# Chapter 1

# General Introduction

During the last decade, the problem of stability, robust stability and stabilizability for uncertain dynamical systems (with or without time-delay, with or without control, with or without impulsive effects and switchings) has been investigated in many researcher [1]-[64]. Uncertainties, time delay, control, impulsive effects and switchings are often encountered in many industrial systems such that chemical processes, biological systems, population dynamics, network control systems, neural networks, neutral networks and large-scale systems, increasing attention problem has been devoted to robust stability criteria for dynamical systems with these characteristics. It is very well known that time delay and uncertainties naturally exist in many dynamical systems and are frequently a source of instability or poor performances in systems. Therefore, the problem of robust stability for dynamical systems with delayed perturbations has been attracted a lot of attention and references therein [4, 6, 9-10, 13-14, 18, 19, 23-30, 32, 34-46, 55, 58-62]. Stability criteria for dynamical systems with time delays is generally divided into two classes: delay-independent ones and delay-dependent ones. Delay-independent stability criteria tends to be more conservative, especially for small size delay, such criteria do not give any information on the size of the delay [5, 13,25, 28, 32, 39, 44-45, 55, 57, 59]. On the Other hand, Delay-dependent stability criteria is concerned with the size of the delay and usually provide a maximal delay size [4, 10, 13-14, 19-20, 34-35, 40-41, 46, 58-59]. Nonlinear perturbations [13, 17, 38, 48], convex polytopic [10, 11, 15, 31, 52, 63] and norm-bounded [4, 8, 13, 20-21, 25, 42-43, 45-46, 53-56, 59] are considered under uncertainties. A common techniques for stability analysis is to use Lyapunov functions and stability criteria in terms of linear matrix inequalities (LMIs) or Riccati differential equations. Many researcher works have beed focused on the problem of linear systems such as LPD

system, uncertain linear system, uncertain linear system with nonlinear perturbation, uncertain linear impulsive switched systems (with delay-independent or delay-dependent) for stability criteria.

## Goal

In this thesis, we shall investigate the problem of the robust stability for linear parameter dependent (LPD) system, uncertain LPD system, uncertain linear system with nonlinear perturbation (with delay-independent or delay-dependent). We consider in the case of continuous and discrete time delay systems. We use appropriate Lyapunov functions and derive stability conditions in terms of linear matrix inequalities (LMIs). However, based on combination of the Riccati equation approach and the use of suitable Lyapunov functional, sufficient conditions for robust stability of linear non-autonomous delay systems with time-varying and norm-bounded uncertainties have been established. The conditions are formulated in terms of the solution of curtain Riccati differential equations, which allow to compute the decay rate as well as the constant stability factor. Moreover, we shall study the problem of robust stability for uncertain impulsive switched system and uncertain impulsive switched LPD system with time-varying delays and nonlinear perturbations which are called the discontinuous time delay systems. By using the Lyapunov function method and linear matrix inequality (LMI) technique, sufficient conditions have been obtained. Numerical examples will be presented to illustrate the effectiveness of the theoretical results.



## Structure

This thesis is organized in 6 chapters that are structured as follows.

## Chapter 1

The first chapter investigates about general introduction and reason for the problem of robust stability of uncertain linear systems with delays and we present the goal and structure of the thesis.

## Chapter 2

In chapter 2, we present about important notations and mathematical definition of linear parameter dependent (LPD) system, uncertain LPD system, uncertain linear system with nonlinear perturbation, uncertain linear non-autonomous system, uncertain impulsive switched system and uncertain impulsive switched LPD system and nonlinear perturbations (with delay-dependent or delay-independent). We give some general concepts of stability, important definitions and lemmas because it will be recalled.

## Chapter 3

This chapter investigates the problem of robust stability for continuous-time delay systems such as LPD system with time-delay, uncertain LPD system with time-varying delays, uncertain linear system with time-varying delays and nonlinear perturbations. We use appropriate Lyapunov functions and derive stability conditions in terms of linear matrix inequalities (LMIs). Based on combination of the Riccati equation approach and the use of suitable Lyapunov functional, sufficient conditions for the exponential stability of linear non-autonomous systems with time-varying delays and norm-bounded uncertainties have been established. The conditions are formulated in terms of the solution of curtain Riccati differential equations. Numerical examples are presented to illustrate the effectiveness of the theoretical results.



## Chapter 4

The goal of the fourth chapter presents the problem of robust stability for discrete-time delay systems such as LPD system with time-delay, uncertain LPD system with time-varying delays, uncertain linear system with time-varying delays and nonlinear perturbations. By using the Lyapunov function method and linear matrix inequality (LMI) technique, sufficient conditions have been established. For illustration, examples are solves by using the sufficient conditions obtain.

## Chapter 5

In chapter 5, we investigate the problem of robust stability for discontinuous time delay systems with nonlinear perturbation such as uncertain impulsive switched systems with time-varying delays and uncertain impulsive switched LPD system with time-varying delays. We use appropriate Lyapunov functions and derive stability conditions in terms of linear matrix inequalities (LMIs). Numerical examples are presented to illustrate the effectiveness of the theoretical results.

## Chapter 6

The last chapter provides a summary of the results.

## Personal publications

The research exposed in this thesis can be found in the following publications.

[1] K. Mukdasai and P. Niamsup, Stability and stabilizability of linear parameter dependent system with time delay, *Proceeding IMECS*, **2**(2008), 1353-1358.

[2] P. Niamsup, K. Mukdasai and V. N. Phat, Improved exponential stability for time-varying systems with nonlinear delayed perturbations, *Appl. Math. Comput.*, **204**(2008), 490-495.

[3] P. Niamsup, K. Mukdasai and V. N. Phat, Linear uncertain non-autonomous time-delay systems: stability and stabilizability via riccati equations, *Electron. J. Differential Equations*, **26**(2008), 1-10.