

# DEVELOPMENT OF DIGITAL SYSTEMS

Examination  
24. 01. 2014

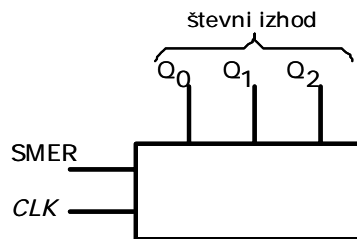
1. Implement the function  $f$  using a single multiplexer 4/1.

$$f(x_1, x_2, x_3, x_4) = \&(1, 2, 5-7, 9, 10, 14) \text{ in } \&_x(0, 4, 11, 13)$$

2. Implement a given function  $f$  using a single 4-bit arithmetic logic unit (ALU). Resulting negations of variables must be implemented within same ALU.

$$f(a, b, c, d, e) = a \cdot b \cdot d + \bar{c} \cdot d + \bar{e}$$

3. Draw the circuit diagram of a three bit up-down synchronous counter, using T type flip-flops and any logical gates. Design the state transition table and express equations of flip-flop inputs. The counter has a three bit count output ( $Q_2, Q_1, Q_0$ ), a clock input (CLK) and a count direction input (SMER). Count direction is downwards when (SMER='0'), and upwards when (SMER='1'). Name the signals according to figure below.



4. Draw the state transition diagram of a Moore type finite state machine, which controls the movement of a garage door. The control circuit has an input (DOOR) and an input (PROTECTION), which is set to '1' whenever a current limit of the motor is reached. The motor current limit input is used to detect both door end positions as well as for protection against obstacles in the door path. The control circuit has a two bit motor output:

| Operation code  |                 | Motor operation       |
|-----------------|-----------------|-----------------------|
| OP <sub>1</sub> | OP <sub>0</sub> |                       |
| 0               | 0               | motor stop            |
| 0               | 1               | door moving upwards   |
| 1               | 0               | door moving downwards |

When the door knob is pressed (DOOR='1'), the door starts to move upwards. If an obstacle is in the door path or the door reaches its upper end position (PROTECTION='1'), the motor stops. When the door knob is pressed again, the door starts to move downwards until the protection limit is reached again. After the door knob is pressed again, the process is repeated.

Examination duration is 60 minutes. Each assignment is worth 10 points.

Please sign your answer sheet using your enrollment number.

Solutions and examination results will be announced on course web page: <http://rds.fe.uni-lj.si>