Technical Documentation

PQP-176-P

Universal pump control module with integrated power stage

CONTENTS

1 General Information

1.1 Order number

PQP-176-P - pump control module for cascade regulation in the open hydraulic circuit with analogue control output and integrated power stage and analogue demands

Alternative products:

PQP-176-P-PFN - pump control module for cascade regulation in the open hydraulic circuit with analogue control output, integrated power stage and ProfinetIO interface

PQP-179-P pump control module for the open or closed circuit with integrated power stage and optionally activatable spool position controller for the control valve

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

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: 08.01.2025

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 device represents a pump controller for the displacement, pressure and power/torque control of servo pumps.

The module can control directional valves for swivel angle adjustment of the pump with one or two solenoids. For controlling valves with integrated electronic the power stage can be deactivated.

Control structure is a cascade regulation which makes it universal for using with many different pumps of several producers. Negative swiveling for active pressure reducing (mooring mode) can also parameterized.

Miscellaneous parameters allow an optimal adaption to the relating application.

The command values and the feedback values are read in via scalable analogue signals in the range of 0… 10 V or 4… 20 mA.

The output current is closed loop controlled and therefore independent from the supply voltage and a varying solenoid resistance. The output stage is monitored for broken cable and switches off in case of detected error.

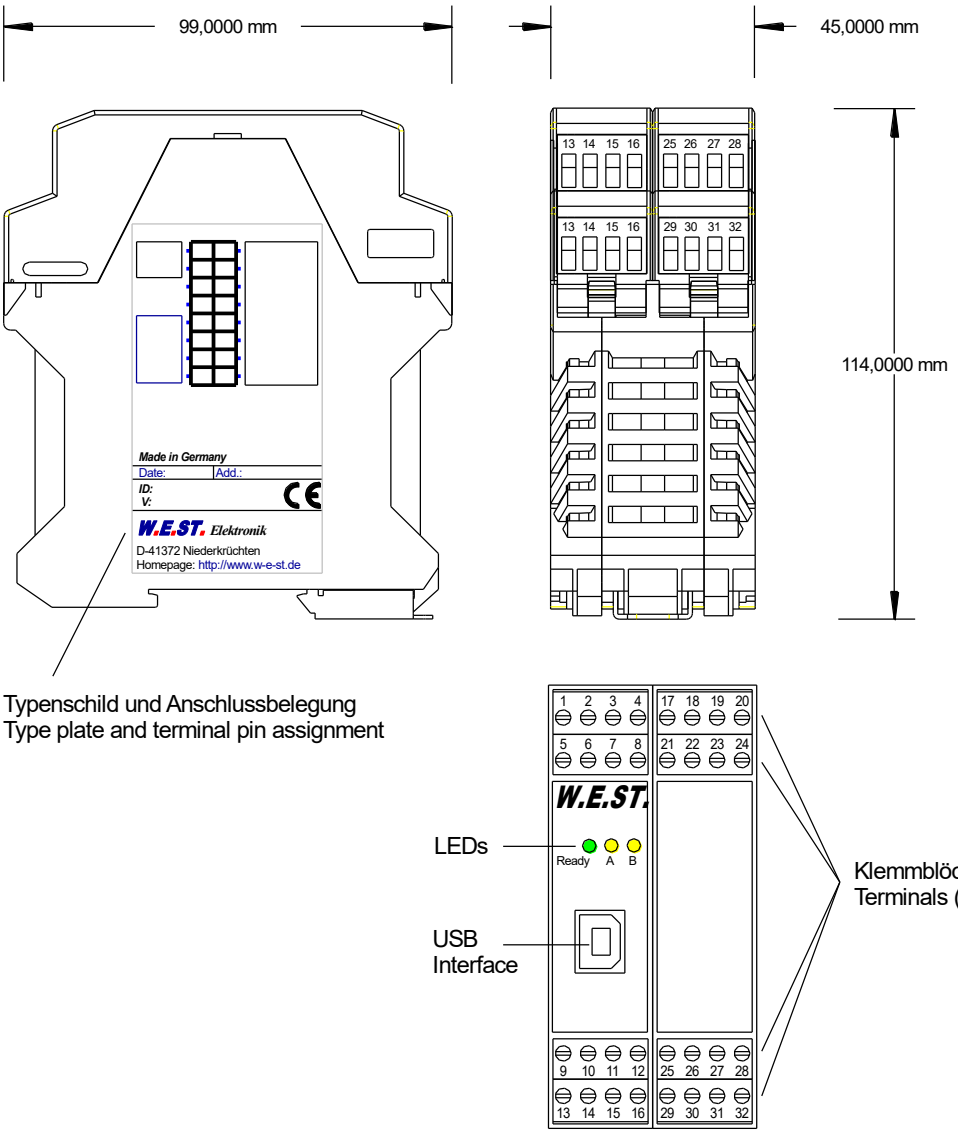
Because of the easy and job-oriented handling a very short training period is guaranteed.

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

Features

- **Displacement, pressure and power limitation control**
- **Digital reproducible adjustments**
- **Free scaling of the analogue input signals**
- **Compact housing**
- **Optimized control function**
- **Application oriented parameterizing**
- **Two parameter sets for the pressure controller**
- **Swivel angle limitation function**
- **Integrated power stage**
- **Alternative analogue output for controlling valves with OBE**
- **Fault diagnosis and extended function checking**
- **Simplified parameterization with WPC-300 software**

2.1 Device description



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.

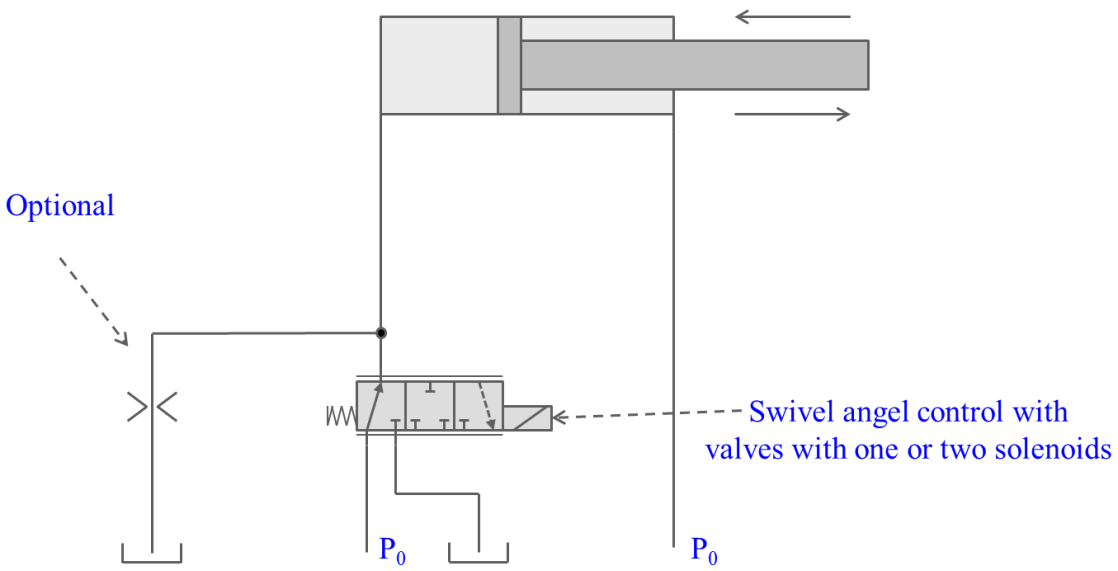
- The module should be installed and wired in accordance with the documentation bearing in mind EMC principles. If other consumers are operated with the same power supply, a star-shaped ground wiring scheme is recommended. The following points must be observed when wiring:
  - The signal cables must 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 Method of operation

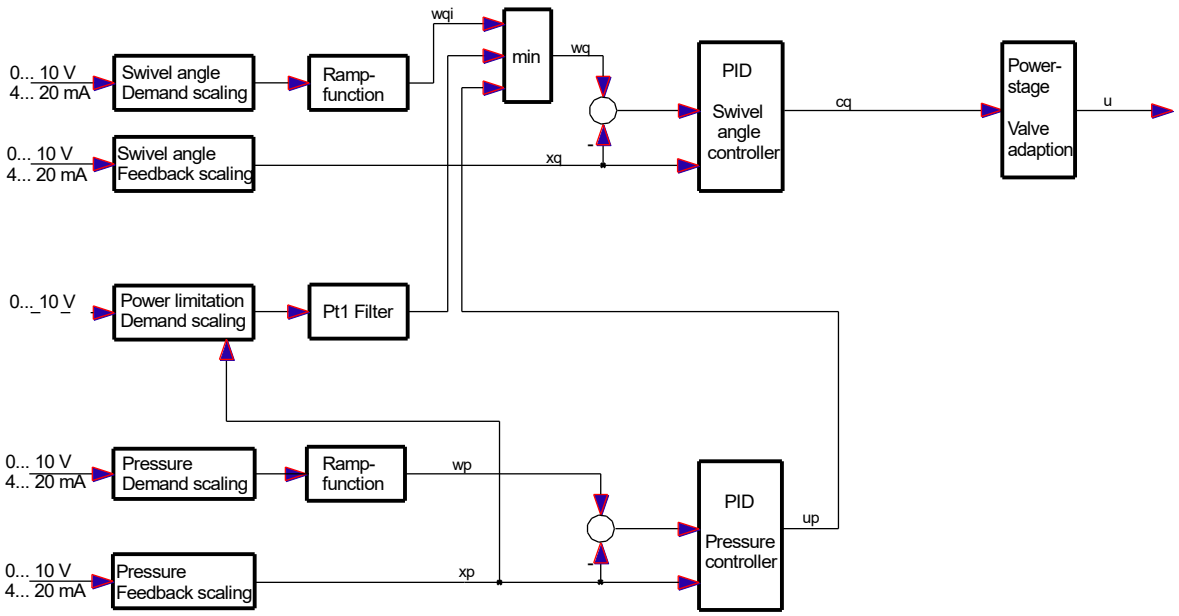
The here described device realizes a pump control by controlling its swivel angle valve. Similar to the movement of a cylinder in a positioning control the swivel angle can be driven out and back in order to reach the requested demand respective opening level. The external demand can be influenced by several parameters and functions. A volume flow correction factor can be added as well as limitation function can come to action. The integrated power limitation function and the pressure controller, which can be activated and deactivated, can limit the swivel angle command value. If an active pressure reducing (mooring mode) is possible, the pressure controller can be released for the negative control range.

Because of its relative low mass the actuator has a high natural frequency what results in the swivel angle valve determining the dynamic behavior predominantly. From this follows that the quality of the control is proportional to the quality and capacity of the valve.



3.3 Control structure

The control structure describes the common behavior of the system. The swivel angle demand value WQI can be limited by the power limitation or pressure controller. So the lowest of the active signals will be taken over for the swivel angle controller. The pressure controller can also be parameterized for controlling negative swivel angle values for active pressure reducing (mooring mode).



The swivel angle feedback input can be set to 0… 10 V or 4… 20 mA whereby an inverting can be realized by the following scaling function.

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 dimensioning and the connection diagram) the following parameters: Output signal, valve adaption and scaling of the inputs. Pre-parameterization is necessary to minimize the risk of an unintentional movement / pressure. Please read up the required information or talk to the responsible persons.
Control signal	Check the control signal to the valve. At the current state it should be 0 mA, at the analogue output as well as the power stage.
Switching on the hydraulics	The hydraulics can now be switched on. The module is not yet generating a signal, means there should no (unwanted) reaction occur.
Activating ENABLE	**CAUTION!** With the ENABLE the output stage gets activated. Depending on the settings now the valve will be controlled. Wrong parameterization can cause uncontrolled behavior. *Swivel angle controller* and *power limitation controller* (if activate) are enabled now.
Activating PRESSURE CONTROLLER	With ENABLE_P the pressure controller gets activated. The system now works in closed loop control for the pressure control (PQ mode). **CAUTION!** Wrong parameterization can cause uncontrolled behavior.
Controller optimization	Now optimize the settings. The PID parameters have to be adapted depending on the application.

4 Technical description

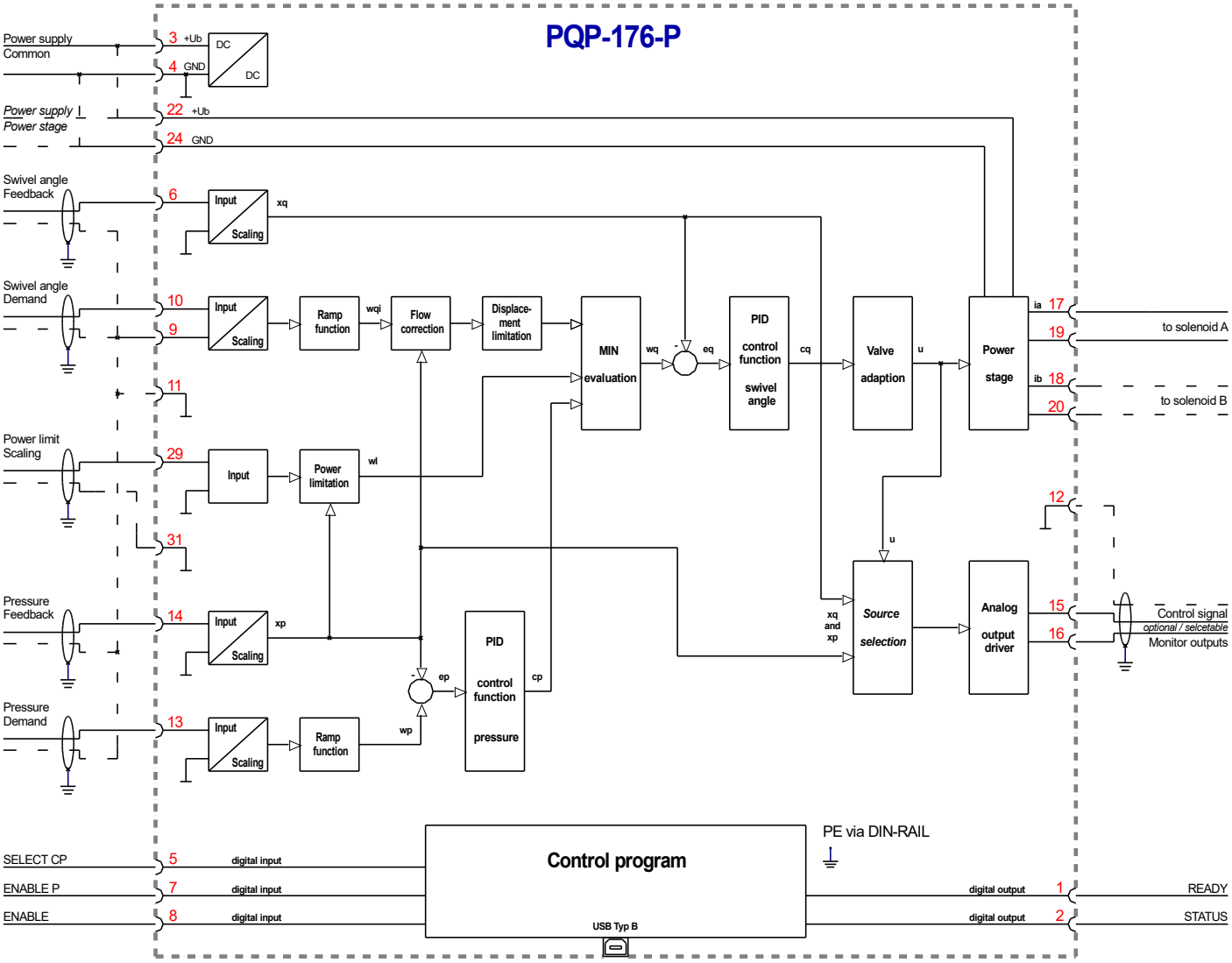
4.1 Input and output signals

Connection	Supply
PIN 3	Power supply (see technical data).
PIN 4	0 V (GND) connection.
PIN 22	Power supply (see technical data) of the power stage.
PIN 24	0 V (GND) connection of the power stage.
Connection	**Analogue signals**
PIN 6	Feedback value swivel angle (XQ), signal range 0… 10 V or 4… 20 mA, scalable.
PIN 10	Demand value swivel angle (WQI), signal range 0… 10 V or 4… 20 mA, scalable.
PIN 9	Demand value swivel angle, connect to 0 V when using unipolar signals.
PIN 13	Command value pressure (WP), signal range 0… 10 V or 4… 20 mA, scalable.
PIN 14	Feedback value pressure (XP), signal range 0… 10 V or 4… 20 mA, scalable.
PIN 11	0 V (GND) reference potential for analogue input signals.
PIN 12	0 V (GND) reference potential for analogue output signals.
PIN 15	Control output + (U) or monitoring signal (XQ), 0… 10 V or 4… 20 mA.
PIN 16	Control output - (U) or monitoring signal (XP), 0… 10 V or 4… 20 mA.
Connection	**Digital inputs and outputs**
PIN 8	**ENABLE input:** Generally enabling of the application. Activates swivel angle (Q) controller and output.
PIN 7	**ENABLE P input:** Activates the pressure (P) controller.
PIN 5	**SELECT CP input:** Selecting the responsible parameter set for the pressure controller (ON = CP2).
PIN 1	**READY output:** **ON:** The module is enabled; there are no discernable errors. **OFF:** ENABLE is not available or an error has been detected.
PIN 2	**STATUS output:** **ON:** The system is in power limitation. **OFF:** Power limitation function not active.
Connection	**Valve outputs**
PIN 17 / 19	Solenoid A
PIN 18 / 20	Solenoid B

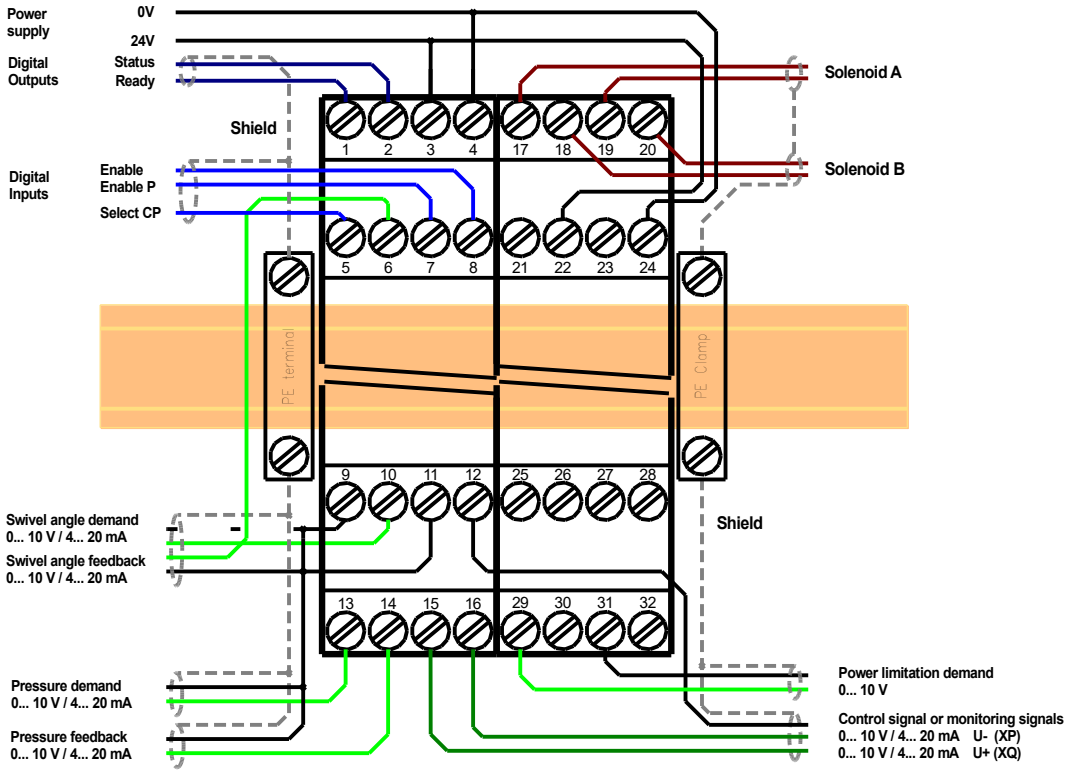
4.2 LED definitions

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 Not active if SENS = OFF.
YELLOW A	**OFF:** No active power limitation. **ON:** System is in power limitation.
YELLOW B	**OFF:** No active pressure limitation. **ON:** System is in pressure limitation.
	Error messages
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 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.

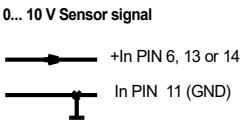
4.3 Circuit diagram

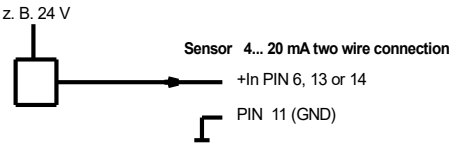


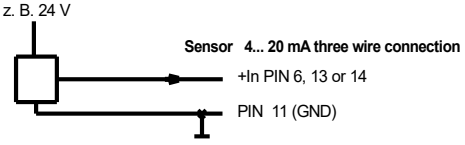
4.4 ypical wiring



4.5 Connection examples







4.6 Technical data

Supply voltage (Ub)	**[VDC]**	12… 30 (incl. ripple)
Power consumption	**[W]**	max. 1,2 + consumption of the connected coils
External protection	**[A]**	3 medium time lag
Digital inputs		
OFF	**[V]**	< 2
ON	**[V]**	> 10
Input resistance	**[kOhm]**	25
Digital outputs		
OFF	**[V]**	< 2
ON	**[V]**	max. Ub
Maximum current	**[mA]**	50
Analogue inputs		Unipolar / differential
Voltage	**[V]**	0… 10 / -10… 10
Input resistance	**[kOhm]**	min. 25
Signal resolution	**[%]**	0,003 incl. Oversampling
Current	**[mA]**	4… 20
Burden	**[Ohm]**	240
Signal resolution	**[%]**	0,006 incl. Oversampling
Analogue outputs		
Voltage	**[V]**	0… 10, +/- 10 differential
Maximum load	**[mA]**	10
Current	**[mA]**	4… 20
Maximum load	**[Ohm]**	390
Signal resolution	**[%]**	0,007
PWM output		Wire break and short circuit monitored
Max. output current	**[A]**	2,6
Frequency	**[Hz]**	60… 2941 selectable in defined steps
Controller cycle times		
Solenoid current control	**[µs]**	125
Signal processing	**[ms]**	1
Serial interface	**-**	USB - virtual COM Port
Transmission rate	**[kBaud]**	9,6… 115,2
Housing		Snap -on module acc. EN 50022
Material	**-**	PA 6.6 polyamide
Flammability class	**-**	V0 (UL94)
Weight	**[kg]**	0,28
Protection class	**[IP]**	20
Temperature range	**[°C]**	-20… 60
Storage temperature	**[°C]**	-20… 70
Humidity	**[%]**	< 95 (non-condensing)
Connections		
Communication	**-**	USB type B
Plug connectors		4 x 4-pole terminal blocks
PE		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
	MODE	SYSTEM	-	Visible parameter group
Basic parameters				
	LG	EN	-	Selecting language
	SENS	ON	-	Malfunction monitoring
System configuration				
	CTRLOUT	2SOL	-	Configuration of the control output
	LIM:XQ	0	0.01 %	Cable break monitoring swivel angle feedback
	PL:CTRL	OFF	-	Aktivation of the power limitation function
Input signal adaption				
Pressure demand				
	SYS_RANGE	100	bar	System pressure demand
	SIGNAL:WP	100	bar	Type of input signal
	RAP:UP **RAP:DOWN**	100 100	ms ms	Ramp times pressure demand
Pressure feedback				
	SIGNAL:XP	U0-10	-	Type of input signal
	N_RANGE:XP	100	bar	Nominal pressure of the sensor
	OFFSET:XP	0	mbar	Sensor Offset
Swivel angle command				
	SIGNAL:WQ	U0-10	-	Type of input signal
	RAQ:UP **RAQ:DOWN**	100 100	ms ms	Ramp times swivel angle demand
	CORR:Q	0	0.01 %	Volume flow correction factor
	CQ:LF **CQLF:PV** **CQLF:WQ**	OFF 5000 2500	- 0.01 % 0.01 %	Swivel angle limitation function
Swivel angle feedback				
	SIGNAL:XQ	U0-10	-	Type of input signal
	ZERO:XQ **MAX:XQ**	0 10000	0.01 % 0.01 %	Scaling swivel angle feedback signal

Group	Command	Default	Unit	Description
Control parameters				
Swivel angle				
	CQ:FF	5000	0.01 %	Offset value for neutral position of valves with one solenoid
	CQ:P **CQ:I** **CQ:I_LIM** **CQ:D** **CQ:T1**	100 4000 2500 0 10	0.01 0.1 ms 0.01 % 0.1 ms 0.1 ms	PID controller swivel angle
Pressure				
	CP:LLIM	0	0.01 %	Lower limit pressure controller
	CP1:P **CP1:I** **CP1:D** **CP1:T1**	100 4000 0 10	0.01 0.1 ms 0.1 ms 0.1 ms	PID controller pressure parameter set 1
	CP2:P **CP2:I** **CP2:D** **CP2:T1**	100 4000 0 10	0.01 0.1 ms 0.1 ms 0.1 ms	PID controller pressure parameter set 2
Power limitation				
	PL:RPM **PL:QMAX** **PL:EFF** **PL:PL** **PL:T1**	1500 100 7850 318 500	1/min cm³ 0.01 % 0.1 kW 0.1 ms	Power limitation function
Output signal adaption				
	SIGNAL:M	U0-10	-	Type of output signals
	SIGNAL:UP	+	-	Polarity of control signal to the power stage
	SIGNAL:U	U+-10	-	Type and polarity of the control signal
	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
	CURRENT	1000	mA	Rated solenoid current
Power stage				
	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	- -	Closed loop current controller

5.2 Basic parameters

5.2.1 MODE (Parameter view)

Command	Parameters	Unit	Group
MODE x	x= SYSTEM|IO_CONF|Q_CTRL| P_CTRL|PL_CTRL|ALL	-	-

This command defines the parameter list. For a better overview only the parameters of the selected group are displayed. If wanted alternatively all active parameters can be shown, too.

5.2.2 LG (Changing the language)

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

Either German or English can be selected for the help texts.

5.2.3 SENS (Malfunction monitor)

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.

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.

5.2.4 CTRLOUT (Chosing control signal)

Command	Parameters	Unit	Group
CTRLOUT x	x= ANA|1SOL|2SOL	-	**SYSTEM**

The output stage is designed for universal controlling of valves with OBE or standard proportional valves (4/3 directional valves) with one or two solenoids.

ANA: Control signal via universal analog output to control valves with OBE.

1SOL: Control signal via power stage to valves with one solenoid and offset.

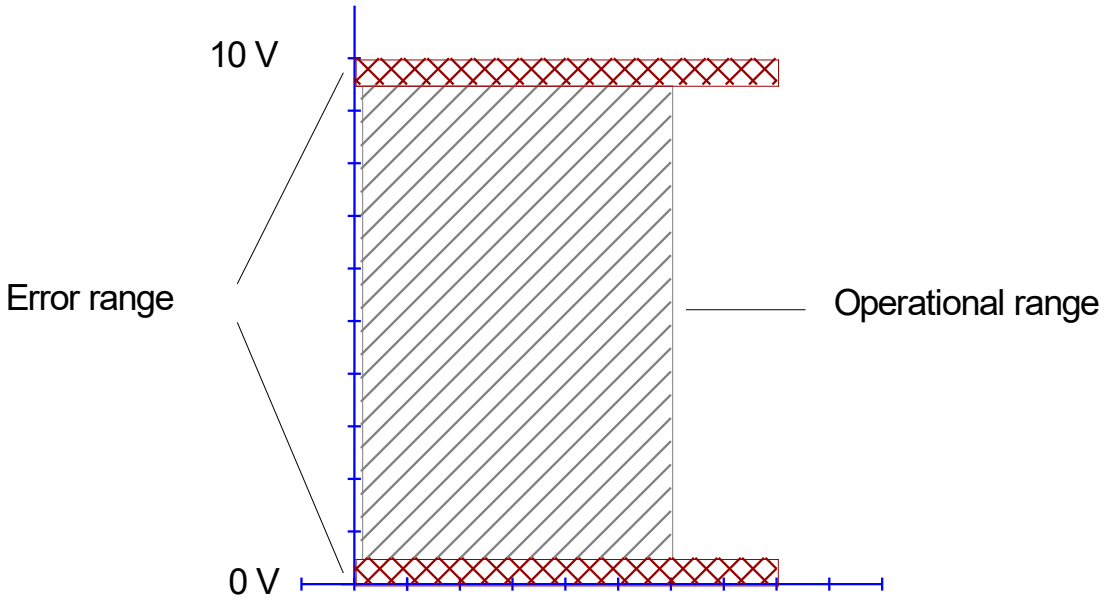
2SOL: Control signal via power stage to valves with two solenoid.

5.2.5 LIM:XQ (Cable break monitoring swivel angle)

Command	Parameter	Unit	Group
LIM:XQ X	x= 0… 2000	0.01 mV	**SYSTEM**

This parameter defines the threshold above 0 V and below 10 V in which the signal will be defined as faulty. If set to 0 the function is not active.

If a current signal is used, the monitoring is automatically active (depending on SENS). A value below 3 mA is always rated as cable break, means detected error.



5.2.6 PL:CTRL (Power limitation function)

Command	Parameter	Unit	Group
PL:CTRL x	x= OFF|INT|EXT	-	**SYSTEM**

This command activates / deactivates and configures the power limitation function.

OFF: Performance value XL is calculated depending on the parameterization, but is not considered.

INT: The calculated performance value XL can limit the swivel angle command value.

EXT: The parameterizable power limit PL:PL can be scaled via PIN 29 between 0… 100 %.

5.3 Input signal adaptation

5.3.1 SYS_RANGE (System pressure)

Command	Parameter	Unit	Group
SYS_RANGE x	x= 10… 1000	bar	**IO_CONF**

The system pressure which refers to 100% of the command input signal is defined here. Wrong settings may lead to incorrect system settings and depending parameters can not be calculated correctly.

5.3.2 SIGNAL (Type of input signal)

Command	Parameters	Unit	Group
SIGNAL:XQ x SIGNAL:i x	x= U0-10|I4-20 i= WQ|WP|XP x= OFF|U0-10|I4-20| U10-0|I20-4	-	**IO_CONF**

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.

5.3.3 N_RANGE:X (Sensor nominal pressure)

Command	Parameter	Unit	Group
N_RANGE:X X	x= 10… 1000	bar	**IO_CONF**

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.

5.3.4 OFFSET:X (Sensor offset)

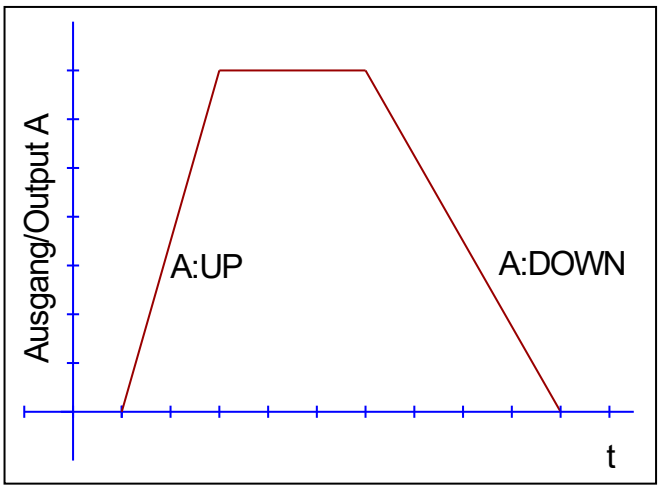
Command	Parameter	Unit	Group
OFFSET:X X	x= -60000… 60000	mbar	**IO_CONF**

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

5.3.5 RA (Command signal ramp time)

Command	Parameter	Unit	Group
RAP:I X	i= UP|DOWN		**P_CTRL**
RAQ:I X	x= 1… 600000	ms	**Q_CTRL**

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



5.3.6 CORR:Q (Volume flow correction)

Command	Parameter	Unit	Group
CORR:Q x	x= 0.. 1000	0.01 %	**Q_CTRL**

With this command the loss of volume flow can be compensated. This can be necessary to keep correct values because the volume flow of the pump decreases linear with increasing pressure.

It is recommended to use the ramp function in order to avoid unwanted oscillations then.

5.3.7 CQLF (Swivel angle limitation function)

Command	Parameter	Unit	Group
CQ:LF x	x= OFF|ON	-	**Q_CTRL**
CQLF:PV x	x= 0… 10000	0.01 %	
CQLF:WQ x	x= 0… 10000	0.01 %	

The following parameters allow an open loop pressure controlled limiting of the swivel angle.

Explanation:

CQ:LF - Aktivation of the function

CQ:LFPV - Percental switching value (XP in relation to WP).

CQ:LFWQ - Swivel angle command value if active.

If the actual pressure rises above the relation factor LFPV (e.g. 5000 = 50 %), the swivel angle command value will be reduced immediately to the parameterized value LFWQ. Pressure overshoots can be reduced efficiently that way.

CAUTION: parameterizing to low command values for the swivel angle can cause a pressure break down and lead to an oscillating of the system with relatively low frequency.

5.3.8 XQ (Scaling function swivel angle feedback)

Command	Parameter	Unit	Group
ZERO:XQ x	x= 0.. 10000	0.01 %	**IO_CONF**
MAX:XQ x	x= 0.. 10000	0.01 %	

The sensor at the pump serves a unipolar signal of 0… 10 V or 4… 20 mA. This Signal can be scaled properly with those parameters. The input signal for the real 100% position (MAX:XQ) and 0% position (ZERO:XQ) have to be put in. This enables also negative Values for the mooring mode. The input value before this scaling is provided constantly as process data XQA.

5.4 Control parameters

5.4.1 CQ (PID controller swivel angle)

Command	Parameter	Unit	Group
CQ:I X	i= FF|P|I|I_LIM|D|T1|		**Q_CTRL**
	:FF x= 0… 10000	0.01 %	
	:P x= 0… 10000	0.01	
	:I x= 0… 30000	0.1 ms	
	:I_LIM x= 0… 10000	0.01 %	
	:D x= 0… 1200	0.1 ms	
	:T1 x= 10… 1000	0.1 ms	

The control function Q will be parameterized via this command. It is realized as classic PID controller.

Explanation:

CQ:FF - Offset value for adjusting the neutral position of the valve (1 solenoid). Typical value = 5000.

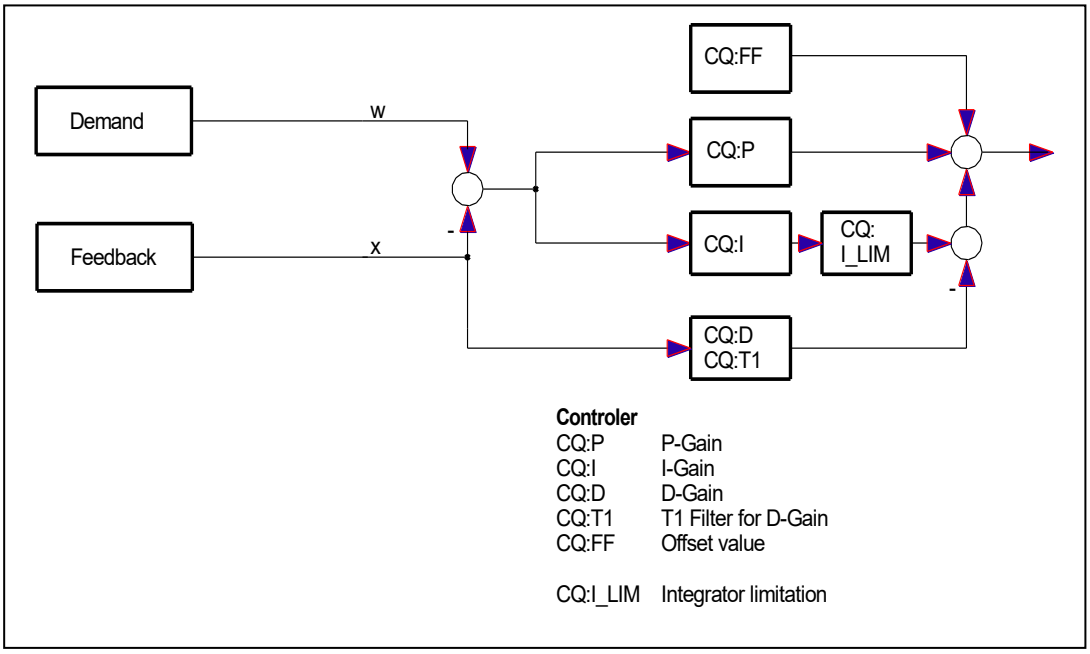
CQ:P - P gain of the controller.

CQ:I - I-gain of the controller. The integrator can be deactivated with a programmed value of 0.

CQ:I_LIM - Limitation of the working range. This value should be chosen as low as possible because only the nonlinearity of the system has to be compensated by it.

CQ:D - D-gain of the controller.

CQ:T1 - The T1 factor is used for the D-gain in order to suppress high-frequency noise.



5.4.2 CP (PID controller pressure)

Command	Parameter	Unit	Group
CP:LLIM X	x= 0… -10000	0.01 %	**P_CTRL**
CP1:I X	i= P|I|D|T1|		
CP2:I X	:P x= 0… 10000	0.01	
	:I x= 0… 30000	0.1 ms	
	:D x= 0… 1200	0.1 ms	
	:T1 x= 10… 1000	0.1 ms	

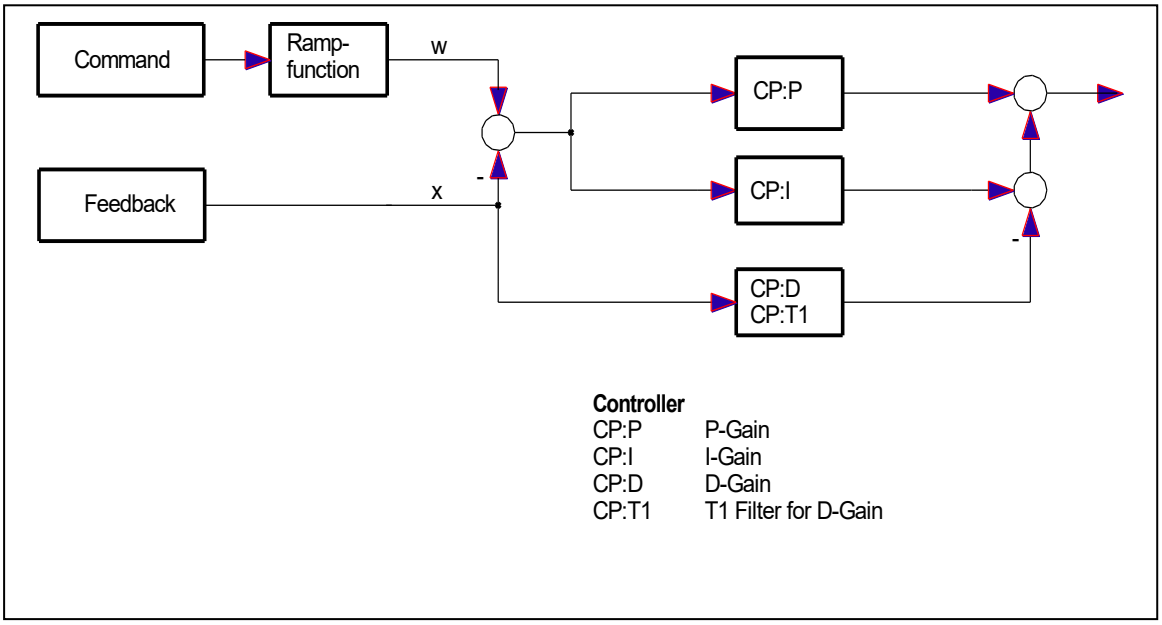
The control function P will be parameterized via this command.
There are two parameter sets for this controller between which can be switched by the digital input PIN 5.

Explanation:
CP:LLIM - Lower limit for the pressure controller. It can be expanded from 0% to -100%.

CAUTION: If CP:LLIM will be negative, the mooring mode gets enabled. For that the swivel angle monitoring signal can be scaled for -100 % to.100 % instead of 0… 100 %.

CP:P - P gain of the controller. As a result of the pressure control via pressure control valve relatively small values have to be parameterized. Typical values: 50… 200.
CP:I - I-gain of the controller. The integrator can be deactivated with a programmed value of 0.
CP:D - D-gain of the controller.
CP:T1 - The T1 factor is used for the D-gain in order to suppress high-frequency noise.

The limitation for the integrator in positive direction is the swivel angle command. The limit for the negative direction is parameterized by LLIM (integrator and therefore controller output).



5.4.3 PL (Power limitation function)

Command		Parameter	Unit	Group
PL:RPM	X	x = 300… 3000	1/min	**PL_CTRL**
PL:QMAX	X	x = 1… 1000	cm³	
PL:EFF	X	x = 5000… 10000	0.01 %	
PL:PL	X	x = 1… 10000	0.1 kW	
PL:T1	X	x = 10… 10000	0.1 ms	

These commands are used to parameterize the power limitation function. It can be activated via the parameter PL:CTRL in the system group.

Explanation:

PL:RPM - Engine speed.
PL:QMAX - Displacement of the pump.
PL:EFF - Degree of efficiency.
PL:PL - Capacity limit.
PL:T1 - Time factor.

Depending on this input the theoretical maximum power is calculated:

$$P_{MAX} = \frac{QMAX \cdot RPM \cdot P_{\text{SYS\_RANGE}}}{Eff \cdot 600}$$

If changes of the containing parameters are done, the value of P:MAX is calculated automatically.

The parameterizable capacity limit PL is limited automatically by this maximum power. The lowest adjustable value is 20% of P:MAX. PL can further be limited by the analogue input at PIN 29 if PL:CTRL is set to EXT. 10 V correspond to 100 %, means the capacity limit PL.

The time factor determines the dynamic of the power limitation. Typical values are between 20 and 50 ms.

5.5 Output signal adaptation

5.5.1 SIGNAL (Type / polarity of the output)

Command	Parameter	Unit	Group
SIGNAL:U x	x= OFF|U+-10|I4-20| U-+10|I20-4	-	**IO_CONFIG**
SIGNAL:UP x	X= +|-	-	
SIGNAL:M x	X= U0-10|I4-20|U0-5-10| I4-12-20	-	

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

Explanation:
SIGNAL:U - Type and polarity of the control signal at PIN 15 / 16 if analogue control is selected.
SIGNAL:UP - Polarity of the control signal to the power stage if direct solenoid control is selected.
SIGNAL:M - Type of the monitoring signals at PIN 15 and 16 if active power stage is selected.

ATTENTION: If the connections PIN 15 and 16 are used as monitoring outputs, on PIN 16 the scaled pressure value is available as well as the swivel angle value on PIN 15. In normal use the 0… 100 % swivel angle value can be displayed with 0… 10 V or 4… 20 mA. But it is also possible to get negative swivel angle vlaues up to -100%. For that the options 0… 5… 10 V and 4… 12… 20 mA are provided in order to display also the negative range. 5 V respective 12 mA are corresponding to the zerp position then.

This option has no influence on the pressure monitor, it is always scaled for 0… 100 %.

5.5.2 MIN (Deadband compensation)

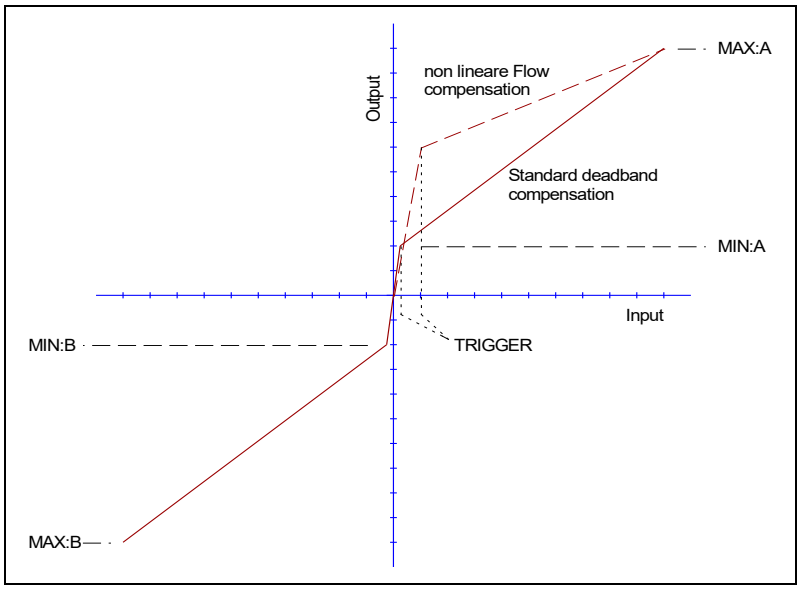
5.5.3 MAX (Output scaling)

5.5.4 TRIGGER (Response threshold for the MIN parameter)

Command	Parameters	Unit	Group
	i= A|B		**Q_CTRL**
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 to the valve is adjusted by means of these commands. A kinked volume flow characteristic is used for position and other closed loop controls instead of the typical overlap step. The advantage is better and more stable (positioning) behavior.

CAUTION: If there should also be adjustment options for deadband compensation on the valve or valve amplifier, it must be ensured that the adjustment is performed either at the power amplifier or in the module.
If the MIN value is set too high, this has an effect on the minimum valve opening, which can then no longer be adjusted. In extreme cases this leads to oscillation around the controlled position.



5.6 Power stage

5.6.1 CURRENT (Rated solenoid current)

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

The nominal current of the solenoid is set here. Dither and also MIN/MAX always refer to this current value.

5.6.2 DITHER (Dither settings)

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

The dither signal 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.

CAUTION: *The PPWM and IPWM parameters influence the effect of the dither setting. These parameters should not be changed after the dither has been optimized. If the PWM frequency is less than 500 Hz, the dither amplitude DAMPL should be set to zero.*

5.6.3 PWM (PWM Frequency)

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

The frequency can be changed in defined steps (60 Hz, 70 Hz, 80 Hz, 90 Hz, 100 Hz, 110 Hz, 120 Hz, 130 Hz, 150 Hz, 199 Hz, 230 Hz, 280 Hz, 336 Hz, 405 Hz, 511 Hz, 1069 Hz, 1470 Hz, 1960 Hz, 2252 Hz, 2941 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. This settings are done automatically if ACC is set to ON.*

5.6.4 ACC (Current loop auto adjustment)

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

Operation mode of the closed loop current control.

ON: In automatic mode PPWM and IPWM are calculated depending on the PWM-frequency.
OFF: Manual adaption by the user is necessary.

5.6.5 PPWM (P gain of the current loop)

5.6.6 IPWM (I gain of the current loop)

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

The PI current controller for the solenoid control is parameterized with these commands.
A higher P-gain increases the dynamic of the closed current loop and so its influence on the dither. The I-gain should only be changed if having detailed knowledge about the current control.

CAUTION: These parameters should not be changed without adequate measurement facilities and experience. Changes are only possible if ACC is set to OFF.

Having a PWM frequency > 1000 Hz, the dynamic of the current controller can be increased.
Possible values of PPWM = 7 and IPWM = 40 can be chosen.
At an adjusted PWM frequency < 250 Hz, the dynamic of the current controller has to be decreased.
Typical values are: PPWM = 1… 3 and IPWM = 40… 80.

5.7 PROCESS DATA (Monitoring)

Command	Description	Unit
WQI	Swivel angle demand	%
WQ	Swivel angle command value	%
XQ	Swivel angle actual value	%
EQ	Control deviation swivel angle	%
CQ	Output signal swivel angle controller	%
WP	Pressure command value	bar
XP	Pressure actual value	bar
EP	Control deviation pressure	bar
CP	Output signal pressure controller	%
WL	External power limitation demand	%
XL	Power limitation output value	%
XQA	Swivel angle feedback signal before scaling	%
U	Control signal to the valve	%
IA	Valve current solenoid A	mA
IB	Valve current solenoid B	mA

The process data are the variables which can be observed continuously 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	Characteristic
Analogue input PIN 6	Out of range or broken wire	The power stage and the READY output will be deactivated.
Analogue input PIN 10 4... 20 mA	Out of range or broken wire	The power stage and the READY output will be deactivated.
Analogue input 13 4… 20 mA	Out of range or broken wire	The power stage and the READY output will be deactivated.
Analogue input 14 4… 20 mA	Out of range or broken wire	The power stage and the READY output will be deactivated.
Solenoid A on PIN 17 + 19	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.

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 bad signal at an analogue input if 4… 20 mA signals are used. • Signal out of range of the dwivel angle sensor • 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.
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[1]. • 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). • Instable PID control loop (swivel angle). The control parameter P, I, D have to be checked, first steps:: a. Decrease P (e.g. to half of the actual value) b. Increase I (slow integration time) c. Decrease D d. Observe the behavior and notice the differences after your changes. Relating to this you can evaluate the next steps for optimizing.

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

7 Notes