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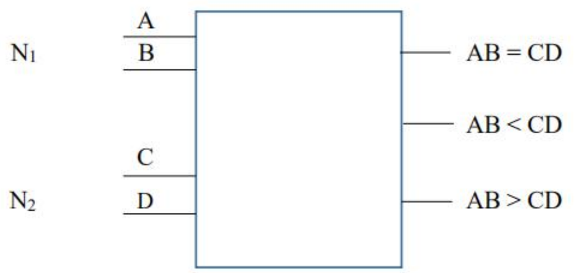
CS220
Practical 2

Two Bit Comparator Circuit

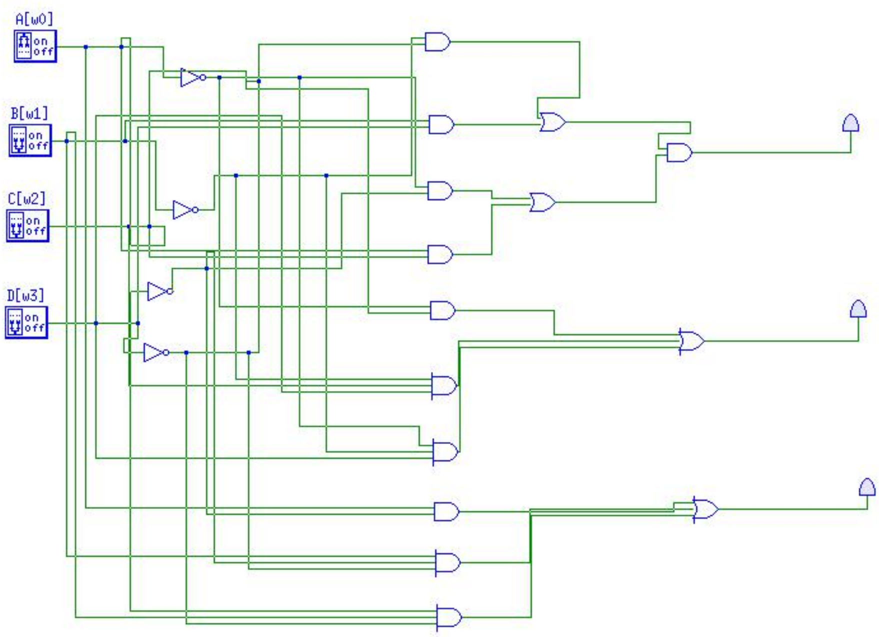
Design a circuit that takes as input two 2-bit numbers N_1 and N_2 to be compared and generates
three outputs:- one output for N_1=N_2, one for N_1< N_2 and one for N_1>N_2.
The outputs are logic 1 if the corresponding condition is true and logic 0 otherwise.
A block diagram of the circuit is given below:-



$$F_{eq}(A,B,C,D) = \overline{A}\,\overline{B}\,\overline{C}\,\overline{D} + \overline{A}B\overline{C}D + ABCD + A\overline{B}C\overline{D}$$
$$= (\overline{B}\,\overline{D} + BD)(\overline{A}\,\overline{C} + AC)$$

$$F_{lt}(A,B,C,D) = \overline{A}C + \overline{A}\,\overline{B}D + \overline{B}CD$$

$$F_{gt}(A,B,C,D) = A\overline{C} + B\overline{C}\,\overline{D} + AB\overline{D}$$



AB = CD

AB < CD

AB > CD

Switching Equations

Derive the minimal sum of products expressions for each function from the respective K-Maps above.

$$F_{eq}(A,B,C,D) = \overline{A}\overline{B}\overline{C}\overline{D} + \overline{A}B\overline{C}D + ABCD + A\overline{B}C\overline{D}$$

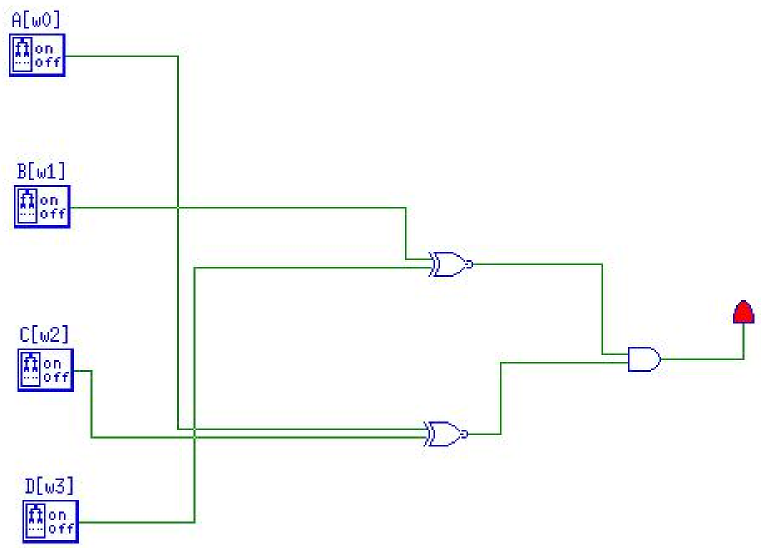
$$F_{lt}(A,B,C,D) = \overline{A}C + \overline{A}\overline{B}D + \overline{B}CD$$

$$F_{gt}(A,B,C,D) = A\overline{C} + B\overline{C}\overline{D} + AB\overline{D}$$

In the case of the Feq function, simplify the sum of products expression so that the function can be expressed in two levels using two 2-input XNOR gates and one 2-input AND gate instead. Show your workings.
(Note that A’B+AB’ = A EXOR B and A’B’ + AB = A XNOR B)

$$F_{eq}(A,B,C,D) = \overline{A}\overline{B}\overline{C}\overline{D} + \overline{A}B\overline{C}D + ABCD + A\overline{B}C\overline{D}$$
$$= (\overline{B}\overline{D} + BD)(\overline{A}\overline{C} + AC)$$

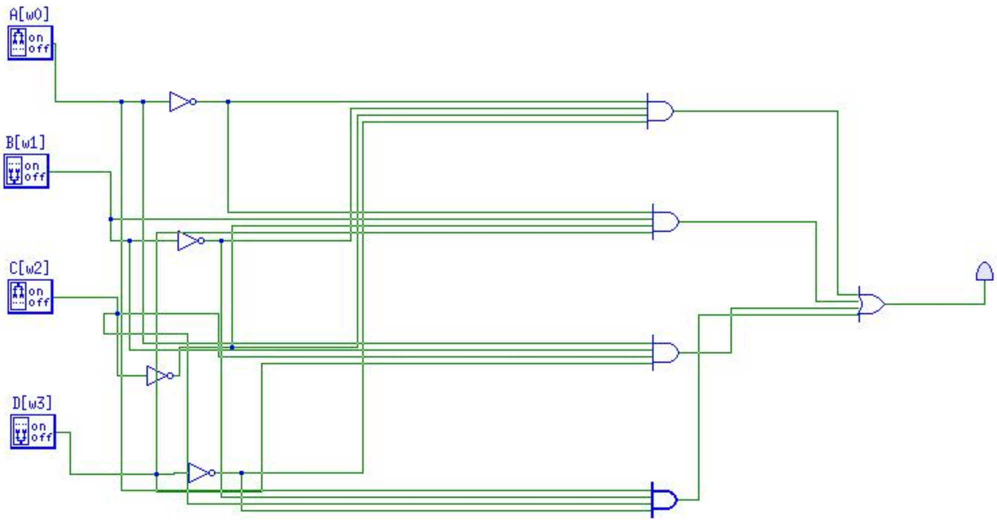
$$= (B\ \ XNOR\ \ D)\ (A\ \ XNOR\ \ C)$$



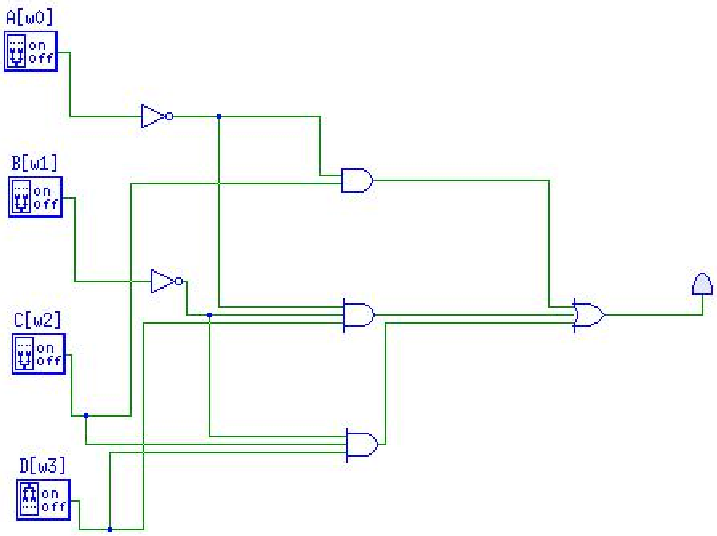
Logic Schematics

Create the comparator circuit from the switching equations you derived from the k-maps.

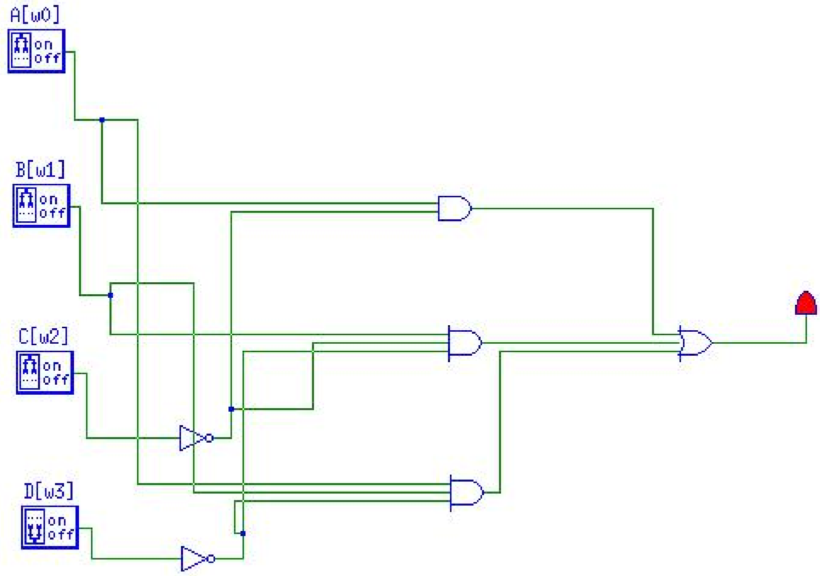
① $F_{\mathrm{eq}}(A,B,C,D) = \overline{A}\,\overline{B}\,\overline{C}\,\overline{D} + \overline{A}B\overline{C}D + ABCD + A\overline{B}C\overline{D}$



② $F_{lt}(A,B,C,D) = \overline{A}C + \overline{A}\,\overline{B}D + \overline{B}CD$



③ $F_{gt}(A,B,C,D) = A\overline{C} + B\overline{C}\,\overline{D} + AB\overline{D}$



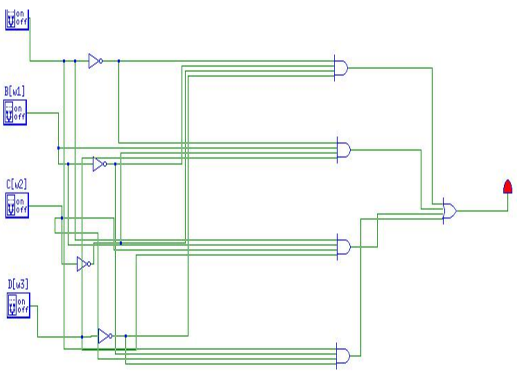
In the case of the equality function (N1=N2), implement both the sum-of-products form and the form which uses XNOR gates.

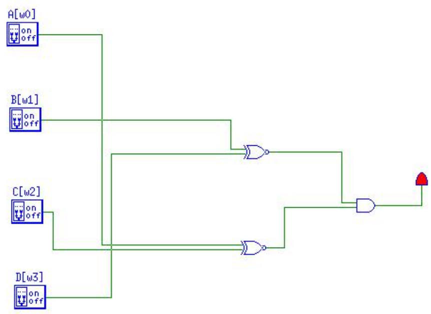
$$F_{eq}(A,B,C,D) = \overline{A}\,\overline{B}\,\overline{C}\,\overline{D} + \overline{A}B\overline{C}D + ABCD + A\overline{B}C\overline{D}$$
$$= (\overline{B}\,\overline{D} + BD)(\overline{A}\,\overline{C} + AC)$$

$$F_{eq}(A,B,C,D) = (B\ \ XNOR\ \ D)\ (A\ \ XNOR\ \ C)$$

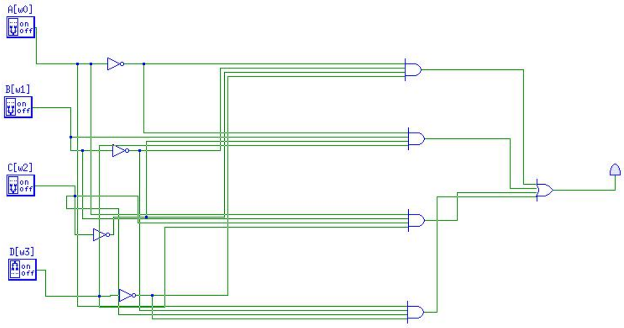
Verify that both implementations of the equality function produce the same outputs for all combinations of inputs. (Hint: Use the same input switches for both implementations to simplify testing.)

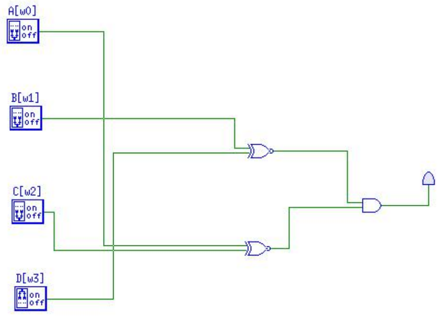
A = 0 B = 0 C = 0 D = 0





A = 0 B = 0 C = 0 D = 1





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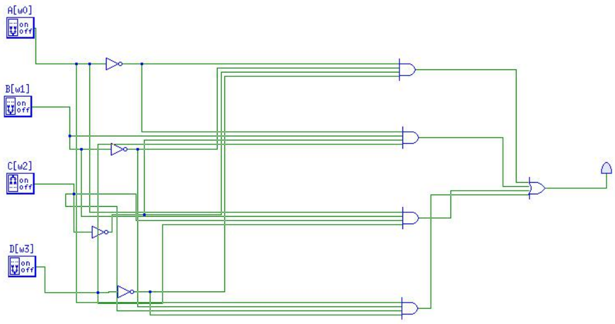

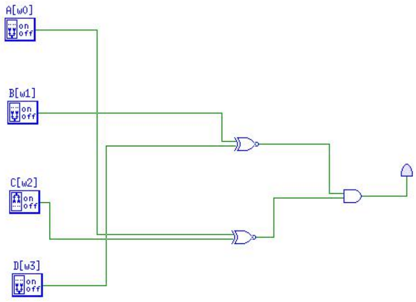

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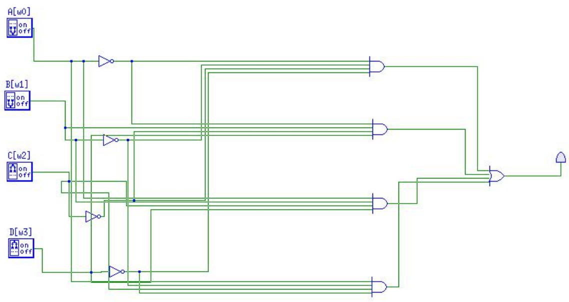

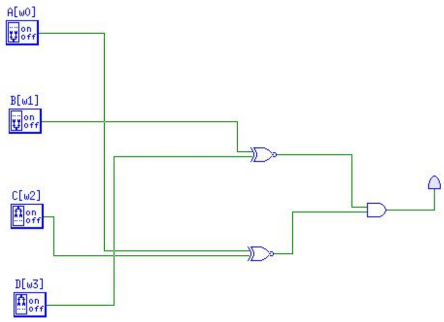

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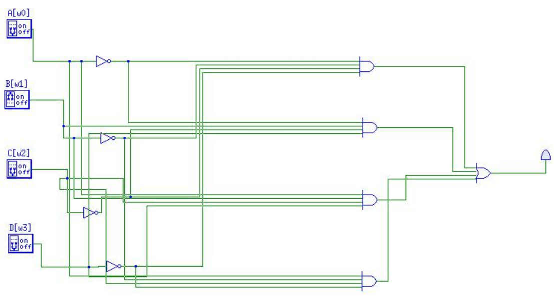

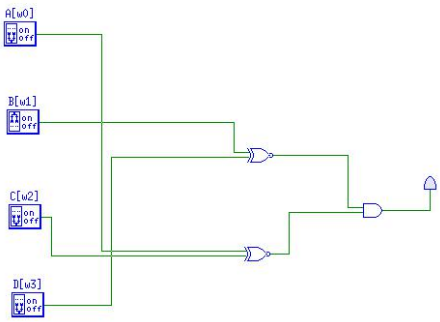

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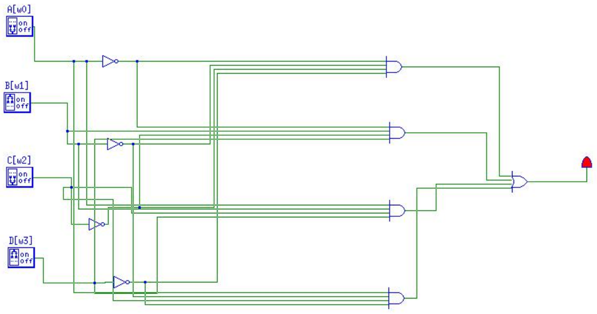

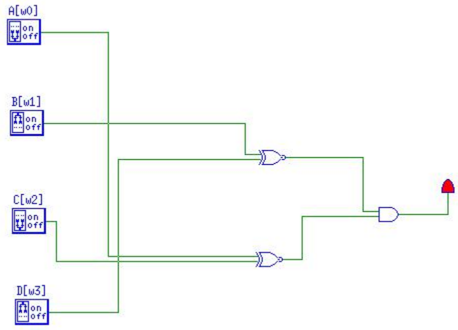

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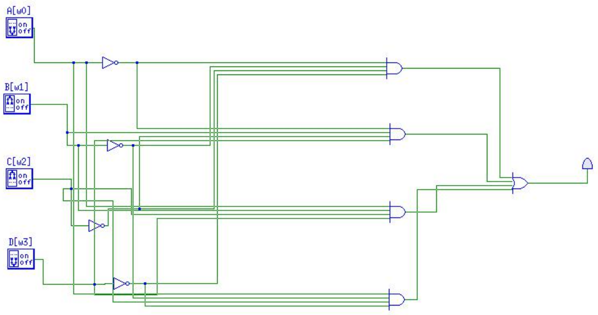

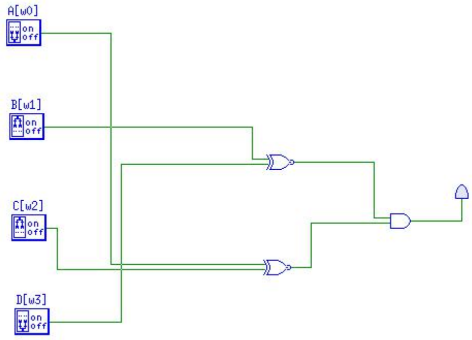

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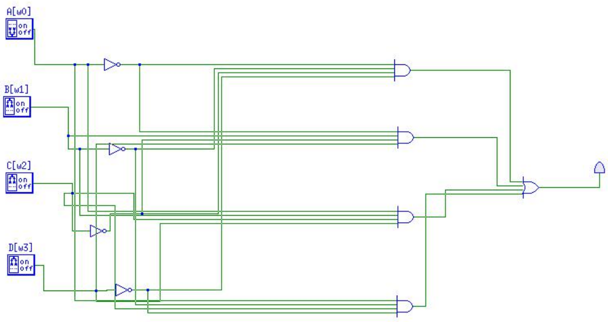

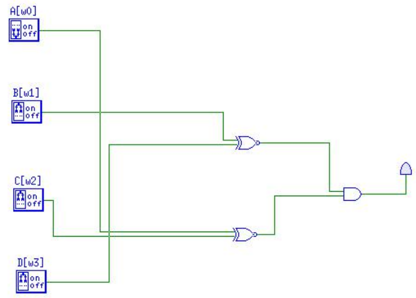

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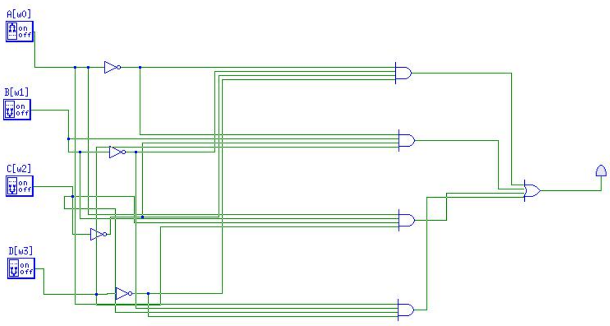

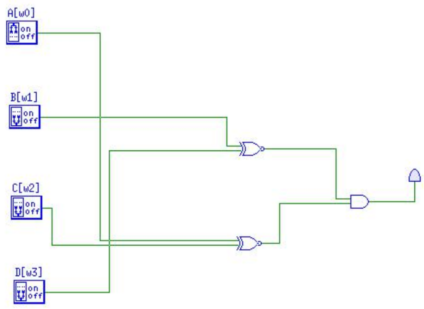

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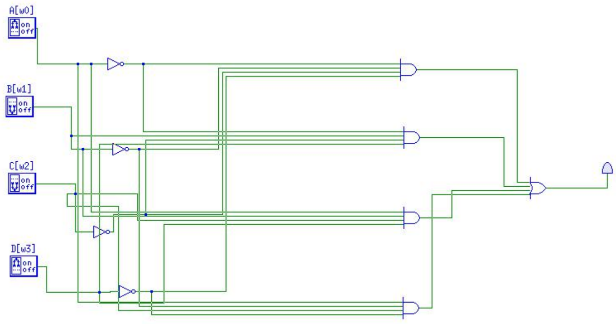

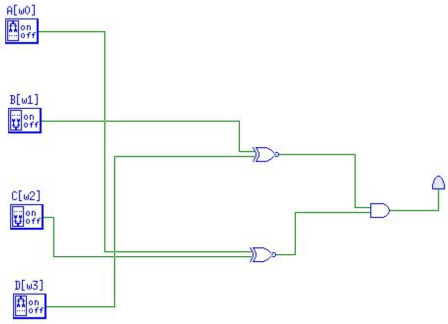

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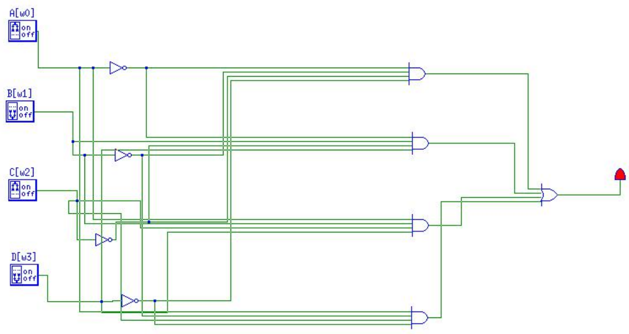

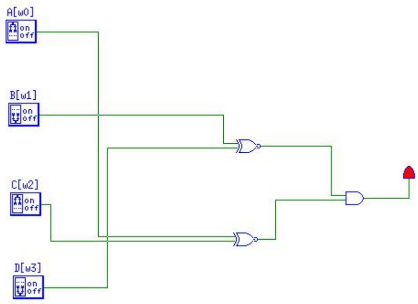

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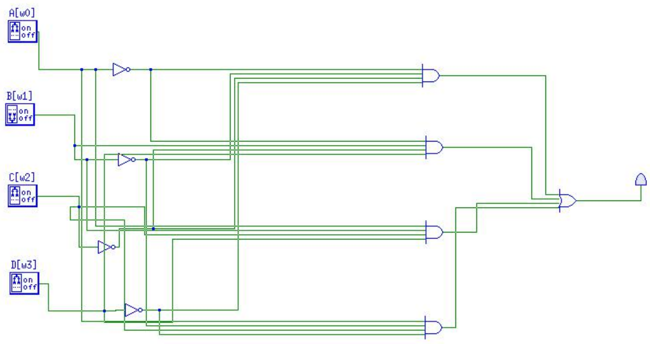

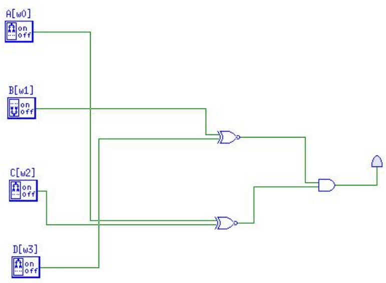

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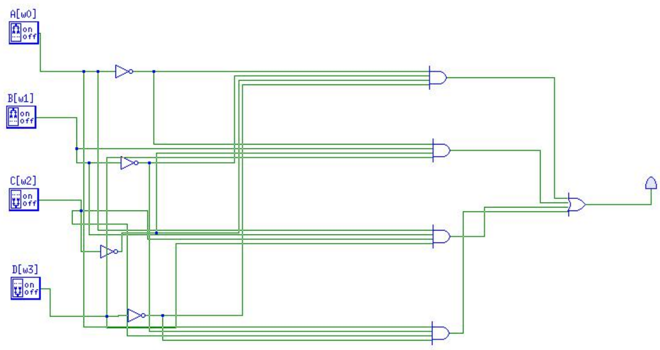

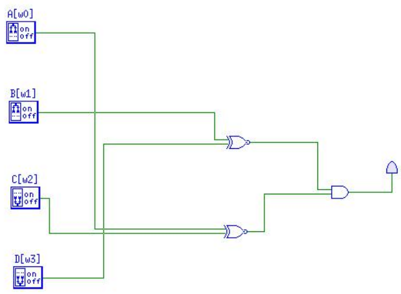

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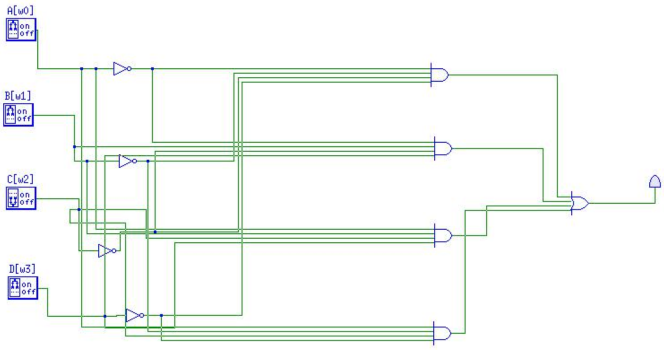

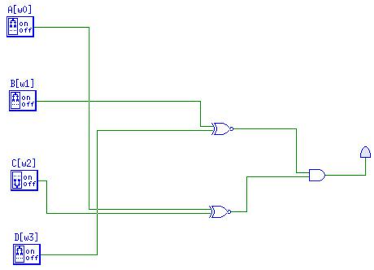

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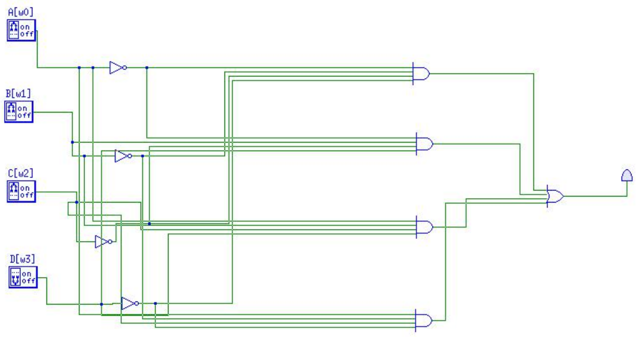

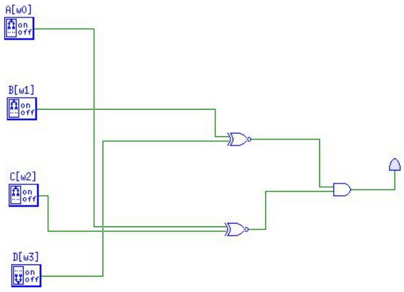

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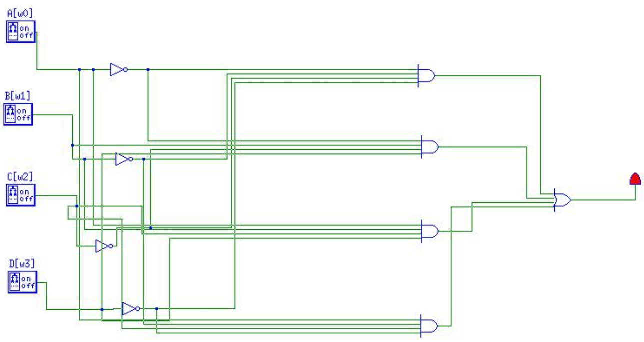

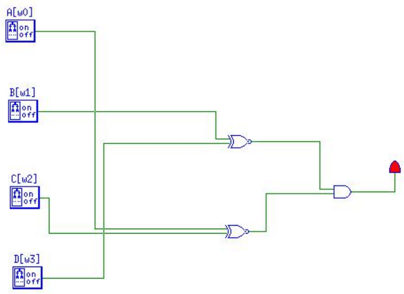

So that both implementations of the equality function produce the same outputs for all combinations of inputs.