Design and Simulation of Fuzzy Controlled Suspension

DeepaPandey[1], Swati Kapoor[2]
[1]Department of Electronics & Communication Engineering, RPIIT, Karnal, Haryana, INDIA
[2]Department of Electronics & Communication Engineering, RPIIT, Karnal, Haryana, INDIA

ABSTRACT:
Improvement in ride quality of vehicle while passing through rough terrain or speed bump is of great importance for design engineers. The quality is controlled by introducing electronic controlled suspension system. A fuzzy control is an intelligent control which can improve the suspension performance significantly. In this paper a fuzzy controller has been designed and simulated to bring the overshoot of sprung mass within the range of 5% which is a worldwide acceptable range for good ride quality. A two degree of freedom quarter car model was developed with fuzzy controller to analyse its performance in bringing the overshoot with in the desired range.

KEYWORDS: *Fuzzy,Intelligent controller, Overshoot, Quarter car model, Simulation.*

1. INTRODUCTION

Suspension is the term given to the system of springs, and linkages that connects a vehicle to its wheels and allows relative motion between the two.Suspension system is an important part of an automobile engine. It is used to prevent the road shocks which causes bounce in the vehicle body. It consists of springs, and damper. The energy of road shock causes the springs to oscillate. These oscillations are restricted by a damper. Functions performed by the components of the suspension system are as follows:[1]

- Shock forces are reduced by them.
- Vehicle's weight is supported by them.

2. MATHEMATICAL MODEL

A quarter car passive suspension system math model has been created. The model considered is a two degree of freedom system .The Fig.1 shows a quarter car model of two degree of freedom.For the analysis, it is assumed that vehicle is rigid body with the suspension[2][3].

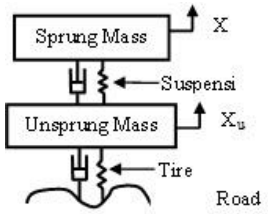

figure 1 Quarter Car Model

The free body diagram of force for sprung and unsprung mass is shown by Fig. 2 and 3 respectively. The equations of motion obtained are (1) and (2) respectively[4][5].

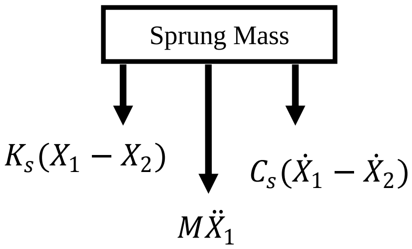

figure2 Sprung Mass Freed Body Force Diagram

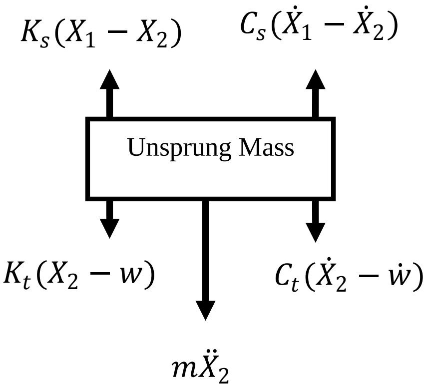

figure 3Unsprung Mass Free Body Force Diagram

$$M\ddot{X}_1 + K_S(X_1 - X_2) + C_S(\dot{X}_1 - \dot{X}_2) = 0 \quad (1)$$

$$m\ddot{X}_2 + K_t(X_2 - w) + C_t(\dot{X}_2 - \dot{w}) - K_S(X_1 - X_2) - C_S(\dot{X}_1 - \dot{X}_2) = 0 \quad (2)$$

3. FUZZY CONTROLLER

Fuzzy logic is a form of many-valued logic; it deals with reasoning that is approximate rather than fixed and exact. A two input and one output fuzzy controller has been designed using Matlab/Simulink[6]. The relative velocity and sprung mass velocity are used as input and damping coefficient as output membership functions for the controller and are shown in Fig. 4 and 5respectively[7]. The range selected for input MF i.e. relative velocity and sprung mass velocity is -1.5 to 1.5 and for output membership function i.e. damping coefficient is 300 to 3000 N-s/m.Fuzzy design rules are shown in TABLE 1.and input parameters to the system are given in TABLE 2.[8]

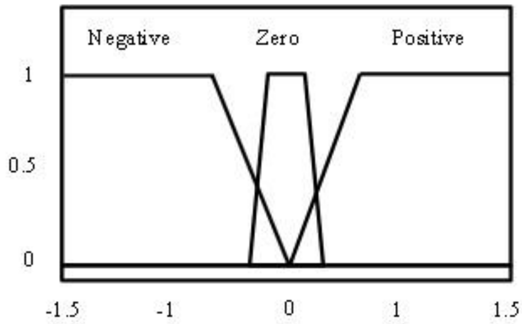

figure 4 Input Membership Function

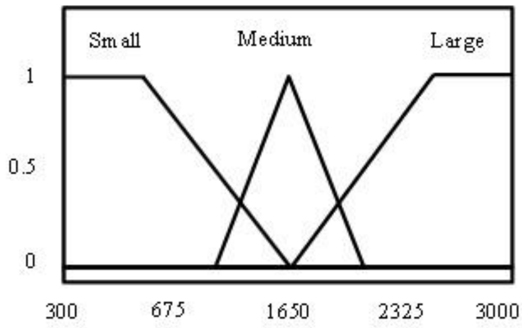

figure 5 Output Membership Function

Table 1: Fuzzy Rules for Quarter Car Model

Relative Velocity Sprung Mass Velocity	Negative	Zero	Positive
Negative	Large	Medium	Small
Zero	Medium	Medium	Medium
Positive	Small	Medium	Large

Table 2: Input Parameters

Parameter	Value
M	241.5 Kg
m	41.5 Kg
Ks	6000 N/m
Cs	300 N-s/m
Kt	140000 N/m
Ct	1500N-s/m

4. SIMULATION & RESULTS

The simulation model of fuzzy controlled suspension is shown in Fig.4 Model is simulated for road input as step function of value 10 cm. Sprung andunsprung mass displacement and settling time response are shown by Fig.5 and.6.[9][10]

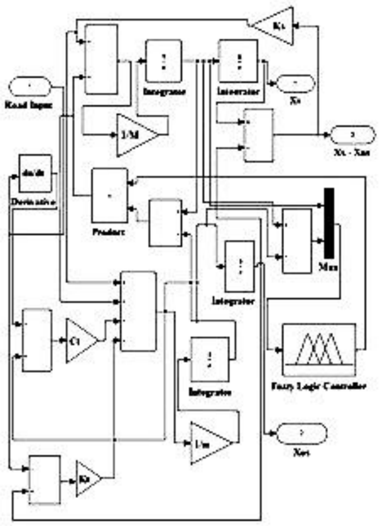

figure 4 Fuzzy Control Suspension

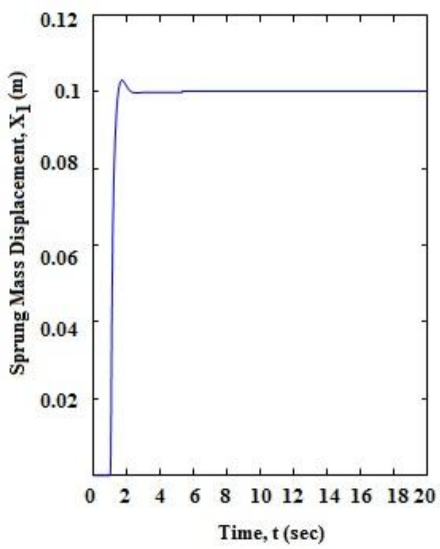

figure 5 Fuzzy Control Suspension

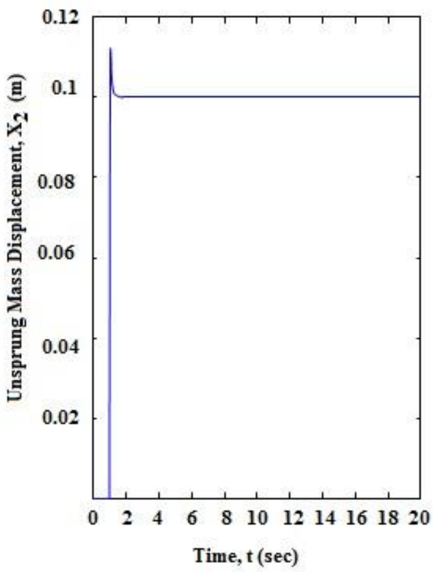

figure 6 Fuzzy Control Suspension

The results of simulation are given in Table.3

Table 2: Results

Overshoot (m)		**Settling Time (sec.)**	
Sprung Mass	**Unsprung Mass**	**Sprung Mass**	**Unsprung Mass**
0.103	0.11	1.2	0.2

5. CONCLUSIONS

The sprung mass overshoot is 3% and is within the range of 5% which will ensure high quality of ride comfort. Settling time for sprung and unsprung mass is coming out as 1.2 sec and 0.2 sec which is also very low to give good ride performance.

6. ABBREVIATIONS

M Sprung Mass
m Unsprung Mass
K_s Suspension Spring Stiffness
C_s Suspension Damping Co-efficient
K_t Tire Stiffness
C_t Tire Damping Co-efficient
w Speed Bump Height

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