A COMPARATIVE STUDY OF DIFFERENT CONTROL TECHNIQUES FOR ACTIVE SUSPENSION SYSTEMS

By

Rana Mohamed Abdel Rahman Saleh

A Thesis Submitted to the

Faculty of Engineering at Cairo University

In Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

In

ELECTICAL POWER AND MACHINES ENGINEERING

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under the Supervision of

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Title of Thesis: A COMPARATIVE STUDY OF DIFFERENT CONTROL TECHNIQUES FOR ACTIVE SUSPENSION SYSTEMS

Keywords: Active Suspension, Fuzzy, PID, Particle Swarm Optimization, Feedback Linearization

Summary:

This research focuses on implementing a group of control techniques to enhance the performance of Active Suspension System for different vehicle’s models under the presence of various road profiles.

Linear and nonlinear mathematical models of quarter and half vehicle and a linear model of full vehicle are presented. PID controller is used for the linear models and Feedback Linearization control is used for the nonlinear models whereas Fuzzy Logic controller is used for both the linear and nonlinear models. Particle Swarm Optimization is the tuning method for the provided controllers.

MATLAB/SIMULINK software is used for simulation which is based on the mathematical models. A comparison between the behavior of passive and active suspensions is demonstrated. Active suspension shows a significant enhancement compared to passive suspension.

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NOMENCLATURE

Acronyms

ASS	Active Suspension System
HVASS	Half Vehicle Active Suspension System
HVSS	Half Vehicle Suspension System
PID	Proportional Integral Derivative
PSO	Particle Swarm Optimization
PSS	Passive Suspension System
QVASS	Quarter Vehicle Active Suspension System
QVSS	Quarter Vehicle Suspension System
RMS	Root Mean Square

Greek Symbols

α	Factor Depends on the road surface	rad/s
θ_s	Pitch Angle of Sprung Mass	rad
ρ	Relative degree of the output signal w.r.t the disturbance signal	

Roman Symbols

A	Gaussian White Noise	
c_1	Individual Weight	
c_2	Sociality Weight.	
C_s	Suspension Damping Coefficient	N.s/m
C_{sf}	Front Suspension Damping Coefficient	N.s/m
C_{sr}	Rear Suspension Damping Coefficient	N.s/m
C_t	Tire Damping Coefficient	N.s/m
d	Problem Dimensions	
e	Error Signal	

h, h_1, and h_2	Bump Height	m
i	Number of iterations	
I_s	Pitch moment of inertia	Kg
K_d	Derivative Gain	
K_i	Integral Gain	
K_{ls}	Linear Component of Suspension Stiffness Coefficient	N/m
K_{ns}	Nonlinear Component of Suspension Stiffness Coefficient	N/m^3
K_p	Proportional Gain	
K_s	Suspension Stiffness Coefficient	N/m
K_{sf}	Front Suspension Stiffness Coefficient	N/m
K_{sf}^{nl}	Front Suspension Nonlinear Stiffness Coefficient	N/m^3
K_{sr}	Rear Suspension Stiffness Coefficient	N/m
K_{sr}^{nl}	Rear Suspension Nonlinear Stiffness Coefficient	N/m^3
K_t	Tire Stiffness Coefficient	N/m
K_{tf}	Front Tire Stiffness Coefficient	N/m
K_{tr}	Rear Tire Stiffness Coefficient	N/m
L	Distance between the axle	m
L_1	Distance from Front Suspension Location to C.G. of the Sprung Mass	m
L_2	Distance from Rear Suspension Location to C.G. of the Sprung Mass	m
M_s	Sprung Mass	Kg
M_s	Sprung Mass	Kg
M_t	Unsprung Mass	Kg
M_{tf}	Front Unsprung Mass	kg
M_{tr}	Front Unsprung Mas	Kg
p_{gd}	Particle's Global Best Solution	
p_{id}	Particle's Local Best Solution	
r	Relative degree of the output signal w.r.t the input signal	