2010 Paper 2 Question 1

Digital Electronics

(*a*) In a particular computer system, numbers are represented using words having a length of 4 bits.

(*i*) What is the range of positive numbers that can be represented using unsigned binary numbers? [2 marks]

(*ii*) Explain how the 2's complement representation can be used to describe signed binary numbers, using 4-bit words as an example. [3 marks]

(*iii*) Using decimal (base 10) representation for the answers, perform the following 2's complement 4-bit additions, noting any problems:

- $0110 + 1101$
- $1010 + 1011$ [4 marks]

(*b*) Complete the following truth table that describes a single-bit full adder:

C_{IN}	A	B	C_{OUT}	sum
0	0	0	0	
0	0	1	0	
0	1	0	0	
0	1	1	1	
1	0	0	0	
1	0	1	1	
1	1	0	1	
1	1	1	1	

where C_{IN} is carry-in, A and B are the input data, C_{OUT} is carry-out and sum is the sum output. Remember to write your answer on the script paper, i.e. not on the question paper. [2 marks]

(*c*) Show how 4 single-bit full-adders can be combined to implement a 4-bit ripple carry-adder. [2 marks]

(*d*) Briefly describe how the speed of operation of the approach in part (*c*) could be improved. [4 marks]

(*e*) Show how C_{OUT} in part (*b*) can be implemented using only NAND gates. [3 marks]