Australian National University | ANU College of ENGINEERING, COMPUTING AND CYBERNETICS

ENGN 4213/6213 Digital Systems and Microprocessors

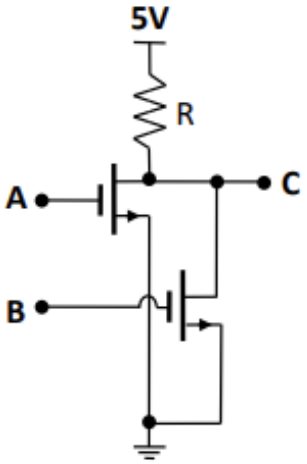
Semester 1, 2023

Tutorial 1

Part 1: Analog behaviour of logic gates

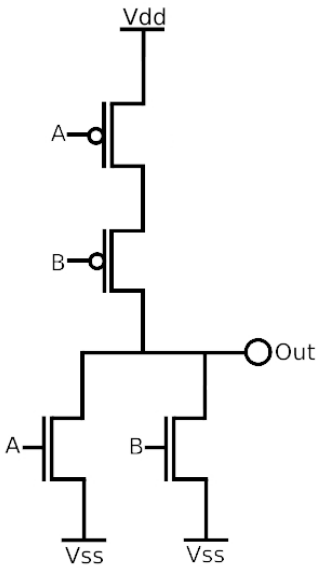
Question 1:

Take a look at the electrical circuit described below.



a. Identify, and explain in a couple of sentences, what happens to the output C when the inputs A and B are set to 5 V or 0 V, respectively.
b. Write a truth table and name the corresponding logic function.
c. Explain the role of resistor R in the design.

Considering that the same circuit can be implemented as shown below, identify two points of difference which make one implementation more advantageous than the other and/or vice-versa, and explain.



Part 2: Combinatorial logic and hazards

Question 2:

Design a digital circuit with four inputs that will output a 1 if the majority (3 or 4) of the inputs are 1.

[Tips: *Understand the concept of the majority circuit from the question. Then translate your concept to a truth table. From the truth table, create a Karnaugh map to produce Sum of Product (SOP) expression for the majority circuit.*]

Question 3:

Design a 2-bit comparator that will compare two 2-bit inputs, $a[1:0]$ and $b[1:0]$ and output the following three signals.

$a\_eq\_b = 1$ if $a = b$;
$a\_gt\_b = 1$ if $a > b$;
$a\_lt\_b = 1$ if $a < b$;

[Tips: *You need to draw three Karnaugh maps to produce three different SOP expressions. Each SOP will be associated with one output only*.]

Then, comment on whether any of your circuits are likely to exhibit timing hazards and if so, for what input combinations. Also comment whether said hazards can be removed through SOP redesign.

Part 3: Review of number systems

Question 4:

Convert the decimal number 27 to binary, and hexadecimal numbers using the most appropriate conversion method.

Question 5:

Convert binary number 101110 to hexadecimal and decimal numbers using the most appropriate conversion method.

Question 6:

Convert hexadecimal number ABC to binary and decimal numbers using the most appropriate conversion method.

Question 7:

Calculate $A + B$, $A - B$, $-A + B$, and $-A - B$ for binary numbers 1010101, 1010 assuming a two's complement number system and $n = 8$. Check your results by decimal arithmetic. Explain any unusual results.

Question 8:

In most memory structures the addresses of locations are specified in binary numbers that identify each memory circuit where a data word is stored. The number of bits that make up an address will depend on how many memory locations there are. Since the number of bits can be very large, the addresses are often specified in hex instead of binary.

a. If a microcomputer uses a 20-bit address, how many different memory locations are there?
b. How many hex digits are needed to represent the address of a memory location?
c. What is the hex address of the 256^{th} memory location? (Note: the first address is always 0)