Lab 2: The Design Hierarchy

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Part I

1. If the truth table in Table 2.1 of the handout was given in full, how many rows would it have?

   It would have 64 rows.

2. Export the schematic of the mux4to1 subcircuit as an image and include it in your report.

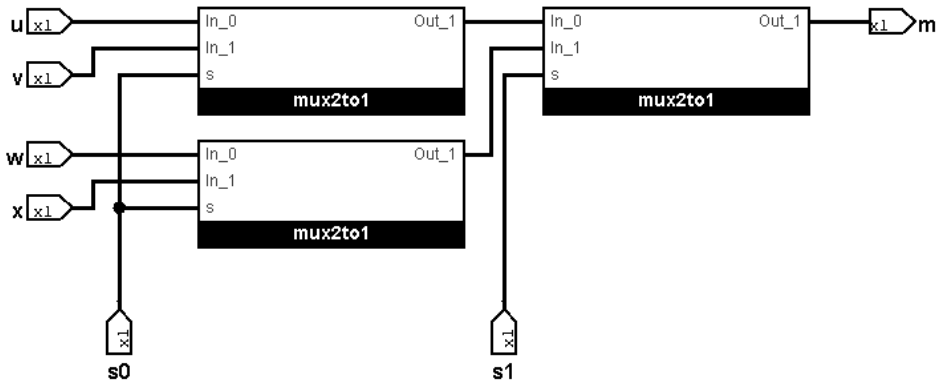

Figure 1: A schematic of the 4-to-1 multiplexer

Part II

1. Derive seven truth tables, one for each segment of the 7-segment decoder.

$D_{3:0}$	Character	S_0	S_1	S_2	S_3	S_4	S_5	S_6
0000	0	1	1	1	1	1	1	0
0001	1	0	1	1	0	0	0	0
0010	2	1	1	0	1	1	0	1
0011	3	1	1	1	1	0	0	1
0100	4	0	1	1	0	0	1	1
0101	5	1	0	1	1	0	1	1
0110	6	1	0	1	1	1	1	1
0111	7	1	1	1	0	0	0	0
1000	8	1	1	1	1	1	1	1
1001	9	1	1	1	0	0	1	1
1010	A	1	1	1	0	1	1	1
1011	b	0	0	1	1	1	1	1
1100	c	1	0	0	1	1	1	0
1101	d	0	1	1	1	1	0	1
1110	E	1	0	0	1	1	1	1
1111	F	1	0	0	0	1	1	1

D3	D2	D1	D0	m_0	m_2	m_3	m_5	m_6	m_7	m_8	m_9	m_{10}	m_{12}	m_{14}	m_{15}	S_0
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1
0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1
0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1
0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1
1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1
1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1

D3	D2	D1	D0	m_0	m_1	m_2	m_3	m_4	m_7	m_8	m_9	m_{10}	m_{13}	S_1
0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	1	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	1	0	0	0	0	0	0	0	1
0	0	1	1	0	0	0	1	0	0	0	0	0	0	1
0	1	0	0	0	0	0	0	1	0	0	0	0	0	1
0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	1	0	0	0	0	0	1	0	0	0	0	1
1	0	0	0	0	0	0	0	0	0	1	0	0	0	1
1	0	0	1	0	0	0	0	0	0	0	1	0	0	1
1	0	1	0	0	0	0	0	0	0	0	0	1	0	1
1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	1	0	0	0	0	0	0	0	0	0	1	1
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

D3	D2	D1	D0	m_0	m_1	m_3	m_4	m_5	m_6	m_7	m_8	m_9	m_{10}	m_{11}	m_{13}	S_2
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1
0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1
0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1
0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1
1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1
1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1
1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

D3	D2	D1	D0	m_0	m_2	m_3	m_5	m_6	m_8	m_{11}	m_12	m_{13}	m_{14}	S_3
0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	1	0	0	0	0	0	0	0	0	1
0	0	1	1	0	0	1	0	0	0	0	0	0	0	1
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	0	1	0	0	0	1	0	0	0	0	0	0	1
0	1	1	0	0	0	0	0	1	0	0	0	0	0	1
0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	1	0	0	0	0	1
1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	1	0	0	0	0	0	0	1	0	0	0	1
1	1	0	0	0	0	0	0	0	0	0	1	0	0	1
1	1	0	1	0	0	0	0	0	0	0	0	1	0	1
1	1	1	0	0	0	0	0	0	0	0	0	0	1	1
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

D3	D2	D1	D0	m_0	m_2	m_6	m_8	m_{10}	m_{11}	m_{12}	m_{13}	m_{14}	m_{15}	S_4
0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	1	0	0	0	0	0	0	0	0	1
0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
0	1	1	0	0	0	1	0	0	0	0	0	0	0	1
0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	1	0	0	0	0	0	0	1
1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0	1	0	0	0	0	0	1
1	0	1	1	0	0	0	0	0	1	0	0	0	0	1
1	1	0	0	0	0	0	0	0	0	1	0	0	0	1
1	1	0	1	0	0	0	0	0	0	0	1	0	0	1
1	1	1	0	0	0	0	0	0	0	0	0	1	0	1
1	1	1	1	0	0	0	0	0	0	0	0	0	1	1

D3	D2	D1	D0	m_0	m_4	m_5	m_6	m_8	m_9	m_{10}	m_{11}	m_{12}	m_{14}	m_{15}	S_5
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1
0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	1
0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	1
0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1
1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1
1	0	1	1	0	0	0	0	0	0	0	1	0	0	0	1
1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1
1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1
1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1

D3	D2	D1	D0	m_2	m_3	m_4	m_5	m_6	m_8	m_9	m_{10}	m_{11}	m_{13}	m_{14}	m_{15}	S_6
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1
0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1
0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1
0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1
0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1
1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1
1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	1
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1
1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1

2. Use Karnaugh maps to write seven Boolean functions for each segment so that they are optimized.

$$S_0 = \overline{D3}D1 + D2D1 + \overline{D2D0} + D3\overline{D0} + \overline{D3}D2D0 + D3\overline{D2D1}$$
$$S_1 = \overline{D3D2} + \overline{D2D0} + \overline{D3D1D0} + \overline{D3}D1D + D3\overline{D1}D0$$
$$S_2 = \overline{D3D1} + \overline{D3}D0 + \overline{D3}D2 + D3\overline{D2} + \overline{D1}D0$$
$$S_3 = D3\overline{D1D0} + D2\overline{D1}D0 + D2C\overline{D0} + \overline{D3D2D0} + \overline{D2}D1D0$$
$$S_4 = D3D1 + D3\overline{D0} + D3D2 + D1\overline{D0} + \overline{D2D0}$$
$$S_5 = D3\overline{D2} + D3D1 + \overline{D1D0} + \overline{D3}D2\overline{D0} + \overline{D3}D2\overline{D1}$$
$$S_6 = D3\overline{D2} + D3D0 + D3C + D1\overline{D0} + \overline{D2}D1 + \overline{D3}D2D1$$

3. Use the naming scheme `HEX0`, `HEX1`, ..., `HEX6` for each subcircuit. Export each subcircuit schematic as an image and include it in your report.

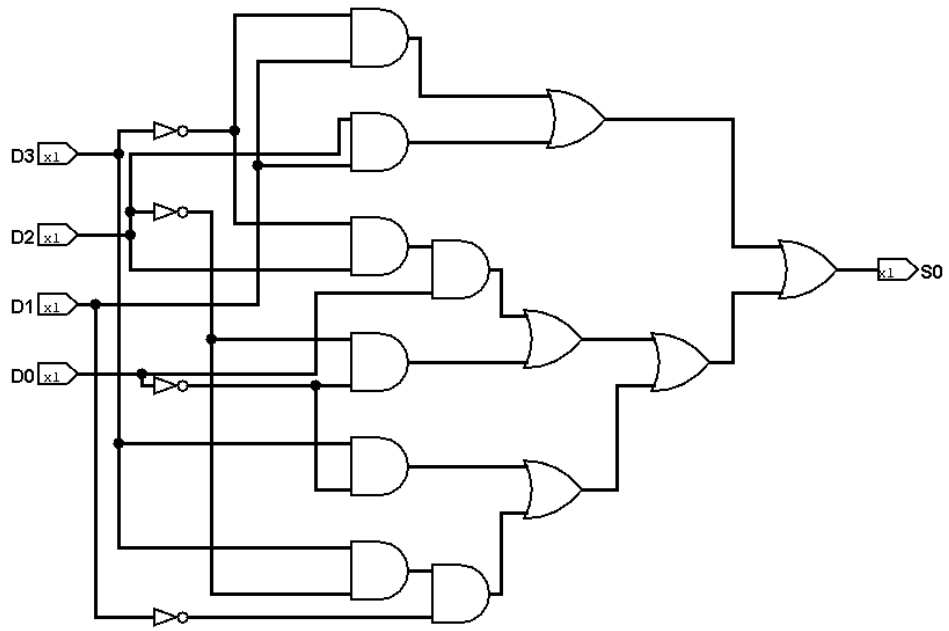

Figure 2: A schematic of HEX0

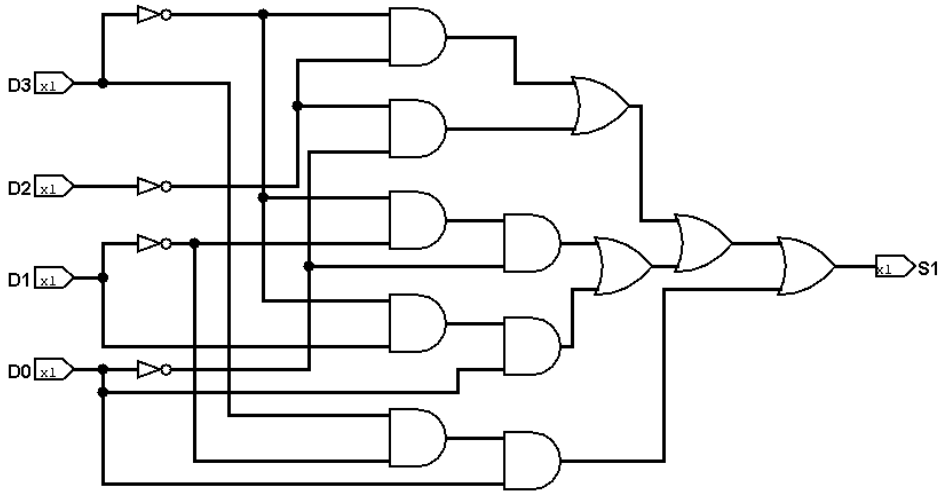

Figure 3: A schematic of HEX1

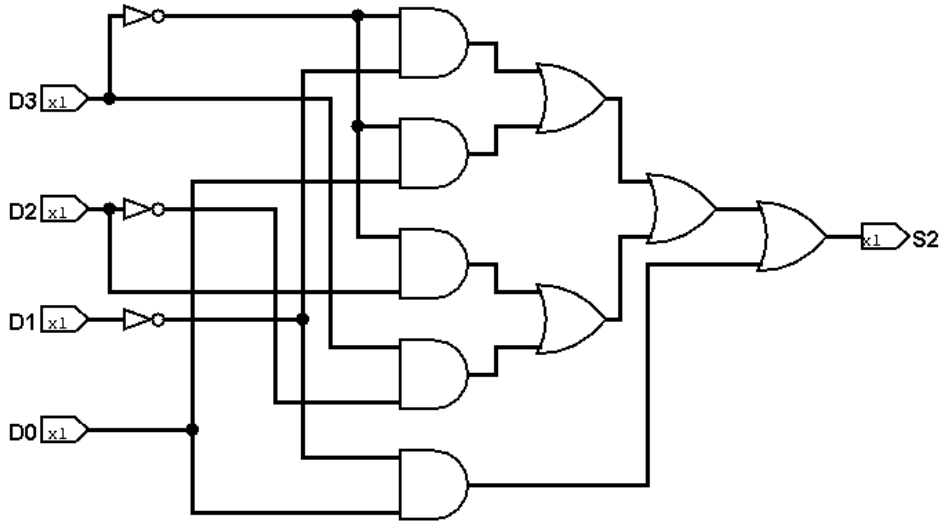

Figure 4: A schematic of HEX2

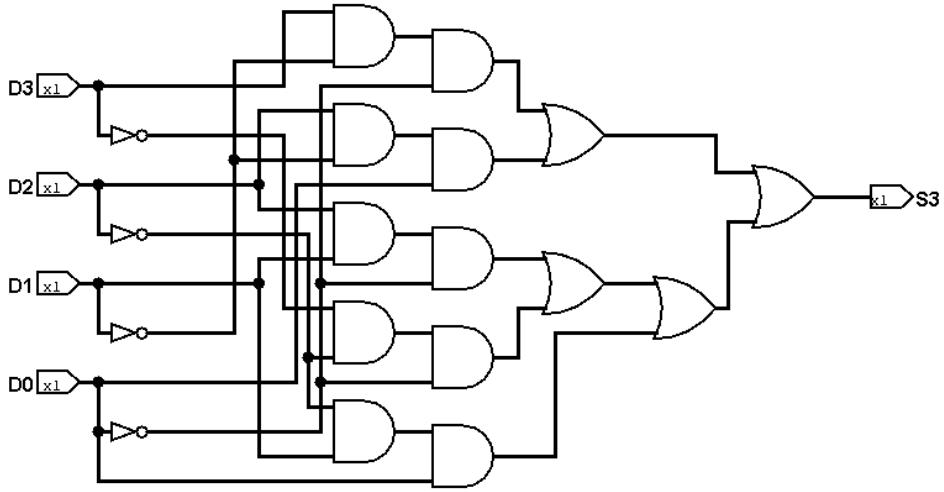

Figure 5: A schematic of HEX3

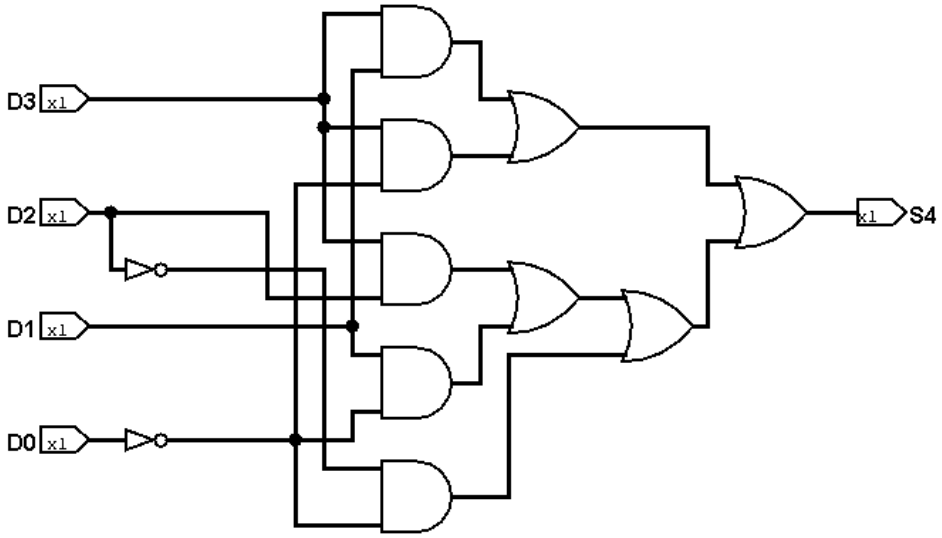

Figure 6: A schematic of HEX4

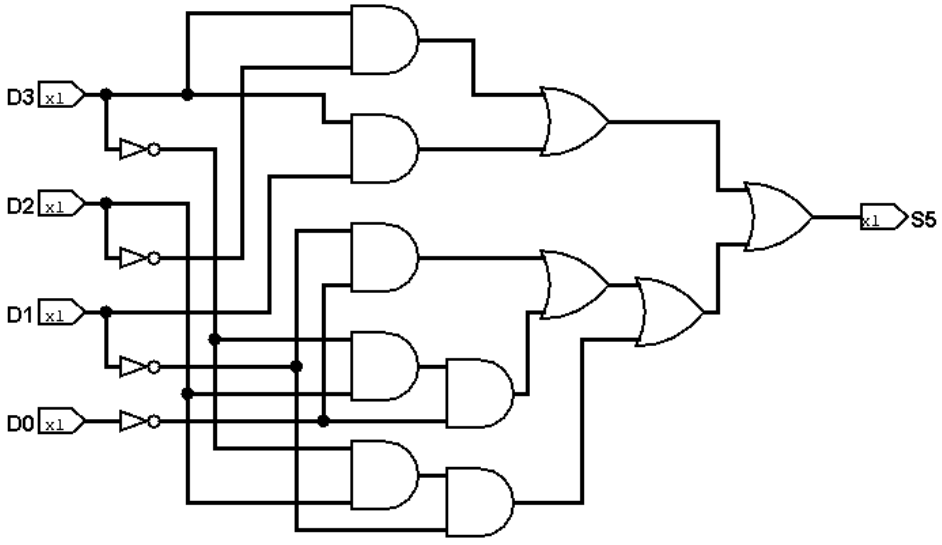

Figure 7: A schematic of HEX5

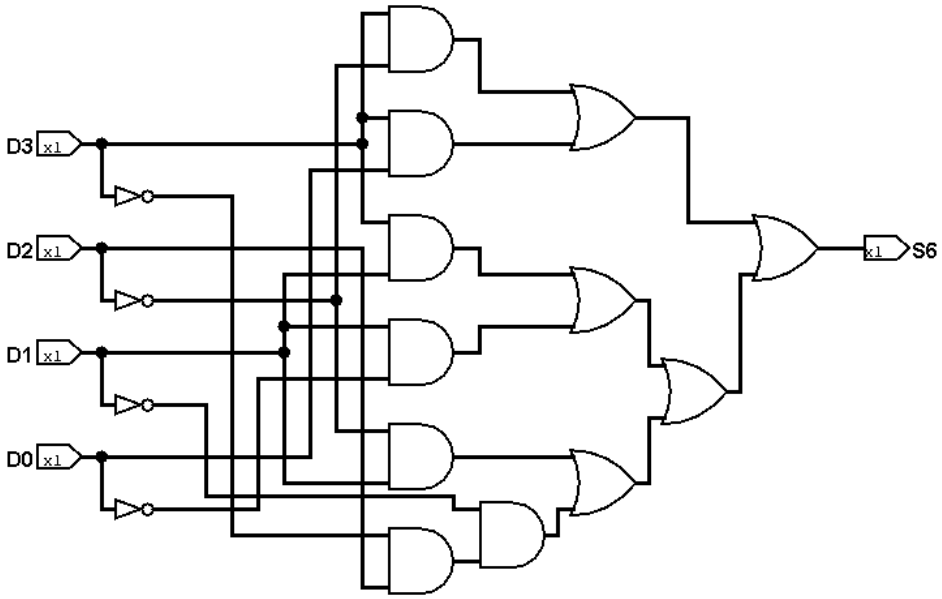

Figure 8: A schematic of HEX6