CON exam 22.02.2021 Matr.nr.: Last name:

The use of examination aids (e.g., calculators) is prohibited. Answers can be given in German or English. Please refrain from using lead pencils and red ink pens.

Grading scale: 00–25: insufficient 26–31: sufficient 32–38: satisfactory
39–44: good 45–50: very good

Q1. (10 points) **SystemVerilog Finite State Machine:**

(a) An incomplete timing diagram can be found on the next page. Complete the missing signals in the diagram. Use binary encoding for signal values.

(b) Draw the ASM diagram for this finite-state machine.

(c) The table on the right specifies the output logic. Specify the logical formulas for two output signals.

(d) What kind of FSM is given? What is the name of the other type of finite-state machines and explain the difference. Change one line of the truth table to create the other tye of FSM.

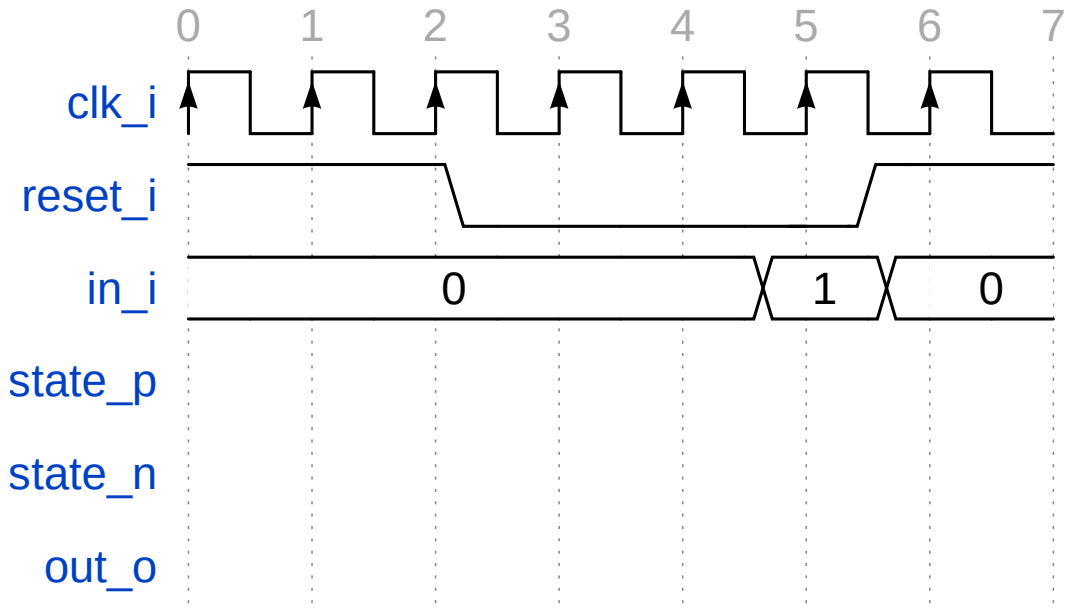
state_p [1]	state_p [0]	in_i	out_o [1]	out_o [0]
0	0	0	1	1
0	0	1	1	1
0	1	0	1	0
0	1	1	1	1
1	0	0	0	0
1	0	1	0	0
1	1	0	1	0
1	1	1	1	0

```
module state_machine(
  input logic clk_i,
  input logic reset_i,
  input logic in_i,
  output logic [1:0] out_o
);
  logic [1:0] state_p, state_n;

  always_ff @(posedge clk_i or posedge reset_i) begin
    if (reset_i) state_p <= 2'b00;
    else         state_p <= state_n;
  end

  always_comb begin
    if (in_i == 0) state_n = state_p + 1;
    else           state_n = state_p << 1;
  end
  // Output defined in truth table
endmodule
```

→


0
1
2
3
4
5
6
7
clk_i
reset_i
in_i
0
1
0
state_p
state_n
out_o

→

Q2. (10 points) **Memory and Cache:** Assume a directly-mapped data cache with a total size of 64 bytes, organized in 8 blocks, and 256 bytes of byte-addressable main memory. The latency for accessing the main memory is 200ns and the latency for accessing the cache is 20ns.

(a) Why are caches used in modern processors, *i.e.*, what problem do they solve?

(b) Name and explain the two types of locality that caches exploit.

(c) Sketch the directly-mapped cache and explain how a cache access to the address 0x56 is performed. What checks are performed on which data and what are the expected values for a cache hit?

(d) Assume the following piece of code being executed on a system. The local variables `i` and `sum2` are kept in registers. The data cache is empty at the beginning of the execution. What is the total latency for accessing *all* elements? For every access, state whether it is a cache hit `H` or miss `M`.

```
// Located at memory address 0x54
char array[4] = {1, 2, 3, 4};

int sum2 = 0;
for(int i = 0; i < 8; ++i)
  sum2 += array[i % 4]
```

Q3. (10 points) **Assembly:**

(a) What is a calling convention and why is it needed? Explain what a calling convention covers.

(b) Transform the following C-code to RISC-V assembly. All local variables of the C-code **must** be allocated on the stack. The global variable `g` is located at address `0xF00`. The RISC-V calling convention must be followed. The assembly startup code including the initialization of the stack is provided below. Write the assembly code for the two functions at the foreseen locations.

```c
// Located at memory address 0xF00
int g;

int addglobal(int* p) {
  return *p + g;
}

int main() {
  int a = 3;
  g = 4;
  return addglobal(&a);
}
```

Assembly Reference

```
LW    rd,imm(rs1)
SW    rs1,imm(rs2)
ADD   rd,rs1,rs2
ADDI  rd,rs1,imm
SUB   rd,rs1,rs2
JAL   rd,imm
JALR  rd,imm(rs1)
```

```
_start:
  ADDI sp, zero, 0x700
  JAL ra, main
  EBREAK

times3:
```

```
main:
```

Q4. (10 points) **IPv6:**

(a) List equivalent representations that shorten the address `2001:0fc7:0:0:2a1:0:0:0` after applying all possible rules for simplification.

(b) How does Multicast work with IPv6?

(c) What tasks are fulfilled by the Neighbor Discovery Protocol? Describe two **in detail**.

Q5. (10 points) **HTTP & DNS:**

(a) Explain the new features introduced by HTTP/2.0. How is it different to previous HTTP versions?

(b) Describe the properties of AJAX, Long Polling, and Web Sockets in relation to overhead and the possibility to push data to the client.

(c) We usually rely on two types of DNS name servers. What is their purpose?

Good Luck!