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Discrete PID and Discrete State Feedback Control of a Brushed DC Motor

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Abstract : Today, digital servo systems are extensively used in industrial manufacturing processes, robotic applications, vehicles and other areas. In such control systems, control action is provided by digital controllers with different compensation algorithms, which are designed to meet specific requirements for a given application. Due to the constant search for optimization in industrial processes, it is of interest to design digital controllers that offer ease of realization, improved computational efficiency, affordable return rates, and ease of tuning that ultimately improve the performance of the controlled actuators. There is a vast range of options of compensation algorithms that could be used, although in the industry, most controllers used are based on a PID structure. This research article compares different types of digital compensators implemented in a servo system for DC motor position control. PID compensation is evaluated on its two most common architectures: PID position form (1 DOF), and PID speed form (2 DOF). State feedback algorithms are also evaluated, testing two modern control theory techniques: discrete state observer for non-measurable variables tracking, and a linear quadratic method which allows a compromise between the theoretical optimal control and the realization that most closely matches it. The compared control systems' performance is evaluated through simulations in the Simulink platform, in which it is attempted to model accurately each of the system's hardware components. The criteria by which the control systems are compared are reference tracking and disturbance rejection. In this investigation, it is considered that the accurate tracking of the reference signal for a position control system is particularly important because of the frequency and the suddenness in which the control signal could change in position control applications, while disturbance rejection is considered essential because the torque applied to the motor shaft due to sudden load changes can be modeled as a disturbance that must be rejected, ensuring reference tracking. Results show that 2 DOF PID controllers exhibit high performance in terms of the benchmarks mentioned, as long as they are properly tuned. As for controllers based on state feedback, due to the nature and the advantage which state space provides for modelling MIMO, it is expected that such controllers evince ease of tuning for disturbance rejection, assuming that the designer of such controllers is experienced. An in-depth multi-dimensional analysis of preliminary research results indicate that state feedback control method is more satisfactory, but PID control method exhibits easier implementation in most control applications.

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