A Graphical Approach for Designing a Unified PID Controller with a Smith Predictor

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Classical and modern control systems separate design techniques into two camps, one designated for continuous-time systems, while the other handles systems that exhibits discrete response behavior. A unified approach offers, as the name suggests, a unified procedural treatment, in terms of analysis and design, for any system whether they manifest continuous-time or discrete- time properties.

The unified approach offers numerical properties far superior to that of the shift-operator while at the same time offering the insight of that of the shift-domain. Additionally, the delta-domain offer the same relative simplicity of the mathematical properties of the Laplace-domain as the complicated convolution process in the time domain transforms to a simple algebraic manipulation process the does not require complicated mathematical procedures. The Laplace- domain representation, in continuous-time case, can be obtained from the delta-domain representation by simply taking the limit of the sampling period as it approaches zero and replacing the γ variable with s, the Laplace variable, to attain the continuous-time representation of the system.

The graphical technique procedure involves using the frequency response of a system that includes the plant, sensors and actuators combined, to design a controller. We utilize the Proportional-Integral-Derivative Controller, or simply PID controller, due to its relative simplicity and wide prevalence in industry. The control law concerning PID controllers involves mainly designing and tuning three coefficients to achieve desirable stability and performance at the systems' output. Those coefficients are K_p, K_i and K_d which are the proportional, integral and derivative gains of the PID controller, respectively. The graphical technique procedure is done by assigning a constant value to one of those coefficients and solving for the remaining two as a function of frequency ω, in radians per unit of time, and sampling for discrete time systems. The presence of delay in systems to be controlled can have a very high cost on the stability and/or performance of any controller to be implemented especially in the presence of large delays.

Smith predictors offer a solution for systems with relatively large delay. This is done by implementing a close approximation, because an exact model is almost impossible to obtain, of the system to be controlled along with an approximation of the delay model present in the systems to be controlled. If the delay model matched exactly the real delay of the system to be controlled, then effectively we have eliminated the delay in point of view of the controller.