COMPUTER-CONTROLLED SYSTEMS

Theory and Design

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1 COMPUTER CONTROL

GOAL *To Introduce the Subject and to Give Some Historical Background on the Development of Computer-Control Technology and Theory.*

1.1 Introduction

Digital computers are increasingly being used to implement control systems. It is therefore important to understand computer-controlled systems well. One can view computer-controlled systems as approximations of analog-control systems, but this is a poor approach because the full potential of computer control is not used. At best the results are only as good as those obtained with analog control. Alternatively, one can learn about computer-controlled systems, so that the full potential of computer control is used. The main goal of this book is to provide the required background.

A computer-controlled system can be schematically described as in Fig. 1.1. The

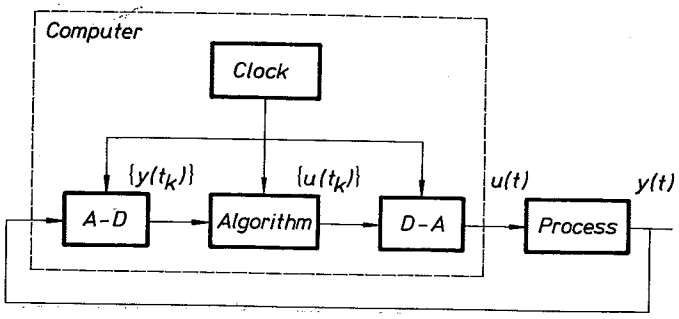

Figure 1.1 Schematic diagram of a computer-controlled system.

output from the process $y(t)$ is a continuous-time signal. The output is converted into digital form by the analog-to-digital (A-D) converter. The A-D converter can be included in the computer or regarded as a separate unit, according to one's preference. The conversion is done at the sampling times, t_k. The computer interprets the converted signal, $\{y(t_k)\}$, as a sequence of numbers, processes the measurements using an algorithm and gives a new sequence of numbers, $\{u(t_k)\}$. This sequence is converted to an analog signal by a digital-to-analog (D-A) converter. Notice that the system runs open loop in the interval between the A-D and the D-A conversion. The events are synchronized by the real-time clock in the computer. The digital computer operates sequentially in time and each operation takes some time. The D-A converter must, however, produce a continuous-time signal. This is normally done by keeping the control signal constant between the conversions. The computer-controlled system contains both continuous-time signals and *sampled*, or *discrete-time* signals. Such systems have traditionally been called *sampled-data systems*, and this term will be used here as a synonym for *computer-controlled systems*.

The mixture of different types of signals sometimes causes difficulties. In most cases it is, however, sufficient to describe the behavior of the system at the sampling instants. The signals are then of interest only at discrete times. Such systems will be called *discrete-time systems*. Discrete-time systems deal with sequences of numbers, so a natural way to represent these systems is to use difference equations.

The purpose of the book is to present the control theory that is relevant to the analysis and design of computer-controlled systems. This chapter provides some background. A brief overview of the development of computer-control technology is given in Sec. 1.2. The need for a suitable theory is discussed in Sec. 1.3. Examples are used to demonstrate that computer-controlled systems cannot be *fully* understood by the theory of linear, time-invariant, continuous-time systems. An example shows not only that computer-controlled systems can be designed using continuous-time theory and approximations, but also that substantial improvements can be obtained by other techniques that use the full potential of computer control. Sec. 1.4 gives some examples of inherently sampled systems. The development of the theory of sampled-data systems is outlined in Sec. 1.5.

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