The Math Behind the Curtain - BBB (Borrow)
Advanced PID Control by Karl Åström and Tore Hägglund
Reviewed by Nick Sands

One of the automation professional's most powerful tools is the venerable PID controller. In *Advanced PID Control*, Karl Åström and Tore Hägglund present analysis and improvements techniques to maximize the PID controller. Dr. Karl J. Åstrom received his Ph.D. in Automatic Control from the Royal Institute of Technology in Sweden. Since 1955, he has taught at KTH, worked at IBM Research Labs, and held various posts, including Dean of the Department of Engineering and Physics, at Lund Institute of Technology. Åström has received many awards including ASME's Oldenburger medal in 1985, IFAC's Quazza medal in 1987, and IEEE's Medal of Honor in 1993. Dr. Tore Hägglund received his Ph.D in Automatic Control from Lund Institute of Technology in 1984. He has been a professor at Lund, and worked for Alfa Laval Automation. Åström and Hägglund have published several books, including the two previous books of their controller trilogy, *Automatic Tuning of PID Controllers,* and *PID Controllers: Theory, Design, and Tuning*. The capstone is *Advanced PID Control*.

The introductory chapter is an excellent map of the books contents, everything that should be in a first chapter. It is also a hook that makes the reader want more. The next chapters are the foundation for the rest of the book; process models, mathematical descriptions of processes, and the PID controllers. The features of the models and the controllers introduced here are used throughout the book. Of note is the rare theoretical treatment of integral wind-up.

In the next several chapters the theory gets deep. Let the reader beware. Measures for controller performance and stability are introduced, including the 'gang of six' key transfer functions and stability margin. Feedforward control is examined before the review of tuning methods. Ziegler-Nichols step response and ultimate gain method, empirical tuning, and model base methods such as pole placement, lambda tuning, internal model control tuning, optimization criteria, and loop shaping are compared. In the following chapter the authors expand upon their own MIGO (M constrained Integral Gain Optimization) method with the AMIGO (Approximate MIGO) method of tuning on an impressive analysis of a test batch of process models.

The later chapters cover more advanced controllers and some practical techniques. There is a review of predictive controllers like the Smith Predictor and the PPI controller. Another chapter covers the history and current techniques for automatic and adaptive tuning. The chapter on loop performance includes discussion of several practical diagnostics. The techniques for reducing loop interaction and improving control paradigms can be used to improve performance. The final chapter reviews some commercial implementations of PID controllers, from pneumatic to electronic to computer.

Åström and Hägglund have written a masterpiece of control theory that will benefit the advanced automation professional, at least those familiar with Nyquist diagrams. As a bonus, each chapter has an excellent summary and reference section that includes a history of key related work. *Advanced PID Control* can be a challenging read, but if you design control algorithms or tune complex controllers, the insights and techniques are worth the time. While this book is expertly written, because the audience may be limited, it averages to a (BBB) borrow. It is available for $89 (member price) at ISA.Org.