TVET CURRICULUM DEVELOPMENT, ASSESSMENT AND CERTIFICATION COUNCIL (TVET CDACC)

Qualification Code	**:**	**071606T4MCT**
Qualification	**:**	**Mechatronic Technician Level 6**
Unit Code	**:**	**ENG/OS/MC/CR/05/6/A**
Unit of Competency	**:**	**Carry out mechatronic programming**

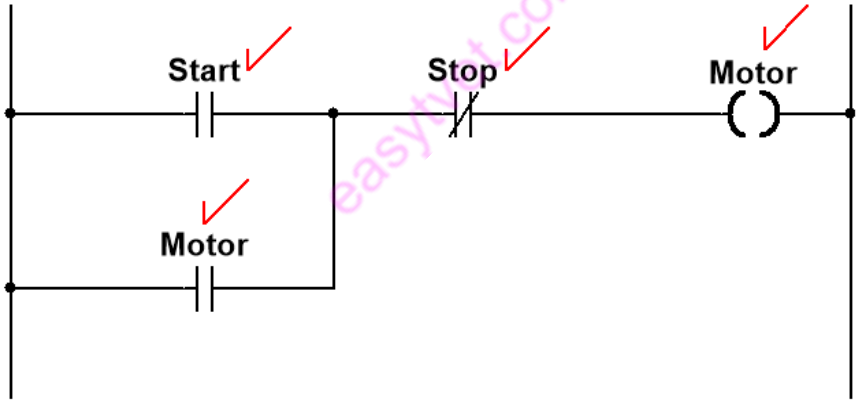
WRITTEN ASSESMENT

INSTRUCTIONS TO ASSESSOR

1. Marks for each question are indicated in the brackets.
2. Answers provided are model answers.

SECTION A: SHORT ANSWER QUESTIONS (40 MARKS)

1. List the **FIVE** standard PLC languages as defined by the International Standard for Programmable Controllers. (5 marks)
   - ✓ ***Ladder Diagram (LD)***
   - ✓ ***Function Block Diagram (FBD)***
   - ✓ ***Sequential Function Chart (SFC)***
   - ✓ ***Instruction List (IL)***
   - ✓ ***Structured Text (ST)***
2. Identify **FOUR** possible causes of a complete stoppage of the control operation and the PLC with the power-on lamp off. (4 marks)
   - ✓ ***Power failure***
   - ✓ ***Supply off***
   - ✓ ***Power tripped***
   - ✓ ***Faulty power cable***
3. State the two general sensing classifications for analog input modules. (2 marks)
   - ✓ ***Voltage sensing***
   - ✓ ***Current sensing***
4. A motor is switched on by pressing a spring-return push-button start switch, and the motor remains on until another spring-return push-button stop switch is pressed. Draw the ladder rungs to perform the operation. (4 marks)



5. Name the tag type used for each of the following: (3 marks)
   i. Create an alternate name for a tag.
      - ✓ ***Alias tag***
   ii. Share information over a network.
      - ✓ ***Produced/consumed tags***
   iii. Store various types of data.
      - ✓ ***Base tag***
6. List the **THREE** major components of CPU of a PLC. (3 marks)
   - ✓ ***Processor***
   - ✓ ***Memory system***
   - ✓ ***System power supply***
7. Identify **FOUR** types of timers used in PLC. (4 marks)
   - ✓ ***On delay timer***
   - ✓ ***Off delay timer***

- ✓ ***Retentive or accumulative timer***
- ✓ ***Pulse timer***

8. Explain why a stop button must be normally closed and a start button must be normally open. (4 marks)
   - ✓ ***If a NC stop button is damaged, the machine will act as if the stop button was pushed and shut down safely.***
   - ✓ ***If a NO start button is damaged the machine will not be able to start.***
9. Describe **TWO** ways of replacing a defective PLC card. (4 marks)
   - ✓ ***In a rack the defective card is removed and replaced.***
   - ✓ ***If the card has wiring terminals these are removed first, and connected to the replacement card.***
10. Name **TWO** uses of the indicator lights on a PLC. (2 marks)
    - ✓ ***Diagnostic use***
    - ✓ ***Maintenance***
11. Given a clear plastic bottle, list **THREE** different types of sensors that could be used to detect it. (3 marks)
    - ✓ ***capacitive proximity***
    - ✓ ***contact switch***
    - ✓ ***photo-optic retroreflective/diffuse***
    - ✓ ***ultrasonic***
12. identify the difference between wiring a sourcing and sinking output. (2 marks)
    - ✓ ***Sourcing outputs supply current (from PLC terminal) that will pass through an electrical load to ground.***
    - ✓ ***Sinking output allow current to flow from the electrical load, to the common (PLC terminal).***

SECTION B: EXTENDED ANSWER QUESTIONS (60 MARKS)

13. Given that for the circuit shown in the **Error! Reference source not found.** below,

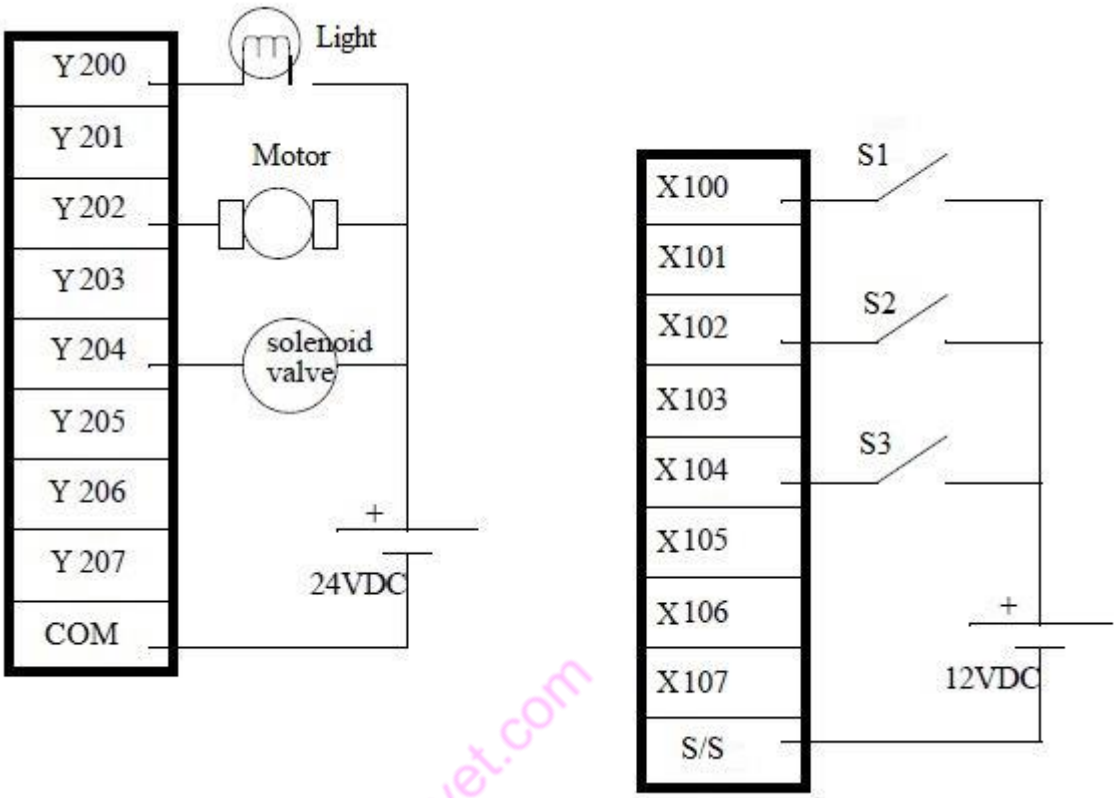


Figure 1

Switch S1 controls the light, switch S2 the motor, and S3 the solenoid valve;

i. List the input and output addresses for the PLC. (6 marks)

Outputs:

- ✓ ***Y200 - light***
- ✓ ***Y202 - motor***
- ✓ ***Y204 – solenoid valve***

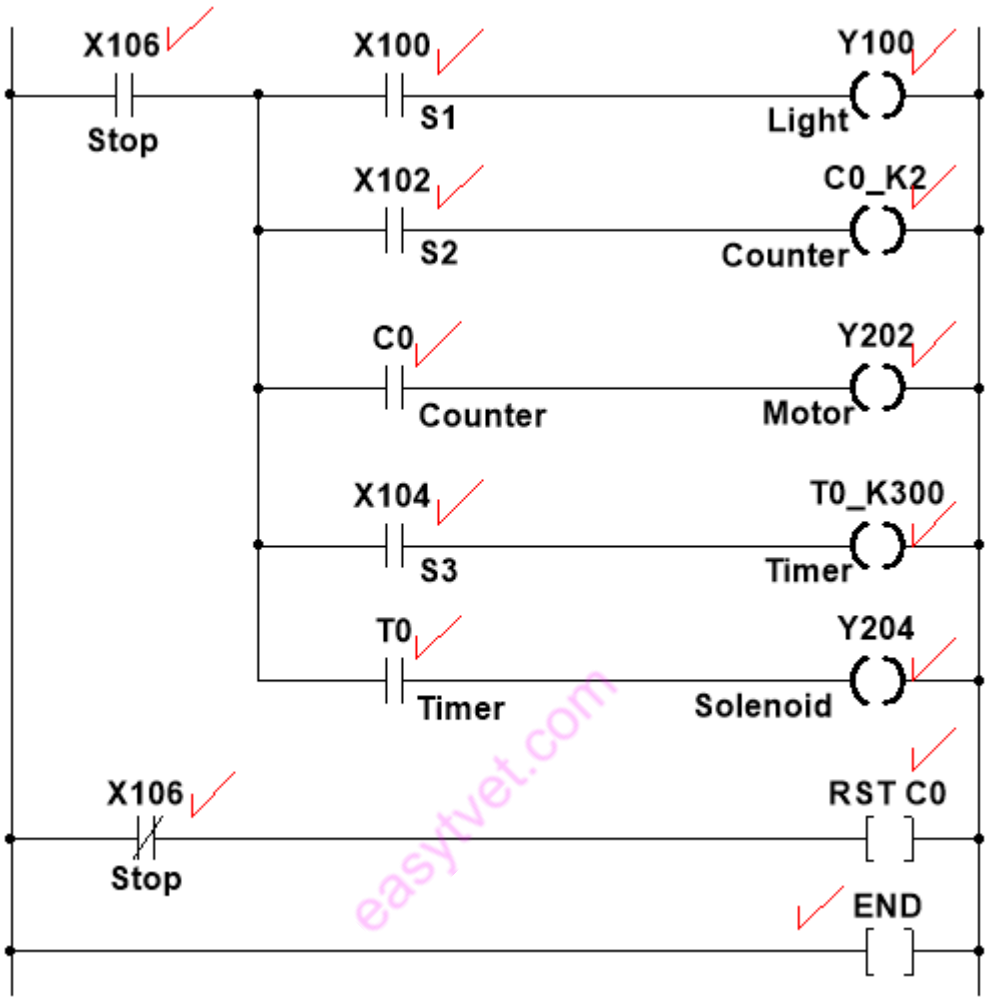
Inputs:

- ✓ ***X100 - switch S1***
- ✓ ***X102 - switch S2***
- ✓ ***X104 - switch S3***

ii. Write a simple ladder logic program having the following additional information; (14 marks)

- A stop switch S4 is connected to input X106 – it switches off everything.

- The motor runs after pressing S2 twice.
- Solenoid valve energize for 30 seconds (time base of 0.1s)



14. A PLC model has a number of different CPU units that can be ordered. One model has 10 I/O terminals of 6 DC outputs and 4 outputs and can be ordered for use with either AC or DC power supplies. The outputs can be selected as either relay output or transistor output with two forms of transistor output available –namely, sink or source type. Explain the capability of such a PLC and the significance of the various forms of output. (20 marks)

The output channels enable the PLC outputs to be available in a form suitable for direct connections to external circuits. Outputs are specified as being of relay type and transistor type.

- ***With the relay type,***

- ✓ ***the signal from the PLC output is used to operate a relay and is able to switch currents of the order of a few amperes in an external circuit.*** √1mark
- ✓ ***The relay not only allows small currents to switch much larger currents but also isolates the PLC from the external circuit.*** √1mark
- ✓ ***Relay outputs are suitable for AC and DC switching.*** √1mark
- ✓ ***They can withstand high surge currents and voltage transients.*** √1mark

- ***The transistor type of output***
  - ✓ ***uses a transistor to switch current through the external circuit.*** √1mark
  - ✓ ***This gives a considerably faster switching action.*** √1mark
  - ✓ ***It is, however, strictly for DC switching and is destroyed by overcurrent and high reverse voltage.*** √1mark
  - ✓ ***Opto-isolators are used to provide isolation.*** √1mark

The terms sourcing and sinking are used to describe the way in which DC devices are connected to a PLC.

- ***With sourcing,***
  - ✓ ***using the conventional current flow direction as from positive to negative,*** √1mark
  - ✓ ***an input device receives current from the input module, that is,*** √1mark
  - ✓ ***the input module is the source of the current.*** √1mark
- ***With sinking,***
  - ✓ ***using the conventional current flow direction,*** √1mark
  - ✓ ***an input device supplies current to the input module, that is,*** √1mark
  - ✓ ***the input module is the sink for the current.*** √1mark
- ✓ ***If the current flows from the output module to an output load, the output module is referred to as sourcing.*** √1mark
- ✓ ***If the current flows to the output module from an output load, the output module is referred to as sinking.*** √1mark

It is important to know the type of input or output concerned so that it can be correctly connected to the PLC.

- ✓ ***Thus, sensors with sourcing outputs should be connected to sinking PLC inputs and*** √1mark

- ✓ ***sensors with sinking outputs should be connected to sourcing PLC inputs.*** $\sqrt{}$***1mark***
- ✓ ***The interface with the PLC will not function and damage may occur if this guideline is not followed.*** $\sqrt{}$***1mark***
- ✓ ***It is worth noting that the PLC provided has got all the capabilities.*** $\sqrt{}$***1mark***

15. Although the PLC can't talk, it can communicate in various ways to show what the problem is. There are status lights on the processor, power supply, and I/O rack that indicate proper operation, as well as status lights that alert the trouble-shooter to the problem. Elaborate on **SIX** indications of the status lights of a typical processor with built-in power supply. Give a possible **solution(s)** in each case. (20 marks)

- ✓ ***DC POWER ON—***
  - ✓ ***If this LED is not lit, there is a fault in the DC power supply.***
  - ✓ ***Check the power supply fuse and/or incoming power.***
- ✓ ***MODE—***
  - ✓ ***Indicates which operating mode the processor is in (run, halt, test, program, etc.).***
  - ✓ ***The fault may simply be that the key switch is in the wrong position.***
- ✓ ***PROCESSOR FAULT—***
  - ✓ ***When this status light is on, it indicates a fault within the processor.***
  - ✓ ***This is a major fault, and requires changing the processor module.***
- ✓ ***MEMORY FAULT—***
  - ✓ ***This status light illuminates when a parity error exists in the transmission of data between the processor module and the memory module.***
  - ✓ ***Replace only one module at a time. If the first module does not correct the problem, reinstall the original module and then replace the second module.***
  - ✓ ***If replacing the second module doesn't clear the problem, replace both modules.***
- ✓ ***I/O FAULT—***
  - ✓ ***This light indicates a communication error between the processor and the I/O rack.***

- ✓ ***Check that the communication cables are fully inserted into their sockets.***
- ✓ ***If available, connect a programming device with a monitor to the processor, and look for error codes and/or fault messages for further diagnostic assistance.***

✓ ***STANDBY BATTERY LOW—***

- ✓ ***When this LED is illuminated, the RAM backup batteries are low and***
- ✓ ***Need to be replaced. Although this is not a fault condition, failure to replace batteries results in losing the program when the system is shut down or a power failure occurs.***

16.

i. Discuss **FIVE** distinct advantages that PLCs offer over conventional relay-based control systems. (10 marks)

- ✓ ***Increased Reliability. Once a program has been written and tested, it can be easily downloaded to other PLCs. Since all the logic is contained in the PLC's memory, there is no chance of making a logic wiring error. The program takes the place of much of the external wiring that would normally be required for control of a process. Hardwiring, though still required to connect field devices, is less intensive. PLCs also offer the reliability associated with solid-state components.***
- ✓ ***More Flexibility. It is easier to create and change a program in a PLC than to wire and rewire a circuit. With a PLC the relationships between the inputs and outputs are determined by the user program instead of the manner in which they are interconnected. Original equipment manufacturers can provide system updates by simply sending out a new program. End users can modify the program in the field, or if desired, security can be provided by hardware features such as key locks and by software passwords.***
- ✓ ***Lower Cost. PLCs were originally designed to replace relay control logic, and the cost savings have been so significant that relay control is becoming obsolete except for power applications. Generally, if an***

application has more than about a half-dozen control relays, it will probably be less expensive to install a PLC.

- ✓ ***Communications Capability. A PLC can communicate with other controllers or computer equipment to perform such functions as supervisory control, data gathering, monitoring devices and process parameters, and download and upload of programs.***
- ✓ ***Faster Response Time. PLCs are designed for highspeed and real-time applications. The programmable controller operates in real time, which means that an event taking place in the field will result in the execution of an operation or output. Machines that process thousands of items per second and objects that spend only a fraction of a second in front of a sensor require the PLC's quick-response capability.***
- ✓ ***Easier to Troubleshoot. PLCs have resident diagnostics and override functions that allow users to easily trace and correct software and hardware problems. To find and fix problems, users can display the control program on a monitor and watch it in real time as it executes.***
- ✓ ***Easier to Test Field Devices. A PLC control panel has the ability to check field devices at a common point. For example, a control system consisting of hundreds of input and output field devices may be contained within a very large manufacturing area. Thus, it would take a considerable amount of time to check each device at its location. By having each device wired back to a common point on a PLC module, each device could be checked for operation fairly quickly.***

ii. Demonstrate your understanding of functions of **FIVE** major components of a PLC (10 marks)

- ✓ ***Processor***

  The processor examines the status of the input signals, executes the logic and sequencing functions, and operates on the outputs
- ✓ ***Memory unit***

  The memory unit stores the work cycle program, I/O status information, and controller system operation information.
- ✓ ***Power supply***

This module is used to provide the required power to the whole PLC system. It converts the available AC power to DC power which is required by the CPU and I/O module.

- ✓ ***Input/output (I/O) module***
  I/O module helps to interface input and output devices with a microprocessor.
- ✓ ***Programming device.***
  This device provides a means of entering the work cycle program into the memory module of the PLC.