JOURNAL OF MECHANICS OF CONTINUA AND MATHEMATICAL SCIENCES
www.journalimcms.org

ISSN (Online) : 2454 -7190 Vol.-15, No.-2, February (2020) pp 224-235 ISSN (Print) 0973-8975

A FUZZY PID CONTROLLER MODEL USED IN ACTIVE SUSPENSION OF THE QUARTER VEHICLE UNDER MATLAB SIMULATION

Eman Mohammed[1], Karim Hassan Ali[2]

[1,2] Department of mechanical engineering, University of Baghdad

Corresponding Author Email: emanmsc85@gmail.com

https://doi.org/10.26782/jmcms.2020.02.00020

Abstract

Development has been achieved to the road vehicle industry so as to manufacture types of automobiles with high ride passenger comfort. One requirement needed to obtain good quality of drive handling efficient operating characteristics of the model system which is equipped for road automobile. The suspension systems are mainly used to restrain externally disturbance from affecting ride tripper rest .Our research had been presented (Fuzzy PID) control for investigate active road vehicle suspension controller. The Fuzzy logic function is used to improve tuning and performance the gain of the road vehicle suspension with PID controller. Undesired displacements of the road vehicle body during dynamic process are presented and compared for two road vehicle models with PID controller and FUZZY PID controller. The final simulated results show the influence of the active road vehicle suspension controller on the efficiency of ride road vehicle handling however raising the strength and execute slick driving. Then, a robust control is executed to optimize these operating characteristics of the suspension systems to improve the road vehicle.

Keywords: Fuzzy PID controller, active suspension, quarter vehicle model, MATLAB simulation

I. Introduction

Suspension systems classify to the most important part on the vehicle. The ride comfort must be achieved against the external disturbance [X] There are a lot of ways of control had been studied to cope the suspension failing. large of the active suspension approximation like adaptive control and non linear control had been expanded for passing the trouble in progress[I, VI]. Gysen studied active suspension with electromagnetic used to occur stability in brake and rounding .they designed these suspension in form of the quarter car[VII].Changisi and Rohni used The fuzzy technique for tuning the damper on the car suspension they collated consolation with PID viewing the dynamic response of displacement and the speed[III]. Chavan and Phvithran caucused a model mathematically for the types suspension passive and active to the quarter automotive and supported the dynamics in terms of the displacement sprung mass [II].Aly applied the controller(robust)on active system in quarter car by MATLAB Simulink [IX].Tiwari and Mishre dell with active type under PIDcontrol and the model solved by Rang- kuta 4th order [IX].Gasemalizada referred to MATLAB simulink and comparedthe acceleration under three controller with passive model[V].The parameters of the suspension supposed fixed the MATLAB is applied to resolve this characteristics[VIII, IV]. The aim, of this paper is to design a active model and applied fuzzy PID to achieve stability for vehicle against external disturbance The result discussed the response amplitude and the time settling, a comparison results has been viewed the displacement between active model with PID controller and the active model with fuzzy PID controller and has been showed the best between them to the vehicle against the disturbance of the road [VIII]. The FUZZY PID controller has been used with the parameters and gains arranged by genetic algorithm [VIII]. .The disturbance has been submitted on a step input types [IV].The displacement on Sprung Mass and Mass of Unsprung for quarter vehicle design of active suspension are offered.

II. Procedure

II.i. Mathematical Modeling of Active Suspension System (equation of the model):

A number of the highly developed adaptive suspension model can be described active suspensions. This model submit which control by acting hydraulic cylinders called actuators .That was increased at each wheel of vehicle. The model of a suspension is associated with unsprung weight of the axle. The elements of Quarter-car models shown in Fig. 2. The equations of motions for quarter model which founded by addition vertical force on top of the sprung and unsprung masses. The helical spring, absorber and a adaptable force created building block positioned between the sprung and unsprung masses represented suspension.

For calculate the model and the parameters of active suspension system is shown in figure (1). We assumed, ms is the Sprung mass, mw is the Unsprang mass, ks is (stiffness)

of body mass, kt is (stiffness) of tire, cs is coefficient damper formass body, ct is dampercoefficient of the wheel, Fa(Hydraulic actuator force), xs(displacement of mass body), xu is the (wheel displacement) and xr (impute road).The Newton second law has been applied to the parameters.Therefore the body mass and tire mass presented as well as

For equation for the unsprung mass (well), the equation of Mu

$$Fa + bs(\dot{X}u - \dot{X}s) + ks + bt\,(\dot{X}u - \dot{X}r) + Pu + kt(Xu - Xr) \;= -Mu \times \ddot{X}u$$

$$\ddot{X}u =$$
$$(Fa + bs((Xu)^{\cdot} - (Xs)^{\cdot}) + ks(Xu - Xs) + bt((Xu)^{\cdot} - (Xr)^{\cdot}) + Pu + kt\,(Xu - Xr))/(-Mu) \quad \ldots \mathbf{(1)}$$

For sprung mass, the equation for Ms:

$$Fa + bs\,(\dot{X}u - \dot{X}s) + ks\,(Xu - Xs) - Ps = Ms \times \ddot{X}s \qquad \ldots (\mathbf{2})$$

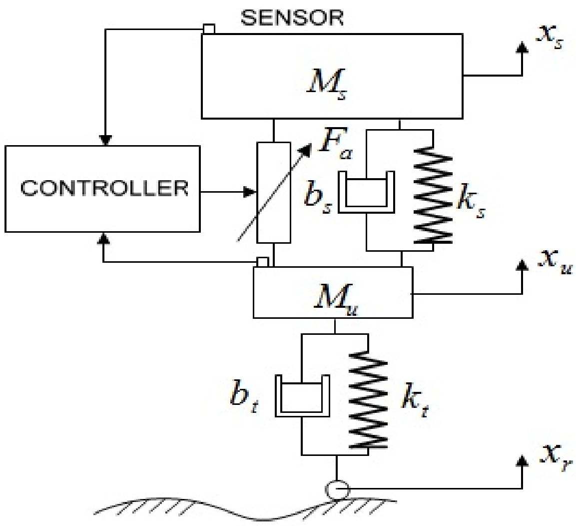


Fig. (1) Active suspensionfor the quarter vehicle

Table 1 The parameters for thequarter vehicle

Parameter	Describe	value	Unite	
MS	Mass sprung	250	KG	
MU	Unsprung mass	50	Kg	
KS	Coefficient stiffness	18600	N\M	
Kt	Stiffness of a wheel	190000	N/M	
Bs	Dampeningcoefficient	1000	N.s/ M	
Bt	Damper of the wheel	0	Ns\M	
Fa	Hydraulic actuator Force	1500	N.	

II.ii. Fuzzylogic control

The (FLC) has included in its system:

Three steps: fuzzification step, the inference stage and defuzification. in fuzzification step change realnumber (crisp) to Fuzzy rate but on the fuzzy inference procedure the datum and register the controller, fuzzy values, convert into real-numbers by the defuzzification step.(fuzzy set) mean choice the best values of membership functions for the input and output variable of active suspension system symbolize in Fig.(2).

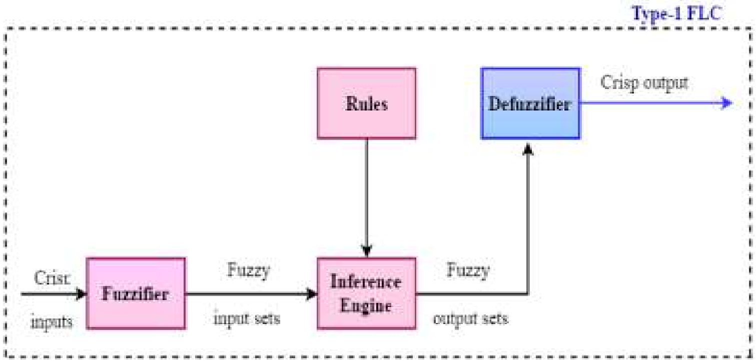


Fig (2) fuzzy logic

The equation of a PID controller has the following form:

$$u(t) = K_P\, e(t) + K_I \int_0^t e(t) + K_D \dot{e}(t)$$

Where K_P, $K_I$and $K_D$are called the
propositional, integral and derivative gains, respectively.

We used fuzzy logic for settingof (PID) controller utilized for obtaining preferable data for gains of the PID controll.

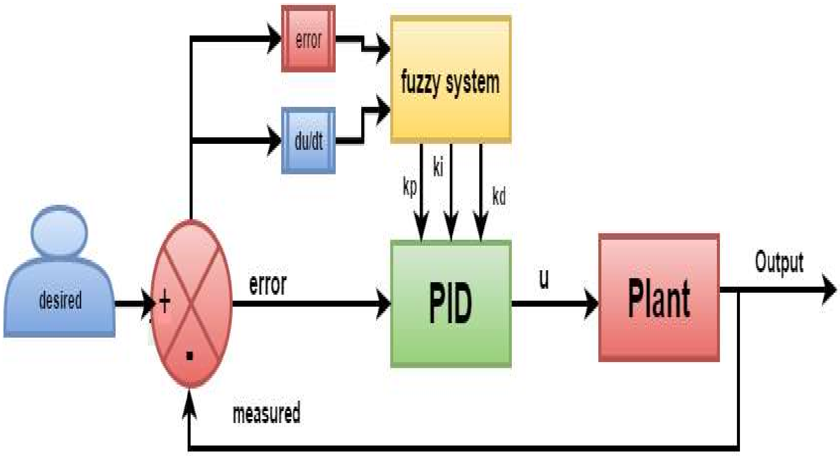


Fig. (3) Block diagram for fuzzy PID

Fuzzy logic has been applied on gains ki .kp ,kd to realize the prefect result. Fuzzy has two input (error and error derivative) and three outputs $K_p, kd,$ andK_i. The triangul form is used for arrangement the parameters steps of prepared the fuzzy input and output are offered in

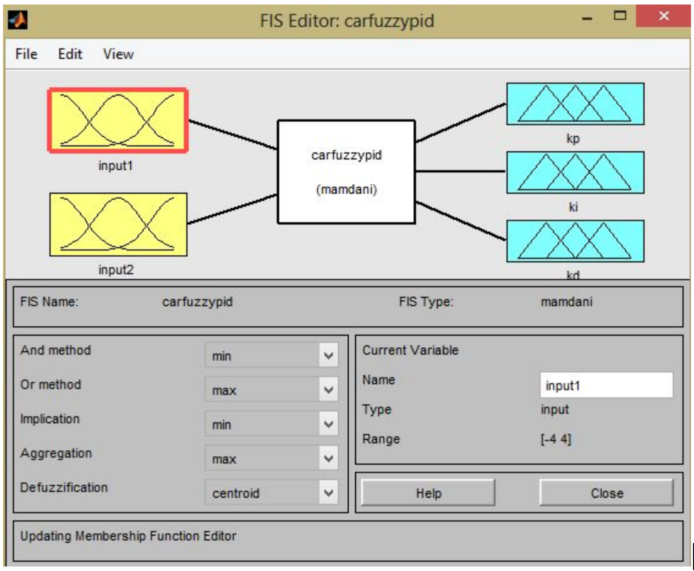
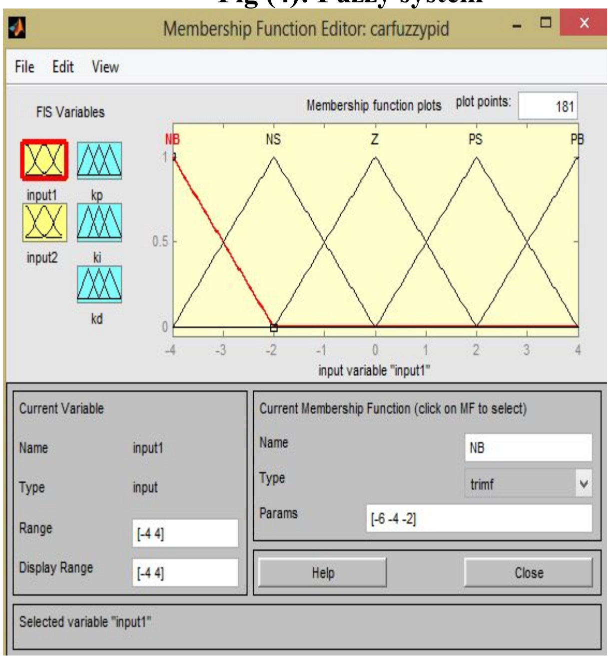
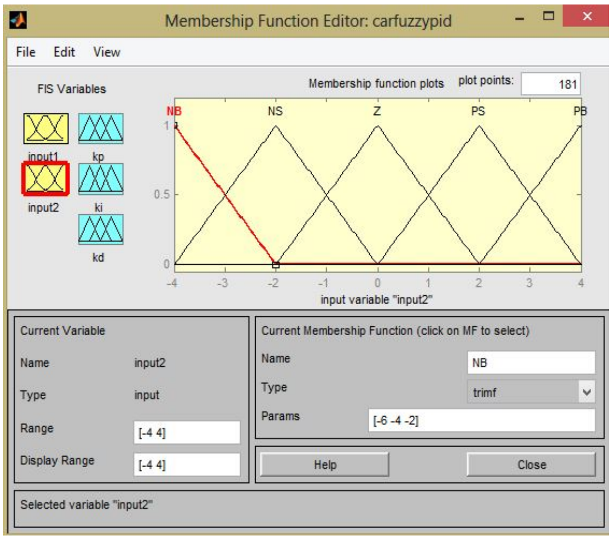


Fig (4): Fuzzy system



(a)



(b)

Fig (5): a) Error b) divertive error

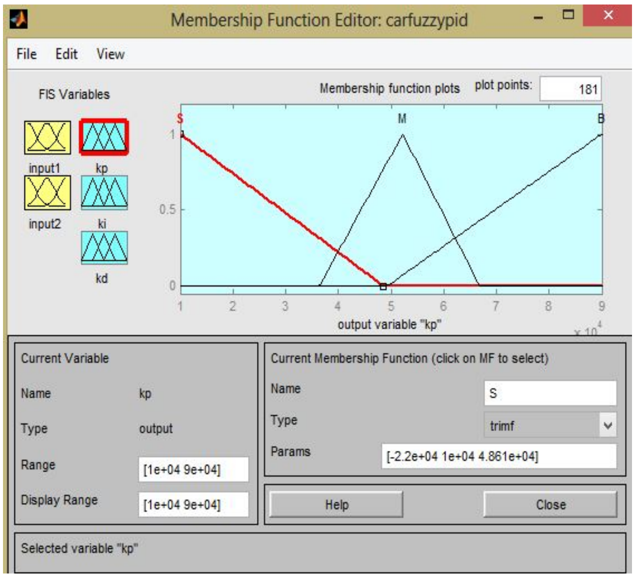


Fig (6): The memberships (KP) for PID controller

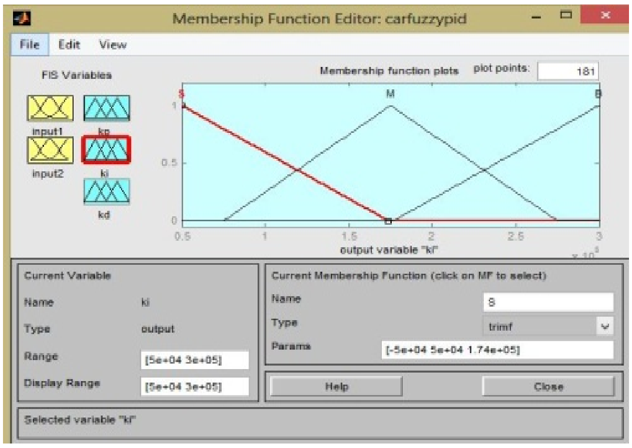


Fig (7): Membership for (KI)

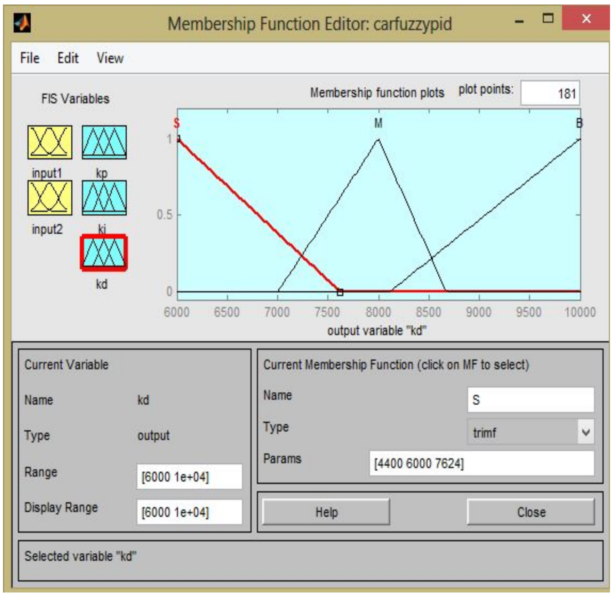


Fig. (8): kd parameters of output sources

In the wake of characterizing the information sources and the yield for each tuner, we arranged the guidelines base. For this situation, 25 rules are required. This is on the grounds that we utilized two information sources every one of which thus contains five enrollment capacities. The quantity of standards equivalent five increased by five.

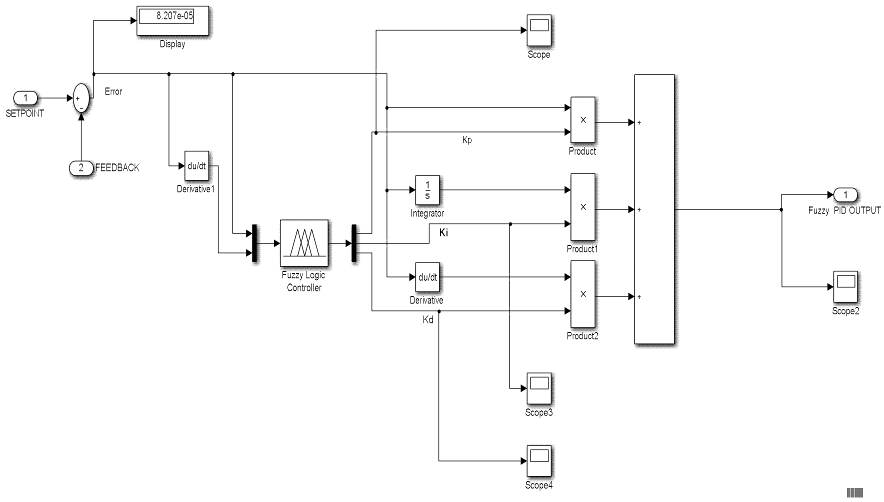


Fig (9): Simulink of the Fuzzy PID controlled

Table (2): The simulation parameters for PID controller

Parameter	Value
Kp	1000
Ki	60000
Kd	6000

Where:
kp = proportional gain
ki= integral gain
Kd= derivative gain

III. Simulation

Simulation results had been showed and compared between the displacement behavior under utilizing PID control with displacement when execution the (FUZZY PID) for actives model . The result showed the dynamic behavior for both masses of the FUZZY PID control and PID controller.figure10-figure14 present these results.

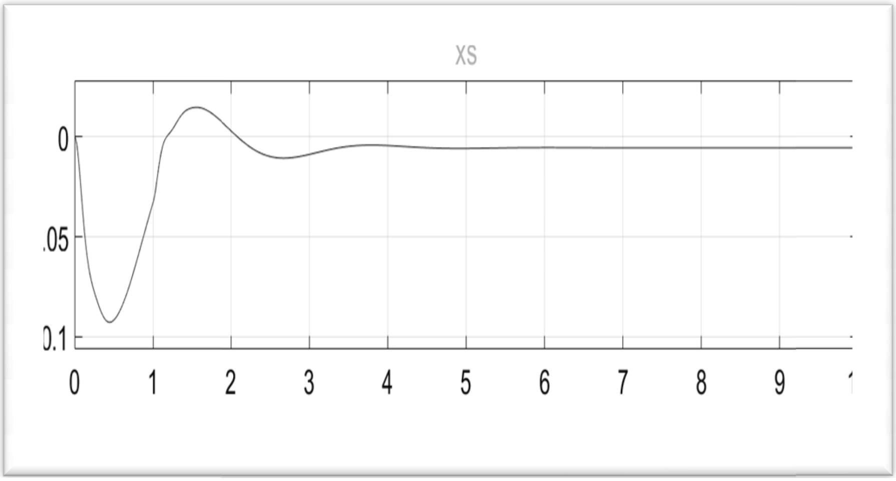


Fig.(10): Sprung Mass displacement for active PID control

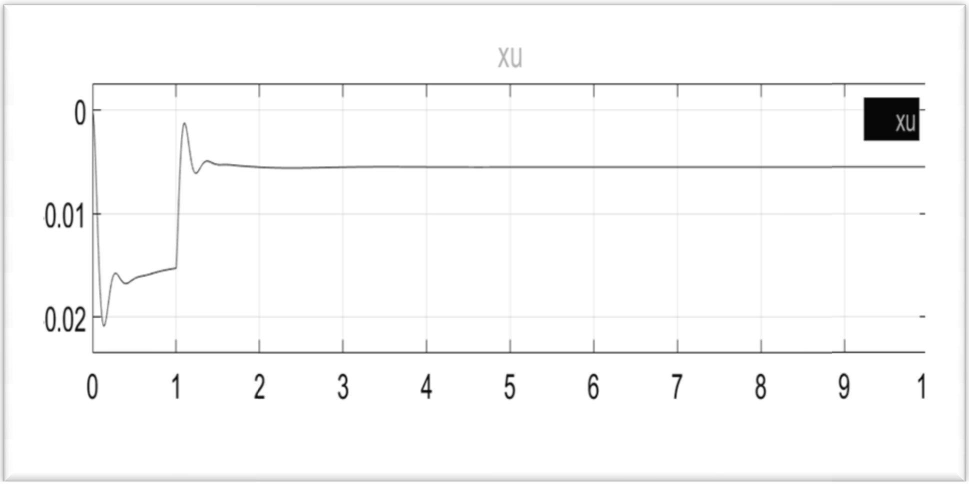


Fig.(11): Unsprung Mass displacement for active PID control

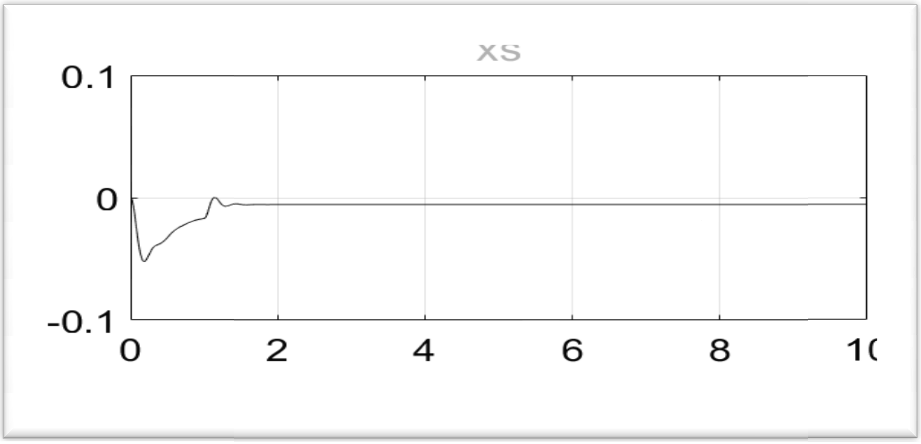


Fig.(12): Sprung Mass displacement for active FUZZY PID control

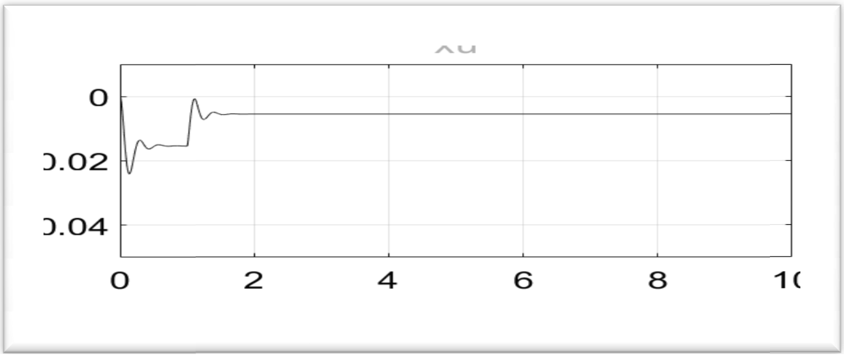


Fig.(13):Unsprung Mass displacement for active FUZZY PID control

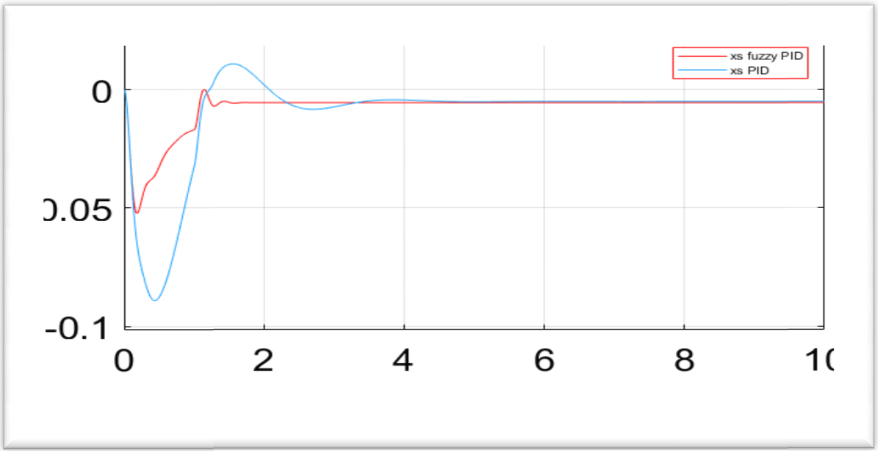


Fig.(14): Sprung Mass displacement for active FUZZY PID and PID control

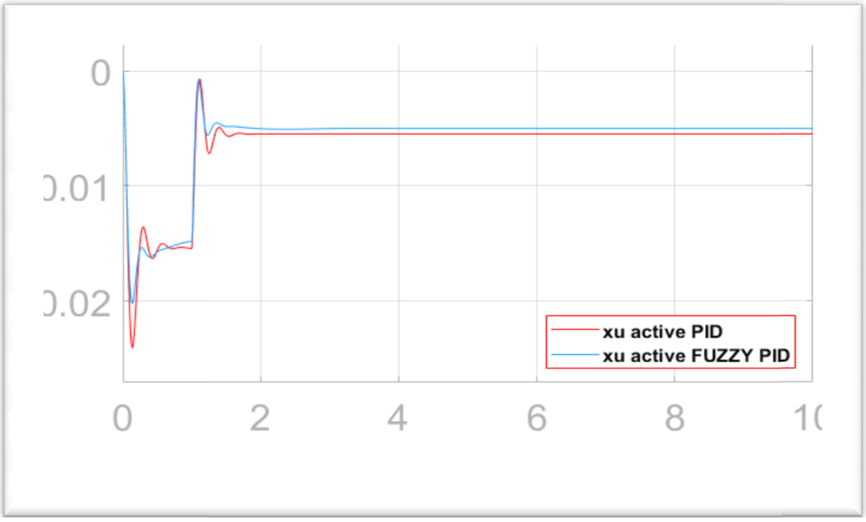


Fig. (15): Unsprung Mass displacement for active FUZZY PID and PID control

IV. Conclusions

In this document the original dynamic suspension control construction is intended to achieve the ride consolation and best industry. The consequences of the dynamic suspension structure by utilizing the FUZZY PID controller moreover saw an improved strength of the onequarter vehicle superior to the PID controller .The setting time is shorter when we connected the FYZZY PID controller on the dynamic suspension than we connected the PID controller likewise From these results it is clear that fuzzy PID control presented lesser value of peak over shoot compared with PID control which is absolutely associated to driver security.

References

I. Alleyne, A., & Hedrick, J. K. (1995). Nonlinear adaptive control of active suspensions. *IEEE transactions on control systems technology*, *3*(1), 94-101.

II. Agharkakli, A., Sabet, G. S., & Barouz, A. (2012). Simulation and analysis of passive and active suspension system using quarter car model for different road profile. *International Journal of Engineering Trends and Technology*, *3*(5), 636-644.

III. Changizi, N., & Rouhani, M. (2011). Comparing PID and fuzzy logic control a quarter car suspension system. *The journal of mathematics and computer science*, *2*(3), 559-564.

IV. Dukkipati, R. V. (2007). *Solving vibration analysis problems using MATLAB*. New Age International.

V. Ghasemalizadeh, O., Taheri, S., Singh, A., & Goryca, J. (2014). Semi-active Suspension Control using Modern Methodology: Comprehensive Comparison Study. *arXiv preprint arXiv:1411.3305*.

VI. Gordon, T. J., Marsh, C., & Milsted, M. G. (1991). A comparison of adaptive LQG and nonlinear controllers for vehicle suspension systems. *Vehicle System Dynamics*, *20*(6), 321-340.

VII. Gysen, B. L., Paulides, J. J., Janssen, J. L., & Lomonova, E. A. (2009). Active electromagnetic suspension system for improved vehicle dynamics. *IEEE Transactions on Vehicular Technology*, *59*(3), 1156-1163.

VIII. Hatch, M. R. (2000). *Vibration simulation using MATLAB and ANSYS*. CRC Press.

IX. Tiwari, P., & Mishra, G. (2014). Simulation of quarter-car model. *JOSR Journal of Mechanical and Civil Engineering*, *11*(2), 85-88.

X. Yagiz, Nurkan, and Yuksel Hacioglu. "Backstepping control of a vehicle with active suspensions." *Control Engineering Practice*16.12 (2008): 1457-1467.