Data-driven Controller Design for a Fast-Pulsed Power Converter Control Application

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Abstract

$$f(x) = \frac{x}{x^2 + 2 * x + 3} \tag{1}$$

The complex structures of today's systems create challenging tasks for the control engineer in designing a viable controller. In order to simplify the controller design process, these systems are approximated with low-order models; this reduces both time and effort in synthesizing a controller. However, this approximation can create stability and performance problems since these low-order models are subject to model uncertainty. Data-driven control methods seek to alleviate this problem by synthesizing controllers based on time-domain or frequency-domain data (i.e., synthesis is model independant). A survey on the differences associated with model-based control and data-driven control has been addressed in [1] and [2]; the authors assert that model-based control methods are inherently less robust due to the unmodeled dynamics of a process, and that these controllers are unsafe for practical applications. In other words, the parametric uncertainties and the unmodeled dynamics associated with the data-driven scheme are irrelevant, and the only source of uncertainty is the measurement noise.

Data-driven control methods using frequency-domain data are design schemes that continue to spark the interest of many researchers. The frequency-domain approach offers many advantages compared to time-domain methods
:

- Without knowledge of the transfer function, the dynamics of a system can be captured experimentally through the frequency response.

- Relative and absolute stability of a closed-loop system can be determined with the knowledge of the open-loop frequency response.

- Noise disturbance generated in the system can be easily determined using frequency analysis.

- System uncertainties can be modeled at discrete frequency points (which reduces the conservatism associated with uncertainty modeling).

For this specific application, an *RST* controller structure was implemented to control the dynamics of the power converter control system. The *RST* controller structure is an effective discrete-time two-degree of freedom (2DOF) polynomial controller where the tracking and regulation characteristics of a closed-loop system can be formulated independently [3]. To design this controller, a $\mathcal{H}_\infty$ loop-shaping method was used to shape a desired sensitivity function. Robust controller design methods belonging to the $\mathcal{H}_\infty$ control framework minimizes the $\mathcal{H}_\infty$ norm of a weighted closed-loop sensitivity function [4]. In this method, a convex optimization problem can be formulated if each of the *RST* polynomials are linearly parameterized [5].

For this power converter application, it was desired to track a desired reference signal while maintaining sufficient stability margins. Therefore,

References

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