X	0	X
0	0	1	0	1	0	1	0	1	0	X	1	X
0	1	0	0	0	0	1	0	0	0	X	X	1
0	1	1	1	0	1	1	1	0	1	X	X	1
1	0	0	0	0	1	0	0	0	X	1	0	X
1	0	1	1	1	0	1	1	1	X	0	1	X
1	1	0	0	0	1	1	0	0	X	1	X	1
1	1	1	0	0	1	1	0	0	X	1	X	1

$T_1 = Q_0R + Q_1\overline{R}$

$T_0 = R + Q_0$

$D_1 = \overline{Q_1}Q_0R + Q_1\overline{Q_0}R$

$D_0 = \overline{Q_0}R$

Q_0R / Q_1	00	01	11	10
0	0	1	0	0
1	0	1	0	0

Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0	0	0	0	X	0	X
0	0	1	0	1	0	1	0	1	0	X	1	X
0	1	0	0	0	0	1	0	0	0	X	X	1
0	1	1	1	0	1	1	1	0	1	X	X	1
1	0	0	0	0	1	0	0	0	X	1	0	X
1	0	1	1	1	0	1	1	1	X	0	1	X
1	1	0	0	0	1	1	0	0	X	1	X	1
1	1	1	0	0	1	1	0	0	X	1	X	1

$T_1 = Q_0R + Q_1\overline{R}$

$T_0 = R + Q_0$

$D_1 = \overline{Q_1}Q_0R + Q_1\overline{Q_0}R$

$D_0 = \overline{Q_0}R$

$J_1 = Q_0R$

Q_0R / Q_1	00	01	11	10
0	0	0	1	0
1	X	X	X	X

Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0	0	0	0	X	0	X
0	0	1	0	1	0	1	0	1	0	X	1	X
0	1	0	0	0	0	1	0	0	0	X	X	1
0	1	1	1	0	1	1	1	0	1	X	X	1
1	0	0	0	0	1	0	0	0	X	1	0	X
1	0	1	1	1	0	1	1	1	X	0	1	X
1	1	0	0	0	1	1	0	0	X	1	X	1
1	1	1	0	0	1	1	0	0	X	1	X	1

$T_1 = Q_0R + Q_1\overline{R}$

$T_0 = R + Q_0$

$D_1 = \overline{Q_1}Q_0R + Q_1\overline{Q_0}R$

$D_0 = \overline{Q_0}R$

$J_1 = Q_0R$

$K_1 = \overline{R} + Q_0$

Q_0R / Q_1	00	01	11	10
0	X	X	X	X
1	1	0	1	1

Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0	0	0	0	X	0	X
0	0	1	0	1	0	1	0	1	0	X	1	X
0	1	0	0	0	0	1	0	0	0	X	X	1
0	1	1	1	0	1	1	1	0	1	X	X	1
1	0	0	0	0	1	0	0	0	X	1	0	X
1	0	1	1	1	0	1	1	1	X	0	1	X
1	1	0	0	0	1	1	0	0	X	1	X	1
1	1	1	0	0	1	1	0	0	X	1	X	1

$T_1 = Q_0R + Q_1\overline{R}$

$T_0 = R + Q_0$

$D_1 = \overline{Q_1}Q_0R + Q_1\overline{Q_0}R$

$D_0 = \overline{Q_0}R$

$J_1 = Q_0R$

$K_1 = \overline{R} + Q_0$

$J_0 = R$

Q_0R / Q_1	00	01	11	10
0	0	1	X	X
1	0	1	X	X

Trenutno stanje		Ulazni signal	Naredno stanje		Pobuda T-FF		Pobuda D-FF		Pobuda JK-FF			
Q_1	Q_0	R	Q'_1	Q'_0	T_1	T_0	D_1	D_0	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0	0	0	0	X	0	X
0	0	1	0	1	0	1	0	1	0	X	1	X
0	1	0	0	0	0	1	0	0	0	X	X	1
0	1	1	1	0	1	1	1	0	1	X	X	1
1	0	0	0	0	1	0	0	0	X	1	0	X
1	0	1	1	1	0	1	1	1	X	0	1	X
1	1	0	0	0	1	1	0	0	X	1	X	1
1	1	1	0	0	1	1	0	0	X	1	X	1

$T_1 = Q_0R + Q_1\overline{R}$

$T_0 = R + Q_0$

$D_1 = \overline{Q_1}Q_0R + Q_1\overline{Q_0}R$

$D_0 = \overline{Q_0}R$

$J_1 = Q_0R$

$K_1 = \overline{R} + Q_0$

$J_0 = R$

$K_0 = 1$

Q_0R / Q_1	00	01	11	10
0	X	X	1	1
1	X	X	1	1

- Realizacija konačnog automata upotrebom *Logisim*-a, na osnovu izračunatih funkcija pobuda flipflopova:

$$T_1 = Q_0 R + Q_1 \overline{R}$$
$$T_0 = R + Q_0$$
$$D_1 = \overline{Q_1} Q_0 R + Q_1 \overline{Q_0} R$$
$$D_0 = \overline{Q_0} R$$
$$J_1 = Q_0 R$$
$$K_1 = \overline{R} + Q_0$$
$$J_0 = R$$
$$K_0 = 1$$