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PLC Based Operation of a Process control Model- A Learning Aid for Undergraduate Students

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Abstract— *This paper present a PLC based learning tool for operation of a liquid processing sequence that is typical of many liquid process sequences that are found in process industry. To keep the illustration, a four-tank batch process model is used. The process consists of four tanks and five pumps. Two level switch (high and low) of a final storage tank (tank 4) control the operation of the process. Two manual switch start and stop used to control the execution of the PLC program. If the low level switch of final storage tank became on it turns on two pumps for 10 sec to fill up liquid to two tanks. After that another two pumps turn on for 10 sec and shift liquid from previous storage tanks to an intermediate storage tank. Then an agitating motor will turn on for 20 sec to agitate the liquid (for fluid mixing, reactions & settling). After this the fifth pump turn on for 15 sec to fill the final storage tank. During this period the heater H remains ON. If high level switch of the tank became on then all the pumps turned off. If tank-4 becomes empty then the whole process repeats again. All criteria for safe starting, maintaining process sequences, and protection of the system are taken into consideration in the software used for the PLC. This paper will enhance the method of teaching and learning of PLC based industrial process systems operation and control at undergraduate level.*

Keywords- PLC, industrial process sequences, industrial process automatition, Sucosoft V5.02 Moeller PLC software

1.INTRODUCTION

All industrial production system follows a fixed sequence of actions that are determined by the identified steps in the production process. A simple liquid processing sequence that is typical to many liquid process sequences that are found in the process industry will help to understand easily to the undergraduate students for learning aid. “Perhaps the greatest challenge to power engineering education is the modern role of laboratory”-IEEE PES Committee [1]. Introducing the role of Programmable Logic Controller (PLC) in the laboratory may contribute to meet one of the challenges. The wide applications of PLC in many areas have significantly contributed to the operation and automatic control of electrical and electronic systems [4-6]. There is a need however for better understanding of the impact of PLC on operation, protection, and control of industrial process systems and its components. Understanding on the interfacing of PLC with real system, development of appropriate software and finding solution to problems in such activities is essential to the young engineers who choose their carrier in the process industries, chemical industries, or power system field. This understanding from the undergraduate program will provide them with the necessary principles to face real-time problems.

This paper introduces an interesting educational procedure to teach PLC-based project in the undergraduate curriculum. The teaching procedure not only covers the theory of PLC, but also covers the modeling of operational features process sequences as development of necessary hardware and software in the laboratory. Certainly, the understanding of PLC and its applications from the academic point-of-view will equip the students with necessary principles to handle real-life problems. The experimental set up will also enable students to work on more difficult problems and become an innovative tool in the learning process.

2.PLC MODULE SET UP

A PLC is a 'digital operating system' designed specially for use in an industrial environment, which uses a programmable memory for its internal operation of user-orientated instructions and for implementing specific function such as logic, sequencing, timing, counting and arithmetic. PLC controls digital and analog inputs and outputs in the various types of machines.

PLC was first designed by General Motor Corporation in 1968 to eliminate the costly and bulky assembly line relay logic circuit. Presently more then 50 companies are manufacturing PLCs all over the world. A PLC is essentially a computer adapted to the needs of industry. Its inputs and outputs are not designed for humans, but for use in the control of machines. Machine and operator interact solely by way of limit switches, momentary-contact switches, or photoelectric switches.

The GUNT Moeller PLC model IA 130 can be used to perform basic exercises on a PLC. The front panel is designed as a laboratory patch board, where the input ports and output ports of the PLC can be connected to switches and displays via laboratory cables. In order to write programs the PLC must be connected to a PC (not supplied) via an RS232 interface shown in Figure 1 [2].

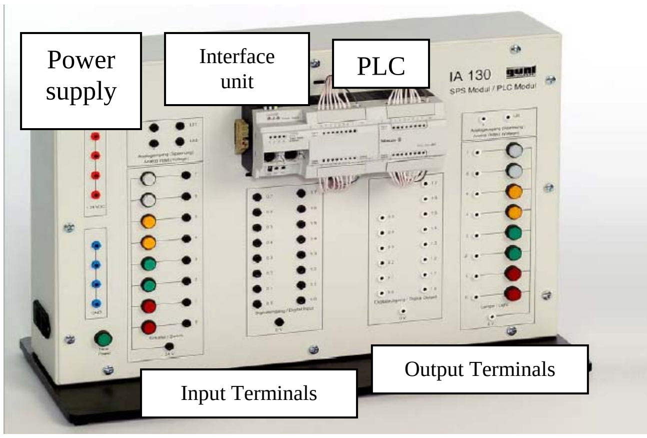


Figure1: PLC experimental set up

Figure 2 shows the block diagram of the complete set up of the PLC. The sensor and load modules in the block diagram are marked as input and output modules respectively in the photograph. The complete set up has the following facilities.

1. Programmable Logic Controller (PLC)
2. Interface Unit
3. Power supply for PLC input & output module
4. Power supply for Lamps supply (24V DC)
5. 24V DC Relay
6. Two contact relay base
7. Push button switch
8. 24V DC Flashing lamps
9. Cables
10. A Personal Computer (PC)
11. Sucosoft V5.02 programming software

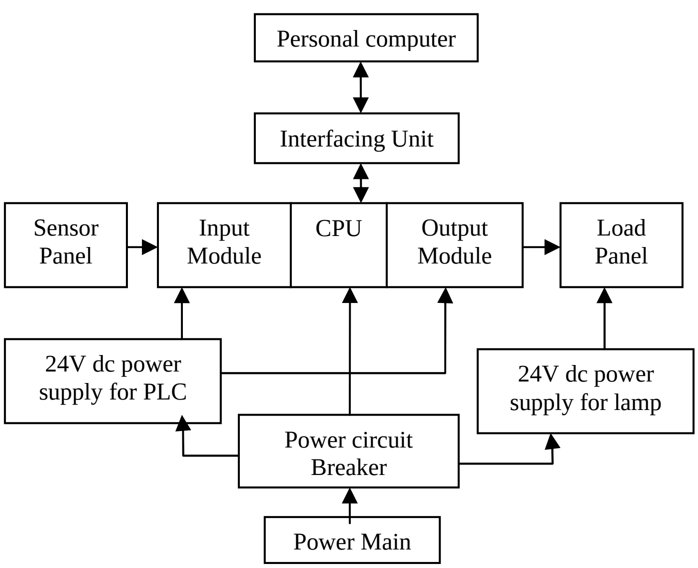


Figure 2. Block diagram of the PLC together with interfacing components

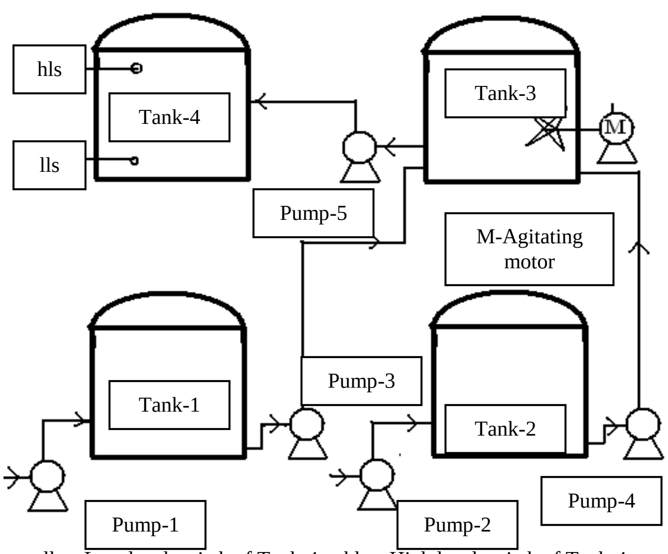
The PLC programming software conforms to the international standard IEC 61131-3, and permits programming in the following languages: Statement List (STL), Ladder Diagram (LD), Structured Text (ST) and Function Block Diagram (FBD). Ladder Diagrams are based on graphical representations with contacts, coils and boxes, as per the circuit diagrams. Function Block Diagram language is based on graphical representation of the interlinking of logical function blocks, analogous to the logic diagrams. Statement List is an assembler-type language with a small, standardised non-hardware-dependent command set [2].

3.PROCESS LOGIC DESIGN & PROGRAMMING

3.1Process Model Development

The process module has been explained in Figure 3, different input and output points of the process which is interfaced with the PLC module. The above mention process sequences are categorized as follows.

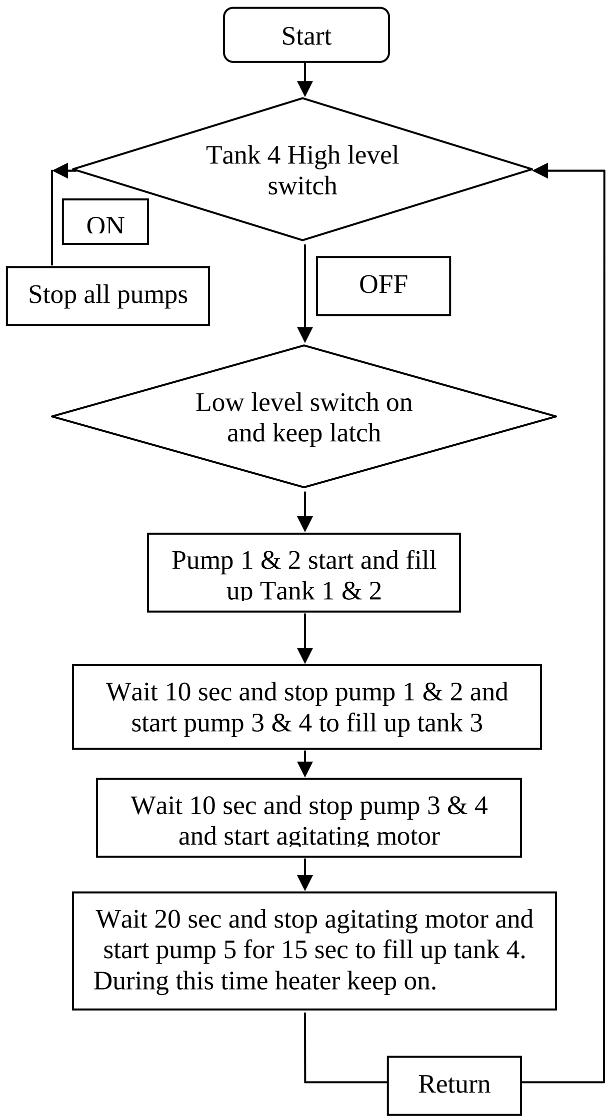
1. Start and stop switch is used to control the program execution.
2. If tank-4 empty then the level switch actuate and at this time Pump 1 and Pump 2 becomes ON to fill up tank-1 and tank-2 respectively for 10 seconds.
3. Then, Pump 1 and Pump 2 go to OFF and Pump 3 and Pump 4 go to ON for 10 seconds to fill up tank-3.
4. After this the agitator motor becomes ON for 20 seconds to agitate the liquid.
5. After this the Pump 5 becomes ON for 15 seconds fill up the tank-4.
6. During this period the heater H remains ON.
7. If tank-4 becomes empty then the whole process repeats again.
8. If high level switch of tank-4 become on, all pumps turned off.



lls – Low level switch of Tank-4, hls – High level switch of Tank-4,

Figure 3 . The process model schematic diagram

3.2 Process Flow Diagram

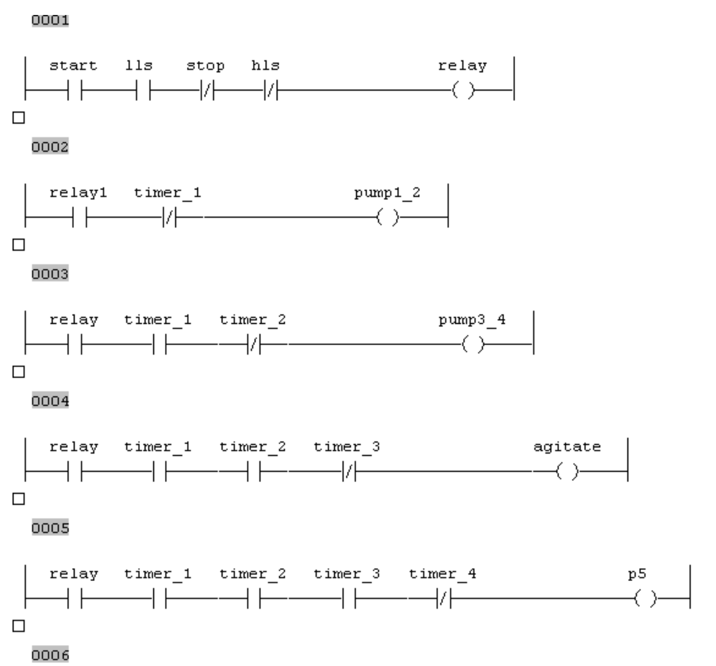


3.3 Program Developmet

Automation software of PLC is programmed in **Sucosoft V5.02 programming software** and this software is the simulation software of the **Moeller** PLC. The Ladder Diagram (LD) PLC programming language used easy to understand. Ladder Diagrams are based on graphical representations with contacts, coils and boxes, as per the circuit diagrams. Indicator lights are used as outputs where as push button switches are used as inputs.

	Name	Type	Initial	Address
1	start	BOOL		%I0.0.0.0.0
2	stop	BOOL		%I0.0.0.0.1
3	timer_1	BOOL		%I0.0.0.0.2
4	timer_2	BOOL		%I0.0.0.0.3
5	timer_3	BOOL		%I0.0.0.0.4
6	timer_4	BOOL		%I0.0.0.0.5
7	lls	BOOL		%I0.0.0.0.6
8	hls	BOOL		%I0.0.0.0.7
9	relay1	BOOL		%I0.0.0.1.0
10	pump1_2	BOOL		%Q0.0.0.0.0
11	pump3_4	BOOL		%Q0.0.0.0.1
12	agitate	BOOL		%Q0.0.0.0.2
13	timer1	S_TimeRising		
14	uitime1	UINT	10	
15	timer2	S_TimeRising		
16	uitime2	UINT	20	
17	timer3	S_TimeRising		
18	uitime3	UINT	40	
19	timer4	S_TimeRising		
20	uitime4	UINT	55	
21	timer1out	BOOL		%Q0.0.0.0.3
22	timer2out	BOOL		%Q0.0.0.0.4
23	timer3out	BOOL		%Q0.0.0.0.5
24	timer4out	BOOL		%Q0.0.0.1.0
25	relay	BOOL		%Q0.0.0.1.1
26	p5	BOOL		%Q0.0.0.1.2
27	heater	BOOL		%Q0.0.0.1.3

Figure 4. The process variable declearation for PLC system



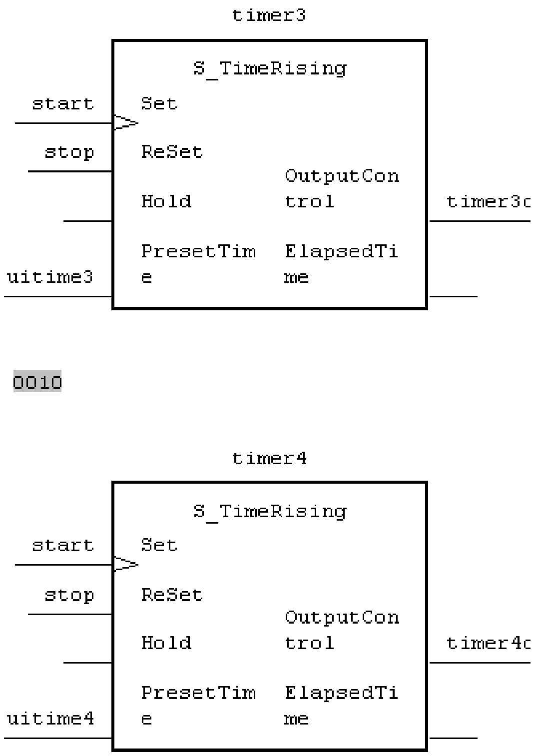


Figure 4. Ladder logic program developmet for the process system

3.4 Program Execution

The ladder logic program execution by Sucosoft V5.02, Moeller PLC software requires the following steps [3]-

1. Program development in pou editor
2. Topology configaration
3. Program code generation
4. Program transfer from computer to PLC
5. Test and commissioning

After following the above mentioned steps then the PLC become ready to run the program. PLC executes the program successfully after pressing the start switch. PLC always scan its input address and give an output signal according the instruction of the program. A stop switch is used to stop the program execution. If the process sequences may need changed or modification only change in the program will sufficient for successful program execution.

4.CONCLUSION

This paper introduces an interesting educational procedure to teach PLC-based experiment in the undergraduate power curriculum. The simulated system is described in detail and instruction goals that can be accomplished are also presented. The teaching procedure not only covers the theory of PLC, but also covers the modeling of a process system, development of software for safe starting and protection of the process. Certainly, the understanding of PLC and its application from academic point-of-view will equip the students with necessary principles to handle real-life problems. The experimental set up will also enable the students to work on more difficult problems and become an innovative tool in the learning process.

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