

Design of Digital Circuits: Lab Report		
Lab 4: Finite-State Machines		
Date		Grade
Names		
		Lab session / lab room

**You have to submit this report via Moodle.**

Use a zip file or tarball that contains the report and all other files you used for the report, i.e., the entire Verilog project folder and/or all schematics you drew. If any files are missing, it may negatively impact your grade. No shortcuts/links will be accepted.

Only one member from each group should submit the report. All members of the group will get the same grade.

The submitted file's name should be *Lab4\_LastName1\_LastName2\_LastName3.zip* (or *.tar*), where *LastName1*, *LastName2*, and *LastName3* are the last names of the members of the group.

The deadline for the report is a hard deadline and it will not be extended.

### Exercise 1. Implementing Dimmed LEDs (3 Points)

In this exercise, you need to make the transitions in Thunderbird tail lights smoother. Instead of directly turning on the LED when performing the left or right sequence, gradually increase the intensity of the next LED to see smoother transitions. It is completely up to you to design an appropriate state machine and decide on the implementation details. We recommend you to start simple by first making a single LED dimmed. Then, you can instantiate your module for dimming an LED in your top module that performs smoother transition in Thunderbird tail lights. You can find a reference implementation's behavior in the linked video:

<https://polybox.ethz.ch/index.php/s/Dp6s2bPkaU7QJmu>

#### **Tip: Pulse-Width-Modulation**

An LED is turned off when the signal driving the LED has logic-0 value. Similarly, as long as the signal driving the LED is logic-1, the LED glows with constant light intensity. In digital circuits, since a signal can only drive logic-0 or logic-1, we cannot make an LED glow with less intensity by driving a value between 0 and 1.

For a different intensity, we need to design a circuit that will continuously switch the LED between the ON and OFF states. Depending on the ratio of time spent while in the ON or OFF states, the LED will illuminate at a different level. For example, the LED's brightness will be roughly 50% of its maximum brightness if the circuit repeats the sequence of keeping the LED ON for 1 cycle and then keeping the LED OFF for 1 cycle,

while the brightness will be roughly 75% for the ON and OFF state durations of 3 and 1 cycles, respectively. This method is called Pulse-Width-Modulation (PWM).

## Feedback

If you have any comments about the exercises (e.g., related to mistakes in the text, the difficulty level, or anything else that will help us improve them), please submit them through Moodle, using the corresponding “Lab 4: Feedback” form:

<https://moodle-app2.let.ethz.ch/mod/feedback/view.php?id=889878>