On the Structure of the Transfer Function which can be Structurally Stabilized by the PID, PI, PD and P Controller

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Abstract

We consider a negative unity feedback control system in which the PID, PI, PD or P controller and a transfer function having only poles are in cascade. We define the notion of the structural polynomial which means that there exists a subdomain of the coefficient space in which the polynomial is Hurwitz (left half plane stable) polynomial. We obtain the necessary and sufficient condition of the structure of the transfer function of which the characteristic polynomial is a structural polynomial. In addition, this paper present another necessary and sufficient condition for the existence of a constant gain controller with which the characteristic polynomial is structurally stable. For the structurally stabilizable P controller, it is allowed that the transfer function may not be all pole plants.

1. Introduction

In 1990's many papers are comcerned with stabilization of the control systems with the PID contollers[1,2,3]. Consider a unity feedback closed-loop control system such that a PID controller and a given plant having a transfer function with only poles are in cascade. The main question is: Does there exist a PID controller for which the characteristic polynomial of the closed loop system is stable? We can obtain the existence of PID controller by the classical approach such as the root locus method[4], the Nyquist stability criterion or the Routh-Hurwitz criterion. By using the root locus method or the Nyquist stability criterion, we can determine the existence of a PID controller graphically. By the Routh-Hurwitz criterion, we can determine the existence of a PID controller analytically. By the generalized Hermite-Biehler theorem[5], Ho, Datta &Bhattacharyya[6,7] obtain the conditions under which the overall system is stable. In this paper, we present the necessary and sufficient conditions for the existence of a PID controller analytically under which the overall system is structurally stable. The main results are based on Lehnigk's lemmas[8]. We present the lemmas in section 2 and then the main result in section 3.

2. Notations

Let three polynomials be $f_0(s)$, $f_1(s)$ and $f(s)=f_0(s)+f_1(s)$, which we write as

$$f_0(s)=\sum_{\nu=0}^{n} b_\nu s^\nu \qquad (b_\nu>0)$$

$$f_1(s)=\sum_{\nu=0}^{n_1} c_\nu s^\nu \qquad (c_{n_1}\neq 0,\ n_1<n)$$