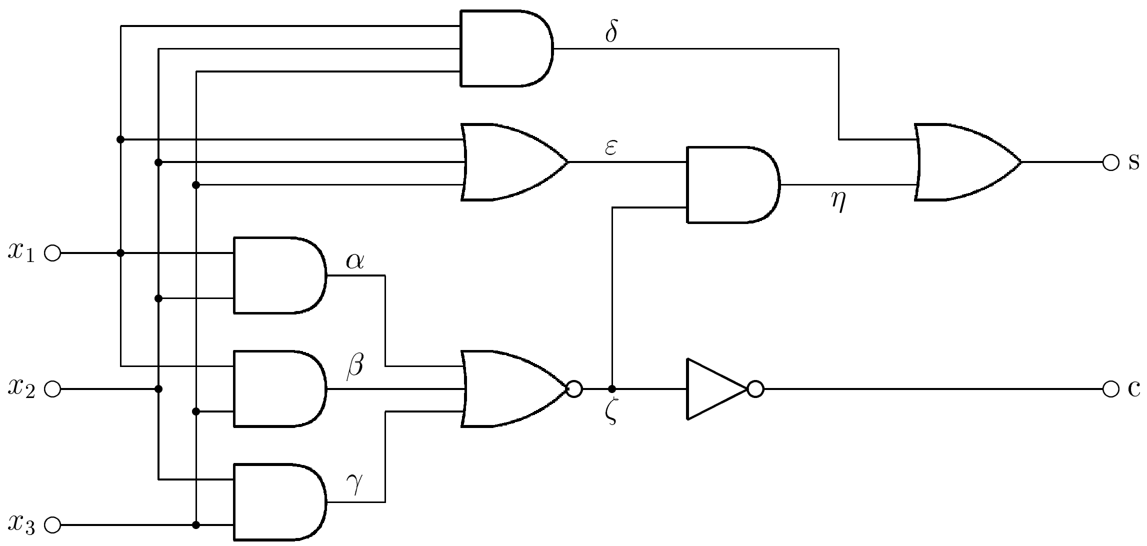
3 Test Pattern Generation

Problem 3.1: Test setup.

Devise a combinational circuit $\mathcal{C}$ with some signal S and a test t such that t detects both S stuck-at-0 and S stuck-at-1.

Problem 3.2: Boolean differences.



The circuit shown above realizes a full-adder. Use Boolean differences to solve the following questions.

Question 1 Determine all tests for x_1 stuck-at-0 and x_1 stuck-at-1.

Question 2 Determine all tests for x_2 stuck-at-0, x_2 stuck-at-1, x_3 stuck-at-0, and x_3 stuck-at-1.

Question 3 Determine all tests for s stuck-at-0, s stuck-at-1, c stuck-at-0, and c stuck-at-1.

Question 4 Determine all tests for ζ stuck-at-0 and ζ stuck-at-1.

Question 5 Determine the minimal test pattern set that tests all single stuck-at faults on x_1, x_2, and x_3.

Question 6 Determine the minimal test pattern set that tests and uniquely identifies all single stuck-at faults on x_1, x_2, and x_3.

Question 7 Suggest a minimal number of test patterns achieving 100% fault coverage.

Problem 3.3: Boolean differences.

Two Boolean functions f and F can be written as

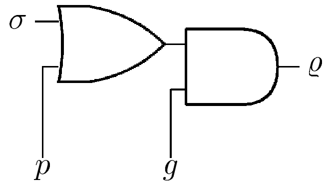
$$f(x, \boldsymbol{y}, \boldsymbol{z}) = g(h(x, \boldsymbol{y}), \boldsymbol{z}) \qquad \text{and} \qquad F(x, \boldsymbol{y}, \boldsymbol{z}) = G(H(x, \boldsymbol{y}), K(x, \boldsymbol{z})).$$

Question 1 Prove the simple chain rule

$$\frac{\partial f(x, \boldsymbol{y}, \boldsymbol{z})}{\partial x} = \frac{\partial g(h(x, \boldsymbol{y}), \boldsymbol{z})}{\partial h(x, \boldsymbol{y})} \cdot \frac{\partial h(x, \boldsymbol{y})}{\partial x}$$

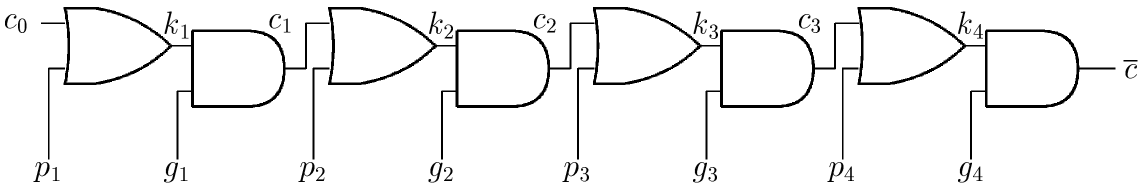
Question 2 Show that a similar relationship does not hold

$$\frac{\partial F}{\partial x} \neq \frac{\partial G}{\partial H} \cdot \frac{\partial H}{\partial x} + \frac{\partial G}{\partial K} \cdot \frac{\partial K}{\partial x}$$



Question 3 In the circuit above, σ is a function of x. Show the following relation

$$\frac{\partial \varrho}{\partial x} = g \cdot \overline{p} \cdot \frac{\partial \sigma}{\partial x}$$



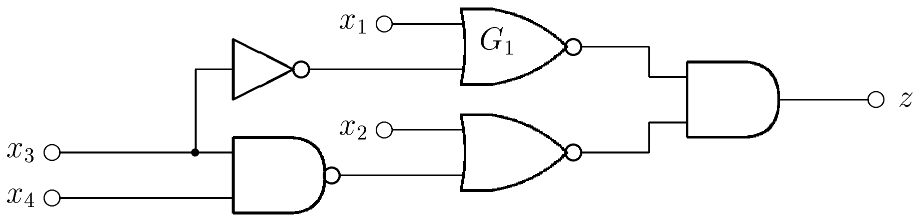
Question 4 For the carry-lookahead circuit shown above, calculate all tests for c_0 stuck-at-0 and c_0 stuck-at-1.

Question 5 Calculate the Boolean differences $\frac{\partial c}{\partial p_i}$ and $\frac{\partial c}{\partial g_i}$ for all values of i.

Question 6 Four test patterns have been suggested for the carry-lookahead circuit $(c_0, p_1, p_2, p_3, p_4, g_1, g_2, g_3, g_4)$:
(100001111), (000001111), (011000011), and (011000111).
Indicate all nodal single stuck-at faults tested by the 4 test patterns and calculate the fault coverage.

Question 7 Suggest a minimal number of test patterns achieving 100% fault coverage.

Problem 3.4: **Test generation.**



Question 1 Determine the output function for the circuit above under the presence of the fault an AND bridge between the inputs of gate G_1.

Question 2 Determine the output function under the presence of the multiple fault (x_3 stuck-at-1, x_2 stuck-at-0).

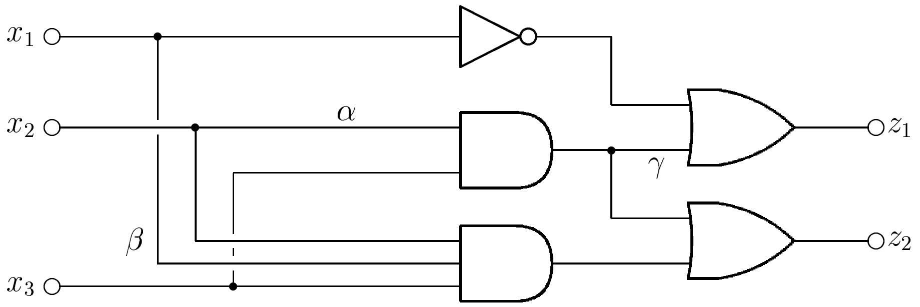
Question 3 Which of the tests (0111), (1111), (1101), and (1010) detects the fault x_1 stuck-at-0 ?

Question 4 Find all tests that detect the fault x_3 stuck-at-0.

Question 5 Find all tests that detect the fault x_2 stuck-at-0.

Question 6 Find all tests that detect the fault x_2 stuck-at-1.

Problem 3.5: **Fault diagnosis.**



Question 1 Find the set of all tests that detect the fault β stuck-at-1 in the circuit above.

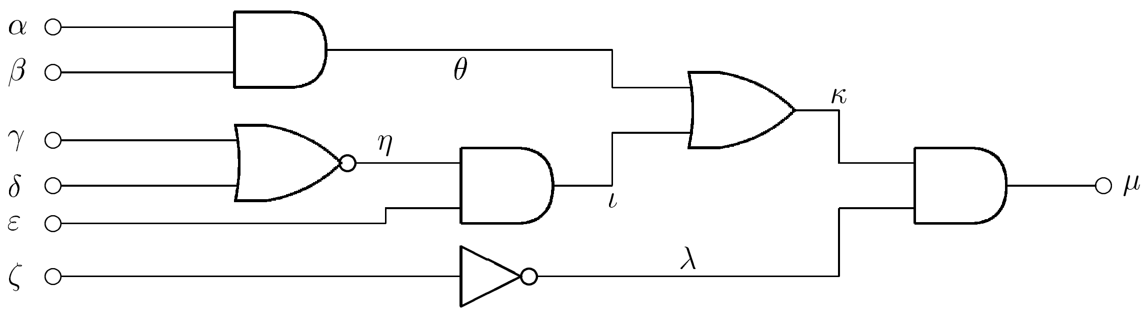
Question 2 Find the set of all tests that distinguish the faults α stuck-at-0 and γ stuck-at-0.

Question 3 Find the set of all tests that distinguish the multiple faults (α stuck-at-0, β stuck-at-1) and (β stuck-at-1, γ stuck-at-0).

Problem 3.6: **D-notation.**

Construct the 5-valued truth table of an EXOR function of two inputs (the five logic values 0, 1, X, D and $\overline{D}$).

Problem 3.7: Test generation algorithms.

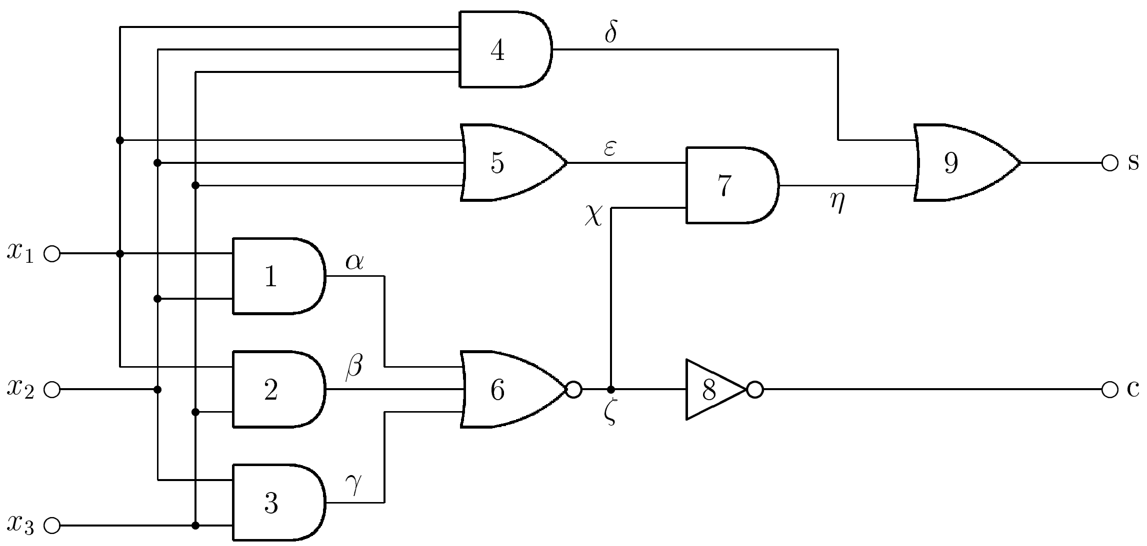


Question 1 Use the D-algorithm to generate a test for the fault θ stuck-at-1.

Question 2 Use the Podem algorithm to generate a test for the fault θ stuck-at-1.

Question 3 Determine all other faults detected by this test.

Problem 3.8: Test generation algorithms.



Question 1 Use the D-algorithm to generate a test for the fault χ stuck-at-0 in the full-adder shown above. Indicate all decision points.

Question 2 Use the Podem algorithm to generate a test for the fault χ stuck-at-0. Indicate all decision points.

Question 3 Determine all free lines, head lines and bound lines of the full-adder.

Question 4 Use the FAN algorithm to generate a test for the fault χ stuck-at-0. Indicate all decision points.