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A Disturbance Observer-Based Robust Controller Design for Systems with Right Half Plane Zeros and Poles

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***Abstract*- This paper analytically derives the bandwidth limitations of Disturbance Observer (DOB) when plants have Right Half Plane (RHP) zero(s) and pole(s). If the plant is non-minimum phase, then the bandwidth of DOB should be set at a lower value than its upper bound to improve the robust stability and performance. If the plant is unstable, then the bandwidth of DOB should be set at a higher value than its lower bound to achieve the robust stability. The upper and lower bounds are analytically derived by using Poisson integral formula. It is shown that the bandwidth limitation of DOB is directly related to the locations of the RHP zero(s) and pole(s) and becomes more severe as they get close each other. A minimum phase approximation of the non-minimum phase nominal plant model is proposed by using Genetic Algorithm (GA) to tackle the internal stability problem of the DOB-based robust control systems. Simulation results are given to verify the proposed robust controllers.**

***Index Terms:* Disturbance Observer; Non-minimum Phase Systems; Robust Control; Robustness and Performance Trade-off; Unstable Systems.**

I. INTRODUCTION

It is a well-known fact that plants with RHP zero(s) and pole(s), i.e., non-minimum phase and unstable plants, have several constraints, such as bandwidth limitation and achievable sensitivity reduction, in the design of feedback control systems [1, 2]. As it is pointed out by G. Stein in 1989 Bode lecture, control of such systems is quantifiably harder than minimum phase stable systems, and special consideration is required due to their fundamental characteristics such as local stability [3, 4]. The control problem of non-minimum phase and/or unstable plants becomes more severe when they suffer from plant uncertainties. Goodwin et al. showed that the average performance of such systems in the presence of model uncertainties can significantly depart from the best achievable nominal performance, i.e., the performance without model uncertainties [5]. Therefore, the robust control problem of plants with RHP zero(s) and pole(s) is a very challenging problem in the literature.