Problem Set #2, EE part

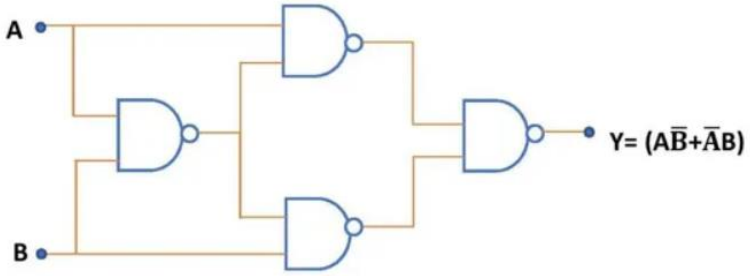
Issue date: Sept. 30, 2022; Deadline: 23:59, Oct. 10, 2022

Student Name: _____ Student No.: _____

1. *CMOS logic gate*

   An XOR gate can be built using NAND gate. The circuit diagram is shown below. Try building a XOR in multisim with NAND gate.

   - Draw the truth table. Implement the circuit in multisim, use logic converter to generate its truth table, compare the simulation results with your answer. (10') (In this problem, you can use NAND2 as your logic gate)
   - Implement your design in Multisim, it should be CMOS-level implementation. If you don't know which MOSFET to use, you can use ZVN4424 and ZVP4424. (If you don't know what is CMOS-level implementation, you can refer to *HOW_TO_MOSFET.pdf* on piazza) (15')
   - Use logic converter to generate the truth table of your design. (5')
     (If you don't know how to use logic converter, you can watch *HOW_TO_CMOS.mp4* on piazza)



2. *Combinational logic circuit exercises*

   - For each one of the truth tables, write down the Boolean equations in canonical sum of products form. (1' * 5)
     (If you don't know what is canonical SOP form, you can refer to textbook *Harris:2.2.2*. Or you can also google this term.)
   - Simplify the logic using the K-map (2' * 5)
   - Implement the circuits in Multisim using logic gates. Use logic converter to generate their truth tables. (2' * 5)
     (If you are having difficulties with this problem and the next one, try reading the entire chapter 2 of *Harris*)

(a)

A	B	Y
0	0	1
0	1	0
1	0	1
1	1	1

(b)

A	B	C	Y
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

(c)

A	B	C	Y
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

(d)

A	B	C	D	Y
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	1
1	0	0	1	0
1	0	1	0	1
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	1
1	1	1	1	0

(e)

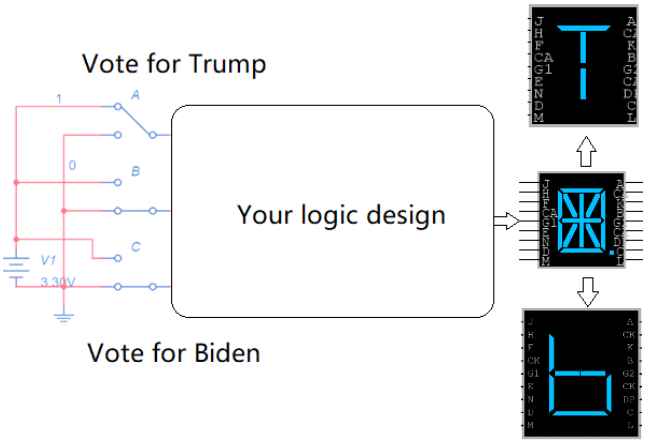
A	B	C	D	Y
0	0	0	0	1
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1
1	0	1	0	1
1	0	1	1	0
1	1	0	0	1
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

3. *Majority voting and 14-segment display*

Refering to the majority voting system introduced in the lecture, design a logic circuit with Multisim and show the voting result with a 14-segment display as follows (T for Trump and b for Biden). (You can only use one 14-segment display, not two)

(If you don't know how to use 14-segment display, please refer to HOW_TO_HEXDISPLAY.pdf)

- Show the design procedures(Truth table, Boolean equations, etc) and final circuit schematic. (15')
- Show the result pictures of eight input conditions. (5')



4. *MCU development*

- Make your esp32's onboard LED blink with 25Hz frequency for one second, then 5Hz for one second. Repeat this cycle (25Hz 5Hz 25Hz 5Hz 25Hz……) for 100 times, then turn off the LED.(25')
  (Attach the code in your homework. The code should be able to be copy and pasted.)

Here's some example code that will turn on the LED for 2 seconds to help you turn on and turn off your LED:

```
from machine import Pin
import time

p2 = Pin(2, Pin.OUT)      # create output pin on GPIO2, which is connected to onboard LED
p2.value(1)               # set pin 2 to "on" (high) level, the LED will turn on
time.sleep(2)             # wait for 2 seconds
p2.value(0)               # set pin 2 to "off" (low) level, the LED will turn off
```

(Refer to https://docs.micropython.org/en/latest/esp32/quickref.html#delay-and-timing if you don't know how about timing)

** When capturing circuit schematics and simulation results, taking a screenshot is mandatory. Please refrain from using your phones to take a photo of the screen. If you do so, 20% of the full grades will be deducted from that problem.*

** Please submit the softcopy of your solutions to the problems on gradescope. When uploading to gradescope, please select all corresponding pages related to each question.*

** Please use English. Answers using Chinese or other language will be deducted 5 points.*

** Discussion on methodology is allowed, yet, the assignment should be done individually. Plagiarism, once found, grades zero for the whole homework assignment.*