Experiment 11 – Combinational Logic Design: A 3-6-9 Detector

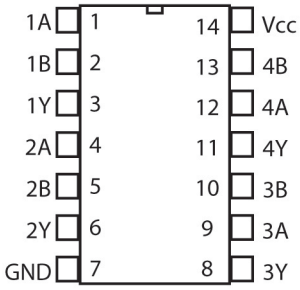
Physics 242 – Electronics

In this lab you will design and build a "3-6-9 Detector" circuit. The input to the circuit is a BCD (binary coded decimal) number, so there will be four input lines required (to express the binary numbers 0 through 9). The output of the circuit is a single line which should be HIGH if the input number is 3, 6, or 9, and LOW if the input number is 0, 1, 2, 4, 5, 7, 8. Since inputs above 9 will not occur, the output is X (either 0 or 1) for such inputs. It is convenient to use the slide switches at the bottom of your breadboard for the inputs and one of the LEDs at the top for the output.

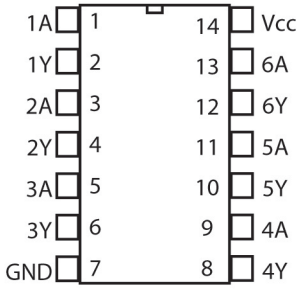
I. Logic Gate Implementation

You are allowed to use standard AND (7408), OR (7432), and NOT (7404) gates for your circuit (pinouts shown below). To design your circuit, begin by writing the truth table; include columns for the four input variables and the output variable. Certain combinations of the input variables, like 1111, will never occur as input to your circuit, since 1111 is not a valid BCD code—for these inputs, write X ("don't care") for the output. Draw a Karnaugh map, including both 1's and X's on the map. As usual, identify groups of 1's and remember that an X may count as 1 or 0, whichever is convenient. From your Karnaugh map, write the simplest SOP (sum of products) expression for the output and design your circuit accordingly.

Be sure to demonstrate the successful operation of your circuit to the instructor, either during the lab period or later in the week. For maximum credit, use only three chips (one each of 7404, 7408, 7432); for slightly less than maximum credit, you may use four chips. For extra credit, construct the circuit using only two 7400 (NAND) chips (same pin connections as the 7408 shown below). You are advised to verify the operation of the gates on your chips before investing time into building your circuit design. Your lab report should be a brief description of your design, including the truth table, K-map, SOP (sum of products) expression and any subsequent Boolean algebra rearrangement, and a neat sketch of the circuit.



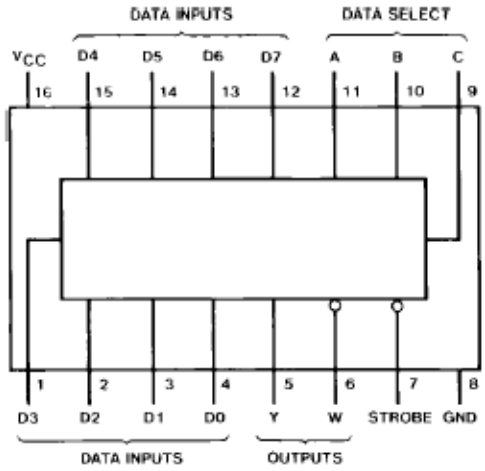
7408 AND
7432 OR



7404 Inverter

(over)

Connection Diagram



Truth Table

Inputs				Outputs	
Select			Strobe	Y	W
C	B	A	S		
X	X	X	H	L	H
L	L	L	L	D0	$\overline{D0}$
L	L	H	L	D1	$\overline{D1}$
L	H	L	L	D2	$\overline{D2}$
L	H	H	L	D3	$\overline{D3}$
H	L	L	L	D4	$\overline{D4}$
H	L	H	L	D5	$\overline{D5}$
H	H	L	L	D6	$\overline{D6}$
H	H	H	L	D7	$\overline{D7}$

H = HIGH Level
L = LOW Level
X = Don't Care
D0, D1...D7 = the level of the respective D input

II. Multiplexer Implementation

In this part, you will construct the same 3-6-9 detector using the 74151 chip, a 1-of-8 line data selector/multiplexer and (if needed) a 7404 inverter. To figure out how to connect your multiplexer, begin by writing the truth table again; include columns for the four input variables, the output variable, and a column for the output as a function of one of the input variables, as we discussed in class.

Be sure to demonstrate the successful operation of your circuit to the instructor, either during the lab period or later in the week. Your lab report should include your truth table and a neat sketch of your circuit design.