IMPERIAL COLLEGE LONDON

B.Eng., M.Eng. and ACGI Examinations 2016
Part 1

Biomedical Engineering

BE1-HLDS   Logic and Digital Systems

23/05/2016   **11.00-12.30**

Duration: 90 minutes

The paper has 2 questions.

Answer ALL questions.

Separate circuit sheet for answer to Question 2b) provided.

Marks for questions and parts of questions are shown next to the question. The marks for questions (and parts thereof) are indicative, and they may be slightly moderated at the discretion of the Examiner.

Logic and Digital Systems

Question 1

a) If Q = - 03H and R = 7H, calculate S=Q - R and T=Q x R in 2's complement binary form. Show your working.

25 marks

b) Prove that NAND gate is functionally complete.

15 marks

c) Describe the difference between an analogue and a digital system. What are the advantages and disadvantages of each?

20 marks

Question 2

a) Explain how to use an EPROM for logic operations, and produce a truth table and a circuit diagram to demonstrate the implementation of a full adder using an EPROM.

20 marks

b) Using logic gates and functional modules (e.g. adders or counters etc) you have learnt, design a logic system hardware that produce the absolute value of the difference between two input 4-digit binary signed numbers A and B,

20 marks

Answers:

Q 1

a) If Q = - 03H and R = 7H, calculate S=Q - R and T=Q x R in 2's complement binary form. Show your work.

Q1 (a). $Q = -3H = -000011 = 111101$. (5)

$R = 7H = 000111$ (5.)

$-R = 111001$.

$S = Q - R = 111101$ (2)
      111001
      $\overline{}$
      $\times 110110 = (-10)_{10}$. (5).

$T = Q \times R = 111101$
                000111
                $\overline{111101}$ (3).
               111101
              111101
              $\overline{11,1,0,1}$
            $/\emptyset 101011 = (-21)_{10}$. (5)

Q1 (b). Inverter : A —[&]— $\bar{A}$ $\overline{A \cdot A} = \bar{A}$ (5)

AND   A —[&]—[&]— A.B   ~~A·B~~ (5)
         B

OR   A + B = $\overline{\bar{A} \cdot \bar{B}}$ (5)

b) Can you prove that NAND gate is functionally complete?

15 marks

c) Define the analogue system and the digital system and describe their advantages and disadvantages.

20 marks

- Analogue system deals with information/signals that vary in a continuous way
- Digital systems deals with signals that vary abruptly between two defined levels/values (5 marks)
- Advantages of digital: (10 marks)
    - Known level of accuracy throughout the system
    - Reliable, because more immune to electrical interference, temperature and humidity, component ageing
    - Can introduce "intelligence" (eg. error checking) and improve communication with the user
    - Can change the design easily (eg. to add new functions)
- Disadvantages of digital: (5 marks)
    - Circuits are more complex and require more interconnecting wires

    However this disadvantage is overcome by building more of the complexity into each element ("chip") so that fewer are needed.
    Cost of chips has fallen, despite increase in complexity; and there is now a huge range to choose from

Question 2

d) Explain how to use an EPROM for logic operations, and describe how to implement a full adder using an EPROM.
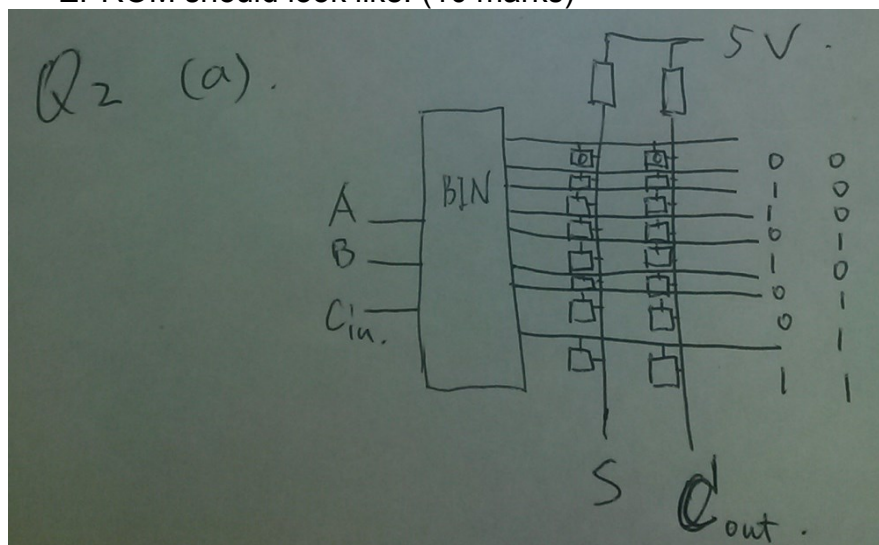
20 marks

- EPROM can be used for logic operations by using the address lines as logic input and the data output lines as the logic output, and storing the output data in the truth table in the corresponding cells of the EPROM. (5 marks)
- A full adder truth table: (5 marks)

Full Adder Truth Table

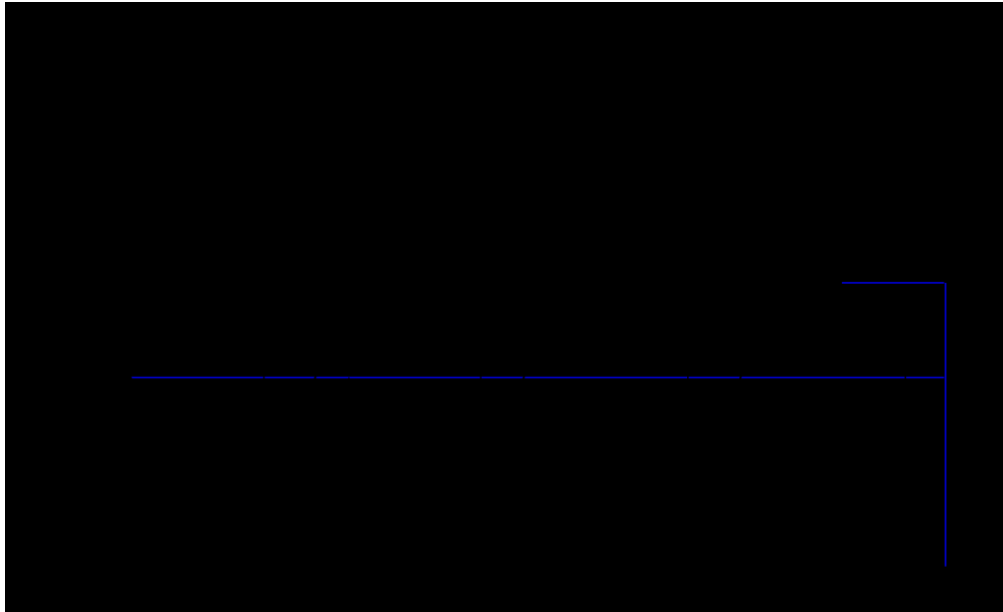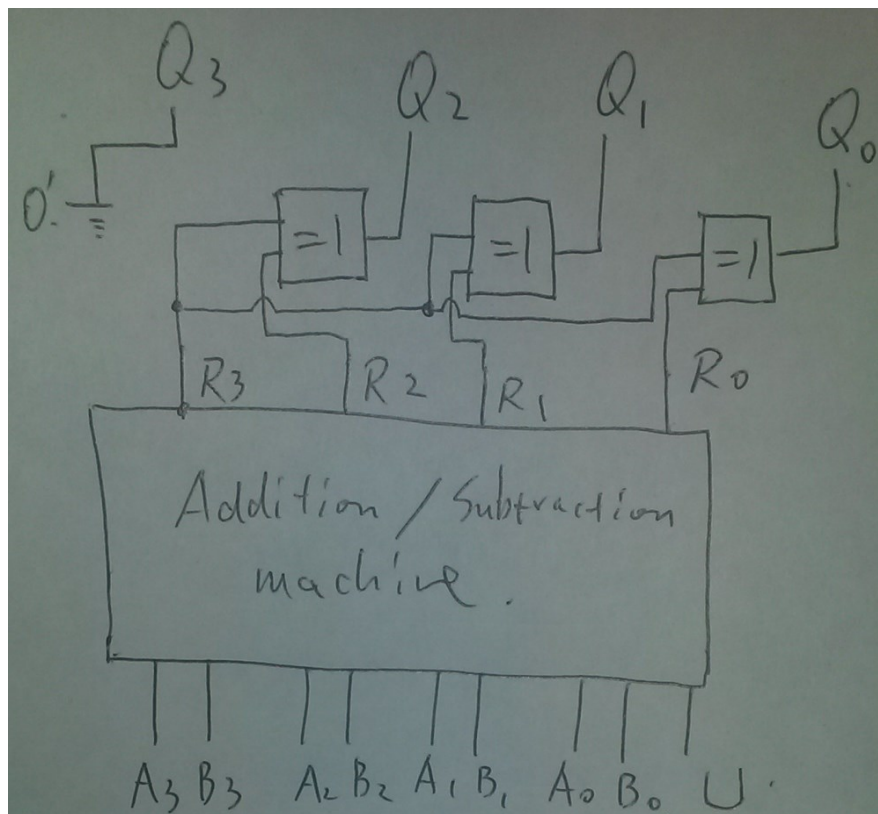| A	B	Cin	S	Cout
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

- EPROM should look like: (10 marks)

e) Can you design a logic system that produce the absolute value of the difference between two input 4-digit binary signed numbers A and B? You do not need to show individual gates in the design.

20 marks

Below is the 4-bit subtraction/addition machine.

10 marks

10 marks