W.E.S.T. Elektronik GmbH

Technical Documentation

PAM-195-P-PVG

Power amplifier for directional valves with ratiometric input

CONTENTS

1 General Information

1.1 Order Number

PAM-195-P-PVG - power amplifier for directional valves with ratio metric setpoint control

1.2 Scope of supply

The scope of supply includes the module plus the terminal blocks which are a 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 below 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 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.

1.6 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 is used for the control of a directional valve with two solenoids. Various adjustable parameters allow an optimized adaptation to the respective valve. The integrated power amplifier with a short cycle time of 0,125 ms for the current loop is an inexpensive and space-saving solution.

Setpoint setting is realized via a ratiometric input. That means the command signal is provided as precentral value relating to the supply voltage. For that the relevant voltage is measured at a separate input. Via another input the command value is set by a signal between 25% and 75% of the supply voltage with 50% as zero position.

The output current is closed loop controlled and therefore independent from the power supply and the solenoid resistance. The output stage is monitored for cable breakdown, is short circuit proof and disables the power stage in case of an error.

RAMP, MIN and MAX, the DITHER (frequency and amplitude) and the PWM frequency are programmable.

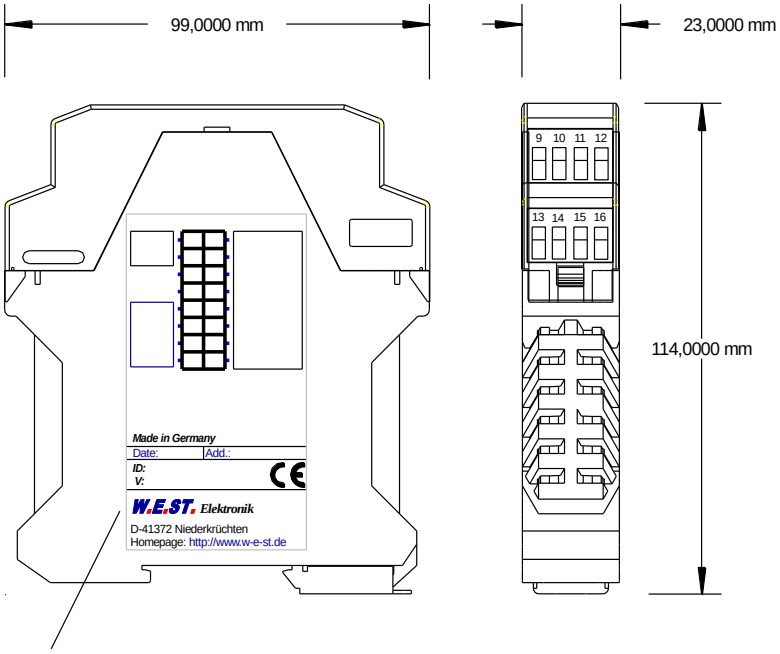
In addition, the valve characteristics can be linearized via 10 XY-points. For example: using pressure valves a linear behavior between input signal and pressure can be reached.

Typical applications: Control with ratiometric joysticks (Danfoss compatible control).

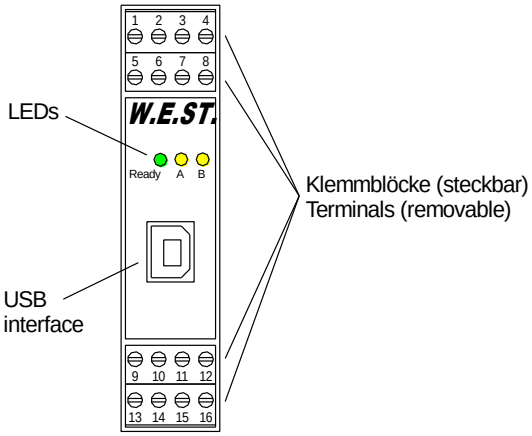
Features

- **Control of directional valves**
- **Compact housing**
- **Digital reproducible adjustments**
- **Ratiometric command value input**
- **Separate reference input for the ratiometric command input**
- **Characteristics linearization via 10 XY-points per direction**
- **Free parameterization of RAMPS, MIN und MAX, output current, DITHER (frequency, amplitude)**
- **Nominal output current range: 0,5… 2,6 A**
- **Simple and application orientated parameter settings via WPC-software**
- **Failure monitoring and extended function check**

2.1 Device description



Typenschild und Anschlussbelegung
Type plate and terminal pin assignment



3 Use and application

3.1 Installation instruction

- 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 a requirement that no strong electro-magnetic interference sources are installed nearby when using our open and closed loop control modules.

- **Typical installation location:** 24V 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 space close to the PLC (24 V area) is most suitable. All digital and analogue inputs and outputs are fitted with filters and surge protection 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-connected 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 > 3m. 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.
  - With 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). Particular care is required with cables of over 40 m in length – 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 connected to the same power supply) must always be provided with appropriate overvoltage protection directly at the coil.

3.2 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. **ATTENTION!** A USB driver has to be installed and properly configured. See WPC-300 short guideline. Further commissioning and diagnosis are supported by the operating software. **ATTENTION!** The COMPORT (in WPC-300) has to be closed before the USB plug is to be disconnected. Otherwise the WPC-300 is going to be instable.
Pre-parameterization	Now set up the following parameters (with reference to the system design and circuit diagrams): The nominal output CURRENT and the typical valve parameters such as DITHER and MIN/MAX. Pre-parameterization is necessary to minimize the risk of uncontrolled movements.
Control signal	Check the control signal with an amp meter. The control signal (the current of the solenoid) is within the range of 0... 2, 6A. In the actual status it should show approximately 0 A. **ATTENTION!** You can monitor the current of the solenoids also in the WPC-300 program.
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) if it is a proportional valve.
Activating ENABLE	**CAUTION!** The drive can now leave its position and move to an end position with full speed or the pressure can reach maximum. Take safety measures to prevent personal injury and damage. The amplifier can be controlled now via the command value input.

4 Function modes and technical description

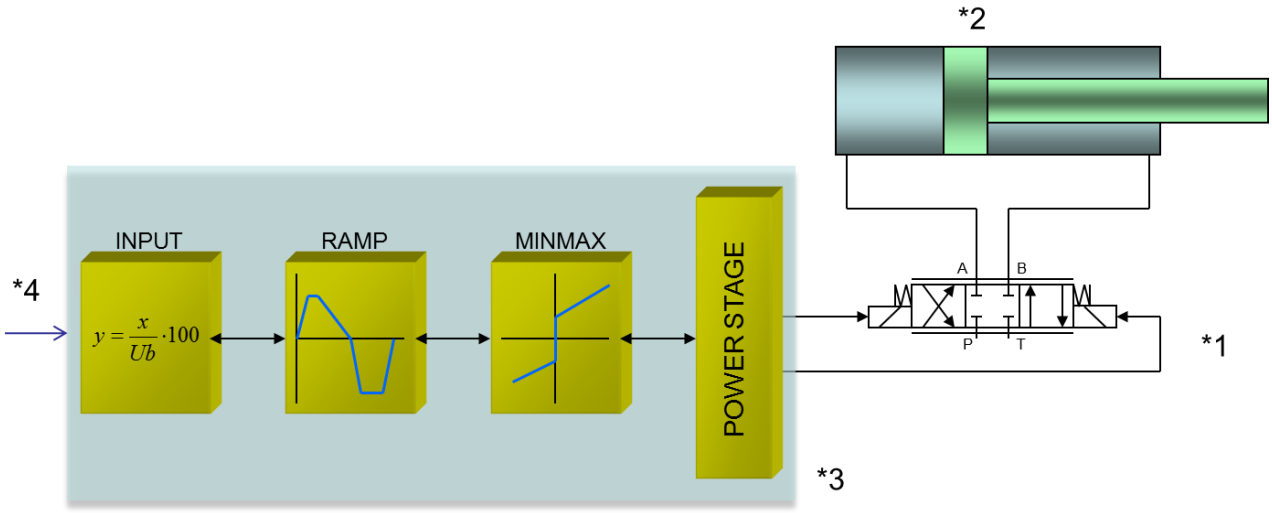
4.1 LED Indications

LEDs	Description of the LED function
GREEN + YELLOW	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 + YELLOW	**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.
GREEN	Identical to the READY output. **OFF:** No power supply or ENABLE is not activated **ON:** System is ready for operation **Flashing:** Error detected (e. g. valve solenoid or 4… 20 mA). Not active when SENS = OFF.
YELLOW	LED in the middle position = Current to the solenoid; the intensity is proportional to the actual output current.

4.2 Typical system structure

This minimal system consists of the following components:

(*1) proportional valve
(*2) hydraulic cylinder
(*3) power amplifier PAM-195-P-PVG
(*4) reference supply and ratiometric signal



4.3 Method of operation

This power amplifier is controlled by a ratiometric input signal (normally from a joystick). That means 25% up to 75% of the separately measured voltage value are used as command signal. 50% are the zero position. An ENABLE signal (typically 24V) activates the module and the READY output indicates this, if no internal or external error was detected.

The integrated standard functions will be configured via different parameters.

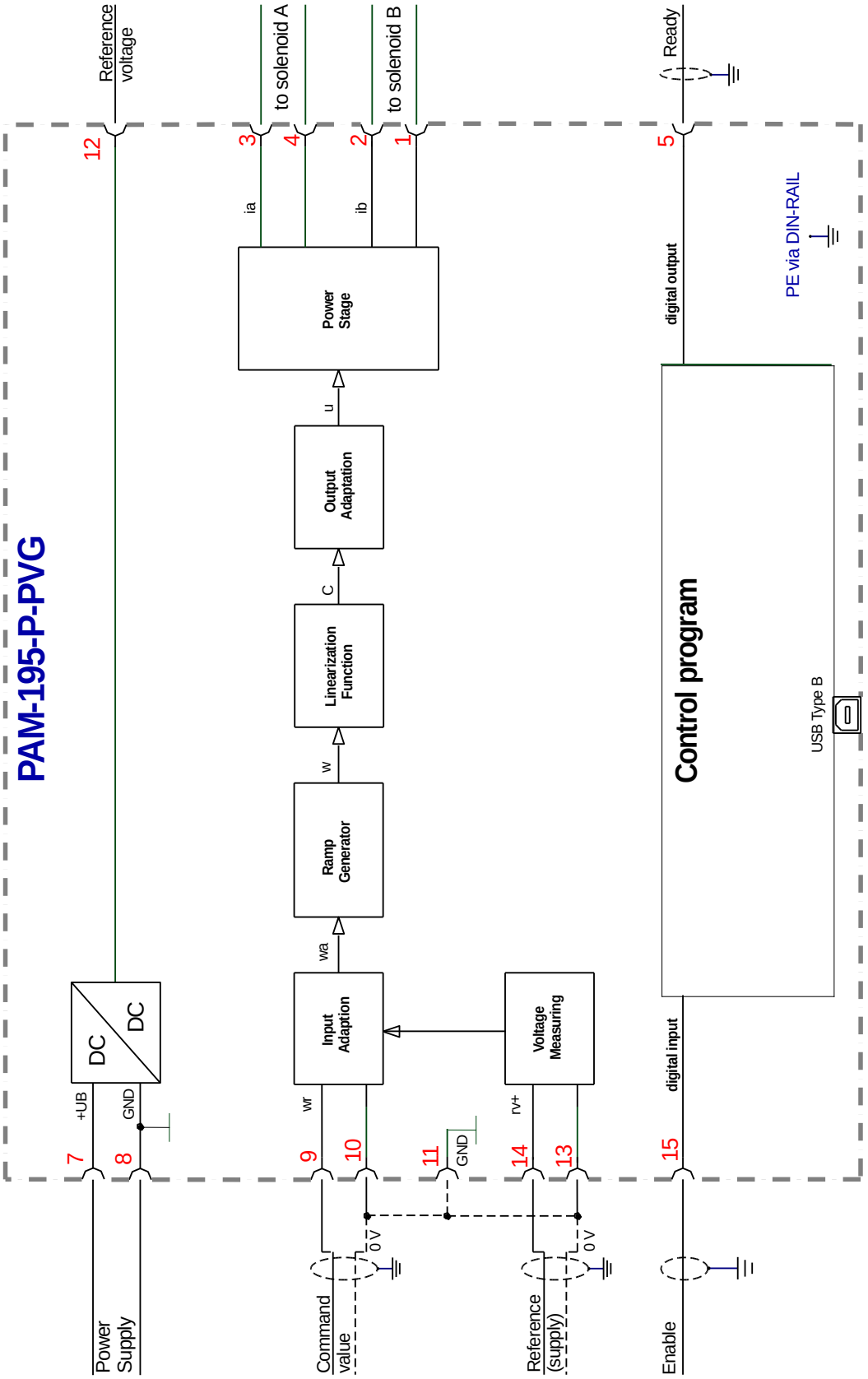
In case of a fault, the power output stage will be deactivated and the fault will be indicated through a deactivated READY output and a flashing READY LED. Depending on the configuration the error may has to be quit by resetting ENABLE.

The output current is closed loop controlled whereby a high accuracy and a good dynamic will be obtained. All custom proportional valves (up to 2,6A) may be controlled with this power amplifier.

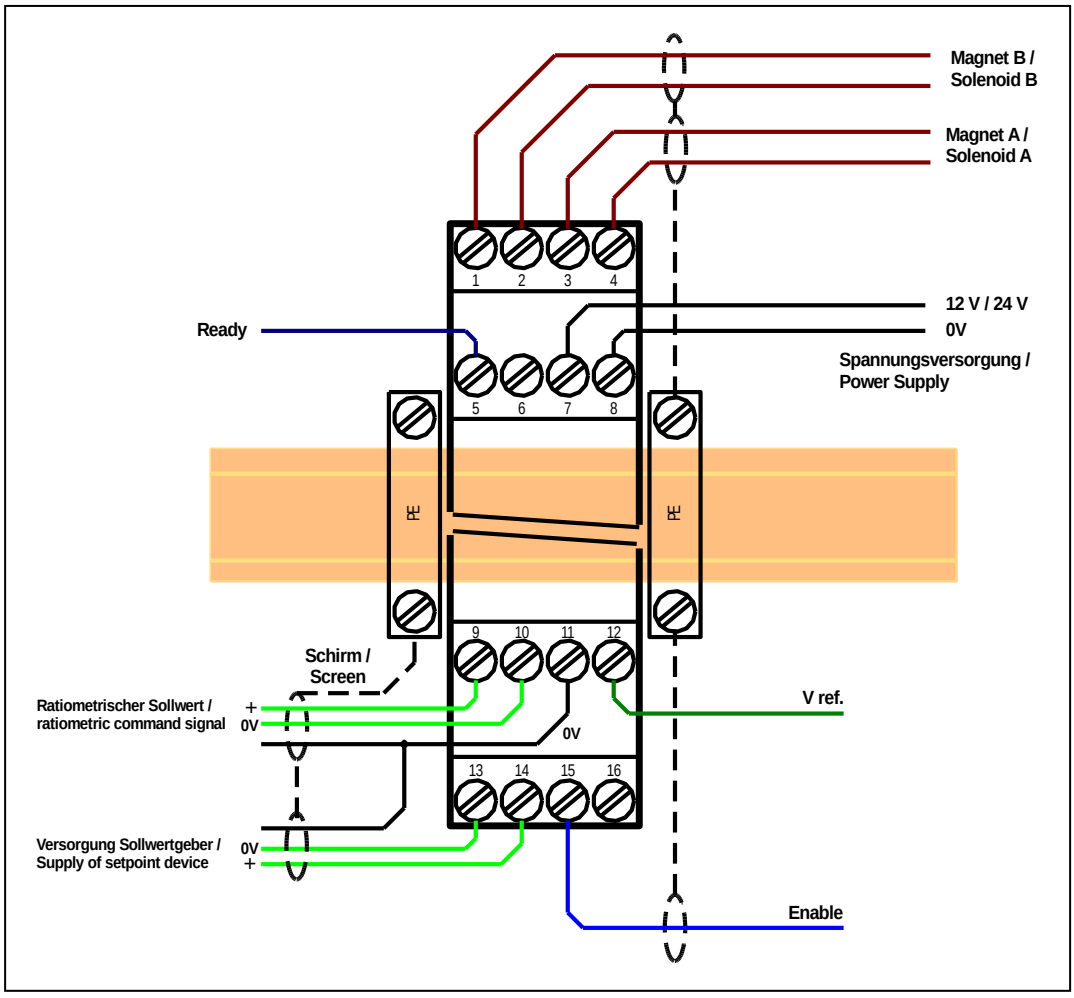
4.4 Input and output signals

Connection	Supply
PIN 7	Power supply (see technical data)
PIN 8	0 V (GND) Power supply (ground).
Connection	**Reference voltages output**
PIN 12	Reference output voltage (8 V).
Connection	**PWM output**
PIN 3 / 4	Current controlled PWM outputs for solenoid A.
PIN 1 / 2	Current controlled PWM outputs for solenoid B.
Connection	**Analogue input signals**
PIN 9	Command signal input, range 25…75 % of reference value (supply voltage) for -/+100%.
PIN 14	Reference value, supply voltage of the setpoint device (8… 30 V).
PIN 10 / 13	Potential connectors of the inputs, have to be connected to 0 V (GND)
PIN 11	0 V (GND) reference (potential of PIN 8), e.g. for the signal inputs.
Connection	**Digital inputs and outputs**
PIN 15	**Enable Input**: Application and power stage get activated, reported by Ready.
PIN 5	**READY output**: **ON:** Module is ready, no errors are detected **OFF:** ENABLE (PIN 15) is deactivated or an error is detected.

4.5 Circuit diagram

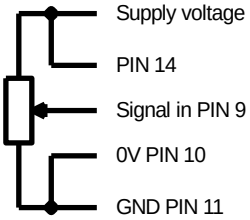


4.6 Typical wiring

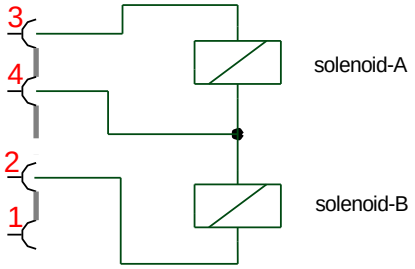


4.7 Input connection (examples)

Potentiometer / Joystick



3 wire connection e.g. for HAWE valves



4.8 Technical data

Power supply (U_b)	**[VDC]**	12… 30 (incl. ripple)
Power consumption max.	**[mA]**	30 + solenoid current
External fuse	**[A]**	3 medium time lag
Reference output		
Voltage	**[V]**	8
Maximum load	**[mA]**	25
Digital inputs		
OFF	**[V]**	< 2
ON	**[V]**	> 10
Input resistance	**[kOhm]**	25
Digital outputs		
OFF	**[V]**	< 2
ON	**[V]**	max. Ub
Maximum output current	**[mA]**	50
Reference supply		
Voltage	**[V]**	8… 30
Resistance	**[kΩ]**	min. 400
Ratiometric input		
Voltage	**[V]**	2… 22.5 (depending on reference)
Resistance	**[kΩ]**	min. 200
PWM power outputs		broken wire and short circuit monitored
Maximum output current	**[A]**	2.6
Frequency	**[Hz]**	61… 2604 selectable in steps
Sample times		
Current controller	**[µs]**	125
Analog inputs	**[ms]**	1
Serial Interface	**-**	USB - virtual COM Port
Transmission rate		9,6… 115,2
Housing		Snap-on module to EN 50022
Material	**-**	PA 6.6 polyamide
Flammability	**[class]**	V0 (UL94)
Weight	**[kg]**	0,190
Protection class		IP20
Temperature range	**[°C]**	-20… 60
Storage temperature	**[°C]**	-20 …70
Humidity	**[%]**	<95 (not condensing)
Vibration	**-**	IEC 60068-2-6 (category C)
Connections	**-**	
Communication		USB type B
Plugs		4pol. screw terminals
PE		PE: direct via DIN rail
EMC		EN 61000-6-2: 8/2005 EN 61000-6-4: 6/2007 ; A1:2011

5 Parameter

5.1 Parameter list

Group	Command	Default	Unit	Description
Basic parameters				
	LG	EN	-	Changing language help texts
	MODE	STD	-	Parameter view
	SENS	AUTO	-	Malfunction monitor
	CCMODE	OFF	-	Activation and deactivation of the characteristic linearization
Input signal adaptation				
Signal monitoring				
	LIM	1000	0.01 %	Range for the input signal monitoring
Ramp function				
	RA:1 **RA:2** **RA:3** **RA:4**	100 100 100 100	ms ms ms ms	Command signal four quadrant ramp times
Output signal adaptation				
	CC	-	X Y	Free definable characteristic linearization
	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
	SIGNAL:U	+	-	Output polarity
Parameters of the power stage				
	CURRENT	1000	mA	Rated solenoid current
	DAMPL	500	0.01 %	Dither amplitude
	DFREQ	121	Hz	Dither frequency
	PWM	2604	Hz	PWM frequency
	ACC	ON	-	Current loop auto adjustment
	PPWM **IPWM**	7 40	- -	P-Gain of the current loop I-Gain of the current loop

5.2 Basic parameters

5.2.1 LG (Changing the language for the help texts)

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

Either German or English can be selected for the help texts in the WPC-300 program.

CAUTION: After changing the language settings the parameter list has to be updated by pressing the speed button “ID”.

5.2.2 MODE (Switching between parameter groups)

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

This command changes the parameter mode. Various commands (defined via STD/EXP) are blanked out in standard mode. The several commands in expert mode have more significant influence on the system performance. Therefore they should be changed with care.

5.2.3 SENS (Failure 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. This mode should be used in case of active enabling and monitoring by a PLC (READY signal).

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 especially for troubleshooting.

AUTO MODE: The module checks each second the actual failure status, which will (in case of a persistent error) trigger the LED and the READY output for a short time.

5.2.4 CCMODE (Activation of the characteristic linearization)

Command	Parameters	Unit	Group
CCMODE X	x= ON|OFF	-	**EXP**

This command will be used for activation or deactivation of the characteristics linearization (CC, CCA and CCB). Through deactivating this parameter a simple and quick estimation of the linearization is possible.

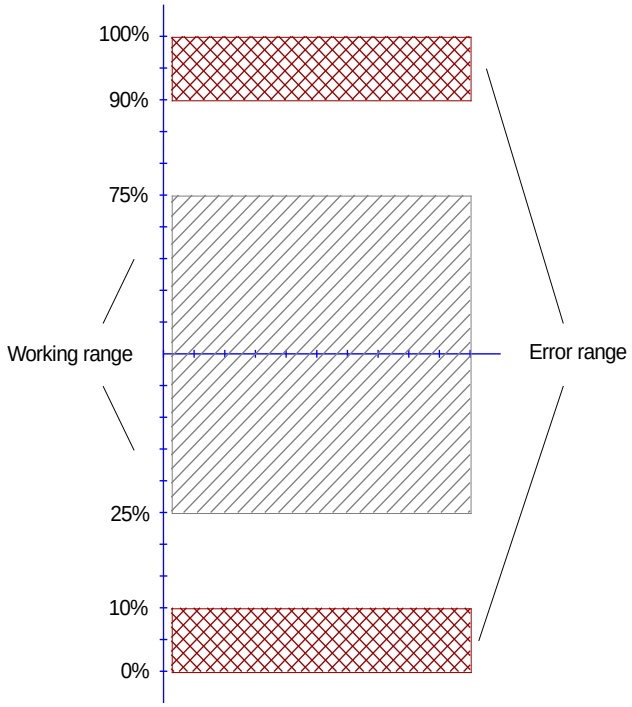
CAUTION: If CC command is used, parameters MIN, MAX and TRIGGER have to be considered. CC and those commands affect each other. Pay attention to that if it is necessary to use both kind of settings at the same time.

5.3 Input signal adaption

5.3.1 LIM (Signal monitoring)

Command	Parameters	Unit	Group
LIM X	x= 0… 2000	0.01 %	**STD**

The signal monitoring deactivates the output current and the READY output if the input signal leaves the permitted range after scaling. This function makes it possible to detect a short circuit or cable break of a joystick or potentiometer.



Example: LIM 1000 (10 % upper and lower limit, is also default).

The percentage values refer to the ratiometric signal. If the input signal increases above 90% or decreases below 10% it will be detected as error.

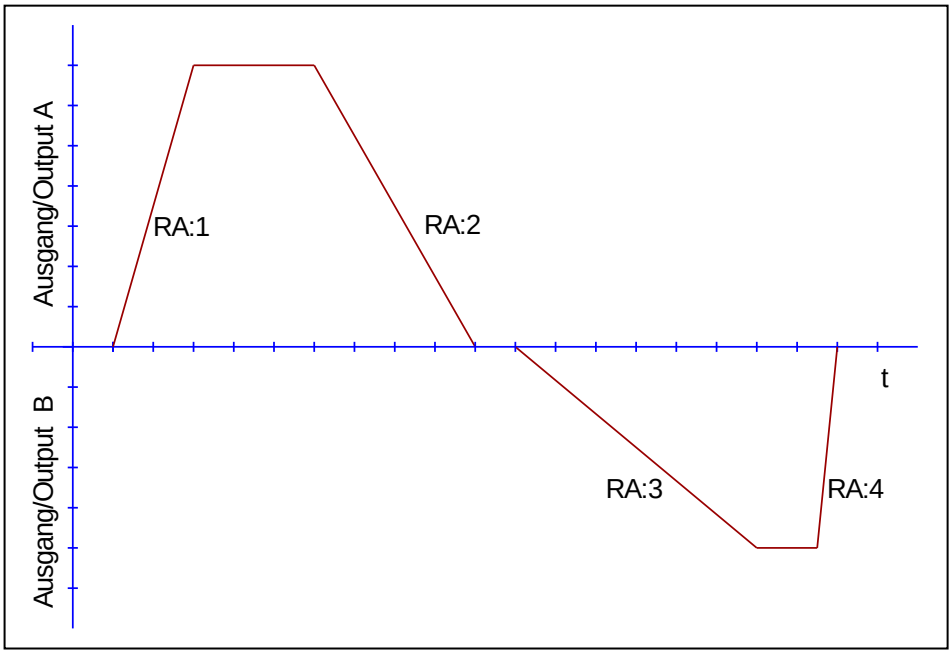
5.3.2 RA (Ramp function)

Command	Parameters	Unit	Group
RA:I X	i= 1… 4 x= 1… 120000	- ms	**STD**

Four quadrants ramp function.

The first quadrant means the acceleration ramp for solenoid A and the second one stands for the deceleration ramp of solenoid A. According to this the third quadrant represents the acceleration ramp for solenoid B so that the fourth quadrant remains for the deceleration ramp for solenoid B.

ATTENTION: Because of internal calculations rounding errors may be occur on the display.



5.4 Output signal adaption

5.4.1 CC (Characteristics linearization)

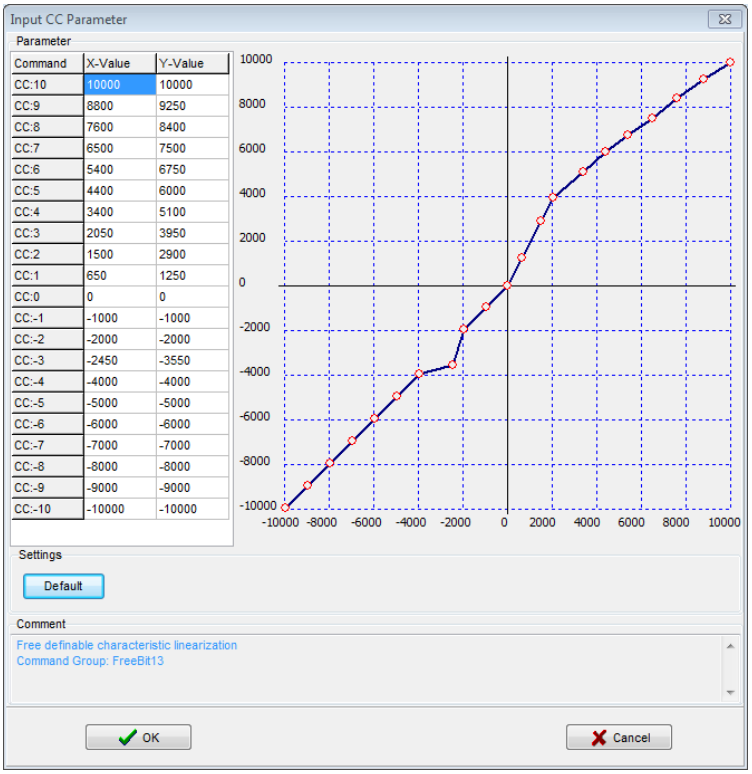
Command	Parameters	Unit	Group
CC:I X Y	i= -10… 10 x= -10000… 10000 y= -10000… 10000	- 0.01% 0.01%	**CCMODE=ON**

A user defined signal characteristic can be set by this function. For activating the parameter CCMODE has to be switched to ON.

The positive indexes stand for the solenoid A, the negative ones represent the solenoid B. The curve is calculated according to the equation of the linear interpolation: **y=(x-x1)*(y1-y0)/(x1-x0)+y1**.

The influence of the linearization can be estimated via the process data on the monitor or on the oscilloscope.

For the input of the characteristics linearization, the WPC-300 program provides a table and a graphic data input. The input signal is mapped on to the X-axis and the output signal is mapped on to the Y-axis.



5.4.2 MIN (Overlap compensation)

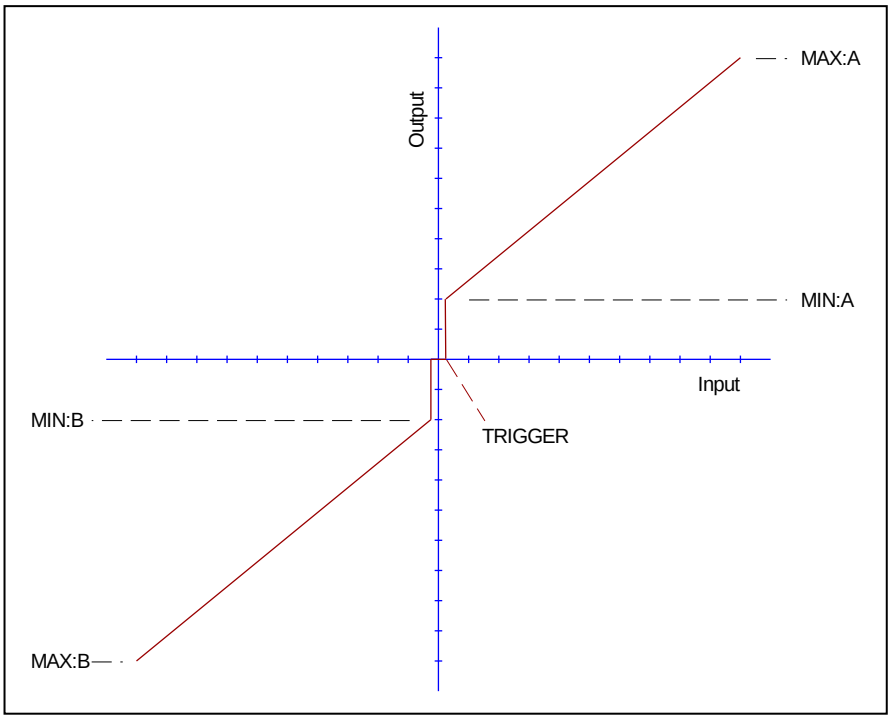
5.4.3 MAX (Output scaling)

5.4.4 TRIGGER (Threshold value of MIN function)

Command	Parameters	Unit	Group
	i= A|B	-	**STD**
MIN:I X	x= 0… 6000	0.01%	
MAX:I X	x= 5000… 10000	0.01%	
TRIGGER X	x= 0… 3000	0.01%	

The output signal is adapted to the valve by these commands. 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[1] can be specified.

CAUTION: If the MIN value is set too high, it influences the minimal velocity, which cannot be adjusted any longer.



[1] 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).

5.4.5 SIGNAL:U (Output polarity)

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

This command allows switching the direction of the output signal (A/B).

5.5 Parameters of the power stage

5.5.1 CURRENT (Nominal output current)

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

The nominal solenoid current is set with this parameter. The DITHER and also the MIN/MAX parameter always refer to the selected current range.

5.5.2 DAMPL (Dither amplitude)

5.5.3 DFREQ (Dither frequency)

Command	Parameters	Unit	Group
DAMPL X	x= 0… 3000	0.01 %	**STD**
DFREQ X	x= 60… 400	Hz	

The dither[2] can be defined freely with this command. Different amplitudes or frequencies may be required depending on the respective valve. The dither amplitude is defined in % of the nominal current (see: CURRENT command). Depending on internal calculations the setting at higher frequencies is only possible in steps. Always the next higher step is chosen.

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

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

[2] The DITHER is a superimposed signal to reduce the hysteresis. This function is defined by the amplitude and frequency. The DITHER frequency should not be confused with the PWM frequency. In some proportional valve documentations a mistake is done by the definition of the DITHER / PWM frequency. It is recognizable by missing information about the DITHER amplitude.

5.5.4 PWM (PWM frequency)

Command	Parameters	Unit	Group
PWM X	x= 61… 2604	Hz	**STD**

The frequency can be changed in the 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.*

5.5.5 ACC (Auto adaptation of the closed loop current controller)

Command	Parameters	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.

5.5.6 PPWM (Solenoid current controller P gain)

5.5.7 IPWM (Solenoid current controller I gain)

Command	Parameters	Unit	Group
PPWM X	x= 0… 30	-	**ACC=OFF**
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 experiences.

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.

5.6 Process data (Monitoring)

Command	Description	Unit
WR	Command value (real Unit)	V
WA	Scaled command value	%
W	Command value after ramp function	%
C	Control signal	%
U	Output signal to power stage	%
IA	Current to solenoid A	mA
IB	Current to solenoid B	mA
RV+	Reference supply voltage	V

The process data are the variable values which can be continuously observed 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	Characteristics
Command signal PIN 9 (LIM)	Out of range	The power stage is deactivated.
Solenoid A PIN 3 / 4 Solenoid B PIN 1 / 2	Broken wire	The power stage is deactivated.
EEPROM (monitored during power on procedure)	Data error	The power stage is deactivated. The module can be activated by saving new parameters (pressing of the SAVE Button).

6.2 Troubleshooting

Initial situation is an operable status of the device and existing communication between the module and the WPC-300 program. Furthermore, the parameterization of the valve control has to be done with the assistance of the valve data sheets.

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

CAUTION: If using the RC (Remote Control) mode, all safety aspects have to be checked solidly. In this mode the module is actuated directly and the machine control has no influence on the module.

FAULT	CAUSE / SOLUTION
ENABLE is active, the module does not respond, and the READY LED is off.	Probably the power supply is disconnected or the ENABLE signal is not present. If there is no power supply there is also no communication via our operating program. If the connection to the WPC-300 exists, the power supply is also available. In this case the availability of the ENABLE signal can be checked via the monitor.
ENABLE is active, the READY LED is flashing.	The flashing READY LED indicates that a fault is detected by the module. The fault could be: • Failure detection at command signal input (LIM command). • A broken cable or incorrect wiring to the solenoids. • Internal data error: execute the command / press the button SAVE to delete the data error. The system reloads the DEFAULT data. With the WPC-300 operating program the failure can be localized directly via the monitor.

7 Notes