# Tuning the Spectrum of Time-Delay Systems Using Modern Optimization Methods

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*Abstract:*

Delay is a generic component of many processes and systems, not just industrial ones. If it acts in feedback loops within the controlled system or if it is not sufficiently compensated, the feedback control system has an infinite spectrum. This phenomenon apparently worsens regulatory quality, especially in terms of stability, robustness, and response oscillation. If the control law (regulator) contains one or more adjustable parameters, these can be used to appropriately shape the spectrum of the feedback system, e.g., for various prescribed positions of a finite number of feedback poles. At the same time, it is a natural effort to shift the entire remaining spectrum as far to the left as possible in the complex plane, i.e., into the "stable" region. This task is difficult and complex, especially for so-called neutral systems with delay, where the entire spectrum of poles generally exhibits discontinuous behavior with respect to the values of the controller tuning parameters. At the same time, the stability of such systems is sensitive to the slightest changes in the delay values.

The work aims to develop and implement modern optimization algorithms for solving non-smooth, non-convex, and non-Lipschitz optimization problems, specifically for tuning an infinite spectrum of systems with delays for appropriately chosen advanced control laws (preferably not of the PID type). Such an optimization problem can be formulated in many ways (e.g., minimizing the abscissa of the residual spectrum, maximizing attenuation, determining the center of gravity of the stabilizing parameter area, etc.). The work should also focus on assessing or ensuring the robustness of the control system. The proposed procedures should be verified both by simulation (e.g., in the Matlab-Simulink environment) and in laboratory conditions.

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