***King Fahd University of Petroleum and Minerals***

***College of Computer Science and Engineering***

***Computer Engineering Department***

**COE 202: Digital Logic Design (3-0-3)**

**Term 141 (Fall 2014-2015)**

**Major Exam 1**

**Saturday October 18, 2014**

**Time: 90 minutes, Total Pages: 8**

**Name:\_KEY\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ID:\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Section: \_\_\_\_\_\_\_**

**Notes:**

* Do not open the exam book until instructed
* **No Calculators are allowed** (*basic, advanced, cell phones, etc*.)
* Answer all questions
* All steps must be shown
* Any assumptions made must be clearly stated

|  |  |  |
| --- | --- | --- |
| **Question** | **Maximum Points** | **Your Points** |
| **1** | **17** |  |
| **2** | **16** |  |
| **3** | **12** |  |
| **4** | **15** |  |
| **Total** | **60** |  |

**Question 1. (17 points)**

1. Without converting to decimal, express the binary number (111.0101)2 in **Octal** and **Hexadecimal**. **(4 points)**

(111.010\_100)2 = (7.24)8.

(0111.0101)2 = (7.5)16.

1. Express the decimal number 129.33 in **Binary** and **BCD** (with 4-bit fraction accuracy).

 **(6 points)**

129=128+1=27+20=10000001.

0.33 x 2 = 0.66 => 0

0.66 x 2 = 1.32 => 1

0.32 x 2 = 0.64 => 0

0.64 x 2 = 1.28 => 1

129.33 = (1000 0001.0101)2 = (0001 0010 1001. 0011 0011)BCD

1. Adding an **even parity** bit as the MSB, the Binary code 1001101 becomes 01001101.

 **(1 point)**

01001101

1. Perform the following arithmetic operations in the given bases. (Show your work) **(6 points)**

|  |  |  |
| --- | --- | --- |
| **Binary Multiplication** | **Binary Subtraction** | **Hexadecimal Addition** |
| 1011x 101101100000101100110111 |  | 100.10- 11.01001.01 |  | 37A+ 9340D |  |

**Question 2. (16 points)**

Use Boolean algebra to solve the following questions. Show clearly all your steps.

|  |
| --- |
| 1. Simplify each the following Boolean functions to the specified number of literals:

 1. $F1=x y z+\overline{x} y+\overline{x} \overline{y} $ **(3 literals) (3 points)**

= xyz + x’ (y + y’)= xyz + x`= x’ + yz1. $F2=\overline{x} \overline{y} \overline{z}+\overline{x} y \overline{z}+\overline{x} y z+x \overline{y} \overline{z} $ **(4 literals) (4 points)**

= y’z’ (x’ + x) + x’y (z` + z)= y’z’ + x’y 1. $F3=w x+w x y+\overline{w} y z+\overline{w} \overline{y} z+\overline{w} x y \overline{z}$ **(6 literals) (5 points)**

 = ( wx + wxy) + ( w’yz + w’y’z) + w’xyz’= wx + w’z + w’xyz’= wx + w’(z + xyz’)= wx + w’(z + xy)= wx + w’z + w’xy= w’z + x(w+ w’y)= w’z + x(w+ y)= w’z + wx + xy |
| 1. **Without simplification**, write out the **complement** and **dual** forms of the following expression:

$\left(x+\overline{y} \overline{z}\right)\left(w \overline{x} z+ \overline{w} y \overline{z}\right)$ **(4 points)**The **complement** of the function is:F’ = x’. (y + z) + (w’ + x + z’) . (w + y’ + z) The **dual** of the function is: x. (y’ + z’) + (w + x’ + z) . (w’ + y + z’)  |
|  |

**Question 3. (12 points)**

1. Express the Boolean function Y of the following given circuit without simplification: **(3 points)**



 $Y=(A+B)(\overline{A}+\overline{B})+B C+\overline{D}$

1. Given the Boolean function $F\left(X,Y,Z\right)=\left(X+Y\right)\left(\overbar{X}+Z\right)(\overbar{Y}+\overbar{Z})$: **(6 points)**
2. Express F as a **product-of-maxterms**, $F=\prod\_{}^{}M$.
3. Find the ***algebraic* sum-of-minterms** expression for *F*.
	1. $\overline{F}=\overline{X} \overline{Y}+X \overline{Z}+Y Z$ = $\sum\_{}^{}m\left(0, 1, 3, 4, 6, 7\right)$

$$F=\prod\_{}^{}M\left(0, 1, 3, 4, 6, 7\right)$$

* 1. $F=\sum\_{}^{}m\left(2, 5\right)$

$$F=\overline{X} Y \overline{Z}+X \overline{Y} Z$$

1. Given that $F(A,B,C)=\sum\_{}^{}m\left(0,2,5,6\right)$ and $ G\left(A,B,C\right)=\prod\_{}^{}M\left(1,2,5,7\right), $ express the function $F.\overbar{G}$ as a **sum-of-minterms**. **(3 points)**

$$\overbar{G}=\sum\_{}^{}m(1, 2,5,7)$$

$F.\overbar{G}=\sum\_{}^{}m(2,5)$

**Question 4. (15 points)**

1. Circle the correct word in the following statements: **(3 Points)**
2. It is desirable to have a low noise margin NML as ( **large** - small ) as possible
3. It is desirable to have a high noise margin NMH as ( **large** - small ) as possible
4. It is desirable to have VIH as ( large - **small** ) as possible
5. It is desirable to have VIL as ( **large** - small ) as possible
6. It is desirable to have VOH as ( **large** - small ) as possible
7. It is desirable to have VOL as ( large - **small** ) as possible
8. Fill in the Truth Table for each of the following three circuits. Indicate whether the circuit operates properly or not. If circuit operation is improper (invalid) state the reason for that. InputsA, and B are independent of one another and may assume any possible binary values. **(6 Points)**

|  |  |  |
| --- | --- | --- |
| **Circuit** | **If circuit operation is valid, what is the output function?** | **If circuit operation is invalid, state why.** |
| 0.jpg |

|  |  |
| --- | --- |
| **A B** | **F** |
| **0 0** | **0** |
| **0 1** | **X** |
| **1 0** | **X** |
| **1 1** | **0** |

 | The output has a short circuit at 2 conditions AB= 01 and 10 |
| II-a.jpg |

|  |  |
| --- | --- |
| **A B** | **X** |
| **0 0** | **0** |
| **0 1** | **1** |
| **1 0** | **0** |
| **1 1** | **0** |

 | **√** |
| Drawing1.jpg |

|  |  |
| --- | --- |
| **A B** | **Y** |
| **0 0** | **Hi-Z** |
| **0 1** | **1** |
| **1 0** | **0** |
| **1 1** | **0** |

 | The output has a short circuit at AB= 11 but the outputs are the same (0) in this case, i.e. no conflict. |

1. The shown table gives propagation delays of some basic gates. For the circuit shown below, answer the following:

|  |  |
| --- | --- |
| **Gate** | **Delay** |
| Inverter | 1 ns |
| 2-Input AND | 2 ns |
| 2-Input OR | 3 ns |
| 3-Input AND | 3 ns |
| 3-Input OR | 4 ns |

1. Identify the critical path of the circuit (path with longest propagation delay). What is its associated delay value?

**(3 Points)**



Critical Path is: G2-G5

Delay of Critical Path = 4 + 3 = 7ns

1. What is the maximum frequency at which the circuit may be operated? **(1 Point)**

Fmax = 1/(7x 10-9) ≈ 142.8 M Hz

1. The gate which drives the largest load is gate **G2** **(1 Point)**
2. Name *a gate* that has the highest fanin in the circuit ( {G2, G5} ), the fanin of this gate is **3** **(1 Point)**