HAZARDS (1)

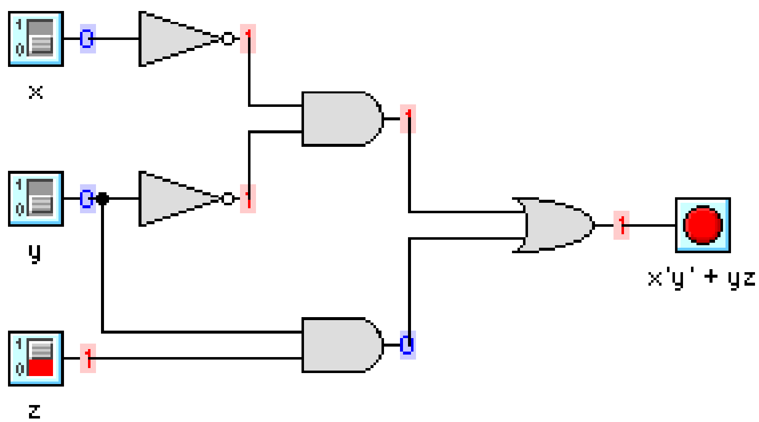
- A **hazard** is a condition in a *logically correct* digital circuit or computer program that may lead to a logically incorrect output
- Static hazards: Output should stay constant, but doesn't
  - ▷ Static 1 hazard: Output should be a constant 1, but when one input is changed drops to 0 and then recovers to 1
    - ◦ Cannot occur in a POS implementation
  - ▷ Static 0 hazard: Output should be a constant 0, but when one input is changed rises to 1 and then drops back to 0
    - ◦ Cannot occur in a SOP implementation

HAZARDS (2)

- **Why do hazards matter?**
  - ▷ The output of a hazard-prone circuit or program depends on conditions other than the inputs and the state
  - ▷ The signal passed to another circuit by a hazard-prone circuit depends on exactly when the output is read
  - ▷ In edge-triggered logic circuits, a momentary glitch resulting from a hazard can be converted into an erroneous output

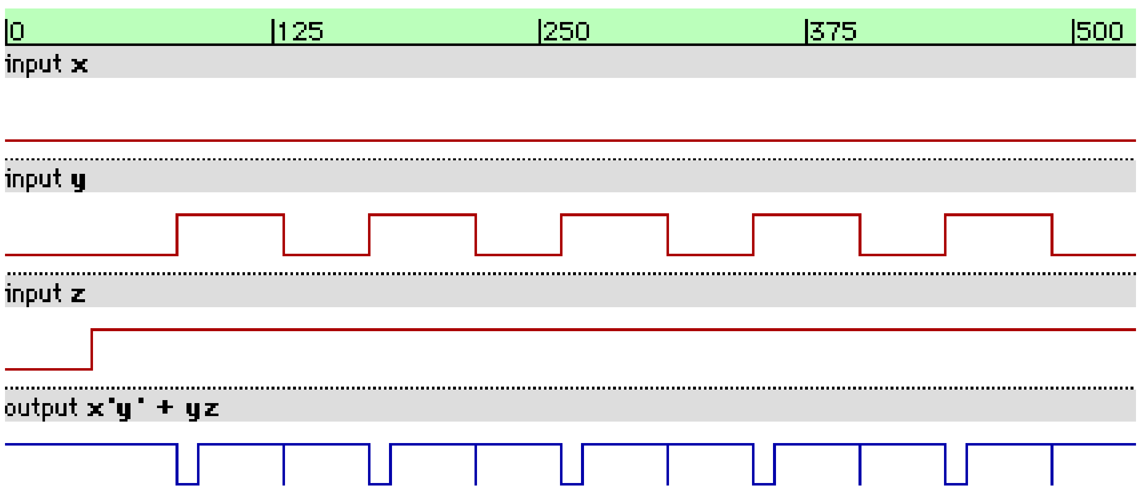
HAZARDS (3)

- The circuit below for $\overline{xy} + yz$ has a static 1 hazard
  - ▷ If the input y is changed from 0 to 1, control of the output of the OR gate shifts from one AND gate to the other
  - ▷ Any difference in delays between the two AND gates will result in a glitch in the output of the OR



HAZARDS (4)

- The timing diagram below shows the inputs and outputs of a circuit for $\overline{xy} + yz$ with a static 1 hazard

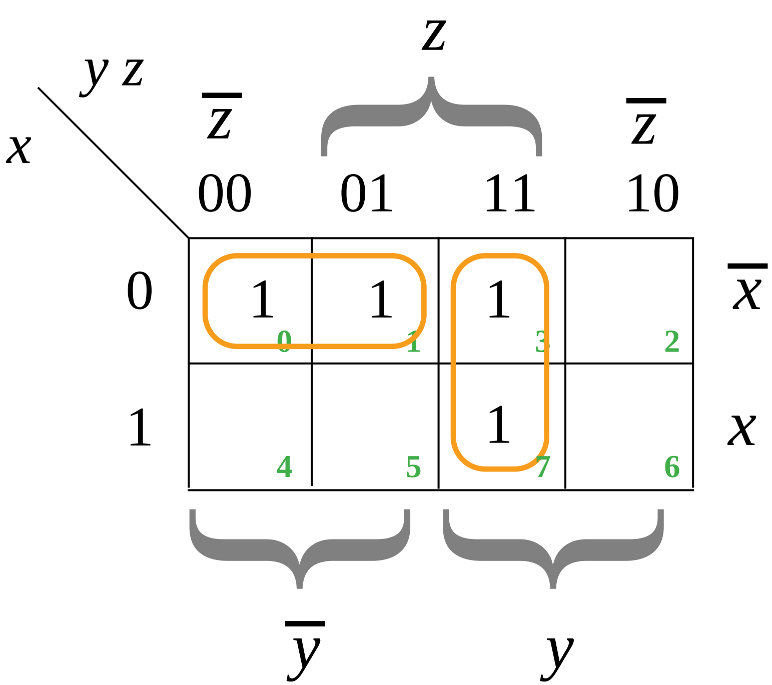


HAZARDS (5)

- Static 1 hazard detection using a Karnaugh map:
  - ▷ Reduce the logic function to a minimal sum of prime implicants
  - ▷ A Karnaugh map that contains adjacent, disjoint prime implicants is subject to a static 1 hazard
    - ◦ Adjacent prime implicants: Only one variable needs to change value to move from one prime implicant to the other
    - ◦ Disjoint prime implicants
      - ◇ No prime implicant covers cells of both of the disjoint prime implicants
      - ◇ Correspond to AND gates that must both change their outputs when a particular input is changed

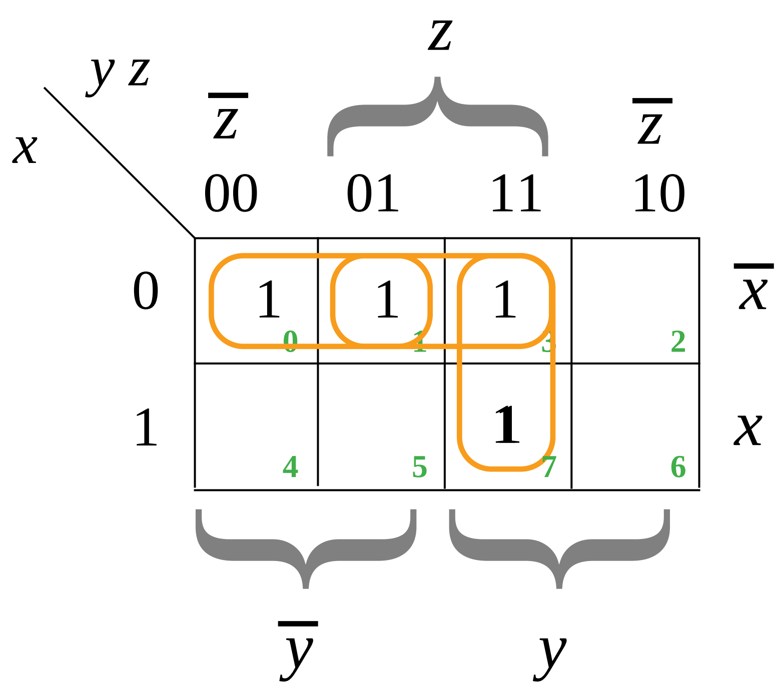
Hazard detection

$$F(x,y,z) = \Sigma m(0,1,3,7)$$



$$F(x,y,z) = \overline{x}\,\overline{y} + yz$$

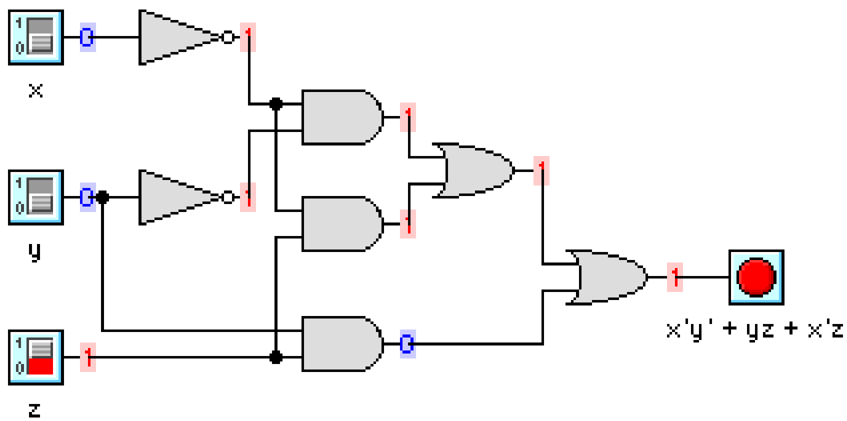
Hazard elimination



$$F(x,y,z) = \bar{x}\bar{y} + yz + \bar{x}z$$

HAZARDS (6)

- The circuit below for $\overline{xy} + yz$ has no static 1 hazard



HAZARDS (7)

- The timing diagram below shows the inputs and outputs of a revised circuit for $\overline{xy} + yz$ with no static 1 hazard