Investigtion on the Implementation of Logic Gates Using Transistor Circuits CS1025

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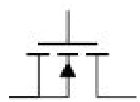
1 Objectives

The objectives of this experiment is to implement the logic function of the circuits shown in the subsequent diagrams and devise with a truth table, the actual logical gate which the circuit is working as.

2 Apparatus

Resistor ($1\,\mathrm{k}\Omega$ $5\,\mathrm{k}\Omega$)



2N7000 E-MOSFET

- Voltage source (+5V); - Light emitting diode (LED).

3 Theory

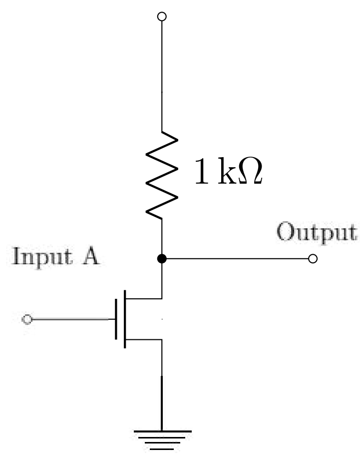
The Metal Oxide Semiconductor Field Effect Transistor or MOSFET for short, has it's gate input electrically insulated from the main current carrying channel. It has a very thin layer of silicon dioxide between the gate and the substrate. MOSFETSs are three terminal devices with a gate, drain and a source and both P-channel and N-channel. For this experiment, an N-channel MOSFET is used. This layer is kept as thin as possible to give the gate as much control over the drain current as possible.

The transistor requires a threshold gate sourceG_{GSth} voltage to effectively switch if OFF or ON depending on the type of MOSFET. For an N-channel one, ss the gate-source voltage increases, electrons are drawn from the source into the gate region forming an N-channel(inversion layer) between the drain and the source, thus current is obtained. This is required in the following experiment as an NMOS is used.

4 Data and Analysis

The First Circuit:

Circuit Diagram:



The Following is the truth table of this circuit:

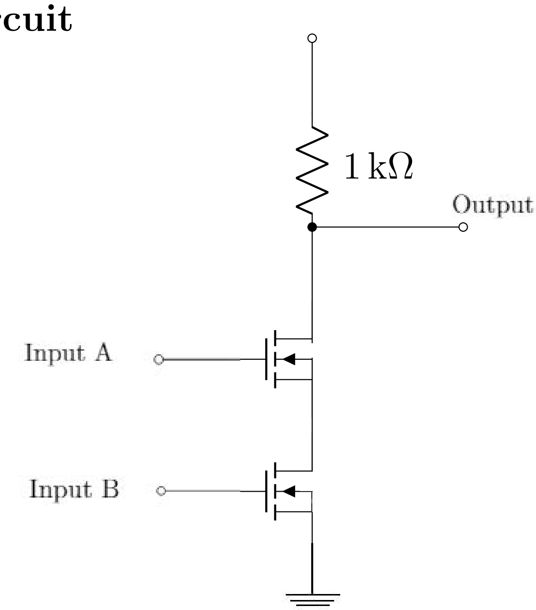
Input	Output	LED
High	Low	OFF
Low	High	ON

The output in the circuit is connected to an LED which verifies the logic level of the output. It is concluded from the above results that the circuit is a NOT gate. If the input is of high voltage, current flows from the drain to the source, hence the transistor is switched ON. If the resistor at the drain is chosen to be much greater that the 'ON' resistance of the transistor, according to the potential divider mechanism, most of the supply voltage would be dropped across the drain resistor, hence the output would be low. In which the LED would not light up.

If the input is low, the transistor is switched OFF. There is no drain current and the output voltage is equal to the supply voltage which is high. Hence the LED lights up proving the high output.

The Second Circuit

Circuit diagram:



The Following is the truth table of this circuit:

Input A	Input B	Output	LED
Low	Low	High	ON
Low	High	High	ON
High	Low	High	ON
High	High	Low	OFF

The output in the circuit is connected to an LED which verifies the logic level of the output. In conclusion to the above results, the circuit behaves as a NAND gate, which only output low when both inputs are high and output high in all other situations. When the both inputs are of high voltage, both transistors are activated (switched ON), current flows from the drain to the source. Both transistors will conduct which creates a short circuit to ground. If the resistor at the drain is chosen to be much greater than the 'ON' resistances (combined) of the transistors, according to the potential divider rule, the output would be low, meaning that most of the supply voltage would be dropped across the drain resistor. Where the LED does not light up as a result of a low output

If any of the inputs are low, the transistor of low input is switched OFF. The current supplied would not be ablt to flow through the transistors to ground and hence flows through the output. Thus the output is high, this is verified by the LED lighting up.

It is observed that, when a resistor of higher resistance substitutes the exitsting $1\,\mathrm{k}\Omega$ resistor, the current flowing through the resistor decreases, hence the resistance increases which switches the output to a logical low. Hence the LED does not light yo for any of the above situations.

5 Conclusion

In the first transistor circuit, it has the function of an NOT gate. Which is a logic gate that only takes one input, and outputs the opposite logic level of the input. Hence, when the input is high, the output is low, therefore the LED does not lit up; when the input is low, the output is high with the LED lighting up.

The second transistor circuit has that of a function of a NAND gate. A NAND gate is one which takes two inputs and only outputs low if both the inputs are high, hence all other situations are high.

However in the second circuit, if the resistance of the resistor is increased from $1\,\mathrm{k}\Omega$ to a higher resistance , $5\,\mathrm{k}\Omega$ for instance, it is observed that the

LED does not light up even for both a low input as the resistor has too high a resistance.