Analysis of Digital Control Systems

APPENDIX L

L.1 ■ INTRODUCTION

Most feedback control in the chemical process industries is currently implemented using digital computers. While most key features of control engineering are the same for continuous and digital control, some unique features of digital control should be considered. Therefore, the basic concepts of digital control were introduced in Chapter 11, and digital forms of common control algorithms are provided in Chapters 11 (PID), 12 (filtering and windup), 15 (feedforward), 21 (decoupling), and 23 (DMC). The reader is encouraged to review this material, especially the introductory material in Chapter 11, before proceeding to study this appendix.

In this appendix, we present rigorous methods, based on the z-transform, for analyzing a digital control system. As shown in Figure L.1, the z-transform enables the engineer to combine a continuous process and digital controller into one transfer function model. As with continuous systems, we can use the transfer function model to determine important properties of the system, such as its stability, final value, and frequency response. This appendix begins with an introduction to z-transforms for digital systems, which are analogous to Laplace transforms for continuous systems. Then, the application of z-transforms for control system analysis is presented. Finally, these analysis methods are applied to determine key results for PID and IMC closed-loop systems.

L.2 ■ THE *Z*-TRANSFORM

The digital controller has no information on the continuous controlled variable; it has only sampled values of the controlled variable. Therefore, our analysis