WEST

Technical Documentation

CSC-151-U
CSC-151-P

Synchronization control module for the synchronization of two cylinders in bypass, alternatively with power output stage

Electronics
Hydraulics meets
meets Hydraulics
Electronics

CONTENTS

1 General Information

1.1 *Order number*

CSC-151-U - with programmable output (±10 V differential output or 4… 20 mA) and analogue sensor interface

CSC-151-P - with integrated power output stage up to 2,6 A (*see additional information*)

1.2 *Scope of supply*

The scope of supply includes the module plus the terminal blocks which are part of the housing.
The Profibus plug, interface cables and further parts which may be required should be ordered separately.
This documentation can be downloaded as a PDF file from www.w-e-st.de.

1.3 *Accessories*

WPC-300 - Start-Up-Tool (downloadable from our homepage – products/software)

Any standard cable with USB-A and USB-B connector can be used as the programming cable.

1.4 *Symbols used*

General information

Safety-related information

1.5 *Using this documentation*

Structure of the documentation:
The standard product is descibed up to chapter 6. The extensions like POWER STAGE or SSI-INTERFACE are described in the chapters ADDITIONAL INFORMATION.

1.6 *Legal notice*

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1.7 *Safety instructions*

Please read this document and the safety instructions carefully. This document will help to define the product area of application and to put it into operation. Additional documents (WPC-300 for the start-up software) and knowledge of the application should be taken into account or be available.
General regulations and laws (depending on the country: e. g. accident prevention and environmental protection) must be complied with.

These modules are designed for hydraulic applications in open or closed-loop control circuits. Uncontrolled movements can be caused by device defects (in the hydraulic module or the components), application errors and electrical faults. Work on the drive or the electronics must only be carried out whilst the equipment is switched off and not under pressure.

This handbook describes the functions and the electrical connections for this electronic assembly. All technical documents which pertain to the system must be complied with when commissioning.

This device may only be connected and put into operation by trained specialist staff. The instruction manual must be read with care. The installation instructions and the commissioning instructions must be followed. Guarantee and liability claims are invalid if the instructions are not complied with and/or in case of incorrect installation or inappropriate use.

CAUTION!
All electronic modules are manufactured to a high quality. Malfunctions due to the failure of components cannot, however, be excluded. Despite extensive testing the same also applies for the software. If these devices are deployed in safety-relevant applications, suitable external measures must be taken to guarantee the necessary safety. The same applies for faults which affect safety. No liability can be assumed for possible damage.

Further instructions

- The module may only be operated in compliance with the national EMC regulations. It is the user's responsibility to adhere to these regulations.
- The device is only intended for use in the commercial sector.
- When not in use the module must be protected from the effects of the weather, contamination and mechanical damage.
- The module may not be used in an explosive environment.
- To ensure adequate cooling the ventilation slots must not be covered.
- The device must be disposed of in accordance with national statutory provisions.

2 Characteristics

This electronic module has been developed for controlling hydraulic synchronization systems. The typical synchronization accuracy is about 0.1% to 1% of the sensor length (depending on the hydraulic system).

A flow divider (valve or gear pump) will synchronize the axis with limited accuracy. A proportional valve parallel to the directional valve and flow divider is compensating the flow error in one or both cylinders. The flow rate of this valve should be in the range of the flow error of the flow divider. This kind of synchronization control is extremely stable and simple to use.

About the AUTO SETUP, the offset error between the two axes can be adjusted automatically. The POLARITY input provides the switching of the output signal. Depending on the hydraulic concept, the polarity changes depending on the direction.

Such a system is extremely stable and can be handled without any problems.

Proportional valves with integrated electronics and external power amplifiers can be driven by the analogue differential output.

Controlling internal functions, sync error and sensor failure are monitored by the two digital outputs: **ready** and **status**.

Setting up this module is simple and easy to handle with our WPC-300 start-up software. Various functions for operation and troubleshooting are also included.

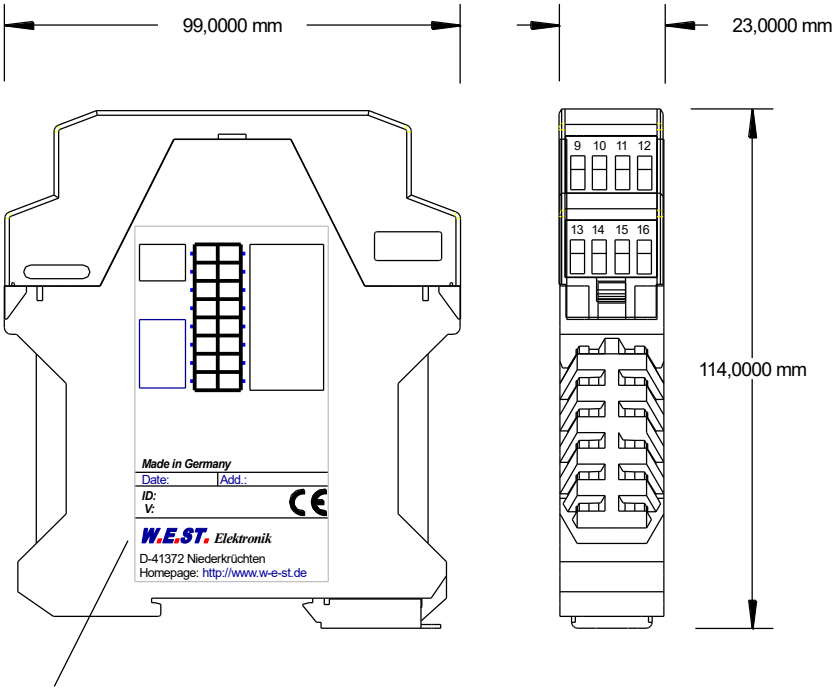
Typical applications: Synchronization control with bypass valve.

Features

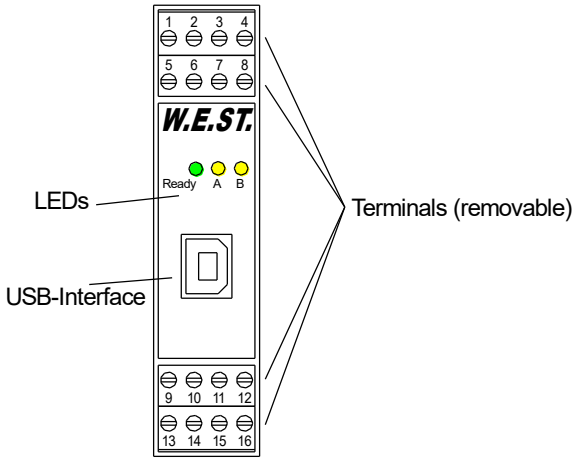
- **Analogue feedback sensors**
- **Simple and intuitive scaling of the sensor**
- **Simple and inexpensive system with one proportional directional valve**
- **Principle of bypass control (parallel to flow divider)**
- **Safety in emergency cases by driving through the flow divider only**
- **Expandable up to four axes with three control modules**
- **Usable with overlapped proportional valves and with zero lapped control valves**
- **Fault diagnosis and extended function checking**
- **Simplified parameterization with WPC-300 software**
- **Optionally:**
  - **Integrated power output stage (P version)**

2.1 *Device description*

Standard module – for the P-Version look at point 7.2



Type plate and terminal pin assignment



3 Use and application

3.1 *Installation instructions*

- This module is designed for installation in a shielded EMC housing (control cabinet). All cables which lead outside must be screened; complete screening is required. It is also necessary to avoid strong electro-magnetic interference sources being installed nearby when using our open and closed loop control modules.

- **Typical installation location:** 24 V control signal area (close to PLC)
  The devices must be arranged in the control cabinet so that the power section and the signal section are separate from each other.
  Experience shows that the installation place close to the PLC (24 V area) is most suitable. All digital and analogue inputs and outputs are fitted with filters and surge absorbers in the device.

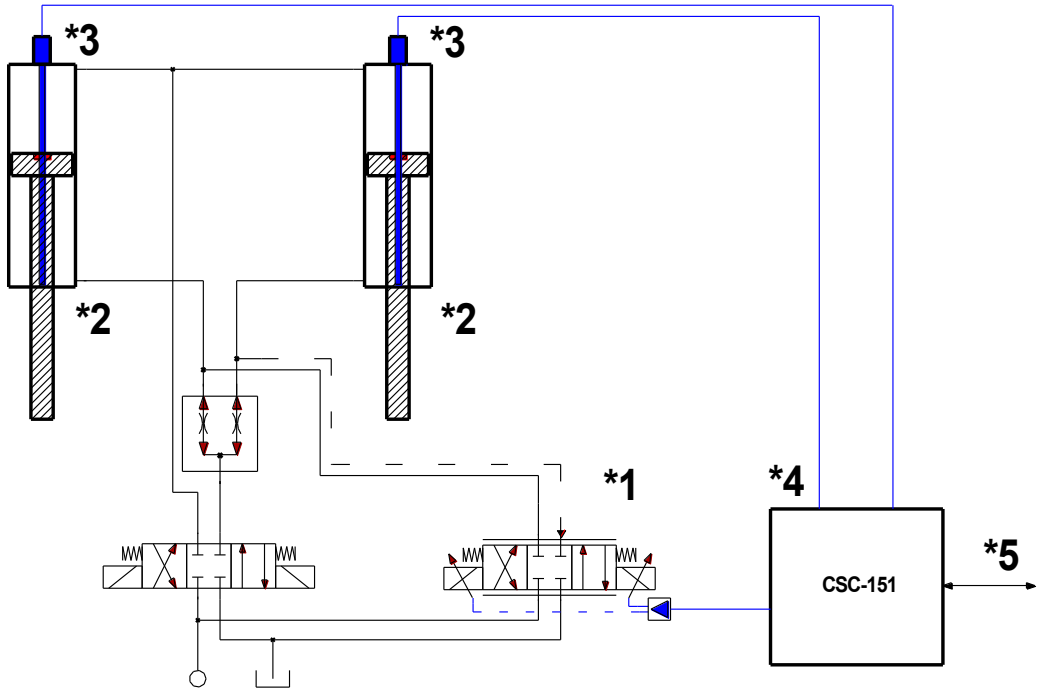
- The module should be installed and wired in accordance with the documentation bearing in mind EMC principles. If other consumers are operated with the same power supply, a star-shaped ground wiring scheme is recommended. The following points must be observed when wiring:
  - The signal cables must be laid separately from power cables.
  - Analogue signal cables **must be screened**.
  - All other cables must be screened if there are powerful interference sources (frequency converters, power contactors) and cable lengths > 3 m. Inexpensive SMD ferrites can be used with high-frequency radiation.
  - The screening should be connected to PE (PE terminal) as close to the module as possible. The local requirements for screening must be taken into account in all cases. The screening should be connected to at both ends. Equipotential bonding must be provided where there are differences between the connected electrical components.
  - If having longer lengths of cable (> 10 m), the diameters and screening measures should be checked by specialists (e. g. for possible interference, noise sources and voltage drop). Special care is required if using cables of over 40 m in length, and if necessary the manufacturer should be consulted if necessary.

- A low-resistance connection between PE and the mounting rail should be provided. Transient interference is transmitted from the module directly to the mounting rail and from there to the local earth.
- Power should be supplied by a regulated power supply unit (typically a PELV system complying with IEC364-4-4, secure low voltage). The low internal resistance of regulated power supplies gives better interference voltage dissipation, which improves the signal quality of high-resolution sensors in particular. Switched inductances (relays and valve coils) which are connected to the same power supply must always be provided with appropriate overvoltage protection directly at the coil.

3.2 *Typical system structure*

This minimal system consists of the following components:

(*1) Proportional valve for deviance compensation
(*2) Hydraulic cylinder
(*3) Integrated analogue or SSI position sensor (alternatively also with external measurement system)
(*4) CSC-151 control module
(*5) Interface to PLC with analogue and digital signals



3.3 *Method of operation*

Both cylinders are mainly driven by the switching valve and the flow divider. The pump flow is split in two almost equal flow rates. To compensate the flow error (typical in a range of 2...10%) a proportional valve is working parallel. If the second cylinder is driving faster or slower than the first one, the proportional valve will be opened to increase or to reduce the flow rate in one or in both cylinders.
This is managed by the electronic control function and both position sensors.
In case of brake down (prop. valve, sensor or electronic) the system can drive through the flow divider only.

ENABLE: This digital input signal initializes the application and error messages are deleted. The controller and the **READY** signal are activated. The output signal to the control element is enabled.

If the **ENABLE** input is deactivated the output is switched off. **Attention:** Take care of the **EOUT** command.

Activating the **RUN** input starts the controller. The feedback inputs are evaluated now. The output signal is calculated depending on the control deviation of the axes with its relating parameterization.

With the **AUTO SETUP** input (one second on) the offset failure between both sensors can be measured and compensated automatically. For this setup, the cylinders must be driven at the top or bottom end. After changing cylinders or sensors no manual adjustments are necessary.

The **POLARITY** input allows reversing the output signal.

3.4 *Commissioning*

Step	Task
Installation	Install the device in accordance with the circuit diagram. Ensure it is wired correctly and that the signals are well shielded. The device must be installed in a protective housing (control cabinet or similar).
Switching on for the first time	Ensure that no unwanted movement is possible in the drive (e. g. switch off the hydraulics). Connect an ammeter and check the current consumed by the device. If it is higher than specified there is an error in the wiring. Switch the device off immediately and check the wiring.
Setting up communication	Once the power input is correct the PC (notebook) should be connected to the serial interface. Please see the WPC-300 program documentation for how to set up communication. Further commissioning and diagnosis are supported by the operating software.
Pre-parameterization	Now set up the following parameters (with reference to the system design and circuit diagrams): The STROKE, SENSOR SETTINGS and DECELERATION. Parameterize specific settings for the control element (MIN for deadzone compensation and MAX for maximum velocity). Pre-parameterization is necessary to minimize the risk of uncontrolled movements.
Control signal	Check the control signal with a voltmeter. The control signal (PIN 15 to PIN16) lies in the range of ± 10 V. In the current state it should show 0 V. Alternatively, if current signals are used, approx. 0 mA should flow (PIN 15 to PIN 12).
Switching on the hydraulics	The hydraulics can now be switched on. The module is not yet generating a signal.Drives should be at a standstill or drift slightly (leave its position at a slow speed).
Activating ENABLE	**CAUTION!** Drives can now leave their position and move to an end position. Take safety measures to prevent personal injury and damage.
Activating START	With the start signal the Auto setup signal is locked, so that there may be no unintentional offset settings. This signal sends the output signal of the controller to the output, often the START input is connected to the ENABLE input in parallel.
Optimize controller	Now optimize the controller parameters according to your application and your requirements.[1]

[1] Attention! Compared to previous versions of this controller the gain is not adjusted, but the position error in which the proportional valve is fully open. The smaller this value is, the more accurate the system boots and the higher the gain.

4 Technical description

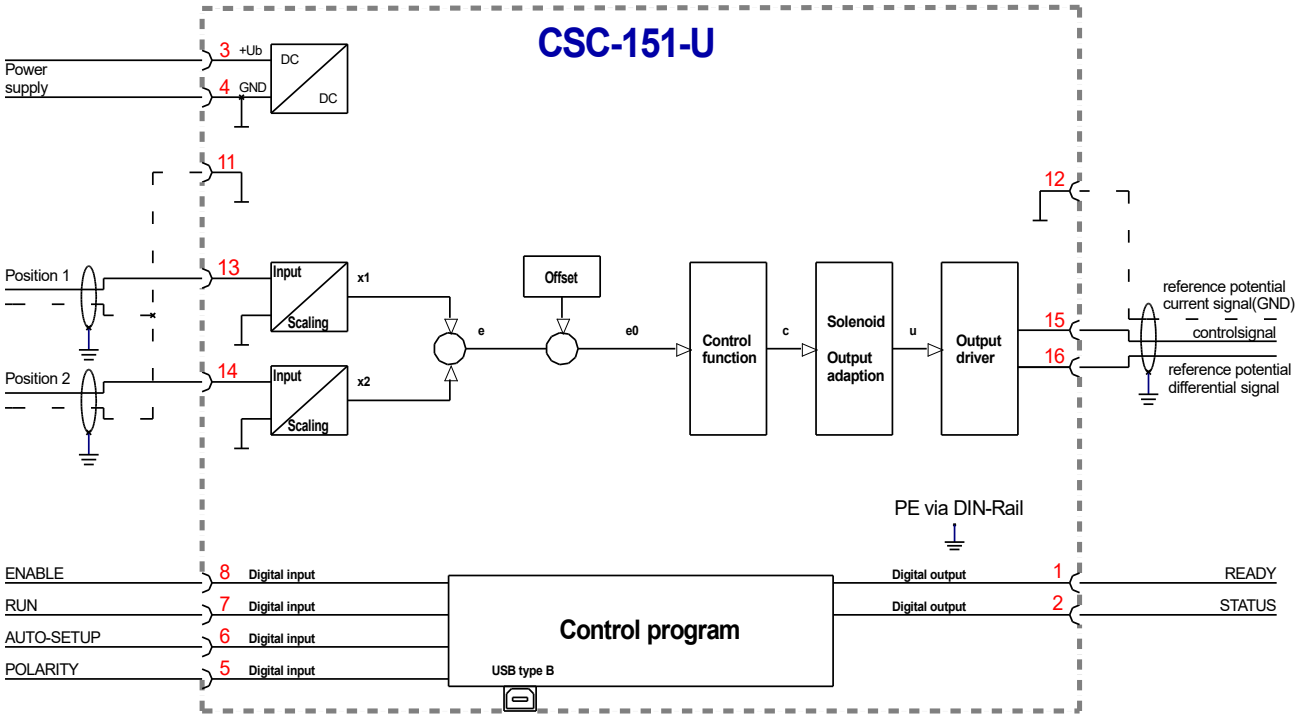
4.1 *Input and output signals*

Connection	Supply
PIN 3	Power supply (see technical data)
PIN 4	0 V (GND) connection.
Connection	**Analogue signals**
PIN 13	Actual value (X1), signal range 0… 10 V or 4… 20 mA (scalable)
PIN 14	Actual value (X2), signal range 0… 10 V or 4… 20 mA (scalable)
PIN 11	0 V (GND) connection for analogue input signals
PIN 12	0 V (GND) connection for analogue output signals
PIN 15 / 16 PIN 15 / 12	Valve control signal. Signal liegt im Bereich von +/- 10V oder 4… 20mA. Type of signal and polarity can be selected by the parameter SIGNAL:U.
Connection	**Digital inputs and outputs**
PIN 8	**Enable input:** General enabling of the application.
PIN 7	**START (RUN)** input: **ON:** The synchronization controller is active. **OFF:** The synchronization controller is not active. Auto setup can be used.
PIN 6	**AUTO SETUP input:** The offset error between the two sensors is automatically measured and stored as a correction value. The input must be activated for longer than a second.
PIN 5	**POLARITY input:** The polarity of the control loop can be switched on this input.
PIN 1	**READY output:** **ON:** The module is enabled; there are no discernable errors. **OFF:** Enable (PIN 8) is disabled or an error (sensor or internal error) has been detected.
PIN 2	**STATUS output:** **ON:** (CD window). The axes are within the set control deviation window. **OFF:** (CD window). The axes are outside the set control deviation window.

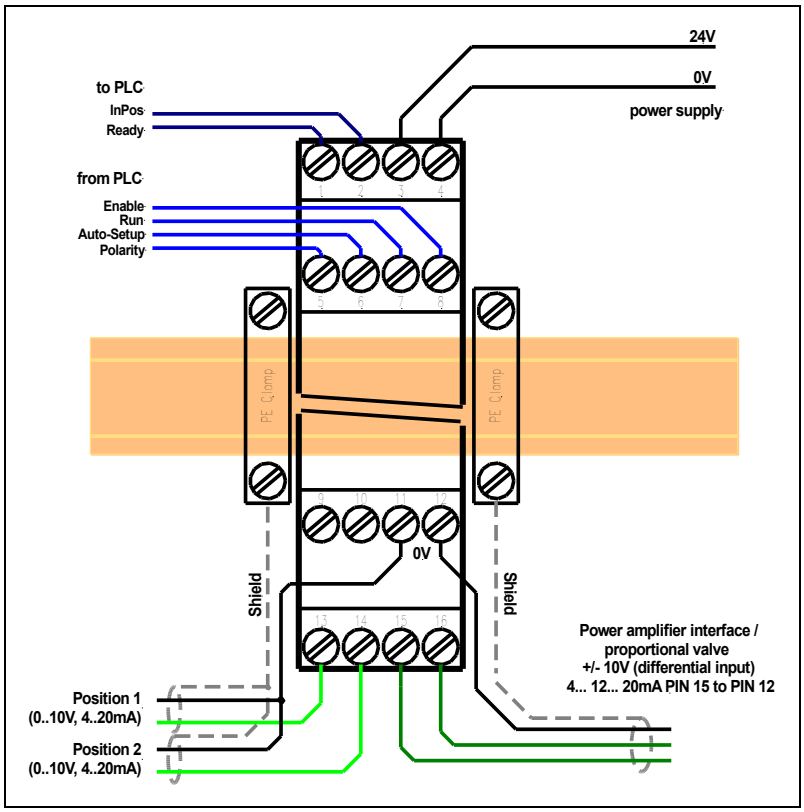
4.2 *LED definitions*

LEDs	Description of the LED function
GREEN	Identical to the **READY** output. **OFF:** No power supply or ENABLE is not activated **ON:** System is ready for operation **Flashing:** Error discovered Only active when SENS = ON
YELLOW A	Identical to the STATUS output. **OFF:** The axis is outside the control deviation window. **ON:** The axis is within the control deviation window.
GREEN + YELLOW A+B	1. **Chasing light (over all LEDs):** The bootloader is active. No normal functions are possible. 2. **All LEDs flash shortly every 6 s:** An internal data error was detected and corrected automatically! The module still works regularly. To acknowledge the error the module has to be cycle powered.
YELLOW A + YELLOW B	**Both yellow LEDs flash oppositely every 1 s:** The nonvolatile stored parameters are inconsistent! To acknowledge the error, the data have to be saved with the SAVE command or the corresponding button in the WPC. If the function of the module has changed via the FUNCTION parameter, all parameters are deleted purposely and set to default values. In this case the LEDs indicate no error, but a desired state. To acknowledge please save.

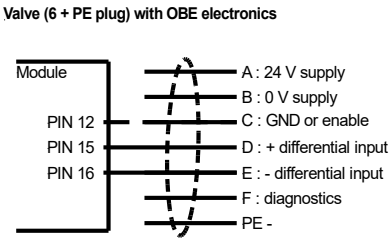
4.3 *Circuit diagram*

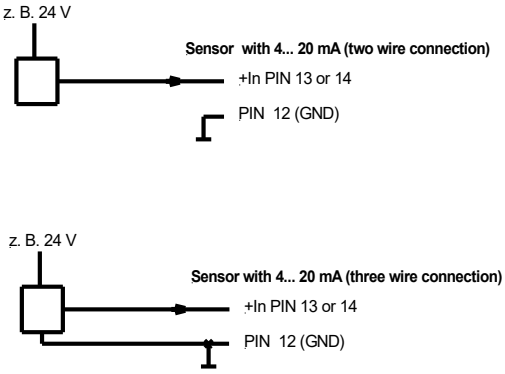


4.4 *Typical wiring*



4.5 *Connection examples*





4.6 *Technical data*

Supply voltage (U_b)	**[VDC]**	12… 30 (incl. ripple)
Power consumption	**[W]**	max. 1.2
External protection	**[A]**	1 medium time lag
Digital inputs		
OFF	**[V]**	< 2
ON	**[V]**	> 10
Input resistance	**[kOhm]**	25
Digital outputs		
OFF	**[V]**	< 2
ON	**[V]**	max. U_b
Maximum current	**[mA]**	50
Analogue inputs		Unipolar
Voltage	**[V]**	0… 10
Input resistance	**[kOhm]**	min. 25
Signal resolution	**[%]**	0.003 incl. Oversampling
Current	**[mA]**	4… 20
Burden	**[Ohm]**	240 Ohm
Signal resolution	**[%]**	0.006 incl. Oversampling
Analogue outputs		
Voltage	**[V]**	0… 10 / +/- 10 differential
Maximum load	**[mA]**	10
Current	**[mA]**	4… 20
Maximum load	**[Ohm]**	390
Signal resolution	**[%]**	0.007
Controller cycle times		
Signal processing	**[ms]**	1
Serial interface	**-**	USB - virtual COM Port
Transmission rate	**[kBaud]**	9.6… 115.2
Housing		Snap -on module acc. EN 50022
Material	**-**	PA 6.6 polyamide
Flammability class	**-**	V0 (UL94)
Weight	**[kg]**	0.15
Protection class	**[IP]**	20
Temperature range	**[°C]**	-20… 60
Storage temperature	**[°C]**	-20… 70
Humidity	**[%]**	< 95 (non-condensing)
Connections	**-**	
Communication		USB type B
Plug connectors		4 x 4-pole terminal blocks
PE		via the DIN mounting rail
EMC	**-**	EN 61000-6-2: 8/2005 EN 61000-6-4: 6/2007 + A1:2011

5 Parameters

5.1 *Parameter overview*

Group	Command	Default	Unit	Description
Basic parameters				
	LG	EN	-	Changing language help texts
	MODE	STD	-	Parameter view
	SENS	ON	-	Malfunction monitor
	INPOS	200	µm	Size of the control deviation window
Input signal adaptation				
	SYS_RANGE	100	mm	Axes working stroke
Sensor scaling				
	SIGNAL:X1	U0-10		Type of input
	N_RANGE:X1	100	mm	Sensor nominal length
	OFFSET:X1	0	µm	Sensor offset
	SIGNAL:X2	U0-10	-	Type of input
	N_RANGE:X2	100	mm	Sensor nominal length
	OFFSET:X2	0	µm	Sensor offset
Closed loop control parameters				
	D:A **D:B**	25 25	mm mm	Deceleration strokes
	PT1	1	ms	PT1 time constant
	CTRL	SQRT1	-	Control characteristic
Output signal adaptation				
	MIN:A **MIN:B**	0 0	0,01 % 0,01 %	Deadband compensation
	MAX:A **MAX:B**	10000 10000	0,01 % 0,01 %	Output scaling
	TRIGGER	200	0,01 %	Deadband compensation trigger point
	OFFSET	0	0,01 %	Output offset value
	SIGNAL:U	U+-10	-	Type of output signal and polarity
Special commands				
	AINMODE	EASY	-	Input scaling mode
	AIN:X1 **AIN:X2**	A: 1000 B: 1000 C: 0 X: V	- - 0,01 % -	Free scaling of the analogue inputs. Replaces SIGNAL commands if AINMODE is set to MATH.

5.2 *Basic parameters*

5.2.1 LG (Changing the language)

Command		Parameters	Unit	Group
LG	x	x= DE|EN	-	**STD**

Either German or English can be selected for the help texts.

CAUTION: After changing the language settings, the ID button (SPEED BUTTON) in the menu bar (WPC-300) must be pressed (module identification).

5.2.2 MODE (Parameter view)

Command		Parameters	Unit	Group
MODE	x	x= STD|EXP	-	**STD**

This command changes the operating mode. Various commands (defined via STD/EXP) are blanked out in Standard Mode. The commands in Expert Mode have a more significant influence on system behavior and should accordingly be changed with care.

5.2.3 SENS (Malfunction monitoring)

Command		Parameters	Unit	Group
SENS	x	x= ON|OFF|AUTO	-	**STD**

This command is used to activate/deactivate the monitoring functions (4… 20 mA sensors, output current, signal range and internal failures) of the module.

ON: All monitoring functions are active. Detected failures can be reset by deactivating the ENABLE input.

OFF: No monitoring function is active.

AUTO: Auto reset mode. All monitoring functions are active. If the failure doesn't exist anymore, the module automatically resumes to work.

Normally the monitoring functions are always active because otherwise no errors are detectable via the READY output. Deactivating is possible mainly for troubleshooting.

5.2.4 INPOS (Size of the control deviation window)

Command	Parameters	Unit	Group
INPOS x	x= 2… 200000	µm	**STD**

This parameter is entered in µm.
The INPOS command defines a monitoring range window for which the INPOS message is generated. The monitoring window monitors the deviation between the feedback signals X1 and X2. If the deviation is within the INPOS window, this is signaled via the status output and the INPOS LED. The control process is not influenced by this signal.

5.3 *Input signal adaptation*

5.3.1 SYS_RANGE (Working stroke)

Command	Parameters	Unit	Group
SYS_RANGE x	x= 10… 10000	mm	**STD**

This command defines the full stroke, which corresponds to 100 % of the input signal. If the demand is set incorrectly, this leads to incorrect system settings, and the dependent parameters such as speed and gain cannot be calculated correctly.

5.3.2 SIGNAL (Type of input)

Command	Parameters	Unit	Group
SIGNAL:i x	i= X1|X2 x= OFF|U0-10|I4-20| U10-0| I20-4	-	**EASY**

This command can be used to change the type of input signal (voltages or current) and to define the direction of the signal. This command is available for all analogue inputs (W, X, and V).
OFF= Deactivation of the input.

5.3.3 N_RANGE:X (Nominal range of the sensor)

Command	Parameter	Unit	Group
N_RANGE:i x	i = X1|X2 x= 10… 10000	mm	**EASY**

N_RANGE (nominal range or nominal stroke) is used to define the length of the sensor. This value should be always higher than SYS_RANGE. The control parameter cannot be calculated correctly in case of wrong values.

5.3.4 OFFSET:X (Sensor offset)

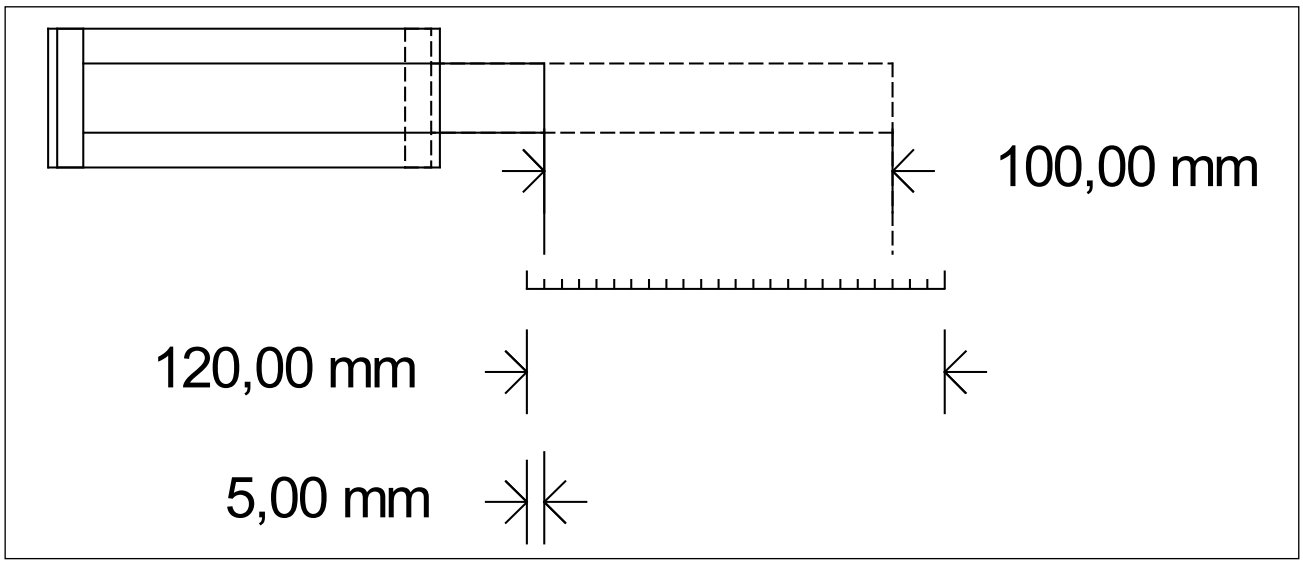
Command	Parameter	Unit	Group
OFFSET:i x	i = X1|X2 x= -100000… 100000	µm	**EASY**

Adjustment of the zero point of the sensor.

5.3.5 Using of the commands SYS_RANGE, N_RANGE:X and OFFSET:X

The application scaling will be done by these three commands. In this example the system is defined by a length of 120 mm of the sensor, a working stroke of 100 mm of the cylinder and an offset of 5 mm. These parameters have to be typed in and the axis is driving between 5 mm and 105 mm of the sensor stroke and between 0 mm and 100 mm of the cylinder stroke.

Correct scaling:
SYS_RANGE = 100 (mm); N_RANGE:X = 120 (mm); OFFSET:X = -5000 (µm)



5.4 *Control parameter*

5.4.1 D (Deceleration / braking distance)

Command	Parameters	Unit	Group
D:i x	i= A|B x= 1… 10000	 mm	**STD**

This parameter is specified in mm[2].
The deceleration stroke is set for each direction of movement (A or B). The control gain is calculated internally depending on the deceleration distance. The shorter the deceleration distance, the higher the gain. A longer deceleration distance should be specified in the event of instability.

$$G_{Intern} = \frac{STROKE}{D_i}$$ Calculation of control gain

CAUTION: If the maximum stroke (SYS_RANGE command) is changed, the deceleration distance must also be adjusted. Otherwise this can result in instability and uncontrolled movements.

5.4.2 PT1 (Timing of the controller)

Command	Parameter	Unit	Group
PT1 x	x= 0… 300	ms	**EXP**

This parameter can be used to change the internal timing of the control function.
Hydraulic drives are often critical to control especially in case of high speeds and very fast valves. The PT1 filter can be used to improve the damping rate and allows therefore higher loop gains.

Requirements for the use are: The natural frequency of the valve should be equal or higher than the natural frequency of the drive.

[2] **CAUTION!** In older modules this parameter was specified in % of the maximum stroke. Since data specification for this module has now been converted to mm, the relationship between the stroke (SYS_RANGE command) and these parameters must be taken into account.

5.4.3 CTRL (Deceleration characteristics)

Command	Parameters	Unit	Group
CTRL x	x= LIN|SQRT1|SQRT2	-	**STD**

The deceleration characteristic is set with this parameter. In case of positively overlapped proportional valves the SQRT function should be used. The non-linear flow function of these valves is linearized by the SQRT[3] function.

In case of zero lapped valves (control valves and servo valves) the LIN or SQRT1 function should be used regardless of the application. The progressive characteristic of the SQRT1 function has better positioning accuracy but can also lead to longer positioning times in individual cases.

LIN: Linear deceleration characteristic (gain is increased by a factor of 1).

SQRT1: Root function for braking curve calculation. The gain is increased by a factor of 3 (in the target position). This is the default setting.

SQRT2: Root function for braking curve calculation. The gain is increased by a factor of 5 (in the target position). This setting should only be used with a significantly progressive flow through the valve.

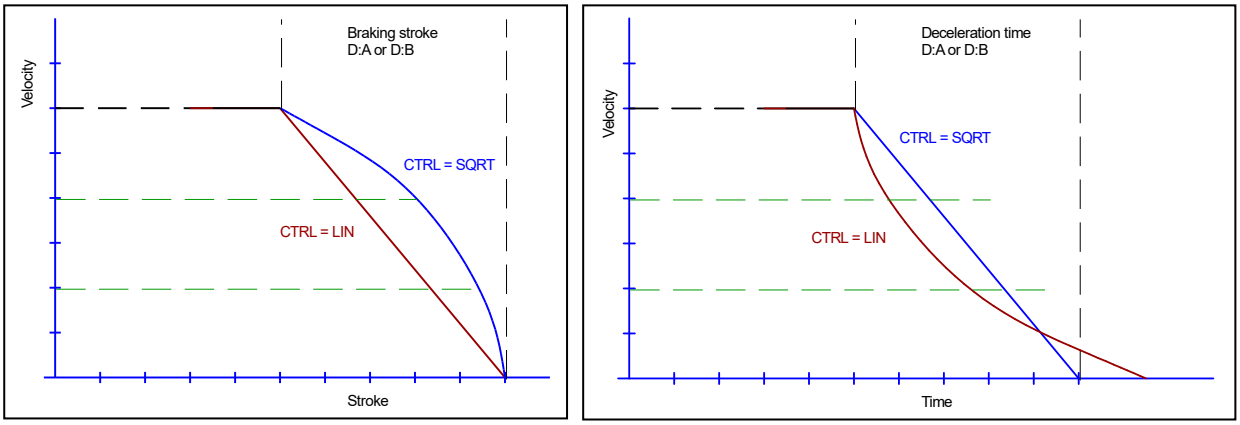


Figure 2 (Braking function with respect to stroke and time)

[3] The SQRT function generates constant deceleration and thus reaches the target position faster. This is achieved by increasing the gain during the deceleration process.

5.5 *Output signal adaptation*

5.5.1 MIN (Deadband compensation)

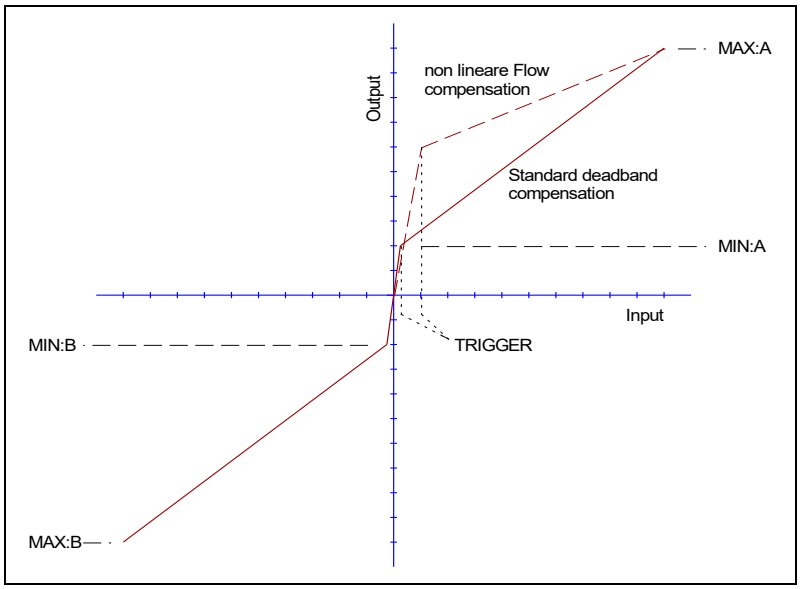
5.5.2 MAX (Output scaling)

5.5.3 TRIGGER (Response threshold for the MIN parameter)

Command	Parameters	Unit	Group
	i= A|B	-	**STD**
MIN:i x	x= 0… 6000	0,01 %	
MAX:i x	x= 3000… 10000	0,01 %	
TRIGGER x	x= 0… 4000	0,01 %	

The output signal to the valve is adjusted by means of these commands. A kinked volume flow characteristic is used instead of the typical overlap step for the position controls. The advantage is better and more stable positioning behavior. At the same time, kinked volume flow characteristics can also be adjusted with this compensation[4].

CAUTION: If there should also be adjustment options for deadband compensation on the valve or valve amplifier, it must be ensured that the adjustment is performed either at the power amplifier or in the module.
If the MIN value is set too high, this has an effect on the minimum speed, which can then no longer be adjusted. In extreme cases this leads to oscillation around the controlled position.



[4] Various manufacturers have valves with a defined nonlinear curve: e.g. a kink at 40 or 60 % (corresponding to 10 % input signal) of the nominal volume flow. In this case the TRIGGER value should be set to 1000 and the MIN value to 4000 (6000).

If zero lapped or slightly underlapped valves are used, the volume flow gain in the zero range (within the underlap) is twice as high as in the normal working range. This can lead to vibrations and jittery behavior. To compensate this, the TRIGGER value should be set to approximately 200 and the MIN value to 100. The gain in the zero point is thus halved and an overall higher gain can often be set.

5.5.4 OFFSET (Zero correction)

Command	Parameters	Unit	Group
OFFSET x	x= -4000… 4000	0,01 %	**STD**

This parameter is entered in 0,0 1% units.
The offset value is added to the output value. Valve zero offsets can be compensated with this parameter.

5.5.5 SIGNAL:U (Type and polarity of the output signal)

Command	Parameter	Unit	Group
SIGNAL:U x	x= U+-10|I4-12-20| U-+10|I20-12-4	-	**STD**

This command is used to define the output signal (voltage or current) and to change the polarity[5].

Differential output ± 100 % corresponds with ± 10 V (0… 10 V at PIN 15 and PIN 16).
Current output ± 100 % corresponds with 4… 20 mA (PIN 15 to PIN 12). 12 mA (0 %) = center point of the valve.

An output current of << 4 mA indicates an error and the module is disabled. The current input of the proportional valves should be monitored by the valve. The valve have to be deactivated in case of < 4 mA input signal. Otherwise the EOUT command can be used to get a defined output signal.

5.6 *Special commands*

5.6.1 AINMODE (Input scaling mode)

Command	Parameter	Unit	Group
AINMODE x	x= EASY|MATH	-	**TERMINAL**

The AINMODE is used to define the kind of parameterizing of the analogue inputs. The EASY mode (DEFAULT) supports a simple and application oriented input scaling.
The MATH mode supports the free input scaling by a linear equation. This mode is compatible to our older modules.

Attention: This command can be executed in the terminal window only. In case of switching back, DEFAULT data should be reloaded.

[5] The older POL command is removed.

5.6.2 AIN (Analogue input scaling)

Command	Parameters	Unit	Group
AIN:i	i= X1|X2		**MATH**
A	a= -10000… 10000	-	
B	b= -10000… 10000	-	
C	c= -10000… 10000	0,01 %	
X	x= V|C	-	

This command can be used to scale the individual inputs. The following linear equation is used for scaling.

$$Output = \frac{a}{b}(Input - c)$$

The ***"C" value*** is the offset (e.g. to compensate the 4 mA in case of a 4… 20 mA input signal).
The variables ***A*** and ***B*** are defining the gain factor with which the signal range is scaled up to 100 % (e.g. 1.25 if using 4… 20mA input signal, defined in default current settings by A = 1250 and B = 1000). The internal shunt for the current measuring is activated with switching the ***X*** value.

The gain factor is calculated by setting the usable range (***A***) in relation to the real used range (***B***) of the input signal. Usable are 0… 20mA, means (***A***) has the value **20**. Really used are 4… 20mA, means (***B***) has a value of **16** (20-4). Not used are 0… 4mA. In a range of 20mA this is an offset of 20%, means a value of **2000** for (***C***). Last but not least (***X***) has to be set to **C** choosing current signal.

In this case AIN command would look like this: AIN:I 20 16 2000 C or AIN:I 1250 1000 2000 C

Typical settings:

Command	Input	Description
AIN:I 1000 1000 0 V	0… 10 V	Range: 0… 100 %
AIN:I 10 8 1000 V OR **AIN:I 1000 800 1000 V**	1… 9 V	Range: 0… 100 %; 1 V = 1000 used for the offset and gained by 10 / 8 (10 V divided by 8 V (9 V -1 V))
AIN:I 10 4 500 V OR **AIN:I 1000 400 500 V**	0,5… 4,5 V	Range: 0… 100 %; 0,5 V = 500 used for the offset and gained by 10 / 4 (10 V divided by 4 V (4,5 V -0,5 V))
AIN:I 10 5 0 V OR **AIN:I 2000 1000 0 V**	0… 5 V	Range: 0… 100%. No offset. Gain is 2 (10 V / 5 V).
AIN:I 20 16 2000 C OR **AIN:I 2000 1600 2000 C** OR **AIN:I 1250 1000 2000 C**	4… 20mA	Range: 0… 100 % The offset will be compensated on 20 % (4 mA) and the signal (16 mA = 20 mA – 4 mA) will be gained to 100 % (20 mA). Each of this parameterization for 4… 20 mA is setting the range to 0… 100 %.

5.7 *PROCESS DATA (Monitoring)*

Command	Description	Unit
X1	Actual value	mm
X2	Actual value	mm
E	Error value	mm
C	Output of the controller	%
U	Output signal of the module	%
IA	Solenoid current A	mA (P Version only)
IB	Solenoid current B	mA (P Version only)

The process data are the variables which can be observed continuously on the monitor or on the oscilloscope.

6 Appendix

6.1 *Failure monitoring*

Following possible error sources are monitored continuously when SENS = ON/AUTO:

Source	Fault	Characteristic
Feedback signal PIN 13 4... 20 mA	Out of range or broken wire	The output will be switched off.
Feedback signal PIN 14 4… 20 mA	Out of range or broken wire	The output will be switched off.
P-VERSION Solenoids on PIN 17-20	Wrong wiring, broken wire	The power stage will be deactivated.
EEPROM (when switching on)	Data error	The output is deactivated. The module can only be activated by saving the parameters again!

CAUTION: Take care of the EOUT command. Changes will influence the behavior.

6.2 *Troubleshooting*

It is assumed that the device is in an operable state and there is communication between the module and the WPC-300. Furthermore, the valve control parameterization has been set with the assistance of the valve data sheets.

The RC in monitor mode can be used to analyze faults.

CAUTION: All safety aspects must be thoroughly checked when working with the RC (Remote Control) mode. In this mode the module is controlled directly and the machine control cannot influence the module.

FAULT	CAUSE / SOLUTION
ENABLE is active, the module does not respond, and the READY LED is off.	There is presumably no power supply or the ENABLE signal (PIN 8) is not present. If there is no power supply there is also no communication via our operating program. If a connection has been made to the WPC-300, then a power supply is also available.
ENABLE and START are active, the READY LED is flashing.	The flashing READY LED signals that a fault is been detected by the module. The fault could be: • A broken cable or no signal at the inputs, if 4… 20 mA signals are parameterized. • A broken cable or incorrect wiring to the solenoids (in the P version only). • Internal data error: press the command/SAVE button to delete the data error. The system reloads the DEFAULT data. With the WPC-300 operating program the fault can be localized directly via the monitor.

FAULT	CAUSE / SOLUTION
ENABLE is active; the READY LED is on, the system moves to an end position.	The control circuit polarity is incorrect. The polarity can be changed with the POL command or by reversing the connections to PIN 15 and PIN 16.
ENABLE and START are active, the READY LED is on, the STATUS LED is not on and a tracking error is not compensated.	The synchronization controller is in bypass to a flow divider. Synchronization is only possible during the movement. This means that the error decreases continuously with a properly working system of the tracking error during the movement. As a result of an incorrect configuration or a faulty system design it can lead to larger position errors. • Selection of the cylinder stroke is correct? • Are the braking distances correct? For starting the system, the braking paths are to be set at about 20 ... 25% of cylinder stroke[6]. The smaller the stopping distance is set, the more accurate the system will drive[7]. • Is it a zero lapped control valve or an overlapped proportional valve? In case of the proportional valve, the valves present overlap has to be compensated with the MIN parameters. The typical values are given in the datasheet of the valves.
ENABLE is active, the READY LED is on, and the system oscillates on the target.	• Braking distance is too small or the correction valve is too large. First the stopping distance should be increased. • The MIN parameter was set too high.

6.3 *Description of the command structure*

The command structure:

[nnnn:i x] or
[nnnn x]

Meaning:

nnnn - used for an arbitrary command name
nnnn: - used for an arbitrary command name, expandable by an index.
Indexed commands are indicated by the sign ":"
i oder **I** - is a dummy for the index. E. g. an index can be „A" or „B", depending on the direction.
x - parameter value, in case of special commands more than one parameter are possible.

Examples:

MIN:A 2000 nnnn = "MIN", i = "A" and x = "2000"
OFFSET 50 nnnn = „OFFSET" and x = „50"
C:IC 2000 nnnn = "C", i = "IC" and x = "2000"

[6] The stability criterion of the hydraulic axes must be taken into account.

[7] CAUTION! Too large correction valves may cause relatively high errors. The maximum flow of the valve should be twice of the error of the flow divider. If the valve has a much higher flow rate the accuracy is reduced.

7 ADDITIONAL INFORMATION: Power output stage

7.1 *General function*

The power output stages have been developed for controlling proportional valves without spool position feedback. The output stage is controlled by the microcontroller on the basic module by means of pulse width modulated signals, and the current is continuously controlled. The cycle time for the controller is 0,125 ms.

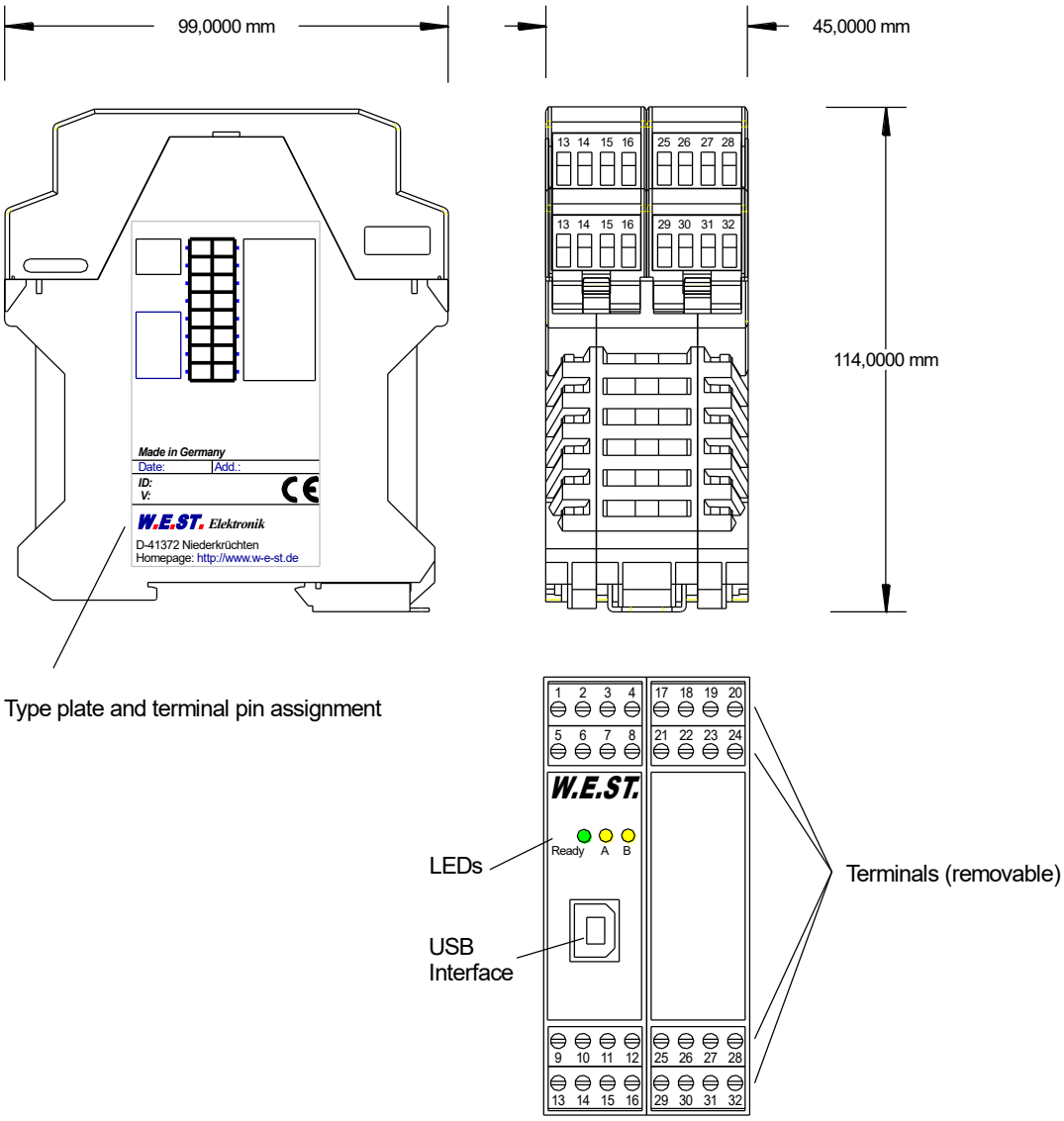
The output stage can be ideally adjusted to dynamic requirements via internal parameters.

Valve technology: Proportional valves manufactured by REXROTH, BOSCH, DENISON, EATON, PARKER, FLUID TEAM, ATOS and others.

Features

- **Two power output stages with maximum output range of 0.5 A to 2,6 A**
- **Hardware short-circuit protection with 3 µs response time**
- **Adjustable PWM frequency, dither frequency and dither amplitude**
- **High current signal resolution**
- **No additional delay times between the control function and the power stage**
- **Separate power supply for safety-relevant applications**
- **Integrated into the standard controller, no additional wiring necessary**
- **Optimum price/performance ratio**

7.2 *Device description*

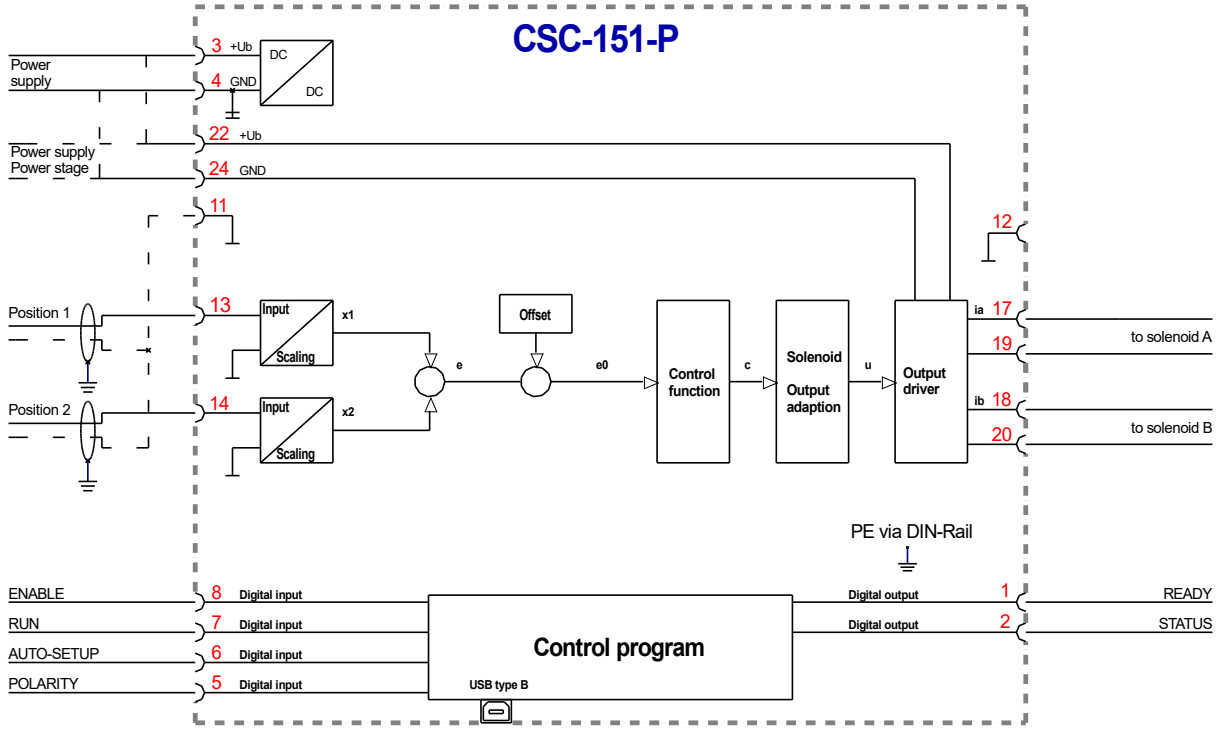


Type plate and terminal pin assignment

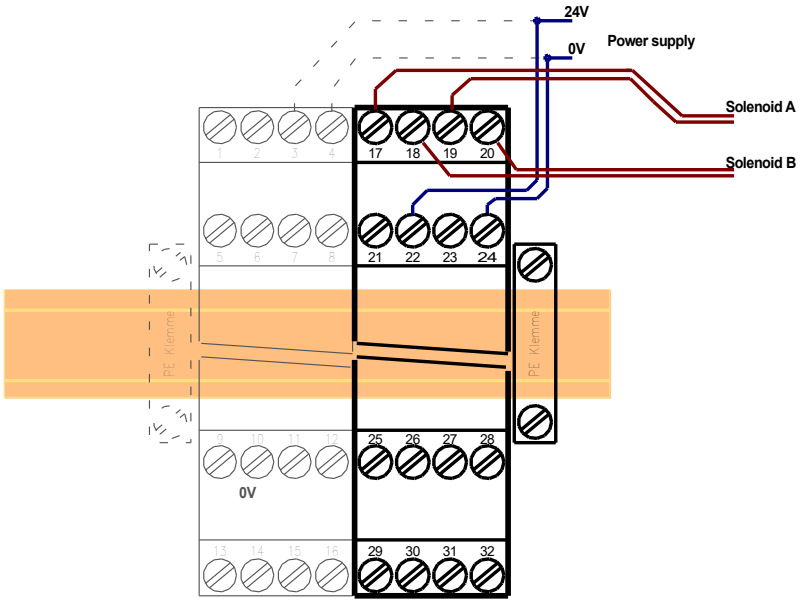
7.3 *Inputs and outputs*

Connection	Signal description
PIN 22 + PIN 24 -	**Power supply: 10… 30 VDC:** For safety-related applications, the output stage can be deactivated thanks to the separate power supply inputs.
PIN 17+19	Solenoid current output A
PIN 18+20	Solenoid current output B
Connection	**Signals modified from the standard (U version)**
PIN 15	Not usable
PIN 16	Not usable

7.4 *Circuit diagram*



7.5 *Typical wiring*



CAUTION: The solenoid cables should be screened due to electro-magnetic emissions.

CAUTION: plugs with free-wheeling diodes and LED indicators cannot be used with current-controlled power outputs. They interfere with the current control and can destroy the output stage.

7.6 *Technical data*

Supply voltage Power consumption max. Fuse protection	**[VDC]** **[W]** **[A]**	12... 30 (incl. ripple) max. 1.2 + Power of the connected coils 3 medium time lag
PWM output Max. output current Frequency	 **[A]** **[Hz]**	wire break and short circuit monitored 2.6 61… 2604 selectable in defined steps
Controller cycle time Solenoid current control	 **[µs]**	 125
Weight	**[kg]**	0.28 (incl. base module)
Connections		6 x 4-pole terminal blocks (incl. base module)

7.7 *Parameter overview*

Command	Default	Unit	Description
CURRENT	1000	mA	Output current range
DFREQ	121	Hz	Dither frequency
DAMPL	500	0,01 %	Dither amplitude
PWM	2604	Hz	PWM frequency
ACC	ON	-	Automatical calculation of the PPWM and IPWM parameter
PPWM **IPWM**	7 40	- -	Current control loop PI control dynamics
SIGNAL:U	+	-	Output polarity
SIGNAL:M	V	-	Type of the monitor output signals

The standard parameterization has been used with a large number of proportional vales from various manufacturers. This parameterization has proved to be good as long as no special demands concerning the application have to be fulfilled.

7.8 *Parameter description of the power stage*

7.8.1 CURRENT (Rated output current)

Command	Parameters	Unit	Group
CURRENT x	x= 500… 2600	mA	**STD**

The nominal output current is set. Dither and also MIN/MAX always refer to this current range.

7.8.2 DFREQ (Dither frequency)

7.8.3 DAMPL (Dither amplitude)

Command	Parameters	Unit	Group
DFREQ x	x= 60… 400	Hz	**STD**
DAMPL x	x= 0… 3000	0,01 %	

The dither[8] can be defined with this commands. Different amplitudes or frequencies may be required depending on the valve.

The dither amplitude is defined in % (peak to peak value) of the nominal output current[9] (see: CURRENT command).

The dither frequency is defined in Hz. Depending on the internal calculations, the frequency is adjustable in steps only[10].

CAUTION: *The PPWM and IPWM parameters influence the effect of the dither setting. These parameters should not be altered again after the dither has been optimized.*

CAUTION*: If the PWM frequency is less than 500 Hz, the dither amplitude DAMPL should be set to zero.*

7.8.4 PWM (PWM Frequency)

Command	Parameter	Unit	Group
PWM x	x= 61… 2604	Hz	**EXP**

The frequency can be changed in defined steps (61 Hz, 72 Hz, 85 Hz, 100 Hz, 120 Hz, 150 Hz, 200 Hz, 269 Hz, 372 Hz, 488 Hz, 624 Hz, 781 Hz, 976 Hz, 1201 Hz, 1420 Hz, 1562 Hz, 1736 Hz, 1953 Hz, 2232 Hz and 2604 Hz). The optimum frequency depends on the valve.

Attention: *The PPWM and IPWM parameters should be adapted when using low PWM frequencies because of the longer dead times which forces a reduced stability of the closed loop control.*

[8] The dither is a ripple signal which is superimposed on the current set point and is defined by the amplitude and frequency: the dither frequency and the PWM frequency. The dither frequency should not be confused with the PWM frequency. In some documentations the PWM frequency is described as a dither. This can be recognized by the lack of the dither amplitude.

[9] The dither amplitude is a command signal. Derivations between the commanded amplitude and the real amplitude are possible, depending on the dynamic of the solenoid.

[10] The lower the dither frequency, the smaller the steps. Therefore no practical problems are expected.

7.8.5 ACC (Current loop ato adjustment)

Command	Parameter	Unit	Group
ACC x	x= ON|OFF	-	**EXP**

Operation mode of the closed loop current control.

ON: In automatic mode PPWM and IPWM are calculated depending on the preset PWM-frequency.
OFF: Manual adjustment.

7.8.6 PPWM (Solenoid current controller P element)

7.8.7 IPWM (Solenoid current controller I element)

Command	Parameters	Unit	Group
PPWM x	x= 0… 30	-	**EXP**
IPWM x	x= 4… 100	-	

The PI current controller for the solenoids is parameterized with these commands.

CAUTION: These parameters should not be changed without adequate measurement facilities and experience.

CAUTION, if the parameter ACC is set to ON, these adjustments are done automatically.

If the PWM frequency is < 250 Hz, the dynamic of the current controller has to be decreased.
Typical values are: PPWM = 1… 3 and IPWM = 40… 80.

If the PWM frequency is > 1000 Hz, the default values of PPWM = 7 and IPWM = 40 should be chosen.

7.9 *Changed and additional parameters relating to U-version*

7.9.1 SIGNAL:U (Polarity of the output signal)

Command	Parameters	Unit	Group
SIGNAL:U x	x= +|-	-	**STD**

The output polarity is set by this parameter.

8 Notes