

SIEMENS

Stefan Kruse

LOGO! 8

A Practical Introduction,
with Circuit Solutions and Example Programs



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A Practical Introduction,
with Circuit Solutions and Example Programs

by Stefan Kruse

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and Joachim Zimmermann

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Preface

Thanks to the LOGO! universal control module, there has been a reliable, quick, and flexible option for implementing simple automation tasks for many years now. The easy-to-operate hardware unit integrates the controller, an operating and display unit, the power supply, and the interfaces for program modules, networks, and PC connections. The intuitively designed software contains the preconfigured basic functions typically used in practice, e.g. for delayed switching ON/OFF, counting functions, protective relay, comparator levels or arithmetic operations, which can be connected via analog or digital inputs and outputs. Thanks to the modular layout of the hardware, the easy-to-program software, and numerous preset basic functions, the system is not only suited for use in industry, but also for private use and hobbies.

Due to the simple and convenient operability of the programming, the easy integration of the LOGO! into an electrical circuit, and minimal wiring effort, even relatively unskilled amateur technicians can achieve professional results in their small automation projects.

This book explains the basics of information technology and should allow entry-level technicians to take their first step into automation technology using LOGO!. In addition, we present a wide variety of interesting and customizable projects to the passionate amateur technician.

All of the implemented projects have a modular layout. This means that competence gained from everyday examples can easily be transferred to individual projects step-by-step. Even if not all of the ideas that are presented have to be put into practice, many challenges are addressed and a wide variety of solution variants are offered. The circuits that are presented can largely also be implemented using previous LOGO! modules. Some projects, however, adopt the new capabilities of LOGO! 8, such as the SMS function, enhanced functions of the Look & Feel text display, or the integrated web server. In addition to 15 interesting everyday projects, a soldering course, parts lists, and sources of supply are also provided for any required hardware.

We hope you enjoy and wish you much success with interesting Siemens LOGO! projects.

April 2015

*Stefan Kruse,
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1 Modern information technology

The developments in information technology in the last few decades have changed the lives of people more than any other technological field. Modern information technology encompasses many aspects. It includes the following fields:

- Electrical engineering (research, development, and production of artifacts and methods used in connection with electrical energy)
- Computer engineering (systematic processing of information),
- Technical computer engineering (planning, design, implementation, operation, and analysis of computer engineering systems),
- Communications engineering (recording, transmitting, processing, and saving of information),
- Automation engineering (connecting the overlaps of measurement, control and closed-loop control engineering) and
- the human-computer interaction that has appeared in recent years (planning and design of interactive systems and the human-machine interface).

Fig. 1.1 shows the connection of the disciplines involved in information technology.

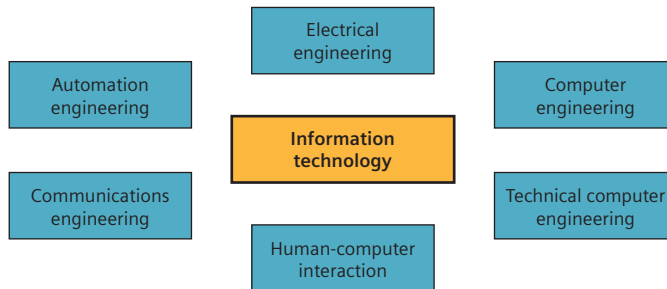


Fig. 1.1 Disciplines involved in information technology

All of the disciplines at the heart of information technology are based on the same operating principle: Most information technology processes can be described in terms of the basic systematic principle of input, processing and output (IPO), both chronologically and spatially. The connection to a classification of the various types of work objects by material, energy and information allows the clear assignment of the information technology elements and a description of the interaction between the system's components and its environment (see Table 1.1).

Table 1.1 Combination of the IPO principle with the systematics of the basic technological procedures

Work objects	"IPO" principle		
	Input (I)	Processing (P)	Output (O)
Material	e.g. water	e.g. warming	e.g. water vapor
Energy	e.g. solar energy	e.g. heat exchanger	e.g. heat energy
Information	e.g. actual temperature value	e.g. triggering a switching action	e.g. setpoint temperature value

1.1 Fundamentals of electrical engineering

For the planning of an automated circuit, this "IPO" operating principle must be transferred to the project to be processed. In the planned open-loop and closed-loop control system, information is transferred and processed by means of electrical voltage. Process states are detected by sensors, which convert the detected data into information which can be further processed. The acquired information is converted in such a way that it can be processed by the controller as an input variable. After the information is processed, it is converted into information that can be read by the actuator, which converts it into process energy. The flow diagram in Fig. 1.2 illustrates this in an example.

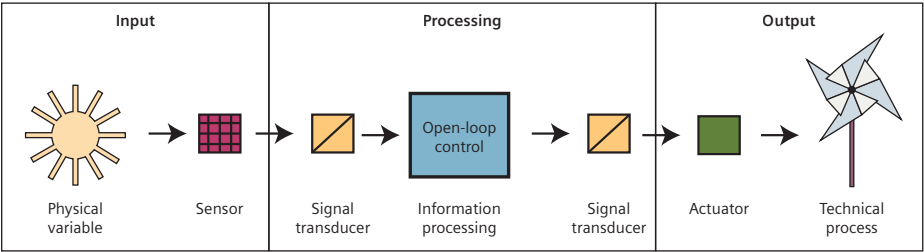


Fig. 1.2 Flow diagram and components of a control system

1.1.1 Sensors

Sensors are used to record measurement signals or physical environmental values. They detect information about properties, states, and processes. Non-electrical measurement variables, such as temperature, pressure, acoustic and optical variables, are converted into electrically analyzable variables. These electrical variables can be processed in a control unit. Thus, via sensors, a system can perceive specific information, properties, states, or processes from its environment.

Just like the sense organs in human beings, sensors can detect different physical and chemical environmental conditions. With the aid of infrared sensors, ultrasonic sensors, or simple touch sensors, a robot can detect obstacles or drop-offs, for example, in order to be able to move about its environment. In addition there are sensors for measuring temperature, air humidity, humidity, radiation,

pressure, vibration, gas, motion, light, and sound. Modern robots also have GPS modules which allow them to determine and share accurate information about their location.

All of the sensors are basically subject to the following criteria:

- A sensor should be designed and operable as easy as possible. This concerns the properties of the enclosure, the connection options, and the ability to calibrate the sensor.
- A sensor should be as robust as possible. Sensors are generally subjected to physical stress such as impacts, vibration, or environmental factors such as sunlight or inclement weather. This means that the actual sensor should be protected by an enclosure or some technical measure.
- In sensor design, a distinction is made between an active and passive module. Some sensors need an active power source (e.g. an infrared sensor with an infrared LED). Then, increased consumption of power must be taken into consideration. Passive sensors receive their signals from the environment (e.g. a pushbutton is pushed). The majority of ambient variables such as temperature, humidity, light, vibration, or force are recorded with the aid of passive components.
- The measured values are represented by analog or digital signals. Analog signals are often analyzed based on the principle of the voltage divider: A base voltage is entered in the sensor and a partial voltage is output. The resulting difference is recorded and analyzed in the program using a value table. A digital signal or a pulse is analyzed as a clearly defined input and is further processed.

1.1.2 Actuators

Whereas sensors convert a physical variable into an electric current, as described, actuators do exactly the opposite, as the technical counterpart to sensors. They convert electrical signals from the control unit into a different form of energy such as physical movement or into other physical variables¹ such as light intensity, temperature, or sound. Electrical energy is converted to a different form of energy, e.g. kinetic energy (for movement). In this way, the system can influence its environment.

Actuators can be systematized in the following areas corresponding to their conversion method:

- **Electromagnetic actuators:** Electrical energy is converted to mechanical energy. This can take place in the form of kinetic energy or rotational energy via a switch, slider, or potentiometer. Speakers which generate sound pressure via a diaphragm or motors with rotors that are moved by an electromagnetic field also belong in this category.
- **Piezoelectric actuators:** The converse of the Piezo effect is used here. This is based on the fact that when a voltage is applied to a piezoelectric crystal, a distortion is created in the length or width. Applications of piezoelectric actuators include printers, speakers, or switches.

¹ http://en.wikipedia.org/wiki/Physical_property

- **Optical and opto-electronic actuators:** Light is emitted by electrical energy. These types of actuators are used for the direct output of illumination such as for spotlights or in optical transmission technology, e.g. in optocouplers, displays, or for image recognition.
- **Magnetostrictive actuators:** The variation in length of ferromagnetic materials in magnetic fields is used here. These types of actuators can be used under high pressures and at high temperatures as very precise final controlling elements in the micrometer range.
- **Electrostatic actuators:** Electrostatic fields are used to move small mechanical parts in micro system engineering. This technology is used in speakers, for moving micro mirrors in optical switches, and in printing technology.

The most important actuators in the amateur field include motors, lamps, speakers, pneumatic cylinders, ultrasonic motors, and diaphragm pumps.

1.2 Open-loop and closed-loop control

As a rule, inputs and outputs are used in control technology.

When dealing with automation engineering, the terms “open-loop control and closed-loop control” are often used. However, what do these terms mean in engineering? This is explained in the standard IEC 60050-351. “Open-loop control” or “closed-loop control” are defined there as follows:

“... Controlling is a process in a system in which one or more input variables influence one or more output variables in a specific way. The flow of information for this is open. A signal is entered in the technical system as an input variable and it shows up at another location in the system as an output variable. This output variable does not influence the input variable in any way.”²

On the other hand, closed-loop controlling is a process “... in which a variable and the control variable (the variable to be controlled) are consecutively recorded, compared to another variable (the command variable), and influenced in terms of harmonization with the command variable.”³

1.2.1 Classification of open-loop control systems

Essentially, all control systems have the same operating principle: An input variable influences an output variable in a system in a targeted manner by means of specific laws. Controls do not make any comparison of input variables and output variables; their action flow is open. Depending on the type of control, a distinction is made between command and program controls (Fig. 1.3).

The distinguishing options of commonly used controls are, for example, the energy of the power supply for the system, the type of signal processing, an analog or digital process, or the controlled variable. As shown in Fig. 1.4, the technical representation of a control is implemented using block diagrams.

^{2,3} Cf. Beuth (2014): DIN IEC 60050-351 – International Electrotechnical Vocabulary

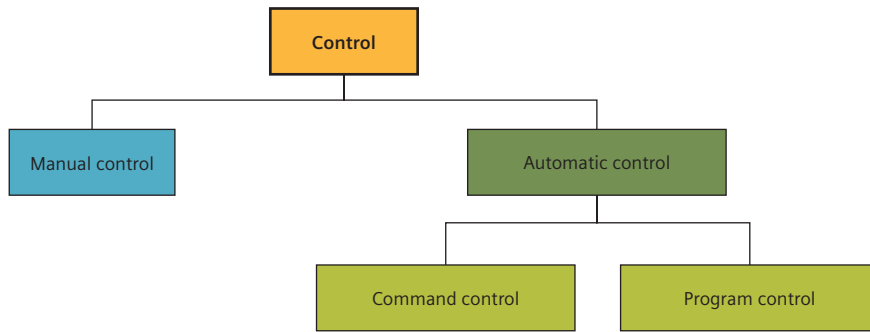


Fig. 1.3 Systematization of the control systems

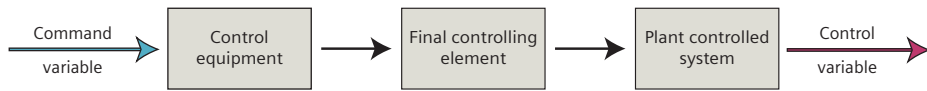


Fig. 1.4 General block diagram of a control system

The simplest form of control is the manual control system. It can be explained using the simple examples of opening a faucet, pressing a button for a doorbell, or steering a bicycle. This is shown in Fig. 1.5.

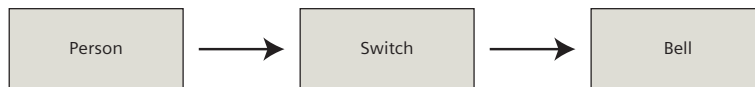


Fig. 1.5 Block diagram of a doorbell system

Automatic controls are more complex and function even without an operator influencing the system. With this type of system, the controlled variables are independently adapted to the specified command variable.

This procedure can be easily illustrated via an illumination system:

As soon if someone enters a building at night, the light is supposed to switch on. The input of the motion detector receives signals. The acquired signals are processed by a circuit. A lamp is connected at the output of the system. Once the detector registers a movement in its detection range, it causes the lamp to switch on. The circuit diagram and block diagram of this system is shown in Fig. 1.6 and 1.7.

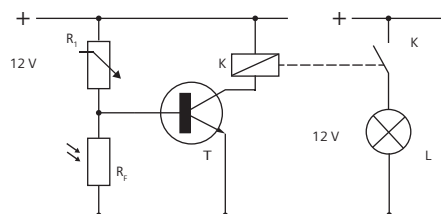


Fig. 1.6 Circuit diagram of an illumination system



Fig. 1.7 Block diagram of an illumination system

1.2.2 Classification of closed-loop control systems

In contrast to an open-loop control system, the variable to be influenced in a closed-loop control system is permanently measured and compared to the setpoint that is saved in the system. When the actual value (control variable) deviates from the setpoint (specified command variable) due to an external disturbance variable, the system responds and corrects itself. To do this, the control variable must be constantly recorded and compared to the command variable:

$$\text{Control deviation} = \text{Command variable} - \text{Closed-loop control variable}$$

This task is generally taken over by an electronic control system or a computer between the final controlling element and the output. If a control deviation occurs between the setpoint and actual value, a control signal is automatically output and the deviation of the values is compensated. The operating principle can easily be illustrated using a heating system as an example:

An operator sets the desired room temperature. The desired temperature is a setpoint, meaning that the temperature in the room should remain at this value. A final controlling element now consecutively checks whether the desired temperature has been reached. The actual room temperature is thus an actual value. If the room temperature is too cold, the final controlling element ensures that more hot water is directed into the heating element. Fig. 1.8 and 1.9 show a schematic of this.

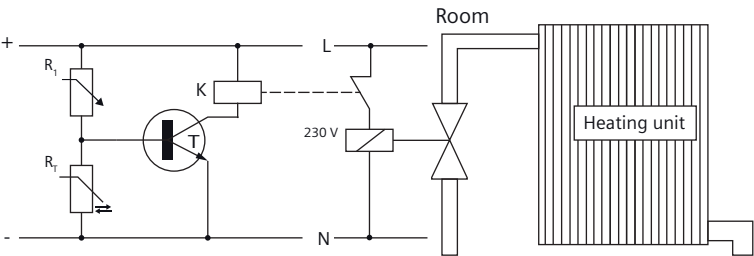


Fig. 1.8 Circuit diagram of a heating control system

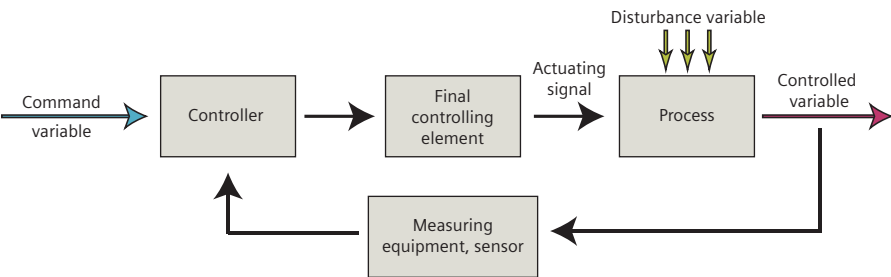


Fig. 1.9 Block diagram of a heating control system

Depending on the type of closed-loop control, a distinction is made between continuous and non-continuous control. For continuous control, an infinitely variable, mostly linear control device is used. For non-continuous control, on the other hand, this is a control unit which, in contrast to the continuous output adjustment, conducts intermittent ON/OFF operation. The diagrams in Fig. 1.10 and 1.11 illustrate this.

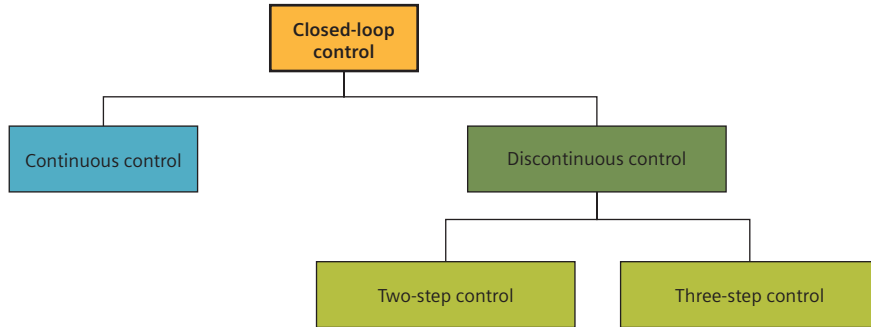


Fig. 1.10 Systematization of closed-loop controls

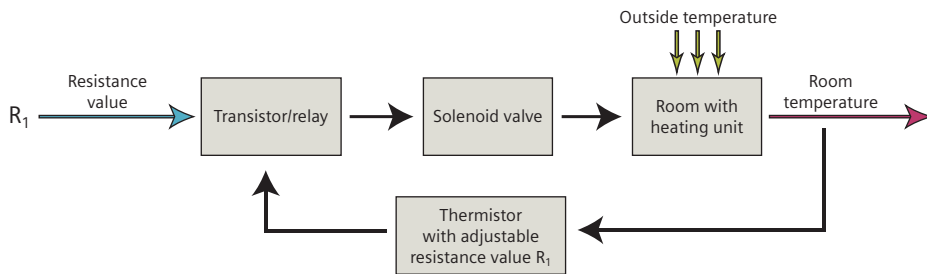


Fig. 1.11 Block diagram of a closed-loop control

In the annex in Chapter 7.1, there is a table displaying signal designations.

1.3 Programmable logic circuits and programmable relays

Automatically executing processes and movements have always been of interest to humans. With the aid of so-called programmable logic controllers (PLCs), a wide variety of processes can be automated and used in many diverse areas of application. More precisely, the LOGO! used in this book (Fig. 1.12) is a mini-controller, a so-called DDC module (Direct Digital Control). This computer-like electronic module is used for open-loop control and closed-loop control tasks for a wide variety of automation tasks.

The control systems of transport systems, elevators, conveyor belts, monitoring systems or house and building technology, heating systems, ventilation systems, and blinds can be implemented using LOGO! with simple technical know-



Fig. 1.12 Basic unit LOGO! 8

how and a minimum of resources. During this, the DDC module has the task of processing signals coming in from the sensors and controlling the actuators depending on the programming, in order to respond to changed environmental conditions.

The program needed for the control is either entered directly on the device via keys or created on a computer with the easy-to-learn and easy-to-use, user-friendly LOGO! Soft Comfort software. When the program is created, a graphical circuit diagram is drawn as function block diagram (FBD) or as ladder logic (LAD) via drag & drop.

The digital logical gates are the basis of the circuit diagram. In addition to the basic digital engineering functions (AND, OR, NOT, etc.), LOGO! Soft Comfort also provides a large number of special functions (e.g. latching relay, ON/OFF delay, operating hours and pulse counter). After a program is created, LOGO! Soft Comfort gives you the option of testing the results in a simulator. If the program meets the requirements, it can be transferred to the hardware via a special interface. Changes and fine adjustments can also be made later using this method or directly on the device via the keys whenever required.

In comparison to other systems or micro-controllers, LOGO! stands out due to the possible cycle frequency, the number of inputs, the individual programming interface, and a multitude of expandable components. The different types and designs of LOGO! and their expansion components can be learned in the Computer based Training (CBS) along with an introduction to working with Siemens LOGO! Soft Comfort. You can find the CBS on the following web site: www.siemens.de/sce/logo