Synthesis of Robust PID Controller by the Maximum Stability Degree Criterion

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Abstract—**The new approach for determining and imposing the maximum stability degree of the system in function of the control object parameters and the number of tuning parameters of PID controller is proposed in this work. The elaborated method of synthesizing the typical controllers represents a simple analytical procedure, that requires the reduced volume of calculation and not impose the restrictions on the complexity of control object. The control systems synthesized by this criterion can be characterized by the high speed, a low overshot and good robustness.**

Keywords–control object; PID controller; automatic control sys-tem; maximum stability degree, geometric mean root, robustness

I. INTRODUCTION

One of the most important problem in the automatic control, from the theoretical and the practical point, is the problem of synthesis the controllers. The synthesis of controllers involves the designing or the choosing a control algorithm (the structure of controller) and determination its optimal parameters, such as to be achieved and maintained the objective of controlling and satisfied the imposed performances to the automatic control system as: stability, dynamic and static properties, sensitivity, disturbance rejec-tion, robustness at the parameter object variation etc. [1, 2].

The practice of the automation of the technological processes demonstrates that about 90-95% of the controllers actually used in the industrial installations use the controllers that functioned on the basis of the PID algorithm, and its variations. This is explained by the fact that in the limits of the automatic control structure, the PID control algorithm is optimal, if we refer to the specific functions of the controller. The failure function of the automatic control system can be appeared not from reason of non-satisfactory action of PID algorithm (with condition that it is tuned optimal), but from the reason of uncertainty information about the control object and the degree of approximation of the mathematical model of process [3, 4].

It should be noted that the use of PID control algorithm does not guarantee priori the optimal control of the system and either its stability. And if the controller is tuned incorrectly, then the performance of the automatic control system decrease, which leads, for example to reduction in the quality of the output final production, low energy efficiency and as a result increases in operating costs and harmful emissions into the environment [4]. The providing of the high performances depends on the choosing the corresponding values of the controller tuning parameters. The determination of tuning parameters, in dependency of the desired performances, represents the complex and difficult procedure, for which there is no single approach and that continues to be one of the most actually problem in the automatic control [1, 2, 4].

One of the criteria used to design the automatic control systems is the maximum stability degree criterion. This criterion assumes the maximum displacement in front of the imaginary axe of the localization domain in the complex plan of the nearest roots. This fact involves the reducing of the duration of the transient response and ensures the high stability degree of the system, which leads to the satisfactory performances of the control system even in the most unfavorable variations of the object parameters from their nominal values [5, 6].

In this work is proposed the new approach for determining and imposing the maximum stability degree of the system in function of the control object parameters and number of tuning parameters of the controller.

II. DESIGN OF PID CONTROLLER FOR THE CONTROL SYSTEM WITH MAXIMUM STABILITY DEGREE

A. Formulation and solving of the problem to synthesis the control system with maximum stability degree

The problem of synthesis the control system with maximum stability degree can be formulated as follows. Is considered that is given the control system (Fig.1) that includes the control object with known parameters

$$H_F(s) = \frac{k\exp(-\tau s)}{a_0 s^r + a_1 s^{r-1} + \dots + a_{r-1}s + a_r}, \tag{1}$$

and selected controller

$$H_R(s) = \sum_{j=1}^{m} b_j s^{(j-1)}, \tag{2}$$