



Knowledge is Wealth (*Sapientia divitia est*)

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DEPARTMENT OF PHYSICAL SCIENCES

**EXAMINATION FOR THE AWARD OF BACHELOR OF SCIENCE IN ELECTRICAL
AND ELECTRONIC ENGINEERING**

EENG 354: DIGITAL LOGIC DESIGN

INSTRUCTIONS:

**Answer question ONE and any other TWO questions
Do not write on the question paper**

QUESTION ONE

- Show the logic arrangements for implementing a NOT circuit using a two-input EX-NOR gate (2 Mks)
- Define the following terms as used in digital design (4 Mks)
 - Frequency division.
 - A Synchronous Counter
 - A Finite State Machine (FSM)
 - A state
- In a 7-segment display, each of the seven segments is activated for various digits. For example, segment *a* is activated for the digits 0, 2, 3, 5, 6, 7, 8, and 9, as illustrated in Figure 1.1 Since each digit can be represented by a BCD code, derive an SOP expression for segment *a* using the variables *ABCD* and then minimize the expression using a Karnaugh map (4 Mks).



Figure 1.1

- d. Apply DeMorgan's theorems to the following expression: (3 Mks)

$$\overline{AB + \overline{CD} + EF}$$

- e. A portion of a periodic digital waveform is shown in Figure 1.2. The measurements are in milliseconds. Determine the following:
- period (1 Mk)
 - frequency (1 Mk)
 - duty cycle (1 Mk)

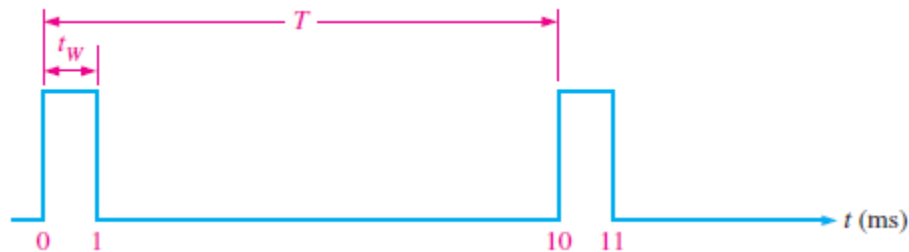


Figure 1.2

- f. Simplify the following expression using k-map (4 Mks)
- $$F(A, B, C, D) = \pi M(0, 1, 3, 6, 7, 8, 9, 11, 13, 14, 15)$$
- g. Prove the following Boolean identity : $(A + B)(A + \overline{B})(\overline{A} + C) = AC$ (3 Mks)
- h. A grocery retail outlet entrance door needs a counter that will count the number of customers who come shopping each day. A photodetector and a light source combination is used to generate a single pulse, each time a person enters the door. The counter must be able to count as many as 1000 persons. How many flip-flops are required to construct the counter (3 Mks)?
- i. From the relevant Boolean expressions for half-adder and half-subtractor circuits, design a halfadder-subtractor circuit that can be used to perform either addition or subtraction on two one-bit numbers. The desired arithmetic operation should be selectable from a control input (4 Mks).

QUESTION TWO

- a. In a certain chemical-processing plant, a liquid chemical is used in a manufacturing process. The chemical is stored in three different tanks. A level sensor in each tank produces a HIGH voltage when the level of chemical in the tank drops below a specified point.
- Design a circuit that monitors the chemical level in each tank and indicates when the level in any two of the tanks drops below the specified point (5 Mks).

- ii. If the sensors in the chemical tanks are being replaced by a new model that produces a LOW voltage instead of a HIGH voltage when the level of the chemical in the tank drops below a critical point, modify the circuit to operate with the different input levels and still produce a HIGH output to activate the indicator when the level in any two of the tanks drops below the critical point. Show the logic diagram (5 Mks).
- b. Determine the output waveforms in relation to the clock for Q_A , Q_B , and Q_C in the circuit of Figure 2.1 and show the binary sequence represented by these waveforms (5 Mks).

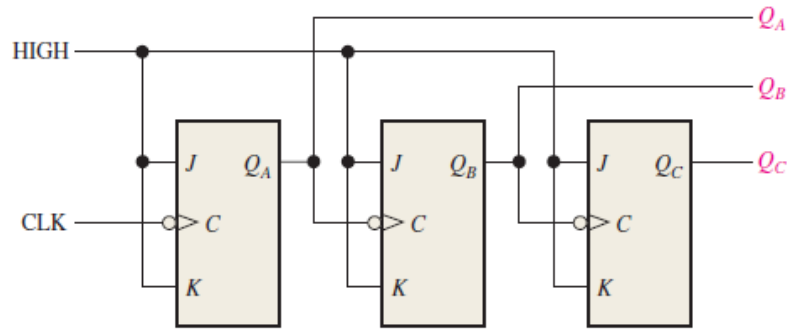


Figure 2.1

- c. Design a circuit from the following Boolean expressions using a *PROM* (5 Mks).

$$f_1(x_2, x_1, x_0) = \sum m(0, 1, 2, 5, 7)$$

$$f_2(x_2, x_1, x_0) = \sum m(1, 2, 4, 6)$$

QUESTION THREE

- a. Design a logic circuit with four input variables that will only produce a 1 output when exactly three input variables are 1s (5 Mks).
- b. Design a counter with the irregular binary count sequence shown in the state diagram of Figure 3.1. Use D flip-flops (10 Mks).

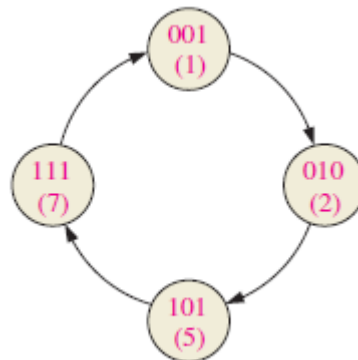


Figure 3.1

QUESTION FOUR

- a. As part of an aircraft's functional monitoring system, a circuit is required to indicate the status of the landing gears prior to landing. A green LED display turns on if all three gears are properly extended when the "gear down" switch has been activated in preparation for landing. A red LED display turns on if any of the gears fail to extend

properly prior to landing. When a landing gear is extended, its sensor produces a LOW voltage. When a landing gear is retracted, its sensor produces a HIGH voltage. Design a circuit to meet this requirement (5 Mks).

- b. Design a synchronous 3-bit up/down counter with a Gray code sequence using J-K flip-flops. The counter should count up when an $UP/\overline{DOWN}$ control input is 1 and count down when the control input is 0 (12 Mks).
- c. Discuss three applications of FPGA (3 Mks)