Indian Institute of Science Education and Research, Bhopal
ECS 326/676: Digital Circuits and Systems

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Instructions

Kindly let me know if there are any updates or corrections that need to be made. Good luck and have fun!

For any queries/clarifications/mistakes, feel free to reach out to me at `ishanya21@iiserb.ac.in`.

Note: You can try out more questions beyond the ones listed here. This is not the end of it. All decisions are up to the instructor of the course.

Questions

1. Boolean Algebra

1. Simplify the following Boolean expression: $A \cdot (B + C) + A' \cdot (B' + C')$.
2. Using Boolean algebra, prove that $A + AB = A$.
3. Simplify the expression $(A' + B' + C)(A + B + C)(A' + B)$ using Boolean algebra.
4. Prove that $(A \cdot B) + A' = (A + B) \cdot (A' + B')$ using Boolean identities.
5. Derive a minimal SOP (Sum of Products) form for the Boolean function $F(A, B, C, D) = A'BC + AB'C + A'B'C'$.

2. Simplify the Function

1. Simplify the function $F(A, B, C) = AB + A'C + B'C$ using Boolean algebra.
2. Given the Boolean function $F(A, B, C, D) = AB + A'C + B'D$, find its minimal representation using Boolean identities and Karnaugh maps.
3. Find the simplest expression for $F(A, B, C, D) = A'BC + AB'C' + AC$ using Boolean algebra and Karnaugh maps.
4. Using Boolean algebra, simplify $F(A, B, C, D, E) = AB + A'C + BC'D$, and implement it with the minimum number of gates.
5. Derive the minimal Boolean expression for the function $F(A, B, C) = A'B + A'BC + A'B'C$.

3. Number Systems: Binary, Decimal, Octal, Hexadecimal

1. Convert the binary number 1011011_2 to its equivalent decimal, octal, and hexadecimal forms.
2. Perform the subtraction $110101_2 - 10101_2$ and express the result in hexadecimal.
3. Convert the octal number 345_8 to binary, decimal, and hexadecimal.
4. Convert the hexadecimal number $C7_{16}$ to binary, octal, and decimal.
5. Perform the addition of 101110_2 and 110111_2 and express the result in both binary and hexadecimal.

4. Complement of a Function

1. Find the complement of the Boolean function $F = (A + B)(C + D)(A' + B')$.
2. Compute the complement of the Boolean function $F = A'B + AB' + A'C$ and implement the result using only NAND gates.
3. Find the complement of the Boolean function $F = A \cdot (B + C) + A' \cdot (B \cdot C)$ using Boolean algebra and draw its corresponding logic circuit.
4. Derive the complement of $F = AB + A'B'C$ using Boolean identities.
5. Using Boolean algebra, derive the complement of the function $F = (A + B') \cdot (C + D') \cdot (A' + B)$.

5. Karnaugh Maps: 3-variable, 4-variable, 5-variable

1. Simplify the Boolean function $F(A, B, C) = A'BC + AB'C + AB'C'$ using a 3-variable Karnaugh map.
2. Simplify the Boolean expression $F(A, B, C, D) = AB + A'C + BD$ using a 4-variable Karnaugh map and draw the simplified circuit.
3. Use a 4-variable Karnaugh map to simplify the Boolean function $F(A, B, C, D) = A'B'C + A'BC + AB'C'$ and show the steps for minimal expression.
4. Simplify the 5-variable Boolean function $F(A, B, C, D, E) = AB'C + A'BC + C'D$ using a 5-variable Karnaugh map.
5. Solve for the minimal expression using a Karnaugh map for $F(A, B, C, D) = A'B'C + A'BC + AB'C' + ABCD$.

6. Prime Implicants

1. Find the prime implicants for the Boolean function $F(A, B, C, D) = AB'C' + A'BC + AB'C$.
2. Derive the prime implicants for $F(A, B, C, D) = A'B + C'D + A'BC$ using a Karnaugh map.
3. Determine the prime implicants for the Boolean expression $F(A, B, C, D) = A'BC + AB'C + B'D$.
4. Using a Karnaugh map, find the prime implicants for the Boolean function $F(A, B, C, D, E) = A'B + C'D + AB'C$.
5. Find the minimal SOP form using the prime implicants for the function $F(A, B, C, D) = ABCD + A'BC$.

7. NAND and NOR

1. Implement the function $F(A, B, C) = A \cdot B + A' \cdot B'$ using only NAND gates and derive its truth table.
2. Show how to implement the Boolean expression $F(A, B) = A + B$ using only NOR gates and provide the simplified logic circuit.
3. Convert the Boolean expression $F(A, B, C) = AB + A'C$ into an equivalent logic circuit using only NAND gates.
4. Implement the following Boolean function $F(A, B, C) = A \cdot (B + C) + A' \cdot B$ using only NOR gates.
5. Prove that NAND gates alone can be used to realize all the basic logic gates (AND, OR, NOT), and show the corresponding circuits.

8. Don't-Care Conditions

1. Simplify the Boolean function $F(A, B, C) = AB + A'C$ using a Karnaugh map with the condition that $F = 1$ when $A = 0$ and $B = 1$.

2. Simplify $F(A, B, C, D) = A'B + C'D$ using the Karnaugh map, where $D = 1$ is a don't-care condition.

3. Minimize the Boolean function $F(A, B, C, D) = AB + A'C + BD$ with the don't-care condition $C = 1$.

4. Simplify the expression $F(A, B, C) = A'B + AC$ with a don't-care condition for $B = 0$.

5. Simplify the Boolean function $F(A, B, C, D) = ABCD + A'B'C'$ considering the don't-care condition where $C = 0$.

Questions from references

The following questions are referenced from the book *Digital Design with an Introduction to the Verilog HDL, Fifth Edition* by M. Morris Mano and Michael D. Ciletti. The questions could help in deeper understanding and exploration.

Chapter 1

☐ 1.5 ☐ 1.6 ☐ 1.9

Chapter 2

☐ 2.4 ☐ 2.8 ☐ 2.9 ☐ 2.10 ☐ 2.14 ☐ 2.18 ☐ 2.19 ☐ 2.20
☐ 2.22 ☐ 2.30 ☐ 2.31

Chapter 3

☐ 3.4 ☐ 3.7 ☐ 3.9 ☐ 3.10 ☐ 3.17 ☐ 3.23 ☐ 3.28 ☐ 3.29

Chapter 4

☐ 4.5 ☐ 4.8 ☐ 4.9 ☐ 4.11 ☐ 4.12 ☐ 4.28 ☐ 4.29 ☐ 4.33

Chapter 5

☐ 5.2 ☐ 5.3 ☐ 5.6 ☐ 5.9 ☐ 5.10 ☐ 5.11