CSCB58 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`

We will design and implement the circuit of an **upgraded** version of this pen that does "**6 clicks to arm, 4 clicks to disarm**", using the finite state machine design techniques that we learned from the lectures. You will design the circuit in the prelab report and demonstrate it in the lab.

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

Note: We only care about the "armed" and "disarmed" state. Please do not try to blow up your circuit and/or computer.

PRELAB REPORT: This lab requires the submission of a prelab report to Quercus to **by the start of your lab section**. The deadline shown on Quercus may not apply to you. Your TA will access your prelab submission during the lab and ask you about it.

2 Prelab: 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.

Complete and submit the **PRELAB REPORT** which includes the following content:

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. The circuit diagram.

3 In-Lab: Demonstrate your implemented Circuit

Design and test your circuit before your one-on-one session with the TA in your lab, and then **demonstrate the circuit to your TA**. You should also be able to answer any questions about the design of your FSM and how the states and transitions were assigned.

4 Summary of TODOs

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

1. Before the lab, design the circuit, complete and submit the prelab report. Implement and test your circuit based on the design.
2. In the lab, demonstrate your circuit's operation to the TA, and briefly describe your design decisions for the FSM.

Evaluation (5 marks in total):

- 3 marks for prelab report.
- 2 mark for the circuit in Logisim-Evolution.