ON FEEDBACK CONTROL DESIGN OF SINGULARLY PERTURBED SYSTEMS
WITH APPLICATIONS TO SYNCHRONOUS MACHINES

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DEDICATED TO

THE MEMORY OF MY FATHER

WHO TAUGHT THE VALUE OF

HARD AND HONEST WORK

C E R T I F I C A T E

This is to certify that the thesis entitled, "ON FEEDBACK CONTROL DESIGN OF SINGULARLY PERTURBED SYSTEMS WITH APPLICATIONS TO SYNCHRONOUS MACHINES" being submitted by Nagendra Prasad Singh for the award of the degree of DOCTOR OF PHILOSOPHY to the Indian Institute of Technology, Delhi is a record of bonafide research work he has carried out under our supervision. The results contained in this thesis have not been submitted to any other University or Institute for award of a degree or diploma.

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A B S T R A C T

The primary objective of this thesis is to develop new methods for the design of different types of controllers for linear time-invariant singularly perturbed systems. Composite and/or reduced-order feedback control systems are designed employing the slow and fast subsystem models obtained through iterative time-scale separation. New algorithms for state-feedback, output-feedback, dynamic compensators, observers and observer-based controllers are developed. To illustrate the proposed techniques, we focus on a single-machine-infinite-bus system. Multi-time-scale models of a synchronous machine connected to an infinite-bus through a transmission line are developed. The effectiveness of the algorithms presented in the thesis is examined through digital simulation studies.

New design techniques for composite state-feedback controllers and near-optimum control with a prescribed degree of stability are developed. A new approach to the design of near-optimal composite observers using parameter optimization methods is proposed. Two-time-scale optimal output feedback control and the design of robust dynamic compensators is presented. The performance of these controllers is tested on the linearized and nonlinear seventh-order synchronous machine models for small disturbance and under three-phase fault conditions, respectively. The simulation results of

the proposed composite controller are compared with those of the controller designed using quasi-steady-state (qss) technique. The effectiveness of the composite observer is examined through linear simulation on the same seventh-order model.

The design of near-optimal observer-based controllers for multi-time-scale systems via iterative time-scale decomposition is presented. The performance of the proposed control scheme is evaluated through digital simulation on the linearized twelfth-order model of a single-machine-infinite-bus power system. The simulation results are compared with those obtained via qss approach.

For the sake of completeness, relevant background material, reviews and suggestions for further research in this area are included. The investigations carried out have significant potential in the analysis and control of other classes of singularly perturbed systems.

LIST OF PUBLICATIONS BASED ON THE THESIS WORK

1. N.P.Singh, Y.P.Singh and S.I.Ahson, "An iterative approach to reduced-order modeling of synchronous machines using singular perturbation", Proc. IEEE, Vol. 74, pp.892-893, June, 1986.

2. ______, "Near-optimal controllers for synchronous machines with prescribed degree of stability via iterative separation of time-scales", Proc. IEEE, Vol. 74, pp.1466-1468, Oct., 1986.

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6. ______, "Design of composite controllers via iterative time-scale separation", Proc. National Systems Conference, New Delhi (India), pp. 49-53, December, 1986 (Best Paper Award).

7. N.P. Singh, "Optimal observers with several time-scales for synchronous machines", Proc. National Systems Conference, Kurukshetra (India), December, 1987.

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C O N T E N T S