


1.5 Hazards in Combinational Circuits

1 Definition

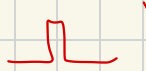
When the input to comb. circuit changes, unwanted **switching transients** may appear in the output.

- These transients occur when different **paths** from input to output have different propagation delays.

2 Types

1. static 1 hazard ()

In response to an input change and **for some combination of propagation delays**, a circuit output may momentarily go to 0 when it should remain a constant 1.

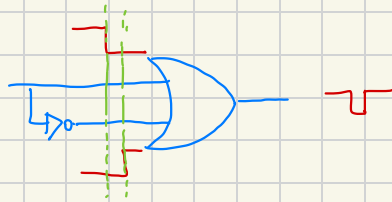
2. static 0 hazard ()

if the output may momentarily go to 1 when it should remain at 0.

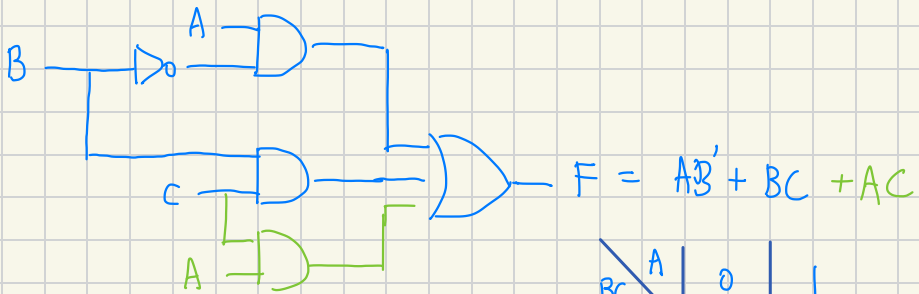
3. dynamic hazard ($\Sigma\Sigma\Sigma$, $\Sigma\Sigma\Sigma$)

when the output is supposed to change from 0 to 1 (or 1 to 0), and the output may change ≥ 3 times.

Ex 1. static 1 hazard



3 Elimination of Static 1 Hazard



AC removes the 1-hazard in the original circuit

$BC \backslash A$	0	1
00	0	1
01	0	1
11	1	1
10	0	0

identifying static hazards in a given circuit:

- static 1 hazard
 - Write an expression for the output in terms of the inputs exactly as it is implemented in the circuit & manipulate it to SOP form, treating x_i and x_i' as independent variables,
 - ↳ testing the circuit under non-ideal conditions
 - A K-map can be constructed, and all implicants corresponding to each term can be circled.
 - If any pair of adjacent 1's is not covered by a single term, a static 1 hazard can occur.
- static 0 hazard
 - POS

4 Design of Hazard-free Circuits

- hazard-free : free of static and dynamic circuits.
- Method 1 : Sum of Products (SoP)
 - Find a SoP expression (F^t) for the output in which every pair of adjacent 1's is covered by a 1-term (i.e. an AND-term)
 - o A 2-level AND-OR circuit based on F^t will be hazard-free.
 - If a different form of circuit is desired, manipulate F^t to the desired form by using simple factoring, De Morgan's Law, and so on.
Treat x_i and x_i' as independent variables to prevent introduction of hazards.

★ Exercise of 1.5

For the circuit below,

(a) Find all of the static 1 hazards in the circuit. (identify)

(b) Indicate which changes are necessary to eliminate the hazards, and derive the revised equation of F . (elimination)