Digital Design Preliminary Exam (Spring 2011)

Problem 1	15 points
Problem 2	10 points
Problem 3	10 points
Problem 4	10 points
Problem 5	15 points
Problem 6	15 points
Problem 7	25points
Total	100 points

Name or Student ID:

Date: 03/25/2011

Problem 1: Numbers

a. Show the IEEE 754 binary representation of the number -0.75_{10} in single precision (32 bits binary).

b. Convert the following from hexadecimal to BCD.

$1A_{16}$ =

c. Find the 2's complement form for –7 using 8 bits binary.

Problem 2: Addressing Mode (Based on Intel processor, little endian.)

a. Are the following assembly instructions correct or not? If correct, which addressing mode it is using? If incorrect, why?

i. MOV AL, 22H

ii. MOV CL, BX

iii. MOV AL, [EBX+2*ECX]

b. Show the value of BX after POP BX instruction while before the POP instruction we have SS=0000, SP=1002, (SS: stack segment register; SP: stack pointer)

at physical memory location 01001 stores 12H,

at physical memory location 01002 stores 34H,

at physical memory location 01003 stores 56H,

at physical memory location 01004 stores 78H.

Problem 3: Combinational design

Design a four input priority encoder which satisfies the following truth table:

Inputs				Outputs		
D_0	D_1	D_2	D_3	x	y	V
0	0	0	0	X	X	0
1	0	0	0	0	0	1
X	1	0	0	0	1	1
X	X	1	0	1	0	1
X	X	X	1	1	1	1

Problem 4: Combinational design

Implement $f = w_1 \otimes w_2 \otimes w_3$ using:

a) 2-to-1 multiplexers

b) a 4-to-1 multiplexer

Problem 5: PLA design

Design a system using PLA. The system has four inputs: A, B, C, and D; three outputs: F, G, and H. Where

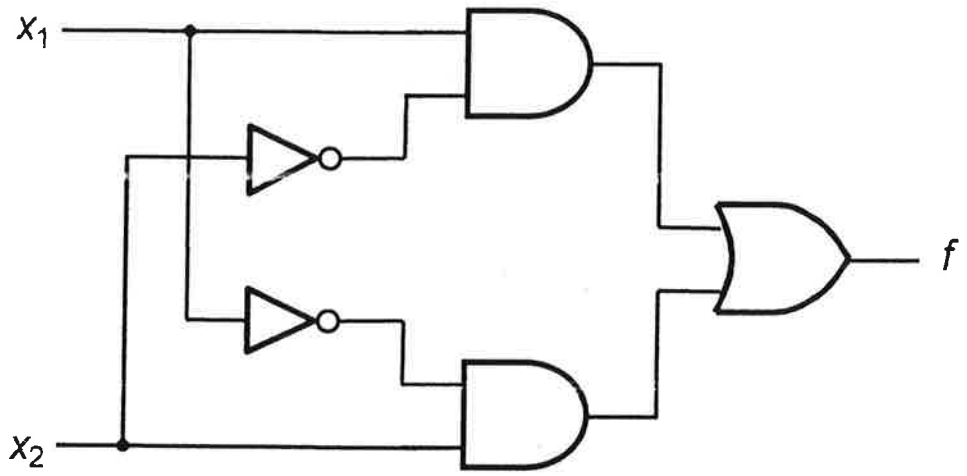
$$F(A, B, C, D) = \sum m(0,2,6,10,11,14,15)$$

$$G(A, B, C, D) = \sum m(0,3,6,7,8,9,12,13,14,15)$$

$$H(A, B, C, D) = \sum m(0,3,4,5,7,10,11,12,13,14,15)$$

Problem 6: VHDL Design

Write VHDL code for the below circuit. Note the top-level file must structural VHDL. Only the basic gates can use behavioral. (Write only entity and architecture.)



Problem 7: FSM Design

Design a sequential logic circuit that controls and maneuvers a mobile robot lawn mower. The robot is equipped with a light sensor and an obstacle sensor (Figure 1). The light sensor detects the ambit light intensity. The obstacle detects obstacles in the path of the robot. The outputs of the sensors are shown in Table 1.

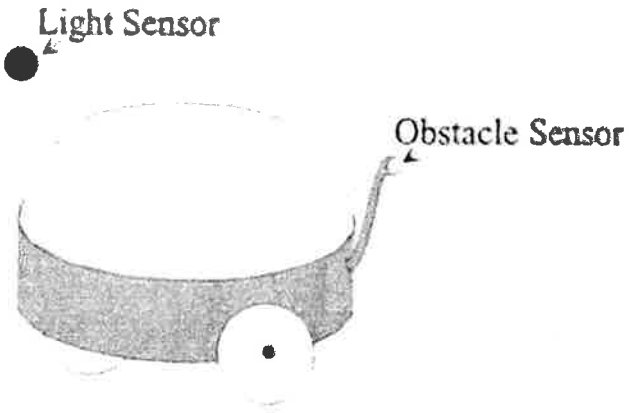


Figure 1: Illustration of Robot Lawn Mower

Table 1: Sensor signals and their meanings

Sensor	Signal	Meaning	
Light	X	0:dark	1: bright
Obstacle	Y	0: obstacle free	1: obstacle detected

The sequential circuit uses two output signals (p and q) to control two robot motors, respectively. Each motor drives a wheel. A motor turns on if its control signal is 1 and turns off if the control signal is 0. The robot moves according to Table 2.

Table 2: Relations between control signals and robot movements

P1	Left motor	Right motor	Robot
00	Off	Off	Stops
01	0ff	On	Turns left
10	On	Off	Turns right
11	On	On	Goes straight

The maneuver of the robot around obstacles is carried out using the following algorithm:

- In order to avoid accidents, the robot stops moving when there is not enough ambient light (x=0). It resumes its movement when the lighting is adequate (x=1).
- The robot always goes straight (pq=11) initially after it resumes its movement.
- The first obstacle in the robot's path (y=1) after it resumes its movement causes the robot to turn left (i.e., pq =01). The robot continues to turn until no obstacle is detected.
- The robot remembers its previous turning direction. When a new obstacle is detected, the robot turns in a direction different from its previous one. For example, if the robot has turned right last time to avoid an obstacle, it turns left until not obstacle is detected.