

Name \_\_\_\_\_

# EET 251 Lab #2

## Decoders and Encoders

### Equipment and Components

ETS-7000 Digital-Analog Training System  
Integrated Circuits: 7442, 74138, 74148

### Breadboarding Guidelines

First, review the breadboarding guidelines posted on the course website (also at <http://people.sinclair.edu/nickreeder/eet131/breadboardingTips.htm>.) Remember, your grade on labs will depend on how well you follow these guidelines, in addition to whether or not your circuit works correctly.

### Decoders

1. The first sentence in Section 6-5 of your textbook defines the word **decoder**. Copy this sentence below and make sure you understand what it means.

A **decoder** is

2. Using a copy of the "TTL Data Book" or Texas Instruments' website (<http://www.ti.com>), find the datasheets for the following chips:
  - 7442 (or 74LS42)
  - 74138 (or 74LS138)
  - 7447

The heading in the upper corner of a chip's datasheet gives the chip number and a brief description of the kind of circuit contained on the chip. For instance, the heading in the upper datasheet for the 7404 says that it is a **Hex Inverter** chip. According to your datasheets, what kind of circuits are on the following three chips?

7442 \_\_\_\_\_

74138 \_\_\_\_\_

7447 \_\_\_\_\_

## 7442 Decoder

1. A chip's datasheet will give two diagrams that show the pin names and pin numbers. These two diagrams are organized differently. One of them, called the **pin diagram**, shows the pins ordered as they actually are on the physical DIP. The other one, called the **logic symbol**, generally shows input pins on the left and output pins on the right. Both diagrams are important and useful. The logic symbol is more useful when you're thinking about how data flows through the chip, and the pin diagram is more useful when you're wiring the chip in a circuit. In the space below, copy the 7442's pin diagram and logic symbol. **Be sure to include each pin's name and number.** Also be sure to include any markings that indicate active-low inputs or outputs.

7442 pin diagram

7442 logic symbol

2. Use the 7442's logic symbol to answer the following questions:

How many **input** pins does a 7442 have? \_\_\_\_\_

Which one of the following statements is true?

- All of the 7442's inputs are active-high.
- All of the 7442's inputs are active-low.
- Some of the 7442's inputs are active-high, and some are active-low.

How many **output** pins does a 7442 have? \_\_\_\_\_

Which one of the following statements is true?

- All of the 7442's outputs are active-high.
- All of the 7442's outputs are active-low.
- Some of the 7442's outputs are active-high, and some are active-low.

3. Wire a 7442 chip on the breadboard, connecting data switches to the chip's input pins. Using a logic probe to test the output levels, fill in the following function table for this chip. Write **L** for LOW and **H** for HIGH. I've completed part of the table for you.

<b>Inputs</b>				<b>Outputs</b>									
<b>D</b>	<b>C</b>	<b>B</b>	<b>A</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>
L	L	L	L	L	H	H	H	H	H	H	H	H	H
L	L	L	H										
L	L	H	L										
L	L	H	H										
L	H	L	L										
L	H	L	H										
L	H	H	L										
L	H	H	H										
H	L	L	L										
H	L	L	H										
H	L	H	L										
H	L	H	H										
H	H	L	L										
H	H	L	H										
H	H	H	L										
H	H	H	H										

4. When you're finished, ask me to check your table.

Table correct? \_\_\_\_\_    DIP inserted correctly? \_\_\_\_\_    Using power bus? \_\_\_\_\_  
 Wire colors? \_\_\_\_\_    Wire lengths? \_\_\_\_\_    Wire ends trimmed? \_\_\_\_\_  
 DIP accessible? \_\_\_\_\_

### 74138 Decoder

The 74138 is similar to the 7442, except for two important differences:

- It's a 3-line to 8-line decoder instead of a 4-line to 10-line decoder.
- In addition to its data inputs it also has three enable inputs.

1. In the space below, copy the 74138's pin diagram and logic symbol. Be sure to include each pin's name and number. Also be sure to include any markings that indicate active-low inputs or outputs.

74138 pin diagram

74138 logic symbol

2. Use the 74138's logic symbol to answer the following questions:

How many **input** pins does a 74138 have? \_\_\_\_\_

Which one of the following statements is true?

- All of the 74138's inputs are active-high.
- All of the 74138's inputs are active-low.
- Some of the 74138's inputs are active-high, and some are active-low.

How many **output** pins does a 74138 have? \_\_\_\_\_

Which one of the following statements is true?

- All of the 74138's outputs are active-high.
- All of the 74138's outputs are active-low.
- Some of the 74138's outputs are active-high, and some are active-low.

- Wire a 74138 chip on the breadboard, connecting data switches to the chip's A, B, and C input pins.

Also, connect an LED each of the output pins. Be sure to match the numbers of the LEDs and the output pins. In other words, connect output Y0 to LED 0, and connect output Y1 to LED 1, and so on.

**Enable the chip by connecting its active-high enable input to +5 V, and connecting its active-low enable inputs to ground.**

Use the data switches and LEDs to fill in the following function table. I've completed part of the table for you.

Inputs			Outputs							
C	B	A	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
L	L	L	L	H	H	H	H	H	H	H
L	L	H								
L	H	L								
L	H	H								
H	L	L								
H	L	H								
H	H	L								
H	H	H								

- When you're finished, ask me to check your table.

Table correct? \_\_\_\_\_ DIP inserted correctly? \_\_\_\_\_ Using power bus? \_\_\_\_\_  
 Wire colors? \_\_\_\_\_ Wire lengths? \_\_\_\_\_ Wire ends trimmed? \_\_\_\_\_  
 DIP accessible? \_\_\_\_\_

- Next, to investigate the operation of the chip's enable inputs, connect its G1 pin to ground instead of +5 V. Use the data switches and LEDs to examine the outputs for different combinations of inputs A, B, and C. What do you find?

- Now connect the G1 pin back to +5 V, and make sure that the chip works as it did before. Then connect the  $\overline{G2A}$  pin to +5 V. Use the data switches and LEDs to examine the outputs for different combinations of inputs A, B, and C. What do you find?

7. Now connect the  $\overline{G2A}$  pin back to ground, , and make sure that the chip works as it did originally. Then connect the  $\overline{G2B}$  pin to +5 V. Use the data switches and LEDs to examine the outputs for different combinations of inputs A, B, and C. What do you find?

### Encoders

1. The first two sentences in Section 6-6 of your textbook define the word **encoder**. Copy these two sentences below and make sure you understand what they mean.

An **encoder** is

2. Using a copy of the “TTL Data Book,” find the datasheet for the following chips:
  - 74147 and 74148

These two chips are so similar that they’re both described on the same datasheet. According to the headings in the upper corner of your datasheets, what kind of circuits are on these chips?

74147 \_\_\_\_\_

74148 \_\_\_\_\_

### 74148 Priority Encoder

5. In the space below, copy the 74148’s pin diagram and logic symbol. Include each pin’s name and number, and include any markings that indicate active-low inputs or outputs. (Note: The logic symbol’s notation for pin 5 is confusing. This is an active-low input, and you can ignore the line going to V18.)

74148 pin diagram

74148 logic symbol

6. Use the 74148's logic symbol to answer the following questions:

How many **input** pins does a 74148 have? \_\_\_\_\_

Which one of the following statements is true?

- All of the 74148's inputs are active-high.
- All of the 74148's inputs are active-low.
- Some of the 74148's inputs are active-high, and some are active-low.

How many **output** pins does a 74148 have? \_\_\_\_\_

Which one of the following statements is true?

- All of the 74148's outputs are active-high.
- All of the 74148's outputs are active-low.
- Some of the 74148's outputs are active-high, and some are active-low.

7. Wire a 74148 chip on the breadboard, connecting data switches to the chip's input pins. Be sure to match the numbers of the switches and the input pins. In other words, connect input pin 0 to switch SW0, and connect input pin 1 to switch SW1, and so on.

**Enable the chip by connecting its enable input to either +5 V or ground, depending on whether the enable input is active-high or active-low.**

Using LEDs or a logic probe to test the output levels, fill in the following function table for the input combinations I've listed below. Notice that in each of the table's rows, one switch is set LOW and all of the others are set HIGH.

Inputs								Outputs		
7	6	5	4	3	2	1	0	A2	A1	A0
L	H	H	H	H	H	H	H			
H	L	H	H	H	H	H	H			
H	H	L	H	H	H	H	H			
H	H	H	L	H	H	H	H			
H	H	H	H	L	H	H	H			
H	H	H	H	H	L	H	H			
H	H	H	H	H	H	L	H			
H	H	H	H	H	H	H	L			

8. When you're finished, ask me to check your table.

Table correct? \_\_\_\_\_ DIP inserted correctly? \_\_\_\_\_ Using power bus? \_\_\_\_\_  
 Wire colors? \_\_\_\_\_ Wire lengths? \_\_\_\_\_ Wire ends trimmed? \_\_\_\_\_  
 DIP accessible? \_\_\_\_\_

9. Based on the data in your table, briefly describe how the 74148 operates. In your description, include some discussion of the chip's active levels (active-low or active-high).

10. Now let's look at a few other input combinations that involve setting more than one switch LOW at the same time. Try the settings in the table below, and record the output levels.

Inputs								Outputs		
7	6	5	4	3	2	1	0	A2	A1	A0
L	H	L	H	H	L	H	H			
H	L	L	L	H	H	H	H			
H	L	L	H	L	H	L	H			
L	L	L	L	L	L	L	L			

11. Based on the data in this table, what additional information can you give about the 74148 that you couldn't tell from the earlier table? Your answer should include discussion of the term "priority encoder." What does that term mean?