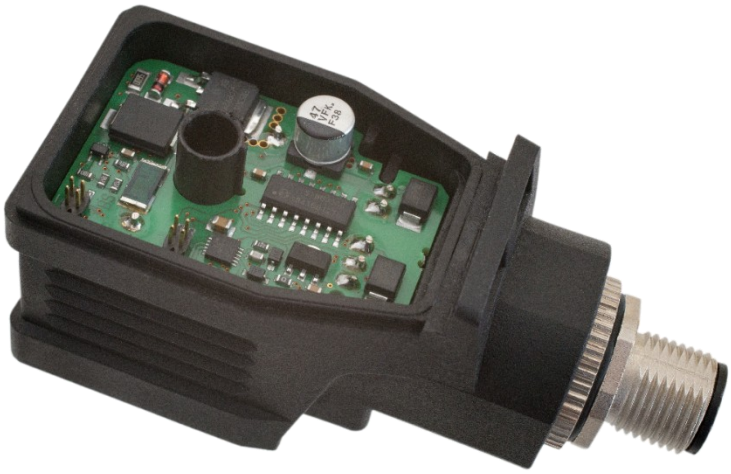
WEST

Technical Documentation

PAM-190-P-IO

Amplifier plug for proportional valves with IO-Link interface



Electronics meets Hydraulics
Hydraulics meets Electronics

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1 General Information

1.1 Order number

PAM-190-P-IO - Power amplifier for proportional valves with IO – Link interface and M12 connector

PAM-190-P-IO-S9 - Variant of the PAM-190-P-IO with 180° rotated valve plug

Alternative products

PAM-140-P - Mobile amplifier in IP65 housing with 0… 10 V or 4… 20 mA command signal input

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

PAM-190-P-A - Power amplifier in plug housing for proportional valves with 0… 10 V input

PAM-190-P-A-S9 - Variant of the PAM-190-P-A with 180° rotated valve plug

PAM-190-P-I - Power amplifier in plug housing for proportional valves with 4… 20 mA input

PAM-190-P-I-S9 - Variant of the PAM-190-P-I with 180° rotated valve plug

PAM-390-P - Single channel plug amplifier for proportional valves with USB interface

PAM-392-P - Double plug amplifier for proportional valves with USB 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

SAC-5P-FS - 5 pin M12 connector with connecting cable
IOA-312 - Adapter for connection to a class A master, incl. power supply

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

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

Date: 30.07.2025

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.

This document is protected by copyright.

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 amplifier plug is used to control proportional valves with one solenoid. The compact and inexpensive solution will be mounted directly on the solenoid.

The device is intended for control and parameterization via I / O - Link and has a Port Class B.

The output current is closed loop controlled and therefore independent from the supply voltage and a varying solenoid resistance.

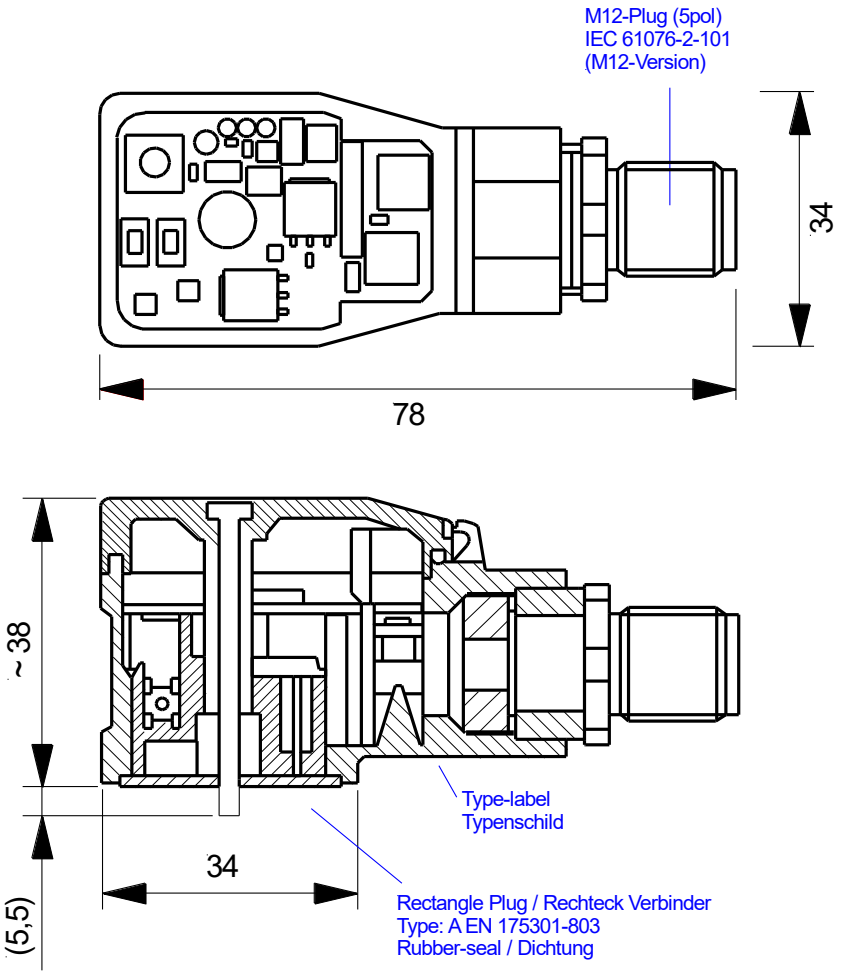
By the free parameterization of the amplifier plug all typical proportional valves of the different manufactures can be optimal adapted.

Typical applications: Controlling of the solenoid of proportional throttle or pressure valves and for current control in general inductive loads.

Features

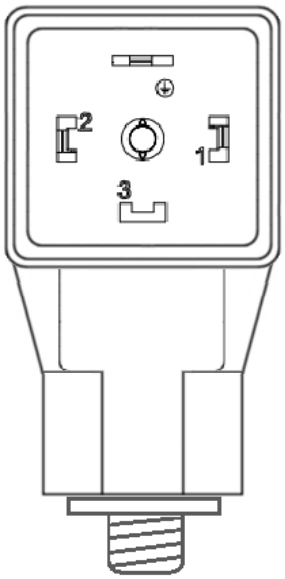
- **Power amplifier for proportional valves mounted in a DIN EN 175 301-803-A plug housing**
- **I/O – Link Port Class B, with internal galvanic isolation of the auxiliary power source**
- **Complies with specification V1.1, data rate COM3 = 230,4 kBaud**
- **Digitally reproducible adjustments**
- **Also usable as Soft-Switch-amplifier (soft switch-on and switch-off)**
- **M12 connector**
- **Parameterization via I/O - Link**
- **Free adjustment of ramps, MIN and MAX, DITHER (frequency, amplitude) and PWM frequency**
- **Output current up to 2.5 A, parameterizable**
- **Adaptable to all standard proportional valves**

2.1 Device description

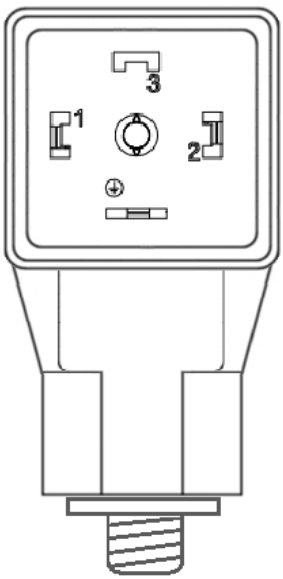


Valve plug polarity:

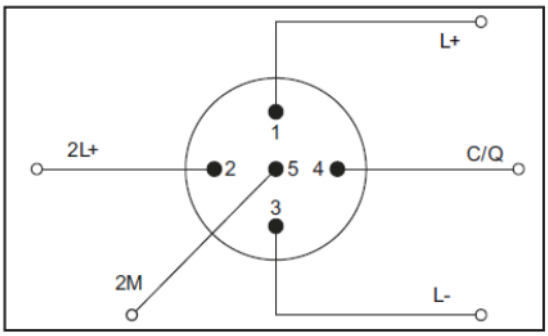
standard version

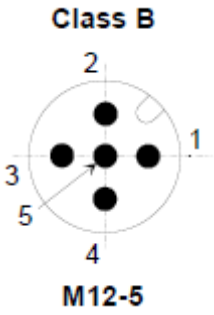


-S9 version



Pin assignment Port Class B (plan view of the device side):





3 Use and application

3.1 Installation instructions

- 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 wiring must be carried out according to the IO-Link specification. The device is wired to the master via a maximum of 20m unshielded 5-wire standard cable with a cross-section of >= 0.34 mm².
- A low-resistance connection between PE and the mounting rail should be provided. Transient interference is transmitted from the equipment directly to the mounting rail and from there to the local earth.
- Power should be supplied by a regulated power supply unit (typically a PELV system complying with IEC364-4-4, secure low voltage). The low internal resistance of regulated power supplies gives better interference voltage dissipation, which improves the signal quality of high-resolution sensors in particular. Switched inductances (relays and valve coils connected to the same power supply) must always be provided with appropriate overvoltage protection directly at the coil.

3.2 Commissioning

If you would like to start up the device without PLC, we recommend using our adapter IOA-312 and reading the AN-108 This document describes the procedure based on an IO - Link Master, which you can operate on the USB - interface of your computer. In this way, parameterisation and control of the device is possible with a minimum of additional components.

The general procedure for commissioning is as follows:

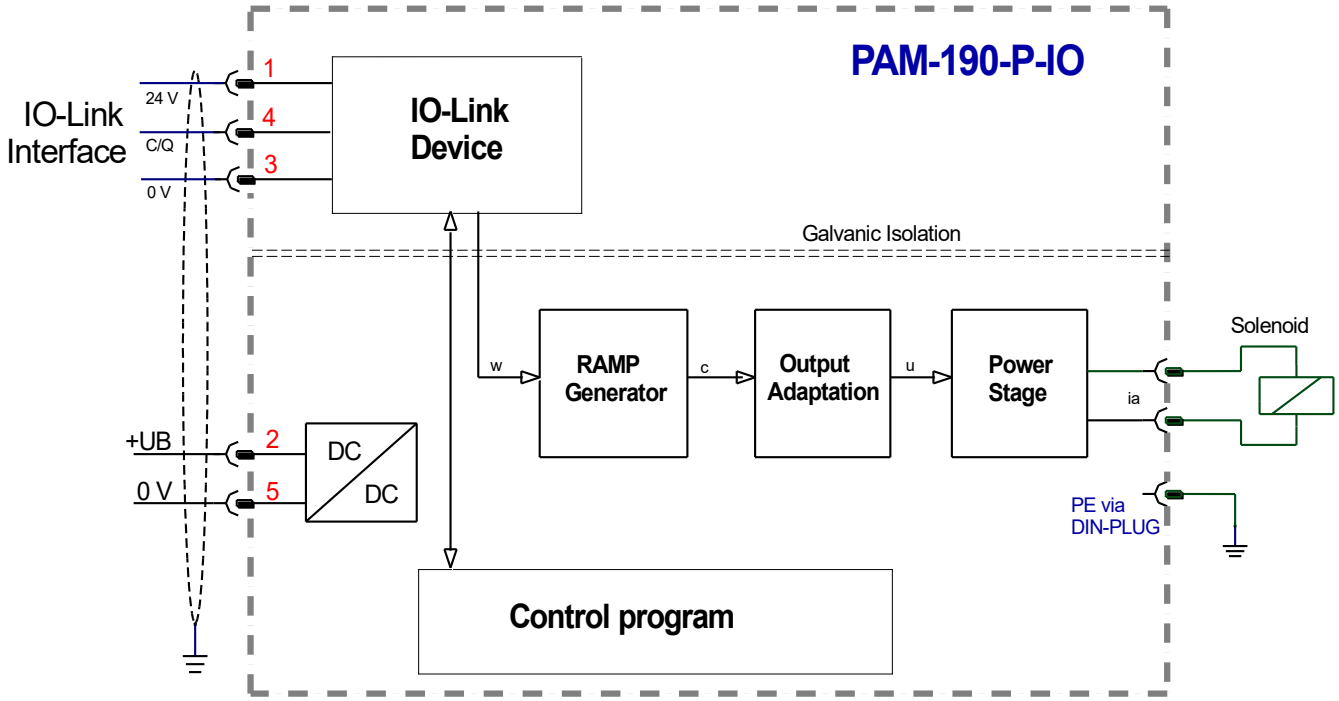
Step	Task
Installation	Install the device in accordance with the circuit diagram. Ensure it is wired correctly and that the signals are well shielded.
Switching on for the first time	Ensure that no unwanted movement is possible in the drive (e. g. switch off the hydraulics). Connect an ammeter and check 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	If the current consumption is correct, the I / O - Link Master should be connected. The procedure for setting up communication can be found in the master manufacturer's documentation.
Pre-parameterization	Parameterize now (with the help of the system redundancy and the connection diagram) the following parameters: 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. You also have the option of displaying the valve current in the cyclic process data through IO Link as feedback of the device to the master.
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.

4 Technical description

4.1 Input and output signals

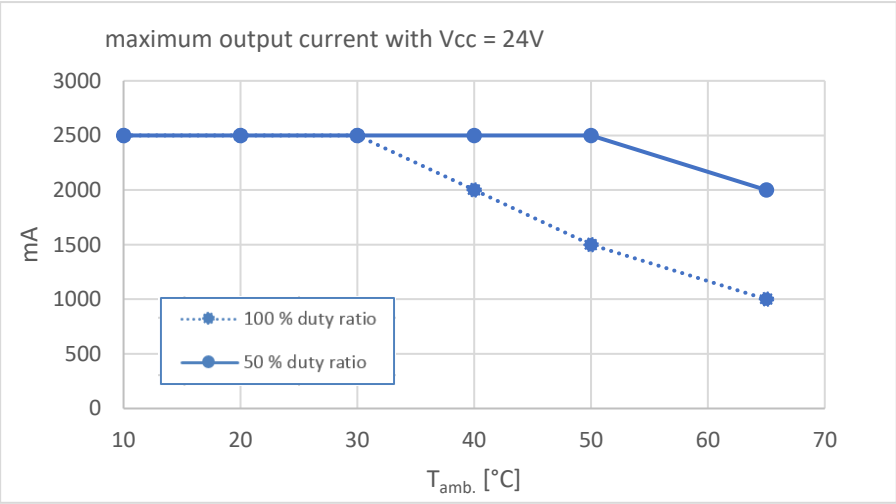
Connection	IO - Link
PIN 1	Power supply 24 V
PIN 3	0 V (GND) connection.
PIN 4	Communication (C/Q)
Connection	**Analogue signals**
PIN 2	Supply of the power stage, 12… 30 V (including ripples)
PIN 5	0 V (GND) – internal galvanic isolation from PIN 3

4.2 Circuit diagram



4.3 Technical data

Supply voltage power stage Current requirement External protection	**[VDC]** **[mA]** **[A]**	12… 30 (incl. ripple) < 50 + solenoid current 3 medium time lag
PWM output Max. output current Frequency	 **[A]** **[Hz]**	Wire break and short circuit monitored 2,5 61… 2604 selectable in defined steps
IO-Link min cycle time Sample time Sample time (solenoid current control)	**[ms]** **[ms]** **[ms]**	4 1 0,125
IO - Link Port Data rate	 **[kBaud]**	according specification V1.1 Class B with internal galvanic isolation[1] 230,4 (COM3)
Isolation 24-V-Supply (logic- and sensor power supply) / IO-Link bus		500 V AC 50 Hz 1 min.
Housing		Hirschmann GDME DIN EN 175 301-803-A
Weight	**[kg]**	0,110
Protection class Temperature range Storage temperature	 **[°C]** **[°C]**	IP65 (with gasket) -20… 65[2] -20 …70
Connections		M12, 5-pole (DESINA standard)
EMC		EN 61000-6-4: 2007 EN 61000-6-2: 2005



[1] The integrated galvanic isolation is required by the IO - Link specification. The advantage for the user is that no earth loops can occur. Also, the quality of the supply voltage for the output stage has no influence on the functional reliability of the IO-Link interface.

Depending on the structure of the power supply for logic (IO - Link / PLC) and output stage, the ground connections may, of course, be connected in the customer system.

[2] At ambient temperatures above 30°C, restrictions for the solenoid current must be considered. See diagram.

5 Parameters

5.1 Parameter overview

	Command	Default	Unit	IO - Link Index / Bytelänge	Description
Basic parameters					
	SENS	ON	-	1000/1	Failure monitoring
Input signal adaptation					
	Signal scaling				
	IO_BASE	10000	-	1018/2	Value base for the command value
	Ramp function				
	R_UP **R_DOWN**	100 100	ms ms	1002/4 1004/4	Command signal ramp times
Output signal adaptation					
	MIN	0	0,01 %	1006/2	Dead band compensation
	MAX	10000	0,01 %	1007/2	Output scaling
	TRIGGER	200	0,01 %	1008/2	Dead band compensation trigger point
Powerstage parameters					
	CURRENT	1000	mA	1009/2	Nominal solenoid current
	DFREQ	121	Hz	1011/2	Dither frequency
	DAMPL	500	0,01 %	1010/2	Dither amplitude
	PWM	2604	Hz	1012/2	PWM frequency
	ACC	ON		1015/2	ON activates the automatic setting of the current loop settings
	PPWM **IPWM**	7 40	- -	1013/2 1014/2	Gain of the current loop

5.2 System parameters

5.2.1 SENS (Failure monitoring)

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

This command is used to activate/deactivate the monitoring functions (output current 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.

5.3 Input signal adaptation

5.3.1 IO_BASE (Scaling of the input and output signals)

Command	Parameter	Unit
IOBASE X	x= 100… 32767	-

The reference value for 100% command and feedback values can be defined here. So it can be adapted to the used number system. E.g. a value of 10000 can be chosen to use 0.01% units or 16383 to use 3FFF as maximum.

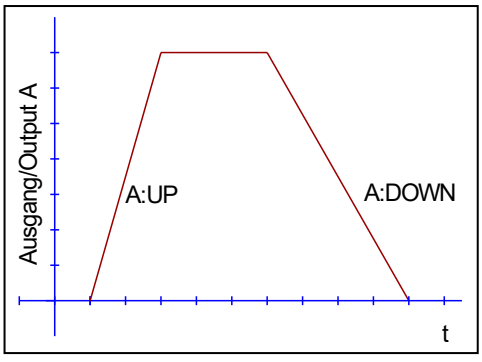
Example: A 350 bar pressure valve should be controlled with 0.1 bar resolution. IO_BASE is parameterized to 3500.

5.3.2 R (Command signal ramp time)

Command	Parameter	Unit
R:I X	i= UP|DOWN x= 1… 120000	ms

Two quadrant ramp function.

The ramp time is separately set for UP and DOWN ramps



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5.4 Output signal adaptation

5.4.1 MIN (Deadband compensation)

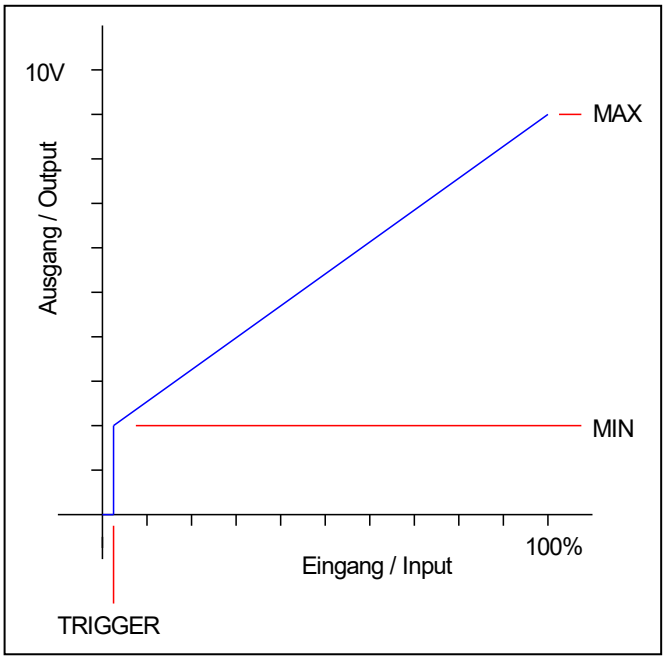
5.4.2 MAX (Output scaling)

5.4.3 TRIGGER (Response threshold for the MIN parameter)

Command		Parameters	Unit
MIN	X	x= 0… 6000	0,01 %
MAX	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 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.



5.5 Power Stage Parameters

5.5.1 CURRENT (Rated output current)

Command	Parameters	Unit
CURRENT X	x= 500… 2500	mA

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

5.5.2 DFREQ (Dither frequency)

5.5.3 DAMPL (Dither amplitude)

Command	Parameters	Unit
DFREQ X	x= 60… 400	Hz
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.*

If there are no adjustment data from the valve manufacturer, proceed as follows: First, the amplitude is adjusted based on the hysteresis of the valve. Then setting starts with a low dither frequency. The user should increase it step by step. The aim is that no oscillation (often observed as humming of the valve) is noticeable at the end of the tuning procedure.
Alternatively, the PWM frequency can also be used as a dither. In this case, the dither amplitude must be set to zero and a relatively low PWM frequency is set (typically: 60 ... 250 Hz). Again, no humming on the drive should be detectable after the adjustment.

[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
PWM	X	x= 61… 2604	Hz

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

***CAUTION:** when using low PWM frequencies the PPWM and PPWM parameters should be adjusted[4]. This happens automatically if ACC = ON (see below).*

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 ACC (Automatic setting of the current controller)

Command		Parameter	Unit
ACC	**X**	**x= ON|OFF**	-

Operating mode of the current controller.

ON: In AUTOMATIC mode the PPWM and IPWM values are calculated on the basis of the PWM frequency.

In ACC ON mode the PPWM and IPWM values cannot be changed via IO - Link. The writing of PPWM and IPWM parameters is reported positively by IO-Link, but the settings are changed immediately by the internal logic.

OFF: Manual setting.

[4] Due to the longer dead times at low PWM frequencies the stability of the control circuit is reduced. Typical values are then: PPWM = 1… 3 and IPWM = 40… 70.

5.5.6 PPWM (P gain of the current loop)

5.5.7 IPWM (I gain of the current loop)

Command	Parameters	Unit
PPWM X	x= 0… 30	-
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.

If the PWM frequency is < 250 Hz, the dynamic of the current controller has to be decreased.
Typical values are: PPWM = 1… 3 and IPWM = 40… 80.
If the PWM frequency is > 1000 Hz, the default values of PPWM = 7 and IPWM = 40 should be chosen.

5.6 IO – Link Process Data

The process data are the variables which are cyclically exchanged via IO link.

The process data length of the device is 4 bytes in both directions.

PDOUT (Data direction from master to slave):

No.	Byte	Function	Range	Unit
1	0	Control word High Control word Low	-	-
2	1			
3	2	Setpoint High Setpoint Low	0 - IOBASE	
4	3			

Definition of the control word:

Byte 0 – Control word 1 High			
No.	**Bit**	**Function**	
1	0	---	
2	1	---	
3	2	---	
4	3	---	
5	4	---	
6	5	---	
7	6	---	
8	7	ENABLE	General activation of the device

Byte 1 – Control word 1 Low			
No.	**Bit**	**Function**	
1	0	---	
2	1	---	
3	2	---	
4	3	---	
5	4	---	
6	5	---	
7	6	---	
8	7	---	

PDIN (Data direction from slave to master):

No.	Byte	Function	Type	Range	Unit
1	0	Solenoid current High Solenoid current Low	int	0 - 2500	mA
2	1				
3	2	Status word High Status word Low	int	-	-
4	3				

Note: The measured value of the solenoid current is filtered internally and therefore the feedback is delayed. However, the device reacts immediately to setpoint changes.

Definition of the status word:

Byte 2 – Status word High			
No.	**Bit**	**Function**	
1	0	---	
2	1	$\overline{\text{OPENSOL}}$	Solenoid error: open circuit
3	2	$\overline{\text{SHORTSOL}}$	Solenoid error: short circuit
4	3	$\overline{\text{APIHTEMP}}$	Warning: Temperature of the µC for current control is high
5	4	$\overline{\text{APILOWVWRN}}$	Warning: Auxiliary voltage is low
6	5	$\overline{\text{APILOWVERR}}$	Error: Auxiliary voltage is too low
7	6	$\overline{\text{ERROR}}$	General error flag
8	7	READY	General operational readiness

Byte 3 – Status word Low			
No.	**Bit**	**Function**	
1	0	---	
2	1	---	
3	2	---	
4	3	---	
5	4	---	
6	5	---	
7	6	$\overline{\text{DERROR}}$	Internal data error
8	7	$\overline{\text{IOLHTEMP}}$	Warning: Temperature of the µC for IO – Link communication is high

CAUTION: Error flags are inverted. High state means “no error”.

6 Appendix

6.1 Failure monitoring

Following possible error sources are monitored continuously:

Source	Fault	Characteristic
Solenoid output	Broken wire / Open circuit	The power stage is deactivated and the error bit OPENSOL in the status word is reset.
Solenoid output	Short circuit	The power stage is deactivated and the error bit SHORTSOL in the status word is reset.
EEPROM (when switching on)	Data error	The power stage remains deactivated and the error bit DERROR in the status word is reset. The module can only be activated by saving the data again. This is detected when a parameter is written via IO - Link. If SENS = ON, a rising edge of the ENABLE signal must be provided for startup.
Temperature of the µC for the power stage too high	> 105°C	The microcontroller of the power stage reports a warning. The device is operating at temperatures outside the specification. The control is not switched off. A further increase in temperature can lead to a failure of the device.
Temperature of the µC for IO – Link communication too high	> 105°C	The microcontroller for communication reports a warning. The device is operating at temperatures outside the specification. The control is not switched off. A further increase in temperature can lead to a failure of the device.
Under voltage of the power stage (warning)	< 10 V	The supply voltage of the power stage is less than 10V. A warning is generated. The control is not switched off.
Under voltage of the power stage (error)	Controller switches off due to the under voltage	The supply voltage of the power stage is too low for operation of the current controller.
ERROR	Common error	This bit summarizes all errors that lead to a shutdown of the current control.



In case of an EEPROM error, the parameters are set to default values. The user settings are lost. It is recommended to save the parameter settings also in the master.

6.2 Troubleshooting

It is assumed that the device is in an operable state and there is communication between the module and the IO – Link master. Furthermore, the valve control parameterization has been set with the assistance of the valve data sheets.

FAULT	CAUSE / SOLUTION
Communication setup error	Presumably no power supply is present. If there is no power supply there is also no communication via IO - Link. If the connection to the module is established, a power supply is also available on the IO-Link side.
Malfunction	The ERROR bit of the status word indicates that the module has detected an error. The error description can be found in chapter 6.1.

7 Notes