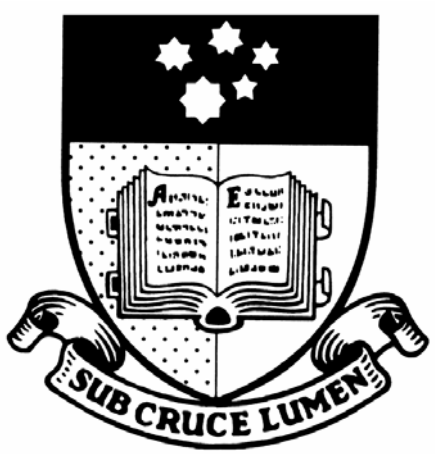


# Active Vibration Control of a piezoelectric laminate plate using Spatial Control Approach

Yong Keat Lee

Department of Mechanical Engineering
University of Adelaide
South Australia 5005
AUSTRALIA

*submitted for the degree of Master of Engineering Science*

# Abstract

This thesis represents the work that has been done by the author during his Master of Engineering Science candidature in the area of vibration control of flexible structures at the School of Mechanical Engineering, The University of Adelaide, between March 2003 and June 2004. The aim of this research is to further extend the application of the Spatial Control Approach for two-dimensional flexible structures for attenuating global structural vibration with the possible implication of reduction in noise radiation. The research was concentrated on a simply supported thin flexible plate, using piezoelectric ceramic materials as actuators and sensors. In this work, active controllers were designed for the purpose of controlling only the first five vibration modes (0-500Hz) of the plate.

A spatial controller was designed to minimize the total energy of the spatially distributed signal, which is reflected by the spatial $H_2$ norm of the transfer function from the disturbance signal to the vibration output at every point over the plate. This approach ensures the vibration contributed by all the in bandwidth (0-500 Hz) vibration modes is minimized, and hence is capable of minimizing vibration throughout the entire plate.

Within the control framework, two cases were considered here; the case when the prior knowledge of the incoming disturbance in terms of reference signal is available and the case when it is not available. For the case when the reference signal is available, spatial feedforward controller was designed; whereas for the case when the reference signal is not available, spatial feedback controller was designed to attenuate the global disturbance.

The effectiveness of spatial controllers was then compared with that of the standard point-wise controllers numerically and experimentally. The experimental results were

found to reflect the numerical results, and the results demonstrated that spatial controllers are able to reduce the energy transfer from the disturbance to the structural output across the plate in a more uniform way than the point-wise controllers. The research work has demonstrated that spatial controller managed to minimize the global plate vibrations and noise radiation that were due to the first five modes.

# Statement of Originality

To the best of my knowledge and belief, all the material presented in this thesis, except where otherwise referenced, is my own original work, and has not been published previously for the award of any other degree or diploma in any university. If accepted for the award of the degree of Master of Engineering Science, I consent that this thesis be made available for loan and photocopying.

Yong Keat LEE

# Acknowledgements

Most of all, I would like to thank my supervisors, Dr. Lei Chen and Dr. Dunant Halim for their friendly guidance, comments and encouragement during my time here. Dunant's enthusiasm was contagious to me, and from the discussions and interactions with him, new ideas necessary for the progress and achievement of this work have emerged, his enlightening advice have helped me to stay motivated, and made this thesis possible. I am especially grateful that he gave me the opportunity to work on this project.

I am indebted to the University of Adelaide for providing me the International Postgraduate Research Scholarship (IPRS). Specifically, I wish to acknowledge Professor Colin Hansen and Dr. Tien-Fu Lu who have made this possible.

I would like to thank Dr. Ben Cazzolato and Dr. Xun Li for showing their interest in my work and giving me valuable advices and suggestions. They were always resourceful and encouraging with personal generosity. I am also thankful to the members of the ANVC group, especially Professor Colin Hansen, Dr. Simon Hill, and Dr. Rick Morgan for all their early inputs and support in many ways.

Generous help from George Osborne and Derek Franklin in preparing the experimental apparatus used in my experiments is greatly appreciated. Without their support this research may have never been done.

Many appreciations are also expressed to my parents, my brother and friends who have always provided me encouragement, care, love and prayer. I hope they realise how much I appreciate their thoughtful care and concerns for me. Finally, I want to thank GOD for sustaining me throughout this project. HE has served as a constant source of strength and wisdom, without which I might not be able to finish this work.

*Dedicated*

*to*

*my father, my mother*

*&*

*my brother.*

# Contents

# List of Figures

# List of Tables