PROGRAMMABLE LOGIC CONTROLLERS

Sixth Edition

W. Bolton

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Preface

Technological advances in recent years have resulted in the development of the programmable logic controller (PLC) and a consequential revolution of control engineering. This book, an introduction to PLCs, aims to ease the tasks of practicing engineers coming into contact with PLCs for the first time. It also provides a basic course for students in curricula such as the English technicians' courses for Nationals and Higher Nationals in Engineering, giving full syllabus coverage of the National and Higher National in Engineering units, company training programs, and serving as an introduction for first-year undergraduate courses in engineering.

The book addresses the problem of various programmable control manufacturers using different nomenclature and program forms by describing the principles involved and illustrating them with examples from a range of manufacturers. The text includes:

- The basic architecture of PLCs and the characteristics of commonly used input and outputs to such systems
- A discussion of the number systems: denary, binary, octal, hexadecimal, and BCD
- A painstaking methodical introduction, with many illustrations, describing how to program PLCs, whatever the manufacturer, and how to use internal relays, timers, counters, shift registers, sequencers, and data-handling facilities
- Consideration of the standards given by IEC 61131-3 and the programming methods of ladder, functional block diagram, instruction list, structured text, and sequential function chart
- Many worked examples, multiple-choice questions, and problems to assist the reader in developing the skills necessary to write programs for programmable logic controllers, with answers to all multiple-choice questions and problems given at the end of the book

Prerequisite Knowledge Assumed

This book assumes no background in computing. However, a basic knowledge of electrical and electronic principles is desirable.

Changes from the Fifth Edition

The fourth edition of this book was a complete restructuring and updating of the third edition and included a more detailed consideration of IEC 61131-3, including all the programming methods given in the standard, and the problems of safety, including a discussion of emergency stop relays and safety PLCs. The fifth edition built on this foundation by providing more explanatory text, more examples, and more problems and includes with each chapter a summary of its key points. The sixth edition has a new Chapter 1 with a comparison of relay, microprocessor and PLC controlled systems, an updated consideration of commercial PLCs, and more discussion of the merits and problems of the various PLC programming methods given by the IEC 61131 standard. Chapter 2 has had some new material on sensors included. The discussion of sequential function charts in Chapter 6 has been rewritten to give more detail of the method. In Chapter 10 the part concerned with the sequencer has been rewritten. The section of Chapter 13 concerned with forcing has been extended and Chapter 14 has had more case studies added.

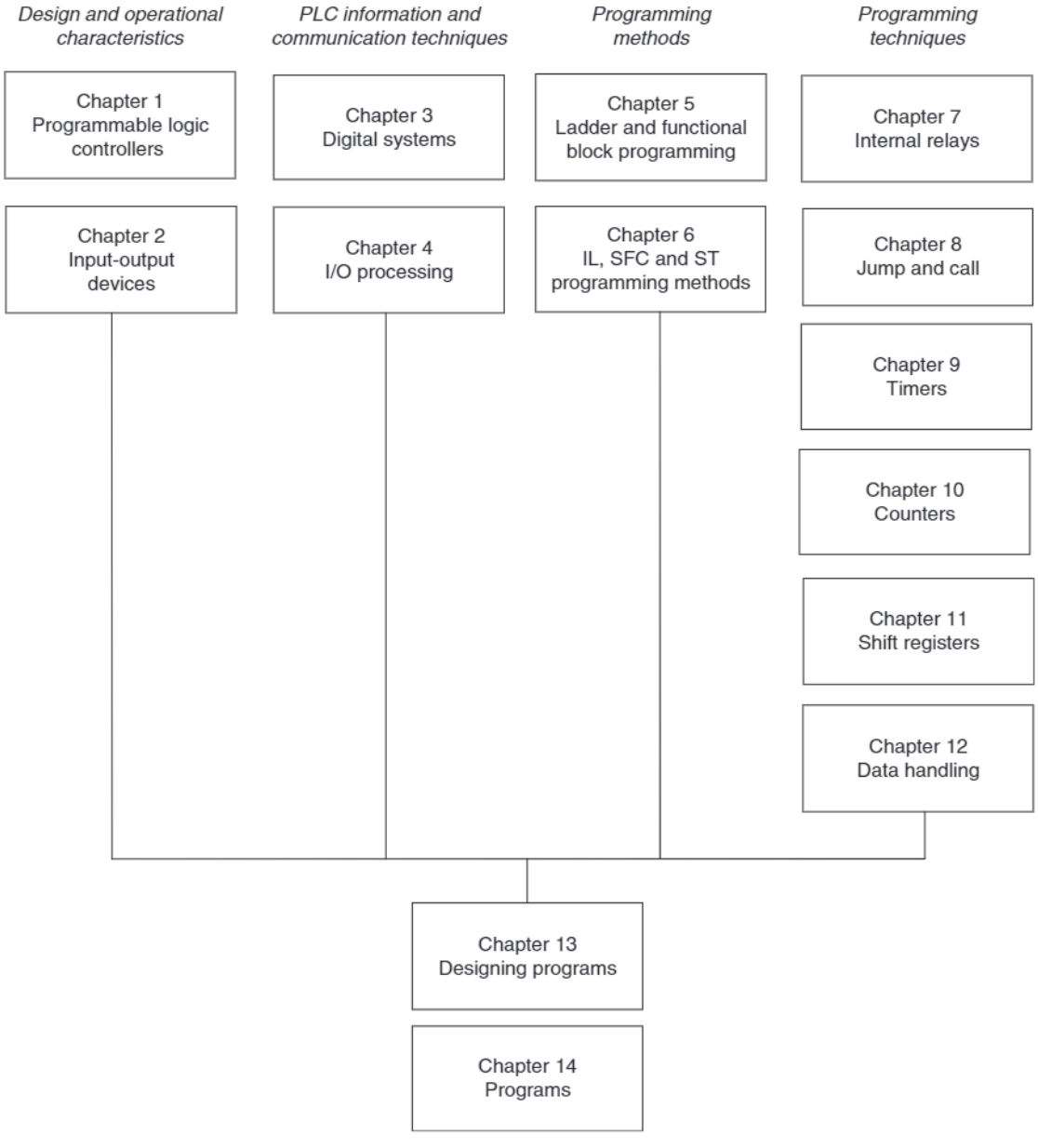
Aims

This book aims to enable the reader to:

- Identify and explain the main design characteristics, internal architecture, and operating principles of programmable logic controllers.
- Use PLCs of different sizes and from different manufacturers.
- Use commonly used input and output devices with PLC systems, taking account of their characteristics.
- Explain the processing of inputs and outputs by PLCs so that input and output systems can be used correctly with PLCs.
- Use communication links involved with PLC systems, recognizing the protocols and networking methods involved.
- Use ladder programs involving internal relays, timers, counters, shift registers, sequencers, and data handling to tackle applications.
- Identify safety issues with PLC systems so they can be used safely.
- Use methods used for fault diagnosis, testing, and debugging.

Structure of the Book

The following figure outlines the structure of the book.



Acknowledgments

I am grateful to the many reviewers of the various editions of this book for their helpful feedback and comments.

—W. Bolton

CHAPTER 1

Programmable Logic Controllers

This chapter is an introduction to the programmable logic controller (PLC) and its general function, hardware forms, and internal architecture. PLCs are widely used for a range of automation tasks in areas such as industrial processes in manufacturing. This overview is followed by more detailed discussion in the following chapters. For a summary of the history, development, features, and comparison with other control systems, see the Wikipedia entry for Programmable logic controller.

1.1 Controllers

What type of task might a control system handle? It might be required to control a sequence of events, maintain some variable constant, or follow some prescribed change. For example, the control system for an automatic drilling machine (Figure 1.1a) might be required to start lowering the drill when the workpiece is in position, start drilling when the drill reaches the workpiece, stop drilling when the drill has produced the required depth of hole, retract the drill, and then switch off and wait for the next workpiece to be put in position before repeating the operation. Another control system (Figure 1.1b) might be used to control the number of items moving along a conveyor belt and direct them into a packing case. The inputs to such control systems might come from switches being closed or opened; for example, the presence of the workpiece might be indicated by it moving against a switch and closing it, or other sensors such as those used for temperature or flow rates. The controller might be required to run a motor to move an object to some position or to turn a valve, or perhaps a heater, on or off.

What form might a controller have? For the automatic drilling machine, we could wire up electrical circuits in which the closing or opening of switches would result in motors being switched on or valves being actuated. Thus, as a result, we might have a relay (Figure 1.2) closing or opening contacts which, in turn, switches on the current to a motor and causes the drill to rotate (Figure 1.3). Another switch might be used to activate a relay and switch on the current to a pneumatic or hydraulic valve, which results in pressure being switched to drive a piston in a cylinder and so results in the workpiece being pushed into the required position. Such electrical circuits would have to be specific to the automatic drilling machine. For controlling the number of items packed into a packing case, we could likewise wire up

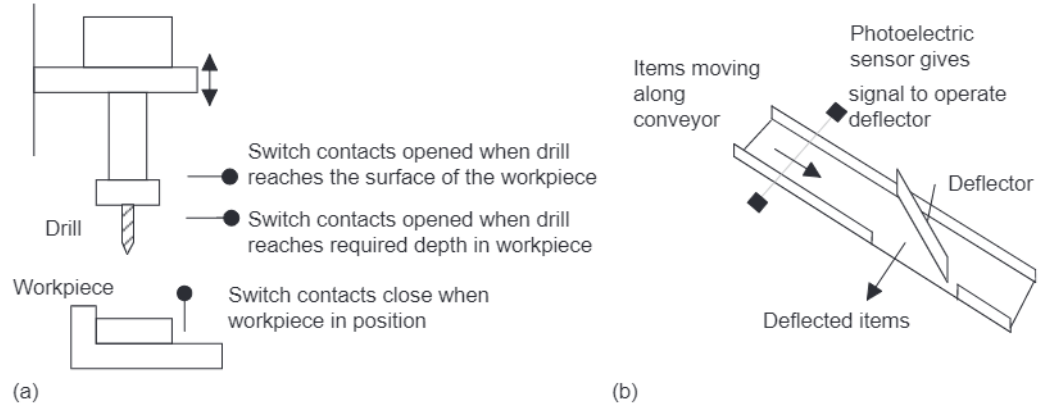


Figure 1.1: An example of a control task and some input sensors: (a) an automatic drilling machine; (b) a packing system.

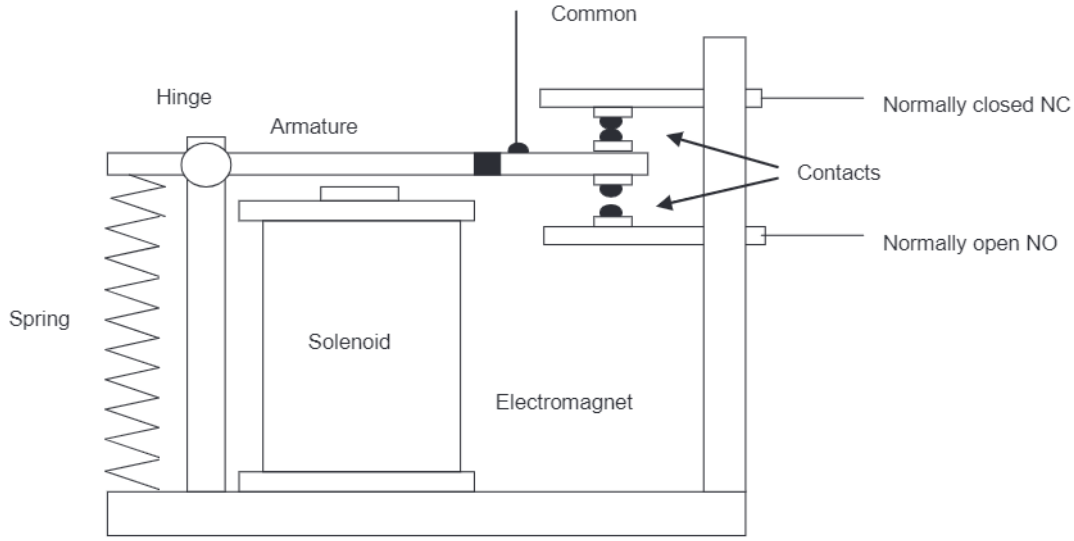


Figure 1.2: A basic relay.

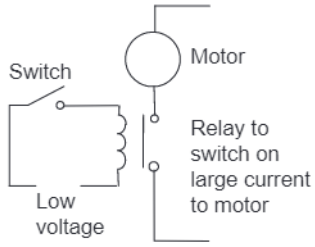


Figure 1.3: A control circuit.