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STABILITY ANALYSIS OF THE SIMPLEST TAKAGI-SUGENO FUZZY CONTROL SYSTEM USING POPOV CRITERION

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Abstract. *In this paper, the mathematical properties of the simplest Takagi-Sugeno (T-S) fuzzy controller are first investigated in detail. Next, based on the well-known Popov criterion with graphical interpretation, a sufficient condition in the frequency domain is proposed to guarantee the globally asymptotical stability of the simplest T-S fuzzy system. A performance comparison is also made between the simplest T-S fuzzy and conventional linear controllers. It is concluded that the simplest T-S fuzzy controller outperforms its linear counterparts, when both the disturbance and sensor noise are considered.*
Keywords: T-S fuzzy controller, Popov criterion, Stability analysis, Frequency response methods, Frequency domain

1. **Introduction.** The T-S fuzzy model [1] is a landmark in the history of fuzzycontrol theory. Numerous fuzzy control issues, such as stability analysis, systematic design, robust stability, and optimality, can be addressed under the framework of this T-S fuzzy model [2]. Especially, given a T-S fuzzy model, a fuzzy controller design method, namely Parallel Distributed Compensation (PDC), has been proposed by Sugeno and Kang [3]. The corresponding stability analysis is also made in one of their papers [4]. The unique advantage of the PDC technique is that a lot of conventional linear controller design solutions based on both classical and modern control theory, which are actually for linear control systems, can be employed in designing the nonlinear T-S fuzzy controllers as well.

As we know, frequency response methods have been well-developed and widely used in industrial applications, which are straightforward and easy to follow by practicing engineers. For example, two popular frequency response methods, Bode and Nyquist plots, provide a graphic insight into the control systems under study, and can help engineers efficiently synthesize their controllers. Therefore, fusion of the T-S fuzzy model and frequency response methods is indeed important in the field of control engineering. It is apparently necessary to analyze the stability of T-S fuzzy control systems in the frequency domain, if these frequency response methods are utilized in designing T-S fuzzy controllers.