Exercise 3: Combinational logic circuits with static hazard

The exercise has two parts. Each part has to be verified by the teacher. The student has to propose Boolean function of four variables f(abcd) that in minimized realization has static hazard (each person in a group proposes different function).

The steps of the exercise:

1. Build and test the sub-circuit used for hazard detection (based on flip-flop D_1, see Fig. 1). Check if LED1 and LED2 change their stated during changes of clock signal. LED1 should change its' state two times more frequently than LED2.
2. Build the circuit with hazard and connect it to the hazard detection sub-circuit. Observe LED1 to test if it realizes the proposed function f(abcd).
3. Observe LED1 and LED2 to test if hazard can be observed. Hazard manifests itself with change of the state of LED2 while the state of LED1 is not changed.
4. Ask the teacher to verify observation of hazard.
5. Modify the circuit to eliminate the hazard. After successful modification LED2 can change its' state only in result of visible change of state of LED1 (when change of value of single input changes value of f(abcd) from 1->0 or 0->1).
6. Ask the teacher to verify observation of proper circuit behavior and hazard elimination.

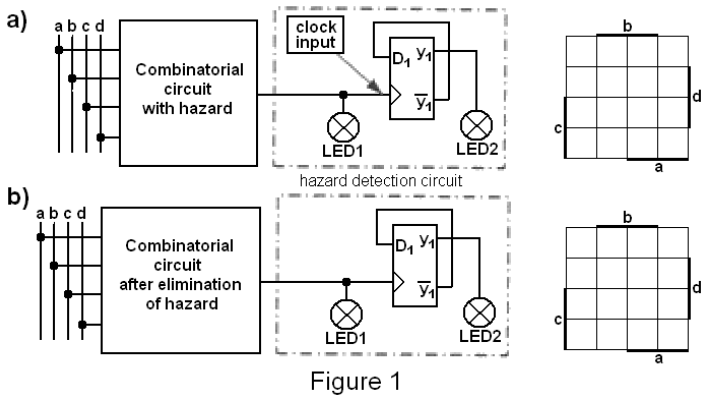

Figure 1

Content of the report:

- On page 1 shortly describe the phenomenon of static hazard for proposed Boolean function.
- On page 2 describe the principle of operation of the hazard detection circuit. Please give in points disadvantages of its use in relation to oscilloscope.
- On the last page please show circuits as proposed on Fig. 1. Instead of rectangles representing combinatorial circuit one should draw minimized circuit that realizes f(abcd) function (a) and the circuit after elimination of hazard (b).
- In the Karnaugh map (a) show groups of 1's related to minterms of Sum of Product (SOP) representation of f(abcd). To minimize the function make groups containing total number of terms in power of two like 2,4,8 ...(except 1) and try to cover as many elements as you can in one group. Show with an arrow the change of the state of the input variable that results with hazard. In the K-Map (b) show groups of minterms after elimination of hazard.

Comments:

1. In this exercise you can use only NAND and NOT gates.
2. If you are sure that the circuit is correct but the hazard is not detected please increase the delay causing hazard with additional NOT or NAND gates (without changing the function!)
3. Output signals should be connected to the display as shown on Fig.1 (LED1, LED2).
4. The round, crossed element represents light bulb not LED. It is used here for simplicity.