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# A Survey Paper on Design & Control of an Elevator for Smart City Application

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**ABSTRACT:** This paper explains design and control of three floor elevator for smart city application. The main requirement of the multi storage buildings are elevators. Elevators ease the work human being and keep them in the comfortable zone. One can make the better use of PLC in the designing of the elevator control system. This control is based on the input that is received from the operator as well as from the sensors. Elevator control system is needed to control all the functions of the elevator. It is the one which guides the elevator car, Elevator car is one which actually carries the passengers between the different floors; it also controls the opening and closing of doors at different floor, and the safety switches are also controlled by the elevator control system. The ladder logic programming is used to simulate the proposed system. Because of use of PLC, elevator systems are getting better, faster, stronger and better quality elevators are produced. Hence more importance is given to the design of an elevator control system.

**KEYWORDS:** Elevator, sensors, PLC, floors, motor, switches.

### I. INTRODUCTION

Due to the cause of rapid population growth at the cities and multi-stored buildings, the need of elevators is being increased. With the rising life standards and attention to human and with tremendous development in structural and architectural engineering for multi storage building, the installation of elevators in these high rise buildings becomes an integral part of the infrastructure for the movement of goods and people. So, the control system is essential in the smooth and safe operation of the elevator. Hence more importance is given to the design of an elevator control system which is easy for the maintenance and to perform an efficient function.

In our project we use PLC in the designing of the elevator control system. PLC has many advantages over other control systems. It is known for its flexibility, operational speed, reliability, ease of programming, security, and it is easy in implementing changes and correcting errors. A PLC is an example of a real time system since output results must be produced in response to input condition within a given period of time, Programmable logic controller (PLC) is a digital computer used for automation of processes. It controls all the functions of the elevator such as door opening and closing at different floors etc., Because of the use of PLC, elevator systems are getting better, faster, stronger and better quality elevators are produced.

### II. LITERATURE SURVEY

In [1], author introduced the basic structure of elevator control system design and the simulation of the design using Indra-works-engineering which is a Bosch-Rexroth group PLC simulation software. The main objective of this paper is to replace the traditional relay logic elevator control system with the modern PLC based elevator control system and explained block diagram of overall PLC system and signal control system. It explains elevator control system using PLC ladder logic for interfacing of various sensors, up-down movement etc.

In [2], explained about an elevators operation which uses an AC motor to drive the elevator cabin and is fully automated using PLC. Its control is based on the input that we get from the operator as well as from the sensors. According to that



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signal PLC will make the drive motor and door motor to work correspondingly. This paper described the entire circuit diagram and development of ladder logic. The developed ladder logic has been implemented by using VersaPro 2.02.

In [3], author explained research paper an attempt has been made to integrate the programmable logic controller (PLC) with elevator for developing its control system. It is observed that the PLC based controller for elevator works better than the other control systems. It explained flow chart of whole operation of elevator control system, development of hardware and software for interfacing PLC with elevator. The programming language used is ladder diagram.

### III. WORKING OF AN ELEVATOR

An elevator is a simple device which is used to save human efforts. The elevator won't need to use much energy at all the time because it will always be getting back as much (when it goes down) as it gives out (when it goes up). Elevator consists of simple hoist with a cage passing over a pulley. It uses more energy to lift people up but it would have no way of getting that energy back. So elevator is the good example of law of energy conservation. When people are coming down there is small amount of loss in cable and brakes.

**Lift installation:** Lift installation consist of cover design, supply delivery installation, testing and commissioning of passenger lift. It also consists of rope pulley arrangement. Minor building work comprising holes and making good the car and counter weight rail brackets and some indicators.

**Foundation:** The machine shall be placed directly above the hoist way upon the machines room slab. The car shall be mounted on the frame so that vibrations and noise get minimized so that, passenger feel comfort in travelling.

**Control:** Controlling of an elevator can be done automatically or manually. In our project controlling is done automatically with the help of PLC.

**Counter Balance:** The elevator car is balanced by a heavy counterweight that weighs nearly the same amount as the car when it's loaded half-full. When the elevator goes up, the counterweight goes down and vice-versa.

- The counterweight makes it easier for the motor to raise and lower the car the motor needs to use much less force to move the car either up or down.
- If less force is involved, strain on cable is less which results in safer operation. The counterweight reduces the amount of energy that motor needs to use.

**Overload Warning:** When there is overload in the car then buzzer shall operate during this period and the door will be open till the overload is removed.

**Car Enclosures:** The car enclosure shall include lamps at ceiling; cooling fan and the lift have the sensor so that the fan is operating only when there is at least one person inside the lift. The car has plain finish for passenger.

**Car Door:** The car entrance shall be provided with acrylic material door in plain finish for giving a clear opening and transparency. Car doors protect riders from falling into the shaft. The most common configuration is to have two panels that meet in the middle, and slide open laterally.

**Emergency Stop Button:** This button is on the interior button panel of each cab. A passenger can press this button to stop the elevator no matter where it is in a shaft. The controller interacts with this button by receiving a signal from it that indicates that it was pressed, as well as the cab that it came from.

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## IV. BLOCK DIAGRAM

Block diagram for PLC based elevator control system is as shown in figure. PLC controller is main element in this system which controls elevator functions.

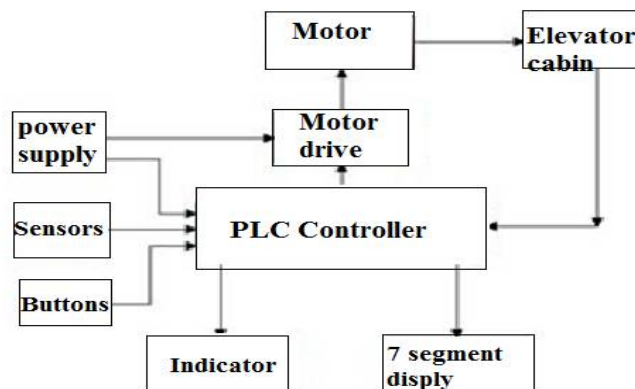


Fig. 1: Block Diagram of Elevator

Many sensors which are mounted on different floors for performing various functions and buttons are connected to PLC input module. PLC controller produces control signals via output module which controls the motor operation and feedback is given to PLC controller. Indicators and displays are also connected at output module of PLC.

## V. WORKING PRINCIPLE

**Programmable Logic Controller (PLC):** A PLC is user friendly microprocessor based specialized computer that carries out control function of many types and levels of complexity. Elevator system is completely automatic using PLC based control. The outputs of various sensors are connected to PLC input module. RTD is connected to PLC analog input module while load cell and IR sensor are connected to PLC digital input module. Push buttons are also connected to PLC input module. Elevator motor, motor used for door opening and closing, cooling fan motor, lights, displays, buzzers are operated through PLC output module. Additional input output modules can also be connected if required.

**DC Motor:** A motor is an electrical machine which converts an electrical energy in mechanical energy. DC motor works on Fleming's left hand rule. The working principle of a DC motor is that, "Whenever a current carrying conductor is placed in a magnetic field, it experiences a mechanical force". The elevator motor is responsible for moving an elevator car up and down between floors. Elevator system uses a roped mechanism. The elevator engine is connected to a pulley with ropes are looped around. The controller interacts with the elevator engine by sending it a signal that specifies in what direction the engine should be going in.

- Motor driver

Motor driver is used to control the motor in forward and reverse direction. There are four switching elements are used. The name H Bridge is derived from actual shape of switching circuit which controls the motion of motor.

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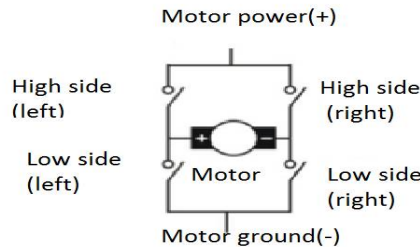


Fig. 2: H-Bridge Motor Driver

Truth table for H bridge motor driver is given below which shows that how a single motor can operate in both direction by combinations of switches.

High Left	High Right	Low Left	Low Right	Description
On	Off	Off	On	Motor runs clockwise
Off	On	On	Off	Motor runs anticlockwise
On	On	Off	Off	Motor stops or decelerates
Off	Off	On	On	Motor stops or decelerates.

Table 1. Truth Table

With one IC we can interface 2 DC motors which can be controlled in both clockwise and counterclockwise direction.

Sensors: A sensor is a device which converts a physical quantity into a signal used by an observer or an instrument. Sensor provides information about presence or absence of an object.

- Infrared Sensor

Infrared sensor is used as Obstacle detector. This sensor detects the obstacles. When the IR transmitter emits radiation, it reaches the object and some of the radiation reflects back to the IR receiver.

Infrared Transmitter is a light emitting diode (LED) which emits infrared radiations. Hence, they are called IR LED's. The radiation emitted by infrared transmitter is invisible to the human eye. Infrared receivers can be photodiodes, phototransistors etc.



Fig. 3: IR Sensor

In obstacle sensor various options are available for detecting object but because of low cost we are using IR sensors instead of proximity sensor. In actual systems, generally IR sensors curtains are used. It prevents the door closing when a person or object is present in between and 3 IR sensors are used for 3 floors such that doors will be open at each floor at location that is when an internal and external door exactly matches.



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- Load Cell

Load Cell is a transducer or sensor which converts force which is to be measured into an electrical signal. Strain gauge is a resistive load cell. When a load/force/stress is applied to the sensor, it changes its resistance. This change in resistance is measured in terms of electrical voltage, when an input voltage is applied. Load cell works on wheatstones bridge principle. These load cells have been in use for many decades now, and can provide very accurate readings but require many tedious steps during the manufacturing process. It is mainly used for protecting motor and rope from overloading. Here it also serves the function of occupancy sensor. When the weight is at or less than set minimum value for sufficient time then it make the fans and extra lights off and when the weight is more than max preset value, the control system will stop the motor. Motor will not start until the load is dropped below max preset value. Buzzer is also used to warn people that the preset value is exceeded.

- Oxygen Sensor

An oxygen sensor (or lambda sensor) is an electronic device that measures the proportion of oxygen (O<sub>2</sub>) in the gas or liquid being analysed.



Fig. 4: Oxygen Sensor

It is used in elevator application for protecting people during emergency situation. Whenever there is any failure in supply system and lift is blocked, then oxygen level in car will go on decreasing and it may harm people who are locked inside and hence oxygen sensor is used which senses oxygen level and when it detects minimum set level, it will give an signal to PLC so that car will be moved to nearest floor and will open the door. It is connected to analog input module of PLC.

Switches:

- Limit Switch

A limit switch is an electromechanical device consists of an actuator which is mechanically linked to set of contacts. Limit switch is a switch operated by the motion of machine part or presence of an object. They are used for controlling machinery as a part of control system, as a safety interlocks.

- Push Button Switch

Push button is mostly used in industrial application. There are normally two types are available one is maintained push button while other is momentary push button. These are used at every floor for calling purpose.

## VI. IMPLIMENTATION

Hardware Implementation: Before actual construction we made a design of car and floors. We are using three motors, one for car movement one for door opening closing and one for cooling fan. We have done demo model with dimensions given in following table,

Sr. No.	Descriptions	Specifications in cm.
1	Model dimensions	29*25*81
2	Spacing between two floor	4
3	Spacing between first floor and bottom parts	2
4	Spacing between third floor and upper part	5



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5	Car dimensions	14*10*22
6	Space left Between car and model on each side	7.5
7	Space left backside of car for counter-weight	12.5

Table 2. Specifications of Demo Model

Software Implementation: Different PLC programming languages are outlined in IEC1131-3 standard. IEC 1131-3 is the international standard which defined the programming languages. It also provides different guidelines about implementations and various applications of PLC programming languages. The following is list of programming languages specified by this standard IEC 1131-3:

- Ladder diagram (LD)
- Sequential Function Charts(SFC)
- Function Block Diagram(FBD)
- Structured Text(ST)
- Instruction List(IL)
- Cyclic Function Chart

## VII. ADVANTAGES AND DISADVANTAGE

PLC and various sensors are used to perform various functions, which are advantageous for providing comfort to human being.

Advantages:

- Automatic door opening and closing helps to increase comfort level.
- Load cell which also functioning as occupancy sensor can result in reduction in energy usage.
- Overload buzzer can warn people that elevator is overloaded so can prevent motor from overloading.
- To reduce the risk of fire and explosion this system uses temperature sensor in car.
- Emergency alarm can reduce accidents and risk to human life.
- More flexible as easy to reprogram the PLC if in future we wish to introduce any advanced functions with negligible changes.

Disadvantages:

- More costly as compared to microcontroller based control.

## VIII. CONCLUSION AND FUTURE SCOPE

Previously we use relays and IC boards for controlling of elevator. But due to its inconvenience now it is replaced by PLC. PLC is easy for controlling machines used in elevator. An elevator mentioned here is fully automated using PLC. To program a PLC we use ladder logic. The developed ladder logic has been implemented by Ladder diagram programming. By using input signals from operator and sensors control operations are performed such as moving forward and reverse, door opening and closing etc. According to that signal PLC will make the drive motor and door motor to work correspondingly. With this control operations implementation of elevator can be applied in the real world.

This model can be improved further as described below:

- The proposed system can be extended for synchronization of multiple elevators operating at the same time.
- The safety of the system can be improved by adopting more safety techniques.



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