MODELING AND SIMULATION

OF ACTIVE ATTITUDE CONTROL FOR SATELLITES

By

OUHOCINE CHERIF

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

September 2004

DEDICATION

To my parents, brothers, sisters

and my wife Zahra

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

MODELING AND SIMULATION OF ACTIVE ATTITUDE CONTROL FOR SATELLITES

By

OUHOCINE CHERIF

May 2004

Chairman: **Mohammad Nizam Filipski**

Faculty: **Engineering**

One of the most important problem in satellite design is that of attitude stabilization and control, which is the combination of mathematics, dynamics, and control theory. Basic types of control systems are spin control, where the entire satellite is spun, dual-spin control, where the major portion spun while only the payload despun, three-axis active control, where the major part of satellite despun, and gravity gradient control.

Different attitude control strategies of satellite in Low Earth Orbit (LEO) are presented in this thesis as well as their simulation with the MATLAB® software. Firstly the linear mathematical model of the satellite is derived for the gravity gradient (GG) control method, which represents a passive control design. The advantages of this control method are long life, simplicity of design, no mass or energy expenditure, and low cost. The simulation results show the main disadvantage of this technique, which is a marginally stable response of the satellite to initial conditions. In other words, a poor pointing accuracy with respect to the orbiting reference frame. The second phase of this thesis

focuses on the design of a control algorithm used to damp the satellite oscillations around its equilibrium position with a simple hardware setting added to the satellite. The system stability of the model has been checked by using Routh Hurwitz method. The mathematical model of the new system is developed and simulation about the roll and yaw axes are realized. A consequent amelioration in the satellite response can be observed.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PEMODELAN DAN SIMULASI
KAWALAN ATITUD AKTIF UNRUK SATELIT

Oleh

OUHOCINE CHERIF

September 2004

Pengerusi: **Mohammad Nizam Filipski**

Fakulti: **Kejuruteraan**

Salah satu masalah terpenting di dalam merekabentuk satelit ialah kesetabilan gayaterbang dan kawalan yang merangkumi penyatuan matematik, dinamik dan teori kawalan. Asas sistem kawalan ialah kawalan putar, di mana seluruh satelit berputar, kawalan putar-berasing di mana bahagian utama berputar manakala beban berbayar tidak berputar, kawalan tiga-paksi aktif dimana bahagian utama satelit tidak berputar, dan kawalan kecerunan graviti.

Strategi pelbagai kawalan gayaterbang untuk satelit kecil di orbit bumi rendah (LEO) dipersembahkan didalam tesis ini berserta simulasi dengan perisian MATLAB. Fasa pertama ialah membentuk model matematik lelurus pada satelit untuk kawalan kecerunan graviti dimana innya satu rekabentuk kawalan pasif. Keistimewaan kawalan cara ini ialah berhayat panjang, rekabentuknya rirgkas, tiada jisim atau tenaga digunakan dan kos endah. Keputusan simulasi menunjukkan keistimewaan utama teknik ini ialah tindakbalas

kestabilan yang kecil oleh satelit terhadap keadaan permulaan. Dengan lain perkataan ianya menunjukkan ketepatan yang rendah berasaskan rangka asa pengorbitan. Fasa yang kedua tesis ini tertumpu kepada rekabentuk kawalan algorithma gunanya untuk menyekat ayunan satelit pada posisi keseimbangan dengan mentatahkan perkakasan yang ringkas pada satelit tersebut. Kestabilan sistem untuk model berkenaan telah diperiksa dengan menggunakan kaedah Routh Hurwitz. Model matematik untuk sistem yang baru telah dibangunkan dan simulasi terhadap paksi golek dan putar posisi (Roll and Yaw) telah direalisasikan. Kesan pembaikan pada tindakbalas satelit telah dapat dilihat.

ACKNOWLEDGEMENTS

A particular note of thanks is given to my supervisor, Mr. Mohammad Nizam, for his technical help and moral support.

In addition I would like to extend my sincere appreciation to my family and friends for their support in making this project a success.

I certify that an Examination Committee met on 3rd September 2004 to conduct the final examination of Ouhocine Cherif on his Master of Science thesis entitled "Modeling and Simulation of Active Attitude Control for Satellites" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Chairman, Ph.D.
Professor

Faculty of Graduate Studies
Universiti Putra Malaysia
(Chairman)

Examiner 1, Ph.D.
Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Member)

Examiner 2, Ph.D.
Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Member)

Independent Examiner, Ph.D.
Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Independent Examiner)

GULAM RUSUL RAHMAT ALI, Ph.D.
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Master of Science.The members of the Supervisory Committee are as follows:

Lecturer Mohamad Nizam Filipski
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Samsul Bahari Bin Mohd. Noor, Ph.D.
Faculty of Engineering
Universiti Putra Malaysia

(Member)

Mohd. Ramly Ajir, PhD.
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

_____

AINI IDERIS, Ph.D.
Prefessor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I hereby declared that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

OUHOCINE CHERIF

Date:

TABLE OF CONTENTS

CHAPTER