

**CS2100: Computer Organisation**  
**Tutorial #7: Combinational Circuits**  
(Week 9: 11 – 15 October 2021)  
**Answers to Selected Questions**

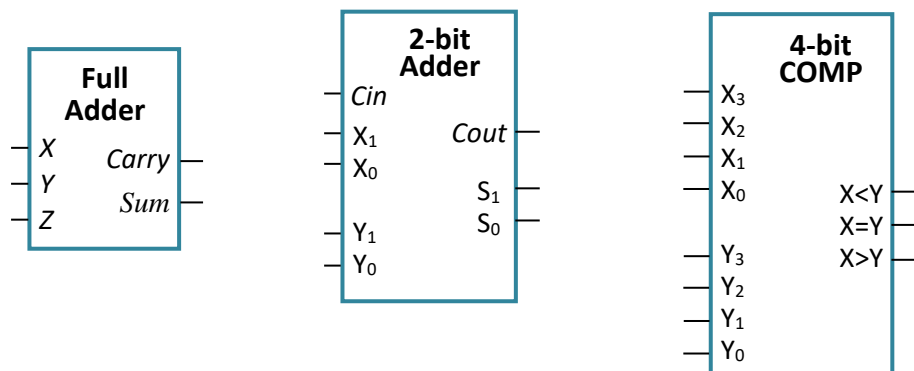
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**Tutorial questions**

Note that for questions on logic design, you may assume that logical constants 0 and 1 are always available. However, complemented literals are not available unless otherwise stated.

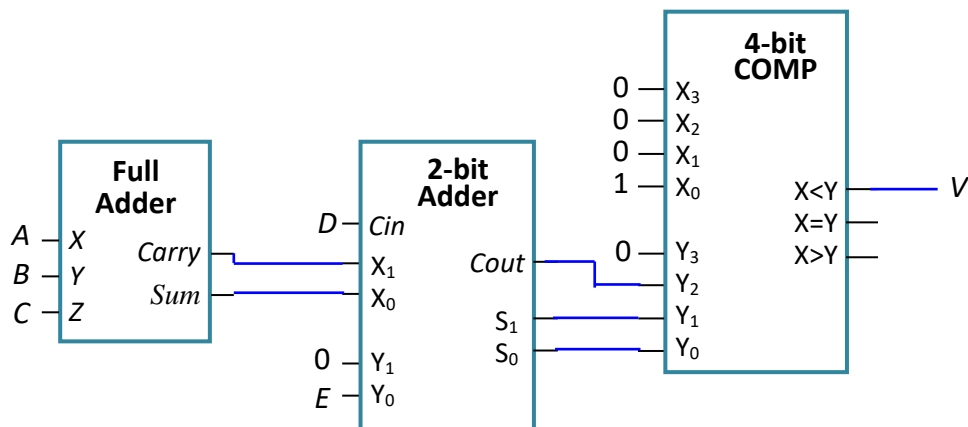
1. [Past-year's question]

You are to design a circuit to implement a function  $V(A,B,C,D,E)$  that takes in input  $ABCDE$  and generates output 1 if  $ABCDE$  is a valid input for the circuit in question D3 above, or 0 if  $ABCDE$  is an invalid input. You are allowed to use only the following devices: full adder, 2-bit parallel adder, and 4-bit magnitude comparator. You should use the fewest number of these approved devices, and no other devices or logic gates. The block diagrams for these devices are shown below.



*Answer:*

Idea: Count the number of 1's in  $ABCDE$ . If count > 1, then it's a valid input.



2. [Past year's exam question]

- a. You want to construct a circuit that takes in a 4-bit unsigned binary number  $ABCD$  and outputs a 4-bit unsigned binary number  $EFGH$  where  $EFGH = (ABCD + 1) / 2$ . Note that the division is an integer division. For example, if  $ABCD = 0110$  (or 6 in decimal), then  $EFGH = 0011$  (or 3 in decimal). If  $ABCD = 1101$  (or 13 in decimal), then  $EFGH = 0111$  (or 7 in decimal).

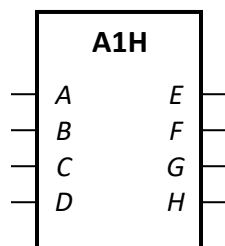
Construct the above circuit using a single **4-bit parallel adder** and at most one logic gate with no restriction on its fan-in.

- b. The following table shows the 4221 code and 8421 code (also known as BCD code) for the ten decimal digits 0 through 9.

Digit	4221 code	8421 code
0	0000	0000
1	0001	0001
2	0010	0010
3	0011	0011
4	0110	0100
5	1001	0101
6	1100	0110
7	1101	0111
8	1110	1000
9	1111	1001

You want to construct a 4221-to-8421 decimal code converter, which takes in a 4-bit 4221 decimal code  $PQRS$  and generates the corresponding 4-bit 8421 decimal code  $WXYZ$ .

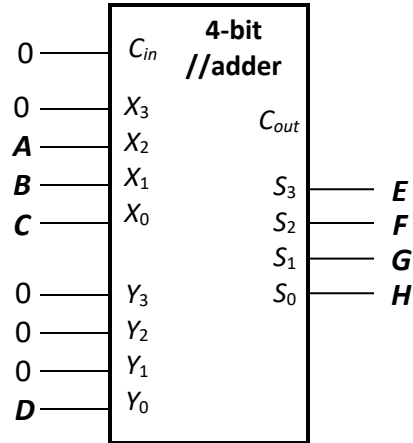
Let's call the circuit you created in part (a) above the A1H (Add-1-then-Half) device, represented by the block diagram below. Implement your 4221-to-8421 decimal code converter using this A1H device with the fewest number of additional logic gates.



Answers:

2(a)

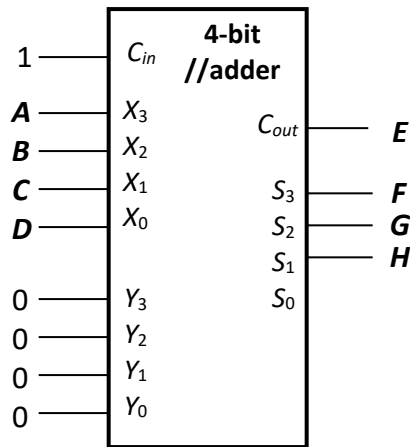
Solution 1:



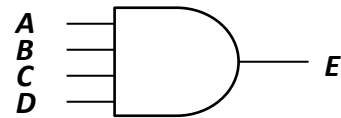
A	B	C	D	E	F	G	H
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1
0	0	1	0	0	0	0	1
0	0	1	1	0	0	1	0
0	1	0	0	0	0	1	0
0	1	0	1	0	0	1	1
0	1	1	0	0	0	1	1
0	1	1	1	0	1	0	0
1	0	0	0	0	1	0	0
1	0	0	1	0	1	0	1
1	0	1	0	0	1	0	1
1	0	1	1	0	1	1	0
1	1	0	0	0	1	1	0
1	1	0	1	0	1	1	1
1	1	1	0	0	1	1	1
1	1	1	1	1	0	0	0

Solution 2:

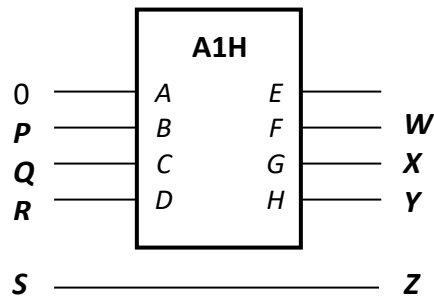
Or  $Y_0 = 1$ ;  $C_{in} = 0$



Alternative solution for E:



2(b)



P	Q	R	S	W	X	Y	Z
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1
0	0	1	0	0	0	1	0
0	0	1	1	0	0	1	1
0	1	1	0	0	1	0	0
1	0	0	1	0	1	0	1
1	1	0	0	0	1	1	0
1	1	0	1	0	1	1	1
1	1	1	0	1	0	0	0
1	1	1	1	1	0	0	1

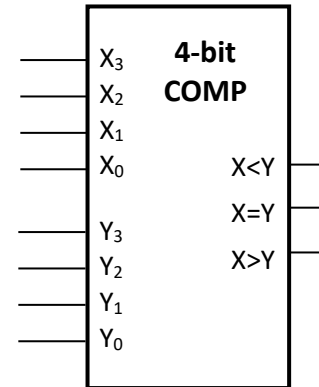
4. Given a 4-bit magnitude comparator as shown on the right, implement the following 4-variable Boolean functions using only this single magnitude comparator with no other logic gates. (Note that there could be multiple answers.)

(a)  $F(A,B,C,D) = \sum m(12 - 15)$ .

(b)  $G(A,B,C,D) = \sum m(0, 6, 9, 15)$ .

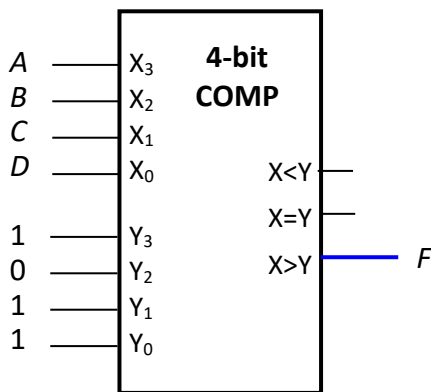
(c)  $H(A,B,C,D) = \sum m(0, 1, 6, 7, 8, 9, 14, 15)$ .

(d)  $Z(A,B,C,D) = \sum m(1, 3, 5, 7, 9, 11, 13)$ .

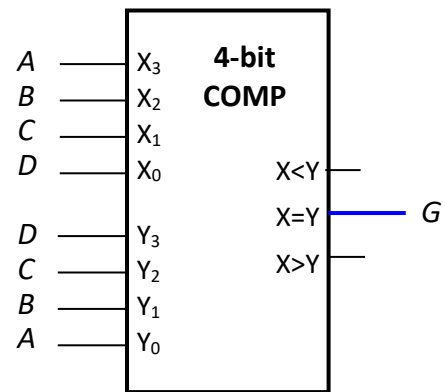


Answers:

(a)



(b)



Other solutions possible.