Handout no.5
PLC PROGRAM DEVELOPMENT FOR CONTROL APPLICATIONS
Sequential Logic

Problem no.1

A feed belt moves components, successively, towards an assembly machine. When a component is in position, in front of the assembly machine, a limit switch, LS1, turns on to stop the feed belt. An arm is then extended to push the component firmly inside the machine which turns on another limit switch LS2. This stops the arm and after a delay of 10 seconds, the arm starts to return back to its normal position. A limit switch LS3 turns on when this happens. This limit switch indicates that the arm is away from the assembly machine so that it can be activated to press the component into the desired shape. When the pressing operation is completed and the resulting part is ejected from the machine a sensor LS4 turns on. This indicates that the next component can be moved and the process is repeated continuously.

It is required to develop a PLC program to control the above system.

Problem no.2

It is required to develop a PLC program to control the operation of a nurse calling system according to the following conditions:

* The system monitors the calls from 3 different rooms.
* There is a red lamp and a yellow lamp corresponding to each room.
* There is only one bell in the system.
* In each room there are 3 pushbuttons. The first pushbutton is pressed by the patient to CALL the nurse. The second pushbutton is pressed by the nurse when she enters the patient's room to ACKNOWLEDGE the call. The third pushbutton is pressed by the nurse before leaving the room to indicate END of call.
* When a patient presses the CALL pushbutton, the red lamp corresponding to the patient's room is turned ON and the bell is activated. When the nurse enters the room and presses the ACKNOWLEDGE pushbutton, the red lamp is turned OFF, the yellow lamp is turned ON and the bell is deactivated. When the nurse presses the END of call pushbutton, the yellow lamp is turned OFF.

Problem no.3

A system having 3 loads is required to be controlled in the following manner:

* When a START pushbutton is pressed, load no.1 is activated.
* After 3 minutes, load no.2 (a lamp) starts flashing (0.5 sec. OFF and 1.0 sec. ON) and load no.1 remains active.
* After 2 minutes from starting to flash load no.2, load no.1 is switched OFF, load no.2 is activated steadily and load no.3 is switched ON.
* After 1 minute from activation of load no.3, both loads no.2 and no.3 are switched OFF and load no.1 is activated again and the above process is repeated continuously.
* Pressing a STOP pushbutton at any moment switches OFF all the loads and the process can be restarted from the first step by pressing the START pushbutton.

It is required to develop a PLC program to control the above system.

Problem no.4

It is required to develop a PLC program to control a system having 3 loads, in the following manner:

- When a START pushbutton is pressed, load no.1 is activated.
- While load no.1 is active, pressing a pushbutton PB1 deactivates load no.1 and activates load no.2.
- While load no.2 is active, pressing a pushbutton PB2 deactivates load no.2 and activates load no.3.
- While load no.3 is active, pressing a STOP pushbutton deactivates load no.3 and the system is stopped. It can be restarted by pressing the START pushbutton.
- During activation of any load, pressing a PAUSE pushbutton deactivates this load and turns ON a YELLOW lamp. This load can be reactivated and the YELLOW lamp is switched OFF by pressing a RESUME pushbutton. Pressing any pushbutton other than the RESUME pushbutton while a load is paused should have no effect.

Problem no.5

A fire alarm and fighting system in a certain warehouse is designed to protect 3 different zones. Each zone has a fire detector and a gate to be closed in case of fire to isolate this zone, so that fire does not propagate to other zones of the warehouse. Each zone has a fire fighter, which when activated, produces water showers in case of fire.
It is required to develop a PLC program to implement this system according to the following conditions:

* The system has START and STOP pushbuttons. It also has an ACKNOWLEDGE and TERMINATE pushbuttons.
* When the START pushbutton is pressed the system starts to monitor the fire detectors of the 3 zones. If a fire detector is ON, this indicates that a fire exists in that zone. When this happens, the closing mechanism of the gate leading to that zone should be activated, its water fighter should be turned ON, an alarm siren is operated and a red lamp corresponding to that zone on the control panel should be turned ON. These actions should be maintained even if the fire detector becomes OFF.
* If the STOP pushbutton is pressed while there is no fire in any zone, the system is stopped.
* If fire exists in all of the 3 zones, the closing mechanism of the main gate of the warehouse is activated.
* When the ACKNOWLEDGE pushbutton is pressed after a fire has been detected, all the gate closing mechanisms are deactivated and the siren is stopped. The fire fighters and red lamps remain ON until the TERMINATE pushbutton is pressed. Afterwards the system can be restarted by pressing the START pushbutton.
* If a fire is detected and the ACKNOWLEDGE pushbutton has been pressed but the TERMINATE pushbutton not yet pressed and fire starts in a new zone, its fire fighter is activated and its red lamp is turned ON. The gate closing mechanism and alarm siren are not activated.

Problem no.6

It is required to develop a PLC program to control a system with 3 loads in the following manner:

- When a START pushbutton is pressed, load no.1 is activated.
- After 1 minute from activation of load no.1, pressing a pushbutton PB1, at any time, deactivates load no.1 and activates load no.2. If PB1 is not pressed until a period of 3 minutes passed from the moment of pressing the START pushbutton, then load no.1 should be switched OFF and load no.2 should be switched ON.
- After 1 minute from activation of load no.2, pressing a pushbutton PB2, at any time, deactivates load no.2 and activates load no.3. If PB2 is not pressed until a period of 5 minutes passed from the moment of pressing the START pushbutton, then load no.2 should be switched OFF and load no.3 should be switched ON.
- After 1 minute from activation of load no.3, pressing a STOP pushbutton, at any time, deactivates load no.3 and the system is stopped. It can be restarted by pressing the START pushbutton. If the STOP pushbutton is not pressed until a period of 8 minutes passed from the moment of pressing the START pushbutton, then load no.3 should be switched OFF and the system is stopped. It can be restarted by pressing the SATRT pushbutton.

Problem no.7

An automatic cutting system is used to cut material into blocks of pre-specified lengths. This is done by counting pulses from the sensor of the drive rolls. The cutting system can be used for one of two standard lengths selected by a two position switch. For standard length no.1, 50 pulses should be counted from the sensor of the drive rolls, whereas 90 pulses should be counted for standard length no.2.

The process cycle begins when a position sensor becomes ON indicating that there is material to be cut between the drive rolls. When this happens, according to the position of the selection switch, pulses of the drive rolls are counted for the required standard length. When the specified number of pulses is received, the drive rolls are stopped and the cutter is activated for 30 sec. After this period, the feed-belt is activated to move the cut block. When the block reaches the weighing system a limit switch becomes ON so that the feed-belt is stopped. Weighing takes 1 minute, after which the recorded weight is compared with the standard weight and a signal coming from the weighing system is checked. This signal indicates the result of comparison: if it is LOW, the recorded weight is ACCEPTED and the process cycle is repeated. On the other hand, if this signal is HIGH, this indicates that the recorded weight is REJECTED. Consequently, the system is halted and a RED lamp is turned ON. This indicates a CUTTING ERROR and the cutting system should be checked. A RESET pushbutton should be pressed afterwards so that the process can be repeated. Develop a PLC program to implement the above system.

Problem no.8

A chemical system consists of 3 tanks with 5 pumps to transfer the liquid contents through the system. Each tank has two sensors to detect EMPTY and FULL states. Tank no.2 has a heater and an associated temperature sensor. Tank no.3 has a stirring arm to mix liquids A and B coming from tanks 1 and 2, respectively. Tank no.3 has enough capacity to accommodate the contents of tanks 1 and 2. The system has two modes of operation: MIXING and WASHING modes. A two-position mode selection switch enables the operator to choose between the two modes.

Upon pressing a START pushbutton with the mode selection switch on MIXING position, tanks 1 and 2 are filled simultaneously with liquids A and B through pumps 1 and 2, respectively. When a tank FULL sensor becomes ON, the corresponding pump (1 or 2) is stopped. When tank no.1 is FULL, pump1 is stopped and pump3 is activated to transfer liquid A to tank no.3. When tank no.2 is FULL, pump2 is stopped and the heater is activated to raise the temperature of liquid B to a required value indicated by the temperature sensor becoming ON. When this happens the heater is turned OFF and pump4 is activated to transfer heated liquid B to tank no.3. When a tank EMPTY sensor becomes ON, the corresponding pump (3 or 4) is stopped.

The stirring arm is activated when either liquid A or heated liquid B starts to be pumped into tank no.3. Stirring of liquid A and heated liquid B continues for 5 minutes timed from the moment when both tanks 1 and 2 are empty. Afterwards the mixture is pumped out of tank no.3 through activation of pump5. When tank no.3 is EMPTY, pump5 is stopped. This marks the end of the mixing process. It can be repeated by pressing the START pushbutton with the mode selection switch on MIXING.

If the START pushbutton is pressed with the mode selection switch on WASHING position, water is pumped into tank no.3 through pump6 and the stirring arm is activated. When tank no.3 is FULL, pump6 is stopped is stopped and stirring continues for 3 more minutes. Afterwards the stirring arm is stopped and pump5 is activated to discharge the water out of tank no.3. When tank no.3 is EMPTY, this marks the end of one step of washing. The WASHING process consists of 3 repeated steps. After the third step, the WASHING mode is finished and it can be repeated by pressing the START pushbutton with mode selection switch on WASHING position. An indicator lamp should be turned ON during all the steps of the WASHING mode.

It is required to develop a PLC program to control the above system.

Problem no.9

A system has ‘START’ and ‘STOP’ push-buttons in addition to three loads. It also has three push-buttons: ‘PB 1-2-3’, ‘PB 2-3-1’ and ‘PB 3-1-2’. It is required to develop a PLC program to control this system in the following manner:

* If the ‘START’ and ‘PB 1-2-3’ push-buttons are pressed simultaneously, the system operates in MODE A. In this mode load no.1 is activated for 5 sec. then deactivated. Afterwards load no.2 is activated for 5 sec. then deactivated. Finally load no.3 is activated for 5 sec. then deactivated which marks the end of MODE A operation.
* Similarly if the ‘START’ and ‘PB 2-3-1’ push-buttons are pressed simultaneously, the system operates in MODE B. In this mode the loads are activated as before but with the sequence load no.2 then 3 then 1.
* Similarly if the ‘START’ and ‘PB 3-1-2’ push-buttons are pressed simultaneously, the system operates in MODE C. In this mode the loads are activated as before but with the sequence load no.3 then 1 then 2.
* While the system is operating in any mode, pressing the ‘STOP’ push-button ends this mode. Afterwards the system can be operated in any mode as before.
* While the system is operating in any mode, pressing any push-button other than the ‘STOP’ push-button should have no effect.
* Each mode of operation has a special indicator, which should be turned ON while the system is operating in this mode and turned OFF otherwise.

Problem no.10

It is required to develop a PLC program to control a chemical system having 3 tanks and 6 pumps. Each tank has two sensors to detect EMPTY and FULL states. Tank no.2 has a heating element and 2 temperature sensors to indicate 60˚C and 80˚C, respectively. Tank no.2 has a stirring arm to mix liquid A from tank no.1 with liquid B or liquid C from tank no.2. Tank no.3 has enough capacity to accommodate the contents of tank no.1 and tank no.2. The system has two modes of operation. The first is MIXING A and B and the second is MIXING A and C. A two-position mode selection switch enables the operator to choose between the two modes.

Upon pressing the START pushbutton with the mode selection switch on MIXING A and B, tanks 1 and 2 are filled, simultaneously, with liquids A and B through pumps 1 and 2, respectively. If the START pushbutton is pressed with the mode selection switch on MIXING A and C, tanks 1 and 2 are filled, simultaneously, with liquids A and C through pumps 1 and 6, respectively. When a tank FULL sensor becomes ON, the corresponding pump (1, 2 or 6) is stopped. When tank no.1 is FULL pump1 is stopped and pump3 is activated to transfer liquid A to tank no.3. Pump3 is stopped when tank no.1 is EMPTY. When tank no.2 is FULL, pump2 is stopped and the heater is activated to raise the temperature of liquid B to 60˚C, which is indicated by temperature sensor no.1 or pump6 is stopped and the heater is activated to raise the temperature of liquid C to 90˚C, which is indicated by temperature sensor no.2. Afterwards, pump4 is activated to transfer heated liquid B or C to tank no.3. When tank no.2 becomes EMPTY, pump4 is stopped. The stirring arm is activated when any liquid (A, heated B or heated C) starts to be pumped into tank no.3. Stirring of liquids A and heated B continues for 3 more minutes timed from the moment when both tanks 1 and 2 become EMPTY. Stirring of liquids A and heated C continues for 5 more minutes timed from the moment when both tanks 1 and 2 become EMPTY. Afterwards, the mixture is pumped out of tank no.3 by activating pump5. When tank no.3 is EMPTY pump5 is stopped. The system has two indicators. The first should be turned ON while pumping out MIXTURE A and B. The second should be turned ON while pumping out MIXTURE A and C. When tank no.3 is EMPTY the active indicator should be switched OFF. This marks the end of the mixing process. It can be repeated by pressing the START pushbutton with the mode selection switch on the proper position.