Technical Documentation

PQP-179-P-PFN

Universal pump control module for the open or closed circuit with integrated
power stage, optionally activatable spool position controller for the control valve and Profinet interface

CONTENTS

1 General Information

1.1 Order number

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

Alternative products:

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 (analog interface)

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

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 setpoint input and control is carried out via Profinet. Current process data and status information can be read back via this connection.

The 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.

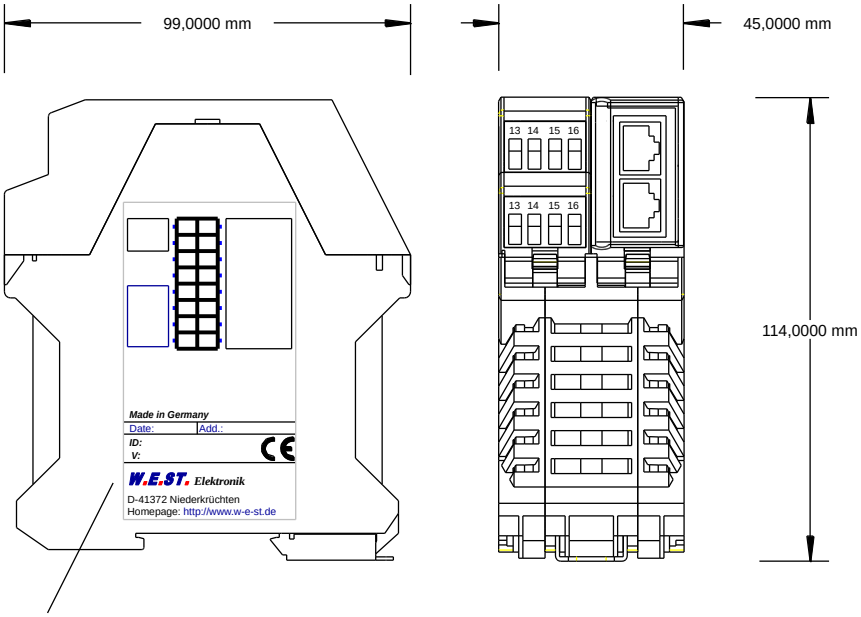
Adjustment is simple and problem-oriented, ensuring a very short familiarisation time.

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

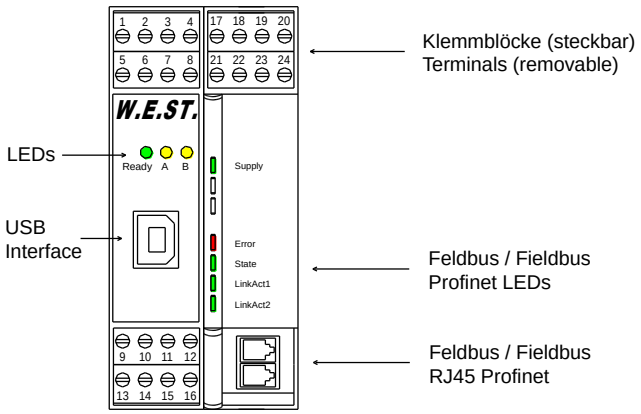
Features

- **Displacement, pressure and power limitation control**
- **For pumps in open or closed hydraulic circuit**
- **Universally applicable, also for valve position control and other control tasks**
- **Setpoint specification and monitoring via fieldbus (Profinet)**
- **Ideal replacement for OEM controller cards such as Rexroth VT-VPCD for HS4 or EO4 adjustment**
- **Free scaling of the analogue input signals, possibility of expansion with an LVDT module**
- **Optimized control function, digitally reproducible settings**
- **Two parameter sets for the pressure controller**
- **Integrated power stage**
- **Alternative analogue output for controlling valves with OBE**
- **Master - slave function for controlling multiple pumps connected in parallel**
- **Simplified parameterization with WPC-300 software or via fieldbus**

2.1 Device description



Typenschild und Anschlussbelegung
Type plate and terminal pin assignment



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 PQP-179-P controller is highly versatile and can be used to control pumps, valve combinations and for pressure control.

The device contains the following controllers, which can be activated in different combinations:

1.) Pressure controller
2.) Power limitation controller
3.) Swivel angle controller
4.) Valve – spool position controller
5.) Solenoid current controller

This list also shows the priority or order of the individual controllers in the possible cascades. Different combinations are activated depending on the application.

In principle, the main applications can be distinguished with their ‘master controllers’:

A: Pump control using electronic swash plate angle control

B: Pressure control with variable displacement pumps or valves (without swash plate angle control)

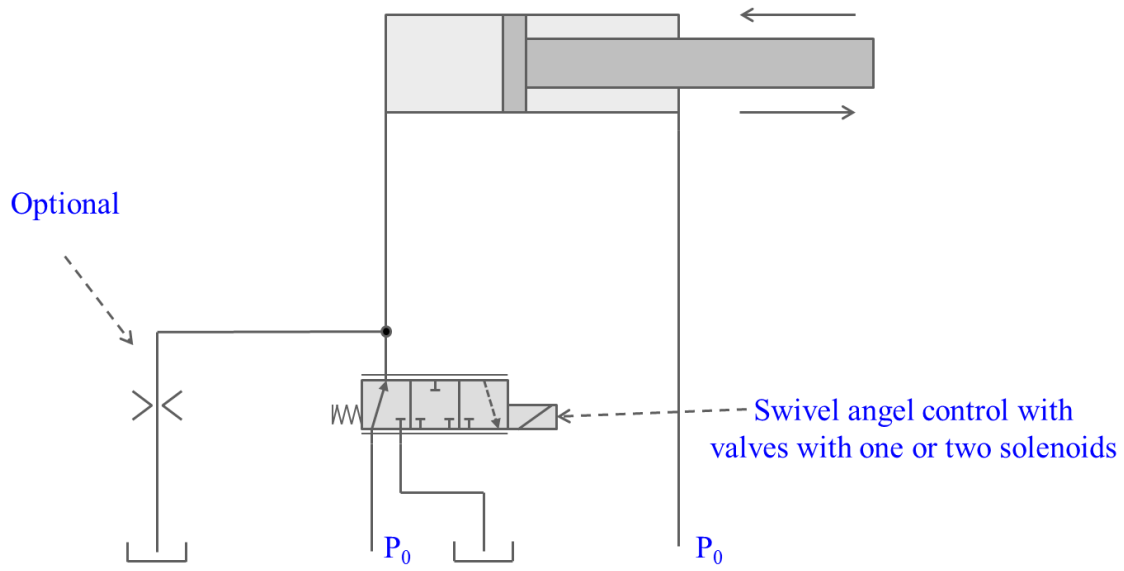
C: Spool position control of valves (without any pump control)

These variants are described in more detail below.

3.2.1 Case A, pump control using electronic swash plate control

The module realises a pump control for reversible or non-reversible variable displacement pumps by controlling the swash plate valve. Similar to the movement of a cylinder in a positioning control, the swash angle can be swivelled open and closed in both directions to achieve the desired target position or the desired degree of opening. The external specification can be influenced by various parameters and functions. A volume flow correction factor can be added, for example, but a parameterisable limiting function can also be used. The integrated power limiting function and the pressure controller, which can be connected in a cascade, can be used in both flow directions. The pressure limitation acts on the value measured in the flow direction, while the power limitation determines the maximum possible volume flow from the pressure difference.

Due to the relatively small mass, the natural frequency of the actuator is high and the dynamic behaviour is largely determined by the directional control valve. This means that the quality of the control is proportional to the quality and performance 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.

Operating in FUNCTION MASTER or SLAVE are special cases. These are applications in which several pumps deliver into one system and regulate the pressure together. Devices in SLAVE mode then receive their swash angle setpoint from the MASTER via an analogue input; the pressure controller can then be activated in this device.

Parameterisation:

CIRCUIT – OPEN or CLOSED for operation in an open or closed hydrostatic circuit

FUNCTION – usually STD, MASTER / SLAVE for several parallel pumps.

With these settings, the swash plate angle controller and the power stage of the device with the solenoid current controller are selected. The spool position controller can be added via CTRLOUT = 2SCL.

Activation via control bits:

ENABLE – general operation release (swash plate angle controller, power stage, spool position controller, if used)

ENABLE P – additionally activates the pressure controller

ENABLE PL – additionally activates the power limitation

3.2.2 Case B, pressure control

In this operating mode, the swash plate angle controller is deactivated and the signal from the pressure controller is passed on to the power stage. It is not possible to limit the power because there is no direct influence on the flow rate. If you want to control a pump in this operating mode, it must have a control system that realises a hydraulic-mechanical pressure control and is controlled by a proportional pressure valve. In this case, it makes sense to activate feedforward control at the pressure controller. Normally, CTRLOUT = 1SOL would be set, i.e. only one coil would be activated.

In some cases, the pressure is to be controlled by two proportional directional control valves, or by one with negative overlap or zero cut. In this case, feedforward control is not required. CTRLOUT is parameterised to 2SOL or 2SCL, the latter if you want to implement a spool position control at the same time.

Since the use of the pressure controller is mandatory for this operating mode, activation via the control bit ENABLE P is not required. Rather, the pressure controller is always active as soon as the device is ready for operation.

Parameterisation:

CIRCUIT – PCTRL

The spool position controller can be added via CTRLOUT = 2SCL.

Activation via control bits:

ENABLE – general operation release

3.2.3 Case C, Swivel angle control or pure valve position control

For pumps with a hydraulic-mechanical swashplate angle control, a power stage is sufficient for control in the simplest case. The PQP-179-P-PFN also includes the option of electronic power limitation. Simultaneous activation of the spool position controller is not normally required in this application.

Another variant of the device's use in this operating mode is the spool position control on individual valves with setpoint specification via Profinet. By setting the parameter SIGNAL:ANA accordingly, the control signal VA can be supplied to additional power amplifiers, thus controlling several pilot control stages working in parallel.

Parameterisation:

CIRCUIT – FCTRL

The slider position controller can be added via CTRLOUT = 2SCL.

Activation via control bits:

ENABLE – general operation release

ENABLE PL – activates power limitation

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 22	0 V (GND) connection.
PIN 4	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	(-) for the input PIN10, to be connected with 0 V for unipolar signals.
PIN 10	Feedback position control valve, signal range 0… 10 V, +/- 10V or 4… 20 mA, scalable.
PIN 13	Feedback value pressure (XP1), signal range 0… 10 V or 4… 20 mA In Slave – Mode: Svivel angle setpoint Q+, positive Range, 0 – 10 V
PIN 14	Feedback position control valve, 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, 0… 10 V or 4… 20 mA.
PIN 16	Control output - (U) or monitoring signal, 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 1	**READY output:** **ON:** The module is enabled; there are no discernable errors. **OFF:** ENABLE is not available or an error has been detected.
Connection	**Valve outputs**
PIN 17 / 19	Solenoid A
PIN 18 / 20	Solenoid B

4.2 LED definitions

4.2.1 First section with USB

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.

4.2.2 LEDs fieldbus (2nd section)

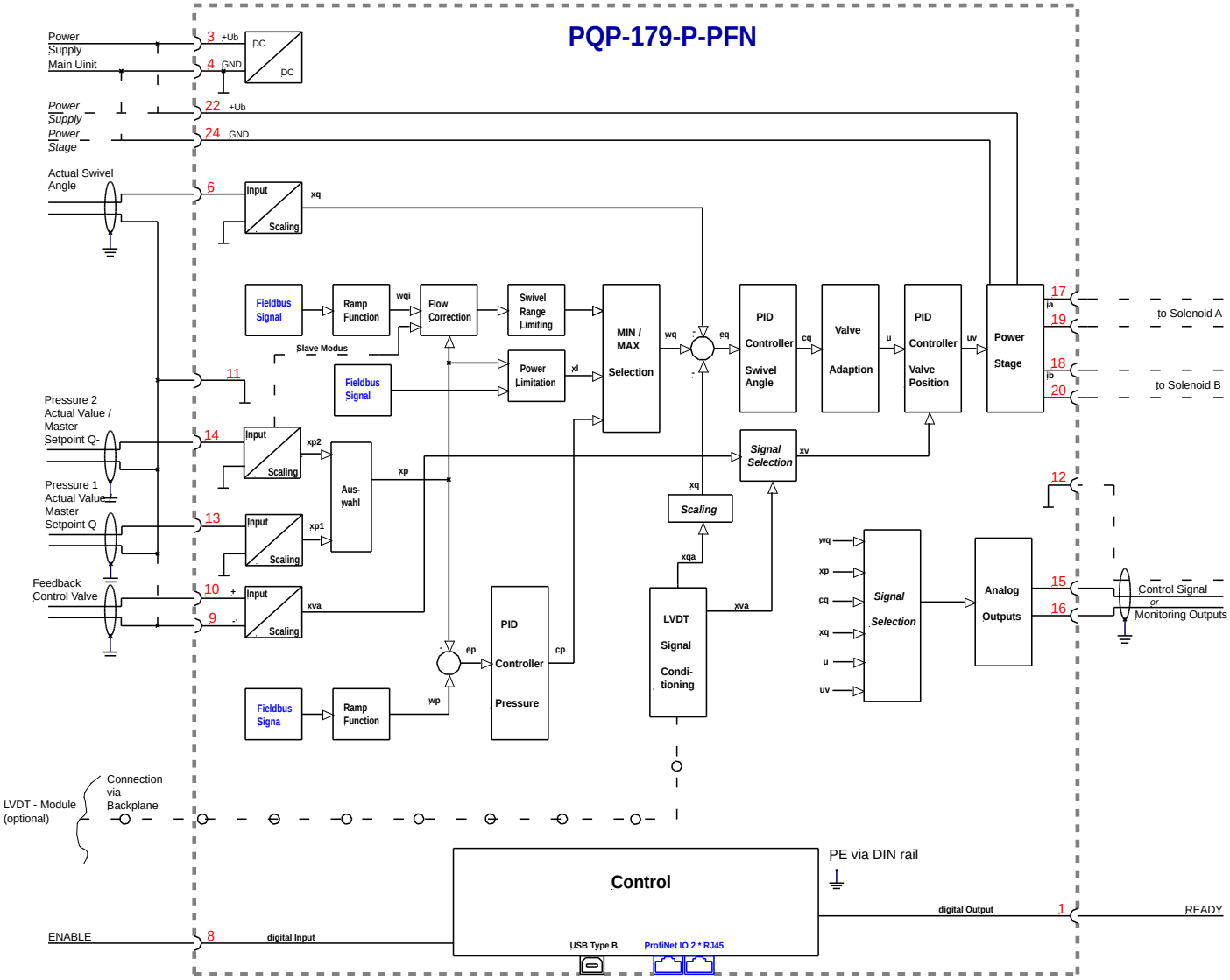
LEDs	Description of the LED functionality (device)
GREEN	Supply: **OFF:** No power supply for the fieldbus module. **ON:** 3.3 V system voltage is available.
LEDs	**Description of the LED functionality (fieldbus)**
RED	Error: The red ERR LED indicates an error status. **OFF:** No fieldbus error. **ON:** Error at the fieldbus communication.
GREEN	The green RUN LED shows the status of the central communication node. **OFF:** Bus not started yet **FLASHING:** PROFINET Initialisation **ON:** Connection established
GREEN	LinkAct1: The green LED indicates data access via the data network at the corresponding port. **OFF:** No connection **ON:** Working network connected to port **FLASHING:** PROFINET device flash test
GREEN	LinkAct2: The green LED indicates data access via the data network at the corresponding port. **OFF:** No connection **ON:** Working network connected to port **FLASHING:** PROFINET device flash test

4.3 Block diagrams

The device function varies depending on the setting selected for the CIRCUIT parameter.
See also chapter 3.1.

4.3.1 Case A, pump control by electronic swivel angle control

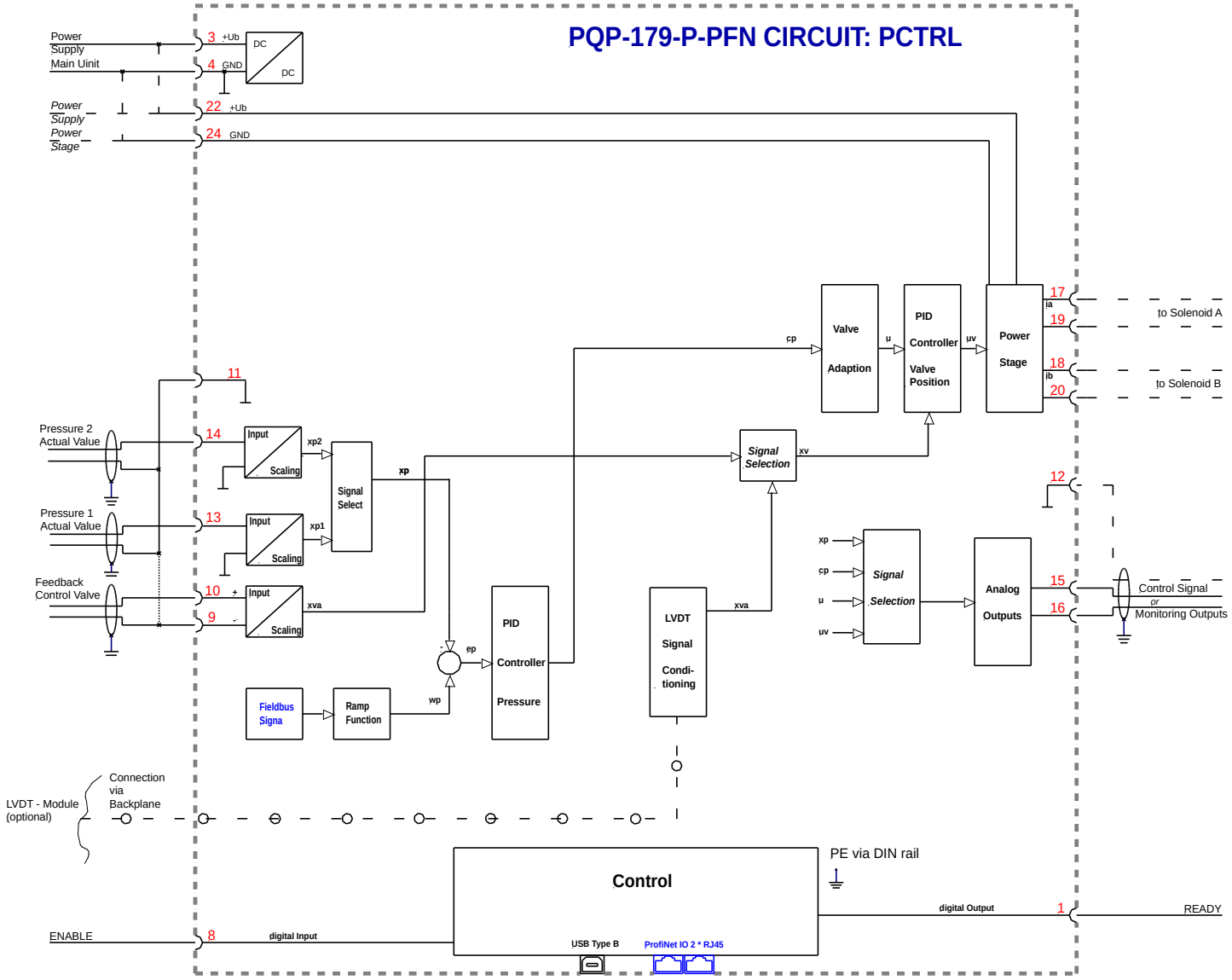
CIRCUIT = OPEN or CLOSED



4.3.2 Case B, pressure control

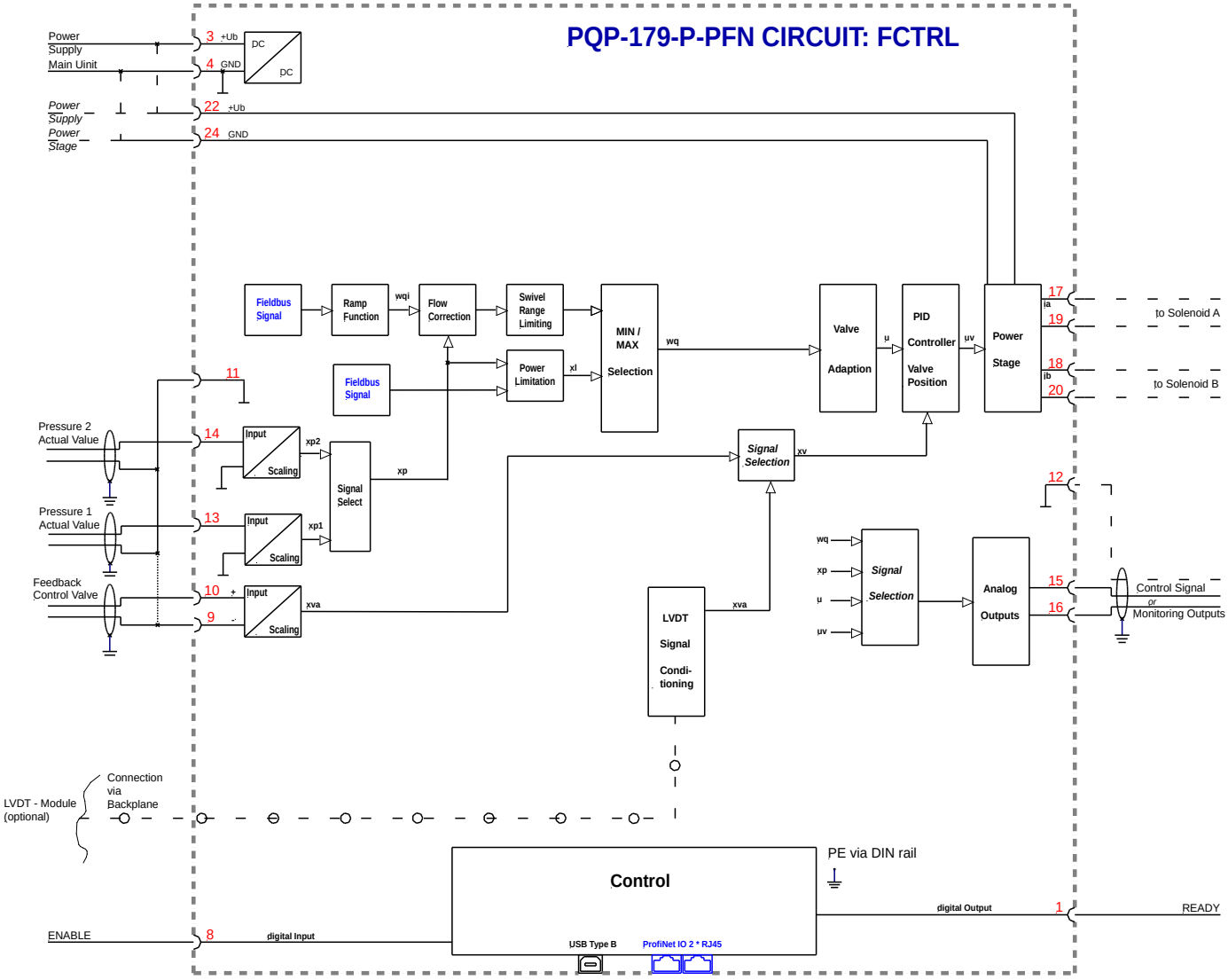
CIRCUIT = PCTRL

As described in chapter 3.2, the swivel angle controller and the power limitation function are not required. Valve spool position control can be activated as an option.

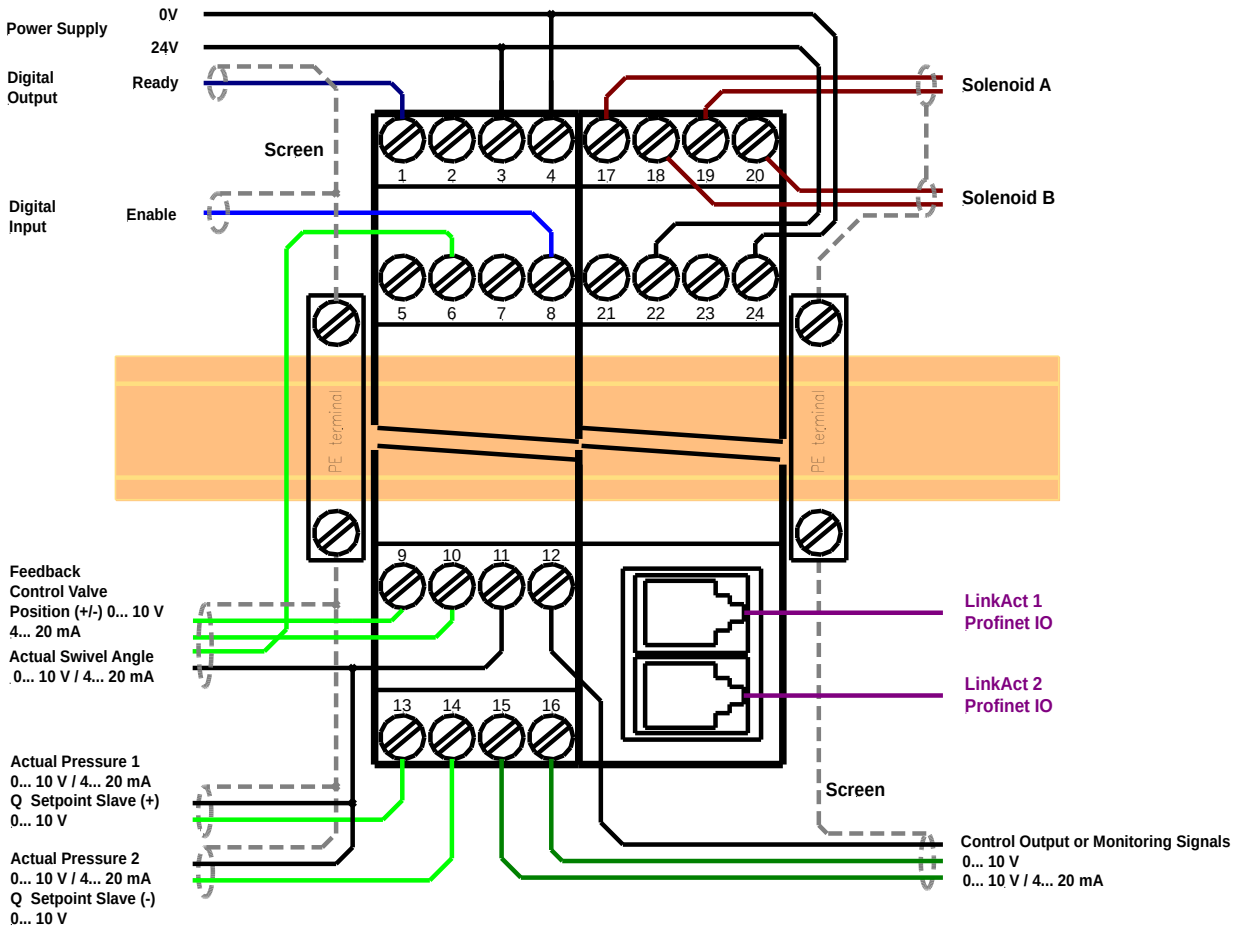


4.3.3 Case C, swivel angle open loop control or pure spool position control

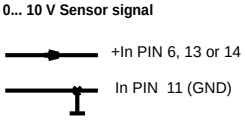
CIRCUIT = FCTRL

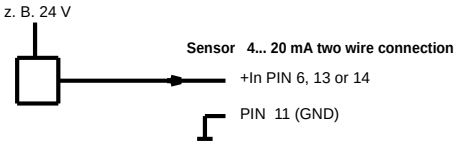


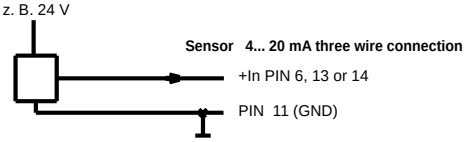
4.4 Typical wiring



4.5 Connection examples







4.6 Technical data

Supply voltage (Ub)	**[VDC]**	12… 30 (incl. ripple)
Power consumption	**[W]**	max. 4,8 + 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]**	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]**	61… 2604 selectable in defined steps
Controller cycle times		
Solenoid current control	**[µs]**	125
Signal processing	**[ms]**	1
PROFINET IO		
Data rate	**[Mbit/s]**	100
Conformity class	**-**	CC-B
Redundancy (optionally usable)	**-**	S2
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]**	0,34
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

Please note: In older WPC versions, the numerical values are sometimes entered with a decimal point shift, for example: 100.00 % - > enter "10000". This can be seen from the comment text displayed there, e.g. [0.01 %] in this case. The Index / Factor column is relevant for parameterisation via Profinet, see chapter 6.8.2.

Group	Command	Default	Unit	Description	Index [hex.] / Factor [dez.]
	MODE	SYSTEM	-	Visible parameter group	
Basic parameters (SYSTEM)					
	LG	EN	-	Selecting language	
	SENS	ON	-	Malfunction monitoring	2001
	PASSFB	0	-	Password for fieldbus parameterisation	
System configuration					
	CIRCUIT	OPEN	-	Hydraulic circuit selection	2002
	CTRLOUT	2SOL	-	Configuration of the control output	2003
	LIM:XQ	0.0	%	Cable break monitoring swivel angle feedback	2004 / 100
	FUNCTION	STA	-	Device function in the system	2005
Input signal adaption (IO_CONF)					
Pressure					
	SYS_RANGE	100	bar	System pressure range (normalisation basis for 100%)	2010
Pressure feedback 1					
	SIGNAL:XP1	U0-10	-	Type of input signal	2011
	N_RANGE:XP1	100	bar	Nominal pressure of the sensor	2012
	OFFSET:XP1	0	mbar	Sensor Offset	2013
Pressure feedback 2					
	SIGNAL:XP2	U0-10	-	Type of input signal	2014
	N_RANGE:XP2	100	bar	Nominal pressure of the sensor	2015
	OFFSET:XP2	0	mbar	Sensor Offset	2016
Swivel angle feedback					
	SIGNAL:XQ	U0-10	-	Type of input signal	2017
	ZERO:XQ **FULL:XQ+** **FULL:XQ-**	0.0 100.0 0.0	% % %	Scaling swivel angle feedback signal	2018 / 100 2019 / 100 2072 / 100
Feedback control valve position					
	SIGNAL:XV	U+-10	-	Type of input signal	201A
	ZERO:XV **FULL:XV+** **FULL:XV-**	50.0 100.0 0.0	% % %	Scaling feedback signal control valve position	201B / 100 201C / 100 2073 / 100
Output Signals (IO_CONF)					
	SIGNAL:ANA	V	-	Type of the output signals	201D
	SEL15	U	-	Signal selection for PIN15	201E
	SEL16	U	-	Signal selection for PIN16	201F

Group	Command	Default	Unit	Description	Index [hex.]
Control parameters (Q_CTRL / P_CTRL)					
Swivel angle command					
	RAQ:1	100	ms	Ramp times swivel angle demand	2020
	RAQ:2	100	ms		2021
	RAQ:3	100	ms		2022
	RAQ:4	100	ms		2023
	CORR:Q	0.0	%	Volume flow rate correction factor	2024 / 100
Swivel angle controller					
	CQ:FF	50.0	%	Offset value for neutral position of valves with one solenoid	2025 / 100
	CQ:P	1.0	-	PID controller swivel angle	2026 / 100
	CQ:I	400.0	ms		2027 / 10
	CQ:I_LIM	25.0	%		2028 / 100
	CQ:D	0.0	ms		2029 / 10
	CQ:T1	1.0	ms		202A / 10
Pressure command					
	RAP:UP	100	ms	Ramp times pressure command	202B
	RAP:DOWN	100	ms		202C
Pressure controller					
	CP:LLIM	0	0.01 %	Lower limit pressure controller	202D
	CP1:FF	0.0	%	PID controller pressure parameter set 1	2071 / 100
	CP1:P	1.0	ms		202E / 100
	CP1:I	400.0	%		202F / 10
	CP1:I_ACT	0.0	ms		2070 / 100
	CP1:D	0.0	ms		2030 / 10
	CP1:T1	1.0			2031 / 10
	CP2:FF	0.0	%	PID controller pressure parameter set 2	2073 / 100
	CP2:P	1.0	-		2032 / 100
	CP2:I	400.0	ms		2033 / 10
	CP2:I_ACT	0.0	%		2072 / 100
	CP2:D	0.0	ms		2034 / 10
	CP2:T1	1.0	ms		2035 / 10
Power limitation					
	PL:RPM	1500	1/min	Power limitation function	2036
	PL:QMAX	100	cm³		2037
	PL:EFF	78.5	%		2038 / 100
	PL:PL	31.8	kW		2039 / 10
	PL:T1	50.0	ms		203A / 10
Output signal adaption (Q_CTRL)					
	MIN:A	0.0	%	Deadband compensation	203B / 100
	MIN:B	0.0	%		203C / 100
	MAX:A	100.0	%	Output scaling	203D / 100
	MAX:B	100.0	%		203E / 100
	TRIGGER	2.0	%	Deadband compensation trigger point	203F / 100
	POL:U	+	+/-	Rated solenoid current	2040

Controller parameterisation - spool position (V_CTRL)					
PID Controller					
	CV:P	1.0	-	P Gain	2050 / 100
	CV:I	400.0	ms	I Proportion, Integrating time	2051 / 10
	CV:D	0.0	ms	D Proportion, derivative time	2052 / 10
	CV:D_T1	50.0	ms	D Proportion, filter	2053 / 10
	CV:FF	80.0	%	Feedforward	2054 / 100
Integrator control					
	CV:I_LIM	25.0	%	Limitation	2055 / 100
	CV:I_ACT	100.0	%	Activation threshold	2056 / 100
	CV:I_DZ	0.0	%	Dead zone	2057 / 100
Linearisation					
	VA:MIN:A	0.0	%	Minimum control (for spring preload)	2058 / 100
	VA:MIN:B	0.0	%		2059 / 100
	VA:MAX:A	100.0	%	Maximum control	205A / 100
	VA:MAX:B	100.0	%		205B / 100
	VA:TRIGGER	2.0	%	Minimum control trigger point	205C / 100
	POL:UV	+	+/-	Polarity of the control valve	205D
Endstufenparameter (IO_CONF)					
	CURRENT	1000	mA	Rated solenoid current	205F
	DFREQ	121	Hz	Dither frequency	2060
	DAMPL	5.0	%	Dither amplitude	2061 / 100
	PWM	2604	Hz	PWM frequency	2062
	ACC	ON	-	Current loop auto adjustment	2063
	PPWM	7	-	Closed loop current controller	2064
	IPWM	40	-		2065
Sonderkommandos (TERMINAL)					
	VLVCTRL	ON	-	Operating mode spool position control	2066
	EOUT	0	0.01 %	Output signal if no ready	2067
	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, power limit controller and output signal adjustment
P_CTRL	Pressure 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(1)|OFF(2)|AUTO(3)	-	**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 PASSFB (Password fieldbus)

Command	Parameters	Unit	Group
PASSFB x	x= 0… 10000000	-	**SYSTEM**

The value entered here serves as password for the parameterisation via fieldbus. For enabling parameterisation it has to be send via fieldbus to the address 0x2200, before any other parameter can be written. For a value of “0” the password protection is deactivated.

5.2.5 CIRCUIT (Selection of the hydraulic circuit)

Command	Parameters	Unit	Group
CIRCUIT x	x= OPEN(0)|CLOSED(1) |PCTRL(3)|VCTRL(4)	-	**SYSTEM**

Selection of whether the pump is operated in an OPEN or CLOSED circuit. For the controller, this means that in a closed circuit, it is possible to control the swash angle in the negative range.

The PCTRL setting deactivates the swash angle controller, i.e. the output signal of the pressure controller is forwarded directly to the output stage or the spool position controller. This option should be selected, for example, if the pump has an internal pressure control and the electronic controller is used to increase accuracy.

The VCTRL setting forwards the bipolar setpoint signal WQ directly to the output stage or the slide position controller via the MIN/MAX function. Power limitation is still possible if the corresponding control bit is set.

5.2.6 CTRLOUT (Selection of the control signal)

Command	Parameters	Unit	Group
CTRLOUT x	x= ANA(1)|1SOL(2)|2SOL(3)|2SCL(4)	-	**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.

5.2.7 LIM:XQ (Cable break monitoring swivel angle)

Command	Parameter	Unit	Group
LIM:XQ X	x= 0… 100.0	%	**SYSTEM**

This parameter can be used for additional error monitoring of the swivelling angle signal. If a value > 0% is specified here, a raw input value that falls below this threshold is interpreted as faulty. This makes it possible, for example, to implement cable break monitoring for voltage signals. For current signals 4..20 mA, cable break monitoring generally takes place at 3.5 mA, but with LIM:XQ this limit could be increased.

Example: Voltage input, error detection for signals < 2V desired -> set LIM:XQ to 20.0%, since 2V corresponds to 20% of the measuring range.

5.2.8 FUNCTION (Device function in the system)

Command	Parameter	Unit	Group
FUNCTION x	x= STD(1)|MASTER(2)|SLAVE(3)	-	**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 and the power limitation.

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 SIGNAL:XP1 x SIGNAL:XP2 x	x= U0-10(1)|I4-20(2)|LVDT(3) x= U+-10(1)|I4-20(2)|LVDT(3) x= OFF(1)|U0-10(2)|I4-20(3)| U10-0(4)|I20-4(5)	-	**IO_CONF**

This command defines the type of input signal of the analog inputs. At the same time, the signal direction can be reversed for the pressure signals.

Special features 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. The same displays are used to show the raw values for analog inputs. Since the polarity can be easily changed by scaling (see below), there is no option to select it here.

Actual pressure value XP2:

For applications in an open circuit, the two pressure sensors can be used alternatively; switching is done via the SELECT XP control bit over the field bus.

If the controller is used for pumps that are operated in a closed circuit, it is expected that for XP1 the sensor in the direction of flow is connected with a positive swash angle and for XP2 the sensor is connected to the other connection.

If only one pressure sensor is used, which always detects the pressure in the direction of flow due to acorresponding hydraulic connection, it is connected to the input for XP1 and SIGNAL:XP2 = OFF is parameterised.

If the device is parameterised as ‘SLAVE’, the inputs at PIN13 and PIN14 are used for the swing angle setpoint. In this case, there is no input available for a pressure measurement value; the parameters for the pressure measurements are inactive.

5.3.3 N_RANGE (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 XQ (Scaling function swivel angle feedback)

Command	Parameter	Unit	Group
ZERO:XQ x FULL:XQ+ x FULL:XQ- x	x= 0.0.. 100.0	%	**IO_CONF**

The sensor at the pump provides a unipolar signal 0...10 V or 4...20 mA. This signal can be scaled appropriately using the parameters provided here. The input value corresponding to the actual positions of 100% (FULL:XQ+), 0% (ZERO:XQ) and, if there is a possibility of reverse delivery, -100% (FULL:XQ-) swivel angle must be specified. This also allows negative actual values. The input value before scaling is permanently available as process data XQA for the analogue signals or for the optional LVDT input LD1.

The value FULL:XQ- is automatically reset to the same value as ZERO:XQ for pumps in open circuit and to a value that results in symmetrical scaling for CIRCUIT = CLOSED each time FULL:XQ+ or ZERO:XQ is entered. Accordingly, this value should be set last.

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

Command	Parameter	Unit	Group
ZERO:XV x FULL:XV+ x FULL:XV- x	x= -100.0… 100.0	%	**IO_CONF**

The sensor on the valve supplies a current or voltage signal to terminals 9/10, which can be either unipolar or bipolar. Alternatively, the valve position can be detected via an LVDT sensor on channel LD2. The raw signal XVA can be scaled as required using the parameters provided here.

The value FULL:XV- is automatically reset to a value that results in symmetrical scaling each time FULL:XV+ or ZERO:XV is entered. Accordingly, this value should be set last, if necessary.

To set these values, see also Section 6.3 (Commissioning).

5.3.7 SIGNAL:ANA (Type of output signal)

Command	Parameter	Unit	Group
SIGNAL:ANA x	x= V(1)|C(2)	-	**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

5.3.8 SEL15/16 (Signal selection)

Command	Parameter	Unit	Group
SEL15/16 x	x= WQ(1)|XP(2)|CQ(3) |XQ(4)|U(5)| UV(6)	-	**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.

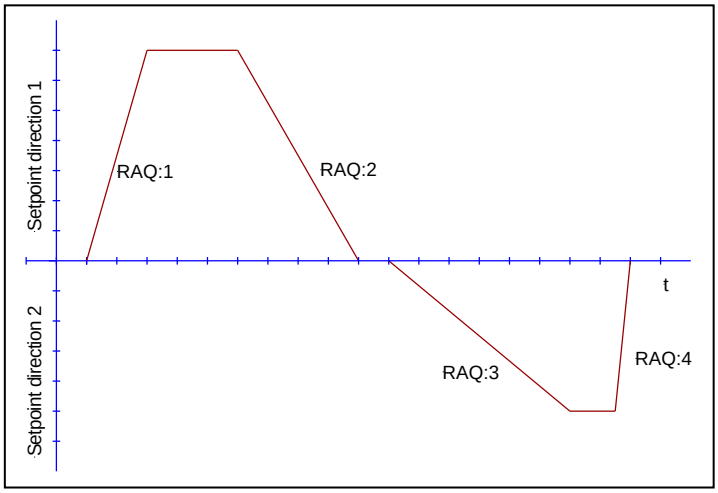
5.4 Controller parameterization

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 by selecting CIRCUIT = OPEN, 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.. 10.0	%	**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… 100.0	%	
	:P x= 0… 100.0	-	
	:I x= 0… 3000.0	ms	
	:I_LIM x= 0… 100.0	%	
	:D x= 0… 120.0	ms	
	:T1 x= 10… 100.0	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.

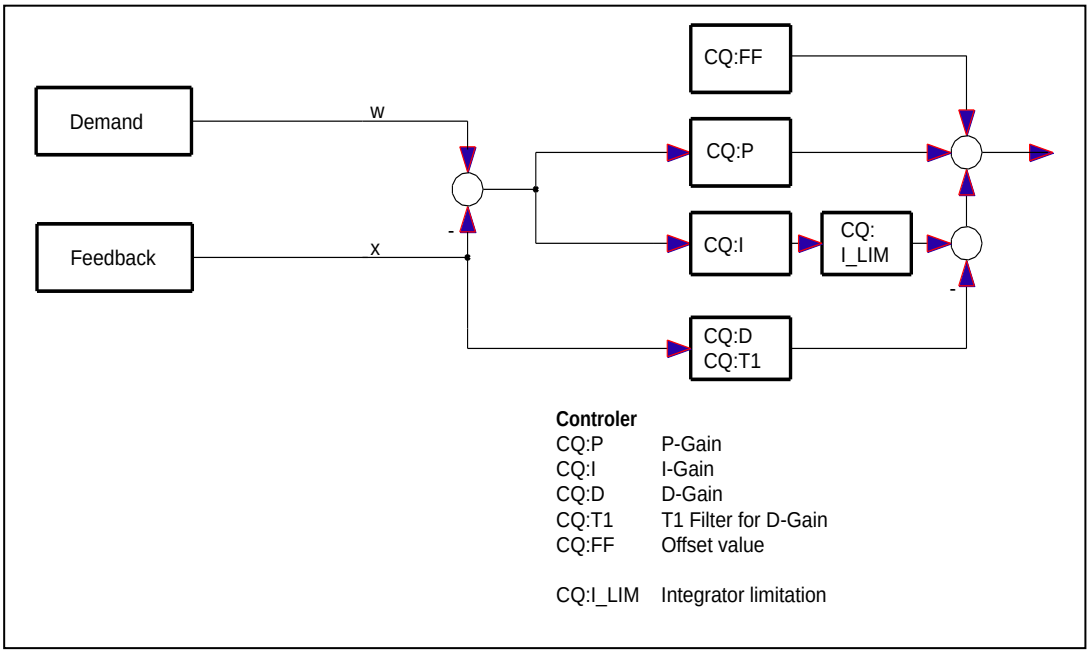
CQ:P - P gain of the controller.

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.

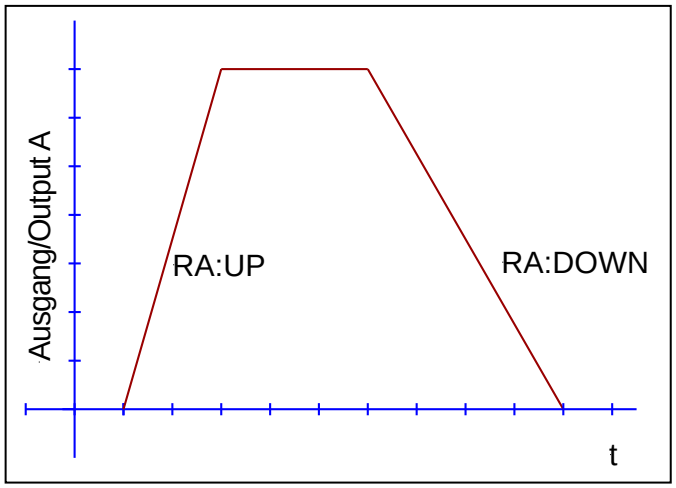
CQ:T1 - The T1 factor is used for the D-gain in order to suppress high-frequency noise.



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= 0.0… -100.0	%	**P_CTRL**
CP1:I X	i= FF|P|I|I_ACT|D|T1		
CP2:I X	:FF x= 0… 150.0	%	
	:P x= 0… 100.0	-	
	:I x= 0… 3000.0	ms	
	:I_ACT x= 0… 100.0	%	
	:D x= 0… 120.0	ms	
	:T1 x= 10… 100.0	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:FF - Pilot control, is typically used when the pressure is not controlled via the swivel angle adjustment but via a pressure valve.

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.

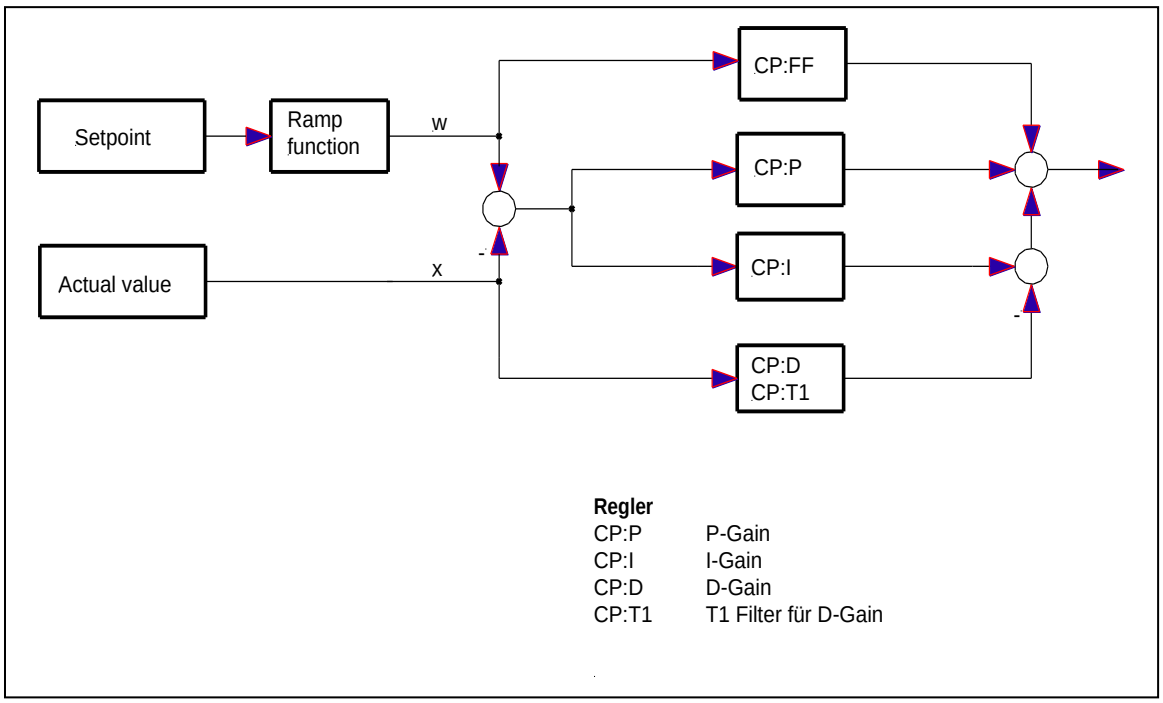
CP:I - I-gain of the controller. The integrator can be deactivated with a programmed value of 0.

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	rpm	**PL_CTRL**
PL:QMAX	X	x = 1… 1000	cm³	
PL:EFF	X	x = 50.0… 100.0	%	
PL:PL	X	x = 0.1… 1000.0	kW	
PL:T1	X	x = 1.0… 1000.0	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)

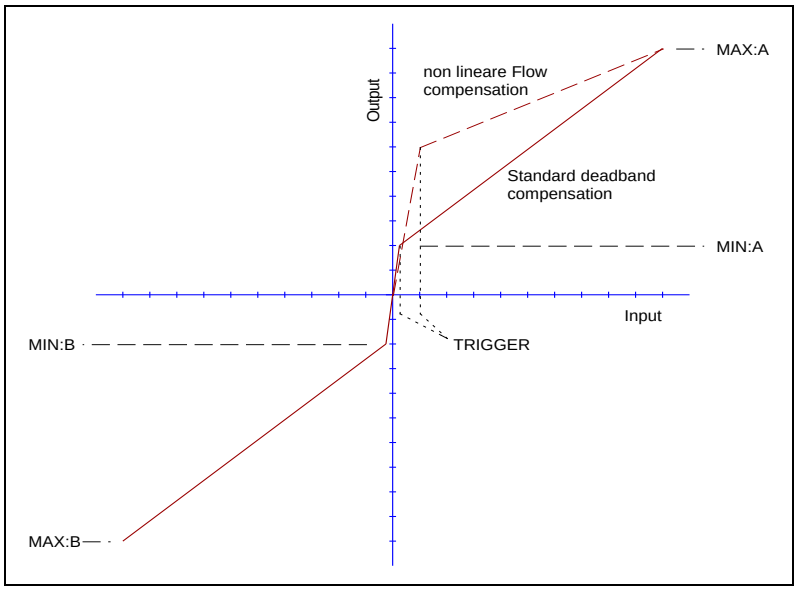
Kommando	Parameter	Einheit	Gruppe
	i= A|B	-	**Q_CTRL**
MIN:i x	x= 0.0… 60.0	%	
MAX:i x	x= 50.0… 100.0	%	
TRIGGER x	x= -40.0… 40.0	%	

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.

A negative setting of the trigger parameter can be used to implement an overlap of the valve controls for double-solenoid valves. In this case, the process variable U only indicates the difference between the two output signals. The effect of this setting variant can be assessed by observing the solenoid currents. If the manipulated variable is applied to the analogue outputs (SEL15 = U or FUNCTION = MASTER), the individual signals at PIN15 and PIN16 are also superimposed accordingly.

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= +(1)|-(0)	-	**Q_CTRL**

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

5.6 Spool position control

5.6.1 PID controller

Command	Parameter	Unit	Group
CV:i x	i= P|I|D|D_T1|FF		**V_CTRL**
	P x= 0.01… 100.0	-	
	I x= 0… 3000.0	ms	
	D x= 0… 120.0	ms	
	D_T1 x= 1.0… 100.0	ms	
	FF x= 0.0… 100.0	%	

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.

5.6.2 Integrator control

Command	Parameter	Unit	Group
CV:I_LIM x	x= 0.0… 100.0	%	**V_CTRL**
CV:I_ACT x	x= 0.0… 100.0	%	
CV:I_DZ x	x= 0.0… 100.0	%	

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= 0.0… 60.0	0.01 %	
VA:MAX:i x	x= 40.0… 100.0	0.01 %	
VA:TRIGGER x	x= -40.0… 40.0	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.

A negative setting of the trigger parameter can be used to overlap the valve control in the case of double-solenoid valves. In this case, the process variable UV only indicates the difference between the two output signals. The effect of this setting variant can be assessed by observing the solenoid currents. If the manipulated variable is applied to the analog outputs (SEL15 = UV), the individual signals at PIN15 and PIN16 are also superimposed accordingly.

5.6.6 POL:UV (polarity of the control valve)

Command	Parameter	Unit	Group
POL:UV x	x= +(1)|-(0)	-	**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= 0,0… 30,0	%	

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(1)|OFF(2)	-	**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(1)|SIMOL(2)|SIMCL(3)	-	**TERMINAL**

This command is used to activate the spool position control for the control valve or to select a start-up func-

tion. 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= -100,0… 100,0	%	**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 PROFINET IO RT interface

6.1 PROFINET IO function

PROFINET is the standard for Industrial Ethernet based on IEEE 802.xx. PROFINET is based on the 100 Mb/s-version of full duplex and switched Ethernet. PROFINET IO is designed for the fast data exchange between Ethernet-based controllers (master functionality) and field devices (slave functionality) with cycle times up to 4 ms.

6.2 Profinet Installation guideline

The Profinet IO field devices are connected exclusively via switches as network components. A Profinet IO network can be set up in star, tree, line or ring topology. Profinet IO is based on the Fast Ethernet standard transmission with 100 Mbit / s. The transmission media are copper cables CAT5.

For the IP20 environment in the control cabinet, the RJ45 connector CAT5 according to EN 50173 or ISO / IEC 11801 is used. The pin assignment is compatible with the Ethernet standard (ISO / IEC 8802-3).

The connection between Profinet participants is called Profinet channel. In most cases, Profinet channels are built with copper cables to IEC 61784-5-3 and IEC 24702. The maximum length of a Profinet channel, which is constructed with copper cables is 100 m.

6.3 PROFINET address assignment

All PROFINET IO slave devices need name and IP address to initiate communication.

Both are assigned to the device by the Profinet-IO-controller (PLC). The device name of the PROFINET IO device is stored in persistent memory in the device. It can be modified by a Profinet IO supervisor, e.g. the programming system of the belonging PLC.

Default address:

IP Address:	0.0.0.0
Subnet-Mask:	0.0.0.0
IP Address Gateway:	0.0.0.0

Address Example.:

IP Address:	192.168.1.111
Subnet-Mask:	255.255.255.0
IP Address Gateway:	192.168.1.111

6.4 Device data file (GSDML)

The characteristics of an IO device are described by the device manufacturer in a general station description (GSD) file. The language used for this purpose is the GSDML (GSD Markup Language) - an XML based language. For I/O data, the GSDML file describes the structure of the cyclic input and output data transferred between the programmable controller and the PROFINET IO device. Any mismatch between the size or structure of the input and output data and the actual internal device structure generates an alarm to the controller.

In the configuration of transmission data select 32 bytes for input and 32 bytes for output.

This unit requires the file GSDML-V2.43-W.E.St-GTW_PFN_v6-20240116.xml

6.5 IO Description

The demand values are set in a range up to 10000 (100%) and reported the same way.
Pressure signals are set and reported with an resolution of 0.1 bar.
For the control and status bits “1” means activation respective activity.
Error bits are displayed inverted because a “0” reports an active error.

The module is controlled with a control word consisting of following bits

ENABLE	General activation of the system linked with the hardware enable. Swivel angle controller and output stage get activated.
ENABLE P	Activation of the pressure controller.
ENABLE RAMP	Activation of the ramp function.
ENABLE PL	Activation of the power limitation function (Including scaling via fieldbus). If activated the demand WL has to be preset. It scales the limit value PL:PL.
SELECT CP	Select the active parameter set for the pressure controller (activation for CP2).
SELECT XP	Selection of the active pressure actual value for the controller (activation for XP2), only relevant in the operating mode for the open circuit (CIRCUIT = OPEN).
PARAREAD	Reads out the value of the parameter which is determined by PARA ADDRESS and returns this value in PARA VALUE of the data sent to the fieldbus. If the address is not valid the function will return „0xffffffff“.
READLLIM	PARAREAD returns the lower limit for the selected parameter instead of the value. This function is primarily used for the automatic initialisation of a PLC parameterisation module.
READULIM	ditto, but output of the lower range limit.
PARAMODE	Enables the ability to set parameters.
PARA VALID	Parameter value is transmitted at the rising edge of this control bit.
LIVEBIT IN	If this bit is set in the “ready” – state of the module, an internal watchdog function will be activated. In the further course it is monitored if there is a value change in the data received by the bus at least once per second. This could be e.g. this bit. If there is a period longer than 1s without data change, the “ready” – state of the module will be deactivated. The value read here will be returned by the bit “LIVEBIT OUT” in the status word.

Further data words to the module:

DEMAND SWIVEL ANGLE	Demand value for maximum valve opening, unit percent
DEMAND PRESSURE	Pressure demand in 0.1 bar units
DEMAND POWER LIMITATION	Setpoint for the limit function in % of the power limit (100% = PL:PL)
PARAMETER VALUE	Value of the parameter to be transmitted
PARAMETER ADDRESS	Address of the parameter which should be changed or read out

Feedback takes place with a status word including following bits:

READY	Common readiness of the system (enable available and no error occurred)
POWER LIM	System is in power limitation
P ACTIVE	System is in pressure limitation
XQ ERROR	Error at swivel angle feedback
XP1 ERROR	Error at pressure feedback 1
XP2 ERROR	Error at pressure feedback 2
IA ERROR	Error at solenoid A
IB ERROR	Error at solenoid B
DERROR	Internal data error (parameters have to be saved)
BUS ERROR	Error in the processing of the field bus data (buffer overflow, checksum- or livebit error)
PARA ACTIVE	Parameterization via fieldbus was enabled
PARA READY	Parameter value was transferred correctly. This bit will be reset by resetting the control bit PARAVALID likewise.
LIVEBIT OUT	Monitoring of the fieldbus communication. Return of the **LIVEBIT** IN signal.

Further feedback values to the fieldbus:

ACTUAL SWIVEL ANGLE	Measured swivel angle of the pump (XQ)
ACTUAL PRESSURE 1	Measured pressure value at sensor 1 (XP1)
ACTUAL PRESSURE 2	Measured pressure value at sensor 2 (XP2)
ACTIAL VALUE LIMITATION	Actual output value of the limitation function (XL)
CONTROL SIGNAL	Control signal to the valve (U)
SOLENOID CURRENT A	Current at solenoid A (IA)
SOLENOID CURRENT B	Current at solenoid B (IB)
PARAMETER VALUE	parameter value, requested by PARA READ

6.6 Commands via Profinet

6.6.1 Overview

Nr.	Byte	Function	Type	Range	Unit
1	0	Control word 1 High Control word 1 Low	int		
2	1				
3	2	Control word 2 High Control word 2 Low	int		
4	3				
5	4	Swivel angle demand High Swivel angle demand Low	int	-10000… 0 … 10000	0.01 %
6	5				
7	6	Pressure demand High Pressure demand Low	int	0… 10000	0.1 bar
8	7				
9	8	Power limitation demand High Power limitation demand Low	int	0… 10000	0.01 %
10	9				
11	10	---			
12	11	---			
13	12	---			
14	13	---			
15	14	---			
16	15	---			
17	16	---			
18	17	---			
19	18	---			
20	19	---			
21	20	---			
22	21	---			
23	22	---			
24	23	---			
25	24	---			
26	25	---			
27	26	Parameter value High (MSB)	long	Depending on the selected parameter	Depending on the selected parameter
28	27				
29	28				
30	29	Parameter value Low (LSB)			
31	30	Parameter address High Parameter address Low	int	0… 0x2065	-
32	31				

6.6.2 Definition control word 1

Byte 0 – control word High			
No.	**Bit**	**Function**	
1	0	SELECT XP	Select active feedback input for the pressure controller
2	1	SELECT CP	Select active parameter set for the pressure controller
3	2	---	
4	3	---	
5	4	ENABLE PL	Activation of the power limitation function
6	5	---	
7	6	ENABLE P	Activation of the pressure controller
8	7	ENABLE	Enabling of the system

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

6.6.3 Definition control word 2

Byte 2 – control word High			
No.	**Bit**	**Function**	
1	0	LIVEBIT IN	fieldbus monitoring
2	1	---	
3	2	---	
4	3	---	
5	4	---	
6	5	---	
7	6	---	
8	7	---	

Byte 3 – control word Low			
No.	**Bit**	**Function**	
1	0	---	
2	1	---	
3	2	---	
4	3	READLLIM	PARAREAD returns the lower limit for the selected parameter
5	4	READULIM	PARAREAD returns the upper limit for the selected parameter
6	5	PARA READ	Reading out the selected address
7	6	PARA VALID	Transmitting parameterization
8	7	PARA MODE	Activation of the parameterizing mode

6.7 Feedback via Profinet

6.7.1 Overview

Nr.	Byte	Function	Type	Range	Unit
1	0	Status word 1 High Status word 1 Low	int		
2	1				
3	2	Status word 2 High Status word 2 Low	int		
4	3				
5	4	Swivel angle actual value High Swivel angle actual value Low	int	+/- 10000	0.01 %
6	5				
7	6	Pressure actual value 1 High Pressure actual value 1 Low	Int	0… 10000	0.1 bar
8	7				
9	8	Pressure actual value 2 High Pressure actual value 2 Low	Int	0… 10000	0.1 bar
10	9				
11	10	Output signal power limitation High Output signal power limitation Low	Int	0… 16383	0.01 %
12	11				
13	12	Control signal to the valve High Control signal to the valve Low	Int	+/- 10000	0.01 %
14	13				
15	14	Solenoid current A High Solenoid current A Low	Int	0… 2600	mA
16	15				
17	16	Solenoid current B High Solenoid current B Low	Int	0… 2600	mA
18	17				
19	18	Feedback spool position High Feedback spool position Low	Int	+/- 10000	0.01 %
20	19				
21	20				
22	21				
23	22				
24	23				
25	24				
26	25				
27	26				
28	27				
29	28	Parameter value High (MSB)	long	Depending on Parameter	Depending on Parameter
30	29				
31	30	Parameter value Low (LSB)			
32	31				

6.7.2 Definition status word 1

Byte 0 – status word High			
No.	**Bit**	**Function**	
1	0	---	
2	1	---	
3	2	---	
4	3	---	
5	4	---	
6	5	PRESSURE LIM	Pressure controller is leading
7	6	POWER LIM	Power limitation is leading
8	7	READY	System is enabled and no errors are detected

Byte 1 – status word Low			
No.	**Bit**	**Function**	
1	0	---	
2	1	$\overline{\text{XV ERROR}}$	Error spool position sensor
3	2	$\overline{\text{IB ERROR}}$	Error at solenoid B
4	3	$\overline{\text{IA ERROR}}$	Error at solenoid A
5	4	$\overline{\text{XQ ERROR}}$	Error swivel angle feedback
6	5	$\overline{\text{XP2 ERROR}}$	Error pressure feedback 2
7	6	$\overline{\text{XP1 ERROR}}$	Error pressure feedback 1
8	7	$\overline{\text{ERROR}}$	Accumulated error

6.7.3 Definition status word 2

Byte 2 – status word High			
No.	**Bit**	**Function**	
1	0	---	
2	1	---	
3	2	---	
4	3	---	
5	4	---	
6	5	$\overline{\text{BUS ERROR}}$	Field bus communication error (internal)
7	6	---	
8	7	$\overline{\text{DERROR}}$	Internal data error

Byte 3 – status word Low			
No.	**Bit**	**Function**	
1	0	LIVEBIT OUT	Monitoring of the communication
2	1	---	
3	2	---	
4	3	---	
5	4	---	
6	5	---	
7	6	PARA READY	Parameterization successful
8	7	PARA ACTIVE	Parameterization via fieldbus active

6.8 Parameterising via Fieldbus

Note: For Siemens PLCs, we offer a free function block for convenient parameter transfer and data backup in the control system. There are separate instructions for this.

The parameters can be addressed, read and written via the indices given in the overview. The same limits and scaling apply to numerical parameters as to their representation in the WPC. The options for selection parameters are represented by numerical values, which are given in brackets after the options in the respective parameter description.

6.8.1 Mode of operating

Preparation:

- Power supply of the different sections has to be available.
- For safety issues the system should not be active.
  If active, the ENABLE bit in the control word has to be reset.
  Attention: Parameterization via fieldbus can also be done having an active system. In this case it should be done very carefully because changes are directly operative.

Parameterization:

- At first the **PARA MODE** bit has to be set to enable parameterizing via ProfiNet.
  This will be reported via the **PARA ACTIVE** bit.
- Provide **address** and new **value** of the parameter which should be changed.
- Setting the **PARA VALID** bit to high will transmit the data.
  The **PARA READY** bit will report a successful parameterization.
  Attention: A missing **para ready** bit means parameterization was not performed.

Storing:

- Same procedure as parameterizing standard parameters.
- Selecting **0x2100** as **address**, written **value** does not matter (below 60000).

Password protection:

- If a password was set this has to be entered first for enabling parameterization. Procedure is the same as if parameterizing standard parameters.
- Select **0x2200** as **address** and send the password (PASSFB) as **value**.
- After **PARA READY** reports success, subsequently parameterizing can be done as long as **PARA MODE** stays active. If is reset, the protection becomes active again. This means, in order to change more parameters after setting **PARA MODE** first the password itself needs to be send. See above.

If the password was transferred incorrectly three times, the parameterization mode gets locked (reported by deactivated **PARA ACTIVE** bit). Only restarting the device enables three new attempts.

Please note that a storage of the parameterization via Profinet is limited in the number of writing cycles. Means it should be done only when necessary.

6.8.2 Number format

Since only integers are transmitted when transferring the parameters via the field bus, the parameters must be converted accordingly.

The information in the ‘Parameter overview’ table, Index / Factor column, is used for this purpose.

For read parameters, the supplied value must be divided by the factor listed there; for writing, the desired parameter must be multiplied by it.

Example:

MIN:A is to be set to 21.5 %. The table provides the value ‘100’ as the factor for this parameter. Accordingly, the numerical value 21.5 * 100 = 2150 is to be transmitted. When this parameter is read, the same value is returned.

Selection parameter:

The various options are coded as numbers.

The assignment of the numerical values to the selection options is given in brackets in the table of the respective parameter description. See e.g. 5.3.2 (parameter SENS).

7 Appendix

7.1 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.
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!

7.2 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).

7.3 Commissioning of the control valve position controller

7.3.1 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 0.0… 30.0 61… 2604	Use the data sheet information of the valve. [2]	**IO_CONF**
CV:FF	0… 200.0	First set to the value 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.

7.3.2 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 the neutral position without activation is now entered in the parameter ZERO:XV, the value at maximum opening in the increasing direction in the parameter FULL:XV+, and in the decreasing direction in FULL:XV-.

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.

7.3.3 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.

7.3.4 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.

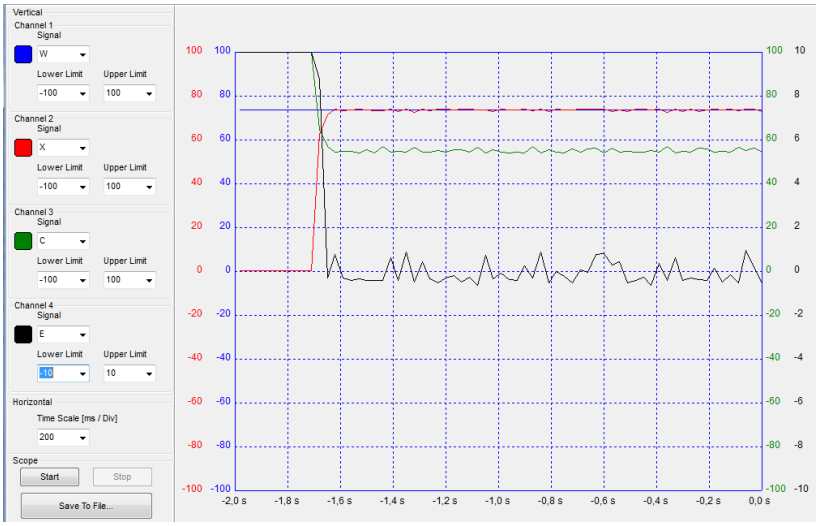
The oscilloscope view in the WPC is useful for evaluating the transient response.

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

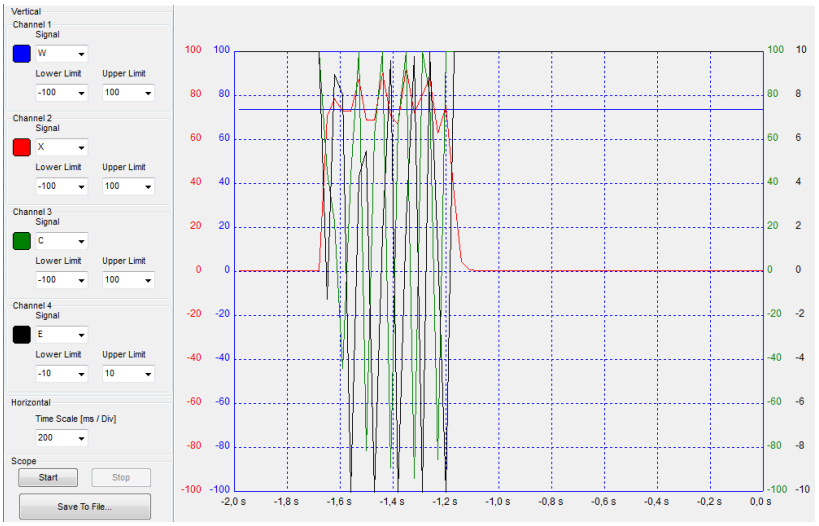
To be able to observe the transient response, it is necessary to have the oscilloscope window active during a signal change.

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:



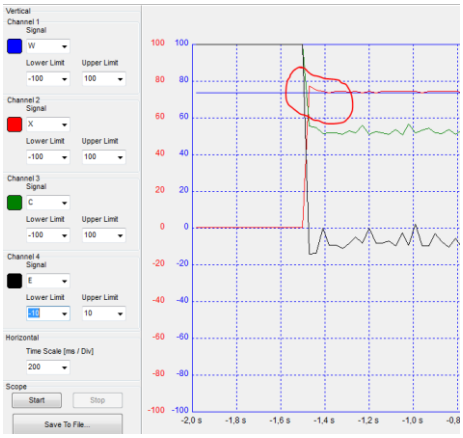
The simplest procedure for setting the proportional gain is to gradually increase CV:P until instability occurs. The value of CV:P then has to be divided by 2-4 again to get a definitely stable but high value.

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 500.0.

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 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 "100") 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.

8 Profinet-Driver Blocks for Simatic-Controllers

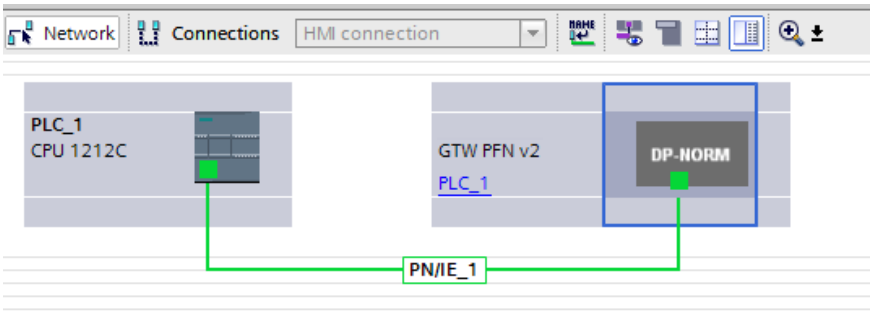
8.1 Integration of the Block into the PLC program

For use within the „TIA Portal“ software we provide two driver blocks that enable a convenient access out of the application program:

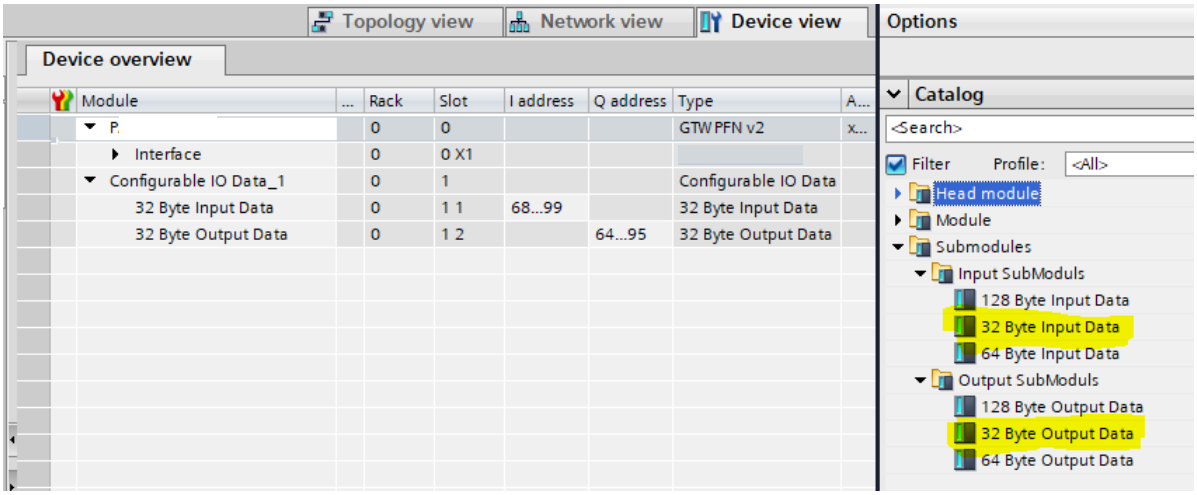
a) The source WEST_PQP_179_P.scl for controllers of the S7-1200 and -1500 series
b) The source WEST_PQP_179_P_TIA_KLASSIK.scl for controllers of the S7-300 and -400 series

Below their integration in the TIA project and the interconnections are explained.

1. Import the GSDML-file
2. Project the connection between PLC and controller card via Profinet:



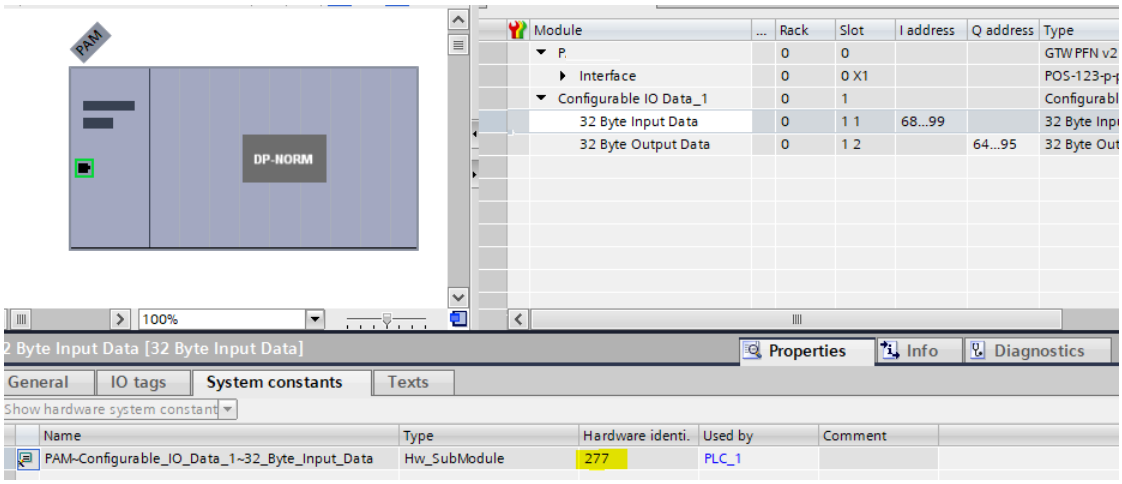
3. Install two submodules in the device:
   32 byte output data
   32 byte input data



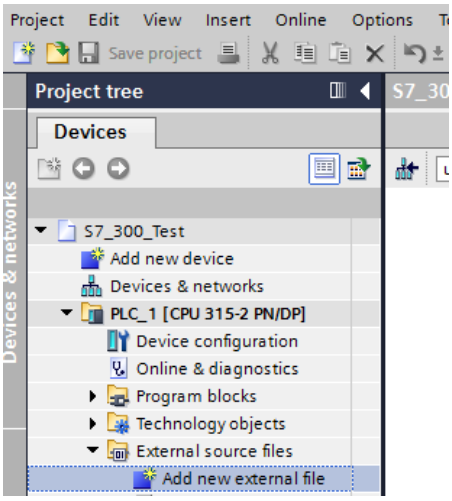
The addresses are assigned automatically. The automatically assigned hardware identifiers are also important for connecting the program module when using the S7-1200 / -1500. These can be determined by right-clicking on the two modules in the device overview and selecting the context menu item "Properties":

These numbers are different and must be noted separately for the input and output data.

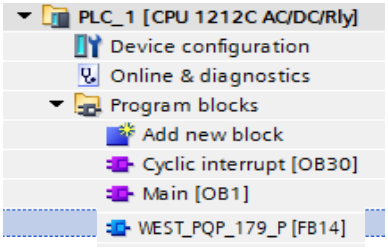
If an S7-300 / -400 is used, the input and output addresses of the IN/OUT module are required.



4. The driver block is supplied as SCL – source. In order to assemble it into the project, the file has to be added to the TIA – Portal as “new external file”:



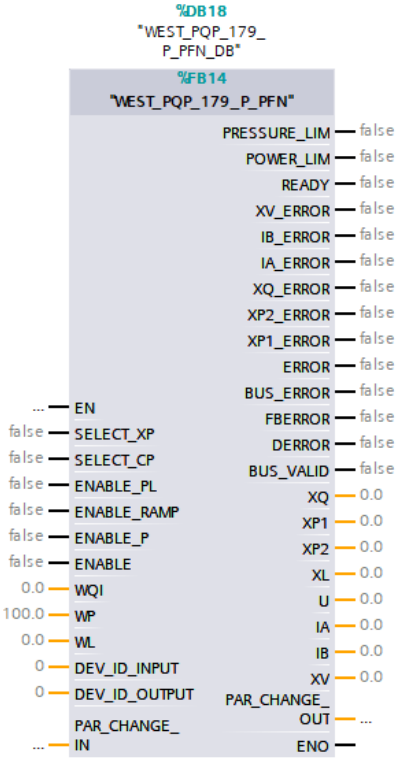
5. Subsequently click on the imported file and chose “generate blocks from source”. After this step the driver block can be found in the “blocks” folder. Its number may differ.



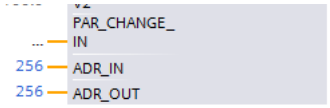
This FB can now be called out of the application program. This must happen in a cyclic interrupt with an execution time >= 4 ms.

If the block is called faster or in the free cycle (OB1), the time-dependent live bit monitoring does not function reliably and an error may be erroneously output.

View of the block in FUP without interconnection:



Address designation for S7-300 / -400 (example):



The start addresses of the input and output data are specified here, not the hardware identifiers.

The connectors of the driver block correspond as far as possible to the description in the previous chapter. The following differences have to be considered:

- Transduction of setpoints in the number format “real”, units “%” and “bar”
- The signals allowing to change parameters are bundled in structures (usage is optional).
- As parameter „DEV_ID_INPUT“ and „DEV_ID_OUTPUT“ the hardware identifiers of the IO Module have to be entered (S7-1200 / S7-1500)
- As parameters ADR_IN / ADR_OUT the starting addresses (see HW config.) have to be entered (S7-300 /-400).
- The values „ERROR…“ are not inverted, which mean “TRUE” indicates the presence of an error.
- The bit “BUS_VALID” signals the operation of the bus data transfer.
- Feedback of the actual values in the number format “real”, units “%” and “bar”

BUS_ERROR_CODE:

This output parameter contains various error bits of the fieldbus communication and the device in bit-coded form. In the good state, the number is "0". The meaning is as follows:

	Bit - Number	Valence (decimal)	Valence (hex.)
Data Error (DERROR)	0	1	0x01
Bus Error	2	4	0x04
Driver error when receiving data	3	8	0x08
Driver error when sending data	4	16	0x10
Livebit Error	5	32	0x20

If several errors occur at the same time, several bits are set and the number output is the sum of these.

If the bus data exchange is faulty, the feedback values are not reliable. In most cases they will be frozen in that case. If the output values are processed and used to control further functions, the valid bit has also to be considered. In case of a bus failure adequate fall-back values have to be used so that the complete system is kept in a safe state.

9 Notes