Midterm Exam

(October 18^{th} @ 5:30 pm)

Presentation and clarity are very important! Show your procedure!

PROBLEM 1 (24 PTS)

a) Complete the following table. The decimal numbers are unsigned: (5 pts.)

Decimal	BCD	Binary	Reflective Gray Code
			110111
	000100100110		
		1000101	

b) Complete the following table. The decimal numbers are signed. Use the fewest number of bits in each case: (15 pts.)

	REPRESENTATION		
Decimal	**Sign-and-magnitude**	**1's complement**	**2's complement**
-63			
			10000
		10100	
			010110
	1100000		
		11111	

c) Convert the following decimal numbers to their 2's complement representations. (4 pts)

- ✓ 17.125
- ✓ -16.625

PROBLEM 2 (12 PTS)

- The figure below depicts the entire memory space of a microprocessor. Each memory address occupies one byte. 1KB = 2^{10} bytes, 1MB = 2^{20} bytes, 1GB = 2^{30} bytes.
  - ✓ What is the size (in bytes, KB, or MB) of the memory space? What is the address bus size of the microprocessor? (3 pts)
  - ✓ If we have a memory chip of 128 KB, how many bits do we require to address those 128 KB of memory? (1 pt.)
  - ✓ We want to connect the 128 KB memory chip to the microprocessor. For optimal implementation, we must place those 128 KB in an address range where every address shares some MSBs. Provide a list of all the possible address ranges that the 128 KB memory chip can occupy. You can only use the non-occupied portions of the memory space as shown below.

PROBLEM 3 (20 PTS)

a) Perform the following additions and subtractions of the following unsigned integers. Use the fewest number of bits n to represent both operators. <u>Indicate every carry (or borrow) from c_0 to c_n (or b_0 to b_n).</u> For the addition, determine whether there is an overflow. For the subtraction, determine whether we need to keep borrowing from a higher bit. (6 pts)

- ✓ 49 + 17
- ✓ 22 - 33

b) Perform the following operations, where numbers are represented in 2's complement. <u>Indicate every carry from c_0 to c_n</u>. For each case, use the fewest number of bits to represent the summands and the result so that overflow is avoided. (11 pts)

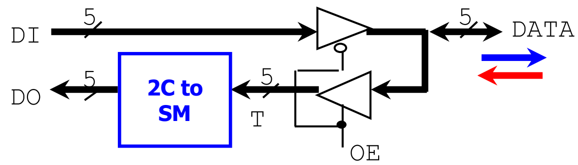
- ✓ -61 - 18
- ✓ 22 - 33

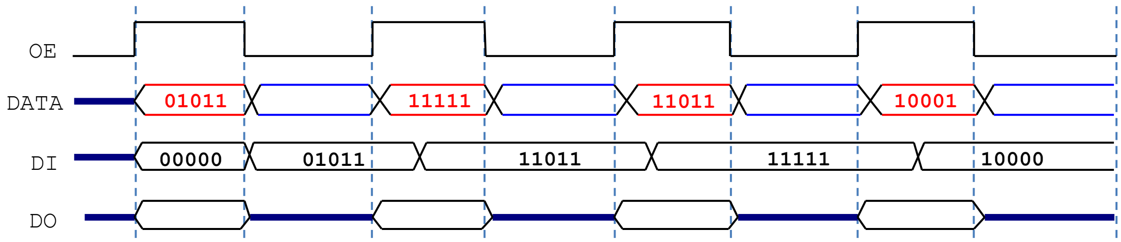
c) Perform binary multiplication of the following numbers that are represented in 2's complement arithmetic with 4 bits. (3 pts)

- ✓ -7 x 6.

PROBLEM 4 (12 PTS)

- Complete the timing diagram (signals DO and $DATA$) of the following circuit. The circuit in the blue box treats the input T as a 5-bit signed (2C) number and converts it to the sign-and-magnitude representation with 5 bits.
  - ✓ Example: if T = 10110, then DO = 11010.

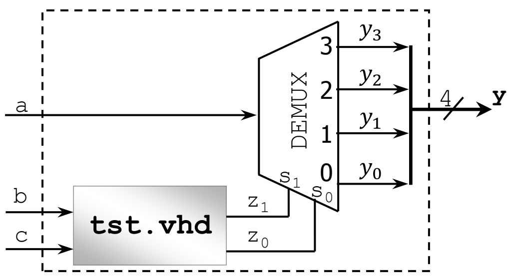




PROBLEM 5 (15 PTS)

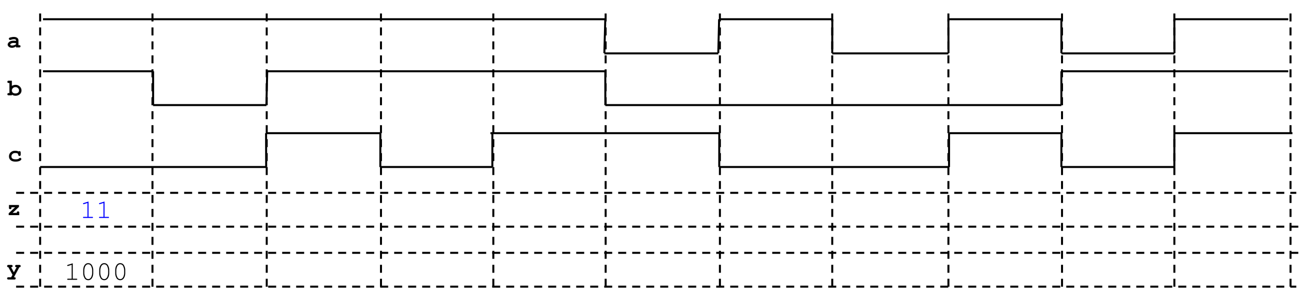
- Complete the timing diagram of the following circuit. The VHDL code (tst.vhd) corresponds to the shaded circuit.

$z = z_1z_0$, $y = y_3y_2y_1y_0$




```
library ieee;
use ieee.std_logic_1164.all;

entity tst is
  port (b,c : in std_logic;
        z: out std_logic_vector(1 downto 0));
end tst;
```

```
architecture bhv of tst is

begin

  process (b, c)
  begin
     z <= b & '0';
     if c = '0' then
        z <= b & (not(c));
     end if;
  end process;

end bhv;
```



- Get the Boolean equations for y_3, y_2, y_1, y_0 based on a, b, c (4 pts)

$y_3(a,b,c) =$ $y_2(a,b,c) =$

$y_1(a,b,c) =$ $y_0(a,b,c) =$

PROBLEM 6 (17 PTS)

- Given the circuit in the figure:
  - ✓ Implement s_0 using ONLY an 8-to-1 MUX. (5 pts.)
  - ✓ Implement c_1 using ONLY 2-to-1 MUXs (AND, OR, NOT, XOR gates are not allowed). (12 pts)