CS 061 – Computer Organization

Homework 3 solution

1. (5 points)

Design a digital combinational logic circuit with four inputs: a, b, c & d, where (a, b) represents a 2-bit unsigned binary number X; and (c, d) represents a 2-bit unsigned binary number Y (i.e. both X and Y are in the range #0 to #3).
The circuit has a single output z, which is 1 whenever X > Y, and 0 otherwise (this circuit is part of a "2-bit comparator").
...

Show ***all*** your working, including the truth table and the steps by which you sinplify the boolean expression.

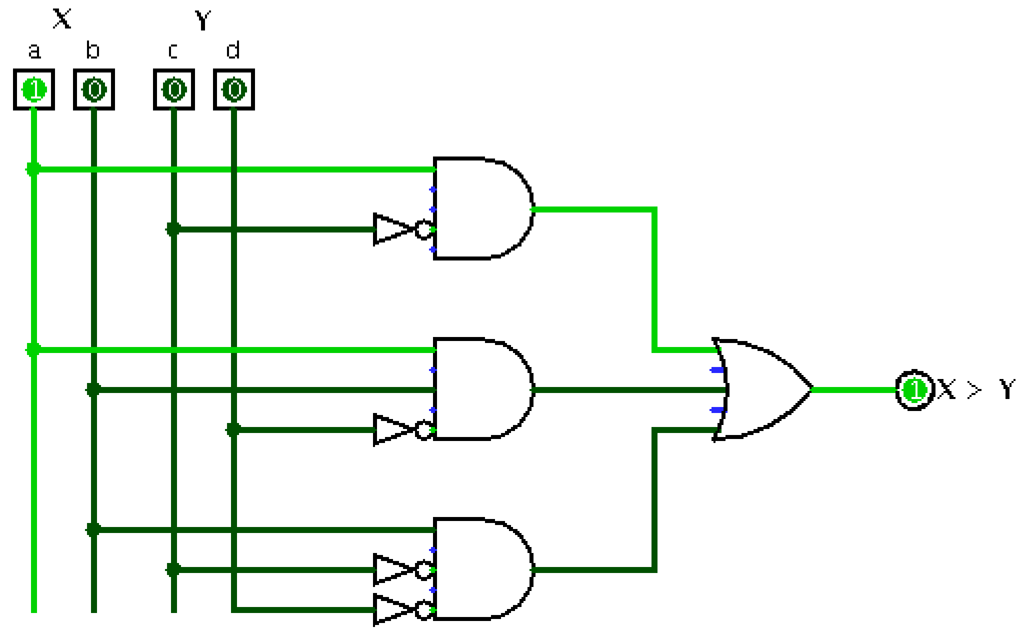
The relevant rows (i.e rows with output = 1) in the truth table come from:

01 > 00
10 > 00
10 > 01
11 > 00
11 > 01
11 > 10

This leads to the Boolean expression

a.c' + a.b.d' + b.c'.d'

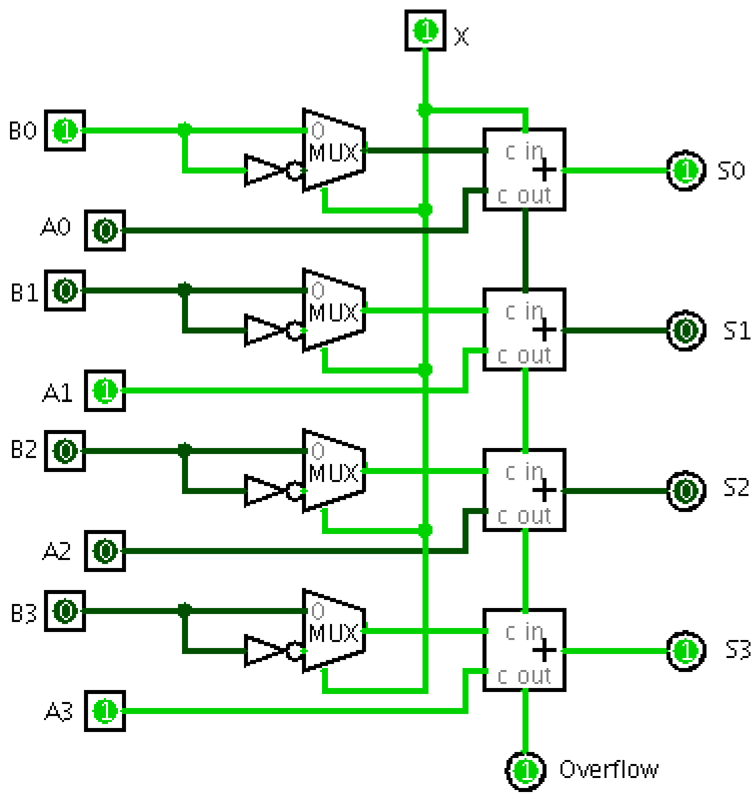
which corresponds to the circuit:
(Here showing that b10 is indeed greater than b00)



2. 3.24 **(2 points)**

a) Input x allows us to choose which bits are applied to the second adder input: if x = 0, then bits B0 to B3 are selected (i.e. S = A + B);
if x = 1, the bits C0 to C3 are selected, and S = A + C
In other words, x selects between the two operations (A + B) and (A + C)

b) The key to solving this is to recognize that subtracting corresponds to adding the two's complement, and that we obtain the two's complement by inverting each bit and adding 1. In this case, we take each bit of the multi-bit number B, and invert it; the inverted bit then becomes the input C of part a); finally, we add 1 – ***by applying a 1 to the carry input of column 0***.
Where do we get the 1?
Simple: use the input x = 1, which is also used to select the inverted bits of B for input to the adder.
(Here shown ***subtracting*** (since x = 1) B = b0001 = #1 from A = b1010 = #-6, getting 1001 = #-7 as expected).



(This would have looked nicer if rotated by 90' – unfortunately logisim won't let you rotate the adders).

3. 3.30 **(2 points)**

The 1-bit G, E, L circuits are:

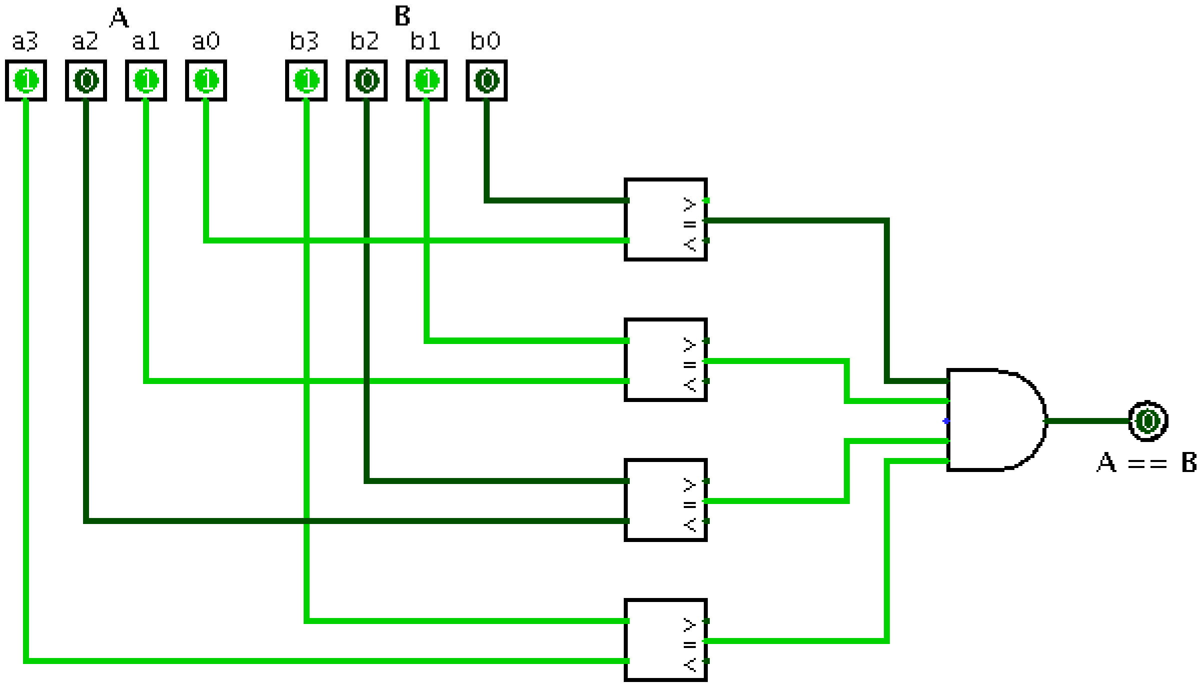
G = A.B'

E = A'.B' + A.B

L = A'.B

And the 4-bit comparator circuit is (using logisim's 1-bit comparator module):

(Here showing that b1011 != b1010)



4. 3.27 **(1 point)**

(a) When S=0, Z = A

(b) When S=1, Z retains its previous value.

(c) Yes; the circuit is a storage element.