Abrar Ahmed
Ph.D. scholar
Department of Electrical Engineering
PIEAS

Abstract

This thesis develops and demonstrates the research complemented by theory and applications carried out in ensuring stability of actuator constrained linear control systems. The work focuses the *posteriori* approach in the design of controller dealing with saturation effect. Anti-windup compensator is therefore explicitly synthesized for ensuring stability of constrained state delay systems and constrained cascade control systems. Having gone through a detailed study of contemporary research literature, it has been devised that constrained state delay systems and constrained cascade control systems are the areas need to be addressed significantly using anti-windup compensator technique.

Therefore the first prong of research focused stability of constrained state delay systems using Lyapunov-Krasovskii functionals. Anti-windup compensation is incorporated in Linear Matrix Inequality (LMI) based formulations in varied conditions of state delay systems. First, the research taps the stability of constrained multiple state delays system. This work broadly envisages mixed delay-dependent / delay-independent multiple state delays, delay-independent multiple state delays, delay-dependent multiple state delays, delay-independent single state delay and delay-dependent single state delay linear control systems. Second, the research devises a novel approach of dealing with saturation

problem using two-controller anti-windup design for enlarging domain of stability of constrained state delay systems. This approach is yet not found in the literature surveyed. Third, the research addresses an improved asymptotic and exponential stability of constrained state delay systems by removing the inherent system steady state delay with higher delay bounds. Lastly, the research concerns stability issue in constrained uncertain state delay systems.

In the second prong of research a modified full order and static low order anti-windup compensators are successfully designed for decoupled architecture based actuator constrained cascade control systems. Besides, the same compensator is designed for rate limiter incorporated actuator constrained control systems. The design parameters are based on LMIs and solved using optimization techniques. To validate the design, detailed experimental results are also generated while successfully applying on temperature and motor speed control process variables.

It is said that the thesis is a heuristic compendium of inferring the core significance of anti-windup compensators in overcoming the wind-up effect in PID based process control.

Keywords - Anti-Windup Compensator, Time-Delay Systems, Linear Matrix Inequalities, Domain of Stability, Pole-Constraints, Cascade Control, Norm-Bounded Uncertainty, Multi-loop Compensation, Amplitude-Rate Limiter, Motor Speed Control, Cascade-loop Compensation, Block Diagonal Quadratic Lyapunov, Lyapunov-Krasovskii Functional and System Identification.