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Simulation and Modelling of 3-Floor Elevator System using PLC

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Abstract - *Elevators are a common vertical mode of transport in buildings, warehouses, construction sites, etc. The elevator's design and mechanics undergo continuous modification to make it more efficient and inexpensive for daily use. The design of the elevator based on the Programmable Logic Controller is one such innovation (PLC). Despite the fact that contemporary elevators are not exclusively controlled by PLC, this field has great potential to become the future of the elevator industry. PLC is a solid-state device whose response is dependent on the user-defined program's input. PLC-based elevators have improved the current elevator systems by eliminating the need for a machine room. Due to its compact system and programmable PLC, elevators can be utilized in a number of different fields. The primary objective of this research was to demonstrate the modeling of elevator motion using PLC ladder logics.*

Key Words: **Elevator Control, Function Block Diagram, Ladder Logic, PLC, TIA Portal.**

1. INTRODUCTION

All-solid-state PLCs respond to user input in response to instructions. Industrial Microcontrollers have hardware and software tailored to industrial needs. They supply data-analyzers for automated production and service lines. Systems controlled by microprocessors and PLCs can be found in elevators. Programming is usually done on a personal computer in ladder logic. Reprogramming PLC controllers is often done on a computer, but it can also be done manually with programmes. The aim is to control the elevator using PLC. It's easy to use and PLC-upgradable. Conventional elevators require a lot of space and a maintenance room. Building shorter or smaller elevators is difficult. PLC-based elevators are easier to maintain, cheaper, and can be upgraded as needed. Following the execution of the user programme that has been saved in application memory, the PLC will either activate or deactivate field output devices depending on the control scheme that has been loaded into the PLC.

1.1 Principle

The user's control scheme is interpreted by the PLC, which then activates or deactivates field output devices, reads all field input devices through input interfaces, and executes the user programme stored in application memory. Mechanical and maintenance space is needed for conventional elevators. Shorter/smaller buildings can't install elevators. Easy-to-maintain, cost-effective, and upgradeable PLC elevators. Despite improvements, elevators are hard to install and maintain. PLC-based elevator systems reduce elevator size, making them easier to maintain, reprogram, and access.

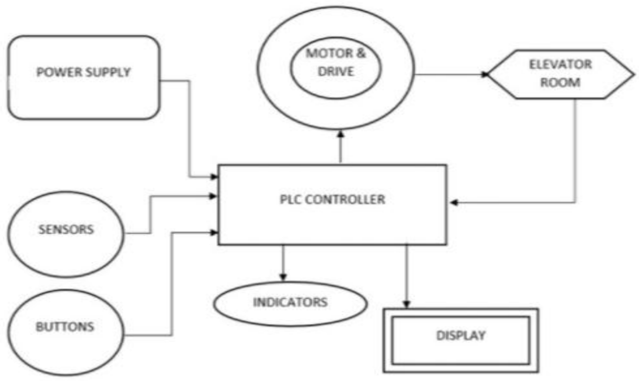

Fig. 1 Block Diagram of PLC Elevator Control

1.2 Pros and Cons

The use of a PLC system comes with a number of benefits, including its compact size, the ability to be reprogrammed and customized, and the simplicity with which the application can be replicated and documented. PLC manufacturers only offer a closed-loop architecture, which is one of the system's disadvantages, as well as the fact that it runs on a predetermined circuit.

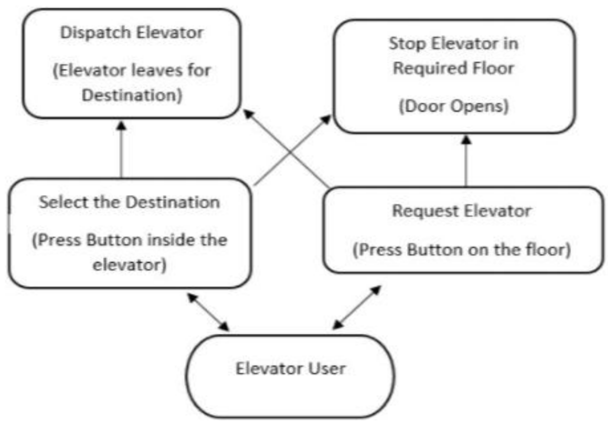

Fig. 2 Understanding the Flow

1.3 Terminologies

PLC language uses some unique terms that are different from terms that are used daily. In order to understand the working of the ladder logic there is a need to understand some of the terms that are mentioned below:

1. Central Processing Unit (CPU) - It is the PLC controller's brain. It is one of the microcontrollers and is responsible for communication and interconnection with other sections of the PLC controller, as well as program execution, memory operation, input monitoring, and output setup.

2. Memory - PLC has two types of memories used namely

   a. Read Only Memory (ROM) - The memory location which stores the symbols and other information necessary while the execution of the program.

   b. Random Access Memory (RAM) - The memory location that stores the calling functions based on the ladder logics.

3. Power Supply - The power necessary for the PLC to perform all the functions that are necessary was provided through an AC source. A 240V SMPS is used in the simulation.

4. I/O module: The I/O module is a Rack that provides all the Necessary information to both the PLC and the user. It provides the address of all the inputs and outputs.

5. Programming Devices:

   a. Ladder Logic Diagram (LAD) - It is a step diagram of the Logics that is proposed for the working of the elevator. It uses Symbols and components of the element in a line diagram that shows the hard wire control.

   b. Statement List (STL) - It is another view of the instructions provided to the PLC in the form of text. The operation is shown to the left and the operand is shown to the right.

   c. Function Block Diagram (FBD) - It is a set of instructions in the form of a block diagram. The functions are indicated by a rectangle and have a specific task.

6. Interfacing Devices

The interfacing Devices available for the PLC are given below:

   a. Profibus

   Point to Point Interface – USB

   Multipoint Interface - USB

   b. Profinet

   Ethernet - The Interfacing Devices used are TCP/IP which is a collection protocol used for communication. It consists of 3 components: IP, TCP and UDP.

S7 Program(1) (Symbols) -- Lift\SIMATIC 300(1)\CPU 315-2 PN/DP

	Statu	Symbol	Address	Data type	Comment
1		1_sensor	I 2.3	BOOL	
2		2_sensor	I 2.4	BOOL	
3		3_sensor	I 2.5	BOOL	
4		4_sensor	I 2.6	BOOL	
5		Close_Button	I 5.7	BOOL	
6		Delay_reset_4	DB 8	DB 8	
7		Door_Close	M 20.1	BOOL	
8		Door_Close_Time	DB 5	DB 5	
9		Door_Closed	M 20.0	BOOL	
1		Door_Motor	Q 7.0	BOOL	
1		Door_Open_Time	DB 2	DB 2	
1		Door_Opened_F1	M 3.6	BOOL	
1		Door_Opened_F2	M 3.3	BOOL	
1		Door_Opened_F3	M 3.4	BOOL	
1		Door_Opened_F4	M 3.5	BOOL	Door Open from Floor 4
1		Door_Reopened	M 20.3	BOOL	
1		Down_mem	M 3.2	BOOL	
1		F1_Visit	M 0.5	BOOL	
1		F2_Visit	M 0.6	BOOL	
2		F3_Visit	M 0.7	BOOL	
2		F4_Visit	M 1.0	BOOL	
2		FC_F4	I 5.0	BOOL	Floor Call from Floor 4
2		Lift Ladder	OB 1	OB 1	
2		Lift_Call_F4	I 4.3	BOOL	Lift call from Floor 4
2		lift_logic	FC 1	FC 1	
2		Motor_Down	Q 7.2	BOOL	
2		Motor_Up	Q 7.1	BOOL	
2		Obstacle	I 2.1	BOOL	
2		Open_Button	I 5.5	BOOL	
3		Overload	I 2.2	BOOL	
3		Reset_Close Button	DB 9	DB 9	
3		Reset_OpenTime	DB 6	DB 6	
3		Step_Count	MW 10	WORD	
3		Up_mem	M 3.1	BOOL	
3					

Fig. 3 Symbol Table

2. METHODOLOGY

After careful investigation, some characteristics including motor ratings and automobile weight were calculated. PLC CPU requirements were dependent on DC Motor and rope strength. Some knowledge on software compatibility and usability were required since it is simulation-based. For a rudimentary implementation, the use of switches and logic like AND, NAND, OR, and XOR with NC and NO LAD switches. The inputs observed are 6 signals namely Car Location, Floor Buttons, Car Buttons, Car Movement (Direction), Door Status, and Signal Triggers. This signal is represented by the HMI Toolbox Button. With these factors in mind, the ladder logics were created and simulated.

2.1 Sequence of Operation

The PLC continuously carries out 3-4 basic steps namely Error Check, Input scan, Logic scan, Output scan. Before running the program, the software checks for any presence of any error. Input Scan is known as the inputs provided by the user are scanned by the plc and stored in the memory. Logic scan is the CPU of the PLC is the controller of the logic. It reads inputs, executes the programme step-by-step, and updates output. Output scan is the logic scan's final presentation from memory.

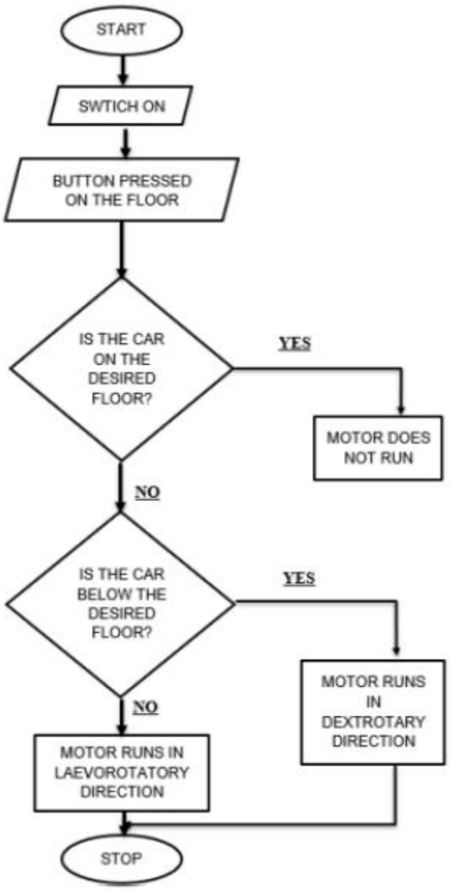

Fig. 4 Flowchart of the Process

2.2 Components

1. Power Supply
2. PLC S-Series 315
3. Simulation Software:
    a. Siemens PLCSIM
    b. Siemens Simatic Manager
    c. Siemens TIA portal
    d. Siemens WinCC Viewer
    e. Siemens Step 7
4. Ladder Logic Circuits
5. Display Module
6. Switches, Sensors and Elevator Car

2.3 Calculations

Calculations helped choose simulation components for the hardware implementation. In order to reduce the elevator's cost, the most versatile and reliable parts were needed.

Car Specification:

Weight of the cabin = 100 kg

Counter weight = 100 kg

Limit of 10 people each weighing 65 kg = 650kg

Rope strength:

F= mg ; F= (650+100+100) *9.8 = 8330N = 8.33 KN Motor Specification:

Power:

P= *Force*Velocity*; P= (650*9.8) N*1m/s = 6370W

Since, 1hp = 745 W, 6370 W=8.55hp ; 9hp = 6705W

Torque:

T = $P/2\pi\omega$ = 6705/2π (1500) = 31.5 Nm

2.4 Design of System

Ladder logic allows us to control door openings, travel direction, and time. Call buttons will move the car. Elevator motion affects the amount of power and time used. Motive is finding an efficient design and logic.

STEP 7 can be used to programme SIMATIC S7-1500 and S7-300 Controllers and configure SIMATIC HMI Basic Panels. This functionality allows STEP 7 to do both. TIA Portal gives you unrestricted access to digitized automation services, from planning to engineering to operation. Siemens' SIMATIC WinCC is a simulation software for SCADA and HMI systems. STEP 7 can be used to programme SIMATIC S7-1500 and S7-300 Controllers and configure SIMATIC HMI Basic Panels.

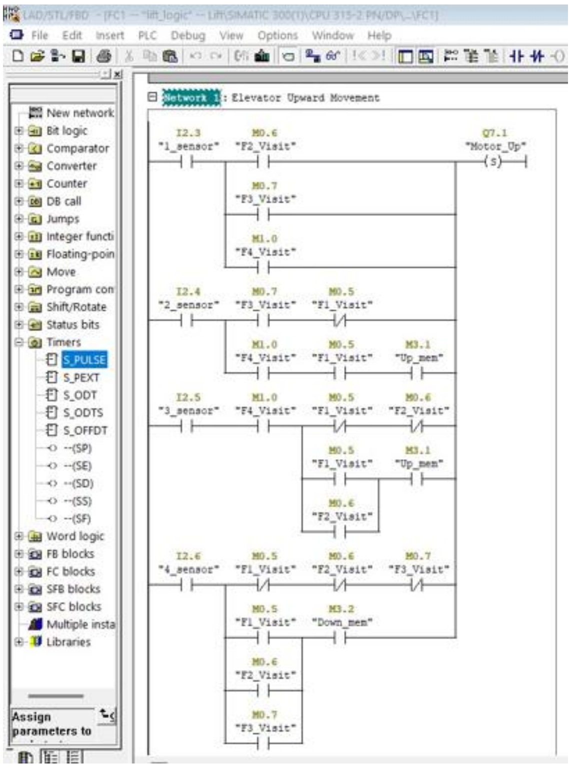

Fig. 5 Upward Movement Logic

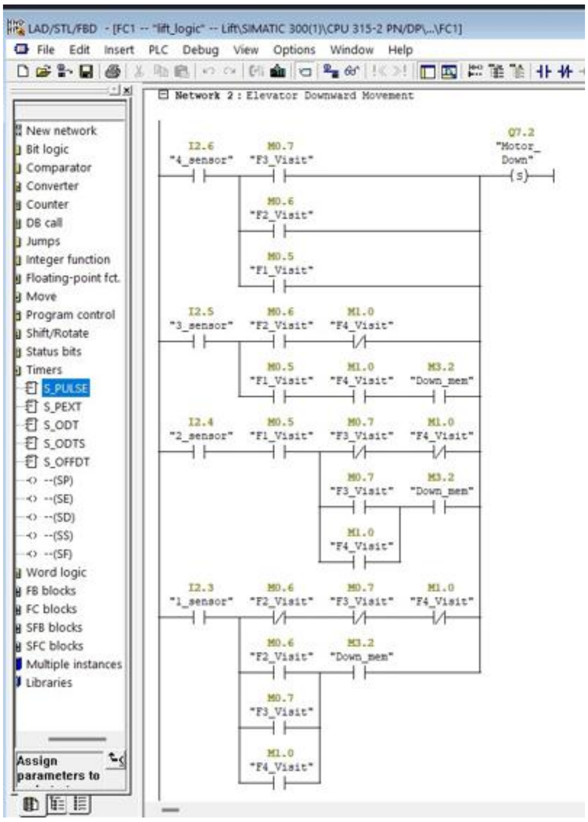

Fig. 6 Downward Movement Logic

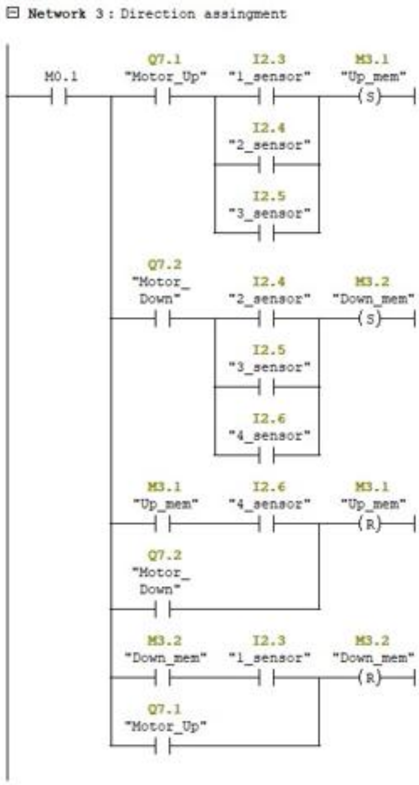

Fig. 7 Direction Assignment Logic

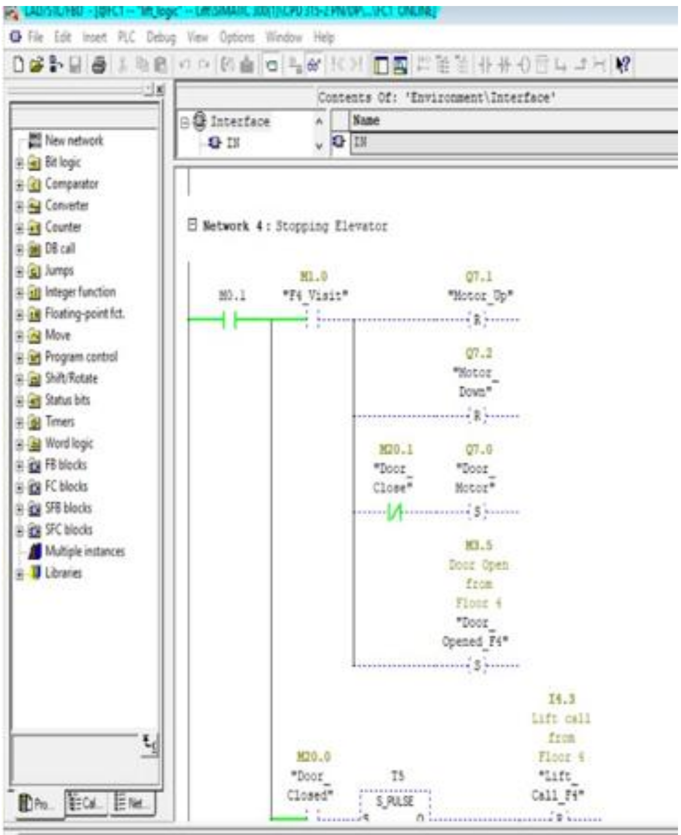

Fig. 8 Stopping Elevator Logic

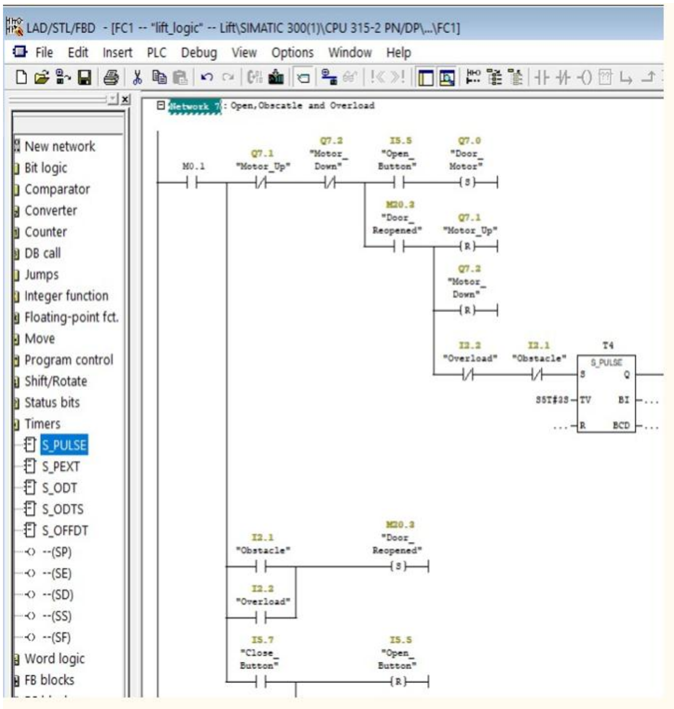

Fig. 9 Open, Obstacle and Overload Logic

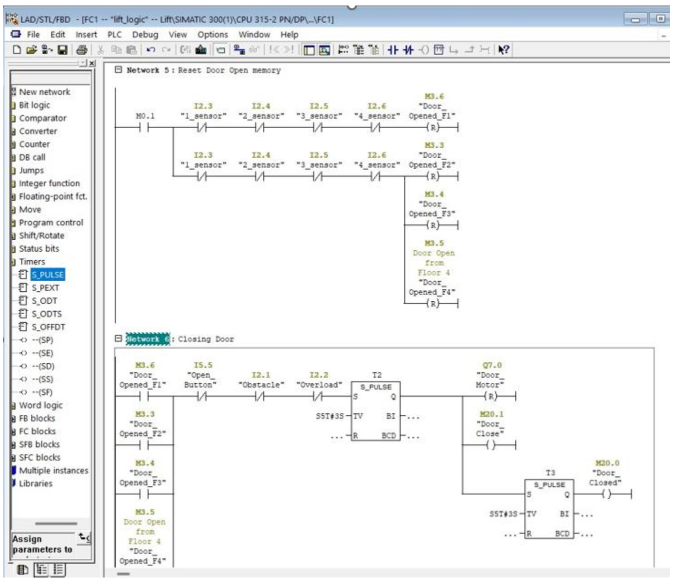

Fig. 10 Reset Open Door and Closing Door Logic

2.5 Working of the Simulation

The first floor marks the beginning of the operation for the car. It makes no difference to the programme if the elevator is located on a different floor. The car is started by push buttons. It moves in an order that maximises the amount of power saved, so if the car is moving in one direction and another call comes in, it will respond to all of the calls in the first direction before it responds to any calls in the second direction. When the call signal and the floor sensor are a match, the elevator will hang up the phone. When the signal from the level sensor on the second floor is high, a floor call is placed. Every call signal on the second floor has been turned back to 0 now. After having been opened for a predetermined amount of time, the door is then closed in preparation for moving to the next level. When the door is shut, the car is able to move forward once more. If the door is closing, pressing the Open button will reopen it, and if it is already open, it will reset the amount of time it has been open. When the passenger door is shut, the vehicle remains stationary until it receives a signal from the Open button. In the event that there is a barrier or that the elevator is too full, the door will either remain open or reopen. An HMI screen will display all of the operations when you are simulating. The operation is the same in its entirety, with the exception of a PLC and switches (Buttons). When modelling, researchers need to take into account a variety of factors that have the potential to affect elevator motion and put customers in harm's way. In order to determine whether or not the elevator is moving, fluctuating elevator speed, and steady elevator slowing, the creation of the model ought to centre on environmental analysis.

3. RESULT AND DISCUSSION

Following the completion of the error checking and the interfacing of the PLC with the elevator, the trials of the setup were carried out, and it was found that the setup functioned correctly. The operation begins with pressing the button for the desired flow, and if the elevator is already on that floor, the motor will start running according to it; for example, if the elevator is located below the desired floor, it will rotate in a clockwise direction, but if it is located above the desired floor, it will rotate in a counter clockwise direction. There is a significant amount of room for advancement in this simulation, for instance. incorporating a weight sensor into the lift in order to establish a maximum permissible load for the lift to carry. Also, adding weight sensors to each floor so that you can keep track of which floor has the most people on it, or employing a weight counterbalancing technique, should be done in order to make it operationally feasible and for additional safety measures like sounding the alarm when the weight of the lift reaches the predetermined maximum level or when the door is unable to close due to some obstacles, respectively. When there are only a few stories in a building, this is one of the most efficient and cost-effective ways to implement an elevator. It is also possible to implement this using other Softwares, some of which have more features and are more compatible with one another that can drastically optimize the modelling in real time scenarios.

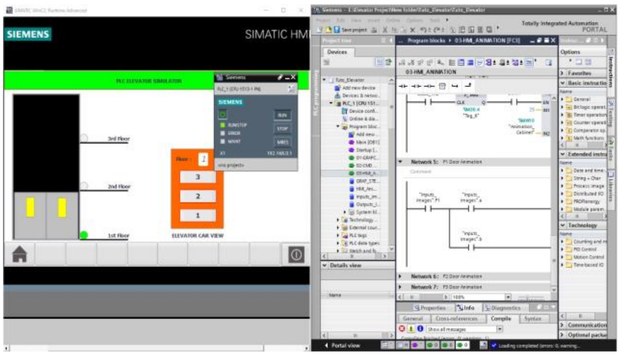

Fig. 11 Live Simulation in TIA Portal

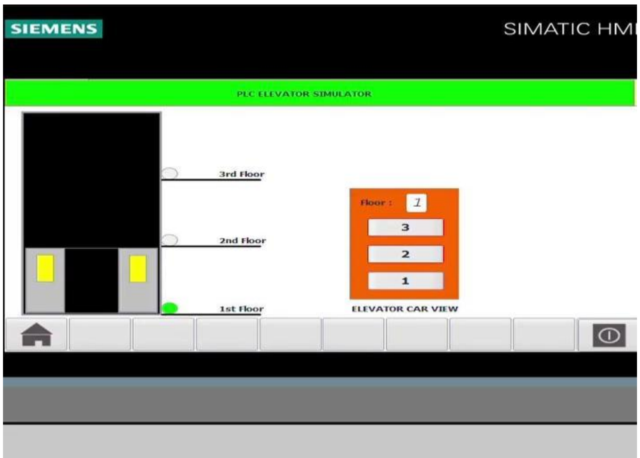

Fig. 12 Working Interface with HMI

4. CONCLUSION

Simulation ran successfully. Logic inputs and outputs for elevator forward and reverse motoring, door opening and closing motor operation, and other sensors on each floor have been added, and the programme is evaluated and simulated using Graphic Interface. Simulations of logic have been created. The smaller size of wireless solutions makes changes easier and faster. Diagnostics which are centralized and overrides are built into PLCs.

REFERENCES

[1] Gupta, Shrey. (2015). PLC based Multi-Floor Elevator Control System. IAES International Journal of Robotics and Automation (IJRA). 4. 202. 10.11591/ijra.v4i3.pp202-208.

[2] Deepthi L R, Divya Dharshini J N, et.al (2021), Design and Implementation of Three Floor Lift Using PLC. International Conference on Advances in Materials, Computing and Communication Technologies (IJSRST), Vol 9 Issue 1, April 2021, ISSN 2395-6011.

[3] Ali, Mohammed. (2018). Design and Implementation of an Electrical Lift Controlled using PLC. International Journal of Electrical and Computer Engineering. 8. 1947-1953. 10.11591/ijece.v8i4.pp1947-1953.

[4] Han, Xiaohu. (2020). Design and research of elevator control systems based on PLC. Journal of Physics: Conference Series. 1449. 012101.10.1088/1742-6596/1449/1/012101.

[5] Soe, Theint. (2019). Design of PLC based Elevator Control System. International Journal for Research in Applied Science and Engineering Technology. 7. 416-421. 10.22214/ijraset.2019.8058.

[6] Htay, Sandar and Yuyus Suryana. “Implementation of PLC Based Elevator Control System.” (2014).

[7] Abdelkarim Ahmed Eltahir Ali, Zhang Jiang Min, "Design of Five Floors Elevator with SCADA System Based on S7200 PLC", International Journal of Science and Research (IJSR), https://www.ijsr.net/get_abstract.php?paper_id=NOV162845, Volume 5 Issue 4, April 2016, 1309 - 1314.

[8] Thabet, Hassaan Th. H., Ibraheem S. Jameel, and Ismail Abduljabar Hasan. “Rehabilitation of an Old Traditional Elevator Based on PLC Techniques”. Wasit Journal of Engineering Sciences 6, no. 3 (December 10, 2018): 76â€“89. doi:10.31185/ejuow.vol6.iss3.106.

[9] Aditi Dutta, Kajal, Rasmita Gouda, “Elevator Operation Control Through PLC”, Abhiyantriki International Journal of Engineering and Technology (AIJET), Vol. 4 No. 4, April 2017.

[10] Thai Nguyen (2020). “PLC Controlling Program of an Elevator”, HAMK University of Applied Sciences.

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