TECHNICAL UNIVERSITY OF MOMBASA

School of Engineering and Technology

Department of Electrical and Electronic Engineering

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONIC ENGINEERING)

EEE 4432: INDUSTRIAL AUTOMATION

END OF SEMESTER EXAMINATION

SERIES: JULY 2025

TIME: 2 HOURS

DATE: JULY 2025

Instructions to Candidates

You should have the following for this examination
-Answer Booklet, examination pass and student ID
This paper consists of **five** Questions; Question ONE is compulsory.
In addition attempt any Other TWO Questions.
Do not write on the question paper.

Question ONE (Compulsory 30 marks)

a) Develop a FBD for a system that will monitor a high temperature salt bath. The systems has *start* and *stop* buttons as normal. The temperature for the salt bath is available in *temp*. If the bath is above 250°C then the *heater* should be turned off. If the temperature is below 220°C then the *heater* should be turned on. Once the system has been in the acceptable range for 10 minutes the system should shut off.

[8 marks]

b) Simplify the following Boolean equation and write corresponding ladder logic.

[10 marks]

(i) $$Y = \overline{\overline{(A\bar{B}\bar{C}D + AB\bar{C}\bar{D} + \bar{A}BCD + \bar{A}\bar{B}CD)} + D}$$

(ii) $$Y = \overline{\overline{C}\left(\overline{\overline{A}+\left(\overline{\overline{A}+\left(\overline{\overline{B}\,\overline{C}\left(\overline{A+\overline{B}\,\overline{C}}\right)}\right)}}\right)}}$$

c) Figure Q1c is chemical mixing process when I0 is pressed, Q0/ V1 will get on resulting material 1 inlet to mixing tank. As material 1 comes in mixing tank, low level sensor I2 will get on and further middle level sensor I3 will be on. As I3 is on, Q0/ V1 should get off and Q1/ V2 should get on. As V2 is on, material 2 will come in mixing tank resulting increase in level and reaches toI4 sensor. As I4 is on, Q1/ V2 will get off and motor Q2 will get on for 10 seconds. After 10 seconds, motor gets off and drain V3 gets on. As drain is on, mixing tank will start getting empty. Slowly level will go down resulting I4 off, I3 and I2 sensors off one by one. As I2 is off repeat the process. I1 is manual stop. Write a PLC program (ladder diagram) for the process.

[12 marks]

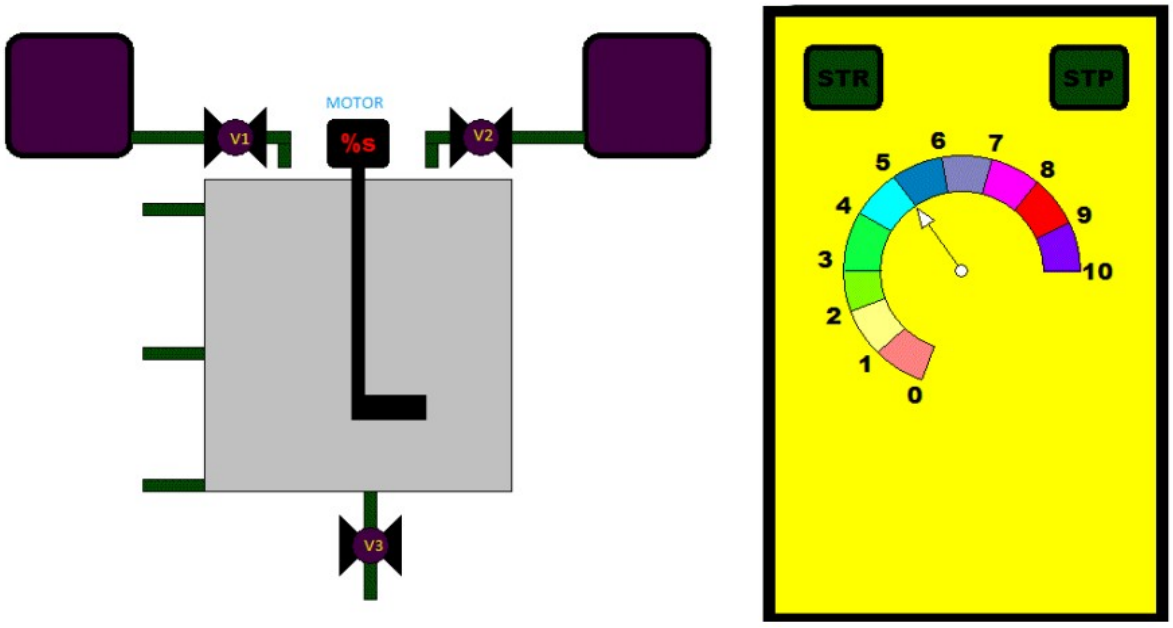


Figure Q1c

Question Two

a) With the aid of diagrams explain the principle of operation of counters in programmable logic controllers.

[6 marks]

b) A cleaning bath Figure Q2b is intended to remove the flux from soldered PCBs. A basket is hooked in and unhooked manually. If you activate pushbuttonS1, the basket automatically enters the cleaning bath five times and stays there for 15 s in each case

to clean the boards. After the cleaning process, the basket can be removed or be filled up and lowered again. The signal lamp shows automatic mode.

[6 marks]

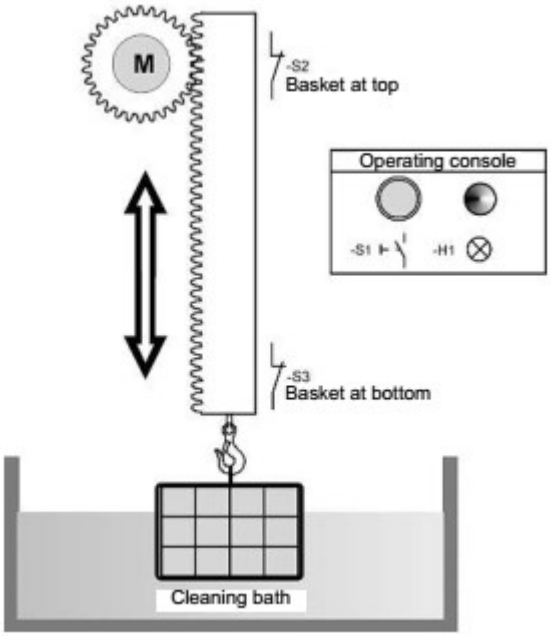
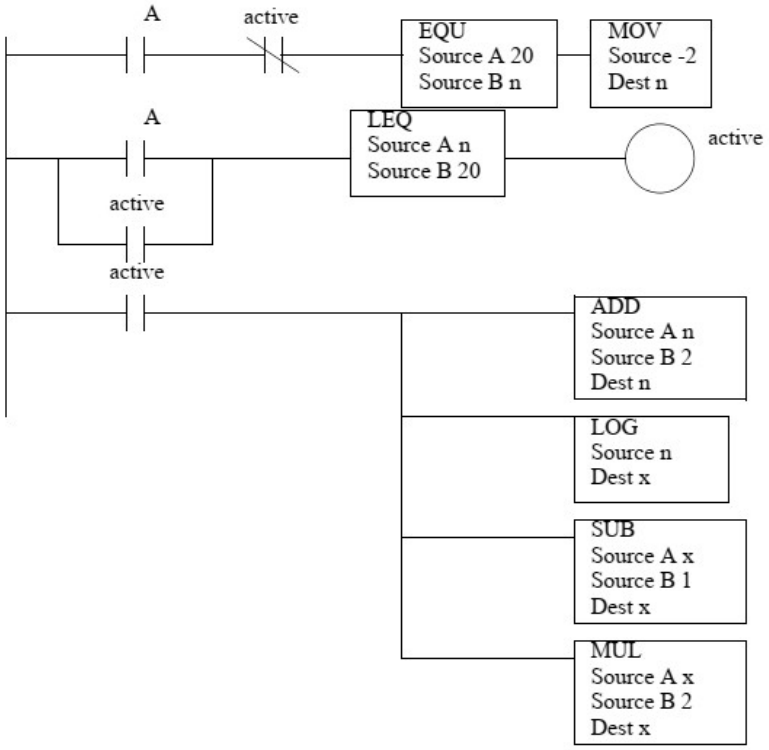


Figure Q2b

c) Write a function block diagram program that will replace the following ladder logic.

[8 marks]



Question THREE

a) with the aid of diagram explain the principle of operation of a two input relay controller

[6 marks]

b) Figure Q3b is a car parking area where we have entry gate Q0 and exit gate Q1. On entry we have two sensors, I0 outside and I1 inside. On exit also we have two sensors I2 and I3. When car comes in front of I0 sensor, gate Q0 is open. When car reaches to I1 sensor, nothing will happen. When car crosses sensor I1 then gate Q0 will be closed and it would be count up. Inside parking area when car reaches to sensor I2, exit gate Q1 is open. When car crosses I3 sensor then Q1 is closed and it would be count down on display to show the present number of cars inside parking area. Maximum 10 cars will be parked. When parking is full and 11th car comes in front of entry sensor I0, entry gate should not get open. Design a PLC program in ladder logic for the parking.

[14 marks]

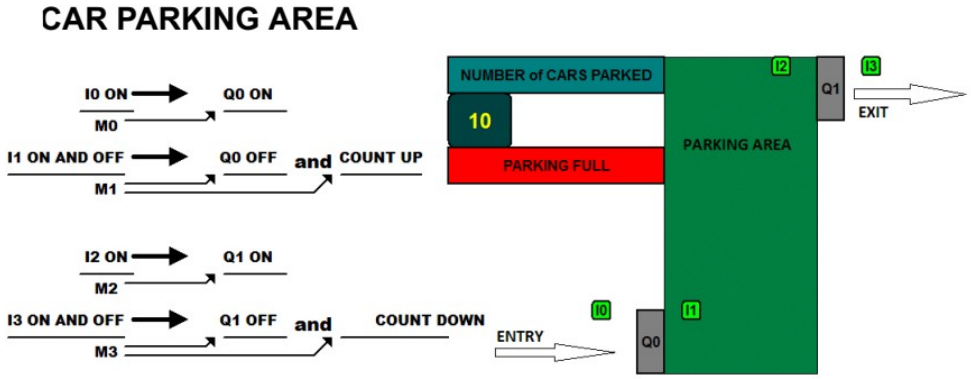


Figure Q3b

Question FOUR

a) (i) Write the simplest Boolean equation for the Karnaugh map given below

(ii) Convert the equation to a ladder logic

[8 marks]

	CD	$C\bar{D}$	$\bar{C}\bar{D}$	$\bar{C}D$
AB	1	0	0	1
$A\bar{B}$	0	0	0	0
$\bar{A}\bar{B}$	0	0	0	0
$\bar{A}B$	0	1	1	0

b) Describe the main function of each of the following main components of a Programmable Logic Controller

(i) processor module

(ii) I/O modules

(iii) Programming device

(iv) power supply module

[12 marks]

Question FIVE

Figure Q5 is a mixing and filling application with alarm, acknowledgement and reset. There are two push buttons I0 and I1 for start and stop (both push buttons are NO type/ green in physical existence). There are three level switches I2, I3, I4 and I5 for low level, middle level high level and bottle detector sensor respectively. There are 3 valves; V1/ Q0 for material 1, V2/ Q1 for material 2 and V3/ Q3 for drain. There is a motor for mixing two materials in the mixing tank and one conveyor Q4. When I0 is pressed, Q0/ V1 will get on resulting material 1 inlet to mixing tank. As material 1 comes in mixing tank, low level sensor I2 will get on and further middle level sensor I3 will be on. As I3 is on, Q0/ V1 should get off and Q1/ V2 should get on. As V2 is on, material 2 will come in

mixing tank resulting increase in level and reaches to I4 sensor. As I4 is on, Q1/ V2 will get off and motor Q2 will get on for 10 seconds. After 10 seconds, motor gets off and conveyor Q4 gets on. Bottle to be filled will move on it. As bottle will be detected by I5 sensor, conveyor Q4 will stop and drain V3/ Q3 will get on for 5 seconds. After 5 seconds again conveyor will be on and drain will get off. Whenever I5 detects bottle, the same cycle of conveyor and drain will repeat. As drain will get on many times, mixing tank will start getting empty. Slowly level will go down resulting I4 off, I3 and I2 sensors off one by one. As I2 is off repeat the process. I1 is manual stop. There is a common low level detector sensor in both upper feeding tanks. If feeding tank low level sensor I6 goes off, whole system should stop. A red lamp Q5 and a hooter Q6 should get on as I6 is off. This is alarm condition. As alarm occurs, someone will hear hooter and will come to monitor the system. I0 push button should be pressed to acknowledge it but by pressing I0 other things should not start. As it is acknowledged, hooter will stop for 20 seconds but red lamp will keep blinking with half second of interval. If problem is not solved with in twenty seconds then hooter will start again. It can be acknowledged again. When problem is solved i. e. feeding tanks are full then hooter and red lamp both will get off and machine can be started by pressing I0 push button. Develop the ladder logic for the system

[20 marks]

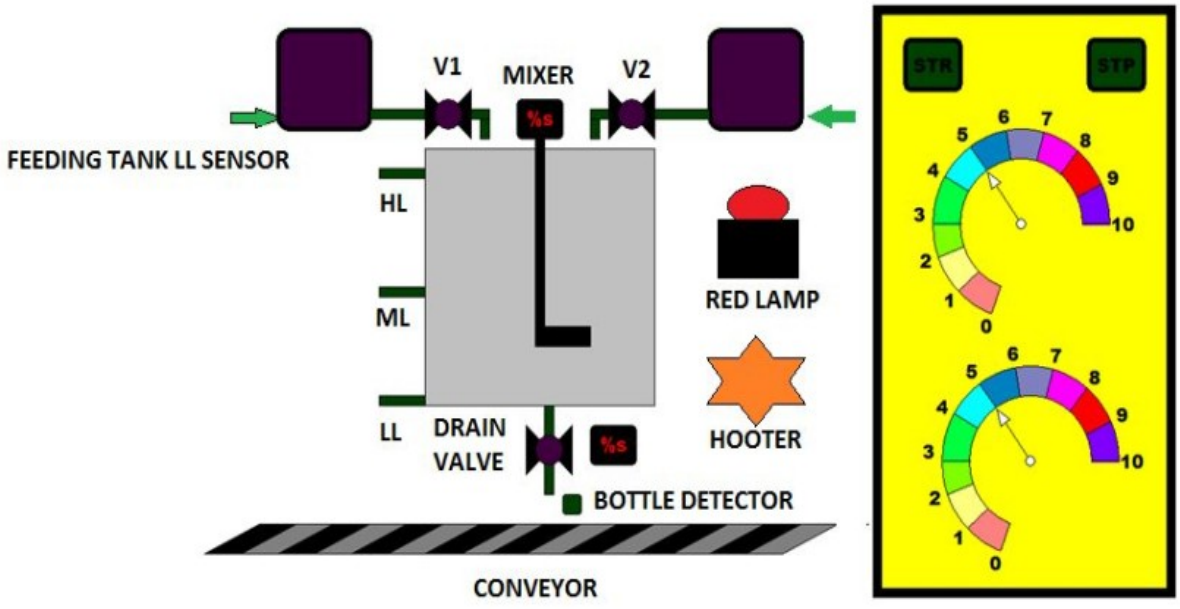


Figure Q5