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PI AND PD CONTROLLER DESIGN FOR FUZZY GAIN AND PHASE MARGIN SPECIFICATIONS

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Abstract. *The paper addresses the problem of PI and PD controller design for linear systems with fuzzy parametric uncertainty. The plant model is considered as a possibility distribution on a plant space and closed loop specifications are given as a fuzzy set of interval gain or phase margins. A set of PI and PD controllers is found that meets the desired specification for each plant of fuzzy set of models. The solution is graphical in nature and uses frequency domain properties of interval control systems.*
Keywords: Fuzzy parametric uncertainty, Gain and phase margin, Robust control, Uncertain systems

1. **Introduction.** Classical robust control approach offers several tools how to deal with uncertain systems with both structured and parametric uncertainty. The former case is usually treated within H_2 and H_∞ optimal control framework [1, 2], whereas the latter deals with interval systems with different kind of dependency of transfer function coefficients on system parameters [3, 4].

Typical task of robust control is to design a controller such that closed loop meets some requirements for any system within a prespecified set. There are various approaches solving the task. Considering linear systems the small gain theorem is applied in [5], in [6] an algebraic approach is used. Applications of robust control of nonlinear systems are described in [7] or in [8] where methods of evolutionary computation are disposed.

Disadvantage of classical approach is that uncertainty of the plant is considered the same regardless of operating conditions. Therefore, the *worst-case* uncertainty occurring very rarely only in unusual conditions has to be taken into account with the same importance as *most-cases* uncertainty caused by the influence of common factors. However, in practical applications the closed loop specifications (e.g., maximum step response overshoot, maximum settling time) are typically stronger for the system that operates in typical conditions than those for the system with its parameters lying far from the normal operating point. Consequently, the controller designed in such a way that it satisfies the worst-case specifications may not lead to satisfactory performance for the most-cases model. Therefore, a degradation of closed loop specifications towards *worst-case* uncertainty would be beneficial.

Fuzzy logic offers an elegant tool how to make it possible to consider such specification degradation. The concept was introduced by Bondia et al. [9] and is based on description of uncertainty by fuzzy sets and its parameterization by α-cuts [10]. They suggest to think of fuzzy sets as possibility distributions [11] and in such a way to describe both