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Microcontroller Based Air Suspension System

Mr. E. Gopal M.E[1], D. J. Gunasekaran [2] , R. Prakash [3], V. Vinisha [4]

[1] Assistant professor, Department of mechanical engineering Krishnasamy college of engineering and technology, Cuddalore .
[2,3,4] Department of mechanical engineering Krishnasamy college of engineering and technology Cuddalore -607 109
Email ID- gunamyr07@gmail.com, vinishavijay23@gmail.com, ramanathanprakash2018@gmail.com

ABSTRACT

The microcontroller technology has revolutionized, the design and implementation of air suspension systems using pneumatic cylinders. The system is design to enhance the comfort of a vehicle by automatically adjusting the height of vehicle. The proposed system uses a microcontroller to controls the air suspension system through program. The microcontroller serves as the central processing unit for the system, controlling the air supply, pressure, and the position of the pneumatic cylinders. This allows for precise and efficient adjustment of the vehicle's suspension, resulting in improved ride quality, stability, and safety. To increase the comfortness of the vehicle by isolating the vibration of the body made by uneven surfaces. The system is designed to be highly reliable, easy to use, and cost-effective. The proposed system has the potential to significantly improve the performance and safety of vehicles equipped with air suspension systems.

KEYWORDS: MICROCONTROLLER ,SUSPENSIONS,PNEUMATIC, SENSORS

1. INTRODUCTION

1.1 DEFINITION

In automobiles, most of the functions are done manually at ancient days. In recent days, all the functioning system of vehicles are changed into automatic functions. Now make a ride in easiest way and reduce the effort of human. Suspension system is one of the parts in automobiles and plays a vital role in vehicle. This system is used to absorb the forces made by the irregularities on roads. An advancement in suspension system, made a ride more comfort than the traditional system.

The evolution of suspension system began with coil spring was patented by R. Tradwell in 1763. Recent technological advance has brought about automobiles. In particular automated pneumatic system with the use of prevention of chassis damage using automated pneumatic system, the automatic chassis adjustment and damage of car chassis is prevented effectively.

In 1804, the stackable leaf spring was invented and used primarily in rear suspension systems. The modern automobile suspension system was developed in 1904. Automobile suspension was quickly upgraded in 1906 when front coil springs were mounted on a flexible, hickory axle that dampened spring bounce.

Rear-end coil springs were first introduced by Buick in 1938 Even today, car suspension systems are being constantly improved and the leaf and coil spring still plays a vital role in the automobile suspension system. The larger cars generally had leaf springs, while smaller cars had coil springs.

Multi-body simulations are given more emphasis over physical tests owing to environmental, financial, and time requirements in the competitive automotive industry. Thus, it is imperative to develop models to accurately predict and analyze the system's behavior. This project is focusing on developing an air suspension model with Electronic Level Control that has the ability to communicate with other air springs in a pneumatic circuit, thus replicating the pneumatic connection in actual truck and regulate the ride height of the vehicle. To accomplish this, a comprehensive literature study is performed to identify an effective control variable to manipulate the air suspension. This is done by understanding the working and thermodynamic principles of air suspension, various Scania pneumatic configurations and decrypting the working of the Electronic Level Control.

1.2 SUSPENSION SYSTEM

Suspension is the system of tires, tire air, springs, shock absorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two.

1.3.1 Independent Suspension System:

This system means that the suspension is set-up in such a way that allows the wheel on the left and right side of the vehicle to move vertically independent up and down while driving on uneven surface. A force acting on the single wheel does not affect the other as there is no mechanical linkage present between the two hubs of the same vehicle. In most of the vehicle it is employed in front wheels.

1.3.2 Dependent Suspension System:

In Dependent Suspension there is a rigid linkage between the two wheels of the same axle. A force acting on one wheel will affect the opposite wheel. For each motion of the wheel caused by road irregularities affects the coupled wheel as well.

1.3.3 Semi-Independent Suspension System:

This type of system has both the characteristics of dependent as well as independent suspension. In semi-independent suspension, the wheel move relative to one another as in independent suspension but the position of one wheel has some effect on the other wheel. This is done with the help of twisting suspension parts.

1.4 AIR SUSPENSION SYSTEM:

Air suspension is a type of vehicle suspension powered by an electric or engine-driven air pump or compressor. This compressor pumps the air into a flexible bellows, usually made from textile-reinforced rubber.

FIGURE 1.1 PNEUMATIC CYLINDERS

1.5 MICROCONTROLLER:

A microcontroller is a compact integrated circuit designed to govern a specific operation in an embedded system

1.5.1 How does its work

A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip.

FIGURE 1.2 MICROCONTROLLER

2. LITERATURE REVIEW

"A contemporary adaptive air suspension using LQR control for passenger vehicles"- Gokul Prassad S. and Malar Mohan K. / ISA Transactions 93 (2019)- A quarter car model was considered to analyze the performance of a suspension system under user defined bumps, pot holes and random road conditions with and without control strategies. Unlike the conventional air suspension systems that solely ensure the level of the vehicle with respect to ground, with no explicit concentration on Stiffness of the system, the proposed system concentrates on providing the necessary dynamic Stiffness, based on the load experienced. When the necessary control strategies are introduced, the system adapts itself to the road conditions and performs efficiently providing better ride comfort and handling characteristics. The system controlled with LQR control strategy effectively tuned by PSO technique, reduces the overshoot from 44.6% to a negligible 3.17% and thereby providing better ride comfort.

"The optimum matching control and dynamic analysis for air suspension of multi-axle vehicles with anti-roll hydraulically interconnected system"-H.Lietal(2020)- The study presents the optimum matching control technique of multi-axle vehicle suspension system with the anti-roll hydraulically interconnected system through dynamic analysis. Firstly, three types of anti-roll controllers for single-axle, dual-axle and tri-axle suspension systems of semitrailers are preliminarily modeled in AME Sim, and then seven coupling vehicle systems are established by co-simulation method in AME Sim, Truck Sim and MATLAB/Simulink. Dynamic analysis shows that the D23 and A123 controllers can be used as the optimum matching scheme considering both the overall cost and the anti-roll performance. Subsequently, for the problem of insufficient anti-roll ability of D23, a fuzzy controller is designed as the second auxiliary control of the suspension. The results indicate that the designed control strategy can further improve the handling stability of vehicle.

"Electronic Control Unit Design of Electronically Controlled Air Suspension (ECAS) for Vehicle based on Freescale Microcontroller"- Xinqiang Liu, Yan Tianyi (2016)- In this paper, they designed an electronic control unit of automobile electronically controlled air suspension system (ECAS) including the hardware system and the control strategy, after introducing the composition and the principle of electronically controlled air suspension. In the real vehicle experiments, ECAS system improved the car's fuel economy, traffic-ability and ride comfort.

"Kinematics & compliance analysis of double wishbone air suspension with frictions and joint clearances" -Tianqi Lv a, Yunqing Zhang a , ∗, Yupeng Duan a, James Yang b (2021)- This study proposed a new double wishbone air suspension force element model and illustrates that the influence of suspension components friction and joint clearances for suspension K&C characteristic. In order to provide more accurate test data, a new K&C test rig test procedure based on non-contact binocular vision system is developed. K&C characteristic experiments were carried out on HUST K&C test rig and simulation results were obtained for the proposed suspension model and traditional suspension model.

Evaluation of Effectiveness of Pneumatic Suspensions: Application to Liquid Sloshing Problems -Sibi Kandasamy, Brynne Nicolsen, Ahmed A. Shabana, Giovanni Falcone- In this investigation, an equivalent mechanical air-spring model similar to the linear Nishimura model is used. The model is compared with other models such as linear and non- linear Nishimura, Vampire, and Berg models by evaluating the dynamic stiffness of the air spring at various frequencies. In this formulation, only the orifice damping is considered and the inertial effects of the air mass present in the surge pipe are neglected. It is observed that the model used in this investigation can accurately capture the air-spring behavior at low and high frequency values. Air springs have lower stiffness value at low frequency which is due to the air flow between the bellow and the surge tank and become stiffer when the frequency which is due to the stiffness of the bellow alme as there is not sufficient time for the air to travel between the two volumes. The air spring model is integrated with an MBS algorithm that allows developing detailed tanker truck and railroad vehicle models to compare the air and coil-spring performance. In the case of the tanker truck model, the variation in vertical acceleration of the tank due to sloshing is analyzed when both air and coil spring suspensions are used during lane change and straight-line deceleration summaries In the case of the railroad passenger vehicle model, the performance of air springs secondary suspension is evaluated by assessing the vertical acceleration and roll angle of the car body and the wheel/rail contact forces when the vehicle negotiates a track with a vertical deviation. The effectiveness of the air springs is observed in the railroad freight vehicle model. Although in the t model, the fluid motion was similar for the two s maximum roll angle were reduced sign braking scenario, the fluid experience valuation of the roll angle m Jane change scenario and rail tanker tensions, the vertical acceleration and the when using the air springs. In the truck larger displacement when the air springs are used, but the oscillations die out quickly compared to the coil springs.

Active suspensions and seam-active suspensions are becoming popular in various vehicle suspension systems. They are considered better options for adjusting the vibration isolation characteristics as compared to passive suspension systems Nonetheless, active suspension systems are more complex, require frequent maintenance, consume more power, and are more expensive Semi-active suspension systems have a limited range of damping, as discussed in the paper Air suspensions, on the other hand, do not require an active control system to achieve the desired suspension behavior at the vibration frequency and amplitude range that is most critical for the ride quality Nonetheless, selection of appropriate air-spring design parameters is important to achieve the optimal suspension behavior.

3. OBJECTIVES AND METHODOLOGY

The major objectives of this study and methodology followed to achieve the objectives are given in this section

3.1 OBJECTIVES

- The automatic built pneumatic system is used to lift the car chassis from the ground.

- Pneumatic lifting system is used to provide ground clearance at the time of wild roads and speed breaker.
- To Scope the shortage of fuel and go for compressed air as working medium.
- In order to full fill the needs of present car problems and making a all-environment challenging vehicle.
- To Minimize the human effort.

3.2 METHODOLOGY

- We referred the paper in various journal of ground clearance.
- In this work, we have lifted the chassis by the help of pneumatic cylinder.
- Based on the road condition the sensor may be activated (on-road, off- road).
- The mechanism takes maximum 5sec to lift the chassis after providing the input to the controller.
- The ground clearance of the vehicle is increased by 3cm along the obstacles.
- The car chassis is prevented from being damaged.

4. WORKING PRINCIPLE

The automatic in-built pneumatic system is used to lift the chassis from the ground without human efforts and time. Pneumatic lifting technique system is used to provide higher ground clearance at the time of rough roads and speed bumps. To cope up the shortage of most commonly used fuel and go for compressed air or liquid fuel as a working medium. While driving four-wheeler, we faced a problem related to tyres. A hydraulic operated jack is placed in a supportable position where transitional motion to lift vehicle. In several automobile garages, revealed the facts that mostly some difficult methods were adopted in lifting the vehicles for reconditioning. Hence a suitable Design has been designed such that the vehicle can be lifted from the floor land without application of any impact force.

4.1 PROGRAM:

```
const int trigPin = 2;
const int echoPin = 3;
const int relay = 7;
long duration;
int distance;
int safetyDistance;
void setup()
{
  // put your setup code here, to run once:
pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
pinMode(echoPin, INPUT);
pinMode(relay, OUTPUT);// Sets the echoPin as an Input
Serial.begin(9600); // Starts the serial communication
}
void loop() {
  // put your main code here, to run repeatedly:
// Sets the trigPin on HIGH state for 10 micro seconds
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
```

```
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin,LOW);
// Reads the echoPin, returns the sound wave travel time in microseconds
duration = pulseIn(echoPin,HIGH);
// Calculating the distance
distance= duration*0.034/2;
Serial.println(distance);
delay(50);
safetyDistance = distance;
if((distance>=25))
{
   digitalWrite(relay, LOW);
}
  else if(distance<25)
 {
    digitalWrite(relay, HIGH);
       delay(20000);
  }
```

5. FABRICATION WORK

5.1 DESIGN CALCULATIONS

In this chapter discussed that the calculations were made for designing the pneumatic suspension system.

5.1.1 PNEUMATIC COMPONENTS AND ITS SPECIFICATION:

The pneumatic auto feed drilling machine consists of the following components to full fill the requirements of complete operation of the machine.

1. Double acting pneumatic cylinder
2. Solenoid Valve
3. Flow control Valve
4. Connectors
5. Hoses

5.1.1.1 Double Acting Pneumatic Cylinder:

Technical Data

Stroke length	: Cylinder stoker length 170 mm-0.17 m
Piston rod	: 18 mm 18 x 10"
Quantity	:1
Seals	: Nitride (Buna-N) Elastomer
End cones	: Cast iron

Piston	: EN-8
Media	: Air
Temperature	: 0-80°C
Pressure Range	: 8 N/m²

5.1.1.2 Solenoid Valve:

Size	: 0.635 x 10 m
Part size	: 0.635 x 10 m
Max pressure range	: 0-10 x 10 N/m²
Quantity	:1

5.1.1.3 Flow Control Valve:

Port size	: 0.635 x 10 m
Pressure	:0-8 x 10 N/m²
Media	: Air
Quantity	:1

5.1.1.4 Connectors:

Max working pressure	: 10 x 10 N/m²
Temperature	: 0-100 ° C
Fluid media	: Air
Material	: Brass

5.1.1.5 Hoses:

Max pressure	: 10 x 10 N/m²
Outer diameter	: 6 mm = 6 x 10'm
Inner diameter	: 3.5 mm 3.5 x 10^3m

5.2 COMPONENTS REVIEW

The major components used in this system, their types and working principles are being discussed briefly in this chapter.

- Pneumatic Cylinder
- Solenoid Valve
- Wiper Motor
- Arduino
- Relay
- Battery
- PU tube
- Ultrasonic Sensor

5.2.1 PNEUMATIC CYLINDER:

Pneumatic cylinder(s) (sometimes known as air cylinders) are mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion.

Like hydraulic cylinders, something forces a piston to move in the desired direction. The piston is a disc or cylinder, and the piston rod transfers the force it develops to the object to be moved. Engineers sometimes prefer to use pneumatic because they are quieter, cleaner, and do not require large amounts of space for fluid storage.

Because the operating fluid is a gas, leakage from a pneumatic cylinder will not drip out and contaminate the surroundings, making pneumatics more desirable where cleanliness is a requirement. For example, in the mechanical puppets s of the Disney Tiki Room, pneumatics is used to prevent fluid from dripping into people below the puppets.

FIGURE 5.1 PNEUMATIC CYLINDER

5.2.1.1 Types:

Although pneumatic cylinders will vary in appearance, size and function, they generally fall into one of the specific categories shown below However, there are also numerous other types of pneumatic cylinder available, many of which are designed to fulfill specific and specialized functions.

5.2.1.1.1 Single-Acting Cylinders

Single-acting cylinders (SAC) use the pressure imparted by compressed air to create a driving force in one direction (usually out), and a spring to return to the "home" position. More often than not, this type of cylinder has limited extension due to the space the compressed spring takes up. Another downside to SACS is that part of the force produced by the cylinder is lost as it tries to push against the spring.

5.2.1.1.2 Double-Acting Cylinders:

Double-acting cylinders (DAC) use the force of air to move in both extend and retract strokes. They have two ports to allow air in, one for outstroke and one for instroke. Stroke length for this design is not limited, however, the piston rod is more vulnerable to buckling and bending.

5.2.1.1.3 Multi-Stage, Telescoping Cylinder:

Telescoping cylinders, also known as telescopic cylinders can be either single or double-acting. The telescoping cylinder incorporates a piston rod nested within a series of hollow stages of increasing diameter. Upon actuation, the piston rod and each succeeding stage "telescopes" out as a segmented piston. The main benefit of this design is the allowance for a notably longer stroke than would be achieved with a single-stage cylinder of the same collapsed (retracted). length. One cited drawback to telescoping cylinders is the increased potential for piston flexion due to the segmented piston design. Consequently, telescoping cylinders are primarily utilized in applications where the piston bears minimal side loading.

5.2.2 SOLENOID ACTUATING DIRECTION CONTROLVALVE:

A solenoid valve is an electromechanical device used for controlling liquid or gas flow. The solenoid valve is controlled by electrical current, which is run through a coil. When the coil is energized, a magnetic field is created, causing a plunger inside the coil to move. Depending on the design of the valve, the plunger will either open or close the valve. When electrical current is removed from the coil, the valve will return to its de-energized state. The most common solenoid valve has two ports: an inlet port and an outlet port.

FIGURE 5.2 SOLENOID ACTUATING DIRECTION CONTROL VALVE

5.2.2.1 Solenoid Valve Terminology:

- way is a two-port valve that turns the flow on or off
- way is a three-port valve that allows flow through the valve into a chamber, and then out through the valve exhaust. The universal function can also be used as a diverted valve
- 5/2 way is a five port, two position valve that will put a fluid or air into one end of a double acting device as well as allowing the other end vent to exhaust.
- Zero Differential are solenoid valves that can operate under zero head pressure (do not need a differential pressure drop across the valve to work). This is made up of two categories, direct acting and coupled diaphragm.
- Direct acting are solenoid valves that are activated purely by the electromagnetic forces in the valve and do not rely on the fluid pressure to assist. Hence, they are used where little or no fluid pressure is available such as vacuum service or low-pressure applications.
- Differential operated are solenoid valves that do rely on the fluid pressure to assist in activating the valve. This helps in developing valves with larger orifices, higher pressures and smaller coils. Normally closed (N.C.) means that when the solenoid valve is not energized the supply pressure port is closed off. In the case of 3 way valves the downstream port is open to the exhaust port.
- Normally open (N.O.) means that when the solenoid valve is not energized the supply pressure port is open to the downstream port. In the case of 3 way valves the downstream port is closed to the exhaust port.
- IP rating is an international standard to denote the degree of protection against water and solid objects. All of our electrical coils with DIN plugs have an IP65 rating. The '6' denotes a complete protection against items as small as dust and '5' is protection against low pressure jets of water from all directions.

5.2.3 WIPER MOTOR:

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. y. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electro-mechanical or electronic, to periodically change the direction of current flow in part of the motor.

DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field winding's Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight brushed motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

FIGURE 5.3 WIPER MOTOR

5.2.4 BATTERY:

In electricity, a battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. Since the invention of the first battery (or "voltaic pile") in 1800 by Alessandro Volta and especially since the technically improved Daniell cell in 1836, batteries have become a common power source for many household and industrial applications. According to a 2005 estimate, the worldwide battery industry generates US$48 billion in sales batteries (disposable batteries), which are designed to be used once and discarded, and secondary batteries (rechargeable batteries), which are designed to be recharged and used multiple times. Batteries come in many sizes, from miniature cells used to power hearing aids and wristwatches to battery banks the size of rooms that provide standby power for telephone exchanges and computer data centers.

FIGURE 5.4 BATTERY

A battery is a device that converts chemical energy directly to electrical energy. It consists of a number of voltaic cells; each voltaic cell consists of two half-cells connected in series by a conductive electrolyte containing anions and cations. One half-cell includes electrolyte and the electrode to which anions (negatively charged ions) migrate, i.e., the anode or negative electrode; the other half-cell includes electrolyte and the electrode to which cations (positively charged ions) migrate, i.e., the cathode or positive electrode. In there dox reaction that powers the battery, cations are reduced (electrons are added) at the cathode, while anions are oxidized (electrons are removed) at the anode. The electrodes do not touch each other but are electrically connected by the electrolyte. Some cells use two half-cells with different electrolytes. A separator between half-cells allows ions to flow, but prevents mixing of the electrolytes. Each half-cell has an electromotive force (or emf), determined by its ability to drive electric current from the interior to the exterior of the cell. The net emf of the cell is the difference between the emfs of its half-cells, as first recognized by Volta. Therefore, if the electrodes have emfs E1 and E2, then the net emf is &-E; in other words, the net emf is the difference between the reduction potentials of the half-reactions. The electrical driving force or AV across the terminals of a cell is known as the terminal voltage (difference) and is measured in volts. The terminal voltage of a cell that is neither charging nor discharging is called the open- circuit voltage and equals the emf of the cell Because of internal resistance, the terminal voltage of a cell that is discharging is smaller in magnitude than the open-circuit voltage and the terminal voltage of a cell that is charging exceeds the open-circuit voltage.

5.2.4.1 Types of Battery:

Batteries are classified into two broad categories, each type with advantages and disadvantages.

5.2.4.1.1 Primary Batteries:

Irreversibly (within limits of practicality) transform chemical energy to electrical energy When the initial supply of reactants is exhausted, energy cannot be readily restored to the battery by electrical means Primary batteries can produce current immediately on assembly. Disposable batteries are intended to be used once and discarded. These are most commonly used in portable devices that have low current drain, are used only intermittently, or are used well away from an alternative power source, such as in alarm and communication circuits where other electric power is only intermittently available.

5.2.4.1.2 Secondary Batteries:

It can be recharged that is, they can have their chemical reactions reversed by supplying electrical energy to the cell, restoring their original composition. Some types of primary batteries used, for example. for telegraph circuits, were restored to operation by replacing the components of the battery consumed by the chemical reaction. Secondary batteries are not indefinitely rechargeable due to dissipation of the active materials, loss of electrolyte and internal corrosion. Secondary batteries must be charged before use; they are usually assembled with active materials in the discharged state.

5.2.5 ARDUINO:

Arduino is a single-board microcontroller to make using electronics in multidisciplinary projects more accessible. The hardware consists of a simple open source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. The software consists of a standard programming language compiler and a boot loader that executes on the microcontroller.

MICROCONTROLLER

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler tool chains, the Arduino project provides an integrated development environment (IDE) based the Processing language project.

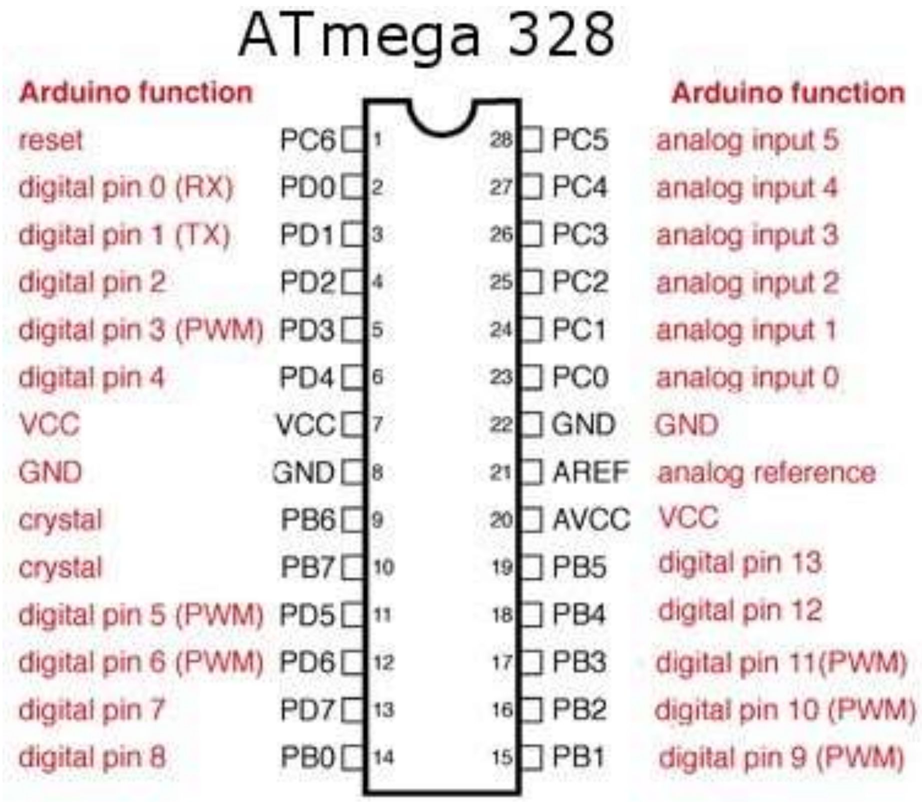

FIGURE 5.6 PIN CONFIGURATION OF ARDUINO

5.2.7 RELAY:

A relay is classified into many types, a standard and generally used relay is made up of electromagnets which in general used as a switch the act of passing something from one thing to another, the same meaning can be applied to this device because the signal received from one side of the device controls the switching operation on the other side. So relay is a switch which controls (open and close) circuits electromechanically. The main operation of this device is to make or break contact with the help of a signal without any human involvement in order to switch it ON or OFF. It is mainly used to control a high powered circuit using a low power signal.

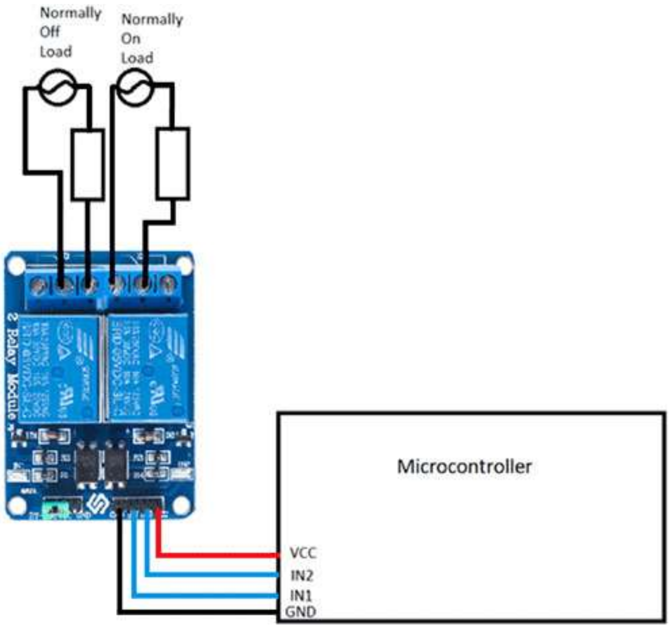

FIGURE 5.7 RELAY

5.2.7.1 How to use a relay:

Relays are most commonly used switching device in electronics. Let us learn how to use one in our circuits based on the requirement of our project. Before we proceed with the circuit to drive the relay, we have to consider two important parameters of the relay. Once is the Trigger Voltage; this is the voltage required to turn on the relay that is to change the contact from Common->NC to Common->NO. Our relay here has 5V trigger voltage, but you can also find relays of values 3V, 6V and even 12V so select one based on the available voltage in your project. The other parameter is your Load Voltage & Current, this is the amount of voltage or current that the NC, NO or Common terminal of the relay could withstand, in our case for DC it is maximum of 30V and 10A. Make sure the load you are using falls into this range

5.2.7.2 Features of 5-Pin 5V Relay:

Trigger Voltage (Voltage across coil) : 5V DC

Trigger Current (Nominal current) : 70mA

Maximum AC load current : 10A @ 250/125V AC

Maximum DC load current : 10A @ 30/28V DC

Compact 5-pin configuration with plastic molding

Operating time : 10msec Release time: 5msec

Maximum switching : 300 operating/minute (mechanically)

5.2.7.4 Applications of Relay:

- Commonly used in switching circuits.
- For Home Automation projects to switch AC loads
- To Control (On/Off) Heavy loads at a pre-determined time/condition

5.2.8 POLY URETHANE TUBE (PU TUBE):

Polyurethane Tube is a polymer composed of organic units joined ethyl carbamate (urethane) links. While most polyurethanes are thermosetting polymers that do not melt when heated, thermoplastic polyurethanes are also available.

Polyurethane polymers are traditionally and most commonly formed by reacting a di- or polyisocyanate with an ethylene glycol. Both the isocyanates and polyols used to make polyurethanes contain, on average, two or more functional groups per molecule.

Polyurethane products often are simply called "urethanes", but should not be confused with ethyl carbamate, which is also called urethane. Polyurethanes neither contain nor are produced from ethyl carbamate.

Some noteworthy recent efforts have been dedicated to minimizing the use of isocyanates to synthesize polyurethanes, because the isocyanates raise severe toxicity issues. Non-isocyanate based polyurethanes (NIPUS) have recently been developed as a new class of polyurethane polymers to mitigate health and environmental concerns.

Polyurethanes are used in the manufacture of high-resilience foam seating, rigid foam insulation panels, microcellular foam seals and gaskets, durable elastomeric wheels and tires (such as roller coaster, escalator, shopping cart, elevator, and skateboard wheels), automotive suspension bushings. electrical potting compounds, high performance adhesives, surface coatings and surface sealants, synthetic fibers (e.g., Spandex), carpet underlay, hard- plastic parts (e.g., for electronic instruments), condoms, and hoses.

FIGURE 5.9 POLYURETHANE TUBE DIAGRAM (PU TUBE)

5.2.9. ULTRASONIC SENSOR:

Ultrasonic transducers and ultrasonic sensors are devices that generate or sense ultrasound energy. Ultrasonic sensors work by emitting sound waves at a frequency too high for humans to hear. They then wait for the sound to be reflected back, calculating distance based on the time required. This similar to how radar measures the time it takes a radio wave to return after hitting an object.

They can be divided into three broad categories: transmitters, receivers and transceivers. Transmitters convert electrical signals into ultrasound, receivers convert ultrasound into electrical signals, and transceivers can both transmit and receive ultrasound.

FIGURE 5.10 ULTRASONIC SENSOR

5.2.9.1. Principle of working:

Ultrasonic sensors work by sending out a sound wave at a frequency above the range of human hearing. The transducer of the sensor acts as a microphone to receive and send the ultrasonic sound. Our ultrasonic sensors, like many others, use a single transducer to send a pulse and to receive the echo.

5.2.9.2. APPLICATIONS AND PERFORMANCE:

Ultrasound can be used for measuring wind speed and direction (anemometer), tank or channel fluid level, and speed through air or water. For measuring speed or direction, a device uses multiple detectors and calculates the speed from the relative distances to particulates in the air or water. To measure tank or channel liquid level, and also sea level (tide gauge), the sensor measures the distance (ranging) to the surface of the fluid. Further applications include: humidifiers, sonar, medical ultrasonography, burglar alarms, non-destructive testing and wireless charging.

Systems typically use a transducer that generates sound waves in the ultrasonic range, above 18 kHz, by turning electrical energy into sound, then upon receiving the echo turn the sound waves into electrical energy which can be measured and displayed.

This technology, as well, can detect approaching objects and track their positions.

Ultrasound can also be used to make point-to-point distance measurements by transmitting and receiving discrete bursts of ultrasound between transducers. This technique is known as Sono micrometry where the transit-time of the ultrasound signal is measured electronically (i.e., digitally) and converted mathematically to the distance between transducers assuming the speed of sound of the medium between the transducers is known.

This method can be very precise in terms of temporal and spatial resolution because the time-of-flight measurement can be derived from tracking the same incident (received) waveform either by reference level or zero crossing. This enables the measurement resolution to far exceed the wavelength of the sound frequency generated by the transducers.

5.2.9.3. Types of ultrasonic sensors:

There are three basic types of ultrasonic sensors;

- Ultrasonic diffuse proximity sensor
- Ultrasonic retro-reflective sensors
- Ultrasonic through-beam sensors

5.2.9.3.1. Ultrasonic diffuse proximity sensor:

An ultrasonic proximity sensor with both the transmitter and receiver integrated into one housing, showing both the emitted sound wave and the reflected wave from the detected object.

Because ultrasonic proximity sensors use sound rather than light, they can be used where photoelectric sensors have difficulty, such as in detecting clear plastic objects and labels, highly reflective surfaces that throw off optical sensors, or even liquid levels. They're also immune to common contaminants such as dust, moisture, and ambient light.

5.2.9.3.2. Ultrasonic retro-reflective sensor:

Traditional ultrasonic sensor designs determine sensor-to-target distances by timing the propagation delay of high-frequency sound pulses as they travel from the sensor to the target and return. But problems occur when the target reflects the sound pulses away from the sensor, making the target acoustically invisible. Retroreflective ultrasonic sensors compare the echo return time from a known, fixed acoustic reflector, such as a wall or ceiling. If that time changes, or the echo disappears, the sensor knows there's a target present.

5.2.9.3.3. Ultrasonic through-beam sensor:

Ultrasonic thru-beam sensors are always comprised of two separate components: the emitter and the receiver. The evaluation and switching output electronics are located in the receiver.

The emitter and receiver are mounted directly opposite one another. As soon as an object interrupts the sound beam between the emitter and the receiver, the sensor switching output activates.

6. RESULT AND DISCUSSION

6.1 RESULT TABLE:

TABLE 6.1 OBSERVATION TABLE WITHOUT MICRO CONTROLLER:

SI NO	**SURFACE**	**PRESSURE**		
		5 BAR	**6 BAR**	**7 BAR**
1.	CEMENT SURFACE	21	22	21
2.	SAND SURFACE	26	27	26
3.	CONCRETE SURFACE	24	25	23

FIGURE 6.1 PRESSURE VS FREQUENCY WITHOUT MICROCONTROLLER

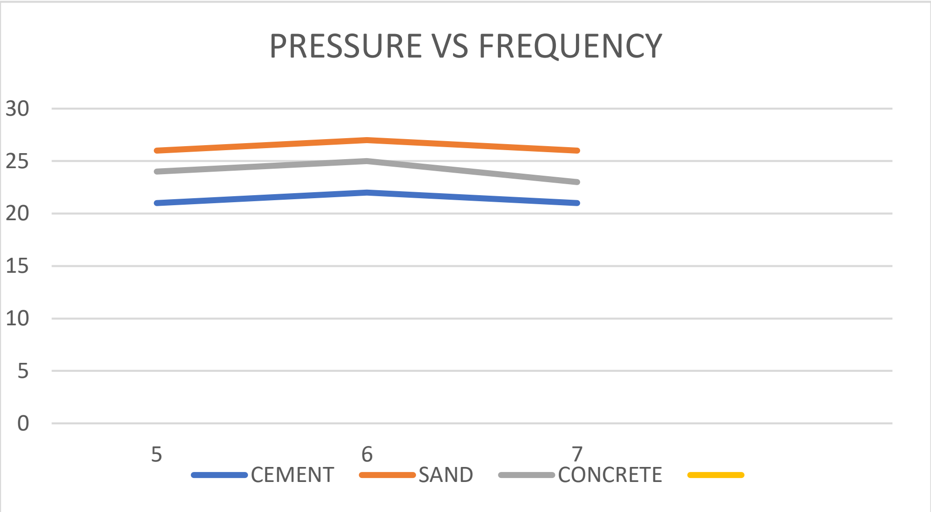

TABLE 6.2 OBSERVATION TABLE WITH MICROCONTROLLER:

SI NO	**SURFACE**	**PRESSURE**		
		5 BAR	**6 BAR**	**7 BAR**
1.	CEMENT SURFACE	38	39	40
2.	SAND SURFACE	52	56	58
3.	CONCRETE SURFACE	44	48	51

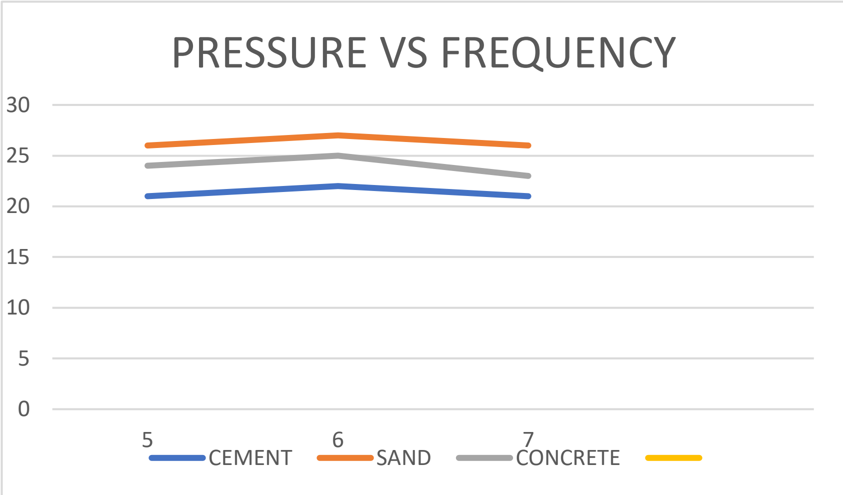

FIGURE 6.2 PRESSURE VS FREQUENCY WITH MICROCONTROLLER

We were finding out the result of our project, that the frequency of vibrations on the vehicle made by the uneven surfaces such as cement surface, sand surface, and concrete surface.

Before the lifting will be done, the frequency of vibration is high and after the lifting will be done, the frequency of vibration decreases.

Decreasing of vibration can be done by the pneumatic cylinders which damping the vibrations in it with the help of pressurized air given to connections by solenoid actuating flow control valve from the storage tank.

The solenoid actuating direction control valve was actuated by the microcontroller program. The program will be changed by our convenient.

It is the best way to damping the vibrations on an uneven surface by our convenient program and obtaining the comfortness for the passengers.

Even the road conditions were not good, the riding was good and smooth by microcontroller-based air suspension system on vehicle.

6.2 EXPERIMENTAL SETUP:

FIGURE 6.3 PHOTOGRAPHIC VIEW

7. CONCLUSION

The microcontroller air suspension system using pneumatic cylinders is a sophisticated and effective way to control the suspension of a vehicle for providing comfortness. The system utilizes sensors and actuators to adjust the height of the vehicle.

Accordingly, resulting in a smooth and comfortable ride by isolation of vibration on the body of the vehicle. The use of a microcontroller allows for precise and reliable control over the conventional suspension system, and the pneumatic cylinders offer a durable and reliable solution for the suspension compared with air bellows.

The use of a microcontroller allows for real-time monitoring and control, making adjustments as necessary to ensure optimal performance. The system also provides the ability to adjust the suspension height and stiffness, allowing for customization based on the preferences of the driver.

By maintaining a consistent ride height and adjusting suspension stiffness, the system can improve stability and handling, especially during high-speed driving and cornering.

Overall, the microcontroller-based air suspension system is a highly effective and customizable solution for those looking to improve the ride quality and handling of their vehicle.

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