COMPUTER SCIENCE TRIPOS Part IA – 2019 – Paper 2

1 Digital Electronics (ijw24)

(a) (i) Show that

$$A + B.C = (A + B).(A + C)$$ [2 marks]

(ii) Using the distributive law in Part $(a)(i)$, express the following equation in product of sums form with 4 product terms, each with a sum of 3 variables:

$$F = H + I.\overline{J} + \overline{K}.L$$ [4 marks]

(b) (i) Write down the truth table for the logic unit (LU) defined in the following table that can execute one of 4 logical operations at a time on 2 data inputs (Y_1, Y_0), to yield output (Z). The LU is under the control of inputs (I_1, I_0) and the logical operations are encoded to 2-bit instruction codes as follows:

Operation	OR	AND	XOR	NOP
Instruction code $(I_1 I_0)$	00	01	10	11

Note that operations OR, AND and XOR have their usual meanings and that the execution of NOP implies Z can take any binary value.

[3 marks]

(ii) Use a Karnaugh Map to determine a simplified expression for Z in Part $(b)(i)$. [2 marks]

(c) (i) Show using a circuit diagram how W can be implemented in 2-level sum of products form using AND gates followed by OR gates. Remember to include any NOT gates required since only uncomplemented input variables are available:

$$W = \overline{B}.\overline{C} + \overline{A}.B.C + A.C.\overline{D}$$

[2 marks]

(ii) Consider the implementation in Part $(c)(i)$. Assume that the gates have finite propagation delay. Describe what happens at W when inputs $\{A, B, C, D\}$ change from $\{1, 0, 1, 0\}$ to $\{1, 0, 0, 0\}$.

[3 marks]

(iii) Determine the other single input variable change that will give a similar problem to that observed in Part $(c)(ii)$.

[2 marks]

(iv) Determine a modified sum of products expression for W that will eliminate the problems observed in Part (c)(ii) and Part (c)(iii).

[2 marks]