
## Faculty of Mechanical Engineering

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

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**MSc.in Mechanical Engineering**

**2009**

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

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**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

## ACKNOWLEDGEMENTS

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.

I am very indebted to my advisor Dr. Khisbullah Hudha. Without him, I simply would not be here to pursue my Master. I would like to thank him for his guidance and suggestions in conducting my studies, and especially for his constructive criticisms, encouragement of independent thinking, and allowing me the freedom to pursue my own interests. From him, I learned not only the knowledge and scientific skills, but also the love of science and hard work which helped me transformed to a researcher. The past two years (2007- 2008) will be an invaluable asset from which I will benefit during the rest of my life. I would also like to thank my secondary supervisors, Prof. Dr. Md Radzai.Said and Mr. Ahmad Rivai for providing invaluable input on many aspects of my research and contributing their time and effort throughout this study.

My appreciations are also addressed to Center For Graduate Studies, and The Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka for opening opportunity to conduct a research study. Special thanks go to the Ministry of Science, Technology and Innovation Malaysia (MOSTI) scholarship and MARA for providing me a financial support. Many thanks to those people whom I am working with now or I have worked with in the past. I thank Mr Mohammad Zakaria Mohammad Nasir; Mr Mad Nasir Ngadiman; Mr Habi Rafidi from Department of Automotive, Zulkiffli Abd Kadir; Fitrian Imaduddin Ahmad Dahlan; Ubaidillah Sabino from Smart Material and Automotive Control Group, Mdm Siti Aisya Daud; Mdm Siti Sabrinah Buang; Mr Abu Zar Hashim from Center For Graduates Studies and

Mdm Nor Hazlen Niza Hussein from Center For Language and Human Development of Universiti Teknikal Malaysia Melaka, for their suggestions and constructive feedback.

Finally, it is difficult to know where to begin to thank my parents, Hj Ahmad Hj Badri and Hjh Hamsin Hj Sulaiman for all they have done for me in which I will never forget. Their long sacrifice, patience and encouragement are deeply invaluable. Without them, all this would simply become meaningless. My deepest respect and thanks go to my spirit, my strength, my aspiration and my wife, Norazira Ahamad. All I can think of is: Thanks for everything. I also would like to thank to all my teachers in secondary and primary school for bring me to this stage. Not to forget, special thanks go to all my students at TATIUC, my brothers and sisters, Along, Angah, Kak Saba, Kak ea, Kak Cu, Ate, Kak Ila, Jerah, Adah, Ayid and Amu for giving me a real support, pray, and all they have, and to support me in ups and downs. To my whole family – you're the best family I ever have!

## 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 Kebolehupayaan 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 penderia. 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.

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