Department of Computer Engineering
Faculty of Engineering, University of Peradeniya

CO221 : Digital Design
Lab 4 - Prelab

THEORY

The given below is a truth table for three inputs A, B, C that gives the output F.

Inputs			Output (F)
A	**B**	**C**	
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

Let's see how to write the logic equation for F using the method called sum of min terms and then simplify it by using few laws in Boolean algebra.

- For A=0, B=0, C=0; output is 1 and hence the corresponding minterm is $\bar{A}.\bar{B}.\bar{C}$
- The next F=1 is for A=0, B=1, C=0 and the minterm is $\bar{A}.B.\bar{C}$
- Similarly, we can write minterms for all cases where the output is 1. When doing so if the input(X) is 1 we put X and if X is 0 we put $\bar{X}$.
- Finally, we get the equation for F by writing the sum of all the minterms as

$$F = \bar{A}.\bar{B}.\bar{C} + \bar{A}.B.\bar{C} + \bar{A}.B.C + A.\bar{B}.\bar{C} + A.B.\bar{C}$$

- Now we can use the commutative law (A+B=B+A) to rearrange terms as

$$F = \bar{A}.\bar{B}.\bar{C} + A.\bar{B}.\bar{C} + \bar{A}.B.\bar{C} + A.B.\bar{C} + \bar{A}.B.C$$

- Then using the distributive law (A.B+A.C = A.(B+C))we can write as

$$F = (\bar{A} + A).\bar{B}.\bar{C} + \overline{(A} + A).B.\bar{C} + \bar{A}.B.C$$

- Next using the complement (A+$\bar{A}$ = 1) we can rewrite as $F = 1.\bar{B}.\bar{C} + 1.B.\bar{C} + \bar{A}.B.C$
- Then using the identity law (A.1=A) it can be written as $F = \bar{B}.\bar{C} + B.\bar{C} + \bar{A}.B.C$
- Similarly it can be simplified up to $F = \bar{C} + \bar{A}.B.C$

Note that the final equation you get may not be the same as it deps on the order you apply the laws. But all the possible ways to simplify would give the same truth table.

QUESTIONS

- Each individual should have a written/printed pre-report.
- No need to waste your time unnecessarily on neatness.
- Write down the intermediate steps while you solve the problem.
- If you have any questions or you need help put a post in the forum for CO221 in FEeLS rather than copying from someone else.
- If you are caught copying you get 0 for the prelab and also the marks for the rest of the lab would be reduced by 50%.

When designing logic circuits, you are only allowed to use only following gates

- Inverters
- 2-input AND, OR, NAND, NOR, XOR

Hints:

- If you have an expression like A.B.C that requires a 3-input AND gate write it as A.(B.C) and implement it using two 2-input AND gates
- If you have an expression like A.B.C.D that requires a 4-input AND gate write it as (A.B).(C.D) and implement using three 2-input AND gates

---

1. Derive and simplify the Boolean equation for the truth table given below.

Inputs			**Output (F)**
A	**B**	**C**	
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

2. Derive and simplify the Boolean equations for each output in the truth table given below. Then draw the logic circuit for all the outputs.

Inputs			Output		
A	**B**	**C**	**F1**	**F2**	**F3**
0	0	0	1	0	0
0	0	1	1	0	0
0	1	0	1	0	1
0	1	1	1	0	1
1	0	0	0	1	1
1	0	1	0	1	1
1	1	0	0	1	0
1	1	1	0	1	0

3. Follow the steps below to design a prime number indicator for the range 0-7.
    a. How many bits are required to represent a value in the range 0-7?
    b. Consider each bit in the value as inputs and the indicator as the output (indicator is 1 for a prime number or else 0) and draw the truth table.
    c. Derive a simplified Boolean equation for the output.
    d. Draw the logic circuit for all outputs.

4. Follow the steps below to design a circuit to compare two 2-bit numbers XY and PQ. Output should be '1' if XY is greater than PQ and '0' if otherwise.
    a. There are 4 inputs X,Y,P,Q and 1 output. Draw the truth table.
    b. Derive a simplified Boolean equation for the output.
    c. Draw the logic circuit for all outputs.

5. Follow the below steps to design a circuit that outputs the addition of a 2-bit number XY with a 1-bit number A. Let the output be a 2-bit number QR. (As 11+1 gives 100 which has three bits omit the overflow and take it as 00).
    a. There are 3 inputs X, Y and Z and 3 outputs Q,R. Draw the truth table.
    b. Derive simplified Boolean equations for the outputs.
    c. Draw the logic circuit for all outputs.