WEST

Technical Documentation

MDR-133-U
MDR-133-P

Pressure control module

Electronics
Hydraulics meets
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Electronics

CONTENTS

1 General Information

1.1 Order number

MDR-133-U[1] - with programmable output (0… 10 V or 4… 20 mA) and analogue sensor interface
MDR-133-P - with additional power output stage up to 2,6 A (*see additional information*)

Alternative Products

MDR-137-P - with integrated power stage up to 2,6 A and analogue interface

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] Compared with older versions (ordering code **A** for voltages output and **I** for current output) the code **U** (universal) is used for programmable outputs.

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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The data and characteristics described herein serve only to describe the product. The user is required to evaluate this data and to check suitability for the particular application. General suitability cannot be inferred from this document. We reserve the right to make technical modifications due to further development of the product described in this manual. The technical information and dimensions are non-binding. No claims may be made based on them.

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 module was developed for controlling of pressure and force in hydraulic systems. The controller structure is optimized for pressure closed-loop control systems with typical pressure valves.

The controller works in a bypass control function, where the input signal is linked directly to the control output (pressure valve) and the PID compensator has to control the linearity deviations only. In many cases the optimization without further test equipment (only a pressure sensor is needed) can be carried out.

The output signal is available as 0…10 V or 4… 20 mA signal for the direct connection of valves with integrated electronics. Also external amplifiers and power plugs can be used.

Alternatively, the controller (P-version) is available with an integrated power output stage (see additional information: POWER OUTPUT STAGE). The advantage of the integrated power output stage is founded in the integrated control behavior without additional dead times. This allows higher dynamics and higher stability respectively.

The start-up procedure is supported by our software tool WPC-300 (free download from our homepage).

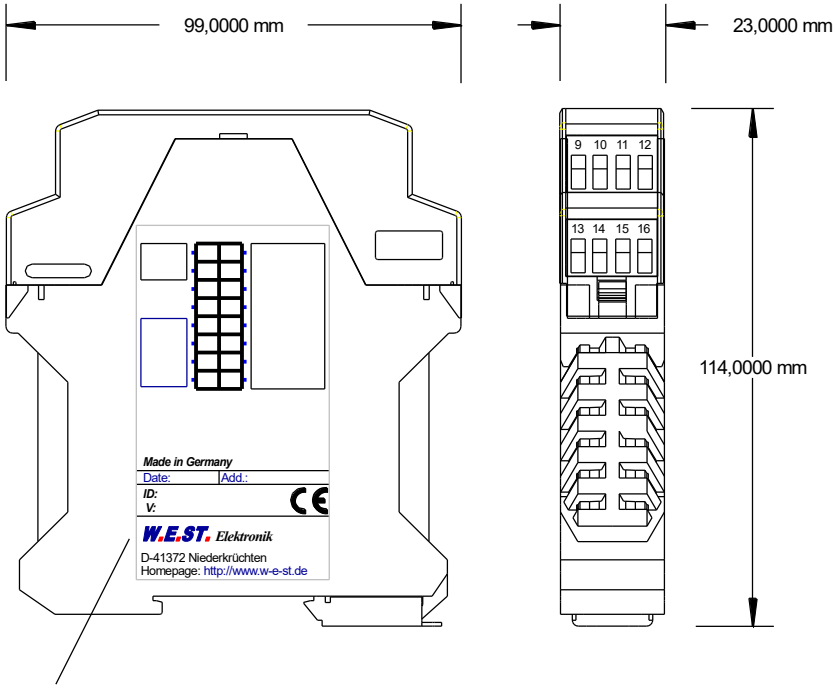
Typical applications: pressure control with pressure limitation valves and/or pressure reducing valves.

Features

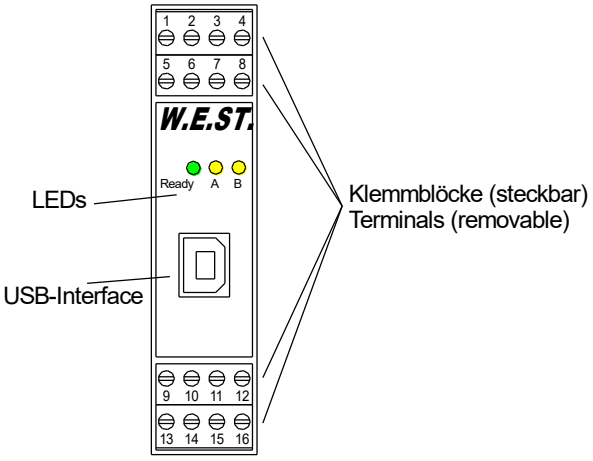
- **Analogue pressure command and actual values**
- **Special pressure control concept for pressure reducing and relief valves**
- **Optimized controller for pressure closed loop control**
- **Integrated functions to prevent pressure overshoots**
- **Simple optimizing of the controller**
- **Ramps for pressure loading and unloading**
- **Simple and application orientated parameter settings**
- **Standard USB interface**
- **Fault diagnosis and extended function checking**
- **Simplified parameterization with WPC-300 software**
- **Optional with power output stage (P version)**

2.1 Device description

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



Typenschild und Anschlussbelegung
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.

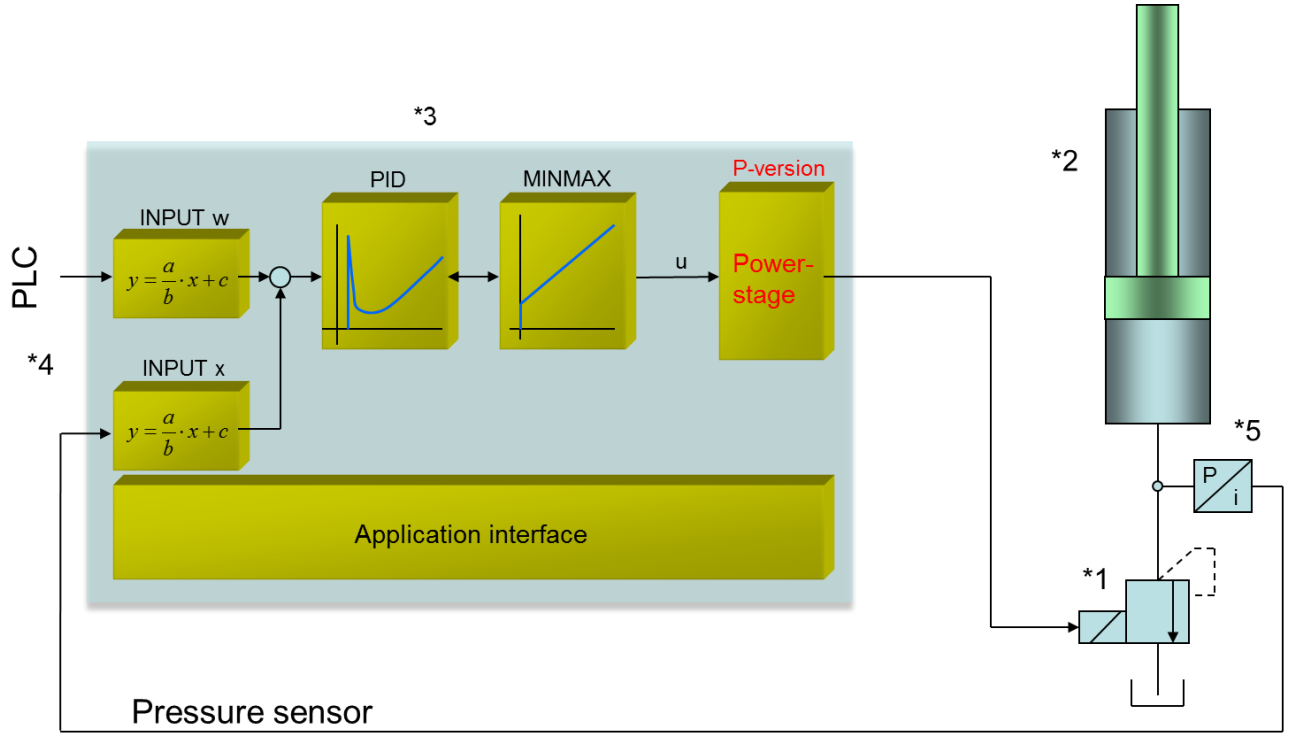
- The module should be installed and wired in accordance with the documentation bearing in mind EMC principles. If other consumers are operated with the same power supply, a star-shaped ground wiring scheme is recommended. The following points must be observed when wiring:
  - The signal cables must 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) Pressure relieve valve (alternative: pressure controlled servo pump)
(*2) Cylinder / actuator
(*3) MDR-133 pressure controller
(*4) Interface to PLC
(*5) Pressure or force sensor



3.3 Method of operation

This module is useful for pressure control in very different applications.The output signal controls various pressure valves (with integrated electronics or external power amplifier as well as with power plugs).

Optionally the device can control valve coils directly via integrated power stage (P-version). The advantages are an easier handling, lower costs and less spares inventory.

Because of the very high stability of the pressure control structure this module is recommended where open loop applications are not sufficient concerning the accuracy. Pressure controls with constant pumps or remote controllable servo pumps and for force and torque controls with cylinders and motor drives are typical applications.

By means of an **enable** signal the output gets activated and can be controlled by the command value. The operational readiness is reported via a **ready** signal. With setting the **start** signal, the feedback value will be read in and the PID controller starts calculating and generating the output signal depending on the control deviation and the parameterization. The **ramp** function for the command signal can be switched on and off with this corresponding digital input. The type of the output signal is selectable (**SIGNAL:U**).

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	Parameterize now (with the help of the system redundancy and the connection diagram) the following parameters: The SYSTEM PRESSURE, the SENSOR SETTINGS, the OUTPUT SIGNAL as well as the COMMAND SIGNAL and approximately the PID CONTROLLER. Pre-parameterization is necessary to minimize the risk of an unintentional movement / pressure.
Control signal	Check the control signal with a voltmeter. The control signal lies in the range of 0… 10 V. In the current state it should be 0 V. Alternatively, if current signals are used, approx. 0 mA should flow.
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 at full speed. Take safety measures to prevent personal injury and damage. The device can now be used in open loop control by the command input.
Activating START	This digital signal activates the PID controller. The feedback value will be read in and the output signal gets calculated.
Controller optimization	Now optimize the parameterization of the controller according to your application and your requirements.

4 Technical description

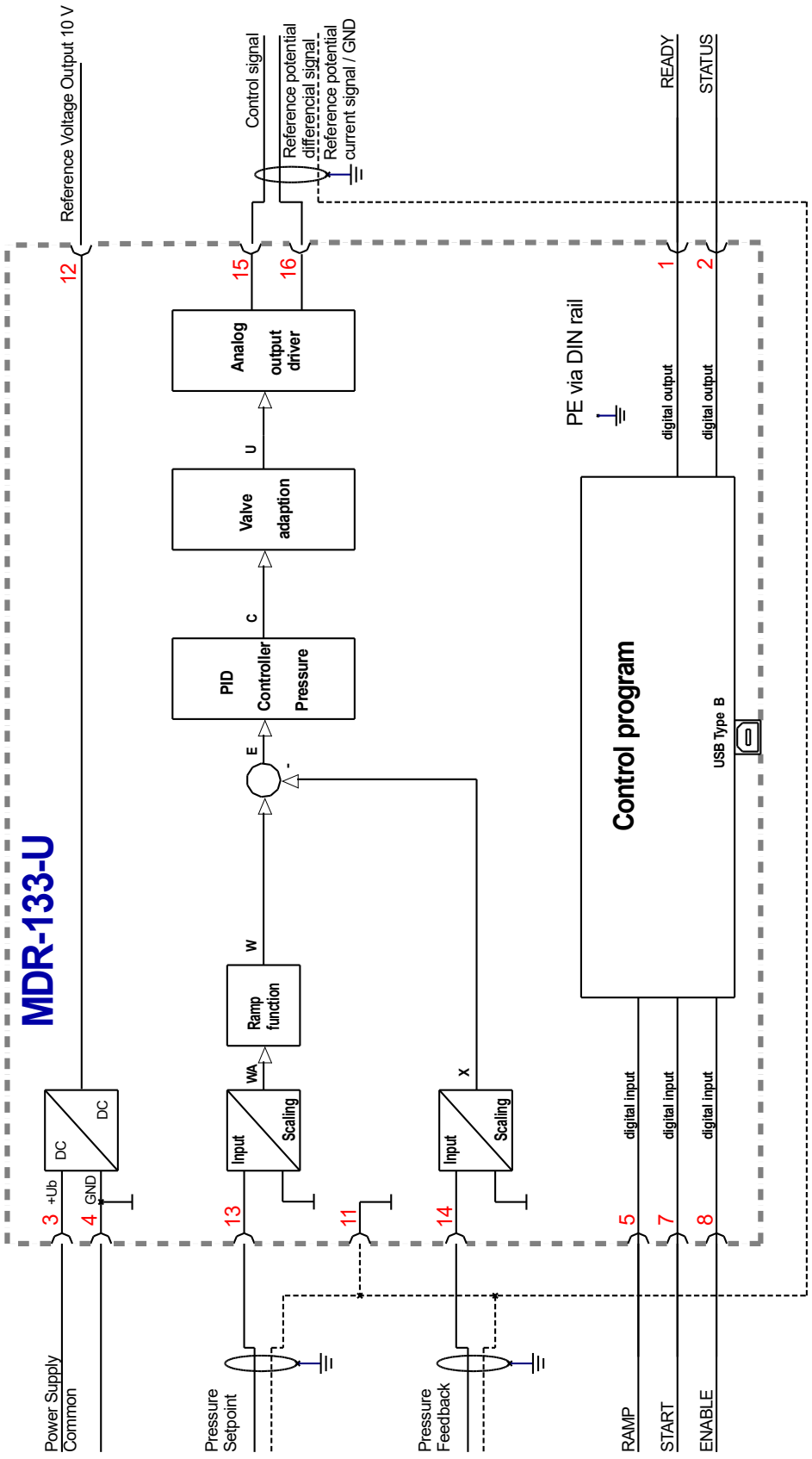
4.1 Input and output signals

Connection	Supply
PIN 3	Power supply (see technical data)
PIN 4	0 V (GND) connection
Connection	**Analogue signals**
PIN 11	0 V (GND) connection
PIN 12	Reference output voltage
PIN 13	Command value input (W), signal range 0… 10 V or 4… 20 mA, scalable
PIN 14	Actual value input (X), signal range 0… 10 V or 4… 20 mA, scalable
PIN 15 / 16 PIN 15 / 11	Output signal to the valve Type and polarity of signal are selectable by SIGNAL:U
Connection	**Digital inputs and outputs**
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:** The control deviation is within the defined range (CDWIN). **OFF:** The control deviation is outside the defined range (CDWIN).
PIN 5	**RAMP input:** Activates the ramp function for the command value.
PIN 7	**RUN input:** Activates the pressure controller.
PIN 8	**ENABLE input:** This digital input signal initializes the application. Error messages are deleted. The analogue output and the READY signal will be activated.

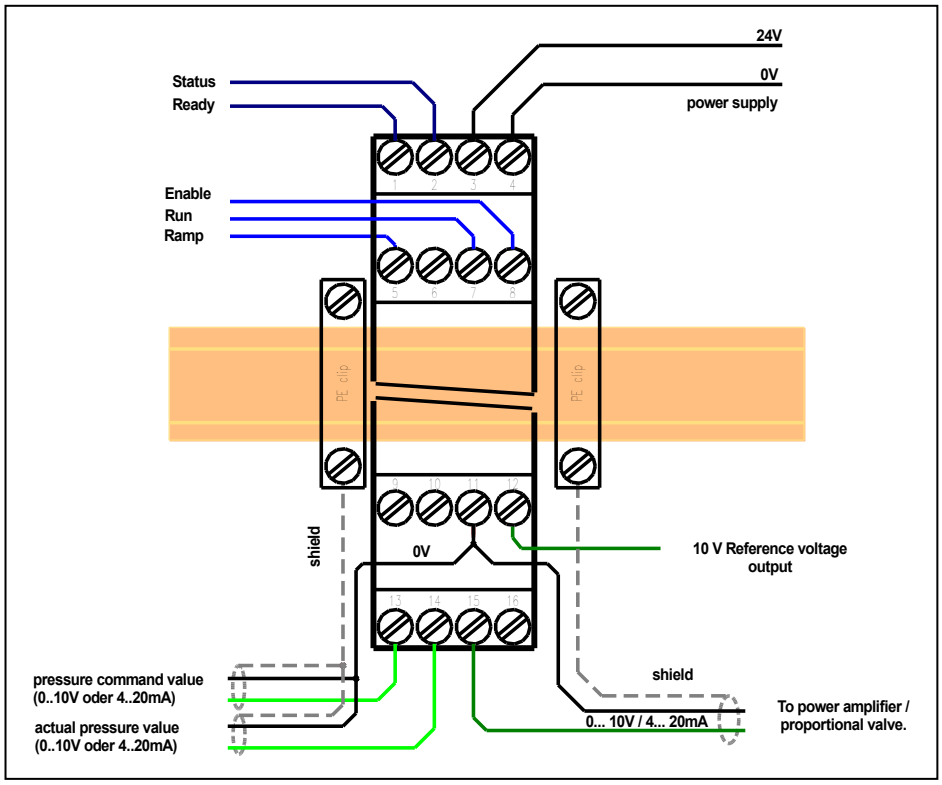
4.2 LED definitions

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 peration ***Flashing***: Error discovered Only active when SENS = ON
YELLOW A	Identical to the STATUS output. OFF: The axis is outside the CDWIN window. ON: The axis is within the CDWIN 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.

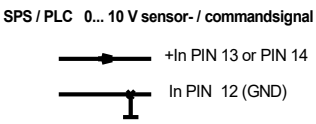
4.3 Circuit diagram

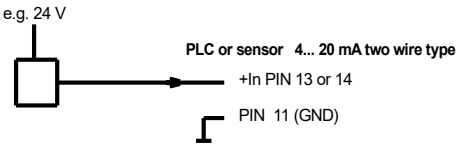


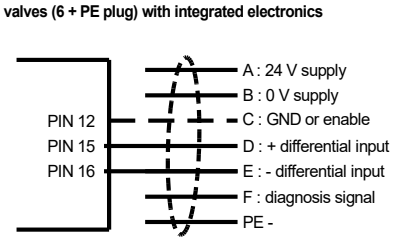
4.4 Typical wiring

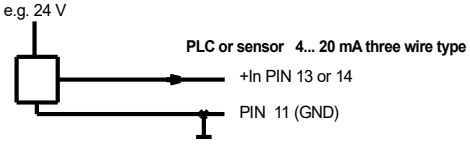


4.5 Connection examples









4.6 Technical data

Supply voltage (Ub) Power consumption External protection	**[VDC]** **[W]** **[A]**	12… 30 (incl. ripple) max. 1,2 1 medium time lag
Digital inputs OFF ON Input resistance	 **[V]** **[V]** **[kOhm]**	 < 2 > 10 25
Digital outputs OFF ON Maximum current	 **[V]** **[V]** **[mA]**	 < 2 max. Ub 50
Analogue inputs Voltage Input resistance Signal resolution Current Burden Signal resolution	 **[V]** **[kOhm]** **[%]** **[mA]** **[Ohm]** **[%]**	Unipolar / differential 0… 10 / -10… 10 min. 25 0,003 incl. Oversampling 4… 20 240 0,006 incl. Oversampling
Analogue outputs Voltage Maximum load Current Maximum load Signal resolution	 **[V]** **[mA]** **[mA]** **[Ohm]** **[%]**	 0… 10, +/- 10 differential 10 4… 20 390 0,007
Controller cycle times Signal processing	 **[ms]**	 1
Serial interface Transmission rate	**-** **[kBaud]**	USB - virtual COM Port 9,6… 115,2
Housing Material Flammability class	 **-** **-**	Snap -on module acc. EN 50022 PA 6.6 polyamide V0 (UL94)
Weight	**[kg]**	0,15
Protection class Temperature range Storage temperature Humidity	**[IP]** **[°C]** **[°C]** **[%]**	20 -20… 60 -20… 70 < 95 (non-condensing)
Connections Communication Plug connectors PE	 **-**	 USB type B 4 x 4-pole terminal blocks 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
	CDWIN	2000	mbar	Size of the control deviation window
	EOUT	0	0,01 %	Output signal if not ready
Input signal adaptation				
	SYS_RANGE	100	mm	System pressure
Sensor scaling				
	SIGNAL:X	U0-10		Type of input
	N_RANGE:X	100	bar	Sensor nominal pressure
	OFFSET:X	0	bar	Offset value
Command signal				
	SIGNAL:W	U0-10	-	Type of input
Ramp function				
	RA:UP **RA:DOWN**	100 100	ms ms	Command Signal ramp times
Closed loop control parameters				
	C:P **C:I** **C:D** **C:D_T1** **C:FF**	50 4000 0 500 8000	0,01 0,1 ms 0,1 ms 0,1 ms 0,01 %	PID control parameters for pressure control
	C:I_LIM **C:I_ACT**	2500 2500	0,01 % 0,01 %	Integrator limitation Integrator activation value
Output signal adaptation				
	MIN	0	0,01 %	Deadband compensation
	MAX	10000	0,01 %	Output scaling
	TRIGGER	200	0,01 %	Deadband compensation trigger point
	SIGNAL:U	U0-10	-	Type of output signal and polarity
Special commands				
	TS	10	0,1 ms	Sample time of the control loop
Scaling mode				
	AINMODE	EASY	-	Input scaling mode
	AIN:W **AIN:X**	A: 1000 B: 1000 C: 0 X: V	- - 0,01 % -	Free scaling of the analogue inputs. Replaces SIGNAL:W and SIGNAL:X (N_RANGE:X, OFFSET:X) if AINMODE is switched to MATH.

5.2 Configuration

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 (Switching between parameter groups)

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.

Other group functions switch over automatically the list of commands. Only the relevant commands are visible.

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 inputs, output current 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 does not 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 CDWIN (Control deviation window)

Command	Parameters	Unit	Group
CDWIN x	x= 100… 50000	mbar	**STD**

This parameter is entered in µm.
The CDWIN command defines a range for which the STATUS message is generated. This function monitors the failure between the command and actual position. If the failure is less than the programmed value a CDWIN message is given to the status output (see Pin description). The positioning process is not influenced by this message.
PIN 7 (START) muss be acivated to generate the CDWIN message.

5.2.5 EOUT (Output signal: READY = OFF)

Command	Parameters	Unit	Group
EOUT x	x= 0… 10000	0,01 %	**EXP**

Output value in case of a detected error or a deactive ENABLE input. A value (degree of valve opening) for use in the event of a sensor error (or the module is disabled) can be defined here.

|EOUT| = 0 The output is switched off in the event of an error. This is normal behavior.

CAUTION! If the output signal is 4… 20 mA, the output is switched off when **|EOUT| = 0**. If a defined value is to be output in the event of an error, EOUT must be set suitable[2].

The output value defined here is stored permanently (independently of the parameter set). The effects should be analyzed by the user for each application from the point of view of safety.

[2] This is necessary if using valves without error detection for signals lower than 4 mA. If the valve has an error detection, it moves into a defined position after switching off the output.

5.3 Input signal adaptation

5.3.1 SYS_RANGE (Sytem pressure)

Command	Parameters	Unit	Group
SYS_RANGE x	x= 10… 1000	bar	**STD**

This command defines the full working range, which corresponds to 100 % of the command signal. If the demand is set incorrectly, this leads to incorrect system settings, and the dependent parameters cannot be calculated correctly.

5.3.2 SIGNAL (Type of input)

Command	Parameter	Unit	Group
SIGNAL:i x	i= W|X x= OFF U0-10 I4-20	-	**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 the analogue inputs (W and X).
OFF= Deactivation of the input[3].

5.3.3 N_RANGE:X (Nominal pressure of the sensor)

Command	Parameter	Unit	Group
N_RANGE:X x	x= 10… 10000	bar	**EASY**

N_RANGE (nominal range) is used to define the maximum pressure of the sensor. This value should be almost the same, better higher than SYS_RANGE, in case of being able to measure the whole working range and even pressure overshoots. The control parameters cannot be calculated correctly in case of wrong values.

[3] The deactivation makes no sense in this application because the control process cannot be realized without one of the input signals.

5.3.4 OFFSET:X (Sensor offset)

Command	Parameter	Unit	Group
OFFSET:X x	x= -60000… 60000	mbar	**EASY**

Adjustment of the zero point of the sensor.
The OFFSET:X is internally limited to SYS_RANGE.

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

With these commands, the feedback sensor is scaled. Suppose you have a pressure control with the following characteristics:

- The system pressure is 350 bar
- The pressure sensor has a 4-20 mA current output
- The nominal pressure of the sensor is 600 bar (20 mA at 600 bar)
- The sensor has an offset of 3 bar (at 0 bar real pressure 3 bar are displayed)

To scale this sensor correctly the following settings should be made:

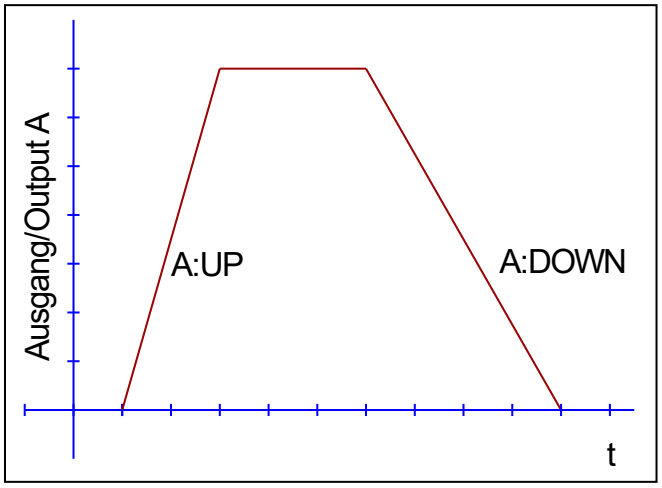
- SYS_RANGE 350 bar
- SIGNAL:X I4-20
- N_RANGE:X 600 bar
- OFFSET:X -3000 mbar

5.4 Ramp function

5.4.1 RA (Command signal ramp times)

Command	Parameters	Unit	Group
RA:I X	i= UP|DOWN x= 1… 600000	ms	**STD**

Two quadrant ramp function.
The ramp time is set separately for increasing pressure (UP) and decreasing pressure (DOWN).



5.5 Closed loop control parameters

5.5.1 PID controller

Command	Parameters	Unit	Group
C:P X	x= 0… 10000	0,01	**STD**
C:I X	x= 0… 30000	0,1 ms	
C:D X	x= 0… 1200	0,1 ms	
C:D_T1 X	x= 0… 1000	0,1 ms	
C:FF X	x= 0… 10000	0,01 %	

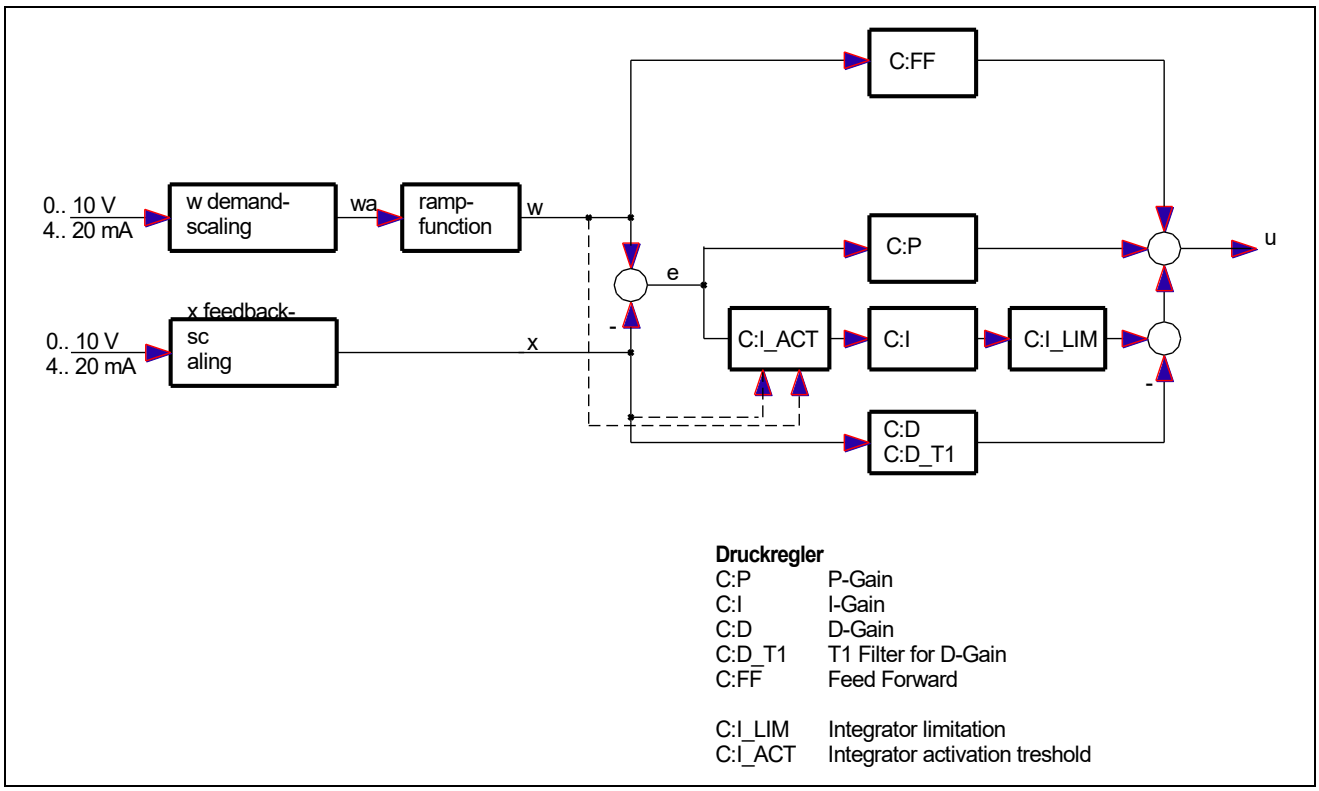
The control function will be parameterized via this command.

The P, I and D gain are similar to a standard PID controller. The T1 factor is used for the D-gain in order to suppress high-frequency noise.

The FF value is a forward control value to control the output by the input signal directly. The PID closed loop control function has only to adjust the difference (the error).

To reduce pressure overshoots, an activation point for the integrator can be programmed via the IC-value.

Setting the integrator to 0 will deactivate it.



5.5.2 Integrator control function

Command	Parameter	Unit	Group
C:I_LIM X C:I_ACT X	x= 0… 10000 x= 0… 10000	0,01 % 0,01 %	**STD**

The integrator function is controlled by this command.

C:I_LIM Limitation of the integrator range (faster control function by reduced pressure overshoots). By a high nonlinearity of the valve the LIM value must be sufficient to compensate it.

C:I_ACT Controls the integrator function. To reduce pressure overshoots, an activation point for the integrator can be programmed via the (I_ACT) value. The integrator is activated if the actual pressure is higher than the programmed threshold.

5.6 Output signal adaptation

5.6.1 MIN (Deadband compensation)

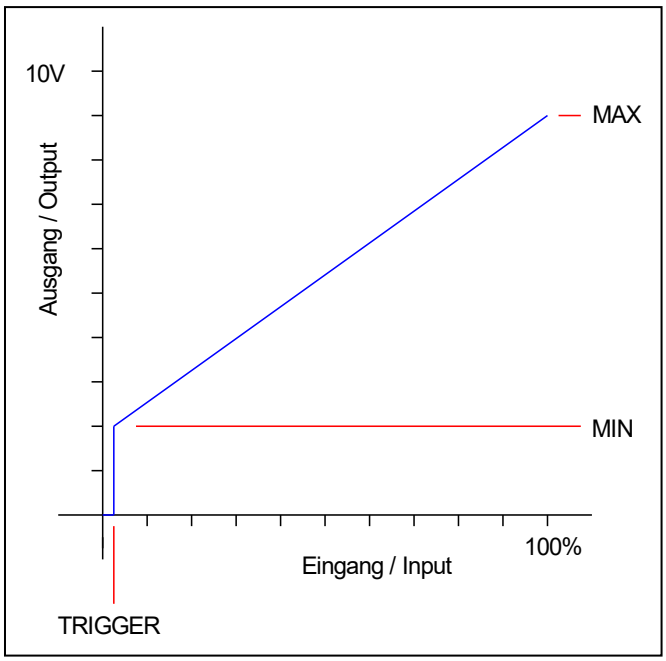
5.6.2 MAX (Output scaling)

5.6.3 TRIGGER (Response threshold for the MIN parameter)

Command		Parameters	Unit	Group
MIN	X	x= 0… 6000	0,01 %	**STD**
MAX	X	x= 4000… 10000	0,01 %	
TRIGGER	X	x= 0… 3000	0,01 %	

With this command, the output signal is adjusted to the valve characteristics. With the MAX value the output signal (the maximum valve current) will be defined. With the MIN value the overlap (dead band of the valve) will be compensated. Via the TRIGGER the activation point of the MIN function is set and so a non-sensitive range around the zero-point[4] can be specified.

CAUTION: If the MIN value is set too high, it influences the minimal pressure, which cannot be adjusted any longer. In extreme case this causes to an oscillating at small input values.



[4] This dead band is necessary, in order to avoid unrequested activations caused by small variations of the input signal. If this module is used in a position controls, the TRIGGER value should be reduced (typical: 1…10).

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

Command	Parameter	Unit	Group
SIGNAL:U x	x= U0-10 I4-20 U10-0 I20-4	-	**EXP**

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

Voltage output 0 to 100 % corresponds with 0… 10 V at PIN 15.
Current output 0 to 100 % corresponds with 4… 20 mA at PIN 15.

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] The older POL command is removed.

5.7 Special commands

5.7.1 TS (Sample time)

Command	Parameters	Unit	Group
TS x	x= 4… 30	0,1 ms	**TERMINAL**

The control dynamics can be influenced with the sample time. Changes should only be made by persons who have sufficient knowledge of the dynamic system behavior.

5.7.2 AINMODE (Input scaling mode)

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

This command is used to switch over the kind of input scaling.

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.

5.7.3 AIN (Analogue input scaling)

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

This command offers an individual scalable input and is provided for the command signal input (w) and the feedback input (x). The following linear equation is used for the 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 (see below)

Typical settings:

Command	Input	Description
AIN:X 1000 1000 0 V	0… 10 V	Range: 0… 100 %
AIN:X 10 8 1000 V OR **AIN:X 1250 1000 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:X 10 4 500 V OR **AIN:X 2500 1000 500 V** OR	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:X 20 16 2000 C OR **AIN:X 2000 1600 2000 C** OR **AIN:X 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 %.

5.8 PROCESS DATA (Monitoring)

Command	Description	Unit
WA	Input signal	bar
W	Command value	bar
X	Feedback value	bar
E	Control error	bar
C	Controller output	%
U	Output	%
IA	Solenoid current	mA (only P-version)

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
Command 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 Solenoid on PIN 17 / 19	Wrong cabling, 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 mode in monitor window 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. If the power supply exists, an attempt should be made to see whether the system can be moved by means of the HAND+ and HAND- inputs (measuring the output signal to the valve helps).
ENABLE is active, the READY LED is flashing.	The flashing READY LED signals that a fault has been detected by the module. The fault could be: • A broken cable or no signal at the input (PIN 13 or PIN 14), if 4… 20 mA signals are parameterized. • A broken cable or incorrect cabling 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.
ENABLE is active; the READY LED is active; no current to the solenoid (no pressure-build-up).	To locate errors in the pressure-control-circuit, it is useful to start with the open loop pressure control (PIN 7 is not activated). In this case the module works like a power amplifier. • No pressure command input is available or the parameterization is incorrect. With the WPC-tool you can check if a command input is available. If not, you should check the wiring and/or the command set-point (in the PLC for example). • If the command input is correct, you have to check the valve control parameter. If the current is set too low (parameter CURRENT), the output current and the expected pressure are too low. • Wrong configured pressure sensor (if PIN 7 is active). If the input-scaling is set to voltage (V) and the pressure sensor supplies a current signal (4... 20mA), the measured pressure value is always high. The output signal to the valve is therefore low. For further checking: disable PIN 6. • The pressure valve is controlled correctly (the output is going up to the nominal current). In this case you may have a hydraulic problem or you are using free-wheeling-diodes in the solenoid plug. Please remove the free-wheeling-diodes to allow a correct current measurement.
ENABLE and START are active, the READY LED is active, and the pressure control loop works, but there are high errors mainly at lower or higher command pressure.	The non linearity of the valve is higher than the controlling range of the integrator. The parameter LIM:I should be increased.

FAULT	CAUSE / SOLUTION
ENABLE and START are active, the READY LED is active, and the pressure control loop works. Lower pressure at the beginning causes that the system is not actuated and that no pressure build-up occurs.	In this case, the integrator threshold (activation point of the integrator) in combination with the controller setting is too high. The parameter LIM: S should be reduced.
ENABLE and START (PIN 6) are active, the READY LED is active, the pressure control loop works, but the pressure is oscillating or the pressure UP and DOWN time is too slow.	The capability of the hydraulic system has to be checked. Deactivate PIN 6 for open loop control and check the pressure build up and down time. If the system is in open loop still instable, check the hydraulic and the dither/ PWM setup first. 1. Check the parameters C:I, C:P and C:SC.The parameter C:SC has the following relevance: With this parameter you can increase or decrease the feed forward gain to the valve. C:SC 8000 (80 %) means, the remaining 20 % must be provided by the PID compensator. The integrator limitation should be set to 2500... 3500 (25 % ... 35 %)[6]. 2. The C:P (P-gain) is to increase in steps[7] to the point where the pressure is going to be instable. At this point, C:P should be decreased for 30… 50 % to get an effectual stability margin. 3. The integrator time constant C:I fixes the static error. Typical values are: 100 ms to 1200 ms. Optimize this parameter by monitoring the transient response.
ENABLE is active, the READY LED is active and the pressure is instable.	In many cases you may have a hydraulic problem. Electrical problems may be: • Electrical noise at the wire of the power supply. • Very long solenoid wiring (> 40 m), disturbance in the current control loop[8]. • Instable current control loop. The adjustments of the PWM-frequency and the dither (frequency and amplitude) have to be checked carefully. Good experiences are made with: a. PWM-frequency = 2600 Hz (higher frequency), the dither has to be aligned to the valve (amplitude and frequency). b. PWM-frequency = 100… 400 Hz (lower frequency), the dither amplitude is set to 0 % (disabled)[9].

[6] The limit value should be higher than the remaining control range (100 % - C:SC), additionally you have to add a value to compensate the non-linearity of the valve.

[7] Optimizing in steps is a general description. Our experience: you can change the parameters in steps from +20 % or rather -20 % for a rough adjustment of the actual value. For a fine adjustment you can select smaller steps.

[8] Maybe you have to adjust / optimize the solenoid control loop (P and I).

[9] In most applications (particularly pressure-actuated pumps) with pressure valves a lower PWM-frequency is the better solution.

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"

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.

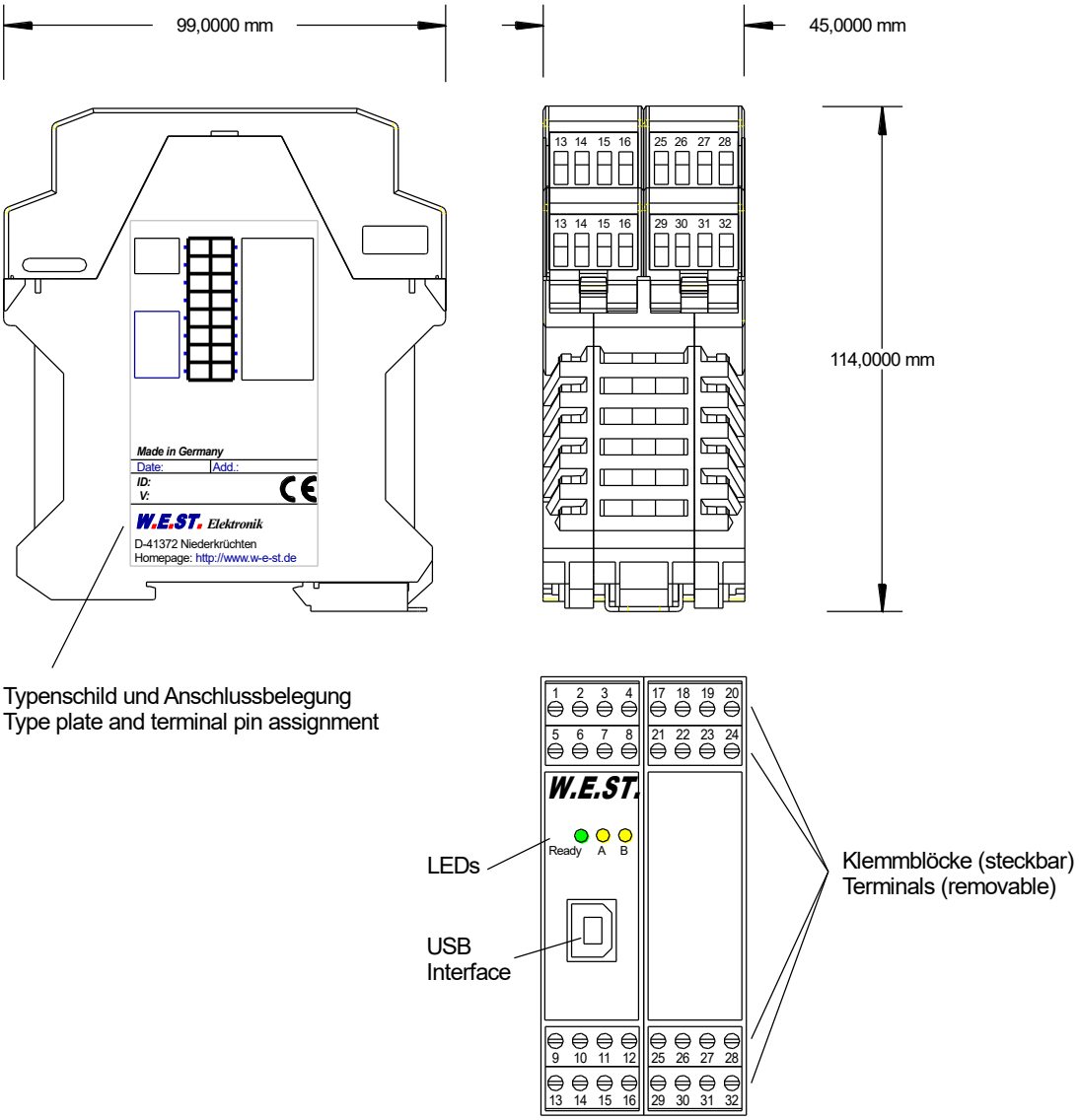
The output stage can be ideally adjusted to dynamic requirements via internal parameters.

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

Features

- **Single power output stage 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**

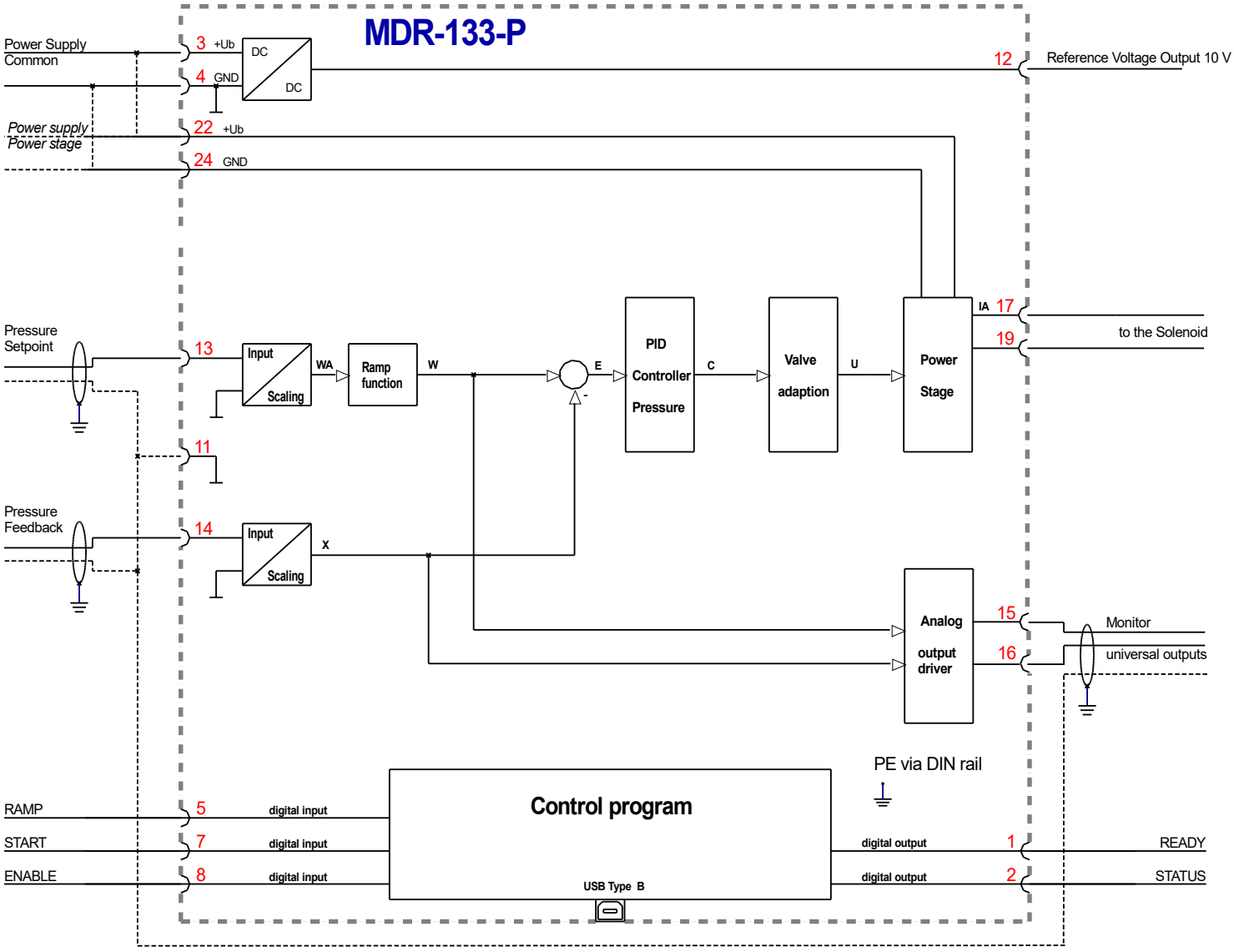
7.2 Device description



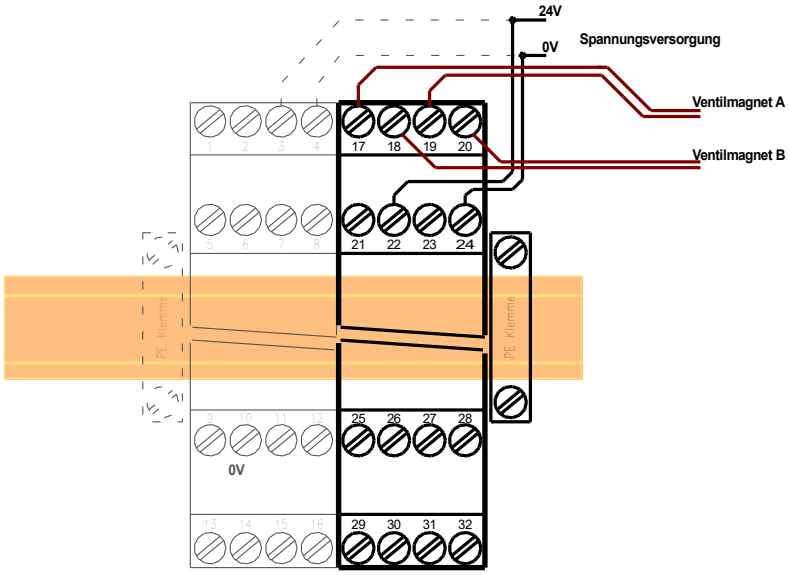
7.3 Inputs and outputs

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
Connection	**Signals modified from the standard U version**
PIN 15	0… 10 V / 4… 20 mA output with the scaled pressure demand value
PIN 16	0… 10 V / 4… 20 mA output with the scaled pressure actual value

7.4 Circuit diagram



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.

7.5 Technical data

Supply voltage (Ub) Power consumption External protection	**[VDC]** **[W]** **[A]**	10… 30 (incl. ripple) max. 1,2 + consumption of the connected coil 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		7 x 4-pole terminal blocks (incl. base module)

7.6 Parameters

7.6.1 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	U0-10	-	Type of the monitor output signal

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.

7.7 Changed parameters from U-version

7.7.1 SIGNAL:U (Polarity of the output signal)

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

This command is used to define the output polarity.

+ 0 % to 100 %, normal output characteristics

- 100 % to 0 %, changed output polarity

7.7.2 SIGNAL:M (Type of the monitor output signal)

Command	Parameter	Unit	Group
SIGNAL:M x	x= U0-10|I4-20	-	**EXP**

This command allows to define the type of signal for the monitoring outputs on PIN 15 and PIN 16.
It can be chosen between 0… 10 V and 4… 20 mA for the scaled command and feedback signal.

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[10] 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[11] (see: CURRENT command).

The dither frequency is defined in Hz. Depending on the internal calculations, the frequency is adjustable in steps only[12].

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.*

[10] 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.

[11] 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.

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

7.8.4 PWM (PWM Frequenz)

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.*

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= 1… 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.

Attention, 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.

8 Notes