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California State University, Northridge

Department of Electrical & Computer Engineering

Experiment 3
Number Systems

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ECE 320L

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Introduction:

The purpose of this experiment is to understand how number systems are converted from decimal to binary, and how binary can be converted to a seven segment display through a circuit. Another objective of this experiment is to become proficient in designing and troubleshooting a logical circuit by constructing truth tables and logical functions.

Equipment used:

1. Proto board

Parts Used:

QTY	Component	Value
7	Resistor	330Ω
1	Resistor	1.0KΩ
1	7447A Decoder	
1	MAN72 seven-segment display	
1	Decoder	
1	LED	

Software Used:

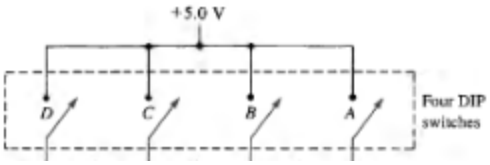
1. Google Docs
2. Krita
3. Snipping Tool
4. Google Sheets

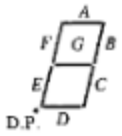
Theory:

To conduct this experiment, It is important to understand number conversion between binary, octal, and decimal, as well as binary coded decimal (BCD). These Binary codes will then be converted to a 7 segment display. The following truth table shows how.

	binary coded decimal				7 segment display						
D	C	B	A	decimal	a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
0	0	0	1	1	0	1	1	0	0	0	0
0	0	1	0	2	1	1	0	1	1	0	1
0	0	1	1	3	1	1	1	1	0	0	1
0	1	0	0	4	0	1	1	0	0	1	1
0	1	0	1	5	1	0	1	1	0	1	1
0	1	1	0	6	1	0	1	1	1	1	1
0	1	1	1	7	1	1	1	0	0	0	0
1	0	0	0	8	1	1	1	1	1	1	1
1	0	0	1	9	1	1	1	1	0	1	1

7 segment displays are represented through 7 individual lights “a” through “g” each would be on or off depending on which number is input. And the binary coded decimal will represent the inputs for Switches D through A.





Using the truth table above, it is possible to construct the logical function for each output. For example the logical function for C in canonical form of sum of products, would be as follows.

$$\bar{D}C\bar{B}\bar{A} + \bar{D}B\bar{C}A + \bar{D}\bar{C}BA + \bar{D}C\bar{B}\bar{A} + \bar{D}CB\bar{A} + \bar{D}CBA + DC\bar{B}\bar{A} + DC\bar{B}A$$

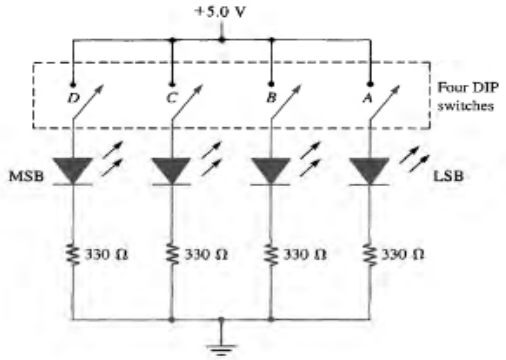
After simplification, we can then use the function to construct a circuit for output C and do the same for all other outputs. The underlying logic for these circuits would be equivalent to the logical circuits found in 7447a decoder used for this experiment.

Procedure & Results:

1. First the pin numbers for the 7447A Decoder and the 7 segment display were looked up, to aide in the construction of the circuit.

2. Then, the circuit shown in Figure 3-1 was constructed which represented the BCD input for the experiment. Rather than making our own switches, we used the switches S1 - S4 on the protoboard to represent Input D - A respectively. This reduced the need for four 330Ω resistors and switch testing.

FIGURE 3–1



3. Then the BCD input was connected to the circuit shown in Figure 3-2.

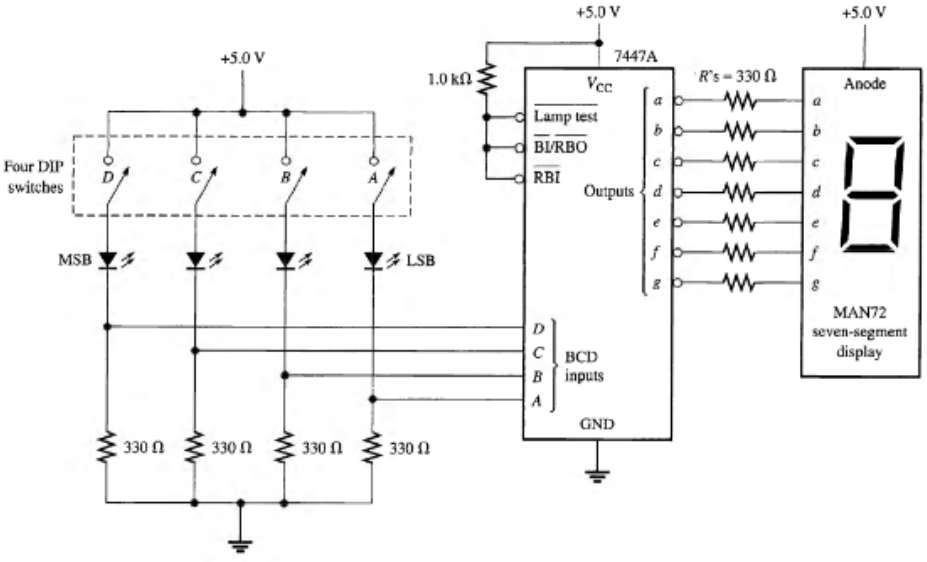
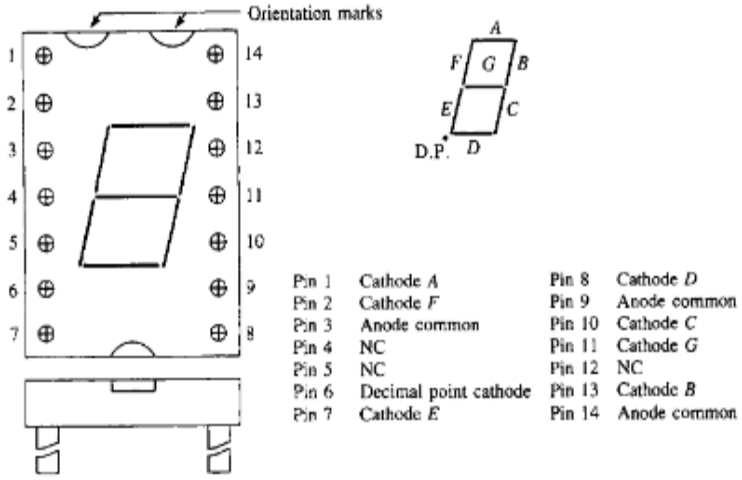


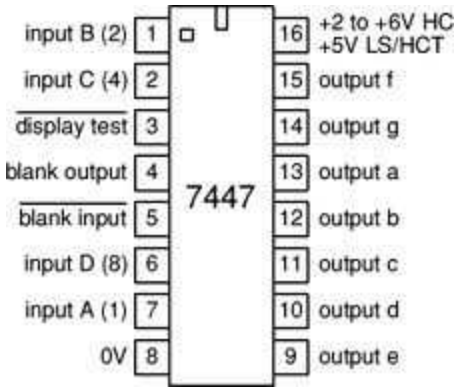
FIGURE 3–2

Using Figure 3-4 and a 7447A diagram found through google, each output “a - g” was connected to the respective cathode “a - g” on the seven segment display, each with a 330Ω resistor between. Then the Lamp test, BI/RBO, and RBI pins were to a 1.0kΩ.

FIGURE 3–4
MAN72 seven-segment display.



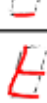
Pin 1	Cathode *A*	Pin 8	Cathode *D*
Pin 2	Cathode *F*	Pin 9	Anode common
Pin 3	Anode common	Pin 10	Cathode *C*
Pin 4	NC	Pin 11	Cathode *G*
Pin 5	NC	Pin 12	NC
Pin 6	Decimal point cathode	Pin 13	Cathode *B*
Pin 7	Cathode *E*	Pin 14	Anode common



7447 pin configuration

4. Once the circuit was complete and functional, all 0-9 decimal and invalid codes were tested and the display was recorded in Table 3-1.

TABLE 3–1

Inputs		Output
Binary Number	BCD Number	Seven-Segment Display
0000	0	
0001	1	
0010	2	
0011	3	
0100	4	
0101	5	
0110	6	
0111	7	
1000	8	
1001	9	
1010	INVALID	
1011	INVALID	
1100	INVALID	
1101	INVALID	
1110	INVALID	
1111	INVALID	

5. Various troubles were simulated and their results were recorded in Table 3-2.

TABLE 3–2

Trouble Number	Trouble	Observations
1	LED for the *C* input is open.	invalid outputs for #'s 2,3,6, & 7
2	*A* input to 7447A is open.	invalid outputs for #'s 1,3,5,7,9
3	$\overline{\text{LAMP TEST}}$ is shorted to ground.	The entire display is off
4	Resistor connected to pin 15 of the 7447A is open.	"B" segment is off

6. For a thought experiment, a method was developed for suppressing leading zeros larger displays.

Result: To suppress leading zeros, a switch or logic gate would be used to short, the Lamp Test which would turn off the displays for leading zeros.

7. (Further investigation). Lastly, a circuit was constructed to convert the 7 segment display from decoding decimal number system to an octal number system in base 8. An LED was to be introduced to the circuit to represent the 0 and 1 for the next digit for the numbers in octal. The method used to make this conversion was recorded and a schematic was drawn.

Result: Switch D was removed from the circuit and connected to an LED with a 330Ω resistor. Input D on the 7447A decoder would always be 0, therefore the pin was shorted to ground. Below is a schematic of the conversion.

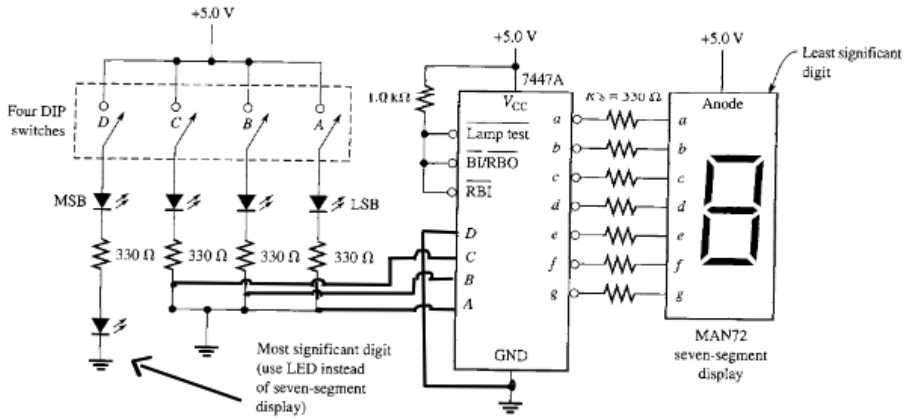


FIGURE 3–5

Conclusions:

Through the experiment, decimal numbers were successfully converted into binary coded decimal which was then used as inputs for a seven segment display, as evidenced in the proper results of displays in Table 3-1.

The experiment emphasizes the importance of logical functions and truth tables in constructing a digital system. By properly analyzing the inputs and outputs of the circuit, it revealed the underlying logic that was used to construct the circuits in all the outputs of the 7447a decimal decoder.

Furthermore, the experiment was also a success in its objective to troubleshoot circuits. The circuit was properly analyzed in all places along the circuit that a problem could have occured. Through simulating troubles and analyzing the observations and invalid outputs, the experiment revealed how the inner logic of the circuit worked and how to fix the issue.