THE BRITISH COMPUTER SOCIETY

THE BCS PROFESSIONAL EXAMINATION
Diploma

ARCHITECTURE

13th May 2003, 10.00 a.m.-12.00 p.m.
Answer FOUR questions out of SIX. All questions carry equal marks.
Time: TWO hours.

*The marks given in brackets are **indicative** of the weight given to each part of the question.*

1. For the function:

$$f = \overline{A}\ \overline{C}\ D + \overline{A}\ \overline{B}\ \overline{C} + \overline{A}\ B\ \overline{C}\ \overline{D} + A\ C\ \overline{D} + \overline{B}\ \overline{C}\ D + A\ B\ C\ \overline{D}$$

a) Construct a Karnaugh map and use it to find a minimum sum of products expression for *f*. **(4 marks)**

b) Draw a logic circuit for the minimised expression using AND, OR and NOT gates. (**3 marks)**

c) Manipulate the expression into a suitable form and hence draw a logic circuit using only NOR gates. **(5 marks)**

d) Manipulate the expression into a suitable form and hence draw a logic circuit using only NAND gates. **(5 marks)**

e) Compare the relative merits of the logic circuit solutions to sections *b*, *c*, and *d.* **(3 marks)**

f) Comment on the implications of implementing this function in a full custom VLSI chip. **(5 marks)**

2. *a)* Compare the software poll and vectored interrupt approaches for handling requests from device interfaces. Your answer must demonstrate an understanding of the principles of each strategy. **(12 marks)**

b) Devices such as the hard disk are supported by a strategy called Direct Memory Access. Outline the principles of operation of this technique and compare it with input/output directly programmed in the main system processor. (**13 marks)**

3. *a)* Briefly describe the technological limitations which are likely to limit the future development of conventional stored program, digital computers. (**7 marks)**

b) Outline the principles of operation of:
i) the neural network computer
ii) the quantum computer

In EACH case, highlight the advantages of each of these designs over the conventional, stored program, digital computer. **(18 marks)**

4. Figure 1 below shows the instruction format of a typical 1980s mini-computer. This mini-computer implements standard 2s complement integer instructions with 16 bit operands and sixteen 16 bit registers. The instruction field definitions are:

The *Function* **field** (6 bits) determines the format of the rest of the instruction format and the behaviour of the processor as the instruction is executed. The format shown is that for normal arithmetic operations.

The *Rx* **field** (4 bits) denotes one of 16 general purpose register which contains the first operand and is also the destination register of the result.

The *Ry* **field** (4 bits) denotes one of 16 general purpose registers which is used in the calculation of the second operand.

The *Mode* **field** (2 bits) denotes one of 4 address modes for the second operand:

00 direct: the second operand is the contents of the register *Ry*;
01 indirect: the second operand is the contents of the memory location the address of which is held in the register *Ry*;
10 indexed: the second operand is the contents of the memory location the address of which is calculated by summing the *extension field* and the contents of the register *Ry*;
11 immediate: the second operand is the value calculated by summing the *extension field* and the contents of the register *Ry.*

The *Extension* **field** (16 bits) is a 16 bit 2s complement integer used to calculate the second operand with address modes 2 and 3 (see above).

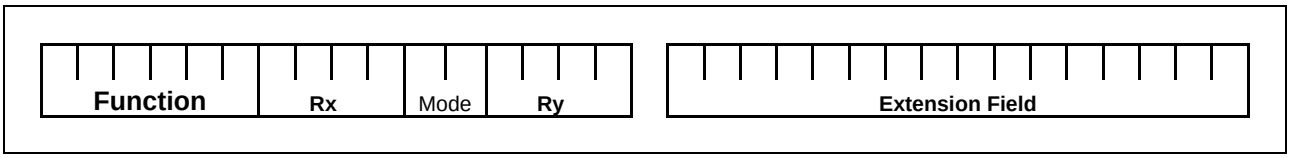

Figure 1 The Computer Instruction Format

a) The cpu data bus is 16 bits wide. If the processor clock speed is 25MHz and the memory cycle time is 66ns, calculate the execution times for each of the four address modes. State clearly, in your answer, any assumptions you have made in your calculations. **(11 marks)**

b) Explain how a main memory cache would improve the performance of such a processor. **(6 marks)**

c) If the processor is equipped with a 64kB 5ns cache and the mean cache hit rate is 90%, calculate the revised execution times for the four address modes. **(8 marks)**

5. *a)* In respect of the computer disks, explain the terms:
- *i)* Sector
- *ii)* Track
- *iii)* Cylinder
- *iv)* Partition
- *v)* Directory **(7 marks)**

b) A disk consists of 11545 cylinders, 5 data surfaces and 498 sectors per track. If a sector is 512 bytes, calculate the capacity of the disk. **(5 marks)**

c) Describe, with the aid of diagrams, how a file is spatially distributed in a FAT file system. **(13 marks)**

6. *a)* What is the OSI 7-Layer model? Give a brief description of the services provided by each layer of the model. **(10 marks)**

b) Describe the format of an HDLC data frame. Explain the function of each field. **(9 marks)**

c) What is meant by *flow control?* Explain how this concept is implemented in the HDLC protocol. **(6 marks)**