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PLC based Multi-Floor Elevator Control System

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ABSTRACT

This paper presents programmable logic controller based elevator control system. Primary focus is on using programmable logic controller to build the elevator model. To control the motion of the elevator through various levels DC geared motor is used. Push buttons are used to give signal to the elevator to come to the desired floor, traversing up and down. Moreover DC relays are used as switches, not protective devices, to drive the motor in clockwise and anticlockwise direction. Ladder logic is used for the model implementation.

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1. INTRODUCTION

Due to rapid population growth in cities and presence of multi-storied buildings, the need of elevators is increasing. With better standard of living, the installation of elevators has become an integral part of the modern world scenario, for the movement of goods and people. Control systems, which provide smooth and safe operation of elevator are in demand.[1]

A Programmable Logic Controller (PLC) is a special digital computer used for automation of industrial processes. PLC is used in many industries such as food processing, robots manufacturing and control, conveyor systems and so on. Programs are typically stored in non-volatile memory to control machine operations. A PLC is an example of a real time system, since output must be produced in response to input conditions within a bounded time, otherwise unintended operation will take place.

Fig. 1 shows the block diagram representing different parts of a PLC [2]. CPU reads the input data from various input devices via input processing circuit, executes stored user programs from memory, and sends appropriate output commands to output devices via output processing circuit. The programming device is used to enter the desired program into the memory of the PLC via communication cable and ports.

PLC has many advantages over other control systems like microcontroller. In microcontrollers, separate timers, counters have to be provided as hardware, whereas, in PLC, these devices are inbuilt. This results in smaller size and less complexity. It saves material cost, installation cost and labour cost. It also provides reliability, flexibility, speed and diagnostics.

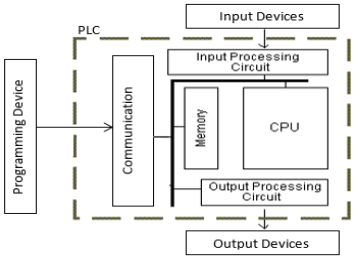

Figure 1. Block diagram with different parts of PLC

2. DESIGN AND CONSTRUCTION OF SOFTWARE AND HARDWARE MODEL

The project includes the design of the ladder diagram on a software installed on the computer. It is downloaded to the PLC, and connected via communication interface. It also includes the interfacing of various hardware devices which are discussed in the sections below.

2.1 Software Model

This section discusses about the development of ladder logic diagram. The relevant PLC has been incorporated based on the requirements of the logic. Here RS Logix 500 has been incorporated to develop and download ladder logic to the PLC.

The program is divided into two parts, upward traversal of the elevator and downward traversal of the elevator. Each part is divided into three cases, one floor traversal, two floor traversal and three floor traversal. A counter is used to indicate the floor on which the elevator is currently present.
Table 1 shows the input address and counter value corresponding to floor number.

Table 1

Floor number	Input Address	Counter value
1	I:1/0	0
2	I:1/1	1
3	I:1/2	2
4	I:1/3	3

The ladder diagram includes the equality block, which will work only when the accumulator value of the counter, here represented as C5:0.ACC, equals the user defined integer value.
Six timers have been used, three in upward motion and three in downward motion of elevator. The Timer Timing bit (TT bit) is used to run the motor. Output address O:0/0 and O:0/1 are used for the upward and downward motion of motor respectively.

2.1.1. Upward Motion

Fig.2, fig.3 and fig.4 describe the logic that has been developed for one floor, two floor and three floor traversal respectively, and table 2 represents the operation of the elevator for upward motion.3

Table 2. Operation of the elevator for upward motion

Initial floor no.	Counter initial value	Input Pressed	Working Equality Block	Bit Latched	Working Timer	Working output address	Counter final value	Operation (floor traversed)	Final floor no.
1	0	I:1/0	None	None	None	None	0	None	1
		I:1/1	1st to 2nd	B3:0/0	T4:0	O:0/0	1	One	2
		I:1/2	1st to 3rd	B3:0/1	T4:2	O:0/0	2	Two	3
		I:1/3	1st to 4th	B3:0/2	T4:3	O:0/0	3	Three	4
2	1	I:1/1	None	None	None	None	1	None	2
		I:1/2	2nd to 3rd	B3:0/0	T4:0	O:0/0	2	One	3
		I:1/3	2nd to 4th	B3:0/1	T4:2	O:0/0	3	Two	4
3	2	I:1/2	None	None	None	None	2	None	3

	I:1/3	3rd to 4th	B3:0/0	T4:0	O:0/0	3	One	4

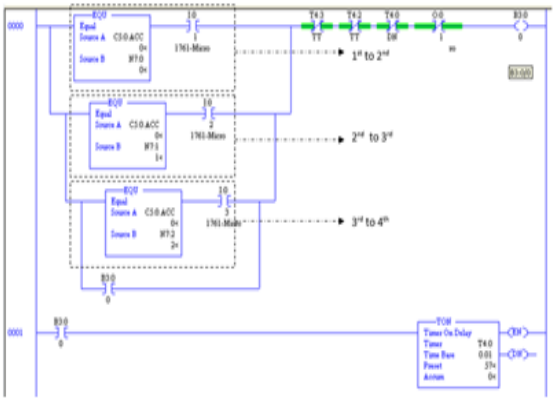

Figure 2. One floor traversal

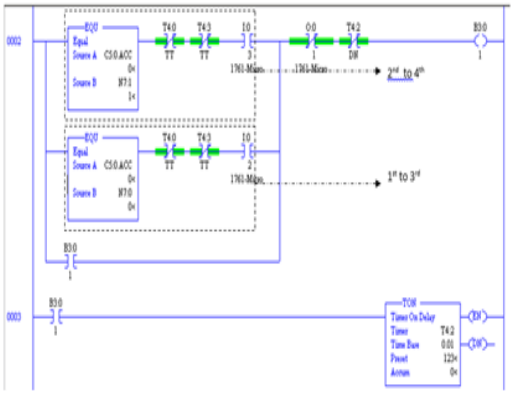

Figure 3. Two floor traversal

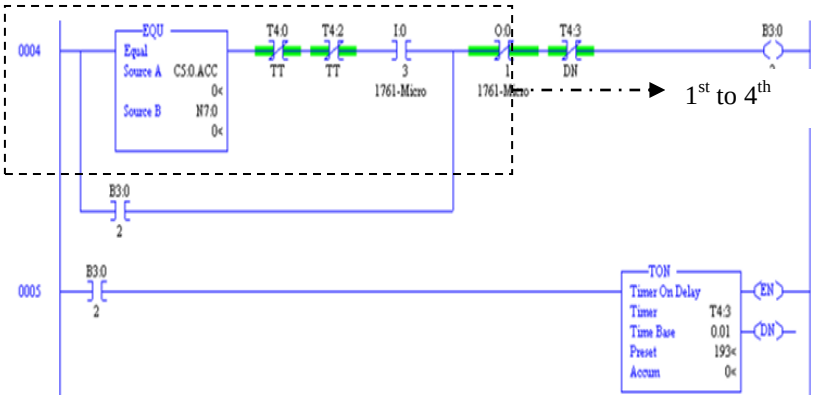

Figure 4. Three floor traversal

The normally close (NC) of the timers' bits are used so that not more than one timer runs at the same time by pressing two or more inputs simultaneously.

2.1.2. Downward Motion

The logic for the downward motion has been developed in a similar fashion as upward motion. The working output address here is O:0/1.

2.2. Hardware Model

The different devices used for the development of this model consist of Allen Bradley PLC, DC geared motor, switched mode power supply (SMPS), dc relay, push buttons and connecting wires. The details of each of the elements mentioned above are given below:

2.2.1.Allen Bradley Micrologix 1000

The project includes the 16-point digital I/O (10 inputs and 6 outputs) PLC version. It provides a compact size of 120 mm x 80 mm x 40 mm and offers fast processing with typical throughput time of 1.5 ms for a 500-instruction program. It also includes built-in EEPROM memory and thus, there is no need for battery back-up or separate memory module. It supports simple connectivity through RS-232 communication channel to a PC for program upload, download and monitoring. Fig.5 shows the pin diagram of the PLC.[3]

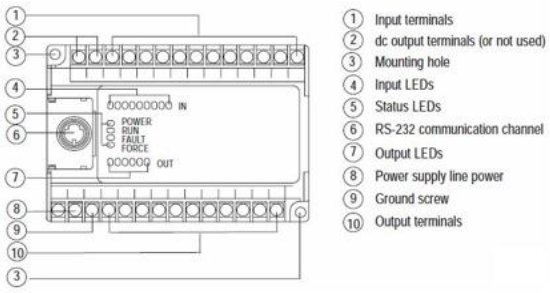

Figure 5. Pin diagram of PLC micrologix 1000

2.2.2. DC Relay

A relay is an electrically operated switch. A relay can also be used as a protective device, which triggers the circuit breaker when current exceeds the pickup value, but in this case, we have considered its operation as a switch. Many relays use an electromagnet to mechanically operate a switch, but, solid-state relays are also used, i.e. relays incorporating solid state devices like thyristors, diodes, transistors, for faster switching time and efficient operation, with improved controllability by application of gate pulses or by changing the firing angle of the thyristors. Relays are used where it is necessary to control a circuit by a low-power signal, 2 relays of contact capacity: AC: 10A 250V, DC: 10A 28V are used in this project. Fig.6 shows the image of the relay. This relay consists of an operating coil, connected between 2 and 7 terminals, which is energized by 24v dc supply. When the coil is energized , due to electromagnetic induction, the contacts, initially at 4 and 5 terminals, are attracted to 3 and 6 terminals and if the motor is connected across the these two terminals. If the supply is connected to 1 and 8 terminals, then the motor will start running.

Figure 6. Relay

2.2.3. Switched Mode Power Supply

A switched-mode power supply (SMPS) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. It converts ac to dc, by means of a rectifier, dc is converted back to ac and sent to a high frequency transformer, which provides isolation (galvanic isolation: isolation by sectioning). This ac is converted back to dc by another rectifier. A feedback control is also present, which compares the actual output and the desired output, and according to the error signal generated, the feedback implemented is positive or negative. Table 3 shows the specification and fig. 7 shows the picture of SMPS used in the project. The advantages of SMPS are:

- Greater efficiency
- Smaller size
- Lighter weight
- Lower heat generation due to higher efficiency.

Table 3: SMPS Specifications

Description	Specification
Output Power	1-50 Watts
Output Voltage	24 Volts
Output Current	2 Ampere
Input Voltage	100-240 Volts

Figure 7. SMPS

2.2.4. DC Geared Motor

A geared DC Motor works on the principle of conservation of angular momentum. The larger the diameter of the gear, lesser will be the speed, and more will be the torque. The smaller the diameter of the gear, more will be the speed, and lesser will be the torque. Gear ratio is given by the ratio of the output teeth of the gear to the input teeth of the gear. A geared motor does not move until and unless the gear is changed. Table 4 and fig. 8 shows the specification and picture of motor used in the project.

The advantages of using this motor are that it immediately stalls as the supply is removed and its shaft does not move without connecting it to supply.

Table 4. Motor Specifications

Description	Specification
Rated Voltage	24 Volts
No load Current	15 milliampere
Operating Speed	50 RPM

Figure 8. DC Geared Motor

2.2.5. Push Buttons

The project includes 4 push buttons, all normally open (NO) type. Fig.9(a) shows the photographic view of push button. NO push buttons don't make electrical contact with the circuit when not pressed down (Fig.9(b)). Once pressed down, NO push buttons now make contact (Fig.9(c)) and the circuit is now closed and powers or turns on the respective part the button was made for.

Figure 9 (a). Push Button

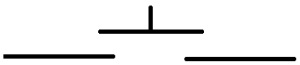

Figure 9(b).

Figure 9(c).

2. INTERFACING PLC WITH ELEVATOR

Fig.10 shows the block diagram of interfacing of different devices discussed above, after downloading the ladder diagram into PLC from PC via RS232 communication cable.

When an AC supply of 220V is given to SMPS, it converts the same to 24V DC. AC voltage is used to turn on the PLC while 24V dc given to PLC is coupled with output terminal O0 and O1. The output O0 and O1 are used for clockwise and anti-clockwise rotation of the motor. Four push buttons are the inputs to the PLC. The output terminals O0 and O1 are connected to motor in such a way that if O0 is turned on then relay-1 will drive the motor in clockwise direction and if O1 is turned on then relay-2 will drive the motor in anti-clockwise direction. Here, clockwise direction of rotation and anti-clockwise rotation of motor are considered as upward and downward motion of the elevator.

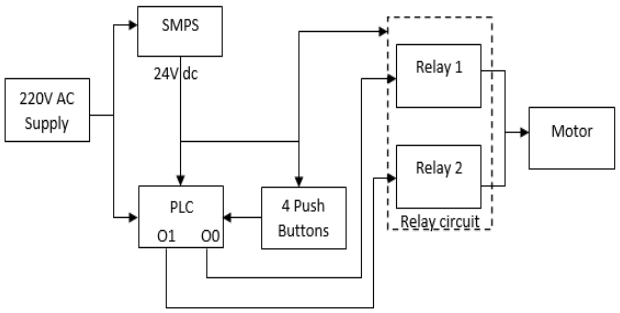

Figure 10. Interfacing PLC with Elevator

3. RESULTS

After interfacing the PLC with the elevator, followed by thorough checking of errors, the trials of the setup were done and the setup under consideration successfully worked. Fig.11 shows the flow chart of whole operation of PLC based elevator.

The operation started with turning on of the supply. When the push button for the desired floor was pressed and the elevator was on the same floor, the motor did not run. When the elevator was below the desired floor, the motor ran in clockwise direction. Thus, the elevator moved in the upward direction. When it was above the desired floor, the motor ran in anti-clockwise direction. Thus, elevator moved in the downward direction.

Similarly, when push button was pressed again, then the motor ran either in the forward or reverse direction according to its position, till the elevator reached its required position and subsequently, it worked successfully for all possible combinations.

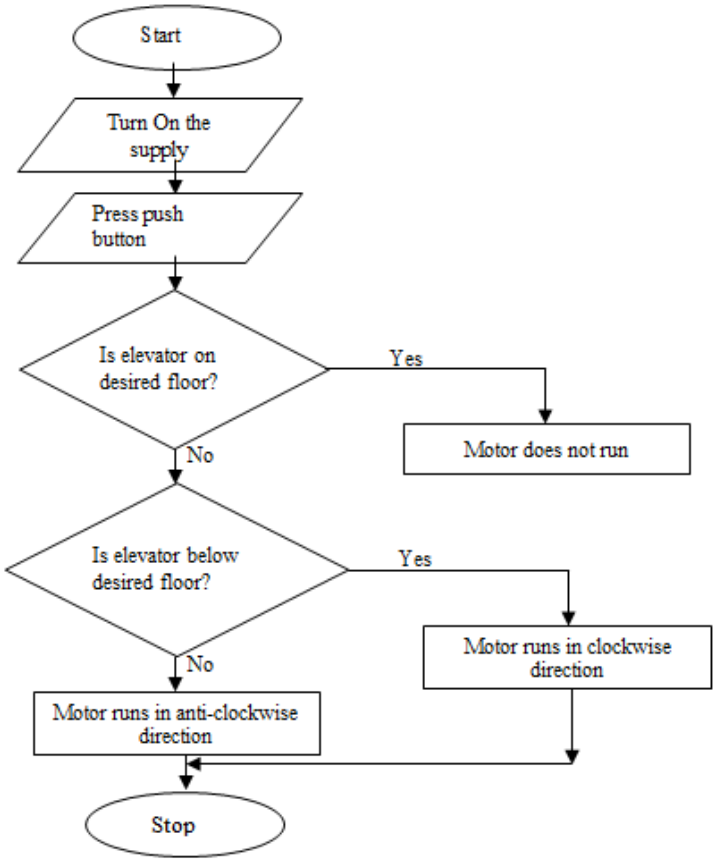

Figure 11. Flow chart of whole operation of PLC based elevator

4. CONCLUSION

Thus, this paper describes the design and development of PLC based elevator. The ladder logic has been implemented by using RS Logix 500 and the PLC Allen Bradley micrologix 1000 has been interfaced with the elevator using RS-232 cable. It can be concluded that

- PLCs can be used for designing of the control system for the elevator.
- The traditionally used relays and IC boards can be replaced by PLC for easy and cheap control of elevators.
- The desired position of the elevator can be forecasted by using PLC based control system.
- By using PLC based elevator control system, the size of the overall infrastructure can be reduced, which includes material cost, installation cost and labour cost.

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