DIPLOMA BOARD EXAMINATION – OCTOBER 2024

ANSWER KEY FOR THE QUESTION CODE – 2203

SUBJECT CODE / NAME:4030531 – CONTROL OF ELECTRICAL MACHINES

BRANCH: EEE SEMESTER: 5 MAXIMUM MARKS: 100

PART-A

1.List out the relays used in control circuit. [Any three] (3 MARKS)

1. Voltage relays
2. D.C series current relay
3. Frequency response relay
4. Latching relay
5. Phase failure relay
6. Overload relay
7. Magnetic dashpot oil-filled relay
8. Time delay relay

2. What is Electronic timer? (3 MARKS)

- Electronic timers are generally of the ON delay type. When supply to the timer is given, it starts counting and the contacts change over their positions after a pre-set delay. The length of time delay period is easily adjusted by a variable resistor placed in the electronic circuit. The timer gets reset when supply to the timer is cut off.

3. What do you mean by jogging control? (3 MARKS)

- Normally DC motors are intended for continuous run operation. In certain cases we may have to run the motor for a few rotations, with full power. A DC motor rotating for a few rotations with full power is called as jogging.

4. What is meant by two speed controller of cage induction motor? (3 MARKS)

- Two speed two winding motor having two electrically separated windings in the stator slots. It provides two speed of any ratio.One set of windings for low speed and other set for high speed.

5. What is planner machine control? (3 MARKS)

- This machine is used for shaping a job / work piece to required dimensions by a cutting tool. The job moves to and for to remove the extra material from the job. The cutting tool is stationary and the job is fixed on a table called bed which is movable. The to and for movement of the bed is achieved by forward and reverse rotation of the motor. The forward and reverse movement of the bed is restricted by the two limit switches LLS and RLS.

6. What is the necessity of providing power limit switches in overhead cranes? (3 MARKS)

- The motion of the crane either in long travel or in cross travel and hoist can be restricted by six control limit switches, two for each type of motion are provided.
- Especially for hoisting and lowering function the power limit switch is used to turn on and off the phases for motor for low speed and high speed after attain a certain distance by hoisting or lowering.

7. Write any three advantages of automation. [Any three] (3 MARKS)

1. Increase in productivity
2. Reduction in production cost.
3. Less floor area required.
4. Reduced maintenance requirement.
5. Minimization of human tiredness.
6. Better working conditions for workers.
7. Improvement in production quality.
8. Reduction in accidents.
9. Uniform components are produced.
10. Reduced operation time.

8. List the various types of PLCs. (3 MARKS)

PLCs have two main categories. They are

- Fixed PLC
- Modular PLC

9. What is OFF delay timer? (3 MARKS)

- The OFF - delay timer used to delay an output off for a fixed period of time after the input is turned off.
- When the input turns off, the timer counts until the preset time has elapsed. When the count equals to the pre-set value timer is turned OFF.

10. Write the features of SCADA software. [Any three] (3 MARKS)

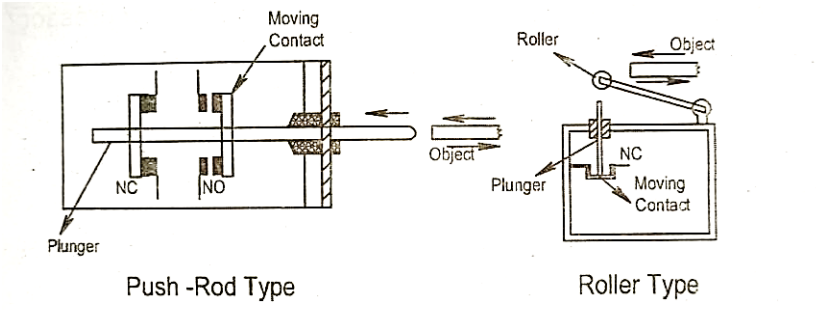
- Alarm Handling
- Graphical user interface
- Data Access and Retrieval
- Computer networking and processing

PART – B

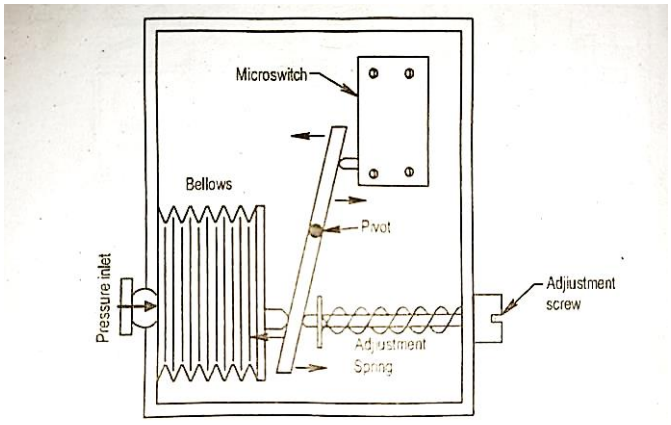
11. (a) Explain the construction and operation of limit switch and pressure switch with a neat diagram. [14 marks]

LIMIT SWITCH (Diagram-4 Marks,Theory-3 Marks)

- A limit switch is a mechanically operated device, the prime function of this switch is to reverse a motor.
- Limit switches are used to prevent excessive load travel. They do this either by switching OFF the motor, or by reversing the direction of load travel, when the load travel has reached the certain limits.
- It is equipped with a set of NO and a set of NC contacts. Limit switch is either stationary and actuated by some moving member or it moves with the machine and it is actuated by stationary member.Mostly this switch is used in a machine tools, cranes, conveyors etc.



PRESSURE SWITCH (Diagram-4 Marks,Theory-3 Marks)



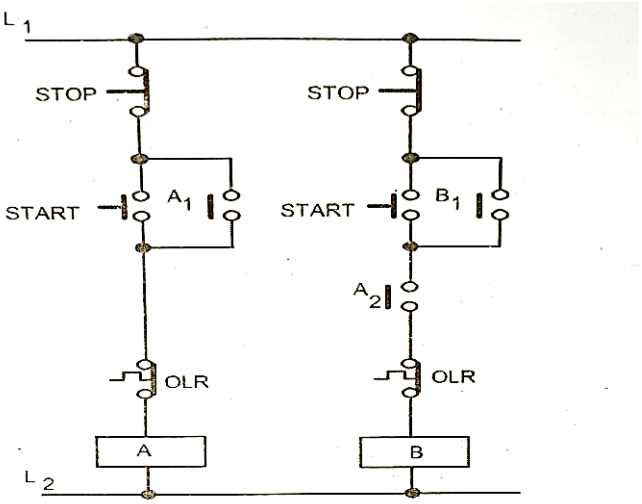
- Pressure switches are used to sense pressure of gas, air or liquid and actuate an electrical control circuit. A pressure switch may have a NO or NC or both. Mostly this type of automatic switch is used to start and stop the compressor motor depending on the pressure of gas in the chamber.
- If the pressure of gas is less the bellow is pushed towards left by the spring. Due, to the pivot the other end closes a NO contact in the micro switch which starts the compressor motor.
- Now the gas pressure builds up and the bellows expands. The pivot presses the micro switch and opens the NO contact and so the compressor motor is stopped. Thus based on pressure the compressor motor will be switched ON or OFF automatically.

(OR)

11. (b) (i) Write short notes on interlocking of drives. [Any two methods] [7 marks]

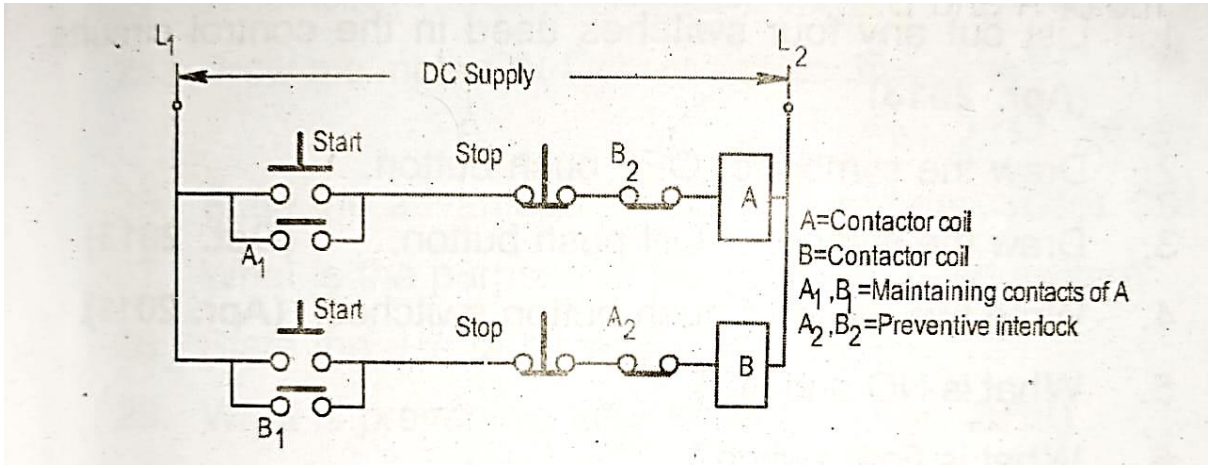
- Interlocks are used to achieve the correct sequence of operation and to prevent the wrong operations of a circuit. Auxiliary contacts of the contactors are used as interlocks.
- If the interlocks are used to achieve the correct sequence of operations are called sequence interlocks.
- If the interlocks are used to protect the wrong operations are called preventive interlocks.

SEQUENCE INTERLOCK



- It is required that motor B should start only after motor A has started for to achieve this condition, we will have to insert a normally open contact A_2 of contactor A in series with contactor coil B.
- Thus, when contactor A is not energized the contact A will be open. The contactor coil B can be energized only when contactor A is energized.

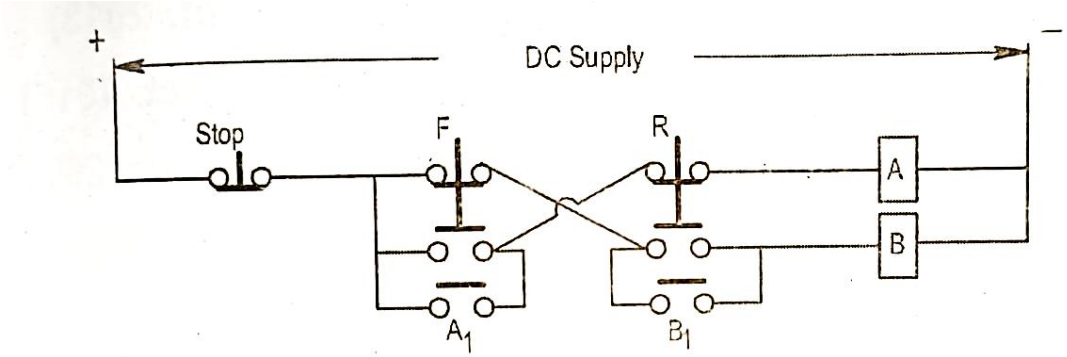
PREVENTIVEINTERLOCK



- Here our requirement is that motor A or B should run only when the other motor is in the off condition. To achieve the above condition, we have to introduce a NC (A_2) of contactor A in series with the contactor coil B. Similarly, a NC (B_2) of contactor B is in series with the contactor coil A. Thus, we get any one of both motors running at a time.

MECHANICAL INTERLOCK

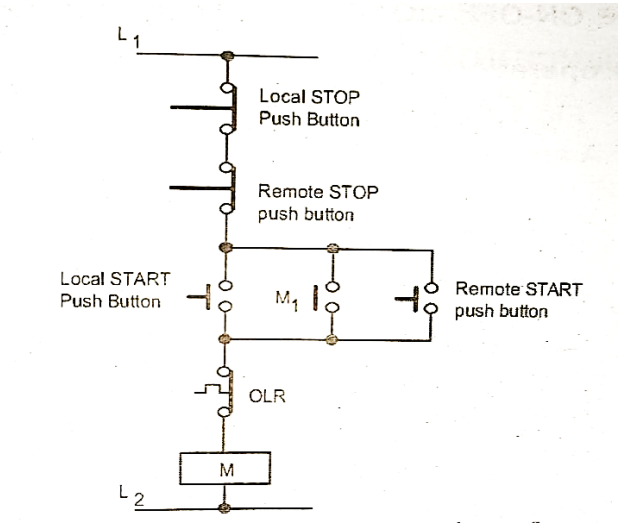
- It acts as a preventive interlock. It prevents simultaneous energization of both A and B contactor coils.
- A_1 and B_1 act as a sealing contact for contactor coils A and B. When F button is pressed, coil A is energized at the same time coil B is disconnected from the supply. Similarly when R button is pressed, coil B is energized at the same time coil A is disconnected from the supply.



11. (b) (ii) Write short notes on remote control operation of drives [7 marks]

(Diagram-4 Marks,Theory-3 Marks)

- Remote control operation means that starting and stopping of the motor from a distant place while the starter being fixed nearer to the motor.
- In this case the control wire will have to be taken to the remote start and stop push buttons from the starter.

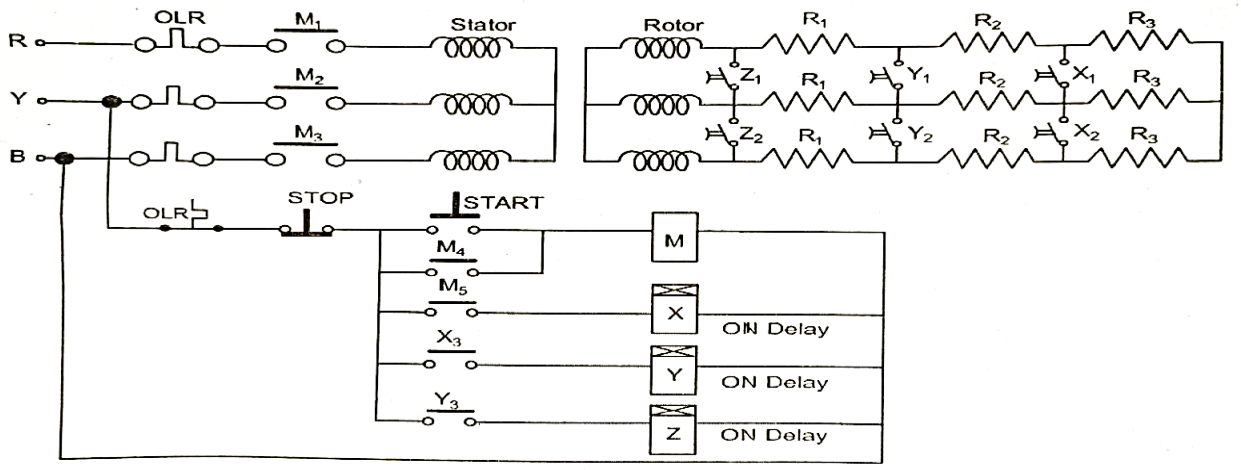


- The remote stop push buttons have been connected in series with local stop push button and the remote start-push button has been connected in parallel with local start push button. The motor can be started and stopped from any number of locations by making all the start push buttons in parallel and all the stop buttons in series.

12. (a) Explain the operation of three step rotor resistance starter for wound induction motor. [14 marks]

(Diagram-7 Marks,Theory-7 Marks)

- In slip ring induction motor it is possible to include resistance in the rotor circuit, due to this the starting current of the motor can be limited. At the same time the starting torque also is increased. The rotor resistance connected is gradually cut out as the motor picks up speed and the slip rings are shorted during the running position.



CIRCUIT OPERATION

1. When the START button is momentarily pressed, coil M is energized and its main contacts M_1, M_2 and M_3 closes giving 30 supply to the stator winding.

2. Now the motor is started with maximum starting resistance i.e., $R_1 + R_2 + R_3$per phase. Auxiliary contacts M_4 and M_5 closes.

3. M_4 acts as a sealing contact to maintain the supply to M coil and M_5 acts as a sequence interlock.

4. Closing of NO contact M_5 energized the on-delay timer x.

5. After the pre-set timer interval, its NO contacts X_1 and X_2 closes thereby cutting out the starting resistance R_3 from the rotor circuit.

6. At the same time X_3 is closed and energized another on-delay timer Y.

7. After the preset time interval, its contacts Y_1 and Y_2 closes thereby cutting out the second stage starting resistance R_2 from the rotor circuit.

8. Similarly after the energization of timer Z, the third stage R_1 also cutout from the rotor circuit.

9. Now the motor is running normally without the starting resistance. When the STOP button is pressed the coils will be de-energized and the motor will come to stop.

(OR)

12. (b) With Neat sketch and explain the principle of field failure protection circuit for DC motor. [14 marks]

(Diagram-7 Marks,Theory-7 Marks)

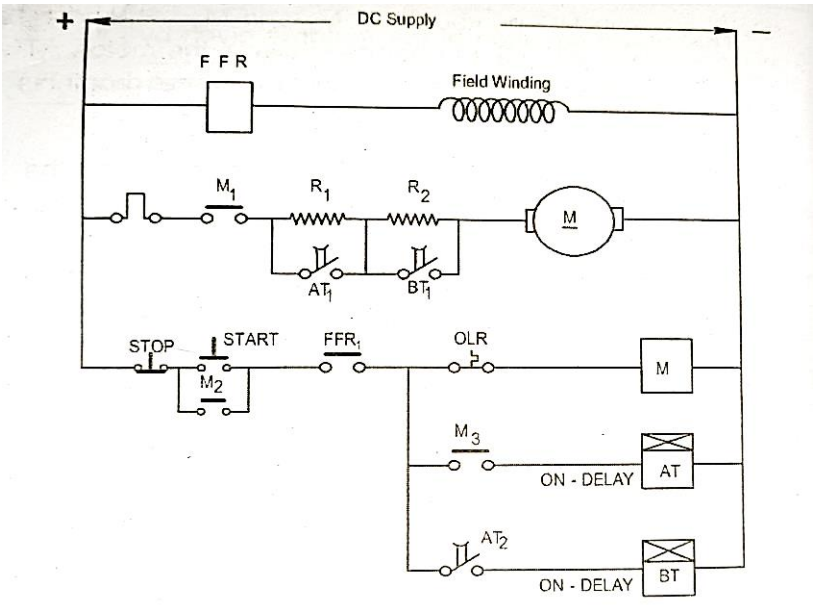
The speed equation of the motor is given by

Speed (N) =(Supply voltage (V) - Armature voltage drop(IaRa))/Field flux (Ø)

- At the time of starting, if the field is open then the motor will fail to start. During running condition if the field fails, i.e. if it gets opened due to break in the field winding or opening of the field circuit terminals, the field flux gets weakened and may fall to zero.
- In such conditions, as the armature still gets supply, the motor continues to rotate and will reach dangerously high speed. Theoretically, almost infinity. This will also lead to destructive commutation. Hence this has to be prevented. The process of cutting off supply to an DC motor when its field winding gets opened is called as field failure protection.

Circuit Operation

- Supply is switched on and the motor is started using definite time acceleration with field failure protection.
- Under normal working condition, the FFR relay in field circuit is energized and the motor runs normally. If the field gets opened due to some fault, then the FFR relay gets de-energized and its NO contact FFR, opens and M contactor coil gets deenergized. Hence supply to the motor gets cut off and motor comes to stop condition.



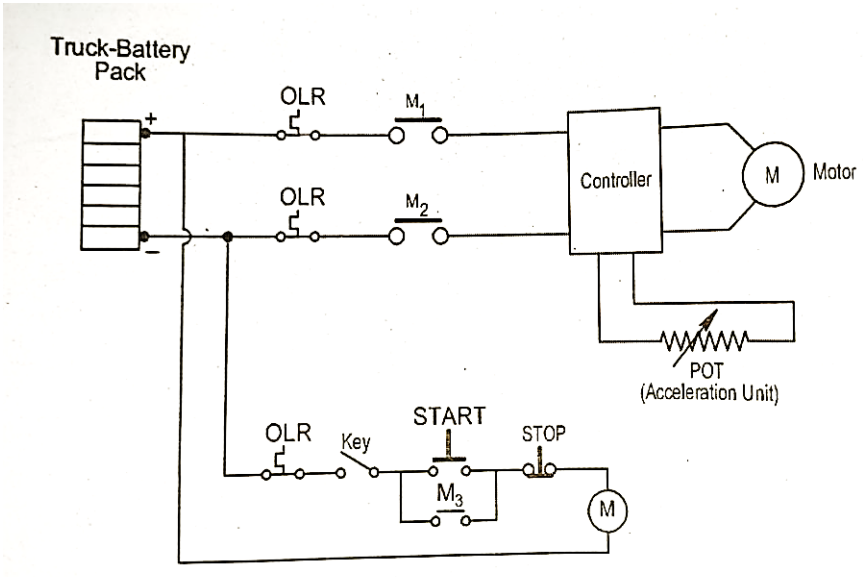
13. (a) Explain the schematic arrangement and control circuit of battery-operated truck.

[14 marks]

(Diagram-7 Marks,Theory-7 Marks)

- Battery operated trucks are primarily used for transferring of materials on road from one place to another place within the factory premises. The unit is eco-friendly and runs on battery. The design of the system can be customized as per the customer's requirements. Brushless AC Asynchronies motors are used in trucks.
- The acceleration unit contains a series of micro switches which energize the contactors in the control circuit. The rate of acceleration is controlled by a fluid dashpot. Hence smooth acceleration is achieved from standstill to full speed. An anti-plugging device is used for safely. It prevents sudden changing of direction of the truck while it is motion. Change of direction is possible only after having the acceleration pedal is brought to the off position.
- All controls are positioned Infront of the operator for easy operation. A key switch controlling the electrical circuit directly in front of the operator. When the key is turned a red warning switch gives indication for the circuit is live and the truck is stationary. The hand brake is positioned by the left hand. The acceleration and brake pedals are conveniently positioned for foot operation.

Control Circuit Operation



- Initially close the key switch, now the circuit is ready for operation. When the start push button is closed the contactor coil M becomes energized and its main contacts M_1, M_2 and M_3 are closed.
- The battery supply is connected to the controller unit through M_1 and M_2, Contact M_3 act as sealing contact for start button. Vary the POT (Potentiometer), correspondingly the speed of the motor increased and the truck will be moved on the road.

- Then decrease the POT position, the motor speed will be reduced. Then applied the mechanical braking to the truck wheel. The vehicle will stop.
- Finally switch off the STOP push button or key. Now the contactor M will be deenergized and the motor is stopped.

(OR)

13. (b) Write the general procedure for troubleshooting in industrial control circuits.

[14 marks]

[Note: First 4 points are enough content]

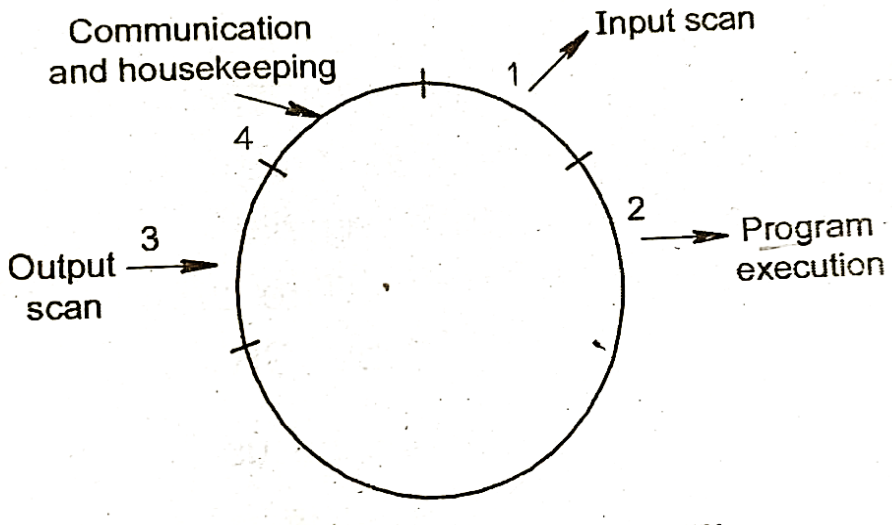
- **The first step should be to analyses the control circuit and ascertain that it has beenproperly designed as per the control function requirement.**
- **The next step is to run the machine and follow the operation and finds the section ofcontrol circuit which is not operating.**
- **After locating the faulty section, wiring should be checked and control components ofthis section should be checked thoroughly.**
- **When trouble in the faulty section is located and removed, the machine should bestarted again to run successfully throughout the complete cycle.**

- While carrying out the maintenance, the necessary safety precaution should be followed during the time of troubleshoot.
- Removing the other circuits while trouble shooting to avoid the other circuit from damage.
- Troubleshooting spots should be checked first during troubleshooting and ensure the given circuit manual is correct.

14. (a) Explain the modes of operation of PLC. [14 marks]

The various modes of operation of PLC's are

- CLEAR program memory mode
- PROGRAMMING mode
- RUN mode
- TESTING program mode
- DIAGNOSTIC test mode
- ENTER/CHANGE Access Code



- When PLC is put in CLEAR mode, the user program stored in the PLC memory can be cleared. Now all the memory vis free for entering a new program.
- A new program can now be entered by bringing the PLC into PROGRAMMING mode be entered by instructions are entered one by one in sequence.
- After entering the program, the program execution can be checked by putting PLC in TEST program mode.
- In test mode, PLC executes the user program but does not energize the outputs, only LED displays for outputs are energized.
- Thus, program working can be checked without actually energizing the outputs. This avoids damage to machinery on account of incorrect program. The machine can be run continuously by bringing the PLC in RUN mode, In RUN mode, the PLC first reads the status of input devices and store then in the memory.
- Then it executes the user program instructions one by one and if any outputs are to be energized, the memory location for that output device is updated by storing binary 1 at that memory location.
- When whole of the program is executed, the output devices are energized. After this the PLC will communicate with any connected devices like hand-held programmer, personal computer and will also perform any necessary memory management.
- Memory management will include updating timers, counters, internal registers etc. This four - step process is called processor scan.
- It is repeated over and over. The scan time of PLC is in milliseconds. The scan time can vary from fraction of millisecond to hundreds of milliseconds depending upon the size of the program.

(OR)

14. (b) (i) Compare hardwire control system and PLC system [7 marks]

- Each different hard wire-controlled machine required its own controller. But it is possible to use one PLC to run number of machines.
- In PLC the amount of wiring required is less compared to hard wire control.
- The PLC system occupies less space compared to hard wire control.
- In a hardwire control, the program alternations. require more time for rewiring of panels and devices. But in PLC, the program can be changed from a keyboard with in few minutes.
- In PLC, the programming error can be corrected quickly compared to hardwire control.
- PLCs are relatively cheap compared to hard wire control.
- A PLC circuits operation can be seen during operation directly on a CRT screen. But it is not possible in hard wire control.
- The operating speed for the PLC program is very fast. But the hard wire control take more time to actuate.
- PLCs are more reliable and less maintenance cost compared to hard wire system.

14. (b) (ii) What are the criteria for the selection of suitable PLC. [7 marks]

CRITERIA FOR SELECTION OF SUITABLE PLC

The following points are kept in mind while selecting a PLC.

1. Number of I/Os

It is very important that the exact number of input and output that are going to be used in the process.

2. Types of I/Os

The user should also known the type of I/O's whether he needs a digital input like sensor, push buttons etc, or a analog input like RTD, thermo couple etc. The requirement of output should be also known. What type of output is required whther a digital output like relay, contactor, lamp etc or analog output like drives and control valves.

3. Memory size of PLC

While selecting the PLC, the size of memory is also important. The memory size depends upon the PLC program

4. Compact (or) Modular PLC

In compact type PLC, the power supply and controller are provided in the same housing. In modular type PLC the power supply and controller are in different housing. So according to the users requirement the compact or modular type PLCs are selected.

5. AC or DC PLC

AC, PLC requires 220 volt for running. DC, PLC requires only 24 volt for running. So the users choose the PLC, according to the power supply available in their control panel.

6. PLC Scan Time

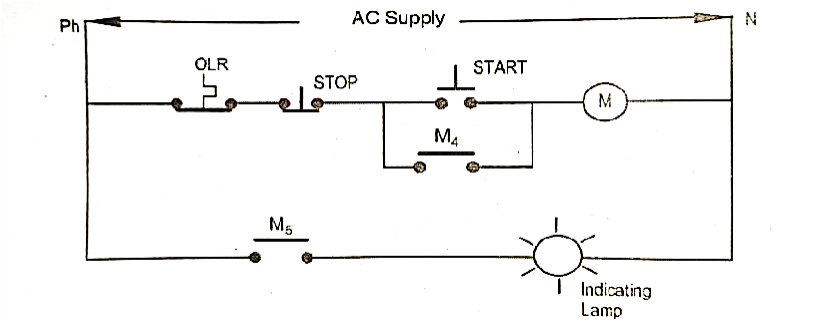
PLC scan time is a time needed for PLC to completely scan one cycle of operation of the PLC. PLC scan time is the time required for reading PLC input status, clearing PLC memory, Executing the PLC program and updating the output. The PLC with less scan time are more costly.

7. Number and type of communication port in PLC

Number of communication port and type of communication port is also very important in choosing a PLC. Suppose the users want to communicate their PLC in MOD BUS, but they don't have a MOD BUS port. So their PLC is of no use. So communication port should also be kept in mind while choosing a PLC.

15. (a) Explain the ladder logic implementation for DOL starter and draw the Hardware circuit. [14 marks]

System description – Relay ladder diagram (Diagram-4 Marks,Theory-3 Marks)



The operation of the above circuit is as follows:

1. When start button is pressed, the contactor coil M gets energized and this closes the main contacts (M_1 to M_3) and auxiliary contacts M_4 and M_5.
2. The closing of main contacts provides supply to the motor and it starts running.
3. At the same time the closing of contact M_5 gives supply to the indicating lamp and it starts to glow. The glowing of bulb indicates that the motor is in running condition.

4. The contact M_4 acts as a sealing contact. i.e., It can provide (or) maintain the supply to the contactor coil M even when the start button is released.
5. The motor will run until the stop button is depressed, or the overload relay opens the OLR contacts.
6. Whenever the stop button is depressed then the contactor coil M is de-energized and all the contacts are opened, thereby supply to the motor is cut-off.

Development of Ladder Logic Diagram (Diagram-4 Marks,Theory-3 Marks)

Step 1: I/O Listing

a) INPUT

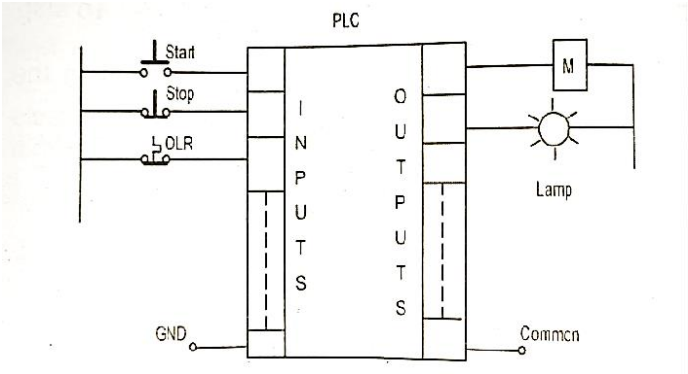
1. START PUSH BUTTON
2. STOP PUSH BUTTON
3. NC contact of over load Relay (OLR)

b) OUTPUT

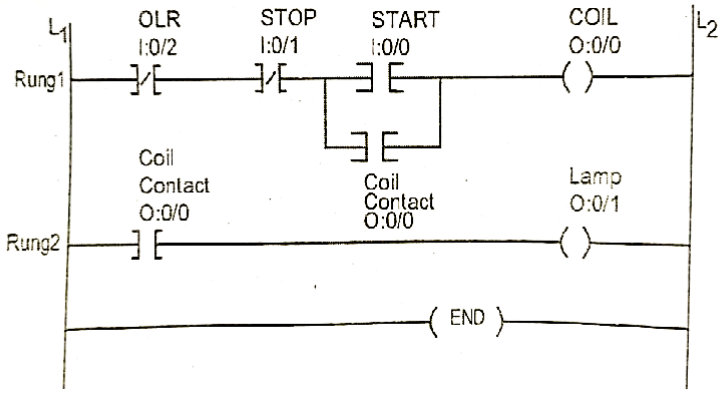
1. Contactor coil (M)
2. Indicating lamp

Step 2: Assigning of addresses to the I/O used

Component	Address
START PUSH BUTTON	I : 0/0
STOP PUSH BUTTON	I : 0/1
NC Contact of over load Relay	I : 0/2
Contactor coil (M)	O : 0/0
Indication Lamp ( )	O : 0/1



Step 3: Ladder logic diagram



Program Execution

- Before the program execution, connect the PLC with PC and connect the motor with PLC outputs. Then down load the program to the PLC and put the PLC in RUN mode. When the PLC is put in run mode, it will start its scan cycle. First the inputs are read and their status is stored in a memory location allotted for each input device.
- To start the motor FORCE ON the start, push button.
- Now all the inputs in the first rung inputs 1:0/2, 1:0/1 and 1:0/0 are high level. Hence the status of the output coil becomes true (logic 1).
- Therefore, the motor is switched ON. To stop the motor, FORCE ON the stop push button, hence the status of 1:0/1 changed from logic 1 to 0.
- So, the output coil memory location is set to logic 0. Now the motor is switched off.

(OR)

15. (b) Explain the various relay type instructions used in PLC. [14 marks]

RELAY TYPE INSTRUCTION

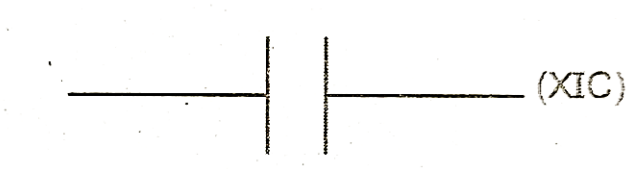
- Relay type instruction form the programming that deals with the simple energizing and de-energizing of inputs and outputs. Contacts and coils contain this type of instruction.

There are two kinds of relay contact input instruction

1. Examine if closed contact instruction

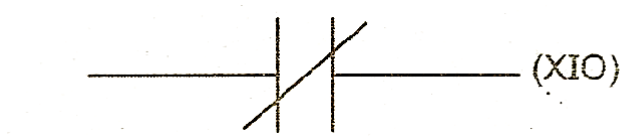
2. Examine if opened contact instruction

1. Examine if closed contact instruction (XIC)



- It is also called normally open instruction. It is abbreviated as XIC. An XIC contact checks the status of its input reference address for ON (or) closed condition. If the reference address is ON, the contact closes, providing continuity through it.

2. Examine if open contact instruction (XIO)

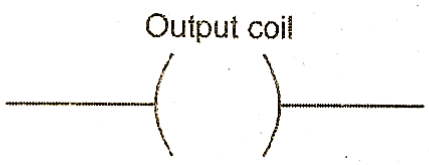


- It is also called a normally closed instruction. It is abbreviated as XIO. A, XIO contacts checks the status of the input reference address for ON or open, condition. If the reference address is OFF, the contact remains closed, providing continuity to the ladder rung.

There are four kinds of relay coil output instructions.

- Standard output coils
- Internal output coils
- Latch/unlatch output coils
- One short rising instruction

1. Standard output coils (OTE)

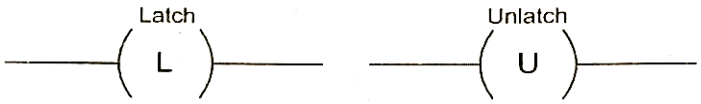


- A standard output coil instruction is also called an output energies instruction. The symbol consisting to two parentheses. If the coil's ladder rung has continuity, then the coil will energies, hence causing the output to turn ON.

2. Internal Output Coils (OTE)

- The internal output coil instruction is same as that of a output coil. It is represented as the same symbol. The functional difference between the two is that a standard output coil is the actual output device wired to the PLC. But an internal output coil has a reference address which is located in the binary file.

3. Latch / Unlatch output coil (OTL / OTU)



- A latch / unlatch output coil instruction, is actually composed of two separate coil instructions. These coil instructions are always used together in a ladder program and always share the same address.

4. One Short rising instruction (OSR)

- A one-short rising instruction is not a coil instruction but it is a contact instruction. It is used to control the behavior of the coil. A one-short rising instruction is used to energies an output coil. A one-short rising instruction is used to energies and output coil for only one scan. It is usually the last contact in a rung, located just before the output coil. Its address bit can be located in either the binary file or the integer file.

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