LAB 3: Code Conversion

The 7-segment display is simple LED-based display that is usually used in electronic devices, such as digital alarm clocks, to display decimal numbers and some letters or symbols. It consists of seven LED's packaged together as shown in Figure 1 below. The ON/OFF combinations of the LED's display the appropriate symbol. For example, to display the number "2", the LED's labeled a, b, d, e, and g are turned ON while the LED's labeled c and f are turned OFF.

The BCD-to-7-Segment decoder (IC 7447) is a combinational circuit that is used to drive the 7-Segment display as shown in Figure 1. It takes a 4-bit input code (labeled DCBA) representing the BCD (Binary-Coded Decimal) number to be displayed and converts it into a 7-bit output code that is used to drive the 7-segment display. Table 1 below partially lists the corresponding BCD-to-7-Segment conversion table.

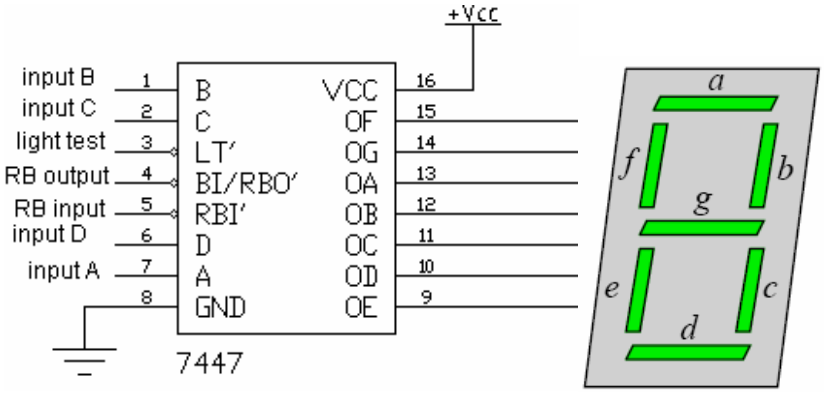

Figure 1: The BCD-to-7-Segment Decoder and the 7-Segment Display Unit

BCD to 7-Segment Conversion Table											
Decoder Inputs				(Decoder Output) 7-Segment Inputs							7-Segment Output
D	C	B	A	a	b	c	d	e	f	g	Number Displayed
0	0	0	0	1	1	1	1	1	1	0	0
0	0	0	1	0	1	1	0	0	0	0	1
0	0	1	0	1	1	0	1	1	0	1	2
0	0	1	1								3
0	1	0	0								4
0	1	0	1								5
0	1	1	0								6
0	1	1	1								7
1	0	0	0								8
1	0	0	1								9
1	0	1	0								
1	0	1	1								
1	1	0	0								
1	1	0	1								
1	1	1	0								
1	1	1	1								

Table 1: BCD to 7-Segment Conversion Table

1. Complete at least the first 10 rows of Table 1. If you can't complete the last 6 rows of the table, leave them blank for now.
2. Construct the circuit shown in Figure 1. Implement the 4-bit BCD code input using 4 switches. Observe the 7-Segment display as you change the input BCD code according to Table 1 and register any discrepancies. Observe and register the output displayed patterns for the last 6 codes of Table 1.

3. A small corporation has 9 shares of stock, and each share entitles its owner to one vote at a stockholders meeting. The 9 shares are owned by 4 people as follows:

Mr.W:1 share
Mr.X:2 shares
Mr.Y:3 shares
Mr.Z:3 shares

Each of these persons has a switch to close (logic-1) when voting "YES" and open (logic-0) when voting "NO" for his or her share(s).
Design a combination circuit that displays the total number of shares that vote "YES" for each measure. Use a 7-segment display and a BCD-to-7-Segment decoder to display the number "YES" votes. Use four 8x1 multiplexers (IC 74151) to design the combinational circuit that converts the input from the stock owners' switches into the BCD input code for the 7447.

4. An encoder is a combinational circuit that performs the reverse function of the decoder. It has 2^n (or less) input lines and n output lines. The output lines represent the binary code of the input line that is selected. A priority Encoder produces the binary code of the highest priority input line.
Derive the truth table of 3-input priority encoder and draw its corresponding logic diagram using NAND gates. Show how the circuit shown in Figure 1 can be used to display the output of the 3-input priority encoder on the 7-Segment display.

Lab Work:

1. Implement the circuit described in Q1 and check its operation.
2. Implement the circuit you designed in Q2 and check its operation.
3. Implement the circuit you designed in Q3 and check its operation.

Questions:

1. Design a combinational circuit with 4 inputs and 4 outputs that converts a 4–bit Gray code into the equivalent 4-bit binary number. Implement the circuit with exclusive-OR gates.

2. Design a circuit with 4 inputs that represent a BCD number and 4 output lines that represent the 9's complement of the input number. Provide a 5^{th} output that detects an error in the input BCD number. This output should be equal to logic-1 when the input is an invalid BCD code.

3. Design a 2x4 decoder using NAND gates.

4. Design a 3x8 decoder using 2x4 decoders.