Extended Abstracts
ISBN 978-952-5183-56-6

Veli-Pekka Pyrhonen

Robust and perfect tracking control of a DC servo motor

Extended abstract: Robust and perfect tracking (RPT) approach enable engineers to design low-order model-based controllers, which result in closed-loop systems that are able to yield fast tracking of target references with small overshoot. In fact, an RPT controller's performance can be adjusted using a single positive scalar tuning parameter, say ϵ, which guarantees internal stability of the closed-loop system and yields arbitrary fast settling time in the faces of external disturbances and initial conditions as long as control signal is free from physical constraints [1–2]. In reality, physical constraints must be considered, and hence, arbitrary fast tracking can never be achieved.

This paper presents the design of a closed-form parameterized two-degree-of-freedom (2DOF) integrating controller using RPT approach for a DC servo motor application. The DC servo motor application is a Quanser QUBE-Servo 2 unit with a metal disc attachment. The motor unit and disc attachment are depicted in Figure 1.

Figure 1. Quanser QUBE-Servo 2 unit with disc load.

The purpose of the closed-loop control system is to position the disc load from the initial position to final position as fast as possible without overshoot and without violating the actuator saturation constraints. For performance comparison, a 2DOF Proportional-Integral-Derivative (PID) controller with set-point weighting is designed using pole placement method. Both controllers are designed such that they initially use the maximum allowable control effort and yield strictly monotone step response with short settling time.

The simulation and experimental results show that the closed-loop system using the RPT controller yields better positioning performance as measured by the settling time. In addition, the closed-loop system with the RPT controller has larger stability margins and lower sensitivity compared with the system using the PID controller. The closed-loop performance measures are collected in Table 1.

TABLE I. CLOSED-LOOP PERFORMANCE MEASURES.

Indicator	PID	RPT
T_s (ms)	81.1	70.1
T_r (ms)	48.3	42.3
GM	∞	∞
PM (deg)	51.7	60.7
s_m	0.74	0.83
S_{max}	1.36	1.20

In Table 1, T_s is the settling time as measured by the 2% criterion, T_r is the rise time as measured from the time taken by a step response to change from 10% to 90%, GM is the gain margin, PM is the phase margin, s_m is the stability margin, and S_{max} is the maximum sensitivity.

In conclusion, RPT approach offers an attractive design framework for point and shoot tracking problems like the positioning of the disc load in this paper. It is also relatively simple to experimentally tune the RPT controller using the tuning parameter ϵ such that desired tracking performance is obtained and that the actuator saturation constraint is not violated.

[1] Liu K., Chen B.M., Lin Z., On the problem of robust and perfect tracking for linear systems with external disturbances, Int. J. Contr., 2001, 74, 158–174

[2] Cheng G., Peng K., Chen B.M., Lee T.H., A microdrive track following controller design using robust and perfect tracking control with nonlinear compensation, Mechatronics, 2005, 15, 933–948

Keywords: robust and perfect tracking, servo control, control applications, linear systems, saturation

***Veli-Pekka Pyrhonen:** Tampere University, Tampere, Finland, e-mail: veli-pekka.pyrhonen@tuni.fi