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Lab 9 report

Introduce and define concepts (with citations)

Cmos - an acronym for complementary metal oxide semiconductor, it is the most common architecture for creating integrated circuits in today's electronics because of its uniquely low power consumption.
Cmos Source

Cmos Inverter: consists of a complementary pair of Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs): one P-type MOSFET (PMOS) and one N-type MOSFET (NMOS). This component performs logical inversion, making a high signal low and a low signal high
Inverter Source

CMOS Transfer Curve: The transfer curve shows the relationship between the input and output signals of the inverter
Transfer Curve Source

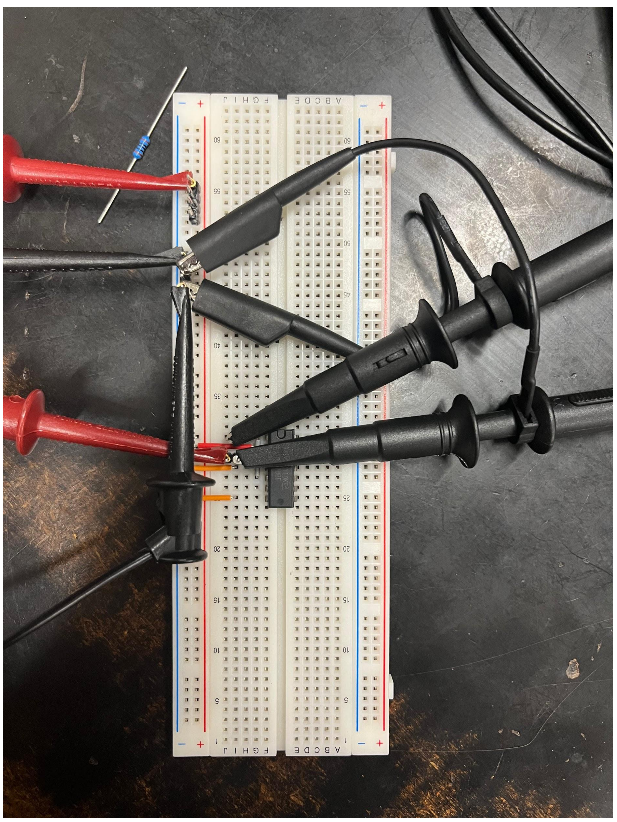
CMOS Noise Margins: these are areas that the input signal could be interpreted as high or low, they are important because noise in the circuit could mess up the desired output
Noise Margins Source

CMOS Power Dissipation: this is the amount of power that is consumed by a CMOS component, CMOS only uses power when it switches.
Power Dissipation

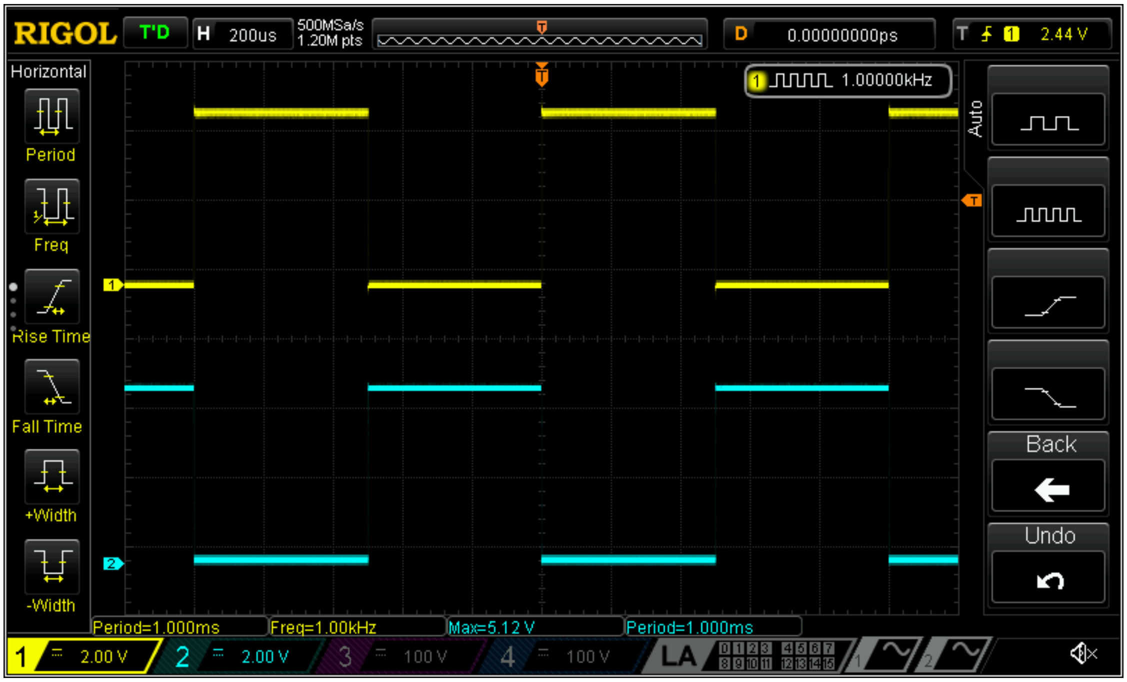
Motivation for experiment

In this experiment, we are becoming more familiar with CMOS inverters, being able to experiment hands on with circuits including them. We are also being introduced to PMOS and NMOS transistors, which work together to create a logic function. Another target for this lab is Transfer characteristics, where we will observe how Vout varies with the input voltage Vin. Ideally, we want to use our knowledge from the lecture and what's given in our lab report, to participate in this experiment in hopes of understanding the principles of CMOS inverters.

1 Experimental Diagram (drawing + PICTURE with labels)



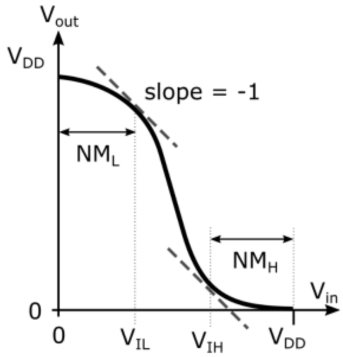
PLOT – CMOS Inverter Transfer Curve (with input)



Analysis (remember to show your work for calculations)

Referring to the plot above, it's clear to see that the output(blue) is the inverse of the input. The waves both appear in a square wave fashion, without the vertical slopes connecting the low and high voltages. At the bottom of the oscilloscope image, it measures that both waves have a max voltage of 2V. This indicates that their min voltage is -2V. It's clear to see that the yellow and blue curves have an inverse relationship. When the yellow input is -2V, the blue output is 2V. When the input is 2V, the output is -2V.

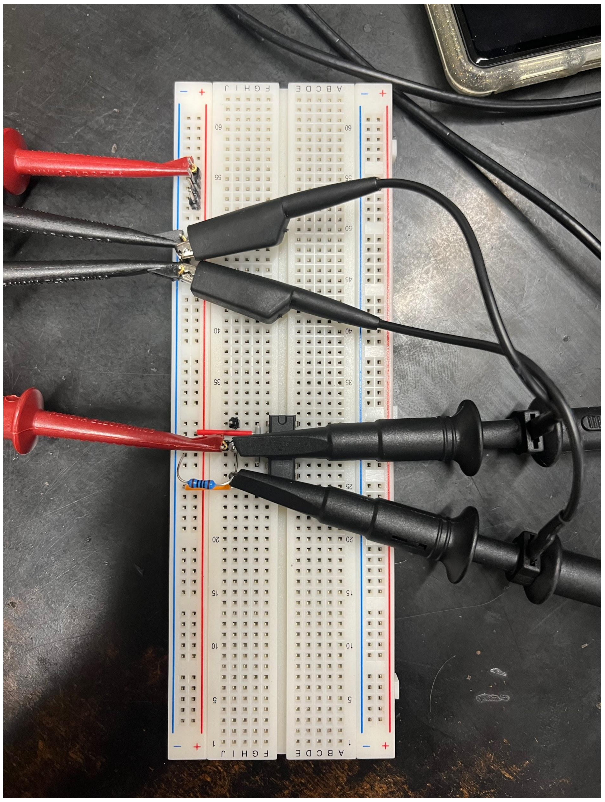
2 TABLE – Noise Margins from Transfer Curve



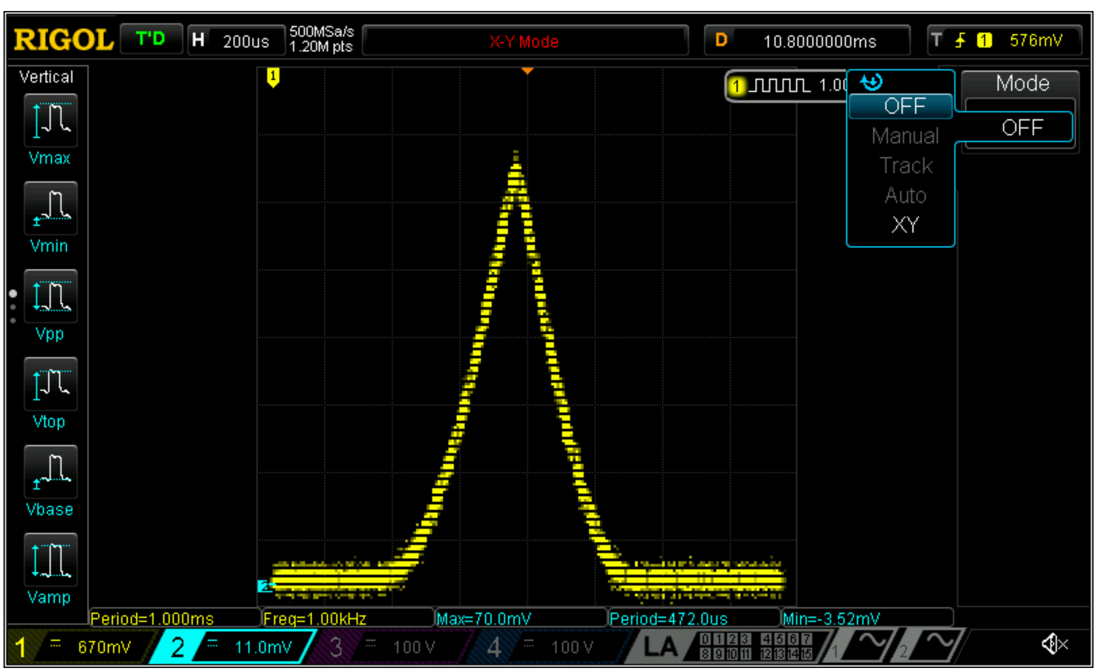
Curves	Noise
VIH	2.5V
VIL	2V
NML	2V
NMH	1.5V

Analysis
Here, all of these values can be pulled directly from the curve on our oscilloscope. Looking at the image above the table, VIL and VIH are the high and low points of the curve where the slope of the tangent is -1V. With those values, NML is the region between 0 and VIL, and NMH is the region between VIH and VDD.

3 Experimental Diagram (drawing + PICTURE with labels)



PLOT – Power dissipation of CMOS inverter (with input)



Analysis (remember to show your work for calculations)

The analysis of the CMOS inverter's power dissipation shows their dynamic behavior. The maximum power dissipation occurs at the peak of the transfer curve when the inverter is transitioning between states. When this happens, the PMOS and NMOS are both only partially on, resulting in a small window where increased current flows. To measure this dissipation, we can use Ohm's Law, in conjunction with the small resistor value to calculate the Wattage loss at precisely the peak of the transfer curve. $P = V * I$

$V = .07,\ I = V/R,\ I = .07/100\ =\ .0007$

$P = .0007 * .07\ =\ .00049$W, the Inverter dissipates 49 mW. Conversely, at the on and off states of the transistors, the power dissipated is zero. Because one of the transistors is completely open, and another is completely closed, the window of time for power dissipation has already closed.

Conclusion

In this lab, we worked closely with CMOS Inverters and witnessed how they reacted in specific circuits. We found that in a circuit with just the inverter and a power supply, the definition of the inverter stayed true as the oscilloscope plotted the input and output waves to be directly inverse to each other. Switching the oscilloscope to XY mode, we can plot the transfer curve, which plots the input/output relationship. By doing so, we were able to find and tabulate the following values: VIH = 2.5V / VIL = 2V / NML = 2V / NMH = 1.5V. NMH and NML are the noise margins that describe the tolerance of the signal. Lastly, by adding a small resistor to the circuit, the current of the transfer curve will be turned into a voltage signal that can be plotted. With the formula P=VI, we calculated that the inverter dissipates 49mW, and the power dissipated is 0W. Overall, this lab helped us become more comfortable with the circuits and calculations regarding CMOS inverters.