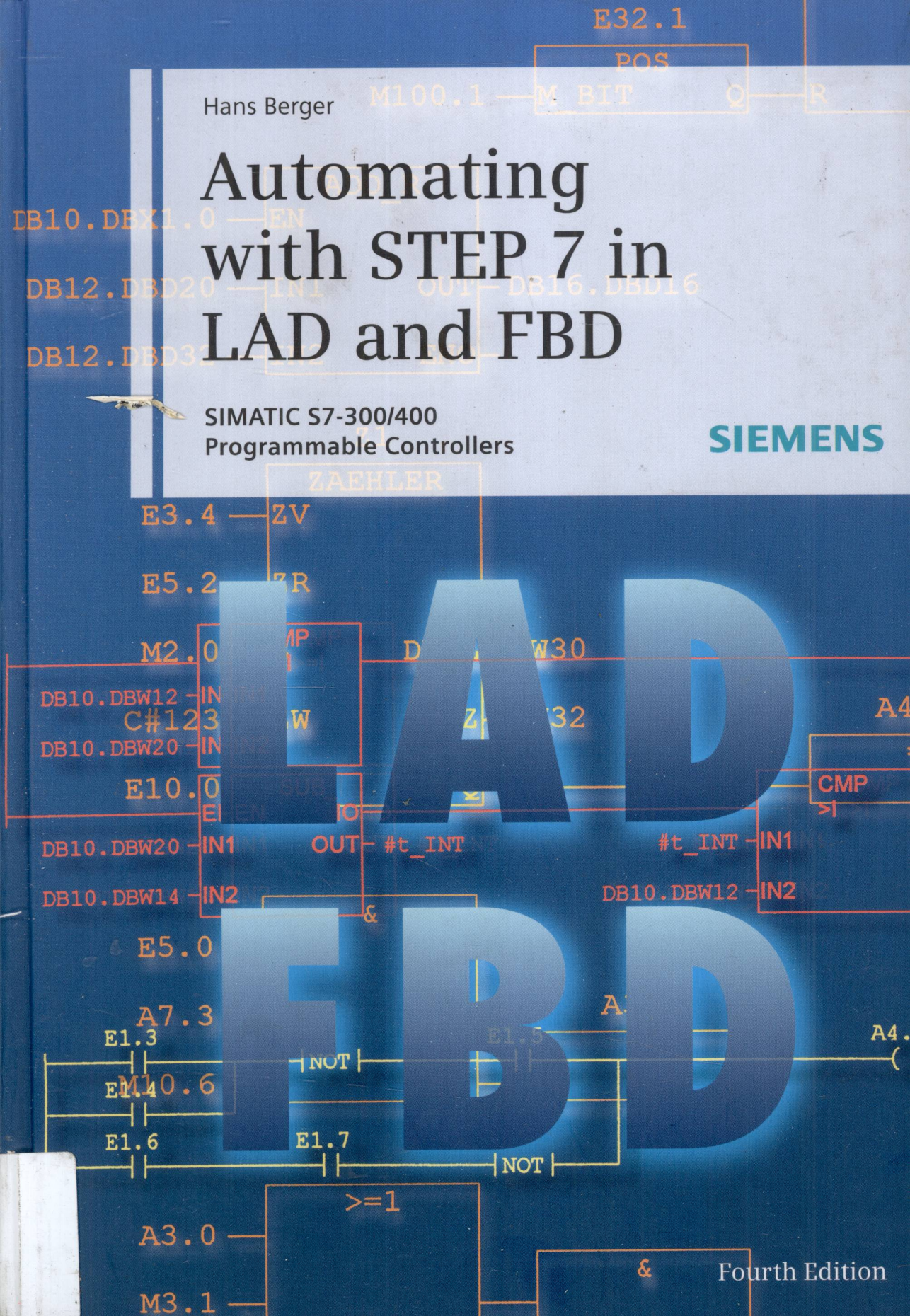
Hans Berger

Automating with STEP 7 in LAD and FBD

SIMATIC S7-300/400
Programmable Controllers

SIEMENS



Fourth Edition

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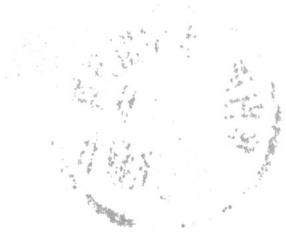

Automating with STEP 7 in LAD and FBD

Programmable Controllers SIMATIC S7-300/400

by Hans Berger

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The programming examples concentrate on describing the LAD and FBD functions and providing SIMATIC S7 users with programming tips for solving specific tasks with this controller.

The programming examples given in the book do not pretend to be complete solutions or to be executable on future STEP 7 releases or S7-300/400 versions. Additional care must be taken in order to comply with the relevant safety regulations.

The author and publisher have taken great care with all texts and illustrations in this book. Nevertheless, errors can never be completely avoided. The publisher and the author accept no liability, regardless of legal basis, for any damage resulting from the use of the programming examples.

The author and publisher are always grateful to hear your responses to the contents of the book.
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Preface

The SIMATIC automation system unites all the subsystems of an automation solution under uniform system architecture into a homogeneous whole from the field level right up to process control. This Totally Integrated Automation (TIA) concept permits integrated configuring, programming, data management and communications within the complete automation system. Fine-tuned communications mechanisms permit harmonious interaction between programmable controllers, visualization systems and distributed I/Os.

As the basic tool for SIMATIC, STEP 7 handles the parenthesis function for Totally Integrated Automation. STEP 7 is used to carry out the configuration and programming of the SIMATIC S7, SIMATIC C7 and SIMATIC WinAC automation systems. Microsoft Windows has been selected as the operating system, thus opening up the world of standard PCs with the user desktop widely used in the office environment.

For block programming STEP 7 provides programming languages that comply with DIN EN 6.1131-3: STL (statement list; an Assembler-like language), LAD (ladder logic; a representation similar to relay logic diagrams), FBD (function block diagram) and the S7-SCL optional package (structured control language, a Pascal-like high-level language). Several optional packages supplement these languages: S7-GRAPH (sequential control), S7-HiGraph (programming with state-transition diagrams) and CFC (connecting blocks; similar to function block diagram). The various methods of representation allow every user to select the suitable control function description. This broad adaptability in representing the control task to be solved significantly simplifies working with STEP 7.

This book describes the LAD and FBD programming languages for S7-300/400. As a valuable supplement to the language description, and following an introduction to the S7-300/400 automation system, it provides valuable and practice-oriented information on the basic handling of STEP 7 for the configuration of SIMATIC PLCs, their networking and programming. The description of the "basic functions" of a binary control, such as e.g. logic operations or storage functions, is particularly useful for beginners or those converting from contactor controls to STEP 7. The digital functions explain how digital values are combined; for example, basic calculations, comparisons or data type conversion.

The book shows how you can control the program processing (program flow) with LAD and FBD and design structured programs. In addition to the cyclically processed main program, you can also incorporate event-driven program sections as well as influence the behavior of the controller at startup and in the event of errors/faults. The book concludes with a general overview of the system functions and the function set for LAD and FBD. The contents of this book describe Version 5.4 Service Pack 3 of the STEP 7 programming software.

Erlangen, May 2008

Hans Berger

The Contents of the Book at a Glance

Overview of the S7-300/400 programmable logic controller

PLC functions comparable to a contactor control system

Handling numbers and digital operands

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1 SIMATIC S7-300/400 Programmable Controller

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Distributed I/O (PROFIBUS DP);

Communications (Subnets);

Module Addresses;

Addresses Areas

2 STEP 7 Programming Software

Editing Projects;

Configuring Stations;

Configuring the Network;

Symbol Editor;

LAD/FBD Program Editor;

Online Mode; Testing LAD and FBD Programs

3 SIMATIC S7 Program

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Nesting Functions

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Edge Evaluation;

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IEC Counter Functions

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Brief Description of the "Message Frame Example"

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System Function Blocks;

IEC Function Blocks;

S5-S7 Converting Blocks;

TI/S7 Converting Blocks;

PID Control Blocks;

Communication Blocks

26 Function Set LAD

Basic Functions;

Digital Functions;

Program Flow Control

27 Function Set FBD

Basic Functions;

Digital Functions;

Program Flow Control

The Programming Examples at a Glance

The present book provides many figures representing the use of the LAD and FBD programming languages. All programming examples can be downloaded from the publisher's website www.publicis.de/books. There are two libraries LAD_Book and FBD_Book.

The libraries LAD_Book and FBD_Book contain eight programs that are essentially illustrations of the graphical representation. Two extensive examples show the programming of functions, function blocks and local instances (Conveyor Example) and the handling of data (Message Frame Example). All the examples contain symbols and comments.

Library LAD_Book

Data Types Examples of Definition and Application	**Program Processing** Examples of SFC Calls
FB 101 Elementary Data Types FB 102 Complex Data Types FB 103 Parameter Types	FB 120 Chapter 20: Main Program FB 121 Chapter 21: Interrupt Processing FB 122 Chapter 22: Start-up Characteristics FB 123 Chapter 23: Error Handling
Basic Functions LAD Representation Examples	**Conveyor Example** Examples of Basic Functions and Local Instances
FB 104 Chapter4: Series and Parallel Circuits FB 105 Chapter5: Memory Functions FB 106 Chapter6: Move Functions FB 107 Chapter7: Timer Functions FB 108 Chapter8: Counter Functions	FC 11 Belt Control FC 12 Counter Control FB 20 Feed FB 21 Conveyor Belt FB 22 Parts Counter
Digital Functions LAD Representation Examples	**Message Frame Example** Data Handling Examples
FB 109 Chapter 9: Comparison Functions FB 110 Chapter 10: Arithmetic Functions FB 111 Chapter 11: Math Functions FB 112 Chapter 12: Conversion Functions FB 113 Chapter 13: Shift Functions FB 114 Chapter 14: Word Logic	UDT 51 Data Structure for the Frame Header UDT 52 Data Structure for a Message FB 51 Generate Message Frame FB 52 Store Message Frame FC 51 Time-of-day Check FC 52 Copy Data Area with indirect Addressing
Program Flow Control LAD Representation Examples	**General Examples**
FB 115 Chapter 15: Status Bits FB 116 Chapter 16: Jump Functions FB 117 Chapter 17: Master Control Relay FB 118 Chapter 18: Block Functions FB 119 Chapter 19: Block Parameters	FC 41 Range Monitor FC 42 Limit Value Detection FC 43 Compound Interest Calculation FC 44 Doubleword-wise Edge Evaluation

The libraries are supplied in archived form. Before you can start working with them, you must dearchive the libraries. Select the FILE → DEARCHIVE menu item in the SIMATIC Manager and follow the instructions (see also the README.TXT within the download files).

To try the programs out, set up a project corresponding to your hardware configuration and then copy the program, including the symbol table from the library to the project. Now you can call the example programs, adapt them for your own purposes and test them online.

Library FBD_Book

Data Types Examples of Definition and Application	**Program Processing** Examples of SFC Calls
FB 101 Elementary Data Types FB 102 Complex Data Types FB 103 Parameter Types	FB 120 Chapter 20: Main Program FB 121 Chapter 21: Interrupt Processing FB 122 Chapter 22: Start-up Characteristics FB 123 Chapter 23: Error Handling
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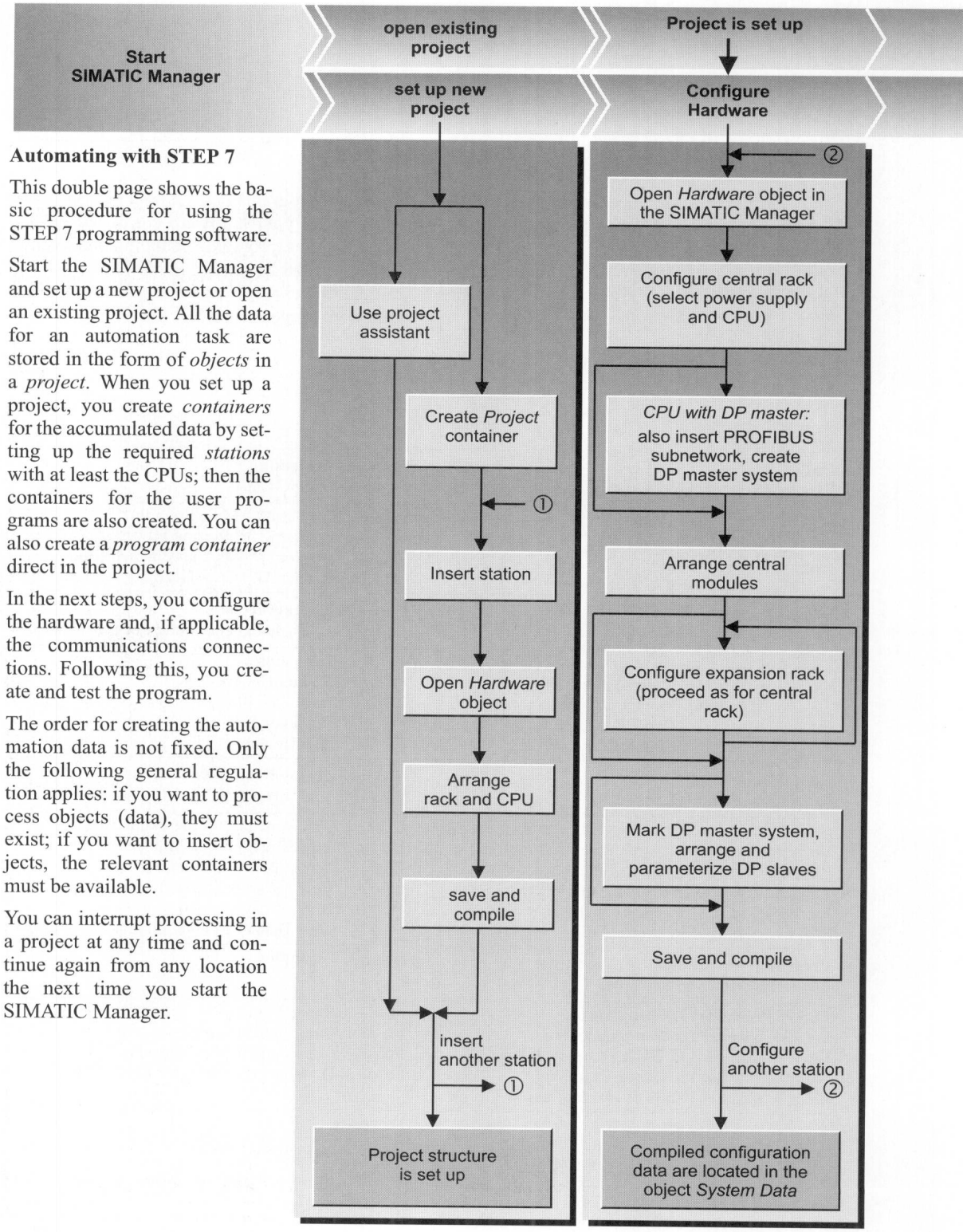


Automating with STEP 7

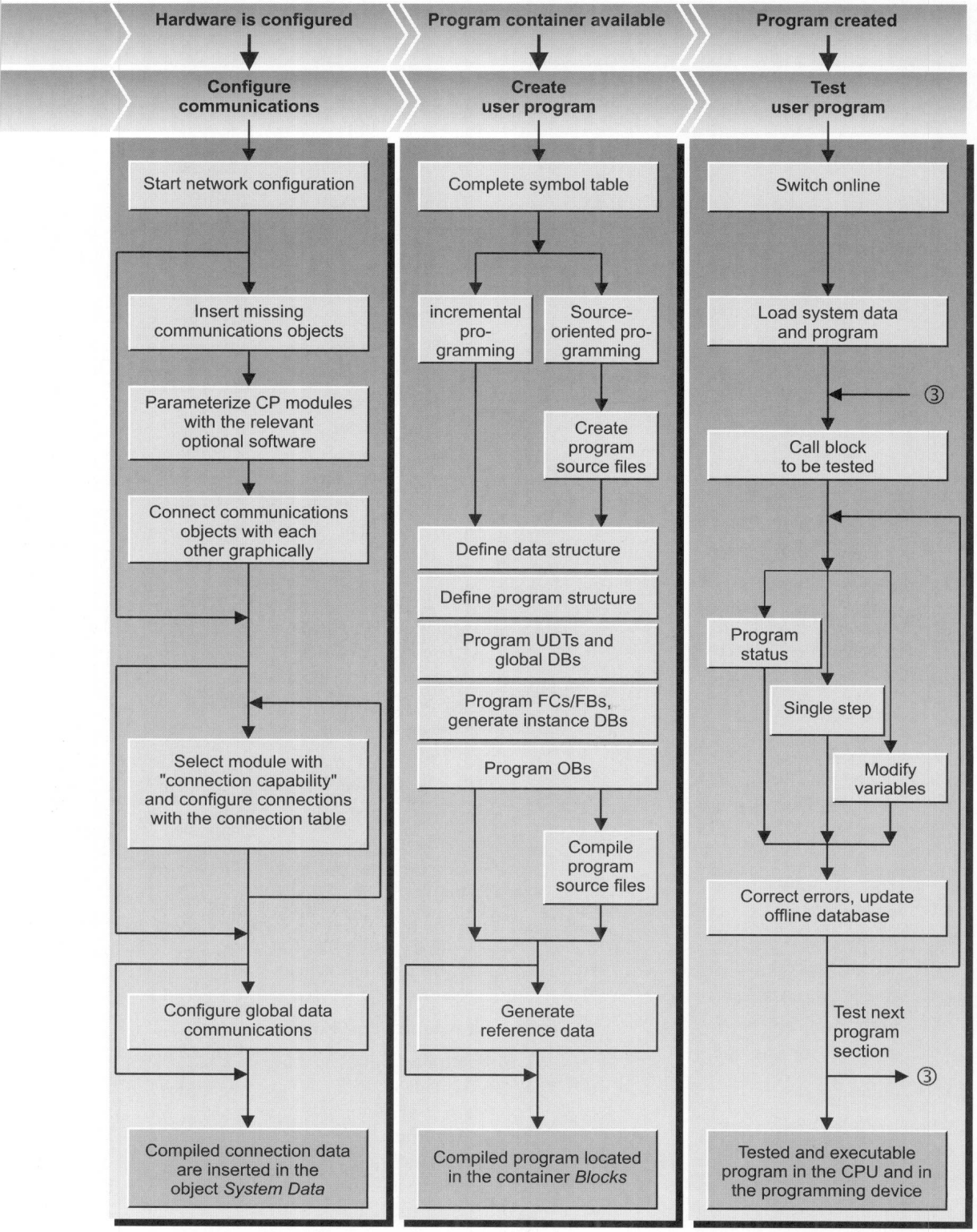
This double page shows the basic procedure for using the STEP 7 programming software.

Start the SIMATIC Manager and set up a new project or open an existing project. All the data for an automation task are stored in the form of *objects* in a *project*. When you set up a project, you create *containers* for the accumulated data by setting up the required *stations* with at least the CPUs; then the containers for the user programs are also created. You can also create a *program container* direct in the project.

In the next steps, you configure the hardware and, if applicable, the communications connections. Following this, you create and test the program.

The order for creating the automation data is not fixed. Only the following general regulation applies: if you want to process objects (data), they must exist; if you want to insert objects, the relevant containers must be available.

You can interrupt processing in a project at any time and continue again from any location the next time you start the SIMATIC Manager.


Hardware is configured
Program container available
Program created
Configure communications
Create user program
Test user program
Start network configuration
Insert missing communications objects
Parameterize CP modules with the relevant optional software
Connect communications objects with each other graphically
Select module with "connection capability" and configure connections with the connection table
Configure global data communications
Compiled connection data are inserted in the object System Data
Complete symbol table
incremental pro-gramming
Source-oriented pro-gramming
Create program source files
Define data structure
Define program structure
Program UDTs and global DBs
Program FCs/FBs, generate instance DBs
Program OBs
Compile program source files
Generate reference data
Compiled program located in the container Blocks
Switch online
Load system data and program
③
Call block to be tested
Program status
Single step
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Correct errors, update offline database
Test next program section
③
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