WEST

Technical Documentation

PAM-140-P

Universal mobile power amplifier

Electronics
Hydraulics meets
meets Hydraulics
Electronics

CONTENTS

1 General Information

1.1 Order number

PAM-140-P-A - Power amplifier for proportional valves with 0…10 V input in IP65-version
PAM-140-P-I - Power amplifier for proportional valves with 4...20 mA input in IP65-version

Alternative and extended products

PAM-190-P - Power amplifier (plug) for proportional valves with M12 connection

PAM-193-P - Amplifier with potentiometers and DIL switches for top hat rail mounting

PAM-199-P - Universal digital amplifier with USB interface for top hat rail mounting

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)
ULA-310 - Programming device with USB interface
AKL-311 - Cable adapter to ULA-310

1.4 Symbols used

General information

Safety-related information

1.5 Legal notice

W.E.St. Elektronik GmbH

Gewerbering 31
D-41372 Niederkrüchten

Tel.: +49 (0)2163 577355-0
Fax.: +49 (0)2163 577355-11

Home page: www.w-e-st.de
EMAIL: contact@w-e-st.de

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.
- The device must be disposed of in accordance with national statutory provisions.

2 Characteristics

This power amplifier is used to control proportional valves with one solenoid. The compact solution is implemented in an inexpensive IP-65 housing.

A typical input signal of 0… 10 V (optional 4... 20 mA) can be used. The output current is closed loop controlled and therefore independent from the supply voltage and a varying solenoid resistance.

The parameterization can be done via the PC interface and the ULA-310 adapter or internally via the UP and DOWN buttons.

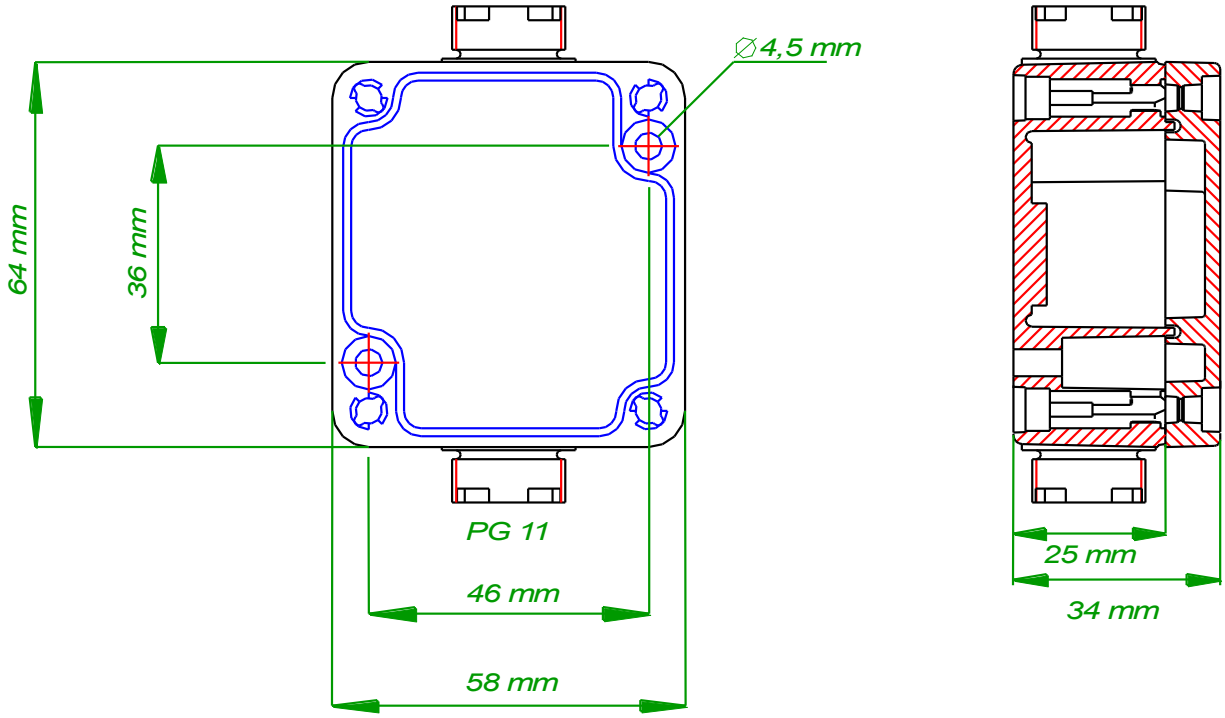
By the free parameterization of the power amplifier all typical proportional valves of the different manufactures can be optimal adapted.

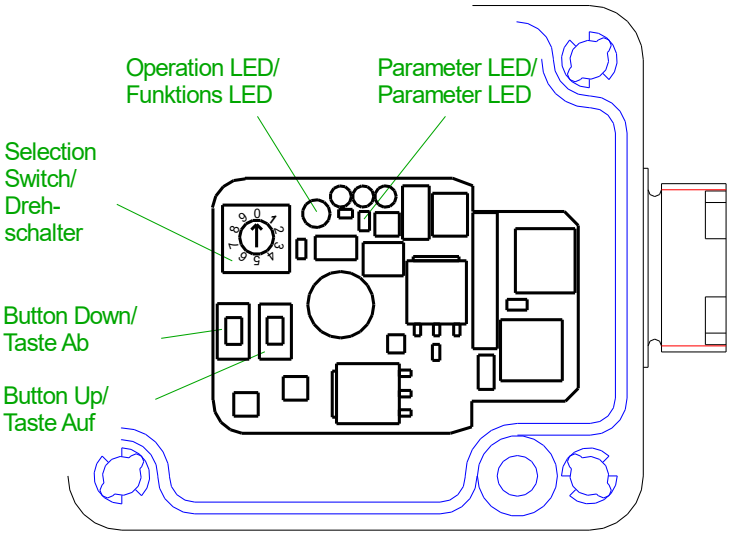
Typical applications: Controlling of the solenoid of proportional throttle or pressure valves.

Features

- **Power amplifier for proportional valves**
- **Electronic board in a housing IP-65**
- **Digital reproducible adjustments**
- **Free scaling of the input signal**
- **Reference output to supply potentiometers**
- **Free parameterization of ramps, MIN and MAX, DITHER (frequency, amplitude) and PWM frequency**
- **Nominal output current range: 0.5… 2.5 A**
- **Simple and application orientated parameter settings**
- **Failure monitoring and extended function check**
- **Adjustments via LIN/USB interface, simplified parameterizing with WPC-300 software**
- **Parameter settings via integrated buttons and a selector switch (reduced functionally against the USB / LIN-bus)**
- **Adaptable to all standard proportional valves**

2.1 Device description





3 Use and application

3.1 Installation instructions

- 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 control and regulation modules.

- The equipment 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:
    - 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 equipment 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.

- 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.
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 via the USB interface and the programming device ULA-310. Please see the WPC-300 program documentation for how to set up communication. **Caution:** The communication works in a HALF DUPLEX process. Further commissioning and diagnosis are supported by the operating software. Alternatively, the set-up can be done by the internal parameter selector and the UP and DOWN buttons.
Pre-parameterization	Parameterize now (with the help of the system redundancy and the connection diagram) the following parameters: The ANALOGUE INPUT, 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... 2.5 A. In the current state it should show around 0 A. The valve current can also be monitored in the WPC 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).
Activating command signal	**CAUTION!** The power stage is always active when power supply exists. The output current to the valve will follow the input signal proportionally.
Controller optimization	Settings like ramp time or dead band compensation can now be done.

3.3 Manual parameterization

3.3.1 Parameter overview

The manual adjustment is comparable with the adjustment via potentiometer. Not all parameter of the power plug are available in this mode[1].

Switch position	Parameter	Setting range	Remark
0	DEFAULT	-	Released only by pressing the button "Up" and "DOWN" simultaneously. Response: a short and fast flashing of the LED.
1	CURRENT	0 | 1	0 = low current range; press button “DOWN“ 1 = high current range; press button “UP“
2	MIN	0…60%	Deadband compensation in relation to the current range
3	MAX	30…100%	Reduction in the maximum current in relation to the current range
4	R:UP	50ms…5sec	Ramp time up
5	R:DOWN	50ms…5sec	Ramp time down
6	PWM	61…1500 Hz	PWM output frequency
7	-		No function
8	-		Current monitoring, no parameter input, see LED definitions.
9	-		Setpoint monitoring, no parameter input, see LED definitions.

3.3.2 Procedural method

1. Press a button or turn the selector switch which activates the manual adjustment mode. The parameter-LED flashes.

2. Select the desired parameter (1… 6) by the selector switch.

3. The parameter LED indicates - by flashing - the parameter mode.
   a. At the lower boundary the LED lights only briefly
   b. At the upper boundary the LED lights almost continuously

4. Press the UP or DOWN button.
   a. A short activation of one of the buttons will change the parameter by a value of app. 1%.
   b. A continual activation of one of the buttons will change the parameter continually (up to the point where the upper or lower boundary is reached).

5. The parameters are stored automatically (app. 1 second after the last parameter adjustment). The manual adjustment will be finished after 60 seconds.

[1] The full functionality of the power plug is available via the PC interface only.

4 Technical description

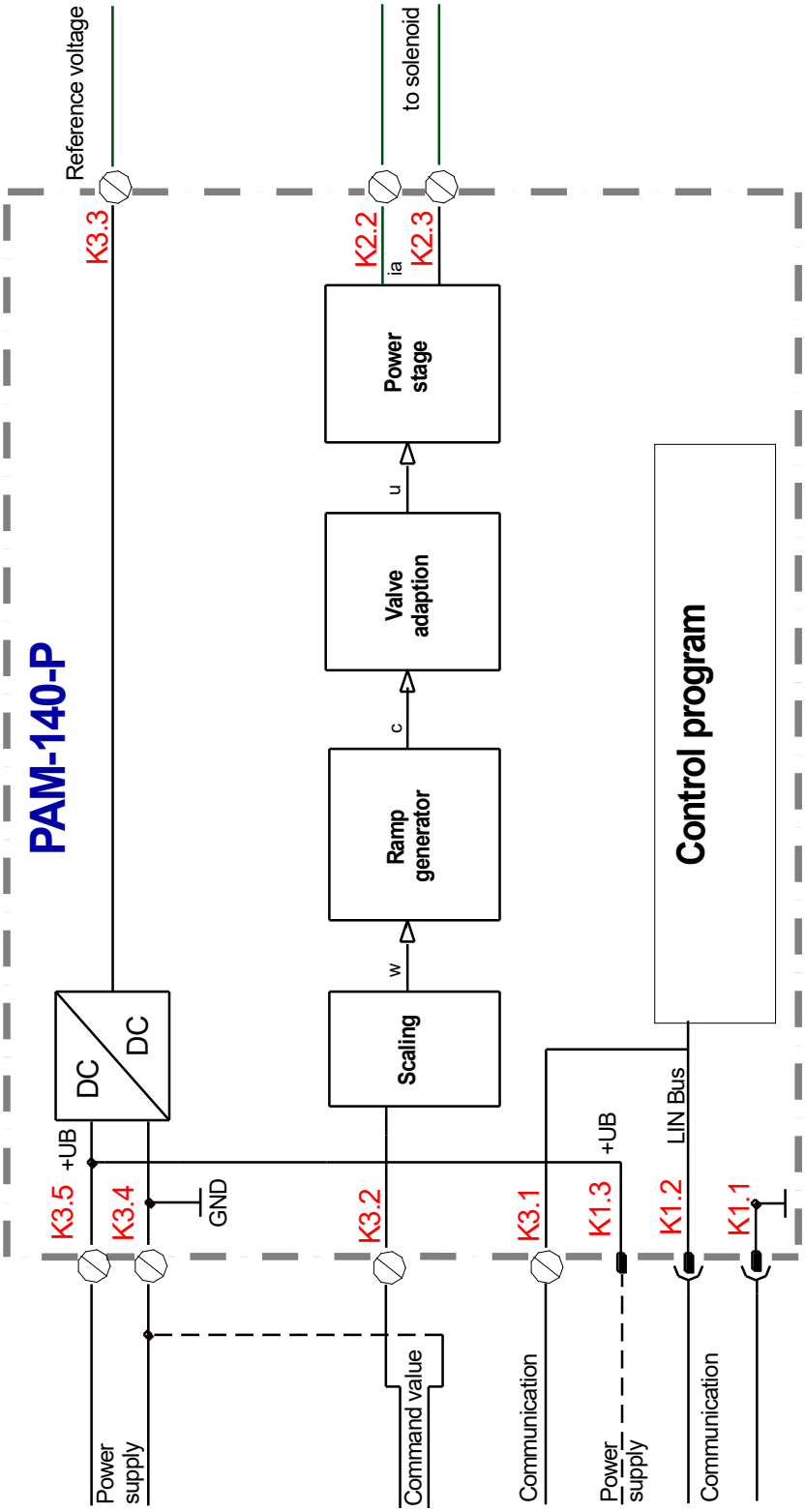
4.1 Input and output signals

Terminal	Analogue inputs and outputs
K3 PIN 2	External command value, range of 0… 10 V or 4… 20 mA, scalable
K3 PIN 3	Reference voltage 8V / 10 mA.
Terminal	**Power supply**
K3 PIN 5	Power supply (see technical data)
K3 PIN 4	0V (GND)
Terminal	**Solenoid**
K2 PIN 2 / PIN 3	PWM output for solenoid control.
K2 PIN 1	PE
Terminal	**Communication interface**
K3 PIN 1	LIN-bus connection
Terminal	**Programming cable AKL interface**
K1 PIN 2	LIN-bus connection
K1 PIN 3	Power supply (optional)
K1 PIN 1	GND

4.2 LED definitions

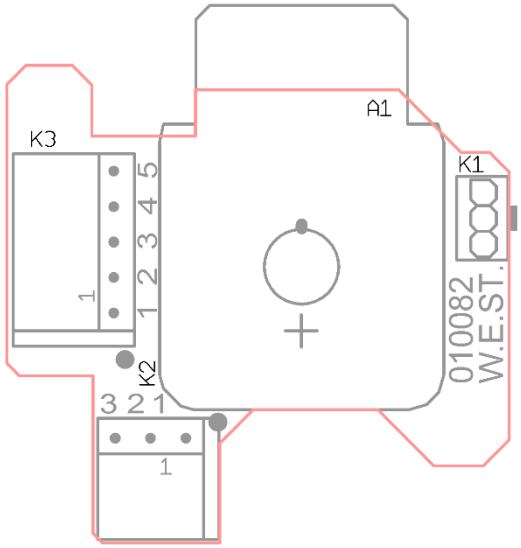
LEDs	Description of the LED function
FUNCTION LED (yellow THD)	OFF: no power supply ON: System is ready for operation Flashing: Error detected:
PARAMETER LED (yellow SMD)	Flashing sequences at rotary switch position 0...6: Manual parameter setting mode is active With rotary switch position 8: from indication "Off" via increasing flashing duration to continuous light, the output current is displayed. At rotary switch position 9: the setpoint is displayed from the "Off" display through increasing flashing duration to continuous illumination.

4.3 Circuit diagram



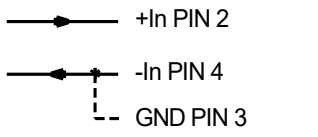
4.4 Typical wiring

Terminal	Pin	Function
K3	1	LIN
	2	AIN +
	3	REF
	4	GND
	5	UB
K2	1	PE
	2	Solenoid
	3	Solenoid
K1	1	GND
	2	LIN
	3	UB



4.5 Connection examples

PLC 0... 10 V

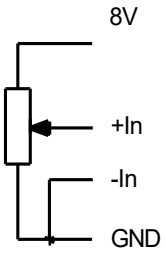


AIN:W 1000 1000 0 V (für 0... 100%)

4... 20 mA input

AIN:W 1250 1000 2000 C (for 0... 100%)

Potentiometer



AIN:W 1000 800 0 V (for 0... 100%)

4.6 Technical data

Supply voltage	**[VDC]**	12… 30 (incl. ripple)
Current requirement	**[mA]**	< 50 + solenoid current
External protection	**[A]**	3 medium time lag
Analogue command input		Unipolar
Voltage	**[V]**	0… 10
Impedance	**[kOhm]**	90
Resolution	**[%]**	0.026
Current	**[mA]**	4...20
Impedance	**[Ohm]**	240
Resolution	**[%]**	0.055
Reference output		
Voltage	**[V]**	8
Maximum load	**[mA]**	10
PWM power output		Cable break and short circuit monitored
Maximum current	**[A]**	2.5
Frequency	**[Hz]**	61… 2941 adjustable stepwise
Sample times		
Current controller	**[µs]**	167
Input signal	**[ms]**	1
Serial interface	**-**	LIN-bus
Baudrate	**[kBaud]**	19,2
Housing	**-**	PA 6-GB 30, Seal: CR
Dimensions	**[mm]**	98 x 64 x 34
Cabel gland		2 x PG11
Cable diameter	**[mm]**	4,5…10
Weight	**[kg]**	0,110
Protection class		IP 65/DIN EN 60529
Temperature range	**[°C]**	-20… 65
Storage temperature	**[°C]**	-20… 70
Connections		Push-in CAGE CLAMP
Cable-cross section	**[mm²]**	0.2… 1.5 / 24… 16 AWG
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
Input signal adaptation				
Signal scaling				
	AIN:W	A: 1000 B: 1000 C: 0 X: V	- - 0,01 % -	Free scaling of the analogue input.
Range monitoring				
	LIM	0	0,01 %	Signal monitoring function (e.g. joystick error)
Ramp function				
	R:UP **R:DOWN**	100 100	ms ms	Command signal ramp times
Output signal adaptation				
	MIN	0	0,01 %	Deadband compensation
	MAX	10000	0,01 %	Output scaling
	TRIGGER	200	0,01 %	Deadband compensation trigger point
	POL	+	-	Output polarity
Powerstage parameters				
	CURRENT	0	-	Current output range
	DFREQ	120	Hz	Dither frequency
	DAMPL	0	0,01 %	Dither amplitude
	PWM	488	Hz	PWM frequency
	PPWM **IPWM**	1 40	- -	Gain of the current loop

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 parameter list has to be updated by pressing the identification button “ID”.

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.

5.3 Input signal adaptation

5.3.1 AIN (Analogue input scaling)

Command	Parameters	Unit	Group
AIN:W			**STD**
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:

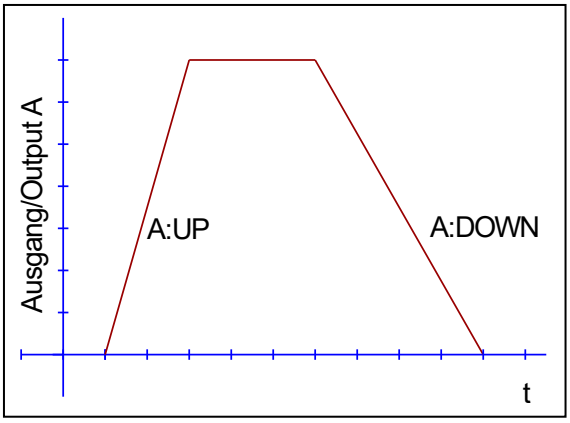
Command	Input	Description
AIN:X 1000 1000 0 V	0… 10 V	Range: 0… 100 %
AIN:X 10 8 1000 V OR **AIN:X 1250 1000 1000 V**	1… 9 V	Range: 0… 100 %; 1 V = 1000 used for the offset and gained by 10 / 8 (10 V divided by 8 V (9 V -1 V))
AIN:X 10 4 500 V OR **AIN:X 2500 1000 500 V** OR	0,5… 4,5 V	Range: 0… 100 %; 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 %.

5.3.2 LIM (Signal monitoring)

5.3.3 R (Command signal ramp time)

Command	Parameter	Unit	Group
R:I X	i= UP|DOWN x= 50… 10000	ms	**STD**

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



5.4 Output signal adaptation

5.4.1 MIN (Deadband compensation)

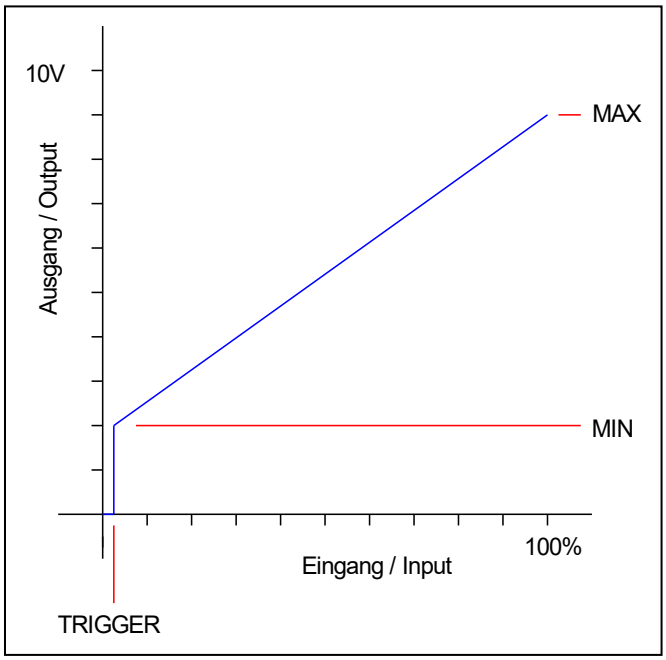
5.4.2 MAX (Output scaling)

5.4.3 TRIGGER (Response threshold for the MIN parameter)

Command		Parameters	Unit	Group
MIN	X	x= 0… 6000	0,01 %	**STD**
MAX	X	x= 2000… 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[2] 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.



[2] 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).

5.4.4 POL (Output polarity)

Command	Parameter	Unit	Group
POL X	x= + | -	-	**EXP**

This command allows a switch over of the output signal direction (after the MIN-MAX function).

Example: POL:A + Input signal 0… 100 %, nominal output current 0… 100 %.
POL:A - Input signal 0… 100 % nominal output current 100… 0 %.

5.5 Output signal adaptation

5.5.1 CURRENT (Rated current range)

Command	Parameters	Unit	Group
CURRENT X	x= 0|1	-	**STD**

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

0 = 1.0 A range

1 = 2.5 A range

5.5.2 DFREQ (Dither frequency)

5.5.3 DAMPL (Dither amplitude)

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

The dither[3] 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).

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.*

[3] 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	Parameter	Unit	Group
PWM X	x= 61… 2650	Hz	**STD**

This parameter is entered in Hz. The optimum frequency depends on the valve.

Due to the longer dead times at low PWM frequencies the stability of the control circuit is reduced. When using low PWM frequencies the PPWM and PPWM parameters should be adjusted.

The PWM frequency can only be set in defined steps. This means that there are deviations between the specified and the actual frequency. The next highest frequency step is always used.

5.5.5 PPWM (P gain of the current loop)

5.5.6 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.

If the PWM frequency is < 250 Hz, the dynamic of the current controller has to be decreased.
Typical values are: PPWM = 2 and IPWM = 60.
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
W	Command value after input scaling	%
C	Comman value after ramp function	%
U	Control signal	%
IA	Solenoid current[4]	mA

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

[4] 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:

Source	Fault	Characteristic
Command signal LIM command K3 PIN 2 / 4	Out of range	The output will be switched off and the FUNKTION LED flashes.
Command signal 4… 20 mA K3 PIN 2 / 4	Out of range or broken wire	The output will be switched off and the FUNKTION LED flashes.
Solenoids output K2 PIN 2 / 3	Wrong cabling, broken wire	The output will be switched off and the FUNKTION LED flashes.
EEPROM (when switching on)	Data error	The output will be switched off and the FUNKTION LED flashes. The module can only be activated by saving the parameters again!

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
FUNKTION LED is off.	Presumably no power supply is present. If there is no power supply there is also no communication via our operating program. If a connection has been made to the WPC-300, then a power supply is also available.
FUNKTION LED is flashing.	The flashing FUNKTION LED signals that a fault is detected by the equipment. The fault could be: • Solenoid error or no signal at the input, if 4… 20 mA signals • LIM monitored input signals are parameterized. • Internal data error: press the command/SAVE button to delete the data error. The system reloads the DEFAULT data. With the WPC-300 operating program and ULA-310 the fault can be localized directly via the monitor.

7 Notes