National University

of Computer and Emerging Sciences Chiniot-Faisalabad Campus

EE1005 – Digital Logic Design
Assignment – 4
Spring 2024

Instructor: Muhammad Adeel Tahir
Sections: BS-SE 2B

Maximum Marks: 100 **Due Date:** Tuesday, 2nd April 2024

- Partially or fully **copied assignments** will be marked as **zero**.
- Only **handwritten** solution on **A4 page** will be accepted.
- Submission on the GCR by the deadline is **Compulsory.**
- Late submissions are not allowed. In case of late submission, assignment will not be accepted.
- Clearly indicate all the calculations in your solution. No points will be awarded in case of missing calculations.
- You can submit your assignment **during the class** on due date. But submitting on GCR as mentioned is compulsory.
- **A formatted submission sheet is uploaded along this assignment. You must use this in printed form and answer your questions on it. Any cutting or bad handwriting will lead to straight 0 in whole assignment. Incase of not using the formatted submission sheet, the assignment will be marked as 0.**
- **Proper calculations including k-map and circuit diagram labelling at each output, simplifications if any are to be implemented, missing steps will receive zero marks in that question straight away.**

Question 1: **(5+5+5= 15 marks)**

Design a combination circuit with N inputs and 3 outputs, X, Y, Z. The inputs represent a binary number, and the outputs represent characteristics of the numbers. Specifically. X should be true if the number is divisible by 3; Y should be true if the number is divisible by 4; and Z should be true if the number is divisible by 7. Suppose N = 4:

Use A_0, A_1. $A_{n...}$ *for the naming convention of input variables. Where* A_0 *is the LSB. Using naming convention other than mentioned above will lead to a 0.*

(a) Design the truth table for this problem.
(b) Implement the circuit with AND gates, OR gates, and NOT gates separately. Use k-map to simplify the output equations.
(c) Can this be reduced or simplified further using XOR gates? If yes, how? You do not need to implement the circuit but show proper working.

Question 2: (3+3+4 = 10 marks)

Before take-off, the pilot and co-pilot of an aircraft carry out preflight safety checks. When all checks have been completed, they each move a switch from the up to the down position.

- When both switches are up, a red indicator on the instrument panel is on.
- This changes to yellow when at least one of them operates their switch.
- When both have operated their switches, a green indicator comes on.
- The engines can only be started when the green indicator is on.

Assume that the switches provide logic level 0 in the up position and logic level 1 in their down position. The LED indicators operate on logic level 1.

a) Write truth table for this circuit.
b) Make circuit diagram for individual outputs, then show a combined circuit. Properly label each question carefully.
c) Explain the assumptions/understanding of the problem in your own words, how did you approach the above problem, what sequence of steps did you take to justify your truth table. **Only 4-5 points which are precise and clear cut.**

Question 3: (4+4+2 = 10 marks)

You are tasked with the design of a combination circuit, operating on certain principles of digital logic. This circuit is characterized by three inputs and three outputs. The inputs are denoted as x, y, and z, while the outputs are represented as A, B, and C. The functionality of this circuit is defined by a specific set of rules based on the binary input values. When the binary input, represented by the combination of x, y, and z, is either 0, 1, 2, or 3, the output is designed to be (N) greater than the input. This means that the circuit performs an increment operation on the input in these cases. On the other hand, when the binary input is 4, 5, 6, or 7, In these cases, the circuit performs a decrement operation on the input. Value is decremented by 2. Handle the don't care conditions carefully. Where N = 1.

a) Draw truth table of the above circuit.
b) Implement the circuit diagram.
c) Explain why and how you chose the DON'T CARE conditions as implemented in part (a) *Answering this wrong will lead to 50% deduction in the overall obtained marks in this question.*

Question 4: **(5+3+2 = 10 marks)**

Devise a sophisticated combinational circuit aimed at determining the equality between two sets of 4-bit numbers. The circuit should yield an output of 1 when the two numbers are identical and 0 otherwise. For this purpose, only the most feasible and to the point solution will be marked as correct. Solving it without using **at least one** of the following gates (XNOR only, NAND only, NOR only) will lead to a straight 0.

a) Draw Truth table for this question in steps, direct steps will lead to a straight 0.
b) Choose the most suitable gate implementation for this question (all gates must be 2-input at the first level). Only the best one will be marked as correct.
c) Why did you choose the above gate implementation? **Maximum 4-5 points which are precise and clear cut.**

Question 5: **(5+5 = 10 marks)**

A combinational switching circuit has four inputs (A, B, C, D) and one output (F). F=0 iff three or four of the inputs are 0.

(a) Write the maxterm expansion for F.
(b) Using AND, OR gates, find a minimum three-level circuit to realize F. *(2-input gates at first level, 3 input gates at second level, 2 input gates at third level) Label each gate output in neat and clean handwriting, any cutting or bad handwriting will lead to a 0 in that question.*

Question 6: **(5+5+5 = 15 marks)**

Imagine a sophisticated switching circuit, an intricate network of electronic components, that is fed by four distinct inputs. These inputs are not random but carry significant information. Inputs A and B are not merely binary digits, but together they represent the first and second bits of an unsigned binary number, which we shall refer to as N1. Similarly, inputs C and D, while individually representing binary digits, collectively form the first and second bits of another unsigned binary number, denoted as N2.

The circuit is designed with a specific functionality in mind. It is tasked with producing an output of 1, but this output is contingent on a particular condition being met: the mathematical product of N1 and N2 must be less than or equal to 3. If this condition is not satisfied, the circuit defaults to an output of zero. Your challenge is to decipher the conditions under which this output is realized.

a) Implement the truth table of the above circuit.
b) Draw the circuit diagram using no more than 2 gates.

c) Explain your design in 3-4 lines including your assumptions, in case the explanation of the implemented circuit is wrong, the question will receive a straight 0.

Question 7 **(5+5+5 = 15)**

You are tasked with the design of a combinational circuit. This circuit is to be characterized by its ability to process a three-bit binary number as its input. The uniqueness of this circuit lies in its output generation. The output is not a mere reflection of the input. Instead, it is a binary number that represents the square of the input number.

(a) Draw the truth table of this circuit
(b) Implement the circuit diagram
(c) How does changing the square to calculating the cube of the input affect our circuit? Explain in 3-4 lines.

Question 8 **(5+3+2+5 = 15 marks)**

Mr James has invested a huge amount of money into buying and selling land. Before he buys a certain land, he must get input from three sources. His first source is Jimmy, a famous property dealer. His second source is Meg, a self-made millionaire in this business, and his third source is Carl, his best friend. After several months of receiving advice from all three, he has come to the following conclusions:
A). Buy if all three say yes.
B). Buy if the Carl says yes and Meg says no.
C). Buy if both the Carl and Jimmy says no.
D). Buy if Jimmy and Meg both say yes even if the Carl says no.
E). Don't buy otherwise.

Your task is to:

a) Explain the process of designing a combinational circuit in general step by step. Write it in your own words but keep it precise. (Limit 5-6 lines) *(Using GPT or copying from any other source will get you zero as it will be checked for this specific purpose, you may take help but first understand it and then write in your own words, there is no restriction on using wrong vocabulary or grammar, but it must be understandable at least)*
b) Implement the truth table of the above question
c) Write the equation in term of SOP
d) Optimize the equation using k-map properly showing grouping and labelling each pair's output in the diagram itself.
e) Draw circuit diagram.