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A LabVIEW Based Fractional-ANFIS PID Controller For Real-Time Microwave Heating System

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Abstract
Utilizing Heating PID control systems is common across numerous industries to attain the desired output. Nevertheless, the development in the status of Fractional Order Proportional Integral Derivative Controllers (FOPID) has led to improved control performance and increased degrees of freedom in industrial applications. The paper proposed real-time microwave heating systems which exhibit several challenging characteristics and are complex enough to effectively demonstrate the robustness advantage of fractional (FOPID) over traditional PID controllers. An Adaptive Neuro-Fuzzy Inference System (ANFIS) was modeled using real-time data to assess the effectiveness of conventional PID and FOPID controllers. The results of the study demonstrated that FOPID controllers outperform conventional PID controllers in terms of performance, robustness, stability, flexibility, and faster response. Additionally, the study utilized MATLAB and LabVIEW software to model the Fractional PID controller, the traditional PID controller, and the ANFIS model. The outcomes illustrate that the FOPID controller demonstrates faster rise times (3.8 seconds vs. 6.0 seconds for PID), lower overshoot (1.0^oC vs. 2.5^oC, and shorter settling times (10 seconds vs. 17 seconds). During setpoint drops, FOPID exhibits reduced undershoot (1.4^0C compared to 3.2^oC) and quicker recovery (5.5 seconds vs. 8.5 seconds). In the final tracking phase, FOPID maintains a lower residual error (0.2^0C vs. 0.7^oC) and achieves a steady-state error of 0.1^oC, compared to 0.5^oC for PID.

Keywords
ANFIS, FOPID, PID, LabVIEW, MATLAB.

I. Introduction

In manufacturing, control system settings are essential because they regulate temperature, pressure, flow, and other quantities. The Proportional Integral Derivative (PID) controller is a reliable, easy-to-use process. The PID constants are the three primary parameters that cause errors to equal zero. Another type of controller that has two more adjustable parameters than the typical PID control structure is the Fractional-order PID (FOPID) controller. The conventional PID controllers proportional (K_p), integral (K_i), and derivative (K_d) parameters, along with the integrator order (λ and differentiator gain (μ) constants, comprise the FOPID controller. The values of the parameters λ and μ are not limited to whole numbers; they can also be fractions. This gives the controller design more flexibility and increases the number that needs to be adjusted. Thus, it is possible to directly and continuously modify the system's response. Fractional-order calculus was suggested as a convincing definition by Riemann-Liouville in 1999 [1]. Since then, advanced control engineering applications have been developed, like liquid level control [2], nuclear reactor power [3], and Autonomous Underwater Vehicle (AUV) [4]. One proposed design of a controller is the FOPID controller, which presents a novel time-varying FOPID controller to relieve the spike of voltage at the output of the controller when a sudden change at the set point [5].