

CHAPTER ONE

INTRODUCTION

1.1 Background

Elevator, is a transport device that is very common nowadays, it used everyday 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.

Elevators began as simple rope or chain hoists. An elevator is essentially a platform that is either pulled or pushed up by a mechanical means. A modern day elevator consists of a cab (also called a "cage" or "car") mounted on a platform within an enclosed space called a shaft or more correctly a hoist way. In the past elevator drive mechanisms were powered by steam and water hydraulic pistons.

During the middle ages, the elevator operated by animal and human power or by water-driven mechanisms. The elevator was first developed during the 1800s and relied on steam or hydraulic plungers for lifting capability. In the latter application, the cab was affixed to a hollow plunger that lowered into an underground cylinder. Liquid, most commonly water, was injected into the cylinder to create pressure and make the plunger elevate the cab, which would simply lower by gravity as the water was removed. Valves governing the water flow were manipulated by passengers using ropes running through the cab, a system later enhanced with the incorporation of lever controls and pilot valves to regulate cab speed.

The granddaddy of today's traction elevators first appeared during the 19th century in the United Kingdom, an elevator using a rope running through a pulley and a counterweight tracking along the shaft wall.

In the 1800s, with the advent of electricity, the electric motor was integrated into elevator technology by German inventor Werner von Siemens. With the motor mounted at the bottom of the cab, this design employed a gearing scheme to climb shaft walls fitted with racks. By 1903, this design had evolved into the gearless traction electric elevator, allowing hundred-plus story buildings to become possible and forever changing the urban landscape. Multi-speed motors replaced the original single-speed models to help with landing-leveling and smoother overall operation.

Electromagnet technology replaced manual rope-driven switching and braking. Besides, Push-button controls and various complex signal systems modernized the elevator even further. Safety improvements have been continual, including a notable development by Charles Otis.

Today, there are intricate governors and switching schemes to carefully control cab speeds in any situation. Buttons have been giving way to keypads. Virtually all commercial elevators operate automatically and the computer age has brought the microchip-based capability to operate vast banks of elevators with precise scheduling, maximized efficiency and extreme safety. Elevators have become a medium of architectural expression as compelling as the buildings, in which they are installed, and new technologies and designs regularly allow the human spirit.^[1]

1.2 Problem Statement

Lack of electric elevators causes time and energy consuming, so elevators had been developed according to requirement application. Therefore, studying and constructing electric elevators had been an important subject to deal with.

1.3 Objectives

The main objectives for this project are :

- To study an elevator control system.
- To build an elevator model to simulate the actual system by using Arduino Mega.
- To construct a program (software) for the overall system according to the real elevator traffic management algorithm.
- To integrate the hardware and software in order to simulate the functions of a basic elevator system.

1.4 Methodology

Arduino Mega is used as the primary controller. Besides, it is consist of various inputs and outputs circuits together with an elevator model. The Arduino Mega is used to coordinate the functions of various hardware circuitries. Service request circuit or keypad and sensors are used as input. Servo motor driver circuit, seven-segment display and various types of LED (light emitting diodes) displays are used as output.

The elevator model was constructed to simulate an actual elevator in the real life. It can be counted as the output hardware of the system. The software for the system was designed according to the real elevator traffic management algorithm. The combination of the hardware and software perform the simulate function of a basic elevator system.

1.5 Project Layout

This project consist of five chapters, chapter one gives a background, problem statement, objectives and methodology. Chapter two defines the elevators components, types and their working principles. Chapter three illustrates the control system in generally then covers elevator control system. Chapter four gives a brief definition for the components which used in this project then discuss the project circuits and their analysis. Rather to the control system block diagram and its parts function and flow chart. Chapter five contains the conclusion and the recommendations.

CHAPTER TWO

ELEVATOR OVER VIEW

2.1 Introduction

There are many usages of elevators in practical application such as:

- **Passenger service:** A passenger elevator is designed to move people between a building's floors. Passenger elevators may be specialized for the service they perform, including: hospital emergency (code blue), front and rear entrances, a television in high-rise buildings, double-decker, and other uses. Cars may be ornate in their interior appearance, may have audio visual advertising, and may be provided with specialized recorded voice announcements. Elevators may also have loudspeakers in them to play calm, easy listening music. Such music is often referred to as elevator music.
- **Freight elevators:** A freight elevator, or goods elevator, is an elevator designed to carry goods, rather than passengers. Freight elevators are generally required to display a written notice in the car that the use by passengers is prohibited (though not necessarily illegal), though certain freight elevators allow dual use through the use of an inconspicuous riser. In order for an elevator to be legal to carry passengers in some jurisdictions it must have a solid inner door.
- **Stage elevators:** Stage elevators and orchestra elevators are specialized elevators, typically powered by hydraulics, that are used to raise and lower entire sections of a theater stage.
- **Vehicle elevators:** Vehicular elevators are used within buildings or areas with limited space (in lieu of ramps), typically to move cars into the parking garage or manufacturer's storage. Geared hydraulic chains (not unlike bicycle chains) generate lift for the platform and there are no counterweights.

- Boat elevator: In some smaller canals, boats and small ships can pass between different levels of a canal with a boat elevator rather than through a canal lock.
- Aircraft elevators: On aircraft carriers, elevators carry aircraft between the flight deck and the hangar deck for operations or repairs. These elevators are designed for much greater capacity than other elevators, up to 91,000 kg (200,000 lb) of aircraft and equipment. Smaller elevators lift munitions to the flight deck from magazines deep inside the ship.
- Residential elevator: A residential elevator is often permitted to be of lower cost and complexity than full commercial elevators. They may have unique design characteristics suited for home furnishings, such as hinged wooden shaft-access doors rather than the typical metal sliding doors of commercial elevators.
- Paternoster: A special type of elevator is the paternoster, a constantly moving chain of boxes. A similar concept, called the manlift or humanlift, moves only a small platform, which the rider mounts while using a handhold seen in multi-story industrial plants.
- Scissor elevator: The scissor elevator is yet another type of elevator. These are usually mobile work platforms that can be easily moved to where they are needed, but can also be installed where space for counter-weights, machine room and so forth is limited. The mechanism that makes them go up and down is like that of a scissor jack. ^[2, 3]

2.2 Elevator Components

The standard elevators will include the following basic components:

- i. Car.
- ii. Hoistway.
- iii. Machine/drive system.

- iv. Control system.
- v. Safety system.

Figure 2.1 shows the main components of elevators.

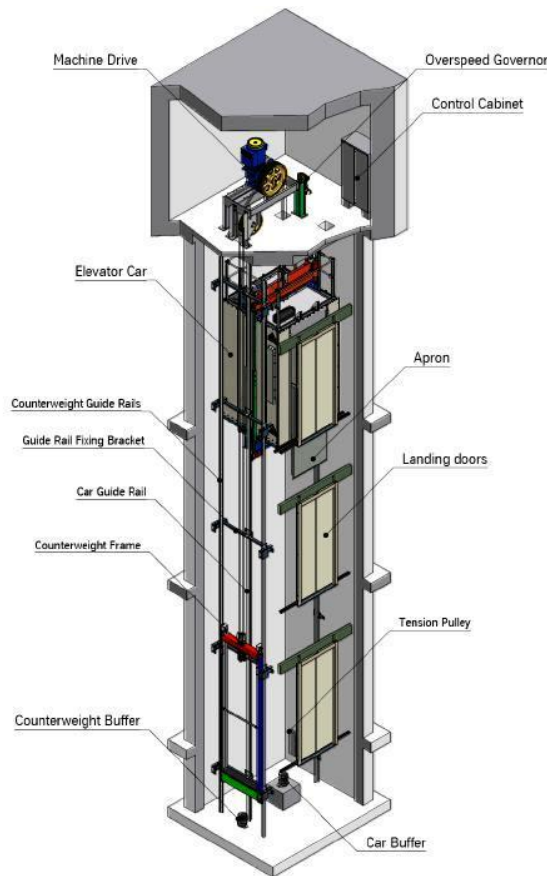


Figure 2.1: Elevator components

2.2.1 Elevator car

Elevator car is the vehicle that travels between the different elevator stops carrying passengers and/or goods, it is usually A heavy steel frame surrounding a cage of metal and wood panels.

Elevator car types: Standard elevator car/cabin can be classified according to the number of entrances and their locations as follows:

- i. Normal cabin
- ii. Open through cabin

iii. Diagonal cabin

These types are represented in Figure 2.2 .

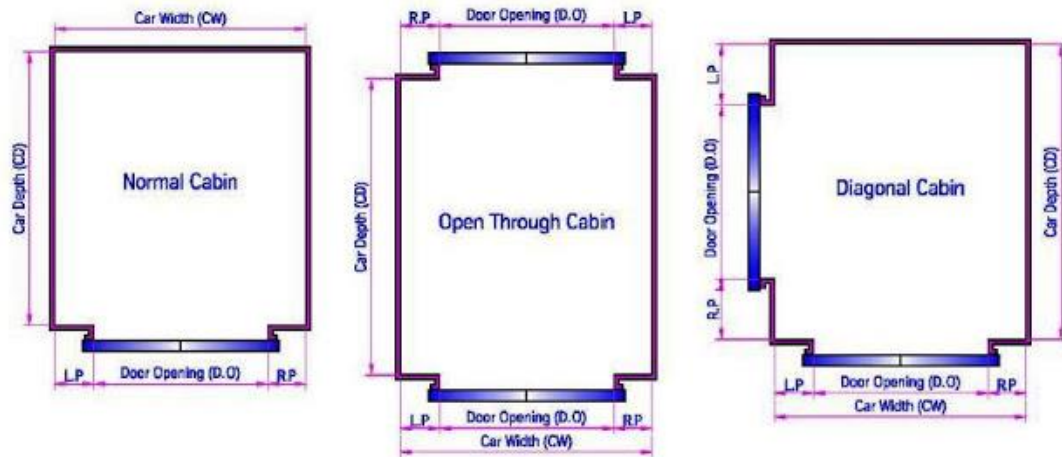


Figure 2.2: Elevator car types

Standard car size: To prevent overloading of the car by persons, the available area of the car shall be limited and related to the nominal/rated load of the elevator. The number of passengers shall be obtained from the formula:

$$\text{Number of passengers} = \text{rated load} / 75 \quad (2.1)$$

Where 75 represent the average weight of a person in Kg.

The standard car size is shown in Table 2.1 below :

Table 2.1: Standard car size.

Type	Q (Kg)	Persons	CW(mm)	CD(mm)
Type (I)	320	4	1000	900
			900	1000
	400	5	1100	1000
			1000	1100
	480	6	1200	1100
			1100	1200
	630	8	1400	1100
			1100	1400
			1200	1300
	750	10	1400	1300
			1300	1400
	800	10	1400	1350
			1350	1400
Type (II)	1000	13	1600	1400
			1400	1600
			1100	2100
	1050	14	1600	1500
	1350	18	1600	1800
	1600	21	2100	1600
			1400	2400

The following definitions for the car dimension are very important:

Car Width (CW): The horizontal dimensions between the inner surfaces of the car walls measured parallel to the front entrance and at 1m above the car floor.

Car Height (CH): The inside vertical distance between the entrance threshold and the constructional roof of the car. Light fittings and false ceilings are accommodated within this dimension.

Car Depth (CD): The horizontal dimensions between the inner surfaces of the car walls measured at right angles to the car width and at 1m above the car floor. ^[2, 3]

Elevator Car Components: Elevator Car is composed of the following components:

- i. Car sling, a metal framework connected to the means of suspension.
- ii. The elevator cabin.
- iii. Mechanical accessories which are: Car door and door operator, Guide shoes, Door Protective Device.

2.2.2 Hoistway

Hoistway is the space enclosed by fireproof walls and elevator doors for the travel of one or more elevators, dumbwaiters or material elevators. It includes the pit and terminates at the underside of the overhead machinery space floor or grating or at the underside of the roof where the hoistway does not penetrate the roof. (Hoistway is sometimes called "hatchway" or "hatch".)

Hoistway components: Hoistway is equipped with the following components:

- i. Guide rails for both the car and counterweight.
- ii. Counterweight.
- iii. Suspension (Hoisting) Ropes (Cables).
- iv. Landing (Hoistway) doors.
- v. Buffers in the pit.

2.2.3 Elevator machine and drive system

Driving machine, this is the power unit of the elevator, and usually located at the elevator machine room. The Driving machine used to refer to the collection of components that raise or lower the elevator. These include the drive motor, brake, speed reduction unit, sheaves and encoders.

Generally, there are three standard types of driving machines provided for elevators. These are: Gearless, Geared, Drum Machines.

❖ Gearless Machine

- It used in high rise applications whereby the drive motor and drive sheave are connected in line on a common shaft, without any mechanical speed reduction unit located between the drive motor and drive sheave.
- Generally, Gearless machines are used for high speed elevators between 2.5 m/s to 10 m/s and they can be also used for lower speeds for special applications.
- Their sizes and shapes vary with load, speed and manufacture but the underlying principles and components are the same.

The Gearless machines comprise the following components:

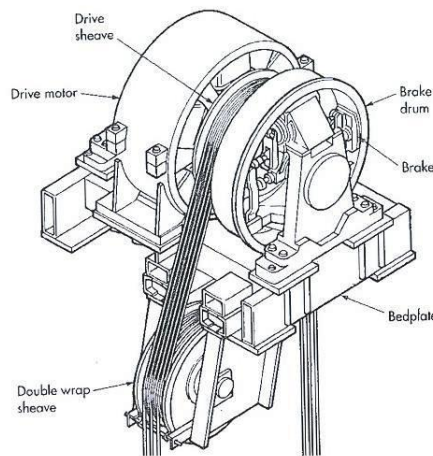


Figure 2.3: Gearless machines components

- Electrical motor.
- Traction sheave or drum.
- Direct current armature in case of DC motor.
- Rotor in case of AC motor.
- Brake.
- Machine bedplate.

- Supporting bearings.
- Deflector or double wrap sheave.

❖ Geared Machine

- It used in low and mid-rise applications. This design utilizes a mechanical speed reduction gear set to reduce the rpm of the drive motor (input speed) to suit the required speed of the drive sheave and elevator (output speed).
- Generally, geared machines are used for speeds between 0.1 m/s and 2.5 m/s and are suitable for loads from 5 Kg up to 50,000 Kg and above.
- Their sizes and shapes vary with load, speed and manufacture but the underlying principles and components are the same.

Essentially, a geared machine includes the following components:

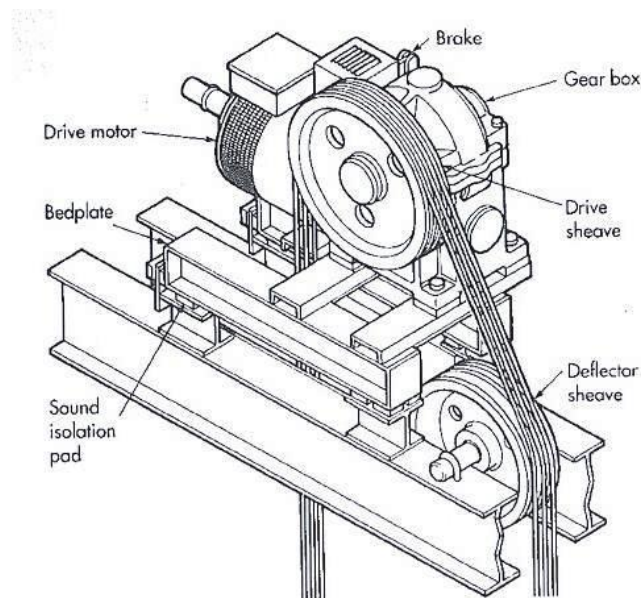


Figure 2.4: Geared machines components

- Drive motor.
- Brake.
- Speed reduction unit or gearbox.
- Drive sheave.
- Bedplate.

- Deflector sheave (if mounted as integral part of the bedplate assembly).

❖ Drum Machine

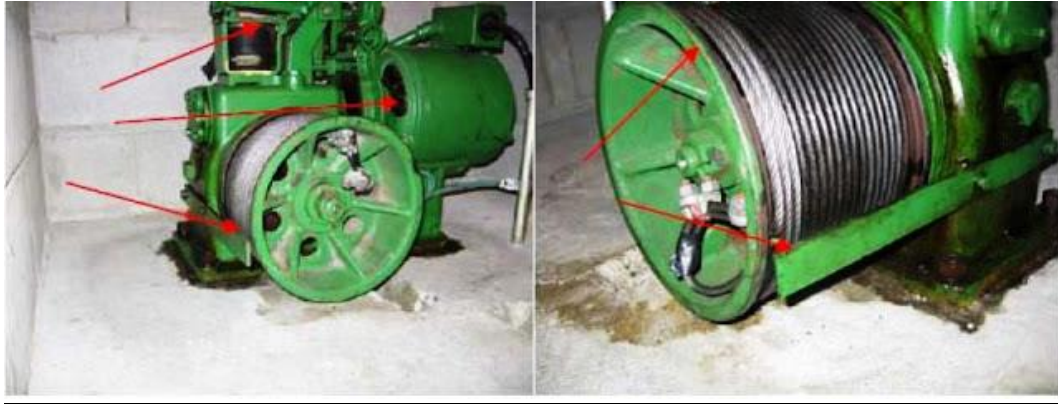


Figure 2.5: Drum machine

It widely used in older passenger and freight elevator applications, though now rarely seen except for dumbwaiters. For many years now the elevator safety code has disallowed the use of such machines for passenger applications. A drum design has one end of the suspension rope affixed to the inside of the winding drum's drive sheave, and then allows to rope to reel in or off the outer surface of its sheave, depending upon the car direction of travel. ^[2, 3]

2.2.4 Safety system

The following list describes all the safety components used in electrical traction elevator safety system: (show Figure 2.6).

- i. Device for locking landing doors (Hoistway Door Interlock).
- ii. Progressive safety gear.
- iii. Overspeed governor.
- iv. Buffers.
- v. Final Limit switches.
- vi. Other safety devices and switches.

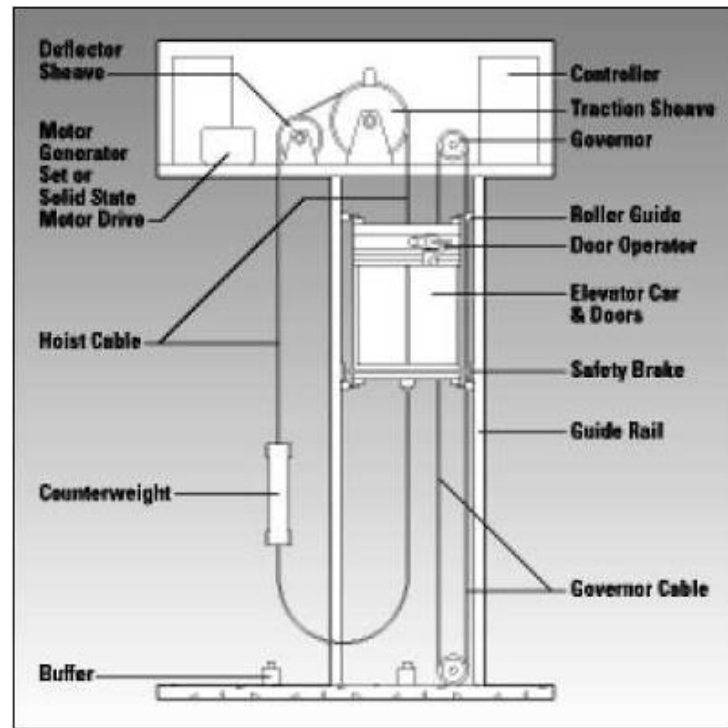


Figure 2.6: Layout of elevator safety system

2.3 Elevator Types

- i. According to hoist mechanism.
- ii. According to building height.
- iii. According to building type.
- iv. According to elevator Location.
- v. According to Special uses.

2.3.1 According to hoist mechanism

Elevators will be classified according to hoist mechanism to 4 main types as follows:

- i. Hydraulic Elevators
- ii. Traction Elevators
- iii. Climbing elevator
- iv. Pneumatic Elevators

- **Hydraulic Elevators (Push Elevators):** Hydraulic elevators are supported by a piston at the bottom of the elevator that pushes the elevator up. They are used for low-rise applications of 2-8 stories and travel at a maximum speed of 200 feet per minute. The machine room for hydraulic elevators is located at the lowest level adjacent to the elevator shaft. Figure 2.7 shows the hydraulic elevators.

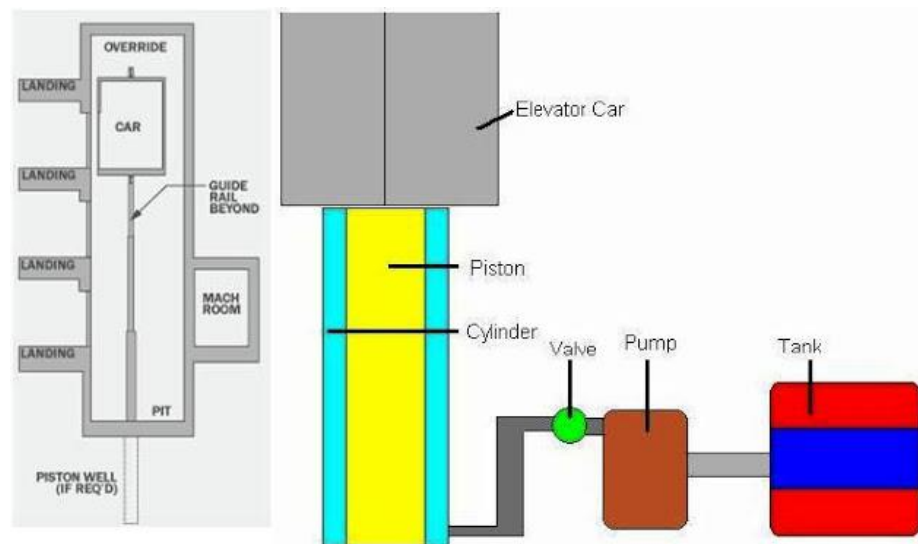


Figure 2.7: Hydraulic elevators

- **Traction elevators (Pull elevators):** Traction elevators are lifted by ropes, which pass over a wheel attached to an electric motor above the elevator shaft. They are used for mid and high-rise applications and have much higher travel speeds than hydraulic elevators. A counter weight makes the elevators more efficient. Traction elevators have 3 main types :
 - i. **Geared traction elevators:** they have a gearbox that is attached to the motor, which drives the wheel that moves the ropes. Geared traction elevators are capable of travel speeds up to 500 feet per minute.
 - ii. **Gear-less traction elevators:** they have the wheel attached directly to the motor. Gear-less traction elevators are capable of speeds up to 2000 feet per minute.

- iii. **Machine-room-less elevators:** they are typically traction elevators that do not have a dedicated machine room above the elevator shaft. The machine sits in the override space and the controls sit above the ceiling adjacent to the elevator shaft. Machine-room-less elevators are becoming more common; however, many maintenance departments do not like them due to the hassle of working on a ladder as opposed to within a room. Figure 2.8 shows the machine-room-less elevators.

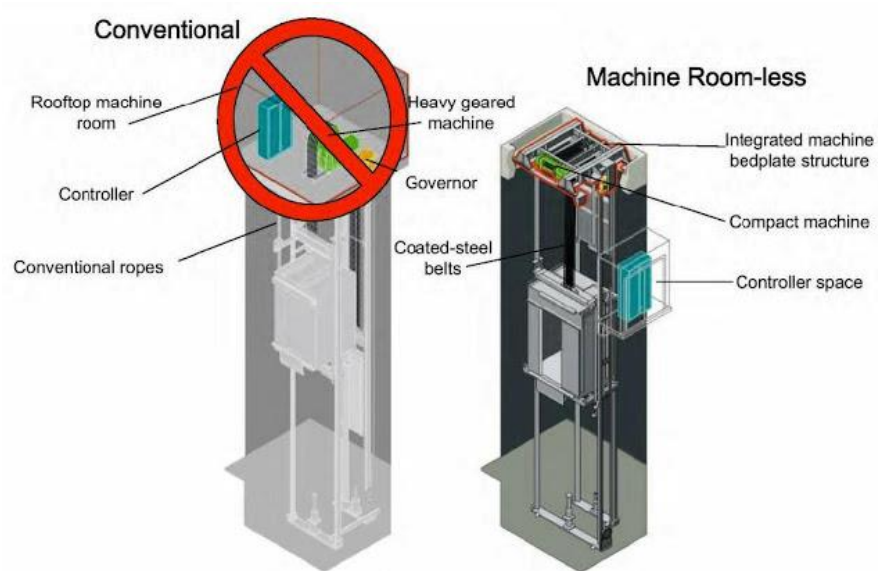


Figure 2.8: Machine-room-less elevators

Geared traction elevators and gear-less traction elevators shown in Figure 2.9 and Figure 2.10, respectively.

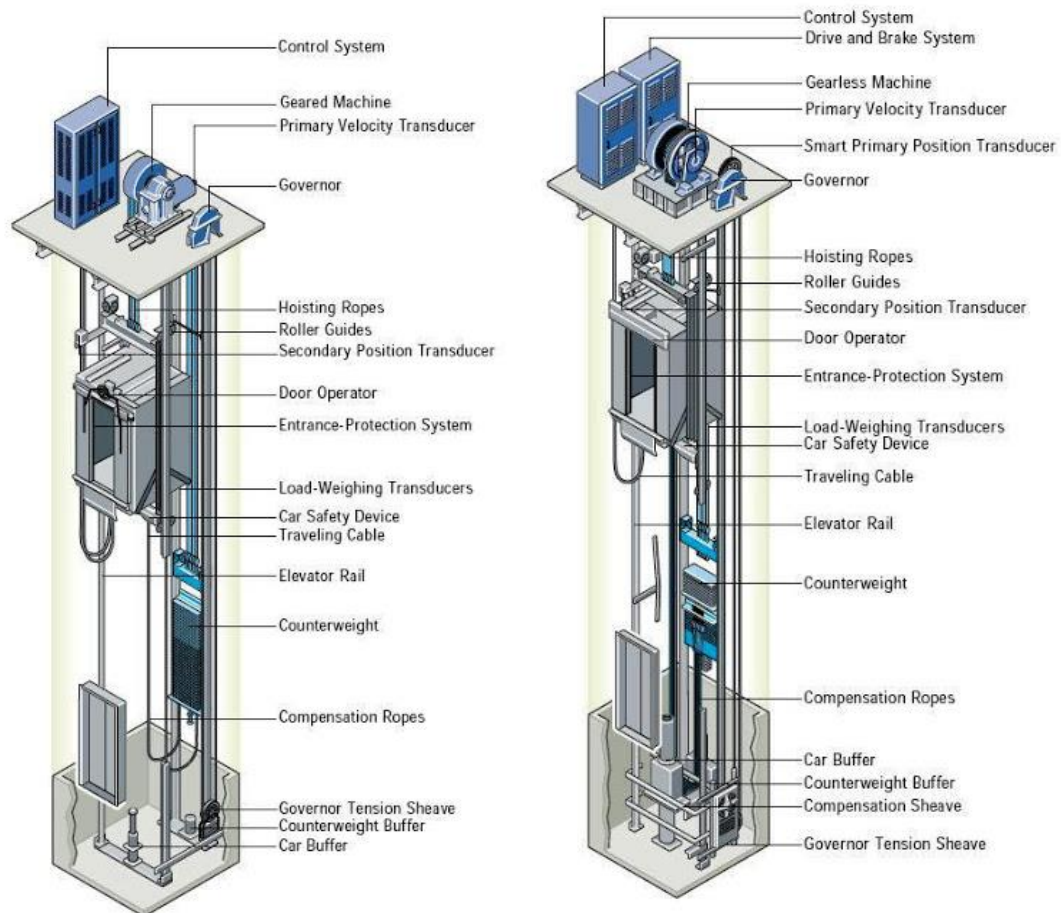


Figure2.9: Geared traction elevators Figure2.10: Gear-less traction elevators

- **Climbing elevator:** They hold their own power device on them, mostly electric or combustion engine. Climbing elevators are often used in work and construction areas.
- **Pneumatic Elevators:** Pneumatic elevators are raised and lowered by controlling air pressure in a chamber in which the elevator sits. By simple principles of physics; the difference in air pressure above and beneath the vacuum elevator cab literally transports cab by air. It is the vacuum pumps or turbines that pull cab up to the next Floor and the slow release of air pressure that floats cab down. They are especially ideal for existing homes due to their compact design because excavating a pit and hoist way are not required. (Show Figure 2.11).

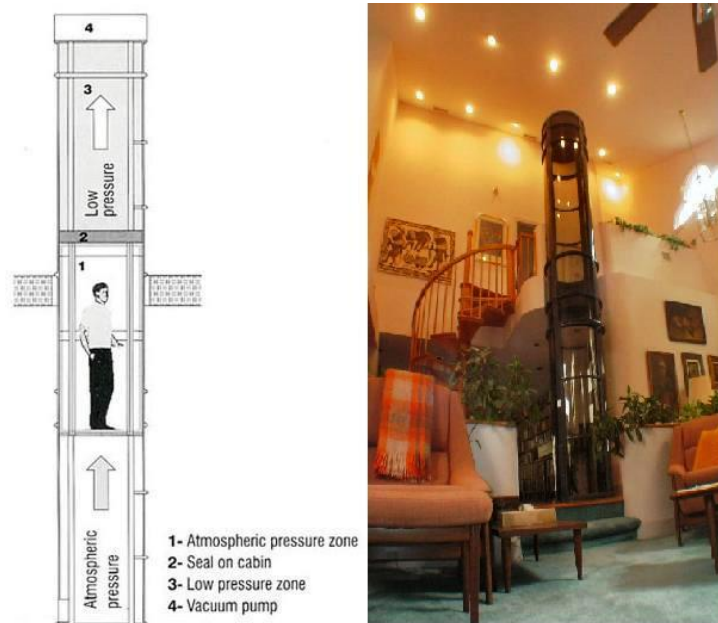


Figure 2.11: Pneumatic elevators

2.3.2 According to building height

- Low-Rise buildings (1- 3 stories): Buildings up to about (1 to 3) stories typically use hydraulic elevators because of their lower initial cost.
- Mid-Rise buildings (4 -11 stories): Buildings up to about (4 to 11) stories typically use geared traction elevators.
- High-Rise buildings (12 + stories): Buildings up to about 12+ stories typically use gear-less traction elevators.

2.3.3 According to building type

Elevators will be classified according to building type to 6 main types as follows:

- i. Hospital elevators.
- ii. Residential /Domestic elevators.
- iii. Agricultural elevators.
- iv. Industrial elevators.

- v. Commercial elevators.
- vi. Parking buildings elevators.

2.3.4 Elevators classification according to elevator location

i. Outdoor Elevators: Common types of outdoor elevators are cargo elevators, platform elevators, and incline and vertical elevators.

ii. Indoor elevators: All elevators installed inside a building which usually need a hoist ways and pits.

2.3.5 Elevators classification according to special uses

i. Handicap Elevators: In reality, any type of elevator that can assist a handicapped person in going up and down various levels of the building could be considered a handicap elevator.

ii. Grain Elevators: A grain elevator is a tower containing a bucket elevator, which scoops up, elevates, and then uses gravity to deposit grain in a silo or other storage facility.

iii. Double-deck elevator: Double-deck elevators save time and space in high-occupancy buildings by mounting one car upon another. One car stops at even floors and the other stops at the odd floors. Depending on their destination, passengers can mount one car in the lobby or take an escalator to a landing for the alternate car.

iv. Sky Lobby: In very tall buildings, elevator efficiency can be increased by a system that combines express and local elevators. The express elevators stop at designated. ^[2, 3]

CHAPTER THREE

ELEVATOR CONTROL SYSTEM

3.1 Introduction

Automatic control has played a vital role in the advance of engineering and science. In addition to its extreme importance space-vehicle systems, missile-guidance systems, robotic systems, and the like, automatic control has become an important and integral part of modern manufacturing and industrial processes. For example, automatic control is essential in the numerical control of machine tools in the manufacturing industries, in the design of autopilot systems in the aerospace industries, and in the design of cars and trucks in the automobile industries. It is also essential in such industrial operations as controlling pressure, temperature, humidity, viscosity, and flow in the process industries.

Since advances in the theory and practice of automatic control provide the means for attaining optimal performance of dynamic systems, improving productivity, relieving the drudgery of many routine repetitive manual operations, and more, most engineers and scientists must now have a good understanding of this field.

3.2 Closed-Loop Control Versus Open-Loop Control

A system that maintains a prescribed relationship between the output and the reference input by comparing them and using the difference as a means of control is called a feedback control system. An example would be a room temperature control system. By measuring the actual room temperature and comparing it with the reference temperature (desired temperature), the thermostat turns the heating or cooling equipment on or off in such a way as to ensure that the room temperature remains at a comfortable level regardless of outside conditions.

Feedback control systems are not limited to engineering but can be found in various nonengineering fields as well. The human body, for instance, is a highly advanced feedback control system. Both body temperature and blood pressure are kept constant by means of physiological feedback. In fact, feedback performs a vital function: It makes the human body relatively insensitive to external disturbances, thus enabling it to function properly in a changing environment.

Feedback control systems are often referred to as closed-loop control systems. In practice, the terms feedback control and closed-loop control are used interchangeably. In a closed-loop control system the actuating error signal, which is the difference between the input signal and the feedback signal (which may be the output signal itself or a function of the output signal and its derivatives and/or integrals), is fed to the controller so as to reduce the error and bring the output of the system to a desired value. The term closed-loop control always implies the use of feedback control action in order to reduce system error.

Those systems in which the output has no effect on the control action are called open-loop control systems. In other words, in an open-loop control system the output is neither measured nor fed back for comparison with the input. One practical example is a washing machine. Soaking, washing, and rinsing in the washer operate on a time basis. The machine does not measure the output signal, that is, the cleanliness of the clothes.

In any open-loop control system the output is not compared with the reference input. Thus, to each reference input there corresponds a fixed operating condition; as a result, the accuracy of the system depends on calibration. In the presence of disturbances, an open-loop control system will not perform the desired task. Open-loop control can be used, in practice, only if the relationship between the input and output is known and if there are neither internal nor external disturbances. Clearly, such

systems are not feedback control systems. Note that any control system that operates on a time basis is open loop. For instance, traffic control by means of signals operated on a time basis is another example Of open-loop control.

An advantage of the closed loop control system is the fact that the use of feedback makes the system response relatively insensitive to external disturbances and internal variations in system parameters. It is thus possible to use relatively inaccurate and inexpensive components to obtain the accurate control of a given plant, whereas doing so is impossible in the open-loop case.

From the point of view of stability, the open-loop control system is easier to build because system stability is not a major problem. On the other hand, stability is a major problem in the closed-loop control system, which may tend to overcorrect errors and thereby can cause oscillations of constant or changing amplitude.

It should be emphasized that for systems in which the inputs are known ahead of time and in which there are no disturbances it is advisable to use open-loop control. Closed loop control systems have advantages only when unpredictable disturbances and/or unpredictable variations in system components are present. Note that the output power rating partially determines the cost, weight, and size of a control system. The number of components used in a closed-loop control system is more than that for a corresponding open-loop control system. Thus, the closed-loop control system is generally higher in cost and power. To decrease the required power of a system, open-loop control may be used where applicable. A proper combination of open-loop and closed-loop controls is usually less expensive and will give satisfactory overall system performance.

There are many applications use the concept of open loop and closed loop control like microcontrollers, PLCs, etc. ^[4]

3.3 Microprocessor, microcomputer and microcontroller

Microprocessor is a Central Processing Unit (CPU) that is compacted into a single chip semiconductor device. It is a general-purpose device, suitable to perform many kinds of applications. When the microprocessor is combined with input or output and memory devices, it is called microcomputer. The choice of these devices that are combined depends on the specific application. For example, most personal computers contain a keyboard and monitor as standard input and output devices.

The major difference of a microcontroller compared to a microprocessor and microcomputer is that microcontroller consists of CPU, memory devices (ROM and RAM), input and output ports and timer embedded into a single chip. They also have many on-chip facilities such as serial port, counters, analog to digital converter and interrupt control so that they can be interfaced with hardware and control functions of many kinds of application. It is ideal for many applications in which cost and space are critical.

Microcontroller has a wide range of applications in many control-oriented activities. For example, they are used as engine controllers in automobiles and as exposure and focus controllers in cameras as well as they are used in an elevator control system.^[4] The different between the microprocessor and microcontroller shown in figure below:

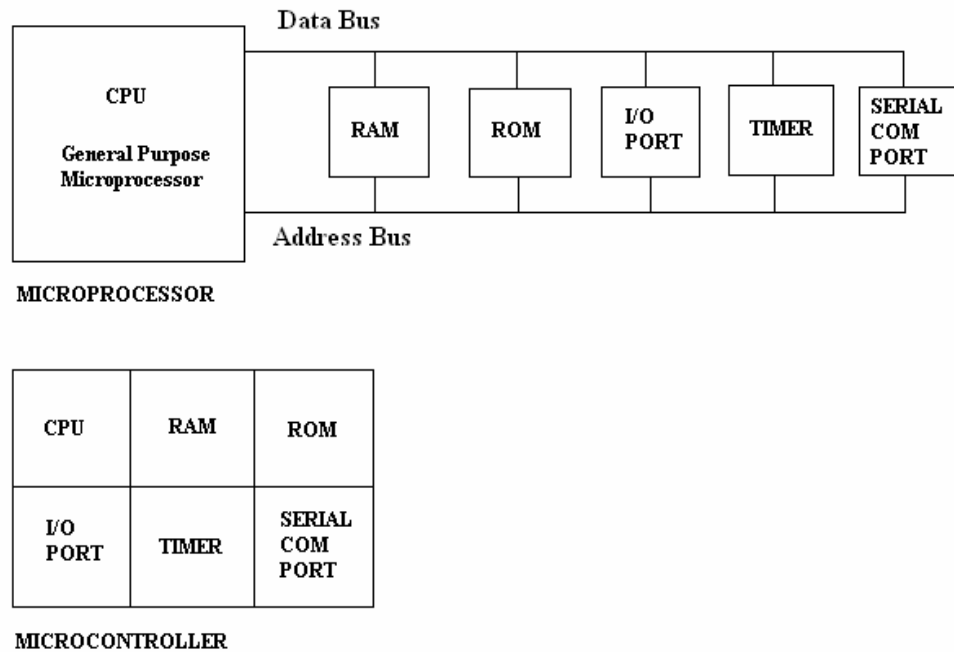


Figure 3.1: The difference between microprocessor and microcontroller

3.4 Elevator Control System Components

Elevator control system is the system responsible for coordinating all aspects of elevator 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 (elevator cars moving, doors opening, etc.). The main aims of the elevator control system are:

- To bring the elevator car to the correct floor.
- To minimize travel time.
- To maximize passenger comfort by providing a smooth ride.
- To accelerate, decelerate and travel within safe speed limits.

The elevator as a control system has a number of components. These can basically be divided into the following: Inputs, Outputs and Controllers. ^[5] The general elevator flow chart shown in figure below:

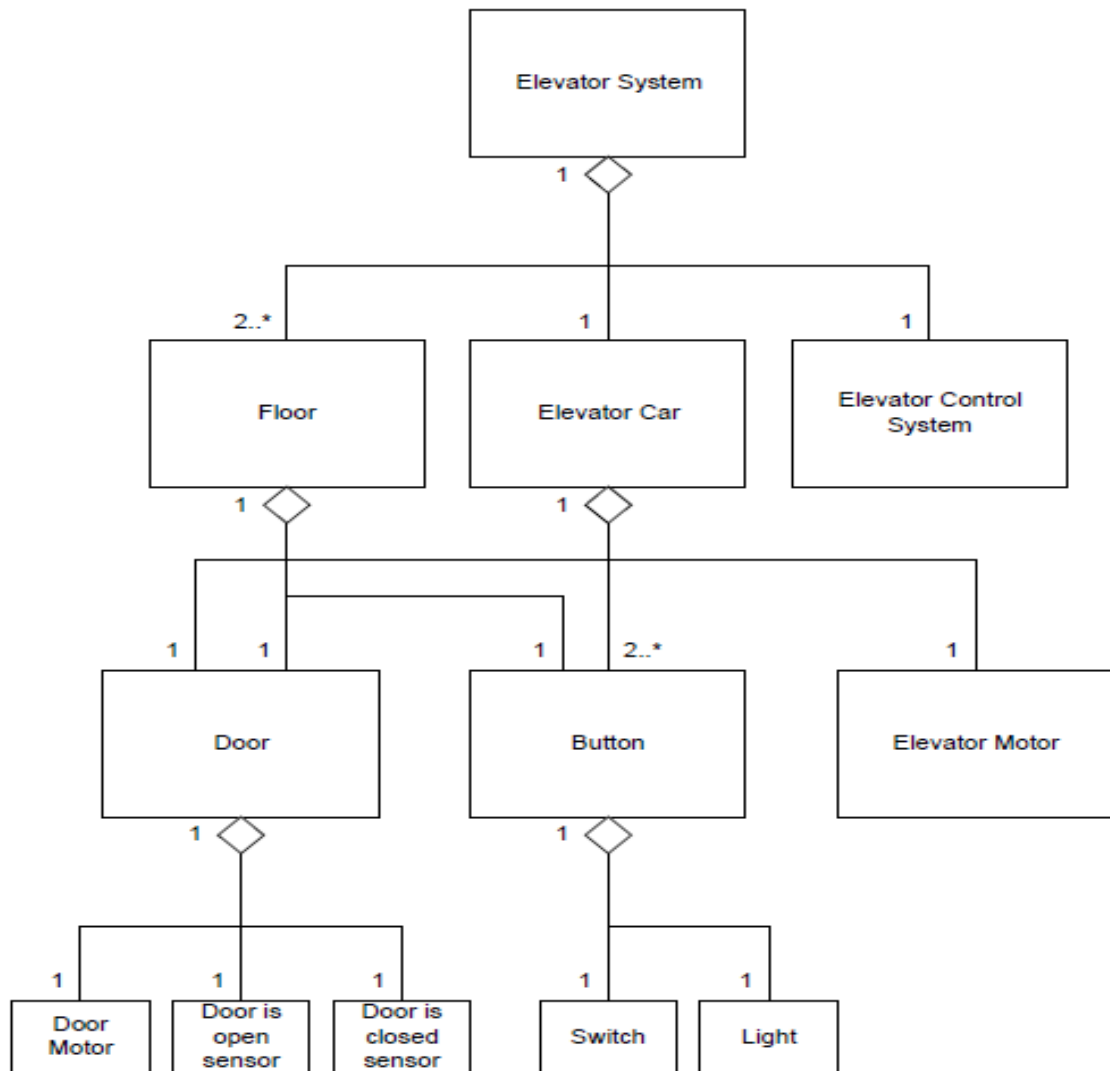


Figure 3.2: General elevator flow chart

3.4.1 Inputs

Which include: Sensors, Buttons, Key controls and System controls.

i. Sensors

- **Magnetic and/or photo electric:** These pick up signals regarding the location of the car.
- **Infrared:** This is used to detect people entering or leaving the elevator.

- Weight sensor (Overload Device): This is placed on the car to warn the control system if the design load is exceeded.
 - PVT (primary velocity transducer): Velocity of the drive sheave is sensed with this encoder.
- ii. Buttons:
- Hall buttons: These buttons are on a button panel on the outside of the elevator shafts and are used by potential passengers to call an elevator cab to the floor that the pressed summon button is located on.
 - Floor request buttons: These buttons are located on a button panel on the interior of each elevator cab. The controller interacts with these buttons by receiving pressed signals indicating the desired floor number.
 - Open door button: This button is on the interior button panel of each cab. A passenger can press this button to open the elevator doors or keep pressing it to keep them open.
 - 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.
 - Emergency bell button: This button is on the interior button panel of each cab. A passenger can press this button to sound a bell to alert people outside of the elevator shaft that someone is trapped inside the elevator cab in case of a malfunction.
- iii. Key controls:
- Key controls may only be activated by the proper keys, and their use is thus restricted to repair people, elevator operators or firemen.
- iv. System controls:
- System controls are used to turn the elevator system on or off, system controls are only accessible from an elevator control room.

3.4.2 Outputs

Which include: Actuators, Bells and Displays

i. Actuators

- Door opening device: On top of each elevator cab is a door opening device. This device opens the inner door of the elevator cab and the outer door of the elevator shaft simultaneously at each floor.

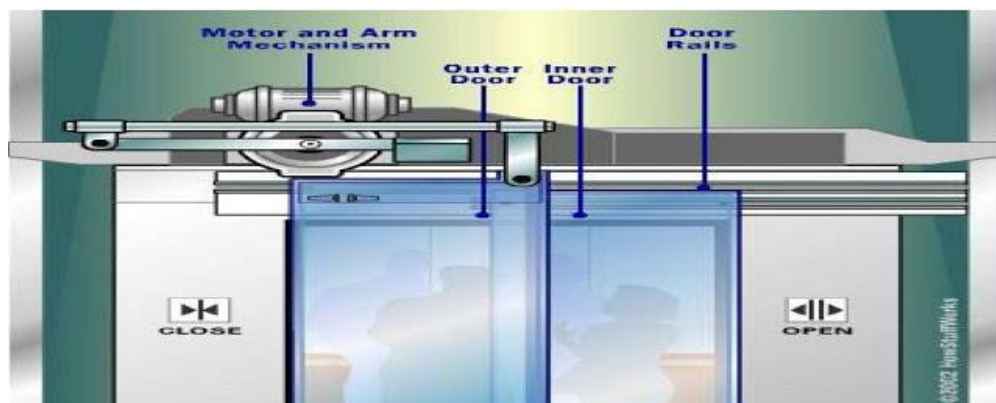


Figure 3.3: Door opening device

- Electric motor: The elevator motor is responsible for moving an elevator cab up and down between floors.
 - Brakes: There are a few brake systems in a typical elevator system. These include the electromagnetic and mechanical brakes.
- ii. Bells:
- Emergency bell: Somewhere in the elevator system is an emergency bell that is used to alert people outside of the elevator system that someone is trapped inside an elevator cab.
 - Load bell: Each cab has a load bell that is used to alert the passengers inside the cab that there is too much weight in it to operate it safely.

iii. Displays

- Car position display: The interior of each elevator cab has a display that indicates to its passengers which floor the elevator cab is currently on.
- Direction display: The interior of each elevator cab has a display that indicates the current direction of an elevator cab; it is either up or down.

3.4.3 Controller

The controller is a device which manages the visual monitoring, interactive command control and traffic analysis system to ensure the elevators are functioning efficiently. The primary function of the elevator controller is essentially to receive and process a variety of signals from several different components of a whole elevator 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 elevator controller is able to keep the elevators 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 elevator system:

- Controls the speed of elevator engines in order to move elevator cabs up and down their respective shafts.
- Queues and processes elevator 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 cab never exceeds the safety limit.
- Processes information sent to it by position marker sensors in order to keep track of where the elevator cabs 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 cab.
- Can sound alarm bells that are either invoked by trapped passengers or required to warn of excess load in a cab.
- Controls the operation of the elevator doors of a cab through communication with door opening devices.

There are 3 primary types of controller technology used to process the logic of the controller as follows:

- Relay based controller (electromechanical switching): A relay is a very dependable device consisting of an electromagnet that opens and closes contacts, routing the logic to various circuits. A simple elevator with a few stops and manual door operation can be served well by a relay controller. Relays can also be used for more complex elevators, and in fact were until the 1980's. However, the number of relays required can make it difficult to troubleshoot should there ever be a problem. The following applications may be recommended as suitable for controllers using electromagnetic relay technology:
 - Single elevators only.
 - Drive speed up to 1 m/s.
 - Passenger elevators in low traffic and usage situations in low-rise buildings, i.e. not more than three stories (e.g. residential buildings, very small hotels, nursing homes).
 - Goods, bullion elevators in low-rise commercial buildings (e.g. offices, hotels, hospitals).
- Solid-State Logic Technology: It includes both discrete transistors circuits and integrated circuit boards. It gives improved reliability, lower power consumption and easy fault diagnosis than electromagnetic relay technology.

The following applications are recommended as suitable for controllers using solid-state logic technology:

- Single elevators and duplex groups.
- Drive speed up to 2 m/s.
- Passenger elevators in low traffic situations in medium-rise buildings, i.e. up to 12 stories (e.g. residential buildings and small hotels).
- Goods, bullion elevators in low-rise commercial buildings (e.g. offices, hotels, hospitals).

iii. PLC controller (computer based technology) : The advent of personal computers has made microprocessor technology affordable for many other fields. Elevator Concepts utilizes a special type of industrial computer called a Programmable Logic Controller PLC to control the logic of more complex jobs. They are very dependable, compact, and simple to troubleshoot.

Computer based controllers are suitable for the following:

- All elevators types.
- All drive speeds (i.e. 0.5 m/s to 10 m/s).
- Elevator groups of all sizes. ^[6, 7, 8]

CHAPTER FOUR

CIRCUIT COMPONENTS AND ANALYSIS

4.1 Introduction

This type of elevator is constructed to cover four floors (up and down) using servo motor. The controller controls motor operation, receiving commands from different location, safety operations, security operations, and be able to interface with computer.

4.2 System Block Diagram

The main elevator control system block diagram represented by Figure 4.1:

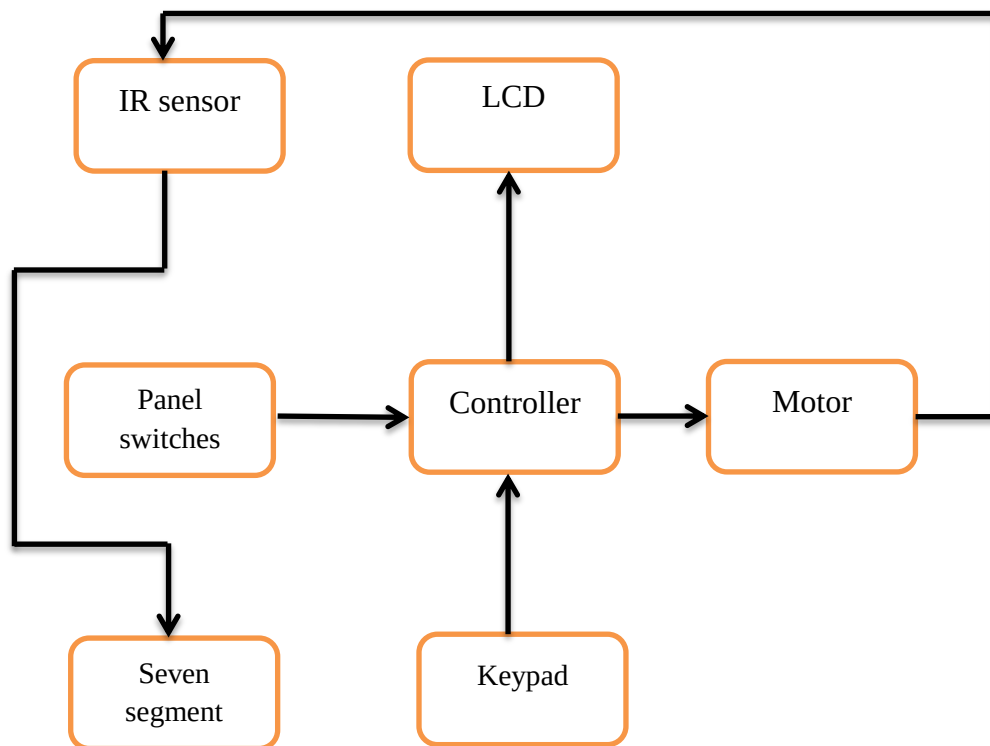


Figure 4.1: Main elevator control system block diagram

- IR sensor: to indicate the position of the elevator room.
- Panel switch (push buttons): to give the user the ability to press a button to select the level.
- Controller (Arduino): to control the motor and read from sensors.
- LCD: to display all of the activities that the controller is working on.
- Keypad: for the security code for the user.
- Seven segment: to indicate the level of the elevator room.
- Motor: servo motor to move the elevator car.
- Thermal sensor: gives an alarm when there is a fire.

4.3 System Components

The main components were used to build the elevator are:

- i. Arduino mega 2560.
- ii. Continuous rotation servo motor SM-S4315R.
- iii. Radio Frequency Identification (RFID).
- iv. IR Sensors.
- v. Magnetic proximity switch sensor.
- vi. Thermal sensor.
- vii. Liquid crystal display LCD 16×2 as an output port.
- viii. Keypad as an input port.
- ix. Seven segment.

These components will be defined briefly, and then its connection with each other will be cleared.

4.3.1 Arduino

Arduino is an open-source computer hardware and software company, project and user community that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control the physical world.

The project is based on a family of microcontroller board designs manufactured primarily by Smart Projects in Italy, and also by several other vendors, using various 8-bit Atmel AVR microcontrollers or 32-bit Atmel ARM processors. These systems provide sets of digital and analog I/O pins that can be interfaced to various expansion boards ("shields") and other circuits. The boards feature serial communications interfaces, including USB on some models, for loading programs from personal computers.

For programming the microcontrollers, the Arduino platform provides an integrated development environment (IDE) based on the processing project, which includes support for C, C++ and Java programming languages.

The first Arduino was introduced in 2005, aiming to provide an inexpensive and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

Arduino boards are available commercially in preassembled form, or as do-it-yourself kits. The hardware design specifications are openly available, allowing the Arduino boards to be manufactured by anyone. Adafruit Industries estimated in mid-2011 that over 300,000 official Arduinos had been commercially produced, and in 2013 that 700,000 official boards were in users' hands.

- Arduino mega 2560: The Arduino/Genuino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for Arduino/Genuino Uno and the former boards Duemilanove or Diecimila. Figure 4.2 shows the Arduino mega.^[9]

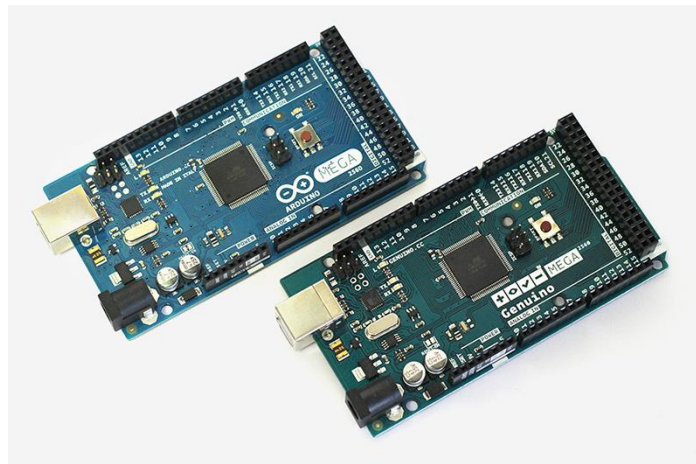


Figure 4.2: Arduino mega 2560

The Arduino mega specifications shown in Table 4.1.

Table 4.1: Technical specifications

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	54
PWM Digital I/O Pins	14
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB
Flash Memory for Bootloader	8 KB
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
Length	101.52 mm
Width	53.3 mm
Weight	37

4.3.2 Servo motor

A servomotor is a rotary actuator that allows for precise control of angular position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system.

Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing.

- continuous rotation servo motor: Continuous rotation servos are servos which do not have a limited travel angle, instead they can rotate continuously. They can be thought of as a motor and gearbox with servo input controls. In such servos the input pulse results in a rotational speed, and the typical 1.5 ms center value is the stop position. A smaller value should turn the servo clockwise and a higher one counterclockwise. Figure 4.3 Shows a continuous rotation servo motor SM-S4315R



Figure 4.3: Continuous rotation servo motor SM-S4315R

4.3.3 Radio frequency identification

RFID is the wireless use of electromagnetic fields to transfer data, for the purposes of automatically identifying and tracking tags attached to objects, generally a RFID system consists of 2 parts. A Reader, and one or more Transponders (Tags). RFID systems evolved from barcode labels as a means to automatically identify and track products and people, it widely used in: Access Control, Contactless Payment Systems and Product

Tracking and Inventory Control. In every RFID system the transponder Tags contain information, this information can be as little as a single binary bit, or be a large array of bits representing such things as an identity code, personal medical information, or literally any type of information that can be stored in digital binary format. Figure 4.4 shows the RFID.

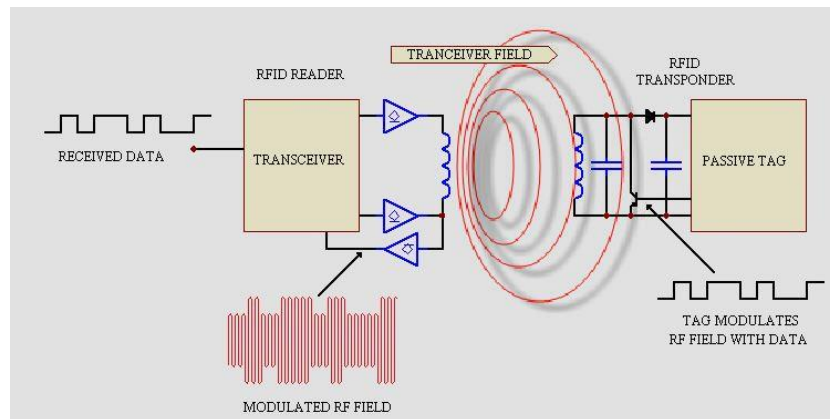


Figure 4.4: RFID

Shown is a RFID transceiver that communicates with a passive Tag. Passive tags have no power source of their own and instead derive power from the incident electromagnetic field. Commonly the heart of each tag is a microchip. When the Tag enters the generated RF field it is able to draw enough power from the field to access its internal memory and transmit its stored information. When the transponder Tag draws power in this way the resultant interaction of the RF fields causes the voltage at the transceiver antenna to drop in value. This effect is utilized by the Tag to communicate its information to the reader. The Tag is able to control the amount of power drawn from the field and by doing so it can modulate the voltage sensed at the Transceiver according to the bit pattern it wishes to transmit.^[10]

4.3.4 IR sensor

Infra-red (IR) is an electromagnetic wave whose wavelength is between 0.75 microns to 1000 microns (1 micron = 1 μ m). Since infra-red is out of visible light range, IR cannot be seen with naked eye. Some of the Infra-Red applications include night vision, hyper spectral imaging, and

communications. IR also used daily in TV remote or any device remote. Figure 4.5 shows an IR sensor.

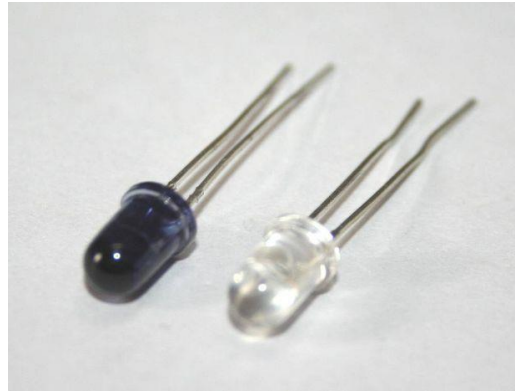


Figure 4.5: Infra-red

IR transmitter and receiver can be obtained at low price. Their shape is looks exactly the same as LED. To distinguish between transmitter and receiver, the transmitter always comes in clear LED while receiver is black in colour. Other than that, there is also receiver that is used to pick up specific frequency IR, 38kHz. For your information, 38kHz frequency IR is commonly used in remote control.

4.3.5 Magnetic proximity switch sensor

The magnetic proximity switch sensor is an electrical switch operated by an applied magnetic field. The magnetic sensor contains a pair (or more) of magnetizable, flexible, metal reeds whose end portions are separated by a small gap when the switch is open. The reeds are hermetically sealed in opposite ends of a tubular glass envelope. Figure 4.6 shows the magnetic proximity switch sensor components.

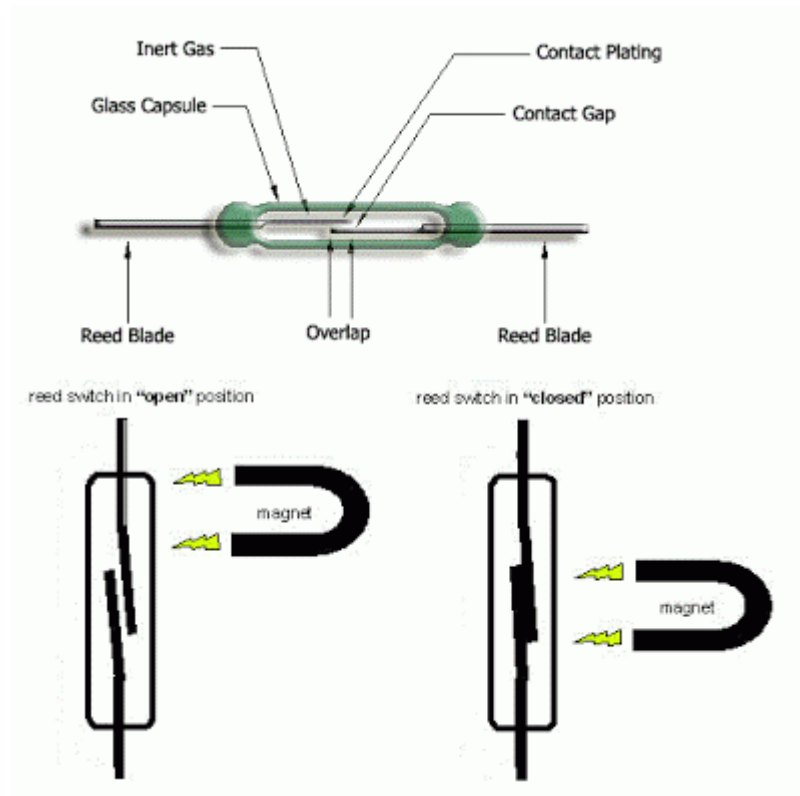


Figure 4.6: Magnetic sensor

4.3.6 Thermal sensor

LM35 is a precision IC temperature sensor with its output proportional to the temperature (in $^{\circ}\text{C}$). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor. It also possess low self-heating and does not cause more than 0.1°C temperature rise in still air.

The operating temperature range is from -55°C to 150°C . The output voltage varies by 10mV in response to every $^{\circ}\text{C}$ rise/fall in ambient temperature, *i.e.*, its scale factor is $0.01\text{V}/^{\circ}\text{C}$. Figure 4.7 shows the temperature sensor LM35.



Figure 4.7: LM35 sensor

4.3.7 Liquid crystal display

A liquid-crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly.

The LCD screen is more energy efficient and can be disposed of more safely than a cathode ray tube CRT. Its low electrical power consumption enables it to be used in battery-powered electronic equipment. It is an electronically modulated optical device made up of any number of segments filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or monochrome. Liquid crystals were first discovered in 1888. By 2008, annual sales of televisions with LCD screens exceeded sales of CRT units worldwide, and the CRT became obsolete for most purposes. Figure 4.8 shows liquid crystal display.



Figure 4.8: Liquid crystal display

4.3.8 Keypad

A keypad is a set of buttons arranged in a block or "pad" which usually bear digits, symbols and usually a complete set of alphabetical letters. If it mostly contains numbers then it can also be called a numeric keypad. Keypads are found on many alphanumeric keyboards and on other devices such as calculators, push-button telephones, combination locks, and digital door locks, which require mainly numeric input. Figure 4.9 shows the keypad.



Figure 4.9: Keypad

4.3.9 Seven segment

A seven segment display is the most basic electronic display device that can display digits from 0-9. They find wide application in devices that display numeric information like digital clocks, radio, microwave ovens, electronic meters etc. The most common configuration has an array of eight LEDs arranged in a special pattern to display these digits.

Seven segment displays are of two types, common cathode and common anode. In common cathode type, the cathode of all LEDs are tied together to a single terminal which is usually labeled as 'com' and the anode of all LEDs are left alone as individual pins labeled as a, b, c, d, e, f,

g & h (or dot) . In common anode type, the anodes of all LEDs are tied together as a single terminal and cathodes are left alone as individual pins.

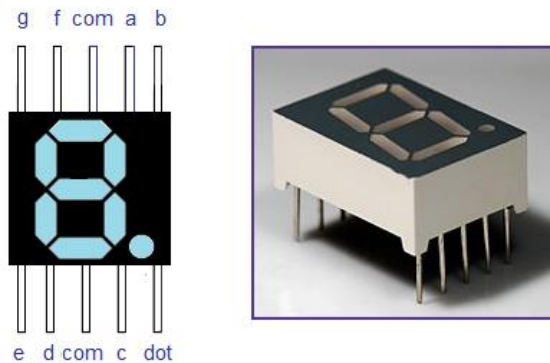


Figure 4.10: Seven segment

4.4 Circuit Implementation and Connection

The elevator control system flow chart shown in figure below :

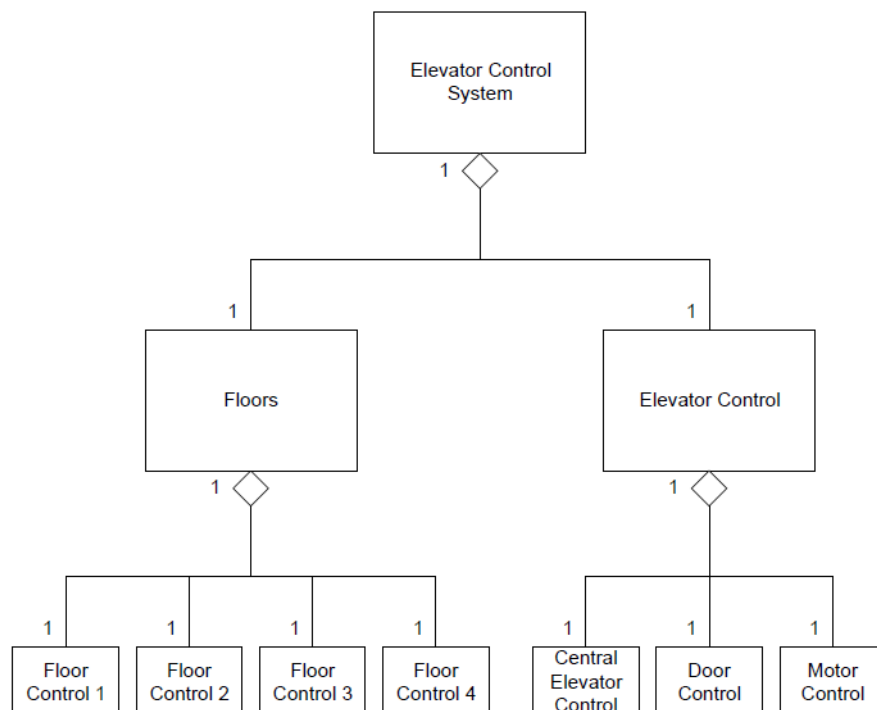


Figure 4.11: Elevator control system flow chart

The model was implemented for three floors beside the ground floor, the materials were used to build the model are (aluminum, fiber and wood), the wires connected to PCBs and bread board. In programming section there are two modes can be chosen by the user.

First: password mode: in this mode the system should ask for a password (each floor has its own password) , only after entering the correct password the motor will take the elevator car to the desired floor.

This mode work as a security mode, it can be used in commercial buildings, or in high-security buildings where are not any person is allowed to use elevator service.

Second: VIP mode: this mode gives the ability of controlling the motor by using computer requests, in other meaning if there is an important person (manager, VIP visitor), coming to the building, it is not right to make him wait for the elevator, so by using this mode, the receptionist can be able to bring elevator car to any floor without any delay.

- Connection section: First of all there are four magnetic sensors in each door connected in pin (9) in the Arduino, for purpose of protection, if any door opened, the motor will never move.

Request switches connected as: ground floor to pin (6), floor one to pin (12), floor two to pin (7), floor three to pin (11).

IR sensors signal connected as: ground floor to pin (5), floor one to pin (4), floor two to pin (3), floor three to pin (2).

Note: it is important to know that IR signal is normally high unless there is something cut the signal between transmitter and receiver.

Seven segments connected with each other in serial and connected to the Arduino in pins (22, 23, 24, 25, 26, 27, and 28).

Motor signal connected to pin (10).

LCD connected to pins (44, 45, 46, 47, 48, and 49).

Keypad connected to pins (32, 33, 34, 35, 36, 37, 38, and 39).

Thermal sensor connected to pin(A0).

4.5 Elevator Control System State Diagram

In the state diagram each state represent a floor and the transporting from one state to another require a certain condition. The middle states is a special states where the elevator supposed to reverse its movement but that only can be done when there is only one request, in other words the request is about calling the elevator down while the request from upper floor or vise versa. ^[11]

Figure 4.12 shows the state diagram of the elevator.

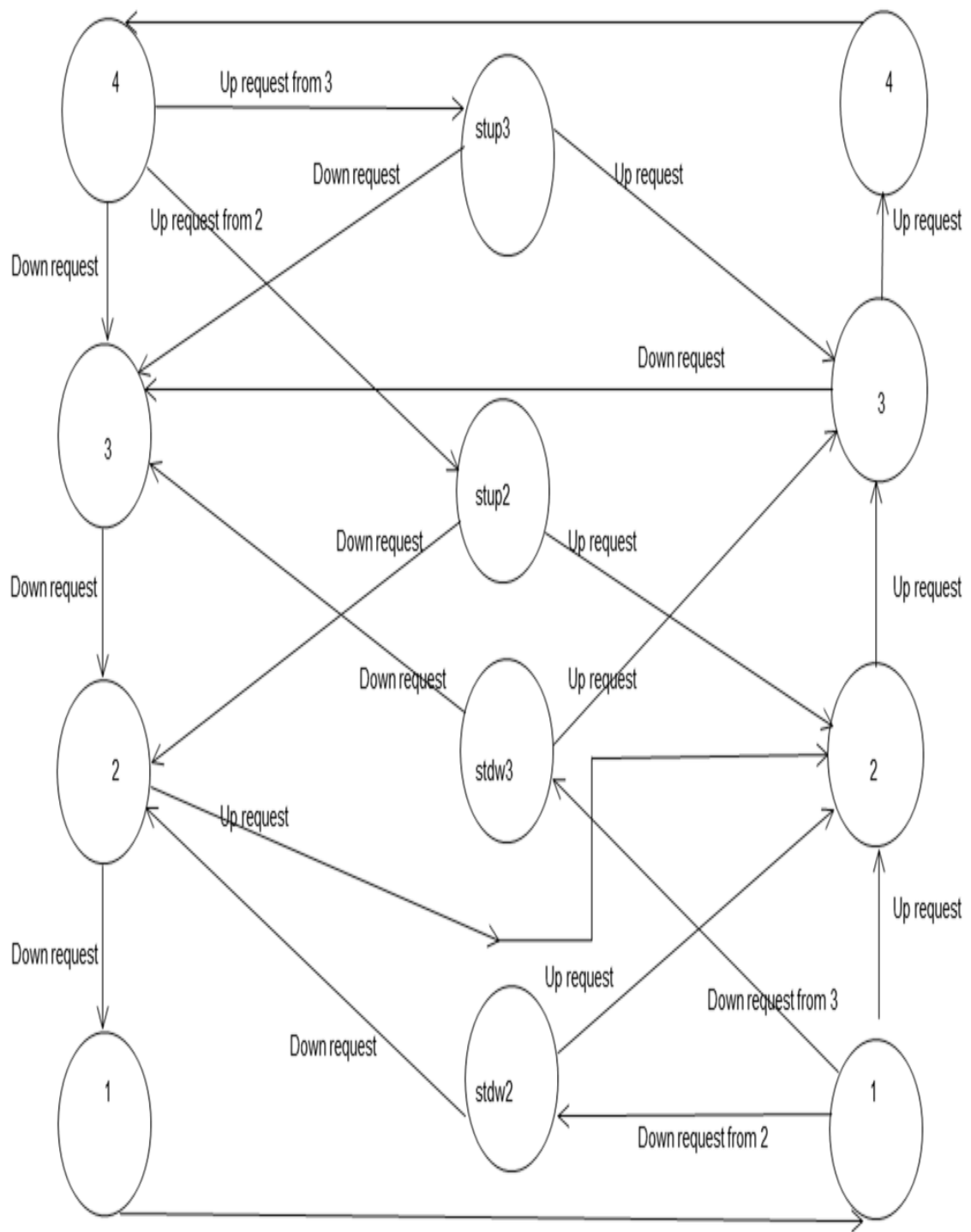


Figure 4.12: The elevator state diagram

CHAPTER FIVE

CONCLUSION AND RECOMONDATIONS

5.1 Conclusions

An intelligent elevator control system model had been built based on an Arduino mega 2560 able to interface with the users throw LCD, request button, seven segments and a security keypad or a computer interfacing.

The Arduino was programed to work as a controller of the model as the priority and requesting elevator algorithm and fire alarming and finally, integrate those systems into the model.

This system can be reprogrammed to interface with more floors for future, or to add new operation instructions.

5.2 Recommendations

- In the more complex elevator where there is more conditions to test, calculate and analysis it is better to use one of the well-known control theories like the fuzzy controlling or use the computer calculation methods.
- More advanced security systems can be integrated like the fingerprint, face, voice, retina or any other kind of biological security system, it could be more secure but more expensive.
- The requesting methods can be more various by adding SMS remote request service or wireless requesting using the internet for the VIP or special cases.
- The doors can be able to open as an automatic door for more flexibility and more advance control, but it is more financially disturbing.

REFERENCES

- [1] Robert Beyer, "Specification Series: Elevators - First Things First", 1994.
- [2] Lava Computer MFG Inc," IEEE 1284: Parallel Ports", Lava Computer MFG Inc, 2002.
- [3] Sajal K. Das, "Mobile Handset Design', John Wiley & Sons", 2010.
- [4] Steven F Barrett, Daniel Pack, Mitchell Thornton, "Atmel AVR Microcontroller Primer: Programming and Interfacing", 2007.
- [5] Van Valkenburg, Mac E, "Reference Data for Engineers", Fairford, GLO, United Kingdom, 2005.
- [6] John Bird, "Electrical and Electronic Principles and Technology", Elsevier Limited, 2010.
- [7] Lambert M. Surhone, Miriam T. Timpledon, Susan F. Marseken, "Printed Circuit Board", VDM Verlag Dr. Mueller e.K., 2010.
- [8] Bhattacharya S. K., "Control Systems Engineering", Pearson Education, India, 2008.
- [9] General Books LLC, "Elevators: Elevator Music, Elevator, Paternoster, Stair lift, Minato Ward 2006 Elevator Accident, Elevator Consultant, Dumbwaiter", General Books LLC, 2010.
- [10] Electrical Engineering and Control: Selected Papers from the 2011 International Conference on Electric and Electronics (EEIC 2011) in Nanchang, China on June 20-22, 2011.
- [11] Martin Bates," PIC Microcontrollers: An Introduction to Microelectronics", Elsevier, 2004 .