WEST

Technical Documentation

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

Electronics
Hydraulics meets
meets Hydraulics
Electronics

CONTENTS

1 General Information

1.1 Order number

PQP-179-P - Pump control module for cascade control in open or closed circuit with analogue control output, integrated power stage and optionally activatable spool position controller for the control valve

Alternative products:

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

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

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)
LDT-401 - Expansion card for reading in two LVDT signals, backplane bus connection

Any standard cable with USB-A and USB-B connector can be used as the programming cable.

1.4 ymbols used

General information

Safety-related information

1.5 Legal notice

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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 module is a pump controller for the swivel angle, pressure and power control of variable displacement pumps.

The module can actuate a directional control valve for swivel angle adjustment on the pump. It is possible to control valves with one or two solenoids. The output stage can be deactivated via a parameter, so that it is possible to connect a control valve with integrated electronics to the module.

It is also possible to activate an internal spool position controller for the control valve, which controls 2 - solenoid valves with electrical feedback of the spool position.

The control structure is designed as a cascade control and is thus suitable for many different pumps from different manufacturers. Swinging beyond zero is possible by a setpoint input in the negative range. In this case, the signal of a second pressure transmitter for this direction of delivery is used for pressure and power limitation (closed loop).

In open circuit applications, so-called mooring operation for active pressure reduction is also possible, in which the pressure controller can provide a delivery setpoint in the negative range. The lower limit for this function is adjustable.

The setpoints and actual values can be read in as voltage signals in the range of 0... 10V or as current signals in the range of 4... 20mA. The inputs are freely scalable so that individual signal ranges can also be interpreted.

Optionally, the module can be operated together with the LDT-401 assembly and in this way read in the actual swivel angle value and/or the position of the valve spool. The connection is made via the backplane bus, the necessary connectors are included in the scope of delivery of the LDT-401.

The output current to the valve coils is regulated and thus independent of the supply voltage and the solenoid resistance. The output stages are short-circuit proof and are monitored for cable breakage to the solenoid. In the event of a fault, the output stages are switched off.

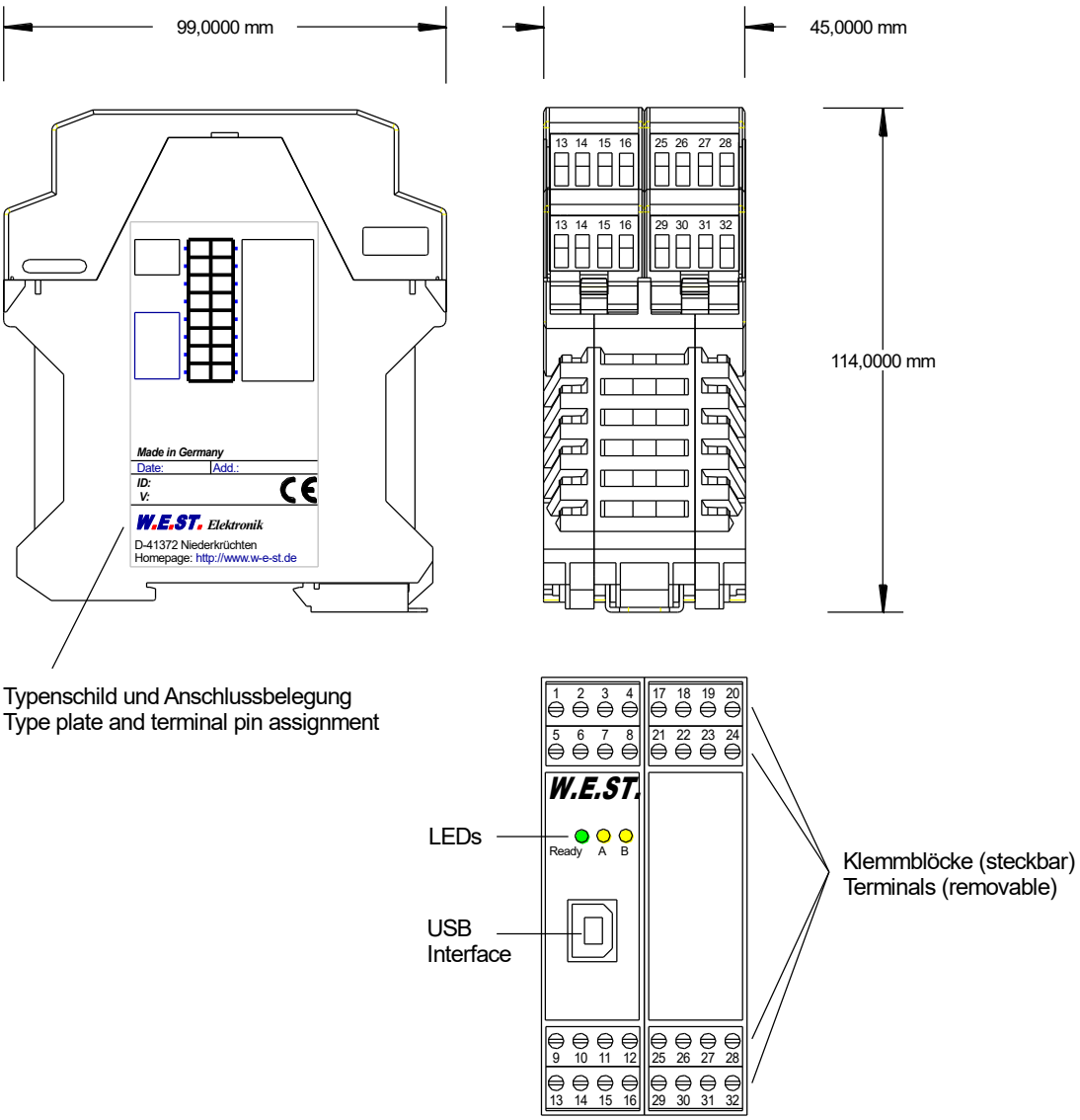
Adjustment is simple and problem-oriented, ensuring a very short familiarisation time.

Typical applications: Swing angle control, pressure control and power control

Features

- **Displacement, pressure and power limitation control**
- **For pumps in open or closed hydraulic circuit**
- **Ideal replacement for OEM controller cards such as Rexroth VT-VPCD for HS4 or EO4 adjustment**
- **Digital reproducible settings**
- **Free scaling of the analogue input signals, possibility of expansion with an LVDT module**
- **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**
- **Master - slave function for controlling multiple pumps connected in parallel**
- **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.

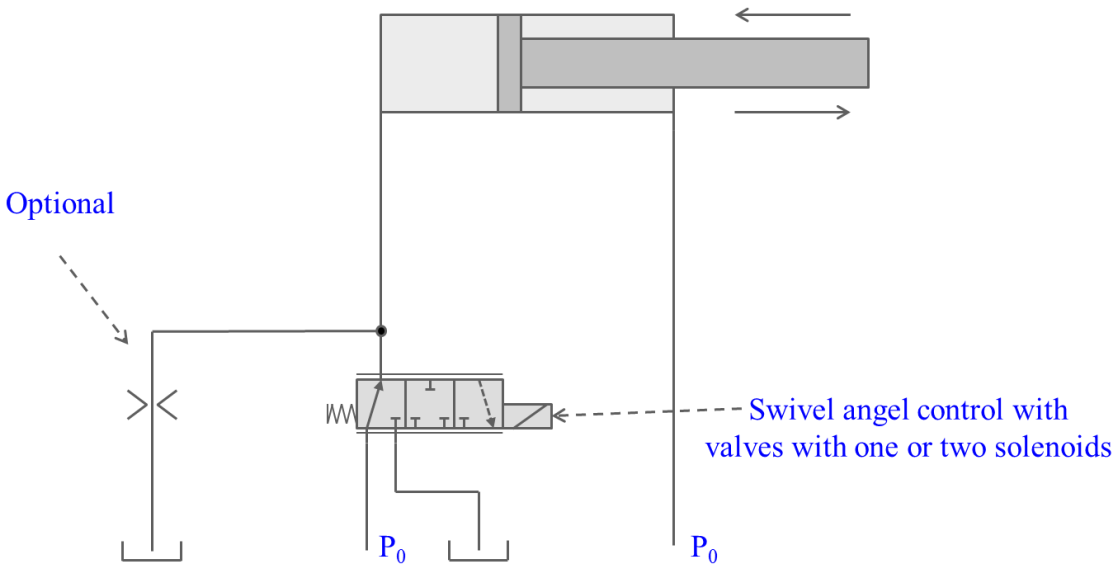
- The module should be installed and wired in accordance with the documentation bearing in mind EMC principles. If other consumers are operated with the same power supply, a star-shaped ground wiring scheme is recommended. The following points must be observed when wiring:
  - The signal cables must 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 module described here implements a pump control for reversible variable displacement pumps by controlling the swivel angle valve. Similar to the movement of a cylinder in a positioning control, the swivel angle can be moved open and closed in both directions in order to achieve the desired target position or the desired degree of opening. The external setting can be influenced by various parameters and functions. Thus, a volume flow correction factor can be added, but also a parameterisable limitation function can intervene. The integrated power limitation function, as well as the pressure limit controller, which can be connected as a cascade, can limit in both delivery directions. The pressure limitation acts in each case on the value measured in the direction of delivery, the output limitation determines the maximum possible volume flow from the pressure difference.

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.



The output current for actuating the control valve is controlled, whereby a high degree of accuracy and good dynamics are achieved.

For control valves with electrical feedback of the spool position, the unit has an additional controller that can be activated as an option. In this case, an additional spool position controller is superimposed on the solenoid current controller in a further cascade. This controller has a pilot control for fast reaction to setpoint changes and a switching integrator with parameterisable dead zone to avoid limit cycles at the operating point.

3.3 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	Pre-parameterisation is absolutely necessary for complex pump control. The selection of the output signal, setting of the valve adjustment and scaling of the analogue inputs are indispensable.
Adjust integrated position controller for the control valve, if activated	This step is mandatory at this point, as cascaded controllers should always be set starting with the innermost loop. For more information, see chapter 6.3.
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.
Optimise swivel angle controller	Carry out setpoint jumps for the delivery quantity and now optimise the setting of the swing angle controller. As this is a controlled system with integrating behaviour, it is particularly important to adjust the proportional gain and the overlap compensation of the control valve (if necessary) well.
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.
Optimise the parameterisation of the pressure control and, if necessary, also of the output limitation.	Now optimize the settings. The PID parameters have to be adapted depending on the application.

3.4 Polarities of the control signals

Since up to four control loops are cascaded in this unit, special attention must be paid to the correct polarity and thus direction of action of the individual loops.

The operating direction of the uppermost level (pressure control) is unambiguous: a high pressure in the direction of conveyance reduces the swivel angle in this direction. It is only necessary to ensure here that the sensor at the input for X1 measures on the pressure side with a positive swivel angle for applications in a closed circuit.

To keep the conditions as simple as possible, it makes sense to scale the input or setpoint signal of the control valve so that a positive value of XV or U causes the pump to swing open in the positive delivery direction. This should also correspond to a positive control signal to the UV output stage. If the control of the control valve solenoids generates a falling signal XV when UV is positive, a remedy should preferably be found on the wiring side by swapping the solenoid connections solenoid A/B. If this is too time-consuming, the parameter POL:UV can be used to carry out this swap on the signal side before the output stage. The parameter POL:U, on the other hand, should only be changed to negative polarity if the same situation occurs when using a control valve without position feedback or if an analogue output value for a valve with OBE must be inverted in order to cause the correct reaction (U > 0 -> XQ increases, see above).

4 Technical description

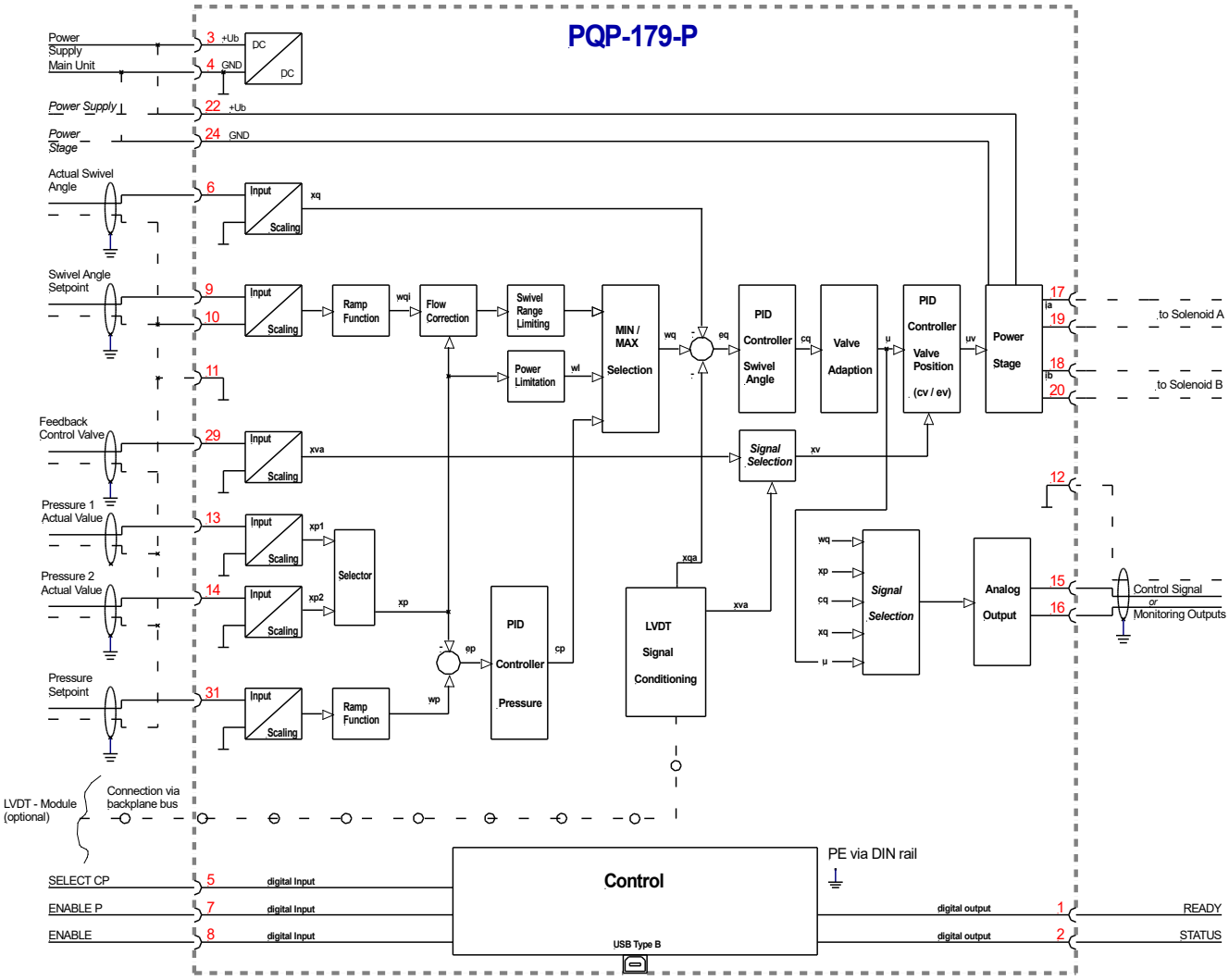
4.1 Input and output signals

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), range 0… 10 V or 4… 20 mA, scalable.
PIN 9	(+) Demand value swivel angle (WQI), range 0… 10 V or 4… 20 mA, scalable.
PIN 10	(-) Demand value swivel angle, connect to 0 V when using unipolar signals.
PIN 13	Feedback value pressure (XP1), signal range 0… 10 V or 4… 20 mA, scalable.
PIN 14	Feedback value pressure (XP2), signal range 0… 10 V or 4… 20 mA, scalable.
PIN 29	Actual position value of the control valve, signal range 4... 20 mA.
PIN 31	Pressure setpoint (WP), signal range 4... 20 mA.
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, 0… 10 V or 4… 20 mA.
PIN 16	Control output - (U) or monitoring signal, 0… 10 V or 4… 20 mA.
PIN 30	0V (GND)
PIN 32	0V (GND)
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

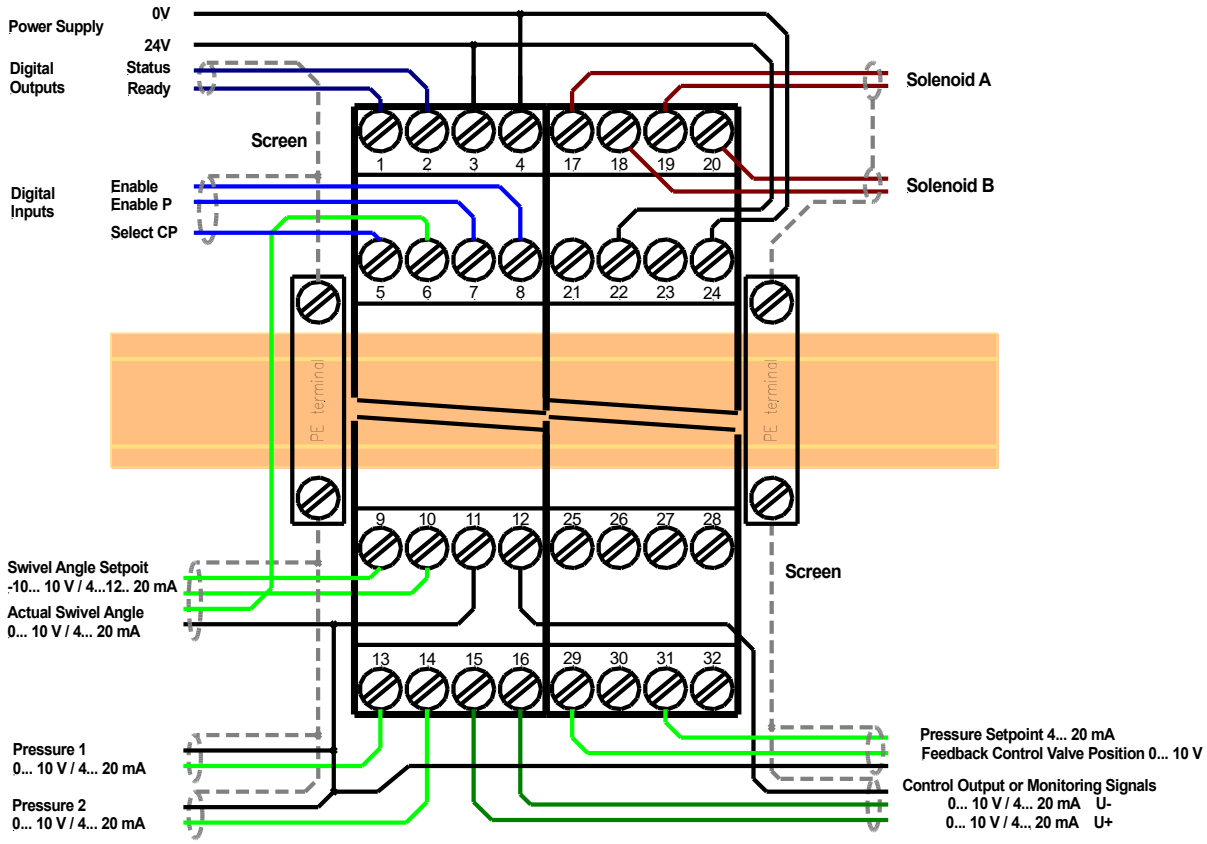
4.2 LED definitions

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.

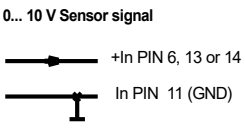
4.3 Block diagram

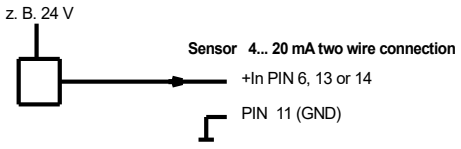


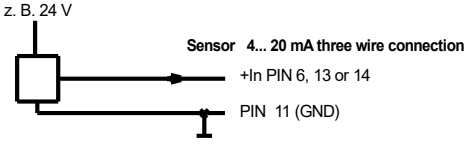
4.4 Typical wiring



4.5 Connection examples







4.6 Technical data

Supply voltage (Ub)	**[VDC]**	12… 30 (incl. ripple)
Power consumption	**[W]**	max. 2,7 + consumption of the connected coils
External protection	**[A]**	3 medium time lag
Digital inputs		
OFF	**[V]**	< 2
ON	**[V]**	> 10
Input resistance	**[kOhm]**	50
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]**	32
Signal resolution	**[%]**	0,003 incl. Oversampling
Current	**[mA]**	4… 20
Burden	**[Ohm]**	240 / 390 (PIN31)
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]**	61… 2604 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]**	0,280
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 IEC 61000-6-2:2019 EN IEC 61000-6-4:2019

5 Parameters

5.1 Parameter overview

Group	Command	Default	Unit	Description
	MODE	SYSTEM	-	Visible parameter group
Basic parameters (SYSTEM)				
	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
	FUNCTION	STA	-	Device function in the system
Input signal adaption (IO_CONF)				
Pressure demand				
	SIGNAL:WP	I4-20	-	Type of input signal
	SYS_RANGE	100	bar	System pressure demand
	WP:FIX	100	bar	Fixed pressure setpoint
Pressure feedback 1				
	SIGNAL:XP1	U0-10	-	Type of input signal
	N_RANGE:XP1	100	bar	Nominal pressure of the sensor
	OFFSET:XP1	0	mbar	Sensor Offset
Pressure feedback 2				
	SIGNAL:XP2	U0-10	-	Type of input signal
	N_RANGE:XP2	100	bar	Nominal pressure of the sensor
	OFFSET:XP2	0	mbar	Sensor Offset
Swivel angle command				
	SIGNAL:WQ	U0-10	-	Type of input signal
Swivel angle feedback				
	SIGNAL:XQ	U0-10	-	Type of input signal
	ZERO:XQ **MAX:XQ**	5000 10000	0.01 % 0.01 %	Scaling swivel angle feedback signal
Feedback control valve position				
	SIGNAL:XV	U0-10	-	Type of input signal
	ZERO:XV **MAX:XV**	5000 10000	0.01 % 0.01 %	Scaling feedback signal control valve position
Output Signals (IO_CONF)				
	SIGNAL:ANA	V	-	Type of the output signals
	SEL15	U	-	Signal selection for PIN15
	SEL16	U	-	Signal selection for PIN16

Group	Command	Default	Unit	Description
Control parameters (Q_CTRL / P_CTRL)				
Swivel angle command				
	RAQ:1 **RAQ:2** **RAQ:3** **RAQ:4**	100 100 100 100	ms ms ms ms	Ramp times swivel angle demand
	CORR:Q	0	0.01 %	Volume flow rate correction factor
Swivel angle controller				
	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 command				
	RAP:UP **RAP:DOWN**	100 100	ms ms	Ramp times pressure command
Pressure controller				
	CP:LLIM	0	0.01 %	Lower limit pressure controller
	CP1:P **CP1:I** **CP1:I_ACT** **CP1:D** **CP1:T1**	100 4000 0 0 10	0.01 0.1 ms 0.01 % 0.1 ms 0.1 ms	PID controller pressure parameter set 1
	CP2:P **CP2:I** **CP2:I_ACT** **CP2:D** **CP2:T1**	100 4000 0 0 10	0.01 0.1 ms 0.01 % 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 (Q_CTRL)				
	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
	POL:U	+	+/-	Rated solenoid current

Controller parameterisation - spool position (V_CTRL)				
PID Controller				
	CV:P	100	0,01	P Gain
	CV:I	4000	0,1 ms	I Proportion, Integrating time
	CV:D	0	0,1 ms	D Proportion, derivative time
	CV:D_T1	500	0,1 ms	D Proportion, filter
	CV:FF	8000	0,01 %	Feedforward
Integrator control				
	CV:I_LIM	2500	0,01 %	Limitation
	CV:I_ACT	10000	0,01 %	Activation threshold
	CV:I_DZ	0	0,01 %	Dead zone
Linearisation				
	VA:MIN:A **VA:MIN:B**	0 0	0,01 % 0,01 %	Minimum control (for spring preload)
	VA:MAX:A **VA:MAX:B**	10000 10000	0,01 % 0,01 %	Maximum control
	VA:TRIGGER	200	0,01 %	Minimum control trigger point
	POL:UV	+	+/-	Polarity of the control valve
Power stage parameter (IO_CONF)				
	CURRENT	1000	mA	Rated solenoid current
	DFREQ	121	Hz	Dither frequency
	DAMPL	500	0,01 %	Dither amplitude
	PWM	2604	Hz	PWM frequency
	ACC	ON	-	Current loop auto adjustment
	PPWM **IPWM**	7 40	- -	Closed loop current controller
Special commands (TERMINAL)				
	VLVCTRL	ON	-	Operating mode spool position control
	EOUT	0	0,01 %	Output signal if no ready
	DIAG	-	-	Query of the last switch-off causes

5.2 Basic parameters

5.2.1 MODE (Parameter view)

Command	Parameters	Unit	Group
MODE x	x= SYSTEM|IO_CONF|Q_CTRL| P_CTRL|V_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.

Meaning of the group names:

SYSTEM	general, overall settings
IO_CONF	Settings for the input and output signals
Q_CTRL	Swivel angle controller and output signal adjustment
P_CTRL	Pressure and power controller
V_CTRL	Valve spool position controller

The two groups P_CTRL and V_CTRL contain parameters that can be completely hidden depending on the function, so that these groups then no longer have any content. For example, if the spool position controller is deactivated (CTRLOUT not equal to 2SCL), this group V_CTRL is empty.

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 (Selection of the control signal)

Command	Parameters	Unit	Group
CTRLOUT x	x= ANA|1SOL|2SOL|2SCL	-	**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 solenoids.

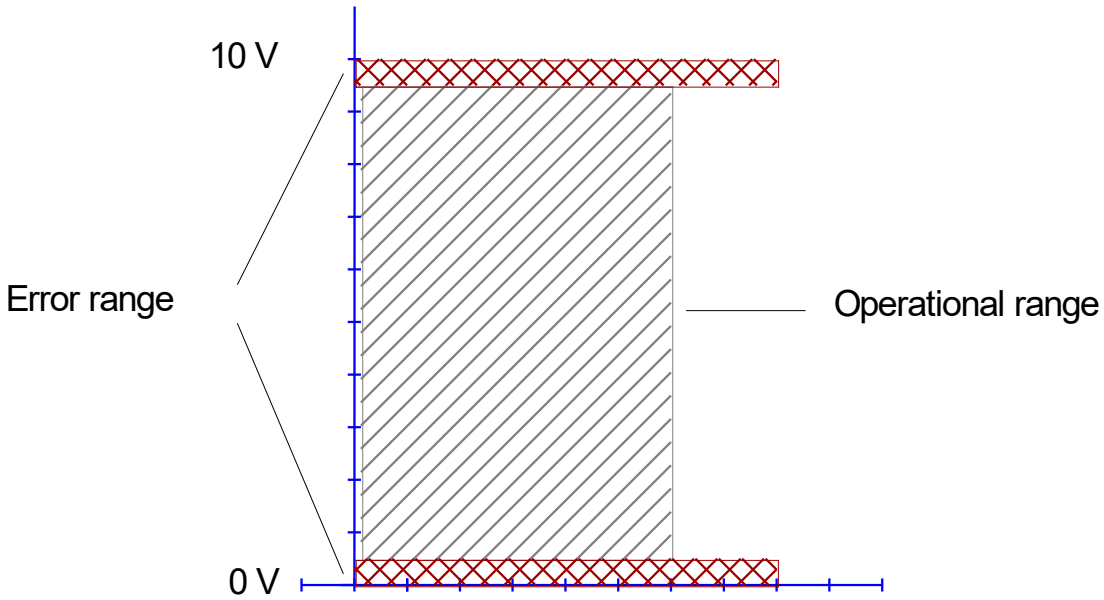
2SCL: Control signal on power output stage for two-solenoid directional control valves with position feedback. Selecting this option activates the valve position controller and the associated parameters.

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|ON	-	**SYSTEM**

This command activates / deactivates the power limitation function.

OFF: The power limitation is switched off.

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

5.2.7 FUNCTION (Device function in the system)

Command	Parameter	Unit	Group
FUNCTION x	x= STD|MASTER|SLAVE	-	**SYSTEM**

This command is used to specify the function of the device in the system:

STD: Single operation, the unit controls a single pump

MASTER: The unit is master in a system where several pumps are connected in parallel. The pressure control and processing of the swivel angle setpoint is taken over by this unit. The outputs at pins 15/16 are permanently parameterized to +/- 10V and output of WQ.

SLAVE: The unit is slave in a system where several pumps are connected in parallel. Pressure control is inactive, as is the setpoint ramp for the swivel angle. The power limitation is active if at least one pressure sensor is connected.

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 cannot be calculated correctly.

5.3.2 SIGNAL (Type of input signal)

Command	Parameter	Unit	Group
SIGNAL:XQ x SIGNAL:XV x	x= U0-10|I4-20|LVDT x= U0-10|LVDT	-	**IO_CONF**
SIGNAL:WQ x	x= OFF|U0-10|U+-10|I4-20|I4-12-20|U10-0|I20-4		
SIGNAL:XP1 x SIGNAL:XP2 x	x= OFF|U0-10|I4-20|U10-0|I20-4		

This command defines the type of input signal (current or voltage) of the analog inputs. At the same time, the signal direction can be partially reversed. This command is available for the signals WQ, XQ, XV, XP1 and XP2.

Special feature SIGNAL:WQ

By selecting a bipolar range (U+-10 or I4-12-20), it is determined that a swivel angle command in the negative range is possible. Thus, the controller is intended for systems in a closed hydraulic circuit.

Special feature SIGNAL:XQ, SIGNAL:XV

These signals can also be read in as LVDT signals from the LDT-401 add-on board. In this case, too, a raw value of the measurement signal must be scaled accordingly. The raw values of the LVDT measurement can be observed as XQA and XVA in the monitor window.

Actual pressure value XP2:

If only one pressure sensor is used, which always detects the pressure in the delivery direction by means of a corresponding hydraulic circuit, this is connected to the input for XP1 and parameterised SIGNAL:XP2 = OFF. If, on the other hand, no pressure control or power limitation is to take place in one of the two conveying directions, the associated input is to be parameterised to "U0-10" but left unconnected.

5.3.3 N_RANGE:X (Sensor nominal pressure)

Command	Parameter	Unit	Group
N_RANGE:XP1/2 X	x= 10… 1000	bar	**IO_CONF**

This command defines the nominal working range of the feedback sensors. 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:XP1/2 X	x= -60000… 60000	mbar	**IO_CONF**

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

5.3.5 WP:FIX (Fixed pressure setpoint)

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

This command is used to specify a fixed pressure setpoint if the hardware input at terminal 31 is not to be used (SIGNAL:WP = OFF). The upper limit is the system pressure SYS_RANGE.

If the hardware input is used, this value has no function and is automatically set to the value of SYS_RANGE.

5.3.6 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. The input value before this scaling is provided constantly as process data XQA.

5.3.7 XV (Scaling of the input for the valve spool position)

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

The sensor on the valve supplies a unipolar signal 0...10 V or is acquired via an LVDT sensor on channel LD2. The raw signal XVA can be scaled appropriately with the two parameters provided here. Specify which input value corresponds to the maximum opening in the steering up direction (MAX:XV) and zero position (ZERO:XV).

5.3.8 SIGNAL:ANA (Type of output signal)

Command	Parameter	Unit	Group
SIGNAL:ANA x	x= V|C	-	**IO_CONF**

This command is used to specify whether voltage or current signals are to be output.

As these are mainly bipolar signals, selecting the "**V**" setting automatically disables the possibility of signal selection at PIN16 (this is set equal to PIN15). The output is now a differential output, PIN16 is used for the negative signal part -100% ... 0 % mapped to 10V - 0V at this output.

Together with the control of pin 15, this results in the voltage difference between pin 15 (+) and pin 16 (-):

Delta U -10V ... 0 ... 10 V

If only the positive range of the signal is of interest, it is sufficient to acquire PIN15.

Setting "**C**":

Both output pins are independently assignable.

Scaling for bipolar signals WQ / CQ / XQ / U: 4-12-20 mA correspond to -100% ... 0 ... 100%

Unipolar signal XP: 4-20mA corresponding to 0 - 100%. Reference: SYS_RANGE

5.3.9 SEL15/16 (Signal selection)

Command	Parameter	Unit	Group
SEL15/16 x	x= WQ|XP|CQ|XQ|U	-	**IO_CONF**

These commands are used to specify which signals are output at the analog outputs.

The signal names correspond to the process variables (see block diagram).

In MASTER mode, it is necessary to output the swivel angle setpoint WQ at pin 15/16.

This is always done as a voltage signal U+/-10V. Thus, these parameters are permanently set to "WQ" in the MASTER operating mode and are also hidden if necessary. The same applies to SIGNAL:15/16, see below.

If CTRLOUT is set to "ANA", the control signal U must be output. Therefore, the selection option is also deactivated here.

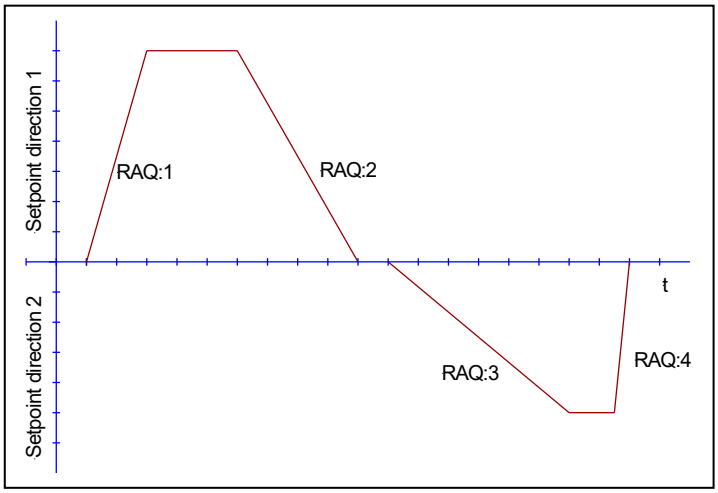
5.4 Controller parameterization

5.4.1 RAQ (Ramp function volume flow setpoint)

Command	Parameter	Unit	MODE
RAQ:I X	i= 1… 4 x= 1… 600000	 ms	**Q_CTRL**

Four quadrants ramp function.

The first quadrant represents the ascending ramp in delivery direction 1, the second quadrant represents the descending ramp (delivery direction 1). The third quadrant represents the ascending ramp (delivery direction 2) and the fourth quadrant represents the descending ramp (delivery direction 2).



If you have configured a unipolar input signal with SIGNAL:WQ, the setting option for RAQ:3 / RAQ:4 disappears.

5.4.2 CORR:Q (Volume flow correction)

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

This command is used to parameterize the correction value of the volume flow loss. As a result of an increasing pressure, the pump volume flow decreases linearly. This correction value can be used to compensate for this (within the scope of the possible flow rate).

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

5.4.3 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.

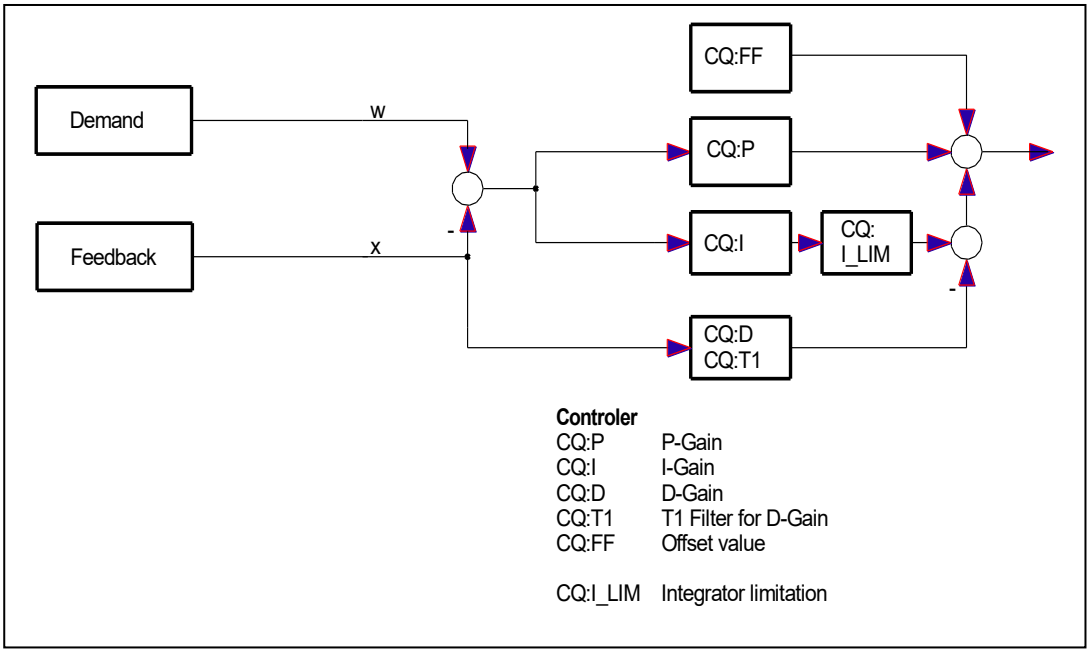
CQ:P - P gain of the controller.

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.

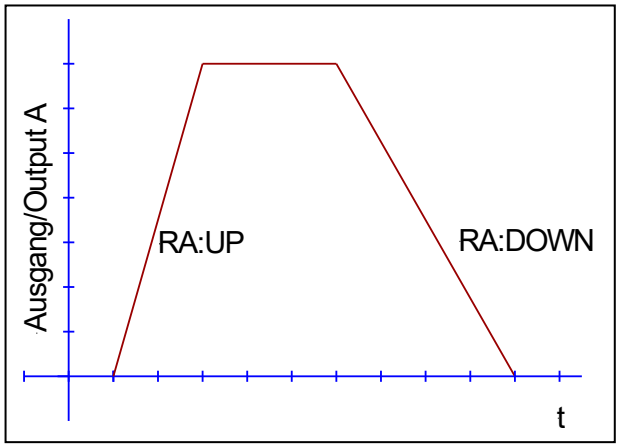
CQ:T1 - The T1 factor is used for the D-gain in order to suppress high-frequency noise.



5.4.4 RAP (ramp function pressure setpoint)

Command	Parameter	Unit	MODE
RAP: IX	i= UP|DOWN x= 1… 600000	 ms	**P_CTRL**

This parameter is entered in ms.
The ramp time is set separately for the rising (UP) and falling ramp (DOWN).



5.4.5 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	
	:I_ACT x= 0… 10000	0.01 %	
	: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 in both directions.

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.

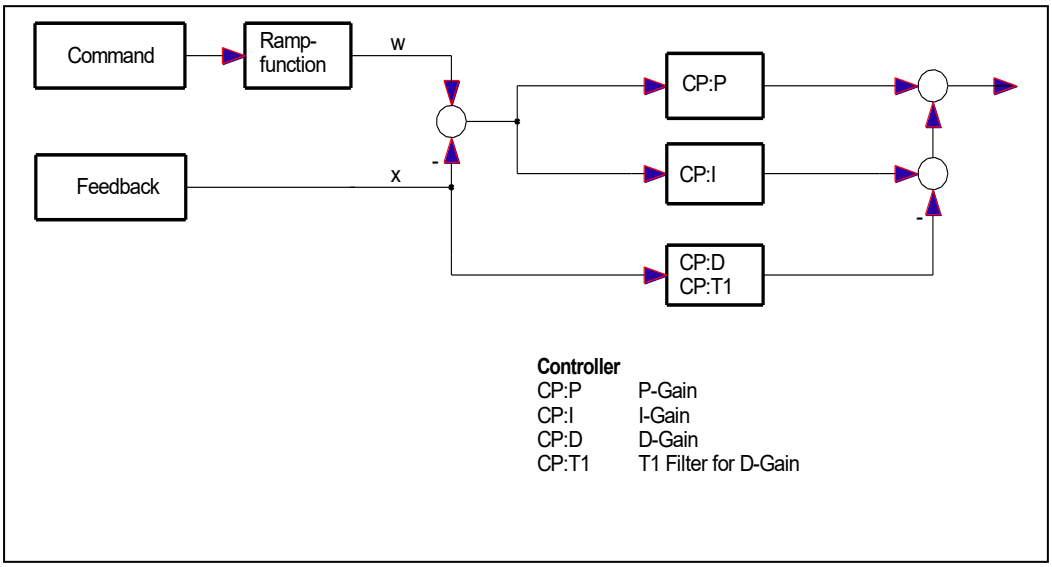
CP:I - I-gain of the controller. The integrator can be deactivated with a programmed value of 0.

CP:I_ACT - Activation threshold that controls the integrator. The integrator is only released when the process value has reached the percentage threshold (I_ACT) of the setpoint. This prevents unwanted integration and thus pressure overshoots.

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).



5.4.6 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:

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

If parameters of the equation are changed, the value for 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.
The time factor determines the dynamics of the power limitation. Typical values are between 20 and 50 ms.

5.5 Output signal adaptation

At this point a first signal adjustment is made, which is used to compensate for the overlap of the control valve. If the internal spool position controller is used, the minimum control of the solenoids for the start of the spool movement is set there with the parameters VA:MIN and at this point the required signal to the spool position controller to overcome the mechanical overlap of the valve spool. Accordingly, the "VA" parameters must be set first during commissioning and then the values following at this point.

5.5.1 MIN (Deadband compensation)

5.5.2 MAX (Output scaling)

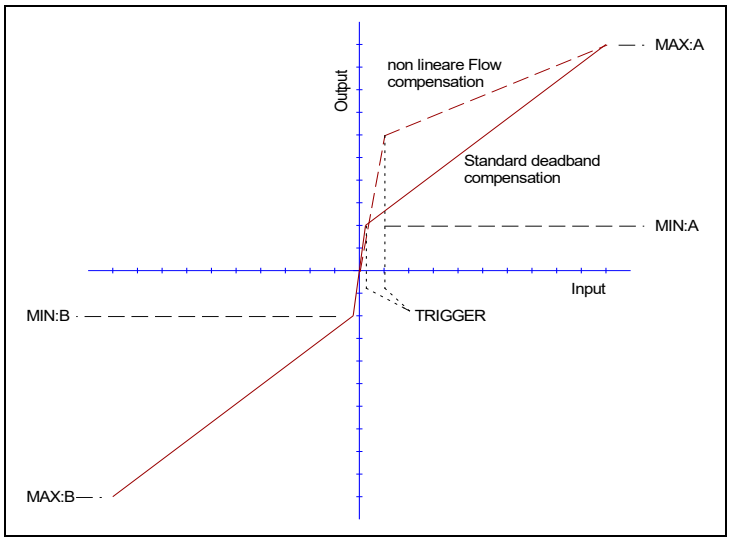
5.5.3 TRIGGER (Response threshold for the MIN parameter)

Command	Parameters	Unit	Group
	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.



5.5.4 POL:U (polarity of the swivel angle control)

Command	Parameter	Unit	Group
POL:U x	x= +|-	-	**Q_CTRL**

This parameter is used to select the polarity of the swing angle controller. For more information, refer to the application description / chapter 3.

5.6 Spool position control

This controller is active when the CTRLOUT parameter is set to "2SCL".

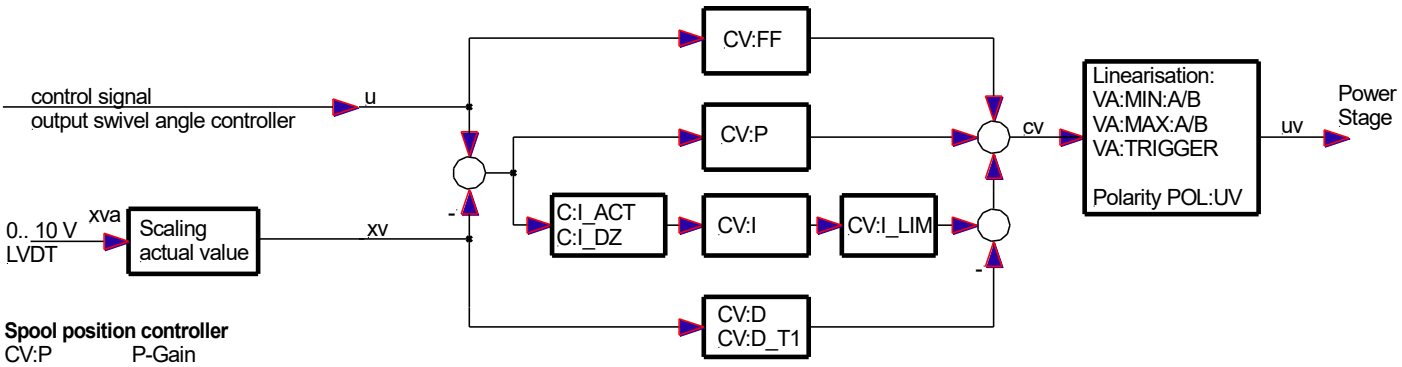
5.6.1 PID controller

Command	Parameter	Unit	Group
CV:i x	i= P|I|D|D_T1|FF		**V_CTRL**
	P x= 1... 10000	0.01	
	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 %	

This commands are used to parameterize the controller.

The P, I and D components behave in exactly the same way as for the pressure and swing angle controllers already described.

The output is controlled directly via the FF value. In this way, the controller only has to compensate for the deviation. This leads to a stable control behaviour and at the same time to a dynamic control.



Spool position controller

CV:P	P-Gain
CV:I	I-Gain
CV:D	D-Gain
CV:T1	T1 Filter for D-Gain
CV:FF	Feed gorward gain
CV:I_LIM	Integrator limit
CV:I_ACT	Integrator activation
C:I_DZ	Integrator dead zone

5.6.2 Integrator control

Command	Parameter	Unit	Group
CV:I_LIM x CV:I_ACT x CV:I_DZ x	x= 0… 10000 x= 0… 10000 x= 0… 1000	0,01 % 0,01 % 0,01 %	**V_CTRL**

The CV:I_LIM parameter limits the operating range of the I component, so that the controller can regulate the process faster without major overshoots. If the value is too small, the effect can occur that the non-linearity of the valve can no longer be 100% compensated.

CV:I_ACT controls the function of the integrator. The integrator is only activated when the control deviation has fallen below the set threshold or the current control deviation leads to a reduction of the integral component. The advantage of this control is noticeable in the case of setpoint jumps: Initially, the influence of the feedforward and the P component is sufficient to effect most of the setpoint change. Before the target is reached, the integrator is switched in and ensures that any permanent deviation is eliminated. Without the integrator being stopped in the meantime, it would move the output signal in the same direction too soon, so that the target value would only be reached after a significant overshoot. A reduction of the integral component, on the other hand, is always desired.

CV:I_DZ defines a dead band for the I - component of the controller. Integration is stopped within this range of the control deviation. This prevents the valve spool from permanently moving back and forth over the range of the mechanical hysteresis in steady-state operation, i.e. performing so-called limit cycles.

5.6.3 VA:MIN (minimum control)

5.6.4 VA:MAX (maximum control)

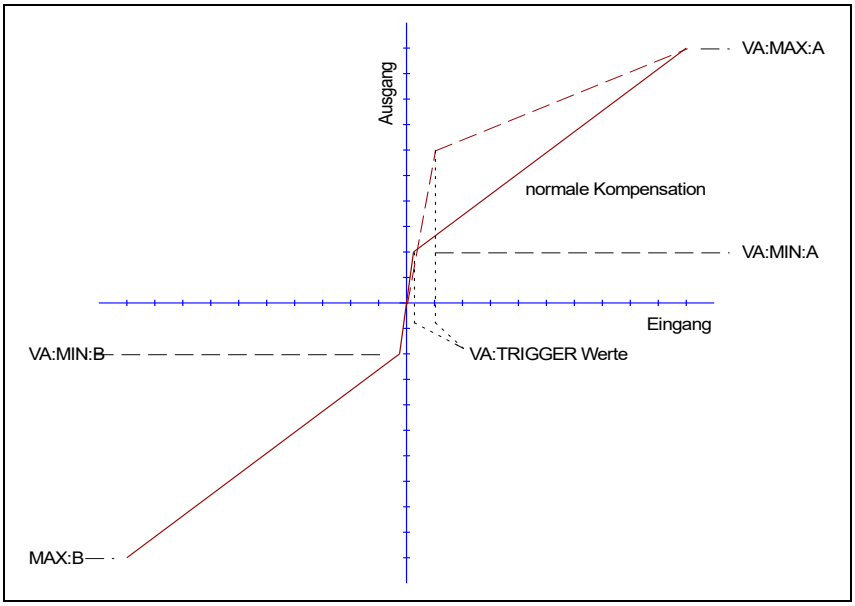
5.6.5 VA:TRIGGER (response threshold of the minimum control)

Command	Parameter	Unit	Group
	i= A|B		V_CTRL
VA:MIN:i x	x= 0… 6000	0,01 %	
VA:MAX:i x	x= 4000… 10000	0,01 %	
VA:TRIGGER x	x= 0… 3000	0,01 %	

In the case of 2-magnet valves, there is a minimum actuation for each side which is necessary to initiate a movement of the spool. These values are usually determined by the preload of the return springs on the valve spool.

Similar to the parameters MIN:A / MIN:B (for overlap compensation), the parameters VA:MIN:A / VA:MIN:B effect compensation, but here for the centering force in the neutral position.

The values VA:MAX:A/:B can be used, if necessary, to realize an asymmetry of the solenoid currents for the two directions of movement.



5.6.6 POL:UV (polarity of the control valve)

Command	Parameter	Unit	Group
POL:UV x	x= +|-	-	V_CTRL

This parameter is used to select the polarity of the control valve control. For more information, refer to the application description / chapter 3.

5.7 Power stage parameters

5.7.1 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.

5.7.2 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.*

5.7.3 PWM (PWM Frequency)

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

The frequency can be changed in defined steps (61 Hz, 72 Hz, 85 Hz, 100 Hz, 120 Hz, 150 Hz, 200 Hz, 269 Hz, 372 Hz, 488 Hz, 624 Hz, 781 Hz, 976 Hz, 1201 Hz, 1420 Hz, 1562 Hz, 1736 Hz, 1953 Hz, 2232 Hz, 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. This settings are done automatically if ACC is set to ON.*

5.7.4 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.

5.7.5 PPWM (P gain of the current loop)

5.7.6 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.

5.8 Special Commands (TERMINAL)

5.8.1 VLVCTRL (Spool position control mode)

Command	Parameter	Unit	Group
VLVCTRL x	x= ON|SIMOL|SIMCL	-	**TERMINAL**

This command is used to activate the spool position control for the control valve or to select a start-up function. This parameter is not saved with SAVE; after each restart of the module, the "ON" setting is initially selected.

ON: Spool position controller is active, setpoint off Swing angle controller (normal operation)

SIMOL: Simulation of controlled operation "open loop" (pure pilot control). Setting during commissioning. The signal WQI before the ramp is used as setpoint for the valve position, preset in the monitor window of the WPC (RC mode).

Attention: in this setting the error processing is inactive, the device operates without READY.

SIMCL: Simulation of the slider position controller including feedforward control. Setting during commissioning. The signal WQI before the ramp is used as setpoint for the valve position, preset in the monitor window of the WPC (RC mode).

Attention: in this setting the error processing is inactive, the device operates without READY.

5.8.2 EOUT (Output signal in the absence of readiness)

Command	Parameter	Unit	Group
EOUT x	**x= -10000… 10000**	**0,01 %**	**TERMINAL**

Output value in the absence of readiness (READY output is deactivated). Here a value (degree of opening of the valve) can be defined for the case of an error or when the ENABLE input is deactivated. This function can be used if, for example, in the event of a sensor error, the actuator is to move (at a preset speed) to one of the two end positions.

|EOUT| = 0 Output is switched off in the event of an error. This is the normal behaviour.

If CTRLOUT = 2SCL has been parameterized, i.e. an internal position control of the valve spool is performed, EOUT specifies the setpoint for the valve position in the event of an error or in the absence of ENABLE.
The position controller therefore remains active if EOUT is not "0" and attempts to set this position.

5.8.3 DIAG (Query of the last shutdown causes)

If this command is entered in the terminal window, the last 10 shutdowns (disappearance of *Ready with Enable* applied) are displayed. However, the shutdown causes are not saved when the supply voltage is switched off. The last cause is displayed in the bottom line of the list. Entries "---" indicate unused memory cells.
Example:

```
>DIAG
---
---
---
---
---
---
---
---
SSI-Sensor
INPUT PIN 6
>
```

5.9 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
XP1	Actual pressure value in direction 1	bar
XP2	Actual pressure value in direction 2	bar
XP	Actual pressure value in the active delivery direction	bar
EP	Control deviation pressure	bar
CP	Output signal pressure controller	%
XL	Power limitation output value	%
XQA	Swivel angle feedback signal before scaling	%
XVA	Input signal valve position before scaling	%
U	Control signal to the valve or setpoint for valve position	%
IA	Valve current solenoid A	mA
IB	Valve current solenoid B	mA
XV	Position of the control valve	%
UV	Output signal to the output stage	%
CV	Output signal of the valve controller	%
EV	Control deviation valve position	%

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 output is deactivated.
Analogue input PIN 10 4... 20 mA	Out of range or broken wire	The output is deactivated.
Analogue input 13 4… 20 mA	Out of range or broken wire	The output is deactivated.
Analogue input 14 4… 20 mA	Out of range or broken wire	The output is deactivated.
Analogue input 31 4… 20 mA	Not in valid range, external pressure setpoint is required	The output is deactivated.
LVDT signals (if used)	Signal failure	The output is deactivated.
Solenoid A on PIN 17 + 19	Wrong cabling, broken wire	The output stage is deactivated.
Solenoid A on PIN 3-4	Wrong cabling, broken wire	The output stage is deactivated.
EEPROM (when switching on)	Data error	The output is deactivated. The output can only 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).

6.3 Commissioning of the control valve position controller

6.3.1 Pre - parameterization

Here, settings are first made on the basis of the system properties and data sheet values. The hydraulics should initially be switched off so that any settings can be made without risk. Please also note that the device can already become active now if the external signals specify accordingly.

The following parameters must be set:

Command	Parameter	Description	Group
CURRENT	500… 2600	Enter the nominal current of the valve here. If this is less than 500 mA, you can use the parameters VA:MAX:A/:B to further reduce the control.	**IO_CONF**
DFREQ DAMPL PWM	60… 400 0… 3000 61… 2604	Use the data sheet information of the valve. [2]	**IO_CONF**
CV:FF	0… 20000	First set to the value "10000" = 100%. The final setting follows in step 3.	**IO_CONF**

Check at the end of the step (optionally):

Activate the RC - mode in the WPC and check if the control of the solenoids works.

Enter `VLVCTRL SIMOL` (input) in the terminal window. The setpoint U for the valve position is then adopted directly via the slider WQI in the monitor window of the WPC.

Since the module operates in "SIMOL" mode, i.e. purely feed – forward controlled, this value is output almost unchanged as the manipulated variable "UV".

So it is now possible to drive both solenoids with their rated current.

6.3.2 Step 2: Scaling the position sensor

The spool position is usually measured by an LVDT position measuring system, which can be connected directly to the LDT-401 expansion module, or whose signal is converted by an external transducer into a voltage value, which is acquired as an analogue value at terminal 29.

The raw value of the measuring signal for the spool position can be read as process variable XVA, independent of the signal source (analogue input or LVDT direct connection).
The value displayed there in neutral position without control is now entered in the parameter ZERO:XV, the value at maximum opening in the controlling direction in the parameter MAX:XV.

Note that these parameters are given in the unit 0.01%.
For activation, use the RC mode as described in the previous chapter (VLVCTRL SIMOL, set WQI to maximum).

[2] There are two basic principles:

1. The solenoid is operated with the highest possible PWM frequency in the kHz range and an additional dither signal. This is the predominant variant in industrial hydraulics.
2. In the mobile area, mainly valves are used which are controlled with a low PWM frequency. In this case, no DITHER signal is used. It is not necessary to use the exact PWM frequency, therefore the input of our devices is done step by step by selection from a table. The nearest step should be selected.

Attention: The information in the data sheet on this topic is often incomplete or misleading, because the terminology is often confused. If there is only one frequency indication, the PWM setting is usually meant. If the DITHER signal is meant, there is usually an indication of frequency and amplitude. Without any information it is recommended to start with the factory settings.

The actual position of the slider is indicated by the process variable "XV". If the scaling is correct, the following picture should result:

WA = U = 0 -> X = 0
WA = U = 100% -> X = 100%
WA = U = -100% -> X = -100%

Note that signals greater than 100% and less than -100% are cut off, i.e. it is better to set to +/- 99%, because at 100% you cannot be sure whether the signal has been limited.

Due to mechanical tolerances, it can happen that the travels deviate in both directions.

6.3.3 Step 3: Set minimum control and pilot control

To compensate for the dead band caused by the spring preload, it is necessary to specify a minimum actuation. The value is set separately for both directions and is easy to determine:

Use the RC mode as above ("SIMOL"), slowly increase the control with the slider for WQI and observe the actual value XV. The point is sought at which the display for XV begins to increase noticeably with further increase of WQI. Note the control signal UV at this point. Repeat the same procedure for the other direction towards negative values for WQI and XV. The value found there for UV is also noted. Then, set the two parameters VA:MIN:A and VA:MIN:B in the group V_CTRL: Direction A for the positive, B for the negative signal direction. Enter the amounts of the minimum actuations (*100, since the entry is made in 0.01%).

It is possible to round off the value generously, but do not enter too large values, otherwise the control will not work in the range around the zero point.

Feedforward:

This parameter is very important. The better the feedforward is set, the less the controller has to "work".

Select at least the two process variables XV and CV (= controller output) in the monitor.

Move the slider slowly to both end positions using the RC mode via the setpoint WA.

Record the values of CV at which full deflection of the slider is achieved in both directions.

The hysteresis can also be taken into account here, i.e. the values at which the reverse movement begins can also be recorded when the signal is lowered. An average value of the amounts of the signals "CV" determined in this way is to be entered in the parameter CV:FF in the group V_CTRL (again take x 100).

6.3.4 Step 4: Optimize position controller

Now it is time to exit the open loop mode and activate the controller. To do this, enter `VLVCTRL SIMCL` (input) in the terminal window.

> *Caution: If the controller is set incorrectly, the control may become unstable, causing strong vibrations. If something like this occurs, reduce the controller gain CV:P to the minimum value, if necessary.*

First set CV:I_LIM to "0", this will suppress the integral part of the controller.

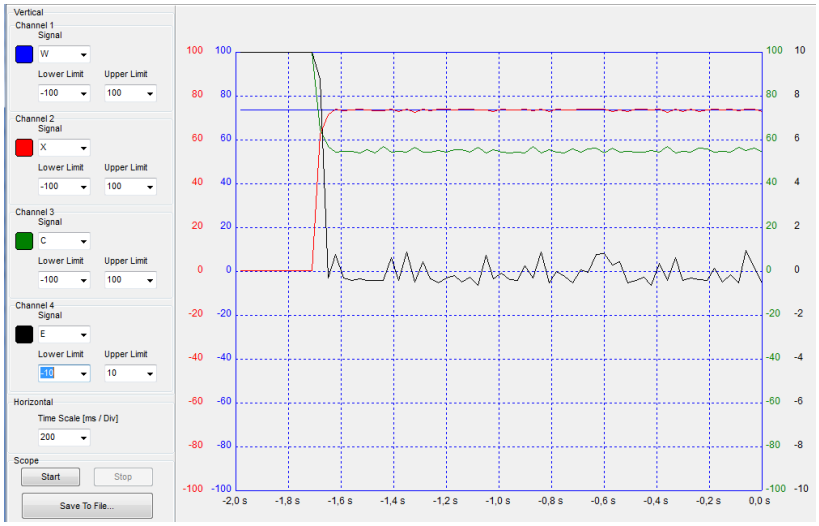
The oscilloscope view in the WPC is useful for evaluating the transient response.

The signals of interest are: XV (slider position), U (setpoint), CV (controller output), EV (control deviation)

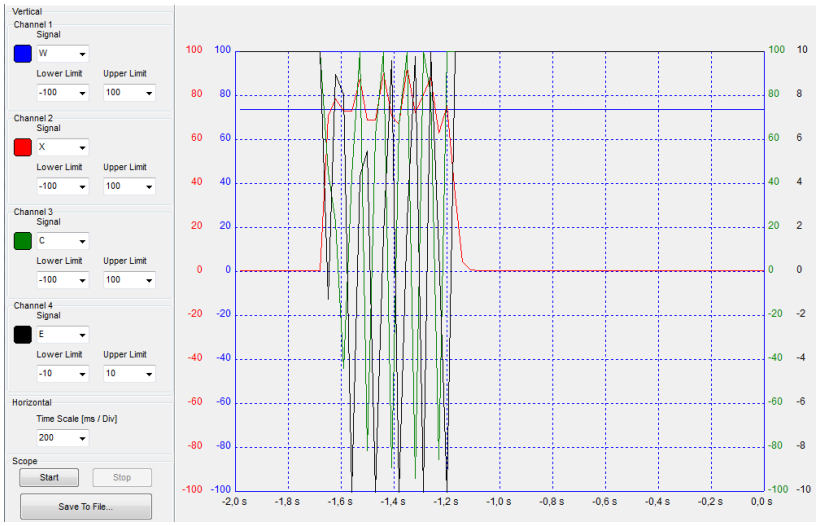
To be able to observe the transient response, it is necessary to have the oscilloscope window active during a signal change.

Setpoint jumps are caused by rapid changes in the setpoint signal via slider WQI.

The following illustration shows a good transition behavior:



In comparison, an unstable controller setting:



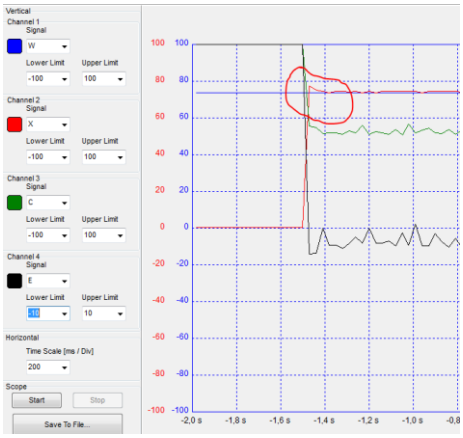
The simplest procedure for setting the proportional gain is to gradually increase CV:P until instability occurs. The value of CV:P then has to be divided by 2-4 again to get a definitely stable but high value.

After setting the proportional gain, the integral component can be activated. First parameterize a large reset time, i.e. a weak I - component: set CV:I e.g. to 5000.

Now, the first task is to find the lowest possible limitation by CV:I_LIM, which, however, is sufficient to compensate for permanent control deviations.

So first increase CV:I_LIM e.g. to 2000 (= 20%) and carry out tests with different control. Observe whether the control deviation "EV" only fluctuates around the zero line after steady-state operation has been reached. If this is not the case in some points, but CV is still not 100% or -100%, increase CV:I_LIM.

Next, set the reset time CV:I to an optimum value. Optimal means: as small as possible, but without oscillation tendency and with little overshoot. Another disturbing effect of too small reset times can be that due to the fast reaction but asymmetrical signal limiting a permanent control deviation occurs again.



Here you can see a disturbing overshoot!

Now the most important control parameters are set.

The following may still be useful depending on the application:

- Activate D - portion (this sometimes allows a higher P - gain), but is often problematic
- Adapt dead band for the integrator (CV:I_DEACT), if in steady-state operation the slider fluctuates cyclically through the I - component (occurrence of so-called limit cycles).
- Adjust the activation threshold for the integrator (reduce default setting of "10000") to further minimise overshoot on setpoint changes. Attention: Do not reduce it too much so that the integrator is no longer reliably activated in stationary operation.
- When the steps for valve controller setting are completed, enter `VLVCTRL ON` (input) in the terminal. In this way, you switch to normal operation and the valve is controlled by the swing angle controller.

7 Notes