

## Homework 5

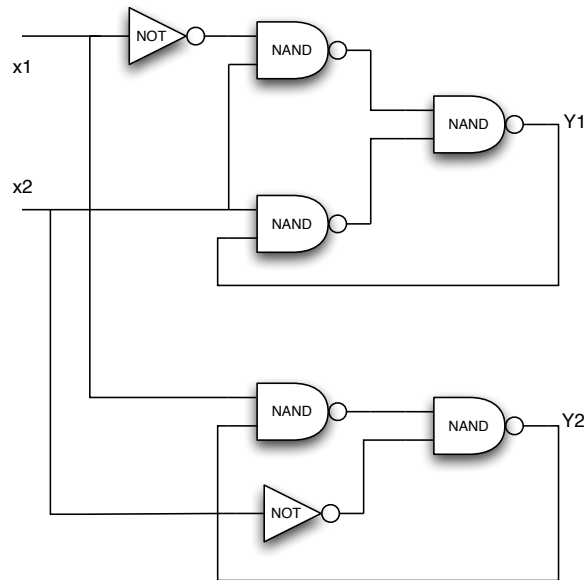
You may discuss the assignments with your classmates but need to write down your solutions independently. Be careful with your handwriting. Unclear solutions will be assumed wrong.

1. (10 pts) What are asynchronous circuits? And what are the benefits of asynchronous circuits over synchronous circuits?
2. (10 pts) What are static 1-hazard, static 0-hazard, and dynamic hazard? Prove that there can not be dynamic hazard in two-level logic circuits.
3. (20 pts) Consider whether each of the following two-level logic circuits is hazard-free, and if not, make it hazard-free.

(a)  $\bar{a}c + b\bar{c} + c\bar{d}$

(b)  $(a + c)(\bar{b} + \bar{c} + \bar{d})$

4. (20 pts) Derive the transition table for the following asynchronous sequential circuit. Is it hazard-free? Determine the sequence of internal states for the following sequence of inputs  $x_1x_2$ : 00, 10, 11, 01, 11, 10, 00.



5. (15 pts) Draw a waveform for using dual-rail encoding and 4-phase handshake to communicate three 2-bit data (0, 0), (1, 1), (1, 0) between two components.
6. (25 pts) Design an asynchronous FIFO buffer which can store up to two 1-bit data.