

Development and Analysis of Quarter Car Vibration Absorption System

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Abstract-Improved high challenge on the car showcase has constrained organizations to investigate elective methodologies to traditional inactive suspension frameworks. So as to improve taking care of and comfort execution, rather than a customary static spring and damper framework, semi-dynamic and dynamic frameworks are being created. A functioning suspension framework has been proposed to improve the ride comfort. A quarter-vehicle 2degree-of-opportunity (DOF) framework is structured and built based on the idea of a four-wheel autonomous suspension to reproduce the activities of a functioning vehicle suspension framework. The reason for a suspension framework is to help the vehicle body and increment ride comfort. An automobile sector has more scope but in automobile especially in passenger vehicles there is always compromise between the passenger comfort and vehicle handling. The main aim of this project is to design development and analyze the performance of the techniques of controlling the non-linear vibration of the quarter car vibration absorption system using the MATLAB (simulink & simscape) and fast Fourier transformer (FFT Analyzer).

Keywords — Quarter car vibration absorption system, MATLAB (simulink & simscape), PID controller, FFT Analyzer

I.Introduction

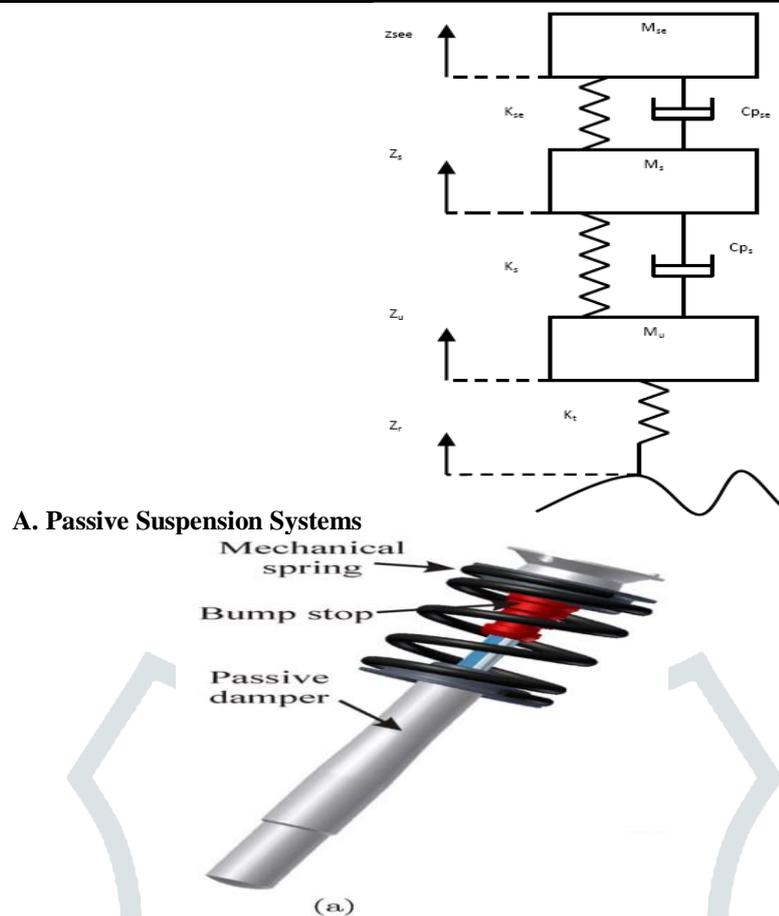
Suspension frameworks have been broadly connected to vehicles, ride from the pony drawn carriages with adaptable leaf spring fixed at four Corners, to current autos with complex control calculations. Each vehicle proceeding onward the arbitrarily profiled street is open to vibrations which are unsafe both for the travelers as far as solace and for the strength of the vehicles itself. In dynamic suspension frameworks using ideal suspension execution under different driving conditions (vehicle speed, street unevenness and so on.) have been considered for a long time and a few frameworks have just been embraced for some rich vehicles. Two kinds of dynamic suspension frameworks are generally viewed as hydrodynamics and pneumatic frameworks. Ride solace might be influenced by around abnormalities, streamlined powers and vibration of the power train system in configuration is to control the subsequent vehicle vibration with the goal that traveler's impression of distress does not surpass a specific dimension. Vehicle suspension configuration must begin with thought of what ride comfort levels are desirables for travelers or what vibration levels are decent for the scope of cargoes to be conveyed. The anticipated ride movement of the vehicle would then be able to be coordinated to these, at the structure organize, if the basic tenets of mechanics are pursued.

Background

The execution of suspension framework has been incredibly expanded vehicle ability apple yard and well store dispersion drive development has proposed a few act attributes to be considered so as to accomplish great suspension framework. These qualities manage guideline of body development, the guideline of suspension development and the power dispersion. In a perfect world the suspension ought to detach the body from aggravations and inertial unsettling influences related with cornering and breaking or speeding up. The suspension should likewise ready to limit the vertical power transmitted to travelers for their solace. This goal can be accomplished by limiting the vertical vehicle body speeding up. An extreme wheel travel will result in non ideal frame of mind of tire with respect to street that will cause poor taking care of and attachment besides, to keep up great taking care of attributes; the ideal tire street contact must be kept up on four wheels. In regular suspension framework, these attributes are clashing don't meet all conditions. Car scientists have examine the suspension framework widely through both investigation and analyses. The primary objective of study is to improve the customary plan exchange among ride and street dealing with legitimately the suspension power to suit with the execution qualities.

II Suspension System

The suspension framework can be classified into latent, semi-dynamic and dynamic suspension framework as indicated by outer power contribution to the framework as well as a control data transfer capacity. An inactive suspension framework is an ordinary suspension framework comprises of a non-controlled spring and stun retaining damper as appeared in figure. Uninvolved suspension frameworks have constraints in improving or upgrading ride quality and taking care of at the same time. The semi-dynamic suspension as appeared in figure has similar components however the damper has at least two selectable damping rate. A functioning suspension is one in which latent segment are increased by actuators that supply extra power. Other than these three sorts of suspension framework, a skyhook type damper has been considered in the early plan of the dynamic suspension framework. In the skyhook damper suspension framework, a nonexistent damper is set between the sprung mass and the sky as appeared in figure .The fanciful damper gives a power on the vehicles body relative to the sprung mass total speed. Thus, the sprung mss developments can be decreased without improving the tire avoidances. In any case, this structure idea isn't doable to be acknowledged (Hrovat, 1988).the actuator has to be placed between the sprung mass and the unsprung mass instead of the sky.



A. Passive Suspension Systems

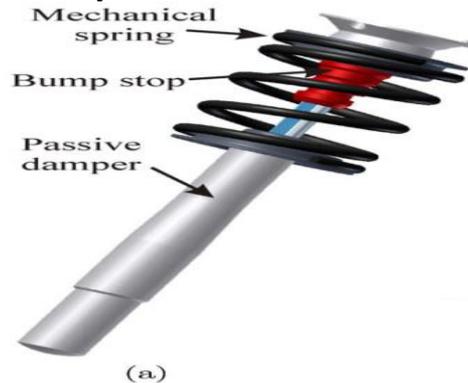


Fig- A quarter car passive model

Detached suspension frameworks are the most widely recognized frameworks that are utilized in business traveler vehicles. They are made out of regular springs, and single or twin-tube oil dampers with consistent damping properties. The architect pre-sets the fix damping properties to accomplish ideal execution for the planned application. The disservice of inactive suspension frameworks with steady damping attributes is that setting the structure parameters is a trade off between the ride quality and dealing with. By and large, gentler dampers give a progressively agreeable ride, while stiffer ones give better security and along these lines better street dealing with. Uninvolved suspension frameworks are tuned by the normal working conditions, however a trade off is constantly made between structuring for the two restricting objectives. In this way, the execution in every zone is constrained by this trade off. Be that as it may, customary detached suspension frameworks are ease, and generally easy to produce.

B. Semi-Active Suspension Systems

Since first proposed by Crosby and Karnopp (1973), semi-dynamic suspension frameworks keep on picking up ubiquity in vehicle suspension framework applications, because of their invaluable qualities over latent suspension frameworks. Semi-dynamic (otherwise called versatile latent) suspension frameworks are basically uninvolved frameworks in which the damping properties can be changed in accordance with some degree. Subsequently, semi-dynamic suspension frameworks expand the conceivable scope of damping qualities reachable from a uninvolved damper. The damping attributes of a semi-dynamic damper can be balanced through applying a low-control flag. Semi-dynamic frameworks are a trade off between the dynamic and uninvolved frameworks. They are popularized as of late by methods for either a solenoid valve as a customizable opening, or MR-liquid dampers, the two of which are over the top expensive. Driving car makers, for example, GM and Volvo have begun the execution of these semi-dynamic suspension frameworks for their top of the line Automobiles. Nonetheless, there exist numerous difficulties that must be defeated for these innovations.

The MR dampers have still some vital issues, for example, MR debasement with time, temperature affectability, and fixing issues. Semi-dynamic frameworks can just change the gooey damping coefficient of the safeguard, and don't add vitality to the suspension framework. In spite of the fact that restricted in their intercession (for instance, the control power can never have unexpected heading in comparison to that of the present speed of the suspension), semi-dynamic suspensions are more affordable to structure and devour far less vitality. As of late, investigate in semi-dynamic suspensions has kept on progressing as for their abilities, narrowing the hole between semi-dynamic and completely dynamic suspension frameworks.

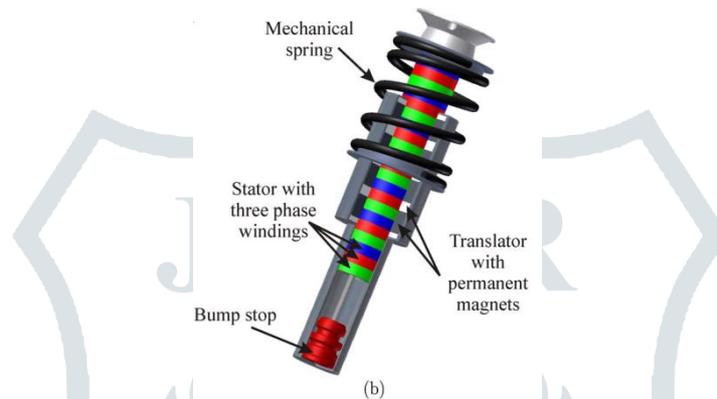
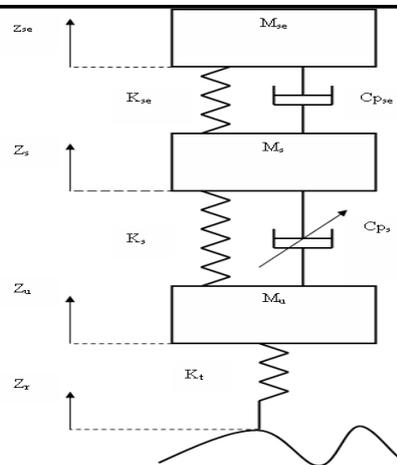


Fig: schematic view of a semi active suspension system

C. Active Suspension Systems

Dynamic suspension framework alludes to a framework that utilizes a functioning force source to activate the suspension interfaces by broadening or contracting them as required (Gillespie, 2006). The primary test in the car suspension framework configuration is the exchange off between the clashing necessities of ride-solace and taking care of. In the previous couple of decades, because of advances in sensors/actuators innovations, dynamic suspension frameworks have developed as a functioning exploration field to address those trade offs. In a functioning suspension, controlled powers are acquainted with the suspension by methods for pressure driven or electric actuators, between the sprung and unsprung-mass of the wheel congregations (Brown, 2005). Karnopp (1983) contemplated the impact of adding a functioning damping power to the suspension framework. Milliken (1988) built up the principal completely dynamic suspension to be utilized in a suspensions framework application. A variable power is given by the dynamic suspension at each wheel to consistently adjust the ride and taking care of qualities. The key distinction between semi-dynamic and dynamic suspension frameworks is that the last applies an outer power to the vehicle body either in an upward or descending heading, paying little heed to the supreme vehicle body speed.

Active suspension beats the tradeoffs required in tuning uninvolved dampers. Sensors, as fundamental components of a functioning suspension, are utilized to quantify the suspension developments at various focuses. Albeit dynamic suspensions have brilliant execution, the viable usage of dynamic suspension in vehicles has been constrained because of their high weight, cost, control utilization, and diminished unwavering quality that are not supported by the restricted gradual advantage to the traveler (Deo, 2007). The vast majority of the suspension frameworks that are proposed and executed in vehicle suspension frameworks depend on water powered or pneumatic gadgets.

Dynamic suspensions, the first to be presented, utilize separate actuators which can apply an autonomous power on the suspension to improve the riding attributes. The disadvantages of this plan (in any event today) are mind-boggling expense, included complexity/mass of the device required for its task, and the requirement for rather visit upkeep and fixes on certain executions. Upkeep can likewise be risky, since just a manufacturing plant approved seller will have the devices and mechanics

who realize how to take a shot at the framework and, a few issues can be hard to analyze dependably.

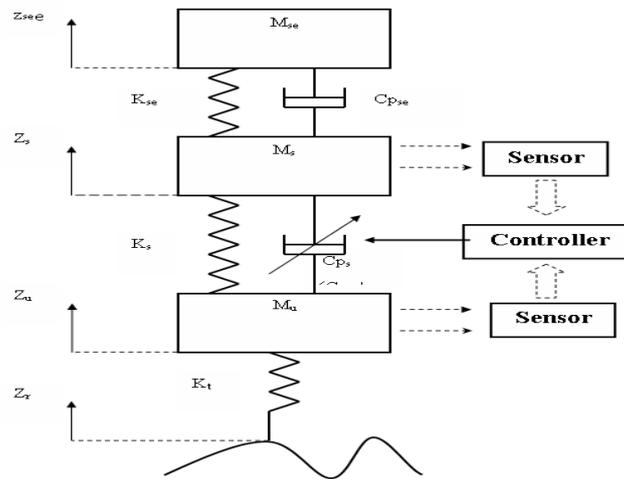


Fig. Quarter Car of Active Suspension system.

Advantages of Active Suspension System

In a functioning suspension framework, the detached power components are supplanted or helped by dynamic power components. These components can deliver a power when required and act autonomous of the suspension condition. In this way, the exchange off between ride solaces, suspension travel and wheel load varieties can be better settled. Besides, a functioning suspension framework can be utilized so as to dispose of body move amid cornering. As an outcome, the wheels can be situated ideally regarding the street both if there should be an occurrence of experiencing a knock and amid cornering. The referenced exchange off vanishes, and furthermore an enemy of move bar isn't required any longer. On account of this framework, the convoluted and space devouring suspension connections can be supplanted with a minimized and straightforward trailing arm suspension. The cost of vitality is consistently expanding and along these lines an essential issue in structuring a vehicle is its vitality utilization. A functioning suspension framework gives a ton of potential outcomes to improve the ride however frequently expends a lot of vitality. It is a gigantic test to make it vitality proficient. An expansion might be to actualize dampers which are fit for changing over their dispersed power into electrical power.

III Vibration absorption System Using Matlab (Simulink & Simscape)

Quarter car vibration absorption system is can be developed by using Matlab software. For developing Quarter car vibration absorption system we have to use two basic tools of Matlab software that are as below. A. Simulink B. Simscape

Simulink: This is one of the basic tools of matlab software which consist of all electrical parts which are required for system development. For Quarter car vibration absorption system we required the following parts such as below.

Signal Builder: - It is used to excite the system according to the signal that we are providing.

Proportional-Integral-Derivative (PID) controller: - It is used to damp the vibration according to the control signal.

Simscape :-This is also the one of the basic tool of matlab software which consist of all mechanical parts which are required for system development. For Quarter car vibration absorption system we required the following parts such as below.

Mechanical Linear (translational) reference:- It is use for reference to system it is just like foundation to the mechanical system.

Linear spring :-It is used for setting tire spring stiffness as well as suspension spring stiffness

Linear damper:-It is used for setting suspension damping coefficient.

Linear(Translational) mass:- It is used for setting the sprung mass and unsprung masses.

PS convertor (Simulink) --:-It is used to convert the simulink signal into the physical single.

Ideal linear sensor:-It is used to sense the velocity and displacement of sprung and unsprung masses.

Method of solving:- It is used to solve the all mathematical calculation required to simulate the system .

Double acting hydraulic cylinder :- It is used to generate external controlling force according to controller signal.

Proportional servo-valve actuator:-It is used to control the flow of fluid in the double acting cylinder.

4-way directional valve:-It is used to change the direction fluid in double acting cylinder according to the signal.

Variational displacement pressure Compensation pump:-It is used to pump the fluid from tank for isolating the system.

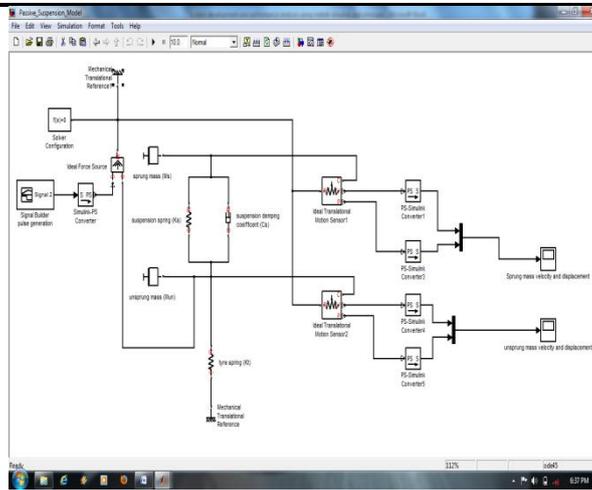


Fig - Development of Quarter Car Vibration Absorption Passive System using matlab (simulink & Simscape)

Input Parameter	Actual values
Sprung Mass	78.48 N
Unsprung Mass	14.71N
Suspension Spring Stiffness	700 N/m
Suspension Damping Coefficient.	275 Ns/m
Spring Stiffness(tire)	85000 N/m

Table No.1 .Input Parameter for Passive System

And the input signal for the developed mechanical passive system is shown in following fig.

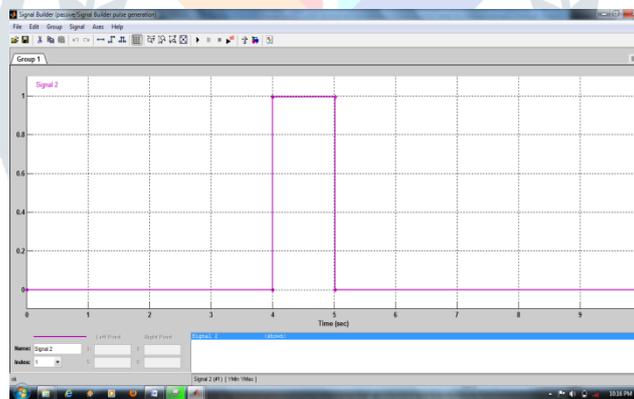


Fig-Input Signal for Passive System

As all above info given to the created mechanical suspension framework utilizing mat lab accordingly to get yield results we use translational mechanical sensor which gives the simple signs for the two masses, for example, sprung mass just as unsprung mass of the framework as far as relocation and speed of the mass in meter and meter every second individually.

IV Vibration Absorption Active System Using PID Controller

The development of the active system using matlab is same as development of passive system. Above steps used in development of passive system are same to create passive system then following steps are used in passive system to convert it into the active system.

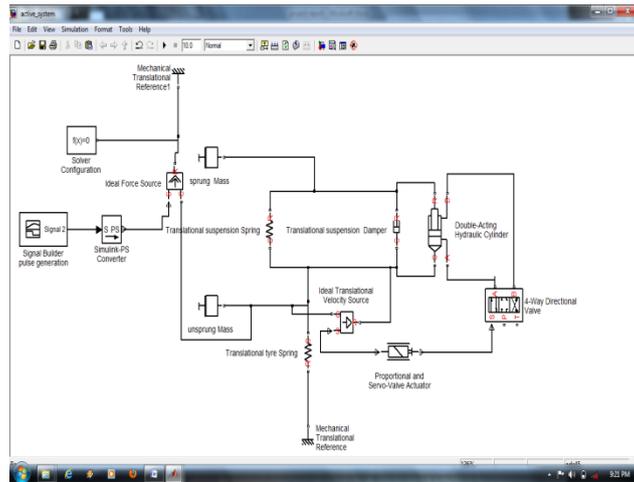


Fig-passive system with active parts

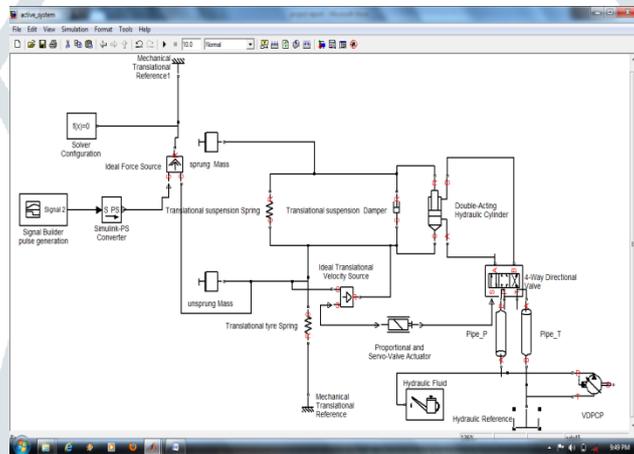


Fig -Active System with Power Unit

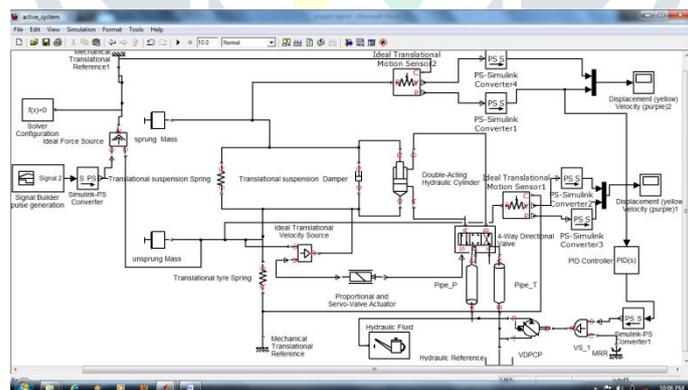
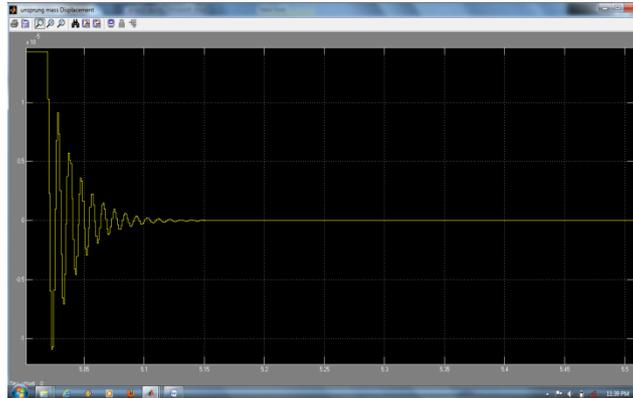


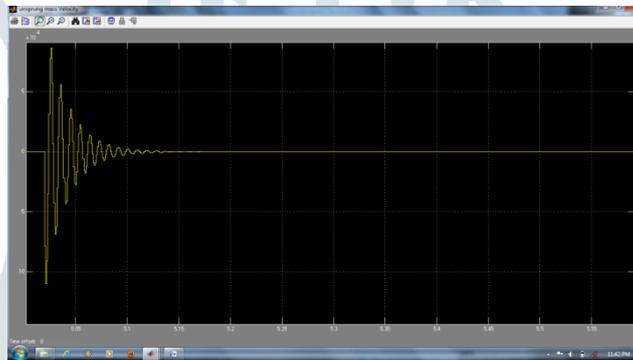
Fig .Development of Quarter Car Vibration Absorption active System with PID controller using matlab (simulink & Simscape)

V. Result Of Active System:

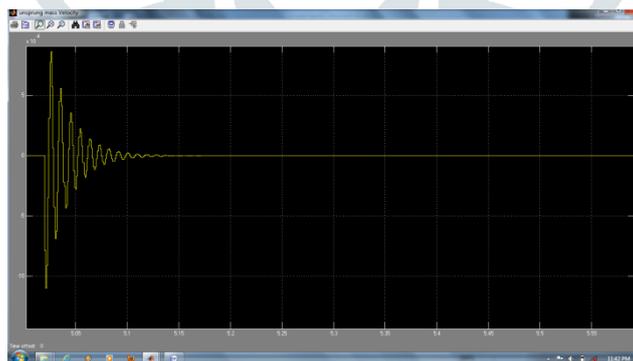
The following graph shows the results in terms of displacement of sprung and unsprung masses of active system for given input to the system. graph no.1 displacement of unsprung mass with respect to the time for active system.



As shown on the graph the displacement of unsprung mass in case of active suspension system is upto the 1.45×10^{-5} . As this maximum displacement of unsprung mass is less than the maximum displacement of unsprung mass in case of passive system as shown in the graph no.1



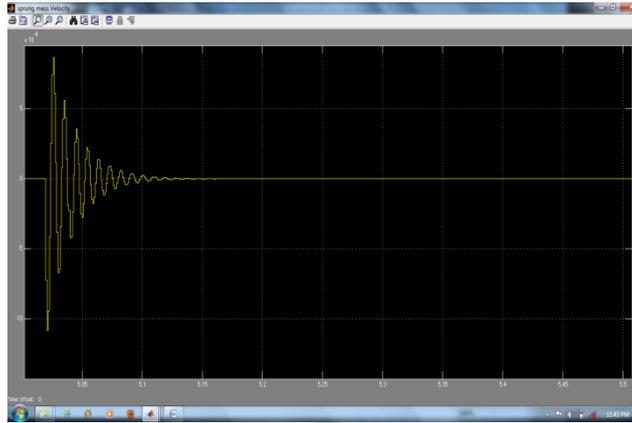
graph no.2. displacement of sprung mass with respect to time for active system. As the graph no.2 shows the maximum displacement of sprung mass in case of active suspension system. The approximate value of maximum displacement is 0.900×10^{-5} meter. This value of maximum displacement is less than that of sprung mass displacement in case of passive system.



graph no.3. velocity of unsprung mass using active system.

Comment on graph no.3 and 4:-

As two above graph shows the velocity of unsprung mass and sprung mass respectively. this graph have the same magnitude of velocity in both case but isolation of this velocity is early in case of active system as compare to passive system because of use of PID controller.



graph no.4.velocity of sprung mass using active suspension system

VII Analysis and Conclusion

Following table gives velocity and displacement of unsprung and sprung masses in case of both passive as well as active vibration absorption system.

Masses	Parameter	Passive system	Active system
Unsprung mass	Displacement(meter)	$1.450 \cdot 10^{-5}$	$1.430 \cdot 10^{-5}$
Sprung mass	Displacement(meter)	$1.350 \cdot 10^{-5}$	$0.900 \cdot 10^{-5}$
Unsprung mass	Velocity (meter/sec)	$1.620 \cdot 10^{-3}$	$0.88 \cdot 10^{-3}$
Sprung mass	Velocity (meter/sec)	$0.430 \cdot 10^{-3}$	$0.88 \cdot 10^{-3}$

Table No.2:-Results of Passive & Active System Response.

As the above table shows the observation of both passive and active vibration absorption system in terms of displacement and velocity of both unsprung mass and sprung mass of the system.

In case of passive system displacement of unsprung mass and sprung mass is not decreases more but as compare to the unsprung mass the graph of sprung mass displacement has more uniform shape. That means we can say that in passive system passenger comfort is increases little bit. (ref graph no.1 & 2)

- 1) In case of passive system the velocity of sprung mass is decreases upto 71.51 % as compare to the unsprung mass (ref table no.2)
- 2) In case of active suspension system displacement of sprung mass is decreases up 78.29 % as compare to the unsprung mass displacement.
- 3) In case of active suspension system velocity of sprung mass displacement is decreases upto the 26.13% as compare to the unsprung mass velocity, and it takes minimum time to isolate as compare to unsprung mass.

REFERENCES

1. PID Controller of Active Suspension System for a quarter Car Model ,IJAET-vol-18 Issue pp-899-909
2. Active control of quarter car suspension system using LQR (Linear quadratic regulator),IJAME June-2011 Vol.3pp.364-372
3. Car dynamics using quarter car model and Passive suspension : Part 1-effect of suspension damping & car speed ,IJCT Journal .Vol-1Issue 2,2014
4. Vehicle suspension system control : A review international journal of control, automation and systems.VCol.2 July 2013 ISSN2165-8277.
5. Simulation & analysis of passive and active suspension system using quarter car model for different road profile, International journal of engineering trends &technology ,Vol.3
6. Modeling analysis and control of active suspension system using sliding mode control and disturbance observer: International journal of scientific and research publications.Vol.3 Issue 1,Jan 2013

