CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATIONS

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

EENG 354: DIGITAL LOGIC DESIGN

STREAMS: **TIME:2 HOURS**

DAY/DATE: THURSDAY 13/04/2023 **11.30 A.M. –1.30 P.M.**

INSTRUCTIONS

Answer question ONE and any other TWO questions

Do not write on the question paper

QUESTION ONE

a. Show the logic arrangements for implementing a NOT circuit using a two-input EX-NOR gate (2 Marks)

b. Define the following terms as used in digital design (4 Marks)

   i. Frequency division.

   ii. A Synchronous Counter

   iii. A Finite State Machine (FSM)

   iv. A state

c. 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 Marks).

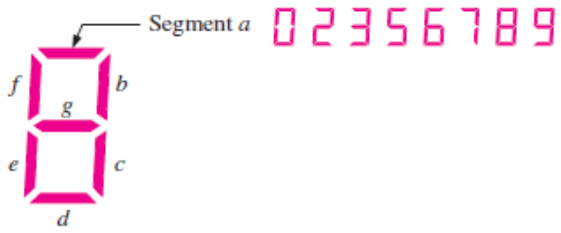

Figure 1.1

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

$$\overline{A\overline{B} + \overline{C}D + EF}$$

e. A portion of a periodic digital waveform is shown in Figure 1.2. The measurements are in milliseconds. Determine the following:

i. Period (1 Mark)

ii. Frequency (1 Mark)

iii. Duty cycle (1 Mark)

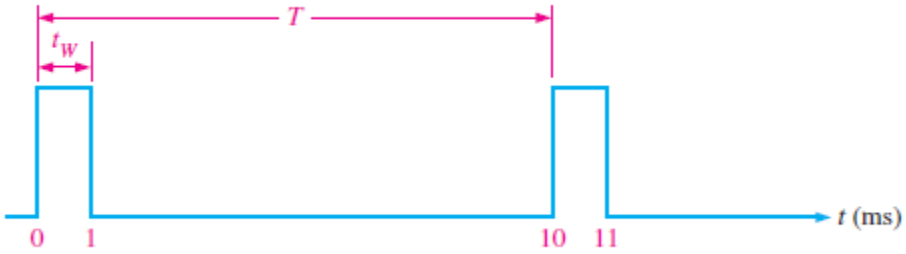

Figure 1.2

f. Simplify the following expression using k-map (4 Marks)

F(A, B, C, D) = πM (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 Marks)

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 Marks)?

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 Marks).

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.

i. 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 Marks).

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 Marks).

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 Marks).

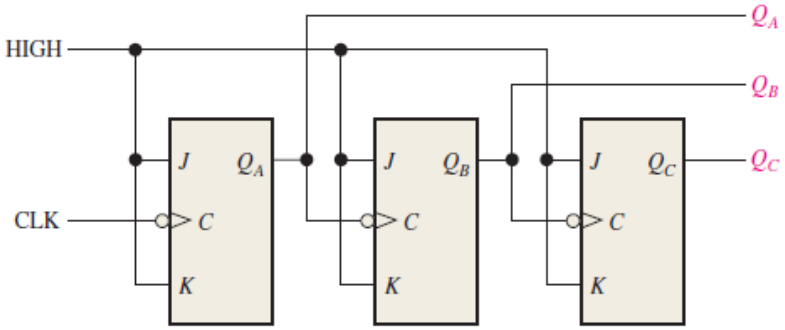

Figure 2.1

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 Marks).

b. Design a counter with the irregular binary count sequence shown in the state diagram of Figure 3.1. Use D flip-flops (10 Marks).

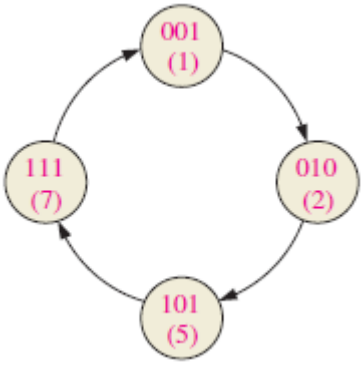

Figure 3.1

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 Marks).

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 Marks).

c. Discuss three applications of FPGA (3 Marks)
