Abstract

Stability is an essential requirement for any control system to perform successfully. But, no physical system can be modelled exactly and so, robust stability has to be considered. The robust stability of linear time-invariant systems (usually with real parameters) to various types of perturbations has been studied in this thesis in a self-contained manner using a matrix approach.

All the four classes of problems that have been tackled in this thesis have been developed using the fundamental concept that the eigenvalues of the Kronecker, the Lyapunov and the bialternate product and sum matrices are definite combinations of the eigenvalues of the system matrices involved. These and several other properties as well as definitions of these matrices have been provided at the outset in Chapter 2 which have been used repeatedly throughout the thesis. It is interesting to note that these eigenvalues properties, used judiciously, are capable tools for attacking a wide range of problems due to the transparency of the concepts they yield.

In this thesis, of the four classes of problems that have been considered, the first three deal directly with the issue of the stability robustness of various types of systems.

The first class of problems (Chapters 3 and 4) deal with the robust stability of a subclass of systems affected by one-parameter perturbations. These are the continuous-time singularly perturbed systems (including the high-gain feedback systems) and the discrete-time singularly perturbed systems. Certain critical stability criteria are obtained in terms of the bialternate sum and product matrices and the system matrices respectively. These are used to obtain the exact bound on the single scalar perturbation parameter such that these systems are stable as long as the parameter lies within the bound.

The second class of problems (Chapter 5) consider the robust stability of physical systems to unstructured perturbations. Although the concept of robust stability remains the same as in the earlier case, the approach differs in this case since it is quantified in terms

of the stability radius which involves the singular values of matrices. Several properties of the stability radii for both real and complex perturbations for the cases of continuous-time and discrete-time systems have been reviewed and derived.

The third class of problems (Chapter 6) involve the interval matrices. The bounds used for the stability radius have been utilized to obtain a necessary and sufficient condition for the stability of these interval matrices. An iterative algorithm has also been provided which makes it possible to check the stability of these matrices.

The fourth problem (Chapter 7) again deals with singularly perturbed systems but the focus is on the separability of the slow and fast eigenclusters of these systems. This property is a prerequisite for the validity of the reduced order model. A necessary and sufficient condition for the separability of these eigenclusters has been proved mathematically. This is then used to devise a method to obtain the exact separation bound of the singular perturbation parameter.