

Uwe Graune, Mike Thielert, Ludwig Wenzl

LOGO!

Practical Training

SIEMENS



Graune/Thielert/Wenzl
LOGO! Practical Training

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by Uwe Graune,
Mike Thielert and
Ludwig Wenzl

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Preface

The LOGO! control relay is being used to an increasing extent in installation technology, and also for simple industrial applications. This is because this mini PLC permits simple implementation of control tasks along with flexible use.

This handbook has a practice-based structure, and is appropriate for trainees, pupils and students as well as technical employees and trainers. In addition to basic "operating instructions", an holistic approach is used to indicate the fundamental procedures when tackling control problems.

At the beginning, programming of the LOGO! control relay is explained by means of a "quick start" using both manual inputs and the LOGO!Soft Comfort software.

Standard situations encountered in control technology are subsequently presented in numerous projects (e.g. interlocks, sequential circuits, safety regulations etc.). Selection of the hardware is considered along with development of the program. The enclosed CD includes a LOGO! demo version. Readers can thus understand the explanations in the book in parallel on a PC, and check using a simulation. The scope of explanations is extremely detailed in the first examples, but is then continuously reduced to the necessary amount.

In the more complex tasks, both the processing of analog values and the connection of LOGO! over the AS-i and EIB bus systems are treated. The comprehensive possibilities offered by the LOGO! control relay are presented here in abbreviated form such that the interest of LOGO! beginners is also aroused.

The following functions of LOGO! are only available with the LOGO! devices starting with release version 0BA6 and with LOGO!Soft Comfort starting with version 6:

- Analog arithmetic operations (Chapter 7.5 Mathematical functions)
- External text display LOGO! TD (Chapter 7.6 and Chapter 8)
- Pulse width modulation (Chapter 7.7 PWM)

All other contents of the book can also be programmed for LOGO! devices of earlier release versions.

The last two chapters of the book are provided for information purposes for the previous project tasks. Detailed reference is made there to control elements, sensors and LOGO! hardware. This part is rounded off by a list of all program commands for LOGO!

The enclosed CD contains the following contents:

- LOGO!Soft Comfort configuring software (demo version)
- LOGO! control programs for the application examples presented in this book
- The LOGO! Manual in eight languages: Chinese, Dutch, English, French, German, Italian, Russian, Spanish, Turkish
- A PDF of a brochure on micro automation and LOGO!

The contents of the book form a training arrangement which directs you toward planned actions in that the steps "Planning" (including documentation), "Implementation" (= programming) and "Checking" (e.g. by means of program simulation) are executed in each project task.

The authors hope you will be able to work successfully with this handbook, and are always grateful to hear your responses or suggestions for improvement.

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LOGO! Practical Training

1 Quick start

1.1 Solving of control tasks with LOGO!

The principle of operation for the control of technical systems with LOGO! control relays can be described in abbreviated form as follows:

Input signals supply the control relay with information on the current state of the process and any operator commands. The control relay reacts to these input signals in accordance with a defined program. It then generates output signals which influence the process in the intended manner via actuators (final control elements).

Small control tasks can be solved using programmable control relays with a minimum of hardware. It is possible to learn and apply the required programming knowledge extremely easily. The following example is a direct introduction to the programming of LOGO!

The control sequence is defined by a corresponding **program** in the memory of the LOGO! device. There are **two different ways** to enter the program. These two programming methods are described in brief below.

Programming of LOGO! control relays

- a) Input of program directly on the device or b) Generation/transfer of program using PC



Fig. 1.1 Programming using manual inputs

The LOGO! basic module can be programmed **directly** on the device without particular effort. The six existing keys and the LCD are used.

When pressing a key, users are provided with menu prompting which allows the input or deletion of a program, parameterization of characteristic values, etc. A **PC is not required!** The program is output on the display in the **Function Block Diagram (FBD)**.

This diagram corresponds to the FBD language used for PLC programming. Logic operations, timers, counters etc. are displayed as rectangular blocks. Only one block can be output on the display at a time, and jumping to other blocks is possible using arrow keys. This programming technique is described in Chapter 1.5.

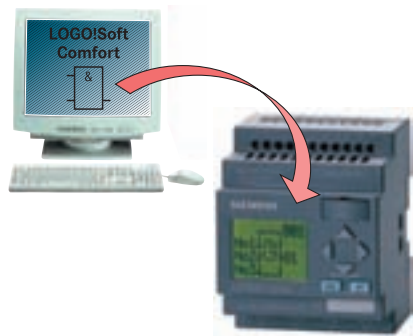


Fig. 1.2 Programming using PC

The LOGO!Soft Comfort software allows a clear display of the complete program on the screen. Following generation and the simulation test, the finished program can be transferred via cable to the LOGO! basic module. An online test permits monitoring of control signals during operation of the device. The LOGO!Soft Comfort software can display programs in the following two ways:

- a) **Function Block Diagram (FBD)**.
- b) **Ladder (LAD)**

The LAD display is referred to in PLC programming as the ladder diagram. It is very similar to a circuit diagram, and therefore represents control programs in an extremely clear manner. This programming method is described in Chapter 1.6.

1.2 Description of control task

Customer orders are assembled on pallets in the warehouse of a wholesale company for sanitary requirements. In the area in front of the warehouse, orders ready for dispatch are transported on a pallet conveyor system (chain conveyor) to the truck ramp (Fig. 1.3).

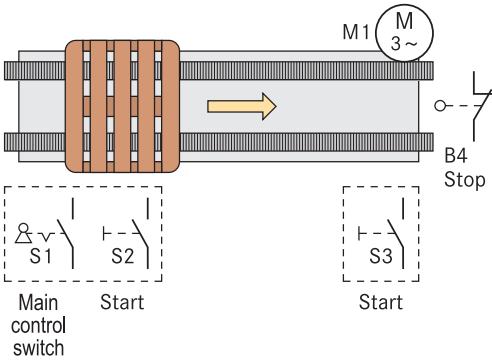


Fig. 1.3 Process schematic of the conveyor system

Control sequence:

The two keys S2 and S3 permit transportation of the pallets in so-called jogging mode. The pallets are only transported further if at least one of the start keys is kept depressed.

The pallets are transported into the end position where they activate the limit contact B4 ("end switch"). B4 prevents a pallet from being unintentionally transported beyond the end position and thus falling off. Switching-off of the master switch S1 suppresses all movements of the chain conveyor drive.

The control task which has just been described was previously executed as a hardwired control system. The circuit diagram of the control circuit is shown in Fig. 1.4.

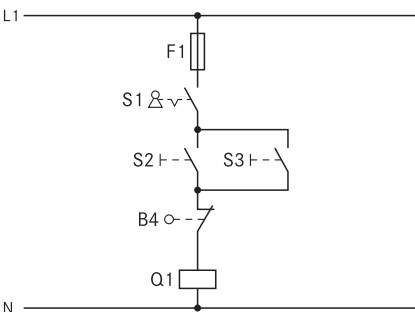


Fig. 1.4 Previous control circuit as hardwired control system

1.3 Implementation of control task with LOGO!

Since the warehouse of the wholesale company for sanitary requirements is to be modernized, this is an appropriate time to replace the previous conventional contactor controls. For the pallet conveyor system, the decision is made by the commissioned electrical company to use the LOGO! programmable control relay.

Application of the control relay provides the user with numerous expansion options for special functions which are already integrated in the device, meaning that no additional hardware costs arise.

Examples can be mentioned here:

- Recording of quantities
- Operating hours counter
- Time functions
- Bus communication (only special modules)

Further chapters in the book provide comprehensive information on the numerous special functions of the LOGO! devices.

In addition to the special functions, such types of control relays can be reprogrammed rapidly and simply. Therefore changes in functions can usually be carried out without modification of the hardware (rewiring).

This increases the flexibility and economy of transportation procedures and production processes. Conversion of the existing, conventional control system to LOGO! is carried out by connecting all previous sensors and control elements individually to the input side. In this case these are the master switch S1, the keys S2 and S3, and the limit contact B4. Assignment: S1→I1 ... B4→I4. The motor contactor (=actuator) is connected to the output side of the logic module (Fig. 1.5). The linking between the input and output sides is carried out by the con-

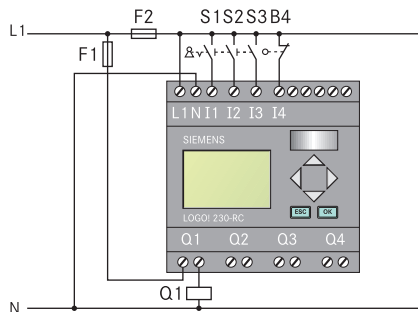


Fig. 1.5 Connection diagram of control system with switching relay

trol program. This is developed on the following pages (Chapter 1.4).

1.4 Generation of LOGO! program

The two start keys are connected in parallel in the circuit diagram. Since the activation of one of these two keys is sufficient for starting, this parallel connection represents **OR logic** (Fig. 1.6) which must also be integrated accordingly in the LOGO! program.

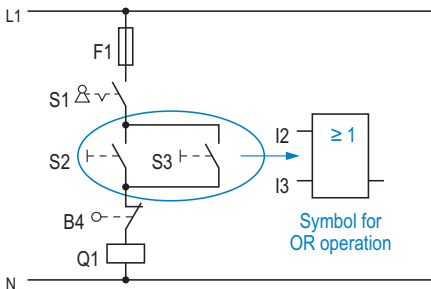


Fig. 1.6 OR logic of contacts

The master switch S1 and the limit contact B4 are connected in series to the start keys. In order to activate the motor contactor, S1 and B4 must also be closed in addition to a start key (Fig. 1.7).

Series connections are implemented in the logic diagram by **AND logic**. Therefore S1, B4 and the OR logic meet in a common AND logic.

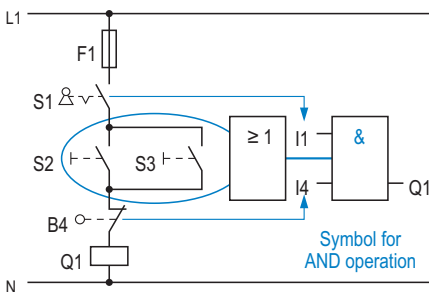


Fig. 1.7 AND logic of contacts

Function analysis: Q1 switches if S1 is activated **AND** (S2 **OR** S3 is activated) **AND** S4 is not activated.

It is recommendable to produce a sketch of the control program prior to direct input in the logic module. This provides you with a clear over-

view during the input, and facilitates documentation and troubleshooting.

Furthermore, an assignment list (cf. Chapter 2.2.2) is extremely helpful, especially with comprehensive control tasks.

This lists the input/output objects which have been used. This list defines the input/output of the control relay to which the objects are connected.

1.4.1 Function block diagram (FBD)

Manual input of the program into the logic module is carried out in the display mode "FBD" (Function Block Diagram).

The individual logic operations are implemented using so-called blocks. In our case, the program consists of two blocks (B1, B2) with simple logic operations.

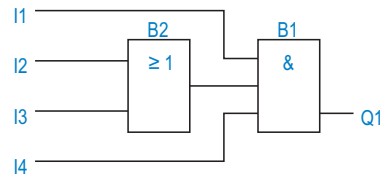


Fig. 1.8 LOGO! program in function block diagram

1.4.2 Ladder diagram (LAD)

Either the display mode FBD (see above) or LAD can be selected when generating the program with LOGO!Soft Comfort. The **Ladder diagram** is relatively similar to the circuit diagram. This display mode is also referred to in PLC programming as the ladder diagram. The parallel connection of contacts is implemented in LAD through parallel arrangement of the inputs (I2, I3). The series connection of contacts (I1, I4) is carried out analogous to the circuit diagram.

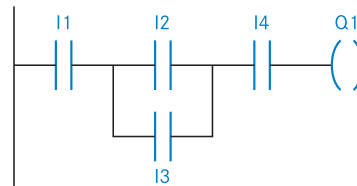


Fig. 1.9 LOGO! program in ladder diagram

Note: The conveyor must only move if NC contact B4 is not activated. A "1" state is then present at I4, thus permitting tripping of the AND logic. Input I4 must therefore be scanned for the idle state "1", i.e. non-inverted.

1.5 Program input directly on LOGO! module

1.5.1 Calling of editing mode

Direct input of the control program on the LOGO! module is used if a PC with the LOGO!Soft Comfort programming software is not available. This can be the case, for example, with small changes or extensions to the program. The input is then carried out directly using the six keys on the control relay. The input is checked using the device's display.

When switching on the LOGO! module, one of the following two messages is output on the display. You can recognize on the display whether the memory is empty or whether a program is already stored there.

To enter a switching program, you must change to **"Programming" mode**. To change to this mode, you must first press the **"ESC"** key.

Note: With earlier devices (up to 0BA2), it is necessary to press the following three keys simultaneously:
OK; ⬅; ➡ (= 3-finger action)
 The menus of earlier devices (up to 0BA4) also differ slightly.

The cursor arrow (>) is moved to the menu items using the up/down keys (▲; ▼). The individual menu items are then selected using the "OK" key. "ESC" is used to return by one menu level.

Once you have accessed the **main menu** in the manner shown on the right, you can

- delete existing programs and subsequently generate new programs,
- edit existing programs in order to check, supplement or modify them.

If an existing program is to be deleted completely, select **"Clear Prg"**. You can subsequently use "ESC" to return to "Edit", and can then enter a new program.

Selection of "Edit" in the **programming menu** opens up the path for generation or modification of control programs in the logic module's memory.

If a password already exists, this must be entered before editing of the program can be started (arrow keys).

Once "Edit Prg" (Fig. 1.10) has been confirmed with "OK", the output Q1 appears in the display as the first part of the program.

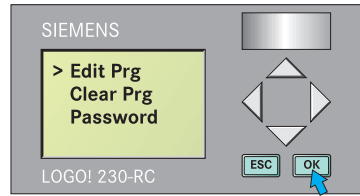
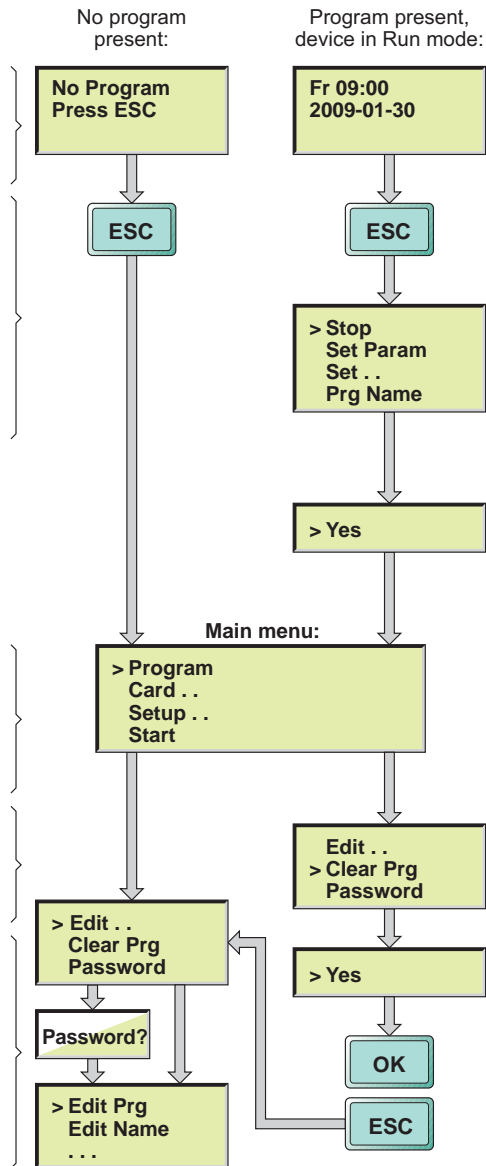


Fig. 1.10 Programming menu



1.5.2 Manual input of program

Commencing with output Q1, the program is entered "backwards" (= in the direction of the inputs). Q1 is confirmed using the "OK" key.

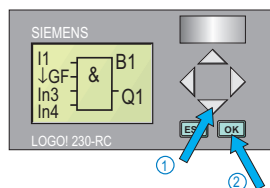
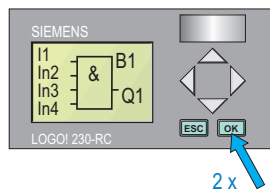
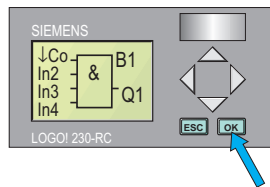
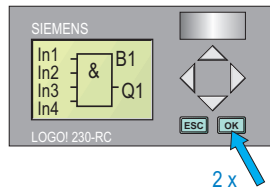
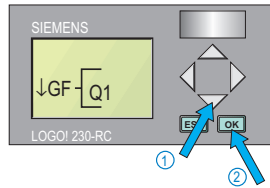
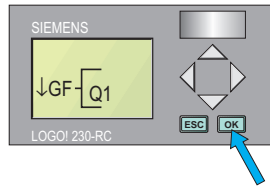
The list "GF" (= basic functions) is subsequently selected using the arrow key ↓ ① and confirmed with "OK" ②.

You then jump to the program input for block 1 (B1), as output at the top of the display. The first block of the GF list is the "&" function. This is selected using "OK".

Once the top input of the & operation has been selected with "OK", "Co" (= connector) is displayed there. Confirm with "OK" to subsequently position the input I1.

Connector I1 appears at the top & input. Confirm the selection of this input using the "OK" key.

The second & input is selected using a further "OK". With the arrow key ↓ ① the "GF" list is obtained. Confirm this selection with "OK" ② in order to subsequently insert the OR logic.



Block 2 (B2) is then shown in the top right corner of the display. The OR logic is selected using the arrow key ↓ ① and then confirmed with "OK" ②.

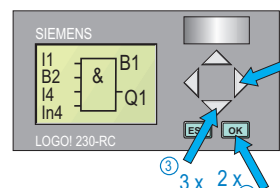
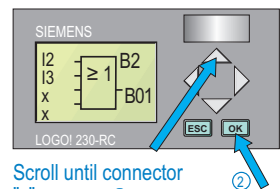
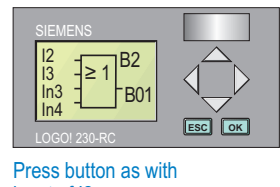
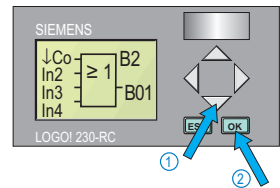
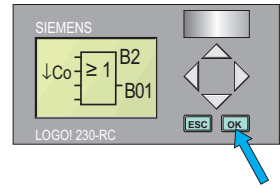
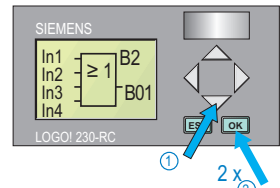
Following repeated pressing of "OK", the top input of B2 can be connected. Since a connector (I2) is to be connected here, confirm the display "Co" with "OK".

Scroll in the "Co" list using the arrow key ↓ ① until input I2 appears. Confirm this with the "OK" key ②.

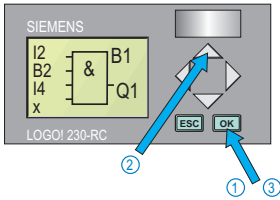
Proceed in the same manner with connector I3 as just described for I2.

The two bottom connections of the OR logic are not required and are therefore connected to "x". Once the inputs of "x" have been completed with the "OK" key ②, return to block 1.

Moving within the program is carried out using the arrow keys, in this case with → ①. Select the next input by pressing "OK" twice ②. Press the arrow key ↓ three times in order to display connector I4 ③.



Finally, the bottom input of the & operation must be connected to "x" since it is not required. Select the input by pressing "OK" twice ①. Press the arrow key ↑ until the connector "x" is displayed ②. Confirm again with "OK" ③.



The program for the pallet conveyor system has now been entered completely. All inputs of the logic have been connected, and editing mode can be left.

1.5.3 Activation of RUN mode

In order to test the program, the LOGO! device is set to Run mode using "Start" (Fig. 1.11).

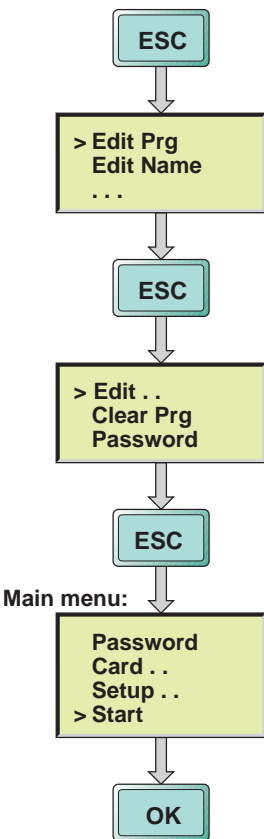


Fig. 1.11 Starting the program in Run mode

1.5.4 Program test

In order to test the program, the contacts connected to the LOGO! device must be set such that Q1 is triggered. The status of the inputs/outputs can be checked by showing them on the display using the arrow key ►.

Note: The outputs should be switched voltage-free during the program test in order to avoid damage in the case of program errors.

If the program is not executed properly, proceed as follows when making changes.

Note: In editing mode, the cursor can be freely moved within the program using the arrow keys (▲; ▼; ◀; ▶).

It is then possible to carry out **changes to the program** even following completion of the input.

To do this, the LOGO! must be set to the STOP state, and the editing menu must be called.

In order to **delete parts of the program** (Fig. 1.12), the cursor must be positioned on the right (in the direction of the output) of the objects to be deleted ①.

The corresponding position is activated with "OK" and connected to a connector "x".

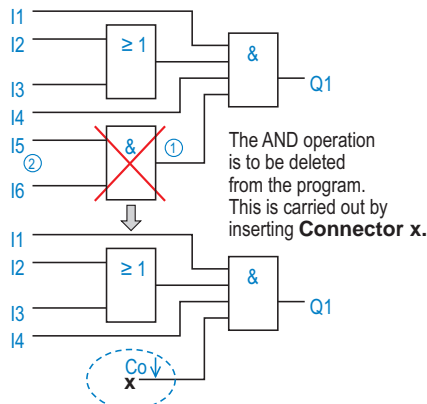


Fig. 1.12 Changing and deleting parts of the program

The & logic ① as well as the two inputs I5, I6 ② have been deleted from the program. If desired, other objects (Co, GF or SF) can be inserted at the position of "x". It is therefore very simple to change existing programs in this manner.

1.6 Programming with LOGO!Soft Comfort

The LOGO!Soft Comfort software is used for

- generation,
- simulation and online test,
- documentation

of switching programs using the PC.

When the program is started (Fig. 1.13), a blank start screen is initially displayed (Fig. 1.14).

The switching programs are transmitted via a cable to the LOGO! control relay following generation on the PC. During startup, the status of the variables can be monitored on the PC in Run mode.

The demo version of LOGO!Soft Comfort has the complete scope of functions for software generation and simulation. The only limitation compared to the full version is that online communication with LOGO! devices is disabled.

1.6.1 Use of LOGO!Soft Comfort

A "circuit diagram" must be opened in order to generate a new switching program. To do this, press the "New" button (Fig. 1.15, ①). This circuit diagram is displayed as standard in FBD format (function block). The "Properties" window ② is opened at the same time as the circuit diagram. The project data can be entered in this window. Definition of this project data (Chapter 2.3.1) is initially ignored here. Therefore the window can be closed using "Cancel".

The individual elements of the circuit diagram are subsequently inserted. To do this, the catalog with the elements of the switching program is opened in the left margin of the screen (Fig. 1.16, ③). It could be the case that this window is so narrow that it is not even visible. The width must then be increased by dragging with the mouse (Fig. 1.16, ④). The catalog contains all elements available in LOGO!Soft which can be used to generate the program.

To insert the elements, select the desired objects in the catalog. The output terminals Q are marked in Fig. 1.17 ⑤. There are two methods for inserting the elements ⑥:

- by dragging & dropping into the circuit diagram

or

- by inserting by mouse click into the circuit diagram.



Fig. 1.13 Desktop symbol of LOGO!Soft Comfort

Start
LOGO!Soft
Comfort

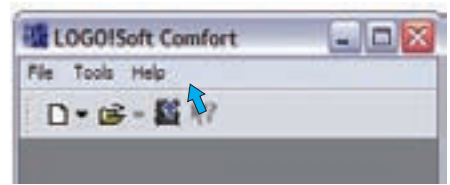


Fig. 1.14 Start screen of LOGO!Soft Comfort

Open
circuit
diagram

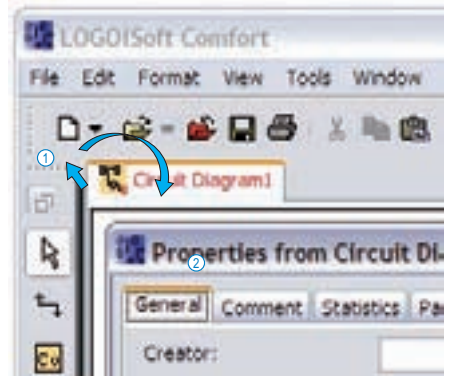


Fig. 1.15 Opening a new circuit diagram

Open
catalog

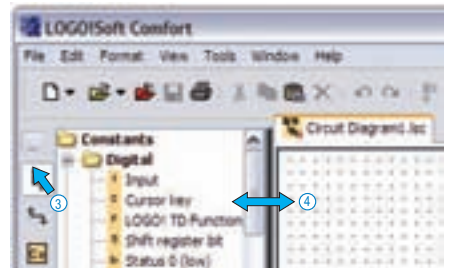


Fig. 1.16 Opening the catalog with the elements

Insert
outputs

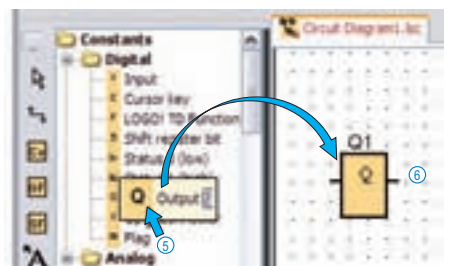


Fig. 1.17 Inserting the output terminal Q1

In order to control the pallet conveyor system, the four input terminals I1...I4 and the output Q1 must be provided in the circuit diagram.

There are two methods for inserting elements in LOGO!Soft:

- selection of the elements in the object overview of the catalog ① or
- selection list "Constants" in the bottom margin of the screen ②.

This selection list is displayed by clicking the "Constants/terminals" button ③ on the left margin of the screen.

The output and input terminals are now to be connected using logic operations.

The elements required are located in the catalog "Basic functions" ④. To control the pallet conveyor system, both AND logic and OR logic are required.

The AND logic is positioned in the circuit diagram by activating the "AND" element and by a mouse click. Insertion of the OR logic is carried out in the same manner ⑤.

The terminals of the elements can be connected together by clicking the "Connect" button ⑥. These connections define the signal routes, and thus the control function.

The connection between the individual terminals is made with the mouse button pressed ⑦.

The basic logic operations (AND, OR) have four connections on the input side as standard.

The connections which are not required can remain open ⑧, they are not involved in the logic. Since the vacant OR inputs have the status "0" and the vacant AND inputs the status "1", they do not influence the function of the circuit.

- In order to drag lines between the elements, the "Connect" button Fig. 1.21) must be selected.
- The "Selection" button (Fig. 1.22) allows elements and lines to be selected, and to shift or delete these.

Insert inputs and outputs

Insert basic functions

Connect elements

Save program

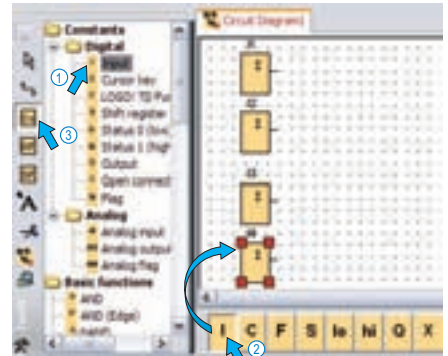


Fig. 1.18 Insertion of input terminal I1 ... I4

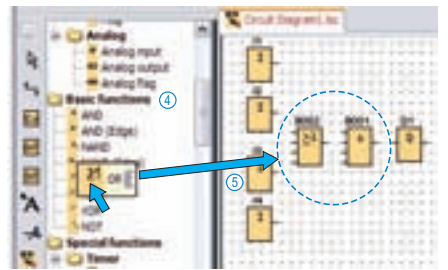


Fig. 1.19 Insertion of basic functions AND/OR

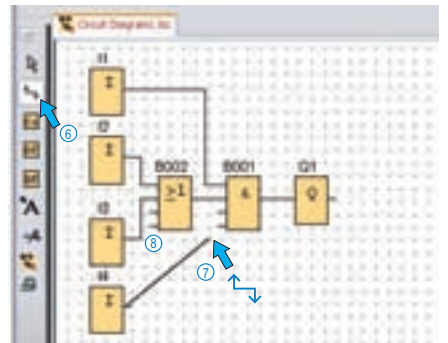


Fig. 1.20 Establishment of signal connections



Fig. 1.21 "Connect" button



Fig. 1.22 "Selection" button

1.6.2 Simulation with LOGO!Soft Comfort

The LOGO!Soft Comfort programming software makes it possible to test programs by simulation even without hardware (control relays).

To do this, the "Simulation" button must be clicked following complete input of the program (Fig. 1.20 and Fig. 1.22, ①).

Simulation switches for adjusting the input signals are then displayed in the bottom margin of the screen. Signal lamps indicate the initial statuses (Fig. 1.21).

Elements and signal lines with a "1" signal are emphasized in red (Fig. 1.22, ②). In the case of outputs with a "1" signal, the associated display lights up in the bottom margin of the screen ③.

The program reacts to the simulated input signals in exactly the same manner as would take place in the real plant.

The three inputs I1, I2 and I4 (Fig. 1.21) have a "1" signal. This corresponds to the status of the contacts in the real plant during transport mode. Output Q1 is triggered, resulting in a motion of the motor.

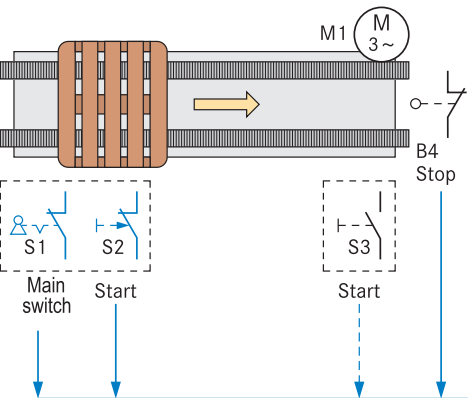


Fig. 1.19 Pallet conveyor system with contacts activated

The program can be saved once it has been checked using the simulation.

The saved program is then available for use at a later date. Programs are saved in order to transfer them later (e.g. on the plant) into the control relay. In addition, saving of programs is significant for backup and documentation purposes.

Saving is carried out – as usual with Windows – using the diskette symbol (Fig. 1.23, ④).

A new window is then opened in which the drive ⑤ and the file name ⑥ can be defined.



Fig. 1.20 "Simulation" button

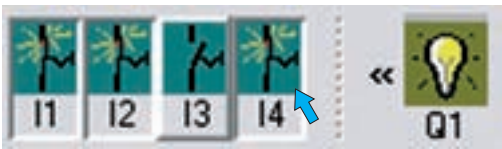


Fig. 1.21 Simulation switch and display of output statuses

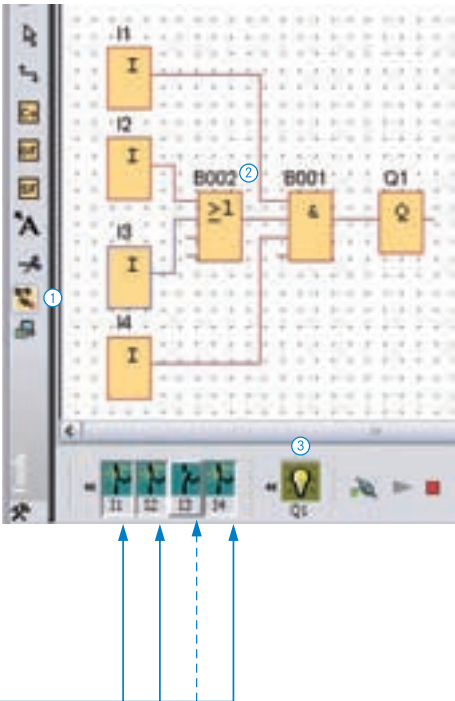


Fig. 1.22 Simulation of the control program for the pallet conveyor system

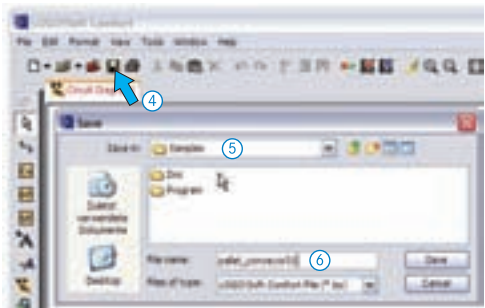


Fig. 1.23 Saving of the control program

2 Shading of a conservatory

The shading of a conservatory roof was previously driven by a crank handle. A storm damaged the blind to such an extent that it had to be replaced.

The manufacturer advises the owner to fit an electric drive (pipe drive). The company will fit the drive, and plan and install the associated control system.

During a site visit, the company informs the customer about appropriate comfort and safety functions. These possibilities are recorded as the basis for further planning.

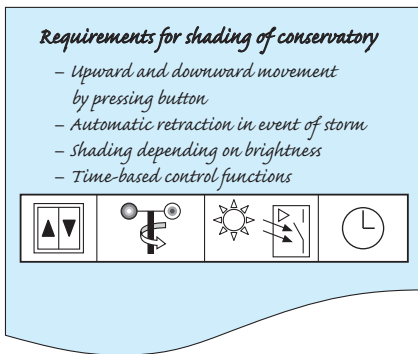


Fig. 2.1 Operating, safety and comfort functions associated with the shading of conservatories

What is the procedure for planning and implementing a control task?

The basic procedure for solving control problems is to be explained using the example of the blind control.

The implementation sequence is shown in Fig. 2.3. The first step – the task analysis – is extremely important, since many points have to be observed here such as customer wishes, ambient conditions, technical conditions etc. The weighting of conditions which are sometimes contrary to one another has a decisive influence on selection of the hardware components and the structure of the software. The relationship between hardware and software is coordinated during commissioning, and the system is optimized in that faults are eliminated. The target is to provide the control functions agreed upon with the customer within the defined deadline without fault, and to document them.

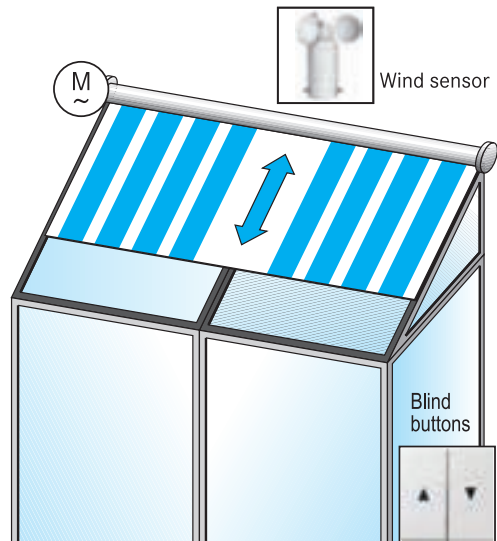


Fig. 2.2 System for shading of conservatory

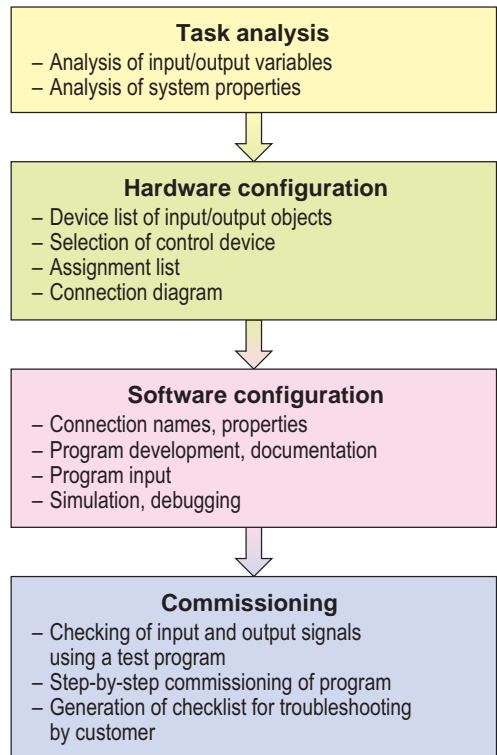


Fig. 2.3 Steps for project planning and implementation

2.1 Task analysis

The shading of a conservatory represents a **technical system** consisting of blind, electric drive and associated control technology. The sequence of the control process is influenced by the operator and by the ambient conditions (wind, sun) (Fig. 2.4).

What is controlled?

The position of the blind determines the amount of light entering the conservatory. If this variable is influenced by the control process, it is referred to as the "controlled variable x " (Fig. 2.4).

In the case of a conservatory, the controlled variable is understood to be

- physically: the incidence of light,
- technically: the position of the blind.

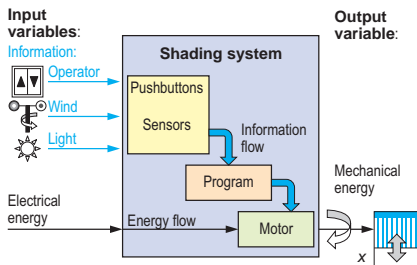


Fig. 2.4 System for shading of conservatory

The **input variables** provide the "System for shading of conservatory" with information concerning operator commands and environmental conditions. This information is processed in the system, and influences the **output variable** (movement of blind). The passing on and processing of the information in the system is referred to as the **information flow** (Fig. 2.4).

In order to move the blind, electrical energy is converted in the system into mechanical energy. The conversion of energy in the system is referred to as the **energy flow** (Fig. 2.4).

The following information blocks explain the most important control terms:

- Systems
- Energy flow and information flow
- Functional sequence, control sequence

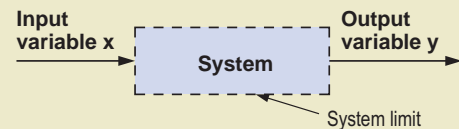
Such a detailed analysis of the control sequence will only be carried out in an exemplary manner in this first task. With subsequent tasks, it will be assumed that readers understand these relationships.

Term: System

The **system technology** is a consideration with which complicated technical relationships can be represented in a simplified manner. Plants, machines and other technical equipment are investigated as systems. The **system limits** represent the separation between the considered system and its environment. In real systems, these limits can be e.g. electrical and mechanical connections or data interfaces.

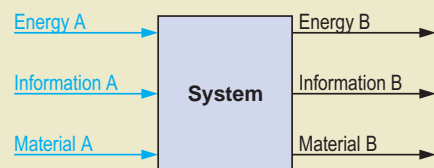
The exchange of information between the system and the environment is carried out using input and output variables. The **input variables** are processed by the system when they arrive, in that they are converted, modified or saved. The **output variables** produced in this manner represent the reaction of the system to the input variables.

Simplified representation of a system



The input and output variables of systems can be divided into three fundamental categories: energy, information and materials.

Input and output variables of systems



Depending on the system, the main function is the processing of one of these three variables.

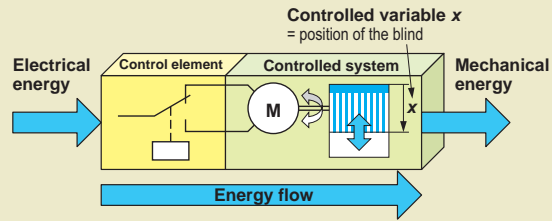
In order to control the conservatory blind, information from the environment must be recorded and subsequently processed in the system. On the basis of these recorded input signals, energy is produced to drive the blind.

The handling of materials (e.g. gases, liquids, granulates, parts) is not involved in the control of the blind. However, the control of materials (**material flow**) is of great significance in most transport and production procedures.

Energy flow

In order to control the movement of the blind, energy is applied to the pipe drive via the so-called "final control element" (e.g. contactor, semiconductor switch).

The pipe drive motor (= controlled system) converts the applied electrical energy into mechanical energy, and thus changes the position of the blind (= controlled variable x). The control system for driving the blind thus changes the flow of energy in the system in order to set the desired shading.



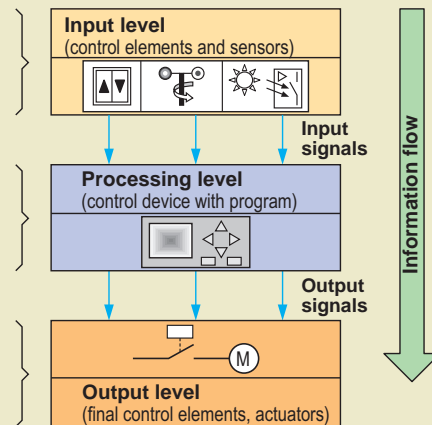
With control processes, **controlled systems** (= system components) are influenced by final control elements such that the controlled **variable x** responds in the defined manner.

Information flow

The flow of energy is controlled depending on the operator commands and ambient conditions. This incoming information is processed in the system, and leads to reactions on the output side.

- **Input objects** are control elements and sensors for recording the system information (wind and sun in this case). The operator commands and system information are converted by the input objects into standardized control signals and passed on to the processing level.
- A **control device** links the incoming signals in accordance with predefined rules (= program) and generates corresponding output signals.
- **Output objects** (actuators) act upon the controlled system as final control elements, and influence the controlled variable x by appropriately changing the energy or material flows.

The flow of information is carried out in accordance with a principle which describes the Input, Processing and Output of signals.

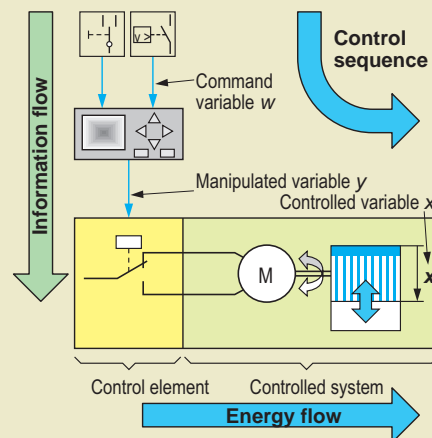


Control principle (control sequence)

Energy and material flows are controlled on the basis of the information flow between the control components.

- Control elements and sensors provide the control device with data for the control sequence. Such input variables are referred to as **command variables w** .
- The control device generates the **manipulated variable y** and uses it to control the final control elements.
- The final control elements (actuators) act on the flow of energy or material in the **controlled system** and thus influence the **controlled variable x** in accordance with the defined program.
- Characteristic of a control procedure is the open function in the form of a control sequence.

- A comparison between the setpoint and actual value of the controlled variable x is not carried out.



2.1.1 Analysis of input and output variables

When selecting the control equipment, it is necessary to exactly define **what is to be recorded and output**. The input and output objects required are derived from this analysis of the input and output variables.

The number and type of input and output objects are based on the technical requirements and the customer wishes.

The following input objects are required:

- Double rocker contact (Fig. 2.5 and Fig. 2.6, ①, ②)
- Limit contacts for end positions (Fig. 2.6, ③, ④)
- Wind sensor (Fig. 2.5 and Fig. 2.6, ⑤)

The motor of the blind is directly connected as an output object to the outputs of the controller since the load current is below the maximum inductive load current of 3 A.

The input and output objects required are entered in a process schematic (Fig. 2.6) following inspection of the system.

2.1.2 Definition of system properties

Until now, it was examined which input and output objects are required for controlling the blind. However, it has not yet been defined **HOW** these objects are to be linked.

The definition of the system properties indicates how the individual components or subsystems within a system are to work together.

These requirements therefore represent the starting point for development of the software (e.g. manual or automatic mode).

How should the control procedures be executed?

First of all, only manual operation of the blind and automatic retraction in the event of a storm are to be controlled. It should be possible to later extend to automatic shading depending on the brightness. It should be possible to activate this automatic mode as an option (Fig. 2.7).

Using contact S1, it is possible to move the blind upwards (Fig. 2.5 and Fig. 2.6, ①) or downwards ② in manual mode. This contact has a double rocker with reverse blocking. This mechanical lock prevents simultaneous activation of both switch contacts. The reversible drive is switched off at the latest in the two end positions by the limit contacts B5 ③ or B6 ④.

If a limit value for the **wind speed v** is exceeded, the wind sensor B4 (Fig. 2.5 and Fig. 2.6, ⑤) outputs a binary signal. The blind can then be retracted in the event of a storm, or its extension is prevented in this case.

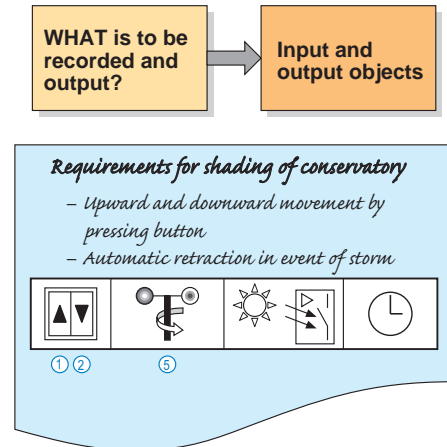


Fig. 2.5 Definition of the input and output objects

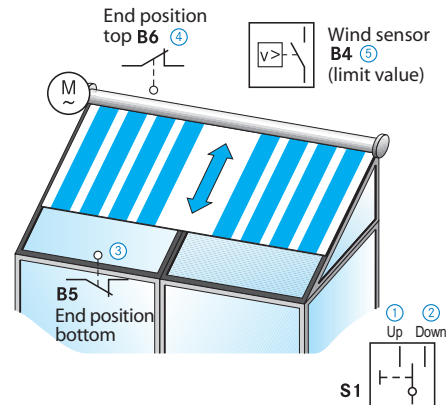


Fig. 2.6 Process schematic with input and output objects

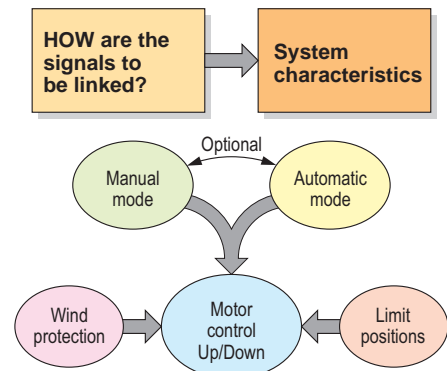


Fig. 2.7 System properties of the blind control

2.2 Hardware configuration

2.2.1 Selection of control relay

LOGO! control relays have a large scope of basic and special functions which are available to the same extent in all basic devices (cf. Chapter 9).

When selecting the device, the number and type of input signals (contacts) and output signals play a decisive role.

- How many contacts are to be connected to the LOGO! control relay?
- What signal and operating voltages do the contacts use? (binary or analog, voltage level)
- How large are the voltage and current of the actuators to be connected?

To assist selection of the hardware, a device list (Fig. 2.8) of the connected objects is produced. In this list it is recorded if the object has to be connected to an input (**DI** = Digital Input) or to an output (**DO** = Digital Output).

Object	Object desig.	LOGO!	
		DI	DO
Blind contact UP, rocker left	S1	X	
Blind contact DOWN, rocker right	S1	X	
Brightness sensor (planned, spare)	B3	X	
Wind sensor, limit monitoring	B4	X	
End contact, blind extended	B5	X	
End contact, blind retracted	B6	X	
Motor control, extend blind	Q1		X
Motor control, retract blind	Q2		X
Circuit-breaker control fuse B 6 A	F1		
Circuit-breaker load fuse B 6 A	F2		
LOGO! Basic 230RC	K1		
Number of digital inputs required		6	
Number of digital outputs required			2

Fig. 2.8 Device list for blind control

LOGO! control relays are available with various signal voltages (12 V, 24 V, 115/240 V) for AC or DC.

LOGO! basic devices have eight digital inputs and four digital outputs. These are usually designed as relay contacts (identified "RC"). Relay outputs can be loaded with currents up to 10 A, older devices have smaller load currents.

The LOGO! 12 V and 24 V DC devices are special cases. They have eight binary inputs, of which I7 and I8 can be used as analog inputs. Instead

of the usual relay outputs, one version of these control relays has four transistor outputs whose output voltage is 24 V at max. 0.3 A. Further information on device selection can be found in Chapter 8.2.

According to the device list (Fig. 2.8), the following objects are required to control the blind:

- 6 digital inputs (DI) and
- 2 digital outputs (DO).

No analog signals need be processed, and therefore no analog inputs are required.

Since all input objects provide a voltage of 230 V, a **LOGO! Basic 230RC** control relay is selected. This has eight digital inputs (DI) and four digital outputs (DO) (Fig. 2.9).

LOGO! basic module									
Versions		Basic		Pure		Clock		Digital	
		With keypad	Without keypad	With keypad	Without keypad	With	Without	8 inputs	4 outputs
		With display	Without display	With display	Without display	Transistor	Relay	Digital	Analog
	AC/DC								
24 V	DC								
12 V/24 V	DC								
115 V/240 V	AC/DC	X						X	X

Fig. 2.9 Configuration matrix for LOGO! Basic devices

The selected control relay (Fig. 2.10) offers the following advantages for the task of controlling the blind:

- Relay outputs which can be loaded with 230 V/3 A inductive. This permits direct control of the blind motor (without motor contactor)
- The operating and control voltage of

115 V/240 V corresponds to the line voltage of 230 V. Since a 24-V power supply unit is not required, the device costs are relatively low.



Fig. 2.10
LOGO! Basic 230RC for
controlling the blind

stead of Q1). They contain the object ID, and possibly also a brief description and the function of the contacts (NO/NC).

The connection table is opened by selecting the menu "Edit" → "Input/Output Names".

2.3.2 Program for manual mode

In order to program the LOGO! control relay, the switching program is initially developed according to the control task. A first step to this end can be a draft on paper.

However, the program is usually produced directly using the LOGO!Soft Comfort software on a PC/notebook. Correct functioning of the program can then be directly checked per simulation. Any errors can thus already be corrected in advance.

To start up, the debugged program is transferred by cable from the PC/notebook to the memory of the control relay.

Program development

The blind is initially only to be driven up and down in manual mode using contact S1, and integration of the wind sensor is to prevent storm damage.

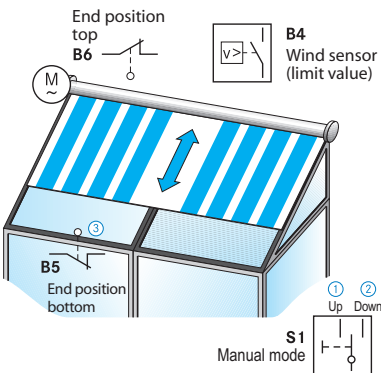


Fig. 2.15 Contacts for control of manual mode

When developing the program, the following conditions must be observed:

- **Jogging mode:** The blind is only moved up or down as long as the double rocker contact S1 (Fig. 2.15, ①, ②) is activated.
- When the contact is released – or at the latest when one of the two end positions is reached – the motor stops.
- The end contacts B5 and B6 are designed as NC contacts. Therefore an interruption in the

signal lines results in automatic stopping (broken wire safety).

- **Wind sensor:** If the wind speed is above the permissible limit, the blind is rolled up, and driving down is not possible with a wind alarm.

Once you have started the LOGO!Soft Comfort software and subsequently defined the "Properties" and "Connection names" (Chapter 2.3.1), the control program is now to be created in the function block diagram (FBD).

Proceed by entering the connectors (inputs I, outputs Q) as described in the Quick start (Chapter 1.6.1). The individual inputs are inserted in succession from I1 to I6 by clicking the "Input" symbol with the element catalog ③ open. Proceed in the same manner for the two outputs Q1 and Q2.

In order to display the object catalog, click the "Restore/Minimize" button ④.

Once the inserted elements have been assigned a connection name in the connection table, they are displayed next to the respective blocks in the program ⑤.

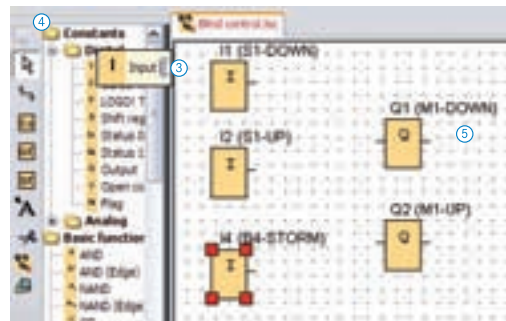


Fig. 2.16 Inserting the connectors

The inserted connectors must then be linked to the outputs by means of the switching program; to do this, click the "Connect" button ⑥.

Since the program to be implemented works in jogging mode, only logic operations are required (AND ⑦, OR).

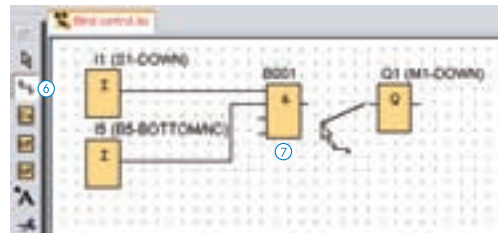


Fig. 2.17 Connecting objects

Inverting of signals

Input I4 (wind sensor) must be inverted, since the blind must only be driven when a wind alarm does not exist. The wind monitor then has the "0" state. Inversion of input I4 can be carried out either by double-clicking ① the associated & input or as a separate block (basic function ②).

Downward movement (Fig. 2.18)

The blind can only be moved downwards with S1 ③ when

- the NC limit contact B5 ④ is **not activated**, so that it has the "1" state **and**
- the wind sensor B4 ⑤ is **not activated and**
- the UP contact at I2 ⑥ is **not activated** (contact locking).

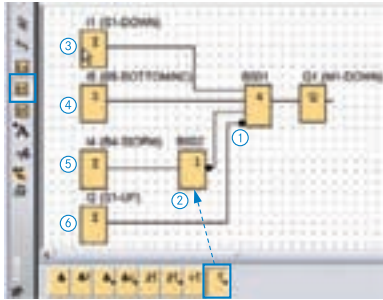


Fig. 2.18 Program for downward movement of blind

Upward movement

The blind moves up if

- the wind sensor B4 ⑦ is activated **or**
- the input I2 ⑧ is triggered using contact S1, where the two directions are mutually interlocked, and therefore I1 is scanned **negated** ⑨ and
- limit contact B6 ⑩ must **not be activated** ("1" state).

The AND logic ⑪ is then switched through (see Fig. 2.19).

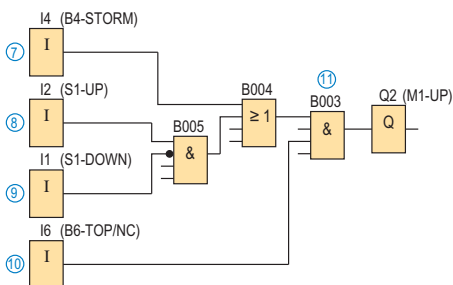


Fig. 2.19 Program for upward movement of blind

Complete program for manual mode

The two parts of the program described in the left column are combined below into the complete program (Fig. 2.20). Since connectors can only be inserted once in the program, a number of inputs must be branched.

The two inputs I1 and I2 must not be activated simultaneously, to ensure that Q1 and Q2 cannot be activated simultaneously. The changeover contact used has mechanical "reverse blocking" which suppresses simultaneous triggering of upward and downward movements by means of mechanical interlocking. Nevertheless, the two inputs I1 and I2 are also mutually locked in the program. The program is therefore also protected against faulty operations if other contacts are connected.

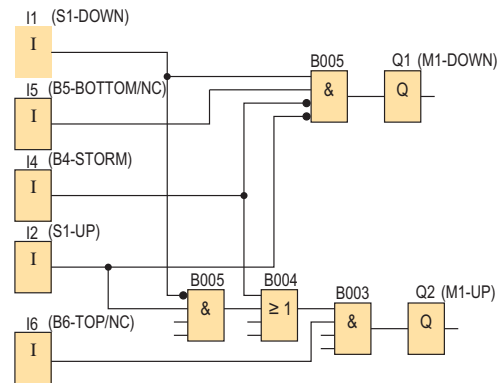


Fig. 2.20 Complete program for manual mode of blind with wind sensor

Simulation

LOGO!Soft Comfort provides the facility for testing the switching program prior to use in the control relay by means of simulation. This presents the advantage that program errors can be debugged before they can cause faults or damage in the system.

When clicking the "Simulation" button, an input bar is displayed at the bottom margin of the screen. This shows the used inputs as switches and the outputs as lamps. Both the switch symbols (Fig. 2.21) and the input symbols in the circuit diagram (Fig. 2.20) can be activated by clicking. The lamps light up when an output is active.



Fig. 2.21 Simulation toolbar and "Simulation" button (above)

The type of simulation sensors can be adapted prior to execution of simulation. Through selection of the object properties (double-click on the respective connector symbol ①), the window in Fig. 2.22 is opened. Switches, NO contacts and NC contacts are available in the "Simulation" ②.

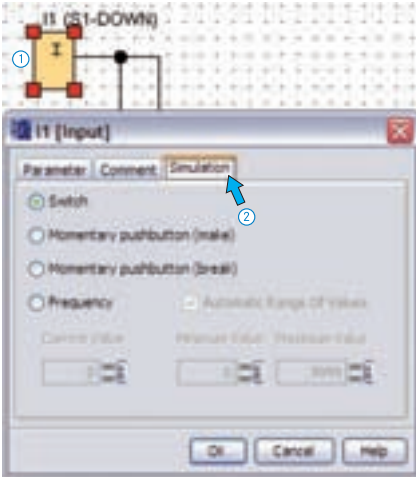


Fig. 2.22 Adaptation of input for simulation

The option "NC contact" is selected for the two limit contacts at I5 and I6 in order to adapt the simulation to the system. You should leave the other inputs occupied by switches for the moment. This option is automatically preset for all inputs. The use of several contacts can result in problems during the simulation since only one contact can be activated at a time using the mouse. On the other hand, switches retain their signal following the switching process.

In addition to simulation of the operating response, it is also possible to simulate the response in the event of a **power failure**. When considering the safety aspects, this possibility is of great importance since drives which could present a danger must not be permitted to restart on their own following a power failure. The saving of operating states, restart etc. can be checked during the simulation by clicking the "Power failure" button (Fig. 2.23).



Fig. 2.23 Button "Power failure"

Since the blind program produced previously does not have a memory function, the "Power failure" button is of no significance during the simulation. Following a power return, the program has the same status as before.

Fig. 2.24 shows the simulation of the complete program in the event of a wind alarm. Input I4 results in triggering of Q2, so that the blind automatically moves up in the event of a storm. The blind is prevented from moving down – triggered by I1 – since Q1 can only be activated if the wind sensor I4 has the "0" state ③.

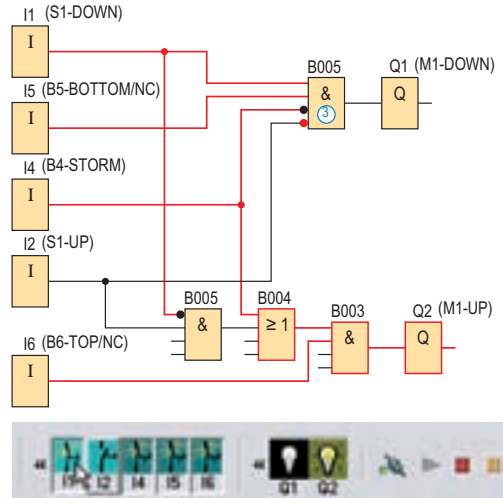


Fig. 2.24 Simulation of the blind control in the event of a wind alarm

The two limit contacts at I5/I6 have been selected in the simulation as NC contacts. Both have a "1" state because the blind is not in an end position.

2.3.3 Transfer of program

Once generated, the control program can be transferred to the LOGO!. The program can be tested online during the commissioning phase, which can be helpful for debugging.



Fig. 2.25
Connection
of PC cable

Online communication between PC/notebook and LOGO! requires the following:

- LOGO!Soft Comfort as full version, since the demo version has no online capability.
- Connection cable between PC/notebook and LOGO! (Fig. 2.25).
- The control relay must not be in run or editing mode.

Connection of PC/notebook to the LOGO!

The cable must be connected to the corresponding port of the PC/notebook. The cover or the program module (card) must be removed from the LOGO! in order to connect the cable there.

Setting the interface

When using the serial ports, the interface must be set in LOGO!Soft Comfort. This setting is made in the menu:

Tools → Options → Interface (Fig. 2.26)

The port can also be determined automatically with this option ①.

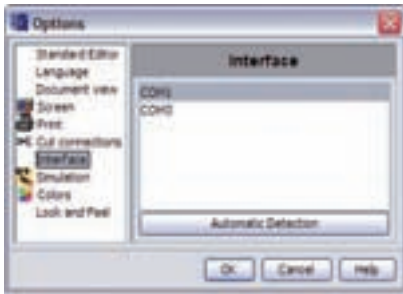


Fig. 2.26 Setting of port for online connection

Setting of PC ↔ LOGO! mode

If the control relay is in run mode, the stop status must be established prior to transfer of the program. This is possible in two ways:

- From the PC using the "LOGO! mode" button ②.
- On the control relay using the **ESC button** and **>STOP**.



Fig. 2.27
Software buttons for
transfer of program

When starting the program transfer, the **PC ↔ LOGO! mode** is set automatically (Fig. 2.28).

Note: With older devices (up to OBA3), the **PC ↔ LOGO! mode** can be set in the following ways:

- Selection of menu items **PC/Card** and **PC ↔ LOGO!** on the display or
- brief switching-off of the power supply. When switching-on, the LOGO! is automatically connected to the PC.

Transfer of programs to the LOGO! (upload)

In order to transfer the control program, the LOGO! is set to STOP mode. This can be carried

out using the LOGO!Soft Comfort software or the input keys on the control relay.

Following output of the connection on the display (Fig. 2.28) or in LOGO!Soft Comfort, the button for the upload (Fig. 2.29) must be clicked.

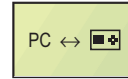


Fig. 2.28 Display
during program transfer



Fig. 2.29
Button "PC → LOGO!"

Transfer of programs from the LOGO! (download)

LOGO!Soft Comfort also allows programs to be transferred from the control relay to the PC where they can be saved. If these programs are protected by a password, this protection also applies when calling in the PC.



Fig. 2.30
Button
"LOGO! → PC"

The same requirements apply to the downloading of programs from the control relay as those applying to uploading. To start the program transfer, click the "LOGO! → PC" button (Fig. 2.30).

Online test

Using the "Online test" (Fig. 2.31) it is possible to observe "live" how the switching program in the LOGO! reacts to various input signals. In contrast to the simulation, the actual statuses are displayed on the LOGO! in this case. This facilitates troubleshooting in the system (e.g. in the case of open-circuits, faulty sensors, incorrect parameterization etc.) because the respective input signals can be observed on the PC.

Monitoring mode (Fig. 2.32) must be activated for this purpose. The blocks to be monitored must be selected in the program.



Fig. 2.31 Button
"Online test"



Fig. 2.32 Button
"Monitoring mode"

Requirements for the online test:

- PC and LOGO! must be connected via cables.
- The LOGO! must be in run mode.
- The program to be tested must be present in FBD and identical in the PC and control relay.
- The parameters of max. 30 blocks can be monitored.

Note: The online test is only possible from device series OBA4 onwards, but not for older ranges.

2.4 Expansion of control to automatic mode

The previous control of the blind in manual mode (Chapter 2.3.2) was highly accepted by the customer. In particular the retraction in the event of a storm guaranteed safe use of the blind. However, it was established that the conservatory often overheated on hot summer days if the blind was not extended manually.

How can the shading be optimized?

The customer remembers that a brightness sensor was already suggested during the initial installation but was not installed for cost reasons. Using this sensor, automatic shading of the conservatory would be possible.

Since the owner wishes to have increased comfort for the shading of his conservatory, he inquires what the costs would be for the required retrofitting. You explain to him that the costs for materials and installation are not particularly high.

However, since you must make a few changes to the switching program, you also calculate working time for extending and commissioning the program in addition to the costs for material and installation.

What outlay is required for automatic mode?

The three inputs I3, I7 and I8 are still vacant on the existing control relay, and therefore no expansion device is required for the LOGO!

The hardware expansion is mainly the installation and connection of the brightness sensor (Fig. 2.33). The connection on the control relay is made at input I3 (see device list, Chapter 2.2.2). A mode switch S7 (Manual/Auto) is required in addition. This is connected to I7 and I8. It can be used to block automatic mode, which is advisable in winter.

The switching program must be modified such that the new sensors B3 and S7 result in automatic operation of the blind.

Note: Expansion of the control to brightness-controlled automatic mode requires additional outlay:

- Installation and connection of brightness sensor B3 for measurement of solar radiation.
- Installation and connection of automatic switch S7.
- Generation of a new switching program for automatic mode.

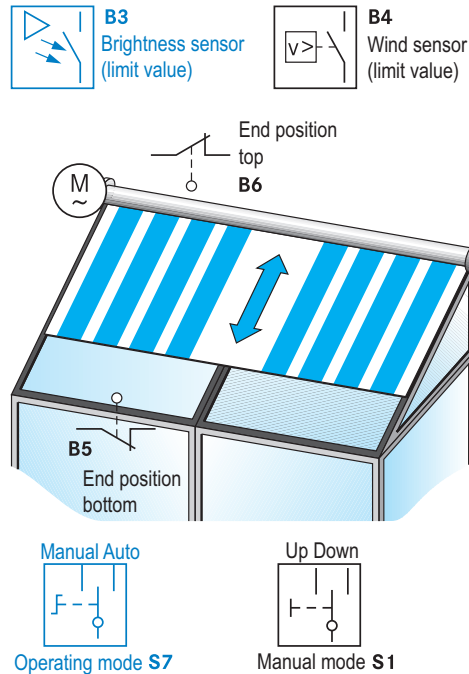


Fig. 2.33 Expansion of the existing system by brightness sensor B3 and manual/automatic switch S7

The brightness sensor B3 has an adjustable limit value above which it switches a binary "1" signal. If the limit value is undercut, the output signal is switched off. The difference between the upper and lower limit values is the so-called hysteresis.

The rotary switch S7 has two positions:

- Manual → Connection to I7 of control relay
- Auto → Connection to I8 of control relay



Task

Produce a cost calculation for the order for expansion of the blind control.

Take into consideration the material requirements for sensors and cables. The wage costs comprise installation, programming, commissioning and documentation.

2.4.1 Copying of program

In order to copy the previous project "Blind control", it is saved under a new name (e.g. "Blind_AUTO.lsc") using the commands "File" → "Save as".

Copying the previous project offers the advantage that the "Connection table" and the "Properties" of the project can be used further. To change the project name, call up the following window (Fig. 2.34) using "File" → "Properties".

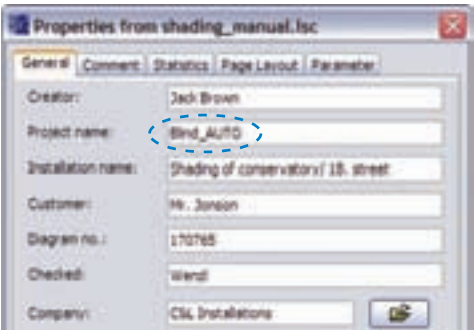


Fig. 2.34 Changing the project name in the "Properties" window

The sensor B3 ① and the manual/automatic switch S7 ② must be inserted in the connection table (Fig. 2.35). The connection table is called using "Edit" → "Input/Output Names".

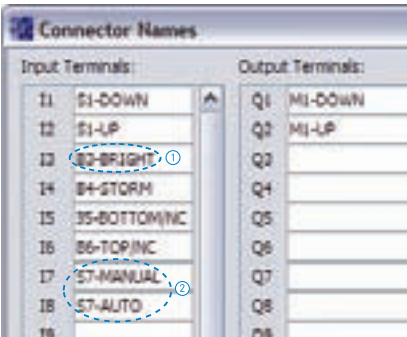


Fig. 2.35 Expansion of sensor B3 and automatic switch S7 in the connection table

Note: If existing LOGO!Soft projects are to be expanded or modified, it is appropriate to copy them.

A copy is created by saving the existing project under a new name. This has the advantage that existing circuit diagrams and connection tables can be used and expanded.

2.4.2 System properties in automatic mode

The blind is to be operated in automatic mode in the future so that it is automatically driven to the bottom position when the solar radiation is high. Automatic stopping at an intermediate position is not provided. Independent of the solar radiation, it is also possible to drive upward and downward using the blind contact S1. The wind sensor should automatically retract the blind in the event of a storm. A downward movement in manual mode is then no longer possible either.

When developing the program, the following conditions must be observed:

- **Manual mode:** If the changeover contact S1 is activated for longer than 0.4 seconds, the blind is driven to the respective end position. It is stopped there by the limit contacts. Brief activation of S1 in the opposite direction stops the moving blind, but the change in direction only takes place if S1 remains activated for longer than 0.4 seconds.
- **Wind alarm:** If the limit value is exceeded, the blind is retracted (UP). Independent of the operating mode, extension is not possible with a wind alarm.
- **Automatic mode:** With sufficient solar radiation on sensor B3, the blind is extended completely. If the solar radiation falls below the limit value, it is automatically retracted again following a delay time.

2.4.3 Program for manual mode

First insert all required inputs (I1 – I7) and outputs (Q1, Q2) in the acquainted manner (Fig. 2.36). Most of these connectors are already

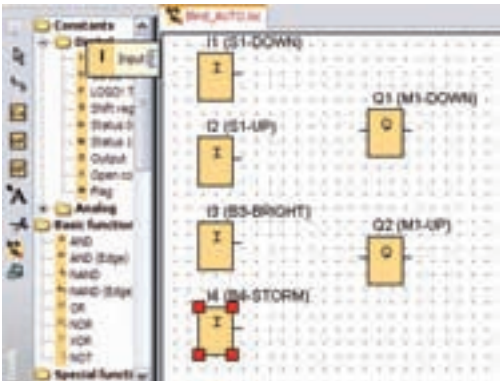


Fig. 2.36 Connectors with connection names

present from the previous program, and it is only necessary to delete the connections using the selection key (arrow button).

Inserting storage elements

So that the movement of the blind remains switched on permanently even following brief signals such as brief activation of the rocker contact, it is necessary to save the movement statuses. Two latching relays are used for this purpose in LOGO!Soft, and serve to save the two directions of movement.

The self-latching relays are present in the element catalog under **"Special functions" → "Miscellaneous" ①**.

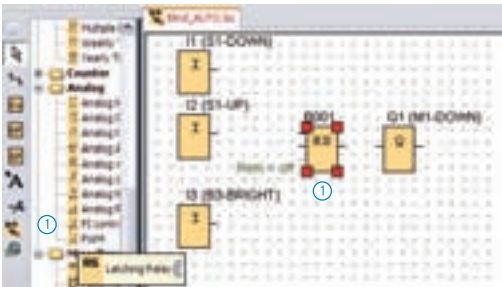


Fig. 2.37 Inserting the self-latching relays

Inserting timers

Two timers "Switch-on delay" are inserted in the circuit diagram.

These prevent the direct switching over between the directions of movement. This is necessary for smooth operation of the drives. In addition, brief activation of the rocker contacts should only stop the movement of the blind, whereas longer activation should reverse the direction of rotation of the drive.

The timers are present in the element catalog under **"Special functions" → "Timers" ②**.

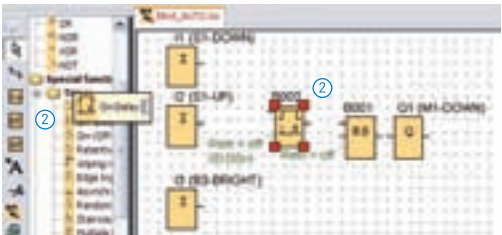


Fig. 2.38 Inserting the timers

Latching relays (RS storage elements)

RS storage elements provide the self-latching function in the control programs in a similar manner to how this is implemented in contactor circuits using the so-called self-holding contact.

A short "1" signal (pulse) is sufficient for setting or resetting. If the two inputs are triggered simultaneously, the **reset input has priority ③**, i.e. the storage element then has the binary state "0".

Retentivity: It is frequently necessary for safety reasons for the storage element to be reset following a power failure.

The retentivity is set to "off" ④ if drives must not restart automatically following a power failure. This response is preset as standard for all storage elements.

However, if certain statuses (e.g. warning lamps, position displays) are to remain saved following a power failure, the retentivity of the storage element must be set to "on".

Timer for switch-on delay

LOGO! control relays can be programmed with numerous timer functions. These are available as special functions. The timer "Switch-on delay" is required to control the blind.

A "1" signal at the trigger input ⑤ starts the preset delay time. The trigger signal must be present permanently until the output is switched; in other words, it must not return to the "0" state during the complete delay time.

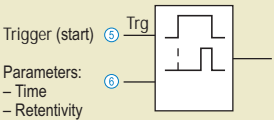
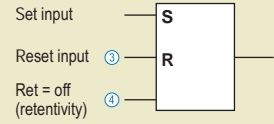
Elimination of the trigger signal results in:

- Abortion of the current delay time, the time must then start again.
- Resetting of the output Q if this was in the "1" state following expiry of the time.

The timer has two adjustable parameters ⑥:

- delay time and
- retentivity (saving in event of power failure)

The two parameters can be set in their own program window. This is opened when the block symbol of the timer is double-clicked.



Setting the timer parameters

The delay time can be set by selecting the time-base (s, min, h) in the window (Fig. 2.39) and subsequently entering the corresponding value using the up and down arrow keys. Note that the first digit block specifies the multiple of the basic unit, whereas the second digit block only specifies a hundredth of this basic unit.

Fig. 2.39 shows the setting for 0.40 seconds ①. 0:40 seconds with the basic unit 1/100 seconds means 0 complete seconds and 40/100 seconds.

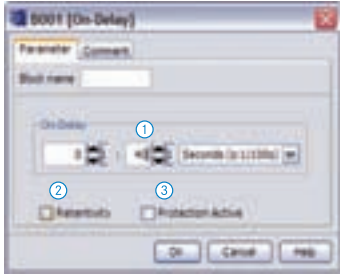


Fig. 2.39 Window for setting the switch-on delay and retentivity

Note: Selection of "Retentivity" ② means that, in the event of a power failure, the time value reached until then as well as the status of the output when the power failure occurs remain saved.
If "Protection active" ② is set, the time can not be modified during ongoing operation.

Downward movement with manual mode

In the previous program (Chapter 2.3.2), the contacts had to be activated permanently dur-

ing movement of the blind. Manual operation of the blind is now to be possible using brief momentary contact signals. The output statuses must therefore be saved in self-latching relays (Fig. 2.40).

Setting the output Q1

- ④ Contact S1-DOWN is activated for at least 0.40 seconds. The RS element B001 can only be set by the timer ⑤ following this switch-on delay.
- ⑥ Output Q2 must be switched off. This scanning corresponds in a hard-wired programmed controller to a protective interlock. Therefore it is scanned negated.
- ⑦ Wind sensor B4 has a "0" state (= no wind alarm). The blind can therefore only be moved downwards at low wind speeds.
- ⑧ Switch S7 is set to "Manual".

Resetting the output Q1

- ⑦ Wind alarm: B4 has a "1" signal or
- ⑨ bottom limit contact B5 has the "0" state on activation or
- ⑩ contact S1 is activated in the upward direction, in other words in the reverse direction (S1-UP).

For clarity reasons, this example omits mutual interlocking of the contacts S1-DOWN and S1-UP by means of software.

Since the contacts have mechanical reverse blocking, it cannot occur that upward and downward movements are switched on simultaneously. This is sufficient for interlocking the two inputs.

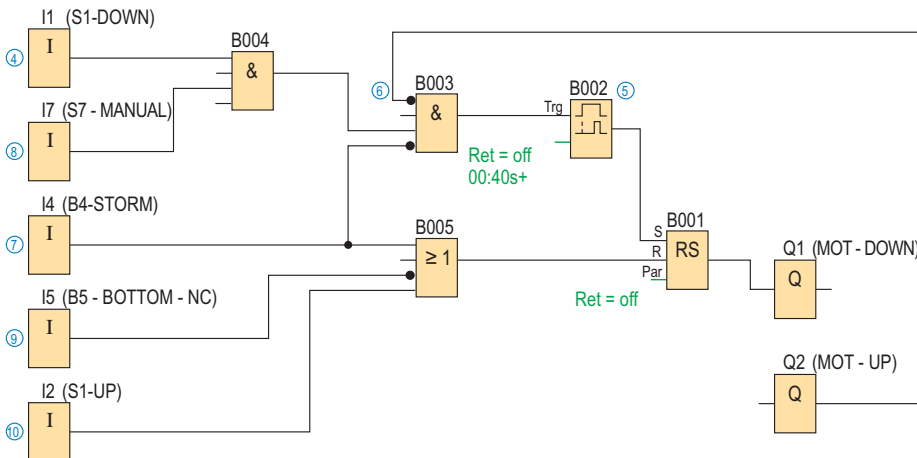


Fig. 2.40 Program section for downward control of blind with manual mode

Upward movement with manual mode

The principle of the program for upward movement of the blind (output Q2) has a similar design to that for downward movement. The main difference is that the wind sensor can also trigger retraction of the blind.

The simulation in Fig. 2.41 shows the response of the program in the event of a wind alarm. A "1" signal is present on the wind sensor B4 which switches on the output Q2. The top end position for limit contact B6 has not yet been reached since input I6 is still receiving a "1" signal.

Setting the output Q2

The RS storage element is set by the sensors

- ① B4 storm (wind monitor) or
- ② S1-UP (blind contact, input I2)

In order to set the output, it is necessary that

- ③ Q1 (downward movement) is switched off (mutual interlocking between Q1 and Q2).

Resetting the output Q2

Resetting of the storage element is carried out either

- ④ with I1, i.e. the contact for moving downward or
- ⑤ activation of limit contact B6, which then outputs a "0" signal.

To switch on the respective direction of movement, the associated rocker of contact S1 must be activated for a period of 0.4 seconds. Brief activation of the contact in the opposite direction stops the movement of the blind.

Complete program for manual mode

The program generated so far for manual mode is shown below. The upward movement of the blind in the event of a storm has priority (Fig. 2.42).

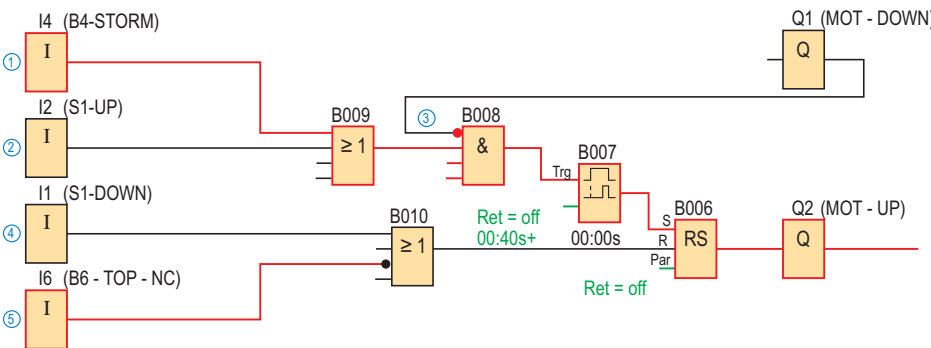


Fig. 2.41 Program for upward control of blind with simulation of wind alarm

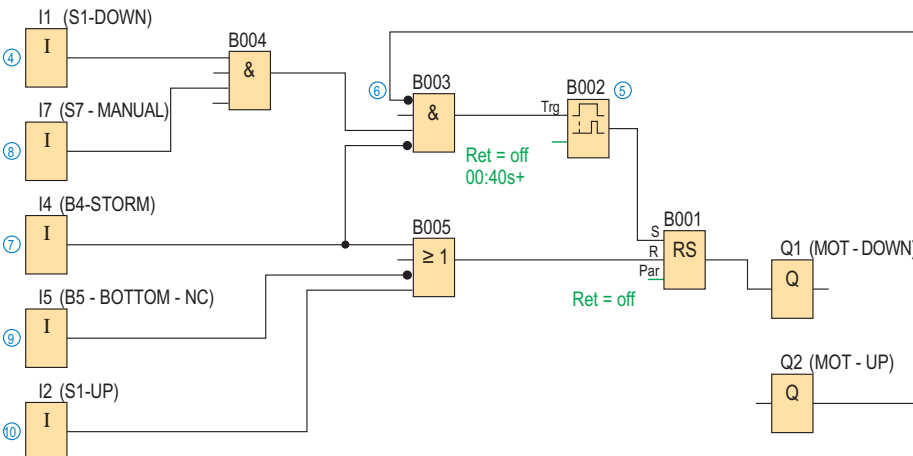


Fig. 2.42 Program for control of the blind in manual mode with delayed reversal of direction and storm warning

2.4.4 Program for automatic mode

The blind was previously only controlled in manual mode (Chapter 2.4.3). The retrofitted brightness sensor B3 is now to be integrated into the program, thus providing automatic shading. In addition to the sensor B3, the switch S7 (manual/auto) has also been retrofitted. This can be used to switch over from manual mode to automatic mode. Manual mode prevents the blind from being operated unintentionally (e.g. in winter).

Separate

Comprehensive circuit diagrams often become unclear because lines cross over frequently. Disconnection of lines avoids such crossing over. The line to be separated is selected by a right mouse click.

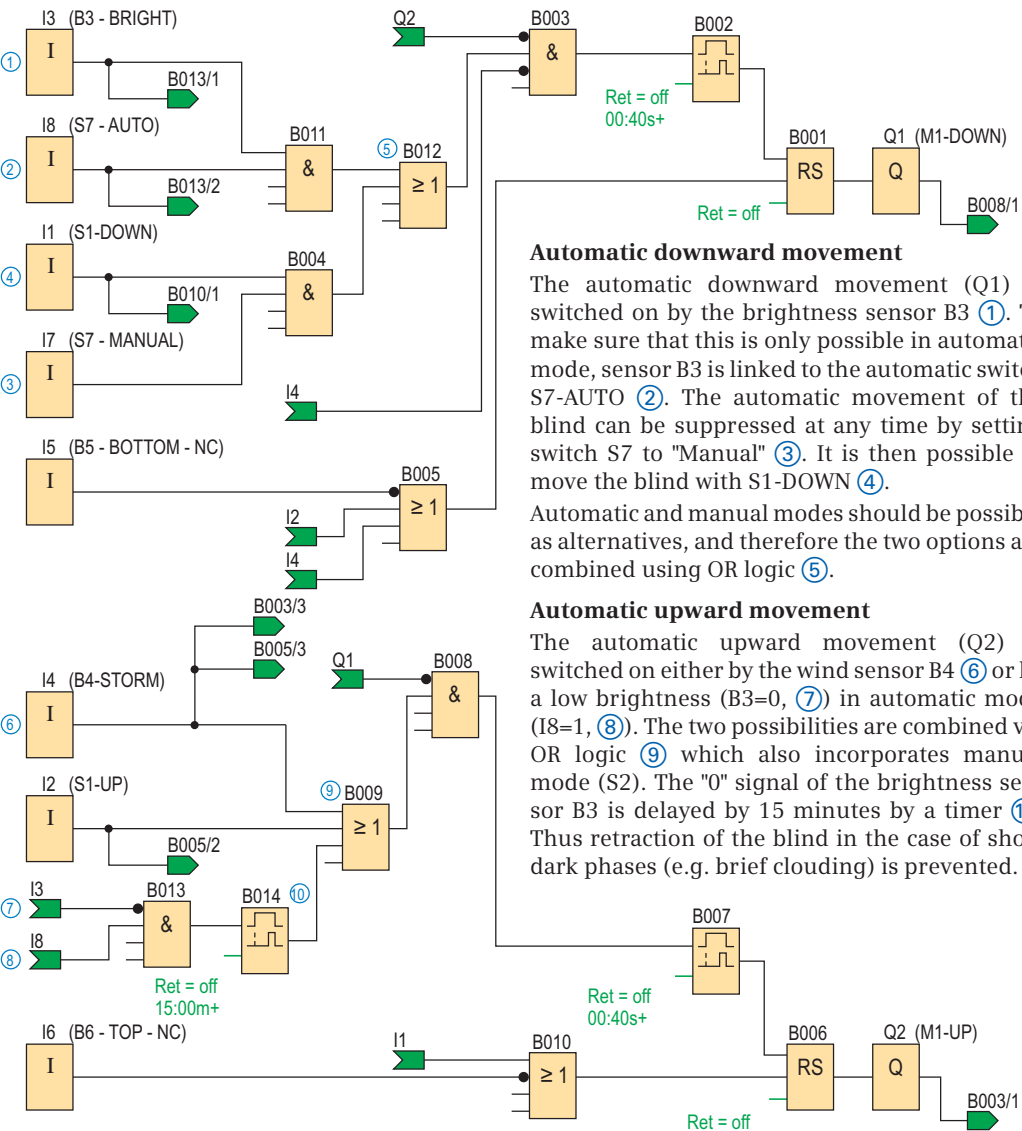
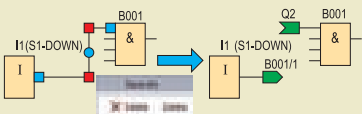


Fig. 2.43 Complete program for automatic control

3 Car park with counting function

3.1 Task description

Downtown Cologne offers only a few possibilities for parking. The company of Gauky wishes to keep its private car park with 12 spaces free for customers and employees, and commissioned the company of Parktechnik to provide the car park with an access control system.

For this purpose, two barriers are each equipped with a reversible motor (Q1 and Q3 open, Q2 and Q4 close), a pillar with a key-switch for the entrance, and the following sensors (NC contacts):

- B1, B6: induction loops in front of the barriers
- B2, B7: reflex sensors for detection of objects "underneath" the barriers
- B3, B8: induction loops behind the barriers

The barriers are equipped with end contacts (NO contacts) for detection of the bottom (B4, B9) and top end positions (B5, B10). In addition, the entrance has a display P1 "Occupied".

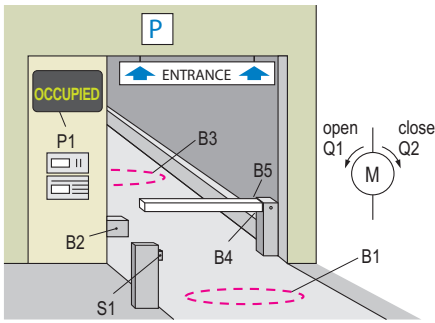


Fig. 3.1 Car park entrance

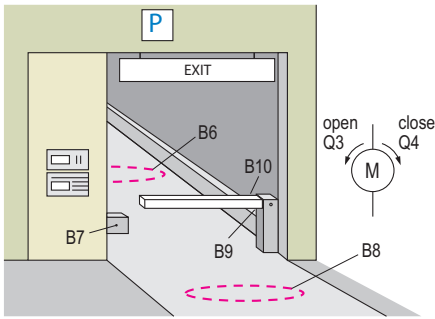


Fig. 3.2 Car park exit

3.1.1 Function description

If a vehicle approaches, the barrier opens if the following conditions are satisfied:

Entrance

- Keyswitch S1 has been activated and
- induction loop B1 has a "1" signal.

Exit

- Induction loop B6 has a "1" signal.

The barriers open up to the end position and cannot be closed as long as the reflex sensors B2 and B7 detect an object ("1" status). The areas are closed by activation of the induction loops B3 and B8.

The signal lamp "Occupied" signals that all spaces are full. The entrance is then blocked.

3.2 Hardware configuration

3.2.1 Selection of LOGO!

In order to select the LOGO! modules, it is first necessary to define the digital inputs (DI) and digital outputs (DO):

Number of inputs and outputs

The adjacent table (Fig. 3.3) lists the required input and output objects. The number of actuators defines the number of outputs, and the number of input objects must be set equal to the number of inputs.

The LOGO! basic device has 8 digital inputs and 4 digital outputs (Fig. 3.4). However, since 11 DIs and 5 DOs are required, an expansion device DM8 is required for the remaining 3 inputs and 1 output (Fig. 3.5).

Inputs

The operating voltage for the selected sensors is between 10 and 36 V DC. As a result of this input circuitry, it is meaningful to use a mini programmable controller of voltage class 1.

24 V logic is the standard system in control technology. It is preferred compared to 12 V because of the better resistance to interference.

Outputs

Master contactors are required because of the hardware-based contactor interlocking (cf. Chapter 3.2.2). The master contactors selected

Object	Object desig.	LOGO!	
		DI	DO
Fuse for outputs	F1		
Fuse for 24 V	F2		
Fuse for inputs	F3		
Induction loop in front of barrier 1	B1	X	
Light barrier underneath barrier 1	B2	X	
Induction loop behind barrier 1	B3	X	
End contact for barrier 1 closed	B4	X	
End contact for barrier 1 open	B5	X	
Induction loop in front of barrier 2	B6	X	
Light barrier underneath barrier 2	B7	X	
Induction loop behind barrier 2	B8	X	
End contact for barrier 2 closed	B9	X	
End contact for barrier 2 open	B10	X	
Keyswitch	S1	X	
Master contactor for barrier 1 – open	Q1		X
Master contactor for barrier 1 – close	Q2		X
Master contactor 24 for barrier 2 – open	Q3		X
Master contactor 24 for barrier 2 – close	Q4		X
LOGO! 24 V RCo	K1		
LOGO! DM8 12/24R	K2		
LOGO! Power	K3		
Signal lamp "Occupied"	P1		X
Number of digital inputs required		11	
Number of digital outputs required			5

Fig. 3.3 Device list

LOGO! basic module									
Versions		Basic		Clock		Digital		Analog	
		With keypad	Pure			8 inputs	4 outputs		
		With display	Without keypad	With	Without	Transistor	Relay	Digital	
		Without display							
24 V	AC/DC		X			8	4		
	DC								
12 V/24 V	DC								
230 V	AC								

Fig. 3.4 Basic module

have a coil voltage of 24 V DC and a holding current below 0.3 A. Thus control relays with relay outputs or transistor outputs can be used.

The cheapest way for connecting the 230 V signal lamp "Occupied" is directly via the relay outputs.

Handling and programming

An operator panel (display and keys) is not required for this application since the controller is to be installed in the control cabinet, allowing selection of the cheapest basic module (Pure) without display or keys.

Costs

The hardware costs of the mini programmable controller are negligible compared to the total cost of the system.

Expansion options

The modular design of the LOGO! takes into account subsequent wishes for expansion, e.g. analog inputs and outputs for controlling a ventilation plant. When using a basic module with clock, it is possible to retrofit day/night mode without high expenditure.

Result

All 24 V basic modules available on the market and DM8 expansion modules could be selected in the matching composition.

For this application, a **LOGO! 24RCo** (Fig. 3.4) is selected with the expansion module **DM8 24R** (Fig. 3.5). This is not the cheapest solution, but the selected hardware has a clock and vacant relay outputs for subsequent expansions.

Expansion modules									
Versions	Digital					Analog		Communica- tion (24 V)	
	DM 8		DM 16			AM2		ASI	EIB
	4 inputs	4 outputs	8 inputs	8 outputs	Inputs	Outputs			
Transistor	Relay	Transistor	Relay	V/mA	Pt100	V			
24 V	3	1							
12 V/24 V									
230 V									

Fig. 3.5 Expansion modules

3.2.2 Connection diagram of LOGO!

Various aspects have to be considered when designing the connection diagram.

Safety

The controllers must always guarantee safety for persons. The corresponding directives for the safety of machines are defined in DIN EN 60204-1 (VDE 0113). A distinction is made between the protection of persons, machines or products (cf. Chapter 4.2.2).

This task is limited to machine protection. The motors are therefore provided with hardware-based contactor interlocking.

The **contactor interlocking** (Fig. 3.6) prevents the simultaneous switching of Q1/Q2 or Q3/Q4. This prevents the danger of a short-circuit resulting from a malfunction of the mini programmable controller or a mechanical fault in the contactors. If contactor Q1 is switched, the auxiliary contact 1 is activated, and Q2 cannot switch. In the reverse direction, auxiliary contact 2 prevents switching of Q1 with the contactor activated.

The limit switches B4, B5, B9, B10 are designed as NC contacts to provide protection against open-circuits (cf. Chapter 4.2.2).

The safety aspects should be discussed in detail with the owner and recorded in writing.

Assignment list

A well-considered assignment of the sensors and actuators prevents subsequent wiring faults and allows clearer and simpler design of the software.

The wiring of the mini programmable controller must be logical and clear for the installation engineer and programmer.

In this case, the object designations for the sensors (B1 – B10) can be largely wired in agreement with the input numbers. For example, the number of the connection name I1 of the object designation B1 ③ or the input I10 (DM8, I2) of the object designation B10 ④.

The inputs "Entrance" constitute the group I1 – I5, and the inputs "Exit" constitute the group I6 – I10. Thus inputs having equivalent functions are offset in each case by 5 units:

- I1 and I6, induction loops in front of the barrier
- I2 and I7, light barriers underneath the barrier etc.

The keyswitch S1 is connected to the input I11 (DM 8, I3).

The outputs Q1/Q2 and Q3/Q4 each constitute a group.

- Hardware and software interlocks are logic operations which prevent undesirable switching statuses.
- An interlock produced using auxiliary contacts is referred to as contactor interlocking.
- For the protection of persons, interlocking must be hardware-based.
- For the protection of machines and products, interlocks can be hardware-based and/or software-based.

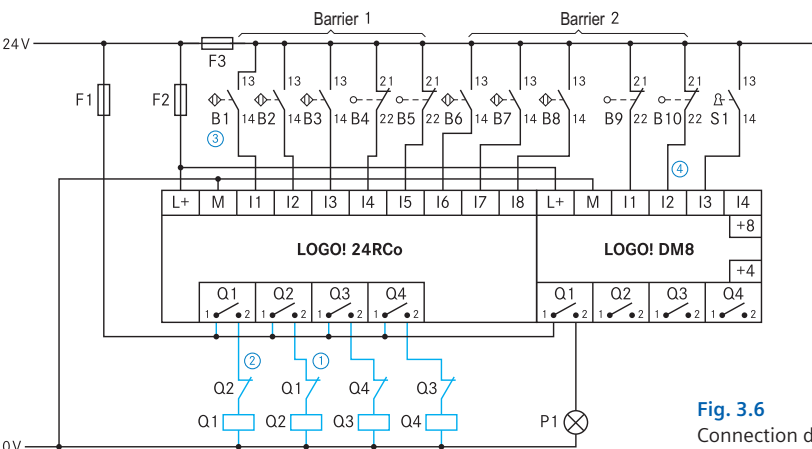


Fig. 3.6
Connection diagram

3.3 Software configuration

3.3.1 Analysis and planning of software

A fundamental system analysis should be carried out before starting with software development. Many programming faults can then be prevented, and the "best" (possibly extremely simple) solution can be found. This requires

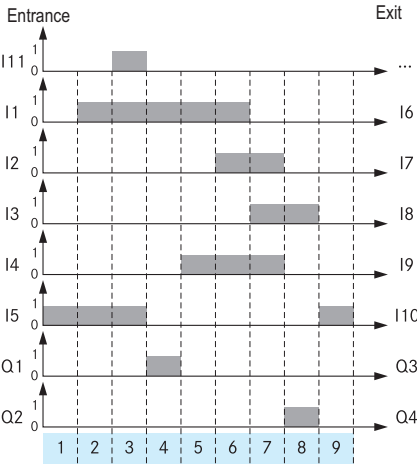


Fig. 3.7 Signal/time diagram

	Entrance/(exit)
1	<ul style="list-style-type: none"> Barrier closed End contact I4 (I9) activated No car in front of barrier
2	<ul style="list-style-type: none"> Car in front of barrier Sensor I1 (I6) is activated
3	<ul style="list-style-type: none"> Keyswitch I11 (entrance only) is activated Sensor I1 (I6) remains activated Sensor I3 (I8) remains inactivated Number of cars < 12, software counter
4	<ul style="list-style-type: none"> Barrier opens Output Q1 (Q3) is set to "1"
5	<ul style="list-style-type: none"> Barrier is fully open End contact I5 (I10) is activated
6	<ul style="list-style-type: none"> Car drives into car park Change in signal I1 → I2 (I6 → I7)
7	<ul style="list-style-type: none"> Car drives into car park Change in signal I2 → I3 (I7 → I8)
8	<ul style="list-style-type: none"> Car is in car park Barrier closes Output Q2 (Q4) is set to "1"
9	<ul style="list-style-type: none"> Barrier closed End contact I4 (I9) activated No car in front of barrier

Fig. 3.8 Signal/time diagram for entrance

more time at the beginning, but this can be more than saved again during subsequent programming. This results in a reduction in project costs.

Subsequent to exact consideration of the task, it appears meaningful to develop a signal/time diagram (Fig. 3.7) for this car park control. The table (Fig. 3.8) explains the individual phases (1 – 9) of the time diagram. The connection names (Fig. 3.9) of the mini programmable controller are used.

The total system becomes clearer by appropriate division into objects:

- Object 1: Open entrance barrier
- Object 2: Close entrance barrier
- Object 3: Interlocking of outputs Q1/Q2
- Object 4: Open exit barrier
- Object 5: Close exit barrier
- Object 6: Interlocking of outputs Q3/Q4
- Object 7: Counter
- Object 8: Signal lamp "Occupied"

The additional statements can be made:

- Object 1 and object 4 have identical functions
- Object 2 and object 5 have identical functions
- Object 3 and object 6 have identical functions
- For safety reasons, the inputs underneath the barrier (I2, I7) are scanned when closing.
- As many inputs (sensors) as required are scanned.
- Each motor output (Q1 – Q4) must be triggered via a self-latching relay with selected retentivity REM=ON (cf. Chapter 9.4).
- The counter must retain its value in the event of a power failure (REM=ON).
- Only the entrance has a keyswitch S1.

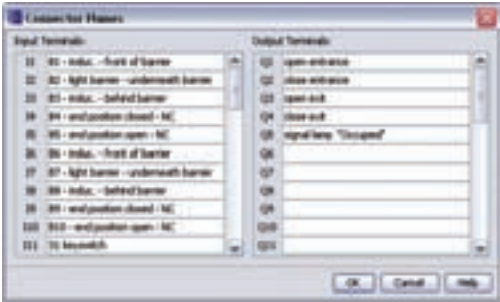


Fig. 3.9 Connection names

3.3.2 Software development

Steps	Function diagram
<p>Object 1: Open entrance</p> <p>The entrance conditions (cf. Fig. 3.1) are linked by an AND operation, and set the self-latching relay (cf. Chapter 9.4). This is reset by the limit switch I5=0 (NC contact). Scanning I3=0 is not essential, and depends on the application.</p> <p>Power failure:</p> <p>The self-latching relay must be protected against power failure, the retentivity function must be set.</p>	
<p>Object 2: Close entrance</p> <p>The input I3=1 sets the self-latching relay. This is reset by the limit switch I4=0. In addition, the self-latching relay can also be reset by the light barrier I2=1 for safety reasons.</p> <p>Power failure:</p> <p>The self-latching relay must be protected against power failure, the retentivity function must therefore be set.</p>	
<p>Object 3: Interlocking of outputs</p> <p>The outputs Q1 and Q2 are mutually interlocked by mutual AND scanning.</p> <p>Simulation:</p> <p>Expand the circuit by the inputs "Object 1" and "Object 2" (cf. Chapter 3.3).</p>	
<p>Object 4: Open exit</p> <p>Object 4 has the same functions as object 1. Object 1 is initially copied, and then the input numbers are changed (rewiring).</p> <p>Power failure:</p> <p>The self-latching relay must be protected against power failure, the retentivity function must therefore be set.</p>	

Steps	Function diagram
<p>Object 5: Close exit</p> <p>Object 2 has the same functions as object 5 and can therefore be copied and rewired.</p> <p>Power failure: The self-latching relay must be protected against power failure, the retentivity function must therefore be set.</p>	
<p>Object 6: Interlocking of outputs</p> <p>Object 3 has the same functions as object 6 and can therefore be copied and rewired.</p> <p>Simulation: Expand the circuit by the inputs "Object 4" and "Object 5".</p>	
<p>Object 7: Counter</p> <p>The counter is controlled by objects 1 and 4 (cf. Chapter 9.4). The limits for switching on and off must correspond to the number of parking spaces. The output of the counter is therefore "1" when the car park is full. The counter output is a further entrance condition (object 1).</p> <p>Power failure: The counter must be protected against power failure, the retentivity function must be set.</p> <p>Simulation: Expand the circuit by the inputs "Object 1" and "Object 4".</p>	
<p>Object 8: Signal lamp "Occupied"</p> <p>The signal lamp Q5 "Occupied" is set if the counter output is "1".</p> <p>Simulation: Expand the circuit by the input "Object 7".</p>	

Tasks

1. Modify the existing hardware.

a) Use a LOGO! 24o and determine an appropriate expansion module DM.

b) Draw a new connection diagram.

c) Does the existing software change? Explain your statement.
2. The car park is only to be open during working hours (9 a.m. – 8 p.m.).

a) Check whether it is necessary to change the hardware.

b) Expand the existing software, and use the object "Working hours".

c) Test your new software.
- 39

3.3.3 Entire representation as FBD

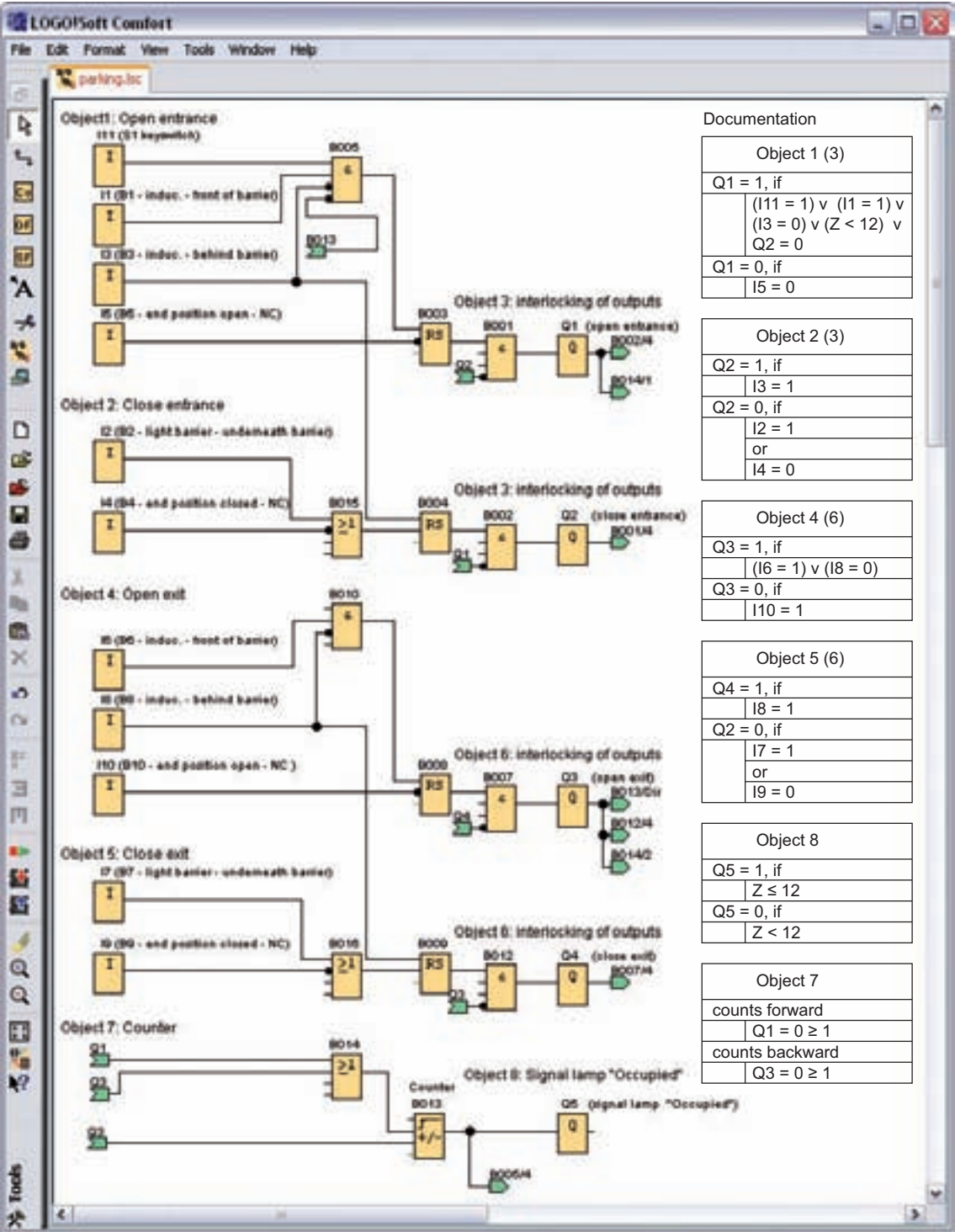


Fig. 3.10 Car park control as FBD

3.3.4 Entire representation as LAD

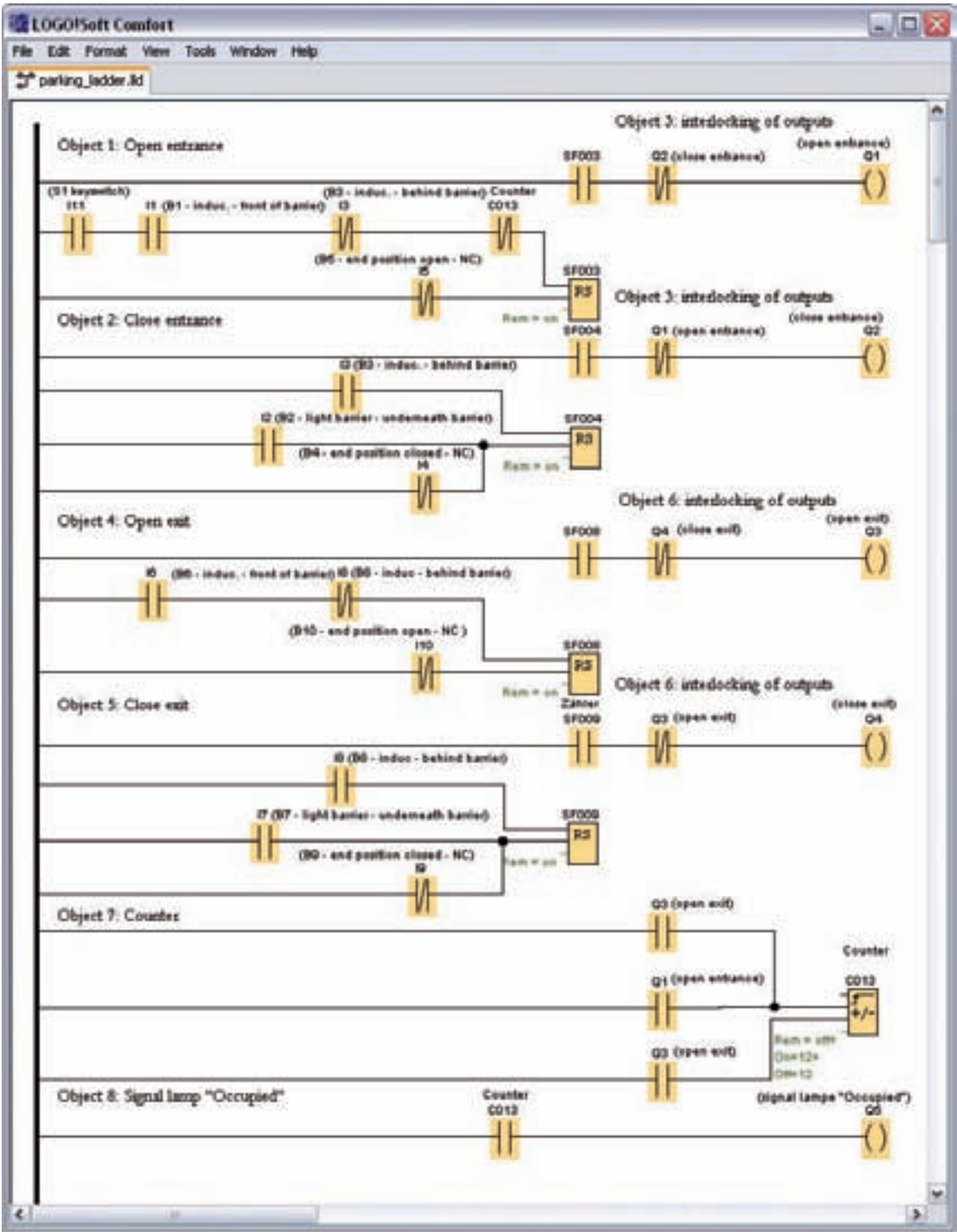


Fig. 3.11 Car park control as LAD

4 Grain store (sequential circuit)

4.1 Task description

A grain store (Fig. 4.1) is to be modernized. The old controller is to be replaced by a LOGO! control relay. The old operating concept with the operator panel (Fig. 4.2) is to be retained so that retraining of the employees is unnecessary. The new controller should be planned on the basis of the existing circuit diagrams (Fig. 4.3). The cheapest version should be selected.

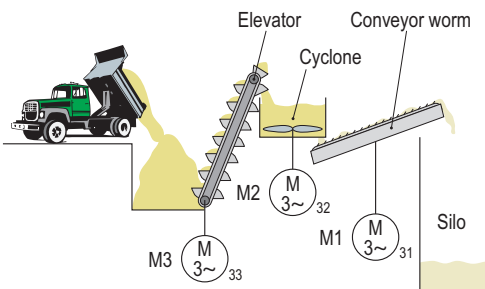


Fig. 4.1 Process schematic

4.1.1 Function description

The grain is tipped into a pit and transported from there into a cyclone by means of an elevator (conveyor belt with scoops). The cyclone separates the corn from the chaff which is blown away. The heavier corn drops downwards and is transported by a conveyor worm into a silo.

To ensure that neither the cyclone nor the conveyor worm is overloaded, the system must be switched on as follows:

Conveyor worm → Cyclone → Elevator

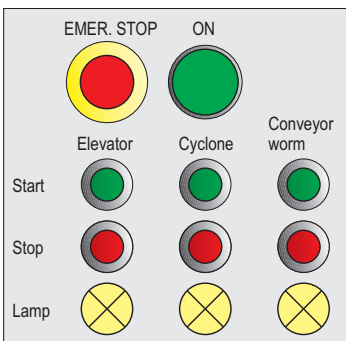


Fig. 4.2 Control panel on control cabinet

The following conditions additionally apply:

- Switching-off must be carried out in the reverse order.
- Operation is only carried out using the existing control panel (Fig. 4.2).
- The emergency stop button is only present on the operator panel.
- The system should be designed in accordance with the safety directives of DIN EN 60204-1.

4.2 Hardware configuration

4.2.1 Selection of LOGO!

Various parameters must be discussed in order to define the LOGO! modules (cf. Chapter 8.2.2):

Number of inputs and outputs

The adjacent device list (Fig. 4.4) specifies all input and output objects required. The total number of digital outputs means that an expansion module is required.

Inputs

The existing EMERGENCY STOP button (S0) as well as the Start and Stop buttons (S1 – S6) are designed for DC or AC voltage up to 250 V. Selection of the voltage therefore does not depend on the input objects.

Outputs

The power contactors and signal lamps which are also used require 230 V AC. Therefore a mini programmable controller with floating relay contacts is required.

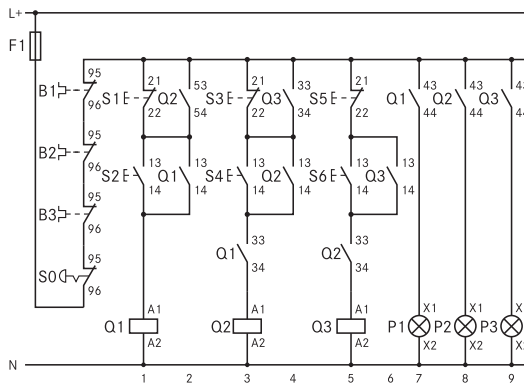


Fig. 4.3 Connection diagram

Object	Object desig.	LOGO!	
		DI	DO
Fuse for inputs	F1		
Fuse for outputs for lamps	F2		
Fuse for outputs for power contactors	F3		
Fuse for EMERGENCY STOP	F4		
EMERGENCY STOP	S0	–	
Start conveyor worm	S1	X	
Stop conveyor worm	S2	X	
Start cyclone	S3	X	
Stop cyclone	S4	X	
Start elevator	S5	X	
Stop elevator	S6	X	
Plant on	S7	–	
Motor protective relay M1	B1	–	
Motor protective relay M2	B2	–	
Motor protective relay M3	B3	–	
Auxiliary contactor for safety circuit	K1	X	
Power contactor for conveyor worm	Q1		X
Power contactor for cyclone	Q2		X
Power contactor for elevator	Q3		X
Signal for conveyor worm	P1		X
Signal for cyclone	P2		X
Signal for elevator	P3		X
LOGO! 230RCo	K1		
DM8 230R expansion module	K2		
Number of digital inputs required		7	
Number of digital outputs required			6

Fig. 4.4 Device list

Handling and programming

An operator panel (display and keys) is not required for this application since the controller is to be installed in the control cabinet. It must only be possible for trained personnel to open the control cabinet.

Costs

Selection of the LOGO! is decisive for the hardware and installation costs. Because of the installation costs for a power supply unit, a LOGO! 230RC should be preferred. In addition, omission of the display reduces the hardware costs by approx. 10%. A basic module with clock is not required.

Expansion options

A discussion was carried out with the plant owner concerning subsequent conversions.

LOGO! basic module									
Versions		Basic		Pure	Clock		Digital		Analog
		With keypad	Without keypad	8 inputs			4 outputs		
		With display	Without display	With	Without	Transistor	Relay		
24 V	AC/DC								
	DC								
12 V/24 V	DC								
230 V	AC		X			8		4	

Fig. 4.5 Basic module

The owner does not intend to retrofit the plant in the near future. Therefore no expansion options need be incorporated in the planning.

Conclusion

A LOGO! 230RCo (Fig. 4.5) and the expansion module DM8 230R were selected (Fig. 4.6). This space-saving control relay does not require a display or keypad.

Part of the control cabinet wiring can be retained, and the input and output objects can be connected directly to the controller. Therefore only low rewiring costs occur.

The LOGO! 230RCo is therefore the cheapest version.

Expansion modules											
Versions	Digital						Analog		Communica- tion (24 V)		
	DM 8			DM 16			AM2		ASI	EIB	
	4 inputs		4 outputs	8 inputs		8 outputs	Inputs				Outputs
	Transistor	Relay	Transistor	Relay	V/mA	Pt100	V				
24 V											
12 V/24 V			2								
230 V											

Fig. 4.6 Expansion modules

4.2.2 Connection diagram of LOGO!

Safety

Controllers must always guarantee safety for persons and plants. The corresponding directives for the safety of machines are defined in DIN EN 60204-1 (VDE 0113).

The most important are:

- An EMERGENCY STOP unit must be provided.
- It must be possible to stop the plant safely.
- The plant must be resistant to open-circuits.

EMERGENCY STOP and resistance to ground faults

If the safety of a person or plant is endangered, it must be possible to stop the plant safely.

The following requirements apply to the EMERGENCY STOP:

- EMERGENCY STOP must have priority over all other operations and functions.
- The state resulting in the danger must be stopped as rapidly as possible without a power supply.
- Resetting of the EMERGENCY STOP must not result in switching-on of the plant again.
- Switching-off of the power supply must be carried out using electromechanical devices or semiconductors.
- EMERGENCY STOP is always carried out using an NC contact.

Fig. 4.7 shows how the grain store controller has been implemented using a control relay. The complete controller is powered with four control circuits:

Circuit 1 ① powers – via F1 – the control relay and the control elements, as well as the NO contact K1: 13/14.

Circuit 2 ② powers – via F2 – the signal lamps P1...P3 at the LOGO! outputs DM 8 Q1...Q3.

Circuit 3 ③ powers – via F3 and the NO contact K1:23/24 – the master contactors Q1...Q3 at the LOGO! outputs Q1...Q3.

Circuit 4 ④ powers – via F4, the EMERGENCY STOP switch S0, the motor protective relays B1, B2 and B3, and the ON button S7 – the self-latching with the auxiliary contactor K1. Such a type of series connection is referred to as a **safety circuit**.

The operator panel is expanded by the ON button S7. The plant is switched on using this button such that the auxiliary contactor K1 switches and the self-latching closes. The auxiliary contactor K1 enables the circuit 3 (K1:23/24), and provides a "1" signal at the input DM 8 I1 (K1:13/14).

Triggering of a motor protective relay (B1, B2, B3) or the EMERGENCY STOP switches off the self-latching of K1, and circuit 3 is interrupted via K1:23/24 such that the master contactors become deenergized and switch off the plant.

The triggering information of the safety circuit S0/B1/B2/B3 is processed by a contact K1:13/14 in the control relay such that, when restarting (S7), the plant does not automatically commence through switching of K1.

- An EMERGENCY STOP unit must be designed using mechanical switchgear or semiconductors.

Protection against open-circuit

This protection is a safety measure which safely switches off a plant if there is an open-circuit and prevents automatic switching-on.

Let us now consider how this condition is implemented in the circuit. In the controller (Fig. 4.7), the plant is started by activating the NO

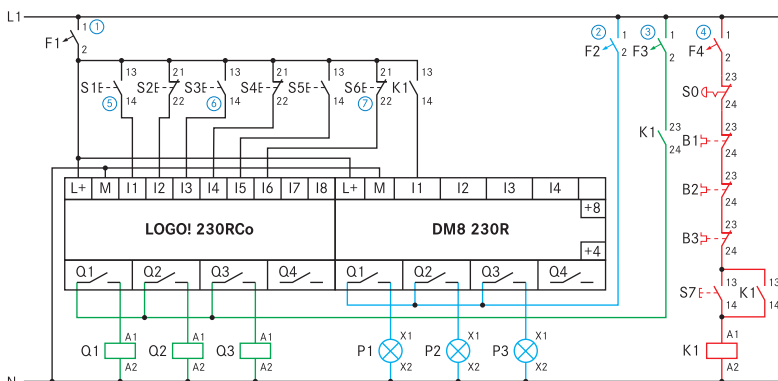


Fig. 4.7 Connection diagram

contact S1. An open-circuit at ⑤ or ⑥ would prevent switching-on. A "1" signal which can be evaluated as start information could not be produced at the input of the LOGO!. An open-circuit in circuit 1 ① would immediately switch off the plant.

With the LOGO!, an open-circuit ⑦ results in a "0" signal at input I6. The control relay interprets this as activation of the button S6, since this also has a "0" signal when activated. The elevator is switched off by the software (cf. 3.3.2). Plants are therefore always **switched on** by **NO contacts**, and **switched off** by **NO contacts**. The division of the switching relay controller into several circuits means that the upstream protection element is immediately triggered by a ground fault.

This provides sufficient resistance to ground faults. If a ground fault occurs in the safety-related circuit 4 ④, F4 is triggered and the self-latching of K1 is switched off, and the plant fails.

- A ground fault is usually an undesired conducting connection between a circuit and the ground potential via a low-resistance current path.
- Protection against open-circuit requires
 - switch-on commands from NO contacts and
 - switch-off commands from NC contacts.

4.3 Software configuration

4.3.1 Analysis and planning of software

During the system analysis (Fig. 4.8), the total system is divided into objects. If possible, these are split into further objects (cf. Chapter 3.3.1). The smallest possible units are then programmed and simulated. The objects are subsequently combined into a total system, and tested using simulation.

The grain store can be divided into the following objects:

- Object 1: Conveyor worm
- Object 2: Cyclone
- Object 3: Elevator
- Object 4: Switch-on interlocking
- Object 5: Switch-off interlocking
- Object 6: Signal lamps

The following statements can be made concerning the sequence:

- Object 1 is a self-latching circuit with upstream auxiliary contactor K1 (object 1.1).

- Objects 1, 2, 3 have identical functions.
- Conveyor worm and cyclone are mutually interlocked with regard to switching on and off.
- Elevator and cyclone are mutually interlocked with regard to switching on and off.
- Auxiliary contactor K1 must be scanned for "0" signal.
- The Stop buttons S2, S4, S6 must be scanned for "0" signal.
- The Start buttons S1, S3, S5 must be scanned for "1" signal.
- The outputs of the signal lamps Q5, Q6, Q7 should be switched depending on the respective output, Q1, Q2, Q3.

4.3.2 Software development

A list of connection names (Fig. 4.9) is initially produced. It is advisable to include object ID, brief description and at least the switching contact type "Normally closed, NC" in the description.

A carefully produced list of connection names helps avoid errors and facilitates updating and maintenance of the plant controller.

The individual objects are then programmed and simulated. The individual objects are then combined step-by-step into a total system. The total system should be tested again before the software is used on the machine.

It must be ensured that the software is sufficiently documented. The list of connection names should be provided with a brief description. This facilitates servicing and maintenance of the machine.

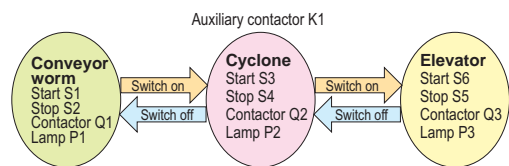


Fig. 4.8 System analysis

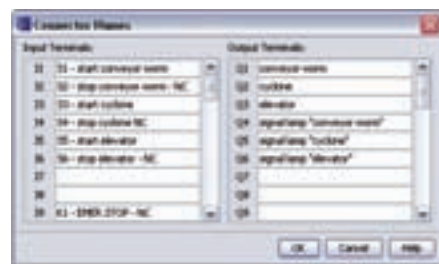


Fig. 4.9 Connection names

Steps	Function diagram
<p>Object 1: Conveyor worm</p> <p>Basic circuit "Self-latching" (cf. Chapter 9.4).</p> <p>Self-latching is implemented using the self-latching relay RS B001.</p>	
<p>Object 1.1: Worm, EMERGENCY STOP</p> <p>The basic circuit "Self-latching" is supplemented by the EMERGENCY STOP input I9.</p> <p>Power failure:</p> <p>No retentivity required since, in the event of a power failure, the EMERGENCY STOP input resets the self-latching relay.</p>	
<p>Object 2: Cyclone</p> <p>Object 1 has the same functions as object 2 and can therefore be copied and rewired (modification of input and output numbers).</p>	
<p>Object 3: Elevator</p> <p>Object 1 has the same functions as object 3 and can therefore be copied and rewired.</p> <p>Power failure:</p> <p>No retentivity required since, in the event of a power failure, the EMERGENCY STOP input resets the self-latching relay.</p>	

Steps	Function diagram
<p>Object 4: Switch-on interlocking</p> <p>Q2 can only be switched on if Q1 is already switched on.</p> <p>Q3 cannot be switched on before Q2.</p> <p>Power failure:</p> <p>No retentivity required since, in the event of a power failure, the EMERGENCY STOP input resets the self-latching relay.</p> <p>Simulation:</p> <p>Expand the circuit by the reset inputs I2, I4, I6.</p>	
<p>Object 5: Switch-off interlocking</p> <p>Q2 can only be switched off if Q3 is already switched off.</p> <p>Q1 cannot be switched off before Q2.</p> <p>Power failure:</p> <p>No retentivity required since, in the event of a power failure, the EMERGENCY STOP input resets the self-latching relay.</p> <p>Simulation:</p> <p>Expand the circuit by the set inputs I1, I3, I5.</p>	
<p>Object 6: Signal lamps</p> <p>The outputs of the signal lamps Q4, Q5, Q6 are to be switched depending on the respective output Q1, Q2, Q3.</p> <p>Simulation:</p> <p>Connect the outputs Q1, Q2, Q3 respectively to the inputs I1, I3, I5.</p>	

Tasks

1. The plant is to be expanded by a fault lamp and should separately display EMERGENCY STOP and motor circuit-breaker faults.

a) Expand the device list by a signal lamp.

b) Modify the existing connection diagram.

c) Supplement the list of connection names.

d) Supplement the software, and simulate the program.
2. The "Full" level of the silo is to be monitored by a digital level sensor. This status is signaled by a further signal lamp.

a) First write down the required hardware modifications.

b) Modify the process schematic.

c) Supplement the existing connection list.

d) Modify the software, and simulate the program.

e) Create documentation.

4.3.3 Entire representation as FBD

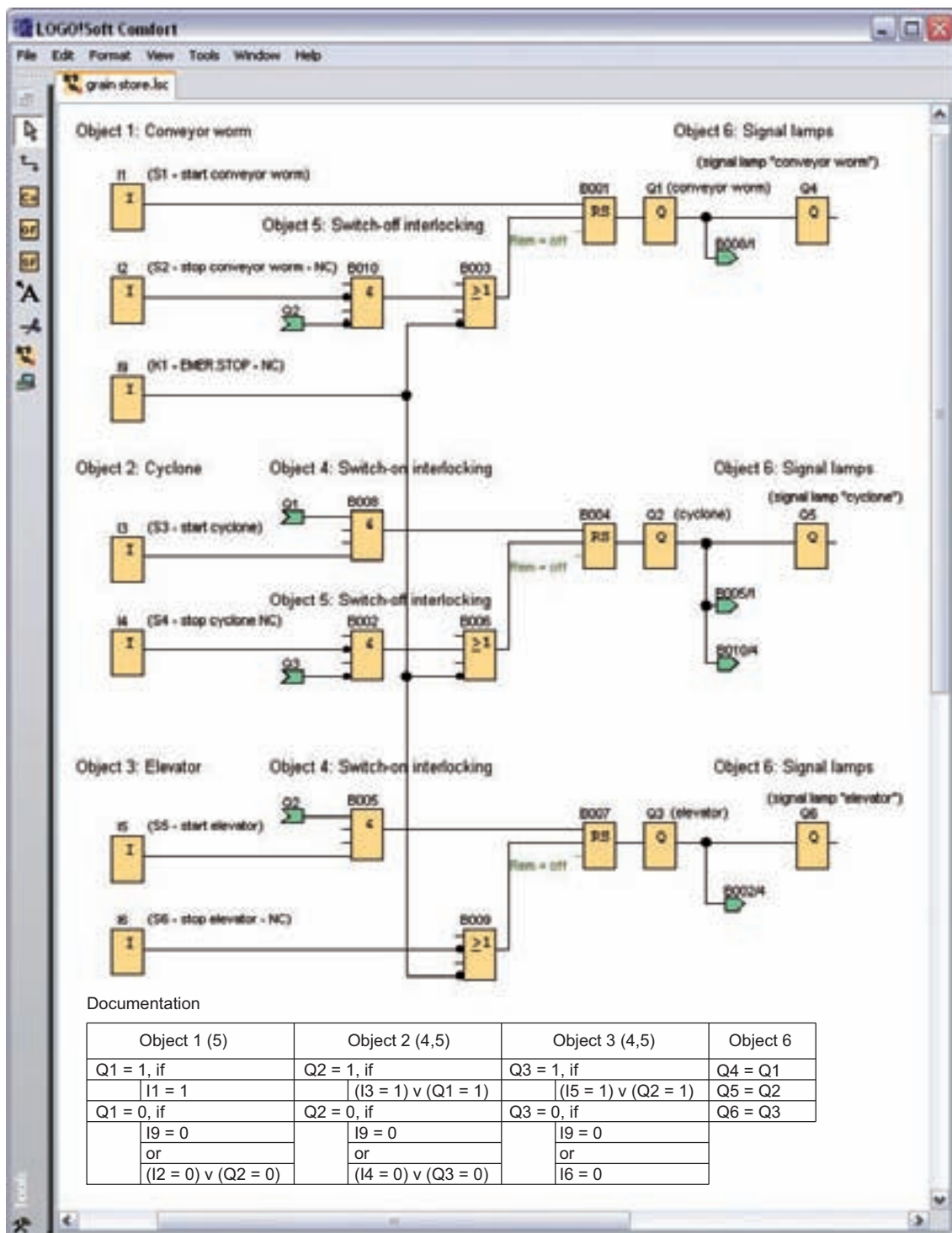


Fig. 4.10 Grain store control as FBD

4.3.4 Entire representation as LAD

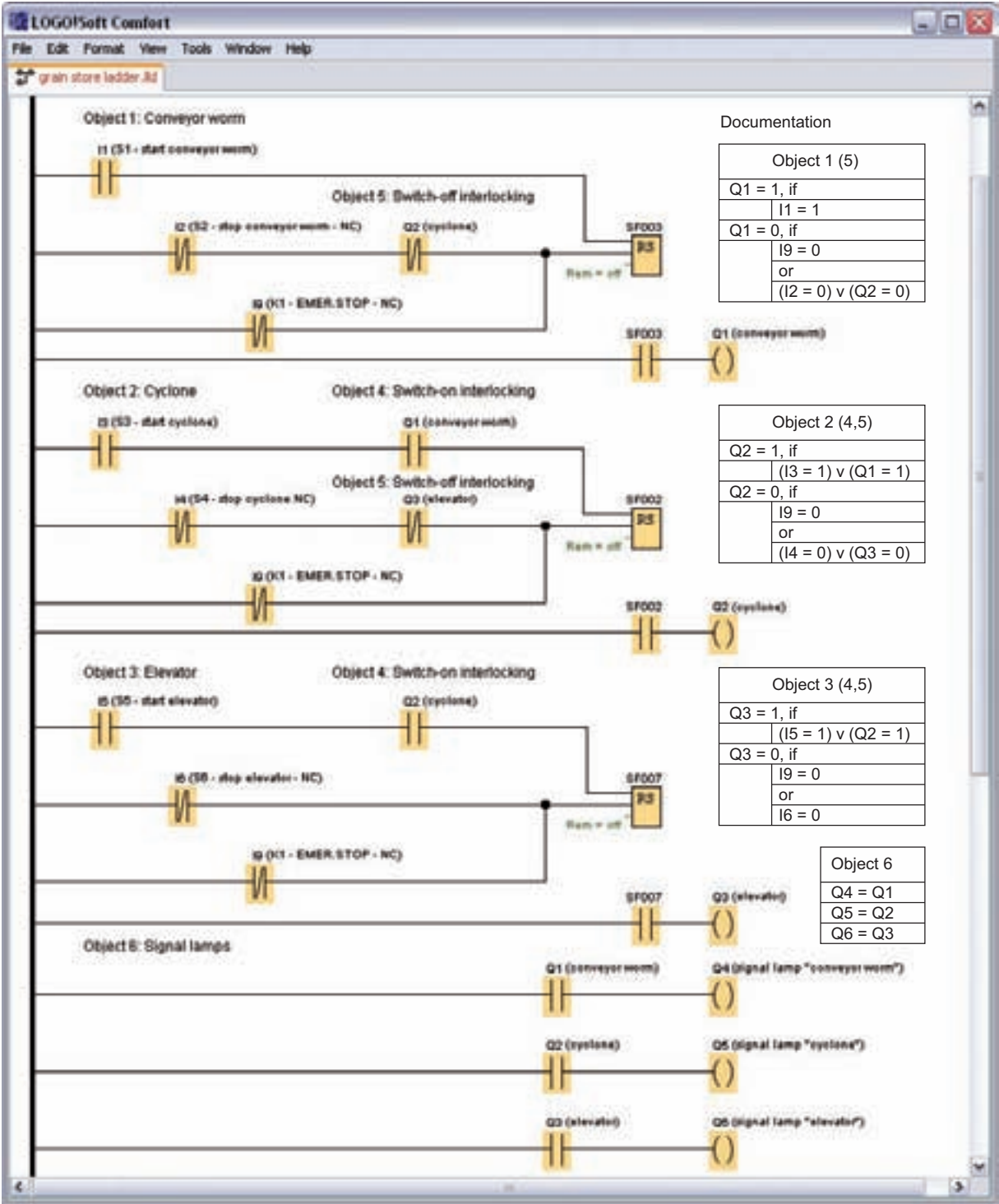


Fig. 4.11 Grain store control as LAD

4.4 Grain store – export version

4.4.1 Task description

The company of Grainmix wishes to export grain stores, and commissions the company of Elektra to design a new low-cost controller.

4.4.1.1 Function description

The old control concept is largely retained, only the safety regulations (cf. 4.2.2) are modified in that the protection of persons can be provided software-based (which may be only conditionally approved in importing countries, e. g. Germany).

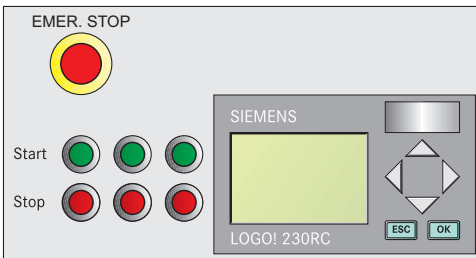


Fig. 4.12 Control panel for export

4.4.2 Hardware configuration

The four control circuits 1–4 (Chapter 4.2.2) are combined in one circuit (Fig. 4.14). This not only reduces the number of devices (Fig. 4.13), but also the installation costs.

Object	Object desig.	LOGO!	
		DI	DO
Fuse	F1		
EMERGENCY STOP	S0	X	
Start conveyor worm	S1	X	
Stop conveyor worm	S2	X	
Start cyclone	S3	X	
Stop cyclone	S4	X	
Start elevator	S5	X	
Stop elevator	S6	X	
Power contactor for conveyor worm	Q1		X
Power contactor for cyclone	Q2		X
Power contactor for elevator	Q3		X
LOGO! 230RC	K1		
Number of digital inputs required		7	
Number of digital outputs required			3

Fig. 4.13 Device list

In addition, a new signaling unit simplifies the control concept. Instead of the signal lamps (Fig. 4.2, page 42), messages are now output on the LOGO! display (Fig. 4.12).

4.4.2.1 Selection of LOGO!

This measure saves the three outputs Q4 – Q6 and thus the expansion module DM8 230R. The Logo! 230RC without display is replaced by a Logo! 230RC with display and input keys.

4.4.2.2 Connection diagram of LOGO!

The export safety regulations and the omission of the signal lamps P1, P2, P3 reduces the size of the connection diagram (Fig. 4.14). The Start and Stop buttons S1 – S6 and the power contactors Q1 – Q3 are retained. Instead of the auxiliary contactor K1, the EMERGENCY STOP button S0 is now connected as an NC contact ① directly to the mini programmable controller.

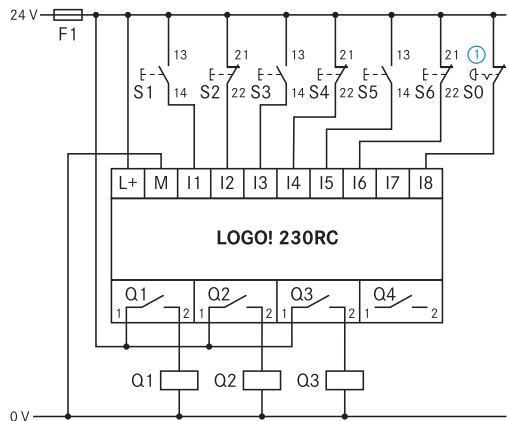


Fig. 4.14 Connection diagram

4.4.3 Software configuration

4.4.3.1 Analysis and planning of software

The software remains largely unchanged. In the objects 1, 2, 3 (cf. 4.3.2), input I9 (auxiliary contactor) is replaced by input I8 (EMERGENCY STOP). Object 6 is reprogrammed.

However, before the signaling unit can be re-programmed, the following questions must be clarified.

- What messages have to be displayed?
- When should the messages be displayed?
- What priorities do the individual messages have?

For this purpose, a matrix has been produced (see Fig. 4.15).

4.4.3.2 Software development

The main work is the programming of the message texts (Fig. 4.15). Each status of the plant is described by a brief text and assigned a priority (importance). Only the message with the highest priority is output on the display, irrespective of how many messages are triggered. The "Fault" message thus overwrites the message "Plant in operation".

A new, active message text is therefore only displayed if its priority is higher than that of the current message text ①.

Steps:

Object 1: Conveyor worm

With regard to the software, object 1 remains approximately the same as the old version, except that input I9 is replaced by input I8.

Retentivity: Following a power failure, the machine must be re-started, and therefore retentivity is not required.

Object 6: Message text

If the EMERGENCY STOP is triggered, the message "Plant fault" is output on the display. With the EMERGENCY STOP enabled, the message "Plant ready" is output on the display. However, this message is overwritten by the message "Worm on" if the operator presses the Start button of the worm. The text with the next higher priority ② is displayed if the cyclone is started in addition. When the message "Plant in operation" is displayed, all machines have been started and no faults are present.

Simulation: Replace the outputs Q1– Q3 by the inputs I1– I3.

The connection IDs (Fig. 4.16) are only changed marginally. In the case of the output terminals, the outputs Q5 – Q7 for the signal lamps are omitted. The input I9 (EMERGENCY STOP circuit) is replaced by the input I8 (EMERGENCY STOP button).

Conditions				Message	Prio
–	–	–	–	Fault	4
–	Q1	Q2	Q3	Plant in operation	3
–	Q1	Q2	–	Worm on, Cyclone on	2
–	Q1	–	–	Worm on	1
S0	–	–	–	Plant ready	0

Fig. 4.15 Message texts



Fig. 4.16 Connection names

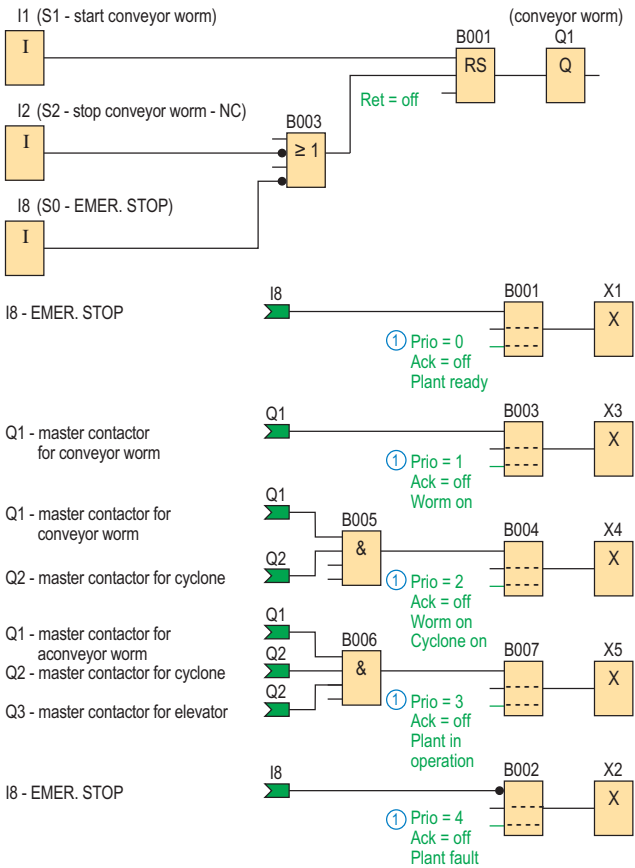


Fig. 4.17 Function diagram of message texts

5 Pallet magazine (step sequence)

5.1 Task description

The company of Mecha has designed a new automatic empty pallet magazine (Fig. 5.1) for 15 Europallets. It commissioned the company of Tronik to implement a simple controller for this prototype with a control relay. This system is for test purposes, and does not satisfy the general safety standards.

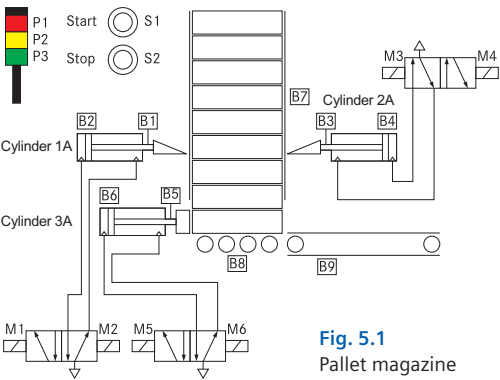


Fig. 5.1
Pallet magazine

5.1.1 Function description

The stacking magazine (Fig. 5.1) is responsible for separating the pallets and passing them on to a further process.

Following activation of the Start button S1, the process starts and the sensor B8 checks for the presence of a pallet on the palletizing table. If the sensor is activated, the cylinders 1A and 2A are simultaneously extended and the pallets above them are lifted.

If the conveyor belt is empty (sensor B9), the cylinder 3A can shift the bottom pallet out of the magazine. Cylinder 3A is then retracted, followed by cylinders 1A and 2A. Scanning of the end positions of the pneumatic cylinders is carried out by sensors B1 – B6.

The process runs automatically and can be stopped using the Stop button S2.

Signaling unit

The degree of filling of the magazine is monitored by the optical sensor B7. A signaling column is used as the signaling unit. The yellow signal lamp P2 indicates that the magazine should be filled again. Green (P1) signals that everything is OK, and red (P3) indicates a fault.

5.2 Hardware configuration

5.2.1 Selection of LOGO!

It is first necessary to define the number of digital inputs (DI) and digital outputs (DO):

Number of inputs and outputs

The total number of digital inputs and outputs (Fig. 5.2) is higher than that of the basic device of the mini programmable controller (Fig. 5.3). An expansion unit is required. The DM 16 expansion unit (Fig. 5.4) has sufficient outputs.

Inputs

For cost reasons and safety aspects, the basic devices have been selected with an operating voltage of ≤ 42 V AC/DC. Therefore only a LOGO! of voltage class 1 is possible.

Object	Object desig.	LOGO!	
		DI	DO
Plant start	S1	X	
Plant stop	S2	X	
Cylinder 1 A extended	B1	X	
Cylinder 1 A retracted	B2	X	
Cylinder 2 A extended	B3	X	
Cylinder 2 A retracted	B4	X	
Cylinder 3 A extended	B5	X	
Cylinder 3 A retracted	B6	X	
Sensor for degree of filling of magazine	B7	X	
Sensor for presence of palletizing table	B8	X	
Sensor for conveyor belt	B9	X	
Magnet coil for cylinder 1 A, forwards	M1		X
Magnet coil for cylinder 1 A, backwards	M2		X
Magnet coil for cylinder 2 A, forwards	M3		X
Magnet coil for cylinder 2 A, backwards	M4		X
Magnet coil for cylinder 3 A, forwards	M5		X
Magnet coil for cylinder 3 A, backwards	M6		X
Red signal lamp	P1		X
Yellow signal lamp	P2		X
Green signal lamp	P3		X
LOGO! 24v	K1		
LOGO! DM 16 24	K2		
LOGO! Power	K3		
Number of digital inputs required		11	
Number of digital outputs required			9

Fig. 5.2 Device list

LOGO! basic module									
Versions		Basic		Pure		Clock		Digital	
		With keypad	Without keypad	With	Without				
		With display	Without display	With	Without	8 inputs	4 outputs	2 inputs	Analog
		Transistor	Relay	Digital					
24 V	AC/DC								
	DC		X		X	8	4		
12 V/24 V	DC								
230 V	AC								

5.3 Software configuration

5.3.1 Analysis and planning of software

A further system analysis must be carried out before starting with the software development. Function diagrams are useful for this, for they provide an overview of the control sequence, and information for the software development can be obtained from them. The function diagrams are developed from the task description (Chapter 5.1).

Travel/step diagram

One possible form of a function diagram is the **travel/step** diagram. This describes the status of the cylinders as a function of the steps. In other words, at which step the cylinder is extended or retracted.

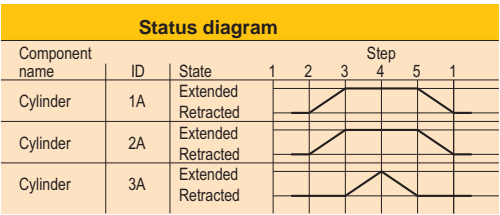


Fig. 5.6 Travel/step diagram

Function diagram

Fig. 5.8 shows the function diagram of the so-called step sequence. It is suitable for representation of sequential controls. The software-based implementation is not mapped in the function diagram. Therefore safety-related logic operations (e.g. cylinders 1A and 2A interlocked with cylinder 3A) are not shown.

Together with the list of connection names (Fig. 5.7), the function diagram serves as the basis for programming the sequence. The respective **step enabling conditions** ① and the **actions**



Fig. 5.7 Connection names

② can be simply integrated into the software concept of a sequence when programming.

The signaling unit is considered separately, and must be designed depending on the task description.

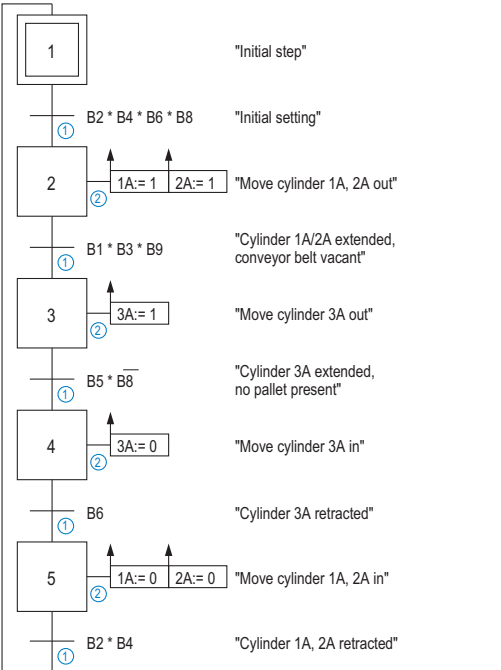


Fig. 5.8 Function diagram

Before commencing with programming, it is clearer if the parts of a sequential control are split further into objects:

Object 1: Operating mode component

- Object 1.1: Start/Stop/Reset
- Object 1.2: Fault

Object 2: Step sequence

- Object 2.1: Step 1, initial step
- Object 2.2: Step 2
- Object 2.3: Step 3
- Object 2.4: Step 4
- Object 2.5: Step 5

Object 3: Actions

- Object 3.1: Action of cylinder 1 A
- Object 3.2: Action of cylinder 2 A
- Object 3.3: Action of cylinder 3 A

Object 4: Signaling component

- Object 4.1: Green signal lamp
- Object 4.2: Yellow signal lamp
- Object 4.3: Red signal lamp

The additional statements can be made:

Object 1

- Automatic mode is set by pressing the Start button.
- Automatic mode is reset by pressing the Stop button.
- A fault is acknowledged by pressing the Start button.
- A fault resets automatic mode.
- The machine enters the fault status if the Stop button is pressed.
- If a step enabling condition is not satisfied within a defined time, the machine enters the fault status.

Object 2

- All steps are executed in sequence.
- Only one step is set at a time.
- A subsequent step is only set if the associated conditions of the step are fulfilled, and if the previous step is set.
- If a step is set, the previous step is reset.
- The step has a "1" signal as long as it is set.
- The input objects of the mini programmable controller should be scanned once per cycle for a "1" signal and a "0" signal. This guaran-

tees that they are functioning. But this should only be carried out if it does not slow down the process.

- In the basic setting, as many inputs as possible are scanned.
- Following a power failure, the step sequence starts with the initial step. The retentivity must therefore be switched off.
- A step triggers an action.
- Fault and Stop result in stopping of the step sequence.

Object 3

- Actions can be set for one or more steps.
- The cylinders 1A/2A are mutually interlocked with 3A for safety reasons.
- The last step enabling condition can be omitted since the basic setting is subsequently scanned.

Object 4

- The red signal lamp signals the fault.
- The yellow signal lamp is independent of the step sequence, and indicates the absence of pallets.
- The green signal lamp signals normal operation.

Process or processing sequences are referred to as **sequential controls**. Due to their modular structure, they are extremely clear and simple to expand and maintain. Configuration and programming are therefore simple and require little time. The graphic presentation is usually made with GRAFCET DIN EN 60848.

Sequential controls comprise

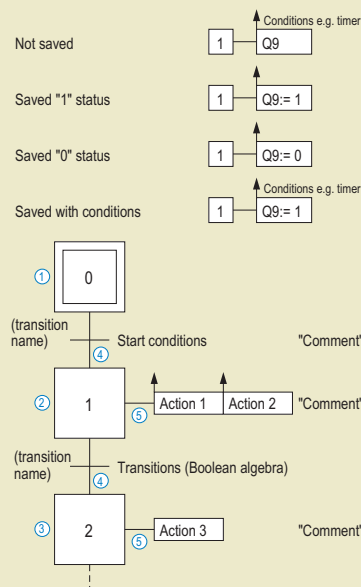
- the operating mode component,
- the steps,
- the actions, and
- the signaling component.

The initial status of the controller is the initial step 1. The progression from one step ② to the next ③ depends on the step enabling condition (transition) ④. Input signals, timers and counters are linked to the basic functions of the control relay into a step enabling condition. They can be represented by graphic symbols, but Boolean expressions should be preferred. A transition name may be present to the left of the transition. This must be specified in parentheses.

Each step triggers a command (actions) ⑤. The type of action is briefly explained in the following table.

Transitions and actions can be commented on the right. The name of the transition must be enclosed by quotation marks.

Examples



5.3.2 Software development

Steps	Function diagram
<p>1: Operating mode component</p> <p>Automatic mode is mapped by the auxiliary flag M21. Auxiliary flags help make the program clearer and easier to understand. They are always associated with an RS element. Thus flag 21 is set by the Start button and reset by the Stop or Fault button. In addition, automatic mode is reset in the event of a fault.</p> <p>The fault flag M22 is set by the Start button and reset by the Stop button. The machine is set to fault if a step enabling condition depending on the step is not fulfilled.</p>	
<p>1.1: Start/Stop/Reset</p> <p>The basic circuit for automatic mode can be applied 1:1 to this prototype.</p>	
<p>1.2: Fault</p> <p>The object 1.2 has the same functions as the basic circuit "Fault".</p> <p>It is necessary to adapt the step flags with the associated step enabling conditions.</p> <p>The timer B014 monitors how long a step is active. A fault is triggered in this case if a change in step does not take place within 30 seconds.</p>	
<p>2: Step sequence</p> <p>The basic object "Step flag" is set if the previous step (x-1), automatic mode, and the step enabling conditions have a "1" signal.</p> <p>The step flag is reset by the subsequent step flag (x+1).</p>	
<p>The basic circuit "First step" is also set by the previous step and reset by the following step. In addition, this flag is reset by the startup flag M8 following the return of power.</p>	

Steps	Function diagram
2.1: Step 1 The object 2.1 has the same functions as the basic circuit "First step". It is necessary to adapt the step enabling conditions and the flags.	
2.2: Step 2 The object 2.2 has the same functions as the basic circuit "Step flags". It is necessary to adapt the Reset input, the step enabling conditions, and the flags. The auxiliary flag 20 "Basic setting" is introduced in addition. This is required in the object 1.2.	
2.3: Step 3 The object 2.3 has the same functions as the basic circuit "Step flags". It is necessary to adapt the step enabling conditions and the flags.	
2.4: Step 4 The object 2.4 has the same functions as the basic circuit "Step flags". It is necessary to adapt the step enabling conditions and the flags.	
2.5: Step 5 The object 2.5 has the same functions as the basic circuit "Step flags". It is necessary to adapt the step enabling conditions and the flags.	

Steps	Function diagram
<p>3. Actions</p> <p>The basic object consists of a step flag ① linked to an output ②.</p> <p>The circuit is extended by OR logic ③ and therefore several step flags can switch an output. ① In addition, the object is supplemented by output interlocking ④. The circuit is to protect persons and machines in the event of a mal-operation or malfunction.</p>	
<p>3.1: Cylinder 1A</p> <p>Starting from the basic object, the output Q1 is linked directly to step flag 2. Step flag 5 is linked together with the safety interlock (cylinder 3A, rear B6) and to the output Q2.</p>	
<p>3.2: Cylinder 2A</p> <p>Object 3.1 has the same functions as object 3.2 and can be copied and rewired (modification of input and output numbers).</p>	
<p>3.3: Cylinder 3A</p> <p>Object 3.3 consists of two basic objects. The step flags are each linked to the outputs.</p>	
<p>4: Signaling component</p> <p>Operating statuses are linked logically to the outputs of the signal lamps.</p>	
<p>4.1: Green signal lamp</p> <p>If no fault is present (object 1.2), flag 22 is set, and the output Q9 has a "1" signal.</p>	
<p>4.2: Yellow signal lamp</p> <p>Output Q8 is switched to a "1" signal if the magazine is empty for longer than two minutes.</p>	
<p>4.3: Red signal lamp</p> <p>The output of the red lamp should have a "1" signal if a fault is present. Output Q7 is therefore the negation of output Q9.</p>	

5.3.3 Entire representation of step sequence

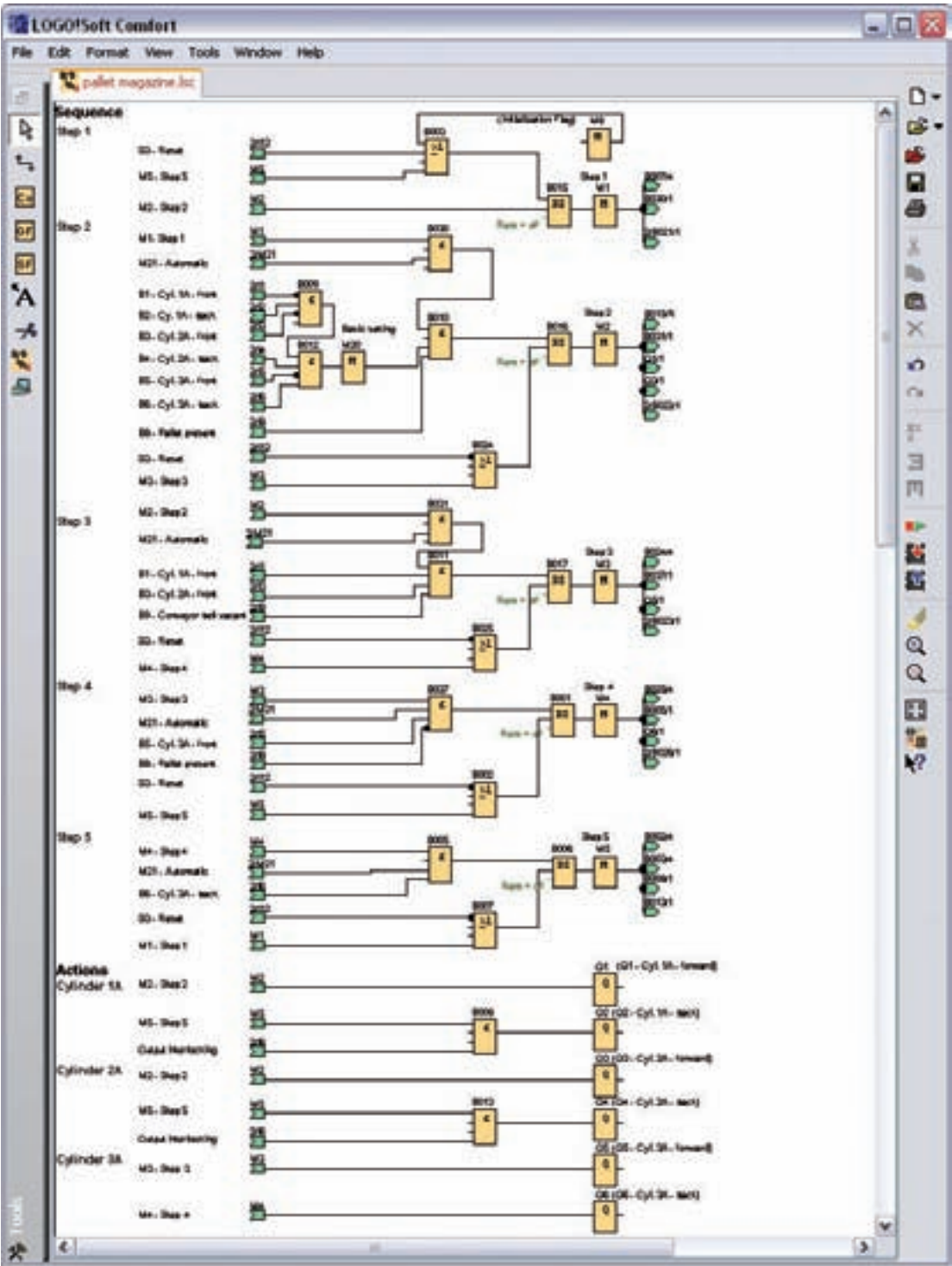


Fig. 5.9 Grain store control as FBD

6 Production Line with AS-Interface

6.1 Task description

A production line with distributed stations for assembly, testing and sorting is to be connected to a host controller. In the first project phase, only the test station is to be connected to the central controller.

The status of the test unit is signaled to the main controller (S7-200) which signals the following information fault-free by means of lamps.

- Red lamp → Plant is in Stop status
- Yellow lamp → Plant running, fault source high
- Green lamp → Plant running

In addition, the plant is to be started and stopped using the central controller.

6.1.1 Function description

The plant (Fig. 6.1) is started and stopped centrally using the S1 and S2 buttons. The information of the buttons is processed further in binary mode via an

- S7-200 (K5) ① and transmitted via an
- AS-i interface CP243-2 (K6) ②, an
- AS-i cable ③ and an
- AS-i module LOGO! CM AS-i (K3) ④ to the
- control relay (K2) ⑤.

The signals can subsequently be processed by the software in the LOGO!

The sensors B1 and B2 ⑥ signal the faulty components to the LOGO! (K2). The evaluation is carried out by the software using two counters (Fig. 6.2).

If the first counter reaches a value of 3, a binary signal is transferred via the AS-i bus to the S7-200 (K5). The S7-200 software processes the signal and triggers the yellow lamp. If the second counter reaches a value of 5, the system is stopped, and the red lamp is additionally triggered by the system. If the test station runs without problem (counter < 3), the green lamp is triggered.

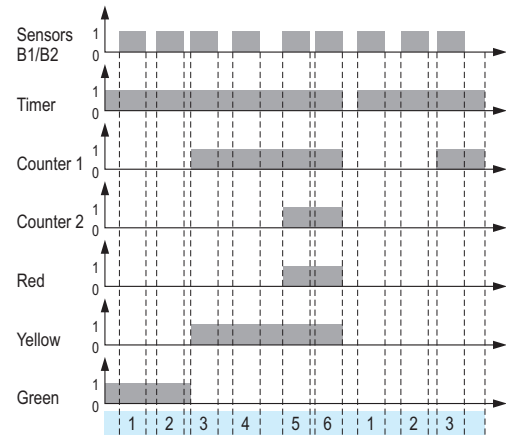


Fig. 6.2 Signal/time diagram

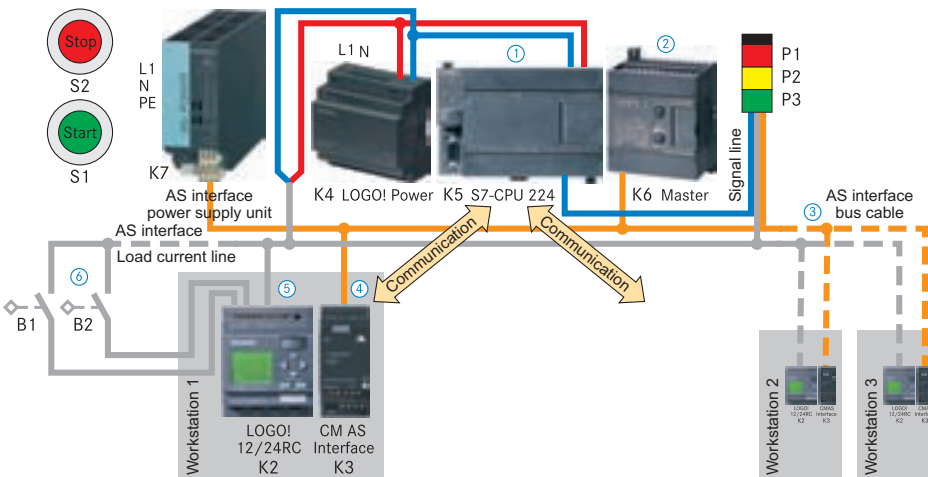


Fig. 6.1 AS-i plan with S7-200 and LOGO!

Object	Object desig.	S7-200	LOGO!
		I/O	I/O
Available components:			
LOGO! Power 24 V 1.3 A	K1		
LOGO! 12/24 V RC	K2		
Inductive proximity sensor	B1		X
Capacitive proximity sensor	B2		X
Additional components:			
LOGO! CM AS-i	K3		
LOGO! Power 24 V 1.3 A	K4		
S7-CPU 224	K5		
CP243-2 (ASI master)	K6		
AS-Interface power supply unit 30 V 2.4 A	K7		
Start button	S1	X	
Stop button	S2	X	
Red signal lamp	P1	X	
Yellow signal lamp	P2	X	
Green signal lamp	P3	X	

Fig. 6.3 Device list

6.2 Hardware configuration

6.2.1 Selection of additional components

Modern machines and plants exchange a wide variety of information. The actuator/sensor interface (AS-i) is used in current production plants for transferring information and power in the bottom control level, the field area. The technical specifications and transmission protocols are defined in EN 50295 for low-voltage switchgear – control and device interface systems – AS-i.

AS-i slave LOGO! CM AS-i

The LOGO! 12/24 V RC of the test station is supplemented by a CM AS-i communication module. The expansion module has 4 virtual inputs and 4 virtual outputs and, in this application, occupies the digital inputs I9–I12 and the digital outputs Q5–Q8 of the control relay. The module serves as AS-i interface between the control relay and the host controller.

The LOGO! can only be used as a slave. AS-i slaves are passive stations, and only reply when addressed by the master. Data cannot be exchanged directly between two control relays. Data is always exchanged via the AS-Interface master.

AS-i master CP 243-2

The CP243-2 communication module serves as master, and performs a central function in the AS-i network. The module scans the data of all stations in the network at exactly defined intervals (master/slave principle), and is connected via the internal bus to the PLC.

S7-200

The PLC used is an S7-200 with the CPU 224. This sends and receives data with the AS-i master in cycles via a reserved data storage area.

AS-i power supply unit

The AS-i power supply unit provides the supply voltage of 30 V DC.

AS-i cable

The transmission medium is an unshielded, yellow two-wire cable ($2 \times 1.5 \text{ mm}^2$) for data and max. 2 A power supply per AS-i line. As a result of the voltage drop, the cable length is limited to 100 m. The rugged design with IP65 or IP67 protection means that the AS-Interface is also suitable for harsh industrial environments.

Power supply unit for auxiliary voltage

An additional LOGO! Power 24 V 1.3 A power supply unit powers the LOGO! 12/24 V RC, the S7-200 and the actuators (lamps).

Network topologies

Flexible designs are possible as with electrical installations with line, star or tree topologies.

Costs

The AS-Interface permits extremely low-cost integration of sensors and actuators into the industrial communication. Comprehensive parallel wiring between sensors and controller is omitted. Costs are reduced further by the saving of terminal boards and I/O cards.

Expansion options

The AS-i bus allows the connection of up to 31 AS-i stations (version 2.0). Each station has a 4-bit I/O user data profile. This results in max. 124 sensors and/or actuators per master. The newer version 2.1 allows 62 AS-Interface slaves. AS-i slave modules (sensors/actuators with integral AS-Interface) can be integrated directly into the system, or sensors and actuators can be connected to the bus via coupling modules.

The S7-200 CPU 224 can be connected via communication modules to further bus systems, for example over Profibus to an S7-300 or over Ethernet to personal computers.

6.3 Hardware and software configurations

The connected AS-i stations must be configured as follows:

Addressing of LOGO! CM AS-i

Each slave must be assigned a valid address (between 1 and 31) prior to operation of an AS-i system. On delivery, this address is set to "0".

Addressing is carried out

- using an addressing unit (Fig. 6.4) directly on the slave or
- over the AS-i cable or
- using an AS-i wizard of the Step 7-Micro/WIN software.



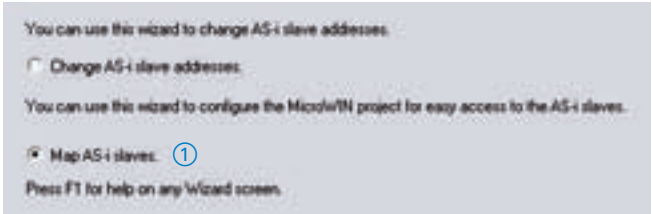



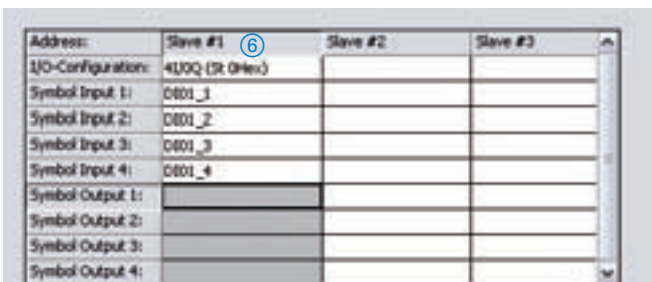
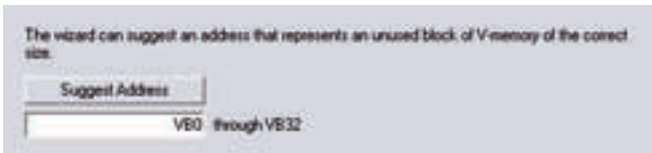
Fig. 6.4
Addressing unit

When addressing using the wizard, the AS-i system should be completely assembled, wired, and switched on (see Chapter. 2). Furthermore, communication should be established between the Step 7-Micro/WIN software and the S7-200.

Steps	Addressing of LOGO! CM AS-i in Step7
1: Calling of wizards After starting the Step 7 – Micro/WIN software, the AS-i wizard is started using the menu command Extras Wizard ① or by opening the operation tree ②.	
2: Selection of addressing The option "Change AS-i slave" is subsequently selected ③ and then confirmed using Continue.	
3: Changing the address The controller finds the master CP243-2 ④. The LOGO! with the slave address 0 ⑤ is connected to this module using the AS-i cable. A new address ⑥ is set, and activated using the Change button. The wizard is exited using the Complete button.	

Configuration of project for mapping AS-i slaves

The AS-i wizard defines addresses of the variables memory in the PLC, and connects these by means of the software to the slave's inputs and outputs. Symbolic addressing of the memory location is also carried out.

Steps	Configuration of CP243-2, and definition of variables range for PLC
1: Configuration of project The wizard is started. The option "Map AS-i slaves" is then selected ① and confirmed using Continue.	
2: Reading of module In online mode, all modules connected to the system can be read out using this button. After clicking on the Read modules button ②, the PLC indicates the detected CP243-2 module at module position 0 ③. Proceed to the next step using Continue.	
3: Offset addresses In online mode, the offset addresses ④ of the LOGO! CM AS-i module are already automatically loaded. The fields are deactivated, and cannot be changed. Proceed to the next step using the Continue button.	
4: Slave type In online mode, the digital standard slave ⑤ is already automatically detected. Proceed to the next step using Continue.	
5: Connected slaves In online mode, the table shows the configuration of the LOGO! CM AS-i module ⑥. The module has four virtual inputs with the selected address 1. The proposed configuration should not be changed, and the last step can be accessed using Continue.	
6: Memory area An internal variables range of the S7-200 must be assigned to the symbolic addresses. The proposed range VB 0 to VB 32 can be used. The wizard is finally completed using the Continue and Exit buttons.	

6.4 Software configuration

6.4.1 LOGO!

The sensors B1 and B2 are wired to the LOGO! and use the inputs I1 and I2.

The LOGO! CM AS-i module provides four inputs and four outputs. Only the inputs I9 and I10 are required for exchanging information between the Start/Stop buttons and the LOGO! (Fig. 6.5). Only the outputs Q5 to Q7 are used for triggering the lamps. The inputs I11 and I12 and the output Q8 are spares for later AS-i applications.

Prior to commissioning the total system, the LOGO! software should be tested by means of simulation.

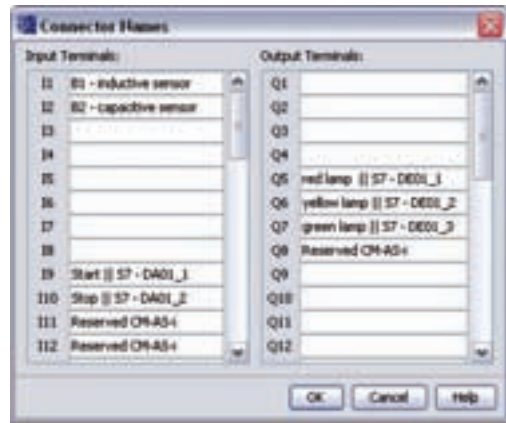
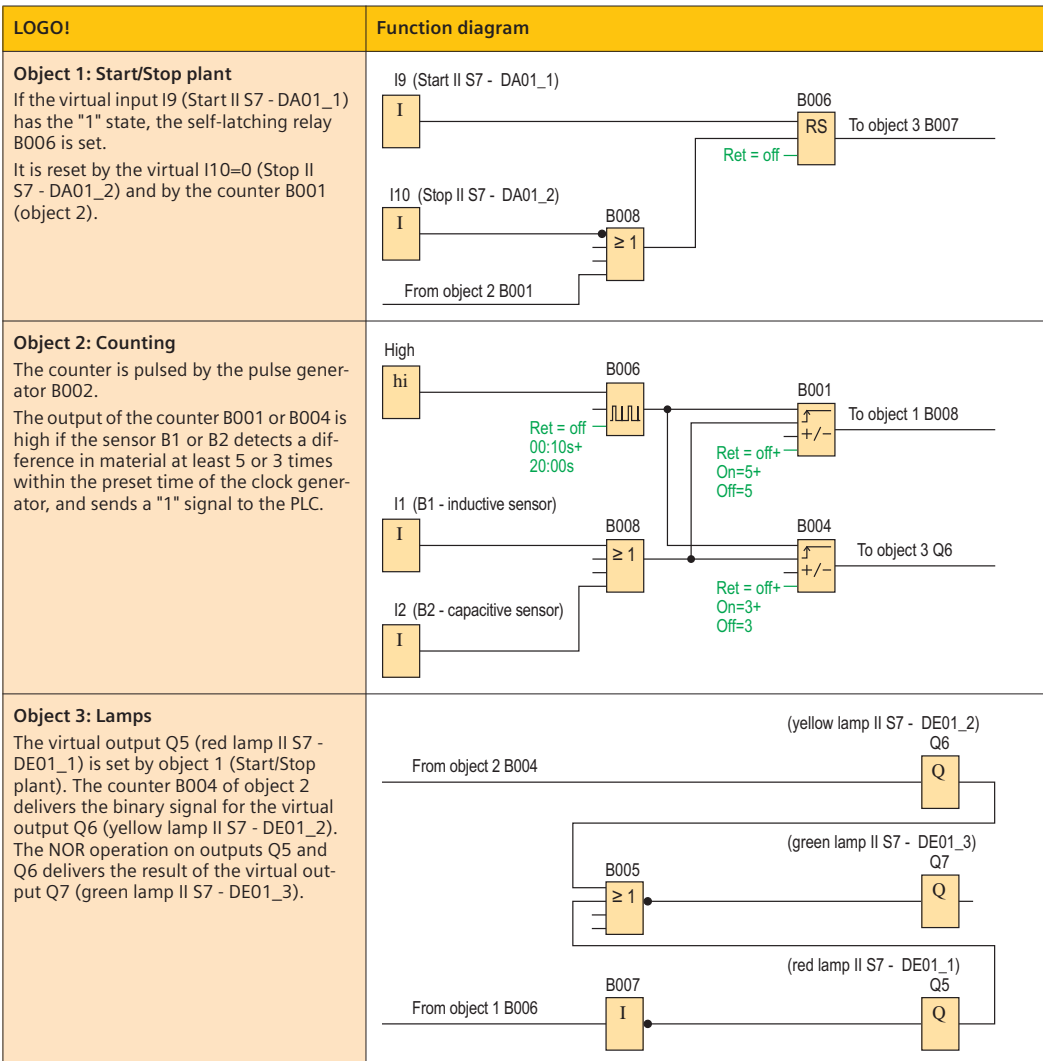


Fig. 6.5 LOGO! connection names



S1_Start	I0.1	Plant starts
S2_Stop	I0.2	Plant stops
P1_Red_Lamp	Q0.1	red lamp
P2_Yellow_Lamp	Q0.2	yellow lamp
P3_Green_Lamp	Q0.3	green lamp
DE01_1	V0.0	red lamp II LOGO!-Q5
DE01_2	V0.1	yellow lamp II LOGO!-Q6
DE01_3	V0.2	green lamp II LOGO!-Q7
DE01_4	V0.3	Reserved CP243-2
DA01_1	V16.0	Start II LOGO! – I9
DA01_2	V16.1	Stop II LOGO! – I10
DA01_3	V16.2	Reserved CP243-2
DA01_4	V16.3	Reserved CP243-2

Fig. 6.6 S7-200 symbol table

The buttons S1 and S2 are wired to the S7-200 and use the inputs I 0.1 and I 0.2.

The output terminals Q 0.1 – Q 0.3 are used by the lamps (red, yellow, green).

The variables memories DA01_1 to DA01_4 are reserved for communication between the PLC and LOGO! and the variables memories DE01_1 to DE01_4 in the reverse direction.

S7-200	Function diagram
Object 1: Start communication The ASIO_CTRL subroutine is called cyclically by a "1" flag. The ASIO_CTRL operation copies the I/O data between the CM AS-i and CP 234-2 communication modules and the variables memories (DE0x_x and DA0x_x). In a further configuration stage, the error codes of the AS-i module can be read and evaluated via the variables memory parameter AS_i_Error.	Network 1
Object 2.1: Plant start The binary signal of the Stop button is assigned to the variables memory DA01_1.	Network 2
Object 2.2: Plant stop The binary signal of the Stop button is assigned to the variables memory DA01_2.	Network 3
Object 3.1: Red lamp The binary value of the variables memory DE01_1 is assigned to the output P1_Lamp_Red.	Network 4
Object 3.2: Yellow lamp The binary value of the variables memory DE01_2 is assigned to the output P1_Lamp_Yellow.	Network 5
Object 3.3: Green lamp The binary value of the variables memory DE01_3 is assigned to the output P1_Lamp_Green.	Network 6

7 Software projects

7.1 Autoclave with Pt100

7.1.1 Task and function description

In a process for manufacturing dyes, two liquids must be mixed together at a pressure of at least 2 bar and a temperature of $119^{\circ}\text{C} \pm 1^{\circ}\text{C}$ (Fig. 7.1). An operator adds the two components manually into a boiler, and then closes the latter. After pressing the Start button S1, the compressed air valve M2 is opened until the setpoint pressure is reached. The heater E1 at the base of the boiler is switched on. During the complete period, the mixture is stirred by the motor M1 ($P_N = 3\text{ kW}$, $U_N = 400\text{ V}$). 15 minutes after reaching the setpoint temperature, the mixing process is terminated. All objects are switched off, and the signal lamp P1 (process finished) is switched on. The signal lamp is switched off when the process is started.

Note: To simplify the presentation, protection units are neglected in this description.

7.1.2 Hardware configuration

An analog sensor with an output signal of 0 to 10 V is used for measuring pressure, and a Pt100 sensor for measuring temperature.

Since the sensor operates with a supply voltage of $U = 24\text{ V}$, it is suitable to use a LOGO! 12/24RC (Chapter 8.2). The analog pressure can be directly connected to the input I7 or I8. The existing number of outputs is sufficient since only four objects need to be switched. The customer can change the limits for switching on and off in the software using the display and input keys.

In order to read in the temperature information of the Pt100, a LOGO! AM2 PT100 module is re-

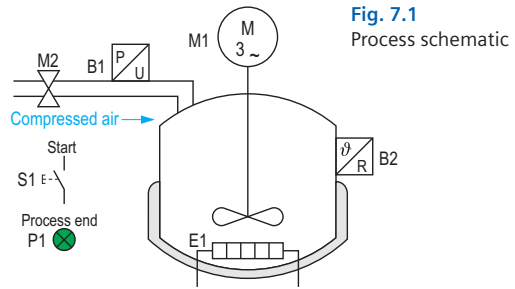


Fig. 7.1
Process schematic

quired. The basic device and the module can be powered from the same 24 V power supply unit.

Connection diagram

Since the LOGO! 12/24RC and the module have to be powered with 24 V DC, a power supply unit is used (Fig. 7.2) ①. The 24 V supply is also used for the two analog sensors B1 and B2 ② and the Start button S1 ③.

In order to keep the load on the relay outputs of the LOGO! low (service life and switching capacity: see Chapter 8.2.2.2), the motor M1 is controlled via the master contactor Q2, and the heater E1 via the master contactor Q3. Only the solenoid valve M2 and the signal lamp P1 are connected directly to the LOGO! A supply voltage of 230 V can be used on the output side ④.

As a result of the short line between the Pt100 and the module, the sensor is connected using a two-wire system. In this case, a jumper ⑤ must be connected between terminals M1+ and IC.

The fuse F1 ④ is rated at 10 A according to the current carrying capacity of the outputs. As a result of the low current consumption of the LOGO!, the module and the sensors, fuse F3

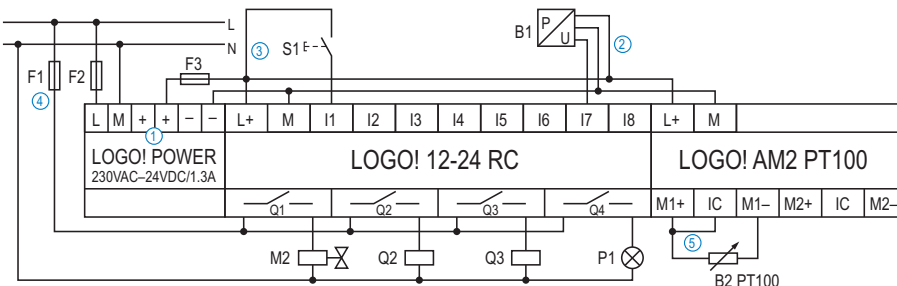


Fig. 7.2 Connection diagram

can be rated at 250 mA. Fuse F2 with a rating of 200 mA is matched to the power supply.

7.1.3 Software configuration

The pressure sensor is connected to terminal I7 of the LOGO! 12/24RC. Since it provides an analog signal, it is processed in the program as AI1 (Fig. 7.3).



Fig. 7.3 Assignment table

The AM2 PT100 module has two analog inputs for Pt100 sensors. Their numbers follow on from the previous ones. The first input (used here) is therefore analog input AI3. The outputs correspond to the connection diagram (Fig. 7.2).

Program description

The process is started by pressing the Start button S1. This sets the self-latching relay B001. The output signal from B001 is negated with the NOT B003, and thus switches off the signal lamp P1 during the process.

Achieving of setpoint pressure:

The analog threshold switch B004 is parameterized such that it enters the "1" state at an input voltage of 0 V and above. If B001 is set, the solenoid valve M2 is immediately switched because the AND B007 enters the "1" state. Since this results in a pressure increase in the boiler, the voltage at input AI1 also increases. The pressure sensor B1 has an output voltage of 8.5 V at an input pressure of 2 bar. The analog threshold switch B004 must switch off at this voltage (Off parameter).

Achievement and holding of setpoint temperature:

In the block properties of the two threshold switches B005 and B006, "PT100" must be selected as the sensor. The signal is then directly interpreted as a temperature value in the LOGO!

and processed accordingly. Since processing is only possible with integral temperature values, 1 °C can be selected as the resolution.

The analog differential threshold switch B006 is parameterized with the On value 119 °C so that this only has a "1" signal when this temperature is reached at the output. This is therefore negated accordingly to control the heater. The AND B008 blocks the output Q3 if the process is inactive.

Since block B006 is in the "0" state when the process is started, the negation results in activation of the heater until the setpoint temperature of 119 °C has been exceeded and block B006 has been switched off. The boiler temperature then drops again, and the heater is switched on again when the parameterized lower limit Δ ($119\text{ °C} + (-1\text{ °C}) = 118\text{ °C}$) is fallen below. Thus the temperature is held constant at $119\text{ °C} \pm 1\text{ °C}$.

The process should be terminated 15 minutes after the setpoint temperature has been reached for the first time. To achieve this, the threshold switch B005 is parameterized with the On value 118 °C so that the "1" state is provided at the switch-on delay B002 when this temperature is exceeded. Since the Off parameter of B005 with 100 °C is lower than the temperature variation to be expected, the signal is retained reliably at the switch-on delay B002. When the output of B002 is switched, the self-latching relay B001 is reset, and the process thus completed.

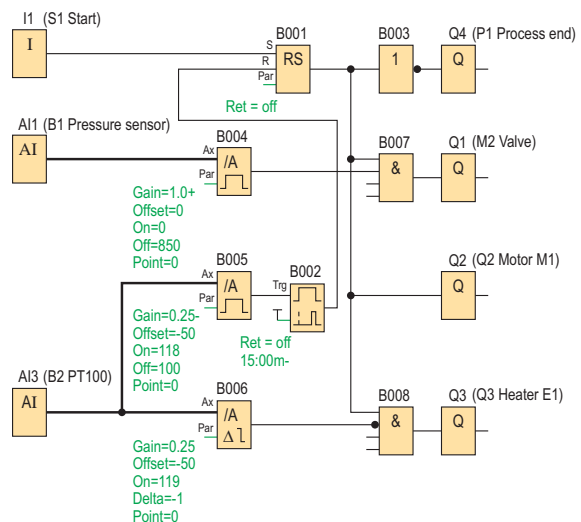


Fig. 7.4 Circuit diagram of autoclave control

7.2 School bell with EIB

7.2.1 Task and function description

In the Werner-von-Siemens school, the school-bell is controlled by a control relay. Monday to Friday, the bell should ring for three seconds at the start of school at 08h00 and at the end of school at 14h45. Furthermore, the breaks should be signaled (09h30 – 09h45, 11h15 – 11h30 and 13h00 – 13h15).

The headmaster and the janitor should be able to activate the bell system from their rooms using buttons with signal lamps. The school is provided with an EIB system (European Installation Bus, see explanation on right).

During school holidays, the bell should be out of operation. It should be possible for the janitor to change the holiday time settings.

7.2.2 Hardware configuration

A LOGO! 12/24RC is selected to switch the school bell since this has a display and clock (Chapter 8.2). A LOGO! CM EIB/KNX expansion module is required in addition. This interface permits the LOGO! to communicate over the EIB with the buttons and signal lamps.

Connection diagram

The headmaster's and janitor's buttons S1 and S2 are connected exactly like the associated signal lamps P1 and P2 on the EIB (Fig. 7.6). The signal lamps are switched by the actuators Q2 and Q3. The EIB is connected to the + and – terminals of the communication module ① (observe correct polarity!). The bell is switched directly by the relay output Q1.

7.2.3 Software configuration

The CM EIB/KNX permits communication with the EIB, and uses a maximum of 16 virtual digital inputs and 12 virtual digital outputs for

this. These are assigned numbers following the real inputs and outputs. The buttons can thus be read in via the virtual inputs I9 and I10 (Fig. 7.5) since these are the first two virtual inputs.

If the LOGO! switches the virtual outputs Q5 and Q6, the signal lamps P2 and P3 are switched via the EIB.

The inputs and outputs are assigned in the EIB system using the EIB software ETS.

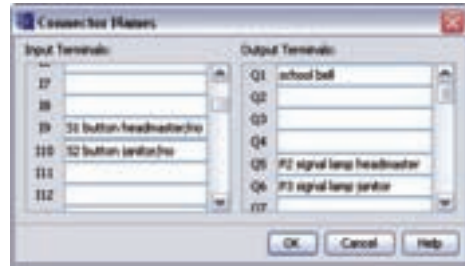


Fig. 7.5 Connection table

Program description

The school bell can be activated at any time using the button S1 or S2 (Fig. 7.7).

The week time switches B006 to B008 switch for one minute at any desired time, e.g. 8:00 is entered as the switch-on time and 8:01 as the switch-off time.

In order to reduce the ringing duration to 3 s, the switching time of the week time switch is limited by the edge-triggered interval time-delay relay B001.

Holidays are entered using the year time switches B005 and B009 to B011. If one of these time switches is active, the AND B013 is blocked via the NOR B012 so that ringing does not take place during the holidays.

Since the holiday times are variable, the block property "Protection" is not activated.

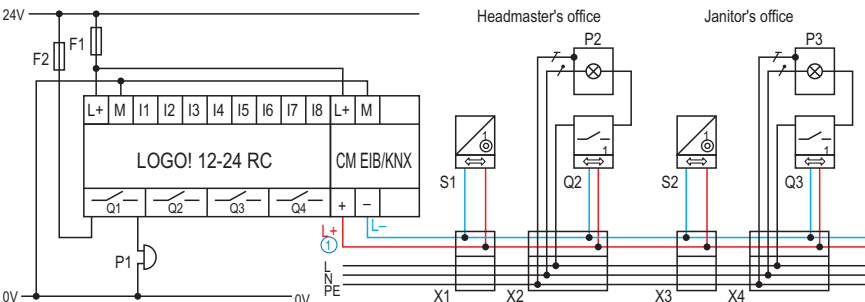


Fig. 7.6 Connection diagram

What is EIB?

In traditional installation engineering, a fixed line is routed e.g. to the associated switch for each ceiling light, and the assignment between the two objects is fixed. In the case of building services, this fixed assignment has been canceled by the application of bus systems such as the standardized European Installation Bus (EIB). In order to implement this, a two-wire bus cable must be provided which combines all bus participants (buttons, switches, sensors, actuators etc.) together. Both line and star topologies are possible for this data bus. If devices are to be switched by means of a voltage of 230 V, switching actuators must be used which are additionally connected to the "normal" circuit.

The bus uses a voltage of 24 V and can be routed next to the 230 V cables. It must be ensured in the branching boxes that a distance of 4 mm is retained between the two circuits. The advantage of this additional installation overhead is to be found in its flexibility. The system is programmed as required using the ETS software.

A fixed address is assigned to each bus participant through which it can be identified in the system. The programmer decides which button switches which lamp, socket or blind. This flexibility is particularly advantageous in offices since, for example, changes in room utilization are easy to carry out.

Bus systems are also being increasingly used in electrical installations since the networking of the participants is continuously increasing. For example, the alarm system can switch on the lights throughout the house in the event of an alarm, or, when leaving the house, the lights can be switched off, the blinds moved into the desired position, and the heating controlled. The functions carried out by the various participants are also highly variable: whether the motion detector in the hallway switches on the lights or activates the alarm system is dependent on the programming.

If the LOGO! is to be integrated in the EIB system as a station, an EIB application must be additionally loaded in the ETS software. This allows specific communication between LOGO! and EIB.

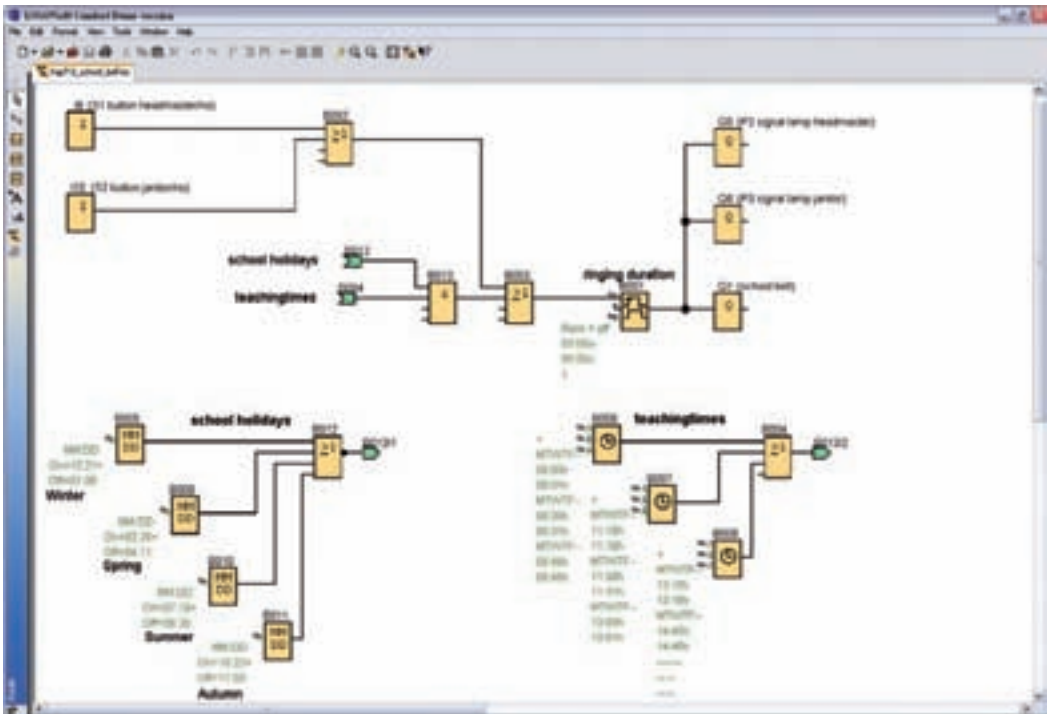


Fig. 7.7 Program for school bell

7.3 Analog value processing in a labeling machine

7.3.1 Task and function description

In the dispatch department of a warehouse, the completed parcels are to be automatically labeled. The parcels are located on a 1 m long conveyor belt which transports them at the same speed as the preceding and following belts (Fig. 7.8). Since this speed is too high for labeling, the belt must be reduced to an adjustable value when the parcel is 78 cm before the end. It is to be accelerated again when the parcel is 20 cm before the end.

Labeling is carried out by a stand-alone machine which is activated by a "1" pulse (1 s) when the parcel has reached the center of the belt. The operator panel should have Start and Stop buttons (S1/S2). It should be possible to adjust the belt speed during labeling using a potentiometer (R1). Operation is indicated on the signal lamp P1.

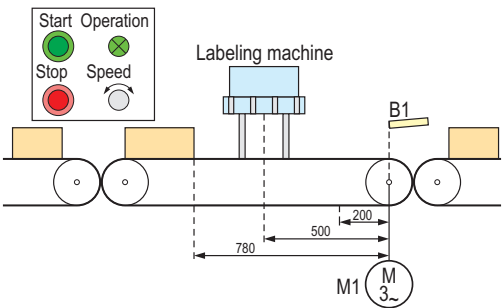


Fig. 7.8 Process schematic

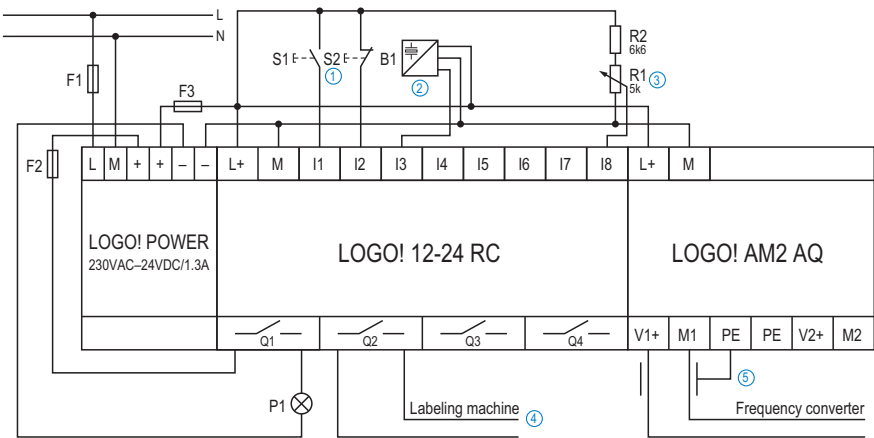


Fig. 7.9 Connection diagram

7.3.2 Hardware configuration

Since the parcels have different shapes, the position is detected using the ultrasonic sensor B1 (frequency output 40...400 Hz, sensing range: 1m, Chapter 8.1.3.9). An analog voltage signal is also generated using the potentiometer R1. Therefore use of a LOGO! 12/24RC is meaningful since this has two inputs which can also read in analog signals with 0 V to 10 V.

The floating outputs can be used as desired, enabling the signal lamp and the labeling machine to be connected directly.

The belt motor M1 is controlled by a frequency converter (FC). To achieve exact adaptation of the belt speed, the frequency converter is controlled by an analog signal (0 V to 10 V). The AM2 AQ expansion module is therefore required (Chapter 8.2.2.2).

The frequency converter is programmed such that the conveyor belt has the same speed as the previous and following belts when a voltage of 10 V is present at the analog input of the converter. The belt is stationary when the voltage is 0 V.

Connection diagram

The Start button S1 is configured as an NO contact in accordance with the safety regulations, the Stop button S2 as an NC contact. The system cannot then start automatically in the event of an open-circuit, or it switches itself off automatically ①. The fuses F1, F2 and F3 guarantee resistance to ground faults.

The ultrasonic sensor B1 is powered by 24 V and connected to the terminal I3 since fast signals can also be processed here (cf. Chapter 8.2.2.1 → Fast inputs) ②.

The analog setpoint input is to be made using the potentiometer R1 = 5 kΩ ③. Since the LOGO! has to be powered with 24 V from a power supply, a series resistor R2 of 6.8 kΩ must be used to generate a signal of 0 V to 10 V. The voltage is limited to the desired range by this voltage divider.

The labeling machine is controlled by the floating output Q2 ④. If this is switched, the stand-alone machine is activated. Limiting of the switching duration (1 s) is set in the software.

The cable between the analog output AQ1 and the frequency converter must be shielded to prevent the signal from being falsified by the high-frequency oscillations in the frequency converter or by other influences. The shielding is connected to the PE terminal ⑤.

7.3.3 Software configuration

Analog values are processed in the LOGO! and may have to be adapted during operation. Since it is easy to change the setting of the potentiometer, this value should be output in the LOGO! display.

In addition, it should be possible for the user to change the parameters for accelerating and braking the belt. The blocks responsible for this (B004 and B005) must therefore not be protected.

Program description

The system is activated by pressing the S1 button (B002 is set). This switches the operation lamp P1 at output Q1, and the ramp B006 is activated via input En. The ramp is parameterized such that it then automatically outputs the ana-

log value 1000 (10 V) and, with a "1" signal at the input Sel, reduces it to the adjustable setpoint. For this purpose, a fixed value of 1000 is entered as level 1, and a reference to the output value of the analog amplifier B007 is set as level 2. This is necessary since the reference to an analog input is not possible.

The switching points for labeling as well as for braking and accelerating are defined by the frequency-dependent threshold switches B003, B004 and B005. Since the ultrasonic sensor outputs a signal of 400 Hz if there are no parcels on the belt, the parameters must be set accordingly. Since a 40 Hz signal is present at the fast input I3 at a distance of 0 cm, it is easy to calculate that the frequency at the beginning of the braking process is 321 Hz (= 78 cm) and for the acceleration 112 Hz (= 20 cm).

If the parcel is in the center of the belt, the threshold switch B003 switches the output Q2 (On = Off = 110, with a gate time of 0.5 s) if the system is active (AND operation B010 is satisfied). B003 is in the "1" state at the beginning, and changes to the "0" state when the parcel is in the center of the belt. The output signal of B003 is therefore negated at the input of B010.

The signal text B009 indicates the current output value of AQ1 and the setpoint. For this purpose, the corresponding output value Aq of the AQ1 and the amplified value Ax of the analog amplifier B007 are entered in the block properties window of the signal text.

It should be noted for the analog output that this can only convert values between 0 and 1000 into voltages between 0 V and 10 V. The parameters of the ramp are defined accordingly.

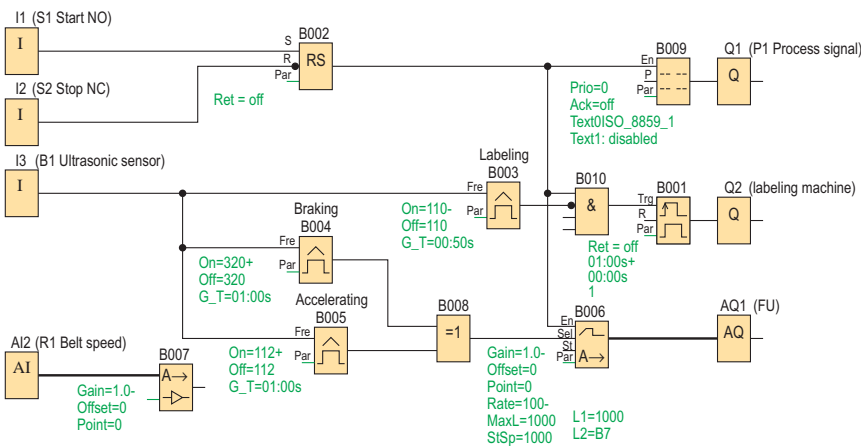


Fig. 7.10 Function diagram of labeling machine

7.4 Greenhouse with PI controller

7.4.1 Task and function description

The company of Planta plans a small, fully-automated greenhouse (Fig. 7.11) which is controlled by a mini programmable controller.

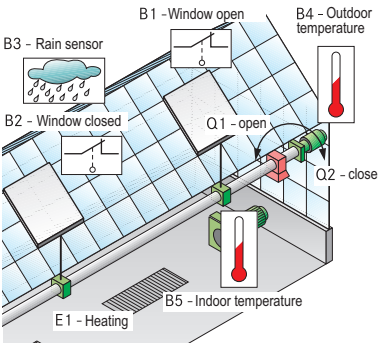


Fig. 7.11 Greenhouse

The greenhouse is ventilated for 15 minutes every two hours during the day (8h00–20h00) by means of a roof window. The window remains closed if it is raining and at outdoor temperatures below 15°C. In addition, an electric heater is provided to ensure that the temperature in the greenhouse does not fall below 15°C. The interior and outdoor temperatures are output on a display.

Note: To simplify the presentation, protection units are neglected in this description.

7.4.2 Hardware configuration

The weather conditions (Fig. 7.11) are detected by a digital rain sensor B3 and an analog temperature sensor B4. In addition, an analog sensor B5 measures the temperature inside the greenhouse. The temperature sensors are designed as Pt100 (cf. 8.1.3.10). The roof window

is opened by motor Q1 and closed by motor Q2. The digital information "Window open" B1 and "Window closed" B2 is provided by two end contacts.

The LOGO! 24RC is appropriate as the mini programmable controller. The LOGO! Basic module has a display, and only digital inputs and outputs. The relay outputs can each be loaded with 10 A. The temperature measurement is evaluated using the analog module AM2 PT100 (cf. 8.2.2.2) and the analog control element of the heater is controlled via the module AM2 AQ.

Connection diagram

The LOGO! Power (Fig. 7.12) powers the individual modules and the sensors with 24 V. To protect the LOGO! power supply unit (cf. 7.1.1), a fuse F2 ⑩ with a rating of 200 mA is connected in series. In the 24 V sensor circuit, fuse F3 ⑪ with a rating of 250 mA protects the objects. The fuse F1 ⑨ has a rating of 10 A according to the current loading capacity of the relay outputs.

The end contacts B1 ① and B2 ② are designed as NC contacts to provide protection against open-circuits (cf. 4.2.2). In addition, this version of the greenhouse includes the rain sensor B3 ③ configured as an NO contact. A three-wire system is used because of the long cables between the module and the Pt100 sensors B4 ④ and B5 ⑤. Deviations resulting from the resistance of the sensor cable are thus minimized.

The ventilation window is controlled by a small AC motor. This can be connected directly to the relay outputs Q1 (open roof window – counter-clockwise) ⑥ and Q2 (close roof window – clockwise) ⑦ of the control relay (cf. 8.2.2.1).

The analog expansion module AM2 AQ is wired directly to the control element for the heater ⑧ and controls this with 0–10 V. The cable should be shielded so that the analog signal is not falsified by external influences.

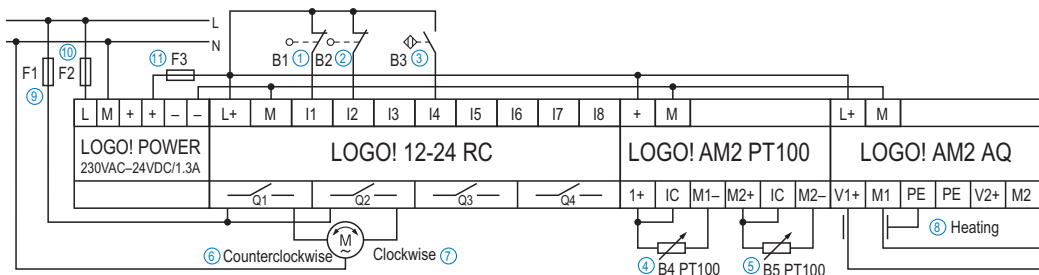


Fig. 7.12 Connection diagram

7.4.3 Software configuration

During the system analysis, the total system can be divided into three objects (cf. 4.3.1):

- Object 1: Temperature control inside greenhouse
- Object 2: Control of roof window
- Object 3: Text display of temperatures

Object 1: Temperature control inside greenhouse

The PI controller (Fig. 7.13) must first be set to automatic mode. To do this, the constant "hi" is connected to the input AM of the PI controller. The analog input B5 which measures the interior temperature is subsequently connected to input PV (controlled variable). The PI controller endeavors to minimize the difference between the indoor temperature and the defined setpoint, and controls the heater via the analog output AQ1 (manipulated variable).

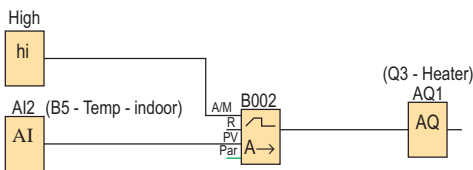


Fig. 7.13 Program section for control of heater

Once the control loop has been drawn up, the controller can be parameterized (Fig. 7.14). PT100 is selected as the type of sensor ①. This measures the temperature at a resolution ③ of 1 in the dimension ② Celsius. The setpoint ④

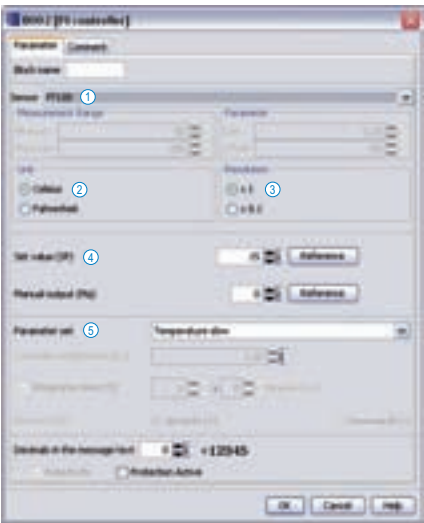


Fig. 7.14 Block properties for PI controller

according to customer information must be set to 15°C.

The control parameters ⑤ of the PI controller can be set according to user definitions or by using predefined parameter sets. The online help suggests selection of the parameter set "Slow temperature" in the case of heater controls in order to avoid fast variations and repeated changes in control.

Further information is provided by the online help under the keywords "Fundamentals on control" and "Fundamentals on controller".

Object 2: Control of roof window

The outputs Q1 and Q2 are interlocked in the software (cf. 3.2.2) so that "Close window" has priority. In addition, the outputs only have a "1" signal if the inputs I1 and I2 (NC) also have a "1" signal. The input I4, the week time switch B009 for night mode, and the analog input AI1 directly control Q2. However, the signal of the analog sensor is processed first by the threshold switch.



Fig. 7.15 Block properties for threshold switch

The analog threshold switch is parameterized analogous to the PI controller. The sensor type ⑥ "PT100" is selected first, and then the associated dimension ⑦ and the resolution ⑧. The threshold value ⑨ is 14, since the windows should be closed below 15°C.

The week time switch B003 together with the pulse generator B004 provide periodic ventilation during the day. The parameterizable pulse/pause ratio of the pulse generator is 1:45 h/15 min in this case.

Object 3: Text display

The constant "hi" (Fig. 7.16, ⑩) ensures that the interior temperature and the outdoor tempera-

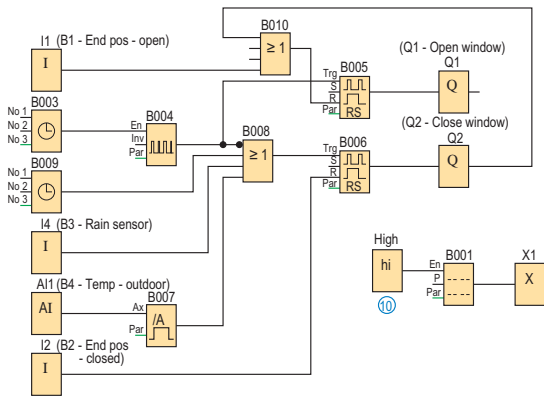


Fig. 7.16 Program section for control of roof window and text display

ture are output up-to-date on the display. The block is parameterized as described in Chapter 7.6.

7.5 Drum speed with mathematical function

7.5.1 Task and function description

In the rolling mill in Solengo, the company of Audito carried out a product audit and suggested several possibilities to the factory management for improving production quality. The company management of the rolling mill decided to implement the results in the short-term.

The first project to be tackled was the milling plant. On this flexible plant (Fig. 7.17), various products are formed with different rolling speeds. The flow speed of the milling process is defined by a host controller, but this is not checked for accuracy.

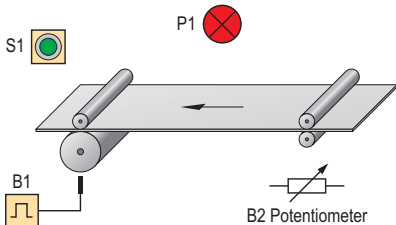


Fig. 7.17 Milling plant

The company's strict quality requirements state that the actual speed must not deviate by more than 5% from the setpoint speed. A monitoring unit must therefore be provided which checks

the actual speed and informs the personnel in the event of a deviation.

7.5.2 Hardware configuration

A prototype is initially designed and tested. In order to measure the actual speed, an inductive proximity sensor B1 (Chapter 8.1.3.3) is used. This sensor generates one pulse per revolution, and requires a 24 V power supply.

The LOGO! 12/24 mini programmable controller selected (Chapter 8.2.2.1) can record and process these fast pulses, and also provides mathematical functions from development release 0BA6 onwards which are necessary to calculate the speed deviations.

Whereas the setpoint is to be provided later in the real plant as an analog value from the host controller, it is generated in the prototype by means of potentiometer B2 (cf. 7.3.2). The scale on the linear potentiometer extends from 1 to 8. A value of 1 corresponds to 10 pulses in 10 s, and is the minimum rolling speed; a value of 8 corresponds to the maximum speed of 80 pulses in 10 s.

If the actual speed varies by more than 4%, a red signal lamp P1 lights up for 2 s.

Connection diagram

The LOGO! 12/24 (cf. 7.3.2) is powered by the LOGO! Power 1.3 A (Fig. 7.18) ①. In addition, all sensors and actuators are supplied with 24 V voltage. The inductive proximity switch B1 ② is connected to the fast digital input I1 (cf. 8.2.2.1). A special feature is the connection of potentiometer B2 ③. This must be connected via a voltage divider (cf. 7.3.2) to analog input I8 in order to generate a signal of 0–10 V. The actuator, the signal lamp, P1 ④ is connected to the relay output Q1.

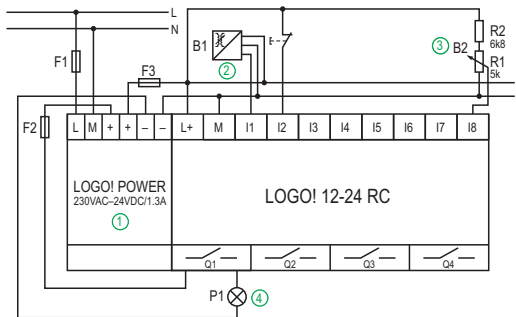


Fig. 7.18 Connection diagram

7.5.3 Software configuration

The heart of the program is the counter B003 (Fig. 7.19, Fig. 7.22 ① ⑩) in combination with the pulse generator B006. During the pulse duration of 10 s, the number of pulses from the pulse generator are accumulated, and the result is then available at the counter output within the interpulse duration of 2 s. If the result is a "0" signal, the operation lamp P1 at the output Q1 is activated.

The pulse counter output in Fig. 7.19 has a "0" signal

- if the switch-on limit ① is fallen below. In this case the rotational frequency is below the lower tolerance and thus too low.
- if the switch-off limit ② is exceeded. In this case the rotational frequency is above the upper tolerance and thus too high.

The pulse counter output in Fig. 7.19 has a "1" signal

- if the counter value is within the defined threshold limits.

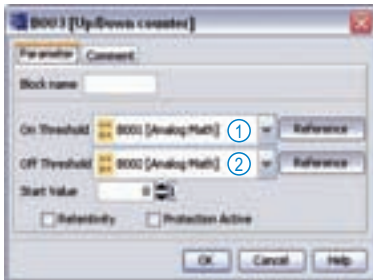


Fig. 7.19 Pulse counter

The associated switch-on and switch-off limits are calculated using the block B002 Analog Arithmetic (Fig. 7.21). The equation of the relative error is applied to calculate the limits:

$$f = \frac{(a - w)}{w} \cdot 100\%$$

w = setpoint, a = actual value,
 f = error tolerance in %

Resolved according to the maximum actual value (switch-off limit) a_A and the minimum actual value (switch-on limit) a_E results in:

$$a_E = w - \frac{f \cdot w}{100\%}$$

$$a_A = w + \frac{f \cdot w}{100\%}$$

Result	Value1 (P1)	Operator1 (priority 1)	Value2 (P2)	Operator2 (priority 2)	Value3 (P3)	Operator3 (priority 3)	Value4 (P4)
①/②	③	④	⑤	⑥	⑦	⑧	⑨
$a_E =$	w	- (L)	f	· (H)	w	/ (L)	100%
$a_A =$	w	+ (L)	f	· (H)	w	/ (L)	100%

Fig. 7.20 Calculation of the threshold values

The table in Fig. 7.20 represents the link between the equation and the conversion into the LOGO! notation (Fig. 7.21).

The values w ③/⑦, f ⑤ and 100% ⑨ are actual values of a different function which has already been programmed. For example, the error tolerance f ⑤ is programmed as an up/down counter B005, and can thus be parameterized.



Fig. 7.21 Mathematical function

Further information on the mathematical functions can be found in Chapter 9.4 or using the help function of the LOGO! software.

Test run

To carry out the test (Fig. 7.22), the setpoint setting ⑫ is set on the potentiometer B2 to a value of 5 as an example. The value is amplified by a factor of 10 by the analog amplifier, and is available as the setpoint ③ for calculating the limits. With an error tolerance ⑤ of 4%, this results in a switch-on limit ① of $a_E = 48$ and a switch-off limit ② of $a_A = 52$.

During the pulse duration of 10 s, the actual value counter ⑩ counts the pulses. If the actual

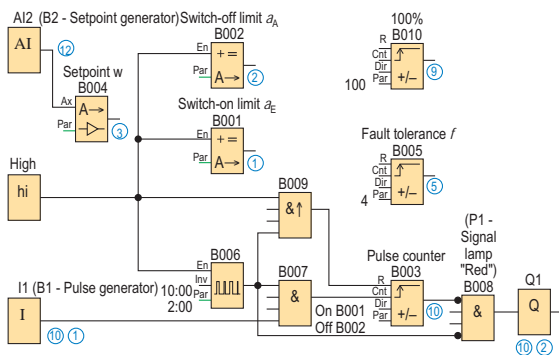


Fig. 7.22 Function diagram for monitoring of milling process

value 10 1 is outside the switch-on and switch-off limits 1/2, the operators are informed during the interpulse duration of 2 s by means of the signal lamp P1 10 1.

7.6 Car wash with LOGO! TD

7.6.1 Task and function description

A supplier of car washes wishes to work with programmable controllers in the future so that it is possible to respond to individual customer requirements. The process information is to be output on a text display. The LOGO! is installed on a DIN rail in the control cabinet, and its display can therefore only be used for maintenance purposes. The text display with its function keys to allow operation of the system by the personnel can be positioned up to 10 m away from the control cabinet.

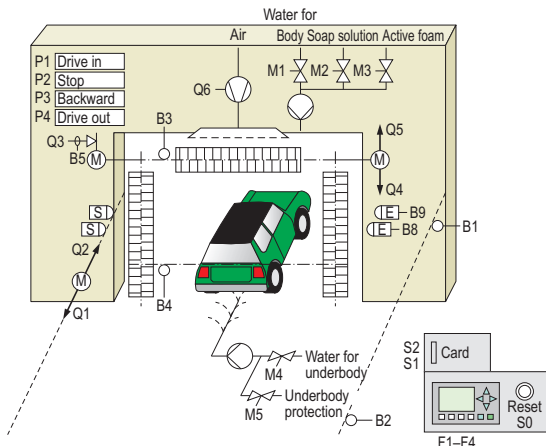


Fig. 7.23 Process schematic of the car wash

The driver of a car is guided into the correct position by the signal lamps P1 "Forward", P2 "Stop" and P3 "Backward". Once the correct position has been reached, the program selection card is inserted into the reader. This card reader is shown here in simplified form with the buttons S1 "Start" and S2 "Prewash". Alternatively, a bonus wash can be entered using function key F2 on the LOGO! text display.

If prewash has been selected, the portal first moves forward up to the front end position (B2) and sprays the car with active foam (M3). The portal is then returned to the rear end position (B1), and the car sprayed with clean water (M1). The steps 2 and 3 are bypassed if the prewash has not been selected 1 (Fig. 7.25).

During the main wash, soap solution is continuously sprayed onto the car (M2). M2 is therefore set in the step sequence 2. In addition, the roof brushes must rotate continuously. To ensure that the contours of the car are detected correctly, the roof brushes are appropriately lowered or raised. For this purpose, the current of the motor for the roof brushes is monitored by the analog sensor B5. If the application pressure is too high, a larger current flows, and the brushes have to be lifted. If the current is too low, a smaller current flows, and the brushes must be lowered. After the portal has been driven forward and backward once, the brushes are driven to the top end position again. The underbody is treated parallel to the main washing of the body 3. During this process, the underbody is initially sprayed with water for 60 s (M4) and then with underseal (M5). In the steps 10 and 11, the car is sprayed with clean water and subsequently dried by the blower.

7.6.2 Hardware configuration

Since the process steps and further information are to be output on a text display, a LOGO! of release version 0BA6 must be used. An older version cannot be used because it should be possible to switch over the menu language. In the LOGO! 0BA6 versions 12/24RC, 12/24RCo, 24 and 24o, several inputs can be used as both digital and analog inputs.

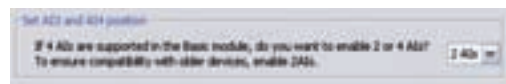


Fig. 7.24 Setting of the positions of AI3 and AI4

The analog sensor B5 (0 V ... 10 V) can thus be connected to terminal I7 or I8 (AI1 or AI2). Or, with the corresponding configuration in the properties under the tab "Parameters" (cf. Fig. 7.24), also to terminal I1 or I2 (AI3 or AI4).

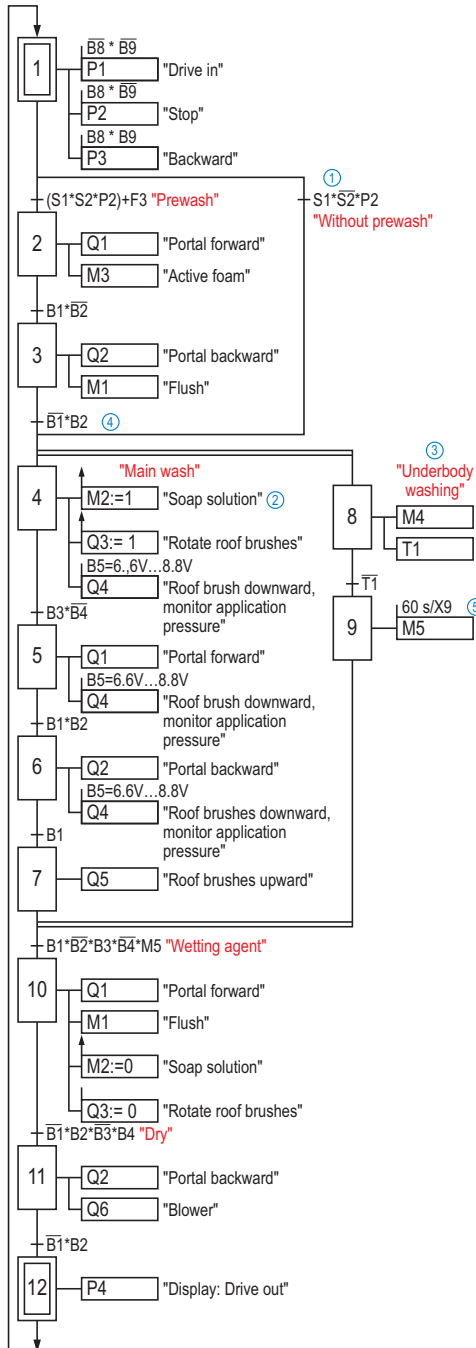


Fig. 7.25 Step sequence of the car wash

Since 10 DI and 15 DO are necessary, the basic device with two DM 16 must be extended by 8 inputs and 8 outputs. Since the sensors and valves operate with 24 V, a LOGO! 12/24RC and two DM 16 12/24R are selected.

In order to represent the process steps, a LOGO! TD with associated cable is used in addition. The four function keys present on this can be used for additional operator functions, such as switching over of the menu language.

7.6.3 Software configuration

Below, implementation of the car wash control as a step sequence is only presented in brief form. Only the important differences compared to the step sequence for the pallet magazine presented in Chapter 5 are explained. It may therefore be advisable to work through the complete program on the enclosed CD yourself. In this chapter, particular attention is paid to configuration of the text messages.

Alternative branches (OR branching)

Depending on customer requirements, the car wash should be carried out with or without pre-washing. An alternative branch ① is therefore present in the step sequence parallel to the steps 2 and 3. Depending on which transition is fulfilled first, either the left or right branch is selected. The associated transition is therefore after the branch. It should be observed in the LOGO! program that both step 2 and step 4 reset step 1. A return is made to the main line prior to the desired step ④.

Parallel branches (AND branching)

The main wash and the underbody wash are to be carried out simultaneously. Since the main wash is carried out depending on the sensors, and the underbody wash is divided into time steps, two lines (② and ③) are executed in parallel in this case.

Parallel branches commence following the completion of the previous transition (in this case: prior to step 4). The two branches are subsequently active, and jump to the respective next step if the associated transition has been fulfilled. The necessary condition to jump from step 4 to 5 is therefore different from that between steps 8 and 9. Step 10 following the combination only becomes active if both branches have been finished. Step 10 deactivates steps 7 and 9.

Time-dependent steps

A switch-on delay is started in step 8, and a jump is made to step 9 when this has been executed. Fig. 7.26 represents this in the LOGO! program. A dropout delay is implemented in step 9. The time for valve M5 is thus limited by an edge-triggered interval time-delay relay.

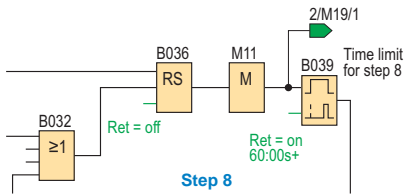


Fig. 7.26 Step with time limiting

Text messages with 0BA6 and later in the TD and display

As of release version 0BA6, the LOGO! provides a significant extension in display functions. These will now be presented here as examples of display of the process information. The various configurations can be comprehended in the specified blocks of the program.

Settings for message text

In the software, a generally valid configuration can be entered under File → Settings for message text for all 50 possible text blocks (Fig. 7.27). In order to be able to use the new functions such as different character sets, bar-graphs or external text display, the choice "Use new feature" ① must be selected. Alternatively, the message texts respond as in the previous versions.



Fig. 7.27 General configuration

Two character sets can be selected in the language setting ②. The background is the function which can be switched over using flag M27 between the two character sets (M27 = 0: character set 1-Text in the display, M27 = 1: character set 2-Text). In the properties of the individual message text (Fig. 7.28, ⑧) it is possible to enter different message texts for the respectively selected character set.

If the text is to move through the display like a ticker text, the speed can be specified ③. The filter time ④ defines the interval at which the specified analog values are updated in the display.

Ticker text

The following information should be displayed if a car is not located in the car wash:

- Manufacturer's name
- Car position: right/wrong
- Language selection German/Russian
- Reference to bonus wash

The area visible in the display is smaller than the number of characters which can be entered. Therefore the text area has a background with different colors ⑧. If more than 12 characters are entered per line, the ticker setting ⑦ can be used to specify whether the line is to be moved from right to left "character by character" through the display or whether switching



Fig. 7.28 Settings of the individual message text

should be alternately carried out between the display pages with the green and turquoise backgrounds ("line by line"). The checkboxes can be used to define the line for which the setting is valid. Since the manufacturer's name and the language selection are specified in the left half, and the car position and the reference to the bonus wash in the right half, "line by line" is used here. The external display LOGO! TD is selected here as the message target ⑨.

Car position

The correct position of the car is to be shown in the display. With version OBA6 and later, the display functions now allow names to be assigned to the individual input or output statuses. In the case shown, the word "Right" is to be displayed when the car has reached the correct position. Otherwise "Wrong" should be displayed. The indicator for the car position in this case is the signal lamp P2 (Q13).

To carry this out, the ON/OFF button must be clicked in the message text (Fig. 7.28, ⑧) in order to open the corresponding properties window (Fig. 7.29). Since the status of output Q13 is to be scanned, it must be selected ⑩. 8 characters can now be specifically assigned to the status of the output. "False" corresponds to the non-switched output status, and "True" to the switched status ⑪.

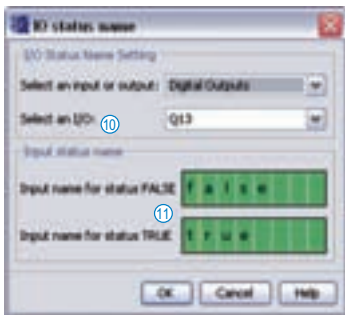


Fig. 7.29 I/O status name

Switching over the character set

The process information is to be output on the display in various languages. The general settings for this have already been described. To enable the text to be entered in Russian, the keyboard language must first be appropriately changed in the operating system (Windows: → Control panel Region and language options → Languages).

The second character set is then selected in the properties of the selected message text (Fig.

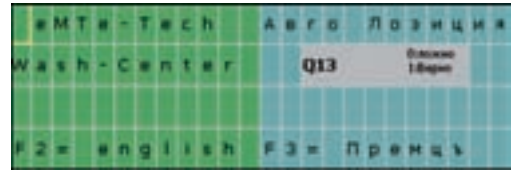


Fig. 7.30 Second language

7.28 ⑥), and an empty text field is then displayed. The foreign language texts can then be entered as appropriate (Fig. 7.30).

The flag M27 must be set so that the second language can be output on the display during operation (Fig. 7.31).

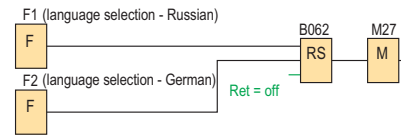


Fig. 7.31 Switching over the character set

If the function key F1 of the external display is clicked, the self-latching element B062 is set and the flag M27 assumes the "1" state so that all message texts now switch over to the second message character set. Switching back is possible again using function key F2.

Priority

Using the priority digits (Fig. 7.28 ⑤) it is possible to define which message texts are output on the display if several texts blocks are active at the same time. The lowest digit represents the lowest priority, and is covered by the higher priority. In order to view the lower digits, scrolling is possible using the cursor arrows.

Bargraph and analog value display

The application pressure of the roof brushes can be monitored using the analog sensor B5. To enable simple monitoring of this value, it should be output in the display together with the parameterized minimum and maximum switching values. In order to indicate the trend in actual value more clearly, this should be visible as a bargraph (Fig. 7.32).

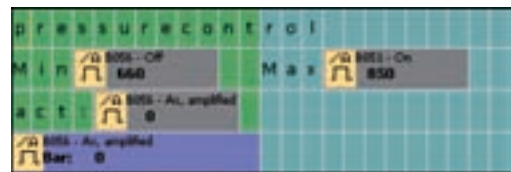



Fig. 7.32 Display for checking the application pressure



Fig. 7.33 Settings for the bargraph

In order to display the analog values, the corresponding block can be selected, and the desired parameter dragged into the text box (Fig. 7.28, below).

To display the trend, the  button is clicked in the message window (Fig. 7.28 ⑧). The block and parameter providing the information are then selected in the associated window (Fig. 7.33). It is also possible to set the size and direction of the bargraph.

7.7 Buffer vessel with PWM

7.7.1 Task and function description

In a biscuit factory, biscuit molds are transported to filling stations. The molds are filled by a stand-alone controller. The free-flowing dough flows through the force of gravity from the buffer vessel into the molds. To ensure that the molds are always filled uniformly, the buffer must always be filled as uniformly as possible at a specific level.

Manual filling of the buffer boilers proved to be too cost-intensive, and an automated solution was therefore required for the four existing filling stations. Dough is to be continuously pumped from a stock into the buffers once the plant has been started (Fig. 7.34: one of the

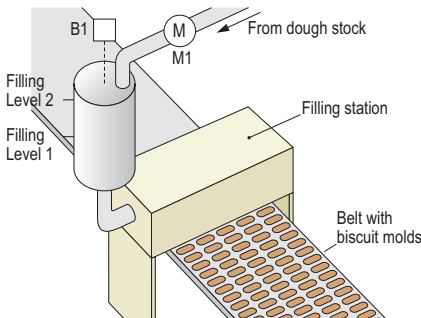


Fig. 7.34 Process schematic of one of the four filling stations

four filling stations). The controller for the filling stations provide signals for

- enabling of filling of the buffer boilers,
- level 1,
- level 2 and
- cleaning.

7.7.2 Hardware configuration

In order to exactly measure the level in the four buffers, laser distance sensors with an analog output (0 to 10 V) are used (Fig. 7.35). These work with a supply voltage of 24 V, and can be directly connected to the terminals I1 (AI3), I2 (AI4) and I7 (AI1), I8 (AI2) of the LOGO! of release version 0BA6 since it is possible to configure these four analog inputs (0 to 10 V). The sensors must be parameterized (using the learning function of the sensors) such that a voltage of 10 V is available with an empty boiler. The minimum distance from the surface of the dough is 20 cm (0 V). The pumps used have the following rated values: $U_N = 230\text{ V}\sim, 290\text{ VA}$.



Fig. 7.35 Laser distance sensor

Since the dough has a viscous consistency, the pump motor must always be operated at full power. In order to handle smaller quantities, pulse width modulation is therefore used (see box). 2 minutes is provided as the period. Since the number of operating cycles to be expected is very high, and the service life of a LOGO! with relay output is therefore too low, a LOGO! with transistor outputs is used here. The motors are controlled by semiconductor contactors since the output current of the non-floating LOGO! outputs is limited to 0.3 A. Semiconductor contactors are electronic switches with electrical isolation. A LOGO! 24 is therefore selected as the control relay (Fig. 7.36).

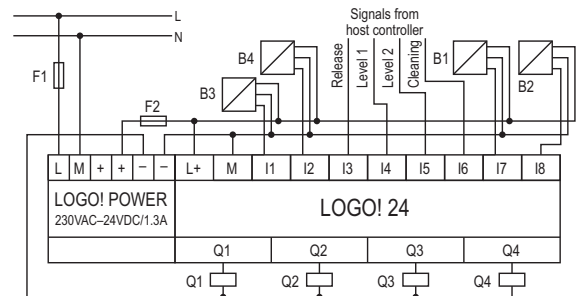


Fig. 7.36 Connection diagram

8 Hardware

8.1 Control elements and sensors

8.1.1 Signals

The IPO principle divides a control function into three components: input, processing and output (cf. Chapter 2). Before considering the control relay, we will first examine the information sources (sensors and control elements) and the objects (actuators) which implement the results in the process or plant.

It becomes clear in the greatly simplified system representation (Fig. 8.1) that the input signals are evaluated in the processing component and that the results are passed on to the actuators (output).

The output information from the previous objects represents the input information for the following object ①. These transfer points are referred to as **interfaces**.

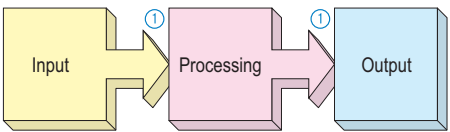


Fig. 8.1 Interfaces

Analog and digital signals

Because **binary signals** are extremely simple to evaluate, these are mainly processed in control engineering. The term "binary signal" simply means that only **two states** (lat.: bi) are possible. These are represented by the so-called **levels**:

High level	Low level
On	Off
High	Low
H	L
1	0

Example:

- An activated NO contact is "1", "On" or "High" (abbreviated to "H").
- A non-activated NO contact is "0", "Off" or "Low" (abbreviated to "L").

Whereas the level describes the state or the signal magnitude, this very general information actually refers to a voltage range which depends on the controller used. The most com-

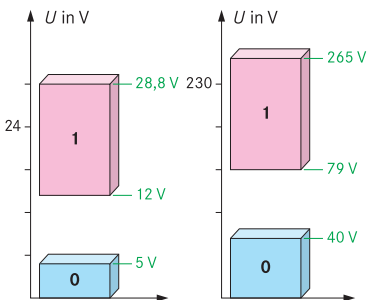


Fig. 8.2 Voltage ranges with different levels

mon ranges used in control engineering are 0 V...12 V, 0 V...24 V and 0 V...230 V. A low voltage range is defined as a "0" signal, and a high voltage range as a "1" signal. Between them is the "forbidden range" as a clear separation of the two levels (Fig. 8.2). Within this zone, a signal cannot be correctly assigned to any level.

The exact values of the levels depend on the manufacturer and the device. With the LOGO! the following values apply to the input signals:

	Input voltage (permissible range)	"0" signal	"1" signal
LOGO! 230RC...	115...240 V AC/DC (85...265 V AC 100...253 V DC)	< 40 V (AC) < 30 V (DC)	> 79 V (AC) > 79 V (DC)
LOGO! 24...	24 V DC (20.4...28.8 V DC)	< 5 V (DC)	> 8 V (DC)
LOGO! 24RC...	24 V AC/DC (20.4...26.4 V AC 20.4...28.8 V DC)	< 5 V (AC/DC)	> 12 V (AC/DC)
LOGO! 12/24...	12/24 V DC (10.8...28.8 V DC)	< 5 V (DC)	> 8 V (DC)

Fig. 8.3 Levels used with the LOGO! range

Some sensors provide an analog signal at their output which can be processed further in a controller. This may be important, for example, if the signal of an ultrasonic sensor is to be evaluated extremely exactly in order to execute certain actions at different intervals.

The manufacturers of control devices and sensors have agreed on the following **standardized analog signal**, among others:

- 0 V to 10 V or
- 4 mA to 20 mA or
- 0 mA to 20 mA

8.1.2 Control elements

Keys, buttons and switches are referred to as control elements if they are used for manual input of commands. They establish the connection between man and controller.

Pushbuttons and switches are used for manual input of a command if, for example, a plant is to be started or stopped, or if it is necessary to select different operating modes such as manual or automatic.

Pushbuttons and switches

If a pushbutton (Fig. 8.4) is equipped with both NO and NC contacts, it must be noted when pressing that the NC contact ① first opens before the NO contact ② closes. This positively driven relationship is clarified in the signal/travel diagram (Fig. 8.5).



Fig. 8.4 Pushbutton

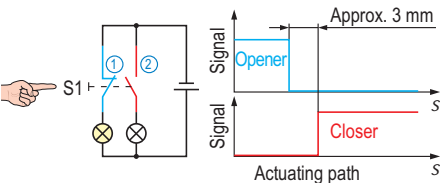


Fig. 8.5 Response of the pushbutton contacts upon activation

The color of the button indicates its function. Specific colors are assigned to the various information as shown in the table. Blue, for example, is used for an essential reset, for example, as is required for an acknowledgement following an emergency stop and for resetting to the basic setting.

Further defined color codes apply in a similar manner to signal lamps and to pushbuttons in which a signal lamp is integrated:

Pushbutton		Color	Signal lamp	
Meaning	Application		Meaning	Application
Emergency	EMERGENCY STOP	Red	Emergency	State resulting in danger
Abnormal	Elimination of abnormal or undesired states	Yellow	Abnormal	Check whether the physical variable has violated the normal range
Normal	Preparation, confirmation, start/on permissible, stop forbidden	Green	Normal	Physical variable is within the normal range
Essential	Reset function	Blue	Essential	Action required
	START/ON STOP/OFF	Grey	Neutral	Check whether switching over is necessary

8.1.3 Sensors

Converters which change any physical variable into a variable which can be processed electrically are referred to as sensors. The term "sensor" roughly means "device for proving and checking" or "feeler of environmental conditions". They are used in a plant to detect the various operating states.

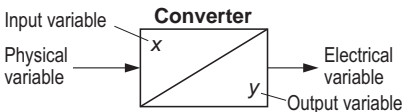


Fig. 8.6 General function of a sensor

A sensor can therefore be understood as a device which converts a physical variable such as temperature or pressure into another variable, for example, a resistance value or a voltage value.

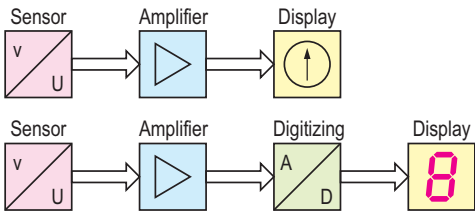


Fig. 8.7 Measuring setup

The output signal must be adapted depending on the subsequent processing, i.e. it must be amplified and/or digitized. Fig. 8.7 shows this using the example of a wind velocity measurement:

The wind velocity is converted here into a voltage value, and amplified such that the signal can be processed. Then it is either output directly on an analog display, or digitized so that it can be output on a digital display or processed further in a controller.

Regarding the sensors associated with control engineering, most objects of this measuring setup are combined into a system. Depending on the initial configuration, either the standardized analog signal or the digitized signal is output. In the circuit diagram, this is represented depending on the further connection (Fig. 8.8a) or as a block symbol (Fig. 8.8b).

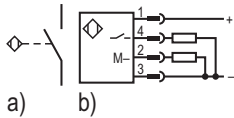


Fig. 8.8 Graphic symbols for sensors

A wide range of physical variables can be detected using standard sensors (Fig. 8.9). The most common sensors are presented below with their function and a number of application examples:

- End switch/limit contact/microswitch
- Proximity sensors:
 - Inductive proximity sensor
 - Capacitive proximity sensor
 - Magnetic proximity sensor (reed contact)
 - Magneto-resistive proximity sensor
 - Optical proximity sensor
- Light barriers
- Pt100 temperature sensor
- Ultrasonic sensor

	Inductive proximity sensor	Capacitive proximity sensor	Optical proximity sensor	Light barrier	Pt100	Limit contact	Reed contact	Ultrasonic sensor
Distance	x	x	x					x
Approaching object	x	x	x	x		x	x	x
Displacement	x	x	x	x		x	x	x
Temperature					x			
Material recognition	x	x	x					
Rotational frequency		x	(x)				x	x
Identification for counting	x	x	x	x		x	x	x
Position of a piston (cylinder status)	(x)	(x)	(x)			x	x	

Fig. 8.9 Most common sensors and their possible applications

8.1.3.1 Limit contact/end switch/microswitch/position switch

Function

End switches are basically normal contacts which are not activated by a person but by a workpiece or a plant component such as, for example, a plunger or a shaft cam. The roller on the activation lever in Fig. 8.10 is provided, for example, to prevent the tilting of workpieces. This is shown in the circuit diagram (Fig. 8.10) by a small circle as the activator. Alternatively, they are manufactured without a lever or with other lever shapes (Fig. 8.11).



Fig. 8.10 Roller-activated limit contact



Fig. 8.11 Different types of position switches

The force required for switching is very small. End contacts usually represent the distance traveled by a workpiece/plant component, i.e. a physical quantity, and they are identified by B.

Service life/field of application

Their service life is limited since the mechanical components are subject to wear ($> 5 \cdot 10^6$ operating cycles). They must always be protected when used in highly contaminated environments. Only very low switching frequencies are possible because of the mechanical design, and the switching point changes as the wear increases. The advantage is their low cost. Mechanical (positive opening) contacts are frequently essential for safety reasons, e.g. for the monitoring of sliding doors.

Example of function

Workpieces are pushed out of a magazine using a pneumatic cylinder, and thus separated. The limit contact is used to determine whether the workpiece has traveled the required path and reached the end position.

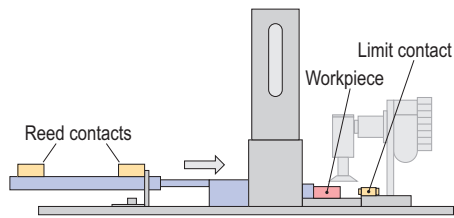


Fig. 8.12 Example of function of limit contact

8.1.3.2 Proximity sensors

Proximity sensors are frequently used as alternatives to the mechanical limit contacts. Whereas limit contacts are triggered by touching or activation, proximity sensors are contactless. They are differentiated according to the physical principle used (Fig. 8.13). Their design is wear-free, and they can also be used in unfavorable environments. If the sensor infor-

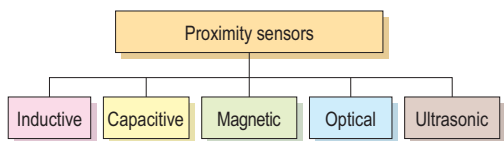


Fig. 8.13 Proximity sensors

mation at the output is converted into binary signals, one also frequently refers to proximity switches. In the measuring technology sector, sensors are primarily used which provide an analog signal in one of the standardized forms (0 V – 10 V, 0 mA – 20 mA or 4 mA – 20 mA). The following terms are mainly used for the specific selection of proximity sensors:

- **Rated operating distance S_n :** The rated operating distance specifies the distance at which a standardized measurement plate made, for example, of St 37 steel is detected by the sensor when approached directly and results in a switching signal. This characteristic value does not take into account manufacturing tolerances or deviations due to temperature or voltages.
- **Assured operating distance S_a :** The operating distance between measurement plate and sensor, at which the sensor operates within the permissible operating conditions. This value therefore describes the distance at which the sensor reliably detects the measurement plate "at the latest".
- **Repeatability of switching value:** Deviation in determined operating distance when a measurement is repeated.
- **Hysteresis:** The hysteresis (H) describes the deviation in the operating distance when the measurement plate approaches the sensor and is then moved away from it again. This results in the modified operating distance $S_{rmin} + H$ and $S_{rmax} + H$.
- **Reduction factor:** The rated operating distance refers to a test plate with standardized dimensions, material and surface properties. In order to be able to determine the switching response for other materials, the material-dependent operating distance (S_r) is determined using reduction factors (Fig. 8.16). Spans are often specified, so that the reduced operating distance S_r is provided with minimum and maximum values.

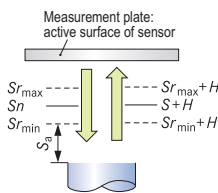


Fig. 8.14 Operating distance

8.1.3.3 Inductive proximity sensor

Function

An inductive proximity sensor detects metallic materials. An electromagnetic alternating field in the range from 100 kHz to 1 MHz is generated in an inductive proximity sensor. If an electrically conducting material is now moved in front of the sensor, energy is removed from the sensor because the sensor's electromagnetic field induces a voltage in the material. This results in a new alternating field which interferes with the field of the sensor. This change in the sensor field is evaluated in the sensor and converted into a signal.

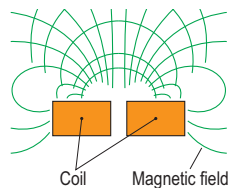


Fig. 8.15 Field of an inductive sensor

It is the case for the reduction factor that a magnetic conductive material is better to detect than just an electrically conductive material.

Reduction factors of the rated operating distance S_n (referred to the measurement plate)	
Material	SIEN-4 B- ...
Steel St 37	$1.0 \times S_n$
Stainless steel St 18/8	$0.7 \times S_n$
Brass	$0.4 \times S_n$
Aluminum	$0.4 \times S_n$
Copper	$0.3 \times S_n$

Fig. 8.16 Reduction factors for inductive proximity sensors (deviations are possible depending on the sensor)

Service life/field of application

Inductive proximity sensors are mainly used to determine the position. They can only be used in very special cases to determine distances using an analog output value. It must then be guaranteed that always the same object or extremely similar objects approach the sensor in exactly the same manner.

The service life for these electronic, contactless sensors is $\sim 10^{10}$ operating cycles or about five years.



Fig. 8.17 Various designs of proximity sensors

Example of function:

During the manufacture of pipes (Fig. 8.18), workpieces are supplied over a ramp for further processing. To enable detection of the material output, an inductive proximity sensor is positioned and its operating distance adapted such that it detects the metal pipe.

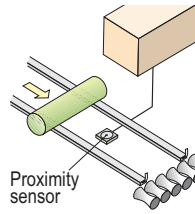


Fig. 8.18 Detection of material during manufacture of pipes

8.1.3.4 Capacitive proximity sensor

Function

The functional principle is similar to that of the inductive proximity sensor, even though the internal design is completely different.

The capacitive proximity sensor detects conducting and non-conducting objects (Fig. 8.19). Since it works with an electric field which develops between the electrodes at the front, each workpiece entering the field is understood as a change in the dielectric. This results in a switch signal.

Material	Reduction factor
All metals	1.0
Water	1.0
Alcohol	0.7
Glass	0.3 – 0.5
Plastics	0.3 – 0.6
Carton	0.5 – 0.6
Wood (dependent on moisture content)	0.2 – 0.7
Oil	0.1 – 0.3

Fig. 8.19 Reduction factors

The operating distance is highly dependent on the material and dimensions. For example, a thick material results in a larger operating distance than a thin one. A teach-in function is therefore frequently provided with which the sensor can be calibrated.

The sensor is sensitive to the atmospheric humidity. Inductive and capacitive proximity sensors require a power supply.

Service life/field of application

The service life is frequently specified as "very high", which can usually be understood as $> 10^{10}$ operating cycles. Switching frequencies are possible up to 300 kHz, but only frequencies up to 1 kHz are common.

Example of function

A possible application is detection of filling through packaging, e.g. a carton or plastic bag. In this example, the sensor is triggered if a carton is empty.

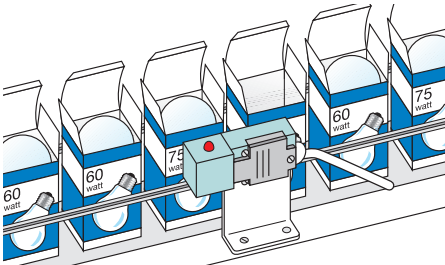


Fig. 8.20 Detection of filling

8.1.3.5 Magnetic proximity sensor/ reed contact

Function

The sensor usually contains a reed contact. The contact consists of two ferromagnetic contact studs in a glass tube.

If a permanent magnet or a coil through which a current is flowing is located in the vicinity, the studs are attracted like two permanent magnets. The circuit is then closed (Fig. 8.21).

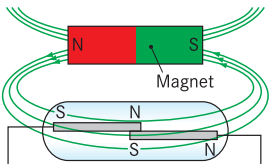


Fig. 8.21 Reed contact

The reed contact therefore detects magnetic fields.

Service life/field of application

Since the switch signal with reed contacts is generated mechanically, its service life is not unlimited (approx. 10^7 operating cycles).

Pneumatic and hydraulic cylinders are frequently equipped by the manufacturer with small permanent magnets on the piston. The position of the piston can be detected in this manner using these low-cost sensors.

In order to detect the two end positions of cylinders, two magnetic proximity sensors must be used (Fig. 8.23).

Because of their simple principle of operation, reed contacts can be used extremely flexibly. In



Fig. 8.22 Magnetic proximity switch

the case of a flow measurement, flowing medium (e.g. water) drives a rotor which is fitted with a magnet. The sensor is switched by each rotation. Thus the switching frequency is a measure of the flowing quantity.

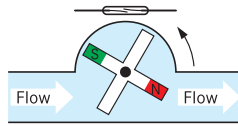


Fig. 8.23
Flow measurement

8.1.3.6 Magneto-resistive proximity sensor

Function

If a magnet approaches this sensor, a semiconductor material in it changes its resistance. This is converted into a switch signal. The sensor requires a power supply.

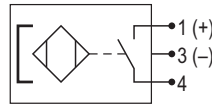


Fig. 8.24
Magneto-resistive proximity sensor

Service life/field of application

Application exactly like that of a reed contact. Service life: approx. 10^{10} operating cycles.

8.1.3.7 Cylinder position transmitter

Function

Position transmitters evaluate the position of a cylinder piston over a defined path, and output this in the form of a standardized analog signal (0...10 V or 4...20 mA). Currently available sensors record a distance of 50 mm, and also recognize if the piston is outside the detection range. The signal repeatability has a deviation of approx. 0.1 mm.

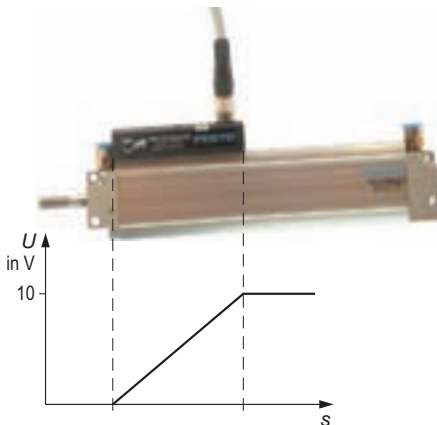


Fig. 8.25 Analog signal proportional to the piston position

Service life/field of application

As with most contactless sensors, the service life can only be specified vaguely as "very high" ($\sim 10^{10}$). Subsequent calibration is unnecessary.

Typical fields of application include e.g. object detection where the cylinder piston position is used to establish whether a workpiece is positioned correctly, or to differentiate between good and bad workpieces. Alternatively, it may be necessary, for example, when converting to other materials to have a different end position. Previously, recalibration of the magnetic end position sensor was necessary in such a case.

8.1.3.8 Optical proximity sensor

Function

Optical thru-beam sensors comprise a light emitter and a light receiver. The sensor generates a red or infrared (invisible) light which is beamed in a specific direction and as straight as possible by using an optical arrangement.

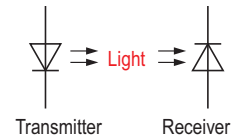


Fig. 8.26
Functional diagram

Infrared light is used if a high luminous power is required, e.g. at distances up to 500 m for the protection of buildings. Only light of exactly the emitted wavelength is evaluated in the receiver, and faults resulting from light from external sources are practically impossible (Fig. 8.26).

As a result of the combination of transmitter and receiver in one housing and the use of light pulsed at a specific frequency, it is possible to counteract the faulty evaluation of light from an external source. The receiver only evaluates light of exactly the transmitted frequency and pulsing.

Optical proximity sensors have a small and rugged design. Depending on the application, the transmitter and receiver are manufactured in a cylindrical or rectangular design in separate housings or in a common housing (most usual design) (Fig. 8.27).

Service life/field of application

The service life of optical sensors is extremely high due to their contactless function ($\sim 10^{10}$ operating cycles).

In the case of **thru-beam sensors**, the transmitter and sensor are separate, and are mount-



Fig. 8.27 Optical proximity sensors

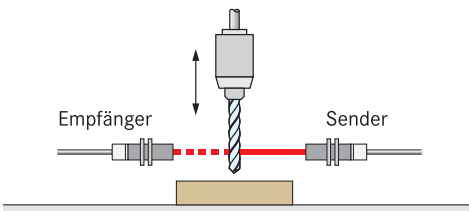


Fig. 8.28 Light barrier for checking drill bit

ed opposite one another. Since the light radiates directly from the transmitter to the receiver, distances of up to 500 m can be covered, and also very small objects with any surface can be detected (Fig. 8.28). Thru-beam sensors are frequently used to protect machines or machine components.

With **reflex sensors**, the transmitter and the receiver are installed close together in the same housing as with the diffuse sensor. The graphic indicates that the two optical systems are located above one another. The installation and calibration of the sensor is therefore extremely simple. With this version, the emitted light beam must be reflected by a suitable material back to the receiver. This is usually carried out by a reflector which appropriately reflects the emitted light. Reflex sensors are frequently used to detect workpieces if only small distances have to be covered and if the environment is not too dusty. Their range is usually up to 50 m.

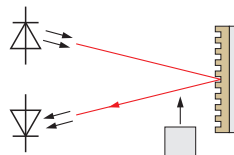


Fig. 8.29 Reflex sensor

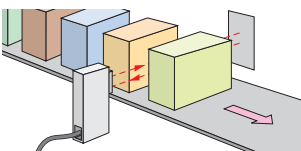


Fig. 8.30 Reflex sensor for counting workpieces

A transceiver is used for a diffuse sensor, i.e. the transmitter and receiver are arranged directly next to each other in one

housing (Fig. 8.27). The transmitted light is reflected back to the receiver by the detected workpiece. If a workpiece is not present in the detection range of the sensor, the background must absorb the light beam or deflect it (away) such that it does not reach the receiver. The sensors used have a single-turn or multi-turn potentiometer with which the response or switching threshold can be set.

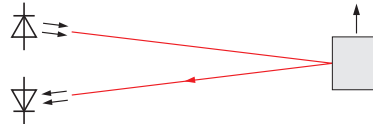


Fig. 8.31 Diffuse sensor

Optical proximity switches with fiber-optic cables

Optical sensors can be equipped with polymer cladded or glass-fiber cables which direct the emitted light beams to any positions almost without loss.

This procedure is used if, for example, insufficient space is available at the position where the information is to be recorded (Fig. 8.32). In such a case, the fiber-optic cable can be inserted through drilled holes or similar. The sensor itself can then also be installed in a more favorable environment (e.g. in the case of hazardous areas). Since polymer cladded fiber-optic cables can be moved like flexible cables, it is also possible to detect objects on moving parts.

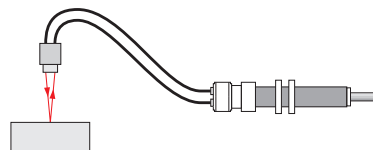


Fig. 8.32 Diffuse sensor with flexible fiber-optic cable

Reflex sensors are equipped if required with fiber-optic cables. Such a sensor can then also be used as a thru-beam sensor (Fig. 8.33). It is then unnecessary to separate the transmitter and receiver.

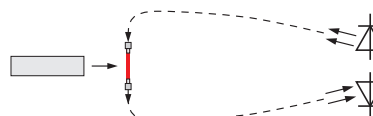


Fig. 8.33 Thru-beam sensor designed using reflex sensor and fiber-optic cables

As a result of the small inlet and outlet openings of the fiber-optic cables, the beam angle is very small. Thus even very small objects such as drill bits can be reliably detected.

Example of function

In combination with other proximity sensors, it is possible to differentiate between materials. In this case a diffuse sensor is used in order to detect the surface structure or color.

In order to detect different materials and surfaces, diffuse sensors are frequently used in practice e.g. together with a capacitive proximity switch. The capacitive sensor determines, for example, whether a carton is in the detection area. An inductive sensor recognizes whether metallic materials are in the detection area. Finally, the diffuse sensor can detect whether the material is bright or dark.

The following objects are difficult to detect using diffuse sensors because of their low degree of reflection, and conclusions on the surface structure are made in combination with another sensor:

- Black rubber
- Matted black plastic
- Materials with rough surface
- Red carton (when using red light).

8.1.3.9 Ultrasonic sensors

Function

An ultrasonic sensor transmits a sound which is not audible to the human ear (between 65 kHz and 400 kHz). If the signal hits an object, it is reflected and returns to the sensor. Since a time elapses between the signal transmission and reception, this "runtime" is a measure of the distance between the sensor and the object. Ultrasonic sensors convert this time in their internal circuitry into a standardized voltage or current signal (analog signal).



Fig. 8.34
Ultrasonic sensor

Various types also output the information as a frequency. The (analog) signal can then read in at a fast digital input of a LOGO!. If a binary output is to be switched when an object is detected at a certain distance from the sensor, this can be set using a teach-in function. Ultrasonic sensors transmit their signal with a beam angle of $\sim 10^\circ$ and a range of up to 12 m.

Service life/field of application

As with all contactless sensors, the service life is specified as "very high", i.e. $\sim 10^{10}$ operating cycles. Ultrasonic sensors are particularly appropriate in the case of unfavorable conditions, e.g. in flour or cement silos, since they can differentiate between near and far objects and have large ranges. Their dependence on external conditions such as dust or moisture is low – use is only impossible in the case of overpressure or underpressure or very hot environments. The structure of the body/material to be detected is irrelevant. The recording of sloping surfaces is problematical since these reflect the sound at an angle, and the echo does not reach the receiver.

Example of function

Workpieces are delivered to a machining station on a conveyor belt. The belt motor should reduce its speed shortly before the workpiece reaches the end position and subsequently switch itself off. Since the workpieces are not positioned exactly on the belt, the distance measurement must be contactless. Using an ultrasonic sensor with binary output, it is possible to measure the distance between the workpiece and the end position.

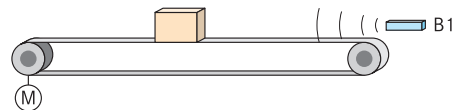


Fig. 8.35 Distance measurement with ultrasonic sensor

8.1.3.10 Temperature sensors

Even though many types of sensor are available for recording thermal values, only the types most relevant to control engineering with LOGO! will be considered here:

Resistance sensor using Pt100 as example

Resistance sensors utilize the property that the resistance of a metal changes depending on its temperature.

The following equation applies to the resistance R_T of a metallic conductor at a specific temperature:

$$R_T = R_{20} \cdot (1 + \alpha \cdot \Delta T)$$

R_{20} = Resistance of conductor at 20°C .

α = Temperature coefficient (platinum: $\alpha = 0.004$ $1/\text{K}$). If the temperature coefficient is great-

er than zero, one refers to a positive temperature coefficient, if it is less than zero, one refers to a negative temperature coefficient.

ΔT = Deviation of actual temperature from 20°C.

Platinum is primarily used for resistance sensors since it has an extremely linear characteristic. It virtually retains its original resistance value even with frequent warming up and cooling. The so-called **rated resistance** is defined at 0°C. This is standardized for resistance sensors, and is 100 Ω, 500 Ω or 1000 Ω. The designation is also derived from this, e.g. Pt100 (platinum sensor with rated resistance of 100 Ω). The characteristic is almost linear in the range from -100°C to 400°C (Fig. 8.36).

The resistant material of this sensor is wound onto a carrier material. In the case of miniature versions, the platinum is vapor-deposited on a ceramic surface. As a result of the small dimen-

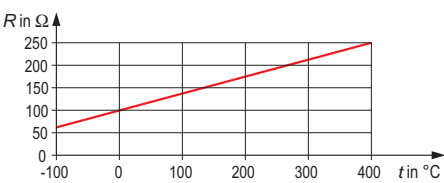


Fig. 8.36 Characteristic of a Pt100

sions, these sensors respond very rapidly to changes in temperature. This is very important, for example, for temperature measurements in chemical processes. The measuring range of Pt100 sensors is usually -200°C to 850°C.

The use of Pt100 sensors together with the LOGO! is particularly advantageous because there is a special module which directly evaluates the sensor information and makes it available as a temperature value (see Chapter 8.2.2.2).



Fig. 8.37 LOGO! 230RC – basic device with maximum configuration

8.2 LOGO! control relays

The LOGO! is a modular system with a basic device which can be expanded depending on the requirements (Fig. 8.37). The minimum and maximum configurations merely represent the limits (Fig. 8.38) – the exact quantities depend on the module, and can be determined using this chapter.

	Minimum configuration	Maximum configuration
Digital inputs	8	24
Analog inputs	–	8
Digital outputs	4	16
Analog outputs	–	2

Fig. 8.38 Configuration limits for LOGO! 230RC as example

With regard to the price/performance ratio, the LOGO! is oriented significantly above the contactor circuits, but below the S7 controllers. Already for the processing of a few timer values, a LOGO! is cheaper and significantly more flexible than large contactor circuits (hardwired

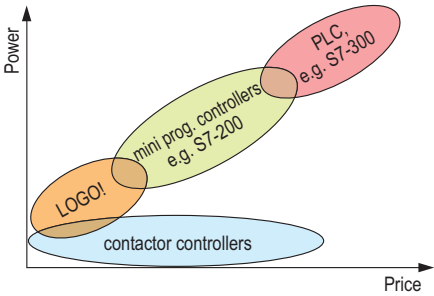


Fig. 8.39 Price/performance comparison between LOGO! and other controllers

controller). Compared to mini programmable controllers and PLCs, however, their range of functions is rather small since, for example, the storage and processing functions for information are very limited (Fig. 8.39).

8.2.1 Voltage classes

Four basic types of LOGO! are available with three voltage levels. In addition to the specified voltage data (e.g. 24 V), it is necessary to consider the permissible voltage ranges and forms (AC/DC) with which they can be operated (Fig. 8.40). With the exception of the analog and communication modules, the expansion modules can only be used within the same voltage class, which is guaranteed by the use of mechanical coding (pins and sockets on the housing). A differentiation is made between the following voltage classes:

- Class 1: < 24 V, i.e. 12 V DC, 24 V DC, 24 V AC
- Class 2: > 24 V, i.e. 115...240 V AC/DC

	Type	Input voltage (permissible range)	"0" signal	"1" signal
Class 1	LOGO! 12/24...	12/24 V DC (10.8...28.8 V DC)	< 5 V (DC)	> 8 V (DC)
	LOGO! 24...	24 V DC (20.4...28.8 V DC)	< 5 V (DC)	> 8 V (DC)
	LOGO! 24RC...	24 V AC/DC (20.4...26.4 V AC 20.4...28.8 V DC)	< 5 V (AC/DC)	> 12 V (AC/DC)
Class 2	LOGO! 230RC...	115...240 V AC/DC (85...265 V AC 100...253 V DC)	< 40 V (AC) < 30 V (DC)	> 79 V (AC) > 79 V (DC)

Fig. 8.40 Voltage levels of the LOGO! basic devices

The manufacturer recommends when combining modules that the digital modules are initially positioned on the right of the basic device, followed by the analog modules. These are then followed if necessary by a communication module (AS-i/EIB).

- The LOGO! range has a modular design and can be combined as desired within certain limits.
- Control relays can be operated in a wide voltage range.
- The permissible combination of individual modules depends on the voltage classes.

8.2.2 Technical specifications of the LOGO! range

8.2.2.1 Basic devices

With and without control elements and display

Depending on the application, the LOGO! can be used with or without keys and displays. The Pure version is mainly used in the control cabinet where no information messages are required for operation and no changes in parameters are necessary, because this version is a little cheaper than the Basic version (Fig. 8.41). The display offers the possibility for indicating the current values of the inputs and of processing blocks such as timers and counters, as well as information text (4 lines with 12 characters each, or as ticker text: 24 characters).



Fig. 8.41 LOGO! 230RC as Pure without display and Basic with display

Special features of the input connections

With the LOGO! 230 devices, the inputs are divided into **groups of four**. It must be ensured that the same phase is used in each group of four. Different phases can be used for different groups. In the installation sector, keys are frequently used with glow lamps. The current flowing through the **glow** lamp is understood by the input of the LOGO! as a "1" signal. To ensure that the signal is evaluated correctly, an **X capacitor** with 100 nF (2.5 kV) must be connected between the input terminal and the N terminal in order to discharge the closed-circuit current. This measure is also necessary when using **proximity sensors with two-wire systems** (NAMUR sensors) (Fig. 8.42).

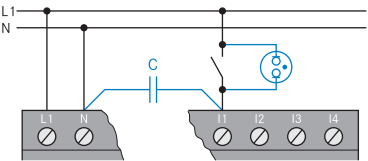


Fig. 8.42 Input circuit of LOGO! 230 when using keys with glow lamps

	LOGO! 12/24RC...RCo	LOGO! 24RC...RCo	LOGO! 24...o
Input voltage	12/24 V DC	24 V AC/DC	24 V DC
Permissible voltage range	10.8 to 28.8 V DC	20.4 to 26.4 V AC 20.4 to 28.8 V DC	20.4 to 28.8 V DC
Permissible line frequency		47 to 63 Hz	
Polarity reversal protection	Yes		Yes
Current consumption	12 V DC: 60 to 175 mA 24 V DC: 40 to 100 mA	24 V AC: 45 to 130 mA 24 V DC: 40 to 100 mA	0.3 A per output
Power failure bridging	12 V: typ. 2 ms 24 V: typ. 5 ms	Typ. 5 ms	
Real-time clock	Yes	Yes	No
Digital inputs			
Number	8	8	8
Input voltage L+ • "0" signal • "1" signal	< 5 V DC > 8.5 V DC	< 5 V AC/DC > 12 V AC/DC	< 5 V DC > 8 V DC
Input current • "0" signal • "1" signal	< 0.85 mA (I1...I6) < 0.05 mA (I1, I2, I7, I8) > 1.5 mA (I1...I6) > 0.1 mA (I1, I2, I7, I8)	< 1.0 mA > 2.5 mA	< 1.0 mA (I1...I6) < 0.05 mA (I1, I2, I7, I8) > 1.5 mA (I1...I6) > 0.1 mA (I1, I2, I7, I8)
High-speed inputs	I1 to I6	No	I1 to I6
Analog inputs			
Number	4 (I1 = AI3, I2 = AI4, I7 = AI1, I8 = AI2)		4 (I1 = AI3, I2 = AI4, I7 = AI1, I8 = AI2)
Range	0 to 10 V (input impedance 72 Ω)		0 to 10 V (input impedance 72 Ω)
Max. input voltage	28.8 V		28.8 V
Digital outputs			
Number	4	4	4
Type of outputs	Relay outputs	Relay outputs	Transistor, switching to P potential *
Output voltage	Floating	Floating	power supply at max. 0.3 A per output
Continuous current I_{th} (per terminal)	Max. 10 A per relay	Max. 10 A per relay	(short-circuit current limiting approx. 1 A)
Switching frequency			
Mechanical	10 Hz	10 Hz	
Electrical			10 Hz
Ohmic load/lamp load	2 Hz	2 Hz	10 Hz
Inductive load	0.5 Hz	0.5 Hz	0.5 Hz

* When switching on the LOGO! 24 and LOGO! 24o, a "1" signal is sent to the digital outputs for 50 ms.
This must be taken into account for devices which respond to fast pulses.

Fig. 8.43 Technical specifications of the LOGO!

Special features of the LOGO! 12/24RC(o) and 24:

High-speed inputs

The standard inputs of the LOGO! are suitable for frequencies up to 5 Hz. However, higher frequencies can occur if, for example, an anemometer is used to measure the wind velocity where the clock pulse is the measure thereof. Or if workpieces transported rapidly past a sensor are to be counted. The inputs **I5** and **I6** are so-

called **high-speed inputs** and can process (as of 0BA6: I3–I6) frequencies up to 2 kHz.



Note: In order to test such signals in the simulation, the item "Frequency" can be selected in the input properties under Simulation.

Analog inputs

The inputs I7 and I8 (as of 0BA6 also I1 and I2) can be used as digital inputs or analog inputs (I7 = AI1, I8 = AI2, as of 0BA6 I1 = AI3, I2 = AI4)

	LOGO! 230RC...RCo
Input voltage	115 to 240 V AC/DC
Permissible voltage range	85 to 265 V AC 100 to 253 V DC
Permissible line frequency	47 to 63 Hz
Polarity reversal protection	Yes
Current consumption	115 V AC: 10 to 40 mA 240 V AC: 10 to 25 mA 115 V DC: 5 to 25 mA 240 V DC: 5 to 15 mA
Power failure bridging	115 V AC/DC: typ. 10 ms 240 V AC/DC: typ. 20 ms
Real-time clock	Yes
Digital inputs	
Number	8
Input voltage L+ • "0" signal • "1" signal	< 40 V AC < 30 V DC > 79 V AC > 79 V DC
Input current • "0" signal • "1" signal	< 0.03 mA > 0.08 mA
High-speed inputs	No
Analog inputs	
Number	0
Range	
Max. input voltage	
Digital outputs	
Number	4
Type of outputs	Relay outputs
Output voltage	Floating
Continuous current I_{th} (per terminal)	Max. 10 A per relay
Switching frequency	
Mechanical	10 Hz
Electrical	
Ohmic load/lamp load	2 Hz
Inductive load	0.5 Hz

Fig. 8.44 Technical specifications of the LOGO! 230RC and RCo

(not with 230 V devices). In this case, the decision whether they are interpreted as digital or analog inputs is specified in the program by the numbering. If the terminal I7 is also evaluated with I7 in the program, the input signal is digital. If AI1 is used in the program, the signal at terminal I7 is interpreted as an analog value. In this case, the input I7 must remain vacant. (Tip: enter "reserved for AI1" in the connection name list.) If an analog module is connected, numbering of the inputs begins with AI3 or 5 (observe configuration of program properties) and is continuous. The analog sensors must be con-

nected to the same power supply which also powers the LOGO!.

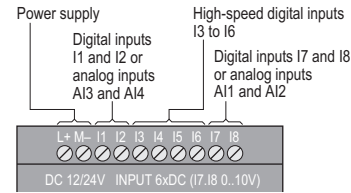
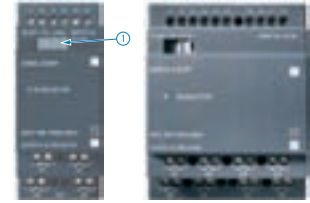


Fig. 8.45 Inputs of the LOGO! 12/24RC and 24

8.2.2.2 Expansion modules

Various expansion modules can be used to increase the number of inputs and outputs of the basic devices. Depending on



the requirements, it is then possible to supplement the number of digital inputs and outputs, or also the analog inputs and outputs and the communication modules (CM) to the AS-i bus or to the EIB/KNX. The modules are connected by means of a slider which establishes mechanical locking ① and the internal communication. Only certain **combinations** are possible which are shown in the table (Fig. 8.46).

LOGO! Type	Expansion modules					
	DM8 12/24R, DM16 24R	DM8 24, DM16 24	DM8 24R	DM8 230R, DM16 230R	AM2, AM2 PT100, AQ	CM
12/24RC...	x	x	x		x	x
24...	x	x	x		x	x
24RC...	x	x	x		x	x
230RC...				x	x	x

Fig. 8.46 Possible combinations

It generally applies that digital modules can only be used within the same **voltage classes**.

To enable optimum communication between the modules and the basic device, the manufacturer recommends the sequence: basic device – digital modules – analog modules – communication module (Fig. 8.47).

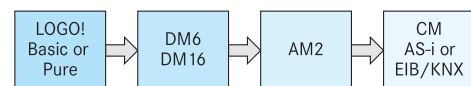


Fig. 8.47 Optimum sequence of devices and modules

	DM8 12/24R	DM8 24R	DM16 24R
Input voltage	12/24 V DC	24 V AC/DC	24 V DC
Permissible voltage range	10.8 to 28.8 V DC	20.4 to 26.4 V AC 20.4 to 28.8 V DC	20.4 to 28.8 V DC
Permissible line frequency		47 to 63 Hz	
Polarity reversal protection	Yes		Yes
Current consumption	12 V DC: 30 to 140 mA 24 V DC: 20 to 75 mA	24 V AC: 40 to 110 mA 24 V DC: 20 to 75 mA	30 to 90 mA
Power failure bridging	12 V: typ. 2 ms 24 V: typ. 5 ms	Typ. 5 ms	Typ. 5 ms
Real-time clock	Yes	Yes	Yes
Digital inputs			
Number	4	4	8
Input voltage L+ • "0" signal • "1" signal	< 5 V DC > 8.5 V DC	< 5 V AC/DC > 12 V AC/DC	< 5 V AC/DC > 12 V AC/DC
Input voltage L+ • "0" signal • "1" signal	< 0.85 mA > 1.5 mA	< 1.0 mA > 2.5 mA	< 1.0 mA > 2.0 mA
High-speed inputs	No	No	No
Analog inputs	No	No	No
Digital outputs			
Number	4	4	8
Type of outputs	Relay outputs	Relay outputs	Relay outputs
Output voltage	Floating	Floating	Floating
Continuous current I_{th} (per terminal)	Max. 5 A per relay!	Max. 5 A per relay!	Max. 5 A per relay!
Switching frequency			
Mechanical	10 Hz	10 Hz	10 Hz
Ohmic load/lamp load	2 Hz	2 Hz	2 Hz
Inductive load	0.5 Hz	0.5 Hz	0.5 Hz

Fig. 8.48 Technical specifications of the LOGO! expansion modules DM8 12/24R, DM8 24R and DM16 24R

Switching capacity and service life of the relay outputs

The service life of the relay contacts largely depends on the current load because of the mechanical contacts and the material used. The two curves show the service life depending on

the switching current for the different loads (ohmic/inductive). It can be seen, for example, that with an inductive load of 0.8 A (e.g. a motor) approximately 600,000 operating cycles ① are possible, but only 230,000 operating cycles at 2.5 A ②.

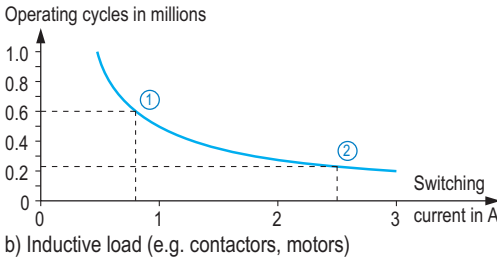
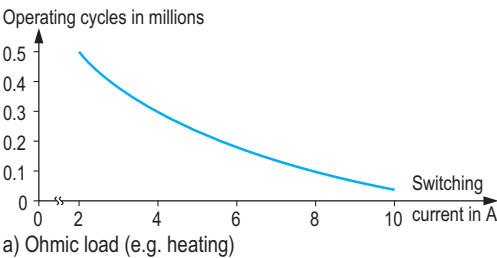


Fig. 8.49 Switching capacity and service life of the contacts

	DM8 24 / DM16 24	DM8 230R	DM16 230R
Input voltage	24 V DC	115 to 240 V AC/DC	115 to 240 V AC/DC
Permissible voltage range	20.4 to 28.8 V DC	85 to 265 V AC 100 to 253 V DC	85 to 265 V AC 100 to 253 V DC
Permissible line frequency		47 to 63 Hz	47 to 63 Hz
Polarity reversal protection	Yes		
Current consumption	30 to 45 mA 0.3 A per output	240 V AC: 10 to 20 mA 240 V DC: 5 to 10 mA	240 V AC: 10 to 40 mA 240 V DC: 5 to 20 mA
Power failure bridging		115 V AC/DC: typ. 10 ms 230 V AC/DC: typ. 20 ms	115 V AC/DC: typ. 10 ms 230 V AC/DC: typ. 20 ms
Digital inputs			
Number	4 / 8	4	8
Input voltage L+ • "0" signal • "1" signal	< 5 V DC > 8 V DC	< 40 V AC < 30 V DC > 79 V AC > 79 V DC	< 40 V AC < 30 V DC > 79 V AC > 79 V DC
Input current • "0" signal • "1" signal	< 1.0 mA > 1.5 mA	< 0.03 mA > 0.08 mA	< 0.03 mA > 0.08 mA
High-speed inputs	No	No	No
Analog inputs	No	No	No
Digital outputs			
Number	4 / 8	4	8
Type of outputs	Transistor, switching to P potential *	Relay outputs	Relay outputs
Output voltage	△ Power supply	Floating	Floating
Continuous current I_{th} (per terminal)	Max. 0.3 A output	Max. 5 A per relay	Max. 5 A per relay
Switching frequency			
Mechanical		10 Hz	10 Hz
Electrical	10 Hz		
Ohmic load/lamp load	10 Hz	2 Hz	2 Hz
Inductive load	0.5 Hz	0.5 Hz	0.5 Hz

* When switching on the LOGO! 24 and LOGO! 24o, a "1" signal is sent to the digital outputs for 50 ms. This must be taken into account for devices which respond to fast pulses.

Fig. 8.50 Technical specifications of the LOGO! expansion modules DM8 24 and DM16 24 as well as DM8 230R and DM16 239 R

Analog modules

Many sensors provide analog values for processing. These standardized values can be read in using analog inputs I7 and I8 of the LOGO! 12/24RC... and LOGO! 24 or with the **analog module AM2** and then processed. Each input has three terminals:

- I1: input for signals from 0 to 20 mA compared to M1.
- M1: ground connection for analog input 1.
- U1: input for signals from 0 to 10 V compared to M1.



Fig. 8.51
AM2 module

	AM2
Input voltage	12 to 24 V DC
Permissible voltage range	10.8 to 28.8 V DC
Current consumption	25 to 50 mA
Power failure bridging	Typ. 5 ms
Analog inputs	
Number	2
Type	Unipolar
Input range	0 to 10 V (input impedance 76 Ω)
	or 0 to 20 mA (input impedance < 250 Ω)
Resolution	10 bits standardized to 0 to 1000
Error limit	±1.5 %
Analog outputs	No

Fig. 8.52 Technical specifications of the LOGO! AM2

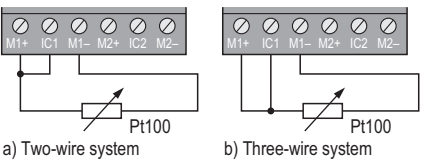


Fig. 8.53 AM2 module

The analog module AM2 PT100 is used to evaluate temperatures recorded by a Pt100 resistance thermometer (see Chapter 8.1.3.9). With this module, the Pt100 resistor is connected directly to the terminals M1+ and M1-. An external power source is unnecessary. A three-wire system is frequently used to suppress the influence of the cable length. In this case, the second cable is connected to IC1. With the two-wire system, IC1 must be linked to M1+ (Fig. 8.53).

	AM2 PT100
Input voltage	12/24 V DC
Permissible voltage range	10.8 to 28.8 V DC
Current consumption	25 to 50 mA
Power failure bridging	Typ. 5 ms
Sensor inputs	
Number	2
Type	Pt100 resistance thermometer
Connection of sensors	<ul style="list-style-type: none">• Two-wire system• Three-wire system
Measuring range	-50°C to +200°C -58°F to +392°F
Linearization of characteristic	No
Error limits	0°C to +200°C: ±1.0% -50°C to +200°C: ±1.5%
Length of cable	10 m

Fig. 8.54 Technical specifications of the LOGO! AM2 PT100

The **analog module AM2 AQ** is primarily used to control analog final control elements. It is a **module with two analog outputs** (0 to 10 V). Together with the analog inputs and the special functions, it is possible to program e.g. a **control loop** for controlling a soft-start ventilator. It should be noted that the devices connected to the outputs must have an input resistance (load resistance) of at least 5 kΩ.

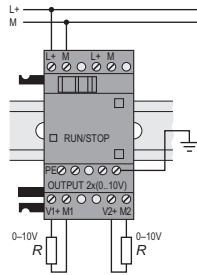


Fig. 8.55 AM2 AQ

	AM2 AQ
Input voltage	12/24 V DC
Permissible voltage range	10.8 to 28.8 V DC
Current consumption	25 to 50 mA
Power failure bridging	Typ. 5 ms
Analog outputs	
Number	2
Output range	0 to 10 V
Load resistance	5 kΩ
Resolution	10 bits standardized to 0 to 1000
Error limits	±2.5 %
Short-circuit protection	Yes
Length of cable	10 m (shielded and twisted)

Fig. 8.56 Technical specifications of the LOGO! AM2 AQ

8.2.2.3 Communication modules
CM EIB/KNX

Mainly in the office sector, electrical installations are often provided with building automation systems to achieve maximum flexibility. All sensors, control elements and actuators are then connected together by means of an (additional) two-core bus cable. Information frames are sent to the respective bus participants over this cable. All participants must therefore be assigned an individual address. The power supply required for the actuators is connected via a second cable.



Fig. 8.57 CM EIB/KNX

The complexity of image processing is rather low in this bus system since a contact is e.g. only assigned a specific function such as the switching-on of a group of lights. More comprehensive logic operations can be carried out e.g. in a LOGO!. The communication module CB EIB/KNX is required so that the LOGO! can communicate with the EIB in order to read the incoming frames and to generate outgoing ones.

Addressing and assignment are carried out within the EIB system using the ETS software (EIB Tool Software). For this purpose, an application program for the LOGO! (included in accessories) must be imported into the ETS in order to carry out the required parameter settings.

	CM EIB/KNX
Input voltage	24 V AC/DC
Permissible voltage range	20.4 to 26.4 V AC 20,4 to 28.8 V DC
Current consumption	Max. 25 mA (5 mA via bus)
Data transmission rate	9600 baud
Displays and control elements	
LED "RUN/STOP"	Green CM communicates with basic device Red No communication Orange Initialization Off No voltage
LED "BUS"	Green OK Red Bus faulty Orange Programming mode
Programming	Programming button S1 for address setting
Connections	
LOGO! link	Interface for Class 1 (12–24 V) and Class 2 (> 115 V)
Bus link	2-pin, screw terminals
Input and outputs	
Digital inputs, virtual	Max. 16
Analog inputs, virtual	Max. 8
Digital outputs, virtual	Max. 12
Special data	
	Max. 64 group addresses
	Max. 64 associations

Fig. 8.58 Technical specifications of the LOGO!-CM EIB/KNX

CM AS-i

The AS-i bus is primary used in the harsh field applications of industrial automation. This works with a two-core cable which is used to transmit both power and information. In contrast to the EIB system where the address of the slave (device) can be assigned using the programming software, this can also be carried out with AS-i devices using a programming device prior to connection to the bus.

Inputs/outputs

With both communication modules, the addressable inputs and outputs are "appended" to the actually existing inputs/outputs. If a LOGO! with the expansion module DM8 has a total of 12 DIs and 8 DOs, the first virtual input would be I13 and the first virtual output Q9.

8.3 Motor control unit

Motors with different power consumptions are controlled in automation technology applications. Different methods are used depending on the application.

	CM AS-i
Input voltage	24 V DC
Permissible voltage range	19.2 to 28.8 V DC with reverse polarity protection
Current consumption	Max. 70 mA
Displays and control elements	
LED "RUN/STOP"	Green CM communicates with basic device Red No communication Orange Initialization Off No voltage
LED "AS-i"	Green AS-i communication OK Red AS-i comm. faulty Flashes Slave has address "0" Off No voltage
Connections	
LOGO! link	Interface for Class 1 (12–24 V) and Class 2 (> 115 V)
Bus link	2-pin, screw terminals
Input and outputs	
Digital inputs	4 (the next four follow after the actually existing DIs)
Analog inputs	None
Digital outputs	4 (the next four follow after the actually existing DOs)
Analog outputs	None
I/O configuration	7 (hex)
ID code	F (hex)
ID1 code	F (hex, default setting, var. 0...F)
ID2 code	F (hex)

Fig. 8.59 Technical specifications of the LOGO!-CM AS-i

Switching with contactor

Actuators with a rated current of up to $I_N = 10$ A can always be connected directly to the relay outputs of the LOGO!. However, since the service life of the relays is largely dependent on the load, a contactor should be used to switch currents larger than approx. 1 A. The hum-free LOGO!Contact contactors have been specially developed for noise-sensitive areas (building installations). When using direction reversal, it is essential to use contactors. An interlocking circuit in the auxiliary circuit makes it impossible to switch both directions of rotation simultaneously ①. This mechanical interlocking also prevents simultaneous switching of both contactors should one of them remain stuck because of a fault.

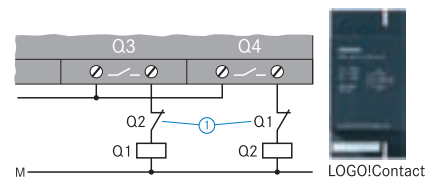


Fig. 8.60 Control circuit

Three-phase motors (asynchronous motors) are normally used for **changing the direction of rotation** because with them it is only necessary to interchange two phases in the main circuit ②. Simultaneous activation of both main contactors would result in a short-circuit.

As shown in Fig. 8.61, a DC motor can also be controlled with reversal of direction of rotation.

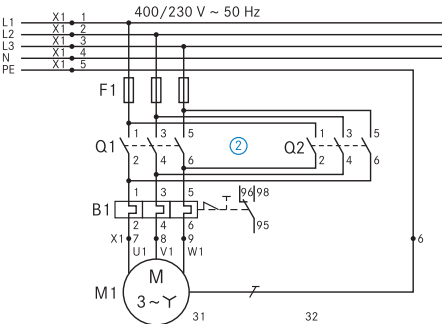


Fig. 8.61 Main circuit with reversal of direction of rotation

Frequency converter

The rotational frequency of motors can be changed in highly different manners. A frequency converter is used where flexibility is important. These converters apply the fact that the rotational frequency of three-phase motors depends on the frequency of the voltage and on the voltage itself.

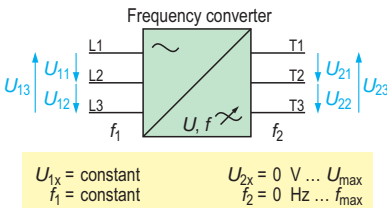


Fig. 8.62 Frequency converter

A wide range of properties and values can be influenced by the frequency converter:

- Ramp function of rotational frequency up to the setpoint
- Different rotational frequencies as programmed or entered manually
- Deceleration ramp (braking of motor)
- Current limitation
- Slip control
- Reversal of direction etc.



Fig. 8.63 Frequency converter with control panel

Control is carried out via digital or analog inputs or via a bus connection (e.g. Profibus or Profinet).

Using the digital inputs, certain operating values preprogrammed in the frequency converter can be exactly selected. Monitoring of these values (comparison between setpoint and actual value) can be carried out in the frequency converter if a corresponding encoder is connected for monitoring the rotational frequency of the motor. By means of the analog input, a standardized analog signal (0 to 10 V or 4 to 20 mA) can be used to directly control the rotational frequency. To this end, the limits of the rotational frequency are programmed on the frequency converter. The analog value present at the input is converted into a specific rotational frequency.

By means of the analog output AQ2 of the LOGO! the LOGO! can therefore be used as a controller for all rotational frequencies of a motor.

Note: The cable between LOGO! and frequency converter must be shielded since the latter and the motor cables could interfere with the signal (problem of electromagnetic compatibility).

8.4 Electropneumatic objects

Since movements are easy to implement using actuators driven by compressed air, electropneumatic objects are frequently used in automation engineering. The force is easy to vary using compressed air, and linear movements can therefore be carried out without complication. The pneumatic objects of the pneumatic diagram in Fig. 8.64 will therefore be initially considered and then the function will be described.

Cylinders are differentiated between double-action and single-action in accordance with their function.

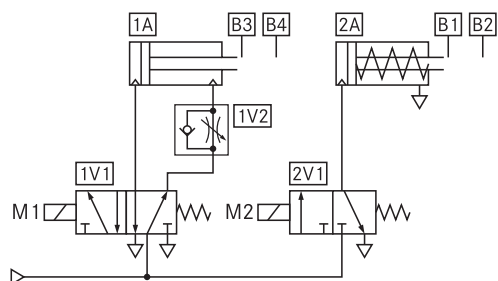


Fig. 8.64 Pneumatic diagram

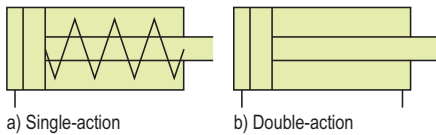


Fig. 8.65 Pneumatic symbols for cylinders

With **single-action cylinders** (Fig. 8.65a), the piston is pressed by the compressed air in only one direction. This compresses a spring. The displaced air is discharged via the vent. If the cylinder has to be returned to the basic setting, the compressed air line must be vented (unpressurized). The spring then pushes the piston back to its basic position (return stroke, Fig. 8.66). This type of cylinder therefore only experiences the force of the compressed air when "advancing", since the return stroke is carried out by the spring – it only acts in one direction. It is therefore used e.g. to push workpieces off a belt since force is only required in one direction.

With double-action cylinders (Fig. 8.65b), the return stroke is also carried out with the force of the compressed air, making a second air connection necessary (Fig. 8.67). A significantly higher stroke is possible with double-action cylinders since a reset spring is not used.

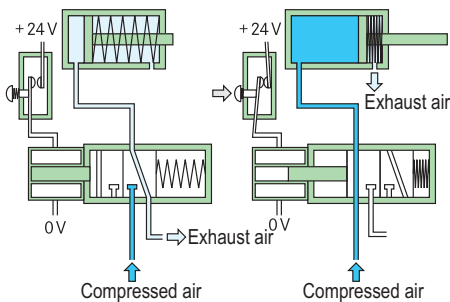


Fig. 8.66a Air path with 3/2-way valve and single-action cylinder

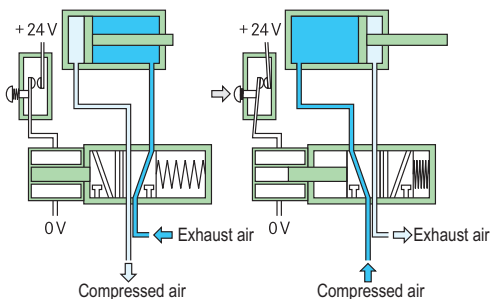


Fig. 8.66b Air path with 5/2-way valve and double-action cylinder

With both types of cylinder, it must be possible for the air to be supplied or discharged through the same line depending on the direction of movement. Reference is made to compressed air and exhaust air depending on the direction. Switching over of the flow direction is carried out using valves.

Solenoid valves

A solenoid valve is a pneumatic valve which is activated electromagnetically. It is also the link between the (electric) controller and the pneumatic actuators. One therefore refers to this type of controller as an **electropneumatic controller**.

Depending on whether a double-action or single-action cylinder is to be controlled, a valve must be used which has one or two pressure outputs.

3/2-way valve

"Ways" refers to switched positions. The identification 3/2 means that the valve has **3 connections** and **2 switched positions**. The connections are numbered according to their function (Fig. 8.67):

- 1: compressed air (P)
- 2: output (A) – connection line to valve
- 3: vent (R)

The positions are identified by a (switched position) and b (rest position).

The manual **activation unit** can be used to move the valve by hand.

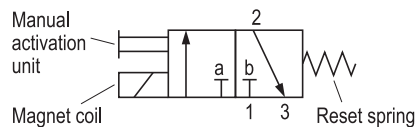


Fig. 8.67 Symbol of a 3/2-way valve with manual activation unit

A valve always requires one activation unit per direction. In Fig. 8.67, the valve is switched by the magnet coil or manual activation unit, and returned to its rest position by the reset spring. A magnet coil can also be used as an alternative to the reset spring.

Function: In the rest position (b) the magnet coil is not energized. Therefore the passage from 1 (compressed air) to 2 (output) is blocked. The output (2) is vented via 3.

In switched position (a) the magnet coil is energized. The left rectangle of the symbol in Fig.

8.67 can then be considered as being shifted underneath the connections. The compressed air can thus pass from input 1 to output 2. The vent 3 is blocked. The 3/2-way valve is used to control single-action cylinders.

5/2-way valve

The 5/2-way valve is used to control the double-action cylinder (Fig. 8.66b) where the connection lines have to be reversed.

Depending on the position of the valve, compressed air is connected to one or the other line. The other line in each case is vented.

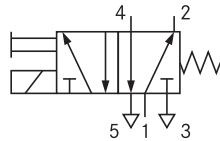


Fig. 8.68 5/2-way valve

Representation in circuit diagrams

In circuit diagrams, valves are represented independent of their exact function by their electrical design (magnet coil) and by the symbol for the valve (Fig. 8.69). This is the interface between the electric and pneumatic systems.

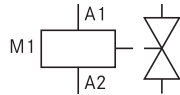


Fig. 8.69 Valve symbol in circuit diagrams

Restrictor non-return valve

Different stroke speeds of a cylinder can be implemented using restrictor non-return valves. Such a valve is frequently mounted directly on the outlet of a cylinder, and allows the compressed air to flow through unhindered, while restricting (reducing) the flow of exhaust air. This prevents irregular operation from arising as a result of changes in load on the piston rod. The restrictor gap can be varied using a screw. If the forward stroke is to be reduced, the valve must be mounted on the forward stroke inlet. If the return stroke is to be reduced, it is mounted on the return stroke inlet.

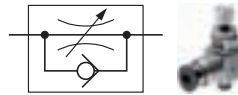


Fig. 8.70 Restrictor non-return valve

Identification in pneumatic diagrams

Each object in a pneumatic plant has an enclosed identification (Fig. 8.71). This consists of

- the circuit number,
- the ID for the type of component, and
- the consecutive component number.

The circuit number 0 is reserved for power supply elements. In our example, display of the supply elements has been omitted.

Example:

1V2: circuit 1, V: valve, component 2

ID letter	Component	Examples
P	Pump, compressor	Reciprocating compressor
A	Drive element	Cylinder
V	Other valves	Restrictor non-return valve

Fig. 8.71 Identification of pneumatic objects

Function description of pneumatic diagram (Fig. 8.64)

If valve 1V1 is switched by magnet coil M1, compressed air flows via the energized valve 1V1 into the single-action cylinder 1A1. This is then extended and activates sensor B2 when the end position is reached. If the current flow through M1 is interrupted, valve 1V1 is returned by the spring force into the basic setting and the supply line to the cylinder is vented. Cylinder 1A1 thus returns into its basic position through the force of the reset spring. The exhaust air is discharged via valve 1V1. Sensor B1 is activated when cylinder 1V1 has reached its end position.

If magnet coil M2 is switched, compressed air is supplied to cylinder 2A via the energized valve 2V1. The exhaust air of cylinder 2A is reduced by the restrictor non-return valve 2V2, so that cylinder 2A1 is slowly extended. The exhaust air of the cylinder is subsequently vented via valve 2V1. Sensor B4 is activated when the end position is reached. If coil M2 is switched off, valve 2V1 returns to the basic position as a result of the spring force of the reset spring, and the inlet air presses the piston of cylinder 2A1 back into the basic position. The exhaust air is discharged via valve 2V1. Sensor B3 is activated when the end position is reached.

9 Logic operations

9.1 Representations

Information can be linked together in different ways. In automation engineering, highly different representations are sometimes used depending on the sector, which are now to be examined more closely using the OR logic operation.

OR operation

In the case of OR logic, at least one input signal must be "1" so that the output is a "1" signal.

Circuit diagram

In the circuit diagram with detached representation, the OR logic is formed by parallel connection of the two buttons S1 and S2. The function can be analyzed through activation of the individual buttons: if the button S1 OR the button S2 is activated, the auxiliary contactor K1 is switched. This closes the NO contact of K1, and the signal lamp P1 lights up.

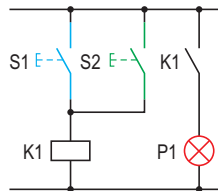


Fig. 9.1 Circuit diagram

Ladder diagram

The ladder diagram is similar to the circuit diagram, but is rotated by 90° in the counterclockwise direction. The input signals are represented by square parentheses, the output signals by round parentheses. In the LOGO!Soft Comfort software, the square parentheses are only shown as parallel lines.

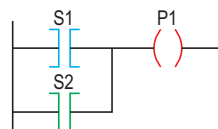


Fig. 9.2 Ladder diagram

Logic symbol

The graphic symbol represents the OR logic. The "≥ 1" symbol (in words: greater than or equal to one) can be understood as follows: the "1" signal results at the output if one or more inputs have a "1" signal.

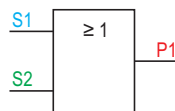


Fig. 9.3 Logic symbol

Pneumatic circuit diagram

In pneumatic circuits, OR logic is produced using shuttle valves (1V1). If the 3/2-way valve 1S1 or the 3/2-way valve 1S2 is activated, the compressed air is passed on by the shuttle valve 1V1 to the single-action cylinder 1A. The respective unpressurized input is blocked. The circle symbolizes a ball inside the valve.

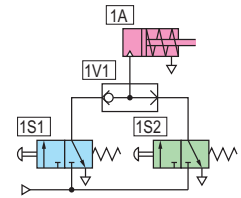


Fig. 9.4
Pneumatic diagram

Signal/time diagram

In a signal/time diagram the sources of information are represented in their response with respect to time. Since the information (buttons S1 and S2 in this case) and the result of the logic operation (signal lamp P1 in this case) are arranged above each other, the mutual dependency is clear. This is simplified by the division into time intervals.

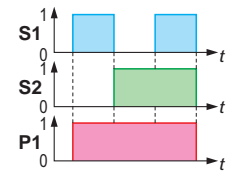


Fig. 9.5
Signal/time diagram

Value table

The value table (truth table) clarifies the relationships by means of levels: 1 = closed, 0 = open. The following method for reading the table results from this:

S2	S1	P1
0	0	0
0	1	1
1	0	1
1	1	1

Fig. 9.6 Value table

1st cell: S1 and S2 open → P1 does not light up (S1 = 0, S2 = 0, P1 = 0)

2nd cell: S1 closed, S2 open → P1 lights up (S1 = 1, S2 = 0, P1 = 1)

3rd cell: S1 open, S2 closed → P1 lights up (S1 = 0, S2 = 1, P1 = 1)

4th cell: S1 and S2 closed → P1 lights up (S1 = 1, S2 = 1, P1 = 1)

All possible combinations of the input signals are displayed in a value table. In this case, $2^2=4$

combinations result for two inputs, $2^3 = 8$ combinations for three inputs, $2^4 = 16$ combinations for four inputs, etc.

Lower-case letters are frequently used as input variables in truth tables. The first letters of the alphabet represent the inputs of a logic operation, the last letters the outputs.

Equation

A logic operation can also be represented by an equation in addition to the forms already described. In this case the two input variables are linked by the logical OR symbol "v". In the literature, a "+" is occasionally used instead of the "v". The equation is read as follows: P1 is equal to S1 OR S2.

$$P1 = S1 \vee S2$$

Fig. 9.7 Equation

9.2 Basic logic operations

AND operation

An AND operation only has a "1" state at the output if **all** inputs have a "1" state.

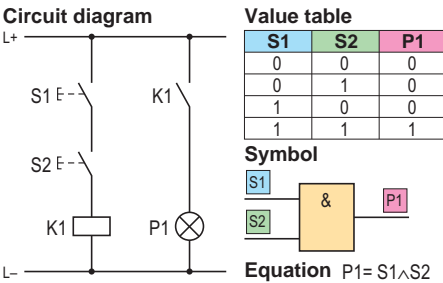


Fig. 9.8 AND logic operation

Note: The logic operation symbol is easy to remember: the & symbol is the so-called "commercial AND".

The equation is read as follows: P1 is equal to S1 AND S2.

NOT operation

If a "1" state is present at the input of a NOT operation, a "0" state is present at the output, and vice versa. The input state is **negated**.

The signal state is reversed by the NOT operation, one therefore also refers to **negation**. The negation is indicated in the logic diagram by a circle at the output (Fig. 9.9).

In the logic equation, the negation is indicated by a dash above the input variable.

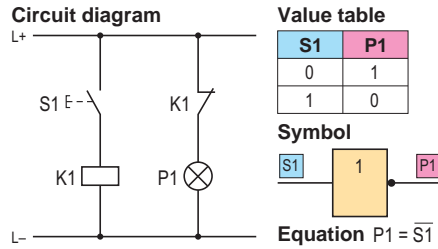


Fig. 9.9 NOT logic operation

The equation is read as follows: "P1 is not equal to S1" or "P1 is equal to S1 negated" (there is no standardized form).

NAND operation

The output of a NAND operation only has the "0" state if all inputs have the "1" state. This operation can be implemented by connecting two known logic operations.

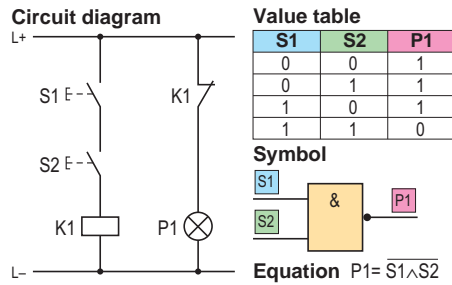


Fig. 9.10 NAND logic operation

If we compare the value tables of the AND operation with the table of our circuit, it becomes clear that the output information in our table is negated compared to the AND operation. It can therefore be derived that the NAND operation consists of an AND operation with a NOT operation at the output (Fig. 9.11).

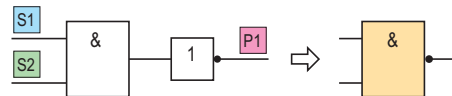


Fig. 9.11 NAND comprising AND and NOT operations

Since this type of operation is used extremely often, a simplified symbol has been agreed upon: the output negation is simply identified by a circle (Fig.10). The equation is read as follows: "P1 is equal to not S1 and S2" or "P1 is equal to S1 and S2, completely negated".

NOR operation

The output of a NOR operation has the "0" state if one or more inputs have the "1" state. The NOR operation can be combined like the NAND operation from an OR operation and a NOT operation. The simplified symbol is shown in Fig. 9.12. The equation is read as follows: "P1 is equal to not S1 or S2" or "P1 is equal to S1 or S2, completely negated".

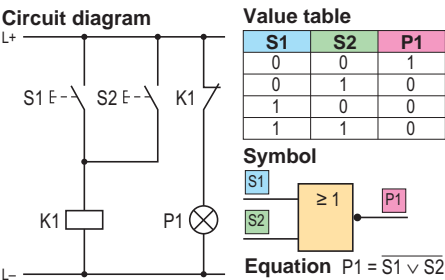


Fig. 9.12 NOR logic operation

AND with edge evaluation

The output of an AND operation with edge evaluation only has a "1" state at the output if all inputs have a "1" state and at least one has changed in the last program cycle (see box on next page) from the "0" state to the "1" state (in Fig. 9.13). This is used, for example, for sequential circuits. The arrow pointing upwards indicates this positive edge from "0" to "1".

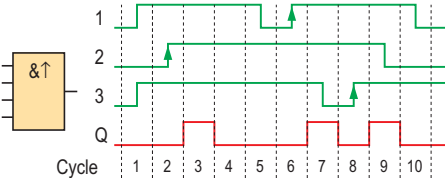


Fig. 9.13 Symbol and signal/time diagram: AND (edge)

NAND with edge evaluation

Just like the AND operation with edge evaluation, this operation also functions dependent on a change in state. However, the arrow pointing downwards in the symbol indicates that the

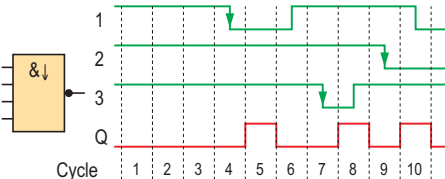


Fig. 9.14 Symbol and signal/time diagram: NAND (edge)

negative edge (change from "1" state to "0" state) is evaluated (Fig. 9.14). The output only has a "1" state if at least one input has assumed the "0" state and if all inputs had the "1" state in the previous cycle.

XOR (exclusive-OR operation)

The exclusive-OR operation (XOR) only has a "1" state at the output if the input states are different (non-equivalent). This is particularly clear in the value table (Fig. 9.15).

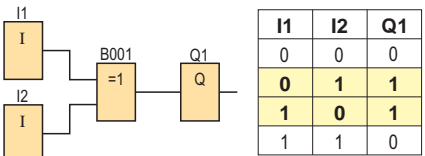


Fig. 9.15 Symbol and value table: XOR

9.3 Constants/terminals

(Binary) input and analog input

Digital and analog inputs are represented by the input terminals of the LOGO!. They can be changed with regard to their numbering using the block properties.

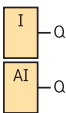


Fig. 9.16 Inputs

Output and analog output

Outputs are represented by the output terminals. With the analog outputs (max. two), it must be noted that the values to be represented must be between 0 and 1000 (corresponding to 0 to 10 V). The output Q of the symbol has the same signal as the input.



Fig. 9.17 Outputs

Cursor key

The four cursor keys of the LOGO! can be used like normal inputs. To do this, the corresponding window is selected in RUN mode. To carry out an operation, ESC and the desired key must be pressed simultaneously.



Fig. 9.18 Cursor key

TD function key

As of release version 0BA6, the external text display TD can also be used. In addition to a text block, this also has four function keys. The function keys can be evaluat-



Fig. 9.19 Function key

ed in the program just like normal keys or buttons. An F input is assigned in the program to the corresponding key F1 – F4.

Fixed levels

The fixed levels are used to generate defined signals. A "1" state is generated by "hi" (high), a "0" state by "lo" (low). These are necessary, for example, with a PI controller in order to select a specific operating mode (manual/automatic).

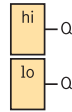


Fig. 9.20
Levels

Shift register bit

The individual states of a shift register can be read out using the eight shift register bits S1 to S8 (Chapter 9.4 Special functions: shift registers). A change can only be carried out using a shift register.



Fig. 9.21
Shift register bit

Open terminal

The "Open terminal" has a function like an output, but is only present virtually in the program. It is used if a block has to be followed by another, such as, for example, the message text (Chapter 9.4 Special functions).



Fig. 9.22
Open terminal

Flags

The signal of the input of the previous program cycle is always present at the output of a flag. The value is not changed within a program cycle. Its func-

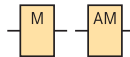


Fig. 9.23
Digital and analog flags

tion thus corresponds to an output without a real connection terminal, and can, for example, be used for decoupling, as necessary with recursions (connection of an output signal to an input in the same signal path). 24 flags (M) are available for digital signals, and 6 flags (AM) for analog signals. In addition, flags M25 to M27 have special functions. The flag numbers can be assigned by parameterizing the block.

Start-up flag M8

Flag M8 is a special case: it is set in the first cycle of the program, and can therefore be used, for example, in step sequences as a start-up flag. It is automatically reset when the first cycle has been completed, and responds in all further cycles just like every other flag.

Background illumination flags M25 and M26

Whereas with the development levels prior to OBA6 the background illumination of the text display was only activated during activation of the message text for 30 s, this can now be directly and permanently controlled using the flags M25 and M26. M25 controls the background illumination of the LOGO! display, M26 that of the LOGO! TD (text display).

Character set flag M27

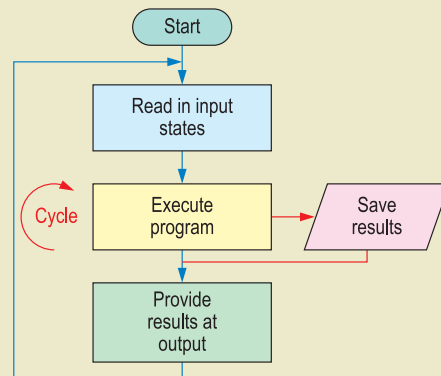
During configuration of a message text, it is possible to optionally define a second character set (cf. Chapter 7.6.3). Flag M27 can be used in the program to switch over to the second character set and to deactivate the message text of the other set. It is then possible, for example, to display a message text in a different language.

Program cycle

Invisible to the user, the programs in a LOGO! are processed exactly as in a PLC: An image of the input values is initially stored internally.

The program is stored in text form in the LOGO! invisible to the user. This is subsequently executed line by line. The respective output assignments and results of the logic operations are saved in an internal output memory.


The results are assigned from the memory to the outputs only when the program has been completely executed. The cycle subsequently begins again from the beginning.



9.4 Special functions

Special functions are presented below which can process times, analog values, and much more. It is also possible to set block-specific properties (parameters). This is carried out in the **Block properties** which can be called in LOGO!Soft Comfort by double-clicking on the associated block. These parameters can also be changed on the LOGO! during ongoing operation using the display and input keys.

Protection and password

Unauthorized modification of parameters could possibly destroy a plant. Therefore they can be protected against manipulation by selecting  in the block properties.

If this is activated, the set parameters can only be changed in the edited program, but not during operation. To additionally enable the complete program to be protected against changes, a **password** (*File Properties*) can also be used.

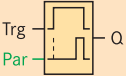
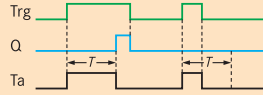
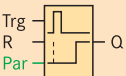
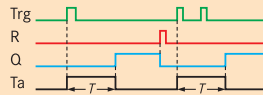
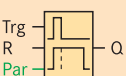
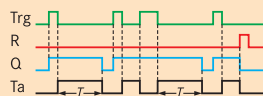
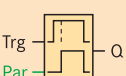
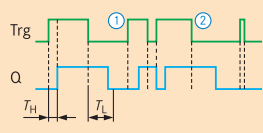

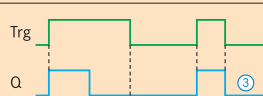
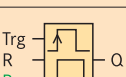
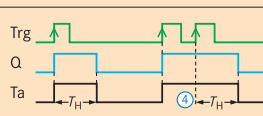
Retentivity

Retentivity (continuation, lat.) means that, following a power failure, the selected block reassumes the same state it had prior to the failure. This is important, for example, if a counter is used and the power failure should not result in its value being reset.

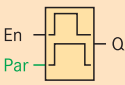
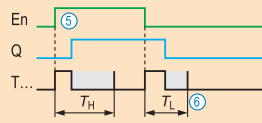

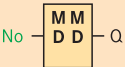
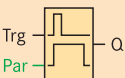
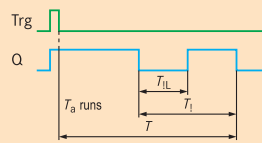
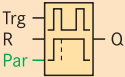
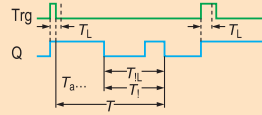


Note: The following representations provide a rapid overview. More detailed elaboration is appropriate using the extremely comprehensive [software help](#) or the [manual](#).

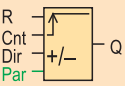
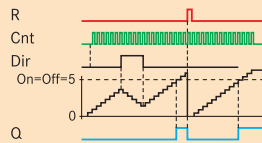
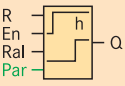
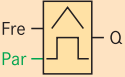
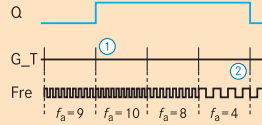
Timers

Symbol	Signal/time diagram	Explanations
		Switch-on delay If the Trg input has a "1" signal, the output assumes a "1" state following expiry of the parameterized delay time T . If the input signal falls to the "0" state, the output also assumes a "0" state.
		Retentive switch-on delay Just like with the switch-on delay, the output only has a "1" state following expiry of the parameterized time T . However, the output is reset by a "1" signal at the R input.
		Switch-off delay The output assumes the "1" state as soon as the input has a "1" signal. If the input signal falls, the output still has a "1" signal for a parameterized time T .
		Switch-on/off delay The input signal is passed on with a delay to the output following the positive edge (change in signal from "0" to "1" state ①), and extended at the output by the parameterized time following the negative edge (change in signal from "1" to "0" state ②).
		Interval time-delay relay (pulse output) If the Trg input has the "1" state, the output assumes the "1" state for a parameterized time. The output also assumes the "0" state if the input assumes the "0" state prior to expiry of the parameterized time ③.
		Edge-triggered interval time-delay relay The edge-triggered interval time-delay relay starts the parameterized time depending on a positive change in edge at the Trg input. Each further change in edge at this input restarts the time ④.

Timers (continued)


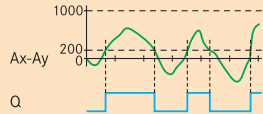
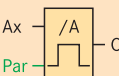
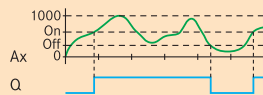
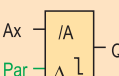
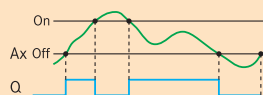
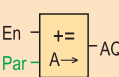
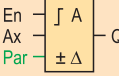
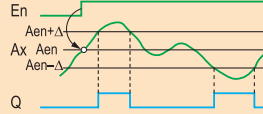
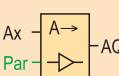
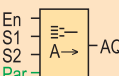
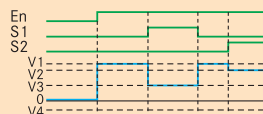
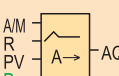
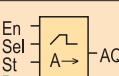
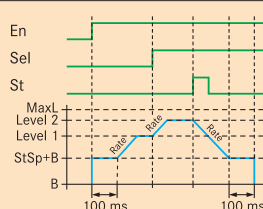
Symbol	Signal/time diagram	Explanations
		Random generator Following a positive change in edge at the En ⑤ input the output assumes the "1" state following expiry of a random time between 0 s and the parameterized value T_H . Following a negative edge at the En input, the output remains in the "1" state for 0 s up to the time value T_L ⑥.
	Week time switch This is used for switching on and off depending on the day of the week and the time. Parameterization is carried out using three independent lines, the "cams".	
	Year time switch This switches exactly according to the day and month.	
		Staircase lighting timer The Q output is set by a positive edge at the Trg input. The parameterized holding time T is started by the negative input edge. The running time is reset if the switch is activated again during the switch-off delay. A pre-warning T_{IL} and T_I can be activated prior to switching-off.
		Convenience switch The convenience switch is an extended staircase lighting timer. In addition to the function described above, a "1" signal at the Trg input results in switching over to continuous lighting ("1" state at the output) for the parameterizable duration T_L .

Counters

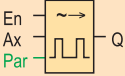
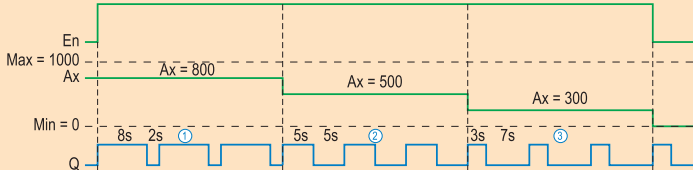

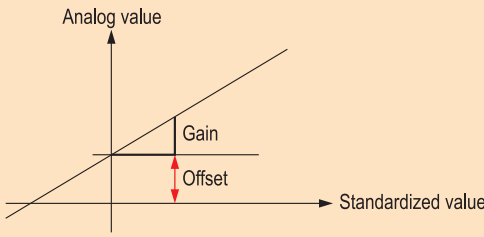
Symbol	Signal/time diagram	Explanations
		Up/down counter This counts the positive input edges at the counter input Cnt. depending on the counting direction Dir (Dir=0 up counter). The switch-on and switch-off thresholds can be parameterized, the Q output then has a corresponding "1" or "0" signal. The maximum counted value is 999. Resetting is carried out by a "1" signal at the R input.
	Operating hours counter The operating hours counter records the duration for which the En input is in the "1" state. This value (parameter OT; can be preset) can be displayed by means of the message text. In addition, a maintenance interval (MI) can be defined, and the Q output is set when this has expired. The R input acknowledges this, and resets the output and the interval monitoring. The Ral input completely resets the current values of the operating hours counter and the maintenance interval.	
		Threshold counter This monitors the Fre input with regard to a continuous change in signal. The Q output is switched when the parameterizable signal frequency On is exceeded at the Fre input ① (in this case: On=9 Hz). The output only returns to the "0" state when the parameterizable Off frequency is fallen below ② (in this case: Off=5 Hz). The switching over only takes place following unambiguous detection of the frequency. This so-called gate time can be parameterized between 00:05 s and 99:99 s.

Note: When setting the measuring range and the gain and offset values, please observe the references on the page after next.

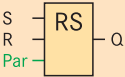
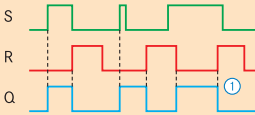
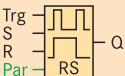
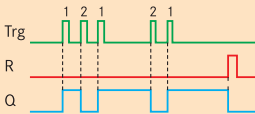
Analog

Symbol	Signal/time diagram	Explanations
		Analog comparator This compares the two analog values at the inputs Ax and Ay. If the difference exceeds the parameterized value On, the Q output is switched on. If the difference falls below the parameterized value Off, the Q output is switched off.
		Analog threshold switch If the analog input signal Ax exceeds the parameterized value On, the Q output is switched. It is only switched to the "0" state again when the parameterized value Off is fallen below.
		Analog differential threshold switch The Q output switches to the "1" state when the input value Ax is between the two parameterized values for the On and Off thresholds (Off = On + Δ).
		Analog arithmetic With this block, calculations can be carried out with up to four analog values. Both the operands and the operators can be defined by the user. Using a reference, the current values of other blocks which process analog values can be assigned to the operands, or also a fixed value. Priorities can be assigned to the operations (High = H, Medium = M and Low = L), so that bracketed calculations are indirectly possible. The En input can be parameterized such that the output value is either the last calculated value or zero, if En = 0. Examples: The input 15 + (M) 6 * (H) 7 + (L) 3 corresponds to (15 + (6 * 7)) + 3 = 60 The input 31 - (H) 3 / (L) 19 + (M) 5 corresponds to (31 - 3) / (19 - 5) = 2
		Analog value monitoring The analog value Ax is read in upon a positive edge at the En input, and saved as the value Aen. As long as the En input is in the "1" state, the current value Ax is monitored. If this value leaves the window between Aen + Δ and Aen - Δ, the Q output is switched.
		Analog amplifier This is used to adapt an analog signal since e.g. the value of an analog output must only be in the range 0 to 1000.
		Analog multiplexer (MUX) With a "1" state at the En input, an analog signal is output at the AQ output. Four different analog signals can be generated depending on the S1 and S2 inputs. The output signals can be freely set with reference to other blocks processing analog values.
		PI controller The A/M input can be used to switch over between automatic and manual modes. A "1" signal at the R input resets the AQ output to the value "0". The controlled variable is read in at the PV input. The setpoint can be read in as a fixed parameter, or also as a reference from another block. Fixed parameter sets are already available for standard applications. Please observe the notes in the online help under the keywords "Fundamentals on control" and "Fundamentals on controller".
		Ramp control A "1" signal at the En input starts the ramp so that the parameterized value StSp+B (offset) is output at the AQ output for 100 ms. The parameterized Level 1 or Level 2 is then driven to at the parameterized rate (Sel = 0 ⇒ Level 1, Sel = 1 ⇒ Level 2). A "1" signal at the St input causes the output value AQ to be reduced again at the parameterized rate to the value StSp+B and switched off after 100 ms. The Level can be changed at any time via the Sel input.

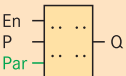
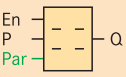
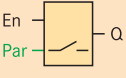
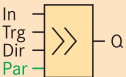
Analogue (continued)

Symbol	Signal/time diagram	Explanations
	<p>Pulse width modulation (PWM)</p> <p>Using pulse width modulation, frequency signals can be generated depending on an analog value. An upper limit (Max) and a lower limit (Min) can be defined within which the input signal is converted into a frequency. The periodic time (PT) defines the time window within which the period is modulated. If the current value (Ax) is exactly at the upper limit, a continuous signal is output at Q. Q is not switched at Ax=0. On the other hand, each value between Min and Max is converted into a corresponding pulse-to-pause ratio, where the periodic time is observed. The En input enables the PWM.</p> <p>If Max = 1000, Min = 0 and PT = 10 s, the following apply, for example:</p> <ul style="list-style-type: none">- Ax = 800 a pulse-to-pause ratio of 8 s : 2 s ①- Ax = 500 a pulse-to-pause ratio of 5 s : 5 s ②- Ax = 300 a pulse-to-pause ratio of 3 s : 7 s ③ 	
<p>Analogue value processing</p> <p>In the LOGO! it is possible to process the standardized analog signals 0...10 V and 0...20 mA. These are converted internally into values between 0 and 1000 ("standardized"). Adaptations can be carried out in the blocks for processing analog values:</p> <p>Gain refers to amplification of the input signal. Using the offset, it is possible to adjust the zero point of the input signal. Both are necessary if e.g. analog signals from sensors are not exactly set, or cannot be set, or the evaluation of the signal is to be carried out much more exactly. The internal analog value is calculated from:</p> <p>Analogue value = (Standardized value · Gain) + Offset</p> <p>The measuring range is a direct conversion of gain and offset into specific values.</p>	 	

Miscellaneous

Symbol	Signal/time diagram	Explanations
		<p>Self-latching relay</p> <p>The Q output is set by a "1" signal (pulse) at the S input. The Q output also remains in the "1" state if the S input subsequently returns to the "0" state. The output is reset if a "1" signal is present at the R input. The reset input has priority ①.</p>
		<p>Pulse relay</p> <p>The relay is set by the first edge at the Trg input, and reset by the second edge. It can be set/reset independent of the state by means of the S and R inputs.</p>

Miscellaneous (continued)

Symbol	Signal/time diagram	Explanations
		<p>Message text</p> <p>This is used to output, for example, operating modes or current values on the display or the text display. The display has 4 lines with 2·12 characters. The first 12 characters are displayed directly, the second 12 can either be switched alternately or displayed as ticker text. Current values can be displayed as a bargraph. The target can be selected to define whether information is to be output on the display, on the text display, or on both. Texts can be assigned to I/O states in order, for example, to directly display operating states without generating specific message texts. The flag M27 can be used to switch over between two character sets with their own message texts.</p> <p>Note: The message text block must be followed by a logic operation, an output (Q), a flag (M) or an open terminal (x).</p>
		<p>Message text</p> <p>This is used to output, for example, operating modes or current values on the display. Note: The message text must be followed by a logic operation, an output (Q), a flag (M) or an open terminal (x).</p>
		<p>Software switch</p> <p>Function of a mechanical switch/button. Operation using "Parameterize" mode.</p>
		<p>Shift register</p> <p>The signal present at the In input is read in upon each positive edge at the Trg input, and written into the first shift register bit. At the same time, the signal states in the other seven bits are shifted on by one position. The shift direction is reversed by a "1" signal at the Dir input. Individual bits can be read out by the S connector (see constants/terminals).</p>

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Picture sources

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