CL150, CL151, CL150A, CL151A -DP, -CAN, -IBS, -DEV Manual / Operations List

Edition 101

CL150

CL150, CL151, CL150A, CL151A
-DP, -CAN, -IBS, -DEV
PLC Manual / Operations List

1070 072 188-101 (00.04) GB

Discretionary charge 20.-- DM

1 Safety Instructions

Before you start working with the CL150, we recommend that you thoroughly familiarize yourself with the contents of this manual. Keep this manual in a place where it is always accessible to all users.

1.1 Intended Use

This instruction manual presents a comprehensive set of instructions and information required for the standard operation of the described products. The described products are used for the purpose of CL150.

The products described hereunder

- were developed, manufactured, tested and documented in accordance with the relevant safety standards. In standard operation, and provided that the specifications and safety instructions relating to the project phase, installation and correct operation of the product are followed, there should arise no risk of danger to personnel or property.
- are certified to be in full compliance with the requirements of the
  - EMC directives (89/336/EEC 93/68/EEC, and 93/44/EEC)
  - Low voltage directive (73/23/EEC)
  - Harmonized standards EN 50081–2 and EN 50082–2
- are designed for operation in an industrial environment (Class A emissions), i.e.:
  - Direct connection to the public low–voltage power supply is not permitted.
  - Connection to the medium and/or high–voltage system must be provided by a transformer.

  The following applies for application within a personal residence, in business areas, on retail premises or in a small–industry setting:

  - Installation in a control cabinet or housing with high shield attenuation.
  - Cables that exit the screened area must be provided with filtering or screening measures.
  - The user will be required to obtain a single operating license issued by the appropriate national authority or approval body. In Germany, this is the Federal Institute for Posts and Telecommunications, and/or its local branch offices.

This is a Class A device. In a residential area, this device may cause radio interferences. In such case, the user may be required to introduce suitable countermeasures, and to bear the cost of the same.

Proper transport, handling and storage, placement and installation of the product are indispensable prerequisites for its subsequent flawless service and safe operation.

1.2 Qualified Personnel

This instruction manual is designed for specially trained personnel. The relevant requirements are based on the job specifications as outlined by the ZVEI and VDMA professional associations in Germany. Please refer to the following German–Language publication:

Weiterbildung in der Automatisierungstechnik
Hrsg.: ZVEI und VDMA
MaschinenbauVerlag
Postfach 71 08 64
60498 Frankfurt

This instruction manual is specifically designed for PLC-technicians. The versions with fieldbus connection require special skills in handling the fieldbus system.

Interventions in the hardware and software of our products not described in this instruction manual may only be performed by our skilled personnel.

Unqualified interventions in the hardware or software or non–compliance with the warnings listed in this instruction manual or indicated on the product may result in serious personal injury or damage to property.

Installation and maintenance of the products described hereunder is the exclusive domain of trained electricians as per IEV 826–09–01 (modified) who are familiar with the contents of this manual.

Trained electricians are persons of whom the following is true:

They are capable, due to their professional training, skills and expertise, and based upon their knowledge of and familiarity with applicable technical standards, of assessing the work to be carried out, and of recognizing possible dangers.

They possess, subsequent to several years' experience in a comparable field of endeavor, a level of knowledge and skills that may be deemed commensurate with that attainable in the course of a formal professional education.

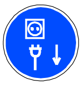
With regard to the foregoing, please read the information about our comprehensive training program. The professional staff at our training center will be pleased to provide detailed information. You may contact the center by telephone at (+49) (0 60 62) 78-258.

1.3 Safety Markings on Components

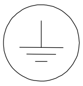
DANGER! High voltage!

DANGER! Corrosive battery acid!

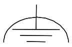
CAUTION! Electrostatically sensitive components!



Disconnect mains power before opening!



Lug for connecting PE conductor only!



Functional earthing or low–noise earth only!

Screened conductor only!

1.4 Safety Instructions in this Manual

DANGEROUS ELECTRICAL VOLTAGE
This symbol warns of the presence of a **dangerous electrical voltage**. Insufficient or lacking compliance with this warning can result in **personal injury.**

DANGER
This symbol is used wherever insufficient or lacking observance of this instruction can result in **personal injury.**

CAUTION
This symbol is used wherever insufficient or lacking observance of instructions can result in **damage to equipment or data files.**

⇒ This symbol is used to alert the user to an item of special interest.

1.5 Safety Instructions for the Described Product

DANGER
Fatal injury hazard through ineffective Emergency–OFF devices! Emergency–OFF safety devices must remain effective and accessible during all operating modes of the system. The release of functional locks imposed by Emergency–OFF devices must never be allowed to cause an uncontrolled system restart!

Before restoring power to the system, test the Emergency–OFF sequence!

DANGER
Danger to persons and equipment!
Test every new program before operating the system!

DANGER
Retrofits or modifications may interfere with the safety of the products described hereunder!

The consequences may be severe personal injury or damage to equipment or the environment. Therefore, any system retrofitting or modification utilizing equipment components from other manufacturers will require express approval by Bosch.

DANGEROUS ELECTRICAL VOLTAGE
Unless described otherwise, maintenance procedures must always be carried out only while the system is isolated from the power supply. During this process, the system must be blocked to prevent an unauthorized or inadvertent restart.

If measuring or testing procedures must be carried out on the active system, these must be carried out by trained electricians.

CAUTION
Only Bosch–approved spare parts may be used!

CAUTION
All ESD protection measures must be observed when using the module! Prevent electrostatic discharges!

Observe the following protective measures for electrostatically endangered modules (EEM)!

- The Employees responsible for storage, transport and handling must be trained in ESD protection.
- EEMs must be stored and transported in the protective packaging specified.
- Out of principle, EEMs may be handled only at special ESD work stations equipped for this particular purpose.
- Employees, work surfaces and all devices and tools that could come into contact with EEMs must be on the same potential (e.g. earthed). An approved earthing wrist strap must be worn. It must be connected to the work surface via a cable with an integrated 1 MΩ resistor.
- EEMs may under no circumstances come into contact with objects susceptible to accumulating an electrostatic charge. Most items made of plastic belong to this category.
- When installing EEMs in or removing them from an electronic device, the power supply of the device must be switched OFF.

1.6 Documentation, Versions and Trademarks

Documentation

The present manual provides the user with comprehensive information about operation and installation of the CL150, CL151, CL150A, CL151A controllers and the versions with fieldbus connection -DP, -CAN, -IBS and -DEV. For further detailed information regarding the operation of B~IO modules, the programming unit software and other general information regarding the different fieldbus systems, please refer to the specific manuals.

Versions

The CL150, CL151, CL150A, and CL151A versions and the ones with fieldbus connection DP, -CAN, -IBS and -DEV are different from each other only with regard to specific details. The description of the basic characteristics of the CL150 version represents the basic characteristics of all other versions. Differences are explicitly mentioned.

❖ This sign indicates the description of an action to be performed by the user.

Trademarks

All trademarks referring to software that is installed on Bosch products when shipped from the factory represent the property of their respective owners.

At the time of shipment from the factory, all installed software is protected by copyright. Software may therefore be duplicated only with the prior permission of BOSCH or according to the license agreement of the respective manufacturer.

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PROFIBUS® is a registered trademark of PROFIBUS Nutzerorganisation e.V. (user organization).

INTERBUS-S® is a registered trademark of Phoenix Contact.

DeviceNet® is a registered trademark of ODVA (Open DeviceNet Vendor Association, Inc.).

2 System Overview

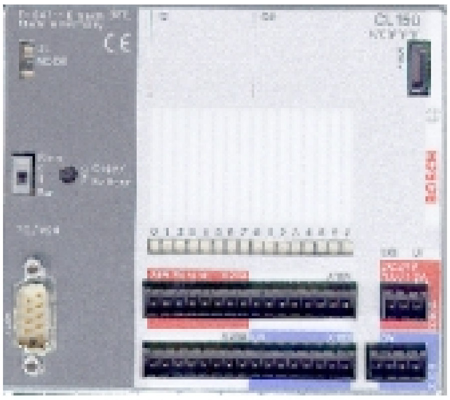


Fig. 2-1 CL150 Controller

The CL150 controller completes the Bosch PLC program below the CL200 performance category.

It is a low-priced but powerful compact controller of small dimensions for limited and quick local controlling tasks.

The module can be extended with components of the decentralized B~IO system because the CL150 is part of the B~IO system and offers the functionality of a PLC on this automation level.

Several versions of this compact basic device and the possibility of modular extension with B~IO components make it possible to adapt it specifically to the respective application purpose.

Versions with a fieldbus connection (Slave) make the integration into an integrated automation system and thus, the creation of a so-called decentralized intelligence possible.

Areas of Application

- Handling devices
- Mounting systems
- Woodworking
- Special machines
- Mechanical engineering in general

and other applications

Overview of Versions

Version	Digital In-/ and Outputs	Analog In-/ and Outputs	Serial Interfaces	Fieldbus Interface	Clock	Dimensions w x h x d (mm)
CL150	8 I, 24 V 8 O, 24 V/0.5 A	none	V.24	none	no	123x105x38
CL151	16 I, 24 V 8 O, 24 V/0.5 A	none	V.24 V.24/20 mA	none	yes	184x105x38
CL150A	16 I, 24 V 8 O, 24 V/0.5 A	2 I, 0 – 10 V 1 O, 0 – 10 V, $^+$/-10 V, 20 mA	V.24	none	yes	184x105x38
CL151A			V.24 V.24/20 mA	none	yes	184x105x38
CL150-DP	8 I, 24 V 8 O, 24 V/0.5 A	none	V.24	DP-Slave	yes	184x105x38
CL151-DP	8 I, 24 V 8 O, 24 V/0.5 A	none	V.24 V.24/20 mA		yes	184x105x38
CL150-CAN	8 I, 24 V 8 O, 24 V/0.5 A	none	V.24	CAN-Slave	yes	184x105x38
CL151-CAN	8 I, 24 V 8 O, 24 V/0.5 A	none	V.24 V.24/20 mA		yes	184x105x38
CL150-IBS	8 I, 24 V 8 O, 24 V/0.5 A	none	V.24	Interbus-Slave	yes	184x105x38
CL151-IBS	8 I, 24 V 8 O, 24 V/0.5 A	none	V.24 V.24/20 mA		yes	184x105x38
CL150-DEV	8 I, 24 V 8 O, 24 V/0.5 A	none	V.24	DeviceNet-Slave	yes	184x105x38
CL151-DEV	8 I, 24 V 8 O, 24 V/0.5 A	none	V.24 V.24/20 mA		yes	184x105x38

In comparison to the CL150 versions, CL151 versions are provided, in addition to the programming unit interface, with a second serial interface.

2.1 Structure

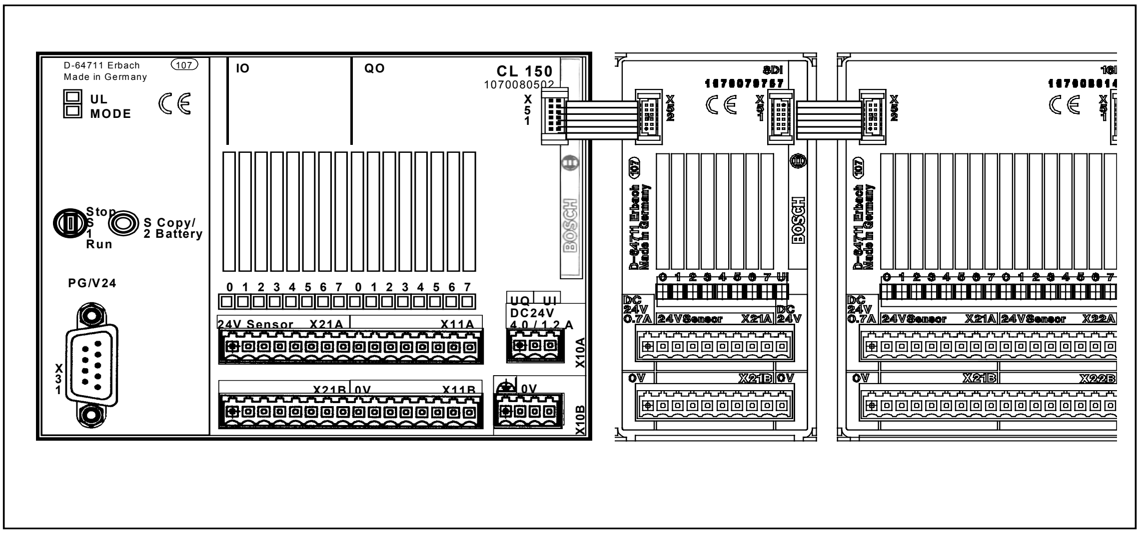


Fig. 2-2 Modular Structure

The CL150 programmable logic controller is a compact controller with the possibility of modular extension.

Compact Controller

As a compact device, the CL150 comprises all functions of a programmable logic controller:

- Power supply module for providing the entire internally necessary power supply.
- I/O-Interface, digital and analog, quantity according to version
- V.24 interface for connection of programming units
- 2. serial interface, V.24 or 20 mA passive, for all CL151 versions, e.g. for connecting an operator terminal
- All elements of the control function

⇒ **In fieldbus versions, the fieldbus connection is integrated as well.**

Modular Extension

In addition, the modules of the B~IO M- modular system make it possible to adapt the controller to the respective I/O related requirements. Thus, later extensions and modifications can be realized very easily.

With the CL150, any module of the B~IO M- modular system may be used. The modules are connected with each other and with the CL150 by means of module connectors.

Up to 16 modules can be connected in series if the current at the module interface does not exceed 0.5 A.

B~IO-Modules

Description	Order No.
Module connector	1070 079 782
8DI, digital input module, 8 inputs, 24 V	1070 079 757
16DI, digital input module, 16 inputs, 24 V	1070 080 144
16DI-3, digital input module, 16 inputs, 3-wire connection, 24 V	1070 081 862
8DO, digital output module, 8 outputs, 24 V, 0.5 A	1070 079 759
8DO/2A, digital output module, 8 outputs, 24 V, 2 A	1070 080 151
16DO, digital output module, 16 outputs, 24 V, 0.5 A	1070 081 858
8DI/DO, digital combination module, 8 in- or outputs, 0.5 A	1070 080 709
8DO R, output module, 8 outputs, relay	1070 080 680
4AI_UI, analog input module, 4 inputs, voltage and current	1070 080 524
4AI_UIT, analog input module, 4 inputs, voltage, current and thermoelement	1070 080 526
4AO_I, analog output module, 4 outputs, current	1070 080 528
4AO_U, analog output module, 4 outputs, voltage	1070 080 530
I/O-Gateway, for coupling of two fieldbus systems	1070 083 150

For descriptions and technical data of the modules, please refer to the catalogue "Installation Engineering" order no. 1070 072 190.

Mounting

The CL150 and the modules of the B~IO group are provided with a very robust metal housing, suitable for industrial usage, protection category IP20. They are placed directly on a 35 x 7.7 mm support rail as per EN 50022.

In order to comply with the IP65 requirements outside of control cabinets, additional housings can be used.

Actuators and sensors are connected by means of socket connectors. Three different systems are offered:

- Screw terminal
- Spring clamp terminal
- Top screw terminal

For connecting sensors with 3- or 4-wire connections, optional two-tier terminal blocks are available.

2.2 CL150

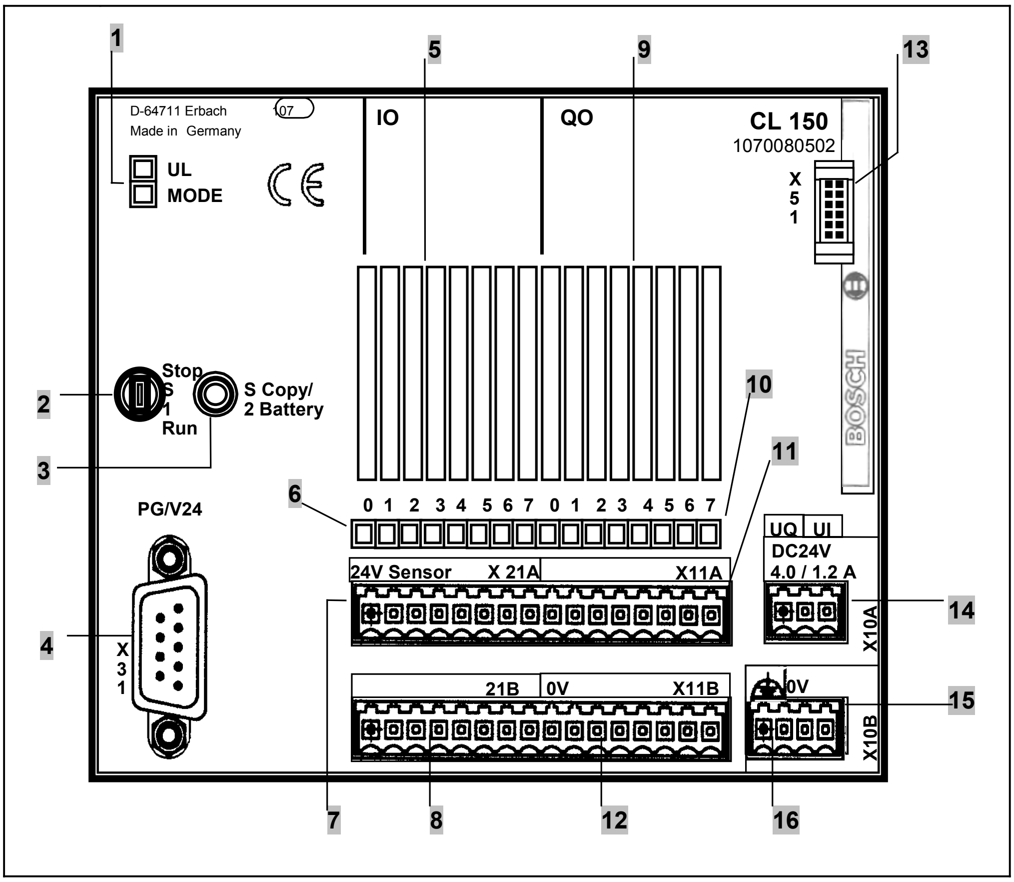
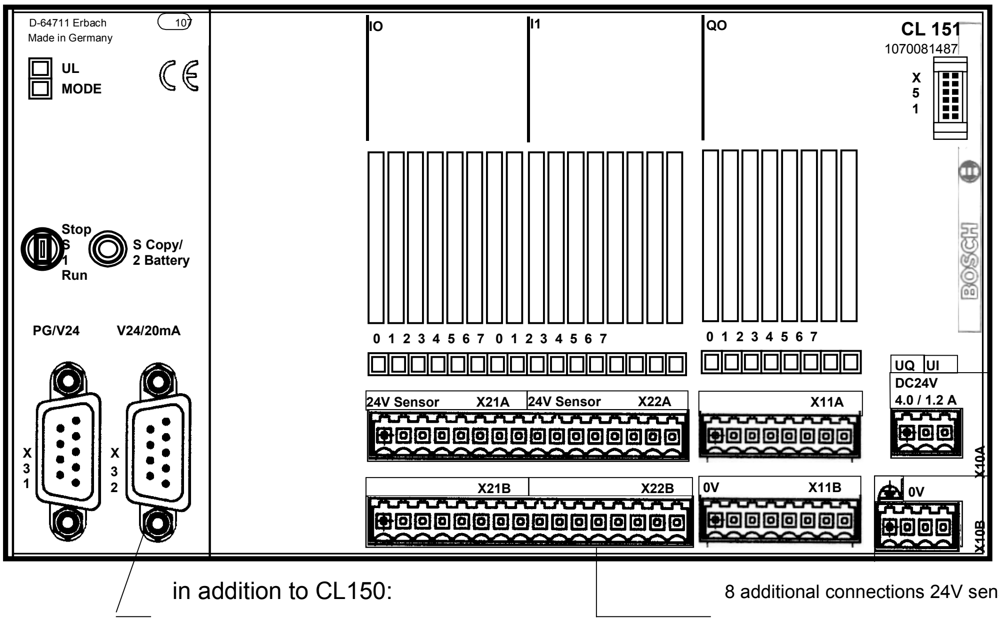


Fig. 2-3 CL150 Programmable Logic Controller

Front Panel Elements

1	LED display
2	Toggle switch Stop/Run
3	Button Copy/Battery
4	V.24 interface for connecting programming units
5	Labeling field for digital inputs
6	Status display for digital inputs
7	24V outputs for sensor power
8	Digital inputs
9	Labeling field for digital outputs
10	Status display for digital outputs
11	Digital outputs
12	0V reference potential for actuators
13	Connector for the B~IO modules
14	24V supply
15	0V reference potential for supply voltages
16	Functional earthing

2.3 CL151



in addition to CL150:

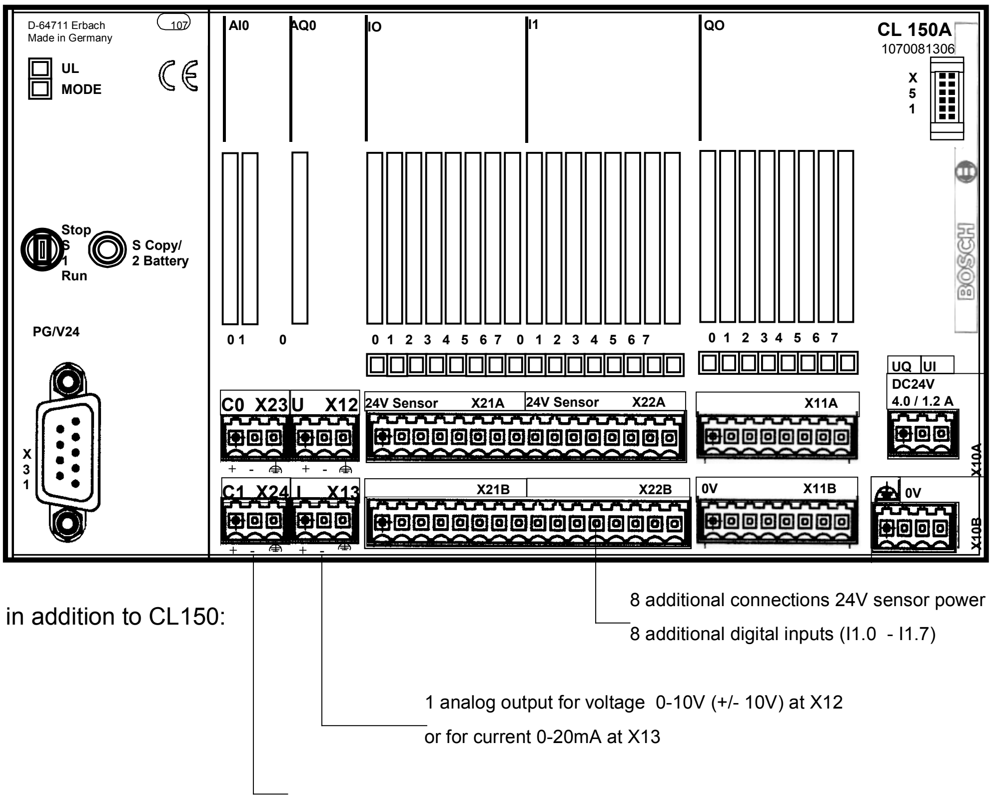
2. serial interface V.24 / 20mA passive

8 additional connections 24V sensor power

8 additional digital inputs (I1.0 - I1.7)

Fig. 2-4 CL151 Programmable Logic Controller

2.4 CL150A



in addition to CL150:

8 additional connections 24V sensor power

8 additional digital inputs (I1.0 - I1.7)

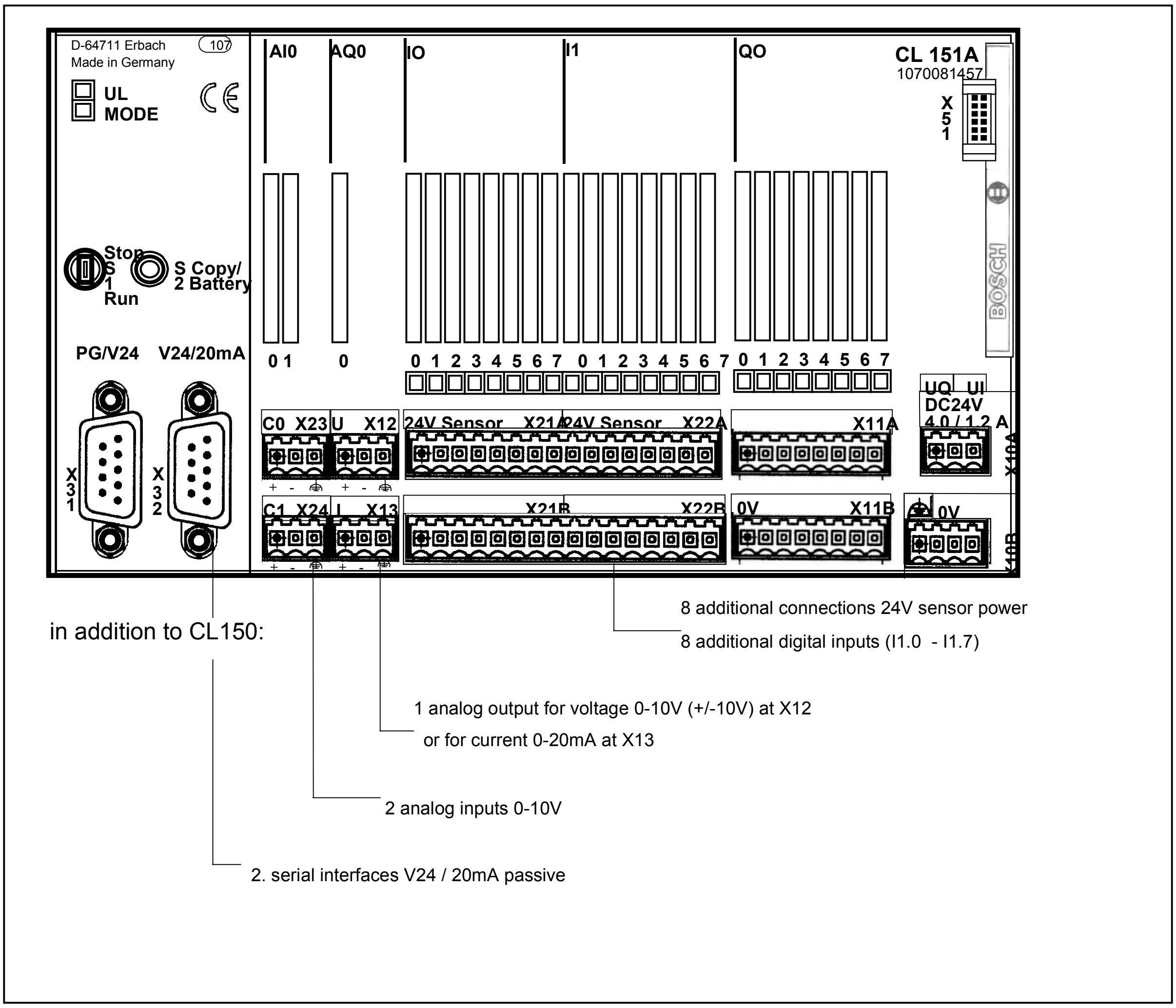
1 analog output for voltage 0-10V (+/- 10V) at X12

or for current 0-20mA at X13

2 analog inputs 0-10V

Fig. 2-5 Controller CL150A

2.5 CL151A



in addition to CL150:

8 additional connections 24V sensor power

8 additional digital inputs (I1.0 - I1.7)

1 analog output for voltage 0-10V (+/-10V) at X12
or for current 0-20mA at X13

2 analog inputs 0-10V

2. serial interfaces V24 / 20mA passive

Fig. 2-6 CL151A Programmable Logic Controller

2.6 Technical Data

Technical Data	CL150	CL151	CL150A	CL151A
Integrated inputs	8	16		
Input address range I	48 byte, addressable in bit mode: I0.0 - I47.7			
Integrated outputs	8			
Output address range O	32 byte, addressable in bit mode: O0.0 - O31.7			
Analog inputs	no		2.0 – 10 V	
Analog outputs	no		1.0 –10 V, $^{+}$/- 10 V, 0 – 20 mA	
Interrupt inputs	3			
Memory mode	64kbyte RAM / 64kbyte Flash-EPROM			
Instruction execution time				
• Bit instructions	0.6 µs			
• Word instructions	0.6 µs - 28 µs			
• Module instructions	46 µs			
I/O image	0.6 - 1.9 ms			
Cycle time for 1K instructions	2.6 ms, typical application program			
Response time on Interrupt	< 1.1 ms			
Register	4, 16bit register, A, B, C, D			
Organization modules OM	12			
FC program modules (function call)	128, FC0 - FC127			
Nesting depth	32 modules			
Nesting level	7			
Formats of operands	Bit, byte, word, double word with constants			
Marker M	152 byte, addressable in bit mode: M0.0 - M151.7			
Software timer T	128, T0 - T127, matrix 10 ms, 100 ms, 1 s, 10 s			
Hardware timer	1, 1ms matrix			
Software counter C	64, C0 - C63			
High-speed counters	2 x 32 bit, upwards/downwards, max. 10 kHz			
Data modules DM	128, DM0 - DM127			
Data fields DF	8 kbyte, DF0 - DF8191			
System area S	256 byte, S0 - S255			
Application stack	512 byte			
Programming unit interface	V.24, BUEP19E			
2. serial interface	V.24/20 mA passive, BUEP19E			
System clock	no	yes		
Programming	WinSPS (editor, monitor)			
Programming modes	Instructions list, ladder diagram, function diagram, sequential function chart, as per IEC 1131, structured programming (modular construction)			
Program execution	Cyclic, time-controlled, interrupt-controlled, startup-dependent			
Range of instructions	Binary links, parenthesized instructions, time-/counter instructions, loading, transferring, comparing, increment, decrement, shift, rotate, convert, safe, arithmetics, program processing instructions, special instructions			
Power supply • Logic: UI • Outputs: UQ	24 V direct voltage, 19.2 - 30 V			
Maximum number of modules	16			
Supply of the modules	Max. 500 mA			
Backup battery	Lithium / 3.6 V / 0.85 Ah			
Weight	350 g	500 g		
Dimensions WxHxD without connector	123x105x38	184x105x38		

Technical Data	CL150	CL151	CL150A	CL151A
Complies with the standards	• DIN EN 61131-2 • EN 50178 • DIN VDE 0110 • DIN EN 60204-1 • EMC directive 93/68/EEC and amending directives			
EMI resistance as per DIN EN61131-2 • High-frequency, electromagnetic fields • Electrostatic discharge on exposed enclosure components • Rapid burst pulses • Dampened sinewave 1 MHz symmetrical	Test field strength 10 V/m, frequency band 26 - 1000 MHz, criterion A ESD resistance 4 for humidity rating RH2, criterion A Test voltage 15 kV air discharge 4 kV contact discharge Direct coupling 2 kV with 24V power supply, criterion A Capacitive coupling 2 kV on digital in-/outputs, criterion A Capacitive coupling 2 kV on data cables, criterion A Capacitive coupling 1 kV on high-speed inputs, criterion B 1 KV as per EN61000-4-12			
Interference emission • Harmful radiation • Radio interference suppression as per DIN EN 50081-2 / Class A	None • Frequency 30 - 230 MHz limit 40 dB (mV / m) in 10 m • Frequency 230 - 1000 MHz limit 47 dB (mV / m) in 10 m			
Protection degree	IP20 as per DIN VDE 0470-1			
Protection class	1 as per DIN EN 50178			
Storage temperature	-25 - 70°C as per DIN EN 61131-2			
Operation temperature	Horizontal installation: 5 - 55°C with a maximum average temperature of 50°C over a 24- hour period			
Atmospheric pressure as per DIN 61131-2	Operation up to 2000 m above sea level			
Insulation test voltage	• 500 V DC • 500 V pulsed 1.2 / 50 µs			
Humidity rating as per DIN EN 61131-2	RH-2, 5 to 95%, condensation not permissible			
Corrosion / chemical resistance	The ambient air must be free of elevated concentrations of acids, alkali, corrosives, salt, metallic vapors, and other electrically conductive pollutants.			

Mechanical stress
• Vibration, sinusoidal oscillations in all 3 axes as per DIN EN61131-2
• Shock, impact on all 3 axes as per DIN 61131-2
	• 10 to 57 Hz
	  • 0.0375 mm constant amplitude
	  • 0.075 mm occasional amplitude
	• 57 to 150 Hz
	  • 0.5 g constant
	  • 1 g occasional
	11 ms semi-sinusoidal 15 g			

Transportability as per DIN EN 50081-2	Height of fall in packaging 1.0 m			

2.7 Order Numbers

Designation	Order No.
CL150	1070 080 502
CL151	1070 081 487
CL150A	1070 081 306
CL151A	1070 081 457

3 Module Description

3.1 Connections

3.1.1 24V Power Supply

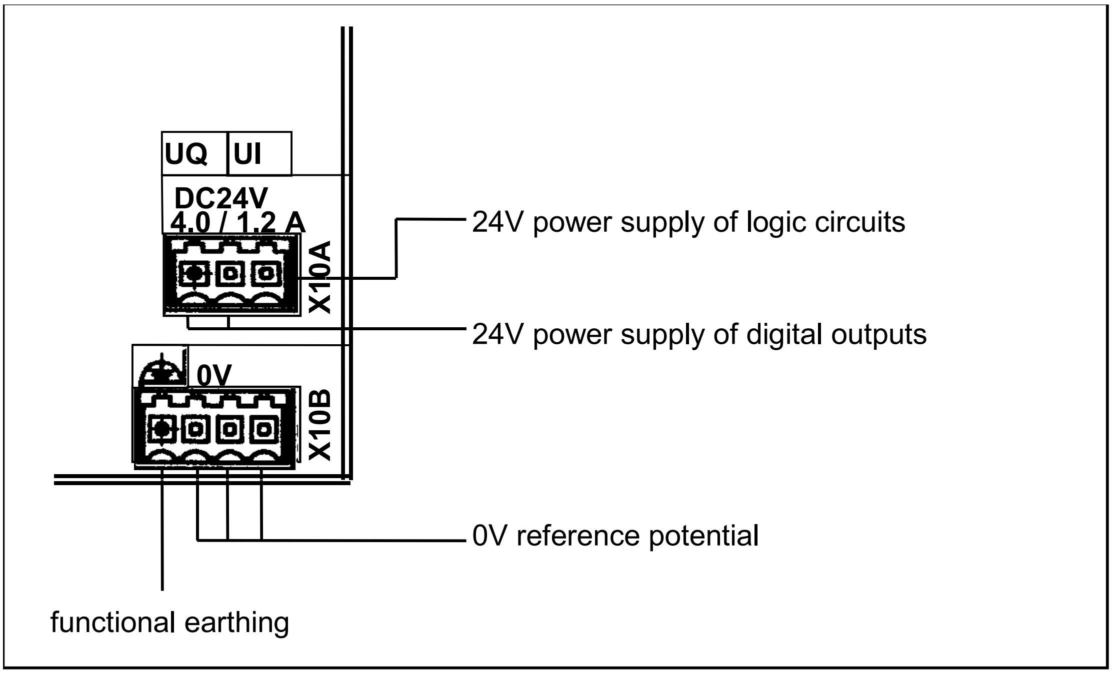


Fig. 3-1 Connections Power Supply

The 24V power supply is connected to the X10A as follows:

- UI for logic circuits, input circuits and sensor power
- UQ for digital outputs

The voltages are galvanically coupled.

The 0V connection at X10B is the same for all supply voltages. The three pins are jumpered internally.

The current input at UI is composed of the need of current for the internal logic circuits, the switched digital inputs and the loads connected to the 24V sensor power.

Both pins for UQ are jumpered internally. The current input depends on the output load, nominal load = 0.5 A.

The functional earth X10B is lead to the enclosure of the module and functions as a shielding potential. The coupling with the internal voltages is only capacitive.

Technical Data	CL150	CL151	CL150A	CL151A
Power supply as per DIN EN 61131-2 • Nominal voltage • Min. • Max.	24 V- 19.2 V 30 V			
Jumpering of power interruptions	Class PS2, ≤ 10 ms repetition rate ≥ 1 s			
Current input at UI • without load on the sensor power supply • with nominal load on the sensor power supply	≤ 0.6 A ≤ 1.2 A			
Peak switch-on current	≤ 16 A		≤ 25 A	
Active time of peak switch-on current	≤ 5 ms			

3.1.2 24V Sensor Power Supply X21A/X22A

The CL150 provides a 24V power supply for up to 8 sensors (CL151, CL150A and CL151A for up to 16).

The pins of the sensor power supply are connected with each other in the module.

The sensor power supply is monitored with regard to short circuits and overload. In case of a short circuit, the output current will be limited.

Technical Data	CL150	CL151	CL150A	CL151A
Output voltage	type UI - 1V			
Nominal output current, sum	0.6 A			
Protection against short circuit / current overload	1.2 - 2.4 A			

3.1.3 Digital Inputs X21B/X22B

8 X21B inputs have been provided for sensors.

CL151, CL150A, CL151A are provided with 8 additional X22B inputs.

The electric circuits of the inputs are galvanically coupled with the internal logic circuits.

The control state can be read at the associated status LEDs.

The addresses of the integrated inputs are defined as follows:

- Inputs at X21B, byte address 0 / bit addresses 0.0 - 0.7
- Inputs at X22B, byte address 1 / bit addresses 1.0 - 1.7

Technical Data	**CL150**	**CL151**	**CL150A**	**CL151A**
Inputs	8	16		
Type	Type1 as per DIN EN61131-2			
Electrical isolation	no			
Reverse voltage protection	yes			
Input voltage • Nominal voltage • 0-signal • 1-signal	24 V -3 to 5 V 11 to 30 V			
Input current • 0-Signal • 1-Signal	≤ 2.5 mA 2.8 to 6 mA			
Delay interval • 0 → 1 • 1 → 0	3.5 ms 2 ms			
Contact rating	max. 8 A per contact / T_U = 55 °C			
Cable length, unscreened	max. 100 m			
Connector pin spacing	3.5 mm			
2-wire proximity switch • Closed circuit current • Voltage drop	≤ 2.5 mA ≤ 8 V			

3.1.4 High-Speed Inputs

General Information

Parallel to the standard input circuits, the inputs I0.0 - I0.3 are lead to the logic circuits via high-speed comparators.

Thus, these inputs are suitable for high-speed interrupt- and counter functions.

⇒ **Please note that high-speed input circuits are more susceptible to interferences than standard circuits. If necessary, use shielded cables.**

Technical Data	**CL150**	**CL151**	**CL150A**	**CL151A**
High-speed inputs	4			
Delay interval • 0 → 1 • 1 → 0	 18 µs 15 µs			
Trigger pulse edge • for interrupt inputs • for counter inputs	 positive edge adjustable			
Pulse duration	≥ 50 µs			
Frequency counter inputs	≤ 10 kHz			
additional data	see digital inputs			

Usage as Interrupt Inputs

The inputs I0.0 - I0.2 can be used as interrupt inputs, please refer also to 7.5.2 Event-Controlled Program Processing OM10/OM11/OM12.

A rising edge causes the insertion of an interrupt module into the process of the application program.

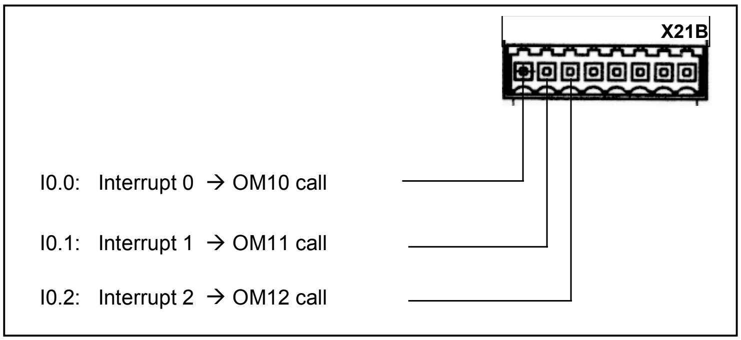


Fig. 3-2 Interrupt Inputs CL150

The interrupt function works parallel to the standard input function.

A previous special configuration is not necessary; releasing the interrupts and including the respective interrupt OM is sufficient.

The interrupt inputs are processed via the OM10 to OM12 organization modules.

The interrupt response times are dependent on a number of circumstances; among others, also on the number and type of the used B~IO modules. Without using B~IO modules, a maximum interrupt response time of 1.1 ms can be expected; the typical time is 0.6 ms.

Usage as Counter Inputs

The input pairs I0.0 / I0.1 and I0.2 / I0.3 can be each configured as pulse/directional inputs for 32-bit bi-directional counters with a counting frequency of up to 10 kHz.

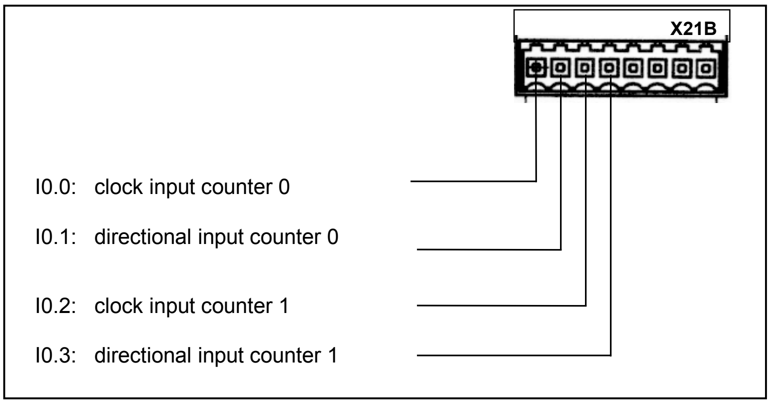


Fig. 3-3 Counter Inputs CL150

The counters are programmed in OM2 and controlled via the system area.

They have 2 limit values each. When these limits are reached, integrated, in OM2 defined outputs are set.

The counter and interrupt functions of a pair of inputs can only be used alternatively, i.e. that even if directional switching is not used, the associated input is assigned to the counter function and cannot be used as an interrupt.

Counter 1 (I0.2 / I0.3) is suitable for realizing an incremental encoder interface with a counting frequency of up to 10 kHz.

3.1.5 Digital Outputs X11A/X11B

At the X11A push-on terminal strip, 8 24V semiconductor outputs are available, while the X11B push-on terminal strip is reserved for the relating zero potential.

8 actuators with a nominal current input of up to 0.5 A each can run contemporarily. The outputs can be switched parallel.

The circuit state is indicated at the relating status LEDs.

In case of a stop of the controller or in case of voltage failure the output signals are set back, secure state.

The outputs are galvanically coupled among each other and with the internal logic circuits.

The outputs are secured with an overload protection. At typical 1.2 A (minimum 0.6 A) the output switches off. If the load current has been reduced accordingly, an automatic restart occurs after approximately 10 ms.

If the overload protection is addressed by one or more outputs, a diagnostic group signal is sent to the operating system. It can also be evaluated in the application program, please refer to 7.7 System Area.

The 0V reference potential of connected loads must be returned to the 0V terminal of the outputs. A two-wire load connection must be established. If the 0V reference potential is not returned (single-wire connection), GND continuity will not be ensured.

When output cables are under power, do not plug them in or out.

The address of the integrated outputs is determined: byte address 0, bit address 0.0 - 0.7.

The direct connection of outputs to type 1 inputs is possible.

Technical Data of the Digital Outputs

Technical Data	CL150	CL151	CL150A	CL151A
Digital outputs integrated	8			
type	semiconductor outputs, non-latching, protected, with automatic restart, with power output			
Electrical isolation	no			
Output voltage	Nominal value 24 V, voltage drop with HIGH signal ≤ 1.5 V			
Rated current • Nominal value • HIGH signal • LOW signal, leakage current	0.5 A 2 mA - 0.6 A ≤ 0.5 mA			
Coincidence (simultaneity) factor	100 %			
Parallel switching of outputs	yes			
Overload protection • Minimum current that leads to switch-off • Automatic restart after	> 0.6 A, typ. 1.2 A 10 ms			
Output delay interval	< 500 µs			
Lamp load	5 W at 8 Hz			
Switching frequency • Resistive load • Inductive load	100 Hz dependent on contactor function			
Inductive cut-off voltage	typ. –26 V			
Contactor size at 1Hz	SG1; 6.2 W			
Contact rating	max. 8 A per contact / T_U = 55 °C			
Cable length, unscreened	100 m			
Connector pin spacing	3.5 mm			

3.1.6 Connection of B~IO Modules, Addressing of Modules

The B~IO modules are connected to the X51 push-on terminal strip by module connectors (ribbon cable).

Designation	**Order No.**
Module connectors	1070 079 782

Up to 16 modules can be connected in series in any order.

The internal logic of the modules is supplied with a 5-V voltage which is available at the push-on terminal strip.

The total current input of all modules connected to this 5-V power supply must not exceed 0.5 A. For information about the single current input of each module, please refer to the corresponding module description.

The modules are addressed only within the input/output cycle of the controller. The possibility of direct access is not available.

The possibility of setting an address on the modules is not available.

Automatic Address Assignment

If the B~IO modules have not been specifically configurated, the operating system of the PLC automatically assigns addresses to all connected B~IO modules.

Consecutive input addresses are assigned to the input modules from left to right according to the order of their setting, starting at byte address 2. For this process, the data width of each module will be considered.

Consecutive output addresses are assigned to the output modules from left to right according to the order of their setting, starting at byte address 1. For this process, the data width of each module will be considered. Word modules always receive even-ordered byte addresses.

Modules with in- and outputs receive equal input- and output starting addresses.

Because of these rules, the occurrence of gaps in the address areas of the I/O modules is possible.

Complying with these rules, assigning addresses to the modules is very easy.

With the programming unit, the automatically processed address assignment can also be read out of the controller:

WinSPS → Editor → Process → I/O Configuration (OM3)

Example of Automatic Address Assignment

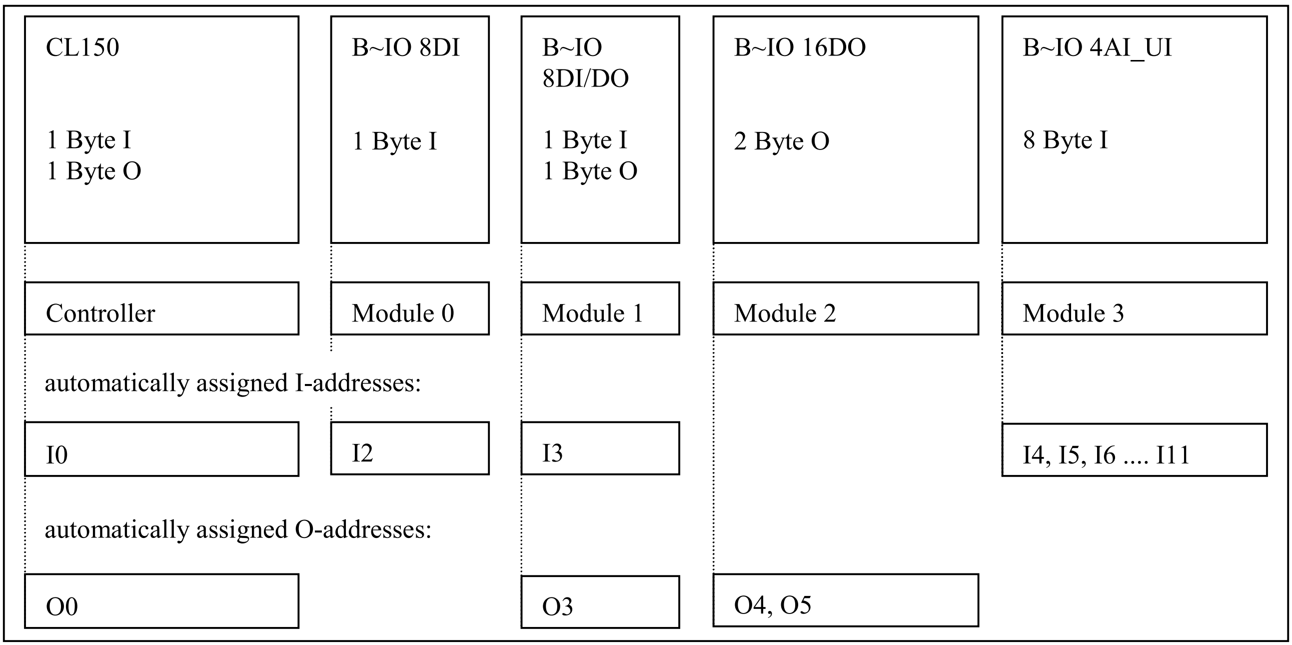


Fig. 3-4 Example of Automatic Address Assignment

Configuration of the I/O-Addresses

Optionally, modules can also be assigned with addresses that are different from those automatically assigned ones.

To do so, enter the module configuration by using the programming software:

WinSPS → Editor → Process → I/O Configuration OM3

Within the scope of the controller‘s address range, the modules can be given the addresses that are necessary for the application. But also in this case, the following rules apply:

- Word modules require even-ordered byte addresses
- Combination modules have equal input and output addresses

The configuration tool stores the module configuration in the CL150 OM3 configuration module which will be linked to the application program and then loaded, together with the program, into the controller.

The operating system of the controller provides a configuration monitoring function. If this function is active, during startup, the desired configuration entered with the configuration tool is automatically compared to the physically existing actual configuration. In case the two values are not conform, the controller does not start and the „Conflict in module configuration diagram“ error message will be given out.

Device Data Base File DDBF

The above described I/O-configuration tool requires information about the B~IO modules which are to be connected to the CL150.

Since the B~IO system is subject to constant development, new modules might be added to the system. Thus, this information is located in the CL150 Device Data Base File (DDBF) which can always be updated if necessary.

The CL150 DDBF carries the designation:
Rbxx0119.GSD; xx represents the two digit version identification.

The DDBF is included in the WinSPS program package and is stored in the WinSPS directory during installation.

The DDBF can be updated by copying the new version into the …\WinSPS directory.

⇒ **In WinSPS versions < V3.0, the old DDBF in the ....\WINSPS directory must be deleted.**

3.1.7 Programming Unit Interface X31

The programming unit is connected via X31, a 9-pin D-SUB connector.

It is a V.24-interface.

The interface is not electrically isolated.

Transfer Format

The parameters of the interfaces are permanently set and cannot be modified:

19200 baud, even parity, 8 databits, 1 stopbit.

Control lines are not available.

Protocol

The protocol BUEP19E is used, PST function only.

Level

Signal level:	logic 1	-5 V
	logic 0	+5 V

The difference between the potential of the transmitter and that of the receiver shall not exceed –2 V < Udiff < +2 V.

Interconnecting Cable

As an interconnecting cable, a screened and twisted-conductor cable of 7 x 0.14 mm^2 or 14 x 0.14 mm^2 is to be used. Do not exceed the following values:

▪ Resistance	0.2 Ω/m
▪ Capacitance	120 pF/m
▪ Length	15 m

Pin assignment X31:

Pin No.	Designation	Note
1		not applicable
2	RxD	
3	TxD	
4		not applicable
5	SIGGND	
6		not applicable
7		not applicable
8		not applicable
9		not applicable

An interconnecting cable set with a length of 5 m is available.

Designation	Order no.
K19, COM Interface CL150	1070 077 753

3.1.8 Serial Interface X32

The versions CL151 and CL151A are provided with a 2. serial interface. Primarily designed for the connection of an operator terminal, it is nevertheless possible to connect all peripheral devices that use the BUEP19E transmission protocol.

The interface is a combined interface: V.24 and 20 mA passive current loop.

The V24 interface is not electrically isolated.

The 20 mA interface is optically isolated.

Transfer Format

The parameters of the interfaces are preset:

19200 baud, even parity, 8 databits, 1 stopbit.

The baud rate can be reduced to 9600 baud via the OM2, so that, when using the 20 mA interface, a cable length of up to 300 m is possible.

Control lines are not available.

Protocol

The protocol BUEP19E is used, PST function only.

Level V.24

Signal level	logic 1	-5 V
	logic 0	+5 V

The difference between the potential of the transmitter and that of the receiver shall not exceed –2 V < Udiff < +2 V.

20 mA Passive

The connected peripheral device must provide the power source.

Line status:	logic 1	20 mA
	logic 0	no current

Interconnecting Cable

As an interconnecting cable, a screened and twisted-conductor cable of 7 x 0.14 mm^2 or 14 x 0.14 mm^2 is to be used. Do not exceed the following values:

▪ Resistance	0.2 Ω/m		
▪ Capacitance	120 pF/m		
▪ Max. Length	V.24	15 m	
	20 mA	150 m	with 19200 baud
		300 m	with 9600 baud

X32 is a 9-pin D-SUB push-on terminal strip with the following assignment:

Pin No.	**Designation**	**Note**
1		not applicable
2	RxD	
3	TxD	
4		not applicable
5	SIGGND	
6	RxD+	20 mA
7	RxD-	20 mA
8	TxD+	20 mA
9	TxD-	20 mA

The type of the interface can be selected by using the corresponding interconnecting cable.

3.1.9 Analog Inputs X23/X24

Each of the versions CL150A and CL151A is provided with 2 analog voltage inputs as per DIN EN 61131-2. The input circuits are not electrically isolated, but the analog inputs are protected against overloads and reverse voltage. An additional power supply is not required.

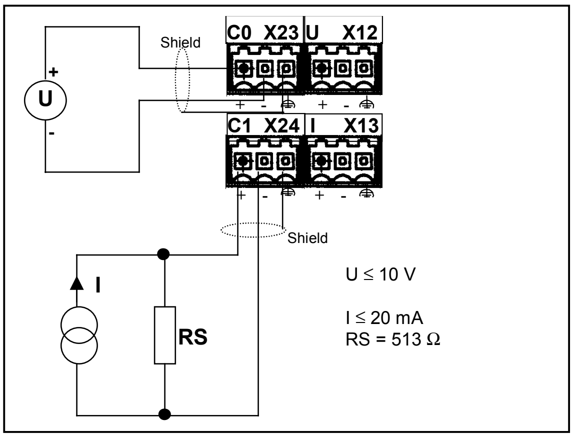


Fig. 3-5 Example of Analog Inputs Connections

The analog inputs are monitored with regard to cable breaks.

The data of the analog inputs and the messages regarding cable breaks are available in the system area; also refer to 7.7 System Area.

Under overload conditions, the minimum and/or maximum digital value is output.

Technical Data	**CL150A**	**CL151A**
Integrated analog inputs as per EN 61131-2	2	
Input voltage	0 to 10 V, unipolar can be standardized to 2 to 10 V	
Electrical isolation	no	
Input resistance	20 kΩ	
Resolution	10 bit	
LSB value	9.8 mV	
Digital display	16 bit, left justified, straight binary	
Temperature coefficient	1%, 0 to 55 °C	
Maximum deviation under the influence of interferences, as per EN 61131-2	< 2 %	
Conversion time	cycle time + 10 ms	
Scanning time	20 µs	
Scanning repeat time	10 ms	
Cable length	max. 100 m, shielded	

Averaging

In order to filter out short-term interferences, an averaging function can be turned on in the OM2 by means of 4 scanning values. The conversion time will not be influenced by this.

Ex works, the averaging function is switched off.

3.1.10 Analog Output X12/X13

The versions CL150A and CL151A provide a short circuit-safe analog output. The analog output value can be picked up at the X12 push-on terminal strip as a voltage level or at the X13 push-on terminal strip as a current level. The parameters are set in the dataword 32 of the OM2, see also 6.3 Initialization Module OM2.

An additional external power supply is not required. The analog output interfaces are not electrically isolated.

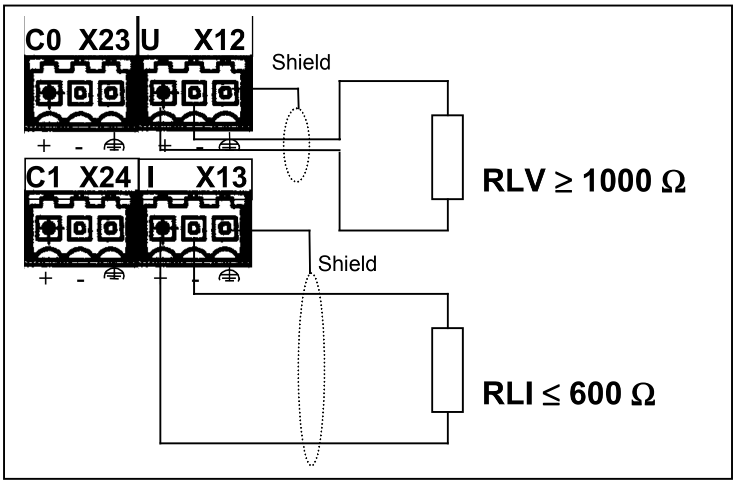


Fig. 3-6 Examples of Analog Output Connections

Operation

The D/A conversion will start when a dataword is written into the S82/S83 address of the system area. The output is started with the following I/O image; see also 7.7 System Area.

Technical Data	**CL150A**	**CL151A**
Integrated analog output as per EN 61131-2	1	
Electrical isolation	no	
Output area • Voltage output • Current output	0 to 10 V, unipolar can be standardized to 2 to 10 V $^+$/- 10 V bipolar 0 to 20 mA can be standardized to 4 to 20 mA	
Admissible load impendance • Voltage output • Current output	≥ 1000 Ω ≤ 600 Ω	
Short-circuit current at the voltage output	32 mA	
Output impendance in the signal area • Voltage output • Current output	24.9 kΩ 11.6 kΩ	
Resolution	12 Bit	
Digital display	16 bit, left-justified, straight binary	
LSB value • Voltage output • Current output	2.4 mV 4.9 µA	
Conversion time	Cycle time + 16 µs	
Settling time upon reaching of established value	< 2 ms	
Overswing	no overswing	
Monoticity	yes	
Non-linearity	< +/- 1 LSB	
Repeatability	> 99 %	
Temperature coefficient	1 % at 0 to 55 °C	
Output ripple	< 100 mVpp	
Max. short-time deviation under the influence of interferences	< 2 %	
Cable length	max. 100 m, shielded	

3.2 LED Displays

The UL LED indicates the proper operational status of the logic circuits (hardware) and the battery backup.

The MODE LED indicates the status of the controller’s operating system.

Explanations:

○	LED is not lit.
●	LED is lit.
☼☼	LED flashes.
—	Display of LED is not significant.

UL	MODE	Significance
● green	—	Controller is ready for operation
	● green	Controller in operating mode Run
☼☼ green	—	Low battery warning
	● red	Battery failure
	○	System error, Restart is required

Independent from the status of the UL LED, for the MODE LED the following is applicable:

MODE	Significance
☼☼ green	Run and outputs are disabled or fixed.
● red	Stop, cause for Stop in Infostatus
☼☼ red	System error, Service-Code possibly in Infostatus
● yellow	Store mode, acknowledgement battery load test
☼☼ yellow	Recall mode
☼☼ yellow /green	Copy function with Store or Recall is active
☼☼ yellow /red	Error with Copy function, Store or Recall

3.3 Switches and Buttons

Toggle Switch S1 Stop/Run

Basic Function

Position up	Controller in Stop status
Position down	Controller in Run status if no other cause for Stop is present.

Secondary functions in relation with pressing the COPY/Bat. button:

Switch from Stop to Run	If controller is in Store mode: Activates the Store function; also refer to 5.4.3 Flash Memory. The current status of the application program and the user data is copied to the non-volatile backup memory. If controller is in Recall mode: Activates the Recall function; also refer to 5.4.3 Flash Memory. Application program and user data are copied from the backup memory to the random access memory; the backup memory will then be deleted.

Button S2 Copy/Battery

Press button in Run status	If battery-powered, a battery load test will be performed. As an acknowledgement for having pressed the button the MODE LED will be yellow for approx. 5 s; also refer to 6.1.2 Operation. In case no battery is used for operation, pressing the button in the Run status has no consequences.
Press button in Stop status	• If battery-powered, a battery load test will be performed. • The controller goes into Store mode, also refer to 6.2.3 Special States. The MODE LED is yellow. The Store mode will be active for about 5 s, afterwards the controller automatically goes into Stop status.
Press button in Store mode	The controller goes into Recall mode, also refer to 6.2.3 Special States. The MODE LED flashes yellow. The Recall mode is active for about 5 s, afterwards the controller automatically goes into Stop status.

3.4 Backup Battery

For backing up the user data when switching off the power supply, an optional battery can be used.

Battery

The lithium battery (1/2 AA, 3.6 V / 0.85 Ah) is, together with a device for its removal, available as an accessory.

Designation	Order No.
Backup battery for CL150/151/150A/151A	1070 081 777

Battery Maintenance Recommendations

The battery is only under significant load when the 24V supply of the controller is switched off.

Taking into consideration a typical backup power requirement of 3 µA, the time for simple data storage - controller without 24V power supply - can be expected to last for up to 3 years.

If the power supply is available most of the time - normal application - expect the following battery maintenance intervals:

1-shift operation	40 h operation / 128 h backup per week	4 years
2- shift operation	80 h operation / 88 h backup per week	6 years
3- shift operation	120 h operation / 48 h backup per week	10 years

These recommendations are valid for an ambient temperature of up to 55 °C.

The manufacturer indicates a battery life of 10 years.

We recommend to check the battery status by using the application program, also refer to 7.7 System Area. In case of a Low Battery Warning, the battery should be changed.

Battery Case

The battery case is located on the back of the module housing.

Battery Change

CAUTION Loss of Data
Removing the backup battery while the 24V power supply is switched off leads to the loss of all remaining data and the PLC program in the RAM!

Change the backup battery only when the 24V power supply is switched on or store data temporarily in the flash memory using the Store and Recall function.

❖ Press the cover of the battery case lightly together and remove.

- Remove old backup battery.

CAUTION! Short circuit risk!
Do not use any metal tools. Use the included removal device only!

- Hit new backup battery lightly onto a resistant pad in order to deactivate the internal oxide film!
- Insert new backup battery. Make sure that polarity is correct.
- Put battery case cover back on.

⇒ **The old lithium backup battery must be disposed according to the local toxic waste disposal regulations. Comply with the regulations of the landfill area.**

3.5 Real Time Clock

The versions CL151, CL150A and CL151A are provided with a real time clock that indicates date, time and day of the week.

The clock module is battery-backed so that, when using a battery, the clock keeps on running even if the 24V power supply of the controller is switched off. This backup is independent from the operating mode „operation with battery“.

If no battery has been put in, the clock will be set to 1.1.00 0:0:0 when the controller is switched on (day of the week is invalid).

The clock can be set either with WinSPS or with the application program, also refer to 7.8 Setting of Time.

The time is displayed in the system area of the controller and can be used in the application program.

4 Installation

4.1 Mechanical Installation

Fixation

The CL150 and the B~IO modules are put directly onto a 35 x 7.5 mm support rail as per EN 50022. In order to facilitate the installation and deinstallation, it is recommended to keep a distance of 2 cm above and underneath the modules.

Mounting

First, hang the CL150 into the support rail's top, then let it snap in at the bottom. Due to the spring pressure of the housing's back, the module is securely fastened.

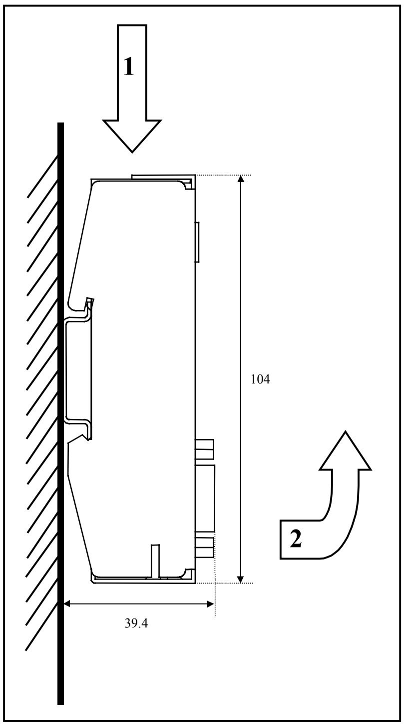


Fig. 4-1 Dismounting of CL150

Dismounting

CAUTION! Damage to the connector of the modules!
Prior to dismounting take off the module connector (ribbon cable) that connects the controller with the neighboring B~IO module.

In order to dismount the CL150, press the unit downwards to overcome the spring pressure (1). This way, the lower enclosing claw can be unsnapped and the module can be lifted off the support rail.

Make sure that the connectors are labeled. This way you can prevent unintentional connector misplacement upon installation.

4.1.1 Installation under Thermal and Mechanical Aspects

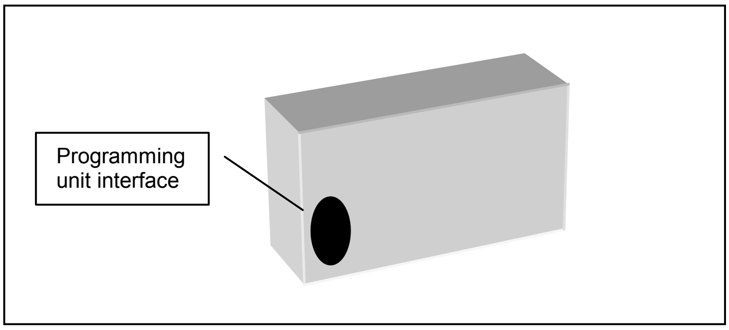
The service life of electronic devices such as the B~IO depends considerably on the ambient temperature in which they are operating. As high temperatures will cause a more rapid aging of all electronic components, special care must be taken to provide an ambient operating temperature that is as moderate as possible. Consider also the installation of air condition devices.

The ambient temperature is determined by measuring the fresh air in the middle of a module‘s lower side.

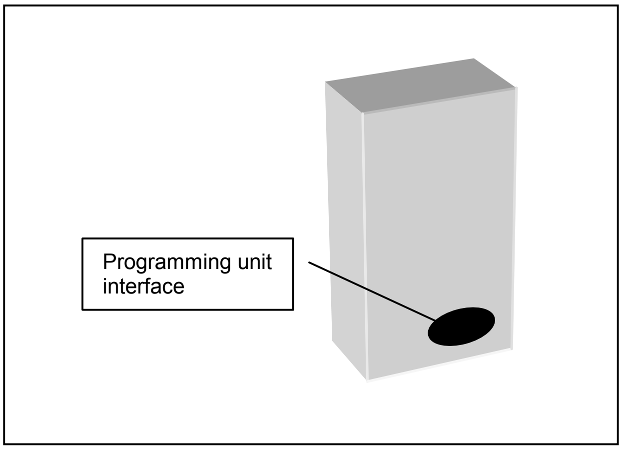
Installation Orientation

The following installation orientations are permitted:

- Normal orientation, on edge, horizontal, programming unit’s interface located on bottom left, operation up to an ambient temperature of 55 °C.

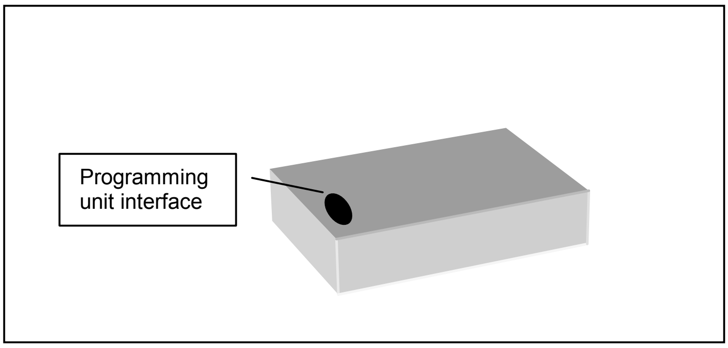


- On edge, vertical, programming unit’s interface located on bottom, operation up to an ambient temperature of 45 °C.



If the unit is installed this way, the extension with B~IO modules is not permitted.

- Lying on its back, front up, operation up to an ambient temperature of 45 °C.

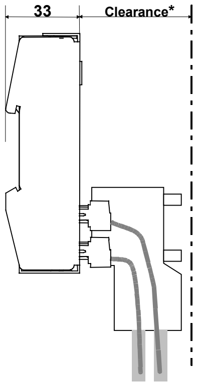


Minimum Distances

Sufficient space must be provided for mounting and dismounting and for the cable ports. In addition, make sure that the ambient air can always circulate.

In case of a multi-tier installation, the temperature of the fresh air under each tier must be measured and the limit values must be observed.

Front Panel Clearances



The required front panel clearances of the B~IO modules are determined by the protrusion dimensions of the used connectors and the cable ports.

Labeling Fields

Labeling fields are available for the identification of the in- and outputs. Use a waterproof permanent marker.

In addition, self-adhesive labels suitable for laser printers are also available.

2-,3- or 4-Wire Connections

For connecting the sensors and actuators, the CL150 is provided with terminals for 2-wire connections.

The standard 2-wire terminals can be easily extended to 3 or 4-wire connections by means of plug-on two-tier terminal blocks (accessories). This arrangement will not require any further wiring subdistribution. Also refer to 4.2.4 Connection of Peripherals.

The terminal block adds 4 cm to the vertical dimension of the module.

4.2 Electrical Installation

General Standards

When installing a system that employs electrical devices such as controllers, comply with the following standards:

- DIN VDE 0100
- VDE 0113 (= EN 60204 Part 1 or IEC 204-1)
- VDE 0160 (= EN 50178)

Danger!
Danger to persons and equipment!
Hazardous system conditions that could cause personal injury or property damage must be prevented!

Strict adherence is required to the regulations governing the configuration and installation of Emergency-STOP devices, as per EN 60204-1!

Uncontrolled restart of machinery upon restoration of power, e.g. subsequent to an Emergency-STOP occurrence, must not be possible!

The prescribed measures (connection to PE conductor, insulation, etc.) must ensure protection against damages and injuries that can result from direct or indirect contact!

4.2.1 Power Supply

The CL150 is supplied with power through the 24V industrial mains.

The power supply unit must feature a transformer with protective separation as per DIN VDE 0551, and the offset AC voltage components (ref. to EN 61131-2) must not exceed 5%. A 3-phase power supply unit with single full-bridge rectification is sufficient. This provided, the 24V-power supply net is then considered to be an extra low voltage with protective separation as per EN50178 section 5.2.8.1. The power can be supplied as Safety Extra Low Voltage = SELV without earthing of the reference conductor or as Protective Extra Low Voltage = PELV with earthing of the reference conductor. All cables of the 24V system's electric circuits must be

- installed separately from cables with higher voltage

or

- specially insulated, with the insulation being at least suitable for the highest voltage encountered, EN 60204 part 1, section 15.1.3.

Earthing of the Power Supply System

Basically, power supply circuits can be installed with or without earth. Two examples:

Reference Conductor Connected to Earth

If the reference conductor (N, 0 V) is connected to the PE conductor system, this connection must be located centrally (at the load power supply unit or at the isolating transformer) and it must be interruptible in order to measure the earth leakage current. This type of connection is to be preferred.

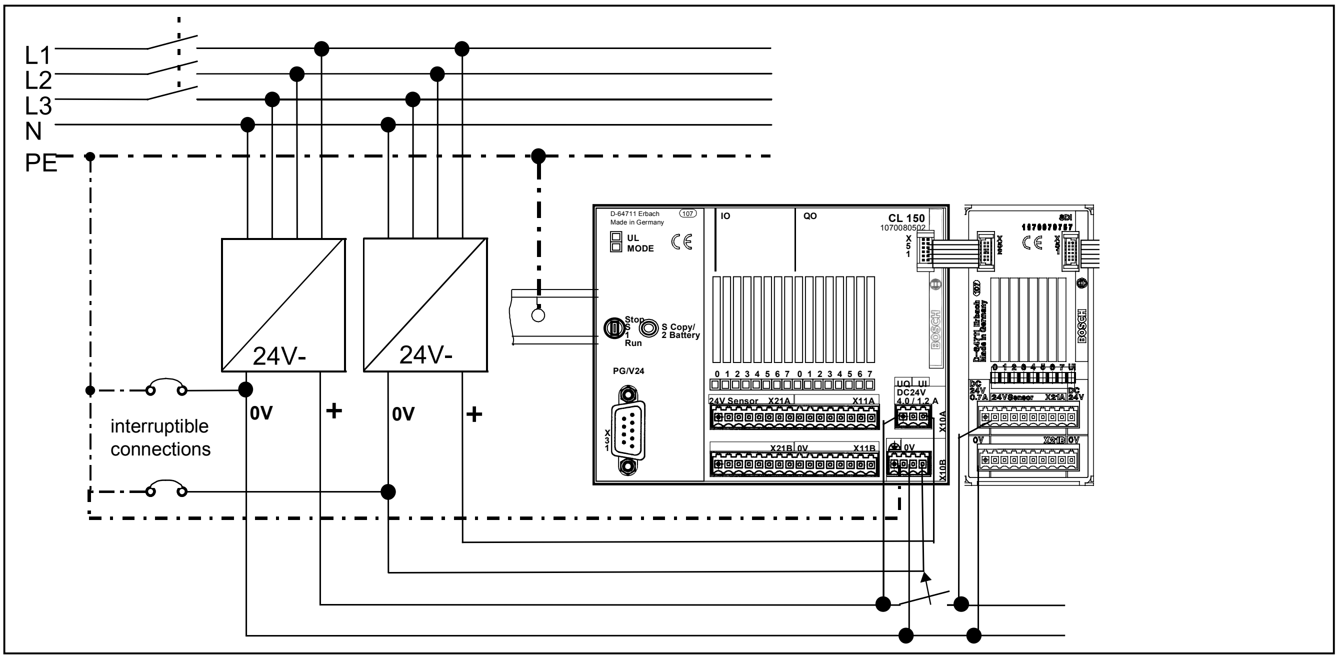


Fig. 4-2 24V Supply, Reference Conductor Connected to PE Conductor

No Connection Between Reference Conductor and PE Conductor

If the reference conductor (N, 0 V) is not be connected to the PE conductor system, an earth leakage monitor must be used for the recognition of earth faults in order to prevent unintentional switch-on in case of insulation faults.

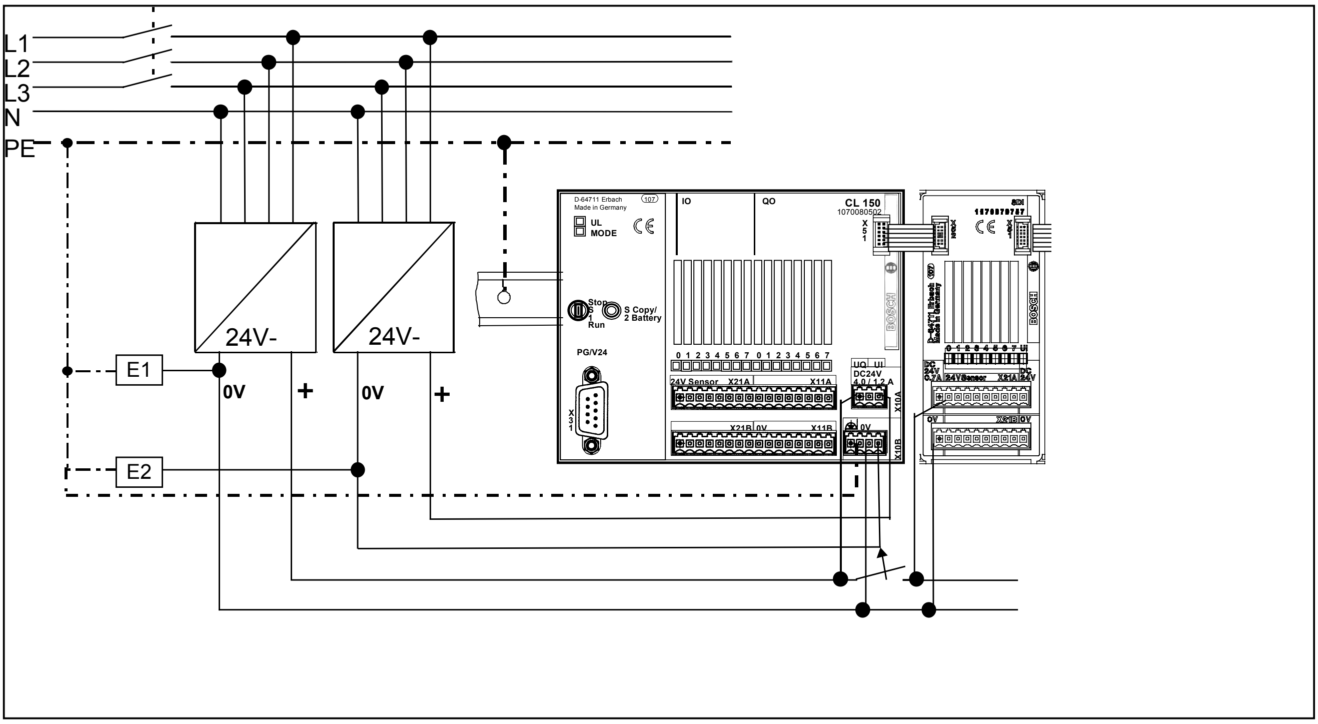


Fig. 4-3 24V Supply, Reference Conductor Is Not Connected to PE Conductor

Isolated and Non-Isolated Circuits

All electric circuits of the CL 150 are galvanically connected. Only the bus connections of the fieldbus versions are galvanically isolated from the power supply. The in- and output bus interfaces of the interbus are even insulated against each other.

Capacitive Load of the Power Supply Network

In order to suppress interferences, capacitances are put between the supply power lines and the earth. This is to be considered when using an earth leakage monitor. In particular, the following capacitances are used:

Connection	Capacitance to earth	
	CL150	CL151, CL150A, CL151A
UI	4.7 nF	220 nF
UQ	4.7 nF	220 nF
0V	9.4 nF	224.7 nF

Operation with One Power Supply Unit

It is also possible to supply the logic circuits and the output loads mutually from one power supply unit only.

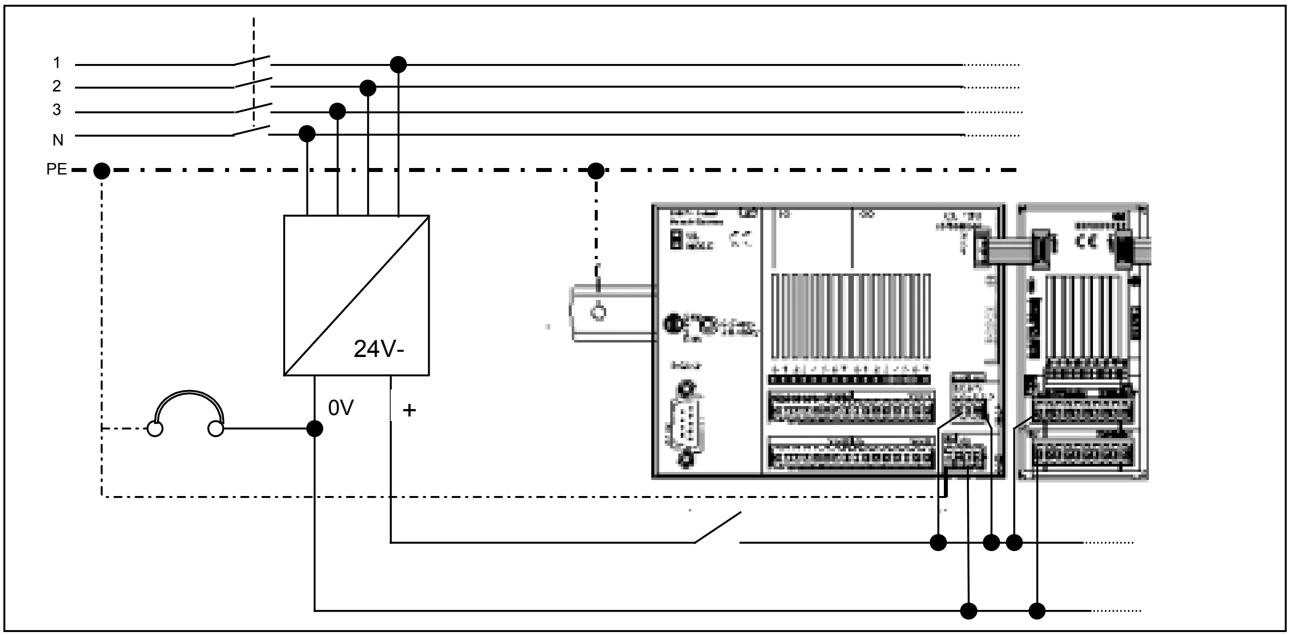


Fig. 4-4 24V Supply from One Power Supply Unit

Power Supply Rating

The rating of the power supply must account for the maximum currents, as per VDE 0100 part 523. The specified supply voltage of 24 V (+20%/-15%) must be applied directly at the device input, taking into consideration

- mains voltage fluctuations which are due e.g. to varying mains loads
- varying load conditions such as short circuit, standard load, lamp load or idle status.

The maximum cross-section of the power supply lines is 1.5 mm².

Master Switch

For the CL150, the sensors and actuators, a master switch conforming to VDE 0100 must be provided.

Fuses

Fuses and circuit breakers protect the lines in an electrical network. In general, the lines used for the wiring of the power supply must be protected. The lines for the sensors and actuators should be protected separately. Please refer to the next paragraph for selective criteria regarding such fuses. Only if the lines used for further subdistribution are shorter than approximately 3 m and inherently earth fault and short circuit proof, additional fuses in these lines are not necessary.

Basic Information Regarding the Selection of Fuses

When selecting fuses, a number of aspects has to be considered. The most important parameter is the nominal current of the electric circuit that needs to be protected, which is also decisive for the cross section of the line.

Selective criteria:	for protective devices:	VDE 0100 part 430
	for line cross sections:	VDE 0100 part 523

Further criteria for the selection of protective devices is:

Nominal voltage, temperature, internal resistance of the fuse, inrush currents, length of lines, preimpendance of the net, possible fault location, vibration.

For additional information, please refer to

Handbuch Nr. 32 (manual no. 32)
VDE Schriftenreihe (VDE publication series)
“ Bemessung und Schutz von Leitungen und Kabeln nach DIN 57100/VDE0100 Teil 430 und Teil 523”

In addition, relevant information is also available from many manufacturers of fuses and circuit breakers.

Wiring of the Power Supply

The connections of the power supply must be routed individually from the terminal blocks in the control cabinet to the terminals corresponding to each bus station. Sensors and actuators are connected directly to the module by means of 2-wire connections. Sensors and actuators utilizing 3- or 4-wire connections are connected through the terminal blocks that are available as optional accessories.

In- and output modules can be wired singularly as well, but a loop-through connection of the power supply is also possible. The same applies to the wiring of the terminal blocks, but special attention must be paid to the maximum applicable current in order to prevent an overload of the modules‘ terminals and circuit board conductors and the terminal blocks.

4.2.2 Earthing

Functional Earthing

The modules must be installed on a properly earthed metallic carrier, e.g. on the rear panel of a control cabinet. The modules are installed by means of top hat rails. The rails must be earthed, with any passivation or similar treatment at the connection point to be removed. In general, this provides for sufficient functional earthing. If low interference levels are to be expected, functional earthing is also possible via the GND terminals of the power supply connections. In this case, please comply with the following: with a cable cross section of 1.5 mm², the length of the cable between the terminal and the GND connection should not exceed 0.5 m.

4.2.3 Equipotential Bonding

Equipotential bonding as per DIN VDE 0100 part 540 must be provided between the system components and the power supply.

4.2.4 Connection of Peripherals

All peripherals, such as digital or analog sensors/actuators, that are going to be connected to the interfaces of the CL150 system must comply with the protective separation requirements of electrical circuits as well.

Connection of Outputs

Inductive Loads

Inductive loads, such as solenoid valves and contactors, must be provided with a suppressor circuit directly at the load. Otherwise, each interruption of the line between the output and an inductive load will result in very high interference levels that, under unfavorable circumstances, might lead to failures of this or other systems.

Especially if a switch (e.g. for safety interlocks) is provided in series with the inductive load, a suppressor circuit is absolutely necessary.

All interference suppression elements that are available in commerce can be used as fuses.

For further information, we recommend the brochure „Handbuch zur Entstörung von geschalteten Induktivitäten“, by Lütze, Weinstadt, Germany.

Output Paralleling

In order to increase output currents, parallel output connections can be used. Therefore, all corresponding output bits in the controller must be set.

Reverse Voltage Protection

Reverse voltage protection is ensured only when no external power supply is connected.

CAUTION!

Damage to the module may be caused by the following:

Polarity switching with simultaneous short circuit of output cables.

Polarity switching with simultaneous connection of externally polarized suppressor diodes at the output cables.

Application of an external voltage exceeding the supply voltage (24 V).

GND Continuity Protection

The 0V reference potential of connected loads must be returned to the 0V terminal of the CL150. A two-wire load connection must be established. If the 0V reference is not returned (single-wire connection), GND continuity cannot be ensured.

If in this case the outputs are addressed, a leakage current may flow although the CL150 does not feature a 0V connection.

If the outputs are not addressed (logic 0), a leakage current of up to 25 mA per output may flow.

If outputs are connected in parallel, the current will multiply accordingly.

Connection of Inputs

Any main switching contacts available in commerce and any kind of 3-wire encoder can be connected to the digital inputs for an operating voltage of 24 V. Electronic 2-wire encoders may only be used if they feature improved qualities (refer to Specification of B~IO Inputs). Electronic 2-wire encoders which largely utilize the IEC 947-5-2 standard cannot be used at the CL150/ B~IO inputs.

2-wire encoders according to the so-called NAMUR standard (NAMUR= committee for standardizations in measuring and control engineering of the chemical industry) are not suitable either.

Coupling of In- and Outputs

Inputs and outputs can be coupled with each other. This is sometimes preferred if output states should be read back as an input parameter. The connection with an additional load is not necessary because the in- and output parameters are well adjusted to each other.

Wiring Example

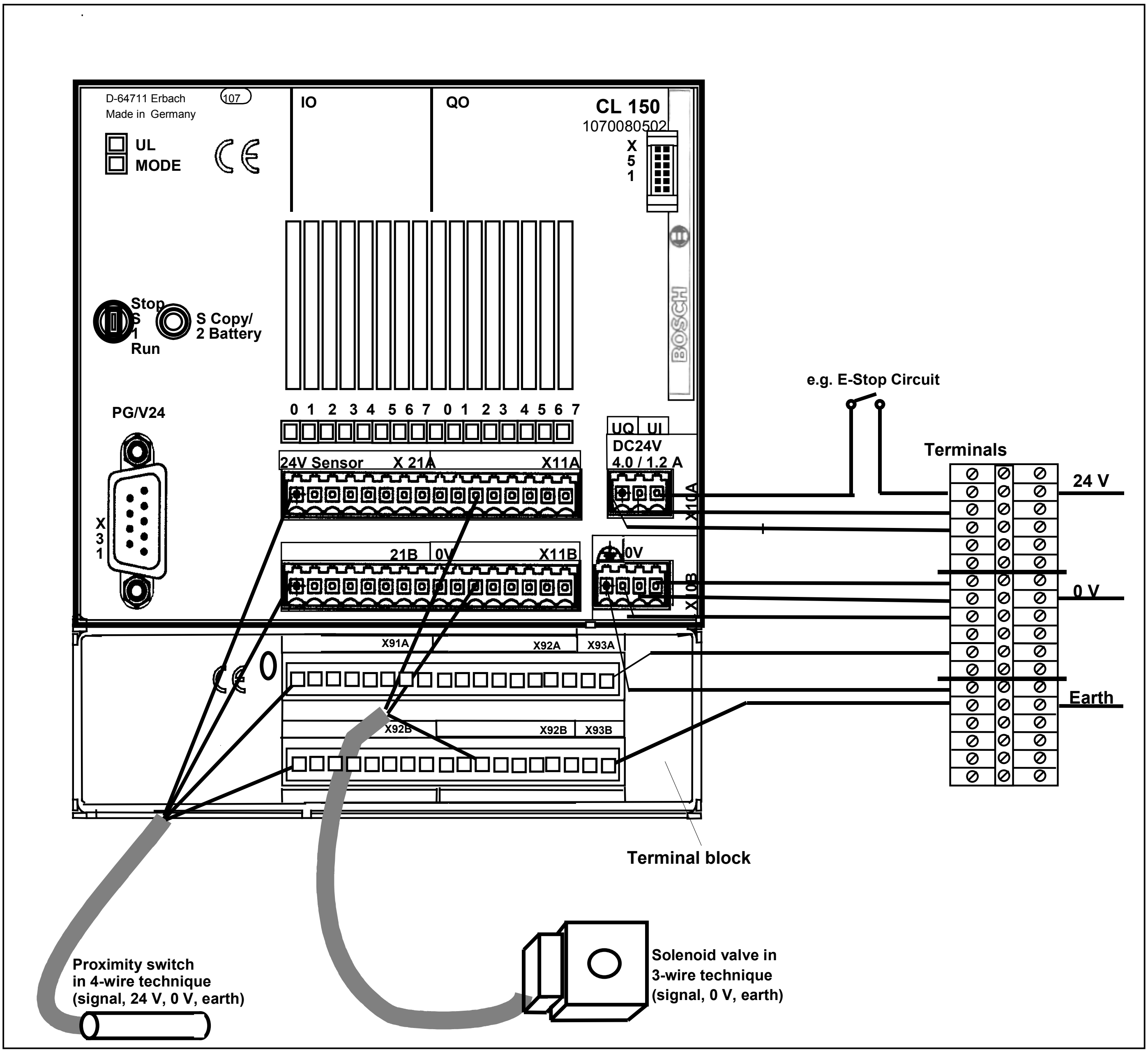


Fig. 4-1 Wiring example

Connection of the push-on terminal strips:

Bus station:	X11A:	Signal output
	X11B:	0 V
	X21A:	24V sensor supply
	X21B:	Signal input
Terminal blocks:	X91A...X92A:	freely assignable, in the example connected with 0 V
	X91B...X92B:	freely assignable, in the example connected with earth

4.3 Electromagnetic Compatibility

According to DIN VDE 0843, electromagnetic compatibility (EMC) is the property of an electrical system to operate satisfactorily within its electromagnetic environment and, in so doing, not to interfere unduly with this environment that also includes other facilities.

Interferences

Possible sources of interferences are:

- self-generated interferences, e.g. by frequency converters, inductive loads, etc.
- externally generated interferences, e.g. by lightning discharges, mains fluctuations, etc.

The major transfers of interference are the following:

- Radiated interference injection
- Conducted interference injection
- Electrostatic discharges

EMC Statute and CE Certification

The CL150 complies with the requirements of the EMC statute which is based on the EMC directives of the Council of the European communities.

This is documented by the CE certification. Upon request, a certificate of conformity can be issued.

The conformity of the CL150 by itself has been verified by EMC tests according to the following standards relevant for the CL150:

- EN 61131-2
- EN 50081-2

Nevertheless, this does not mean that electromagnetic compatibility can be guaranteed for the entire system. The responsibility for the entire system lies solely with the plant engineering supplier.

In order to ensure the electromagnetic compatibility it is absolutely necessary to comply with the additional installation instructions listed below.

Besides compliance with the EMC directive, the installation of the system or machine compound also requires compliance with the low-voltage directive, the EU declaration of conformity, and possible additional directives and/or guidelines that refer to specific types of systems.

4.3.1 Interference Emission

Radiant Emittances & Radio Interference

The CL150 complies with the EN 50081-2 generic standard which defines the limit values for interference emissions. This standard applies exclusively to usage in an industrial environment (in contrast to usage in residential areas). It is characterized by the following:

- No connection to the public mains network (low voltage).
- Availability of a separate high or medium voltage transformer.
- Operation in an industrial setting, or in close proximity to industrial supply networks.

The limit values for industrial applications are higher than for applications in a residential area. For this reason, if the equipment is intended to be used in a residential area, the user will be required to provide additional measures:

- Installation of the I/O system in a control cabinet, and/or in an enclosure providing a high screening attenuation.
- Filtering and screening measures regarding the lines.

If a system is intended to be used within a residential area (including business and commercial areas and small-industry settings), the user is required to obtain a personal operating license issued by the appropriate national authority or approval body. In Germany, this is the *Bundesamt für Post und Telekommunikation* (Federal Office of Post and Telecommunication) and its local branches.

4.3.2 EMI Resistance

Usually, the CL 150 functions correctly also in an environment with relatively strong interferences. For further improvement of the EMC properties it might be necessary to employ additional measures.

Earthing

To facilitate the dispersion of interference potentials acting between the device and the ground reference plane, the device housing or chassis must have a low impedance connection to ground. The inductive coating of simple cables obstructs the dispersion of interference significantly, especially in the case of pulse-shaped interferences with rise times in the nanosecond range. Grounding strips have better high-frequency properties, and shall therefore be preferred.

Screening

Electrical and magnetic interferences can be prevented by sufficient screening and spacial separation. Potentially interference-prone components (power supply and motor cables, contactors, frequency converters, etc.) must be screened or installed separately from components with lower signal-to-noise ratio (e.g. signal cables, electronic controllers). Preference shall be given to the employment of transformers featuring shielding winding because they ensure a very effective attenuation of interferences at higher voltage levels.

Filter

Filtering measures are dependent on the relevant application and the application environment. Suitable filters can be selected from a wide range of available products.

Twisted Pair Wiring

Twisted pair wiring of forward and return data transmission lines as well as twisted pair wiring of power supply lines can, to a great extent, prevent interferences and the development of interference fields in and/or due to these lines.

Parallel Routing of Data Transmission Lines and Interference-Prone High-Voltage Cables

Close and parallel installation of data or input/output cables and interference-prone cables, such as motor cables and cables leading to poorly interference-suppressed contactors, must be avoided. The smaller the distance between parallel-routed cables, the higher the degree of interference. In cable channels and control cabinets, the power and data cables must be installed as distant from each other as possible, maintaining a minimum distance of 10 cm; installation in separate, screened compartments is preferred. Data cables shall cross power cables at an angle of 90°.

Protection Against Electrostatic Discharges ESD

The CL150 contains components which may be destroyed by electrostatic discharges (ESD). A defect of the module caused by such discharges is not necessarily be noticeable immediately, but may also manifest itself in the form of occasional or delayed failures. It is therefore absolutely necessary to comply with the relevant measures regarding the handling of electronic components and modules. In particular, hot insertion and unplugging of connectors is not permitted.

Interference Suppression of Inductive Loads

The outputs of the CL150 utilize built-in DC clamp diodes to keep inductive switching peaks at a safe level. However, the occurrence of a cable break, the removal of a plug from the inductive load (e.g. solenoid valves, contactors, etc.) or the deliberate deenergizing through a mechanical contact causes very high interference voltages which can spread out throughout the system via electrical, inductive and capacitive coupling. To attenuate these interferences, the inductive load must be connected to an appropriate interference suppression device (freewheeling diode, varistor, or resistance-capacitance circuit). Due to their universal applicability, the use of bi-directional suppressor diodes is recommended. These consist either of a pair of reverse-polarity, series-connected suppressor diodes or of a single polarized suppressor diode with bridge rectifier. Ready-to-use modules of this type are readily available in commerce. Another suitable means of interference suppression are varistor modules. Manufacturers of contactors e.g., sell, in addition to their contactors, such matching varistors.

Precautions against Transient Overvoltages (Surge)

All power supply units of the controller must be connected with external varistor modules (e.g. Phoenix MODUTRAB VAR/3S-24AC). All digital in- and outputs that should be protected must be connected to surge suppressor terminals (e.g. Phoenix TERMITRAB SLKK 5/24DC, TERMITRAB UK5/24V or the corresponding modules of the MODUTRAB series). Of course, protective modules of other manufacturers are also suitable.

Quality of the Supply Voltage

To ensure uninterrupted operation, the logic circuit power supply of the CL150 is capable of bridging voltage dips of up to 10 ms. This makes an interruption of the bus operation due to brief voltage dips highly unlikely. No voltage bridging is available for outputs. Accordingly, brief voltage dips may cause contactors and other actuators to drop off. In normal circumstances, the falsification of input data due to voltage dips is already prevented by filters in the input circuits. The normal response time lies at about 3 milliseconds. In the event that interruptions of greater duration occur, the introduction of suitable measures will be required. For example, magnetic IR drop compensators can be employed on the AC side, or backup batteries and/or backup capacitors on the DC side.

5 Programming

Programmable logic controllers process a program in which the controller task is described. To do so, a special programming language is used which may be displayed and printed out in various methods of representation.

The CL150 is programmed with an AT-compatible PC and the WinSPS utility programming package for Windows NT® or Windows 95®. Version 2.40 and higher are suitable.

The program can be edited OFFLINE, i.e. without connection to the controller.

Loading Program

The PLC program is loaded into the controller via the serial connection of the programming unit's COM interface to the X31 or X32 interface of the CL150.

The loading function is called up from the editor of WinSPS.

The following possibilities exist:

- „Load total program“: All modules are loaded, together with the reference list, into the program memory of the controller. „Load total program“ is only possible if the controller is in Stop state. When the entire program is loaded, the controller is set to its initial state, all user operands are set back.
- „Reload single module“: Single modules can be reloaded during normal operation of the controller. The operating system adjusts the reference lists accordingly.

Program Startup

For program startup, please use the monitor function of WinSPS.

A detailed display of the current control state, program tracking, operands display, fixation and other useful „online“ functions make a quick startup of the PLC program possible and help the user with the elimination of interferences in a system.

Program Documentation

WinSPS makes it also possible to create a clear and easily understandable PLC program documentation with reference lists and many comments either on the monitor of the programming unit or as a printout.

5.1 Types of Representation

Instructions List (IL)

Structure of controller instructions

Controller Instructions				
Operation part	Operand attribute	Source operand		Destination operand
OPP	OPA	SRC	,	DEST

Example:

A	B	I0.0		
A	W	-Name	,	A
L	BY	O0	,	B
T	W	C	,	M10
MUL	W	1234	,	D

Ladder Diagram LD

When using the LD representation method, the controller tasks are described by means of standard circuit diagram symbols.

Function Diagram (FUD)

When using the FUD representation method, a graphical symbol display illustrates the logical links.

Sequential Function Chart (SFC)

The SFC represents a graphical programming interface which is used to describe those machine tasks that are to be processed sequentially in the form of a cascade sequence. Before it can be loaded into the PLC, this representation is translated into the executable IL programming language.

5.2 Program Structure

To create a clear PLC program structure which is easy to read, Bosch consistently employs structured programming for its programmable logic controllers. This way, the programs can be divided into functionally interconnected program segments. To support this clear structuring, several module types performing various special functions are available.

5.2.1 Module Types

The controllers utilize the following module types:

- Organization modules
- Program modules
- Data modules

All modules are enabled by being called up or activated in the program. This may be done either unconditionally or conditionally. Such a condition might be the result of a logic operation or a compare function or an arithmetical operation.

Organization Modules (OM)

The organization modules perform all administrative functions of the controller program. They are programmed in the same way as the program modules, but called up by the system program only. The PLC's entire command set is available in the organization modules. There is no limitation to module size.

The organization modules can be divided into 7 functional groups:

OM1	Module which is cyclically called by the system program and which may be utilized as a distribution module for the entire program. At the end of the OM1, the input-output cycle is always processed, regardless of whether it is closed with program end EP or with module end EM.
OM2	Non-executable definition module (initialization table) in which specifications (remanence limits, etc.) for the controller system are defined by modifying entries.
OM3	Non-executable definition module (initialization table) in which the configuration of the B~IO modules can be set. The module is automatically generated by WinSPS's „IO Configuration“ function and, if desired, just needs to be linked to the program (entry in the symbol file).
OM5, OM7	Startup modules for processing a variety of program sequences during a restart of the controller.
OM9	Error module which processes responses to program errors.

OM10- OM12	Interrupt modules for immediate responses to peripheral events.
OM17	Interrupt module which processes responses during the operation of the 1ms timer.
OM18+OM19	Time-controlled processing, time matrix definable in OM2.

Program Modules (FC)

The program modules (FC) contain program segments that are technically and functionally interrelated. Within program modules, any number of additional program modules and data modules may be called up. In addition, the entire command set of the PLC is available in all program modules. The modules are not subject to a size limit.

Program modules are usually concluded with an End of Module (EM) instruction. If the End of Program (EP) instruction is used, the program will be aborted immediately after the instruction has been processed, and the input/output cycle will be activated. Further program processing then recommences with the OM1 organization module.

Due to the option of parameterization, the program modules may be written independently of absolute operands. During the module call-up, the operands required for the current processing task are transferred to the program module in the form of parameter values.

The following input and output parameters may be specified:

- Input parameters: operands, constants and modules
- Output parameters: operands

Data Modules (DM)

The data modules (DM) serve as storage areas for all fixed and variable values and text blocks that are used by the program. This way, it is always possible to keep two data modules enabled during PLC program processing, each of which provides up to 512 bytes of memory capacity.

The following applies to the processing of data modules:

- Before their respective data may be accessed, the data modules must be enabled in the program by means of module call instructions (i.e., CM for the 1st DM, and CX for the 2nd DM).
- Within a given organization module (OM) or program module (FC), the data modules remain valid until other data modules are enabled by the program.
- After the return to the primary module, those data modules which were active at the time of the call-up of the base module are again activated.
- When the OM1 (cyclical program processing) and the startup modules OM5 and OM7 are called, no data module is active.

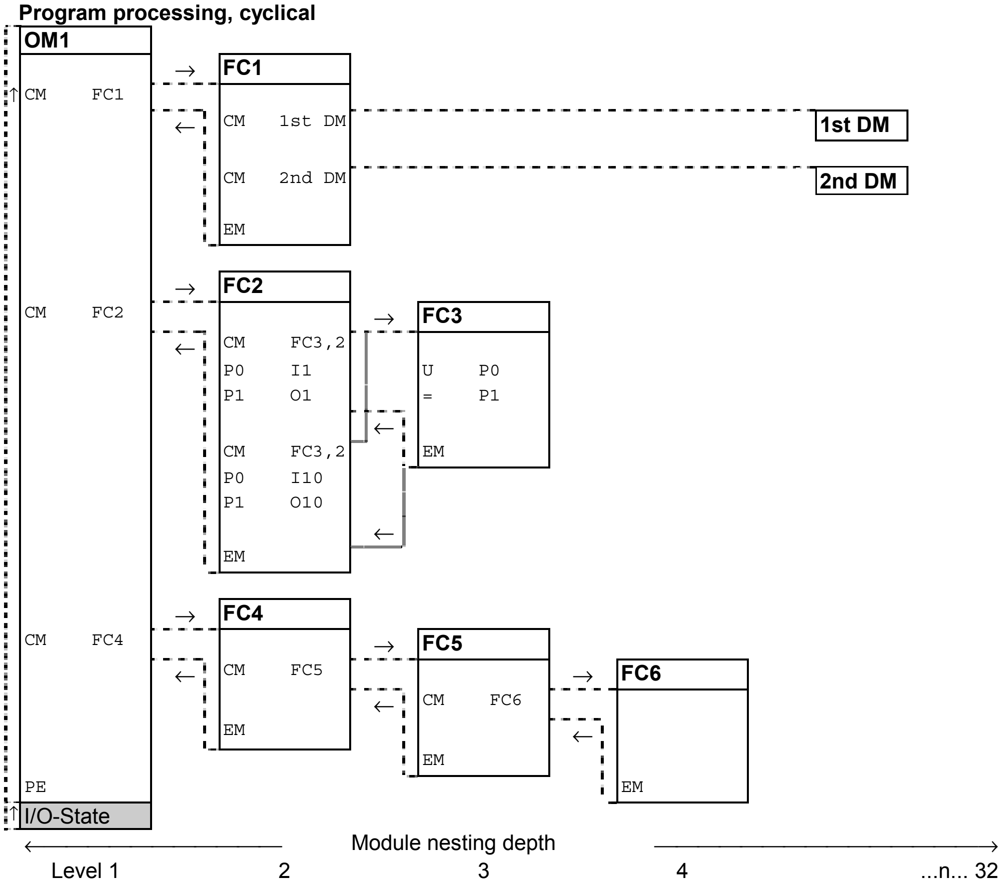
5.2.2 Exemplary Application Program Structure

With the aim of providing a clear overview of the basic organization of program management, the following diagram shows an example of the program structure

Program start-up, one-time only

```
OM5 / OM7
Program
EM
```

Program processing, cyclical



Time-Controlled Program Processing

Processing always commences subsequent to the change of module (not data module call) that follows the expiry of the associated time interval.

```
OM18-OM19
Program
EM
```

Interrupt-Controlled Program Processing

Processing always commences immediately upon appearance of the triggering criterion.

OM10-OM12, OM17
`Program`
`EM`

The trigger for OM17 is the end of the 1ms timer.

Program Processing Subsequent to PGM Error

Processing always commences immediately upon appearance of the triggering criterion.

OM9
`Program`
`HLT`

5.3 Reference List

In the program memory, three data words per module are reserved for the reference list.

They contain:

- Number of the memory segment where the module is located. The RAM of the application program has the segment number 1, the extended memory carries the segment number A; also refer to 5.4.1 Program Memory.
- Address offset of first instruction, and/or of first data word in the module, relative to the initial address of the segment.
- Size of module in byte without module header.

Each of the modules available in the CL150 is characterized by these entries.

The reference list can be displayed on the WinSPS monitor.

This provides you with a detailed and clear overview of the structure of the application program memory and, in particular, of the allocation of a module to the application program‘s RAM and the extended memory.

5.4 Memory Structure

In order to store the application program and the user data, the CL150 provides various memory areas.

Types of Memory

Basically, there are 2 types of memory:

- A Random Access Memory (RAM) which, with the use of a battery, is backed up if the power supply of the controller is switched off or fails.
- A flash memory for non-volatile data storage, also working without backup battery.

The operating system of the controller is located in the flash memory.

5.4.1 Program Memory

User Program RAM

The application program which consists of the reference list, the organization modules (OMs), the program modules FCs and the data modules DMs is generally processed out of the RAM area. To do so, a RAM of 64 kbyte is available.

Backup Memory

To prevent that, in case of operation without a backup battery, the application program is not lost when the power supply is switched off, a copy of the program's RAM is loaded into another FLASH segment, the backup memory, when the program is loaded from the programming unit into the controller.

This backup function is activated only with „Load total program“.

Program modifications that are due to the „reload module“ functions and modifications to the data modules‘ contents that are due to the application program have an impact on the RAM of the application program only, not on the backup memory.

Program modifications that are due to „reload module and „Replace“ are processed in the WinSPS monitor. In this case, it is possible to update the backup memory when leaving the monitor program. If an update takes place, be aware that the current contents of the data modules are copied as well and the initialization values are overwritten.

Extended Memory

It is possible to extend the application program by 64 kbyte. To do so, the OMs, FCs and DMs can be given the identifier „E“ instead of „R“ for declaration in the symbol file. For these modules, the flash memory has reserved a segment of 64 kbyte (extended memory).

The reference list, however, is always stored in the RAM of the application program.

This way, the application program can always comprise a total of 128 kbyte.

The extended memory has no correlation with the backup memory.

⇒ **The following applies to the extended memory:**

- **Monitor operation is not possible in the extended memory.**
- **Only tested and functioning modules should be swapped out into the extended memory.**
- **Data modules in the extended memory cannot be described by the application program. They are only suitable for data that remain constant while the controller is running (e.g. recipes, constant machine parameters, etc.).**
- **The extended memory is described only with „Load total program“. The function „Reload single module“ is not possible.**

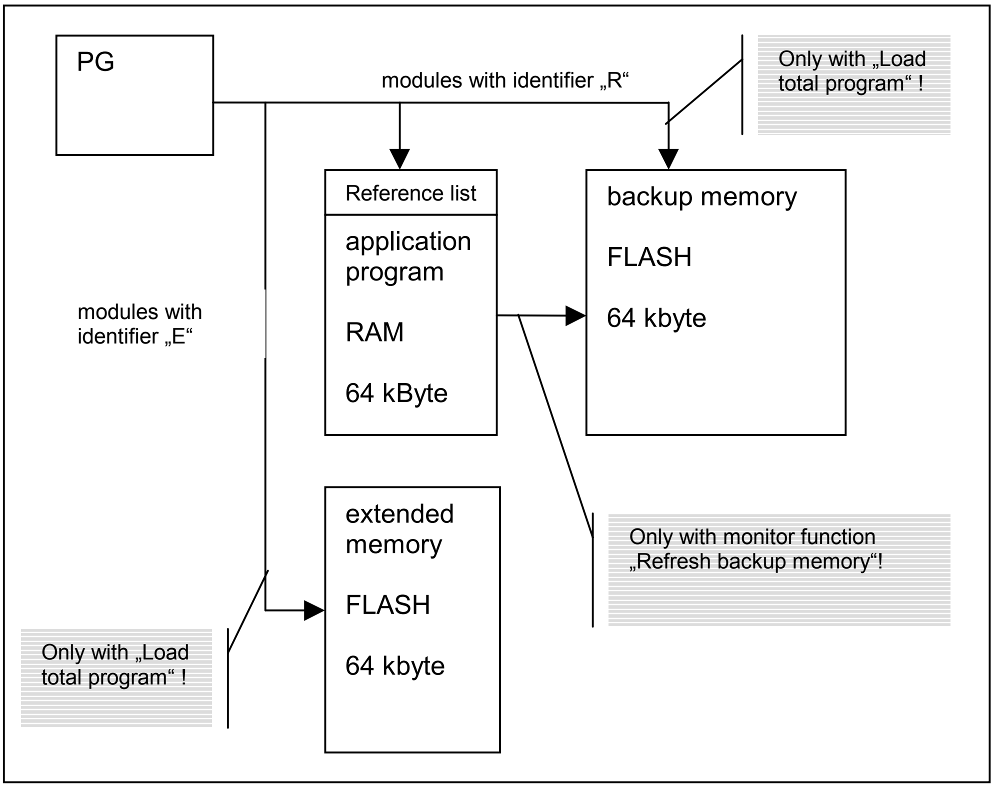


Fig. 5-1 Program Memory Structure

5.4.2 Data Memory

Except for the data modules (see above), all data modules are stored in the RAM areas.

- Image for inputs and outputs
- Actual values and states of times and counters
- Markers
- System area data
- Data field

If a backup battery is used, it is possible to keep this data remanent even if the power supply is switched off or fails.

5.4.3 Flash Memory

In addition to and independent of the above mentioned memory areas, two more FLASH segments are reserved solely for keeping the current status of the program RAM and the current status of the user data temporarily non-volatile. This data backup as well as reloading the data is only possible via the Store and Recall functions, by operating the switch/button at the controller, also refer to 3.3 Switches and Buttons.

This function is mainly used to prevent the loss of data during a battery exchange with the supply voltage being switched off.

Please proceed as follows:

- ❖ Switch CL150 to Stop.
- ❖ Press the button S2 Copy/Battery once; this will take the controller into the Store mode for about 5 s; the MODE LED is yellow.
- ❖ In Store mode: turn the S1 toggle switch to Run. The current data is copied from the RAM into the flash memory. During the copying process the MODE LED blinks yellow/green. Afterwards it returns to red, indicating the initial state. Now the data is non-volatile.
- ❖ Turn the S1 switch back to Stop.
- ❖ Switch off the supply voltage.
- ❖ Change the battery as described in 3.4 Backup Battery
- ❖ Switch on the 24V supply voltage.
- ❖ Press the button S2 Copy/Battery two times; this will take the controller into the Recall mode for about 5 s; the MODE LED blinks yellow.
- ❖ In Recall mode: turn the S1 switch to Run. The data stored in the flash memory is loaded back into the RAM data areas. During the copying process the MODE LED blinks yellow/green. Afterwards it returns to red, indicating its initial state.

❖ Turn S1 back to Stop.

The next time the Run function is switched on, the controller starts with the current data module contents and with the set data remanence; also refer to 6.5.1 Remanent Startup.

⇒ **After the Recall function, the contents of the backup memory are automatically cancelled.**

⇒ **When the flash memory is empty, i.e. if no program status has been stored into the flash memory, the Recall function automatically goes back to the backup memory and the basic status of the application program is loaded (after „Load total program“) together with the initialization values of the data modules. Program modifications that have been previously applied with „Reload module“ and that have not yet been updated in the backup memory, are lost for the controller.**

Backup of the Real Time Clock

The current real time is backed up by the Store function as well.

If the 24V supply is switched off and the backup battery is removed, the contents of the clock module is lost.

By means of the Recall function, the old time and date are reloaded into the clock module. The clock then continues to run but of course with the inaccuracy caused by the interruption.

Is the inaccuracy critical for the application, the clock must be reset by means of the programming unit.

6 Operating Characteristics

6.1 Operating Modes

The CL150 recognizes the operating modes „Operation with Battery“ and „Operation without Battery“. They can be selected by setting the initialization flag DW02, Bit 7 in OM2; also refer to 6.3 Initialization Module OM2.

DW0, Bit 7 = 0	Operation without battery
DW0, Bit 7 = 1	Operation with battery

Ex works, the OM2 is set to „Operation without Battery“.

The set operating mode is displayed in the Infostatus of WinSPS.

6.1.1 Operation without Battery

If the CL150 is operated without a battery, the „Operation without Battery“ operating mode must be set in the OM2.

After starting the controller, the RAM of the application program and the data memory remain, for the time being, in an undefined state.

The operating system automatically copies the application program from the backup memory into the RAM of the application program. The data modules then contain the initialization values, contents after „Load total program“.

The operating system cancels the user data as defined and sets the real time clock to the value 01.01.00 / 00:00; the day of the week remains undefined. A remanent startup is not possible.

In the Run state, the controller starts without generating a battery failure message or a low battery warning.

6.1.2 Operation with Battery

If the CL150 is operated with a battery, all RAM and real time clock contents remain if the 24V supply is switched off.

After switching on the 24V supply, the controller immediately processes the application program currently located in the application program‘s RAM together with those data module contents that have been valid prior to the 24V supply‘s switch-off. The operating system is able to run a remanent startup according to the settings in the OM2.

DANGER!
Danger to persons and equipment!
If the CL150 is supposed to work in the operating mode “Operation with Battery”, the same has to be definitely set in the OM2. Only then can be guaranteed that, in case of a battery failure, a battery failure message or a low battery warning is sent out and an unpermissible startup of the controller is prevented.

Battery Test and Battery Failure

When the controller is switched on, the proper state of the battery backup is checked. If the battery backup does not work correctly and the battery operation is set, a battery failure message is given out. The controller remains in Stop. The blinking of the green operation LED and the lit, red status LED indicate the battery failure which is also reported in the Infostatus.

Reset Battery Failure

After a battery failure, only a completely non-remanent startup is possible. The program must be regenerated or newly loaded by means of the programming unit. This way, the battery failure is automatically reset.

Regenerating the program can be done with the Recall function out of the flash memory or the backup memory; also refer to 5.4 Memory Structure.

When the flash memory is empty, i.e. if no program status has been stored into the flash memory by using the Store function, the Recall function automatically goes back to the backup memory and the basic status of the application program is loaded (after „Load total program“) together with the initialization values of the data modules. Program modifications that have been previously applied with „Reload module“ and that have not yet been updated in the backup memory are lost for the controller

Battery Load Test

The battery load test does not only check if the battery is present but it also checks the battery state by measuring the current with a defined battery load.

The battery load test is automatically performed when the controller is switched on. During operation the user can trigger the battery load test by doing the following:

- By pressing the copy button in Run

  The test is performed once during the following I/O state.

- By pressing the copy button in Stop

  The test is performed once and immediately.

Pressing the copy button is acknowledged by the yellow light of the MODE LED, which lasts for about 5 s.

- In the application program, the battery load test is triggered by setting the control bit S2.0 in the system area. The test is automatically performed once in the following I/O state and the control bit is automatically reset.

⇒ **When a battery load test is performed, current is temporarily taken from the battery. Due to the frequency of the tests, the service life can be reduced. It is therefore recommended to provide the triggering of the battery load out of the application program with a time control mechanism, e.g. the real time clock.**

Low Battery Warning

In case of a weak or non existing battery the battery load test activates the Low Battery Warning.

This means that with the next 24V power supply switch-off, the retention of the data cannot be guaranteed.

The Low Battery Warning does not cause the controller to stop.

It is signaled

- by blinking of the green operation LED
- in the Infostatus
- by setting the status bit S30.7 in the system area, which makes the warning available for a program-related evaluation.

6.2 Operational States

6.2.1 Stop

In the operational status Stop, the controller does not process any application program.

- All outputs are reset.
- The MODE-LED is red.
- The cause for the stop is indicated at the programming unit, WinSPS/Infostatus.

Causes for Stops

There are several causes for the Stop state:

- Stop caused by switch

  Toggle switch S1 in up position

- Stop caused by programming unit

  In WinSPS, the operational state of the controller can be switched.

- Stop through one of the integrated inputs

  In the dataword 37 of the OM2, one of the integrated inputs of the CL150 can be selected as a Stop input. Through this input, the controller can be switched to the Stop state from a peripheral device or with an externally installed switch. This function must be additionally released by an initialization flag, Bit 6 in dataword 2, in the OM2.

- Stop through busmaster

  Versions with a fieldbus connection can also be switched into the Stop state over the bus master.

- Stop because of application error

  Programming errors that can only be detected when the program is already running generally lead to the stop of the controller. A list of all possible errors is included in the description of the system area; also refer to 7.7 System Area. Here, each of the errors has been assigned a bit that is set when the corresponding error occurs.

- HLT command

  By means of the HLT command, the controller can be switched to Stop out of the application program.

6.2.2 Run

The controller automatically goes into Run if there is no cause for a Stop.

The program and the I/O state are executed.

The MODE LED is green.

6.2.3 Special States

Disable Outputs

All digital outputs as a whole can be disabled with the WinSPS/Monitor programming unit.

The controller operates the same way as if in Run, but all digital outputs to the peripherals are reset. The output image is occupied with the current values.

The MODE LED blinks green.

Fixing

Outputs, inputs and markers can be fixed permanently to certain bit states and/or values with the WinSPS/monitor programming unit.

In operation with battery the fixation is remanent.

The MODE LED blinks green.

System Errors

If the operating system detects a system error, the MODE LED blinks red. In general, a service code is given out in the Infostatus, which is very helpful during error analysis.

If, in connection with the Store or Recall function, an error occurs during copying, the MODE LED blinks red/yellow. The function must be repeated.

6.3 Initialization Module OM2

The OM2 is a system initialization table that is linked to the PLC program.

The following is set in the OM2:

- Monitoring functions
- Remanence limits
- Time OMs
- Onboard counter and onboard analog I/O
- Peripheral assignments

With Power On and Stop/Run, the settings in OM2 are taken over by the system and partly copied into the system area even before a possible Startup-OM is processed.

All kinds of influences on the system initialization are shown in the following OM2 printout.

```
;*************************************************************************
;***                                                                   ***
;***           I N I T I A L I Z A T I O N   T A B L E                 ***
;***                                                                   ***
;***                            C L 1 5 0                              ***
;***                                                                   ***
;*************************************************************************
;*** Last change: 21. 05. 1999  (ESA1 Sch)                             ***
;*************************************************************************
;
;*************************************************************************
; OM2 : CL150 - Initialization table
;*************************************************************************
;
;       - must be integrated in every user program which
;         uses different default settings
;
;       - if no OM2 entry in the symbol file is made,
;         the default settings will be used
;
;       I M P O R T A N T   N O T E , please observe in any case
;          =======================================================
;
;          EVERY change of data words (W) in forbidden address ranges
;          =====
;          can result in undefined sytem performance of the PLC.
;
;*************************************************************************
;

;DW 1:   (reserved)
;--------------------
DEFW    W        0

;DW 2:   Initialization flag (entries permitted)
;----------------------------------------------
;                Entry 0 = Function  n o t  checked or executed
;                Entry 1 = Function checked or executed
;
DEFW    W        2#0000000000000000
;          ********||||****      *: reserved
;                        ||||
;                        |||+--------- Control-Enable
;                        |||           (Coupling field of fieldbus connection)
;                        |||            0   PLC program runs self-contained
;                        |||            1   PLC program controlled by
;                        |||                Controlword (Bit 0 - 7)
;                        |||
;                        ||+----------- Disable cycle time monitoring
;                        ||              (OM5 or OM7, respectively)
;                        ||
;                        |+------------ Enable Stop/Run via input bit
;                        |              Selection of input bit see DW37
;                        |
;                        +------------- Operating mode
;                                      0 Battery-less operation
;                                      1 Battery operation

;DW 3: (reserved)
;----------------
DEFW    W        0
```

```
;DW 4:  Maximum cycle time (entries permitted)
;---------------------------------------------
;                Entry as a multiply of timebase 1 ms (1 ms through 1000 ms)
;                for cycle time monitoring. Monitoring is always enabled.
;
DEFW    W        1000

;DW 5:  Number of highest timer loop (entry permitted)
;-----------------------------------------------------
;                Entries from 0 through 127 are possible
;                 10 = Time loops T0 - T10 are available in the PLC program.
;       127 = all possible timer loops T0 - T127 are available
;
DEFW    W        127

;DW 6:  Number of first remanent timer (entry permitted)
;-------------------------------------------------------
;                Entries from 0 through 128 are possible
;                 32 = Remanency for timer loops T32 through T127
;                128 = no remanency
;
DEFW    W        64

;DW 7:  Number of first remanent counter (entry permitted)
;---------------------------------------------------------
;                Entries from from 0 through 64 are possible
;                32 = Remanency for counters Z32 through Z63
;                64 = no remanency
;
DEFW    W        32

;DW 8:  Number of first remanent marker (entry permitted)
;--------------------------------------------------------
;                Entries from 0 through 152 are possible
;                128 = Remanency from marker byte M128/marker bit M128.0
;             Definition of remanency boundary via byte addresses
;                152 = no remanency
;
DEFW    W        76

;                Definition of Timer OMs (entries permitted)
;                ===========================================
;                Entries as multipliers of time base 10 ms from 1 through 65535
;                 0 = no timer-based processing
;                11 = 11 x 10 ms = 110 ms interval of processing time
;
;DW 9:  Timer OM18
;-----------------
DEFW    W        0

;DW 10: Timer OM19
;-----------------
DEFW    W        0

;DW 11:  (reserved)
;-----------------
DEFW    W        0

;DW 12: (reserved)
;-----------------
DEFW    W        0
;

;                Definition of on-board counter (OC) (entries permitted)
;                =======================================================
;       Entry 0 = Function  n o t  executed
;       Entry 1 = Function executed
;
;DW 13: On-board counter 0 settings (OC0)
;----------------------------------------
DEFW    W        2#0000000000000000
;         *******|*****|||       *: reserved
;                |     |++------ Definition of transitions
;                |     |           00 no           transition
;                |     |           01 positive     transitions
;                |     |           10 negative     transitions
;                |     |           11 both         transitions
;                |     +-------- allow external up/down switch-over
;                |
;                +-------------- Count downward

;DW 14/15: Actual value OC0  Low/High word
;-----------------------------------------
DEFW    W        16#0000
DEFW    W        16#0000

;DW 16/17: Nominal value1 OC0  Low/High word
;-------------------------------------------
DEFW    W        16#FFFF
DEFW    W        16#FFFF

;DW 18/19: Nominal value2 OC0  Low/High word
;-------------------------------------------
DEFW    W        16#FFFF
DEFW    W        16#FFFF
```

```
;DW 20: On-board counter 1 settings (OC1)
;----------------------------------------
DEFW    W        2#0000000000000000
;         |******|*****|||       *: reserved
;         |      |     |++------ Definition of transitions
;         |      |     |           00 no          transition
;         |      |     |           01 positive    transitions
;         |      |     |           10 negative    transitions
;         |      |     |           11 both        transitions
;         |      |     +-------- allow external up/down switch-over
;         |      |
;         |      +-------------- Count downward
;         |
;         +--------------------- Incremental rotary encoders

;DW 21/22: Actual value OC1    Low/High word
;-------------------------------------------
DEFW    W        16#0000
DEFW    W        16#0000

;DW 23/24: Nominal value1 OC1  Low/High word
;-------------------------------------------
DEFW    W        16#FFFF
DEFW    W        16#FFFF

;DW 25/26: Nominal value2 OC1  Low/High word
;-------------------------------------------
DEFW    W        16#FFFF
DEFW    W        16#FFFF

;DW 27: Bit number in On-board output byte A0
;--------------------------------------------
;          Output bits can be set when nominal values are reached.
;          Hierfuer muss man in diesem Wort die entsprechenden Bits aktivieren.
;
DEFW    W        2#0000000000000000
;         ************||||       *: reserved
;                     |||+------ Nominal value1 OC0  Bit 0.0
;                     ||+------- Nominal value2 OC0  Bit 0.1
;                     |+-------- Nominal value1 OC1  Bit 0.2
;                     +--------- Nominal value2 OC1  Bit 0.3

;DW 28 - DW 30 (reserved for fast counters)
;------------------------------------------
DEFW    W        0       ;DW 28
DEFW    W        0       ;DW 29
DEFW    W        0       ;DW 30
;

;DW31: Only for versions with analog inputs
;                Number of analog inputs used (entries permitted)
;-------------------------------------------------------
;                Entry of 0 through 2 possible
;                0 = no analog input enabled
;                2 = two analog inputs enabled (channel 0 and 1)

DEFW    W        2

;DW32: Only for versions with analog in- and outputs
;                Selection of normalized analog channels (entries permitted)
;------------------------------------------------------------------
;       Entry 0 = Function  n o t executed
;       Entry 1 = Function executed
;
;       The selected analog inputs are normalized to       2V  - 10V
;       and the enabled analog output is normalized to     2V  - 10V
;       or to                                              4mA - 20mA,
;       respectively.
;       Entry 0 disables normalization

DEFW    W        2#0000000000000000
;         ****||||******||       *: reserved
;             ||||      |+------ Analog input     Channel 0
;             ||||      +-------                  Channel 1
;             ||||
;             ||||
;             ||||               Analog output    Channel 0
;             |||+-------------- Normalization
;             |||                (unipolar operation only)
;             |||
;             ||+--------------- Ranges
;             ||                  0  unipolar     0V  -  10V
;             ||                                  0mA -  20mA
;             ||                  1  bipolar      -10V  - +10V
;             ||                                  (voltage only)
;             ||
;             |+---------------- Type
;             |                     0  Voltage
;             |                     1  Current
;             |
;             +----------------- Averaging analog inputs


DEFW    W        0       ;DW 33
DEFW    W        0       ;DW 34
DEFW    W        0       ;DW 35
```

```
;DW 36: Only for versions with a 2. serial interface
;                Settings for 2nd serial interface (nur bei CL151-Varianten, entries permitted)
;-------------------------------------------------------------------------------------
;       Entry 0 = Function  n o t executed
;       Entry 1 = Function executed
;
DEFW    W        2#0000000101110100
;         │*****││*│││*│**       *: reserved
;         │     ││ │││ │
;         │     ││ │││ +-------- Parity
;         │     ││ │││             1   even
;         │     ││ │││                 (no other setting possible)
;         │     ││ +++---------- Baudrate
;         │     ││                111  19200 Baud
;         │     ││                110   9600 Baud
;         │     ││                101  reserved
;         │     ││                100  reserved
;         │     ││                011  reserved
;         │     ││                010  reserved
;         │     ││                001  reserved
;         │     ││                000  reserved
;         │     ││
;         │     ++-------------- Select protocol
;         │                        00  no protocol
;         │                        01  BUEP19E
;         │                        10  reserved
;         │                        11  reserved
;         │
;         +--------------------- set new parameters

;Default setting:        BUEP19E, 19200 Baud, do not set new parameters
;nicht veraenderbar:     8 data bits, one stop bit, even parity


;DW 37: Selection of input bit for Stop/Run  (entries permitted)
;---------------------------------------------------------------
;       The left byte sets the byte number (0 - 1 permitted), and
;       the right byte sets the bit number (0 - 7 permitted).
;
;       State of input bit
;         0 = Stop
;         1 = Run
;
;       16#0107 = Input 1.7
;
DEFW    W        16#0007


;DW 38: for variants with fieldbus connection only
;       Preset for coupling field start address in data field
;           (entry permitted)
;------------------------------------------------------------
;       Address only required in remote operation;
;       only even-numbered byte addresses permitted;
;       coupling field size is 128 bytes;
;       32 = DF32

DEFW    W        0
;


;       !!!     Internal system memory data     !!!
;       ===========================================
;
;       The following default settings must not be changed.
;       ===================================================

;DW 39 - DW 64 (reserved)
;--------------------------
DEFW    W        0       ;DW 39
DEFW    W        0       ;DW 40
DEFW    W        0       ;DW 41
DEFW    W        0       ;DW 42
DEFW    W        0       ;DW 43
DEFW    W        0       ;DW 44
DEFW    W        0       ;DW 45
DEFW    W        0       ;DW 46
DEFW    W        0       ;DW 47
DEFW    W        0       ;DW 48
DEFW    W        0       ;DW 49
DEFW    W        0       ;DW 50
DEFW    W        0       ;DW 51
DEFW    W        0       ;DW 52
DEFW    W        0       ;DW 53
DEFW    W        0       ;DW 54
DEFW    W        0       ;DW 55
DEFW    W        0       ;DW 56
DEFW    W        0       ;DW 57
DEFW    W        0       ;DW 58
DEFW    W        0       ;DW 59
DEFW    W        0       ;DW 60
DEFW    W        0       ;DW 61
DEFW    W        0       ;DW 62
DEFW    W        0       ;DW 63
DEFW    W        0       ;DW 64
;**************************************************************************
EM
```

6.4 Startup Characteristics

6.4.1 System Startup

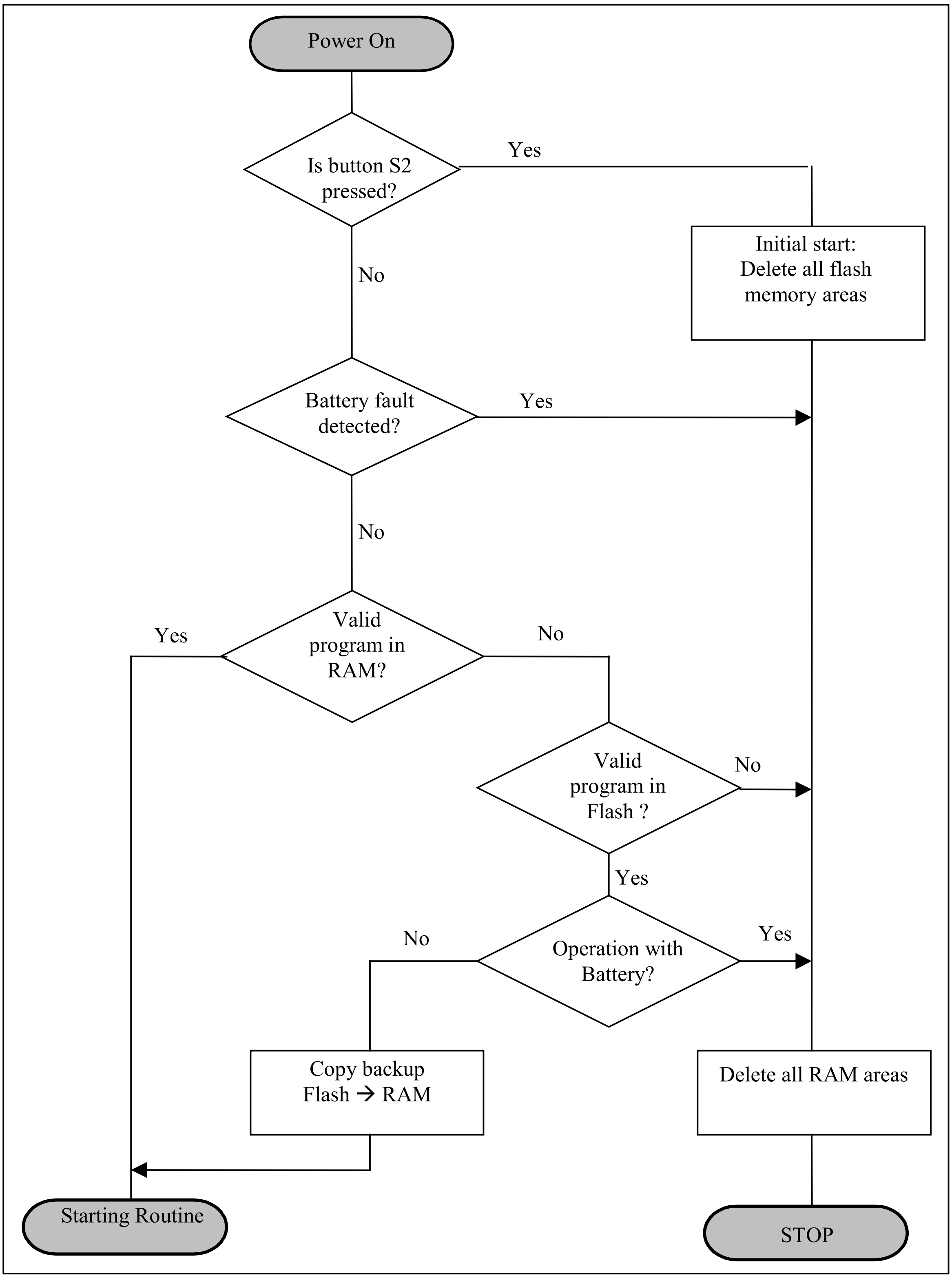


Fig. 6-1 System Startup

6.4.2 PLC Program Startup

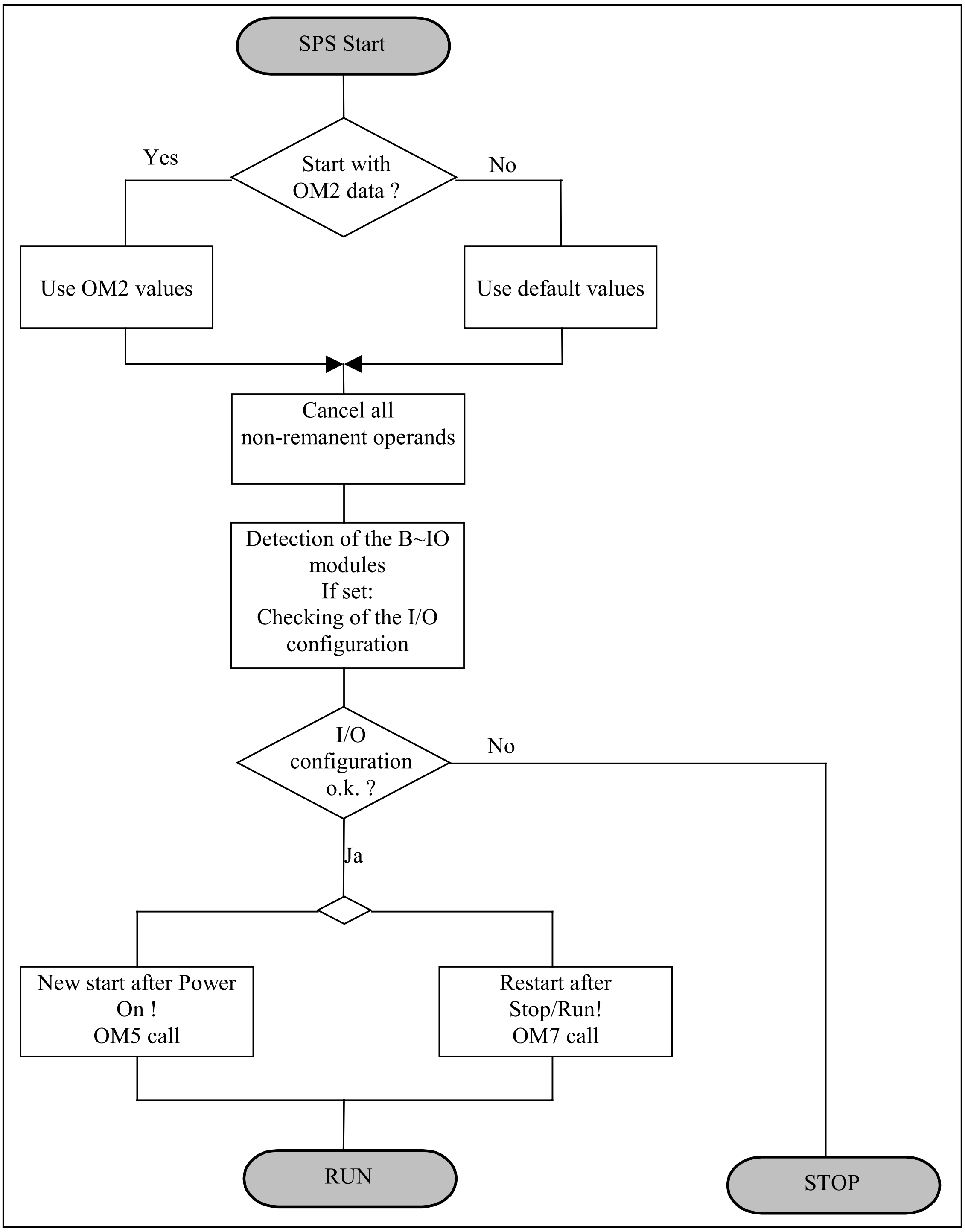


Fig. 6-2 PLC Program Startup

6.5 Remanence Characteristics

Unless other limits are specified within the OM2, the remanence characteristics of the CL200 are subject to the range limits described below. These limits cannot be changed by means of the PLC program.

6.5.1 Remanent Startup

In remanent operation, the statuses of the operands designated as remanent are retained after a Stop/Run and Power-On/Off mode change. As a precondition, the operating mode must be set to „Operation with battery“ and there must not have been detected any battery fault.

In the absence of specific designations in the OM2, the following areas are remanent:

- The upper half of the marker range, M76 to M152
- The upper half of the counters, C32 to C63
- The upper half of the times, T64 to T127

The operands which are set to be non-remanent are deleted, irrespective of the operating mode.

The entire data field, the data modules and the fixation are always remanent. They are deleted only upon fixations following a programming unit request.

6.5.2 Non-Remanent Startup

The non-remanent operation is set by shifting the remanence limits in the OM2 to the highest possible address.

In the operating mode „Operation without Battery“ only a non-remanent startup is possible after switching on the 24V supply.

6.6 Fixation

The CL150 offers the option of fixing the operands by means of the programming unit.

This way, operands can be permanently set to specific bit statuses and/or values, in contrast to the "Control" function of the programming unit.

The following data areas in the CL150 are fixable:

- Inputs
- Outputs
- Markers

Remanence of Fixation

An established fixation remains enabled under the following conditions:

- After a Stop/Run operational status change
- In operation with battery after power on/off.

6.7 Watchdog and Cycle Time

HW Watchdog

The processor function of the CL150 is monitored by a hardware watchdog, typical watchdog time: 1.6 s.

Fault response

- The CPU is brought into a defined status with Reset and signals HW error.
- An error code is given out in Infostatus.

Cycle Time Monitoring

The CL150 monitors the cycle time with regard to the maximum value of about 1 s. A second cycle time barrier in the OM2 can be determined below this value. During operation, this barrier cannot be modified anymore by the program. The cycle time is always measured from OM1 to OM1 and contains therefore the time of the I/O state as well.

Fault response

- Cycle time error message in Infostatus
- OM9 call, then Stop
- or, if the OM9 is not linked, immediate Stop status.

Switching Off Cycle Time Monitoring

Cycle time monitoring can be switched off in the OM2 for the time of the starting modules. This way, very long starting routines and the initialization of peripheral modules do not lead to the controller‘s Stop.

DANGER!
Danger to persons and equipment!
In the case of peripheral operations with the hardware watchdog disabled, faulty programming (endless loops) may create dangerous system conditions!

6.8 Error Characteristics

The controller‘s operating system performs several monitoring functions during the startup and execution of the program.

System Errors

Serious system errors like defective modules, are detected right after switching on the supply voltage. The controller does not start. The error is signaled by the red flashing MODE LED and generally requires repair work on the modules by BOSCH's service personnel.

A system error can also be generated during operation if a defect of a module triggers the hardware watchdog.

Depending on the cause of the error, a service code can be displayed in the Infostatus which facilitates the analysis and the elimination of the error essentially.

Battery Failure

When the 24V supply is switched on and a data loss occurs in the RAM, the CL150 remains in Stop and indicates a battery failure if the operating mode „Operation with Battery“ is set in OM2. The UL LED blinks green and the MODE LED is red.

The battery failure is displayed in the Infostatus.

The error is eliminated by replacing the non-functional battery with a new one. The program can be restored with a new start or with the Recall function.

Configuration Error

If the desired configuration of the B~IO modules is preset by linking the OM3, it will always be compared to the actual configuration taken up with the 24V supply when the system is started.

Differences are displayed in the Infostatus as „Conflict in module configuration diagram“ and the controller remains in Stop.

The error is eliminated by adjusting the desired and the actual configuration.

The configuration monitoring can only be switched off by removing the OM3 from the symbol file, which will lead to an automatic configuration and address assignment; also refer to 3.1.6 Connection of B~IO Modules, Addressing of Modules.

Application Program Error

The following error messages are triggered by errors in the PLC program.

They inevitably lead to the stop of the controller.

If the OM9 error module is linked to the application program, it is processed before the status changes from Run to Stop. The cause of the error is displayed in the error words of the system area. This way, a program reaction to the relevant error is possible before the controller goes into Stop.

- Addressing error
- Parameter error
- Module stack overflow
- DM too small
- Error "Jump direct“
- Illegal write-access
- Opcode error
- Timer no. too large
- DM not active
- Nonexistent module called
- Under-/Overflow of the application stack
- Cycle time error

The error is signaled in the Infostatus of the programming unit.

By using the monitor function „Go to“, the error in the PLC program can be localized very quickly.

7 Program Execution

7.1 List of Modules

The CL150 manages the following modules:

- 12 organization modules
- 128 program modules
- 128 data modules

Name	Function	Comment
OM1	Cyclical program execution	
OM2	Initialization table	refer to 6.3 Initialization Module OM2
OM3	Configuration table	I/O configuration; also refer to 3.1.6 Connection of B~IO Modules, Addressing of Modules
OM5	Startup module after Power-ON	
OM7	Startup module after Stop/Run	
OM9	Error module	e.g. cycle time error
OM10	Interrupt module	assigned interrupt I0, priority 1
OM11	Interrupt module	assigned interrupt I1, priority 2
OM12	Interrupt module	assigned interrupt I2, priority 3
OM17	Interrupt module 1ms timer	1ms time matrix
OM18	Time-controlled module	matrix definition in OM2 or S10, priority 1
OM19	Time-controlled module	matrix definition in OM2 or S12, priority 2
FC0-FC127	Program modules	
DM0-DM127	Data modules	

7.2 Operand & Module Identifiers

Abbr.	Operand	Peripheral Access/ Data Width	Image Update
I	Input with image	Image/ bit, byte, word	in I/O state
II	Interface inputs[1], physically equal to I	direct/ byte, word	with program processing
O	Output	Image/ bit, byte, word	in I/O state
IO	Interface outputs[2], physically equal to O	direct/ byte, word	with program processing
M	Marker		
T	Time (Timer)		
C	Counter		
D	Data word, 1. act. DM		
DX	Data word, 2. act. DM		
DF	Data field		
OC	Onboard counter		
S	System area		
K	Constant		
DM	Data module	DMnn ; Call 1. active DM DMnn ; Call 2. active DM	
FC	Program module		

---

[1] Interface inputs are only available in integrated I/O areas

[2] Interface outputs are only available in integrated I/O areas

7.3 Startup Modules OM5 and OM7

Two startup modules are available: OM5 and OM7. If a startup module is linked to the PLC program, it will automatically be processed when the controller is started.

- OM5: Startup module for new start, is always processed after Power-On. This is also applicable if the CL150 is in Stop after Power-On. In this case the OM5 is processed when the operational status switches from Stop to Run. The OM5 is also processed after Program-Loading.
- OM7: Startup module for restart, is processed after the operational status has changed from Stop to Run provided that it is not a first startup after Power-On.

The entire instruction set can be used in the startup modules.

As a close instruction for the startup modules, both the EM and the EP instruction can be used. Both have the same effect on the module.

In the event that program modules are called during the processing of startup OMs, the close instructions of such program modules will have the established meaning:

- EM: Return to the calling startup OM
- EP: Cancel, continue with OM1

7.4 Cyclical Program Processing

The operating system cyclically calls the OM1 organization module.

Prior to each call, the I/O image of the CL150 is updated.

The OM1 primarily serves for program controlling. It starts the bottom level of the program modules.

The OM1 must be linked to each PLC program once.

7.5 Interrupt-Controlled Program Processing

The CL150 recognizes several groups of interrupts:

TI	Program interruption through time-controlled OM
PI	Program interruption through peripheral event, interrupt inputs

When an interrupt occurs, the normal program flow is interrupted and the corresponding organization module is activated.

The group of time interrupts has the lowest priority, the group of peripheral interrupts the highest. Within the groups, the interrupt that has been assigned the lowest OM number is the one with the highest priority.

The 1ms timer interrupt OM17 is special. Even though it is a time interrupt by nature its mode of functioning corresponds to a peripheral interrupt.

7.5.1 Time-Controlled Program Processing OM18/OM19

The time OM is called up

- 1. when the established time has elapsed **and**
- 2. after a module change.

Neither a DM call nor an EP instruction is considered a change of module.

The time interrupts are always enabled by standard. Interrupt disabling and enabling are controlled by interrupt mask programming.

⇒ **Due to programmed module nesting within time OMs, additional time OMs can appear and be processed, with the understanding that active time modules are incapable of causing their own interruption.**

7.5.2 Event-Controlled Program Processing OM10/OM11/OM12

In addition to their standard function, the inputs I0.0, I0.1, and I0.2 can also be used as interrupt inputs, peripheral interrupts.

A peripheral interrupt is triggered by a 0→1 (LOW → HIGH) signal change at the associated input. The processing is not linked to a module change. Instead, it branches into the respective interrupt OM immediately after processing the current instruction in the PLC program.

In this process, the flag register, i.e. RES, etc. and the system register contents are rescued.

The user is responsible for effecting possibly necessary rescues of registers, scratch markers, etc.

The peripheral interrupts are always disabled by default. Interrupt disabling and enabling are controlled by interrupt mask programming.

⇒ **Active peripheral interrupts are neither capable of interrupting themselves, nor can they be interrupted by time interrupts.**

7.5.3 1ms Timer Interrupt OM17

The interrupt is triggered by the processing of the hardware timer with 1ms matrix.

The time OM17 is called up when the established time has elapsed and the processing of the current instruction is finished.

The 1ms timer interrupt has the highest priority of all interrupts. The interrupt OM17 can neither be interrupted by peripheral interrupts nor by time interrupts.

The 1ms timer interrupt works like a peripheral interrupt.

With regard to administration though (interrupt register, interrupt mask, interrupt command), the 1ms timer interrupt has been assigned to the group of time interrupts.

7.5.4 Instructions for Interrupt Handling

An interrupt mask has been assigned to each interrupt group, time interrupts (TI) and peripheral interrupts (PI). The TIM and LIM instructions are used to read from and write to these masks.

Within an interrupt group, each interrupt is provided with a bit in the corresponding mask.

If such a bit is set, it means that the respective interrupt is enabled. If such a bit is not set, it means that the respective interrupt is disabled.

In order to actually enable the interrupts assigned in the mask, the additional EAI (Enable All Interrupts) instruction is required!

In order to generally disable an interrupt group without influencing the mask entries, the DAI (Disable All Interrupts) instruction is required.

Incoming interrupts cause an entry in the corresponding interrupt register even though the corresponding interrupts are masked. Again, a bit has been assigned to each interrupt.

If the interrupt is executable, i.e., enabled, the bit in the interrupt register will be automatically canceled by the call-up of the interrupt OM.

If the interrupt is disabled, the bit will remain in the interrupt register while the interrupt is waiting to be enabled.

The interrupt register can be read with the LAI (Load All Interrupts) instruction and waiting interrupts can be canceled with the RAI (Reset All Interrupts) instruction.

With a Stop/Run change of the operating mode and with Power-Off/On, all waiting interrupts are canceled.

During startup, i.e. during the processing of OM5 and OM7, all interrupts are disabled.

The peripheral interrupts remain disabled and the corresponding mask bits are reset. Required interrupts must be enabled by the user with the TIM and the EAI instruction.

Time interrupts in the program cycle are enabled by default. They can be disabled with DAI/TI in general or by resetting the corresponding mask bits.

7.6 Error Module OM9

OM9 is the error module. If the module is linked to the PLC program, any error occurrences which normally cause an immediate stop of the central processing unit, will result in an automatic OM9 call.

After the processing of the OM9, the CL150 goes into Stop.

Exception:

If an upper cycle time limit has not been set and the hardware-dependent cycle time limit is reached due to a programming error, the CL150 will automatically enter Stop mode. In this case, enabling an error OM will no longer be possible.

The error module can be programmed with remedial measures to be launched in the event that an error occurs. For example, data and, possibly, error bits in the system area can be copied to non-volatile memory areas.

Retriggering program processing with error acknowledgement is excluded. After the OM9 has been processed, the CL150 always goes into Stop, regardless whether the EM or the EP instruction was used as the close instruction for the module.

7.7 System Area

The CL150 features a system area encompassing 128 words (S0 through S255).

The system area is the location of the CL 150‘s control parameters and status messages which can be processed while the system is running.

Part of the specifications defined in the OM2 are copied into the system area where they can be read by the PLC program.

If useful, system declarations can also be changed while the system is running. This includes the time intervals of the time-controlled organization modules and the system clock.

System Area Assignments

Address	Contents	Comment
S0 / S1	Initialization flags like OM2_DW2	read only
S2	S26.0, execute battery load test in the following I/O state	read and write
S3	Reserved for command flags	
S4 - S9	Reserved	
S10 / S11	Time value for time-controlled processing OM18	read and write; this way, time values can also be changed via PLC program
S12 / S13	Time value for time-controlled processing OM19	
S14 - S19	Reserved	
S20 / S21	Counter for actual cycle time, factor 1ms	Time from beginning of OM1 to beginning of OM1, reset upon Stop/Run, time refresh upon error-based jump or in I/O state.
S22 / S23	Max. cycle time, factor 1ms	Time from beginning of OM1 to beginning of OM1, reset upon STOP/RUN
S24 / S25	Min. cycle time, factor 1ms	
S26 / S27	Error word 1, OM9 call Bit: S26.0 Addressing error S26.1 Parameter error S26.2 S26.3 Module stack overflow S26.4 S26.5 S26.6 DM too small S26.7 Error „Jump indirect“ (JP [R]) S27.0 Illegal write-access S27.1 Opcode error S27.2 S27.3 Timer no. too large S27.4 S27.5 DM not active S27.6 Transfer error peripheral bus S27.7	

Address	Contents	Comments
S28 / S29	Error word 2, OM9 call Bit: S28.0 S28.1 S28.2 Non-existent module called S28.3 S28.4 Underflow of application stack S28.5 Overflow of application stack S28.6 S28.7 Cycle time error S29.0 S29.1 S29.2 S29.3 S29.4 S29.5 S29.6 S29.7	
S30 / S31	Bitfield Bit: S30.0 Log. 0 S30.1 Log. 1 S30.2 Flashing marker 2 Hz S30.3 Trigger pulse with new start and restart S30.4 Trigger pulse with new start and load program and deleting remanent areas S30.5 I/O fixed S30.6 Output disabled S30.7 Low battery warning S31.0 Diagnosable periph. module group under fault S31.1 Cable breaks, analog inputs S31.2 S31.3 S31.4 S31.5 S31.6 Error fieldbus S31.7	 reset after 1. EP. reset after 1. EP. Only „Operation with Battery“ Summary message, modules under development Summary message Only for versions with fieldbus connection Status bit for 1ms timer
S32 / S33	Reserved	
 S34 / S35 S36 / S37 S38 / S39 S40 / S41 S42 / S43 S44 / S45	**Onboard Counter OC0** Actual value Low word High word Spec‘d value 1 Low word High word Spec‘d value 2 Low word High word	Upon reaching the specified values, the outputs defined in OM2/DEFW27 will be set.
 S46 / S47 S48 / S49 S50 / S51 S52 / S53 S54 / S55 S56 / S57	**Onboard Counter OC1** Actual value Low word High word Spec‘d value 1 Low word High word Spec‘d value 2 Low word High word	Upon reaching the specified values, the outputs defined in OM2/DEFW27 will be set

Address	Contents	Comments

S58 / S59	**Onboard Counter OC0, control bits** S58.0 OC0 counting direction 0 = upwards 1 = downwards S58.1 Set OC0 actual value S58.2 Set OC0 specified value S58.3 S58.4 S58.5 S58.6 S58.7 **Onboard Counter OC1, control bits** S59.0 OC1 counting direction 0 = upwards 1 = downwards S59.1 Set OC1 actual value S59.2 Set OC1 specified value S59.3 S59.4 S59.5 S59.6 S59.7	After the transfer, the CL150 will delete the bits. After the transfer, the CL150 will delete the bits.
S60-S63	Reserved	
 S64 / S65 S66 / S67	**Analog inputs** Analog input channel 0 Analog input channel 1	
S68 - S79	Reserved	
S80	**Cable break message bits** S80.0 Analog input channel 0 S80.1 Analog input channel 1	
S81	Reserved	
S82 / S83	**Analog output**	
S84-S89	Reserved	
S90	**Control byte fieldbus connection** S90.0 Diagnosis message by user	Only for versions with fieldbus connection
S91	Reserved	
S92 / S93	**Device diagnosis** S92.0 Short circuit of an integrated output S93.7 Summary bit module diagnosis	
S94 / S95	Reserve 1 for diagnosis	
S96 / S97	**Module diagnosis** S96.0 Module 0 S96.7 Module 7 S97.0 Module 8 S97.7 Module 15	
S98 / S99	Reserve 2 for diagnosis	
S100 - S127	Reserved	

Address	Contents	Comments
	System clock	
S128	Seconds	0-59
S129	Minutes	0-59
S130	Hours	0-23
S131	Day	1-31
S132	Month	1-12
S133	Year	0-99
S134	Weekday	0-6 (0=So)
S135 - S143	Reserved	
	Initialization values of the CL150	
S144 / S145	Module type ID (word)	00H CL150 01H CL150A 02H CL150-DP 03H CL150-IBS 08H CL150-CAN 09H CL150-DEV 10H CL151 11H CL151A 12H CL151-DP 13H CL151-IBS 18H CL151-CAN 19H CL151-DEV
S146	Hardware version (byte)	
S147	Reserved	
S148	System firmware version (byte)	Firmware loadable with programming unit
S149-S255	Reserved	

7.8 Setting of Time

The real time clock can be set either with the programming unit or in the PLC program.

Handling

The system clock is set by writing into the S128-S134 system area, whereby the writing must be done in a transition-controlled (pulse) way. Otherwise, the time will be reset in each PLC program cycle.

⇒ **In the event that, when setting the system clock, the respective permitted value range is exceeded, the existing clock settings will remain unchanged.**

Value ranges:

▪ Minutes	0-59	
▪ Seconds	0-59	
▪ Day	1-31	
▪ Hours	0-23	
▪ Year	0-99	
▪ Month	1-12	
▪ Weekday	0-6	0=Sunday .. 6=Saturday

With the following I/O state, the operating system takes over the new time settings.

Program Example: Setting the Clock

```
;Version:                    In the following, the designation CL150 represents the name
;                            of a fieldbus version of the CL150, e.g. B~IO CL150-DP.
;                            The process is the same with
;                            any other fieldbus version.
;Process:                    The fieldbus master has transferred the time to be set
;                            into the switching matrix and, by setting a flag in the
;                            switching matrix, requests the CL150 to take this time over into the
;                            real time clock immediately.
;                            The CL150 acknowledges the acceptance of the time by setting
;                            an acknowledgement flag in the switching matrix upon which the
;                            fieldbus master resets the request to set the time.
;Switching Matrix            The switching matrix start address is entered into the dataword 38
;                            of the OM2.
;                            If the default entry is not altered:
;                            DW38:          DEFW    W      0
;                            the data field area DF0 - DF127 is reserved as the switching matrix
;                            for the fieldbus communication.
;                            The following is defined:
;                            Data direction Master -> CL150:  DF0  - DF63
;                            Data direction CL150  -> Master: DF64 - DF127
;Time Entry:                 DF2 = Seconds
;                            DF3 = Minutes
;                            DF4 = Hours
;                            DF5 = Day
;                            DF6 = Month
;                            DF7 = Year
;                            DF8 = Weekday
;Request Flag:               DF1, Bit0
;Acknowledgement Flag:       DF65, Bit0
;Preconditions:              0->1 - Transfer from DF1, Bit0
;Edge Detection:             For edge detection, the value of the acknowledgement flag
;                            is used, which is, in the sense of a handshake, corrected to
;                            the value of the request flag. If the value of the acknowledgement flag
;                            is 0 and the value of the request flag is 1, a rising edge
;                            is preseent and the precondition is fulfilled.

; Program Instructions:
; --------------------

L       B       DF1,A           ;Flag byte for correction request
L       B       DF65,B          ;Flag byte for Acknowledgement

;Verifiy conditions:

A               B.0             ;If the value of the acknowledgement flag is = 1
ON              A.0             ;or the precondition is = 0
JPC             nop             ;then --> do not set time

;otherwise: Preconditions are fulfilled -> transfer time into system area

L       W       DF2,C
T       W       C,S128          ;Seconds and minutes
L       W       DF4,C
T       W       C,S130          ;Hours and Day
L       W       DF6,C
T       W       C,S132          ;Month and Year
L       B       DF8,C
T       B       C,S134          ;Day of the week
A               A.0
S               B.0             ;Set acknowledgement flag
T       B       B,DF65          ;and transfer to switching matrix;
EP                              ;immediatley activate I/O state
                                ;in order to set the clock immediately

nop:                            ;Preconditions are not fulfilled
A               A.0
=               B.0             ;update acknowledgement flag,
T       B       B,DF65          ;with 0 the handshake is finished

EM
```

7.9 Application Stack

The application stack (AST) comprises a pushdown-pop-up memory stack with a storage depth of 128 words, using FILO (first-in-last-out) processing.

The PUSH and POP instructions make word-by-word data transfer between the registers and the contents of the application stack possible.

Example:

```
PUSH W  A      ; Shift contents of register A to application stack
PUSH W  B      ; Shift contents of register B to application stack
PUSH W  C      ; Shift contents of register C to application stack
PUSH W  D      ; Shift contents of register D to application stack

POP  W  D      ; Shift contents of application stack to register D
POP  W  C      ; Shift contents of application stack to register C
POP  W  B      ; Shift contents of application stack to register B
POP  W  A      ; Shift contents of application stack to register A
```

In the event of an application stack underflow, bit S28.4 will be set in the system area. In the event of an application stack overflow, bit S28.5 will be set in the system area.

Both application stack (AST) underflow and overflow conditions will cause the Stop state.

The application stack is deleted after each EP!

7.10 Addressing in the CL150

7.10.1 Register Structure

The CL150 features 4 working registers which can be addressed in a bit-wise, byte-wise or word-by-word fashion. In this context, it should be noted that byte/word addressing always addresses the low-byte word

Working registers
A, B, C and D

15 … 8	7 … 0
High byte	Low byte
Word	

With operations that exceed the 16bit format, permanent register pairs are created from the registers.

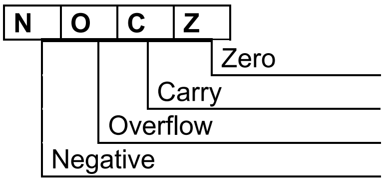
Working register pair
A + B

15 … 8 7 … 0
Word 2 = Low word B
Word 1 = Low word A

Working register pair
C + D

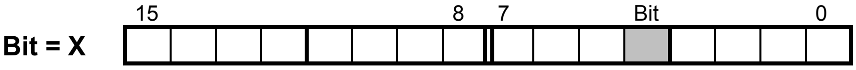
15 … 8 7 … 0
Word 2 = Low word D
Word 1 = Low word C

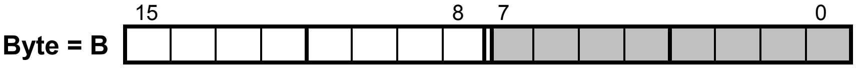
Status bits



The negative flag always corresponds to the MSB (most significant bit) of the specified data format. I.e. that for byte operations, it is Bit 7, and for word operations, it is Bit 15.

7.10.2 Data Formats





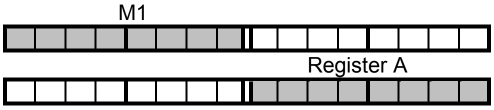
This addressing mode differentiates between load and transfer instructions.

Load Instructions

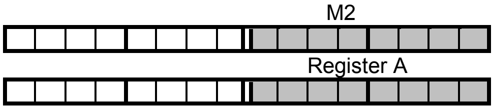
The source operand may be either the even-numbered LOW byte or the odd-numbered HIGH byte.

In the case of the destination operand (register), the LOW byte is always addressed.

Examples: L B M1,A



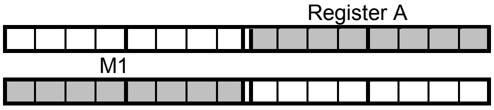
L B M2,A



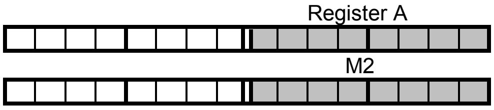
Transfer Instruction

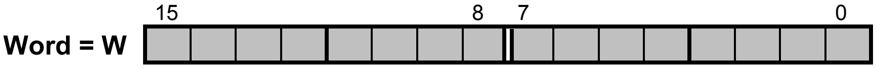
In the source operand (register), the LOW byte is addressed. The destination operand may be either the even-numbered LOW byte or the odd-numbered HIGH byte.

Examples: T B A,M1



T B A,M2





7.10.3 Representation of Constants

Data type		PLC Utility Program
Explanation	**Representation**	**WinSPS**
UINT (unsigned integer)	binary / dual	2#0000000000000000 2#1111111111111111
	decimal, word	00000 - 65535
	hexadecimal	16#0000 - 16#FFFF
USINT (unsigned short integer)	binary / dual	2#00000000 2#11111111
	decimal, byte	000-255
	hexadecimal	16#00 - 16#FF
INT (signed integer)	decimal, word	-32768 - +32767
Text, STRING(2)	ASCII	'AB'
Time value, TVALUE	Time value (+Timebase r) r: 0=10 ms, 1=100 ms 2=1 s, 3=10 s	T#10ms - T#10230s T#0.r - T#1023.r

7.10.4 Program Module Call

	PLC Utility Program WinSPS	
Program module/Function call (IEC1131/3)	CM	FC5
Data module	CM	DM4

7.10.5 Jump Instructions

	PLC Utility Program WinSPS	
Jump instruction	JPx	label
Jump destination	label:	

7.10.6 Bit and Module Addresses

Operand	Addresses (dec.)	
I	0.0-47.7	
O	0.0-31.7	
II	0.0-1.7	not for B~IO modules
IO	0.0-0.7	
M	0.0-151.7	optionally remanent
T status	0-127	optionally remanent
C status	0-63	optionally remanent
DM	0-127	
FC	0-127	

7.10.7 Byte Addresses

Operand	**Addresses (dec.)**	**Comment**
I	0-47	I1 only with the CL151, CL150A and CL151A version
II	0-1	Physically identical with I0 and/or I1; I1 only with the CL151, CL150A and CL151A version
O	0-31	
IO	0	physically identical with O0
Actual T value	0-127	Time range 10 ms-1023 s, matrix 0.01; 0.1; 1; 10 s
Actual C value	0-63	Counter range 0-8191
M	0-151	
S	0-255	Here, the following is administered: - System initialization values - Analog onboard I/O - Onboard high-speed counters - System clock - Auxiliary bits, log1/0, RI, flasher, etc.
TST	0-31	
DF	0-8191	
D	0-511	
DX	0-511	

The even-numbered byte addresses are used to address words.

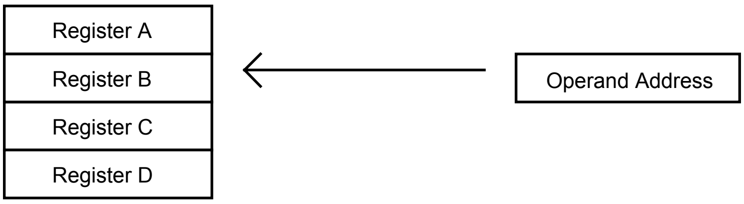
7.10.8 Addressing Modes

Direct Addressing

Operands for absolute addressing

Byte/word readable	I, O, M, T, C, Constant, DF, D, DX, S, II*	for T/C, the actual values are applicable * only onboard inputs
Byte/word writable	O, M, DF, D, DX, S, IO*	* only onboard outputs

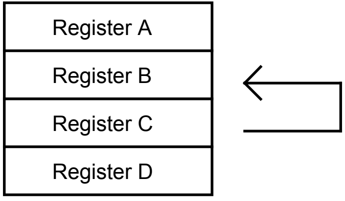
Direct addressing of all absolute addressable operands



Examples:

```
L   B      I10,B      ;  Loads the status of input byte I10 into B.
L   W      100,C      ;  Loads the decimal value 100 into Register C.
```

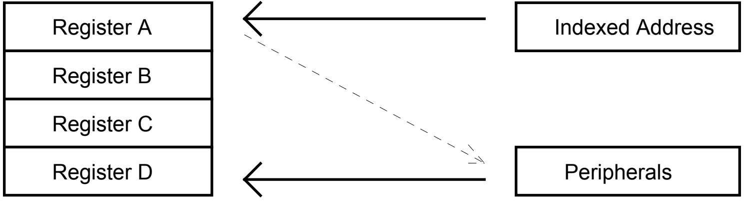
Register - Register Addressing



Example:

```
L   W      C,B        ;  Loads the contents of register C to B
```

Register indirect Addressing



Examples:

```
L   W      10,A       ;  Loads index address as byte number to A
L   W      I[A],D     ;  Loads status of I10 (Address in A) to register D
```

7.10.9 Indirect Addressing

The indirect addressing method – whether word/byte or bit-oriented – uses an operand prefix containing the operand identifier and the operand address. This facilitates the handling and monitoring of operand addresses greatly.

In addition, all data and program modules can be called up indirectly.

The operand prefix is structured as follows:

OPD[R] OPD = Operand identifier
[R] = Operand address in register A, B, C or D

Demonstration of the Indirect Addressing Principle, Using the Example of a Block Transfer:

Objective: Five input words on address I10 are to be transferred to marker words starting with address M50.

```
L        W       5,A    ; Loading loop counter
L        W       10,B   ; Loading I10 byte base address
L        W       50,C   ; Loading M50 byte base address
continue:               ; Loop entry label
L        W       I[B],D ; Reading of contents (operand status)
T        W       D,M[C] ; Writing of loaded status
INC      W       B,2    ; Next I-word (byte address + 2)
INC      W       C,2    ; Next M-word
DEC      W       A,1    ; Loop counter -1
JPN      continue       ; not all words processed so far
```

Indirect Byte addresses

OPD ID	Byte Address (dec.)	Instructions	Example
I	0 - 47	L	L 10,A
II	0 - 1	L	L I[A],B
O	0 - 31	L, T	
IO	0	T	
Actual T value	0 - 127	L	
Actual C value	0 - 63	L	
M	0 - 151	L, T	L 10,A
S	0 - 255	L, T	T B,M[A]
DF	0 – 8191	L, T	
D	0 - 511	L, T	
DX	0 - 511	L, T	

To address the next byte and/or the next T/C when starting from an address, the address must be increased by 1. To address the next word, the address must be increased by 2.

In the event that an attempt is made to access a word by using an odd-numbered address (operand attribute = W), the controller will enter the Stop state with address error.

The CL150 does not perform range monitoring. Accordingly, the programmer is responsible for staying within the range limits. In the case of write-access range limit violations, data will be destroyed.

Indirect Bit Addresses

OPD ID	Bit Address (dec.)	Instructions	Examples
I	0 - 383	A, AN, O, ON	L 10,A A B I[A] = B M[A]
O	0 - 255	A, AN, O, ON, S, R, =	
M	0 - 1215	A, AN, O, ON, S, R, =	
S	0 - 2047	A, AN, O, ON	
DF	0 - 65535	A, AN, O, ON, S, R, =	
T Status	0 - 127	A, AN, O, ON	
C Status	0 - 63	A, AN, O, ON	

To address the next bit when starting from an address, the address must be increased by 1.

If a range limit violation is detected, the controller will enter the Stop mode. The cause of the fault can then be displayed by means of the programming unit.

Indirect Module Addresses

Operand	Module No.	Instructions	Example
DM	0 - 127	CMx BXx	`L W 10,A` `CM DM[A]`
FC	0 - 127	CMx BAx	`L W 100,A` `CM FC[A]`

To address the next module starting from a module number, the module number must be increased by 1.

If a range limit violation is detected, or if the module is not available, the controller will enter the Stop mode. In both cases, the fault can subsequently be displayed by means of the programming unit.

7.10.10 Parameterized Modules

In case of a program module call, up to 32 parameter values can be transferred. The number of transferred parameter values is stated as part of the module call-up instruction, followed by the actual parameters, starting with the number P0.

All parameters that are to be used as a byte or word in the module being called up are transferred without operand attribute.

All parameters to be used as bits in the module being called up are transferred with the operand attribute B!

⇒ **If times and counters are transferred in the form of parameters without operand attribute, they may be utilized as both a word function, i.e., time/counter value, and a bit function, i.e., time/counter status, in the module which is to be called up.**

Example of parameter transfer:

```
CM      FC100,7   ;Call up FC100 and transfer 7 parameters
P0      43        ;Parameter P0: FC no. as decimal constant K43
P1      4         ;Parameter P1: DM no. as decimal constant K4
P2      O26       ;Parameter P2: Output word with byte address O26
P3      I7.3      ;Parameter P3: Input bit I7.3
P4      T2        ;Parameter P4: Time T2
P5      C13       ;Parameter P5: Counter C13
P6      O10.0     ;Parameter P6: Output bit O10.0
```

Utilization of parameters in called-up module FC100:

```
L       P1,A      ;Load DM no. 4
CM      DM[A]     ;Open DM4
CX      -DM5      ;Open DM5 as 2. data module
L       P0,A      ;Load FC no. 43
CM      FC[A],2   ;Call up FC43 and transfer two parameter values
P0      D2        ;Parameter P0: D2 of active 1st DM, i.e. DM4
P1      DX6       ;Parameter P1: DX6 of active 2nd DM, i.e. DM5
L    W  P2,A      ;Load output word O26
L    W  P4,B      ;Load time value from T2 to B
A    B  P3        ;I7.3
A    B  P4        ;Status of T2
A    B  P5        ;Status of C13
=    B  P6        ;O10.0
```

7.11 Processing of the Interrupt Inputs

In the case of a signal change from 0→1, the interrupt inputs trigger the assigned peripheral interrupt. The response to the interrupt is programmed in the corresponding interrupt OM.

Interrupt I 0	OM10	Priority 1
Interrupt I 1	OM11	Priority 2
Interrupt I 3	OM12	Priority 3

Minimal programming required for interrupt detection and processing:

```
L    W   16#7,A  ;Prepare all three interrupts for enabling.
TIM  W    A,PI   ;Write peripheral interrupt mask
EAI        PI    ;Enable interrupts
```

In the event that a signal transition occurs at one of the interrupt inputs, the associated OM will be called. If this module has not been integrated into the program, the controller will enter STOP mode while returning the corresponding error message. If several interrupts occur at the same time, they will be processed according to the above listed priority ranking.

7.12 Programming of High-Speed Counters

For high-speed counting and positioning tasks, the CL150 is provided with two independent 32-bit counters which can be operated in both upward and downward counting modes. The counting direction can be reversed either through the PLC program or externally, through special directional inputs.

In addition, the „Incremental Rotary Transducer" counter mode is available.

Incremental Rotary Transducer

The „Incremental Rotary Transducer" counter mode is available for counter 1, but not for counter 0.

This mode is enabled by setting the MSB in word 20 of the OM2. This makes all other bits in this word meaningless.

The maximum counter performance is 10 kHz and/or a line count of 10,000 per second.

At the same time, counter 0 may only be used without directional change.

In the event that the maximum counting rate of 10 kHz is used in the "Incremental Rotary Transducer" mode, a slow-down in the PLC cycle rate of approximately 35% can be expected. The response time to the inputs, in particular the interrupt response time is subject to the same influence.

The "Transducer" mode does not permit specified value monitoring.

The "Transducer" mode provides the PLC with a dual interpretation, i.e., both the rising and falling edges of pulses are counted. Accordingly, a rotary transducer with 1000 lines per revolution produces a counter value of 2000 with each revolution.

The permissible limit frequency of 10 kHz is not monitored. If the frequency limit is exceeded, counting errors will be the result.

In the event that the zero-pulse is to be used as an interrupt input, it must have a minimum duration of 80 µs.

When using these counters, the OM2 is a mandatory requirement. All parameter values required for the counter are predefined in the data words DW13-DW27.

For utilization within the PLC program, the counter values and the required control bits can be accessed in S34-S58 of the system area.

OM2 Presettings

Onboard counter settings (OC0: DW 13 / OC1: DW 20)

```
13/20   DEFW W 2#0000000000000000B
                 *******|*****|||       *: reserved
                 |      |     |++------ Definition of transitions
                 |      |     |           00 no transition
                 |      |     |           01 positive transitions
                 |      |     |           10 negative transitions
                 |      |     |           11 both transitions
                 |      |     +-------- Allow external up/down
                                        switchover
                 |      +-------------- Downward (backward) counting
                 |                      not with DW13
                 +--------------------- Incremental rotary transducer
```

Preset actual values, low/high word

OC0: DW 14/15 / OC1: DW 21/22

Values can be changed by means of the PLC program

```
14/21   DEFW W  0
15/22   DEFW W  0
```

Preset specified value 1, low/high word (with DW17/24 not for transducer mode).

OC0: DW 16/17 / OC1: DW 23/24

Values can be changed by means of the PLC program

```
16/23   DEFW W  16#FFFF
17/24   DEFW W  16#FFFF
```

Preset specified value 2, low/high word (with DW19/26 not for transducer mode).

OC0: DW 18/19 / OC1: DW 25/26

Values can be changed by means of the PLC program

```
18/25   DEFW W  16#FFFF
19/26   DEFW W  16#FFFF
```

Upon reaching the specified values, the determined outputs in the output byte 0 can be set automatically if the function in OM2 (DW27) is enabled.

```
;DW 27: Bit number in the onboard output byte O0
;-----------------------------------------
;Upon reaching the specified values, output bits can be set.
;To do so, the corresponding bits must be enabled in this word.
;
DEFW      W      2#0000000000000000
;                ************||||       *: reserved
;                            |||+------ Specified value1 OC0  Bit 0.0
;                            ||+------- Specified value2 OC0  Bit 0.1
;                            |+-------- Specified value1 OC1  Bit 0.2
;                            +--------- Specified value2 OC1  Bit 0.3
```

The outputs are to be reset by means of the PLC program.

System Area

Address	Contents	Comments
	Onboard Counter OC0/OC1	
S34/S46 S36/S48	Actual value low word high word	Actual values can be modified via the PLC program; refer to Control bits
S38/S50 S40/S52	Spec'd value 1 low word high word	Specified values can be modified via the PLC program; refer to Control bits
S42/S54 S44/S56	Spec'd value 2 low word high word	Upon reaching the specified values, defined outputs are set in OM2/DEFW27.
S58/S59	Onboard Counter OC0/OC1 Control bits Bit0 counting direction 0 = upwards 1 = downwards Bit1 set actual value Bit2 set spec'd value Bit3 Bit4 Bit5 Bit6 Bit7	After transfer, bits are deleted.

In the event that, during counting up (or counting down) the maximum value FFFFFFFF_H (minimum value 0_H) is reached, the counter will again start at 0 (FFFFFFFF_H).

The process of setting new actual/specified values is transition-controlled, and occurs in the following sequence:

- The "Set current/specified value" bit must be reset.
- In the system word, the new current/specified value is preset, and the "Set current/specified value" control bit is set once (never cyclically).
- In the subsequent cycle, the value will be transferred and the control bit will be deleted. In the case of actual value manipulations, the system variable again is used as the current display of the actual values.

The updating of actual values in the system area occurs, without exception, in the I/O state. Irrespective of the program processing, the outputs assigned to the specified values are affected immediately.

⇒ **To prevent the loss of pulses, the default entry for change of direction and for counting pulses must not occur simultaneously.**

Program Example

```
; ************************************************************************
; *                         High-Speed Counters                          *
; ************************************************************************

; Examples of onboard counters (high-speed counters) in the CL150

; The CL150 provides 2 high-speed counters, called
; "OC0 onboard counter" and "OC1 onboard counter" hereunder.

; The OM2 initialization module must be linked, and data words
; 13 to 32 in this module must be suitably modified.

;+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

; The OM2 entries for the high-speed counters are described below
;       Definition of onboard counters (OC) (entries permitted)
;       =======================================================
;       Entry 0 = Function NOT available, and/or DO NOT execute
;       Entry 1 = Function available, and/or execute
;
; DW 13: Settings, on-board counter 0 (OC0)
;--------------------------------------------
; 13   DEFW W  2#0000000000000110
;                *******|*****|||       *: reserved
;                       |     |++------ Definition of transitions
;                       |     |           00 no       transition
;                       |     |           01 positive transitions
;                       |     |           10 negative transitions
;                       |     |           11 both     transitions
;                       |     +-------- allow external up/down switchover
;                       |
;                       +-------------- Downward-counting

; DW 14/15: OC0 actual value, LOW/HIGH word
;------------------------------------
; 14   DEFW W  0
; 15   DEFW W  0

; DW 16/17: OC0 spec'd value1   LOW/HIGH word
;--------------------------------------
; 16   DEFW W  16#FFFF
; 17   DEFW W  16#FFFF

; DW 18/19: OC0 spec'd value2   LOW/HIGH word
;--------------------------------------
; 18   DEFW W  16#FFFF
; 19   DEFW W  16#FFFF

;DW 20: Settings for onboard counter 1 (OC1)
;--------------------------------------------
; 20   DEFW W  2#0000000000000000
;               |******|*****|||       *: reserved
;               |      |     |++------ Definition of transitions
;               |      |     |           00 no       transition
;               |      |     |           01 positive transitions
;               |      |     |           10 negative transitions
;               |      |     |           11 both    transitions
;               |      |     +-------- allow external up/down switchover
;               |      |
;               |      +-------------- Downward-counting
;               +--------------------- Incremental rotary transducer

;DW 21/22: OC1 actual value, LOW/HIGH word
;--------------------------------------
; 21   DEFW W  0
; 22   DEFW W  0

;DW 23/24: OC1 spec'd value 1 LOW/HIGH word
;--------------------------------------
;
; 23   DEFW W  16#FFFF
; 24   DEFW W  16#FFFF

;DW 25/26: OC2 spec'd value2 LOW/HIGH word
;--------------------------------------
; 25   DEFW W  16#FFFF
; 26   DEFW W  16#FFFF
```

```
     ;DW 27: Bit number in onboard output byte O0
     ;-------------------------------------------
     ;    Upon reaching the specified values, output bits can be set.
     ;    For this purpose, the corresponding bits must be activated in this word.
     ;
     ;  27  DEFW W   2#0000000000000000
     ;                 ************||||       *: reserved
     ;                             |||+------ Spec’d value1 OC0  bit 0.0
     ;                             ||+------- Spec’d value2 OC0  bit 0.1
     ;                             |+-------- Spec’d value1 OC1  bit 0.2
     ;                             +--------- Spec’d value2 OC1  bit 0.3

     ;+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

     ; Assignments in system area
     ; ---------------------------
     DEF     S34,-OC0_IwL      ;   Onboard Counter OC0 actual value LOW word
     DEF     S36,-OC0_IwH      ;   Onboard Counter OC0 actual value HIGH word
     DEF     S38,-OC0_Sw1L     ;   Onboard Counter OC0 spec’d value1 LOW word
     DEF     S40,-OC0_Sw1H     ;   Onboard Counter OC0 spec’d value1 HIGH word
     DEF     S42,-OC0_Sw2L     ;   Onboard Counter OC0 spec’d value2 LOW word
     DEF     S44,-OC0_Sw2H     ;   Onboard Counter OC0 spec’d value2 HIGH word

     DEF     S46,-OC1_IwL      ;   Onboard Counter OC0 actual value LOW word
     DEF     S48,-OC1_IwH      ;   Onboard Counter OC0 actual value HIGH word
     DEF     S50,-OC1_Sw1L     ;   Onboard Counter OC0 spec’d value1 LOW word
     DEF     S52,-OC1_Sw1H     ;   Onboard Counter OC0 spec’d value1 HIGH word
     DEF     S54,-OC1_Sw2L     ;   Onboard Counter OC0 spec’d value2 LOW word
     DEF     S56,-OC1_Sw2H     ;   Onboard Counter OC0 spec’d value2 HIGH word

     DEF     S58,-OC_StB       ;   Onboard Counter control bits
                               ;
                               ;       S58.0 OC0 counting direction
                               ;               0 = upwards
                               ;               1 = downwards
                               ;       S58.1 Set OC0 actual value
                               ;       S58.2 Set OC0 spec'd values
                               ;
                               ;       S59.0 OC1 counting direction
                               ;               0 = upwards
                               ;               1 = downwards
                               ;       S59.1 Set OC1 actual value
                               ;       S59.2 Set OC0 spec'd values

;+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

     ;DW 27: Bit number in onboard output byte O0
     ;-------------------------------------------
     ;  Upon reaching the specified values, output bits can be set.
     ;  For this purpose, the corresponding bits must be activated in this word.
     ;
     DEFW      W      2#0000000000001111
     ;               ************||||       *: reserved
     ;                           |||+------ OC0 Spec’d value1 bit 0.0
     ;                           ||+------- OC0 Spec’d value2 bit 0.1
     ;                           |+-------- OC1 Spec’d value1 bit 0.2
     ;                           +--------- OC1 Spec’d value2 bit 0.3

;========================================================================

     ; *** Set Specified Value ***

     ; Transition control for 'Set Specified Value' instruction - the loading
     ; procedure for specified value will be enabled only
     ; if a 0-to-1 transition is detected on input I0.4.

     AN   B  I0.4              ; 'Set Specified Value' input bit
     R    B  M120.0            ; reset help marker
     A    B  I0.4
     AN   B  M120.0
     S    B  M120.0
     JPCI    -noload1
```

```
     ; Loading procedure for specified value
     ; Load OC0 specified value (on-board counter0) and enable control bit for
     ; 'Set Specified Value' command. The control bit will be reset automatically
     ; by the PLC once the value has been transferred.
     ; Write spec'd value1  (S40, S38)

7    L    W  10,D
8    L    W  0,C
9    T    W  D,S38              ; OC0 onboard counter, spec'd value1 LOW word
10   T    W  C,S40              ; OC0 onboard counter, spec'd value1 HIGH word
     ; Write spec'd value2  (S44, S42
11   L    W  100,D
12   L    W  0,C
13   T    W  D,S42              ; OC0 onboard counter, spec'd value2   LOW word
14   T    W  C,S44              ; OC0 onboard counter, spec'd value2   HIGH word
     ; Enable 'Set Specified Value' control bit
     ; Note: May be active during one cycle only (see Transition Control, above)
15   L    W  2#0000000000000100,A
16   T    W  A,S58              ; Onboard counter, control bits

          -noload1

     ; *** Set Actual Value ***

     ; Transition control for 'Set Actual Value' instruction - the loading
     ; procedure for actual value will be enabled only
     ; if a 0-to-1 transition is detected on input I0.5.

17   AN   B  I0.5              ; 'Set Actual Value' input bit
18   R    B  M120.1            ; Reset help marker
19   A    B  I0.5
20   AN   B  M120.1
21   S    B  M120.1
22   JPCI    -noload2

     ; Loading procedure for actual value
     ; Load OC0 actual value (onboard counter0) and enable control bit for
     ; 'Set actual value'. The control bit will be reset automatically
     ; by the PLC once the value has been transferred.
     ; Write actual value (S36,S34)
23   L    W  50,D
24   L    W  0,C
25   T    W  D,S34              ; OC0 onboard counter, actual value   LOW word
26   T    W  C,S36              ; OC0 onboard counter, actual value   HIGH word
     ; Enable 'Set Actual Value' control bit
     ; Note: May be active during one cycle only (see Transition Control, above)
27   L    W  2#0000000000000010,A
28   T    W  A,S58              ; Control bits, onboard counter

          -noload2


     ; Read and reset output bits which are set by direct access by
     ; the counter (specified in initialization module OM2, W27)

29   A    B  O0.0            ; OC0 Spec'd value1 was reached
                             ; This location for programming additional responses as required
30   R    B  O0.0
31   A    B  O0.1             ; OC0 Spec'd value2 was reached
                              ; This location for programming additional responses as required
32   R    B  O0.1             ;

33   L    W  M110,A
34   INC  W  A,1
35   T    W  A,M110
36   A    B  A.4
37   =    B  O0.4
38   A    B  I0.7
39   =    B  O0.5
40   L    W  S34,A              ; OC0 onboard counter, actual value    LOW word
41   L    W  S36,A              ; OC0 onboard counter, actual value    HIGH word
42   L    W  S38,A              ; OC0 onboard counter, spec'd value1   LOW word
43   L    W  S40,A              ; OC0 onboard counter, spec'd value1   HIGH word
44   L    W  S42,A              ; OC0 onboard counter, spec'd value2   LOW word
45   L    W  S44,A              ; OC0 onboard counter, spec'd value2   High word

46   EP
```

7.13 Programming of Analog Interface CL150A/CL151A

For the processing of analog values, the CL150A and the CL151A are provided with two analog inputs and one analog output. Additional analog in- and outputs are available at the B~IO modules.

For usage within the PLC program, the analog values and the cable-break messages of the analog inputs are accessible in the system area S64-S82.

When the controller is switched on without the OM2, the processing of all analog inputs within a voltage range of 0-10 V is enabled.

OM2 Settings

OM2 is not an indispensable requirement.

To enable the control processor to restrict processing to channels actually in use, assigned analog inputs are specified in DW 31.

```
;DW 31: Number of used analog inputs (entries permitted)
;----------------------------------------------------------------
;   Entries are possible from 0 to 2
;   0 = no analog input enabled
;   2 = two analog inputs enabled (channel 0 and 1)
```

Select whether or not and which analog inputs are to be standardized and/or whether the analog output is to be standardized.

```
;DW 32: Standardization of the analog channels (entries permitted)
;--------------------------------------------------------
;       Entry 0 = Function  n o t  available and/or to be executed
;       Entry 1 = Function available and/or to be executed
;
;       The selected analog inputs are standardized to   2V  - 10V
;       and the enabled analog output is standardized to 2V  - 10V
;       and/or to                                        4mA - 20mA
;       Entry 0 turns standardization off

  DEFW  W     2#0000000000000000
;               ****||||******||      *: reserved
;                   ||||      |+----  Analog input  Channel 0
;                   ||||      +-----                Channel 1
;                   ||||              Analog output Channel 0:
;                   |||+------------  Standardization
;                   |||               (only with unipolar operation)
;                   ||+-------------  Areas:
;                   ||                0  unipolar  0V - 10V
;                   ||                            0mA - 20mA
;                   ||                1  bipolar -10V - +10V
;                   ||                   (only with power)
;                   |+--------------     Type
;                   |                      0  Voltage
;                   |                      1  Current
;                   +---------------- Averaging
;                                     Analog inputs
```

7.13.1 Analog Inputs

The voltage value present at the analog inputs is converted and subsequently written into the system area for further processing in digital form.

If a cable break is detected during standardized operation (value < 4 mA and/or < 2 V), this will be reported in word S80 of the system area.

System Area

	Analog Inputs
S64	Analog input value channel 0
S66	Analog input value channel 1
S72	Reserved
S74	Reserved
S76	Reserved
S78	Reserved
	Cable break reporting bits
S80	S80.0 Analog input channel 0 S80.1 Analog input channel 1

Value Representation

Value Bit										Without Significance					
9	8	7	6	5	4	3	2	1	0	x	x	x	x	x	x
MSB									LSB						

LSB voltage value without standardization: 10 V/1024 = 9.8 mV

LSB voltage value with standardization: 8 V/1024 = 7.8 mV

7.13.2 Analog Output

The PLC program writes into the system area the digital representation of the voltage or current output value that is to be output, and transfers it to the output in the I/O state.

System area

S82	Analog output value

Value Representation

Value Bit								Without Significance							
11	10	9	8	7	6	5	4	3	2	1	0	x	x	x	x
MSB											LSB				

LSB voltage value without standardization: 10 V/4096 = 2.4 mV

LSB voltage value with standardization: 8 V/4096 = 2.0 mV

LSB current value without standardization: 20 mA/4096 = 4.9 µA

LSB current value with standardization: 16 mA/4096 = 3.9 µA

7.13.3 Program Example

```
; Examples of analog inputs and the analog output on the
; CL150A and CL151A.
;
; Measuring ranges:   analog inputs       0 - 10 Volt
;                                         2 - 10 Volt
;                     analog output       0 - 10 Volt
;                                         0 - 20 mA
;                                         2 - 10 Volt
;                                         4 - 20 mA
; Note: Whenever an example specifies standardized operation,
; the OM2 initialization module must be linked to the program,
; and data word 32 in the OM2 must be appropriately modified.

; **************************************************************************
; *                    Analog Inputs CL150                                 *
; **************************************************************************

DEF     S64,-AnaKan0      ;   Analog value  channel 0
DEF     S66,-AnaKan1      ;   Analog value  channel 1
DEF     S80,-KaBruch      ;   Cable break message channel 0 = Bit 0
                          ;   Cable break message channel 1 = Bit 1
     ; Cable break is reported only during standardized
     ;  2-10 V operation (as specified in OM2 W32)

;    Bit assignment:
;    +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
;    | 15| 14| 13| 12| 11| 10| 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
;    +MSB+---+---+---+---+---+---+---+---+LSB|---+---+---+---+---+---+
;    |<============ Analog value =============>|**** not used ****|

;    Example:    1111111111xxxxxx   =  Analog value  10 Volt
;                 0000000000xxxxxx  =  Analog value   0 Volt

; ========================================================================ag
; *     Start of Sample Programs "Reading and Scaling Analog Values      *
; ==========================================================================

;Example 1
;
; Loading analog value from channel 0 (default operating mode / non-
; standardized) using 0-1023 scaling
;  over 0-10000 (mV). The value is filed in data module DM0, in word 0.

CM      DM0
L    W  S64,A     ; =  Analog value  channel 0
SLR  W  A,6       ; and load into bits 0-11.
                  ; Scale 0-1023 value over 0-10000 mV
L    W  9775,C    ; at weighting 1 bit = 0.9775 mV
MUL  W  C,A       ; a multiply with loaded value
L    W  1000,C    ; --"--
DIV  W  C,A       ; --"--
T    W  A,D0      ; Output scaled analog value in data word 0 of DM

;Example 2

; Reading of analog value from channel 1 (standardized operating mode /
; entry in OM2 DW32) using 0-1023 scaling
; over 2000-10000 (mV). The value is filed in data module DM0, word 2.

CM      DM0
L    W  S66,A     ; =  Analog value  channel 1
SLR  W  A,6       ; and load into bits 0-11
                  ; Scale value 0-1023 over 0-10000 mV
L    W  7820,C    ; at weighting 1 bit = 0.7820 mV
MUL  W  C,A       ; and multiply with loaded value
L    W  1000,C    ; --"--
DIV  W  C,A       ; --"--
L    W  2000,D    ; Scale value 0-8000 over 2000-10000 mV
ADD  W  D,A       ; --"--
T    W  A,D2      ; Output scaled analog value in data word 2 of DM

L    W  S80,B     ; = Cable break message, channel 0 = Bit 0
A    B  B.1       ; --"--
=    B  O0.0      ; Response to cable break

; *      End of sample programs "Reading and Scaling Analog Values       *
```

```
     ; ************************************************************************
     ; *                    Analog Output CL150                               *
     ; ************************************************************************

     DEF     S82,-AnaAus       ; =  Analog output

     ; Default setting  0 - 10 V and/or  0 - 20 mA
     ; or
     ; Standardized operation   2 - 10 V  and/or  4 - 20 mA as defined
     ; in OM2 w32

     ;    Bit Assignment:
     ;    +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
     ;    | 15| 14| 13| 12| 11| 10| 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
     ;    +MSB+---+---+---+---+---+---+---+---+LSB|---+---+---+---+---+---+
     ;    |<================   Analog value   =================>| not used |

     ;    Example:    111111111111xxxx   = Analog value 10 Volt
     ;                 000000000000xxxx  = Analog value  0 Volt (standardized 2 Volt)

     ; ======================================================================ag
     ; *     Start of sample program „Scaling and Outputting Analog Value“    *
     ; ========================================================================

     ;Example 1
     ;
     ;  Outputting an analog value after prior scaling.
     ;  The value of 0-10000 (mV) in data module DM0, on word 20 is to be
     ;  output as a voltage of 0-10 V.

22   CM       DM0       ; Open data module
23   L    W  D20,A      ; Load analog value
                        ; Scale value of 0-10000 mV over 0-4095
                        ; at weight: 1 bit = 0.2442 mV
24   L    W  1000,C     ; --"--
25   MUL  W  C,A        ; --=--
26   L    W  2442,C     ; --"--
27   DIV  W  C,A        ; --"--
28   SLL  W  A,4        ; Load value into bits 4-15
29   T    W  A,S82               = Analog output

     ; * End of sample program "Scaling and Outputting Analog Value“ *

30   EM
```

8 CL150 Instruction List

8.1 Structure of Controller Instructions

Controller Instruction				
Operation part	Operand attribute	Source operand		Destination operand
OPP	OPA	SRC	,	DEST

Examples:

A	B	I0.0		
A	W	-Name	,	A
L	BY	O0	,	B
T	W	C	,	M10
MUL	W	1234	,	D

8.2 Flags

The flags (status bits) are influenced by the following instruction groups:

- Compare
- Convert
- Swap
- Increment, decrement
- Shift
- Rotate
- Add
- Subtract
- Multiply
- Divide

They are equally applicable in program processing instructions (jumps, module instructions) and logical links (flag queries). Also refer to

- 8.17.1 Jumps
- 8.17.2 Module Calls
- 8.17.3 End of Module Instructions
- 8.8 Compare Instruction

Flags	**PG Display**	**JP... CM...**	**Flag Query**		**Explanation**
CY=1	C	...C	A	CY	Carry
CY=0		...CN	AN	CY	Carry Not
O=1	O	...O	A	O	Overflow
O=0		...ON	AN	O	Overflow Not
Z=1	Z	...Z	A	Z	Zero
Z=0		...N	AN	Z	Not Zero
N=1	N	...M	A	N	Negative/Minus
N=0		...TST	AN	N	Positive
AG=1		...AG	AN	Z	Arithmetically greater
			(		
			AN	O	
			AN	N	
			O	O	
			A	N	
			)		
AG=0	N∨Z	...MZ	A	Z	Minus/Zero
			O	N	
			AN	O	
			ON	N	
			A	O	
LG=1		...LG	AN	Z	Logically greater
			AN	CY	
LG=0	C∨Z	...CZ	A	Z	Carry/Zero
			O	CY	

8.3 Key to Abbreviations

OPP	Operation
OPA	Operand attribute
X	Bit
B	Byte
W	Word
SRC	Source Operand
DEST	Destination Operand
I	Input
II	Interface Input, not for RMM65CL
O	Output
IO	Interface Output, not for RMM65CL
M	Marker
T	Time/Timer
C	Counter
D	Data word, within data module
DF	Data field
OC	Onboard counter
S	System area
DM	Data module
DX	2. active data module
FC	Program module
SYM	Symbolic, max. 8 characters
R.bit	Register bit with R = A, B, C, D and bit = 0 through 15
OPD[R]	Register indirect with operand prefix
TI	Timed interrupt, time-controlled processing
PI	Peripheral interrupt
RG	Program rung
A	Permitted operation at RG start
E	Operation concluding RG
AddrMode.	Addressing mode
D	Direct
R	Register A, B, C or D
[R]	Register indirect with operand prefix
Flag	
V	Result of Logic Operation RES
CY	Carry
O	Overflow
N	Negative
Z	Zero
Length	Length of instruction in byte
Time	Processing time of instruction

8.4 Binary Links

Control Instruction				RG		Addr. Mode			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
A	X	I/O/M		•		•			•					4*	0.6	A X I0.0	AND link, query for status 1 4*: Length is valid for branch center only; at start of branch + 2 byte Processing time at start of branch + 0.3 µs
		II		•		•			•					10	10.0	A X II0.2	
		T/C/SYM		•		•			•					4*	0.6	A X T0	
		R.bit		•			•		•					4*	0.6	A X A.0	
		TST		•		•			•					10	21.3	A X P0	
		OPD[R]		•				•	•					10	17.4	A X M[O]	
		CY,Z,N,O		•		•			•					4*	0.6	A X CY	
AN	X	I/O/M		•		•			•					6*	0.9	AN X O0.0	AND link, query for status 0 6*: Length is valid for start of branch only, in branch center + 2 byte Processing time at start of branch + 0.3 µs
		II		•		•			•					10	10.3	AN X II0.2	
		T/C/SYM		•		•			•					6*	0.9	AN X C0	
		R.bit		•			•		•					6*	0.9	AN X B.0	
		TST		•		•			•					10	21.9	AN X P1	
		OPD[R]		•				•	•					10	18.0	AN X M[O]	
		CY,Z,N,O		•		•			•					6*	0.9	AN X Z	
O	X	I/O/M		•		•			•					8	1.2	O X M0.0	OR link, query for status 1
		II		•		•			•					10	10.9	O X II0.3	
		T/C/SYM		•		•			•					8	1.2	O X -SYMBOL	
		R.bit		•			•		•					8	1.2	O X C.0	
		P		•		•			•					10	21.9	O X P10	
		OPD[R]		•				•	•					10	18.0	O X M[O]	
		CY,Z,N,O		•		•			•					8	1.2	O X N	
ON	X	I/O/M		•		•			•					8	1.2	ON X M31.7	OR link, query for status 0
		II		•		•			•					10	10.9	ON X II0.0	
		T/C/SYM		•		•			•					8	1.2	ON X -Name	
		R.bit		•			•		•					8	1.2	ON X D.0	
		P		•		•			•					10	21.9	ON X P1	
		OPD[R]		•				•	•					10	18.0	ON X M[O]	
		CY,Z,N,O		•		•			•					8	1.2	ON X O	
=	X	O/M/SYM			•	•								8	1.2	= X O0.0	Result assignment equal to RES
		IO			•	•								10	13.2	= X IO0.2	
		P			•	•								10	21.6	= X P0	
		R.bit			•		•							8	1.2	= X A.0	
		OPD[R]			•			•						10	20.4	= X M[O]	
S	X	O/M/SYM			•	•								10	0.6	S X O0.0	Set bit when RES = 1 Processing time with RES = 0: + 0.3 µs
		IO			•	•									13.9	S X IO0.5	
		P			•	•									21.3	S X P0	
		R.bit			•		•								0.6	S X A.0	
		OPD[R]			•			•							20.4	S X M[O]	
R	X	O/M/SYM			•	•								10	0.6	R X O0.0	Reset bit when RES = 1 Processing time with RES = 0: + 0.3 µs
		IO			•	•									13.9	R X IO0.7	
		P			•	•									21.3	R X P0	
		R.bit			•		•								0.6	R X A.0	
		OPD[R]			•			•							20.4	R X M[O]	

8.5 Time Programming

8.5.1 Time Instructions

Time starts are activated only when the RES signal undergoes a transition from $_0{\uparrow}^1$.

Prior to the time start, the time value is loaded into the used register.

Reset and stop functions of times are always static and RES signal-dependent.

The time status for logical links is instruction-dependent, and appears in the time diagrams.

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
SP		R	, T , SYM , P		•	• •								8	9.6[1] 17.6[2] 14.0[3] 19.8[1] 27.6[2] 24.0[3]	SP A,T0 SP A,-Symbol SP A,P0	Start time as pulse [1] with RES = stable [2] with RES = $_0{\uparrow}^1$ [3] with RES = $^1{\downarrow}_0$
SPE		R	, T , SYM , P		•	• •								8	9.6[1] 17.6[2] 11.6[3] 19.8[1] 27.6[2] 21.6[3]	SPE A,T0 SPE A,-Symbol SPE A,P0	Start pulse extended [1] with RES = stable [2] with RES = $_0{\uparrow}^1$ [3] with RES = $^1{\downarrow}_0$
SR		R	, T , SYM , P		•	• •								8	9.6[1] 14.8[2] 14.0[3] 19.8[1] 24.8[2] 24.0[3]	SR A,T0 SR A,-Symbol SR A,P0	Start time as raising delay [1] with RES = stable [2] with RES = $_0{\uparrow}^1$ [3] with RES = $^1{\downarrow}_0$
SF		R	, T , SYM , P		•	• •								8	9.6[1] 17.6[2] 11.6[3] 19.8[1] 27.6[2] 20.8[3]	SF A,T0 SF A,-Symbol SF A,P0	Start time as falling delay [1] with RES = stable [2] with RES = $_0{\uparrow}^1$ [3] with RES = $^1{\downarrow}_0$
SRE		R	, T , SYM , P		•	• •								8	9.6[1] 17.6[2] 11.6[3] 19.8[1] 27.6[2] 21.6[3]	SRE A,T0 SRE A,-Symbol SRE A,P0	Start time as raising delay extended [1] bei VKE = stable [2] bei VKE = $_0{\uparrow}^1$ [3] bei VKE = $^1{\downarrow}_0$
RT		T SYM P			•	• •								10	8.4[1] 13.6[2] 18.4[1] 23.6[2]	RT T0 RT -Symbol RT P0	Reset time with RES = 1 [1] with RES = 0 [2] with RES = 1
TH		T SYM P			•	• •								10	8.4 18.4	TH T0 TH -Symbol TH P0	Timer halt with RES = 1, with RES = 0 time continues running

8.5.2 Time Format

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
x	x	x	x	R	R	W	W	W	W	W	W	W	W	W	W
				Time matrix		Time value: 1 - 1023									
				0	0	0: 10 ms									
				0	1	1: 100 ms									
				1	0	2: 1 s									
				1	1	3: 10 s									

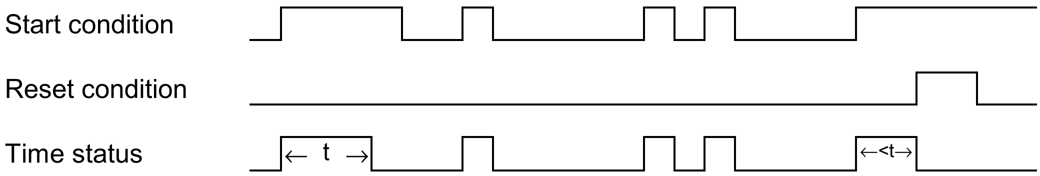
:

Program entry of time constant:

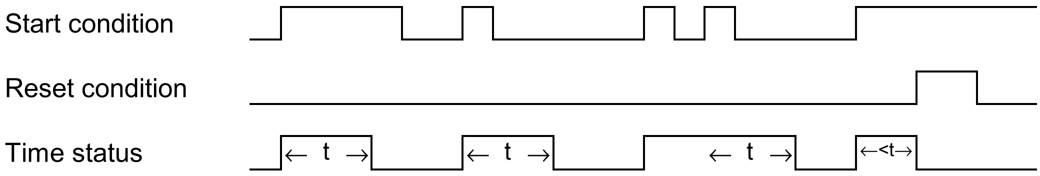
w.r with w as a time value ranging from 1 to 1023 and r as a time matrix from 0 to 3

8.5.3 Time Diagrams

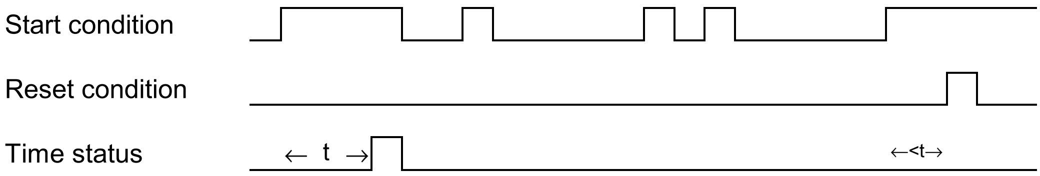
SP, Start Time as Pulse



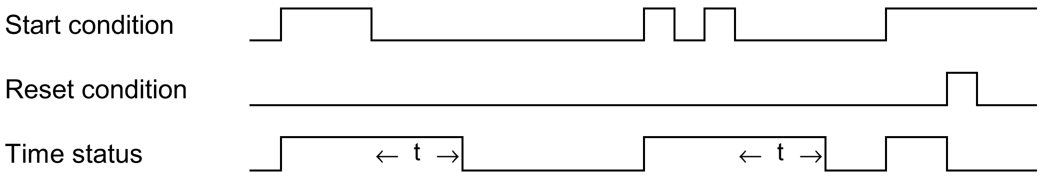
SPE, Start Pulse Extended



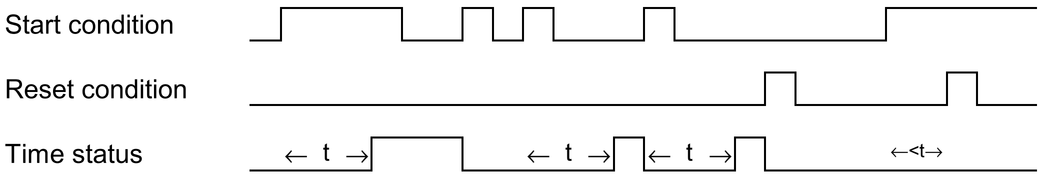
SR, Start Time as Raising Delay



SF, Start Time as Falling Delay



SRE, Start Time as Raising Delay Extended



8.6 Counter Instructions

8.6.1 Software Counter

The setting of the counter and the up- and downwards counting are activated only when the RES signal undergoes a transition from $_0\uparrow^1$.

Beforehand, the required counter value is loaded into the used register.

Counter reset functions are statical and RES signal-dependent.

The counter status for logical links depends on the counter content. For counter values > 0, the status is = 1; for counter values = 0, the status is = 0.

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
SCY		R	, C , SYM , P		•	• •								8	8.4[1] 14.8[2] 9.6[3] 18.4[1] 25.2[2] 19.6[3]	SC A,C0 SC A,-Symbol SC A,P0	Set counter [1] with RES = stable [2] with RES = $_0\uparrow^1$ [3] with RES = $^1\downarrow_0$
CU		C SYM P			•	• •								10	10.4[1] 14.0[2] 11.6[3] 20.5[1] 24.2[2] 21.6[3]	CU C0 CU -Symbol CU P0	Count up [1] with RES = stable [2] with RES = $_0\uparrow^1$ [3] with RES = $^1\downarrow_0$
CD		C SYM P			•	• •								10	10.4[1] 14.0[2] 11.6[3] 20.5[1] 24.2[2] 21.6[3]	CD C0 CD -Symbol CD P0	Count down [1] with RES = stable [2] with RES = $_0\uparrow^1$ [3] with RES = $^1\downarrow_0$
RCY		C SYM P			•	• •								10	8.0[1] 12.0[2] 17.6[1] 22.0[2]	RC C0 RC -Symbol RC P0	Reset counter with RES = 1 [1] with RES = 0 [2] with RES = 1

8.6.2 High Speed Onboard Counter

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
CS		OC			•	•								6	16.8	CS OC0	Onboard counter stop with RES = 1

8.7 Digital Links

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
A	W,B	R	, R				•			0	0	•	•	6	0.9	A W A,B	Digital AND link between source and destination. The result is written to destination.
	W,B	Constant				•				0	0	•	•	8	1.2	A B 10,A	
AN	W,B	R	, R				•			0	0	•	•	8	1.2	AN W A,B	Digital AND NOT link between source and destination. The result is written to destination.
	W,B	Constant				•				0	0	•	•	10	1.5	AN B 10,A	
O	W,B	R	, R				•			0	0	•	•	6	0.9	O W A,B	Digital OR link between source and destination. The result is written to destination.
	W,B	Constant				•				0	0	•	•	8	1.2	O B 10,A	
ON	W,B	R	, R				•			0	0	•	•	8	1.2	ON W A,B	Digital OR NOT link between source and destination. The result is written to destination.
	W,B	Constant				•				0	0	•	•	10	1.5	ON B 10,A	
XO	W,B	R	, R				•			0	0	•	•	6	0.9	XO W A,B	EXCLUSIVE OR link between source and destinationl. The result is written to destination.
	W,B	Constant				•				0	0	•	•	8	1.2	XO B 10,A	
XON	W,B	R	, R				•			0	0	•	•	8	1.2	XON W A,B	EXCLUSIVE OR NOT link between source and destination. The result is written to destination.
	W,B	Constant				•				0	0	•	•	10	1.5	XON B 10,A	

8.8 Compare Instruction

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
CPLA	W,B	Constant	, R			•				•	•	•	•	8	1.2	CPLA W 255,B	Arithmetical comparison. The result is logical and can be evaluated arithmetically.
	W,B	R					•			•	•	•	•	6	0.9	CPLA B B,C	

Comparison Values:

- logical: positive, integer
- arithmetical: two’s complement, signed

Binary result evaluation of compare results by means of conditional jump instruction or by flag query.

Examples:

Compare destination A with Source B		CPLA			
		Logical		Arithmetical	
CPLA	**B,A**	**Jump Instruction**	**Flag Query**	**Jump Instruction**	**Flag Query**
Equal to	A=B	JPZ	A Z	JPZ	A Z
Not equal to	A≠B	JPN	AN Z	JPN	AN Z
Less than	A<B	JPCY	A CY	JPM	AN N A O O N AN O
Less than or equal to	A≤B	JPCZ	A Z O CY	JPMZ	A Z O N AN O ON N A O
Greater than	A>B	JPLG	AN CY AN Z	JPAG	AN Z (AN O AN N O O A N)
Greater than or equal to	A≥B	JPCN	AN CY	JPP	AN N AN O O N A O

8.9 Load, Transfer

8.9.1 Load Instructions

Control Instruction					RG		Addr.			Flag					Length	Time	Example			Comment
OPP	OPA	SRC		DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs				
L	W,B	I/O/M/SYM	,	R			•								see below*	see below *	L	W	I0,A	Load contents of SRC operand to DEST operand
		T/C/Constant					•										L	B	0,B	
		DF/S					•										L	W	S0,C	
		D/DX					•										L	B	D0,D	
		II					•										L	B	II0,A	
		R						•									L	B	B,C	
		OPD[R]							•								L	W	M[C],D	
		P					•										L	B	P0,A	
L	DW	Constant	,	R,R+1			•								12	1.5	L	DW	16#20000,A	Load constant >64 k to register R/R+1

* Instruction Lengths and Processing Times:

SRC	**direct**				**indirect**				**as Parameter**			
	W		**B**		**W**		**B**		**W**		**B**	
	Byte	**µs**	**Byte**	**µs**	**Byte**	**µs**	**Byte**	**µs**	**Byte**	**µs**	**Byte**	**µs**
Constant	4	0.6	4	0.6					8	17.4	8	18.15
R	2	0.3	2	0.3								
I,O,M	4	0.6	4	0.6	8	1.2	8	1.2	8	17.7	8	19.4
T	8	7.3	8	7.3	6	7.3	6	7.3	8	22.6	8	22.6
C	4	1.5	4	0.75	12	1.8	12	1.9	8	18.8	8	18.6
S	4	0.9	4	0.75	8	1.8	8	1.65	8	18.0	8	19.4
DF	4	0.9	4	0.75	8	1.8	8	1.65	8	18.0	8	19.4
D,Dx	8	9.9	8	9.1	6	9.9	6	8.8	8	24.6	8	24.7
II	8	7.9	8	8.2	6	7.6	6	7.9	8	23.2	8	23.5

LIMR Instruction

This instruction is used exclusively for reference list verification, e.g. verification of whether a module is available or if a module with sufficient length is linked!

Control Instruction					RG		Addr.			Flag					Length	Time	Example			Comment
OPP	OPA	SRC		DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs				
LIMR	W	O	,	C				•							6	11.7	LIMR	W	A,C	Load contents of address in A/B to C.

8.9.2 Transfer Instructions

Control Instructions					RG		Addr.			Flag					Length	Time	Example			Comment
OPP	OPA	SRC	DEST		A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs				
T	W,B	R	,	O/M/SYM			•								see below	see below	T	W	A,M0	Transfer contents of the SRC operand to the DEST operand.
			,	S/DF			•								*	*	T	B	B,DF0	
			,	D/DX			•										T	W	C,D0	
			,	IO			•										T	B	D,IO0	
			,	R				•									T	W	A,B	
			,	OPD[R]					•								T	B	B,M[C]	
			,	P			•										T	W	D,P0	

* Instruction Length and Processing Times

SRC	**direct**				**indirect**				**as Parameter**			
	W		**B**		**W**		**B**		**W**		**B**	
	Byte	**µs**	**Byte**	**µs**	**Byte**	**µs**	**Byte**	**µs**	**Byte**	**µs**	**Byte**	**µs**
R	4	0.6										
O,M	4	0.6	8	0.6	8	1.2	8	1.2	8	17.6	8	19.8
D,Dx	8	11.7	8	11.2	6	11.4	6	10.9	8	24.6	8	24.8
IO			8	7.6			6	7.3			8	22.9
S, DF	4	0.9	4	0.75	10	1.8	10	1.65	8	18.0	8	20.2

8.10 Convert Instructions

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
BID	W B	R					•			0	•	0	•	10	26.4 18.3	BID W A BID B B	Binary → BCD (decimal). Result >9999 sets the overflow bit
DEB	W B	R					•			0	•	0	•	10	28.0 17.9	DEB W C DEB B D	BCD (decimal) → Binary. Incorrect BCD encoding sets the overflow bit.
TC	W,B	R					•			•	•	•	•	6	0.9	TC W A TC B B	Converts the register's contents to the two's complement
N	W,B	R					•			0	•	0	•	8	1.2	N W C N B D	Negates the register's contents (one's complement).

Representation of Positive and Negative Numbers

A negative number corresponds to the two's complement of the positive number.

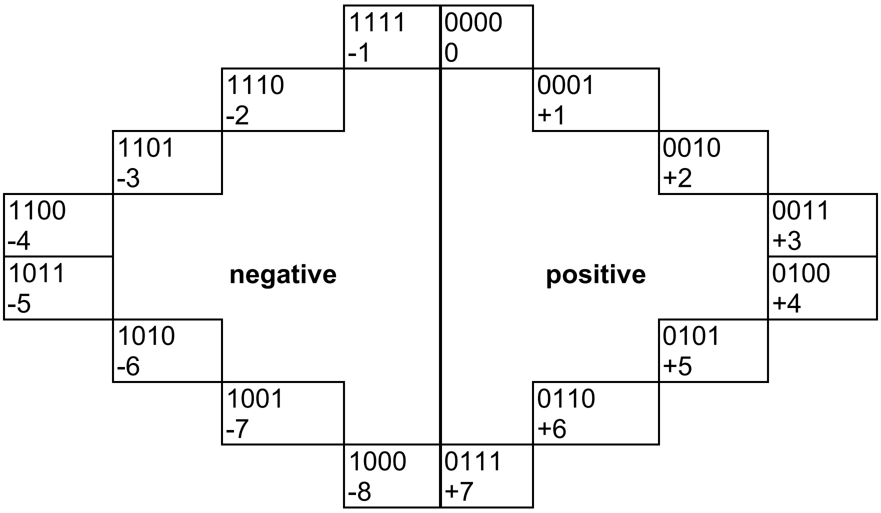
Example:	0 1 1 0	positive number 6
	1 0 0 1	Negation and/or one's complement
	+ 1	
	1 0 1 0	two's complement = negative number 6

In the case of word operations, the differentiation between positive and negative number is determined by Bit 15. In the case of byte operations, it is determined by Bit 7.

Word:	Bit 15 = 0	Byte:	Bit 7 = 0	positive number
	Bit 15 = 1		Bit 7 = 1	negative number

Range of Numbers

Positive number:	Word	0 to 32767	Byte	0 to 127
Negative number:		0 to 32768		0 to 128



8.11 Swap Instruction

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
SWAP	W	R					•							4	0.6	SWAP W A	Byte swap in registers, High byte ↔ Low byte

8.12 Stack Instructions

The available stack area comprises 128 words.

In the event of underflow, bit S28.4 is set in the system area; overflow sets system area bit S28.5.

The I/O state deletes the entire application stack.

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
PUSH	W	R					•							4	7.5	PUSH W A	Saves the register contents to the application stack and lowers the stack address .
POP	W	R					•							4	7.5	POP W B	Raises the application stack address and reads the saved contents from the stack.

8.13 Increment, Decrement

Increment/decrement the contents of SRC:

- by number n, n = 1 to 7
- with n = 0 and with [C] by the number stored in C, max. 7.

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
INC	W,B	R	, n			•				•	•	•	•	6	0.9	INC B A,5	Raise (increment) the contents of SRC.
			, 0				•			•	•	•	•	10	1.5	INC W B,0	
			, [C]					•		•	•	•	•	10	1.5	INC W B,[C]	
DEC	W,B	R	, n			•				•	•	•	•	6	0.9	DEC B A,5	Lower (decrement) the contents of SRC.
			, 0				•			•	•	•	•	10	1.5	DEC W B,0	
			, [C]					•		•	•	•	•	10	1.5	DEC W B,[C]	

8.13.1 Shift Instructions

Shift the contents of SRC:

- by number n
- with n = 0 and with [C], by the number stored in C

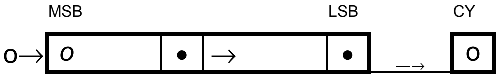
with OPA = W, n = 1 to 15

with OPA = B, n = 1 to 7

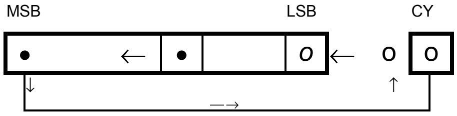
Control Instruction				RG		Addr.			Flag					Length	Time	Example			Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs				
SLR	W,B	R	, n			•				•		0	•	6	0.9*	SLR	W	A,7	Logical SHIFT right
			, 0				•			•		0	•	10	1.5	SLR	B	B,[C]	* applies to W, for B + 0.6 µs
			, [C]					•		•		0	•	10	1.5				
SLL	W,B	R	, n			•				•		0	•	6	0.9*	SLL	W	A,7	Logical SHIFT left
			, 0				•			•		0	•	12	1.8	SLL	B	B,[C]	* applies to W, for B + 0.9 µs
			, [C]					•		•		0	•	12	1.8				
SAR	W,B	R	, n			•				0	•	•	•	6	0.9*	SLL	W	A,7	Arithmetical SHIFT right
			, 0				•			0	•	•	•	10	1.5	SLL	B	B,[C]	* applies to W, for B + 0.6 µs
			, [C]					•		0	•	•	•	10	1.5				

Logical SHIFT

SLR W A,n



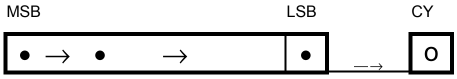
SLL W A,n



Arithmetical SHIFT

All bits being vacated are filled up with the contents of the MSB.

SAR W A,n



In the case of shift operations exceeding one space (n>0), the overflow bit is set after a "1" was shifted through CY.

8.13.2 Rotation Instructions

Shift the contents of the SRC:

- by number n
- with n = 0 and with [C], by the number stored in C

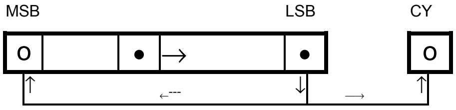
with OPA = W, n = 1 to 15

with OPA = B, n = 1 to 7

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
ROR	W,B	R	, n			•				•	•	•	•	6	0.9*	ROR B A,7	Rotate right
			, 0				•			•	•	•	•	12		ROR W A,0	* applies to W, for B + 0.9 µs
			, [C]					•		•	•	•	•	12		ROR W B,[C]	
ROL	W,B	R	, n			•				•	•	•	•	6	0.9*	ROL B A,7	Rotate left
			, 0				•			•	•	•	•	12		ROL W A,0	* applies to, for B + 0.9 µs
			, [C]					•		•	•	•	•	12		ROL W B,[C]	
RCR	W,B	R	, n			•				•	•	•	•	8	7.2*	RCR B A,7	Rotate through CARRY right
			, 0				•			•	•	•	•			RCR W A,0	* 7.2 µs + 2.4 µs per bit with W
			[C]					•		•	•	•	•			RCR W B,[C]	* 7.8 µs + 2.4 µs per bit with B
RCL	W,B	R	, n			•				•	•	•	•	8	8.1*	RCL B A,7	Rotate through CARRY left
			, 0				•			•	•	•	•			RCL W A,0	* 8.1 µs + 2.4 µs per bit with W
			, [C]					•		•	•	•	•			RCL W B,[C]	* 8.6 µs + 3.0 µs per bit wth B

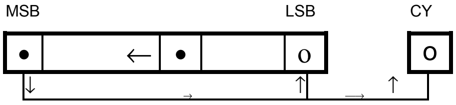
Rotate right

ROR W A,n



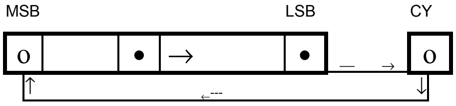
Rotate left

ROL W A,n



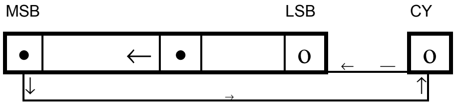
Rotate through CARRY right

RCR W A,n



Rotate through CARRY left

RCL W B,n



With Rotate instructions by more than one digit, the following occurs:

- The overflow bit is set when a "1" has passed through CY.
- The negative bit is set, when the MSB contains a "1".

MSB: Bit 7 when OPA = BY

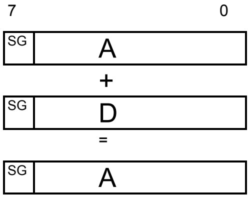
MSB: Bit 15 when OPA = W

8.14 Arithmetics

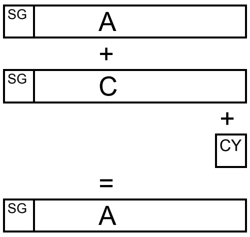
8.14.1 Add Instructions

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
ADD	W,B	Constant	, R			•				•	•	•	•	8	1.2	ADD W 255,B	Fixed point addition of signed integers. Source + Destination = Destination
		R					•			•	•	•	•	6	0.9	ADD B B,C	
ADC	W,B	Constant	, R			•				•	•	•	•	12	1.8	ADC W 255,B	Fixed point addition of signed integers with consideration of CARRY (CY). Source + Destination + CY = Destination
		R					•			•	•	•	•	10	1.5	ADC B B,C	

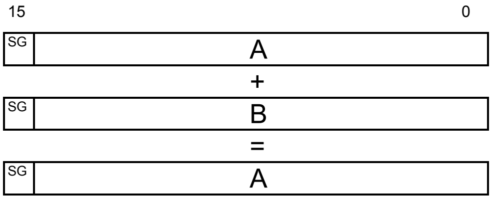
ADD B D,A



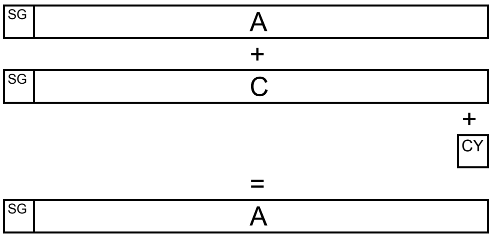
ADC B C,A



ADD W B,A



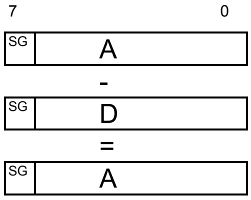
ADC W C,A



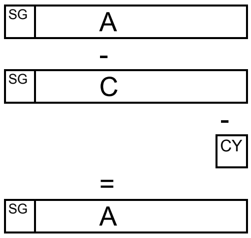
8.14.2 Subtraction Instructions

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
SUB	W,B	Constant R	, R			•	 •			• •	• •	• •	• •	8 6	1.2 0.9	SUB W 255,B SUB B B,C	Fixed point subtraction of signed integers. Destination - Source = Destination
SBB	W,B	Constant R	, R			•	 •			• •	• •	• •	• •	12 10	1.8 1.5	SBB W 255,B SBB B B,C	Fixed point subtraction of signed integers with consideration of negative Carry (-Carry = Borrow). Destination - Source - CY = Destination

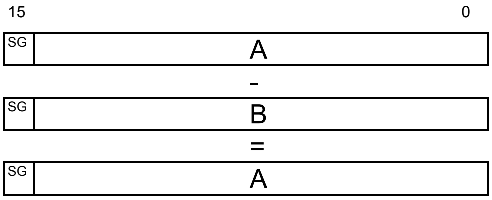
SUB B D,A



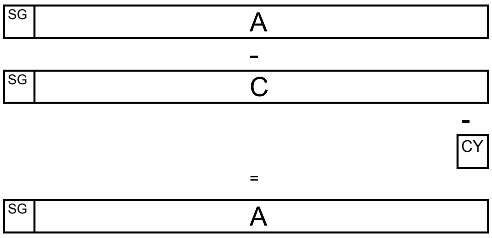
SBB B C,A



SUB W B,A



SBB W C,A

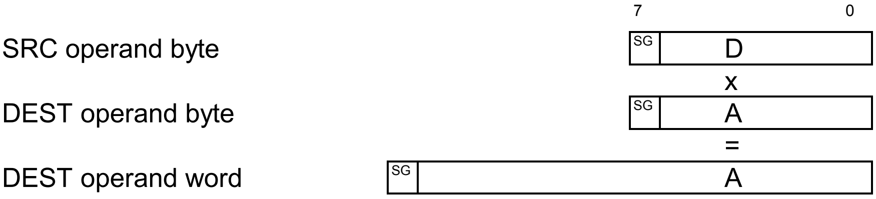


8.14.3 Multiplication Instructions

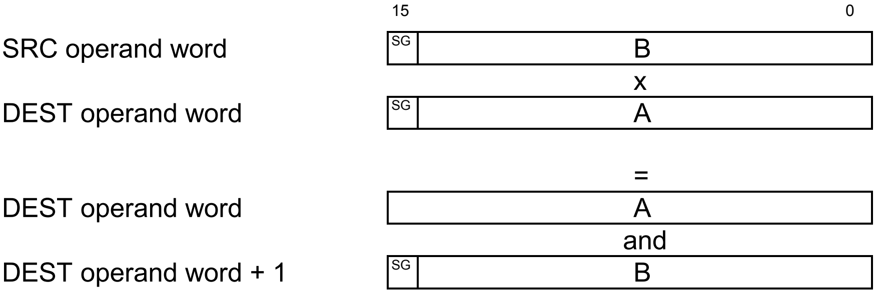
Control Instruction					RG		Addr.			Flag					Length	Time	Example			Comment
OPP	OPA	SRC	DEST		A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs				
MUL	W,B	Constant R	,	R			•	 •			0 0	0 0	• •	• •	10 10	11.1* 10.8*	MUL MUL	W B	100,A B,A	Fixed point multiplication of signed integers. * applies to B, with W + 2.0 µs

The product of any multiplication operation always occupies twice the width of the starting operands.

MUL B D,A



MUL W B,A



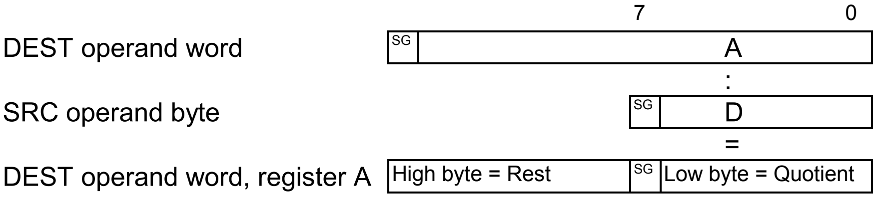
8.14.4 Division Instructions

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
DIV	W,B	Constant	, R			•				0	•	•	•	10	14.0*	DIV W 100,A	Fixed point division of signed integer.
		R					•			0	•	•	•	10	13.7*	DIV B B,A	* applies to W, with B + 0.8 µs

The dividend DEST of any division operation occupies twice the width of the divisor SRC. The result of the division is located in DEST.

Operand Attribute = Byte

DIV B D,A



Operand Attribute = Word

DIV W C,A

In order to facilitate the entry, the following instruction can be used:
L D 16#FFFFEEEE,A
Then, FFFF is located in register B and EEEE in register A.

In the case of a division by 0, the division instruction will not be carried out and the overflow bit will be set.

The overflow bit will also be set if the result is > ±32768.

When the overflow bit is set, the status of the negative bit is undefined.

8.15 Definitions

8.15.1 Parameter Assignments

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
TSTZ	W B X	I/O/M/T/C II/IO S/SYM D/DX /DF Constant				• • • • •								8	-	P0 X I0.0 P1 B II0 P2 W S0 P3 W D0	Parameter definition with parameterized module calls. n = 0 to 31

8.15.2 Local Symbol Names

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
DEF		I/O/M/T/C II/IO S/SYM D/DX /DF FC/DM Constant	, SYM											-	-	DEF I0.0,-symbol DEF I0,-name	Definition of symbolic names that is valid only within the module in which it has been entered. Essential for the creation of library modules.
*		n												6	12.4	*1	Definition of auxiliary flags for program tracking. The processing of these auxiliary flags is entered in the marker buffer only, and can be evaluated only in the case of an error. The auxiliary flag has no influence on the program. n = 0 to 63

8.15.3 System Variable

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
DEFW	W	Constant												4	-	DEFW W 16#0000	Definition of function for system variable in OM2; refer to 6.3 Initialization Module OM2 corresponding chapter

8.16 Parenthesized Instructions, No-Operation Instructions, CARRY Manipulations

Parentheses can be nested. 7 nesting levels are permitted.

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
(														2	0.3		AND-parenthesis open at start of branch
(														6	0.9		AND-parenthesis open at center of branch
)														10	1.5		Parenthesis closed
O(														10	1.5		OR- parenthesis open
)N														14	2.1		Negation of contents of parenthesis
NOP0														2	0.3		No-operation with zeros in the buffer location
NOP1														2	0.3		No-operation with ones in the buffer location
SCY										•				2	0.3		Set CARRY flag unconditionally to 1.
RCY										•				2	0.3		Set CARRY flag unconditionally to 0.

8.17 Program Processing Instructions

8.17.1 Jumps

Jump operations may be executed unconditionally and also in dependence of a binary link and/or mathematical operation. With one exception, namely JP [R], jump operations are programmed symbolically.

The entry point must be located at the start of a program rung.

The given instruction execution time stands for the condition satisfied/not satisfied.

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
JP		SYM				•								12	2.1/--	JP -LABEL1	Unconditional jump to destination -LABEL
JP		[R]						•						12	26.7/-	JP [A]	Unconditional jump by jump distance (words) in reg. A
JPC		SYM			•	•			1					12	10.2/11.1	JPC -LABEL2	conditional, see status bits
JPCI		SYM			•	•			0					12	10.2/11.1	JPCI -LABEL3	conditional, see status bits
JPCY		SYM				•				1				12	2.1/1.8	JPCY -LABEL4	conditional, see status bits
JPCN		SYM				•				0				12	2.1/1.8	JPCN -LABEL5	conditional, see status bits
JPO		SYM				•					1			12	2.1/1.8	JPO -LABEL6	conditional, see status bits
JPON		SYM				•					0			12	2.1/1.8	JPON -LABEL7	conditional, see status bit
JPM		SYM				•						1		12	2.1/1.8	JPM -LABEL8	conditional, see status bits
JPP		SYM				•						0		12	2.1/1.8	JPP -LABEL9	conditional, see status bits
JPZ		SYM				•							1	12	2.1/1.8	JPZ -LABEL10	conditional, see status bits
JPN		SYM				•							0	12	2.1/1.8	JPN -LABEL11	conditional, see status bits
JPAG		SYM				•			Binary Flag Query refer to 8.2 Flags					12	2.1/1.8	JPAG -LABEL12	conditional, see status bits
JPMZ		SYM				•								12	2.1/1.8	JPMZ -LABEL13	conditional, see status bits
JPLG		SYM				•								12	2.1/1.8	JPLG -LABEL14	conditional, see status bits
JPCZ		SYM				•								12	2.1/1.8	JPCZ -LABEL15	conditional, see status bits

The jump instruction JP [R] causes an unconditional jump whose destination must always be a jump instruction. This instruction is designed for easy realization of jump distributors. The controller goes into Stop if the entry point is not a jump instruction. Then, the error status of the programming unit indicates the cause of the error.

Example

PLC Program Interlude

```
Jump distance calculation in register A for the following jump sequence A
may contain odd values (1, 3, 5, ...) only.
JP      [A]         ; 1-word instruction        fixed program sequence
JP      -DEST1      ; 2-word instruction
JP      -DEST2      ; 2-word instruction
:
JP      -DESTn      ; 2-word instruction
```

```
        -DEST1      ; Partial program 1
PLC Program
JP      -End
```

```
        - DEST2     ; Partial program 2
PLC Program
JP      -End
```

```
:
:
```

```
        - DEST n    ; Partial program n
PLC Program
JP      -End
```

```
        -End
PLC Successor Program
:
```

8.17.2 Module Calls

Module call instructions may be executed unconditionally as well as in dependence of a binary link and/or a mathematical operation.

Two data modules may be kept enabled at the same time. For this purpose the following module calls are available :

- BA, BAB DMx: enables DMx as 1. DM
- BX, BXB DMy: enables DMy as 2. DM

Control Instruction				RG		Addr.			Flag					Length	Time	Example		Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs			
CM		DM				•								6	20.8	BA	DM0	unconditional, direct
		FC				•								10	46.0	BA	FC0	
		FC	, n			•								10	46.0	BA	FC1,2	parameterized, list follows
		FC[R]						•						10	48.8	BA	FC[A]	indirect
		FC[R]						•						10	23.4	BA	DM[A]	
CMC		DM			•	•								6	6.6/22.4*	BAB	DM0	conditional, RES dependent
		FC				•								10	10.5/48.8*	BAB	FC0	direct
		FC	, n			•								10	10.5/48.8*	BAB	FC1,2	parameterized, list follows
		FC[R]						•						10	10.5/50.2*	BAB	FC[A]	indirect
		DM[R]						•						10	6.6/25.2*	BAB	DM[A]	* RES = 1
CX		DM				•								6	20.8	BX	DM0	unconditional, direct
		DM[R]						•						10	23.7	BX	DM[A]	
CXC		DM			•	•								6	6.6/22.4*	BXB	DM0	conditional, RES dependent
		DM[R]						•						10	6.6/25.5*	BXB	DM[A]	* RES = 1

8.17.3 End of Module Instructions

End of Module instructions may be executed unconditionally as well as in dependence of a binary link and/or mathematical operation.

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	μs		
EM														6	31.6	BE	unconditional
EMC					•									6	7.2 / 33.6*	BEB	conditional, RES-dependent * RES = 1

8.17.4 Interrupt Instructions

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	μs		
TIM		R	, TI PI			•								8	17,6 24,4	TIM A,TI	Transfer interrupt mask. Writing of interrupt mask for disabling and/or enabling interrupts. The masks were first loaded into a register
LIM		TI PI	, R			•								8	14,0 13,6	LIM PI,B	Load interrupt mask defined interrupt mask
EAI		TI PI				•								6	14,8 28,4	EAI PI	Enable interrupt group
DAI		TI PI				•								6	16,0 18,4	DAI PI	Disable interrupt group
LAI		TI PI	, R			•								8	13,6 16,8	LAI PI,A	Load interrupt register, read statuses
RAI		R	, TI PI			•								8	42,8 17,2	RAI A,TI	Reset of interrupts after previously loaded mask.

PI Peripheral Interrupts Mask,

Bit 7	Bit 6	Bit 5	Bit4	Bit 3	Bit 2	Bit 1	Bit 0
					PI2*	PI1*	PI0*
					OM12	OM11	OM10
					I0.2	I0.1	I0.0

*Peripheral interrupts are generally disabled

TI Time Interrupts Mask

Bit 7	Bit 6	Bit 5	Bit4	Bit 3	Bit 2	Bit 1	Bit 0
						TI1*	TI0*
						OM19	OM18

* Time interrupts are generally enabled

8.17.5 Program Stop/End

Control Instruction				RG		Addr.			Flag					Length	Time	Example	Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs		
HLT														6	-	HLT	Halt instruction, the controller goes into Stop, the program address is entered into the error stack and the outputs are cleared (deleted).
EP														6	-	EP	Program end, the I/O state is initialized and the program cycle starts again at the beginning. At least one EP must be available.

8.17.6 1ms Timer

Control Instruction				RG		Addr.			Flag					Length	Time	Example			Comment
OPP	OPA	SRC	DEST	A	E	D	R	[R]	V	CY	O	N	Z	Byte	µs				
SMST		R					•							8	13.6 bis 17.8	SMST		A	depends on CEN, RES and R/A
LMST			R				•							8	10	LMST		B	

SMST <Register> Start/Control instruction for 1ms timer

The 1ms timer is directly assigned to a micro controller hardware timer. This makes parallel processing possible without a negative impact on the program processing time.

The 1ms timer can create times of up to 400 ms with an accuracy of 6.4 µs.

In the event of timer end or timer overflow the flag S31.7 is set in the system area.

If OM17 is linked to the program, it is automatically called at timer end and timer overflow.

The following information can be expected to appear in the designated register:

Control flags			not used				Upper range value in 1ms matrix, maximum 190 hex = 400 ms								
CEN	RES	R/A					EW8	EW7	EW6	EW5	EW4	EW3	EW2	EW1	EW0

CEN, Count-Enable

- 0 = Timer Stop
- 1 = Timer Start

RES, Reset

- 0 = Actual timer value remains
- 1 = Actual timer value is reset

R/A, „Rund/Ablauf”

R/A stands for the following: R = Timer runs cyclically; A = Timer runs one time only and stops at the end of the operation

- 0 = At the end of its operation, the timer automatically stalls
- 1 = Timer runs cyclically

LMST <Register> Read instruction for 1ms timer

Reads the actual timer value with an accuracy of 0.1 ms from the micro controller.

9 Fieldbus Connections

Our product line comprises the following versions with fieldbus connection:

Designation	Order no.	Function
B~IO CL150-DP	1070 081 304	CL150 with PROFIBUS-DP slave connection, real time clock
B~IO CL151-DP	1070 081 463	CL150 with PROFIBUS-DP slave connection, real time clock and 2. serial interface
B~IO CL150-CAN	1070 081 467	CL150 with CANopen slave connection, real time clock
B~IO CL151-CAN	1070 081 470	CL150 with CANopen slave connection, real time clock and 2. serial interface
B~IO CL150-DEV	1070 081 473	CL150 with DeviceNet slave connection, real time clock
B~IO CL151-DEV	1070 081 476	CL150 with DeviceNet slave connection, real time clock and 2. serial interface
B~IO CL150-IBS	1070 081 386	CL150 with Interbus-S slave connection, real time clock
B~IO CL151-IBS	1070 081 453	CL150 with Interbus-S slave connection, real time clock and 2. serial interface

This manual is limited in its descriptions of the relevant fieldbus interfaces of these CL150 versions; it contains only such information that is essential for programming and operating the modules.

More detailed information about the fieldbus systems are not included. The only difference between the CL150 and CL151 fieldbus version is a second serial interface. Below, the designation CL150 is also applicable to the CL151 versions.

9.1 Switching Matrix

For the purpose of communication with the primary control, the host PLC, a switching matrix has been defined.

The structure of the switching matrix is equal for all fieldbus versions. The only difference is its data width.

This switching matrix comprises the following functions:

- Synchronization of the decentralized controller with the host controller;
- Transfer of status messages from the decentralized controller to the host controller;
- User-defined data transfer from the decentralized controller to the host controller.

During the programming and configuration of the host controller, addresses are assigned to the switching matrix by means of the corresponding fieldbus‘ configuration tools.

For Bosch controllers, these are I/O and/or EI/EO addresses
(EI = Extended Input; EO = Extended Output).

Host Controller		**Switching Matrix**			**Decentralized PLC** Data Field
Output field	⇒	Control word bit 0-7	⇒	read	n*
	⇒	Control word bit 8-15	⇒		n + 1
	⇒	Data field Host→Slave	⇒		...
	⇒	...	⇒		...
	⇒	...	⇒		...
	⇒	...	⇒		n + 63
Input field	⇐	Status word bit 0-7	⇐	write	n + 64
	⇐	Status word bit 8-15	⇐		...
	⇐	Data field Host←Slave	⇐		...
	⇐	...	⇐		...
	⇐	...	⇐		...
	⇐	...	⇐		n + 127

▨ : application-oriented usable
*: The start address of the switching matrix is entered in OM2.

The switching matrix basically consists of

- a control word bit 0-15,
- a status word bit 0-15
- and a data field for Host→Slave and for Host←Slave with variable size.

By principle, the width of the data field for Host→Slave and the one for Host←Slave are equal in size and symmetrical.

By principle, the maximum width of the switching matrix in the CL150‘s data field is 64 byte Read and 64 byte Write.

The switching matrix start address n can be set in the OM2. The data direction is predefined:

- DFn through DFn+63 for Read, data direction Host→Slave
- DFn+64 through DFn+127 for Write, data direction Host←Slave

In the fieldbus connections, the used data width of the switching matrix can be set individually.

Control Word, Data Direction Host→Slave

If Control_Enable is set = 1 in the OM2 (DW2, bit 4), the bits 0-7 are evaluated by the operating program.

If Control_Enable is set = 0, the bits 0-7 are ignored by the operating program.

Bit	Designation	Explanation	Function
0	RUN_REQ	run_request	0: CL150 remains in Stop
			1: CL150 goes into Run, if no other stop source is present.
1	OUT_EN	output_enable	0: CL150 goes into „disabled outputs“
			1: The outputs of the CL150 are enabled if no other CLAB source is present.
2 to 7	reserved		
8 to 15	control flags: here, application-oriented control and synchronization flags can be determined.		

Status Word, Data Direction Host←Slave

Bit	Designation	Explanation	Function
0	RUN	operating state	0: CL150 is in Stop 1: CL150 is in Run
1	Stop_on_user	Stop state by operation	0: No stop source by operation could be detected 1: A stop source by operation is available: Stop request through - programming unit - switch - digital input
2	PLC-Program not available	no PLC program loaded	0: PLC program is loaded 1: PLC program is not loaded
3	reserved		
4	DIAG	Diagnosis	0: no diagnosis available 1: a group diagnosis is available, identical with the entry in system area S31.0
5	DIAG_on_user	User diagnosis	With regard to system area S90.0, a user diagnosis can be generated: 0: User diagnosis inactive 1: User diagnosis active
6	reserved		
7	VALID	Status word is valid	0: Status word is not valid 1: Status word is valid and can be evaluated by user
8 to 15	status flags: here, the user can determine freely definable status and synchronization flags.		

9.2 PROFIBUS-DP Interface

B~IO CL150-DP and CL151-DP provide a PROFIBUS-DP interface as per EN50170-2.

Type	RS485
Electrical isolation	yes
Baud rate	up to 12 MBaud
DP connection	9-pin socket connector D-SUB
Terminal address	set via 2 rotating encoding switches

The interface can be used as a slave interface only.

A Device Data Base File (DDBF) as per EN50170-2-DP is delivered together with the CL150-DP.

This file contains data for connecting the module to any DP master (as per EN 50170-2-DP). The manufacturer of the master delivers and/or defines the relevant configuration tools.

The bus station number BTN is set by means of the rotary encoding switches on the device.

Pin Assignment

Pin No.	Designation	Explanation
1		
2		
3	RxD/TxD	Received/Transmitted Data - P
4	CNTR_P	Repeater Control Signal - P
5	DGND	Data Reference Potential
6	VP	Supply Voltage Plus
7		
8	RxD/TxD_N	Received/Transmitted Data - N
9	DGND	Repeater Control Signal - N

Baud Rates

The CL150-DP automatically recognizes the baud rate that has been set in the PROFIBUS-DP. Baud rates of 9.6 kBaud up to 12 MBaud are supported.

Bus Station Address

The bus station address of the B~IO CL150-DP is set decimally by means of the two rotating encoding switches S3 and S4. S3 specifies the ten’s digit, S4 the unit‘s digit.

Addresses are possible from 2 through 99. Each address may be specified for each PROFIBUS-DP one time only.

The set address will be established by the CL150 when the power supply is switched on. An alteration of the set address during operation takes effect only the next time the power supply is switched on.

Indication of the DP Interface

The operating states of the DP interface are indicated by 2 light emitting diodes (LEDs):

Explanations:

○	LED is not lit
●	LED is lit

BUS	● green	Bus connection is in normal operation, no error display
	○	Error
BF	● red	Bus error (baud rate, bus station address, bus cable)
	○	Bus without error

Switching Matrix

The data width of the switching matrix regarding the fieldbus and thus regarding the host controller can be set to several levels:

2, 4, 8, 16, 24, 32, 40, 48, 56, 64 byte

each with byte consistency or with overall consistency.

The levels are selected by means of the relevant configuration tools. For Bosch controllers, these are provided by the WinDP configuration software.

Consistency

The consistency of the transfer data can be set by means of the WinDP configuration software. The operation system of the B~IO CL150-DP module processes the switching matrix coherently in the I/O cycle of the controller. Therefore, the consistency settings apply to the contents of the switching matrix as well.

Device Data Base File DDBF

The DDBF as per DIN EN 50170-2 contains all data necessary for connecting the B~IO CL150-DP to any DP master. The file is evaluated by the DP configuration program.

The DDB-File’s name for B~IO CL150-DP is RBxx0119.GSD; xx indicates the release.

9.3 CANopen Interface

OSI

The model of the CANopen communication is oriented towards the ISO/OSI Basic Reference Model.

Reference:

- ISO 7498, 1984, Information Processing Systems - Open System Interconnection - Basic Reference Model

CAN

The lower layers of the Basic Reference Model are based on CAN.

Reference:

- Robert Bosch GmbH, CAN Specification 2.0 Part B, September 1991
- ISO 11898, November 1993, Road Vehicles, Interchange of Digital Information - Controller Area Network CAN for high-speed Communication

CANopen

All CANopen requirements and guidelines are located in the CiA specifications.

Reference:

- CiA/DS 102,CAN Physical Layer for Industrial Applications
- CiA/DS 201, CAN Reference Model, February 1996
- CiA/DS 202-1, CMS Service Specification, February 1996
- CiA/DS 202-2, CMS Protocol Specification, February 1996
- CiA/DS 202-3, CMS Encoding Rules, February 1996
- CiA/DS 203-1, NMT Service Specification, February 1996
- CiA/DS 203-2, NMT Protocol Specification, February 1996
- CiA/DS 204-1, DBT Service Specification, February 1996
- CiA/DS 204-2, DBT Protocol Specification, February 1996
- CiA/DS 205-1, LMT Service Specification, February 1996
- CiA/DS 205-2, LMT Protocol Specification, February 1996
- CiA/DS 206, Application Specific Data Types, February 1996
- CiA/DS 207, Application Layer Naming Specification, Feb. 1996
- CiA/DS 301, CAL-based Communication Profile, Oct. 1996

Electrical isolation	yes
Baud rate in kbaud	10/20/50/125/250/500/1000
CAN connection	9-pin inline contact strips D-SUB

Connection

The CANopen is connected through a 9-pin D-SUB socket which is screwed to the X71 D-SUB connector of the CL150-CAN.

The connection assignments correspond to the CANopen standards:

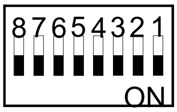
- CIA/DS 102, CAN Physical Layer for Industrial Applications Feb. 1996
- CiA/DS 301, CAL-based Communication Profile, Oct. 1996.

Pin	Signal	Explanation
1		Reserved
2	CAN_L	CAN_L bus line, dominant low
3	CAN_GND	CAN Ground
4		Reserved
5	(CAN_SHIELD)	Optional CAN Shield
6		Reserved
7	CAN_H	CAN_H bus line, dominant high
8		Reserved
9		Reserved

Table 1: Connector X71, CANopen

Baud Rate, DIP Switch S3

The baud rate of the CL150-CAN bus connection is set by means of the S3 DIP switch.



Ex works, all switches are set to OFF.

SW3, SW2, SW1	Baud rate
SW6, SW5, SW4	Default switching matrix length
SW7	Reserved for Bosch
SW8	OFF: CL150-CAN is CANopen-conform
	ON: CL150-CAN is Bosch rho-conform

Baud Rate [kBaud]	SW3	SW2	SW1	max. Cable Length [m]	Comment
1000	on	on	on	25	
	on	on	off		reserved
500	on	off	on	100	
250	on	off	off	250	
125	off	on	on	500	
50	off	on	off	1000	
20	off	off	on	2500	
10	off	off	off	5000	min baud rate

Table 2: Setting the baud rate

Switching Matrix Length [Byte]	SW6	SW5	SW4	Comment
32	on	on	on	Status/Ctrl + 30 byte I/O
24	on	on	off	Status/Ctrl + 22 byte I/O
20	on	off	on	Status/Ctrl + 18 byte I/O
16	on	off	off	Status/Ctrl + 14 byte I/O
12	off	on	on	Status/Ctrl + 10 byte I/O
8	off	on	off	Status/Ctrl + 6 byte I/O
4	off	off	on	Status/Ctrl + 2 byte I/O
2	off	off	off	Status/Ctrl, ex works

Table 3: Setting the default switching matrix length

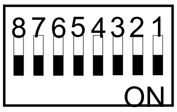
Ex works:

- 1Mbit/s,
- Switching matrix length 2 byte,
- CANopen

off	off	off	off	off	on	on	on

Node ID, DIP Switch S4

Each bus connection at the CANopen must receive its own node ID. A bus station address can be assigned one time only in the entire CANopen. The node ID 1 to 127 of the CL150-CAN bus connection is set by means of the S4 DIP switch.



SW7 to SW1	Node ID 1 to 127
SW8	reserved

Node ID	SW7	SW6	SW5	SW4	SW3	SW2	SW1	Comment
0	off	off	off	off	off	off	off	not usable
1	off	off	off	off	off	off	on	
2	off	off	off	off	off	on	off	
3	off	off	off	off	off	on	on	
4	off	off	off	off	on	off	off	
...								
126	on	on	on	on	on	on	off	
127	on	on	on	on	on	on	on	not permitted with more than 16 I-bytes or 16 O-bytes.

Table 4: Setting the node ID

The address of a node ID must not be set to 0. The setting node ID = 0 leads to a system halt.

The set node ID is reread upon Power-On, after „NMT Reset Node“ and after „NMT Reset Communication“ of the CL150-CAN bus module.

An alteration of the node ID during operation will only take effect after one of the above mentioned events.

The bus station address can be written onto the labeling field on the front panel.

Ex works: Node ID = 1.

Indication of the CAN Interface

The operational state of the CAN interface is indicated by 2 LEDs:

Explanations:

○	LED is not lit
●	LED is lit
❆❆	LED flashes

BUS	● green	Bus connection is in operational mode

	❆❆ green	Bus connection is in preoperational mode
		• Slave has not yet received an NMT_Start node message
		• Guarding failure
		• Synchronization error, missing PDOs in SYNC mode
		• CAN master has set Slave into preoperational mode, due to the following:
		  • NMT_RESET_NODE
		  • NMT_RESET_COM
		  • NMT_STOP
		  • NMT_DISCONNECT
		  • NMT_PREOPERATIONAL

	○	Bus connection is in initialization mode
		• Wrong node ID, node ID = 0 or node ID >127
		• Partner not reachable
		  • remaining CAN bus stations switched off.
		  • Bus cable removed, defect or faulty
		  • Incorrect baud rate has been selected

BF	● red	Bus off
	❆❆ red	• Invalid node ID, node ID = 0, or node ID > 127 • Synchronization error, a SYNC message has been received in SYNC mode, without prior transmission of the correct number of PDOs. • Bus Warning Level exceeded
	○	Bus o.k.

Switching Matrix

The length of the switching matrix is limited to a maximum of 32 input bytes and 32 output bytes and a maximum of 4 PDOs each for receiving and sending, 8 byte per PDO.

The length of the switching matrix can be set by means of DIP switches or configurated by using CAN.

Consistency

The consistency of the transfer data can be set by means of the WinCAN configuration software as to the extent of a PDO. Therefore, consistency can be guaranteed for transferring a maximum of 8 bytes. The operating system of the B~IO CL150-CAN module processes the switching matrix coherently in the I/O cycle of the controller. Thus, the consistency settings also apply to the contents of the switching matrix.

Electronic Data Sheet EDS

The EDS is a CiA specified ASCII file which describes the objects of a CANopen device. This file is available for the CL150-CAN module and is named RBxxCL15.EDS; xx indicates the release.

The EDS can be read into certain CANopen configuration tools, e.g. the Nodemaster configuration tool by Vektor, which provides the user with a comfortable configuration solution.

9.4 DeviceNet Interface

Requirements and guidelines from Open DeviceNet Association, Inc. (ODVA):

- DeviceNet Specification Volume I, Release 2.0
- DeviceNet Communication Model and Protocol
- DeviceNet Specification Volume II, Release 2.0
- DeviceNet Device Profiles and Object Library

Electrical isolation	yes
Baud rate in kbaud	125/250/500
Connector	5-pin Open Style Connector

Connection

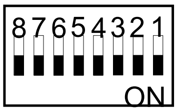
The DeviceNet is connected through a 5-pin connector according to the DeviceNet specifications: Pluggable Open Connector. The connection assignment corresponds to the DeviceNet standard: DeviceNet Specification Volume 1, Release 2.0.

Pin	Signal	Explanation
5	V+	24V bus power supply
4	CAN+	CAN_H bus line, dominant high
3	Shield	Shield
2	CAN-	CAN_L bus line, dominant low
1	V-	GND bus power supply

Table 5: X71 Connector, DeviceNet

DIP Switch S3

The baud rate and the switching matrix length are set by means of the DIP switch S3.



The DIP switch is read upon the following event:

- After Power-On
- After receiving the reset node message
- After switching on the bus power supply
- Upon Re-Init after Bus off

SW3, SW2, SW1	Baud rate
SW6, SW5, SW4	Default switching matrix length
SW7, SW8	Reserved for Bosch

Baud Rate [kBaud]	SW3	SW2	SW1	Max. Cable Length [m]	Explanation
1000	on	on	on		reserved
	on	on	off		reserved
500	on	off	on	100	
250	on	off	off	250	
125	off	on	on	500	
50	off	on	off		reserved
20	off	off	on		reserved
10	off	off	off		reserved

Table 6: Setting the baud rate

Switching Matrix Length [Byte]	SW6	SW5	SW4	Explanation
32 byte	on	on	on	Status/Ctrl + 30 byte I/O
24 byte	on	on	off	Status/Ctrl + 22 byte I/O
20 byte	on	off	on	Status/Ctrl + 18 byte I/O
16 byte	on	off	off	Status/Ctrl + 14 byte I/O
12 byte	off	on	on	Status/Ctrl + 10 byte I/O
8 byte	off	on	off	Status/Ctrl + 6 byte I/O
4 byte	off	off	on	Status/Ctrl + 2 byte I/O
2 byte	off	off	off	Status/Ctrl, ex works

Table 7: Setting the default switching matrix length

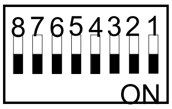
Ex works:

- 500Kbit/s
- Switching matrix length 2 byte

off	off	off	off	off	on	off	on

MAC ID, DIP Switch S4

Each bus connection at the DeviceNet must receive its own MAC ID bus station address. A bus station address can be assigned one time only in the entire DeviceNet. The MAC ID 0 to 63 of the B~IO CL150-DEV bus connection is set by means of the S4 DIP switch.



SW6, SW5, SW4, SW3, SW2, SW1	MAC-ID 1 to 63
SW7,SW8	reserved

MAC-ID	SW6	SW5	SW4	SW3	SW2	SW1
0	off	off	off	off	off	off
1	off	off	off	off	off	on
2	off	off	off	off	on	off
3	off	off	off	off	on	on
4	off	off	off	on	off	off
...						
63	on	on	on	on	on	on

Table 8: Setting the MAC ID

The DIP switch S4 is read upon the following events:

- After switching on the 24V supply UI
- After receiving the „Reset all connection objects“ message
- After switching on the bus power supply
- Upon Re-Init after Bus-Off

An alteration of the MAC ID during operation will only take effect after one of the above mentioned events. The bus station address can be written onto the labeling field on the front panel.

Indication

The operational states of the CL150-DEV bus connection are indicated by 2 LEDs:

Explanations:

○	LED is not lit
●	LED is lit
❋❋	LED flashes

LED	Indication	Explanation
BUS		Operation display
	● green	24V supply via bus is available. Module is in operating state.
	❋❋ green	24V supply via bus is missing
	○	Bus connection is in INIT mode
MNS		Module/Net Status
	● green	Module is online with bus, connections for communication have been established
	❋❋ green	Module is online with bus, connections for communication have not been established
	❋❋ red	Timeout, module has not been addressed by bus master within the set monitoring time
	● red	Bus error, BUS-OFF state or Rx/Tx-Queue overrun Possible causes: - Wrong baud rate - Bus cable or connector is defect or connected incorrectly - Strong interferences on bus The bus error status can be left by pressing the RUN/STOP switch (transition RUN→ STOP) if the cause for the error has been eliminated.
	○	Module is in INIT mode, possible cause is a missing 24V power supply through the CAN bus; refer to LED BUS.

Switching Matrix

The length of the switching matrix is limited to a maximum of 32 input bytes and 32 output bytes and a maximum of 4 PDOs each for receiving and sending, 8 byte per PDO.

The first word of the input switching matrix and the first word of the output switching matrix each contain a control and/or status word.

The length of the switching matrix can be set by means of DIP switches or configurated by using DevNet.

Consistency

Based on the protocol characteristics, the transfer data as a whole is consistent. The operating system of the B~IO CL150-DEV module processes the switching matrix coherently in the I/O cycle of the controller. Thus, the consistency also applies to the contents of the switching matrix.

Electronic Data Sheet EDS

The EDS is an ASCII file specified by the CiA, which describes the objects of a DeviceNet device. This file is available for the B~IO CL150-DEV module and is named RBxxCL15.EDS; xx indicates the release.

The EDS can be read into certain DeviceNet configuration tools, which provides the user with a comfortable configuration solution.

9.4.1 Supported DeviceNet Objects

Identity Object, Class 1

Class and Instance Attributes:

Object Class [Hex]	Object Instance	Object Attribute	Object Description
1	0	1	Revision, revision of the identity object
1	1	1	Vendor ID, the vendor ID of Robert Bosch GmbH is 0xFF
		2	Product type, 0x07 general purpose discrete I/O
		3	Product code, 6
		4	Revision of CL150-DEV
		5	Status, summed-up device status, bit encoding according to DeviceNet specification
		6	Serial number
		7	Product name „CL150-DEV/CL151-DEV DeviceNet Slave“

Supported Common Services:

Service Code	Service Name
0x05	Reset
0x0E	Get Attribute Single

Comment: Class 1, Instance 1, Attribute 0 for Reset service

Message Router Object, Class 2

Class and Instance Attributes: No attributes are supported with regard to this object.

Supported Common Services: No services are supported with regard to this object.

DeviceNet Object, Class 3

Class and Instance Attributes:

Object Class [Hex]	Object Instance	Object Attribute	Object Description
3	0	1	Revision, revision of the DeviceNet Object
3	1	1	MAC-ID, MAC-ID of the addressed node
		2	Baud rate, ID of the set baud rate
		3	BOI, support of the Bus Off Interrupt
		4	Bus Off Counter, number of Bus Off events
		5	Allocation Information, information about the active connections of the Predefined Master/Slave Connection Set

Supported Common Services:

Service Code	Service Name
0x0E	Get Attribute Single

Supported Object Specific Services:

Service Code	Service Name
0x4B	Allocate Master/Slave Connection Set
0x4C	Release Master/Slave Connection Set

Assembly Object, Class 4

Class and Instance Attributes:

Object Class [Hex]	Object Instance	Object Attribute	Object Description
4	0	1	Revision, revision of DeviceNet Object
		2	Max Instance, maximum number of instances of this object.
4	X	3	Assembly Object 1, data of the objects to be sent
4	Y	3	Assembly Object 2, data of the objects to be received

This results in the following object instances:

Number of Producing Data Bytes	Assembly Object Instance X	Number of Consuming Data Bytes	Assembly Object Instance Y
1	4	1	34 (22hex)
2	5	2	35 (23hex)
4	6	4	36 (24hex)
other number	7	other number	37 (25hex)

Supported Services:

Service Code	Service Name
0x0E	Get Attribute Single
0x10	Set Attribute Single

The assembly object is automatically configurated in dependence on the set switching matrix length of the CL150-DEV.

Connection Object, Class 5

Class and Instance Attributes:

Object Class [Hex]	**Object Instance**	**Object Attribute**	**Object Description**
5	0	1	Revision, revision of the connection object
5	X	1	State, status of the connection
		2	Instance Type, Type of connection, either I/O or messaging
		3	TransportClass_trigger, defines the behavior of the connection
		4	Produced_Connection_ID, Connection ID (CAN Identifier) of the producing connection
		5	Consumed_Connection_ID, Connection ID (CAN Identifier) of the consuming connection
		6	Initial_Comm_Characterics, defines the message groups of this connection, producing and consuming
		7	Produced_Connection_Size, maximum number of bytes that can be sent through this connection
		8	Consumed_Connection_Size, maximum number of bytes that can be received through this connection
		9	Expected_Packet_Rate, defines the times for inactivity and watchdog of this connection
		12	Watchdog_Timeout_action, defines how inactivity and watchdog events are to be treated.
		13	Produced_Connection_Path_Length, number of bytes in the Produced_Connection_Path attribute
		14	Produced_Connection_Path, specifies the application objects whose data is sent through this connection
		15	Consumed_Connection_Path_Length, number of bytes in the Consumed_Connection_Path attribute
		16	Consumed_Connection_Path, specifies the application objects whose data is received through this connection

In the above mentioned table, X is defined as follows:

X	**Type of Connection**
1	Explicit Messaging Connection
2	Poll I/O Connection
3	Bit Strobe I/O Connection
4	COS/Cyclic I/O Connection
5	Reserved

Supported Class Services:

Service Code	Service Name
0x08	Create

Supported Common Services:

Service Code	Service Name
0x0D	Apply Attributes
0x0E	Get Attribute Single
0x10	Set Attribute Single

Discrete Input Point, Class 8

Class and Instance Attributes:

Object Class [Hex]	Object Instance	Object Attribute	Object Description
8	0	1	Revision, revision of DeviceNet object
		2	Max Instance, maximum number of instances of this object

The value of the „Max Instance“ attribute represents the number of input points. This value is always a multiple of 8.

Supported Services:

Service Code	Service Name
0x0E	Get Attribute Single

Discrete Output Point, Class 9

Class and Instance Attributes:

Object Class [Hex]	Object Instance	Object Attribute	Object Description
9	0	1	Revision, revision of DeviceNet object
		2	Max Instance, maximum number of instances of this object

The value of the „Max Instance“ attribute represents the number of output points. This value is always a multiple of 8.

Supported Services:

Service Code	Service Name
0x0E	Get Attribute Single

9.4.2 Vendor-Specific Objects

I/O Data Object, Class 100

Class and Instance Attributes:

Object Class [Hex]	Object Instance	Object Attribute	Object Description
100	0	1	Revision, revision of I/O data objects
		2	Max Instance, maximum number of instances of the I/O data object
100	1	100	Number Of Inputs, number of input bytes
		101	Number of Outputs, number of output bytes
		102	Input Data, input data as entire stream
		103	Output Data, output data as entire stream
100	2	100 + i	Input Data (Byte), input data as single byte i = 0, Byte 0 of input data i = 1, Byte 1 of input data etc.
100	3	100 + i	Output Data (Byte), output data as single byte i = 0, Byte 0 of output data i = 1, Byte 1 of output data etc.
100	4	100 + i	Input Data (Word), input data as single word i = 0, Word 0 of input data i = 1, Word 1 of input data etc.
100	5	100 + i	Output Data (Word), output data as single word i = 0, Word 0 of output data i = 1, Word 1 of output data etc.

Supported Common Services:

Service Code	Service Name
0x0E	Get Attribute Single
0x10	Set Attribute Single

Status Object, Class 101

Class and Instance Attributes:

Object Class [Hex]	Object Instance	Object Attribute	Object Description
101	0	1	Revision, revision of status and diagnostic objects
		2	Max Instance, maximum number of instances of the status and diagnostic object
101	1	100	Manufacturer Status Register, status of the CL150-DN system
		101	Module Serial Number, individual serial number of the module
101	2	100	Diagnostic Data Length
		101	Diagnostic Status

Supported Common Services:

Service Code	Service Name
0x0E	Get Attribute Single

9.5 Interbus-S Interface

Type	RS485
Electrical isolation	yes
Baud rate	500 kbaud
Connector	9-pin socket connector D-SUB IN 9-pin inline contact strip D-SUB OUT

Connection

The B~IO CL150-IBS module is additionally provided with a fieldbus connection for the 2-wire long-distance bus of the Interbus-S. The Interbus-S is connected through a 9-pin D-SUB socket which is screwed to the D-SUB connector IN X72 of the CL150-IBS. An additional IBS component is to be connected to the OUT-X71 interface.

The connection assignment corresponds to the Interbus-S D-SUB assignment of Phoenix Contact.

Pin No.	Signal IN X72	Signal OUT X71	Explanation
1	DO	DO	Transmitted data
2	DI	DI	Received data
3	COM	COM	Zero V reference potential
4			Free
5		+5V_ISO	For bridge RBST
6	/DO	/DO	Transmitted data
7	/DI	/DI	Received data
8			Free
9		RBST	Identifier, further stations are connected

When implementing a connection cable, the bridge from pin 5 to pin 9 must be available in the OUT bus cable connector.

If not mentioned otherwise, please comply with the installation guidelines and the cabling recommendations for the Interbus-S by Phoenix Contact, e.g. IBS SIG Part 1 UM or Installation Manual IBS SYS INST UM.

Displays

The operating states of the Interbus connection are indicated by 3 bus-specific LEDs:

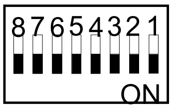
Name	Color	Function
RC	green	The incoming long-distance bus is properly connected and Bus Reset of the Busmaster is inactive.
BA	green	Messages are transferred to the bus
RD	red	The forwarding long-distance bus is switched off.

The UL operation display of the B~IO CL150-IBS is different from the UL of all other CL150 versions with regard to one detail: the continuous green light means „Supply voltage o.k.“. It does not give any information about the processor’s availability for operation.

Battery faults and low battery warning are not indicated by a flashing green but a flashing orange light.

DIP Switch S3

The CL150-IBS bus connection is provided with an 8-fold SMD switch.



Ex works, all switches are set to OFF.

The switches comprise the following functions:

Switch	Status	Function
1	OFF	Free
	ON	
2	OFF	Data width switching matrix
	ON	
3	OFF	
	ON	
4	OFF	
	ON	
5	OFF	High and low byte swap, corresponds to Bosch's representation
	ON	No high and low byte swap, corresponds e.g. to Siemens‘ representation
6	OFF	Free
	ON	
7	OFF	Diagnosis message at busmaster
	ON	No diagnosis message at busmaster
8	OFF	Free
	ON	

The settings of the switch are read in only once after having switched on the 24V power supply.

Switches 2, 3, and 4:

With these switches, the data width of the switching matrix, with which the decentralized CL150-IBS logs into the central busmaster, is set.

SW4	SW3	SW2	Data Width Switching Matrix
0	0	0	2 byte in- and output data
0	0	1	4 byte in- and output data
0	1	0	6 byte in- and output data
0	1	1	8 byte in- and output data

Switch 5:

In contrast to the Bosch connection, other busmaster connections (Siemens, AEG, etc.) have their low and high byte switched. If necessary, this can be adjusted centrally by means of addressing and decentrally by using the switch.

The switch‘s setting to OFF corresponds to the Bosch representation.

Switch 7:

This switch is used for determining whether diagnosis messages should be sent to the busmaster or not.

Startup Characteristics

The CL150-IBS establishes the data width of the switching matrix on the basis of the DIP switch S3‘s position and sends it to the busmaster.

ID

Because the CL150-IBS always occupies a symmetrical in- and output field, it is provided with 03H, the general identification code for digital in- and output long-distance bus stations.

Cyclical exchange of user data

In the cyclical exchange of the user data, the CL150-IBS bus connection is faultlessly parameterized and configurated. The in- and output data of the switching matrix is cyclically transferred between the PLC and the CL150-IBS through the Interbus-S.

Consistency

Because of the characteristics of the bus, the transfer data as a whole is consistent. The operating system of the B~IO CL150-IBS module processes the switching matrix coherently in the I/O cycle of the controller. Thus, the consistency also applies to the contents of the switching matrix.

10 Appendix

10.1 Accessories

Designation	**Order No.**
Backup battery for CL150/151/150A/151A	1070 081 777
Programming unit cable K19, COM interface/ CL150	1070 077 753
Socket connector set for CL150, CL150-DP, CL151-DP, CL150-CAN, CL151-CAN, CL150-IBS, CL151-IBS, CL150-DEV, CL151-DEV	
- Screw terminals	1070 080 342
- Spring clamp terminals	1070 080 349
- Top screw terminals	1070 080 363
Socket connector set for CL151	
- Screw terminals	1070 081 805
- Spring clamp terminals	1070 081 804
- Top screw terminals	1070 081 806
Socket connector set for CL150A, CL151A	
- Screw terminals	1070 081 801
- Spring clamp terminals	1070 081 800
- Top screw terminals	1070 081 802
Terminal blocks for CL150	1070 080 157
Terminal blocks for CL150A, CL151, CL151A, CL150-DP, CL151-DP, CL150-CAN, CL151-CAN, CL150-IBS, CL151-IBS, CL150-DEV, CL151-DEV	1070 080 155

Modular Extension

Designation	Order No.
Module connector	1070 079 782
8DI, digital input module, 8 inputs, 24 V	1070 079 757
16DI, digital input module, 16 inputs, 24 V	1070 080 144
16DI-3, digital input module, 16 inputs, 3-wire connection, 24 V	1070 081 862
8DO, digital output module, 8 outputs, 24 V, 0.5 A	1070 079 759
8DO/2A, digital output module, 8 outputs, 24 V, 2 A	1070 080 151
16DO, digital output module, 16 outputs, 24 V, 0.5 A	1070 081 858
8DI/DO, digital combination module, 8 inputs or outputs, 0.5 A	1070 080 709
8DO R, output module, 8 outputs, relay	1070 080 680
4AI_UI, analog input module, 4 voltage and current inputs	1070 080 524
4AI_UIT, analog input module, 4 voltage, current and thermoelement inputs	1070 080 526
4AO_I, analog output module, 4 current outputs	1070 080 528
4AO_U, analog output module, 4 voltage outputs	1070 080 530
I/O gateway, for coupling of two fieldbus systems	1070 083 150

For additional accessories for the fieldbus systems and B~IO devices, please refer to the Installation Engineering catalogue, order no. 1070 072 190.

10.2 Abbreviations

Abbreviations	Explanation
EEM	Electrostatically Endangered Modules
ESD	ElectroStatic Discharge abbreviation for all terms that concern electrostatic discharges, e.g. ESD protection, ESD danger
RTC	Real Time Clock
DDBF	Device Data Base File file that describes the characteristics of a device with regard to a PROFIBUS-DP connection
EDS	Electronic Data Sheet file that describes the characteristics of a device with regard to a CANbus and/or DeviceNet connection
CAN	Controller Area Network fieldbus as per ISO11898
DP	PROFIBUS-DP fieldbus as per EN50170-2
DEV	Device Net fieldbus according to the requirements and guidelines of Open DeviceNet Association Inc. (ODVA)
IBS	Interbus-S fieldbus as per DIN 19258

10.3 Index of Figures

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