ELEC-313
Lab 5: CMOS Circuits

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Contents

1 Objective **3**

2 Equipment **3**

3 Schematics **3**

4 Procedure **4**
4.1 CMOS Inverter 4
4.2 CMOS NAND 4

5 Results **4**

6 Conclusion **5**

List of Figures

1 Circuits used in this lab. 3

List of Tables

1 Logic Table. 4
2 Pulse-width modulation 5

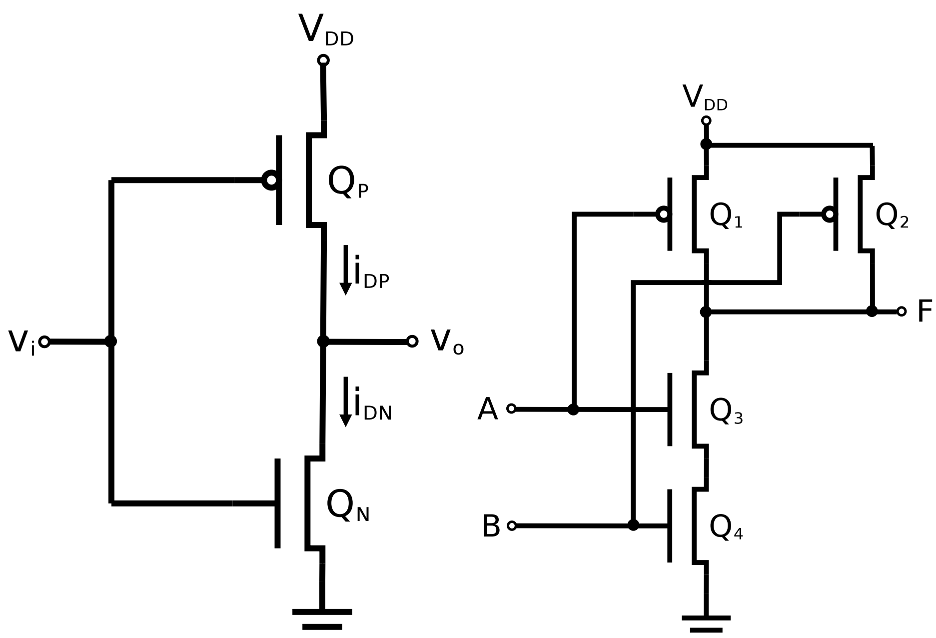
1 Objective

The objective is to construct and observe the operation of a CMOS inverter and NAND gate.

2 Equipment

- ALD1105 Dual N-channel and P-channel matched pair MOSFET
- Power supply: HP E3631A
- Oscilloscope: Agilent 54622D
- Function generator: HP 33120A

3 Schematics



(a) CMOS Inverter (b) CMOS NAND

Figure 1: Circuits used in this lab.

4 Procedure

4.1 CMOS Inverter

First, the (+) and (−) terminals of the motor driver board were connected to the 6 V DC power supply. Wires were connected to the motor output terminals on the left side of the motor driver board. Inputs L_1, L_2, and $E1-2$ (Enable) were connected in accordance with Table 1. The output of the DC power supply was set to 6 V and the motor output voltage (V_{out}) was measured and the LED's were observed, with values recorded in Table 1. Then, the output of the DC power supply was turned off and 6 V DC motor was connected to the output of the motor driver board. The output of the DC power supply was set to 6 V and inputs were connected in accordance with Table 1 and the direction of motor rotation was also recorded in Table 1. Finally, L_1, L_2, and *Enable* were set in the clockwise motor rotation and the DC power supply was swept from 6 V to 3 V in 0.1 V increments and the effect on the motor's speed.

4.2 CMOS NAND

First the function generator was set to a square wave with a frequency of 20 kHz. Channel 1 of the oscilloscope was connected to the output of the function generator and the square wave was offset for 0 V to 5 V. L_1 and L_2 were again set for clockwise rotation and the *Enable* input was connected to the function generator. The DC power supply was turned on and set to 6 V. Then, the %Duty of the square wave was swept from 20% to 80% in 10% increments and the motor driver board output was recorded in Table 2. After that, the output of the DC power supply was turned off and the %Duty of the function generator was rest to 50%. Then, the 6 V DC motor was connected to the motor output of the motor driver board and the output of the DC power supply was set to 6 V. The %Duty of the square wave was swept from 50–80% in 1% increments and motor speed was observed.

5 Results

Enable	L_1	L_2	V_{out}	LED	Motor
L	L	L	−0.01 V	off	off
L	L	H	−0.01 V	off	off
L	H	L	−0.01 V	off	off
L	H	H	−0.01 V	off	off
H	L	L	−0.18 V	off	off
H	L	H	5.7 V	red	CW
H	H	L	5.5 V	green	CCW
H	H	H	0.01 V	both	off

Table 1: Logic Table.

Duty Cycle	V_{out}
20%	$-3.01\,V$
30%	$-3.39\,V$
40%	$-3.76\,V$
50%	$-4.13\,V$
60%	$-4.49\,V$
70%	$-4.84\,V$
80%	$-5.19\,V$

Table 2: Pulse-width modulation

6 Conclusion

The motor driver board can be adjusted to control the speed and direction of the DC motor. First, the *Enable* input must "see" 5 V before the motor driver board can then allow the L_1 and L_2 inputs control the phase/rotation of the output. To control the output rotation, the L_1 and L_2 inputs must also see 5 V separately. In our configuration, L_1 caused the motor to rotate counter-clockwise. Similarly, L_2 caused clockwise rotation, so enabling both causes the motor to stop.

The motor driver board speed was adjusted via two different approaches in the experiment: in part one, the input voltage was adjusted, changing the output voltage; in part two, the frequency of the input signal was adjusted, which also affected output voltage.