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Vibrationanal Analysis of Half Car Model

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ABSTRACT

Many researchers worked on root mean square (RMS) responses to acceleration input for four state variables. Wide research had conducted on Half-car2-DOF (degree of freedom) models. Researchers applied nonlinear MIMO system and input-output feedback linearization method for control purpose. Review show that wide research had conducted on PID controller controller. Researchers developed half car model through bond graph.

Keywords:- DOF, MIMO, VIBRATIONAL ANALYSYS, HAVSS,PASSIVE AND ACTIVE SUSPENSION SYSTEM, QUARTER, HALF CAR MODEL, FFT ANALYSER, PID CONTROLLER, MATLAB

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I. INTRODUCTION

Conventionally Automobile suspension strategies have been a compromise among three contradictory criteria of road holding, rattle space requirements and ride comfort of passenger. The suspension arrangement need to take care of the vehicle handling parameters during vehicle moving over a terrain and be responsible for effective separation of passengers from road disturbances (Robert L.W 1997). Though a passive suspension system has the capacity to collect the energy through a spring and to drive away it via a shock absorber, their factors are normally fixed. These fixed parameters support to attain a definite level of settlement among road holding and comfort by the selection of different stiffness and damping parameters (Robert L.W 1997).The passive suspensions have inherent limitations as a consequence of the choice of elastic and damping characteristics to ensure an acceptable behavior for the entire working frequency range. The need to obtain a compromise between the conflicting requirements among different vibrations modes of the vehicle justify the research of the active suspension systems, the intelligence being determined by a controller that takes data from the vehicle dynamics.The response of the passive suspension is only affected by the external excitations and the system parameters that have a direct action on the suspension. Instead, the intelligent suspension is affected by indirect parameters, such as acceleration of the roll, pitch or vertical oscillations. The way to implement intelligence in a suspension system is to use variable damping – semi-active suspension, or to create a counter-force system – active suspension

II. LITERATURE SURVEY

S.I.Ihsan[1] et al. studied, the root mean square (RMS) responses to acceleration input for four state variables: the msvertical acceleration, the ms pitch angular acceleration and the front and rear deflections of the suspension.They were presented Half-car2-DOF (degree of freedom)models and also derived equations of motion.

Li-Xin Guo [2] et al.studied theory of pseudoexcitation method. They were analysed the Half-Car, Five-DOF Vehicle System in Changeable Speeds. They were obtained, the vibration response characteristics of the half-car, five-DOF automobile system by pseudoexcitation method.

Shital.P.Chavan[3] et al. Their study is based on the analysis of the vibration effect when the vehicle is subjected to harmonic road excitation by the road profile. They described suspension nonlinearities. They represent half car vehicle by mathematical model.

Anirban C Mitra [4] et al. Their studied is vehicle dynamics for improvement of ride comfort using a half-car bond-graph model.They used nine degree of freedom system half carmodel. This is used for portrayal of exchange of power between various elements maintaining the constraints of the system ensured through the use of junction elements 0 and 1.

S.S. Patole [5] et al. Thair studied about the mathematical model of half car suspension model. They present 4 DOF half car vehicle model.

Amin Toorani [6] et al. Their studied about based on stability and internal dynamics of half car model. They considered as nonlinear MIMO system and input-output feedback linearization method will be applied for control purpose.

Abdullahi B. KUNYA [7] et al. their studied about modelling and simulation of nonlinear, Half-car Active Vehicle Suspension System (HAVSS) reinforced with PID controller. it has been established that the proposed active suspension system proved to be more effective in controlling the vehicle oscillation.

L.V.V. Gopala Rao [8] et al. Their studied about Preview control of random response of a half-car vehicle model traversing rough road. They used statistical linearization technique to derive an equivalent linear model

Mukesh Hadpe [9] et al. Their study about vibration analysis of two Wheeler, and theory of Whole Body Vibration And Its effects.

Sumedh Marathe [10] et al. Their studied is based on half-car model vibration system using Magneto rheological Dampers. It studied about passive and semi active vehicle seat suspension system.

Wael Abbas [11] et al. Their studied about optimal vehicle and seat suspension design for a half-car vehicle model. They present biodynamic lumped human linear seat model which are coupled with half-car model of ground vehicles as illustrated. They described the Genetic algorithm parameters.

Sushant S. Patole [12] et al. their studied about Vehicle Dynamic System Subjected To different Road Profiles With Wheel Base delay And Nonlinear Parameters. They presented 4 DOF half car model. They shown the mathematical model of half car suspension system. They discussed the parameters of Hyundai Elantra 1992 Half Car Model.

Nripendra Kumar Chaudhari [13] et al. their studied about developed half car model through bond graph. Their study is base on development of computational model of half car through bond graph for comfort evaluation. Determine the amplitude of vibration at various speed by simulating the model on symbol Shakti sonata software by using computational model.

W. Gao [14] et. al their studied about the analysis of vehicles with random parameters of half car model. They consider the equation of motion for the vehicle body and the front/rear wheels. They present the stochastic half car model of vehicle.

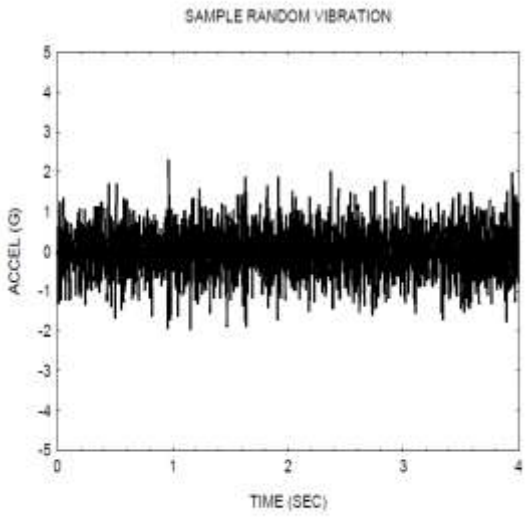
S.S.Patole [15] et al. The aim of study is Analysis of HalfCar Model Passive Vehicle Dynamic System. They presented4dof NONLINEAR HEAVY VEHICLE SUSPENSION ride comfort.

Random Forcing Function and Response:

Consider a turbulent airflow passing over an aircraft wing. The turbulent airflow is a forcing function. Furthermore, the turbulent pressure at a particular location on the wing varies in a random manner with time.For simplicity, consider the aircraft wing to be a single-degree-of-freedom system. The wingwould vibrate in a sinusoidal manner if it were disturbed from its rest position and then allowed to vibrate freely. The turbulent airflow, however, forces the wing to undergo a random vibration response.

Random Base Excitation:

Consider earthquake motion. The ground vibrates in random manner during the transient duration. Buildings, bridges, and other structures must be designed to withstand this excitation. An automobile traveling down a rough road is also subjected to random base excitation. The excitation may become periodic, however, if the road is a "washboard road."Direction of Flight



Common Characteristics

One common characteristic of these examples is that the motion varies randomly with time. Thus, the amplitude cannot be expressed in terms of a "deterministic" mathematical function.

Dave Steinberg wrote in Reference 1:

The most obvious characteristic of random vibration is that it is non-periodic.

A knowledge of the past history of random motion is adequate to predict the probability of occurrence of various acceleration and displacement magnitudes, but it is not sufficient to predict the precise magnitude at a specific instant.

The relationships are

For $\Omega \leq \Omega_0 = 1/2\pi$ cycles/m

$$S_g(\Omega) = S_g(\Omega_0)(\Omega/\Omega_0)^{-N_1}$$

For $\Omega > \Omega_0 = 1/2\pi$ cycles/m

$$S_g(\Omega) = S_g(\Omega_0)(\Omega/\Omega_0)^{-N_2}$$

The range of values of $S_g(\Omega_0)$ at a spatial frequency $\Omega_0 = 1/2\pi$ cycles/m for different classes of road is given in table and the values of N_1 and N_2 are 2.0 and 1.5 respectively.

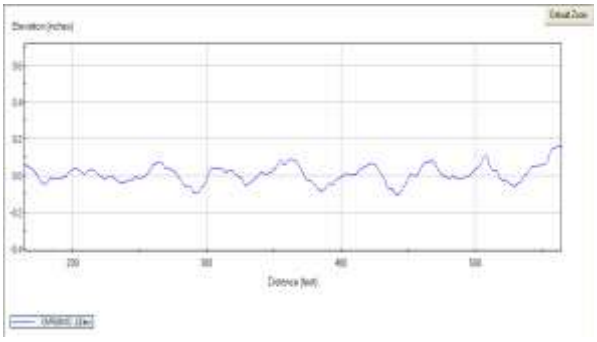
For instance, for a class B road (which is considered to be a 'good' road from a surface

For the lower bond

For $\Omega \leq \Omega_0$ $S_g(\Omega) = 8 \times 10^{-6} (2\pi\Omega)^{-2}$ m^2/cycles/m

For $\Omega > \Omega_0$ $S_g(\Omega) = 8 \times 10^{-6} (2\pi\Omega)^{-1.5}$ m^2/cycles/m

Typical Profile Measured With Inertial Profiler



We consider random vibrations of road vehicles excited by random road surfaces. Thevehicle is modelled by a multibody system consisting of rigid bodies coupled by springsand dampers. Nonlinear characteristics of springs and dampers are approximated by polynomials. The resulting mathematical model is a system of nonlinear ordinary differential equations of second order

$$\mathbf{A}\mathbf{p}'' + \mathbf{B}\mathbf{p}' + \mathbf{C}\mathbf{p} + \eta\mathbf{D}(\mathbf{p}, \mathbf{p}') = \mathbf{f}$$

Thereby the irregularities of the one dimensional road time-shifted at the several axles of the vehicle. Denoting the random height of the road profile at position x by g(x;w) the profile is modelled by

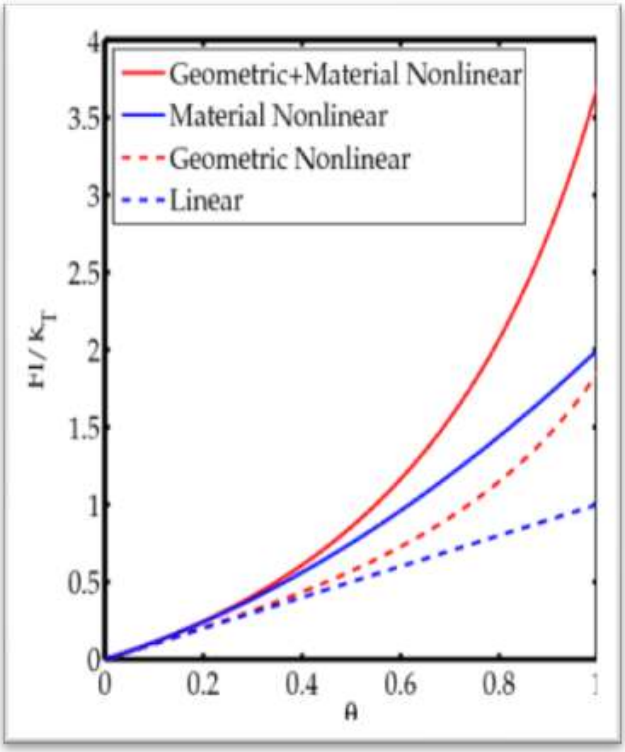
$$g(x,\omega) = \int_{-\infty}^{x} Q(x-u)h_{\varepsilon}(u,\omega)du,$$

Representations of the response variables of(1) are derived by applying the perturbation method. Approximations of the statistical response characteristics are given in terms of expansions as to the correlation length ".

Geometric Nonlinearities:

Geometric nonlinearity leads to two types of phenomena: change in structural behaviour and loss of structural stability. There are two natural classes of large deformation problems: the large displacement, small strain problem and the large displacement, large strain problem. For the large displacement, small strain problem, changes in the stress-strain law can be neglected, but the contributions from the nonlinear terms in the strain displacement relations cannot be neglected. For the large displacement, large strain problem, the constitutive relation must be defined in the correct frame of reference and is transformed from this frame of reference to the one in which the equilibrium equations are write

Figure shows how the inclusion of material nonlinearities affects the solution.



NON LINEAR VIBRATIONS:

We consider random vibrations of road vehicles excited by random road surfaces. The vehicle is mode led by a multi body system consisting of rigid bodies coupled by springs and dampers. Nonlinear characteristics of springs and dampers are approximated by polynomials. The resulting mathematical model is a system of nonlinear ordinary differential equations of second order

$$\mathbf{A}\mathbf{p}'' + \mathbf{B}\mathbf{p}' + \mathbf{C}\mathbf{p} + \eta\mathbf{D}(\mathbf{p}, \mathbf{p}') = \mathbf{f}$$

with some initial conditions p(0) = p0 and p'(0) = p1 and a random input term

f = f (t,w) containing the excitation functions. For a n degrees of freedom system the

response vector p = (p1,….., pn)_ describes the positions of the rigid bodies, A;B;C

are real n×n matrices, D(p, p') is a vector including the nonlinear terms of spring and

damper models and η is a perturbation parameter needed in the solution procedure.

Passive half car -

A half car model consists of a front & a rear wheel of one side for vibrational analysis. The analysis can be done by using two movements involved in the motion of the car.As we have discussed earlier, that a vehicle represents a complex vibration system with many degrees of freedom. However, it's possible to simplify the system by considering only some of its major motions. In case of half car model, the two degrees of freedom which can be taken into consideration are bounce(z) & pitch (θ), to which the vehicle or the model is subjected as shown in figure.

Simulation results indicate that the vibrations due to bounce(z) & pitch (θ), are minimized in an active half car model compared to passive half car model .

Pitch (o)-it's the angular movements experienced by the vehicle.
Bounce(z)-it's the lateral movements expressed during the motion of the vehicle.
The linear passive half car system is governed by the equations.

$$m_s\ddot{z}+k_f(z-l_f\theta-q)+k_r(z+l_r\theta-q)+c_f(\dot{z}-l_f\dot{\theta}-\dot{q})+c_r(\dot{z}+l_r\dot{\theta}-\dot{q})=0$$

$$m_s r_s^2\ddot{\theta}+k_f l_f(z-l_f\theta-q)+k_r l_r(z+l_r\theta-q)+c_f l_f(\dot{z}-l_f\dot{\theta}-\dot{q})+c_r l_r(\dot{z}+l_r\dot{\theta}-\dot{q})=0$$

The non linear spring passive half car system is governed by the equations.

$m_s\ddot{z}+k_0+k_1(z-l_f\theta-q)+k_2(z-l_f\theta-q)^2+k_3(z-l_f\theta-q)^3+k_r(z+l_r\theta-q)+c_f(\dot{z}-l_f\dot{\theta}-\dot{q})+c_r(\dot{z}+l_r\dot{\theta}-\dot{q})=0$

$I_y\ddot{\theta}+l_f[k_0+k_1(z-l_f\theta-q)+k_2(z-l_f\theta-q)^2+k_3(z-l_f\theta-q)^3]+k_r l_r(z+l_r\theta-q)+c_f l_f(\dot{z}-l_f\dot{\theta}-\dot{q})+c_r l_r(\dot{z}+l_r\dot{\theta}-\dot{q})=0$

The non linear damper passive half car system is governed by the equations.

$m_s\ddot{z}+k_f(z-l_f\theta-q)+k_r(z+l_r\theta-q)+c_1(\dot{z}-l_f\dot{\theta}-\dot{q})+c_2(\dot{z}-l_f\dot{\theta}-\dot{q})^2+c_r(\dot{z}+l_r\dot{\theta}-\dot{q})=0$

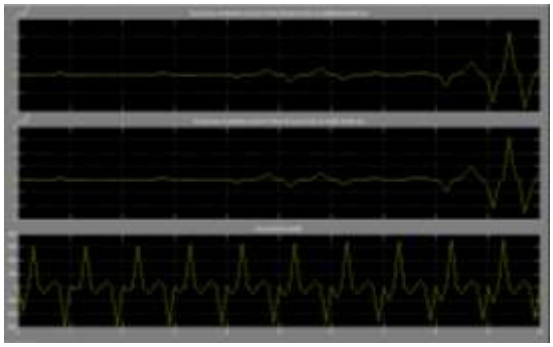
$I_y\ddot{\theta}+k_f l_f(z-l_f\theta-q)+k_r l_r(z+l_r\theta-q)+l_f[c_1(\dot{z}-l_f\dot{\theta}-\dot{q})+c_2(\dot{z}-l_f\dot{\theta}-\dot{q})^2]+c_r l_r(\dot{z}+l_r\dot{\theta}-\dot{q})=0$

The non linear mass passive half car system is governed by the equations.

$(m_s+m')\ddot{z}+k_f(z-l_f\theta-q)+k_r(z+l_r\theta-q)+c_f(\dot{z}-l_f\dot{\theta}-\dot{q})+c_r(\dot{z}+l_r\dot{\theta}-\dot{q})=0$

$I_{y'}\ddot{\theta}+l_f k_f(z-l_f\theta-q)+k_r l_r(z+l_r\theta-q)+c_f l_f(\dot{z}-l_f\dot{\theta}-\dot{q})+c_r l_r(\dot{z}+l_r\dot{\theta}-\dot{q})=0$

Non linear spring passive half car model
Response of passive half car model (spring nonlinearity)



III. CONCLUSION

By using the nonlinear spring, damping and mass model obtained from nonlinear vehicle model with two DOF which is subjected to random road excitation are studied through MATLAB simulation. It is found that the response exists in nonlinear suspension. The theory of nonlinear dynamics is applied to study the nonlinear model. Although the mechanical model of the vehicle is only a simplified one, the results may still be useful in dynamic design of the ground vehicle. The vibration control will definitely help us to improve vehicle ride conditions and reduce the shocks and noise which in turn will increase the comfort level of the passengers'.

REFERENCES

[1] S. I. Ihsan, M. Ahmadian, Waleed F. Faris,and E. D. Blancard " Ride performance analysis of half-car model for semi-active system using RMS as performance criteria" Shock and Vibration 16 (2009) 593–605

[2] Li-Xin Guo and Li-Ping Zhang "Vehicle Vibration Analysis in Changeable Speeds" Hindawi Publishing Corporation Mathematical Problems in Engineering Volume 2010, Article ID 802720, 14 pages

[3] Shital.P. Chavan and S.H. Sawant "Experimental Verification of Passive Half Car Vehicle Dynamic System Subjected to Harmonic Road Excitation with Nonlinear Parameters" International Conference on Challenges and Opportunities in Mechanical Engineering, Industrial Engineering and Management Studies 527 (ICCOMIM - 2012), 11-13 July, 2012

[4] Anirban C Mitra, Nilotpal Benerjee "Vehicle Dynamics for Improvement of Ride Comfort using a Half-Car Bondgraph Model" International Journal of Researchers, Scientists and Developers Vol. 2 No. 1 January 2014 www.ijrsd.org ISSN: 2347-3649

[5] S.S. Patole and Dr. S.H. Sawant "Theoretical and Numerical Analysis of Half Car Vehicle Dynamic Model Subjected to Different Road Profiles with Wheel Base Delay and Nonlinear Parameters"International Journal of Multidisciplinary and Current Research ISSN: 2321-3124 11 June 2015, Vol.3 (May/June 2015 issue)

[6] Amin Toorani,Seyyed Arash Haghpanah,Hasasan Zohoor "Stability Analysis and International Dynamics of a MIMO Half Car Active Suspension System" Global journal of science,engg and technology(ISSN:2322-2441 Issue10(1),2013,pp.1-8

[7] Abdullahi B. KUNYA, Atef A. ATA "HALF CAR SUSPENSION SYSTEM INTEGRATED WITH PID CONTROLLER"

[8] L.V.V. Gopala Rao, S. Narayanan," Preview control of random response of a half-car vehicle model traversing rough road" Journal of Sound and Vibration 310(2008) 352-365

[9] Mukesh Hadpe, Dr.D.S.Deshmukh, P.M.Solanki, " Vibration Analysis of a Two Wheeler" International jornal of Innovative Research in Science,Engg and Technology,vol.3.Issue 11, November 2014

[10] Sumedh Marathe, Swapnil Hatwalane, Sandeep Thorat and Nilesh Dhokane "A Review of half-car model vibration system using Magneto rheological Dampers" International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

