RIDE HEIGHT CONTROL TECHNIQUE IS BASED ON DC SYNCHRONOUS MOTOR

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ABSTRACT

A spring is defined as an elastic body, whose function is to distort when loaded and to recover its original shape when the load is removed. Though it has been implemented in the high end vehicles, but this mode of ride height control used in those high end vehicles costs much. The method of controlling the ride height of the vehicle using screw spindle mechanism was simulated and the graph was plotted. Through the experiment it is observed that for every 10km/hr increase in throttle the damper is compressed in steps of 2.5mm and thus the damper height is observed to be 29mm between 10-40kms and it is compressed to maximum when the speed gets increased.

Keywords: *Spring, Vehicle and motor.*

INTRODUCTION:

Vehicles can be categorized in numerous ways. For example, by means of the body style and the "level of commonality in vehicle construction as defined by number of doors and roof treatment (e.g., sedan, convertible, fastback, hatchback) and number of seats" that require seat belts to meet safety regulations.

SUV: A sport utility vehicle or suburban utility vehicle (SUV) is a vehicle classified as a light truck, but operated as a family vehicle. They are similar to a large station wagon or estate car, usually equipped with four-wheel drive for on- or off-road ability. Some SUVs include the towing capacity of a pickup truck with the passenger-carrying space of a minivan or large sedan.

SEDAN:A sedan or saloon is a passenger car in a three-box configuration with A, B & C-pillars and principal volumes articulated in separate compartments for engine, passenger and cargo. The passenger compartment features two rows of seats and adequate passenger space in the rear compartment for adult passengers. The cargo compartmert is typically in the rear, with the exception of some rear-engined models, such as the Renault Dauphine, Tatra T613, Volkswagen Type 3 and Chevrolet Corvair. It is one of the most common car body styles. A battery electric sedan such as the Tesla Model S has no engine compartment, but a front cargo compartment and a rear compartment for cargo or optionally for additional passengers.

Hatchback: Incorporates a shared passenger and cargo volume, with rearmost accessibility via a rear third or fifth door, typically a top-hinged liftgateand features such as fold-down rear seats to enable flexibility within the shared passenger/cargo volume. As a two-box design, the body style typically includes A, B and C-pillars, and may include a D-pillar. Ride height (also called ground clearance or simply clearance) is the amount of space between the base of an automobile tire and the lowest point (typically the Axel); or, more properly, to the shortest distance between a flat, level surface, and the lowest part of a vehicle other than those parts designed to contact the ground (such as tires, tracks, skis, etc.). Ground clearance is measured with standard vehicle equipment, and for cars, is usually given with no cargo or passengers.

Suspension system: Suspension is the system of tires, tire air, springs, shock absorbers and linkagesthat connects a vehicle to its wheels and allows relative motion between the two. Suspension systems serve a dual purpose — contributing to the vehicle's road holding/handling and braking for good active safety and driving pleasure, and keeping vehicle occupants comfortable and a ride quality reasonably well isolated from road noise, bumps, vibrations, etc.These goals are generally at odds, so the tuning of suspensions involves finding the right compromise. It is important for the suspension to keep the road wheel in contact with the road surface as much as possible, because all the road or ground forces acting on the vehicle do so through the contact patches of the tires. The suspension also protects the vehicle itself and any cargo or luggage from damage and wear. The design of front and rear suspension of a car may be different.

Bose Suspension System: While there have been enhancements and improvements to both springs and shock absorbers, the basic design of car suspensions has not undergone a significant evolution over the years. But all of that's about to change with the introduction of a brand-new suspension design conceived by Bose -- the same Bose known for its innovations in acoustic technologies. Some experts are going so far as to say that the Bose suspension is the biggest advance in automobile suspensions since the introduction of independent design.

OBJECTIVES:

- ✓ Controlling the ride height of the vehicle according to its speed.
- ✓ This is due to the usage of magnetically energised fluid, flow lines, etc.
- ✓ Here the ride height control technique is based on DC synchronous motor and so the cost is deliberately reduced.
- ✓ This technique can be used in low end vehicles.

MATERIALS AND METHODS

A shock absorber (in reality, a shock "damper") is a mechanical or hydraulicdevice designed to absorb and damp shock impulses. It does this by converting the kinetic energy of the shock into another form of energy (typically heat) which is then dissipated. Most shock absorbers are a form of dashpot (fig 1). In a vehicle, shock absorbers reduce the effect of travelling over rough ground, leading to improved ride quality and vehicle handling. While shock absorbers serve the purpose of limiting excessive suspension movement, their intended sole purpose is to damp spring oscillations (fig 2). One design consideration, when designing or choosing a shock absorber, is where that energy will go. In most shock absorbers, energy is converted to heat inside the viscous fluid. In hydraulic cylinders, the hydraulic fluid heats up, while in air cylinders, the hot air is usually exhausted to the atmosphere. In other types of shock absorbers, such as electromagnetic types, the dissipated energy can be stored and used later. In general terms, shock absorbers help cushion vehicles on uneven roads.

Spring-based shock absorbers commonly use coil springs or leaf springs, though torsion bars are used in torsionalshocks as well. Ideal springs alone, however, are not shock absorbers, as springs only store and do not dissipate or absorb energy. Vehicles typically employ both hydraulic shock absorbers and springs or torsion bars. In this combination, "shock absorber" refers specifically to the hydraulic piston that absorbs and dissipates vibration. Now composite suspension systems are used mainly in 2 wheelers and also leaf springs are made up of composite material in 4 wheelers. Most vehicular shock absorbers are either twin-tube or mono-tube types with some variations on these themes (fig 3).

Basic twin-tube:Also known as a "two-tube" shock absorber, this device consists of two nested cylindrical tubes, an inner tube that is called the "working tube" or the "pressure tube", and an outer tube called the "reserve tube". At the bottom of the device on the inside is a compression valve or base valve. When the piston is forced up or down by bumps in the road, hydraulic fluid moves between different chambers via small holes or "orifices" in the piston and via the valve, converting the "shock" energy into heat which must then be dissipated.

Twin-tube gas charged:Variously known as a "gas cell two-tube" or similarly-named design, this variation represented a significant advancement over the basic twin-tube form. Its overall structure is very similar to the twin-tube, but a low-pressure charge of nitrogen gas is added to the reserve tube. The result of this alteration is a dramatic reduction in "foaming" or "aeration", the undesirable outcome of a twin-tube overheating and failing which presents as foaming hydraulic fluid dripping out of the assembly. Twin-tube gas charged shock absorbers represent the vast majority of original modern vehicle suspensions installations.

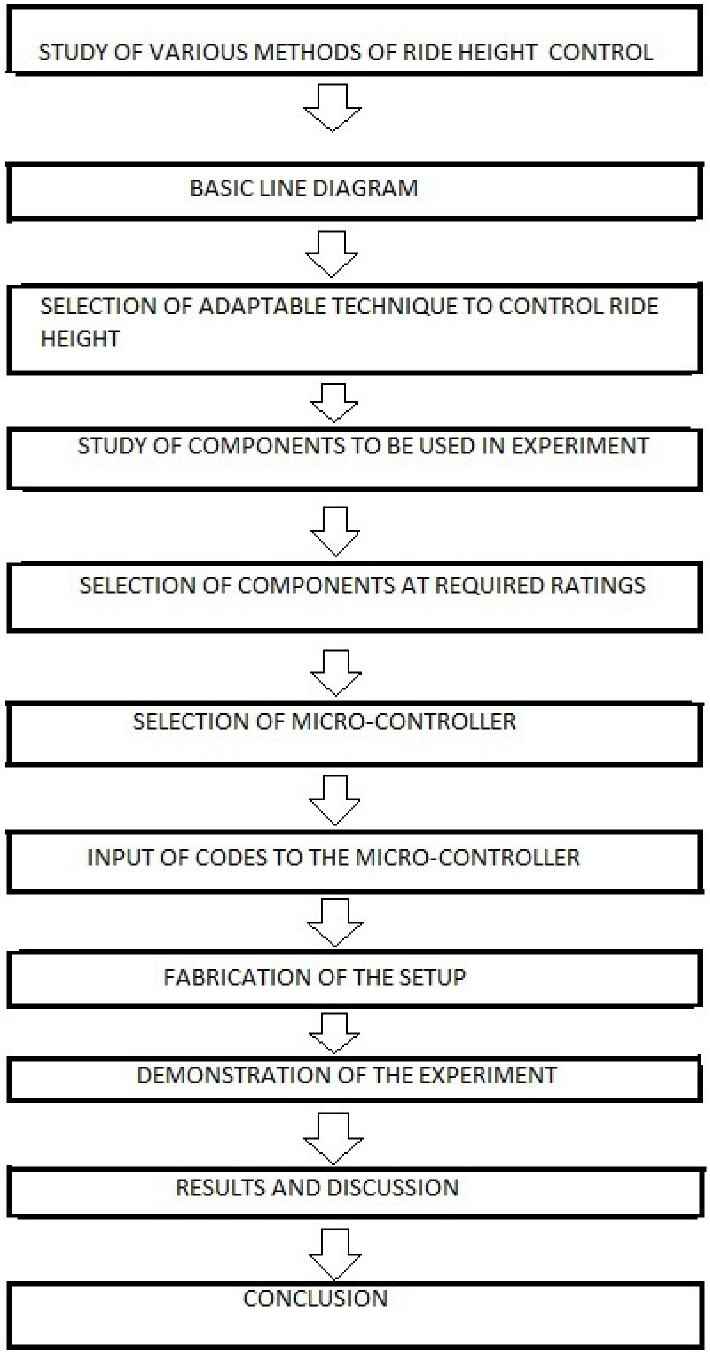
Position sensitive damping:Often abbreviated simply as "PSD", this design is another evolution of the twin-tube shock. In a PSD shock absorber, which still consists of two nested tubes and still contains nitrogen gas, a set of grooves has been added to the pressure tube. These grooves allow the piston to move relatively freely in the middle range of travel (i.e., the most common street or highway use, called by engineers the "comfort zone") and to move with significantly less freedom in response to shifts to more irregular surfaces when upward and downward movement of the piston starts to occur with greater intensity (i.e., on bumpy sections of roads— the stiffening gives the driver greater control of movement over the vehicle so its range on either side of the comfort zone is called the "control zone"). This advance allowed car designers to make a shock absorber tailored to specific makes and models of vehicles and to take into account a given vehicle's size and weight, its manoeuvrability, its horsepower, etc. in creating a correspondingly effective shock.

Acceleration sensitive damping:The next phase in shock absorber evolution was the development of a shock absorber that could sense and respond to not just situational changes from "bumpy" to "smooth" but to individual bumps in the road in a near instantaneous reaction. This was achieved through a change in the design of the compression valve, and has been termed "acceleration sensitive damping" or "ASD". Not only does this result in a complete disappearance of the "comfort vs. control" trade off, it also reduced pitch during vehicle braking and roll during turns. However, ASD shocks are usually only available as aftermarket changes to a vehicle and are only available from a limited number of manufacturers.

Coil-over:Coil-over shock absorbers are usually a kind of twin-tube gas charged shock absorber around which has been mounted a large metal coil. Though common on motorcycle and scooter rear suspensions, coil-over shocks are uncommon in original equipment designs for vehicles, though they have become widely available as aftermarket add-ons. Coil-over shocks for cars have been considered specialty items for high performance and racing applications where they allow for significant reductions in overall vehicle height, and though high-quality aftermarket options with wide sturdy springs may provide improvements in vehicle performance, there is dispute over whether or not most aftermarket coil-over shocks confer any material benefits to most drivers and may in fact reduce performance over original equipment installations.

Mono Tube: The principal design alternative to the twin-tube form has been the mono-tube shock absorber which was considered a revolutionary advancement when it appeared in the 1950s. As its name implies, the mono-tube shock, which is also a gas-pressurized shock and also comes in a coil-over format, consists of only one tube, the pressure tube, though it has two pistons. These pistons are called the working piston and the dividing or floating piston, and they move in relative synchrony inside the pressure tube in response to changes in road smoothness. The two pistons also completely separate the shock's fluid and gas components. The mono-tube shock absorber is consistently a much longer overall design than the twin-tubes, making it difficult to mount in passenger cars designed for twin-tube shocks. However, unlike the twin-tubes, the mono-tube shock can be mounted either way— it does not have any directionality. It also does not have a compression valve, whose role has been taken up by the dividing piston, and although it contains nitrogen gas, the gas in a mono-tube shock is under high pressure (260-360 p.s.i or so) which can actually help it to support some of the vehicle's weight, something which no other shock absorber is designed to do.

WORK PLAN: Here illustrated the methodology and 2d diagram, black diagram were given in fir 4 and 5 respectively.



METHODOLOGY: The setup consists of PIC micro controller circuit coupled with brushless DC motor (Engine), RPM counter & LCD. The RPM counter has a sensor which sends signal to the micro-controller circuit in the form of PWM (pulse width modulation) It also consists of a DC driver(H bridge type) , DC synchronous motor connected to the damper. The engine motor is excited by the external power source which in turn drives the driver motor. As the engine motor starts running, the speed of the engine motor can be adjusted by the knob provided in the control panel. The speed of the motor can be calculated by the RPM counter provided in the setup. The RPM counter, LCD and motor are coupled with pic circuit. The motor sends a pulse width modulation to the rpm counter where it gets processed and the speed of the motor can be calculated and the result is displayed on the LCD display. These calculations and processes are processed in the pic counter (8). The reading from the pic counter makes the driver motor (2298D) drive at the speed which is obtained from the engine motor. The DC synchronous motor acts accordingly such as to compress or expand the spring. When the speed of the engine is increasing, the DC synchronous motor running at a relatively high speed. Which in turn leads to the compression of the spring which makes the height of the ride lowered. If the speed of the engine decreases, the speed of the DC synchronous motor reduces relatively so that the spring is expanded which in turn makes the height of the ride increases. In other words, if the speed of the vehicle increases, the ride height decreases and vice-versa.

Table 1. Values of allowable shear stress, Modulus of elasticity and Modulus of rigidity for various spring materials.

Material	Allowable shear stress (τ) MPa			Modulus Of Rigidity (G)	Modulus elasticity (E)
	Severe service	Average service	Light service		
1. Carbon steel					
(a) Up to 2.125 mm dia.	420	525	651		
(b) 2.125 to 4.625 mm	385	483	595		
(c) 4.625 to 8.00 mm	336	420	525		
(d) 8.00 to 13.25 mm	294	364	455	80	210
(e) 13.25 to 24.25 mm	252	315	392		
(f) 24.25 to 38.00 mm	224	280	350		
2. Music wire	392	490	612		
3. Oil tempered wire	336	420	525		
4. Hard-drawn spring wire	280	350	437.5		

SPRING DESIGN:

D= 26mm, d= 4.5mm, n= 20 , 1kg = 9.81N , W1= 100 kg = 980N, W2= 400 kg = 3924N

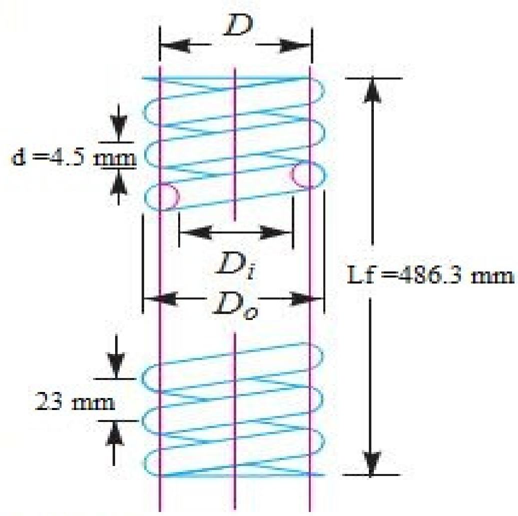


Fig 5 A. Spring Dimensions

Allowable shear stress:

τ =385mpa (for severe service, for carbon steel up to 4.625mm)

Modulus of rigidity:

$G = 84\ kN/m^2$

D- Mean diameter of the spring coil for a maximum load ofW2= 3924N,

d- Diameter of the spring wire

We know that,

Twisting Moment:

T = W2 * (D/2): = 3924 * (26/2): T = 51012 N mm.

We know that outer diameter of the spring coil,

$D_o = (D+d) = 26+4.5 = 30.5mm$

and the inner diameter of the spring coil,

$D_i = (D-d) = 26-4.5 = 21.5mm$

Deflection of the spring:

$\delta = (8. W.c^3.n)/ G.d$

The axial deflection of the spring for the load range from 980N to 3924N i,e deflection for maximum load 2944N is,

(for squared and grounded ends n'=20+2 =22)

$= (8 \text{ x } 2944 \text{ x } 6^3 \text{x } 22)/ (84*10^3 \text{ x } 4.5)$

$= (101744640) / 378000: = \delta = 253\text{mm}$

Maximum compression for 2944N is,

$\delta_{max} = (\delta/W) * W2 = (253/2944) * 3924$

$\delta_{max} = 337\text{mm}$(under maximum load)

<u>Free length of the spring:</u>

$Lf = n'.d + \delta_{max} + 0.15(\delta_{max})$

$= 22(4.5) + 337 + 0.15(337) = 486.3\text{mm}$

<u>Pitch:</u>

$= Lf / (n'-1) = 486.3 / (22-1) = 486.3 / 21 = 23\text{mm}$

<u>TEST IN ANSYS:</u>

Max.principle stresses (mpa)

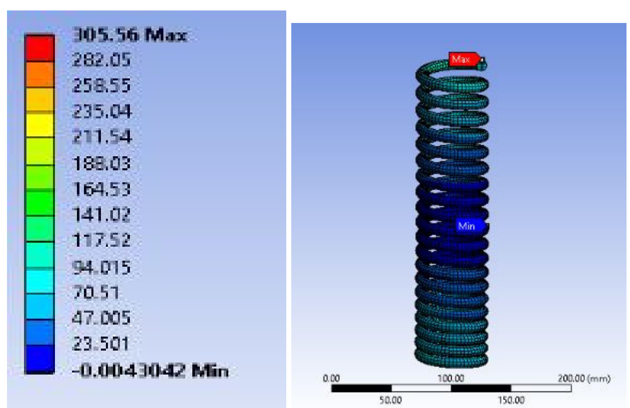


Fig 6. Test at 1000N

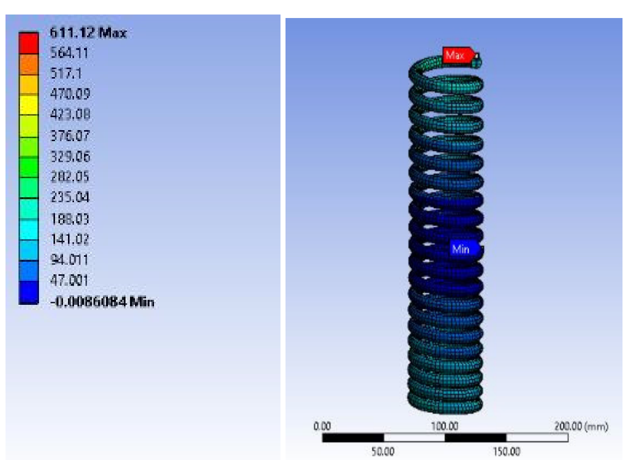


Fig 7. Test at 2000N

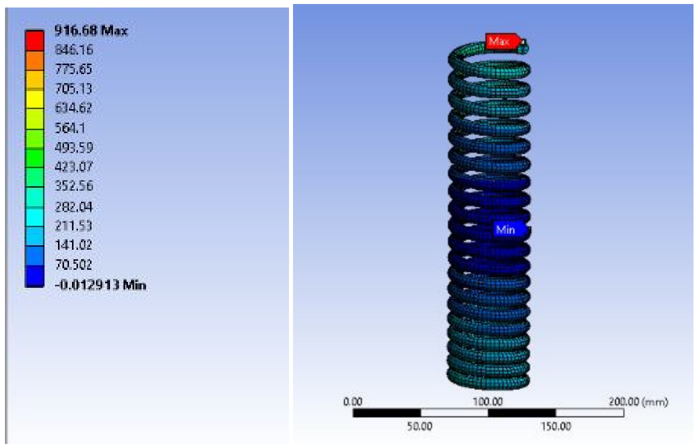


Fig 8. Test at 3000N

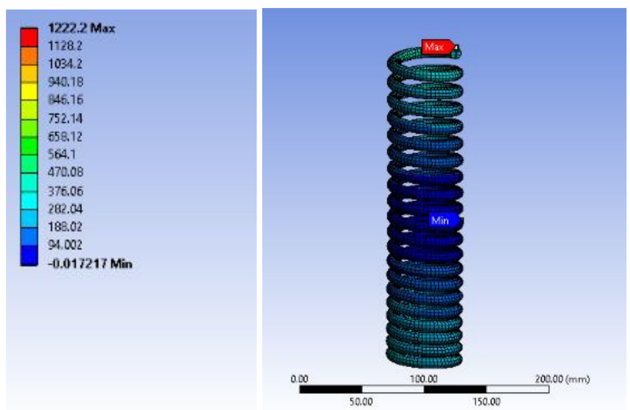


Fig 9.Test at 4000N

SPEED VS HEIGHT GRAPH

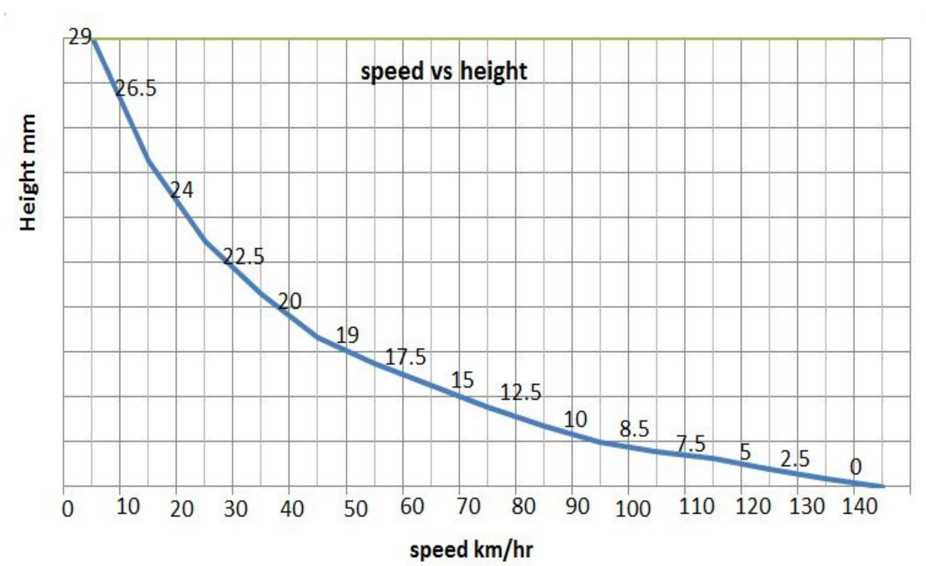


Fig 10. speed vs height graph

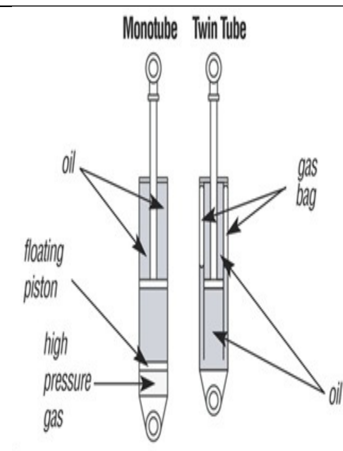
RESULT:

The damper is designed as a carbon steel of 4.5mm wire diameter for severe service to a maximum load of 3924N and the results showed that the designed spring is capable to withstand a load of 4000N. Through the test in ANSYS, the maximum principle stress is at the top of the damper while compression and the minimum stress act in the central region of the damper.

The method of controlling the ride height of the vehicle using screw spindle mechanism was simulated and the graph was plotted. Through the experiment it is observed that for every 10km/hr increase in throttle the damper is compressed in steps of 2.5mm and thus the damper height is observed to be 29mm between 10-40kms and it is compressed to maximum when the speed gets increased.

CONCLUSION:

- ✓ The ride height of the vehicle can be controlled by using synchronous motor powered by PIC micro-controller circuit.
- ✓ The ride height of the vehicle is adjusted according to its speed.
- ✓ Thus the method of controlling the ride height using the synchronous motor which is coupled with a microcontroller, which is no less in performance of those technique used in high end vehicles.
- ✓ Implementation of screw spindle mechanism reduces the cost of the technique, ultimately it can be implemented in low end vehicles also.
- ✓ Therefore the ride height of the vehicle is controlled according to its speed in this project.

		
Fig 1. Shock Absorber	Fig 2. Shock Absorber Fitted With Wheel	Fig 3..Mono & Twin tube shock absorber

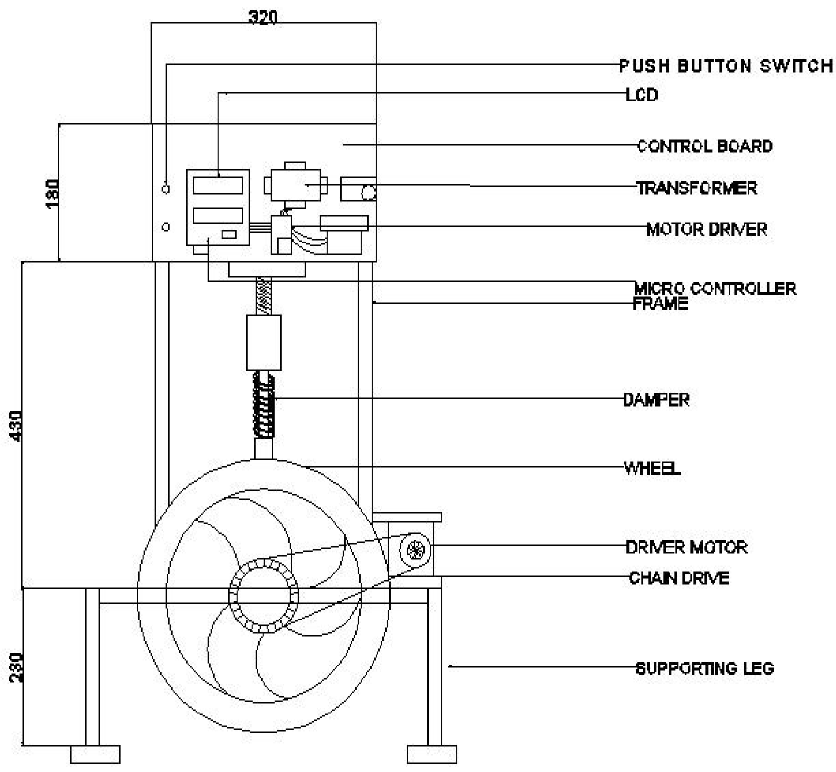


Fig 4. 2D Diagram

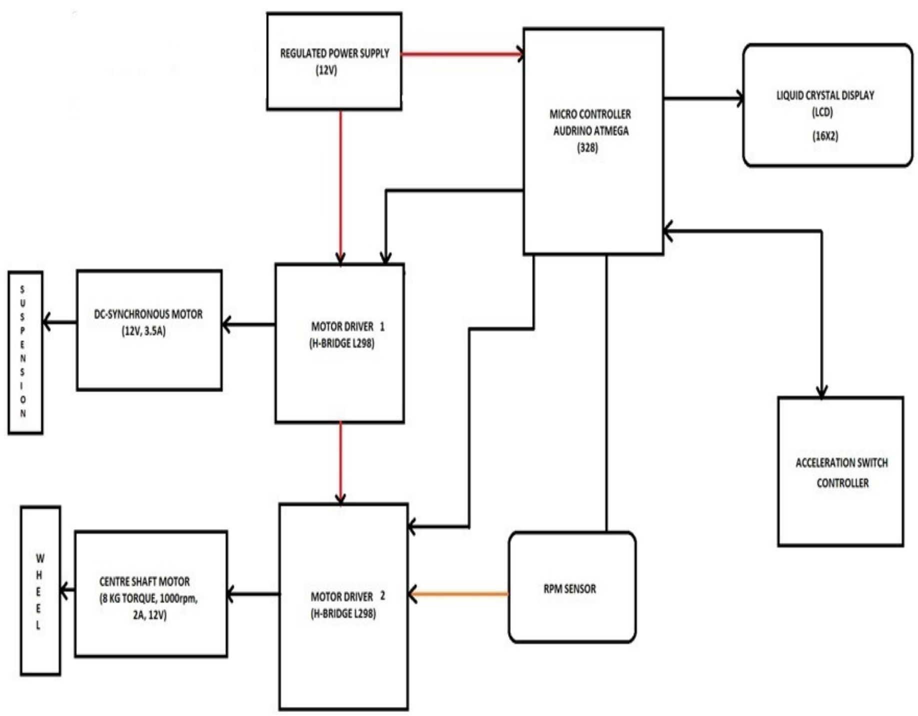


Fig 5. Black Diagram

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