Digital Design & Computer Arch.

Lab 4 Supplement:
Finite-State Machines

Prof. Onur Mutlu
ETH Zurich

Spring 2023

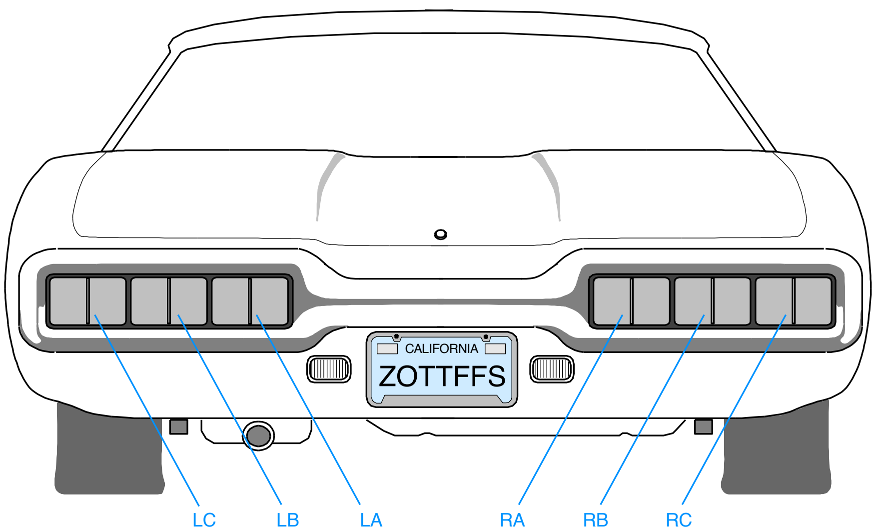
23 March 2023

What Will We Learn?

- In Lab 4, you will implement a finite-state machine using Verilog.
- Design and implement a simple circuit that emulates the blinking lights of a Ford Thunderbird.
- Understand how the clock signal is derived in the FPGA board.
- Write an FSM that implements the Ford Thunderbird blinking sequence.

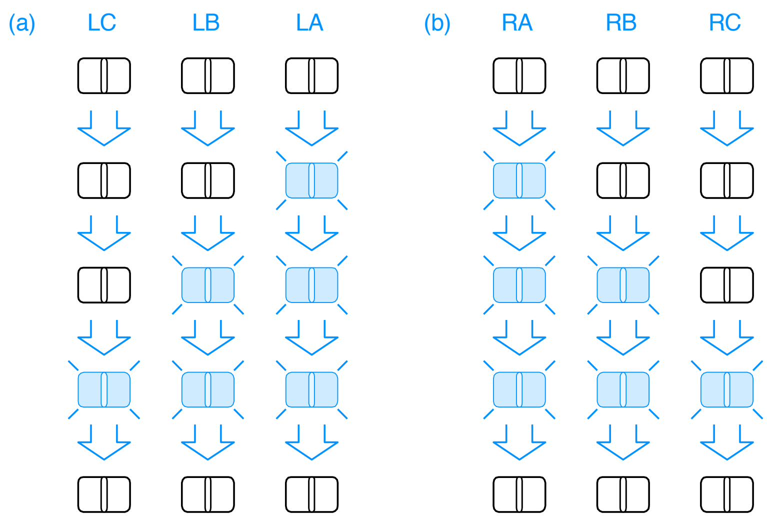
Tail Lights of a 1965 Ford Thunderbird

- In this lab, you will design a finite-state machine to control the tail lights of a 1965 Ford Thunderbird.



Tail Lights of a 1965 Ford Thunderbird

- There are three lights on each side that operate in sequence to indicate the direction of a turn.



Part 1: FSM Design

- An FSM must do three things:
  - **Next State Logic:** Determine the next state from the present state and the inputs.
  - **Output Logic:** Determine the output signals based on the present state and input signals.
  - **State Register:** keeps track of the present state; must be updated at every clock cycle.

The manual contains the details of this FSM specifications.

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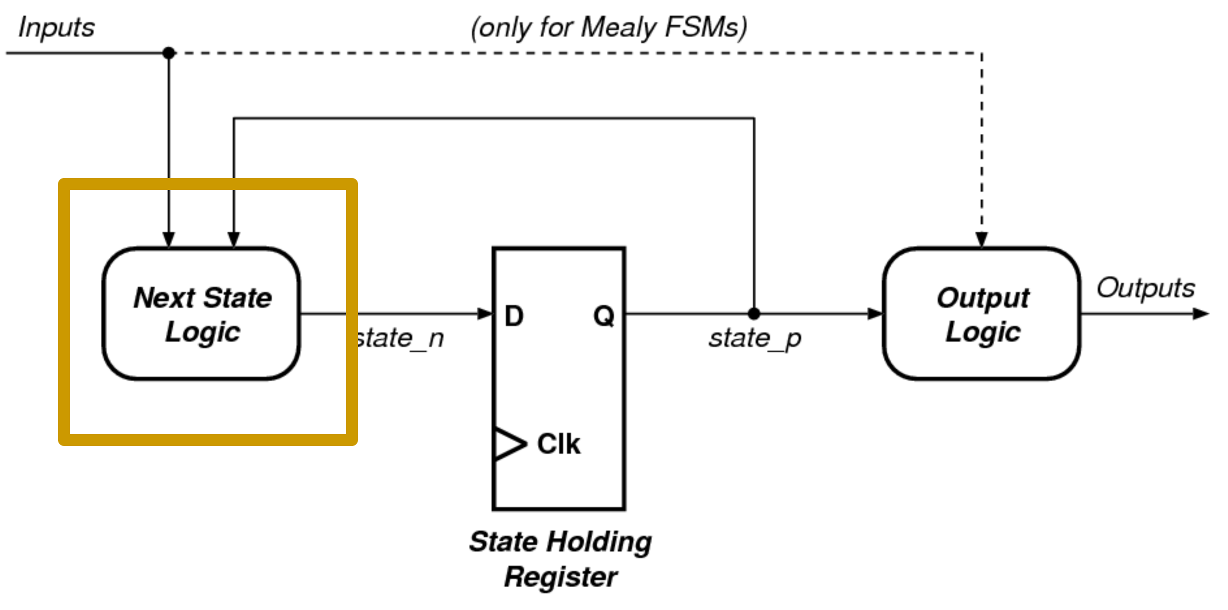
For more details, please refer to Lecture 5a:

- Slides 44+: Finite State Machines
- Slides 64+: Moore vs. Mealy FSMs

Part 2: Verilog Implementation

- Separate three parts of the code:



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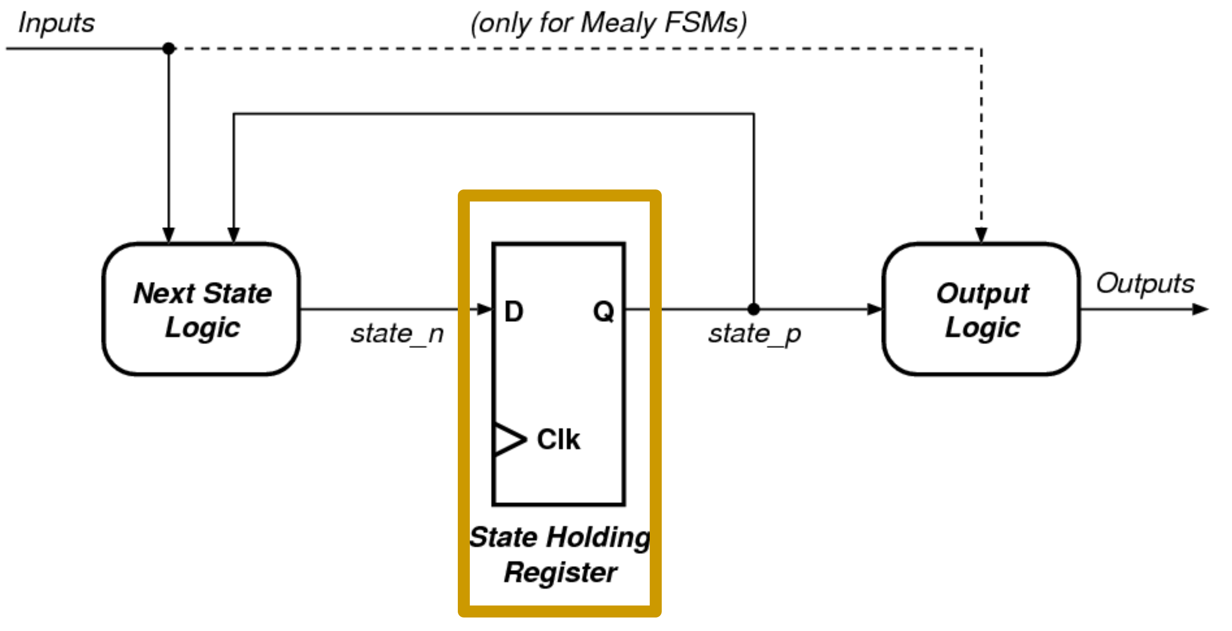

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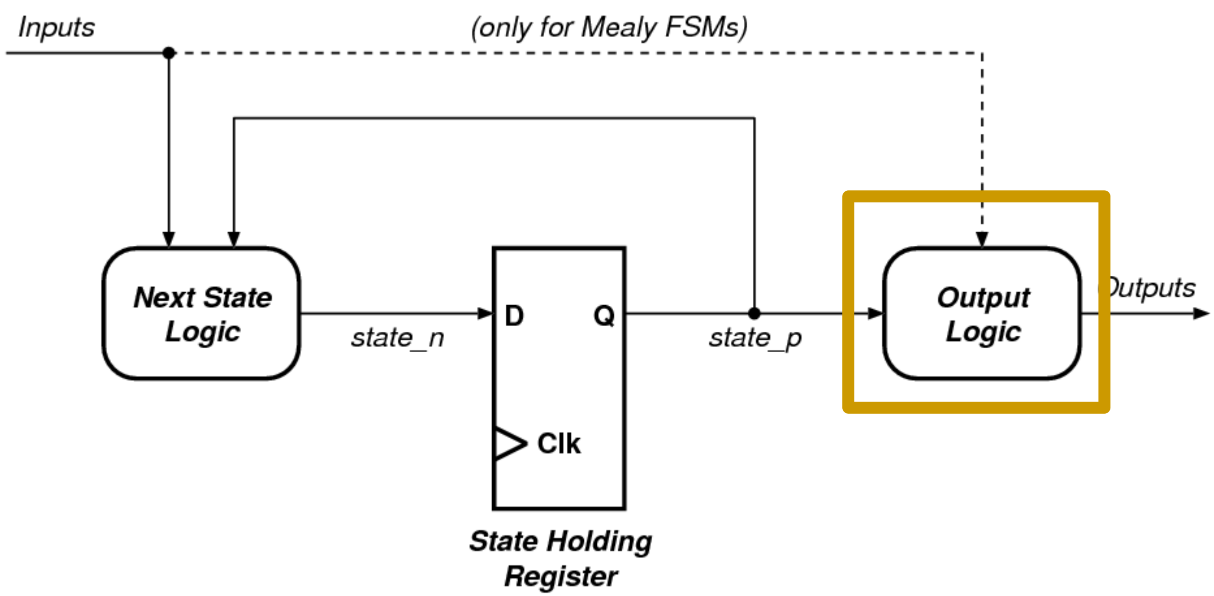
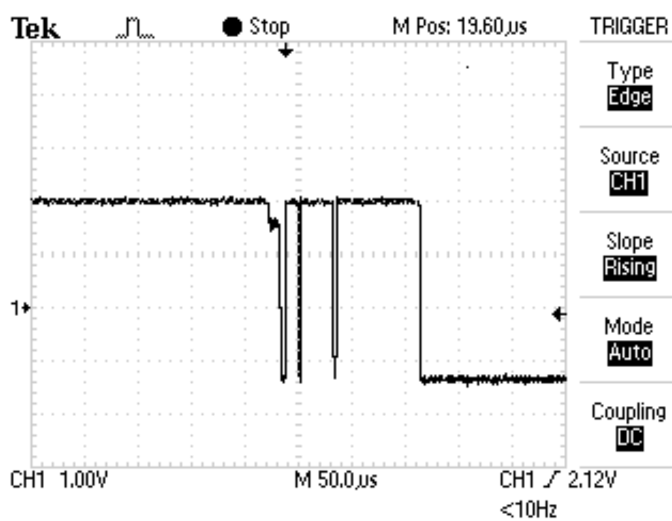


Part 3: Implementing the Clock (I)

- The problem of using push-buttons as clock:
  - Compared to the speed of the FPGA the change in a push button is *very* slow (~ 1 million times slower)
  - During the slow transition, the FPGA will see many fast occurring transitions and would interpret each of them as a clock edge. (Bouncing)



Part 3: Implementing the Clock (II)

- CLK100Mhz (W5): Your board contains a 100Mhz crystal oscillator circuit.
- Problem: The clock is too fast.
- Solution: A clock divider:

```
module clk_div(input clk, input rst, output clk_en);
  reg [24:0] clk_count;
 always @ (posedge clk)
 //posedge defines a rising edge (transition from 0 to 1)
   begin
    if (rst)
     clk_count <= 0;
    else
     clk_count <= clk_count + 1;
   end
  assign clk_en = &clk_count;
endmodule
```

Part 4: Defining the Constraints

- We must specify constraints for:
  - Buttons for control
  - LEDs for output lights
  - Connections for clock

The manual contains more information about the constraints.

Last Words

- In Lab 4, you will implement a finite-state machine using Verilog.
- Design and implement a simple circuit that emulates the blinking lights of a Ford Thunderbird.
- Understand how the clock signal is derived in the FPGA board.
- Write an FSM that implements the Ford Thunderbird blinking sequence.
- In the report you will implement a dimming function, so that the lights are not only on and off, but can have intermediate levels

Report Deadline

23:59, 21 April 2023

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