Palestine Polytechnic University

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Graduation Project
ANTI-Theft Smart Braking System

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January -2008

Acknowledgement

First off all, we would like to thank our god for the help to complete this wok successfully, and we would like to acknowledge and thank Palestine Polytechnic University for the efforts they had done in order to facilitate our work.

We would like to thank our supervisor Dr. Mohammad Al Qawasme For his help and continuous encouragement to the team work.

Our project is a result of hard work and participation among us "the project team" and our supervisor who gave us all his energy and experience in order to pass this project.

Finally, we would like to thank our families because of there support and encouragement through our study time, then we want to thank our friends and any one help us to finish the work.

ABSTRACT

Because of the increase in cases of cars stealing and malfunctioning of the alarm and security systems of the cars, A need for smart and efficient security systems is increasing; these systems must be constructed depending on new created technologies; For this reason this project is chosen to design a clever and efficient security system.

All security systems depend on light and sound alarm, and it's can't prevent the thief from stealing the car, cause of this a need for a security system can prevent a car stealing is so important.

The idea of the project to design a new security system has the ability to lock the wheels when the car is parking, and recognize the user by a password to unlock the wheels, this idea will make the car as stone in its place and prevent any one from moving it unless it's user.

This System consists of two parts, electronic and hydraulic system. The electronic system controls the hydraulic system through a code entered by the user; the hydraulic system locks the wheels of the car through braking system with some necessary changes in the design of braking system, to ensure that this system operate well; an explanation is provided in this document.

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Chapter One

Introduction

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1.1 General Idea about Project:

Rather than advancing technology in electronics and security systems, the stealing is not stopped, but it's also increased.

The main function of the proposed system is to prevent the car from being stolen through building a security system that locks the wheels.

A new vehicle security system will be design to prevent a car stealing; by applying braking forces on wheels when alarm system on.

During normal operation of brake system, an accumulator shares hydraulic pressure, accumulator pressure will be released by using two solenoids (NC) located in the accumulator gate; this operation is controlled by password code.

1.2 Importance of the Project:

In our project we are going to design the "Anti-Theft Smart Braking System" because of the following reasons:

- ✓ The importance and use of this system in the vehicles to prevent a car stealing.
- ✓ The importance to design a new car security system which can recognize the car user by the password.
- ✓ To design this system with high efficiency and low cost for the consumer to be able to buy it.

1.3 Project Objectives:

1. Development of new alarm system.
2. Building a new system on the car incorporation with hydraulic components of brake system.
3. Designing control unit for controlling the hydraulic components by using electrical circuit.
4. The new system will eliminate the need of hand brake (parking brake).

1.4 Time Consumed:

This table introduces the time period which have been taken in order to finish the project and the work progress each week.

Work progress	Time Consumed
Selecting the project	Six Weeks
Collecting primary information about our project form references, internet, catalogs and companies deal with this subject.	Four Weeks
Determining the necessary components needed in the project.	Two Weeks
Writing the first part of the project	Two Weeks
Rewrite the first part of project.	Three Weeks
Design the system and determine components specification and location in the system.	Tow Week

Search about the hydraulic and electronic components.	Four Weeks
Built the electronic code lock circuit and testing it.	Two Weeks
Built the hydraulic system and connecting it to electronic code lock circuit and testing the whole system.	Two Week
Write the final report.	One Week

Table 1.1 Time consumed

1.5 Cost:

The cost for hydraulic system per wheel will be as follows:

Component	Units	Cost
Solenoid	2	40$x2
Accumulator	1	50$
Check valve	2	10$x2
Pipes & Junctions		5$
Total		155$

Table 1.2 Cost for hydraulic system

The cost for electronic code lock circuit will be as follows:

Component	Units	Cost
Pic 16F84	1	15$
keypad	1	15$
Keypad encoder	1	13$
Transistor	2	1$x2

Relay	2	3$x2
Crystal	1	8$
Resistors & Capacitors		5$
Led	2	1$x2
Wires		5$
Voltage regulator	1	2$
Electronic Board		5$
Sockets	5	1$x5
Total		93$

Table 1.3   Cost for electronic code lock circuit

1.6 Description of chapters:

This project contains six chapters and these chapters can be summarized as the following:

Chapter 1: Introduction.

Chapter 2: Development of alarm systems in vehicles.

Chapter3: General idea of proposed alarm system, principle of operation and main components.

Chapter 4: Detailed principle of operation of the proposed system.

Chapter 5: Electronic codes lock circuit of the system.

Chapter Two

Development of alarm systems in vehicles

2.1 Introduction:

The first documented case of a car theft was in 1896, only a decade after gas-powered cars were first introduced.

Cars have been a natural target for thieves: They are valuable, reasonably easy to resell and they have a built-in getaway system. Some studies claim that a car gets broken into every 20 second.

In this chapter general study about current security systems in vehicles will be presented, previous security systems will be presented then disadvantages and advantages of new proposed system will be discussed.

2.2 Definition of Car Alarm System:

An advanced electrical alarm system circuit consists of a sound operation circuit (Srinh) and a flasher circuit. Its function is to control the opening and closing of the car's doors through receiving electrical signals from the sensors attached to the car's body such as a highly sensitive internal microphone.

To increase Safety, an advanced password circuit is used, which is working to increase the security of the alarm system.

2.3 Alarm system's Parts:

Most modern car alarm systems are much more sophisticated by this characteristic. They consist of:

- An array of sensors that can include switches, pressure sensors and motion detectors.

- A siren, often able to create a variety of sounds so that you can pick a distinct sound for your car.

- A radio receiver to allow wireless control from a key fob.

- An auxiliary battery so that the alarm can operate even if the main battery gets disconnected.

- A computer control unit that monitors everything and sounds the alarm -- the "brain" of the system.

The brain in most advanced systems is actually a small computer, and brain's job is to close the switches that activate alarm devices horn, when certain switches that power sensing devices are opened or closed.

Security systems differ mainly in which sensors are used and how the various devices are wired into the brain.

Variety of sensors is listed to see how they work and how they are connected to the alarm system's brain. As shown in fig (2.1).
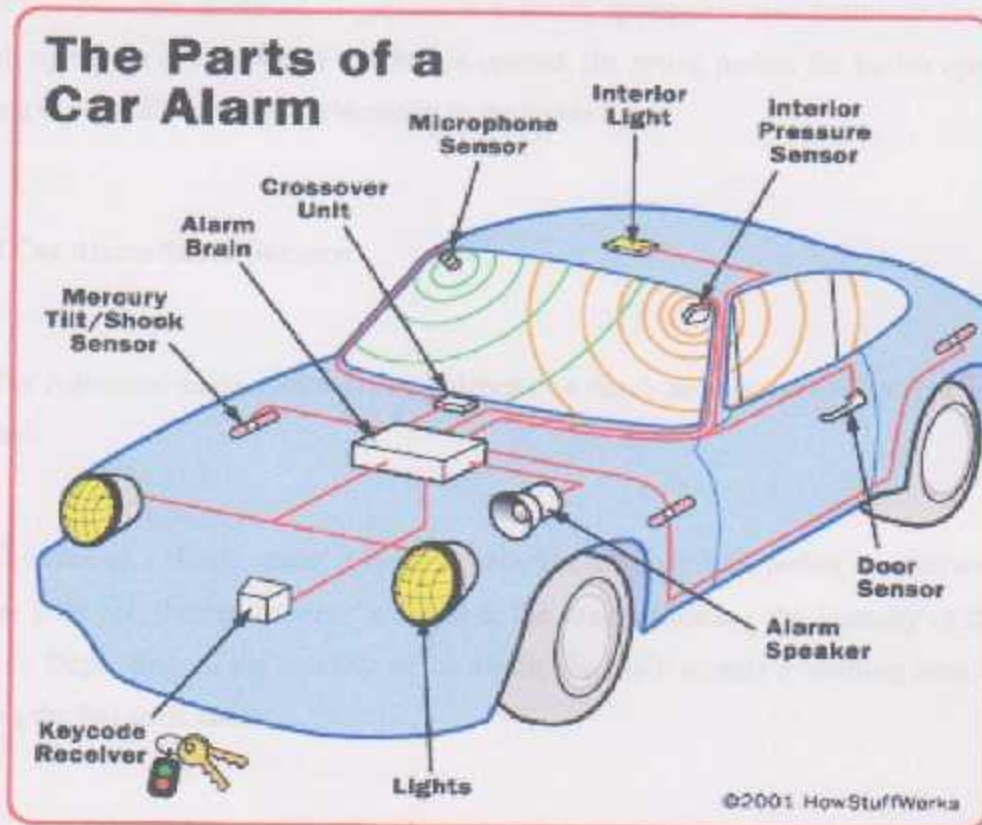
Fig: (2.1) Parts of an Alarm System

2.3.1 Car Alarm Door Sensors:

The most basic element in a car alarm system is the door alarm. When you open the hand of the door, trunk or any door on a fully protected car, the brain triggers the alarm system.

Most car alarm systems utilize the switching mechanism that is already built into the doors. In modern cars, opening a door or trunk turns on the inside lights. The switch that makes this work is like the mechanism that controls the light in your refrigerator.

When the door is closed, it presses in a small, spring-activated button or lever, which opens the circuit. When the door is opened, the spring pushes the button open, closing the circuit and sending electricity to the inside lights.

2.3.2 Car Alarm Shock Sensors:

The Advanced alarm systems mostly depend on shock sensors to deter thieves and vandals.

The idea of a shock sensor is fairly simple: If somebody hits, jostles or otherwise moves your car, the sensor sends a signal to the brain indicating the intensity of the motion. Depending on the severity of the shock, the brain signals a warning horn or sounds the full-scale alarm.

2.3.3 Car Alarm window Sensors:

The most common glass-brakeage detector is a simple microphone connected to the brain. Microphones measure variations in air-pressure fluctuation and convert this pattern into a fluctuating electrical signal; breaking glass has its own distinctive sound frequency.

The microphone converts this to an electrical current of that particular frequency, which it is sent to the brain.

2.3.4 Pressure Sensors:

Another way to detect breaking glass, as well as somebody opening the door, even if there is no pressure difference between the inside and the outside, the act of opening a door or forcing in a window pushes or pulls on the air in the car, creating a brief change in pressure.

You can detect fluctuations in air pressure with an ordinary loudspeaker driver. A loudspeaker has two major parts:

- A wide, movable cone.

- An electromagnet, surrounded by a natural magnet, attached to the cone

2.3.5 Car Alarm Motion and Tilt Sensors:

An armed thief with a tow truck can just lift up your car and drag the entire the car alarm wiring away and dismantle them.

Some alarm systems include perimeter scanners, devices that monitor what happens immediately around the car. The most common perimeter scanner is a basic radar system, consisting of a radio transmitter and receiver. The transmitter sends out radio

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signals and the receiver monitors the signal reflections that come back. Based on this information, the radar device can determine the proximity of any surrounding object.

2.3.6 Car Alarm Alerts:

In the previous sections, various sensing devices were demonstrated that inform the alarm system's brain when something disturbs the car. No matter how advanced these systems, the alarm system isn't much good if it doesn't set off an effective alarm. An alarm system must trigger some response that will deter thieves from stealing your car.

As it has seen, a lot of alarm devices that are already built into your car are made for effective alarm signals. At the minimum, most car alarm systems will honk the horn and flash the headlights when a sensor indicates an intruder see figure (2.2). They may also be wired to shut off the ignition starter, cut off the gas supply to the engine or disable the car by other means.

Fig: (2.2) Car-alarm Alerts

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An advanced alarm system will also include a separate siren that produces a variety of piercing sounds. Making a lot of noise brings attention to the car thief, and many intruders will flee the scene as soon as the alarm blares. With some alarm systems, you can program a distinctive pattern of siren noises so you can distinguish the alarm on your car from other alarms.

A few alarm systems play a recorded message when somebody steps too close to your car. The main purpose of this is to let intruders know that you have an advanced alarm system before they try anything at all. Most likely, a veteran car thief will completely ignore these warnings, but to the opportunistic amateur thief, they can be a strong deterrent. In a sense, it gives the alarm system a commanding personality. On some unconscious level, it may seem like the car's not just a collection of individual parts, but an intelligent, armed machine.

A lot of alarm systems include a built-in radio receiver attached to the brain and a portable radio transmitter that can be carried on the keychain.

2.3.7 Car Alarm Transmitters:

Most car alarm systems come with some sort of portable keychain transmitter see figure (2.3). With this device, instructions can be sent to the brain to control the alarm system remotely.

The primary purpose of the keychain transmitter is to give a way to turn the alarm system on and off, after stepping out of the car and closing the door; the system can be armed with the touch of a button, and can be disarmed later on demand.

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In the most systems the brain will flash the lights and tap the horn when the alarm system is armed and disarmed on the car.

Fig: (2.3) Car-alarm Transmitters

2.4 Disadvantages of current alarm systems:

1. When fixing all sorts of alarms in a car, these devices are not be able to protect or prevent the theft of the car, but only help in the issuance of voices and lights distress cars.

2. Cause and provide warning Beaverton internal organs is highly sensitive to all the voices that spoke car or around the lights and sounds an alarm and high annoying.

3. As for alarm systems, which depend on sending radio signals to remote, and phone the owner of the car which depends on the wireless distance which could be affected by random obstacles such as building.

4. When the robber sense of the existence of the warning He gets done very quickly reversed, whether through a broken window or through the opening of the closure of one of the doors in one way or another, and so more easily than the mind can imagine

that some of them even became unable to complete the entire task in just a part of the minutes, using an ordinary screwdriver and without any other tools.

5. The owner of the car near the lack thereof, may not be able to catch up when his car stolen, since the time of storm thief in the car and sit in front of the vehicle and delivery of the electrical circuit and management of engine and drive off of a person's coach, is not commensurate with the time harvested from the car on foot from the place where his car was found.

Form the above mentioned disadvantages, it is noticeable that the car is not prevented from stealing, because the owner or car driver will not be in the stealing place to protect his car or turn on the protecting system on it.

But the system which we present is silent and has more efficiency to prevent stealing the car, since the car can't be moved from its initial position, and the car will be more secure from being intruded by strangers because of the Anti-theft smart braking system.

Chapter Three

General idea of proposed alarm system, principle of operation and main components

3.1 Introduction:

The system consists of two parts, the first part is a hydraulic circuit and the second is electronic control unit, the hydraulic circuit incorporated with the braking system which consists of

- Accumulator
- Check valve
- Solenoid

The electronic control unit involves integrated circuit, which presents the code circuit interfacing with the hydraulic circuit.

The function of each part will be explained in details in the next chapter.

3.2 Description of the proposed alarm system:

The components described will be used to design a hydraulic circuit (fig 3.1) to perform the following task:

A check valve (7) will be added before the first junction between the master cylinder (6) and the accumulator (1) to make the oil pressure pass to the accumulator and prevent the oil from returning back to the reservoir, the second way of the junction has a N.O. solenoid (5), closed when a signal is applied, the second path of the accumulator has a N.C. solenoid (2) opened when a signal is applied, and has another check valve (3) to prevent the oil from returning to the accumulator, this path meets the other after the first solenoid, the accumulator stores the pressure and apply it when the brake system or the alarm system need it, illustrated in figure (3. 1).

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The component described before will control to operate in lock mode and unlock mode by electronic code lock circuit, the password will lock and unlock the system, in the next chapter the circuit will describe in detail.
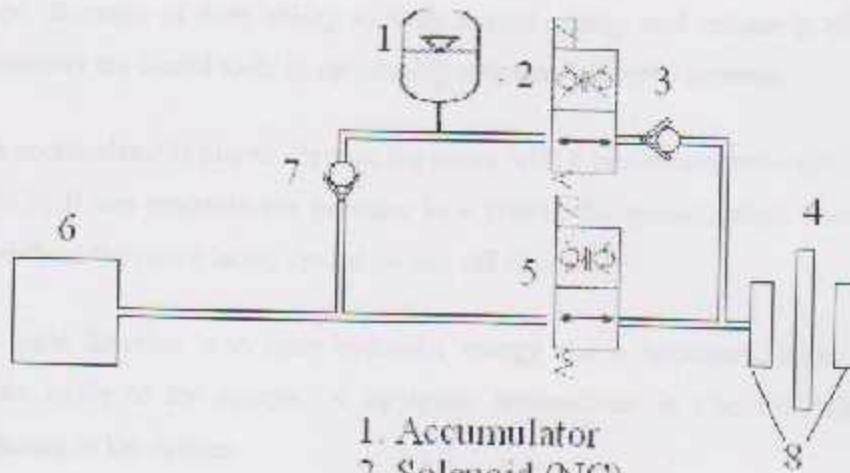
1. Accumulator
2. Solenoid (NC)
3. Check valve
4. Wheel
5. Solenoid (NO)
6. Master cylinder
7. Check valve
8. Brake pads

Fig (3.1) hydraulic system design

3.3 Accumulator:

Accumulators are simple devices that store energy in the form of fluid under pressure. Because of their ability to store excess energy and release it when needed, accumulators are useful tools in developing efficient hydraulic systems.

An accumulator is placed close to the pump with a non-return valve preventing flow back to it. It can maintain the pressure in a system for periods when there are slight leaks without the pump being cycled on and off constantly.

Its main function is to store hydraulic energy and is necessary, make the energy available again to the system. A hydraulic accumulator is also referred to as the capacitance of the system.

The most common accumulators used today are hydro-pneumatic types. They use a gas as a spring cushion in conjunction with a hydraulic fluid, shown in fig (3.2).

Fig (3.2) Accumulator

3.3.1 Types of accumulator:

An accumulator is basically an energy storage device, Fig 3.3 show the different types of accumulator:
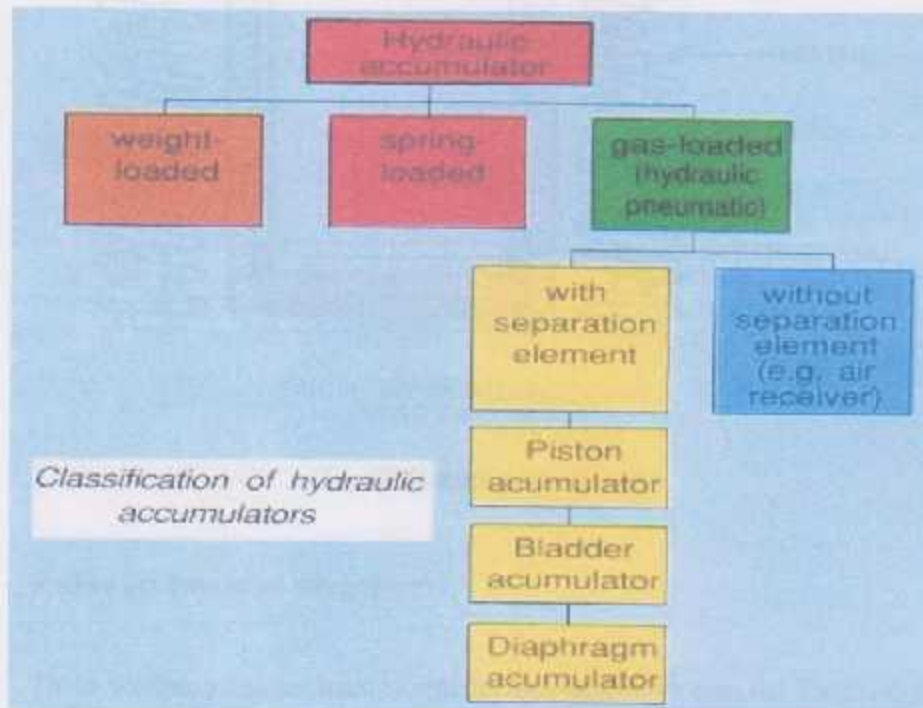
Fig (3.3) Types of accumulator

3.3.1.1 Spring type:

A spring type accumulator is similar in operation to the gas-charged accumulator above, except that a heavy spring (or springs) is used to provide the compressive force, see fig (3.4).

Generally small and lightweight, making them useful in mobile applications, a spring gives a repeatable output force. However, spring-loaded accumulators are limited to small volumes and pressure below 500 psi.
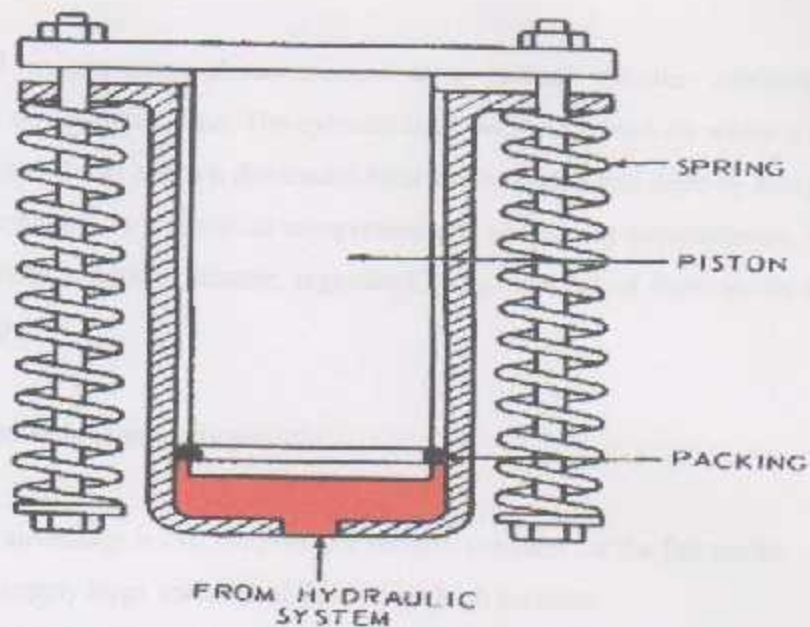
Fig (3.4) spring accumulator

- **Spring accumulator advantages:**

✓ These accumulators are usually smaller less expensive than the dead weight type and mounting is easy.
✓ They are built directly into the power unit.

- **Spring accumulator disadvantages:**

✓ They supply a small volume of oil at low pressure.
✓ The pressure does not remain constant, the accumulator pressure reaching its peak as the spring compresses and drops to a minimum as the springs approach free length.
✓ It has to be taken care of that the leakage oil is vented from the spring chamber.

3.3.1.2 Raised weight:

A raised weight accumulator consists of a vertical cylinder containing fluid connected to the hydraulic line. The cylinder is closed by a piston on which a series of weights are placed that exerts a downward force on the piston and there by energizes the fluid in the cylinder. In contrast to compressed gas and spring accumulators, this type delivers a nearly constant pressure, regardless of the volume of fluid in the cylinder, until it is empty.

- **Raised weight advantages:**

  ✓ Their advantage is that the pressure remains constant for the full stroke.
  ✓ They supply large volumes of fluid under high pressure.
  ✓ They can serve several hydraulic systems at a time and are most often used in ill and central hydraulic systems.

- **Raised weight disadvantages:**

The dead weight type accumulators, however, have some disadvantages too. Being very bulky, the larger sizes are extremely expensive, particularly those delivering high pressures and volumes.

3.3.1.3 Hydro-pneumatic accumulator:

A hydro-pneumatic accumulator consists of a cylinder with two chambers that are separated by an elastic diaphragm or by a floating piston. One chamber contains hydraulic fluid and is connected to the hydraulic line. The other side contains an exert gas under pressure that provides the compressive force on the hydraulic fluid.

The hydro-pneumatic accumulators are the most commonly used accumulators and apply force to the liquid by using a compressed gas that acts as the spring.

The fluid section connects to the hydraulic circuit so that as pressure rises fluid enters the accumulator and the gas compresses. Then, as pressure in the system falls, the compressed gas expands and forces the stored fluid back into the system.

Hydro-pneumatic accumulators are sub-divided according to their separating element (between the gas and fluid).

The different types of hydro-pneumatic accumulators used are:

1) Non-separator type:

It consists of a cylinder with hydraulic fluid and the charging gas with no separation between them. They are generally used on die casting machines or other similar places. They are always to be mounted vertically.

2) Separator type:

✓ **Piston accumulator:**

It consists of a cylinder body and a movable piston. The gas that occupies the volume above the piston is compressed as the cylinder body is charged with liquid, Fig 3.5 shown the piston accumulator.

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Fig (3.5) Piston accumulator

Piston accumulators have an outer cylinder tube, end caps, a piston element, and sealing system. The cylinder holds fluid pressure and guides the piston, which forms the separating element between gas and fluid. Charging the gas side forces the piston against the end cover at the fluid end. As system pressure exceeds the minimum operating level for the accumulator, the piston moves and compresses gas in the cylinder, see fig 3.6.
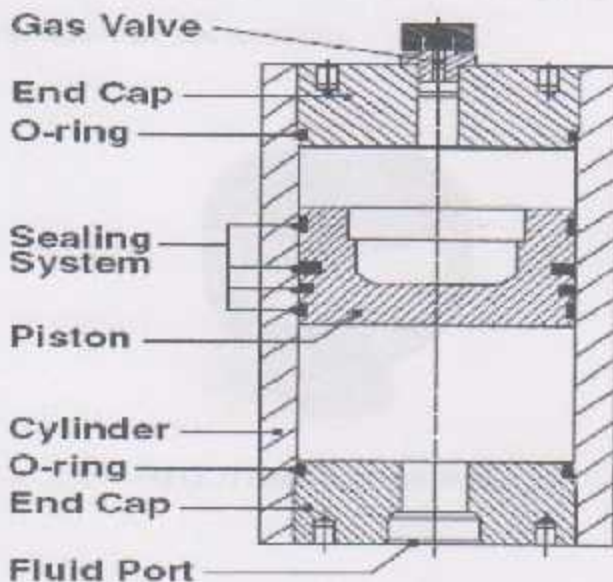
Fig (3.6) Parts of piston accumulator

Piston accumulators may operate in any position. Vertical installation is preferable with the gas side up.

✓ **Diaphragm accumulator:**

Diaphragm accumulators (see fig 3.7) are usually comprised of a spherical or cylindrical pressure vessel, containing the separating element an elastomeric diaphragm.

There are two different designs: welded and threaded see fig (3.8). In the former, the diaphragm is pressed into the bottom half of the vessel before the seam is electron-beam welded; in threaded models, the diaphragm is held between top and bottom valves of the vessel by a threaded ring. As in the bladder type, a poppet prevents the diaphragm from being ejected through the fluid connection.

Threaded models can be disassembled and the diaphragm replaced. Welded diaphragm accumulators are non repairable.

Fig (3.7) Diaphragm accumulator
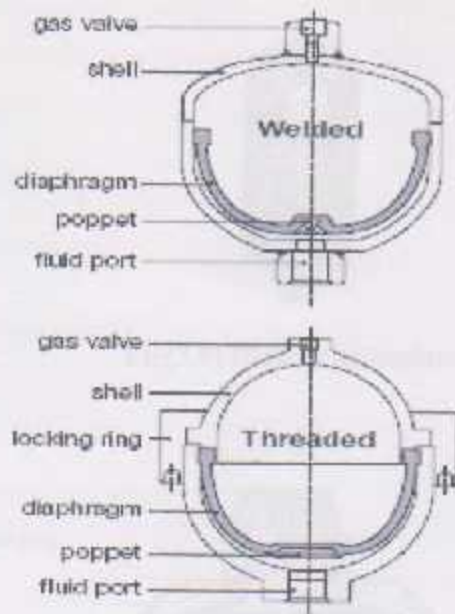
Fig (3.8) Types of diaphragm accumulator

Diaphragm accumulators by design may be mounted in any position. In systems where contamination is a problem, it recommends a vertical mount with fluid port oriented downward.

✓ **Bladder accumulator:**

Bladder accumulators (see fig3.9) consist of a pressure vessel and an internal elastomeric bladder that contains the gas. The bladder is charged through a gas valve at the top of the accumulator, while a poppet valve at the bottom prevents the bladder from being ejected with the out flowing fluid, see fig (3.10).

Bladder accumulators provide a means of maintaining the performance of hydraulic systems. They are useful for storing energy, minimizing pressure, hydraulic shock, and dampening pump pulsation in a hydraulic system.

The bladder accumulator is quite versatile, can be used to perform many functions and requires minimum maintenance, and have long life.

Bladder accumulators have special advantages, its fast response is particularly suited for gas charge.

Fig(3.9) Bladder acumulator

Fig (3.10) Parts of bladder accumulator

To operate, the bladder is charged with nitrogen to a pressure specified by the manufacturer according to the operating conditions. When system pressure exceeds gas-pre charge pressure of the accumulator, the poppet valve opens and hydraulic fluid enters the accumulator. Fig (3.11) shows the operation cycle of Bladder accumulator.

Bladder accumulators provide a means of regulating the performance of a hydraulic system. They are suitable for storing energy under pressure, absorbing hydraulic shocks, and dampening pump pulsation and flow fluctuations.

Bladder accumulators provide excellent gas and fluid separation ensuring dependable performance, maximum efficiency, and long service life.

Bladder accumulators may operate in any position. Vertical installation is preferable with the gas side up.

Fig (3. 11) cycle of operation for bladder accumulator

3.3.1.4 Comparison of hydro-pneumatic Accumulators:

Each type of separated, hydro-pneumatic accumulator has advantages, but bladder designs are generally considered the most versatile of the three. For shock and pulsation, for example, bladder and diaphragm models are ideal. Piston units are not recommended because they are too slow to react to shock waves, the seals in piston types are not designed to hold pressure indefinitely without being cycled. The system can leak and fail with no obvious indication to the outside.

An advantage diaphragm accumulator's hold is that they can be mounted in any position. For piston and bladder accumulators vertical mounting is the preferred orientation, with the gas side up.

Diaphragm accumulators are the least expensive, but maximum capacity is only about one gallon. Bladder designs predominate between one and 15 gallons, but are available to about 125 gallon capacity. The largest piston designs are typically about 100 gallon capacity. For similar quality and performance, bladder and piston models are competitively priced.

Another difference is the ratio of maximum operating pressure to gas-pre charge pressure. Pressure ratios are generally 10:1 for threaded, 8:1 for welded and 4:1 for bladder accumulators. In other words, for an accumulator with a maximum operating pressure of 3,000 psi, minimum gas-pre charge pressures would be 300 psi for threaded, 375 psi for welded, and 750 psi for bladder types. Accumulators with a higher pressure ratio are more efficient because they have a greater volume of usable fluid.

The following tables will display the difference between the types of hydro-pneumatic accumulators.

Type	Nominal volume	Maximum work pressure psi	Pressure ratio	Flow rate
Diaphragm	5 to 230 in3	3000, 5000 (up to 10,000)	8:1 typically (up to 10:1)	up to 60 gpm
Bladder	1 quarter to 15 gallon	3000, 5000 (up to 10,000)	4:1	up to 480 gpm
Piston	1 quarter to 100 gallon	3000, 5000 (up to 10,000)	∞:1	up to 2000 gpm

Table 3.1 Comparison of hydro-pneumatic Accumulators

Type	Mounting position	Weight	cost	Design consideration
Diaphragm	any	lowest	lowest	.small volume and flow .low weight .compact design .good for shock applications *(good response characteristics*
Bladder	prefer vertical	middle	middle	.best general purpose .wide range of standard sizes .good for shock applications *(good response characteristics*
Piston	prefer vertical	highest	middle to highest	• best for large stored volumes • best for high flow rates • not recommended for shock applications • best for use with backup nitrogen bottles

Table 3.2 Comparison of hydro-pneumatic Accumulators

3.3.2 Choosing an accumulator:

For the designed system the specification of the required accumulator is as follows:

- ✓ Its maximum work pressure must be over than or equal the original brake system pressure (2000psi).
- ✓ Its maximum capacity is more less than one litter because the brake oil in the reservoir is only one litter.
- ✓ It can be mounted at any position which provides a lot of possible choices to place it.
- ✓ It's not expensive.
- ✓ Light weight.
- ✓ It has minimum flow rate.

There for, the diaphragm accumulator with is the suitable choice for this system, the welded diaphragm accumulator is used in the designed system and its has the following specification:

- ✓ Its maximum work pressure 2600 psi.
- ✓ Its weight is .8 Kg.
- ✓ Its nominal volume 0.16 litter.
- ✓ Its effective gas volume $10_{in}3$.

3.4 Solenoid:

Solenoid valves are electrically operated devices that control the flow of liquids. Solenoid valves are electro-mechanical devices that use a wire coil and a movable plunger, called a solenoid, to control a particular valve. As shown in fig (3.3).

The solenoid controls the valve during either the open or closed positions. Thus, these kinds of valves do not regulate flow. They are used for the remote control of valves for directional control of liquids.

Fig (3.12) Solenoid

Solenoid valves control the flow of hydraulic fluid (oil), often at around 5000 psi.

3.4.1 How solenoid valves work:

A typical electric solenoid is shown in fig (3.13). It consists of a coil, armature, spring, and stem.

The coil is connected to an external current supply. The spring rests on the armature to force it downward. The armature moves vertically inside the coil and transmits its motion through the stem to the valve. When current flows through the coil, a magnetic field forms around the coil. The magnetic field attracts the armature toward the center of the coil. As the armature moves upward, the spring collapses and the valve opens. When the circuit is opened and current stops flowing to the coil, the magnetic field collapses. This allows the spring to expand and shut the valve.

A major advantage of solenoid actuators is their quick operation. Also, they are much easier to install than pneumatic or hydraulic actuators.
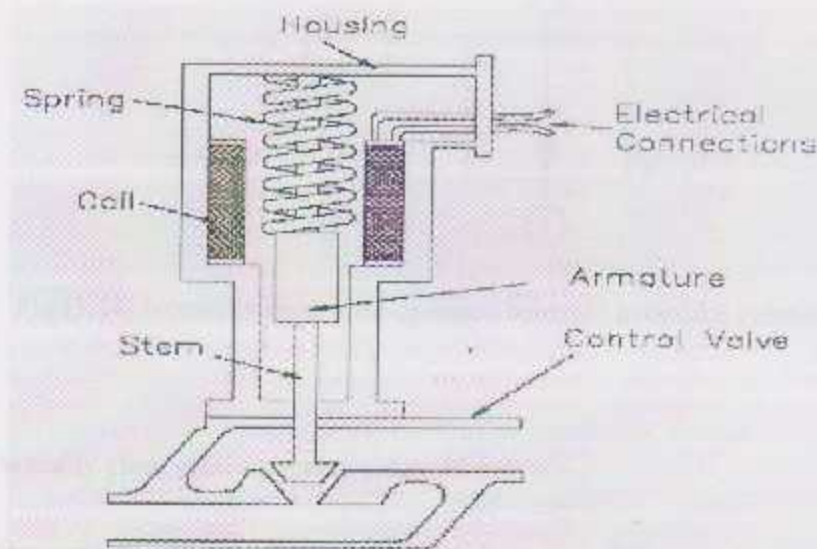
Fig (3.13) Parts of solenoid

3.4.2 Solenoid valves types:

There are two general types of solenoid valves: direct-acting and pilot-operated. Direct-acting solenoid valves have a plunger that is in direct contact with the primary opening in the body. This plunger is used to open and close the orifice. The pilot-operated solenoid valve works with a diaphragm rather than a plunger. This valve uses differential pressure to control the flow of fluids.

3.4.2.1 Pilot-operated solenoid valve:

✓ **Normally open pilot-operated solenoid valve:**

When de-energized the solenoid allows flow from port 2 to port 1. See fig (3.14), while flow from port 1 to port 2 is severely restricted. When energized the valve's poppet closes on its seat, blocking flow from port 2 to port 1. Flow from port 1 to port 2 is allowed when hydraulic pressure generated force overcomes solenoid force.
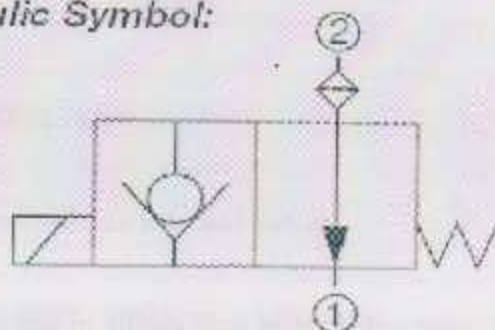
Fig (3.14) Normally open pilot-operated solenoid hydraulic symbol

✓ **Normally close pilot-operated solenoid valve:**

When de-energized the solenoid blocks flow from port 2 to port 1, while allowing flow from port 1 to port 2. When energized the poppet lifts and opens the flow from port 2 to port 1, while the flow from port 1 to port 2 is severely restricted. See fig (3.15).

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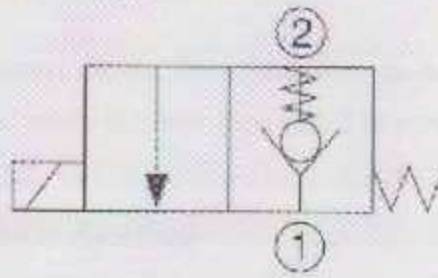
Hydraulic Symbol:

Fig (3.15) Normally close pilot-operated solenoid valve hydraulic symbol

3.4.2.2 Direct-acting solenoid valve:

✓ **Normally open direct-acting solenoid valve:**

When de-energized the solenoid allows flow in both directions. When energized the solenoid closes and blocks the flow from port 2 to port 1 and from port 1 to port 2. See fig (3.16).

Hydraulic Symbol:
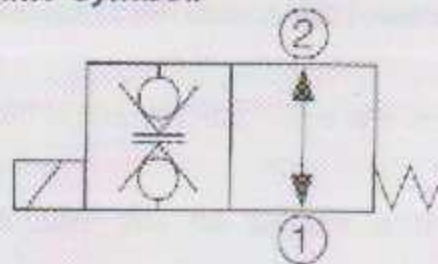
Fig (3.16) Normally open direct-acting solenoid valve hydraulic symbol

✓ **Normally close Direct-acting solenoid valve:**

When de-energized the solenoid blocks flow, leak free, in both directions. When energized the solenoid lifts and opens the flow from port 2 to port 1 and from port 1 to port 2. See fig (3.17).

Hydraulic Symbol:
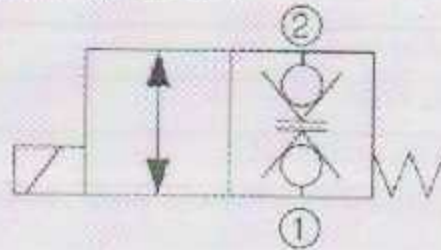
Fig (3.17) Normally close direct-acting solenoid valve hydraulic symbol

3.4.3 Choosing a solenoid valve:

For the designed system the specification of the required solenoid valve is as follows:

✓ Its applied voltage not exceed 12 volt cause it high possible voltage that can the car supply it fro battery.
✓ It controls the flow of oil in direction, that means stop or run the flow in both directions in same time.
✓ It's operating pressure more than the pressure in brake system or the accumulator that used.

There for, the direct acting solenoid valve is the suitable choice for this system, and the following table will shows the specification of used solenoid:

Operating Pressure	3600 psi
Nominal Flow	5 gpm
Internal Leakage	Leak tight (less than 5 drops/min. at 5000 psi)
Current Draw	1.5 A at 12VDC
Response Time	Energized 35 ms De-energized 50 ms
Cartridge Weight	(0.14 kg)
Coil Weight	0.19 kg)
Installation	No orientation restrictions

Table (3.3) direct acting solenoid valve specification

3.5 Check valve:

The non-return valves or check valves (see fig (3.18)) are used to block the reverse flow of oil or gas in a fluid power circuit. Additionally this valve may be used for pressure control or directional control. The check valve consists of a valve body with inlet and outlet ports and an internal movable member biased by the spring. The movable member can be a flapper or a plunger but most often in valves of hydraulic systems, it is a ball or poppet. They are built to provide free flow in one direction and a check in the other direction and prevent flow-back in hydraulic systems; as shown in fig (3.19) and fig (3.20).

3.5.3 Types of check valves

3.5.3.1 Ball check valve

Fig (3.18) check valves
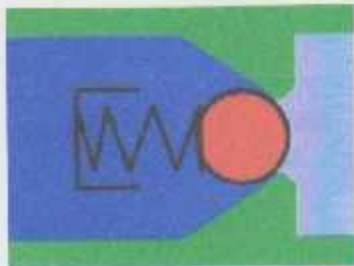
Fig: (3.19) Closed check valve   fig: (3.20) open check valve
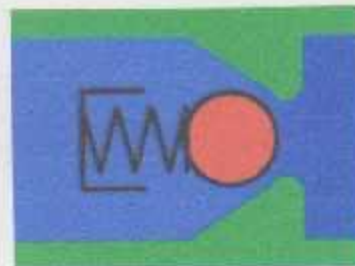
Check valves are often part of common household items. Although they are available in a wide range of sizes and costs, many check valves are very small, simple, and/or cheap. Check valves work automatically and most are not controlled by a person or any external control.

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3.5.1 Types of check valves: ~~the flow stops or reverses the disk is held tightly onto the~~ ~~seat of the valve by both the backflow and gravity.~~

3.5.1.1 Ball check valve:

Is a check valve in which the disc, the movable part to block the flow, is a spherical ball in many ball check valves, illustrated in figure (3.21), the ball is spring-loaded to stay shut, as the flow enters, the ball is raised within guides from the seat by the pressure of the upward flow. When the flow stops or reverses, the ball is forced onto the seat of the valve by the back flow.
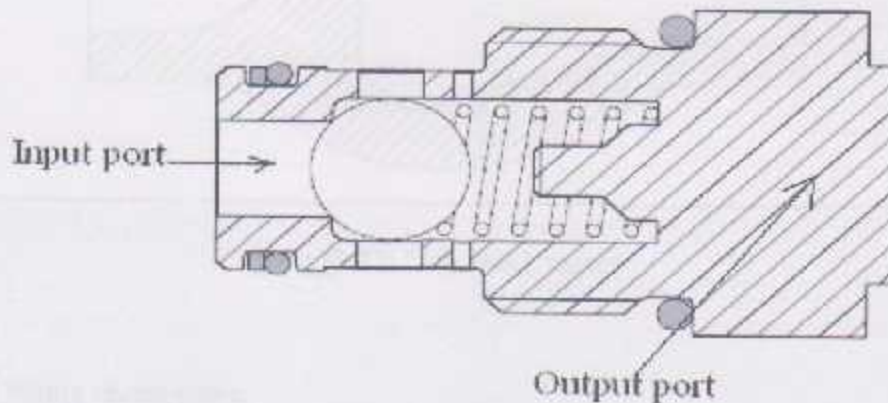
Fig (3.21) Ball check valve

3.5.1.2 Lift-check valve:

Flow to lift check valves, illustrated in figure (3.22), must always enter below the seat. As the flow enters, the disk or ball is raised within guides from the seat by the pressure

of the upward flow. When the flow stops or reverses, the disk or ball is forced onto the seat of the valve by both the backflow and gravity.
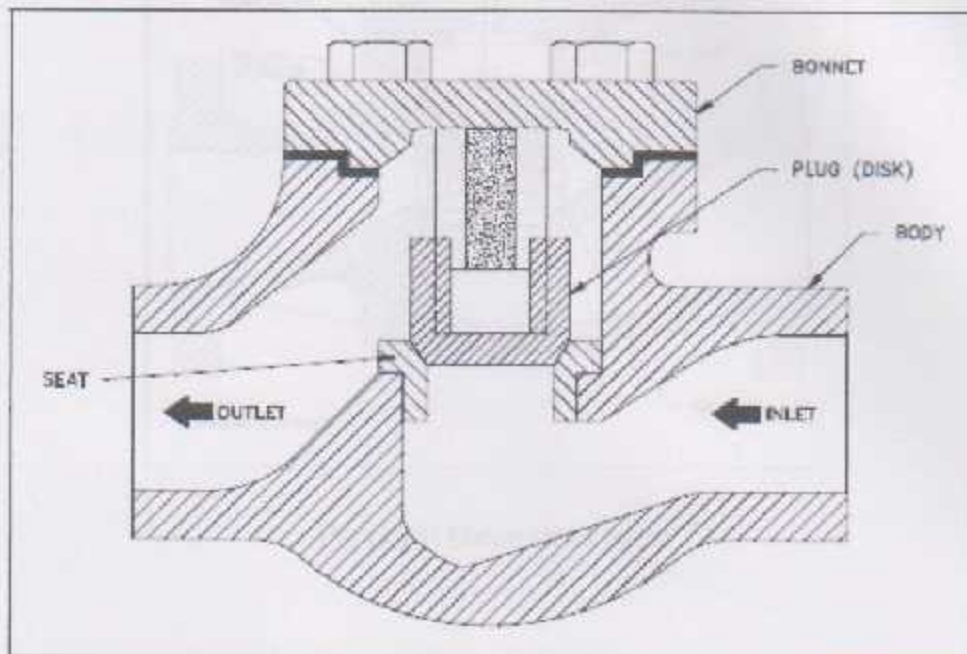
Fig (3.22) Lifts check valves

3.5.1.3 Piston check valve:

A piston check valve, illustrated in figure (3.23), is essentially a lift check valve. It has a dashpot consisting of a piston and cylinder that provides a cushioning effect during operation. Because of the similarity in design to lift check valves, the flow characteristics through a piston check valve are essentially the same as through a lift check valve.
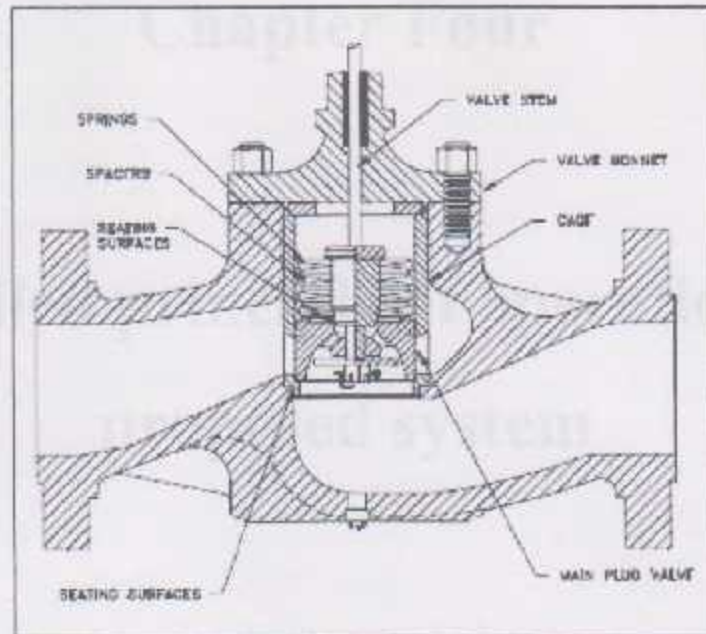
Fig (3.23) Piston check valve

3.5.2 Choosing a check valve:

In this system a ball check valve will used cause it perform the requirements and it the cheap type of the check valves.

Chapter Four

Detailed principle of operation of proposed system

4.1 How the system works

4.2 Conclusions

4.1 How the system works:

When starting the vehicle, the new loop of the system- work is start, see fig 4.1, that it starting to store the pressure in the accumulator (3), so that every press on the brake pedal, the brake oil moves to verify its job. At the same time, a part of the oil pressure is passes the junction to pass the check valve (1) and not to return through it, and stored in the accumulator to use it as pressure, and it can't pass the accumulator(3) to going forward to the wheel because of the normally close solenoid(4) is not activated yet.

When the driver would like to switch the alarm system on in his car he enter the code in control unit, if the code is match the stored code the system will start lock mode.

When lock mode is start, the normally open solenoid will close to prevent the oil from returning back to the reservoir, after 2 sec the normally close solenoid (5) will open to allow for the oil pressure to go forward from the accumulator to the brake wheel cylinder and lock it, while the check valve (2) prevent the oil pressure from returning back to accumulator.

The system will operate in lock mode with effective pressure equal 2600 psi applied at every wheel, and it will end if the code is entered again.

This system is applied on the four wheels to complicate the system and guarantee the effectiveness, and prevent stealing and make the alarm system more accurate.
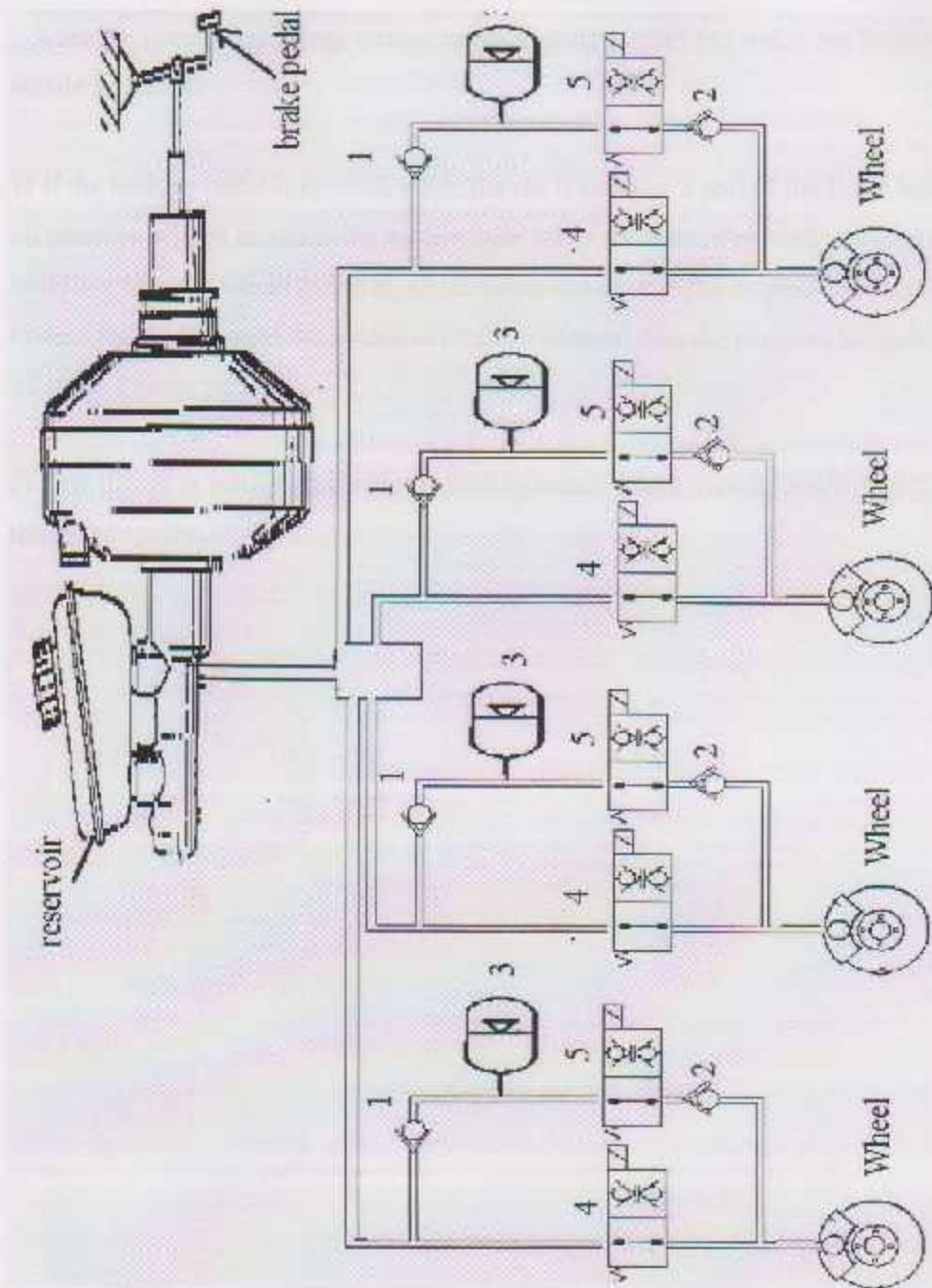
Fig (4.1) Anti-theft smart brake system

4.2 Conclusions:

After the system designing, testing, and obtaining the desired result, the following should be noted:

1) If the braking pedal is pressed, while the car is moving, a part of the brake hydraulic oil pressure will be stored in the accumulator while the remaining brake oil pressure will flow to brake wheel cylinder, which cause decrease in the original pressure in brake system for a while until the accumulator fully charged then the pressure become fixed in all brake system parts.

2) This design is suitable for any cars with hydraulic brake system, and will builds up in the brake system.

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Chapter Five
Electronic Code Lock circuit

5.1 Introduction:

The circuit, illustrated in figure (4.1), utilizes the microcontroller (pic16F84) to control all of the inputs and outputs for the system. The microcontroller essentially acts as the brain of design and reads all of the inputs entered by the user.

The keypad is connected to a 16-key encoder by which all 16 keys are encoded so that the microcontroller can recognize which key is pressed. While entering the 4-digit password, the microcontroller accepts one digit at a time and subsequently compares each digit to the stored password. Once the correct password is entered, the microcontroller sends an output signal to inform the user to proceed with locking the brake system.

Once the user enters the correct password and decides to lock the brake system, the microcontroller sends an output pulse to brake system. Another output is sent that the brake system is in its locked position so that the user is now able to unlock the brake system.

There are two outputs from the circuit, first output is for normally open solenoid and the second output output is for the normally closed solenoid.

This brake system lock design is intended to have low operating power consumption. With this in mind, we designed the brake system lock to retract or unlock only when 12 volts are applied to it.

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When the two outputs from code lock circuit is 5 volts. An amplifier circuit is used to convert voltage from 5 volts to 12 volts.

The code lock circuit operates at 5 volts, when the voltage from car battery is equal 12 volts. For this reason, a regulator circuit is used to convert the voltage from 12 volts to 5 volts.

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5.3.1 Keypad Input

The circuit were started by connecting keypad, which, as its name implied, were required by user to endure the pass...

The buttons where the keypad of MC... as... input after the number were pressed. The ...

The main controller device of the circuit board was the ... There were three input that ... were used to send ... and ... for a correct input was read through the keypad connected to dedicated encoder.

The keypad encoder output connected to the microcontroller ... simplified the keypad and only who take input to microprocessor ... recognized whether any button has pressed.

Fig 5.1 The electronic code locks circuit

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5.2 Design Procedure:

5.2.1 Keypad Input:

The device uses a keypad for user input. This will allow the person who knows the password to lock or unlock the brake system.

Ten buttons are used to represent digits zero through nine for inputting the password. One button is used to lock the brake system.

Therefore, using a twelve-button keypad would have been the best. However, twelve-button keypads are extremely rare, so the common sixteen-button keypad was used instead. The keypad is connected to a keypad encoder.

This keypad encoder outputs connected to the Microcontroller, How the keypad is connected to the encoder and what information is outputted to the Microcontroller is discussed in the next sections of this chapter.

5.2.2 Microcontroller:

5.2.2.1 What Is a Microcontroller?

A microcontroller is an inexpensive single-chip computer. Single-chip computer means that the entire computer system lies within the confines of the integrated circuit chip. The microcontroller on the encapsulated sliver of silicon has features similar to those of our standard personal computer.

Primarily, the microcontroller is capable of storing and running a program (it's most important feature). The microcontroller contains a CPU (central processing unit), RAM (random-access memory), ROM (read-only memory), I/O (input/output) lines, serial and parallel ports, timers, and sometimes other built-in peripherals such as A/D (analog-to-digital) and D/A (digital-to-analog) converters.

5.2.2.2 Why Use a Microcontroller?

Microcontrollers are stated, are inexpensive computers. The microcontroller's ability to store and run unique programs makes it extremely versatile. For instance, one can program a microcontroller to make decisions (perform functions) based on predetermined situation (I/O-line logic) and selections. The Microcontroller's ability to perform math and logic function allows it to mimic sophisticated logic and electronic circuits.

5.2.2.3 Microcontrollers versus Microprocessors:

Microcontroller differs from a microprocessor in many ways. First and the most important is its functionality. For a microprocessor to be used, other components such as memory, or components for receiving and sending data must be added. In short that means that microprocessor is the very heart of the computer. On the other hand, microcontroller is designed to be all of that in one. No other external components are needed for its application because all necessary peripherals are already built into it. Thus, we save the time and space needed to construct devices.

5.2.3 Voltage regulators:

A Voltage Regulator (also called a "regulator") has only three legs and appears to be a comparatively simple device but it is actually a very complex integrated circuit. A regulator converts varying input voltage and produces a constant "regulated" output voltage.

Voltage regulators are available in a variety of outputs, typically 5 volts, 9 volts and 12 volts, (See table 4.1); the last two digits in the name indicate the output voltage.

Name	Voltage	Name	Voltage
LM7805	+ 5 volts	LM7905	- 5 volts
LM7809	+ 9 volts	LM7909	- 9 volts
LM7812	+ 12 volts	LM7912	- 12 volts

Table 5.1 Voltage regulators

The "LM78XX" series of voltage regulators are designed for positive input. For applications requiring negative input the "LM79XX" series is used; this device looks like a transistor, but it is actually a complex Integrated Circuit, Figure 4.2 shows the symbol of the 78XX.

Figure 5.2 7812 symbol

As a general rule the input voltage should be limited to 2 to 3 volts above the output voltage. The LM78XX series can handle up to 30 volts input, but the power difference between the input voltage/current ratio and output voltage/current ratio appears as heat.

If the input voltage is unnecessarily high, the regulator will get very hot. Unless sufficient heat-sinking is provided, the regulator will shut down.

5.2.4 Amplifier circuit:

An amplifier circuit is designed to convert voltage from 5 volt to 12 volt; a circuit is used in this case transistor and relay.

5.2.4.1 Transistor:

A transistor is a semiconductor device, commonly used as an amplifier or an electrically controlled switch. The transistor is the fundamental building block of the circuitry in computers, cellular phones, and all other modern electronic devices.

The transistor's low cost, flexibility and reliability have made it a universal device for non-mechanical tasks, such as digital computing. Transistorized circuits have replaced electromechanical devices for the control of appliances and machinery as well. It is often easier and cheaper to use a standard microcontroller and write a computer program to carry out a control function than to design an equivalent mechanical control function. Figure 4.3 shows the transistor types.
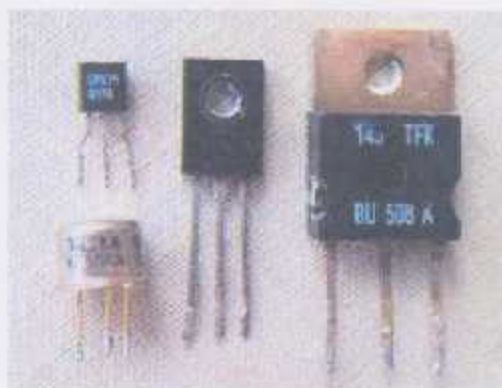
Fig 5.3 Transistors

5.2.4.2 Relay:

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to

open or close one or many sets of contacts. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be, in a broad sense, a form of an electrical amplifier. Figure 4.4 shows the relay.

Fig5.4 Relays

5.3 Design Details:

5.3.1 16-Buttons Keypad:

The keypad itself consumes no power. It works by simply making connections between wires.

The keypad has eight inputs: one for each of the four rows of buttons and one for each of the four columns of buttons. When a button is pressed, a connection is made between the input for the row and the input for the column in which the button is located.

For example, suppose the input for the first column is grounded and a voltage is applied at the input for the first row. If no button is pressed no current will flow through any input. Yet, if button "1," which is located in the first row and first column, is pressed, a connection is made between the two inputs mentioned above and current flows through each input. This will only happen if button "1" is pressed.

With this configuration it would have been possible to connect the keypad directly to the microcontroller, there is an encoder designed specifically for this type of keypad. Therefore, the keypad encoder, which is discussed below, was used.

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5.3.2 Keypad Encoder:

The MM74C922 keypad encoder implements all the logic necessary to interface a keypad to a digital system. The encoder finds if any connections are being made in the keypad and outputs five bits corresponding to the state of the keypad. One of the output bits, the "Data Available" bit, is high when a button is being pressed and low when no button is being pressed. The other four output bits are data bits which output a number depending on which of the sixteen buttons is being pressed. Figure 4.5 shows pins of the encoder.

Figure 4.7 shows a detailed diagram of how the encoder is used. The eight inputs from the keypad are connected directly to the encoder. The "Data Available" bit and the data bits are on the right side of the diagram. The "Data Available" bit is also connected to an inverter whose output is connected to OE or "Output Enable" pin of the encoder. This logic is used to ensure that the data bits output a number only when a button is being pressed.

The two capacitors located at the KBM and OSC pins of the encoder are used for eliminating key bouncing. Figure 4.6 shows the debounce period versus the capacitor value at the KBM input in microfarads. Using this graph, a capacitor value of $4.7\mu F$ was chosen. This gives a debounce period of around 0.05s, which will eliminate all key bouncing but is not so large that it requires the user to hold the button down a long time before the encoder recognizes the input. Finding the value of the capacitor at the OSC pin is just a matter of dividing the capacitance of the KBM capacitor by 10. Therefore, a capacitor with a value of $.47\mu F$ is used.

Pin Assignment for DIP
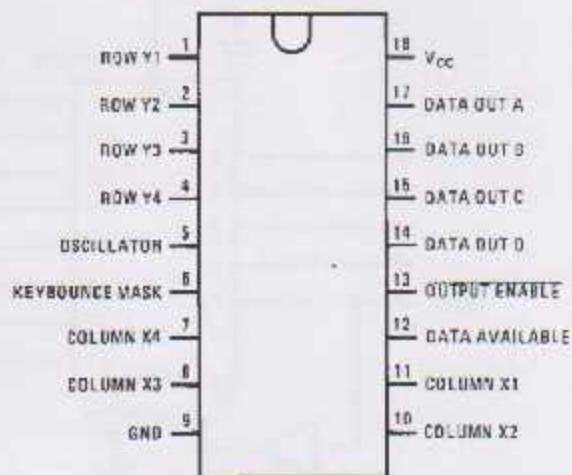
Fig 5.5 Top View MM94C922
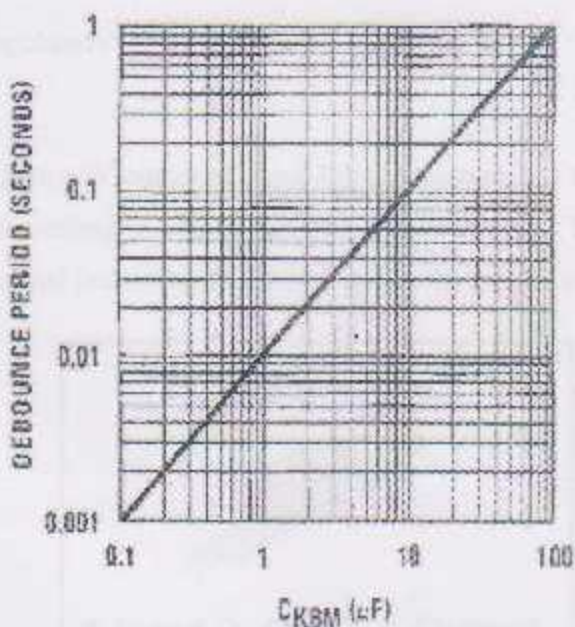
Fig5.6 Graph of debounce period versus capacitor value at KBM input of encoder.
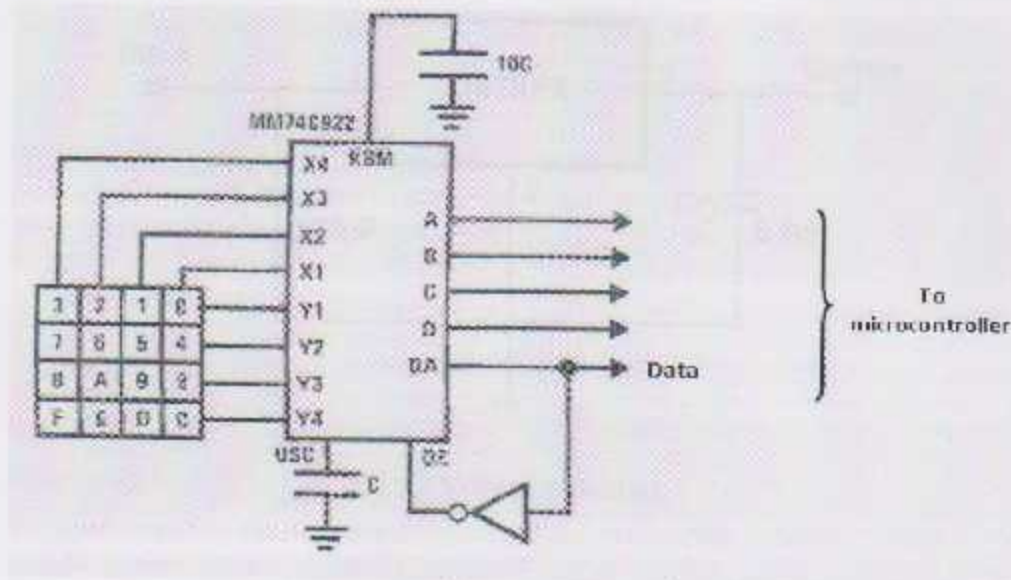
Fig. 5.7 Diagram of keypad and keypad encoder.

5.3.3 Voltage regulators

This circuit can give 5V output at about 150 mA current, but it can be increased to 1 A when good cooling is added to 7805 regulator chip. The circuit has over overload and terminal protection. Figure 4.8 shows the pins of voltage regulator.
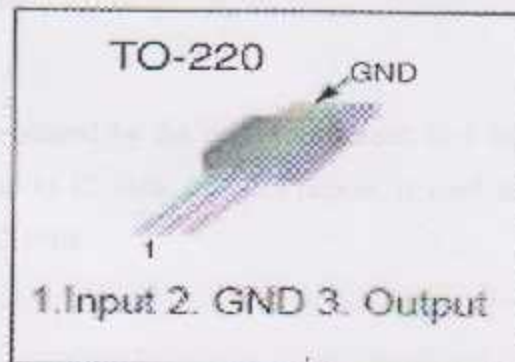
Fig5.8 Circuit diagram of the power supply.
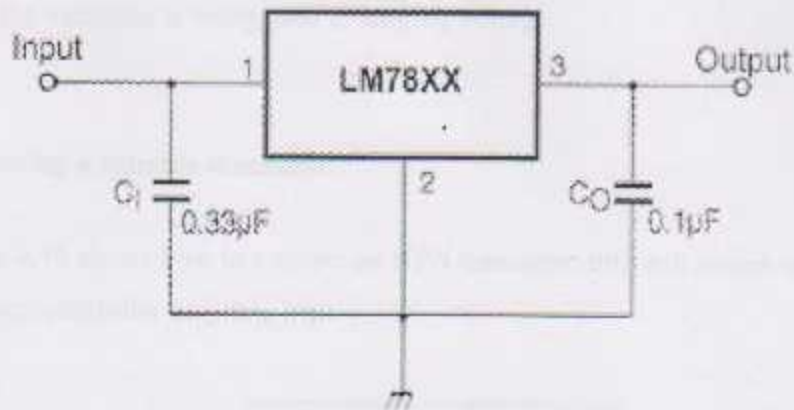
Fig 5.9 Voltage regulators

Where CO improves stability and transient response, and C1 is required if regulator is located an appreciable distance from the power supply filter. Figure 4.9 shows how to connect the two capacitors.

This circuit must be used to generate 5 volts from 12 volts that applied from car battery since the code lock circuit is operated at V_{cc} equal 5 volts.

5.3.4 Amplifier circuit:

The output voltage produced by the code lock circuit is 5 volts and the solenoids operate at voltage equal to 12 volts. For this reason, is used the amplifier circuit to generate 12 volts from 5 volts.

Transistors amplify current, for example Transistors can be used to amplify the small output current from a logic chip so that it can operate a lamp, relay or other high current device. In many circuits a resistor is used to convert the changing current to a changing

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voltage, so the transistor is being used to amplify voltage.

5.3.4.1 Choosing a suitable transistor:

The figure 4.10 shows how to connect an NPN transistor; this will switch on the load
when the microcontroller output is high.
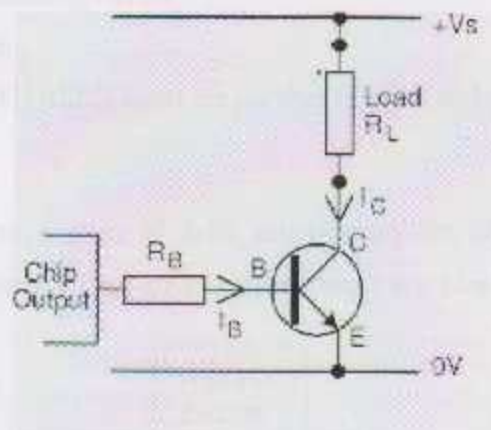
Fig 5.10 NPN Transistor

BC475 transistor where it's gain (β) = 90 is chosen, the calculation below determines
the resistance of the base.

V_S / R_L =voltage to run the load/ resistance of the relay coil=12/400=30mA

I_B= I_C/β=30Ma/90=0.33mA

R_B= output voltage from microcontroller / base current =5v/0.33mA = 14kΩ.

5.3.5 Microcontroller:

5.3.5.1 Why PIC16F84?

This microcontroller is selected because of:

1-It has wide customer group.

2-It is cheap and can be found easily.

3-It has a cheap programming circuit.

4-Very easy to program.

5-It just has 13 pins (I/O) which equal the number of input and out pins we need.

PIC16F84 belongs to a class of 8-bit microcontrollers of RISC architecture. Its general structure is shown in the fig4.11 representing basic blocks.
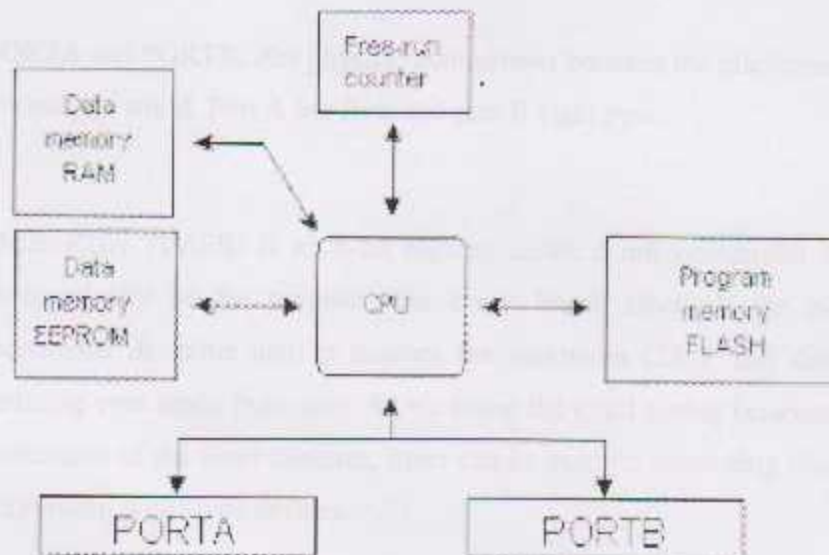
PIC16F84 microcontroller outline

Fig5.11 PIC 16F84 microcontroller

1) Program memory (FLASH): for storing a written program. Since memory made in FLASH technology can be programmed and cleared more than once, it makes this microcontroller suitable for device development.

2) EEPROM: data memory needs to be saved when there is no supply. It is usually used for storing important data that must not be lost if power supply suddenly stops. For instance, one such data is an assigned temperature in temperature regulators. If during a loss of power supply this data was lost, it must make adjustment once again upon return of supply. Thus device looses on self-reliance.

3) RAM: Data memory used by a program during its execution. In RAM are stored all inter-results or temporary data during run-time.

4) PORTA and PORTB: Are physical connections between the microcontroller and the outside world. Port A has five, and port B eight pins.

5) FREE-RUN TIMER: Is an 8-bit register inside a microcontroller that works independently of the program. On every fourth clock of the oscillator it increments its value until it reaches the maximum (255), and then it starts counting over again from zero. As we know the exact timing between each two increments of the timer contents, timer can be used for measuring time which is very useful with some devices.

6) CENTRAL PROCESSING UNIT: has a role of connective element among other blocks in the microcontroller. It coordinates the work of other blocks and executes the user program.

5.3.5.2 Pin description:

PIC16F84 has a total of 18 pins. It is most frequently found in a DIP18 type of case but can also be found in SMD case which is smaller from a DIP. DIP is an abbreviation for Dual in Package. SMD is an abbreviation for Surface Mount Devices suggesting that holes for pins to go through when mounting aren't necessary in soldering this type of a component. Figure 4.12 shows the pins of 16f84 pic.

Fig5.12 Top view of pic16f84

Pins on PIC16F84 microcontroller have the following meaning:

1- Pin no.1 RA2 Second pin on port A. has no additional function.

2- Pin no.2 RA3 Third pin on port A. has no additional function.

3- Pin no.3 RA4 Fourth pin on port A. TOCK1 which functions as a timer is also found on this pin.

4- Pin no.4 MCLR Reset input and Vpp programming voltage of a microcontroller.

5- Pin no.5 Vss Ground of power supply.

6- Pin no.6 RB0 Zero pin on port B. Interrupt input is an additional function.

7- Pin no.7 RB1 First pin on port B. No additional function.

8- Pin no.8 RB2 Second pin on port B. No additional function.

9- Pin no.9 RB3 Third pin on port B. No additional function.

10- Pin no.10 RB4 Fourth pin on port B. No additional function.

11- Pin no.11 RB5 Fifth pin on port B. No additional function.

12- Pin no.12 RB6 Sixth pin on port B. 'Clock' line in program mode.

13- Pin no.13 RB7 Seventh pin on port B. 'Data' line in program mode.

14- Pin no.14 V$_{DD}$ Positive power supply pole.

15- Pin no.15 OSC2 Pin assigned for connecting with an oscillator.

16- Pin no.16 OSC1 Pin assigned for connecting with an oscillator.

17- Pin no.17 RA2 Second pin on port A. No additional function.

18- Pin no.18 RA1 First pin on port A. No additional function.

5.3.5.3 Microcontroller clock:

In order to step through the instructions, the microcontroller needs a clock frequency to orchestrate the movement of the data around its electronic circuits. This can be provided by 2 capacitors and a crystal or by an internal oscillator circuit.

Common crystal frequencies would be 32 kHz, 1 MHz, 4 MHz, 10 MHz and 20 MHz. Inside the Microcontroller, there is an area where the processing (the clever work), such as mathematical and logical operations are performed, this is known as the central processing unit or CPU. There is also a region where event timing is performed and another for interfacing to the outside world through ports.

5.3.5.4 The microcontroller system:

The block diagram of the microcontroller system is shown in Figure 4.13.
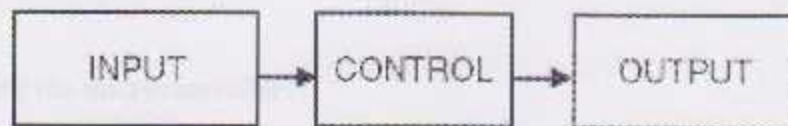
Figure 4.13 The basic microcontroller system

The input components consist of digital devices such as, switches, push buttons, pressure mats, float switches, keypads, radio receivers etc. and analogue sensors such as light dependant resistors, thermostats, gas sensors, pressure sensors, etc.

The control unit is of course the microcontroller. The microcontroller will monitor the inputs and as a result, the program would turn outputs on and off. The microcontroller stores the program in its memory, and executes the instructions under the control of the clock circuit.

The output devices would be made up from LEDs, buzzers, motors, alpha numeric displays, radio transmitters, 7 segment displays, heaters, fans et.

The most obvious choice then for the microcontroller is how many digital inputs, analogue inputs and outputs does the system require. This would then specify the minimum number of inputs and out puts that the microcontroller must have. If analogue inputs are used then the microcontroller must have an Analogue to Digital (A/D) module inside. The next consideration would be what size of program memory storage is required. This should not be too much of a problem when starting out, as most programs would be relatively small. All programs in this book fit into a1k program memory space.

The clock frequency determines the speed at which the instructions are executed. This is important if any lengthy calculations are being undertaken.

The higher the clock frequency the quicker the micro will finish one task and start another.

5.3.5.5 Using the microcontroller:

In order to use the microcontroller in a circuit need to understand how to connect the microcontroller to the hardware.

The hardware that the microcontroller needs to function is shown in Figure 4.14The crystal and capacitors connected to pins 15 and 16 of the 16F84 produce the clock pulses that are required to step the microcontroller through the program and provide the timing pulses. The 0.1mF capacitor is placed as close to the chip as possible between 5v and 0v. Its role is to divert (filter) any electrical noise on the 5v power supply line to 0v,

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thus bypassing the microcontroller. This capacitor must always be connected to stop any noise affecting the normal running of the microcontroller.
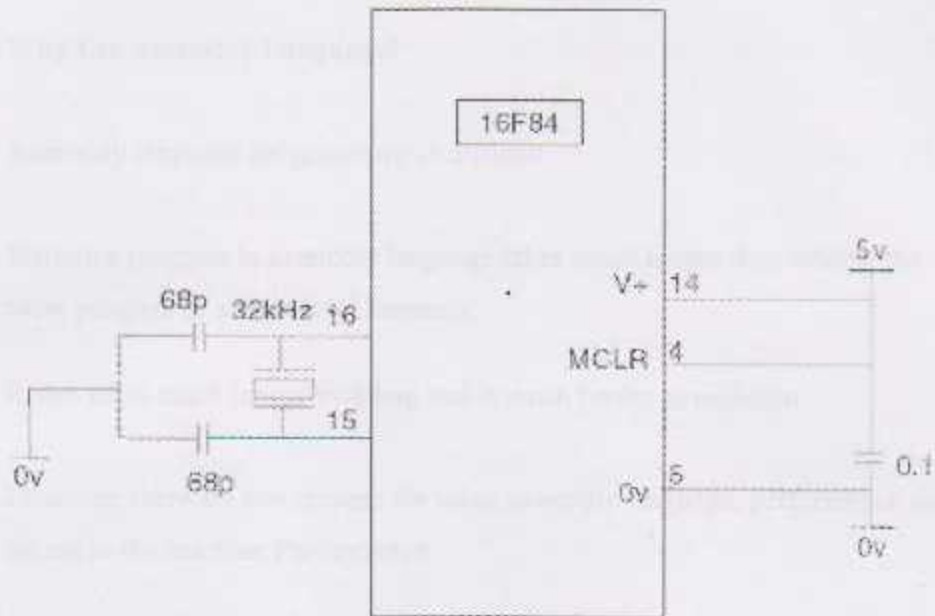
Figure 5.14 The microcontroller circuit

5.3.6 Assembly Program:

5.3.6.1 What is an Assembly Language?

A pure assembly language is a language in which each statement produces exactly one machine instruction. There is a one-to-one correspondence between machine instructions and statements in the assembly program. If each line in the assembly language program contains exactly one statement and each machine word contains

exactly one machine instruction, then an n-line assembly program will produce an n-word machine language program.

5.3.6.2 Why Use Assembly Language?

1) Assembly language programming is difficult.

2) Writing a program in assembly language takes much longer than writing the same program in a high-level language.

3) It also takes much longer to debug and is much harder to maintain.

4) However, there are two reasons for using assembly language, performance and access to the machine Performance.

5) An expert assembly language programmer can often produce code that is much smaller and much faster than a high-level language programmer can.

5.3.6.3 Programming a PIC using Assembly Language:

Various software development tools can assist in testing and debugging assembly language programs written for a microcontroller.

Simulator: This is software that runs on a PC and allows the microcontroller code to be simulated (run) on the PC. Most programming errors can be identified and corrected during simulation.

Emulator: This is a hardware that connects a PC to the microcontroller in a prototype control system. It usually consists of a printed circuit board connected to the control system through ribbon cables.

The emulator can be used to load and run a program on the actual microcontroller attached to the control system hardware (containing sensors, actuators, and control circuits). The emulator allows the PC to monitor and control the operation of the microcontroller while it is embedded in the control system.

5.3.6.4 Instruction Set:

The assembly language used to program a PIC16F84 consists of 35 commands that control all functions of the PIC. This set of commands is called the instruction set for the microcontroller.

The complete instruction set and brief command descriptions for the PIC16F84 are listed in table 4.2.

Each command consists of a name called the mnemonic and, where appropriate, a list of operands. Values must be provided for each of these operands.

Mnemonic Operands	Description
ADDWF f, d	Add W and f
ANDWF f, d	AND W with f
CLRF f	Clear f
CLRW	Clear W
COMF f, d	Complement f
DECF f, d	Decrement f
DECFSZ f, d	Decrement f, Skip if 0
INCF f, d	Increment f
INCFSZ f, d	Increment f, skip if 0
IORWF f, d	Inclusive OR W with f
MOVWF f	Move W to f
MOVF f, d	Move f
NOP	No operation
RLF f, d	Rotate f left 1 bit
RRF f, d	Rotate f right 1 bit
SUBWF f, d	Subtract W from f
SWAPF f, d	Swap nibbles in f
XORWF f, d	Exclusive OR W with f
BIT-ORIENTED FILE	**REGISTER OPERATIONS**
BCF f, b	Bit clear f
BSF f, b	Bit set f
BTFSC f, b	Bit test f, skip if clear
BTFSS f, b	Bit test f, skip if set
LITERAL AND CONTROL	**OPERATIONS**
ADDLW k	Add literal and W
ANDLW k	AND literal with W
CALL k	Call subroutine
CLRWDT	Clear watch-dog timer
GOTO k	Go to address
IORLW k	Inclusive OR literal with W
MOVLW k	Move literal to W
OPTION k	Load OPTION register
RETLW k	Return with literal in W
SLEEP	Go into standby mode
SUBLW k	Subtract W from literal
TRIS f	Load TRIS register
XORLW k	Exclusive OR literal with W

Table 5.2 Assembly instruction

The project depends on the program to generate pulses, and to fix the speed by processing the input signal from the keypad. The program will be able to make the circuit work as the figure 4.15.
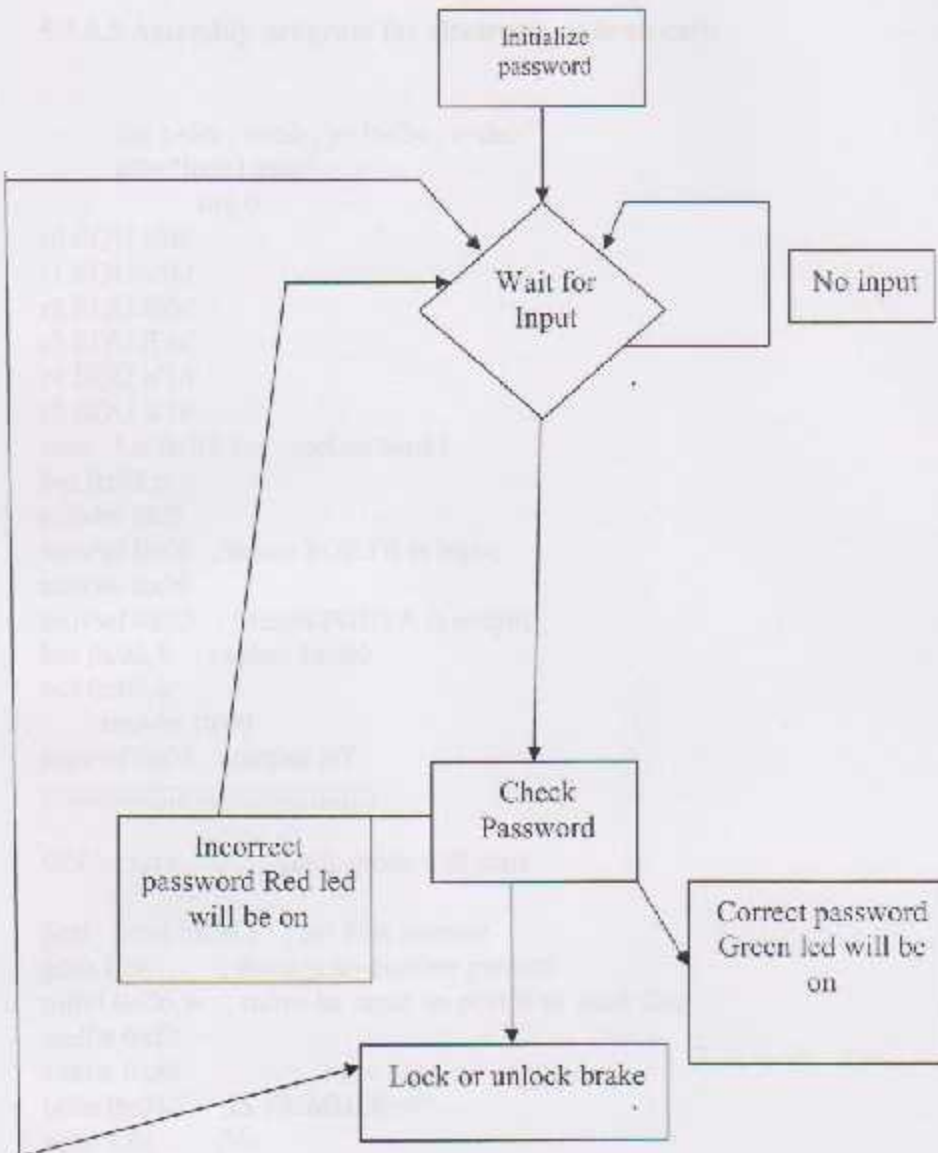
Fig 5.15 Flow Diagram of microcontroller program

5.3.6.5 Assembly program for electronic code circuit:

```
      list c=80 , n=60 , p=16f84 , r=dec
      title "lock1.asm"
              org 0
r0 EQU h'0c'
r1 EQU h'0d'
r2 EQU h'0e'
r3 EQU h'1c'
r4 EQU h'1d'
r5 EQU h'1e'
start  bsf 0x03,5     ;select bank1
bcf 0x03,6
movlw 0xff
movwf 0x06  ;Means PORTB is input
movlw 0x00
movwf 0x05   ; Means PORTA is output
bcf 0x03,5    ; select bank0
bcf 0x03,6
     movlw 0x00
movwf 0x05   ; output off
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

ON    nop        ;lock mode will start

first  btfss 0x06,3  ; get first number
goto first       ; there is no number pressed
movf 0x06,w   ; move he input on port B to work flag
andlw 0xf0
sublw 0x80
btfss 0x03,2   ;IS NUMBER=8?
goto  ON       ;No
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

call delay2        second
btfss 0x06,3   ; get second number
goto second   ; there is no number pressed
movf 0x06,w   ; move he input on port B to work flag
andlw 0xf0
sublw 0x40
btfss 0x03,2   ;IS NUMBER=4?
goto  ON       ;No
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
```

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```
call delay2   third
btfss 0x06,3 ; get third number
goto third   ; there is no number pressed
movf 0x06,w  ; move he input on port B to work flag
andlw 0xf0
sublw 0x80
btfss 0x03,2  ;IS NUMBER=8?
goto ON  ;No
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

fourth  call delay2
  btfss 0x06,3  ; get fourth  number
  goto fourth  ; there is no number pressed
  movf 0x06,w  ; move he input on port B to work flag
  andlw 0xf0
  sublw 0x40
  btfss 0x03,2  ;IS NUMBER=4?
  goto ON  ;No

    bcf 0x05,2  ;red off
bsf 0x05,3  ;green on
bsf 0x05,0 ; solenoid B will be on
call delay1 ; delay 2 sec
bsf 0x05,1  ; solenoid A will be on
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

OFF   nop       ;unlock mode will start

first1  btfss 0x06,3  ; get first  number
goto first1    ; there is no number pressed
movf 0x06,w   ; move he input on port B to work flag
andlw 0xf0
sublw 0x80
btfss 0x03,2  ;IS NUMBER=8?
goto OFF  ;No
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

second1 call delay2
btfss 0x06,3       ; get second number
goto second1    ; there is no number pressed
movf 0x06,w     ; move he input on port B to work flag
andlw 0xf0
sublw 0x40
```

```
btfss 0x03,2   ;IS NUMBER=4?

goto OFF   ;No
.................................
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

call delay2 third1
btfss 0x06,3    ; get third number
goto third1     ; there is no number pressed
movf 0x06,w     ; move he input on port B to work flag
andlw 0xf0
sublw 0x80
btfss 0x03,2    ;IS NUMBER=8?
goto OFF        ;No
.................................
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

fourth1 call delay2
   btfss 0x06,3    ; get fourth  number
   goto fourth1    ; there is no number pressed
   movf 0x06,w     ; move he input on port B to work flag
   andlw 0xf0
   sublw 0x40
   btfss 0x03,2    ;IS NUMBER=4?
   goto OFF        No

bcf 0x05,3    ;green OFF
bSf 0x05,2    ;red ON
bcf 0x05,0    ;solenoid B will be on
bcf 0x05,1    ; solenoid B will be on
goto ON       ; go to star lock mode
.................................
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

delay1 movlw 0x20
       movwf r0
   movlw 133      d1
   movwf r1
d2     movlw 250
   movwf r2
   decfsz r2      d3
   goto d3
   decfsz r1
   goto d2
   decfsz r0
   goto d1
   return
```

```
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

delay2   movlw 0x02
            movwf r3
      movlw 133      d11
      movwf r4
d21       movlw 250
      movwf r5
      decfsz r5      d31
      goto d31
      decfsz r4
      goto d21
      decfsz r3
      goto d11
return
      end
```

5.3.6.6 How assembly program for the electronic code circuit work:

The following charts will display how the program executes instructions of the program.

```
┌─────────────────────────────┐
│      Set port B as input    │
│      Set port A as output   │
│       Clear all outputs     │
└─────────────────────────────┘
              │
              ▼
      ┌───────────────────┐
      │  Start lock mode  │
      └───────────────────┘
              │
              ▼
      ┌───────────────────┐
      │  Get first number │◄──────────┐
      └───────────────────┘           │
          │           │               │
          ▼           ▼               │
      ┌───────┐   ┌───────┐           │
      │  Yes  │   │  No   │───────────┘
      └───────┘   └───────┘
          │
          ▼
   ┌───────────────────┐
   │  Compare whit first│
   │   stored number    │
   └───────────────────┘
              │
              ▼
          ◇ Equal ◇
          │       │
          ▼       ▼
      ┌───────┐ ┌───────┐
      │  Yes  │ │  No   │
      └───────┘ └───────┘
          │         │
          ▼         ▼
┌──────────────────────┐  ┌──────────────────────┐
│ Go to get second number│  │ Go to start lock mode │
│    after 2m sec        │  │        again          │
└──────────────────────┘  └──────────────────────┘
```

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```
                    ┌──────────────────────┐◄──────────┐
                    │  Get second number   │           │
                    └──────────────────────┘           │
                       │              │                 │
                       ▼              ▼                 │
                  ┌────────┐      ┌────────┐────────────┘
                  │  Yes   │      │   No   │
                  └────────┘      └────────┘
                       │              │
                       ▼              ▼
                  ┌──────────────────────────┐
                  │  Compare whit second     │
                  │     stored number        │
                  └──────────────────────────┘
                              │
                              ▼
                         ◄─────────►
                         │  Equal  │
                         ◄─────────►
                          │       │
                          ▼       ▼
                    ┌────────┐  ┌────────┐
                    │  Yes   │  │   No   │
                    └────────┘  └────────┘
                         │           │
                         ▼           │
        ┌──────────────────────────┐ │
        │  Go to get third number  │ │
        │      after 2m sec        │ │
        └──────────────────────────┘ │
                                      ▼
                          ┌──────────────────────────┐
                          │  Go to start lock mode   │
                          │         again            │
                          └──────────────────────────┘
```

```
                    ┌─────────────────────────┐
                    │    Get third number     │◄──────────┐
                    └─────────────────────────┘           │
                       │                  │               │
                       ▼                  ▼               │
                  ┌────────┐         ┌────────┐           │
                  │  Yes   │         │   No   │───────────┘
                  └────────┘         └────────┘
                       │                  │
                       ▼                  ▼
                  ┌───────────────────────────┐
                  │   Compare whit third      │
                  │     stored number         │
                  └───────────────────────────┘
                              │
                              ▼
                          ╱───────╲
                         ╱  Equal  ╲
                         ╲         ╱
                          ╲───────╱
                       │              │
                       ▼              ▼
                  ┌────────┐     ┌────────┐
                  │  Yes   │     │   No   │
                  └────────┘     └────────┘
                       │              │
                       ▼              │
        ┌───────────────────────────┐│
        │ Go to get fourth number   ││
        │      after 2m sec         ││
        └───────────────────────────┘▼
                              ┌───────────────────────────┐
                              │   Go to start lock mode    │
                              │          again             │
                              └───────────────────────────┘
```

```
                    ┌─────────────────────┐
                    │  Get fourth number  │◄──────────────┐
                    └─────────────────────┘               │
                         │          │                      │
                         ▼          ▼                      │
                    ┌───────┐   ┌───────┐                  │
                    │  Yes  │   │  No   │──────────────────┘
                    └───────┘   └───────┘
                         │          │
                         ▼          ▼
                    ┌─────────────────────┐
                    │ Compare whit fourth │
                    │   stored number     │
                    └─────────────────────┘
                              │
                              ▼
                          ╱───────╲
                         ╱  Equal  ╲
                         ╲         ╱
                          ╲───────╱
                         ╱          ╲
                        ▼            ▼
                    ┌───────┐    ┌───────┐
                    │  Yes  │    │  No   │
                    └───────┘    └───────┘
                        │            │
                        ▼            ▼
        ┌──────────────────────┐  ┌─────────────────────┐
        │      Red led off     │  │  Go to start lock   │
        │     Green led on     │  │     mode again      │
        │     Solenoid B on    │  └─────────────────────┘
        │ After 2 sec solenoid A on │
        │   Go to unlock mode  │
        └──────────────────────┘
```

```
                    Start unlock mode

                         |
                         v

                    Get first number  <-------+
                                              |
                    |          |              |
                    v          v              |
                 +------+   +------+          |
                 | Yes  |   |  No  |----------+
                 +------+   +------+

                    |
                    v

            Compare whit first stored
                    number

                         |
                         v

                      /  Equal  \
                     <           >
                      \         /

                    |              |
                    v              v
                 +------+       +------+
                 | Yes  |       |  No  |
                 +------+       +------+
                    |              |
                    v              v

         Go to get second number   Go to start unlock mode
             after 2m sec                  again
```

```
                    ┌─────────────────────┐
                    │  Get fourth number  │◄──────┐
                    └─────────────────────┘       │
                       │              │           │
                       ▼              ▼           │
                  ┌────────┐     ┌────────┐        │
                  │  Yes   │     │   No   │────────┘
                  └────────┘     └────────┘
                       │
                       ▼
              ┌─────────────────────┐
              │ Compare whit fourth │
              │    stored number    │
              └─────────────────────┘
                       │
                       ▼
                   ╱─────────╲
                  ╱   Equal   ╲
                  ╲           ╱
                   ╲─────────╱
                  │           │
                  ▼           ▼
             ┌────────┐   ┌────────┐
             │  Yes   │   │   No   │
             └────────┘   └────────┘
                  │           │
                  ▼           │
      ┌────────────────────┐  │
      │    Red led on      │  │
      │   Green led off    │  │
      │   Solenoid B off   │  ▼
      │   Solenoid A off   │ ┌─────────────────────┐
      │  Go to lock mode   │ │ Go to start lock mode│
      │                    │ │        again         │
      └────────────────────┘ └─────────────────────┘
```
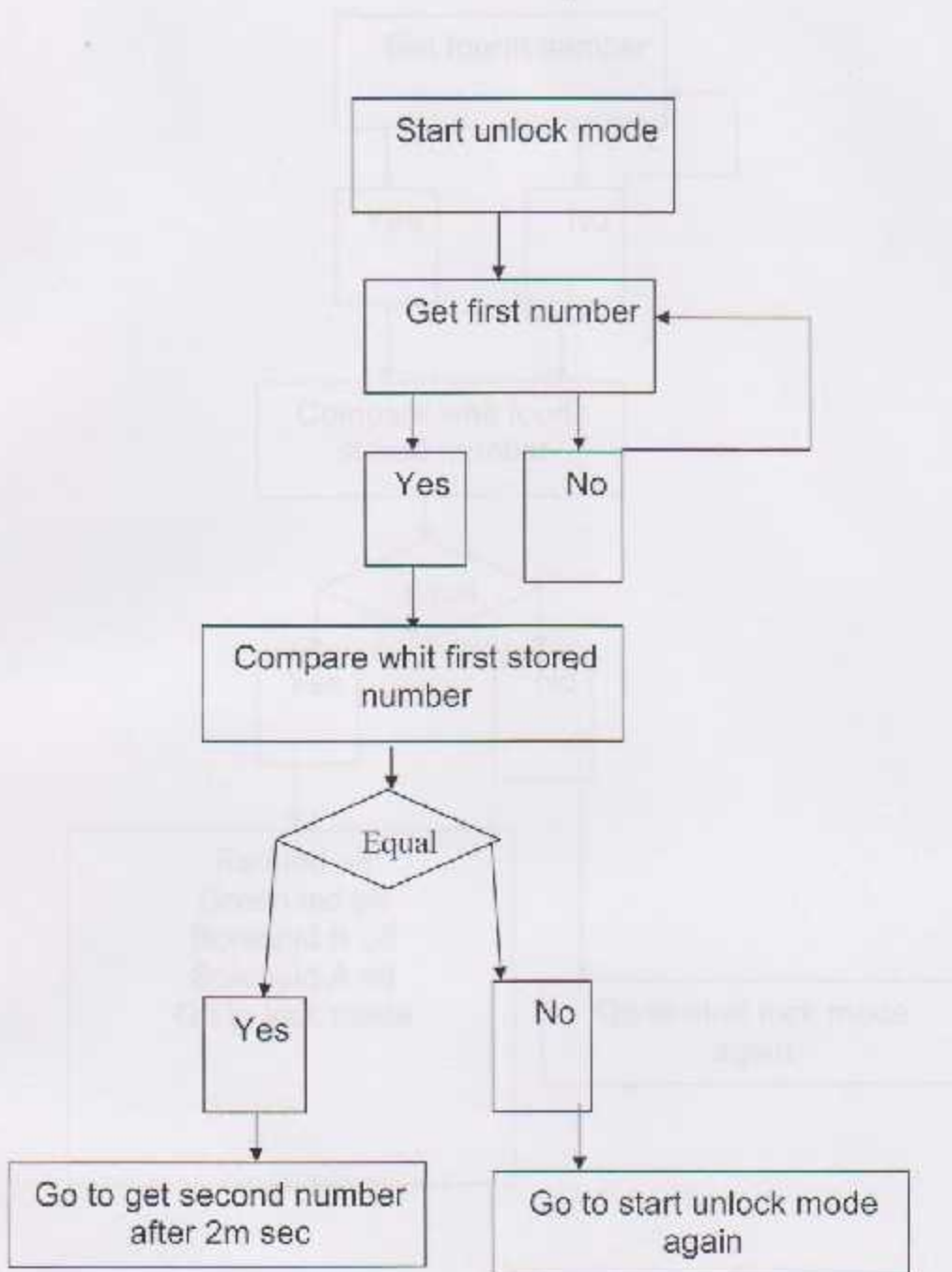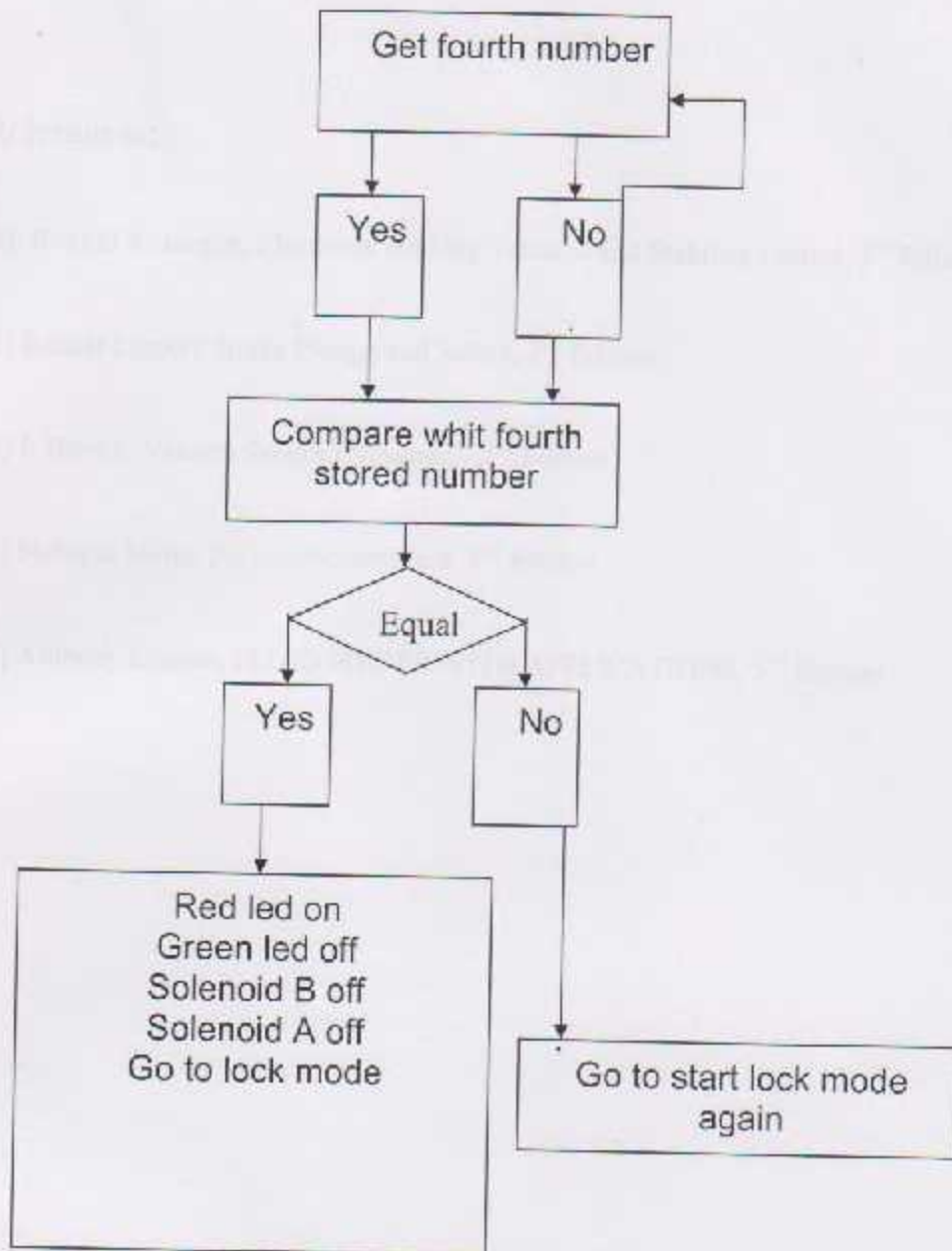
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