Bangladesh University of Engineering and Technology
Department of Electrical and Electronic Engineering
EEE 318 Control System I Laboratory
Experiment 2
Control of a conveyor system using Programmable Logic Controller (PLC) – Part I

Introduction:

In industry the monitoring and control of many manufacturing processes and conveyor systems (Systems for material handling and transporting) demand a series of operations which are to be performed sequentially and repetitively. This purpose was served in earlier time using mechanical timers and sequencers involving gears and cams which were later replaced by electromechanical relays, contacts, counters, timers and sequencers. Even these days the relay control has not yet been obsolete rather is favorite to the engineers in many industries of the various parts of the world who understand a process and its control better using Relay Ladder diagram. However, the relays suffer from a number of problems viz: larger size, slower operation, contact wear and reliability problems, inability to accept more than one input simultaneously and the necessity of replacing the whole control panel in case another set of operations different from those for which the relays have been hard wired are to be performed because rewiring the relays is difficult and time consuming. This is why Programmable Logic controller (PLC) has been evolved. A PLC is a solid state device specially designed to operate with immunity to electrical interference when installed on the factory floor in noisy industrial environment and perform all the logic functions shown in a Relay Ladder Diagram using 'software' relays, contacts, timers and sequencers instead of physical hard wired relays. A PLC has a microprocessor and a memory chip and can be programmed using a pocket or hand held programmer which has a key board with the symbols of contacts, relays or output devices, timers, sequencers etc. Whenever a key on the programmer is pressed it creates a software version of the associated symbol and an address is to be assigned to it. To program a PLC the required operations are represented first in a Relay Ladder Logic diagram which is similar to Relay Ladder diagrams but uses the symbols of software relays, contact etc. Then each rung of this ladder diagram is programmed from the keyboard of the programmer. Once programmed the program is saved in the PLC memory and the PLC is brought into RUN mode and then programmer can be switched off but the PLC left ON. The PLC in RUN mode starts the operations if its output and input terminals are already connected respectively with input and output terminals of the plant i.e. the system under control. There are interfaces between the PLC input terminals and the processor to convert the signals coming from plant sensors, push buttons, limit switches etc. to low level (+12V) DC voltage and to provide electrical isolation to these signals as well as the processor from noise and voltage spikes (transients) on the input lines using opto-coupler or opto-isolator (a combination of LED and a photo transistor). Similarly there are interfaces between PLC processor and output terminals to send signals and actuate the plant components like motor starters, solenoid valves, indicating lamps etc. The electrical isolation for the PLC output signals and the processor is provided by a transistor/triac switching circuit.

The PLC Training System in the Lab:

The system has three main parts:

1. **Plant:** The plant (system under control) PC45 comprises a conveyor belt driven by a 12 Volt, 2.5 Watt DC motor, two infrared sensors for detecting the objects and three cylinders whose pistons are operated pneumatically i.e. by compressed air at a pressure of maximum 3 bars (45 lbs/sq. inch). The compressed air flow is controlled by the valve opening actuated by electrical solenoid coils. The pistons can push the objects on the conveyor (while the conveyor runs) to drop them into different sections of a bin according to the object diameters or heights as decided by logical operations programmed into the PLC.

2. **PLC:** This is the heart of the PLC system. This is an Allen Bradley SLC150 controller having the characteristics mentioned in the Introduction.

3. **Compressed Air Pump:** This is a manually pumped plastic reservoir (PC49) supplying pressurized air to the solenoid valve manifold of the cylinder set of PC45. To fill the pump with compressed air, one has to simply twist its handle to release it from its clamped position and then manually pump the handle (raise up and lower down) until some resistance is felt while pumping. The pump has a built-in pressure relief valve which will open whenever the pressure exceeds 3 bars thereby ensuring that excessive air pressure can not be applied to the PC45.

Input and Output wiring connections between the PC45 and SLC150

Outputs from PC45 to be connected with inputs to SC150			**Physical address of inputs to SLC150**
Green Pushbutton switch (SWG)			001
Red Pushbutton switch (SWG)			002
Sensor 1 (S1)			003
Sensor 2 (S2)			004
Sequence switch module	Switch 1		005
	Switch 2		006
	Switch 3		007
	Switch 4		008
	Switch 5		009
Limit (Reed) switch on cylinders		R1	101
		R2	102
		R3	103

Inputs to PC45 to be connected with outputs from SC150	**Physical address of outputs to SLC150**
Green lamp (LG)	012
Red lamp (LR)	013
Conveyor forward Run (E)	011
Conveyor reverse Run (R)	111
Input for Cylinder 1 (C1)	112
Input for Cylinder 2 (C2)	113
Input for Cylinder 3 (C3)	114

Notes:

1. The bar (-) above an input e.g. C1 means this input will be activated when 0 volt is applied to it.

2. The address of 'input' and 'output' terminals of SLC150 are physical and termed external addresses.

Other Connections

VAC/VDC common terminal For output terminals 12 and 13 of SLC150	Connect to 0V
VAC/VDC common terminal for output 112,113 and 114 of SLC150	Connect to 0V
Common terminals of outputs 11 and 111 of SLC150	Strap together and connect to 0V
Common terminal (COM) on input side of SLC150	Connect to 0V
V_{SWITCH} terminal of sequence switch module	Connect to 0V

EXERCISE – 1

Using three switches of the sequence switch module as push buttons switches (i.e. switch ON and then immediately switch OFF) produce a start up sequence such that the conveyor will start only if the first three push buttons are operated in order – 1, 2, 3. The conveyor should stop when switch 4 is operated.
For this Exercise program the Ladder diagram (i.e. relay ladder logic diagram) shown in Figure – 1.

Note:

The address beginning with 7 in a Ladder diagram are internal addresses and do not imply any physical terminals rather refer to 'software' relays and corresponding 'software' contacts. The SLC150 can address the software relays and associated contacts using the numbers 901 to 932 but pressing different function keys for symbols of timers, counter and sequencers.

EXERCISE – 2:

Extend Exercise – 1 such that the conveyor will run only when switches 1, 2, 3 of sequence switch module are operated in the order 1, 2, 3 and an object is placed between transmitter and receiver of sensor 1 but not between sensor 2. Also the conveyor must stop when the object reaches sensor 2.

The Ladder diagram for this Exercise is given in Figure -2.

Note:

1. To activate the cylinder 2 exactly when the object reaches it a timer is necessary to time the interval for the object to move from sensor 2 to cylinder 2 so that the cylinder will not be energized earlier rather the cylinder will operate after the time (set by the timer) elapses. Also once the cylinder is activated it must not be deactivated unless its piston fully pushed the object into the bin compartment. For this another timer should also be used. If the arrival of the object, activation of cylinder 2 and push by its piston do not match the preset (PR) values of one or both the timers may have to be changed by trial and error.

2. Both the sensors must be set at such a height that they can sense tall as well as short objects.

3. It may happen that despite having appropriate PR values the timers, the piston of cylinder 2 partially pushes out or does not push at all. In this case the pressure of the air flow is low and manually pull out the piston from cylinder to reset the whole system. Then pump the handle of the compressed air pump several more times until sufficient pressure has been attained. Now run the program again. Further note that once the pump has attained enough pressure the pressure will remain unchanged for many operations of the cylinders and pistons.

REPORT:

1. Explain the logic of the Ladder diagram programmed for each exercise.

2. Record the results of Exercise – 3 as in the given Table:

Observation No.	**Object nature (tall/short and heavy/light)**	**Timer-1 PR (sec)**	**Timer-2 PR (sec)**	**Object pushed or not?**

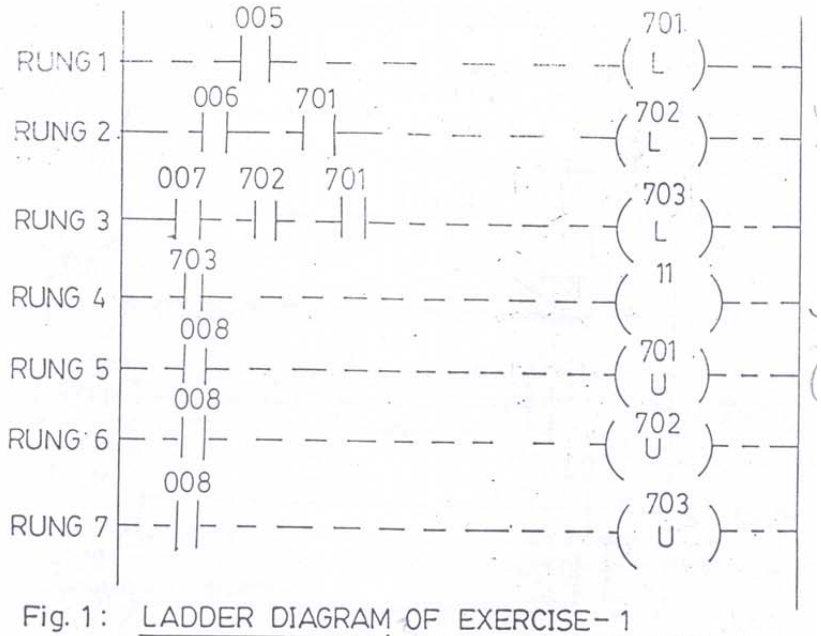

Fig. 1: LADDER DIAGRAM OF EXERCISE-1

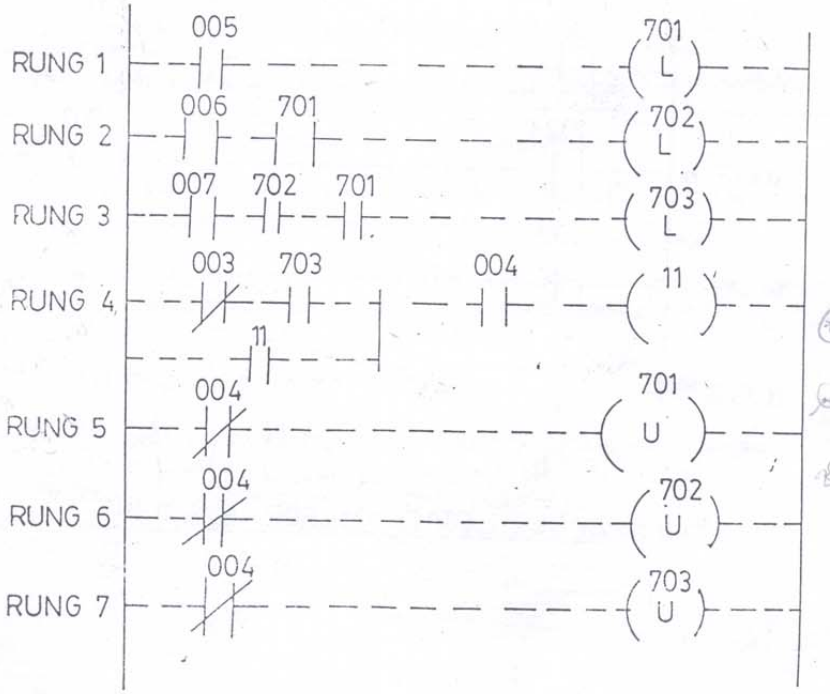

Fig. 2: LADDER DIAGRAM FOR EXERCISE-2

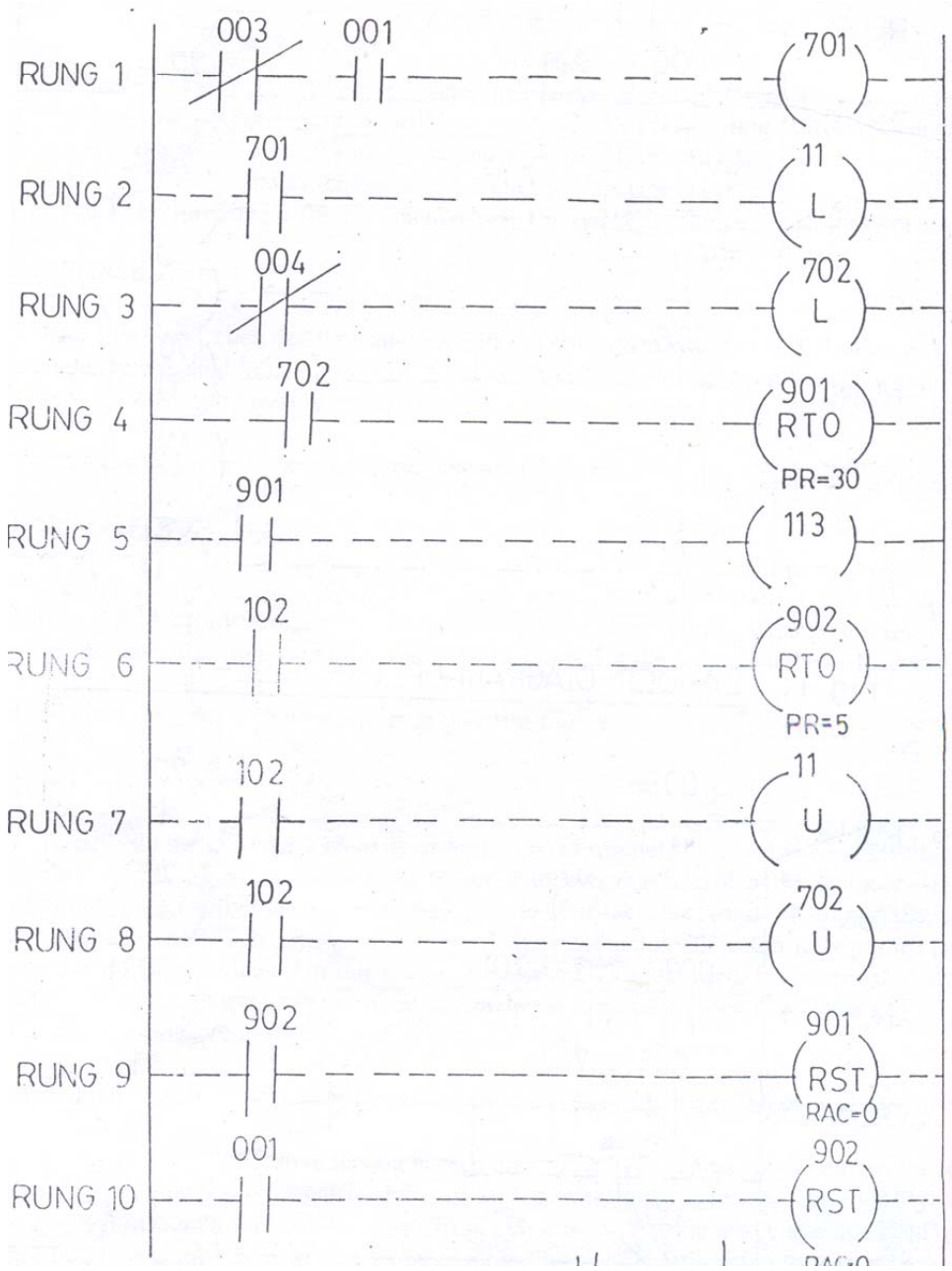

FIG. 3: LADDER DIAGRAM OF EXERCISE 3

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