Palestine Technical College

Engineering Professions Department

EEE14356 - Digital Logic Fundamentals

***Experiment* 5**

Code Converters

Student No	***Name Surname***	***Group***	***Lecturer***	***Grade***

2022-2023

Objectives:

1. To build a Gray code to binary converter.
2. Use design steps of combinational circuits in designing a gray code to binary converter.
3. Use a BCD to seven-segment decoder and seven-segment display to show the equivalent of BCD number in decimal.

***Note*: Verify the IC's numbers and validity before using it in any circuit.**

Equipment and materials:

- Digital trainer M21-5000
- Seven-segment LED display (CA)
- Integrated circuits (ICs)
  - 7447 BCD-to-seven segment decoder
  - 7486 Quadruple 2-input XOR gates
  - 74191 synchronous up/down 4-bit binary counter

Introduction:

Digital systems use different types of binary coding. These codes include binary coded decimal (BCD), gray, octal, hexadecimal, and other codes. Frequently, it is necessary to convert between different codes. As an example, the output of one system (BCD) is used as an input to another system (7-segment LEDs). Therefore, the utilized digital system must be capable of processing the data in a standard format. Consequently, the data must be transformed from one type of coding to another for various purposes, where gates can be used to create various code converters.

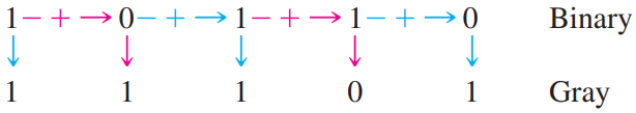
A ***gray code*** is defined as a modified binary code in which a decimal number is represented in binary form in such a way that each gray-code number differs by a single bit from the previous and subsequent numbers. For example, in the transition from decimal 3 to 4, the gray code changes from 0010 to 0110, whereas the binary code changes from 0011 to 0100, a change of 3 bits.

A ***BCD*** is a method for representing each decimal digit (0 to 9) in a 4-bit binary code. For example, **$(23)_{10}$** is represented by **(0010-0011)** using **BCD** code rather than **$(10111)_2$**. Due to our preference for reading and writing in decimal, the BCD code offers an excellent interface to binary systems. Such interfaces include keypad inputs and digital displays.

To convert from a binary number to a gray code word, apply the following rules:

1. The most significant bit (left-most) in gray code is the same as the corresponding MSB in the binary number.
2. Going from left to right, add each adjacent pair of binary code bits to get the next gray code bit, while discarding the carries.

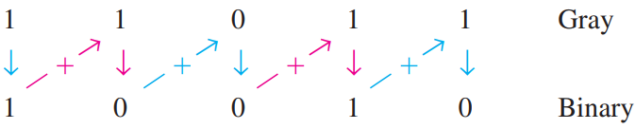
For example, the conversion of the binary number **10110** to gray code is **11101**:



To convert from gray code to binary, apply the following rules:

1. The most significant bit (left-most) in the binary code is the same as the corresponding bit in the gray code.
2. Add each binary code bit generated to the gray code bit in the next adjacent position and discard carries.

For example, the conversion of the gray code word **11011** to binary number is **10010**:



Part A – Gray to Binary Code Conversion

1. Design a combinational circuit with 4-inputs and 4-outputs that converts a 4-bit gray code number into the equivalent 4-bit binary number and record the output states in table 5.1.
2. Simplify the output states of table 5.1 using *K*-map method and ***implement*** the circuit using **XOR gates** only.

Table 5.1. Gray to binary conversion.

Decimal	Gray				Binary			
	A	***B***	***C***	***D***	***w***	***x***	***y***	***z***
0	0	0	0	0				
1	0	0	0	1				
2	0	0	1	1				
3	0	0	1	0				
4	0	1	1	0				
5	0	1	1	1				
6	0	1	0	1				
7	0	1	0	0				
8	1	1	0	0				
9	1	1	0	1				
10	1	1	1	1				
11	1	1	1	0				
12	1	0	1	0				
13	1	0	1	1				
14	1	0	0	1				
15	1	0	0	0				

K-map

	00	01	11	10
00				
01				
11				
10				

Boolean Expressions of w:

	00	01	11	10
00				
01				
11				
10				

Boolean Expressions of x:

	00	01	11	10
00				
01				
11				
10				

Boolean Expressions of y:

	00	01	11	10
00				
01				
11				
10				

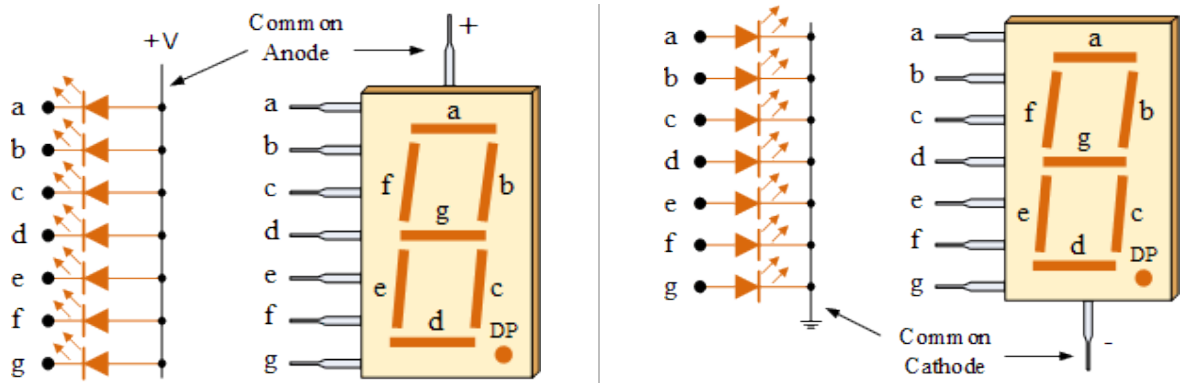
Boolean Expressions of z:

Logic diagram using XOR gates:

3. Summarize your results and discuss any issues you encountered during circuit building or testing.

Part B – BCD to 7-segments Decoder

The 7-segment LED display (***common anode or common cathode)*** is not an IC. It contains seven discrete LEDs on a small PCB, and they are identified as segments (*a, b, c, d, e, f, g*). In ***common anode mode***, all the anode connections of the LED segments are tied together to +5Vdc, while the cathode of the particular segments (a-g) are connected to a ground via a resistor. In the case of ***common cathode mode***, all the cathode connections of the LED segments are tied together to ground, while the individual anode terminals (a-g) are connected to a +5Vdc via a resistor. The 7-segment display is used to display any one of the decimal digits 0 through 9. However, BCD to 7-segment decoder accepts a decimal digit in BCD and generates the corresponding 7-segment code.



1. Set up the circuit shown in figure 5.1 and make sure to connect pin 16 to +5Vdc and pin 8 to ground of the 7447 IC, while pin 3 of the 7-segment display is connected to +5Vdc through 50 ohm resistor and the output of the 7447 IC is applied to the inputs of the 7-segment display.
2. Apply the combination of 4-bit binary through switches SW1-SW4 and monitor the decimal display output at the 7-segment display.
3. Verify the circuit of BCD to 7-segment code conversion by completing the truth table 5.2.

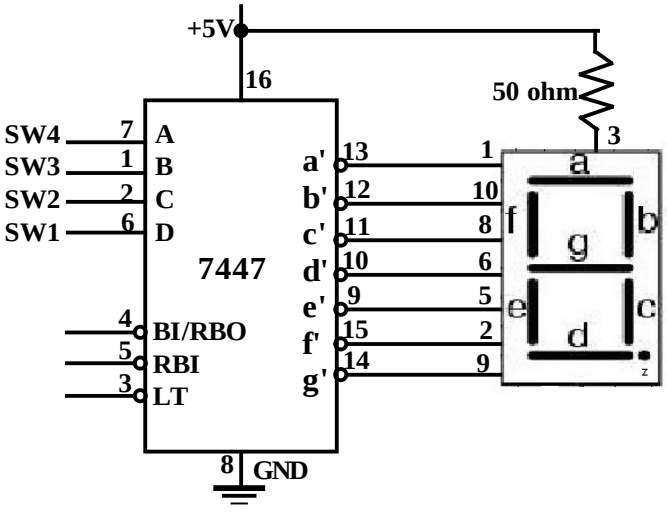


Figure 5.1. BCD to 7-segment decoder.

Table 5.2. BCD to 7-segment decoder.

Decimal	BCD				Seven segment						
	A	*B*	*C*	*D*	*a*	*b*	*c*	*d*	*e*	*f*	*g*
0	0	0	0	0							
1	0	0	0	1							
2	0	0	1	0							
3	0	0	1	1							
4	0	1	0	0							
5	0	1	0	1							
6	0	1	1	0							
7	0	1	1	1							
8	1	0	0	0							
9	1	0	0	1							
10	0	0	0	0							
11	0	0	0	1							
12	0	0	1	0							
13	0	0	1	1							
14	0	1	0	0							
15	0	1	0	1							

4. What is your observation on the 4-bit inputs and 7-bits output patterns of table 5.2?

Part C –Synchronous 4-bit binary counter

1. Construct the synchronous 4-bit binary counter circuit shown in figure 5.2. The connection of 7447 IC & 7-segment display is the same as in figure 5.1 except that pins 3&5 are connected to +5Vdc. Either you connect pin 4 or 5 to the CLK switch (1Hz pulse) & the other pin to +5Vdc of the 74192 IC.
2. You set the up/down pins of the counter by feeding 1Hz pulse train into pin 5 or 4 of the 74192 IC and monitor the counter output on the 7-segment display.

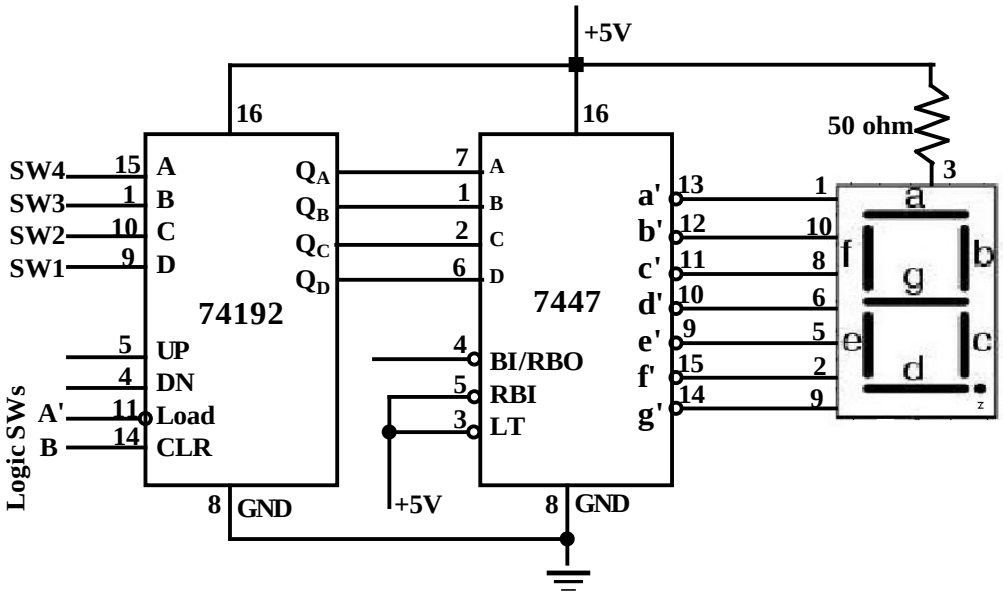


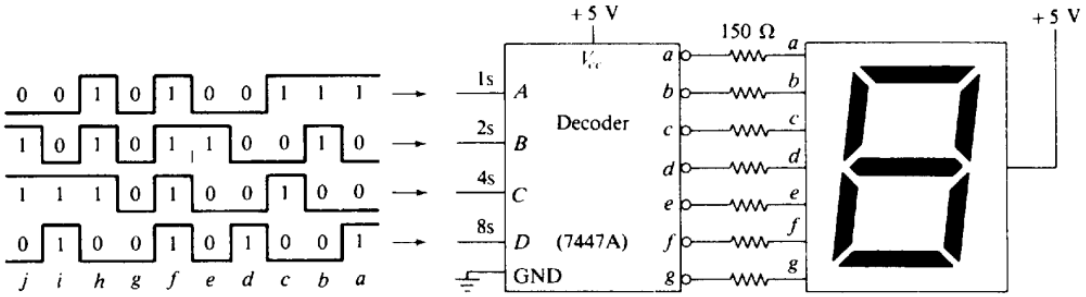
Figure 5.2. Synchronous 4-bit binary counter.

Questions:

1. Convert the gray code 01011001 to decimal number and show your work.

2. Convert the gray code 00101101 to binary number and show your work.

3. List the decimal indication of the seven-segment display for each input in the figure below.



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4. The counter is counting up when connecting pin 5 to _____ & pin 4 to _____.
5. The counter is counting down when connecting pin 5 to _____ & pin 4 to _____.
6. Set up the SWs to 0101, and connecting pin 5 to 1Hz pulse train & pin 4 to +5V. Depress the A' pushbutton and hold it, note the number in the 7-segment display_____. Release the A' logic switch and record your observation on the result?

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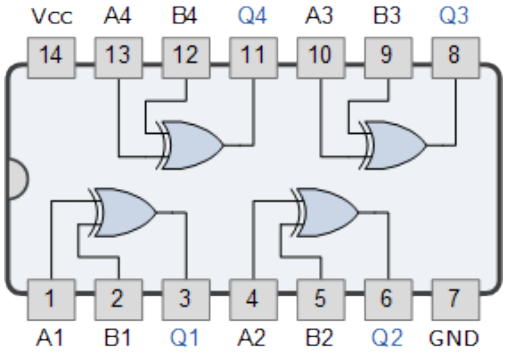
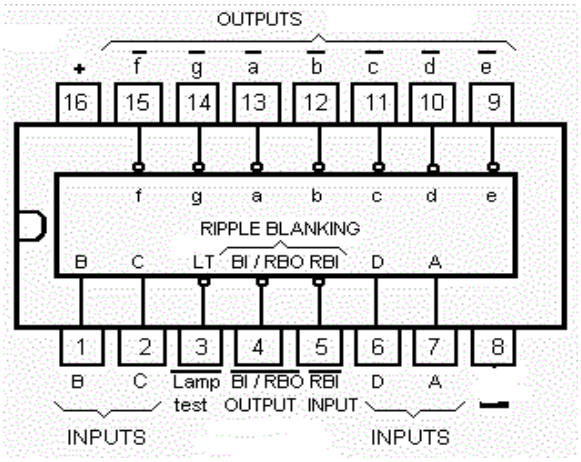
7. Depress & hold the B logic switch while the counter is counting, what happens to the 7-segment display?_____. Release the B logic switch, and record your observation on the result?

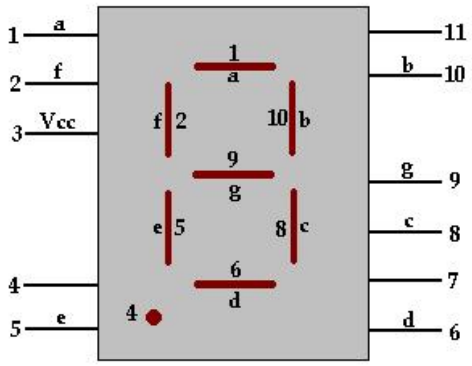
Pin Configuration:



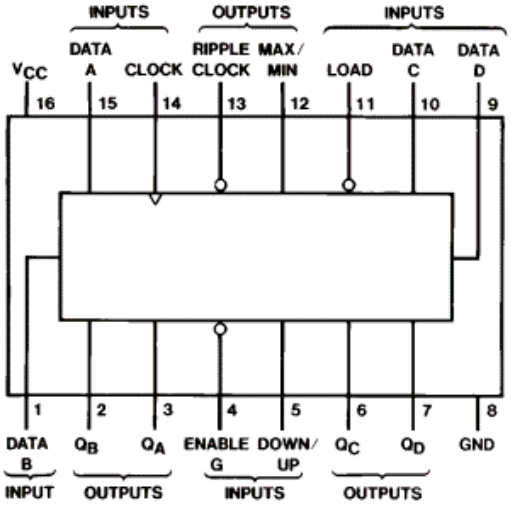
7486 XOR gate



7447 BCD-to-seven segment decoder



7 Segment LED Display



74191 Synchronous up/down 4-Bit Binary Counter