CSC258H Lab 5: The GoldenEye Pen

1 Introduction

In this lab, we will implement the **variation** of a James Bond gadget – the Pen Grenade – from the 1995 movie "GoldenEye". At the following link is a video clip that shows the usage of it.

`https://www.youtube.com/watch?v=Vi4LmILZU0g`

At the link below is the device's official documentation at MI6 HQ.

`https://www.mi6-hq.com/sections/q-branch/pengrenade.php3?t=mi6&s=ge`

We will design and implement the circuit of an **upgraded** version of this pen that does "**4 clicks to arm, 5 clicks to disarm**", using the finite state machine design techniques that we learned from the lectures. You will design the circuit before the lab and test it in the lab.

Note: You must implement the upgraded version of the pen. No mark will be given to a circuit that does the original "3 clicks to arm, 3 clicks to disarm".

Required Submissions: This lab requires the submission of a circuit file ("`lab5.circ`") and a lab report ("`lab5report.pdf`") to MarkUs by **Tuesday, March 2, 10:00 PM**. Please read the syllabus regarding the late policy. All submitted work must be completed **individually**.

2 Before the Lab: Circuit Design

The main part of the circuit has **one input** (a push button), and one output (an LED that indicates whether the pen is armed). The push button connects to the **clock** inputs of all flip-flops used in the circuit. **Note: your circuit should NOT include any unnecessary input/output (e.g., an "enable" input)**. To complete the circuit design, you need to finish the following steps:

1. Determine what the different states are of the circuit.
2. Determine the transitions between the states, *i.e.*, draw the state transition diagram.
3. Determine the number of flip-flops that are needed to store these states.
4. Assign flip-flop values to each of the states, so that none of the transitions would cause unexpected behaviour.
5. Write down the state table according to the state transition diagram and the flip-flop value assignment.
6. Derive the combinational logic based on the state table.
7. Connect the flip-flops in the circuit diagram according to the derived combinational logic.
8. Determine the output value assigned to each state, *i.e.*, which states should be considered "armed" and which states should be considered "disarmed".
9. Derive the logic expression of the output in terms of flip-flop values.

10. Add the combinational logic for the output to the circuit diagram.

Additional reset input: To make the circuit easier to test, you should also add a "reset" input that sets the FSM to the initial state anytime you want. You have two options for implementing the reset input.

1. If you are using the D flip-flops that you implemented in previous labs, the reset function can be implemented by adding some AND logic at the input of each flip-flop. You can reset the circuit by first switching the reset input to 0 and then provide a positive edge of clock.

2. You can also use the D flip-flop symbol that is provided by Logisim-Evolution under `Memory`, which exposes `S` and `R` inputs. The value of the D flip-flop is immediately set to 1 whenever `S` is 1, and 0 whenever `R` is 1 – this is called an "asynchronous active-high set/clear". It is asynchronous because it does not depend on the clock signal, and it is active-high because the clear happens when `S/R` is high.

3 In the Lab: Implement and Test Your Circuit

In the lab, implement your design using Logisim-Evolution and test it to verify that your circuit works as expected. Demonstrate the circuit to your TA.

4 Lab Report

Include the following in your lab report named "`lab5report.pdf`".

1. Your name and student number.

2. Your state transition diagram with flip-flop values assigned.

3. Your state table and the K-maps for the combinational logic to be generated.

4. The expressions of the combinational logic.

5. The logic expression of the output LED (armed or disarmed).

6. A screenshot of the circuit diagram (in the poke/simulation mode) when the output LED just became "armed" (after the 4th click from the initial state). The screenshot should show which state the circuit is in by the wire colours.

5 Summary of TODOs

Below is a short summary of the steps to be completed for this lab:

1. Before the lab, design the circuit.

2. In the lab, implement your circuit using Logisim-Evolution and demonstrate it's operation to the TA.

3. Complete the lab report.

4. Submit `lab5.circ` and `lab5report.pdf` to MarkUs before the deadline.

Evaluation (2 marks in total):

- 1 marks for circuit design.
- 1 mark for the screenshot showing the first "armed" state.