



Faculty of Mechanical Engineering

**GAIN SCHEDULING PID CONTROL WITH PITCH MOMENT REJECTION FOR
PNEUMATICALLY ACTUATED ACTIVE SUSPENSION**

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PNEUMATICALLY ACTUATED ACTIVE SUSPENSION**

FAUZI BIN AHMAD

**A thesis submitted
in fulfillment of the requirements for the degree of Master of Science**

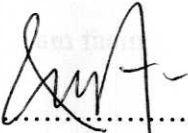
Faculty Of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2009

DECLARATION

I declare that this thesis entitle “Gain Scheduling PID Control With Pitch Moment Rejection For Pneumatically Actuated Active Suspension” is a result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not currently submitted in candidature of any other degree.

Signature : 

Name : Fauzi Bin Ahmad

Date : 1 Mac 2009

DEDICATION

**To my beloved parents and family, especially for Kak Nor who loves me in every situation I
am facing**

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In the name of ALLAH SWT, the most Gracious, who has given me the strength and ability to complete this study. All perfect praises belong to ALLAH SWT, lord of the universe. May His blessing upon the prophet Muhammad SAW and member of his family and companions.

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ABSTRACT

This study deals with the use of pneumatically actuated active suspension in canceling out the effects of weight transfer to the vehicle dynamics performance in longitudinal direction. The main content of this study is the development of a full vehicle model, which consists of ride, handling and tire subsystems as to study the vehicle dynamics behavior in longitudinal direction. The full vehicle model is then validated experimentally using an instrumented experimental vehicle based on the driver input from brake and throttle pedals. Two types of vehicle dynamics tests are performed for the purpose of model validation namely sudden braking test and sudden acceleration test. The results of model validation show that the behaviors of the model closely follow the behaviors of a real vehicle with acceptable error. An active suspension control system is then developed on the validated full vehicle model to reduce unwanted vehicle motions during braking and throttling maneuvers such as body pitch angle, body pitch rate, vertical displacement and vertical acceleration of the vehicle body. A proportional-integral-derivative (PID) scheme integrate with pitch moment rejection loop is proposed to control the system. In presented scheme the result verifies improved performance of the proposed control structure during braking and throttling maneuvers compared to the passive vehicle system. It is also noted that the additional pitch moment rejection loop is able to further improve the performance of the PID controller for the system. It is well-known that conventional PID scheme is not robust for controlling the system with unknown disturbances. To improve the performance of PID scheme, a gain scheduling proportional-integral-derivative (GSPID) control with pitch moment rejection loop is then proposed of the active suspension system. The results of the study show that the proposed control structure is able to significantly improve the dynamic performance of the vehicle during sudden braking and sudden acceleration maneuvers compared to conventional PID and the passive vehicle system under various conditions. The effectiveness of the proposed control algorithm on a road test using instrumented experimental vehicle is also observed. Finally, potential benefits in the use of this control are investigated. The result of the study

demonstrates the potential benefits of the gain scheduling PID controller in controlling the active suspension.

ABSTRAK

Kajian ini adalah berkenaan Kebolehpayaan system penggantungan aktif menggunakan Pneumatik sistem untuk mengurangkan kesan pemindahan beban pada pergerakan kenderaan dalam arah membujur. Kandungan utama dalam kajian ini adalah pembangunan model penuh kenderaan, yang mengandungi model tayar, tunggangan dan pengendalian untuk mengkaji kelakuan sifat kenderaan didalam arah membujur. Model berkenaan kemudian disahkan secara eksperimen dengan menggunakan kenderaan ujian yang dilengkapi dengan pelbagai jenis penerima. Dua jenis ujian dilaksanakan iaitu ujian brek mengejut dan ujian pecutan mengejut. Secara keseluruhannya hasil kedua-dua ujian menunjukkan kelakuan model sama seperti kelakuan kenderaan sebenar dengan sedikit perbezaan yang boleh diabaikan. Kawalan untuk system penggantungan aktif kemudian dibangunkan pada model yang telah disahkan untuk mengurangkan pergerakan yang tidak dikehendaki pada kenderaan, seperti darjah putaran, halaju putaran, sesaran menegak dan pecutan menegak badan kenderaan. Sebuah kawalan perkadaran-integrasi-terbitan dengan gelung penolakan momen putaran telah dibangunkan. Daripada simulasi, ia mengesahkan sistem yang dicadangkan sangat efektif berbanding kawalan perkadaran-integrasi-terbitan tanpa gelung penolakan momen putaran dan sistem pasif. Lanjutan daripada itu kawalan perkadaran-integrasi-terbitan berjadual dengan gelung penolakan momen putaran telah dibangunkan. Keputusan simulasi, menunjukkan sistem kawalan yang dicadangkan adalah lebih bagus dalam mengurangi pergerakan tak diingini pada pergerakan kenderaan berbanding dengan sistem yang menggunakan kawalan perkadaran-integrasi-terbitan biasa dan sistem pasif. Faedah Algoritma kawalan berkenaan kemudian dikaji dengan menggunakan kenderaan ujian sebenar. Hasil daripada eksperimen menunjukkan bahawa algoritma kawalan tersebut bagus dan berkesan untuk pengawalan sistem penggantungan aktif kenderaan.

TABLE OF CONTENT

CHAPTER	TITLE	PAGE
	TITLE PAGE	I
	DECLARATION	III
	DEDICATION	IV
	ACKNOWLEDGEMENT	V
	ABSTRACT	VII
	ABSTRAK	IX
	TABLE OF CONTENT	X
	LIST OF TABLES	XVII
	LIST OF FIGURES	XX
	LIST OF SYMBOLS	XXVIII
1	INTRODUCTION	
1.1	Overview	1
1.2	Problem Statement	2
1.3	Background of the Study	2
1.4	Objectives and Scopes of the Study	3
1.5	Significance of the Study	4
1.6	Methodology	5
1.7	Structure and Layout of the Thesis	6

2 LITERATURE REVIEW

2.0	Introduction	8
2.1	Classification of Vehicle Suspension System	8
2.1.1	Passive Suspension System	9
2.1.2	Semi Active Suspension System	10
2.1.3	Active suspension system	11
2.2	Review of Previous Work on Active Suspension Control	12
2.2.1	LQR Control	14
2.2.2	Fuzzy Logic Control	14
2.2.3	Sliding Mode Control	15
2.2.4	Adaptive Control	15
2.2.5	Hybrid Control	16
2.3	Summary of Existing Control Methods and Active Suspension	16

3 14 - DOF DYNAMICS MODELING AND MODEL VERIFICATION

3.0	Introduction	19
3.1	Modeling Assumptions	19
3.2	Full Vehicle Model with Calspan Tire Model	20
3.2.1	Vehicle Ride Model	21
3.2.2	Vehicle Handling Model	26
3.2.3	Wheel Equation of Motion	30
3.2.4	Simplified Calspan Tire Model	31
3.3	Discription of the Simulation Model	33
3.4	Verification of the Response 14-DOF Vehicle Model with CarSimEd Software	34
3.5	Model Verification for Sudden Braking Test	34
3.5.1	Result of Model Verification for Sudden Braking Test	

	at Constant Speed 40kph	35
3.5.2	Result of Model Verification for Sudden Braking Test at Constant Speed 50kph	38
3.5.3	Result of Model Verification for Sudden Braking Test at Constant Speed 60kph	40
3.6	Model Verification for Sudden Acceleration Test	43
3.6.1	Result of Model Verification for Sudden Acceleration Test at Constant Speed 20kph	44
3.6.2	Result of Model Verification for Sudden Acceleration Test at Constant Speed 30kph	46
3.6.3	Result of Model Verification for Sudden Acceleration Test at Constant Speed 40kph	49
3.7	Conclusion	51

4 MODEL VALIDATION WITH AN INSTRUMENTED EXPERIMENTAL VEHICLE

4.0	Introduction	53
4.1	Validation of Passive Full Vehicle Model with Instrumented Experimental Vehicle	53
4.2	Development of Instrumented Experimental Vehicle	54
4.3	Sensors Installations	55
4.4	Validation of the 14-DOF Full Vehicle Model For Sudden Braking Test	60
4.5	Validation of the 14-DOF Full Vehicle Model for Sudden Braking Test	61
4.5.1	Response of the Vehicle in Sudden Braking Test Constant Speed 40kph	62
4.5.2	Response of the Vehicle in Sudden Braking Test	

	Constant Speed 50kph	65
4.5.3	Response of the Vehicle in Sudden Braking Test	
	Constant Speed 60kph	68
4.6	Validation of the 14-DOF Full Vehicle Model	
	For Sudden Acceleration Test	70
4.6.1	Response of the Vehicle in Sudden Acceleration	
	Test Constant Speed 20kph	71
4.6.2	Response of the Vehicle in Sudden Acceleration	
	Test Constant Speed 30kph	74
4.6.3	Response of the Vehicle in Sudden Acceleration	
	Test Constant Speed 40kph	77
4.7	Conclusion	80
5	PID CONTROLER	
5.0	Introduction	82
5.1	Controller Structure of Active Suspension System	83
	5.11 Proportional Integral Derivative (PID) Controller	83
	5.12 Pitch Moment Rejection Loop	84
5.2	Decoupling Transformation	87
5.3	Simulation Parameters	88
5.4	Performance Assessment of the Proposed Control	
	Structure on Sudden Braking Test	90
5.4.1	Performance of the Control Structure on Sudden	
	Braking Test at 1Mpa Brake Pressure	90
5.4.2	Performance of the Control Structure on Sudden	
	Braking Test at 3Mpa Brake Pressure	93
5.4.3	Performance of the Control Structure on Sudden	
	Braking Test at 6Mpa Brake Pressure	95

5.5	Performance Assessment of the Proposed Control Structure on Sudden Acceleration Test	97
5.5.1	Performance of the Control Structure on Sudden Acceleration Test at 0.2 Step Throttle	98
5.5.2	Performance of the Control Structure on Sudden Acceleration Test at 0.6 Step Throttle	100
5.5.3	Performance of the Control Structure on Sudden Acceleration Test at Full Step Throttle	103
5.6	Conclusion	105

6 GAIN SCHEDULING PID CONTROL WITH PITCH MOMENT REJECTION LOOP OF THE PNEUMATICALLY ACTUATED ACTIVE SUSPENSION

6.0	Introduction	108
6.1	Gain Scheduling PID Control	108
6.2	Performance Evaluation of GSPID Control	114
6.3	Performance Assessment of the Proposed Control Structure on Sudden Braking Test	114
6.3.1	Performance of the Controller for Sudden Braking Test at 1Mpa Brake Pressure	115
6.3.2	Performance of the Controller for Sudden Braking Test at 3Mpa Brake Pressure	117
6.3.3	Performance of the Controller for Sudden Braking Test at 6Mpa Brake Pressure	119
6.4	Performance Assessment of the Proposed Control Structure on Sudden Acceleration Test	121
6.4.1	Response of the Controller for Sudden Acceleration Test at 0.2 Step Throttle	121

6.4.2	Response of the Controller for Sudden AccelerationTest at 0.6 Step Throttle	123
6.4.3	Response of the Controller for Sudden AccelerationTest at Full Step Throttle	126
6.5	Response of the Controller for Unbounded Signal	128
6.5.1	Response of the Controller for Unbounded Braking Input	128
6.5.2	Response of the Controller for Unbounded Throttle Input	131
6.6	Conclusion	133

7 EXPERIMENTAL EVALUATION OF PNEUMATICALLY ACTUATED ACTIVE SUSPENSION SYSTEM

7.0	Introduction	135
7.1	Component of Actuation System	137
7.2	Installation of the Pneumatic System into Experimental Vehicle	139
7.3	Controller Development	140
7.4	Road Testing of Active Suspension System Installed on an Instrumented Experimental Vehicle	142
7.5	Step Change Test Driver Input	143
7.5.1	Performance of the Active Suspension on Sudden Braking Test at 40kph	144
7.5.2	Performance of the Active Suspension on Sudden Braking Test at 60kph	147
7.5.3	Performance of the Active Suspension on Sudden Acceleration at 10kph	150
7.5.4	Performance of the Active Suspension at 40kph Sudden Throttle Input	153
7.6	Conclusion	156

8 CONCLUSION AND RECOMENDATION

8.1	Conclusion	156
8.2	Open Problem And Recommendation for Future Works	160

	REFERENCES	161
--	-------------------	------------

	APPENDIX A: LIST OF PUBLICATIONS	168
--	---	------------

	APPENDIX B: GSPID CONTROL PARAMETERS	171
--	---	------------

	APPENDIX C: GSPID CONTROL ALGORITHM	175
--	--	------------

	APPENDIX D: DATA AND SPECIFICATION OF SPEED SENSOR	179
--	---	------------

	APPENDIX E: DATA AND SPECIFICATION OF STEERING ANGLE SENSOR	182
--	--	------------

	APPENDIX F: DATA AND SPECIFICATION OF GYROSCOPE SENSOR	185
--	---	------------

	APPENDIX G: DATA AND SPECIFICATION OF TRI-AXIS ACCELOROMETER SENSOR	188
--	--	------------

	APPENDIX H: DATA AND SPECIFICATION OF FORCE SENSOR	192
--	---	------------

	APPENDIX I: DATA AND SPECIFICATION OF IMC DEVICE	195
--	---	------------

	APPENDIX J: DATA AND SPECIFICATION OF PNEUMATIC CYCLINDER	220
--	--	------------

LIST OF TABLES

TABLE NO.	TITLE	PAGE
4.1	Poton Iswara technical specification	55
4.2	Pin Configuration	60
5.1	Controller parameters	89
5.2	Tire parameters	89
5.3	PTP and RMS values of simulation results on PID control with pitch moment rejection loop, PID control without pitch moment rejection loop and passive system for sudden braking test at 1Mpa brake pressure	92
5.4	PTP and RMS values of simulation results on PID control with pitch moment rejection loop, PID control without pitch moment rejection loop and passive system for sudden braking test at 3Mpa brake pressure.	95
5.5	PTP and RMS values of simulation results on PID control with pitch moment rejection loop, PID control without pitch moment rejection loop and passive system for sudden braking test at 6mpa brake pressure.	97
5.6	PTP and RMS values of simulation results on PID control with pitch moment rejection loop, PID control without pitch moment rejection loop and passive system for sudden acceleration test at 0.2 step throttle.	100

5.7	PTP and RMS values of simulation results on PID control with pitch moment rejection loop, PID control without pitch moment rejection loop and passive system for sudden acceleration test at 0.6 step throttle	103
5.8	PTP and RMS values of simulation results on PID control with pitch moment rejection loop, PID control without pitch moment rejection loop and passive system for sudden acceleration test at full step throttle	105
6.1	RMS value for pitch angle response for 1Mpa, 3Mpa and 6Mpa brake when used 1Mpa controllers	109
6.2	RMS value for pitch angle response for 3Mpa, 1Mpa, and 6Mpa brake when used 3Mpa controllers	110
6.3	RMS value for pitch angle response for 3Mpa, 1Mpa, and 6Mpa brake when used 6Mpa controllers	111
6.4	PTP and RMS values of simulation results on GSPID control, PID control and passive system for sudden braking test with 1mpa brake pressure	116
6.5	PTP and RMS values of simulation results on GSPID control, PID control and passive system for sudden braking test with 3mpa brake pressure	118
6.6	PTP and RMS values of simulation results on GSPID control, PID control and passive system for sudden braking test with 6mpa brake pressure	120
6.7	PTP and RMS values of simulation results on GSPID control, PID control and passive system for sudden acceleration test at 0.2 step throttle	123
6.8	PTP and RMS values of simulation results on GSPID control, PID control and passive system for sudden acceleration test at 0.6 step throttle	125
6.9	PTP and RMS values of simulation results on GSPID control,	

	PID control and passive system for sudden acceleration test at full step throttle	127
6.10	PTP and RMS values of simulation results on GSPID control, PID control and passive system for unbounded braking input	130
6.11	PTP and RMS values of simulation results on GSPID control, PID control and passive system for unbounded throttle input test	133
7.1	PTP and RMS Values of experimental results on active suspension with GSPID control, active suspension with PID and passive system for Sudden Braking Test at 40kph	147
7.2	PTP and RMS Values of experimental Results on active suspension with GSPID control active suspension with PID and Passive system for Sudden Braking Test at 60kph	150
7.3	PTP and RMS Values of experimental Results on active suspension with GSPID control, active suspension with PID and Passive system for Sudden Acceleration Test at 10kph	153
7.4	PTP and RMS Values of experimental Results on active suspension with GSPID control, active suspension with PID and Passive system for Sudden Throttle Input Test	156

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Passive suspension system	9
2.2	Semi active suspension systems	10
2.3	A low band with or soft active suspension system	11
2.4	A high-band with or stiff active suspension system	12
3.1	14-DOF full vehicle model	20
3.2	A 7-DOF Vehicle handling model	28
3.3	Free Body Diagram of a Wheel	31
3.4	Full Vehicle Model in MATLAB Simulink	34
3.5	Braking input for sudden braking test	35
3.6	Longitudinal acceleration for sudden braking test at 40kph	36
3.7	Pitch rate for sudden braking test at 40kph	36
3.8	Front left tire longitudinal slip for sudden braking test at 40kph	37
3.9	Front right tire longitudinal slip for sudden braking test at 40kph	37
3.10	Rear left tire longitudinal slip for sudden braking test at 40kph	37
3.11	Front left tire longitudinal slip for sudden braking test at 40kph	38
3.12	Longitudinal acceleration for sudden braking test at 50kph	38
3.13	Pitch angle for sudden braking test at 50kph	39
3.14	Front left tire longitudinal slip for sudden braking test at 50kph	39
3.15	Front right tire longitudinal slip for sudden braking test at 50kph	39
3.16	Rear left tire longitudinal slip for sudden braking test at 50kph	40
3.17	Rear right tire longitudinal slip for sudden braking test at 50kph	40
3.18	Longitudinal acceleration for sudden braking test at 60kph	41

3.19	Pitch angle for sudden braking test at 60kph	41
3.20	Front left tire longitudinal slip for sudden braking test at 60kph	42
3.21	Front right tire longitudinal slip for sudden braking test at 60kph	42
3.22	Rear left tire longitudinal slip for sudden braking test at 60kph	42
3.23	Rear right tire longitudinal slip for sudden braking test at 60kph	43
3.24	Throttle input for sudden acceleration test	43
3.25	Longitudinal acceleration for sudden acceleration test at 20kph	44
3.26	Pitch rate for sudden acceleration test at 20kph	45
3.27	Front left tire longitudinal slip for sudden acceleration test at 20kph	45
3.28	Front right tire longitudinal slip for sudden acceleration test at 20kph	45
3.29	Rear left tire longitudinal slip for sudden acceleration test at 20kph	46
3.30	Rear right tire longitudinal slip for sudden acceleration test at 20kph	46
3.31	Longitudinal acceleration for sudden acceleration test at 30kph	47
3.32	Longitudinal acceleration for sudden acceleration test at 30kph	47
3.33	Front left tire longitudinal slip for sudden acceleration test at 30kph	48
3.34	Front right tire longitudinal slip for sudden acceleration test at 30kph	48
3.35	Rear left tire longitudinal slip for sudden acceleration test at 30kph	48
3.36	Rear right tire longitudinal slip for sudden acceleration test at 30kph	49
3.37	Longitudinal acceleration for sudden acceleration test at 40kph	49
3.38	Pitch rate for sudden acceleration test at 40kph	50
3.39	Front left tire longitudinal slip for sudden acceleration test at 40kph	50
3.40	Front right tire longitudinal slip for sudden acceleration test at 40kph	50
3.41	Rear left tire longitudinal slip for sudden acceleration test at 40kph	51
3.42	Front left tire longitudinal slip for sudden acceleration test at 40kph	51
4.1	3D View of Proton Iswara	54
4.2	IMC device	56
4.3	Pin addressing on the IMC back-plane	56
4.4	Four sensors that mounted at the body center of gravity	57
4.5	Vehicle speed sensor	58
4.6	Front wheel speed sensor	58

4.7	Rear wheel speed sensor	59
4.8	Steering angle sensors	59
4.9	On-board data acquisition system	60
4.10	Sudden braking test at constant speed 60kph	61
4.11	Vehicle speed for sudden braking test at constant speed 40kph	62
4.12	Longitudinal acceleration for sudden braking test at constant speed 40kph	63
4.13	Pitch rate for sudden braking test at constant speed 40kph	63
4.14	Front left tire longitudinal slip for sudden braking test at constant speed 40kph	64
4.15	Front right tire longitudinal slip for sudden braking test at constant speed 40kph	64
4.16	Rear left tire longitudinal slip for sudden braking test at constant speed 40kph	64
4.17	Rear right tire longitudinal slip for sudden braking test at constant speed 40kph	65
4.18	Vehicle speed for sudden braking test at 50kph	65
4.19	Longitudinal acceleration for sudden braking test at constant speed 50kph	66
4.20	Pitch rate for sudden braking test at constant speed 50kph	66
4.21	Front left tire longitudinal slip for sudden braking test at constant speed 50kph	66
4.22	Front right tire longitudinal slip for sudden braking test at constant speed 50kph	67
4.23	Rear left tire longitudinal slip for sudden braking test at constant speed 50kph	67
4.24	Rear right tire longitudinal slip for sudden braking test at constant speed 50kph	67
4.25	Vehicle speed for sudden braking test at constant speed 60kph	68
4.26	Longitudinal acceleration for sudden braking test at constant speed 60kph	68

4.27	Pitch rate for sudden braking test at constant speed 60kph	79
4.28	Front right tire longitudinal slip for sudden braking test at constant speed 60kph	69
4.29	Front left tire longitudinal slip for sudden braking test at constant speed 60kph	69
4.30	Rear left tire longitudinal slip for sudden braking test at constant speed 60kph	70
4.31	Rear right longitudinal slip for sudden braking test at constant speed 60kph	70
4.32	Sudden acceleration test at constant speed 40kph	71
4.33	Vehicle speed for sudden acceleration test at constant speed 20kph	72
4.34	Longitudinal acceleration for sudden acceleration test at constant speed 20kph	72
4.35	Pitch rate for sudden acceleration test at constant speed 20kph	72
4.36	Front left tire longitudinal slip for sudden acceleration test at 20kph	73
4.37	Front right tire longitudinal slip for sudden acceleration test at 20kph	73
4.38	Rear left tire longitudinal slip for sudden acceleration test at 20kph	73
4.39	Rear right tire longitudinal slip for sudden acceleration test at 20kph	74
4.40	Vehicle speed for sudden acceleration test at constant speed 30kph	75
4.41	Longitudinal acceleration for sudden acceleration test at constant speed 30kph	75
4.42	Pitch rate for sudden acceleration test at constant speed 30kph	75
4.43	Front left tire longitudinal slip for sudden acceleration test at 30kph	76
4.44	Front right tire longitudinal slip for sudden acceleration test at 30kph	76
4.45	Rear left tire longitudinal slip for sudden acceleration test at 30kph	76
4.46	Rear right tire longitudinal slip for sudden acceleration test at 30kph	77
4.47	Vehicle speed for sudden acceleration at constant speed 40kph	77
4.48	Longitudinal acceleration for sudden acceleration at 40kph	78
4.49	Pitch rate for sudden acceleration at 40kph	78
4.50	Front left tire longitudinal slip for sudden acceleration at 40kph	78

4.51	Front right tire longitudinal slip for sudden acceleration at 40kph	79
4.52	Rear left tire longitudinal slip for sudden acceleration at 40kph	79
4.53	Rear right tire longitudinal slip for sudden acceleration at 40kph	79
5.1	The Proposed Control Structure for active suspension system	83
5.2	Free body diagram for pitch motion	85.
5.3	Pitch rate for sudden braking test at 1Mpa brake pressure	91
5.4	Pitch angle for sudden braking test at 1Mpa brake pressure	91
5.5	Body acceleration for sudden braking test at 1Mpa brake pressure	92
5.6	Body displacement for sudden braking test at 1Mpa brake pressure	92
5.7	Pitch rate for sudden braking test at 3Mpa brake pressure	93
5.8	Pitch angle for sudden braking test at 3Mpa brake pressure	94
5.9	Body acceleration for sudden braking test at 3Mpa brake pressure	94
5.10	Body displacement for sudden braking test at 3Mpa brake pressure	94
5.11	Pitch rate for sudden braking test at 6Mpa brake pressure	96
5.12	Pitch angle for sudden braking test at 6Mpa brake pressure	96
5.13	Body acceleration for sudden braking test at 6Mpa brake pressure	96
5.14	Body displacement for sudden braking test at 6Mpa brake pressure	97
5.15	Pitch rate for sudden acceleration test at 0.2 step throttle	99
5.16	Pitch angle for sudden acceleration test at 0.2 step throttle	99
5.17	Body acceleration for sudden acceleration test at 0.2 step throttle	99
5.18	Body displacement for sudden acceleration test at 0.2 step throttle	100
5.19	Pitch rate for sudden acceleration test at 0.6 step throttle	101
5.20	Pitch angle for sudden acceleration test at 0.6 step throttle	102
5.21	Body acceleration for sudden acceleration test at 0.6 step throttle	102
5.22	Body displacement for sudden acceleration test at 0.6 step throttle	102
5.23	Pitch rate for sudden acceleration test at full step throttle	104
5.24	Pitch angle for sudden acceleration test at full step throttle	104
5.25	Body acceleration for sudden acceleration test at full step throttle	104
5.26	Body acceleration for sudden acceleration test at full step throttle	105
6.1	Response of the system when used 1Mpa controllers for all 3Mpa and 6Mpa brake	109