WEST

Technical Documentation

PAM-198-P

Power amplifier for directional valves with feedback position control

Electronics
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Electronics

CONTENTS

1 General Information

1.1 Order Number

PAM-198-P - power amplifier for directional valves with feedback position 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 – 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: 07.01.2025

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 the spool position of directional valves with electrical feedback. Various adjustable parameters allow for 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. The closed loop of the application works with a sample time of 1 ms.

Command value and feedback value are read in via free scalable analog inputs (voltage signals in the range of 0… 10V or +/-10V respectively current signals in the range of 4… 20mA). 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.

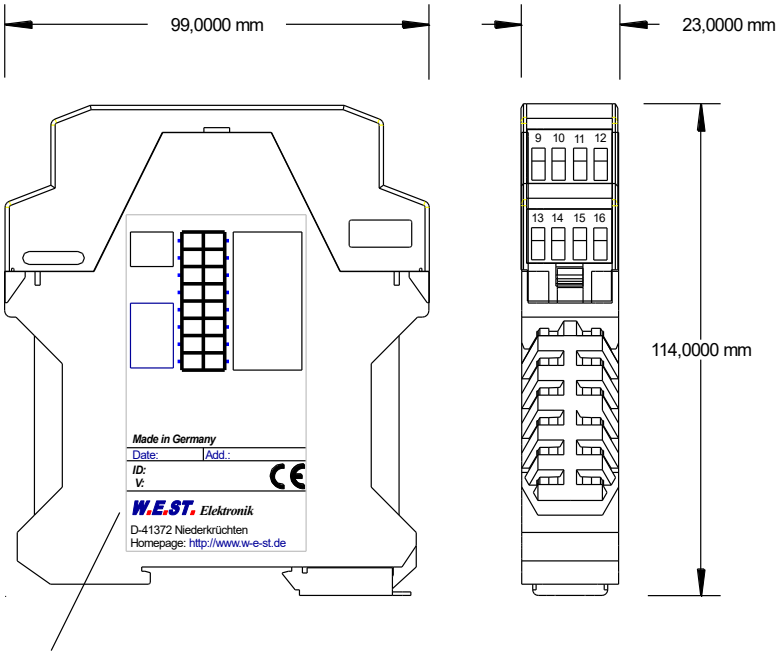
RAMP, MIN and MAX, the DITHER (frequency and amplitude) and the PWM frequency are programmable.

In addition, the valve characteristics can be linearized via 10 XY-points.

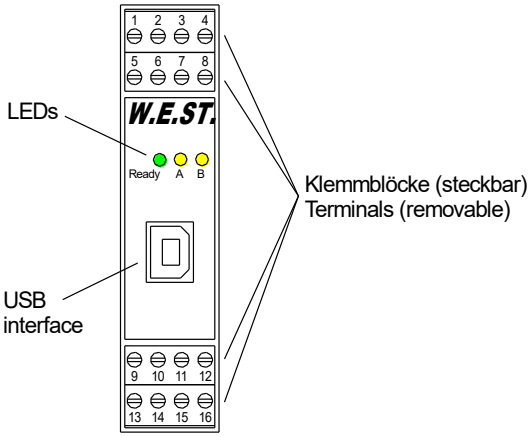
Features

- **Control of directional valves with spool position feedback**
- **Compact housing**
- **Digital reproducible adjustments**
- **Free scaling of the analogue inputs**
- **PID controller with feed forward function**
- **Controlling valves with one or two solenoids**
- **Bipolar controlling via differential 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 up to 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.

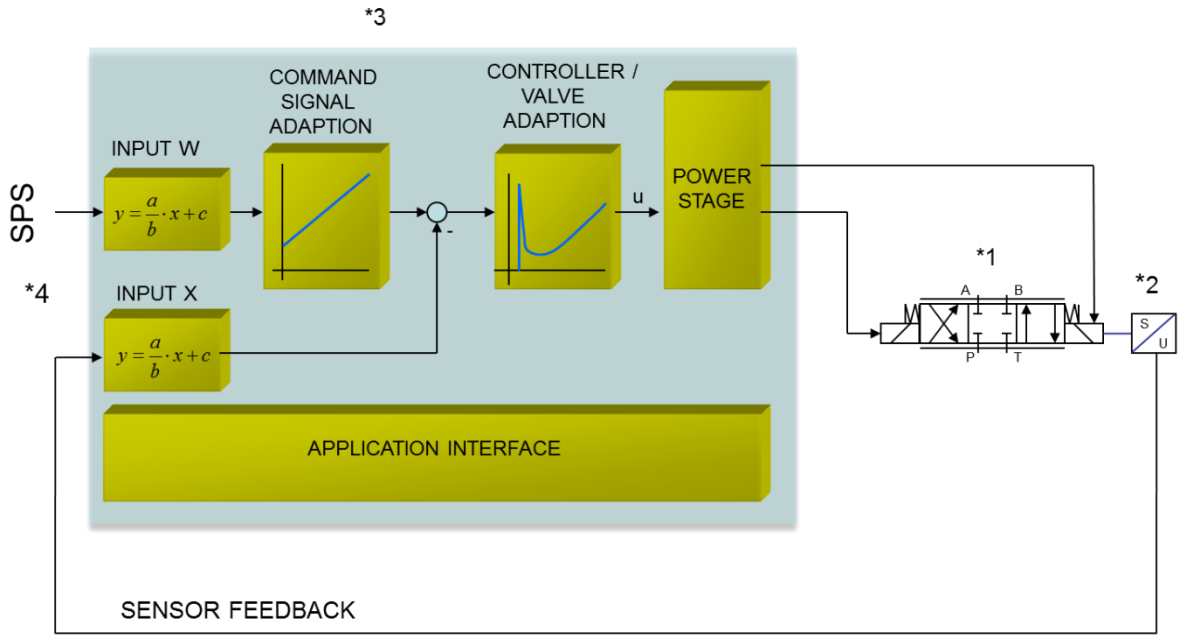
- A low-resistance connection between PE and the mounting rail should be provided. Transient interference is transmitted from the module directly to the mounting rail and from there to the local earth.

- 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 Typical system structure

This minimum example system contains of following components:

(*1) Proportional valve
(*2) Spool position sensor
(*3) Control module PAM-198-P
(*4) Interface to the PLC



3.3 Method of operation

This power amplifier with integrated spool position control is controlled by an analog command signal. The ENABLE signal activates the power stage and application functionality and the READY output reports an error free operation.

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

The output current is closed loop controlled which leads to a high accuracy and a good dynamic.

Superior controller is the spool position controller. It has a feed forward function for fast reactions when the command value changes and a switching integrator with parameterizable Deadband in order to avoid limit cycling at the operation point.

The output can be adapted to valves with one or two solenoids.

In open loop control mode the power stage can be controlled by the feed forward function which leads the command value directly to the output. In closed loop control mode the control deviation and parameterizing of the controller define the output signal.

3.4 Commissioning

Step	Task
Installation	Install the device in accordance with the circuit diagram. Ensure it is wired correctly and that the signals are well shielded. The device must be installed in a protective housing (control cabinet or similar).
Switching on for the first time	Ensure that no unwanted movement is possible in the drive (e.g. switch off the hydraulics). Connect an ammeter and check the current consumed by the device. If it is higher than specified, there is an error in the wiring. Switch the device off immediately and check the wiring.
Setting up communication	Once the power input is correct the PC (notebook) should be connected to the serial interface. Please see the WPC-300 program documentation for how to set up communication. The further start-up is supported by this program.
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. The analog inputs with scaling function AIN. 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 actual current 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 valve can now be controlled by the analog command value (depending on the settings).
Optimizing settings	Now the adjustment can be optimized. The PID controller has to be adapted to the relative application and its requirements.

4 Function modes and technical description

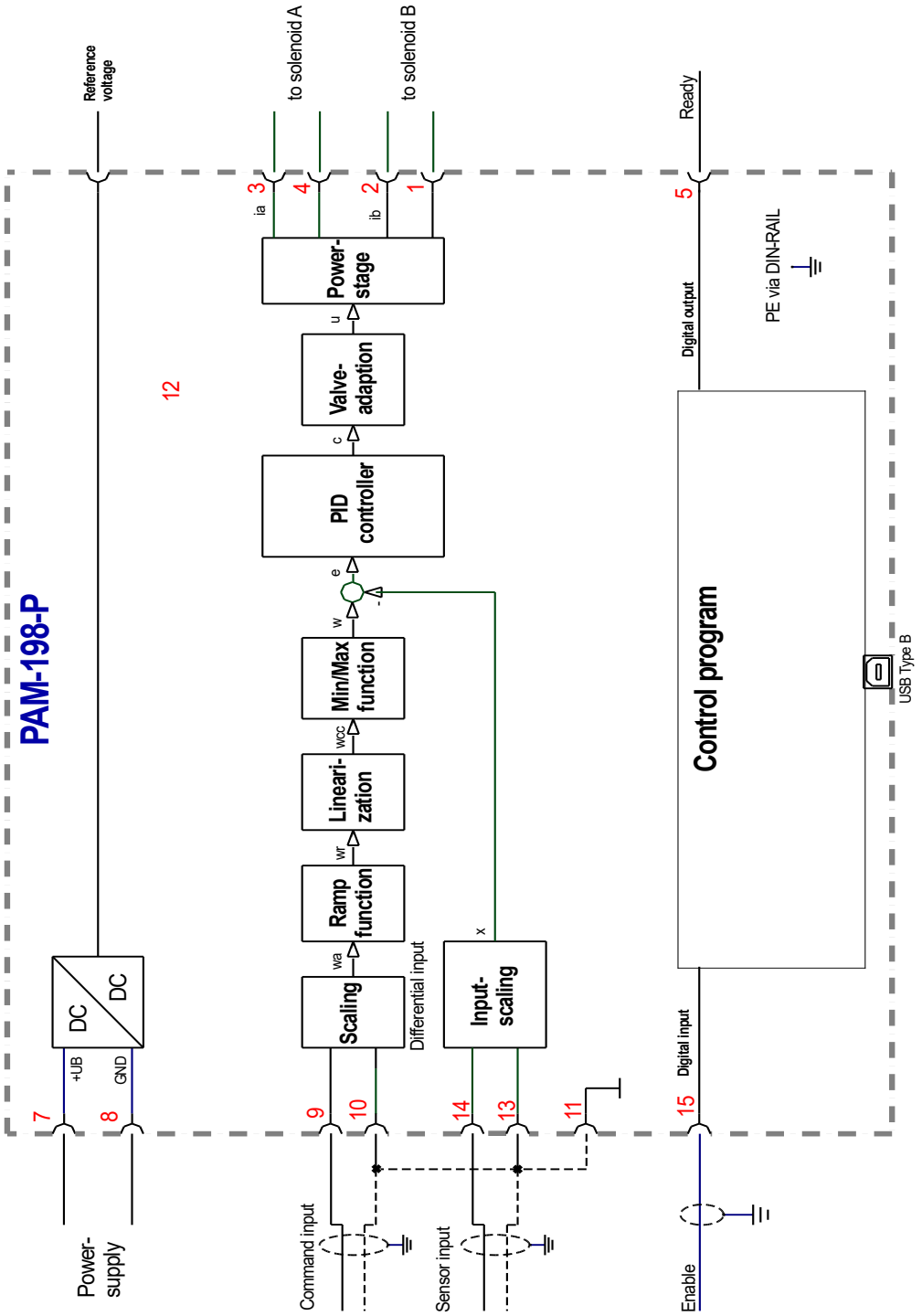
4.1 Input and output signals

Connection	Supply
PIN 7	Power supply (see technical data)
PIN 8	0 V (GND) Power supply (ground).
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 signals**
PIN 9 / 10	Command signal input (WA), range +/- 10 V or 4…20 mA, scalable
PIN 14 / 13	Feedback signal input (X), range 0… 10 V or 4… 20 mA, scalable
PIN 11	0 V (GND) reference for the signal inputs
PIN 12	8 V reference voltage output
Connection	**Digital inputs and outputs**
PIN 15	**Enable Input**: This digital input signal initializes the application and the power stage.
PIN 5	**READY output**: **ON:** Module is ready, no errors are detected **OFF:** ENABLE is deactivated or an error was detected.

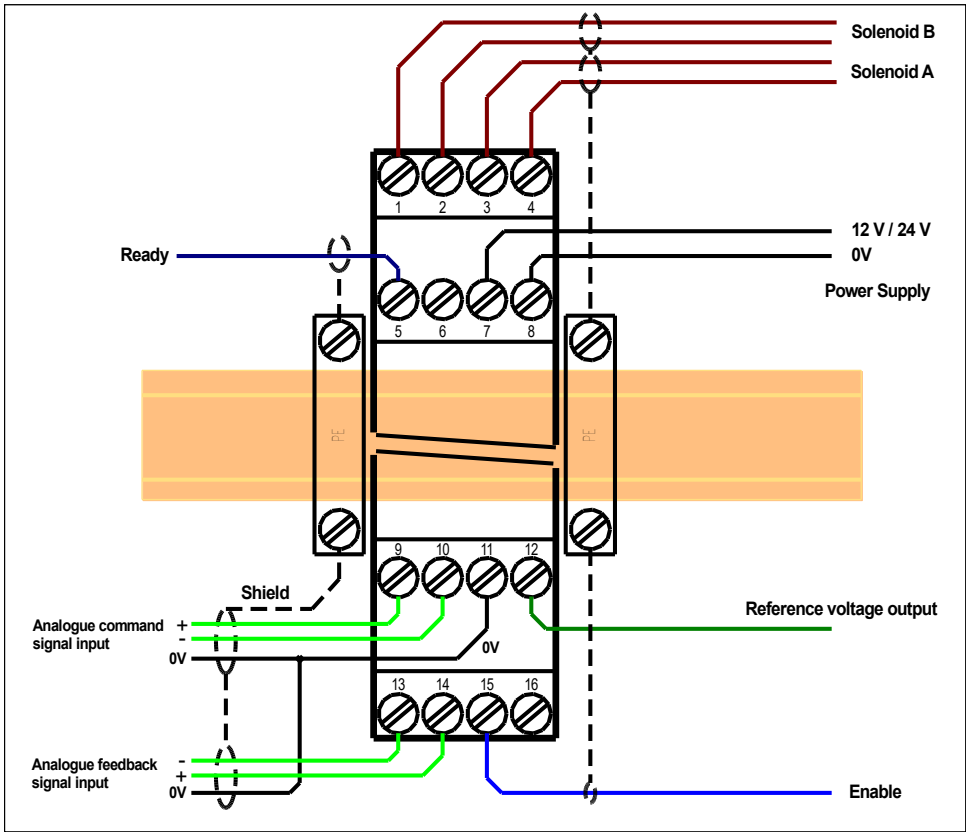
4.2 LED Indications

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.
GREEN	Identical to the READY output. **OFF:** No power supply or ENABLE is not activated **ON:** System is ready for operation ***Flashing:*** Error detected
YELLOW A	Current to the solenoid A; the intensity is proportional to the actual output current.
YELLOW B	Current to the solenoid B; the intensity is proportional to the actual output current.

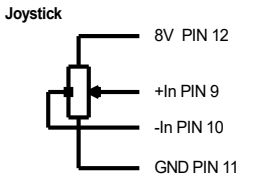
4.3 Circuit diagram

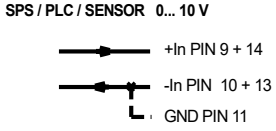


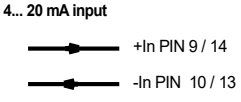
4.4 Typical wiring

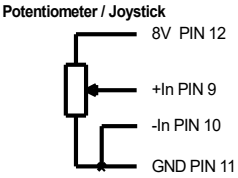


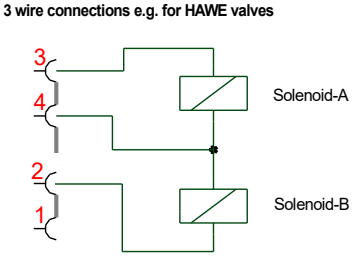
4.5 Input connection (examples)











4.6 Technical data

Supply voltage (U_b) Current requirement External protection	**[VDC]** **[mA]** **[A]**	12… 30 (incl. ripple) 60 + 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. U_b 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 <0.01
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 Pressure control	 **[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]**	0,190
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 Parameter

5.1 Parameter list

Group	Command	Default	Unit	Description
Basic parameters - SYSTEM				
	MODE	---	-	Switching visible parameter group
	LG	EN	-	Language selection
	CTRLMODE	CL	-	Open and closed loop selection
	CCMODE	OFF	-	Aktivation / Deactivation CC command
	SENS	AUTO	-	Failure monitoring
In- and output adaption - IO_CONF				
Sensor signal				
	AIN:X	U0-10	V	Mathematic scaling function sensor
Command signal				
	AIN:W	U0-10	-	Mathematic scaling function demand
Control signal				
	SIGNAL:U	2S+	-	Type and polarity of the output signal
One solenoid				
	VA:OFFSET	0	0,01 %	Zero point setting
Two solenoids				
	VA:MIN:A **VA:MIN:B**	0 0	0,01 % 0,01 %	Minimum control for spring pre-load
	VA:MAX:A **VA:MAX:B**	10000 10000	0,01 % 0,01 %	Maximum control
	VA:TRIGGER	200	0,01 %	Treshold for minimum control
Command signal adaption - ADAPT				
Ramp function				
	RA:1 **RA:2** **RA:3** **RA:4**	100 100 100 100	ms ms ms ms	Ramp times for command signal
Linearization function				
	CC	X Y-	0,01 %	Parameterizing linearization by 10 points
Deadband compensation / direction depending scaling				
	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 %	Treshold for deadband compensation

Group	Command	Default	Unit	Description
Parameterizing the controller - CTRL				
PID controller				
	C:P	100	0,01	P gain
	C:I	4000	0,1 ms	I gain
	C:D	0	0,1 ms	D gain
	C:D_T1	500	0,1 ms	D gain filter
	C:FF	8000	0,01 %	Feed forward
Integrator control				
	C:I_LIM	2500	0,01 %	Working range limitation
	C:I_ACT	10000	0,01 %	Activation treshold
	C:I_DZ	0	0,01 %	Deadband
Power stage - PAM				
	CURRENT	1000	mA	Solenoid nominal current
	DFREQ	121	Hz	Dither frequency
	DAMPL	500	0,01 %	Dither amplitude
	PWM	2604	Hz	PWM frequency
	ACC	ON	-	Automatical adjustment of the current controller
	PPWM	7	-	P-gain of the current controller
	IPWM	40	-	I-gain of the current controller

5.2 Basic parameters

5.2.1 LG (Changing the language for the help texts)

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

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

5.2.2 MODE (Selecting visible parameter group)

Command		Parameters	Unit	Group
MODE	X	x= SYSTEM|IO_CONF|ADAPT| CTRL|PAM|ALL	-	**SYSTEM**

This command defines the group which parameters should be displayed. Inactive parameters are partially masked independent from the selected group.

SYSTEM	Basic settings of the device or application
IO_CONF	Definitions of the input and output signals of the device
ADAPT	Signal processing and adaption
CTRL	Parameterizing of the position controller
PAM	Parameters of the power stage
ALL	No selection, all active parameters are visible

5.2.3 CTRLMODE (activation spool positioning control)

Command		Parameters	Unit	Group
CTRLMODE	X	x= OL|CL	-	**SYSTEM**

Switching between **O**pen **L**oop control mode as simple power amplifier and **C**losed **L**oop control mode with PID controller and connected feedback for spool position control.

In open loop mode the power stage can be controlled directly via the feed forward parameter. This option normally can only be used for valves which ensure a stable positioning of the spool without electronic control. But it can also be useful here to optimize the feed forward and offset settings before activating the PID controller.

5.2.4 CCMODE (Activation of the characteristic linearization)

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

This command will be used for activation or deactivation of the characteristics linearization. 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. Otherwise try to use only one of this options for those settings.

5.2.5 SENS (Failure monitoring)

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

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.

5.3 Input signal adaption

5.3.1 AIN (Analogue input scaling)

Command	Parameters	Unit	Group
AIN:I a b c x	i = A|B a= -10000… 10000 b= -10000… 10000 c= -10000… 10000 x= V|C	- - - 0.01% -	IO_CONF

This command offers an individual scalable input. The following linear equation is used for the scaling.

$$Output = A/B \cdot (Input - C)$$

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** for choosing current signal.

Means AIN command would look like this: AIN:I 20 16 2000 C or AIN:I 1250 1000 2000 C (20/16 = 1.25)

Changing the polarity/direction of the signal is realized by negating one of the gain factors.

Specific characteristic here:

-> For the sensor a unipolar signal is used to map a bipolar value range. At the scaling function this is simulated by virtual doubling up the available signal range. Additionally the offset is set to the middle of the used signal range.

Typical settings (examples):

AIN settings	Input signal	Description
AIN:W 1000 1000 0 V	-10… 10V	Gain 1 – range: -100%… 100%
AIN:W -1000 1000 0 V	10… -10V	Gain 1 – range: 100%… -100%
AIN:X 1000 1000 0 V	0… 10 V	Gain 1 – range: 0… 100%
-> x 2000 1000 5000 V	0… 5… 10V	**-> Range -100%... 0… 100%**
AIN:W 20 16 2000 C OR	4… 20 mA	Gain 1 – range: 0… 100%
AIN:X 1250 1000 2000 C		
-> W,X 2500 1000 6000	4… 12… 20 mA	**-> Range -100%... 0… 100%**

If the settings are unknown it is recommended to use the standard settings for the sensor (0…10V or 4… 20mA). The displayed feedback value X represents the zero position (C). Now generate a full control with 100% feed forward in OL mode and then the X value represents the used signal range (B). For being sure repeat the last process in negative way (SIGNAL:U = 2S-). If higher this value should be taken for B. At last double up the A value. For this adjustment procedure the remote control mode of the module can be used which can be handled easily by the WPC-300 program.

5.3.2 SIGNAL:U (Type and polarity of the control signal)

Command	Parameters	Unit	Group
SIGNAL:U x	x= 1S+|1S-|2S+|2S-	-	**IO_CONF**

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

5.3.3 VA:OFFSET (Zero point setting)

Command	Parameters	Unit	Group
VA:OFFSET X	x= 1… 10000	0.01 %	**IO_CONF** **1S**

Using valves with one solenoid this parameter defines the basic current for the zero position.

5.3.4 A:MIN (Minimum control)

5.3.5 VA:MAX (Maximum control)

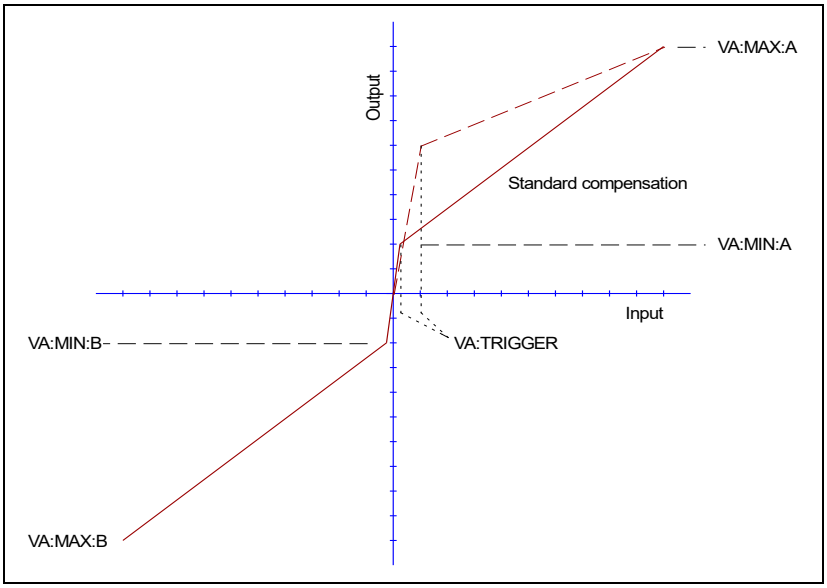
5.3.6 VA:TRIGGER (Response threshold for the MIN parameter)

Command	Parameters	Unit	Group
	i= A|B	-	**IO_CONF**
VA:MIN:i x	x= 0… 6000	0.01 %	**2S**
VA:MAX:i x	x= 4000… 10000	0.01 %	
VA:TRIGGER x	x= 0… 3000	0.01 %	

Having valves with two solenoids each direction has a minum control which is necessary for starting a movement of the spool. The needed values are normally defined by the initial load of the retunr springs of the spool.

Similar to MIN:A and B (for deadband compensation) the VA:MIN parameters also effect a compensation, but for the centering power of the zero position.

The values of VA:MAX can be used for example to realize an asymmetry of the solenoid currents between both directions.



5.4 Signal processing

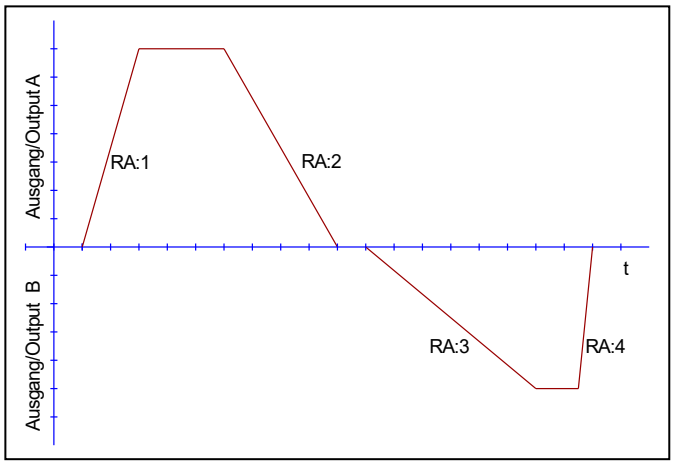
5.4.1 RA (Ramp function)

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

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.



5.4.2 CC (Characteristics linearization)

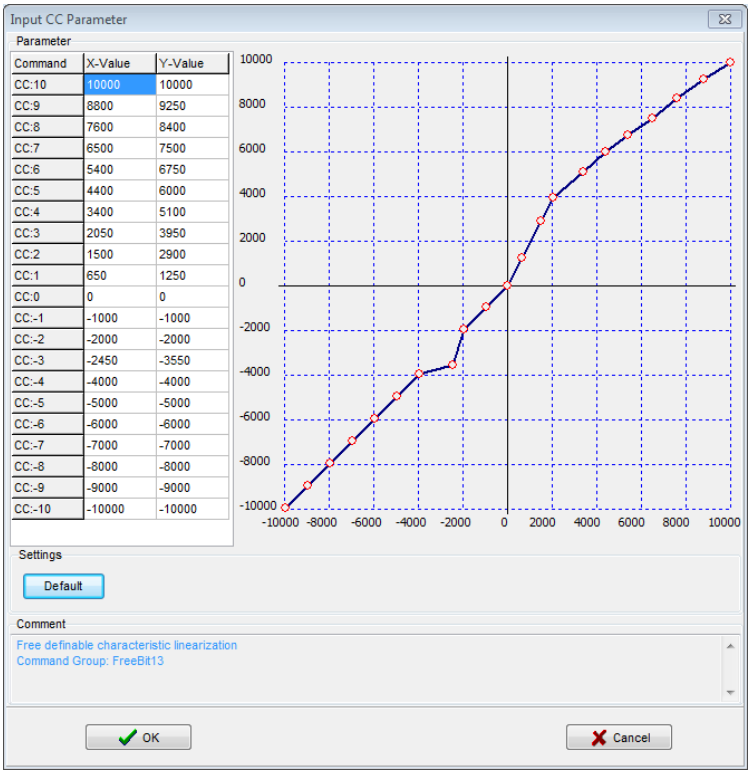
Command	Parameters	Unit	Group
CC:I X Y	i= -10… 10 x= -10000… 10000 y= -10000… 10000	- 0.01% 0.01%	**ADAPT** **CCMODE**

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.



If the CC command is used, the TRIGGER of the MIN/MAX function should be set to 0 and the function should not be used if possible. Both functions influence each other and make the behavior really difficult to evaluate.

5.4.3 MIN (Overlap compensation)

5.4.4 MAX (Output scaling)

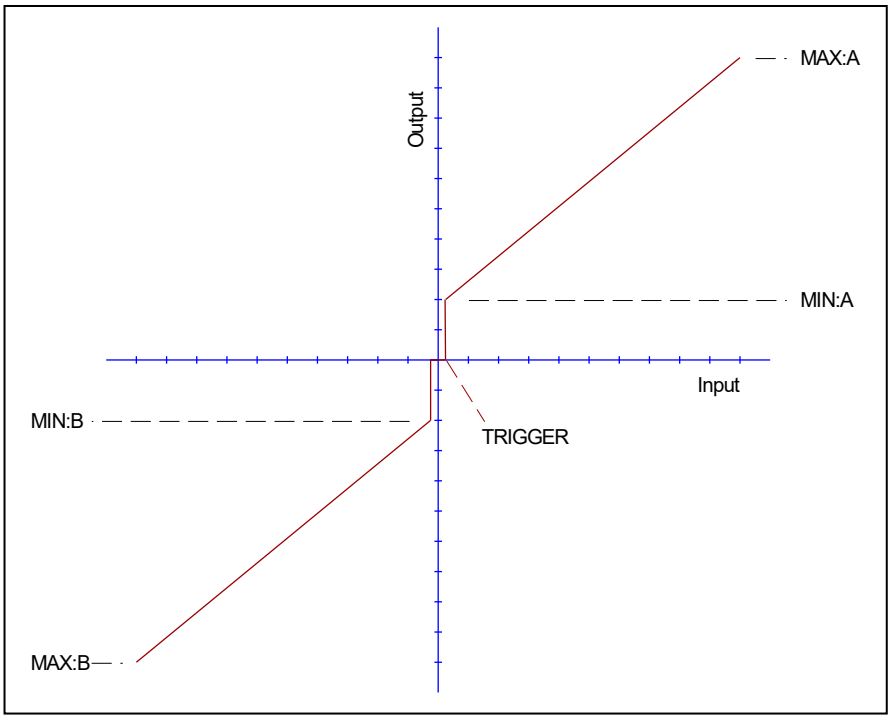
5.4.5 TRIGGER (Threshold value of MIN function)

Command	Parameters	Unit	Group
	i= A|B	-	**ADAPT**
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.

If the CC command is used, the TRIGGER of the MIN/MAX function should be set to 0 and the function should not be used if possible. Both functions influence each other and make the behavior really difficult to evaluate.

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).

5.5 Parameters of the closed loop controller

5.5.1 PID controller

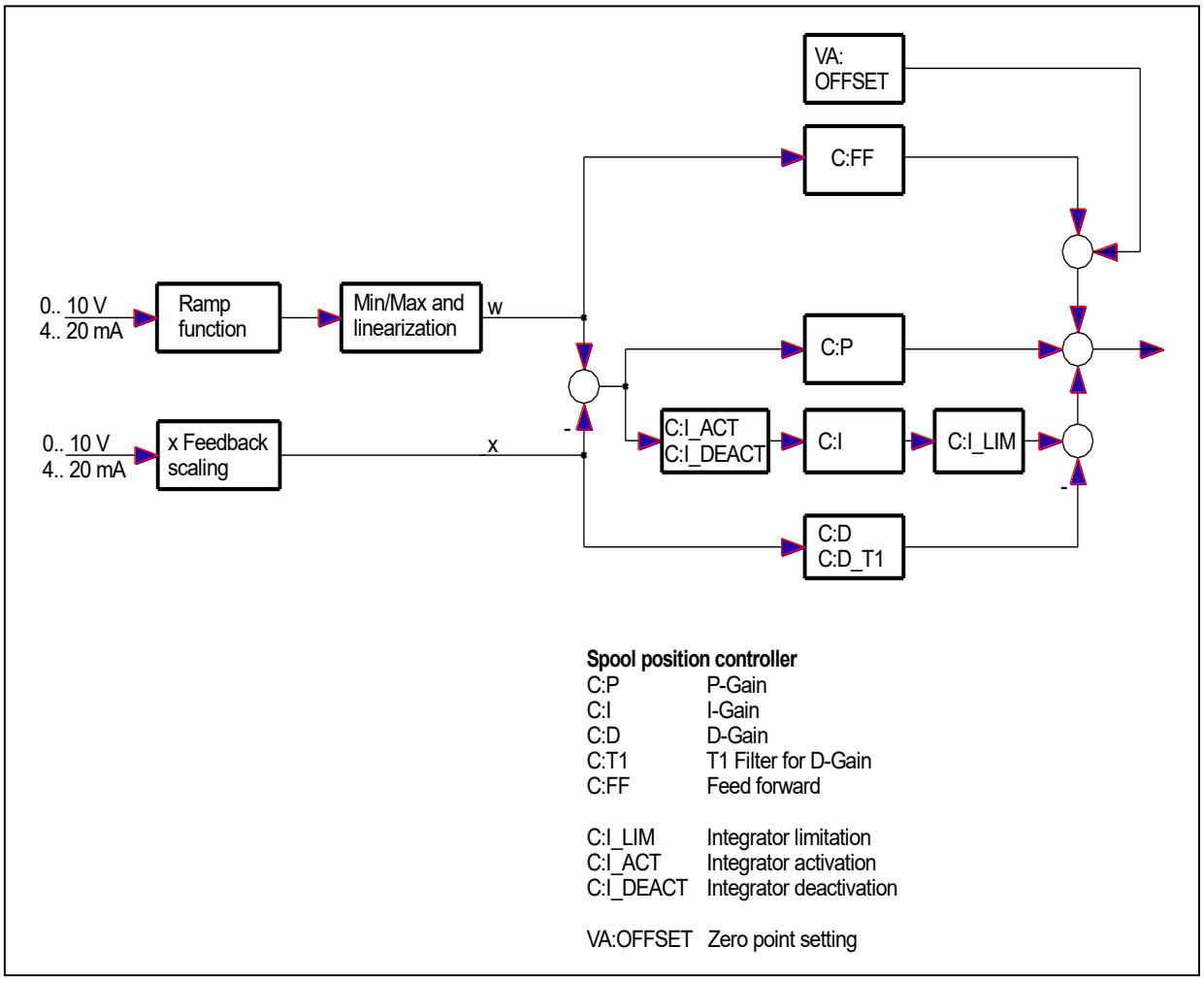
Command	Parameters	Unit	Group
C:I X	I= P|I|D|D_T1|OFFSET		**CTRL**
	:P x= 1… 10000	0.01	**CL**
	:I x= 0… 30000	0.1 ms	
	:D x= 0… 1200	0.1 ms	
	:D_T1 x= 10… 1000	0.1 ms	
	:FF x= 0… 10000	0.01 %	

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.

Setting the I-gain to “0” deactivates the integrator.

Via the FF value the output gets directly controlled. So the closed loop controller only has to compensate the deviation. This leads to a stable control behavior and a dynamic activation at once.



5.5.2 Integrator control

Command	Parameters	Unit	Group
C:I_LIM x	x= 0… 10000	0.01 %	**CTRL**
C:I_ACT x	x= 0… 10000	0.01 %	
C:I_DZ x	x= 0… 1000	0.01 %	

The parameter C:I_LIM limits the working range of the integrator in order to make a faster working of the controller without important overshoots possible. Choosing too low values may lead to a not completely compensated non-linearity of a valve.

C:I_ACT defines the activating threshold of the integrator. Not before the control deviation falls below this value the integrator starts working. Reducing the integral part depending on the deviation is always active. The advantage of this kind of control becomes noticeable at large command value changes. At first the P gain eliminates the biggest part of the deviation. The I gain gets activated later to eliminate the remaining deviation. An always active integrator would lead to overshoots because of too early pushing the signal.

In order to avoid limit cycling the C:I_DZ allows defining a Deadband around the setpoint. Within this range of the control deviation the integrator will be stopped.

5.6 Parameters of the power stage

5.6.1 CURRENT (Nominal solenoid current)

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

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 DAMPL (Dither amplitude)

5.6.3 DFREQ (Dither frequency)

Command	Parameters	Unit	Group
DAMPL X	x= 0… 3000	0.01 %	**PAM**
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.*

5.6.4 PWM (PWM frequency)

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

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.*

[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.

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

Command	Parameters	Unit	Group
ACC x	x= ON|OFF	-	**PAM**

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.

5.6.6 PPWM (Solenoid current controller P gain)

5.6.7 IPWM (Solenoid current controller I gain)

Command	Parameters	Unit	Group
PPWM X	x= 0… 30	-	**PAM**
IPWM X	x= 1… 100	-	**ACC = OFF**

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.

5.7 Process data (Monitoring)

Command	Description	Unit
WA	Input signal	%
WR	Command value after ramp function	%
WCC	Command value after linearization	%
W	Command value (after MIN/MAX)	%
X	Actual feedback value	%
E	Control deviation	%
C	Controller output signal	%
U	Control signal	%
IA	Solenoid current A	mA
IB	Solenoid current B	mA

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 / 10 4...20mA	Out of range	The power stage and READY output will be deactivated.
Feedback signal PIN 14 / 13 4… 20mA	Out of range	The power stage and READY output will be deactivated.
Solenoid A PIN 3 / 4	Broken wire	The power stage and READY output will be deactivated.
Solenoid B PIN 1 / 2	Broken wire	The power stage and READY output will be deactivated.
EEPROM (monitored during power on procedure)	Data error	The power stage and READY output will be deactivated. Activation can be realized by saving the parameters.

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 in case of current signals at input PIN 9/10 or 14/13. Input signal below 3 mA. • A broken cable or incorrect wiring to the solenoids. • Internal data error. With the WPC-300 operating program the failure can be localized directly via the monitor.
ENABLE is active; the READY LED is active; no current to the solenoid (no spool movement).	• No command value is available or the parameterization is incorrect. With the WPC-tool you can check if a command value 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 signal adaption. In OL mode the feed forward value has to be used. • If the current is set too low (parameter CURRENT/MAX), the output current and the expected pressure/movement are too low. • Wrong configured position sensor. If the input-scaling is set to voltage (V) and the sensor supplies a current signal (4... 20mA), the measured value is always high. The output signal to the valve is therefore low. • The 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 spool position is instable.	In many cases you may have a hydraulic problem. Electrical problems may be: • Bad parameterized closed loop controller. • Electrical noise at the wire of the power supply. • Very long solenoid wiring (maybe current controller has to be adapted). • 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).

7 Notes