Design & Control of an Elevator Control System using PLC

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Abstract: This paper explains control of three floor elevator using PLC. With the rising life standards and attention to human and with tremendous development in architectural engineering for multi storage building, the installation of elevators becomes an integral part of the infrastructure for the vertical movement. So, the control system is essential for smooth and safe operation of the elevator. Hence for more efficient performance and maintenance, more importance is given to the design of an elevator control system. In this case one can make the better use of PLC for controlling of elevator which is beneficial due to its flexibility, operational speed, reliability, ease of programming, security, and it is easy in implementing changes and correcting errors. Since output results must be produced in response to input condition within a given period of time, it is an example of a real time system. Ladder diagram programming is selected as it is easy to program the PLC.

Keywords: Elevator, sensors, PLC, floors, motor, switches.

I. INTRODUCTION

The main requirement of the multi storage buildings are elevators for movement of goods and people. Elevators ease the work of human being and keep them in comfort zone. Elevator control system is needed to control all the functions of the elevator. It is the one which guides the elevator car, 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. Preliminarily, traditional elevator control systems work on the relay logic. Some of the drawbacks of the traditional system are the control system have high failure rate that were mainly due tonumerous contacts, complexity of wiring circuit. In addition, electrical contacts were easy to burn out, which could result in poor contact[1].

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 at every floor. 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.

II. WORKING OF AN ELEVATOR

An elevator is a simple device which is used to save human efforts. Elevator is the good example of law of energy conservation. When peoples are coming down there is small amount of loss in cable and brakes. Lift installation consist of cover design, supply delivery installation, testing and commissioning of passenger lift. It also consists of rope pulley arrangement. 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. Controlling of an elevator can be done automatically or manually. Speed regulating system in elevator is called as governor.The elevator car is balanced by a heavy counterweight that weighs nearly the same amount as the car when it is loaded half-full. When the elevator goes up, the counterweight goes down and vice-versa. The counterweight reduces the amount of energy that motor needs to use. Safety brake prevents the elevator car from crashing the floor. 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.

The car enclosure shall include LED lamps and fan at ceiling. The lift have sensorso that the fan is operating only when there is at least one person inside the lift, the car has plain finish for passenger.
Car doors protect riders from falling into the shaft. Emergency stop 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.

III. PROPOSED TECHNOLOGY

For controlling elevator we are using PLC. We give the sensor as an input to the PLC. As per our requirement we choose sensors like IR sensors, oxygen sensor, load cell etc.

IR sensors are used for detecting object. It prevents the door closing when a person or object is present in between. It is also used to detect floor. The limit switches are used for holding a car in correct position at each floor. Load cell is used to measure weight present in car. Load cell also functions as occupancy senor. 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 maximum preset value. Oxygen sensor is the additional feature used in elevator. 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 which 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.

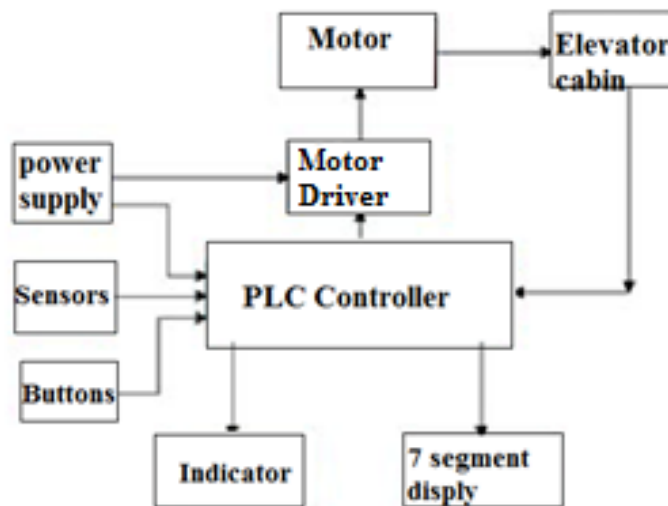### IV.BLOCK DIAGRAM OF AN ELEVATOR

Fig. 1: Block Diagram of an Elevator

Block diagram for PLC based elevator control system is as shown in figure [2].

A.   PLC Controller

A PLC is user friendly microprocessor based specialized computer that carries out control function of many types and levels of complexity. PLC controller is main element in this system which controls elevator functions. PLC receives input signal from operator or various sensors used at different floor for performing many functions.PLC controller produces control signals via output module which controls the motor operation and feedback is given to PLC controller.

B.   Elevator Cabin

Elevator cabin is nothing but elevator car which carries peoples as well as goods in upward and downward direction. No. of switches and sensors are connected in an elevator car. According to conditions present in car respective sensors are operate automatically. Lighting and cooling arrangement is also provided in elevator cabin.

C.   Power Supply

Power supply is given to PLC controller as well as motor drive circuit. The power available in most plants is 230 volts AC at 50 HZ. Most PLC operates on +5volts and -5volts DC. Therefore the PLC CPU must contain circuitry to convert 230 volts AC input to the required 5 volts DC value.

D.   Motor

A motor is an electrical machine which converts an electriceal energy in mechanical energy. 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 at which speed and in what direction the engine should be going in. A stop signal is simply constructed by setting the speed parameter of the signal to zero.

E. 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 [4].
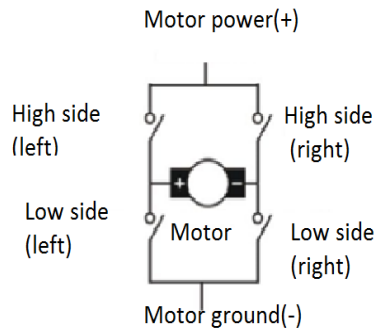

Fig. 2: H-Bridge Motor

TABLE I. TRUTH TABLE

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.

F. Sensors

A sensor is a device which converts a physical quantity into a signal used by an observer or an instrument. A sensor's sensitivity indicates how much the sensor's output changes, when the measured quantity changes.
Many sensors are mounted on different floors for performing various functions.

- 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. Based on the intensity of the reception by the IR receiver, the output of the sensor is defined. The radiation emitted by infrared transmitter is invisible to the human eye. As the output of infrared detector is very small, we need amplifier for signal processing.

- 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.
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.

- Oxygen Sensor

An oxygen sensor (or lambda sensor) is an electronic device that measures the proportion of oxygen (O_2) in the gas or liquid being analysed.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.

G. Buttons

Buttons are connected to PLC input module.
- Limit Switch

A limit switch is an electromechanical device consists of an actuator which is mechanically linked to set of contacts. An object comes into contact of actuator, the device operates the contacts to make or break an electrical connection[5].

- Push Button Switch

There are normally two types are available one is maintained push button while other is momentary push button. In maintained push button when we push button, it will activate, to deactivate it, we want to again push it, so it is also called push-push button. In momentary type push button, when we push button, it will activate and it will deactivate when we release it.

H.   7 Segment Display

In an elevator 7 segment display is used for floor indication.

I.   Indicator

Indicator is connected at output module of PLC. It indicates direction of car which may be upward or downward.

V. SOFTWARE IMPLEMENTATION

Ladder diagram has commonly used programming languages for the PLC. As it is the simplest method with the basic knowledge of computers and logic circuits one can program the PLC by the use of this method [5].
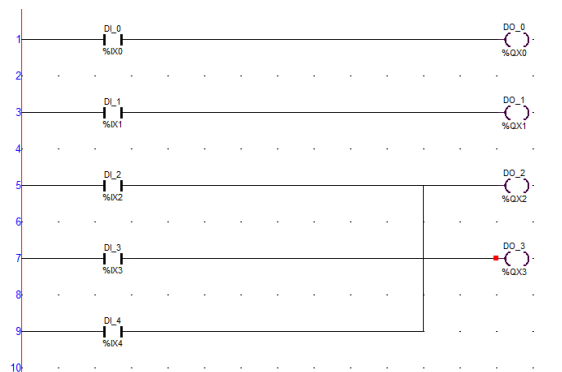

Fig. 3. Ladder Logic for motor control

Sensors are connected to input module of PLC, while motor driver as well as lighting and fan load is connected to output module of PLC [3].
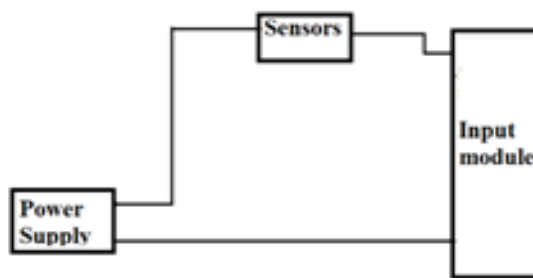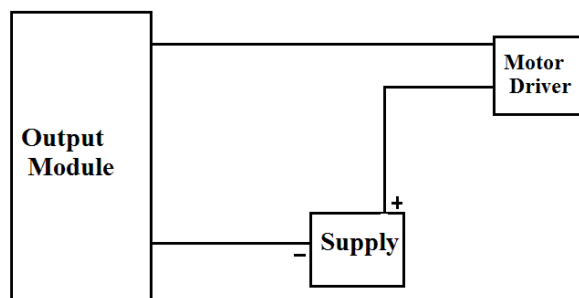

Fig. 4. Interfacing of Sensors with PLC

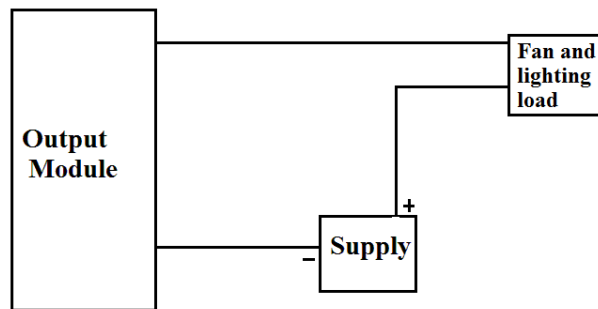Fig. 5. Interfacing Of Motor Driver with PLC

Fig. 6. Interfacing of Fan and Lighting Load with PLC

VI. ADVANTAGES AND DISADVANTAGES

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

A.   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.
- Oxygen level monitoring adds extra safety feature in case whenever there is any   failure in supply system.
- 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.

B.   Disadvantages
- More costly as compared to microcontroller based control.

VII. 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. 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. The proposed system has been implemented by using Ladder diagram programming as it is easy to program the PLC.

This model can be improved further as described below:
- Use of Solar Energy for elevator control system.
- Implement some techniques like Floor-Having-More-People First, by adding weight sensor to each floor, to know which floor has the maximum crowd.

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