ECE 270 Lab Verification / Evaluation Form

Experiment 2

Evaluation:

IMPORTANT! You must complete this experiment during your scheduled lab period. All work for this experiment must be demonstrated to and verified by your lab instructor *before the end* of your scheduled lab period.

STEP	DESCRIPTION	MAX	SCORE
1	Installation and Test of Potentiometer	1	
2	LED Voltage and Current Measurements Using the DMM	6	
3	Gate Voltage and Current Measurements Using the DMM	6	
4	Timing Measurements Using the Oscilloscope	8	
5	Thought Questions	4	
	TOTAL	25	

Signature of Evaluator: ____

Academic Honesty Statement:

IMPORTANT! Please carefully read and sign the Academic Honesty Statement, below. *You will not receive credit for this lab experiment unless this statement is signed in the presence of your lab instructor.*

"In signing this statement, I hereby certify that the work on this experiment is my own and that I have not copied the work of any other student (past or present) while completing this experiment. I understand that if I fail to honor this agreement, I will receive a score of ZERO for this experiment and be subject to possible disciplinary action."

Last Name (Printed): ______________________ **Lab Div:** _____ **Date:** ____________

E-mail: __ __ __ __ __ __ __ __ @purdue.edu **Signature:** ________________________

Measurement of Gate Electrical and Timing Characteristics

Instructional Objectives:

- To become familiar with the functions and capabilities of the digital multimeter and the digital oscilloscope
- To learn how to make voltage and current measurements using the digital multimeter
- To learn how to measure logic signal transition times and propagation delays using the digital oscilloscope

Prelab Preparation:

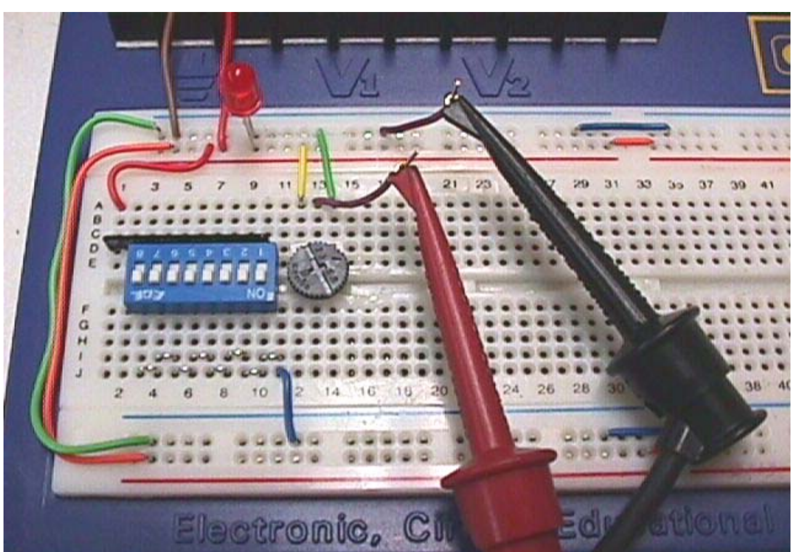
- Read this document in its entirety

Lecture/Demonstration:

Your lab instructor will give a brief presentation that includes the following:

- A demonstration of how to measure voltages and currents using the digital multimeter (DMM) at your lab station
- An explanation of how to read resistor color codes
- An explanation of the difference between a resistor LED and a non-resistor LED
- A demonstration of how to install the 20 MHz oscillator module on your breadboard
- A demonstration of how to install the 10K ohm potentiometer ("pot") on your breadboard
- A demonstration of how to measure rise and fall times of a logic gate using the oscilloscope
- A demonstration of how to measure rise and fall propagation delays using the oscilloscope

Step (1): Installation and Test of Potentiometer



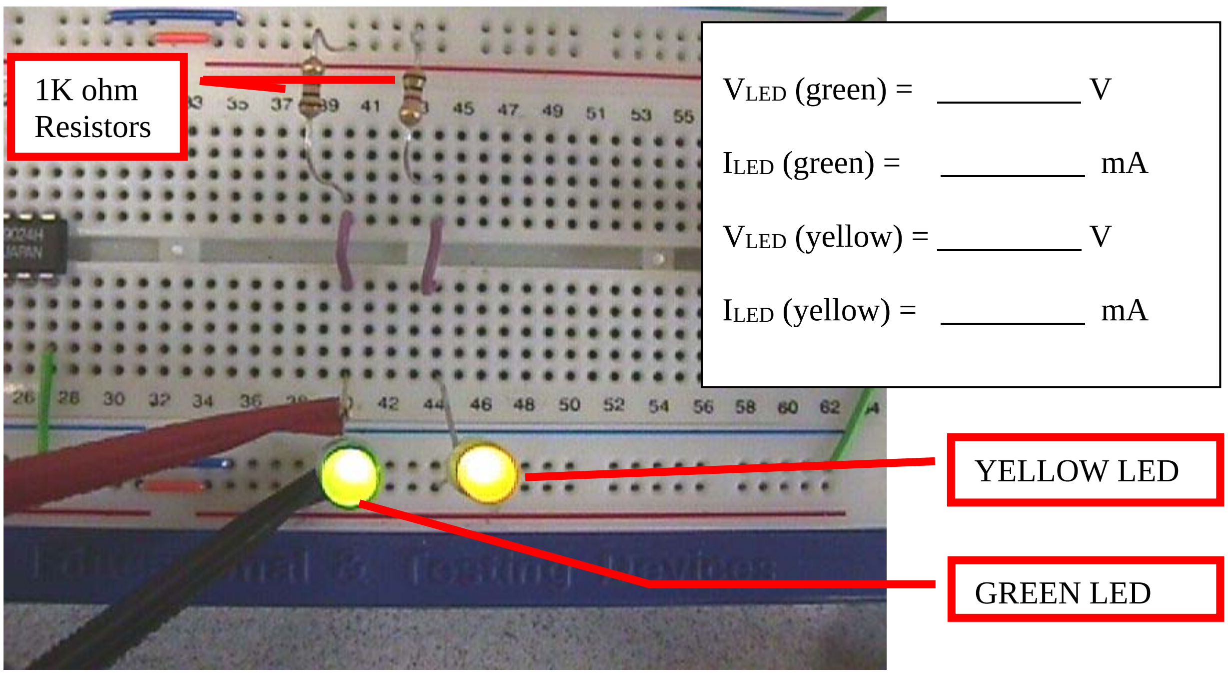
Connect the 10K ohm potentiometer to +5 VDC and ground, as shown, and measure the voltage on the "wiper" (middle terminal) with respect to ground using the Digital Multimeter (DMM). Verify that you measure 0 volts when the potentiometer is fully counter-clockwise, and measure close to 5.0 volts when the potentiometer is fully clockwise.

<u>Trouble-Shooting Tip</u>: When making measurements using the DMM, make sure the probes are connected to the correct DMM inputs (note that different pairs of inputs are used for measuring voltage and current) and that the function selector dial is set to measure DIRECT CURRENT (D.C.) voltage or current, respectively.

Step (2): LED Voltage and Current Measurements Using the DMM

Perform the following exercises and record your results.

(a) Connect a GREEN **non-resistor** LED and a YELLOW **non-resistor** LED in series with 1K ohm resistors (color bands brown-black-red) as illustrated below. Note that the 1K resistor on the left should be connected between +5VDC and the anode (long lead) of the GREEN LED (the cathode of which should be connected to ground), while the 1K resistor on the right should be connected between ground and the cathode (short lead) of the YELLOW LED (the anode of which should be connected to +5 VDC). Measure the *forward voltage* V_{LED} across each LED and record your results in the space provided. Then, remove the "jumper wires" between the resistors and LEDs and measure *the forward current* I_{LED} of each LED, and record your results in the space provided.



V_{LED} (green) = _________ V

I_{LED} (green) = _________ mA

V_{LED} (yellow) = _________ V

I_{LED} (yellow) = _________ mA

(b) Using the DMM, measure the *actual* impedance of a "brown-black-red" (1K ohm) resistor.

$R_{measured}$ = _________________ ohms

(c) Calculate I_{LED} based on the following equation (Ohm's law): $(5.0 – V_{LED})/R_{measured}$

I_{LED} *(calculated)* = _______________

How does the *calculated* value of I_{LED} compare with the value *measured* above?

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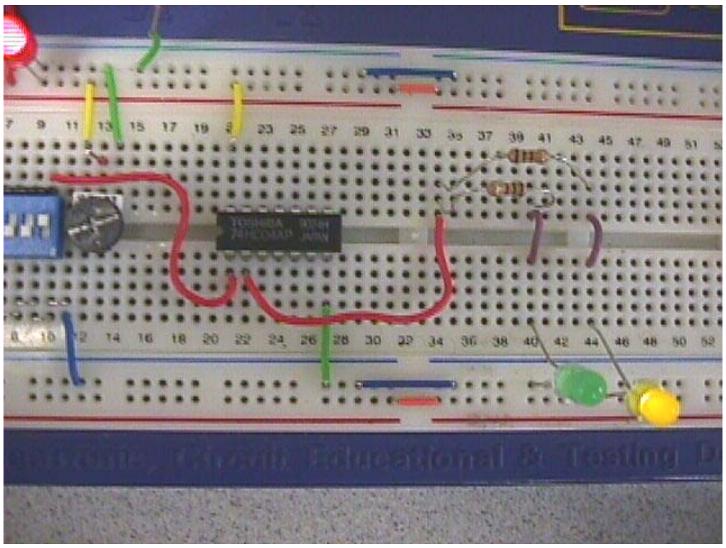
Step (3): Gate Voltage and Current Measurements Using the DMM

Perform the following exercises and record your results.

(a) Disconnect the resistors (used in the previous step) from +5 VDC and ground (for the GREEN and YELLOW LEDs, respectively). Connect both resistors to pin 2 of the 74HC04 (hex inverter). Connect pin 1 of the 74HC04 to a DIP switch. Verify that the green LED illuminates when the switch input is LOW, and that the yellow LED illuminates when the switch input is HIGH.

(b) Using this configuration, measure V_{OH}, I_{OH}, V_{OL}, and I_{OL} of the 74HC04 using the DMM. Compare the measured values with those given in the data sheet appearing on page 98 (Table 3-3) of the course text. Are there any notable differences?



Notable differences?

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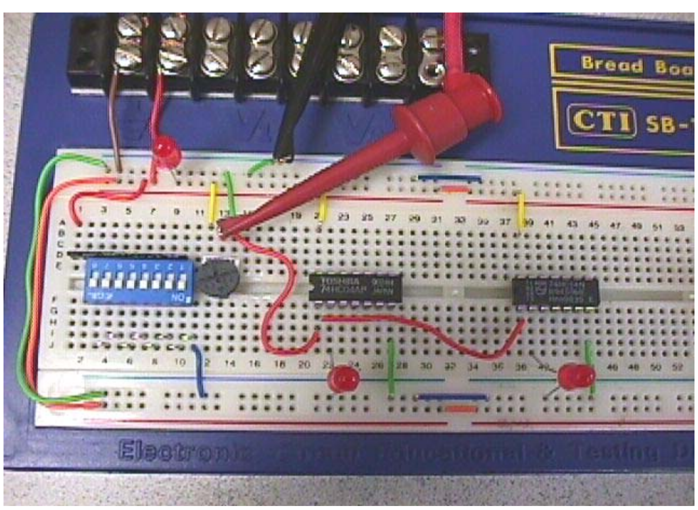
V_{OH} = ____________ V

I_{OH} = ____________ mA

V_{OL} = ____________ V

I_{OL} = ____________ mA

(c) Remove the non-resistor (GREEN and YELLOW) LEDs and resistors from your breadboard and install a 74HC14 (hex inverter with Schmitt trigger inputs); leave the 74HC04 (already in place) on the board, but connect pin 1 of both chips to the wiper of the potentiometer. Connect the DMM between the wiper of the potentiometer and ground in order to measure the input voltage. Connect pin 2 of each chip to the anode of a RED (resistor) LED, and the cathode to ground. Slowly change the potentiometer and note when the LEDs turn on and off. Record the value of V_T for the 74HC04 and the values of V_{T-} and V_{T+} for the 74HC14.



V_T = ____________ V

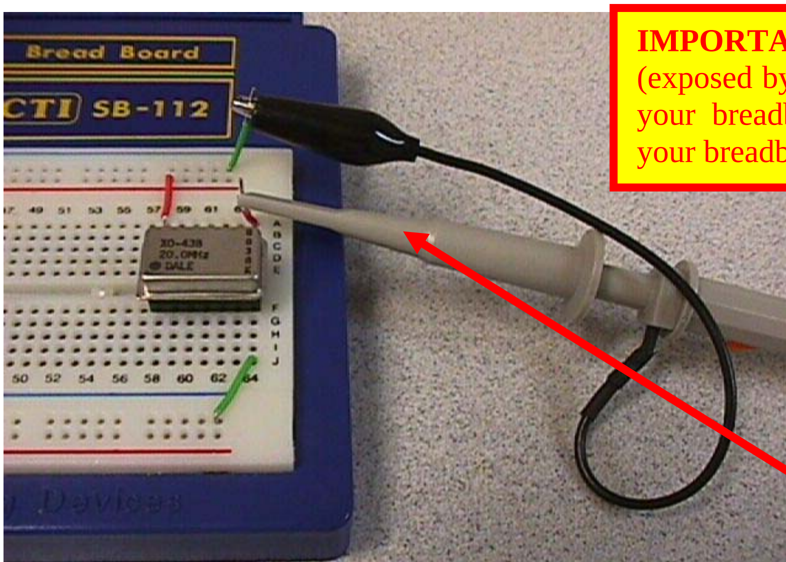
V_{T-} = ____________ V

V_{T+} = ____________ V

Step (4) Timing Measurements Using the Oscilloscope

Here we will use the oscilloscope to perform timing measurements using the 20 MHz oscillator module and the inverter.

(a) Using properly grounded oscilloscope probes, connect the output of the oscillator to Channel 1 of the oscilloscope. Measure the *rise* (t_{TLH}) and *fall* (t_{THL}) times of the output waveform.



IMPORTANT: Do not stick the probe tip (exposed by removing the cap) directly into your breadboard! Doing so will damage your breadboard and/or the scope probe.

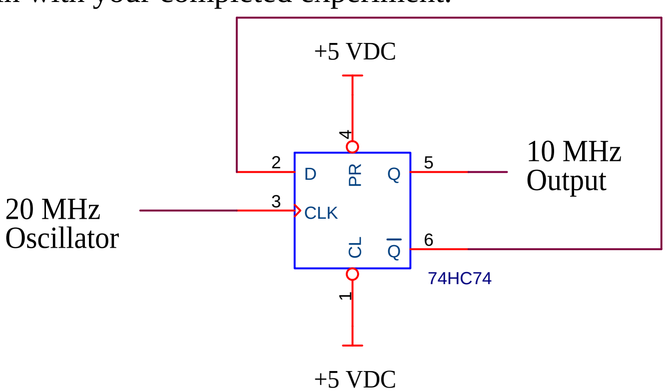
t_{TLH} = ____________ ns

t_{THL} = ____________ ns

Channel 1 Probe

<u>Trouble-Shooting Tip</u>: If the waveform display looks like noise, try pressing the AUTO-SCALE button on the oscilloscope.

(b) Using a 74HC74 (edge-triggered "D" flip-flop), construct the circuit illustrated below. The output of the 20 MHz oscillator should be connected to the CLK input (pin 3) of the 74HC74, pin 6 should be connected to pin 2, and pins 1 & 4 should be connected to +5 VDC. The oscillator frequency divided by two (10 MHz) will be output on pin 5. Connect the Channel 1 probe to the 20 MHz oscillator and the Channel 2 probe to the 10 MHz signal produced by the 74HC74 and verify that your frequency divider circuit is working correctly. Capture and print the display using the PC at your workstation; attach the printed copy to the material you turn in with your completed experiment.



NOTE: Also, be sure to connect pin 7 of the 74HC74 to GROUND and pin 14 to POWER (+5 VDC).

<u>Trouble-Shooting Tip</u>: If communication between the PC and oscilloscope is lost (get a "no device connected" error message), close the capture software and restart the oscilloscope; then, re-launch the capture software on the PC.

(c) Connect the 10 MHz output of the frequency divider constructed in step (b), above, to the input of one of the 74HC04 inverter gates. Connect Channel 1 of the oscilloscope to the output of the frequency divider, and connect Channel 2 of the oscilloscope to the output of the inverter gate. Capture and print the display using the PC at your workstation. Measure and record the *rise propagation delay* (t_{PLH}) and the *fall propagation delay* (t_{PHL}) of the gate.

t_{PLH} = ___________ t_{PHL} = _______________

(d) Connect the output of the inverter gate in (c), above, to the input of a second inverter gate. Connect Channel 2 of the oscilloscope to the output of the second inverter gate (leave Channel 1 connected to the 10 MHz frequency divider). Measure and record the *rise propagation delay* (t_{PLH}) and the *fall propagation delay* (t_{PHL}) of the two inverter gates "cascaded" together.

t_{PLH} = ___________ t_{PHL} = _______________

(e) Disconnect the second inverter gate and, in its place, connect a GREEN LED (in series with a 150 ohm resistor) to the first inverter's output in a *current sinking* configuration, i.e., anode connected to +5 VDC, cathode connected to gate output via 150 ohm resistor. Connect the inverter output, thus loaded by the LED, to Channel 2 of the oscilloscope. Measure the rise and fall times of the output waveform along with the propagation delays. Note any differences between the measurements taken here versus those taken in Parts (c) and (d). Capture and print the display for reference in answering the Thought Questions.

t_{TLH} = _______ t_{THL} = _______ t_{PLH} = _______ t_{PHL} = _______

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(f) Modify the circuit used for Part (e), above, so that it is a current *sourcing* configuration (i.e., cathode of LED connected to ground, anode connected to gate output via 150 ohm resistor). Connect the inverter output, thus loaded by the LED, to Channel 2 of the oscilloscope. Measure the rise and fall times of the output waveform along with the propagation delays. Note any differences between the measurements taken here versus those taken in Parts (c) and (d). Capture and print the display for reference in answering the Thought Questions.

t_{TLH} = _______ t_{THL} = _______ t_{PLH} = _______ t_{PHL} = _______

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Step (5) Thought Questions

Place your answers to the following "thought questions" in the space provided below:

(a) Did any of the measurements you made (electrical or timing) vary from what you anticipated? Why or why not?

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(b) Describe the procedure you would use to measure the I_{IH} and I_{IL} parameters of a logic gate (illustrate using a schematic).

(c) Describe how the *shape* of the output waveform changed when the gate output was loaded down by an LED (compare the *sinking* and *sourcing* configurations).

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(d) Why do you think the LED appeared to be "dimmer" in step (4.e) than it did in step (3.b)?

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