LINEAR AND ROBUST CONTROL SYSTEMS - - ELEC 9731, Session I 2008

Course Organisation: There are two parts to the course.

Part I: Linear Systems and Control: weeks 1-6 - Prof Solo.

Part II: Robust Control: weeks 7 -12 - Prof Savkin.

Prerequisites: Undergraduate Control Course.

Instructors:

Part I: Prof Victor Solo, **Office**: Room 237, **E-Mail:** v.solo@unsw.edu.au (use subject: ELEC 9731), **Office Hours:** Wed, 4pm-5pm.

Part II: Prof Andrey Savkin, **Office**: Room 203, **E-Mail:** a.savkin@unsw.edu.au (use subject: ELEC 9731), **Office Hours:** Wed, 4pm-5pm.

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Class Times: Wed, 6pm-9pm , Weeks 1-12, Room: G24.

Aims: Provide an introduction to multivariable linear system theory and control from both an input/output and a state space point of view. Provide an introduction to optimal control, robust control, optimal and robust filtering.

Assessment : To pass, students must obtain a pass level in each part of the course.

Part I: Assignments – 20%, Final Exam (Take-home)– 30%.

Part III: Assignments – 20%, Final Exam (Take-home) – 30%.

Assignments and Exams are to be completed on your own. Assignments should have a School Assignment Sheet as the first page. These sheets are available from the School Office, or may be downloaded from the School web page. It is recommended that you keep a copy your assignment and exam. Late assignments will be penalised at 10% of the maximum value per day late.

Assignment, Exam Timetable:

Part I, Assignment **1**: out - TBA ; due - 2 weeks later;

Part I, Assignment **2**: out - TBA ; due - 2 weeks later;

Part I, Exam: out - TBA ; due - TBA;

Part II, Assignment **1**: out - TBA ; due - 2 weeks later;

Part II, Assignment **2**: out - TBA ; due - 2 weeks later;

Part II, Exam: out - TBA ; due - TBA.

Resources:

Part I:

Software: Matlab.

Textbook: none.

References: in Library Open Reserve.

i T. Kailath (1980). Linear Systems. Prentice Hall. P003/202.

ii GC Goodwin, SF Graebe, ME Salgado (2000), Control System Design. Prentice Hall. P629.8/203.

iii K Zhou (1998). Essentials of Robust Control. Prentice Hall. P629.8/205.

Part II:

Software: Matlab.

Textbooks:

i R.C. Dorf and R.H.Bishop. Modern Control Systems. Addison Wesley, 8th edition, 1998.

ii G.C. Goodwin, S.F. Graebe and M.E. Salgado. Control Systems Design. Prentice Hall, 2001.

iii J.B. Burl. Linear Optimal Control. Addison Wesley, 1999, pp. 329-364.

Recommended Reading:

i K. Zhou. Essentials of Robust Control. Prentice Hall, 1998.

ii M.S. Grewal and A.P. Andrews. Kalman Filtering. Prentice Hall, 1993.

iii I.R. Petersen and A.V. Savkin. Robust Kalman Filtering for Signals and Systems with Large Uncertainties. Burkhauser, Boston, 1999.

iv I.R. Petersen, V.A. Ugrinovskii and A.V. Savkin. Robust Control Design Using H-infinity Methods. Springer-Verlag, 2000.

Teaching Strategies:

Lectures – to give the basic material in written form, and to highlight the importance of different sections, and help with the formation of schema.

Assignments – to give practice in problem solving, and to assess your progress.

Examination – the final test of competency.

Learning Outcomes:

At the end of the course the student will be familiar with basic aspects of multivariable linear system theory and robust control, from both an input/output and a state space point of view. The student will be able to use this knowledge to solve basic problem in multivariable linear system theory, optimal and robust control design, optimal and robust filtering.

Academic Honesty and Plagiarism:

Plagiarism is the unacknowledged use of other peoples work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a serious offence by the University and severe penalties may apply. For more information about plagiarism, refer to http://www.lc.unsw.edu.au/plagiarism .

Administrative Matters: On issues and procedures regarding such matters as special needs, equity and diversity, occupational heath and safety, enrolment, rights, and general expectations of students, please refer to the School policies, see http://scoff.ee.unsw.edu.au/ .

Matrix Review Handout: Including: eigenvector decomposition; singular value decomposition; matrix inversion lemma; projection lemma; generalised inverses.

Topic 1a: Review SISO State Space. Including: transformation between transfer function and state space ; modal transformation; controllability ; observability.

Topic 1b: state space decomposition theorem; polynomial division; Sylvester resultant and coprimeness.

Topic 2a: Feedback. Linear state feedback; Bass-Gura formula; modal approach; classical one degree of freedom control review; sensitivity function; internal model principle.

Topic 2b: Linear state feedback with observer; transfer function view; Bezout equation.

Topic 2c: limits to control; right half plane zeroes.

Topic 3a: tracking and disturbance rejection; state space approach and transfer function equivalent; Bezout equations; internal model principle.

Topic 3b: MIMO systems; introduction; state space modal form; Gilbert's form; transfer function; matrix fraction description; state space; controllability, observability.

Topic 4a: Polynomial Matrices; unimodular matrices; Smith form; Smith-McMillan form; Kalman minimal state space representation; McMillan degree.

Topic 4b: MIMO poles and zeroes. State space view; matrix fraction description view; transfer function view (Smith McMillan form); equivalences.

Topic 5a: MIMO decomposition theorem; transform to controllability form, crate diagram; controllability indices.

Topic 5b: Hankel methods. Silverman-Ho-Kung-Aoki method for minimal realization from Markov parameters.

Topic 6a: Balanced realization.

Topic 6b: MIMO Linear state feedback with observer and MFD equivalent.

Topic 7: The concept of robust control; uncertain systems; Kharitonov theorem; edge theorem.

Topic 8: Classical approach to robust control design; case studies.

Topic 9: robust PID controllers; case studies.

Topic 10: optimal control; dynamic programming; linear quadratic optimal control problem; Riccati equations; case studies.

Topic 11: model predictive control; Kalman filtering; case studies.

Topic 12: H-infinity control; differential games; H-infinity filtering; Kalman filtering versus H-infinity filtering; case studies.