iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL
FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** V **Month of publication:** May 2020

DOI: http://doi.org/10.22214/ijraset.2020.5406

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

Validation of Simulation of Nonlinear Passive Vehicle Suspension System

P. Ravichandra[1], M. R. Khodke[2], Dr. U. S. Chavan [3]
[1]PG Scholar, Department of Mechanical (Design) Engineering, Vishwakarma Institute of Technology, Pune, India
[2, 3]Professor, Department of Mechanical Engineering, Vishwakarma Institute of Technology, Pune, India

Abstract: In this paper the nonlinear behaviour of passive suspension system for quarter car is studied. The mathematical model is developed with the help of equations of motions. In the actual practice, all system behaves nonlinearly but for simplification purpose it consider as linear. A linear system can capture basic performances of vehicle suspension such as body displacement, body acceleration, wheel displacement, wheel deflection, suspension travels. Performance of suspension system is determined by the ride comfort and vehicle handling. It can be measured by car body displacement and wheel deflection performance. Two types of road profiles are used as input for the system. The quarter car two degree of freedom and MATLAB-SIMULINK model is developed for the nonlinear quarter car passive suspension system.

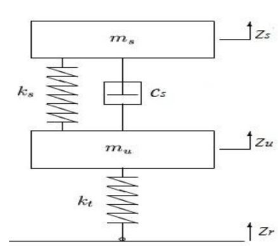
I. INTRODUCTION

Vehicle suspensions are mainly classified into three types i.e., passive, semi active and active suspensions, which depend on the operation mode to improve vehicle ride comfort, vehicle safety, road damage minimization and the overall performance. This paper presents mathematical modelling of nonlinear quarter car. The nonlinear quarter car model consists of quadratic tyre stiffness and cubic stiffness in suspension spring as nonlinearities. It also reduces the vibrations passing to the vehicle body. The quarter car (1/4th) model of suspension system is developed for the analysis purpose [2]. The passive vehicle suspension system has spring and damper. The motivation behind damper to disperse the energy while spring acts as an energy storing element. Both the elements never add energy to system such type of automobile suspension systems called as passive suspension system. There are fixed parameters in this system, which select to get a specific level of trade-off between ride comfort, road holding and load conveying. The main problem in this suspension system is that designed of the damper. If the damper is heavy then it will throw the car on unbalanced of road. If the damper is light in design then its effect on stability of the vehicle while turning or changing lane. Sometimes car may be swing due to such design. The road profiles plays important role in the performance suspension system. In the passive suspension system, if spring stiffness increases then the ride comfort decreases and vice versa [5]. Daniel Fischer et al [1] derived the mathematical models for suspensions with variable dampers and springs as well as active components for fault detection and diagnosis of the damper by combining parameter estimation and parity equation methods.

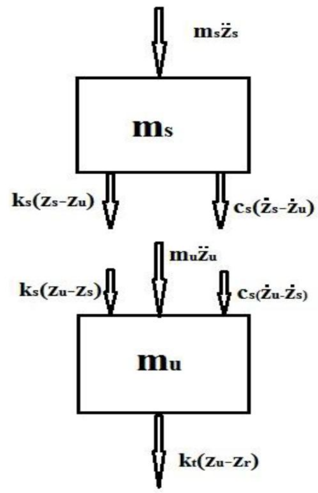
II. MATHEMATICAL MODELING

A. Quarter car model: Bounce Motion

Ms=sprung mass in kg.
Mu= unsprung mass in kg.
Ks=suspension stiffness. N/m
Cs= damping for sprung mass. Ns/m
Kt=tire stiffness. N/m
Zs= displacement of sprung mass into x direction.
Zu= displacement of unsprung mass into x direction.
Zr= road excitation.



B. Equations of Motion and FBD



For sprung mass:

$$m_s\ddot{z}_s+k_s\,(z_s-z_u)+c_s\,(\dot{z}_s-\dot{z}_u)=0$$

$$\ddot{z}_s=k_s/m_s\,(z_u-z_s)+c_s/m_s\,(\dot{z}_u-\dot{z}_s)$$

For unsprung mass:

$$m_u\ddot{z}_u+k_t\,(z_u-z_r)-k_s\,(z_s-z_u)-c_s(\dot{z}_s-\dot{z}_u)=0$$

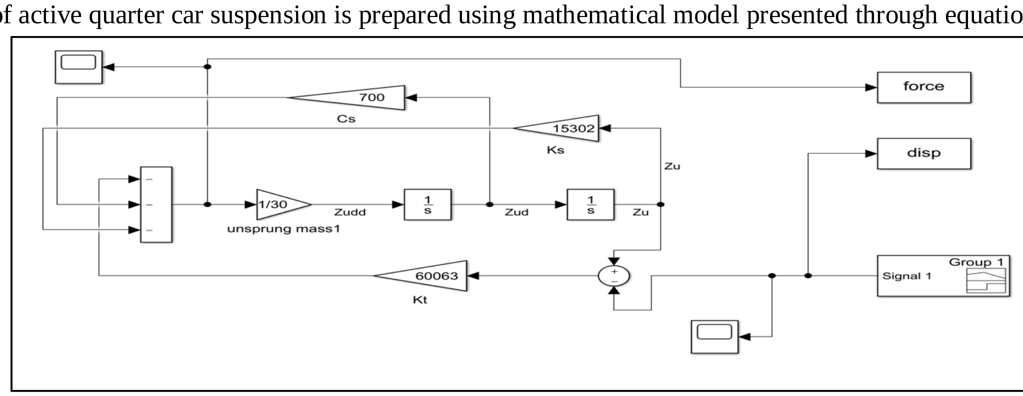
$$\ddot{z}_u=-k_t/m_u\,(z_u-z_r)-k_s/m_u\,(z_u-z_s)-c_s/m_u\,(\dot{z}_u-\dot{z}_s)$$

C. Data

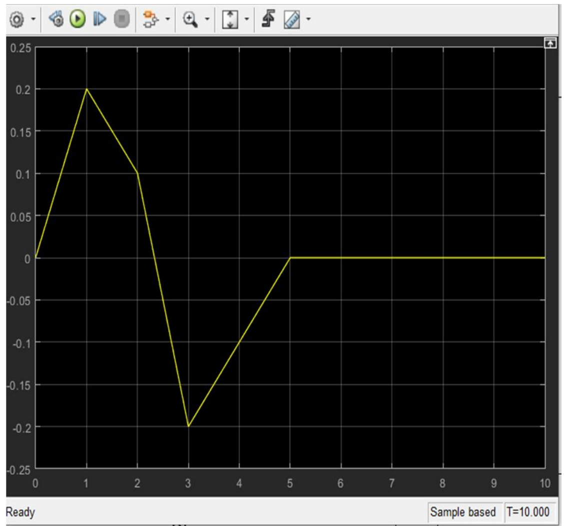
1) Total sprung mass, m=1200kg
2) Quarter sprung mass, ms=300kg
3) Total unsprung mass, mut=0.12*m=144kg
4) Quarter unsprung mass, mu=144/4=36kg
5) By taking the natural frequency of sprung mass= 1.2 Hz
6) RR=((1.2*2π)^2)*ms=15633 N/m
7) ks=RR(6/5) (taking the tyre stiffness kt=5*ks)
8) Cc=2√(ks*ms) Ns/m
9) ς =0.2
10) Cs=ς*Cc Ns/m

III. MODELING OF QUARTER CAR WISHBONE SUSPENSION USING SIMULINK

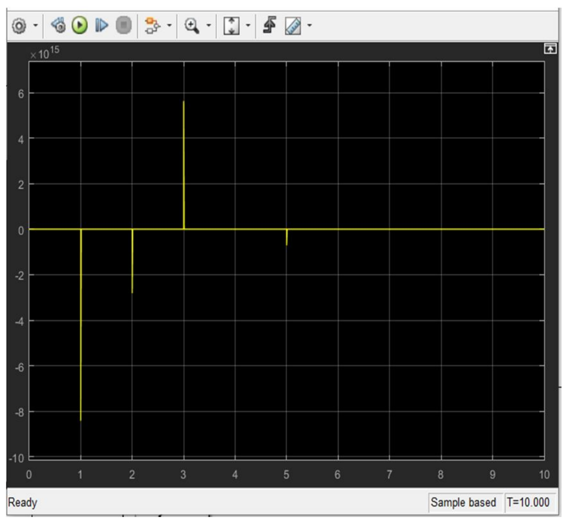
Simulink is a block diagram environment for multi-domain simulation and model-based design available in MATLAB software. It supports system-level design, simulation, automatic code generation, and continuous test and verification of embedded systems. Simulink provides a graphical editor, customizable block libraries, and solvers for modeling and simulating dynamic systems [8]. Simulink model of active quarter car suspension is prepared using mathematical model presented through equations



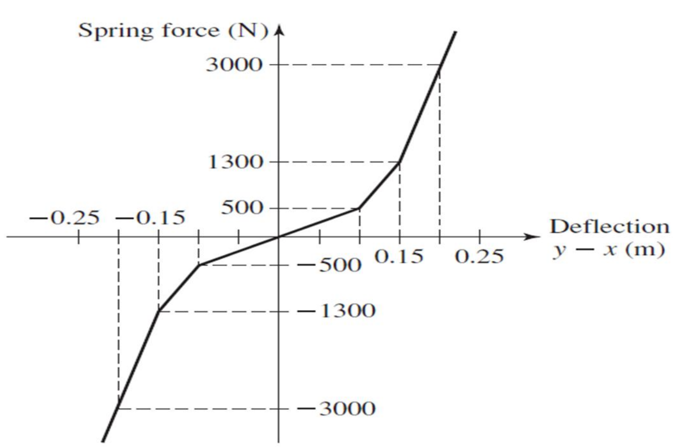
A. Displacement vs Time



B. Force vs Time

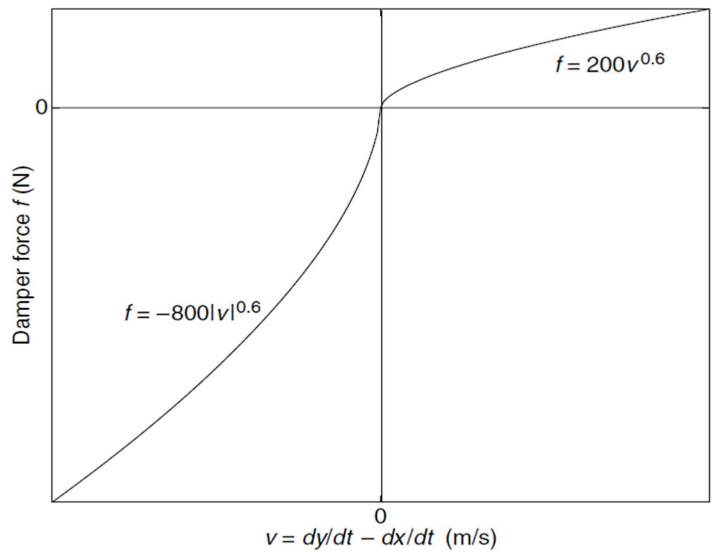


IV. MATLAB PROGRAM FOR NON-LINEAR SPRING FORCE , DAMPING FORCE AND ROAD PROFILE

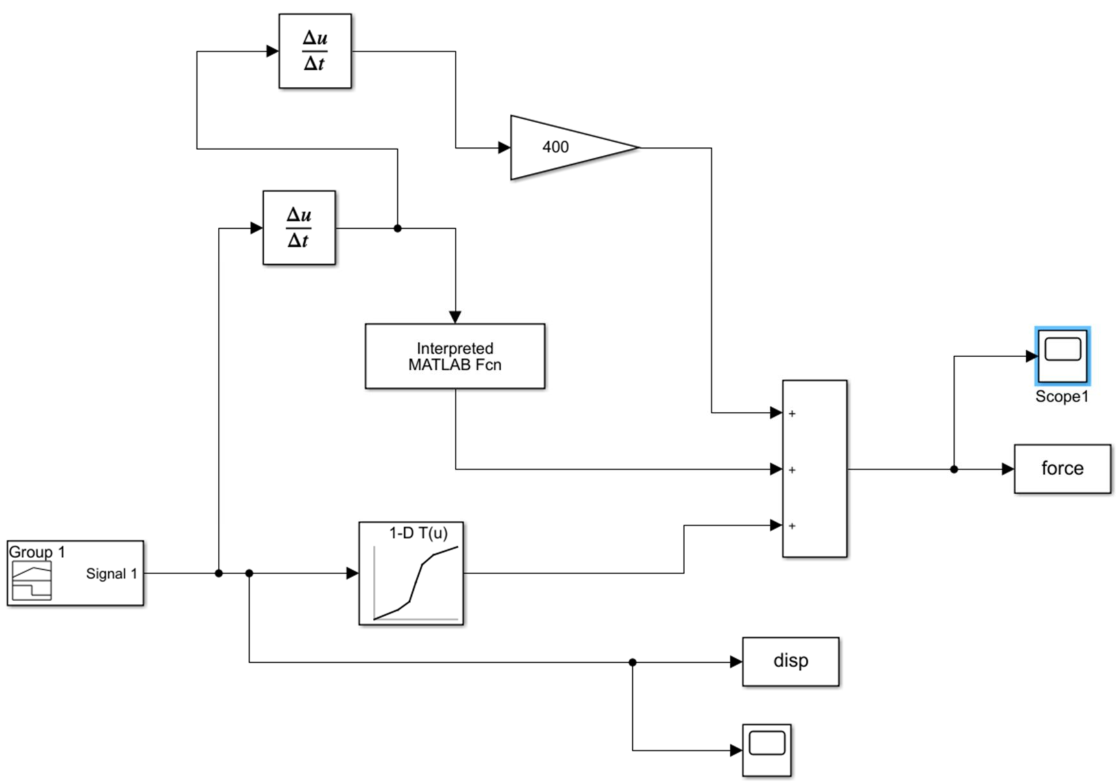


ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

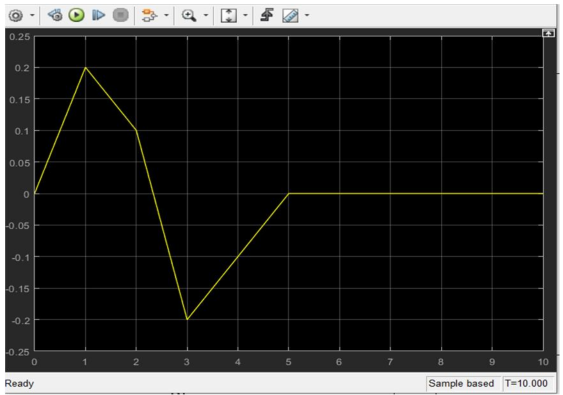
```
function f = damper(v)
if v <= 0
f = -800*(abs(v)).^(0.6);
else
f = 200*v.^(0.6);
end
```



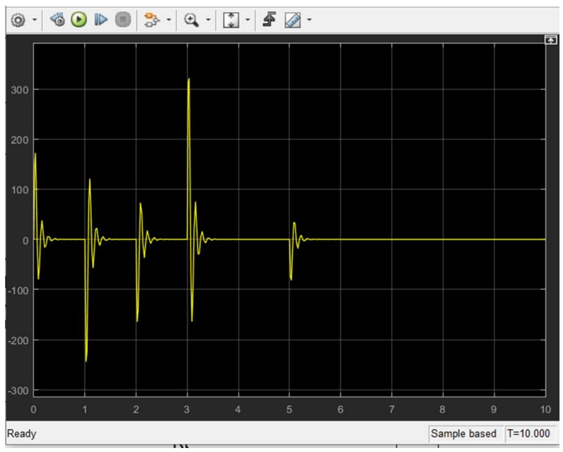
A. Simulink Model



B. Displacement vs Time



C. Force vs Time



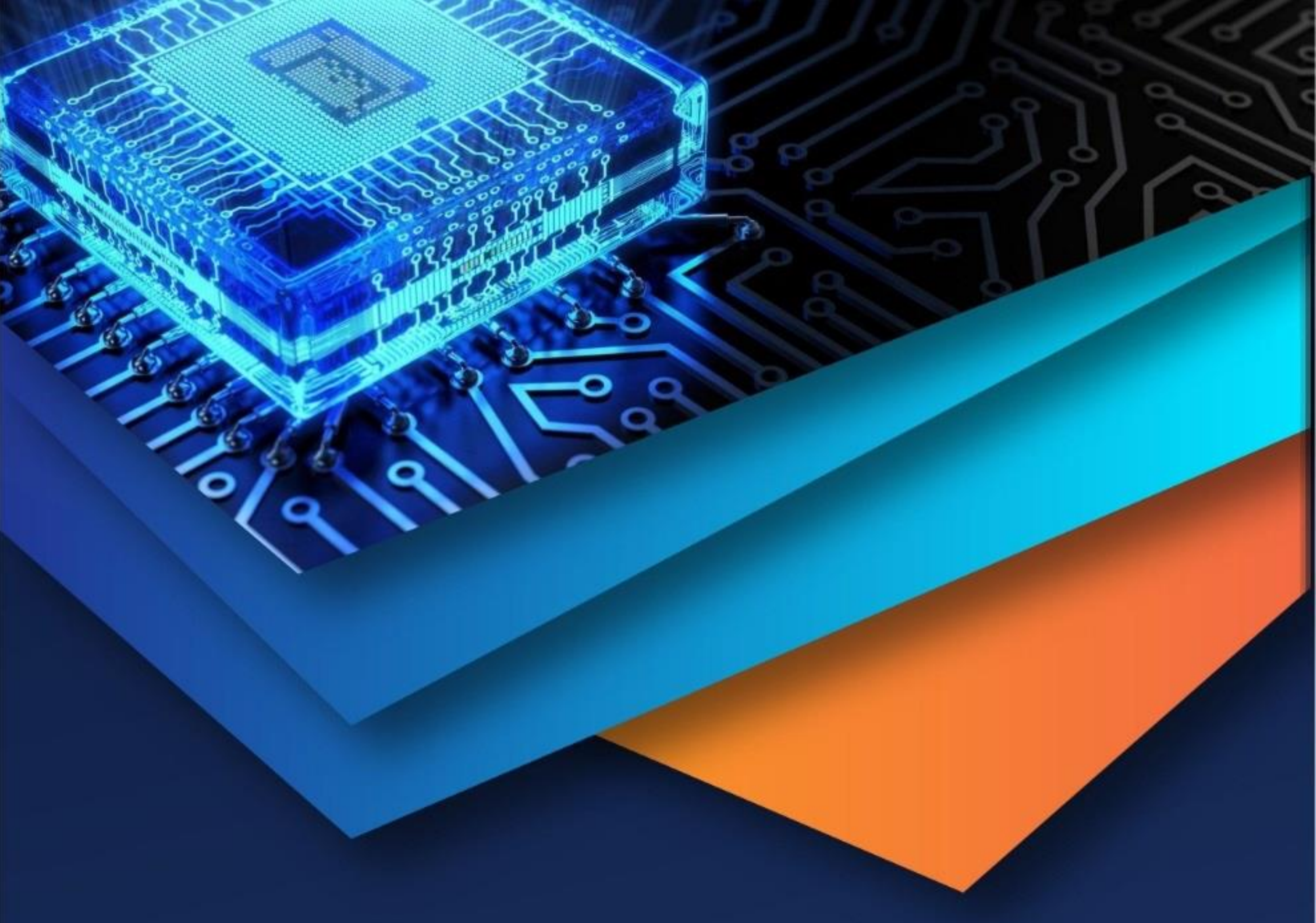
Every suspension system is nonlinear due to its non linear properties spring, damper, and other parts of system. After comparing both graphs it can be clearly shown the nature of graph is nonlinear. But normally for the analysis purposes vehicle suspension spring is assumed to be linear behaviour.

V. CONCLUSIONS

In this paper the Quarter car nonlinear passive vehicle suspension mathematical model is developed using newton's 2nd law of motion and the equation is solved using MATLAB-SIMULINK model. From the results it can be concluded that the RMS acceleration value of nonlinear system is smaller so Ride Comfort is better than the linear system. Also considering the nonlinear behavior of spring analysis can be observed more accuracy with experimental results than linear one. From the results it can be concluded that for the ride comfort is obtained by using introducing nonlinearity in the spring.

REFERENCES

[1] Shpetim Lajqi, Stanislav Pehan Designs and Optimizations of Active and Semi-Active Non-linear Suspension Systems for a Terrain Vehicle
[2] Trupti P. Phalke, Anirban C. Mitra Analysis of Ride comfort and Road holding of Quarter car model by SIMULINK Materials Today: Proceedings 4 (2017) 2425–2430.5th International Conference of Materials Processing and Characterization (ICMPC 2016)
[3] D. Ozgur, K. Ilknur, C. Saban. Modeling and control of a nonlinear half-vehicle suspension system: a hybrid fuzzy logic approach. Nonlinear Dynamics 67(2012) 2139–2151.
[4] MVC Rao, V. Prahlad. A tunable fuzzy logic controller for vehicle-active suspension system. Fuzzy Sets Systems 85 (1997) 11-21.
[5] Haiping, D., Kam, Y.S. and James, L. (2005) Semi-active H infinity control of Vehicle suspension with Magnetorheological dampers, Journals of Sound and Vibration,283,981-996.
[6] Harvat, D. (1997) Survey of advanced suspension developments and related optimal control applications, Automatica, 33(10), 1781-1817.
[7] D. A. Mantaras, P. Luque, C. Vera, Development and validation of a three-dimensional kinematic model for the McPherson steering and suspension mechanisms, Mechanism and Machine Theory. 39(2004) 603–619.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)