2 Elements of systems engineering of digital control

Control systems are the subsystems of plants which generate and send the commands to the plants’ ‘working’ components. Hence, they are the elements which turn motors on and off, regulate inputs, record (or log) data on the processes, send messages to operators, etc. The level of sophistication is decided at the systems engineering stage, with the goal of using control components and techniques appropriate to the task – neither using a supercomputer to turn a heater on and off nor a commercial personal microcomputer for a sophisticated satellite antenna pointing system. The various decisions involved are aspects of systems engineering, and require decisions at a number of levels. This chapter explores only two levels: system structuring and component selection.

2.1 SYNOPSIS

The objective of systems engineering is to provide orderly overall management of the development and operation of systems. It is this management aspect that the engineer must keep in mind, often at several levels simultaneously. Among the intermediate level problems are the selection of the layout, or structure, of the control system. Here it is decided whether control is centralized or distributed, and whether in multiple computer cases the computers interact at all, and if so, whether hierarchically.

At the lowest level are the problems of component and algorithm selection. Objective evaluation is possible in several different formats: qualitative checklists, qualitative/quantitative ranking and weighting, and quantitative scoring. A knowledge of how project costing is evaluated is essential to contributing to business decisions.
2.2 MANAGEMENT-LEVEL CONSIDERATIONS

The top level of systems engineering is the program planning level. It is likely to deal heavily in general rather than specific systems elements, with specifics derived as needed from lower level studies. The study may be of whether a new or refurbished plant or assembly line or a new ship control system should have an overall digital computer control system and even whether a flexible manufacturing system (FMS) is to be installed; the impetus may have come from one or more of several sources, such as salesmen talking to management extolling the virtues of specific systems or a researcher finding that further automation of the assembly line might be expected to produce better quality control.

At this level are investment decisions and operations management, both of which are beyond the scope of this book.

2.3 SYSTEMS CONFIGURATION ENGINEERING – THE INTERMEDIATE LEVEL

The intermediate level in computer control systems is the configuration design. Choices must be made as to quantities to be measured and logged, quantities to be controlled, how automatic operations are to be structured, how communications are to be carried out, etc. All of these choices are specific to the task at hand, but do not necessarily involve particular component selection. Configuration design can be among the most difficult parts of design: the answers must allow for a great many, possibly only partly known, factors.

2.3.1 Closing the loops

For many control problems, the system to be controlled is a relatively uncomplicated one: a motor to be speed controlled or an amplifier to be frequency-response compensated. For these, the theoretical classical control methods, which are largely single-input–single-output (SISO) and which require well structured problems, are directly and obviously applicable.

Larger problems will typically require many more decisions, with choices which may or may not be obvious. Among the choices are the following: