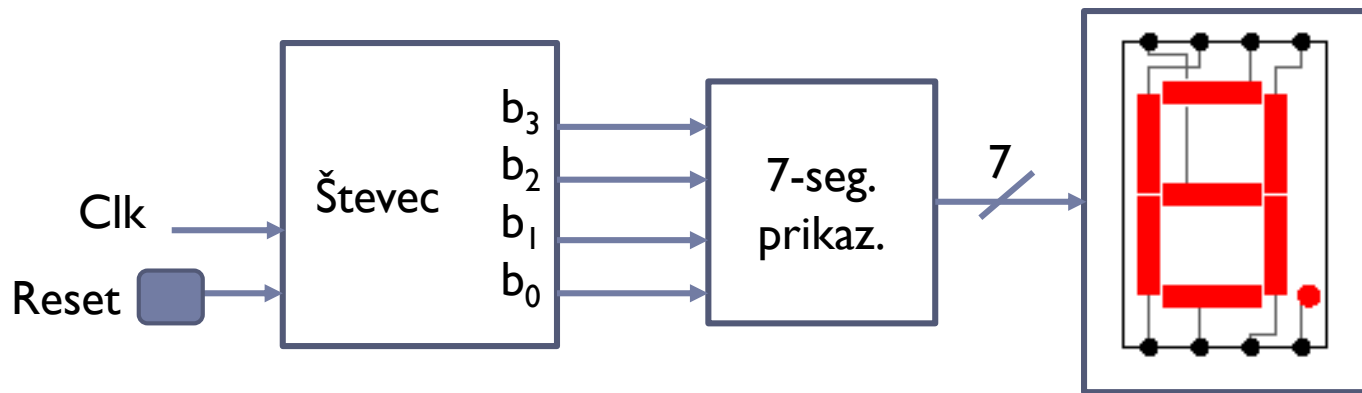


# Digitalna vezja UL, FRI

V4 Logično vezje za prikaz BCD kode

# Naloga

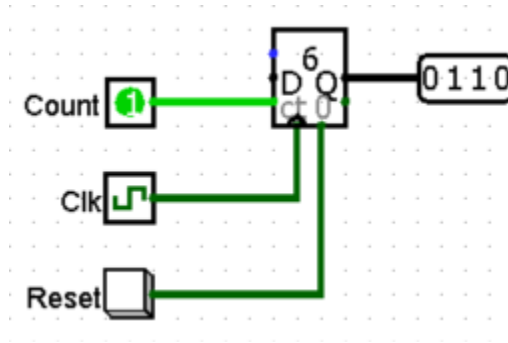
- Realizirajte logično vezje za prikaz BCD števil (0, 1, ..., 9), ki jih dobimo na izhodu 4-bitnega števca, ki omogoča povečevanje vrednosti za 1 od 0 do 9. Podana je blok shema vezja z vključitvijo števca s krmilnim vhodom Clk in 7-segmentnega prikazovalnika za katerega je potrebno določiti krmilne signale a, b, c, d, e, f, g.



- Naloge:
  - Pravilnostna tabela
  - Minimalne oblike logičnih funkcij (MDNO, MKNO)
  - Realizacija vezja v logisimu, kjer so v 'main' zgornji trije moduli (Števec, Logično vezje in prikazovalnik)
  - Oddaja datotek .circ in minimizacija funkcij v Karnaughjevem diagramu.

## ❑ Števec – povezava in nastavitve

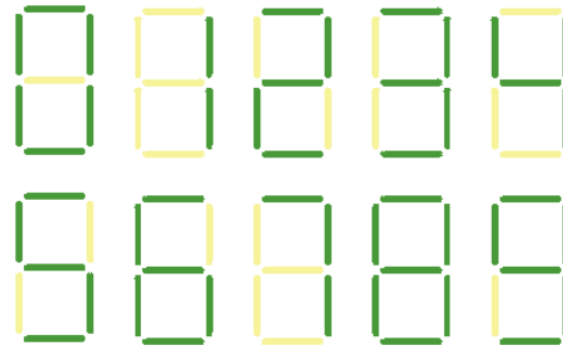
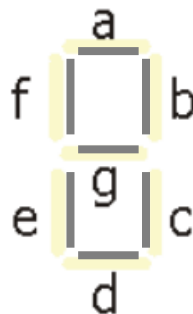
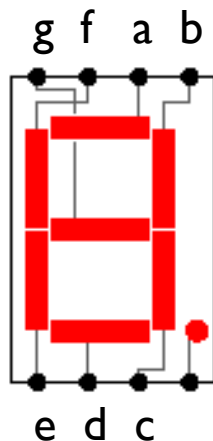
- Count = 1 – inkrement števca
- Clk – urin signal
- Reset – števec se postavi na 0
- Maximum value: 0x9



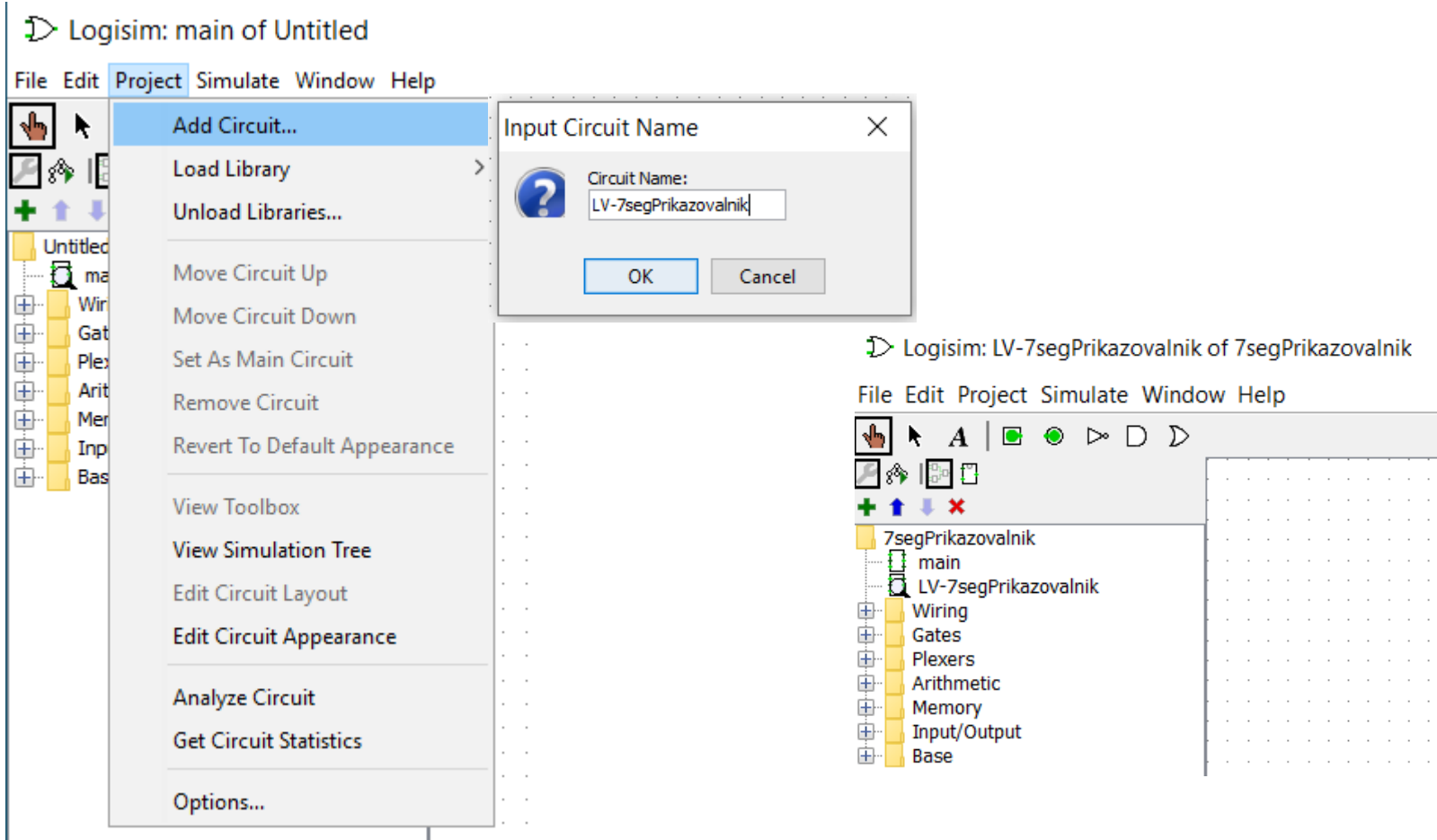
| Counter            |                    |
|--------------------|--------------------|
| Data Bits          | 4                  |
| Maximum Value      | 0x9                |
| Action On Overf... | Wrap around        |
| Trigger            | Rising Edge        |
| Label              |                    |
| Label Font         | SansSerif Plain 12 |

## ❑ 7-segmentni prikazovalnik

- a,b,c,d,e,f,g – krmilni signali za posamezen segment prikazovalnika



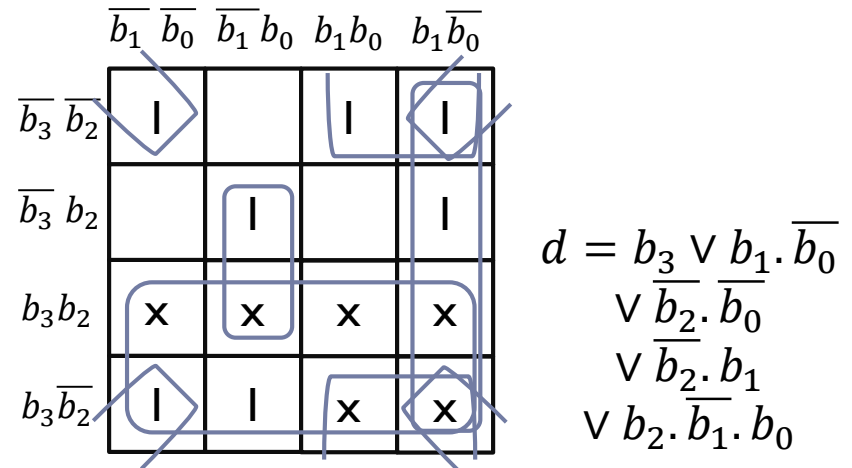
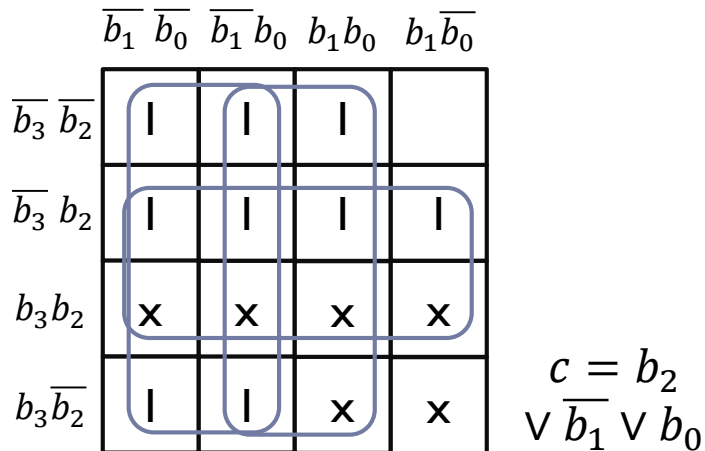
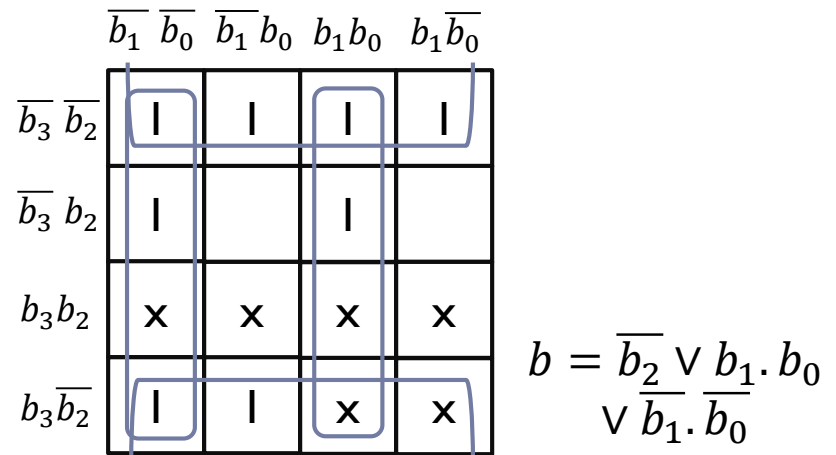
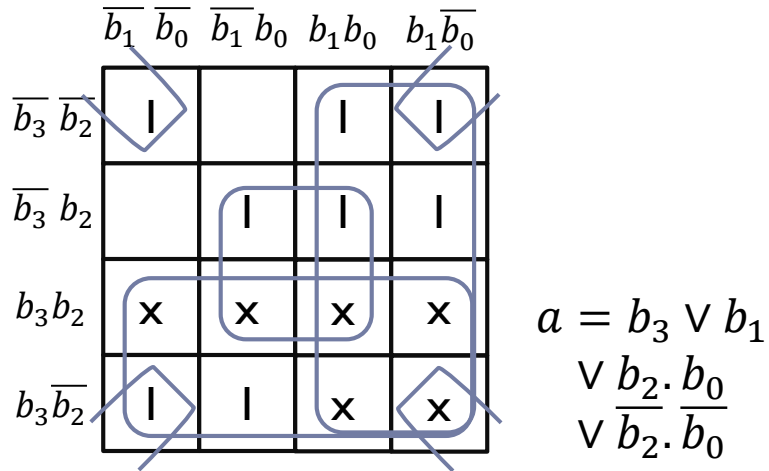
- Logisim – logično vezje za krmiljenje 7-segmentnega prikazovalnika izdelamo kot samostojno vezje (LV-7segPrikazovalnik), ki ga vključimo in povežemo s števcem.



## Pravilnostna tabela

|    | $b_3$ | $b_2$ | $b_1$ | $b_0$ | $a$ | $b$ | $c$ | $d$ | $e$ | $f$ | $g$ |
|----|-------|-------|-------|-------|-----|-----|-----|-----|-----|-----|-----|
| 0  | 0     | 0     | 0     | 0     | 1   | 1   | 1   | 1   | 1   | 1   | 0   |
| 1  | 0     | 0     | 0     | 1     | 0   | 1   | 1   | 0   | 0   | 0   | 0   |
| 2  | 0     | 0     | 1     | 0     | 1   | 1   | 0   | 1   | 1   | 0   | 1   |
| 3  | 0     | 0     | 1     | 1     | 1   | 1   | 1   | 1   | 0   | 0   | 1   |
| 4  | 0     | 1     | 0     | 0     | 0   | 1   | 1   | 0   | 0   | 1   | 1   |
| 5  | 0     | 1     | 0     | 1     | 1   | 0   | 1   | 1   | 0   | 1   | 1   |
| 6  | 0     | 1     | 1     | 0     | 1   | 0   | 1   | 1   | 1   | 1   | 1   |
| 7  | 0     | 1     | 1     | 1     | 1   | 1   | 1   | 0   | 0   | 0   | 0   |
| 8  | 1     | 0     | 0     | 0     | 1   | 1   | 1   | 1   | 1   | 1   | 1   |
| 9  | 1     | 0     | 0     | 1     | 1   | 1   | 1   | 1   | 0   | 1   | 1   |
| 10 | 1     | 0     | 1     | 0     | x   | x   | x   | x   | x   | x   | x   |
| 11 | 1     | 0     | 1     | 1     | x   | x   | x   | x   | x   | x   | x   |
| 12 | 1     | 1     | 0     | 0     | x   | x   | x   | x   | x   | x   | x   |
| 13 | 1     | 1     | 0     | 1     | x   | x   | x   | x   | x   | x   | x   |
| 14 | 1     | 1     | 1     | 0     | x   | x   | x   | x   | x   | x   | x   |
| 15 | 1     | 1     | 1     | 1     | x   | x   | x   | x   | x   | x   | x   |

## □ Minimizacija izhodnih funkcij a, b, c, d, e, f, g (**MDNO**)



|                                 | $\overline{b_1} \overline{b_0}$ | $\overline{b_1} b_0$ | $b_1 b_0$ | $b_1 \overline{b_0}$ |
|---------------------------------|---------------------------------|----------------------|-----------|----------------------|
| $\overline{b_3} \overline{b_2}$ |                                 |                      |           |                      |
| $\overline{b_3} b_2$            |                                 |                      |           |                      |
| $b_3 b_2$                       | x                               | x                    | x         | x                    |
| $b_3 \overline{b_2}$            |                                 |                      | x         | x                    |

$$e = \overline{b_2} \cdot \overline{b_0} \vee b_1 \cdot \overline{b_0}$$

|                                 | $\overline{b_1} \overline{b_0}$ | $\overline{b_1} b_0$ | $b_1 b_0$ | $b_1 \overline{b_0}$ |
|---------------------------------|---------------------------------|----------------------|-----------|----------------------|
| $\overline{b_3} \overline{b_2}$ |                                 |                      |           |                      |
| $\overline{b_3} b_2$            |                                 |                      |           |                      |
| $b_3 b_2$                       | x                               | x                    | x         | x                    |
| $b_3 \overline{b_2}$            |                                 |                      | x         | x                    |

$$f = b_3 \vee \overline{b_1} \cdot \overline{b_0} \vee b_2 \cdot \overline{b_1} \vee b_2 \cdot \overline{b_0}$$

|                                 | $\overline{b_1} \overline{b_0}$ | $\overline{b_1} b_0$ | $b_1 b_0$ | $b_1 \overline{b_0}$ |
|---------------------------------|---------------------------------|----------------------|-----------|----------------------|
| $\overline{b_3} \overline{b_2}$ |                                 |                      |           |                      |
| $\overline{b_3} b_2$            |                                 |                      |           |                      |
| $b_3 b_2$                       | x                               | x                    | x         | x                    |
| $b_3 \overline{b_2}$            |                                 |                      | x         | x                    |

$$g = b_3 \vee b_1 \cdot \overline{b_0} \vee b_2 \cdot \overline{b_1} \vee b_2 \cdot b_1$$

## □ Minimizacija izhodnih funkcij a, b, c, d, e, f, g (MKNO)

|                       | $\bar{b}_1 \bar{b}_0$ | $\bar{b}_1 b_0$ | $b_1 b_0$ | $b_1 \bar{b}_0$ |
|-----------------------|-----------------------|-----------------|-----------|-----------------|
| $\bar{b}_3 \bar{b}_2$ |                       | 1               |           |                 |
| $\bar{b}_3 b_2$       | 1                     |                 |           |                 |
| $b_3 b_2$             | x                     | x               | x         | x               |
| $b_3 \bar{b}_2$       |                       |                 | x         | x               |

$$\bar{a} = \frac{b_2 \cdot \bar{b}_1 \cdot \bar{b}_0 \vee \bar{b}_3 \cdot \bar{b}_2 \cdot \bar{b}_1 \cdot b_0}{a = (\bar{b}_2 \vee b_1 \vee b_0). (b_3 \vee b_2 \vee b_1 \vee \bar{b}_0)}$$

|                       | $\bar{b}_1 \bar{b}_0$ | $\bar{b}_1 b_0$ | $b_1 b_0$ | $b_1 \bar{b}_0$ |
|-----------------------|-----------------------|-----------------|-----------|-----------------|
| $\bar{b}_3 \bar{b}_2$ |                       |                 |           |                 |
| $\bar{b}_3 b_2$       |                       | 1               |           | 1               |
| $b_3 b_2$             | x                     | x               | x         | x               |
| $b_3 \bar{b}_2$       |                       |                 | x         | x               |

$$b = (\bar{b}_2 \vee b_1 \vee \bar{b}_0). (\bar{b}_2 \vee \bar{b}_1 \vee b_0)$$

|                       | $\bar{b}_1 \bar{b}_0$ | $\bar{b}_1 b_0$ | $b_1 b_0$ | $b_1 \bar{b}_0$ |
|-----------------------|-----------------------|-----------------|-----------|-----------------|
| $\bar{b}_3 \bar{b}_2$ |                       |                 |           | 1               |
| $\bar{b}_3 b_2$       |                       |                 |           |                 |
| $b_3 b_2$             | x                     | x               | x         | x               |
| $b_3 \bar{b}_2$       |                       |                 | x         | x               |

$$c = \frac{b_2 \vee \bar{b}_1 \vee b_0}{c = b_2 \vee \bar{b}_1 \vee b_0}$$

|                       | $\bar{b}_1 \bar{b}_0$ | $\bar{b}_1 b_0$ | $b_1 b_0$ | $b_1 \bar{b}_0$ |
|-----------------------|-----------------------|-----------------|-----------|-----------------|
| $\bar{b}_3 \bar{b}_2$ |                       | 1               |           |                 |
| $\bar{b}_3 b_2$       | 1                     |                 | 1         |                 |
| $b_3 b_2$             | x                     | x               | x         | x               |
| $b_3 \bar{b}_2$       |                       |                 | x         | x               |

$$d = \frac{(\bar{b}_2 \vee b_1 \vee b_0). (\bar{b}_2 \vee \bar{b}_1 \vee \bar{b}_0). (b_3 \vee b_2 \vee b_1 \vee \bar{b}_0)}{d = (\bar{b}_2 \vee b_1 \vee b_0). (\bar{b}_2 \vee \bar{b}_1 \vee \bar{b}_0). (b_3 \vee b_2 \vee b_1 \vee \bar{b}_0)}$$

|                                   | $\overline{b_1} \ \overline{b_0}$ | $\overline{b_1} \ b_0$ | $b_1 \ b_0$ | $b_1 \ \overline{b_0}$ |
|-----------------------------------|-----------------------------------|------------------------|-------------|------------------------|
| $\overline{b_3} \ \overline{b_2}$ |                                   | 1                      | 1           |                        |
| $\overline{b_3} \ b_2$            | 1                                 | 1                      | 1           |                        |
| $b_3 \ b_2$                       | x                                 | x                      | x           | x                      |
| $b_3 \ \overline{b_2}$            |                                   | 1                      | x           | x                      |

$$e = \overline{b_0} \cdot (\overline{b_2} \vee b_1)$$

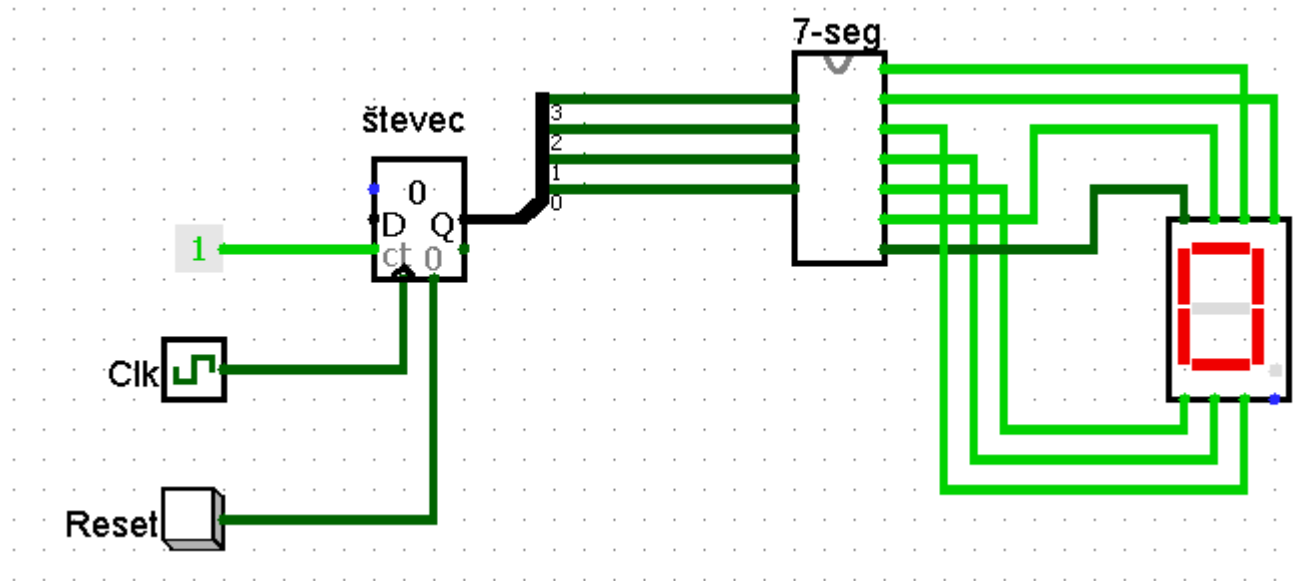
|                                   | $\overline{b_1} \ \overline{b_0}$ | $\overline{b_1} \ b_0$ | $b_1 \ b_0$ | $b_1 \ \overline{b_0}$ |
|-----------------------------------|-----------------------------------|------------------------|-------------|------------------------|
| $\overline{b_3} \ \overline{b_2}$ |                                   | 1                      | 1           | 1                      |
| $\overline{b_3} \ b_2$            |                                   |                        | 1           |                        |
| $b_3 \ b_2$                       | x                                 | x                      | x           | x                      |
| $b_3 \ \overline{b_2}$            |                                   |                        | x           | x                      |

$$f = (\overline{b_1} \vee \overline{b_0}) \cdot (b_3 \vee b_2 \vee \overline{b_0})(b_3 \vee b_2 \vee \overline{b_1})$$

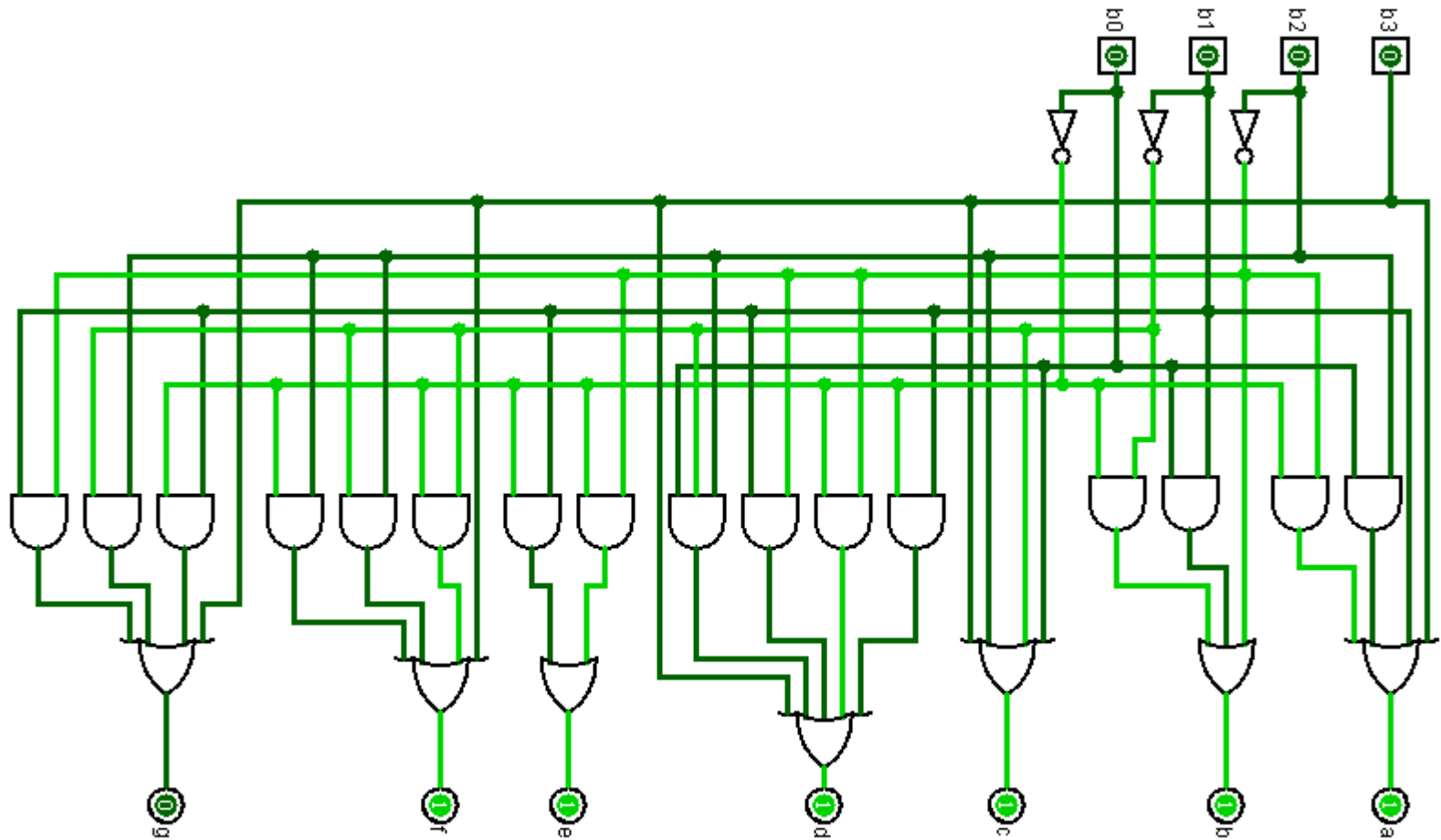
|                                   | $\overline{b_1} \ \overline{b_0}$ | $\overline{b_1} \ b_0$ | $b_1 \ b_0$ | $b_1 \ \overline{b_0}$ |
|-----------------------------------|-----------------------------------|------------------------|-------------|------------------------|
| $\overline{b_3} \ \overline{b_2}$ | 1                                 | 1                      |             |                        |
| $\overline{b_3} \ b_2$            |                                   |                        | 1           |                        |
| $b_3 \ b_2$                       | x                                 | x                      | x           | x                      |
| $b_3 \ \overline{b_2}$            |                                   |                        | x           | x                      |

$$g = (b_3 \vee b_2 \vee b_1) \cdot (\overline{b_2} \vee \overline{b_1} \vee \overline{b_0})$$

## Realizacija vezja v logisimu



## Logična shema - MDNO



## Logična shema - MKNO

