WEST

Technical Documentation

PQP-171-P

Universal pump control module

Electronics
Hydraulics meets
meets Hydraulics
Electronics

CONTENTS

1 General Information

1.1 Order number

PQP-171-P - pump control module with integrated power output stage up to 2,6 A and analouge sensor 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.

1.4 Symbols used

General information

Safety-related information

1.5 Legal notice

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Date: 08.01.2025

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 as universal closed loop control module, e.g. for displacement swivel angel control. It has an integrated power amplifier for proportional valves. Several setting parameters offer optimal adaption to the valve. The controller runs with a loop time of 1 ms and the amplifier with 0,125 ms for the current control.

The command value and the feedback value are driven by scalable analogue signals (range 0… 10V or 4… 20mA). Ramp function and PID controller can be used universal. The output current is closed loop controlled and therefore independent from the supply voltage and a varying solenoid resistance. The output stage is cable broken monitored and switches off in case of detected error.

Programmable are the following control parameters: SC, P, I, D, T1 and LIM for the integrator limitation as well as different static settings and valve adjustments for the power stage like MIN, MAX, DITHER (in frequency and amplitude) and the PWM frequency.

By the free parameterization of the power stage all typical proportional valves of the different manufactures can be optimal adapted.

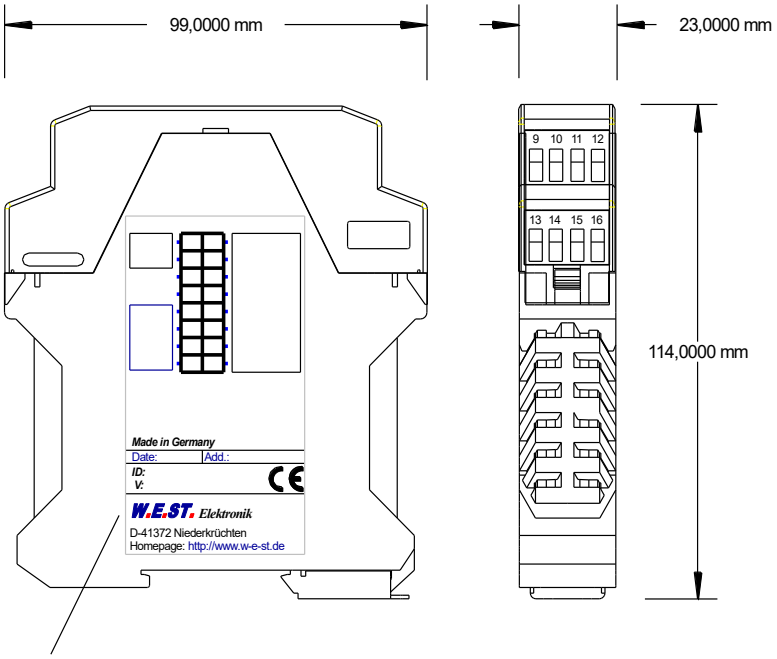
Because of the easy handling a very short training period is guaranteed.

Typical applications: General pressure control with pressure valves (direct or via a servo pump).

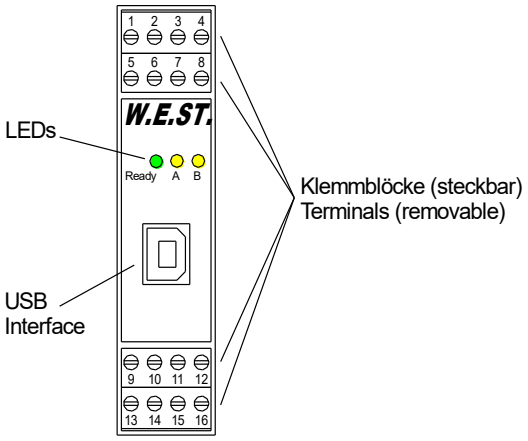
Features

- **Universal pump control module for proportional directional valves**
- **Compact housing**
- **Digital reproducible adjustments**
- **Free scaling of the analogue input signals**
- **Universal PID controller**
- **Free parameterization of ramps, MIN and MAX, DITHER (frequency and amplitude) and PWM frequency**
- **Output current up to 2,6 A**
- **Adaptable to all standard proportional valves**
- **Application orientated parameter settings**
- **Fault diagnosis and extended function checking**
- **Simplified parameterization with WPC-300 software**

2.1 Device description



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.

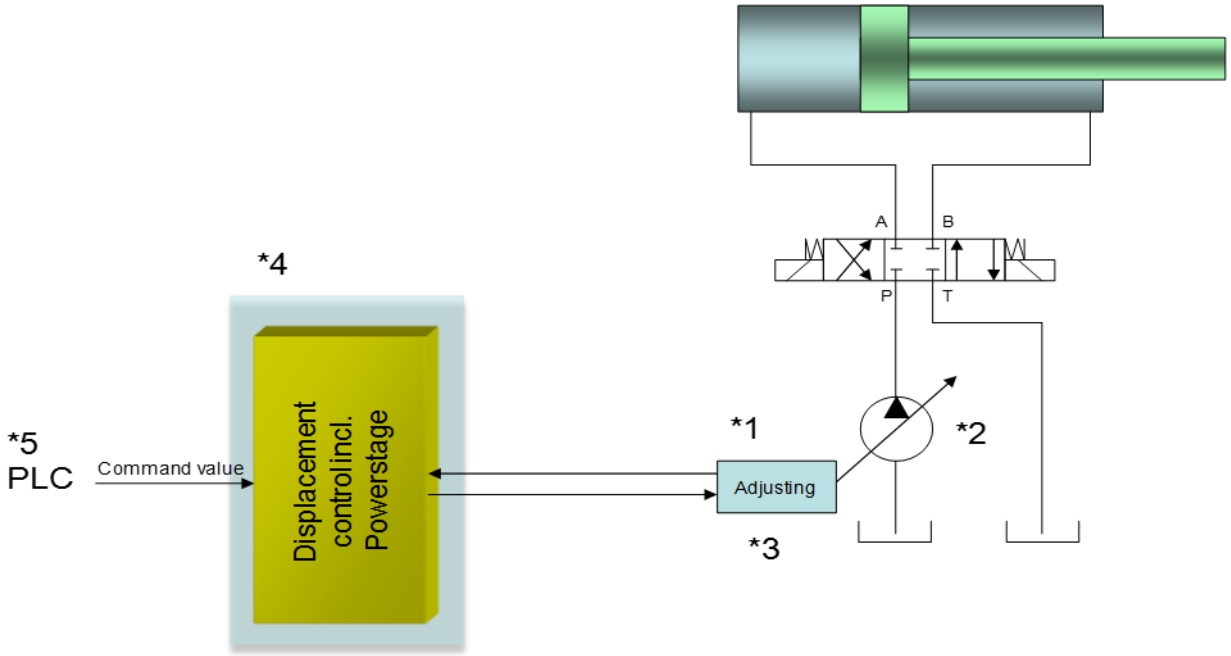
- The module should be installed and wired in accordance with the documentation bearing in mind EMC principles. If other consumers are operated with the same power supply, a star-shaped ground wiring scheme is recommended. The following points must be observed when wiring:
  - The signal cables must 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) Swivel angel adjustment
(*2) Servo pump
(*3) Swivel angel sensor
(*4) Pump controller PQP-171-P
(*5) Interface to PLC



3.3 Method of operation

This swivel angel controller is driven via an analogue signal. The ENABLE signal (typical 24 V) activates the functionality and reports this at a READY output if no error occurs.

In case of malfunction the power stage gets deactivated and the error is reported by a deactivated READY output and a flashing READY LED.

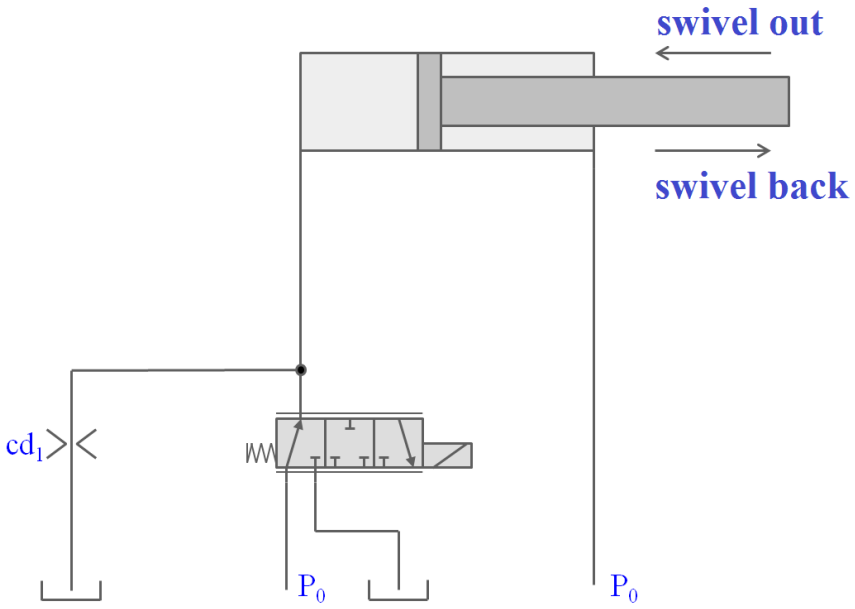
The output is current controlled whereby a high accuracy and a good dynamic is obtained.

In this system the speed of the cylinder is adjusted by the swivel angel of the pump. Because of the relatively pressure independent volume flow compared to a throttle control with a proportional valve the actuator can be driven by relative continual speed.

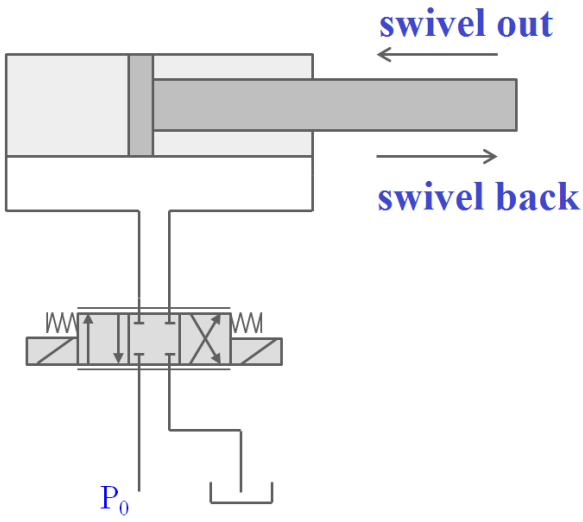
The system is realized by an electro-hydraulic control equipment controlled by our module. As feedback the swivel angel is measured and send back to the module.

Via a modified and optimized PID controller the behavior can be adapted to the respective pump.

The valve controlling can be switched between such with one solenoid and also two solenoids (shown on pictures 1 and 2).



Picture 1: valve with one solenoid



Picture 2: valve with two solenoids

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. The operating software supports further commissioning and diagnosis.
Pre-parameterization	Parameterize now (with the help of the system redundancy and the connection diagram) the following parameters: The NOMINAL PRESSURE for the ANALOGUE INPUTS. See specifications of the system and the sensors. The output CURRENT and the typical valve parameter DITHER and MIN/MAX. Pre-parameterization is necessary to minimize the risk of an unintentional movement / pressure.
Control signal	Check the control signal (output signal). The control signal (solenoid current) lies in the range of 0... 2,6 A. In the current state it should show around 0 A. **CAUTION!** This signal depends on the EOUT setting.
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!** The power stage gets activated. The controller can now be driven by the analogue command value. The feedback value is read in and the output signal gets calculated by means of the control deviation and the parameterization.
Controller optimization	Now optimize the settings. The PID parameters have to be adapted depending on the application.

4 Technical description

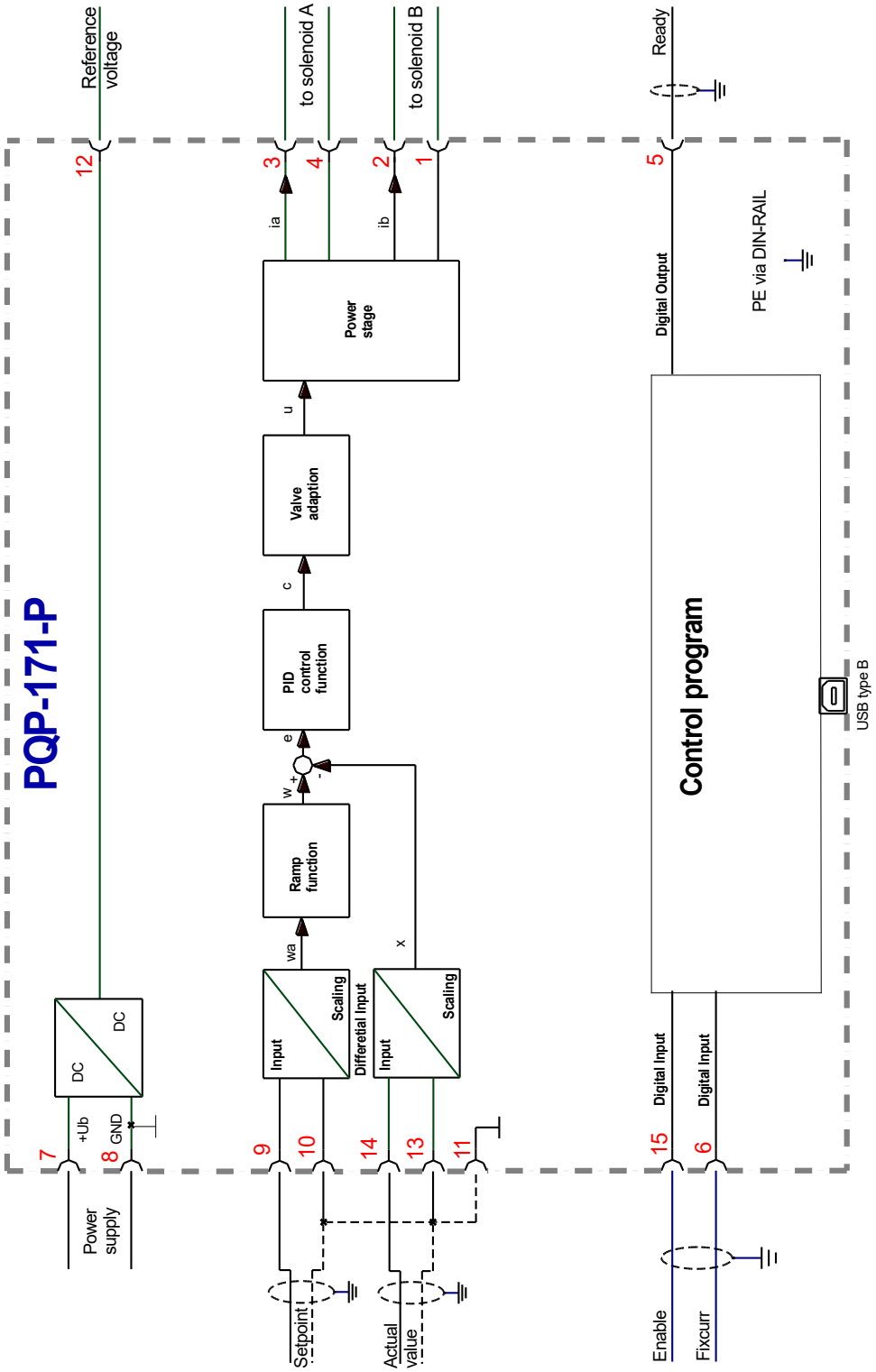
4.1 Input and output signals

Connection	Supply
PIN 7	Power supply (see technical data)
PIN 8	0 V (GND) connection.
Connection	**Analogue signals**
PIN 9 / 10	Command value (WA), signal range 0… 10 V or 4… 20 mA, scalable
PIN 13 /14	Feedback value (X), signal range 0… 10 V or 4… 20 mA, scalable
PIN 11	0 V (GND) connection for analogue signals
PIN 12	8V reference voltage output
Connection	**Solenoids**
PIN 2 / 1	PWM output solenoid B
PIN 3 / 4	PWM output solenoid A
Connection	**Digital inputs and outputs**
PIN 15	**ENABLE input:** Generally enabling of the application. Activates controller, power stage and READY.
PIN 6	**FIXCURRENT input**: **ON:** Direct control of the power stage via the FIXCURR parameter. **OFF:** Swivel angel control is active (normal state).
PIN 5	**READY output:** **ON:** The module is enabled; there are no discernable errors. **OFF:** ENABLE is not available or an error has been detected.

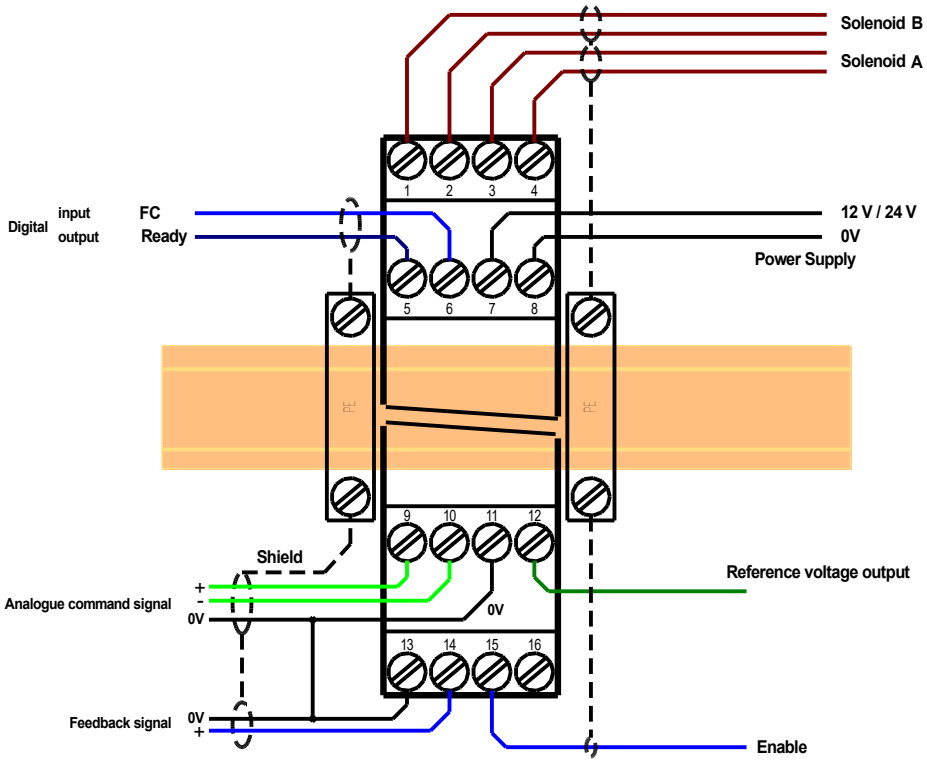
4.2 LED definitions

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
YELLOW A	Intensity of the current at solenoid A
YELLOW B	Intensity of the current at solenoid B
GREEN + YELLOW A	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, data has to be saved with the SAVE command or the corresponding button in the WPC.

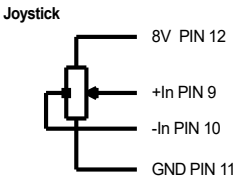
4.3 Circuit diagram

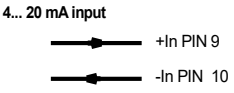


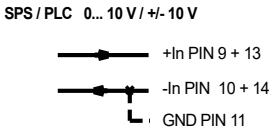
4.4 Typical wiring

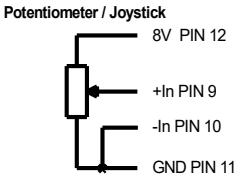


4.5 Connection examples

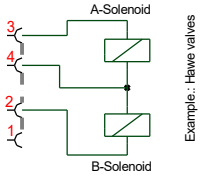








Alternative 3 – wire connection of two solenoids:



4.6 Technical data

Supply voltage (U_b) Current requirement External protection	**[VDC]** **[mA]** **[A]**	12… 30 (incl. ripple) 30 + solenoid current 3 medium time lag
Reference output Voltage Max. load	 **[V]** **[mA]**	 8 25
Digital inputs OFF ON Input resistance	 **[V]** **[V]** **[kOhm]**	 < 2 > 10 25
Digital outputs OFF ON Max. output current	 **[V]** **[V]** **[mA]**	 < 2 max. V_{cc} 50
Analog inputs: Voltage Input resistance Current Burden Signal resolution	 **[V]** **[kOhm]** **[mA]** **[Ohm]** **[%]**	Unipolar / differential 0… 10 / -10… 10 min. 90 4… 20 390 0,03
PWM output Max. output current Frequency	 **[A]** **[Hz]**	Wire break and short circuit monitored 2,6 61… 2604 selectable in defined steps
Controller cycle times Solenoid current control Signal processing	 **[µs]** **[ms]**	 125 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]**	0,13
Protection class Temperature range Storage temperature Humidity Vibration resistance	**[IP]** **[°C]** **[°C]** **[%]** **-**	20 -20… 60 -20… 70 < 95 (non-condensing) IEC 60068-2-6 (Category C)
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
	FIXCURR			Fix output value for corresponding digital input
	CTRLMODE	OL	-	Closed loop (CL) or open loop (OL) control.
	CCMODE	OFF	-	Activation / deactivation of the CC function.
	SENS	ON	-	Malfunction monitor
	EOUT	0	0.01 %	Output signal if not ready
Input signal adaptation				
Sensor scaling				
	SIGNAL:X	U0-10	V	Type of input
	N_RANGE:X	100	%	Sensor working range in relation to system working range
	OFFSET:X	0	0.01 %	Sensor offset
Command signal scaling				
	SIGNAL:W	U0-10	mbar	Type of input
Ramp function				
	RA:UP **RA:DOWN**	100 100	ms ms	Command signal ramp times
Characteristic linearization				
	CC	X Y	0,01 %	X Y parameter for up to 10 points.
Control parameters				
PID controller				
	C:P **C:I** **C:D** **C:D_T1** **C:OFFSET**	100 4000 0 500 0	0.01 0.1 ms 0.1 ms 0.1 ms 0.01 %	P gain I gain D gain D gain filter Direct control
Integrator control				
	C:I_LIM	2500	0.01 %	Integrator limitation
Extended control parameter				
	C_EXT:P **C_EXT:T1** **C_EXT_FF**	0 200 0	0.01 0.1 ms 0.01 %	P gain P gain filter Feed forward
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
	SIGNAL:U	1S+	-	Type and polarity of the output

Group	Command	Default	Unit	Description
Parameters of the power stage				
	CURRENT	1000	mA	Rated solenoid current
	DFREQ	121	Hz	Dither frequency
	DAMPL	500	0.01 %	Dither amplitude
	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
Special commands				
Scaling mode				
	AINMODE	EASY	-	Input scaling mode
	AIN:X **AIN:W**	A: 1000 B: 1000 C: 0 X: V	- - 0.01 % -	Free scaling of the analogue inputs. Gets activated when AINMODE is switched over 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 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 FIXCURR (Fix output value)

Command	Parameters	Unit	Group
FIXCURR x	x= -10000… 10000	0.01 %	**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.

5.2.4 CTRLMODE (Control function)

Command	Parameters	Unit	Group
CTRL x	x= OL|CL	-	**STD**

Switching the control function between OL (open loop) for direct control of the solenoid current and CL (closed loop) for using extended PID controller with feedback sensor.

5.2.5 CCMODE (Characteristics linearization)

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

This command activates the characteristic linearization function. Deactivating immediately allows an easy and fast evaluation of the linearization.

5.2.6 SENS (Malfunction monitor)

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.

5.2.7 EOUT (Output signal if not ready)

Command	Parameters	Unit	Group
EOUT X	x= -10000… 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. This function can be used if, for example, the drive is to move to one of the two end positions (at the specified speed) in case of a sensor error.

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

CAUTION!

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.

5.3 InSignal adaptation

5.3.1 SIGNAL (Type of input signal)

Command	Parameters	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 all analogue inputs (W and X).
OFF= Deactivation of the input

5.3.2 N_RANGE:X (Sensor nominal pressure)

Command	Parameter	Unit	Group
N_RANGE:X X	x= 1… 10000	%	**EASY**

This command defines the nominal working range of the feedback sensor. Wrong parameterization causes wrong system settings. The control parameters cannot be calculated correctly in case of wrong values.

The N_RANGE:X value is set per cent in relation to the working range. Because this is a universal controller, the working range of the system is defined to 100% as reference value. The N_RANGE should not be set lower than 100% if possible-

5.3.3 OFFSET:X (Sensor offset)

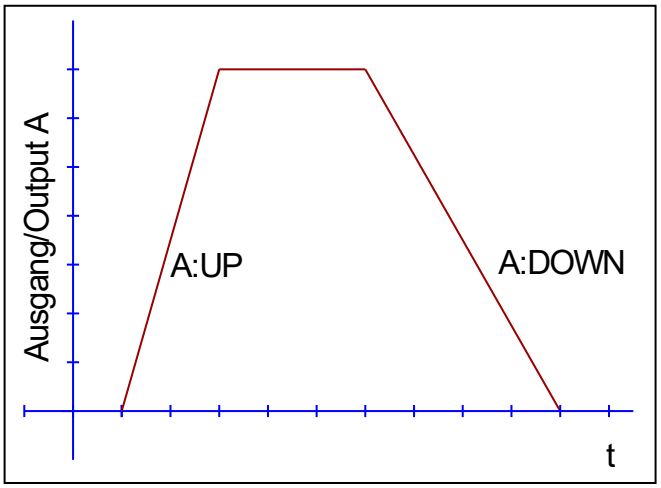
Command	Parameter	Unit	Group
OFFSET:X X	x= -60000… 60000	0.01 %	**EASY**

Adjustment of the zero point of the sensor. Reference value is always the working range.

5.3.4 RA (Command signal ramp time)

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

Two quadrant ramp function.
The ramp time is separately set for UP and DOWN ramps.



5.3.5 CC (Characteristics linearization)

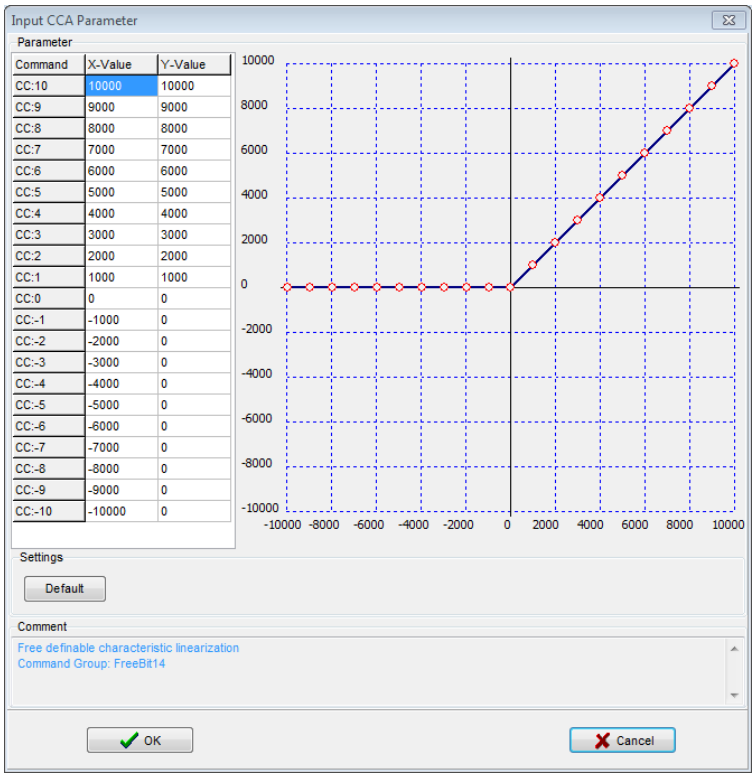
Command	Parameters	Unit	Group
CC:I X Y	i= 0… 10 x= -10000… 10000 y= -10000… 10000	- 0.01% 0.01%	**CCMODE**

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

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 Control parameters

5.4.1 PID controller

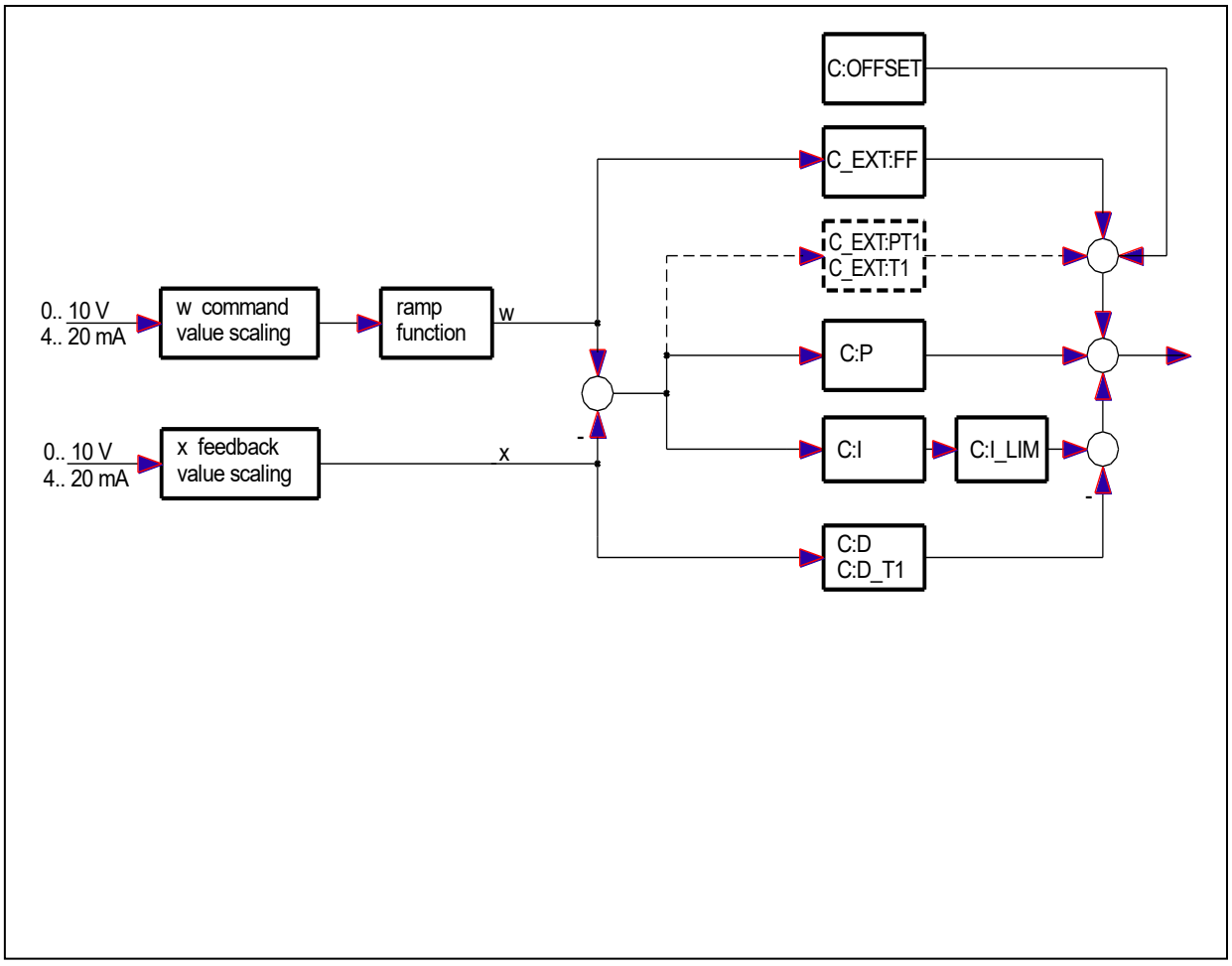
Command	Parameter	Unit	Group
C:I X	I= P|I|D|D_T1|OFFSET :P x= 0… 10000 :I x= 0… 30000 :D x= 0… 1200 :D_T1 x= 0… 1000 :FF x= 0… 10000	 0.01 0.1 ms 0.1 ms 0.1 ms 0.01 %	**CL**

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.

Via the OFFSET value the output is controlled directly. The PID closed loop control function has only to adjust the difference (the error). This leads to a stable control behavior and also to a dynamic drive. This parameter is active only if valves with one solenoid are used (-> SIGNAL:U).

Value 0 deactivates the integrator.



5.4.2 Integrator control function

Command	Parameter	Unit	Group
C:I_LIM X	x= 0… 10000	0.01 %	**CL**

C:I_LIM means 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.

5.4.3 C_EXT (Extended control parameters)

Command	Parameter	Unit	Group
C_EXT:I X	I= P|T1|FF :P x= 0… 10000 :T1 x= 0… 1000 :FF x= 0… 10000	 0.01 0.1 ms 0.01 %	**CL+EXP**

These commands are used to parameterize an additional PT1 control part parallel to the P-gain.

The time-damped P-gain can be driven with a higher gain than the direct P-gain. The stability is enhanced by the T1 value.

Via the FF parameter this part of the command value is given directly to the output. So the controller has to compensate only the deviation. The outcome of this is a stable control performance and a dynamic driving at the same time. This parameter is active only if valves with one solenoid are used (-> SIGNAL:U).

5.5 Output signal adaptation

5.5.1 MIN (Deadband compensation)

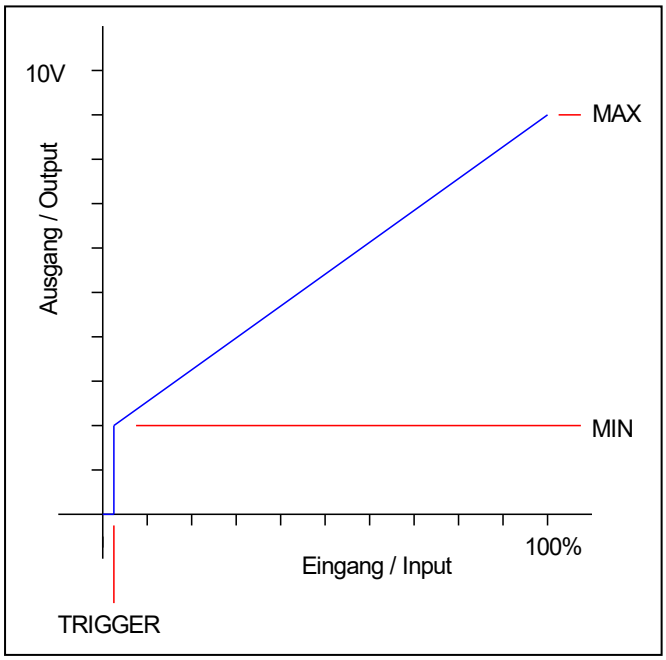
5.5.2 MAX (Output scaling)

5.5.3 TRIGGER (Response threshold for the MIN parameter)

Command	Parameters	Unit	Group
MIN:I X	x= 0… 6000	0.01 %	**STD**
MAX:I X	x= 3000… 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[1] 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.



[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).

5.5.4 SIGNAL:U (Output polarity)

Command	Parameter	Unit	Group
SIGNAL:U X	x= 1S+|1S-|2S+|2S-	-	**STD**

This command is used to define the type of output signal and its polarity.

Selectable are one solenoid or two solenoid control. Furthermore the direction of the output signal can be switched. Using applications with one solenoid it means an inverted characteristic curve. If two solenoids are used it effects the switching of the solenoids.

- 1S+: One solenoid standard
  - U = 0… 100% -> IA = 0… 100%
- 1S-: One solenoid inverted
  - U = 0… 100% -> IA = 100… 0%
- 2S+: Two solenoids standard
  - U > 0 -> Controlling IA
  - U < 0 -> Controlling IB
- 2S-: Two solenoids switched
  - U > 0 -> Controlling IB
  - U < 0 -> Controlling IA

5.6 Power stage

5.6.1 CURRENT (Rated solenoid current)

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

The nominal current (for 100% opening) of the solenoid is set here. Dither and also MIN/MAX always refer to this current value.

5.6.2 DFREQ (Dither frequency)

5.6.3 DAMPL (Dither amplitude)

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

The dither[2] 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 (see: CURRENT command). The dither frequency is defined in Hz. Depending on the internal calculations, the frequency is adjustable in steps only.

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.*

5.6.4 PWM (PWM Frequency)

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

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.*

5.6.5 ACC (Current loop auto 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.

[2] 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.

5.6.6 PPWM (P gain of the current loop)

5.6.7 IPWM (I gain of the current loop)

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.

5.7 Special commands

5.7.1 AINMODE (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.

5.7.2 IN (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. 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 after scaling	%
W	Command value after ramp function	%
WCC	Command value ather linearization	%
X	Feedback value	%
E	Control error	%
C	Controler output	%
U	Output to valve	%
IA	Solenoid current[3] A	mA
IB	Solenoid current B	mA

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

[3] The display of the solenoid current (in WPC-300 program) is damped in order to be able to bring out a stable signal.

6 Appendix

6.1 Failure monitoring

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

Source	Fault	Characteristic
Command signal PIN 9/10 4... 20 mA	Out of range or broken wire	The power stage and the READY output will be deactivated.
Feedback signal PIN 14/13 4… 20 mA	Out of range or broken wire	The power stage and the READY output will be deactivated.
Solenoid A on PIN 3-4	Wrong cabling, broken wire	The power stage and the READY output will be deactivated.
Solenoid A on PIN 3-4	Wrong cabling, broken wire	The power stage and the READY output will be deactivated.
EEPROM (when switching on)	Data error	The power stage and the READY output will be deactivated. Module can be activated by saving the parameters.

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 is not present. Other errors are displayed via the READY LED. If there is no power supply, there is also no communication via our operating program. If a connection has been made, then a power supply is also available. In this case in monitor window the ENABLE input can be checked.
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. • Internal data error: press the command/SAVE button to delete the data error. The system reloads the DEFAULT data. With the operating program the fault can be localized directly via the monitor.

FAULT	CAUSE / SOLUTION
ENABLE is active; the READY LED is active; no current to the solenoid (no pressure-build-up).	• 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 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. • 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 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[4]. • 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)[5].
ENABLE and START (PIN 6) are active, READY LED is ON, the pressure control works, but the pressure is not equal to the command input.	The system works generally, but wrong control loop settings or wrong adjustment of the input signals cause control errors. 1. The feedback value is proportional to the command input value, but the output values are too high or too low. In this case the scaling of one input is wrong. a. The scaling of the valve is affected by the adjustment of the output current and the parameter **MAX**. E.g. the valve has a nominal range of 320 bar and the working pressure range is 240 bar, the parameter MAX has to be decreased. b. AIN-command for sensor scaling. The working range of the sensor is 400 bar and the control range should be 240 bar following changes have to be done: ***AIN:X 400 240 0 V***. c. For a sensor with current output you have to consider the 4... 20 mA scaling: ***AIN:X 1250 1000 2000 C*** d. 4… 20 mA plus sensor scaling: ***AIN:X 1250 600 2000 C*** (600 = 1000 * 240 bar / 400 bar).

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

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

7 Notes