



Digitalna vezja UL, FRI



Vaja 1 Boolova algebra, logisim, breadboard

1 Boolova algebra

X – množica elementov: $x, y, 0, 1, \bar{x} \in X$;

O – množica operacij: konjunkcija (\cdot), disjunkcija (\vee), negacija ($\bar{\quad}$)

P – množica pravil (postulati):

Zaprtoost: $P1: x \vee y \in X$

$P1^*: x \cdot y \in X$

Nevtralni element: $P2: x \vee 0 = x$

$P2^*: x \cdot 1 = x$

Komutativnost: $P3: x \vee y = y \vee x$

$P3^*: x \cdot y = y \cdot x$

Distributivnost: $P4: x \vee (y \cdot z) = (x \vee y) \cdot (x \vee z)$

$P4^*: x \cdot (y \vee z) = (x \cdot y) \vee (x \cdot z) = x \cdot y \vee x \cdot z$

Inverzni element: $P5: x \vee \bar{x} = 1$

$P5^*: x \cdot \bar{x} = 0$

Število elementov: $P6: x \neq y$

Lastnosti:

Idempotenca:

$$x \vee x \vee \dots \vee x = x$$
$$x \cdot x \dots \cdot x = x$$

Absorbicija:

$$x \vee (x \cdot y) = x$$
$$x \cdot (x \vee y) = x$$

Asociativnost:

$$(x \vee y) \vee z = x \vee (y \vee z) = x \vee y \vee z$$
$$(x \cdot y) \cdot z = x \cdot (y \cdot z) = x \cdot y \cdot z$$

DeMorganovo pravilo:

$$\overline{x_1 \vee x_2 \dots \vee x_n} = \overline{x_1} \cdot \overline{x_2} \cdot \dots \cdot \overline{x_n}$$
$$\overline{x_1 \cdot x_2 \dots \cdot x_n} = \overline{x_1} \vee \overline{x_2} \vee \dots \vee \overline{x_n}$$

Primer:

□ Z uporabo postulatov dokažite enakost $x \vee 1 = 1$!

$$x \vee 1 = (x \vee 1) \cdot 1 \quad (\text{P2}^*)$$

$$= (x \vee 1) \cdot (x \vee \bar{x}) \quad (\text{P5})$$

$$= x \vee (1 \cdot \bar{x}) \quad (\text{P4})$$

$$= x \vee \bar{x} \quad (\text{P2}^*)$$

$$= 1 \quad (\text{P5})$$

Naloga 1: Poenostavljanje logičnih funkcij

□ Poenostavljanje logičnih funkcij z uporabo Booleove algebre

□ Primer:

$$f(x, y, z) = \bar{x} \cdot \bar{y} \cdot z \vee \bar{x} \cdot y \cdot z = \bar{x} \cdot z \cdot (\bar{y} \vee y) = \bar{x} \cdot z \cdot 1 = \bar{x} \cdot z$$

$$\begin{aligned} f(x, y, z) &= \bar{x} \cdot \bar{y} \cdot z \vee x \cdot \bar{y} \cdot \bar{z} \vee x \cdot \bar{y} \cdot z \vee \bar{x} \cdot y \cdot z = \\ &= \bar{x} \cdot z (\bar{y} \vee y) \vee x \cdot \bar{y} \cdot (\bar{z} \vee z) \\ &= \bar{x} \cdot z \vee x \cdot \bar{y} \end{aligned}$$

□ Poenostavite logične funkcije.

1. $f(x, y, z) = \bar{x} \cdot \bar{y} \cdot z \vee x \cdot y \cdot z \vee x \cdot y \cdot \bar{z} \vee x \cdot \bar{y} \cdot z = ?$

2. $f(x, y, z, u) = \bar{x} \cdot \bar{y} \cdot z \cdot u \vee x \cdot y \cdot z \cdot u \vee x \cdot y \cdot \bar{z} \cdot u \vee x \cdot y \cdot z \cdot \bar{u} = ?$

3. $f(x, y) = \overline{\bar{x} \cdot \bar{y}} \vee x \cdot y = ?$

4. $f(x, y, z) = \overline{(\bar{x} \cdot \bar{y} \vee y \cdot z)} \vee (x \vee z) = ?$

5. $f(A, B, C, D) = A \cdot C \vee \overline{(\bar{A} \cdot \bar{B} \vee A \cdot B)} \cdot (\bar{C} \vee \overline{A \cdot D}) = ?$

6. $f(A, B, C, D) = A \vee C \cdot \overline{(\bar{A} \cdot \bar{B} \vee B)} \vee \bar{C} \cdot \overline{B \vee \bar{D}} = ?$

Logična vrata:

Negacija NE (NOT):

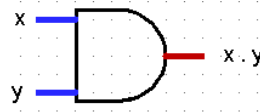
$$\bar{x} = x' = \sim x$$



| x | \bar{x} |
|---|-----------|
| 0 | 1 |
| 1 | 0 |

Konjunkcija: IN (AND)

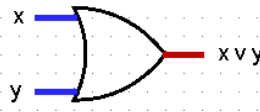
$$x \& y = x \wedge y = x \cdot y$$



| x | y | $x \cdot y$ |
|---|---|-------------|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

Disjunkcija: OR (ALI)

$$x \vee y = x + y$$

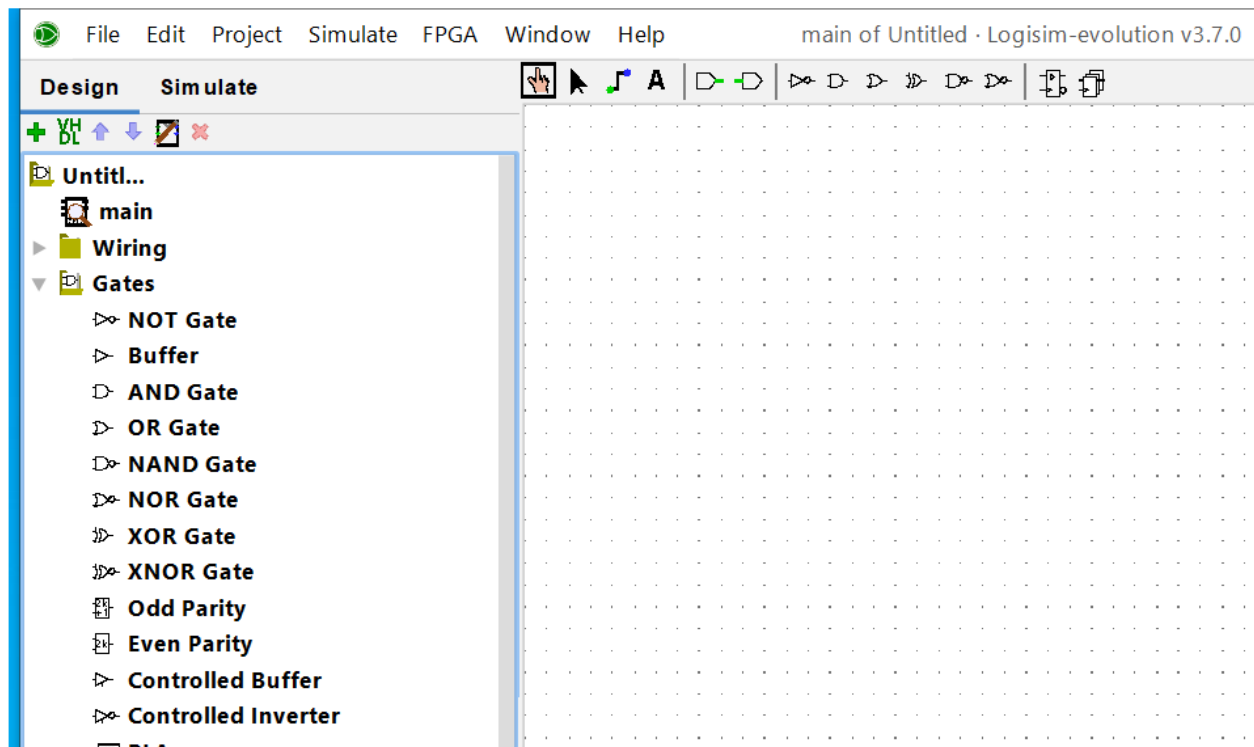


| x | y | $x \vee y$ |
|---|---|------------|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

2 logisim-evolution

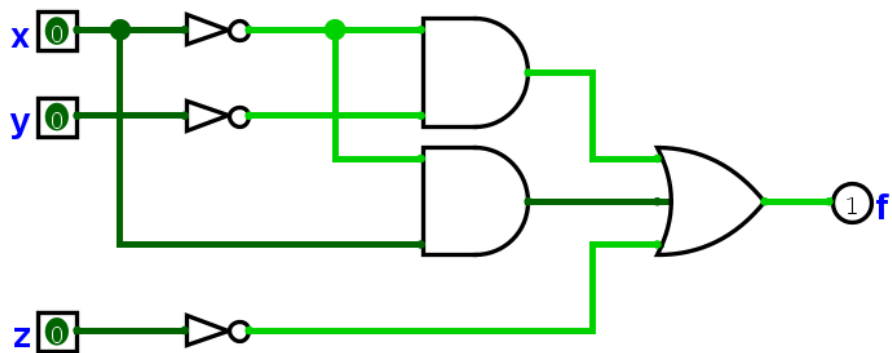
- Načrtovanje in simulacija digitalnih/logičnih vezij

<https://github.com/logisim-evolution/logisim-evolution>



Naloga 2

- Narišite vezje v logisimu



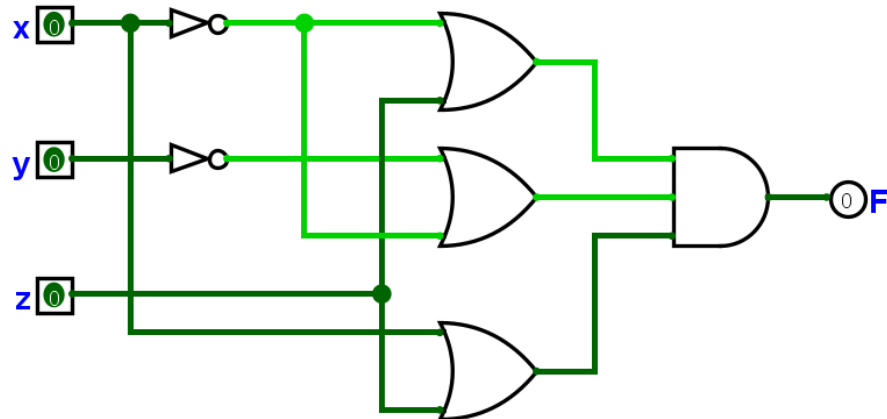
- Zapišite izhod logičnega vezja (f) z operatorji NOT, AND, OR

$$f = \overline{x \cdot y} + x \cdot z + \overline{z}$$

- Zapišite pravilnostno tabelo

| x | y | z | f |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 0 |

- Narišite vezje v logisimu



- Zapišite izhod logičnega vezja (F) z operatorji NOT, AND, OR

$$F = \overline{(x+z)} \cdot \overline{(y+x)} \cdot (x+z)$$

- Zapišite pravilnostno tabelo

| x | y | z | F |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 0 |

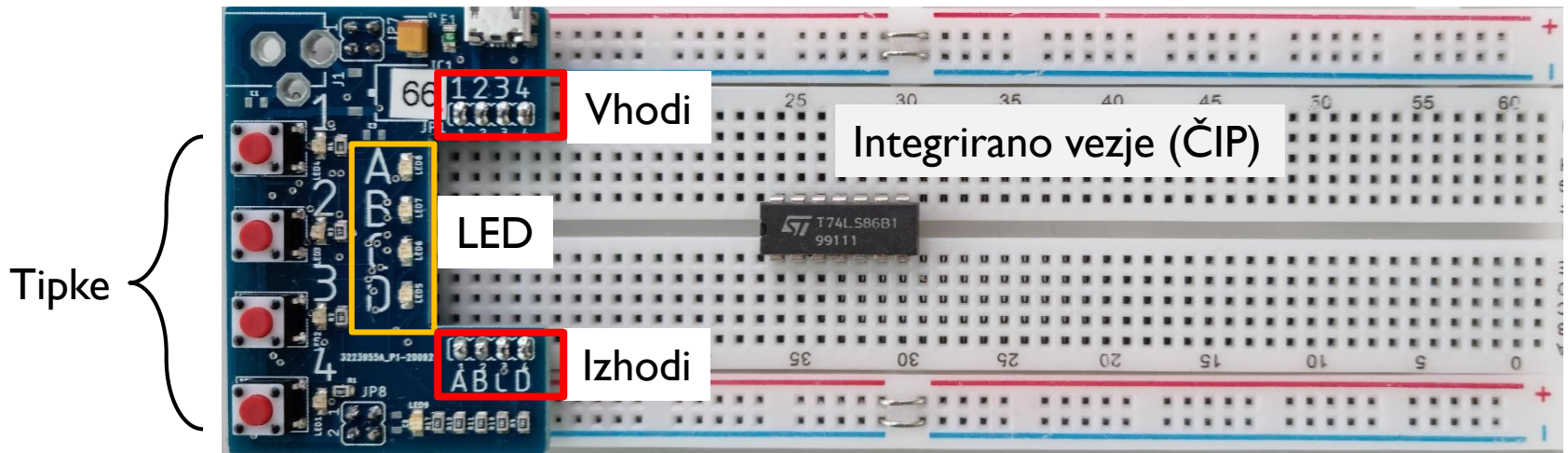
3 Testna plošča (ang. breadboard)

□ Oprema I

USB napajalnik (5V)

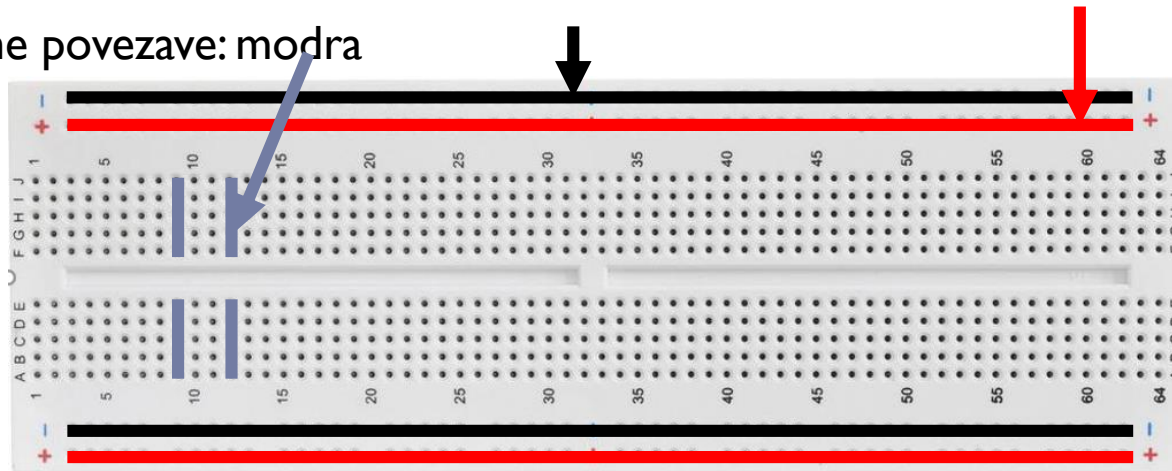


Testna plošča z napajalnim modulom, vhodi (tipke) in izhodi (svetleča dioda - LED)

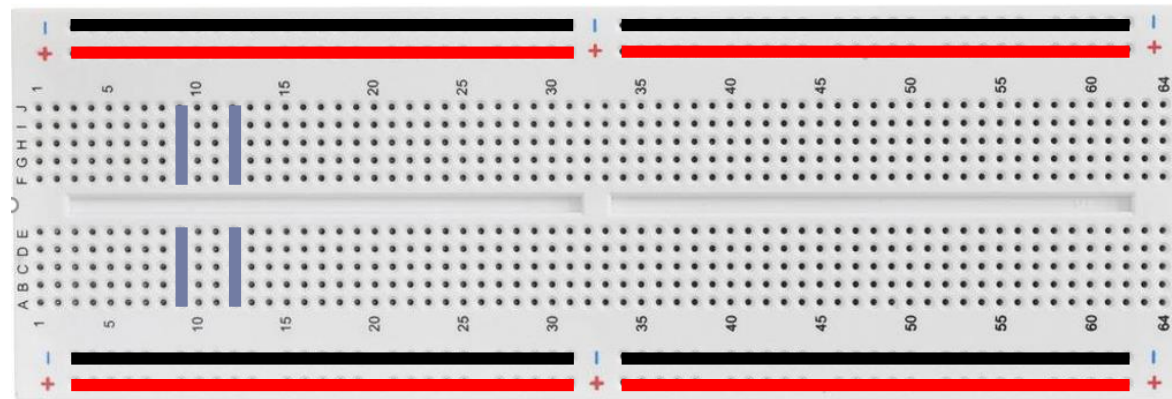


□ Povezave na testni plošči:

- Vzдолžne povezave: Gnd (masa) – črna (!), Vcc (napajanje) - rdeča (+)
- Prečne povezave: modra



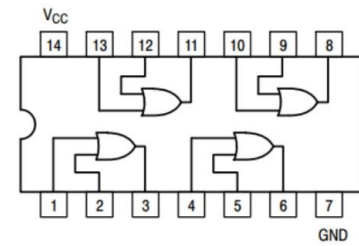
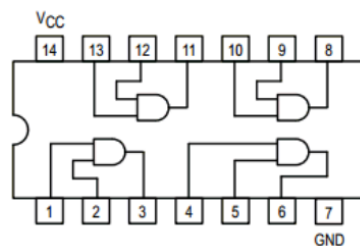
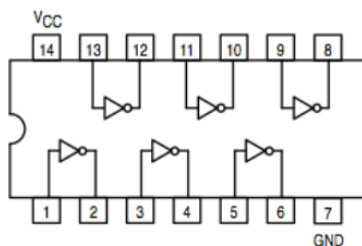
ali



Naloga 3 Realizacija vezja

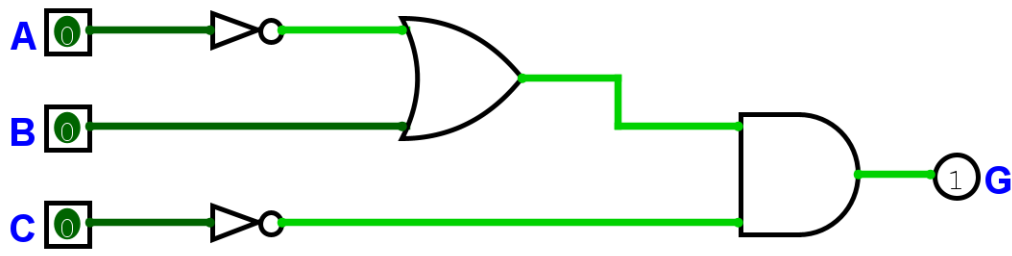
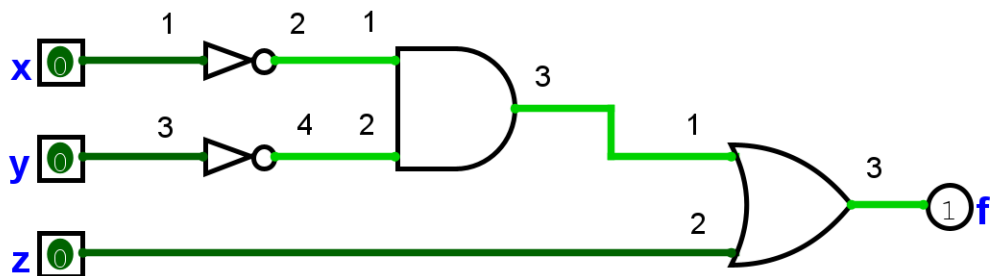
□ TTL čipi - Podatkovni list

- NOT (7404)
- AND (7408)
- OR (7432)



□ Shema

□ Oznake povezav



□ Realizacija