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CSC 270
Lab #4

Lab #4: Decoders and Their Role in Combinational Circuits and as Dedicated Decoders and the 1-Bit Circuit

Introduction

In this lab we will take a closer look at the 74LS42 decoder, which is a 4-to-10 decoder. We will be using it to implement a 3-to-8 decoder with enable and active-low outputs. Additionally, we will use the 74LS42 decoder along with only one extra logic chip to implement a majority voter of 3 input signals. Finally, we will examine a circuit of NORs used as a 1-bit circuit.

Materials

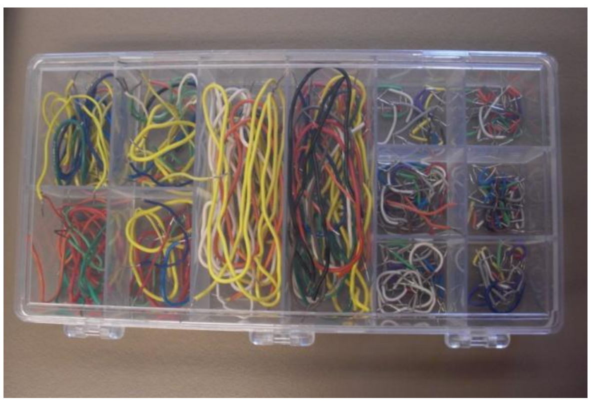

Figure 1. Wiring Kit.

Figure 2. Digital Training Kit.

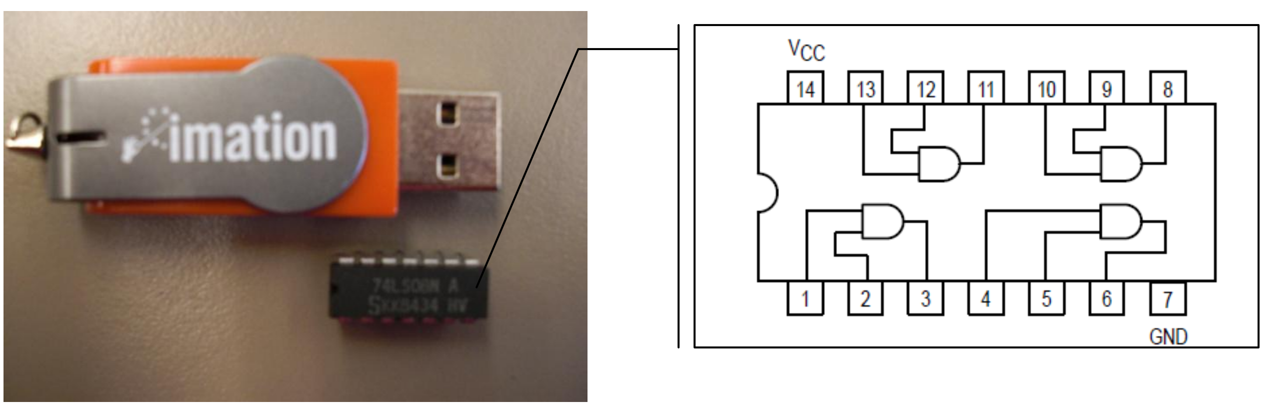

Figure 3. Quad 2-Input AND Gate 74LS08 Compared to a USB Flash Drive.

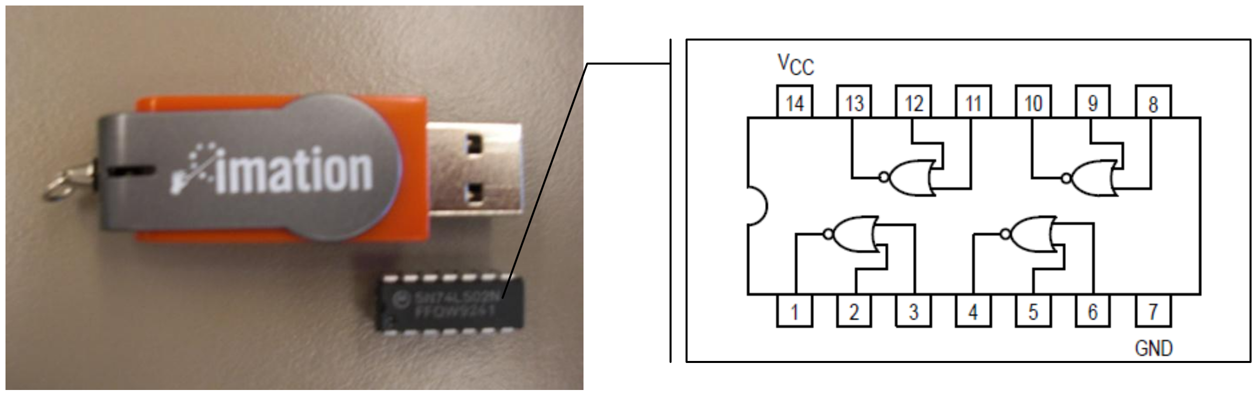

Figure 4. Quad 2-Input NOR Gate 74LS02 Compared to a USB Flash Drive.

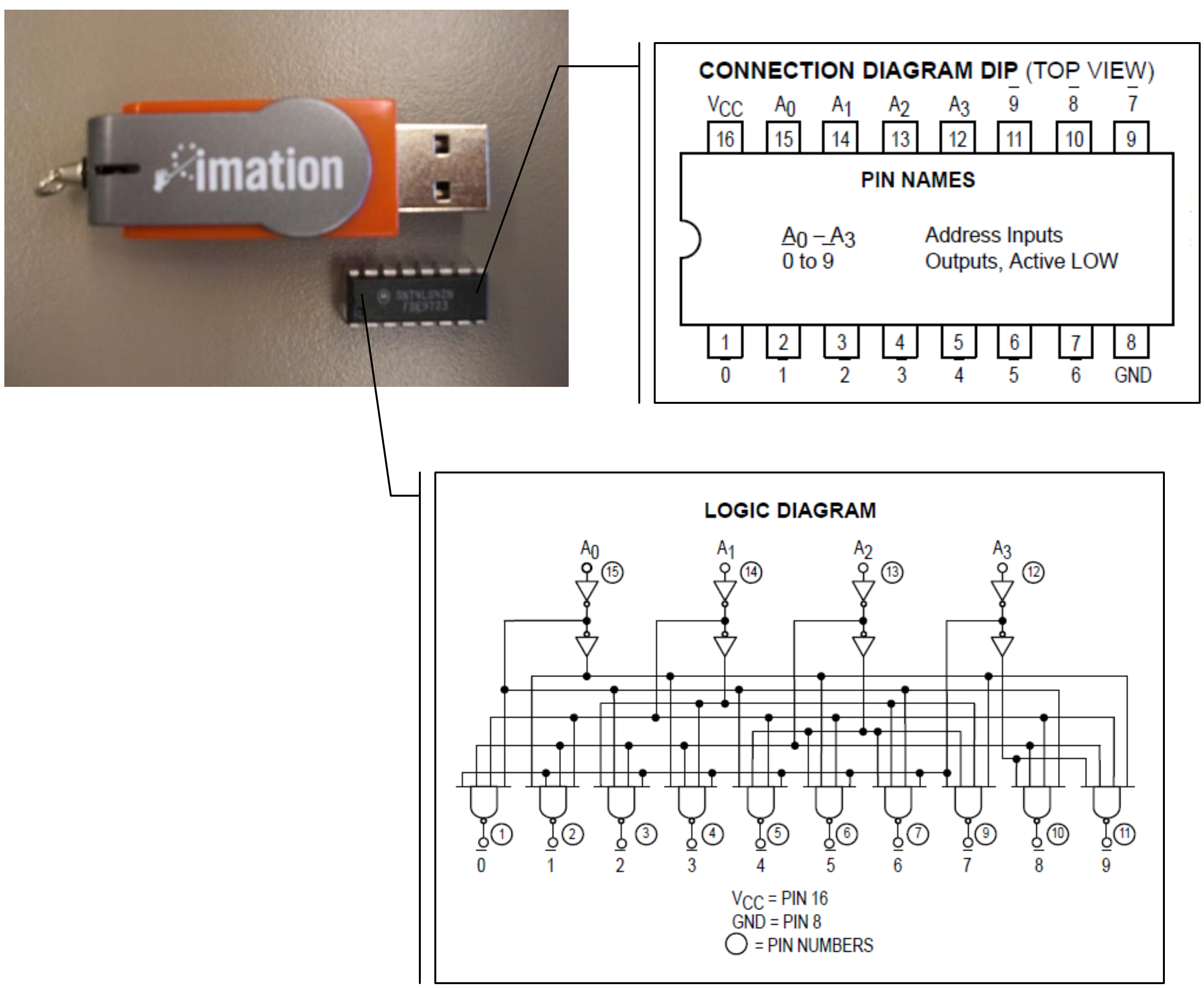

Figure 5. One-of-Ten Decoder 74LS42 Compared to a USB Flash Drive.

3-to-8 Decoder with a 74LS42

Using a 74LS42, which is a 4-to-10 decoder with active-low outputs, we implemented a 3-to-8 decoder, which as the following truth table:

b2	b1	b0	y'0	y'1	y'2	y'3	y'4	y'5	y'6	y'7
0	0	0	0	1	1	1	1	1	1	1
0	0	1	1	0	1	1	1	1	1	1
0	1	0	1	1	0	1	1	1	1	1
0	1	1	1	1	1	0	1	1	1	1
1	0	0	1	1	1	1	0	1	1	1
1	0	1	1	1	1	1	1	0	1	1
1	1	0	1	1	1	1	1	1	0	1
1	1	1	1	1	1	1	1	1	1	0

Table 1. Truth Table for a 3-to-8 Decoder with Active-Low Outputs

To do this, we chose one of the inputs as an enabler based on the truth table for the 4-to-10 decoder:

A_0	A_1	A_2	A_3	$\overline{0}$	$\overline{1}$	$\overline{2}$	$\overline{3}$	$\overline{4}$	$\overline{5}$	$\overline{6}$	$\overline{7}$	$\overline{8}$	$\overline{9}$
L	L	L	L	L	H	H	H	H	H	H	H	H	H
H	L	L	L	H	L	H	H	H	H	H	H	H	H
L	H	L	L	H	H	L	H	H	H	H	H	H	H
H	H	L	L	H	H	H	L	H	H	H	H	H	H
L	L	H	L	H	H	H	H	L	H	H	H	H	H
H	L	H	L	H	H	H	H	H	L	H	H	H	H
L	H	H	L	H	H	H	H	H	H	L	H	H	H
H	H	H	L	H	H	H	H	H	H	H	L	H	H
L	L	L	H	H	H	H	H	H	H	H	H	L	H
H	L	L	H	H	H	H	H	H	H	H	H	H	L
L	H	L	H	H	H	H	H	H	H	H	H	H	H
H	H	L	H	H	H	H	H	H	H	H	H	H	H
L	L	H	H	H	H	H	H	H	H	H	H	H	H
H	L	H	H	H	H	H	H	H	H	H	H	H	H
L	H	H	H	H	H	H	H	H	H	H	H	H	H
H	H	H	H	H	H	H	H	H	H	H	H	H	H

H = HIGH Voltage Level
L = LOW Voltage Level

Table 2. Truth Table for a 74LS42.

Since we are using an active-low output decoder, an enabler set at 0 or low would produce minterms indicated by a low voltage level. Looking at the truth table (Table 2), the first 8 combinations of inputs A_0, A_1, A_2, and A_3 produce the minterms 0' through 7' where A_3 can be treated as the enabler, A_2 as b0, A_1 as b1, and A_0 as b2. To show that the decoder can be used as a 3-to-8 decoder, we have to wire a circuit so that A_0, A_1, A_2 are connected to switches that can be switched on and off, A_3 is connected to a switch that is always off, and outputs 0' through 7' are connected to LEDs. The L's in the truth table will be indicated by an LED with light off and the H's in the truth table will be indicated by an LED with light on. However, because there are only 4 LEDs, we have to wire two circuits, one to check the lower four output bits using combinations of inputs from the first 4 lines in the truth table (Table 2) and one to check the upper four output bits using combinations of inputs from the second set of 4 lines in the truth table (Table 2).

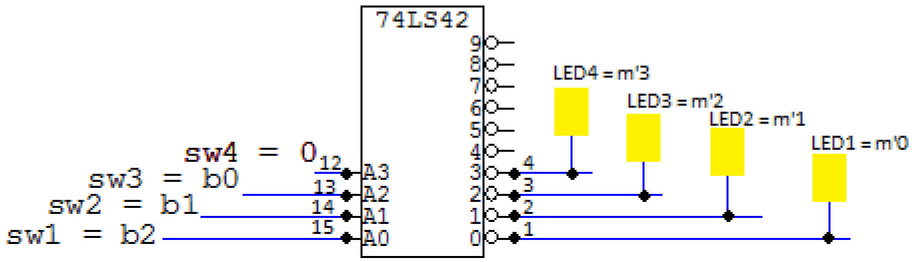

Figure 6. First 3-to-8 Decoder Circuit Using a 74LS42

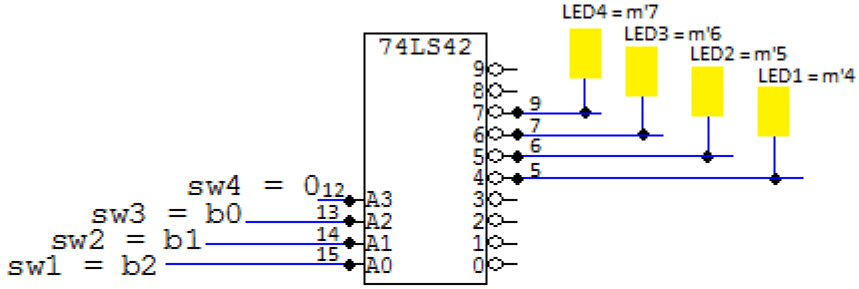

Figure 7. Second 3-to-8 Decoder Circuit Using a 74LS42

When the first circuit (Fig. 6) was wired, the outputs indicated by the LEDs matched the first four rows in the truth table for a 3-to-8 decoder (Table 1) when looking at only outputs y'0 through y'3. The second circuit (Fig. 7) had outputs that matched the second set of four rows in the truth table for a 3-to-8 decoder (Table 1) when looking at only output y'4 through y'7. Thus we successfully built a 3-to-8 decoder from a 74LS42 decoder.

Majority Voter with a 74LS42

Using a 74LS42 and only one extra chip, we created a majority voter of 3 input signals. Recall that a majority voter has the following truth table:

a	**b**	**c**	**y**
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Table 3. Truth Table for a Majority Voter.

To create a circuit for this truth table, we would need to sum (OR) the minterms as follows Σ(3, 5, 6, 7). However, since the 74LS42 produces active-low outputs, we need to use DeMorgan’s Law and take the product of the Maxterms (M_0, M_1, M_2, M_4), thus the one extra chip we will use along with the decoder chip is the 74LS08 (the AND gate). Also, since we want to use the 74LS42 as a majority voter of 3 inputs, we will implement the decoder as a 3-to-8 decoder as we did in the previous section.

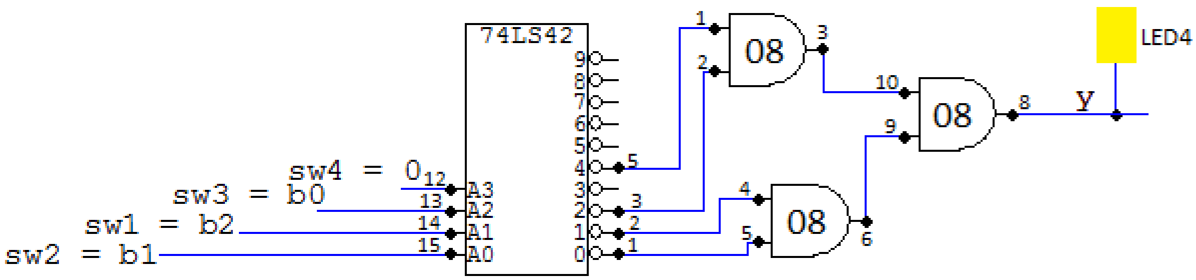

Figure 8. Majority Voter of 3 Inputs Using a 74LS42 Decoder and a 74LS08 AND Gate.

When the above circuit was implemented, the outputs produced matched those of Table 3, where light on indicated a 1 and light off indicated a 0. Thus, we successfully wired a majority voter of 3 inputs using only the 4-to-10 decoder and one chip containing AND gates.

The 1-Bit Circuit

Finally, we took a first look at an example of a sequential circuit, a circuit whose input is dependent of a previous output, with the 1-bit circuit:

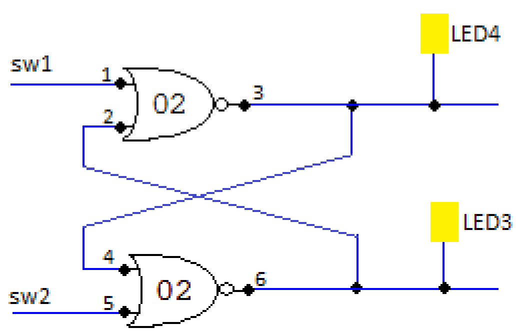

Figure 9. 1-Bit Circuit Made Up of 2 NOR Gates.

After wiring the above circuit, we played around with the outputs. We discovered that this circuit has the ability to “remember” what was last set to 1. With both switches starting at 0, we switched sw1 to on (or 1) and then switched it off (or 0) and the LED4 remained on. When we then switched sw2 to on and then switched it off, LED3 remained on.