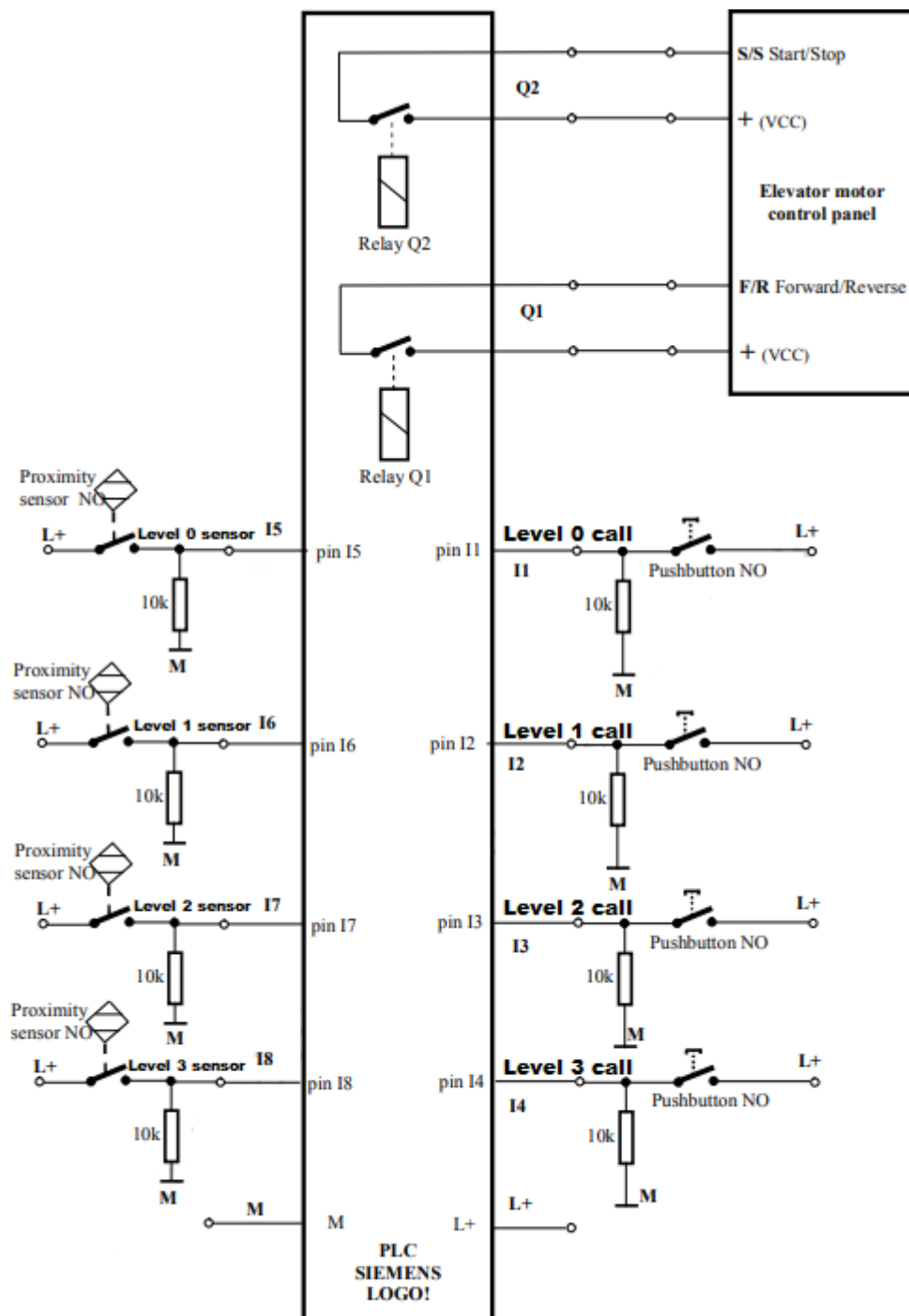
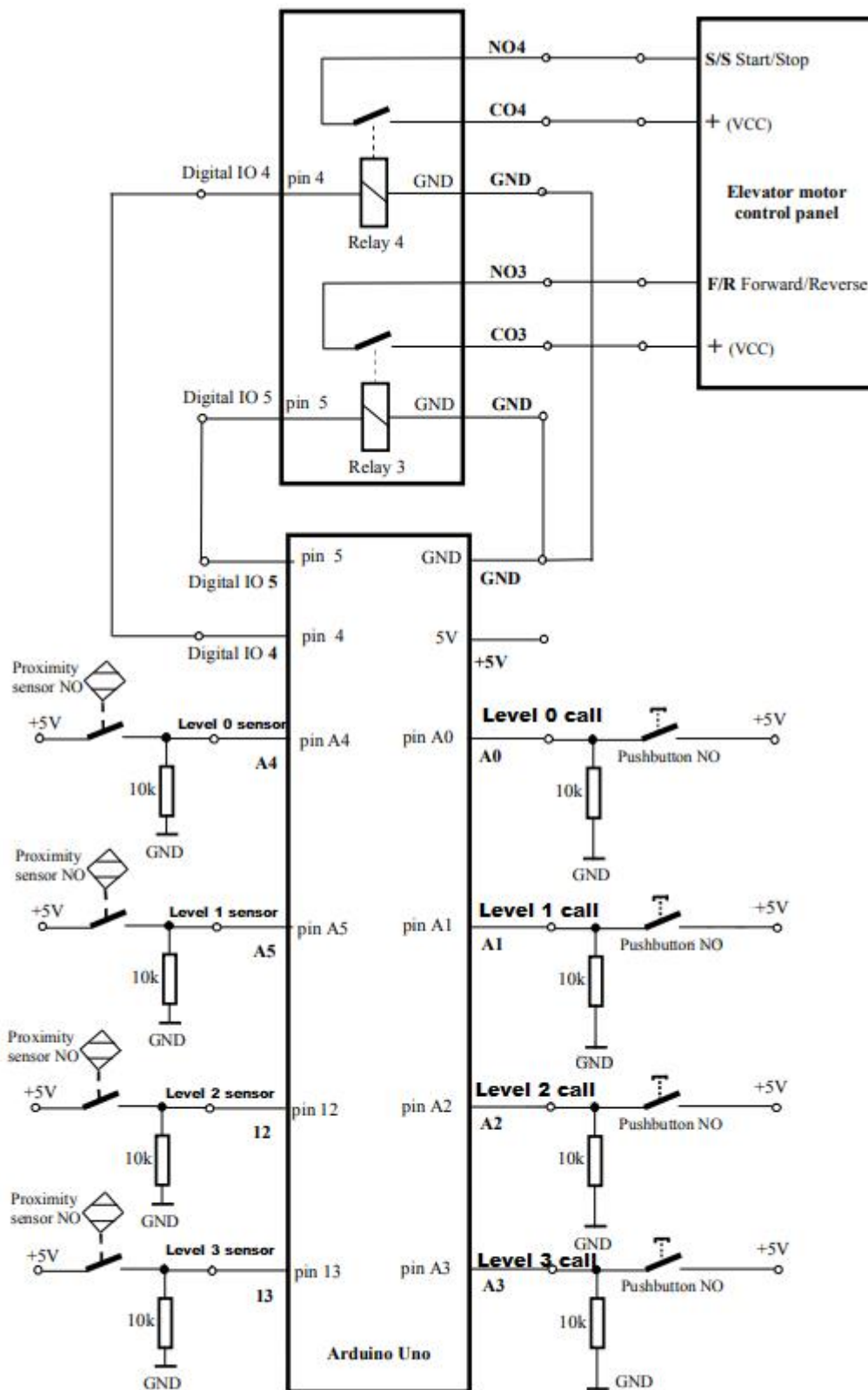


PLC connection diagram:



Arduino connection diagram:



Assumptions

- I1 P₁ - button for sending the elevator to the 0th floor
- I2 P₂ - button for sending elevator to the 1st floor

I3 P₃ - button for sending elevator to the 2nd floor

I4 P₄ - przycisk wysyłania windy na 3 kondygnację

I5 P₅ - elevator presence sensor on the 0th floor

I6 P₆ - elevator presence sensor on the 1st floor

I7 P₇ - elevator presence sensor on the 2nd floor

I8 P₈ - elevator presence sensor on the 3rd floor

Controlling the elevator motor

F/R, S/S – motor control inputs connected to PLC outputs

F/R output Q1

S/S z output Q2

| F/R (direction bit) | S/S (stop bit) | Reaction |
|------------------------|-------------------|-----------------------|
| 0 | 1 | stop |
| 0 | 0 | ↑(go up) |
| 1 | 0 | ↓(go down) |
| 1 | 1 | forbidden combination |

Controlling the elevator motor (ARDUINO)

Pin 5 - F/R (direction bit) - Q1

Pin 4 - S/S (stop bit) - Q2

The #define directives in Arduino sketch

```
#define Button1Pin A0
```

```
#define Button2Pin A1
```

```
#define Button3Pin A2
```

```
#define Button4Pin A3
```

```
#define Sensor1Pin A4
```

```
#define Sensor2Pin A5
```

```
#define Sensor3Pin 12
```

```
#define Sensor4Pin 13
```

```
#define OutputQ1Pin 5
```

```
#define OutputQ2Pin 4
```

Definition of state machine states

0 - elevator sets on the 3rd floor - initial state

1 - elevator is on the 0th floor

2 - elevator is on the 1st floor

3 - the elevator is on the 3rd floor

4 - elevator moves from 0 to 1 floor

5 - elevator moves from 0 to 3rd floor

6 - elevator moves from 1st to 3rd floor

7 - elevator moves from 1 to 0 floor

8 - elevator moves from 3 to 1 floor

9 - elevator moves from 3 to 0 floor

The way to encode the states of a state machine

| Stan | X1 | X2 | X3 | X4 |
|------|----|----|----|----|
| 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 |

State machine transition diagram

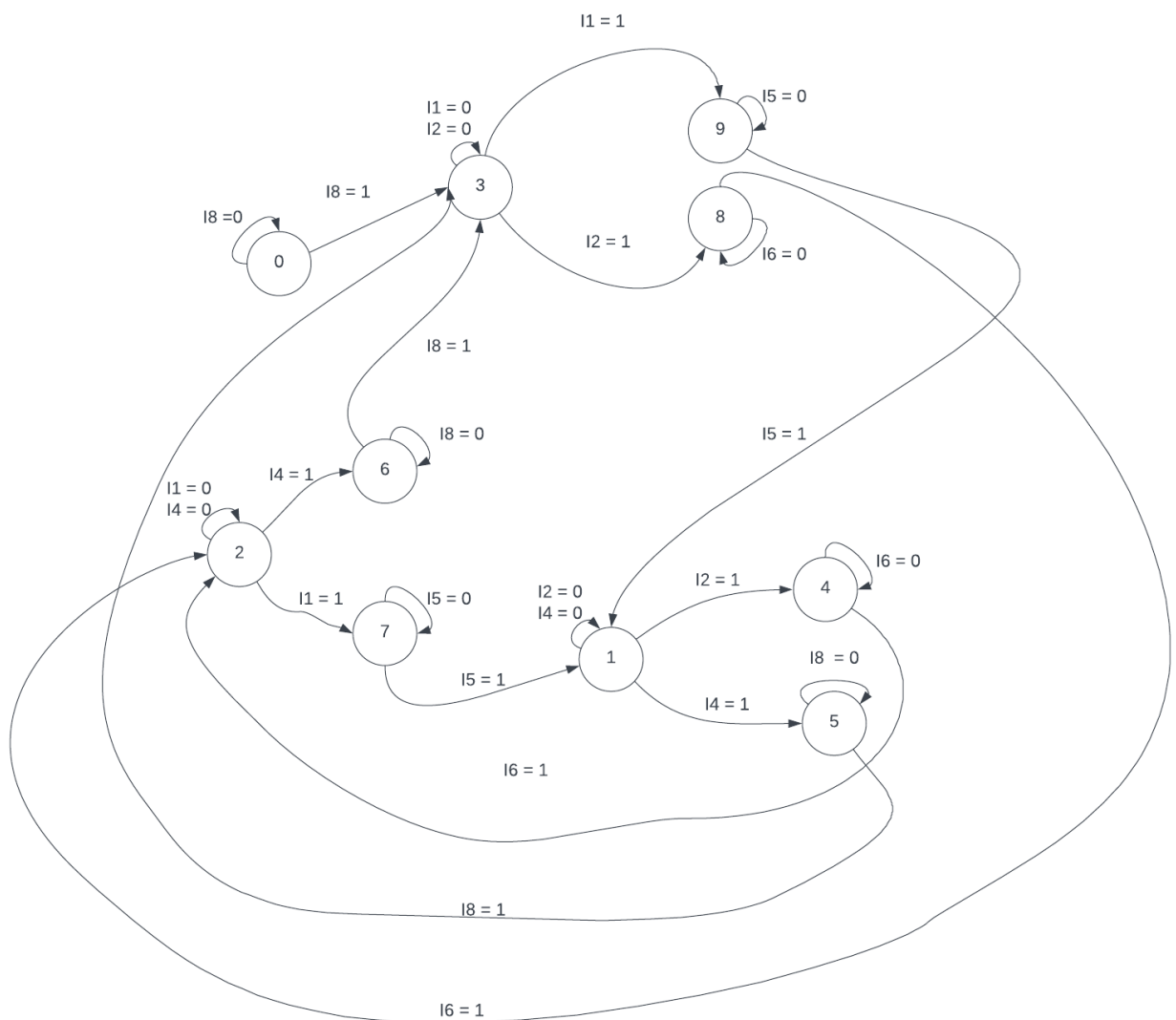


Table of state transitions

| X1(t) | X2(t) | X3(t) | X4(t) | I1 | I2 | I4 | I5 | I6 | I8 | X1(t+1) | X2(t+1) | X3(t+1) | X4(t+1) |
|-------|-------|-------|-------|----|----|----|----|----|----|---------|---------|---------|---------|
| 0 | 0 | 0 | 0 | - | - | - | - | - | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | - | - | - | - | - | 1 | 0 | 0 | 1 | 1 |
| 0 | 0 | 0 | 1 | - | 1 | - | - | - | - | 0 | 1 | 0 | 0 |
| 0 | 0 | 0 | 1 | - | - | 1 | - | - | - | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 0 | 1 | - | - | - | - | - | 0 | 1 | 1 | 1 |
| 0 | 0 | 1 | 0 | - | - | 1 | - | - | - | 0 | 1 | 1 | 0 |
| 0 | 0 | 1 | 1 | 1 | - | - | - | - | - | 1 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 | - | 1 | - | - | - | - | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | - | - | - | - | 1 | - | 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 | - | - | - | - | 0 | - | 0 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | - | - | - | - | - | 1 | 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 1 | - | - | - | - | - | 0 | 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 0 | - | - | - | - | - | 1 | 0 | 0 | 1 | 1 |
| 0 | 1 | 1 | 0 | - | - | - | - | - | 0 | 0 | 1 | 1 | 0 |
| 0 | 1 | 1 | 1 | - | - | - | 1 | - | - | 0 | 0 | 0 | 1 |
| 0 | 1 | 1 | 1 | - | - | - | 0 | - | - | 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 | - | - | - | - | 1 | - | 0 | 0 | 1 | 0 |
| 1 | 0 | 0 | 0 | - | - | - | - | 0 | - | 1 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | - | - | - | 1 | - | - | 0 | 0 | 0 | 1 |
| 1 | 0 | 0 | 1 | - | - | - | 0 | - | - | 1 | 0 | 0 | 1 |
| 0 | 0 | 0 | 1 | - | 0 | 0 | - | - | - | 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 0 | 0 | - | 0 | - | - | - | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 | - | - | - | - | 0 | 0 | 1 | 1 |

State transition functions:

The expressions **highlighted in red** can be simplified as follows $ABC(!D) + ABC(D) = ABD(D + !D) = ABC1 = ABC$

X1 state transition function::

$$X1 = !X1!X2X3X4!I1 + !X1!X2X3X4!I2 + X1!X2!X3!X4!I6 + X1!X2!X3X4!I5$$

X2 state transition function::

$$X2 = !X1!X2!X3X4!I2 + !X1!X2!X3X4!I4 + !X1!X2X3!X4!I1 + !X1!X2X3!X4!I4 + !X1X2!X3!X4!I6 + !X1X2!X3X4!I8 + !X1X2X3!X4!I8 + !X1X2X3X4!I5$$

X3 state transition function::

$$X3 = !X1!X2!X3!X4!I8 + !X1!X2X3!X4!I1 + !X1!X2X3!X4!I4 + !X1X2!X3!X4!I6 + !X1X2!X3X4!I8 + !X1X2X3!X4!I8 + !X1X2X3!X4!I8 + !X1X2X3X4!I5 + X1!X2!X3!X4!I6 = !X1!X2!X3!X4!I8 +$$

$$\begin{aligned} & !X_1!X_2X_3!X_4!1 + !X_1!X_2X_3!X_4!4 + !X_1X_2!X_3!X_4!6 + !X_1X_2!X_3X_4!8 + !X_1X_2X_3!X_4 + \\ & !X_1X_2X_3X_4!5 + X_1!X_2!X_3!X_4!6 + !X_1!X_2X_3!X_4!1!1!4 + !X_1!X_2X_3X_4!1!1!2 \end{aligned}$$

X4 state transition function::

$$\begin{aligned} X_4 &= !X_1!X_2!X_3!X_4!8 + !X_1!X_2!X_3X_4!4 + !X_1!X_2X_3!X_4!1 + !X_1!X_2X_3X_4!1 + !X_1X_2!X_3X_4!8 + \\ & !X_1X_2!X_3X_4!5 + !X_1X_2X_3!X_4!8 + !X_1X_2X_3X_4!5 + !X_1X_2X_3X_4!5 + X_1!X_2!X_3X_4!5 + \\ & X_1!X_2!X_3X_4!5 = !X_1!X_2!X_3!X_4!8 + !X_1!X_2!X_3X_4!4 + !X_1!X_2X_3!X_4!1 + !X_1!X_2X_3X_4!1 + \\ & !X_1X_2!X_3X_4 + !X_1X_2X_3!X_4!8 + !X_1X_2X_3X_4!1 + X_1!X_2!X_3X_4 + !X_1!X_2!X_3X_4!2!1!4 + \\ & !X_1!X_2X_3X_4!1!1!2 \end{aligned}$$

Output function table:

| X1 | X2 | X3 | X4 | F/R (Q1) | S/S (Q2) |
|----|----|----|----|----------|----------|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 1 | 0 |
| 1 | 0 | 0 | 1 | 1 | 0 |

Output functions:

The expressions highlighted in red can be simplified as follows $ABC(!D) + ABC(D) = ABD(D + !D) = ABC1 = ABC$

Q1 output function:

$$Q_1 = !X_1X_2X_3X_4 + X_1!X_2!X_3!X_4 + X_1!X_2!X_3X_4 = !X_1X_2X_3X_4 + X_1!X_2!X_3$$

Q2 output function:

$$Q_2 = !X_1!X_2!X_3X_4 + !X_1!X_2X_3!X_4 + !X_1!X_2X_3X_4 = !X_1!X_2!X_3X_4 + !X_1!X_2X_3$$