# Design and Implementation of Embedded Based Optimal Elevator Control System

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***Abstract -*** Lift or elevator is transport devices that are used to move goods or peoples vertically. In this paper, the PIC16F877A microcontroller based lift control system is constructed to simulate as an actual lift in the real life. This paper findings and results of a research on a microcontroller based lift control system. In this paper an optimized a three floor lift (G+3) is constructed. There are two push buttons; one is in internal part of the lift and another is in external part. It is used to close and open of the lift car. The lift cars can be carrying below 6 man and 65 kg totally 390 tons.

## I. INTRODUCTION

Lift is a transport device that is very common to us nowadays. We use it every day to move goods or peoples vertically in a high building such as shopping center, working office, hotel and many more. It is a very useful device that moves people to the desired floor in the shortest time. Lift is generally powered by electric motors. The most popular lift is the suspension type lift. In the rope lift, the car is raised and lowered by transaction with steel rope. Lifts also have electromagnetic brakes that engage, when the car comes to a stop. The electromagnetic actually keeps the brakes in the open position. Instead of closing them with the design, the brakes will automatically clamp shut if the lift loses power. Lift also has automatic braking systems near the top and the bottom of the lift shaft.

Many modern lift are controlled by a computer. The computer job is to process all of the relevant information about the lift and turn the motor correct amount to move the lift car in correct position. In order to do this the computer [1] needs to know at least three things .Those is where people want to go, where each floor is and where the lift car is. The buttons in the lift car and the buttons in each floor are all wired to the computer, when anyone presses these buttons, the computer logs this request.

Lift is the vital part of everyone's life living in large buildings, and moreover it is the necessary thing in large buildings or any big construction having number of floors for transportation. The central and most visible component of a lift is the passenger car. The car frame consists of the upper crosshead beam, two vertical uprights (stiles) joining upper and lower members, and lower safety plank, provides the supporting structure for the car. The suspension ropes are attached to the crosshead beam. The safety plank supports the car platform, on which passengers or other loads rest during travel. A pair of guide rails is placed on two opposite sides of the car, guiding the car during its vertical motion. The weight of the car and part of its load is balanced by the counterweight. The counterweight consists of steel frame and stacked fillers or weights secured by two or more tie-rods. These weights fill up to two-third of the height of the counterweight. Both passenger car and counterweight are connected through traction ropes that pass through traction system at the top of the hoist way consisting of driving sheaves and electric motor. Similar to the passenger car, the counterweight is also guided by two guide rails along its sides during the vertical motion.

## II. LIFT SYSTEM OVERVIEW

Fig.1 shows the lift system overview. This figure consists of floor where passenger wants to visit. Lift car moves it either upward or downward direction. The level sensor detected the arrival of the lift to the respective floor. Floor button is used to take the lift to the respective floor. Floor lamp shows the indication of floor and direction lamp shows the direction of lift movement, whether it is upward or downward direction. Lift button is used for moving the lift car either in upward and downward direction. Based on the lift switch pressed, the lift car is moved either in upward and downward direction. D.C. Motor is another important component of lift system. Based on the switch pressed, the

D.C. Motor either moves in forward and reverse direction to move the lift in either upward or downward direction. Door of the lift system is one of the important factors of lift system. When lift car stops in particular floor, the door of the lift is opened for passenger to be come out and come in to the lift car. Arrival sensor is used in every floor, for detecting the lift car. When a particular car is reached to the particular floor, this arrival sensor detects the lift car and stops that car.

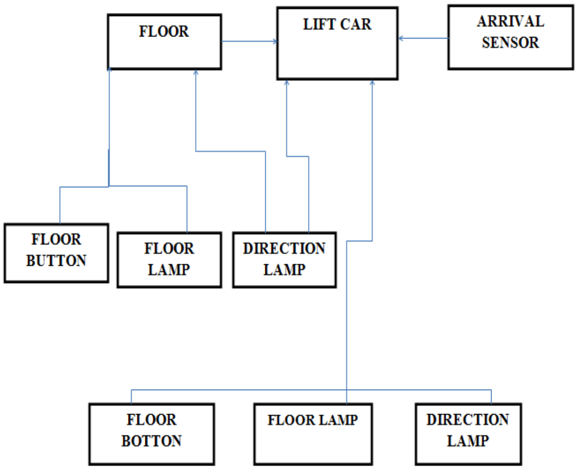



Fig. 1 lift System overview

## III. LIFT SYSTEM

We can explain lift in small words as a vertical transportation system (vertical vehicle) that efficiently moves people or goods between floors of a building. They are generally powered by electric motors that either drive traction cables and counter weight system or pump hydraulic fluid to raise a cylindrical piston. Lift is a transport device that is very common to us nowadays. We use it every day to move goods or peoples vertically in a high building such as shopping center, working office, hotel and many more. It is a very useful device that moves people to the desired floor in the shortest time. There are different types of lift in the world but we can classify them into two major parts by the mechanism they use to move the car, which are **Traction lift and hydraulic lift.**

**a) Traction lift:** According to electric motor they are traction motors are also classified in to two parts which are Geared and gearless traction elevators.

Geared traction lifts are driven by AC or DC electric motors. Geared machines are use warm gears to control mechanical movement of lift cars by rolling steel hoist ropes over a drive sheave which is attached to a gearbox driven by a high speed motor. These machines are generally the best options for basement or overhead traction use for speeds up to 2.5 m/s. Gearless traction lifts use low speed, high torque electric motors powered by either AC or DC supply. In these case the drive sheaves is directly attached to the end of the motor. Gearless traction lift can reach speeds up to10 m/s or even higher. A brake is mounted between the motor and drive sheaves to hold the lift stationary at floor level. This brake is usually an external drum type and actuated by spring force and hold. Open electrically a power failure will cause the brake to engage and prevent the lift from falling.

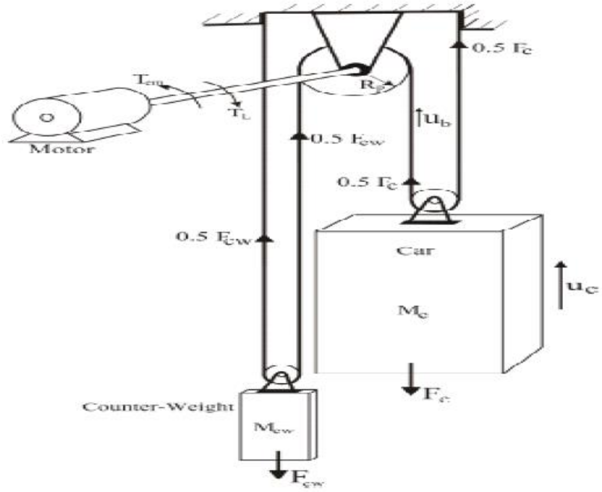



Fig.2 Traction type lift

**b) Hydraulic lift:** A hydraulic lift system lifts a car using a hydraulic ram, a fluid driven piston mounted inside a cylinder. The fluid is connected to a fluid pumping system (typically, hydraulic system uses oil, but other incompressible fluid would also work). The hydraulic system has three parts

- A tank (the fluid reservoir)
- A pump, powered by an electric motor
- A valve between the cylinder and the reservoir.

The pump forces fluid from the tank into a pipe leading to the cylinder. When the valve is opened, the pressurized fluid will take the path of least resistance and return to the fluid reservoir, but when the valve is closed, it pushes the piston up, lifting the lift car.

When the car approaches the correct floor, the control system sends a signal to the electric motor to gradually shut off the pump. To lower the car, the lift control system sends a signal to the valve. The valve is operated electrically by a base solenoid switch. When the solenoid opens the valve, the fluid that has reserved in the cylinder can flow out in to the fluid reservoir. The weight of the car and the cargo pushes down on the piston, which drives the fluid into the reservoir. The car gradually descends. To stop the car at a lower floor, the control system closes the valve again.

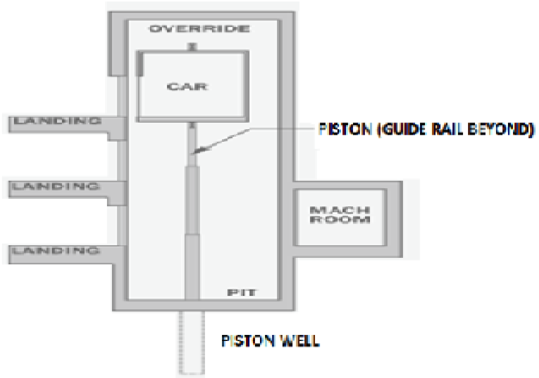



Fig.3

Hydraulic lift

**Lift Control System:** is the system responsible for coordinating all aspects of lift service such as travel, speed, and accelerating, decelerating, door opening speed and delay, leveling and hall lantern signals. It accepts inputs (e.g. button signals) and produces outputs (lift cars moving, doors opening, etc.).

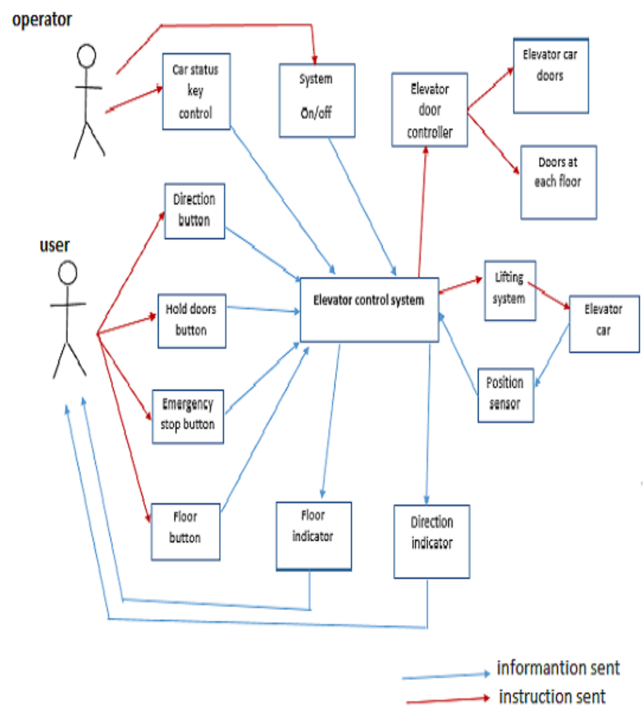
**Lift control system components**

The lift as a control system has a number of components. These can basically be divided into the following:
1. Inputs. Includes: - Sensors, Buttons, Key controls, and System controls.
2. Outputs. Includes: - Actuators, Bells, and Displays.
3. Controllers. Is a device which manages the visual monitoring, interactive command control and traffic analysis system to ensure the lifts are functioning efficiently?

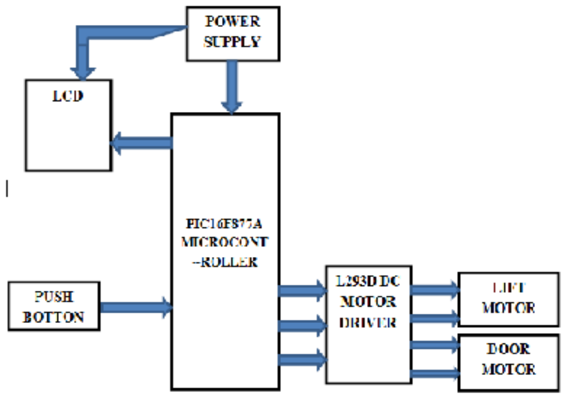
**The controller** is a device which manages the visual monitoring, interactive command control and traffic analysis system to ensure the lifts are functioning efficiently [2].

The primary function of the lift controller is essentially to receive and process a variety of signals from several different components of a whole lift system. It is able to send signals in response to the ones it receives in order to operate all of the other components in the system. This exchange of signals is how the lift controller is able to keep the lifts running smoothly on a day-to-day basis.
Here are a few of the following ways the controller interacts with the other components of the lift system [1]:

- Controls the speed of lift engines in order to move lift cars up and down their respective shafts. It is controlled by pulse width modulation.
- Queues and processes lift summons and floor requests from passengers through the signals provided to it by several buttons.
- Processes information sent to it by load sensors in order to ensure that the load of a car never exceeds the safety limit.
- Processes information sent to it by position marker sensors in order to keep track of where the lift cars are at all times, as well as their speed.
- Provides feedback to passengers through the lights on some of the buttons and the floor number and direction displays in each car.
- Controls the operation of the lift doors of a car through communication with door opening devices.




## IV. DESIGN AND ANALYSIS




**Block diagram description** :When User presses a lift button, the lift button sensor sends the lift button request to the system, identifying the destination floor the user wishes to visit. When any new request comes, this new request is added to the list of floors to visit. If the lift is stationary, the system determines in which direction the system should move in order to service the next request. The system commands the lift door to close, when user presses the lift door closed button. When the door has closed, the system commands the motor to start moving the lift, either in up and down direction, based on switch pressed. When the lift moves between floors, the level sensor detects that the lift is approaching a floor and notifies the system to stop the lift and open the door of the lift system. Material selection for any design task is a time consuming and difficult part of the overall works of the design. The materials required for designed microcontroller based lift control system are briefly discussed as follow:

**Design of lift Car**

The lift car is designed by having in mind the number of passengers it is going to accommodate. Also it should have the capacity to bear the weight of the passengers travelling in the elevator. So we assumed that the proposed elevator is having the capacity to accommodate 6 (six) persons of approximately 65kg mass

Maximum No. of passengers can be accommodated in the car= 6.

Approximate mass of each person =65kg

Maximum mass that the car can handle = 65*6=390kg.

To accommodate persons the car has been designed with the following dimensions 1.5*1.5*2.2. The mentioned dimensions are in meter.

The tension on the rope and its choice of selection can be determined with the following simple calculation. The force excreted on the rope can be found by using Newton's formula.

. **a) Rope strength**

The force which acts on the rope can be found out by the following calculation. The force acting on the rope is the sum of counter weight, the weight of empty car, and weight of passengers. In this design we assume the weight of a counter weight is equal to the weight of empty car to aid the motor when the car is under lode (at no load).we assume

**Mc= Mcw** = 80kg

F=mg

**F= (390+80+80)*9.8N=3390N**

The force acting on the string is 3.39 KN. So a string with the capacity to bear at least 4KN has to be chosen.

From the rope manufacturer's data sheet, for our requirement we can go for the cable with 4.89KN safe load capacity and thickness of 6.4mm

**b) Motor rating selection**

The motor [3] used here is a permanent magnet DC motor. Based on the design specification the output power and the output torque of the motor are calculated by a simple calculation.

Power and torque calculation

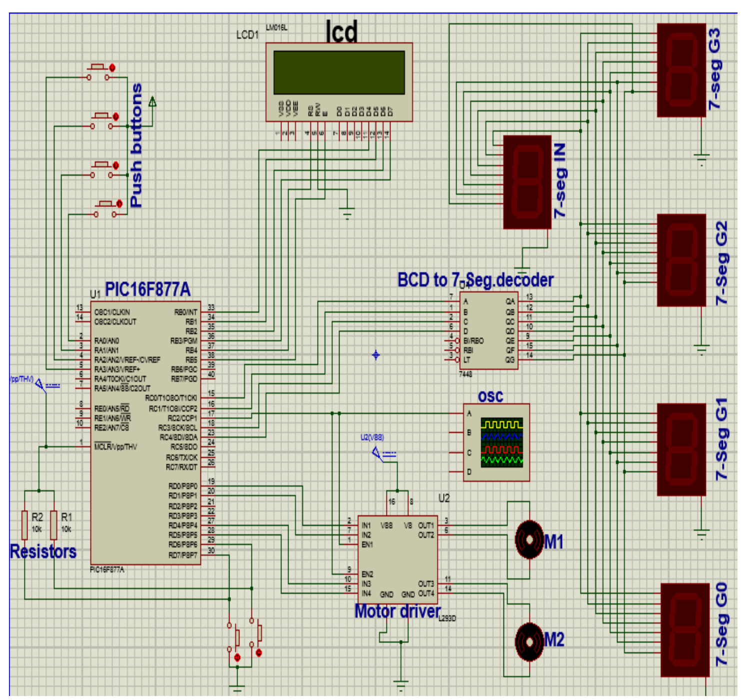
Weight of empty car =80kg

Counter weight=80kg

Six (6) person's with65kg =390kg

For constant speed operation of 1m/s

The power can be calculated using the general equation.



$$Pmc = (mc - mcw).g.uc - mc.\frac{duc}{dt}$$

Since the speed is constant and the mass of empty car is balanced by a counter weight we get the equation for the motor power as

$$Pmc = Mm.g.uc$$

$$Pmc = 390 * 9.8 * 1 = 3822watt = 3.822kw$$

Since 1hp=746watt

Therefore 3822watt=5.12hp so we use a motor of 6hp=4476watt.

We can determine the torque of the drive by assuming a specific angular velocity or diameter of pulley. Let we assume the angular speed is $\omega = 300RPM$

Now we can determine the radius of the pulley

$$Uc = wrp$$

Therefore

$$Rp = \frac{uc}{\omega} = 3.2cm$$

$$\text{Torque of motor} = \frac{\text{power in watt}}{\text{angular speed}}$$

$$Tm = 4476 * \frac{60}{2\pi\omega} = 142.47Nm$$

**Algorithms**

The algorithms we follow to do the flow chart of the system are limited for only two calls within a time. Similar algorithms taken for rest calls

Case 1a.The car location is at ground, G0 and calls are at G1 and G2:

- if the direction of call is at G1-down and G2 up the car first goes to G2 else G1

case1b. The car location is at ground, G0 and calls are at G1 and G3

- if the direction of call is at G1 up and G3 down the car first goes to G1 else G3

case1c. The car location is at ground G0 and calls are at G2 and G3

- if the direction of call is at G2 up and G3 down the car first goes to G2 else G3

case2a. The car location is at G1 and calls are at G0 and G2:

- The car goes to G0 for any call direction.

Case2b: The car location is at G1 and calls are at G0 and G3:

- The car goes to G0 for any call direction

Case2c: The car location is at G1 and calls are at G2 and G3:

- if the direction of call is at G2 up and G3 down the car first goes to G2 else G3

case3a: The car location is at G2 and calls are at G0 and G1:

- if the direction of call is at G0 up and G1 up the car first goes to G0 else G1

case3b: The car location is at G2 and calls are at G0 and G3:

- The direction of call is at G0 up and G3 down the car first goes to G3

Case3c: The car location is at G2 and calls are at G1 and G3:

- if the direction of call is at G1up and G3 down the car first goes to G1 else G3

case4a: The car location is at G3 and calls are at G0 and G1:

- if the direction of call is at G0 up and G1 down the car first goes to G1 else G0

case4b: The car location is at G3 and calls are at G0 and G2:

- if the direction of call is at G0 up and G2 down the car first goes to G2 else G0

case4c: The car location is at G3 and calls are at G1and G2:

- if the direction of call is at G1 up and G2 up the car first goes to G1 else G2

## V. CONCLUSION

Lift Control System using microcontroller is the system responsible for coordinating all aspects of lift service such as travel, speed, and accelerating, decelerating, door opening speed and delay, leveling and hall lantern signals by using PIC microcontroller. PIC16F877A microcontroller is chosen as the core control component for lift control system and DC motor. Based on the key pressed the lift moves either in upward or downward direction and infrared tubes are used for detecting the location of the lift, thus acquiring real-time information for opening and closing of the door of lift. To make the lift more comfortable for passenger, PWM signal based on load factor of lift car and maintain the constant speed of the DC motor for smooth running of lift system.

The control system that we design is optimal control system means that control system gives faster performance by reducing the average waiting time (AWT) of the passengers. It also reduces the power consumption of the lift system. For this we take different algorithms. Depending on thus algorithms if two calls coming at the same time, then the car goes to the call that have high priority.

Even if we design the lift control system for only 4 floors, it is possible to design for more than 4 floors. The only thing is selecting the microcontroller family which has more than 33 input output pins. The c code can be written as the same way as the 4 floor. And also the components used are similar to that of our design.

## VI. REFERENCES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