

## EE2700 Digital Circuits

### Lab 2 – Analysis of an Inverter

**Objective:** To understand and analyze the behavior, the input requirements and the output capabilities of a digital device such as a 74LS04 inverter.

**Parts:** 1-Proto board (will be used for all labs)  
1-74LS04  
1-100Ω resistor

**Preparation:** Write the title and a short description of this lab in your lab book. Make sure the page is numbered and make an entry in the table of contents for this lab.

Find the data sheet for the manufacturer of your 74LS04 (from lab 1) and print it. (Many are available at [www.datasheetcatalog.com](http://www.datasheetcatalog.com)) Make sure your datasheet includes a pin diagram and the DC characteristics, particularly  $I_{IH}$ ,  $I_{IL}$ ,  $V_{OH}$ ,  $V_{OL}$ ,  $I_{OH}$  and  $I_{OL}$ . Attach or copy the pin diagram and the DC characteristics to your lab book.

Bring your notebook, the datasheet and the necessary parts (below) to your lab section.

**Procedure:** Connect the red and black leads to the fixed 5V output of the power supply. (If the power supply has no fixed 5V output, see your lab instructor.) Connect the leads to the Vcc and Ground on your proto-board as you did in Lab 1.

If your circuitry from Lab 1 is no longer intact, insert 74LS04 into the proto board, connect pin 14 to Vcc (+5V) and pin 7 to ground. (Refer to the pin diagram in your lab book.) Caution: If you connect the Vcc and ground pins backward, or if you connect the Vcc pin to a voltage greater than 5 Volts, you will destroy the 74LS04.

Select one of the unused inverters on the 74LS04 to test. (Use your datasheet to decide which one you will use and make note of the input and output pin numbers.)

#### Experiment 1. Plotting Input vs. Output Voltage

This experiment investigates how the output of a 74LS04 inverter responds to its input.

Turn on the power supply and adjust one of the variable outputs to 0V. Connect the negative lead to ground and the positive lead to the input of the inverter under test. Connect a volt meter to the output of your inverter. (See Figure 1.)

Ramp the input voltage from 0 to 5 volts, then record and graph (in your lab notebook) the output voltage as a function of the input voltage (as displayed on the power supply). Make particular note of the output voltage when the input voltage equals  $V_{IL}$  and when it equals  $V_{IH}$  (from the datasheet). Take enough data points to get an accurate graph. What conclusions can you draw from this graph? What is the output voltage when the input voltage equals  $V_{IL}$  and  $V_{IH}$ ? Record your observations in your lab book. Note: Be prepared to show your data and your graphs to the lab instructor at the end of your lab session.

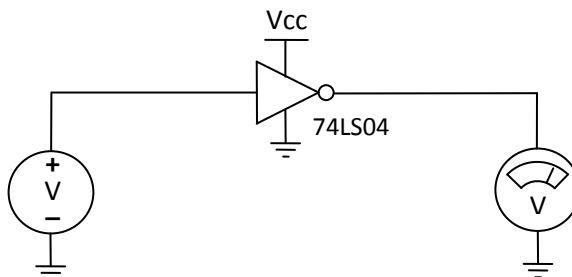


Figure 1. Measuring output voltage as a function of input voltage.

### Experiment 2. Measuring $I_{IL}$ and $I_{IH}$

Sometimes it is important to know how much current an input consumes at various input voltages. Configure a multi-meter to measure current and insert it in series with the variable power supply (Figure 2). You may also need to connect a  $100\Omega$  load resistor in parallel with the variable power supply. Adjust the input voltage over the range 0-5v, then record and graph (in your lab book) the input current as a function of input voltage. Pay particular attention when the input voltage (displayed on the power supply) is 0.4v and 2.7v. The currents at these two voltage levels are known as  $I_{IL}$  and  $I_{IH}$ , respectively. Record them in your lab book and compare them with the maximum  $I_{IL}$  and  $I_{IH}$  from the data sheet. Is your 74LS04 within specifications?

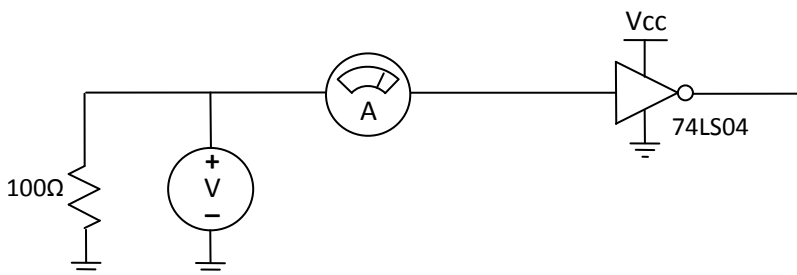


Figure 2. Measuring  $I_{IL}$  and  $I_{IH}$ .

### Experiment 3. Measuring $V_{OH}$ .

Sometimes we also need to know what voltage the output will be under maximum load. Connect the meter to the output of the inverter and connect the input of the inverter to ground as shown in Figure 3. Adjust the voltage over the

range 2.4-5v, then record and graph (in your lab book) the output current as a function of output voltage. Pay particular attention when the output current equals the  $I_{OH}$  given in your datasheet. The voltage at this current level is known as  $V_{OH}$ . Record this value in your lab book and compare it to the minimum  $V_{OH}$  from the data sheet. Is the  $V_{OH}$  you measured within specification?

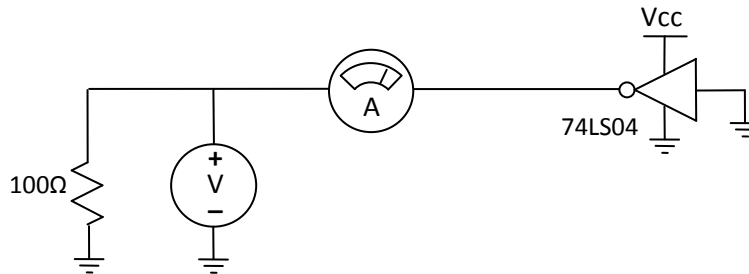


Figure 3. Measuring  $V_{OH}$ .

#### Experiment 4. Measuring $V_{OL}$ .

*Caution. Before running this experiment, adjust the variable power supply to 0v.*

Connect the input of your inverter to  $V_{cc}$  (pin 14). Leave the output connected as it was in Experiment 3. Adjust the voltage over the range 0-2v, then record and graph (in your lab book) the output current as a function of output voltage. Pay particular attention when the output current equals the  $I_{OL}$  given in your datasheet. The voltage at this current level is known as  $V_{OL}$ . Record this value in your lab book and compare it to the maximum  $V_{OL}$  from the data sheet. Is the  $V_{OL}$  you measured within specification?

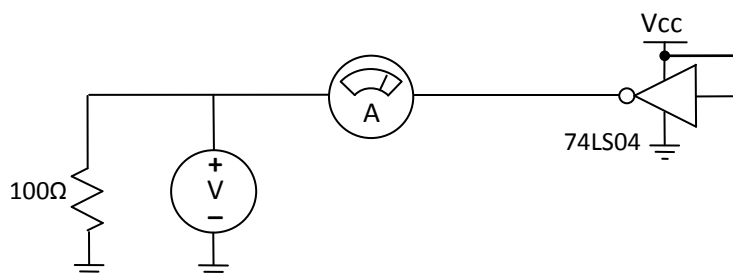


Figure 2. Measuring  $V_{OL}$ .

Write a short summary of your observations and conclusions. Did the  $I_{IH}$  and  $I_{IL}$  that you measured differ from the maximum  $I_{IH}$  and  $I_{IL}$  in the datasheet? If so, is that a problem? Why or why not? Repeat the analysis for  $V_{OL}$  and  $V_{OH}$ . After writing your summary, sign and date it. Present your lab book to the lab instructor for grading.

Signoff: A lab score can only be given if all four experiments have been completed.

Rubric (10 points total)

- Lab book is bound, clearly legible and in ink. (1 point)
- Lab book contains a clear title and a short description of the lab. (1 point)
- Pin Diagrams and DC Characteristics are included in lab book (1 point)
- Accurate graphs have been drawn in the lab book. (1 point)
- $I_{IH}$ ,  $I_{IL}$ ,  $V_{OH}$ ,  $V_{OL}$  are recorded and compared in the lab book. (1 point)
- Lab book contains no obliterations (no white-out and nothing scribbled out or overwritten). (1 point)
- Lab book contains a signed, dated summary describing the lab results. (1 point)
- Each used page has a page number and is initialed\* and dated\* (1 point)
- The experiments were completed before the end of the scheduled lab period. (2 points)

\* It is not necessary to initial and date a page that contains a signature and date unless the dates are different.