# ECE111: Digital Circuits: Mid-Semester Exam

## Date: Sept. 18, 2018

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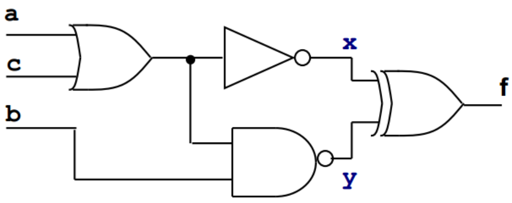
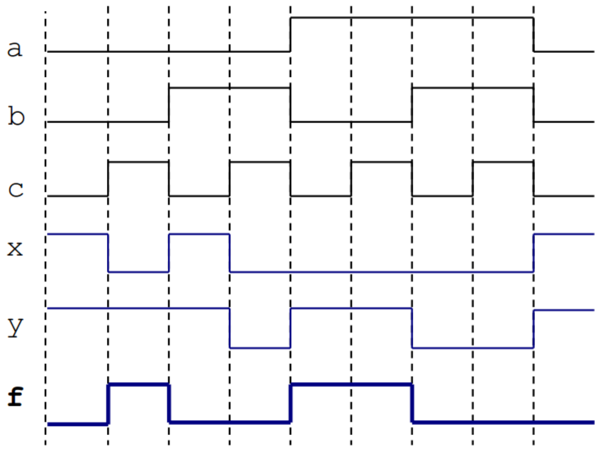
# <u>Set A – 10 Marks</u>

A1. Assuming zero delay between input and output of each gate, complete the timing diagram of the following circuit. (In answer sheet, show all 6 timing diagrams corresponding to boolean variables a,b,c,x,y,f on the same page).

**3 Marks**



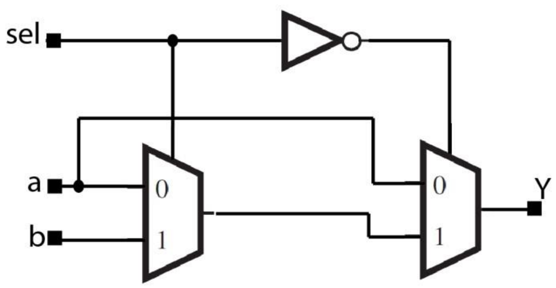




A2. Design a combinational circuit using minimum number of basic gates (2-input AND, 2-input OR, 1-input NOT) with three inputs, x, y, z, and three outputs, A, B, C. When the binary input is 4, 5, 6, or 7, the binary output is 2 less than the binary input. When the binary input is 0, 1, 2, or 3, the output is 4 more than the binary input.

**5 Marks**

Ans: $A = \bar{X} + Y, B = X \oplus Y, C = Z$

A.3




$Y = a.(sel')' + (a.sel' + b.sel).sel'$

$= a.sel + a.sel'.sel' + b.sel.sel'$

$= a.sel + a.sel' = a$

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# Set B – 15 Marks

B1. Perform the following operations:
Find 8’s and 9’s complement of : $(172)_9$
Find 10’s and 11’s complement of : $(1A1)_{11}$

**4 Marks**

Ans: 716, 717, 909, 90A

**Solution B2:**

Converting the equation in base-10

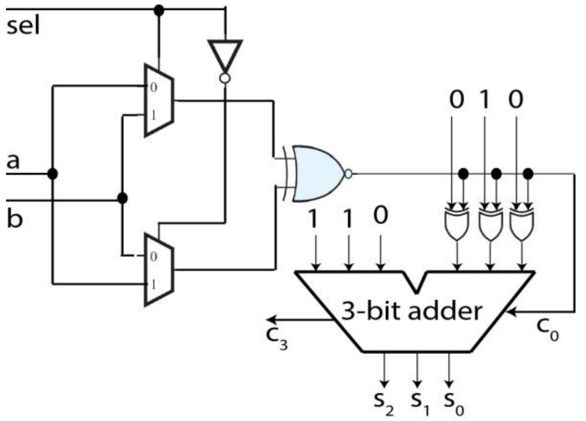
$(N^2 + 0N + 5) - (4N + 0) = (5N + 5)$

$\Rightarrow N^2 - 9N = 0$

$\Rightarrow N(N - 9) = 0$

$\Rightarrow N = 9$

**Solution B3:**




The output of the top multiplexer is: $a.sel' + b.sel$

The output of the bottom multiplexer is: $b.(sel')' + a.sel' = a.sel' + b.sel$

Therefore, both the inputs to the XNOR gate is the same.

Therefore, the output of the XNOR gate is 1.

Therefore, the second input of the adder will be made 2’s complement, before reaching the adder, i.e (101+1=110).

The result of the adder will be the sum: (110+110)=(1100)

Therefore, the outputs are as follows:

$c_3 = 1$, $s_2 = 1$, $s_1 = 0$ and $s_0 = 0$.

In decimal, the adder operates as: 6-2=4 (the carry out bit is ignored).

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# Set C – 15 Marks

C1. Assume that you have four switches $S_1$,$S_2$,$S_3$,$S_4$ and two LEDs out of which one is Green (**G**) and the other is Red (**R**). LED **R** and **G** will glow according to the following switching scheme. Design a combinational circuit for that.

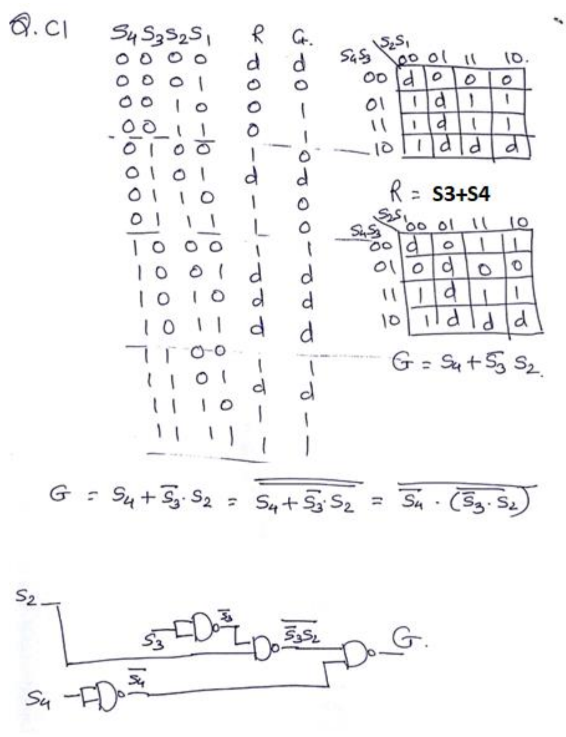
a) If $S_1$ alone is ON, then both the LED **R** and **G** should be OFF. If $S_2$ alone is ON, then **R** should be OFF and **G** should be ON. If $S_3$ alone ON, then **R** should be ON and **G** should be OFF. If $S_4$ alone ON, then **R** should be ON and **G** should be ON.Assume that more than one switch is not ON at the same time.

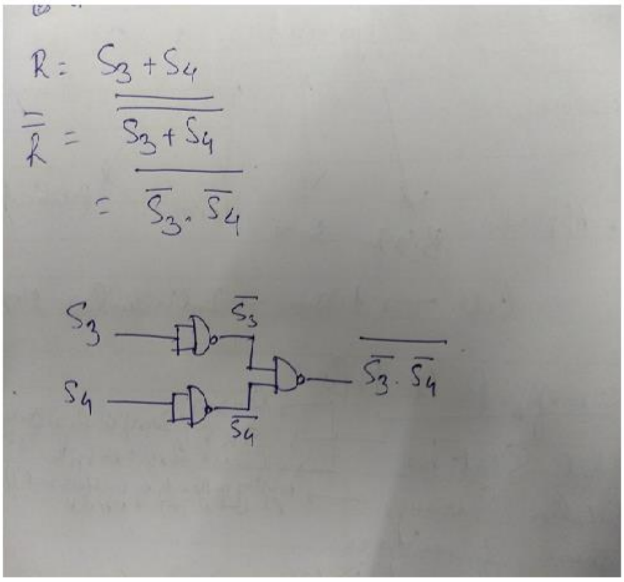
b) Now consider, if any of two switches say, $S_n$ and $S_{n+1}$ are simultaneously ON, then Switch $S_{n+1}$ should be given higher priority than $S_n$

c) If any of three switches $S_n$ ,$S_{n+1}$ and $S_{n+2}$ are simultaneously ON, then Switch $S_{n+2}$ should be given higher priority than other switch.

d) If all the switches are ON, $S_4$ should be given highest priority than any other switch.

**15 Marks**




# OR

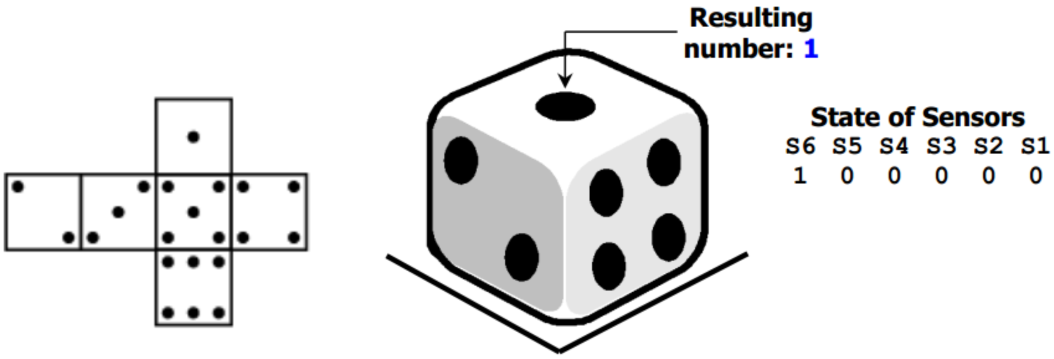
C1. Whenever a side rests on a surface, the sensor on that side outputs a logic ‘1’ (which is transmitted wirelessly to a controller); otherwise, it outputs a ‘0’. The sensors are named Si, where i is the number printed on the respective side.

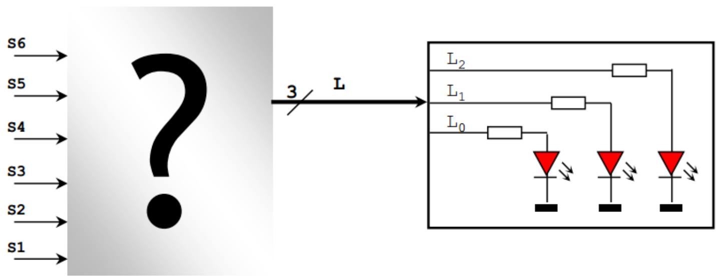
We want to design a circuit that reads the state of the 6 sensors and outputs the value of the upper surface. That decimal value is represented using the binary number system (see table below). A LED ON is represented by the logic value of ‘1’, and a LED OFF is represented by a logic value of ‘0’. For example, in the figure below, the resting side has six dots while the upper surface has one. The resulting decimal number is then ‘**1**’, which is represented by 001 on the LEDs. The state of the sensors is S6=1, S5=0, S4=0, S3=0, S2=0, S1=0.

Under normal circumstances, we expect only one sensor activated at a time. However, due to a variety of problems, we might have the following cases:

- Two or more sensors produce a ‘1’ at the same time: In this case, the state of the LEDs must be 000.
- No sensor produces a ‘1’: In this case, the state of the LEDs must be 000.

Using the state of the sensors as inputs, provide the Boolean expression for each LED: L2, L1, L0. Use the canonical Sum of Products for each function.




| $L_2$ | $L_1$ | $L_0$ | Number |
|---|---|---|---|
| 0 | 0 | 0 | - |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 2 |
| 0 | 1 | 1 | 3 |
| 1 | 0 | 0 | 4 |
| 1 | 0 | 1 | 5 |
| 1 | 1 | 0 | 6 |
| 1 | 1 | 1 | - |

**5 Marks**

| S1 | S2 | S3 | S4 | S5 | S6 | $L_2$ | $L_1$ | $L_0$ | Number |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 2 |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 3 |
| 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 4 |
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 5 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 6 |
| | | | | | ... | 0 | 0 | 0 | - |

$$L_2 = \overline{S1}\,\overline{S2}S3\overline{S4}\,\overline{S5}\,\overline{S6} + \overline{S1}S2\overline{S3}\overline{S4}\,\overline{S5}\,\overline{S6} + S1\overline{S2}\,\overline{S3}\,\overline{S4}\,\overline{S5}\,\overline{S6}$$

$$L_1 = \overline{S1}\,\overline{S2}\,\overline{S3}\,\overline{S4}S5\overline{S6} + \overline{S1}\,\overline{S2}\,\overline{S3}S4\overline{S5}\,\overline{S6} + S1\overline{S2}\,\overline{S3}\,\overline{S4}\,\overline{S5}\,\overline{S6}$$

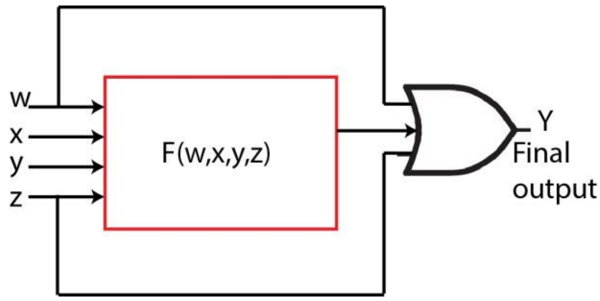
$$L_0 = \overline{S1}\,\overline{S2}\,\overline{S3}\,\overline{S4}\,\overline{S5}S6 + \overline{S1}\overline{S2}\overline{S3}S4\overline{S5}\,\overline{S6} + \overline{S1}S2\overline{S3}\,\overline{S4}\,\overline{S5}\,\overline{S6}$$

**Solution**

**C3:**

a)

| wx \ yz | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 1 | 0 | 0 | 1 |
| 01 | 1 | 0 | 0 | 1 |
| 11 | 0 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 | 0 |




$F(w, x, y, z) = \mathrm{w'z'}$

b) The output Y will be 1 irrespective of $F(w, x, y, z)$, if the inputs to the OR gate is 1. This will be true when either $w$ is 1 or $z$ is 1. The input combination corresponding to this are as follows (shown as {wxyz}):

{1000}, {1001}, {1010},{1011},{1100},{1101},{1110},{1111},{0001}{0011}{0101}{0111}

And the minterms are {$m_{12}$,$m_{13}$,$m_{14}$,$m_{15}$,$m_8$,$m_9$,$m_{11}$,$m_{10}$,$m_1$,$m_5$,$m_3$,$m_7$}

c) The K-map for $F(w, x, y, z)$ with don't care conditions is as shown:

| wx \ yz | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 1 | X | X | 1 |
| 01 | 1 | X | X | 1 |
| 11 | X | X | X | X |
| 10 | X | X | X | X |

All don't care can be assigned a value of 1.

The minimized function is: $F(w, x, y, z) = 1$

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