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Process Control Computer Technology



a programmed introduction

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Schäfer

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Computer Technology—
A Programmed Introduction

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Process Control Computer Technology—

A Programmed Introduction

Peter Schäfer



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SIEMENS AKTIENGESELLSCHAFT
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Introduction

The programmed training manual *Introduction to Process Control Computer Technology* is intended for self-tuition and deals with the terms and methods of process control computer and process automation technology.

The examples used for explaining certain terms and methods refer in all cases to the process control computers of the Siemens 300-16 bit system and to the names commonly used in that system.

In order to study this programmed manual, some knowledge of and familiarity with number systems is assumed.

The material contained in this book is intended for those who must familiarize themselves with the topics mentioned above in order to undertake advanced courses in process control computer technology or in order to be able to follow the relevant literature in this area.

The topics in this manual are presented so that the first section (Data Processing Systems) provides the basic knowledge about the topics discussed later. Specific information about process control computers is given, using examples in the following sections, based on this knowledge.

Each of the six sections is divided into individual learning steps (lessons). After each learning step, the student should use the 'Questions' to test whether he has correctly understood the material. His own answers can then be compared to those given under 'Answers'.

The format of this programmed training manual makes it possible for selected sections to be studied in isolation. The programmed manual can be used as a reference work for those with the relevant previous knowledge.

Berlin, Munich, September 1978

SIEMENS AKTIENGESELLSCHAFT



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Section 1

Lesson 1.1 Scope of computers

Lesson 1.2 Structure of EDP systems

Lesson 1.3 Process control computers

Lesson 1.3.1 Peripheral units

Lesson 1.3.2 Characteristics of process control computers

Lesson 1.4 Central processing unit

Lesson 1.4.1 Central processor

Lesson 1.4.2 Main memory

Lesson 1.4.3 Input/output interfaces

Lesson 1.4.4 Maintenance panel

Lesson 1.4.5 Power supply unit

Lesson 1.4.6 Performance evaluation

Lesson 1.5 Process control computing systems

Lesson 1.5.1 System software

Lesson 1.5.2 User software

Lesson 1.5.3 Redundant process control computing systems

Lesson 1.5.4 Evaluation of performance

Lesson 1.6 Automation processes

Lesson 1.6.1 Process data acquisition

Lesson 1.6.2 Process monitoring

Lesson 1.6.3 Open and closed loop control

Lesson 1.6.4 Process identification

Lesson 1.6.5 Process control

Lesson 1.6.6 Process optimization

Learning goal

The important fundamental technical terms of digital computer systems, especially those in connection with process control computers are described and explained.

After successfully studying this chapter the student should be able to describe

- ▶ the criteria and technical terms associated with digital computer systems,
- ▶ the structure of a data processing system by block diagrams,
- ▶ the functions of the process control computer,
- ▶ different sorts of process control computer and their special characteristics,
- ▶ the functions of the central processing unit,
- ▶ the organization and functions of EDP systems,
- ▶ the action of code and programs in the main memory,
- ▶ automation processes in process control computers.

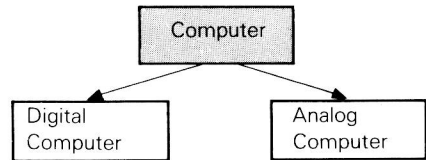
Computer is a collective term for a number of different information processing machines including the process control computer. Computer manufacturers today offer a wide choice of efficient computers and computer systems for different applications:

e.g. pocket calculator, desk computer, book-keeping machines, computers for controlling technical processes, technical and scientific computers, large commercial computing systems.

An important characteristic of these computers is their *program-controlled operation* using stored programs.

Computer processing can be digital or analog. Therefore computers are called

Digital computers or Analog computers



Machines or mechanisms which do not have program-controlled operation will be called computing aids.

Program-controlled operation

Program-controlled operation requires automatic processing of the instructions of the program.

The stored programs can either

- ▶ be fixed (as hardwired circuits or in read-only memory) or be freely changeable by the user.

This enables program controllers to be differentiated as those which

- ▶ process fixed function sequences, e.g. program controllers for paper tape or punched cards. In this case no variations, caused by branch instructions, are possible within a program.
- ▶ process programs in which the function sequence can be varied by means of branching.

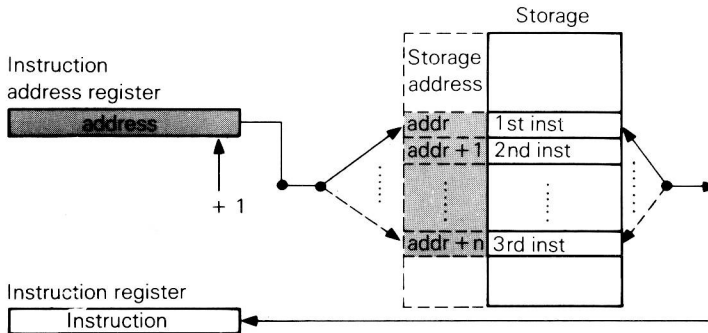
Whereas the analog computer is permanently programmed by the appropriate wiring diagram—that is the wiring connections for the required computing elements—for the task, the digital computer has an interchangeable memory or a freely programmed memory. This enables it to react to certain events in a specific manner ('stored-program' computers).

Program control of a digital computer

A program controller with its own instruction set is called a *processor*.

Digital computer processors usually operate under control of clock pulses in a defined pulse sequence (synchronous operation).

The program to be processed by the digital computer is loaded into computer storage. The instruction address register—also called instruction counter—is loaded by the processor together with the starting address of the program.



During the step-by-step processing of this program, each instruction is addressed in storage by the instruction address register, read from storage and loaded into the instruction register. While the instruction is being executed, the instruction address register is incremented by +1, thus loading the instruction address of the next instruction. If the instruction to be processed is a branch instruction, the instruction address register is reloaded to the address specified in the branch instruction.

Thus a processor—a program controller in the digital computer—has three basic functions:

- program-dependent control of the instruction sequence to be executed
- interpretation of the instructions to be executed
- execution of the operations defined in the instructions.

Programmability of computers

Functional units (computer systems) whose behaviour is determined by exchangeable stored programs are called stored-program units.

One distinguishes between:

programmable computers with interchangeable memory and freely programmable computers

Whereas the programs of a computer with interchangeable memory are stored in read-only memory, which can only be read and not changed during program execution, the programs of a freely programmable computer are stored in random access memory, where they can be altered or exchanged at any time.

Questions**Question 1**

Name the two computing methods used by computers.

Question 2

What characteristics do all the computers used in electronic data processing systems have?

Question 3

What does one call a program controller which has its own instruction set?

Question 4

How do most of the program controllers for digital computers work?

- a) asynchronously
- b) clock-controlled (synchronously)

☐
☐

Please tick the box you think corresponds to the correct answer.

Question 5

A computer is always freely programmable, if

- a) the program contains branch instructions
- b) it has random access memory
- c) it contains an interchangeable read-only memory.

☐
☐
☐

Answers**Answer 1**

Computers can be either digital or analog.

Answer 2

The computers used in EDP systems have program-controlled operation based on stored programs.

Answer 3

A program controller with its own instruction set is called a processor.

Answer 4

Most of the program controllers for digital computers work

b) clock-controlled (synchronously).

Answer 5

A computer is always freely programmable if

b) it has random access memory.

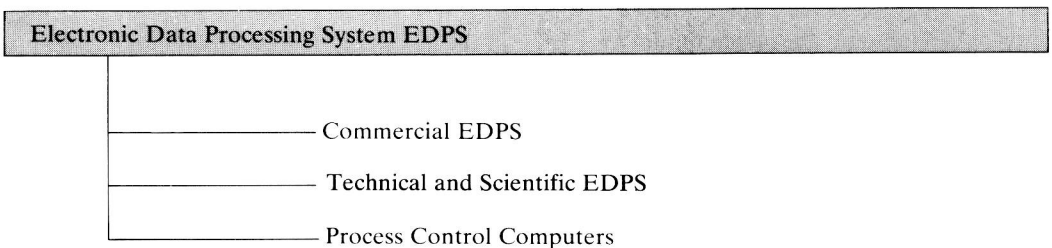
A data processing system (DPS) is a stored-program machine for processing data and signals, which usually works automatically and electronically.

By 'system or machine' one understands a combination of several units, e.g. a computer with input/output units.

If the data processing system is primarily composed of electronic devices or functional units, one speaks of an

electronic data processing system (EDPS) or an
electronic data processing machine (EDPM)

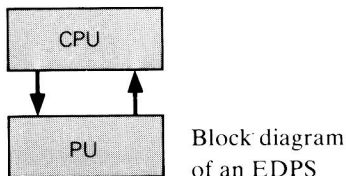
Modern computer systems can be classified under the general term EDPS according to their applications as follows:



Most data processing systems are digital EDP systems. The following chapters are therefore restricted to

digital, stored-program, electronic data processing systems

Electronic data processing systems comprise a central processing unit (CPU) and peripheral units (PU).



The central processing unit (CPU) is the central part of the (digital) computer or EDP system in which the input data are:

buffered

processed according to certain program-controlled instructions and

the results made available for output

The peripheral units (PU) comprise:

- a) input units
- b) output units
- c) dialogue units
- d) peripheral storage units

The input units a) include all devices which can input data or programs to the central processing unit.

- e.g.
- Paper tape reader
 - Punched card reader
 - Keyboard (e.g. teletypewriter)
 - Visual display unit (VDU)
 - Magnetic character reader
 - Magnetic tape drive
 - Floppy disk drive
 - Diagram scanner
 - Process I/O device

The output units b) include all devices which can output data from the central processing unit.

- e.g.
- Paper tape punch
 - Card punch
 - Teletypewriter
 - Visual display unit (VDU)
 - Lineprinter
 - Plotter (drawing devices)
 - Magnetic tape drive
 - Floppy disk drive
 - Process I/O device

The dialogue units in c) include all combined input and output devices which the operator needs for giving input to the computer system.

- e.g.
- Console teletype
 - Visual display unit (VDU)
 - Maintenance panel (belongs to CPU)

The peripheral storage units in d) are peripheral storage units which, for technical reasons, cannot be operated within the central processing unit as can the main memory.

The peripheral storage units comprise the drives containing the storage medium and a controller.

In the main, programs and data which can be called by the central processing unit during program processing are stored on peripheral storage. Peripheral storage units can be omitted for smaller EDP systems.